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Snow complexity representation and GCM climate

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Accurate simulations of the snow cover strongly impact on the quality of weather and climate predictions as the solar radiation absorption at land-atmosphere interface is modified by a factor up to 4 in response to snow presence (albedo effect). In Northern latitudes and Mountainous regions snow acts also as an important energy and water reservoir and a correct representation of snow mass and snow density is crucial for temperature predictions at all time-scales, with direct consequences for soil hydrology (thermal insulation effect).

Three different complexity snow schemes implemented in the ECMWF land surface scheme HTESSEL are tested within the EC-EARTH framework. The snow schemes are: 1) OLD, the original HTESSEL single bulk layer snow scheme (same as in the ERA-40 and ERA-Interim reanalysis); 2) OPER, a new snow scheme in operations since September 2009, with a liquid water reservoir and revised formulations of snow density, fractional cover and snow albedo; and 3) ML3, a multi-layer version of OPER. All three snow schemes in HTESSEL are energy- and mass- balance models.

The multi-layer snow scheme, ML3, was validated in offline mode covering several spatial and temporal scales: (i) site simulations for several observation locations from the Snow Models intercomparison project-2 (SnowMip2) and (ii) global simulations driven by the meteorological forcing from the Global Soil Wetness Project-2 (GSWP2) and the ECMWF ERA-Interim re-analysis. On point locations ML3 improve snow mass simulations, while on a global scale the impacts are residual pointing to the need of coupled atmosphere simulations.

The 3 schemes are compared in the framework of the atmospheric model of EC-EARTH, based on the current seasonal forecast system of ECMWF. The standard configuration runs at T159 horizontal spectral resolution with 62 vertical levels. Three member ensembles of 30 years (1979-2008) simulations, with prescribed SSTs and sea ice, were performed for each of the snow schemes.

The impact on the model´s climate of snow representations of increasing complexity is evaluated. Comparison includes near surface temperature, snow cover extension and variability, and northern hemisphere circulation patterns and variability. The increased complexity of a multi-layer snow scheme shows its potential in modelling thick snowpacks in open areas (low vegetation) such as prairies or tundra in Northern Latitudes. This leads to an improved match to the observed near surface air temperature.