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Use of auxiliary NO_2 and CO satellite observations to estimate CO_2 emissions from cities and power plants with a future European CO_2 satellite

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The majority of anthropogenic CO_2 is emitted on a tiny fraction of the globe by cities and large power plants. A growing number of cities have implemented long-term policies for reducing their energy demand and carbon footprint. The effective management of these policies will require consistent, reliable, and timely information on CO_2 emissions that are currently not available. The European Space Agency and the European Commission are therefore proposing a constellation of CO_2 imaging satellites to support the quantification of CO_2 emissions and to assist greenhouse gas mitigation policies at the national, city and facility level. Previous studies have shown that such satellites will have the potential to quantify emissions from strong point sources during a single overpass. Here, we present the results of a high-resolution model simulation study with the goal to investigate the benefit of auxiliary NO_2 and CO satellite observations as tracers of anthropogenic activity for estimating CO_2 emissions. For this purpose, we have set up a GPU-accelerated version of the COSMO numerical weather prediction model for a domain centered on the city of Berlin and covering a large number of power plants in Germany and neighboring countries. The simulations were conducted at a horizontal resolution of 1 x 1 km2 and sampled along the tracks of future CO_2 satellites expected to have a pixel size of 2 x 2 km2. In addition, several NO_2 and CO instrument scenarios were created considering the options of flying on the same or a different satellite platform with different overpass times. Unstructured and spatially correlated noise was applied to the simulated observations in order to investigate the ability to detect CO_2 plumes and to quantify CO_2 emissions with and without the support of NO_2 or CO observations. The results emphasize the need for high measurement precision and high observation frequency to identify a sufficient number of cloud-free pixels with local CO_2 enhancements above detection limit. An additional NO_2 instrument will greatly help distinguishing between CO_2 signals from anthropogenic sources and the biosphere and will be able to detect parts of the plumes where the CO_2 observations are below detection limit. Although CO would be another excellent tracer for anthropogenic emissions complementary to NO_2, its required precision and spatial resolution would have to be significantly better for than those of current CO observing instruments, which are already very demanding. This conclusion, however, is limited to the targets over Europe, where combustion is typically well controlled and CO emissions correspondingly low. In developing countries, a CO instrument may still add valuable information.