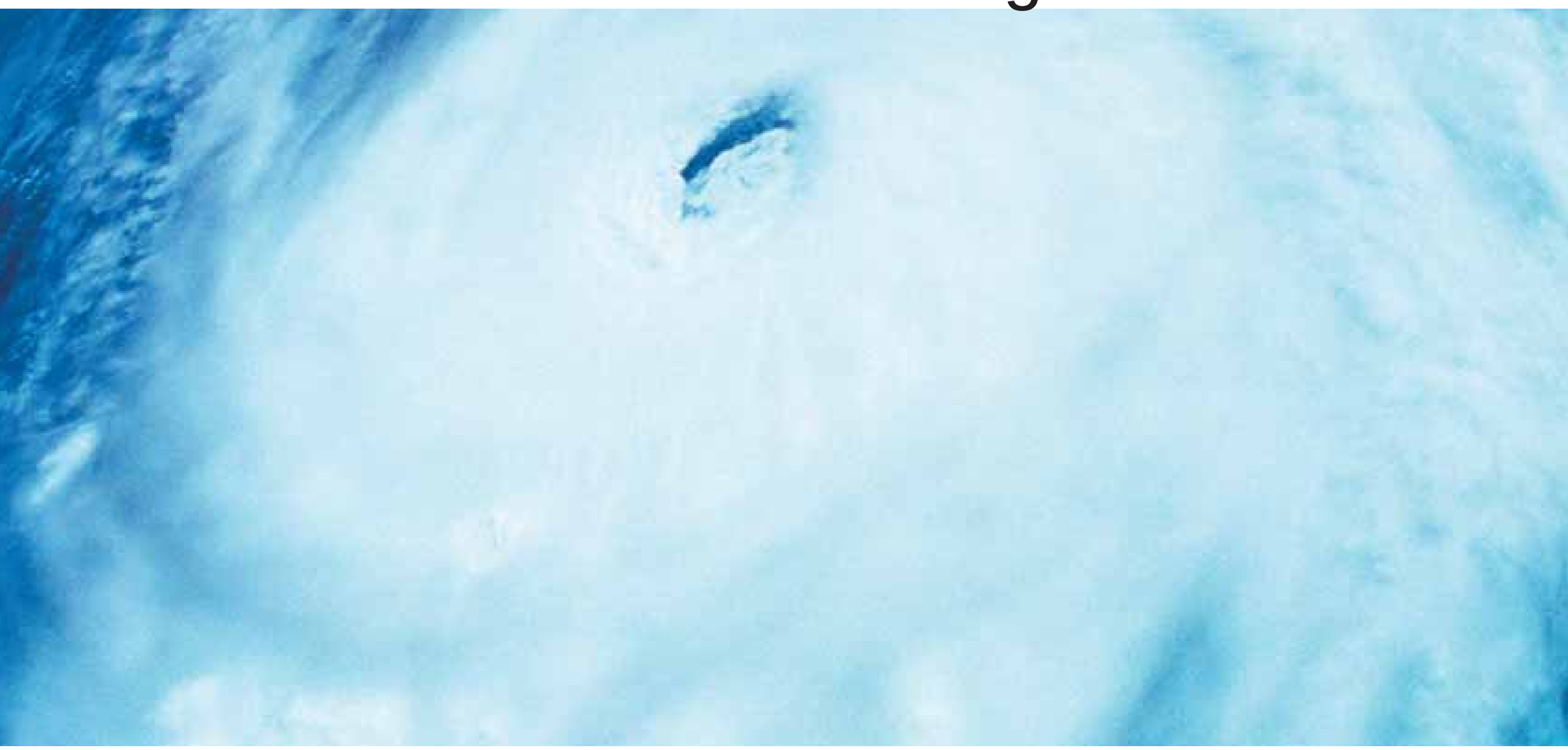
Proceedings from the joint workshop co-organized by:

the World Bank, the United Nations International Strategy for Disaster Reduction, and the World Meteorological Organization

Washington, D.C. – March 12, 2012

The Role of Hydrometeorological Services in Disaster Risk Management



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The United Nations Office for Disaster Risk Reduction

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GFDRR
Global Facility for Disaster Reduction and Recovery

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Table of Contents

Introduction v

Part I. Best Practices in Hydro and Weather Hazard Monitoring and Early Warning for Extreme Events

Lessons Learned from Seven Good Practices in Multi-hazard Early Warning Systems and Standards for Meteorological, Hydrological and Climate Services 2

Application of Climate Models in Improved Decision Support Services 9

Advances in Hydrologic Forecast and Flood Warning Services 13

Preparedness and Response to Mitigate Flood Losses in the United States 19

Technology of Stream Measurement, Monitoring and Visualization of Information 21

The Experience of the French "Vigilance Map": Complementing More Classical Early Warning Systems through Direct Communication with Populations 24

Meteo Alarm: European Multiservice Meteorological Awareness Project (EMMA project) 27

Hydromet Monitoring and Warning in the Italian Civil Protection System 29

Part II. Strengthening of Weather and Climate Services in Client Countries

Europe and Central Asia: Disaster Risk Mitigation and Adaptation Project (DRMAP) in Albania 34

Disaster and Climate Risk Management Project (DCRMP) in Moldova 36

Status of Hydromet Services in Georgia 39

An Introduction to Hydrometeorological Services in Central Asia 43

Central Asia Hydrometeorology Modernization Project (CAHMP) 47

Development of Hydromet Modernization Projects in the World Bank ECA Region 49

Africa: Coordinated Approach for Stakeholder Involvement in Climate Outlook Simulation 53

Closing Remarks 57

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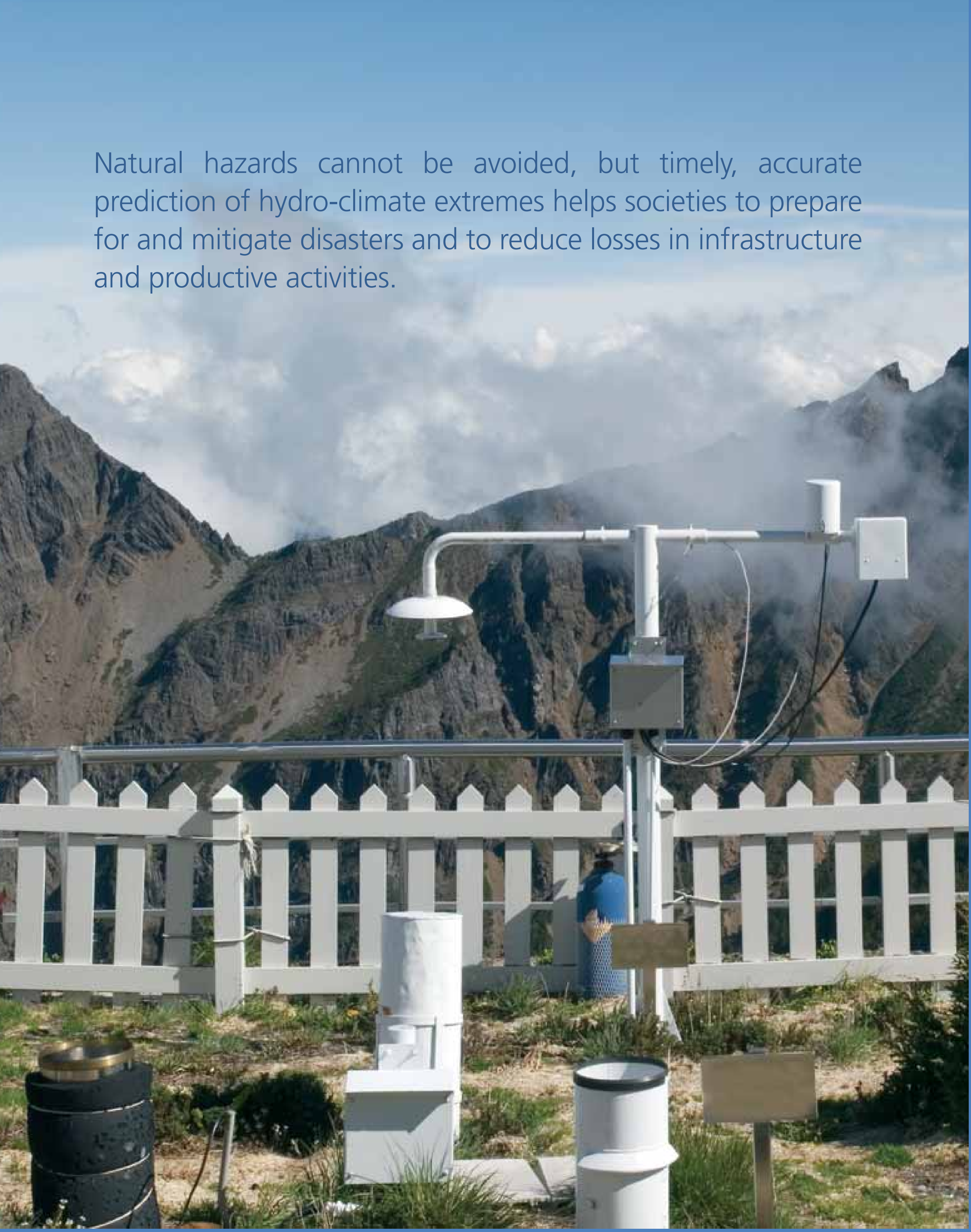


Introduction

Laszlo Lovei, World Bank, Director, Sustainable Development Department, Europe and Central Asia

Natural hazards cannot be avoided, but timely, accurate prediction of hydro-climate extremes helps societies to prepare for and mitigate disasters and to reduce losses in infrastructure and productive activities. Early warning systems and forecasts provide lead time, which together with public awareness, education and preparedness, can allow people to act quickly in response to hazard information, thereby increasing human safety and reducing the human and economic losses from natural disasters. To support governments in Eastern Europe and Central Asia to improve their early warning and forecasting capabilities, on March 12, 2012 the World Bank, the United Nations International Strategy for Disaster Reduction (UNISDR), and the World Meteorological Organization (WMO), came together to host a workshop—*"The Role of Hydrometeorological Services in Disaster Risk Management."* This one-day workshop focused on sharing best practices and experience in innovative and state-of-the-art hydrometeorological services and their use in disaster risk reduction mechanisms that can protect lives, livelihoods and assets.

Regional Context

Weather and climate hazards such as storms, heat waves, cold waves, floods and droughts cause more economic damage and loss of life than any other natural disasters. As some studies indicate, climate change could make such events even more severe. European and Central Asian countries are among those suffering considerable losses from natural disasters.

The importance of early warning systems in disaster risk reduction, especially mitigating flood losses, cannot be over emphasized—especially in the challenging atmosphere of climate change and the increasing occurrences of climate extremes. Early warning systems coupled with response, mitigation, awareness and preparedness are needed in many developing countries. Due to the current and projected impact of weather-induced natural hazards, the effective functioning of hydrometeorological systems is critical for disaster risk mitigation, preparedness and response.

Governments and regional organizations engaged in providing comprehensive hydrometeorological services are bolstering the efficiency of disaster risk management systems through the knowledge and experience they are acquiring. For example, many governments have made advances in the application of hydromet technologies and data for better management of disaster risk. The hydrometeorological services are also instrumental to several other sectors, such as water resources, hydropower, agriculture, transport, urban development, health and others.

To strengthen hydrometeorological (i.e. hydromet) services in Eastern Europe and Central Asia, the World Bank and other organizations are providing support to countries like Albania, Kyrgyz Republic, Moldova, Poland, Russia, Tajikistan and Turkey. These collective efforts are spurring global, regional and national initiatives in which emergency management agencies are sharing experiences and best practices across organizations.

In order to nurture and sustain this knowledge-sharing trend, *"The Role of Hydrometeorological Services in Disaster Risk Management"* brought together experience and expertise from European and Central Asian countries, WMO, UNISDR, the World Bank, European and U.S. institutions, as well as client countries. The first part of the workshop focused on best practices in hydro and weather hazard monitoring and early warning for extreme events. The second part focused on investments that are being undertaken by countries with World Bank support to strengthen weather and climate services for better disaster risk management.

This report contains the workshop proceedings, and is intended as a resource document for both practitioners and new comers to the field of hydrometeorological services in disaster risk management. Speakers' presentations can be found at: http://www.gfdrr.org/gfdrr/node/1083.

Part I

Best Practices in Hydro and Weather Hazard Monitoring and Early Warning for Extreme Events

Lessons Learned from Seven Good Practices in Multi-hazard Early Warning Systems and Standards for Meteorological, Hydrological and Climate Services

Maryam Golnaraghi and Mary Power,
World Meteorological Organization (WMO)

Socio-economic impacts of weather and climate-related extremes are on the rise, with statistics showing that extreme weather is increasingly impacting country economies. In the Caucuses and Central Asia, for example, the main economic sectors of many countries are directly impacted by meteorological, hydrological and climate-related hazards such as heat waves, forest fires, droughts, floods, etc. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the frequency and severity of these hazards are increasing because of climate variability and climate change.

The Hyogo Framework for Action (HFA) focuses disaster risk-management strategies into three principal areas: *risk identification, risk reduction* and *risk transfer*. The HFA stresses that successful disaster risk management should be supported by effective governance, legislation, legal frameworks and institutional capacities from the national to local levels. These capacities should be supplemented by effective information and knowledge-sharing mechanisms among different stakeholders. For weather- and climate-related hazards, this means that National Meteorological and Hydrological Services (NMHSs) should be focused on a comprehensive end-to-end service delivery that engages a multitude of stakeholders and agencies at the regional, national and local levels.

Need for Significant Capacity Development of NMHSs for Delivery of Meteorological, Hydrological and Climate Services

The changing characteristics of meteorological, hydrological and climate hazards and conditions combined with development decisions, are leading to increasing risks associated with such hazards, requiring multi-sectoral risk management—a capacity lacking in many at-risk countries. Science-based meteorological, hydrological and climate services are critical input for informed decision-making. According to a World Meteorological Organization 2006 survey to which 155 countries' National Meteorological and Hydrological Services responded:[1]

- Droughts, flash and river floods, strong winds and severe storms, tropical cyclones, storm surges, forest and wild land fires, heat waves, landslides, sand and dust storms, marine and aviation hazards, as well as rapid melting of the glaciers and potential risks to quality and quantity of water supply, are among the top hydrometeorological hazards of concern to members;
- Nearly 70 percent of countries require new or revised DRR policies and legislation to clarify the role of the NMHS;
- Over 65 percent of NMHSs need modernization or strengthening of their core infrastructure for observation, telecommunications and operational forecasting;
- Nearly 80 percent of NMHSs need guidelines, as well as management and technical training; and
- Over 80 percent of NMHSs need strengthening of their strategic and operational partnerships with various DRR stakeholders across various sectors and levels.[2]

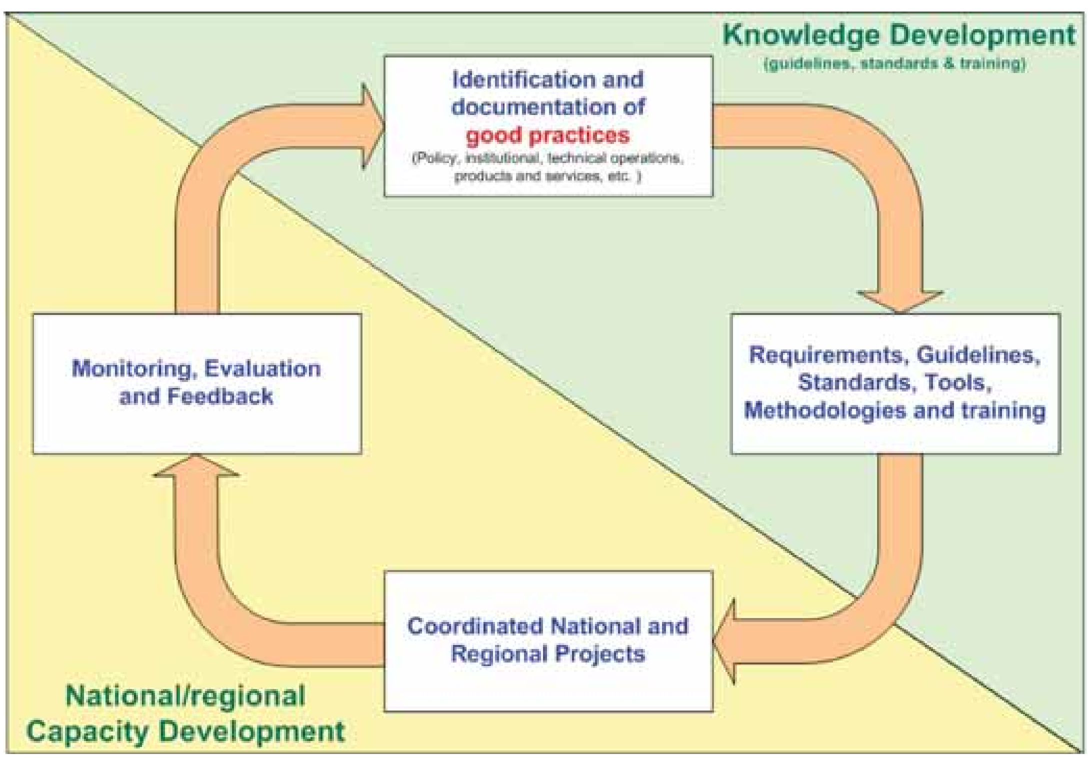
[1] WMO DRR Survey 2006: http://www.wmo.int/pages/prog/drr/natRegCap_en.html

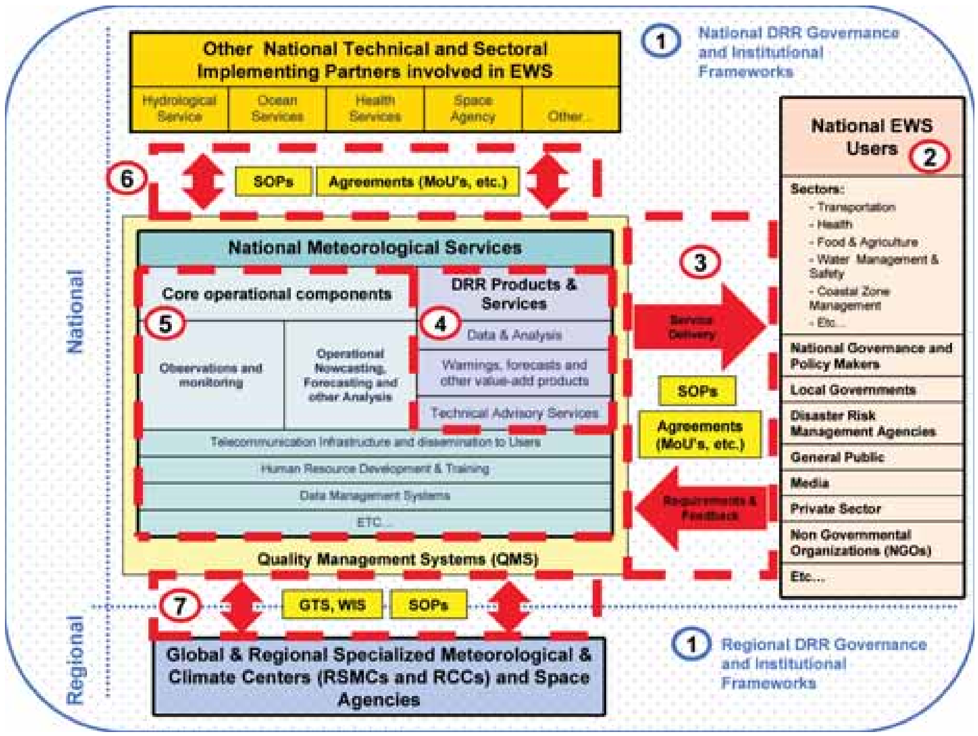
[2] Note: In terms of strengthening capacity, 80 percent of countries reported that they required (1) Tools, standards and technical and management training; and (2) The strengthening or building of multi-sectoral institutional partnerships and service delivery standard operating procedures (quality management systems and standard operating procedures).

World Meteorological Organization's Role in Disaster Risk Reduction

Disaster risk reduction is a priority for the World Meteorological Organization because the protection of lives, property and livelihoods is at the core of the priorities of the WMO Members and the National Meteorological and Hydrological Services. Furthermore, the implementation of the Hyogo Framework for Action by national governments is leading to changes in national DRR policies and legal and institutional frameworks, with implications for the role, responsibilities and new working arrangements for the NMHS. These changes provide opportunities such as increased recognition of the NMHSs by their governments and stakeholders, which could result in strengthened partnerships and increased resources. However, NMHSs face new challenges and liabilities related to the provision of products and services to larger and more diverse groups of DRR stakeholders (e.g. government authorities, public and private sectors, non-governmental organizations (NGOs), general public and media, etc.) who have direct responsibilities for DRR decision-making to support risk assessment, sectoral planning (medium and long term) and disaster risk financing including weather-indexed and catastrophe insurance.

