climate change initiative

→ CLIMATE MODELLING USER GROUP

D6.2 CMUG Slidedeck

CMUG Activities, Results & Scientific Highlights

V1.0: September 2023 – January 2024

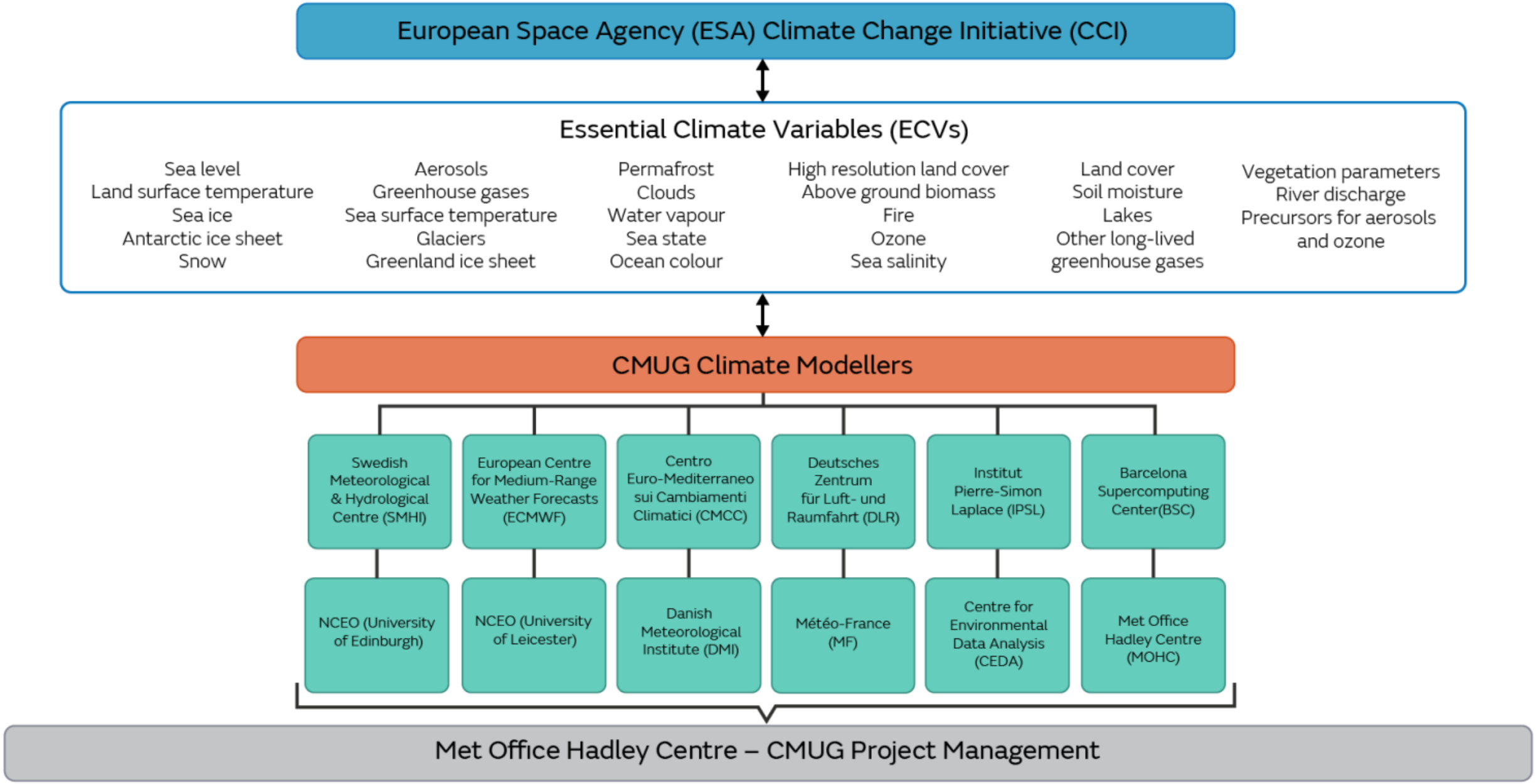
cmug cci

What is CMUG?

ESA has established the Climate Modelling User Group (CMUG) to place a climate system perspective at the centre of its Climate Change Initiative (CCI) programme. CMUG also provides a dedicated forum through which the Earth observation data community and the climate modelling and reanalysis community can work closely together. CMUG works with the Essential Climate Variable (ECV) CCI projects to achieve this goal.

