NCEO AND CEOI EARTH OBSERVATION CONFERENCE 2019 - SCIENCE, MISSIONS AND TECHNOLOGIES

Book of Abstracts. Key orange = keynote; yellow = oral presentation; grey=poster. Arranged alphabetically by first name (keynote speakers first)

Name	Abstract Title	Abstract Detail
Anna Hogg	Hot Topics in Glaciology	Satellite Earth observation has revolutionized our understanding of the remote and inaccessible Polar Regions. Without this critical resource we would have a far less complete understanding of which regions are changing, the timing and pace at which events occur, and what physical mechanisms are responsible for driving change. In Antarctica, satellite data has been vital for revealing the continent-wide spatial pattern of ice flow; for uncovering dynamic imbalance and the associated large sea level contribution of the marine-based West Antarctic Ice Sheet; for mapping the seasonal growth and decay of sea ice extent; and for measuring the size and recovery of the Ozone hole. These major advances are noteworthy, but are just a fraction of the key findings that would not have been made without the availability of satellite data. This highlights what an essential tool Earth observation is for improving our understanding of environmental change in Antarctica, and why it is so important to continue to study this important topic. Here I present a review of recent key science findings made using Earth Observation data in Antarctica and Greenland, and I highlight emerging hot topics in glaciology. This illustrates how satellite datasets are more critical than ever for improving our understanding of the Polar Regions, enabling us to better predict how they will change in the future.
Anna Hogg	Biography:	Dr Hogg is a University Academic Fellow (UAF) in the School of Earth and Environment at the University of Leeds, working in the Centre for Polar Observation and Modelling (CPOM). She was awarded a Natural Environment Research Council (NERC) Knowledge Exchange Independent Research Fellowship in 2018, and is formally affiliated with the UK Satellite Applications Catapult. Dr Hogg's primary field of expertise is Earth Observation of the Polar regions, where over the past decade she have gained a detailed technical understanding of how to process a range of satellite data types (e.g. Synthetic Aperture Radar (SAR), and radar altimetry), from a large number of Earth Observation satellites (e.g. ERS-1/2, ENVISAT, TerraSAR-X, Sentinel-1, CryoSat-2), using multiple processing techniques (e.g. interferometry (InSAR), feature tracking). Dr Hogg has used satellite Earth Observation data to write journal papers on ice speed, grounding line location, ice elevation change, and calving front migration. Dr Hogg is deeply connected to the international Earth Observation community, and through her role on the UK Space Agencies (UKSA) Earth Observation Advisory Committee (EOAC), where she enjoys working with academics and space industry experts to identify scientific and industrial strategic goals that shape the future direction of our national Earth Observation capability. Dr Hogg has broad experience of collaborative research after having managed, led or worked on 12 international research projects funded by ESA, NERC, & NASA; collaborated with international project partners from 35 institutions in 11 countries including: USA, Germany, France, Italy, Austria, Denmark, Netherlands, Spain, Switzerland, Norway and the UK. Anna delivers NERC national capability for CPOM by runing the world's first Near Real Time (NRT) ice velocity monitoring service, through which ice velocity maps are distributed for six key outlet glaciers of the Antarctic and Greenland ice sheets in near real time, including Pine Island, Thwaites, Brunt, Petermann, Jackobshavn Isbrae and 79 Fjorden Glaciers.
Richard Lucas.	Earth Observation: Preparing for the Future whilst Building on the Past	When asked "what remote sensing has done for us?", the Earth observation community today can clearly show capability and effectiveness in highlighting events (e.g., fires, floods) and processes (e.g., global forest loss, reductions in polar sea ice and mountain glaciers, sea level fluctuations) that have an impact on many of us. This has been achieved by designing, launching and utilising a diverse range of well-designed sensors that have captured the state and dynamics of our landscapes in multiple dimensions. All of this has involved considerable investment and innovation. Despite these efforts, we are still faced with a rapidly changing climate, substantive and widespread losses in biodiversity and food and water shortages (as examples). Effective use of EO in averting, moderating or reversing these processes is therefore less easy to showcase and this has most likely arisen from our focus on the past. Whilst we should continue to do this, there is also an increasing and perhaps urgent need to place more emphasis on using EO data to proactively plan our future planet for the well-being of ourselves and future generations. Different scenarios also need to be considered. There are many pathways and opportunities to achieve this thorough EO, including understanding how past activities have shaped current landscapes, linking with process-based models for predicting/designing future landscapes, and using derived products for economic, social, political and sustainability planning. Making data and products more freely available and useable is also essential. However, these efforts and associated investments need to be well-strategized, planned and coordinated, lead to practical and tangible outcomes, and involve a wide range of stakeholders at all levels. In this way, we can better prepare for a better future that is built on what we have achieved in the past.

Richard Lucas.	Biography:	Professor Richard Lucas holds a Sêr Cymru Research Chair within the Earth Observation and Ecosystem Dynamics (EOED) Research Group (RG), Department of Geography and Earth Sciences (DGES), Aberystwyth University. He has also held positions at the University of New South Wales Australia, the Australian Federal Government and Swansea University (UK). He has expertise in quantifying and understanding the response of terrestrial and coastal ecosystems and environments to change (including that associated with climatic variation) through integration of Earth observation data from various sources and has developed innovative methods for extracting relevant information on terrestrial ecosystems at scales ranging from individual trees to the global. Key achievements include the generation and public release of the Australia's Mangrove Portal and Plant Biomass Library, the development of the Earth Observation Data for Ecosystem Monitoring (EODESM) system for routine monitoring of land cover and change, and advancing both the retrieval of forest biomass and structural attributes at regional to global scales and local to global characterisation, mapping and monitoring of mangroves. He currently leads the Living Wales project which is facilitating the development of international land cover monitoring to support conservation and sustainable use of environments.
Shaun Quegan	The trials and tribulations of an ESA mission PI	There are currently eight ESA Earth Explorer (EE) missions: GOCE (launched 2009); SMOS (2009); CryoSat (CryoSat-1 was lost in 2005 when the launch vehicle malfunctioned; CryoSat-2 was launched in 2010); Swarm (2013); Aeolus (expected launch 2007, but actually in 2018); EarthCARE (expected launch in 2013; now due for launch in 2021); BIOMASS (2022) and FLEX (2023). The selection procedures for EE-9 and -10 are still in train. But where did these missions come from and what is the process by which ESA selected them? And what happens after they are selected: do the mission proposers and science team sit back and wait while the instrument is built and data comes on-stream? This talk will cover these issues and describe how the sometimes stressful endeavours leading up to selection are only the beginning. What follows is a continual re-evaluation of the mission concept, together with resolving problems if industrial compliance comes into conflict with science aims, finalisation of algorithms, defining the external calibration concept, developing the ground segment and engaging with the potential users of the data. These activities occur within an ESA-industry-science structure which can lead to communication delays and difficulties. These issues will be illustrated by the BIOMASS experience.
Shaun Quegan	Biography:	Shaun Quegan is a Professor at the University of Sheffield and a researcher within the National Centre for Earth Observation. For around 25 years, his research has focused on using satellite data and ecosystem models to clarify the role of the land surface, and especially forests, in the Earth's carbon cycle and climate. He was Director of the National Environmental Research Council Centre of Excellence in Terrestrial Carbon Dynamics (CTCD) from 2001 until, in 2008, it was subsumed into the National Centre for Earth Observation (NCEO), in which he led the terrestrial carbon cycle theme. This highly multi-disciplinary programme brought together the capabilities of research groups in several universities to work on assimilating satellite and other data into models of the land carbon cycle and characterizing the ensuing uncertainties. He is the proposer and Principal Investigator of the European Space Agency BIOMASS mission, launching in 2022, which will measure forest biomass, height and disturbance worldwide. He has been a member of several influential committees advising on climate and Earth Observation by satellites, including the ESA Earth Science Advisory Committee and the Terrestrial Observations Panel for Climate, and has contributed to all the GCOS Adequacy and Implementation Reports going back to the First Adequacy Report in 1998. In addition he has been the leader or science leader on numerous EU and ESA projects, and has published two books on the use of radar and over 250 research papers.
Adam Jagoe-Williams (Undergraduate)	Green Propellant and Mars Extraction Rover (MER)	undergraduate poster
Adam Povey	A new perspective on satellite data	Many researchers use satellite data that has been averaged onto a regular spatio-temporal grid (known as Level 3 data) as it is easy to manipulate and understand while more closely resembling typical model outputs. The limitations of such data have been the focus of much discussion, such as biases from spatio-temporal sampling and the masking of regional effects. This talk outlines an alternative approach that avoids many of these issues by using statistics to describe the distribution of the observed data. The technique is illustrated by comparing five satellite datasets of aerosol optical depth to an Earth System Model. In many areas of the world, the data is best represented by a bi- or tri-modal distribution. By reporting the properties of each mode rather than an overall mean, a more physically motivated comparison can be made between different methods and scales. For example, the positive bias of ORAC retrievals relative to Dark Target can be explained by different flagging of high AOD events, with the two datasets otherwise exhibiting similar behaviour. Bulk statistics can be recovered from the new parameters, while being less cumbersome than providing users with a full histogram.

Alex Cornelius	"Microclimate Temperature Modelling - a Novel Tool for Integrated Pest Management Services	The use of biopesticides in the control of plant pests within integrated food security schemes has been experimented with for many years but never fully implemented on large scales. Biopesticides offer an ecofriendly alternative to traditional chemical biocides. However, many uncertainties still exist regarding the efficacy of the biopesticide in its time taken to control pest populations. Crop microclimate and climatic conditions and are key determinants in the effective time to control pest populations, namely the east Asian migratory locust. There are models within the literature that do model the biopesticide efficacy rate and demonstrate their accuracy in lab work on locust pest species. However, they have yet to be implemented in operational monitoring systems using earth observation or meteorological reanalysis data. Efficacy rates are best calculated using temperatures the represent that which the pest resides – within the crop canopy. As of yet, this data is lacking, which prevents wide scale implementation. To combat this, work has been done to adapt an agrometeorological energy balance approach to derive the intra-canopy ambient temperature. This is done using ERA5 reanalysis data on environmental temperatures and surface energy fluxes. This method is validated against fieldwork measurements and shown to better represent the canopy temperature better than all other included sources of temperature. This method represents an invaluable tool for future environmentally friendly, effective locust control systems, with potential improvements coming from the integration of earth observation data in a data assimilation scheme
Alex James Webb	Regeneration of CO2 Satellite Column Data tailored to an Atmospheric inversion Scheme	Current atmospheric inversion schemes assume rather realistic prior information (to the first order) when projected in concentration space while satellite retrieval schemes try to maximize the measurement contribution in the retrievals by giving a very weak weight to prior information. Such inconsistent statistical hypotheses between XCO2 retrieval and atmospheric inversion schemes may be a significant cause of error in atmospheric inversions assimilating satellite data. By using sounding-specific covariances from model covariances representing the prior flux uncertainties of the MACC model projected in space and time, we can derive satellite CO2 columns tailored towards and consistent with the specific assumptions of the MACC atmospheric inversion scheme. Using global level-2 CO2 column data from the NASA OCO-2 satellite, we reconstruct CO2 columns with prior information from the MACC model using linear approximations thus avoiding the need for time-consuming re-retrieval of the satellite observations. In this presentation, we will describe the approach that is used for re-constructing the satellite CO2 columns and we will evaluate the re-constructed CO2 columns from OCO-2 against the MACC model and ground-based TCCON data before using them for a formal atmospheric inversion with the MACC model.
Alison Fowler	Information Aware Data compression of high-resolution observations	In order to capture the evolution of hazardous small-scale weather events, the resolution of numerical weather prediction models is increasing. The need for high-resolution observations to constrain these models is being met by advances in technology, however these new observation types will provide unprecedented volumes of data, many orders of magnitude greater than are currently assimilated. The challenges of assimilating such large volumes of data may prove prohibitive in terms of data storage, computational time and complications caused by correlated errors. Information Aware Data compression (IADC) that allows for a reduction in the volume of the data, whilst retaining the key information is explored in an idealised framework in which the observations have significant spatial error correlations. It is illustrated that when the observation error correlation length-scales are large (in comparison to the prior error correlations), the IADC will select observations of the smaller scales for assimilation whilst throwing out the larger scale information. In this case it is shown that there is a discrepancy between the observations with the maximum information and those that minimise the analysis error variances. Experiments are performed using the Ensemble Kalman Filter and the Lorenz-1996 model, comparing different forms of data reduction. It is found that as the observation error correlation length-scales increase the assimilation becomes more sensitive to the choice of data reduction technique and the IADC approach is more beneficial.

Alison Waterfall	How to archive your NCEO data at CEDA	The CEDA archive provides long term archiving for NCEO and other EO and atmospheric datasets, ensuring the data is properly curated, searchable, discoverable and accessible in the long term. DOI's can be assigned to the datasets, providing permanent identifiers that can be cited and used in published papers, which is increasingly a requirement of many journals. CEDA can also provide advice on suitable data formats to use when archiving data, and help with checking data formats. The CEDA archive is located on the JASMIN processing infrastructure, allowing easy and fast access to your archived products for further data analysis. CEDA also facilitates access on JASMIN to a number of third party datasets. In this poster we will describe the procedure for submitting data to the CEDA archive, and for suggesting new third party datasets for consideration. We will be available throughout the conference to discuss any data related questions from NCEO and other data producers.
Ana Maria Pacheco-Pascagaza	Multi-Temporal and Multi-Frequency Analysis to Assess Forest Degradation in Bajo Calima - Colombia	Forest degradation serious problem significantly contributing to greenhouse emissions and biodiversity loss. Quantifying its impact on the carbon budget is challenging because of the diversity of definitions, varying scale of the changes, and many drivers that are applying pressure on the forests. This research investigated the structural differences in the forests of Bajo Calima, and associated them to forest degradation. For this, it was used a combination of multi-temporal in-situ data, LiDAR data and multi-frequency and multi-temporal SAR data. First, forest structure data collected from field plots in 2014 and 2017 were classified using K-means cluster analysis. AGB, tree density and basal area were the variables better explaining the variations in forest structure. With a precision of 0.77%, four levels of disturbance were identified in the area: low to severe degraded forest. Second, integrating multi-frequency Synthetic Aperture Radar (SAR) data: ALOS PalSAR-2, Sentinel-1 and the DEM from TanDEM-X, in combination with LiDAR and field data, we retrieved the forest structure parameters derived from the field data analysis. Results showed a very good approximation to model information from different metrics of forest structure and categorise them in degrees of forest disturbance. Accuracies were higher of 90% for the regressions, while Kappa indexes were above 0.80 for the classifications. Using the DEM derived from the X-band was determinant to achieve these higher accuracies.
Anthony J Illingworth	WIVERN: A Spaceborne 94GHz Scanning Radar to Provide Global In-Cloud Winds, Precipitation and Cloud Properties	We report on the status of "WIVERN" (WInd VElocity Radar Nephoscope): a conically scanning spaceborne Dopplerised 94-GHz radar, proposed in response to the recent ESA call for Earth Explorer (EE10) missions. WIVERN aims to provide global measurements of: a) in-cloud winds using the Doppler-shifted radar returns from hydrometeors, and b) global rainfall and cloud properties from the radar reflectivity. The measured winds, when assimilated into weather forecasts, should lead to further improvements in the accuracy and effectiveness of forecasts of severe weather and better focusing of activities to limit damage and loss of life. Ground-based and aircraft observations confirm that polarization diversity radar at 94 GHz can measure high wind speeds with the required accuracy. The mission was one of five EE10 proposals recommended for phase-zero studies by the ACEO (Advisory Committee on Earth Observation) in September 2018, but the final verdict was for further studies. Two recent developments are encouraging. The ACEO highlighted the requirement of azimuthal pointing knowledge of the rotating antenna accurate to 200□rad as "very challenging"; however, the recent phase zero study of the EE9 "SKIM" mission to measure ocean surface waves using a rotating feed, rather than the complete antenna, indicates that such accuracy should be achievable. Secondly, the first results of the AEOLUS mission reported at LPS19 in May, indicate that the AEOLUS winds from the Doppler shift of the molecular backscatter detected by a 355um lidar have a positive impact in ECMWF analyses. WIVERN in-cloud winds would complement these clear-air winds.

