Modular Relaxed Eddy Covariance sensor for Air Quality: MOREC-AQ

- A low-cost approach to air quality flux measurements

Lekan Popoola[(1)],Thomas Wall[(2)], Zaheer Nasar[(3)]

(1) Yusuf Hamied Department of Chemistry, University of Cambridge, UK
(2) STFC RAL Space, Rutherford Appleton Laboratory, Harwell Campus, UK
(3) School of Water, Energy and Environment, Cranfield University, UK

(1) oamp2@cam.ac.uk
(2) thomas.wall@stfc.ac.uk
(3)z.a.nasar@cranfield.ac.uk

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1 Defra's Areas of Research Interest (ARI) in air quality challenge being addressed include:

- ARI 1: AQ improvements and link to health and environmental impact & outcome: (a) addressing issues non-exhaust emission (NEE) from farming and agriculture (b) quantifying and costing impact of ecosystem change
- ARI 2: evidence capability transformation and innovation: (a) use of low-cost sensors and (b) data to improve local emission inventories

2 Aims of Scoping Study

- Proof of concept for a low-cost Modular Relaxed Eddy Covariance (MOREC-AQ) measurement approach for general flux determination
- Feasibility study of miniature NH_3 instrument to incorporate into MOREC-AQ

(Spectroscopy Group at RAL Space- STFC)

4 Outputs of MOREC-AQ project: (I) Relaxed Eddy simulation

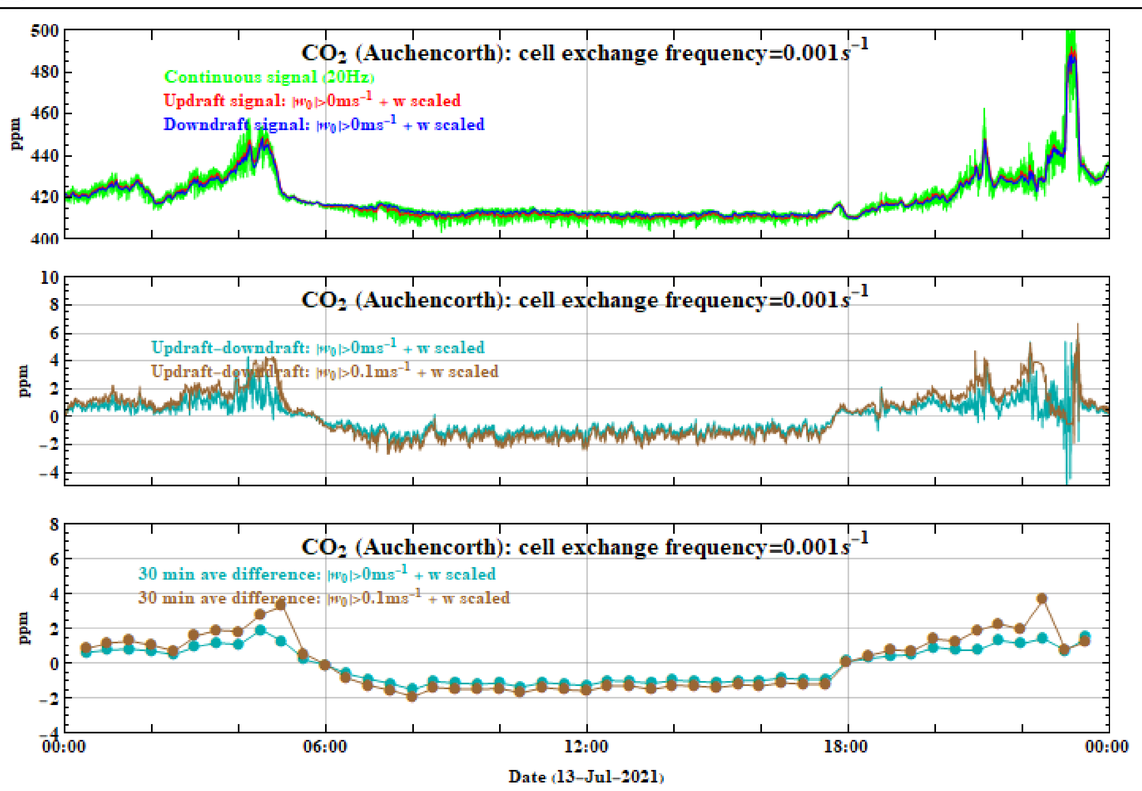

Figure 2: Example data for CO_2 at Auchencorth Moss field CEH, (a) continuous real data from high grade reference instrument at 20Hz (green), simulated signal expected in updraft and downdraft component (blue and red respectively), (b) difference between the updraft and downdraft signals (a measure of flux) with-(brown) and without a dead band (cyan), (c) hourly averages of the signal shown in (b).