CMUG is a consortium comprising: Met Office Hadley Centre, DLR, ECMWF, IPSL, Météo-France, SMHI, BSC, CMCC, DMI, and NCEO (Uni Leicester and Uni Edinburgh).

Met Office Climate Modelling User Group (CMUG) Project Structure



CMUG - Objectives

CMUG's objectives are:

1. Support the integration within the CCI programme through:
   a) Requirements and user assessment from the Climate Modelling Community
   b) Feedback from a 'climate system' perspective
2. Foster the exploitation of Global Satellite Data Products within the Climate Modelling Community by:
   a) Promoting the use of CCI data sets to climate modellers
   b) Building partnerships and links with existing research organisations, networks and scientific bodies of the Climate Modelling Community
3. Assess quality and impact of individual/combined Global Satellite Data Products in Climate Model and Data Assimilation context by:
   a) Assessing suitability of products for climate applications (e.g., climate modelling, decadal prediction, reanalysis, etc.)
   b) Quantifying their incremental value on model performance in an objective manner

CMUG – Main activities

CMUG's main activities are:

1. Refining of scientific requirements derived from GCOS for climate modellers
2. Provide technical feedback to CCI projects
3. Assess the global satellite climate data records (CDRs) produced from the CCI consortia
4. Look specifically at required consistencies across ECVs from a user viewpoint
5. Promote and report on the use of the CCI data sets by climate modellers
6. Interaction with related climate modelling and reanalysis initiatives

CMUG – Future Evolution of Obs4MIPs

A wide variety of observationally-based datasets are used for climate model evaluation. Obs4MIPs (Observations for Model Intercomparisons Project) refers to a limited collection of documented datasets that have been organised according to the Coupled Model Intercomparison Project (CMIP) model output requirements and made available on the Earth System Grid Federation (ESGF).

This effort was initiated with support from NASA and the U.S. Department of Energy (DOE) and has now expanded to include contributions from a broader community including ESA. Obs4MIPs underpins model evaluation in CMIP (and beyond) and thus makes a significant contribution to the assessment of and sustained improvement in model quality, e.g. as reported by IPCC. The CCI ECV projects contribute ECV data sets, which are decided to be of most interest to the CMIP community, to Obs4MIPs.

https://aims2.llnl.gov/search/obs4MIPs/

CMUG – ESMValTool

The Earth System Model Evaluation Tool (ESMValTool) is an open-source community-developed diagnostics and performance metrics tool for the evaluation and analysis of Earth System Models (ESMs). ESMValTool allows for a comparison of single or multiple models against predecessor versions and observations. The aim of the ESMValTool is to take model evaluation to the next level by facilitating analysis of many different ESM components, providing well-documented source code and scientific background of implemented diagnostics.

https://esmvaltool.org/

CMUG – Scientific Study WP5.1

Study WP5.1 Machine Learning to Advance Climate Model Evaluation and Process Understanding

- This study is led by Lisa Bock. Additional contributors to this Study are Axel Lauer and Veronika Eyring from DLR.
- The main CCI ECVs used in this Study are Cloud, Land Cover, Land Surface Temperature, Sea Surface Temperature, Water Vapour, Soil Moisture, Permafrost, and Snow.
- It is estimated that this Study will run from September 2023 until March 2025.

Description

The Study comprises three parts. The first focuses on enhancing observational products for climate model evaluation with machine learning. This involved developing and applying a Machine Learning (ML)-based approach to derive cloud classes from high-resolution satellite data and coarse-resolution climate models; the application of NN to ESA CCI Cloud data leading to timeseries of labelled ESA CCI Cloud data; and the use of this dataset for an evaluation of clouds by cloud classes in climate models (here: ICON-A). The second focuses on causal model evaluation for cloud regimes and land cover types by calculating causal networks from the timeseries of several cloud variables of ESA CCI data to analyse and investigate the causal connections among the cloud properties and their controlling factors. Then causal networks are analysed for different cloud regimes and different land cover types. The same method is then applied to output from global climate models (here: ICON-A) and resulting causal networks are then compared to the ones obtained from the observations to evaluate the models. Thirdly, the evaluation of CMIP6 models with the ESMValTool will be undertaken. This involves CCI Snow and Permafrost datasets being implemented into ESMValTool and whenever possible, the CCI uncertainty estimates will be used to assess whether differences in the model simulations compared with the observations are significant.