Antonio Di Noia	Greenhouse gas retrievals from GOSAT for the Copernicus Climate Change Service (C3S)	The Copernicus Climate Change Service (C3S) aims at providing data users with accurate, quality-controlled Essential Climate Variable (ECV) data products with the atmosphere thematic area covering datasets on atmospheric composition including greenhouse gases. University of Leicester/NCEO generates global datasets about the concentration of carbon dioxide (CO2) and methane (CH4) in the atmosphere which are then included in the C3S climate data store. These are derived by inverting top-of-atmosphere radiances measured by the TANSO-FTS instrument aboard the Japanese satellite GOSAT. In this presentation, we will outline the main features of the UoL greenhouse gas retrieval algorithm, we will discuss the present status of the C3S greenhouse gas data products, covering the period from 2009 to 2018, and we will discuss the methods used to characterise uncertainties in the space-based greenhouse gas datasets.
Antonio Giovanni Bruno	Observations and modelling of hydrogen cyanide in the atmosphere	Wildfires in Indonesia are seasonal events regulated mainly by the agricultural practice of burning old vegetation for land clearing in order to prepare the soil for the new planting season. El Niño exacerbates the typical extreme weather conditions of the Indonesian wildfire season, making burning events difficult to control, as they were towards the end of 2015. Indonesian land contains a high percentage of peat, a carbon-rich type of soil, which emits a large amount of hydrogen cyanide (HCN) when burning. For this reason, HCN is typically considered a good atmospheric tracer for peat fires. In this work we present a preliminary study of HCN focused on the emissions of the 2015 Indonesian peat fires. The University of Leicester IASI Retrieval Scheme (ULIRS), originally developed to retrieve carbon monoxide profiles from IASI radiances using an optimal estimation approach, has been expanded to retrieve HCN profiles. The ULIRS HCN data are compared with HCN retrieved using a one-step non-linear retrieval scheme. For the first time, HCN chemistry has been included in TOMCAT, a 3D state-of-the-art chemical transport model. Here we compare model outputs with HCN profiles measured by the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS).
Anu Dudhia	The Reference Forward Model (RFM)	The Reference Forward Model (RFM) The RFM is a line-by-line radiative transfer model supported by NCEO. It is suitable for a wide range of infrared and microwave applications, such as modelling spectral observations of the earth's atmosphere from ground, air and space-based instruments. The code has been developed with the non-expert user in mind, hence an emphasis on robustness and simplicity of use. In April 2018 RFM v5.00 was released, completely recoded in FORTRAN90 and compatible with HITRAN 2016 and GEISA 2015 spectroscopic data. Since then there have been updates every 6 months, mostly bug-fixes and minor improvements. However v5.10, currently under testing, involves some significant recoding in order to handle diffuse surface reflection and Collision Induced Absorption, the new third category of spectroscopic data (in addition to line parameters and absorption cross-section data). The next significant development will be the ability to use the Hartmann-Tran Profile (considered more accurate than the standard Voigt lineshape). This requires extra parameters, available in the HITRAN database, but not as part of the standard line parameter file that the RFM uses at present. So the main challenge here is finding a simple and robust method to extract the required parameters from the database and pass these into the RFM.
Barbara Hofmann	D-MOSS: Introducing an earth observation-driven dengue fever forecasting system for Vietnam	Dengue is the fastest-growing mosquito-borne viral infection in the world today. Currently around 40 percent of the world's population live in countries where dengue is a daily risk. The economic toll of dengue fever and its impact on health systems is higher than that of other major infectious diseases. Since 2000, there has been an increase of over 100% in the number of cases in Vietnam and 2019 is exhibiting exceptional high numbers. At present mitigating actions are taken based on reported cases and local knowledge, leading to a reactive rather than proactive approach of disease control. By combining Earth Observation data with vector-borne disease modelling expertise we have developed D-MOSS (Dengue Model Satellite System). D-MOSS is the first fully integrated dengue fever forecasting system incorporating Earth Observation data and seasonal climate forecasts to routinely issue warnings. It is funded by the UK Space Agency's International Partnership Program and aims to predict the likelihood of future dengue epidemics up to 7 months in advance. It will enable public health authorities in Vietnam to identify areas at risk of future dengue fever outbreaks and take proactive measures of disease control. We are working closely with the Vietnamese Government to achieve SDG3 - Good Health and Wellbeing. Initially designed for Vietnam we have recently been awarded with an extension to our grant allowing us to implement D-MOSS in another 6 countries in South East Asia. The system is operating live since June and we will show and discuss our first results.

Betsabe de la Barreda, Susana Baena, Doreen Boyd, Andrew Sowter et al	The use of Copernicus programme to support Peatlands restoration in Southeast Asia	Tropical peatlands are the most important carbon deposits on Earth, removing CO2 from the atmosphere to store in soil peat deposits via above ground vegetation. Indonesian and Malaysian peatlands store a large proportion of this carbon, but of late have been over-exploited, damaged, and heavily drained for agriculture (e.g. oil palm and pulp wood plantations). This has led to greater susceptibility of peatlands to fires with many negative consequences, including the further loss of stored carbon. Further, when peatlands are drained, peat soil decomposes by oxidation releasing additional CO2 to the atmosphere. This, in combination with physical compaction causes peat subsidence with long-term negative implications. Therefore, it is necessary to understand the extent and condition of tropical peatlands in order to sustainably manage them and this is the aim of the current UK Space Agency IPP Peatland Assessment in SE Asia by Satellite (PASSES) project. Effort has been made to collect in-situ data related to peat condition (i.e. water table, peat depth). However, to scale these data and monitor the vast expense of peatland in these regions remote sensing techniques are required and in PASSES Sentinel-1 SAR (the Intermittent Small Baseline Subset (ISBAS) InSAR technique) surface motion is being explored. Preliminary results reveal good correspondence between land cover history (via Sentinel-2), as a proxy for peatland condition, and subsidence in Indonesian peatlands. This paper will review progress of PASSES to-date and outline future plans for the project.
Bo Dong	Global heat and water flux data sets from EO data	We look at multiple satellite products for global energy and water fluxes over continents in preparation for budget studies, (Thomas et al 2019). Comparing surface radiation from CERES-EBAFv2.8 and v4.0, ISSCP-FH and SRB, we note that over North America the upward shortwave differs substantially between CERES-EBAFv2.8 and v4.0, and the difference is much larger than the given uncertainty, and further investigation is required. Comparisons at grid cells with the BSRN in situ data show broad consistency in spatial biases among different products. We hope to include newer version of CERES data and new radiation products based on the CCI water vapour analyses in future. Turbulent energy fluxes over land are hard to obtain directly but we use FluxCOM which is in situ based and machine-learning mapped data. Despite large uncertainty in FluxCOM data, especially for latent heat, the implied net surface fluxes agree well with the land surface temperature and JULES modelling based heat fluxes from DEEPCv3 and V4 products. In future we intend to start using CCI land surface temperatures with their uncertainties directly in the inverse analysis. GRACE land mass measurements effectively constrain the net land water budget due to the large uncertainties in the evapotranspiration and runoff products. It is especially useful to evaluate precipitation trends. We compare African precipitation variability in GPCPv2.2 and v2.3 data. No precipitation trends are found in GPCPv2.2, but the step increase in rainfall in 2006 in GPCPv2.3 is found to be consistent with the water storage trends in GRACE data.
Callum Middleton	Overview of CHAFF: CubeSat Hyperspectral Application For Farming	Hyperspectral imagers aboard CubeSats have the potential to greatly benefit Earth Observation scientists and end users with the advantages that large constellations of small satellites can provide. For example, such a constellation can aid in the rise in precision agriculture, by providing more frequent revisit times and crop analysis. However, the challenges of supplying high spectral/medium spatial resolution from such a small platform are great; the demands of small optical instrument design are also accompanied by the pointing stability/accuracy constraints and the restricted data downlink budget of the platform itself. CHAFF (CubeSat Hyperspectral Application For Farming) is a prototype for a CubeSat-based hyperspectral imager, with the intention of providing high fidelity data sets to the scientific and agricultural communities. A holistic design methodology has been employed, considering all challenges of the CubeSat platform together; this has resulted in an optical design which allows optically aided geometric co-registration, thus allowing construction of the hyperspectral data cube on-board the satellite. This in turn facilitates the use of lossless data compression techniques to alleviate the data downlink bottleneck. In this talk, the results from a preliminary field trial of the CHAFF prototype are presented and discussed. The prototype has shown basic functionality, with an auxiliary image for the co-registration technique obtained with an associated spectral image. The shape of the obtained raw spectrum is as expected, and a promising signal-to-noise ratio has been achieved. To conclude, future work will then be discussed, including calibration methodology and further field trials of the instrument.
Cathie Wells (Undergraduate)	The route to more sustainable flight	undergraduate poster

Chris Banks	CryoSat-2 in the open ocean - ongoing cal/val and oceanographic studies from pole to equator	With the ability to operate in different modes, CryoSat-2 can provide a wealth of information not just over ice but over ice infested waters, the open oceans and coastal regions. CryoSat-2, ESA's cryospheric mission, provides a variety of oceanographic products for the global oceans. A dedicated operational CryoSat-2 ocean processor (COP) has existed since April 2014 which was updated in November 2017. In this presentation, we consider the quality and utility of the CryoSat-2 data in the open oceans where the altimeter operates mainly in conventional low-resolution-mode (LRM) but also in SARM (synthetic aperture radar mode) over a few regions. Within the ESA funded CryOcean-QCV project, the National Oceanography Centre is responsible for routine quality control and validation of CryoSat Ocean Products. Activities include daily and monthly reports providing global assessments and quality control of Sea Surface Height Anomaly (SSHA), Significant Wave Height (SWH), backscatter coefficient (Sigma0) and wind speed, as well as a suite of validation protocols involving in situ data, model output and data from other satellite altimetry missions. This presentation will present some of the metrics and results obtained for CryoSat Ocean Products for SSHA, SWH and wind speed using data from tide gauges, buoys, model output, HF radar data and comparisons with Jason-2/3. Finally, the utility of the data from CryoSat-2 for oceanographic studies will be demonstrated using sea surface height anomalies. We will present examples of the benefits for oceanographic studies using a Level 3 product, including investigations of propagating features (e.g. Rossby-type wave propagation).
Chris Wilson	Quantifying long-term South American emissions of CH4 using a 4D-Var inverse model and remote sensing observations from GOSAT	We present results from global inversions of methane (CH4) for the period 2009-2018 in which flask measurements and remote sensing observations have been assimilated using a 4D-Var framework. Focusing on South America, we compare the results of inversions based on the latest proxy version of GOSAT CH4 retrievals provided by the University of Leicester. We quantify the total emissions, seasonal variations, trends and posterior error reductions produced and assess the ability of the posterior results to accurately characterise global and South American methane emissions over this decade. This work uses the latest version of the INVICAT model, based on the TOMCAT chemical transport model, and includes some assessment of sectorial analysis of the emissions. We compare results with and without the use of the GOSAT observations and also compare to independent vertical profile observations of CH4 made within the Amazon Basin in particular. We also compare to IASI CH4 observations provided by the Rutherford Appleton Laboratory.
Christopher N Thomas	Superconducting system-on-chip filterbank spectrometers for hyperspectral microwave atmospheric sounding	System-on-chip filterbank spectrometers implemented with superconducting electronics are a promising technology for future satellite microwave sounding and other radiometric observations from 40-700 GHz. These devices comprise a set of filter circuits operating at signal frequencies to channelize the radiation and corresponding set of detectors to measure the power in each component, all of which are integrated together on the same, small (a few cm2), chip. The use of superconducting detectors means the spectrometer can be made extremely sensitive; Transition Edge Sensors (TESs), for example, now regularly achieve Noise Equivalent Powers (NEPs) better than 10-16 W/Hz1/2 at operating temperatures as high as 350mK. Further, the low-loss and slow-wave properties of superconducting transmission lines make it possible to realise filters with narrow bandwidths (R = bandwidth / centre frequency > 100), while still keeping the physical dimensions as small a few mm2 or less per channel. Finally, because all processing takes places at the frequency of the signal, the instantaneous observing bandwidth is limited only by the feed and the filterbank architecture allows control over channel placement and shape. As a result, large numbers of spectral channels (potentially hundreds) can be provided over a wide bandwidth and at high sensitivity and resolution, making the technology ideal for hyperspectral microwave sounding. In this talk I will give an overview of the basic technology and report on a lab-based demonstration of technologies for temperature sounding on the 60GHz Oxygen line as part of the CEOI-funded HYMAS project. I will then discuss our plans to demonstrate operation at higher frequencies as part of a follow on programme called HYMAS-X.
Christopher Taylor	Satellite observations reveal strong impact of deforestation on convective storms in Southern West Africa	The loss of tropical forest has affected much of southern West Africa. In Côte d'Ivoire and Ghana, only "islands" of intact forest remain, typically within protected areas. This deforestation produces mesoscale patterns of land-atmosphere fluxes of heat, water and momentum, depending on both the nature of the subsequent land use (e.g. cocoa plantations, urbanisation) and the phase of the seasonal cycle. Previous Amazonian research has shown how mesoscale deforestation affects local dry season rainfall. Here we use satellite observations since 1991 to identify strong impacts of West African deforestation on convective storms throughout the wet season. To map where and when changes in tree cover have occurred, we exploit the sensitivity of land surface temperature (LST) to deforestation. Trends in dry season LST from MODIS (2001 onwards) and Meteosat (which begins 10 years earlier) are highly consistent with independent datasets of global forest change and Vegetation Optical Depth. Changes in deep convective storms during this period are monitored using sub-hourly Meteosat cloud-top temperatures. We find that trends in LST are positively correlated with trends in convective core frequency during the afternoon/evening peak in activity. Examining specific local deforestation "events" in more detail, a clear pattern of more frequent convective storms above deforested areas emerges, consistent with enhanced triggering due to differential forest cover. Later in the evening, enhanced convection is found to the west of the deforested area, associated with westward propagation of storms. This study provides unique observational evidence of how West African land use change is affecting rainfall.

