climate change initiative

→ CLIMATE MODELLING USER GROUP

Introduction to the 11th CMUG Integration Meeting

Richard Jones, CMUG Science Lead
Met Office Hadley Centre

richard.jones@metoffice.gov.uk

cmug
cci

Meeting Outline

9:15-10:00 Overview of CMUG phase 2

Presentation of CMUG plans for phase 2 (1 slide per WP/study) (30’)

10:00-11:00 First Breakout Session: Joint kick-offs for science studies

Room 1 (Moon) = WP5.1 Machine learning for process understanding

Room 2 (Mars) = WP5.8 Machine learning for wetland methane emissions

11:00-11:30 Coffee break 30’

11:30-12:30 First Breakout Session: Joint kick-offs for science studies

Room 1 (Moon) = WP5.3 Land cover (moon room)

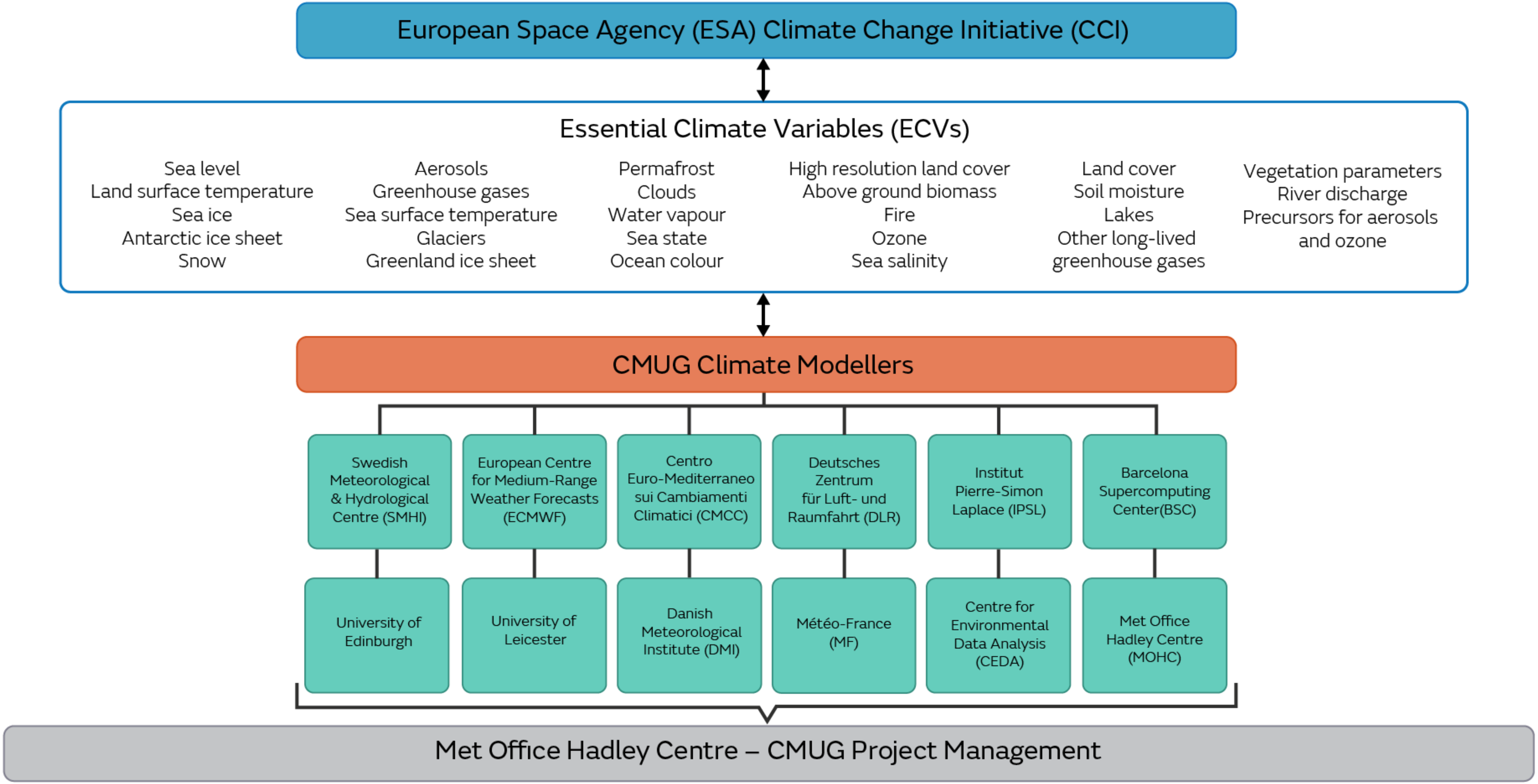
Room 2 (Mars) = WP5.6 Snow dynamics (mars room)

