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Downscaling fossil-fuel CO2 emissions to policy relevant scales: Current errors and biases, expected improvements, and future perspectives

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Many of the global and regional gridded emission inventories used in atmospheric are based on downscaling techniques. Regardless of their limitations compared to locally-constructed mechanistic emission inventories, such gridded datasets will keep a key role of transferring the information reported as emission inventories into science-based emission verification support (EVS) systems. Given the use of inverse modeling in the EVS systems, characterizing errors and biases associated with the downscaled emission field is critical in order to obtain robust verification results. However, such error characterization is often challenging due to the lack of objective metrics.

This study compares downscaled emissions from the ODIAC global high-resolution dataset to values taken from the reported inventories and from other independent emission products with the intent of assessing the validity (e.g., error, bias, or accuracy) of downscaled emissions databases at different policy relevant scales. ODIAC is based on its flagship high-resolution emission downscaling using satellite-observed nighttime lights (NTL) and point source information. The sole use of the NTL proxy for diffuse emissions has limitations. However, that provides a good opportunity to solely evaluate the performance of NTL as an emission proxy. It is now relatively straightforward to create detailed, high-resolution emission maps due to the advancements in geospatial modeling. However, such geospatial modeling techniques, which combine multiple pieces of information from different sources, are often neither validated nor even carefully evaluated.

As commonly done in previous emission uncertainty studies, we use the differences and agreements as a proxy for errors and improvements. We collect emission information reported at policy relevant scales, such as state/province/prefecture, cities and facility level (only for point sources). We also use locally-constructed fine-grained emission inventories as a quasi-truth for the emission distribution. We also assess the performance of NASA's Black Marble NTL product suites as a new emission proxy in relation to current the ODIAC proxy that is based on older NTL datasets. We also look at how these emission differences translate into atmospheric concentration differences using high-resolution WRF simulations.

Based on results from the comparison, we identify and discuss the challenges and limitations in the use of downscaled emissions in carbon monitoring at different policy-relevant scales, especially at the city level, and propose possible ways to overcome some of the challenges and provide emission fields that are useful for both science and policy applications.