Geophysical Research Abstracts
Vol. 15, EGU2013-11604, 2013
EGU General Assembly 2013

Improving physical consistency for convective precipitation through cloud-resolving climate model simulations

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High spatial resolutions of a few kilometres or less allow switching off the regional climate model (RCM) parameterisation of convection, which is known as a major source of uncertainty. The crucial point is to determine if and to which extent higher resolution simulations are outperforming those at coarser resolution and only few studies are available on this topic on climatological time-scales. In this context, 30 years were simulated in a triple nesting setup with 50, 7 and 2.8 km resolutions with the RCM COSMO-CLM, driven with ERA40 reanalysis data. The investigation area covers the state of Baden-Württemberg in southwestern Germany, which is a region known for abundant orographically induced convective precipitation. A very dense network of rain gauges, with high temporal resolution, is used for evaluation of the model simulations. The purpose of this study is to examine the differences between the 7 and 2.8 km resolutions in the representation of both precipitation and the atmospheric conditions leading to convection. Besides standard analysis of the intensity distributions and diurnal cycle, also instability of the atmosphere and vertical profiles of temperature and humidity as well as cloud cover, radiation budget and triggering mechanisms are considered. Our results show that the RCM run at a cloud-resolving scale reduces the drizzle problem from the coarser resolutions, and improves the representation of both the hourly intensity distribution and the diurnal cycle of precipitation. In addition, the 2.8 km resolution shows a more consistent representation of the atmospheric conditions leading to convection, whereas the coarser simulation with convective parameterisations disconnects from the physical processes leading to convection. The results imply a large improvement in the physically consistent simulation of precipitation at higher spatial and temporal resolutions, which must be the way forward for regional climate modelling.