PROMISE

Predictability and variability of monsoons, and the agricultural and hydrological impacts of climate change

2nd Annual Report

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Project Home Page: http://ugamp.nerc.ac.uk/promise/

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SECTION 1

1.1 Objectives of the reporting period

- To investigate the natural variability of monsoonal systems on seasonal, interannual and interdecal timescales.
- To provide a statistical toolset to describe monsoon variability.
- To investigate the impact of regional SST anomalies on African and Asian monsoon climates.
- To investigate the role of land surface/vegetation processes and feedbacks in determining the variability and predictability of monsoon climates.
- To assess the value of high resolution regional model simulations for describing the future impacts of anthropogenic climate change on the Indian and African monsoons.
- To complete the development of land use scenarios and schemes to represent the effects of irrigation; to commence assessment of the impact of land use changes on monsoon climates.
- To complete development and testing of the detailed hydrological model for West Africa; to commence assessment of the impact of climate change on the wter balance in the major river catchments.
- To develop crop models to translate climate change scenarios into agronomic impact scenarios for the dry zones of West Africa; to develop further a general methodology to link weather and crop yields on a spatial scale typical of that used by seasonal and climate prediction models.
- To update the PROMISE database of observed and simulated data on meteorology, hydrology and agriculture for monsoon climates.
- To hold a workshop with scientists from monsoon-affected countries to promote the aims of PROMISE and to develop collaboration on the modeling and agricultural/hydrological impacts.
- To undertake a series of networking trips to establish active links with scientists in agricultural centres in monsoon countries.

1.2 Scientific/Technical progress

Good progress has been made on all the work packages. The objectives for Year 2, as summarized in Section 1.1, have been met. Figure 1 shows the updated GANTT chart as presented in the original contract. The planned and used manpower and finances are summarized in Table 1. A list of staff working on PROMISE is provided in Table 2.

Table 1: Planned and used manpower (man months) and finances (Euros)

Partner	*Planned Manpower*	*Used Manpower*	*Planned Spend*	*Actual Spend*
UREADMY	27.0	27.0	139 703	119 878
CIRAD	4.0		23 812	
MF	14.7	16.5	58 600	56 043
DMI	7.0	10.3	41 160	84 360
ICTP	8.0	4.0	-	-

Partner	*Planned Manpower*	*Used Manpower*	*Planned Spend*	*Actual Spend*
NERC	11.9		59 923	
LMD	14.6	35.5	52 675	89 611
MPG.IMET	12.0	12.0	78 659	77 951
Met Office	14.0	11.4	61 487	54 670
UREADAG	2.0		20 818	
ECMWF	1.0	-	-	-
UB	12.0	11.0	38 849	19 124

1.2.1 WP1: Natural variability and predictability of current monsoon climates on seasonal, interannual and interdecadal timescales.

General circulation models (GCMs) have systematic errors which may compromise their use for providing skillful seasonal forecasts and reliable estimates of climate change. A particular focus of PROMISE research has therefore been on reducing model error by improving the representation of physical processes and the accuracy of the numerical schemes.

A representation of the seasonal cycle in vegetation has been developed from observational data; this can influence the lower atmosphere through changes in leaf area index (LAI), roughness length and surface albedo. Initial results suggest that surface temperatures and water budgets are most significantly impacted in semi-arid and continental regions. The main impact on monsoon environments is seen primarily outside the main rainy season. Better representations of vegetation phenology and surface albedo have also been shown to improve simulations of the multidecadal variability in Sahelian rainfall. The dynamic response of the vegetation to precipitation changes acts as an amplifier for low frequency behaviour associated with SST forcing.

Understanding the factors that gave rise to the multidecadal signal in Sahelian rainfall has been a particular focus of research. As well as the role of vegetation noted above, the influence of changes in atmospheric aerosol loading associated with sulphur emissions from North America and Europe and their impact on the inter-hemispheric Atlantic SST gradient has been highlighted.

The response of the climate system to SST forcing lies at the heart of seasonal prediction, and several studies have reported on the non-linearity in this response. For example, further analysis of the relationship between ENSO, the Indian Ocean Zonal Mode (IOZM) and East African Rainfall has shown that only IOZM events which reverse the east-west SST gradient in the Indian Ocean for several months lead to heavy rainfall. It has also been shown that when ENSO forcing is sufficiently strong, it can predispose the Indian Ocean to an IOZM event. Non-linearity has also been noted in the response of Sahelian rainfall to Atlantic SST anomalies.

A major deliverable for Year 2 is the provision of a set of statistical tools to investigate the variability and predictability of monsoon climates. A novel method for extracting variations in the seasonality of the monsoon has been developed using an unconstrained method for signal decomposition. A toolset for describing statistically the intraseasonal variability has been assembled and placed on the PROMISE website. This consists of a portable package of scripts and programs as well as a facility to provide graphical output of the results.

