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

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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 (pyroCb) 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.

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