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Topographic effects on longwave and shortwave surface radiation in a kilometre-scale regional climate model

Christian Steger[1], Jesus Vergara-Temprado[1], Nikolina Ban[2], and Christoph Schär[1]
[1]ETH Zürich, Institute for Atmospheric and Climate Science, Environmental Systems Science, Zürich, Switzerland
[2]Department of Atmospheric and Cryospheric Sciences (ACINN), University of Innsbruck, Innsbruck, Austria

Weather and climate in alpine areas are strongly modulated by complex topography. Besides its influence on atmospheric flow and thermodynamics (such as orographic precipitation and foehn winds), topography also affects incoming surface radiation in various ways. Direct shortwave radiation might be blocked due to shading effects from neighbouring terrain. Diffuse shortwave radiation can be altered by a reduced sky view factor and reflectance of radiation from surrounding terrain. Similar, the net longwave radiation is affected by emissions from neighbouring terrain.

Radiation in virtually all state-of-the-art weather and climate models is only computed in the vertical direction using the column approximation, and the above-mentioned effects are usually not represented. Still, a few models consider topographic effects by correcting incoming radiation fluxes based on topographic parameters like slope aspect and angle, elevation of horizon, and sky view factor. The Consortium for Small-scale Modeling (COSMO) model includes such a scheme, which is currently only used in the Numerical Weather Prediction mode of the model.

In this study, we apply the surface radiation correction scheme in the climate mode of COSMO. To study its impacts in detail, we force COSMO's land-surface model (TERRA) offline with output from a COSMO simulation, which was run without radiation correction at a horizontal resolution of 2.2 km and for a domain covering the Alps. A useful proxy to study the impact of the correction scheme is snow cover duration (SCD), because snow cover length is, amongst other factors, strongly controlled by incoming surface radiation that drives ablation. A comparison of SCD simulated by COSMO with satellite-derived snow cover data (MODIS and AVHRR) reveals a distinctive bias, where SCD is overestimated for south-facing grid cells and underestimated for north-facing cells. Applying the radiation correction in the offline TERRA simulation shows only a moderate reduction of the bias. One reason for this minor improvement is the fact that the topographic parameters are computed from a smoothed digital elevation model (DEM) – thus the impact of the radiation correction scheme is damped. If topographic parameters are computed from unsmoothed DEM, biases in SCD are further reduced. Currently, further sensitivity experiments are conducted to investigate the effect of computing the topographic parameters from a sub-grid DEM and to assess the energy conservation of the radiation correction scheme.