UNIVERSITY OF LEICESTER

Field Spectroscopy Facility
Natural Environment Research Council

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

THE LONDON CARBON EMISSIONS EXPERIMENT

NEIL HUMPAGE – *UNIVERSITY OF LEICESTER*

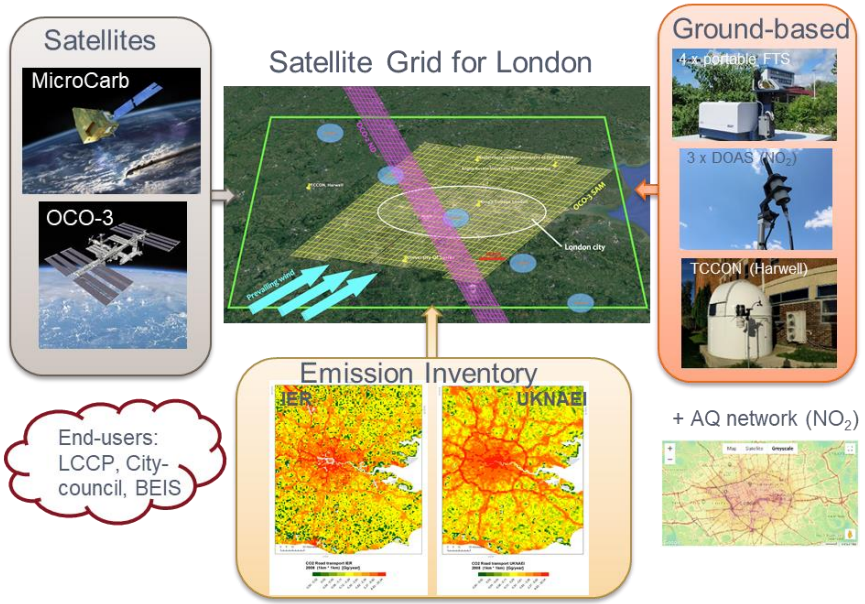
HARTMUT BOESCH – *NCEO, UNIVERSITY OF LEICESTER*

ROBBIE RAMSAY, ANDREW GRAY, JACK GILLESPIE, MATHEW WILLIAMS – *FIELD SPECTROSCOPY FACILITY, UNIVERSITY OF EDINBURGH*

JEROME WOODWARK – *UNIVERSITY OF EDINBURGH*

THE LONDON CARBON EMISSIONS EXPERIMENT CONCEPT

- Part of UK Natural Environment Research Council (NERC) DARE-UK project – see *dareuk.blogs.bristol.ac.uk*
- Establish ground-based remote sensing network (CO_2, CH_4, CO, NO_2, aerosol)
- Combine with city-focused satellites (OCO-3, MicroCarb)
- City-scale modelling to link to emission inventories
- London as testbed for studies on CO_2 emissions



NERC FIELD SPECTROSCOPY FACILITY – INVOLVEMENT IN PROJECT

- In 2019, the Field Spectroscopy Facility (FSF) acquired transformational capital to build a greenhouse gas (GHG) monitoring network
- Working with the University of Leicester, FSF will build three nodes that will be deployed to monitor London emissions
- Each node will include an automatic weather station, a Multi-Axis Differential Optical Absorption Spectrometer (MAX-DOAS), and an EM27/SUN Fourier transform spectrometer.
- This network will monitor CO_2, CH_4, CO, NO_2 and other trace gases above London, and provide a crucial resource for validating satellite-derived measurements of GHG products.