Claire Bulgin, Christopher Merchant	Variability, persistence and re-emergence of sea surface temperature anomalies	Quantifying sea surface temperature (SST) and its evolution over time is critical to our understanding the Earth's climate and biogeochemical systems. SST is of global significance, impacting global lateral energy transport, air-sea energy exchange, the water cycle and modifying the atmospheric boundary layer. We use a 37-year gap-filled, daily mean SST analysis product developed within the European Space Agency (ESA) SST Climate Change Initiative (CCI) project to characterize SST anomaly variability, persistence and re-emergence over the satellite era (1982-2018). We find a warming trend of 0.4 K between 1982-2018, and de-trend the data to look at the underlying variability in SST and how this relates to global ocean processes including the El-Nino Southern Oscillation (ENSO), and the SST signatures of decadal modes in the Atlantic and Pacific oceans.
Clare Rumsey	Community Earth Observation Intelligence Service: Prototyping for Deployment at Scale	Omanos Analytics is a space technology start-up delivering bespoke space data knowledge to support the narratives of communities across the globe. We present data in tailored, accessible formats in order to reveal impact on local environments and communities, working with the communities themselves as well as international NGOs as intermediaries. EO data and analysis is inaccessible to most people which limits its huge potential to support humanitarian and environmental work; we increase the public value of EO data, bring the benefits of EO insights to a wider audience, and empower communities in low infrastructure regions. We are being supported by ESA, through the EO Science for society programme, to develop a prototype for a highly flexible image-processing pipeline that can be adapted on a case-by-case basis to meet the needs and demands of the communities in target regions. The service demonstrates how EO data can amplify and validate local reporting, connecting communities to EO data and processing resources that are currently inaccessible to them. The service will provide a systematic interface for merging EO data and community intelligence, ensuring traceability, scientific objectivity, and transparency in analysis and data presentation. Our proof of concept work has used EO imagery from Sentinel 1 and 2 and the Landsat satellites to investigate cases of land grabs in Guinea and Cambodia, and oil spill pollution in the Caspian Sea. This work has been used successfully in pursuit of corporate accountability before the World Bank's private-sector arm, the International Finance Corporation (IFC).
Corwin Wright	Do the Gravity Waves Generated by Tropical Cyclones, Hurricanes and Typhoons Matter?	Tropical convective systems are major sources of atmospheric gravity waves (GWs). These waves are a key driver of the global atmospheric circulation, especially in the middle and upper atmosphere. Tropical cyclones (TCs) such as hurricanes and typhoons are particularly dramatic examples of such systems, and are therefore potentially significant individual sources of GWs. To investigate this effect, I produce and analyse GW observations from three satellite limb-sounders in the vicinity of TCs. By statistically combining 15 years of GW observations from 1379 individual TCs represented in the International Best Track Archive for Climate Stewardship, I show that TCs are associated with a 15% increase over background GW amplitudes, and a 25% increase in measured momentum fluxes (MFs), primarily during the period immediately before the TC. While this additional contribution is small relative to other GW-generating processes, and thus individual TCs do not have a large quantitative effect on middle-atmospheric dynamics, stronger GW activity is associated with TCs which will later develop into hurricane-intensity storms than those that will not. Thus, my results suggest that better space-based monitoring of stratospheric GW activity could be a useful tool to help better forecast strong hurricane events in the presence of obscuring tropospheric cloud.
Daniel Clewley	The NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS)	The NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS; https://www.neodaas.ac.uk/) based at Plymouth Marine Laboratory (PML) provide a range of services to support the use of Earth Observation (EO) data within the UK's scientific community. Key services include: operational satellite data processing, development of new products, near real-time support and rapid response using satellite data, airborne data processing (formerly provided through NERC Airborne Research Facility Data Analysis Node) and user support. Following a review of NERC services and Facilities, NEODAAS was re-commissioned for a further five years in April 2019. Recognising the evolving requirements of the community, and expanding range of fields looking to incorporate EO data within their research, NEODAAS will continue to develop new products and services as part of the re-commissioning in consultation with the user community. New services will include more user training, provision of data from geostationary satellites and support for researchers looking to apply deep learning methods to EO data including computational resources using a large GPU cluster to be hosted at PML.

Daniel Fisher	Top down particulate matter estimation for extreme fires in SE Asia	Recent work by Mota and Wooster presents a novel 'top down' approach for the generation of biomass burning emissions inventories that directly links measures of fire radiative energy (FRE, in MJ) to total particulate matter estimates (TPM, in g) via biome specific coefficients (C, in g MJ^{-1}) derived from observations of smoke plume optical depth. Here we present work investigating the application of this approach to the challenging conditions of the extreme 2015 fire season in SE Asia. We obtain measures of FRE (at 2km resolution) from time integrated fire radiative power (MW) observations from Himawari-8. Estimates of TPM are derived using peatland specific emission coefficients and optical depth data from the VIIRS polar orbiter (at 750m resolution) produced using a combination of standard and ORAC AOD products and adjusted to AERONET in-situ AOD observations of smoke. The resulting TPM emission factors are used to generate emissions estimates for extreme fire events in region over the course of the episode and preliminary evaluations are made against the prevailing emissions databases. As this work develops, it is expected that the outcomes could be of considerable assistance. The TPM emissions estimates produced by this approach may for example lead to enhancements in near real time smoke dispersion modelling and air quality forecasting across the region, and there will also be a greater evidence base for national governments in prioritising their fire reduction and landscape management policies.
Daniel Watters	The Summertime Diurnal Cycle of Precipitation Derived from IMERG	The Integrated Multi-satellitE Retrievals for GPM (IMERG) precipitation product derived from the Global Precipitation Measurement (GPM) constellation offers a unique opportunity of observing the diurnal cycle of precipitation in the latitudinal band 60˚N–S at unprecedented 0.1˚ × 0.1˚ and half-hour resolution. The diurnal cycles of occurrence, intensity and accumulation are determined using four years of data at 2˚ × 2˚ resolution; this study focusses on summertime months when the diurnal cycle shows stronger features. Harmonics are fitted to the diurnal cycle using a non-linear least squares method weighted by random errors. Results suggest that mean-to-peak amplitudes for the diurnal cycles of occurrence and accumulation are greater over land (generally larger than 25% of the diurnal mean), where the diurnal harmonic dominates and peaks at ~16–24 LST, than over ocean (generally smaller than 25%), where the diurnal and semi-diurnal harmonics contribute comparably. Over ocean, the diurnal harmonic peaks at ~0–10 LST (~8–15 LST) over open waters (coastal waters). For intensity, amplitudes of the diurnal and semi-diurnal harmonics are generally comparable everywhere (~15–35%) with the diurnal harmonic peaking at ~20–4 LST (~3–12 LST) over land (ocean), and the semi-diurnal harmonic maximises at ~5–8 LST and 17–20 LST. The diurnal cycle of accumulation is dictated by occurrence as opposed to intensity.
Darren Ghent	Land Surface Temperature CCI: approaches to long-term data for climate	The land surface temperature (LST) CCI project aims to deliver a significant improvement on the capability of current satellite LST data records to meet the strict GCOS requirements for climate applications of LST data. Accurate knowledge of land surface temperature (LST) plays a key role in describing the physics of land-surface processes at regional and global scales as they combine information on both the surface-atmosphere interactions and energy fluxes within the Earth Climate System. This provides important information across a range of disciplines including monitoring drought, impact on human health, and changes in vegetation. The first year of the programme of work has achieved some excellent progress: • Detailed climate user input into the specifications of the LST ECV products, and user assessment of these products to drive LST exploitation in climate science • Strong buy-in from the climate science community coordinated by the Climate Research Group • A first suite of high quality IR LST ECV Products and MW LST ECV Products for geostationary (GEO) and low earth orbit (LEO) satellites from the ATSRs, MODIS, SLSTR, SEVIRI and SSM/I • An improved long-term LST CDR of 17 years from 1995 to 2012 for ATSR-2 through to AATSR • First datasets being made available on UK JASMIN project workspace for assessment by the Climate Research Group and Climate Modelling User Group (CMUG) • Maintaining consistency with other CCI and input into cross-ECV activities We present here the approaches taken and these first results to realise the full potential of long-term LST data for climate science.

David Barry, Charles Woffinden	Evolution of Earth Observation with TDI Sensors	The use of image sensors in Earth Observation applications has become integral to many aspects of everyday life including weather monitoring, satellite navigation, monitoring natural disasters and defence as well as longer term surveys addressing climate change and ocean health. Until recently, the implementation of Time, Delay and Integration (TDI) sensors for Earth and planetary observation had been considered best suited to CCDs. The inherent charge transfer mechanism and characteristic low noise make the CCD well suited to such “moving target” applications with low integration times. There is however an increasing drive for higher spatial resolution (achieved through higher line rates and smaller pixels) and more complex sensors incorporating higher numbers of multispectral bands – limiting factors when using CCD technology. Such requirements are best served using CMOS technology. Teledyne e2v, in partnership with Surrey Satellite Technology Ltd (SSTL) and the Centre for Electronic Imaging (CEI – The Open University) have been developing a new charge-domain TDI CMOS device (qTDI) intended for very high resolution (<10cm) TDI imaging across panchromatic and several multispectral channels. As well as providing the inherent benefits of CMOS (reduced power consumption, improved integration, enhanced radiation resilience), these charge domain devices will permit more on-chip functionality resulting in smaller, more efficient payloads which, in turn allow for smaller and more cost effective satellite solutions. Herewith, Teledyne e2v will present the design and architecture of the TDI CMOS device alongside test-chip results from radiation testing. Ultimately, these qTDI sensors are intended to provide performance which far surpasses that which is achievable with CCDs.
David Moore	IASI observations of pyrogenic species during the 2017 Canadian boreal wildfire season	The burning of forest vegetation releases large amounts of pollutants into the atmosphere; these have adverse effects on public health and the environment. Very intense fires initiate plumes of rising smoke and hot, turbulent air. When coupled with favourable atmospheric conditions, dense, towering, clouds form from the water vapour carried upwards by these powerful air currents; such clouds are given the name pyrocumulonimbus (pyroCb) and are particularly associated with thunderstorms. PyroCb storms can in exceptional cases funnel the particulates and trace gases produced by wildfires directly into the Earth's lower stratosphere like a chimney. The 2017 boreal wildfire season exhibited a number of such storms, particularly in western Canada on 12 August. These fires created a plume of smoke and trace gases that rank amongst the biggest in the satellite era (post 1978). Here we present (nadir) observations for a number of pyrogenic trace gases, such as carbon monoxide (CO) and ethene (C2H4), derived from Infrared Atmospheric Sounding Interferometer (IASI) measurements over the Canadian boreal region during August–September 2017. Observations are compared with the output of TOMCAT, a state-of-the-art offline three-dimensional chemical transport model (CTM), which includes an extensive tropospheric chemistry scheme and is forced using winds, temperature, and humidity from European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim meteorological analyses.
Dongxu Yang	New results of TanSat XCO2 retrieval	Atmospheric Carbon Dioxide (CO2), which is a main anthropogenic greenhouse gas whose concentration increase leads to heating of the troposphere and subsequently to global warming. We need to characterize the distribution and trend globally and investigate human emission contributions to the atmospheric CO2 growth. On 22 Dec 2016, China launched a carbon dioxide observation satellite, TanSat, which is the first Chinese greenhouse gas monitoring satellite that has been supported by the Ministry of Science and Technology of China, the Chinese Academy of Sciences, and the China Meteorological Administration. In-orbit calibration tests were completed in the summer of 2017, and the performance of the instrument has since been evaluated in test sessions. In this study, we introduce the TanSat retrieval by using UoL-FP algorithm and novel approach toward high accurate TanSat XCO2 retrieval. The inter-comparison with TanSat XCO2 retrieval algorithm (IAPCAS) will be shown in this study as well. The retrieval accuracy and precision of both, the IAPCAS and UoL algorithm, has been also well investigated by verifying them against TCCON measurement. Validation against TCCON measurement show a good agreement on both algorithms. The method used in this study and results can help to improve the XCO2 retrieval from TanSat and subsequently the L2 products.
Emma Dodd	Space	The Copernicus Global Land Service provides a wide range of satellite and earth observation derived products focused on monitoring of the terrestrial environment. These products must be validated using independent data sources to ensure they are of high quality and consistency. The Ground-Based Observations for validation of Copernicus Global Land Products (GBOV) project aims to develop and distribute robust in-situ datasets from ground-based monitoring sites for a systematic and quantitative validation of all seven Copernicus Global Land Products (CGLPs). In GBOV, observations from identified monitoring sites are processed and then upscaled in order to be more representative of the equivalent CGLP pixel, which will cover a much wider spatial area. Here we present the methods used to upscale in situ Land Surface Temperature (LST) data for validation of the Copernicus Global Land Service LST product. We describe the derivation of in situ LST data from radiometric observations at several ground-based monitoring sites. We then outline the upscaling method used to estimate LSTs which are equivalent to a CGLP pixel from the derived point-scale in situ LSTs. We also present results comparing the validation of the Copernicus Global Land Service LST product with upscaled LST data instead of point in situ LST data

Emma J Barton	Impact of Soil Moisture Patterns on Convective Systems over the Tibetan Plateau	The Tibetan plateau plays an important role in the East Asian monsoon, influencing onset and precipitation intensity through topographical and thermal effects. During the summer months, mesoscale convective systems (MCS) develop in the late afternoon over the eastern plateau. Some of these systems can travel out of the plateau, bringing heavy rain and flooding to downstream areas of China. Plateau-scale soil moisture distribution has been shown to influence MCS genesis in the eastern plateau during the monsoon season, however the impact of transient surface wetness variability on scales ~10s km has yet to be investigated. In this study we perform a statistical analysis of satellite imagery to examine the impact of transient soil moisture features on convective systems over the Tibetan Plateau during the monsoon season (May – September). We consider convective initiation and the propagation of mature systems over heterogeneous soil moisture features. Convective clouds are identified using the Fengyun-2 cloud top temperature product. Fengyun-2 is a series of geostationary satellites that provide hourly data, allowing us to track systems as they evolve. Land surface temperature anomalies are used as a proxy to map pre-storm mesoscale soil moisture patterns. We show how soil moisture patterns influence the life cycle of convective storms over the Tibetan Plateau. The results suggest that improved representation of land-atmosphere coupling on the plateau within weather and climate models could impact the entire region.
Eoghan Darbyshire	Monitoring conflict related environmental damage in Libya using EO	Environmental damage in conflict zones, either via direct fighting or the collapse of governance, represents serious threats to human wellbeing and ecosystem services at local, regional and potentially global scales. Receiving limited academic attention, the scale and magnitude of contemporary and historical impacts remains uncharacterised. In some part this is because regions of active conflict are data poor and access for in-situ measurements is limited – likely to remain the case for interminable contemporary conflict zones. Earth observations can fill this data gap and provide a wealth of information from short-term, high impact risks to long-term trends. Together this helps target locations for humanitarian response, remediation, and later in-situ data collection, whilst also aiding environmental peacebuilding and accountability endeavours. Here, we present a summary of the EO research around the ongoing conflict in Libya by our charity, the Conflict and Environment Observatory (CEOBS). This includes a novel land dynamics classification, based on remotely sensed climate and vegetation data, showing the spatial distribution of land deterioration and improvement during the conflict. This is linked to trends in remotely sensed climate parameters, changes in surface water NDWI, and open source intelligence. High resolution imagery, fire hotspots and InSAR are combined to identify and characterise illegal landfills; these are widespread along the coast and pose a substantial environmental threat. Multi-spectral imagery is used to characterise contamination events at wastewater treatment plants and oil facilities. Ideas for future avenues of research and active monitoring techniques applicable across varying conflict zones will be posited.
Ewan Pinnington	Data Assimilation with the JULES land surface model	Data assimilation methods allow us to combine observations with models to improve predictions. We present a new data assimilation system for the Joint UK Land Environment Simulator (JULES) to optimise model parameter and state values given a set of observations using a Four-Dimensional Ensemble Variational (4DEnVar) technique. Unlike other variational methods (such as 4DVar) 4DEnVar avoids the often complex calculation of a model adjoint. The method also requires no modification to the underlying code and is hence easily adapted to new code releases, and can, in principle, be applied to any model component. We show that when applied to JULES-Crop, assimilating observations of leaf area index, canopy height and gross primary productivity, the system can optimise seven model parameters and improve estimates of crop yield by 74% at a maize site in Nebraska, USA. Future applications will involve the assimilation of soil moisture observations to improve JULES soil parameter ancillaries for Africa (as part of the NCEO Official Development Assistance project) and the UK (as part of Hydro-JULES).
Feng Yin, H Ma, J Gomez-Dans, Q Wu, P Lewis	Monitoring wheat yield at field scale on a national level using Sentinel-2 data and a mechanistic crop growth model	Monitoring croplands is of major importance within the context of changing climate and demographics. EO data provides a way of monitoring crops over large regions, and with the recent introduction of Sentinel-2, crop monitoring at the field scale at regional level can now be pursued. In this contribution, we present efforts to develop a wheat monitoring system for the North China Plain (NCP) using Sentinel 2 data assimilated into a crop growth model, and used to predict crop yield. We first describe a simple approach to retrieve leaf area index (LAI) from Sentinel 2 observations. Time series of retrieved LAI are then assimilated into a locally probabilistically calibrated crop growth model (the WOFOST crop model in this case). Assimilation is based on a local ensemble run of the model, which encompasses the variability of crops in the local area due to parameters and meteorology. For each 10 m pixel, observed LAI observations are used to weight ensemble trajectories that are consistent with the data. These weightings are then used to combined the final crop yields from each of the ensemble simulations, thus providing uncertainty quantified yield estimates at 10 m spatial resolution. We demonstrate the use of the method in China, providing some initial validation, and some comments on its portability to other areas/crops. The approach is sufficiently fast to be applied to very large areas, and versions of the proposed methods are available as stand alone code, or code that allows processing with the Google Earth Engine infrastructure.
Francesca Morris (Undergraduate)	Fast Linear Retrievals with IASI	undergraduate poster