Study progress

- Study kick-off at Integration Meeting (Nov, ‘23)
- Paper submitted (Kaps et al., 2023)
- Daily CLOUD CCI data implemented into ESMValTool began
- Tests of causal discovery for clouds with Tigramite package

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.2

Study WP5.2 Impacts and Evaluation of Vegetation Phenology Changes on Observed and Modelled Land-Atmosphere Processes

- This Study is led by Daniele Peano from CMCC. Additional contributors to this Study are Debbie Hemming and Rob King from the Met Office.
- The main CCI ECVs used in this Study are Vegetation, Snow, Water Vapour, Land Surface Temperature, Biomass, Land Cover, and Soil Moisture.
- It is estimated that this Study will run from September 2023 until August 2025.

Description

The Study comprises two parts. The first will occur during the development phase of the CCI Vegetation and, through interaction with the CMUG team, will provide testing and feedback on preliminary LAI (Leaf Area Index) and FAPAR (Fraction of Absorbed Photosynthetically Active Radiation) data. The second involves analysis of the relationships between phenology and land-atmosphere processes by defining a core set of phenology indicators at the global and habitat scale, quantifying the influence of phenology on land-atmosphere interactions, and comparisons with model and observed values.

Study progress

- Exchanged first LAI dataset from Vegetation CCI group
- Met with Vegetation CCI group (11th Jan) to share info on first LAI dataset

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.3

Study WP5.3 Impacts of Integrating CCI Land Cover Data in the ISBA Land Surface Model

- This Study is led by Jean-Christophe Calvet from Météo-France.
- The main CCI ECVs used in this Study are Land Cover, Land Surface Temperature, Soil Moisture, and Snow.
- It is estimated that this Study will run from September 2023 until August 2024.

Description

The Study will assimilate CCI Snow Water Equivalent (SWE) in the ISBA land surface model of Meteo-France and CCI soil moisture and land surface temperature products are used as a benchmark to compare simulations with and without SWE assimilation. This comparison is repeated twice, with and without using CCI land cover maps.

Study progress

- Contacted by Vegetation Parameters CCI (9th Jan) and informed that demo of 'effective' LAI product available

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.4

Study WP5.4 Seasonal Predictability of Ocean Biogeochemistry and Potential Benefits of ESA CCI Data Assimilation

- This Study is led by David Ford from the Met Office. Additional contributors to this Study are Pablo Ortega and Joan Llort from BSC.
- The main CCI ECVs used in this Study are Sea Surface Temperature, Sea Surface Salinity, Sea Ice, Sea Level, and Ocean Colour.
- It is estimated that this Study will run from April 2024 until July 2025.

Description

The models EC-Earth3-CC and GloSea6/MEDUSA are used. This Study has a tentative start date of April 2024 and comprises of two main parts with a third optional part. The first main part is the assimilation of ESA CCI variables to produce forced ocean/sea-ice reconstructions with EC-Earth3-CC and GloSea6/MEDUSA predictions systems. This includes the assimilation of physical variables: Sea Surface Temperature, Sea Ice Concentration and 3D ocean temperatures from EN4 below the ocean mixed layer. Then additional assimilation of Ocean Colour to determine the role of non-physical variables to BGC predictability and then additional assimilation of Sea Surface Salinity, Sea Surface Height and 3D ocean salinity from EN4 (GloSea6/MEDUSA). The second main part is exploring the impact of assimilation choices of these reconstructions on physical and biogeochemical properties such as evaluating physical properties of reconstructions and identifying a best strategy to reconstruct ocean biogeochemistry. The third, optional, part is to explore the impact of assimilation choices of these reconstructions on seasonal predictions.

Study progress

- Start date decided – April 2024
- Planned work mentioned at OceanPredict Science Team meeting (Nov)

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.5

Study WP5.5 Cloud and Aerosol Analysis

- This Study is led by Angela Benedetti and Kirsti Salonen from ECMWF. Additional contributors to this Study are Axel Lauer from DLR and Jeronimo Escribano from BSC.
- The main CCI ECVs used in this Study are Aerosol, Cloud, Soil Moisture, and Water Vapour.
- It is estimated that this Study will run from September 2023 to August 2024.

