ABSTRACTS

Technical Conference on Changing Climate and Demands for Climate Services for Sustainable Development

with a Special Joint Session with the Joint Scientific Committee (JSC) for the World Climate Research Programme (WCRP)

Antalya, Turkey, 16-18 February 2010

In conjunction with the

Fifteenth Session of the Commission for Climatology

WMO
World Meteorological Organization

WCRP
World Climate Research Programme
World Climate Research Programme

METEOROLOJİ
Turkish State Meteorological Service

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Abstracts of the Technical Conference on Changing Climate and Demands for Climate Services for Sustainable Development

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(Antalya, Turkey, 16-18 February 2010)

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NOTE

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PREFACE

Evidence from observations of the climate system, which includes an increase of 0.74 ± 0.18°C in global average surface temperature over the last century, and an even greater warming trend over the last 50 years, has led to the conclusion that human activities are increasingly contributing to a warming of the Earth's atmosphere. Climate change is widely accepted as the single most pressing issue facing society on a global basis, and the growing awareness of the impacts of climate change on different sectors is forcing decision-makers to refocus on the demands climate change places on sustainable development. Broad concepts in sustainable development encompass ecological, economic, and social parameters, whereas more narrowly defined concepts are mostly concerned with environmental issues such as optimal resource and environmental management. When global climate change is viewed in the wider context of sustainability, it is imperative that a holistic view must be taken of nature, man and climate, and science and technology as a source of innovative ideas and solutions. It is important to manage the social, environmental and economic impacts of climate change in a structured manner to help affected countries to manage climate related risks more efficiently and to strengthen its ability to thrive in the future.

Previous efforts of WMO and partners to engage with the user communities included the organization of the Technical Conference on "Climate as a Resource", (Beijing, China, November 2005), the International Workshop on "Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risks" (Espoo, Finland, July 2006) and the Madrid Conference on "Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services" (Madrid, Spain, March 2007).

WMO, in cooperation with other UN agencies, Governments and the private sector, organized the World Climate Conference-3 (WCC-3) from 31 August to 4 September 2009, in Geneva, Switzerland. Heads of States and Governments, Ministers and senior government officials of 160 countries participated. More than 2,500 scientists, sector experts, and decision makers discussed the urgent need for accurate and timely climate information. WCC-3 decided to establish a Global Framework for Climate Services (GFCS) to strengthen the production, availability, delivery and application of science-based climate prediction and services.

With the forgoing impetus, the World Meteorological Organization (WMO), together with the World Climate Research Programme (WCRP) and the Turkish State Meteorological Service, is organizing the Technical Conference on "Changing Climate and Demands for Climate Services for Sustainable Development" in Antalya, Turkey, from 16 to 18 February 2010. The Conference is co-sponsored by Météo-France. The agenda importantly includes a one-day joint meeting between the Commission for Climatology (CCl) of WMO and the Joint Scientific Committee (JSC) for the WCRP. The Conference will focus on how both climate variability and change affect sustainable development, and how the WCRP climate research community and other partners can work with the CCl to improve responses by WMO to the needs of society in this regard.

Specific objectives of the Technical Conference are to:

- Review the benefits and risks to society from climate variability and change; the requirements of society for climate information, products and services to support adaptation to climate variability and change, as well as sustainable development; and known gaps in meeting user requirements;
- Identify within WMO and its partners, currently available tools, techniques, infrastructure, systems and human capacity for serving user requirements across a range of climate information products and services at all levels;
- Assess the adequacy of these with respect to societal requirements;

- Review recent advances in seasonal prediction research, consider their operational uptake and formulate joint CCI/WCRP efforts to sustain research-operations linkages particularly at regional/national scales; and

- Recommed to the upcoming fifteenth Session of CCI, new approaches to improving the contributions of CCI and WCRP and other relevant partners.

The Technical Conference is organized in 6 sessions (including the opening session and the Special Joint Session with the JSC of WCRP) during which 32 invited papers are presented addressing the different specific objectives of the Conference.

This volume includes the abstracts of the 32 invited papers and of 15 posters that will be displayed during the Conference. The Sponsors of the Conference would like to thank all the authors for their efforts and for their cooperation in bringing out this volume in time.

SESSION II

Societal Demands for Climate Services for Adaptation and Risk Management

Chairman: Mehment Karaca
Rapporteur: Rupa Kumar Kolli

INTEGRATING SOCIETAL NEEDS INTO THE DEVELOPMENT OF CLIMATE SERVICES

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Abstract

Governments, communities, businesses and resource managers are increasingly challenged to develop and implement programs, policies and procedures that reduce vulnerability and enhance resilience in the face of changing climate conditions. These actions should address both today's climate-related challenges (e.g., climate-related extreme events) and support planning for the future in the context of climate change. Borrowing from Mickey Glantz, this requires an approach to climate science and services that:

1. reflects a continuously evolving understanding of the integrated "climate-society system" and

2. embraces an adaptive management approach that provides for regular evaluation and adjustment of decisions as new scientific insights emerge and socio-economic conditions change.

Mainstreaming climate considerations into societal decision-making in this manner requires a new partnership through which scientists and decision-makers develop a shared understanding of the nature and consequences of changing climate conditions (shared learning) and support joint problem-solving based on the unique insights and expertise that each brings to the table.

The WCC-3 commitment to a Global Framework for Climate Services provides an exciting opportunity to forge this critical science-society partnership. Over the past two decades, climate observations, data stewardship, research, modeling, assessment and fledgling information services in NOAA, the United States and around the world have highlighted a number of lessons learned that could serve as guiding principles for us as we embrace this opportunity including:

- Engaging users in the development and continued evolution of services through sustained and iterative dialogue;

- Adopting a problem-focused approach that supports the development, dissemination and use of products and services on time and space scales relevant to decision-making;

- Transforming climate science and data into understandable, usable, useful and accessible information; and

- Establishing effective partnerships involving government, academia, NGOs, the private sector and decision-makers that leverage their unique assets and capabilities.

This presentation will explore the implications of these and other lessons in the context of designing and developing climate services for society.

CLIMATE SERVICES FOR DISASTER RISK MANAGEMENT

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Abstract

Between 1980 and 2007, nearly 90% of disasters related to natural hazards, 70% of casualties and 75% of economic losses were caused by meteorological, hydrological and climate-related hazards such as tropical cyclones and storm surges, floods, droughts, and extreme temperature (source: EM-DAT). IPCC Fourth Assessment Report has provided scientific evidence that the severity, intensity and frequency of climate related hazards such as droughts, heat waves, floods, forest fires and tropical cyclones are increasing as a result of human-induced climate change.

Traditionally, many countries have been reactive to disasters leading to significant losses in lives and livelihoods of their citizens. However, the adoption of "Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters," by 168 countries, has led to a new paradigm in disaster risk management focused on prevention and preparedness at the national level to reduce the impacts of disasters. The UNFCCC Bali Action Plan has stressed the need for disaster risk management as a critical component of climate adaptation and risk management of all countries. During this presentation components of effective disaster risk management will be discussed, including, (1) Risk Assessment, (2) Risk Reduction through early warning systems, and medium and long-term sectoral planning (e.g., land zoning, infrastructure and urban development, agricultural management) and (3) Financial Risk Transfer through weather-indexed insurance and other financial mechanisms to reduce the impacts of disasters at various levels. Emergence of climate modelling and analysis tools provides unprecedented opportunities for development of climate services for effective disaster risk management. These opportunities will be presented through concrete examples.

CLIMATE INFORMATION FOR ADAPTATION AND RISK MANAGEMENT WITHIN LOCAL COMMUNITIES

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Abstract

Climate information can be of value, only if it can be used to make a positive difference in decisions involving risks posed by adverse weather or climate. Impacts on people's lives and livelihoods by climate extremes display an alarming increase. Factors like increasing size of the population living in hazard prone area, poverty, social setting and demographic pressures have significantly contributed to the sensitivity of communities to climate. Added to this, is the possible additional risks due to climate change. Effective management of adverse climate, so as to avert these risks from becoming either disasters or threats to livelihoods, can be achieved only through systems that can generate and use climate information to its full potential.

Reliable weather, climate and water information generated by the National Meteorological and Hydrological Services is the crucial first step for early warning which is important for preparedness to weather/climate risks. The chain that starts with monitoring of weather and climate events, leading up to community level response can be functionally disintegrated into steps wherein interventions can contribute to preparedness and reduction of climate risks at the community level. There are however many gaps in this chain at present. Projects aimed at creating systemic linkages between climate information producers and users, as well as those that facilitate this process can contribute significantly towards forging linkages in the end-to-end chain.

Examples like translating early warnings of rainfall, into river basin level runoffs to alert locations where flood risks could be high and triggering community level actions to prepare for the risks illustrate the potential use of climate information for managing risks and as adaptation measures for future climate change. Similarly, making practical use of ENSO forecasts in designing risk management strategies for climate sensitive activities, particularly agriculture and water resources at institutional and community levels can be replicated for enhanced use of climate information.

CLIMATE RISK MANAGEMENT FOR AGRICULTURE: THE AUSTRALIAN EXPERIENCE

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Abstract

Australia has remarkably high year-to-year variability in both rainfall and agricultural yield. However, a feature of this variability is that it is strongly El Niño-Southern Oscillation (ENSO) dominated (Nicholls and Wong, 1990), suggesting good opportunity for use of seasonal forecasts to aid risk management, especially if based on aspects of ENSO. However, seasonal forecasts can provide higher value to users in aiding climate risk management if integrated with agricultural simulation models and so provide more decision-relevant outputs such as agricultural yield or pasture growth rates. In this respect, it has been emphasized in Australia that in application of climate risk management for agriculture, simply having knowledge of climate variability and the influence of such climate drivers as ENSO is not necessarily sufficient to reduce vulnerability to climate extremes and assist risk management. To reduce vulnerability in agricultural production, there is a need to modify actions ahead of likely climate impacts. In Australia, appropriate seasonal forecasting systems have provided the means to reduce agricultural production vulnerability to extremes of climate variability, especially when they are integrated with crop and pasture simulation models and delivered in a form of relevance to users in an iterative, participatory environment.

A further key requirement in climate risk management identified in Australia is the need for producers of seasonal forecasts (of either climate or agricultural yield) to, if possible, personally meet with decision-makers through targeted workshops relevant to the agricultural sector. Indeed, Hammer (2000) points out that “climate forecasting has no value unless it changes a management decision” implying a strong requirement for management decisions to be clearly articulated by users and for this information to be provided in an iterative process to the developers of seasonal forecasts and associated information so that effective outputs may be produced.

To aid the required connectivity between climate forecast output and agricultural management additional opportunity has been provided through the key linking role of integrated climate forecast-agricultural simulation modelling which can then be used to evaluate outcomes and risks relevant to various decisions in agriculture. Additional facilitation of the decision-making process to aid risk management can be made through use of ‘discussion-support systems’ where agriculturalists can discuss climate risk management options with climate experts and agronomists to aid their decision making.

Risk management and associated decisions in agricultural production in Australia have been shown to be related to climate systems occurring at a variety of temporal scales – intraseasonal, seasonal/annual (strongly ENSO related), biennial, decadal, multi-decadal, low frequency systems and also those necessarily associated with climate change. These management decisions range from logistical and tactical decisions (scheduling of planting and harvesting; application of fertiliser) through to those strategic decisions related to cropping type and sequence, crop rotation, and related to low frequency systems, industry scale and landuse policy decisions. Appropriate climate modelling and forecast systems relevant to those decision-scales need to be developed.

CLIMATE INFORMATION FOR HYDROLOGICAL OUTLOOKS

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Abstract

This paper describes how hydrologists and climate scientists in New Zealand collaborate to produce seasonal outlooks for soil moisture and river flows, based on information about current conditions and on seasonal "climate" outlooks for air temperature and rainfall. The hydrological outlooks estimate the probability that soil moisture and river flows averaged over the coming three months for the forecast regions will lie within the top, middle or bottom third of their distributions. These three-month "tercile" outlooks are updated at the beginning of each month. The "normal" period from which the tercile boundaries are calculated is 1971 to 2000.

The climate and hydrological seasonal outlooks are provided for six New Zealand forecast regions. These regions were chosen based on an analysis of spatial coherence in temperature and rainfall variability. Until recently the outlooks were disseminated through a monthly four-page update and outlook document available over the web and as a printed copy. Dissemination now is "web-only", with end-users able to sign up for a monthly email alert containing web links to the outlooks.