Francesco Nencioli	Agulhas Ring Transport Efficiency From Combined Satellite Altimetry and Argo Profiles	Agulhas rings are one of the main processes contributing to the westward transport of Agulhas leakage water across the South Atlantic basin. Here we quantified the water transported and exchanged by three Agulhas rings by combining remote sensing altimetry and in-situ Argo observations. Satellite velocities showed that two of the eddies formed within the Cape Basin west of South Africa at the beginning of 2013 and reached the Mid-Atlantic Ridge by the end of 2014. There, they merged forming the third eddy that dissipated a year later when it approached the Brazilian continental shelf. Eddy structure reconstructed from Argo profiles showed that the eddies were at least 1,500 m deep and that their dynamics was strongly affected by the two open-ocean ridges encountered along their path. Between the ridges, eddy volumes were mostly conserved, but waters were continuously exchanged. During eddy dissipation, volume losses and water exchanges were more pronounced at depth. These findings highlight the importance of combining surface with in-situ information to accurately represent Agulhas ring transport and exchanges. Overall, the eddies transported roughly 0.5x1013 m3 of water from the Cape Basin to west of 30 W in a 3-year span. Lagrangian diagnostics indicated that, after an initial period of instability, the surface waters exchanged by the eddies along their tracks dispersed roughly in the same direction as the eddies, albeit at a much slower rate. These results further confirm that Agulhas eddies are the most efficient process for westward transport across the South Atlantic basin.
Harbinder Rana, Andrew Haslehurst	DarkCarb: An Innovative Approach to Infrared Imaging	DarkCarb is a pioneering Earth observation (EO) satellite, under development at SSTL, designed to acquire high resolution Mid Wave Infrared (MWIR) imagery and video from low Earth orbit. The DarkCarb satellite features an innovative low mass and volume MWIR imager which, when combined with the implementation of novel image enhancement algorithms, will achieve high quality 3.5m GSD imagery. The high spatial resolution MWIR imagery DarkCarb provides the capability to differentiate between objects and surfaces of different temperature and emissivity. As the detectable signal is only dependent on the temperature of the scene, DarkCarb also has the ability to extend imaging opportunities into night time and has the potential to become a high value data product for the EO market. The video capability of DarkCarb allows information on highly dynamic features in scenes to be provided and has the potential to assist with disaster support from wildfires to volcanic eruptions and flooding. Other potential applications include providing an indication of the operational status of industrial installations via the detection of heat from the operation of equipment, and detecting waste and pollution spills or discharge from sewage plants and power plants. This paper will discuss the system design and provide initial results from the testing being conducted on the detector which is funded under the 12th CEOI call.
Harjinder Sembhi	Supporting agricultural-decision making with Sentinel 3, UAV and in-situ measurements in a critical zone observatory located in the Ganga Basin, India	Critical Zone Observatories (CZO) provide an integrated research laboratory that determines how geological, chemical and atmospheric interactions impact the ecosystem over different spatial and temporal scales. The Ganga Alluvium Plain (GAP) CZO encompasses an agriculturally-dense landscape (major crops being wheat and rice) that is particularly vulnerable due to poor agricultural practises, excessive water extraction and fertiliser-use. Challenges in monitoring the Ganges basin include a lack of high temporal and spatial resolution data at sub-regional, district -level scales as well as large uncertainties in land surface measurements over the heterogeneous landscape. The GAP CZO comprises a high-resolution data repository that monitors hydro-meteorological parameters and soil properties and provides independent sources of information about the landscape. In this study, we will demonstrate how land surface temperature measurements from the Sea and Land Surface Temperature Radiometer (SLSTR) on the Sentinel-3 missions have been used to characterise changes in agriculture, crop stress and water availability. Complementary measurements made by thermal and multi-spectral sensors on unmanned aerial vehicle (UAV) and a ground-based thermal infrared (TIR) radiometer has been used to determine the land-use processes contributing to groundwater depletion and crop stress. A close interaction with local farmers, supported by Non-Government Organisations (NGOs), has helped to understand the cropping pattern, crop yield, irrigation water source and their current water management. We will show how these innovative datasets and community perspectives have been combined to rejuvenate and optimise agricultural management practises in the region.

Hartmut Boesch	The UK Contribution to the MicroCarb mission	MicroCarb will be the first European CO2 mission dedicated to observations with the precision needed to infer CO2 sources and sinks. The mission has been developed by the French Space Agency CNES for a launch on a microsatellite. The launch is planned for 2021 when many of the current missions will have come to an end of their lifetime and MicroCarb will represent a critical contribution to the international efforts for a continuous presence of CO2 observations from space. MicroCarb also features an exploratory city-mode which allows mapping out regions with increases resolution and coverage to observe emission from localized sources; thus providing us with an important dataset for the preparation of the planned space-based system for verification of anthropogenic CO2 in support of the Paris agreement. The UK has become a partner in the MicroCarb mission in 2016 contributing to elements throughout the whole mission ranging from space hardware to retrieval methods to science exploitation. In this presentation, we will provide an overview over the MicroCarb missions, its science goals and the expected capabilities of MicroCarb to observe atmospheric CO2. Furthermore, we will discuss the contributions by UK scientist and UK space industry to the mission including Satellite Assembly and Integration (AIT), development of the pointing and calibration unit and performance studies of the expected observations obtained by MicroCarb.
James Brennan	Towards consistent burned area products from multiple sensors	Growing focus on generating long-term Climate Data Records (CDRs) means unique challenges for producing burned area datasets that are consistent across multiple satellite instruments. Adapting present algorithms for use across a diverse range of optical and thermal instruments is challenging because of differences between available spectral channels and the inherent uncertainties of each instrument. To produce a long-term consistent CDR of burned area, therefore, requires a move towards algorithms which can utilise the varying information content of different sensors. This requires a spectrally invariant treatment of the fire signal and a full propagation of uncertainties to produce a CDR that is consistent and of use to modellers and fire-related disciplines. The presented algorithm can merge observations from multiple sensors by exploiting a spectrally invariant model of the optical burn signal which is inverted and updated via data assimilation methods. The algorithm is demonstrated with observations the Suomi-NPP VIIRS and Sentinel-3 OLCI instruments. In comparison with an independent implementation on MODIS, the algorithm can consistently estimate burned area between the two sensor systems. Intercomparison with the MODIS MCD64 Collection 6 burned area product suggests that the algorithm is more attuned to detect small fires and pixels which are only partially burned. Validation against reference burned area from Sentinel-2 MSI indicates that the algorithm has lower omission errors than the MCD64 algorithm and better overall performance as indicated by higher values of the Dice Coefficient.
Jan Vermeiren	The European Low Flux Image Sensor (ELFIS)	On behalf of ESA, Caeleste has designed, manufactured and tested the first series of ELFIS devices. For step & stare operation, a charge domain truly global shutter pixel is developed together with LFoundry-It. This technology allows to combine Global shutter operation with Integrate-While Read operation; in this way the maximum possible integration time can be obtained for a given frame rate. A charge domain global shutter pixel also allows to have low dark signal – and hence low dark noise – contributions from the floating diffusion read node. The Image sensor has also Correlated Double Sampling (CDS) for low noise, high gain operation. An in-pixel, single integration time High Dynamic Range (HDR) operation completes the pixel design. By reading out the High Gain and the Low Gain information, it is possible to reach dynamic ranges in excess of 100 dB. The device is manufactured in a Backside illuminated configuration, achieving a Quantum Efficiency > 90% with a conventional Anti-reflective coating. Alternative backside treatments for UV operation are available on request. The 15 µm pixel is designed for high sensitivity missions; the design is also made stitch ready to allow future manufacturing of other large format sensors, starting from the same reticle set. The device is also designed to be radiation tolerant both for TID and SEE.
Javier Amezcua	Iterative methods in compartmental systems with unknown parameters.	Data assimilation has been successfully performed in areas like numerical weather forecasting and ocean state estimation. Sometimes the non-linear evolution and observation operators often lead to the use of iterative methods (e.g. outer loops in the variational framework, or iterative kalman filters/smoothers) to find optimal values for the state variables. DA methods are now being used in more systems, like compartmental systems that are at the core of carbon and land surface models. The dynamics of the state variables are linear in these systems. However, the parameters are often unknown and related in a non-linear manner amongst them and with the state variables. Hence, the care-less application of iterative methods can lead to problems such as jumping between different fixed points or cycles of the system. We illustrate this and present some plans in this research area.
Jin-Soo Kim	Fire activity in Equatorial Asia related to the El Niño diversity	Fire activity in Equatorial Asia shows large interannual variability. Large-scale atmospheric teleconnections by El Niño–Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) are linked to drought and fire events over Equatorial Asia; however, we found here that interannual variability of the fire activity in October still has large variability even after statistically removing the effects of ENSO and IOD. Here, we found that local Sea Surface Temperature (SST) over the Banda Sea, located between Kalimantan and New Guinea, explains 62% of the variance in Equatorial Asian burned area. Strengthened seasonal circulation in October leads to a negative SST anomaly through Wind–Evaporation–SST mechanism. This local air-sea interaction sustains the dry season into October, and that brings more fires over Equatorial Asia. In addition to local circulation, the sensitivity of precipitation to SST is higher in October than in other months, hence fire in Equatorial Asia can be sensitively driven by local SST changes. Identification of this regional sensitivity will underpin better predictions of fire activity and air quality in Equatorial Asia.

Joao Carreiras	Maximizing synergies between optical and radar satellite data to improve discrimination of land cover classes and detection of change in Kenya	Kenya has experienced a decline in forest cover, from 11% in 1963 to 6% in 2010. The drivers of deforestation are mainly unsustainable utilisation and conversion of forest land to other land uses. The objective of this study is to evaluate the ability of combining high-resolution optical (Landsat 8 Optical Land Imager, Landsat 8 OLI) and radar data (Sentinel-1 Interferometric Wide Swath, S-1 IW) to map country-wide land cover classes and forest loss between 2014 and 2017. A machine learning (Random Forests) algorithm was used to classify stable forest (SF), stable other vegetation (SOV), stable other land (SOL), stable water (SW), and forest loss (Floss) as a function of Landsat 8 OLI bands and derived vegetation indices. This classification was validated with an independent reference subset, which resulted in low commission errors in all classes (<10%), and higher omission error in stable other land (34%), mainly as misclassification as stable other vegetation. Random Forests outputs the proportion of votes in each class on a pixel-by-pixel basis. This was used to define a 3-class classification confidence (or likelihood): “unlikely”: < 0.33, “about as likely as not”: 0.33-0.66, and “likely”: > 0.66. According to this scale, likely SF and Floss occupied 4.1% and 0.1% in Kenya between 2014 and 2017. This poster will also highlight recent advances in the use of test-based change detection methods applied to time-series of dual-polarised S-1 IW data.
Jon Styles, Gerardo Lopez-Saldana	The Assimila approach to generate Analysis Ready Data (ARD) for the UK	A typical workflow for any EO data user involves i) discovering a dataset, ii) download the corresponding image(s), iii) create a spectral and/or spatial subsets, iv) perform any pre-processing needed. After all these steps, data is ready to be analysed. This is a major barrier to fully exploit EO data by any user, the Committee on Earth Observation Satellites (CEOS) has identified these limitations as a threat to major global and regional. CEOS Analysis Ready Data for Land (CARD4L) are satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis with a minimum of additional used effort and interoperability both through time and with other datasets. The CEOS CARD4L specification for optical surface reflectance applies to: Data collected with multispectral sensors operating in the VIS/NIR/SWIR wavelengths with a ground sample distance and resolution in the order 10- 100m however the specification is not inherently limited to this resolution. In this communication we focus on generating coarse resolution optical surface reflectance ARD at 500m using the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the Terra and Aqua platforms and the Ocean and Land Colour Instrument (OLCI) instrument on board Sentinel-3 that fulfil the CARD4L specification over the UK and Colombia for 2018. The processing chain involves pre-processing the top-of-the-atmosphere (TOA) data to retrieve the atmospherics components, derived per-overpass surface reflectance using the Sensor Invariant Atmospheric Correction (SIAC). Using these retrievals, BRDF model descriptors are derived using an optima estimation framework. Ultimately, the ARD dataset is produced and make it available to the final user using a simple interface that allows an easy manipulation of the data and associated uncertainties.
Jose Gomez- Dans, F Yin and P Lewis	University College London, National Centre for Earth Observation	High resolution optical and active microwave sensors provide unprecedented revisit capabilities that would allow monitoring the land surface with a very high temporal frequency. However, the different information content in each domain caused by the different physical processes that are dominant in optical and microwave make combining information challenging. In this work, we present an approach based on exploiting temporal correlation and the assumption of some equivalences in parameters in both domains that allow us to exploit the combination physically-based radiative transfer models for optical (PROSAIL) and SAR (water cloud model). Both models assume a turbid medium controlled in one case by leaf area index and leaf angle distribution (optical), whereas vegetation optical depth in the water cloud model is a function of the amount of leaves and stems, their dielectric properties and their orientation. We assume that simple transformations of the optical parameters can be used to define the SAR vegetation optical thickness, which opens a direct linkage between SAR and optical domains (at least for grasslands and croplands). For S2 observations, a number of parameters from PROSAIL can be reliably retrieved using a two layer neural network. We use them to provide a prior distribution for inverting the SAR backscatter observations using the water cloud model. We demonstrate the system over an agricultural site in Germany, providing comparisons for retrieved parameters and in situ measurements.

Jose Gomez-Dans , F Yin	Atmospheric Correction matters! A case study with Sentinel 2 data over the UK	The advent of the Sentinels is revolutionising how we monitor the land surface. Sentinel-2, in particular provides high spatial and temporal resolution monitoring capabilities with rich spectral sampling. In conjunction with Landsat 8 and the upcoming Landsat 9 missions, the combination of these satellite families provides a global monitoring capability at a field scale. An important and often overlooked part of the processing is the level 2 processor, comprising atmospheric correction and cloud clearing. In this contribution, we compare three different level 2 processors (Sen2Cor from ESA, ARCSI from JNCC/University of Aberystwyth and SIAC from UCL) for Sentinel 2 data over the UK. We start by comparing their ability to estiamte atmospheric composition (e.g. aerosol optical thickness, AOT) by comparing retrieved parameters with in situ measurements from the AERONET network. We then model the difference between the processor-corrected surface reflectance and the theoretical correction (i.e., using the in situ parameterisation to correct the original product), and then assess the difference processors for a number of pracitcal tasks, such as retrieving vegetation biophysical parameters such as leaf area index (LAI) or leaf pigment concentrations. We found that the different processors have different performance in terms of AOT retrieval: Sen2Cor has a RMS difference to the AERONET AOT reference of 0.065, ARCSI has a RMSD of 0.091 and SIAC has the smallest RMSD, 0.045. Correlations between retrieved AOT and in situ also varied (0.40, 0.58 and 0.75 linear correlation coefficient for Sen2Cor, ARCSI and SIAC, respectively). We show that there are differences between Sentinel-2 Level 2 products and contemporary Landsat data, except when both have been processed consistently using the SIAC processor. We also demonstrate that shortcoming in atmospheric correction have important consequences for surface monitoring.
Kamil Mroz	Triple-frequency Doppler retrieval of characteristic raindrop size	A retrieval of the characteristic raindrop size and width of the drop size distribution (DSD) based on triple-frequency vertical Doppler radar measurements is presented. The algorithm is founded on approximately 7,900 hours of DSD measurements and it exploits a statistical relation between the difference in mean vertical Doppler velocities at W, Ka and X bands and a characteristic raindrop size and a mass spectrum variance of the DSD. Additionally, a retrieval of a mean mass-weighted diameter (Dm) based only on the X-W measurements is presented; its performance is compared to the analogous algorithm based on higher frequency bands (Ka-W). The validation is performed with the data gathered for the TRIplefrequency and Polarimetric radar Experiment for improving process observation of winter precipitation where disdrometer measurements were performed in close proximity to the vertically pointing radars. The triple Doppler velocity (TDV) retrieval of Dm works to within a precision of 25% for characteristic sizes ranging from 0.75 mm to 2 mm; this performance is comparable to DDV techniques for sizes below 1.2 mm, however it significantly surpasses the Ka-W algorithm for larger drops (20% versus 35% bias). There is also an improvement of approximately 5% over the X-W retrieval for the high end of considered diameters. The TDV retrieval of the width of the DSD performs with an uncertainty of 30-40%, which improves the climatological estimate by 5%.
Kate Page (Undergraduate)	Great Walls of Fire: An investigation of trace gases released into the atmosphere from Boreal wildfires	undergraduate poster
Keith Haines	Global surface energy and water cycle variability 2001-2011 from satellite data.	We derive internally consistent, monthly to interannual, energy and water budgets, with uncertainties, for all the main continents and ocean basins over 2001-2011 based principally on satellite data. An inverse model is used following the Thomas et al (2019) climatology study and the NASA energy and water cycle study (NEWS), L'Ecuyer et al. (2015), Rodell et al. (2015). Input data include CERES (radiation), FluxCOM (land turbulent heat fluxes), JOFURO3 (ocean turbulent heat fluxes), GPCP2.3 (Precipitation), GRACE (total water storage), ERA5 (atmospheric water storage), GRUNv1 (land runoff, Ghiggi et al. 2019), and we compare these with alternative products to assess component uncertainties. The different components are then brought together and adjusted within respective uncertainties to achieve balanced energy and water budgets. Preliminary results focus on seasonal and interannual variability over land. Seasonal modifications to the water budget over Eurasia and N America include a delay in spring runoff (and reduced evapotranspiration over Eurasia) as GRACE data indicates retention of water mass over land. The runoff correction maybe compensating for lack of a routing scheme in the GRUNv1 product. The reduced evapotranspiration also brings the land energy budget closer to the DEEPC Liu et al (2015) results demonstrating the value of coupling the energy and water cycles. Strong correlated interannual variability in African precipitation, runoff and GRACE derived water storage is found, and we assess the relative consistency of different data products, particularly for precipitation, where multiple datasets are available and uncertainties are large. Clear ENSO signals are seen, particularly over South America in 2010 and Australia in 2010-11, with correlated variability in rainfall, runoff and water storage distributions. Further work assessing uncertainties and evaluating against other products is underway.

