Volumes and Issues | Contents of Issue 23

Atmos. Chem. Phys., 7, 5945-5957, 2007
www.atmos-chem-phys.net/7/5945/2007/

Small-scale mixing processes enhancing troposphere-to-stratosphere transport by pyro-cumulonimbus storms

G. Luderer[1,*], J. Trentmann[2], K. Hungershöfer[3,**], M. Herzog[4,***], M. Fromm[5], and M. O. Andreae[1]

[1]Max Planck Institute for Chemistry, Dept. Biogeochemistry, Mainz, Germany
[2]Institute for Atmospheric Physics, Johannes Gutenberg University Mainz, Mainz, Germany
[3]Institute for Meteorology, University of Leipzig, Leipzig, Germany
[4]NOAA GFDL, Princeton, New Jersey, USA
[5]Naval Research Laboratory, Washington DC, USA,
[*]now at: Potsdam Institute for Climate Impact Research, Potsdam, Germany
[**]now at: LISA, CNRS/Univ. Paris 7&12, Créteil, France
[***]now at: Department of Geography, University of Cambridge, Cambridge, UK

Abstract. Deep convection induced by large forest fires is an efficient mechanism for transport of aerosol particles and trace gases into the upper troposphere and lower stratosphere (UT/LS). For many pyro-cumulonimbus clouds (pyroCbs) as well as other cases of severe convection without fire forcing, radiometric observations of cloud tops in the thermal infrared (IR) reveal characteristic structures, featuring a region of relatively high brightness temperatures (warm center) surrounded by a U-shaped region of low brightness temperatures.

We performed a numerical simulation of a specific case study of pyroCb using a non-hydrostatic cloud resolving model with a two-moment cloud microphysics parameterization and a prognostic turbulence scheme. The model is able to reproduce the thermal IR structure as observed from satellite radiometry. Our findings establish a close link between the observed temperature pattern and small-scale mixing processes atop and downwind of the overshooting dome of the pyroCb. Such small-scale mixing processes are strongly enhanced by the formation and breaking of a stationary gravity wave induced by the overshoot. They are found to increase the stratospheric penetration of the smoke by up to almost 30 K and thus are of major significance for irreversible transport of forest fire smoke into the lower stratosphere.

Final Revised Paper (PDF, 4208 KB) | Discussion Paper (ACPD)

Citation: Luderer, G., Trentmann, J., Hungershöfer, K., Herzog, M., Fromm, M., and Andreae, M. O.: Small-scale mixing processes enhancing troposphere-to-stratosphere transport by pyro-cumulonimbus storms, Atmos. Chem. Phys., 7, 5945-5957, 2007. Bibtex | EndNote | Reference Manager