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Regional pollution potentials of megacities and other major population centers

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Abstract. Megacities and other major population centers represent large, concentrated sources of anthropogenic pollutants to the atmosphere, with consequences for both local air quality and for regional and global atmospheric chemistry. The tradeoffs between the regional buildup of pollutants near their sources versus long-range export depend on meteorological characteristics which vary as a function of geographical location and season. Both horizontal and vertical transport contribute to pollutant export, and the overall degree of export is strongly governed by the lifetimes of pollutants. We provide a first quantification of these tradeoffs and the main factors influencing them in terms of "regional pollution potentials", metrics based on simulations of representative tracers using the 3-D global model MATCH (Model of Atmospheric Transport and Chemistry). The tracers have three different lifetimes (1, 10, and 100 days) and are emitted from 36 continental large point sources. Several key features of the export characteristics emerge. For instance, long-range near-surface pollutant export is generally strongest in the middle and high latitudes, especially for source locations in Eurasia, for which 17–34% of a tracer with a 10-day lifetime is exported beyond 1000 km and still remains below 1 km altitude. On the other hand, pollutant export to the upper troposphere is greatest in the tropics, due to transport by deep convection, and for six source locations, more than 50% of the total mass of the 10-day lifetime tracer is found above 5 km altitude. Furthermore, not only are there order of magnitude interregional differences, such as between low and high latitudes, but also often substantial intraregional differences, which we discuss in light of the regional meteorological characteristics. We also contrast the roles of horizontal dilution and vertical mixing in reducing the pollution buildup in the regions including and surrounding the sources. For some regions such as Eurasia, dilution due to long-range horizontal transport governs the local and regional pollution buildup; however, on a global basis, differences in vertical mixing are dominant in determining the pollution buildup both around and further downwind of the source locations.

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