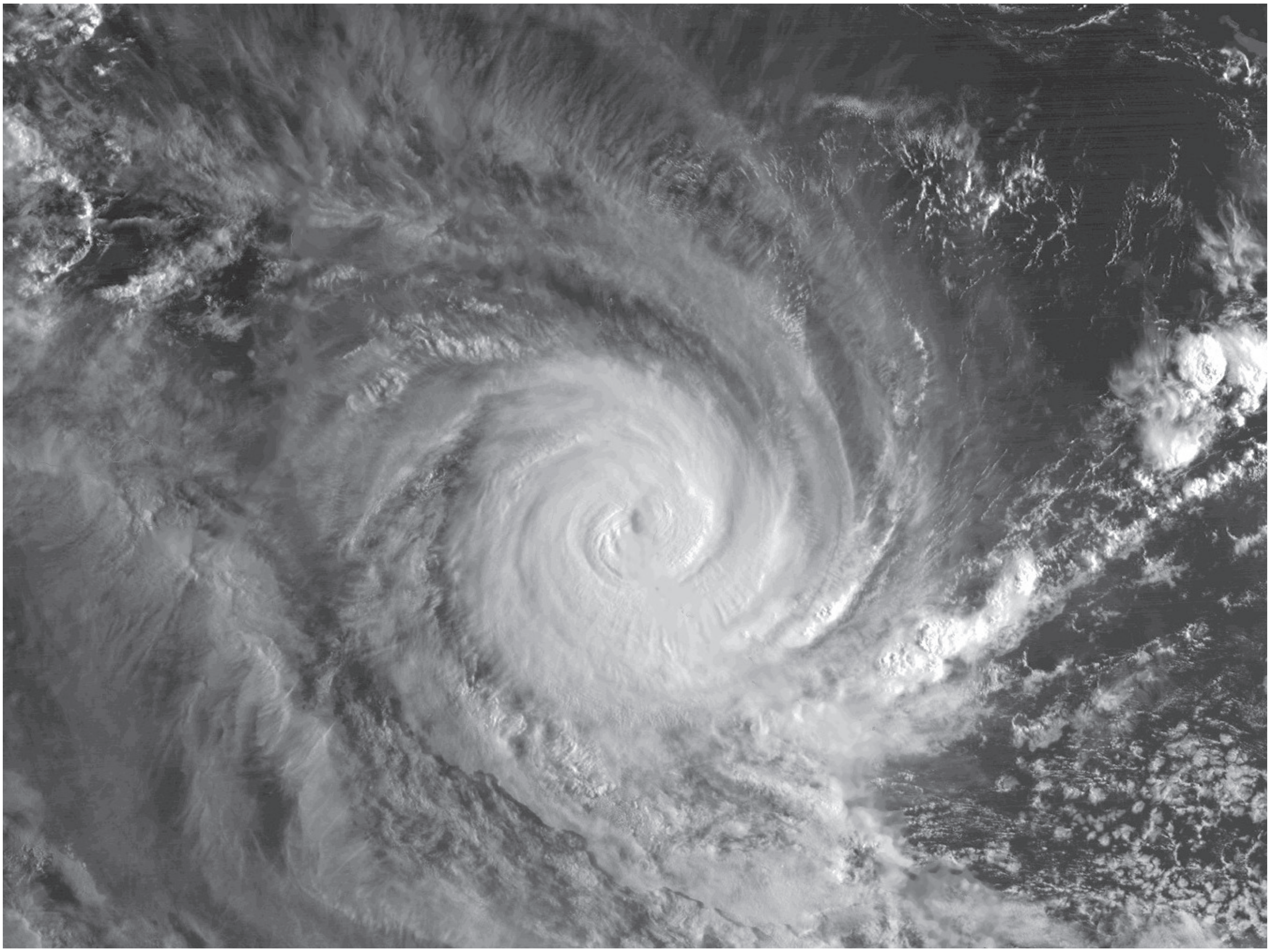
REVIEW of HYDROLOGICAL AND METEOROLOGICAL SERVICES IN THE CAUCASUS AND CENTRAL ASIA REGION:

A study covering Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan and Armenia, Azerbaijan, Georgia



Kerava, Finland 2010

The World Bank

GFDRR
Global Facility for Disaster Reduction and Recovery

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ISDR
International Strategy for Disaster Reduction

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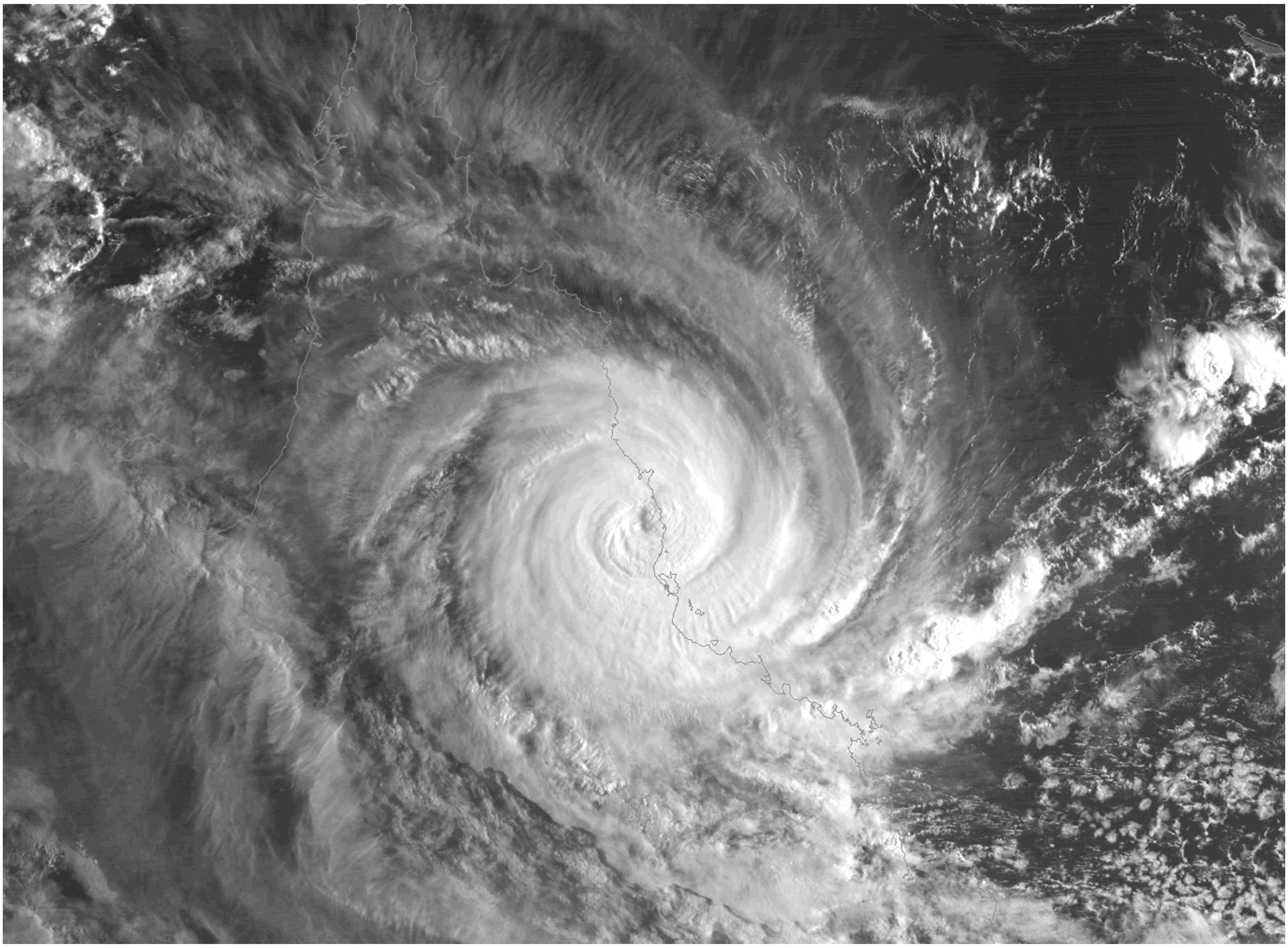

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PREFACE

The region of Central Asia and the Caucasus (CAC) is highly vulnerable to natural disasters. Occurrence of natural hazards in all eight countries of the two sub-regions is very high – substantial parts of the territory are covered by mountains and practically all natural hazards, such as earthquakes, landslides, debris flows, avalanches, floods and droughts are present there. While the earthquakes are the most dangerous of them, weather-related hazards are usually causing largest economic damage. Climate change is expected to exacerbate natural disasters associated with hydro-meteorological conditions, with associated damages particularly impacting the rural economy.

Within the context of the Global Facility for Disaster Risk Reduction (GFDRR), the World Bank and United Nations International Strategy for Disaster Reduction Secretariat (UNISDR) under the umbrella of the Central Asian Regional Economic Cooperation Program (CAREC) and in collaboration with other international partners have initiated a Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI), which is in line with the Hyogo Framework for Action 2005-2015 (HFA), and aims at reducing the vulnerability of CAC to the risks of disasters. CAC DRMI incorporates three focus areas, with the possibility to include new activities: (i) coordination of disaster mitigation, preparedness and response; (ii) financing of disaster losses, reconstruction and recovery, and disaster risk transfer instruments such as catastrophe insurance and weather derivatives, and (iii) hydro-meteorological forecasting, data sharing and early warning. The initiative will form the foundation for regional and country specific investment priorities in the areas of early warning, disaster risk reduction, and financing. The initiative builds on the existing cooperation that already exists in the region, and will complement and consolidate the activities of the institutions involved to promote more effective disaster mitigation, preparedness and response. These institutions include International Finance Institutions (IFIs), the EU, the Council of Europe, the UN [notably UNDP/BCPR, the UN Office for the Coordination of Humanitarian Affairs (OCHA) and UNICEF], regional cooperation institutions such as the Economic Cooperation Organization (ECO), bilateral donors such as the Swiss Development Cooperation (SDC), and the Japan International Cooperation Agency (JICA).

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AMDAR	Aircraft Meteorological Data Relay
APT	Advanced Power Technology
ASH	Armenian State Hydromet
AWS	Automatic Weather Station
CA	Central Asia
CAC	Central Asia and Caucasus
CA-CRM	Central Asian Multi-Country Program on Climate Risk Management
CAC DRMI	The Central Asia and Caucasus Disaster Risk Management Initiative
CAREC	Central Asia Regional Economic Cooperation
CASPCOM	Coordinating Committee on Hydrometeorology and Pollution Monitoring of the Caspian Sea
CC	Climate Change
CIMO	The Commission for Instruments and Methods of Observations (WMO)
CIS	Commonwealth of Independent States
COST	European Cooperation in Science and Technology
CRED	Centre for Research on the Epidemiology of Disasters (WHO)
DCP	Data Collection Platforms (to collect data from AWSs)
DRR	Disaster Risk Reduction
DWD	German National Weather Services (Deutsches Wetter Dienst)
ECMWF	European Center for medium-range Weather Forecasts
EDB	Eurasian Development Bank
EHMH	Extreme (high impact) Hydrometeorological Hazards
EM-DAT	Emergency Events Database (by CRED)

EC	European Commission (EU)
EU	European Union
EUMETcast	A scheme for dissemination of various (mainly satellite based) meteorological data operated by EUMETSAT
EUMETNET	A network grouping 26 European National Meteorological Services
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization of the United Nations
FMI	Finnish Meteorological Institute
FP7	Seventh Framework Program (EU)
FWS	Flood Warning System
GCM	Global Climate Model
GDP	Gross Domestic Product
GDP(PPP)	GDP at purchasing power parity (PPP) per capita
GIS	Geographical Information System
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GTS	Global Telecommunication System (WMO)
HF	High Frequency (radio; frequencies are between 3 and 30 MHz)
HMH	Hydrometeorological Hazards
HMI	Hydrometeorological Information
HRPT	High Resolution Picture Transmission
HRTP	High Resolution Temperature Product
IBRD	International Bank for Reconstruction and Development

ICAO	International Civil Aviation Organization
ICH CIS	Interstate Council on Hydrometeorology of the Countries of the Commonwealth of Independent States
ICI	International Cooperation Instrument of MFA of Finland
ICT	Information and Communication Technology
ICCP	Intergovernmental Panel on Climate Change
IFAC	International Federation of Automatic Control
IHM	National Institute of Hydrometeteorology of Georgia
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental panel on Climate Change
IRI	International Research Institute for Climate and Society
IT	Information Technology
LAM	Local Area Model
LAN	Local Area Network
LAPS	Local Analysis and Prediction System
MDGs	Millennium Development Goals
MF	Medium Frequency (radio 300–3000 kHz)
MFA	Ministry of Foreign Affairs of Finland
MoES	Ministry of Emergency Situations
MSG	Meteosat Second Generation (satellite data receiving system)
NCEP	National Centers for Environmental Prediction (NOAA, USA)
NHMS	National Hydrometeorological Service
NOAA	National Oceanic and Atmospheric Administration (USA)
NOGAPS	Navy Operational Global Atmospheric Prediction System (USA)
NWP	Numerical Weather Prediction
RA II	Regional Association, WMO region II

RA VI	Regional Association, WMO region VI
RCM	Regional Climate Models
RHC	Regional Hydrological Centre of IFAC
R&D	Research and Development
R&D&D	Research and Development and Demonstration
SDC	Swiss Agency for Development and Cooperation
SEE	South East Europe
SIDA	Swedish International Development Cooperation Agency
SMS	Short Message Service (Mobile Phones)
SWOT	Strengths, Weaknesses, Opportunities and Threats
TECO	Technical Conference (WMO)
UHF	Ultra High Frequency (between 300 MHz and 3 GHz)
UKMO	United Kingdom Meteorological Office
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
Uzhydromet	Centre of Hydro-Meteorological Service at Cabinet of Ministers of the Republic of Uzbekistan
VCP	Voluntary Cooperation Program (WMO)
VCP-F	Voluntary Cooperation Program Fund (WMO)
WAN	Wide Area Network
WB	World Bank
WCP	World Climate Program

WHO	World Health Organization (UN)
WMO	World Meteorological Organization (UN)
VSAT	Very Small Aperture Terminal
www	World Wide Web (or web)

CONTENTS

EXECUTIVE SUMMARY

The geographical and economic size of the countries, structure of economy, socio-economic development and vulnerability to natural hazards vary strongly from country to country in the Central Asia[1] and South Caucasus[2] (CAC) region. However, the economy and socio-economic development depend strongly on climate and weather related sectors. The CAC region is highly vulnerable to natural disasters. Occurrence of natural hazards in all eight countries of the two sub-regions is very high - substantial parts of the territory are covered by mountains and practically all natural hazards, such as earthquakes, landslides, debris flows, avalanches, floods and droughts are present there. Additionally to these there are several other weather related phenomena which cause every year human and economic losses: heat and cold waves, poor traffic conditions, poor air quality, spreading of insect pest and diseases, and others.

The economic development of the CAC countries is still strongly related to agriculture and other weather sensitive sectors, giving the share of GDP varying from 40% to close to 70%.

Proper production and use of climate and weather data and information by the Disaster Risk Reduction (DRR) management and different socio-economic sectors would not only help to prevent natural hazards from becoming human and economic disasters, but also promote mitigation of impacts of the hazards, adaptation to the climate change, and thus promote socio-economic development and achievement of the Millennium Development Goals (MDGs) put by each country.

Currently the CAC National Hydrometeorological Services do not have the capacity to provide services to the DRR management and different socio-economic sectors at adequate level. The CAC National Hydro-meteorological Services (NHMSs) have faced significant changes in their operational environment and operational conditions since early 1990s. The observation networks have severely declined during the last two decades, and the NHMSs have not been capable to modernize the production systems and processes. The CAC NHMSs have very much lost the track of sustainable or any development. The status of NHMSs in some countries is really bad, in some countries much better, but in none of the countries good with reference to developed NHMSs.

In order to promote national and regional economic development and reduce the risk of natural disasters in the CAC countries it is critical to enhance the technical and human NHMS resources to ensure better operational monitoring, forecasting and warning. Furthermore, in context of the increasing risks, but also opportunities, associated with climate variability and climate change, there needs to be enhanced investments in climate modeling and forecasting and analysis to support sector planning for different socio-economic sectors.

There are several factors which need to be taken into account when determining the way(s) and financial magnitude to modernize the NHMSs and to improve their institutional structure. But before investing in technology it is critical to invest in training of the managers and the staff in order to increase the awareness and know-how about operation of modern NHMSs and modern facilities available today, about needs and benefits from better interaction with the economic sectors and the

[1] *Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan*

[2] *Armenia, Azerbaijan and Georgia*

industry, and in improvement of the communication and data management systems and skills of the technical staff.

It is difficult to estimate very accurately the total economic benefits from improved hydrometeorological services of different scales in the Caucasian countries because there is very little, if any, data available about economic losses caused by weather related phenomena, and the economic sectors do not fully recognize the benefits which could be achieved through modern state-of-the-art observation network, more timely and accurate site specific weather forecasts, and other services and tailored products.

However, very coarse estimation, mainly based on benchmarking to some other countries with a bit better data, show that investments in modernization of the NHMSs would pay back to the national economic development many folds. On annual level the impact could be around 0.1%-0.3% of the GDP, or even more.

Regional cooperation and data sharing among the Caucasian and Central Asian NHMSs would significantly promote the quality and quantity of hydrometeorological services, and decrease the impacts of natural hazards in each country. However, as the countries are very big, and the common issues are very large it is difficult to achieve similar benefit from regional cooperation in modernization of the observation network that what could be shown in the modernization plan for the South European countries.

In order to build a reliable and a sustainable development plan it is critical to introduce a reliable vision, and plan an end-to-end data collection and service production system based on identified and recognized customer and end-user needs. The increasing needs of better hydrometeorological data and services by different sectors, together with intensive discussion of climate change and natural hazards, which are threats to the communities, offers the NHMSs also big opportunities to promote their visibility and to get national, and also international, support and financing for their modernization.

1 THE CAC COUNTRIES IN A NUTSHELL

The Central Asia and Caucasus (CAC) consists of eight former Soviet republics: five Central Asian countries Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, and three Caucasian countries Armenia, Azerbaijan and Georgia. The CAC region covers an area of 4.2 million square kilometers, and has a population of around 75 million. Corresponding figures for EU27 are 4.3 sq km and 51 million. The geographical and economic size of the countries, structure of economy, socio-economic development and vulnerability to natural hazards vary strongly from country to country in the CAC region.

The economy of the CAC countries is under strong reformation. However, agriculture still remains the main source of livelihood in CAC. Agriculture is also the economic sector most vulnerable to weather and climate variability.

Under the old Soviet central planning system, Armenia developed a modern industrial sector, supplying machine tools, textiles, and other manufactured goods to sister republics, in exchange for raw materials and energy. Armenia has since switched to small-scale agriculture and away from the large agroindustrial complexes of the Soviet era. Armenia has managed to reduce poverty, slash inflation, stabilize its currency, and privatize most small- and medium-sized enterprises.

With a history of industrial development of more than 100 years, Azerbaijan proved to be a leading nation in Southern Caucasus until nowadays. Oil is the most prominent product of Azerbaijan's economy with cotton, natural gas and agriculture products contributing to its economic growth over the last years.

Georgia's main economic activities include the cultivation of agricultural products such as citrus

Figure 1. Caucasian and Central Asian Countries

	Armenia		Azerbaijan		Georgia		Kazakhstan		Kyrgyzstan		Tajikistan		Turkmenistan		Uzbekistan	
Area sq km	29,743		86,8		69,7		2,724,900		199,951		143,100		488,100		447,400	
- land area sq km	28,203		82,629		69,7		2,699,700		191,801		469,930		469,930		425,400	
- water area sq km	1,540		3,971		0		25,200		8,150		18,170		18,170		22,000	
Population (x 1000)	2,967		8,239		4,616		15,400		5,432		7,350		4,885		23,000	
GDP (PPP) USD billion	18.97		78.47		21.68		181.1		11.83		13.92		30.69		72.47	
GDP per capita (PPP) $	6,400		9,600		4,700		11,700		2,200		1,800		6,400		2,700	
	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF
Agriculture	19	46.2	5.6	38.3	12.2	55.6	6	31.5	26.9	48	20.1	49.8	10.1	48.2	26.7	44
Industry	33	15.6	61.4	12.1	26	8.9	42.8	18.4	18.4	12.5	22.2	12.8	30.5	14	39.7	20
Services	48	38.2	33	49.6	61.8	35.5	51.2	50	54.7	39.5	57.7	37.4	59.4	37.8	33.5	36
Populat. below Powerty Line	26%		11%		31%		12%		40%		60%		30%		26%	
Unemployment rate	7.1%		6%		16.4%		6.3%		18%		2.3%		60%		1%	

Table 1. Size, population, GDP and share of GDP and labor force (LF) by sector in 2008, and latest figures for share of population below the Poverty Line and unemployment rate (CIA, 2010).

fruits, tea, hazelnuts, and grapes; mining of manganese and copper; and output of a small industrial sector producing alcoholic and nonalcoholic beverages, metals, machinery, and chemicals. The country imports the bulk of its energy needs, including natural gas and oil products. Its only sizable internal energy resource is hydropower.

Kazakhstan, the largest of the CAC countries, possesses enormous fossil fuel reserves and plentiful supplies of other minerals and metals. It also has a large agricultural sector featuring livestock and grain. Kazakhstan's industrial sector is primarily focused on the extraction and processing of these natural resources.

Agriculture remains a vital part of Kyrgyzstan's economy and a refuge for workers displaced from industry. Cotton, wool and meat are the main agricultural products and exports. Subsistence farming has increased in the early 2000s. Industrial exports include gold, mercury, uranium and electricity (hydropower).

Tajikistan has great hydropower potential, and has focused on attracting investment for projects for electricity internal use and exports. Agriculture is a significant sector for GDP and employment. However, more than 80 percent of the land in use for agriculture depends on irrigation. Tajikistan has rich deposits of gold, silver, and antimony.

Turkmenistan is largely a desert country with intensive agriculture in irrigated oases and huge gas and oil resources. One-half of its irrigated land is planted in cotton; formerly it was the world's 10-15th largest producer.

Agriculture is the backbone of the economy of Uzbekistan. Agriculture sector employs 44% of the country's labor force and contributes 27% of its GDP. Crop agriculture requires irrigation and occurs mainly in river valleys and oases. Minerals and mining also are important to Uzbekistan's economy.

In general the economy of the CAC countries is strongly based on weather sensitive sectors such as agriculture, energy production and transmission, construction, transportation and communication, even if there are big differences between the countries. The share of identified weather sensitive sectors of national GDP vary from about 70% in Armenia to 42% in Turkmenistan, as shown in Table 2.

Country	Share of weather-dependent sectors, % GDP
Azerbaijan	51
Armenia	69
Georgia	62
Kazakhstan	43
Turkmenistan	42
Tajikistan	61
Kyrgyzstan	48

Table 2. Estimation of the share of main weather dependent sectors of national GDP in different countries in 2008. (WB, 2009).

Poverty is a general problem for all CAC countries, even if the of number people under poverty line differ very much between the countries. The poverty threshold, or poverty line, is the minimum level of income deemed necessary to achieve an adequate standard of living in a given country. Generally the national estimates of the percentage of the population falling below the poverty line are based on surveys of sub-groups, with the results weighted by the number of people in each group. Definitions of poverty vary considerably among nations. For example, rich nations generally employ more generous standards of poverty than poor nations. In the national Millennium Development Goals (MDGs) for the CAC countries, which are tuned to meet their own specific needs, the main target is reduction of poverty.

The economic, and more generally the socio-economic development, and reduction of the poverty (MDG No1), combat of malaria and other diseases (MDG No 6) and promotion of environmental sustainability (MDG No 7) depend strongly on climate[3] and weather related sectors in the CAC countries. The importance of weather dependent economic sectors makes the economic development prone to annual variation of meteorological components and weather conditions.

The climate in Armenia is highland continental: hot summers and cold winters. There are six climatic zones from dry subtropical to rigorous high mountains. The weather is conditioned by anticyclone (46%), cyclone fields (33%), the local air circulation (14%) and by the impact of southern hot dry tropical air (7%). Wind velocity at 10 m height a.g.l. might reach 20 m/s. The maximum temperature recorded is 43^0C. The average winter temperature in Armenia is -6.7^0C. The annual total precipitation is 592 mm, and in the driest part of the country (Ararat valley) around 200-250 mm.

The temperature regime and its distribution throughout Azerbaijan is regular and depends on the features of air masses, entering to the country, the regional landscape and proximity to the Caspian Sea. The Caspian Sea causes temperatures in the maritime areas (20 km away from the sea) to decline in the summer and raises it in the winter. At the same time it relatively softens the influence of hot and dry air masses coming from Central Asia. The maximum temperature is +44oC (Julfa, Nakhchevan) and the minimum -42oC (Great Caucasus Mountains). Annual average number of precipitation: 500 mm (min 200, max 2300).

[3] *Climates encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall and other meteorological elements in a given region over long periods of time. Climate can be contrasted to weather, which is the present condition of these same elements and their variations over periods up to two weeks. Popular definition: "Climate is what you expect, weather is what you get."*

Georgia's climate is affected by subtropical influences from the west and by Mediterranean influence from the east. Due to the big variety of physical and geographical conditions almost all types of climate are present over Georgia. The Greater Caucasus range moderates the local climate by serving as a barrier against cold air from the north. Along the Black Sea coast the humidity and annual precipitation is high ranging on average from 1000 to 2000 mm, while the western part of Meshketi Mountain range receives around 4500 mm. Maximum temperature reaches 42 oC, and minimum falls down to -42 oC at 3650 m a.s.l.

Kazakhstan's climate is very continental and faces climatic extremes – very hot in the summer and bitterly cold in the winter. Average winter temperatures are -3°C in the north and 18°C in the south; summer temperatures average 19°C in the north and 28°-30°C in the south. Within locations differences are extreme, and temperature can change very suddenly. The winter air temperature can fall to -50°C, and in summer the ground temperature can reach as high as 70°C. Precipitation in the mountains of the east averages as much as 600 millimeters per year, mostly in the form of snow, but most of the republic receives only 100 to 200 millimeters per year. Precipitation totals less than 100 millimeters in the south-central regions around Qyzylorda. A lack of precipitation makes Kazakhstan a sunny republic; the north averages 120 clear days a year, and the south averages 260.

Kyrgyzstan has a continental climate with relatively little rainfall. It averages 247 sunny days a year. In the summer in the mountains the mornings are generally fine and the afternoons hazy with occasional rain. In the lowlands the temperature ranges between -4°/-6°C (21-24°F) in January to 16-24°C (61-75°F) in July. In the highlands the temperatures range from -14°/-20°C in January to 8-12°C (46-54°F) in July. There are heavy snowfalls during winter. Precipitation varies from 2,000 millimeters per year in the mountains above the Fergana Valley to less than 100 millimeters per year on the west bank of Issyk-Kul.

In general, Tajikistan's climate is continental, subtropical, and semiarid, with some desert areas. The climate changes drastically according to elevation, however. The Fergana Valley and other lowlands are shielded by mountains from Arctic air masses, but temperatures in that region still drop below freezing for more than 100 days a year. In the subtropical southwestern lowlands, which have the highest average temperatures, the climate is arid, although some sections now are irrigated for farming. At Tajikistan's lower elevations, the average temperature range is 23° to 30° C in July and -1° to 3°C in January. In the eastern Pamirs, the average July temperature is 5° to 10°C, and the average January temperature is -15° to -20°C. The average annual precipitation for most of the republic ranges between 700 and 1,600 millimeters. The heaviest precipitation falls are at the Fedchenko Glacier, which averages 2,236 millimeters per year, and the lightest in the eastern Pamirs, which average less than 100 millimeters per year. Most precipitation occurs in the winter and spring.

The climate of Turkmenistan is sharply continental, with the exception of the inshore zone of the Caspian Sea and the mountains. Average annual air temperature along the whole territory is positive and ranges on plain part of Turkmenistan from 12oC-17oC in the north to 15oC-18oC in the south-east. The absolute maximum reaches 48-50oC in central and south-east Karakum, being a little diminished in the north of Turkmenistan, at the coast of the Caspian Sea and in mountain areas. The average annual precipitation is 210 mm. The biggest amount is observed in the mountains, and in forelands the average is up to 398 mm (Koyne-Kesir), the smallest - above Kara-Bogaz-Gol bay (95 mm) and northeast of Turkmenistan (105 mm). On average there are 69 days per year with more than 0.1 mm of precipitation or

5.8 days with a quantity of rain, sleet, snow etc. per month.

Uzbekistan is located in the Northern band between subtropical and temperate zones. The climate is continental, with hot and dry summers and rather cold winters. The average daily maximum temperature in summer on the plains is about 35 oC, and the average daily minimum temperature in winter is around -5 oC. Maximum temperature can exceed 50 oC, and the minimum drop below -40 oC. Most parts of the country are arid, with precipitation less than 200 mm. Deserts receive only about 80 mm per year. In the foothills precipitation can be 300-400 mm, and about 600-800 mm on the West and SW slopes of mountain ridges.

In the study made by the International Bank for Reconstruction and Development in 2006 an index of meteorological vulnerability of the economy was introduced for the Caucasian countries.

The dimensionless indicator of meteorological vulnerability Y was calculated by the following formula:

where
Tmax is extreme maximum temperature,

Tmax is the mean maximum temperature for selected category of extremes (5%),

F1 is mean annual frequency of extreme maximum temperature. It shall be calculated as the number of cases falling into the 5 percent category divided by the number of years in the sample.

Respectively P is for 24-h precipitation and W for wind speed.

Following categories were used for Y:

High: Y > 750

Relatively high: Y = 750-500

Moderate: Y = 500-400

Relatively low: Y = 400-350

Low: Y < 350.

Based on climatological data for the 30-year period (1961-1990) for the countries, Georgia is highly vulnerable for meteorological impacts while Armenia and Azerbaijan are relatively

$$Y = \frac{T\max}{\overline{\overline{T\max}}} \bullet F1 + \frac{T\min}{\overline{\overline{T\min}}} \bullet F2 + \frac{P\max}{\overline{\overline{P\max}}} \bullet F3 + \frac{W\max}{\overline{\overline{W\max}}} F4$$

	Extremes				Y	Class
	Tmax	Tmin	Precipitation	Wind		
Armenia	41°C	-20°C	213 mm	40 m/s	719	relatively high
Azerbaijan	43°C	-42°C	176 mm	53 m/s	739	relatively high
Georgia	43°C	-42°C	269 mm	35 m/s	775	high
Kazakhstan	47°C	-46°C	117 mm		600	relatively high
Kyrgyzstan	44°C	-54°C	100-2000 mm	45 m/s	652-950	high
Tajikistan	NA	NA	700-2000 mm	NA	NA	relatively high
Turkmenistan	NA	NA	210 mm	NA	NA	moderate
Uzbekistan	45	- 40	80-800 mm	NA	NA	relatively high

Table 3. Calculated indices of meteorological vulnerability for the CAC. Values for Caucasian countries are from IRBD (2006). The index for CA countries is estimated to describe most part of the country. NA=data not available.

highly vulnerable. Similar study has not been done for the Central Asian countries, but a coarse estimation can be done based on general data. Anyhow, the meteorological vulnerability is very much not only regional scale but also mesoscale parameter, so within the countries they may vary significantly, and should actually be produced e.g. separately for agriculture areas, forestry areas, etc.

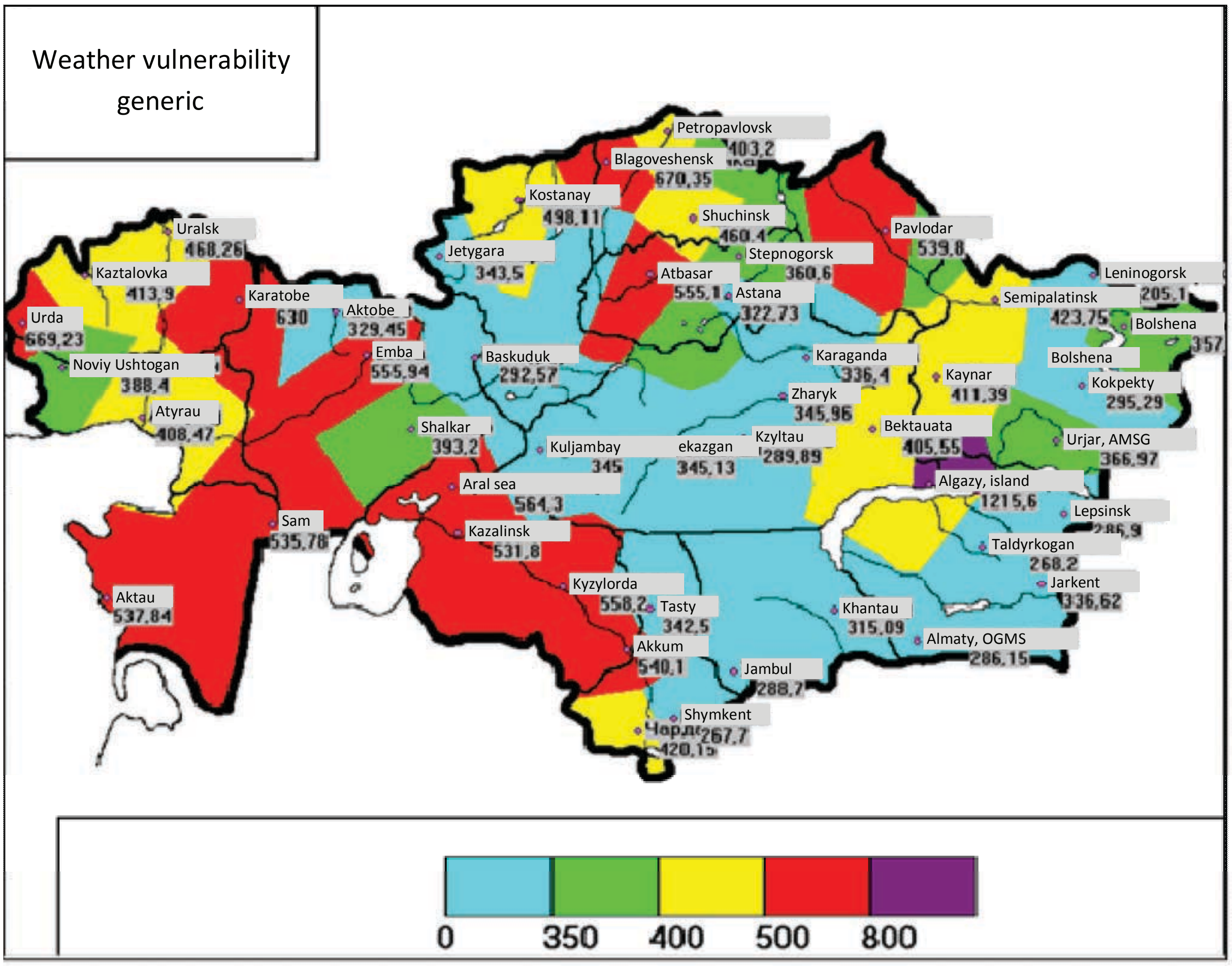
It is actually very difficult to give one weather vulnerability figure for the countries due their geographical features and differences in the climate in different parts of the countries. E.g. in Kazakhstan the vulnerability factor varies from 205 to 1216 (Figure 2)

Due to geographical location and climate characteristics hydrological extreme events are quite frequent which causes natural hazards (heavy rain, drought, icing rain, high wind speed or turbulence,..) causing a threat of negative effect on people and the environment. A natural hazard may lead to natural disaster and cause financial, environmental and/or human losses, which may significantly affect the economic development.

Disasters lead to social, economic and environmental losses. It is often the cumulative effect of high-frequency and low-impact disasters that cause most of the losses, particularly among the poorest section of the community. The social impact of disasters includes loss of livelihoods, assets (e.g. homes and livestock), infrastructure and communication, and results in discontinued development programs. Environmental losses are often the most significant, as the poor very much depend on a well functioning environment for their livelihoods. The number of affected people depends, to a large extent, on the vulnerability level of the population concerned. In general disasters tend to hit the poorest in the society most. This group has little or no financial and physical resilience, and therefore, has to struggle to rebuild their lives, livelihoods and assets in the aftermath of a disaster.

Geographically and geologically, both regions are not only disaster-prone but also have limited financial resources and physical resilience. Central Asia and Caucasus governments are fiscally unprepared to deal with catastrophic losses. The insurance system is not yet adequately developed and mature to carry the economic loads of the reconstruction phase.

Figure 2. Weather vulnerability factor calculated for 59 stations in the Republic of Kazakhstan. (IBRD, 2007).



2 NATURAL HAZARDS

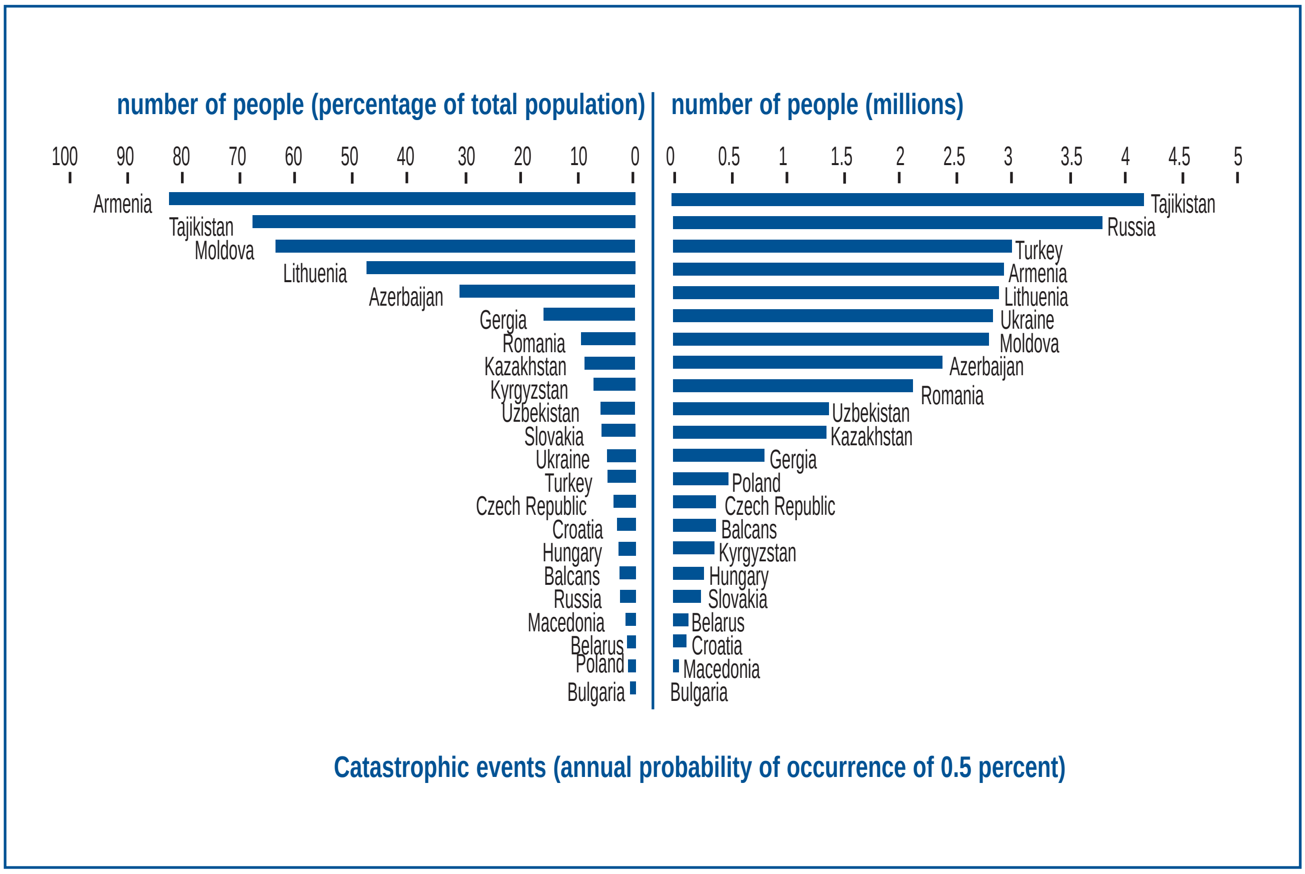
Hydrometeorological extreme events happen all the time, but they become more noticeable when they may develop to natural hazards by causing threat to human safety, housing, infrastructure, agriculture, forest or other economic activities. When a hazard occurs and destroys property and human life, the hazard has become a natural disaster.

The CAC region, with Turkmenistan as an exception, is highly vulnerable to climate and weather related natural disasters. Occurrence of natural hazards in all seven other countries of the two sub-regions is very high - substantial parts of the territory are covered by mountains and practically all natural hazards, such as earthquakes, landslides, debris flows, avalanches, floods, spring frosts and droughts are present there. Additional to these there are several other weather related phenomena which cause every year human and economic losses: heat and cold waves, poor traffic conditions, slippery roads, poor air quality, spreading of insects, pest, and diseases, and others. Turkmenistan is highly prone to earthquake hazard; the earthquake of 1948 killed over 100,000 people in Ashgabat.

In the 2005 report – "Natural Disaster Hotspot – A Global Risk Analysis" the World Banks lists Armenia among the top 60 countries exposed to multiple hazards. As shown in Figure 3 over 80% of Armenia's population is exposed to catastrophic events. Also in Tajikistan the risk is very high. The number of people under danger is much less in Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan and Uzbekistan but still at a high risk level compared to European countries. The Turkmen population is much less prone to weather and climate related hazards than the population of other CAC countries.

The region is also exposed to a range of man-made disasters, such as industrial accidents, hazardous mine tailings entering downstream water bodies, and potential downstream impacts

Figure 3. Population at risk of exposure to catastrophic events in different countries. (WB 2009).



resulting from the operation of large water reservoirs. In many cases the impacts of the hazards are related to weather and climate.

Currently there are not so detailed national statistics available of the frequency of different types of hazards and their impacts to life and property in most of the countries. The international EM-DAT database is to some extend a reliable source for major hazards, or disasters, and their impacts in the countries. It does not include data on smaller hazards as in order for a disaster to be entered into the database at least one of the following criteria has to be fulfilled:

- 10 or more people killed
- 100 people reported affected
- a call for international assistance
- declaration of a state of emergency.

Thus the statistics do not include hazards caused by icy roads, as typically the number/amount of losses per case is small in relation to above given criteria.

For the CAC countries the EM-DAT database includes only the cases since 1991, as the earlier data is included in current data for Russia.

Armenia has 2.1 million hectares of agricultural land, 72% of the country's land area, and almost half of the population is employed by the agriculture sector. For Armenia, damage from natural hazards becomes a crucial economic issue when agricultural production is affected. Hailstorms cause annually damage worth tens of millions USD. The other major problem for agriculture is drought. In Armenia icing poses risks to vehicles and power lines in high mountain areas and passes. The region is also exposed to range of man-made disasters such as industrial accidents and potential downstream impacts resulting from the operation of large water reservoirs.

In ***Azerbaijan*** stormy wind of 35-40 m/s occurs for several days a year at the coastal region and in the archipelago, causing risk for the oil and gas industry, marine transport, construction sector and marine transport. The events of hailstones causing significant damage to agriculture have become more frequent. The greatest repeatability of hailstones is observed in mountain areas of the Lesser Caucasus, and also on the southern slopes of the Great Caucasus. Air and water pollution are widespread and pose great challenges to economic development. Some lowland areas are threatened by rising levels of the Caspian Sea. However, these are not reflected in the EM-DAT statistics.

In Georgia the value of economic losses due to weather related events differs quite much depending on the statistics available.

In ***Kyrgyzstan*** about 50% of the populated territory is prone to debris flows and flash floods, and 199 of 1000 high mountain glacier lakes are identified as being dangerous (collapse of natural dams). The number of avalanches per year is actually very high and causes big human and economic losses. Avalanche risk differs between regions. The most intensive avalanche activity is noted in the basins of rivers Chatkal and Chichkan, which have 400-700 avalanches per year.

In ***Tajikistan*** almost all rivers in low and mid-mountain areas experience mudflows caused by soil erosion, sharp incline of river channels, intensive snowmelt and heavy rains in spring-summer period.

Tajikistan is proving to be incapable of coping with the low winter temperatures, as factories have stopped production and millions of people across the country have been left without electricity. Icing of roads and power lines is frequent.

For ***Turkmenistan*** the EM-DAT statistics indicate very few hazards. For the WB study in 2009 Turkhydromet experts collected data on frequency of occurrence of hydrometeorological hazards in Turkmenistan by types of events.

For the period 1996-2007 the records give: 34 floods and mudflows, 1293 cases with strong wind, 290 dust storms, 9 droughts, 402 dry winds, 68 spring frosts, 36 autumn frosts, 116 heavy rainfalls, 438 extreme heat periods, 58 severe frosts, 15 heavy snowfalls, 11 strong hail events and 1 dust cyclone case, The EM-DAT statistics gives another picture of the vulnerability of Turkmenistan to natural hazards.

Uzbekistan is located in a region where mud floods, mudflows, and avalanches are the most dangerous weather-related phenomena. The mud floods, which were for the most part the component of the natural correction of the river system, are currently significant natural disasters caused by the extension of anthropogenic activities into the flood plains. All rivers in Uzbekistan, including temporal water streams within the mountains and foothills are hazardous in terms of mudflows.

Avalanche activity is shown practically everywhere where scarp slopes exist and heavy snow cover underlay. Avalanches impact on many sectors, specifically transport sector is heavy with high probability of the human lives losses (Figure 4).

Climate change is expected to exacerbate natural disasters associated with hydro-meteorological conditions, with associated damages particularly impacting the rural economy.

		# of Events	Killed	Tatal Affected	Damage (000 US$)
Drought	Drought	1	-	297000	100000
	ave. per event		-	297 000.0	100000.0
Earthquake (seismic activity)	Earthquake (ground shaking)	1	-	15000	33333
	ave. per event		-	15000.0	33333.0
Flood	Unspecified	2	4	7144	8120
	ave. per event		2.0	3572.0	4060.0
	General flood	1	1	-	-
	ave. per event		1.0	-	-

Table 4. Summarized Table of Natural Disasters in Armenia from September 1991 to August 2010. (EM-DAT).

