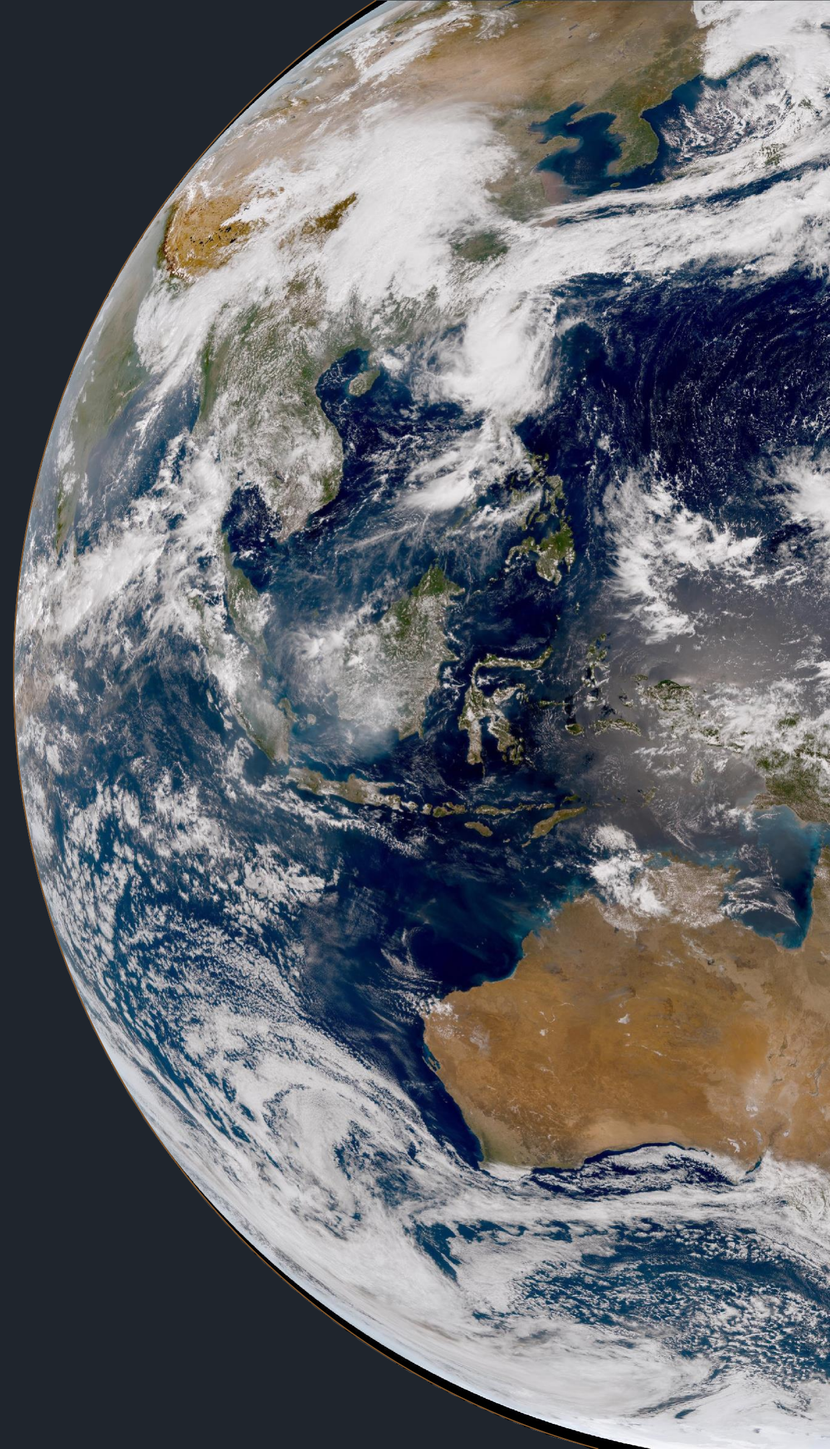
ABSTRACTS

UK Earth Observation Conference 2024

10-12th September National STEM Centre, York



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Session 7A – Vegetation Applications – Grassland and Drought
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Session 7D – Snow

Keynote

Susan Mecklenburg

ESA’s Earth Observation Programme and EO science strategy update

Tuesday 09:30 – 10:30

European Space Agency

The European Space Agency’s (ESA) long-running Climate Change Initiative has generated a suite of global multi-mission and multi-decadal datasets for more than 25 Essential Climate Variables. Collectively, these data provide the evidence record to understand the state and evolution of the climate as part of the IPCC assessments. Efforts have now been extended through the recently approved climate initiative, CLIMATE-SPACE (2023-2029) which continues to extend and expand these global data. Additionally, it is responding to new requirements for Earth Observation to support international decision and policy-making and implementation monitoring relating to the UNFCCC Paris Agreement - the main driver for action responding to climate change.

Currently, ESA is preparing for the 2025 Ministerial Council, with a strong focus on Earth Action and the provision of actionable climate data to support global climate resilience and adaptation policy. A core component of this endeavour is ESA’s Space for Green Future (S4GF) accelerator, which will act to mobilise space-based data through ever-closer working with non-space partners.

The UK is accelerating national climate action at pace. Currently, to name but one, the UK National Climate Science Partnership (UKNCSP) - an alliance of the Met Office and seven NERC centres - is combining capabilities to provide climate information and tools to enable public and private sectors adapt effectively and build resilience to future environmental change.

This presentation explores the opportunities and benefits of deepening connections between the UK climate research and Earth observation community and ESA’s climate activities being hosted at the ECSAT facility, located on the Harwell Science and Innovation campus. ECSAT is the Agency’s focal point for climate activities and hosts the WCRP’s CMIP international project office has strong links with the global modelling community and provides opportunities to foster greater extend collaboration and UK research impacts across ESA Member States and the world.

Session 1A

Terrestrial Environmental Monitoring

Martin Wooster

NCEO Airborne Earth Observatory Accomplishments in 2023-24

Tuesday 11:00 – 12:00

NCEO Kings College London

The NCEO Airborne Earth Observatory (NAEO) has flown in the UK, Italy and Canada in 2023 in support of various NERC, ESA and NASA initiatives - including collecting data for the evaluation of the Sentinel-3 Active Fire Products, for the development of a potential fire product from the forthcoming FLEX mission, and for supporting the development of the Copernicus Land Surface Temperature Measuring Mission (LSTM) and the somewhat similar US-Italy SBG mission. Here we will provide an overview of the capabilities deployed by the NAEO in support of these activities and show the deductions, accomplishments and contributions to the mission plans that have resulted from these data so far.

Abigail Marie Waring

Progress Towards Improving Earth's Surface Temperature Observations from Space using Machine Learning Techniques

Tuesday 11:00 – 12:00

NCEO University of Leicester

Land surface temperature (LST), along with latent and sensible heat fluxes, is crucial for understanding climate trends influenced by rising greenhouse gases. Enhancing global LST observations is essential for improving climate warming predictions, a key objective of the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. While thermal infrared (TIR) observations suffer from clear-sky bias, microwave (MW) LSTs have lower accuracy and spatial resolution. Combining IR and MW LSTs is vital for all-sky climate applications. In collaboration with the National Centre of Earth Observation (NCEO) and the ESA Climate Change Initiative Land Surface Temperature project, our PhD project aims to enhance understanding of global LST diurnal variability by developing an integrated all-weather LST dataset for climate model comparison. We will use a Convolutional Neural Network (CNN), specifically the U-Net architecture, to merge TIR and MW LST datasets. The U-Net CNN maps features from input surface temperature data, enabling downsampling of coarse MW data to match the higher-resolution TIR data. We will initially merge MODIS TIR data and AMSR-E/2 MW data from NASA's Aqua satellite, exploiting their identical temporal resolution. Training the model with diverse scenes, we aim to spatially downscale MW data to TIR resolution at 5 km. A gap-filling technique will then create a merged Earth dataset. To improve accuracy, we will correct the least accurate LST product using validation and inter-comparison products and explore the relationship between LST and land surface air temperature (LSAT) to address clear-sky bias.

Felipe Husadel Poyer

Land-use change analysis for wind and solar power plants installations in Brazil using remote sensing

Tuesday 11:00 – 12:00

National Institute for Space Research (INPE - Brazil) and University of Manchester (UK)

Brazil's electricity sector has undergone a major transformation in recent decades, with the deployment of large-scale wind and solar photovoltaic power plants. This energy transition is contributing to Brazil's greenhouse gas emission reduction targets and a cleaner future. However, while renewable energy is an important alternative for climate change mitigation, the massive installation of large-scale wind and solar farms has led to land-use changes that contribute to growing conflicts with local communities and environmental conservation. This research uses remote sensing techniques to examine how land use and land cover have changed in more than 200 locations where these farms have been built. We will use the georeferenced information of these locations and MapBiomas datasets to understand the changes. We will also analyse the trends of these changes over time before and after the installation of the wind and solar farms using Sentinel 2 images. All the analyses will be done in Google Earth Engine. Although this analysis was developed for the Brazilian case, these renewable energy land-use conflicts have been reported in other parts of the world such as South Africa, Portugal, India, Mexico and others. This is the first time that such approach is being applied in Brazil.

Charlotte J Paton

Understanding the UK’s thermal environment with satellite remote sensing

Tuesday 11:00 – 12:00

University of Leicester

Over 50% of the worlds population is already living within urban areas. That percentage is expected to grow as the population rises and it is certain that infrastructure will increase in order to accommodate these changes. It’s therefore more important than ever to consider how rising temperatures will affect our cities and the health of those living in them.

This research aims to aid in the understanding of urban thermal environments across the UK by improving our knowledge of the surface characteristics linked to emissivity. Throughout this work data will be acquired from Landsat 8 & 9 Satellites, at 100m spatial resolution. Firstly, a series of indices will be calculated using visible and short-wave infrared bands. By analysing the relationship between these indices, and setting a series of statistical thresholds, land can be partitioned into 8 thermal environment classifications. Samples from the ECOSTRESS and SLUM spectral libraries are attributed to each classification, and relationships between emissivity and NDVI are determined. These relationships allow for prior emissivities to be calculated and used in University of Leicester’s split window and optimal estimation retrievals. The resulting Land Surface Temperatures are validated against in-situ measurement sites.

This work will directly feed into the ongoing EOCIS CHUK surface temperature work. The thermal classification further allows for a robust rural background region to be defined for each city in order for urban heat islands to be evaluated between 2013-2023. This provides insight into how the thermal environments change, with specific focus on the effects of heatwaves.

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Session 1B

Climate Data Studies 1

Fergus Craig

Exploiting Open Data for Methane Emission Observation & Visualisations

Tuesday 11:00 – 12:00

NV5 Geospatial

Observing greenhouse gases from space can be accomplished through various methods. Given the growing need for legal enforcement related to significant methane-emitting sources and the monitoring of other emission points, it is crucial to develop tools that integrate multiple datasets to enhance spatial and temporal resolution, thereby maximising the utility of space assets, notably NASA and ESA operate satellites such as EMIT, Landsat 8, Landsat 9, and Sentinel-2A and Sentinel-2B.

These satellites provide freely accessible high-resolution data capable of detecting methane emissions both on land and at sea. By combining available data within the 30-meter to 60-meter spatial resolution range, we can more frequently identify emissions. Our R&D efforts have led to tools that ingest lists of emission sources or focus on specific areas of interest, retrieve available datasets and enhance the data rapidly, emphasising methane plumes while reducing noise. Users have control over various visualisation techniques and output options, allowing for integration with other datasets.

Additionally, machine learning training datasets can be generated by collecting plume shapes, sizes, and spectral signatures. This approach moves us toward automated plume extraction in regions associated with oil and gas production, agriculture, landfills, and other methane sources. These versatile tools can be used alongside commercial sensors, user accounts, and API tools to retrieve imagery. Given the challenge of cloud cover in areas like coastal drilling sites, accessing, analysing, and visualising multisource/modal data can significantly contribute to efficient methane emission control efforts.

Ka Lok Chan

Observation of Tropospheric Ozone from Nadir-Viewing Satellite Sounders and the First Results from GEMS and TEMPO

Tuesday 11:00 – 12:00

RAL Space

The UV ozone profile retrieval algorithm developed at RAL can be applied to nadir-viewing sensors in polar orbit (e.g., GOME-2, OMI, TROPOMI, and Sentinel-5) and geostationary orbit (e.g., GEMS, TEMPO, and Sentinel-4). The retrieval utilizes spectral observations in the UV band together with the optimal estimation method to retrieve height-resolved ozone profiles. Information on tropospheric ozone (surface to 450 hPa layer) from polar orbiters has been exploited in a number of scientific studies.

The RAL ozone profile retrieval scheme has been improved and re-engineered to harmonize application to different instruments. It has recently been optimized for and implemented on the geostationary satellite instruments GEMS and TEMPO. We present the current status of tropospheric ozone data retrieved from polar orbiters and the first results from the geostationary instruments GEMS and TEMPO, and the comparison to other polar orbit sensors.

Paul Palmer

Do we understand observed year-to-year changes in satellite observations of isoprene?

Tuesday 11:00 – 12:00

University of Edinburgh (NCEO)

Isoprene is a biogenic volatile organic compound that is emitted by a subset of trees in warm and sunny conditions. It is a precursor for tropospheric ozone and secondary organic aerosol, and therefore plays a key role in atmospheric chemistry. Seasonal isoprene hotspots are found mainly over tropical forests and over selected midlatitude forests, e.g. Southeast US. There remain substantial uncertainties associated with the spatial and temporal distribution of isoprene, particularly over tropical ecosystems.

In this presentation, we present a statistical analysis of new satellite observations of isoprene retrieved from the Cross-Track Infrared Sounder (CrIS) that reveal some interesting responses to regional drought events linked with large-scale climate variations.

Sammy Petch

Exploring the relationship between Terrestrial Water Storage and atmospheric CO2 Growth Rate

Tuesday 11:00 – 12:00

University of Edinburgh (NCEO)

The carbon growth rate (CGR) in atmospheric CO2 concentration is characterised by large interannual variability, predominantly caused by variations in the land carbon uptake, which remains the most uncertain component of the global carbon budget. We explore the relationship between CGR variations and global terrestrial water storage (TWS) from GRACE over 2001-2023. We find a strong negative correlation between these quantities, indicating that in drier years there is a higher CGR, suggesting reduced uptake by the land. We then look to regionalise the contributions to the global TWS-CGR correlation based on both land cover type and large spatial regions. We further look to attribute different interannual variability events in the CGR to TWS variations in particular regions.

Additionally, we use atmospheric CO2 inversion products to infer regional contributions of terrestrial CO2 fluxes. We assess the agreement among products as well as their consistency with the GRACE data.

Session 1C

Machine Learning and Algorithm Development for Atmospheric Applications

Elisa Carboni

STFC - RAL Space

Decomposition of satellite datasets: relationship between cloud properties, radiative fluxes and climate indices

Tuesday 11:00 – 12:00

We describe here a technique, singular vector decomposition (SVD), that identifies the spatial patterns that best describe the temporal variability of a global satellite dataset. These patterns and their temporal evolution are then correlated with established climate indices. We apply this technique to de-seasonalised monthly anomalies, which remove long-term trends and biases between datasets. Datasets of cloud properties and radiative fluxes over three decades ((A)ATSR/SLSTR, MODIS, IASI and CERES) are analysed. The leading singular vectors for independent global data sets on both cloud properties (cloud fraction, cloud-top height) and top-of-atmosphere radiative fluxes, covering different time periods are strongly correlated with ENSO indices. SVD technique can provide a new perspective on consistency between climate models and satellite data sets, which are now multi-decadal and are to be extended through planned future satellite missions.

Fang Chen

Automatic Methane Plume Detection in Satellite Remote Sensing Imagery

Tuesday 11:00 – 12:00

University of Leicester

Methane is a crucial anthropogenic greenhouse gas, which has significant impact on global warming due to its strong radiative forcing. Besides, methane has much shorter atmospheric lifespan compared to carbon dioxide. The strong radiative forcing in combination with the shorter timescale make the reduction of methane emissions critical in combating global warming. Satellite remote sensing provides an effective means for monitoring methane emissions because of the wide coverage, and the observed data provide valuable information for indicating methane plumes of emissions. Therefore, developing intelligent technique to conduct effective methane plume detection in satellite remote sensing image data is a critical step in mitigating climate change. Here, we introduce a deep learning-based approach, which is tasked to operate effective methane plume detection in an automatic manner. Specifically, in practical operation, we design the methane detection as the problem of training a deep neural model giving image training dataset, and the trained model can operate methane plume detection without human intervention. To achieve this, we construct a generative net, which is trained to generate features for methane plume characterisation. The generative net thus plays the essential component in operating methane plume detection, and to enhance its capability for feature generation, a discriminative net is constructed. In the training process, these two nets perform against each other, constructing a competition manner. This helps for empowering the learning capability of the generative net for accurate feature generation. The generated features are then decoded to produce methane plume maps, achieving effective methane plume detection.

Jawairia Ahmad

UK Centre for Ecology and Hydrology

Nowcasting convective cores using deep learning

Tuesday 11:00 – 12:00

The importance of nowcasting extreme rainfall in West Africa is increasing with the changing climate. In this study, deep learning is used to predict the initiation and propagation of convective cores within organised convective systems in West Africa. A previous study used wavelet scale analysis to identify convective core boundaries using thermal infrared images and showed their association with intense rainfall.

A U-Net architecture is used to predict the initiation and propagation of these convective cores by leveraging the spatiotemporal flexibility of convolutional neural networks (CNN). The input data consists of thermal infrared brightness temperatures at multiple preceding timesteps, while the target comprises a binary map of convective core presence at each pixel at the nowcasting time period. A spatially enhanced loss function (fractions skill score, FSS) is used during training to account for the spatial structure of convective cores. The output consists of a probability of the presence of a convective core at each pixel. A suit of simulations is carried out to optimize the model layers and the selection of training data.

Results show that prediction accuracy decreases with lead time. Skilful predictions (FSS>0.5) are achieved even at longer lead times (4hrs) at spatial scales around 120 km. Using recent thermal infrared information as compared to equal time steps in the past yields better predictive accuracy at longer lead times. The results indicate considerable potential of the described framework for nowcasting convective cores, and hence intense rainfall, in West Africa.

Lakshmi N Bharathan

Enhancing High-Latitude Data Coverage in GOSAT Methane Observations Using a Genetic Algorithm Approach

Tuesday 11:00 – 12:00

University of Leicester

The Greenhouse Observing Satellite (GOSAT) has been providing a long-term (~15 year) data record of atmospheric methane with near-surface sensitivity, aimed at measuring continental scale sources and sinks (Kuze et al., 2009). However, acquiring reliable measurements at high latitudes is difficult due to infrequent satellite observations and weak signal detection. The use of the “proxy” retrieval algorithm (Parker and Boesch 2020) helps mitigate the effects of signal contamination by aerosols or instrumental factors, leading to the generation of an operational global dataset (Parker et al., 2020). Nonetheless, enhancing data coverage across high latitudes requires making generalised decisions related to data filtering, which can be achieved by optimising the data filtering process. Genetic Algorithms (GAs) are powerful tools for enhancing the efficiency and accuracy of data analysis in satellite remote sensing. This study investigates the application of a GA to optimise the post-retrieval quality filtering of methane data from the GOSAT satellite over high-latitude regions (north of 50°N). Inspired by Darwinian natural selection, GAs treats potential solutions as "individuals" or "chromosomes"—sets of rules or parameters relevant to the specific problem. In this context, the potential solutions or chromosomes are sets of data quality filter parameters, and the objective is to maximise data coverage over high-latitude regions while maintaining data quality. The GA iterates through generations by selecting the fitter individuals (filter combinations) as "parents" and performing crossover (combining genetic material from the parent chromosomes/solutions) and mutation (random modifications promoting genetic diversity) to produce new solutions/offspring. This process evolves towards the optimal solution by evaluating the fitness of each individual. In our problem, the fitness of each solution is evaluated based on a combination of the number of valid GOSAT observations at high latitudes, the Root Mean Square Error (RMSE) between GOSAT retrievals and ground-based data from the Total Carbon Column Observing Network (TCCON), and the number of outliers in the GOSAT-TCCON collocated observations, with higher fitness achieved by increasing the number of observations and decreasing both the RMSE and the number of outliers. Initial findings indicate that GA-optimised post-filtering thresholds can substantially increase the number of valid satellite soundings over high latitudes with minimal compromise on data quality, suggesting promising potential for this approach. Future research will investigate the generalisability and regional applicability of this approach. This work demonstrates the potential of GAs for improving data coverage in challenging high-latitude regions while maintaining while maintaining the accuracy of the data.

Session 1D

Uncertainty & Calibration

Jonathan Murray

UNIRAS: A new configurable airborne spectrometer for the mid-to-far-infrared

Tuesday 11:00 – 12:00

Imperial College London

New mission concepts, designed to provide new insights into controls on atmospheric composition, clouds and surface properties will push observational capacity towards higher precision and higher spatial resolution. With the advent of NASA's PREFIRE and ESA's FORUM missions a new observational window, covering the far-infrared (100-667 cm-1) will be investigated for the first time. Given these developments there is a clear need to develop the capability to deliver proxy observations that can (a) test and refine new concepts, including the retrieval methods being developed to deliver the level 2 products, and (b) offer a calibration validation framework for the level 1 radiances that are the actual measurand of the satellite instruments this initiative seeks to benefit.

The UNiversal InfraRed Airborne Spectrometer, UNIRAS, jointly funded by NERC and ESA, is capable of measuring spectrally resolved radiances in the 100 cm-1 to 1600 cm-1 wavenumber range and will be flown on the FAAM Bae146 aircraft. The spectrometer design concept for UNIRAS is based on one of the industrial studies undertaken for FORUM phase A. To expand instrument versatility beyond FORUM and PREFIRE, UNIRAS employs configurable detectors to switch between the Mid-to-Far-IR and the extended Mid-IR, the latter offering higher temporal and spatial resolution and improved signal to noise. UNIRAS is a combination of two main units: A spectrometer, assembled at ABB, Canada, and the calibration and scene selection unit currently being assembled at Imperial College. In this talk we provide an update on progress and planned deployment.

Pieter. De.vis

Hyperspectral in-situ surface reflectances from the LANDHYPERNET network

Tuesday 11:00 – 12:00

National Physical Laboratory (NPL)

The HYPERNETS project developed an innovative hyperspectral radiometer (HYPSTAR®) integrated in automated networks of water (WATERHYPERNET) and land (LANDHYPERNET) bidirectional reflectance measurements for satellite validation. This new network of automated hyperspectral radiometers will be invaluable for radiometric validation of water and multi-angle land surface reflectance for hyperspectral (and multi-spectral) satellite sensors. We here present the LANDHYPERNET network, including its measurement protocol, processing to surface reflectance and examples of satellite validation of various products.

The HYPSTAR®-XR instrument used in the LANDHYPERNET network features both a VNIR and SWIR sensor. It provides VNIR data with a wavelength range of 380–1000 nm with 0.5 nm sampling and 3 nm resolution, and SWIR data ranging from 1000–1680 nm with 3 nm sampling and 10 nm resolution. The raw data is automatically transferred to a central server, processed in near real-time to reflectance and other variables and archived for web distribution. Furthermore, to achieve fiducial reference measurement quality, measurement uncertainty is propagated through the full processing chain, including treatment of temporal and wavelength error-covariance, a level of detail unique for such satellite validation network.

We also highlight some results comparing the LANDHYPERNET network data to satellite data. These include a study looking at the feasibility of using LANDHYPERNET surface reflectance data for vicarious calibration of multispectral (Sentinel-2 and Landsat 8/9) and hyperspectral (PRISMA) satellites and a study utilising LANDHYPERNET data products to understand the seasonal dynamics of the reflectance’s of a deciduous broadleaf forest in the UK.