WMO's strategic goals in DRR are derived from the Hyogo Framework for Action, pertaining to those high priority areas that fall under the mandate of WMO and NMHSs. WMO takes a cross-cutting approach to achieving its DRR objectives by: leveraging expertise, resources and capacities of beneficiaries and other supporting members, WMO technical programs and expert networks, WMO global and regional operational centers and other U.N. international and regional partners. The WMO DRR two-tier work plan (hereafter referred to as the DRR Work Plan) links, (i) Development of guidelines, standards and training modules for DRR thematic topics based on documentation and synthesis of good practices; and (ii) Coordinated DRR and climate adaptation national/regional capacity development projects, to strengthen hydrometeorological capabilities. WMO uses this two-tiered approach to the development of meteorological, hydrological and climate services capacities to support DRR and adaptation decision-making at the national, regional and global levels.





Comprehensive End-to-end Service Delivery

The potential relationships and exchange of information and knowledge involved in a comprehensive end-to-end service delivery are illustrated above. This figure shows a comprehensive service-delivery approach for National Meteorological Services to provide products and services to a variety of DRR users.

Through this approach, WMO aims to assist NMHSs to:

- Engage as relevant stakeholders in the national DRR and adaptation governance and institutional frameworks;
- Identify, prioritize, establish partnerships and service-delivery agreements with the national DRR user community (users) and develop mechanisms for engagement with the users for identification of requirements, delivery of products and services and for obtaining on-going feedback;
- Develop and deliver core and specialized products and services for DRR decision support (e.g. hazard/risk analysis, multi-hazard early warning systems (MHEWS), sectoral risk management and disaster risk financing and risk transfer) in a cost-effective, systematic and sustainable manner;
- Ensure that core operational capacities (e.g., observing networks, operational forecasting systems, telecommunications systems, data-management systems, human resources, etc.) are built upon the principles of quality management systems (QMS) to support product and service development and delivery;
- Establish partnership agreements with other national technical agencies (e.g. hydrological services, ocean services, etc.) as well as global and regional specialized centers (e.g. WMO Global Producing Centres (GPC), Regional Specialized Meteorological Centres (RSMCs), Regional Climate Centres (RCC), UNESCO-IOC Regional Tsunami Watch Centers, etc.);
- Engage in regional and global efforts for development of risk information for large-scale and transboundary hazards, through strengthened regional and global cooperation, information sharing, and engagement in regional DRR platforms and Regional Climate Outlook Forums (RCOFs), etc.;
- Use principles of quality management to deliver data and forecasts, products and services that meet quality control standards—for example ISO-9000 standards.

As a result of this two-tiered approach to knowledge and capacity development, WMO and its partners are engaged in producing a variety of resources. Together with the U.N. Development Group, the World Bank, and decision-makers from disaster management agencies and various economic sectors, WMO and partner countries are developing good practices in multi-hazard early warning systems and knowledge products and guidelines aimed at strengthening end-to-end service delivery pertaining to the provision of meteorological, hydrological and climate services to support risk assessment, sectoral risk management (e.g., land zoning, infrastructure planning, etc.) and disaster risk financing. WMO is also working with disaster risk management (DRM) agencies, agriculture, water, energy, health ministries and other government sectors to establish policy forums where all potential partners and NMHSs can collaborate and discuss climate and weather information needs to support decision-making.

Early Warning Systems Require Coordination across Many Levels and Agencies: reflected in national to local disaster risk reduction plans, legislation and coordination mechanisms

Early warning systems involve four elements, which need to be supported by governance, coordination mechanisms from national to local levels, and by appropriate infrastructure. These four elements include: (a) Observing, detecting and developing hazard forecasts and warnings; (b) Assessing the potential risks and integrating risk information in the warning messages; (c) Rapidly and reliably distributing understandable warnings to authorities, risk managers and the population at risk; and (d) Emergency preparedness and response to warnings at all relevant levels to minimize the potential impacts. These need to be coordinated across many agencies at national to community levels for the system to work. See the components of an effective early warning system (EWS) below. Failure in one component or

lack of coordination across the many agencies can lead to the failure of the whole system.

WMO has recently published a book, titled *"Institutional Partnerships in Multi-hazard Early Warning Systems: A Compilation of Seven National Good Practices and Guiding Principles"*, documenting different countries' good practices and experience in developing their early warning systems EWS[3]. A detailed synthesis of these good practices has revealed 10 principles common to all, irrespective of the political, social and institutional setting in each country. This initiative supports development and strengthening of early warning systems with systematic initiatives underway in a number of sub-regions.

Successful early warning systems generally adhere to these following 10 principles:

1. There is a strong political recognition of the benefits of EWS reflected in harmonized national to local disaster risk management policies, planning, legislation and government budgeting;

2. Effective EWS are built upon four components: (i) Hazard detection, monitoring and forecasting; (ii) Analyzing risks and incorporation of risk information in emergency planning and warnings; (iii) Disseminating timely and "authoritative" warnings with clarity on the responsibilities and mandate for issuance of warnings; and, (iv) Community emergency planning and preparedness and the ability to activate emergency plans to prepare and respond, with coordination across agencies involved in EWS, at national to local levels;

3. EWS stakeholders are identified and their roles and responsibilities clearly defined and documented within the national to local plans, legislation, directives, MOUs, etc., including those of the technical agencies such as the National Meteorological and Hydrological Services;

4. EWS capacities are supported by adequate resources (e.g., human, financial, equipment, etc.) across national to local levels and the system is designed and implemented accounting for long-term sustainability factors;

5. Hazard, exposure and vulnerability information is used to carry out risk assessments at different levels, as critical input into emergency planning and development of warning messages;

6. Warning messages are, (i) Clear, consistent and include risk information; (ii) Designed with consideration for linking threat levels to emergency preparedness and response actions (e.g., using color, flags, etc.) and understood by authorities and the population; and (iii) Issued from a single (or unified), recognized and "authoritative" source;

7. Warning dissemination mechanisms are able to reach the authorities, other EWS stakeholders and the population at risk in a timely and reliable fashion;

8. Emergency response plans are developed with consideration for hazard/risk levels, characteristics of the exposed communities—e.g., urban, rural, ethnic populations, tourists and particularly vulnerable groups such as children, the elderly and the hospitalized—coordination mechanisms and various EWS stakeholders;

9. Training on risk awareness, hazard recognition and related emergency-response actions are integrated in various formal and informal educational programs and linked to regularly conducted drills and tests across the system to ensure operational readiness; and

10. Effective feedback and improvement mechanisms are in place at all levels of EWS to provide systematic evaluation and ensure system improvement over time.

National/Regional Capacity Development Projects within an Integrated Service-delivery Model

To date a number of projects have been initiated by WMO with a number of partners around the world. The development of these projects is based on the following considerations:

[3] Golnaraghi, M (ed.), *"Institutional Partnerships in Multi-hazard Early Warning Systems: A Compilation of Seven National Good Practices and Guiding Principles"*, Springer Verlag Berlin, Heidelberg 2012, ISBN: 978-3-642-25372-0, Pp243.

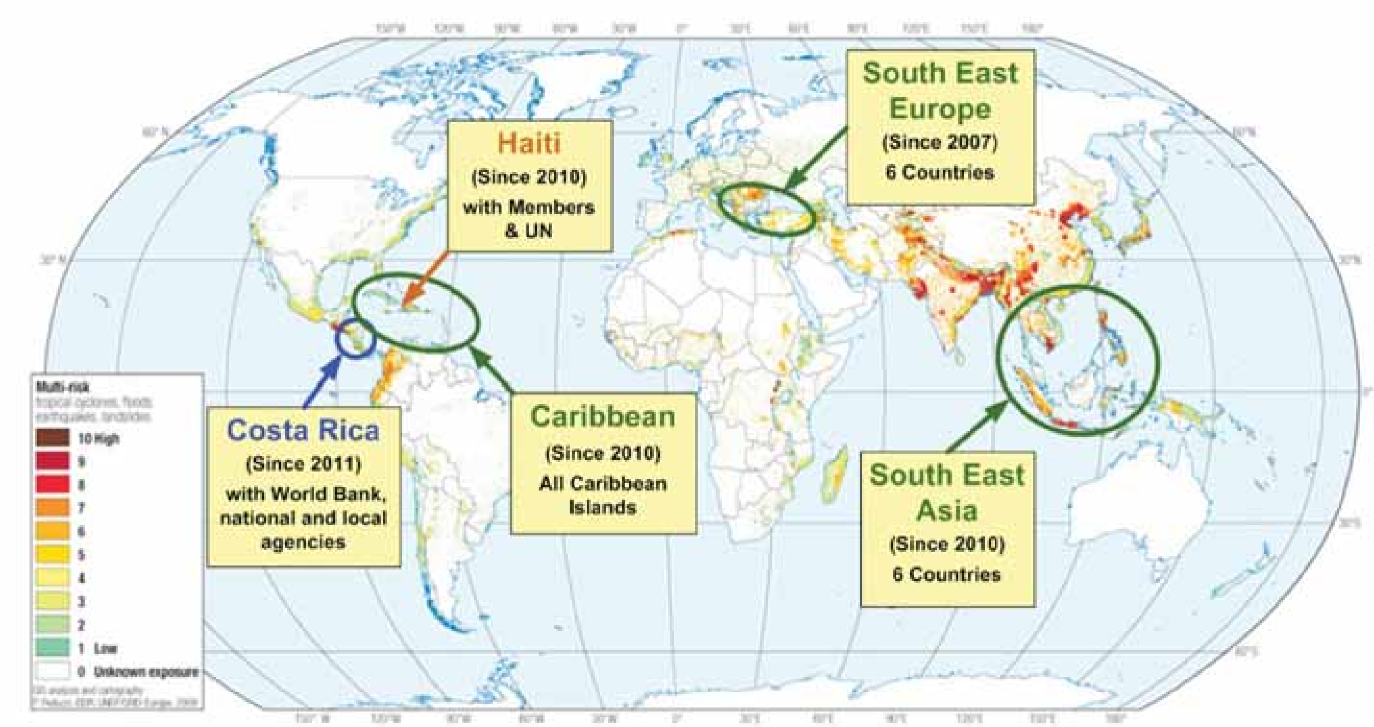
- Government interest, engagement and commitment to DRR and climate adaptation;
- Multi-stakeholder and multi-sectoral engagement and development of strategic alliances (national, regional, global);
- Engagement of WMO members and various regional and technical mechanisms, as well as the WMO globally-coordinated operational network;
- Partner and donor engagement from an early stage;
- Leveraging existing projects and their outcomes;
- User-driven assessment of gaps, needs, prioritization and requirements;
- National/regional development component:
    - National: DRR policies, institutional roles, partnerships, capacity development;
    - Regional: Strengthening of Regional Specialized Meteorological Centers (RSMCs) and Regional Climate Centers (RCCs) and cooperation with NMHSs;
- Integrated service delivery for development of meteorological, hydrological and climate services:
    - National: strengthening of NMHS, technical cooperation and development of products and services as per requirements of target users;
    - Regional: engagement and strengthening of RSMCc and RCCs and their cooperation with NMHSs;
- Sustainability.

Overall expected outcomes of these projects include:

- Increased clarity of the role of NMHSs in the national DRR institutional framework (planning, coordination, etc.) and linkage to the users who have direct responsibility with decision-making under the national DRR institutional frameworks;
- Increased coordination and cooperation at national and regional levels for provision of meteorological, hydrological and climate information to the targeted socio-economic sectors;
- Increased utilization and demonstrated benefits of meteorological, hydrological and climate knowledge in the decision-making processes of governments and targeted socio-economic sectors.

The main thrusts of these projects are:

- Engagement of NMHSs in the national DRR planning and institutional frameworks and reflection of the roles of NMHSs with partners such as the U.N.



Development Programme (UNDP) and the U.N. International Strategy for Disaster Reduction (UNISDR);

- Identification and prioritization of NMHS DRR users and establishment of agreements as per national DRR priorities and institutional frameworks;
- Assessment of DRR user needs and requirements for meteorological, hydrological and climate products and services;
- Development of relevant partnership agreements and alliances (national, regional, global);
- Modernization and/or strengthening of core capacities (e.g., observing network, operational forecasting systems, telecom, etc.) of NMHSs (with partners such as the World Bank);
- Development of products and services, underpinned by quality management system (QMS) principles:
    - Severe weather and marine services: Increased access to forecasting tools and severe weather warning services and utilization of related products by users;
    - Hydrological services: Increased access to national and regional flood-management information systems;
    - Climate services: Increased access to climate data, analysis tools and climate-forecast products and services.
- Data-management systems and data exchange: Increased regional dialogue and agreements for exchange of meteorological, hydrological and climate data and regional products (space, radar, etc.)
- Strengthened cooperation with RCCs, RSMCs and Regional Drought Management Centers;
- In-country technical support and feedback;
- Phased implementation and evaluation and expansion.

Moving Hydrometeorological Development Forward

Moving the development of the hydrometeorological services agenda forward is not without difficulty. The challenge is how to engage the NMHSs to align themselves with the pulse of their respective government and its development priorities. Instead of being a technical push of information, the NMHSs should proactively engage the end-users to ensure that they get relevant information for their decision-making. Many government infrastructures could benefit from strengthened cooperation and participation from NMHSs to incorporate science-based information into their decision-making. Encouraging government sectors to work together (for example, to share data for mutual benefit) is fundamentally needed, especially to address multi-sectoral, multi-level, multi-hazard decision scenarios confronting the governments for better management of their disaster risks.

The development and strengthening of technical agencies such as the NMHS has to be considered an investment towards development[4]. The role of these agencies with respect to provision of meteorological, hydrological and climate-hazard information to support risk assessment, early warning systems, medium- and long-term sectoral risk management and risk financing such as weather indexed insurance should be recognized and reflected in the national development plans for DRR. Investments need to be directed to strengthening core infrastructure for monitoring, forecasting and human resources of these agencies to meet their mandates and provide the critical information that is needed. WMO (in parallel) is endeavoring to establish or strengthen regional meteorological and climate centers that support NMHSs through the provision of a variety of "guidance" products and tools.

WMO in partnership with the World Bank and other development partners is able to assist country NMHSs in modernizing and strengthening hydrometeorological services and facilitating regional cooperation fundamental to the ability of countries to successfully and effectively manage their weather-, water- and climate-related risks.

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[4] This was also a recommendation of the recently published report by the World Bank and the UN, on *"Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention"* (2010).

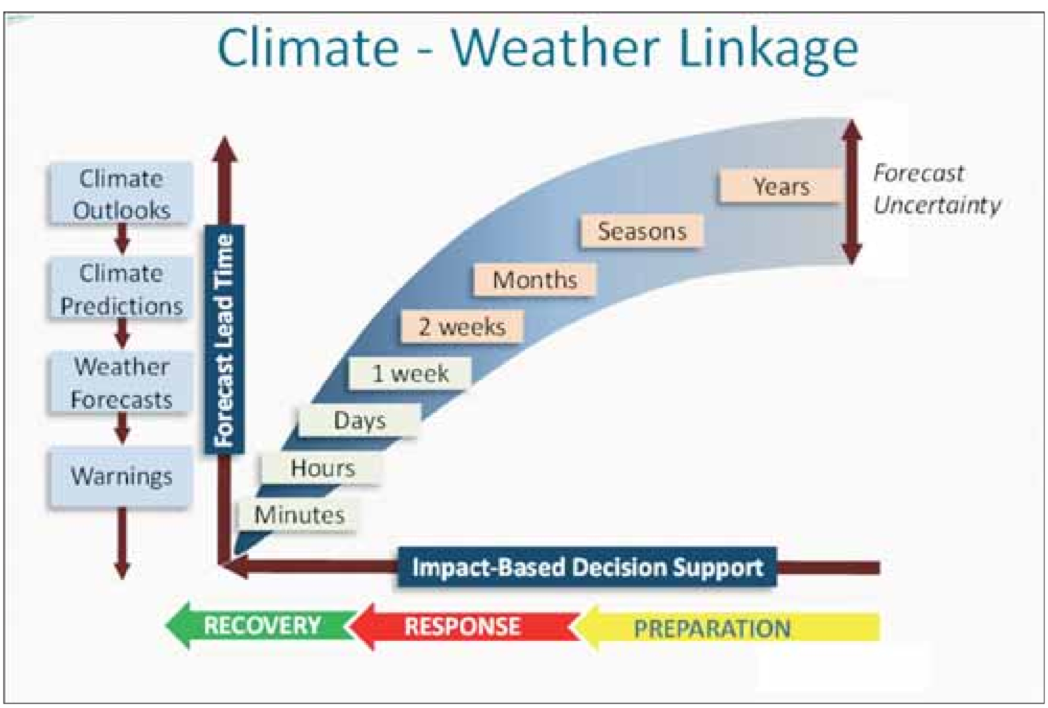
Application of Climate Models in Improved Decision Support Services

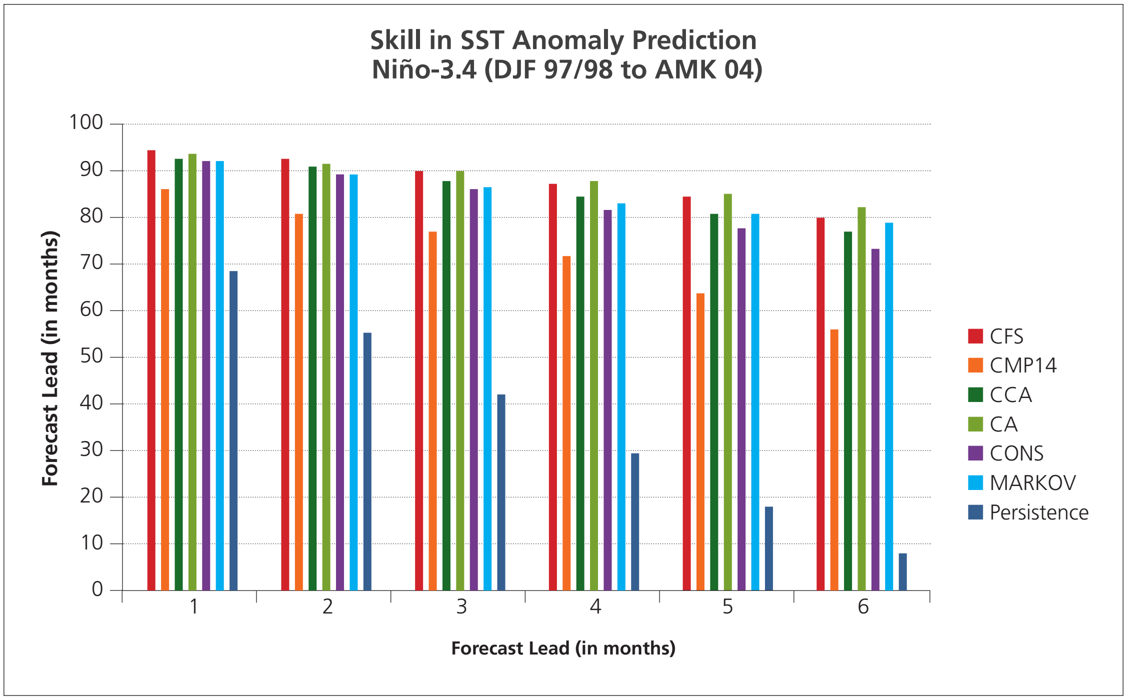
Wassila Thiaw, **National Oceanic and Atmospheric Administration (NOAA)**

Many human threats could be better predicted if partnerships between the operational climate community and users of climate information could be strengthened. The Weather Service's Climate Prediction Center at the United States National Oceanic and Atmospheric Administration (NOAA) seeks to link the meteorological community with decision-makers across the globe, so that they understand uncertainties in forecasts and learn to manage them effectively. Linking climate signals to weather and water impacts could have tremendous decision-support value for agriculture, health, water and many other sectors.

The Role of NOAA in Improved Decision Support Services

Decision support services can begin at the climate outlook scale. The timeframes that climate outlooks consider range from seasonal to multi-year. Climate outlooks are expressed in tercile probability forecasts of temperature and or precipitation for a given area and for three different categories for above, near-average and below average. So, for example, precipitation forecasts are expressed in terms of tilt in the odds to favor either the above-average category, the near-average, or the below-average category in the next three months. With outreach, partners will be able to understand the uncertainties in the long-range outlooks and factor this uncertainty into the decision-making process. Preparatory actions can also begin at long lead times when climate signals have been identified. For instance, emergency managers can prepare for flood/drought, hurricanes; health managers can preposition medical supplies; water managers can better prepare for arid conditions. NOAA's core capabilities include observing, monitoring and predicting climate and weather, which enable these sectors and others to respond and perform better to climatic variability.