Room 3 (ECSAT 243) = WP5.7 Ice sheets (ECSAT 243)

Room 4 = Drop in for ESMValTool demo

11:30-12:30 Concluding remarks and meeting close (30')

Climate Modelling User Group (CMUG) Project Structure



CCI+ CMUG Phase 2 workpackages

WP 1: Climate Community Requirements Collection and Analysis

- WP1.1 User requirements for the new CCI ECVs
- WP1.2: User requirements update for all ECVs

WP 3: CMUG support to the future evolution of obs4MIPs

WP 4: CCI contributions to ESMValTool

WP 5: Cross-ECV Climate Science Studies

WP 6: Communications and Outreach

- Internal/external comms: Newsletters, Slide Decks, Website
- Internal/external meetings: Integration, Colocation, LPS, GCOS, WCRP

CMUG Phase 2 Science Studies

- Machine learning for process understanding
- Cloud and aerosol
- Ocean biogeochemistry seasonal predictability
- Land cover
- Machine learning for wetland methane
- Vegetation
- Ice Sheets
- Snow dynamics

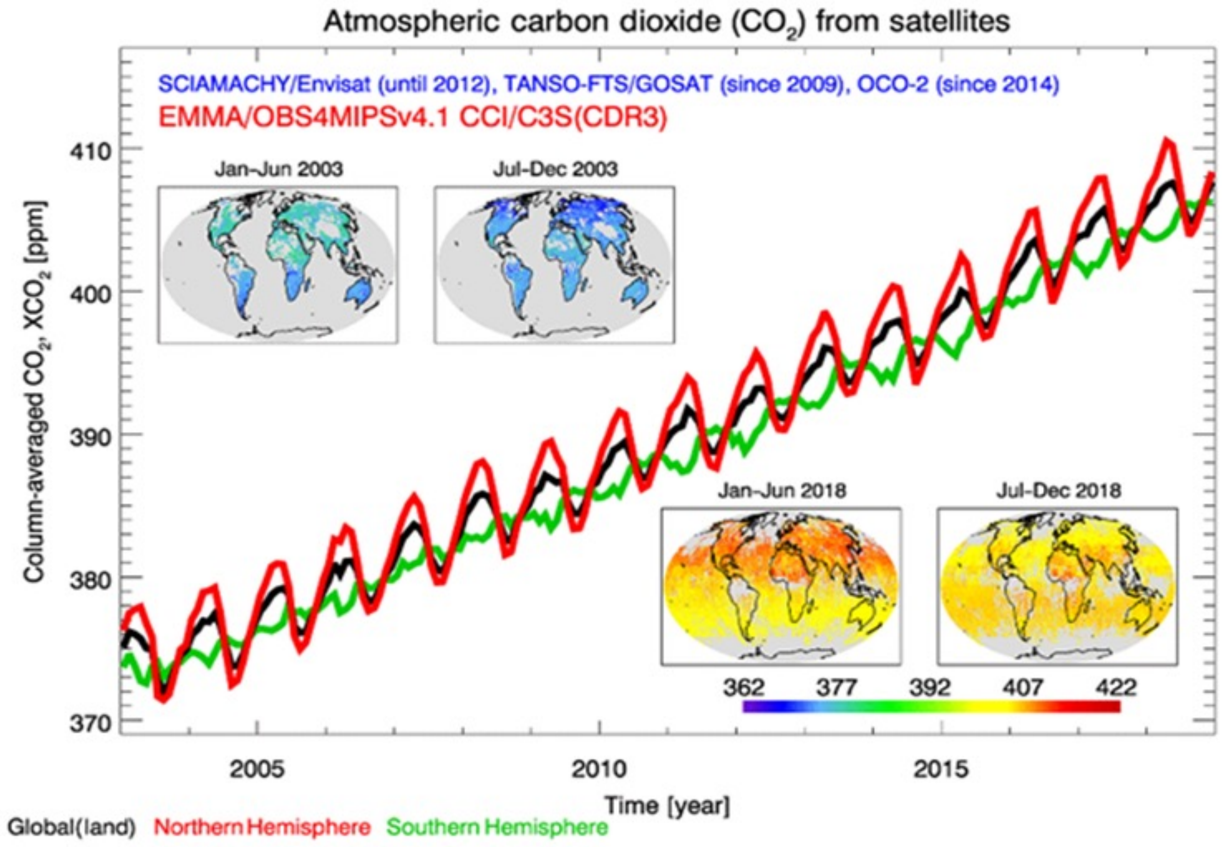
Obs4MIPs

Obs4MIPs (Observations for Model Intercomparison Projects) is a climate modelling community initiative to encourage widespread uptake of satellite observations for climate model verification and development.

- Excellent platform for sharing CCI data
- Consistent format
- Easily accessible
- Metadata included
- User documentation (Technical note)

How should obs4MIPs evolve??

- Higher resolution datasets
- Storage solutions
- Accessibility
- Data format
- Licensing



XCO2 CCI_GHG data set from obs4MIPs. Time series over land for three latitude bands and global maps. From Reuter et al. (2020).

ESMValTool

CMIP: understand climate changes and make the multi-model **output publicly available in a standardized format**

https://www.wcrp-climate.org/wgcm-cmip

CORDEX: develop regional climate downscaling **and foster communication and knowledge exchange** with users of regional climate information

https://cordex.org/

ESMValTool: *a community tool for fast and easy evaluation and analysis of Earth System Models*

- Traceable and reproducible
- Model performance assessment and quality control
- Publicly available, international community effort
- ESMValTool plots used in IPCC AR6
- CORDEX implementation under development
- Plans for use with CMIP7
- https://www.esmvaltool.org/

Summary

ESA Climate Change Initiative produces freely available long term climate data records of 26 Essential Climate Variables