The paper begins with a description of the methods used to develop the seasonal climate updates and outlooks. Many of New Zealand's climate stations are automated, with daily transfer of data into the centralised national climate database (CLIDB) operated by NIWA. A simple water balance model is run using the standard climate measurements to estimate daily values of soil moisture, and spatial interpolation techniques are used to produce national maps of temperature, rainfall, and sunshine anomalies averaged over the last one and three months, and soil moisture at the end of the month. Such maps are provided as part of the monthly update material on the website, and the data behind them provide the statistics for defining tercile boundaries and for validating the seasonal climate outlooks. The three-month outlooks for air temperature and rainfall draw on regional and local projections from various sources. These include projections from several international Centres of the state of the El Niño Southern Oscillation (ENSO), projections from several global modelling groups of precipitation and temperature over New Zealand, observed sea surface temperatures, and locally-developed statistical predictions based on circulation, ENSO and sea surface temperature parameters. These products are discussed at a monthly meeting of climate, ocean and hydrological scientists, and a "consensus" probabilistic seasonal (three-month) outlook for temperature and rainfall is produced for each of the six forecasting regions.

These outlooks, providing estimates that precipitation and temperature for the coming three months will lie in the lowest, middle, or upper terciles, are provided to a group of hydrologists. This group also has access to data summaries and anomaly maps of flows of many New Zealand rivers, and to maps of soil moisture anomaly. From this material they produce consensus seasonal (three-month) outlooks of river flow and soil moisture anomalies, for the same forecast regions as used for the seasonal climate outlooks.

We will show results from the routine ongoing validation of these seasonal climate and hydrological projections, which indicate variations in skill between regions, seasons, and

forecast parameters. We will also briefly discuss research on the predictability of New Zealand seasonal temperature and rainfall variations.

CLIMATE CHANGE IMPACTS ON AGRICULTURE AND WATER RESOURCES IN AND AROUND TURKEY

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Abstract

Climate system is comprised by the complicated interactions among the atmosphere, the ocean, the cryosphere, the surface lithosphere and the biosphere. Human beings are altering atmospheric composition. Since the Industrial revolution, atmospheric CO concentration increased from 280 to 400 ppm due to mainly fossil fuel uses.

Climate change is technically characterized by a shift in means. Small changes in the mean can cause a large change in the likelihood of extreme event. Climate change is already happening and will be impact on all sectors, especially agriculture and water resources.

It is accepted that one of the most important environmental problems of the present century will be climate change. This will give rise to changes in weather patterns, and an increase in the frequency and severity of extreme events. In the Eastern Mediterranean, as in the rest of the world, global climate change will cause an increase in the severity and frequency of extreme events such as heat waves, sea level rise, extreme rainfall and flood events in some regions but increased drought in the others, in a way that will directly affect living conditions.

According to IPCC 4th assessment report and various climate models, the Eastern Mediterranean Basin and the subtropical zone, which includes Turkey, will experience increasing temperature and decreasing precipitation (especially in winter). In a study including 87 countries by the WMO, Turkey was one of 74 countries affected by drought.

On the other hand, studies on water resources have shown that many catchment areas of the country will experience serious water shortages. Turkey is not a “water rich” country. It has around 1500m^3 per person per year of available water amount, which is expected to fall down to 1000m^3 per year with the climate change and the current rate of population growth (1.31%). As the largest user of water (70%), the agricultural sector is expected to be affected by global climate change more than the other sectors.

In the Eastern Mediterranean where water will become a limiting factor, productivity could potentially be reduced due to the added stress of heat and salinization. Water scarcity also means food scarcity because 70% percent of water is used for food production.

In this study global climate change and its impact on agriculture and water resources in and around Turkey will be evaluated.

SESSION III

Capabilities for Data Management, Monitoring and Assessment

Chairman: Laban Ogallo
Rapporteur: Omar Baddour

CLIMATE DATA MANAGEMENT INCLUDING CLIMATE METADATA DEVELOPMENT AND THE CAPABILITIES OF GLOBAL CLIMATE DATA ARCHIVING CENTRES

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Abstract

According to the WMO Guide to Climatological Practices climatological data are most useful if they are edited, quality controlled, and stored in a national archive or climate center and made readily accessible in easy-to-use forms. Although technological innovations are occurring at a rapid pace, many climatological records held by the NMHSs are still in non-digital form.

At its fourteenth session, the Commission for Climatology (CCl) of WMO decided on a structure including an Open Programme Area Group (OPAG) on Climate Data and Data Management with the following Terms of Reference: “To maintain an active and responsive overview of all activities related to climate data and data management, including the implementation of climate networks, climate observing requirements and standards, the implementation of climate data management systems, the rescue, preservation and digitization of climate records, and metadata for climate applications”. This work is reviewed in the documentation of the CCl XV (cf. also the other presentations of this TC).

Requirements for metadata have also been reviewed. An adequate set of metadata must be available to inform users of data archives about the nature of the data in the system, how the various data sets were collected, and any inherent problems. It is recommended that the database management includes all information that can affect the homogeneity of a data set or series,

For the members of the WMO the obligation to share data and metadata with other members, and the conditions under which these may be passed to third parties is covered under the WMO Resolution 40 (Cg-XIII) for meteorological data, the WMO Resolution 25 (Cg-XIV) for hydrological data, and the Intergovernmental Oceanographic Commission Resolution XXII-6 for oceanographic data. The Resolutions embody the concepts of “essential” and “additional” data, with a specification of a minimum set of data that should be made available in a nondiscriminatory manner and at a charge of no more than the cost of reproduction and delivery without charge for the data and products themselves.

Data are also shared through International Council for Science World Data Centers (WDCs). The WDC system works to guarantee access to relevant environmental data. WMO is actively involved in the provision of data to a number of these WDCs, and there are a number of associated centers operated directly through the WMO. Exchange of digital data is simple for many members because of the range of computer communications systems available. The data sets are generally provided to research centers.

The current WMO information systems have been developed to meet a diverse set of needs for many different purposes. The multiplicity of systems has resulted in incompatibilities, inefficiencies, duplication of effort, and higher overall costs for Members. An alternative approach planned to improve efficiency of the transfer of data and information among countries is the WMO Information System (WIS). It provides an integrated approach suitable for all WMO Programmes to meet the requirements for routine collection and

automated dissemination of observed data and products, as well as data discovery, access and retrieval services for all weather, climate, water and related data produced by centres and Member countries in the framework of any WMO Programme.

CLIMATE DATA MANAGEMENT SYSTEMS: THE STATUS OF IMPLEMENTATION IN DEVELOPING COUNTRIES AND THE NEW FEATURES OF CDMS

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Abstract

In the mid 1980s, WMO took a major initiative to support the management and storage of climatological data particularly in developing countries, by implementing the CLImat COMputing (CLICOM) project. The CLICOM project is considered to have been very successful and was characterized by a common software shared by almost a hundred countries. Towards the end of the 1990s, with the end of the maintenance and upgrade of the CLICOM software, the panorama in 2010 has completely changed. It is no longer one but several Climatological Database Management Systems (CDMSs) which are available to National Meteorological and Hydrological Services (NMHSs).

The new CDMSs fall into a number of categories that differ in their technical solutions, their functions as well as their commercial policies. After presenting the methods used to implement those new CDMSs up to now, the current worldwide CDMSs installations and working status especially for developing countries, will be assessed and evaluated.

Meanwhile there is a demand for the CDMSs to incorporate new features like managing remote sensing data (radar, model), facilitating the interoperability of data and metadata (WIS, GIS) or allowing end-to-end data quality approach from the observation site to the final user.

The issue of the sustainability of the CDMSs in developing countries and the adaptability of the systems to meet new user requirements deserves special attention.

WMO CLIMATE DATA MANAGEMENT COORDINATION INCLUDING REGIONAL LEVEL ASPECTS

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Abstract

During WCC-3 it was repeatedly stated that neither climate documentation nor prediction can be made on a technical and scientific sound basis without reliable observations of the past and current weather. Observation systems based on remote sensing need reliable in-situ measurements as reference, to calibrate not only time series, but also periods and instruments. Observation and data collection are the backbone of NMHSs activities and quality assurance and control of in-situ observational data is one of the most important challenges today.

Quality assurance should start at the station level: change of instrumentation, change of location, shift from manual to automatic stations etc. This will insure more quality to current and future use (Numerical Weather Prediction models, real time data presentations in decision aiding systems, seasonal forecast, aid for meteorologists and climatologists in their work).

Standardized homogenization tests need to be widely used to create high quality datasets. Unfortunately, only a limited number of experts are familiar with the scientific and technical development of methods and tools to conduct standardized homogeneity tests and corrections.

There have been substantial efforts in modernizing climate data management and data rescue in various regions in terms of software implementation and training.

Climate Database Management systems should include international QC standard as well national standards and assist NMHSs in climatological operations such as homogenization practices, climatological and statistical recommended/standard/best methods analyses, etc…

Training on Climate database management should not only depend on specific climate database management systems, but good recommended practices, data quality control, metadata management, statistical analyses with good practice of SQL language for standard databases.

WMO CLIMATE MONITORING CAPABILITIES AND STRATEGY FOR DEVELOPMENT

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Abstract

Consider a city running low on drinking water during a drought. If you were in charge of the city's long-term water planning, what would you do? The answer depends on the climatic conditions: Is this a once in 200 year drought or a once in 20 year drought? Do long-term data (and model projections) indicate that droughts of this magnitude are tending to become more frequent or less frequent? Essentially, it would be very difficult to make the right decision without climate monitoring information.

Since 1993, WMO in collaboration with the Commission for Climatology (CCl) has been issuing an annual statement on the status of the climate system. The statement is an authoritative climate monitoring mechanism based on yearly update of the global temperature trend combining global major global datasets and a summary of major climate anomalies and related weather and climate extreme events associated with socio-economic impacts.

Efforts to improve climate monitoring around the world are progressing on many different tracks. Several of these will be discussed in detail in other presentations. Notable among these is the *Bulletin of the American Meteorological Society*'s annual State of the Climate report with 280 authors from 42 different countries, This effort has fostered regional climate monitoring collaboration and exchanging of data and information across national borders in many different parts of the world.

Also presented separately are regional climate change workshops which not only provide information on how extremes are changing but also often provide participants with their first analysis of how their data indicate that the climate is changing in their country.

During the last four years, the CCl Expert Team was dedicated to Climate Monitoring, including the use of satellite and marine data and products. This team has undertaken a number of actions designed to enhance WMO Member States' ability to monitor their climate. They've published a paper in the *WMO Bulletin* on "Monitoring the Earth's Climate" They created a web site and pamphlet pointing to resources that scientists in WMO Member States could use to improve their climate monitoring capabilities. Most recently they worked at building connections between satellite institutions and individuals in other countries with an eye towards helping the NMHSs in those countries improve their capacity to use satellite data in climate monitoring.

The lessons learned from these activities show that building the capacity to use their data to understand and monitor how their local climate is changing is often a necessary first step to many other activities. For example, until one can use the data, it is difficult to appreciate why it is so important to digitize and rescue the data. Until one can see how their climate anomalies fit into global and regional patterns, it is difficult for one to appreciate the importance of sharing their data. These lessons are crucial for developing an effective strategy to improve climate monitoring in all parts of the world. The strategy covers improved long term climate monitoring and further development of high quality homogenous global and

regional climate data sets; improved knowledge and related data bases for monitoring climate anomalies and related extremes at all time-scale; and an enhanced capacity of NMHSs in developing countries to access and use up-to-date knowledge, methods and tools to develop national climate monitoring and watch systems.

CLIMATE ASSESSMENT AND EMERGING DATA RESCUE INITIATIVES

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Abstract

Reliable and robust climate assessments, particularly those dealing with climate variability and change at either global, regional or local spatial scales, rely on long-term and high-quality instrumental climate data, which are also necessary for a wide range of climate applications. The longer and high-standard instrumental climate records are extremely useful for placing extreme events in a long context, enhancing knowledge about instrumental climate variability and change and their forcing factors and physical causes, improving climate change detection and attribution studies, generating climate change scenarios and validating climate model outputs (both RCMs and GCMs). They also provide input to extend back in time historical reanalysis, calibrating natural/documentary climate proxies and satellite estimates of surface variables, assessing climate change impact sector models and/or defining/adopting the best strategies to adapt the countries to climate change impacts, among other climate applications. In this context, scientists, application communities and decision makers require the best data for their studies.

Although the atmosphere has been regularly and carefully monitored in the past either by the National Meteorological and Hydrological Services (NMHSs) or by early scientists pre-dating the founding of NMHSs, the existing data heritages are still largely under-exploited, since fewer climate records than required, specially at smaller than global scales, are available and accessible in digital form or are of good enough quality for confidently using them in any climate assessment. Besides, currently available digital climate data do not always reach the required standards of high-quality and homogeneity, making the use of the data not subjected to quality control and homogenisation exercises questionable. However, integrated efforts in order to facilitate the recovery of historical surface (terrestrial and marine) weather observations and the development of high-quality and homogeneous climate datasets are being promoted over the last decades by international bodies, regional meteorological associations, NMHSs, scholars, research groups and centres. These past and ongoing data rescue (DARE) activities have enhanced the availability of high-quality climate data, although still much more work has to be undertaken, in order to improve temporal and spatial resolution of key climate records at the national level.