1.2.2 WP2: Assessment of anthropogenic climate change scenarios for monsoon climates.

The Indian and African monsoons contain considerable regional variations associated with the seasonality of the monsoon circulation as well as its sub-seasonal variability. For these reasons, PROMISE research during Year 2 has focused specifically on high-resolution global and regional simulations to provide a more complete picture of potential changes in monsoon climates under the influence of enhanced greenhouse gases. For Africa, in particular, where the latitudinal gradients in precipitation are very pronounced, the use of higher resolution has been shown to improve the simulations.

In general, the scenarios indicate an increase in monsoon precipitation over the Sahel and India throughout the next century. However, there can be significant decadal variability within this trend, with several decades of reduced or unchanged precipitation. A detailed analysis of the temporal behaviour of the monsoon rains has also shown that the trend towards stronger monsoons is also accompanied by more extreme daily and monthly rainfall amounts.

Changes in land-use will be a key aspect of the human response to increasing population numbers as well as to a changing climate. The sensitivity of the climate to vegetation and soil water has already been demonstrated in WP1. One of the responses to climate change with regard to food security is to increase the level of irrigation. This will have a significant impact on soil water, vegetation and river run-off. As part of an important step towards an integrated approach to climate change prediction, a sophisticated land surface model, which predicts levels of irrigation and its consequent effects, has been developed.

Scenarios of current and future changes in land use for Africa have been completed which include a reduction in tropical forest due to the expansion of agricultural land required to feed a growing population. Preliminary results suggest that the effect of this deforestation is smaller than previously estimated primarily because evapo-transpiration is controlled more by soil moisture availability than by direct changes in vegetation cover.

1.2.3 WP3:Impact of natural and anthropogenic climate change on ground hydrology and agricultural systems.

Good progress has been made on developing a grid-based approach to modelling water resources in West Africa. The methodology will enable researchers to assess water availability in relation to changing demand at a scale consistent with regional general circulation models. The methodology being used is being developed as part of the GWAVA modelling system. Over the first two years of PROMISE, GWAVA has been developed to enable the potential impacts of land use change, in combination with climate change, to be assessed for West Africa. The baseline situation has been satisfactorily validated using observed data and now provides a sound basis for simulations of future monsoon climate.

In the first year of PROMISE, development of a sophisticated river routing scheme for India was started. Progress has continued during the second year and the scheme is now fully integrated into ORCHIDEE (a land-surface parameterization that can be coupled to a GCM). Comparisons with observations of river flow for the largest catchment basins in India and Africa are very encouraging and the scheme will now be incorporated into GCMs for future climate model runs.

The agricultural impacts of climate change can be assessed by coupling crop model to the climate prediction model provided the gap between the spatial and temporal scales of the two models can be bridged. Following work in Year 1 which identified an optimum spatial scale for describing the observed relationship between crop yield and climate variability, a new process-based crop model has been developed which has the appropriate complexity to capture the spatial variability of the yield whilst still being simple enough for the necessary inputs (e.g. soil type, crop genotype) to be known to a reasonable level of accuracy. The

model is currently being tested before being used with the seasonal prediction ensembles from the EU DEMETER project.

The impact of natural vegetation changes and anthropogenic deforestation in South America has been assessed using a coupled climate-vegetation simulation. A scenario of a transition from an undisturbed Amazon rainforest to partial deforestation (as predicted in Brazil for 2020) shows a small decreasing trend in Amazonian rainfall.

1.2.4 WP4, WP5 and WP6: Promotion, management and coordination of PROMISE

Various datasets have been added to the PROMISE data archive, which now contains seasonal hindcast ensembles, climate simulations for current and future scenarios from several models. The datasets are accompanied by detailed documentation.

Substantial progress has been made on the establishment of an international network of scientists through several visits to CGIAR centres. So far the following institutions have been visited: International crop Research Institute for the Semi-Arid Tropics (ICRISAT, India), Food and Agriculture Organisation (FAO, Rome), Centro Internactional de Agricultura Tropical (CIAT, Colombia), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, Mexico) and International Rice Research Institute (IRRI, the Philipines). These visits have provided valuable feedback on the way that agricultural end-users of monsoon research make use of seasonal forecasts. There has also been considerable interest in building long-term collaborations.

Development of the PROMISE website has continued. The website provides the first view of PROMISE for many scientists and end users of monsoon research. It now contains detailed information about the project's progress and the PROMISE partners. A new 8-page brochure has been produced and will shortly be distributed widely within both the end-user and research communities.