Morven Sinclair

Application of BRDF Model Optimisation Using In-Situ Measurements From the LANDHYPERNET HYPSTAR-XR Instrument Over Satellite Cal/Val Site in Gobabeb, Namibia

Tuesday 11:00 – 12:00

National Physical Laboratory (NPL)

Satellite products are often validated by comparing them against near-simultaneous data from in-situ validation sites or another reference satellite. In order to make the satellite data comparable to the reference, one has to account for differences in the viewing and solar geometries. This is typically done using a Bidirectional Reflectance Distribution Function (BRDF) model; which characterises the behaviour of the surface and the distribution of the reflected light for different incident light conditions. From a BRDF model, corrections can be made to compare observations with different incident and viewing angles.

Automated sites are important sources of steady data for use in satellite calibration and validation activities in remote and complex locations, yet many are limited to an output product of one specific viewing angle. The novel hyperspectral radiometer (HYPSTAR-XR), developed as part of the LANDHYPERNET network, has pointing capability and takes hyperspectral measurements between 380 nm – 1680 nm. As part of this study, a HYPSTAR-XR was programmed with an extensive multi-angular measurement sequence to gather upwelling radiance over the course of several days in October 2023 and May 2024 over the Gobabeb validation site in Namibia (homogeneous desert gravel plain).

We present these LANDHYPERNET BRDF measurements and the methodology that was used to mask invalid measurements (e.g. shadow). We also show how we fit the chosen BRDF models: the Rahman-Pinty-Verstraete (RPV) and Ross-Thick Li-Sparse (RTLS) models. The results are presented comparing the different BRDF models, their spectral variability and assessing the effects these have on satellite validation.

Session 2A

The Business of EO

Daniel Potts

Investigating the barriers and pathways to implementing satellite data into air quality monitoring, regulation and policy design in the United Kingdom

Tuesday 13:30 – 14:30

University of Leicester

Satellite measurements relevant to air quality could help to inform policy and assist the monitoring and management of key air quality issues, both in the United Kingdom and internationally. This study investigates the barriers facing experts, across both scientific research and air quality management, in translating and incorporating satellite data into end user activities, and identifies pathways for the use of current and future satellite data by potential end users. Through an iterative Delphi-inspired two-round study, two groups of experts were issued parallel, near-identical surveys. These groups were Group A: current users of satellite data such as satellite product developers, researchers and air quality scientists, and Group B: potential end users of satellite data such as regulatory bodies, local authorities, government departments and independent air quality consultancies.

This study confirmed that satellite data has had minimal penetration into Group B activities, and that a number of barriers currently prevent its adoption into regulation, namely: personnel-related issues such as lack of resources, technical skills and training, and technical limitations such as spatio-temporal resolution, uncertainties and data storage concerns. Despite this, there was a strong desire across both groups for collaboration and joint data exploration, but current progress has been minimal.

Moving forward, we propose the creation of a network of experts, facilitated by a dedicated boundary organisation, designed to promote collaboration and knowledge exchange between these two groups, with the objective of transferring satellite data sets into end user work flows and to prepare end users to utilise future data sets.

Gareth Thomas

Developing a satellite driven solar energy monitoring system

Tuesday 13:30 – 14:30

STFC RAL Space

Satellite Imagery for Solar Energy Monitoring (SISEM) is an EOCIS Actionable Information Project that aims to develop an end-to-end system for predicting and monitoring the energy output of a large portfolio of solar photovoltaic energy installations, using satellite-derived surface insolation as its primary driver.

The project is a collaboration between RAL Space (providing insolation derived using the Optimal Retrieval of Aerosol and Cloud (ORAC) applied to Meteosat SEVIRI), Amira Technologies (which has developed a solar-PV modelling system) and Ecovision Asset management (which manages approximately 18,000 solar energy systems across the UK). The high temporal sampling and relatively high spatial resolution of the satellite observations allow a step change in the fidelity of the monitoring of solar-PV performance, with should result in improvements in fault detection and efficiency.

This talk will give a summary of the monitoring system developed for SISEM and present early results of its spin-up and operational application.

Jason Hopkins

When GEO met EO

Tuesday 13:30 – 14:30

—The Business of EO

Ordnance Survey

Ordnance Survey (OS) have been mapping Great Britain since 1791. Currently much of the data we deliver is derived from aerial imagery. But what happens when new technology becomes available? How and what can it be used for?

This session will highlight some of the innovative applications of Earth Observation data at OS aimed at delivering new products and services to our customers and efficiencies in existing workflows. Finally, we will focus on how geospatial data is key to unlocking value in Earth Observation data.

Mathias Disney

New EO measurements for assessing the status of woodland carbon code (WCC) projects

Tuesday 13:30 – 14:30

UCL

The Woodland Carbon Code (WCC) is a UK government-backed scheme to enable independently verified assessment of woodland creation schemes in the UK, from the perspective of carbon credits. Woodland creation provides many benefits beyond carbon, including economic, recreational and environmental but carbon is an important driver for new investment. Currently, the WCC verification process does not use Earth Observation (EO) data and relies on independent field surveys of each project, collecting measurements of tree diameter-at-breast height (DBH) and height (H), tree numbers and species. From these, species-specific ‘tariff numbers’ are calculated, which are used to derive estimates of total volume and then biomass from empirical tables. Crown and root biomass components are estimated as simple species-specific functions of DBH, then scaled up to the project by basal area. These methods are hard to replicate or scale and new remotely sensed measurements could address these limitations and so help inform investment and management decisions. We present results from a pilot project to estimate aboveground biomass (AGB) at 15 year WCC sites, using terrestrial laser scanning (TLS) to estimate AGB. TLS is being increasingly adopted as the ‘gold standard’ non-destructive approach to estimating AGB. TLS also provides DBH, H and basal area measures that allow WCC calculations. We compare TLS-derived AGB with WCC estimates at UK sites and show how these new estimates could be used to reduce uncertainty in WCC verification through site-specific assessments, updating tariff tables and scaling up to airborne (including UAV) and satellite observations.

Session 2B

Climate Data Studies 2

Richard Allan

Evidence of acceleration in aspects of the global energy and water cycles

Tuesday 13:30 – 14:30

University of Reading

Increasing rates of energy accumulation and decreasing continental liquid water storage are being monitored through Earth Observation. A positive imbalance in Earth's energy budget is driving climate change, yet this imbalance has doubled from 0.5 ± 0.2 Wm−2 to 1.0 ± 0.2 Wm−2 from the 1st to the 2nd decade of the 21st century with this increase appearing to extend back further in time in satellite-based reconstructions (0.1 ± 0.6 W m−2 during 1985-1999). An increasing global energy imbalance is symptomatic of accelerating climate change, which is not unexpected based on climate change simulations. The energy imbalance increases since the early 2010s are primarily explained by reduced reflection of sunlight to space that is dominated by cloudy ocean regions. Coincident with these energy budget changes are trends in the global water cycle, including global increases in total column water vapour of 0.3 mm/decade (1.3%/decade) during 1988-2019, yet continental relative humidity has been in decline. Gravimetric satellite measurements indicate a drop in terrestrial water storage during the 2015/16 El Niño and an overall decline of 9.1 mm sea level equivalent between 2003-2014 and 2015-2019. Evidence from reanalysis and hydrological model estimates suggest the declining terrestrial water storage since 2003 is part of a longer trend extending back to the 1980s, though with substantial uncertainty. Improved understanding of the physical drivers and linkages between these recent changes in Earth's energy and water cycles are essential in projecting near term and far future changes in climate, critical to societies and the ecosystems upon which they depend.

Zixia Liu

King's College London

Global landscape fire occurrence and direct emissions estimation in EOCIS

Tuesday 13:30 – 14:30

We detail the progress made in establishing a global inventory of landscape fire occurrence and emissions for the tropics and sub-tropics, using the Fire Radiative Energy Emission (FREM) methodology applied to data from geostationary satellites. This initiative aims to directly estimate fuel consumption and emissions of smoke, carbon, reactive gases, and greenhouse gases from landscape fires with the minimum of assumptions and the maximum use of satellite observations, as part of the UK Earth Observation Climate Information Service (EOCIS). Using a network of geostationary satellites, we have developed a unique global Active Fire and Fire Radiative Power (FRP) system that has garnered attention from thousands of users worldwide - for example with the data served within NASA | LANCE | FIRMS in almost real-time. We have extended these data using the FREM approach linking satellite FRP data to (intially) emission rates of total particulate matter (TPM) and carbon monoxide (CO) - through spatially varying smoke emissions coefficients (g.MJ−1). These coefficients are derived from matchups of FRP with smoke plume aerosol optical depth (AOD) from MODIS and CO concentration from the TROPOMI instrument on board Sentinel-5P. We have an operational FREM smoke emissions product from Meteosat Second Generation (MSG) for eight smoke species (including PM, CO, and CO2 etc) in two versions (hourly and daily) and are extending this to the GOES-W, GOES-E, and Himawari geostationary satellites. By blending these four geostationary FREM outputs we aim to create a comprehensive inventory of landscape fire occurrence and emissions that relies on observations - and not assumptions, models or conversion factors derived using other databases - and thus can act as a fully independent source of information on these activities.

Martyn Chipperfield

Recovery of Stratospheric Ozone: Is It Happening and How Should We Quantify It?

Tuesday 13:30 – 14:30

University of Leeds

The Montreal Protocol is successfully protecting the stratospheric ozone layer. The main chlorine- and bromine-containing substances responsible for ozone depletion have been regulated under the Protocol, and their combined atmospheric abundances are declining. Accordingly, ozone is showing signs of recovery in some regions such as the upper stratosphere and Antarctic springtime lower stratosphere. However, this recovery is not a smooth transition. There have been many recent events that have acted to increase ozone depletion in the short term which confounds the search for recovery.

These events include the 2020 Australian New Year fires, which injected smoke into the stratosphere, and the 2022 eruption of the Hunga Tonga-Hunga Ha'apai volcano, which increase the global burden of stratospheric water vapour by 10%.The (slow) timescale for recovery is often measured by the estimated time that it will take for the ozone layer to return to levels observed in 1980, a somewhat arbitrary date but one which corresponds with the start of extensive satellite observations. There are, however, many problems with this metric, not least that it measures the extent of an ongoing process by the timing of a single event. It takes no account the trajectory of ozone recovery.

This presentation will summarise the latest satellite-based evidence for ozone recovery (or not) and the impact of recent perturbations. Model studies will be used to project how the ozone layer will evolve in the future and how we should measure the timing and extent of recovery.

Session 2C

Future EO Missions, Mission Development & Validation 1

Daniel Gerber

ESA EE12 Candidate Mission: Keystone

Tuesday 13:30 – 14:30

RAL Space

Keystone is a proposed limb-sounding satellite mission to explore the mesosphere - lower thermosphere from 70km-150km. Its main objective is a first global measurement of atomic oxygen, the dominant component of the upper atmosphere and main source of residual drag in low Earth orbit. Atomic oxygen is the missing keystone for a complete understanding of upper atmospheric chemistry, composition, and energy balance. After more than a decade of preparatory activities in the UK, Keystone has been down-selected by ESA for Phase-0 study as potential 12th Earth Explorer mission.

We will elaborate why atomic oxygen is considered The Holy Grail of upper atmospheric research and describe the numerous secondary science objectives Keystone will meet.

James O’Connor

The HotSat constellation: mission description and first light imagery

Tuesday 13:30 – 14:30

SatVu

The HotSat constellation will collect mid-wave infrared thermal imagery at a sampling resolution and frequency unlike any other Earth Observation instruments available today, with a sampling distance of 3.5 m at nadir. Once the planned constellation of 10 satellites is realised, the constellation will be able to image point targets on earth up to 20 times per day, both day and night.

Within this talk, we will highlight imagery collected from HotSat-1, our pathfinder mission, and show use cases we aim to serve with these data. We will discuss innovation with the image processing pipeline we have developed and show how this processing pipeline is supporting the delivery of data using open standards. The current product offering will be explored and a roadmap for future development and calibration/validation activities presented which aims to expand the product offering in the medium term, with a view to HotSat-2 and HotSat-3 launches next year.

Finally, we will look at synergistic opportunities of using the HotSat constellation in conjunction with current and planned public science missions and how we aim to provision data through public bodies to get data to the science community as soon as practical.

Ben Stern

Status of ESA Scout HydroGNSS Hydrology Reflectometry Mission and Introduction to HydroSwarm

Tuesday 13:30 – 14:30

SSTL

GNSS reflectometry (GNSS-R) uses signals from Global Navigation Satellite System satellites as L-Band radar sources, detected from a receiver in low Earth orbit. UK-developed instruments on TechDemoSat-1 and CYGNSS missions demonstrated its capability for taking valuable measurements over ocean, ice and land. Water is a natural resource vital to climate, weather, and life on Earth, and unforeseen global variability in hydrology poses one of the greatest threats to the world's population. Global soil moisture measurements are valuable for accurate weather forecasting, flood warnings and agricultural irrigation, thus water management, as well as climate modelling.

The ESA Scout HydroGNSS mission comprises two small GNSS-R satellites due for launch in 2025. The mission objectives are to measure parameters related to the Essential Climate Variables (ECVs) over land: soil moisture, inundation, freeze/thaw and biomass, with secondary objectives of ocean wind speed and sea ice extent. SSTL in UK provides space and ground segments and works closely with ESA and science partners including Sapienza, Tor Vergata University of Rome, IFAC, IEEC/CSIC-ICE, NOC and Nottingham. After launch, data will be owned by ESA and made available on a free and open basis for hydrological and other applications.

The HydroSwarm mission concept proposed by SSTL and IEEC uses 6 small satellites in a close formation to take images using GNSS-R. It targets tropical forested river networks such as the Amazon which otherwise pose a sensing challenge due to the overlying vegetation. This presentation will give the status of HydroGNSS, introduce HydroSwarm and other ongoing GNSS-R activities.

Steve Hancock

Developing swath lidars for mapping global vegetation structure: Requirements and technological developments to address current limitations

Tuesday 13:30 – 14:30

University of Edinburgh

Over the last few years, satellite lidar's like NASA's GEDI and ICESat-2 have provided revolutionary data to improve our understanding of the biosphere and cryosphere. Lidar provides the highest resolution and most direct measure of vegetation structure, allowing maps of biomass, microclimate and modelled biodiversity to be produced. However, the current lidar satellites have sparse coverage over forested areas which leads to large sampling errors (15-20%) and does not allow robust change detection. The coverage of a lidar is limited by the power required to illuminate the surface. To increase the coverage some combination of the improvements below are required:

* More payload power
* More efficient lasers or detectors
* Larger receiving telescope
* Signal processing that requires fewer detected signal photons
* Lower orbit

Improvements in lidar photonics, signal processing and small satellites have the potential to allow lidar satellites with a continuous swath. But even with these improvements, the power requirement of lidar prevents a single satellite being able to achieve high spatial sampling (>20% coverage) regularly (more than once every 4 years). For this reason a constellation of satellites may be needed for some applications.

The Global Lidar Altimetry MISsion team (GLAMIS) has developed a lidar constellation end-to-end simulator, adapted from the GEDI simulator, in order to explore the options for achieving global lidar coverage. This analysis suggests that a spatial sampling density of 20%, once every 1-2 years is required for robust biomass change detection and reporting, whilst requirements for biodiversity and microclimate mapping are less certain. This coverage could be achieved by 2-6 small satellites carrying novel laser diode-based lidars with photon counting detectors. The technologies to enable a constellation of 2-6 small-sat swath lidars is under development, with an airborne demonstrator flown and key components bench tested.

Session 2D

EO Environmental Monitoring – Water Quality

Aidan Byrne

LAQUA: a LAke water QUality retrieval tool for east Africa

Tuesday 13:30 – 14:30

Natural History Museum

East Africa contains some of the world's largest and deepest lakes, supporting the wellbeing and livelihoods of millions of people through drinking water, irrigation for agriculture and inland fisheries. However, growing human populations and anthropogenic climate change are placing increasing pressures on these ecosystems, threatening lake water quality. Effective water quality monitoring is essential for the sustainable use of lake resources. Remote sensing water quality retrieval methods have been developed for lakes globally, however African lakes are often underrepresented in training data, limiting their applicability to the region and the accuracy of water quality estimates.

This study aimed to make satellite water quality information for East African lakes easily accessible through a Google Earth Engine app and assess the accuracy of global water quality retrieval algorithms for African lakes. Here, we collated a dataset of in situ surface water quality measurements to develop and identify water quality retrieval models from Landsat satellite imagery that are suitable for East African lakes. Published band algorithms and global models were compared, and new regression models were developed, to determine the most suitable Landsat retrieval models for chlorophyll-a, Total Suspended Solids (TSS) and Secchi Disk Depth (SDD). A Google Earth Engine application, named LAQUA, was developed to incorporate the best performing retrieval models and to ensure the accessibility of remote sensing methods to water resource managers and practitioners, facilitating more effective water quality monitoring of East Africa's lakes.

Barbara Hofmann

Sewage outfall assessment by remote sensing - initial results

Tuesday 13:30 – 14:30

HR Wallingford

Sewage spills into the ocean and lakes have become a high profile topic of public concern relating to water quality and long term environmental impact. Sewage contributes to e-coli, algal bloom and the resultant depletion of oxygen in aquatic ecosystems which can lead to fatal consequences to animal and plant life as well as impacts to public health (Wear et al. 2021; Gordon et al., 2020). It can be devastating to human health, local biodiversity and the environment. Defra have recorded over 400,000 incidents of raw sewage being put into coastal waters and rivers in just one year, a situation that it has stated as being unacceptable (ITV News, 2021).

In February 2022, the UK Government set out new strategic priorities for the water regulator, Ofwat. These priorities make it clear that Ofwat and water companies should prioritise action on significantly reducing the frequency and volume of discharges from storm overflows: “water companies must reduce pollution from sewage and wastewater” (Defra, 2022, p1). In response, water companies have pledged to almost double their investment in water and sewage infrastructure between 2025 and 2030 to £96 billion (Water UK, 2023).

SOARS aims to utilise machine learning algorithms and both SAR and multispectral satellite data to identify and assess the impact of sewage spills in coastal waters. Here we present early work of this study.

Davide Lomeo

Mapping cyanobacteria occurrence and bloom risk in a tropical lake

Tuesday 13:30 – 14:30

King's College London

Cyanobacteria blooms threaten water quality in lakes and reservoirs worldwide. Existing remote sensing approaches for cyanobacteria focus on quantifying diagnostic pigments like phycocyanin or mapping surface accumulations by buoyant species in calm weather. However, these approaches are not fully complementary and do not provide intuitive understanding of water quality risks under all conditions.

Optical Water Types (OWTs) offer a classification framework for inland and ocean waters to dynamically select suitable algorithms in evolving water conditions. Yet, the widely adopted OWT framework for lakes derives from a limited in-situ dataset, primarily from temperate regions, underrepresenting biogeochemical processes in complex tropical waters.

Here, we extend an OWT framework to capture various states of cyanobacterial bloom in Lake Victoria, an optically complex tropical lake. Sentinel-3 Ocean and Land Colour Instrument (OLCI) images were used to extract spectra from 18 million pixels associated with cyanobacteria presence. K-means clustering was applied to explore intra-class variabilities, and similarities between candidate types were analysed to design a Cyanobacteria Risk Index (CRI) leveraging information from various cyanobacteria classes.

Our 25 candidate water types outperform the original 13 types, and the prevalence-based CRI offers an alternative risk assessment model, grouping risk into three categories for clearer interpretation.

This study highlights the shortcomings of the current OWT framework for tropical waters, while our extended library and CRI capture bloom phases and transitional waters, improving cyanobacteria risk mapping. This approach enables proactive water management strategies and offers a baseline for future cyanobacteria risk assessments and management in tropical, optically complex waters.

Mayra Rodriguez

Global trends of marine ecological indicators: The ocean ecosystem's response to climate forcing

Tuesday 13:30 – 14:30

Plymouth Marine Laboratory

The past two years have recorded the highest sea surface temperatures (SST). Physical factors such as SST force the growth of phytoplankton, the primary producers in the ocean, and changes in this forcing can directly influence phytoplankton abundance and distribution. In turn, changes in phytoplankton affect primary productivity and could have a significant effect on the marine food web. Although not the only relevant physical variable influencing the marine environment, understanding the temporal variations and co-variation between SST and chlorophyll-a (Chl-a), a proxy for phytoplankton biomass, is crucial for assessing the impact of a changing climate on ocean ecology.

In this study, we aim to understand how elevated SST, and its dynamics, influence Chl-a concentrations using statistical and trend analysis at the global scale, for different Longhurst biogeochemical provinces and pixel-by-pixel at 4-9km resolution. Preliminary results show that Chl-a for the period of 2019-2024 are within two standard deviations of concentrations between 1998-2018, but 2024 values are (so far) below the mean Chl-a concentration for 1998-2018. Analysis of linear trends shows an intensification of trends when comparing different periods. In most provinces, the correlation between SST and Chl-a is negative and high, however, in the Polar and some coastal regions the correlation is positive. This analysis provides valuable insights into the complex interactions between physical forcing and the phytoplankton ecosystem, shedding light on the response of ocean ecosystems to changing climate conditions.

Session 3A

EO for Society & Education

Fei Yao

Commerce, pollution, and solar energy yield gaps

Tuesday 15:00 – 17:00

The University of Edinburgh

Particulate matter (PM) in the atmosphere and deposited on solar photovoltaic (PV) panels reduce PV energy generation. However, we lack a global understanding of which sectors would be most effective at reducing PM sources to enhance solar energy generation. We combine well-evaluated models of solar PV performance and atmospheric composition to show that deep cuts in air pollutant emissions from the residential sector substantially benefit Asian PV power output. Halving residential emissions of PM would lead to an additional 10.3 TWh yr-1 of PV energy generation in China and 2.5 TWh yr-1 in India in 2020, respectively. Compared to the 2020 electricity generation of 261.6 TWh yr-1 from solar PV technology in China and 54.4 TWh yr-1 and India, these additional PV energy generation represent an improvement of approximately 4-5%. While anthropogenic PM sources originate mainly from producers, they respond to changes in domestic and international consumer demand. A comprehensive understanding of solar energy generation losses embodied in trade is still lacking but is crucial for promoting a virtuous cycle of improved air quality and increased PV energy generation.

We investigate the source-receptor relationship of PV energy losses attributable to PM pollution across Northeast Asia (NEA) by incorporating a multi-regional input-output model into the combined models of solar PV performance and atmospheric composition. We estimate a PV energy generation loss of 33.6 TWh yr-1 due to emissions from the production of goods across NEA in 2019. In contrast, we estimate a lower PV energy generation loss of 24.6 TWh yr-1 across NEA in 2019, with the reduced amount of 9 TWh yr-1 accounting for the net exports of goods outside NEA. Imports have only avoided a PV energy generation loss of 1.4 TWh yr-1 across NEA in 2019. Addressing solar energy generation losses due to transboundary PM pollution requires a coordinated response from the producers and consumers of goods.

Calum Hoad

SatSchool: Observing the Earth from Space, in the Classroom

Tuesday 15:00 – 17:00

University of Edinburgh

SatSchool is an outreach initiative aimed at engaging lower secondary school pupils (aged 11-14) with Earth observation (EO) science, while highlighting the relevance of STEM subjects and showcasing the diverse pathways into EO careers. Initially spearheaded by PhD students from the Satellite Data in Environmental Science Centre for Doctoral Training (SENSE CDT), SatSchool has evolved into a collaborative effort involving early career researchers from institutions across the UK. SatSchool offers the opportunity for PhD students to engage in outreach as part of a supportive network, alleviating the time constraints and stress associated with individual organisation of such activities.

Supported by funding totalling £23,850 from sources including NERC, SENSE CDT, the Ogden Trust, and SAGES, SatSchool has already made a significant impact, having reached over 2000 students across 37 schools nationwide. SatSchool's outreach package contains six modules (Introduction to EO, Hands on with Data, Cryosphere, Biosphere, Atmosphere, and Oceans), which draw from the broad expertise and creativity of SENSE CDT students and have been enhanced by liaison with school teachers and the European Space Education and Resources Office UK (ESERO-UK). At the upcoming SAGES ASM, we will showcase our materials, present insights gained from the development of SatSchool, and outline our future objectives.