CMUG is demonstrating and encouraging use of CCI datasets for a wide range of climate modelling and climate science applications

ESMValTool and Obs4MIPs are key community resources for evaluation and analysis of climate models

Meeting Outline

9:15-10:00 Overview of CMUG phase 2

Presentation of CMUG plans for phase 2 (1 slide per WP/study) (30’)

10:00-11:00 First Breakout Session: Joint kick-offs for science studies

Room 1 (Moon) = WP5.1 Machine learning for process understanding

Room 2 (Mars) = WP5.8 Machine learning for wetland methane emissions

11:00-11:30 Coffee break 30’

11:30-12:30 First Breakout Session: Joint kick-offs for science studies

Room 1 (Moon) = WP5.3 Land cover (moon room)

Room 2 (Mars) = WP5.6 Snow dynamics (mars room)

Room 3 (ECSAT 243) = WP5.7 Ice sheets (ECSAT 243)

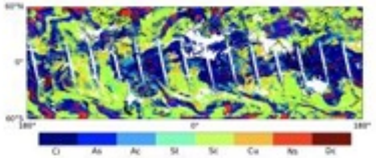
Room 4 = Drop in for ESMValTool demo

11:30-12:30 Concluding remarks and meeting close (30')

Machine learning to advance climate model evaluation and process understanding

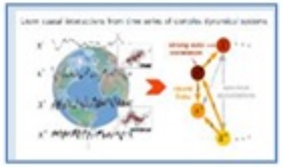
DLR esa

WP5.1.1
Enhancing observational products for climate model evaluation with machine learning



- Developing and applying a ML-based approach to derive cloud classes from high-resolution satellite data and coarse-resolution climate models
- Application of NN to ESA CCI **Cloud** data → timeseries of labelled ESA CCI **Cloud** data
- Use of this dataset for an evaluation of clouds by cloud classes in climate models (here: ICON-A)

WP5.1.2
Causal model evaluation for cloud regimes and land cover types



- Causal networks are calculated from the time series of several cloud variables of ESA CCI data in order to analyse and investigate the causal connections among the cloud properties and their controlling factors
- Causal networks are then analysed for different cloud regimes and different land cover types
- Same method is applied to output from global climate models (here: ICON-A) and resulting causal networks are then compared to the ones obtained from the observations in order to evaluate the models

WP5.1.3
Evaluation of CMIP6 models with the ESMValTool

ESMValTool
Earth System Model Evaluation Tool

- CCIs SNOW and PERMAFROST ESA CCI dataset implemented into ESMValTool as part of Task 4 will be applied to the CMIP6 model ensemble
- Whenever possible, the CCI uncertainty estimates are used to assess whether differences in the model simulations compared with the observations are significant.