		# of Events	Killed	Total Affected	Damage (000 US$)
Drought	Drought	1	-	-	100000
	ave. per event		-	-	100000.0
Earthquake (seismic activity)	Earthquake (ground shaking)	3	33	712474	15000
	ave. per event		11.0	237491.3	5000.0
Flood	Unspecified	2	16	81000	29000
	ave. per event		8.0	40500.0	145000.0
	General flood	4	3	1756500	61700
	ave. per event		0.8	439125.0	15425.0
	Storm surge/coastal	1	-	2800	5500
	ave. per event		-	2800.0	5500.0
Mass movement wet	Avalanche	1	11	-	-
	ave. per event		11.0	-	-

Table 5. Summarized table of natural disasters and their human and economic impact in Azerbaijan from August 1991 to August 2010. (EM-DAT).

		# of Events	Killed	Total Affected	Damage (000 US$)
Drought	Drought	1	-	696000	200000
	ave. per event		-	696000.0	200000.0
Earthquake (seismic activity)	Earthquake (ground shaking)	4	15	30212	35000
	ave. per event		4	7553.0	87500.0
Flood	Unspecified	1	-	200	-
	ave. per event		-	200	-
	General flood	7	9	3790	33856
	ave. per event		1	541.4	4836.6
Storm	Unspecified	1	-	900	-
	ave. per event		-	900.0	

Table 6. Summarized table of Natural Disasters and their human and economic impact in Georgia from April 1991 to August 2010. (EM-DAT).

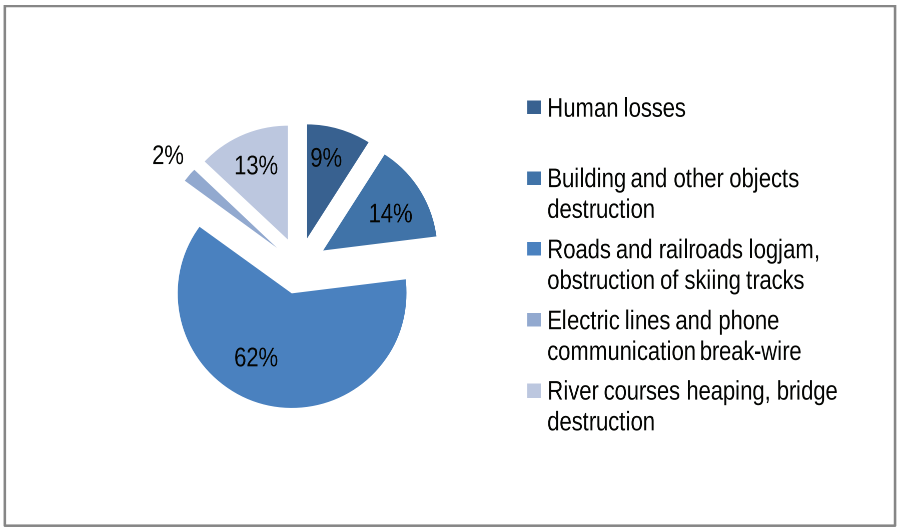
		# of Events	Killed	Total Affected	Damage (000 US$)
Earthquake (seismic activity)	Earthquake (ground shaking)	1	3	36626	-
	ave. per event		3.0	36626.0	-
Epidemic	Unspecified	1	-	166	-
	ave. per event		-	166.0	-
	Bacterial Infectious Diseases	1	7	593	-
	ave. per event		7.0	593.0	-
	Viral Infection Diseases	1	-	114	-
	ave. per event		-	114.0	-
Extreme temperature	Cold wave	2	3	600012	-
	ave. per event		2.0	300006.0	-
Flood	Unspecified	2	-	6168	1500
	ave. per event		-	3084.0	750.0
	Flash flood	2	44	41200	40202
	ave. per event		22.0	20600.0	20101.0
	General flood	3	11	56000	166532
	ave. per event		4.0	18666.7	55510.7
Mass movement wet	Landslide	1	48	-	-
	ave. per event		48.0	-	-
Storm	Unspecified	1	112	-	3000
	ave. per event		112.0	-	3000.0
Wildfire	Forest fire	1	-	8000	-
	ave. per event		-	8000.0	-

Table 7. Summarized table of natural disasters and their human and economic impacts in Kazakhstan from December 1991 to August 2010 (EM-DAT):

Types of events	2001	2002	2003	2004	2005	2006	2007	Total
Mudflows and floods	9	95	43	46	44	33	70	340
Landslides *	5	19	47	53	31	13	5	173
Avalanches	4	12	25	23	21	30	14	129
Earthquakes *	21	14	11	16	21	12	17	112
Water logging *	7	20	5	4	4	8	4	52
Rainstorms	23	3	9	2	11	13	3	64
Land subsidence *	4							4
Erosion *	2							2
Formation of ravines :	3							3
Large-scale fires **	24	14	6	17	16	21	39	137
Infections, invasions *	29	13	7	12	2	16	14	93
Man-made accidents, including major road accidents	15	17		10	15	23	24	104
Hurricane force wind	20	12	2	9	5	6	4	58
Hail		15	1	2	3	1	3	25
Snowfall	8	3	8	2	2	8		31
Rock falls, landfalls *	2	2	2	4	5		5	20
Other	16	2			1	1		20
Total:	192	241	166	200	181	185	202	1367
* Events, which are not monitored by Kyrgyzhydromet on a regular basis with a view of their detection and forecasting.								
** Including industrial and house hold fire.								
*** Including damages/accidents in industry, energy sector, municipal sector, etc.								

Table 8. Frequency of occurrence of natural hazards in Kyrgyzstan in 2001-2007. (WB, 2009).

Figure 4. Distribution of the damage from avalanches in Uzbekistan



		# of Events	Killed	Total Affected	Damage (000 US$)
Earthquake (seismic activity)	Unspecified	1	74	1197	-
	ave. per event		74.0	1197.0	-
	Earthquake (ground shaking)	5	58	153086	163000
	ave. per event		12	30617.2	32600.0
Epidemic	Bacterial Infectious Diseases	1	22	336	-
	ave. per event		22.0	336.0	-
	Viral Infection Diseases	1	-	458	-
	ave. per event		-	458.0	-
Extreme temperature	Cold wave	1	11	-	-
	ave. per event		11.0	-	-
Flood	Flash flood	1	1	7728	2400
	ave. per event		1.0	7728.0	2400.0
	General flood	2	3	2895	2860
	ave. per event		2	1447.5	1430.0
Mass movement wet	Avalanche	1	11	2	-
	ave. per event		11.0	2.0	-
	Landslide	7	238	68159	37500
	ave. per event		34.0	9737.0	5357.1
Storm	Unspecified	1	4	9075	-
	ave. per event		4.0	9075.0	-

Table 9. Summarized table of natural disasters and their human and economic impacts in Kyrgyzstan from August 1991 to August 2010 (EM-DAT).

		# of Events	Killed	Total Affected	Damage (000 US$)
Drought	Drought	2	-	3800000	57000
	ave. per event		-	1900000.0	28500.0
Earthquake (seismic activity)	Earthquake (ground shaking)	7	17	38000	23500
	ave. per event		2.0	5428.6	3357.1
Epidemic	Bacterial Infectious Diseases	4	171	23590	
	ave. per event		43.0	5897.5	-
Extreme temperature	Extreme winter conditions	1	-	2000000	840000
	ave. per event		-	2000000.0	840000.0
Flood	Unspecified	5	1367	67139	300000
	ave. per event		273.0	13427.8	60000.0
	Flash flood	4	51	192995	58990
	ave. per event		13.0	48248.8	14747.5
	General flood	12	170	497918	99000
	ave. per event		14.0	41493.2	8250.0
Insect infestation	Locust	1	-	-	-
	ave. per event		-	-	-
Mass movement dry	Avalanche	1	12	-	-
	ave. per event		12.0	-	-
Mass movement wet	Avalanche	5	104	2681	-
	ave. per event		21.0	536.2	
	Landslide	8	252	102539	214700
	ave. per event		32.0	12817.4	26837.5
Storm	Unspecified	1	-	830	234
	ave. per event		-	830.0	234.0
	Tropical cyclone	1	-	1500	200
	ave. per event		-	1500.0	200.0

Table 10. Summarized table of natural disasters and their human and economic impact in Tajikistan from September 1991 to August 2010 (EM-DAT).

		# of Events	Killed	Total Affected	Damage (000 US$)
Earthquake (seismic activity)	Earthquake (ground shaking)	1	11	-	-
	ave. per event		11	-	-
Flood	General flood	1	-	420	99870
	ave. per event		-	420.0	99870.0

Table 11. Summarized table of natural disasters and their human and economic impact in Turkmenistan from October 1991 to August 2010 (EM-DAT).

		# of Events	Killed	Total Affected	Damage (000 US$)
Drought	Drought	1	-	600000	50000
	ave. per event		-	600000.0	50000.0
Earthquake (seismic activity)	Earthquake (ground shaking)	1	9	50000	-
	ave. per event		9.0	50000.0	-
Epidemic	Bacterial Infectious Diseases	1	40	148	-
	ave. per event		40.0	148.0	-
Flood	Flash flood	1	-	1500	-
	ave. per event		-	1500.0	-
Mass movement dry	Landslide	1	1	400	-
	ave. per event		1.0	400.0	-
Mass movement wet	Avalanche	1	24	-	-
	ave. per event		24.0	-	-

Table 12. Summarized table of natural hazards in Uzbekistan from August 1991 to August 2010 (EM-DAT).

3 CLIMATE CHANGE

The main consequence of climate change is increase in global surface temperature and changes in the hydrological circle, triggering changes in precipitation levels, causing melting of the glaciers and thus chancing the quantity and quality of water resources.

The Central Asia and Southern Caucasus region show climate induced changes with increasing temperatures, shrinking glaciers, sea level rise, redistribution of river flows, decreasing snowfall and an upward shift of the snowline.

Intensive climate warming is being recorded throughout Central Asia, and the forecast for the region's water resources as a result of that warming suggests that none of the aforementioned scenarios envisages an increase in water resources. Calculations show that by 2050 the water runoff in the basins of the Amu Darya and the SyrDarya will dry up by 10% to 15% and by 6% to 10% respectively. Central Asian states are seeking ways to prevent or mitigate economic damage as a result of contamination and depletion of water resources. The states of the Aral Sea basin all face the task of enhancing more effective and economical use of water, management or water demand, and finding a compromise between the interests of upstream and downstream states. Moreover, there is the need to serve the requirements of both water users and ecosystems.

The climate of the Southern Caucasus region is changing as well. The glaciers of the Caucasus are melting rapidly (Figure 5). During the last century, the glacial volume in the Caucasus declined by 50%.

Socio-economic and environmental problems of the Caspian Sea have evolved as a result of development of natural resources in the sea and in coastal areas. These problems have been aggravated by fluctuations of the sea, which have recently been influenced by global climate change impacts on river flow. During 1978-95, the river flow increased by 10-11% which, in turn, contributed to a 2.5 m rise in sea level.

According to analyses in hydrometeorological data it can be noted that more extreme weather events have characterized the weather in CAC in the last ten years. This has increased the number of weather dependent hazards like flooding, landslides, forest fires and coastal erosion with significant economic losses and human casualties as a result.

Figure 5. The glaciers of Caucasus are melting rapidly; the Labola Glacier, Georgia, 1972 (a) and 2002 (b). Source: Institute of Geography, Tbilisi University, Georgia.

Figure 5. (a)

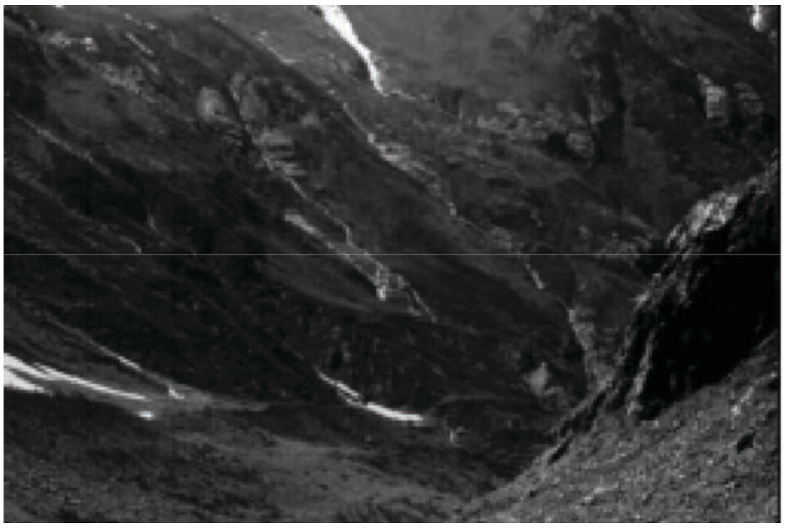


Figure 5. (b)

In the CAC region the water resources are especially crucial for a wide range of issues related to national and regional security, since water is being consumed by all sectors of the regional economy. Irrigation consumes more than 90% of the available water resources in the Aral Sea basin. Water resources are also of utmost importance to energy supplies to the region and account for 27.3% of its power generating capacity. In Tajikistan and Kyrgyzstan, this percentage exceeds 90%, thereby indicating that their economies all but entirely depend on the availability of water resources for their daily life. Armenia, Azerbaijan and Georgia rely heavily on the Kura-Araks river system as a major source of water for all users. Climate change and human activities may further influence the levels of Aral and Caspian seas, which will affect the ecosystems, agriculture and human health in the neighboring regions. Therefore, any change affecting water resources in CAC is bound to have a profound impact on these countries' economies and their social and socioeconomic development.

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Climate change will have significant impact on development of different socio-economic sectors. With climate modeling using regional and local level models, it is possible to predict the impact of the changing climate, and use this information for building strategies to achieve most optimal adaptation to the climate change. (see e.g. the Nordic Climate and Energy project).

All the eight countries of the region have completed the preparation of the Second National Communication on climate change, implemented within GEF UNDP project. The assessment of climate change and development of the scenarios was based on the Global Climate Models (GCMs), which simulate the processes defining climate over the regions. But they represent only broad features and patterns and are able to reproduce the changes in the large scale. The pattern of climate change varies significantly from region to region.

Adaptation planning would benefit from knowledge of how the climate will change at spatial resolution that is much finer than coarse resolutions of GCMs (> 100 km). Regional climate models (RCM) statistical downscaling is used to produce scenarios of future climate at high resolution (< 10-25 km). The main objective of downscaling is to take coarse resolution climate change results and produce information at higher spatial scale, which is required for the impact application. Thus RCMs provide climate information with finer detail, including generally more realistic local extreme events and they have the potential to produce assessments of country's vulnerability to climate

Figure 6. Total number of days with hydrometeorological hazards recorded in the period of 1975-2006 in Armenia.

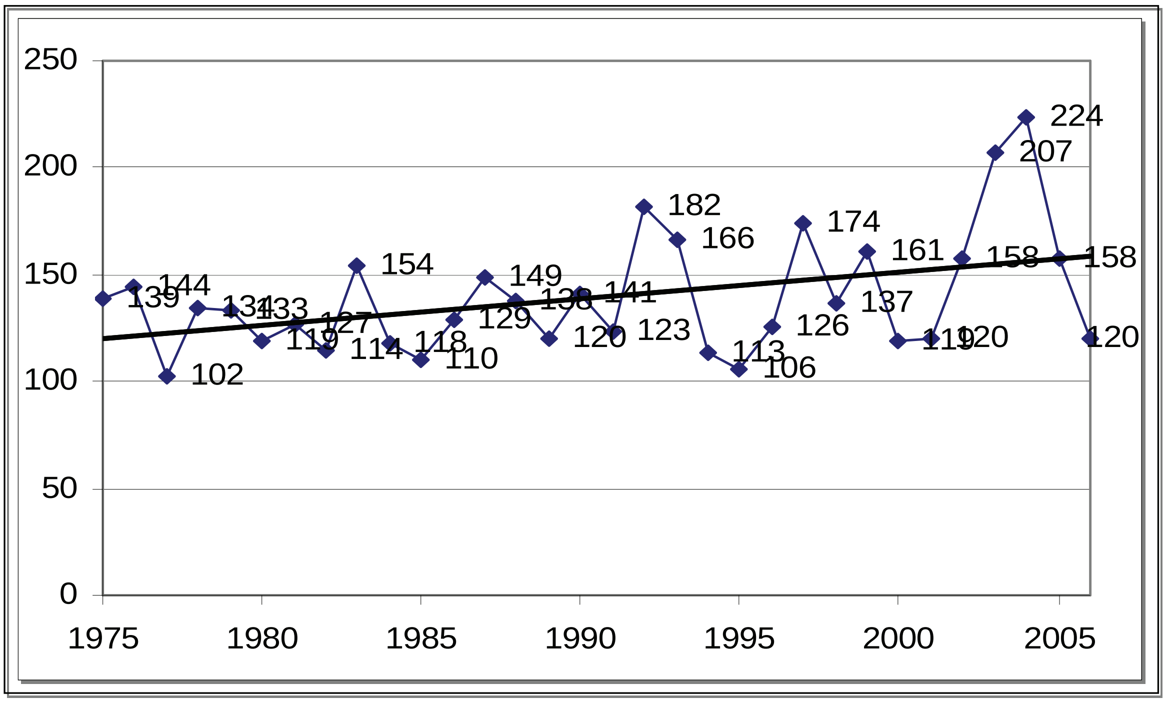
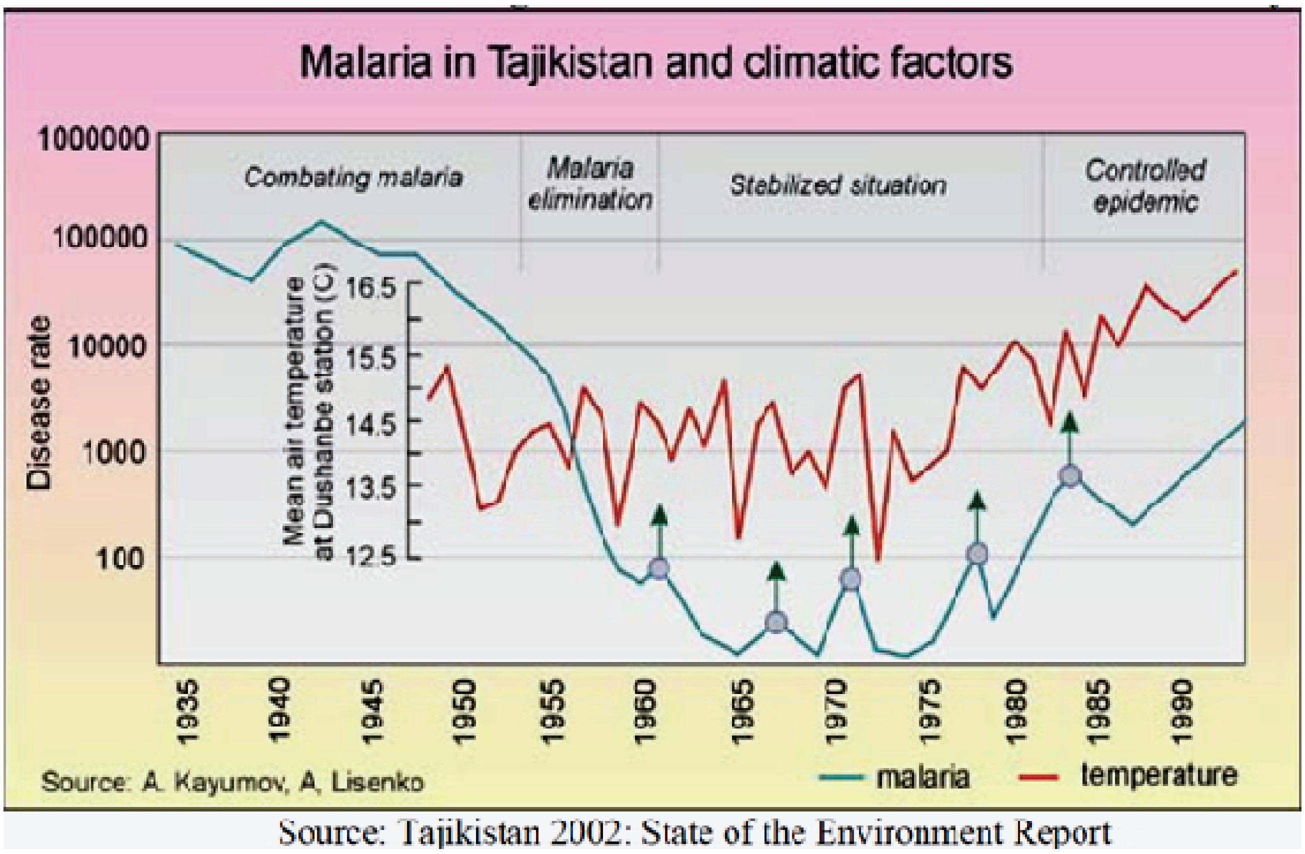


Figure 7. Malaria and climatic factors in Tajikistan. (Perelet, 2007).



4 ROLE OF THE NHMSs IN DRR, ACHIEVEMENT OF THE MDGs AND PROMOTION OF ECONOMIC DEVELOPMENT

4.1 General role of advanced NHMSs

Traditionally the public sector has formed the major customer and end-user group of hydro-meteorological and environmental data and services. However, during the last decades the demand of more end-user specific (commercial) products for public and different economic sectors has been significantly increasing in developed countries. This is due to fact that the quality of weather forecast and other services have improved, the industry and public has learned to use weather forecasts and weather radar and satellite images through internet, the industry has computing power to handle large amounts of hydrological and meteorological data, and the cooperation and partnerships with the private sector has increased. Weather information from other countries has become important part of risk management for companies operating globally. Figure below illustrates some application areas from both public and private sectors, which would benefit from having accurate and customized hydro-meteorological and environmental (air quality and water quality) information product and services.

Also the weather forecasting market is changing with developments in IT technology which allows fast dissemination of large amount of data, big computing power at relatively low costs, availability of commercial forecasting models, growing demand to produce more local, short-term and customer-specific forecasts to the public and various socio-economic sectors, increasing awareness of weather and climate and climate change, of increasing number of natural disasters, provision of useful data and products on internet, etc., which has made hydrometeorological business more interesting also for the private sector.

Figure 8. The NHMSs need to cooperate with large range of socio-economic sectors.

PROTECTION OF LIFE AND PROPERTY
- NUCLEAR ACCIDENTS
- POLLUTION
- MARINE RESCUE
- FLOODING, HAIL, etc.

GENERAL PUBLIC
- WARNING SERVICES: MARINE TRAFFIC, UV, AIR POLLUTION, MULTIHAZARDS, etc.
- TV, RADIO, INTERNET

TRANSPORTATION
- SAFETY: AVIATION, MARINE, ROAD TRAFFIC
- ENVIRONMENTAL IMPACTS OF TRAFFIC
- SMOOTH FLOW TRAFFIC

HEALTH
- HEAT VAVES
- EXTRAORDINARY WEATHER
- AIR and WATER QUALITY
- COMMUNITY PLANNING

COMMERCIAL CUSTOMERS
- ENTERPRISES
- PRIVATE INDIVIDUALS

ENVIRONMENT
- AIR and WATER QUALITY
- CLIMATE CHANGE
- COMMUNITY PLANNING

DEFENCE
- SERVICE FOR NORMAL AND EXCEPTIONAL SITUATIONS

WATER MANAGEMENT
- PRECIPITATION, DISCHARGE
- SURFACE and GROUND WATER

RESEARCH AND DEVELOPMENT
- ATMOSPHERIC RESEARCH
- HYDROMET OBSERVATIONS
- REMOTE SENSING

INTERNATIONAL OBLIGATIONS
- WMO, ICAO, EUMETSAT, ECMWF, EUMETNET, etc

AGRICULTURE AND FORESTRY
- WEATHER SERVICES
- ADAPTATION TO CLIMATE CHANGE

The value of hydrometeorological services is rapidly growing. Today weather forecasts are important, visible, well selling prime time programs for the TV channels. As the value of services has increased, the number of private weather companies and service producers have increased, and the supply of site specific 1-5 days weather forecasts available for no charge on internet has increased explosively. The legislation is changing allowing the private sector to produce security services which traditionally have been provided by governmental organizations, "European single skies" being good example of this. Some decades ago there was also a mutual agreement among the NHMSs that each NHMS provided weather services only for their own country. This is not the case anymore; NHMSs give forecasts, and even provide warnings, to other territories, and private companies produce weather forecasts for any major city around the world and disseminate this information through the internet.

All this has forced the European NHMSs to adapt their activities and strategies to the market. This has lead to improvement in the hydrometeorological services of the NHMSs in order to ensure their visibility, governmental financing and share of the weather market. This benefits the governments, the public and the industry.

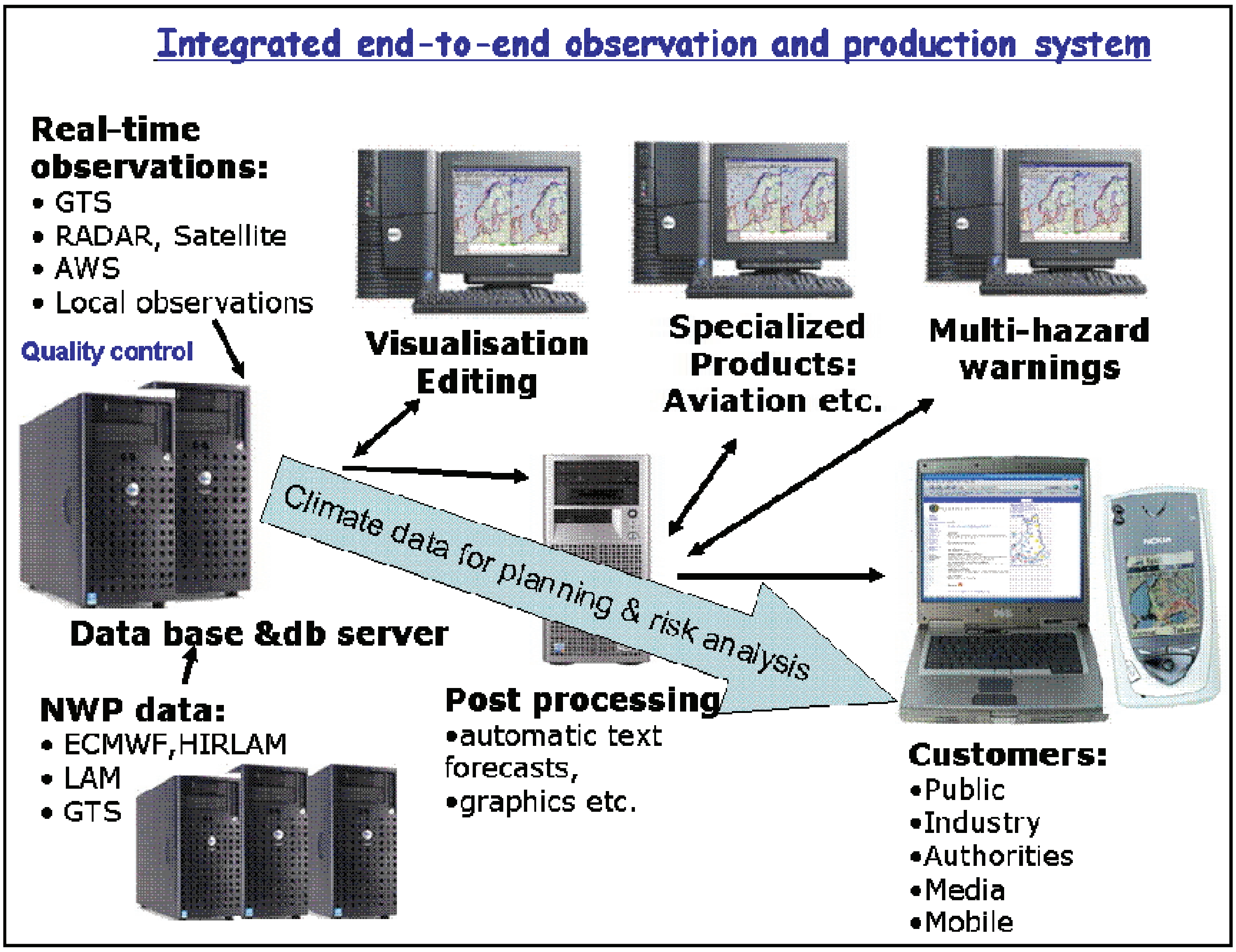
It is obvious that the future of each NHMS lies in its capability to develop and more effectively deliver hydro-meteorological products and service outcomes that produce added value to a nation's social and economic development, to protection of the environment and to the public. Production of relevant hydro-meteorological information, forecasts and warnings require seamless international cooperation, monitoring of hydrometeorological data and data sharing to international and regional use, adequate observation networks and operational atmospheric and hydrological models, qualified and motivated staff, national and international data-sharing and cooperation and highly automated and digitalized analyzing and production systems (Figure 9). Only scientific improvement in hydrometeorological products and services is not enough, but the information needs to be disseminated efficiently and timely to all relevant levels all the way down to the grass root level, the information needs to be properly understood and to be adequately used to improve the decision-making processes.

The experience from FMI cooperating with several economic sectors shows that it is essential that those who provide hydrological and meteorological information need to understand the marketplace. In the process of increasing benefits industry must also be educated to use weather information in the decision-making process. Learning to produce improved services and integrating these improved services into the decision-making processes within different economic sectors takes time.

By providing timely, accurate and scientifically high level weather and hydrological information and services for disaster reduction management, different authorities, business and general public the National Hydro-Meteorological Services (NHMSs) help to ensure the safe functioning of society and safety of people and property, and to promote economic development the countries. Knowledge of weather and climate events and their extremes, and adaptation to the climate change are necessary for the development of sound socio-economic and environmental programs for sustainable development.

In order to have the capacity to produce adequate high level forecasts and other products to the community, and to give added value to the general weather forecasts available on internet, the NHMSs need to have a functioning integrated end-to-end observation and production system, tailored products based on user needs, and scientifically and technically qualified staff. The core of the production system is data management.

Figure 9. A schematic description of an almost fully automated integrated end-to-end observation and production system implemented at the FMI.



5 ORGANIZATIONS RESPONSIBLE FOR HYDROMETEOROLOGICAL AND AIR&WATER QUALITY IN CAC

Armenia

- Meteorological observations and/or services:

Armenian State Hydrometeorological and Monitoring Service

- Hydrological observations and/or services;

Armenian State Hydrometeorological and Monitoring Service

- Aviation weather services:

Aviation Meteorological Centre at all airports – Ministry of Nature Protection.

- Air quality monitoring

ArmEcoMonitoring – Ministry of Nature Protection

- Water quality monitoring

ArmEcoMonitoring – Ministry of Nature Protection

Azerbaijan

- Meteorological observations and/or services:

State Hydrometeorological Committee

- Hydrological observations and/or services;

State Hydrometeorological Committee (land water)

State Committee of Geology and Mineral resources (underground waters)

- Aviation weather services:

State Hydrometeorological Committee.

- Air quality monitoring

- Water quality monitoring

Georgia

- Meteorological observations and/or services

Department of Hydrometeorology at National Environmental Agency

- Hydrological observations and/or services

Department of Hydrometeorology at National Environmental Agency

- Aviation weather services

Department of Hydrometeorology at National Environmental Agency

Aviameteorological Centre of Tbilisi" with 100% governmental share on license basis.

- Air quality monitoring

Department of Environment Pollution Monitoring at National Environmental Agency

- Water quality monitoring¨

Department of Environment Pollution Monitoring at National Environmental Agency

Kazakhstan

There are two organizations in Kazakhstan responsible for hydrological, marine/off-shore, aviation meteorological services, air/water quality monitoring and services - Kazakhstan National Hydrometeorological Service (KazHydroMet) and KazAviaService JSC.

- Meteorological observations and/or services:

Republic State Enterprise Kazhydromet

- Hydrological observations and/or services.

Republic State Enterprise Kazhydromet

- Aviation weather services:

JSC KazaviaService

- Air quality monitoring:

Republic State Enterprise Kazhydromet

- Water Quality monitoring:

Republic State Enterprise Kazhydromet

Kyrgyzstan

- Meteorological observations and/or services

Kyrgyzhydromet Central Hydrometeorology Administration

- Hydrological observations and/or services

Kyrgyzhydromet Central Hydrometeorology Administration

- Aviation weather services
  State enterprise "Kyrgyzaeronavigation"

- Air quality monitoring
  Kyrgyzhydromet Central Hydrometeorology Administration

- Water quality monitoring¨
  Kyrgyzhydromet Central Hydrometeorology Administration

Tajikistan

- Meteorological observations and/or services
  Tajikhydromet State Hydro meteorological Agency

- Hydrological observations and/or services
  Tajikhydromet State Hydro meteorological Agency

- Aviation weather services
  Tajikhydromet State Hydro meteorological Agency

Turkmenistan

- Meteorological observations and/or services
  Turkhydromet National Hydro meteorological Committee

- Hydrological observations and/or services
  Turhydromet National Hydro meteorological Committee

- Aviation weather services
  Turhydromet National Hydro meteorological Committee

Uzbekistan

- Meteorological observations and/or services:
  Centre of Hydrometeorological Service at Cabinet of Ministers of the Republic of Uzbekistan (Uzhydromet)

- Hydrological observations and/or services
  Uzhydromet

- Aviation weather services
  Uzhydromet

- Air quality monitoring
  Uzhydromet

- Water quality monitoring
  Uzhydromet

There are no significant private weather forecasting companies in the CAC countries. However, it is important to recognize that on Internet 1-7 day weather forecasts are available for practically all countries and (major) towns, produced by different international NHMSs, or even in most cases by private companies having access to global or regional NWP products in digital format In comparison with the web pages of the CAC NHMSs, the free information available on internet is usually visually much more attractive, and in many cases includes more information than the CAC NHMSs products.
As governmental institutes, companies and in growing amount practically all people start to have access to internet the question often made is that what additional information can the NMHSs produce compared to that what is today available on internet.

6 OVERVIEW OF RISK REDUCTION AND EMERGENCY MANAGEMENT

Armenia:

Government has passed significant legislation since 1991 to improve risk reduction and emergency management systems; the Law on Armenian Rescue Service (2005), the Law on Rescue Forces and Status of Rescuers (2004), the Law on Civil Defense (2002), the water Code (2002), Law of Seismic Protection (2002), the Law on Fire safety (2001), the Law on Protection of Population in Emergency Situations (1998); the Law on Protection (1997, 2008), etc. In 2008 Government established the Ministry of Emergency Situations (MoES).

of the new structure. The MES is the authorized state agency for prevention and response and preparedness for emergency situations, with very wide scope of responsibilities. The Ministry had taken over a number of functions that were fulfilled earlier by other ministries:

- civil defense – from Ministry of Defense
- fire service – from ministry of Internal Affairs
- technical supervision over construction
- seismic safety
- water rescue (CasSpas)
- rescue service
- nuclear and technological safety
- state reserve for emergency situations.

	"Overall coordination"	"Flood mitigation"	"Seismic reduction"	"Landslide mitigation"	"Hail protection"	"Emergency response"
MoES	X				X	
MoES/ARS						X
MoES/ASH		X				
MoES/NSSP			X			
MoNP/WRMA		X				X
MoA		X		X		
MoTA/SCWM		X				
Municipality			X			X
MoUD			X	X		
MoE			X			
ARC						X

Table 13. The role of different organizations in the Armenian Risk Reduction and Emergency Management (WB, 2009). ASH = Armenian State Hydromet.

Azerbaijan:

The Government of Azerbaijan made the decision on strengthening activities and policy in prevention and response to disasters in 2003. Consequently, the State Commission on Emergency Situations was formed, comprising representatives of ministries and territorial administration, mainly for the purposes of response and rehabilitation after disasters. The Ministry of Emergency Situations (MoES) of the Republic of Azerbaijan was established by decree of President on December 16, 2005. The decree determined the structure, functions and responsibilities, ensured state budget funding

Among other functions, MES ensures safety and rescue works at the sea oil platforms and oil processing facilities; the Ministry possesses and operates a number of special vessels to do this work. The degree of provision with equipment of the Ministry is quite high, and the central government ensures regular and sufficient funding.

The MES is still in the process of forming its regional structures (each for 7-8 districts); four of regional centers already function. MES continues hiring the staff of the headquarters through careful selection and evaluation. The headquarters will employ 200-250 persons at various units. The Civil

Defense troops of MES will consist of paramedic service, military service and regular service.

The emergency rescue service at Caspian Sea is part of MES, and has 9 ships, of which 7 are in operational condition.

MES actively works in all above areas, coordinates the work, cooperates with relevant international organizations, and supports all initiatives relevant to its mandate. The area of disaster risk reduction is one of priority areas in the work of the Ministry, and MES is highly interested in cooperation with UNISDR and other UN agencies.

In general, the Government of Azerbaijan demonstrates strong commitment to disaster management and disaster risk reduction. The Ministry of Emergency Situations receives significant financial and political support, continues building up its staff, maintains and develops its units and functions in many geographic and technical areas, and is interested in cooperation with international organizations. The MES is the authorized government agency in the field of disaster management, and had assigned its official representative for liaising with international organizations, their programs and projects. The MES has extensive legislative mandate, powers and authority in supervision of quality of construction, retrofitting the existing infrastructure, cooperation with the Red Crescent Society. Units and departments of the Ministry function in accordance with laws, regulations, standards and norms acting in the field of their respective expertise. The Ministry had just signed an agreement with Russian Federation in the area of training, supply of equipment, exchange of expertise. Similar cooperation exists in relations with Turkey and other countries.

Georgia:

Commission on Extreme Occurrences, headed by the Deputy Prime Minister, is responsible for arrangements to prevent and minimize damage and loss of human life in the event of natural hazards.

The organizational structure for Disaster Risk Management in Georgia is somewhat complicated. The main forum for developing policies and providing broad-based advice to the Head of State is the National Security Council (NSC) of Georgia with the mandate to coordinate efforts and activities of relevant ministries and government institutions in the sphere of crisis management, preparation and response in relation to any emergency that may occur. At present, the NSC has been tasked to develop the so-called "Threat Assessment" for Georgia in cooperation with scientists and respective academic institutions.

The state structure directly authorized and responsible for management of emergency situations arising from natural and technological disasters is the Emergency Management Department (EMD) of the Ministry of Internal Affairs of Georgia. The main functions of the EMD are defined in the Law on Protecting the Population and Territory from Natural and Technological Emergency Situations and are somewhat limited by disaster response. At present, despite all good intentions, the Emergency Management Department of the MIA of Georgia is hardly involved in the whole disaster risk management cycle, including disaster prevention and mitigation activities.

There are various agencies and institutions which participate at different stages of a disaster management cycle, such as the Ministry of Environmental Protection and Natural Resources (including the National Environmental Protection Agency), Institute of Geophysics, other scientific and academic institutions, local governance bodies, individual experts, etc. Moreover, there is no agency in the country involved in the whole disaster management cycle, starting with preparedness, prevention, mitigation, response, and recovery. Efforts are scattered in this sector regardless of a unanimous understanding of an

"Who Does What?"													
Abbreviation of Office	Disaster response	Contingency planning	Emergency Preparedness	Risk assesment and risk mapping	Awareness raising activities	Training and capacity development	Policy dialogue	Structural asessments of infrastructure	Engineering preventive measures	Bio-engineering preventive measures	Retrofitting of buildings	Early warning systems	Coordination
ACF	xx	xx	xx	x	x	xx						x	x
BMA	x	x	x		xx	xx							
British Emb.		xx	x	x		xx							xx
CARE				x	x	x	x						x
CENN	x	x	x	xx	xx	xx	xx		x	x		xx	xx
CRBRE		x		xx			x						
DRC		xx	x	xx	xx	xx	xx					x	xx
DTROG	x		x		x	xx	xx	xx		xx			xx
EC						x	x						x
EMD MIA	xx	x	xx	xx	xx	xx	x	x					xx
FAO	xx	x	xx	x	x	x	x					xx	xx
GA					x		x						
GNCDRR	xx	xx	xx	xx	xx	xx	xx					xx	xx
GRCS	x	xx	xx	xx	x	xx	x					x	x
GWMI	xx	xx	x	xx	xx	x	x	xx	xx	xx	x	xx	x
ICRC													
IFRC	x	x	x	x	x	x	x					x	x
IG	x	x	x	xx	x	x			x		x	xx	x
IHM	xx	xx	x	xx					x			xx	
"Inst. Geography"	x			xx	xx				x	x		xx	xx
"Inst. Geology"													
"Inst. Hydrology"	xx	xx	x	x	x	x	x	x	xx	x	x	xx	x
"Inst. Mineral"		xx		xx			xx		x	xx			

Table 14. Who does what in the DRR management system in Georgia. IHM is the Institute of Hydrometeorology. (UNDP, 2010).

urgent need for better coordination which will not only help avoid economic losses but will also save human lives.

Kazakhstan:

The Ministry for Emergency Situations is the prime organization at the central government, which carries out response activities for large emergencies and disasters. It controls industrial technical safety, coordinates measures on the prevention, supervises national fire service, and serves as the coordinating body for civil defense in Kazakhstan. Patterned under the US 911, the 051 response system has been established in 10 large cities.

The Comprehensive Kazakhstan Natural Disaster Preparedness Plan serves as a guide for central and local governments in the country in implementing measures on disaster reduction. It was elaborated with the assistance of UNDP. It is proposed that the Plan be periodically revised and re-approved to ensure that it remains current.

The Prime Minister heads the civil defense of the country. The direct management of activities by state bodies in emergency situations is assigned to the Minister of the Ministry for Emergencies of the Republic of Kazakhstan, which has been established in 2004 on the basis of the State Emergency Agency. The Ministry for Emergencies of the Republic of Kazakhstan is the central management body responsible for prevention and reduction of the consequences of all natural disasters.

Currently there is no national legislation which would define the role of the NHMS in disaster risk reduction.

Kyrgyzstan:

The Ministry of Emergency Situations of the Kyrgyz Republic (MoES) is the central body of the executive state government, which is responsible for performing the tasks of population protection from natural and man-made emergency situations, prevention and response, civil defense, technological and technical safety monitoring of industry and mining, as well as fire safety.

The Ministry of Emergency Situations of the Kyrgyz Republic is responsible for the implementation of the state policy in prevention and elimination of natural and man-made emergencies, performance of controlling and permitting functions of the governance in the sphere of industrial safety supervision, mining supervision, hydrometeorology provision and fire protection. At present, the Ministry of Emergencies undertakes a complex of organizational-legal interventions aimed to reform the current system of population protection. The goal of the reform is to establish and improve the civil protection system of the Kyrgyz Republic based on integration of the Standard State System of prevention and elimination of emergencies and civil protection of the Kyrgyz Republic into the State System of Civil Protection.

The Government of the Kyrgyz Republic approved the Regulation "On the Ministry of Emergency Situations of the Kyrgyz Republic" by its Resolution from 16/05/2007, under No.175

The MoES activities are governed by the Constitution of the Kyrgyz Republic, the existing legislation, executive orders and decrees of the President of the Kyrgyz Republic, orders and directives of the Chief of Defense Forces of the Kyrgyz Republic, decrees and resolutions of the Government of the Kyrgyz Republic, other existing regulations of the Kyrgyz Republic, and by the Regulation "On the Ministry of Emergency Situations of the Kyrgyz Republic".

In close cooperation with other line ministries, state committees, administrative bodies, international and non-governmental organizations, the MoES carries out its tasks directly, or through its subordinate institutions.

The MoES is funded from the government budget and from allocations to the disaster response fund.

Tajikistan:

The state structure directly authorized and responsible for management of emergency situations arising from natural and technogenic disasters is the Committee for Emergency Situations and Civil Defense under the Government of the Republic of Tajikistan (CoES), first formed in 1994. The legal support is provided by Resolution 479 of the Government of RT of November 27, 1999 – "Regulation on the Ministry for Emergency Situations and Civil Defense of Republic of Tajikistan". CoES has the staff of about 200 officers, in its headquarters in Dushanbe and in its territorial structures in the regions (provinces) cities, and districts. The territorial structures at all levels are part of the relevant executive authorities.

The organizational structure for Disaster Risk Management in Tajikistan is as follows. The multi-sector State Commission on Emergency Situations (SCES) is the main forum for developing policies and providing broad-based advice to the Head of State who is at the same time the Chairman of the Council of Ministers. The Prime Minister as the first deputy chairman of the SCES has the mandate to coordinate preparation and response in relation to any emergency that may occur. Under this Prime Minister's authority is the Committee for Emergency Situations and Civil Defense (CES). Fire Service – the Main Directorate for Fire Safety is under the authority of the Minister of Internal Affairs

Turkmenistan:

The Cabinet of Ministers is in charge of natural disaster management in Turkmenistan. The State Commission on Emergency Situations (SEMC) under the Ministers of Turkmenistan is the primary agency in charge of emergency situations related to natural hazards. SEMC coordinates all response activities during emergency situations. The national law defines the roles and mandates of the different actors.

Turkmenistan is the only country of Central Asia which has not committed itself to the HFA. However, positive developments of the last couple of years include the establishment of the State Agency for Disaster Management in May, 2007 that was later replaced by the Disaster Management Unit under the Ministry of Defense of Turkmenistan. It is expected that a fully functional Ministry of Emergency Situations will be established in 2010 (tentatively, end of March) and it is important to note that its construction was fully covered from the state budget (USD 218 million).

In autumn of 2008, disaster preparedness was for the first time included in UNDAF for Turkmenistan during the mid-term review. The Regional conference on seismic risk reduction in the capital city Ashgabat in October 2008 is a compelling evidence of the on-going changes and the readiness of Turkmenistan to cooperate at the regional level.

On the whole, based on the general trends in the country policy and informal meetings with government officials of Turkmenistan there are no doubts in the positive situation development.

Uzbekistan:

Commission on Emergency Situations of Cabinet of Ministers of the Republic and the Ministry of Emergency Situations of the Republic coordinate the actions of all of the ministries. The Ministry of Emergency Situations is the national disaster management ministry and the coordinating body for disaster management in the country. Each city has an appointed person who is a Mayor of the city responsible for disaster management. At community level - community leaders are responsible for disaster management. The Ministry of Emergency Situations coordinates all agencies, organizations, communities involved activities.

According to the Resolution of Cabinet of

Ministers of Republic of Uzbekistan from December 27 of 1997 #558 on "Governmental System of Response to Disasters of Republic of Uzbekistan", The Ministry of Internal Affairs is a functional system to keep public order, road and fire protection, guarding of buildings, and protection of public goods.

