

GEMINI-UK: establishing a national network of EM27/SUN spectrometers to help track progress towards net-zero emissions targets

Neil Humpage – National Centre for Earth Observation, University of Leicester, UK, nh58@le.ac.uk

Paul Palmer, Liang Feng, Alex Kurganskiy – National Centre for Earth Observation, University of Edinburgh, UK // Jerome Woodwark – University of Edinburgh, UK // Stamatia Doniki, RAL Space, Rutherford Appleton Laboratory, UK

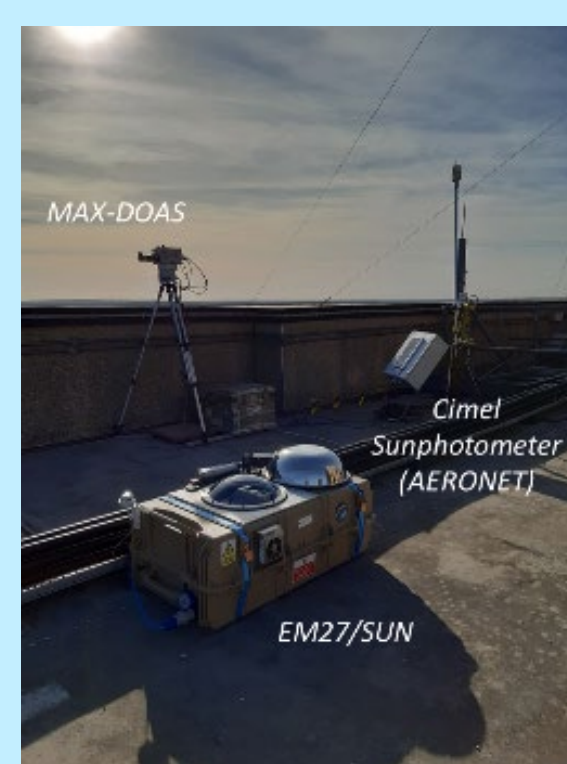
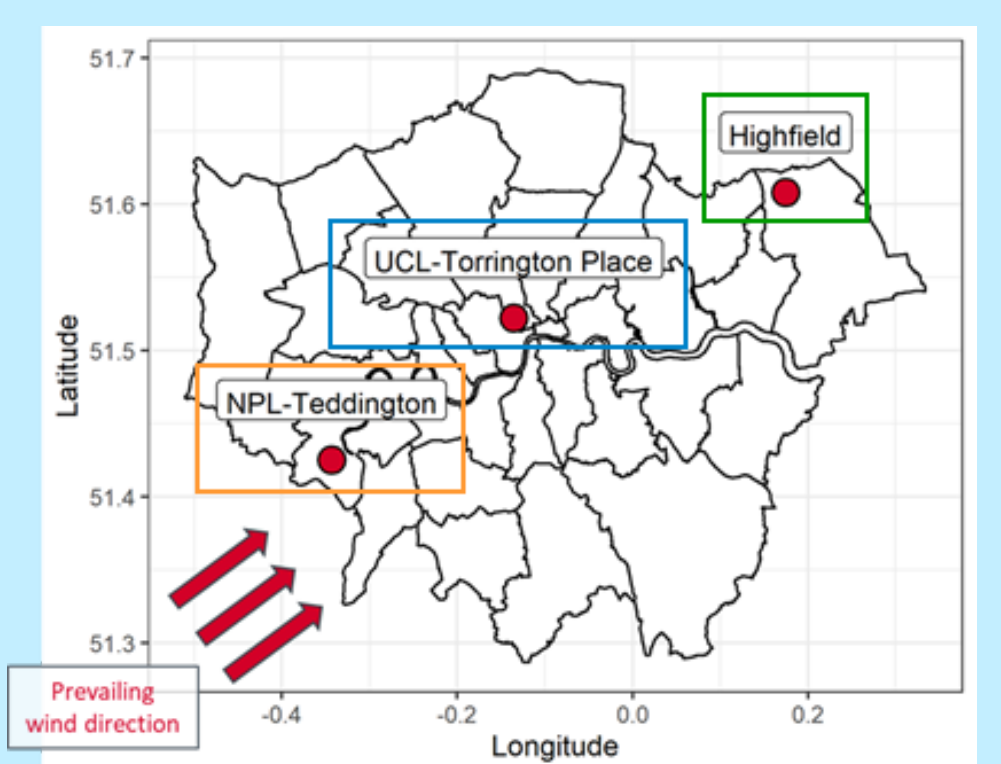
