*AP-1*

## Is it Possible to Forecast Health in the UK Using Seasonal Climate Forecasts?

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The findings of the NERC/COAPEC project, Climate Information for the Health Sector, are presented here. The project aims to establish how climate products from coupled climate models may be used to develop a decision support tool for winter planning in UK hospitals. Ischaemic heart disease (IHD) is a leading cause of death in the UK and has been linked to seasonal changes in temperature. The UK is one of the most sensitive countries in Europe to winter-related mortality. Climate forecasts are a relatively new product available from the climate modelling community. Although these products have been applied in agricultural forecast modelling, they have not been investigated for use in health forecasting. The relationship between daily IHD mortality data (1974-1999) versus observed surface temperatures was investigated over varying time-scales (monthly to intra-seasonal) using correlation and linear regression techniques. The differences between male/female and age groups (65 years and over; under 65 years) were investigated. The results show strong relationships between total IHD mortality and monthly average temperatures for December (65 years and over) and January (other mortality categories) for several UK counties. The utility of these biometeorological indices for use in a health-forecasting model was tested over a range of possible errors in a climate forecast. The variability within retrospective ensemble seasonal (winter) temperature forecasts for the UK (1986-1999), supplied by the UK Met Office using coupled atmosphere/ocean general circulation model data, was investigated and also compared to observed temperatures. The utility of monthly and seasonal climate forecasts for predicting health in the UK was also investigated. The spatial scale and accuracy of the climate forecast was evaluated in terms of application to a UK county-scale health forecast.

*AP-2*

## Winter Climate and Ischaemic Heart Disease Mortality in England: Implications for Climate Based Health Forecasting

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Background: As cold weather is an ischaemic heart disease (IHD) risk factor, year-to-year variations of the level of IHD mortality may be partly determined by inter-annual variations in winter climate. We investigated whether there is any association between the level of IHD mortality for three English counties and the winter North

Atlantic Oscillation, which exerts a fundamental control on the nature of winter climate over Western Europe.

Methods: Correlation and regression analysis was used to explore the nature of the association between IHD mortality, stratified by age and sex, and a climate index (CI) that represents the interaction between the NAO and temperature across England for the individual winter months of December, January and February and the winter seasons (DJF) of 1974/75 to 1989/99.

Findings: Statistically significant inverse associations between the CI and the level of IHD mortality were found at both the monthly and seasonal time scales. For the individual months of D, J and F the CI explained between 17 and 48 percent of the variation in monthly IHD mortality. At the seasonal level the winter CI was able to explain between 32 and 48 percent of the variability of an all England mortality index. The levels of explanation achieved by the CI are generally superior to those obtained by single climate variables such as the winter NAO or the Central England Temperature. Generally, high levels of winter IHD mortality are associated with a negative CI, which represents winters with a strong negative phase of the NAO and anomalously low temperatures across England. Moreover, the nature of the CI in the early stages of winter appears to exert a fundamental control on the general level of winter IHD mortality such that a high overall winter mortality level is associated with a negative phase of the NAO and anomalously cold conditions in December.

Interpretation: Because winter climate is able to explain a good proportion of the inter-annual variability of winter mortality, long-lead forecasting of winter IHD mortality appears a possibility. The integration of climate based health forecasts into decision support tools for advanced general winter emergency service and capacity planning could form the basis of an effective adaptive strategy for coping with the health effects of harsh winters.

*AP-3*

## Climate Variability – Human Health

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At last the human beings have started realizing that their inadvertent level of activity through industrialization, urbanization and changes in land use are the prime causal factors resulted in global radiative forcing of the climate system with regional implications of extreme events that encompass from storms to heat and cold waves through floods and droughts that are associated with varied degrees of psychophysiological ailments. Further the internal dynamics of the world climate system has been resonating the world's climate system with ENSO/LNSO mode that sweeps from southern tropical Pacific compared to any other quasi-permanent systems and has been inflicting on the society with its aperiodicity by harboring the environmental

problems that have been affecting the human health in the varied geographical settings of the world. It is traced and reported that the invariable changes in global temperature and rainfall have significantly and adversely limiting humans' health by enhancing the survival of bacteria for the spread of cholera, typhoid and dysentery, respiratory track infections and measles on one hand and increase in physiological ailments on the other hand respectively which in turn determine the vulnerability to psychophysiological disorder sensations of the human's system across the world.

The aim of the present investigation is not only to understand the moisture and thermal regimes of India but also the stability in them through the well established classifications in the distinct epochs since changes in them affect human health through multiple pathways including direct and indirect effects that operate ranging from climate related stress to disease vectors with economic disruption. Interannual variation of temperature and rainfall along with the regression of rainfall on temperature in the representative months of the summer and winter seasons along with annuals for All India are diagrammed and the implications are discussed. The paper then proceeds in obtaining the spectrum of heat load and wind chill in the representative months of summer and winter for selected ENSO and LNSO events along with the normal in the climate spectrum of India by following the well known concepts based on meteorological phenomena and psychophysiological sensations of the human system.

*AP-4*

## Dynamics of Atmospheric Pollutants Around the Middle Atlantic Region

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Virginia and Maryland are eastern seaboard states in the USA. The coastal winds affect this region and, as a result, pollutants are found to be highly dynamic. In the present paper, we have used a Kriging interpolation technique to study the various greenhouse gases measured at various locations for the periods 1993 – 2003. The annual and inter-annual variability of these gases show significant spatial variations in the region and as a result impact human respiratory health. We have also used total ozone column and aerosol index retrieved from TOMS and MODIS satellite sensors over this region, respectively. The annual and inter-annual variability of the greenhouse gases, total ozone column and aerosol will be discussed in view of the population dynamics and land use/land cover changes. We have also found incidence of respiratory ailments in the region appear to be related to pollution variations.

*AP-5*

# Variability of Uv Index in the Metropolitan Zone of Guadalajara (Zmg) and Its Relation with the Contamination Index during 2003

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The UV Index is an indicator of the correlation between the solar radiation and its effects on the diverse types of skin. The tropical zones (as in the case of the ZMG) receive high solar intensities of radiation reaching their maximum in the zenith. In these zones the UV index always presents values above 4. The objective of this work was to show behavior of the UV Index and its relation with the indices of contamination in the ZMG (CO, NOx, NO2, SO2, PM10, and O3) during 2003. The UV index data were collected by means of an automatic weather station Vantage Davis Pro Plus every 10 min., the Institute of Astronomy and Meteorology of the University of Guadalajara being the pioneer in the registry of information of the UV index in the ZMG. The contamination indices were acquired through the network of monitoring of polluting agents operated by the Secretary of the Environment and Sustainable Development (SEMADES) of the government of the State of Jalisco, which monitors the polluting agents every 10 min in 8 stations located strategically in the ZMG.