Description

The Study comprises of three parts. The first part is undertaking dust aerosol analysis with the BSC system (Jeronimo Escribano, BSC). This would involve constraining global dust aerosol simulations from the BSC MONARCH model with CCI data to produce dust analyses during the extraordinary event of June 2020. The second part is to undertake Cloud / Aerosol analysis with the ECMWF system (Angela Benedetti and Kirsti Salonen, ECMWF). This would involve joint assimilation of Aerosol and Cloud ECVs in the ECMWF IFS during June 2020 and September 2021 with the IFS 4DVar scheme in CAMS configuration. The third part is to undertake the Cloud and Aerosol analysis validation Study (Angela Benedetti and Kirsti Salonen, ECMWF; Axel Lauer, DLR; and Jeronimo Escribano, BSC) involving evaluation using the ESMValTool and internal tools at BSC/ECMWF.

Study progress

- Study kick-off Dec 2023
- WP5.5.1 Swansea Uni provided SLSTR v1.14 data for Dust aerosol analysis with BSC system. Also, first look at SLSTR AOD, Dust AOD, and Coarse/fine AOD data (Dec-Jan)
- WP5.5.2 Technical work ongoing to process data into format ingested to ECMWF system for cloud/aerosol analysis with ECMWF system

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.6

Study WP5.6 Snow Dynamics Impacts on Temperature / High Latitude Climate

- This Study is led by Philippe Peylin and Catherine Ottle from IPSL.
- The main CCI ECVs used in this Study are Snow Cover, Land Cover, Land Surface Temperature, Fire, and Biomass.
- It is estimated that this Study will run from September 2023 until February 2025.

Description

The Study's main objective is to improve our understanding and modeling of snow-vegetation-atmosphere feedback, with the IPSL climate model (LMDZORCHIDEE) and various CCI products (especially snow products). The Study comprises several parts. The first part involves data analysis including consistency check/analysis between Snow Cover (mass & extent), Land Cover and other CCI products (LST; Fire; Biomass; LAI) + Albedo with analysis of the differences between short and tall vegetation and Deciduous & Evergreen. The second part involves ORCHIDEE model evaluation with the evaluation of the simulated snow cover dynamics (mass and extent) and snow albedo using simulations with prescribed climate forcing (e.g., ERA5) and define a set of key “homogeneous points” for the identification of model biases. The third part involves model improvement with improved soil thermics (carbon impact on soil thermal properties; ongoing work) and SCF parameterizations and accounts for Shrubs and the representation of Snow - Vegetation dynamics. The fourth part involves Snow model parameter optimisation with model sensitivity experiments to identify critical parameters (Morris / Sobol approaches) and multi-site optimisation (local/global approaches, History Matching etc.) using Albedo, SCF and SWE data. The fifth, optional, part is to explore Coupled Model simulations with the use of the Coupled LMDZ -ORCHIDEE model (AMIP type simulation: fixed SST, SIC) and exploring historical simulations to analyse the impact of the “improved snow model” on surface-atmosphere feedbacks.

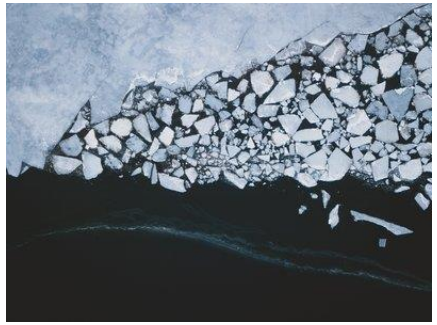
Study progress

- WP5.6.1 Analysis of SCF and SWE products and their uncertainties in relation with vegetation type undertaken. Comparison with modelled SCF in ORCHIDEE (over 40°N) and links with surface albedo products have been studied. Comparison between surface albedo products and modelled albedos in ORCHIDEE undertaken.
- WP5.6.2 first comparison of SCF and SWE in ORCHIDEE undertaken, ongoing model sensitivity analysis to identify key parameters to optimise, ongoing optimisation of snow cover fraction and snow albedo parameterisation in ORCHIDEE, and ongoing evaluation of assimilation results

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.7



Study WP5.7 Ice Sheets and Atmospheric Drivers

- This Study is led by Ulrika Willén from SMHI. Additional contributors to this Study are Ruth Mottram and Shuting Yang from DMI.
- The main CCI ECVs used in this Study are Land Surface Temperature, Total Column Water Vapour, Cloud, and Snow.
- It is estimated that this Study will run from February 2024 until August 2025.

