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Stochastic approach to represent subgrid-scale variability of snow cover in RUC Land-Surface Model (RUC LSM)

Tatiana G. Smirnova (1,3), Siwei He (1,2), Stanley G. Benjamin (1), and John M. Brown (1)

(1) National Oceanic and Atmospheric Administration, Boulder, United States (tanya.smirnova@noaa.gov), (2) National Research Council, Washington, DC, United States, (3) CIRES, University of Colorado, Boulder, CO, United States

The RUC Land-Surface Model (LSM) is used as a land surface component in the NOAA operational Rapid Refresh (RAP) short-range weather prediction model over North America domain and in the High-Resolution Rapid Refresh (HRRR) over CONUS and Alaska domains. It is also implemented in the Next Generation Global Prediction System (NGGPS) as part of the advanced physics (RAP/HRRR) suite. The RUC LSM performance has been evaluated for almost two decades within the real-time operational weather prediction systems focused on storm-scale predictions for severe weather and safer aviation. Valuable feedback from the National Weather Service forecast offices has motivated further advances in RUC LSM towards providing a more accurate lower boundary condition, including in snow-covered regions. One of them is the new treatment of energy budget for grid cells partially covered with snow. Sub-grid variability of snow depth is important for the evolution of the atmospheric boundary layer, since spatial distribution of snow is generally very heterogeneous and its properties are quite different from properties of snow-free surfaces.

In this paper, a new “mosaic” approach considers snow-covered and non-snow-covered portions of a grid cell independently, and independently determined surface fluxes are aggregated to feed back into the surface-layer scheme at the end of each time step. This new approach removes the constraint of keeping skin temperature of partially covered with snow grid cells at or below the freezing point, and helps to reduce cold biases in these regions. It also helps to improve the evolution of cycled model snow cover together with the new semi-empirical formulations for the density of frozen precipitation depending on hydrometeor type and surface temperature.
With the new “mosaic” approach for patchy snow, specification of a snow-covered fraction of a grid cell becomes critical. A scheme that gives more objective evaluation of snow fraction and represents sub-grid variability of snow depth has been implemented in RUC LSM. This new parameterization scheme is a stochastic model that describes spatial distribution of snow through an advection-diffusion equation, which is also called Fokker-Planck Equation (FPE). This enhancement to the RUC snow model, referred to as RUC-FPE LSM, is currently being validated through participation in the new Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP), and also is being tested in the experimental versions of RAP/HRRR at the NOAA Earth System Research Laboratory (ESRL). The RUC-FPE LSM is planned to be implemented in the next operational versions of RAP and HRRR at the NOAA National Centers for Environmental Prediction (NCEP). Description of the snow model enhancements and results from RUC-FPE LSM validation will be presented at the meeting.