The results show that during 2003 the UV index varied from 0.30 to +15. The high and very high extreme values occur between 10:30 and 16:30 hours varying according to the month. The minimum percentage of high and very high the UV indices appeared during the first 4 months of the year, whereas the highest percentages were registered in the rest of the year. It is possible to appreciate the reason why in the most important UV index analysis, the values are registered during the period before the rainy season, when the insolation is high.

The contamination Index had a great variability during 2003: There are zones with a great concentration of primary polluting agents which favored the diminution of the UV index, while in the zones where the contamination did not present great concentrations, a greater exposure to solar radiation was what caused an increase of the UV index in those zones. In the case of the secondary polluting agents such as ozone, greater concentrations appeared when the solar radiation was more intense.

Apparently in the ZMG an inversely proportional correlation exists between UV radiation and the concentrations of primary polluting agents, whereas for the secondary polluting agents the correlation is directly proportional.

*AP-6*

# Climatic Variability in Natural Grasslands Ecosystems in the Northeast Region of Uruguay

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Seventy years of records show a strong variability in rainfall between decades, years, seasons and sites in the northeast region of Uruguay. The annual rainfall mean is 1300 mm with a coefficient of variation of 100 %, leading to different types of climates in successive years.

Variability does not follow a stable pattern through time; winter and spring are relatively predictable seasons, while summer and autumn are less, giving a combination of possible events which lead to extremely wet or dry periods with a considerable impact on productivity.

Yield of the different components of the ecosystems vary according to this variability:

- a range of four times the minimum dry mater yield per hectare has been reported, including changes in botanical composition of natural communities, with an affect on animal performance under grazing conditions (calving ranging from 38 to 82 % in the whole region and milk production from 4.000 to 12.000 lt. per month in small dairy farms);
- variation in the proportion of introduced species such as white clover, changed from 52 % in spring to 64 % in autumn after a relatively wet summer (rainfall / evaporation = 0.81) and from 66 % in spring to 11 % in autumn after a relatively dry summer (rainfall / evaporation = 0.24); in dry summers white clover populations have been lost when soil water content was near the permanent wilting;
- impacts on summer crops such as corn and soybean have been recorded, with corn yields going from 500 to 10.000 kg ha-1 in successive years and with only two out of five years being suitable to grow soybean.

A sequence of favorable years, coupled with commodity prices, encourage farmers to increase cultivated areas, while under unfavorable conditions the opposite is true. These circumstances increase environmental and economic risks reducing sustainability of the production system in the long-term, increasing soil erosion, weed infestations and lost of valuable local forage species associated to economic losses.

A better characterization of the climatic variability at different scales could help to establish farming systems biologically and economically adapted to the environment.

On the other hand, natural ecosystems have the biodiversity, basically forage species, potentially adapted to this variability, which could be important genetic resources facing possible future global climatic changes.

*AP-7*

## Climate Variability and Agriculture in Switzerland: Assessing the Vulnerability of Crop Production Systems.

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In Switzerland, as in other European countries, the agricultural sector is subject to increasing economic pressure. For agriculture to achieve competitiveness it is not only necessary to maximize the average production but also to minimize its vulnerability with respect to environmental threats. The negative consequences of the exceptionally warm summer of 2003 for the swiss agriculture clearly demonstrated: (i) that a better understanding of the impact of climate variability on the most important production systems is needed; and (ii) that professional associations are very much interested in the development of expert systems for supporting farmers in planning their activities in the short and medium term and for assessing economic risks.

Based on these considerations, the present contribution reports on recent developments in the study of the impact of climate variability on agricultural systems in Switzerland. The work is carried out as part of the programme of the National Center of Competence in Research on Climate (NCCR Climate), which was established in 2001 by the Swiss National Science Foundation. On the one hand, we show how a set of hydrological and crop models is used to define critical climatic conditions for selected crop systems in Switzerland. On the other hand, we outline strategies to optimally combine the results of this analysis with information drawn from seasonal predictions and climate scenarios. This latter step provides the basis for assessing the vulnerability of the agricultural sector in a changing climate at the regional scale, and is also a first move toward the development of an expert system flexible enough to continuously take advantage of the most recent advances in the field of seasonal and climatic predictions.

*AP-8*

## Storm Frequency, Regime Variability and Crop Yield Impacts in a Part of Sudano-Sahelian Nigeria

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In the study of rainstorm producing system and their effect on agriculture in Minna and its environs, relationship between climatic variables have been analyzed and examined. Rainfall variability (especially on the international scale) has been marked over West Africa since 1969-1973. This has had significant impacts on agricultural production in the semi-arid zone of the sub-region. As a result of the over-arching dominance of storm systems as contributors to the seasonal rainfall total, some studies have examined interannual rainfall variability in terms of storm characteristics with some results indicating associated shifts in storm tracks, frequency and intensity. Partly because these were large scale studies in the main, and also because attmepts were not made to associate results with agricultural productivity, this study examines storm variability on one hand, and, agriculturally significant climatic elements on the other, as they impact on crop production within the Sudan-Sahel region in the context of potential vulnerability and adaptation issues of climate change. Data were collected from various

sources. These were agroclimatological elements such as temperate rainfall, relative himidity, line squalls and thunderstorms. These information were obtained from Ministry of Aviation, Nigeria Meteorological Department, Minna. Data on agricultural yield were aslo obtained. These data were subjected to various statistical analyses so as to ensure the reliability of the study. The study reveals that there are no significant relationshop between sunshine and temperature (r=0.55); there is high relationship between temperature (r=0.94). The study furhter revealed that strong relationships exists between relative humidity and thunderstorm (r=0.94). The study also reveals that there are seasonal and annual variations in rainstorm occurrence with two peaks. These peaks have impact on agricultural production. Using some selected crop yields between 1991 to 2000, it was found that there is no significant relationship between some of the selected crops and total annual rainfall amount (=.046)



## A Conceptual Framework for Enhancing the Utility of Rainfall Forecasts for Agriculture in Semi-Arid Environments

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Semi-arid and dry sub-humid areas (especially in the tropics) are characterized by high inter-annual and intra-seasonal rainfall variability. Agriculture, which employs the bulk of the rapidly increasing populations, is largely rain-fed, low-input based and highly resource-dependent. Recent spates of drought have, therefore, easily exacerbated the now-too-familiar spectre of famine and starvation in these areas with glaring examples being the recurring episodes in sub-Saharan Africa since the great Sahel drought of 1969-1973. A great need for accurate and timely hazard forecast products in aid of agriculture thus exists. Several schemes are currently employed by various agencies around the globe in this direction. There does remain, however, a big gap between product provision and user expectations. This contribution examines these issues and suggests a framework within which some of them can be addressed as an action agenda for the climate science community. The paper posits that changes are possible to existing methodologies, which, within the context of current science, can greatly enhance the utility of forecast products for agriculture in marginal areas. Two key research questions have been identified as necessary pointers in the direction to follow in achieving this task. Specific examples of the status quo and of work currently underway, where necessary, are cited from southern Africa – a region currently attracting international attention as a result of recent droughts and the threat of famine.

