Global Drought Monitoring and Forecasting based on Satellite Data and Land Surface Modeling

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Introduction

Monitoring drought globally is challenging because of the lack of dense in-situ hydrologic data in many regions. This is especially problematic for developing regions such as Africa where water information is arguably most needed, but virtually non-existent on the ground. With the emergence of remote sensing estimates of all components of the water cycle there is now the potential to monitor the full terrestrial water cycle from space to give global coverage and provide the basis for drought monitoring. However, many challenges remain in using these data, especially due to biases in individual satellite retrieved components, their incomplete sampling in time and space, and their failure to provide budget closure in concert.

A potential way forward is to use modeling to provide a framework to merge these disparate sources of information to give physically consistent and spatially and temporally continuous estimates of the water cycle and drought. Here we present results from our experimental global water cycle monitor and its African drought monitor counterpart. The system relies heavily on satellite data to drive the Variable Infiltration Capacity (VIC) land surface model to provide near real-time estimates. Ongoing work is adding a drought forecast component based on a successful implementation over the U.S. and agricultural productivity estimates based on output from crop yield models.

Global Water Cycle and Drought Monitoring

The Princeton U.S. drought monitor has been extended to an experimental global water cycle and drought monitoring system, with a focus on Africa. The VIC model is run in near real time forced by a mixture of observations and modeled/remotely sensed meteorology to produce updates of water cycle variables (soil moisture, runoff, evapotranspiration, snow). Drought is monitored in terms of low soil moisture percentiles.

The system comprises three parts: (1) a retrospective reconstruction of the global terrestrial water cycle forced by merged reanalysis observational meteorological forcing. This forms the climatology against which current and future conditions are compared; (2) a real-time monitoring system driven by remote sensing precipitation and atmospheric analysis data that tracks drought conditions in near real-time; (3) a seasonal forecast system based on downscaled climate forecasts to provide seasonal hydrologic, drought and agricultural data.

Challenges of Global Drought Monitoring

In Africa, where real-time (and historic) observations of key hydrologic variables such as precipitation are generally lacking, we resort to alternative sources of data. These include remote-sensing based precipitation that can be used as input to the hydrologic modeling. Remotely sensed evapotranspiration, soil moisture can be used directly or through assimilation into the model. Below shows comparisons of observation-based precipitation versus three satellite MW-R merged products that are available in near real-time.

Development of Agricultural Productivity Component

Initial development of an experimental agricultural monitoring component has focused on using existing global agricultural datasets and statistical yield models. Regressions with climate data (Schlenker and Lobell, 2010) are used to predict changes in yield, which are anchored to yield estimates for the year 2000 (Monteith et al., 2008) and adjusted based on cropping area and harvested area. Future plans include prediction on crop yields based on these regressions, process-based models and CFS climate forecasts.

Acknowledgments: this work was funded by UNESCO grant 4500041171 and NOAA grant NA10OAR4310130

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