A global blended drought Index from merging satellite observations and LSM simulations

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Data and Method

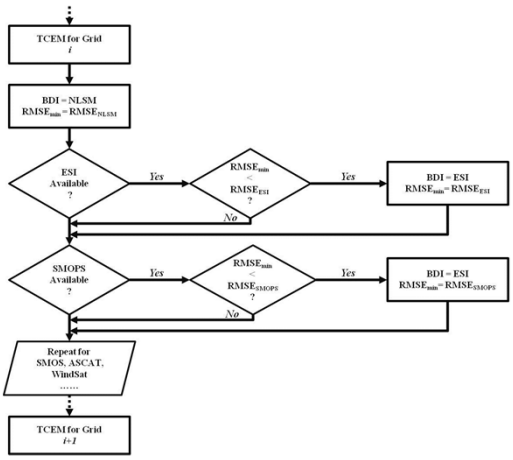
NLSM: Based on the layer weighted average, the top three soil layer simulations from the Noah 3.2 land surface model are characterized as root zone (0-100 cm) SM. NLSM-based drought estimates are subject to errors in the model representation and in the meteorological forcing data.

ESI: Evaporative Stress Index (ESI) data are produced from Atmosphere Land Exchange Inverse (ALEXI) model using land surface temperature data retrieved from satellite thermal infrared imagery. ESI does not use any precipitation input, but is sensitive to the accuracy of the thermal infrared (TIR) satellite LST and other model inputs.

MWSM: We use four microwave-based SM products including SM data from the Advanced Scatterometer (ASCAT), WindSat and NOAA Soil Moisture Operational Product System (SMOPS) and Soil Moisture and Ocean Salinity (SMOS) retrievals. These products are influenced by instrument noise and uncertainty in microwave emission modeling, especially as vegetation cover increases.

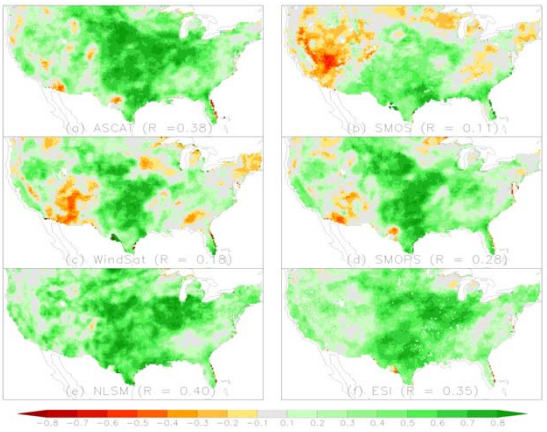
All of the SM retrievals are temporal composited over 4-week intervals on a near-global gridded domain at 25 km spatial resolution. Based on the Triple Collocation Error Model (TCEM), the monthly root mean square errors (RMSEs) for the standardized anomalies of above 6 SM datasets can be estimated grid by grid within the global domain.

Blended Drought Index (BDI)



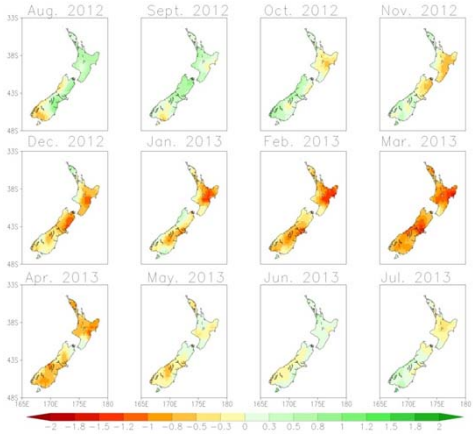
The procedure for constructing the BDI using the RMSEs estimated from the TCEM implemented for each grid in each calendar month. $RMSE_{min}$ is the minimum RMSE for a grid. And $RMSE_{SMOPS}$, $RMSE_{NLSM}$ and $RMSE_{ESI}$ are the monthly RMSE values for SM data from SMOPS, NLSM and ESI cases, respectively.

Validations with United States Drought Monitor (USDM)

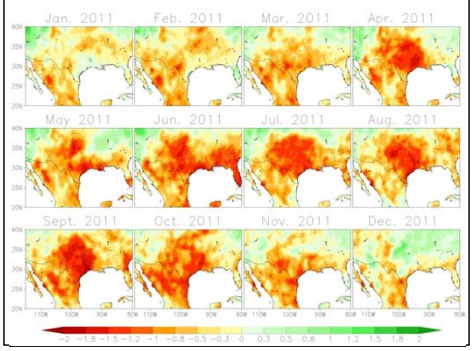


Correlation coefficients (R) between the weekly USDM and ASCAT, SMOS, WindSa-t, SMO-PS, NLSM, ESI and BDI. The grey color indicates insignificant over the 2008-2014 period.

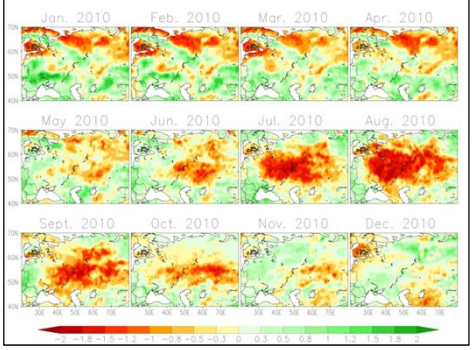
Case 1: BDI for New Zealand drought



Case 2: BDI for U.S drought



Case 3: BDI for Russia drought



Official records:

Case 1: the drought from Oct. 2012 to May 2013 with the entire New Zealand experiencing the severe drought in Mar. 2013.

Case 2: the drought started in Nov. 2010 and lasted through Oct. 2011. The dry situation was mitigated across the southeast Texas Panhandle and eastern Rolling plains in Nov. 2011 by heavy precipitation

Case 3: the 2010 western Russia drought started in May and lasted through Nov. with response to the record-breaking high temperature.

Summary:
(1). The BDI is capable of integrating the optimal SM retrievals with the lowest RMSEs.
(2). The SM-based BDI demonstrated reasonable agreement with the U.S. Drought Monitor and official records.
(3). In addition to operational insights, the BDI is a sustainable developed indicator with merging any new upcoming satellite SM products and more available agricultural drought evaluations that can respect to the TCEM assumptions.