# Implications of Long-Term Climate Variability and Change for Crop Agriculture in Bangladesh

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The climate of Bangladesh is highly influenced by Asian monsoon circulation. During the five monsoon months, from June to early October, the country receives over 80% of annual rainfall, while the rest of the rainfall is distributed over the remainder of the year. Such a temporal distribution only plays a partial role towards defining the country's hydrology, since over 92% of the water flowing through the rivers of Bangladesh is actually generated outside its borders. Therefore, the regionally available water greatly influences the temporal variability of water resources within the country, which in turn is influenced by Asian monsoon.

The agrarian society of Bangladesh, representing over 75% of its 138 million population, has been adapt to long-term climate variability over millennia and grow a variety of crops to maintain their food security. The crop calendar followed by the farmers allows them to take advantage of free flowing waters during the wet period, while avoiding the adverse impacts of floods and inundations. The farming communities know what to cultivate and the timing of the sowing/transplantation, given any short-term variability in the monsoon-governed water regime. The rapid increase in population during the past four decades and resulting demand on foodgrain have forced poor farmers to cultivate in the most-marginalized floodplains and face consequences, while improved technologies and input-based modern cultivation practices allowed them to enjoy increased food production.

As revealed by the global scientific community, climate change is likely to change the monsoon distribution over South Asia. In addition to the general increase in average temperature, both the long-term spatial and temporal variability of rainfall are likely to change. The early modeling exercises show that the dry season will be drier while the wet season is likely to be wetter under climate change regime. In winter and pre-monsoon, the landmass will face increased evapo-transpiration, while low flow in the rivers during the dry season will cause increased salinity ingress along the coastal rivers - both affecting dry season crop production. Simultaneously, enhanced monsoon activity with spells of intense rainfall is likely to increase flood risks for the most common crops - which is otherwise already vulnerable to floods. It is found that, the CO2 fertilization effect will be negated by the adverse impacts of climate change caused by long-term variability of the monsoon system. This article provides an in-depth analysis of potential threats of long-term climate variability of crop agriculture for Bangladesh.

*AP-11*

# Estimation of Variability of Saline Soils in Armenia

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The Republic of Armenia is situated in the South of Caucasus and occupies 29 800 km2. The prevailing part of the territory has complex mountainous relief. Ararat valley is the main agricultural region of Armenia. The climatic conditions in the valley are favourable for growth of apricot, grapes, peach, vegetables and wheat. But more than 35 percent of cultivated areas have a heightened salinity. The ground waters also contain plenty of salt – 2-3 gram per litre.

Study of Ararat valley agro-meteorological characteristics revealed direct correlation between moisture capacity, evaporation and ground water depth. Taking into account this correlation the evaporation from soil surface depended on depthes of ground water was determined by means of empirical equation.

Analysis of air temperature and precipitation data series on meteorological stations in this territory for the period of 1930-1990 has shown that air temperature has increased by 0,5-1.00C, the amount of precipitation has decreased by 11% and consequently the evaporability has increased by 5%. In these conditions 1000-1500 kg additional salt may be accumulated on 1 hectare of the soil surface.

The thermal regime of air and soil, radiation balance, soil moisture for the extremely warm and arid last decade were also estimated. The results have shown that in this period sharp increase of salinity of soil and intensive process of desertification are observed.

In the work the social economic and ecological consequences of this phenomenon are estimated and integrated measures on their prevention and mitigation are suggested.

*AP-12*

## Climate Change Impact on Rice Crop in India: Uncertainties Due to Scenarios and Crop Models

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Assessment of impact of climate change on crop production could be biased depending upon the uncertainties in climate change scenarios, region of study, crop models used for impact assessment and the level of management. This study reports the results of a study where the impact of various climate change scenarios has been assessed on grain yields of irrigated rice with two popular crop simulation models –Ceres-Rice and ORYZA1N at different levels of management. Both crop simulation models use different approaches for simulating growth and yield. A dataset of 32 experiments consisting of 98 treatments was assembled from an extensive literature search. These experiments were conducted over a period of 1980 to 1993 in diverse Indian locations from 11oN to 33o N. The treatments varied in N management, sowing dates, varieties and seasons. The flowering duration in the dataset varied between 37 to 86 days and grain yields between 2587 kg ha-1 to 8877 kg ha-1. The genetic coefficients of seven varieties used in the analysis were estimated by repeated iterations until a close match between simulated and observed phenology and yield was obtained. Both

models predicted satisfactorily the trends of leaf area and dry matter growth, grain number, days to flowering and grain yields and it was concluded that both models are adequate to simulate the effects of climate change on rice yields in diverse agro-environments of India.

Application of CLIVAR Science to Society The results showed that the direct effect of climate change on rice crops in different agro-climatic regions in India would be always be positive irrespective of the various uncertainties. Rice yields increased between 1.0 and 16.8% in pessimistic scenarios of climatic change depending upon the level of management and model used. These increases between 3.5 and 33.8% in optimistic scenarios. At current as well as improved level of management, southern and western parts of India which currently have relatively lower temperatures compared to northern and eastern regions, are likely to show greater sensitivity in rice yields under climate change. The response to climate change is small at low N management on the uncertainty in climate change scenarios, level of management and crop model used. These conclusions are highly dependent on the specific thresholds of phenology and photosynthesis to change in temperature used in the models. Caution is needed in using the impact assessment results made with the average simulated grain yields and mean changes in climatic parameters.

*AP-13*

## Climatic Variability and Rice-Wheat Productivity across Different Altitude Regimes of the Western Development Regions of Nepal

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Rice-wheat production system is considered the most important production system in Nepal which covers about 0.6 million hectare. The Western Development Region has altitude variation from 60 m to nearly 8000 m above sea level. The human settlement and agriculture operation are prevalent upto 4000 m. Rice is grown upto 2100m whereas wheat goes as high as 3700 m. The rainfall pattern is the most vital to the Nepalese agriculture. Monsoon is the dominant influence. Every year Nepal faces some sort of either drought or flooding situation, which have direct bearing with the rice and wheat production potential. Many times, due to climatic extreme events particularly the rainfall pattern, productivity has been greatly influenced. The rainfall intensity ranges from 200 to 5000 mm during the rainy season. Objective of this study was to understand the climatic variability, and the seasonal rainfall anomaly during crop season, and its influence on rice and wheat yield and compare the yield and phenological gaps between the actual and potential, and understand nutrient uptakes of different altitude regimes of the Western Development Region of Nepal.

