How uncertainties in surface drag impact the large-scale circulation

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Despite their importance for the large-scale circulation, to date the representation of drag processes remains a major source of uncertainty in global models. Among the different drag processes the representation of orographic drag is particularly challenging. This has been recently highlighted by the WGNE ‘Drag project' which demonstrated that the main NWP and climate models differ significantly in representation of the total parametrized surface stress and in the partitioning of surface stress among various physical processes, particularly in regions with orography. Here we show how uncertainties in the representation of parametrized surface stress, both over land and over oceans, influence the large-scale circulation on timescales ranging from a few days to climate timescales. Moreover, we show that the representation of the resolved orography is also very different, even among models with similar headline resolution. We then use the Integrated Forecasting System of the European Centre for Medium-Range Weather Forecasts (ECMWF) to demonstrate how much inter-model differences either in the resolved orography or the subgrid orography affect the skill of medium-range weather forecasts. We demonstrate that the representation of the resolved orography plays an important role for the prediction of both near-surface temperatures and the large-scale circulation. The degradation in forecast skill resulting from using a smoother resolved orography can only partially be alleviated by using more variability in the subgrid orography. This suggests that the parametrized drag does not affect the flow in exactly the same way as the resolved drag.