

## Editorial

### Monsoons: prediction, variability and impact

It is estimated that more than 60% of the world's population depends heavily on monsoon rainfall for their subsistence. While a poor monsoon season can trigger food crisis and have a negative impact on a country's economy, an exceptional monsoon can have disastrous consequences on people's lives and property due to floods and landslides triggered by torrential rains. Even small variations in rainfall relative to the average expected monsoon rainfall can have a dramatic effect.

Crop yields and water resources are controlled by the cycles of monsoon circulation and it is of no surprise that analysis of monsoon variability and monsoon prediction on monthly to seasonal time scales are extremely important scientific activities. Accurate forecasts of daily precipitation during the monsoon season are also essential in order to issue effective warnings of severe weather events. This special issue assembles a series of articles on the state of the art scientific understanding of prediction, variability and the impact of monsoons.

The first set of papers (Agnihotri and Mohapatra, Sardar *et al.*, and P. Kumar *et al.*) looks at daily and monthly forecasts of monsoon rainfall, as well as forecasts of upper tropospheric humidity fields. The sensitivity to different convection schemes is assessed comparing monthly rainfall forecasts to satellite derived observations. The understanding of forecast uncertainty linked to different parameterization of convection is crucial for a better representation of physical processes in numerical weather prediction models and thus better predictions.

The use of multi-model ensembles in order to account for forecast uncertainty has become increasingly popular in current scientific practice and this special issue includes four papers on the topic (A. Kumar *et al.*, Goswami *et al.*, Singh *et al.* and Samala *et al.*). The performance of a simple ensemble mean and a weighted average, whereby weights are calculated using

neural network concepts, are discussed. Moreover, the improvements of post-processed model output using a Canonical Correlation Analysis (CCA) is compared to direct model output. The multi-model ensemble is also used to examine weaknesses in forecasts of circulation anomalies during weak Indian monsoon years.

The next set of papers (Ha *et al.*, Mujumdar *et al.* and Rajeevan *et al.*) includes a review of the multi-scale variability of the East Asian monsoon, where possible links between climate change and monsoon variability are explored. The variability of the Indian monsoon is looked at in relation to La Niña. Moreover, the variability of the Northeast monsoon over India is discussed together with its predictability.

The final collection of papers describes droughts resulting from changes in the monsoon regimes in South America and India (Coelho *et al.* and M. Naresh Kumar *et al.*). In the case of South America, the large-scale oceanic and atmospheric conditions are discussed as possible mechanisms associated with drought conditions. The analysis of time series of the Standardized Precipitation Index for India has shown that the drought frequency has increased in recent years.

There is no doubt that further scientific research on monsoon processes and variability, and their predictability and impacts, is still urgently required. The complexity of physical processes and atmospheric forcings renders the task of understanding monsoons challenging for the scientific community, and this special issue is a contribution towards this effort.

Anna Ghelli,<sup>a\*</sup> Hannah Cloke<sup>b</sup> and Ashwini Kulkarni<sup>c</sup>

<sup>a</sup> ECMWF, Reading, UK

<sup>b</sup> King's College London, UK

<sup>c</sup> Indian Institute of Tropical Meteorology, Pune, India

\*E-mail: anna.ghelli@ecmwf.int