climate change initiative

→ CLIMATE MODELLING USER GROUP

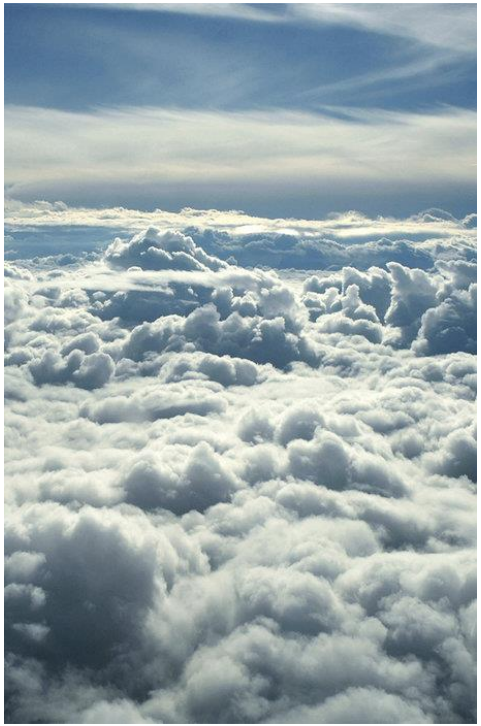
Overview of CCI+ Phase 1
Science and Technical Highlights WP5 (Adaptation of community climate evaluation tools for CCI)

L. Bock, A. Lauer, A. Benedetti, R. Dragani, B. Gier, B. Hassler, D. Hemming, R. King, J. Vegas-Regidor, K. Weigel, U. Willén, K. Zimmermann, and the ESMValTool development team

cmug cci

ESA UNCLASSIFIED - For Official Use

Earth System Model Evaluation Tool



ESMValTool
Earth System Model Evaluation Tool

Outline

- Earth System Model Evaluation Tool (ESMValTool)
- Technical highlights
- Highlights from evaluation of CMIP6 models with ESA CCI data
- Summary

Earth System Model Evaluation Tool

International ESMValTool development team

- 17 funded projects
- 63 institutions
- 203 developers

scientific documentation

Righi et al., 2020
Technical overview

Eyring et al., 2020
Large-scale diagnostics

Lauer et al., 2020
Diagnostics for emergent constraints and future projections

Weigel et al., 2021
Diagnostics for extreme events, regional and impact evaluation

ESMValTool
Earth System Model Evaluation Tool

- Tool for fast and easy routine **evaluation and analysis** of Earth system models including provenance records for all results (**traceability and reproducibility**)
- Well-established analysis based on **peer-reviewed literature**
- Many diagnostics and performance metrics covering **different aspects of the Earth System** (dynamics, radiation, clouds, carbon cycle, chemistry, aerosol, sea-ice, etc.) and their interactions
- Extensive **documentation** (user guide, peer-reviewed papers, tutorial)
- Supported production of a subset of figures of the **IPCC WGI AR6**