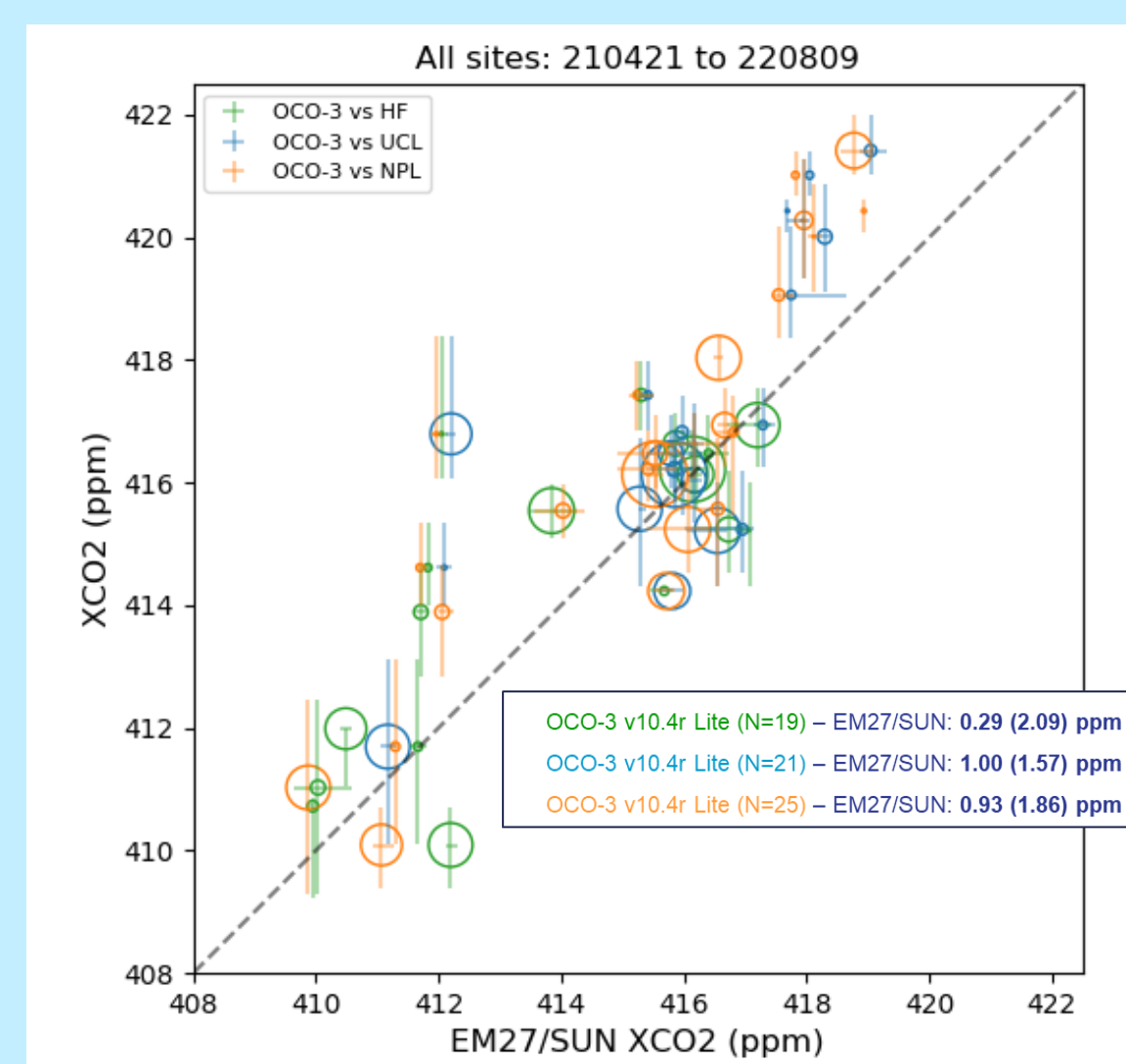
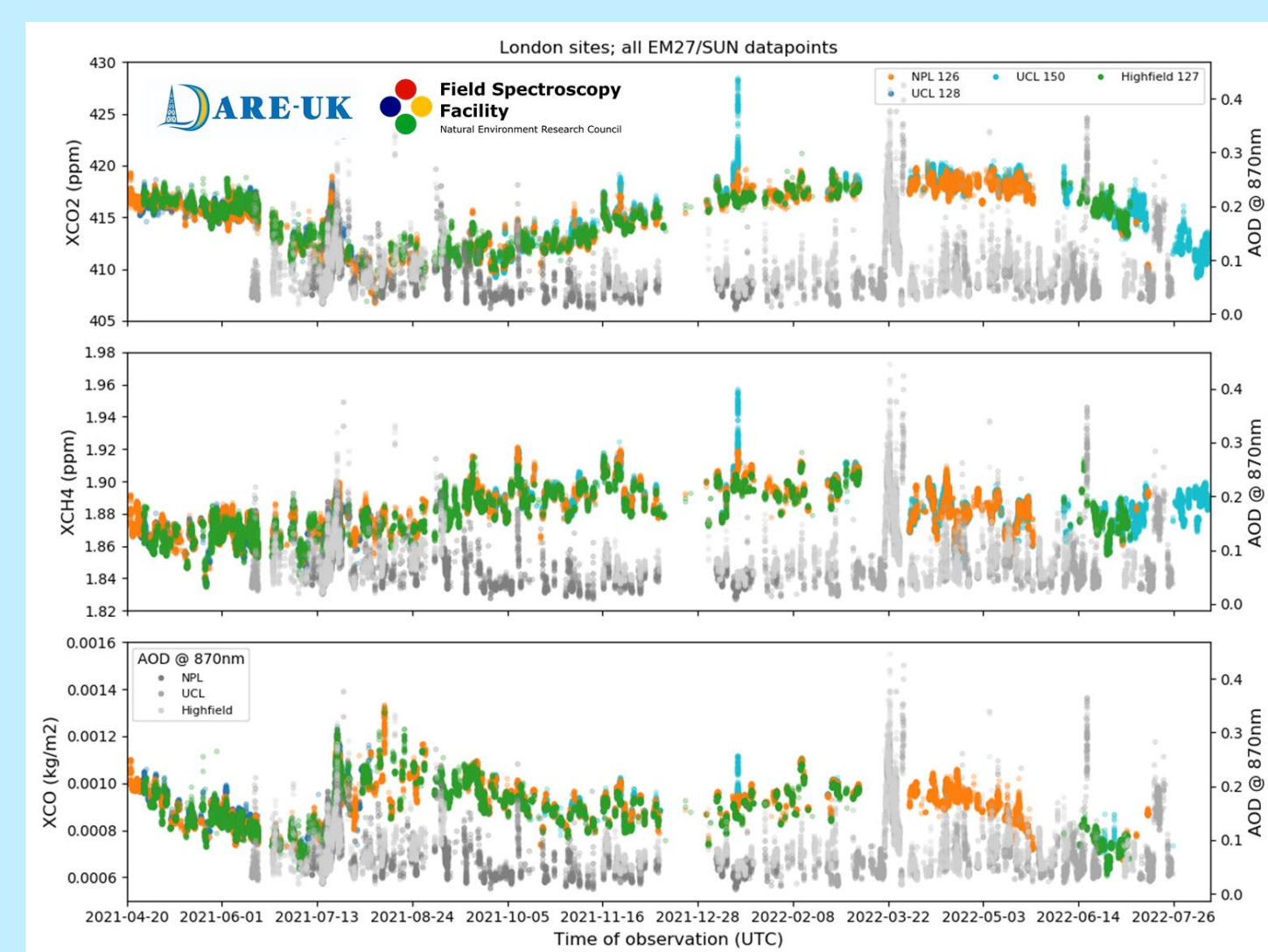
Robbie Ramsay – Field Spectroscopy Facility, University of Edinburgh, UK // Hartmut Boesch – National Centre for Earth Observation, University of Leicester, UK (now at IUP, University of Bremen, Germany)

