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Simultaneous CO_2 and $^{14}CO_2$ atmospheric inversions over Europe to quantify fossil fuel CO_2 emissions

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The concentration of atmospheric carbon dioxide (CO_2) has increased since the pre-industrial era (1750) due to human activity leading to a warming of the global land and ocean surface of 1.0 ± 0.2 °C over the last 30 years could reach 1.5 °C between 2030 and 2052. A better understanding of the fossil fuel CO_2 emission sources is essential to develop strategies to reduce these emissions, and thus trying to stop the global warming produced by the accumulation of CO_2 in the atmosphere. Policies to achieve these reductions require accurate and robust estimates of these emissions by a monitoring system based on independent atmospheric observations. This system must be able to separate the impact of anthropogenic CO_2 emissions from the effect of the complex natural carbon cycle, which both affect atmospheric CO_2 concentrations.

Radiocarbon ($^{14}CO_2$) measurements have been used in conjunction with total CO_2 measurements on both local (e.g. Indianapolis and Heidelberg) and regional scales (e.g. North America and Europe) to separate fossil fuel CO_2 fluxes from biogenic CO_2. The estimation of fossil fuel emissions from atmospheric observations can, in principle, be done by inverse modeling. In this work we will use the LUMIA (Lund University Modular Inversion Algorithm) for performing a series of observation system simulation experiments (OSSEs) inverting simultaneously terrestrial CO_2 and $^{14}CO_2$ observations from the Integrated Carbon Observation System (ICOS) station network to solve for both the natural fluxes (mainly terrestrial) and the anthropogenic fossil fuel emissions, accounting also for the ocean and terrestrial ^{14}C disequilibrium fluxes. The OSSEs will be performed on a spatial domain over Europe, with a spatial resolution of 0.1° for fossil fuel CO_2 sources and 0.5° for natural CO_2 fluxes and a weekly temporal resolution for natural and anthropogenic emissions and monthly for ocean and terrestrial disequilibrium fluxes 2009 to 2011. We will assess the suitability of the current ICOS $^{14}CO_2$ observation network as well as potential extensions to estimate anthropogenic fossil fuel emissions.