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- towards climate change services

Sensitivity of snow cover to horizontal resolution in a land surface model

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Snow cover is a highly variable land surface condition that exerts a strong control on the heat and moisture budget of the overlying atmosphere. Modeling studies based on long integrations of global circulation models (GCM) are normally carried out at very low resolution (typically coarser than 100 km) due to their high computational demand. On local scales, snow cover plays an important socioeconomic role, ranging from water management applications to outdoor recreation. These latter applications vary in horizontal resolution from a few hundred meters to a few kilometers, where small scale topography, land cover and local circulation effects play a significant role. In this study our focus will be on horizontal scales ranging from typical GCM global climate modeling to high resolution global weather forecasts.

In the land surface component of a GCM (land surface model – LSM), snow cover temporal and spatial variability is mainly determined by the overlying atmospheric conditions. However, once snowfall settles on the ground, the sub-grid scale variability associated with complex terrain and land cover variability (not resolved at the model resolution) is parameterized following simple physical and/or empirical relations. The present study intends to access the impact of horizontal resolution in the European Centre for Medium-Range Weather Forecasts (ECMWF) land surface model (HTESSEL). HTESSEL is forced by the ECMWF operational weather forecasts since March 2006 to December 2009 (runs in offline/stand-alone mode). The control run is carried out at the horizontal resolution of the forecasts at TL799 (gaussian reduced grid N400 -about 25 km). Two lower horizontal resolutions are then tested: TL255 (gaussian reduced grid - about 80 km, same as the ERA-Interim reanalysis), and TL95 (gaussian reduced grid N48 - about 200 km). The length of the simulations is rather small (only 46 months), however global meteorological forcing at 25 km can only be accessed through the ECMWF recent weather forecasts. Such high resolution associated with the state of the art modeling and assimilation frameworks guarantees that the atmospheric conditions seen by the LSM are as close as possible to reality. To assure that the two lower horizontal resolution simulations have a good quality forcing, an energy/mass conserving remapping was applied when upscaling the forcing fields. Special care was taken for the upscaling of temperature, specific humidity, surface pressure and downward longwave radiation considering the changes in mean orography between resolutions.

Snow cover simulations are validated against two daily observational products: 1) IMS Daily Northern Hemisphere Snow and Ice Analysis at 4 km resolution (National Snow and Ice Data Center) and 2) SNOWCLIM snow depth daily European domain at 0.1° resolution (German Weather Service). The present work is focused over Europe, namely in four domains: Alps, Central and Eastern Europe and Scandinavia, where conditional spatial sampling is performed in order to distinguish between complex versus flat terrain and forest versus exposed (low vegetation and bare ground) areas. The results are model dependent, but allow deriving important relations between resolution, orography and vegetation variability impacts on snow cover simulations.