With thanks to Lisa Bock

Impacts and evaluation of vegetation phenology changes on observed and modelled land-atmosphere processes.

Daniele Peano (CMCC), Deborah Hemming & Rob King (MO)

Task 5.2.1

Testing and feedback on preliminary LAI datasets

Vegetation CCI LAI and FAPAR

CMUG team

In the development phase of the CCI Vegetation and **interaction** with the CMUG team will provide **testing** and **feedback** on preliminary LAI and FAPAR data.

Task 5.2.2

Analyses of relationships between phenology and land-atmosphere processes

Snow

LAI and FAPAR

Land cover

Water vapour

biomass

soil moisture

Land surface temperature

ERA5

FluxNet

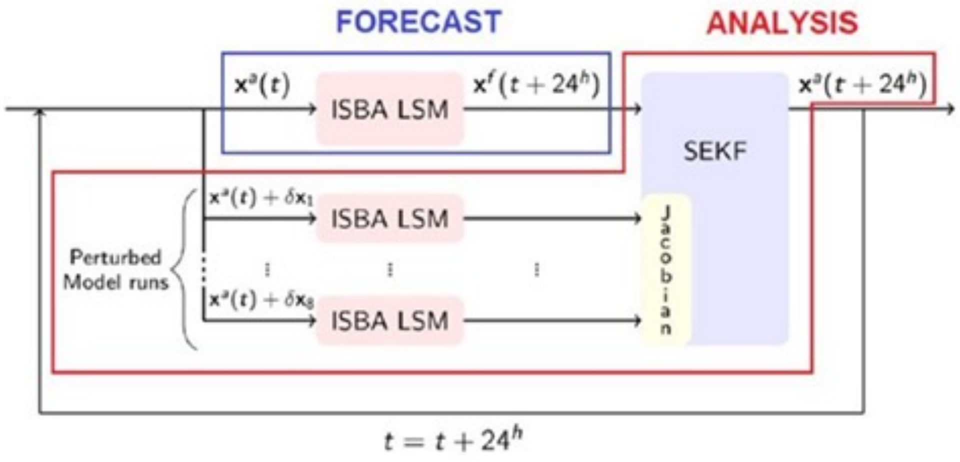
CMIP6

In this tasks, the **CMUG team** will:

- ➢ define a core set of **phenology indicators** at global and habitat scale;
- ➢ Quantify the influence of phenology on **land-atmosphere** interactions;
- ➢ **Compare** with model and observed values.

With thanks to Debbie Hemming

$$x^a = x^f + K(y^o - H(x^f))$$



- **LDAS-Monde**
  - Integration of satellite observations into the ISBA land surface model
  - Involves the CTRIP river discharge model
  - Sequential assimilation of LAI
    - Flexible LAI thanks to photosynthesis-driven phenology
    - Root-zone soil moisture can be analysed assimilating LAI
    - Joint LAI and SM assimilation is possible
  - Sequential assimilation of Snow Water Equivalent (SWE)

With thanks to Jean-Christoph Calvet

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry

- WP1: Assimilation of ESA CCI variables (SST, Sea Ice, SSS, Sea Level, Ocean Color) to produce reconstructions
  - Subtask 1.1: assimilate only physical CCI variables
  - Subtask 1.2: assimilate physical and biogeochemical CCI variables

- WP2: Impact of assimilation choices of these reconstructions on physical and biogeochemical properties
  - Subtask 2.1: evaluate physical properties of reconstructions
  - Subtask 2.2: identify best strategy to reconstruct ocean biogeochemistry

- [Option, unfunded] WP3: Impact of assimilation choices of these reconstructions on seasonal predictions
  - Subtask 3.1: production of seasonal predictions
  - Subtask 3.2: evaluation of seasonal predictions (e.g., ACC, RMS Skill Score)