Six sites for wheat and five sites for rice having different altitudinal variations were taken as representatives of the Western Development Region. CERES–Rice and CERES-Wheat models embedded in the DSSAT Ver. 3.5 were first calibrated using the Experimental Coordinated Varietal Trials of rice and wheat. The model were validated from those trials which were not used previously in the calibration. In rice, varities Masuli

and Sabitri for the plain and Khumal-4 for the hill were used. Similarly, in wheat variety RR-21 both for the plain and hill was used.

The potential yield of rice varied between 9 to 12.5 t/ha. Whereas, the actual yield was very much site specific. Differences between the actual and potential phenological events in rice were also observed unlike in wheat. The anthesis and maturity of rice varied between 65 to 100 days and 95 to 200 days respectively. Such a location specific gap in the phenological events are accounted for the altitude variation. The potential yield of wheat varied between 4.1 to 7.5 t/ha. The anthesis and maturity of wheat varied significantly ranging from 65 to170 days and 110 to over 200 days, but between actual and potential remained the same.

Relationship between rice productivity and rainfall variability remained poorer whilst it was stronger in wheat. In other word, greater effect of winter rain was pronounced in influencing wheat yield than the summer rain in rice. However the level of association was not consistent across the locations.

The yield gap analysis between the actual and the potential was also compared. The yield potential corresponded with the maturity period more in wheat than in rice but the actual yields remained as the function of other inputs particularly the soil status. Total top-N and grain-N uptakes were also respective soil specific and likely to be low at cooler environment (high altitude) than at warmer environment (low altitude). And also the N uptake trend decreased with the rise in temperature more at warmer environment than at the cooler environment.

*AP-14*

## Response to the Warming Climate in Grain Crops in Heilongjiang Province, Northeast China

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Using meteorological data, grain plantation areas and per-unit-area yield in Heilongjiang Province from 1952 to 2000, response to the warming climate in Grain Crops in Heilongjiang Province is studied. It is found that, (1) Roughly 25% of the increased rice yield per unit area was contributed by the warming during 1985 to 1999. But technology advancement weakened rice dependence on temperature. (2) From 1952 to 2000, there is a significant positive correlation between paddy plantation area and per-unit-area yield. (3) Paddy plantation area extends to north about 0.5-1.0 degree in latitude. This extent is consistent with temperature change. Up to the end of 1990s, paddy has become one of the dominating grain crops instead of wheat in Heilongjiang Province.

*AP-15*

## Effect of Climate Variability on Rice Yield and Methane Emission in Central Thailand

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The natural variability of rainfall, temperature and other conditions becomes the main factor behind variability in agricultural production including emission of some greenhouse gases from agricultural areas. The study on emission of methane in a rice-fallow-rice cropping sequence in central Thailand was carried out at Suphanburi Rice Research Center in central Thailand during 1999-2001. It was found that

1. annual rainfall during the study period turned down from 1342.8 mm in 1999 to 1112.1 mm in 2000 and to 987.6 mm in 2001;
2. average grain rice yields also decreased from 138 kg/ha in 1999 to 110 kg/ha in 2000 and to 75 kg/ha in 2001;
3. average methane fluxes were in the range of -2.6 to 13.2 mgC m-2 h-1. CH4 emission was depended on soil moisture, temperature and microorganism activities which would directly affect from a distribution of rainfall.

This could be said that agriculture is a victim of climate variability. To increase agricultural efficiency and flexibility under current conditions, the monitoring and establishing effective early warning systems for agriculture practices are need to do more technical researches.

*AP-16*

## Linking Seasonal Climate Forecasts and Crop Simulation Modeling in Predicting Corn Yields in the Philippines

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In recent years, there have been major advances in the capability to predict the seasonal variability of climate, especially in regions affected by the El Niño phenomenon. These advances suggest the opportunity to enhance crop productivity at the farm level by improving farm management decisions based on better understanding of climatic changes. Moreover, advances in crop science enable the development of process-based crop simulation models which together with other systems research tools such as geographic information systems (GIS), databases, and remote sensing have provided an opportunity to accelerate the use of interdisciplinary knowledge in predicting crop yield. Linking dynamic seasonal climate forecasts with crop simulation model involves downscaling the seasonal climate information to match with spatial and temporal scales of the process-based crop model which often requires daily weather data as input. Translating the seasonal climate forecasts for crop simulation modeling is done through statistical methods such as determining historical analogs using principal

component analysis and cluster analysis, and generating daily weather data using stochastic disaggregation. A case study using advanced seasonal climate forecasts downscaled to a specific location, and linked with an ecophysiological crop model CERES-Maize validated with locally- grown corn varieties was conducted to predict corn yields in Isabela, Philippines. The study has demonstrated that with access to advanced climate information and process-based crop simulation model, crop forecasts given the climate outlook months ahead is expected to improve the prediction of crop yields thereby increasing farmers' profits and reducing their production risks.

*AP-17*

## Diagnosis and Impacts of Warm Season Storms, Floods and Sediment Inputs into the Middle Colorado River: Applications to Decision Making and Adaptive Management in the Grand Canyon Region

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The planning and decision processes in the Glen Canyon Dam Adaptive Management Program (GCDAMP) strive to balance numerous, often competing, objectives, such as, water supply, hydropower generation, low flow maintenance, maximizing the tributary supplied sediment, endangered species recovery, and flood control. In this context, use of monitored and predictive information on the warm season floods (at point-to-regional scales) has been identified as lead-information that can potentially facilitate improved planning and operations. In this work, we focus on a key concern identified by the GCDAMP, related to the timing and volume of sediment input into the Grand Canyon. Episodic and intraseasonal variations in the southwest hydroclimatology are investigated to understand the magnitude, timing and spatial scales of warm season floods. Furthermore, the coupled variations of the flood-driven sediment input (magnitude and timing) from Paria and Little Colorado Rivers into the Colorado River is also investigated. The physical processes are mapped alongside the planning and decision processes for the releases from the Glen Canyon Dam which are aimed at achieving restoration and maintenance of sandbars and instream ecology.

