

Article

Air Quality Standards and Extreme Ozone Events in the São Paulo Megacity

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Supplementary Materials

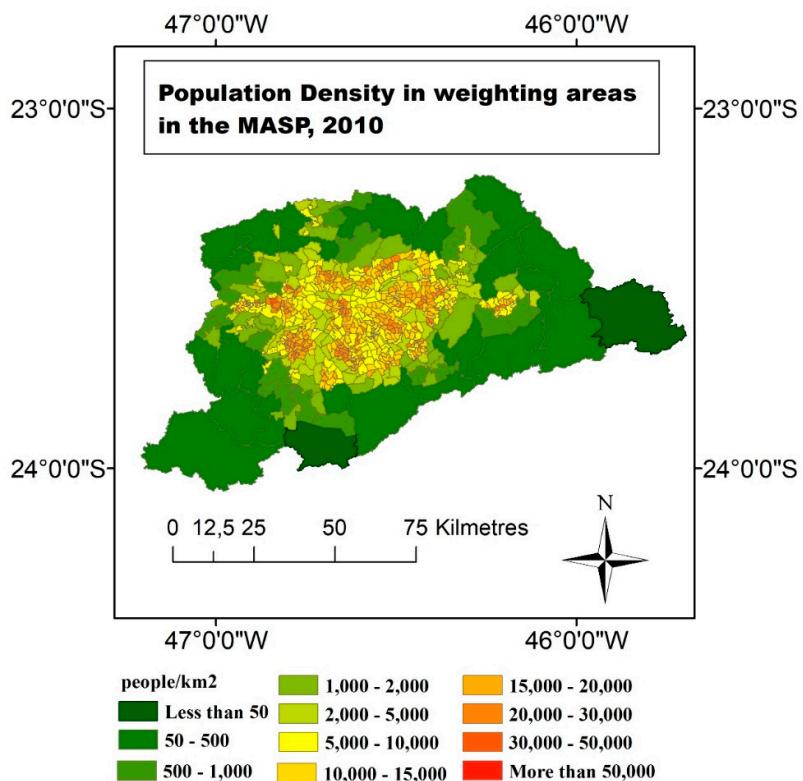


Figure S1. Population Density in the MASP weighting areas.

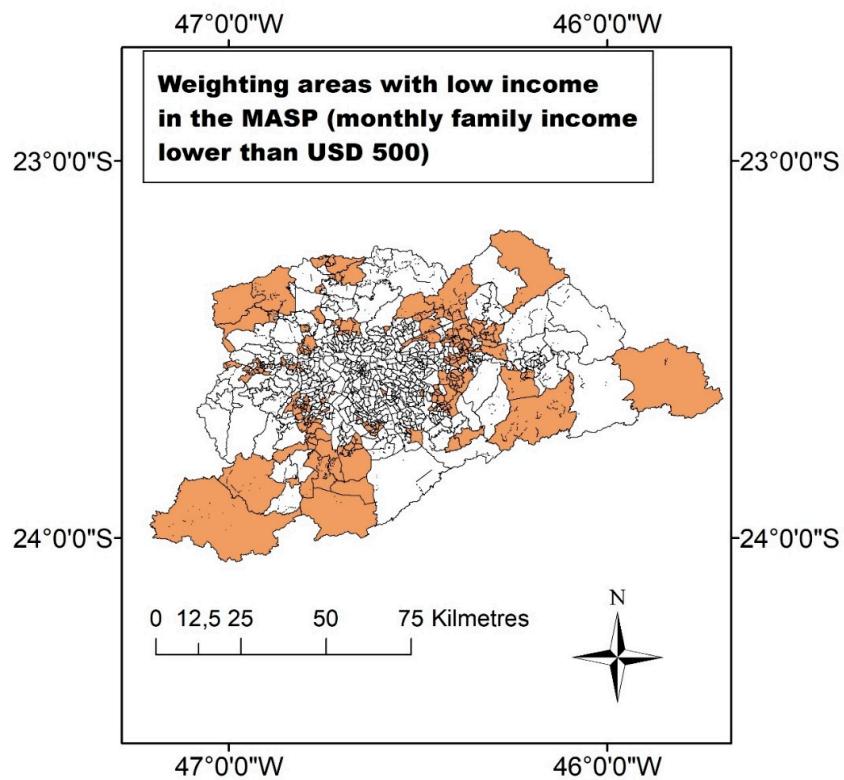
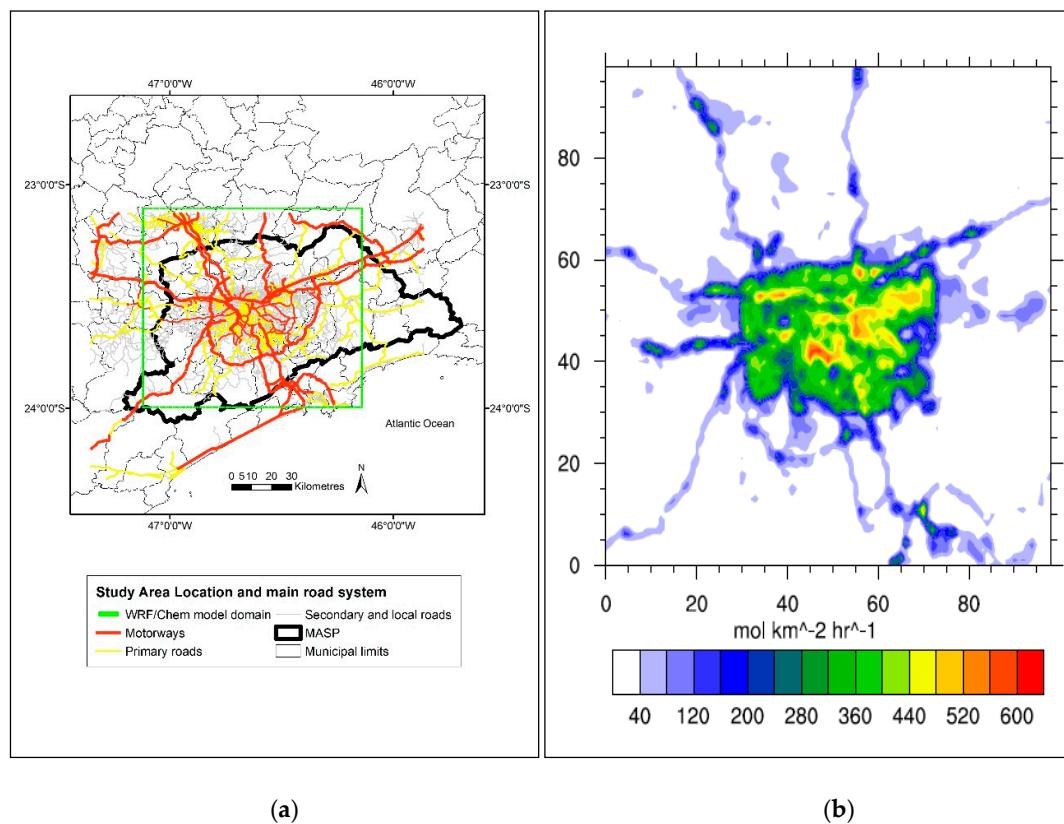