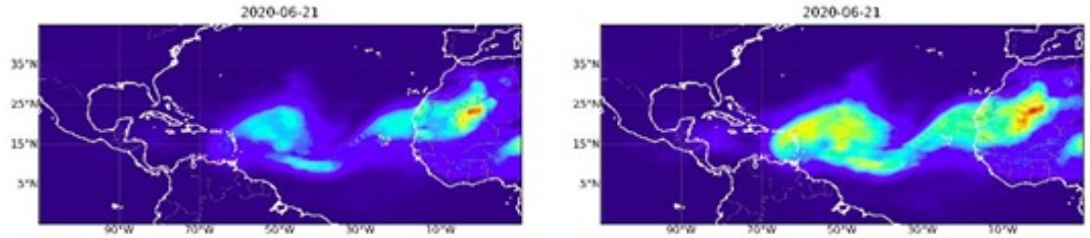
With thanks to David Ford

WP5.5 Cloud and Aerosol Analysis Study

Aerosol ECVs : Aerosol Optical Depth (Dust AOD, FM AOD, AOD)
Cloud ECVs : Cloud Optical Depth (Cloud Top Height, Cloud Fraction, Ice Water Path, Liquid Water Path)

WP5.5.1 Dust aerosol analysis with the BSC system

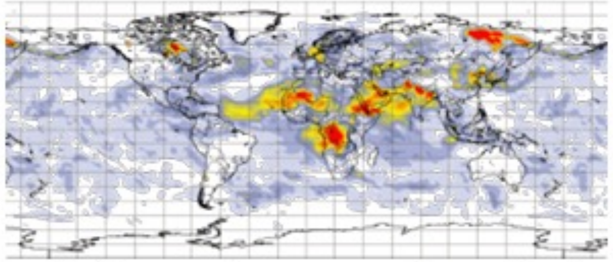
Jeronimo Escribano (**BSC**)



Constrain global **dust** aerosol simulations from the BSC MONARCH model with CCI data to produce dust analyses during the extraordinary event of June 2020.
→ Explore pixel-level uncertainties, Coarse AOD vs DOD, Comparison with DOMOS results.

WP5.5.2 Cloud/Aerosol analysis with the ECMWF system.

Angela Benedetti and Kirsti Salonen (**ECMWF**)



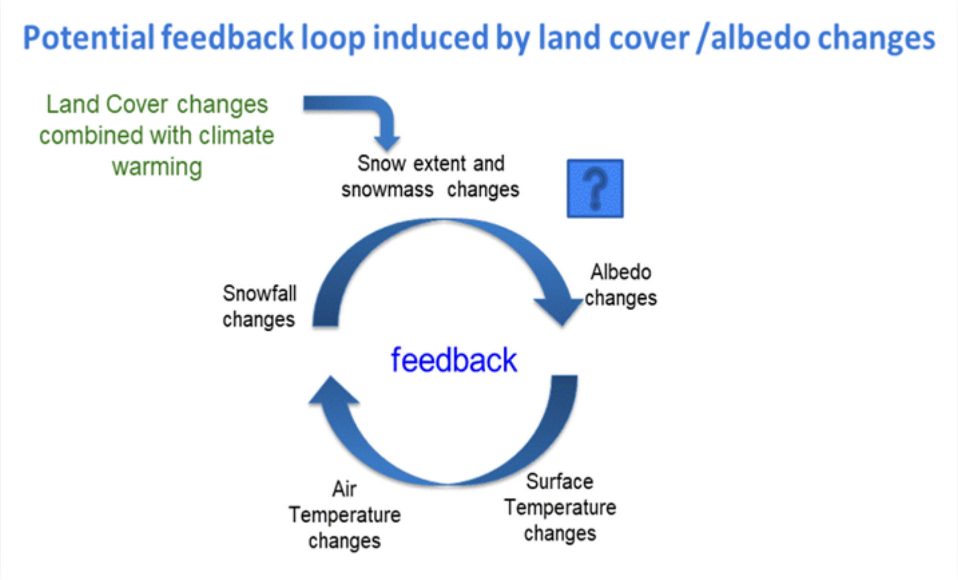
Joint assimilation of **aerosol** and **cloud** ECVs in the ECMWF IFS during June 2020 and September 2021 with the IFS 4DVar scheme in CAMS configuration.
→ Impact of COD and AOD level 2 data on the 4D-Var analysis

OWP5.5 Cloud and Aerosol Analysis Validation Study:
Evaluation using the ESMValTool and internal tools at BSC/ECMWF
Soil Moisture, Water Vapour ECVs.
A. Benedetti and K. Salonen (ECMWF), Axel Lauer (**DLR**), J. Escribano (BSC)

With thanks to Jeronimo Escribano

Main project objective

⇒ Improve our understanding and modeling of snow-vegetation-atmosphere feedback, with the IPSL climate model (LMDZ-ORCHIDEE) and various CCI products (especially snow products)



With thanks to Catherine Ottlé

Atmospheric drivers and feedback processes affecting the Greenland and Antarctic ice-sheets in observations and regional climate models

Mottram et al 2019

Fig5a. Mass change time series for the entire GrIS generated by DTU (red) and TUDR (blue).

