SECTION 2

Contract n°	**EVK2-CT-1999-00022**	Reporting period:	Mar. 2001-Feb. 2002
Title	Predictability and variability of monsoons, and the agricultural and hydrological impacts of climate change: PROMISE		

Objectives:

- To investigate the natural variability of monsoonal systems on seasonal, interannual and interdecal timescales, and to provide a statistical toolset to describe that variability.
- To investigate the impact of regional SST anomalies and 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 use complex land surface schemes and land-use scenarios to investigate the effects of irrigation and land use changes on monsoon climates, and to apply these schemes to studies of the water balance of major river catchments in Africa and India.
- To implement a detailed hydrological model for West Africa for the assessment of the impact of climate and land-use change on water availability at the regional scale.
- 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 promote the active collaboration with scientists in monsoon-affected countries by (a) further developments of the PROMISE website and database, (b) an international workshop, and (c) a series of networking trips to establish active links with scientists in agricultural centres in monsoon countries.

Scientific achievements: The primary driver of climate in monsoon regions is the interaction between the oceans and the surrounding continents. Observational and modelling studies have been used to clarify the way that the sea surface temperature (SST) controls rainfall in North and East Africa. The non-linearity of the climate response to El Nino and Indian Ocean SST has been demonstrated.

Sensitivity studies performed in the first year of PROMISE highlighted the importance of the land surface in controlling monsoon climates and influencing their variability. Considerable progress has been made with incorporating more sophisticated representations of seasonally varying vegetation phenology into the climate models. These have demonstrated that the main impact on monsoon environments is seen primarily outside the rainy season with significant changes in the surface temperature and the soil water budget. Better representation of vegetation phenology and surface albedo has also been shown to improve simulations of the multi-decadal variability in Sahelian rainfall. The dynamic response of the vegetation to changes in precipitation acts as an amplifier for low frequency behaviour associated with SST forcing.

High-resolution global and regional simulations have been used 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.

One response 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. This will be used in the later stages of the project to investigate how irrigation practices may influence future estimates of climate change. In addition, scenarios of current and future changes in land use for Africa have been completed; these 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.

Water availability will be of over-riding importance for seasonally arid, monsoon environments in the future. Good progress has been made on developing a comprehensive model of water resources in West Africa, which will enable researchers to assess water availability in relation to changing demand at a scale consistent with regional general circulation models. On the larger scale, an integrated soil hydrology scheme has been used to study river routing and the water balance of major river basins. 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 a 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.

Socio-economic relevance and policy implications: Understanding the natural variability of monsoon climates is a prerequisite for understanding and quantifying climate change in these sensitive regions and for making seasonal predictions. The land surface is key to providing more accurate climate simulations that will be of significant value for regional climate change forecasting and for impact assessment. Changes in vegetation, particularly those associated with changes in land-use, may act to mitigate or exacerbate climate change.

The assessment of the impact of climate change due to anthropogenic causes on monsoon areas has obviously a direct economic implication for these regions. A good understanding and prediction of monsoon variability is of paramount importance to plan ahead and limit climate induced socio-economic problems. As the demand for water increases, an important issue is the evaluation of changes of the hydrological budget, not only due to climatic change related to CO_2 increase, but also due to human disturbances through reservoir construction and water use by agriculture. The water resource modeling being developed in PROMISE will allow policy makers and others to make better informed resource allocation decisions, and facilitating the assessment of impacts of human activities (such as climate change) on global water distributions.

Food production in seasonally arid areas is inherently risky. PROMISE has initiated an important collaboration between climate and crop modelers. The final goal of the collaboration is to achieve substantial progress towards the development of an integrated system for the interpretation of seasonal forecasts and climate change predictions in terms of their agricultural impacts. An international network of scientists concerned with the impacts of climate variability and change on cropping systems of Africa and India has been established through a series of visits and has provided valuable feedback on the key issues that need to be addressed in PROMISE.

The transfer of technology to developing countries is essential if EU research is to be properly exploited. The provision of the PROMISE data archive, a well-maintained website and the organization of an international workshop and conference, with sponsorship for scientists from developing countries, have all contributed to the achievement of this goal.

Conclusions: As a result of PROMISE, improvements in our understanding of the predictability and variability of monsoon climates are being achieved. Considerable progress has been made in developing the agricultural and water resource models that can take advantage of the information from weather and climate prediction models. Methodologies for establishing constructive links with scientists in monsoon-affected countries have been established.

Keywords: monsoons, climate change, seasonal prediction, crop modelling, water resources