Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 6, 5067-5104, 2006
www.atmos-chem-phys.net/6/5067/2006/

The atmospheric chemistry general circulation model ECHAM5/MESSy1: consistent simulation of ozone from the surface to the mesosphere

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Abstract. The new Modular Earth Submodel System (MESSy) describes atmospheric chemistry and meteorological processes in a modular framework, following strict coding standards. It has been coupled to the ECHAM5 general circulation model, which has been slightly modified for this purpose. A 90-layer model setup up to 0.01 hPa was used at spectral T42 resolution to simulate the lower and middle atmosphere. With the high vertical resolution the model simulates the Quasi-Biennial Oscillation. The model meteorology has been tested to check the influence of the changes to ECHAM5 and the radiation interactions with the new representation of atmospheric composition. In the simulations presented here a Newtonian relaxation technique was applied in the tropospheric part of the domain to weakly nudge the model towards the analysed meteorology during the period 1998–2005. This allows an efficient and direct evaluation with satellite and in-situ data. It is shown that the tropospheric wave forcing of the stratosphere in the model suffices to reproduce major stratospheric warming events leading e.g. to the vortex split over Antarctica in 2002. Characteristic features such as dehydration and denitrification caused by the sedimentation of polar stratospheric cloud particles and ozone depletion during winter and spring are simulated well, although ozone loss in the lower polar stratosphere is slightly underestimated. The model realistically simulates stratosphere-troposphere exchange processes as indicated by comparisons with satellite and in situ measurements. The evaluation of tropospheric chemistry presented here focuses on the distributions of ozone, hydroxyl radicals, carbon monoxide and reactive nitrogen compounds. In spite of minor shortcomings, mostly related to the relatively coarse T42 resolution and the neglect of inter-annual changes in biomass burning emissions, the main characteristics of the trace gas distributions are generally reproduced well. The MESSy submodels and the ECHAM5/MESSy1 model output are available through the internet on request.

Final Revised Paper (PDF, 10522 KB) Supplement (251 KB) Discussion Paper (ACPD)

Citation: Jöckel, P., Tost, H., Pozzer, A., Brühl, C., Buchholz, J., Ganzeveld, L., Hoor, P., Kerkweg, A., Lawrence, M. G., Sander, R., Steil, B., Stiller, G., Tanarhte, M., Taraborrelli, D., van Aardenne, J., and Lelieveld, J.: The atmospheric chemistry general circulation model ECHAM5/MESSy1: consistent simulation of ozone from the surface to the mesosphere, Atmos. Chem. Phys., 6, 5067-5104, 2006. Bibtex EndNote Reference Manager