Information Document:

UK Earth Observation Climate Information Service

1 INTRODUCTION

The UK Earth Observation Climate Information Service is a collaborative project led by the National Centre for Earth Observation, involving over a dozen UK universities and research organisations. Project leadership is placed at NCEO University of Reading, and administrative and investment leadership at NCEO University of Leicester.

The funded partner organisations in EOCIS are:

- University of Reading
- University of Leicester
- University of Leeds
- University of Southampton
- University of Edinburgh
- University College London
- Bangor University
- Swansea University
- Northumbria University
- King's College London
- National Physical Laboratory
- Rutherford Appleton Laboratory
- Plymouth Marine Laboratory
- Centre for Polar Observation and Monitoring
- National Centre for Earth Observation (investment lead)

Assimila Ltd (UK) were contracted to provide initial project management services until 30 April 2023. There is a cooperation agreement with the Space for Climate partnership (which is supported by the UK Space Agency and member organisations).

EOCIS commenced in the first quarter of 2023 and is currently funded until 31 March 2025.

EOCIS will demonstrate the UK's first national supply chain for a range of essential climate variables obtained by Earth Observation (EO) and building on UK research excellence. EOCIS will invest in transformations of climate data into higher-level climate information that advances both climate science and informed practical action in response to the challenge of climate change.

EOCIS has been funded by the National Environment Research Council, part of UK Research and Innovation, using earmarked funding provided by the Department for Science, Innovation and Technology (formerly within BEIS)[1] [2].

1.1 EOCIS mission and activity

The UK Earth Observation Climate Information Service exists to make a positive difference to responses to the climate emergency. Climate information is an important tool in responding to climate change, in science, decision-making and business. EOCIS brings together UK research-community expertise to create and make available high quality, trustworthy climate information based on measurements of Earth's environments from space. EOCIS will complement and collaborate with others meeting the need for climate information: nationally and internationally, and across science, commerce and policy.

Five programmatic elements will address the above scope shown in the figure below. The appendix lists the activities within these programmatic elements and briefly describes their main ambitions.

[1] https://www.gov.uk/government/publications/earth-observation-investment
[2] https://www.nceo.ac.uk/article/uk-government-commits-close-to-400-million-to-earth-observation-research-and-industry-projects/

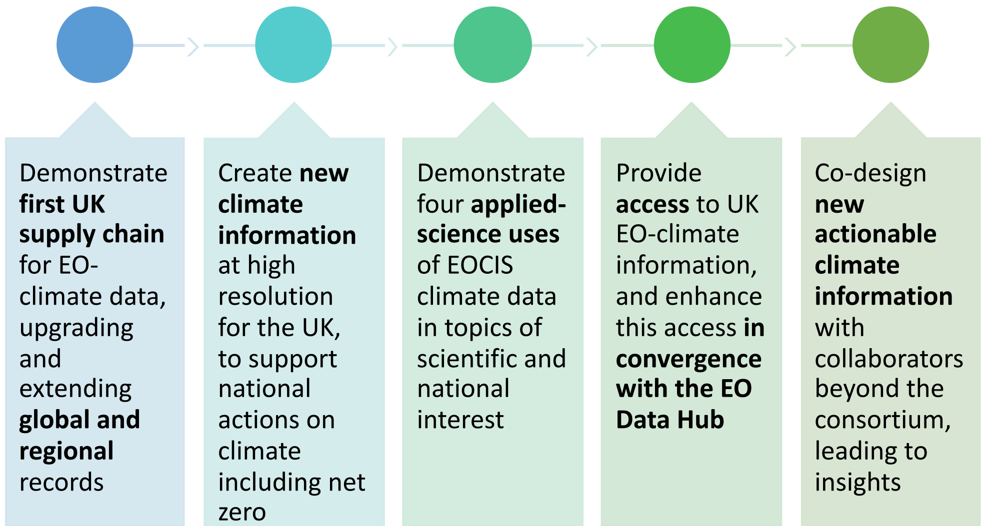

Figure 1 – Strands of activity within the EOCIS.