*AP-18*

## Drought Tendency Investigations Based on Homogeneous Database and Drought Sensitivity in the Hungarian Drought Strategy Plan

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Hungary is located in Central Europe, in the Carpathian basin. Drought is a returning natural phenomenon and disaster also here. During history several severe drought events have been recorded for each century. From the view-point of drought frequency the period since 1983 is the most unusual: severe drought and water scarcity became almost universal.

As far as the future tendencies are concerned an analysis of climatic data on long-term observations demonstrates that there is a significant increasing of the temperature and a decreasing tendency of the precipitation amounts and the soil moisture content. Drought, as a complex phenomena depends on many parameters, which has usually inhomogeneous time series. Therefore, the real long-term climatological research has to be esteblished on homogeneous series. Unfortunately, only few applied homogenization methods have well established mathematical basis (especially for rain series and daily data), although most of the drought indices are sensitive to one or more climatological parameters.

Our poster shows the influence of the data quality on the long-term drought tendency research. We will evidence, that big differences can occur within small distances in the characteristics of drought events, e.g. different regions of Hungary behave on different way.

Another aim of the poster to show the regional drought sensitivity of the country. We took into consideration the orography (slope, direction of slopes), soil characteristics (organic matter content, depth of the soil layer, etc.), land use and climatological parameters. We will present an attempt to describe the temporal variability of drought sensitivity.

All this information is included in the Hungarian Drought Strategy Plan, recently finished and discussed by the wide expert community of the country. The Plan contains the past, present and future processes, events and activity in connection with the drought in Hungary. It will be accepted by the government in 2004. The poster discusses the main structure and tasks of this Plan.

*AP-19*

## A Study on the Relationship of Global Anomalies with Extreme Hydrological Events and Regional Climate Shifts Over India

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Global anomalies always have impact on the hydrologic cycle leading to extreme water conditions and the effect of such extremes are reflected in all facets of life in India, as the rural employment and national economy are largely related to agriculture, the largest consumer of water. Varied nature of geography results in large spatial variation of rainfall and this creates a number of types of climate in India, ranging from arid to per humid. Monsoon, the principal source of rainfall over the country undergoes wide inter annual variability, changing the moisture regime and shifting the regional climate temporarily towards an either drier or wetter category.

In this paper, extreme water balance conditions and climate shifts in different regions of India during the last century have been estimated incorporating the approaches developed by Ayibotele(1974) and Thornthwaite (1948) and modified to suit the conditions in India. Interrelationship between extremes in monsoons and water balance conditions, and shifts in climate categories and anomalies in global temperature and SOI are studied. Changes in hydrothermal coefficients have also been studied to check the response of water resources to temperature and rainfall anomalies. Proneness to floods and droughts in different meteorological subdivisions to floods and droughts have been studied, using the criteria adopted by the India Meteorological Department.

Results show that large variations in water balance conditions occurred during the study period. Climate shifted to both wetter and drier directions considerably during the extremes. Positive rainfall departures have a correspondence with the high phases of the SOI. But, global temperature anomaly alone seems to have no direct link with the water balance or climate shifts. Hydro Thermal Coefficients show that India in general remained wetter during the last century. No significant relationship with the Hydro Thermal Coefficient and the global anomalies were found. All meteorological subdivisions exhibited proneness to floods (10-30%) and droughts (10-40%) and the severity of these extremes do not vary much for different subdivisions No subdivision is seriously vulnerable (chronic) to floods or droughts.

*AP-20*

## Water Resources in India and Impact of Climate Change

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Providing sufficient water for growing demands and increasing climate variability is a major challenge for water managers worldwide in the coming decades. There is now clear evidence for an observed change in India's surface temperature, rainfall, evaporation and extreme events since the start of 20th century. In recent times, several studies around the globe shows that climatic change is likely to impact significantly upon fresh water resources availability. In India, the demand for water has already increased tremendously over the years due to an increasing population, expanding agriculture, rapid industrialization, urbanization and economic development. Simultaneously, unplanned development of surface and groundwater resources, haphazard disposal of municipal and industrial wastes, excessive application of pesticides and fertilizers have led to the problem of water quality deterioration/pollution presenting new challenges on water management and conservation front. Today, in most agro-climatic regions and river basins of India, the hydrological cycle is being modified by human activities such as changes in cropping pattern, land use pattern, over-exploitation of water reservoirs and groundwater, irrigation and drainage. In view of the above, sustainable management of water and the supporting natural environment have gained considerable importance in recent years. In the context of future national requirements, an assessment of the availability of water resource and expected impact of climate change and variability is critical for planning regional and national long-term strategies for its sustainable development. This paper examines the potential for sustainable development of surface and groundwater resources within the constraints imposed by the possible climate

change and hydrologic regimes and suggests some adoptive measures and future research needs in India.

*AP-21*

## Water Resource and its Variability in Asia in the 21st Century

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Japanese six institutes (MRI, NIES, NIAES, CSIS/UT, IIS/UT, CRIEPI) are participating in a project, Water Resource and Its Variability in Asia in the 21st Century (FY2001-FY2003), that consists of (1) Spatial and temporal interpolation of land-use and land surface environment, (2) Projection of global and Asian water circulation, and (3) Future perspective of variability of water resources in Asia based on climate projection. By making most of the existing research framework for global water resource prediction, and also by considering seasonal changes in agricultural water demand and future changes in crops and/or land use due to climate variability, we assess the change of water supply/demand situation in Asia in the 21st century, paying attention to considerable interannual changes.

In the conference poster, we show an overall result of this project. In the first part, estimation of future land use has been done based on available future scenarios on population growth, urban expansion, industrial structure, agricultural productivity and possible changes in natural vegetation. Two global climate models (MRI and CCSR-NIES) are used under the SRES-A2 scenario, and three regional climate models (MRI, NIES and CRIEPI) are integrated for mid-21st century using boundary conditions obtained by two global climate models. Statistical downscaling method is also used for Japan and China region. Finally, estimation of total future water demand is made based on estimation of population change, water demand due to agricultural use and better living standard and change in irrigation. This is contrasted with calculated future water resources, and assessment of water supply/demand balance is conducted.

*AP-22*

## The Effects of Climate Variability on Atlantic Cod

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Atlantic cod (Gadus morhua) inhabit the continental shelves of the northern North Atlantic and have traditionally supported one of the most important commercial fisheries in the Atlantic Ocean. Heavy fishing pressure, especially during the second half of the last century, has lead to declines in cod abundance throughout much of their distributional range. However, several studies including those carried out by the ICES/GLOBEC Cod and Climate Change programme indicate significant effects of climate variability on the distribution, growth, and recruitment of cod. For example, cod distribution extended northward during the dramatic warming of the 1920s in the

northern North Atlantic. Along the west coast of Greenland cod originating from Iceland began to appear in significant numbers. Cod fishing soon became the dominant industry in West Greenland and remained so until the fishery collapsed in the 1970s, which coincided with a cooling of the West Greenland waters. Temperature can explain the differences in the size-at-age of cod between stocks throughout the North Atlantic and temperature variability accounts for some of the interannual variations in growth within a stock (with higher temperatures promoting increased growth).

