ECMWF ACTIVITES IN PREPARATION FOR THE LAUNCH OF THE SMOS SATELLITE

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1. INTRODUCTION AND MOTIVATION

Numerical Weather Prediction (NWP) centers have increasingly focused their attention on the physical processes occuring between the land surface and the boundary layer. Effectively, the evolution of physical processes at the lower troposphere such as cloud formation depends on the land surface feedback. In this respect soil moisture plays a crucial role. Soil moisture regulates the exchange of energy and water fluxes between the land surface and the lower troposphere. Therefore it is important to monitor surface soil moisture at global scale on a regular basis.

The current global analyses of soil moisture in the ECMWF Integrated Forecast System (IFS) relies on the assimilation of routinely observations of 2 m temperature and humidity. These variables are indirectly linked to soil moisture and they need to be strongly coupled to the surface in order to be informative over the soil state. New data is needed to obtain accurate maps of surface soil moisture. [1] and [2], among many others, suggested that microwave 1.4 GHz measurements are the most suitable to extract information of the superficial soil water content. The Soil Moisture and Ocean Salinity (SMOS) mission of the European Space Agency (ESA), scheduled to be launched in summer 2009, will provide this information. For the first time, global fields of L-band brightness temperatures will be provided. SMOS brightness temperatures will be integrated in the ECMWF full data assimilation chain. [3] and [4] showed that a good initialization of soil moisture in NWP models could have a significant impact at continental and regional scales, respectively. It is expected that the use of the SMOS data will have an impact over the quality of the ECMWF short range weather forecast.

In preparation for the launch of the SMOS satellite and the assimilation of the incoming SMOS L-band observed radiances, the ECMWF is undertaking some activities. This paper presents these activities and it shows some ongoing results.

2. ECMWF PLANNED ACTIVITES

2.1. Implementation and adjustments of the new surface data assimilation system

An advanced data assimilation system is currently being implemented and adjusted in order to integrate conventional observations and satellite measurements. It is based on a simplified Extended Kalman Filter (EKF). It minimizes a cost function J as in variational methods under a linear approximation ([5], [6]). The soil moisture in the three root zone layers (state vector $\mathbf{x}$) is adjusted by optimally combining the information between the model first guess ($\mathbf{x_b}$) and the vector of observations $\mathbf{y}$ (conventional observations and satellite radiances). The solution for the analyzed stated at time t is :

$$\mathbf{x_a^t} = \mathbf{x_b^t} + \mathbf{K}(\mathbf{y^t} - \mathbf{H}\mathbf{x_b^t})$$

with $\mathbf{H}$ the Jacobian of the observation operator and $\mathbf{K}$ the gain matrix :

$$\mathbf{x} = [\mathbf{B^{-1}} + \mathbf{H^T}\mathbf{R^{-1}}\mathbf{H}]^{-1}\mathbf{H^T}\mathbf{R^{-1}}$$

The Jacobian $\mathbf{H}$ is computed in finite differences, perturbing individually each component of the state vector by a small perturbation. This is computationally very expensive and it constitutes the main constraint in the implementation of the new surface analyses scheme. A decoupling approach is being tested to produce Jacobians at a reduced cost (de Rosnay et al., IGARSS 2009).

Another issue is the dynamical evolution of the background error covariance matrix $\mathbf{B}$. Some results have being obtained keeping $\mathbf{B}$ constant ([7]). This permets a fair comparison between the operational Optimal Interpolation scheme (OI) and the new simplified EKF performances. In order to take fully advantage of the new EKF scheme, our following step consists of cycling the $\mathbf{B}$ matrix. It will allow dynamically propagate the background error state between assimilation cycles producing more realistic background error fields. Some results will be shown.

2.2. Bias correction

By definition, the soil moisture analyses will only be optimal if there are negligible systematic errors between observations and the modelled background. ECMWF will develop and test a bias correction scheme (likely based on parameters like roughness and vegetation class) and applied to AMSR-E C-band data available since 2002. After the SMOS launch, the structure of the bias will be investigated at L-band and spatial and temporal structures will be compared between C-band and L-band.

2.3. Assimilation experiments

The previous developments will permit to test a set of assimilation experiments using the future operational simplfied EKF. Firstly, the new assimilation scheme will be tested with screen level variables. In parallel, another research experiment will be based on the assimilation of AMSR-E C-band brightness temperatures. Both experiments will be contrasted with the analyses increments obtained with the combined assimilation of screen level variables and C-band brightness temperatures. The future launch of SMOS will allow test this scheme with L-band observations, allowing the evaluation of the whole ECMWF assimilation chain at both C-band and L-band, and comparing the performances between the two frequencies.

3. REFERENCES

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