There are several non-governmental organizations and NGOs involved in disaster management activities, such as Red Crescent Society of Uzbekistan; ECOSAN Foundation; OSI Open Society Institute etc. There is an Agreement between Ministry of Emergency Situations, Ministry of Health and Red Crescent Society of Uzbekistan about cooperation in work on preparation and response to disasters and other emergency situations inside of the country.

Currently there are many international projects going on in order to support and promote the DRR management system in the CAC countries.

The Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI) aims at reducing the vulnerability of the countries of Central Asia and Caucasus to the risks of disasters. The CAC DRMI incorporates three focus areas, with the possibility to include new activities:

- coordination of disaster mitigation, preparedness, and response;
- financing of disaster losses, reconstruction and recovery, and disaster risk transfer instruments such as catastrophe insurance and weather derivatives; and
- hydro-meteorological forecasting, data sharing and early warning.

The initiative forms the foundation for regional and country specific investment priorities in the areas of early warning, disaster risk reduction, and financing. The initiative builds on the existing cooperation in the region, and complements and consolidates the activities of the institutions involved to promote more effective disaster mitigation, preparedness, and response.

The initiative is coordinated by the World Bank, the United Nations International Strategy for Disaster Reduction (UN-ISDR), and the World Meteorological Organization under the CAREC umbrella. The Global Facility for Disaster Reduction and Recovery (GFDRR) and other donors are financing the initiative.

	Mitigation	Response
National	- Ministry of Emergency Situations of Republic of Uzbekistan;	
- Ministry if Internal Affairs;		
- Ministry of Health;		
- Ministry of Agriculture and Water Management;		
- Hydrometeorological Department of Uzbekistan	15 minutes	
Regional	Regional Agency "Natotur" under the Ministry of Internal Affairs	10 minutes
Provincial	Emergency Centers	
District	Emergency Centers	

Table 15. Governmental organizations involved in disaster management in Uzbekistan.

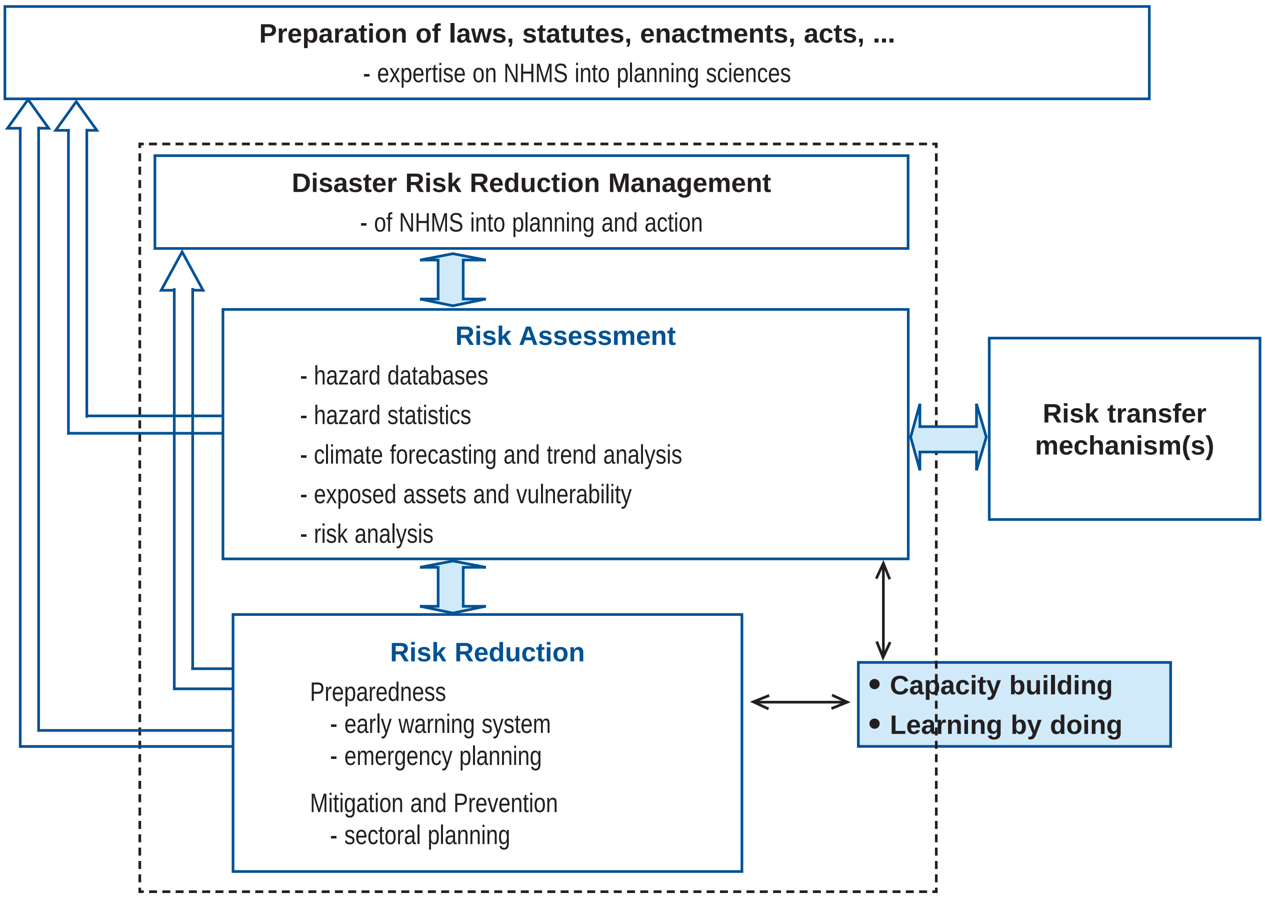
7 CURRRENT ROLE OF THE HYDROMETEOROLOGICAL SECTOR IN DRR

The importance of effective DRR in saving lives and protecting livelihoods is widely recognized in the CAC countries.

Most of the natural hazards in the CAC region are related to meteorological and hydrological extremes, and many others hazardous phenomena to human or nature (like some diseases, allergic reactions to pollen, dispersion of pests, dispersion of air and water borne pollutants, slippery roads,…) are weather dependent. Thus it is natural, and very critical, that the NHMSs and the hydrometeorological sector in general, are strongly integrated in national and regional DRR system at its different levels and phases, not only as data producers, but significant contributors and partners.

Reducing the threat of disasters has to be systematically integrated into policies, plans and programs aimed at sustainable development. Moreover, effective DRR needs strong institutional basis, which can be made stronger through e.g. capacity building, good governance, promotion of appropriate policies and legislations, facilitating information, and effective coordination mechanism.

Figure 10. The NHMSs may have a significant role in the interactive multidisciplinary Disaster Risk Reduction system for natural hazards.



7.1.1 Policy level

The status of the NHMSs varies in the governmental hierarchy; some NHMSs are:

a) directly under the government:

Uzhydromet, jointly with other ministries and agencies, took part in the planning and development of the national program on mitigation of natural hazards

b) under some ministry.

Category "a" NHMSs have the possibility to act directly on the policy level, while others act via their ministries. In case "b" the NHMSs are mainly providers of hydrometeorological statistics on request to the ministry, which forwards it the policy making.

Up to now only Armenia and Kazakhstan has established the national DRR Platform. Others, except Turkmenistan, have well developed national coordination mechanism in DRR.

7.1.2 Implementation level

All NHMSs have a described role at the implementation level dealing with risk assessment and early warning. However, generally they are not central actors, but more as providers of basic information to other DRR organizations.

The mandates and duties of the NHMSs are described by laws, statutes and/or other governmental administrative instructions.

Armenia: NHMS activities are based on the National Safety Concept. The operating procedures for the case of severe weather is described in "The recommendations to the National Hydro meteorological Service on the order of actions to the observation stations on the transmission of data (information) in the case of hydrometeorological hazards/risks (approved 2005). However, this document does not discuss e.g. production and dissemination of warnings. In Armenia Water Resources Management Agency, Rescue Agency, and in Azerbaijan the Ministry of Emergency Situations, has the main responsibility for flood related preparedness and mitigation.

Azerbaijan: The law about hydrometeorological activities (1998) describes also the role of NHMS in DRR.

Georgia: Legal status of the National Environmental Agency (Approved by the Minister of Nature Protection).

Kyrgyzstan: Kyrgyzhydromet disseminates warnings to the management of the Ministry of Emergencies and its structural subdivisions, Prime-Minister's Office, concerned ministries and agencies, regional and local administrations.

Tajikistan: The CoES has the main responsibility of DRR management. Currently CoES uses forecasting information provided by Tajikhydromet and the Hydromet Center of Russia, and warnings by Tajikhydromet when available. Climate information is used by CoES to study trends in the frequency of hydrological hazards associated with climate change.

Turkmenistan: The role of the NHMS is to provide meteorological, hydrological, climatic and agrometeorological data for risk assessment and forecasts on extreme hydrometeorological hazards to the emergency situations management.

7.2 RISK ASSESSMENT

Risk assessment is a methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. The process of conducting a

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Duties and mandates by law	yes	yes	yes					yes
Standard operating procedures	yes	yes	yes	yes				yes
Member of the DRR committee/platform	yes	yes	yes	no				yes
-policy making	yes	yes	yes					?
-provider of basic data and information	yes	yes	yes					yes
-provider of warnings	yes	yes	yes					yes
Provides support for DRR agencies								
-hazard mapping	yes	yes	yes	yes				yes
-emergency planning and preparedness	yes	no	yes	yes				yes
-emergency response operations	yes	yes	yes	no				yes
-reconstruction phase	yes	yes	yes	no				yes
Provides support at following levels								
-province or state	yes	yes	yes	yes				yes
-municipal or local level	yes	yes	no	yes				yes
Cooperation with Red Cross/Red Crescent	yes	yes	no	no				yes
Cooperation with UN coordinator in country	yes	yes	?	yes				yes
Participation in DRR activities in RAAII/RAVI	yes	no	no	yes				yes

Table 16. Indication of activities which the CAC NHMSs have, related to different topics in the DRR management.

risk assessment is based on a review of both the technical features of hazards such as their location, intensity, frequency and probability; and also the analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure, while taking particular account of the coping capabilities pertinent to the risk scenarios. (Source: ISDR).

Good-quality long-term and geographically representative hydrometeorological data is essential for risk assessment and production of hazard maps. The quality and representativeness of the data depends on the density of the monitoring network, type of measurements done and type of sensors used, and on data management including quality control.

However, in order to produce proper and optimal risk assessment it is critical to have cooperation and joint projects with hydrometeorological experts and the experts from different sectors and from different levels of the DRR and Civil Protection systems.

7.2.1 Meteorological and hydrological databases

All the CAC NHMSs are responsible for both meteorological and hydrological data bases. Currently most of the national databases are not in user friendly format, which makes production of analyses and statistics time consuming. Typically 30 year periods are used as reference for different types of analyses.

Armenia: Hourly and daily data from all observation stations are stored. From 5 stations the time series is more than 120 years, and from more than 30% of the stations more than 60 years. Much of the data in form of paper copies, which needs to be digitalized. Digital data base is stored at the funds of Armstatehydromet.

Azerbaijan: Meteorological synoptic data since 1935. Also hydrological and marine hydrometeorological databases are maintained. The database is in format of notebooks and table sheets.

Georgia: Meteorological data (every 3 hours) is stored in digital format for the period 1966-2009. Hard copies are available from 1844 to 2010.

Kazakhstan: Maximum length of the meteorological time series is about 49 years. Hydrological data are collected and published in annual books, which are published since 1930th. Most of the meteorological and hydrological data is stored on hard copies (tables, books, paper copies of images) and every year the amount is increasing. Only some data are partially digitized.

Kyrgyzstan: Climate data is available mostly in hard copies (only data on mean monthly temperature and precipitation amount are available in electronic format for some stations), which restricts preparation of climate information for the DRR and other purposes. There is a database of 1976-1985 data in CLICOM format stored in 280 1.44 Mb floppy discs (403.3 Mb in total).

Turkmenistan: Turkhydromet has meteorological data available from 1980. In 1993-1994 the database of major meteorological parameters for Turkmenistan for the period before 1980 was obtained from VNIIGMIMTsD on diskettes, but this data set is lost.

7.2.2 Hazards databases

In general the NHMS have data of different hazards as part of the observation data base. However, some NHMSs have also separate database for phenomena like coastal flooding, wild fire and drought. However, the hazard databases kept vary from country to country and there is no RAII or RAVI standard.

Armenia: The NHMS keeps historical data base for strong winds, hailstorm, thunderstorm and lightning and dense fog.

Azerbaijan: The NHMS has (manual) database on flash flood, river flood, coastal flooding, strong winds, hailstorm, thunderstorm and lightning, heavy snow, storm surge, drought, marine hazards and wild fire.

Georgia: Flash flood, strong winds, hailstorm, thunderstorm and lightning, heavy snow, dense fog, storm surge, coastal flooding, heat wave, cold wave, drought, river flooding, marine hazards, hydrometeorological hazards to aviation and avalanche.

Kazakhstan: The NHMS keeps historical data archives for flash floods, strong winds, hailstorm, thunderstorm and lightning, heavy snow, freezing rain, dense fog, heat wave, cold wave, drought, sandstorm and avalanche.

Kyrgyzstan:

Floods: The State Agency for Hydrometeorology.

Slides/avalanches: Germen Federal Institute: creation of computer database of landslides in Kyrgyzstan.

Uzbekistan: The regular accounting of mudflows has been carried out by Glavgidromet since 1954 using a special questionnaire.

In general e.g. the lightning recordings are based on old type and very few monitoring systems, as none of the countries have modern lightning detection systems available. The CAC NHMSs could actually collect lightning data from international providers.

7.2.3 Hazard statistics

Currently the CAC NHMSs only have possibility to produce climatological hazard statistics (hydrometeorological events and return times) only for the hydrological and meteorological (synoptic) stations, for which adequate time series in digital format available.

The hydrometeorological time series available in digital format at the CAC NHMSs are generally too short, and in many cases recent quality of data (and metadata) is not adequate, for production of comprehensive studies on return times of different types of extremes which could lead to hazards.

However, basic statistical analyses (distributions) of different hydrometeorological parameters have been produced. E.g. in Turkmenistan quite extensive database on natural hazards has been collected in 2008/2009 as part of a WB project.

Due to lack of long time series, and in some cases quite sparse observation network it could be vital to produce and reproduce meteorological statistics using NWP models and ERA 40 time series, as has been done e.g. for the Finnish Wind Atlas 2009. However, this approach requires huge computing power, which is not currently available at the CAC countries.

7.2.4 Hazard maps

It is easy and quick to produce different types of maps from a digital database with proper software. Hazard maps can be produced when

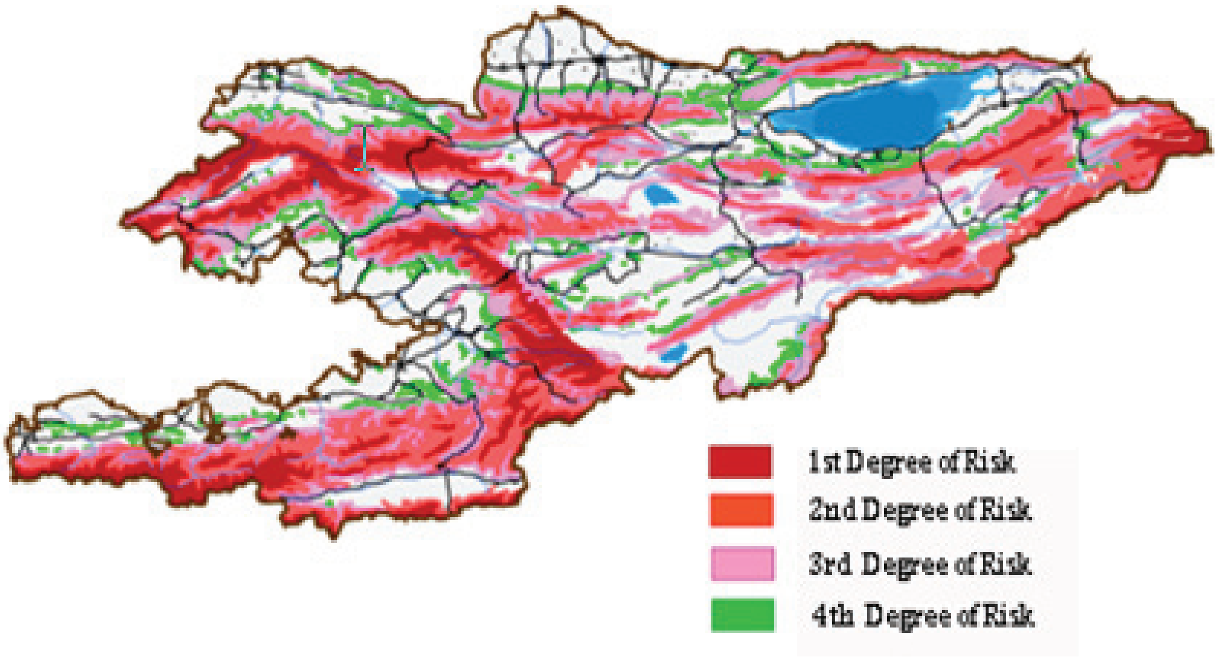


Figure 11. Example of avalanche hazard mapping in Kyrgyzstan. The degree of risk is divided into four categories. Source: Ministry of Emergency Situations (WB, 200).

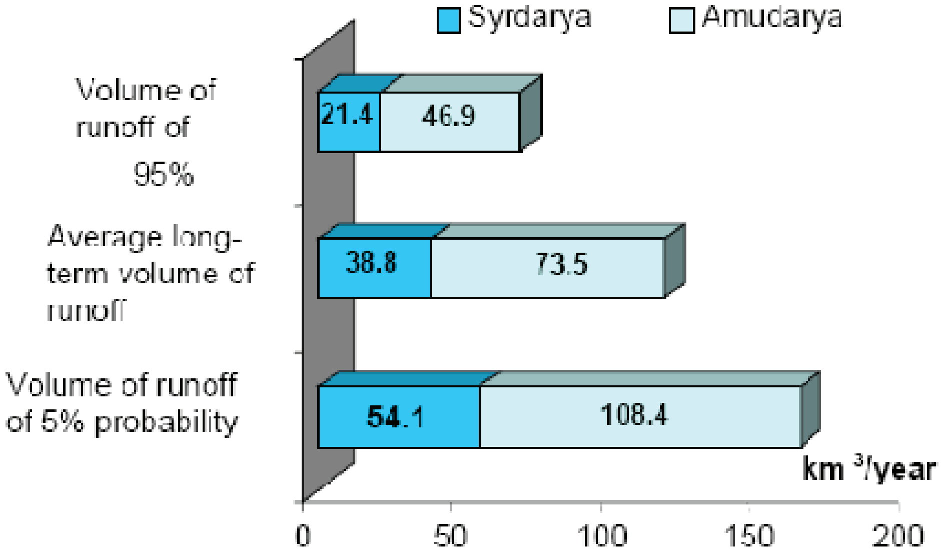


Figure 12. Annual river runoff of different probability of the Amudarya and Syrdarya Rivers.

the threshold values in terms of magnitude and intensity for different parameters are defined. The threshold values may be same from country to country, or they can be different. E.g. low temperature -10°C has different impact in Spain (hazard) than in Finland (normal in winter). On the other hand it is easy to produce hydrological inundation maps in universal form. The threshold values need to be produced on scientific bases in cooperation with NHMSs and different institutions having expertise of impacts of the phenomenon.

In some of the CAC countries some threshold values have been taken into use, some countries are working on the issue, and some countries are not.

Up to now some hazard maps have been produced in the CAC countries, but there is no coherent approach and systematic production of the maps. In general the maps are expected to be produced by request (government, communities), but the NHMSs have also produced some maps independently,

Some examples are given below.

In Kyrgyzstan hazard maps have been developed for the entire country by UNDP funding by the beginning of 2000s.

An example of the values of annual river runoff of various probabilities of the Amudarya and Syrdarya Rivers in Uzbekistan.

7.2.5 Risk analysis

Risk caused by natural hazards can be defined as in the following equation:

$$\text{Risk} = \frac{\text{hazard x vulnerability}}{\text{resilience}}$$

where vulnerability is measure of susceptibility to a specific hazard, and resilience is the measure of the capacity to withstand from the hazard event. Vulnerability to hazards is increased by many factors: e.g. poverty, increasing population density and rapid urbanization, poor land-use planning, poor scientific understanding of the hazard, poor public education and awareness of the hazard, poor governance, poor

Marz	HAZARD											
	Earth quake	Hail storm	Flood	Land slide	Chem. Waste	Snow	Flash flood	Cold	Swamp	Wind	Drought	Average
Yerevan	1.00	0.35	0.70	0.70	0.35	0.35	0.35	0.00	0.35	0.00	0.00	0.37
Shirak	1.00	0.70	0.70	0.35	0.70	1.00	0.70	1.00	0.70	0.70	0.00	0.68
Kotaik	0.70	0.35	1.00	0.70	0.35	0.00	0.70	0.70	1.00	1.00	0.00	0.59
Vayots Dzor	0.70	0.70	0.70	1.00	1.00	0.35	0.70	0.00	0.00	0.70	0.00	0.53
Armavir	0.35	0.70	0.35	0.35	0.70	1.00	0.70	0.70	0.70	0.00	0.00	0.50
Ararat	0.70	0.35	0.35	0.70	0.70	0.70	0.35	0.35	0.35	0.00	0.35	0.44
Lori	0.70	1.00	0.70	0.70	0.35	0.35	0.70	0.00	0.00	0.00	0.00	0.40
Syunik	0.35	0.70	0.35	0.35	0.35	0.70	0.35	0.00	0.00	0.00	0.70	0.35
Araga tsotn	0.35	0.35	0.35	0.00	0.00	1.00	0.35	0.35	0.00	0.00	0.70	0.31
Geghark unik	0.35	0.70	0.35	0.35	0.70	0.00	0.00	0.35	0.00	0.35	0.35	0.31
Tavush	0.35	0.70	0.35	0.35	0.35	0.00	0.35	0.00	0.00	0.00	0.00	0.22
Average	**0.60**	**0.60**	**0.53**	**0.50**	**0.50**	**0.49**	**0.47**	**0.31**	**0.28**	**0.25**	**0.19**	**--**

Table 17, Hazard matrix by marzes and Yerevan city. (WB 2009)

natural resource management, environmental degradation, increasing climate change and the fact that more people are living today in exposed areas.

Generally the CACNHMSs have not systematically been involved in risk analysis projects in their countries. However, hydrometeorological data may have been used in some risk assessments.

The Armenian Rescue Service (ARS) and State Academy of Crisis Management (SACM) have developed a hazard matrix for Armenia's 10 administrative divisions (Marz) and Yerevan city. Each marz is assigned a rating: 0 indicates "no possibility", 1 indicates "dangerous", to rate the potential for losses from each hazard

It is critical to increase production of risk analyses, e.g. as a regional multidisciplinary research project.

7.3 RISK REDUCTION

7.3.1 Early Warning System for weather and climate related hazards

Early warning means provision of timely and effective information that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response. Early warning is a corner stone of the DRR.

NHMSs (can) produce and disseminate different types of warnings.

A warning is issued when a hazardous weather or hydrologic event is occurring, imminent or likely. A warning means weather conditions pose a threat to life or property. People in region prone the phenomena need to take protective action.

A watch is used when the risk of a hazardous weather or hydrologic event has increased significantly, but its occurrence, location of timing is still uncertain. It is intended to provide enough lead time so those who need to set plans in motion can do so. A watch means that hazardous weather is possible. People should have a plan of action in case of a storm threatens and they should listen for later information and possible warning especially when planning travel or outdoor activities.

An advisory is issued when a hazardous weather or hydrologic event is occurring, immediately or likely (e.g. notices for mariners about strong wind). Advisories are for less conditions than warnings, that because significant inconvenience and if caution is not exercised, could lead to a situation that may threaten life or property.

NHMSs, as scientific expert organizations, need to have capacity to be able to produce predictions and forecasts of weather and climate related hazards in order to provide good lead-time.

The essential elements of an operational warning system for meteorological or hydrological hazards are:

- Data collection;
- Routine monitoring;
- Hazard detection;
- Hazard prediction;
- Watch and warning formulation;

	Kyrgyzstan	Turkmenistan
Strong wind	15-24 m/s[4]	≥ 15 m/s
Heavy rain	15-29mm/12h	≥20 mm/12h
Snow	7-19 mm/12h	
Frost	< 0^0C	-15^0C/5d
Hail storm		Ø ≥ 20 mm
Hail	Ø 6-19 mm	
Glaze	Ø 6-19 mm	Ø ≥20mm
Rime	Ø ≥50 mm	
Wet snow	7-12 mm/12h	
Heavy fog (MVR value)	50-500 m/3h or 50m/6h	MVR < 100m
Heat		≥40^0C/5 days
Thunderstorm		any
Snow storm	11-14 m/s during ≥3 h or ≥15m/s/12h	
Dust storm	same as above	
Storm surge		wave ≥1.5 m
Dry hot wind	X[5]	
Drought	X[6]	
Flood		Mountain rain ≥20 mm/12h
Mudflow		as for flood
Avalanche		

Ø = diameter of deposit of glaze, rime, wet snow or hail.

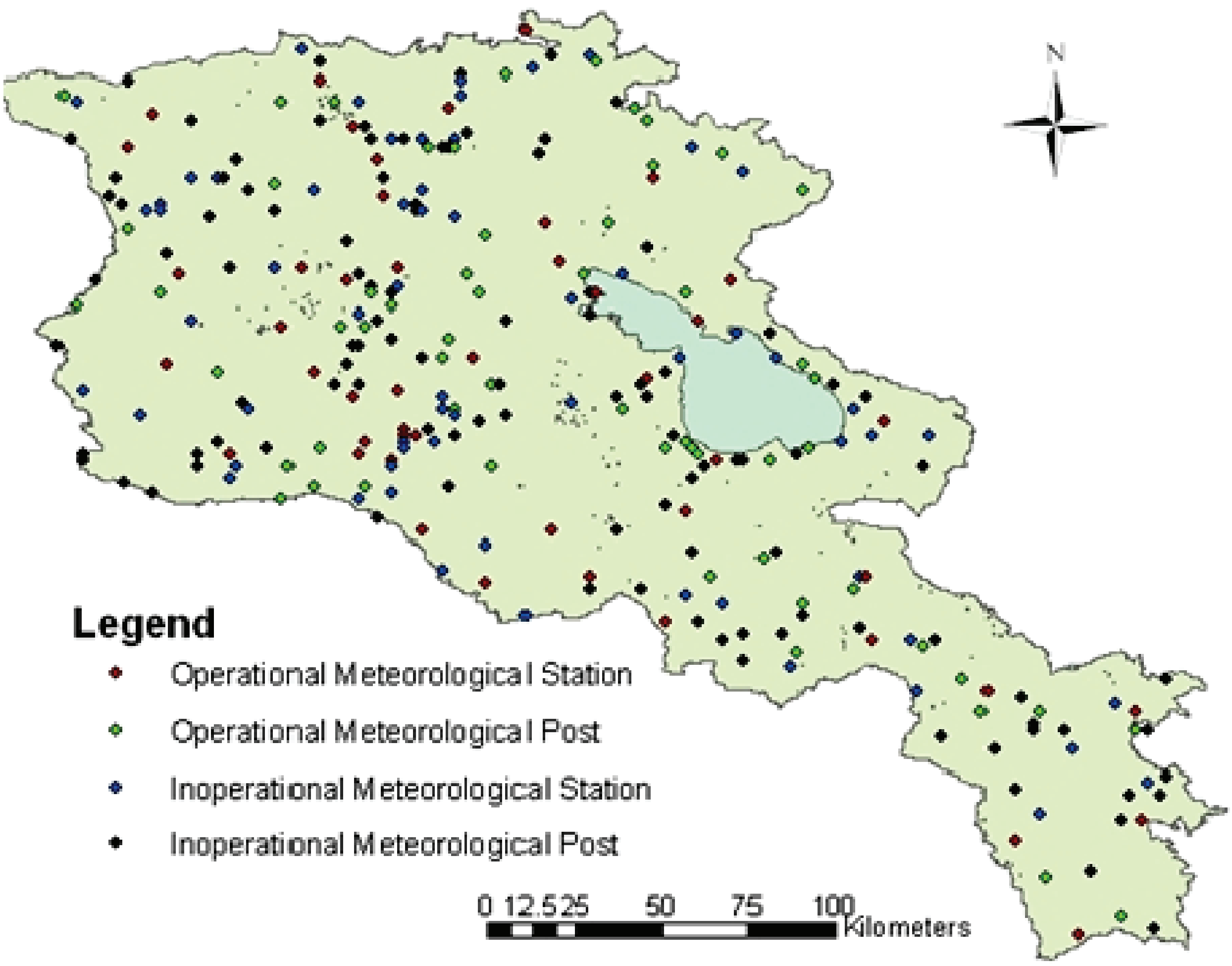
Table 19.Warning threshold values for different hydrometeorological events adopted by NHMSs in Kyrgyzstan and Turkmenistan.

[4] *In water area of the Issyk-Kul lake ≥ 10 m/s.*

[5] *During 5 days or longer at air temperature of 30^0C or higher and wind speed > 5 m/s*

[6] *Soil drought: During 2 ten-day periods available moisture. Atmospheric drought: no effective precipitation in the growing season during 30 days etc.*

Figure 13. Types of typical mandates of NHMSs in the national warning system (M. Golnaraghi, 2009).



- Information dissemination;
- Community response and feedback and
- Post-disaster support

Typically the NHMSs have different roles in the Early warning system: they may have full mandate to issue some warnings, or they may have a shared mandate with some other agency or institute, or mandate is under some other agency but NHMS has a strong contribution. Provision of warnings varies from country to country. However, in general the Caucasian NHMSs provide warnings for bigger number of hydrometeorological phenomena than e.g. the Central Asian or many of the South East European NHMSs.

It may be noted, that warnings on dispersion of airborne hazardous substances (i.e. nuclear, biological [e.g. pollen], chemical, ash from forest fires and volcanoes from national or international sources) are not included into the products and services of the NHMSs. In general these hazards are not well covered in the national DRR plans.

It is not actually very well defined what is meant by having the mandate to issue warnings. However, within the aviation sector this very clearly defined in the way that who is responsible to give what information to whom. In general the CAC NHMSs have the mandate to issue type I warnings concerning the meteorological parameters (wind, precipitation, temperature, hail, etc.). Warnings based on

	Armenia						Azerbaijan						Georgia						Kazakhstan					
	Y/N	F1	w	freq	lt (h)	hit	Y/N	F1	w	freq	lt (h)	hit	Y/N	F1	w	freq	lt (h)	hit	Y/N	F1	w	freq	lt (h)	hit
Tornado or similar	Y	x	Y	1	1	70	Y		N				Y		N				Y					
strong winds	Y	xxx	Y	7	12	92	Y	xxx	Y	72/190			Y	xx	Y	25	72	90	Y		Y			85/97
storm surge	N						Y	x	Y				Y	x	Y	6	24	83	Y					
flash flood	Y	x	Y	1	6	80	Y	xxx	Y				Y	xx	Y	10	24	83	Y	xx	Y			60/70
river flood	Y	x	Y		24	75	Y	xxx	N				Y	xx	Y	5	360	80	Y	xxx	Y			70/80
coastal flooding	N						Y		Y				Y	x	Y	4	48	80	Y		N			
hail storms	Y	xxx	Y	3	12	75	Y	xxx	Y				Y	xx	Y	4	24	80	Y		Y			
thunderstorms	Y	xxx	Y	4	24	90	Y	xxx	Y				Y	xxx	Y	130	24	92	Y		N			
heavy snow	Y	xx	Y	3	24	85	Y		Y				Y	x	Y	6	72	83	Y		N			
freezing rain	N						N						N						Y	x	N			
dense fog	Y	xx					Y	xx	Y				Y	xx	Y	8	48	80	Y	xx				
heat wave	Y	xx	Y		72	90	N		Y				Y	xx	Y	12	72	83	Y	x	N			
cold wave	Y	xx	Y		72	90	Y		Y				Y	xx	Y	16	72	87	Y	x	N			
marine hazards	N						Y		Y				Y		Y				Y		N			
aviation hazards	Y	xx	N				Y	xx	N				Y	xxx	Y	286	4	95	Y	x				
transport accidents	Y	xx	N				Y	xx	N				Y	xx	N				Y	xxx	N			
sandstorms	Y		N				N						N						?					
landslide or mudslide	Y		N				Y	x					Y	x	N				Y	x	N			
avalanche	Y	x	Y		24		N						Y	xx	Y	11	24	91	Y	x	Y			85/9?
airborne hazards	Y	x					Y	x	N				Y		N				Y	x	N			
waterborne hazards							?						Y		N				Y		N			
wild fires	Y	xx	Y	1	24	80	Y		N				Y		N				Y		N			
drought	Y	x	Y	1	72	85	N	x					?						Y		N			
epidemic	?						?						?						Y	x				
health hazards	Y	?	N				Y	?	Y				Y		N				Y	x	N			
disp. of insect pests	Y	?	N				Y	?	N				Y		N				Y		N			
dispersion of pollen	Y	xxx	N				Y	?	N				Y		N				Y		N			

Table 18. Hazard and warning matrix by country recognized by the CAC NHMSs. Y/N indicates whether the hazard occurs or not, F1 gives the average annual frequency of the phenomena with a scale 'xxx' high and 'x' low, W indicates whether the NHMSs has the mandate to issue warnings, column 'freq' shows how many times the warning was issued in 2008, column 'lt(h)' is the lead time in hours, and 'hit' the accuracy or hit rate (%) as indicated by the NHMS in the questionnaire.

	Kyrgyzstan						Tajikistan						Turkmenistan						Uzbekistan					
	Y/N	F1	w	freq	lt (h)	hit	Y/N	F1	w	freq	lt (h)	hit	Y/N	F1	w	freq	lt (h)	hit	Y/N	F1	w	freq	lt (h)	hit
Tornado or similar																								
strong winds	Y		Y				Y		Y				Y		Y				Y		Y			
storm surge													Y		Y									
flash flood	Y	xx	Y				Y	xxx	Y				Y		Y				Y		Y			
river flood	Y	xx	Y				Y	xxx	Y				Y	xx					Y		Y			
coastal flooding	N						N						Y						N					
hail storms	Y		N				Y						Y						Y		Y			
thunderstorms	Y		N				Y						Y						Y		Y			
heavy snow	Y		Y				Y						Y						Y		Y			
freezing rain	Y		Y				Y						Y						Y		N			
dense fog	Y		N				Y						Y						Y		Y			
heat wave	Y		N				Y						Y						Y		Y			
cold wave	Y		N				Y						Y						Y		Y			
marine hazards	Y		N				N						Y						N		N			
aviation hazards	Y	xx	N				Y	xx					Y	xx					Y		Y			
transport accidents	Y	xx	N				Y	x					Y	x					Y					
sandstorms	Y		N										Y						Y		N			
landslide or mudslide	Y	xx	Y				Y	xxx					Y						Y		N			
avalanche	Y	x	Y				Y						Y						Y		Y			
airborne hazards	Y	xx	N				Y	x					Y						Y		N			
waterborne hazards	Y		N										Y						Y		N			
wild fires	Y		N				Y						Y						Y		Y			
drought	Y		N				Y	x					Y						Y		N			
epidemic	Y	x	N				Y	x					?											
health hazards	Y	x	N				Y						Y						Y		N			
disp. of insect pests	Y		N				Y						Y						Y		N			
dispersion of pollen	Y		N				Y						Y						Y		N			

Table 18. Hazard and warning matrix by country recognized by the CAC NHMSs. Y/N indicates whether the hazard occurs or not, F1 gives the average annual frequency of the phenomena with a scale ´xxx´ high and ´x´ low, W indicates whether the NHMSs has the mandate to issue warnings, column ´freq` shows how many times the warning was issued in 2008, column ´lt(h)´ is the lead time in hours, and ´hit´ the accuracy or hit rate (%) as indicated by the NHMS in the questionnaire.

calculated parameters like "forest fire index" or "discharge" or "dose from air borne pollutant" are not produced. The warnings are sent to the authorities and on contractual bases also to specific economic customers. However, as the NHMSs disseminate printed versions to the media, the media has the possibility to edit the weather forecasts and also different types of warnings included. The NHMSs do not have the mandate to have warnings added into TV programs (warning stripes) or break up radio broadcasting.

Up to now there is no tradition to produce type II warnings e.g. in cooperation with the health sector.

Type III warnings; e.g. dispersion of smoke or allergic reactions due to pollen are not produced or given.

Currently the CAC NHMSs do not have the status of National Early Warning Center for Natural Hazards.

In some countries (e.g. Finland) the NHMSs has given the mandate and resources to act as national analyzing and warning centers for multi-hazards, not only for weather related hazards. This role is quite relevant for the NHMSs, as they typically have a 24/7/365 staff for forecasting and data management. In order to have an effective warning system it is critical that the Warning Centers have the right and capability to put the urgent warnings (short-term forecasting) on internet, TV and radio without any intermediaries or through a complex disaster management organization.

7.3.2 Lead time

A lead time[7] is the period of time between the warning of any natural hazard forecasted to occur and the real occurrence of the phenomena. It is essential that the people under threat and responsible organizations get the warning of potential hazard as early as possible. For industry and authority use it would be vital if probabilistic forecasts could be given.

The CAC NHMSs have considered the lead time to be same as the time for which the weather forecast is valid (up to 10 days). This would actually give quite long lead times for different hydrometeorological or weather related hazard. However, between the forecast and event (7-10 days for longer forecasts) the probable event/hazard may not be forecasted, or if it is the forecast may change some times before the event. The CAV NHMSs do not have capacity to produce probabilistic forecasts.

In European Meteoalarm system the warnings are valid 24 hours or 48 hours, depending on the country.

It would be vital to study the actual lead time in case of different types of hazards.

7.3.3 Warning dissemination mechanism

Currently the CAC NHMSs have the mandate to disseminate warnings directly (phone, email, fax, telegraph) to government, media and partly through authorities. Uzhydromet uses also SMS messages. The hydrometeorological information is delivered by the forecaster on duty. The CAC NHMSs do not have forecasters on duty nominated especially for hazard analyses and production of warnings. Currently the NHMSs have no automatic sending system in operation.

In most of the cases the NHMSs disseminate warnings as bulletins, in text format, by phone and through internet. However, as mentioned

[7] *Original definition comes from industry: A lead time is the period of time between the initiation of any process of production and the completion of that process.*

also elsewhere internet is not an active warning system, but rather an information system to those who want to have more information about the warning.

The NHMSs do not have the mandate to cut TV or radio programs for dissemination of hydrometeorological warnings. Currently e.g. TV stations cannot add warning bars on the TV presentations.

Currently the dissemination of warnings through the internet on the NHMSs´ home pages is at very poor level. There are no regional or sub-regional cooperative products like METEOALARM in the EU countries under preparation. Anyway, warnings on internet cannot be considered as a very effective warning/alarming system, but rather as a source of more information concerning meteorological hazards.

7.4 RESPONSE PHASE

Accurate weather forecasting, and early warning of weather phenomena, is critical also during response and rescue after or during the hazard event.

The CAC NHMSs have the responsibility to produce and disseminate short term weather forecasts and transform data from the observation stations to the authorities and DRR organizations. However, in most of the countries lack of sound and reliable communication systems, good observations, NWP models and real time weather radar images and composite picture significantly reduces the adequate data and short term site and time specific weather forecasts.

The governmental communication systems (e.g. TETRA) are not operational or the NHMSs do not have access to them.

7.5 RECONSTRUCTION PHASE

Natural hazards assessment and mitigation should be routinely included in development planning and in the identification of investment projects.

7.6 CLIMATE CHANGE

Impact of Climate Change is studied mainly based on the IPCC reports. However, more detailed local scale information is required about impacts of climate change on different socio-economic sectors for longer perspective (100 years and more) and for typical investment periods of the industry (20-50 years). Good examples are shown by the Nordic “Climate Change and Energy” projects.

7.7 PROMOTION OF THE DRR

Technical and human NHMS resources should be enhanced in operational monitoring, warning and forecasting and mapping of meteorological and hydrological hazards. Operational cooperation of the Civil Defense authorities and NHMSs should be further strengthened based on joint training and development of standard operating procedures across the agencies linked to the different threat levels in case of potential disasters. Dissemination mechanisms for warnings to the authorities and public must be well established and public outreach programs be developed targeted at communities. Furthermore, in context of the increasing risks associated with climate variability and climate change, there needs to be enhanced investments in climate modeling and forecasting and analysis to support sector planning for at-risk sectors.

8 SETUP, SERVICES AND HUMAN AND TECHNICAL CAPACITY OF THE NHMSs

The analysis of the current conditions of the Caucasian NHMSs are based on the information collected by the UNISDR consultant's questionnaires sent to Armenia, Azerbaijan and Georgia, and reporting about these countries during the first half of 2009, WB reports of Georgia, and information on Internet and at WMO.

At present NMHSs of the CAC states slowly revive the observation network, upgrade and modernize the equipment, try to apply new technologies. But all these activities have random and not coordinated character, which doesn't allow meeting the increasing requirements of users in the accurate, reliable, specialized products and information.

8.1 Historical background

All eight countries of the CAC region have been republics of the former Soviet Union. During that period the hydrometeorological services operated under the coordination of the Russian hydrometeorological service (Roshydromet) and the scientific guidance of the Main Geophysical Observatory (MGO) of St Petersburg. Therefore hydrometeorological services in all Soviet republics had similar structure, terms of references and methods. Observation data were annually provided to Moscow, where those were quality controlled and published in the Annual Books (TM1), containing all 8-term, decadal and monthly average values of all observed parameters.

After collapsing of the Soviet Union all the hydrometeorological services became individual, national-level organizations, lacking the regional cooperation. Gradually the existing network no longer functioned effectively due to lack of funds, decreasing the staff and antiquated equipment.

In 1992-93 all the countries of CAC region became the members of World Meteorological Organization (WMO) and started collaborating with international organizations such as USAID, UNDP, SDC, GTZ, SIDA etc. as well as with international forecasting centers (ECMWF) and advanced meteorological and hydrological services of developed countries, e.g. UK Met Office, Meteo France, Deutscher Wetterdienst (DWD), etc.

8.2 Legal status

Legal status of NMHSs in all the CAC countries is quite clearly defined by different laws:

- Armenia: The National Safety Concept
- Azerbaijan: Law on Hydrometeorological Activities.
- Georgia:
- Kazakhstan:
- Kyrgyzstan: The Law of the Kyrgyz Republic on hydrometeorological activity, enforced by Decree of Government of KR No. 54 of 08.06.2006.
- Tajikistan: The Law of the Republic of Tajikistan on Hydrometeorological Activity (2002).
- Turkmenistan:
- Uzbekistan:

All other NHMSs except Azerbaijan and Turkmenistan have official web pages.

Globally there is a big variation in distribution of ministries subordinating the NHMSs. In the CACs the NHMSs in Uzbekistan and Turkmenistan are at the Ministry level while the others are more or less under the ministry of environment. In Armenia the NHMS is subordinated by the Ministry of Emergency Situations.

All countries are members of the WMO. The Permanent Representative (PR) with WMO is nominated by the Government. Currently the directors of the NHMSs hold the post of the PR.

Armenia, Azerbaijan and Georgia are members of the WMO RAVI, while rest of the countries are members of RAII.

8.3 Annual reporting

Annual reports are made to the line ministries or governments. Reporting is much simpler than the "business-like" annual financial reports produced by modern NHMSs (which are also available on internet).

For this study annual reports were not available.

8.4 Basic branches and activities of the NHMSs

In most of the CAC countries, NHMSs are responsible for providing most of the hydrology, meteorology and environment related services. NHMSs have expertise within the whole area of the hydrological cycle and related environmental topics, which in principle provides them with comprehensive opportunities to provide not only

Country	Full name of the NHMS	Subordinated by	Web page
Armenia	Armstatehydromet - Armenian State Hydrometeorological and Monitoring Service	Ministry of Emergency Situations	www.meteo.am/
Azerbaijan	National Department on Hydrometeorology	Ministry of Ecology and Natural Resources	
Georgia	Department on Hydrometeorology at the National Environmental Agency	Ministry of Nature Protection and Natural Resources	www.hydromet.ge
Kazakhstan	Kazhydromet - Republican state-owned enterprise	Ministry of Environmental Protection of the Republic of Kazakhstan	www.meteo.kz
Kyrgyzstan	Kyrgyzhydromet - Central Hydrometeorology Administration	Ministry of Ecology and Emergency Situations of the Kyrgyz Republic	www.meteo.ktnet.kg
Tajikistan	Tajikhydromet - State Hydrometeorological Agency	State Committee of Environmental Protection and Forest Management of the Republic of Tajikistan	www.meteo.tj
Turkmenistan	Turkmenhydromet - National Hydrometeorological Committee	Cabinet of Ministers of Turkmenistan	
Uzbekistan	Uzhydromet -Hydrometeorological Services Center	Cabinet of Ministers of the Republic of Uzbekistan	www.meteo.uz

Table 20. General information about the NHMSs

weather forecasts and basic hydrometeorological and climatological information, but also good different types of combinations of multidisciplinary science-based services for the governments and the communities.

In many countries the services to the aviation sector contributes to the biggest share of their commercial revenue. However, in Armenia, Georgia, Kazakhstan, Kyrgyzstan civil aviation sector receives hydrometeorological information from separate agencies created in government sector, specifically to meet the requirements of this sector. In general, they are technically and financially better equipped than the NHMSs.

Weather modification, (hail suppression) remains a significant sector within hydrometeorology service in most of the services. In Armenia Hail suppression service in Rescue Agency has been given a mandate to carry out this task. However in most of the countries weather modification mainly is funded by the government.

All NHMSs have hydrological observations and services as part of their activities. However, in Uzbekistan, the Interstate Commission for Water Coordination (ICWC) fulfils functions of water resources management and development and maintenance of sustainable natural and hydro ecological processes on water resources directly through two BWOs "Amudarya" and "Syrdarya".

They have been mandated by the respective governments to take observations as necessary and provide meteorological and hydrological services including early warning of hydrometeorological disasters. In the government hierarchy, the ministerial subordination of national hydrometeorological services varies widely from country to country (Table 21.).