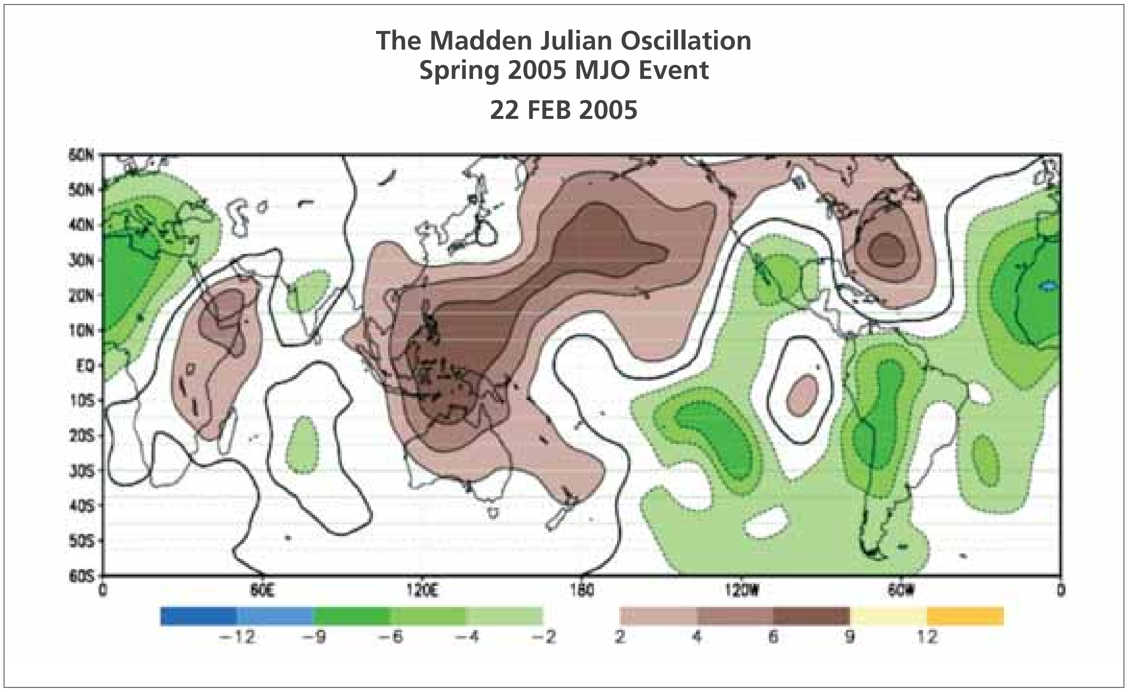
Climatic Models

Climate models are getting increasingly skillful. There are several climate-prediction models that can be used to predict for temperature and precipitation anomalies and can bolster decision-support services. One model is the National Centers for Environmental Prediction (NCEP) Climate Forecast System (CFS). The most predictable climate signal is the El Niño Southern Oscillation (ENSO), which has a major impact on the climate of many parts of the world, especially in the tropics. Prediction skill of ENSO at one month lead in the NCEP CFS is about 0.9 and surpasses the previous NCEP dynamical model the CMP14 and all other statistical models (See figure above). A better understanding and prediction of ENSO has also led to improved seasonal forecasts in several regions. In the case of precipitation for example, correlation between the observations and the forecasts reach about 0.6 or even 0.7 at some locations, increasing the level of accuracy in the forecasts. Such high-skill forecasts can be used effectively in decision-making, However, forecast skills tend to be lower as lead time increases, such that a four-month lead forecast will be less accurate than a one-month lead forecast. However, there are times when the climate signals are not strong and the forecast is weak or tilted toward near-average conditions. Such information is still useful, but requires careful monitoring of the state of the global climate so that rapid changes in the climate system can be taken into account in preparatory actions.

Skill in Seasonal Surface Temperature (SST) Anomaly Predictions

The **Madden Julian Oscillation** (MJO) (time scale roughly 2-3 weeks) is another climate signal that is extremely useful for predicting extreme events such as hurricanes and torrential rains at lead times of one to three weeks. It is a global-scale wave that occurs in the tropics but can also expand into the temperate latitudes. The MJO has alternating phases of increased rainfall and suppressed rainfall. the chart on the next page is an example of an MJO event. Predictions of the MJO have tremendous value in enhancing predictions of precipitation and temperature at shorter lead times.

The Arctic Oscillation (AO) or North Atlantic Oscillation (NAO) is a third example of a climate index that can be used to predict precipitation and temperature patterns at shorter lead times between one and two weeks, especially in a temperate climate. The NAO index is such that surface temperatures tend to be below normal during the negative phase and above normal during the positive phase of the NAO.



Way Forward

NOAA has established the following priority action areas to strengthen decision-support services:

- Develop capacity to respond to short-term climate variability and extreme weather events;
- Track and share data on environmental conditions related to climate variability and change;
- Expand capacity for modeling and forecasting flood/ drought effects;
- Build on existing model production suites (e.g. NOAA);
- Provide high-gig resolution regional models and downscaling;
- Train an interdisciplinary work force knowledgeable about climate signals that are linked to flood/ drought impacts.

To support these actions, the Climate Prediction Center (CPC) has launched a Residency Training Program. Funds obtained from both the United States Agency for International Development (USAID) and the U.S. State Department are used to train meteorologists from various African country NMSs. Each student is trained for four months for each desk (Africa, South America, Central America and the Caribbean and Indian Ocean) and in general 24 students (meteorologists) are trained each year.

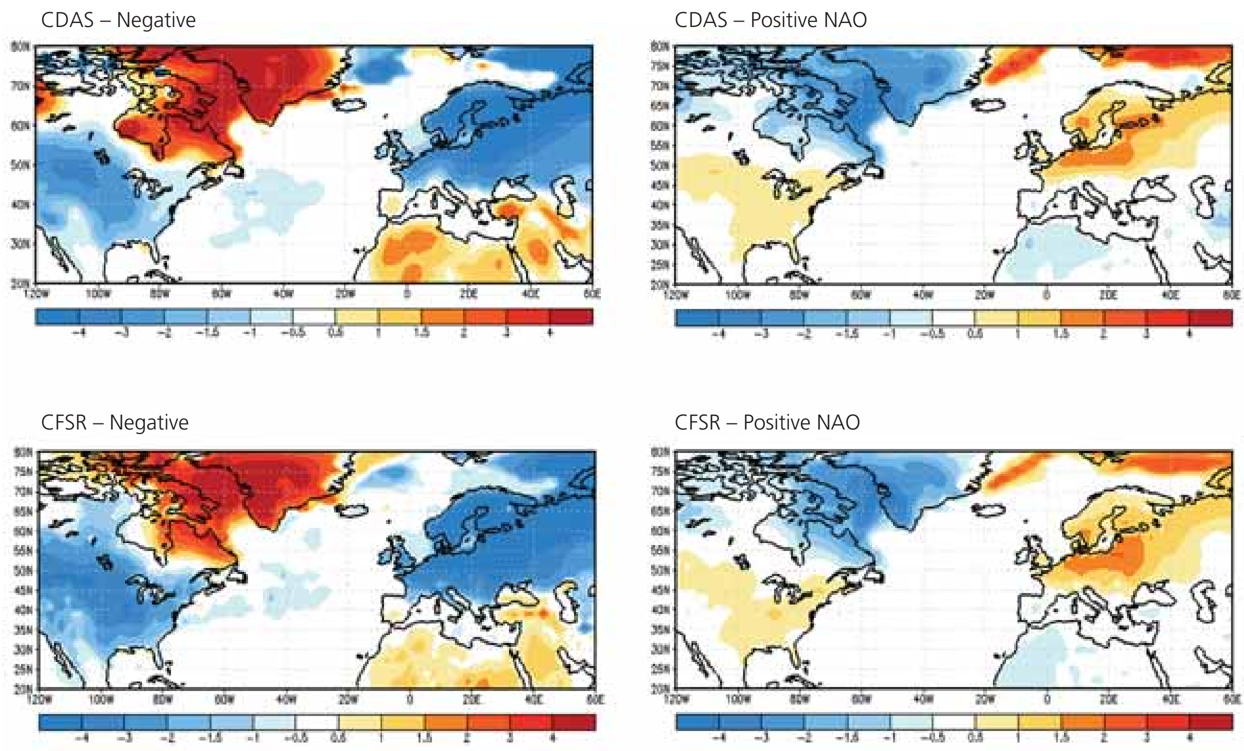
CPC is also providing rainfall forecasts to monitor drought conditions in Africa and supports the WMO Severe Weather Forecasting Demonstration Project (SWFDP) to improve forecasts and early warnings of high-impact threatening weather. The recent Horn of Africa drought was clearly predicted with a long lead time which allowed early intervention of food and emergency relief to the large population affected.

Additionally, CPC is expanding decision-support services to African countries by developing and improving the following products that directly threaten human safety:

- Forecasts of persistent rainfall deficits;
- Forecasting high frequency rainfall events;
- Extreme temperatures;
- Changes in humidity and pressure;
- Winds.

Finally, the goal is to expand the capacity of modeling using high-resolution climate models that are downscaled to regional models. In order to achieve this, there will need to be a significant increase in data in regions such as Africa.

Surface Temperature with



Advances in Hydrologic Forecast and Flood Warning Services

Edward Clark, **NOAA National Weather Service Office of Climate, Water and Weather Services**

The National Oceanic and Atmospheric Administration, (NOAA) is helping the United States build a weather-ready nation by providing forecasts and warnings for the U.S. and its territories with emphasis on outreach to the public and increasing public awareness of hazards and risks. This mission is increasingly important, as population growth and economic development continue to stress water supplies and increase vulnerability.

A changing-climate regime is also impacting the quantity and distribution of water supplies. Coastal communities face unprecedented demands to manage threatened water resources and fragile ecosystems, while other communities face escalating vulnerability and risk of being threatened by floods and droughts.

In order to identify, analyze and respond to these risks, NOAA has established forecasting centers throughout the U.S., with many in the Washington, D.C. area, where NOAA has its headquarters. The National Weather Service (NWS) is the organization within NOAA with primary responsibility for forecasting and providing warnings to the public. The NWS produces hydrologic forecast products and services—for flash floods, river floods and water supply/drought.

As seen on the next page, the NWS is organized into six administrative regions, with 13 River Forecasting Centers (RFCs) and 120 Weather Forecast Offices (WFOs). The RFCs provide river and flood forecasts for 4000 locations on rivers, water supply forecasts for mountainous areas that have snow, and support flash flood warnings. The WFOs operate 24 hours a day, seven days a week and provide weather forecasts, flash flood watches and warnings, river forecasts and warning services delivered to users, local outreach and education, flood verification and event-based decision warning.

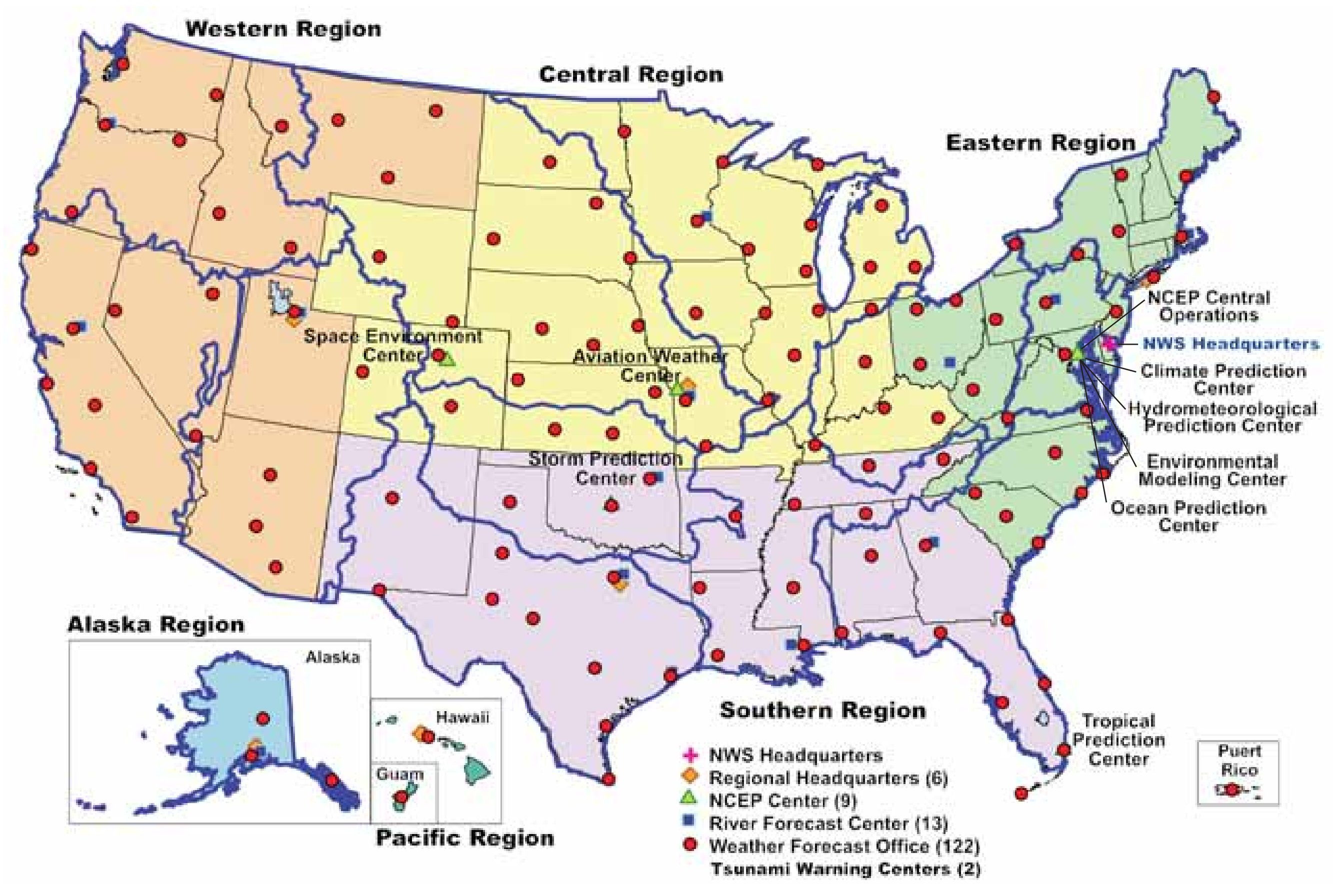
Mission

- "NOAA's NWS provides weather, hydrologic and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy."

NOAA Weather-ready Nation Objectives

- Reduced loss of life, property and disruption from high-impact events;
- Improved freshwater resource management;
- Improved transportation efficiency and safety;
- Healthy people and communities due to improved air and water quality services;
- A more productive and efficient economy through environmental information relevant to key sectors of the U.S. economy services.

NWS Operational Infrastructure



Hydrological Services Roles and Responsibilities

The National Weather Service has several centers and components involved in providing hydrological services.

There are three National Center for Environment Prediction centers (NCEP) that provide national guidance and analysis:

- Hydrometeorological Prediction Center (HPC);
- Storm Prediction Center (SPC);
- Climate Prediction Center (CPC).

River Forecast Centers (RFCs) operate and manage a regional hydrologic model. Their activities include: multisensor precipitation analyses; quantitative precipitation forecast (QPF); hydrologic modeling at gauged points; and routine multi-agency collaboration. Their outputs generally include: river forecast guidance (deterministic and probabilistic) with extended service/hours during flood events; flash-flood guidance; and water-supply forecasts.

Weather Forecast Offices (WFOs) are responsible for local monitoring and warning, and provide weather forecast and hazard warnings like flash-flood watches and warnings and river forecasts and warnings. In addition, WFOs have a strong role in local outreach and education (service hydrologist, hydro focal point or warnings-coordination meteorologist); flash-flood and river-flood verification (local storm reports and storm data reports); event-based decision-support services with federal, tribal, state and local agencies; and web service delivery.

As depicted in the graphic (at the top of page 15) these three components of the NWS are essential for an effective warning system.

Product Dissemination

Disseminating forecast and hazard information is vital to empowering people to respond. NOAA has several principal methods for disseminating its products, including:

- Internet (http://www.weather.gov/);
- NOAA Weather Radio All Hazards;
- Emergency Managers Weather Information Network;
- NOAA Weather Wire Service;
- NOAAPORT;
- Emergency Alert System (EAS);
- Broadcasts by local media partners.

Additional details are provided below:

NOAA Weather Wire Service (NWWS) is a satellite data-collection and dissemination system operated by the National Weather Service (NWS). Its purpose is to provide state and federal governments, commercial users, media and private citizens with timely delivery of meteorological, hydrological, climatological and geophysical information. The vast majority of NWWS products are weather and hydrologic forecasts and warnings issued around the clock from 141 NWS offices nationwide.

NOAA Weather Radio All Hazards (NWR) is a nationwide network of radio stations broadcasting continuous weather information directly from the nearest National Weather Service office. NWR broadcasts official Weather Service warnings, watches, forecasts and other hazard information 24 hours a day, seven days a week.

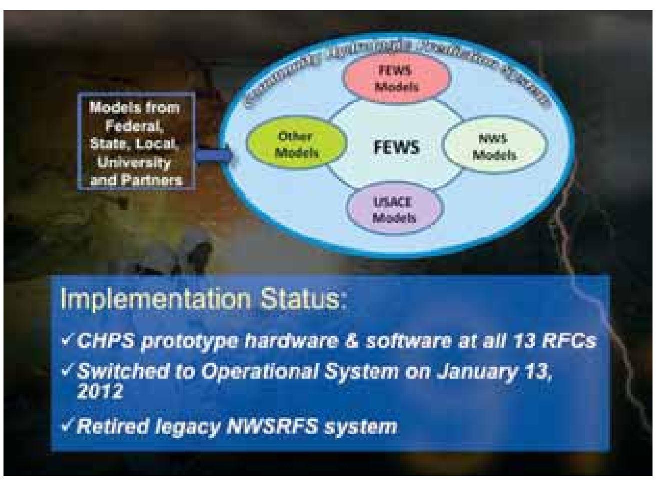
The **NOAAPORT** broadcast system provides a one-way broadcast communication of NOAA environmental data and information in near-real time to NOAA and external users. This broadcast is implemented by a commercial provider of satellite communications utilizing the C-band. It's primary purpose is to provide internal communications within the National Weather Service and for providing forecasts, warnings and other products to the mass media (newspapers, radio stations, TV, etc.), emergency management agencies and private weather services.

The **NOAAPORT satellite communications system** is operated by GTE Corp., under contract to the NWS. The system uses satellite transmitting (i.e. "uplink") equipment at NWS forecast offices throughout the continental U.S., Alaska, Hawaii and Puerto Rico. Each uplink site transmits NWS-generated weather information products which are then re-broadcast via satellite to users.

The **Emergency Alert System** (**EAS**) is a national public-warning system that requires broadcasters, cable television systems, wireless cable systems, satellite digital audio radio-service (SDARS) providers, and direct-broadcast satellite (DBS) providers to provide the communications capability to the U.S. President to address the American public during a national emergency. The system also may be used by state and local authorities to deliver important emergency information, such as AMBER alerts (child abduction emergency) and weather information targeted to specific areas.

Partnerships Promoting Public Safety

For nearly three decades, the NWS has been using a closed system for hydrologic forecasting, which has constrained incorporation of new science and technology developed by our federal partners and by universities. NWS is turning that around with the Science and Technology Community Hydrologic Prediction System (CHPS)—an open service-oriented (open modeling) architecture that facilitates the incorporation of new tools and information, and makes it possible for the first time to establish interoperability with our federal partners. This new CHPS river and flood-forecasting system includes two-dimensional flood-mapping capabilities so users can visualize flood impacts in their community. An online interactive-map website shows the extent and depth of flooding. Already, 666 inundation flood maps have been developed in the U.S. for flood-prone locations.



CHPS provides the foundation that will enable future science and technology enhancements. FEWS is the software system through which Integrated Water Resource Science and Services will foster broader collaboration across multiple agencies. FEWS provides standard system infrastructure, data formats, and adapter mechanisms to allow modules to "talk to" one another.

Flood Inundation Mapping Services

The Flood Inundation Mapping Services provided by NOAA in partnership with the U.S. Federal Emergency Management Agency (FEMA), the United States Army Corps of Engineers, (USACE), the United States Geological Survey (USGS), states and others have resulted in 66 flood inundation map libraries to date. The libraries include NWS flood-severity categories and regulatory FEMA flood-frequency maps.