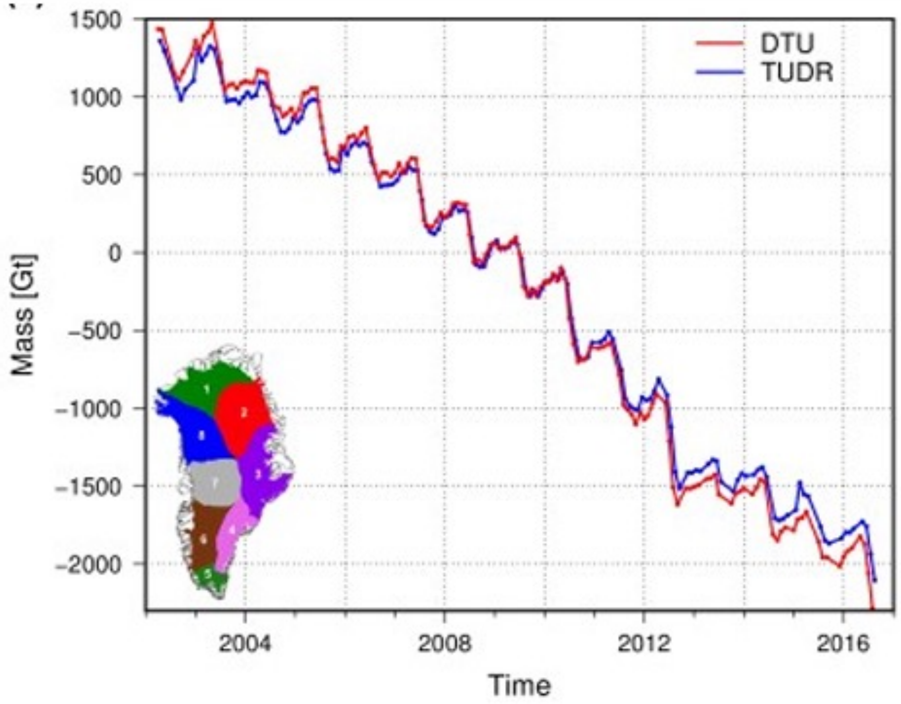
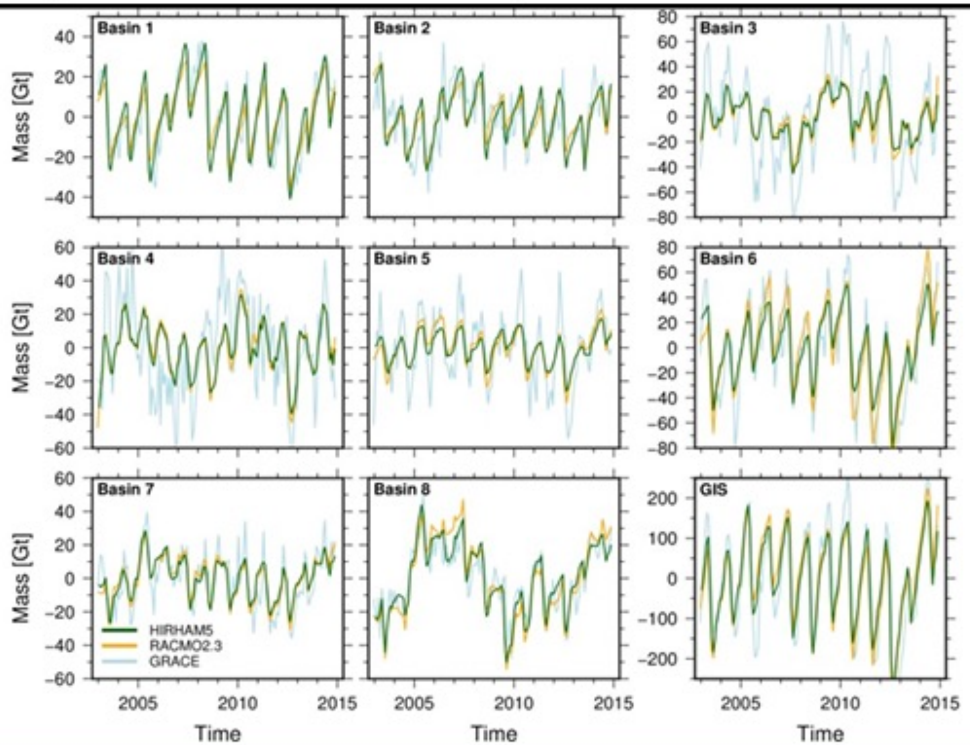