NHMSs are expected to carry out basic duties and liabilities which are defined in the legislation, governmental statements and annual budget, and in national agreements with WMO, so in principle the mission is quite clear.

The NHMSs carry out hydrological and meteorological monitoring and provide warnings of extreme weather events. In the case of extreme events, the information is forwarded to state authorities, economic agents, and the mass media, in order to protect people and property, and to avoid or mitigate damage.

The hydrometeorological products are mainly disseminated to governmental agencies and authorities. In many cases, the public accessibility and availability of the products is very low. The needs of end-users and potential customers are not well enough assessed and recognized, and the cooperation with the private economic sector is at low level. In general, the current services and products of the NHMSs are not very end-user oriented.

The NHMSs do environmental measurements and monitoring, and keep a database, but they do not have capacity or capability to forecast air quality, or to make dispersion calculations of air borne or water borne pollutants, or forecast their dispersion.

However, the countries are not capable to fulfil the expectations and requirements due to outdated or destructed observation networks, old-fashioned and manual working systems, lack of adequate communication systems and adequate financing.

8.5 Vision

A vision statement outlines what the organization wants to be. It is the guideline for the management and the staff, and gives bases for the strategy. It is critical that the vision is accepted by the owner (governments) and internalized by the staff, and well known by the customers.

Currently the CAC NHMSs were not able to introduce any specified, documented and accepted vision for the services. The NHMSs mainly perform the duties and obligations stated in the laws. However, NHMSs could be much more and do much more. This depends on their ambition and

Activities	Armenia	Azarbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Applied climatology	yes		yes					
Weather forecast	yes	yes	yes	yes	yes	yes	yes	yes
Climate change prediction/ analyses		yes	yes					
Operational NWP models	yes	no		no	no	no	no	no
- 24/7/365 meteorologists	yes	yes						
- 24/7/365 ICT staff								
Meteorological R&D	some	limited	limited	climate				
Meteorological observation network	yes	yes	yes	yes	yes	yes	yes	yes
Aviation meteorological service	no	yes	yes	no	no	yes	yes	yes
Marine weather forecasts	no			yes			yes	
Agrometeorology			yes					
Agrometeorological R&D			limited					
Agrometeorological observation network								
Hydrological forecasts				no	no	no	no	no
Hydrological NWP based forecasts				no	no	no	no	no
Hydrological R&D	some		some					
Hydrological observation newtork	yes		yes	yes	yes	yes	yes	yes
Hail suppression	yes							
Weather modification						yes		
Air quality monitoring network			no	yes	yes			
Air quality R&D	some		no					yes
Air quality laboratory			no					
Water quality monitoring network			no	yes	yes			yes
Water quality R&D			no					
Water quality laboratory			no	yes	yes			
Dispersion modelling for airborne			no	no	no	no	no	no
Dispersion modelling for waterborne	no		no	no	no	no	no	no
Radioactivity	no		no		yes			
Seismology	no	no	no	no	no	no	no	no
Commercial services	some	limited		some	some	some		
Commercial R&D services	some	no	yes					
Training programme for managers	no	no	no	no				
Training programme for scientists	some		some	some	some	some	some	some
Training programme for staff	some	some	some	some	some	limited	limeted	some
Training modules for DRR		yes						
Building awareness of hydmet hazards	no	yes	no					
Training the customers/stake holders	no	no	no					
Training of the new media	no	no	no					

R&D produces scientific articles (no year books)

Table 21. Different main activities carried out by NHMSs from different countries.

activity of the staff to enhance and upgrade their activities and raise their national and international importance and visibility.

It is vital to establish a vision, long term and short term strategies, and policy concerning the staff and modernized salary system,

As an example FMI`s current vision: Cutting-edge expertise in European know-how. Which means that FMI invests a lot in R&D and international cooperation.

8.6 Institutional structure and management

In Talas and Batken Regions, the hydrometeorological service functions of a hydrometeorological center (HMC) are performed by Regional Hydrometeorological Services (RHMS). In Chui Region, hydrometeorological services are provided by the Department of Hydrometeorological Observations, Forecasts and Information (HMC). It should be noted that the HMCs performs no operational and forecasting functions although they have operational and forecasting units. All forecasts are produced at the Department of Hydrometeorological Observations, Forecasts and Information, and then communicated (by phone) to HMC. In practice, operational and forecasting units disseminate forecasting data among the users of hydrometeorological information within their respective regions.

In Uzbekistan the Uzhydromet is directly under the government, at the same level as the ministries. Thus the Institutional structure of Uzhydromet is quite massive consisting of production departments and 4 sub-organizations.

Within the framework of WMO, Uzhydromet in Tashkent serves as:

- a Regional Telecommunication Hub with the responsibility to relay meteorological information to and from other countries in Central Asia;
- a Regional Specialized Meteorological Centre with geographical specialization with the responsibility to prepare and provide meteorological information to assist weather forecasting in other countries in Central Asia;
- a Regional Training Centre (Tashkent Hydrometeorological Professional College) with the responsibility to provide professional training to meteorological personnel from other countries in Central Asia;
- a Regional Drought Management Centre in Central Asia (RDMCCA).

Generally the institutional structure of the CAC NHMSs is rather administrative than operational, rather hierarchic and bureaucratic instead of manageable and cooperative, and too In many cases the cooperation between the units is not what could be expected in order to achieve the common main objectives. Organizations are often also built too much on territorial principles, which is not at all necessary with modern technology and communication systems.

"Are we cutting stones or are we building a temple?"

8.7 Financial resources

The annual budgets available to most of the NMHSs are in general very low, and strongly oriented towards personnel costs. The budget mainly consists of governmental financing. In the cases where the NHMS is under some ministry, the financing comes only from the line ministry, without any "external" revenue from other ministries which are beneficiaries of the services. All funds obtained through commercial activities are spent to cover the costs such as additional remuneration to employees in the form of extra-payments, premiums, travelling expenses and acquisition of technological equipment. Most of the NMHSs also get financial support from bilateral, multilateral and international agencies.

International experience shows that provision of special purpose information services may generate revenues reaching 20-40% of the total annual budget of a NHMS. In this case also the aviation weather services and military weather services are produced by the NHMS. In the CAC countries only Kazhygromet has significant (in terms of US$) earnings from special weather services - 24 % of its budget in 2004, while for the others the revenues are very marginal in terms of money.

Generally the commercial service system is not mature at the CAC NHMSs. The NHMSs do not manage their own accounts, and no working time monitoring system is available. Actually there is no proper procedure to calculate the cost of various works, the prices of work (salary + social costs + overhead) and data are not defined, the profit is unknown and calculations do not reflect the actual expenses incurred by NHMSs to produce information products.

Modern hydrometeorology is expensive, as modern (mainly western) equipment technology is expensive, as well as computer technology and software required to run NWPs and to produce and disseminate the products. With respect to the GDP levels, the modern technology is relatively much more expensive in CAC countries than e.g. in USA or the old EU countries.

For modernization and sustainable development of the NHMS governmental financing and budgets have to be increased manifolds. In addition to proper budget allocation, the salary level of employees, especially for educated experts, IT and other technical staff has to be enhanced. Without this it will be difficult to retain such high skill personnel. It may be noted that without high skill man power modernization of NMHSs shall not be possible just by enhancing technical capabilities.

It is also necessary that the NHMSs get bigger independence and responsibility of their own budget and own account(s), and have the possibility to include all the revenues into their account.

In comparison, as a reference: In Finland, the annual budget of FMI is €45.6million, including external revenues of 37 per cent (2008).
The private sector and other governmental organizations also participate in investments in observation network, especially like in weather radars, as they also benefit from the improved observations and services.

8.8 Human resources

The impression from meetings with the staff, where it was possible, was that the staffs is devoted to their jobs, and saw their work to important to the community. However, due to low salary level of academic experts the branch is not seen very attractive for young people, and

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
	2004	2004	2004	2004	2007	2007		2007
Share of GDP (%)	~ 0.02							
Total budget (million) USD)	0.46	1.60	0.46	7.80	0.50	0.51		2.20
Share from commecial (%)	5	10	3	24	1 - 3			3
Share of salaries (incl. social)					85	70		
Share of capital investments					0			

Table 22. Financial resources of each NHMS in 2007 and in 2009. For Turkmenistan the data is not available.

Figure 14. Institutional structure of Armenian NHMS.

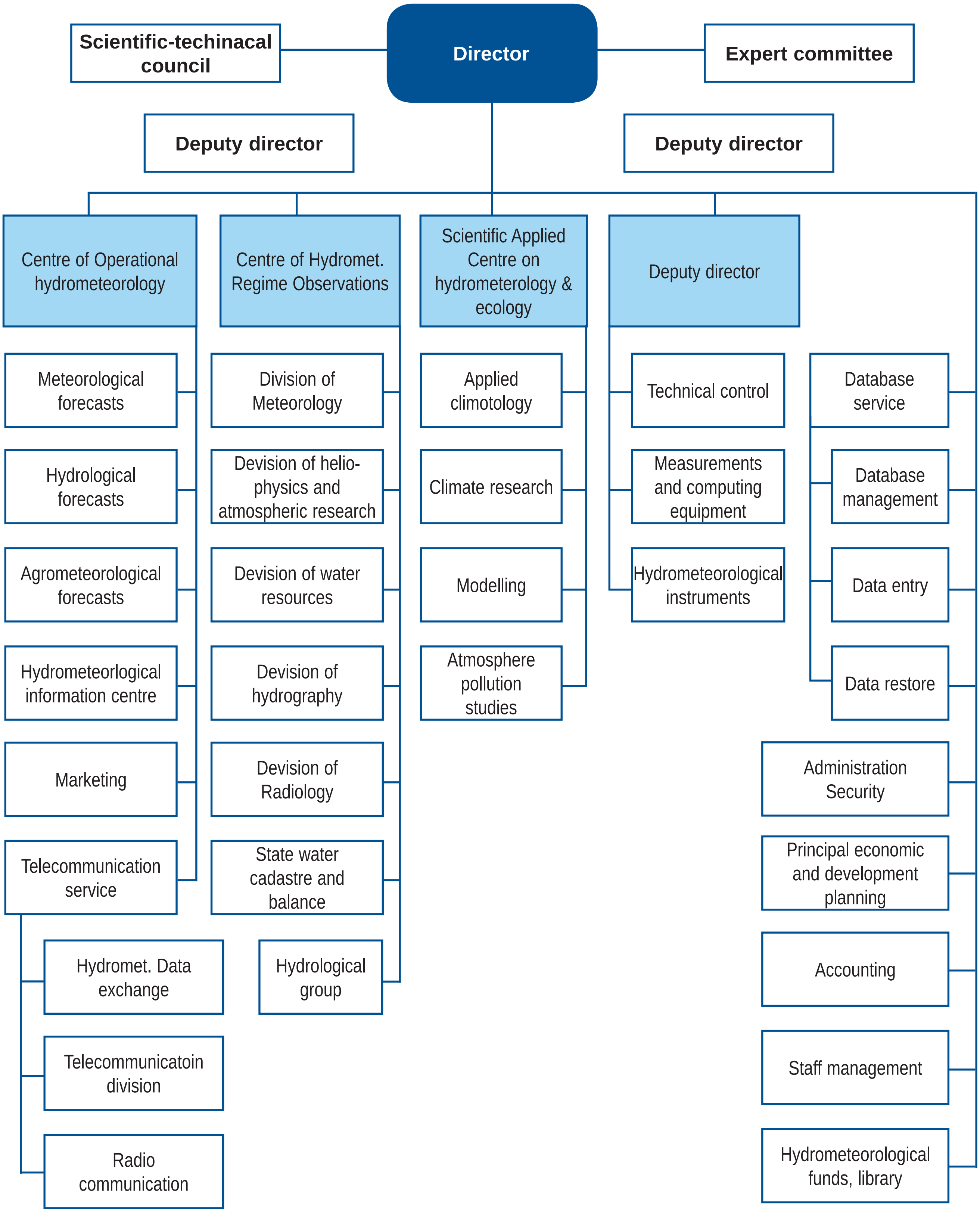


Figure 15. Institutional structure of the NHMS of Georgia.

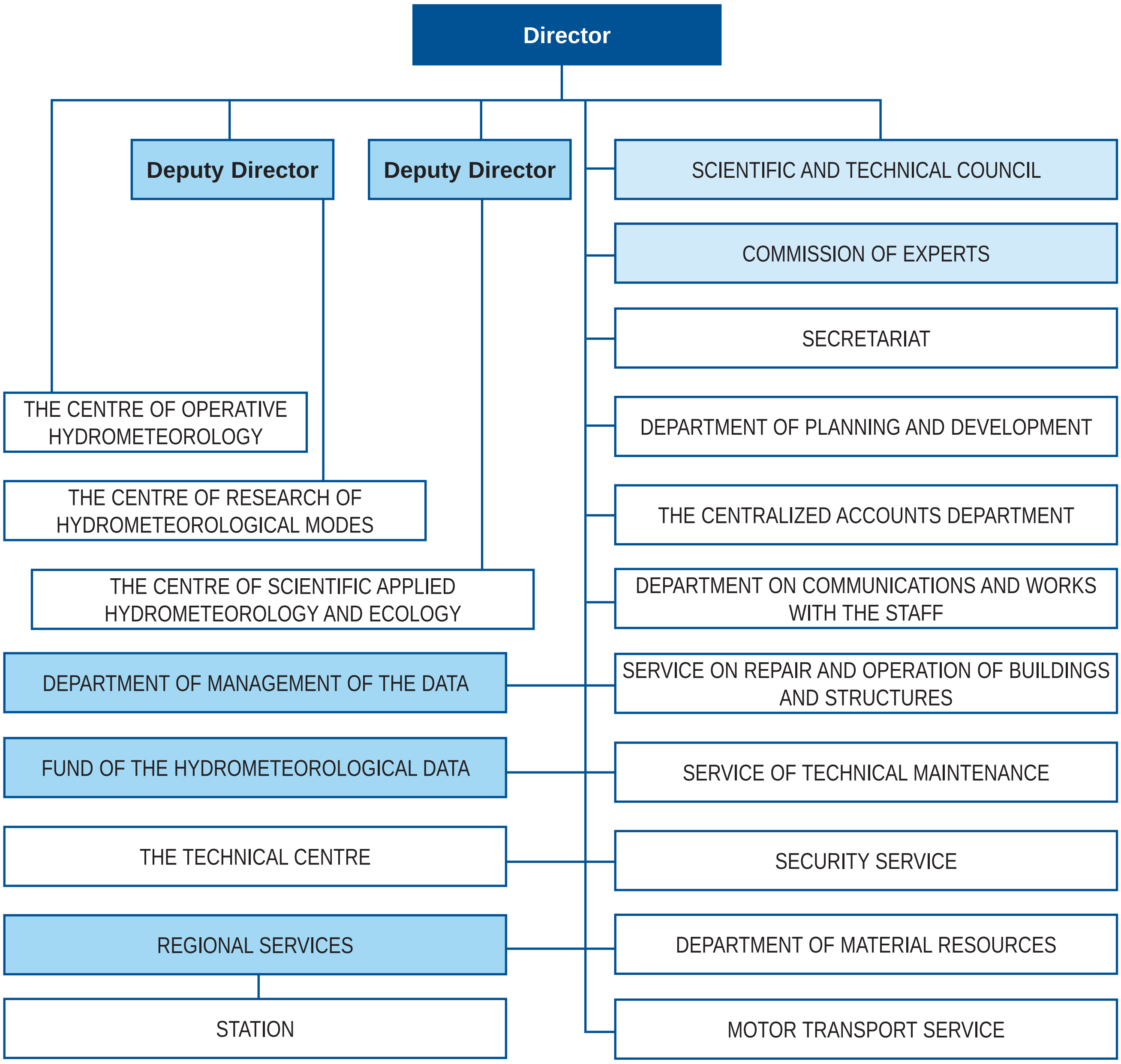


Figure 16. Organizational structure of the Hydrological Department of the NHMS of Kazakhstan.

Administration										
Director General										
Deputy Director General			First Deputy Director General					Deputy Director General		
Assistant on the regime services	Department of international cooperation	Department on hydrometeoro-logical services	Department of human resources	Accounting department	Planning and analysis department	Department on Governemnt Purchases and legislative provisions	International control service	Logistics services	Special devision	Office
Strucutral Sub-departments										
Hydromet centre	Meteorology department	Agro-meteorology department	Hydrology department	Ecological monitoring department	Information provision department	Department on the development of hydrometeorological and		14 provincial centres on hydrometeoro-logy	2 centres on hydrometeorological monitoring of Astana	

Figure 17. Institutional structure of the NHMS of Kyrgyzstan.

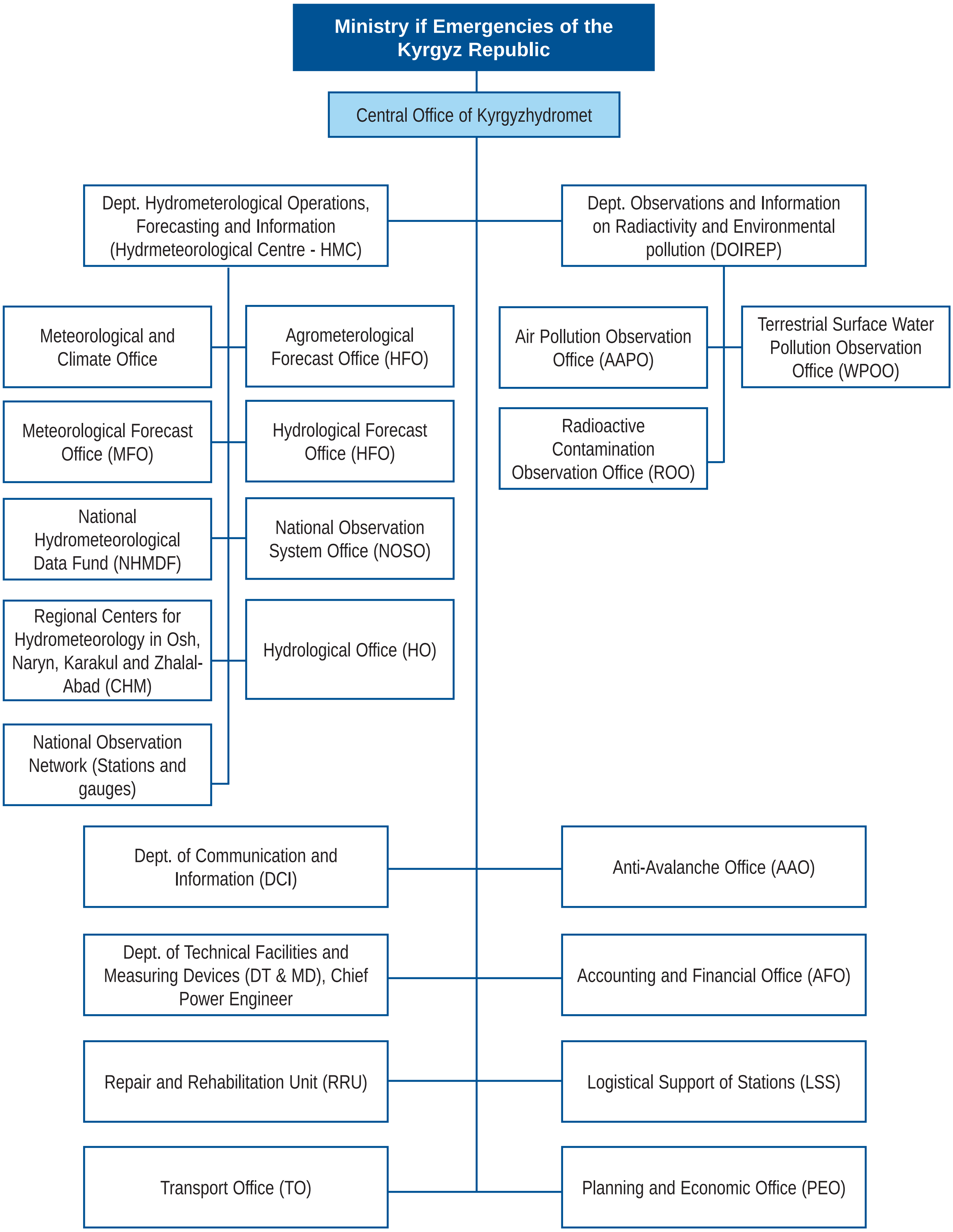


Figure 18. Institutional structure of the regional center of Osh, as part of the NHMS organization in Kyrgyzstan.

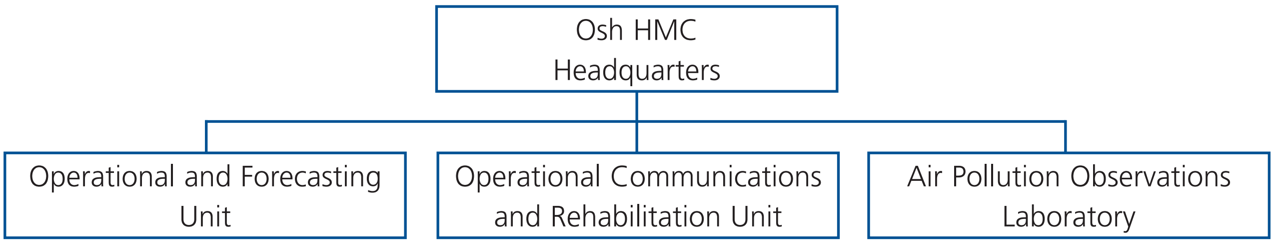
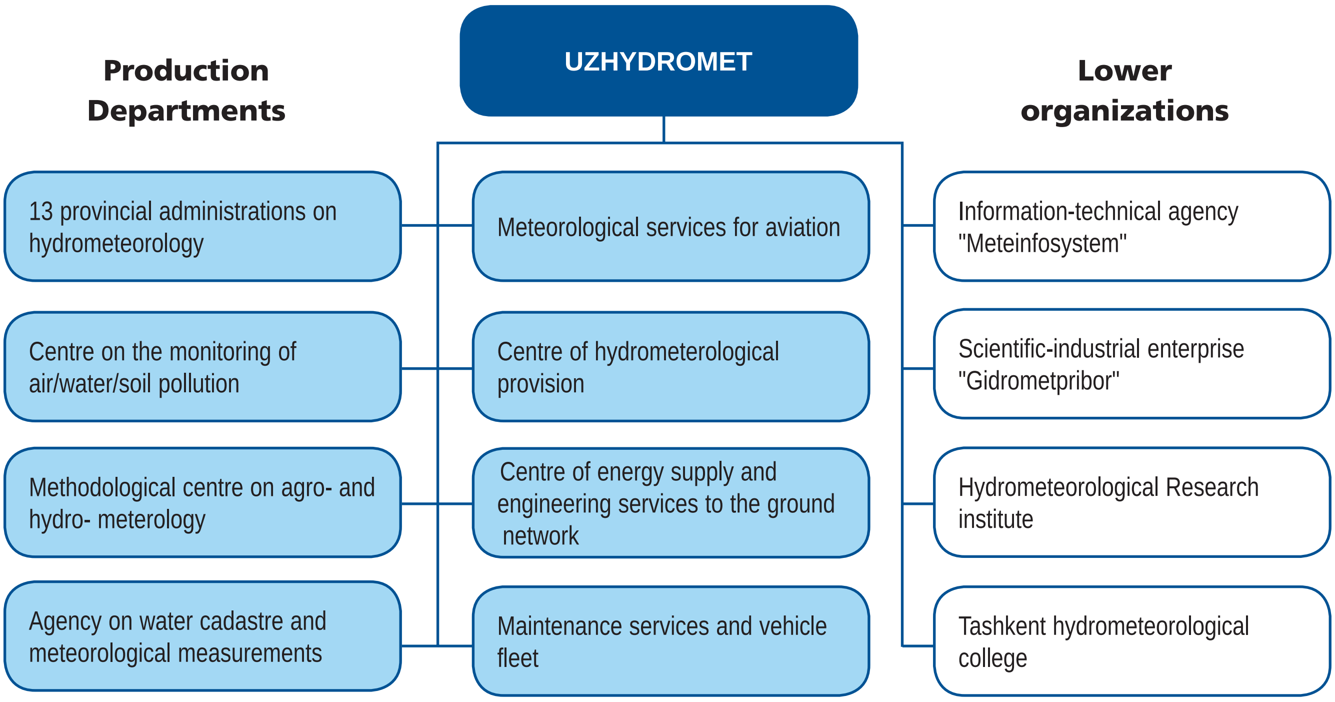


Figure 19. Institutional structure of Uzhydromet.



quite many leave the NHMSs and move to the private sector.

In general the number of staff at different CAC NHMSs is high, especially the number of observers, but in many cases the number of staff is less than the amount of vacancies. The main amount of the staff are technicians or professional with the lover academic degree (BSc[8]), while the amount of staff with higher academic education (MSc., PhD) and the number of qualified ICT staff are very low compared to e.g. the NHMSs in the Nordic Countries. The educational level of the staff and number of specialized technical people do not meet the current demands, and especially coming requirements when automated data collection and production systems, and improved forecasting systems and increased cooperation with economic sectors are going to be implemented.

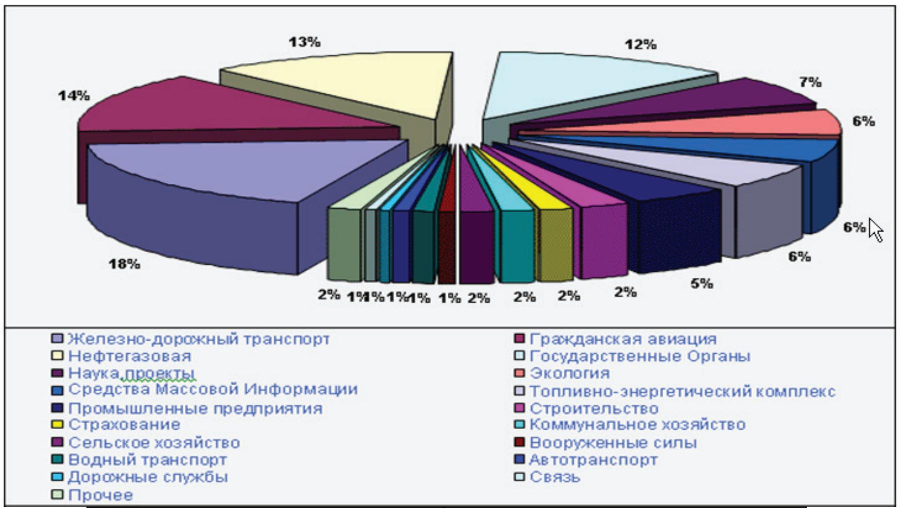
Typically the hydrometeorological sector promotes employment of women.

In general the number of staff has significantly decreased at all CAC NHMSs. In following some examples are given:

The total staff of Kyrzhydromet was 1113 in 1991 but in 2001 only 547.

The total number of staff including vacancies at the Tajikistan NHMS is 952 persons, of whom 712 people are operational staff. The staffing level equals 74%. The staffing position in respect to engineers (hydrometeorology) make up to 37%, meteorological technicians 64%, chemical

Figure 20, Distribution of earnings of Kazhydromet from special weather services by sector in 2005. (IBRD, 2007).



Railway transport	**Civil aviation**
Oil & gas	**Governmental bodies**
Science, design	**Environmental**
Mass media	**Fuel & power industry**
Industrial enterprises	**Construction**
Insurance	**Municipal utilities**
Agriculture	**Armed forces**
Water transport	**Motor transport**
Road services	**Communications**
Other	

[8] *A bachelor's degree is usually an academic degree awarded for an undergraduate course or major that generally lasts for four years, but can range from two to six years depending on the region of the world.*

engineers 48%, communication engineers 81%. About 50-55% of staff members have professional education. The NHMS faces a shortage of specialists in weather forecasting, hydrology, agrometeorology and actinometry. (WB).

The current number of the Turkmenistan NHMS staff is around 700, while in year 2000 it was 617. Number of staff members with higher education (BSc or more) was in 2007 110, while in 2003 it was 89. (WB). In 2008 Turkmenhydromet hired two graduates from the Hydrometeorological University (St-Petersburg, Russia) who were trained by WMO VCP.

An example of a very modern mid-size NHMS: The number of staff of the FMI is around 600 man months per year, including 220 people working full time on research and development. The staff also includes 40 IT personnel, with about 15 people who perform three-shift work as supervisory staff. The number of observers is 10. About 18 per cent of the staff has a PhD. Within the R&D sector it is expected that the new staff has done their PhD before getting a permanent job. www.fmi.fi

In general NHMSs with low automation level and without modern observation and production technology require much staff and forecasters, while at NHMSs equipped with modern technology the forecaster mainly conducts the forecasting process.

The amount and structure of the staff differs significantly from that in a modern and advanced NHMS like FMI, where the number of staff is about 600, but about 50 per cent of the staff works in R&D, the basic education level is MSc, and about

In the CAC NHMSs the knowledge of languages among the management and the staff does not meet the needs of today. It is significant benefit for the NHMSs that the staff to have adequate skills in English; lots of information is available on internet, most important scientific

	Total staff 2009	male	female
Armenia	660	331	329
Azerbaijan	1723	847	876
Georgia	267	62	205
Kazakhstan	2948	877	2071
Kyrgyzstan	464		
Tajikistan	952		
Turkmenistan	~ 700		
Uzbekistan	1340	518	822

Table 22 . Total number of staff and number of male and female in each CAC NHMS.

papers are in English, need of international cooperation is increasing rapidly, participation in EU programmes, etc.

The NHMSs are important employers on the countryside (weather stations). It is difficult to fill open vacancies for advanced experts due to low number of university graduates specialized in hydrometeorology, low salary level and low visibility and appreciation of the NHMSs. The competitiveness on labour market is low.

8.9 Training

Armenia:

It is not possible to achieve BSc or MSc level education in meteorology or hydrology. Yerevan State University, Faculty of Geography has a course on hydrology and meteorology. The HMS has some in-house capacity building concerning DRR related matters.

Azerbaijan:

University level education in meteorology is available in the Baku State University. In recent years about 10-20 people have received MSc but less than 1 person has received the PhD annually. The Service has collaboration with schools and universities to develop educational programmes and curriculum for hydrometeorological hazards.

Georgia:

	Armenia						Azerbaijan						Georgia						Kazakhstan					
	Tec	BSc	MSc	PhD	oth	tot	Tec	BSc	MSc	PhD	oth	tot	Tec	BSc	MSc	PhD	oth	tot	Tec	BSc	MSc	PhD	oth	tot
Observation network	333	102	16			451							52	25				77	1108	29	35		425	1597
Calibration & mainten.																								0
Telecommunications	8	11	2			21							4	22				26	30	2			49	81
Data management	6	4	12			22								78	3	1		82	22	34	13			69
Weather forecasting	16	9	10			35								40		1		41	17	29	47		38	131
Hydrological forcasting						0																		0
Air quality						0																		0
Water quality						0																		0
Avalanche																								0
NWP models		2	2			4																		0
Hail suppression	4	4				8																		0
R&D	2	2	12	4		20														7	20			27
Communic,& inform.	5	5	4			14								11	8			19	9	2	8		26	45
Other IT staff																								0
Accounting	4	2	4			10													12	5	5		56	78
Administration		10	18	1		29																		0
Others	21	16				37								13				13	292	65			514	871
total by education	399	167	80	5	0	651							56	189	11	2	0	258	1490	173	128	0	1108	2899

Table 23. Distribution of staff according to level of education over different branches in each CAC NHMS.

	Kyrgyzstan						Tajikistan						Turkmenistan						Uzbekistan					
	Tec	BSc	MSc	PhD	oth	tot	Tec	BSc	MSc	PhD	oth	tot	Tec	BSc	MSc	PhD	oth	tot	Tec	BSc	MSc	PhD	oth	tot
Observation network						17													502	143	6		46	697
Calibration & mainten.						5																		
Telecommunications																								
Data management																			1					1
Weather forecasting																			17	22			7	46
Hydrological forcasting																								
Air quality						28																		
Water quality																								
Avalanche						2																		
NWP models																								
Hail suppression																								
R&D																								
Communic,& inform.						18													9	5				14
Other IT staff																			7	12	3			22
Accounting																								22
Administration																								
Others						17													293	178		1		472
total by education						87													829	360	9	1	53	1274

Table 23. Distribution of staff according to level of education over different branches in each CAC NHMS.

University level (BSc, MSc and PhD) education is available in meteorology and hydrology at the Tbilisi State University. Some 15 staff members have attended short-term seminars since 2005.

Kazakhstan:

Hydrology and meteorology can be studied at the Kazakh National University of Al-Farabi Faculty of Geography Department of Meteorology; BSc 4 years, MSc + 2 years. Hydrology related topics can also be studied at the Department of Land Hydrology.

Kyrgyzstan:

The NMHS management actively participates in various meetings and workshops held in CIS countries, as well as seminars organized by international institutions and under international projects. Once in five years the calibration specialists of Kyrgyzhydromet attend professional recertification courses at Voykov Main Geophysical Observatory (Saint-Petersburg). Insufficient financing of operational costs related to travel expenses and staff development does not allow the NMHS to adequately organize and ensure professional upgrading of network personnel.

Turkmenistan:

BSc or MSc in meteorology or hydrology cannot be achieved in Turkmenistan. Training of specialists in hydrometeorology is provided at the Turkmen State University by the Department of geography and Nature Use. The department annually trains about 10 specialists, but the graduates rarely come to the NHMS. WMO training is not currently utilized. Lack of staff knowing English is an obstacle for international training.

Uzbekistan;

The university level education in meteorology and hydrology is available at the National University of Uzbekistan, Faculty of Geography, and Tashkent Hydro- meteorological college. The Scientific-research Hydrometeorological Institute of Uzhydromet provides possibility for post-graduate studies.

The NHMS management actively participates in meetings and workshops available in the region, and also in seminars organized by international institutions.

The Tashkent Hydrometeorological Professional College and Scientific-Industrial enterprise "Hydrometpribor" under Uzhydromet is a former Soviet Union, and today a WMO regional training centre, which provides in-house training especially for technical staff and observers. However, currently there are very limited training programmes for the managers, mid management and the academic staff in the NHMSs. The technical equipment of the "Hydrometribor" needs to upgraded to a level of modern NHMSs.

There are quite limited training programmes or systematic capacity building in all the CAC NMHSs for the hydrological, meteorological, technical and the management staff. The newly hired employees are provided basic training, so that they can initiate their activity. The NHMSs have some DRR training, but not very systematic. There is a lack trained trainers, and the budget for training is minimal. E-learning is poorly known and utilized. Therefore, the level of training provided currently to the staff is at a quite low level compared to more advanced NMHSs.

It is necessary to increase the share of staff with academic degrees; MSc and PhD. To ensure sustainable development of the NHMS it is critical to in training and capacity building of the staff, and especially training in English, and to pro-actively increase networking and cooperation with more advanced NHMSs. It is vital to exploit the possibilities for scholarships available internationally.

Typically in NHMSs, and generally in scientific organizations, the directors and managers are experts in their substance areas, but not trained in management, and especially not in business management. It is vital to build a training programme for the top managers, and especially for the mid-management and lower mangers, which is more cooperating with the scientists, experts and technicians.

8.10 Premises

Azerbaijan has a new constructed headquarters building, which meet the requirements of modern technologies.

In rest of the NMHSs the premises are rather old and the space for staff does not meet typical standards per person. The space and housing of computing systems are in most of the countries not satisfactory organized with respect to space and fire safety. Uzhydromet is a clear exception due to its role also as a regional hub of communication.

Generally the current premises do not promote the image of the NMHSs as dynamic and productive high-tech enterprises.

8.11 Observation network

In general the number of observation stations and posts, and the relative and absolute quality of the sensors and instruments, has declined since 1991. The observation stations are mainly manned, while the number of automatic stand-alone stations is low compared to developed countries, and also with respect to the national needs for improved DRR system. The number of manned stations can remain quite high as the salary level of observers is extremely low compared to prices of state-of-the art automatic stations. Manned stations may provide high frequency data (24/7) in case of emergency. Anyway, the strategy needs to be towards implementation of automatic on-line hydrological and meteorological stations and active remote sensing. However, currently the automation is not too much taken into account in the development strategies of the NHMSs. It is also notable that the number of stations which data is sent to the global and regional use through the WMO GTS system is quite low.

The density of established stations and posts is relatively high in Caucasian, while it is quite low in the CA countries. According to the WMO standards e.g. in Kazakhstan the number of meteorological stations should be about 5 times and hydrological stations about 3 times the current number of stations. WMO recommendations give an overall figure of needed density of observation stations. However, the density need depends strongly on the national topography, climatic characteristics, numerical models operated and needs from the industry and the community. The general tendency in industrialised countries is to increase the number and density of the surface observation network, as the demand for more accurate forecasts and observations in time and space in increasing from the end-user side, including the DRR management. In CAC countries the main concern concerning density and areal representatives of stations is to upgrade the currently non-operational stations, rather than to plan new stations.

In general most manned stations are equipped with obsolete instruments, absence of automatic stations, absence of computers and modern communication facilities for data processing and transmission are main deficiencies of the hydrometeorological observation networks in CAC. However, the quality of measuring instruments and devices vary from country to country.

In Armenia the degree of deterioration of instruments and equipment at meteorological stations is about 70 %, and it is expected that in these days for 25 % of the equipment the expiration date will be over.

In Kyrgyzstan the overall hydrometeorological system and its major observational networks, as well as operating principles, were developed before the mid-1970-s, and have not been changed since. Stations and posts use obsolete instruments, equipment and communication facilities devices have been in operation for over 30 years. As many of the gauges have been broken due to lack of spear parts and maintenance manual measurements and observations are done; wind observations are performed using manual observations of a wind vane and cloud altitude and visibility range are estimated by eye.

In Tajikistan since 1991 no technical upgrading of meteorological and hydrological equipment has been performed. Deterioration of many instruments and devices exceeds 80 %. Modern automatic meteorological and hydrological measurement facilities are non-operational due to lack of qualified personnel, and funds to finance the services of communication operators.

8.11.1 Meteorological observations

At synoptic stations the CAC NMHSs measure and observe mainly the same parameters than developed NHMSs. Manually operated actinometer measurements are still used by the NHMS to measure solar irradiation. In general actinometers give instant spot values and require manual operation, while in developed NHMSs they are replaced by pyranometers, pyrheliometers and computer-assisted sun trackers.

However, the current meteorological and hydrological observing systems in all countries have severely declined, in terms of amount of stations and quality of data, during the last two decades. Most of the countries are not capable to fulfil the international and regional obligations, which are agreed between the Governments and the World Meteorological Organization (WMO), concerning collecting, quality and dissemination of hydrometeorological data and weather and climate information the hydrometeorological, and especially the meteorological, observation network in the CAC countries is far behind the level of networks operated in Western Europe, USA, Japan and Australia in terms of quality and quantity of monitoring systems and amount and quality of data. E.g. in Kyrgyzstan the quality of meteorological does meet even WMO basic recommendations.

However, there has also been some progress in the CAC countries. After the last reorganization, i.e. since the middle of 1999, Kazhydromet has taken steps to restore the previously closed sectors of its activity. In particular, hydrological observations at some of the closed points, the snow avalanche service, and environmental monitoring have been restored. Due to improved funding of the weather sector in the few recent years, the most acute problems related to the reduction of observation points and types, and to obsolete technologies, instruments, and equipment, were mainly solved. The existing network of weather observations generally ensures coverage of the country's area with weather parameters and characteristics. However, some types of observation are seriously insufficient or totally non-existent. In particular, this refers to upper-air, agriculture-related, and hydrological observations in some regions of Kazakhstan, and to weather radar coverage of the Caspian, Astana, and Almaty regions.

In most of the CAC countries synoptic manned stations are mainly equipped with old fashion instruments. Sensors like sonic anemometer, present weather sensor, cloud height sensors, pyranometers and sun trackers are not known and not used. Only Azerbaijan and Kazakhstan have invested in automatic weather stations, even if the share of AWSs of the observation network and regional coverage is still very low compared to advanced NHMSs in Europe, Northern America, Japan and elsewhere.

	Armenia						Azerbaijan						Georgia					
km2	29 800						86 600						69 875					
	#	den	p/r	on-line	GTS	T	#	den	p/r	on-line	GTS	T	#	den	p/r	on-line	GTS	T
Observatory													6	0,086				
Manned SYNOP st.	47	1,577	45		6	47	87	1,005	65		7		25	0,358	13		12	50
AWS	0	0,000					13	0,150	12		2							30
- incl. Solar (G, D)																		
- incl. Precipitation																		
- incl. Present weather																		
- incl. Ceilometer																		
Manned AGROMET st.	38	1,275	38			38	1	0,012	1				5	0,072				20
Autom. AGROMET st.																		
Climate station	4	0,134	4		4	4	18	0,208	16		5							
Manned PRECIPITATION	28	0,940				28	204	2,356	78		7		30	0,429	30			70
Autom. PRECIPITATION																		
Autom. TOWER							6	0,069	4									
MARINE weather stations							15	0,713	14									
LAKE weather stations																		
Weather radar							2	0,023	2				1	0,014				
Upper air sounding	1	0,034	1		1	1	2	0,023	1			1	2	0,029				
Rado wind							1	0,012	1			1	2	0,029				
PILOT													1	0,014				
Lightning detection							87	1,005	65		7		3	0,043	1			10
Satellite receiving system													4	0,057	1			4
UV																		
upper air UV	2	0,067	1		1	2							1	0,014				
Actinometer	7	0,235	7										7	0,100				7
Hydrological stations																		
Water discharge/stream	94	3,154	94			94	127	1,467					110	1,574	24			100
Air quality																		
Autom. air quality																		
GAW	1	0,034	1		1	1		0,000										
Water quality																		
Autom. water quality																		

Table 24. The current total number of stations(#), number of stations per 1000 km2 (den) , number of stations sending manually near-real time data by phone of radio (p/r), number of stations on-line, number of stations sent to the WMO GTS, and (T) the target (optimum) number of different types of meteorological in each country as indicated by the NHMSs.

	Kazakhstan					Kyrgyzstan					Tajikistan					Turkmenistan					Uzbekistan				
area km2	**2724900**					**199100**					**143100**					**488100**					**447400**				
	Current			Target		Current			Target		Current			Target		Current			Target		Current			Target	
	#	#/1000 km2	WMO GTS	#	#/1000 km2	#	#/1000 km2	WMO GTS	#	#/1000 km2	#	#/1000 km2	WMO GTS	#	#/1000 km2	#	#/1000 km2	WMO GTS	#	#/1000 km2	#	#/1000 km2	WMO GTS	#	#/1000 km2
Surface synop	259	0,095	62	350	0,128	32	0,161	7	83	0,4169	52	0,3634	14	80	0,559	48	0,098	20	100	0,205	78	0,174	19	78	0,174
Manual	207	0,706	62		0,000	28	0,141	7	83	0,4169	52	0,3634	14		0		0	20		0	78	0,174	19	78	0,174
AWS	42	0,015	0	350	0,128	4	0,020	0	0		0	0	0		0	0	0	0		0	0	0	0	0	0
Agromet	184	0,068	0	?		31	0,156	0	0		28	0,1957	0		0	27	0,055	0	56	0,115	2	0,004	0	2	0,004
Automated	0	0,000		?		0			0			0			0		0			0		0			0
Rainfall	232	0,085	0	250	0,092	0		0	0		67	0,4682	0		0	40	0,082	0		0			0		
Automated	0			?		0			0			0			0		0			0		0			
Climate	33	0,012	43		0,000	0		4	0		15	0,1048	15		0	13	0,027	13		0	78	0,174	12	78	0,174
Offshore/ lake	34	0,012	0	50	0,018	4	0,020	0	0			0	0		0	0	0	0		0	3	0,007	0	3	0,007
Towers	0	0,000	0		0,000	0		0	0			0	0		0	0	0	0		0	0	0	0	0	0
Sounding	9	0,003	8	14	0,005	0		0	0			0	2		0	0	0	2		0	0	0	0	0	0
Weather radar	0		0	?		0		0	0		0	0	0		0	0	0	0		0	3	0,007	0	3	0,007
Lightning	0		0		0,000	0		0	0		0	0	0		0	0	0	0		0	0	0	0	0	0
Hydro/ stream	257	0,094	0	350	0,128	76	0,382	0	147	0,7383	81	0,566	0	138	0,9644	32	0,066	0		0	10	0,022	0	10	0,002
Autom. data. coll.	P			YES																	NO			YES	
Observers						328					712										689				
Forecasters	28															23					22				
ICT experts						18										6					32				
Total staff	2948					548					952					712					2062				

Table 25. The current total number of stations(#), number of stations per 1000 km2, number of stations sending data by to the WMO GTS, and the target (optimum) number of different types of meteorological in each country as indicated by the NHMSs.

Manually operated actinometers measurements are still used by the NHMS to measure solar irradiation. In general actinometers give instant spot values and require manual operation, while in developed NHMSs they are replaced by pyranometers, pyrheliometers and computer-assisted sun trackers.

The contribution from the observation network to the society, industry, protection of environment and production of weather and hydrological forecasts is not what actually could be expected in order to fulfil the missions. The number of surface observation stations is not adequate (according to the replies to the questionnaires sent to the NHMSs), but the quality of data is questionable due to obsolete gauges, and the sensors are in urgent need of maintenance and replacement with new ones. As the data are sent and collected mainly by old-fashioned systems, the observations cannot be used in best way to support the forecasting.

Also the operation of remote sensing systems is at much lower level than in e.g. the EUMENET countries.

Upper air observations

Upper-air observation data are critical for global, regional and local Numerical Weather Prediction models, and the data are also very essential especially for the aviation weather forecasting and for short term predictions in general. Upper-air data are used also for composing synoptic maps of high surfaces, and for weather forecast, and it is critical for forecasters who do not have access to NWP data.

Upper-air observations can be done by balloon carried sensors sent from manned or automated sounding stations, different types of wind profilers or by regular line aircraft carried sensor systems (AMDAR). Balloon carried sensors are used to produce data about air temperature, humidity, pressure, wind direction and speed up to height of 30-35km.

Currently only balloon carried sounding systems are available in the CAC countries.

The current density of upper-air sounding stations is low in respect to the large size of the CAC area; only 13 stations are in operation. On the other hand the density of upper air stations in Caucasian sub-region is relatively high, even if the absolute number 3 is not very high.