A key relationship in delivering the EOCIS mission is with the Earth Observation Data Hub (EODH) investment in digital infrastructure. EODH runs in parallel, led by the Centre for Environmental Data Analytics and also administered by NCEO. EOCIS will work with EODH to help shape the latter's technical approach and will exploit its outcomes; EODH provides much of the expansion in digital infrastructure needed to achieve EOCIS goals.

1.2 EOCIS management structure

The activities of EOCIS are organised in six work packages (WPs) as illustrated below.

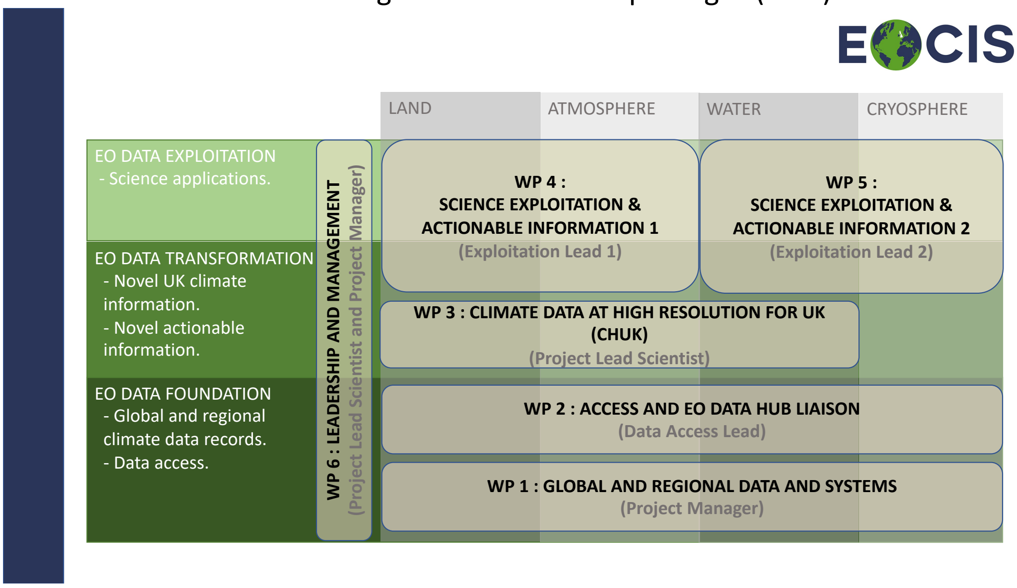

Figure 2 -- EOCIS management structure

As shown in Figure 2, the project manager will deliver project manager services within WP 6 (Leadership and Management) and will be lead coordinator for WP 1 (Global and Regional Data and Systems). Quality review of data and documentation is led by the project manager within WP 1.

The five WP leads (including the project lead and project manager) constitute the project management group (PMG) for EOCIS. The PMG is responsible for progress monitoring and co-ordinating agile responses to raised issues by activity leads. The project manager is responsible for organising onward reporting of progress and issues to NCEO and NERC.

2 Activities within EOCIS

EOCIS brings together expertise across over a dozen UK universities and research centres, selected to bring strong experience on creating high-quality, trustworthy climate information. The strands of activity within EOCIS are explained below.

2.1 Global and Regional Datasets

EOCIS will support continuity of production of several global and regional datasets, many with a long heritage of both UK national and ESA CCI research and development [1], and several having been generated routinely within Copernicus services until 2022 or early 2023. Improvements in global and regional datasets will include: better energy efficiency of processing to improve the sustainability of production; increased processing chain resilience; and improved timeliness of routine generation.

For most of the global and regional variables, the fundamental remote sensing science that is essential for climate data record creation will continue to be pursued through international collaboration within the ESA Climate Change Initiative and within the programmes of the National Centre for Earth Observation and Centre for Polar Observation and Modelling.

Table 1 lists the global and regional climate data record activities, the lead partners, and highlights of the EOCIS activities.

