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Using global satellite and in-situ information to constrain CO_2 emissions

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Attempts to use atmospheric CO_2 and tracer measurements for constraining surface-atmosphere CO_2 anthropogenic emissions at various scales using atmospheric inversions are motivated by the need to improve bottom up accounting of human-induced emissions following the Paris Agreement on Climate. Different scales are addressed below, from sub-continental regions to countries and from countries to cities and large point sources. Policy makers not only need accurate and transparent information on emissions, but also, and more importantly on emission trends. Because anthropogenic emissions are spatially concentrated in cities, industrial centers and power plants, a key focus is on urban and industrial 'hot-spots' of emissions with high resolution observations and to use tracers that can separate the signal of fossil fuel CO_2 sources.

The European Copernicus CO_2 Report [Ciais et al., 2015] recommended an observing strategy based on sampling emissions hotspots using a constellation of satellites that could produce 2-d images of XCO_2. Research studies showed that a typical spatial resolution of 2 km x 2 km and individual sounding precision of less than 1 ppm would be sufficient to provide an error reduction of up to 50% on the emission of a large city [Broquet et al., 2017] or a large power plant [Bovensmann et al., 2010]. Actual column CO_2 measurements [Nassar et al., 2017] from OCO-2 acquired during satellite overpasses of a few large power plants and inverted with a Gaussian plume model showed U.S. power plants emission estimates could be constrained within 1–17% of reported daily emission values [Nassar et al., 2017]. Additional results on the estimation of CO_2 emissions from large cities using OCO-2 data [Lauvaux et al. in prep] will be shown. The ability of a constellation of satellite XCO_2 imagers to quantitatively constrain the national or regional budgets of CO_2 emissions from the sum of hotspots emissions observations, given the coverage and time sampling of the satellites, is still an open scientific question. Preliminary results from a global inversion of CO_2 emissions from emission hotspots will be presented to illustrate the potential of imagers.

Because smaller sources will not be detected from space, and because total CO_2 also in hot-spot areas contain significant contributions from ecosystem fluxes, it has been proposed to complement satellites by continental scale sampling of 14C in CO_2 and other fossil fuel CO_2 tracers like carbon monoxide [Levin et al., 2003; Levin and Karstens, 2007]. Measuring 14C in CO_2 (radiocarbon) represents the most promising approach for separating fossil CO_2 in the atmosphere from the signal of natural fluxes and hence for inversions to constrain fossil fuel CO_2 emissions. Results from an OSSE study to quantify fossil fuel CO_2 emissions at the scale of a mid-size European country was performed by [Wang et al., 2017], involving a coarse resolution transport model and continental scale networks consistent with ICOS to assess the 'uncertainty reduction' estimated from a Bayesian inversion and the performance of the inversion scheme to retrieve a 'true' emission field will be presented.