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Understanding the ECMWF winter surface temperature biases over Antarctica

Emanuel Dutra (1), Irina Sandu (1), Gianpaolo Balsamo (1), Anton Beljaars (1), Helene Freville (2), Etienne Vignon (3,4), and Eric Brun (2)

(1) ECMWF, Reading, United Kingdom (emanuel.dutra@ecmwf.int), (2) CNRM-GAME UMR3589, Météo-France and CNRS, Toulouse, France , (3) Université Grenoble Alpes, LGGE – UMR5183, 38000 Grenoble, France, (4) CNRS/UJF–Grenoble 1, Laboratoire de Glaciologie et Géophysique de l'Environnement,UMR5183

Atmospheric reanalysis provide long-term estimates of the state of the atmosphere and surface. However, the reanalysis quality is dependent on the quality and quantity of observations used by the data assimilation systems and by the performance of the forecast model. Recent studies have found that the ECMWF ERA-Interim reanalysis has a warm bias of surface temperature over Antarctica. We evaluate several factors that could explain this bias of surface temperature, and to some extent 2-meters temperature, in the ECMWF model and ERA-Interim reanalysis over Antarctica during winter. We focused on the Polar night where the solar radiation and latent heat fluxes can be neglected. Four main changes, derived from the surface energy balance, were tested including (i) reduction of the snow thermal inertia, (ii) full decoupling of the skin layer from the surface; (iii) reduced roughness lengths and (iv) different stability functions for the transfer coefficients calculations in the surface layer. Different configurations were tested within the ECMWF Integrated Forecasts System (IFS) in short-range forecasts and in stand-alone surface-only simulations at South Pole station. It was found that the model underestimates strong radiative cooling events and this can be mainly associated with a too strong land-atmosphere coupling over glaciers. The reduction of the snow thermally active depth had a positive effect allowing the model to better represent those radiative cooling effects. The reduction of the roughness lengths and the different stability functions also result in further cooling in stand-alone mode, but their impact was not so pronounced in the coupled forecasts. In general, averaged over the Antarctic continent, the reduction of the snow thermal active depth leads to a cooling of 1 K. The reduction of the roughness lengths resulted in an additional cooling of about 1 K. Our results indicate that the representation of a fast time scale to the thermal exchanges between the atmosphere and the surface is beneficial, suggesting the potential of a multi-layer snow scheme.