Jade Bowling

Harnessing Earth Observation for nature: Living England habitat maps

Tuesday 15:00 – 17:00

Natural England

The ‘Living England’ project, led by Natural England, is a multi-year programme funded by the Defra Environmental Land Management Scheme (ELMS) and Natural Capital and Ecosystem Assessment (NCEA) programmes. Launched in 2016, the project employs a novel multidisciplinary approach bringing together expertise in ecology, Earth Observation (EO) and data science to create a national-scale map of England’s diverse habitats.

Living England leverages open-source datasets including satellite imagery (Sentinel-1, Sentinel-2), terrain, climate, and geological information. These data are combined with a bespoke national ground survey to train a Random Forest classification model to predict the extent and distribution of broad habitats across England. The project has developed multiple reproducible analytical pipelines, such as a Google Earth Engine cloud-masking framework and coherence-based bare ground mapping. The latest map features innovative developments, including national solar farm mapping and the inclusion of a “reliability” score, offering users an easy-to-interpret measure of confidence in each prediction. Enhanced quality assurance workflows, involving both ecologists and modellers, help identify patterns and anomalies, targeting areas or specific habitats for further survey and refinement. The Living England approach is standardised, with new maps produced every two years to track habitat changes over time.

The national habitat probability map is published under an Open Government Licence (OGL) and is being used to provide evidence to key policy areas (25YEP, 30by30, Biodiversity Net Gain) and for reporting national statistics of our natural capital assets. Living England is being used across the sector by government, commercial users, NGOs and academia to help users make evidence-led decisions about our habitats and aiding efforts towards nature recovery.

Luke Bateson

The role of Earth Observation in advancing our understanding of high sustained temperature leading to dry condition multi-hazard compound events

Tuesday 15:00 – 17:00

British Geological Survey

Between January and June 2022, the UK experienced the driest weather in over 40 years. This culminated in July, when temperatures exceeded 40 degrees Celsius for the first time since records began. Unprecedented hot, dry conditions resulted in hazards and multi-hazard interactions that have not previously been experienced in the UK. This expression of high temperature induced multi-hazards along with more commonly seen hot weather induced hazards with longer residence times may lead to increased direct and indirect impacts on society and ecosystems as experienced in other parts of the world.

The accurate, timely, and efficient derivation of information and data products from EO data and technologies is instrumental in predicting, monitoring, assessing, and evaluating the occurrence of single natural hazard events and their potential impacts. What is not so well understood is the role of EO-derived environmental indicators in characterizing complex causal relationships and underlying mechanisms leading to cascading or compounding multi-hazard impacts. This may be demonstrated using time series analysis of a single indicator or derived from several time series of two or more indicators of interrelated hazard events such as droughts, heatwaves, subsidence, wildfires, flooding, and landslides.

In this study, we aim to advance the state-of-the-art by using long-term EO satellite data to identify thresholds, trends, and tipping points within time series of established environmental metrics which indicate the dynamic evolution of a multi-hazard event. This information will be complemented by in-situ observations and local, regional, and global models to identify environmental precursors and chains of effects that may be suggestive of multi-hazard event onset conditions. By utilizing several vulnerability and impact assessment models, such as impact chains, we will demonstrate the utility of EO techniques and datasets in enhancing multi-hazard risk assessment and management.

In this presentation, we briefly introduce the research context, questions, methodological approaches, preliminary results, and future direction of the UK Science Case as part of the High Impact Multi-hazards Science (EO4Multihazards) project funded by the European Space Agency (2023 – 2026).

Paul Fisher

Leveraging the UK-ESA partnership to deliver climate action

Tuesday 15:00 – 17:00

European Space Agency

The European Space Agency's (ESA) long-running Climate Change Initiative has generated a suite of global multi-mission and multi-decadal datasets for more than 25 Essential Climate Variables. Collectively, these data provide the evidence record to understand the state and evolution of the climate as part of the IPCC assessments.

ESA's new climate Initiative, CLIMATE-SPACE (2023-2029) continues to extend and expand these global data. Additionally, it is responding to new requirements for Earth Observation to support international decision and policy-making and implementation monitoring relating to the UNFCCC Paris Agreement - the main driver for action responding to climate change.

The UK is accelerating national climate action at pace. Currently, the UK National Climate Science Partnership (UKNCSP) - an alliance of the Met Office and seven NERC centres - is combining capabilities to provide climate information and tools to enable public and private sectors adapt effectively and build resilience to future environmental change.

This presentation explores the opportunities and benefits of deepening connections between the UK climate research and Earth observation community and ESA's ECSAT facility, located on the Harwell Science and Innovation campus. ECSAT is the Agency's focal point for climate activities and hosts the WCRP's CMIP international project office has strong links with the global modelling community and provides opportunities to foster greater extend collaboration and UK research impacts across ESA Member States and the world.

Stephanie Mottershead

AquaWatch-AUK

Tuesday 15:00 – 17:00

Surrey Satellite Technology Ltd

AquaWatch-AUK is a bilateral programme addressing the critical need for water-body quality measurements to inform water-related risks, e.g. human health impacts, ecosystem health, and industrial applications, to enable more effective management of water resources. It comprises the development of a world class monitoring and forecasting system, for implementation across the UK, Australia, and beyond. It will provide actionable information on inland and coastal water quality by integrating satellite, in-situ, and modelling data to fulfil the goals of assessing and predicting water quality.

Water quality is very high on the agenda, both nationally and globally, with issues such as fish kills, drought, pollution, and harmful algal blooms regularly reported. Satellites offer a cost-effective solution to global-scale monitoring. Various approaches are currently used for larger water bodies (oceans and lakes), but there is a need to cover smaller, disparate water bodies to provide a more comprehensive picture.

SSTL has partnered with UK organisations Assimila, RAL Space, Pixalytics, and Cefas, and with CSIRO and SmartSat in Australia to develop this work, using funding from UK Space Agency and Australian Space Agency through an International Bilateral Fund Direct Award. This bilateral work will further build a strong community of users, evaluate new and existing in-situ pilot sites in UK territories, evaluate space segment instruments and concepts, and evaluate requirements for combining multiple data sources into a datahub to provide regional catchment to coast monitoring and prediction through a range of user services. We will present an overview of the study, including the current status.

Session 3B

EO Information Services (EO DataHub)

Federica Moscato

Earth Observation Data Hub

Tuesday 15:00 – 17:00

CEDA, RAL Space

The Earth Observation Data Hub is a UK pathfinder project aiming to deliver access to Earth Observation data for effective decision-making across academia, government and business.

The project is being delivered by a strong partnership led by NCEO with extensive expertise in technical, scientific and operational EO data projects and services.

In this presentation we would like to update the UK community on the development of the programme, and the contribution that the Centre of Environment Data Analysis (CEDA) has made to the project in this last year.

In particular, we will focus on the open data sets that will be available on the Hub. In addition of the Sentinel-1 and Sentinel-2 data, and their equivalent Analysis Ready Data for the UK and UK territories, CEDA is collaborating with the EOCIS (https://eocis.org/) team to make available the datasets provided through this project.

The UK Earth Observation Climate Information Service exploits the observations available from environmental sensors orbiting in space to create climate data records and climate information. CEDA is hosting these datasets and Earth Observation Hub will index these them into its search services in order to disseminate them to the UK community. These data will be accessible in conjunction with the Sentinel datasets and high resolution and very high resolution optical and SAR data provided by commercial providers, such as Planet and Airbus.

Alasdair Kyle

Earth Observation Data Hub Platform

Tuesday 15:00 – 17:00

Telespazio UK Ltd

Telespazio UK are delivering the Platform for the Earth Observation Data Hub (EODH), a UK Pathfinder project delivering improved access to Earth Observation (EO) and climate data to support effective decision-making. The project is supported by UKRI NERC, Department for Science Innovation and Technology (DSIT) and the UK Space Agency. Telespazio UK would like to present the Platform which is currently under development, demo early functionality to users attending the conference, and outline what functionality will be available for testing from Q4 2024.

The EODH Platform aims to act as a conduit to existing data archives and processing services, massively simplifying the user journey. The Platform addresses a well-recognised need for more findable, accessible, interoperable and re-usable (FAIR) EO, climate and other data. It will offer users a range of services:

- Federated Data Discovery & Access - Simplified Findability and Accessibility to open and commercial data archives regardless of where they are hosted.
- Data-proximate User-defined Processing - Allow the user to ‘bring their processing to the data’.
- Data Fusion – Facilitate ‘interoperable data’ for exploitation of data across domains, such as standard discovery APIs which can perform metadata mapping.
- Data Quality - Provide product quality, uncertainty and instrument health metrics and reports for data, offering data sets and derived information with readily interpretable quality metrics for users to assess confidence and ‘fitness for purpose’.
- Scalable Storage & Compute - Rapidly scalable data storage for online, near-line and cold storage, and provide users access to highly flexible and scalable, cloud-based compute infrastructure.

Alastair Graham

EODH Integration: simplifying access and compute

Tuesday 15:00 – 17:00

Oxidian

The Earth Observation DataHub (EODH) will be a new world-leading UK-specific software infrastructure that will enable the UK to be at the forefront of digital EO technologies, reducing data downloads and data volumes for storage. This poster presents the work undertaken to date by the developers delivering platform integration. It highlights the Python API client and QGIS plugin tools, both of which help end users access the Hub's functionality in an intuitive and familiar way. This poster lays out how to access the tools and training materials, and demonstrates the user interface.

Andrew Tewkesbury

Airbus Data in the Earth Observation Data Hub (EODH)

Tuesday 15:00 – 17:00

Airbus Defence and Space Ltd.

Airbus is working with the National Centre for Earth Observation (NCEO) and its partners to make Airbus very high resolution satellite imagery available via the Earth Observation Data Hub (EODH). The EODH will be a new software infrastructure for the UK to facilitate wider access to EO data and a consolidated, collaborative EO application development space. Key parts of Airbus' EO portfolio will be accessible via the EODH. This includes: Pléiades Neo, enhanced Pléiades Neo HD15, Pléiades, SPOT, TerraSAR-X and TanDEM-X, delivering optical and radar image products from 15 cm to 40m spatial resolution. This data will be discoverable in the EODH, and available with flexible data licensing options.

The EODH will support the next generation of EO application development. We showcase three applications developed with Airbus data. Firstly, activity analysis leveraging AI based feature detection and classification to report changing levels of vehicle, ship, and aircraft abundance. Secondly, we will outline recent rail-focused land use monitoring using Pléiades to help maintain a safe and efficient rail network. Lastly, we will show how a range of radar data can be utilised to generate near real-time vessel detection reports to support maritime security.

The EODH and Airbus data have the potential to enhance the uptake and value delivery of EO data. We give a future outlook on how this could develop to include a summary of potential future Airbus data availability, and a view on how EO data could be adopted in the future.

Samantha Malone

Quality Assurance Service to underpin the Earth Observation Data Hub

Tuesday 15:00 – 17:00

National Physical Laboratory

In the UK's National Space Strategy and Action, the ambition was identified to "make the UK a global centre for trusted EO data". To deliver on this vision, the EODH project is developing a data QA service to ensure users can trust the quality of the data provided, which is crucial for those requiring quantitative measured outputs they can rely on.

As part of the QA service, novel systems are being developed which put data products from a variety of providers (both public and commercial) through a comprehensive quality check process, including a review of the supporting documentation and automated direct testing for validation against well-defined references. A clear summary of the output of these processes will be presented to users as part of the catalogue interface, to enable them to find trustable data to support their applications.

The work also responds to the need for such services identified by international fora such as the Committee for Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV). Where the wider EO user community has expressed an interest in the development of an objective, open platform to compare the mission performance – particularly for "new space" missions.

Presented here is the progress on the development of this system, including a demonstration that currently considers comparison of the Sentinel-2 and Landsat missions to CEOS' RadCalNet and presents the results in a web dashboard. This system will be extended to include a wider range of target products and references across the EODH catalogue, ultimately through contributions to it as an open-source software project.

Luisa Teixeira

How Planet is supporting the scientific sector in the UK

Tuesday 15:00 – 17:00

Planet

Since 2016, UK scientists have been able to access Planet's dedicated Education & Research program, which provides easy access to up to 100 million square kilometers of almost daily global data. Planet data is used by hundreds of users. Currently, more than 50% of UK universities using satellite data choose Planet data.

Planet’s Education and Research Program provides researchers, academics, and scientists with the ability to observe changes on Earth in near real-time. In the hands of these experts, our satellite data helps power models, reveal planetary changes, and deliver spatial-temporal insights across various academic fields.

Worldwide, Planet’s data has contributed to over 2,500 academic publications in 10 different languages.

This presentation will explore the breadth and depth of the program’s adoption, delve into the user community, and examine use cases and their impact. This will be exemplified by Professor Richard Lucas's work at Aberystwyth University, leveraging Planet datasets in research areas as diverse as tree species, detection of changes in grasslands, estimation of canopy cover, land cover and land use change. Additionally, we intend for this presentation to help uncover the challenges faced by academics and researchers regarding data access and uptake, as well as identify opportunities for collaboration within the community.

Session 3C

Fusion of remote sensing data and models

Guannan Hu

Assessing the value of observations in weather forecasting

Tuesday 15:00 – 17:00

University of Reading

National weather services typically use tens of millions of observations each day to improve global and regional predictions of weather on timescales from hours to weeks. Forecast accuracy relies on optimal use of these observations to create model initial conditions, using a mathematical technique known as data assimilation. The same data assimilation approach is used to produce reanalyses. Thus, assessments of the value of different types of observations (e.g., satellites, radar or aircraft data) for numerical weather prediction provide evidence to help design and improve observation networks and evaluate and improve data assimilation systems. In this presentation we introduce some commonly used methods for assessing the value of observations and their advantages and disadvantages. We discuss our new results on measures of observation information content for use with ensemble data assimilation systems. We conclude that observation influence and impact assessment is critical, but the results need careful interpretation by users.

Christopher M. Taylor

How does soil moisture influence convective storm initiation across the diverse landscapes of Sub-Saharan Africa?

Tuesday 15:00 – 17:00

UKCEH

We have learnt a great deal about how soil moisture influences convective storms from satellite-based studies over the Sahel, an extensive and largely flat, semi-arid region in tropical North Africa. Contrasts in soil moisture create temperature and humidity structures in the lower atmosphere, in turn influencing local dynamical and convective responses.

Near real time observations of land surface state have been used for several years to provide additional predictability of where, given favourable larger-scale atmospheric conditions, storms will trigger in the next few hours. This is important as it can contribute to better-targeted early warnings of severe hazards (notably flash flooding) on scales of tens of kilometres. Here we expand on previous analysis of convective initiations by generalising to all of Sub-Saharan Africa, with its large diversity of climate, vegetation and terrain.

We use twenty years of data from the Meteosat Second Generation (MSG) series of satellites to identify several million cases of daytime initiation of deep convective clouds. To characterise land surface conditions, we use both Land Surface Temperature (from MSG) and surface soil moisture from the Advanced Scatterometer (ASCAT) on board MetOp satellites. As in the Sahel, we find that African storms initiations are favoured over locally warmer, drier soils. We explore the relative importance of this effect as a function of wind speed, topography, season and climate zone. The results will feed in to improved nowcasts, developed in collaboration with African meteorological agencies.

Elizabeth Good

Towards a Blended Satellite-Station Sunshine Duration Dataset for the UK

Tuesday 15:00 – 17:00

Met Office

Sunshine Duration (SD) is a key climate variable that has been measured at weather stations since the 1800s. This presentation describes work at the Met Office to create a new blended UK SD dataset, based on station and satellite observations. The addition of satellite data improves spatial representation and reduces uncertainties and will enable provision of daily gridded UK SD data for the first time.

This study uses the satellite-based SARAH-3 dataset (SDsat) and station data from Met Office's archive (SDstn). An intercomparison between SDsat and SDstn is performed as part of the data pre-processing and quality-control. This analysis highlights some anomalous station observations, which are subsequently excluded from the SDstn dataset. SDstn and SDsat are then blended using a two-step process: first, a generalised linear model (GLM) estimates SDstn from co-located SDsat, and second, a Gaussian Process (GP) is trained on the GLM residuals to produce a correction field. Three GLM models are trialled with different combinations of explanatory variables: SDsat only, SDsat & latitude, and SDsat & latitude & SDsat^2. A 15-fold cross-validation finds that all models have a similar root mean square error (RMSE: 1.4 hours), residual mean (μ: 0.2 hours) and residual standard deviation (σ: 1.4 hours). After training a GP on the daily GLM residuals and then revising the GLM estimates, the updated validation results show an overall improvement in the blended SD estimates (RMSE: 1.2, μ: 0.0, σ: 1.2). However, local improvements may be much larger.

Emily Lear

The Diurnal Cycle of Atmospheric Waves in GNSS-RO Satellite Data

Tuesday 15:00 – 17:00

University of Bath

Atmospheric gravity waves transport momentum and energy throughout the atmosphere and affect the winds. Understanding gravity wave processes is important for the improvement of weather and climate models. Convection, which is a source of gravity waves, is known to have a diurnal cycle, so it is expected that convective gravity waves should also follow a diurnal cycle. However, although this cycle can be simulated in models and observed in ground based data at fixed locations, it is difficult to observe in global satellite observations, since most gravity wave resolving instruments have sun-synchronous orbits and therefore always observe the same local solar time.

In this study, Global Navigation Satellite System Radio Occultation (GNSS-RO) data are used to investigate whether a diurnal cycle in gravity wave amplitudes can be seen in the stratosphere using these observations, which are randomly distributed in local solar time. Radio occultation uses GNSS signals received by a satellite that measures the bending angles and phase delay, due to these signals passing through the atmosphere. Temperature profiles can then be retrieved from the measurements.

Specifically, in this work, GNSS-RO dry temperature data are used from multiple satellite missions, including COSMIC 1 and 2, Metop-A, -B and -C, and CHAMP. A diurnal cycle in gravity wave activity can be seen in the results and comparisons to IMERG precipitation rate data suggest this is strongly linked to convection. These results are also compared to the diurnal cycle in gravity wave activity observed using data from Strateole-2 superpressure balloons.

Sukun Cheng

Improved Arctic sea ice forecasting by combining ensemble Kalman filter with a Lagrangian sea ice model

Tuesday 15:00 – 17:00

NCEO University of Reading

Accurate prediction of Arctic sea ice is crucial for understanding climate change and its impacts. This presentation focuses on improving sea ice forecasting using a stand-alone Lagrangian sea ice model, neXtSIM, combined with a deterministic Ensemble Kalman Filter (DEnKF).

neXtSIM's Lagrangian mesh, while offering advantages in representing sea ice dynamics, presents a unique challenge for data assimilation. The varying grid numbers and positions across ensemble members require a novel approach. We address this by performing DEnKF analysis on a fixed reference mesh, interpolating model variables between the reference and individual ensemble meshes.

Our ensemble-based data assimilation system incorporates observations of sea ice concentration (SIC) from OSI-SAF and sea ice thickness (SIT) from CS2SMOS. We demonstrate significant improvements in modeled SIT by assimilating CS2SMOS data, highlighting its importance for accurate thickness predictions. Daily assimilation of OSI-SAF SIC leads to notable improvements in SIC and ice extent, although it is constrained by the need for daily updates of ocean forcing.

Our results show that assimilating specific observations enhances the forecast skill of relevant variables. With a proper assimilation strategy, neXtSIM achieves efficient performance and maintains good forecasting skills comparable to coupled models. This research provides valuable insights into the potential of DEnKF for improving Arctic sea ice forecasting using Lagrangian models.

Yumeng Chen

A Python interface to parallel data assimilation framework: pyPDAF

Tuesday 15:00 – 17:00

University of Reading

Data assimilation (DA) is an essential component of numerical weather and climate prediction. Efficient implementation of DA benefits both operational prediction and research. A variety of DA software programs are available. One of the notable DA libraries is the Parallel Data Assimilation Framework (PDAF) designed for ensemble data assimilation. The DA framework is widely used with complex high-dimensional climate models. Meanwhile, there exists increasing need for flexible and efficient DA implementations using Python due to the increasing amount of intermediate complexity models as well as machine learning based models coded in Python.

To accommodate for such needs, we introduce a Python interface to PDAF, pyPDAF. The Python interface allows for flexible DA system development while retaining the efficient implementation of the core DA algorithms in the Fortran-based PDAF. The ideal use-case of pyPDAF is a DA system where the model integration is independent from the DA program, which reads the model forecast ensemble, produces a model analysis and update the restart files of the model, or a DA system where the model can be used in Python.

This study demonstrates the use of pyPDAF and PDAF for coupled data assimilation (CDA) in a coupled atmosphere and ocean model, MAOOAM. Using both weakly and strongly CDA, we demonstrate that capability and limitations of pyPDAF. Our CDA experiments confirm the benefit of strongly coupled data assimilation compared to the weakly coupled data assimilation.

Session 3D

Environmental Monitoring – Atmosphere

Alexander Kurganskiy

UK net fluxes of CO2 using the new GEMINI-UK ground-based remote sensing network: simulation experiments

Tuesday 15:00 – 17:00

University of Edinburgh

All UK greenhouse gas (GHG) emissions are to reach net zero by 2050, with interim targets to ensure the UK meets this target. The UK Government issued a statement in May 2024 stating that the UK in the period 2018-2022 had over-performed on planned reductions in carbon emissions. Such claims are largely based on inventory estimates. Atmospheric measurements of GHGs provide an independent approach to verify these estimates.

Funded by the UKRI Building a Green Future theme, we are establishing a ground-based network of ten Bruker EM27/SUN Fourier Transform spectrometers that will collect CO2 and methane data across the UK and be used to infer regional carbon budget, complementing existing in situ GHG data collected at tall towers in the UK. The spectrometers form the Greenhouse gas Emissions Monitoring network to Inform Net-zero Initiatives for the UK (GEMINI-UK) that will be fully operational in Autumn 2024. GEMINI-UK data also provides ground-truthing of the upcoming Copernicus CO2M satellite constellation, providing an opportunity for the UK to leverage substantial investment in these satellite instruments.

In this presentation, we used focused closed-loop numerical experiments to report the potential benefits of GEMINI-UK to estimate spatially resolved net fluxes of CO2 across the UK over and above the information collected by the tall towers. We will show how GEMINI-UK enhances the UK's ability to leverage atmospheric CO2 data provided by the existing measurement networks, thus supporting the country's net-zero initiatives.

Antonio Giovanni Bruno

Analysis of long-term stratospheric fluorine and chlorine trends: a comparison of machine-learning based models, CTM simulations and satellite measurements

Tuesday 15:00 – 17:00

University of Leicester

TOMCAT, a three-dimensional (3D) off-line chemical transport model, uses winds and temperatures from meteorological analyses to specify the atmospheric transport and temperatures, and calculates the abundances of chemical species in the troposphere and stratosphere. The model contains a comprehensive chemistry scheme for the stratosphere and has been used widely in the past to help interpret observations of ozone depleting substances in the atmosphere, and to diagnose the extent of stratospheric ozone depletion.

Recently, a machine-learning (ML) data assimilation scheme using extreme gradient-boosting (XGBoost) has been applied to ACE-FTS (Atmospheric Chemistry Experiment - Fourier Transform Spectrometer) data of halogenated species and collocated TOMCAT calculated profiles. This has produced gap-free profiles for a range of chlorine/fluorine species with reduced biases and a better representation of seasonal variability. This dataset makes use of 20 years of measurements by the ACE-FTS of atmospheric composition by solar occultation from low Earth orbit.

Here we report on trends and variability for a range of atmospheric fluorine and chlorine species using this ML dataset, and compare these with the individual TOMCAT and ACE-FTS datasets.

