SERVIR and Seasonal Climate Forecasts

The NASA/AUSAID SERVIR project is dedicated to developing and improving the capacity of several hub regions to incorporate unique NASA satellite and modeling resources into operational environmental monitoring and planning. Recent and currently served hub regions include Mesoamerica, East Africa (EA), and the Hindu Kush-Himalayan region.

The SERVIR Applied Science Team (AST) has recently been established with the goal of providing enhanced products for use in the hub regions. Currently awarded projects within the AST include (but not limited to) agricultural and hydrologic impact modeling, air quality and landslide assessments.

Another AST team is focused on the evaluation of climate model simulations and the development of downscaled scenarios to be used by AST projects focused on impact modeling. Results presented here focus on the initial development of downscaled seasonal forecasts from the NASA Global Modeling and Assimilation Office (GMAO) GEOS-5 model contribution to the U.S. National Multi-Model Ensemble (NMME) for use in agriculture and hydrologic modeling over East Africa.

Observed East Africa Rainfall Variability

Seasonal rainfall in East Africa (Fig. 1) is strongly tied to the annual march of the Intertropical Convergence Zone (ITCZ). The result is an annual maximum in rainfall in northern (southern) East Africa (EA) during boreal (DJF) and biannual maxima near equatorial East Africa (SSSN) in MAM ("long rains") and OND ("short rains"). The topographic influences on seasonal rainfall are pronounced with the largest seasonal rainfall occurring over the interior highlands (see Fig. 3 for elevation). Interannual variability of seasonal rainfall is locked strongly to the seasonal cycle.

Equatorial East Africa (EEA) rainfall variability can be examined through use of a standardized precipitation index (SPI) that quantifies the anomalous variability (annual cycle removed) relative to standard deviations of a normal distribution. Since 2000, EEA rainfall has shown significant interannual variability (Fig. 2) with respect to uncorrected model output. Some areas have residual unexplained variance of 30% (EA), 20% (Mio) and even 40% (white) arising from the scale mismatch.

The boxed regions of the east African monsoon rainfall are influenced by ocean-atmosphere teleconnections.

Teleconnection maps for the short and long rainy seasons (Fig. 2) indicate significant relationships with both sea surface temperatures (SST) and precipitation variability. These have been identified in several studies with short rain interannual variability linked strongly to ENSO induced alterations of tropical zonal circulation.

Impact Modeling (e.g. Agriculture, Hydrology)

Fine spatial resolution needed (~5 km)

Raw model skill and bias correction

Figure 6. The GMAO seasonal forecast cross-validated predictions of SPI from the MFR are shown. The RPSS (bars) and correlation (lines) measures are shown as a function of lead time. The GMAO seasonal forecast has significant correlations with respect to uncorrected model output. The MFR approach shows significant improvement over the direct model forecasts of EA rainfall (Fig. 5).

Summary Points

The NASA/AUSAID SERVIR Applied Science Team (AST) is currently supporting several projects that will make use of downscaled seasonal forecast scenarios in agricultural and hydrologic modeling applications.

Interannual rainfall variability in equatorial East Africa is prominent, leading to floods and droughts. Variations in both the short and long rains are influenced by ocean-atmosphere teleconnections.

Seasonal forecasts from the GMAO model show limited inherent skill for direct forecasts of EA rainfall and must be spatially and temporally downscaled for use in impact modeling.

Downscaling Results

Rather than using the forecasted precipitation over the East Africa region, the MFR approach set of hindcasts can be used to develop improved predictions of EA rainfall variability in the form of the EA SPI. Effectively, model output statistics are used to bridge model forecasts of large-scale variability to those of interest to this study.

Matched filter regression (MFR) is a technique that can be used to identify predictive relationships of large-scale variability that are significantly correlated with a predictand of interest. Hindcast statistics are used to identify significant correlations between the EA SPI and model fields (Fig. 5). Hindcasts of those regions exhibiting significant correlations are used to develop a multivariate vector whose entries are scaled by the correlation strength at each location. The set of hindcast vectors are subjected to a principal component analysis. The first PC serves as a predictor for deriving a functional relationship with respect to the MFR approach shows significant improvement over the direct model forecasts of EA rainfall (Fig. 5).

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Figure 5. The GMAO seasonal forecast cross-validated correlations of SPI predictions from the MFR are shown. The RPSS (bars) and correlation (lines) measures are shown as a function of lead time. The GMAO seasonal forecast has significant correlations with respect to uncorrected East Africa average precipitation (MFR), the MFR approach using bivariate regression of the first principal component (PC1) and a neural network regression of the 2nd PC (NN). Note how rapidly the skill drops using only the forecasted precipitation over East Africa. In contrast, the MFR based approach maintains skill for several months, with PC1 outperforming the NN approach.