Kelvin Choi	Spectrally Resolved DNI for Solar Energy Applications from Earth Observations	Multi-junction solar cells in concentrator photovoltaic systems (CPV) offer the potential for highly efficient, low-cost electricity generation. However, these systems are typically designed and rated against reference spectra or for standard atmospheric conditions which are often not representative of the real deployment environments. Indeed, it has been shown that the use of unrealistic spectra can impact annual energy yield estimations by up to 75%. Hence there is a need to routinely generate spectrally resolved direct normal irradiance (DNI) estimates that are based on real observations so that CPV systems can be optimised appropriately for different locations. Here we will first present an automated scheme to estimate spectrally resolved DNI based on the integrated use of a radiative transfer model, AERONET ground-based observations and analyses from the European Centre for Medium Range Weather Forecasting Copernicus Atmospheric Monitoring Service (ECMWF CAMS). Our approach takes particular care to account for aerosol effects, circumsolar irradiance and other relevant atmospheric parameters. The results have been tested against various ground-based observations at Santiago, India, Niger, Finland, Amazon and America, covering a wide array of aerosol climatologies. We will then present our preliminary work on integrating the said spectrally resolved DNI estimation scheme with satellite retrieved aerosol optical depths from the Oxford-RAL Aerosol and Cloud (ORAC) retrieval scheme using (A)ATSR / SLSTR observations, and Solcore, a semiconductor solver for CPV power output estimations. This will enable a global, long-term assessment of CPV solar energy generation, and even the possibility of near-real-time power estimates.
Kofi Asare	Research activities conducted by the Remote Sensing and Climate Center (RSCC)	Effective environmental monitoring and efficient agricultural crop production are important components of the Sustainable Development Goals. In Sub-Saharan Africa however, environmental monitoring and the issue of attaining sustainable food security for the population is a challenge because of the dependence on rain-fed agriculture with drought impacting negatively on yield. Drought has the potential to hinder the governments' flagship program of Planting for Food and Jobs. This will be worsened with the difficulty of predicting and providing yield results in near real-time. Although mining contributes significantly to the economy of Ghana, illegal mining activities known as "Galamsey" impacts on the environment. It is exacerbated by the lack of monitoring technology to curb these activities in near real time. At the Remote Sensing and Climate Center (RSCC) we undertake research projects with the aim of mapping illegal mining sites, monitor its environmental footprints, assess the impact of global climate modes on drought variability and provide crop yield results for maize. In this talk we present initial results from some of these projects. This includes: (1) the finding that yield results for maize were not uniform across the studied districts; (2) the environmental footprint of illegal mining activities has resulted in land degradation, especially near river banks, which in turn contributes to river pollution in the study area; (3) there is inter-annual mode of drought variability and decreasing intensification during the dry season; and (4) multiple regression analysis shows climate indices as having a different association with drought variability on a different timescale.
Laura Warwick	Improved retrieval of upper tropospheric water vapour by measurement of far-infrared radiance	Accurate measurements of upper tropospheric water vapour are required to improve numerical weather prediction and assess the performance of global climate models. The water vapour feedback, which is a key component of the Earth's climate sensitivity, is also particularly sensitive to changes in upper tropospheric water vapour. Current water vapour products from satellites suffer from coarse resolution and considerable disagreement in this layer of the atmosphere. However, hyper-spectral radiance measurements in the far-infrared (wavelengths > 15 microns) have the potential to improve water vapour retrievals particularly in the upper troposphere. In this poster, we present upwelling radiance measurements in the far-infrared taken using the Imperial College Tropospheric Airborne Fourier Transform Spectrometer. These measurements were made during a high-level flight onboard the Facility for Airborne Atmospheric Measurement aircraft in conjunction with mid-infrared radiance measurements and in-situ measurements from dropsondes. These radiance measurements were used to retrieve the water vapour profile below the aircraft. The far-infrared retrievals demonstrate improved sensitivity to upper tropospheric water vapour compared to numerical weather prediction.

Lauren Biermann	Towards a method for detecting macroplastics by satellite: examining Sentinel-2 earth observation data for floating debris in the coastal zone.	With improved spatial and spectral resolution offered by the Sentinel-2 earth observation satellites, it is increasingly possible to detect 'small' objects in coastal waters. These objects can include boats, wind turbines, aquaculture cages, drifting Sargassum seaweed and, for our purposes, aggregations of floating debris. At 10m spatial resolution, individual pieces of plastic are unlikely to be detectable. However, fronts, eddies and other submesoscale features are known to aggregate floating materials into patches. We propose that the Sentinel-2 spatial resolution and spectral band configuration is sufficient to detect aggregated objects, likely a mix of macroalgae and natural sources of debris, as well as anthropogenic sources - increasingly plastics and polystyrene. For enhanced detection at sub-pixel scales, we developed a multi-spectral instrument (MSI) Floating Debris Index (FDI). Mean spectral signatures of macroplastics and macroalgae were generated by applying the FDI to plastic targets deployed off Greece, and rafts of Sargassum off Barbados, respectively. By examining FDI values of plastic, seaweed and seawater alongside a vegetation index, we were also able to develop a Marine Algae to Plastics reference model, MAP_ref. We present examples where Sentinel-2 was used to detect aggregations that included materials likely to be floating macroplastics, namely: Ghana, South Africa, Canada, and Scotland. Wherever we observed floating materials, selected pixels resembled the spectral signature of plastic, and fit within MAP_ref, suggesting presence of 'non vegetation' materials. Without access to in situ data to validate our detections, we can only report that patches appeared to be dominated by 'non vegetation' materials.
Liang Feng	Improved flux estimates of CO2 and CH4 by assimilating GOSAT full-physics XCO2 retrievals and proxy XCO2:X CH4 retrievals	The Japanese Greenhouse gases Observing SATellite (GOSAT) has since 2009 been measuring atmospheric carbon dioxide (CO_2) and methane (CH_4) concentrations with unprecedented precision. We use an ensemble Kalman filter, together with the GEOS-Chem global 3-D atmospheric transport model, to infer simultaneously surface fluxes of methane (CH_4) and carbon dioxide (CO_2) from complementary GOSAT full-physics column retrievals of CO_2 (XCO_2) and proxy XCH_4:XCO_2 retrievals. The resulting posterior CO_2 and CH_4 concentrations are consistent with independent observations, reproducing observed annual seasonal cycles and annual growth rate. Our results reveal significant interannual variations in CO_2 and CH_4 fluxes, particularly over tropical regions during the strong 2015/2016 El Nino event. We discuss these variations in context with changes in other environmental factors.
Loreena Jaouen	Quantification of Birch and Bracken Encroachment on Heathland using Airborne Hyperspectral Imagery and Sentinel-2 Satellite Imagery	In the 1800s, forestry and agriculture led to the decline of heather in Sandy, Bedfordshire. Heathlands are home to a wide variety of species and is especially crucial to some ground nesting birds including nightjars, woodlarks and curlews. Since 2005, the RSPB has been working on heather restoration at the Sandy Lodge Reserve, but extensive birch and bracken encroachment on heathland has fragmented the landscape. As part of an effort to track the restoration progress, this project assesses the application of airborne hyperspectral data for the classification and quantification of heather, birch and bracken. Airborne true-colour and hyperspectral imagery was collected by 2Excel geo on 26th June 2018. A cloud free Sentinel-2 image was also acquired for the site on the same day as the airborne collection. The Phase 1 habitat classification map of the reserve was compared against the true-colour airborne imagery and manually updated to inform the identification of heathlands across the reserve. Following the identification of heathlands, the airborne hyperspectral imagery and Sentinel-2 imagery were applied independently for the classification of heather, birch and bracken. The classifications considered several techniques including the use of spectral libraries (informed by field spectroscopy) and machine learning algorithms. The performance of the airborne and satellite derived classifications were compared to allow the capability of the two platforms and sensors to be considered. The classification results also allowed the percentage of heather, birch and bracken in the heathlands across the reserve to be quantified for heathland condition reporting to Natural England.

Lucinda King	Opportunities and Challenges of GNSS Reflectometry in Back-scatter Mode: Investigation Using TDS 1 Raw Data Collections	Global Navigation Satellite System Reflectometry (GNSS-R), a passive bi-static L-band system using navigation satellites as transmitters of “Signals of Opportunity", has found many applications in the field of Earth observation including ocean wind-speed detection, ice altimetry, soil moisture monitoring and more. The main focus of GNSS-R research to date has been on forward-scattered reflections, but recent theoretical work has proposed a back-scattering geometry and associated new application opportunities, including marine target detection. During the period of operations of the UK's TechDemoSat-1 (TDS-1) mission over 200 raw reflectometry data collections were made over a variety of Earth surfaces, each containing approximately 2 minutes of data. These raw data are the unprocessed recordings from the instrument front end and offer opportunities for new modes of processing other than those used on board the spacecraft. For this research a software-defined receiver which had previously been used to process raw data for forward scattering was updated to predict backscatter reflection points, thereby allowing generation of delay-Doppler maps of backscattered power. This work presents the methods and results from this processing with results from sea ice and oil rig data sets. The study has also identified a key issue with the backscatter method which stems from the repeating codes used for GNSS signals. For certain geometries the forward-scattered power from the specular point may contaminate the data, a phenomenon we have termed “Specular Intrusion”. The theory behind this and a software tool for predicting such occurrences is presented.
Luke Smallman	Development and validation of an intermediate model of gross primary productivity and evapotranspiration	Photosynthesis and evapotranspiration (ET) are ecosystem processes with significance for global biogeochemical cycles and ecosystem services. The mechanisms governing these processes are complex but well understood. There is strong coupling between these processes, mediated directly by stomatal conductance and indirectly by root zone soil moisture content and its accessibility. This coupling must be effectively modelled for robust predictions of earth system responses to global change. It is highly demanding to model leaf and cellular processes with response times of minutes, over decadal and global domains. Computational demand means models resolving this level of complexity cannot be easily evaluated for their parameter sensitivity nor calibrated using earth observation information through data assimilation approaches requiring large ensembles. To overcome these challenges, we constructed a coupled photosynthesis-evapotranspiration model of intermediate complexity operating at canopy scale and daily time-step. Through the inclusion of simplified representation of key process interactions, it retains sensitivity to variation in climate, leaf traits, soil states and atmospheric CO2. The model, ACM-GPP-ET, is calibrated to match the responses of a complex terrestrial ecosystem model (TEM). ACM-GPP-ET generates unbiased estimates of photosynthesis and ET and captures 80%–95% of the sensitivity of carbon and water fluxes by the complex TEM. Independent evaluation of ACM-GPP-ET at FLUXNET sites, using a single global parameterisation, shows good agreement, with typical R2 0.60 for photosynthesis and ET. Our modelling approach allows Monte Carlo-based quantification of parameter and structural uncertainties, global-scale sensitivity analyses and is fast enough for use within model–data fusion frameworks requiring large ensembles.
Maggie Marvin	Characterizing fine particulate matter over Southeast Asia using the GEOS-Chem atmospheric chemistry transport model and Earth Observation datasets: Preliminary results	Over Southeast Asia, emissions of gases and particles from nature and human activity sustain atmospheric concentrations of fine (radii smaller than 2.5 microns) particulate matter (PM2.5) at levels that are harmful to human health. Understanding the biogenic, anthropogenic, and pyrogenic drivers of PM2.5 is key to developing effective strategies for improving Southeast Asian air quality. Here, we use the nested GEOS-Chem atmospheric chemistry transport model (horizontal resolution of 0.5° x 0.625°) to characterize the composition and spatiotemporal behaviour of PM2.5 over this geographical region during January–June 2016. We will report a critical evaluation of the GEOS-Chem model using a variety of Earth Observation datasets that provide observational constraints on PM2.5 and its precursor species. In particular, we will directly evaluate model PM2.5 using aerosol optical depth retrievals from the NASA MODIS instrument. We will also evaluate a selection of GEOS-Chem gaseous PM2.5 precursors using NCEO data products, including CO columns from IASI and tropospheric O3 profiles from OMI. Preliminary results will be presented in context of our longer-term research objectives within the NCEO atmosphere-biosphere science framework.
Mark Lunt	An increase in methane emissions from tropical Africa between 2010-2016 inferred from satellite data	Emissions of methane from the tropics, and particularly Africa, represent one of the biggest uncertainties in the global CH4 budget. In particular, the role of tropical CH4 emissions in the ongoing rise in global CH4 emissions is still not fully understood. Satellite observations of atmospheric CH4 columns can help to reduce this uncertainty by virtue of their broad spatial coverage. In this work we use column retrievals of CH4 from the Greenhouse gases Observing SATellite (GOSAT), together with the nested GEOS-Chem model in a regional Bayesian inversion framework to infer emissions of CH4 from tropical Africa between 2010 and 2016. We find a positive linear trend in tropical African CH4 emissions during our 7-year study period of around 1.5 Tg yr-1. A large part of this trend is due to a short-term increase in emissions from the Sudd wetlands in South Sudan. Using satellite data of auxiliary variables we show this increase is consistent with an increase in wetland extent due to increased inflow from the White Nile, and consistent with rising water levels in Lake Victoria during the study period.