Ground-based greenhouse gas remote sensing observations in the UK

- **London Carbon Emissions Experiment:** three EM27/SUNs across London to focus on urban GHG emissions from Spring 2021 to autumn 2022
- **TCCON Harwell:** operated by RAL Space, officially part of TCCON global GHG monitoring network since 2022
- **GEMINI-UK:** Greenhouse gas Emissions Monitoring network to Inform Net-zero Initiatives for the UK – *ten new EM27/SUNs located around the UK* to help improve national and regional estimates of GHG emissions, to be established in 2024

The London Carbon Emissions Experiment

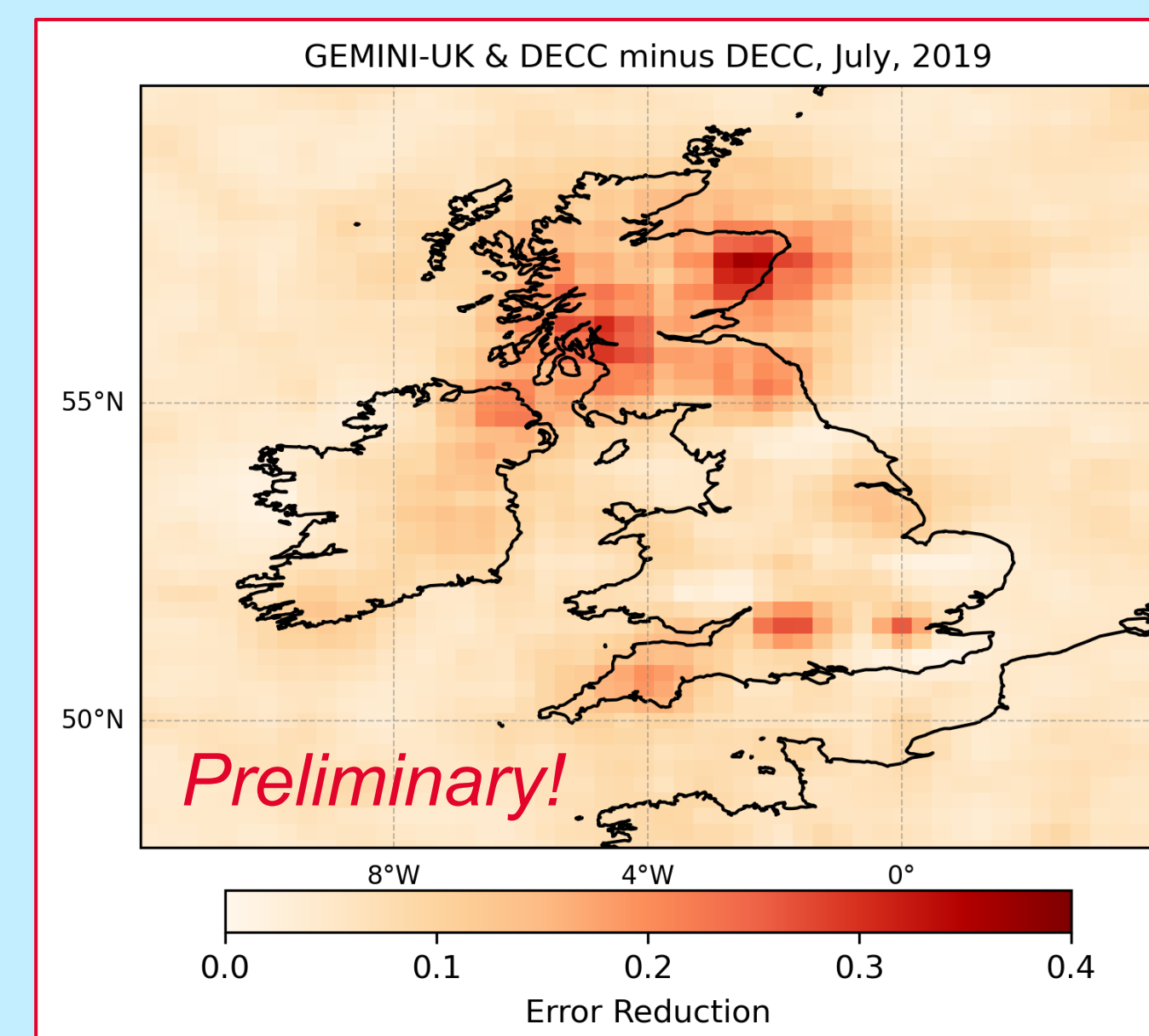
- Precursor to GEMINI-UK, part of NERC DARE-UK project: dareuk.blogs.bristol.ac.uk
- NERC Field Spectroscopy Facility *Spectral Atmospheric Suite* deployed at three sites across London: EM27/SUN + MAX-DOAS + Cimel Sunphotometer (AERONET) – see fsf.nerc.ac.uk
- Automated enclosure allows for very good temporal coverage – *similar design to be used for GEMINI-UK*



Top left: time series of X_{CO_2} , X_{CH_4} and X_{CO} observed at the three London locations, shades of grey correspond to aerosol optical depth
Top right: scatter plot of daily median EM27/SUN X_{CO_2} vs OCO-3, colours correspond to locations and circle sizes correspond to number of OCO-3 datapoints on each day
Bottom: map of measurement locations, photograph of Highfield site

Planning for GEMINI-UK

- Funding from NERC through the NPL-lead *GEMMA* (Greenhouse gas Emissions Measurement Modelling Advancement) programme for *10 EM27/SUNs and weatherproof enclosures*
- Create a single integrated network to monitor all sources and sinks of greenhouse gases in the UK, using a “top-down” systems approach to provide monthly estimates of national emissions
- Combine emissions and atmospheric transport models, along with the EM27/SUN vertical sensitivity, to *estimate likely ‘footprints’ for candidate sites* – ensure that the ten sites are chosen to maximize sensitivity to UK greenhouse gas emissions, and are complementary to existing measurements