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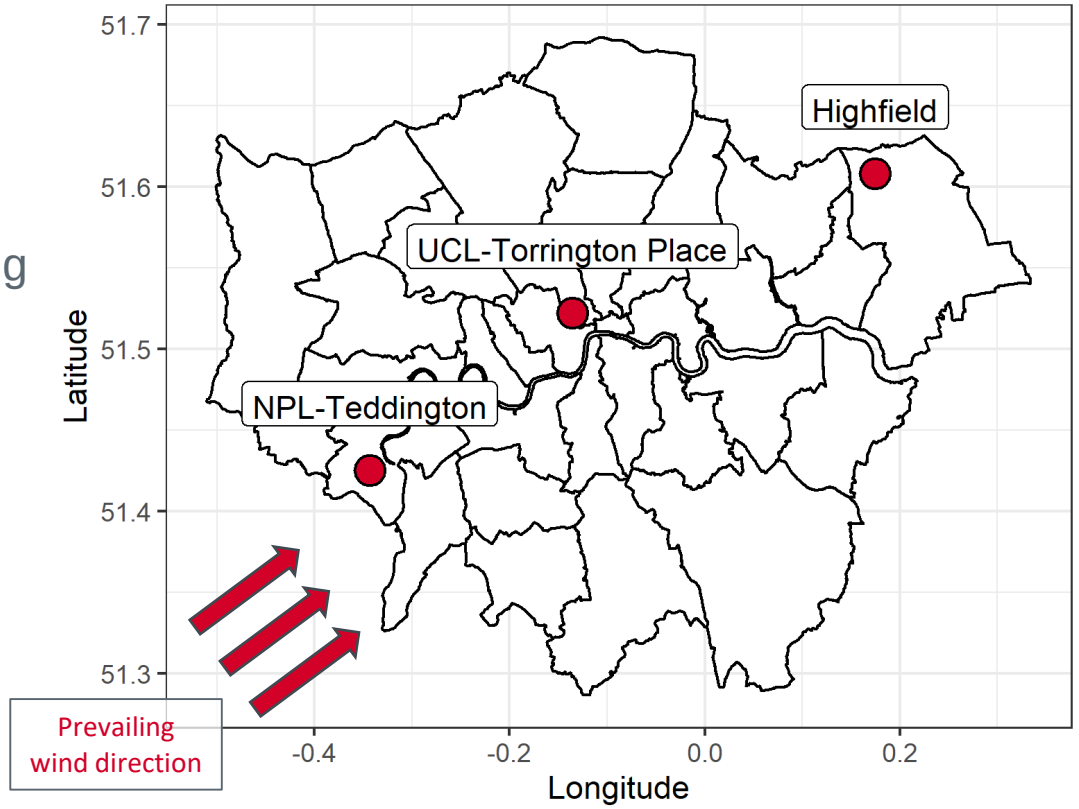
PROPOSED LOCATIONS

- Three “nodes” along a SW-NE transect, following the prevailing wind direction:
- SW Node – National Physical Laboratory, Teddington
- Central Node – University College London, Torrington Place
- NE Node – Highfield Residential Tower



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BRUKER EM27/SUN SPECTROMETER FOR GREENHOUSE GAS MONITORING

- Measures atmospheric absorption spectrum using direct sunlight as the light source: automatic solar tracker uses camera-based feedback system
- Fourier Transform spectrometer: in standard operation, 10 interferograms are co-added per observation → temporal frequency approximately 1 minute
- Two detectors at 0.5 cm^{-1} spectral resolution:
  - 5000 to 14500 cm^{-1} (0.69 to 2.0 µm): InGaAs detector
  - 4000 to 5500 cm^{-1} (1.8 to 2.5 µm): for carbon monoxide, extended range InGaAs detector with Ge filter
- Internal calibration source
- Portable and robust instrument
- Performance vs. TCCON (Gisi et al. 2012 AMT): difference in retrieved XCO_2 of (0.12 ± 0.08) % over 26 measurement days
- COCCON (Collaborative Carbon Column Observing Network, Frey et al. 2019 AMT):
  - Over 100 instruments in network, operated by universities and research institutes around the world
  - Calibrated against Karlsruhe Institute of Technology (KIT) reference instrument → traceability
  - Retrieval software (PROFFAST) developed by KIT and used by all EM27/SUN operators → consistency of data processing approach