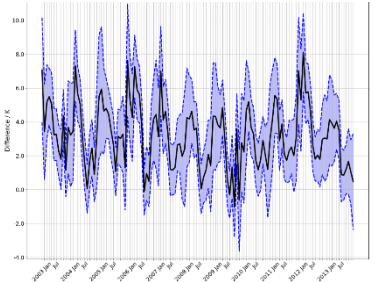
https://www.esmvaltool.org/

ESA CCI datasets implemented into ESMValTool

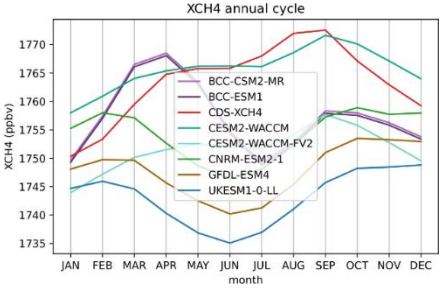
Dataset	Variable(s)	Resolution	Years
Aerosol	od550aer, od870aer, od550lt1aer, abs550aer	1°x1°	1997-2011
Cloud	clivi, clt, clwvi, rlut, rlutcs, rsut, rsutcs	0.5°x0.5°	1982-2016
Fire	burntArea	0.25°x0.25°	2005-2011
Greenhouse Gases	xco2, xch4	5°x5°	2003-2016
Ozone	tro3, tropoz, toz	1°x1°	1997-2010
Land Cover	lccs_class: grassNcropFrac, shrubNtreeFrac	300 m	2000, 2005, 2010
Land Surface Temperature	ts	0.1°x0.1°	2003-2018
Ocean Colour	chl	4 km	1998-2020
Sea Ice	sic	25 km	1992-2008
Sea Surface Temperature	tos	0.5°x0.5° (0.05°x0.05°)	1982-2019
Sea Surface Salinity	sos	25 km (50 km)	2010-2018
Soil Moisture	sm	0.25°x0.25°	1988-2005
Water Vapour	prw	0.5°x0.5°	2003-2017

New diagnostics in ESMValTool

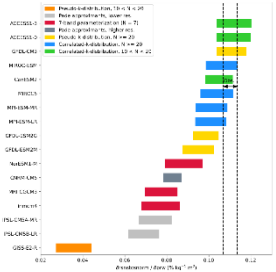
Land surface temperature



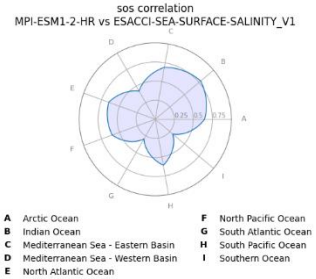
GHG (XCH4)



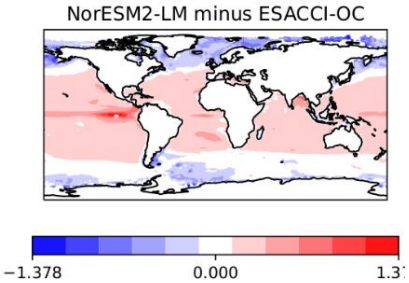
Water Vapour



Sea Surface Salinity



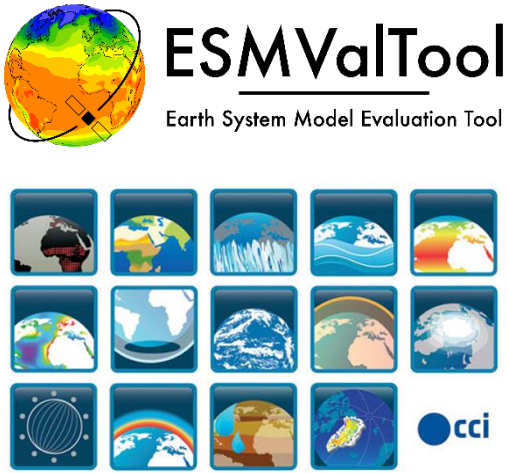
Ocean Colour



All CMUG diagnostics implemented into ESMValTool have been released as part of ESMValTool version 2.5.