Therefore, in this talk we will assess ongoing and emerging integrated projects for the recovery of historical instrumental climate data, including the development of high-quality climate datasets, with a focus at both global/regional and national scales.

SESSION IV

Capabilities for Climate Prediction and Projection

Chairman: Thomas C. Peterson
Rapporteur: Peer Hechler

BUILDING UP SUSTAINABLE REGIONAL CLIMATE INFORMATION SYSTEMS

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Abstract

Some of the key structural elements of the proposed Global Framework of Climate Services are the regional components, which could be substantially different from both the global and the national perspectives. This paper intends to elaborate some of the necessary elements to ensemble a regional climate information system, and making it operational and most of all sustainable.

The proposed approach is mostly based on the 7 years of experience that CIIFEN has by working very closely in the Western South America Region with the NMHSs from Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela.

To design, conduct and achieve our regional activities, we applied the principles of the regional public goods. Combining essential pieces of different theories on this matter, we started promoting the need to conceive the climate information in WCSA region as regional public good based on the following elements: 1) to improve the existing capabilities of NMHSs through a collective action; 2) to share the knowledge of nation-specific benefits and the experience of NMHSs to improve the understanding and prediction of the regional climate system but also providing benefits to each country; 3) to contribute to the reduction of asymmetries among countries; 4) to demonstrate through facts that a regional climate service can only be enhanced as a result of the improvement of the national components, and 5) to agree on a coordination mechanism, that in this region was assumed by CIIFEN.

Since early 2007, the WCSA region was able to implement a Regional Climate Data base which has become an integrating factor and the basis for new initiatives. A Regional Group on Climate Modelling was created and is currently working involving colleagues from Latin America. The region was able to improve their forecast capabilities and to run several models even in countries without this capacity before the process started. From now on, statistical and dynamic climate predictions are available for the region and synthesized in an operational product which is the Seasonal Forecast for WCSA, produced operationally every month. The Regional Climate Outlook Forum has evolved and it has become a place of coordination, review of achievements and technical discussions to improve the forecast, based on the lessons learnt on the NMHSs. Currently, a “Predictors Catalogue” is being prepared and a WIKI is on line to assist with dynamic models implementation.

Apart from the operational developments, dissemination information systems have been built to increase the application and usefulness of the provided climate information. The system includes in each country: users from Government institutions, community organizations, the private sector, local authorities and the media. Strong relationships have been built in order to provide the climate information. At a regional scale, the climate products are highly required by international organizations, financial entities, private companies, and different users who need a regional perspective of the climate evolution to adjust actions that can be implemented in their programs at national level.

This regional cooperation network has provided the necessary elements to innovate on tailoring sectoral applications such as the Climate-agriculture Risk mapping which has become operational in most of the countries. These added value climate services are being

supported in some cases by local governments, NGOs, other cooperation agencies and the beneficiaries from the private sector. New applications on water resources management and biodiversity and ecosystems services are now being worked and tested through pilot projects. They are expected to be implemented at regional scale to contribute with climate risk management and adaptation in WCSA region.

Regional Climate products are sustainable services that are tightly linked to their salience, quality, usefulness, and on increasing demand from users.

CLIPS A TOOL BOX FOR THE GLOBAL FRAMEWORK FOR CLIMATE SERVICES (GFCS)

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Abstract

During Cg-XII (1995) Congress requested the WMO Secretary-General and the president of CCI to take appropriate action to ensure interprogramme coordination of the development of the Climate Information and Prediction Services (CLIPS) project within the framework of CCI in coordination with the Joint Scientific Committee for WCRP and with necessary interaction with other constituent bodies of WMO and GCOS. Congress emphasized the need for provision of required data and other necessary information in order to ensure optimal development and global dissemination of climate prediction services.

The CLIPS project builds on the activities over the past decades which include successful atmospheric and oceanographic research (e.g., Climate/ENSO predictability; Coupled atmosphere-ocean modelling,…); improved climate monitoring (e.g., TAO buoys) and data management capabilities; a developing capability to predict climate on monthly, seasonal and interannual time scales, and regional space scales; effective networking of climate providers as well as users; and the development of consensus approach to climate outlooks (RCOFs, El Niño/La Niña update).

Regional Climate Outlook Forums (RCOFs) had two main components: first, training of experts from NMHSs (CLIPS National Focal Points) and end-users (RCOFs, CLIPS Curriculum); and second, joint activities with research programmes such as WCRP to bring in state-of-the-art science into climate services. The main asset of these RCOFs is the establishment of a Regional mechanism for the formulation and dissemination of climate forecasts and outlooks bringing together providers and users of SIPs. RCOFs, initiated just prior to the major 1997–1998 El Niño event, constitute an important vehicle in developing regions for providing advance information on the likely climate features of the upcoming season, and for developing a consensus product from amongst the multiple available individual predictions. RCOFs stimulate the development of climate capacity in the NMHSs of the area, and do much to generate decisions and activities that mitigate adverse impacts of climate and help communities adapt to climate variability.

As main CLIPS applications one can note coordination of demonstration and pilot projects; involvement of Focal Points in demonstration and pilot projects; partnership with application sectors at national, regional and global levels; examination of improved project design; examination of impacts of climate services on applications; and examination of data requirements.

In terms of CLIPS Capacity Building, the achievements are the establishment of CLIPS Focal Points network (a global network of climate scientists/service providers specially trained in climate science, statistical modelling and prediction, applications and project management who ensure national and regional coordination of climate information and prediction products); reporting of CLIPS activities by CLIPS Focal Points, and sharing the experiences through WMO; development of CLIPS Training Curriculum; Regional/sub-regional CLIPS Training Workshops; and user-awareness development through workshops, projects and Climate Outlook Forums.

As infrastructure development CLIPS initiated the Regional Climate Centres (RCCs). These RCCs were conceived to be Centres of Excellence, as designated by CBS and CCl, to perform regional-scale climate functions, including: Operational LRF and Climate Monitoring, coordination between RCCs, GPCs and NMHSs in the region, Data services and Climate Applications, Training and capacity building and Research and Development. RCCs will be complementary to and supportive of NMHSs, who will deliver all warnings and national-scale products.

Sustainability and Future Evolution

The CLIPS project's vision, objectives and achievements are expected to be integrated into the upcoming Global Framework for Climate Services (GFCS). In the mean time, a special focus will be given to further develop the national level by improving the user liaison as well as end user services within, e.g., National Climate Outlook Forums on the basis of global and regional centres and mechanisms, like GPCs, RCCs and RCOFs.

The future evolution of CLIPS is being built on the foundation provided by the achievements and assessments presented above. Elements of future CLIPS activities may include: a holistic capacity building effort on existing institutions and infrastructure development, training extended to all stakeholders including users in natural resource management as well as policy making positions; networking and partnerships, demonstration projects on the application of the latest advances in climate science; review and update of climate products to improve climate services; expansion and/or integration of global, regional and national climate outlooks; expansion of RCCs and National Climate Centres; and support to the development of more iterative provider-user interfaces at global, regional and national levels.

In particular CLIPS can be considered as a solid basis for further development of User-targeted Climate Services (GFCS ToolBox vers 0) involving Training component (Build global curriculum on seasonal prediction for use by specialized training centres and NMHSs and Train the trainers), Cost and business component (Engage the user sectors – if the value of the climate information is demonstrated to business and policy users, they are more likely to support the process and explore cost-efficient methods for collaboration where possible (email, teleconference, etc.)), Succession planning (keep bringing new people on board and foster an atmosphere of continual learning – keep up with research by institutionalizing the process within the regions creating sustained networking of relevant climate/user agencies; Regional Drought Monitoring/Management Centres can play a pivotal role to nurture and sustain RCOFs) and local ownership component (local ownership of the RCOF process and minimal dependence on external sources are critical to the sustainability of RCOFs).

NEW PERSPECTIVES FOR GPCs, THEIR ROLE IN THE GFCS AND A PROPOSED CONTRIBUTION TO A "WORLD CLIMATE WATCH"

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Abstract

There are currently 11 WMO-designated Global Producing Centres for long-range forecasts (GPCs) adhering to criteria developed by CBS for e.g. forecast issuance schedule, minimum product range and forecast validation. Two associated Lead Centres have also been established; a lead centre for long-range forecast multi-model ensembles (LC-LRFMME) and a lead centre for the Standard Verification System for Long-range Forecasts (LC-SVSLRF). Responsibilities of the LC-LRFMME include provision of a single portal from which users can access GPC forecasts in common graphical and digital formats, and research into multi-modelling techniques. Responsibilities of the LC-SVSLRF include maintenance of a website providing access to verification information for all GPC forecast systems, and maintaining datasets and code for verification. The current status of the GPC network and lead centres will be reviewed. Progress in making use of GPC and Lead Centre products at Regional Climate Outlook Forums will be summarised.

With progress in coordination of GPC predictions and establishment of the LC-LRFMME there is now an opportunity to develop a seasonal forecast 'World Weather Watch', providing routinely updated global outlooks for temperature and precipitation. The outlooks could be developed using GPC multi-model output and consensus among stakeholders, following a procedure similar to that used to construct the current WMO WCASP El Niño/La Niña updates. Potential strategies for developing such outlooks, and further underpinning work that is needed, will be explored together with the potential challenges of communication (e.g. harmonisation with issued regional/national outlooks).

Although the definition of long-range forecasts extends to 2 years, GPCs are currently committed to provision only of seasonal-range forecast products (specifically lead times up to 4 months); there is no similar operational infrastructure or standards (beyond the research-oriented IPCC climate projections) coordinating development and exchange of predictions for inter-annual, decadal or longer timescales. This infrastructure will need to be considered in the development of the Global Framework for Climate Services (GFCS). It will be recommended that such infrastructure and exchanges can now be started for the inter-annual and decadal range forecast systems that are being developed by some GPCs. To support this recommendation, example products and validation from the Met Office decadal prediction system will be shown.

PROFESSIONAL DEVELOPMENT FOR CLIMATE PREDICTION AND PROJECTION

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Abstract

This presentation will employ a framework for climate prediction/projection design and use that first was proposed almost 30 years ago (BAMS, 1981). The framework involves an interdisciplinary approach featuring three demanding, reasonably sequential prerequisites for climate prediction/projection to have maximum societal value. First, the human activities most impacted by climate variability must be identified by geographical region, times of year, and weather parameters responsible. The second prerequisite is the determination of how affected regional economies can adjust or change to capitalize substantially on the availability of skilful climate predictions/projections. Satisfaction of these two prerequisites should focus the development of climate prediction/projection schemes that have the greatest possible societal value.

When viewed within this framework, the professional development required to enhance climate prediction/projection is wide ranging and extends substantially beyond the atmospheric sciences. It should include appreciation of the need for and acquiring competence in the following development of “impacts” data sets; the combined statistical analysis of these data with climate data to qualify linkages; and the use of decision models to estimate the values of alternative economic adjustments to climate variation. The success of these endeavours will determine the societal value of the increased understanding of climate system behavior and predictability that must underpin improved climate prediction/projection skill.

The above themes will be developed using examples from Sub-Saharan West Africa and the United States of America.

REGIONALIZATION OF CLIMATE CHANGE INFORMATION: PROJECTIONS FOR TURKEY

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Abstract

Global climate change caused by human activities is happening now and is a growing threat to society. All countries are exposed to climate change and need to adapt it. Regionalization of climate change information is required for climate change impact assessments and regional climate models are the tools widely used for this purpose. In Turkey, regional climate model studies are rather new. Although preliminary studies date back to early 2000s, simulations for future climate change have been performed since 2006. Currently, regional climate models of RegCM3 of the ICTP and PRECIS of the UK Met Office Hadley Center are in use in the Turkish State Meteorological Service.

In this paper, the results of the TUBITAK Project "Climate Change Scenarios for Turkey" will be presented which was implemented jointly by the Turkish State Meteorological Service and the Eurasia Earth Sciences and Informatics Institutes of the Istanbul Technical University. In this study, for future simulations, ECHAM5 GCM outputs based on A2 and B1 emission scenarios have been used. RegCM3 regional climate model was run for 1961-2000 and 2000-2099 periods with a horizontal resolution of 27 km. A2 and B1 scenario simulations have been compared with the reference period (1961-1990) simulations to obtain future changes in climate.

Being located in the Mediterranean Basin, Turkey is among the countries which will be severely affected by climate change. Results of A2 scenario indicate an increase in temperatures up to 6 °C with regional differences by the end of this century. Highest warming has been projected in summer in southern parts, especially in the Southeastern Anatolia Region of Turkey. As for precipitation, severe reductions are projected in winter and spring precipitation which is very important for water resources and agricultural activities. For 2041-2099, there will be an increase in precipitation in Northern Turkey while a decrease in South. It is remarkable that during same period, precipitation in summer is expected to decline significantly over most of Turkey, by more than 30% over interior parts of Turkey. Changes in runoff are highly sensitive to the changes in temperature and precipitation. Due to temperature increases, in Eastern Anatolia Region, there will be more runoff in winter and less in spring that means a change in runoff regime. Model results for precipitation and temperature changes based on ECHAM5 B1 scenario show generally similar patterns to those that are based on ECHAM5 A2 scenario but the magnitude of the changes is usually smaller.

IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES IN CHINA

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Abstract

Affected by both natural variability and human activities, climatic conditions in China have obviously changed for last 60 years. Temperature in northern part rose about 1.0 - 2.5^{o}c, while in southern and southwestern parts decreased in 1970- 1980's and then rose in 1990's gradually. Climate change has undeniable impacts on water resources in China. In the last 60 years, besides Pearl River and Songhua River, stream flow in most main basins such as stream Yangtze River, Huai River, Yellow River, Hai River and liao river abated in different rates. The decreasing rate in Hai River is as high as 22.5 - 23.4 percent.

According to the simulated results of nested hydrology and climate models, by the year 2030, temperature in China will increase 1.4 – 3.1^{o}c. Precipitation as a whole in future will augment to certain degree, but in some northern parts increase just slightly or even decrease, while in the Northwest seems to increase obviously.

Case studies indicate warm and dry trend under double CO_2 in North China. Temperature will rise about 2.8^{o}c in the two basins. Precipitation will also increase but with different values for the two basins. Mean annual runoff values of Luan He and Sanggan He basins would be 74mm and 71mm, respectively, which are approximately a quarter of mean annual runoff value (284mm) of whole China. The simulated results indicate the warm and dry trend will continue in the two river basins under doubled CO_2 scenarios.

In terms of modeling results, runoff of main river basins will increase except a few ones such as Yellow River, but the results have many uncertainties. For the whole country, water demand will exceed $1\times10^{12}m^3$, which is $0.3259\times10^{12}m^3$ more than in the 1990's.

Climate change and population growth will cause water shortage for some basins such as Hai River and Yellow River. The shortage amount for the two basins is as high as 25.2×10^8 and $13.5\times10^8m^3$, respectively, which will obstruct sustainable development in the regions. In order to adapt and mitigate impacts of climate change on water resources in China, some specific strategies such as water saving, industry structure change, rational water allocation and water contamination disposal have been adopted, and the programs of water transfer from the south to the north are being implemented.

SESSION V

Partnerships and Collaborative Activities

Chairman: Shourong Wang
Rapporteur: Amir Delju

NAIROBI WORK PROGRAMME ON IMPACTS, VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE: CATALYZING ACTION AND FACILITATING LEARNING FOR ADAPTATION

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Abstract

Climate data and information are central to all the aspects of adaptation to climate change: public awareness raising, research and assessments of the diverse impacts of current and future climate variability and change, and planning for implementation, monitoring and evaluation of adaptation actions. Given the multi-stakeholder, multi-disciplinary and multi-scale nature of climate change adaptation, understanding climate related risks, planning for and implementing adaptive actions require strong and sustainable partnerships and collaboration amongst the key stakeholder groups. They include public policy makers at different levels, academics of varying disciplines, practitioners, Intergovernmental Organisations (IGOs), Non-governmental Organisations (NGOs), community leaders, and the private sector.

To provide an international platform for fostering partnerships, facilitating learning, and catalyzing actions and collaboration amongst these diverse ranges of adaptation stakeholders, the Conference of the Parties to the UNFCCC initiated the Nairobi work programme on impacts, vulnerability and adaptation to climate change (NWP) was under its Subsidiary Body for Scientific and Technological Advice (SBSTA) in 2005. The NWP is a 5-year programme with the objective of improving the capacity of all Parties to the Convention in (1) understanding and assessing the impacts of and vulnerability to climate change; and (2) making informed decisions on adaptation. Through the implementation of a wide range of activities, the NWP has engaged over 160 organisations, identified a wide range of action priorities in 9 Calls for Action, and catalyzed more than 90 action pledges, and developed and disseminated numerous knowledge products.

Drawing on the experiences of implementing the NWP to date, this paper:

- Outlines the diverse need for climate information and services in support of adaptation analyses and planning, by different user groups;
- Reviews progress made so far by NWP partners in meeting the needs of the Parties;
- Shares good practices and lessons learned for building partnerships and facilitating collaboration; and
- Explores further opportunities to enhance partnership and collaboration under the NWP and within the context of relevant initiatives (e.g., the planned GFCS) outside the Convention process.

THE GLOBAL CLIMATE CHANGE ADAPTATION NETWORK, FACILITATING ACCESS TO CLIMATE SERVICES FOR ADAPTATION

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Abstract

Adaptation is a knowledge-intensive undertaking, and access to relevant and usable information and knowledge is an important prerequisite for successful adaptation efforts.

The overall objective of the Global Adaptation Network (the Network) is to help build climate resilience of vulnerable human systems, ecosystems and economies through the mobilization of knowledge and technologies to support adaptation capacity building, policy-setting, planning and practices. The concept of the Network, including its core set of services and corresponding structure, has evolved through international and regional consultation meetings undertaken since October 2008. It also takes into account of the draft decisions of AWG-LCA at COP15 regarding adaptation, technology and capacity, and the proposals for setting up relevant centres and networks/platforms. The Network aims to deliver the following Core Set of Services (CSS):

CSS 1: Knowledge sharing: improved availability and accessibility of knowledge for adaptation, and broadened dissemination of good adaptation practices;

CSS 2: Knowledge services: strengthened targeted knowledge products and advisory services to governments, planners and practitioners;

CSS 3: Technology support: enhanced development, diffusion and transfer of technologies;

CSS 4: Capacity development: increased capacity for adaptation of national and regional institutions in the developing world, and improved quality and sustainability of their services.

The Network is being developed in partnership with WMO, UNFCCC, World Bank, and others, to provide a common platform and services which are complementary to the existing and planned initiatives, especially to support the establishment of the Global Framework for Climate Services led by WMO, and the activities of the Nairobi Work Programme on Impacts, Vulnerability and Adaptation coordinated by the UNFCCC Secretariat.

CLIMATE SCIENCE IN SUPPORT OF SUSTAINABLE AGRICULTURE

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Abstract

Agriculture is deeply interconnected with weather and climate, the dominant source of the overall variability of food production and a continuing source of disruption to environmental sustainability. Agriculture constitutes the principal livelihood of 70% of the world's poor; many of the world's poor and hungry are smallholder farmers, herders, fisherfolk, forest-dwellers, including indigenous people living in climate sensitive vulnerable areas. As the silent hunger crisis has already reached a historic high with 1.02 billion people going hungry every day, raising food production by some 70% to meet the needs of the world population of 9.1 billion people in 2050 without harming the natural resources in the light of the impacts of climate change may be one of the biggest challenges to agriculture.

Climate science has offered a depth of knowledge to systematically characterize the agroclimatic resources and develop climate responsive agriculture policies, programmes and practices. However, as the food systems are expanding more and more into marginal and vulnerable areas, a renewed and holistic focus is now indispensable taking into account ecological, economic and social perspectives. National agriculture policies must therefore develop synergies and embrace innovation and ideas of climate science to support land use planning, agro-ecological zoning, identify emerging areas of concern (AoC) and facilitate climate change adaptation planning at a time when agriculture has an increased role to play to supply food, fodder, fibre and energy.

The recent advances in climate prediction up to a season and beyond provide a strong prospect for pro-active management of risks and opportunities in agriculture. Previous efforts in this regard are largely administered by international programmes with limited involvement of national level mandated agencies, despite some pilot projects. Within a changing context, it is important for national climate and agriculture services to take ownership and responsibility for sustaining these initiatives. However, new investment and modernization efforts are needed both in national climate and agriculture services to strengthen monitoring infrastructure, climate-crop data, institutional and technical capacity building.

In order to meet the needs of food system communities for adaptation to climate variability and change, a number of existing gaps in climate based agriculture services related to content, lead-time and communication must be addressed. Nonetheless, the emerging ability to translate timely, skilful climate information to optimize sustainable agricultural practices and communicate to the farmers through cost effective means provide opportunities for managing current climate risks and move towards strategic climate change adaptation. The action-oriented climate advice should contain seasonal (climate and crop yield forecasts, crop-weather insurance indices), intra-seasonal (information on rainfall, dry and wet spells, hot and cold waves, land slides, floods, pest and diseases, crop and management alternatives) and long term (changing vulnerability and risk profiles, environmental services, biodiversity conservation etc.,) strategies for optimal and sustainable use of land, water and other inputs. Strong partnership and collaboration among international

institutions, national focal agencies, community-based organizations and social networks are a precondition.

FAO assists its member countries in strengthening crop yield forecasting, food security early warning and climate sensitive agriculture policies; and promotes community networks and local knowledge hubs to facilitate Farm Adaptive Dynamic Optimization (FADO) for climate risk and opportunity management. The approach combines historical climate data, modern climate information products and communication technologies for real-time analysis of impacts; and delivery of optimal management practices at the farm level. All these efforts present key challenges, but offer immense opportunities for both climate and agricultural services to support sustainable agriculture.

CLIMATE SERVICES AS A RESOURCE FOR PROTECTING HUMAN HEALTH

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Abstract

Ongoing changes in mean values, and in the geographical and temporal distribution of temperature and precipitation, are expected to bring direct and indirect health impacts, particularly in the poorest populations. One of the main responses proposed by both the Intergovernmental Panel on Climate Change and the World Health Organization is to strengthen health surveillance systems, including the use of meteorological and other environmental information to provide earlier and more accurate warnings of health risks. This has coincided with the renewed focus in the meteorological community on "climate services" to end-user sectors, resulting in a supportive environment for work on health early-warning systems.

There are now a large number of research studies documenting temporal correlations between meteorological variables, health hazards, and health impacts. These range from heatwaves and extreme cold, outbreaks of directly transmitted, water-borne, and vector-borne infectious diseases, to food insecurity. Almost all of these diseases demonstrate seasonal patterns, and many show significant correlations with meteorological anomalies; both of which could potentially be used to improve health planning. Early warning systems that use meteorological information have now been established for cold-related cardio-pulmonary disease in the United Kingdom, heatstress in selected cities in the US, Europe and Asia, for malaria in several countries in southern Africa, with others under development.

However, the demonstration that the distribution or intensity of health events is correlated with, or even directly caused by, meteorological conditions, does not by itself provide a justification for weather-based early warning systems. It is also necessary to characterize the health decisions that could be improved by provision of early warning, identify the full range of constraints (e.g. institutional, human and financial resources) to using the information, and characterize the opportunity cost of investing in early warning systems as opposed to supporting other components of the health system. This requires the development of sustained partnerships between the meteorological and health communities from the global level (defining best practice and sharing experiences), the regional level (increasing efficiency by using regional climate forecasts and outlooks), and most importantly at the national and sub-national level, where most implementation activity occurs.

Recent positive steps in this area include the ongoing series of global meetings bringing together health and climate actors (including the Espoo Conference on Living with Climate Change Variability in 2006, and health sessions in the World Climate Conference-3), regional and national demonstration projects for health early warning systems, and the establishment of national Climate and Health working groups in several developing countries. These have identified a series of priorities for future work, including, inter alia, (i) stronger institutional linkages between the climate and health communities, for example through the proposed Global Framework for Climate Services; (ii) shared capacity building activities, such as basic training courses in the use of meteorological information in public health planning; and (iii) definition of criteria and implementation of "End-to-end" evaluation of the operational effectiveness of health early warning systems. There is a need for sustained support to partnership-building in order to realize the full potential of meteorological services to protect health.

CLIMATE CHANGE AND FUTURE PROSPECTS FOR TOURISM

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Abstract

Tourism is one of the largest global economic sectors and is a vital contributor to the economy of many nations and is promoted by several international organizations as an important means of poverty reduction in developing countries. The tourism sector has a complex and important relationship with climate change. With its close relationship to the environment and climate, tourism and travel is considered to be a highly climate-sensitive economic sector. Tourism is also a non-negligible contributor to climate change through the emission of greenhouse gases (approximately 5% of global carbon dioxide emissions), and is therefore also vulnerable to increasingly stringent policies to mitigation climate change. As a consequence, the integrated effects of climate change and climate policy are anticipated to have far-reaching impacts on tourism businesses and destinations, as well as the destination choices and mobility of individual tourists, in the decades ahead. Indeed, a 2008 report by the United Nations World Tourism Organization, United Nations Environment Programme and World Meteorological Organization identified climate change as the greatest threat to sustainable tourism in the 21st century.

This paper will outline the climate sensitivity of tourism sector and review its main vulnerabilities to climate change (negative and positive impacts), as well as recent policy discussions on mitigation policy and passenger levies to support adaptation that would have major implications for international tourism. The most at-risk tourism destinations ('vulnerability hotspots') and tourism sectors will be identified. Regardless of their relative vulnerability to climate change, all tourism and travel businesses and destinations will need to adapt to climate change in order to minimize associated risks or capitalize upon new opportunities, in an economically, socially and environmentally sustainable manner. The paper will conclude with a discussion of role of climate services to support climate change adaptation in the tourism sector.