Dr Harjinder Sembhi

Quantifying Madrid’s landfill methane emissions using Sentinel-5P TROPOMI, and GHGSat satellite and aircraft observations

Tuesday 15:00 – 17:00

Earth Observation Science, University of Leicester

Active monitoring of landfills using satellite sensors can be a useful way to gain perspectives on the spatial extent, frequency and behaviour of methane (CH4) plumes originating from individual waste management sites. Whilst area flux mappers such as Sentinel-5P TROPOMI can capture regional fluxes, plume observations from point source imagers such as GHGSat can be linked more directly to landfill site operations which can help ascertain the efficacy of waste management protocols.

Across Europe, one of the largest CH4 hotspots observable in Sentinel-5P TROPOMI data originates from the urban area of Madrid where enhanced CH4 concentrations are continuously detected. Analysis of GHGSat data helped attribute a large part of the observed CH4 plumes to two major landfills located in Madrid. To quantify the emissions from these sites, an aircraft campaign was conducted in summer 2022 in which high-resolution GHGSat airborne data (1 x 1 m2) was obtained.

We performed an intercomparison of GHGSat satellite and GHGSat aircraft emission data and found strong consistency between overlapping observations across both aircraft and satellite spatial scales. We also conducted an independent analysis of the Madrid regional CH4 fluxes using two TROPOMI datasets. We present our evaluation and comparison of CH4 emission rates estimated using both TROPOMI products and GHGSat and discuss how representative they each are of fine and urban-scale emissions within and beyond the two landfills. Finally, we discuss how these results demonstrate the potential and value of using high-resolution GHGSat data to inform and target corrective methane mitigation activities.

Jeremy Harrison

The LOng-LIved greenhouse gas PrOducts Performances (LOLIPOP) CCI+ project

Tuesday 15:00 – 17:00

NCEO University of Leicester

ESA's CCI programme provides high-quality datasets of climate-sensitive variables measured by satellite instruments, and has already addressed atmospheric gases like ozone, water vapour, carbon dioxide and methane. However, for a complete understanding of the Earth's climate, it is essential to consider other greenhouse gases such as nitrous oxide (N2O) and a range of halogenated species such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). These gases are collectively known as 'Other long-lived greenhouse gases' (OLLGHGs) and are recognized collectively as one of the GCOS Essential Climate Variables (ECVs). While GCOS has outlined a list of requirements for N2O, no user requirements have been identified for the other OLLGHGs. The LOng-LIved greenhouse gas PrOducts Performances (LOLIPOP) CCI+ project, which started in November 2023, aims to fill this gap. The goals of LOLIPOP are:

- to assess the state-of-the-art of OLLGHG satellite measurements;
- to establish a baseline of user requirements for all the OLLGHGs not already included in the GCOS list, and compare this baseline with the quality of the existing satellite observations;
- to investigate if the quality of the existing data is sufficient to be used for selected applications in climate and atmospheric chemistry models and services; and
- to suggest actions to be taken to either improve the quality of satellite measurements of the OLLGHGs (through new retrieval techniques applied to existing satellite missions) or to develop dedicated satellite missions for their monitoring.

This presentation will provide an overview of the project and work completed so far.

Richard Siddans

Methane retrievals from IASI and combination with Sentinel-5P.

Tuesday 15:00 – 17:00

NCEO RAL Space

We present the status of the RAL scheme to retrieve global height-resolved information on methane from IASI. Previously, the scheme had been used to reprocess the IASI MetOp-A record, producing a global 10-year v2.0 dataset (2007-17). Through the NCEO and ESA Methane+ the scheme has now been improved and applied to process the complete Metop A and B record and is running in near-real time for both Metop-B and -C.The data can be viewed in near-real time at http://rsg.rl.ac.uk/vistool).

The near-real time scheme provided the only direct satellite measurements of the main plume from the Nordstream pipeline explosion in September 2022 (https://doi.org/10.5194/egusphere-2023-1652). While providing information on two independent vertical layers in the troposphere, sensitivity of IASI decreases towards the ground, due to decreasing thermal contrast between the atmosphere and surface. Within the Methane+ project, a combined wavelength scheme has been developed specifically to resolve near-surface information. This exploits the high signal-to-noise of Sentinel-5P (SWIR/column) with co-located soundings from IASI MetOp-B (TIR/height-resolved). Both the IASI-only and IASI-S5P datasets have been used in inverse modelling trials and the data sets will be publicly available via CEDA.

Here we present findings from ethane+ project and an assessment of the long-term datasets as well as outlining new work to address the remaining limitations related to spectroscopic parameters that will be conducted within the new ESA SMART-CH4 project.

Rui Song

Analysing Stratospheric Volcanic Ash Deposition Using CALIOP Measurements

Tuesday 15:00 – 17:00

University of Oxford

Volcanic eruptions can inject significant amounts of ash and sulphur dioxide into the stratosphere. The resultant aerosols (ash and droplets of sulphuric acid) impact atmospheric chemistry and Earth's radiation balance. Volcanic ash particles can persist in the atmosphere for weeks or even months in extreme cases. The Cloud Aerosol Lidar with Orthogonal Polarization (CALIOP), launched in 2006 on board the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) platform, measures the vertical distribution of aerosols in the troposphere and lower stratosphere using attenuated backscatter signals at 532 and 1064 nm.

This research focuses on the ash deposition process following the June 2011 eruption of Puyehue-Cordón Caulle, which injected the ash plume up to 13 km into the stratosphere. The ash cloud subsequently circled the globe primarily between latitudes 40° and 60° S before descending into the troposphere. Using CALIOP version 4's upgraded automated aerosol classification products, which now include volcanic ash as a subtype of stratospheric aerosols, this study traces the ash deposition. The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model and Infrared Atmospheric Sounding Interferometer (IASI) observations are employed to ensure consistent tracking of the ash cloud across different CALIOP profiles.

Sarah Cheesbrough

Satellite derived emissions data – barriers and opportunities to uptake

Tuesday 15:00 – 17:00

Satellite Applications Catapult

This session will present insights from the Methane Monitoring Data Supply for the UK Programme, funded by UKSA.

The session will discuss the demand for asset level greenhouse gas plume emissions data by regulators, operators and investors. Current challenges and related barriers to the operational adoption of these data will be covered, drawing from the experiences of the project team's engagements. Findings across a range of sectors will be discussed including Oil and Gas, Financial Services, Waste Management and Agriculture. T

he talk will provide an invitation for the audience to engage with the remainder of the programme which continues until March 2025. Through the programme access is provided to archive and tasking opportunities with GHGSat data.

Session 4A

Future EO Missions, Mission Development & Validation

Robert Elliott

CLEAR Sensor for high repeat measurement of UK Land Surface Temperatures

Wednesday 09:00 – 10:00

SSTL

The Climate Monitoring for Earth (CLEAR) Sensor aims achieve an unprecedented step change in capability through a small satellite constellation of primarily Thermal IR cameras providing surface temperature (ST) measurement across the whole of the UK several times per day at 100 m spatial resolution. The cameras aim to possess sufficient dynamic range to address temperatures expected over UK land surfaces, coastal and inland waters whilst also providing useful global data and a pathway to create international partnerships. Surrey Satellite Technology Ltd (SSTL) have teamed with the National Centre for Earth Observation (NCEO) to co-design the instrument and deliver a viable mission concept based on extensive experience of working with scientific and operational end users, of world-leading ST algorithms and satellite sensor design. Ultimately, it is the frequent revisit at different local times (diurnal coverage) which differentiates our concept from other scientific missions operating in the same waveband and resolutions (such as LSTM, TRISHNA) and will enable the UK to accelerate ST/surface emissivity applications in agriculture, urban living/health, wildfires, asset valuation/financial services and environmental risk management. The work is being part funded by the UKRI STFC Earth Observation for Marine and Climate Mission Development Programme (EO4MCM) and the presentation will discuss current progress on scientific requirements, instrument design, calibration, outline mission concept and future exploitation.

Stephen Hobbs

Water Cycle Science and Hydroterra+

Wednesday 09:00 – 10:00

Cranfield University

Earth's water cycle is fundamental to life and to human society and is largely well understood. Satellites provide data which are fundamental to this understanding, but there are still important observation gaps. One of the most significant gaps is the ability to observe water in the atmosphere and at the land surface several to many times a day across scales of 1000 km or more. Important water cycle processes which fall into this gap include partitioning of precipitation to evaporation, run-off or soil moisture, snow accumulation and melting, and the development of intense mesoscale convective systems (MCS). These processes are expected to become more important as Earth's climate changes, e.g. MCS are already responsible for over 50% of rainfall in the Tropics and this fraction is expected to increase. Around the Mediterranean, mesoscale storms regularly have significant impacts on society, but have proved to be very difficult to predict accurately.

Of the Earth observation technologies to address the measurement gap, a radar (sensitive to water in both the atmosphere and at the surface) in geosynchronous orbit (enabling observations whenever required) is a potentially powerful solution. The Hydroterra+ mission, recently chosen by ESA as a candidate for its 12th Earth Explorer mission, proposes a geosynchronous radar to advance water cycle science.

Hydroterra+ would bring a transformational observation capability with applications beyond the water cycle (especially for ground motion science – earthquakes and landslides). It would significantly enhance global EO capabilities and its applications enable new science and important societal benefits.

Prateek Dongre

Cyclops EO constellation and its application to forest health monitoring

Wednesday 09:00 – 10:00

AAC Clyde Space

This abstract presents the new Cyclops EO constellation that AAC Clyde Space will launch in 2025 to provide high-resolution, multi-spectral imaging capability using CubeSat technology but incorporating many of the features users are familiar with from more traditional, larger systems. This builds on AAC Clyde Space's 16U EpicVIEW Max platform, developed under the xSPANCION programme as part of ESA's ARTES Pioneer programme. The payload is provided by Simera Sense, who's innovative camera design is optimised to be accommodated in this size of platform.

The system is designed to provide VNIR spectral data for use in agriculture, forestry and other land management applications. The spectral bands are aligned to Sentinel-2, which will allow the wealth of research and development invested in algorithms to analyse this data to be applied at a higher resolution. In addition to good spatial and spectral coverage, the constellation will offer a daily revisit across the globe.

This paper will focus on the application of this new EO constellation to plant health monitoring across Scotland's forests. Remote sensing is needed in this context to target interventions on the ground to limit the spread of pest and disease that are being accelerated by further trade globalisation and climate change. Results will be shown from AAC Clyde Space's works with Scottish Forestry to develop and test a tree health index, which is based on spectral analysis of satellite imagery.

Agnieszka Soszynska

Preparation and algorithm selection for the future high resolution ESA satellite mission of Land Surface Temperature Monitoring

Wednesday 09:00 – 10:00

University of Leicester

The Copernicus/ESA Land Surface Temperature Monitoring (LSTM) mission is planned to launch in 2029. The main purpose of the mission is to provide high resolution and high accuracy land surface temperature (LST) products. As a preparation step, selected LST retrieval algorithms were developed in an agnostic version that allows testing of various sensor parameters, and the sensitivity of the algorithms to perturbations. Another crucial step in the preparation of the mission was to choose the most accurate LST retrieval algorithm, using a round robin procedure in which a set of algorithms was compared using a simulated database. The database was designed to mirror the conditions of natural ecosystems and atmospheric profiles, including various land covers (classified as biomes, according to ESA Land Cover cci). A set of 6 algorithms were compared: University of Leicester algorithm (UoL), Generalised Split Window (GSW), Temperature-Emissivity Separation (TES), Optimal Estimation (OE), DirecTES, and Hybrid Optimal Estimation (HybridOE). Each algorithm was run on the whole database, and the retrieved LST was compared to the true LST for each pixel. The results were used to calculate a set of accuracy metrics: bias, precision, and sensitivity. Additional information, such as mission compliance, complementarity, improvability, and difficulty of implementation were also considered. Algorithms were ranked based on a weighted score from each criterion. From there, two algorithms were selected for further development.

Session 4B

Novel Applications and Machine Learning

Keneuoe Anne Maliehe

Enhancing Methane Emission Characterisation with Causality-Constrained Machine Learning and Satellite Observations

Wednesday 09:00 – 10:00

Nottingham Geospatial Institute, University of Nottingham

Methane (CH4) is a potent greenhouse gas, originating from both natural (40%) and human (60%) sources, with its atmospheric concentration escalating from 722 ppb pre-industrial era to approximately 1,922 ppb in 2019. Accurate measurement and monitoring of CH4 are vital to mitigate climate change impacts. However, significant uncertainties in bottom-up inventories (e.g., emission estimations from activity data and gas-loss rates) reported to the UNFCCC hinder policymakers from setting precise emission reduction targets. This research investigates whether a causality-constrained machine learning framework can provide better characterisation of CH4 emissions on the Earth's surface compared to standard bottom-up approaches.

We conducted an analytical inversion of satellite observations from TROPOMI to derive the best posterior estimate of CH4 emissions. The method for the inversion, comprised a Bayesian cost function, GEOS-Chem as a chemical transport model, smoothed TROPOMI fields, and a bottom-up CH4 emissions inventory from the second version of the Global Fuel Economy Initiative.

While this state-of-the-art method provides high-resolution methane flux estimates, it is data-intensive and costly. To overcome these limitations, we develop a causality-constrained machine learning model that integrates 22 independent variables including co-occurring trace gases, meteorological fields, land use, land cover, population, livestock, and quality of life survey data. By combining these with near-real-time Earth observation data, we create a cost-effective tool which is just as effective for predicting CH4 fluxes. This provides a more accessible and reliable tool for policymakers and researchers. This work exemplifies the potential of advanced AI and Earth observation techniques in addressing critical environmental challenges.

Jonathan Walsh

Earth observation for understanding environmental harm in armed conflicts

Wednesday 09:00 – 10:00

The Conflict and Environment Observatory (CEOBS)

Armed conflicts are becoming the defining global feature of the decade. The impacts on the environment are severe and manifold, and may be expressed instantaneously or create long legacies.

Two approaches can come together to overcome the many data gaps and challenges. There is already an emerging body of work for the first - assessing landscape scale impacts and processes (e.g. satellite based mapping of deforestation, fire mapping, crater detection). There is less attention on the second - investigating specific locations with discrete incidents of harm, be they pollution events or the loss of ecosystem services. Here, we introduce a generic methodology to capture, detail and archive these incidents, and compile them into databases, using examples in Ukraine and Sudan. The fundamental approach is to integrate a diversity of earth observation data with information from social and mass media, to understand an incident's genesis, evolution and environmental harm.

It is our ambition that the incident and database framework is an important contribution to the grand challenge of collecting environmental data in armed conflicts, for humanitarian, recovery, remediation or accountability purposes. To encourage further novel and applied earth observation studies in this space, we will introduce a recent initiative - the Conflict and Environment Academic Network.

Chlöe Schooling

Parametrising NOx Chemistry to help assess the future role of satellite observations of NO2 to help quantify fossil fuel CO2 emissions

Wednesday 09:00 – 10:00

University of Edinburgh

Nitrogen oxides (NOx = NO + NO2) are key components of surface air pollution, with elevated levels linked with deleterious effects on human health. They are co-emitted with CO2 during incomplete fossil fuel combustion and consequently provide a statistical constraint on estimating fossil fuel CO2 emissions (ffCO2). Reliable estimates of NOx emissions are therefore crucial for assessing regional changes in air quality and ffCO2. Atmospheric NOx has a relatively short lifetime (on the order of hours to days) due to photochemistry and physical processes. This short lifetime means that we can link elevated NO2 columns observed by satellites to their parent emissions. A key disadvantage that has limited the widespread use of NOx to infer ffCO2 is the computational overhead of the associated atmospheric photochemistry. We describe a machine learning methodology to parametrise NOx chemistry using meteorological parameters. We train the regression on outputs from a nested GEOS-Chem model simulation, centred on mainland Europe for 2019. We demonstrate the approach using four seasonal prediction models that all have a high degree of predictability performance (R2>0.9), and can reproduce atmospheric columns of NOx with less than 1% mean absolute error maintained through a 10-day model run. We also parameterise the NO2:NO column ratio, allowing us to convert NOx to NO2 for comparison with NO2 satellite column data. We discuss our results in the context of a joint NO2:CO2 inversion to quantify robust ffCO2 estimates across Europe.

Geoff Smith

Monitoring the impact of fluvial flooding on intertidal surfaces

Wednesday 09:00 – 10:00

Specto Natura

Coastal flooding from storms is expected to increase as a consequence of climate change. As well as generating tidal surges and increased wave heights, which are directly damaging to coastal features, the consequent heavy rainfall over land can also result in extensive river flooding which could have impacts on the coastal zone. Estuaries and coastal habitats can be impacted by fluvial sediments, nutrients and pollution (e.g. pesticides, toxic material) brought in from great distances away.

The Vis4Sea (Visualisation and assessment of water quality using an Open Data Cube (ODC) for the western English Channel) is seeking monitoring solutions to address the environmental problems caused by agricultural and urban run-off arising from flooding events. The project is building a cohesive ODC to facilitate the use of in situ sampling, automated sensor networks and multi-source, multi-sensor satellite data for monitoring the water quality in Plymouth Sound, UK and the Fitzeroy River and Murray Darling, Australia.

This paper will outline the approach of using high cadence fine spatial resolution EO data to monitor intertidal surfaces in the immediate aftermath of a storm and then assess the longer-term damage and/or recovery in relation to the levels of nutrients or pollutions deposited in the event. The work will also explore the potential of upcoming hyperspectral systems to measure the subtle changes in sediment type and vegetation conditions likely to accompany the flooding events. The EO-based results will be compared to ground and water samples to assess the sensitivity of the approaches.

Session 4C

Environmental Monitoring - Water

Aser Mata

Mapping wild Pacific oysters with drones and Deep Learning

Wednesday 09:00 – 10:00

Plymouth Marine Laboratory

Wild Pacific oysters are classified as an invasive species across Europe. They have a very high reproduction rate that has the potential to impact negatively the ecosystem balance of marine protected areas in UK. Their recent geographical expansion due to the warmer seasons caused by climate change, has raised further the need of urgent monitoring solutions for environmental management.

Currently, the monitoring of wild Pacific oysters is carried out on walking surveys that rely on large numbers of volunteers. These surveys are very laborious and cannot be difficult access to areas such as mudflats or cliffs. Implementing the use of Uncrewed Aerial Systems (UAV, aka drones) for the automated detection of Pacific oysters potentially could provide a cost effective solution even in complex terrain.

This study aimed to develop a novel proof of concept in mapping individual Pacific oysters. Two surveys in Devon collected drone imagery at low tides and at low altitudes in the intertidal environments of mudflats and rocky shores. Four Convolutional Neural Networks architectures were trained and assessed for Pacific oyster detection resulting on model precision up to 88%, with variations across the two backgrounds. Metrics for each model will be presented, highlighting their strengths and weaknesses. Model outputs include the geolocation of individual Pacific oysters unlocking detailed seasonal studies to identify trends. Grid maps that capture the number of oysters per square meter were also implemented allowing easy visualisation of the density of Pacific oysters to identify hotspots.

Christopher Merchant

Exceptional global sea surface temperatures associated with the 2023 and 2024 El Niño

Wednesday 09:00 – 10:00

University of Reading

Not only was 2023/24 record-breaking in temperature, it was record-breaking to an unusual degree. The main thermal inertia that moderates the rate of global warming is that of the oceans, and global mean sea surface temperature (SST) is a key climate variable. Using data from the Earth Observation Climate Information Service and ESA Climate Change Initiative, it is shown that there is an apparent acceleration in the rate of SST increase in the past decade compared to expectations based on previous decades. The degree to which this is explained by the record of Earth energy imbalance is explored. Implications for future rates of SST increase are of huge significance, and will be discussed.

Laura Risley

Implications of alternative velocity control variables in variational ocean data assimilation

Wednesday 09:00 – 10:00

University of Reading

In variational data assimilation, as part of the formulation of the background error covariances, state variables are transformed to control variables that are assumed to be mutually uncorrelated. In the global ocean, the transformed velocity variables are commonly taken to be their ageostrophic components. With a view of assimilating future ocean current measurements, we seek alternative velocity control variables based on Helmholtz Theorem. This decomposes the velocities into their nondivergent and irrotational parts, given by stream function and velocity potential. Ageostrophic stream function and velocity potential are proposed as alternative velocity control variables for global ocean assimilation.

We investigate the implications of using these alternative control variables. Using a shallow water model, we perform the transformation from the velocities to their nondivergent and irrotational parts. We show that the boundary conditions that are implicitly imposed on stream function and velocity potential cause some numerical issues, and we offer some potential solutions to these. We then investigate the assumption that the cross-correlations of control variables are approximately zero. We show that this assumption is more valid when using the alternative control variables. However some of the numerical implications discussed previously must be carefully considered when calculating the cross-correlations.

Yanna Alexia Fidai

Trends in coastal ocean primary productivity

Wednesday 09:00 – 10:00

Plymouth Marine Laboratory, Earth Observation Science and Applications

The coastal ocean is a region of socio-economic, ecological and Earth system importance. Yet, this system is under immense pressure from global and climate change and other anthropogenic hazards, which threaten ecosystem services and increase the vulnerability of the growing coastal population and infrastructure. Whilst the coastal ocean is under pressure, it can also be part of the solution to manage and adapt to changes, with the phytoplankton ecosystem as an example of this. Primary production by phytoplankton plays an important role in the global carbon cycle through the drawdown of inorganic carbon from the atmosphere into the ocean, where some of it is converted to organic carbon via photosynthesis. This process is not only important for global climate regulation, but also essential for supporting all coastal ecosystem services. We therefore explored the trends in coastal ocean primary production from 1998-2022 in Longhurst's coastal provinces. We found six provinces with statistically significant increasing or decreasing linear trends in primary productivity. In this study we explore key questions including: i) which coastal provinces are experiencing statistically significant trends?; ii) what are the causes of these trends?; and iii) is the classification of the coastal zone into ecological provinces as defined by Longhurst suitable for studying change in the global coastal ocean? We thereby contribute to developing an understanding of the changes experienced in the global coastal ocean, which is essential knowledge for management of coastal challenges and pressures globally.

Session 4D

Vegetation Applications 1

Nicole Reynolds

Review of Satellite-Based Methods for Condition Monitoring of Northern Peatlands: An Indicator Approach

Wednesday 09:00 – 10:00

National Physical Laboratory

In the UK, 80% of the 3 million hectares of peatland are in a degraded condition, contributing ~4% of the UK's total annual greenhouse gas emissions. The UK has set a goal of restoring 2 million hectares of peatland to good condition by 2040, to protect the huge carbon stocks in peatlands and capitalize on their carbon sequestration potential. Current estimates on the total emissions contribution from restored peatland areas are inaccurate and characterized by significant uncertainties. Peatland restoration needs to be underpinned by condition monitoring to determine restoration success, so further management practices can be implemented, and to allow for accurate emission/sink reporting. This requires a cost-effective national-scale approach for monitoring peatlands. EO (Earth Observation) data and retrieved indicators, such as vegetation cover and soil moisture, can provide a potential solution to monitor peatland condition.

Most studies which assess the health and condition of the peatland only investigate one of the many EO-based indicators at a time. The aim of this study is to identify a set of key indicators of peatland condition and present a comprehensive review of the utility of remote sensing satellites to measure and monitor these indicators at different spatial scales. This review will facilitate the future development of a peatland health monitoring framework that incorporates multi-scalar datasets (ground, airborne, satellite) to classify and track peatland condition and associated emissions through time. Such a tool will be crucial for assessing restoration success in a systematic way, informing the UK government on its peatland restoration target progress and land management decisions.

Ross Maidment

A new, long-term and operational satellite-derived root zone soil moisture dataset for Africa

Wednesday 09:00 – 10:00

TAMSAT Group, University of Reading

Root zone soil moisture is an extremely useful indicator of agricultural drought, a peril which frequently affects Africa. While the top layer of soil (0-5cm) can be readily observed from satellites, determining soil moisture at depth (~1m), where the roots of mature crops such as maize are found, is non-trivial. Consequently, stakeholders across Africa lack access to such information, preventing appropriate actions from being taken when agricultural drought occurs.

