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Quantifying fossil fuel CO_2 from continuous measurements of APO: a novel approach

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Using atmospheric measurements to accurately quantify CO_2 emissions from fossil fuel sources requires the separation of biospheric and anthropogenic CO_2 fluxes. The ability to quantify the fossil fuel component of CO_2 ($ffCO_2$) from atmospheric measurements enables more accurate 'top-down' verification of CO_2 emissions inventories, which frequently have large uncertainty. Typically, $ffCO_2$ is quantified (in ppm units) from discrete atmospheric measurements of $\Delta 14CO_2$, combined with higher resolution atmospheric CO measurements, and with knowledge of CO:$ffCO_2$ ratios. In the United Kingdom (UK), however, measurements of $\Delta 14CO_2$ are often significantly biased by nuclear power plant influences, which limit the use of this approach.

We present a novel approach for quantifying $ffCO_2$ using measurements of APO (Atmospheric Potential Oxygen; a tracer derived from concurrent measurements of CO_2 and O_2) from two measurement sites in Norfolk, UK. Our approach is similar to that used for quantifying $ffCO_2$ from CO measurements ($ffCO_2$(CO)), whereby $ffCO_2$(APO) = (APOmeas – APObg)/RAPO, where (APOmeas – APObg) is the APO deviation from the background, and RAPO is the APO:CO_2 combustion ratio for fossil fuel. Time varying values of RAPO are calculated from the global gridded COFFEE (CO_2 release and Oxygen uptake from Fossil Fuel Emission Estimate) dataset, combined with NAME (Numerical Atmospheric-dispersion Modelling Environment) transport model footprints. We compare our $ffCO_2$(APO) results to results obtained using the $ffCO_2$(CO) method, using CO:CO_2 fossil fuel emission ratios (RCO) from the EDGAR (Emission Database for Global Atmospheric Research) database. We find that the APO $ffCO_2$ quantification method is more precise than the CO method, owing primarily to a smaller range of possible APO:CO_2 fossil fuel emission ratios, compared to the CO:CO_2 emission ratio range.

Using a long-term dataset of atmospheric O_2, CO_2, CO and $\Delta 14CO_2$ from Lutjewad, The Netherlands, we examine the accuracy of our $ffCO_2$(APO) method, and assess the potential of using APO to quantify $ffCO_2$ independently from $\Delta 14CO_2$ measurements, which, as well as being unreliable in many UK regions, are very costly. Using APO to quantify $ffCO_2$ has significant policy relevance, with the potential to provide more accurate and more precise top-down verification of fossil fuel emissions.