African Drought Monitor

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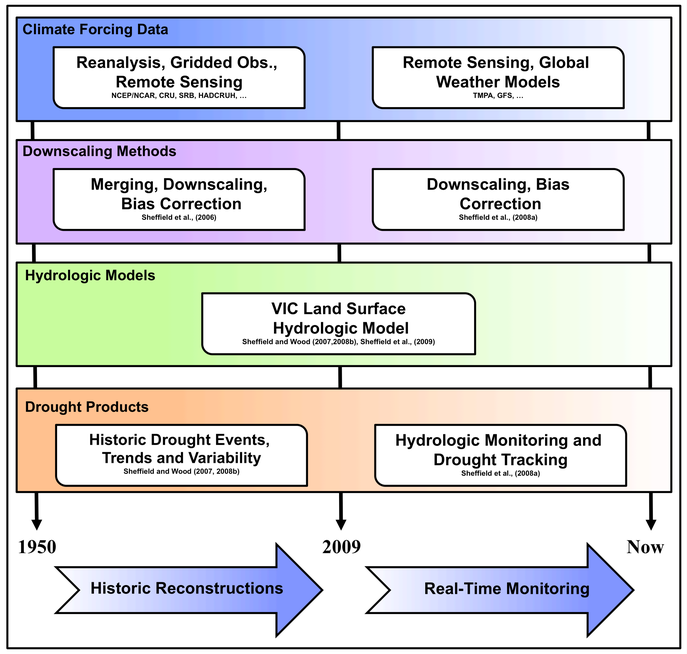
Introduction

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 our African drought monitor. The system relies heavily on satellite data to drive the Variable Infiltration Capacity (VIC) land surface model to provide near real-time estimates. In mid-December, this system together with the web user interface that was developed will be transferred over to AGRHYMET in Niamey, Niger for operational use over Africa.

The Monitoring System

The system comprises two 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.



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, and evapotranspiration). Drought is monitored in terms of low soil moisture percentiles.

Multiple variables are then calculated at stream gauge locations over Africa corresponding to the GRDC network and the FAO reservoir database. The variables include simulated discharge and basin averaged water cycle variables.

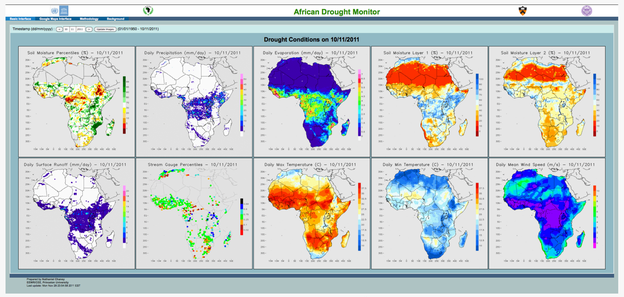
The Monitoring System User Interface

A challenge present in monitoring efforts is the ability for researchers and policy-makers to access the data in a simple and intuitive manner. To address this issue, a graphical user interface was developed for the African Drought monitor.

Users can access the entire daily record from 1950 to two days before real-time. The monitor output areal data can be viewed as animations or static images, with the ability to zoom in and focus on regions of special interest to the user.

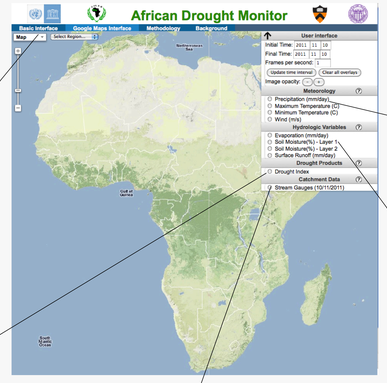
The variables which are available through the monitor include: areal maps and basin averages of evaporation, runoff, soil moisture, drought index, precipitation, temperature, average wind speed together with simulated discharge at gauges over the continent.

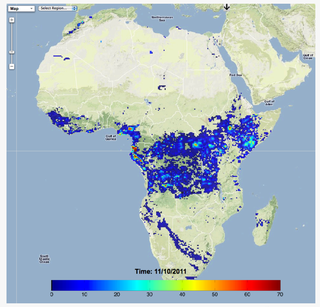
Basic Interface:
The user is able to access the preprocessed images ready for download at the continental scale.



Output of basic interface on Nov. 10th, 2011.

Interactive Interface:
Google Maps is used to provide the user an enhanced experience in viewing and accessing the monitor.

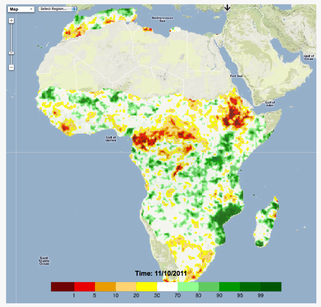




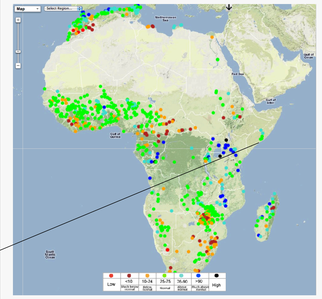
Precipitation (mm/day) from TMPA on Nov. 10th, 2011.

