ASSIMILATION of BRIGHTNESS TEMPERATURES from the SOIL MOISTURE ACTIVE and PASSIVE (SMAP) MISSION: IMPACT STUDIES on SHORT-RANGE NUMERICAL WEATHER PREDICTION

S. Bélair, M. Carrera, B. Bilodeau, L. Ioannidou,, S. Solomon, M. Charron
Meteorological Research Division, Environment Canada

C.A. Lavaysse
McGill University

Soil moisture has been shown in many studies to be an important variable in numerical weather prediction (NWP) systems [1, 2, 3]. In many regions of the world, soil moisture exerts an important control on land surface evaporation, and is thus a determining factor in the partitioning of downwelling radiative energy incident at the surface. This energy partitioning into sensible and latent heat surface fluxes plays a major role in the evolution and structure of the atmospheric boundary layer, with associated impacts on clouds, precipitation, and large (synoptic) scale weather systems.

In NWP systems currently operational at Environment Canada, soil moisture is initialized by assimilating screen-level air temperature and relative humidity. This indirect approach to specify soil moisture initial conditions relies on the physical link that exists in certain atmospheric conditions between soil moisture and near-surface air characteristics. Soil moisture (and surface temperatures) analysis increments are related to errors of the atmospheric model for screen-level air temperature and relative humidity using a simple optimal interpolation technique (e.g., if the model prediction near the surface is too cold and too humid, then negative analysis increments are applied to soil moisture). Inclusion of this assimilation technique for soil moisture has been shown to have a considerable positive impact on deterministic NWP at Environment Canada, for both short-range (regional) and medium-range (global) predictions [4].

This sensitivity of NWP to soil moisture, also observed in many other national operational centers, has been a motivating factor in the development of a new Canadian Land Data Assimilation System (CaLDAS), which main purpose is to better exploit available land surface information (from static databases, near-surface atmospheric conditions, and space-based remote sensing data) and to maximize their impact on environmental prediction (most importantly NWP) [5]. Current emphasis with this new system is to improve first guess modeling, significantly increase the amount of data used in land surface data assimilation, and use more sophisticated assimilation techniques for the optimal combination of background information (i.e., model first guess) and observations.

CaLDAS performance for the assimilation of L-band brightness temperatures, such as what will become available with NASA's Soil Moisture Active and Passive (SMAP), is currently being evaluated in the context of so-called synthetic experiments, or Observing Systems Simulation Experiments (OSSEs). The main objective of these experiments is to test the proper functioning of the land data assimilation system, focusing on an Ensemble Kalman Filter (EnKF) version of CaLDAS (it should be mentioned that a variational version of CaLDAS also exists). These tests are also used to evaluate the potential for new techniques recently developed at Environment Canada for the specification of first guess error covariance matrices. Very simple OSSE configurations are currently used, but more complex (i.e., more realistic) experimental set-ups are being prepared.

In order to examine the potential impact of the assimilation of SMAP brightness temperatures in CaLDAS, the OSSE experiments are in the process of being extended to include an atmospheric component. The sensitivity of atmospheric predictions on soil moisture conditions is being examined for both deterministic and probabilistic NWPs. In the deterministic mode, a series of North American atmospheric integrations initialized with CaLDAS soil moisture (based on the assimilation of synthetic L-band brightness temperatures) are compared with integrations issued from soil moisture from both a reference land surface cycle (considered as the 'truth') and from an open-loop cycle (initialized with soil moisture conditions quite different from the reference cycle, without any data assimilation). Although these tests are relatively simple and do not represent the entire range of interactions between land surface and atmospheric systems, they will provide a preliminary estimation of the potential impact of soil moisture improvements related to the inclusion of SMAP data into CaLDAS.

In the probabilistic mode, the impact of including an ensemble of soil moisture initial conditions from the EnKF version of CaLDAS on the performance of a Regional Ensemble Prediction System (REPS) [6] is being evaluated. Recent investigations have shown that the current version of this system underestimates the model dispersion of low-level atmospheric conditions, leading among other things to poor reliability in the Brier Skill Score.

Results for all these experiments, together with their implications for short-range NWP, will be presented at the conference.

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