PRedictability and variability Of Monsoons and the agricultural and hydrological impactS of climate changE (PROMISE)

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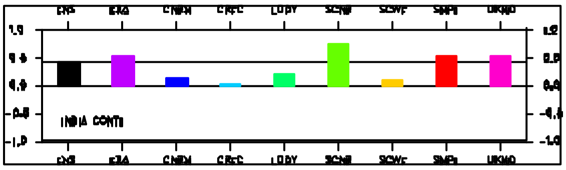
Final report (WP1100)

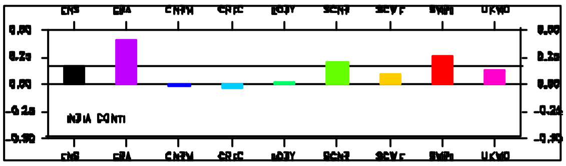
Dr. Wilhelm May (DMI), Dr. Laura Ferranti (ECMWF) and
Dr. Julia Slingo (UREADMY)

1. DMI's contribution

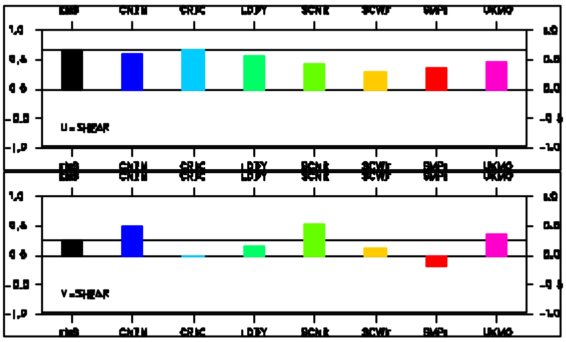
At DMI, the performance of the DEMETER multi-model ensemble system for seasonal predictions has been assessed with respect to the Indian summer monsoon. The prediction system consists of 7 different coupled models, each of them performing an ensemble of 9 seasonal forecasts. Due to the delays in the production of ERA-40 and, hence, in the DEMETER predictions, only 12 years of data (1987-1998) could be considered. Due to the short period of data available, we have not applied any technique to combine the predictions with the different models in such a way that the forecast skill of the multi-model ensemble mean is maximized. However, preliminary results taking the interannual variability of the various models into account suggest a potential for improving the forecasts of the Indian summer monsoon by weighting the forecasts of the individual models in an optimal way.

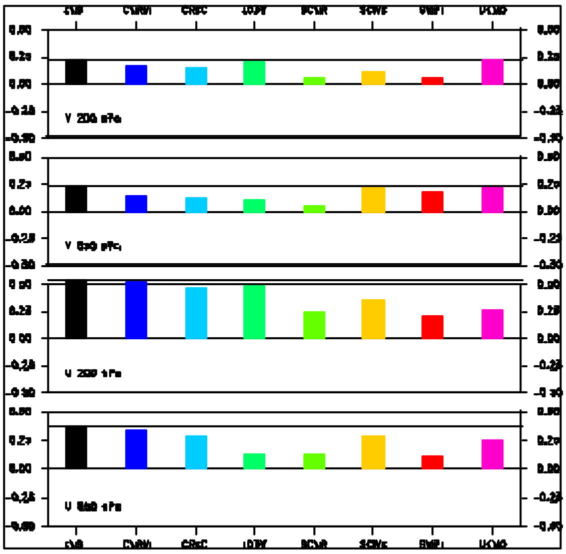
The seasonal predictions of the Indian summer monsoon have been verified against the CMAP data set for precipitation and against ERA-40 for the other atmospheric variables. Both large-scale indices describing the strength of the monsoon, i.e., the rainfall in India and the vertical shear of the zonal and the meridional wind component, respectively, and the local values of the rainfall and the winds are considered. The results are shown in the following:





The panel on the left shows the forecast skills, i.e., the anomaly correlation coefficients ("ACCs"), for the All India Rainfall (AIR) for the multi-model ensemble ("ENS"), the 7 different models ("CNRM", … "UKMO"), and ERA-40 ("ERA"). The panel on the ride, on the other hand, shows the mean values of the local ACCs of the rainfall averaged over India. According to this, 3 of the models have a better skill for predicting AIR than ENS with an ACC of about 0.5. The other 4 models have, however, a very poor skill. The picture is somewhat different, when the local predictions are considered. In this case, only two of the models exceed ENS, and the ranking of the 2 best models is different than for AIR. 2 of the models actually have a negative skill. In general, the forecast skills are better for AIR than for the local changes of rainfall, i.e., about a factor of 2 for the corresponding ACCs.