Aerological observations in Armenia have been conducted since 1948 on the aerological station located on the territory of "Erebuni" airport. Since 2000 the aerological station in Yerevan operates in Davitashen district and with assistance of "METEO-FRANCE" supplied with the modern equipment "Digi Cora II" of Finnish company "VAISALA". In 2001 the station have got also from "METEO-FRANCE" the equipment "Gasogenerator MP 8" for filling of sound rubber shells by hydrogen.

Azerbaijan has two upper-air sounding stations, but only one located Mashtagi is operational and makes one sounding per day at 00 GMT.

Kazakhstan operates 9 sounding stations located in Almaty, Aktobe, Atyrau, Zhambyl, Zhezkazgan, Karaganda, Kostanai and Pavlodar. Soundings are made twice a day at 00 GMT and 12 GMT. The sounding system is based on modern Russian technology, but GPS system is not yet in use.

In Kyrgyzstan one sounding station, located in Bishkek, is partially operational; the station can afford to launch 100 donated (WMO VCP) radiosondes per year. In 2003 the aerological computing complex was modernized, and further upgraded in 2005 through the WMO VCP. However, the operation is not ensured due to lack of professional staff. Up until 1992 Kyrgyzhydromet had also two other aerological stations: Jalal-Abad (operational through 1968-1992), and Naryn (operational 1972-1999).

Georgian NHMS has 2 stations, but currently they are not operational. Currently upper-air sounding stations are not either operated in Tajikistan, Turkmenistan and Uzbekistan.

Lack of upper-air observations significantly affects the quality of local weather forecasts, as well as the results of global and regional numerical weather prediction model results for the CAC region, and globally.

Weather radars are very powerful tools for aviation meteorology, tracking precipitation areas, to measure intensity of precipitation, flood forecasting and for short term weather forecasting (nowcasting). It will not be wrong to assert that weather radars, at least for today, are the only and essential instruments as active remote sensing systems which can provide real time (less than 15 minutes depending on the scanning strategy and processing features), accurate and high resolution (up to 150 m) weather information in large scale area (up to 500 km depending on the frequency used) particularly for nowcasting purposes.

In the CAC region the weather radar network is poor in geographical coverage, and data and information from existing radars is poorly disseminated and used.

The current number of weather radars operated by the NHMSs in the three Caucasian countries is 2: Armenia 0, Azerbaijan 2 and Georgia 0.

The current number of weather radars operated by the NHMSs in CA is 3: Kazakhstan 0, Kyrgyzstan 0, Tajikistan 0, Turkmenistan 0, and Uzbekistan 3. Currently meteorological weather radars operated by the NHMS in Uzbekistan (3 MRL-5 radars from 1987-1989; in Nukus, Tashkent and Samarkand). The radar data is only visible for the forecasters, but the images are not disseminated to end-users, and there are not any radar data customers. No composite pictures are available.

In Tajikistan 4 old MRL-5 meteorological radars are used by the Department of Weather Modification in their hail suppression operations. The radar information is used only for hail suppression purposes, and the radar data is unavailable for assessment of weather conditions and producing weather forecasts.

Also the aviation weather organizations operate some weather radars, but this data is not available for the NHMSs.

The current data management system at the CAC NHMSs does not allow using much more real-time observations and handling of large amounts of data coming from NWPs, radars and others.

In Armenia the first actinometrical observation for direct radiation had been implemented in 1928-1932 in the basin of the lake Sevan, and then such observations had been conducted in 1931 on Aragats h/m and continued till 1946. In 1936-1937 at meteorological station Yerevan -agro had been conducted actinometrical observations. The highest station of actinometrical network is Aragats h/m (height 3277m. e.g.) and the lowest one is Yerevan - agro (height 942m e.g.). On initial stage the measurements at all posts had been conducting for direct, scattered and reflected short-wave radiations. Later in 1957 - 1959 were organized observations on heat balance. In 1962 began the integration of some radiation elements. In 1983 at some stations were installed recorders that allowed recording all parameters of radiation balance. At present actinometrical observations have been implementing at 7 meteorological stations: Yerevan - agro, Sevan HMS, Gyumri, Martuni, Vorotan/pass, Tashir and Hamberd.

8.11.2 Hydrological stations and posts

Hydrological measurements (precipitation, snow depth and water content, discharge and runoff, water level and evaporation) are essential for all countries, but especially for countries with high probability of river flooding and flash floods. As

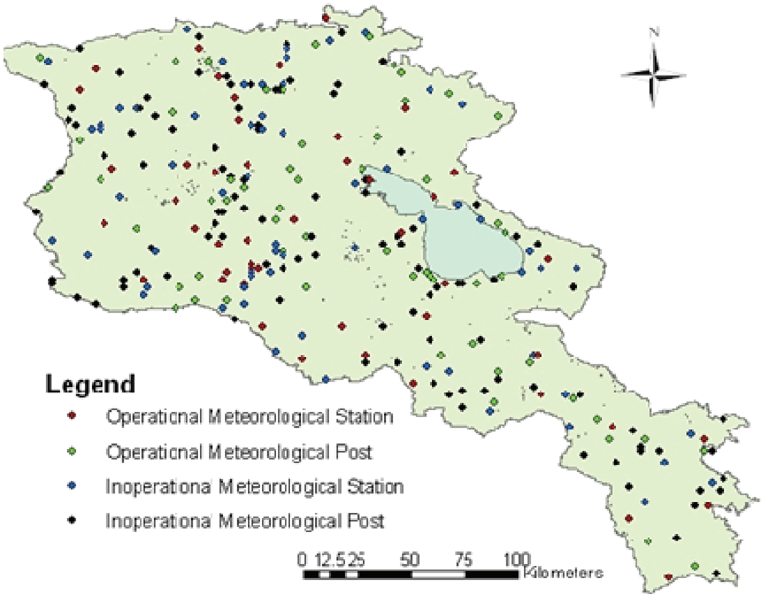


Figure 21. Map of historical and current meteorological stations and posts in Armenia.

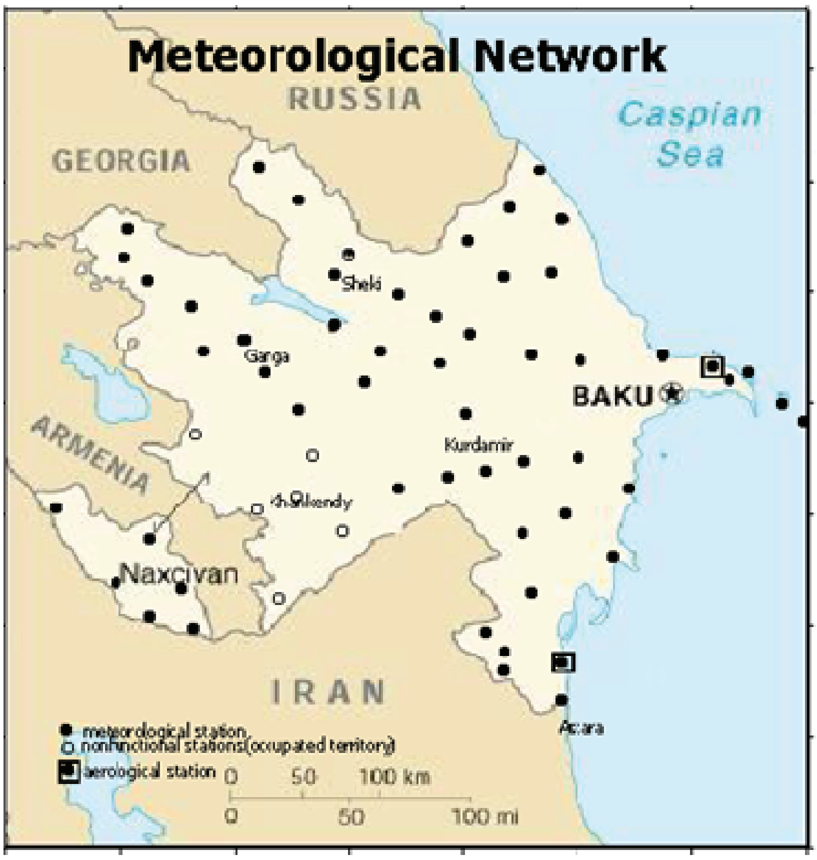
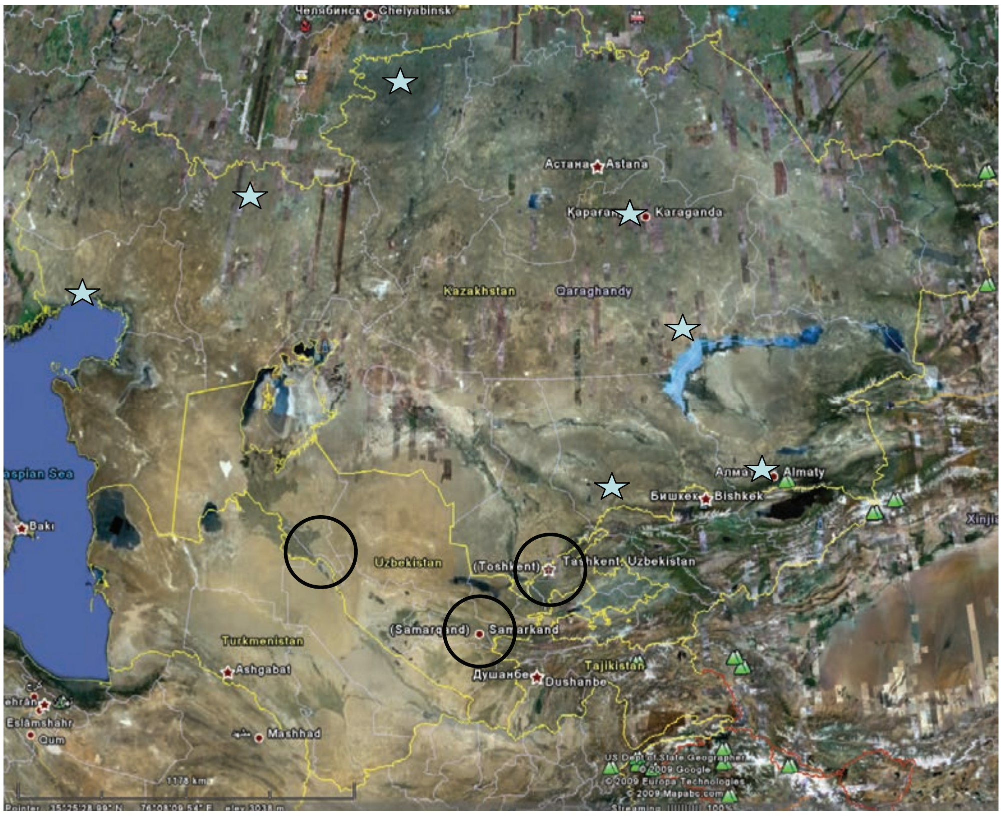


Figure 22. Meteorological observation network in Azerbaijan; operational station with black dots and non-functional stations with open circles.

Figure 23 Operational upper air sounding stations (blue stars) and weather radars with estimated 150 km radius in the Caucasian countries.

Figure 24 Operational upper-air sounding stations (blue-grey stars) and regional potential coverage (black circles with 200 km radius) of the current weather radar network operated by the CA NHMSs.



many of the rivers are transboundary it is critical to have capacity to share real-time data, and historical data, with the neighboring countries.

There is lack of automated hydrological measurements and real-time or near real-time date generally in all of the countries.

The operational effectiveness of the hydrological network is low in many of the countries. The situation is worst in Kyrgyzstan, where 90% of the hydrological instruments are worn out. At Lake Issyk-Kul that can be used in regular hydrological and hydrochemical observations. However, for the lack of funds to pay for diesel fuel, no regular observations are performed in the lake water area. Life-saving equipment and special wear for staff for safe water operations are non-existent. Lack of vehicles makes it difficult to reach the measurement post when needed. The data provided by hydrological posts is insufficient to produce reliable and timely flood forecasts using the currently applied techniques.

8.11.3 Agrometeorological stations

Agrometeorologial stations measure standard meteorological parameters, but also many agriculture and agrology specific parameters like evaporation, soil temperature and humidity, heat fluxes, etc. The number of agrological stations varies in the CAC countries, depending mainly on the size of the agriculture sector. Currently there are no automated agrometeorological stations in operation.

The situation is the worst in Kyrgyzstan. In 30 years the number of stations has been reduced by 50% due to lack of proper measuring instruments. Due to lack of car transport, and lack of willingness to use other transportation, the observation sites located at a distance of 5-10 km from stations are not visited. The capacity to provide agriculture sector with any data and services is very poor.

8.11.4 Snow and avalanche stations

There are only three operative snow avalanche stations. Avalanche observations currently cover no more than 10% of the avalanche-hazardous areas. Aerial snow surveys are performed occasionally. Snow-measuring rods at the aerial network have not been repaired and reconstructed since 1989; aerial network sites in many basins are completely destroyed.

Uzhydromet has five avalanche stations, which monitor all avalanche risk zones, particularly along the mountain pass to Fergana valley. Aero-visual snow-measurements are done at seven snow measuring locations within seven basins.

Today satellite monitoring of snow cover and depth of snow is available. Use of satellite information in avalanche risk analyses, as well as participation in international R&D projects could be increased among the CAC NHMSs.

Figure 25. Location of hydrological stations and posts in Armenia.

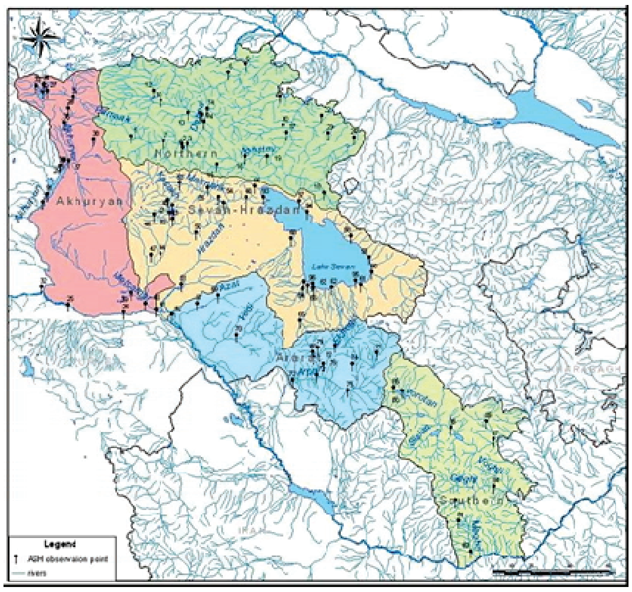
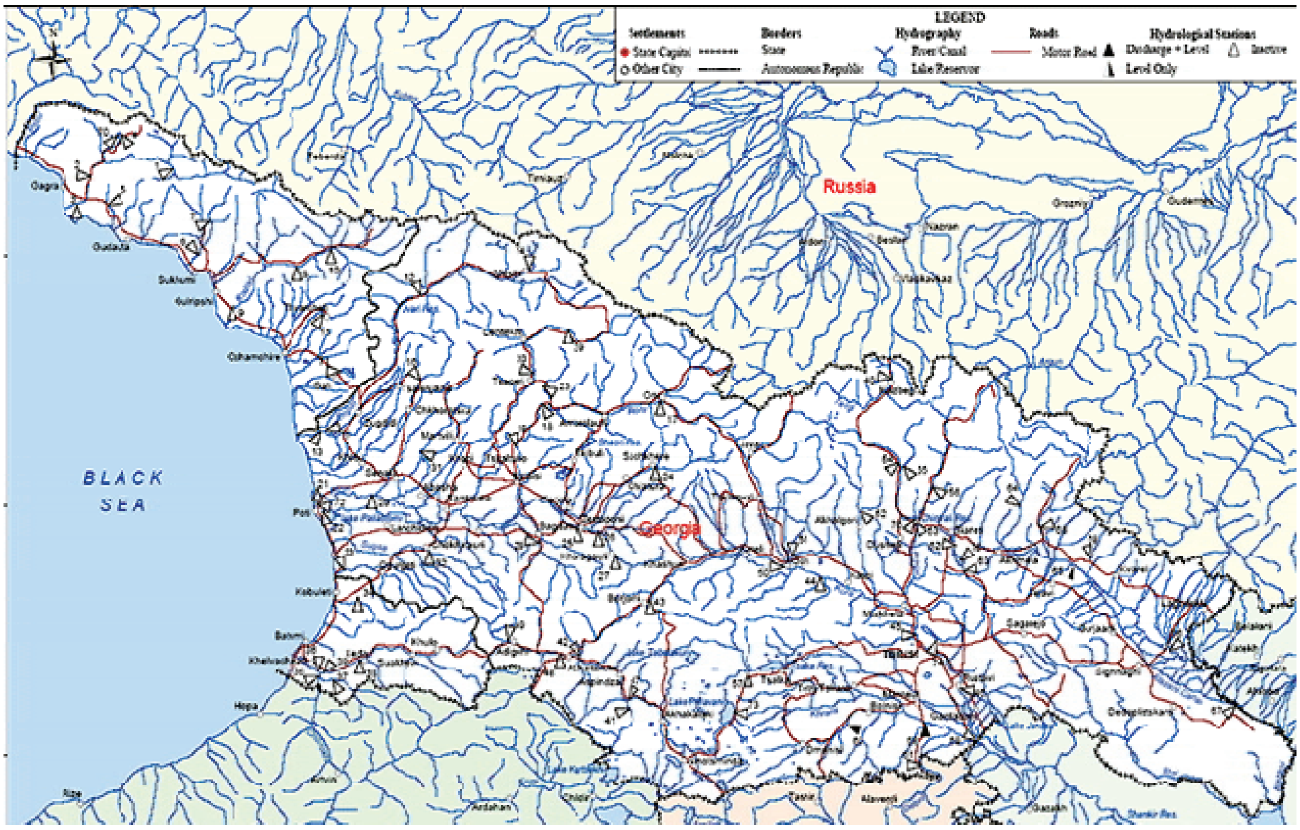


Figure 26. Hydrological station network in Georgia.



8.11.5 Technical support of meteorological and hydrological equipment

It is critical for all national applications and global use, that the meteorological and hydrological measuring and observation equipment and sensors are appropriate and properly calibrated, maintained, or replaced when needed. It is necessary e.g. that in cold climate regions e.g. ice-free sensors are used.

The capacity to provide support to the meteorological and hydrological equipment varies significantly from country to country. In general all countries have insufficient funds to properly maintain and develop the observation network.

Armenia: The NHMS has a Centre for Technical Support (Department). Calibration of meteorological equipment is done according to the WMO guide with adequate references and equipment.

Azerbaijan:

Georgia: Earlier existing maintenance and calibration system is fully disabled. The needed specialized laboratory (equipped with appropriate and reference devices) for this aim is absent. As a result the quality of initial materials, which are received from observational network, is low.

Kazakhstan: ?

Kyrgyzstan: In general the status of meteorological support is unsatisfactory. The internal data quality assurance service is very weak due to obsolete reference instruments and lack of qualified staff.

Tajikistan: NHMS has a Registration Certificate to calibrations of actinometric, wind, pressure and temperature sensors. Periodic calibrations are performed to its own gauges, and also to measuring devices owned by other institutions. Since 1992 the NHMS has not had the equipment and capacity to calibrate hydrological current meters.

Turkmenistan: The overall status of meteorological support is unsatisfactory. Almost no calibration and maintenance of meteorological instruments are performed due to lack of adequate reference equipment. No verification of reference instruments is performed. Verification and calibration of hydrometric current meters have not been performed for several years.

Uzbekistan: The NHMS has adequate calibration systems for most essential meteorological sensors. The new wind tunnel is adequate for calibration of standard cup anemometers, and partially also sonic anemometers.

8.12 Satellite data

Satellite data gives good information of location of fronts, cyclones and clouds. Availability of satellite images are very important for forecasters to be used in short term and long term weather predictions.

In Caucasian countries satellite information is received from NOAA, Russian Express AM1 (Armenia), Meteosat/EUMETSAT (Azerbaijan) and Meteosat/EUMETSAT, NOAA (Georgia). Recently also images from Chinese satellites became available. The NHMSs download imageries through HRPT and APT.

Kazhydromet has during the last years received satellite data receiving station and receives images through HRPT and HRTP data from the NOAA satellites.

Turkmenistan does not have equipment to directly receive satellite data, but it receives two NOAA-18 maps that are daily transmitted from Uzhydromet via a direct allocated channel Ashgabat-Tashkent. Images from NOAA-15 and 18 are three times a day emailed from Kazhydromet.

Most of the NHMSs need to upgrade the satellite data receiving equipment.

8.13 Collection and transmission of data and information

All NHMSs prefer to increase the number of automatic weather and hydrological stations, to increase use of remote sensing (radars, satellite data, etc.), to implement local area numerical weather forecasting models, to automate the analysing systems and to increase number of hydrometeorological services and products. All this will increase the amount of data flow and data, and will put big demands on communication and data management systems and capacity.

Uzbekistan as a regional hub for data communication has large and quite advanced communication systems. On the other hand e.g. Azerbaijan has not established a data Communication Centre.

In Tajikistan the Center of Automated Communication of the NHMS collects and disseminates hydrometeorological information through the facilities of the Ministry of Communications. Due to high costs of provider service, the three regional centers are cut off from web-based facilities and are therefore unable to get information from the central office. In general the data communication system in Tajikistan is obsolete and leads to big losses of data taken at the observation stations. Currently there is almost no qualified communication specialists at the NHMS.

In Kyrgyzstan the communication facilities and IT infrastructure are deteriorated and obsolete, and fail to ensure receipt and transmission of large data amounts required to produce modern information products. Information support technology is obsolete. The quantity of data transmissions has declined by 50-70% since the mid-1980s. Power supply facilities that include diesel generators, gas-powered units and alkaline accumulators, are obsolete and unable to ensure continuous power supply of the technological equipment, and even the minimum domestic power supply at highland stations.

In Turkmenistan the data communication is based on use of obsolete radio and telephone systems. Modernization of the MSC center is planned to be implemented under the Swiss Support to Asian Hydrometeorological Services in Central Asia program.

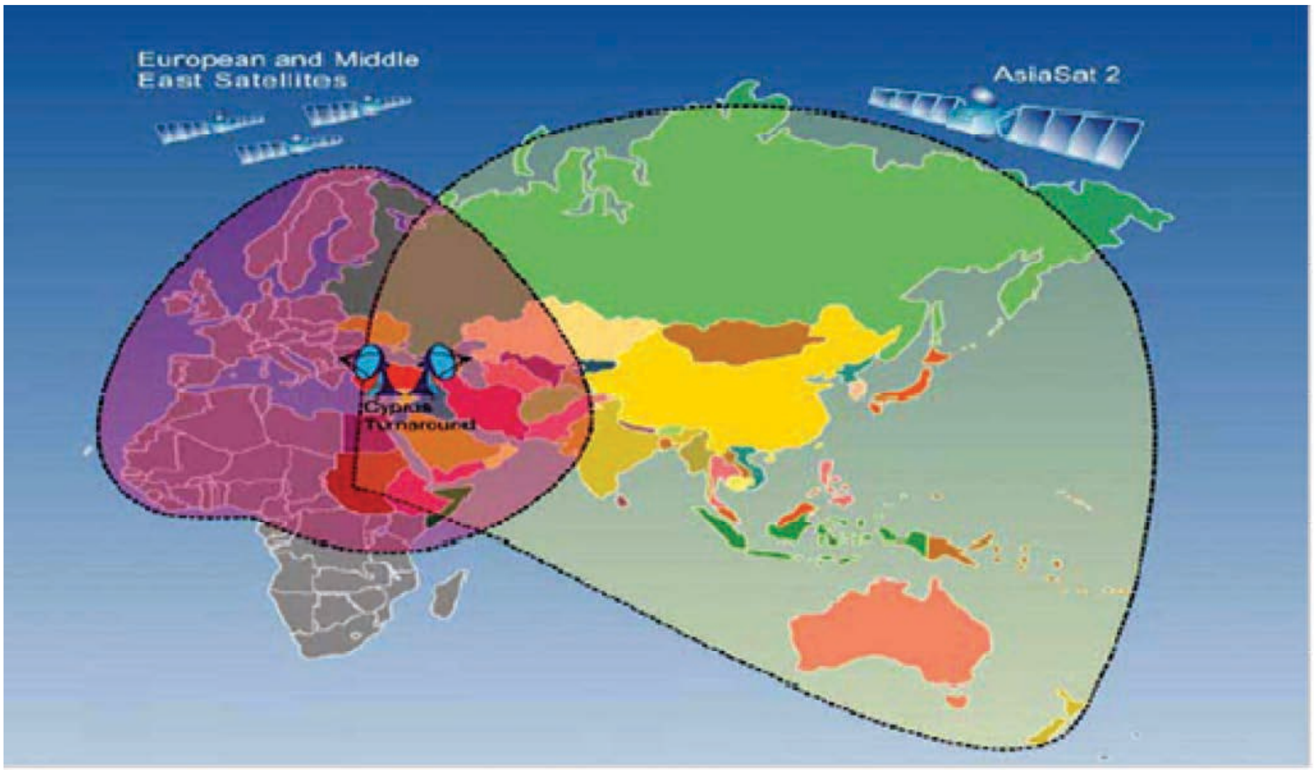
The message Switching Center (MSC) acts as the automated data collection and dissemination center. Computer setting and software vary.

8.14 Data management

Fluent data management and proper data base is the core of modern operation of NWPs and (automated) production and dissemination of products and services.

Today it also is critical to have the capacity to produce different types of analyses about different hydrological and meteorological parameters, and combined parameters, distributions and correlations, with a very short delivery time. This is very complicated to be implemented if most of the hydrological and meteorological information is stored only on paper or hard copies, as the case is in many of the developing countries. Digital climate databases[9] are essential for production of climate information, different climatological and applied studies and services, for research on climate variability and change, and for production of hazard maps for the DRR management. Storage of observation note books, or data on paper sheets etc. must not be called a database. However, too much of the different types of

Figure 27. Spatial coverage of EUMETCast and GEONETCast.



hydrological, meteorological, environmental and other data is still filed as paper sheets and are in very poor condition.

The CAC countries have quite long time series of hydrological and meteorological observations. Much of the data series are still in paper format, which makes it difficult to use long time series for different types of scientific analyses. New data is generally in digital format and stored as hourly or three hourly recordings. However, generally the data storages are not in a very user friendly format, and the computer capacity is very limited, which are an obstacle for production of long time statistics e.g. within couple of minutes or hours. The computing is generally solved by PCs of Pentium IV type. Actually data management is one of the crucial weaknesses of the CAC NHMSs.

CLICOM (CLImate COMputing) system is based on the WMO project initiated in 1985. The objective of the WMO project was to co-ordinate the implementation, maintenance and upgrading of automated Climate Database Management Systems (CDMSs) in WMO Member countries. One WMO CLICOM support area center is in Moscow. More information: http://www.wmo.ch/web/wcp/wcdmp/clicom/html/clicom31.html. CLICOM database system was donated to Armenian NHMSs by MeteoFrance.

CLICOM system has (or has had) some 100 members, mainly in the developing countries. More advanced NHMSs has typically their own data bases systems, often based on Oracle, which is a bit expensive to use due to the license costs.

8.15 Use of GIS format

Today it is critical for DRR hazard mapping, rescue management, community and land use planning, construction etc. that general climatological map information[10], numerical weather forecasts and other products are given out in GIS format. The system offers a comprehensive way to use map data in vector format and combine different types of maps produced by different sectors, institutes and companies. There are several software applications available to produce digital maps from adequate databases. However, for NHMSs it is vital to employ experts with geographical education in order to produce high quality map information, as it has been e.g. at FMI.

For different applications and products it is necessary that the countries have map data in digital format available. Some CAC countries have adequate maps, while some of the countries have just some small-scale maps available, or none.

In CAC countries Uzhydromet produces GIS based maps, while the others are at the stage of planning it.

8.16 Editing and visualization tools

Editing tools allow the forecaster to work on observations, change soundings and forecasts. Visualization actually covers a wide range of products from analyse and forecasting maps, and charts, to digital analysing and editing of NWP products and observations. E.g. tailored ready-to-print products can be produced and sent automatically to each newspaper, or disseminated on the NHMS web pages. Typically the modern NHMSs, and especially the private commercial forecasting offices, have a fully end-to-end automated production system. These NHMSs have also invested significantly in

[9] *A database consists of an organized collection of data for one or more uses, typically in digital form. Digital databases are managed using database management systems, which store database contents, allowing data creation and maintenance, and search and other access.*

[10] *See e.g. the Finnish Wind Atlas 2010 www.windatals.fi*

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Telecommunication service	yes		yes	yes	poor	yes		yes
- maintenance	yes		yes	yes				yes
- data collection	yes		yes	yes		yes		yes
- data dissemination	yes		yes	yes		yes		yes
- intranet	yes		yes					yes
- internet Kb/s	512/256	126	256	256	500Kb/day			1000
WMO GTS	"Moscow via Rostow"	Moscow	Moscow	"Moscow Tashkent"	"Moscow via Tashkent"	"Moscow via Tashkent"	"Moscow via Tashkent"	Moscow
- Kb/second			9.6	22.8/14.4				19-24
MSC				UniMAS		UniMAS	UniMASS	
Networking infrastructure	LAN, WAN	LAN	LAN	LAN etc.				LAN, WAN, VPN
Data communication								
- telephone	D, I, W	D, I, W		D, I, W		D, I	D	D, I, W
- mobile phone SMS	D	D	D, W	D, I, W		D, I		
- telefax		D, I, W						
- dedicated leased lines	D, I	D, I		D, I	D			D, I, W
- UHF radio		D		D, I	D	D, I		
- HF single sine band								D, I, W
- MF radio							D	
- VSAT		D, I						
- DCP								
- GTS	D, I	D, I	D, I	D, I, W				D, I
- MSG	D							
- other satellite systems			D	D, I				D
- Internet	D, I	D, I, W	I, W	D, I, W	D			D, I
- Email	D, I, W	D	I, W					I
- post/mail	D	D, I, W						
- print media	I, W	D, I, W	I					I
- TV-national	I, W	D	I					I
- TV-commercial	I, W	D, I, W	I					
- radio	I, W	D, I, W	I					I
- bulletins		D	I					I

D = receive/send data
I = send/receive information
W = send/receive warnings

Table 26. Communication facilities used by the NHMSs. D=to receive observations, data, information, products; I = to send observations, data, information, products, W = to receive or send warnings.

	CLICOM	Oracle	Ingres	P-SQL	My*SQL	MSACCESS	other	backup
Armenia	X				x			monthly
Azerbaijan							CLIPPER	occasional
Georgia						X		monthly
Kazakhstan		X			X	X	Excel	none
Kyrgyzstan							Disks	Disk
Tajikistan								
Turkmenistan							Paper	
Uzbekistan							FireBird	monthly

Table 27. Database systems used by various CAC NHMSs. Typically the data backup is in format of DVD and hard copy.

proper number of experts working with software development.

Modern technology is still poorly adopted by the CAC NHMSs and the products are produced manually or semi-manually, which is time and manpower consuming, and limits the number of products. In most of the NHMSs all routine operations are performed manually (data plotting, preparation and analysis of forecast charts, etc.). Forecasters cannot construct diagrams and profiles to specify the forecasts. There are no automated workstations that would permit data visualization or the processing and integration of satellite and other data to help the meteorologist prepare forecasts, except in Azerbaijan where TURKMETCAP system is implemented, and in Uzhydromet, who has developed its own visualization software to produce synoptic maps, tables and schemes.

8.17 Library

Even if internet, and possibilities of distance library services provide excellent possibilities to have access to international and national scientific articles and papers, libraries still have a vital role in providing possibilities to keep the scientific and technical level of the staff high.

The Armenian NHMS has own scientific central library.

In Turkmenistan almost no scientific and technical literature and hydrometeorological textbooks have been received in the recent 15 years.

8.18 Weather forecasting

8.18.1 Routine weather forecasts

In all the CAC countries the weather forecasting and issuing of warnings are operational on 24/7/365. The parameters/phenomena forecasted are air temperature and humidity at 2 m above ground, precipitation, wind speed and direction, atmospheric pressure, fog and solar radiation.

Modern forecasting technologies are non-existent at most of the CAC NMHSs. All NHMSs produce forecasts from short-range (24 hours) to medium range (2-5 days) for the countries in general and for a. limited number of cities.   The short-range and medium-range forecasts are issued and disseminated once a day, which is less than at the more advanced NHMSs. Some NHMSs also produce monthly outlooks (Table 29).

Own observations, observations from the WMO GTS, satellite images and numerical weather forecast products from advanced NHMSs are used for weather predictions. At most of the

CAC NMHSs all this information is available only as paper copies or as images through the internet. In CAC only Georgia has capacity to operate NWP models. The forecasts are issued mainly once a day (seeTable 30).

All NHMSs produce forecasts from short-range (24 hours) to medium range (2-5 days) for the countries in general and for a limited number of cities. The short-range and medium-range forecasts are issued and disseminated once a day, which is less than at the more advanced NHMSs. Kazhydromet also produces seasonal outlooks (Table 29)

8.18.2 Access to NWP products

Today weather forecasting produced by the advanced NHMSs is based on use of Numerical Weather Prediction Models, and use of remote sensing technology. In NWP models the atmosphere is divided into small grid cells. Distance between the cells, or grid points are the resolution of the model. The atmospheric equations are solved at each grid point. Higher resolution and shorter time steps mean higher accuracy in time and space. The boundary conditions are taken from large scale models. Smaller scale models are like looking at the larger scale model through a magnifying glass. Typically the mid-size and small meteorological services use global or regional NWP products (in digital format) produced by big and advanced NHMSs for mid-range (3-10 days) weather forecasts, and also for short-range forecasting if they do not have capacity to run any Local Area Models (LAM). The spatial and temporal resolutions of the global models are very low (25-50 km). Typical spatial resolution of Regional Scale Models is around 7-15 km.

Increase in spatial accuracy means more grid points and height levels, and in time shorter time steps, which all increases strongly the demands for computing power.

The general tendency e.g. in EUMETNET countries, based on needs from the public, customers and DRR management, is to use forecasts up to 10 days produced by the ECMWF global model (spatial resolution 16 km) and to start to run High Resolution Models with spatial resolution of 1-3 km and temporal resolution of some minutes. Use of high resolution models promotes the quality and accuracy (in time and space) of short-range (12-36 h) weather forecasts.

Production and operation of NWPs is based on international cooperation, as only few centers or NHMSs have capacity to produce and develop sophisticated large global scale NWP models. The largest NWP consortium in Europe is the HIRLAM (HIRLAM consortium) + ALADIN (France), all together 21 countries, which has produced the state-of-the-art HARMONIE model, typically run at 2-3 km resolution. MeteoFrance still has also its ALADIN model. Germany operates its own model (also used by some South East European Countries) and ECMWF has its own model.

Of the CAC countries only Georgia operates a LAM with 14 km spatial resolution, while the other countries only use NWP results produced

		Characteristics	Disc space	Security
Armenia	PC P-IV	3Ghz CPU	80 Gb	
Azerbaijan	10 PCs P-IV		80 Gb	
Georgia	PC P-IV	2 GHz CPU	12 Gb hard disk	AVEST antiv.
Kazakhstan	PC P-IV	2 GHz	80 Gb +	Cisco, AVP
Uzbekistan	server	Dual Core Inte l Xeon 5130; 1 Gb	2x160Gb	

Table 28. Some information of computer systems used for data management by the CAC NHMSs.

Figure 28. Linkage between different scale forecasting models and use of observation data. Advanced centers use data assimilation

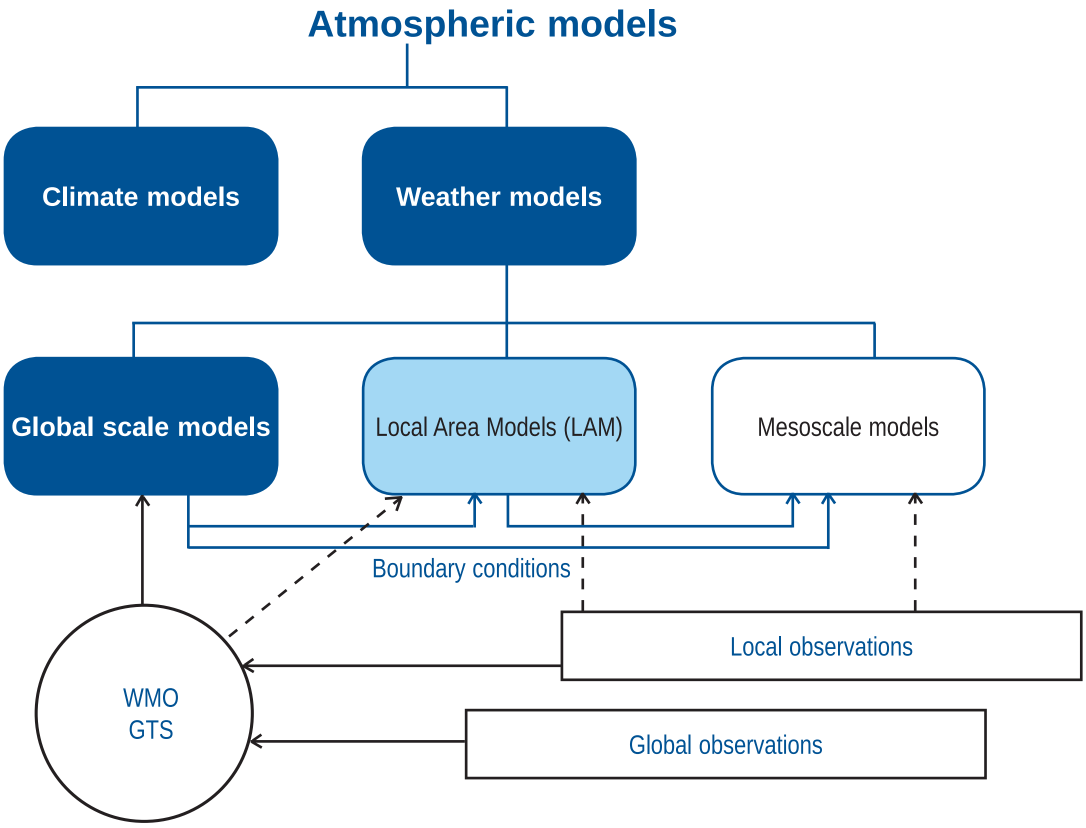
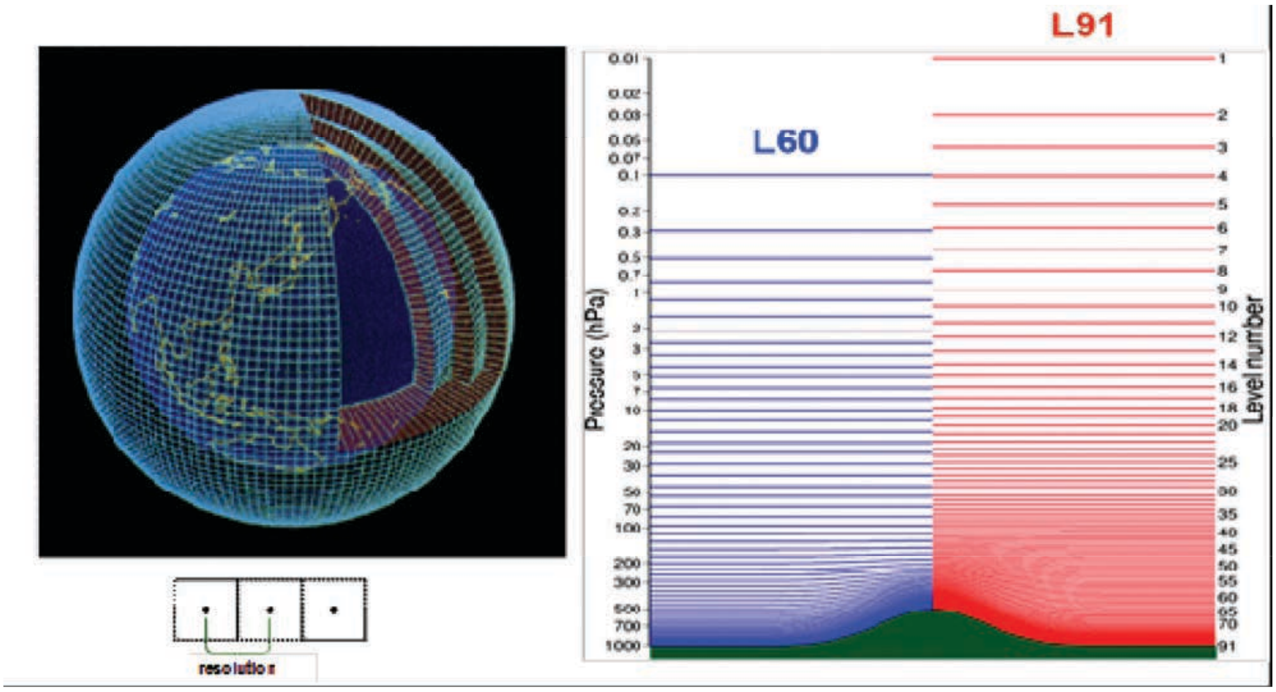


Figure 29.Schematic presentation of grids in NWPs (on right) and typical distribution of calculation altitudes (pressure in HPa) in case of model with 60 and 91 levels.



	Nowcasting			Short-range			Mid-range			Long-range			Seasonal			Climate			24/7	
	valid	issued	web	valid	issued	web	valid	issued	web	valid	issued	web	valid	issued	web	valid	issued	web	forecasters	NWP
Armenia	12 h	2/d	no	24 h	1/d	yes	5 d	1/d	no	1 m	1/m	no	no		no	no		no	yes	no
Accuracy %																				
Azerbaijan	3 h	1/d	no	24 h	1/d	no	2-3 d	1/d	no	1 m	1/m	no	no			no		no	yes	no
Accuracy %	93-94			92-93			90-92			60-70										
Georgia	12 h	1/d	yes	24-36h	1/d	yes	48-72h	1/d	yes	1 m	1/m	no				no		no	yes	yes
Accuracy %	88-90			86-88			83-85			65-70										
Kazakhstan	12 h		no		1/d	yes		1/d	yes	1 m	1/m	no	yes			yes		no	yes	no
Accuracy %	?			85-95			83-93			60-90										
Kyrgyzstan	no		no	24 h	1/d	yes	3 d	1/d	no	no		no	no		no	no		no	yes	no
Accuracy %				86			90													
Tajikistan	no		no	24 h	1/d	yes	3 d	1/d	yes							no		no	yes	no
Accuracy %																				
Turkmenistan	no		no	24 h	1/d		3 d	1/d	no	no		no	no		no	no		no	yes	no
Accuracy %				86			75													
Uzbekistan	12 h	1/d	yes	24 h	1/d	yes	2-5 d	1/d	yes	1 m	2/m	no	no		no	no		no	yes	no
Accuracy %	97			95			93			76										

Table 29. Routine weather forecast products of the centers; how long they are valid (h) and how often they are issued daily (/d), accuracy of forecasts (%) given by the NHMSs, and indication about whether the forecasts are available on the Web pages or not (Web.).

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Regional NWP models run	none	none	no	none	none	none	none	none
- boundary conditions from								
Local Area Models operated	none	none	Yes (which model)	none	none	none	none	none
- temporal resolution			1 hour					
- spatial resolution			14 km					
- frequency of LAM runs								
- data assimilation used	none	none	no					
- boundary conditions from			NCEP (USA),					
Mesoscale models	none	none	WRF, HRM	none	none	none	none	none
.- modelling used for			forecasting					
- temporal resolution								
- spatial resolution								
- boundary conditions from			DWD (Germany)					
Verification method of NWPs			?					

Table 30. Numerical weather prediction models in operational use and some of their properties in different countries.

by advanced international NHMSs. Armenia is planning to implement the High Resolution Model HRM from DWD (Germany) in the near future.

Most of the other CAC countries have access to NWP data produced by more advanced centers.

8.18.3 Special weather forecasts

All the CAC NHMSs, except Turkmenhydromet, produce also special (tailored) forecasts for different industrial sectors. Generally the special forecasts are charged from non-governmental customers according to fixed prices.

8.18.4 Accuracy of weather forecasts

The accuracy of routine forecasts is estimated by the CAC NHMSs to be very high, as seen in Error! Reference source not found.. (e.g. in comparison to the FMI products produced with most advanced forecasting systems; see Figure 30). The evaluation of the model products is performed according to the manuals produced by the NHMSs; e.g. Turkmenistan: "The Manual for weather Forecast services, Gidrometeoizdat, 1982". 1-day forecasts are verified for site and others for area.

Each NMHS expects the quality of short term weather services to improve further, if more real-time hydrometeorological and environmental data are available to the forecasters.

However, the accuracy of forecasting different parameters varies a lot. E.g. for Turkmenistan it was estimated (WB, 2009) that the accuracy is satisfactory only for air temperature and wind. Duration of hail and ground frost is not forecasted. Forecasting of precipitation is poor with respect to needs of flood warnings.

Due to lack of adequate hydrometeorological observations, regional and national on-line data, and adequate data management facilities, it is not possible to provide very accurate "nowcasting" and warning services for 0-12 hours of any hydrometeorological phenomena.

In general the end-users and DRR authorities consider the accuracy of forecasts unsatisfactory in time and space with respect to their needs.

8.19 Hydrological forecasts

The hydrological services in all CAC countries are greatly demanded, since most of the disasters in the region have hydrological origin. However, the information provided by the CAC NHMSs does not meet the current and increasing needs of end-users. There is a considerable need to promote services for water management and the hydroelectricity sector, and in particular to support the early warning systems for floods. It is also recommended to increase the number of automatic hydrological stations, to promote capability to produce numerical weather prediction-based forecasts for discharge. The necessity of strengthening regional and international cooperation is also highlighted.

In Turkmenistan the Hydrological Unit if the NHMS analyzes information obtained from hydrological stations and observation sites. Short- (5 days) and long term (month or more) forecasts of water flow and level of major rivers are produced by basic calculations, as numerical models are not available. Forecasts are sent to the Ministry of Water Management, but e.g. the agriculture sector and different design institutes are neglected.

8.20 Climate change

In principle the NHMSs are expected to monitor the climate and at least interpret the results from global climate models on the local level to the government. It is also vital to produce local scale analyses and projections for single parameters (temperature, precipitation) but also to study combined parameters like evaporation, runoff, wind energy, etc.