Temperature also affects cod recruitment, which is the number of young cod that survive long enough to enter into the fishery. The effect is domed shaped such that rising temperatures lead to higher recruitment for cod stocks inhabiting cold waters but lower recruitment for cod stocks in relatively warm waters. Relationships between the NAO and both cod growth and recruitment are also presented. We contend that climate changes have contributed to the recently observed decline in cod stocks and effective management of cod stocks needs to consider climate variability.

*AP-23*

## North Pacific Climate Regime Signals in the Atmosphere, Ocean, and Fisheries

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Climate regime shifts are rapid transitions from one climate state, or regime, to another. These changes are on the scope and magnitude of El Niño impacts in the extratropics, but remain for decades rather than seasons. Abrupt shifts in North Pacific climate, ocean conditions, and ecosystem structure have been observed around 1924, 1942, 1976, 1989, and 1998. Although many physical and biological time series display change points on or around these years, the exact timing of the changes and the mechanisms by which they occur are poorly understood. We summarize the morphology and evolution of these shifts and the intervening climate states, using historical data sets, data assimilation models, and innovative application of mathematical methods. In particular, state-space models are used to identify long-term trends, significant change points, and the non-stationarity of the seasonal cycle in historical ocean/atmosphere observations from the Northeast Pacific. We characterize spatial (regional and ocean depth-dependent) differences in the timing and amplitude of the regime shifts, in the oceanic response to El Niño events, and in the seasonality of wind forcing and upper-ocean thermal structure. Since a number of fishery time series also suggest population shifts that correspond with, but may precede or lag, the proposed physical-based regime shifts, we suggest that the paradigm of a sudden transformation in the physical and biological state of the North Pacific, as implied by surface-derived indices such as the Pacific Decadal Oscillation, may need to be re-evaluated. In addition, the North Pacific may experience more than two alternating regime states. Effective ecosystem-based fisheries management strategies depend on the ability to quickly recognize, if not

predict, regime shifts. Thus it is imperative to understand the morphodynamics of climate regimes and the transitions between regimes and to develop ecologically-relevant, mechanistic-based indicators of climate state that can be applied to resource management and policy making.

*AP-24*

## Modelling the Effects of Climate Variability on the Pelagic Ecosystem and Tuna Populations

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To explore the underlying mechanisms by which the environmental variability affects the pelagic ecosystem and tuna populations, a spatial environmental population dynamic model (SEPODYM) has been developed. The model is a multi-species multi-fisheries 2D coupled physical-biological interaction model at the scale of ocean basin, combining a forage (prey) production model with an age structured population model of targeted (tuna predator) species. The model contains environmental and spatial components used to constrain the movement and the recruitment of tuna. Input data set for the model are sea surface temperature, oceanic currents, dissolved oxygen concentration and primary production predicted from coupled physical-biogechemical models. Applications to two tuna species, skipjack (Katsuwonus pelamis) and albacore (Thunnus alalunga) in the Pacific Ocean are presented. Simulations reproduce both interannual and decadal fluctuations predicted independently from a statistical population model using large fishing data sets. The interannual signal presents a correlation with the Pacific Decadal Oscillation, leading to two different regimes characterized by higher intensity and frequency of either El Niño or La Niña events. Interestingly, the impact of the climate signals appear to be opposite according to the species, e.g., an El Niño event would have a positive influence on the recruitment of skipjack while the effect would be negative on the albacore.

*AP-25*

## Japanese Sardine and Ocean/Climate Variations in the North Pacific

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We overview analyses on the relationship between Japanese sardine and oceanic environment in the Northwastern Pacific. Yasuda et al.(1999FO) showed that the sardine catch fluctuation during 17th-20th centurywere related to the air temperature in the west coast of North America and SST east of Japan. Large catch periods correspond to warm (low) temperature in the NAWC (EJ). Noto and Yasuda (1999CJFAS) shows thatthe mortality coefficient from post-larvae to Age-1 is closely relatedto winter-spring SST in the Kuroshio Extension and its southernrecirculation area

(KESA) on a year-to-year basis, and that the sardine population decline since 1989 is related to warm temperature in the KESA. Using this relationship, Noto and Yasuda (2003FO) constructed a empirical biomass model considering sardinelife-history, the biomass-egg production and density effects, reproducing sardine fluctuation in the 20th century. We will discussthe variations in the mixed layer temperature and depth in the KESAand North Pacific, relating to the food abundance and sardine variation.

*AP-26*

## Comparison of Climate Forcing of Bering and Barents Sea Ecosystem

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Recent studies have suggested that climate variations may affect the mechanisms that control marine populations. This has implications for fishery management, since a given rate of harvest may have quite different impacts on fish stocks in different climate patterns. The focus of this study is a comparison of two subarctic seas, the Bering Sea and the Barents Sea. They both feature seasonal ice cover that affects their regional ecosystems, and appear to be undergoing substantial changes, likely due to climate forcing. The two high latitude seas experienced a regime shift followed the winter of 1976/77, notably in association with a switch in the sign of the PDO. The Barents Sea also appears to respond to fluctuations in the NAO. Previous studies have shown that the fish stocks of several species and marine mammals in the Bering Sea displayed distinct changes with the PDO regime shift. Similarly, cod stocks in the Barents Sea are closely related to fluctuations in the NAO. Here we compare how the elements of the atmospheric forcing important to the marine ecosystem have changed in these two high latitude seas over the last few decades, and the extent to which these changes can be linked to variations in marine populations on seasonal to decadal time scales.