Table 1. Listing of global and regional datasets

Climate record	Lead	Headline relevance	Evolution and targets
Aerosol and particulate matter	Peter North, NCEO Swansea	Atmospheric aerosols modify climate change globally and regionally. Sources such as wildfires, transport and industry are policy sensitive. Factor in air quality and human health.	Improve surface reflectance model (see also UK Hi-Res entry). Global reprocessing to create history, with ongoing generation at 10 day timeliness. Develop a surface particulate matter (PM) estimator (PM2.5 & 10). Routine processing.
Cloud-aerosol-radiation	Brian Kerridge RAL-NCEO	Climate radiative forcing and feedback. Radiation environment for planning solar energy.	Produce multi-year Sentinel-3/SLSTR data set to address user needs, benefitting from new L1 data and improvements through R&D in UK-NCEO & ESA CCI. Routine processing in delayed mode. Adapt SEVIRI NRT processing system to address user needs.
Radiatively active gases (H_2O, CH_4, O_3)	Brian Kerridge RAL-NCEO	Climate radiative forcing and feedback. Methane (CH_4) emissions and budget. Air quality.	Produce multi-year data sets to address user needs, benefitting from new L1 data and R&D in UK-NCEO & ESA projects. Routine processing in NRT. Application in "UK Methane Budget"
Methane (GOSAT)	Rob Parker, NCEO Leicester	CH_4 is a potent greenhouse gas, amenable in principle to emissions control, and thus important for climate change mitigation. Existing record exploited in >50 high quality publications.	Continue GOSAT record on annual update, and evolve to incorporate also GOSAT-2 ongoing. Upgrade quality in Arctic region specifically. See also exploitation study "UK Methane Budget".
Sea and lake surface temperature	Owen Embury, NCEO Reading Laura Carrea, Reading	Interface of ocean heat and atmosphere, marine heatwaves, ecosystem impact, fisheries. Usage: >110 citations of current version, ~150 users at CEDA last quarter; IPCC; climate modelling inc. Met Office.	Improve timeliness to 10 days or less, while maintaining ICDR production. Upgrade version following ESA CCI reprocessing. Add new sensors as arise. Link to ocean colour. Add marine heatwave alert to portal dashboard. See also "UK / global-coastal" targets.
Ocean reflectance and chlorophyll	Shubha Sathyen-dranath, NCEO PML	Characterise phytoplankton distributions, marine carbon uptake and net zero strategy, fisheries. Usage: ~200 papers; ~400 users at CEDA, inc. IPCC, Met Office.	While maintaining 2-day timeliness of ICDR: reduce compute energy/CO_2 ; AI-driven quality upgrade; incorporate major new data flow (VIIRS). Link to SST. See also "UK / global-coastal" targets.
Land surface temperature (LST)	Darren Ghent, NCEO Leicester	LST is a constraint on ecosystem functioning, and monitors heatwave and drought impacts.	Increase timeliness from few months to 5 days. Improve efficiency of processing to reduce carbon footprint of computing. Incorporate VIIRS as new data stream to capture more of diurnal cycle. Link to "climate-data at high resolution for the UK" (CHUK)
Fire Occurrence & Fire Emissions	Martin Wooster NCEO King's College London	Landscape fire is Earth's largest terrestrial disturbance agent, influenced by climate	Investigate AI-driven plume detection; false alarm fire detection masks; use of joint Sentinel-5P, MAIC and geostationary data on