Special Joint Session with the Joint Scientific Committee (JSC) for the World Climate Research Programme (WCRP)

Chairman (Morning Session):	Antonio J. Busalacchi
Rapporteur (Morning Session):	Valery Detemmerman
Chairman (Afternoon Session):	Pierre Bessemoulin
Rapporteur (Afternoon Session):	Leslie Malone

CLIMATE SYSTEM MONITORING AND RESEARCH NEEDS

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Abstract

The state of the art in global climate system monitoring is summarized annually in the *Bulletin of the American Meteorological Society*'s State of the Climate report. The presentation will review accomplishments of this report, with a particular focus on the GCOS Essential Climate Variables (ECVs), and discuss the research needs to improve both the number of ECVs covered and the quality of those ECVs that are quantified annually.

The table below shows the 2009 GCOS Essential Climate Variables (ECVs) and soil moisture (an emerging ECV) and their monitoring status. Like traffic stop lights, green indicates yes, this ECV is being monitored on a global- or near global-scale and that the 2008 State of the Climate report includes a section that describes the ECV's changes over time. Yellow indicates that the ECV is explicitly discussed in that year's *State of the Climate*, but the data are not updated through the end of that year or the coverage is not global. Red indicates more work needs to be done in order to monitor and document this ECV.

Atmospheric	Ocean	Terrestrial
Surface	**Surface**	Soil moisture (Emerging ECV)
Air temperature	Sea surface temperature	Snow cover
Precipitation	Sea surface salinity	Permafrost and seasonally-frozen ground
Air pressure	Sea level	Glaciers and ice caps
Surface radiation budget	Sea state	River discharge
Wind speed and direction	Sea ice	Water use
Water vapor	Current	Ground water
Upper Air	Ocean color	Lake levels
Earth radiation budget	Carbon dioxide partial pressure	Albedo
Upper-air temperature	**Subsurface**	Land cover
Wind speed and direction	Temperature	Fraction of absorbed photosynthetically active radiation
Water vapor	Salinity	Leaf area index
Cloud properties	Current	Biomass
Composition	Nutrients	Fire disturbance
Carbon dioxide	Carbon	
Methane	Ocean tracers	
Ozone	Phytoplankton	
Nitrous oxide		
Chlorofluorocarbons		
Hydrochlorofluorocarbons		
Hydrofluorocarbons		
Sulphur hexaflurorides		
Perfluorocarbons		

IMPROVING OUR UNDERSTANDING OF THE HYDROLOGIC CYCLE AND ITS CHANGES: OBSERVATIONAL AND MODELLING NEEDS

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Abstract

The global hydrological cycle and its changes over time are examined in light of observations and current understanding. A particular focus is on how precipitation changes as the climate changes and on changes in extremes, including risk of flooding and drought. Net changes in surface evaporation are fairly modest and a much larger percentage change occurs in the water-holding capacity as atmospheric temperatures increase (7% per ºC). Where moisture supply is not limited (such as over oceans) a consequence is increased water vapour in the atmosphere which feeds storms and thus leads to more intense precipitation; increased water vapour, heavier rains and stronger storms are already observed to be happening. In these cases the Clausius-Clapeyron relationship leads to positive correlations between temperatures and precipitation. However, the disparity between modestly enhanced evaporation and heavier rains means decreases in frequency of precipitation, longer dry spells and enhanced droughts. "It never rains but it pours!" Over land in summer and tropical continents, moisture is limited in supply and conditions tend to be either hot and dry or cool and wet. The diurnal cycle plays a strong role. In these cases temperature and precipitation are strongly negatively correlated. Generally, with more moisture, wet areas get wetter and dry areas get drier leading to the "rich get richer and the poor get poorer" syndrome. However, with more precipitation per unit of upward motion in the atmosphere, i.e. "more bang for the buck", the atmospheric circulation weakens, causing monsoons to falter. In the tropics and subtropics, very strong patterns of precipitation denote convergence zones and monsoon troughs vs subtropical anticyclones and deserts, and changes are dominated by shifts in these patterns as sea surface temperatures change, with El Niño as a good example. Dipole structures often result as one region becomes drier while another becomes wetter. The eruption of Mount Pinatubo in 1991 led to an unprecedented drop in land precipitation and runoff, and widespread drought as precipitation shifted over oceans and evaporation faltered, providing lessons for possible geoengineering.

It is important to understand not only changes in mean precipitation, but also the intensity, frequency, duration, and type, and this also applies to the storms that bring precipitation. Models are demonstrably poor at many aspects of the hydrological cycle, especially the spurious seasonal migration of the Intertropical Convergence Zone and the extremes in the tropics, where failure to adequately simulate the diurnal cycle, the Madden-Julian Oscillation, tropical storms, and easterly waves leads to large errors. Most models have precipitation that occurs prematurely and too often, and with insufficient intensity, resulting in recycling that is too large and a lifetime of moisture in the atmosphere that is too short, affecting runoff and soil moisture. Understanding the profound consequences of climate change on water and the model capabilities and shortcomings is especially important for water managers.

CLIMATE CHANGE DETECTION, EXTREME EVENTS AND INDICES: OVERVIEW AND FUTURE PERSPECTIVES

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Abstract

Changes in extreme weather and climate events have significant impacts and are among the most serious challenges to society in coping with a changing climate. As a result, the demand for information services on weather and climate extremes is growing. The sustainability of economic development and living conditions depends on our ability to manage the risks associated with extreme events.

According to the IPCC 4th Assessment Report, most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. Discernible human influences also extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns. Evidence that human influence is affecting many aspects of the hydrological cycle on global and even regional scales is now also accumulating. These changes in mean state inevitably affect extremes. Moreover, the extremes themselves may be changing in such a way as to cause changes that are larger than would simply result from a shift of variability to a higher range.

Successful adaptation to climate change will require improved monitoring and understanding of extremes, including the ability to detect and project changes in their frequency and intensity. Basic monitoring of changes in extremes is therefore an imperative. The joint CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI) has helped to develop the capacity needed to meet this need by designing and implementing a system of indices and tools that enable a consistent approach to the monitoring, analysis and detection of changes in extremes of temperature and precipitation by countries and regions across the globe.

This paper will describe the indices and tools that have been developed by the ETCCDI and the approach that has been used to build the capacity to monitor changes in extremes through the use of these tools. It will also discuss some scientific issues that are associated with the ETCCDI indices and describe simple solutions that have been developed to overcome these issues. Having introduced the indices in this way, the talk will review recent detection results that link changes in some indices of extremes to human influence in the climate system. It will also consider prospects for further enhancement of detection results including the detection of changes in extremes on regional scales and the possibility of attributing changes in the likelihood of extremes to external influences from human activity and other sources.

RESEARCH NEEDS FOR SEASONAL TO INTERANNUAL CLIMATE PREDICTION

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Abstract

The presentation will introduce the overall framework for Long Range Forecast (LRF), covering seasonal to inter-annual timescales, and coordinated by:

i) the World Climate Research Programme (WCRP) for research aspects;

ii) the WMO Commission for Basic Systems (CBS) for operational aspects: Global Producing Centres (GPCs), Regional Climate Centres (RCCs), Lead Centre for LRF Multi-Model Ensembles (LRFMME), and Lead Centre for the Long Range Forecast Verification System (SVSLRF);

iii) the WMO Commission for Climatology (CCl) for operational use of LRF within the CLIPS programme, especially during the Regional Climate Outlook Forums (RCOFs).

We will then focus on research needs for seasonal forecasting and its applications, especially on how to improve related climate products and services.

LRF generally takes advantage of slowly varying forcings on climate at global scale, such as the strong interactions between land areas and the ocean due to slow variations of the SST and their remote impacts via notably teleconnections.

From a modelling point of view a lot of considerations are relevant like the impact of resolution (horizontal and vertical), physical parameterizations, surface conditions, stratosphere influence, and multi-model ensemble issues, etc. Some of them will be presented.

We will also consider the properties of modelled climate at global and regional scales, e.g. how well circulation regimes and teleconnections are represented in GCMs, how relevant is the modelled intra-seasonal information (including MJO, monthly desegregation of LRF, …), the extremes, what is the predictability of other parameters of the Climate system than T, RR, SST, etc.

In terms of Climate impacts on sectoral activities and decision making, the need for downscaled information will be underlined, as well as the sensitivity of decision making chain to the Climate information.

Finally, some aspects of the value of seasonal forecasts for the users will be considered.

RESEARCH NEEDS FOR DECADAL TO CENTENNIAL CLIMATE PREDICTION: FROM OBSERVATIONS TO MODELLING

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Abstract

With the approaching IPCC AR5 and the developing Global Framework for Climate Services, this is a good time to review the research needs for providing more credible and reliable predictions on the decadal to centennial timescales. Whilst centennial climate projections have been the bedrock of previous assessments, the need for decadal timescale predictions has emerged more recently and they present their own specific challenges. On both timescales the need for information at the regional scale is a core driver of current research agendas.

This talk will address the common and distinctive elements of decadal and centennial prediction in terms of the major outstanding problems in climate modelling and the growing need for observations to underpin the science and prediction on both timescales.

The physical climate system is at the core of predictions on all timescales, and this talk will emphasise those elements, such as the regional water cycle, that should be priorities for research. On timescales beyond two to three decades, Earth system and biogeochemical processes grow in importance but remain hugely uncertain. Major challenges in modelling the Earth system will be discussed, particularly in the context of the physical climate system.

Finally the differences between the two timescales will be emphasised in terms of decadal prediction as an initial value problem and centennial prediction as a 'forced boundary-value' problem. The implications for representing uncertainty, and for initialising and evaluating the predictions will be discussed.

PROVIDING DOWNSCALED REGIONAL CLIMATE CHANGE INFORMATION FOR IMPACT AND ADAPTATION APPLICATION: THE CORDEX FRAMEWORK

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Abstract

Downscaling of climate information, using both physical models (e.g. regional climate models, or RCMs) and statistical methods (statistical downscaling, or SD), is becoming an increasingly widespread and useful approach to meet the demands of impact and adaptation studies. A factor that has so far limited the application of RCM and SD based products is the lack of a coordinated international program to assess the model performance and produce ensemble-based regional climate change projections. Under the auspices of WCRP, such a program is currently being designed and implemented: the Coordinated Regional climate Downscaling Experiment, or CORDEX. CORDEX is intended to establish a framework to: 1) benchmark and possibly improve downscaling models and techniques; 2) produce a new generation of ensemble based climate projections covering regions worldwide for use in impact and adaptation work; and 3) foster the interaction between the science and end-user communities and the involvement of scientists and end-users from developing countries. This paper will describe the structure of the CORDEX effort and will discuss its motivations, objectives and first implementation phase. The future prospects of CORDEX along with its envisioned needs and expectations will also be examined.

PRACTICAL APPLICATIONS OF SEASONAL TO INTERANNUAL CLIMATE PREDICTIONS ON REGIONAL AND NATIONAL SCALES

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Abstract

Interannual variability of seasonal climate, particularly on regional and national scales, has long been recognized to be a major factor in decision making in a variety of socio-economic sectors on national and regional scales. In the Greater Horn of Africa, the ICPAC has been coordinating regional climate outlook forums (RCOFs) since 1998, mainly focusing on seasonal climate outlooks on a regional scale, which also had considerable uptake at the national level in the countries within the region. This presentation will consider the experiences and lessons that have been gained from these activities, along with a few examples from the RCOFs in other parts of the world. In addressing this wide-ranging topic, the following aspects would be of key interest:

- Societal demands for seasonal climate information for disaster risk reduction and sustainable development in the Greater Horn of Africa
- Approaches to seasonal to inter-annual predictions by different African and other regional centres
- Case studies from ICPAC experiences
- Challenges and new demands by the climate change community
- Sectoral linkages to RCOFs

The presentation also addresses certain key challenges in attempting to provide seasonal to interannual climate prediction products. These include:

- Downscaling of global climate products to regional/local levels
- Verification
- Lack of observations and relevant data
- Limited capacity at regional and national levels (human, hardware, software, etc), both in operations and research
- Tailoring of climate information for sector specific climate risk management applications
- Difficulties in the communication and use of probabilistic prediction products

- New demands by various climate sensitive sectors, and climate applications for adaptation to climate change

Some of the regional efforts in the Greater Horn of Africa to deal with these challenges will be highlighted.

BRIDGING THE GAP BETWEEN CLIMATE CHANGE INFORMATION PROVIDERS, STAKEHOLDERS AND POLICY-MAKERS

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Abstract

The overwhelming weight of scientific evidence supports a human induced influence on climate and projections of warming and other changes in climate as assessed in successive IPCC reports.

On one hand science can be considered to have been very successful in drawing the attention of the world to the risk presented by climate change, despite the fact that it is a complex scientific topic, where predictions of the future cannot be verified on decision-making timescales.

