Introduction

Soil moisture is a crucial variable for numerical weather prediction (NWP). Accurate, global initialization of soil moisture is obtained through data assimilation systems. However, analyses depend largely on the way observations and background errors are defined. In this paper, a wide range of short experiments with contrasted specification of the observation error and soil moisture background were conducted. As observations, screen-level variables and brightness temperatures from the Soil Moisture and Ocean Salinity (SMOS) mission were used. The region of interest was North America given the good availability of in-situ observations. The impact of these experiments on soil moisture and the atmospheric layer near the surface was evaluated. The results highlighted the importance of assimilating sensitive observations to soil moisture for air temperature and humidity forecasts. The benefits on the soil water content were more noticeable with increasing SMOS observation error and with the introduction of soil texture dependency in the soil moisture background error.

ECMWF Land Data Assimilation System (LDAS)

H-TESSEL land surface model (Balsamo et al. JHM 2009), simplified EKF (de Rosnay et al. QJRMS 2013)

Soil Moisture and Ocean Salinity (SMOS)


Numerical Experiments

Two sets of NWP 1-month experiments are conducted (Sept-Oct 2012):
- Observations impact: OL (Open Loop), SLV (Screen level Variables) assimilation, SMOS and SLV assimilation, SMOS only assimilation.
- Sensitivity to error specifications: with SMOS assimilation and different values of the background and observations errors as detailed in the table.

Analysis Increments

Left: Time series of 12h area averaged analysis increments of the control SLV experiment and the SMOS+SLV (black) experiment for the top soil layer. Right: Averaged time series of the 40 degrees incidence angle gain component for the SMOS and SMOS+2R experiments.

Impact on soil moisture

Validation against in situ soil moisture stations
- U.S. Climate Reference Network (USCRN) and the Soil Climate Analysis Network (SCAN)
http://www.wcc.nrcs.usda.gov/scan/
- U.S. Climate Reference Network (USCRN) National from the Oceanic and Atmospheric Administration's National Climatic Data Center (Bell et al. JHM 2013)

Impact on the observing system on near surface weather forecasts

Validation against operational analyses

Left: averaged forecast biases and RMS forecast errors of 2 m dew point temp. compared to observations (SYNOP), as a function of the forecast lead time. Right: Near-surface air temperature (left panel) and air humidity (right panel) normalized RMSE forecast of SLV (black), SMOS (red) and SLV+SMOS (green) experiments compared to the control OL, as a function of the forecast lead time.

Impact of error specifications on near surface weather forecasts

Near-surface air temperature (left panel) and air humidity (right panel) normalized root mean square forecast error compared to the control SMOS experiment for: (left) SMOS+2R (red) and SMOS+PI (black) compared to the control SMOS experiment, (right) SMOS+Btext (red), SMOS+Bprop (black) and SMOS+3DB (green).

Summary

- Impact of soil moisture data assimilation for NWP with assessment of observing system, observation and model background error specifications
- Tests conducted in operational-like 1-month NWP experiments
- Atmospheric impact is limited to the closest layer to the surface
- Compared to the Open Loop, screen level data assimilation improves atmospheric forecast but it is neutral on soil moisture
- SMOS assimilation slightly reduces soil moisture RMSE but it slightly degrades correlations
- Increased SMOS observations error specification for SMOS (to account for representativeness errors) has a slightly positive impact on atmospheric forecasts
- Using a background error matrix as a function of soil texture and/or soil depth has a neutral impact on the near-surface forecast.
- Longer term experiments using the full observing system will be the topic of a follow-up paper with an exhaustive analysis of the meteorological impact due to the assimilation of SMOS TB.

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