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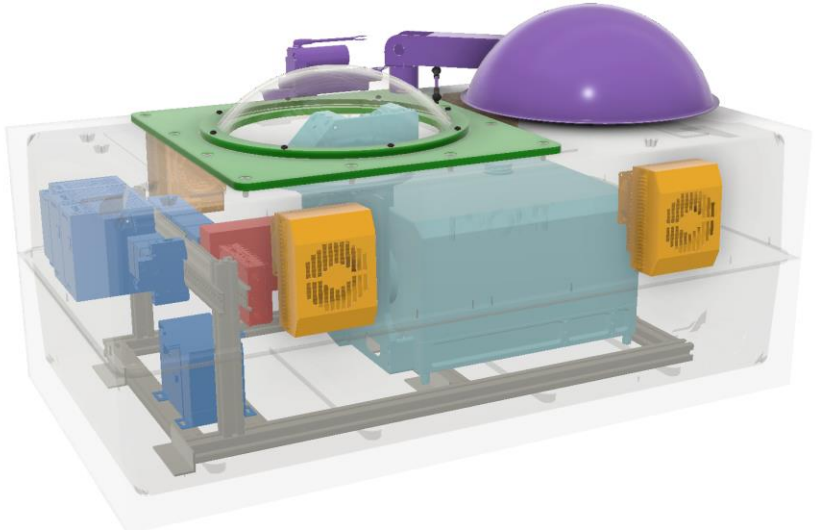
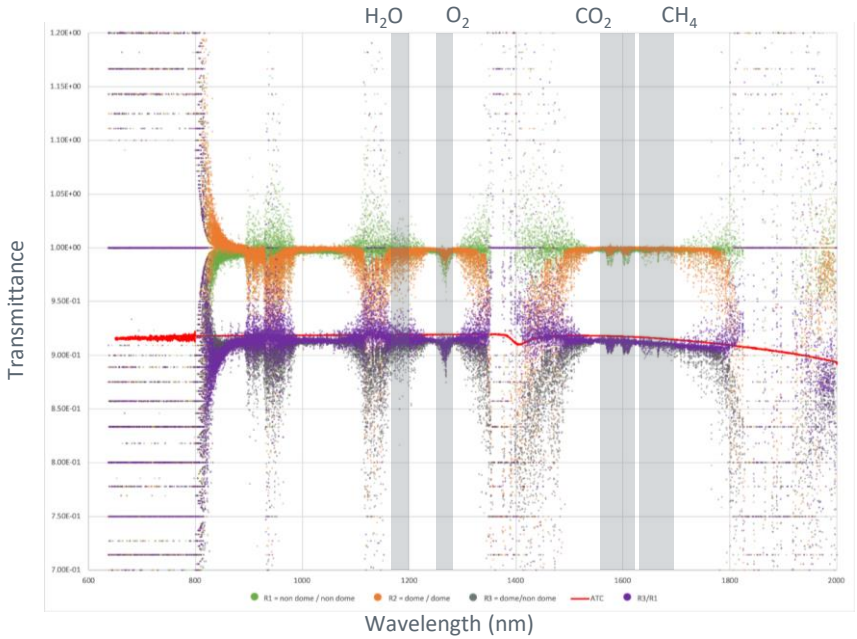
NEW ENCLOSURE DESIGN FOR THE EM27/SUN

- EM27/SUNs are not weatherproof → operate from within an enclosure, which also allows remote and autonomous operation
- Original concept by Heinle and Chen, AMT 2018 (TU Munich)
- Design by Jerome Woodwark (University of Edinburgh)
- Key to CAD rendering:
  - EM27/SUN
  - Power system components: includes UPS in case of sudden interruption of power supply, allowing safe shutdown
  - Control systems: mini-PC controlling spectrometer, other sub-systems, remote access via Internet
  - Thermal control: fan-assisted heating and cooling to prevent extremes of temperature
  - Optical dome mount: protects interior whilst allowing high optical transmittance across the observed wavelength range
  - Movable dome protective cover: for protection from dust, dirt when not observing
  - System support frame



