Improve and maintain LSM in NAM

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In weather and climate models, land surface models (LSMs) represent the land surface interactions with the atmosphere. The surface-atmosphere interactions have important impacts on atmospheric boundary layer dynamics and weather and climate variability. To improve the NAM (North American Model) performance, work has been conducted in two fields related to its LSM to: (1) accurately present timely land surface physical characteristics in land surface models; and (2) improve the parameterizations which represent the land surface interactions with the atmosphere.

1. Improve land surface physical parameters used in the NAM system.

   1.1 Incorporate real time fire products derived from satellite remote sensing into the NAM system. Wild fires can cause significant and rapid changes in land surface physical characteristics. Two fire burned area products have been developed: 1 km resolution data twice a day which covers the area between 20°N and 70°N, and 12 km resolution data four times a day which covers the area from the equator to the North Pole. A parameterization for land surface physical characteristics of burning areas in land surface models was developed. In this scheme, the changes in vegetation cover, surface albedo and surface roughness length caused by wild fires are considered. The parameterization was tested with the several fire cases, and has been implemented in the parallel NAM system.

   1.2 Incorporate a high resolution lake surface temperature climatology into the NAM system. Thousands of lakes in N. America on the scale of 4km (NAM target) are not resolved by the SST analysis. The influence of previously unresolved lakes may be felt on this scale and can no longer just be "filled in". Lakes significantly affect the structure of the atmospheric boundary layer and therefore surface momentum, mass and heat fluxes. Lake storage of runoff regulates stream outflow by sustaining low flows and suppressing peak discharges. Lake-effect precipitation occurs on the downwind coastal area of many medium to large size temperate lakes in winter. A lake-effect on air temperature has been observed near a small lake (less than 200 km^2) (Takahashi and Itagaki, 1980). In order to consider lake effects in the NAM system, a 1 km resolution lake surface temperature climatology was created by using Flake and 30 year NARR climatology data. Then this lake surface temperature climatology was combined with real time SST, and has been implemented in the parallel NAM system.

1.3 Incorporate a real time green vegetation fraction product in the NAM system. Green vegetation fraction is a very important parameter for representing the land surface interactions with the atmosphere. Monthly mean values from five year data from 1985 to 1989 is currently used in the NAM. Obviously, this data cannot represent the current real situation. Therefore, a new satellite product at 1 km resolution is under development. This new product has a weekly value updated daily, and has been tested in the NAM.

2. Improve the parameterizations which represent the land surface interactions with the atmosphere.

2.1 Snow cover significantly affects the earth surface albedo which can lower the short wave radiation absorbed by the surface and increase the long wave radiation emitted by the surface. Snow cover can also cause insulating effects for vegetation and wildlife. In addition, snow cover can affect water supplies, transportation, cultural practices, travel, and recreation for millions of people. Therefore, accurately forecasting snowfall and surface snow accumulation is important. In the previous version of the NAM, surface snow accumulation was based on the binary assumption of snow or no-snow, and surface snow density was based on the lowest model level air temperature. Recently, the rime factor from microphysics was added to the NCEP NAM land surface model (Noah) to expand the range of possible snow densities. Higher rime factor values allow greater snow density, which in turn decreases the snow depth. Incorporating rime factor information into the snow density calculation in the land surface model is based on the hypothesis that snowfall and accumulation forecasts in regions with mixed-phase precipitation would be improved. This new scheme has been implemented in the parallel NAM system.

2.2 Improve the energy budget calculation over frozen soil in the NAM. The total soil moisture can be divided into three parts: solid (ice), liquid (water) and gas (water vapor). The gas part is ignored in most LSMs. In summer (nonfrozen soil), the liquid soil moisture is the same as total soil moisture. However, in winter (frozen soil), the liquid soil moisture is the difference between the total soil moisture and soil ice. In most LSMs, the calculation of latent heat is based on total soil moisture, not the liquid soil moisture. This causes an inconsistency between the latent heat calculation in summer and winter. This is also the case in the NAM. The NAM obviously over-forecasts 2 m dew point temperatures in winter seasons, so a modification was made in the calculation. The latent heat is now calculated based on the liquid soil moisture. This not only removes the inconsistency between summer and winter seasons but also improves NAM performance. This modification has been implemented in the parallel NAM system.