Conversely, given the increasingly alarming projections of the impacts of climate change it can equally be argued that the scientific community has failed to successfully impart the urgency of action required to respond to climate change. World governments failed to agree emissions reductions targets in Copenhagen and there appears to be a resurgence of attacks on the science.

The presentation will examine the gap between what the science dictates is required and the current status of global action and will ask what more can be done by the scientific community to bridge that gap.

ENHANCING LINKAGES BETWEEN CLIMATE SERVICE PROVIDERS AND USERS TO FACILITATE CLIMATE ADAPTATION AND CLIMATE RISK MANAGEMENT

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Abstract

Recent major advances in the scientific ability to provide information about future weather and climate conditions have been implemented into operations by National Meteorological Services and other climate service providers around the globe. However, it is quite clear, especially with some of the newly emerged products such as seasonal forecasts, that there remains a major gap between the technical ability to produce climate information and its actual uptake. In this presentation, a range of hindrances to the use of weather and climate information will be indicated, which create gaps in the effective functioning of climate adaptation and risk management. Specifically, four main categories of gaps exist: data availability; information provision; information uptake; and policy constraints. Examples will be presented of how the meteorological community can contribute to addressing all of these gaps. A strong message will be that the effective use of climate information for adaptation and risk management requires far more than just improvements in the quality and coverage of existing products. The importance of tailoring information, and of integrating information from different time and spatial scales in ways that answer users' questions rather than meteorologists' questions is emphasized. However, these efforts can only be successful if there is a constructive dialogue between the producers and users of climate information. Some examples of the establishment of successful dialogues will be presented, primarily involving the health and disaster risk management communities, and the necessary ingredients for such success will be highlighted.

ENHANCING CLIMATE CHANGE RESEARCH AND APPLICATION IN DEVELOPING COUNTRIES

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Abstract

This presentation will review strategic examples of ongoing or planned projects in climate-sensitive sectors in various developing countries. The analysis is aimed at identifying current research gaps and revealing potential opportunities for promoting the engagement of developing countries in climate research jointly enabled by WCRP & CCI. The presentation will emphasize the need for having significant focus on demand driven research initiatives in developing countries to maximize responsiveness and relevance to national development programs and agendas. It is hoped that this bottom-up approach advocated in the presentation will contribute to the creation of effective pathways for enhancing the participation of developing countries in climate research.

Poster Abstracts

AN OPERATIONAL SEASONAL FORECAST SERVICE FOR AGRICULTURE IN ITALY: THE TEMPIO PROJECT

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Abstract

Seasonal forecasting represents the attempt to predict, in a statistical context, the spatial and temporal distribution of weather anomalies a few months into the future. Even though the detailed dynamical evolution of atmospheric systems is not predictable on those time scales, some of their statistical features and behaviours can be predicted. In particular it is possible to figure out the average behaviour over a month or season, and how much the probability distribution of such averages, or anomalies, differs from the "climatology". Since late 90's seasonal forecasts experienced a growing role, despite the large uncertainties still present (Palmer and Anderson, 1994). Precipitation and temperature anomalies knowledge, available a few months early, can be useful for technical services and companies in order to better manage water resources, crop and energy.

In 2006 CRA-CMA and CNR-IBIMET started a two years joint research project, financed by the Italian Ministry of Agricultural, Food and Forestry Policies (MiPAAF) for developing a forecasting system with the main aim of supporting agricultural activities and with the more general objective of increasing information for "decision making". The Project main goal was to develop a novel forecasting methodology for temperature and precipitation monthly anomalies, and for the development of an early warning system of heat and cold waves (Baldi et al., 2006) at National scale. A special effort has been devoted to the downscaling of forecast information at local scale for seven Italian sub regions climatically homogeneous. In particular we succeeded in:

- identifying climate homogeneous sub regions using a combination of Functional Data Analysis (FDA) and Partitioning Around Methods (PAM) clustering technique on a dataset composed of daily precipitation and daily minimum and maximum temperature data collected for the period 1961-2007 from 96 Italian stations. The Monthly Mean of Medium Temperature and Monthly Cumulated Rainfall were calculated and analysed (Pasqui et al, 2008). Thus, we obtained 96 time series of two climatic variables, each series composed by 564 monthly values, which form the basis for the climatic classification;

- isolating the climate mechanisms acting at a monthly timescale on the climate variability of the Central Mediterranean Basin all along the seasons by a selection of climate indices. The climate indices include both the fast – varying atmospheric and the slow varying oceanic indices;

- developing a coherent mathematical framework for computing forecast anomalies, by isolating information contributions coming from different climate dynamics mechanisms (Pasqui et al., 2009, Primicerio et al., 2009).

Furthermore an extensive validation study has been done in order to highlight benefits and limitations of forecasts both with respect to observed data, in order to measure internal reliability, and with respect to other existing forecast systems, in particular the IRI – forecast model.

Even if the original design was developed as an effective support tool tailored for the agriculture sector, this forecast system reveals potential benefits also for civil protection activities and, more in general, for better water resources management. Since the conclusion of the research and development phase activities, the seasonal forecast system is now operational and easily available for a large community of operators from different economical sectors. In the future it is desirable to continue the research with the aim of better understanding the climate dynamics of the Mediterranean region in order to increase the skill of the forecast and to produce seasonal forecast at finer spatio-temporal scales and to produce an operative seasonal forecast system accessible to a wider community through the diffusion of handy means of communication.

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CAPABILITIES FOR DEVELOPMENT OF CLIMATE INFORMATION SERVICES IN BULGARIA

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Abstract

In the past, the published Climate Reference Book for Bulgaria, with its more than a thousand of pages information about a variety of different climatic parameters, calculated for numerous meteorological stations, was a backbone of climate information services in the country. At present, the mentioned parameters can be used occasionally, in scientific investigations or for information, but not for climate information services, as far as their values are calculated on basis of data for the period 1931-1970 and represent out-of-date information for the user′s requirements.

On the other hand, many investigations reveal availability climate change indications in Bulgaria, like for example: decreasing annual and summer precipitation from the end of 1970s and several drought episodes during 20th century (Alexandrov et al, 2004); winter warming with significant air temperature increase and winter precipitation decrease in North Bulgaria resulting in decrease of maximum snow depth and snow cover duration (Petkova et al, 2008); increasing of annual mean number of days with heavy precipitation (≥100 mm/24 h) during the period 1997 - 2007 in comparison with the average for 1961 – 1990 period (Bocheva et al, 2009); increasing of annual number of days with dry wind after the year 1990 (Gocheva et al, 2006); especially hot spells registered in the last decades not only in the southern regions (like in the past) but on the whole territory of the country (Gocheva et al, 2006); etc.

The present climate information services in the country consist of numerous particular responses to numerous different user's demands and some greater contracts in some cases, like for example these ones for: preparation of climate information for building design of Calafat-Vidin bridge on river Danube; calculation and initiating into practice of the parameters used for estimation of wind, snow and air temperature loads on buildings according to the requirements of Eurocode 1; preparation of agroclimatological information for the purposes of plant defence; etc.

The work on a piecemeal manner as well as the old equipment and diminishing number of stations, the lack of enough financial resources and the reduced staff, represent main challenge for the climate information services in the country at present.

The first steps for bettering the system require gradually implementation at least of the following measures: development of a national programme with emphasis on the climate information services; identification of especially dangerous climate extremes/hazardous events and economic sectors most in risk; choice of appropriate climatic parameters amongst the ocean of specialized indices; mapping of the territory by the selected characteristics and gathering the information by administrative districts; appropriate form of communication with the main users of climate information (by sectors) and the municipalities; etc.

The role of WMO in the case could be unique through additional activities like for example: recommendations for choice of appropriate indices by sectors of the economy; preparation of exemplary models for bettering the system in case of lack of enough

resources and reduced staff; information about possible financial sources (including for new meteorological equipment); dissemination of lessons learned; pilot projects; etc.

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CHANGING CLIMATE AND DEMANDS FOR CLIMATE SERVICES FOR SUSTAINABLE DEVELOPMENT

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Abstract

Drought is one of the most damaging climate-related hazards to impact societies. Although drought is a normal part of climate, it can develop as an extreme climatic event and turn into a natural hazard which can have severe impact on local people and water-dependent sectors. The combination of rainfall deficiency with other climatic factors and in particular high temperature create serious risk of drought in the central and South-eastern parts of the country where agriculture is the main economic sector that sustain communities. In this study, monthly total precipitation and monthly mean temperature data of the period 1965-2007 from Turkish State Meteorological Service were analyzed by using Aridity Index in order to determine the desert prone areas in Turkey. Their spatial and temporal distribution and climatic trends were also analyzed. It is observed that the arid areas are extending to the west of Central Anatolian region and desertification prone areas extend from Konya Basin to Eastern Mediterranean region. It is obvious that drought phenomenon will create a vulnerable environment for the agricultural sector and water resources in Turkey considering its spatial and temporal impacts especially in the low and variable rainfall regions of the country.

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CLIMATE CHANGE DETECTION AND INDICES: PRECIPITATION TRENDS OVER CYPRUS

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Abstract

Long-term trends from 1900 to 2008 have been observed in precipitation amount over many large regions. Reduction of precipitation has been also observed in many parts of Mediterranean area. A decreased trend has been also observed for the area average precipitation over Cyprus. The rate of decrease is 1mm/year. The mean annual value of the area average precipitation for the period 1901-1930 is 556 mm, while for the most recent 30 year period of 1971-2000 it is 462 mm, i.e. there is a reduction of about 100 mm. More intense and longer droughts have been also observed since 1970. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. The frequency of heavy precipitation events has increased, consistent with warming and observed increases of the atmospheric water vapour. Long period of records have also shown that the number of rain days with precipitation less than 10 mm have decreased showing that the number of weather systems affecting the island have been reduced. In contrast to the above, the number of systems originating from Sahara has significantly increased causing considerable allergic problems and affecting negatively human health.

Climate change in Cyprus is very likely to affect ecosystem by reducing soil fertility and water availability. The stability of forest ecosystems will be negatively affected by accelerating tree mortality. The natural disturbances (fire, insects) will have a negative impact on forests. Under climate change conditions, it is expected that irrigation water demand will further increase, aggravating the competition with other sectors whose demand is also projected to increase. In addition, an expected lowering of the groundwater table will make irrigation more expensive. As the evaporative demand will increase due to higher temperatures, it is expected that capillary rise will increase the salinisation of soils which leads to desertification which is now evident in the island (Iacovides et al. 2008).

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CLIMATE CHANGE DETECTION AND INDICES: TEMPERATURE TRENDS OVER CYPRUS

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Abstract

In the eastern Mediterranean, studies have shown significant decreases in the diurnal temperature range (DTR), due to significant increases in minimum temperature. Long term temperature data from two stations in Cyprus (one inland and one coastal location) have shown an increasing trend of approximately 1°C/100 years in the annual mean temperatures (Price et al., 1999). However, the study showed that the minimum daily temperatures have generally increased at a larger rate than the maximum daily temperatures, resulting in a decrease in the long-term diurnal temperature range which ranges from -0.5 °C/100 years to -3.5 °C/100 years depending on the location. The changes in the diurnal temperature range can be possibly be explained by increases in cloud cover and/or tropospheric aerosols. Furthermore, these changes are caused by local land–use changes, primarily by the increasing urbanization of Cyprus.

Temperatures in the last 20 years showed that this period was the warmest in the instrumental record of global surface temperature. Similarly, temperature data over various locations of the island showed significant increases of temperature during the period 1991-2008. Mean annual temperature differences of about 1.2°C from the normal value of 1961-90, were recorded. Widespread changes in extreme temperatures have been also observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days and hot nights and heat waves have become more frequent.

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CLIMATE CHANGE PROJECTIONS FOR TURKEY WITH PRECIS REGIONAL CLIMATE MODEL: HADAM3P SRES A2 SCENARIO

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Abstract

Due to her existence in the Mediterranean Basin and to the possibility that Turkey will be among the one of the most affected countries by climate change impacts, the target of this study was to obtain detailed climate projections for Turkey and the surrounding regions by using the UK Met Office, Hadley Centre for Climate Prediction and Research's Regional Climate Model, PRECIS (Providing Regional Climates for Impacts Studies). The Model was run with Hadley Centre's GCM HadAMP3 outputs and reference period (1961-1990) and corresponding future period (2071-2100) A2 scenario simulations have been compared with each other to analyze climate change.

According to the results of simulations, 5-6 °C increases in mean temperatures were projected in Turkey except the coastal regions. In winter season, while temperatures in Eastern region will increase 4-6 °C, during summer in the west, this will be 6-7 °C. In summer season, up to 8 °C high increases in the large scale was eye-catching. In winter season, minimum temperature will increase 5-6 °C in Eastern and 7-8 °C in the continental parts of Aegean region during summer season. Changes in precipitation regime, from east to west, within decreases of up to 40% attract one's attention. There will be decreases in precipitation in Western and Southern regions but in summer season this case will be reversed. In terms of water budget, snow depth will lessen in the Eastern and the Eastern Black Sea regions. Parallel to decrease in precipitation and increase in temperature, as a result of evaporation increase, water loss is enhanced. The differences between the precipitation and evaporation, although changes in the large scale domain of Turkey were not apparent, in Southern Marmara, Aegean, Eastern Black Sea, North of Southeastern Anatolia regions and along the Taurus Mountains line, decreases were evident.

