LDAS-Monde sequential assimilation of satellite-derived vegetation and soil moisture products forced by ERA5 ECMWF latest reanalysis applied over North America

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In this study LDAS-Monde, a land data assimilation system with global capacity forced by ERA5 European Center for Medium Range Weather Forecast (ECMWF) latest reanalysis, is applied over North America to increase monitoring accuracy for land surface moisture energy and water states and fluxes, including evapotranspiration and stream flow as well as vegetation growth. LDAS-Monde ingests information from satellite-derived Surface Soil Moisture (SSM) and Leaf Area Index (LAI) estimates to constrain the Interactions between Soil, Biosphere, and Atmosphere (ISBA) land surface model (LSM) coupled with the CNRM (Centre National de Recherches Météorologiques) version of the Total Runoff Integrating Pathways (ISBA-CTRIP) continental hydrological system. LDAS-Monde uses the CO_2-responsive version of ISBA which models leaf-scale physiological processes and plant growth, while transfer of water and heat through the soil rely on a multilayer diffusion scheme. SSM from the ESA Climate Change Initiative project and LAI estimates from the Copernicus Global Land Service project are assimilated using a Simplified Extended Kalman Filter (SEKF), which uses finite differences from perturbed simulations to generate flow-dependence between the observations and 8 model control variables (LAI and seven layers of soil: from 1 cm to 100 cm depth).

ERA5 atmospheric reanalysis forces LDAS-Monde. It uses one of the most recent versions of the model and data assimilation methods applied at ECMWF, which makes it able to use modern parameterizations of Earth processes compared to older versions used in ERA-Interim. Two important features of ERA5 are the improved temporal and spatial resolution, from 6-hourly in ERA-Interim to hourly analysis in ERA5, and from 79 km in the horizontal dimension and 60 levels in the vertical, to 31 km and 137 levels in ERA5. A first 7-year segment of ERA5 atmospheric reanalysis has recently been released over 2010-2016 by ECMWF. ERA5 atmospheric reanalysis is re-scaled to a 0.25 degree spatial resolution to force LDAS-Monde leading to a quarter degree reanalysis of the land surface variables.

After an assessment of ERA5 impact in the ISBA LSM with respect to ERA-Interim over North America, LDAS-Monde analysis impact over 2010-2016 is evaluated using satellite-driven model estimates of land evapotranspiration from the Global Land Evaporation Amsterdam Model (GLEAM) project and upscaled ground-based observations of gross primary productivity from the FLUXCOM project. Over the contiguous US, in-situ measurements of soil moisture from the USCRN network and of turbulent heat fluxes from FLUXNET-2015 are used in the evaluation, together river discharges from the USGS. Those data sets highlight the added value of LDAS-Monde compared to an open-loop simulation (i.e. no assimilation). Finally, it has been shown that LDAS-Monde has a strong ability to monitor agricultural drought, by providing improved initial conditions which persist through time, potentially aiding agricultural drought prediction.