*AP-27*

## Influence of Monsoon on Fish Catch of Tamil Nadu Coast, India

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The seasons of tropical Indian coast are monsoon based. The east coast of India has four different seasons viz. monsoon, post-monsoon, summer and premonsoon seasons which are caused by a strong north-east monsoon and relativity weak south-west monsoon. The primary production, secondary production and fish catch in the east coast of India depend exclusively on the influence of north-east monsoon and the extent of freshwater discharge which causes drop in salinity and marked increment in nitrogenous and phosphatic nutrients. The present investigation was carried out in Tamil Nadu Coast in the south-east coast of India for a period of 9 years (1985 – 1993) to get an over all impact of monsoon on the fish catch with special reference to the types and quantity of fish landed. Ribbon fishes such as species of *Trichiurus savala* and *Lepturacanthus salva* and species of penaeid shrimps such as *Penaeus monodon*, *P. indicus* and *P. semisulcatus* were uniformly abundant only in the monsoon season. Similarly carangids (*Selaroides leptolepis, Caranx ignoblis, Carangoides malabaricus* and *Atule mate*) tunnies (*Thunnus alalunga, Katsuwonus pelamis*); cephalopods (*Sepia phoronis, S. inermis* and *Loligo duvaucelli*) and *Stolephorus* spp. showed very high landing during monsoon season. On the other hand perches (*Nemipterus spp., Lutjianus spp*. And *Serranus spp*.); cat fishes (*Arius spp*.), silver bellies (*Leognathus* spp. and *Gazza minuta*), mackerel (*Rastrelliger kanakurta*), elasmobranches (rays and skates) and sciaenids were caught mainly during the post-monsoon season. This investigation suggests that the quality of fish to be caught during monsoon and post-monsoon seasons could be predicted and such information could help the fishermen of Tamil Nadu to select the right fishing grounds for selective fish catch. Interestingly, significant variation were recorded die to the prevailing currents during monsoon and post-monsoon periods in this coast. During monsoon season, the coastal waters of Tamil Nadu showed unique water quality characteristics like low salinity (33.95 – 34.55 ppt), moderate dissolved oxygen concentration (3.5 to 4.1 ml/l) and high level of ammonia (2.9 to 11.62 microgram atom N/l), nitrate (12.42 to 39.51 microgram atom N/l) and phosphate (2.5 to 9.25 microgram atom P/l). During post-monsoon season the salinity was in the range of 34.95 – 35.35 ppt and dissolved oxygen (4.2 to 5.1 ml/l) increased with marked reduction in the concentration of ammonia (1.1 to 5.6 microgram atom N/l), nitrate (10.12 to 16.52 microgram atom N/l) and phosphate (1.10 to 4.25 microgram atom P/l). The relationship between the hydrographical parameters, phyto and zooplankton production and fish catch during monsoon and post-monsoon seasons in this coast has also been determined and discussed.

*AP-28*

## Fishing – Impact of Introduction of Modern Practices in the Near Shore and Influence of Strength of Monsoon: A Case Study of Coast Line of Karnataka, India

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India has relatively long coastline of about 6100 km on its east and west coast. On account of up swelling currents, the fisheries have been more developed on the western coast in comparison with the eastern coast. On western coast, two states, particularly Karnataka and kerela, have a historical tradition of fishing. Over the years, the local community has developed several practices which would ensure the sustainable fishing in the region. For instance, the allotment of fishing rights to particular group of people in particular period, avoiding fishing totally during the breeding season etc.

However, with introduction of energy intensive fishing, the traditional fishing practices are under threat of total disintegration. Coupled with this threat, the anticipated changes on account of the climate change, as most valuable fisheries for the traditional community is near the coast. With any change in the water – quality or quantity will result in drastic changes in the nature of fish harvested.

This paper tries to examine, in view of few projections of climate change that were made for this region, with emphasis on the coast line of Karnataka state. Further, this paper attempts to develop on the basis of the doctrinal studies on the strength of monsoon and fish harvested for the last ten years in this region and attempts to develop projections for shorter duration.

*AP-29*

## An ENSO Early Warning System for Mexico

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The costs of El Niño impacts in Mexico have been substantial. Only during the El Niño event in 1997 and 1998, precipitation deficit resulted in losses in agriculture, forest fires, limited water availability in dams and changes in fisheries. The total economic losses associated with El Niño event were estimated in almost 2 billion dollars. Given our advances in predicting El Niño and its climatological signals at a regional level, an initiative to develop an ENSO early warning system (EWS) for Latin America and the Caribbean was put forward by the World Meteorological Organization with the support of the Inter American Development Bank. The conceptual EWS framework consists of five components: 1) a global climate information system component in which ENSO related global climate predictions are made and disseminated to the region, 2) a technical component that considers the further processing of global information into regional and local climate information to support preparedness decision making and planning, 3) an institutional component addresses the ability of national and local governments to prepare and respond to El Niño events, 4) a civil society component which considers the role of individual households, community groups, non-governmental organizations, and the private sector in response and mitigation activities, and 5) a communication component that focuses on the information dissemination and exchange critical to the success of an ENSO Early Warning System. In Mexico and Central America, this initiative has been well received and is being considered as part of their national planning process. A description of the feasibility study and the implementation process will be given with emphasis on some institutional and technical aspects that requires to be improved in order for this initiative to be implemented.

Climate variability over Mexico, Central America and the Caribbean is modulated to a large extent by warm pools, one off the Mexican Pacific coast and one over the Intra Americas Seas (IAS). Summer precipitation over this region exhibits a relative minimum during the middle of summer (July and August)known as the Mid Summer Drought (MSD). Until recently, only a few field experiments had taken place in the region during summer. The Climate Experiment in the Americas Warm Pools aims at testing a hypothesis on the origin of the MSD and the role of the low ? level jet in the Caribbean as a dynamical element that control summer rains in the Mesoamerican region. The hypothesis on the MSD establishes that prior to the onset of summer rains (May), SSTs are larger than 28°C. The cooling effect of rain, enhanced easterlies and diminished solar radiation leads to SST below 28°C during late July and August. Weakened convective activity over the Pacific coast of Mesoamerica allows more solar radiation reaching the surface, warmer SSTs and conditions favorable for more convective activity in September. Oceanographic and Meteorological measurements on board of the oceanographic vessels of the National University of Mexico, El Puma and Justo Sierra, plus an enhanced regional meteorological network during three campaigns (late May, July-August, early September) allowed to test the hypothesis on the regional dynamics of the atmosphere and ocean. Results from the experiments indicate that air sea interaction in the northeastern Pacific warm pool leas to a bimodal temporal evolution in SST, partly resulting in the MSD. The Caribbean Sea and the north eastern Pacific regions interact through direct circulations associated with variation in their tropical convection. Intense convective activity in the western Caribbean, along the coast of Nicaragua and Costa Rica, appears to result in subsidence in the eastern Pacific during July and August, that in conjunction with variations of the SSTs leads to the MSD. Although the north eastern Pacific warm pool and the IAS exhibit different dynamics, the presence of an intense Low Level Jet over the Caribbean, reaching maximum intensity during the MSD and flowing through the topographic gaps of Mesoamerica also acts as a link between these two regions. Consequently, improved predictability of summer rains in this region, and of the intensity of the MSD, will require an adequate description of convective activity not only over the eastern Pacific, but also over the Caribbean Sea.