Figure S2. Low-income weighting areas in the MASP (monthly family income lower than USD 500).



(a)

(b)

Figure S3. (a) Location of the Metropolitan Area of São Paulo, its main road network and model domain (excluding the sparsely populated areas to the far east); (b) simplified example of emission file in the WRF/Chem model domain (green in figure S3(a)): emission of nitrogen monoxide (NO) at 19 hours.

Table S1. Parametrizations used in WRF/Chem.

Physics Options	Parametrization
Microphysics	Lin [1]
Boundary Layer	Ysu [2]
Cumulus	Grell [3]
Shortwave radiation	Goddard [4]
Longwave radiation	RRTM [5]
Land surface	Noah [6]
Surface layer	MM5 [7]
Gas-phase chemistry	CBMZ [8]
Photolysis	Fast-J [9]

References

1. Lin, Y.L.; Farley, R.D.; Orville, H.D. Bulk parameterization of the snow field in a cloud model. *J. Clim. Appl. Meteorol.* **1983**, *22*, 1065–1092, doi:10.1175/1520-0450(1983)022<1065:BPOTSF>2.0.CO;2.
2. Hong, S.Y.; Noh, Y.; Dudhia, J. A new vertical diffusion package with an explicit treatment of entrainment processes. *Mon. Weather Rev.* **2006**, *134*, 2318–2341, doi:10.1175/MWR3199.1.
3. Grell, G.A.; Dévényi, D. A generalized approach to parameterizing convection combining ensemble and data assimilation techniques. *Geophys. Res. Lett.* **2002**, *29*, 38-1-38-4, doi:10.1029/2002GL015311.

4. Chou, M.D.; Suarez, M.J. A solar radiation parameterization (CLIRAD-SW) for atmospheric studies. *NASA Tech. Memo* **1999**, *104606*, 48.
5. Mlawer, E.J.; Taubman, S.J.; Brown, P.D.; Iacono, M.J.; Clough, S.A. Radiative transfer for inhomogeneous atmospheres: RRTM, a validated correlated-k model for the longwave. *J. Geophys. Res. Atmos.* **1997**, *102*, 16663–16682, doi:10.1029/97JD00237.
6. Tewari, M.; Chen, F.; Wang, W.; Dudhia, J.; LeMone, M.A.; Mitchell, K.; Ek, M.; Gayno, G.; Wegiel, J.; Cuenca, R.H. Implementation and verification of the unified NOAH land surface model in the WRF model. In Proceedings of the 20th Conference on Weather Analysis and Forecasting/16th Conference on Numerical Weather Prediction, Seattle, WA, USA, 11–15 January 2004; American Meteorological Society: Boston, MA, USA, 2004; Volume 1115.
7. Zhang, D.; Anthes, R.A. A high-resolution model of the planetary boundary layer—Sensitivity tests and comparisons with SESAME-79 data. *J. Appl. Meteorol.* **1982**, *21*, 1594–1609, doi:10.1175/1520-0450(1982)021<1594:AHRMOT>2.0.CO;2.
8. Zaveri, R.A.; Peters, L.K.; A new lumped structure photochemical mechanism for large-scale applications. *J. Geophys. Res. Atmos.* **1999**, *104*, 30387–30415, doi:10.1029/1999JD900876.
9. Fast, J.D.; Gustafson, W.I., Jr.; Easter, R.C.; Zaveri, R.A.; Barnard, J.C.; Chapman, E.G.; Grell, G.A.; Peckham, S.E. Evolution of ozone, particulates, and aerosol direct radiative forcing in the vicinity of Houston using a fully coupled meteorology-chemistry-aerosol model. *J. Geophys. Res. Atmos.* **2006**, *111*, doi:10.1029/2005JD006721.



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