The Flood Inundation Mapping Services:[5] provide spatial extent and depth of flood waters; display inundation maps for levels from minor flooding through flood of record; better mitigate impacts of flooding and help build more resilient communities.

The **Hydrologic Ensemble Forecast System** (HEFS) is a probabilistic-modeling system being developed to support mitigation and planning efforts that enables short-term to long-term ensemble (probabilistic) forecasts. The probabilistic atmospheric-prediction models are input to probabilistic hydrologic-prediction models. Presently, NOAA is demonstrating components of short-term capability at six River Forecast Centers and will deploy additional prototypes over the next two years. The initial version of full capability is expected in 2014.

Integrated Water Resource Science and Services (IWRSS) is an interagency initiative involving NOAA, USGS and USACE aimed at developing high-resolution water-resources models that are linked to decision-support tools. IWRSS will integrate information and streamline access; share technology, information, models, best practices; develop system interoperability and data synchronization; create a common operating picture; increase accuracy and timeliness of water information; and provide new summit-to-sea high resolution water-resources information and forecasts. This includes tracking summit-to-sea hydrological flows.

Summit-to-sea Five-point Strategy

NOAA began making high-resolution summit-to-sea water-resources products about eight years ago as part of the National Operational Hydrological Remote Sensing Center's (NOHRSC) national snow analyses

[5] water.weather.gov/ahps/inundation.php

pilot (one kilometer hourly resolution gridded snowpack information—www.nohrsc.noaa.gov). These products provide users with comprehensive snowpack information that can be interpreted at individual points as well as over large regions. In the few short years since we initiated this product, interest has grown substantially. Today, these products receive over 30 million hits per month, and are used by a wide array of stakeholders.

IWRSS will expand on this concept to include a comprehensive suite of water variables that span the past, present and future (predictions), at four times greater resolution (500 meters). Through the IWRSS partnership, we'll be working closely with the USGS on the National Water Census, which will focus on analyzing past water trends, while we focus on what will happen in the future. Together, this information will be critical for helping communities understand risks and develop resilience to variations in water supplies (too much or too little), and develop agility to adapt to uncertainty and change.

The first phase of IWRSS focuses on establishing system interoperability and data synchronization that allows common data access and use. As of March 2012, the IWRSS Memorandum of Understanding among USGS, NOAA, and USACE is in place; groundbreaking work is occurring on the National Water Center; the National Flood Inundation Mapping Services Project is operational; and a system-interoperability and data-synchronization demonstration has occurred.

National Water Center

NOAA is constructing the IWRSS National Water Center (NWC) at the University of Alabama, Tuscaloosa. This center will combine hydrologic forecasting operations and research to fill several critical gaps, including: providing new high-resolution forecasts of water-resource variables to help decision-makers better manage water; extending river and flood forecasting to provide maps showing forecasted spatial extent and depth of flooding; integrating water-resources information to provide one-stop shopping for stakeholders (federal toolbox); and establishing a common operating picture among agencies. The facility will be 58,000 square feet, with full occupancy of 200 staff. The facility will include an operations center for water analysis, forecasting and decision support; applied water resources research and development center; geo-intelligence laboratory; and a distance-learning center.

This facility will be unique in the world, providing a combination of water-forecasting operations, water-resources-support functions, and research and development to help advance integrative and adaptive water-resources management. The facility will likely house an operations center to provide water-resources forecasts and situational awareness of water issues across the country. It would be the IWRSS nerve center to help establish a common operating picture among federal water agencies and stakeholders, and would provide a single portal to enable one-stop shopping for water information. This is intended as a joint facility, with staff from NOAA as well as partner agencies to facilitate the integrative goals of IWRSS.

Future Concepts of Service

By 2020, NOAA hopes to have made several major advances in emergency-management and water-resources services. Today, RFCs focus on river forecasts. In the future, RFCs and the NOAA Water Center will focus on the full spectrum of water-resources services.

The creation of the NOAA (Interagency) Water Center (NWC) will address several critical IWRSS objectives:

- Unique facility combining water-resource forecasting operations, national support and research and development;

- Produce, in partnership with field offices, new high-resolution forecasts of critical water-resource variables to help decision-makers optimally manage our increasingly limited water supply (e.g. snow-water equivalent precipitation, stream flow, soil moisture, evapotranspiration, snow-pack runoff, ground water, surface storage, water quality);
- Extend, in partnership with field offices, river and flood forecasting (currently limited to selected points on rivers) to provide maps showing forecasted extent and depth of flooding and include uncertainty information—which can be easily used by partners/stakeholders to show the risk of inundation of critical infrastructure (e.g. evacuation routes, hospitals, shelters, etc.);
- Implement system interoperability and data synchronization to enable a common operating picture within NOAA and among federal agencies for flood forecasting and integrated water-resource management;
- Integrate critical water-resources information (currently scattered across multiple federal agencies) and provide one-stop shopping for stakeholders;
- Leverage multi-agency capabilities and establish a multi-agency proving ground to accelerate transition of research to operations.

Making advances in hydrological forecasting is not without its challenges. Tensions exist between investing resources in improved modeling and data services versus effectively communicating risks and hazards to the public. For instance, responding to climate change and the changing patterns of hazards may require a greater focus on impact analysis and projections over historic occurrence. NOAA relies on data inputs from USGS and the Army Corps of Engineers, which also requires substantial interagency coordination and collaboration. In contrast, efforts to improve risk communication require working with social scientists to understand how the public understands and responds to risk. This focus is made more pressing due to the burgeoning number of data sources and tools available to people with proper dissemination and end-user capacity building.

Significant improvements in the accuracy and lead time of hydrologic forecasts is being realized because of better science, improved technology and systems applications, the introduction of visualization of forecasts through flood mapping and through the development of integrated approaches to coordination among federal water agencies and partners.

Preparedness and Response to Mitigate Flood Losses in the United States

Doug Bellomo, U.S. Federal Emergency Management Agency (FEMA)

The U.S. Federal Emergency Management Agency (FEMA) supports U.S. citizens and first responders to manage natural hazards (preparedness, mitigation, response, recovery). Not only does FEMA help after a disaster, but its mitigation programs are active throughout the emergency-management cycle.

Within FEMA, the Risk Analysis Division is responsible for:

- Flood-hazard mapping as part of the National Flood Insurance Program (NFIP);
- Working with state, local and tribal governments to develop mitigation plans;
- Implementing the National Dam Safety Program; and
- Maintaining a strong risk-assessment capability within the emergency-management community.

These efforts were unified under a single initiative in 2009 called Risk Mapping Assessment and Planning (Risk MAP).

Federal Emergency Management Agency Mission

Support our citizens and first responders to ensure that as a nation we work together to build, sustain and improve our capability to prepare for, protect against, respond to, recover from and mitigate hazards.

Risk MAP is focused on combining these efforts in a way that improves U.S. capability to manage flood risk and begins to expand that capability to other threats and hazards. Investments in flood-hazard data developed under the National Flood Insurance Program (NFIP) are leveraged to create a picture of flood risk at a watershed level. That information is supplemented, where applicable, with dam-safety information. Dialogue about ways to manage that risk moving forward begins to draw people from the emergency-management community, land-use and other planners, as well as local decision-makers, engineers and scientists. The result—beyond updated flood-hazard information for the NFIP and improved state and local mitigation plans—is a more-informed public engaged in actively managing their flood risk moving forward.

The Process and Desired Outcome

Using resources provided by the federal government, and flood-risk data developed at a national scale, FEMA works with states to identify where Risk MAP projects make the most sense. Once areas of study are identified, FEMA and its partners work with local- and regional-government organizations to better understand the flood risk-management capability and data gaps. Flood risk is then quantified in economic terms—such as expected annual flood losses—using new or existing flood-hazard data. It's important to provide understandable risk communication at the local level. The 100-year flood-frequency concept is an example of how the public's interpretation of this concept becomes a problem in identifying the risk associated with flood magnitudes and frequencies. It is clear that the public does not understand the 100-year flood concept.

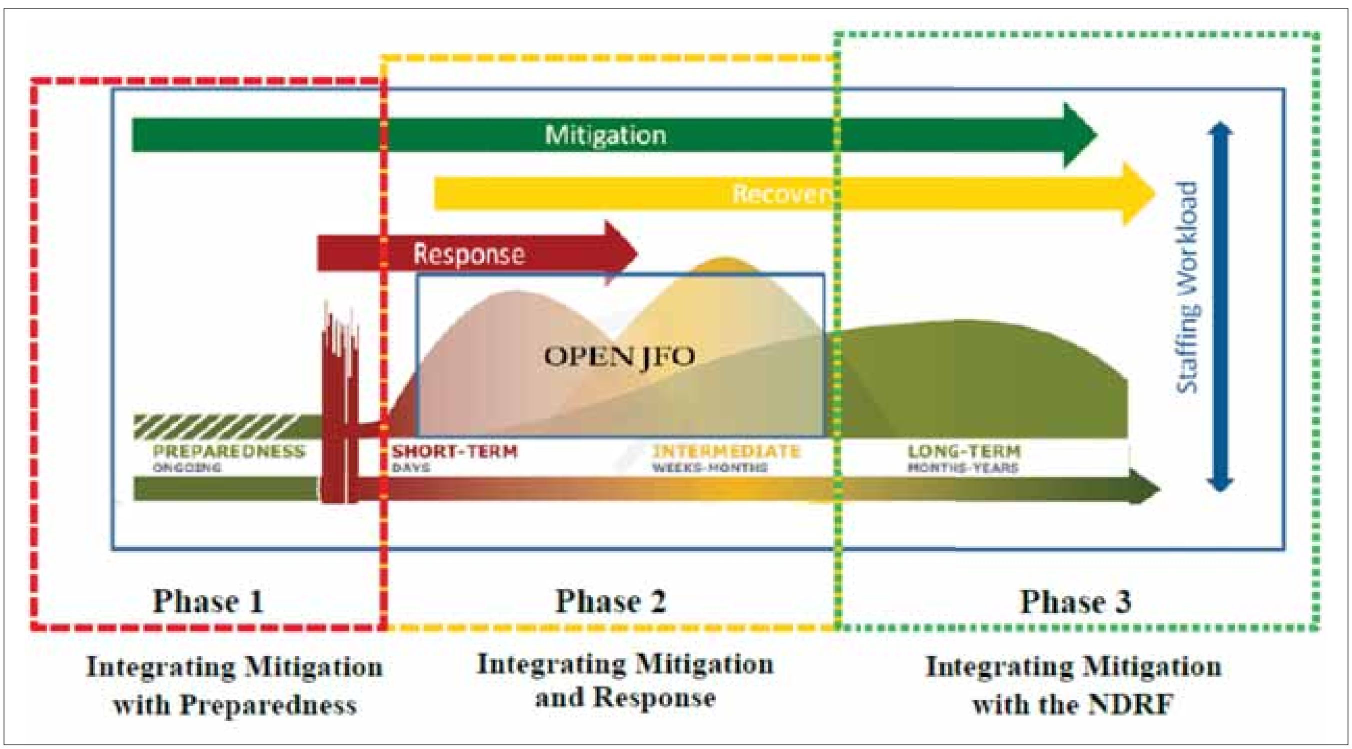
Concurrent with this process, scientists and engineers identify flood-risk mitigation opportunities. This information is then presented to local decision-makers and the broader public as a way of facilitating dialogue aimed at increasing resilience by raising flood-risk awareness and promoting actions which lead to improved flood-risk management capability or reduced risk moving forward.

Conclusion

In addition to a more informed public focused on reducing flood risk, FEMA is creating an environment where relationships among emergency managers, first responders, preparedness professionals and local land-use planners can be forged and reinforced.

Emergency management is more than good response and recovery. It includes working toward more disaster-resilient and sustainable communities. Improved resiliency and sustainability are achieved through strong risk-management capabilities to include all stakeholders.

As the graphic below depicts, the Risk MAP is working to build those capabilities as part of a broader emergency-management discipline. The environment demonstrates how an effective risk-management framework could be used to bridge the gap among these different yet interconnected disciplines. When done effectively, everyone involved becomes better prepared to respond to and recover from the next disaster—regardless of its type.



Technology of Stream Measurement, Monitoring and Visualization of Information

Saud Amer and Robert R. Mason Jr.,
U.S. Geological Survey (USGS)

Flooding is the greatest disaster faced in the United States. Floods occur in all 50 states and are threats for all months of the year. Floods cause more fatalities than any other weather-related phenomenon, with over half those fatalities occurring to people in vehicles caught in flash floods.

USGS Streamgages and National Weather Service (NWS) Forecast Locations

Streamgages are operated for many purposes. One of the more important purposes is flood forecasting. The USGS accounts for 97 percent of NWS river-forecast locations. Every six hours the NWS downloads USGS water-level hydrographs for some 3,000 USGS streamgages to calibrate their rainfall-runoff models. These models combine the National Weather Service rainfall, temperature and soil-moisture forecasts to forecast river **FLOW**. In order to turn the flow forecast into a forecast of river **STAGE**, they use the USGS stage-flow rating.

A rating is developed by visiting the site to physically measure the depth, width and velocity of the water at 25-30 locations across the stream. Streams are measured every six weeks or so and during floods and droughts. The flow measurement is plotted against the concurrent river stage to create the rating. The problem is that ratings change as channel conditions change. When a channel scours or fills, the cross-sectional area of the channel changes; when vegetation grows or dies off it changes the channel roughness. USGS flow measurements track those changes and allow us to shift the rating. Without USGS measurements the river-stage forecast would no longer be correct.

Maintaining the rating is the operational focus of the USGS streamgage network. Streamgages monitor stream stage (the height of the water), not flow. USGS hydrographers measure flow (depth, width and velocity) when they visit streamgages (generally monthly). The hydrographer correlates a series of measured flows with the concurrent stages to develop a "stage-discharge rating". River-flow records are computed by adjusting the rating as necessary so that it is current with stream conditions and applying the stage record to the rating. The problem is that ratings change because streams change. Hence there is a need to continually update the rating. In fact, the chief business of the streamgage is to keep the rating current. That activity keeps USGS busy and is costly.[6]

Recent Developments in River-flow Management

The most important recent development in river-flow measurement has been the development and miniaturization of hydroacoustic technologies. Previously, streamflow measures (using sonar and radar) took 96 minutes; with acoustic technologies streamflow measurement can now take 18 minutes on average.

Hydroacoustic instruments measure velocity based on the Doppler principle. That principal takes advantage of the shift in frequency (pitch) of sound emitted by or reflected from, a moving object. (One experiences the Doppler principle when one notices the shifted pitch of a car horn as a car passes by.) Hydroacoustics are fast and accurate. They can be fitted onto boats and towed, or tethered from a bridge. They used to be limited to deep water. But now they can be used in shallow waters. USGS is also fitting small, rugged acoustic-velocity meters to wading roads for use in very shallow water.

Here is a simple example of the impact that hydroacoustics can have on streamflow measurement. In 1991, before hydroacoustics were widely used, USGS needed

[6] USGS streamgage data for 7800 streamgages and for NOAA NWS stream-forecast points can be obtained from the Internet http://waterwatch.usgs.gov/

a staff of 10 to make the same number of flood measurements that is now done with a staff of six.

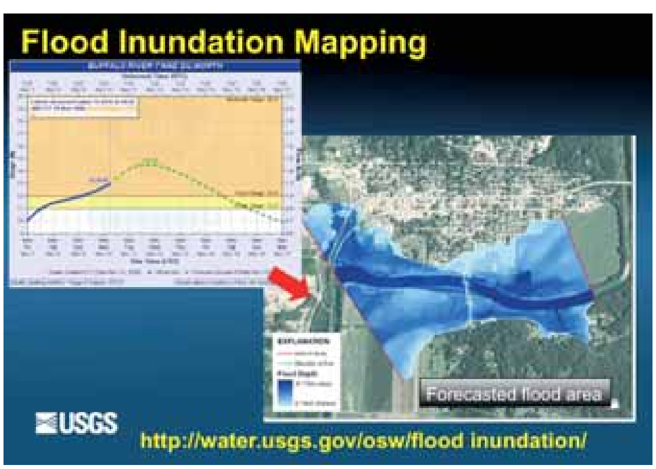
Before Acoustics (1991)	With Acoustics (2003)
52 measurements	62 measurements
10 days	10 days
Staff of 11	Staff of 6
Average time – 96 min.	Average time – 18 min.

Not only are costs reduced, but so is computation time. USGS get the results sooner and shares them faster with those who need them. That means data is more timely and accurate.

Approach to Inundation Mapping

Flood-inundation mapping refers to mapping the area that is expected to be flooded. This is a marriage of hydrology, hydraulics and a geographic information system (GIS), in which one models a range of flows and indexes a set of GIS libraries that show the inundated areas against a range of flood stages. The National Oceanic and Atmospheric Administration (NOAA), USGS, and the United States Army Corps of Engineers (USACE) are determining standards for flood-inundation mapping, which provides information on the spatial extent and depth of flood waters in the vicinity of NWS river-forecast locations. These agencies can therefore display flood-inundation maps for various levels ranging from minor flooding through the largest flood on record.

By linking the forecasted-river stage to a fairly sophisticated hydraulic model and a GIS, one can actually map the area that the flood will inundate. In this case, the inundated area is shown as the blue overlay. (See chart below.)



This type of information allows decision-makers to better mitigate the impacts of flooding and build more resilient communities. Once the boundaries of the flooded area are known, one can determine damages and assess needs: number of displaced people, damaged houses, etc.

A GIS Flood Tool for Mapping Extent of Inundation

Many developing country communities lack flood mapping to build scenarios for mitigation and response planning. USGS developed the GIS Flood Tool (GFT) with support from the U.S. Agency for International Development (USAID) and its Office for Foreign Disaster Assistance. The United Nations Environmental Program (UNEP) and Global Risk Identification Program were also key partners, as was Riverside Technology Inc, which supported the testing and training of the technology. The GFT is used in countries to produce hydrographs based on the countries' digital-elevation model and GIS physical features.

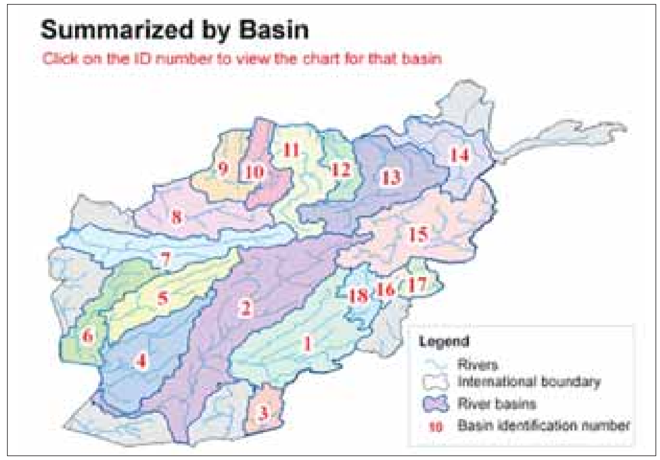
The GFT produces flood-inundation patterns given either: (1) A specified discharge (m^3/s); or (2) A specified stage (m). Translation of discharge to stage is done using the ***Manning equation*** for flow in an open channel.

The GFT software is an ArcGIS-based tool written in the software programs Python and VBA. Using this software, the Manning Equation allows USGS to create a rating of flooding which allows them to map the extent of floods, even where they don't have a gauging station. The software uses digital-elevation models to derive stream network, develop cross-sectional information, and provide a base for inundation mapping. Furthermore, the software can work with any digital-elevation model. For USGS workshops, they use hydrologically-conditioned Shuttle Radar Topography Mission data (using the model-HydroSHEDS-FM).

"How can we equip Afghanistan with the tools to understand and manage water?" This is the question that USAID, FEWS (The Famine Early Warning System) and other partners set out to collectively answer.

The team had datasets from 1966–2001. Tools to measure snow-depletion curves, snow accumulation and melting using the energy-balance models were developed. The NWS Climate Prediction Center provided forecast-rainfall estimates to the model, which allowed the team to look at water volume generated from snowmelt by basin and by province and also allows for a six-day forecast.

Another useful product generated for Afghanistan is the Water Requirement Satisfaction Index (WRSI). The WRSI is a spatially-explicit decadal (in units of 10) product that uses climatological and satellite-based data as an indicator of crop performance during a growing season. The WRSI assesses the current and end-of-season crop condition. This model allows food security managers and decision-makers to assess the food security in the country months before the end of the season.



In addition to using this technology in Afghanistan, a practical display of the use of the snow-monitoring tools and models was demonstrated in Iraq when authorities were considering releasing water to generate electricity downstream or to store water for current use. The data from this product allowed for informed decision-making.

