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Influence of different vertical and horizontal model resolutions on the simulated hydrological cycle of the GCM ECHAM5

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A new version of the atmospheric general circulation model (AGCM) ECHAM has recently become operational at the Max Planck Institute for Meteorology. This study investigates the impact of model resolution on the hydrological cycle in a suite of model simulations using this new ECHAM5 model. The resolutions investigated comprise the spectral horizontal resolutions T42, T63, T106, and T159 as well as two vertical resolutions with 19 (L19) and 31 (L31) vertical levels. The horizontal resolutions correspond to grid sizes of about 2.8°, 1.9°, 1.1° and 0.75° or rather 300 km, 200 km, 110 km and 80 km, respectively. Special attention is paid to the evaluation of precipitation on the regional scale by comparing model simulations with observational data in a number of catchments representing the major river systems on Earth in different climate zones. It is found that increased vertical resolution, from 19 to 31 atmospheric layers, has a beneficial effect on simulated precipitation with respect to both the annual mean and the annual cycle. On the other hand, the influence of increased horizontal resolution is comparatively smaller. For some catchments only the combined effect of increases in both kinds of resolution lead to a significant improvement, which indicates that the increase of resolution in only one dimension (either vertical or horizontal) may not be sufficient to yield a considerable improvement in the hydrological cycle simulated by a AGCM in general. Most of the improvements at higher vertical resolution, on the scale of a catchment, are due to large-scale moisture transport, whereas the impact of local water recycling through evapotranspiration is somewhat smaller. At high horizontal and vertical resolution (T106L31) the model captures most features of the observed hydrological cycle over land, and also the local and remote precipitation response to El Niño/Southern Oscillation (ENSO) events. Major deficiencies are

the overestimation of precipitation over the oceans, especially at higher vertical resolution, along steep mountain slopes and during the Asian summer monsoon season, whereas a dry bias exists over Australia. In addition, the model fails to reproduce the observed precipitation response to ENSO variability in the Indian Ocean and Africa. This might be related to missing coupled air-sea feedbacks in an AGCM forced with observed sea surface temperatures.