	David Moore, NCEO Leicester	and human activities, and responsible for air quality effects causing hundreds of thousands of premature deaths globally per annum. Current fire occurrence data are accessed by tens of thousands of users per day worldwide for up-to-date or historical fire activity.	fires for first time. Generate the first worldwide fire emissions estimation system based on geostationary data. Explore extension to full global (including high latitudes) using polar orbiter data.
REGIONAL DATASETS			
Ice sheet mass	Andrew Shepherd, CPOM Northumbria	Ice sheet mass trends are a key indicator of climate change, a major component of the global sea level budget, an essential constraint on projections of future sea level rise, and an identified tipping point in the climate system.	Production and distribution of polar ice sheet surface elevation change from satellite altimetry. Will be upgraded to daily frequency and to add redundancy for operational stability.
Ice velocity, Antarctic Ice Sheet	Anna Hogg, University of Leeds	Change of ice-sheet marginal dynamics is an early warning for acceleration of ice sheet mass-loss driven sea-level rise.	Move to sustained operation with 6 to 12-day repeat observations (dependent on repeat cycle of Sentinel-1 mission), backed by new reprocessing. Prepare for application to Greenland ice sheet.
Arctic sea ice	Andrew Shepherd, CPOM Northumbria	Arctic sea ice trends are a key indicator of climate change, an obstacle to maritime activities, a factor in habitat loss, and a significant influence on wintertime weather in northwest European	Production and distribution of Arctic sea ice thickness measurements from satellite altimetry. Upgraded timeliness to within 2 hours and increase redundancy for operational stability.
Africa Soil Moisture	Tristan Quaife, NCEO Reading	Understanding the state and likely future evolution of soil moisture is important for use in decision support tools and has particular value for growers and extension workers in drought-prone areas of Africa. Link to food security.	R&D prototype now needs putting on an operational footing. The data can then be embed in decision support tools. Explore the production of other variables, such as vegetation productivity metrics.

As with all EOCIS datasets, global and regional products will be available freely to all under a licence requiring attribution and citation when used in further products, services or publications.

2.2 Climate Data at High Resolution for the UK

A new activity within EOCIS is climate information to support national actions on climate resilience and commitments to net zero carbon. The underpinning science will be development of climate data at high resolution (~100 m) for the UK (CHUK), using methods designed to be applicable to any domain globally. CHUK data will be multivariate, interoperable and oriented towards exploitation within geospatial analysis. High resolution data will be placed in a geospatial context (see section 2.4 on digital infrastructure, and Figure 1) ready for spatial and time-series analyses.

The aspiration for high resolution with reasonable time sampling implies a mix of observational approaches, including combining high-resolution-less-frequent satellite observations with medium-resolution-more-frequent observations, as well as other downscaling approaches. Some uncertainties in downscaling/blending are reducible by harmonisation [2] of sensors prior to their combination. Harmonisation studies for both reflectance wavelengths (improving the combination of Sentinel 2 data and, for example, the Ocean and Land Colour Instrument of Sentinel 3) and infrared wavelengths (for example, to use the Sea and Land Surface Temperature Radiometer and Landsat thermal bands better together). This is led by the National Physical Laboratory.

In addition, two projects address near-real-time responses to climate-related events – landscape fires and urban flooding.

Table 2 – Climate data and High-resolution for the UK (CHUK) projects

Climate record	Lead	Headline relevance	Evolution and targets
All-surface temperature	Darren Ghent, NCEO Leicester Niall McCarroll, NCEO Reading	Surface temperature (ST), seamless for land, lakes and UK coastal zone*. ST is a constraint on ecosystem functioning, and informs heatwave impacts at field, lake/coastal and sub-urban scales; important for food security and city-scale climate adaptation.	Consolidate early-stage Landsat9 processing capabilities (LST, SST/lake). Develop seamless Landsat9-informed downscaling from meteorological sensor ST, testing options. Establish routine processing. Develop value-added indices.
Land vegetation parameters	Jadu Dash, University of Southampton Mat Disney, NCEO UCL	Measures of photosynthesis to constrain land ecosystem modelling, including landscape carbon: 'net zero' policy delivery for UK.	Testing to optimise photosynthesis parameters to UK. Validation for UK sites. Composited, gap-filled on a target of 15 days timeliness. On compatible grids with other UK data.
Coastal-zone water colour	Steve Groom, NCEO PML	Water colour in UK coastal waters including chlorophyll-a and suspended particulates, and related indicators. Usage: 100s papers; 100's of users.	Daily updates: with 1 d latency (for 300m data with downscaling); AI-driven quality upgrade; possible inclusion of new data (Sentinel 2C). Link to high-resolution SST.
Lake catchment change indicators	Stefan Simis NCEO PML	New dataset. Indicators of change for use in 'digital catchment twins' and targeted sampling and monitoring, aiming for increased uptake in policy and management. Variable-resolution change indicators (down to 10 m) also made available on common grid (~100 m).	Daily updates with 'availability + 1d' latency, on-the-fly and delayed event detection, and on-demand archive processing capability. Explore link to lake temperature (within "All-surface ST") and land-use to refine change detection and trigger highest-resolution monitoring.
Urban flooding	Sarah Dance, NCEO Reading	Flooding is a high impact hazard for the UK, interacting with climate change. Urban floodwater	Deep learning approach to automatic detection of change in double-scatter pixels for flooded urban area. Training dataset to

