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Regional pollution potentials of megacities and other major population centers

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Emissions from megacities and other major population centers impact both local air quality and regional and global atmospheric chemistry. The tradeoff between the regional buildup of pollutants near their sources versus long-range export depends on meteorological characteristics which vary as a function of geographical location and season, as well as on the chemical lifetimes of pollutants. We provide a first quantification of this tradeoff and the main factors influencing it in terms of "regional pollution potentials", metrics based on simulations of artificial, representative tracers using the 3D 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 point sources representing the 30 current largest cities around the world plus 6 additional major population centers. Several key features of the export characteristics emerge: 1) long-range near-surface pollutant export is generally strongest in the middle and high latitudes, especially for source locations in Eurasia; 2) on the other hand, pollutant export to the upper troposphere is greatest in the tropics, due to transport by deep convection; 3) there are several substantial intraregional differences, for instance between the sources in western India and Pakistan versus eastern India and Bangladesh; 4) contrary to what one might initially expect, efficient long-range export does not necessarily correspond with a more significant dilution of pollutants near their source, rather the amount of low-level, long-range export (e.g., below 1 km and beyond 1000 km) is well-correlated with exceedences of surface density thresholds on regional scales near the source (e.g., within ~ 1000 km), implying that pollutant buildup to high densities in the surface layer of the region surrounding the source location is more strongly influenced by vertical than horizontal transport.