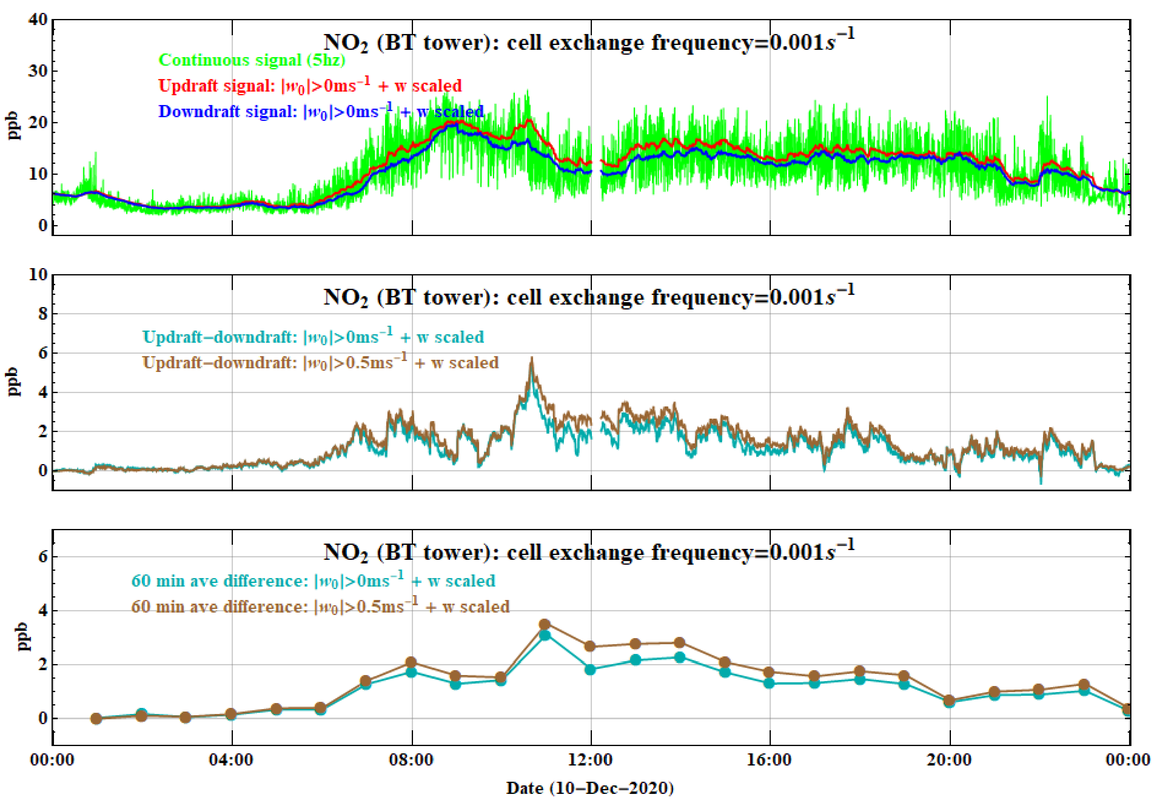

Figure 3: Example data for NO_2 BT Tower London, (a) continuous real data from high grade reference instrument at 5Hz (green), simulated signal expected in updraft and downdraft component (blue and red respectively), (b) difference between the updraft and downdraft signals (a measure of flux) with-(brown) and without a dead band (cyan), (c) hourly averages of the signal shown in (b).