Description

The scientific questions this Study aims to address include:

- Can regional/global climate models represent accurately the atmospheric and surface processes affecting the ice-sheets?
- Do the models capture the variability of the ECV's, and the albedo and emissivity feedbacks over the ice sheets?
- Where, when and why do the surface mass (energy) balance of the models' processes perform least and most well?
- Which ECV's show the most important biases affecting the surface mass budget estimates from regional/global climate models?
- Can the metrics be used for observational based model selection to reduce the spread of the ice sheet contributions to the future sea level rise?

Mottram et al. (2019) showed mass change time series for the entire Greenland Ice Sheet generated by DTU and TUDR and inter-comparison of mass change from GRACE (Greenland Ice Sheet CCI GMB product) and two regional climate models (HIRHAM5 and RACMO2.3) for different drainage basins and the entire Greenland Ice Sheet. This Study plans to repeat this type of inter-comparison for SMB and for the observed Surface Elevation Changes (SEC) for the whole basin and the sub-basins, comparing the observed variability with the regional models Surface Energy Balance (SEB) and the individual components (SWN, LWN, LE, and H) for Greenland and Antarctica.

Study progress

- Study kick-off Integration Meeting (Nov, '23)
- PolarRes regional simulations made for Antarctica and Greenland

Results and conclusions

Will be provided once ready.

CMUG – Scientific Study WP5.8

Study WP5.8 Using Machine-Learning to Evaluate and Understand our Capability to Model Tropical Wetland Methane Emissions

- This Study is led by Rob Parker and Cristina Ruiz Villena from NCEO (University of Leicester). Additional contributors to this Study are Nic Gedney from the Met Office and Paul Palmer from the University of Edinburgh.
- The main CCI ECVs used in this Study are Greenhouse Gas (methane), Land Surface Temperature, Soil Moisture, Land Cover, and possible Vegetation.
- It is estimated that this Study will run from January 2024 until July 2024.

Description

The models used are JULES (land surface) and GEOS-Chem (atmospheric). This Study aims to develop an emulator for JULES wetland methane, use its explainability to show which factors matter in the model, drive the emulator with CCI Earth Observation data to generate wetland fluxes and compare those to a methane inversions performed on GOSAT/TROPOMI ESA CCI data. Current ensembles of JULES simulations with different driving data, temperature dependency, vegetation and wetland masks show massively different methane fluxes. This Study aims to address this.

Study progress

- Discussions with CCI Science Leads at Colocation and Integration meetings
- JULES simulations carried out using multiple model setups
- JULES emulator development – progress on designing emulator development framework to improve efficiency of creation, deployment and analysis of machine-learning based emulators
- JASMIN Group Workshop set up to enable data sharing and Uni Leicester signed data usage agreement ith Met Office

Results and conclusions

Will be provided once ready.

Other Scientific Highlights & Publications

- A new Cloud Class Climatology dataset (CCClim) has been generated which combines active and passive satellite observations with machine learning (ML) and provides a new opportunity for improving the understanding of clouds and their related processes. CCClim is based on cloud property retrievals from the European Space Agency's (ESA) Climate Change Initiative (CCI) Cloud_cci dataset.
- A paper has been submitted (Kaps et al., 2023) which shows that the cloud classes in CCClim are physically meaningful and can be used to study cloud characteristics in more detail. The goal of this is to make real-world clouds more easily understandable and eventually improve the simulation of clouds in climate models.

- Kaps, A., A. Lauer, G. Camps-Valls, P. Gentine, L. Gómez-Chova and V. Eyring, "Machine-Learned Cloud Classes From Satellite Data for Process-Oriented Climate Model Evaluation," in IEEE Transactions on Geoscience and Remote Sensing, vol. 61, pp. 1-15, 2023, Art no. 4100515, doi: 10.1109/TGRS.2023.3237008.

- Kaps, A., Lauer, A., Kazeroni, R., Stengel, M., and Eyring, V.: Characterizing clouds with the CCClim dataset, a machine learning cloud class climatology, Earth Syst. Sci. Data Discuss. [preprint], https://doi.org/10.5194/essd-2023-424, in review, 2023.

- Bock, L., and A. Lauer: Cloud properties and their projected changes in CMIP models with low/medium/high climate sensitivity, Atmos. Chem. Phys. (accepted).