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CLIMATE INFORMATION AND SERVICE IN THAILAND

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Abstract

Thai Meteorological Department (TMD) had integrated climate group and climate academic group forming the Climatological Center which is the unique center of the country to provide climate information, climate research and application, climate prediction, climate change and strengthen cooperation in international climate service and research. Climatological Center is responsible for the preparation and dissemination of climate information and products for early warnings on agriculture, water resources, energy, health and climate disaster risk reduction in country.

Climate observation and monitoring

Climate data at the TMD date back to 1951. Nowadays, there are 123 synoptic stations altogether in all regions of Thailand. They can be divided into 73 surface weather stations, 34 agro-meteorological stations, and 16 hydrological stations. The parameters include air temperature, precipitation, relative humidity, atmospheric pressure, wind speed, wind direction, visibility, cloud types, heights and amounts, soil temperature, evaporation, solar radiation, sunshine duration, thunderstorms, hails, fogs and occurrences of any other natural phenomena. Besides, the climatic normal and averaged values of each climatic parameter are made available as well. All of them are kept in the Department's digital database and can be provided for general public upon request.

Thailand's climate change and variability are a part of global climate change. The variations were calculated by means of the deviation from the normal (1971-2000). The regression equations for the period of 58 years point out the increasing trend for most cases of annual temperature and the change of rainfall is not clear for the whole period of observations made in all parts of Thailand. However, annual rainfall trend was to increase in the last decade. Considering the number of hot days, the surface maximum temperature > 35 ^{o}C over the regional of Thailand and the whole period of observations, a markedly increasing trend is found in all areas of Thailand. Meanwhile, number of clod days, and the surface minimum temperature < 16 ^{o}C show a significant increasing trend over Thailand.

Climate Prediction and scenarios

There are 4 kinds of the long range weather forecasts provided by the TMD: monthly weather forecasts, seasonal weather forecasts, four-week weather forecasts, and three month forecasts. Their main contents are rainfall and temperature forecasts which are the results from processing data since 1951 with relevant statistical techniques and climatological analyses, compared with the seasonal forecasts from ECMWF, NCEP, IRI, and UK as the guidance.

The analogue method has also been used by TMD to forecast seasonal rainfall, temperature and the number of tropical cyclone affecting Thailand in a year. Analogue years are selected by matching the expect strength of ENSO in the coming year as forecast by the National Center for Environment Prediction(NCEP) as well as antecedent conditions such as ENSO strength in the preceding year and how long the event has already persisted. This approach seemed to be able to yield a measure of success, particularly when the ENSO event is strong. For example, temperature is above normal and rainfall is below normal over

Thailand during the strong El Niño event in 1997-1998. The strong La Niña event in 1998-1999 resulted in above normal rainfall in Thailand and below normal temperature.

Further more, the predictions of the numbers of dry days, seasonal rainfall totals and seasonal temperature are regularly analyzed by the Climate Prediction Tool (CPT). Afterwards, the CPT produces the downscaled predictions, based on the outputs of Global Climate Model Predictions from IRI.

At present, G-RSM (Global–Regional Spectral Model) is an experimental model applied to regional predictions for 1 month in Thailand and there are plans to extend these to 3 months in the future.

Climatological center used the PRECIS (Providing Regional Climates for Impact studies) model to predict future climate change and provided the climate change scenarios information and data for the government service and any research activity in the country.

Use of Climate Information and Predictions

Climatological center has maintained the provision of products and services to assist users and stakeholders in deciding on response strategies and adaptation measures to mitigate the impacts of weather and climate related disasters. Climate information is very important in Thailand and is applied in many sectors such as government sector, private company, academic institute etc., and used for several purposes for example: education, research activities etc. Furthermore, climate information can be used to develop strategies and programmes for sustainable agriculture development.

Survey on user needs about application of climate information

It is indispensable to appropriately grasp user needs about climate information for providing climate information and services to meet the needs.

- TMD is considering organizing a user-participating meeting.
- Periodical meetings are held with main users
- Questionnaire surveys are conducted on user needs

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CLIMATE INFORMATION SERVICES IN WESTERN SOUTH AMERICA

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Abstract

After 7 years of operations, CIIFEN has consolidated its presence over Central and South America, by the provision of several climate information services mainly focused on end users and decision makers. One of the main achievements has been the improvement of climate information management at local level in several countries as a key element of real people centered early warning systems.

Since 2007, CIIFEN implemented a regional project with NMHSs from Western South America (Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela). Its main objective was to contribute to the reduction of social and economic impacts due to the effect of climate on agriculture by, supporting the decision-making process, and managing agricultural sector risk in pilot areas in six countries.

The project undertook a complex recovery process and data conversion from meteorological stations to be digitized for a quality process control. At the same time, a Regional Climate Data Base was designed and integrated with more than 4,000,000 files of precipitation, maximum temperature and minimum temperature daily data since 1960 to 2009 from 169 meteorological stations along the region http://vac.ciifen-int.org/Jsp/bdc/Main.jsp

A considerable effort was deployed to enhance the national capacities to seasonal forecasts (1-3 months) in the 6 countries. Statistical tools and numerical models were implemented or improved according to the particular conditions of each country. Now, climate statistical forecast is operational in six countries while climate forecast models are being improved progressively.

Methodologies to support decision making have been developed. In the case of the agriculture sector, a geographic information system was designed to represent spatially the vulnerability of the designated crops according to the area of intervention. Additional information was added such as layers of exposure to different climate hazards levels, resiliency levels estimated on social, economic, political and institutional parameters, land use characterization and water retention capacity, including its topography and texture among other factors. http://ac.ciifen-int.org/sig-agroclimatico/. These systems have been implemented in the NMHSs from WCSA.

CIIFEN has also concentrated on enhancing the climate dissemination process, exploring new ways to reach end users and involve other partners. Key stakeholders were identified and strategic alliances with the local and communitarian media were agreed. A special effort was made to involve the private sector in the process, which leads to successful outcomes. For instance, an agreement with a mobile company was made in order to disseminate non-cost text messages for climate alerts in Ecuador. Likewise, some products of the NMHSs are being published in specialized agro magazines, newspapers or bulletins with no cost to end users and the NMHSs.

An assessment of user perception about the climate information provided was done in the pilot areas in six countries. The access, comprehension and use of the information increased from 30 – 50% of the target population at the start of the project to 60 -65% at the end of the project. One of the main success indicators of this initiative has been the response of the National or local authorities. During the final phase of the project, Governmental funding was given to replicate the initiative in other zones and enhance the installed capacities. The information system reached sophisticated users and decision makers in industries and Government with internet access and easy application and comprehension of products. However the system also reached beneficiaries by other means, such as the radio, local media, and communitarian networks.

Both communities provide their feedback about the information and the format presented was adjusted several times to satisfy the demands as much as possible.

Now the system effectiveness is measured through the demand. Users with e-mail access subscribe to the system and the number of electronic users has increased by no less than 80% in two years. Meteorological services have a long list of key users that disseminate the information regularly. The list is also increasing for the users who receive the information by radio, media and cell phones (massive communication media in the Andean region). Communitarian leaders in different countries received training on how to use the climate information. Educational material was prepared to train the trainers in the use of climate information and take advantage of the information provided by the NMHSs. This material was designed considering social and cultural specific features of communities in each country.

CLIMATE RESEARCH ACHIEVEMENTS AND GAPS: CLIMATE AND HEALTH RESEARCH IN HONG KONG

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Abstract

In recent years, the Hong Kong Observatory has conducted a number of research studies on how local weather would affect human health in Hong Kong in collaboration with local authorities, tertiary institutions and elderly-care organizations. Areas of study included thermal stress, infectious diseases and vector borne diseases.

Results of the study on thermal stress on human health showed that thermal stress could increase the risk of human mortality and morbidity, especially to the elderly and those with pre-existing heart, pulmonary, respiratory and chronic illness. The results showed that when the daily minimum temperature was below 22°C, the number of senior citizens requiring hospitalization increased as temperature dropped. The figures were more than 10% higher when the temperature fell below 12°C. When the daily maximum temperature was higher than 30°C, the number of senior citizens requiring hospitalization increased as temperature rose. The figures were more than 7% higher when the temperature reached 34°C or above. It was also found that dry weather had greater impact on senior citizens in cool seasons. They would have higher health risk in dry conditions (relative humidity at 70% or below) on cold days (with daily minimum temperatures $\leqq$ 12.0 °C).

During the SARS outbreak in 2003, Hong Kong was among the cities hardest hit by this disease. The study on the severe community outbreak at a residential estate showed that temperature, wind speed, wind direction and atmospheric stability could possibly affect the occurrence, transmission and dispersion of SARS virus.

Influenza epidemics occur and cause significant health burden in Hong Kong. A research jointly conducted with a local institution found that, in general, activity of influenza A was higher than that of influenza B in Hong Kong. The two types of influenza showed a different relationship with weather conditions. Influenza A had two seasonal peaks in Hong Kong which occurred respectively in winter/spring months (February to March) and summer months (June to July). This observation is in contrast with the situation in temperate regions where only a single winter peak is observed annually. On the other hand, influenza B also had a clear winter/spring peak, but its activity during the summer months was more variable. It was also found that cold and humid conditions were associated with a higher level of activity of both influenza A and B in winter/spring months. In contrast, hot and humid conditions in summer months were associated with a higher level of activity of influenza A, but the association was not obvious for influenza B.

Aedes albopictus, which can transmit Dengue fever, is one of the common mosquitoes in Hong Kong. To study the effect of weather on the abundance of *Aedes* mosquitoes in Hong Kong, ovitraps were set up at an unperturbed experimental site for a period of 7 days every month to determine the Ovitrap Index, a parameter to indicate the abundance of mosquitoes at a site. Analysis of the Ovitrap Indices at the experimental site

and the weather elements measured at a nearby automatic weather station showed that the Ovitrap Indices were highly correlated with the mean air temperature over a 22-day period comprising the preceding 15 days and the 7 days when the ovitraps were in place, as well as the total rainfall over the 15-day period prior to the setting up of the ovitraps. A Climate *Aedes* Mosquitoes Abundance Model was developed based on the observations to predict the abundance of *Aedes* mosquitoes in Hong Kong.

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GLOBAL FRAMEWORK FOR CLIMATE SERVICES

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Abstract

WMO, in co-operation with other UN agencies, Governments and the private sector, organized the World Climate Conference-3 (WCC-3) from 31 August to 4 September 2009, in Geneva, Switzerland. WCC-3 decided to establish a Global Framework for Climate Services (GFCS) to enable better management of the risks of climate variability and change at all levels, through development and incorporation of science-based climate information and prediction into planning, policy and practice. The GFCS will be crucial for building climate-resilient societies.

Its main objectives are (i) to provide a cooperative framework in which all Nations, international organizations, scientists and sectors will work together to meet the needs of users; (ii) to enable users to benefit from improved climate information and prediction; (iii) to mobilize climate science globally to advance the skills of seasonal-to-interannual and multi-decadal climate predictions to generate and provide future climate information on an operational basis; and (iv) to foster principles and mechanisms for sharing new advances in science and information through a cooperative global infrastructure.

The GFCS comprises the following major components:

Observations: Strengthen local, national, regional and global observational networks and information management systems for climate and climate-related variables

Climate Research, Modelling and Prediction: Enhance climate modeling and prediction capabilities through strengthened international climate research focused on seasonal to decadal timescales

Climate Services Information System (CSIS): Improve national climate service provision arrangements based on enhanced observation networks, prediction models, global and regional cooperation and greatly increased user interaction

Climate User Interface Programme (CUIP): Ensure more effective application of global, regional and national climate information and prediction services by all stakeholders in climate-sensitive sectors in all countries, leading to improved planning and investment in sectors vital to national economies and livelihoods

Capacity Building: Build capacity in developing countries in accordance with their needs and priorities, including their access to global and regional climate models output and the underlying technology embedded in the models, and their ability to independently develop/improve in-country climate services capacity.

An Intergovernmental Meeting, organized by WMO from 11 to 12 January 2010 in Geneva, Switzerland, approved the terms of reference, and endorsed the composition of a High-level Taskforce for the GFCS. Within a twelve months time frame, the Taskforce will

further develop the components of the GFCS and outline a plan for its implementation, including ensuring the central role of national governments, estimating the costs for several implementation options and providing a strategy for capacity building in developing countries, and by addressing the role of the UN system and other relevant stakeholders as well as global data policy.