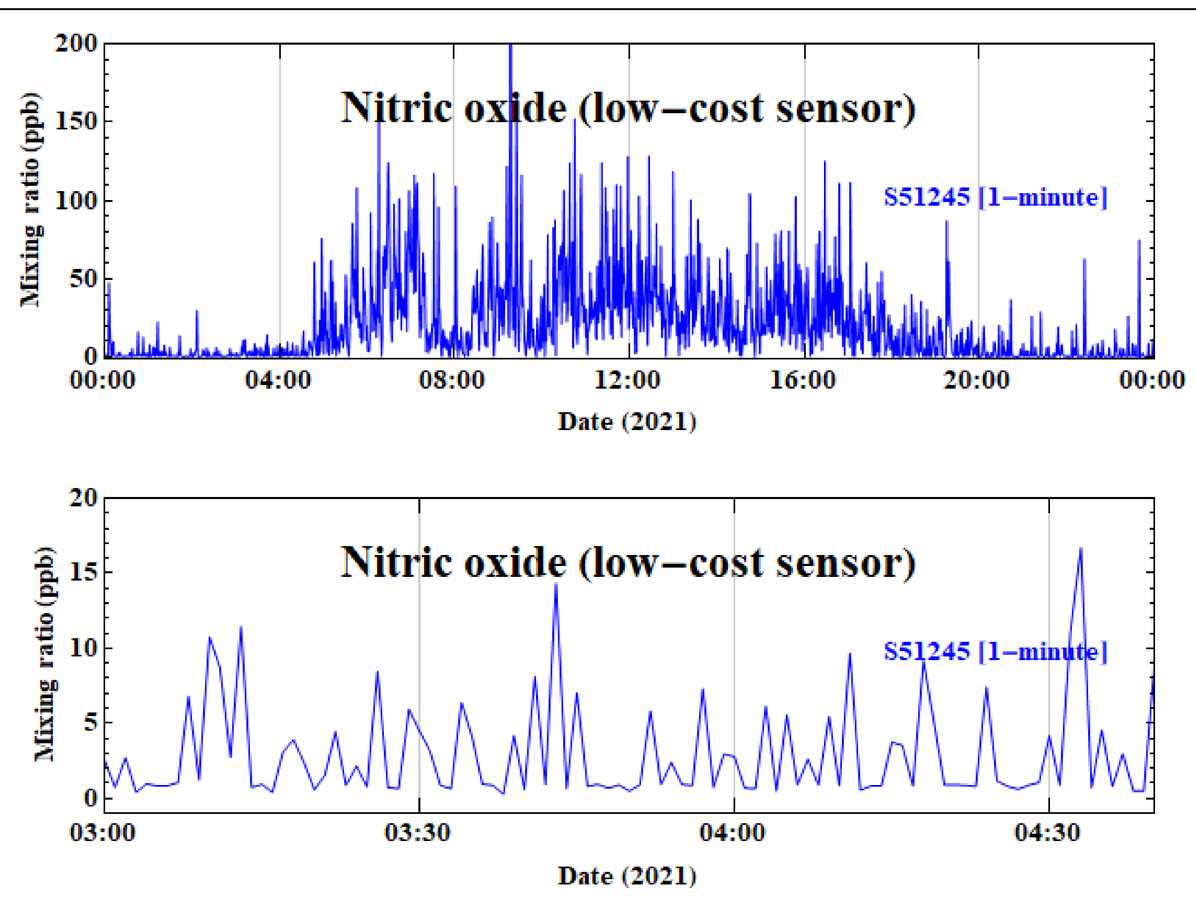

Figure 4: Sample data for real-world 1-minute NO data over a 24hr period (top) and zoomed in on the period 03:00 to 04:40, highlighting the magnitude of the early morning peak signals (bottom). Measurements are at ~4m above street level.