Evaluation of CMIP6 models…

… with ESA CCI data and the ESMValTool



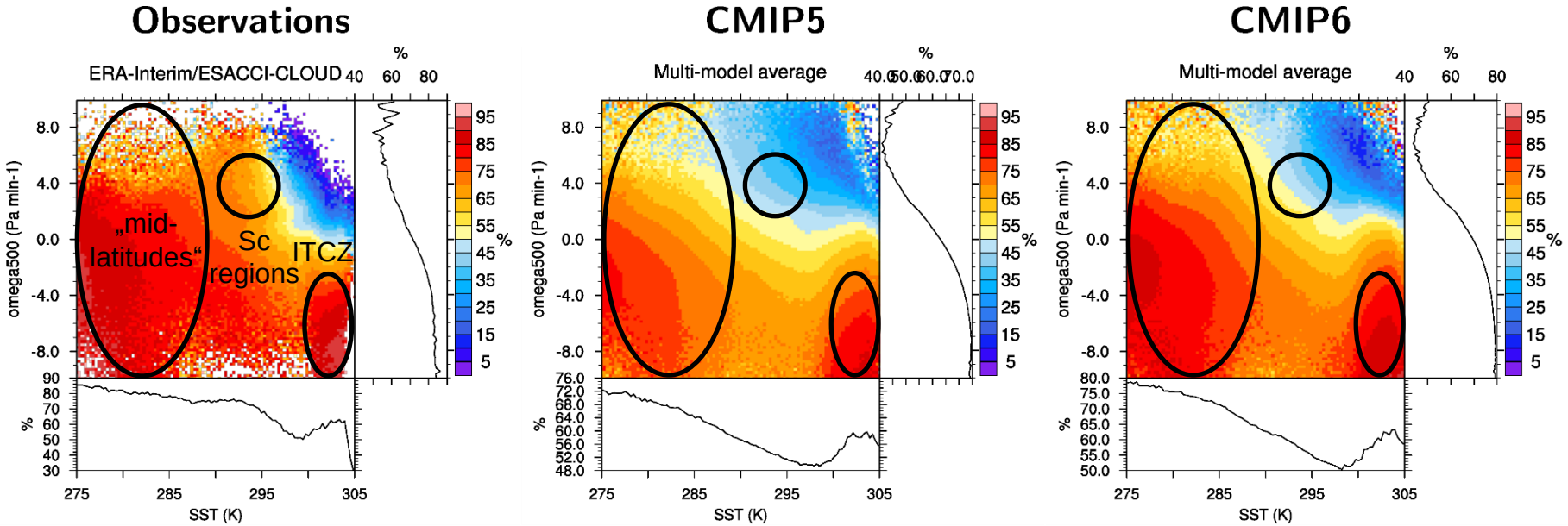
Examples

(1) Clouds
(2) XCO2
(3) Climate parameters (IPCC AR6)

CMIP6 evaluation - clouds

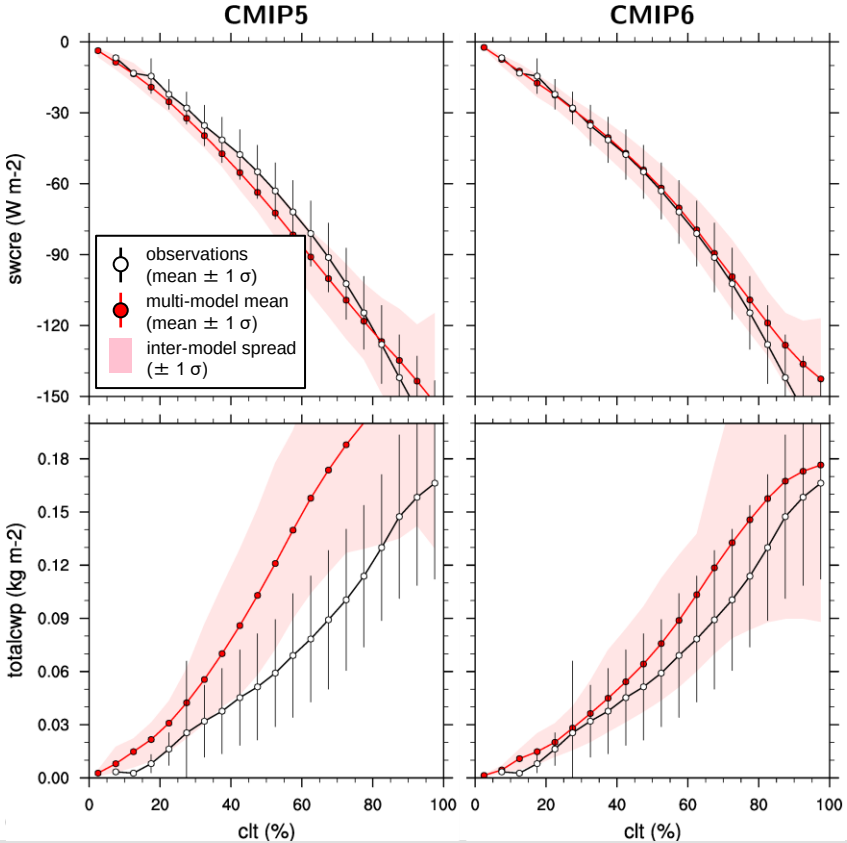
Total cloud cover binned by dynamical regime (SST, ω_{500})