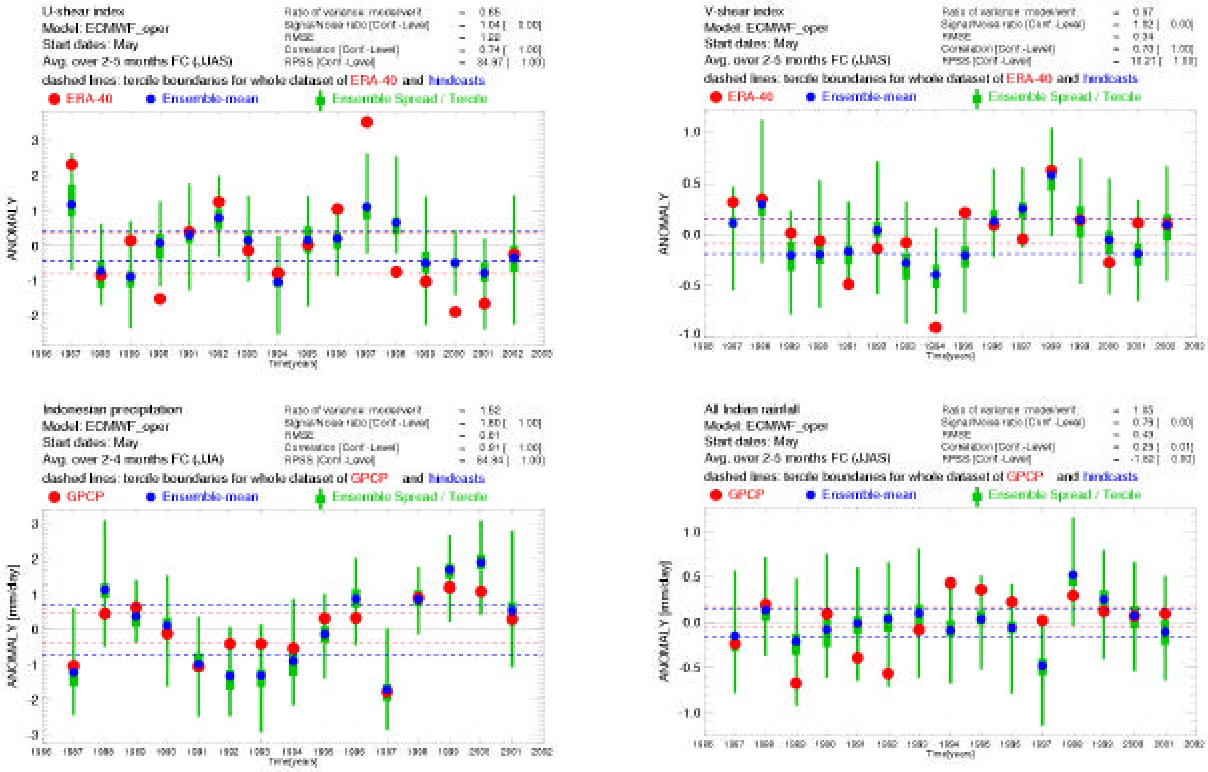


In this case, the panels on the left show the forecast skills for the vertical shear of the zonal wind component ("U-SHEAR") and the vertical shear of the meridional wind component ("V-SHEAR") and the panels on the right the mean values of the local ACCs of the meridional and zonal wind components in the upper and the lower troposphere, i.e., at 200 and at 850 hPa, respectively. For U-SHEAR, none of the individual models has a better forecast skill than ENS, while for V-SHEAR, 3 of the models exceed ENS. 2 of these 3 models also have a rather good skill for predicting AIR. Different to AIR and V-SHEAR, none of the models has a particularly low forecast skill for U-SHEAR. Most models are better suited for predicting U-SHEAR, i.e., changes in the Walker circulation, than for predicting V-SHEAR, i.e., changes in the local Hadley circulation. This is consistent with the fact that the models have a better forecast skill for the local changes in the zonal wind component than for the local changes in the meridional wind component at the two levels. In particular, the forecast skills of the changes in the zonal wind component are generally higher in the upper than in the lower troposphere.

2. ECMWF's contribution

At ECMWF, the seasonal forecast performance with respect to the Asian summer monsoon is monitored operationally. For this purpose, we consider the ensemble forecasts, initiated in May at forecast range 2-5 months. The forecast ensembles, consisting of 40 members, span the period 1987-2002.

Dynamical indices (the vertical shear of the zonal and of the meridional wind component) and spatial averages of rainfall anomalies (India and Indonesia) are used to estimate the observed interannual variability and the skill of the seasonal forecast predictions. GPCP data are used to verify precipitation, while the other atmospheric variables are verified against a combination of ERA-40 and the operational analyses. The results are shown in the following figures:



According to this, interannual fluctuations in the strength of the monsoon circulation are predicted with some skill. Forecasts of rainfall anomalies over Indonesia are also successful, but rainfall predictions for India show very little skill.

From the DEMETER project, various characteristics of the coupled model used for the operational seasonal forecasts (bias, skill, etc.) can be publicly accessed on line at
http://www.ecmwf.int/research/demeter/d/charts/verification
