Submission Title:

Using Regionalized Air Quality Model Performance and Bayesian Maximum Entropy data fusion to map global surface ozone concentration

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Abstract

Estimates of ground-level ozone concentrations have been improved through data fusion of observations and atmospheric chemistry models. Our previous global ozone estimates for the Global Burden of Disease study corrected for bias uniformly across continents and then corrected near monitoring stations using the Bayesian Maximum Entropy (BME) framework for data fusion. Here, we use the Regionalized Air Quality Model Performance (RAMP) framework to correct model bias over a much larger spatial range than BME can, accounting for the spatial inhomogeneity of bias and nonlinearity as a function of modeled ozone. RAMP bias correction is applied to a composite of 9 global chemistry-climate models, based on the nearest set of monitors.

These estimates are then fused with observations using BME, which matches observations at measurement stations, with the influence of observations declining with distance in space and time. We create global ozone maps for each year from 1990 to 2017 at fine spatial resolution. RAMP is shown to create unrealistic discontinuities due to the spatial clustering of ozone monitors, which we overcome by applying a weighting for RAMP based on the number of monitors nearby. Incorporating RAMP before BME has little effect on model performance near stations, but strongly increases R2 by 0.15 at locations farther from stations, shown through a checkerboard cross-validation. Corrections to estimates differ based on location in space and time, confirming heterogeneity. We quantify the likelihood of exceeding selected ozone levels, finding that parts of the Middle East, India, and China are most likely to exceed 55 parts per billion (ppb) in 2017. About 96% of the global population was exposed to ozone levels above the World Health Organization guideline of 60 mg m 3 (30 ppb) in 2017. Our annual fine-resolution ozone estimates may be useful for several applications including epidemiology and assessments of impacts on health, agriculture, and ecosystems.