The USGS, in partnership with USAID and NOAA has successfully used the application of remote-sensing technology and various hydrologic and meteorological models to predict crop health and thus determine the potential development of food-security shortages in Afghanistan.

The Experience of the French “Vigilance Map”: Complementing More Classical Early Warning Systems through Direct Communication with Populations

Catherine Borretti, Meteo France

On December 26 and 27, 1999, two storms seriously affected nearly all of France—highlighting a paradox. The storm that occurred on December 26 was very accurately forecast in terms of its trajectory and its chronology, although wind speed had been slightly underestimated. The storm that occurred on December 27 was forecast much less accurately by the models. The government of France was vehemently criticized by the public regarding the storm on December 26, but given a quite favorable response regarding the one on December 27.

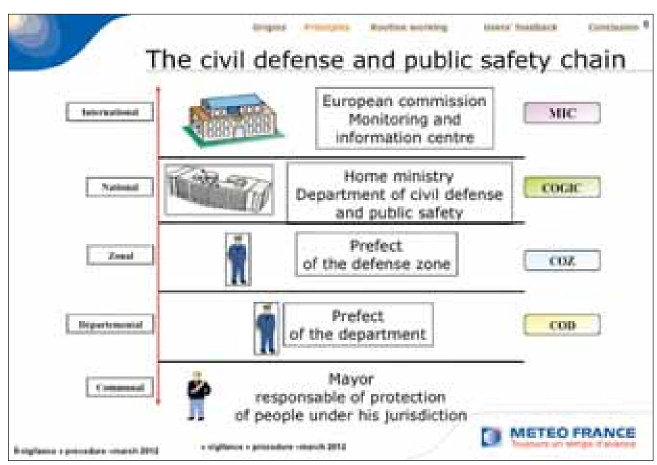
This paradox can largely be attributed to communication with populations. The bulletins issued on December 26 largely went unnoticed for a variety of reasons: It was the Christmas vacation period; alerts the official emergency and civil defense services received were not passed on to the general public in time; and perhaps foremost, the public is unable to associate the intensity of predicted meteorological parameters with a risk level. For these reasons the forecast for the December 26 storm did not have a great impact on the general public.

The public is not necessarily aware of the fact that a 130 kilometer per hour (80 miles per hour) wind, which is what had been announced, can take off roofs, knock down trees and cause considerable damage. For the storm of December 27, the emotion aroused by the earlier storm prompted exceptional vigilance and the public had the perception that it had been alerted and warned properly.

These events highlighted the need for better vigilance and led to the creation of Meteo France whose goals are to better inform the public and have fewer false alarms. Today, Meteo France is not only helping France, but its territories, as well as other countries like Algeria and Canada. It is an improvement to focus on the most important events and to provide an accurate watch with fewer false alarms—this helps build a greater degree of trust with the public.

Principles

Effective October 1, 2001, VIGILANCE replaced the older BRAM and ALARM procedure which had been established in 1993. The goals of this new VIGILANCE early warning system were: (1) To better inform, thanks to a simple and condensed message that focuses on dangerous-weather phenomena; (2) To improve the early warning; and (3) To broaden the dissemination of the information. This new alarm system is directed at governmental services, national, regional and departmental administrative units, the media and the public at large. The following graphic shows how the emergency management system in France works.



Routine Working of Meteo France

VIGILANCE is not an alarm—it is a meteorological watch intended to create a risk culture. With the users of the tool ranging from government services to civil protection to media and the general public, the success of this 10-year old initiative lies in its simplicity and the four-color system—green, yellow, orange and red—based on the degree of risk. It is employed and well known across Europe. An interactive online map has inputs from a meteorologist as well as a communications professional to elaborate on the effects on behavior. The system has also been growing—based on new challenges, pictographs are being incrementally added. The goal is to provide at least 12 hours of lead time for hazards.

The pictographs currently used are in the graphic below, and include: violent winds, heavy precipitation (leading to rain and flooding), thunderstorms, cold wave, heat wave, snow/sleet, flooding, storm surge and avalanches.

The four watch levels are defined as follows:

Green: No particular vigilance is required;

Yellow: Be attentive if practicing activities exposed to meteorological risk, for some phenomena have been forecast, that are occasionally dangerous, although usual in the region (e.g. mistral wind, summer thunderstorms); keep informed about weather developments;

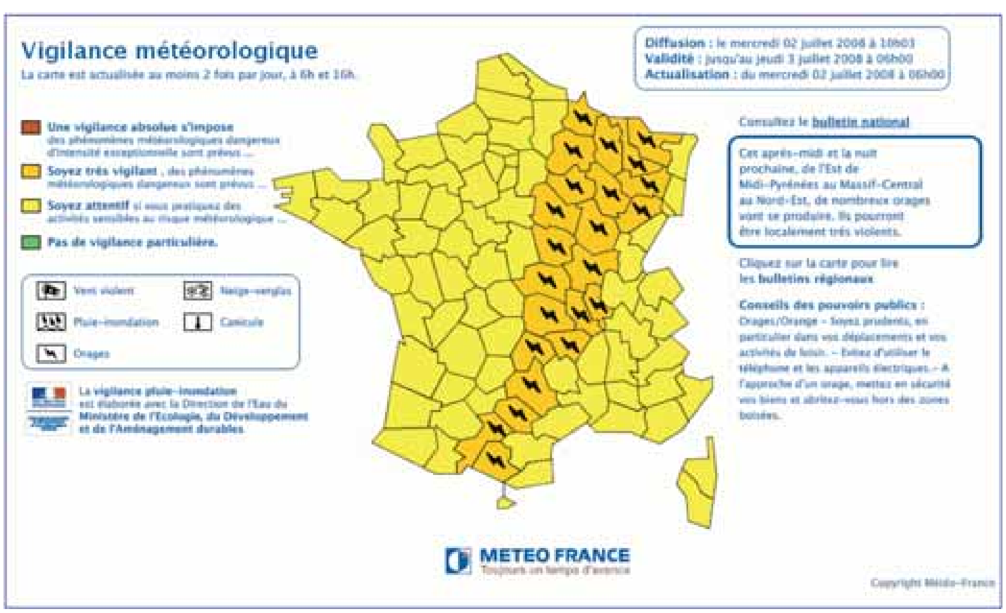
Orange: Be very vigilant; dangerous meteorological phenomena have been forecast; keep informed about weather developments and directives broadcast by the authorities;

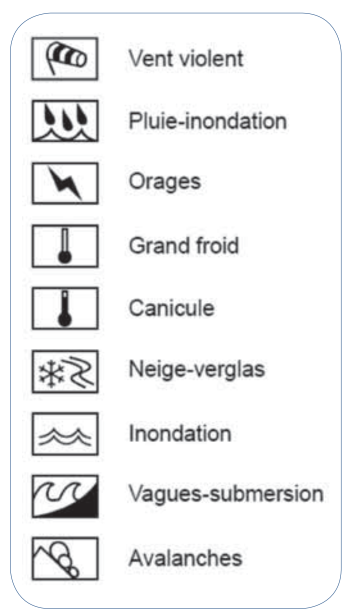
Red: Absolute vigilance is required; dangerous and exceptionally intense meteorological phenomena have been forecast; keep regularly informed about weather developments and conform to directives or orders broadcast by the authorities

When either orange or red vigilance reports are issued, follow-up reports are produced approximately every three hours. These reports describe: the type of event, location and duration (time of start and finish), present situation and development, description of the event (comparisons, frequency), possible consequences, recommendations on behavior and time of the next report.

Under normal circumstances, reports are produced twice a day and broadcast at 6:00 h and 16:00 h standard time. Reports may be initiated outside these hours if the risk significantly increases or diminishes. In case of an orange or red zone, a clear and concise write-up about the phenomenon is added close to the map and includes the main instructions on behavior, drawn up by authorities.

Dissemination of the messages is also vital to creating a culture of risk awareness. In 'input' mode, information





is routinely sent to national, regional and departmental services in charge of civil defense, roads, health, environment and media. Information is disseminated through the www.meteofrance.com website, media outlets, mayors, and corporate and private users.

For crisis management, Meteo France's territorial centers play an essential role interfacing with their local partners: prefects (head of departments), rescue services, customers and media. Customized maps and satellite imagery can be provided via a dedicated Internet site, in response to the needs of the emergency services and crisis-management centers.

Users' Feedback

Meteo France has also put in place feedback mechanisms such as an opinion poll and other market research tools that indicate that TV (92 percent), radio and the Internet were the most common dissemination channels and that 90 percent of respondents know about the vigilance map. Most respondents also answer 'sometimes' or 'every time' to the question "Do you follow the recommendations of the tool?" The feedback responses also point out that communication to mayors and the general public requires further improvement.

In addition to public opinion polls, Meteo France also conducts a series of other evaluations aimed at improving its impact. For instance, it is evaluated and assessed by a group of active partners that meet three times a year. An inter-ministerial steering committee meets once a year to decide on procedural developments. An annual evaluation is also co-authored by all the active partners that review the institutional communications tool on meteorological vigilance and provide feedback about procedure and presentation of statistical data. This 30-page evaluation is co-published by Meteo France, and the Ministry of Interior, Ecology and Transportation and Health.

Conclusion

Communicating risk effectively to the public in a way that impacts people's behavior continues to be one of the primary challenges facing Meteo France. During the violent European windstorm, Xynthia (February 2010) an efficient red-vigilance alert was in effect; however at the time, Meteo France was in the process of fully including coastal risks in the vigilance map most French rely on for storm alerts.

Meteo France sent out messages via media, and other outlets, but people did not notice them and were only prepared for the risk of strong winds. The storm surge hit the coast of France during high tide, which further aggravated the swells, and caused severe flooding. Despite the messages sent by Meteo France, the public was not familiar with the potential impacts of storm-surge hazards and did not respond as appropriately as they could have. Several lives were lost, and Meteo France learned that it still needed to work on educating the public on the surge hazard.

Based on its experiences, Meteo France is taking a partnership approach to educating the public on risks in its efforts to change individuals' behavior. Meteo France is focusing on the most dangerous events, conversion of meteorological thresholds into risks, and having massive and parallel distribution. In addition, Meteo France is focusing on making ongoing improvements to its system in order to adapt thresholds and reports to needs—such as developing storm surge warning criteria; it is also mindful of staying close to end users, as this is what helps build trust with the public and change behaviors in the long run.

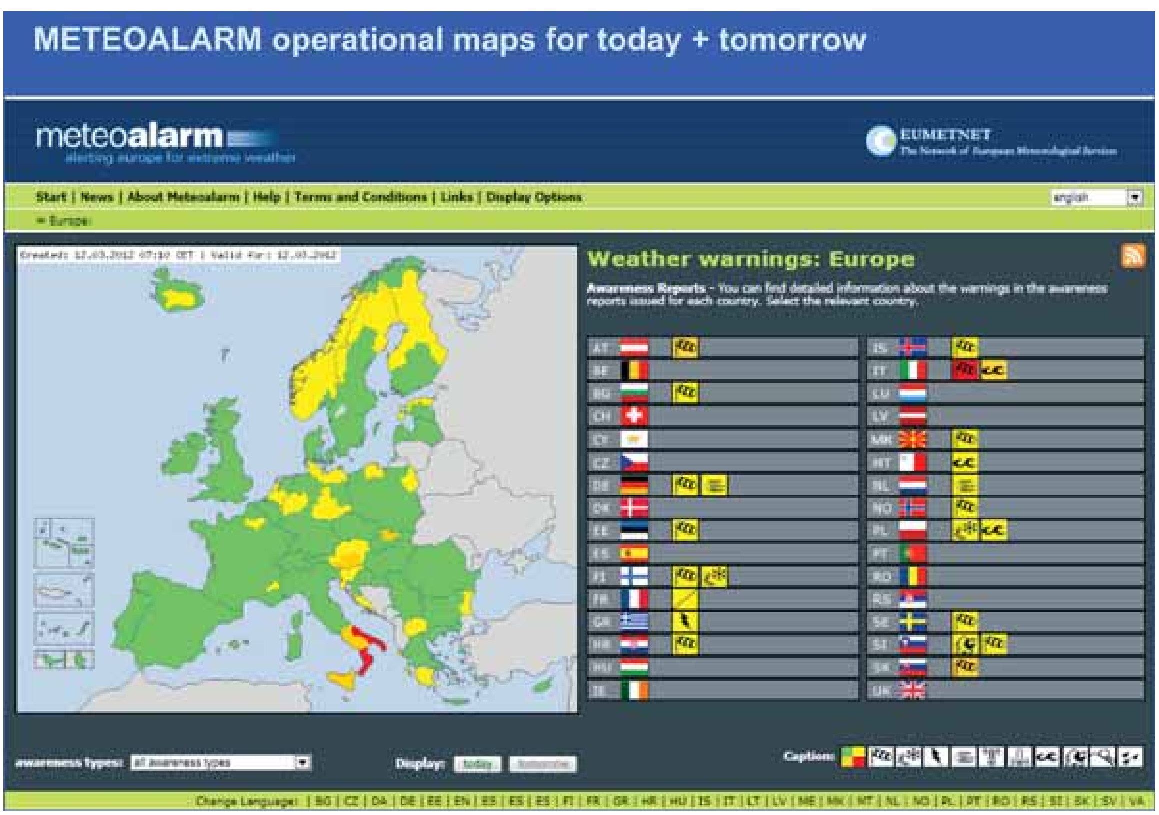
Meteo Alarm: European Multiservice Meteorological Awareness Project (EMMA project)

Michael Staudinger, **Central Institute for Meteorology and Geodynamics, Austria**

Meteo Alarm is a procedure to provide European weather-alert information on an online Internet platform. The system provides for a variety of weather parameters in a format that is understandable (four colors) by all actors from the private and public sectors and is harmonized as far as possible. The sources of information for this system are the National Meteorological and Hydrological Services (NMHSs). Information is relayed in both English as well as local languages. At least 1000 websites are linked to this initiative which has had on average approximately four million hits per day; the system has achieved a high acceptance with public institutions, civil protection and first responders at both the national and regional levels. The European Multiservice Meteorological Awareness Project (EMMA) was requested by the Network of European Meteorological Services, EUMETNET to create a Meteo Alarm system capable of providing pan-European alert information on an online Internet platform.

International cooperation is imperative for such an initiative for a variety of reasons:

- One-third of gross domestic product (GDP) is weather sensitive;
- Early warning systems could mitigate around 60 percent of damages;
- Foreign Direct Investments (FDI) is 10-30 percent



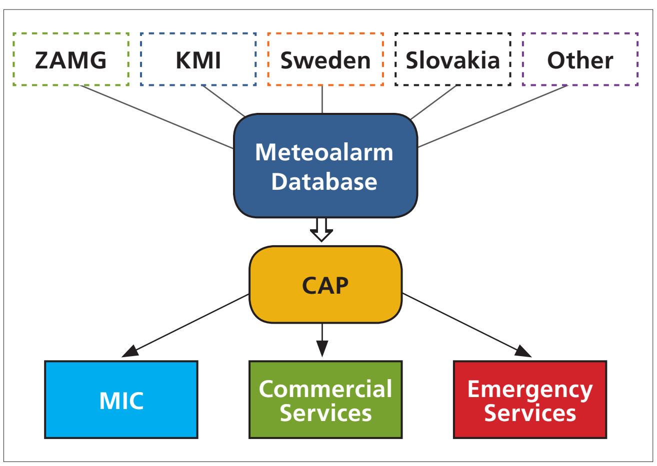
of GDP (examples include: transport carriers across Europe; construction sites with foreign engineers and workers[7];

- The European Union (EU) receives 484 million tourist arrivals per year which corresponds to 316 billion Euros per year in receipts. Travelers are more exposed to weather risks than EU citizens (example: sailing crew along Turkish coast with Swiss operators and British clients);
- Larger catastrophes need first responders from outside the country, (longer response times require longer warning range).

Therefore, close trans-boundary cooperation across the hierarchy of national services is critical.

International Cooperation Supports a Strong Common Alert Protocol (CAP)

The Common Alert Protocol (CAP) is used to develop five-day warnings and integrate products of other services such as flood warnings.



Managing Expectations

As awareness about EMMA grows, and trans-boundary cooperation strengthens, it becomes increasingly important to avoid using 'red' alerts, unless serious danger is highly probable. Frequent or incorrect red-alert forecasts may cause the public to get used to red alerts, and therefore not react appropriately in the event of a real 'red' situation. A red alert is determined by a crisis-decision team which is composed of a forecaster (team leader), a hydrologist (in cases of floods), a representative from the board of the institution, an expert on climate, a media representative and a civil-protection representative. This team goes through a detailed 'decision tree' to define a 'red' situation. The chart below also shows specific parameters for when a red alert may be issued.

Choosing alert levels out of different posibilities

Highest alert level (e.g. of ensembles) → / Level of confidence ↓	Green	Yellow	Orange	Red
0 – 5%	Green	Green	Green	Dark green
5 – 30%	Green	Green	Green	Yellow
30 – 60%	Green	Green	Yellow	Orange
> 60%	Green	Yellow	Orange	Red

EMMA has definition thresholds, which are based on a wide range of factors such as climatology, vulnerability, seasonal variations, possible interaction of parameters, damage and meteorology parameters.

EMMA has demonstrated value when communicating weather-related threats to a population at risk. Experience will help determine how to best communicate information to get maximum usefulness and response. Significant lead time must be balanced with accuracy and credibility. For a warning-dissemination system to work efficiently users must trust the system and know exactly what behavior is appropriate for a given hazard threat and the needed response.

[7] United Nations World Tourism Organization (UNWTO)

Hydromet Monitoring and Warning in the Italian Civil Protection System

Luigi D'Angelo and Paola Pagliara, Italian Civil Protection Department

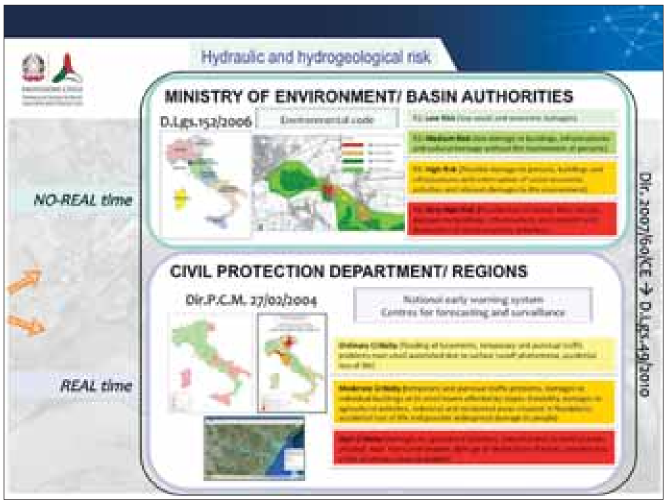
Since 1985, floods and landslides in Italy have impacted about 700 people and caused over 25 billion Euros in damage. In 2004, the Italian Prime Minister established a national early warning system through a directive requiring: "Operational guidelines for the organizational and functional handling of the national and regional warning system on the hydro-geological and hydraulic risk for the purposes of civil protection". This Prime Ministerial Directive ushered in new legislation and planning for hydrogeological and hydraulic risks, which clearly identified all stakeholders involved in the early warning system and defined their roles and responsibilities.

Early Warning System—Institutional Arrangements

The Italian early warning system is based on distributed network. The geographical and administrative configuration of the country implies that effects have to be evaluated in real time at the regional level. Regional centers for forecasting and surveillance of effects ("Centri Funzionali") are responsible in their territory for the announcement, monitoring and surveillance of risk scenarios in real time; declaration of the expected severity levels; and providing warnings that activate operational responses in real time at different territorial levels. Twenty centers for forecasting and surveillance were organized under the responsibility of the Regional Civil Protection Authorities. These regional centers are coordinated by the national center located at the Department of Civil Protection in Rome. Over 2,500 rain and stream gauges throughout the country and hazard maps and risk maps with historical data are integrated with real-time information and shared at the local level.

The Italian government has also set up a network of Centers for Technology and Scientific Services (research centers, universities, spatial agency, etc.) that have the task of supporting Civil Protection Authorities by improving knowledge, models and tools useful for the evaluation of the risk scenarios. One of these centers is the National Meteorological Service, managed by the Italian Air Force, which cooperates and shares meteorological models and data, but does not have the responsibility of issuing the alarms for civil-protection purposes.

It is also important to underline that in Italy no real-time activities (hazard and risk mapping for urban planning and structural interventions for the mitigation of hydraulic risk) are carried out by the Ministry of Environment and the River Basin Authorities.