Currently the CAC NHMSs do not have resources and capacity to run large scale climate models, but Azerbaijan and Georgia receive, analyse and interpret projections produced by international or regional climate centers like ECMWF, Hadley Centre, Max Planck Institute, IRI, ICTP and RosHydromet. However, the NHMSs have capacity to run Regional Scale Climate Models: Armenia MAGICC/SCHENGEN, Azerbaijan PRECIS and Georgia PRECIS&RegCM. For own modelling reanalysis the NHMSs use different data sets: Armenia PRECIS/Hadley Centre, Azerbaijan ECHAM4/Max Planck Institute, Georgia ERA40/ECMWF, NNRP/NCEP, ECHAM4, CRU, PRECIS/Hadley Centre.

Obviously no real studies on impact of climate change upon various socio-economic sectors have been done, and on the other hand research capacity and implementation of downscaling from global scale models to regional or local scale is very limited in the Caucasian region.

It would be profitable to run some joint projects on impacts of climate change among the Caucasian NHMSs in cooperation with some EU centers (see: the Nordic Climate and Energy project).

8.21 Climate monitoring

The NHMSs typically provide review of climate conditions of previous month and year. The climate monitoring information is provided to ministries, some economic sectors and to the media via e-mail, fax and post.

In order to improve climate monitoring products it would be vital to have improvements in data management, software and visualization.

8.22 Dissemination of weather forecasts and other products

Big part of the value of the weather forecasts and warnings depend on how rapidly and in which format the information is disseminated, how well they receive the target groups, and how well the given information can be understood and used by the receivers. Developed NHMSs in industrial countries have during the last years invested especially in dissemination of information and automated on-line delivery of individually tailored products to each customer.

The weather forecasts are provided to government, local authorities, and mass media, public and private organizations (on the contract basis).

Currently all the forecasting products are produced and disseminated manually.

Most of the NHMSs disseminate forecasts and information through their web pages. The weather forecasts are not the main topic on the pages, the given information and types of forecasts is limited, and they are very attractively presented, in comparison with any forecast freely available on internet and provided by different international actors. Currently dissemination through internet does not meet very big part of the population or organizations.

Due to lack of good data management and automated analyzing and production systems the number and variety of daily products is very low. (The number of daily of FMI is around one million, can be given in several languages, and is based on fully automated analyzing, production and dissemination system)

8.23 Research and development

R&D is typically not the main branch in the NHMSs in general (e.g. FMI is a significant exception), and not either in the CAC countries. However, strong investment in R&D is required especially when R&D is highlighted as a task for the NHMSs given by the government, or commercial activities are important part of the strategy of the NHMSs.

In the CAC countries only Armenian and Kazakhstanian NHMSs and Uzhydromet carries

Armenia	GFS (USA), JMA (Japan), ECMWF (EU), GME (Germany), GEM (Canada), NOGAPS (US Navy), UKMO (UK) and GFCX.
Azerbaijan	ECMWF trough GTS WMO, outputs from MM5 from Turkish met. service.
Georgia	GFS (UAS), GME (Germany)
Kazakhstan	None
Kyrgyzstan	ECMWF (EU), GFS (USA), ? (Russia)
Tajikistan	Different products via MSC from Russia and Uzbekistan
Turkmenistan	None
Uzbekistan	ECMWF (+168 h), NOAA (+120h)

Table 31. NWP products available and used by different CAC NHMSs.

	Armenia	Azerbaijan	Georgia	Kazakhstan	Uzbekistan
Agriculture	5d				
daily	24h				
daily	72h, daily	1 month			
1/month	12h-1 m				
17d-2/m					
Transport	5 d				
daily	24h				
daily	3-72h daily	24h			
daily	12-72h daily				
Water trans.	5 d				
daily	24h				
daily	72h. daily	up to 5d			
daily	varies				
Aviation			3-24h, daily		ICAO standards
Energy	5d				
daily	24h				
daily	72h, daily	24-72h			
daily	12 h-1 m				
1/d-2/m					
Construct.		24h			
daily			12-72h		
daily					
Tourism					12h-5 d
daily					
Health					

Table 32. Special forecasts provided to different socio-economic sectors. Also special warnings are produced to these sectors.

actively limited research activities. The scientific level of the R&D is quite low.

In general the number of staff with adequate level of academic education, experience in high level scientific research or with proper international networks is very low in the CAC countries. There are no regional R&D projects and no regional R&D funding, like in e.g. the Nordic countries and EU. The CAC NHMSs have poorly exploited the possibilities to participate in international research projects, in general, and in respect to some other CAC institutions.

Research topics and properly financed international network projects related to burning issues like impacts of climate change, renewable energy sources, remote sensing, early warning systems, climate and weather modelling could be attractive to young academic people.

8.24 Cooperation with customers and end-users

The main customers for the NHMSs are the ministries and generally the public sector. In Kazakhstan and Kyrgyzstan the aviation weather sector is separated from the NHMS, and cooperation between the NHMSs and the aviation sector is at very low level. In Western European countries aviation weather services are typically operated by the NHMSs, and these services also creates significant share of the annual revenues of the NHMSs.

The NHMSs have some information services at user request. The number and quantity of the contracts are controlled by the Ministries. The rates of the services are not counted as commercial services. The current situation not only discourages the NHMSs to expand the system of user services and to invest in training of the staff to better understand the market place and to implement new technology and software.

In general the NHMSs have a clear understanding that in order to make investments into the NHMS sustainability it is necessary to increase (commercial) cooperation with the industry, and better take into account the needs from the end-users.

In 2006 the first survey of user needs was conducted in Tajikistan by Swiss support. World Bank has recently made feasibility studies in some of the CAC countries, with assessment of the major customer needs. However, in general the customer and end-user needs are finally quite poorly assessed by the CAC NHMSs.

Currently, according to the visits to many of the customers or potential customers during the missions, indicated that generally many of governmental organizations and especially the private sector are not satisfied with amount and quality of the services provided and more accurate and tailored services are requested. Also the level of cooperation and communication is considered to be quite low. Inadequate interaction with customers (including media) and end-users prevents the NHMSs from taking into account the current and future needs of target groups in their activities and development planning. The major needs can be summarized as follows:

- better and more reliable hydrometeorological data and climatological overviews at their region;
- more accurate and timely weather forecasts from nowcasting to longer periods;
- faster response and shorter delivery times;
- tailored products and services based on specified needs of the customers;
- use of state-of-the-art models and software;
- better communication and cooperation;
- better use of internet with improved layout and graphics, and more weather information;
- more pro-activity from the NHMS side.

On the other hand many of the customers consider it very difficult for the NHMSs to produce e.g. added value to forecasts available freely on internet with their current policy, observation network, forecasting methods and financing. However, as the customers are not aware of the possibilities which a modern NHMS could have to provide much better and more customer specific products.

For the CAC NHMSs it is critical to be proactive in enhancing their dialogue and cooperation with the industry, aviation sector and authorities, and in increasing their visibility to the public through media and the internet, in order to create better basis for sustainable strengthening of NHMSs. It is critical that the observation network is not only designed to promote climatological and forecasting purposes, but also according to needs of the industry and other economic sectors.

8.25 Visibility and cooperation with the media

Weather forecasts are produced (manually or mainly manually) for newspapers, radio and TV, which the manufacture their own presentations. Currently the level of innovative cooperation with the media is quite low, the number of articles produced in the newspapers by the NHMS staff could be much higher, and there is need to organize annual training and information sessions to the media.

In some of the countries the visibility has recently improved due to regular TV weather forecasts and presentations. However in many of the countries some TV channels broadcast weather forecasts taken from the internet.

Most of the CAC NHMSs have their own internet web sites, but currently the content and quality is poor and does not attract many visitors (even if the number of visitors is not automatically counted).

For some reason it seems that there is a tradition that the directors of many of the CAC NHMSs appear on the TV once or twice a year. This might be a bit formal. As a reference to Finland, where the Director of FMI, and other directors and experts are interviewed quite often on TV, governmental and private radio broadcastings and by the press related to various active topics and issues, and the experts also participate in different types of TV and radio discussions. The FMI also provides twice a year an invitational information day (seminar) to the media.

Anyway, as the NHMSs are non-profit organizations with quite low level of ambition to promote their commercial activities and dissemination of information to the public and the industry, the importance of visibility to development of the NHMSs is not recognized at the same level than in many European countries.

8.26 Internet

Internet is a very powerful tool to disseminate information to authorities and the public, and to foreign visitors. E.g. in Finland the FMI home page is most frequently visited after the biggest newspapers, and the number of daily individual visitors may reach to 5 % of the population of Finland. On the other hand it must be noted that internet pages of the NHMSs are not a method of direct dissemination of warnings (e.g. use of METEOALARM system), but a source of further information.

The NHMSs from Armenia and Georgia have home pages on the internet, but the amount of information, the quality and layout of information and number of visitors is low. The pages are not updated very often or frequently, except for the weather forecasts. The design and layout of the pages do not look very professional and interesting according to this day's standards, and the forecasts are given in a text format or in very simple graphic format Currently Azerbaijan NHMS does not have own web pages in operation. However, the hydrometeorological services and observation networks are presented

Figure 30. An example of development of the accuracy (in %) of temperature (2 m) and precipitation forecasts provided by the FMI. (+24 h = D+1; +48=D+2)

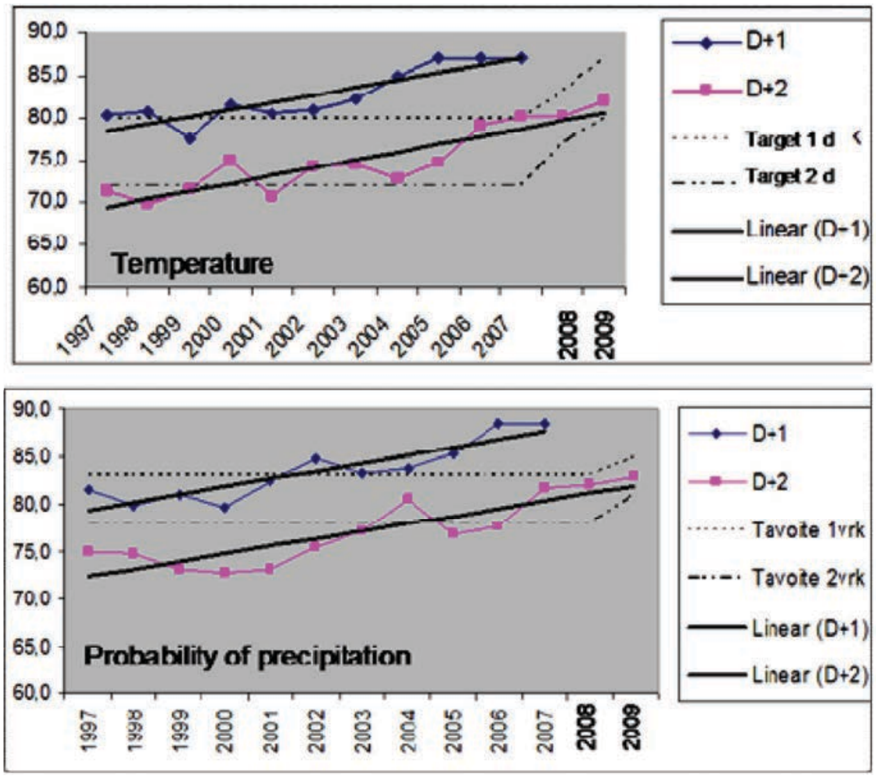


Figure 31. Homepage of the Armenian State Hydrometeorological and Monitoring Service. Weather forecasts are shown in the bar on left as a secondary item.

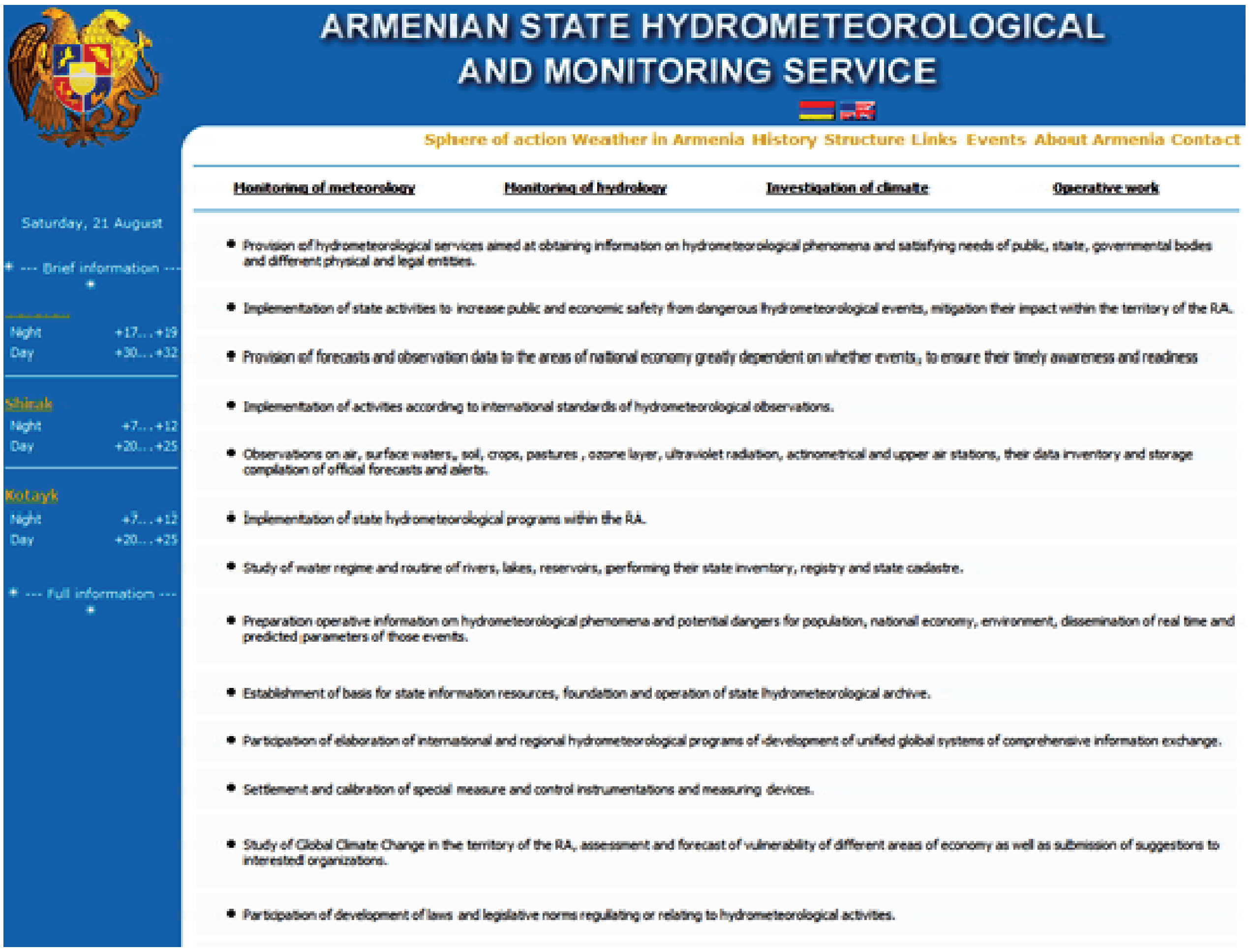


Figure 32. Homepage of the Kazhydromet. Local weather forecasts for selected cities/towns can be reached by pointing the map. Storm warnings have an own button. Several pages available, however, with quite few weather and climate information.

Figure 33. Homepage of the Main Hydrometeorological Administration of Kyrgyzstan. Forecasting text format for regions can be received by clicking the region. Warnings are easily found. On weekends and holidays weather information is not updated.

Figure 34. Homepage of the Uzhydromet. Warnings are found under the forecasts. A still photo from the NOAA AVHRR satellite is shown, but no radar images are shown.

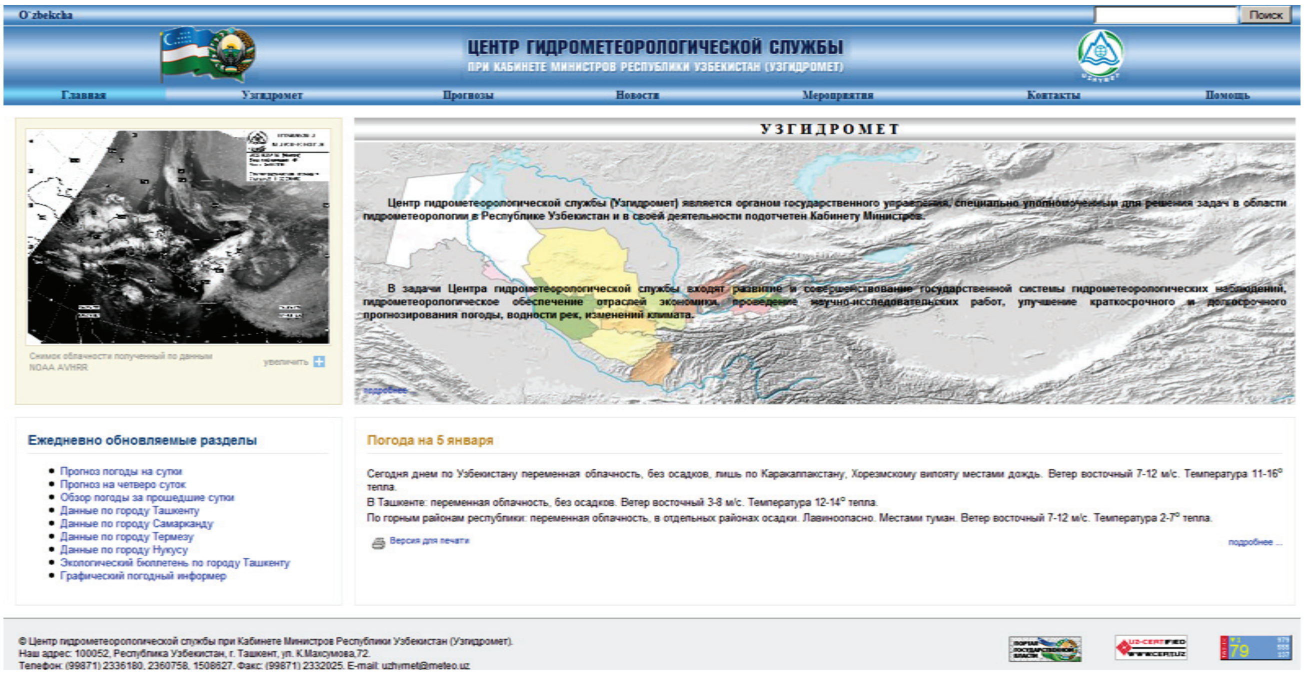


Figure 35. Homepage www.fmi.fi of the Finnish Meteorological Institute (FMI). Local weather forecasts can be received after giving the name of the city or town. Warnings are easy to find, and there is also a link to European Meteoalarm pages. The FMI pages include a significant amount of basic information about weather and climate, research topics, ongoing and past EU research projects, etc. The FMI pages will be modernized in 2010.

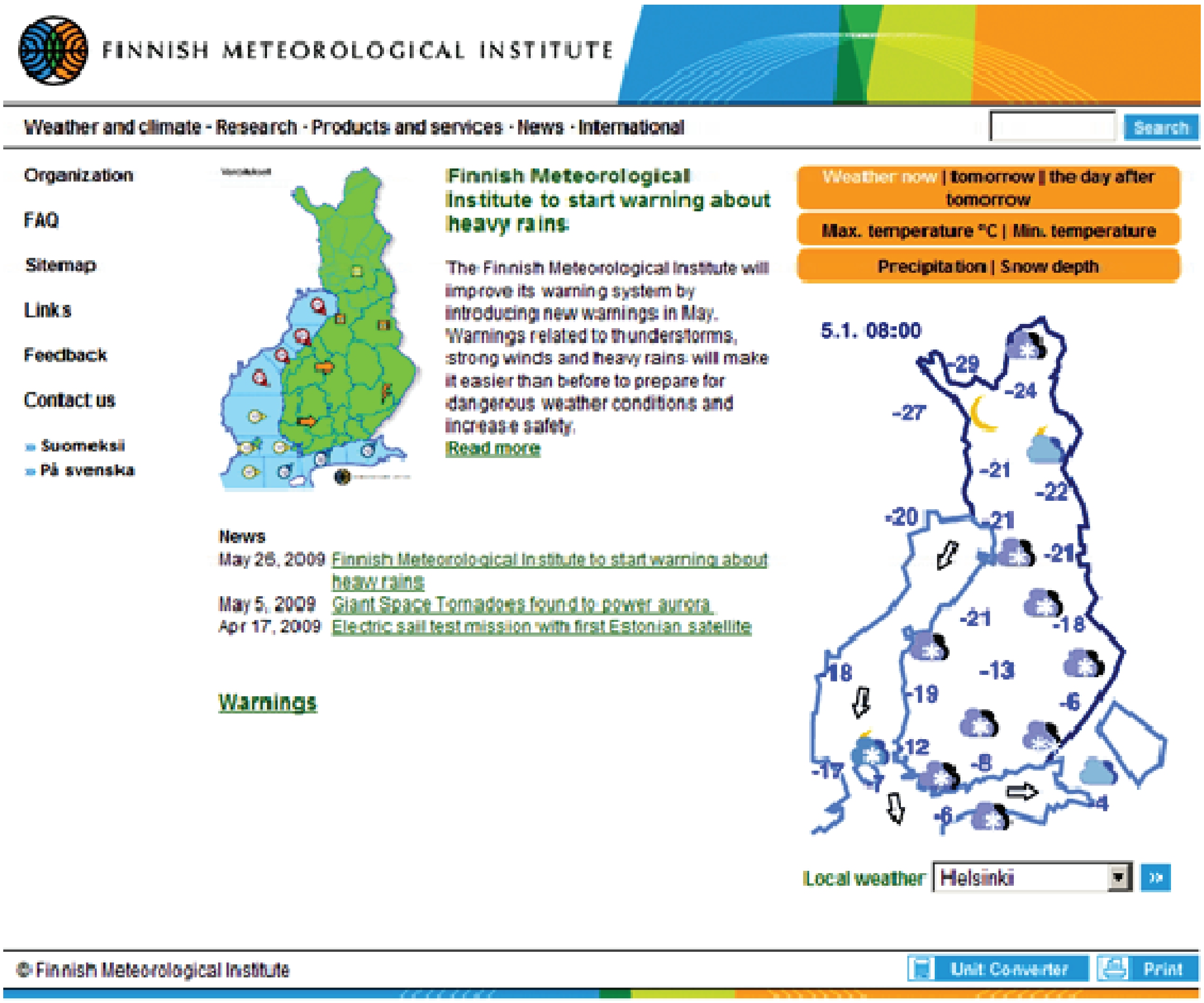


Figure 36. An example of the homepage of the private Finnish meteorological services provider FORECA, which gives forecasts not also for Finland but also globally, presents weather radar and satellite image animations, and provides special weather services (partially in cooperation with industrial partners) with a total staff of about 35 persons.

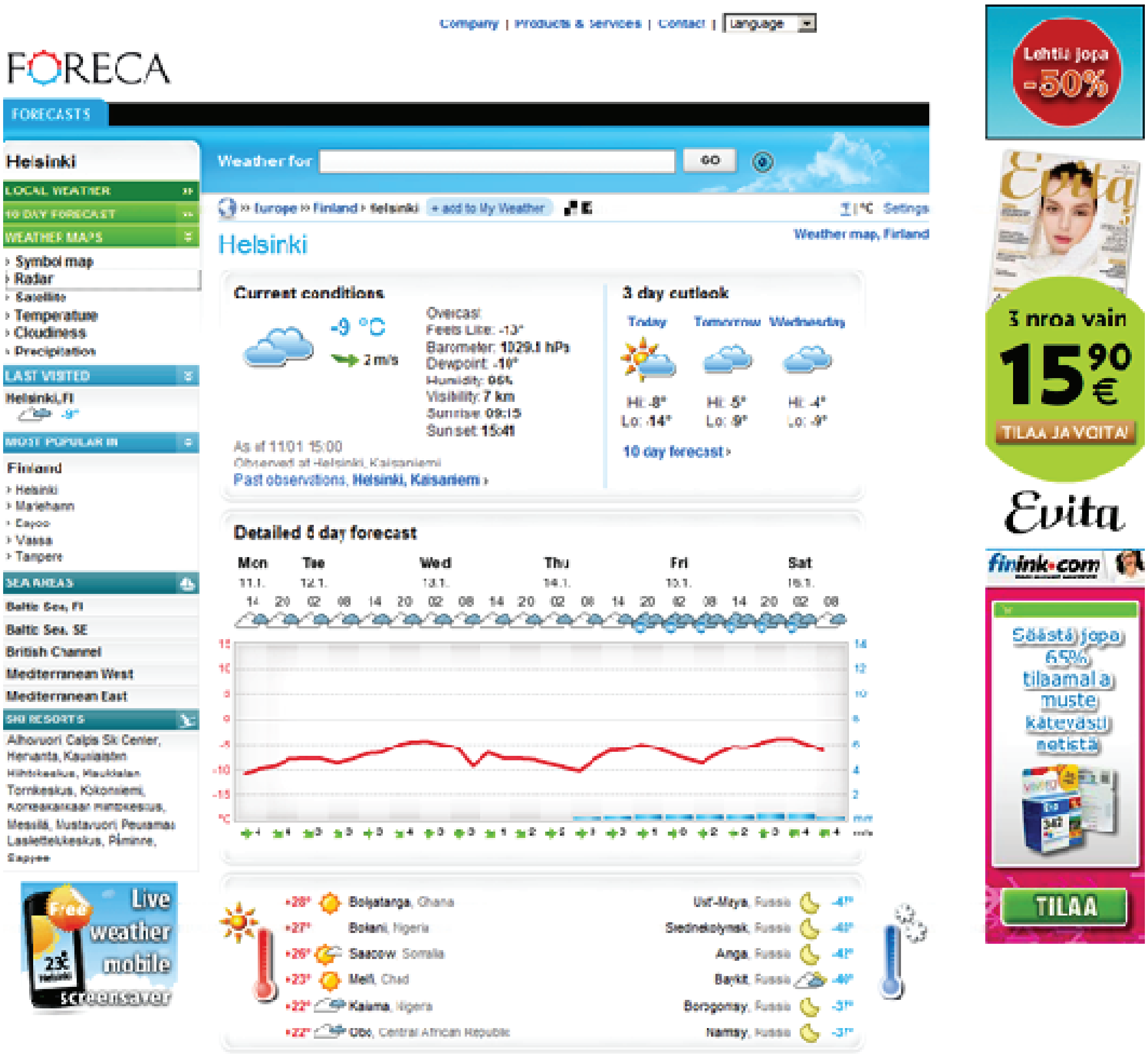
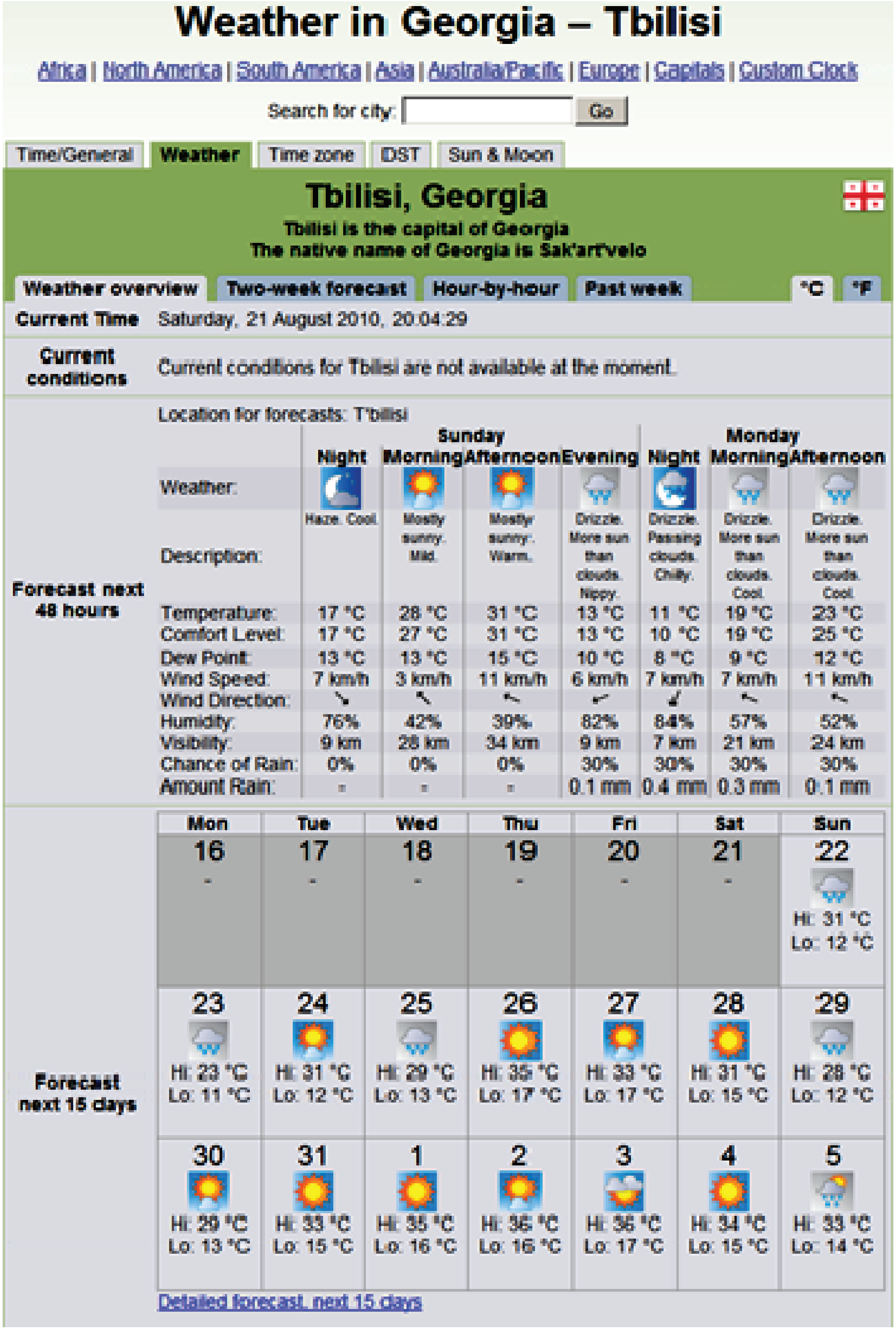


Figure 37. An example of a random search in internet "weather Tbilisi": http://www.timeanddate.com/weather/georgia/tbilisi



Weather in Georgia – Tbilisi

Africa | North America | South America | Asia | Australia/Pacific | Europe | Capitals | Custom Clock

Search for city: [ ] Go

Time/General | **Weather** | Time zone | DST | Sun & Moon

Tbilisi, Georgia

Tbilisi is the capital of Georgia
The native name of Georgia is Sak'art'velo

Weather overview | Two-week forecast | Hour-by-hour | Past week | °C | °F

Current Time	Saturday, 21 August 2010, 20:04:29
Current conditions	Current conditions for Tbilisi are not available at the moment.

Forecast next 48 hours

Location for forecasts: T'bilisi

		Sunday				Monday	
	Night	Morning	Afternoon	Evening	Night	Morning	Afternoon
Weather:							
Description:	Haze. Cool.	Mostly sunny. Mild.	Mostly sunny. Warm.	Drizzle. More sun than clouds. Nippy.	Drizzle. Passing clouds. Chilly.	Drizzle. More sun than clouds. Cool.	Drizzle. More sun than clouds. Cool.
Temperature:	17 °C	28 °C	31 °C	13 °C	11 °C	19 °C	23 °C
Comfort Level:	17 °C	27 °C	31 °C	13 °C	10 °C	19 °C	25 °C
Dew Point:	13 °C	13 °C	15 °C	10 °C	8 °C	9 °C	12 °C
Wind Speed:	7 km/h	3 km/h	11 km/h	6 km/h	7 km/h	7 km/h	11 km/h
Wind Direction:	↘	↖	↖	↙	↙	↖	↖
Humidity:	76%	42%	39%	82%	84%	57%	52%
Visibility:	9 km	28 km	34 km	9 km	7 km	21 km	24 km
Chance of Rain:	0%	0%	0%	30%	30%	30%	30%
Amount Rain:	-	-	-	0.1 mm	0.4 mm	0.3 mm	0.1 mm

Forecast next 15 days

Mon	Tue	Wed	Thu	Fri	Sat	Sun
16 -	17 -	18 -	19 -	20 -	21 -	22 Hi: 31 °C Lo: 12 °C
23 Hi: 23 °C Lo: 11 °C	24 Hi: 31 °C Lo: 12 °C	25 Hi: 29 °C Lo: 13 °C	26 Hi: 35 °C Lo: 17 °C	27 Hi: 33 °C Lo: 17 °C	28 Hi: 31 °C Lo: 15 °C	29 Hi: 28 °C Lo: 12 °C
30 Hi: 29 °C Lo: 13 °C	31 Hi: 33 °C Lo: 15 °C	1 Hi: 35 °C Lo: 16 °C	2 Hi: 36 °C Lo: 16 °C	3 Hi: 36 °C Lo: 17 °C	4 Hi: 34 °C Lo: 15 °C	5 Hi: 33 °C Lo: 14 °C

Detailed forecast, next 15 days

on the web pages of the Ministry of Ecology and Natural Resources.

Looking for weather information in the capitals of the Caucasian countries on internet, the customer is guided to homepages of international forecast providers.

Currently the CAC NHMSs do not have appropriate data management system and software to manufacture automatic products (graphs, radar composite images, real time data, etc.) for their internet pages. Also the amount of staff responsible for the pages, and working time used to update the pages, are limited.

8.27 Data sharing

The regional and sub-regional data sharing is very much limited to dissemination of data from low number of stations to the WMO GTS for international use. According to most of the NHMSs there is urgent need to especially increase the change of hydrological data from the river basins and the mountains among the CAC NHMSs.

On national level the data collected by the NHMSs are poorly shared with aviation weather services in the countries which have separate organization for aviation weather service, other organizations and end-users, and sometimes even within the NHMS between the units.

8.28 Regional cooperation

Hydrology and meteorology are highly international branches, which cannot survive without international cooperation.

Currently the regional cooperation between the NHMSs is in CAC at much lower level than in e.g. the Nordic countries or in EU, where international cooperation and networking have a very high priority.

The number of joint research and development projects is low.

It is important to participate in work of international and regional organizations, and participate in international workshops on the top level. However, for new innovation and motivation, and for sustainable development of the NHMSs, it is critical that the experts are given the possibility to participate in international activities and establish networks.

Currently the CAC NHMSs have been given very little financial resources for regional or international cooperation.

8.29 Certification

In order to provide weather services to the aviation sector the provider has to be certified by an authorised body. In near future especially the aviation weather service sector will face big changes as the market is opened to competition and tendering.

The NHMS tend to apply more and more for international certificates (ISO) for the whole organization or/and for different activities, depending on their quality and management systems.

In 2005 Republican State Enterprise Kazhydromet has been registered achieved the ISO 9001:2000 standard for quality management.

8.30 Summary of the major gaps

Resent reviews of observational networks, service provision, staff and organizational structures of NHMSs, together with assessments of end-user needs of hydrometeorological data and products, also show that the current condition of the NHMSs fails to meet the needs that could be expected by the governments, the weather and climate sensitive social and economic sectors, and the citizens.

The main gaps in the capacity of the eight CAC NHMSs can be put within ten categories:

1. lack of ambitious vision and good strategy;
2. sparse, deteriorating hydrological and meteorological observation networks, lack of remote sensing systems and non-satisfactory regional data sharing;
3. weak communication systems for collection of data and dissemination of the products;
4. deficient data management and numerical modelling capacity;
5. lack of skills in English language which limits the capability to use internet;
6. low financing and poor cooperation with industry and end-users;
7. low financing and poor cooperation with industry and end-users;
8. skills and training of staff not adequate to meet modern requirements;
9. lack of regional and international cooperation at mid management and expert level;
10. organization and management system from the old school.

The NHMSs recognize many of their gaps. However, there are several obstacles to hinder fast development of the CAC NHMSs. there is lack of a clear vision, what the NHMSs should and could be, and lack of strategy how to proceed.

The current level of financing is undersized; the financing is adequate with respect to the current salary level of the staff, but with respect to prices of monitoring equipment, automatic weather stations, remote sensing systems, information and communication technology and licenses of PC and other software, which all needs to be imported, the financing is far below the required. The current very low financing of the NHMSs do not allow sudden, if any, improvements in their capacity and capability to change their conditions and to significantly improve their services.

Due to low salary level available for the staff, it is difficult to employ especially new capable technical and ICT persons. In general the hydrometeorological sector and the NHMSs are not considered to be able to provide very tempting or modern jobs.

The prices of modern equipment are mainly result from the fact that the companies are in industrialized countries, or the price level is pretty much adjusted to their market. With respect to the GDP and GDP (PPP) it can be seen that in practice the same equipment is 10-20 times more expensive to the Caucasian countries than to the EUMETNET countries, relatively speaking.

There are lots of international funding available for research e.g. in environmental, energy, traffic and climate change sectors, which actually are sectors into which the work of hydrometeorological services is very much related. However, awareness of different funds and the capability to arise financing is at very low level at the NHMSs.

8.31 SWOT

Analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) is a tool for auditing an organization and its environment. It is a useful tool for understanding and decision making for all sorts of organizations and activities. It is the first stage of planning and helps the organization to focus on key issues, and helps to build a road map to achieve the vision and objectives. SWOT analysis can be used for the whole organization or for its units (departments etc.). Typically the SWOT analyses would be done in close cooperation between a qualified consultant and the organization.

Climate change and increased number of natural hazards are considered as threats on global and national level. However, climate change also provides opportunities on national and individual level, and there will be many countries that will significantly benefit from it. Or at least the damages can be mitigated, especially if there is enough climatological information to smoothly, and smartly, to adapt at to the change.

Currently there are much more weaknesses than strengths, but on the other hand there are currently many opportunities which could support the national (government, industry, citizens) acceptance of investing in modernization of the NHMSs

	International organizations	NHMSs
Armenia	WMO, RAII, Hadley Centre,	MeteoFrance, DWD, UKMO, Roshydromet, Hydrometeorological Department of Georgia,
Azerbaijan	WMO, ICH CIS, CASP COM	
Georgia	WMO, ICH CIS, IPCC, IRI, ICPT	
Kazakhstan	WMO, RAII, RAVI, ICH CIS, CASPCOM, IOC, UNESCO	
Kyrgyzstan	WMO, RAII	Uzhydromet
Tajikistan	WMO, RAII	Uzhydromet
Turkmenistan	WMO, RAII	Turkish NHMS
Uzbekistan	WMO, RAII, UNFCCC, UNCCD, IPCC, RHC IFAC	

Table 33. International organizations and NHMSs with which the CAC NHMSs have close cooperation.

Figure 38. Hydro meteorological services and their products presented on the web pages of the Ministry of Ecology and Natural Resources of Azerbaijan Republic.

Figure 39. Homepage of the State Administration for Hydrometeorology if Tajikistan. Pages are in Russian and in English. Forecasts in written format, no maps, graphs or statistics. Very little information about weather and climate. Old information about few projects.

Figure 40. An example of the FMI information delivery: Finnish Wind Atlas. It contains of several static pages with maps and text about wind energy and wind energy meteorology, but also dynamic interactive maps where information of wind speed (m/s), wind energy (MWh) and other parameters can be found in 2,5x2,5 km2 grid at several heights above the ground over the whole country. www.tuuliatlas.fi; www.windatlas.fi

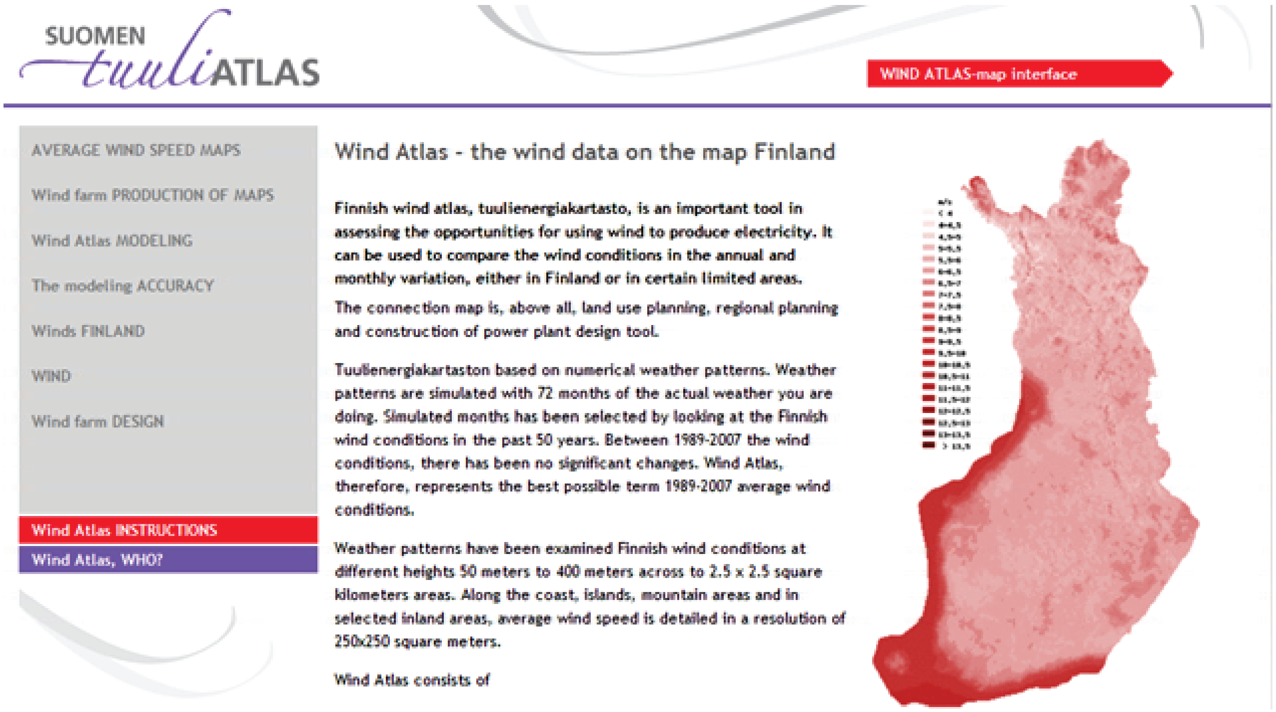


Figure 41. Summarized SWOT analysis for the CA NHMSs

	Helpful *to achieve the objective*	***Harmful*** *to achieve the objective*
Internal origin *attributes of the organization*	**Strengths** • devoted staff • knowledge in hydromet sciences • monopoly in hydromet services • long-time cooperation with RossHydromet	**Weaknesses** • lack of vision • obsolete observation network • lack of modern observation and production tools • lack of cooperatino and partnerships with industry • outdated and byrocratic organization • English poorly known and used • low visibility • low governmentat financing (varies) • monopoly in hydromet services
External origin *attributes of the environment*	**Opportunities** • Climate Change • addition of number of natural hazards • economic growth • incresing understanding of the value of hydroomet data and services by industry • international cooperation • WMO, UN-ISDR	**Threats** • sustainable financial backing ? • donors and international partners will withdraw due to global economic crisis • loss of key staff and IT staff due to low salary level, attractiveness etc. • aviation sector ? • international or private companies

9 COARSE DEVELOPMENT PLAN

In order to promote the capacity of the NHMSs to provide better services early warning services to support the national development, DRR and achievement of the MDGs, it is necessary to provide the CAC NHMSs with state-of-the-art equipment, instruments, and human resources and to quarantine adequate governmental financing to promote sustainable development of the NHMSs.

The long-term or medium-term objective for each NHMS must be to have a modern, cost-effective and scientifically qualified Service, with an automated end-to-end observation and production system, which satisfies the needs of the national communities concerning human safety, wellbeing and sustainable economic development.

The development and investment needs are big, if the objective is to modernize the CAC NHMSs to the current level of NHMSs in the Western Europe (EUMETNET members) in a short time. The question is not only about investments needed into technical equipment, but also in training of current staff and into recruitment of capable IT staff and technicians.

It is important to choose right steps to modernize the NHMSs, as obviously everything cannot be done at once due to lack of sufficient financing, human resources, technical facilities and premises. On the other hand there are possibilities to aim to next generation technology, without following the similar path of development that the European NHMSs has gone.

The objective needs be to produce prepare a State level strategy for provision of hydro-meteorological and environmental (air and water quality) services, and development plan for 10 years, and an investment plan to the NHMSs for 3-5 years, which would still produce critical added value to services provided for emergency management, public safety, and weather sensitive sectors. The approach needs to be customer based rather than "modernization-for-modernization" based. The main customer for a NHMS is the government. It equally important to fulfil the international obligations agreed between the government and the UN-WMO.

However, the impact of the investments to the community depends how the products and services are disseminated and used.

At this stage it is critical to focus on hydrometeorological services, which means that some major sectors of the activities of the NHMS, like air quality and water quality, are not taken into account directly. However, improvements in observation network and modelling will promote these sectors too. It is necessary to build the modernization plan on what can be sustained by each NHMS, especially taking into account the difficulties to have all the experts which are required to confirm operation of the investments and production of improved services.

Priorities

The urgent needs vary from country to country but generally and regionally the priorities could be:

- To invest in training of the top and mid-management, key experts and specialists to increase awareness about managing, operation, technical possibilities and cooperation with customers in a modern Hydrometeorological Service;
- Concerning investments in modern technology the highest priority has to be given to actions which significantly will improve the capacity to collect efficiently data from the observation network and process information from leading international hydrometeorological centres in order to produce timely weather and hydrological forecasts (longer lead time) for the disaster managements nationally and regionally;

- Secondly to improve forecasting of weather and hydrological phenomena, and production and dissemination services to most important (share of GDP, volume of preventable losses) weather sensitive economic sectors;
- Thirdly to fulfil the international obligations concerning data sharing;
- Fourthly to establish data bases with long time data from representative weather stations and hydrological stations in order to improve planning and risk assessment within different economic sectors (energy, construction, transportation, agriculture,…) it is critical;
- Fifthly to promote the lure and image of NHMS as an internationally, nationally and scientifically recognized employer, operating with highly burning issues and providing possibilities to international cooperation;
- And finally to plan and implement a long-term modernization plan to reach the technical and scientific level of more advanced hydrometeorological services.
- To achieve this and to promote production of better, more cost-effective and scientifically adequate services to the communities it is necessary Fifthly to modernize the institutional structure and management

Significant improvements in the capacity of the NHMSs and provision of services can be achieved with considerable small investments (with respect to EU level of NHMSs budgets).