To address this issue, within the EOCIS programme, the TAMSAT Group have developed a new long-term (1983-present) root zone soil moisture product which has been produced using the JULES land surface model tuned to SMAP satellite soil moisture observations and forced with TAMSAT satellite rainfall estimates. This new dataset, which became operational at the start of 2024, provides Africa-wide, daily soil moisture information in near-real time (<7 days) at 0.25□ spatial resolution.

Since its release, there has been a lot of interest in the new dataset. Through EOCIS, we have worked with the African finance sector to pilot the soil moisture estimates within index insurance schemes for smallholder farmers in Rwanda, Zambia and Zimbabwe and are now collaborating with the Kenya Meteorological Department and the Nigeria Meteorological Agency to support their agricultural drought monitoring efforts.

Gerardo Lopez Saldana

ESA’s WorldPeatland project – facilitating peatland mapping and monitoring tools.

Wednesday 09:00 – 10:00

Assimila

Peatland restoration and conservation, including sustainable peatland management, require robust, consistent, efficient, and accessible methodologies to map peatlands, and identify and better understand the changes and impacts of natural and anthropogenic changes, including restoration measures. Peatland mapping and monitoring tools should enable users to (i) locate peat soils; (ii) identify peatlands at risk of degradation and in need of protection and/or restoration; (iii) monitor the success of management interventions; and (iv) support national and international reporting requirements. Given the spatial scale of peatlands lend themselves to use of Earth Observation techniques. In response to these needs, ESA’s WorldPeatland project will work closely with stakeholders in the peatland community to define, validate, and promote Earth Observation-based products and tools that facilitate the mapping and monitoring of peatlands in different states and biomes. We will present the core components of WorldPeatland focusing on how to monitor their hydrology, surface motion and vegetation biophysical parameters. First results of the innovative monitoring products and tools along with some initial results from case studies will be presented.

Mehran Alizadeh Pirbasti

Hedgerow detection using deep learning methods in very high resolution remote sensing imagery

Wednesday 09:00 – 10:00

University College Dublin

Hedgerows are essential for protecting biodiversity, preventing soil erosion, and connecting landscapes in agricultural regions. Accurate detection and mapping of hedgerows are crucial for effective land management and environmental protection. To facilitate hedgerow monitoring, cost-effective and accurate mapping of hedgerows across large spatial scales is required. The objective of this study is to identify hedgerows from very high-resolution remote sensing data using deep learning approaches, aiming to estimate the proportion of the hedgerow network that can be automatically extracted, regardless of its characteristics. We will examine this using high-resolution multispectral Pléiades Neo images, along with hedgerow maps (as a proxy for ground truth data) from the newly released UK Centre for Ecology & Hydrology (UKCEH)’s hedgerow map, which is derived from aerial laser scanning of England’s entire landscape. We will demonstrate the potential of deep neural networks, such as Vision Transformers and Convolutional Neural Networks (CNNs), for hedgerow mapping by investigating performances across different regions and sensors.

— Keynote

Beth Greenway

Earth Observation – the UK Space Agency Perspective

Tuesday 11:30 – 12:30

UK Space Agency

Beth will outline the current portfolio of activities UKSA have underway to support the UK EO sector and give a personal view of the long term challenges and opportunities ahead.

Session 5A

Vegetation Applications 2

Biao Hu

Tracking the heat stress and water deficit experienced by UK rapeseed crop over 2016-2022 with solar-induced chlorophyll fluorescence and vegetation indices

Wednesday 14:00 – 15:15

University of Dundee

The global climate change introduces unprecedented challenges, though also opportunities, for earth systems including the vegetation and agriculture sectors, making monitoring their interactions an imperative task. Our initial research found that heat stress (HS) shows an increasing trend and water deficit (WD) is also a challenging issue for UK rapeseed production during its critical growth stage (i.e., flowering). However, whether these stresses can be observed with remote sensing (RS) data is currently not clear and how can the use of RS data benefit the growth monitoring of UK rapeseed against HS and WD remains unknown.

Given above mentioned gaps, the study aims to utilise vegetation indices (NDVI/normalized difference vegetation index, EVI/enhanced vegetation index, NIRv/NIR reflectance of vegetation, etc.) and physiological signal SIF (solar-induced chlorophyll fluorescence) to monitor the spatiotemporal HS and WD on UK rapeseed and comparatively assess their efficacies. HS and WD values were obtained from established stress indices with inputs from a 1 km spatial resolution climate dataset. NDVI, EVI, and NIRv were obtained from Sentinel-2 surface reflectance or MODIS platform. Additionally, as many research have demonstrated that finer resolution SIF can better monitor vegetation stress, machine learning tools such as convolutional neural network or random forest are being explored to downscale the coarse SIF to finer resolution. The expected findings could provide insights on spatiotemporal dynamics of HS and WD experienced by UK rapeseed and improve its monitoring/yield estimation/land allocation assisted by RS data. The framework established is also transferrable to other vegetation types across differing landscapes.

Khomkrit Onkaew

The Impact of Soil Moisture on Solar-Induced Fluorescence (SIF) and Photosynthetic Dynamics Across Diverse Ecosystems

Wednesday 14:00 – 15:15

University of Reading

Solar-induced fluorescence (SIF) serves as a crucial tool for monitoring crop productivity by providing direct, real-time measurements of photosynthetic activity. SIF is emitted by chlorophyll during photosynthesis and is strongly correlated with gross primary production (GPP), making it a reliable proxy for estimating photosynthetic efficiency and carbon uptake at various scales. We investigated the efficiency of the conversion from absorbed photosynthetically active radiation (APAR) to fluorescence (ϵF) under varying soil moisture conditions. By using NDVI as a proxy for the fraction of APAR, our analysis demonstrated that soil moisture significantly influences ϵF, with higher soil moisture availability enhancing fluorescence efficiency across different land cover types. Notably, evergreen broadleaf forests maintained high efficiency despite soil moisture fluctuations, while grasslands and closed shrublands showed rapid increases in efficiency with improved soil moisture, levelling off at higher thresholds. Croplands exhibited substantial variability, reflecting the diverse responses of different crops to soil moisture levels. This research underscores the importance of SIF as a non-invasive method for assessing plant health and productivity, particularly in the context of water stress, and highlights the complex interplay between soil moisture and photosynthetic efficiency in various ecosystems. Further investigation is required to fully clarify these dynamics and to explore the underlying mechanisms driving these results across different land cover types.

Natalie Douglas

Using 4DEnVar to estimate JULES stomatal conductance and photosynthesis parameters from observational data

Wednesday 14:00 – 15:15

University of Reading

The Joint UK Land Environment Simulator (JULES) has multiple options for modelling photosynthesis and stomatal conductance. The parameters specified in these processes are typically only known to be within a given range. The 4DEnVar data assimilation technique can be used against observational data to find improved estimates of these parameters. This method is particularly attractive in its speed, ease of implementation, lack of model code adaptation and in its avoidance of the construction of tangent linear/adjoint code through the use of a parameter ensemble. The aim of our study is to estimate the photosynthesis and stomatal conductance parameters and identify the optimal JULES option configuration using 4DEnVar against gross primary productivity, latent heat and sensible heat observations that are available at a subset of FluxNet sites. We present the progress made so far in this pursuit.

Angela Harris

Canopy Reflectance Provides a Proxy for Soil Microbial Communities

Wednesday 14:00 – 15:15

University of Manchester

Canopy reflectance captures a range of plant traits related to ecological processes. Plant traits, and therefore canopy spectra, may reflect soil microbial communities. However, the extent to which canopy reflectance can help elucidate soil microbial community composition across biomes remains unclear. Using datasets from 14 NEON (National Ecological Observatory Network) ecoregions (domains) we explore links between aboveground plant traits and belowground soil community composition and develop partial least squares regression models to predict soil microbial groups (PLFA and 16S rRNA) from airborne imaging spectrometer data. We report that plant traits influence the abundance of diverse microbial groups at a regional scale and that spectral reflectance data can be used to identify soil microbial group composition. Our work provides new evidence that remote sensing data can be used as a proxy to facilitate large-scale monitoring of soil microbial communities.

Luke Brown

Combining Earth observation, machine learning, and routine ground reference observations to develop improved decametric vegetation products: the GROUNDED EO project

Wednesday 14:00 – 15:15

University of Salford

Estimates of vegetation biophysical variables such as leaf area index (LAI) are essential for effective agricultural and forest monitoring/management. They also represent a crucial input into models of crop yield, carbon exchange, and the weather and climate systems. Exploiting optical Earth Observation (EO), algorithms including the Sentinel-2 Level 2 Prototype Processor (SL2P) provide routine decametric (10 m to 100 m) retrievals, but are subject to biases due to assumptions embedded within the radiative transfer models used in their training. To overcome these limitations, retrieval approaches might be based on real EO data and contemporaneous ground reference observations. Historically, such observations (typically obtained through one-off field campaigns) have been limited in quantity, and have suffered from inconsistencies and unquantified measurement uncertainties. Recent progress has been made in novel automated field instrumentation, standardised processing, and routine data collection by environmental monitoring networks. In parallel, cutting-edge machine learning approaches such as Gaussian processes have dramatically reduced the number of required training samples (i.e. hundreds as opposed to hundreds of thousands) whilst allowing explicit treatment of measurement uncertainties. Through work under the Fiducial Reference Measurements for Vegetation (FRM4VEG) programme, methods to quantify ground reference measurement uncertainties are also now available. Taking advantage of these developments, the GROUNDED EO project is developing retrieval algorithms trained on real EO data and contemporaneous ground reference observations. Initial results demonstrate increased accuracy in LAI retrievals (RMSD ≤ 0.96, bias = -0.06) compared to SL2P (RMSD = 1.31, bias = -0.54), highlighting the efficacy of the data-driven approach.

Session 5B

Climate Data Studies 3

Dr Paul Green

Satellite-derived methane product standards

Tuesday 15:00 – 17:00

National Physical Laboratory

In response to international agreements including the COP26 Methane Pledge and the COP28 Oil and gas decarbonization charter the reduction of fugitive methane emissions from industrial processes is high on the international agenda. The response over the last few years has taken several forms, from the launch of the UNEP IMEO program, to the development and launch of new monitoring capability. Action to meet these objectives are being enshrined in national targets and policies, and most recently in new regulation. 2023 legislation in the US and EU not only provides an obligation to verifiably reduce emissions but also opens the door to the use of new methods & techniques to identify & report leaks and perform 3rd party verification of the Oil & Gas sectors emission reporting to the regulators. Simultaneously, listed companies are being required to report their emissions, as well as their physical and financial risk associated with resilience to climate change & operating in a low-carbon economy. Although a more derived application, emissions data at a facility and corporate asset level is now a contribution to regulatory reporting requirements with significant financial penalties for non-compliance or gross inaccuracies.

These diverse goals can only be quantifiably met with verified data, with satellite-derived measurements being a key part of the solution to this data need. The global reach and inherent spatial sampling/mapping properties of on-orbit instruments lend themselves to consistent surveys across borders, cataloguing sources (and sinks) of GHG emission to the atmosphere and identifying their geographic locations.
To address this date need, a number of new on-orbit sensors from commercial and philanthropic (new space) stakeholders are joining the longer running public missions tracking methane concentrations at a range of scales (10s m to few km). Innovations have also shown that some public missions not originally designed to monitor methane can be used to do so, albeit limited to the more intense point sources. This plenitude of satellite data has enabled multiple actors to enter the methane emissions product landscape, ranging from start-ups to academia, space agencies, on-orbit asset owners and international organisations.

This rapidly growing yet organic trade for methane emissions data has developed to meet a market need but is susceptible to a number of pitfalls. In a relatively immature and rapidly developing field, divergent emissions estimates from multiple actors will cast doubt on credibility, whereas questionable methods & data quality from new, non-expert actors could significantly undermine the reputation of the entire sector. A suitably agile standards framework would enable this market: endorsing reputable suppliers, rooting out bad actors and provide the necessary confidence to the user/customer base.

Internationally adopted standards, based on transparency, traceability, independence, and evidenced QA would enable and ensure fit-for-purpose data, interoperable between suppliers as an EO contribution to impactful climate action, feeding into the wider carbon cycle economy. This presentation will report on a UKSA funded program, within the auspices of CEOS to develop a fit-for-purpose standards framework, including the outcomes of a recent UK workshop and international collaboration.

Liang Feng

Sensitivity of top-down surface flux estimate to regional bias in OCO-2 XCO2 retrievals

Wednesday 14:00 – 15:15

NCEO, University of Edinburgh

The NASA OCO-2 satellite has since 2014 been continuously monitoring global temporal and spatial variations of atmospheric CO2. The OCO-2 atmospheric CO2 columns (XCO2), retrieved at shortwave IR wavelengths, have been widely used to infer net CO2 surface fluxes over the past decade. These data have been particularly important in challenging our understanding of the carbon cycle over regions where there have been few or no previous atmospheric CO2 measurements. Systematic errors associated with assumptions about atmospheric and land properties used by the retrieval methods, for example aerosols, compromise the authenticity of the resulting CO2 flux estimates. This has caused substantial community debate. In this presentation, we use numerical experiments to study the impacts of assumed regional XCO2 biases on posterior flux estimates. Using the corresponding 3-D posterior CO2 concentrations, we estimate the magnitude of possible biases by comparing model simulations with aircraft and surface measurements. This study helps us to understand the range of acceptable systematic errors that would not compromise broad-scale conclusions inferred from the CO2 flux estimates. It also helps us to design geographically-targeted field campaigns to evaluate bias over regions critical to global carbon balance.

Fei Yao

Inverse modelling of SO2 and NOx emissions over Asia using GEMS geostationary satellite observations

Wednesday 14:00 – 15:15

University of Edinburgh

Conventional bottom-up emission inventories for atmospheric pollutants suffer from infrequent updates and substantial uncertainties. The Geostationary Environment Monitoring Spectrometer (GEMS) now provides columnar measurements for key atmospheric pollutants, including tropospheric O3, aerosols, and their precursors (NO2, SO2, HCHO, and glyoxal), on an hourly basis throughout the sunlit day, with a nominal spatial resolution of a few kilometres. These satellite data represent new constraints to determine top-down estimates of air pollutant emissions, providing complementary information to the bottom-up inventories. Collectively, bottom-up and top-down information provide better actionable information to develop more effective air pollution mitigation strategies. We aim to infer emissions of sulphur dioxide (SO2) and nitrogen oxides (NOx ≡ NO + NO2) across Asia from GEMS column observations of SO2 and NO2 by using the adjoint of GEOS-Chem atmospheric chemical transport model. For this purpose, we use the anthropogenic emissions from the MEIC and MIX inventories as our a priori emissions, and we are currently expanding the capability of the adjoint of GEOS-Chem model to interface with GEMS data to optimize these a priori emissions into a posteriori emissions. We will report diurnal variations in our top-down estimates of SO2 and NOx emissions across diverse Asian cities, assessing their implications for emission policy formulation. We anticipate that our work surrounding GEMS can be extended to other instruments of the geostationary air quality constellation, including TEMPO over North America, launched in April 2023, and Sentinel-4, scheduled for launch in 2024.

Laura Carrea

Sentinel Lakes of sub-Sahelian Africa: An assessment based on multivariate remote sensing data

Wednesday 14:00 – 15:15

University of Reading

Africa is extremely vulnerable to climate change while contributing little. According to the latest IPCC report, five out of nine key risks for Africa are related to freshwater resources deterioration, increasing demand and sensitivity to climate-related extreme events. Currently, studies of lakes in Africa are limited to the African Great Lakes. In this contribution, we undertake an assessment of 190 sub-Sahelian lakes using global datasets aiming to identify “sentinel” lakes that show climate-change-sensitive behaviours such as warming water temperatures, modified hydrological processes, ecologically significant stratification changes and critical response to extreme events. Time series data (chlorophyll-a, turbidity, water temperature, level and extent, and water leaving reflectances) available from the European Space Agency (ESA) Lakes Climate Change Initiative (CCI) project are exploited to identify the sentinel lakes together with meteo variables (air temperature, shortwave and longwave solar radiation, humidity, wind speed) extracted from ERA5-Land and precipitation from TAMSAT and CHIRP satellite-derived datasets. A characterization of the lakes’ behaviour in response to climatic drivers is performed through the evaluation of the climatology of the lake and atmospheric variables. Furthermore, with the analysis of timeseries of the derived water transparency, heat budget and water volume at annual scale, the lakes undergoing, or being more likely to undergo, ecological regime shifts are identified.
By exploring remote sensing to overcome data scarcity in sub-Sahelian African lakes, our study provides the first multivariate assessment of climate change effects on water bodies, in support of a sustainable management of lakes’ resources and climate risk mitigation actions.

Session 5C

Machine Learning for Marine Applications

Ieuan Higgs

Machine learning to improve data assimilation in marine ecosystem modelling

Tuesday 15:00 – 17:00

University of Reading

We implement a hybrid machine learning (ML) and data assimilation (DA) approach to outperform the existing, heavily resource-limited marine biogeochemistry operational system for the North West European shelf seas. In this, we develop an ML-model to predict the background correlations used in the multivariate update of the DA scheme to correct unobserved variables in the system.

Our ML approach aims to significantly reduce the need for large, expensive ensemble methods to estimate the background statistics required for updating the unobserved variables in the system, with a view to go beyond the linear assumptions used in the operational approaches. The data used for this study are obtained from a state-of-the-art coupled marine physics-biogeochemistry model (ERSEM) simulating the vertical column of a coastal station (L4) in the English Channel. The ML-model is trained using the output of large ensemble runs in 1D for computational affordably, and evaluated at multiple locations for robustness.

The results of this study show that we can effectively and efficiently propagate the analysis increment of the singularly observed variable in a system where the background statistics are often poorly estimated. This is a promising step towards using ML emulators as a viable alternative to large, expensive ensembles in an operational setting, where the number of ensemble members can often be a limiting factor.

Amy Tyndall

"Bird's Eye View: Tackling Avian Flu on Bass Rock with Drones and Deep Learning"

Wednesday 14:00 – 15:15

EOLAS Insight Ltd. / University of Edinburgh

This talk explores the innovative use of drones and deep learning to quantify the impact of Highly Pathogenic Avian Influenza (HPAI) on the northern gannet colony of Bass Rock, Scotland. Since 2021, HPAI has caused significant bird mortality in the UK, severely affecting aquatic bird species. The study aimed to assess the impact of this outbreak on the world's largest northern gannet colony, which suffered substantial losses in 2022.

Researchers from the University of Edinburgh, the UK Centre for Ecology and Hydrology, and the Scottish Seabird Centre deployed drones over Bass Rock in 2022 and 2024 to capture RGB imagery of the colony. A deep learning neural network was applied to the imagery to automatically detect and count live and dead gannets, providing population estimates for each year. The model, trained on the 2022 dataset, achieved a mean average precision (mAP) of 37%.

In 2022, the model predicted 18,220 live and 3761 dead gannets, closely aligning with NatureScot’s manual count of 21,277 live and 5035 dead gannets. For 2023, the model predicted 48,455 live and 43 dead gannets, while manual counts reported 51,428 live and 23 dead gannets. These results indicate a significant population recovery, with a 166% increase in live gannets. A 2024 flight is scheduled for end of June, and an up to date population estimate will follow.

This study demonstrates the first known application of deep learning to detect dead birds from drone imagery. It highlights the methodology's potential for ongoing monitoring and mortality assessments of seabird colonies and other wildlife species, presenting a valuable tool for conservation efforts.

Ivo Pasmans

Down the rabbit hole: the ensemble Kalman filter in the latent space

Wednesday 14:00 – 15:15

University of Reading

Data assimilation (DA) is a Bayesian method to combine imperfect observations and a model generated prior to obtain an improved estimate for the true state of the system. It is envisaged that neXtSIM DG , a new sea ice model, is going to be endowed with a DA system. Most of the current DA approaches assume that errors follow a Gaussian distribution. This assumption cannot hold in sea ice models because some sea ice variables are bounded and because attainable sea ice states are limited to those in which stresses are (sub)critical. Studies have tried to overcome these limitations by carrying out the DA in the latent space of a variational autoencoder (VAE) in which the prior distribution is, by construction, approximately Gaussian. Problem with these approaches is that they either do not account for the time-variability of the prior distribution or require a recurrent network to do so. In addition to this, the observation operator and observational error covariances required by the DA are not available in the latent space. In this work we will show that these problems can be overcome by using two, online-trained VAEs: one for the model states and one for the differences between observed and modelled values (innovations). Once these are available a modified version of the ensemble transform Kalman filter (ETKF) can be used to calculate the optimal corrections in the two latent spaces without the need for observational error covariance. After this the corrected ensemble can be resampled using the VAE and moved forward in time using a dynamic model.

Jozef Skakala

Predicting ocean carbon stocks from observable variables using machine learning

Wednesday 14:00 – 15:15

Plymouth Marine Laboratory

We developed a feed-forward artificial neural network (NN) trained on marine physical-biogeochemical model simulations in the North-West European Shelf seas. The NN learned the emergent relationships between observable ocean variables (such as SST and surface chlorophyll), structural, riverine and atmospheric data and the carbon stocks related to dissolved organic matter and detritus. We demonstrate the sensitivity of the predicted variables to model input features and show that the model is generally skilled to predict the test data. We then use the model to predict the carbon stocks using satellite observations as inputs, rather than the model data. We propose different applications of the NN model, both in terms of modelling and Earth Observation science.

Session 5D

Understanding and Monitoring Radiation

Helen Brindley

New observations of surface and atmospheric properties exploiting the far-infrared spectrum: First results from the Andoya 23 Campaign

Tuesday 15:00 – 17:00

Imperial College London

Longwave energy transfers play a critical role in regulating high-latitude climate. Cold surface and cloud emitting temperatures mean that more than 60 % of this longwave energy is located at wavelengths longer than 15 microns in the so-called ‘far-infrared’. Despite its energetic importance, observations of the far-infrared spectrum are severely lacking. With NCEO support we have developed a novel ground-based instrument, the Far INfrarEd Spectrometer for Surface Emissivity (FINESSE), designed to measure the longwave energy spectrum from 6.25-25 microns at high temporal resolution and over all viewing angles, from zenith to nadir. Deployed to Andoya, Norway in early 2023, FINESSE successfully delivered a set of observations spanning a range of sky and surface conditions. In this presentation I will discuss these observations, which are available as a resource for the wider community. I will show how they are being used to estimate surface emissivity of snow and ice extending into the far-infrared. A point of particular interest concerns the question ‘what is skin/surface temperature’ and how does its definition impact the derived emissivity. I will also show initial, combined retrievals of cirrus cloud optical properties and the underlying atmospheric state derived from FINESSE and assess their agreement with in-situ aircraft observations taken at the same time.

Adam Povey

Characterisation of dust aerosols from ALADIN and CALIOP measurements

Wednesday 14:00 – 15:15

NCEO, University of Leicester

Desert dust suspended in the atmosphere has a significant impact on the energy budget through its scattering and absorption of light. The movement of dust through the atmosphere is monitored with various satellite instruments, with passive observations assimilated into numerical weather forecasts. A major source of uncertainty in dust products is an incomplete understanding of the vertical profile of dust. CALIOP has been used for this purpose for over a decade. As a backscatter lidar, CALIOP must assume a lidar ratio before data processing and it has been shown repeatedly that the value used is too small for Saharan dust. As the first spaceborne High Spectral Resolution Lidar, ALADIN onboard the Aeolus satellite can estimate aerosol extinction and co-polar backscatter coefficients separately without an assumption of the lidar ratio. This presentation will summarise a recent publication demonstrating the synergistic use of ALADIN with CALIOP to produce a superior retrieval of dust properties and extent. A statistical analysis of retrievals from both instruments during a June 2020 Saharan dust release demonstrates consistency between the observed backscatter and extinction coefficients. During this extreme dust event, CALIOP-derived aerosol optical depth (AOD) exhibited large discrepancies with MODIS Aqua measurements. Using collocated ALADIN observations to revise the dust lidar ratio, AODs retrieved from CALIOP are increased by 46%, improving the comparison with MODIS data. This study demonstrates the benefits of spaceborne HSRL in directly obtaining the lidar ratio, significantly reducing uncertainties in extinction retrievals.