Building Interoperability through the Civil Protection Information-sharing Platforms

The Civil Protection Department has implemented a platform (DEWETRA) in which all the data needed are collected in real time. In this platform it is possible to share models and data coming from meteorological stations (rain gauges, river gauges, etc.). It is also possible to validate pre-operative products coming from technological innovation. The Civil Protection Department and all the regions share this platform. Each region decides what to share with local levels. In this way, actors involved in risk assessment speak the same language and share the same data in the same way all over the country.

Therefore, DEWETRA is not only a way to share data and model results, but is an operational platform to share standing operating procedures (SOPs) and best practices. The hazard, exposure and vulnerability information is utilized to develop risk assessments for EWS planning and implementation.

Case Studies

Flash floods in Cinque Terre and Genoa

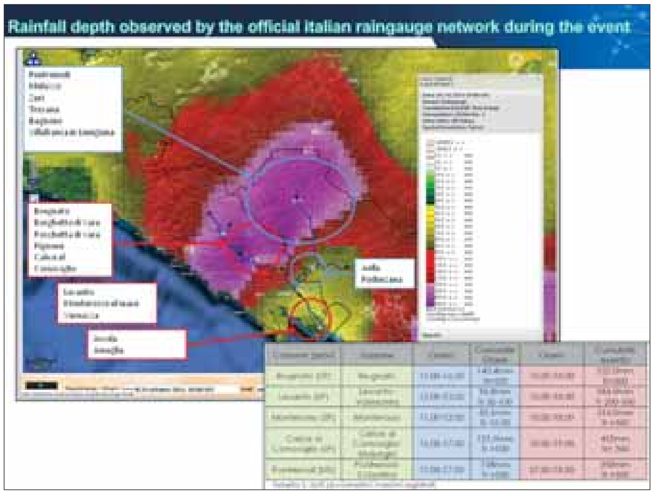
During the final months of 2011, Italy faced severe flooding. On October 25, the tourist area of Cinque Terre experienced 500 millimeters of rain which fell in less than six hours—the average rainfall in Italy amounts to 1000 millimeters per year. The flash flood caused extensive damage and 10 casualties.

The next month, on November 4, a red code, as well as warning messages, were issued in Genoa. This flood caused six casualties.

Flash Flood Oct. 25, 2011—Cinque Terre, Vara and Magra Basins

Impacts

- Many landslides ⟶ Brugnato, Borghetto Vara, Pignone Monterosso, Vernazza;
- 23 disrupted roads (250 kilometers);
- Damage to houses, shops, businesses, essential services such as power lines, gas pipes, telephone lines and public and private transport;
- The highway was blocked for four days between La Spezia and Sestri Levante;
- The railway line was closed for four days;
- The arch of the Colombiera bridge collapsed.



These flash floods were the kind of event that occurs once every 200-500 years. Despite the warnings, the population at risk did not think that the event would be very severe.

In both situations, the events were monitored in real time with satellite data, and red codes were issued in advance of the floods—warning citizens of the impending dangers. The weather forecasts and the warnings that were issued were good, but despite this many casualties occurred. Most of these casualties were caused by erroneous behavior—people did not expect the event to have this magnitude and did not take the necessary precautions. Therefore, it is imperative to inform local communities in a proper way. The responsibility to provide local authorities (such as mayors) with the necessary tools rests with the regional authorities.

Local emergency plans will be effective only if people understand the potential impacts of hazards in their area. Strategies for better communicating risk and improving information systems for both the warning and alarm phases of disasters include:

- Warnings from the beginning of the alert phase, including door to door visits by local bodies involved in civil-protection activities; and handing out a form with the procedures to follow during the warning and alarm phases;
- Brief messages disseminated by local radio and TV;
- Use of loud-speakers to spread messages;
- Intermittent sirens to let everybody know they are in the warning phase and continuous sirens for the alarm phase;
- Organizing citizen committees that can be informed and providing real-time information in terms of people's needs and priorities.

Italy continues to strengthen its early warning system, and is at the same time collaborating with nearby countries (like Albania) to strengthen regional early warning systems. For example, through Italian Centers for Technology and Scientific Services, the International Center for Environmental Monitoring (CIMA), has established a flood-forecasting and forest-fire modeling system for the Albanian Institute of Geoscience, Environment, Water and Energy Institute, (IGEWE) which provides forecasters with the capability to forecast the spread of fires and the occurrence of floods.

The recently created (2004) early warning system in Italy is now fully operational and utilizes an integrated data approach. Regional centers for forecasting both meteorological and hydrological risks have been established.

This system has worked well so far, giving good results in terms of reducing the number of casualties and the amount of damage—at least for hydraulic events at a large scale, such as the ones related to the Italian largest catchments (e.g. Po River). Civil protection authorities, regions, the scientific community and all the actors involved are working to improve the Italian EWS—not from a technical point of view for which a good level of knowledge has already been reached—but on disseminating a better perception of risk to the population and on helping local authorities in constructing a good response system at a municipality level.

Part II

Strengthening of Weather and Climate Services in Client Countries

Europe and Central Asia: Disaster Risk Mitigation and Adaptation Project (DRMAP) in Albania

Jolanta Kryspin-Watson, World Bank, and
Curt Barrett, Consultant

Country Natural Hazard Context

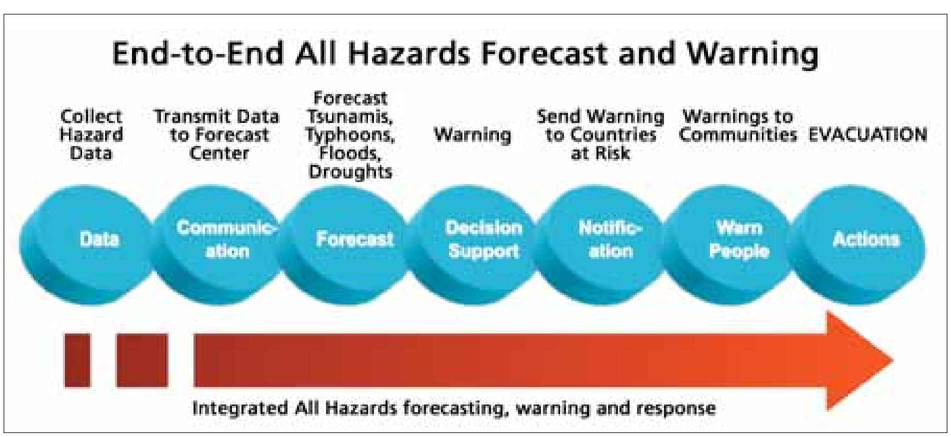
The Disaster Risk Mitigation and Adaptation Project (DRMAP) was launched in Albania about four years ago with partners such as the United Nations International Strategy for Disaster Reduction (UNISDR), the World Meteorological Organization (WMO), the Italian Civil Protection and others, as part of a regional disaster risk mitigation and adaptation program for South Eastern European countries. Albania was the first country to participate in this regional effort. It should be noted that this country has the highest economic risk from disasters with 86 percent of its territories prone to hazards. Sixty-two percent of Albania's disasters have hydro-metrological origins. The intensity and frequency of climate-extreme triggered disasters is expected to grow in the next few years. In addition, Albania's economy is heavily dependent on weather-sensitive sectors such as agriculture and energy.

The objective of the project is to reduce Albania's vulnerability to natural disasters and to limit human, economic and financial losses due to disasters. Among other purposes, the project is intended to strengthen the hydro-metrological capacity of the National Meteorological Service (Institute of Geophysical, Energy, Water and the Environment) IGEWE.

DRMAP consists of four components:

1. Strengthening of disaster risk management and preparedness—the focal point is the Ministry of Interior;
2. Strengthening hydrometeorological services—
   i. Parallel support for the Italian Civil Protection;
   ii. Creating operational links with disaster management;
   iii. New disaster-management center connected to the hydromet agency;
   iv. Issue forecasts and warnings of hazards to the General Directorate of Civil Emergencies;
   v. Forecasts and response—the model of an "end-to-end" multi-hazard forecasting system in Albania.
3. Development of building codes—the focal point is the Ministry of Public Works;
4. Catastrophic risk insurance—the focal point is the Ministry of Finance.

The project assessed the weak links of the end-to-end system (below) and determined that one of the biggest drawbacks in delivering forecasts and warnings was a lack of adequate data and hydrometeorological modeling. Most of Albania's systems are very outdated; however, the strength in the end-to-end system is response. In Shkodra in northern Albania, the population is very vulnerable to a high frequency of floods.



The World Bank and partners are developing capacity to reduce flood losses from these events.

Component two of the project with the World Bank is the strengthening of hydrometeorological services. This component focuses on establishing a foundation of credible services that can be built on in the future. The essential elements of the component are:

- 40 automated observing stations;
- Data rescue—digitization of the majority of paper data which is in a delicate state;
- Establishment of a meteorological work station. This work station will meet the communications requirements of IGEWE to receive data and global modeling products and allow IGEWE to transmit data to benefit regional needs and to meet WMO standards;
- Establishing a website to serve users—this is a critically important activity as data and forecast products will be posted on the Internet to meet user needs;
- Training and capacity building are key activities that are needed for the meteorological and hydrological workforce to receive training on best practices in operations;
- The Italian Civil Protection Department is a partner with the Albanian Government and the World Bank and as part of the project framework it supported:
    - Installation of a forest fire prediction model (RISICO);
    - An operational server which was established in IGEWE and in three other local Civil Emergencies Departments' sites (including Shkodra) so that that the emergency management could receive daily bulletins of forecasted fire hazards;
    - Application of a probabilistic flood-forecast model (PROOFS) for three rivers in the Shkodra Region.

The challenges ahead:

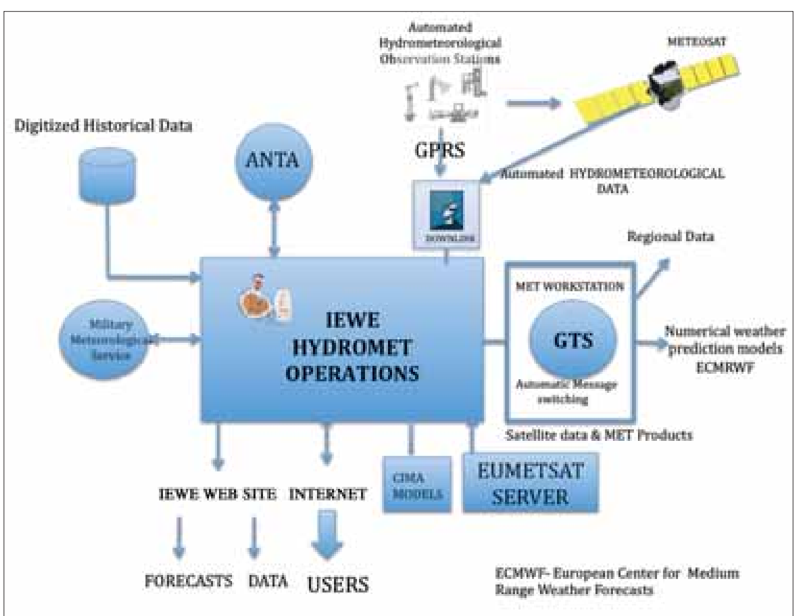
1. Institutional set-up of hydromet services in Albania—IGEWE is located at a university and it is very difficult to assume an operational role in an academic environment;

2. Insufficient number of hydrologists;

3. Cooperation with military and aviation are needed as these sectors have their own hydromet services;

4. Building technical and human capacity;

5. Costs of maintaining and operating the operational infrastructure may be a challenge.



DRMAP COMPONENT 2- ALBANIA HYDROMET ARCHITECTURE

Disaster and Climate Risk Management Project (DCRMP) in Moldova

Anatol Gobjila, World Bank, and **Elina Plesca,** State Hydrometeorological Service, Moldova

Moldova is a small land-locked country in a temperate climate zone with some sub-arid areas in the south of the country. Agriculture and food production are key sectors for employment and exports. Both sectors are highly vulnerable to natural disasters, including floods, droughts and earthquakes, heightening the country's economic vulnerability.

Climate variability is likely to increase the frequency and intensity of natural disasters as evidenced by, most recently, the catastrophic disasters associated with the 2007 drought and devastating 2008 and 2010 floods. To address these challenges, the government of Moldova and the World Bank have launched the Disaster and Climate Risk Management Project (DCRMP).

Disaster and Climate Risk Management Project

DCRMP aims to reduce disaster risks by building the capacity of the meteorological services as well as the disaster management organization. DCRMP also strives to strengthen regional cooperation and coordination through the integration of project activities in the region that focus on hazard monitoring and warning, disaster risk reduction, and climate adaptation. The project is financed through US$10 million from the World Bank's International Development Association (IDA) funds and US$100,000 from the Global Facility for Disaster Reduction and Recovery (GFDRR).

Specifically, the development objective of DCRMP is to strengthen the State Hydrometeorological Service's ability to forecast severe weather and improve Moldova's capacity to prepare for and respond to natural disasters. These project-development objectives will be achieved through strengthened capacities to:

- Monitor weather and issue early warnings of weather-related hazards by providing timely and accurate hydrometeorological forecasts and services;
- Manage and coordinate responses to natural and man-made disasters; and
- Help farmers, be aware of, and adapt to natural hazards and climate variability.

The project has four components.

Component A seeks to strengthen the State Hydro-Meteorological Service's severe-weather forecasting capacity. For example, one activity of the project focuses on developing an end-to-end multi-hazard early warning system. End-to-end refers to establishing a forecast and warning system that links data via communications to the forecasting center which links to users so that when the forecast center issues warnings, they reach the person in the floodplain in time to take protective actions. Another activity is to improve early warning/nowcasting capabilities. Nowcasting is a best-practices procedure of using the latest data, information and model products to issue high-impact short-fused weather warnings designed to save lives from approaching severe weather and/or flash floods. This is being accomplished by the acquisition of dual polarization Doppler radar technology for localized forecasts; installation of a flash flood modeling system; installation of a meteorological workstation; automation of the existing hydromet-observation system; development of plans for seasonal/climate forecasts; staff training in the use of new equipment; and providing opportunities for exploring international experience in weather and climate service delivery.

Component B aims to improve disaster preparedness and emergency response. This is being done through a feasibility study and design of an Emergency Command Center (ECC), establishing an ECC, and building capacity of staff within the department for emergency services.

When feasibility and design studies are complete, the project will support establishment of the ECC by financing the following: (i) Facility renovation and refurbishment works; (ii) ECC furniture and equipment; (iii) Information technology (IT) hardware; (iv) Emergency information management software; and (v) Communications equipment.

Department of Emergency Services (DES) employees will staff the ECC on an as-needed basis, along with staff from other agencies, particularly during emergencies. The project will support capacity building for DES and other agencies by providing training in an emergency-management information system—particularly the operation of the IT decision-support system—for an estimated 100 staff from 15 agencies and all regional and local DES units. To ensure sustainability and facilitate knowledge transfer, capacity building will be designed as "train the trainers" so participants can transfer knowledge to their colleagues.

Component C initiates activities for adaptation to climate risks in agriculture. These activities include: development of a just-in-time communications platform for rapid dissemination of critical, localized weather information to a large number of farmers and rural communities, and adverse-weather adaptation advisory services. The design will focus on the information flows of severe weather alerts originating from the State Hydromet Service (SHS) to farmers via a content provider associated with the Ministry of Agriculture and Food Industry (MAFI), and in collaboration with mobile communication companies. Following the design and testing phases, the platform could be fully rolled-out by MAFI in collaboration with the SHS and mobile phone companies. This project component also provides technical advisory services, including grant-investment support to farmers, farmer groups and rural communities for piloting and testing activities aimed at increasing awareness about coping and adaptation techniques necessary to make agriculture more resilient to adverse weather.

Component D supports overall project management.

Valuable Lessons

DCRMP is still in its early phases of project implementation. Nonetheless, results are already being achieved. Major procurement packages have been initiated—Doppler radar procured; a feasibility study for the Emergency Command Center contracted; the mobile communications platform is under development; and the delivery of climate risk adaptation advisory services is under way. Additional procurement of automated observing systems, linked with upgraded computer and processing software will result in improved forecast products for many agricultural and emergency-management users. A flash-flood forecasting system linked to radar will result in warnings to populations at flood risk before flooding occurs. Impact from the number one hazard to the country is expected to be significantly reduced.

Even in these early stages, valuable lessons are already being learned. Capacity building in targeted entities should begin on day one; and, exposure to regional and international experience can be an extremely facilitative aspect of implementation

Regional Benefits

Natural hazards cross borders and sectors, so managing disaster risks, emergency preparedness and mitigation requires institutional coordination and collaboration among neighboring countries. Collaboration is necessary and beneficial in weather forecasting and early warning systems, in pooling national-risk hazards through insurance mechanisms, and in disaster preparedness and response. South Eastern European countries would be unlikely to cope with a major catastrophe without support from and coordination among neighboring states. Successful regional cooperation rests entirely on building national capacity to respond to disasters, thereby gaining sufficient capacity to support other countries during disasters. Therefore, project components are designed to reduce Moldova's risk and contribute to international and regional cooperation.

The World Bank has supported projects to enhance weather forecasting in countries such as Poland, Russia and Turkey—building a body of knowledge and experience. Ensuring sufficient system integration to achieve full functionality is key to successful weather forecasting; hence, project activities to strengthen weather-forecasting capacity will be clustered in a few contracts to ensure the inter-operability of SHS systems.

Status of Hydromet Services in Georgia

George Zedginidze, **Deputy Minister of Environment Protection of Georgia**

Georgia experiences many extreme climate events including severe storms, floods, drought, avalanches, strong winds, hail and thunderstorms. Hazardous hydrometeorological events between 1995-2010 have resulted in vast economic damage and loss of human life. During that period, a significant increase in the frequency and intensity of hydrometeorological disasters was also recorded in Georgia.

The Hydrometeorological Department of the National Environment Agency of the Ministry of Environment is responsible for forecasting hydrometeorological hazardous events and delivering warnings. Responsibilities of the department include operation and maintenance of the hydrometeorological observation program, preparation and dissemination of short and long-term weather forecasts and warnings, assessment of avalanches, floods, riverbed and other types of hydrometeorological processes in the country. The department is also responsible for establishing frequency and zoning of the intensity of hydrometeorological processes for the country and using artificial means to influence hydrometeorological events—avalanches and hail, risk assessments, vulnerability assessments, participation in response planning and planning preventive measures.

Capital –Tbilisi
Population – 4,469,200
Location – South Caucasus

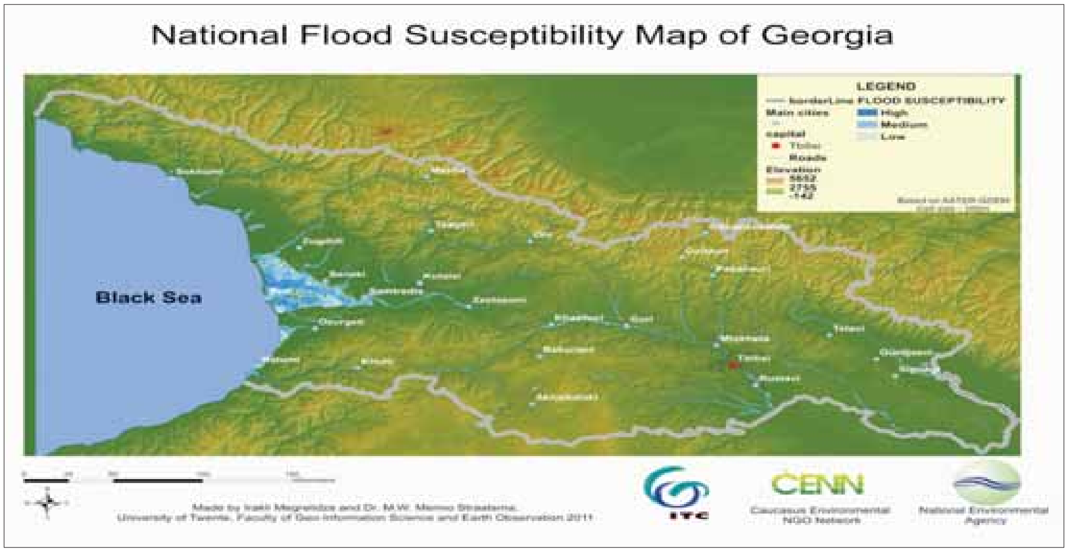
Geographic Characteristics

- Total Area – 69,700 square kilometers (km^2)
  Elevation – 5068 (Shkhara)
- 26,000 rivers
- 865 lakes
- 786 glaciers with 556 km^2 total area
- Wide swamp area (225,000 hectares)
- 44 water reservoirs
- Most rivers are 25 km long and half of the lake's area is less than 0.1 km^2
- 75 percent of the rivers are formed in the western part of Georgia and belong to the Black Sea Basin. Twenty-five percent of the rivers are formed in the eastern part of Georgia and belong to the Caspian Sea Basin.