Hindcasts performed with the same model within the DEMETER project can be retrieved from the public data server
http://www.ecmwf.int/data/d/demeter/pl
On the DEMETER web-site the performance of a multi-model ensemble system for seasonal predictions with respect to the Asian summer monsoon is documented.

3. UREADMY's contribution

Due to the delays in the production of ERA-40 and the consequent effects on the availability of DEMETER ensembles, the work planned on seasonal predictability has been limited. As reported in WP1000, a major project on vegetation-climate interactions has been undertaken instead.

As reported in WP1000, the reproducibility/predictability of monsoon climates in the Hadley Centre atmosphere-only GCM (HadAM3) at a range of horizontal and vertical resolutions has been assessed based on AMIP II integrations and multi-decadal integrations with an idealized El Nino/La Nina cycle. The reproducibility is generally quite high and the model displays considerable inverse symmetry in its response during the growing phases of El Niño and La Niña. However, although the precipitation anomalies over the tropical Pacific are generally well captured the model systematically simulates the wrong sign of the anomalies over India. Thus the level of skill in the predictability of the Asian summer monsoon by HadAM3 is generally low.

The interaction between subseasonal and interannual variability and its role in predictability has been discussed by Sperber et al. (2000), and a detailed description of the observed intraseasonal variability of the Asian summer monsoon has been prepared by Annamalai et al. (2001). Comparison of the intraseasonal variability simulated by HadAM3 with these observational studies has shown that the model has some difficulty in capturing basic characteristics of monsoon active/break cycles. Further, a detailed study of a number of models by Sperber et al. (2001) has suggested that deficiencies in the simulation of subseasonal modes contribute directly to poor seasonal predictability and to systematic error of the mean state.

References:

Annamalai, H. and J. M. Slingo, 2001: Active/break cycles: diagnosis of the intraseasonal variability of the Asian Summer Monsoon. *Clim. Dyn.*, **18**, 85-102.

Sperber, K. R., J. M. Slingo and H. Annamalai, 2000: Predictability and the relationship between subseasonal and interannual variability during the Asian Summer Monsoon. *Q. J. R. Meteorol. Soc.*, **126**, 2545-2574.

Sperber, K. R., and others, 2001: Dynamical seasonal predictability of the Asian Summer Monsoon. *Mon. Wea. Rev.*, **129**, 2226-2248.