Title

Evaluating Commercial Marine Vessel Emissions Inventories Using Observations and the CMAQ Model

Authors

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Abstract

We investigate the representation of emissions from Class 3 commercial marine vessels (c3marine) within the Community Multiscale Air Quality (CMAQ) model. In present emissions inventories developed by the United States Environmental Protection Agency (EPA), c3marine emissions are divided into off-shore and near-shore files. Off-shore c3marine emissions, located within the US Exclusive Economic Zone waters, are assumed to occur above the surface at various vertical levels, reflecting stack-height and plume rise. Near-shore c3marine emissions, located close to the shoreline within state waters, are assumed to occur only at the surface. We describe an adjustment to the near-shore c3marine emissions that vertically distributes the original emissions in a manner consistent with off-shore c3marine emissions. Additionally, we remove near-shore c3marine emissions that overlap with off-shore c3marine emissions. We compare output from baseline CMAQ model simulations for June, July, and August (JJA) 2011 with surface ozone observations from the Air Quality System (AQS) monitoring sites to examine the efficacy of the c3marine emissions improvements. Model results at AQS sites show average maximum 8-hr surface ozone decreases up to ~6.5ppb along the Chesapeake Bay, and increases ~3-4ppb around Long Island Sound.

For some simulations, model improvements consisting of a 50% reduction in on-road mobile NOX emissions, and a reduction in the alkyl nitrate species group lifetime from ~10 days to ~1 day were implemented based off Anderson, et al. 2014 and Canty, et al. 2015, respectively. These model adjustments, coupled with the described c3marine emissions modifications, improve model representation of the atmosphere for our modeling domain.

Formaldehyde (HCHO) and NO2 satellite data from the Ozone Monitoring Instrument in JJA 2011 are used to observe the state of the atmospheric column (VOC or NOX limited) throughout the modeling domain. We also investigate the ability of CMAQ to accurately represent surface ozone production. The improved model scenario more closely simulates the HCHO/NO2 ratio calculated from satellite retrievals than the baseline model scenario for urban regions within the domain.

Model results for JJA 2018 show empirically driven model improvements, along with the c3marine emissions adjustment, reduce surface ozone by as much as ~13ppb for areas around the Chesapeake Bay and ~2-3ppb at sites in NY and CT downwind of New York City. These reductions are larger in 2018 than in 2011, highlighting the importance of c3marine emissions in future modeling scenarios for coastal regions.