The PROMISE workshop to develop links with scientists in monsoon affected countries was held as part of the ICTP Summer School on "Land-atmosphere interactions in climate models" which was followed by a conference on "Climate variability and land-surface processes: Physical Interactions and regional impacts". These activities were attended by over 130 scientists, including about 80 from developing countries some of whom were sponsored by ICTP through the PROMISE contribution to the meeting. During the workshop, the overall structure and goals of the PROMISE were presented, and a demonstration was held on the use of the data archive.

The preparations for the final PROMISE meeting are well underway. The meeting will be hosted by ICTP. Enough sponsorship has so far been raised to fund approximately 50 delegates from developing countries.

1.3 Milestones and Deliverables obtained

The following milestones were obtained:

- Provision of advanced statistical tools for assessing monsoon variability
- Assessment of the impact of seasonally varying vegetation phenology on monsoon climates and variability.
- Further analysis of the impacts of regional SST anomalies on the African and Asian monsoons.
- Assessment of the role of soil moisture in the seasonal to interannual variability and predictability of the African monsoon.

- Comprehensive studies of the detailed greenhouse-gas driven changes in the Indian and African monsoon systems using high-resolution regional model and time-slice integrations.
- Numerical experimentation for African/Amazonian changes in forestation.
- Adaptation and testing of a detailed hydrological model for West Africa.
- Determination of the water balance in large catchments of tropical regions.
- Numerical experimentation to investigate the impacts of land use changes.
- Development of a large-scale, process-based crop model, suitable for coupling to seasonal and climate prediction models.
- Update of the PROMISE data archive with selected results from global and regional climate change scenarios.
- Complete networking trips to international agricultural research centres and summarise requirements of the crop impacts community for delivery to the project collaborators.
- Organization of the workshop with non-EU scientists.
- Further development of website. Annual meeting.

The following Deliverables were obtained. Note that most deliverables are not due until the end of the project.

D1003: Development of advanced statistical techniques for extracting signals of monsoon variability

D3001: Provision of a detailed hydrological model for application to West Africa.

D3101: Identification of the important meteorological parameters for crop models; assessment of the potential shortcomings in seasonal prediction and crop models.

D5001: Publication of a brochure outlining the aims of PROMISE and establishment of a mailing list.

D5002: Workshop with EU and non-EU partners

D5003: Establishment of an international network of scientists concerned with the impacts for monsoon climates

1.4 Deviations from the work plan and/or time schedule

- Description of monsoon variability, including decadal timescales, based on ERA-40 has (one of the year 2 milestones for WP1000) has been postponed until next year because of the delays with ERA40. The delays with ERA40 will also affect the work planned on the DEMETER seasonal prediction ensembles planned for Year 3
- The planned analysis of climate anomalies over the Caribbean, (one of the year 2 milestones for WP 1200) will not happen because of staffing changes at the Met Office.

1.5 Coordination of information

The PROMISE website continues to provide a useful tool for administrating and coordinating PROMISE. The news part of the site is used to publicize forthcoming meetings and other information of relevance to partners. Various powerpoint presentations and online versions of the PROMISE brochures are available on the site. Individual pages for each partner contain brief progress reports as well as links to conferences attended by partners and publications by each of the research groups. PROMISE partners have also been involved in the project meetings for EU FP5 DEMETER, ERA-40. The annual PROMISE meeting (incorporated into

the ICTP Conference on Climate variability and land-surface processes: Physical Interactions and Regional Impacts) was held during 11-14 June 2001. The Year 2 annual meeting will be held at LMD, Paris on 13-15 May. Dr. Pant, Director of the Indian Institute for Tropical Meteorology, Pune, will be a guest at that meeting. PROMISE was also presented at the following meetings:

- FAO meeting of the Interdepartmental Committee for Climate Change to discuss potential sponsorship of the final PROMISE conference.
- Wengen conference titled: Environmental change - implications for population migration
- ECMWF/WGNE Workshop on Reanalysis
- CLIVAR Asian-Australian Monsoon Panel Meeting (Prof. Slingo is co-chair of that panel)

PROMISE has also supported the following networking trips during which several presentations on PROMISE research were made:

Date	**Institute visited**	**Main research interests of institute**
Dec 2001	Food and Agriculture Organisation (FAO, Rome)	Irrigation and Agro-ecological Zones projects
Feb 2002	Centro Internacional de Agricultura Tropical (CIAT, Colombia)	Beans and cassava
March 2002	Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, Mexico)	Wheat and maize
March 2002	International Rice Research Institute (IRRI, the Philipines)	Rice

1.5 Difficulties encountered at management and coordination level

Model systematic error and scaling issues still present obstacles to the effective application of seasonal and climate model predictions within crop and water resource models. These difficulties will be a major focus for discussion at the Year 2 annual meeting.