INTERANNUAL AND INTRA-SEASONAL VARIABILITY IN PRECIPITATION IN GEORGIA

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Abstract

Research of precipitation relation with circulation processes is the subject of numerous studies and papers in Georgia, where many aspects of the problem are investigated and some characters of relationship are established. Despite above mentioned studies, the relation between seasonal features of precipitation field and long scale circulation anomalies is not well known.

The goal of this article is research of seasonal precipitation characters associated with certain major patterns of Northern Hemisphere. Namely, the main atmospheric circulation pattern over extended Mediterranean region including South Caucasus territories was derived from the monthly sea level pressure anomalies (SLP) using principal component analysis (PCA). The pattern, with the centre of high/low pressure over the western Mediterranean, reflects the Mediterranean Oscillation (MO). In the negative (low pressure) phase the MO is linked to the intense cyclogenesis over the western Mediterranean region. As a consequence, anomalously wet conditions over most of the Mediterranean occur with an exception of south-eastern part and black sea territories where the conditions are anomalously dry. Relationship between standardized monthly precipitation time series from 60 meteorological stations of Georgia for time period 1952-2006 and MOI (Mediterranean Oscillation index) and NAOI (North Atlantic oscillation index), as NAO is the most prominent mode of climate variability in the Euro-Atlantic region, was investigated using canonical correlation analyses (CCA).

Significant correlations between MOI and precipitation are found in the winter above the southeastern (positively correlated) Mediterranean region and Black sea side and weak negative correlation of NAOI with precipitation in the Eastern part of Georgia and Northern Caucasus region between November and February. In case MOI is used, the area of significant correlation coefficient with precipitation is larger and the peak correlations are higher as compared to the correlation between NAOI and precipitation. In autumn and spring when the MOI is used the correlations with precipitation are significant over the smaller areas, and it is even worse when using NAOI. In the summer precipitation over Mediterranean region is not significantly correlated either to MOI or NAOI.

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Management, Assessment and Dissemination of Climate Data in the South African Weather Service

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Abstract

The heightened reporting of extreme weather events across the world has caused the local media and the general public to show more interest in the work of the South African Weather Service (SAWS). Experts from the SAWS were sourced in recent months by both print and electronic media to inform about climate services that are specially geared towards adaptation and risk management. Judging by the recent questions and requests received it has become clear that the general public is moving quickly towards understanding today's environmental challenges.

Management, assessment and dissemination of climate data

In the light of the increased demand for climate data related services, the formalization of the climate data processes will ensure that the public will have the utmost confidence in the climate service provided by the SAWS.

The SAWS is in the process of formalizing its processes for the envisaged compliance to the ISO 9001 standards. In this regard the procedures from the verification and validation of incoming climate data, to the eventual dissemination of the data or data-related products, can be described by various processes. The formalization of these processes is crucial to ensure that clients receive data and value-added products of as high a standard as possible. A simplified view of three of the processes is presented, namely:

- Verification and Validation of incoming climate data,
- Research and Analysis on climate data,
- Provision of Climate Consultancy Services.

Increased demand for climate services for adaptation and risk management

For the year that ended March 2009, the majority of clients that requested climate related services were in the main from the insurance and legal industry at 31% (SAWS annual report 2008/09). This was followed by a variety of industries, e.g., construction, consultancies, media and energy at 25%. Other interest groups include schools, government and private individuals. The overall total of all climate data requests was more than 4000.

The insurance industry especially uses climate services for risk management. This industry has shown interest in the SAWS lightning information to settle its claims. Lightning data revenue increased by 80% when compared to 2007/2008, owing to, amongst others, the insurance industry.

MODELING SOLAR ENERGY POTENTIAL IN TURKEY BY USING SECONDARY PARAMETERS

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Abstract

Since the Industrialization revolution, atmospheric CO_2 concentration increased from 280 to 400 ppm due to mainly fossil fuel use in the energy sector. However, a small portion of the incoming solar energy into the world is sufficient to meet human needs. For this reason nowadays use of renewable energy sources such as solar energy is very important to protect atmosphere.

Geographic variables are measured at certain points, and prediction map for the entire area was obtained by some spatial interpolation methods. Spatial distribution of geographic data can be obtained only from this data and also prediction map can be obtained by using secondary variables which have a spatial relationship with the measured values (Bostan et al. 2007).

Geographically Weighted Regression (GWR) and co-kriging methods were applied in the modeling of radiation. GWR is the multi-faceted approach to the analysis of spatial data. GWR opens a window through the data set to calculate local r^2 (Laffan, 1999). Co-kriging is an extension of ordinary kriging method which takes into account the spatial cross-validation between two or more data.

In the modeling of spatial interpolation of radiation data, aspect, latitude, relative humidity and cloudiness were used as secondary variables. Best results were obtained with the cloudiness and relative humidity parameters. Simple linear models were generally solved by ordinary least square method using the formula below.

P= C1+C2+e where;

P= Radiation (KWh/m²)

C1= solar radiation parameters change with the humidity

C2= solar radiation parameters change with the cloud cover

e= error term

Co-kriging and GWR model results were compared by the lowest RMSE and higher r^2 values obtained in the model. Because the RMSE is smaller and r^2 is grater than the Co-kriging result, GWR tool was selected for modeling solar energy potential in Turkey. According to the model results, southern parts of Izmir-Igdir line, have over 1500

KWh/m²/Year radiation potential and is considered as the optimum area for the photovoltaic installation.

RAINFALL AND THE INTERTROPICAL CONVERGENCE ZONE VARIABILITY OVER THE WEST SAHEL

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Abstract

Three spatial networks were constructed for analyzing rainfall variability over West Sahel Africa. For each candidate area the set of annual networks is stored for the period of 1950–2000, reflecting the spatiotemporal variability on the West Sahel African region. It is pointed out that the most significant rainfall climatological changes in the Sahel most probably occurred between 1950 and 1975, with a drastic annual rainfall reduction, about 70%, over the whole region.

It is shown from numerical stochastic evidence that Sahel climate variability is inextricably tied to the global climate variability. Statistical analysis was used to interpret spatial and seasonal variability in West Africa. The last decade (1990–1999) showed some rainfall improvement. However, the more humid conditions of the 1950's and 1960's were not established yet. The persistent and continuous decline of Sahel rainfall since the late 1960's is the most significant feature of climate variability. The trend was interrupted abruptly by a return of adequate rainfall conditions in 1994. This was considered to be the wettest year of the past 30 years and it was thought to, perhaps, indicate the end of the drought period. However, 1994 rainfall total barely exceeded the long-term mean. Also, the 1994 rainy season was unusual in the aspect that the anomalous wet conditions occurred toward the end of the rainy season and in the following months.

The time series of Season1: Jul-Aug-Sep (JAS), Season2: Jun and Oct (J&O) and Season3: Nov-Dec-Jan-Feb-Mar-Apr-May (NCJFMAM) rainfall anomalies were derived for 14 rain gauges of the 6 countries, in the West Sahel region, using data of the World Monthly Surface Station Climatology (WMSSC). The temporal characteristics of the series, such as variance, were evaluated using principal components regression. The Principal Component Analysis was used to understand the underlying data structure and form a smaller number of uncorrelated variables.

Concerning the West Sahel JAS season, the first principal component had a variance (eigenvalue) of 5.85 and accounted for 41.8% of the total variance. The second principal component showed a variance of 2.04 and accounted for 14.6% of the data variability. Together, the first two principal components captured 56.4% of the total variability. Regarding the West Sahel J&O season, the first principal component had a variance of 5.47 and accounted for 39.1% of the total variance, whereas the second principal component had variance 2.63 and accounts for 18.8% of the data variability. Together, the first two principal components represented 57.9% of the total variability. For the West Sahel NDJFMAM season, the evaluation of the first principal component resulted in a variance (eigenvalue) of

5.60 and accounted for 40.0% of the total variance, and the second principal component had a variance of 2.43 and accounted for 17.4% of the data variability. Together, the first two principal components represented 57.4% of the total.

The interannual difference of the rainfall regimes between the two succeeding periods, 1951–1975 being wet, and 1976-2000 being dry was 180mm/yr. It appears that, in the intra-seasonal timescale, the rainfall deficit of the dry period resulted primarily from the reduction of the number of events occurring during the core of the first rainy season for regions extending southward to 9°N–10°N. In the southern areas, the dry period was characterized by a shift in time of the second rainy season. All these characteristics have strong implications in term of agricultural and water resources management.

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RESEARCH IN HISTORICAL CLIMATE CHANGE IN SOUTH AFRICA

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Abstract

The South African Weather Service (SAWS) has, through recent years, conducted extensive research on the changes in the historical climate of South Africa. These research efforts are deemed important for several reasons, but most importantly:

- In the light of the significant climate change that has already occurred, as well as the expected climate change, it is crucial to quantify the changes in the climate that have already occurred and to compare these changes with the projected changes in the climate.
- The surface of the Southern Hemisphere is mostly covered by the oceans, a property which inevitably makes the availability of long-term climate records scarcer compared to the Northern Hemisphere. In this regard the analysis of long-term climate records in countries such as South Africa is crucial for the assessment of global climate change.

The completed and published research includes studies on temperature, rainfall and cloudiness trends over South Africa. The first study regarding temperature trends indicated that most parts of South Africa experienced significant increases in the annual mean maximum and minimum temperatures during the period 1960-2003. Trends of mean seasonal temperature showed that temperature trends are not consistent throughout the year, with the average trend for austral autumn showing a maximum and austral spring a minimum, for almost all of the climate stations investigated. The monthly trends of the average annual temperatures showed large differences in trend between the climate stations and for each of the stations between months, but similar tendencies in trend between months were found to exist for stations close by, and also for groups of stations on a regional basis. Trends in the diurnal temperature range were almost equally divided between positive and negative, with the positive trends in the central interior of the country mainly being caused by large positive trends in the maximum temperature. It was also shown that, in general, days and nights with relatively high temperatures have increased, while days and nights with relatively low temperatures have decreased. ENSO events did not seem to play a significant role in the increasing temperatures observed.

Due to a regional study on trends in rainfall and temperature indices over sub-Saharan Africa, under the auspices of the WMO, a follow-up and first precipitation study, only over South Africa, could be done. This study showed that the spatial variations of trends of relevant extreme precipitation indices for 138 rainfall stations in South Africa, for the period 1910-2004, indicated some significant changes in indices, averaged over specific areas in South Africa.

These included areas with significant increases and decreases in annual precipitation, increases in the longest annual dry spell indicating more extreme dry seasons, increases in the longest annual wet spells indicating more extreme wet seasons, and increases in high daily precipitation amounts. The conclusion was that, while in the largest part of South Africa there had been no real evidence of changes in the mean annual precipitation over the past century, there were however some identifiable areas where significant changes in certain characteristics of the precipitation had occurred.

In a study on trends in cloud cover, seasonal trends in low and total cloud cover, as well as for associated climate variables diurnal temperature range (DTR) and number of rain days, were investigated. The seasonal trends of daily means were examined from quality-controlled data time series of 28 climate stations over South Africa, for the period 1960 to 2005. The main results, taking all seasons into account, was a general decrease in mean daily low cloud cover, and to a lesser extent total cloud cover, over most of South Africa, but an increase in the south and south-west of the country. However, the sizes of same trend regions show considerable variability between seasons. While trends in DTR and rain days were the opposite and the same, respectively, of trends in cloud cover in most cases, it was shown that this was not always the case. A region covering the northern, central and western interior of South Africa, with late-summer (JFM) cloud cover negatively correlated with equatorial Pacific sea-surface temperatures (SSTs), showed only a non-significant decrease in total and low cloud cover for JFM, which corresponded to a non-significant increase in the equatorial Pacific SSTs during the same period.

Studies in historical climate change are still continuing, with two new projects initiated in 2009. These are studies to update and extend the results in the trends in rainfall and temperature, discussed above. The rainfall study focuses on trends in seasonal rainfall variability, but also covers trends in seasonal rainfall totals. There is already a system in place which calculates the significance of trends of seasonal district rainfall, and the mapping of the results afterwards. The district rainfall covers the period 1953-2009. Initial results suggest a statistically significant increase in the variability of summer rainfall in the east, as well as the southern interior of South Africa. For spring the increase is almost countrywide. These results are significant in that the eastern half of the country receives the bulk of its rainfall in summer and spring. For autumn the increase in variability is isolated to some parts of the east, while the western half, as well as most of the southern parts, experienced a decrease in rainfall variability. This result seems to be beneficial for parts of the central interior which receives most of its rainfall in late-summer. For winter we see a decrease in variability in the west, which can also be regarded as a positive result. The trends in total seasonal rainfall were also mapped and it seems clear that for most parts of South Africa there are no significant trends in the total rainfall received. Future work includes the investigation of the possible causes of the trends in variability of the seasonal rainfall, by the calculation of a range of extreme daily rainfall indices for individual rainfall stations. The results of these stations will then be statistically compared to each other, as well as the seasonal results.

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