Flood Vulnerability of Georgia Produced by the National Meteorological and Hydrological Services (NMHS)

Prevention and mitigation of the negative consequences caused by natural hydrometeorological events

Prior to the 1990s, the NMHS of Georgia was under the authority of the USSR State Committee of Hydrometeorology. The service was managed centrally, and provided with necessary financial, technical, technological, methodological support as well as staff training. The NMHS carried out both standard and specialized observations, including: upper air, radar, actinometrical, ozonometric, glaciological, water-balance, agro-meteorological, aeronautical and marine hydrometeorological observations. The hydrometeorological information gathered was centrally processed.



Historical Evolution of Hydromet Services in Georgia

- 1832 – Starting episodic meteorological observations;
- 1844 – Establishing the Tbilisi magnetic-meteorological observatory, that becomes the basis of regular meteorological observations;
- 1850 – Start of glaciological observations;
- 1883 – Start of agro-meteorological observations;
- 1905 – Start of hydrological observations;
- 1930 – Creation of Meteorological and Hydrological Service;
- 1931 – Start of air meteorological observations;
- 1964 – Start of marine hydrometeorological observations;
- 1988 –Start of artificially-created avalanches;
- 1999-2004 - State Hydrometeorological Department of Georgia of the Ministry of Environment Protection and Natural Resources of Georgia
- 2004 – Present - Hydrometeorological Department of the National Environmental Agency within the Ministry of Environment Protection of Georgia

Now, the Hydrometeorological Department of the National Environmental Agency of the Ministry of Environment Protection is the only national organization that implements forecasting of hydrometeorological events and delivers timely warnings to decision-makers.

The NMHS is responsible for:

- Hydrometeorological observation over the territory of Georgia;
- Preparation and dissemination of short- and long-term weather forecasts, warnings on expected hydrometeorological hazardous events;
- Processing of hydrometeorological data; preparing and issuing different types of bulletins, reviews, tables and notes;
- Implementation of field identification-assessment works on snow avalanches, floods, riverbed and other types of hydrometeorological processes in Georgia.
- In the case of of hazardous events, participation in the work of identifying the hazard/disaster-impacted areas, damage assessment, response planning and planning of the relevant preventive measures;
- Zoning of the territory of Georgia on the frequency and intensity of hydrometeorological processes, including diverse hydrometeorological events.

- Artificial influence over hydrometeorological events such as hail, avalanches.

Georgia NMHS has produced hazard-assessment studies for floods, hail, droughts, avalanches and high winds. These illustrative maps depict regions of the country that are susceptible to various hazards throughout the year.

National and International Efforts

Georgia has in the past received assistance from donors such as WMO and USAID to strengthen hydrometeorological capabilities. To outline a few activities, for example: installation of a satellite receiving station, purchase of a telecommunications system, upgrading streamgages, obtaining a Doppler discharge measuring device and support for re-equipment of the Tbilisi Meteorological Station. With the assistance of the World Bank, Georgia has conducted an assessment of the economic efficiency of hydrometeorological services, installed the NOAA mesoscale meteorological -forecast model, installed a German forecast model and installed a hydrological model (FEWS) for the Rioni River Basin. Specific activities include:

WMO

Cooperation with the World Meteorological Organization began in the 1990s. With WMO assistance, in 1998 the NMHS purchased and installed a satellite meteorological information-receiving system and a telecommunications system (MESSIR-COM). WMO also provided assistance with Y2K (Problem of 2000). In 2003, with the WMO's support, Georgia purchased and installed an air meteorological information receiving system (SADIS). More recently, in 2008, WMO provided support for re-equipping the Tbilisi Meteorological Station with modern measurement devices. WMO also provided training for more than 20 specialists.

USAID

The United States Agency for International Development (USAID) has also been a strong partner as Georgia strengthens its hydromet services. In 2003, USAID assisted the NMHS with the re-equipment of two meteorological stations with modern measuring devices and rehabilitation of the stations' buildings, re-equipment of seven hydrological gauges with modern measuring devices, and equipping the agency with satellite Internet (WEB-SAT). More recently, USAID has helped the NMHS develop a website; has equipped the NMHS with a portable water discharge-measuring Doppler device (2007) and helped install a water-resources distribution simulation-model (Mike Basin, 2007).

International Bank for Reconstruction and Development (World Bank).

Beginning in 2006, assistance has been provided to the NMHS in conducting an assessment of economical efficiency of hydrometeorological provision in Georgia. This was followed by the installation of the U.S.A. weather-forecast model (WRF-EMS) for a limited area, installation of a German weather-forecast model (HRM) for a limited area (in 2007), and installation of a hydrological model (FEWS) for the Rioni River Basin in 2008.

Government of Finland

The Government of Finland has also supported Georgia's efforts to re-equip itself by providing for: the re-equipment of seven hydrometeorological gauges with modern measuring means and 10 devices, as well as re-equipping the hydrometeorological department with a portable water-discharge measuring Doppler device. Like USAID, Finland has also contributed to the NMHS's website development.

Government of Canada and the World Bank

With the joint support of the government of Canada and the World Bank in 2008-2009, four hydrological gauges were re-equipped with modern automatic-measuring devices and the hydrological forecasting model was installed for the Rioni River Basin in 2009.

Georgian State Budget

In addition to using donor funds to modernize its hydromet system, the government has also used the state budget. Activities financed through the state budget include: purchase and installation of a telecommunications system (French) TRANSMET (2008); purchase and installation of a modern telecommunications

ESTABLISHED TELECOMMUNICATIONS SYSTEM

System (French) for visualization of synoptic products (SYNERGIE, 2008); and the purchase and installation of automatic meteorological stations (seven units) and automatic meteorological gauges (15 units).

The state and international funds have helped Georgia achieve the following results:

- Thirty-seven automatic hydrometeorological observation points have been installed—seven meteorological stations, 19 meteorological posts, 11 hydrological stations;
- A tool was created to collect and disseminate data gathered by hydrometeorological observations at the national and international levels;
- A tool was created to receive and visualize the synoptic products from the weather centers around the world;
- Validation of short- and medium- range forecasts as well as the warnings about hazardous hydrometeorological events;
- Digitalization of paper-based hydrometeorological data (the process is ongoing);
- Introduction of a geographic information system (GIS) for hydrometeorological information.

Challenges

Georgia's hydrometeorological system is in the process of being modernized, and still requires additional actions to achieve maximum effectiveness. There are currently projects from the Czech Republic and Finland to strengthen and automate the hydrometeorological observation network as well as a project from USAID/OFDA (Office of Foreign Disaster Assistance) to install a flash-flood guidance system. However, additional partnerships and initiatives will be necessary to ensure Georgia has an adequate quantity of the points of terrestrial observation, radar and atmosphere vertical-sensing systems, and high-resolution models for weather and hydrological forecasts.

An Introduction to Hydrometeorological Services in Central Asia

Bengt Tammelin, Independent Consultant for UNISDR

The region of Central Asia and the Caucasus (CAC), covering eight countries—Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan Turkmenistan and Uzbekistan—is highly vulnerable to natural disasters. The national hydrometeorological services (NHMSs) in the CAC countries lack the capacity to provide the range of services needed by disaster risk reduction (DRR) management organizations and different socio-economic sectors to achieve economic development and the Millennium Development Goals (MDGs).

All eight CAC countries were republics of the former Soviet Union. The operation of the HMSs was coordinated by Roshydromet and scientifically guided by the Main Geophysical Observatory. All data was provided annually to Moscow, where it was published. After the collapse of the Soviet Union all the CAC HMSs became individual, national-level organizations, lacking regional cooperation. Gradually the existing network no longer functioned effectively due to lack of funds, decreasing staff and antiquated equipment.

Central Asian and Caucasus Disaster Risk-management Initiative

CAC NHMSs are attempting to revive the observations network, upgrade and modernize their equipment

	Armenia	Azerbaijan	Georgia	Kazakhstan	Kyrgystan	Tajikistan	Turkmenistan	Uzbekistan
Manned synoptic stations;	47	87	25	207	28	52	48	78
Automated weather stations	0	13	0	42	4	0	0	0
Manned sgro	38	1	5	185	31	28	0	2
Automated sgro	0	0	0	0	0	0	27	0
Manned climate station	4	18	NA	33	0	15	13	75
Automated climate station	0	0	0	0	0	0	0	0
Manned rainfall	28	204	30	232	0	67	40	NA
Automated rainfall	0		0	0	0	0	0	NA
Marine/lake	0	15		34	4	15	0	
Weather radar	0	2	1	0	0	0	0	3
Upper air sound.	1	1 (2)	(2)	9	1	0	0	0
Lightning	0	18	3	0	0	0	0	0
Lightning detection system	0	0	0	0	0	0	0	0
Hydrolocical stations	NA	NA		257	76	81	32	10
Satellite receivibg	yes	yes	4	yes	NA	yes	via Uz	yes
Area 1000 km^2	**29**	**86.6**	**69.8**	**2,725**	**199**	**143**	**488**	**447**

and trying to apply new technologies; however, this is happening with little regional coordination. To address these challenges, the Global Facility for Disaster Reduction and Recovery (GFDRR), the World Bank, and the United Nations International Strategy for Disaster Reduction (UNISDR) launched a **Central Asian and Caucasus Disaster Risk Management Initiative (CAC DRMI)**, which aims to reduce the vulnerability of CAC to the risk of disasters. CAC DRMI incorporates four focus areas: 1) Coordination of disaster mitigation, preparedness and response; 2) Financing of disaster losses; 3) Hydrometeorological forecasting; and 4) Data sharing and early warning.

In 2010, the project began with missions to Tajikistan, Turkmenistan and Uzbekistan, in cooperation with the World Meteorological Organization (WMO), which produced a study that included a socio-economic analysis. Ms. Anahit Hovsepyan from the Armenian NHMS also visited Armenia, Azerbaijan and Georgia. Based on the mission reports, literature and Internet research, including World Bank country reports, the UNISDR report was produced. The report covered the eight countries of the CAC region.

In general the observation network of the CAC NHMSs has declined since 1991. Most of the stations are equipped with obsolete instruments. The number of automatic stations is low, as is the number of qualified communication specialists. Most of the climate data is in paper format, and needs to be converted to digital formats. Regional and sub-regional data sharing is limited. In Kyrgyzstan, Tajikistan and Turkmenistan the data-communications systems are obsolete leading to big losses of data. In Tajikistan, alert-warning systems are non-operational due to lack of qualified staff and funding for maintenance.

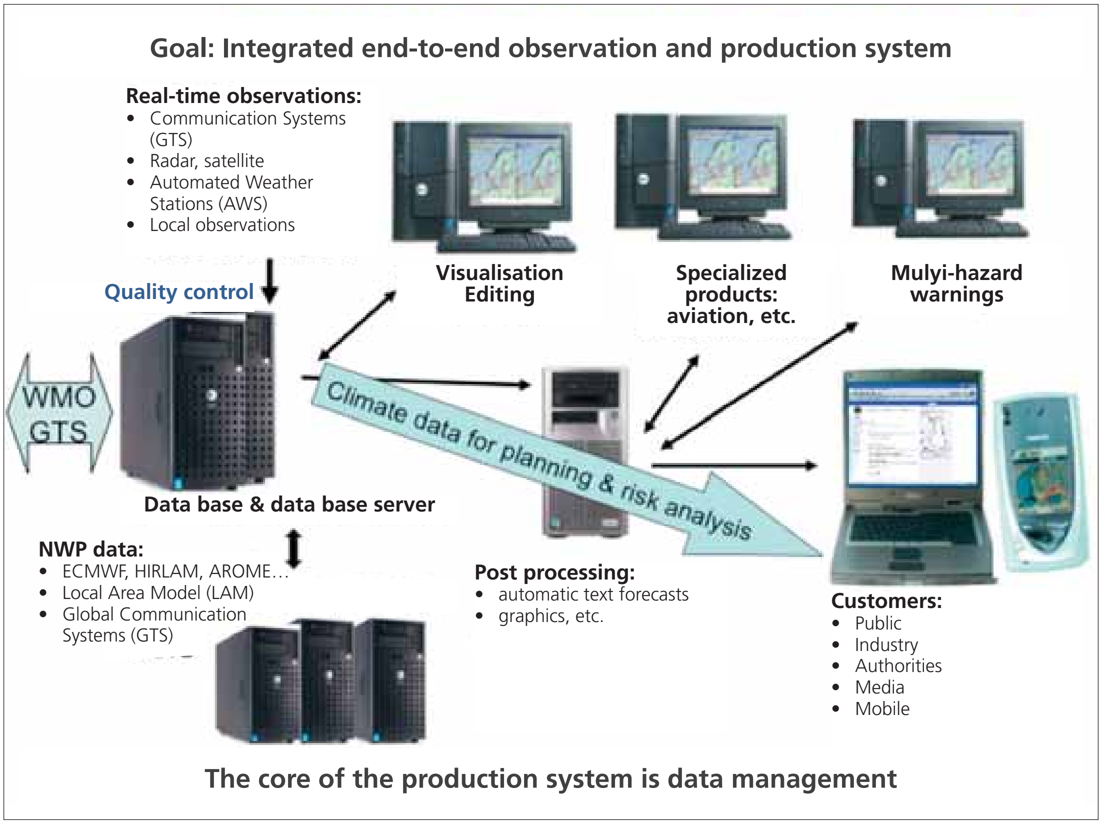
The CAC countries also have challenges when it comes to weather forecasting. In all of the countries the forecasting services are not consistently operational. Of all the CAC countries only Georgia operates a local-area model (LAM), with a spatial resolution of 14 kilometers. Armenia is planning to implement a high-resolution model (HRM) from Deutscher Wetterdienst (DWD), the German Meteorological Service in the near future. Most of the CAC countries do have access to numerical weather-prediction (NWP) products produced by more advanced centers. However, they are not used in digital format (grid point data) and cannot be used for example to manufacture automated weather forecast products for any site, except in Azerbaijan and Uzbekistan.

The studies highlighted that the loss of regional cooperation that occurred following the dissolution of the USSR has had far-ranging negative impacts. Based on project findings, the main gaps in the capacity of the eight CAC NHMSs can be put within the following categories:

- Lack of an ambitious vision and viable strategy;
- Sparse, deteriorating hydrological and meteorological observation networks; lack of remote-sensing systems and unsatisfactory regional data sharing;
- Weak communications systems for collection of data and dissemination of the products;
- Deficient data management and numerical modeling capacity;
- Low financing and poor cooperation with industry and end-users;
- Staff skills and training not adequate to meet modern requirements;
- Lack of regional and international cooperation at mid-management and expert levels;
- Antiquated organizational and management systems;
- Lack of English-language skills which limits the capability to use the Internet and participate/cooperate internationally.

Modernization of the CAC NHMSs

Modernization of the CAC NHMSs is urgently required. Modernization needs to be implemented in a sustainable way taking into account human, technical and financial limitations of the NHMSs. Right now the agencies are in a phase of seeking the best ways to revive their networks and to modernize capacity. The regional goal is an integrated end-to-end observation and production system as depicted on the next page.



The modernization plan contains the following components that are sequenced in phases intended to gradually build capabilities:

- **Training program:** For directors, mid-management (on finance, international cooperation, management); communications and data-management staff; experts and forecasters (on customer needs, modern tools, modern hydrometeorological forecasting services, products); and technical staff;
- **Establishing of a quality-management system:** This refers to the quality management system standards of the ISO 9000:2000 and ISO 9000:2008 series. These principles are used by the World Meteorological Organization as a framework to guide NMHSs towards improved performance;
- **Engaging software experts to improve existing products:** An example would be to transition from text-based warning products to visual-based warning products such as flood-inundation maps showing inundation as well as infrastructure impacted such as roads, buildings, etc;
- **"First Step" modernization of technical facilities:** For example communications and data management, regional data exchange, use of numerical weather-prediction model data in digital format at a local scale, a digital analysis and production system for weather forecasts and services, calibration and maintenance facilities, upgrading of the synoptic stations and automated weather stations (AWS), and a regional lightning-detection system;
- **"Second Step" modernization of technical facilities:** For example weather radar in most critical areas, upper air-sounding systems;
- **Local Area NWP modeling:** Downscaling from global models to local or mesoscale models in order to achieve higher-resolution forecasts and warnings;
- **"Third Step" modernization:** Focused on enhancing the technical facilities.

The modernization plan must be carried out thoughtfully and with a capacity-building focus. For example, governments and donors should not invest in technological solutions, without investing in training the staff that will be using the new technologies. By initially directing training at directors and mid-level services, those decision-makers will gain a better understanding of the end users and their needs.

Building both regional and sub-regional capacity to share data is also a critical need. The technology currently in use is not sufficiently advanced to enable easy sharing of data and information, and the number of qualified communications specialists that could help address this problem is very low.

In terms of regional data exchange, countries need to move towards using the data, and not just the pictures and maps. Many global numerical weather-prediction models available are at high resolution, enabling countries to use them to provide spatially detailed forecasts. In principle, countries can utilize this information for whatever location is requested by the customers. However, having radar available, as well as upper-air sounding data, are also important elements for good forecasting.

Soundings are essential for numerical weather-prediction models, but they are expensive to operate and cannot be undertaken within current agency budgets. Tajikistan, for example, offers an illustration: In 2010, the Tajik Hydromet Agency had an annual budget of US$500,000, with which it paid 700 staff members. Clearly it would be unrealistic to think of operating an upper-air-sounding station with this kind of budget.

Weather radar is the most powerful tool for short-term weather forecasts and tracking of precipitation. The most significant advantage of radar is the production of high-resolution near-real-time regional composite pictures that depict movements of precipitation areas and thunderstorms.

Despite the high cost of improving capabilities, there are potential cost-saving measures. Regional cooperation in radar, and lightning-detection systems, for example, could save money.

Conclusion

The CAC countries are a good example of why a regional approach to strengthening NHMSs is critical. Regional cooperation will enhance the value of any investments that may be undertaken by donors and governments alike.

Central Asia Hydrometeorology Modernization Project (CAHMP)

Xiaolan Wang, **World Bank**

Central Asia Hydrometeorology Modernization Project

The Central Asia Hydrometeorology Modernization Project (CAHMP) has two primary goals: 1) Strengthen the delivery of weather, water and climate services in Central Asia; and 2) Increase cohesion among Central Asia National Hydrometeorological Services by sharing data, information and expertise to rebuild infrastructure and human capacity. Specifically, CAHMP intends to improve the accuracy and timeliness of hydromet services in Central Asia, with particular focus on Kyrgyz Republic and Republic of Tajikistan.

The benefits of improving hydromet services in these countries include: reduced human vulnerability, reduced risk of damage to property and the potential for overall reduction of economic losses as a result of natural disasters; and improved coordination and information exchange among the NHMSs, as well as better regional cooperation in support of climate adaption through generation of more reliable data and better responding to the users' needs.

Project Components

CAHMP is composed of three components:

1. **Strengthening regional coordination and information sharing (International Development Association, IDA, US$8.7 million)** to be implemented by the Executive Committee of the International Fund for Saving the Aral Sea (EC-IFAS). This component will ensure that each of the participating National Hydrometeorological Services can share, use, exchange and archive common hydromet data and information, and that each agency has a comparable level of expertise in the production of information and delivery of hydromet services.
2. **Strengthening hydromet services in Kyrgyz Republic (IDA US$6.0 million)** to be implemented by Kyrgyzhydromet. This component will help strengthen Kyrgyzhydromet to ensure that it has the infrastructure and capability to sustainably observe, forecast and deliver weather, water and climate services that meet the country's identified economic and social needs.
3. **Strengthening hydromet services in Republic of Tajikistan (IDA US$6.0 million; Pilot Program for Climate Resilience, PPCR US$7.0 million)** to be implemented by Tajikhydromet. This component will help strengthen Tajikhydromet to ensure that it has the infrastructure and capability to sustainably observe, forecast and deliver weather, water and climate services that meet the country's identified economic and social needs.

Project preparation began in September 2010, and was approved by the World Bank Board of Directors in May 2011. All three components became effective by May 10, 2012. This project will strengthen capacity and provide better service delivery; the ultimate benefit will be to reduce economic losses and save lives caused by natural disasters. The project will create an opportunity for better regional coordination and information sharing, which can be replicated for the future disaster risk management (DRM) agenda in Central Asia and other regions. The primary risk is that the project would require tremendous coordination and implementation support because it engages a regional agency (EC-IFAS) and four countries with different levels of capacities.

Challenges and Opportunities

From the beginning, the CAHMP project team was straightforward about the potential risks and rewards of the project. Building capacity and sustaining operations are much more challenging than building infrastructure—especially since the project operates in a region where fiscal capacity is limited and there are many competing needs. Implementation will focus on building multi-agency partnerships, enhancing service delivery through better communications and exploration of different business models, and linking hydromet services with early warning and disaster risk reduction efforts.