Jeremy Harrison

Constraining global carbonyl sulfide emissions using novel IASI retrievals and inverse modelling

Wednesday 14:00 – 15:15

University of Leeds

Carbonyl sulfide (OCS) is an atmospheric trace gas that is emitted from a range of natural and anthropogenic sources. It is taken up through the stomata of plants during photosynthesis, through the same process as carbon dioxide (CO2). However, unlike CO2, OCS is not then released by plants during respiration. This means that it has great potential for quantifying the gross primary production (GPP) of the Earth's biosphere, which is difficult to constrain through observations of CO2 alone.

We show here global total column retrievals of OCS using the University of Leicester IASI Retrieval Scheme (ULIRS), using satellite data from Met-Op B for the year 2018. The scheme utilises optimal estimation techniques to derive OCS profiles over ocean regions only. The data show evidence of biosphere-based OCS uptake in tropical regions.

We assimilate these IASI satellite data in a global atmospheric inversion system to optimally constrain the monthly sectoral net flux of OCS at 5.6º horizontal resolution. Using the variational inverse atmospheric model INVICAT, we assimilate the IASI total column OCS values and in situ flask observations from NOAA surface measurement sites. Since the spatial coverage of the surface sites is not well-distributed, assimilating the surface data alone produces unrealistic OCS source regions in the tropics. Adding the IASI data produces a marked improvement in the posterior emission estimates in tropical regions, and indicates that our best prior OCS flux estimates overestimate global vegetative uptake by 22%.

Session 6A

EO Information Services

Ben Calton

Using Open Data Cube to support policy and decision makers in Wales

Wednesday 15:45 – 17:15

PML Applications

Earth Observation data and derived products, such as land cover maps, play a key role in supporting policies in Wales such as the 30x30 target, which aims to be protecting and effectively managing at least 30% of land freshwater and sea for nature by 2030. However, resources required to work with such large datasets often sits within small teams limiting wider adoption within government.

The Welsh Data Cube, part of the Living Wales project, is an innovative platform which provides seamless access to analysis-ready data from Sentinel-1 SAR and Sentinel-2 MSI, alongside a range of derived products, including land cover classification and biomass maps. The Open Data Cube framework is used to provide easy access to these data, with Jupyter Notebooks offering ways to perform common analysis and produce outputs that can be included in reports.

Chandra Taposeea-Fisher

EarthCODE: Earth Science Collaborative Open Development Environment

Wednesday 15:45 – 17:15

Telespazio UK Ltd.

The EarthCODE (Earth Science Collaborative Open Development Environment) vision provides an integrated, cloud-based, user-centric development environment, supporting ESA's science activities and projects. Building on European EO open-source ecosystem and Open Earth System Science community activities (including EOEPCA+, the Open Science Catalogue and EOxHub), ESA is implementing EarthCODE as a collaborative platform for conducting Earth System Science sustainably, adhering to FAIR and Open Science Principles.

EarthCODE will provide an Integrated Development Platform, giving developers tools needed to develop high quality workflows, allowing experiments to be executed in the cloud and the reproduced by other scientists. As EarthCODE evolves, it will allow the federation of data and processing, allowing EarthCODE to have the potential to facilitate processing on other platforms, i.e. DeepESDL, ESA EURO Data Cube, Open EO Cloud/Platform and AIOPEN/AI4DTE. EarthCODE has ambition to deliver a model for a Collaborative Open Development Environment for Earth system science. Researchers will be able to leverage the power of wide ranging EO platform services available to conduct their science, while also making use of FAIR Open Science tools to manage data, code and documentation, create end-to-end reproducible workflows on platforms. Scientists would also have the opportunity to discover, use, reuse, modify and build upon the research of others in a fair and safe way. Overall, EarthCODE aims to enable elements for EO Open Science and Innovation vision, including open data, open-source code, linked data/code, open-access documentation, end-to-end reproducible workflows, open-science resources, open-science tools, and a healthy community applying all the elements in their practice.

Owen Hawkins

Earth-i & Planet integrating EO into cross government operational data services via the EODH

Wednesday 15:45 – 17:15

Earth-i

Earth Observation from space is inherently a global activity. Its distributed nature results in a challenge to government bodies used to supplying certain services free-at-the-point of use, as often the assets which are in demand are controlled by other nations and/or companies. No country has the luxury where all its required assets or data sources are owned directly, plus each country has needs driven by its unique geographical circumstances. It would also be highly inefficient for every country to implement similar space infrastructures and there is no easy way to make public others' space infrastructures. Therefore, in parallel to any national space endeavours, to fill the gaps that remain, there is a need to: first source the required data to answer pressing questions; and second adapt these data sources to the specific challenges at hand. Doing so presents various technical, commercial, legal and scientific barriers which must be considered.

There are analogies from other sectors from which we can learn, and solutions such as the Earth Observation Data Hub (EODH), which seek to reduce or remove the barriers to entry and avoid the duplication of data stores and systems. Here we present the barriers, analogies and solutions to inform the ongoing development of UK EO infrastructure and services. We also will share Planet and Earth-i's contributions to the ongoing implementation of the EODH.

Steve Donegan

Large EO datasets and services at CEDA

Wednesday 15:45 – 17:15

CEDA

The Centre for Environmental Data Analysis (CEDA) provides the data archive component for NCEO and provides access to over 25 petabytes of EO data. CEDA is part of the NERC Environmental Data Service (EDS) providing FAIR (Findable, Accessible, Interoperable & Reusable) access to data. The CEDA EO archive includes data from the Sentinel, Landsat, Terra/Aqua and ENVISAT missions in addition to data from the NERC ARF and DEFRA Sentinel ARD -as well as many other missions and research data outputs. It also hosts datasets from international projects such as the ESA Climate Change Initiative. Daily incoming data flows of 7-8Tb per day are typical for just the Sentinel and MODIS data streams alone.

CEDA provides many methods for users to find and access EO data, not least fast access via the JASMIN environment that allows users access to the data using a world class fast parallel processing cluster. The Satellite Data Finder is a web tool that allows users to quickly find most CEDA EO datasets. Users can access this via a conventional GUI or by an OpenSearch interface. CEDA also offers a system for retrieving Sentinel NRT data to a dedicated JASMIN Group-workspace (GWS) that allows for consistent retrieval of rolling data for use in product generation. We currently support various groups by retrieving Sentinel1 SAR and Sentinel3 SLSTR NRT data. This is useful as sometimes delays can occur between data retrieval and full archive deposit due to archive space issues that can cause problems for product generation.

In the past year CEDA has worked hard to lead on the new UK EO Data-Hub and this shall provide improved EO data services for UK users. CEDA is working to retrieve additional data for the NCEO EOCIS project and to archive the EOCIS output products which will also be made available through the EO Data Hub.

Session 6B

Climate Data Studies (EOCIS)

Jacob Fahy

The calibration and harmonisation of the IR channels of Landsat-8 for high resolution studies of the UK as part of the EOCIS project

Wednesday 15:45 – 17:15

National Physical Laboratory

The Earth Observation Climate Information Service (EOCIS) is creating Climate data at high resolution for the UK (CHUK) to support national action on climate. To underpin the CHUK activities, radiometric observations from the various sensors must be cross-calibrated, or "harmonised", to a common reference together with quantified uncertainties. This will provide both consistency between high-resolution and lower-resolution sensors (generally not achieved when the sensors' operational calibration is used) as well as traceable uncertainty information. Subsequent processing will then be able to provide improved climate products together with associated uncertainties.

One of the sensors being used to generate the thermal CHUK products is the Thermal Infrared Sensor (TIRS) on-board Landsat 8. Landsat-8 is used for many applications due to its high spatial resolution (100 m), but the TIRS has experienced significant issues affecting its radiometric performance. Operationally, corrections have been implemented to improve the situation, but there is limited information regarding the accuracy and uncertainty of the data.

To better understand the calibration of TIRS a reference based on a simulation of the TIRS data over clear sky ocean scenes was created and shows a discrepancy of approximately 0.4 K in Band 10 and 0.1 K in Band 11, with periodic time variation possibly linked to the frequency of instrument calibration updates.

Here we will report an initial correction for the observed errors in TIRS together with uncertainty information. Additionally, we provide an update on the preliminary cross-calibration between Sentinel-3 SLSTR-A/B and Landsat 8 TIRS as part of the harmonisation process.

Peter North

Long term records of atmospheric aerosol and particulate matter under EOCIS, 1995-2024+

Wednesday 15:45 – 17:15

Swansea University

We present new products of global atmospheric aerosol from Copernicus and ESA satellite missions intended to provide climate-quality long term datasets, developed under the NCEO Earth Observation Climate Information Service (EOCIS). In addition to importance to climate, aerosol is required for assimilation into models of air quality and transport. The parameters retrieved include aerosol optical depth (AOD), fine mode fraction, dust AOD, Angstrom exponent and retrieval uncertainty. Relation of satellite retrieved aerosol optical depth and fine mode fraction to surface particulate matter (PM2.5, PM10), has been explored using ancillary climate data and a machine learning approach. We finally breview potential of future missions for high quality aerosol retrieval. The full mission datasets for the (A)ATSR and Sentinel-3 A and B instruments have been processed for the period 1995-2024, and are available for download from EOCIS.

Karen L Veal

EOCIS LST: climate quality with increased timeliness

Wednesday 15:45 – 17:15

University of Leicester

Climate quality LST products have increased accuracy and precision compared with operational products however they are often produced in whole mission reprocessings which may be performed only every few years. Currently LST products are not available through C3S. The EOCIS project aims to make climate quality LST available with good timeliness. We describe the EOCIS LST products from the SLSTRs which are currently available with an average timeliness of around 15 days and the EOCIS LST product from VIIRS which will go online in 2025. Validation against in situ LST show mean absolute differences of < 1 K for both SLSTRA and SLSTRB both in daytime and night-time.

Mike Perry

EOCIS CHUK: Developing UK-wide High resolution Land Surface Temperature

Wednesday 15:45 – 17:15

University of Leicester

There is an ever increasing need for high quality information about the thermal landscape of the UK. From urban heating to evapotranspiration and crop yields, data has become more important in decision making. However many data sources are incompatible and do not come with consistent uncertainty or robust assessment, this makes the job of users and decision makers more difficult. To address this we have been developing high quality 100m Land Surface Temperature datasets for the UK; both from LANDSAT and from downscaling techniques whilst maintaining traceability. This data is within the framework of the EOCIS project.

Owen Embury

A 42-year Sea Surface Temperature Climate Data Record from the ESA Climate Change Initiative

Wednesday 15:45 – 17:15

University of Reading

ESA's Climate Change Initiative (CCI) has released the third major version of the SST CCI Climate Data Record (CDR) which now spans over 4 decades, using data from Advanced Very High Resolution Radiometer (AVHRR), Along Track Scanning Radiometer (ATSR), Sea and Land Surface Temperature Radiometer (SLSTR) instruments, Advanced Microwave Scanning Radiometer (AMSR)-E and AMSR2. The dataset includes both single-sensor products plus a Level 4 SST analysis generated using the Met Office Operational Sea Surface Temperature and Ice Analysis (OSTIA) system.

Complementary to the ESA CCI CDR we are producing an Interim CDR (ICDR) to proving an ongoing extension in time of the SST-CCI CDR at short delay (approx. 2 weeks behind present). The ICDR was funded by the Copernicus Climate Change Service (C3S) for 2022 and is now funded by the UK Earth Observation Climate Information Service (EOCIS) and the UK Marine and Climate Advisory Service (UKMCAS) for 2023 onwards.

Here we present the highlights of the new SST CDR, and the improvements compared to the previous version. We will also outline our plans for the next phase of CCI and work towards the fourth version of the SST CDR.

Theo
H. Morgan Lundie

A preliminary assessment of the added value of thermal infrared satellite retrievals of methane to infer regional methane budgets over the UK

Wednesday 15:45 – 17:15

University of Edinburgh

Methane is a potent greenhouse gas (GHG) with an atmospheric lifetime of ~10 years – much shorter than for other major GHGs – so that a rapid emission reduction would result in an observable atmospheric change within several years. This has led to national and international agreements, such as the Global Methane Pledge, to rapidly reduce methane emissions. The UK Government currently relies mainly on compiled inventories to inform their knowledge about methane budgets, but they are progressively looking to complementary atmospheric measurements to refine emission estimates. Here we use thermal infrared (TIR) retrievals of methane from the Infrared Atmospheric Sounding Interferometer (IASI) instruments on-board ESA MetOp satellites which have been operational since 2007. These data have been used less extensively than short-wave IR (SWIR) data to infer surface emissions of methane, mainly due to their weaker sensitivity to the lowermost troposphere. However, because TIR retrievals do not rely on sunlight, TIR retrievals offer superior data volumes with near-global coverage twice daily. New joint SWIR-TIR retrieval products combine the advantages of both retrievals, resulting in vertically resolved methane columns with sensitivity extending to the lowermost troposphere. We use the GEOS-Chem atmospheric chemistry transport model to evaluate the impact of IASI TIR methane retrievals on current prior knowledge of regional methane emissions across the UK during 2019. Based on the outcome of these experiments, we will use an ensemble Kalman filter to infer regional methane emissions from TIR and/or SWIR-TIR data.

Session 6C

Crop Monitoring

Alex Cornelius

Utilization of Geostationary Himawari Data to Downscale Meteorological Reanalysis Data for Use in Pest Risk Modelling

Wednesday 15:45 – 17:15

- Crop Monitoring

Assimila ltd

With the changing climate, the traditional distribution of crop pests is changing. The distribution of these organisms is predominantly governed by temperature, where insight on this key environmental variable enables pathologists to model potential pest risk.

Traditionally, ERA5-Land is used as the driving variable for such models. ERA5-Land provides the essential representation of 2m air temperature, but at a relatively course 9km spatial resolution, meaning it often fails to capture the diversity of microclimate in a region and can lead to pest risk model bias.

Assimila has been working within the STFC funded UK/Australia EO4Biosecurity project with CABI, as well as Cervantes Agritech, to downscale ERA5-Land data to more accurately, and at a higher spatial scale of ~2km, model the daily minimum and maximum temperature across Australia. This algorithm utilizes Himawari data within a deep learning regression approach, and trained using data from ~8000 meteorological stations across Australia.

Results against unseen site validate data shows that using this approach reduces the RMSE of the daily minimum/maximum temperature significantly when compared to using ERA5 standalone. When predicting the minimum temperature, the RMSE is reduced from 2.6 to 1.2 degrees Celsius, whereas the RMSE for the maximum temperature changed from 1.96 to 0.98 degrees Celsius. This represents a promising new technique for modelling pest risk more accurately and at a much finer spatial resolution.

Feng Yin

Unveiling the First UK-Wide Field-Level Winter Wheat Yield Map

Wednesday 15:45 – 17:15

University College London

Earth observation (EO) data are crucial for modelling crop yields and addressing global food security concerns. However, accurately estimating crop yields using EO data presents challenges due to the need for precise calibration data, especially yield measurements. Within the AgZero+ project, we have developed a crop yield model that uses coarse-scale crop yield statistics to predict field-level yields. This model has proven effective in predicting field level crop yields in both the UK and the US. Consequently, we have produced the first field level UK crop yield map for the years 2017 to 2021. Initial analyses indicate a significant decrease in UK yields during 2019, with reductions exceeding 40% in some areas. This dataset facilitates the identification of yield gaps in the UK, which could help investigate crop yield losses and potentially propose mitigation strategies.

Matthew Payne

Wheat Blast – an interdisciplinary approach to detect and model an emerging threat to wheat security in Bangladesh with a view towards South Asia and Australia.

Wednesday 15:45 – 17:15

University of Leicester

Wheat blast (Magnaporthe oryzae triticum, MoT) is an emerging threat to wheat cultivation around the world. As the climate changes, the microclimates this disease traditionally occupies are moving, exposing new agroclimatic regions to the disease. Wheat blast can significantly impact wheat yields and increase crop mortality. An example of the novel presence of this disease is in Bangladesh, which was first detected in 2016. The Wheat Blast project is a STFC funded project comprised of an international consortium, including CABI, the University of Leicester, Cervantes Agritech, RAL Space, Assimila and CSIRO to develop frameworks for dynamic, disease risk mapping and the remote detection of outbreaks in Bangladesh and support dispersal pathway modelling through South Asia and Australia, guiding monitoring, extension, and early detection efforts.

The project aims to synergistically combine three types of data. The first is to use optical and radar earth observation data to model the complex arrangement of wheat cultivation in Bangladesh, along with phenological and biophysical parameter metrics from wheat areas to indicate crop stress. The second component combines the crop classification maps with ecological niche modeling to identify the regions of Bangladesh that exhibit the optimal climatic conditions for the proliferation of the disease. Finally, the third component is a ground-up approach to explore regions of the electromagnetic spectrum that can detect the spectral signature of wheat blast, from a UAV mounted hyperspectral sensor, and translate this signature to satellite data for large-scale repeat mapping.

Andualem Aklilu

Application of A novel Vegetation Condition Index for developing Crop Index Insurance

Wednesday 15:45 – 17:15

Ethiopian Civil Service University

For some years now, satellite-based crop index insurance has been in place throughout Ethiopia. Nonetheless, existing products are only accessible to limited number of beneficiaries compared to the large number of potential customers. The objective of this study was to develop crop index insurance using a novel method i.e., Vegetation Condition Index derived from Enhanced Vegetation Index (VCI-evi) that potentially address the limitation of existing products. This study is placed in Amhara region, in areas where drought is the major constraint of the production system and crop index insurance schemes have been implemented for several years. The study majorly integrated historical data (2007-2022) both from satellite (MODIS sensor) and secondary data on drought prevalence. Based on information from existing insurance product in the area, this study targeted two major drought perils which occurred at early and late windows in the crop-growing season. According to the result, the VCI-evi variable is found to be a strong predictor of drought at late windows as modeled by logistic regression. The study also determines index insurance parameters, notably, trigger and exit threshold and calculate payout. Based on the payout determination, the years of 2015, 2016, 2018 and 2011are the major drought years where payout is calculated for all study villages. The VCI-evi method of index insurance determination showed interesting characteristics. First, the logic of determining index parameters is intuitive and hence explicit to understand. Second, as the index is set in reference to historical drought, higher reliability of the product is expected.

Erin Goh Bing Bing

Leveraging Earth Observation Data to Enhance Tree Crop Production and Resilience in a Changing Australian Climate: The FruitSense Project

Wednesday 15:45 – 17:15

University of Southampton

Australia is home to a diverse array of tree crops that are crucial to the nation's agricultural sector. According to the ABARES 2024 report, the nominal value of Australian horticulture production is expected to reach $17.2 billion in 2023-24 and is projected to rise 6% to $18.3 billion in 2028-29, driven primarily by increased fruit and nut production (ABARES, 2024). Meanwhile, the nominal horticultural export values are expected to rise by 4% to a record $3.6 billion in 2023-24, and further by 11% to contribute $4.0 billion in 2024-25. Nominal fruit exports are expected to increase by 12% in 2024-25 to $2.0 billion. Despite this growth, Australia's predominantly arid climate and high susceptibility to climate change pose significant challenges to tree crop production. To ensure the ongoing success and sustainability of these crops, it is imperative to develop a comprehensive, countrywide tree crop monitoring system that bolsters the resilience of tree crop production under changing climatic conditions. Earth Observation (EO) data and cloud computing offer substantial promise for monitoring crops and forecasting yields. These technologies provide an opportunity to create a robust tree crop management system that ensures tree crop health and productivity despite climate change impacts. This project aims to harness EO data to develop a web-based tree crop information system designed to promote the sustainability and resilience of tree crops in Australia's evolving climate.

Session 6D

Wildfire

Zhongwei Liu

Probabilistic assessment of extreme fire risk under the impact of climate change

Wednesday 15:45 – 17:15

NCEO - University of Leicester

As major natural hazards, wildfires pose a significant risk to many parts of the world. The occurrence of extensive fires in both hemispheres in recent years has raised important questions about the extent to which the changing nature of such incidents can be attributed to human-induced climate change. Offering reliable answers to these questions is essential for communicating risk and increasing resilience to major wildfires. However, the scarcity of wildfire attribution studies, combined with limited observational records and the complexity of representing fires by different models, poses a challenge in establishing robust and unified conclusions to better inform future forest management strategies.

Here, a globally applicable framework is developed to better understand and quantify how wildfire risk is responding to a changing climate. The framework is based on an empirical-statistical methodology, facilitating its application to 'fire weather' extremes from both observational records and the latest generation of global climate model ensembles (e.g. from CMIP/UKESM). Particular attention is given to the sensitivity of the eventual findings to the spatial scale of the event, the chosen event definition and the climate model(s) used in the analysis. As part of a global analysis, a series of maps are constructed detailing the change in likelihood of fire weather extremes, defined by both intensity and duration, throughout the world's fire-prone regions as a result of rising global temperatures. Both observation- and model-based analyses reveal an increase in likelihood of at least twofold across many parts of the world, with considerable regional and inter-model variation. The value of the framework is demonstrated by combining results from a series of case studies of recent high-impact wildfires that differ by scale, duration and location. The conclusions drawn from this work provide a platform to guide future analysis of fire weather events and facilitate reliable recommendations for responding to the hazards associated with wildfires, and enhancing resilience in the face of climate change.

David Moore

Investigating HCN and CO emissions of biomass burning in the Earth system

Wednesday 15:45 – 17:15

NCEO - University of Leicester

Carbon monoxide (CO) and hydrogen cyanide (HCN) are pyrogenic species that can be used as atmospheric tracers for biomass burning. In particular, HCN is an important tracer of peat fires, but there are significant uncertainties in the HCN atmospheric budget, especially its photochemical and ocean sinks. Extensive work has been undertaken within this study to adapt the TOMCAT 3-D atmospheric model to best-fit ocean uptake. We utilise Global Fire Emissions Database (GFED) v4.1 inputs for HCN biomass burning emissions to simulate global atmospheric HCN distributions for a significant series of peat fires over Indonesia during 2015, associated with a strong El Nino event.

The University of Leicester IASI Retrieval Scheme (ULIRS) utilises optimal estimation techniques to derive profiles of CO and HCN from IASI atmospheric spectra on a global scale. We compare the IASI satellite observations between September and December 2015 to the updated TOMCAT model. Using IASI data, we determine an estimate of HCN emission factors (EFs) from Indonesian peatland, a quantity which relates the mass of trace gas emitted per kilogram of biomass burned. EFs are used extensively in atmospheric models. We discuss uncertainty on these estimates in the context of IASI vertical sensitivity differences and show that the CO and HCN satellite measurements have the potential to improve these operational fire emissions inventories. Finally, we compare and contrast the 2015 IASI observations to those taken during the recent 2023 El Nino event. The year 2023 saw far fewer fires than 2015, which we show was driven by higher soil moisture levels.

Kevin Tansey

Near-real time and archive burned area mapping in the UK using PLANET data

Wednesday 15:45 – 17:15

University of Leicester

Wildfire has a significant and growing impact on the environment. The increasing prevalence and frequency of wildfires directly challenge our ambitions around enhancing habitat and the natural environment, and our ambitions around achieving net zero carbon status. Wildfire risk mapping and managing the recovery of vegetation and communities after fire require effort and resources.

Fire is a feature of the UK climate now and will be even more so into the future. Between January and August 2022, the UK suffered a staggering 969 wildfires, compared to 247 in 2021.