		capability is a major gap, because of difficulty of interpreting synthetic aperture radar (SAR) in cities. Prototype method involving expert intervention validates well and requires automation with a deep learning approach.	be used with semi- or un-labelled machine learning method. Operationalised for <12 hour latency.
Aerosol and particulate matter	Peter North, NCEO Swansea	Sources of aerosol and PM such as wildfires, transport and industry are policy sensitive. Factor in air quality and human health, known to have UK health impacts.	Develop version of processor to generate ~1 km consistent surface reflectance, AOD, PM2.5 and PM10 over UK domain.
UK Rapid Fire Detection System	Martin Wooster King's College London	Wildfires represent around 1/3rd of UK Fire and Rescue Service Call-Outs, and are now included on the UK Risk Register. Early fire detection is of significant importance to fire management.	Explore relevance of MTG and any complementary systems for UK rapid fire detection. Set up system for providing early alerts and web-based display and interrogation of low-latency data.
Harmonisation for downscaling.	Sam Hunt, NPL	To move to high resolution at good temporal resolution, joint use of high and medium resolutions sensors is needed. Harmonisation between these will improve the quality of downscaling and help quantify uncertainty.	For both reflectance and infrared domains, need to: establish a virtual reference; define measurement functions and uncertainty budgets for target sensors; prepare sensor/reference matches; spectral-band adjustments; cross-calibration using metrologically rigorous errors-in-variables regression.

2.3 Scientific demonstrators

EOCIS products will be exploited within the project in four science studies.

The first demonstrator will use CHUK data on vegetation state and surface temperature to constrain a model for land carbon cycling, including land under land management, which runs at high resolution. The intention is to prove resilient results that support national greenhouse gas reporting obligations within UNFCCC.

The second demonstrator will apply digital twin methodologies to create new decision-making support for food security across Africa, in relation to land water balance and timely soil moisture prediction. The digital twin approach will be to emulate a mechanistic land-surface model to enable fast predictive capabilities initialised using EOCIS data.

The third demonstrator is a study of the interaction of inland and coastal waters with climate variability and change, in terms of temperature and water quality.

The final demonstrator is to a use the EOCIS methane concentration datasets, tuned to high latitude conditions, to constrain inversion of a coupled chemistry-climate model to estimate net surface methane fluxes across Eurasia.

2.4 Digital infrastructure

EOCIS will work closely with a sister project, the "Earth Observation Data Hub" developments, to help shape and deliver digital infrastructure that supports accessibility to EOCIS climate data and enables efficient extraction by users of climate information. A key part of the digital infrastructure will be to interface EOCIS data with information from national mapping and environmental agencies, in the context of geographical information system interfaces.

2.5 Projects to drive novel forms of climate information

EOCIS will work with users beyond the consortium to co-design new forms of contextualised information [3] based on EOCIS data sets (not exclusively). These activities will be defined through the course of the running of the service. These projects will be commissioned by a mixture of directed procurements (invitations to tender) and more open call mechanisms. The latter mechanisms are to be defined, and this information document will be updated in due course with more information.

Climate information	Lead	Headline relevance	Evolution and targets
New forms of actionable climate information	Project Management Team Co-PIs to be determined, along with external partners	Galvanise the efficiency and productivity of public and commercial climate-related services by co-designing, with public and commercial stakeholders, new forms of timely climate information from climate data, for data-driven use cases.	Criteria development for initiating, facilitating and monitoring activities. ~10 activities in two tranches of ~5 activities each. Activities will lead to summary (including "dashboard" style) information and indicators on UKEO CIS portal.

3 Contacts

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4 References

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