CAHMP is also laying the groundwork for future regional projects—the project team is proposing that there be a follow up project. For at least five to 10 years, institutional reform will be necessary for governments to accumulate the capacity needed to sustain and further cultivate the capacities in which partners are currently investing. The participating National Hydromet Services (NHMSs) in Central Asia countries plan to build partnerships with WMO, leading NHMSs from other regions and global forecasting centers. In consideration of these needs, the World Bank ECA Region will be examining how national-level investments could combine with regional and global investments in hydromet and disaster risk reduction, more generally.

Development of Hydromet Modernization Projects in the World Bank ECA Region

Vladimir Tsirkunov, World Bank

Central Asia Hydromet Modernization Project

The World Bank's Europe and Central Asia region (ECA) has been a leader in developing a systematic approach that takes into account the full circuit of hydromet clients. To better target its work, ECA undertook a survey of hydromet services in 19 countries and studied the economic efficiency of hydromet modernization programs. Based on this research ECA is systematically undertaking hydromet modernization projects, many of which are now complete or near-complete in countries like Poland, Russia and Turkey,

Analytical results are informing the way ECA interacts with client governments. For instance, it found that most World Bank clients in ECA are organized as integrated Meteorological and Hydrological Services (NMHSs). Some agencies are affiliated with the Ministries of Environment, while others are affiliated with agencies responsible for natural resources, emergencies, civil affairs, transport and urban affairs, and academy of sciences. Few NMHSs are self-standing agencies.

NMHS budgets generally account for 0.01-0.05 percent of national gross domestic product, GDP.[8] A mixed-funding model is common. While basic NMHS products are free, others are contracted on a cost-recovery basis. Revenues from services range from 1-3 percent (Turkmenistan, Uzbekistan), to about 30-35 percent (Russia, Ukraine). In terms of staffing, there are about 19,000 NMHS employees in 18 ECA countries, in addition to the over 36,000 staff in Russia's hydromet service.[9]

[8] source Weather and Climate Services in Europe and Central Asia: A regional review (2005-2007)

[9] source Weather and Climate Services in Europe and Central Asia: A regional review (2005-2007);

Value of Analytical Work

Analytical work helps to identify the role of the hydromet sector in economic development and attract the attention of decision-makers, making it an important tool for mobilizing the resources and political will required to build NMHS capabilities. When ECA began its research, there were no established approaches to assessing the value of investing in hydromet, so the team used simple techniques based on the comparison of expected reduction of losses due to better forecasts with the costs of hydromet modernization programs. In all cases expected benefits of proposed NMHS modernization were 2-10 times greater than modernization costs. Reduction of losses is only a part of expected benefits (households, better business-development opportunities were not accounted for due to lack of data); therefore investing in strengthening NMHSs is more beneficial than ECA's economic assessments seem to indicate.[10]

Results of ECA analytical work were summarized in a study on *Weather and Climate Services in Europe and Central Asia: A regional review (2005-2007).* This study examined the NMHS capacity in 19 countries, and assessed the economic benefits from hydromet services in a subset of countries, including the economic impacts of effective weather warnings. The study also included a review of regional cooperation opportunities in two sub-regions and climate change adaptation proposals in two countries. The chart on the next page captures the economic-efficiency results for several of the proposed NMHS modernization programs.

[10] Studies include: Russian Pilot Study on assessment of economic benefits of RosHydromet modernization (2004); Weather and Climate Services in Europe and Central Asia: A regional review (2005-2007); Joint Study of WB/ISDR/WMO on Strengthening Hydromet Services in South Eastern Europe (2006-2008); Development of an Action Plan for Improving Weather and Climate Service Delivery in High-risk, Low-income Countries in Central Asia (GFDRR, 2008-2009)

Main Results of Economic Efficiency of Proposed NMHS Modernization Programs

Countries	Estimated cost of modernization program, $ million/(exceedance of NMHS annual budget, times)	Investment efficiency,% (across 7 years), benchmarking	Investment efficiency, % (across 7 years), sector-specific assessment
Albania	4.0 (9)	438	320-680
Armenia	5.3 (12)	210	1,070
Azerbaijan	6.0 (3.5)	430	1,440
Belarus	11.5 (4)	530	480-550
Georgia	6.0 (13)	260	1,050
Kazakhstan	14.9 (3.5)	540	–
Serbia	4.4 (0.8)	880	690
Ukraine	45.3	310	410-1,080

Modernization of Central Asia Hydromet Services

ECA continues to build upon the research and analysis it has conducted to pursue the NMHS modernization agenda. For example, through the study on *"Improving Weather and Climate Service Delivery in High-risk, Low-income Countries in Central Asia"* (under the auspices of GFDRR), ECA completed an assessment of natural hazards and climate variability; evaluation of the current status of the NMHSs (hydromets) and assessment of their capacity; user-needs assessment with emphasis on disaster risk management and early warnings, agriculture, water-resources management and irrigation; assessment of the economic benefits of potential NMHS modernization; and development of recommendations and a prioritized plan of improvement of weather and climate service delivery to national users.

The study found that many Central Asia countries are vulnerable to floods, mud flows, droughts, frost, avalanches, hail and strong winds, which cause losses between 0.4 and 1.3 percent of GDP per annum, and, that most of these losses are preventable. Better hydromet services could prevent between US$5.8 million and US$23.0 million in losses.

Hydromet (NMHS) Capacity in Central Asia

NMHS capacity to meet user and government needs is very limited. All facilities are in a poor state. Equipment is obsolete and NMHSs lack access to modern forecasting methods. Overall, there is a downward trend in quality and quantity of observations. The deterioration of NMHS capacity is due largely to the degradation of the observation networks. Many stations closed due to lack of funds, and data from existing stations is unreliable.

Examples of NMHS Investment Programs in ECA

- Poland Emergency Flood Recovery Project (1997-2006) – US$62 million invested in NMHS modernization;
- Turkey Emergency Flood and Earthquake Recovery Project (1998-2005) – US$26 million invested in NMHS modernization;
- Russia Hydromet Modernization project (2005-2012):
  - Project (US$177 million) is approaching completion;
  - Hydromet II Project (US$141million) is under preparation;
- South Eastern Europe Disaster Risk Mitigation and Adaptation Program (2008 - present);
- Investments under implementation in Albania, Moldova.
- Central Asia Hydromet Modernization Project (2011- now)—Investments under preparation in Tajikistan, Kyrgyzstan + regional activities.

	Kyrgyz Republic		Republic of Tajikistan		Turkmenistan	
Component of observation network	**Number, 2008 (Number, 1985)**	**% Reduction since 1985**	**Number, 2008 (Number, 1985)**	**% Reduction since 1985**	**Number, 2008 (Number, 1985)**	**% Reduction since 1985**
Meteorological stations	32 (83)	62	57 (73)	22	48 (100)	52
Hydrological stations and posts	76 (147)	48	81 (138)	41	32 (58)	45
Upper air	0 (3)	100	0 (4)	100	0 (6)	100
Meteorological radars	0 (1)	100	1 (4)	75	0 (1)	100
Agromet observation stations	31 (68)	55	20 (37)	46	48	

In addition to a lack of technical capability, when it comes to service delivery many NMHSs—with the exception of those with commercial divisions—are not very client oriented and are often unaware of their current and potential clients' needs. Consequently, NMHS commitment to modernization is often driven by IT or technology developments, not by client needs. When the installation of new equipment is seen as the final objective of the project, the sustainability of investment can become a major problem.

Modernizing NMHSs will likely require a range of actions, including: the renewal of observation networks; building capacity to deliver services that users want; engaging those users in the modernization efforts; establishing a national climate service within Hydromet; integrating NMHS modernization into broader disaster risk reduction and energy-water development frameworks; and supporting regional activities (e.g. training, improvement of communications networks). The expected results of these modernization efforts are (1) Capacity improvement and better service delivery; and (2) Reduction of economic losses and saved lives.

In the short time the World Bank has been involved in strengthening hydrometeorological services, there is little evidence of significant success yet in developing countries. Rather, the ECA team has learned that building the region's hydrometeorological infrastructure is less challenging than building institutional capacity and ensuring sustainability. Consequently, the sustainability of investments is the main challenge. To address this challenge, ECA tries to test NMHS and government commitment upfront, especially as modernization is a big challenge for NMHSs. As part of the process of ascertaining government commitment, ECA generally explains to Ministries of Finance that proposed modernization should come with increased NMHS budget. ECA also makes an assessment of operations and maintenance (O&M) costs as an obligatory part of project design and supports only those investments which have a chance to be sustainable.

Provision of better services is a key for future sustainability of hydromet services. Consequently, service improvement should be a focus of modernization, and clients should be actively engaged throughout the modernization process. Ensuring that better services are developed may also require finding the appropriate mix of private and public engagement, especially since public-private partnerships could improve service delivery.

Conclusion

ECA experience in hydromet modernization has triggered greater interest in this field of work at the World Bank. As modernization projects are implemented, ECA should continue to show the implementation progress including service delivery improvement, and better client satisfaction and sustainability. ECA's experiments with developing new business models (agency, PPP) should also stay at the forefront of the hydromet discussions at the World Bank.

In part due to the efforts of the ECA region, the World Bank is scaling up its support to NMHSs. Increasingly, the World Bank is playing an advisory role—convincing governments of the high societal and economic significance of weather, climate and hydrological information; making meteorological and hydrological agencies the center of support; helping NMHSs to raise their profile within the government by using the results of economic assessments/cost-benefit analysis and analytical work; identifying priority investment needs and facilitating financial support; and recommending that modernization of NMHSs be a component within larger projects in disaster reduction, water resources management, agricultural support and public-health improvement. The World Bank is also exploring creative use of new financial instruments of climate adaptation and climate investment funds for NMHS support (e.g. the Climate Investment Funds (CIF), the Green Fund). In addition, the World Bank has launched targeted technical-support programs such as GFDRR's *Weather and Climate Information for Decision-support Systems (WCIDS)*, and is actively building partnerships with WMO, leading NMHSs, global forecasting centers and the private sector.

Despite this momentum, modernizing NMHSs has the inherent challenges already mentioned. In addition, there are the generic problems of the public service in transition economies—low salary, lack of flexibility, high uncertainty; a lack of guidance on how to modernize NMHSs using limited resources in an optimal way; and how to plan national NMHS modernization based on available and future globally available hydromet products.

Moving forward, there are five important focus areas for ECA: (1) Working in regions with significant challenges in delivering forecast and warning services (Caucasus, Central Asia, Ukraine); (2) Ensuring sustainability of project impacts; (3) Continuing to seize opportunities as they emerge; (4) Launching a Severe Weather Forecast Demonstration Initiative in Central Asia and possibly in Caucasus; and (5) Building partnerships with WMO, leading NMHSs, global forecasting centers and the private sector.

Africa: Coordinated Approach for Stakeholder Involvement in Climate Outlook Simulation

Doekle Wielinga, **World Bank**

Disaster risk management (DRM) is critical for Africa's economic growth. Vulnerability in Africa is very high, coupled with low capacity to plan and invest in adaptation, as well as limited infrastructure. From 1970-2009 the number of people impacted by disasters drastically increased.

In 2011, at the peak of the drought, 14 million people were affected in the Horn of Africa; the same number of people are expected to experience the impacts of drought in the Sahel this year alone.

Apart from drought, African countries experience floods, coastal erosion and cyclones.

Most African countries share rivers or lakes with one or more neighboring countries. In fact, 17 of 52 major international trans-boundary rivers or lakes are located in Africa (e.g. Congo, Gambia, Niger, Nile, Senegal, Volta, Zambezi, Lake Chad, Lake Victoria). Flooding is a regional phenomenon across the continent—West Africa experienced four consecutive years of floods. In 2010, 1.7 million people were affected by floods in Benin, Burkina Faso, Chad, Ghana, Niger, Nigeria, and Togo. The year before (2009), Benin, Burkina Faso, Niger and Senegal all experienced major floods.

Institutional Challenges

There are five regional economic commissions under the African Union and 34 river-basin organizations and technical agencies; however, there is limited data sharing among these organizations, due in part to considerable language barriers. Seasonal climate forecasts issued by national meteorological services are used to disseminate forecasting information; however, as many as 60 percent of DRM agencies in Africa have never contacted these climate outlook organizations and over 70 percent of DRM agencies never contacted AGRHYMET (regional hydrological organization, Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle).

Climate Outlook Forums

Target and disseminate forecasting information

Climate outlook forums in Africa provide real-time regional climate outlook products and target the next rainy season and drought forecasting. Traditionally they are closely related to the agricultural sector. Recently, they have also become the lead organizers for regional climate centers; for example, in the Greater Horn of Africa, the IGAD Climate Prediction and Application Center (ICPAC) is the regional climate center; for West Africa, the African Center for Meteorological Application for Development (ACMAD).

ACMAD also facilitates climate prediction for Southern Africa with the Southern African Development Community (SADC), and the Central Africa and the Indian Ocean region groups—which include the following predominantly Francophone countries: Burundi, Cameroon, Chad, Comoros, Congo, the Democratic Republic of Congo, Gabon, Madagascar and Rwanda.

Despite the existence of these climate outlook forums, there is a missing link with users of climate information who don't seem to communicate with each other.

West Africa: Regional Flood Simulation Exercise

In 2011, a Regional Flood Simulation Exercise was conducted in West Africa with the objective to: (1) Assess mechanisms for hydromet information monitoring and communication with national-level authorities; (2) Strengthen emergency and contingency planning; and (3) Foster decision-making processes for early warning information. The exercise was developed with data from the 2010 floods in West Africa. The exercise was carried out on June 22-23, 2011 at the Economic Community of West African States (ECOWAS) Headquarters in Abuja, Nigeria. Fifty-one representatives from 16 national structures, 22 representatives from regional organizations and 17 representatives from international organizations convened for the exercise.

The exercise was designed to test capacity and communication. Scenarios allowed players to talk on neutral ground by using fictitious countries in West Africa with water-system and climate characteristics similar to reality. The case study involved two geographic areas: Gassama (English speaking) and Kurubani (French speaking). Details of each country were provided to guide the actions and decisions of participants. ACMAD/AGRHYMET products were adapted (based on real 2010 products), so that participants had access to the seasonal forecast, monitoring bulletins and flood warnings.

Based on the results of the Regional Flood Simulation Exercise, several recommendations emerged:

For ACMAD and AGHRYMET:

- Need to better understand their users;
- Create more user-friendly products (content and format);
- Collaborate with the DRM community to develop more tools and expand the broadcasting targets;
- Coordinate to ensure consistent messages;
- Build national capacity to scale products at the national level.

For national and regional partners:

- Make better use of existing information through data-sharing and user-adaptation;
- Improve interactions among the DRM and the hydro and meteorological communities;
- Strengthen regional and national forecasting capacities;
- Increase involvement and support of regional actors, such as basin authorities;

In addition to these specific recommendations, participants provided general feedback. The feedback highlighted the need for more extensive use of scientific products of hydrometeorological forecasts existing within each of the three communities involved in flood early warning systems. Participants also indicated the importance of creating a platform for dialogue to enable the three communities to interact and strengthen their collaboration at the national level. Finally, they also felt that increasing joint activities would facilitate inter-institutional cooperation.

Towards a Programmatic Approach

A programmatic approach for stakeholder involvement in regional forecasting and early warning should take into consideration that each sub-region in Africa has a distinct disaster profile, and that there is limited capacity and readiness at regional levels. These differences would lead to different program implementation speeds.

Partners may want to consider using West Africa, where the flood simulation occurred, as a pilot region for DRM and hydromet-related activities. Additionally, taking an ecosystem-based approach to interventions could ensure that countries are working together for specific water basins, rivers and lakes. With rapid urbanization, targeting cities as priority intervention areas makes good sense. Given the current status of regional and sub-regional cooperation, these activity lines should occur using a phased approach.

Another key focus should continue to be on connecting science with policy and practice to improve forecasting and risk reduction. A programmatic approach for stakeholder involvement in regional forecasting and early warning might therefore include: mobilizing relevant actors and integrating disaster risk reduction (DRR) and climate change adaptation (CCA) within the institutional capacity of hydromet organizations; developing risk assessment capacities to identify pilot ecosystems and urban disaster hotspots; establishing a vulnerability monitoring framework; introducing DRR and CCA within regional political and economic development agendas; and developing common strategies.

Conclusion

Meteorological organizations need to better understand their end users and devise an effective, user-friendly way to disseminate their products. The interaction among hydrological, meteorological and DRM should be strengthened, as well as regional and national forecasting capacities.

There is also a need to provide support to regional actors, and to use scientific products as much as possible in joint activities and for fostering dialogue and the creation of a community of practice. Ideally, a programmatic approach should link academia and science, and decision-makers and practitioners.

Closing Remarks

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The United Nations Office for Disaster Risk Reduction (UNISDR) for Europe is strongly engaged with the World Bank in collaboration with other regional and national partners in reducing vulnerability in disasters. In 2008, the World Bank and UNISDR Europe launched a program called South Eastern Europe Disaster Risk Mitigation and Adaptation Program (SEEDRMAP) under the auspices of the Global Facility for Disaster Reduction and Recovery (GFDRR). One of the priority areas is focused on hydrometeorological forecasting, data sharing and early warning. This hydrometeorological workshop is part of this priority and set in the context of this initiative.

Why is this workshop and the role of hydrometeorological services in disaster risk management so important? Weather-related disasters count for 80-95 percent of losses and costs of disasters on average per year. The Global Assessment Report of 2011 has looked in detail at nationally-reported disaster losses in 21 countries. Since 1989, there were 63,667 schools and 4,873 health facilities damaged or destroyed, 73,000 kilometers of roads damaged, and 3,605 municipal water systems, 4,400 sewer systems and 6,980 power installations damaged and destroyed. Of these losses, 46 percent of the schools, 54 percent of the health facilities, 80 percent of the roads and more than 90 percent of the water, sewer and power installations were damaged or destroyed in frequently occurring extensive disasters.

In 2010, Europe saw the biggest increase in disaster occurrence (+ 18.2 percent), compared to the decade's averages. In terms of economic damages, Europe accounted for 14.3 percent of the global reported losses in 2010 due to disasters—most of the damages were due to climatological and hydrometeorological events.

The *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)* was approved on November 11, 2011 by member governments of the Intergovernmental Panel on Climate Change (IPCC). More intense and longer droughts are observed in some regions, frequency of hot days will increase by a factor of 10 in most regions of the world, heavy precipitation will occur more often, and the wind speed of tropical cyclones will increase while their number will likely remain constant or decrease.

Added to that picture is the fact that economic-loss risk is continuing to increase—particularly in wealthier countries. In 2010, the economic loss risk to floods in the OECD countries—which concentrate about 53 percent of the global gross domestic product (GDP) exposed per year—is about 170 percent more than in 1990. Economic loss risk in the OECD is rising faster than GDP per capita, meaning that the risk of losing wealth in weather-related disasters is increasing faster than that wealth is being created.

This does not mean that countries are not reducing their vulnerability—they are. But these improvements are not happening fast enough or deep enough to compensate for increasing exposure.

As we have learned, in order to promote national and regional economic development and reduce the risk of disasters caused by natural hazards in Europe and the Central Asia and Caucasus countries, it is critical to enhance the technical and human NHMS resources to ensure better operational monitoring, forecasting and warning. Furthermore, in the 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 sectoral planning for different socio-economic sectors.

The future of each national hydrological and meteorological service (NHMS) lies in its ability to develop and more effectively deliver hydrometeorological products and services that have a recognizable value to government, to different socio-economic sectors and to environmental-protection efforts.

Proper production and use of climate and weather data and information by disaster risk reduction 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 the impacts of hazards, and adaptation to climate change, and thus promote socio-economic development and achievement of the Millennium Development Goals (MDGs) by each country.

Regional cooperation and data sharing among the South Eastern Europe National Hydrometeorological Services (SEE NHMSs) and among Caucasian and Central Asian NHMSs will significantly promote the quality and quantity of hydrometeorolgical services, and decrease the impacts of natural hazards in each country. However, the Caucasian and Central Asian NHMSs countries are very big, and it is difficult to achieve similar benefit from regional cooperation in modernization of the observation network, in comparison to what has been shown in the modernization plan for the South European countries. The NHMSs in Central Asia have identified the need for regional data sharing and exchange, as well as other directions to move in regional coordination.

In order to build a dependable and sustainable development plan it is critical to introduce a reliable vision, and to plan an end-to-end data collection and service-production system based on identified and recognized end-user needs. The increasing need for 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 big opportunities to promote their visibility and to garner national and international support for financing their modernization.

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