Effective wildfire detection and mapping is an important first step in appreciated the scale, frequency and severity of these hazards. The total burned area of the UK is not that well understood as many agencies remain responsible for this task. Furthermore, assessment of the severity and subsequent recovery of systems is not consistently evaluated.

In this paper, we have used data from Planet (near daily repeat, optical, 3-5 m resolution alongside machine learning methods to offer an automated prototype of burned area mapping. The trigger of the prototype service is explored and includes active fire detections. Results are presented that highlights the challenges of mapping wildfire affected areas in complex heterogenous locations in the UK.

Michaela Flegrova

Two decades of fire-induced albedo change and associated radiative effect over sub-Saharan Africa

Wednesday 15:45 – 17:15

Imperial College London

Fire is an important, widespread Earth-system process, influencing local ecosystems and climate around the globe. Over half of global burned area occurs in Africa, with over 10% of the continent affected by fire every year. Fire temporarily alters the surface properties, including surface albedo, causing long-lasting changes to the surface radiation budget.

In this talk, I will present the analysis of 20 years of fire and albedo data in Africa, using the MODIS product suite. Ash and charring cause the ground to darken, but vegetation removal can cause surface brightening; I investigate how each of these processes dominate at different timescales. While I show that the magnitudes of albedo change vary significantly by location and land cover type, I present a widely applicable parametrisation of albedo recovery post-fire.

Changes to albedo affect the surface radiation budget. Using downward surface shortwave flux estimates I evaluate the fire-induced surface radiative forcing in the burned areas as well as the effect when averaged temporally and spatially. I argue that while fires have an overall warming effect at the surface, they also cause surface cooling in certain regions. These spatial differences could be affecting or even driving weather and precipitation patterns in certain regions. As the number of fires in Africa decreases over time, it is important we have a thorough understanding of their different impacts and how these might change in the future.

Susie Shihan Sun

Impacts of biogenic and pyrogenic emissions on tropospheric ozone in Tropical South America

Wednesday 15:45 – 17:15

University of Edinburgh

Tropical South America is a significant source of biogenic volatile compounds, among which isoprene is the most abundant and plays an important role in altering atmospheric oxidative capacity. We use CrIS isoprene retrievals to constrain biogenic emissions, and we apply a chemical transport model GEOS-Chem to investigate how tropospheric ozone is affected by natural and wildfire emissions in this region.

William Maslanka

Direct Estimation of Emissions from High Latitude Wildfires via the FREM Approach

Wednesday 15:45 – 17:15

King's College London

We detail the progress made to the High Latitude (>60°N) Fire Radiative Energy Emission (FREM) methodology aimed at the direct estimation of smoke, carbon, reactive and greenhouse gas emissions from high latitude wildfires. We focus here on carbon monoxide (CO) emissions, and via application of a CO emissions factor on total carbon emissions. Using approximately 800 individual landscape fires observed jointly with the TROPOMI instrument onboard Sentinel-5P and with VIIRS and MODIS in the 2019 – 2023 period, we have developed a set of "FREM" coefficients linking emission rates of wildfire-emitted CO to rates of fire radiative energy (FREM) release by the fire. These CO emission coefficients have been calculated for four different biome types that exist across the high latitude region - Deciduous Needleleaf Forests, Evergreen Needleleaf Forests, Grasslands, and Shrublands. The FRE data used to generate these coefficients come from a developmental version of the Global Fire Assimilation System (GFAS v1.4) that incorporates fire diurnal cycle modelling. Estimates of total wildfire CO emissions have then been calculated for the period 2019 – 2023 based on VIIRS- and MODIS-derived FRE data, and a scaling factor applied to estimate CO emissions over a far longer (2003 – 2023) period when only the publicly available GFAS daily MODIS-derived FRE are provided from the Copernicus Atmosphere Monitoring Service GFAS v1.2.

Thorsten Fehr

ESA’s EO space infrastructure: current and future, including highlights from EarthCARE

Thursday 09:00 – 10:00

— Keynote

European Space Agency

The European Space Agency’s (ESA) long-running Climate Change Initiative has generated a suite of global multi-mission and multi-decadal datasets for more than 25 Essential Climate Variables. Collectively, these data provide the evidence record to understand the state and evolution of the climate as part of the IPCC assessments. Efforts have now been extended through the recently approved climate initiative, CLIMATE-SPACE (2023-2029) which continues to extend and expand these global data. Additionally, it is responding to new requirements for Earth Observation to support international decision and policy-making and implementation monitoring relating to the UNFCCC Paris Agreement - the main driver for action responding to climate change.

Currently, ESA is preparing for the 2025 Ministerial Council, with a strong focus on Earth Action and the provision of actionable climate data to support global climate resilience and adaptation policy. A core component of this endeavour is ESA’s Space for Green Future (S4GF) accelerator, which will act to mobilise space-based data through ever-closer working with non-space partners.

The UK is accelerating national climate action at pace. Currently, to name but one, the UK National Climate Science Partnership (UKNCSP) - an alliance of the Met Office and seven NERC centres - is combining capabilities to provide climate information and tools to enable public and private sectors adapt effectively and build resilience to future environmental change.

This presentation explores the opportunities and benefits of deepening connections between the UK climate research and Earth observation community and ESA’s climate activities being hosted at the ECSAT facility, located on the Harwell Science and Innovation campus. ECSAT is the Agency’s focal point for climate activities and hosts the WCRP’s CMIP international project office has strong links with the global modelling community and provides opportunities to foster greater extend collaboration and UK research impacts across ESA Member States and the world.

Session 7A

Vegetation Applications – Grassland and Drought

Geoff Smith

EU Grassland Watch – An operational service born out of Copernicus

Thursday 10:00 – 11:00

Specto Natura

Grasslands play a key role in maintaining biodiversity, food production and influencing ecological processes on a wide range of scales, such as pollination, water supply, carbon sequestration, and climate regulation. They cover 70 % of the world's agricultural land, resulting in grasslands that are both diverse and extensive habitats. However, these important habitats are currently facing numerous threats, including extensification and abandonment, highlighting the urgent need for effective monitoring and conservation strategies. The EU Grassland Watch (EUGW) service, funded by the European Parliament, represents a significant step towards consistent and effective monitoring services for grasslands protected within the Natura 2000 site network. The platform exploits data and services within the Copernicus Programme to deliver operational grassland information at the pixel level from selected Natura 2000 sites through to European level with summaries to support management and reporting obligations. The service produces yearly land cover maps going back to the mid-1990s with the help of Landsat data. Thanks to the Sentinels, since 2016 the grasslands mapped by the service can also be characterized by their type, management and productivity and are categorised by a set of indicators. EUGW is a flexible and powerful tool to assess the condition of grasslands and how they are evolving over time in response to policies, management practices and climate change. Over the next two years the service will evolve to map more Natura 2000 sites, provide more detailed thematic information, generate more easily interpretable insights, and expose this information through a more user-friendly interface.

Bethan Harris

Global observations of land-atmosphere interactions during flash drought

Thursday 10:00 – 11:00

NCEO - UKCEH

Land-atmosphere interactions are known to be important for the development of flash droughts, and improving the representation of these interactions in subseasonal-to-seasonal (S2S) forecasting models would provide a potential source of skill for predicting these events. However, understanding the land-atmosphere coupling processes involved in flash drought development globally is hindered by the fact that key variables such as root-zone soil moisture and surface latent and sensible heat fluxes cannot be directly observed from satellites. In this study, we use a definition of flash droughts based on ESA CCI soil moisture to explore the composite behaviour of land-atmosphere variables around flash drought onset dates. We exploit satellite-observed land surface temperature (LST) data from ESA CCI to diagnose the balance between latent and sensible surface heat fluxes by computing the difference between LST and 2m air temperature (T2m) from ERA5 reanalysis. Since the standardised anomaly of the sensible heat flux is approximately equal to the standardised anomaly of LST-T2m, this method allows us to identify increases in sensible heat flux anomalies during flash droughts. When radiation conditions remain approximately constant, this is associated with the onset of a water-limited evaporative regime. We explore the spatial variation in the sensitivity of both LST-T2m and Vegetation Optical Depth (VOD) to flash drought events, to understand where the surface energy budget changes most strongly and where impacts on vegetation are most severe. Additionally, we consider which satellite-observable variables are most promising for providing information that can improve the S2S prediction of flash droughts.

Samuel Valman

Operationalizing the hyper-temporal benefits of CubeSats for drought monitoring in a large river system

Thursday 10:00 – 11:00

University of Nottingham

Earth Observation methods are continuously producing new opportunities to measure large-scale river processes. However, the majority of these methods lack the temporal resolution to capture the dynamism inherent in river systems. The PlanetScope CubeSat constellation uses 130+ low-cost optical satellites to provide hyper-temporal ‘daily’ imagery of the Earth. However, combining this information, captured at different altitudes, times of day, and atmospheric conditions comes at the cost of reductions in radiometric quality. Therefore, segmenting images into land and water, the foundation of all subsequent river research, has proven difficult to automate. We applied a novel Artificial Intelligence method to automate the extraction of river water masks from PlanetScope imagery with a median F1 accuracy score of 0.93.This methodology enabled measurements of channel change in the Amazon basin on average every second day during recent droughts. Over 2500 PlanetScope images of 35 river islands on the Madeira River were analysed to show how wetted area corresponded with dry season discharge. We quantify the impacts of these droughts on fishing and shipping through monitoring changes in channel sinuosity, exposed surfaces, and isolated pools. Building on prior satellite remote sensing studies on river islands, our work pushes the envelope regarding the speed and scale of post-event monitoring. Our approach sheds new light on how these islands have shifted in recent years in response to changing hydroclimatic conditions, and gives an indication of how, through the operationalization of the PlanetScope constellation, geomorphic variables can be measured or monitored in exciting new ways.

Luke Smallman

UK high-resolution grassland carbon dynamics

Thursday 10:00 – 11:00

NCEO - University of Edinburgh

Intensively managed agriculture covers a substantial land area across the globe and play a significant role in global C-cycling, often associated with ecosystem degradation and C losses. In the UK improved grassland (e.g. for livestock grazing) covers 40 % of the land. Thus, sustainable land management is essential to maintaining ecosystem services and minimising anthropogenic emissions in response to climate change. To support land managers in making sustainable choices requires rigorous information on and the interactions between ecosystem management and biogeochemical cycles. High spatial resolution satellite-based Earth Observation (EO) now offers the opportunity to detect and quantify land management at field scale. Combining this novel EO information with a process model of managed landscapes across the UK. Here, we present the first spatially consistent, high-resolution and uncertainty bounded analysis of UK grassland carbon dynamics as part of the UK's EOCIS project. Using a Bayesian data assimilation framework, CARDAMOM, we use EO leaf area index (LAI) estimates to train the DALEC intermediate complexity ecosystem model. We validated the trained DALEC model in-situ measurements of grassland grazing activity across the UK. This new analysis of grassland C-cycling will be freely available. Our analysis provides a fully independent quantification of C exchanges for a critical ecosystem, in support of land managers and UK reporting on its greenhouse gas emissions.

Session 7B

Climate Data Studies 4

Luke Smallman

Quantifying the role of managed landscapes in UK C-cycling

Thursday 10:00 – 11:00

NCEO - University of Edinburgh

Terrestrial ecosystems are critical to provisioning cycles, including food production, timber extraction, and the accumulation and storage of carbon (C). Much of the Earth's vegetated land is under direct human management (e.g. arable agriculture) with decisions made by local land managers operating within national policy frameworks. These decisions often have long-term impacts. Furthermore, national governments have requirements on reporting sectoral C-budgets to the UNFCCC, and to develop policies and regulatory frameworks that support resilient land management. We require a rigorous understanding of C-exchanges at local and national scales, including their dependency on management and climate.

As part of the UK-EOCIS project, we present a state-of-the-art analysis of the UK's managed landscapes. We use a Bayesian calibration framework, CARDAMOM, to combine satellite-based Earth Observation (EO) and ecological knowledge to train a process-model of ecosystem functioning, DALEC. Our analysis uses fine spatial-resolution EO (~10 m) aggregated on a per-land-cover-basis to a 5 km resolution across the UK. CARDAMOM generates a probabilistic calibration of DALEC for each 5 km pixel and land cover. This process enables uncertainty quantification in the characterisation of ecosystem functional properties, as represented by DALEC's parameters, and also of diagnostic and prognostic analyses of the C-cycle and it's components (e.g. harvest).

We will present the latest results from our attempts to quantify the contributions of forestry, managed grasslands and arable agriculture to the UK's C budget, and their variations in space and time (2017-2022). These analyses represent the significant progress towards regular, data-informed quantification of national scale C–budget.

Jadu Dash

Applying Computational Leaning in Vegetation Growth Modelling in the UK: application to the EOCIS-CHUK dataset

Thursday 10:00 – 11:00

University of Southampton

The EOCIS Climate High Resolution UK (CHUK) vegetation dataset, encompassing Leaf Area Index (LAI), the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), and canopy chlorophyll content (CCC) is being developed for vegetation monitoring is in the face of rapid environmental and climate change. Leveraging Earth Observation (EO) data from Sentinel-2, this study developed a framework to model vegetation growth cycles across the United Kingdom that would serve as a foundation for CHUK data set. By efficiently integrating computational learning, we demonstrate the potential to trace vegetation growth cycles from pixel level to image. The framework utilizes vegetation-sensitive EO data from Sentinel-2 to mimic physical vegetation growth, operating on the hypothesis that vegetation growth cycles significantly correspond to changes in associated environmental and climatic factors over time. The objective is to model the dynamics of vegetation-sensitive spectral surface reflectance of Near-Infrared (NIR) and Red bands with a 15-day revisit period and 100-meter resolution which are then utilised to derive CHUK products. To reduce computational load and simplify the framework, models were developed over 13 grids (50 x 50 km) across the UK. Vegetation growth dynamics were explained as functions of meteorological variables (maximum and minimum temperature, solar radiation, relative humidity, precipitation, and potential evaporation), geographic variables (elevation, slope, aspect, and land covers), and time. Extreme Gradient Boosting (XGBoost) outperformed Random Forest (RF), regardless of grids or land cover-specific models. The R^2 values of the models were highest in forest and semi-natural vegetation areas (0.80-0.94), followed by wetlands (peat bogs) (0.78-0.95), and artificial surface vegetation (0.83-0.93). However, the models performed less well in agricultural areas (R^2 range 0.6-0.8) due to the complexity of human-controlled vegetation growth, which is difficult to explain based on the selected variables. Despite the challenges posed by cloud cover in multispectral Sentinel-2 data, the framework can efficiently produce seamless vegetation products for the three major land cover categories mentioned.

Mark Warren

Assessing the observability of lake biogeochemical responses to catchment dynamics

Thursday 10:00 – 11:00

Plymouth Marine Laboratory

Lakes are integrators and sentinels of climate change. There are >100M lakes in the world, a fraction of which are suitably sized for observations with the Sentinel-2 and 3 satellites and each representing a unique interaction with weather, climate and surrounding land use.

By observing lake water-leaving reflectance (LWLR), EO satellites capture some elements of the complex response of lakes to changes within their catchment. As part of the EOCIS project, the observability of such responses is being assessed for individual lake catchments.

Using model reanalysis data from ERA5-Land, coarse observations from CCI and Copernicus datasets, and observations of lake water quality, physical parameters such as air temperature and precipitation can be stochastically integrated with turbidity and chlorophyl-a concentration derived from LWLR, to identify linkages with water quality across the catchment. Our progress in data-driven analysis of lake responses will be demonstrated using examples from a selection of UK lake catchments ranging in trophic conditions and catchment morphology.

Richard Pope

Integration of Earth Observation into the UK Met Office Air Quality Forecasting System: Initial Results

Thursday 10:00 – 11:00

NCEO - University of Leeds

Poor air quality (AQ) is one of the largest environmental stresses on human health. In the UK, poor AQ results in 28,000-36,000 premature deaths per year and annual socioeconomic costs of ~£20 billion. To help address this, the UK Met Office (UKMO) provides critical national daily AQ forecasts of key pollutants (e.g. ozone (O3), nitrogen dioxide (NO2) and aerosols) to provide the public and government bodies (e.g. Defra) with prior warning of hazardous AQ events.

To evaluate the skill of their forecast model (AQUM – Air Quality in the Unified Model), and to bias-correct the forecasts, the UKMO use AQ measurements from the UK Automated Urban and Rural Network (AURN) of surface sites. The AURN observations are used in the "Statistical Post Processing of Observations (SPPO)" step to correct the forecasts (known as "hybrid-forecasts") before release. However, sparse surface monitoring sites are often unrepresentative of widespread pollution.

Satellite AQ data provides a powerful resource to help address this issue with daily UK spatial coverage, detection of pollution hotspots and transboundary pollution gradients. Therefore, the new project described here (AIRSAT) aims to integrate key satellite AQ products (e.g. tropospheric NO2 & O3) into the UKMO's SPPO framework to improve these "hybrid-forecasts", thus benefiting the downstream users of this service.

Here, we will present the first results of the AIRSAT project, comparing AQUM hindcast simulations of key air pollutants with a range of satellite products to quantify the existing model biases and determine a suite of suitable satellite products for the SPPO approach.

Session 7C

Machine Learning & Algorithm Development for Terrestrial Applications

Professor Liangxiu Han

Scalable Deep Learning and Its Application to Remotely Sensed Data

Thursday 10:00 – 11:00

Manchester Metropolitan University

Recently, deep learning has achieved remarkable success in a variety of computer vision tasks, including image classification, object detection, and semantic segmentation. It has also shown potential in remote sensing field for various earth monitoring applications such as land cover classification and agricultural monitoring.

This talk will present real case studies to demonstrate how we develop novel deep learning approaches to high spatial resolution remotely sensed data for informative decision-making in various applications ranging from land cover classification and object detection, to vegetation/crop disease recognition.

Ranjini Swaminathan

A Machine Learning Framework to Evaluate Vegetation Modeling in Earth System Models

Thursday 10:00 – 11:00

University of Reading

Terrestrial Gross Primary Productivity (GPP) is the single largest annual flux in the carbon cycle (~132PgC) and has significant implications for the carbon budget calculations. Earth System Models (ESMs) provide the capability to simulate GPP including under different climate change scenarios in the future. However, there is not only a large spread in GPP estimates from different ESMs but there are also large uncertainties in observational products that could be used to evaluate these estimates.

Therefore, there is a real need for evaluation methods that will help us understand better the possible reasons for such a large spread in GPP simulations, both in terms of the influence of atmospheric variables driving GPP as well as in the representation of the processes involved in simulating GPP. We describe an interpretable machine learning (ML) framework to identify these differences to further help us address key gaps in modelling the terrestrial carbon cycle. Our proposed framework comprises of ML emulators for GPP estimation and information theory based distance measures. We show results from initial experiments with pre-industrial control simulations and some recent results from ongoing work with historical simulations and observations.

Khunsa Fatima

Deep Learning Technologies for Tree Health Assessment

Thursday 10:00 – 11:00

University of Leicester

Forests and woodlands cover 13% (3 million hectares) of Great Britain, with total tree cover amounting to 17% (3.75 million hectares) and an annual value of £4.9 billion. Despite their value, these resources are threatened by exotic pests and pathogens. Addressing these threats requires a proactive, comprehensive approach. Our research utilises deep learning and transfer learning techniques to train convolutional neural network (CNN) models for multiclass semantic segmentation of ground based RGB tree images. We trained a UNET model from scratch and retrained pre-trained models—VGG16, VGG19, ResNet34, and ResNet50—using our tree images dataset. The prediction and generalisation capabilities of the trained models were evaluated using model prediction evaluation metrics.

The UNET model achieved an overall accuracy of 82.4% with F1 scores of 0.79, 0.51, and 0.71 for foliage, wood, and ivy, respectively. The retrained ResNet50 model showed slight improvement, with an overall accuracy of 84.3% and F1 scores of 0.81, 0.54, and 0.69 for foliage, wood, and ivy, respectively. Automated workflows were developed to extract biophysical tree health parameters such as defoliation percentage, ivy load, tree height, tree tilt angle (θ), crown symmetry, crown length to tree height ratio, and crown length to crown diameter ratio. The defoliation scores based on model predictions and expert assessments showed a strong positive correlation of 0.83. From these parameters, a tree health index was developed. This study demonstrates the potential of deep learning in tree health assessment and suggests integration with aerial and satellite imagery for a comprehensive multi-scale assessment system.

Session 7D

Snow

Richard Kelly

Ku and L-Band observations of the cryosphere from a new fully polarimetric airborne synthetic aperture radar system (CryoSAR)

Thursday 10:00 – 11:00

University of Waterloo

A newly acquired synthetic aperture radar (SAR) system called the CryoSAR has been deployed to support cryospheric remote sensing applications in Canada and Arctic regions. With a dual frequency Ku and L-Band capability, the fully polarimetric system is being used to develop new approaches to estimate seasonal snow accumulation on land, lakes and sea ice, soil freeze-thaw state, soil moisture and ecosystem state variables. This paper reports on the system characteristics and performance and we describe its deployment for a season-long experiment in Ontario during the 2022-23 winter season. In situ soil state and temperature instruments, and a meteorological station were installed at a farm field site in Powassan, Ontario which is characterized by rolling topography interspersed by forest stands. During the winter season snow surveys were conducted to characterize snowpack bulk properties (snow water equivalent [SWE], snow density, snow depth) and snowpack microstructure properties such as layering, snow specific surface area, temperature and density. CryoSAR overflights were conducted throughout the winter coincident with field measurements to create a comprehensive time-varying Ku and L-band polarimetric image data set. The Ku-band data are being coupled with snow microwave radiative transfer models (IBA, DMRT) to support the development of SWE retrievals in preparation for application to the Terrestrial Snow Mass Mission, a mission in planning at Environment and Climate Change Canada and the Canadian Space Agency. In this paper we demonstrate the sensitivity of the Ku-band polarimetric response to snow mass and its applicability for satellite Ku-band retrievals.

Calum Hoad

Snow melt timing influences Arctic greening in heterogeneous tundra landscapes

Thursday 10:00 – 11:00

University of Edinburgh

Earth Observation is critical for understanding land-surface change in the rapidly warming Arctic tundra biome. Since the 1980s, studies have found positive trends in vegetation indices derived from multispectral satellite imagery over the Arctic - commonly referred to as ‘Arctic greening.’ Greening has many potential drivers, with most studies assuming warming temperatures are enhancing vegetation growth. However, pixel sizes of satellite imagery used in greening analyses range from hundreds to tens of metres, failing to capture the spatial heterogeneity of tundra ecosystems. Where the duration and extent of fine-resolution snow patches are changing concurrently with vegetation, this may confound greening analyses.

To better understand the impact of snow on greening analyses at sub-satellite pixel scales, we used UAV-mounted (drone) multispectral sensors at two tundra sites: Qeqertarsuaq, Greenland and the Yukon, Canada. By comparing these data with Sentinel-2 and NASA HLS S30 data, we assessed the impact of sub-pixel snow cover on vegetation metrics. We found snow persistence within satellite pixels can delay the timing and limit the magnitude of peak NDVI, the summary metric prevalent in greening analyses. Our results highlight that by accounting for snow cover within greening analyses, we will better understand concurrent Arctic land-cover change in a warming climate.

Leam Howe

Automated mapping of late-lying snow from satellite data

Thursday 10:00 – 11:00

University of Edinburgh

Mountain snow provides many services, as a water store, a habitat, a playground; but also poses threats such as flood and avalanche because of its high sensitivity to changes in climate. The high spatial variability of mountain snow compared with the resolutions of satellite sensors and models makes measuring and forecasting snow cover particularly difficult in the environments they are needed most. Large-scale high-resolution snow mapping is required to validate snow physics models; however, current remote sensing products are unable to accurately map late-lying snow in complex terrain due to the heterogeneous physical properties of snow (e.g., grain size, contamination) and viewing conditions (e.g., atmospheric conditions, cloud cover, shade) influencing the retrieval of consistent reflectance spectra from satellites. To address this gap, we develop two methods that utilise multispectral satellite data to map mountain snow patches. The first method adapts established spectral unmixing methods to accommodate late-lying snow characteristics and the second employs machine learning.