Martin Unwin	GNSS Reflectometry on TDs-1 and Future Satellites	The technique of GNSS Reflectometry shows potential for low cost measurement of ocean winds, roughness, soil moisture, flood & ice mapping, and other climate and operational parameters. The CEOI-sponsored SGR-ReSI GNSS remote sensing instrument was flown on UK TechDemoSat-1 in July 2014 and, with sponsorship from ESA, collected data until TDS-1's drag-sail was deployed in May 2019. The experiment demonstrated that GNSS signals can be used as a bistatic radar source for sensing the Earth's surface from space. TDS-1 was a precursor for NASA's CYGNSS mission, using the SGR-ReSI on its 8-microsatellite hurricane sensing constellation. TDS-1 Level 1 Delay Doppler Maps and Level 2 ocean wind measurements are available from the web-site www.MERRByS.org. Over 50 publications based on the use of TDS-1 data by researchers around the world have been logged. Recent results from an ESA-sponsored study TGSCATT showed a collocated ASCAT agreement of around 2 m/s for lower wind speeds. Raw sampled TDS-1 collections have been used to recover Galileo E1C signals, more complex than GPS L1 C/A signals due to wider bandwidth and modulation (similar signals are available from GPS and Beidou), these give improved ground resolution and coverage, but the impact due to the complexity and reduced return signals needs to be understood. Near-term satellite missions will be presented: OTB-3 is a US mission that plans to fly the SGR-ReSI in parallel with an advanced ARGOS payload; the DoT-1 technology demonstrator integrates GNSS-R as a secondary payload on a constellation, and a candidate approach for the ESA Scout-class mission.
Matthew Hammond	GNSS-R Global Ocean Surface Winds from the UK TechDemoSat-1 Mission	Global Navigation Satellite System-Reflectometry (GNSS-R) is an innovative and a strongly developing approach to earth observation that makes use of signals of opportunity from Global Navigation Satellite Systems, which have been reflected off the earth's surface. The UK National Oceanography Centre (NOC) has developed the Calibrated-Bistatic Radar Equation (C-BRE), a GNSS-R wind speed retrieval algorithm designed to use data from satellite borne receivers, which features important calibrations and corrections for radiometry and transmitter power. The UK TechDemoSat-1 (TDS-1) is a technology demonstration platform which now provides GNSS-R data for over three years. GNSS-R based sea-ice detection and calibration in polar areas has allowed the processor to be extended to allow retrievals at all latitudes. Here, the ability of GNSS-R to accurately retrieve global ocean wind speeds is assessed by validating the NOC C-BRE v1.0 geophysical model function, using data from TDS-1, against ECMWF ERA-5 re-analysis model output. The NOC C-BRE wind speed retrieval algorithm shows the potential GNSS-R technology has for accurate wind speed retrieval and sea-ice detection. The abilities of GNSS-R technology can only be improved in future with more platforms with accurate attitude knowledge across the whole globe, offering the potential for frequent high-quality wind speed retrievals at low relative cost. Matthew Lee Hammond, Giuseppe Foti, Christine Gommenginger & Meric Srokosz, National Oceanography Centre, Southampton, UK
Matthew Hethcoat	SAR SENSORS FOR DETECTING TROPICAL SELECTIVE LOGGING: ASSESSING SENTINEL-1 RADARSAT-2, AND PALSAR-2	Selective logging is the primary driver of forest degradation in the tropics. Logging reduces the capacity of forests to harbor biodiversity, maintain key ecosystem processes, sequester carbon, and support human livelihoods. While the preceding decade has seen a tremendous improvement in the ability to monitor forest disturbances from space, advancements in forest monitoring have almost universally relied on optical satellite data from the Landsat program. Yet, the effectiveness of optical data are limited in tropical regions with frequent cloud cover like the northwest Amazon and central Africa. Synthetic aperture radar (SAR) data can penetrate clouds and have been utilized in forest mapping applications since the early 1990s, yet no study has exclusively used SAR data to map tropical selective logging. We utilized a detailed selective logging dataset from three lowland tropical forest regions in the Brazilian Amazon and SAR data from Sentinel-1, RADARSAT-2, and PALSAR-2 to assess their effectiveness at monitoring of tropical selective logging. The C-band sensors of Sentinel-1 and RADARSAT-2 performed rather poorly, having high commission and omission of logging. In contrast, the L-band PALSAR-2 sensor had satisfactory detection of selective logging, with approximately 85% detection rate, 16% commission error, and low commission and omission of unlogged data (3%). This suggests that L-band SAR can detect selective logging activities and has important implications for the forthcoming SAOCOM and NISAR missions and detecting selective logging pan-tropically with freely available data sets.
Michael Cartwright	Understanding the global sources and sinks of atmospheric carbonyl sulfide (OCS) in order to provide insights into carbon cycle processes	The challenge in quantifying the sources and sinks of atmospheric carbon dioxide (CO2) is that the CO2 taken up by plants during photosynthesis cannot be distinguished from the CO2 released by plants and micro-organisms during respiration. It has been shown that carbonyl sulfide (OCS), the sulphur-containing analogue of CO2, can be used as a proxy for photosynthesis. The relationship between vegetative flux of OCS and CO2 has been quantified for various species of plants and ecosystems, the results of which have been used in observing the relationship on a continental scale. The aim of this project is to both quantify the location and magnitude of the sources and sinks of atmospheric OCS, and to use these data to infer photosynthetic uptake of CO2 by vegetation on a global scale. A tracer version of the 3-dimensional chemical transport model TOMCAT has been adapted to include eleven different sources and sinks of OCS, including direct and indirect oceanic emissions, vegetative uptake and stratospheric photolysis. The simulated OCS distribution between 2004 and 2018 generally agrees well with OCS profiles measured by the Atmospheric Chemistry Experiment (ACE-FTS) over the 5 – 30 km altitude range. In addition, work is ongoing to retrieve OCS total columns from measurements taken by the Infrared Atmospheric Sounding Interferometer (IASI) instruments onboard the MetOp satellites. The final goal for this project is to invert the IASI measurements in conjunction with TOMCAT to determine the vegetative OCS flux, thereby providing insights into carbon cycle processes.

Michael Loweth, Armando Rojas	A Novel Deployable Cassegrain Satellite Antenna for Earth Observation Applications	Oxford Space Systems (OSS) is developing a scalable and lightweight Wrapped-Rib parabolic antenna. The Cassegrain architecture uses variants of flight-proven proprietary, high-strain, flexible composites in the form of lenticular ribs, wrapped around a central hub. The antenna's stowage efficiency and lightweight materials provide significant cost-reductions in an efficient stowage envelope. Although being developed for higher frequency applications such as data relay, the antenna's first application is with an X-Band Earth Observation (EO) mission in the form of Synthetic Aperture Radar (SAR) from Low Earth Orbit (LEO). For EO applications, the OSS antenna offers notable benefits over linear RF patch panel arrays, providing superior resolution via larger aperture and wider bandwidth capabilities. The Wrapped-Rib's primary reflector utilises a novel, proprietary metalmesh surface developed in collaboration with a leading UK university. From initial testing undertaken by the European Space Agency, the mesh achieves higher RF performance than incumbent alternatives. To achieve this, the mesh is knitted as a single element, thus requiring only a single seam to create a '3D' parabolic surface. This reduces surface errors, decreases manufacturing time and with further development, is anticipated to provide a route to volume production. The antenna also utilises a novel secondary reflector that serves as the hold down and release mechanism (HDRM). The secondary reflector is deployed into position using a low obscuration variant of the OSS flexible composite. This presentation will examine the technical challenges of developing and testing the antenna and cover how volume production is expected to be achieved.
Michael Perry	Validation of simultaneous retrievals of LST and LSE from ASTER	Knowledge of the fine scale thermal environment is key to addressing the health and sustainability of agricultural and urban areas. The monitoring and assessment of the thermal environment requires spatial resolution and coverage that cannot be studied with current air temperature observations. Land surface temperatures (LSTs) offer the ability through satellite remote sensing to investigate in a robust and consistent manner. Additionally land surface emissivity (LSE) is required to enable accurate LST estimation and characterise broad-scale thermal infra-red properties of materials. In this work, an Optimal Estimation (OE) retrieval of simultaneous LST and LSE data optimised to be robust for highly complex surfaces is presented. It uses the thermal channels of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument with a spatial resolution of 90 m. Validation of the LST and LSE was assessed with an in-situ validation site in Gogabeb, Namib Desert over the current span of the ASTER instruments lifetime with observations over day and night conditions. The OE retrieval performs well against the in-situ validation data from Gogabeb, which assessed the retrievals performance in both LST and LSE. In these assessments the surfaces understudy have large emissivity spectral inter channel variations, providing a flexible approach enabling applications in heterogeneous environments such as urban and arid biomes. These results show the retrieval of robust and scientifically meaningful LST and LSE data for a heterogeneous environment from ASTER.
Murray Ireland	Autonomy assurance for small Earth observation satellites	Craft Prospect provides on-board autonomous systems to maximise the efficiency and utility of space assets. Leveraging advances in machine learning, and the low-power capabilities of FPGAs and other processing hardware, we create solutions which get EO data from acquisition to application in significantly reduced time. In-orbit autonomy can be used for a variety of applications: automated operations; on-board data processing, high-value data prioritisation, fleet management, resource optimisation and upstream-led pass automation. For any of these applications, autonomy introduces a key common property: uncertainty. Automating any aspect of a system introduces risk, and assurance must be given that the software used to implement this automation functions as expected. For example, in-orbit neural networks may be used to classify EO images at the time of capture, using the results to drive other onboard activities. In such a case, how do we obtain confidence that features in the image are identified correctly? Additionally, given that no network is 100% accurate, how do we audit the network outputs and ensure that any incorrect classifications do not risk the satellite or mission? This presentation provides an overview of techniques developed by CPL to assure autonomous components applied to upcoming missions. The application of autonomy algorithms to different use cases is introduced and their capabilities described. The approach to assuring these algorithms is then presented, providing the necessary confidence that these new capabilities will be provided with minimised risk to the mission and platform.
Nancy Nichols	The impact of using reconditioned correlated observation error covariance matrices in the Met Office 1D-Var system	Recent developments in numerical weather prediction have led to the use of correlated observation error covariance (OEC) information in data assimilation systems. Ill-conditioned OEC matrices may cause problems with the convergence of a variational data assimilation procedure, meaning that reconditioning methods are used to improve their conditioning. We apply the 'ridge regression' reconditioning method to assimilate Infrared Atmospheric Sounding Interferometer (IASI) observations in the Met Office 1D-Var system. This is the first systematic investigation of the impact of reconditioning parameter choice on convergence of a 1D-Var routine. 1D-Var is used for quality control, and to estimate key variables that are not analysed by the main 4D-Var data assimilation system. We find that the current (uncorrelated) OEC matrix requires more iterations to reach convergence than any choice of correlated OEC matrix, suggesting that using a correlated OEC matrix in the 1D-Var routine would have computational benefits. However, the impact on retrieved variables is less clear, with a small number of large differences between retrievals for the control and correlated choices of OEC. The improved convergence associated with correlated OEC matrices would allow for more efficient quality control procedures, which is likely to reduce the impact of such large retrieval differences. Authors: Jemima Tabeart, Sarah Dance, Amos Lawless, Nancy Nichols, Joanne Waller, Stefano Migliorini, and Fiona Smith.
Natalie Douglas	Assimilating MODIS white-sky and black-sky albedos for LAI and model parameter retrieval.	The Sellers model of terrestrial radiative transfer is currently used in state of the art land surface schemes. When confronted with remotely-sensed white-sky and black-sky albedos in the visible and near-infrared spectral wavebands, it is possible to retrieve an optimal time series of Leaf Area Index (LAI) along with model parameters. The extent to which the retrieval is meaningful and methods for overcoming pitfalls is presented.

Neil Humpage	Testing an automated enclosure system for a ground-based greenhouse gas remote sensing spectrometer	The Bruker EM27/SUN Fourier transform spectrometer is designed to observe total atmospheric column concentrations of the greenhouse gases (GHGs) carbon dioxide and methane, along with other gases including water vapour and carbon monoxide, by measuring high resolution (0.5 cm-1) near- to shortwave infrared spectra using the sun as the light source. These instruments provide frequent observations over a location of interest, complementary to satellite observations (e.g. TROPOMI, OCO-2/3, GOSAT, TANSAT). Since they are portable, EM27/SUNs can be used to fill gaps in ground-based validation networks in regions where the infrastructure isn't in place to support a more permanent deployment (Frey et al 2019). They are also suitable for short term campaigns, where a network of EM27/SUNs are set up to quantify the emissions from an extended GHG source such as a city (Hase et al 2015, Chen et al 2016). Here we describe the testing of an automated enclosure designed by the Technical University of Munich (Heinle and Chen 2018) for continuous operation of the EM27/SUN in all weather conditions. As well as weather-proofing the instrument, the enclosure enables remote control of the spectrometer. The EM27/SUN can therefore be deployed in locations where daily supervision of the equipment is impractical, and a single person can monitor a network of EM27/SUNs across several locations. We show results from testing of the system at the University of Leicester during summer 2019, in preparation for a longer-term deployment in Uganda as part of the NERC MOYA project studying the global methane budget.
Nigel Fox	Traceable Radiometry Underpinning Terrestrial- and Helio- Studies (TRUTHS): Enabling a Space-based Climate and Calibration Observatory - An ESA EarthWatch mission.	TRUTHS was recently proposed, by UKSA for implementation as part of the ESA EarthWatch program. Subject to subscription at Space19+ in November it will start formal Phase A/B1 in spring 2020 with a planned launch in 2026. TRUTHS is a UK-led mission designed explicitly to meet the exacting needs of climate. Its primary goal is to establish a benchmark dataset of the radiation state of the planet, spectrally and spatially resolved with sufficient accuracy that trends can be detected limited only by natural variability, immune from biases and ambiguities of sensor performance and degradation. It measures incoming and reflected solar radiation from ~320 nm to 2450 nm with an uncertainty of 0.3% (k=2) (a factor ten improvement over existing sensors), globally sampled at 50 m spatial resolution. This allows it not only to quantify radiation balance but also to attribute effects to key climate feedbacks such as Cloud and Albedo as well as account for potential variations in energy inputs total and spectral solar irradiance - facilitating testing of climate forecast models in the shortest time possible. TRUTHS will be the scientific forerunner of a paradigm shift in how the Earth is observed, delivering data not constrained to a single discipline but deliberately specified to allow it to be configured to support applications in and at the boundaries of Land, Ocean and Atmosphere and meet the exacting needs of ECVs e.g. Land and Ocean Carbon cycle. Additionally, it will be a metrology laboratory (NPL) in space, providing and enabling SI-traceable measurements of improved and unequivocal accuracy from other sensors through in-flight calibration. TRUTHS will be an enabling element of the internationally requested 'space-based climate observatory', ideally in conjunction with other benchmark sensors such as CLARREO.
Nikoleta Kalaitzi, H. Boesch, R. J. Parker, Alex Webb	A high-resolution modelling framework for estimating CO2 emissions of megacities from satellites	Urban areas are responsible for the majority of fossil fuel CO2 emissions - accounting for 70% of anthropogenic emissions on a global scale - and this number is expected to increase since the population of urban areas is rising. There is a need to develop a better quantitative understanding of urban carbon budget and create methods for verification of anthropogenic emission estimates from atmospheric data. The purpose of this work is to use the capability of the NASA Orbiting Carbon Observatory-2 (OCO-2) satellite to observe CO2 concentrations at a high spatial resolution over urban areas, proving a new way for observing these emission sources. Using overpasses of OCO-2 over the city of Los Angeles (LA), we can observe the urban enhancement in CO2 compared to background concentrations. A Forward Modelling approach has been applied using the Numerical Atmospheric-dispersion Modelling Environment (NAME) to infer footprints of satellite columns. NAME's column footprints provide essential information of the interaction of air particles with the surface emissions and are used to evaluate further which parts of an urban area contribute to a satellite observation. To estimate the background CO2 concentrations from a global chemistry transport model, we use the airmass history derived from the NAME model. A combination of these footprints along with flux estimates from emission inventories such as ODIAC or EDGAR can then be used to model the enhancement observed by a satellite and to eventually invert the urban CO2 fluxes itself from the satellite observations.
Pedro Rodriguez-Veiga	Quantity and spatial distribution of aboveground biomass carbon in Colombia's forest	In-situ national forest inventory data (NFI) as well as multispectral optical and synthetic aperture radar (SAR) satellite imagery were used to characterize the spatial distribution of forest aboveground biomass carbon (AGBC) stocks in Colombia. ALOS-2 PALSAR-2 gamma-0 backscatter annual mosaics (2015-2017) provided by JAXA were normalised and corrected using previous ALOS PALSAR annual mosaics (2007-2010) as reference. A multi-temporal Landsat 7 & 8 composite over the whole of Colombia was used for the year 2016±1. The NFI in-situ plots used to train our model consisted of 5-subplots each and were collected during the period 2015-2017 in the main biomes of the country. A sample of permanent 1ha plots (PPMs) were also measured. Pan-tropical allometries using diameter, height and specific wood gravity (type I) and a biomass-to-carbon ratio of 0.48 were used to estimate AGBC. A non-parametric random forests (RF) algorithm was used within a k-fold framework to retrieve AGBC at 30m spatial resolution for the whole of Colombia. The algorithm was trained using forest inventory plots and validated at plot (0.35 ha) and PPM level (1 ha). The accuracy assessment found coefficients of determination (R^2) of 0.70 and 0.68, and root mean square errors (RMSE) of 29.93 t C ha^{-1} and 24.79 t C ha^{-1} at plot and at PPM level, respectively. The results were also compared to previous studies.

