World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:18, No:05, 2024

Improved Soil and Snow Treatment with the Rapid Update Cycle Land-Surface Model for Regional and Global Weather Predictions

Authors : Tatiana G. Smirnova, Stan G. Benjamin

Abstract : Rapid Update Cycle (RUC) land surface model (LSM) was a land-surface component in several generations of operational weather prediction models at the National Center for Environment Prediction (NCEP) at the National Oceanic and Atmospheric Administration (NOAA). It was designed for short-range weather predictions with an emphasis on severe weather and originally was intentionally simple to avoid uncertainties from poorly known parameters. Nevertheless, the RUC LSM, when coupled with the hourly-assimilating atmospheric model, can produce a realistic evolution of time-varying soil moisture and temperature, as well as the evolution of snow cover on the ground surface. This result is possible only if the soil/vegetation/snow component of the coupled weather prediction model has sufficient skill to avoid long-term drift. RUC LSM was first implemented in the operational NCEP Rapid Update Cycle (RUC) weather model in 1998 and later in the Weather Research Forecasting Model (WRF)-based Rapid Refresh (RAP) and High-resolution Rapid Refresh (HRRR). Being available to the international WRF community, it was implemented in operational weather models in Austria, New Zealand, and Switzerland. Based on the feedback from the US weather service offices and the international WRF community and also based on our own validation, RUC LSM has matured over the years. Also, a sea-ice module was added to RUC LSM for surface predictions over the Arctic sea-ice. Other modifications include refinements to the snow model and a more accurate specification of albedo, roughness length, and other surface properties. At present, RUC LSM is being tested in the regional application of the Unified Forecast System (UFS). The next generation UFS-based regional Rapid Refresh FV3 Standalone (RRFS) model will replace operational RAP and HRRR at NCEP. Over time, RUC LSM participated in several international model intercomparison projects to verify its skill using observed atmospheric forcing. The ESM-SnowMIP was the last of these experiments focused on the verification of snow models for open and forested regions. The simulations were performed for ten sites located in different climatic zones of the world forced with observed atmospheric conditions. While most of the 26 participating models have more sophisticated snow parameterizations than in RUC, RUC LSM got a high ranking in simulations of both snow water equivalent and surface temperature. However, ESM-SnowMIP experiment also revealed some issues in the RUC snow model, which will be addressed in this paper. One of them is the treatment of grid cells partially covered with snow. RUC snow module computes energy and moisture budgets of snow-covered and snow-free areas separately by aggregating the solutions at the end of each time step. Such treatment elevates the importance of computing in the model snow cover fraction. Improvements to the original simplistic threshold-based approach have been implemented and tested both offline and in the coupled weather model. The detailed description of changes to the snow cover fraction and other modifications to RUC soil and snow parameterizations will be described in this paper.

Keywords : land-surface models, weather prediction, hydrology, boundary-layer processes
Conference Title : ICWFM 2024 : International Conference on Weather Forecasting and Meteorology
Conference Location : Paris, France
Conference Dates : May 16-17, 2024