Session 8A

Vegetation Applications – Forestry

Chuanze Li

Historical dynamics of disturbances in the Cerrado-Amazon Transition using Residual Neural Network

Thursday 11:30 – 13:00

University of Manchester

The Cerrado-Amazon Transition (CAT) is the world's largest tropical ecotone and separates the Cerrado Savannah from the Amazon Rainforest. Deforestation and degradation of large swathes of the dense Amazon rainforest and Brazilian Savanna is leading to irreversible transformation and a critical loss of biodiversity. An increase in wildfire and agriculture-led deforestation make the CAT a dynamic ecological border within the internationally known 'Arc of Deforestation'. Yet, our understanding of the impacts of deforestation and degradation in the CAT is hampered by a lack of knowledge as to where and when these disturbances occur. Here we combine time-series segmentation and deep learning algorithms to identify and quantify disturbances in the CAT over a 35 year period.

Using a combination of the Landtrendr algorithm, Landsat time series data and a Residual Neural Network (ResNet), we identified four different forest disturbance types (forest clearance, savannah clearance, forest wildfire, savannah wildfire) occurring within the CAT, based on their temporal spectral trajectories.

We demonstrate that our approach is able to detect more than 384,000 km2 of disturbance between 1985 and 2020, with forest clearance accounting for the most significant proportion (35%) of identified change. Accuracy of disturbance detection ranged from 88.02 to 93.04%, while the aggregate accuracy of classification reached 95.34%. Disturbance events in savannas are more difficult to accurately classify due to lower vegetation cover. The greatest period of clearance occurred between 1995-1998, due to increased agricultural.

Daniela Rivera-Marin

Vegetation dynamics and its response to climate and human activities in Chile

Thursday 11:30 – 13:00

University of Southampton

Vegetation play a crucial role in land-atmospheric interactions, contributing to the regulation of climate patterns and atmospheric conditions. Chile's diverse vegetation types are critical for providing ecosystem services but face threats from climate change and anthropogenic activities such as agricultural expansion and deforestation. To develop effective policies for managing Chile's vegetation and ensuring the continued provision of ecosystem services, it is essential to understand the temporal dynamics of vegetation and their interactions with climate and human activities.

This study analysed 96.2% of the continental territory of Chile to assess vegetation changes, specifically browning and greening trends, over the last 40 years. We aimed to identify the primary drivers behind these phenomena. Climate variables, such as changes in precipitation and temperature, were examined alongside land cover and land use changes to assess human impacts.

Our findings indicate that approximately 5% (~38,850 km^2) of Chilean territory has experienced browning over the past 40 years, distributed across various regions and vegetation types, suggesting ongoing land degradation processes. Contrarywise, about 7% (~59,600 km^2) of the territory shows a greening effect, predominantly in temperate climates, likely due to natural or artificial reforestation and the establishment of new agricultural areas. These insights are crucial for informing policy and conservation strategies aimed at mitigating degradation and promoting sustainable land use practices in Chile.

Martin Mokroš

Ground-based lidar implementation for forest ecosystem mapping and monitoring

Thursday 11:30 – 13:00

University College London

Ground-based lidar technologies revolutionise the mapping and monitoring of a wide range of science fields and practices. Terrestrial or mobile laser scanning provides high spatial and temporal resolution on a level that was not possible to reach before. In the field of forest ecology research, these technologies have the potential to provide data that will help to understand forest ecosystems on a much deeper level, which is needed for future development under climate change impact.

We are facing challenges in implementing these technologies and taking advantage of their capabilities. The scattered development across the world, fast development that is overrunning the application, a high number of publications, and lack of standards are just a few to name.
We established an international network three years ago that focuses on standardising and implementing ground-based lidar technologies for forest ecosystem mapping and monitoring to face these challenges. It is based on the 3DforEcoTech COST Action. We are focusing on three topics: data collection, processing and fusion. We have worked on establishing state-of-the-art milestones and recognising where we are and where we should go. The full database of data processing solutions from around the world is one of the examples: https://3dforecotech.eu/database/.

The presentation will provide findings on ground-based technologies and their use within forest ecology and precision forestry which are also important for digital twins and remote sensing in general. The presentation will be also a lesson learned from the PI perspective on how networking and interdisciplinarity are crucial to solving research field-level issues.

Nezha Acil

Global trends in remotely-sensed aboveground biomass between 2015 and 2021

Thursday 11:30 – 13:00

University of Leicester

The world's forests play a key role in global carbon cycling, yet little is known about how the carbon stock they hold varies over time. Quantifying temporal changes in aboveground biomass (AGB), at the global scale, has so far been limited by large uncertainties in the space-based estimates of live woody vegetation's AGB, due to limited availability of repeated ground reference data and spatiotemporal inconsistencies across the sensors/instruments used for measurement (e.g. GEDI and ICESat-2, PALSAR ALOS 1 and 2). The new European Space Agency (ESA) Climate Change Initiative (CCI) AGB product Version 5, with an enhanced retrieval algorithm, provides a temporally consistent time series of annual AGB estimates between 2015 and 2021 at 100 m spatial resolution and at the global scale, which open new possibilities for discerning trend patterns worldwide. Using the Google Earth Engine cloud-computing system, we leverage these maps to quantify the direction and magnitude of AGB changes, accounting for sources of uncertainties and potential relationships with other covariates. We also use a globally applicable framework that provides evidence of pressures and impacts from independent optical data to characterise AGB dynamics, illustrating with locally-focused case studies from different biomes across the world, including temperate forests in the UK and Mediterranean woodlands in Australia. Our results highlight hotspots of fast vs slow AGB changes and provide insights into the quality of satellite-derived AGB for tracking changes in carbon stocks and reporting progress toward climate change mitigation.

Wanxin Yang

A new EO aboveground biomass reference dataset for Miombo woodlands in Angola

Thursday 11:30 – 13:00

UCL

Accurate ground measurements of forest aboveground biomass (AGB) are essential for calibrating and validating forest biomass estimates from Earth Observation (EO) missions. However, high-quality reference data is lacking, particularly in high-biomass and/or high-uncertainty regions (much of the tropics). The GEO-TREES initiative aims to address this gap by globally establishing a network of Biomass Reference Measurement (BRM) sites, initially prioritising tropical forests. The key measurements to be made at core BRM sites are forest inventory (species ID and tree diameter), airborne laser scanning (ALS), and terrestrial laser scanning (TLS).

Here, we introduce results from a TLS field campaign conducted at a core BRM site in Bicuar National Park, Angola, and show TLS-derived estimates of AGB for the first time in this area. We captured TLS data across four hectares of woodland plots, segmented woody point clouds of individual trees via our open-source tool TLS2trees, and generated quantitative structure models (QSMs) for each tree. We then used QSM-derived volume, tree height, and diameter at breast height (DBH) to estimate AGB at plot scale through three methods: (1) direct volume conversion, (2) TLS-derived DBH allometry, and (3) TLS-derived DBH-H allometry. We compare these methods with the DBH allometric relationships that underpin EO-derived estimates of AGB. Deploying TLS for direct plot-level AGB estimation and developing area-specific allometry is vital for reducing uncertainty in plot-level AGB estimates used for calibrating and validating biomass mapping in the existing and upcoming space-borne missions including GEDI, ICE-Sat II, NISAR, and BIOMASS.

Meg Stretton

The influence of 3D canopy structure on modelled photosynthesis

Thursday 11:30 – 13:00

University of Reading

Vegetation is one of the largest terrestrial sinks of atmospheric carbon dioxide, driven by the net balance between photosynthesis and respiration. Understanding the processes behind this net flux is critical, as it impacts the atmospheric carbon dioxide concentration. A factor determining the carbon flux into the land surface is the amount of light absorbed by the vegetation, driving photosynthesis. However, climate models commonly represent vegetation canopies as homogenous slabs of randomly positioned leaves, a contrast to real forests which can exhibit large amounts of 3-dimensional heterogeneity.

This work examines the impact of measured 3D vegetation canopy structure on modelled gross primary productivity (GPP). We calculate GPP from output from the explicit radiative transfer model, Discrete Anisotropic Radiative Transfer (DART), following the approach commonly used in land surface schemes. Using 3D structural information from Terrestrial Lidar Scanning (TLS) data for six forest canopy plots, we explore how sensitive modelled GPP is to the assumptions about canopy structure in Earth system models. Here, we use the spatial resolution as a proxy for the canopy structure, with the very coarsest simulations containing no spatial variability in leaf location, with variability introduced as the simulation resolution becomes finer. In almost all cases, the simulated GPP is reduced, and with the finest resolution this is up to 17%, contrasting with recent studies showing the opposite effect. These results suggest that not including the impact of 3D canopy structure could lead to biases in land surface models, particularly in forest's contribution to the carbon budget.

Session 8B

Digital Twins

Heiko Balzter

Towards self-learning digital twins for sustainable land management

Thursday 11:30 – 13:00

University of Leicester

Digital twins, informed by artificial intelligence, have the potential to significantly accelerate the net zero transition. An environmental digital twin is a digital representation of the biophysical environment. It updates its status by ingesting new data from Earth Observation, field measurement stations and physical models. Because a digital twin delivers actionable insights into how the environmental system behaves, it can influence human behaviour and decision-making, and therefore alter the physical environment itself.

Current digital twins generally include static models that do not react to changes in the underlying physical systems. This presentation introduces the concept of self-learning digital twins. The self-learning feature of a digital twin means that it includes a physical process model that represents current human understanding of the environmental system, as well as empirical machine learning models, data input and output pipelines and a visualization user interface. A self-learning digital twin is able to discover new model equations that would improve the goodness-of-fit of the model simulations to the real-world data.

Here, we demonstrate the conceptual framework for a self-learning environmental digital twin based on a physics-informed graph neural network (PiG-NN). We show their architectural framework and describe an integrated approach to using them to accelerate the net zero transition of the agriculture and land use sector in the UK. Distributed machine learning algorithms are deployed together with the JULES-CROP land surface model, eddy covariance flux tower observations of net ecosystem exchange, and Earth Observation data from Landsat and Sentinel-2 to answer user-driven questions around the greenhouse gas impacts of land use decisions in drained lowland peatlands of The Fens in East Anglia. This region is a major source of carbon dioxide emissions from the oxidation of the drained peat soil.

Dale Partridge

Digital twin based on very high-resolution data assimilation to track harmful algae blooms

Thursday 11:30 – 13:00

Plymouth Marine Laboratory

In August 2024 we conducted a mission to use the forecast from a digital twin (DT) in order to navigate a network of ocean gliders and optimise the information they collect. To achieve this we have developed and validated a biogeochemical component of a very-high resolution (1.5 km) data assimilation system for the North-West European Shelf. The predictions generated by the pre-operational 1.5 km model were combined with multi-platform observations (by the satellites and in situ measurements from ship and gliders) and stochastic machine learning driven path-planning model.

The DT was designed to track and observe harmful algae blooms (HABs) of a particular species of phytoplankton (Karenia Mikimoito) and its environmental consequences, like oxygen depletion. The fleet of fully autonomous gliders were navigated by stochastic forecasts informed both by the 1.5 km pre-operational model forecast and observations to areas with HABS and low oxygen. The gliders were calibrated in real time by other observational facilities run under Western Channel Observatory present in the area.

Garin Smith

AI4DTE Artificial Intelligence for digital twin earth software stack

Thursday 11:30 – 13:00

Telespazio UK

Digital Twin Earths (DTEs) will be required to provide actionable information and evidence-based decision support to decision makers, who are not modelling experts. Doing this successfully requires a broad ecosystem of interacting heterogeneous models, data and tools from many sources and purposes. These will include AI models, and data used and data generated by AI modelling. Support will be needed in a future digital platform hosting DTEs for machine learning models and data, so they can play an effective part in this ecosystem.

AI4DTE is an ESA project aiming to deliver the starting point for a core AI-infrastructure used in multiple Digital Twin Earth developments. This digital platform for hosting DTEs must support the openness of AI models to integrate with each other and non-AI models, and tools without requiring model-specific integration logic, permitting the governance and operationalisation of models, including their improvement and replacement - whilst maintaining trust. AI4DTE will provide a representative set of tools and resources relevant to AI-based developments, demonstrating their use through DTE use-cases. The DTE use-cases in this activity are to be understood as a tool to demonstrate the value of the AI software stack applied to likely DTE use scenarios.

By working with a range of real DTE developers, creating a software stack prototype, and ultimately via the generation of a roadmap for future operationalisation, this presentation will demonstrate what the project has explored to meet the above vision and proposes guiding principles and concepts for the use of AI in DTE.

Cristina Ruiz Villena

Machine-Learning Emulators of Land Surface Model ‘JULES’ for African Hydrological Digital Twin Applications

Thursday 11:30 – 13:00

NCEO University of Leicester

Human-induced climate change is the greatest threat the world has ever faced, according to the United Nations (UN). Its impacts are already having devastating consequences for people and the planet, particularly in Africa, with threats to health, food and water security, livelihoods, biodiversity, etc. Therefore, it is imperative to take action for mitigation and adaptation, and climate data are key to make informed decisions.

Digital Twins (DTs) are tools that combine models and observations to provide actionable information for stakeholders. DTs allow users to easily explore the available data and test potential interventions to help decision making. In this work, we present a novel approach for the technical component underpinning DTs. Our proposed solution is an innovative model-data fusion that consists of developing machine-learning emulators for specific processes within Earth system models and driving them using EO data. These emulators are much faster and lightweight than the models they replicate, and can be easily run by non-experts without dedicated high-performance computing facilities, thus providing a way to democratise access to climate data.

We have successfully developed such emulators from land surface model JULES for several applications such as Gross Primary Productivity (GPP) over Europe. We are now developing emulators for hydrological applications in Africa as part of EOCIS and ESA CCI CMUG, including soil moisture and wetland methane emissions, and a framework to automate and streamline emulator development. In this contribution, we will present results from these emulators over Africa and discuss their potential.

Session 8C

The Business of EO 2

Mark Hallows

Automating Biodiversity Net Gain Calculations with Arup's BNG Digital Service

Thursday 11:30 – 13:00

Arup

The Environment Act 2021 has introduced a mandatory requirement for all new developments to deliver a minimum 10% Biodiversity Net Gain (BNG) from 12th February 2024. Arup's BNG Digital Service will provide a rapid, accurate and efficient approach to the mapping of biodiversity baselines and identifying biodiversity change for BNG, facilitated by Earth Observation.

The service will leverage England-wide habitat mapping, classified from Sentinel-1 and Sentinel-2 imagery, as well as detailed habitat mapping derived from VHR imagery. National mapping uses a dual encoder CNN and is classified to the UK Habitat Classification System.

The service will provide a baseline of the site prior to development and will enable monitoring over the long-term to ensure that outcomes are being achieved according to the BNG requirements.

To facilitate rapid habitat baselining, the DEFRA Statutory Biodiversity Metric Calculation Tool will be fully integrated into the service. The service automatically calculates habitat distinctiveness and habitat units and identifies where the largest opportunities for delivering biodiversity net gain are across a scheme.

The tool can also compare a post-construction design to the baseline and automatically calculate the % change in habitat units (Biodiversity Net Gain), facilitating design iterations, ensuring that biodiversity is considered from the earliest stages of the planning process.

Ryan Laird

Utilising Earth Observation Data to Drive Sustainable Marketing and Consumer Behaviour

Thursday 11:30 – 13:00

Green Orbit Digital

Earth Observation (EO) data is revolutionising sustainable marketing by providing actionable insights that help businesses promote eco-friendly practices and influence consumer behaviour. This presentation explores how marketers can leverage EO data to develop impactful campaigns, educate consumers, and foster sustainable purchasing decisions.

By visualising environmental impacts through EO data, marketers can create compelling content that makes the effects of consumption tangible to consumers. Targeted marketing campaigns can address specific environmental concerns in affected regions, using EO data to tailor messages that resonate with local needs.

Transparency is key in building consumer trust. Providing access to EO data related to product sourcing, production, and distribution allows consumers to make informed choices. Interactive platforms can enhance this by enabling consumers to explore the environmental footprint of their consumption habits.

Businesses can also use EO data to substantiate sustainability claims, differentiating their products in a competitive market and enhancing brand credibility. Marketing initiatives that demonstrate the collective impact of individual actions on the environment can drive significant behavioural changes towards sustainability.

From a corporate perspective, integrating EO-driven sustainable marketing practices aligns with Corporate Social Responsibility (CSR) efforts, supporting broader sustainability goals. Collaboration with policymakers to promote regulations that ensure the accuracy of sustainability claims can further strengthen the market for eco-friendly products.

In summary, EO data empowers marketers to create transparent, credible, and impactful campaigns that not only enhance brand reputation but also drive meaningful consumer behaviour changes, contributing to broader environmental and societal benefits.

Tom Walkinshaw

Flight Data from the worlds smallest commercial imaging satellite

Thursday 11:30 – 13:00

Alba Orbital

Alba Orbital has design, built, launched and operated the worlds smallest commercial imaging platform, the Unicorn-2 constellation. Our short term goals are to image earth at night for a select group of early users, with a longer term goals of mass production a constellation to image earth very regularly, upto every 15 minutes. We have now brought down double digits of early commissioning photos as we move toward fulfilling early customer preorders.

Session 8D

Novel Instruments, Applications and Approaches

Shannon Mason

100 days of EarthCARE: radar, lidar and synergistic products

Thursday 11:30 – 13:00

University of Reading & ECMWF

EarthCARE's successful launch on 28 May 2024 marked the start of its 6-month Commissioning Phase. At around 100 days post-launch, we should have access to first products from all four instruments, including EarthCARE's high-spectral resolution atmospheric lidar (ATLID) and Doppler cloud profiling radar (CPR), and be preparing to validate our synergistic products. In this talk we'll provide a review of EarthCARE's launch and commissioning, calibration and first products from each instrument, plans for validation of EarthCARE data products, and an update on prospects for synergistic products going into EarthCARE's operational phase.

Lucy Ventress

Visualisation of long-term atmospheric composition datasets from the RAL Space Infrared and Microwave Sounder (IMS) extended retrieval scheme.

Thursday 11:30 – 13:00

UKRI-STFC RAL Space

The RAL Infrared and Microwave Sounder (IMS) scheme is an optimal estimation retrieval created to combine measurements from the Metop sounding instruments - IASI, AMSU, and MHS, in a joint retrieval of water vapour, temperature, and ozone. It has also been modified to use with CrIS and ATMS, onboard Suomi-NPP and NOAA-20, due to the increased near-surface sensitivity that is crucial for the detection of certain trace pollutants. The extended version of the IMS scheme additionally includes retrievals of carbon monoxide, cloud parameters, dust, volcanic sulphate, and column retrievals of several minor species including ammonia, isoprene, other VOCs, and sulphur dioxide.

High-quality long-term datasets have been created for the full lifetime of the IASI and CrIS instruments for all retrieval parameters and will be illustrated in this paper. The algorithm also runs in near-real time, with the output available to view through the data visualisation portal at http://rsg.rl.ac.uk/vistool.

Data from the extended scheme have been exploited in multiple scientific studies, such as, the nocturnal survival of isoprene (https://doi.org/10.1126/science.abg4506); global OH radical distribution (https://doi.org/10.5194/acp-22-10467-2022); the radiative impact of the Hunga-Tonga eruption (https://doi.org/10.1038/s43247-022-00618-z); methanol and CO from Australian wildfires (https://doi.org/10.1029/2021JD034892); and the tropospheric ozone radiative effect (https://doi.org/10.5194/acp-24-3613-2024).

Additionally, the scheme is being optimised for individual weakly-absorbing minor gas retrievals post IMS processing. Using the IMS retrieved state as the linearisation point, it detects departures in the atmospheric state from a generalised background covariance matrix created using IMS spectral residuals (e.g. Walker 2012). It aims to improve the precision of the minor gas retrievals, whilst mitigating spectral interference from other species/contaminants to reduce systematic errors. The latter is important for isoprene, for example, as the current version is affected by dust contamination. Some results of implementing the improved algorithm are demonstrated.

Anna Michalska

NIMCAM – A high spatial resolution methane monitoring instrument

Thursday 11:30 – 13:00

University of Edinburgh

Methane is a potent greenhouse gas with a comparatively short atmospheric lifetime. Identifying and addressing methane emissions now is an effective strategy to mitigate the effects of climate change in the near-term. Methane concentrations in our atmosphere are increasing at an accelerating rate, yet there are large uncertainties in the origins of the emission sources. Remote sensing data can help improve our understanding of emission sources and drive effective policy to address them. Methane leaks from the oil and gas sector represent a significant proportion of anthropogenic emissions, but high spatial resolution satellite data is needed to accurately locate, quantify, and attribute these point source emissions.

The Near Infrared Multispectral Camera for Atmospheric Methane, NIMCAM, is a new satellite instrument under development at the University of Edinburgh, designed to deliver high spatial resolution mapping of atmospheric methane. With a spatial resolution of 50m, NIMCAM will be the highest resolution instrument capable of continuous global monitoring among those currently available. The multispectral imaging system operates in the short-wave infrared and will be deployed on a constellation of small satellites, detecting methane emissions continuously without the need to pre-select target sites.

We will present results from ground-based field trials, showing NIMCAM's ability to detect methane. We will also describe the design of an aircraft demonstrator instrument, which will be used for future air-borne trials, and present concepts for the satellite instrument and mission.

Dr Samantha Lavender

Supporting the development of hyperspectral missions to monitor atmospheric gas emissions

Thursday 11:30 – 13:00

Pixalytics Ltd

The HERCHI Payload Development project, led by SSTL, is funded by the 16th CEOI Flagship Programme. Gathered requirements will be showcased, which feed into the design of future hyperspectral missions to monitor atmospheric gas emissions. In addition, technical activities focus on analysing data from existing missions and the processing needed to derive atmospheric fluxes.

While atmospheric gas focused missions have traditionally been the domain of government organisations, small satellites focusing on higher spatial and repeat coverage can differentiate themselves from and complement space agency missions. The required temporal coverage could be achieved using a constellation, but there is still likely to be a need to prioritise acquisitions. For example, the UK could be divided into high/low interest areas based on the gas(es) of interest and likely sources for air pollution. Also, if the data is used in a regulatory process, questions will be asked about the accuracy and the data will need to be provided in a format / to a standard the users are already familiar with.

Business models for such products/services are still relatively new, and a proven (paying) customer base is to be developed. Therefore, discussions have also focused on who the end-users / paying customers are for both greenhouse gas measurements and air pollution. The two may differ; for example, the end user could be a farmer, but they would not directly pay for Earth observation data.

Matt Berrington

A Laser Heterodyne Radiometer for atmospheric composition sounding

Thursday 11:30 – 13:00

RAL Space STFC

A Laser Heterodyne Radiometer (LHR) instrument is being developed at the Rutherford Appleton Laboratory for atmospheric composition sounding. The current instrument is capable of measuring CO2 and CH4 autonomously, and has been deployed previously in Sodankylä, Finland, and presently in Oxfordshire. LHR development is currently funded by ESA's Fiducial Reference Measurements for Ground-Based Infrared Greenhouse Gas Observations (FRM4GHG) project which aims to mature low cost, portable instruments suitable for a new greenhouse gas observation system with global coverage. The LHR architecture will be described, with emphasis on its unique advantages and recent upgrades. The next generation of the LHR will also be presented: an ultra-compact LHR suitable for micro-satellite space flight for limb solar occultation (the SOLSTICE mission, previously known as ESA CubeMAP), and a frequency-multiplexed LHR capable of rapid signal acquisition, which enables the spectrometer technology for nadir atmospheric composition sounding (the MUX-LHR project).

#UKEO2024

Date: 10-12 September

Location: National STEM Centre York

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