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Advancement of methods for atmospheric radiocarbon measurements in the UK

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Global atmospheric carbon dioxide (CO_2) levels hit a record high of 410 ppm in 2017, generally accepted to be due to fossil fuel emissions. Estimating CO_2 emissions from fossil fuel burning proves challenging due to natural fluxes in and out of the atmosphere. Radiocarbon (^{14}C) measurements offers a method to measure the amount of recently added CO_2 from fossil fuel burning. This is possible as fossil fuel are completely depleted in radiocarbon, due to their age. Therefore, the amount of recently added CO_2 from fossil fuels can be measured as a depletion of the ^{14}C content in the air.

This method has been applied successfully by several groups on city and regional scales. In the UK we hope to apply the technique on a national scale. Previous studies have shown that $^{14}CO_2$ emissions from the nuclear industry mask the ^{14}C depletion caused by fossil fuel emissions, leading to an underestimation in fossil fuel CO_2. In some regions of the world this is not a problem, however in the UK there is a significant nuclear industry. A correction is applied for the enhancement from the nuclear industry however the $^{14}CO_2$ emissions from the nuclear power plants are highly variable. We are in discussion with the industry to improve the correction applied, as has been done in other countries.

Current sampling and measurement techniques are costly, time consuming and difficulties arise when comparing samples to modelled data. We have improved the flask sample collection method from instantaneous sampling over 1-2 minutes to automated integrated sampling, with a constant varying flow rate following an exponential to allow for equal filling of a large volume over 60 minutes, adapted from J. Turnbull et. al. (2012). This sampling method will provide better comparisons to modelled data for source assignment.

Once samples are collected they will be returned to the lab for analysis by accelerator mass spectrometry (AMS). Traditionally this is done by extracting the sample using liquid nitrogen before graphitising the sample manually, both time consuming processes. With the advancement of automated graphitisation equipment (AGE) L. Wacker et. al. (2010), we have begun developing a manual system for the direct extraction of whole air flasks onto the zeolite trap for graphitisation. This reduces the number of steps and time needed per sample. We will present the initial results from both the sample collection and extraction process.

Turnbull, J., Guenther, D., Karion, A., Sweeney, C., Anderson, E., Andrews, A., Kofler, J., Miles, N., Newberger, T., Richardson, S., Tans, P., An integrated flask sample collection system for greenhouse gas measurements, Atmos, Meas. Tech., 5, 2321–2327, 2012

Wacker, L., Nemec, M. Bourguin, J., A revolutionary graphitization system: Fully automated, compact and simple. NIM B, 268(7-8), 931-934, 2010