Modernization of hydrometeorological observation network, data management and service production the CAC NHMSs to a level of advanced EU NHMSs would cost around 30-90 million US dollars per NHMS. Additionally several millions are required to upgrade the environmental measurements. In order to provide sustainable development for the NHMSs annual a significant increase in the annual budgets of the NHMSs is required. The items numbered from 1 to 5 in the following text can be implemented within 1-3 years. This can be done with reasonable costs. The next steps should be taken within 5-7 years. The main constrain for modernization will be lack of highly qualified experts, especially the IT experts at the NHMSs. It is critical that the investments are done at the level which can be sustained by the NHMSs.

Some barriers and risks

The development plans need to take into account not only investment needs in technology and software, but also investment needs in buildings and new staff. The scientific level of the staff of the CAC NHMSs is not optimal to very rapid modernization and improvement of the services, and the number of IT experts and qualified technicians and engineers is currently very low. Current low salary level of the staff may make it difficult to attempt especially the IT and technology experts.

Automation and modernization of observation, data collecting and running the NWPs and different software and dissemination of products on 24/7 bases require a significant increase in the number of qualified and trained IT staff. E.g. in FMI, which runs all above mentioned state-of-the-art systems and performs lots of air quality etc. services has close to 50 IT experts to operate the communication and computer systems on 24/7 bases and 20 experts to keep the software in operation. On the other hand the private weather services, who do not operate an observation network, but produces very similar weather forecast products for public and customers, can manage with totally 20-40 experts (meteorologists and IT experts).

To plan an end-to-end data collection and production system to meet the short term and longer term vision and strategy to produce customer and user focused products and to enhance the service delivery. Modernization of observation systems does not automatically mean that a NHMS becomes a modern hydrometeorological service. It is critical to recognize the financial needs to promote sustainable development. This means that investments cannot be done separately, but in general it can be estimated that the annual operational costs will increase by 15% for each investment in technology, and each investment requires adequate staff to maintain and develop the system.

10 COARSE INVESTMENT SCHEME

The investment proposal is made to cover a period of 8 years. It is estimated that the basic improvements, which can be done within first 3 years (depending if the required staff is available) will increase experience and capacity, and provide bases for the investments proposed for years 4-8.

1) Training

It is critical to start with a training component in order to promote the overall awareness of scientific and technical possibilities of capabilities which modern NHMSs have to provide state-of-the-art services and best possible weather forecasts to community and different economic sectors, but also to recognize requirements that the production systems put on general attitude, data management, scientific and technical staff and the managers.

a) training of <u>directors, mid-management and experts of general management:</u> from vision to strategy and annual activity planning, leadership skills, management of human resources, rising of financial resources, international cooperation and EU research program, regional cooperation, operation of a modern NHMS, technical possibilities including remote sensing systems, communication & information, cooperation with customer and end-user sectors, dissemination of information;

b) training of the IT staff;

c) training of <u>medium-range personnel</u> for modern hydrometeorological forecasting services;

d) training of <u>experts</u>: modern hydrometeorological services, cooperation with customers, tailored products, modern software;

e) training of <u>technical staff</u> to use AWSs

It is necessary to promote academic studies of the staff in order to increase the number of people with MSc and PhD degrees. E.g. the European Union FP7 research programme provides opportunities which should be exploited by the CA NHMSs. The eligible countries to participate the work programmes, and different training programmes like Marie Curie, are Member States – the EU-27, Associated Countries, Candidate Countries and Third Countries.

In order to motivate the key-staff to promote rapid development and to put adequate objectives for development it is necessary to order technical visits to advanced NHMSs, and to offer training-by-doing during 1-3 month stays abroad.

Internet is today a vital source of information, also scientific, and in order build the capacity to use internet it is necessary to organize training courses in English. This would significantly also promote capacity in international cooperation of the CAC NHMSs.

2) Assessment in the needs of hydrometeorological data and services of different socio-economic sectors

Value of hydro-meteorological information for end-users is actually more than reduction of economic losses. Monitoring of the environment together with climate and hydro-meteorological forecasting is one of the management tools, which may play an important role in decision making, and can increase human safety and business efficiency and productivity.

However, improved scientific knowledge of hydro-meteorology does not automatically increase the socio-economic value of the products of the NHMSs´s. Even a correct forecast has no value if it is not disseminated to the end-user at right time and in right and understandable format.

The needs for different types of hydrometeorological and environmental data and services was assessed by sending questionnaires to representatives of selected economic sectors (road traffic, rail road traffic, maritime, aviation, energy production, civil protection, agriculture, tourism and construction sector) and by interviewing the staff from these and other sectors during the missions to all SEE countries. The meetings with representatives from ministries and the different socio-economic sectors were requested to be arranged by the NMHSs.

3) Modernization plan

It is critical to produce a reliable long term modernization plan based on the vision, and a strategy how to reach it, in cooperation with the line ministry and potential main customers, and to establish a process to implement it.

4) First step modernization of technical facilities

Improved number of observation in the region, especially if they are properly disseminated into international use through the GTS, will promote the accuracy of the weather forecasts provided by the big centers for the CAC region.

It is necessary to increase the number of automatic on-line meteorological stations in all CAC countries. The primary goal is to replace strategically important manned stations with AWSs and hydrological stations. New automatic stations to be established should be located and sited to meet the requirements especially from the civil protection, and also the needs of different economic sectors and potential customers. The number of AWSs required e.g. in mountainous regions depends on demands of potential customers like traffic authorities and their plans to install own road weather stations.

In order to promote 1-2 day weather forecasts the most cost-benefit way would probably be to invest in:

a) communication and data management system

In order to increase the capacity to collect and manage data from the automatic stations and other observations systems, and to promote near real-time use of the data it is necessary to modernize the data communication and data management systems.

Communication and Data management systems

It is critical to plan and install (gradually) a modern and effective communication and data management system to meet the requirements of different types of observations (including radar and satellite data), real time quality control, numerical weather forecasting data, and production of services.

In effective real-time data collection system the role of regional offices will be less important than for manual (radio, manual telephones, email,..) data collection systems, as it is necessary to collect the data directly to the main data management center.

Installation and upgrading of telecommunication systems to ensure more reliable availability of national, regional and global weather/climate data, information and products for enhanced natural disaster mitigation, hydro-meteorological forecasts and services, and adaptation to climate variability and change.

A well functioning Message Switching System (AMSS) to provide the means to exchange real time data and warnings with the Regional Telecommunication Hub.

In order to increase the capability to collect more data from automatic stations and posts it is vital to start to use the General Packet Radio Service system (GPRS) as soon as possible. It is a mobile data service available to users of Global System for Mobile Communications (GSM) and IS-136 mobile phones. GPRS data transfer is typically charged per kilobyte of transferred data, while data communication via traditional circuit switching is billed per minute of connection time, whether or not the user has actually transferred data or has been in an idle state. GPRS can be used for services such as Wireless Application Protocol (WAP) access, Short Message Service (SMS), Multimedia Messaging Service (MMS), and for Internet communications services such as email and World Wide Web access.

It is critical to be able to introduce a platform for the national data management and numerical modeling.

To strengthen data collection and management systems to ensure that end-users in the public and private sectors (Agriculture and food security, electricity generation, disaster risk management, local households) are provided with better and more reliable weather and climate services necessary for national socio-economic development needs. This will require the installation of state-of-the-art data management systems and the provision of appropriate training.

For the IT sector, the annual maintenance cost is expected to be about 15 per cent of the investment, due to the typically very short lifetime of the technology (3-5 years).

Data communication costs are estimated at UD$140 per month per station. Use of General Packet Radio Service (GPRS), when that is available, will reduce the communication costs. The NHMSs also need additional staff, especially IT staff and meteorologists, to operate 24/7/365 analyzing and forecasting services.

b) automatic weather, precipitation and water stream measurement stations, communication and data management so that the data from the AWSs are available for the forecaster in near real- time (change from manual observations to automatic observations needs to happen on adequate number of stations, and then increase of the number of AWSs can be done smoothly);

The automatic stations need to be equipped with a transmission module, which supports use of fixed line, GSM, GPRS and other means, and also can check whether the data was sent successfully or not, and serves also as short time data storage. By this it is possible to reach close to 100 % data availability.

In mountainous areas it is necessary to equip the AWSs with properly heated ice-free sensors, in order to avoid awkward measurement errors caused by atmospheric icing. References to icing and proper sensors can be found in the EUMETNE SWS I and SWS II reports.

However, in order to invest in AWSs, and other automatic stations, it is critical that they can be operated as automatic stations (automatic high frequency measurements and real-time data collection), and that the data is disseminated to central data management and end-users (e.g. forecasting meteorologists) and data assimilation systems of NWPs in real-time or in near real-time.

b) upgrading of some manual observation stations;

As the sensors at the stations are obsolete it is necessary to replace the equipment with new sensors, and provide an adequate amount of spare parts for regular maintenance. However, as the mid-term trend should be to change from manned stations to automatic stations a critical selection of stations to which the current observation systems should be purchased is needed.

As all current stations cannot be changed into fully automatic stations, it necessary to upgrade the sensor systems at the synoptic stations, in order to improve the quality of measurements.

Figure 42. Schematic presentation of a data management system. QC= quality control.

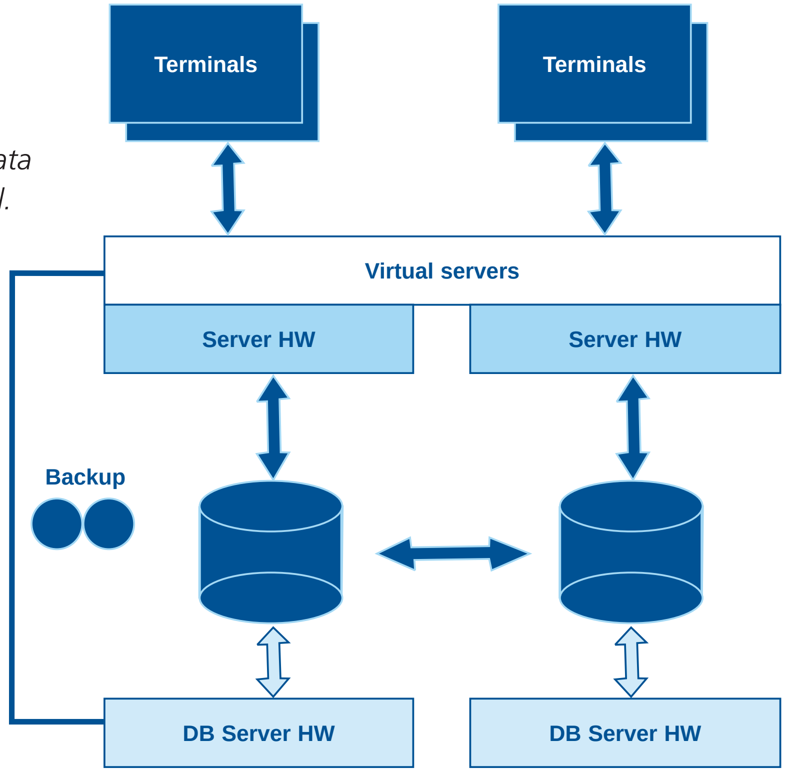


Figure 43. Schematic presentation of a data management system. QC= quality control.

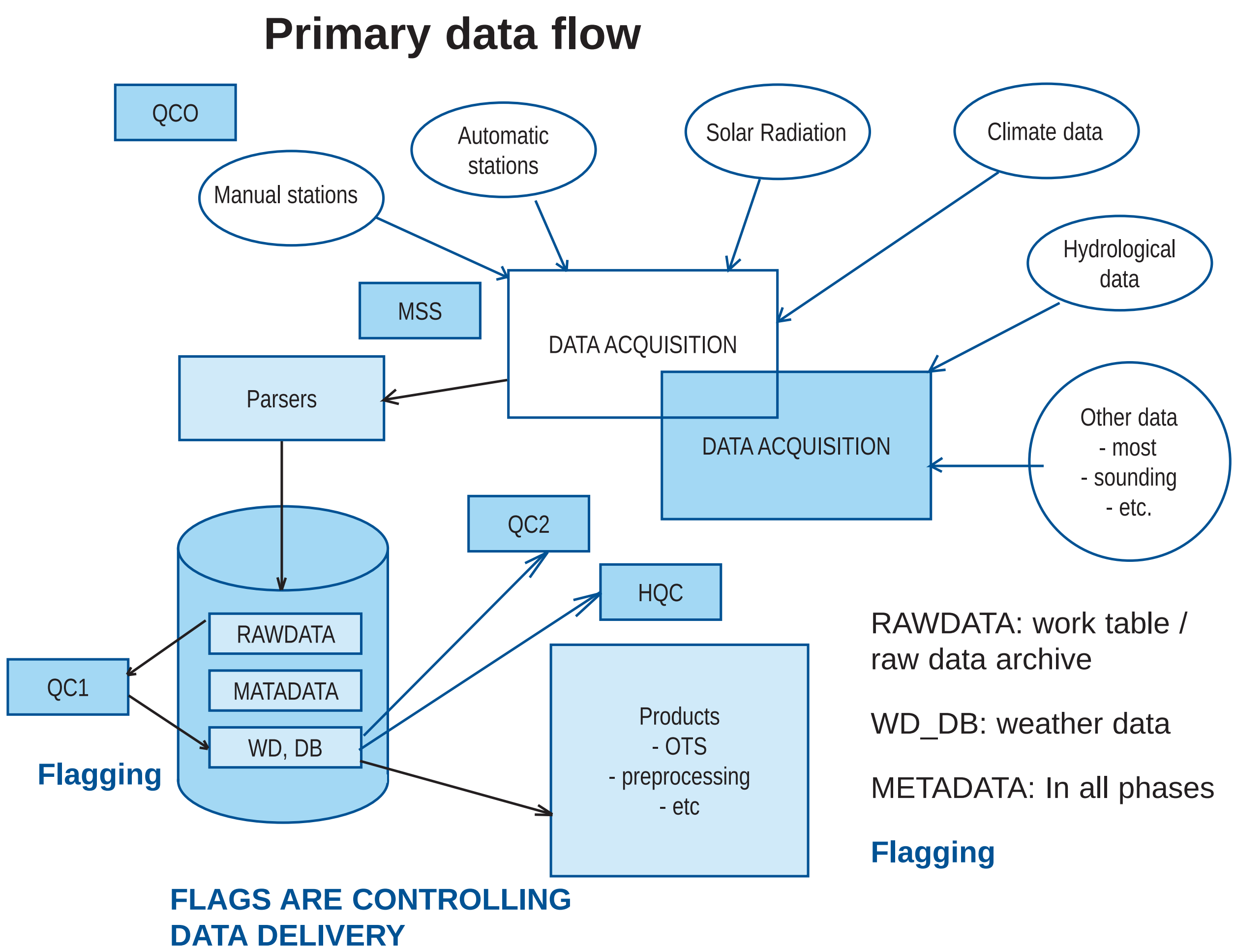
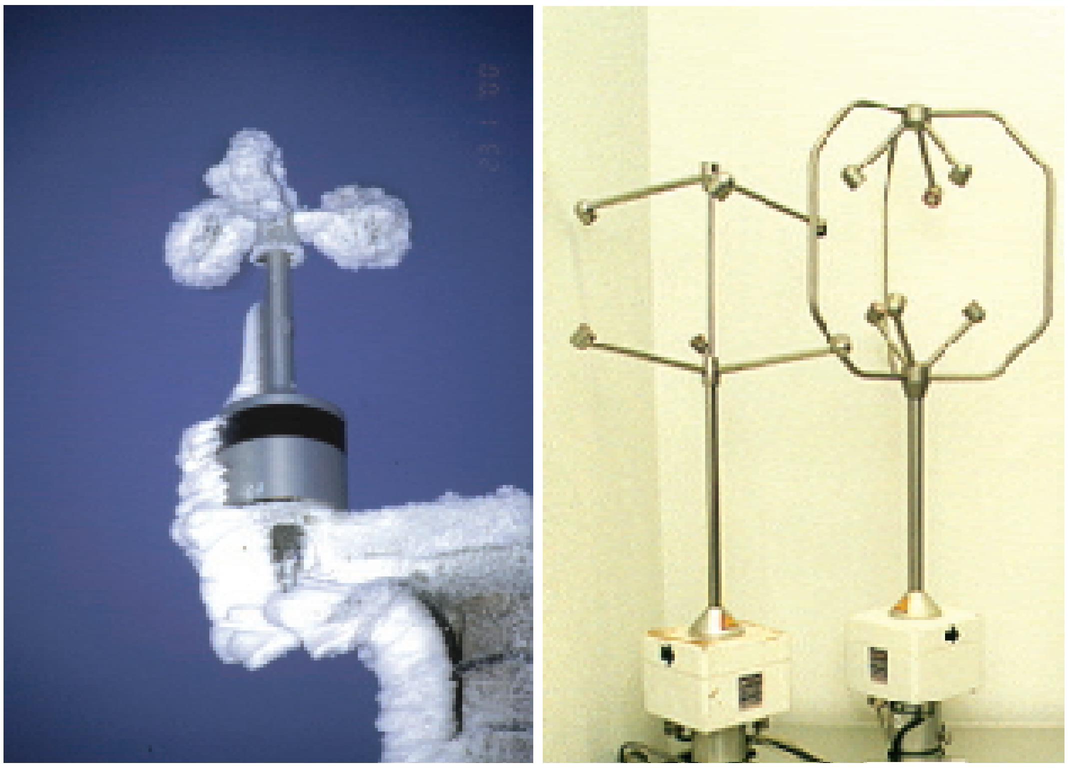


Figure 43. Iced cup anemometer (left) and heated ice-free sonic anemometers (right). (from Tammelin et al, 2004; EUMETNET SWS II).



(a)	Horizontal resolution	Vertical resolution	Frequency of observation
Air temperature	250 km	10 layers in troposphere > 5 layers in stratosphere	2-4 per day
Wind	260 km	10 layers in troposphere > 5 layers in stratosphere	2-4 per day
Relative humidity	250 km	> layers	2-4 per day

(b)	Horizontal resolution	Vertical resolution	Temporal resolution
Temperature	100 km	0.1 km up to 2 km 0.5 km up to 16 km	3 hours
Wind	100 km	0.1 km up to 2 km 0.5 km up to 16 km	3 hours
Relative humidity	100 km	0.1 km up to 2 km 0.5 km up to tropopause	3 hours

Source: www.metoffice.gov.uk

Table 34. Requirements for upper-air observations indicated by the ECMWF.

Figure 45. An automatic balloon release system in operation.

Establishment of new manned synoptic stations is not supported by this project proposal.

c) improve the receiving and exploitation of satellite data

Better knowledge of state and volume of the snow cover is critical for improved avalanche warning system, and for improved hydrological forecasts.

Modern technology to measure and calculate water content of snow cover, height of snow cover, melting of snow cover and other parameters from satellite data is available. And it is not necessary to all this in every NHMS, as international data is also available. For instance the FMI provides snow services based on satellite data (NOAA) and snow observations through an assimilation procedure, which could also be beneficial for the NHMSs (see: http://snow.fmi.fi/ http://globsnow.fmi.fi/).

d) NWP products

Implementation of Local Area Numerical Weather Prediction Model(s), which could be done in a simple way by downscaling to local scale from global or regional scale forecasts. This can be done by relatively small staff, and this methodology is used by many small private weather forecasting companies. Numerical models like MM5 and WRF are available on internet and can be downloaded free of charge. However, running of NWPs require specialized staff.

e) upper-air soundings

Establishment and operation of upper-air sounding stations would not only help local forecasters but also produce valuable data for global and regional NWP models operated by big centers like EMWCF and improve the weather forecasts.

RadioSounding data is critical for aviation applications and short term weather predictions in general. Sounding data provides possibilities to predict atmospheric icing, and it produces essential information to dispersion modelling of airborne pollutants.

Locally upper air observations provide an immediate vertical profile of the atmosphere and are essential for NWP and invaluable as a forecast tool, particularly for severe weather and general aviation forecast.

A radiosonde makes an in situ point measurement of the atmosphere that it passes through. In contrast, a radar or lidar profiler makes a remotely sensed volumetric measurement of the atmosphere above the profiler location. A lidar could be a powerful tool e.g. at the airports.

Kazakhstan operates 8 sounding stations, 7 of them are equipped with quite new Russian systems.

What is the right density for upper-air observations? For general meteorology including numerical weather prediction, the basic set of global requirements for upper-air observational data for global observing systems are as shown in the following Table 34(a). As the numerical weather prediction community seeks to capture increasing amounts of upper-air observations, some even more stringent requirements for data needed to obtain optimum results from numerical weather prediction have been developed (see Table 34(b) below).

Operation of upper-air sounding station is very expensive:

- Hydrogen generation unit around 80000$, sounding system 300000$
- The annual costs for two daily soundings are estimated to be around €140,000.

As the salary level of technicians required to operate the soundings there is no need at the moment to invest in an automatic launching system, which becomes more common in developed NHMSs.

AMDAR

Automated meteorological observations from passenger aircrafts have been available in one form or another since the late 1970s. Aircraft Meteorological Data Relay (AMDAR) is a program initiated by the WMO. AMDAR collects data of wind speed and direction, temperature, and can include turbulence and humidity (which is not measured in Europe). AMDAR is particularly useful for now-casting situations, and is used especially by aviation forecasters. AMDAR data is also useful for NWP models.

Currently the upper air sounding stations (profiles up to 30 – 35 km) cannot be replaced by AMDAR data (profiles up to 10 km), but AMDAR provides complimentary upper air data and in many cases first hand data from the lover atmosphere.

AMDAR data is collected in collaboration with national domestic and international airlines. In Europe the data collection costs via WMO GTS are paid by E-AMDAR, while the instrumentation on the plains is financed by the respective airline company.

Use of AMDAR data would significantly produce increased frequent information about the state of the atmosphere at reasonable costs compared to operation of upper-air sounding stations.

It is critical to ensure the operation of current number of upper air soundings in the Caucasus region, and to establish at least one active upper air station in each country. Unfortunately the operational costs for a sounding station are quite high. The annual costs for two daily soundings are estimated to be around 140 k€, when using high quality sondes, software and facilities.

As the sounding stations will bring immediate benefits to the aviation sector it would be profitable to build partnership with Aviation Weather Services in order to reduce the costs per institute, and to optimize use of the data.

f) Lightning detection system

Lightning information is vital for meteorologist when working with thunderstorm and severe weather short term forecasting. In principle good lightning detection network could compensate lack of a radar network, at least concerning some information. Anyway, the lightning detection network can be established for the whole CAC region at costs close to one modern weather radar station. And the maintenance costs are much lower.

Lightning may be a hazard for human safety, households, aviation, electricity production and distribution, communication, mining, construction, etc. Real time information of lightning, and potential lightning risk, is vital especially for managers responsible for human safety, property protection and risk management.

Electric power and insurance companies, and land management agencies etc. need historic lightning data to correlate and document suspected lightning damage with recorded lightning activity. Seasonal or multi-year studies of lightning trends are important for risk assessment, site selection and optimal protection schemes.

There are several ways of establishing a lightning detection network:

- stand alone systems (10-20 km) around airports and other important sites; location accuracy is limited
- national network: 5-25 sensors and a hub with software per country, depending on the country
- regional networking: 5-25 sensors per country and one regional hub, depending on the country
- to have separate networks for cloud-to-ground (200 km; good location accuracy) and for cloud-to-cloud & cloud-to-ground monitoring (100 km; less accurate in location)

Figure 46. A skiss for a regional cloud-to-cloud and cloud-to-ground lightning detection system (total lightning system) for the CA countries, with some 40-45 stations.

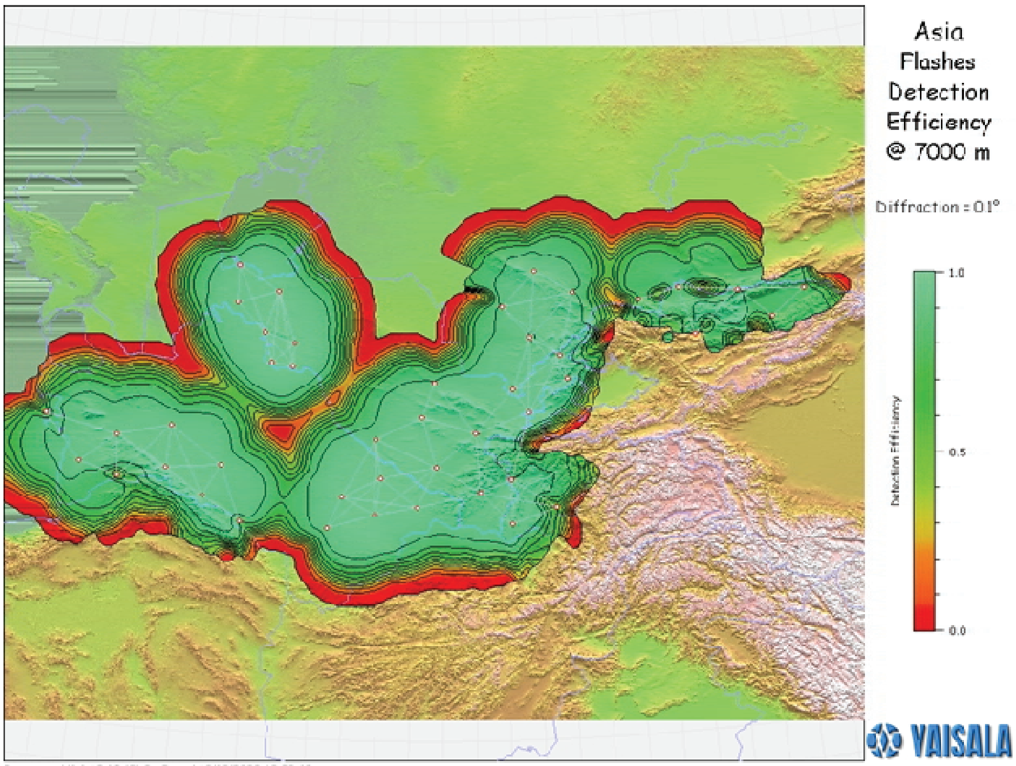
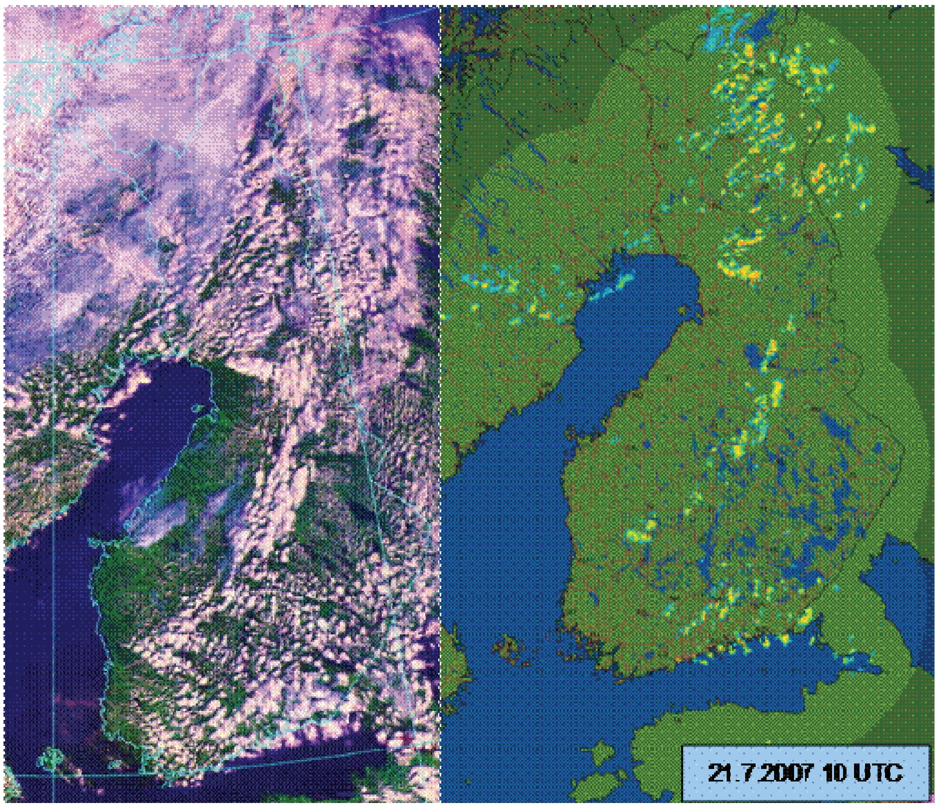


Figure 47. An example of the difference between satellite cloud information (on left) and precipitation information collected by the weather radar network (on right) over Finland in July 2007.



Today it is also possible to buy real-time lightning data from Vaisala Global Lightning Dataset GLD360, without the NHMSs need to make any investments. The data is provided by a Vaisala owned and operated worldwide network.

As the region of CAC countries is very mountainous the number of measurement stations needs to be quite high. It is estimated that some 50-55 stations and one hub would be required to give an accurate regional lightning detection system. Rough estimate for a price could be: 75 k$ per station and 450 k$ per hub with software.

The savings through regional cooperation will become from needs of less stations per country and from only one hub instead of having a hub in each country separately. Also sharing data, or providing services to the aviation sector savings on national level would be achieved, as in countries where aviation weather services are separate from the NHMSs the aviation sector tends to build their own lightning detection system, like in the Balkans.

5) Visibility and dissemination of information

In order to increase the visibility of the NHMSs it is critical to increase cooperation with the media and the industry.

In order to improve the technical production of services to the newspapers it would be vital to invest in an automatic production system.

In past modern NHMSs had their own TV studios, but today there is no reason to invest in modernization of the studios, as the TV channels can produce much better and more sophisticated presentations by themselves. However, it is vital that the presenters of the TV weather forecasts are meteorologists, and also belong to the NHMS staff. (However, in Finland the main TV channels have their own trained meteorologists hired from the FMI staff).

The Internet homepages are most important tool to improve the visibility and to disseminate information.

To be able to exploit modern software to produce static and dynamic images and text in different languages, and up-date the pages and information in-real time, or at least frequently, it is necessary to implement a sophisticated data management system and automated production system of services.

The provision of good forecasts and other products in internet increases request for tailored products and thus also the commercial business opportunities of the NHMS.

It is also critical to improve the communication of information and data to the customers. Typical modern channels and the target groups are:

- Extranet[11]: transport, media, construction, energy, industry (FMI has 30000 daily users)
- Internet: individuals, media (FMI has more than 400000 daily visitors)
- SMS: individuals, transport (FMI has 30000 daily users)
- Telephone services: agriculture, companies, individuals (FMI has 2000 daily users)

High number of daily products and use of modern communication infrastructure requires automatic production system.

7) Digitalization of manual data

It critical for planning and risk analyses purposes to produce as soon as possible a data base with long time historical data.

[11] *An extranet is a private network that uses Internet protocols, network connectivity, and possibly the public telecommunication system to share e.g. information produced by the NHMS with the customers of the NHMS.*

Equipment for digitalization of manual data from paper copies with quality control systems are available at some 300000 – 400000 $, or less. However, as the costs of human resources are still very low in the CACs it is more profitable to hire some staff and invest in PCs, and choose right stations to be copied. A trained typewriter can type some 10 monthly observation reports into an excel file within one day, so one typist could easily manage some 5-6 years per station within one week.

It is clear that for further practical use some stations and their data are much more important, and have better data and meta-data quality, than others so it critical to choose which stations should be done first.

6) Modernization of the observation network and automated analyzing and production systems in phase 2

Each country have large sparsely populated areas with less economic interest, and thus also less interesting for hydrometeorological observations and services, if they are not important e.g. for numerical modelling. .

Amount and geographical density of observation stations is discussed e.g. in the WMO instructions, but on the other hand the density and location of stations needs to be based on local (national) needs, taking into account scientific hydrometeorological bases, but also the needs of industry and potential customers. The number of stations which the NHMSs used to have could be one guide line, after some critical judgment.

On the other hand, as the demand for more accurate forecasts in time and space is increasing also different type of approach can be motivated, as shown e.g. by the Helsinki testbed measurement network and LAPS analyses and forecasting system.

In long run it is necessary to modernize the whole CAC observation network towards a fully automated system, and to enhance use of remote sensing systems. In order to reach this it is critical to invest in modernization of the data management and communication systems, and in the IT staff.

Automatic weather stations

There have been several reasons to strongly invest in automatic weather stations, and other automatic stations, and in general to automate the whole observation and monitoring system as part of the developed and modernization of NHMSs:

- the salary costs of the observers become a big share of operational costs;
- more data more frequently;
- better and more constant measurements/ observations;
- improved data management systems;
- customer orientation;

Use of data assimilation requires good data, good data management and sufficient computer power to produce forecasts in due time for adequate lead time.

Most of the AWSs can be equipped with main measurements (temperature, humidity, pressure, wind speed and wind direction). However, as number of observers will decrease it is necessary to equip some of the AWSs also with rain gauges, solar radiation measurements (R+D), cloud height measurements and present weather sensors.

The investment needs in synoptic stations do not significantly depend whether the project is implemented as a cooperative project or as separate projects for each country. However, joint purchase of AWSs from one manufacturer will surely reduce the unit price of AWSs, but that option is not taken into account in this proposal.

10.1 Weather radar data

A weather radar is used to locate and identify precipitation, calculate its motion, estimate its type (rain, snow, hail etc.), and forecasts future position and intensity. Modern weather radars are mostly Doppler radars, capable of detecting the motion of rain droplets in addition to intensity of the precipitation, and in case of rain droplets found also to calculate the winds. Both types of data can be analyzed to determine the vertical and horizontal structure of storms and their potential to cause severe weather.

To ensure the flash flood warning the radars and radar based nowcasting procedures are the most reliable way from nowadays point of view.

Weather radar can be used to improve the reliability forecasts and accuracy of local precipitation and wind, and is thus a vital tool for meteorologist in duty especially for forecasting rapidly changing weather.

Weather radar data and products are also very useful for EWS, energy sector, traffic safety and road maintenance, agriculture and today even for the public. Radar products provide very important data and information also for aviation safety and improve efficiency of aviation.

There are several approaches when planning a radar network:

- radars close to major airports; strong support to aviation sector
- radars at sites to cover areas of major interest; hydro power sector, aviation, major cities
- total coverage over the whole region, when best benefits from composite pictures can be achieved (see e.g. NORDRAD or EUMETNET OPERA)

Weather radars are very expensive to purchase and to maintain. The radar network needs to give adequate coverage also beyond the borders. The investment in radars must be based on cooperative use of radars within the country and in the region, on-line data sharing (data protocols!, and data management) and production of real time regional composite pictures. It is vital to build partnerships with the industry (energy sector, aviation, agriculture) and different ministries and authorities (road and railway sectors and others) to finance and maintain the radar network.

In EU countries the number of weather radars is about 160, and composite pictures are available. The Nordic NORDRAD differs a bit from the European system, e.g. uses its own code to share basic data, but provides good living expressions of magnitude and movement of the precipitation areas.

The first step in the CA countries other than Uzbekistan (who has 3 operational weather radars) is to install Doppler radars to improve early storm warning in essential areas and densely populated areas, as well as international airports. As the CA countries cover a very large area, it requires time and money to achieve similar weather coverage to that in EU. However, through regional and bi-lateral cooperation it would be possible to significantly promote the weather radar coverage around some major cities, and improve forecasting of floods.

The Caucasian countries are much smaller so a radar coverage with composite pictures could be achieved by much smaller investments. In Figure the coverage is achieved by 4 radars in Azerbaijan, 2 radars in Armenia and 3 radars in Georgia. In siting the radars it is necessary to take into account the needs by different socio-economic sectors like aviation, transportation, maritime activities, agriculture, flood prone areas, and also peoples increasing leisure time activities.

Transforming manual data into digital form.

In order to improve the capability to produce climatological studies, risk analyses based on long term climatological data, and to monitor the climate change, it is vital to transform

Figure 48. Coverage of the EUMETNET OPERA network in 2008. Coloured areas within the area covered by the radars represent precipitation with different intensities.

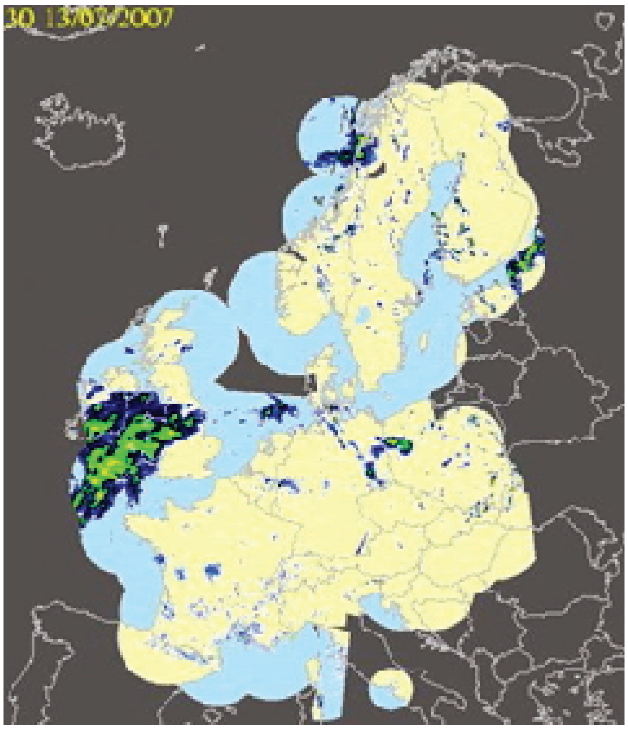


Figure 49. The coverage of the NORDRAD weather radar network over Finland, Denmark, Norway and Sweden. The composite pictures are available in near real-time on Internet: http://www.ilmatieteenlaitos.fi/saa/sadejapi.html http://www.smhi.se/vadret/nederbord-molnighet/blixtar . http://www.smhi.se/vadret/nederbord-molnighet/norden

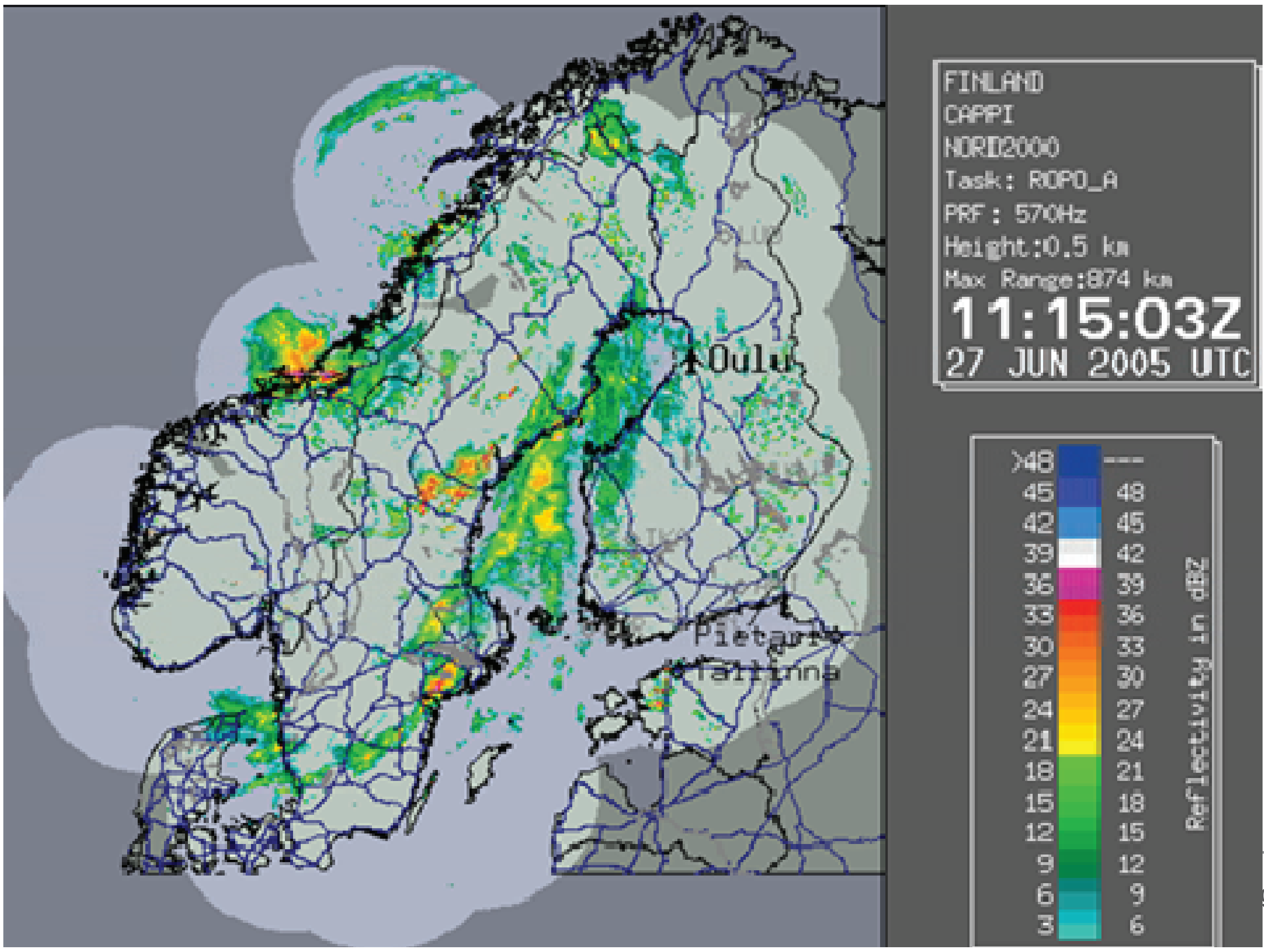


Figure 50. Current operational upper-air sounding stations (grey stars) and weather radars (black circles) operated by the CA NHMSs. Current operational sounding stations operated by neighboring countries are given by green stars. Potential locations additional for first phase weather radars (red circles) and sounding stations (red stars). Operational stations: http://badc.nerc.ac.uk/data/radiosglobe/asia.html

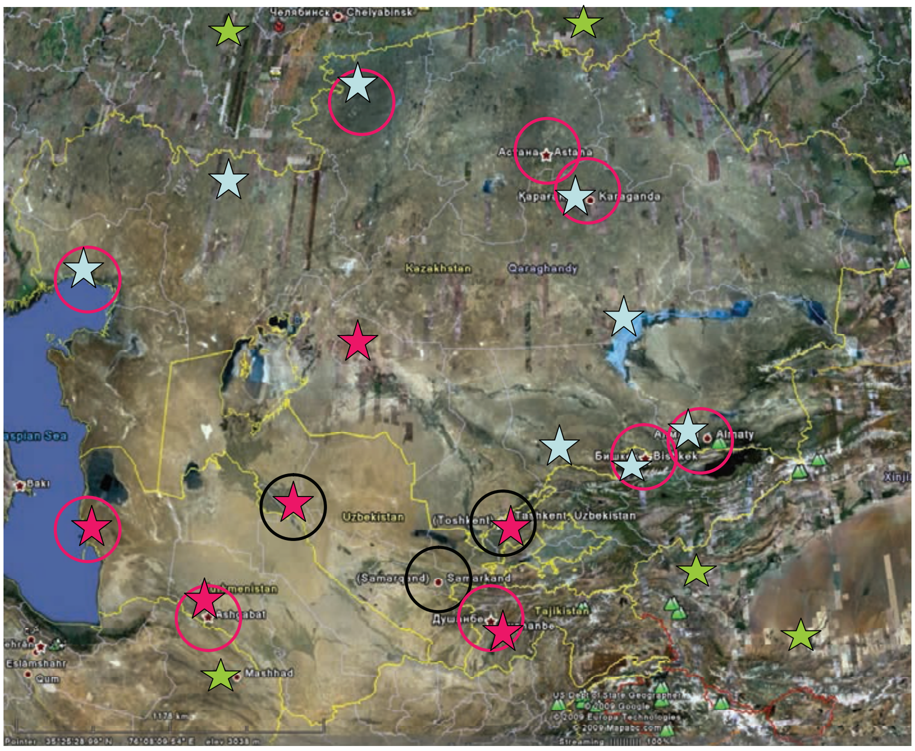


Figure 51. Weather radar network coverage with 250 km range radars.

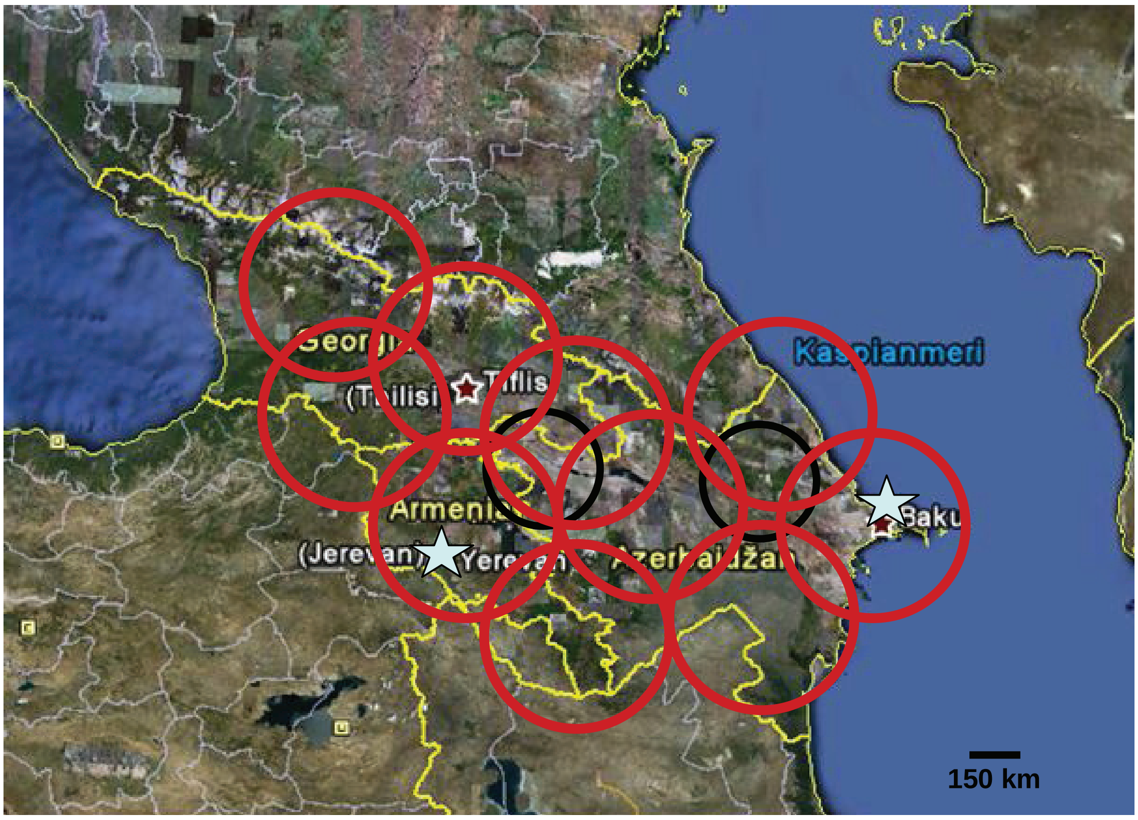


Figure 52. A meteorologist working on an automatic processing and visualization tool. (Photo by Lea Saukkonen, Finnish Meteorological Institute).

