Catrin Mills
Univ. of Illinois

Modification of the Weather Research and Forecasting Model's Treatment of Sea Ice Albedo over the Arctic Ocean

Summary of code changes

The ice and snow albedo parameterization (based on Ross and Walsh 1987) implemented into WRF's NOAH LSM (module_sf_noahlsm.F) is physically based and computationally efficient, using surface air temperature and surface skin temperature to represent the seasonal variability of sea ice albedo. The ice albedo (α_{ice}) and snow albedo (α_{snow}) parameterization is shown below:

$$\alpha_{ice} = \begin{cases} 0.65 \text{ if } T_{sfc} < 0°\text{C} \\ 0.65 - 0.04T_{air} \text{ if } 0°\text{C} < T_{air} < 5°\text{C} \\ 0.45 \text{ if } T_{air} = 5°\text{C} \end{cases} \qquad \alpha_{snow} = \begin{cases} 0.80 \text{ if } T_{sfc} < -5°\text{C} \\ 0.65 - 0.03T_{sfc} \text{ if } -5°\text{C} < T_{sfc} < 0°\text{C} \\ 0.65 \text{ if } T_{sfc} = 0°\text{C} \end{cases}$$

where T_{sfc} represents the surface skin temperature and T_{air} represent the surface air temperature. Curry et al. (2009) finds that the Ross and Walsh (1987) scheme well represents melting ice albedos and winter snow albedos. The

Using the sea ice fraction, the albedo over the ice-covered portion of a given grid point is linearly weighted using the snow and ice albedos calculated using equations (1) and (2). To overcome Noah's 100% snow cover fraction over ice, a snow cover fraction parameterization from Marshall and Oglesby (1994) was chosen for its reasonable representation of snow cover (after sensitivity tests using snow water equivalent depth, as well):

Snow cover = snow depth/(snow depth + surface roughness)

The surface roughness of sea ice is approximated as 0.1 m, adapted from values of sea ice thickness and roughness derived from helicopter laser system observations from Peterson et al. (2008).

In order to test this parameterization, the 1998 summer Arctic atmosphere was simulated using the albedo parameterization over the Surface Heat and Energy Budget of the Arctic (SHEBA) field campaign domain. This model integration was compared to a control run using the original WRF code and to observations from the SHEBA campaign and was shown to reasonably capture sea ice albedo variability during the summer.