Data Assimilation of SMOS data: making sense of soil moisture observations

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1. Introduction:

Soil moisture is one of the key geophysical variables for understanding the Earth's hydrological cycle. (Fig. 1). On November 2009, the ESA Earth Explorer mission SMOS (Kerr *et al.*, 2010) was launched. It is a polar orbiter, and uses L-Band (~1.4 GHz) to measure soil moisture and ocean salinity.

NILU are preparing to assimilate SMOS soil moisture data (AO Project C1P.7512), and receive data for assimilation over Norway (Fig. 2).

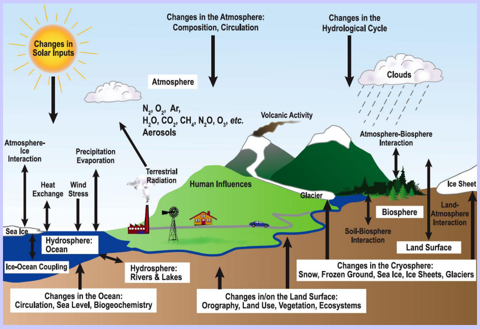


Fig.1 (left): *Global climate system (Figure from IPCC, 2007).*

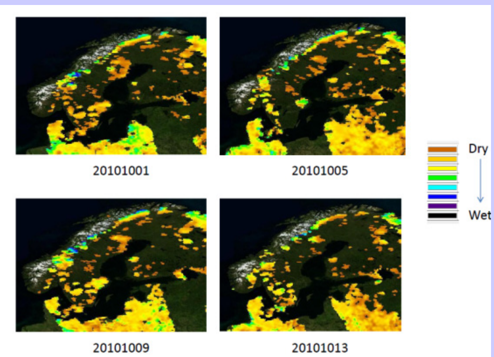


Fig. 2 (left): *SMOS soil moisture (overpasss on various days in October 2010). Blue indicates relatively wet soil; yellow/red relatively dry soil.*

2. Use of SMOS data over Norway and Northern Areas:

NFR (Norwegian Research Council) have funded a 3-yr PhD studentship to make more sense of SMOS soil moisture observations over Norway and Northern Areas. The recently launched SMOS satellite provides data with relatively coarse spatial resolution (~43 km footprint), a limited instantaneous field of view (~1000 km across) and relatively infrequent revisits (1-3 days).

NILU will use data assimilation (DA) ideas to improve spatial & temporal information provided by SMOS to be more in line with user needs, i.e., offer higher rate, higher resolution, wider area "snap shot" information. This addresses the challenge of using SMOS data to understand the hydrological cycle in Norway, characterized by complex orography and frequent snow cover in winter. Beneficiaries include hydrologists, NWP agencies, ESA.

Before assimilating SMOS soil moisture data over Norway, this will be evaluated against other satellite data (AMSR-E - *Advanced Microwave Scanning Radiometer*; ASCAT) and in situ data (from NVE, Norway). Early results are shown in Fig. 3. Note the differences in SMOS and AMSR-E soil moisture variability and the lack of SMOS observations after mid November as snow covers the ground. Note also the RFI (*radio frequency interference*), which affects the SMOS data. These issues are under investigation.

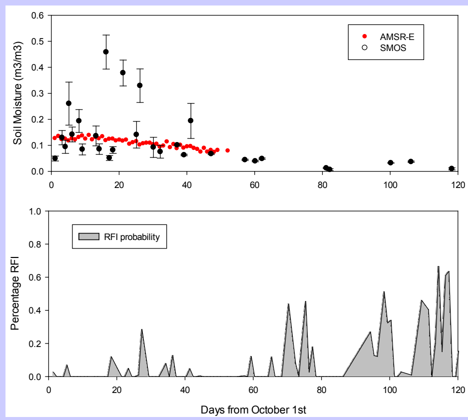
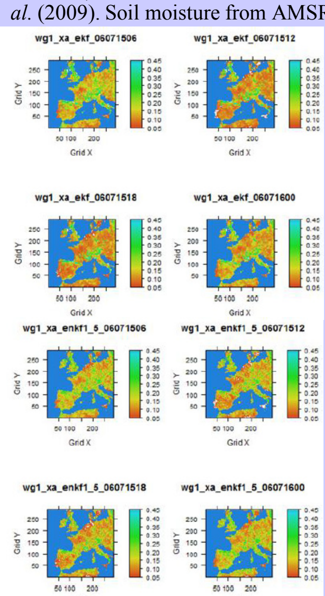


Fig. 3 (left): *Top: SMOS soil moisture versus AMSR-E soil moisture (AMSR-E product is from NSIDC). Bottom: RFI probability.*

3. Assimilation over Norway and Northern Areas:

The NILU land DA system (Lahoz *et al.*, 2010a, b) is developed in collaboration with Met.no and Météo-France. It implements variants of the Ensemble Kalman Filter (EnKF). It is an off-line 1-D system based on the SURFEX land surface model (Le Moigne, 2009). Schemes include 2 versions of EnKF where no perturbation of observations is needed (Sakov & Oke, 2008a, b). NILU also uses the Extended Kalman Filter (EKF) of Mahfouf *et al.* (2009). Soil moisture from AMSR-E is being assimilated (Figs. 4-5).



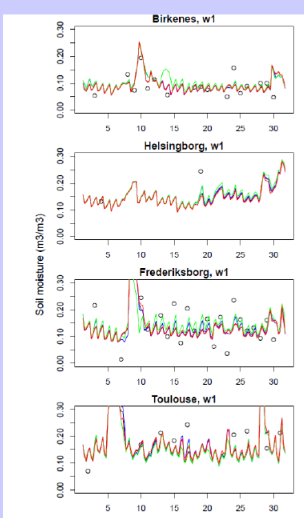


Fig. 4 (left): *Superficial volumetric water content (w1; m^3/m^3) analysed 4 times (06, 12, 18, 24 UTC), 15/Jul/2006. Top, EKF; bottom, EnKF (mean, 5 members).*
Fig. 5 (right): *Time series, analysed w1 (Jul 2006) at 4 sites (top to bottom: Norway; Sweden; Denmark; France). Line colours: black (model run, no DA), blue (EKF, no observational quality control, QC), green (EKF, observational QC), red (square root EnKF, no observational QC). EnKF has 5 members. Circles indicate AMSR-E observations (from Vrije University Amsterdam).*

4. Perspectives for this work:

(i) Hydrological cycle in Norway (NILU, Met.no, MF, CESBIO)

- •Understand error characteristics of SMOS soil moisture and SURFEX model;
- •Evaluate SMOS soil moisture data (aim is for at least one year);
- •Test land DA system (focus on EnKF);
- •Assimilate SMOS soil moisture data & produce soil moisture analyses;
- •Understand hydrological cycle in Norway & Northern Areas.

(ii) Forecast skill from use of SMOS soil moisture data (NILU, Met.no, FMI, CESBIO)

- •Build HARMONIE land DA system (using EnKF and EKF);
- •Assess impact of SMOS soil moisture on NWP forecast skill over Norway & Northern Areas. (see Beljaars *et al.*, 2010);
- •Improve NWP capability;
- •Benefit to HIRLAM community.

(iii) Other potential areas building from this work: Land-use change in the Amazon (NILU, Met.no, CESBIO, U. Amazonas, Manaus)

- •SMOS retrievals over the Amazon;
- •Soil moisture analyses;
- •Focus on land-use change (dry, wet, intermediate seasons);
- •Use convection-resolving models to study impact on hydrological cycle (e.g. cloud cover, precipitation).

References:

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