*AP-30*

## The Role of the Oceans in Climate Change: Focus on the Indian Ocean

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The ocean functions like a thermostat-regulating climate through heat waves. In this paper, the author examines how various factors drive ocean circulation leading to large-scale differences in pressure. The author analyzes the contribution of the Indian Ocean to the North Atlantic Conveyor Belt; the link between the Indian and the Atlantic Ocean; how ‘retroflection’ takes place and its implications for the people. The author proposes that the impact of the ‘Agulhas Leak’ may stabilize the climate over the Atlantic Ocean and fluctuate causing abrupt changes in climate.

This study is conceived for two main objectives: 1. To understand the role of the oceans in global climate change and 2. To analyze the physical processes that govern

the behavior of CO_ in the oceans and how CO_ interacts with the atmosphere. The paper examines how long-term sampling of zooplankton populations maintained at specific time series, yields useful data sets enable us to understand several processes: First: They help us understand the temporal changes and predict future fluctuations in ocean behaviour and also help us to link atmospheric ocean processes together.

Secondly, these data sets yield new insights into the role of the ocean in global cycling of carbon and they offer new ideas for debate about the solubility and biological pump mechanisms. Thirdly, the data show that the ocean is becoming warmer and over the next century, the ocean may become more stratified and the thermohaline circulation may become weaker. The author argues that if the climate warms up it will weaken the physical pump and alter the biological pump as well. It may also strengthen the atmospheric winds and alter their flow patterns and further affect primary production in the ocean ecosystems. If this happens, the paper explains, it may affect the upwelling of micronutrients that are essential for the growth of phytoplankton--the engine that drives the biological pump.

The author proposes, based on these data set trends, that a warming climate may lead to reduced sardine landings, deteriorating mangrove health, irregular rainfall patterns and jeopardizes the food and water supplies for humans and wildlife populations in Africa. The author concludes that if the climate changes it may lead to warming of the oceans and in particular affect the strength of the biological pump and affect the capacity of the ocean to take up CO_ thus altering the entire ocean circulation patterns.

*AP-31*

## The Web-Based KNMI/ERA-40 Global Wave Climatology Atlas

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The European Centre for Medium Range Weather Forecasts (ECMWF) has recently finished ERA-40, an atmospheric reanalysis covering the period from September 1957 to August 2002. The ERA-40 reanalysis was produced using a cheaper version of ECMWF's operational Integrated Forecasting System (IFS). A distinguishing feature of IFS is its coupling to a wave model. Using the output of the wave model the authors have created the KNMI/ERA-40 global wave climatology atlas available at http://www.knmi.nl/waveatlas. The objective of the web-based global wave climatology atlas is two-fold. First, it provides a global description of the ocean wave climate by means of simple statistical measures. Second, it describes the decadal variability of the wave climate.

Climate variability is described in terms of the main EOFs and their relation to conventional climate indices in different ocean basins. The poster focuses on how decadal variability affects estimates of the 100-year return value of significant wave height, a quantity used in the design of ships and marine structures. This is illustrated by

the incompatibility of 100-year return value estimates based on data from 3 different decades (1958-67, 1972-81 and 1986-95).
More specifically, in parts of the North Atlantic and North Pacific storm track regions 100-year return value estimates from the 3 datasets are statistically different. Structures and ships that would have been designed based on estimates from data prior to the 80's could be damaged under the conditions estimated using data from the latest decade. In the North Pacific, the 100-year return value estimates increase from decade to decade, in line with reported increases in wind speed. More interestingly, in the North Atlantic the spatial location of the highest 100-year return value estimates depend on the NAO index: in a decade characterized by a predominantly positive NAO index, the highest estimates are located north of those from a decade characterized by a predominantly negative NAO index; accordingly, in a decade of both positive and negative NAO indexes there are two lobes of high 100-year return value estimates.

*AP-32*

## Estimating Thousand-Year Extremes from ECMWF Seasonal Forecast Data

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We show that the archive of ECMWF seasonal forecast ensembles is a valuable source for investigating extremes in current climate. Extreme value distributions from the archive can be estimated with a higher accuracy than directly from observations. The methodology can also be applied to situations that depend on extremes in more than one meteorological variable.

Weather and weather related extremes have large impacts on society, but it is difficult to estimate their statistical properties from the relatively short observational records. In order to overcome this problem, we use seasonal forecast data of the European Centre for Medium-Range Weather Forecasts (ECMWF). Seasonal forecasts ensembles consist of 6-month forecast runs that have independent weather realizations after at most two weeks. The data amount to 1230 year at a resolution of T95L40, and contain a good simulation of the present climate at synoptic scales.

We investigate the extreme value distributions of storm surges and river discharge in the Netherlands that are caused by synoptic-scale weather systems. The distributions from the simulations show good agreement with the observations. The long record length of the ECMWF data reduces the uncertainty in the 1000-year and 10000-year return values considerably with respect to estimates obtained from observations. Also, we study the distribution of the following impacts: high surge levels prevent sluicing of excess water into the sea, and closure of the main storm surge barrier in the Rhine river. The latter application is an example of how the ECMWF data set allows studying events that depend on more than one variable, in this case on surge level and river water discharge.

# PROSUR: A Regional PROgram for the Study of Regional Climate Variability and Changes, Their Prediction and Impact in the MERCOSUR Area

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A multinational and interdisciplinary team has established to promote research into the causes of climate variability and changes in the MERCOSUR region of South America. Scientists from Argentina, Brazil, Paraguay, Uruguay and the United States belonging to research and university institutions are participating in the regional network. The main objectives of the Program are focused to support an environment conducive to collaborative research in climate variability and climate changes. This is accomplished by sponsoring scientific visits to each of the participating institutions holding regular meetings where results are disseminated and discussed, and by encouraging the free exchange of data. Also, is proposed by the Program, the promotion of the capacity building in the participating institutions, mainly in those with scarce development in the scientific interest area of the Project. The exchange of scientists and students is strongly promoted, searching for alternative funds for post degree fellowships. The interchanged data have already been useful in several diagnostic studies undertaken by scientists within PROSUR.

Within the objectives above mentioned, the researchers are carrying on studies on the floods in La Plata Basin, on the physical and dynamical processes of extreme events in the MERCOSUR area, in assessing the degree of understanding of these

extreme events by stakeholders and population, coordinating and participating in regional studies of the Low Level Jet in South America, support modeling studies to investigate regional climate variability and carry on AGCM experiments to analyze the influence of the Pacific and Atlantic SSTs on the precipitation over the La Plata river basin.

Some of the results produced by the scientists participating in the Program will be offered at the Conference.

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