Research Experience Placement (REP) Scheme 2026

Supervisor Project Proforma

Project title:	Investigating the application of a hybrid optimal estimation and machine learning approach to predict atmospheric composition from IASI
Host Institution:	National Centre for Earth Observation, University of Leicester
Project supervisor (name, department):	Dr David Moore, National Centre for Earth Observation
Project enquiries (supervisor email):	david.moore@le.ac.uk
Co-Supervisor, if any (name, department):	Dr Jeremy Harrison, National Centre for Earth Observation
Proposed start date and weekly hours: (please note project must be of 6 weeks duration)	Any time from June 2026

Please provide a short paragraph or couple of sentences summarising the project to encourage potential applicants to apply (max 75 words)**:**

Satellite instruments orbiting the Earth are able to measure the concentrations of trace gases in the atmosphere. Typically this information is extracted from satellite atmospheric spectra using computationally expensive algorithms that utilise the unique absorption patterns in the infrared of the trace gases. In this project, the candidate will explore a hybrid framework that merges the conventional approach with machine learning and enables trace gas concentrations to be determined more rapidly.

Project description (max 700 words, 1-2 figures may be included):
Proposed projects must:

- Have a clearly defined objective
- Be within the science remit of NERC
- Be feasible for a student to complete within the timescale of the placement
- Include more than purely a computer/modelling component i.e., some element of fieldwork, data collection, activity to give an understanding of the wider context including participation in lab/team meetings, networking, and training etc.
- Give scope for thought and initiative on the part of the student and should not use the student as a general assistant
- Be based at an eligible UK research organisation (remote placements from within the UK are also an option for enabling inclusivity)

Remote sensing of the Earth's atmosphere provides us with a wealth of information on the distribution of trace gases. This information is obtained from direct measurements made by instruments on a variety of platforms, including satellites, that measure infrared radiation passing through the Earth's atmosphere. From these measurements, we can extract the abundances of

atmospheric trace gases via their unique absorption patterns in the infrared, in a process known as a retrieval.

The Infrared Atmospheric Sounding Interferometer (IASI) is a high-resolution, space-borne Fourier Transform Spectrometer that has provided continuous, highly accurate, and detailed infrared radiation measurements of the Earth's atmosphere since 2006. Current optimal estimation (OE) methods for retrieving carbon monoxide (CO) concentrations from the IASI measurements focus on utilizing specific spectral windows to isolate CO signals from strong background absorption. These methods, largely based on the Bayesian OE framework (Rodgers, 2000) are computationally expensive. Emerging techniques merge conventional OE with machine learning (ML) to overcome computational costs. A "hybrid framework" that applies OE to generate training data, would allow ML to rapidly infer CO/trace gas concentrations and diagnostics across satellite measurements.

After a period initially exploring OE approaches to retrieving carbon monoxide from space and using the scheme themselves, the candidate will then investigate the application of a hybrid retrieval scheme using methods developed in Werner et al. (2025) (https://doi.org/10.5194/egusphere-2025-4864). Firstly, the candidate will apply the scheme to CrIS data; the Cross-track Infrared Sounder is a similar instrument to IASI. Once the CrIS scheme is up and running, the candidate will then be given the opportunity to adapt this novel approach to IASI radiance datasets on the Leicester HPC system ALICE. Results from the newly developed IASI hybrid scheme will be compared to the results from the traditional OE approach.

The successful applicant will also have the opportunity to learn about the technique of Fourier transform spectroscopy through the use of the Spectroscopy for Environmental Sensing Research (SPENSER) facility at Space Park Leicester. This facility, co-funded by NERC and the University of Leicester, houses a Bruker IFS 125HR Fourier transform spectrometer. The purpose of this state-of-the-art facility is to provide accurate, SI-traceable quantitative spectroscopic data for satellite remote sensing.

Project timeline:

The project duration is flexible, but expected to be at least 6 weeks. A possible timeline could be:
Week 1-2: Learn about trace gas retrieval from satellite datasets, become accustomed to current state-of-the-art retrieval schemes
Week 3-4: Download and investigate use of the hybrid optimal estimation and machine learning approach that has been used for CO retrieval from CrIS with Python (https://doi.org/10.5194/egusphere-2025-4864).
Week 5-6+: Investigate incorporating these techniques into carbon monoxide retrieval from IASI.

Candidate requirements:

This project is largely computer-based and you should have experience with scientific computer programming. Experience of using Python and/or IDL would be advantageous. The placement will be based at Space Park Leicester.

Background reading and references:

Werner, F., Bowman, K. W., Lee, S., Laughner, J. L., Payne, V. H., and McDuffie, J. L.: A hybrid optimal estimation and machine learning approach to predict atmospheric composition, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-4864, 2025.

Clerbaux, C., Boynard, A., Clarisse, L., George, M., Hadji-Lazaro, J., Herbin, H., Hurtmans, D., Pommier, M., Razavi, A., Turquety, S., Wespes, C., and Coheur, P.-F.: Monitoring of atmospheric composition using the thermal infrared IASI/MetOp sounder, Atmos. Chem. Phys., 9, 6041–6054, https://doi.org/10.5194/acp-9-6041-2009, 2009.

Rodgers, C.D. (2000) Inverse Methods for Atmospheric Sounding: Theory and Practice. World Scientific, River Edge.

To be completed by institutional CENTA PoC

I confirm that:

- The host institution takes responsibility for selecting a suitable undergraduate student and ensuring and confirming their eligibility under the NERC REP student eligibility criteria.
- This REP project falls within the NERC remit, is of suitable quality and meets the REP research project criteria.
- Appropriate supervisory arrangements are in place.
- The application processes used will be inclusive and accessible.
- Reasonable adjustments will be made for students that need them whilst undertaking placements.
- The placement will be carried out in accordance with all applicable ethical, legal and regulatory requirements including but not limited to relevant provisions of the General Data Protection Regulation, the Data Protection Act 2018, the Bribery Act 2010, the Fraud Act 2006, the Equality Act 2010 and the Modern Slavery Act 2015.
- The host organisation takes responsibility for identification, protection and exploitation of any intellectual property rights arising from the work.
- All facilities, agreements about access and collaborations necessary for the work will be obtained before the work commences and can be ensured through the period of the work.
- All costs awarded by NERC for the REPs will be used and accounted for appropriately.
- A report of the project by the student will be submitted no later than one week after the end date of the placement or Friday 25th September 2026, whichever falls first.
- A PhD interview (where possible) will be offered to all students who have completed a REP within the CENTA Doctoral Landscape Award.

Signed: JJ Harrison

Date: 15 April 2026

Position: NCEO PoC