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A high-resolution global inventory of fossil fuel CO_2 emission derived using a global power plant database and satellite-observed nightlight data

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We developed the Open-source Data Inventory of Anthropogenic CO_2 emissions (ODIAC), a global high-resolution fossil fuel CO_2 emission inventory for the years 1980-2007, by applying a combination of country-level fuel consumption statistics, a global point source database, and satellite-observed nightlight data. The primary goal of ODIAC is to provide a-priori information of fossil fuel CO_2 emission to the flux inversions using observational data of the Japanese Greenhouse Gas Observing Satellite (GOSAT).

Fossil fuel CO_2 emissions are a critical quantity required by the established flux inversion framework, as it is assumed to be a known quantity. Recent studies have suggested the feasibility of regional flux inversions using satellite-observed CO_2 beyond the established global inversion, and thus spatiotemporally detailed information of fossil fuel CO_2 emissions will be needed for emerging regional flux inversions. National emissions are often available in the gridded form, and the disaggregation of national emissions have been done using a common surrogate such as population and nightlight data; however, these approaches correlate poorly with sources at a resolution beyond country and city level.

In this study, national total emissions were derived from country-level fuel consumption statistics and emissions from point sources were separately calculated. We utilized point source emission and geographic location data available in the global power plant database CARMA (Carbon Monitoring and Action). The individual point source emissions were placed at the exact locations specified by CARMA. Emissions from other sources, the residual of national total emissions minus point source emissions, were distributed using nightlight data obtained by the US Air Force Defense Meteorological Satellite Project-Operational Line Scan (DMSP-OSL) instruments. As DMSP-OSL instruments often meet instrumental saturation over bright regions such as city cores, the single use of normal nightlight product might not be suitable for spatially allocating emissions at finer scales. We used the calibrated radiance data instead, which were obtained by special measurements operated in the reduced gain mode. Due to the low sensitivity of the instruments, the calibrated radiance data provide spatial variation in light intensity even in cities cores with less saturate pixels compared to the normal product.

Due to the spatial pattern inherited from nightlight data, the resulting spatial distribution of emissions is fairly different from that of conventional population-based emission maps. As nightlight data indicate exact locations of possible source regions, which mostly correspond to human settlements, source regions were well depicted up to city level. In addition to high spatial resolution, prominent point source emissions, which often do not appear on conventional maps, are presented in our inventory. Nighttime data may also work as a surrogate for applications other than human settlements, namely land transportation.

We compared the ODIAC inventory and other four existing inventories with the Vulcan US detailed comprehensive CO_2 emission inventory for the year 2002. The ODIAC inventory showed the best agreement in spatial pattern with the Vulcan among the participant inventories at reduced spatial resolutions, which are adequately useful for suggested emerging regional inversions.