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Introduction of prognostic rain in ECHAM5: design and single column model simulations

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Abstract. Prognostic equations for the rain mass mixing ratio and the rain drop number concentration are introduced into the large-scale cloud microphysics parameterization of the ECHAM5 general circulation model (ECHAM5-PROG). To this end, a rain flux from one level to the next with the appropriate fall speed is introduced. This maintains rain water in the atmosphere to be available for the next time step. Rain formation in ECHAM5-PROG is, therefore, less dependent on the autoconversion rate than the standard ECHAM5 but shifts the emphasis towards the accretion rates in accordance with observations. ECHAM5-PROG is tested and evaluated with Single Column Model (SCM) simulations for two cases: the marine stratocumulus study EPIC (October 2001) and the continental mid-latitude ARM Cloud IOP (shallow frontal cloud case – March 2000). In case of heavy precipitation events, the prognostic equations for rain hardly affect the amount and timing of precipitation at the surface in different SCM simulations because heavy rain depends mainly on the large-scale forcing. In case of thin, drizzling clouds (i.e., stratocumulus), surface precipitation is sensitive to the number of sub-time steps used in the prognostic rain scheme. Cloud microphysical quantities, such as cloud liquid and rain water within the atmosphere, are sensitive to the number of sub-time steps in both considered cases. This results from the decreasing autoconversion rate and increasing accretion rate.

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