Geophysical Research Abstracts
Vol. 20, EGU2018-15773, 2018
EGU General Assembly 2018

Strongly coupled data assimilation (SCDA) of SMOS land surface brightness temperature in WRF using the EnKF

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Data assimilation (DA) of satellite soil moisture into land surface models has shown to improve the representation of surface and root zone soil moisture. Most of the work in satellite soil moisture assimilation has focused on “offline” assimilation, that is, use of prescribed atmospheric forcing and no coupling between the atmosphere and land. Neglecting this feedback could lead to inconsistency between the atmosphere and land, degrading short-term or long-term predictions of both. By simultaneously updating the state variables in both domains (atmosphere and land) this “initialization shock” could be avoided. The novelty of this work lies in the comparison of weakly coupled DA (WCDA) and strongly coupled DA (SCDA) in the atmosphere-land system using real satellite observations.

In this work we use the Advanced Research version of the Weather Research and Forecasting model (WRF-ARW), which is a mesoscale numerical weather prediction system. This model includes the Noah land surface model, a periodic boundary layer scheme and upper atmospheric physics. To ensure consistency between the retrievals and modelling system, we assimilate passive brightness temperature from SMOS. The modelled soil moisture is then converted to modelled brightness temperature using the Community Microwave Emission Model (CMEM). An Ensemble Kalman Filter (EnKF), is used in the data assimilation algorithm. The advantage of using the EnKF in a strongly coupled system is the simplicity of the representation of domain cross-covariance between atmospheric and land variables.

Using the above mentioned system we have performed the following experiments to evaluate the impact of strongly coupled land surface data assimilation: I) Open-loop, no assimilation of land surface variables, II) DAprescribed, no atmosphere-land coupling, but DA of soil moisture, III) DAwcoupled, assimilation of SMOS brightness temperature with atmosphere-land feedback (no simultaneous state update across domains) and IV) DAscoupled, online assimilation of SMOS brightness temperature, atmosphere-land coupling activated (simultaneously update state vectors across domains).
A spin-up period without atmosphere-land DA coupling is applied to ensure consistency between the atmosphere and land variables, after this spin-up period DA is activated using one of the methods in II-IV.

The resulting impact on the state variables of the land surface is evaluated using in situ soil moisture observations. This acts as a first validation step, further work will investigate short-term benefits in e.g., NWP or seasonal2subseasonal prediction.