Fig8. Inter-comparison of mass changes from GRACE (GrIS CCI GMB product) and two regional climate models (HIRHAM5 and RACMO2.3) for different drainage basins and the entire GrIS. Mass changes are give w.r.t a linear and quadratic model.



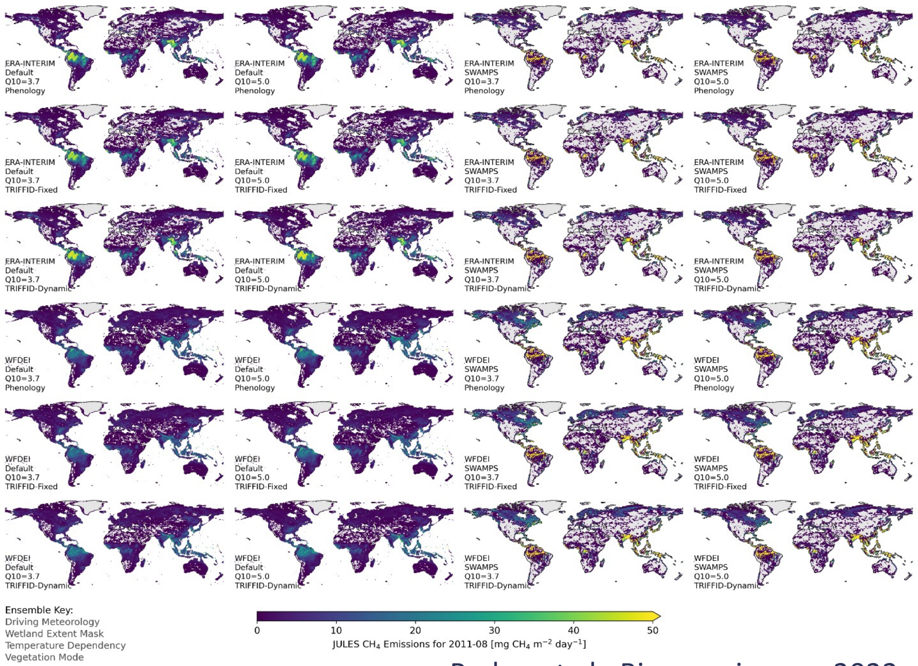
We plan to repeat this type of inter-comparison for SMB and for the observed Surface Elevation Changes (SEC) for the whole basin and the sub-basins, comparing the observed variability with the regional models Surface Energy Balance (SEB) and the individual components (SWN, LWN, LE and H) for Greenland and for Antarctica.

With thanks to Ulrika Willén

Using Machine-Learning to Evaluate and Understand our Capability to Model Tropical Wetland Methane Emissions

- Team: Rob Parker and Cristina Ruiz Villena (NCEO-Leicester), Nic Gedney (Met Office), Paul Palmer (NCEO-Edinburgh)
- Develop an emulator for JULES wetland methane, use its explainability to show which factors matter in the model, drive the emulator with CCI EO data to generate wetland fluxes and compare those to a CH_4 inversions performed on GOSAT/TROPOMI ESA-CCI data.

Figure: Ensemble of JULES simulations with different driving data, temperature dependency, vegetation and wetland mask show massively different methane fluxes!



Parker et al., Biogeosciences, 2022

CCI Datasets

- GHG (methane)
- Land Surface Temperature
- Soil Moisture
- Land Cover
- + Vegetation (?)

Models

- JULES (land surface)
- GEOS-Chem (atmospheric)

With thanks to Rob Parker