Peter Hill, Thorwald Stein, Alex Roberts, Jennifer Fletcher, John Marsham	Evaluating satellite-based nowcasting for tropical Africa	Tropical Africa is subject to weather extremes at a variety of space- and time-scales, leading to droughts, floods and severe storms. The weather has a huge impact on the local population: droughts and floods impact on weather dependent industries such as agriculture or fishing, which much of the population rely on for their livelihoods, while severe storms can lead to destruction of property and even loss of life. Consequently, improved nowcasting systems, which provide a detailed description of the weather at short timescales and small spatial scales could bring huge benefits both to the livelihoods of the local population and to the regional economy. The Eumetsat nowcasting satellite application facility (NWCSAF) provides a number of nowcasting products based on geostationary satellite observations. These are produced operationally over Europe and have recently been made available for tropical Africa as part of the Global Challenges Research Fund African SWIFT project. While the potential of these products is enormous, evaluation is required to ensure that these products, which were initially designed for mid-latitudes, are properly understood and used appropriately in tropical Africa. Our work aims to evaluate how well these nowcasting products capture storms and their pre-convective environment in tropical Africa. We shall present an analysis of the nowcasting products and their relationship with surface rainfall products from other satellite datasets. We will also discuss how our analysis informs future use of the products and the identification of potential future improvements.
Petros Kalogeras	A comparison study between microphysical and dynamical properties of polar region cold clouds	The study of cold cloud microphysics constitutes an important chapter in the polar climate modeling frame. Mass content and radiative properties of ice clouds are thereby quantified in relation to hydrometeor growth mechanisms and the overall thermodynamic interplay. Such a quantification depends on the synergistic utilization of remote sensors and atmospheric thermodynamic measurements. Following this principle, polar-region datasets of multi-wavelength, Doppler radar systems have been established. The Atmospheric Radiation Measurement (ARM) program Mobile Facility 2 (AMF2) recent deployments in Hyytiälä, Finland (BAECC) and McMurdo Station, Antarctica (AWARE) offer the opportunity for a comparison study between microphysical and dynamical properties of cold clouds in cryospheric regimes. Recent publications divulge parameterizations of single-particle mass-size and terminal fall speed-size relations, which when integrated over a particle size distribution (PSD) approximate scattering coefficients and sedimentation velocities, being metrics comparable to radar observables. However, a direct comparison between the two has not been carried out thoroughly, while the associated level of disparity between the assorted parameterizations prohibits conclusiveness in the performed analyses. The current poster demonstrates recent developments in the comparison between microphysical backscattering and dynamical velocity libraries within the context of the triple-frequency and dual- frequency versus velocity spaces by utilizing observed and simulated data at 10, 35, and 95 GHz for backscattering, and at 35 GHz for velocity over a gamut of PSDs for ice, in order to ascertain the degree of association between the triple-frequency approach against an observational setup of two frequencies with Doppler capabilities.
Philip Kershaw	JASMIN Cluster-as-a-Service for Climate Data Analysis	JASMIN provides large-scale computing resources for the NERC environmental science community to support data-intensive science. It provides a range of computing capabilities co-located with access to collaborative workspaces and the CEDA (Centre for Environmental Data Analysis) curated data archive. This infrastructure underpins a range of projects and collaborations related to the generation and analysis of climate datasets. We describe here the development of Cluster-as-a- Service (CaaS), a set of tools and building blocks to enable JASMIN users to create their own shared analysis environments. CaaS enables projects to host their own Jupyter Notebooks, bespoke processing clusters and instances of specific software stacks. The latter includes Pangeo (http://pangeo.io), a web-based community platform which supports use cases for analysis of climate data. We will also present a specific example of a new climate service to be developed and hosted on JASMIN, as part of the ESA Climate Change Initiative Knowledge Exchange (CCI KE) project. This will provide new capabilities for access and analysis for ECVs (Essential Climate Variables) hosted in the CEDA data archive.
Ranjini Swaminathan	Using the ESMValTool and Observation Data Sets for Evaluating Land-Atmosphere interactions with Vegetation in Earth System Models	We present a framework to evaluate how well earth system models (ESMs) simulate complex interactions between key variables representing land, atmosphere and vegetation processes. The major components involved are earth system models, observational data sets and and evaluation tool, ESMValTool (Earth System Model Evaluation Tool). Our framework first analyzes relationships between different variables such as land surface temperature, evapotranspiration, precipitation, net radiation and gross primary productivity as seen in historically observed data. We then evaluate how well these relationship patterns are simulated in the two most recent generations of earth system models from the Coupled Model Intercomparison Project (CMIP6 and CMIP5). This includes the UK's own Earth System Model (UKESM1). The goal of this project is to fill gaps in our understanding of key aspects of the physical climate and also to improve our ability to model it better. For this purpose, we use a variety of observational data including from earth observation programmes (ESA-CCI for soil moisture, GOSAT-SIF for solar-induced fluorescence, CERES-EBAF for net radiation) as part of our evaluation. Our evaluation framework is developed using the ESMValTool, a community driven diagnostic and performance metric tool for analysing earth system models. Through this project, we also endeavour to augment ESMValTool with a variety of new diagnostic and structural components that can be used by the wider research community.

Richard Allan	Global and regional evaluation of current changes in water vapour, precipitation and Earth's energy budget.	An evaluation of current changes in water vapour and precipitation in CMIP5 and CMIP6 climate model simulations using in situ and satellite observations will be presented at the global scale and regionally for tropical Africa. Water vapour, precipitation and Earth's energy balance vary with temperature at the global scale with a 6-7%/K increase in moisture and much weaker response in precipitation that is well understood based on thermodynamics and energy budget of the surface and atmosphere. Globally, outgoing longwave radiation increases at the rate of 2.2 Wm-2K-1 which is offset by increases in absorbed sunlight with increased temperature of 2.9 Wm-2K-1 demonstrating a negative feedback that damps internal variability. However, amplifying cloud feedbacks are identified regionally over stratocumulus in simulations and observations of order 0.1-0.5 Wm-2K-1. Strongly amplifying feedbacks from water vapour are identified and preliminary assessment of water vapour changes throughout the troposphere in CMIP6 simulations will be presented. Finally, an assessment of recent regional changes in precipitation over Africa will be discussed. Specifically, decreases in long season rainfall over East Africa from the 1980/90s to the 2000s are explained by shorter not less intense rainfall. A strong signal of internal variability suggests that these changes are not likely to continue into the future where projections are for increased rainfall although with substantial uncertainty.
Richard Bantges	Comparisons of simulated radiative properties of cirrus across the mid- and far-infrared with aircraft-based observations	Cirrus clouds play an important role in the Earth's energy balance, yet their radiative forcing on a global scale remains highly uncertain owing to the complexity of their ice microphysical properties. Harries et al. (2008) estimated that approximately 35% of the energy emitted to space occurs at far-infrared wavelengths (here defined as wavelengths between 15 and 100 microns), which increases to greater than 50% in the presence of cirrus clouds. In order to better understand their impact on the Earth's energy balance, it is important to know their radiative properties across the visible and infrared spectral regions. The ability to simulate the mid- and far-infrared radiation spectrum emitted by cirrus clouds relies on the capability of optical models to represent the scattering and absorption properties of their complex ice crystals. Here we exploit aircraft based measurements of nadir radiances above cirrus clouds, spanning the near- to far-infrared, obtained during the Cirrus Coupled Cloud-Radiation Experiment (CIRCCREX) to test the ability of the ice cloud bulk scattering models to represent the radiative signatures of cirrus clouds. We focus on observations obtained during the CIRCCREX campaign on the 13th March 2015 over a decaying band of cirrus of the north coast of Scotland, UK. Radiance spectra above the cirrus clouds are simulated for a variety of cases using a combination of in-situ and model data to constrain the cloud and atmospheric properties. Sensitivity of the simulated radiance spectra in the mid- and far-infrared to ice crystal size and habit are investigated, and comparisons are then made between the simulated radiance spectra and those observed by a near- and mid-infrared spectrometer (Airborne Research Interferometer Evaluation System, ARIES) and a far-infrared spectrometer (Tropospheric Airborne Fourier Transform Spectrometer, TAFTS). For the cases considered, results indicate that whilst it is possible to simulate the radiance spectra above cirrus clouds in the mid-infrared to within instrument uncertainties, such simulations were then unable to agree with measurements in the far-infrared to within the estimated uncertainties. Furthermore, it is found that multiple solutions for the cloud optical properties could satisfy agreement to within measurement uncertainties in the mid-infrared, whilst significant sensitivity in the far-infrared could be used to inform on the most consistent solution across the mid- and far-infrared.
Richard Siddans	Global trace gas distributions from the extended Infrared and Microwave Scheme for studies of atmosphere – biosphere interactions	The Infrared and Microwave Scheme (IMS) to retrieve global height-resolved distributions of water vapour, temperature, ozone and surface spectral emissivity jointly from IASI, MHS & AMSU-A on MetOp is producing data for improved IASI methane retrieval and for ESA's CCI water vapour project. Through expanded spectral coverage and other developments, the scheme has now been improved significantly for tropospheric ozone and extended to include CO along with other trace gases such as ammonia (NH3) and methanol (CH3OH). The scheme has also now been adapted and implemented to CrIS on Suomi-NPP, whose observations are twice as dense and made around ~1:30 pm/am local time, rather than MetOp's ~9:30 am/pm. Data from the extended IMS, in conjunction with other satellite data, will be used with chemical transport models in studies of atmosphere-biosphere interactions at global and regional scales. The IMS scheme has also been implemented to run in near-real-time for MetOp and the visualization tool used in support of field campaigns. Some early results will be presented from the improved and extended IMS and its planned combination with complementary, co-located, shortwave observations by Sentinel-5 Precursor.

Robert Parker	The UK Earth System Model	UKESM1 (Sellar et al, 2019) is the UK's latest-generation global Earth System Model, which has been developed to provide policy advice to the UK government and whose simulations will be used in the upcoming Intergovernmental Panel on Climate Change (IPCC) 6th assessment report via the Coupled Model Intercomparison Project Phase 6 (CMIP6: Eyring et al, 2016). This model represents a significant improvement over the previous generation of models in the level of process-complexity it can simulate, and in the degree to which it agrees with present-day climate observations. Model simulations for CMIP6 are now available via CEDA-JASMIN and Earth Observation data will play a critical role in evaluating these simulations in order to gain further scientific insight into the behaviour of the underlying processes both in the current and future climate. We particularly focus on ESA CCI data and discuss the opportunities available through the large number of new Essential Climate Variables being generated as part of CCI+. This presentation provides updates on early results from UKESM1 as well as ongoing efforts to evaluate individual model components. We also discuss opportunities to collaborate and aid future model development. Details of practical steps and training available (e.g. ESMValTool) for people wishing to use UKESM data will also be explained.
Rocio Barrio Guillo	Methane retrieval over anthropogenic point sources using Hyperspectral Remote Sensing	Methane (CH4) is becoming increasingly important towards mitigating climate change due to its shorter atmospheric lifetime and much stronger warming potential per molecule than Carbon Dioxide (CO2). Detecting and quantifying CH4 localised point sources is key due to the current uncertainties in the attribution of individual sources to regional budgets and the CH4 trend. Of specific interest is the anthropogenic component from fossil fuels, agriculture and waste, where monitoring and reducing emissions is possible. We present an investigation into localised CH4 sources using airborne hyperspectral imagery with metre-resolution, which allows mapping out of the emissions plumes. For this purpose, a flight campaign was conducted with NERC-Airborne Research Facility ARF in May 2018 using the AisaFENIX Hyperspectral sensor onboard BSA Twin Otter Aircraft. The target sites focus on major emitters as identified in the UK emission inventory NAEI including an oilfield, landfill and power station. To identify CH4 enhancements in the airborne observations, we employ a statistical retrieval method, which we first test on a CH4 Benchmark Data provided from the NASA AVIRIS-NG hyperspectral instrument. This serves as a verification of our method, later applied to AisaFENIX and other similar instruments. Eventually similar methods will be applied to space-based instrument and we will also discuss the capabilities of space-based instruments for detecting CH4 plumes.
Rose Fenwick	Machine Learning for Earth and Space Observation	The amount of data being produced by satellites is now such that traditional modelling methods have become inefficient and very costly. I am researching the possibility of using a neural network to retrieve Methane from the S5P satellite. Although this task should be relatively simple it is important to note that 'Black Box' approaches such as Neural Networks are not well received in this context as it is necessary for the method to be transparent, explainable and acceptable to the earth observation society. This is the main focus of my project and my poster will outline the necessity for this project, the problems I face and some results which show a neural network producing results for a small sample of data.