TESTING OF SAMPLE MATERIAL FOR THE PROTECTIVE DOME

- Performed observations in Edinburgh both with and without a sample of dome material (5mm thick optical glass) in the line of sight of the solar tracker
- Check optical transmittance of material at wavelengths used by X_{GAS} retrievals – transmittance estimated from EM27/SUN spectra has same wavelength dependence as transmittance from lab measurement
- Confirmed that slight refraction of incoming light does not impair solar tracker performance



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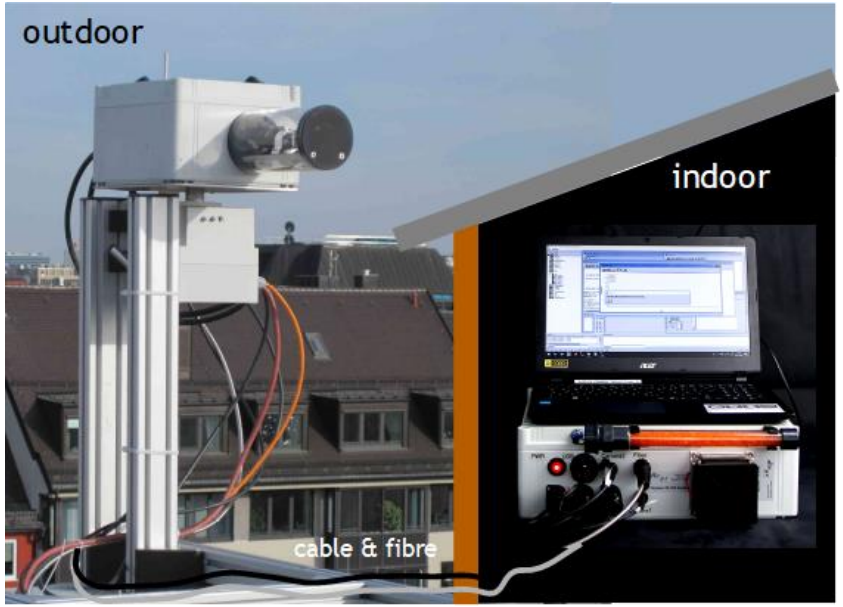
MAX-DOAS INSTRUMENTATION FOR AIR QUALITY MONITORING

- Each node contains one **M**ulti-**AX**is **d**ifferential **o**ptical **a**bsorption **s**pectroscopy unit
- Provided by Enviro Technology Services (ETS), manufactured by AirYX
- Telescope unit mounted on roof; collects stray light. Connected to spectrometer unit.
- Two spectrometers, measuring in UV-Vis (290—450 nm) and Vis (430 – 565 nm) ranges, resolution of 0.6 nm.
- Provides column densities and surface concentrations of NO_2, O_3, SO_2, O_2 dimer, HONO and other trace gases.



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THE LONDON CARBON EMISSIONS EXPERIMENT - SUMMARY

- Currently in the planning stage of setting up three observation nodes for ground-based remote sensing of the atmosphere along a SW-NE transect of London
- Each node will host:
  - Bruker EM27/SUN spectrometer for greenhouse gas monitoring
  - MAX-DOAS instrumentation for monitoring air quality and other trace gases
  - Weather station for local meteorology
- Developing new enclosure design to allow automation of the EM27/SUNs
- Once ground-based remote sensing network is established, incorporate data from city-scale focused satellites, in-situ sampling networks and modelling based on emissions inventories to study London's carbon emissions footprint
- For further info, please contact:
  - Dr Neil Humpage: nh58@le.ac.uk / @DrNeilHumpage
  - Field Spectroscopy Facility: fsf@nerc.ac.uk / @NERC_FSF