Impacts of maritime shipping on air pollution along the U.S. East Coast

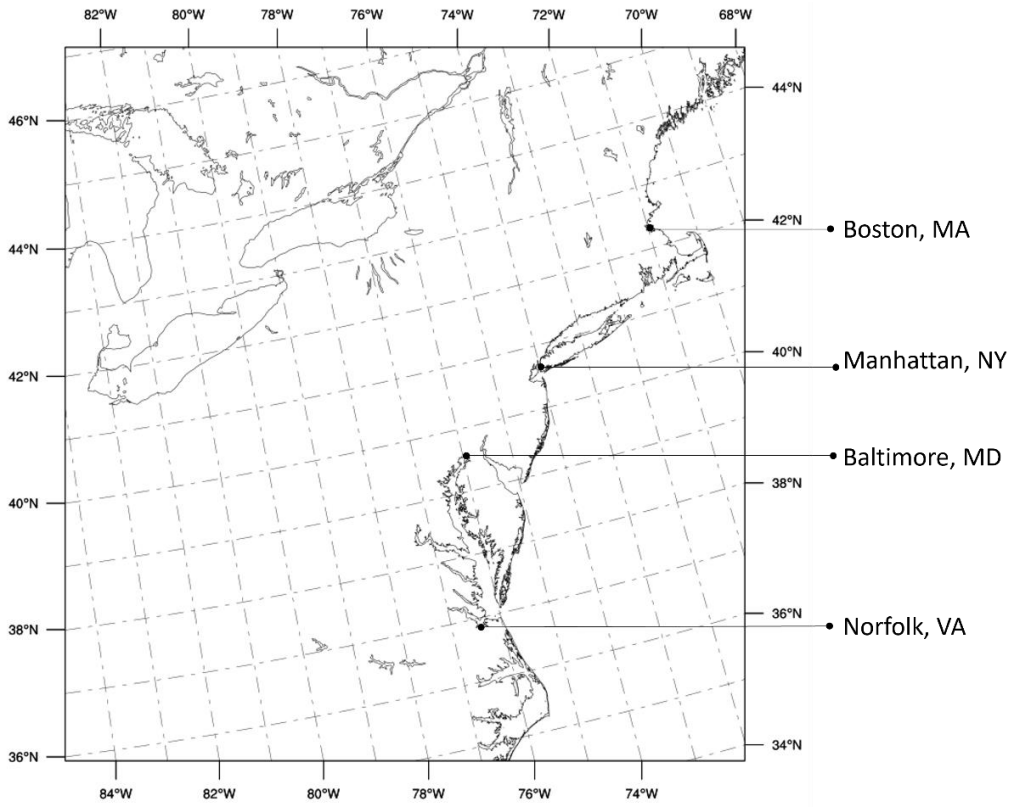
paper rebuttal:

Reviewer #2:

This manuscript offers an assessment of the effects of shipping emissions on air quality along the eastern coast of the United States pointing to substantial impacts within certain regions. I found the discussion to be well-reasoned and insightful, especially when tackling the dynamics between nitrogen oxides, ozone, and VOCs. Also, the perspective added by the authors on meeting the emission regulations currently in place in the U.S. is quite relevant. Thus, with a minor revision addressing the subsequent remarks, I am inclined to recommend its acceptance.
These include a more detailed introduction of the emission inventories (e.g., what anthropogenic sources have been included? And what quantity?), so the reader can better understand the share of shipping within the region studied. A map with the spatial representation of those emission inventories would also be relevant to understanding how the concentrations change compared to where emissions occur. In addition, if authors are willing to discuss the impact of shipping in different U.S. states, it would be relevant to include their location and name in at least one figure to contextualize the non-American readership.

Author Response:

Thanks for bringing this point up, we have added names of some important locations to the map of the domain for unfamiliar readers.



The reviewer brings up a valuable point that showing a map distribution of emissions would help understand the changes in concentrations compared to the emissions. However, an illustration of the spatial distribution of all emissions is challenging, in that, the emissions are provided in different formats (2D emissions and elevated point sources). In addition, in the 2D gridded emissions, several pollutants are included which are primary pollutants. With respect to the reviewer's comment, we produced maps of the 2D gridded emissions. But out of the four pollutants that we study here, only two (NO2 and SO2) are directly emitted into the atmosphere and therefore are included in emission data. We provided the plots for those two pollutants and added them to the "Emission Data" section with the description below:

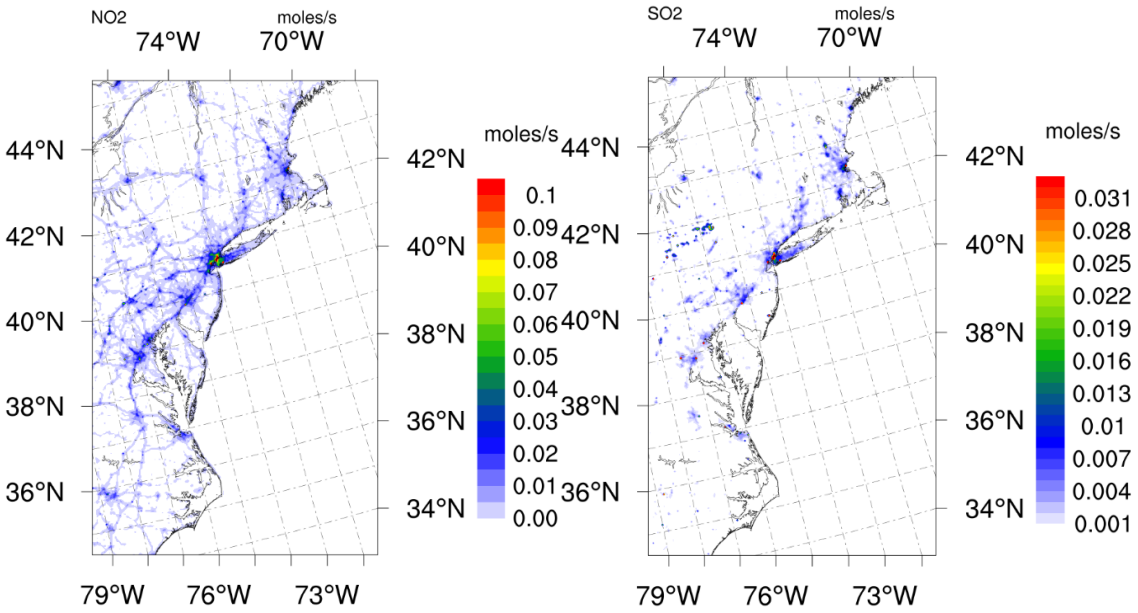


Figure 2. Gridded 2D emission distribution across the domain (averaged over three months) in moles/s for a) NO2, and b) SO2. The gridded emissions include all the 2D anthropogenic and biogenic emissions and exclude the elevated point sources.

> "The spatial distribution of the 2D gridded merged anthropogenic emissions are illustrated in Figure 2. It's important to note that O3 is a secondary pollutant, meaning it isn't directly emitted into the atmosphere. Conversely, PM2.5 is either a primary or secondary pollutant. Hence, we have specifically generated gridded emission maps for NO2 and SO2, only. The distribution of NO2 emissions closely mirrors the pattern of major highways and roads, as transportation stands out as one of the most significant sources of nitrogen oxide (NOx) emissions. The objective of this figure is to explain the spatial distribution of gridded anthropogenic emissions, shedding light on how concentrations change (Figures 6a and 7a) in relation to their emission sources."

About the emission inventory, we originally included a subsection (Emission Data) under the Methods section. However, we realized that it is short and may not be clear. In the original submission, we had:

"*In the 2018 NEI data, the gridded 2D emissions are merged, meaning that they are provided as one set of surface emissions that include all emission sectors. On the other hand, the elevated point sources are provided for each potential sector separately. For ship emissions, we use the emission data for the Commercial Marine Vessels (CMV) sector, which includes Category 1, 2 (small engine), and 3 (large engine) ships. CAMx computes the time-varying buoyant plume rise using stack parameters and the hourly emissions for each emissions sector, including CMV. Unlike previous EPA data sets, the CMV emissions in 2018 are at a one-hour temporal resolution. The initial and boundary conditions for this study are also provided by the EPA."*

To address the reviewer's concern, we have now expanded this paragraph about the emission inventory and different sectors within it as follows:

> "In the 2018 NEI data is based on the year 2017 activity. It contains merged gridded 2D surface emissions, meaning that they are provided as one set of surface emissions that include all the existing 2D emission sectors, i.e., anthropogenic emissions including aircraft emissions, on-road and non-road emissions, railroad emissions, and agricultural emissions. It also includes biogenic emissions. The 2018 inventory, however, lacks the wildfire emissions for this time and domain. Our investigation through the wildfire history showed that 2018 was a year with a low number of wildfires especially along the East Coast (https://www.nifc.gov/fire-information/statistics/wildfires) and therefore we do not believe this to significantly impact our findings. However, in future studies, including wildfire emissions upon availability is recommended. In contrast to the 2D grided emissions, the elevated point sources in this inventory are provided for each sector, separately.
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> For ship emissions, we use the emission data for the Commercial Marine Vessels (CMV) sector, which includes Category 1, 2 (small engine), and 3 (large engine) ships. These emissions are calculated based on the ship's fuel consumption, ship engine type, ship activity, and emission factors specific to those characteristics. EPA's CMV estimates are computed using detailed satellite-based automatic identification system (AIS) activity data from the US Coast Guard (EPA, 2017 & 2020). Unlike previous EPA data sets, the CMV emissions in 2018 are at a one-hour temporal resolution, which is very important and makes this study the first to utilize hourly emissions for the ships.
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> Other point sources present in this inventory include electric generation units, point oil, and gas sources, and any other point sources. CAMx computes the time-varying buoyant plume rise using stack parameters and the hourly emissions for each emissions sector, including CMV. The initial and boundary conditions for this study are also provided by the EPA and are products of the GEOS-Chem model."