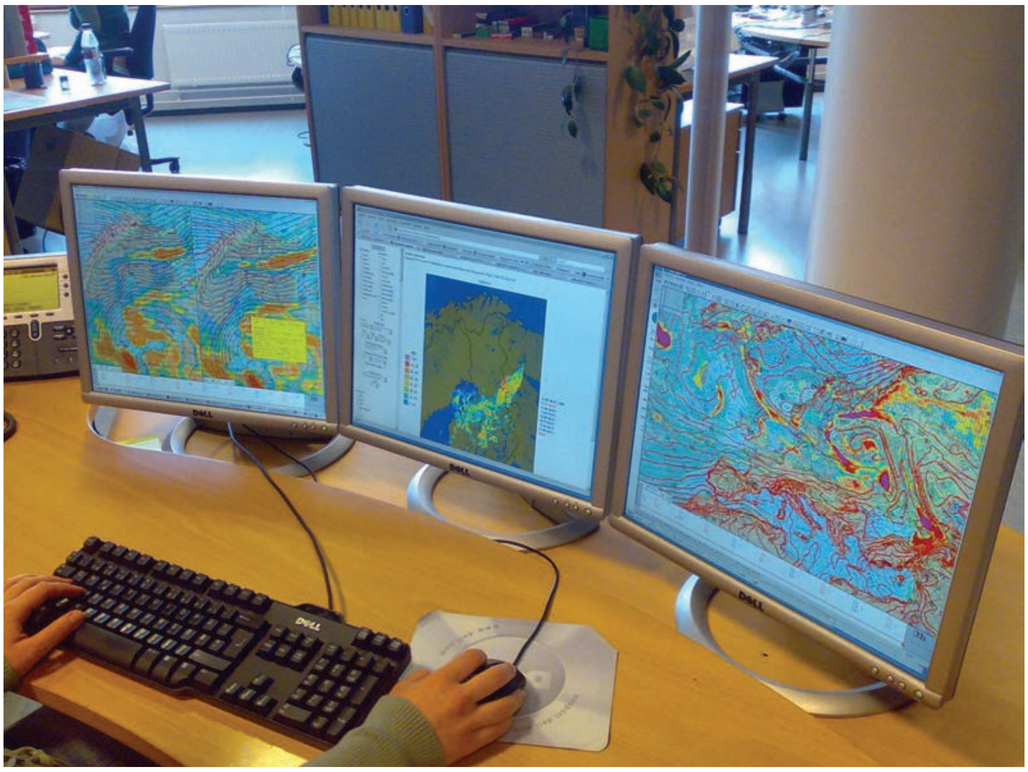
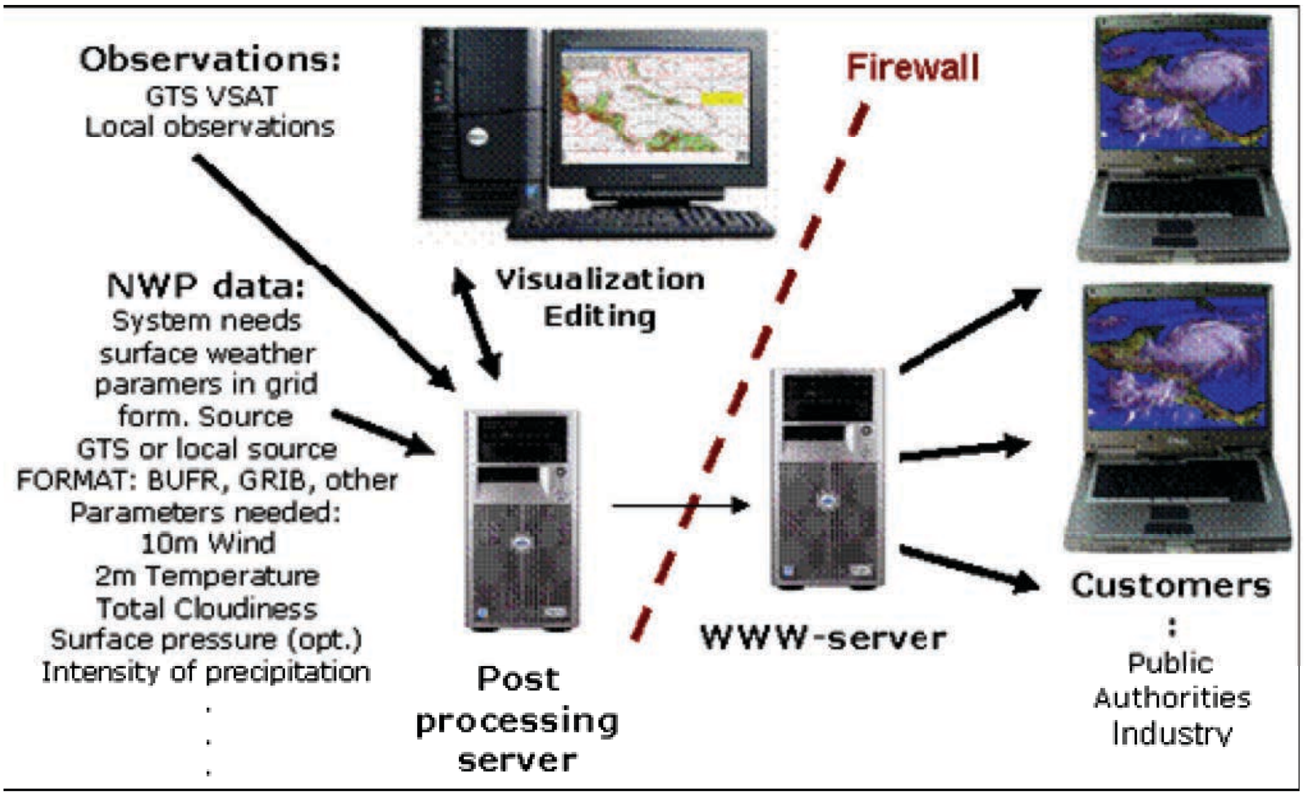


Figure 53. A schematic illustration of a set-up "From observations to services".



manual synoptic station data from paper copies into a digital database. However, as the type of sensors and surroundings of the stations (forest, trees, buildings, etc.) have changed during the years, and the metadata is lacking or the quality of metadata is not very good, it requires a critical analysis and decision making to choose representative stations to be digitalized.

As the salary level is very low in the countries it is profitable to use human power to copy old recordings to a computer format, and further into a data base, rather than purchase hardware and software for digital reading of the paper copies. A professional typist would easily transform the 3 year data (8 observations per day) from one station to an excel database within one working week. Adequate time and software is required for quality control of the digitized data.

Economic benefits from new equipment

Today the objective must be in automated monitoring system. It provides more frequent and more reliable data than manual observation systems.

Another main interest in starting automation of observations was the high salary level of the observers, and difficulty to find willing people to take responsibility of a synoptic station, so by chancing manual observation stations into automatic ones financial savings and longer duration for an observation site could be expected.

Due to low salary level in the CAC countries the economic benefits from changing into an automated observation network would actually be negative during the foreseen years.

Operating and maintenance costs

Introduction of new equipment will require financial and technical support throughout the life cycle of equipment.

10.1.1 Automatic rain gauges

However, according to experience up to now some automatic rain gauges are not as reliable as expected, which causes lots of extra work in the quality control phase, and

10.1.2 Hydrological measurements

Automatic stations in mountains (upper part of the rivers) would provide vital data for early warning of floods.

10.2 Climate services

Long-time time series of various hydrometeorological parameters are essential for community planning, planning and construction of buildings, roads, reservoirs, dams, railroads, airports and other facilities within different socio-economic sectors, and to study the climate change.

It is critical to transform valuable climate information from paperback copies into digital format into a usable data base, so that exploitation of climate data becomes more effective and user friendly. However, it is not necessary to transform all data from all stations into a digital database, at least not at the first stage. The type of sensors has changed during the years, as well as the sites and surroundings of the stations, and obviously good metadata is missing, which makes the use old data quite complicated. Thus it would be profitable to choose some representative stations with good quality data for this transmission. The work should be started soon, as the salary level is low and it is easy to find people to do this job.

It is necessary, that current data is properly collected, quality controlled and stored in electronic database with an adequate backup system.

10.3 Numerical Weather

prediction models

Running of Local Area Numerical models require computing capacity, which depends on which type of model will be chosen, and which grid size is going to be used, and how often the model is gone to be run daily. Prize of a super computer is around 1,2 – 1,5 million euro, but modelling can also be done with much cheaper equipment starting from a powerful PC á 2000 euro.

Automatic weather stations could bring immediate improvement in the accuracy of short term weather forecasts, if the data is collected in real-time, or close to real-time, and it is visible for the meteorologist immediately.

Weather radars are very powerful tools in nowcasting (forecasting up to 2-4 hours ahead) of storms and precipitation, for analyses of precipitation intensity and amount, as source of input data for data assimilation in the NWPs. The effectiveness of radar information is significantly increased when images from several radars is merged to composite pictures.

Increased amount of upper air observations would benefit the global weather forecasts provided by big centers, but also e.g. production of daily forecasts at the NHMSs with current equipment and tools.

Implementation of Numerical Weather Prediction system would increase the number of products and increase the accuracy of forecasts. Different types of real-time weather observations can be used in the NWP data assimilation.

Implementing and running NWP(s) require new staff with adequate skills, new computer capacity, and new IT staff.

6) Automated visualising, editing and production system,

Producing and disseminating of certain weather service products can be fully automated these days. Automation is vital especially for small weather services, but brings s great profits also to big services. Automation makes it possible to improve the NMP forecasts, to produce easily customer tailored products, to increase production modules according to needs, and increase the number of daily products from few to thousands.

- Viewing and editing of all hydro-meteorological data
- Computer-to-computer type products can be used by bigger customers like broadcasting companies, newspapers and air traffic control
- Promotes WEB production; Internet is a great option for delivering weather data and forecast products for public sector and private users
- It is basically possible to deliver all the same data that is delivered by internet also by mobile phones

Forecast visualization and editing tools allow meteorologist to make needed changes and modifications to initial forecast provided by NWP-models. It is critical that professional meteorologist have the possibility to add her/his experience and knowledge in the forecasting which is not perhaps taken into account by the NWP.

The purpose of the visualizing and editing software is

- to provide a tool that can be used to modify NWP output, and to add knowledge and expertise of a meteorologist to the forecast model so that this knowledge and expertise is available for all weather information if they so wish
- to work as a versatile visualization tool for meteorological data

The software tool can be used for automatic manufacturing of tailored products like e.g. web weather, newspaper weather, road weather, agriculture weather, maritime weather etc.

The information can be presented in different forms: isolines, numbers, color fields and symbols.

It is critical that the software tool is able to use input data as:

- data from NWPs –all available levels
- satellite data from EUMETSAT and NOAA satellites
- observation data like SYNOP, METAR messages and other from of data from the observation network
- data from weather radar
- data from lightning detection network
- data from radio soundings

Uzhyrodmet has visualization and editing tools in use. The other NHMSs could significantly benefit from purchasing and operation of such a system. Operation of a system requires a good data management system.

10.4 Weather modification

Weather modification, in most of the cases cloud seeding, is used in some countries like US, China, India, and Russia and in some former Soviet Union or Yugoslavian countries. It is scientifically dubious that such efforts are generally effective. However, these activities are not supported by the WMO.

Resources put into weather modification activities could obviously be used to promote e.g. upper air observation and thus promote improvements in numerical weather forecasts.

10.5 Cooperation with customers and end-users

Ministries, different economic sectors, research institutes and public are the main users, the main customers, of the hydrometeorological data and services.

It is critical to increase dialogue and cooperation with different customers and end-users. Cooperation with industrial sectors promotes the possibilities to increase the number and quality of commercial services.

In this proposal some financing is proposed for cooperative seminars, organized visits, presentations in media. However, the financing finally required depends very much on the activity of the NHMSs.

11 BENEFITS FROM REGIONAL COOPERATION

It is necessary to promote regional cooperation between the Caucasian and whole CAC NHMSs, but also cooperation with other neighbouring countries, in order to promote the services and especially the disaster risk management. It also needs to be noted that many of the international donors and investment banks prefer to have regional development projects rather than country-vice projects.

It is critical to improve the data and information sharing and to promote a regional information system like e.g. the METEOALARM established by the EUMETNET NHMSs in EU.

It is clear, that using common tendering and purchasing of equipment, software and other products the prices can be reduced.

Training

Training provide by consultants e.g. from European countries or NHMSs is quite expensive. The expenses can be decreased if training courses were planned and implemented commonly rather than individually for each country.

It is also vital to implement common courses and seminars for the staff and experts of the CAC NHMSs, as the background of the current staff is very similar in each country, and also the challenges are very common.

Strengthening of the regional training centre in Uzbekistan would benefit all CAC countries, as investments in their own training facilities can be delayed. On the other hand it is necessary to increase use of e-learning methods, and to send experts and scientific staff for training in advanced NHMSs.

Surface observations

As the Caucasian region is quite small and hydrometeorological hazards are transboundary main befits may be achieved through good data sharing.

There are not actual benefits to be expected from harmonization of the type of AWSs and sensors, as anyway each station represents just spot values, and anyway each sensor has to traceable in order to have best possible quality on long term data. E.g. FMI operates several types of wind stations, some types of automatic precipitation gauges, and the AWSs are from different ages.

Lightning detection

If the network is established in cooperation the same accuracy can be received with less monitoring stations, and only one hub would be needed. This approach would save around US$ 1-15 million in investment expenses compared to the situation where the countries would build their own systems.

Weather radars

As the region of the Caucasian countries is not very large it would be easy to achieve similar total weather radar coverage with a regional weather radar network. Production of real time composite pictures for the whole territory would improve weather forecasting and especially flood warnings in each country.

The CA sub-region is very large, and already Kazakhstan is a very big country which makes the investment needs very big if full weather radar coverage would be the objective. However, the capitals or major cities and major international airports are located within a relatively small area, where adequate weather radar coverage could be achieved quite easily.

Anyway, if the current radar network is going to be enlarged in the CAC countries it is vital anyway to take potential data sharing into account, and befits which could be achieved from similar software, maintenance staff and training.

Also just making the radar images from national networks available for other NHMSs and aviation sector would improve the work of forecasters.

Numerical weather prediction

It is worth discussion to analyse whether all the NHMSs need full regional and local scale numerical weather prediction capacity.

Due to the shape and size of the Caucasian countries it would be cost-effective to run an advanced NWP model for the whole sub-region, rather than that each country would establish a full scale numerical weather prediction system.

Uzhydromet again, as more advanced NHMS than Turkmenistan, Tajikistan and Kyrgyzstan could run a state-of-the art regional model, while the other NHMSs could at least start with using e.g. WRF or MM5 models for smaller scale modelling when needed.

R&D

Currently the research and development activities, and capacity to do R&D, are at quite low level in the Caucasian NHMSs. Anyway, there is lots of international funding available for environmental and climate change research, which could be achieved for joint R&D projects in the region. It is assumed, that at least 1-2 joint 2-5 year research projects will be started in the region during this 8 year period.

12 VALUE OF IMPROVED HYDROMETEOROLOGICAL SERVICES TO THE COMMUNITY

Reliable climate information can help countries plan for adverse and beneficial climate events, allocate resources, and achieve development goals. Advances in climate science, including forecasting on seasonal and sub-seasonal timescales, decadal-scale climate change and variability, real-time climate monitoring, and tailoring of climate information to specific user needs, are creating opportunities to improve climate risk management, especially in developing countries where societal needs are greatest.

Several recent studies have shown that national economies, development of different economic sectors and welfare of households can significantly benefit from good hydrometeorological data, services tailored to customer's needs, and close cooperation and partnerships with the NHMSs. It has also been shown that investments done into modernization and improvement of NHMSs will pay back in ten folds, or even more, the investment. It has also been shown that through regional cooperation the investment needs can be significantly reduced, compared to the situation that each country and NHMS acts alone.

The NHMSs seem to evaluate the level and accuracy of their forecast products to be better than what is impression from the industry, especially concerning hydrometeorological extremes and cumulative precipitation leading to natural hazards.

However, currently there is severe lack of information concerning the size of different socio-economic sectors, annual average losses caused by weather and climate, and local expert estimates how much of the losses could be avoided.

Low agricultural output results on old cultivation traditions and losses caused by numerous natural hazards like earthquakes, deforestation, desertification, erosion, winter frost, floods and droughts. Every year hailstorms cause tens of millions of dollars of damage for farmers.

The losses from the disasters are caused by interactions between hazard events and characteristics of exposed elements that make them susceptible to being damaged (vulnerabilities). As a result from natural extremes causing disasters the national economic development, in terms of annual growth of the GDP, may be strongly decelerated, as seen from the following picture.

In UNISDR studies it has been estimated that 35 % of losses caused by natural hazards could be saved with proper warning system.

The author of this paper has included assessment of economic impacts of hydrometeorological services in recent studies made for WMO about seven East African countries (2007) and the Central Asian Countries (2009) and for UNISDR about the South East European Countries (2008). Currently for this very study there is no relevant data available of the size and share of the weather dependent sectors in the Caucasian countries. However, the International Bank for Reconstruction and Development gave in 2006 a report on "Assessment of Economic Efficiency of Hydrometeorological Services in the Countries of the Caucasus region".

The benchmarking method was used for assessing the economic efficiency of hydrometeorological services since it does not require any detailed analytical studies or surveys. The method was based on assessing the level of prevented losses through the correction of basic parameters depending on economic and weather-climate characteristics of a specific country. Benchmarking was also used in the Finnish VTT-FMI study of Croatia and separately of the SEE countries, and in the above mentioned WMO study of the CAC.

Two basic parameters are selected

a) level of direct economic losses from hydrometeorological hazards and unfavorable hydrometeorological events expressed as percentage of GDP;

	Armenia		Azerbaijan		Gergia		Kazakhstan		Kyrgyzstan		Tajikistan		Turkmenistan		Uzbekistan	
Area sq km	29,743		86,6		69,7		2,724,900		199,951		143,100		488,100		447,400	
- land area sq km	28,203		82,629		69,7		2,699,700		199,801		469,930		469,930		425,400	
- water area sq km	1,540		3,971		0		25,200		8,150		18,170		18,170		22,000	
Population (x1000)	2,967		8,239		4,616		15,400		5,432		7,350		4,885		23,000	
GDP USD billion (PPP) 2008	18,97		78,47		21,68		181,1		11,83		13,92		30,69		72,47	
GDP per capita $ (PPP) 2008	6,400		9,600		4,700		11,700		2,200		1,800		6,400		2,700	
GDP USD billion 2009 (oer)	8,785		43,11		10,740		109,3		4,57		4,982		31,86		32,82	
GDP USD billion (PPP) 2009	16,24		85,77		20,23		181,9		12,11		13,67		32,56		78,343	
GDP per capita $ (PPP) 2009	5,500		10,400		4,400		11,800		2,200		1,900		6,700		2,800	
	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF	%GDP	%LF
Agriculture	19	46.2	5.6	38.3	12.2	55.6	6	31.5	26.9	48	20.1	49.8	10.1	48.2	26.7	41
- forestry & fishery							0.1					0.025				
Industry	33	15.6	61.4	12.1	26	8.9	42.8	18.4	18.4	12.5	22.2	12.8	30.5	14	39.7	20
- construction									3							
building construction							7.4									
mining industry							1.6				7.1		6			
- energy																
- electricity production																
- water management																
- transpot							9.7						5			
- aviation																
- road																
- railroad																
- maritime																
- transprot and communication									5.6		8.4					
Services	48	38.2	33	49.6	61.8	35.5	51.2	50	54.7	39.5	57.7	37.4	59.4	37.8	33.5	36
- communication									1		1					
- tourism																
- leisure activities, sports																
- social services																
- health									1.9							

Table 35. Area (sq km), population, GDP, GDP composition (%) by main economic sectors and composition of labour force (%LF) in the CAC countries (CIA, September 2009). The share of different weather sensitive sectors of the GDP is estimated from various sources (Tammelin, 2009).

b) level of prevented losses (i.e. losses prevented due to use of weather forecasts and HH warnings) expressed as a percentage of the total level of losses.

Typically in economic studies the assessment is limited to some most relevant sectors (agriculture, energy, transportation,…) while often e.g. the smaller sectors are left aside, as well as the value of lost lives.

In the WB study it was estimated that the share (in %) of weather dependent sectors of GDP could be 73% in Armenia, 60 % in Azerbaijan and 67 % in Georgia.

Seasonal outlooks and long term forecasts can help to save property and lives in case e.g. droughts or floods leading to famine and diseases. To save property it is critical to use hydrometeorological data for planning and design of structures and the community, siting of power lines and roads, etc. Short term forecasts can help to save lives and losses of transportable property.

UN/ISDR studies indicate that 35 % of losses could be saved with a proper early warning system. This value is used for the Caucasian countries for the values given in Table 38. For the Central Asian countries it is assumed that 50% of lost lives and 20 % of other economic losses could be saved. The value of saved lives is calculated using VOSL (Tammelin 2009).

	Armenia	Azerbaijan	Georgia
Direct economic losses from HH	31.5	67.3	46.6
Direct economic losses avoided with current HM services	9.2	25.6	9.2
Coefficient of prevented losses	0.226	0.275	0.164
Mean annual amount of funds received by NHMS	0.47	1.7	0.47
Efficiency of current hydrometeorological services (%)	1959	1504	1961
Sector specific assessment of direct economic losses of HH	28	48.8	47.6
Sector specific ass, of indirect economic losses from UHE	32.2	11.6	21.3
Share of potentially preventable losses from HH to be avoided by adequate modernization of the NHMSs (%)	16	13,5	15.1
Share of potentially preventable losses from UHA (indirect losses) to be avoided in case of adequate modernization (%)	15.7	11	12.9
Share of expenditure on protective actions (%)	-7,2	-24	-12.8

Table 36. Basic comprehensive assessments of the economic efficiency of HydroMeteorological services currently provided by the NHMSs. Sums in US million. Benchmarking to Russia used. WB 2009.

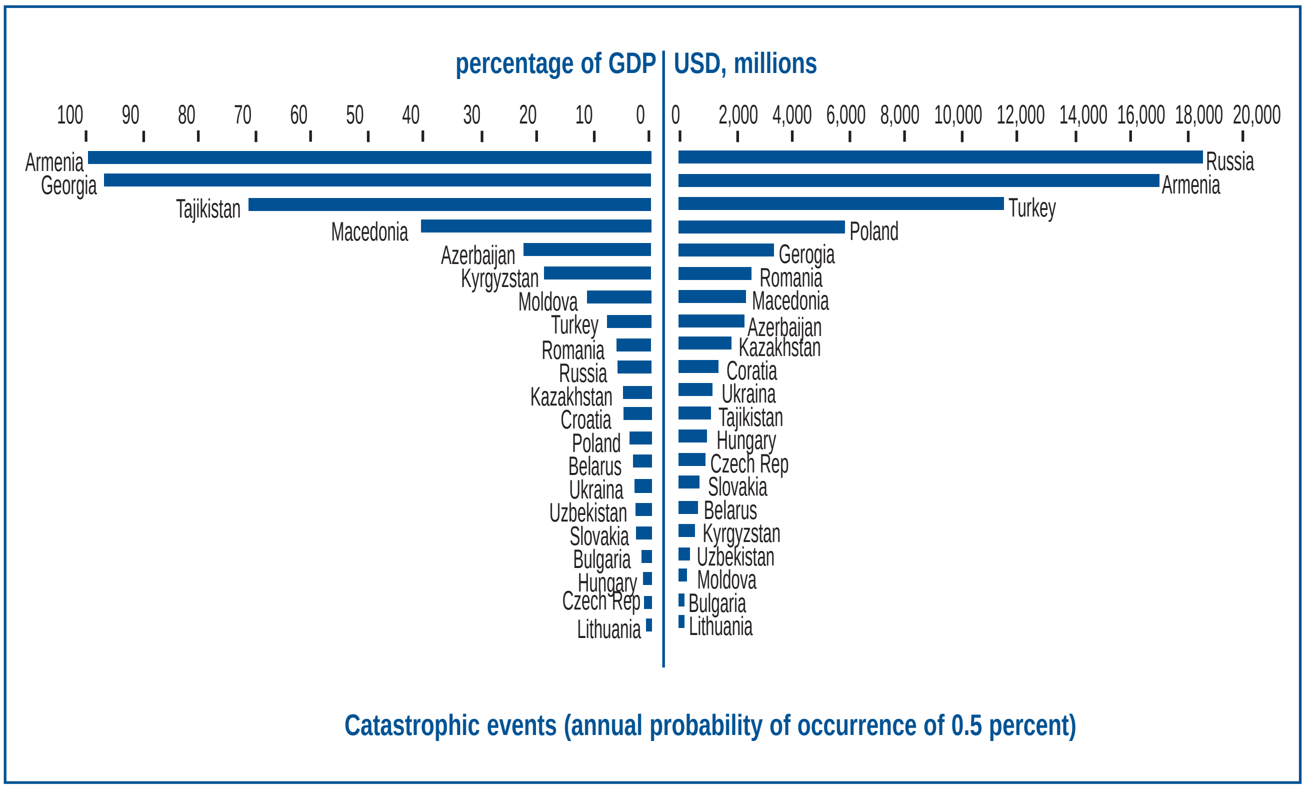
	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Tukmenistan	Uzbekistan
Agriculture	x	x	x	15	3.1	2.2	4	15
Air transport		x		5	2	2	2	2
Road transport	x			46	2.7	1	4.5	
Railway transport		x						
Transport			x					
Water management					0.08	0.9		
Energy	x		x					
Hydro power						0.07		0.1
Building construction				6.2	0.3	0.6		
Health		x	x					
Tourism	x							
Communal services			x					
SUM	2.4	7.1	2.1	72	6	7	10	17

Table 37. Coarse estimation of potential annual average economic benefits in USD million from hydrometeorological services in the CAC countries. The data for Caucasian countries is taken from the IBRD study (2006) and for the Central Asian countries from the WMO study (Tammelin, 2009). The crosses indicate which sectors had been analysed in the IBRD study.

	Armeina	Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
losses from casualties				4.7	1.7	4.4	0	0
potential savings				2.3	0.8	2.2		
losses from injuries								
potential savings								
losses from material				14	0.4	18	10	5
potential savings				2.8	0.08	3.6	2	1
total damage	5.4	9.8	11.7	18.7	2.1	22.4	10	5
total savings	1.9	3.4	4.1	5.1	0.9	5.8	2	1

Table 38. Estimated average annual benefits from avoided losses from natural hazards which could be achieved with proper early warning systems. CA values are from Tammelin 2009.

Figure 54. Potential losses from catastrophic events in some countries, with probability of 0.5 % annual occurrence. (WB, 2009).



13 COST BENEFIT

Significant savings in losses of lives and property can be achieved through better provision and use of hydrometeorological historical data, weather forecasts ranging from seasonal outlooks to nowcasting and sharing of real-time between neighbouring countries.

There are few comprehensive databases available about the average annual losses from hydrometeorological hazards in relation to countries GDP.

In industrial countries the change from manual observations to automated observations has been justified by getting more accurate data more frequently, but also by savings in fixed operational costs through saved labour costs. E.g. Finland, where the monthly salary of an observer and is around 1500-2000 euro, the investment cost in replacing a manual observation station with an AWS could be liquidated within 1-1.5 years, while in Caucasian countries the pay off time would be 10-20 times longer, at current salary level. However, the NHMSs saw replacing of observers by AWSs to be too big social problems due to lost jobs.

Modernization of production tools and processes in a NHMS typically means increased annual communication, maintenance and investment costs, and need to employ especially new IT staff and to build effective training program for the staff.

Due to low salary levels in the NHMSs the NHMSs cannot actually show any economic savings from the investments. They could show significant growth in the revenue, but it would be critical to have the capability to use these revenues into development of the NHMSs directly.

13.1 Benefits to the community

Economical benefits can be expressed by the cost benefit ratio R, which is the net present economic value (E) of an investment divided by investment's initial cost (C). Thus the ratio R taken over a certain period from year 1 to year n is

Eg. (1) $$R = \frac{\sum_{a=1}^{n} E}{\sum_{a=1}^{n} C}$$

Typically n is 5, 7 or 10 years. The costs C comprises of additional costs needed to get the NHMS to a level where the estimated economic value can be achieved: planning costs, investment costs of new equipment and facilities including interest, operational costs of maintenance, communication and data management, leasing costs of software, and labour costs of new staff required, and others.

In many studies the economic benefits (E) from improved hydrometeorological services, and the cost-benefit ratio for a certain period of years, is calculated just by multiplying the potential average annual savings (in $) by the number of years.

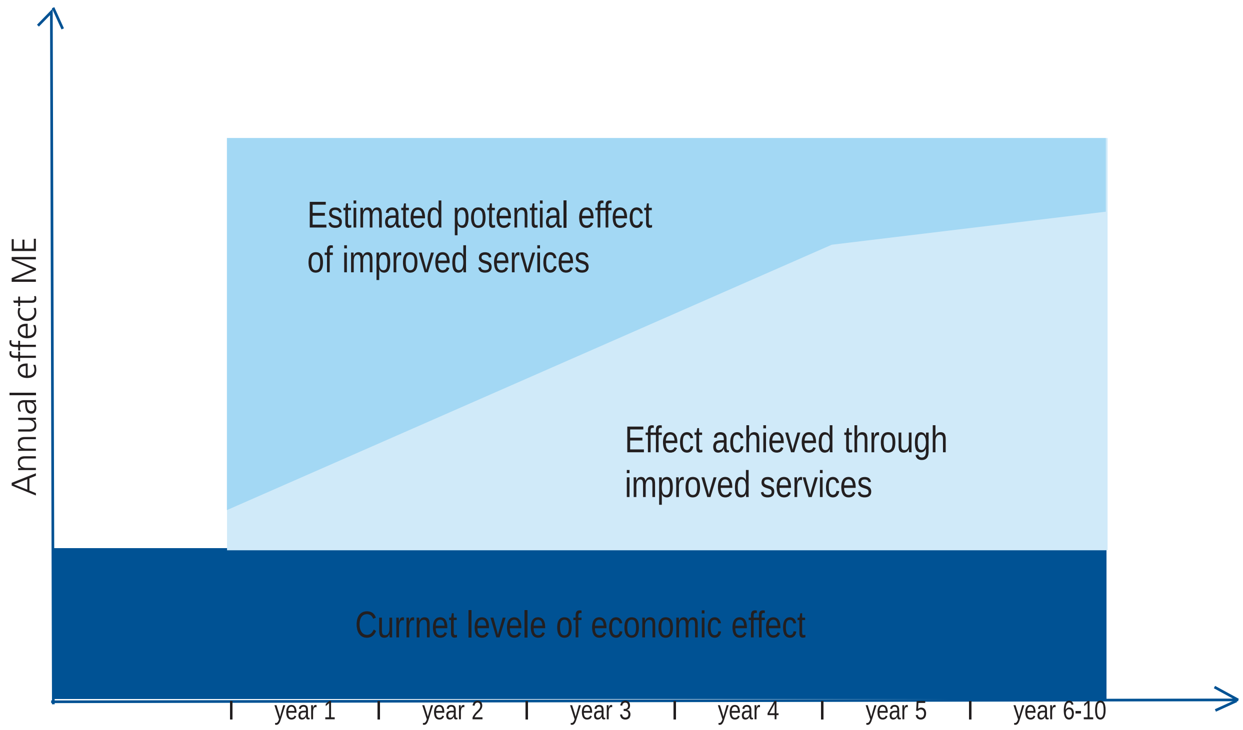
However, it will not be possible to bring actual benefits in Caucasian countries up too quickly to the potential benefit levels. Capacity will constrain implementation of the proposed investments, regardless of the level of willingness. The experience from FMI cooperating with several economic sectors show, that it is essential to those who provide hydrometeorological information need to understand the marketplace. In the process of increasing benefits industry must also be educated in the need to use weather information in the decision-making process. Learning to produce improved services and integrating these improved services into the decision-making processes within different economic sectors takes time. Specific constraints include:

- Time needed by NHMSs to adopt new technology, to manufacture new products, recruit new employees and train the required staff.
- Lack of traditions of cooperation with end-users and economic sectors.
- Lack of marketing skills.
- Lack of both appreciation for NHMSs and awareness of the potential benefits of hydrometeorological services among the economic sectors.
- Lack of traditions for fully incorporating hydrometeorological information in decision-making processes by a number of economic sectors.

In order to find a cost-benefit ratio for the recommended investments, it is estimated that, given the capacity constraints discussed above, the actual savings, or economic benefits, from improved hydrometeorological services could gradually ramp up over five years to the point where they would, in year five, provide approximately 75 per cent of potential economic benefits. (Potential benefits are those that could be achieved by good services, such as the current level provided by FMI). This assumes a very conservative learning curve for the first 5 years. During the following five years, an 80 per cent level of potential annual economic benefits is assumed.

As only few economic sectors, and very little information e.g. from the health sector, has been taken into account, and the data of losses and avoidable losses are very coarse, it can be assumed that the benefits could be bigger than what are estimated here for each country, On the other hand, as the value (in US$) of the products, services and human lives in the CAC countries will increase, also the ratio between the investments in NHMSs and benefits will increase.

Figure 55. Schematic illustration of the relationship between current economic benefits, potential economic benefits and estimated economic benefits to be achieved during the initial five-year period, and during the following five years (from Tammelin, SEE report 2008).



14 REFERENCES and sources of information

Adiguzel, M., 2009. Azerbaijan in-country visit report. WMO. 19 p.

Arabidze, A., 2006. Results of assessment of economic efficiency of meteorological and hydrological provision of Georgia. PowerPoint presentation.

Azoskiy, Igor (2004). Railroads in Central Asian Countries: Problems and Prospects. CA&CC Press AB. http://www.ca-c.org./online/2004/journal. 7 p.

CASPCOM, 2009. Recommendations of the 14th Session of Coordinating Committee on Hydrometeorology and Pollution Monitoring of the Caspian Sea.CASPCOM (14).ISLAMIC REPUBLIC OF IRAN- TEHRAN.23-24 November 2009.

CES, 2007. National Strategy of the Republic of Tajikistan for Disaster reduction. 1st regional consultative meeting for disaster risk reduction in Central Asia, Dushanbe, 14-16 Nov 2007. PowerPoint, 20 slides.

CIA 2010: World Factbook, September 2010.

Dilley, Max, 2006. Disaster risk hotspots: A project summary. In Measuring Vulnerability to Natural Hazards. Ed. Jörn Birkmann.TERI Press, New Delhi, India. United Nations University Press.

Economywatch, June 2009. Econ Stats: Economic Statistics and Indicators for Tajikistan, for the Year 2008. www.economywatch.com/economic-statistics/country/Tajikistan

Ecoworld, 2009. The elusive yet abundant hydropower in Kyrgyzstan

Eugste, S., Jumaeva, S. and Zimmermann, M., 2004. Swiss Disaster Reduction Strategy for Central Asia 2004 – 2008. Swiss Agency for Development and Cooperation, Dushanbe

Feerbai, J. and Zillman, J., 2002a. Economic benefits of meteorological services. Meteorological Applications, 9(1), 33-44

Feebrain, J. and Zillman, J., 2002b. Funding meteorological services. Meteorological applications, 9(1), 45-54

Feebrain, J. and Zillman, J., 2002b. Funding meteorological services. Meteorological applications, 9(1), 45-54

FMI-VTT project, 2008. Authors: Raine Hautala, Pekka Leviäkangas. Jukka Räsänen, Risto Öörni, Sanna Sonninen, Pasi Vahanne, Martti Hekkanen and Mikael Ohlström (VTT), and Bengt Tammelin, Seppo Saku and Ari Venäläinen (FMI). Socio-economic benefits of meteorological services in South Eastern Europe. Project report – VTT.

GEO, 2009: Use of Satellites for Risk Management. GEO 2009-2011 Work Plan, DI-06-09.doc. March 2009.

GORBI, 2005. National Weather Warning Service (NWWS) Survey. World Bank. 33 p.

Ghazaryan, M., 2009. Water resource management problems in South Caucasus region. In: T.H. Illangesakere et al. (eds.), Decision Support for Natural Disasters and International Threats to water Security. Springer Science + Business MediaB.V. 2009.

Global security.org, 2009. Military, Tajikistan

Gunasekera, D., 2003. Measuring the economic value of meteorological information. WMO Bull., 53(4), 366-373

Gupta, S.,(main author) 2009. Risk Assessment for Central Asia and Caucasus – Desk Study Review. Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI). WB-UNISDR-CAREC. 155 p.

Hautala, R., P. Leviäkangas, J. Räsänen, R. Öörni, S. Sonninen, P. Vahanne, M. Hekkanen, M. Ohlström, B. Tammelin, S. Saku and A. Venäläinen, 2008. Benefits of meteorological services in South Eastern Europe – An assessment of potential benefits in Albania, Bosnia-Herzegovina, FYR Macedonia, Moldova and Montenegro.

Hughes, S., Bellis, M., Bird, W. and Ashton, J., 2004. Weather Forecasting as a public Health Tool. Centre for Public Health, Faculty of Health and applied Sciences, Liverpool John Moores University. 25 p.

Hovsepyan, A., 2009. Synthesis report - Central Asia and Caucasus Disaster Risk Management Initiative. Preliminary draft report. ISDR.

Hovsepyan, A., 2009. Country profile: Armenia. - Central Asia and Caucasus Disaster Risk Management Initiative. Preliminary draft report. ISDR

Hovsepyan, A., 2009. Country profile: Georgia. - Central Asia and Caucasus Disaster Risk Management Initiative. Preliminary draft report. ISDR

Hovsepyan, A., 2009. Country profile: Kazakhstan. - Central Asia and Caucasus Disaster Risk Management Initiative. Preliminary draft report. ISDR

Hovsepyan, A., 2009. Country profile: Uzbekistan Main Hydrometeorological Department - Central Asia and Caucasus Disaster Risk Management Initiative. Preliminary draft report. ISDR

International Bank for Reconstruction and Development, 2006. Assessment of Economic Efficiency of Hydrometeorological Services in the Countries of the Caucasus Region (Interim report for discussion). Weather/Climate service pilot study in the countries of Europe and Central Asia. 58 p.

International Bank for Reconstruction and Development, 2007. Cost Efficiency Assessment of the Program of the Republic of Kazakhstan Weather Service. Pikot Study Report. Kazakhstan-reprt-final. doc. Ministry of Environmental Protection of the Republic of Kazakhstan & RSE Kazhydromet. 45 p.

International Bank for Reconstruction and Development, 2008. CONCEPT “Republic of Kazakhstan National Hydrometeorological Service Modernization Project 2009-2011”. The Environmental Protection Ministry of the Republic of Kazakhstan. 67 p.

InterWorks, 2008. A guide to Improving Disaster Resilience of Mountain Communities. Focus Humanitarian Assistance. 59p.

Ibatullin, S., Yasinsky, V. and Mironenkov, A., 2009. The impact of climate change on the water resources in Central Asia. Sector Report. Eurasian Development Bank. September 2009. 42 p.

Khamidov, Alisher, 2009. Kazakhstan: Construction sector still reeling despite government´s bail-out package. Ferghana.ru – Information agency. http://enews.ferghana.ru
Sebastian Eugster, Svetlana Jumaeva, Dr. Markus Zimmermann, (2004) Swiss Disaster Reduction Strategy for Central Asia.

Koskinen, J., 2009. FMI Earth Observations – Hydrology. PowerPoint. FMI-OE

Leviäkangas, P., Hautala, R., Räsänen, J., Öörni, R., Sonninen, S., Hekkanen, M., Ohlström, M., Venäläinen, A. and Saku, S., 2007. Benefits of meteorological services on Croatia. VTT Research Notes 2420. 71 p.+app.2p.

NORDEN: http://www.nordicenergy.net/section.cfm?id=3-0&path=17,49

Pandya, A. and Michel, D., 2009. Troubled Water: Climate Change, Hydropolitics, and Transboundary Resources. The Henry L. Stimson Center.

Perelet, R., 2007. Central Asia: background paper on climate change. Human development report 2007/2008. Human Development Report Office OCCASIONAL PAPER. UNDP.

Rogers, D., Smetanina, M. and Tsirkunov, V., 2009. Improving weather, climate and hydrological services delivery in Kyrgyz Republic. A World Bank Report. Master Document 09-06-08-eng.doc. 119 p.

Russian Academy of Science, 1998. National report to the International Associations of meteorology and Atmospheric Sciences of the International Union of Geodesy and Geophysics 1995-1998.

Stabel, K. et al., 2010 (web). Validation of the GOMOS high-resolution temperature product (HRTP) using lidar. ESA workshop. 6 p.

STUCKY, 2007. Lake Sarez Risk Mitigation Project – Component A. Final Report. Ministry of Emergencies and Civil Defence of the Republic of Tajikistan. AN/PD//4448/4017 a. 108 p.

Sylvén, M., Reinvang, R. and Andersone-Lilley, Ž., 2008. Climate Change in Southern Caucasus: Impacts on nature, people and society. WWF Norway, WWF Caucasus Programme.

Taghiyeva, U., 2009. Problems of forecasting the key natural hydrometeorological phenomena effects, ecological safety of the South Caucasus in the context of Azerbaijan. National Hydrometeorological Department
Republic of Azerbaijan. 2 p.

Tammelin, B., Heimo, A. and Leroy, M., 2002. Ice-free sensors - THE EUMETNET SWS II Project. In: the proceedings of WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2002). Report No 75, WMO/TD-No. 1123

Tammelin, B., 2006. COST 727 – Measuring and forecasting atmospheric icing on structures. DEWEK 2006. Deutsches Windenergie Institut.

Tammelin, Bengt (Main author), 2008. Strengthening the hydrometeorological services in South Eastern Europe. UN/SDR-WB-WMO-FMI.

Tammelin, B., 2009. Meteorological and hydrological information sharing, status, needs and capacity building in Central Asia; Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan - Economic benefits, investment plan and cost benefits. Draft final report. WMO. 95 p.

Tammelin, B. et al., 2009 b. Finnish Wind Atlas.. Finnish Meteorological Institute. www.tuuliatlas.fi, www.windatlas.fi

Vaisala, 2009. Vaisala global lightning dataset GLD360 – Technology, operations, and applications overview. July 2009.

NOAA, 2010: http://www.wrh.noaa.gov/boi/awareness/warningwatchadvisory.php

UNDP, 2002. Disaster management questionnaire – Kyrgyzstan.

UNDP, 2001. Capacity Improvement Activities on Climate Change in the Priority Sectors of Economy of Azerbaijan – Phase II.

UNDP, 2002. Disaster Management questionnaire – Azerbaijan.

UNDP, 2010. Who does what where in disaster risk reduction in Georgia. Second edition, March 2010.

UNDP-UNEP, 2010. Monitoring of Glacier Retreat in Central Asia: Challenges and potential solutions. Summary paper from Regional Workshop. 22p.

UNISDR, 2010: Basic terms of disaster risk reduction. http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm

USAK, 2006. Turkmenistan reports 20 % GDP growth in Jan-May 2006. The Journal of Turkish weekly.

World Bank, 2008. Weather and Climate Services in Europe and Central Asia – A Regional Review. World Bank Working Paper No. 151.

World Bank, 2009. Improving weather, climate and hydrological services delivery in Turkmenistan. Turkmen Report version 09-09-10 eng.doc. A World Bank Report.

World Bank, 2009. Improving weather, climate and hydrological services delivery in Republic of Tajikistan. Tajikistan report version-09-07-1-eng-1.doc. 138 p.

World Bank, 2009. Improving weather, climate and hydrological services delivery in Republic of Kyrgyzstan. Kyrgyzstan report (master document) 09-05-05.

World Bank, 2009. Disaster Risk Reduction and Emergency Management in Armenia. October 2009.

World Bank, 2009. Revitalizing agriculture after years of civil war. http// web.worldbank.org/WBSITE

WMO, 2006. Aral-HYCOS Executive Summary. Prepared by the WMO Secretariat. Geneva, April 2006. 15 p.

WMO, 2009. Proposed list of stations comprising the regional basic synoptic network (RSBN) in region VI. RA VI. XV-RAVI/INF. 5.1. July 2009.

WMO, 1996. Guide to Meteorological Instruments and Methods of Observation. WMO – No. 8. Sixth edition

WMO, 2009. List of stations comprising the basic synoptic network in region II. Annex to resolution 2(XIV-RAII).

XOBAB, 2009. Agriculture of Tajikistan damaged by heavy rains and mudflows. www.khovar.tj 1.7.2009

http://en.wikipedia.org/wiki/agriculture¬_in_tajikistan
http://www.nationmaster .com/country/ July 2009.
http://country-studies.com/turkmenistan/agriculture
http://country-studies.com/turkmenistan/industry
http://aviation-safety.net
http://www.maritime-database.com
http://www.ecogeodb.com/ECO
http:www.unece.org/Uzbekistan
http://www.boeing.com/news/techissues/pdf/statsum.pdf
http://badc.nerc.ac.uk/data/radiosglobe/asia.html
http://globsnow.fmi.fi/
http://snow.fmi.fi
http://waterwiki.net/index.php/Dam_safety_in_Central_Asia:_capacity_building_and_sub-regional_cooperation
http://gpm.gsfc.nasa.gov/

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