climate change initiative

→ CLIMATE MODELLING USER GROUP

CCI+ CMUG Phase 2 Proposals
Machine learning to advance climate model evaluation and process understanding

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cmug cci

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Machine learning to advance climate model evaluation and process understanding

Aim

→ Developing and applying **machine learning** (ML) techniques for advanced climate model **evaluation and process understanding** with **ESA CCI data**

→ Creating enhanced **ML-based observational products** from observations and climate models

→ **Causal networks** derived from **observations** will be **compared** to those from state-of-the-art **global climate models** (CMIP6 and ICON model) to enhance **process-oriented model evaluation** with ESA CCI data

Proposed work packages

WP1 – Enhancing observational products for climate model evaluation with machine learning

WP2 – Causal model evaluation for cloud regimes and land cover types

WP3 – Evaluation of CMIP6 models with the ESMValTool

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WP1 Enhancing observational products for climate model evaluation with machine learning

Can **cloud classes** be derived from ESA CCI CLOUD data with **machine learning** to improve climate model evaluation?

How well does the **ICON** model reproduce the **observed mean properties and variability of satellite derived cloud classes** (regime-oriented evaluation)?

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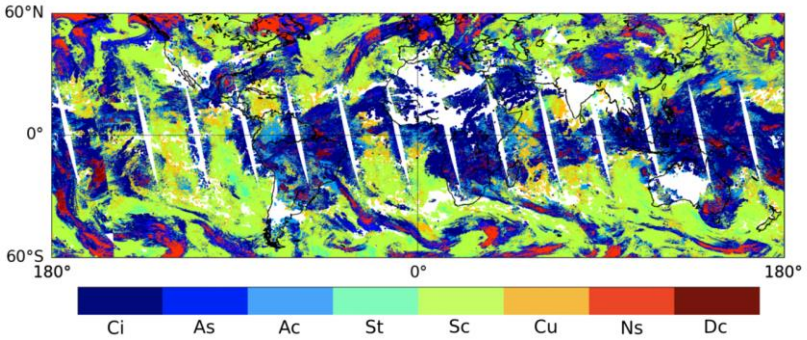
WP1 Enhancing observational products for climate model evaluation with machine learning

- Developing and applying a ML-based approach to derive cloud classes from high-resolution satellite data and coarse-resolution climate models
- Using cloud type labels from CloudSat and collocated physical cloud properties from MODIS - cloud type labels can be generated by a deep neural network (NN) for the MODIS data
- 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)



Zantedeschi et al., 2020

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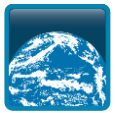
WP1 Enhancing observational products for climate model evaluation with machine learning

Data:



ESA CCI **Cloud** - v3.0, AVHRR AM + PM, L3U (daily)

cloud fraction, liquid water path, ice water path, cloud optical depth,
cloud top pressure/height, effective radius

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WP2 Causal model evaluation for cloud regimes and land cover types

What are the **causal relationships and networks** in the real world as derived from **ESA CCI data**?

Can the **ICON** climate model **reproduce** the **causal networks** between **cloud properties and cloud controlling factors** as derived from ESA CCI data for different cloud regimes? And for different **land cover types**?

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WP2 Causal model evaluation for cloud regimes and land cover types

- **Aim:** (1) better understanding of the causal drivers for specific cloud regimes and land cover types

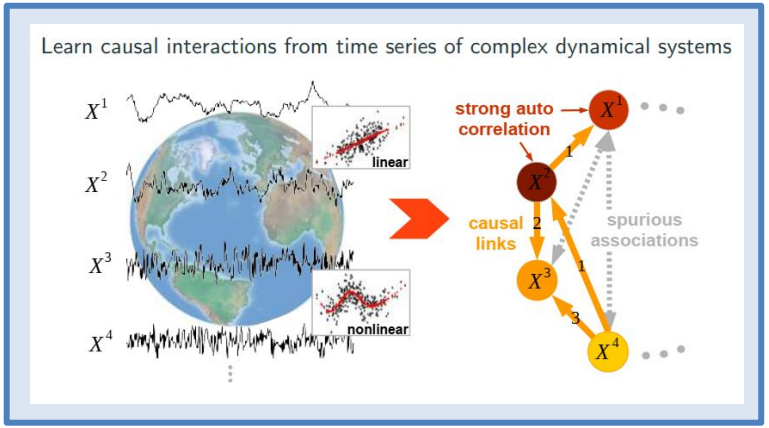
  (2) enhancing regime-oriented causal model evaluation with causal discovery

- Causal networks are calculated from the time series of several variables of ESA CCI data in order to analyse and investigate the causal connections among the properties and the controlling factors

Runge et al., 2015

- 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



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WP2 Causal model evaluation for cloud regimes and land cover types

Data:

daily and/or monthly (we need time periods covered by all ECVs: 2003-2016)


ESA CCI **Cloud:** cloud fraction (low, mid, high), liquid water path, ice water path, cloud optical depth, cloud top pressure/height, outgoing longwave radiation


ESA CCI **Land cover**


ESA CCI **Land surface temperature**


ESA CCI **Sea surface temperature**


ESA CCI **Water vapour**


ESA CCI **Soil moisture**

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WP3 Evaluation of CMIP6 models with the ESMValTool

How well do **CMIP6** models reproduce the **observed variability** and (if detectable in the observations) **trends** in the historical record of **snow cover and permafrost**?

Can the addition of snow and permafrost to the **causal networks** in WP2 improve the analysis?

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WP3 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

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

- Whenever possible, the CCI uncertainty estimates are used to assess whether differences in the model simulations compared with the observations are significant.

Data:

ESA CCI Permafrost - permafrost extent, ground temperature, active layer thickness

ESA CCI Snow - snow water equivalent, snow cover fraction, snow on ground

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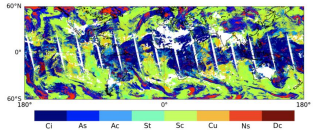
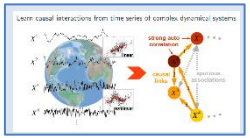
WP1
Enhancing observational products for climate model evaluation with machine learning



WP2
Causal model evaluation for cloud regimes and land cover types



WP3
Evaluation of CMIP6 models with the ESMValTool

ESMValTool
Earth System Model Evaluation Tool