Estimate of error reduction in CO_2 inversion results when adding 10 EM27/SUNs to existing in-situ measurement infrastructure, based on simulated measurements for July 2019



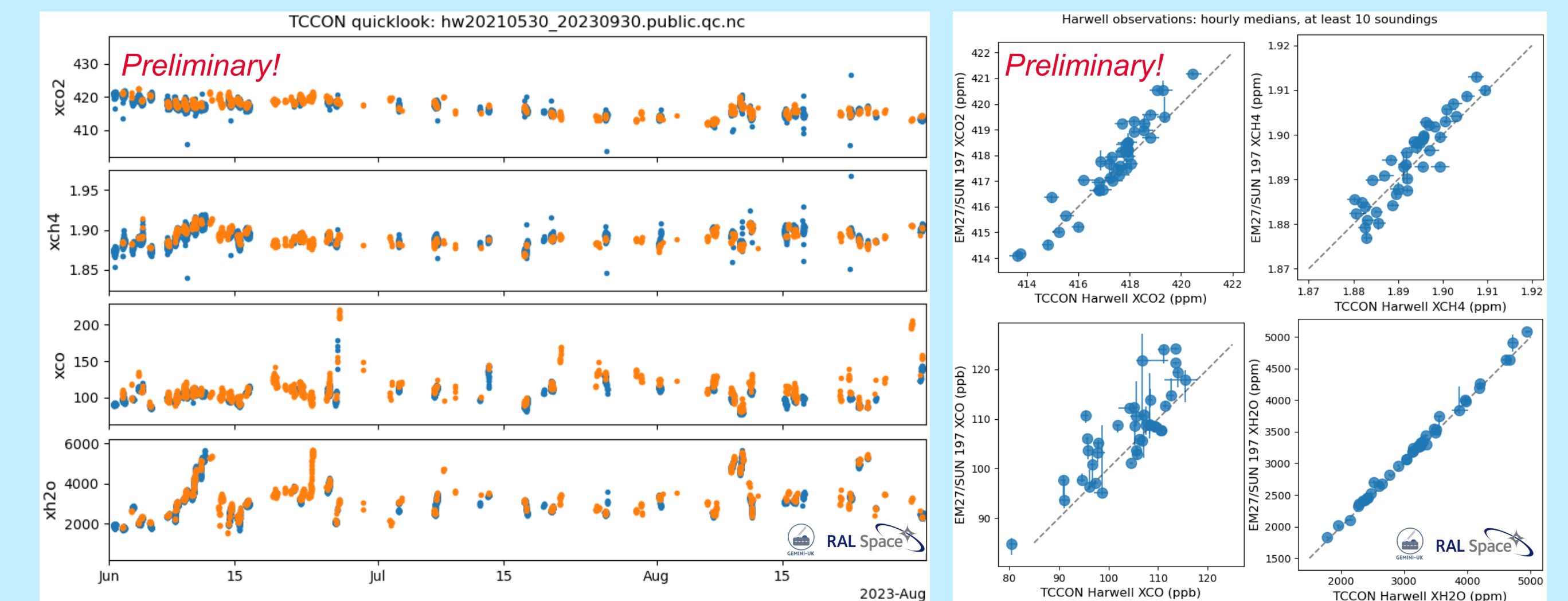
Selected sites for 10 new EM27/SUNs. Measurements will also continue at the FSF site in central London

- One site *co-located with the Harwell TCCON site* for traceability to WMO approved scale – *preliminary observations underway* using an existing enclosure system to test and develop methods, and provide data for intercomparison of *TCCON* and *COCCON* results and processing chains



GEMINI-UK vs TCCON at Harwell

- Long term plan *to tie GEMINI-UK GHG column data to the global TCCON scale*
- Next steps: run EM27/SUN PROFFAST v2 retrieval code on TCCON interferograms, and TCCON GGG2020 retrieval code on EM27/SUN interferograms → confirm consistency of results between different instruments and software
- Left: time series of Harwell *TCCON* and *EM27/SUN* data using standard processing and quality control for each instrument
- Right: scatter plots comparing hourly medians of the Harwell *TCCON* and *EM27/SUN* data



The GEMMA programme

NERC Programme led by NPL: inversions using new and existing observations, atmospheric transport models and inventories to produce UK GHG emissions estimates on a regular basis

