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European export of ozone due to mountain venting based on a lagrangian chemistry model analysis

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The influence of mountain venting on the ozone production of the lower free troposphere (FT) over the Alps was investigated with a chemical box-model. Mountain venting is an efficient lifting mechanism that carries atmospheric boundary layer (ABL) pollutants to the lower FT on summer time fair-weather days. Little is known about the effect on net production in the free troposphere following mountain venting. A parameterization describing air mass export from the ABL to the FT was developed and applied in our model. The simulations were initialized with typical summer time background FT and Alpine ABL mixing ratios. Net O3 production was generally positive for day 0 of the simulation, when mountain venting occurred. From day 1 on net O3 production critically depended on a wide range of parameters, with initial nitrogen oxides (NOx) plus peroxy acetyl nitrates (PAN) mixing ratios in the ABL having the strongest influence. O3 mixing ratios remained larger in the simulations with venting than in the simulations for the FT background for a simulation period of 8 days. For low NO2+PAN situations ozone was destroyed in the FT from day 1 on, while high NO2+PAN in the atmospheric boundary layer led to ozone formation in the FT. Cluster average trajectories showed that pollutants vented in the Alps have a strong influence on the Mediterranean. O3 production on these trajectories was supported by release of NOx from PANs that acted as a reservoir species while the air was descending in the Mediterranean high pressure system. An other pathway of vented pollutants was towards Asia. By further lifting PANs were conserved and might be released, leading to O3 formation, when the air starts descending over Asia. The O3 production efficiency toward NOx destruction of an ABL air mass vented to the lower FT was enhanced to around a 20 ppb ozone per NOx consumed on a first day. The further development of the ozone production efficiency strongly depended on the initial conditions and the chosen trajectory.