Ross Bannister	Analysis of balance in storm-scale weather forecasts	There is huge potential to exploit optimally the full range of observations of storm-scale features of the atmosphere for accurate weather forecasting. It is believed though that this can be done only if a number of issues are addressed. One important issue is to make sure that information provided by the observations is balanced correctly against that provided by the background forecast. This requires the background error statistics to be properly specified, including how mass and wind errors are related at storm-scales, and how current approaches to modelling these relationships in traditional data assimilation systems should be modified. In the past, we have found counter-intuitive evidence from a convective-scale ensemble from the Unified Model that correlations between mass and wind should be enhanced from that found by enforcing geostrophic balance. This is counter-intuitive because we expect in reality geostrophic balance to reduce at small scales meaning that its effect should be reduced. In this work we show results from a convective-scale simplified model and discuss whether they support those found from the Unified Model.
Sandip Dhomse	Microphysically-consistent Volcanic Aerosol Datasets For Agung, El Chichon and Pinatubo Eruptions	Major tropical volcanic eruptions inject huge amounts of SO2 directly into the stratosphere, and create a long-lasting perturbation to the stratospheric aerosol. The abruptly elevated aerosol has strong climate impacts, principally surface cooling via scattering incoming solar radiation. The enhanced tropical stratospheric aerosol can also absorb outgoing long wave radiation causing a warming of the stratosphere and subsequent complex composition-dynamics responses (e.g. Mann et al., 2015; Dhomse et al., 2015). In this presentation we apply the composition-climate model UM-UKCA with interactive stratospheric chemistry and aerosol microphysics (Dhomse et al., 2014) to assess the enhancement to the stratospheric aerosol and associated radiative forcings from the three largest tropical eruptions in the last 60 years: Mt Agung (March 1963), El Chichon (April 1982) and Mt. Pinatubo (June 1991) Accurately characterising the forcing signature from these major eruptions is important for attribution of recent climate change and volcanic effects have been identified as a key requirement for robust attribution of multi-decadal surface temperature trends (e.g. Marotzke and Forster, 2015). Aligning with the design of the ISA-MIP co-ordinated multi-model "Historical Eruption SO2 Emissions Assessment" (Timmreck et al., 2018), we have carried out 3-member ensembles of simulations with each of upper, low and mid-point best estimates for SO2 and injection height for each eruption. The 3D model resolves the microphysical-dynamical evolution of the volcanic aerosol plume during global dispersion, with evaluation against satellite, ground-based lidar and in-situ measurements also ensuring the datasets are consistent with a diverse set of observations. References: Dhomse SS et al., "Revisiting the hemispheric asymmetry in midlatitude ozone changes following the Mount Pinatubo eruption: A 3-D model study", GRL, 42, doi: 10.1002/2015GL063052, 2015. Dhomse SS et al.,"Aerosol microphysics simulations of the Mt. Pinatubo eruption with the UM-UKCA composition-climate model", ACP, 14, doi: 10.5194/acp-14-11221-2014, 2014. Mann, GW, Dhomse, SS, et al.,. "Evolving particle size is the key to improved volcanic forcings", Past Global Change, vol. 23, no. 2, pp. 52-53, 2015.
Shubha Sathyendranath	Biological Pump and Carbon Exchange Processes (BICEP)	The new project BICEP aims to exploit the latest research on the global ocean biological carbon pump (OBCP); ii) improve our understanding of how OBCP functions and varies in time and space; and iii) how it interfaces with the cycling of carbon in other domains of the Earth system. Building on recommendations made in a series of recent meetings and reports; on ESA-led initiatives and projects; and on other relevant programmes (e.g., NCEO, Simons CBIOMES Project, NASA Export Project); the project will synthesise the current knowledge and identify scientific requirements for OBCP products, leading to a novel, satellite-based characterisation of the ocean biological carbon pump, quantifying the pools and fluxes, and their spatial and temporal variation.
Simon Preval	Mind the gap, please: Challenges in detecting low-altitude precipitation and clouds, and future solutions	Low altitude and marine stratiform clouds provide a significant contribution to the energy budget of the atmosphere. Space-borne radar observatories have an advantage over ground-based radars in offering global coverage. However, the downside to observing from space is the presence of surface clutter arising as a result of the radar signal reflecting off the Earth's surface, meaning we lose valuable information from low altitude clouds (e.g. for the CloudSat profiling Radar, where the surface clutter typically extends to ~1 km AGL). This can be mitigated by transmitting pulses shorter than 3.3 microseconds. However, this comes at the cost of sensitivity due to the decreased backscattered power, and increased noise level. We present a future radar concept proposing the use of interlaced short- and long-pulses. Using KAZR data spanning 2015-2018 from the Azores ARM radar we have simulated the instrument responses for multiple radar configurations with different pulse lengths. We constructed Contoured Frequency by Altitude Diagrams (CFADs) for each configuration, and concluded that a dual pulse length mode is optimal, with a 1.7 microsecond short pulse length resolving shallow cloud and precipitation, and a 3.3 microsecond long pulse length resolving low reflectivity atmospheric targets.

Sophie Hebden	ESA Climate Change Initiative	The ESA Climate Change Initiative (CCI) supports UNFCCC by exploiting the 40-year satellite archives of Earth Observations that ESA and its Member states have established. Through its programme of parallel projects, CCI now covers 21 research-quality Essential Climate Variable data products produced by over 450 scientists at 178 institutions. The CCI programme also includes two budget closure projects for sea level and carbon and a dedicated climate modelling user project. Data users can benefit from use of a portal which provides all the CCI products under one roof, a toolbox for combining and analysing the products, and a visualization tool to support outreach. This poster will outline the CCI programme components and how to access resources and datasets. http://cci.esa.int
Stefano Ciavatta	Ecoregions and carbon fluxes in the Mediterranean Sea through the assimilation of ocean-colour phytoplankton functional types	In this work we produced a long-term reanalysis of the phytoplankton community structure in the Mediterranean Sea and used it to define ecoregions. These were based on the spatial variability of the phytoplankton type fractions and their influence on selected carbon fluxes. A regional ocean-colour product of four Phytoplankton Functional Types (PFTs; diatoms, dinoflagellates, nanophytoplankton, picophytoplankton) was assimilated into a coupled physical-biogeochemical model of the Mediterranean Sea (POLCOMS-ERSEM) by using a 100-member Ensemble Kalman filter, in a reanalysis simulation for years 1998-2014. The reanalysis outperformed the reference simulation in representing the assimilated ocean-colour PFT fractions to total chlorophyll, although the skill for the ocean-colour PFT concentrations was not improved significantly. The reanalysis did not impact noticeably the reference simulation of not-assimilated in situ observations, with the exception of a slight bias reduction for the situ PFT concentrations, and a deterioration of the phosphate simulation. We found that the Mediterranean Sea can be subdivided in three PFT-based ecoregions, founded on the spatial variability of the PFT fraction dominance or relevance. Picophytoplankton dominates the largest part of open-ocean waters; microphytoplankton dominates in a few, highly-productive coastal spots near large-river mouths; nanophytoplankton is relevant in intermediate-productive coastal and Atlantic-influenced waters. The trophic and carbon sedimentation efficiencies are highest in the microphytoplankton ecoregion and lowest in the picophytoplankton and nanophytoplankton ecoregions. The reanalysis and regionalization offer new perspectives on the variability of the structure and functioning of the phytoplankton community and related biogeochemical fluxes, with foreseeable applications in Blue Growth of the Mediterranean Sea.
Stephen Goult	The Massive GPU cluster for Earth Observation: Supporting Artificial Intelligence research	The growth of satellite observations is set to accelerate with planned future missions: notably, recent high-resolution sensors have increased the scale and scope of these observations. To fully understand and exploit these data in many cases requires manual inspection; however, due to the quantity, many data may never be fully inspected by an expert. Based on training and development from expert users, Deep Learning and Machine Learning (DL/ML) tools offer an opportunity to automatically interpret these data at a rate vastly superior to human operators. NERC recently recommissioned the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) at Plymouth Marine Laboratory (PML) for a five-year period and awarded significant funding to create the Massive GPU cluster for Earth Observation (MAGEO). This will provide a high-performance compute capability to support Artificial Intelligence covering DL/ML in the Earth Observation data space. MAGEO will provide through NEODAAS a service to UK researchers supporting Earth Observation scientists seeking to apply DL/ML tools to their own data, or artificial intelligence experts looking to apply their techniques to EO data. Details of the hardware, and its anticipated usage through the Deep Learning service will be outlined.
Stephen Hobbs	G-CLASS Hydroterra: an Earth Explorer mission for Water Cycle Science	G-CLASS Hydroterra is a proposal for ESA's 10th Earth Explorer mission. It is now in competitive Feasibility Study phase along with Daedalus (a thermosphere science mission) and Stereoid (for land and ocean science). Hydroterra's science focus is the diurnal water cycle, using a geosynchronous C-band radar to observe atmospheric humidity and the land surface several or many times during a day. Hydroterra's temporal sampling would allow significant water cycle processes such as intense rainfall and diurnal evapo-transpiration to be observed directly, from mid-Europe to southern Africa. A geosynchronous orbit enables imaging whenever required across the field of view at resolutions from km down to 10s of metres with geographical coverage determined mainly by beam-pointing rather than the orbit track. Since the orbit relative to Earth repeats daily, InSAR products are available with a 24 hr baseline several times a day: enabling ground motion observations for landslides, earthquakes and volcano monitoring with dramatically reduced response times. The science innovations are expected from (a) using current radar techniques such as atmospheric water vapour mapping, soil moisture estimation, or flood mapping on much shorter timescales (minutes and hours rather than days) and (b) from new techniques enabled by the fine temporal sampling – e.g. direct measurement of rates of change of surface moisture (separating evaporation processes from soil moisture and plant physiology). We believe this is a significant opportunity for Earth observation, using a mission which powerfully complements existing EO systems and which could open up important new areas of water cycle science.

Steve Donegan, Ed Williamson	CEDA and JASMIN Services	The Centre for Environmental Data Analysis (CEDA) provides the data archive component for NCEO and provides access to over ten petabytes of EO data. This includes data from the Sentinel, Landsat, Terra/Aqua and ENVISAT missions in addition to data from the NERC ARF as well as many other missions. CEDA provides access to this data via a number of methods, not least fast access via the JASMIN environment which allows users access to the data using a world class fast parallel processing cluster. JASMIN has undergone recent upgrades that have allowed further improvements, including advances in archive storage. The CEDA Satellite Data Finder is a web tool that allows users to quickly find many CEDA EO datasets. Users can access this via a conventional GUI or by an OpenSearch interface. CEDA is consistently engaged in developing systems to manage the large volumes of data curated as well as tools to find and access this data.
Steve Maddox	Quantum Gravity Sensing in Space	Developments in quantum technology have resulted in the ability to harness the quantum properties of atoms to directly measure accelerations, rotations, magnetic fields and frequency with great sensitivity and low drift. Applications for this technology in space are very broad and range from gravity sensing for Earth science and commercial uses such as oil and gas exploration to non-gravity applications such as inertial navigation and timing references for atomic clocks. Gravity sensors in space are already used for many Earth observation applications including monitoring polar ice mass, ocean currents and sea level. Cold atom technology has the potential to bring improvements over existing space based gravity sensing capabilities which would enable monitoring of smaller water sources and discovery of new underground natural resources which are currently undetectable. This technology could also pave the way to establishing continuous gravity Earth observation rather than one-off missions such as GOCE and GRACE. In order to address the technology readiness level (TRL) barrier, Teledyne e2v have built a CubeSat demonstrator which includes the basic building blocks of cold atom systems in a space suitable, low size, weight and power (SWAP) form. In parallel, Teledyne e2v are working with partners to define a quantum gravity sensor mission and instrument as well as developing a ground based gravity sensor. Authors: Diviya Devani 1, Stephen Maddox 1, Helen Sweeney 1, Trevor Cross 1 1 Teledyne e2v, Chelmsford, United Kingdom; Raffaele Nolli 2, Michael Holynski 2, Kai Bongs 2 2 University of Birmingham, Birmingham, United Kingdom
Tianran Zhang	Developing a Deep Learning Model to Support VIIRS Active Fire Detection and Validation	Research into Deep Learning (DL) has yielded well-publicised and often inspirational developments in areas such as computer vision, where for example facial recognition for security and social media applications and real-time object detection for self-driving cars have seen vast strides in performance in recent years. The algorithms underlying these applications primarily make use of convolutional neural networks (CNN), and fundamentally process imagery made of pixels, hierarchically detecting complex patterns of values and gradients to gain information. This is relatively similar to the algorithm structure commonly used when processing satellite imagery for the extraction of features such as thermal anomalies associated with the presence of active fires. By introducing DL techniques in this area, it is expected to be the potential to construct a robust, reproducible model given training data and reliable output (“labels”), without the developer manually set the thresholds of the detection tests. Within this study we will explore the possibility of adapting a few DL models to data from VIIRS spaceborne sensor instead of RGB images that those models were normally optimised for. The reflectance and radiance data from 16 channels of VIIRS will be used as training input while its active fire product will be used as labels. Furthermore, this study will also explore whether such DL models are capable to validate the fire detection results by learning the patterns from external “labels” of ESA-CCI high resolution landcover map and adapt it to the VIIRS multiple channels input data.
Tim Trent	Evaluation of TCWV in CMIP6 models using the G-VAP Archive	Satellite observations of total column water vapour (TCWV) represent one of our longest records of absolute concentrations of water vapour in the Earth climate system. A key challenge in using these columnar records for climate assessment is that while they provide global coverage, they do not intrinsically resolve vertical variability that was responsible for ~50% of the variance seen in the CMIP5 models from the last IPCC. This study aims to address this by combining TCWV estimates with complimentary variables that allow the assessment of dynamical processes within the CMIP6 model runs. The GEWEX Water Vapor Assessment (G-VAP) archive (ensemble product) will be used with the ECMWF wind fields and precipitation data from the Global Precipitation Climatology Project (GPCP) to assess convective and recycling processes within CMIP6 models.
Tristan Quaife	Updates on Solar Induced Fluorescence modelling activities	Solar induced fluorescence (SIF) is becoming widely used as a proxy for gross primary productivity (GPP) and can be measured by Earth Observation satellites such as OCO and GOSAT. A major attraction of SIF is that it is independent of the assumptions embedded in light use efficiency based GPP products derived from satellite missions such as MODIS. However, to compare land surface model predictions of GPP to SIF data requires either (a) translation of SIF into estimates of GPP, or (b) direct predictions of SIF from the land surface model itself. The former typically relies on empirical relationships, whereas the latter can make direct use of our physiological understanding of the link between photosynthesis and fluorescence at the leaf scale and is therefore preferable. In this talk I present updates on the development of a forward modelling framework for SIF for the Joint UK Land Environment Simulator (JULES, the land surface component of the UK Earth System Model). I use a two stream radiative transfer approximation that is capable of translating between the leaf scale fluorescence and the canopy leaving radiance taking into account all levels of photon scattering. I will present global predictions of SIF from JULES, discuss the role of water stress and options for including this in the modelling, and show initial comparisons against satellite observed SIF.

Vincent Faure	Heat and salt content anomalies in Mozambique Channel Eddies using In Situ and satellite altimetry data	Mozambique Channel Eddies (MCE) are large anti-cyclonic eddies that propagate southward in the Mozambique Channel. Madagascar Dipoles are westward propagating cyclonic and anticyclonic eddy pairs that form south of Madagascar. All three eddy types are thought to contribute to the south-westward transport of heat and salt associated with water masses originating mostly in the Pacific Ocean, and transformed in the Indian Ocean. These eddies dissipate into the Agulhas Current, influencing the water that is eventually fed downstream into the South Atlantic Ocean via Agulhas Rings shedding, and contributing to the meridional overturning circulation (MOC). Using available hydrographic observations, Argo profiles and satellite altimetry data, we estimate heat and salt anomalies due to the eddies, along isopycnal surfaces, at the levels of the typical water masses found in the Channel: SubTropical Surface Water (STSW) and South Indian Central Water (CW). In the northern channel, MCE are associated with positive anomalies (of heat content and salt) in STSW, and negative anomalies at the CW level. Upon reaching the southern limit of the Channel MCEs tend to entrain colder waters of southern origin, or merge with local eddies. There, estimates of heat and salt transport suggest that the MCE anomalous properties are rapidly eroded before merging into the Agulhas Current, that would minimize their contribution to the MOC.
Wilfred Calder-Potts	The Effect of CO2 Concentration on Solar Induced Fluorescence.	Solar induced Fluorescence (SIF) is emerging as a promising new way to remotely measure photosynthesis, being more directly related to photosynthesis than reflectance based methods such as NDVI (Normalised Difference Vegetation Index). Satellite measurements of SIF have been successfully taken for over 10 years, and often show a linear relationship between SIF and GPP (Gross Primary Productivity – a measure of photosynthesis). Despite this fact, there is still much unknown about the relationship between SIF and photosynthesis. We are conducting an experiment in a greenhouse to investigate the effect of environmental factors on SIF and it's relationship to photosynthesis. Leaf level SIF measurements will be taken of Cocoa plants in different CO2 concentrations and temperatures. We hope to show whether or not CO2 concentration affects SIF. Preliminary results will be shown.
William Jay	Airborne Remote Sensing Capability available within NCEO	NCEO has the capability to collect and process airborne remote sensing data for environmental research in the UK and internationally. The suite of sensors within NCEO comprises: hyperspectral instruments covering the visible to short wave infrared (Specim Fenix) and thermal (Specim Owl) as well as a medium format digital camera (PhaseOne iXU). Data processing capability is provided through the NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS) by the team formerly operating as the NERC Airborne Research Facility Data Analysis Node. With over a decade of experience processing airborne data, including writing custom processing software and developing procedures for instrument calibration, NEODAAS is able to generate high quality standard products (e.g., calibrated and mapped data) for environmental research. Additionally, they are able to process data acquired in non-standard configurations and offer advice on data processing from new sensors. As well as processing new data, NEODAAS work with users via a help desk service to produce new products from the archive of airborne data held at CEDA such as atmospherically correcting data and applying Structure from Motion photogrammetry to analogue and digital photographs. Airborne remote sensing continues to remain relevant in environmental research. Although satellite swaths cover a larger area at once and drones offer high spatial resolution, the flexibility and larger payload capacity of aircraft means they are still able to collect unique and valuable datasets to support research.

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