3 Methodology

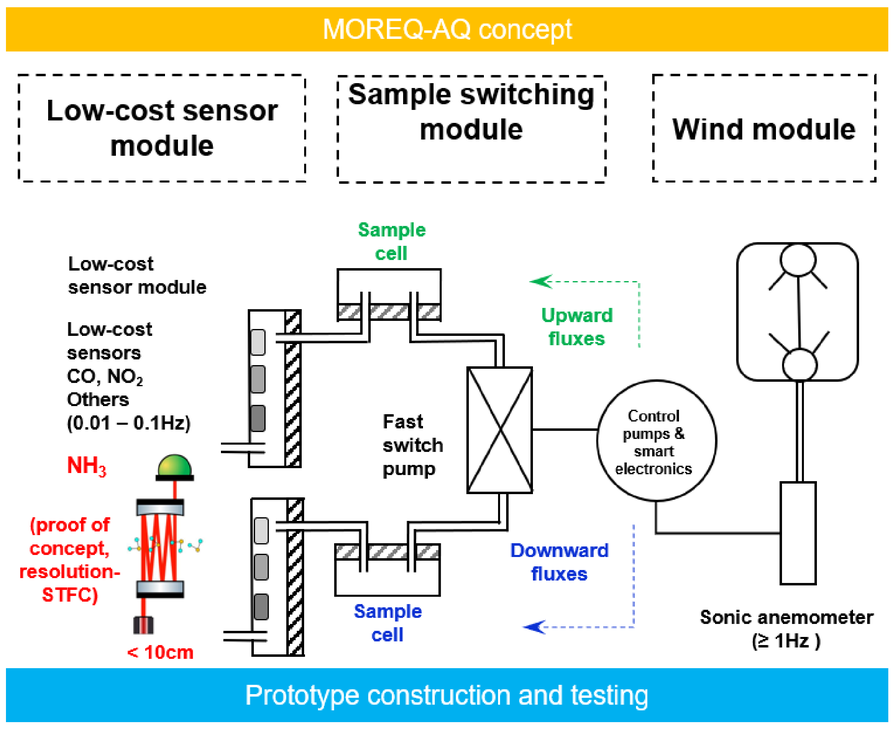

Figure 1: Schematics of prototype modular relaxed eddy instrumentation. The three modular units that comprise the design are shown in the figure

4 Outputs of MOREC-AQ project: (II) NH_3 simulation

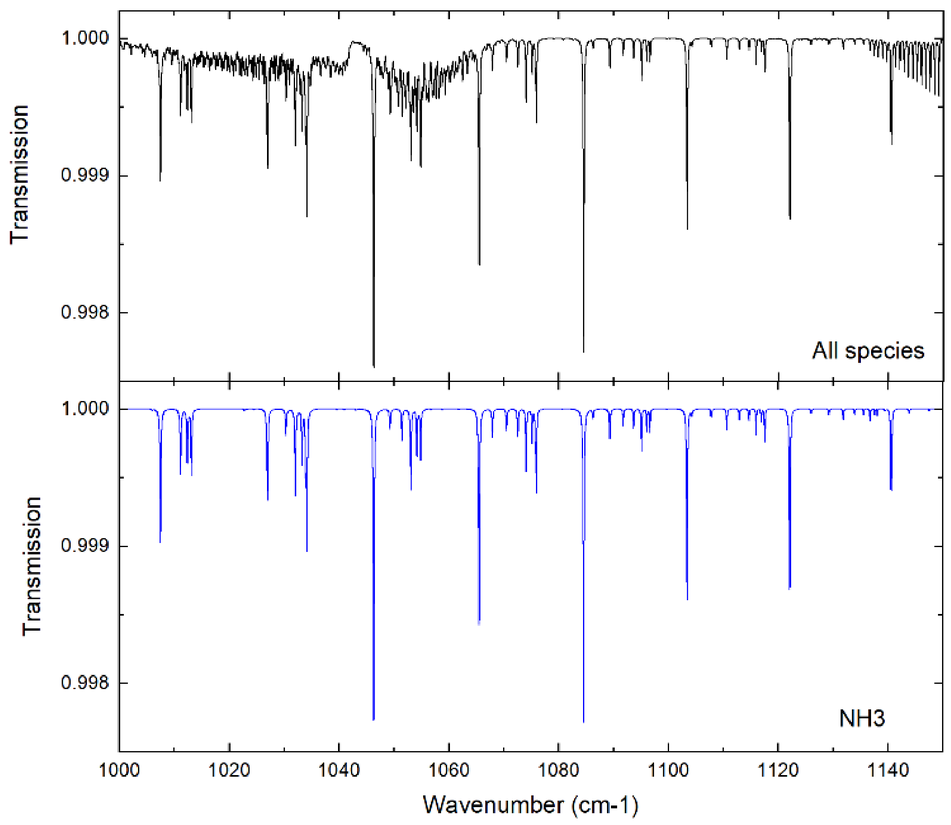

Figure 5: an example of modelled transmission spectra. The top panel shows the transmission through a 30 m optical path inside an MPC, with all atmospheric species included. The lower panel shows the same spectrum, but this time only with NH_3 included. The optimal molecular resonance in this spectral region is the one centred on 1084.6 cm^{-1}. This resonance leads to a strong feature that is well separated from interfering features from other atmospheric species. The phase dispersion modelling identified this as a good region for Chirped Laser Dispersion spectroscopy (CLaDS) detection, as well as the spectral region around 1103 cm^{-1}.

5 Future plans

Figure 6: Rendering of a MOREC-AQ unit shown to size in relative to a typical 3-D sonic anemometer

- Build and test an experimental prototype MOREC-AQ unit
- Explore additional species like CH_4 through the STFC RAL Space Spectroscopy Group
- Explore funding to opportunities to actualise these activities
- Testing of prototype as part of Landscape-Regen project (UCam-Regen)

Acknowledgements

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