Meteorology:
The weather variables obtained from TMPA and GFS drive the land surface model. The daily minimum and maximum temperatures together with the daily average wind speed are obtained from GFS. The precipitation comes from TMPA when available and if not from GFS.

Drought Products:
The drought index is measured by calculating the soil moisture percentile of the averaged relative soil moisture of layers 1 and 2 with respect to the empirical probability distribution function of the historical simulations (1948 – 2008).

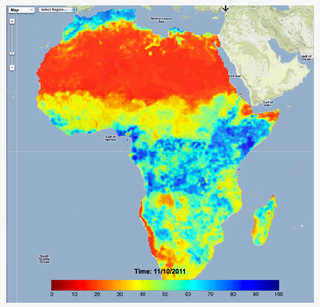


Drought Index (%) on Nov. 10th, 2011.



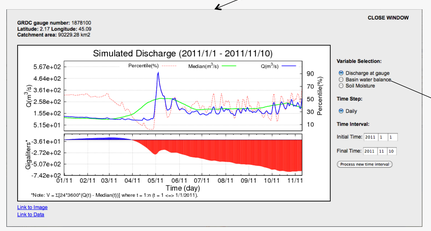
Percentiles of the stream gauges on Nov. 10th, 2011.

Catchment Data:
Using the land surface model output, several hydrologic variables are estimated for over 800 catchments over Africa. These variables include simulated discharge, percentiles and basin averaged runoff, evaporation, precipitation, and drought index.

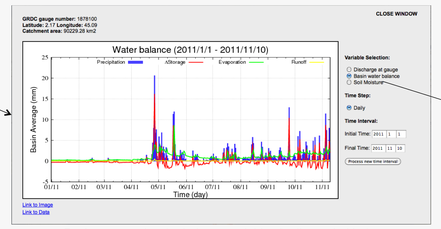


Relative soil moisture (%) of layer 1 (10 cm) from the land surface model output on Nov. 10th, 2011.

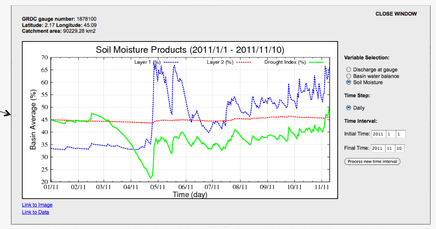
Hydrologic Variables:
The land surface model is run at a daily time step at a one quarter degree resolution over the African continent. Images of the main variables including evaporation, runoff, and soil moisture are then prepared and uploaded to the interface.



Simulated discharge, percentiles and accumulated deficit for the period between Jan 1st and Nov 10th, 2011 for GRDC gauge 1878100.



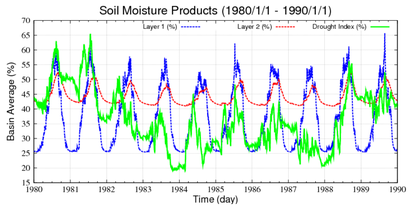
Basin averaged water balance variables for the period between Jan 1st and Nov 10th, 2011 for GRDC gauge 1878100.



Basin averaged soil moisture and drought index for the period between Jan 1st and Nov 10th, 2011 for GRDC gauge 1878100.

To view the monitor, please visit: *http://hydrology.princeton.edu/~nchaney/Africa_Drought_Monitor_Webpage*

Scan the barcode to access the website.

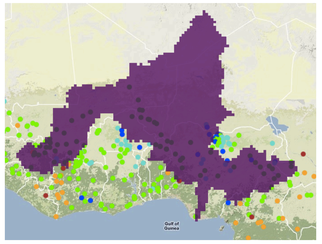


User interface output of the soil moisture products from the Niger basin between 1980 and 1990.

Niger Basin

Operating primarily out of AGRHYMET in Niamey, Niger the system will be used primarily for drought monitoring over western Africa.

The system has shown the ability to capture the different historical drought events that have affected the region since 1950, including, as shown to the left, the drought over the Sahel in the 1980's.



Future Work

1. Address consistency between the satellite precipitation and historical data set.
2. Use real-time precipitation gauges to correct the precipitation fields.
3. Include water management in the routing model used to simulate discharge.
4. Apply user interface to the global drought monitor.
5. Move to finer resolution.
6. Add other remote sensing data products including soil moisture and LAI.

1. Sheffield, J., K.M. Andreadis, E. F. Wood, and D. P. Lettenmaier, 2009: Global and continental drought in the second half of the 20th century: severity-area-duration analysis and temporal variability of large-scale events, *J. Climate*, 22(8), 1962-1981.
2. Sheffield, J. , and E.F. Wood, 2008: Global Trends and Variability in Soil Moisture and Drought Characteristics, 1950-2000, from Observation-Drive Simulations of the Terrestrial Hydrologic Cycle, *J. Climate*, 21, 432-458.
3. Sheffield, J., and E. F. Wood (2007), Characteristics of global and regional drought, 1950-2000: Analysis of soil moisture data from off-line simulation of the terrestrial hydrologic cycle, J. Geophys. Res., 112, D17115, doi:10.1029/2006JD008288.

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