Projected changes in global tropospheric ozone to 2030

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Introduction
Surface ozone levels have more than doubled over Europe since 1860, and are projected to rise further, as anthropogenic emissions of O₃ precursors (NOₓ, CO, CH₃, NMVOCs) increase globally. Emissions controls have been used successfully to reduce peak O₃ values seen during pollution episodes, and relatively tight regulation of future emissions is expected across much of the developed world to combat these episodes. However, O₃ episodes sit on top of a background level, which is determined by downward transfer from the free troposphere, where O₃ lifetimes are longer, wind-speeds are higher, and intercontinental transport is more important. Surface O₃ therefore depends on a combination of global and local processes. Rapid growth in developing world emissions, in particular from S.E. Asia, may counteract many of the benefits from local emissions controls in the developed world. Climate change may also affect future O₃ through changes in both chemistry, which is temperature and water vapour dependent, and meteorology, e.g. through changes in stratosphere-troposphere exchange (see poster by Collins et al), convection, rainfall, and cloud distributions. Other global scale influences may include changes in stratospheric O₃ and changes in natural emissions (e.g. lightning NOₓ, isoprene from vegetation). This modelling study uses the global chemistry-transport model STOCHEM to simulate the distribution of O₃ in 1990 and 2030, and then isolates the contributions from changes in anthropogenic emissions from Europe, N. America, and Asia over that time period. The impact of the projected increase in CH₄ is considered in a further experiment.

Asian O₃ export
(increase 1990-2030, 3 ppbv issuersurface)

The largest increases are seen over parts of the developing world, particularly in the tropics (S.E. Asia, Africa, Latin America). Mid-latitude Europe (~50°N) benefits from emissions reductions in E. Asia, Africa, Latin America). Mid-latitude Europe (~50°N) benefits from emissions reductions in E. America, and offers these are offset by long-range transport to the region.

Asian plume
S.E. Asia shows the largest regional increase in emissions, and suffers the largest increases in surface O₃. Asian ozone is exported over the Pacific and beyond (most strongly in NH spring), and also in a mid-tropospheric easterly plume in summer. The upper troposphere is affected over the whole of NH mid-latitudes, and for much of the year.

Conclusions
Surface ozone is expected to rise almost everywhere in the near future, but most strongly in the developing world, as emissions rise steeply. Regions with falling emissions will fare better, but will import ozone via long-range transport, more than offsetting benefits from local emissions reductions. Long-range transport is at its most effective in NH spring, due to the coincidence of two factors: a relatively long O₃ lifetime, and the seasonal increase in O₃ production leading the increase in O₃ destruction. These conspire factors, together with the spring peak in stratospheric input, also explain the spring maximum observed at many remote stations in the NH. Predicted O₃ increases are generally largest in spring, although near sources, the peak increase is in summer.

References