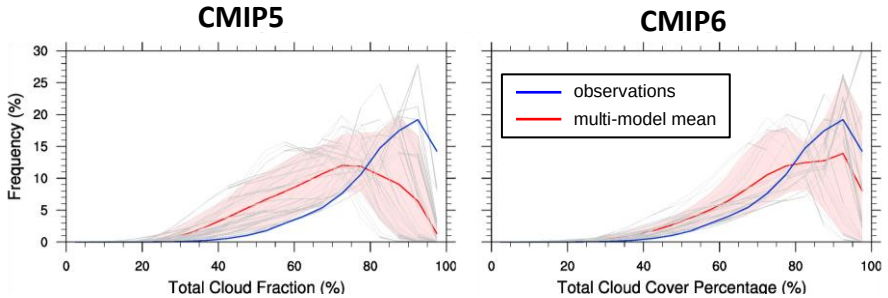
clt



From: Lauer et al. (J. Climate, accepted)

CMIP6 evaluation - clouds





20 year DJF means over Southern Ocean

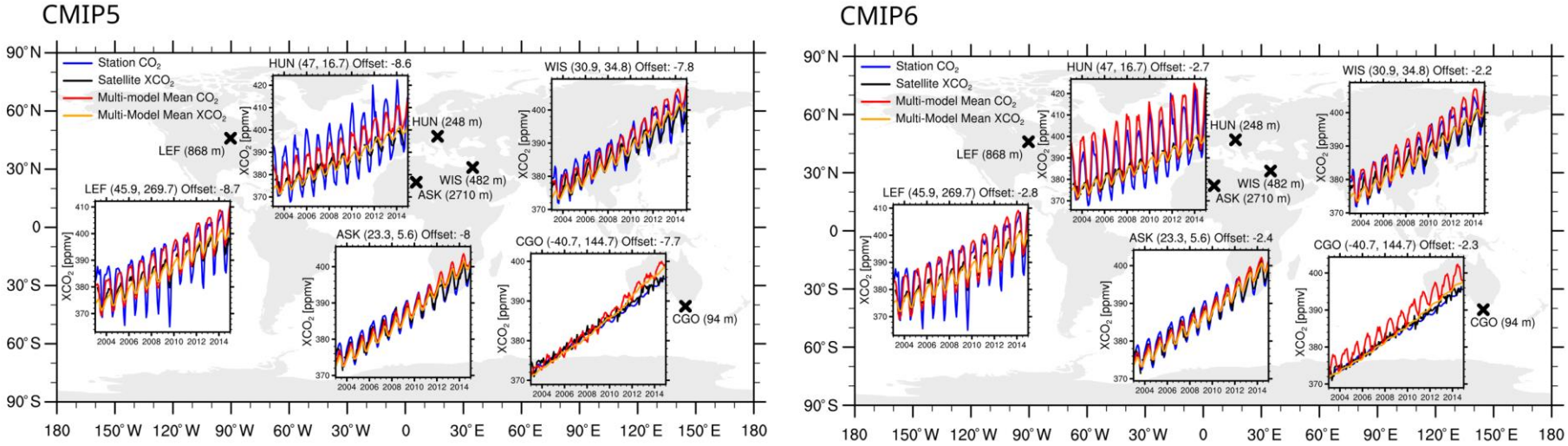
- CMIP5 models overestimate swcre for most total cloud cover values
- This bias is improved in CMIP6 (20% < clt < 80%)
- Possible reason: decrease in total cloud water in CMIP6
- Increase in frequency of high total cloud cover values in CMIP6
  → improved agreement with observations (ESA CCI CLOUD)

From: Lauer et al. (J. Climate, accepted)

CMIP5 problem of too few but too reflective clouds over the Southern Ocean is significantly reduced in CMIP6

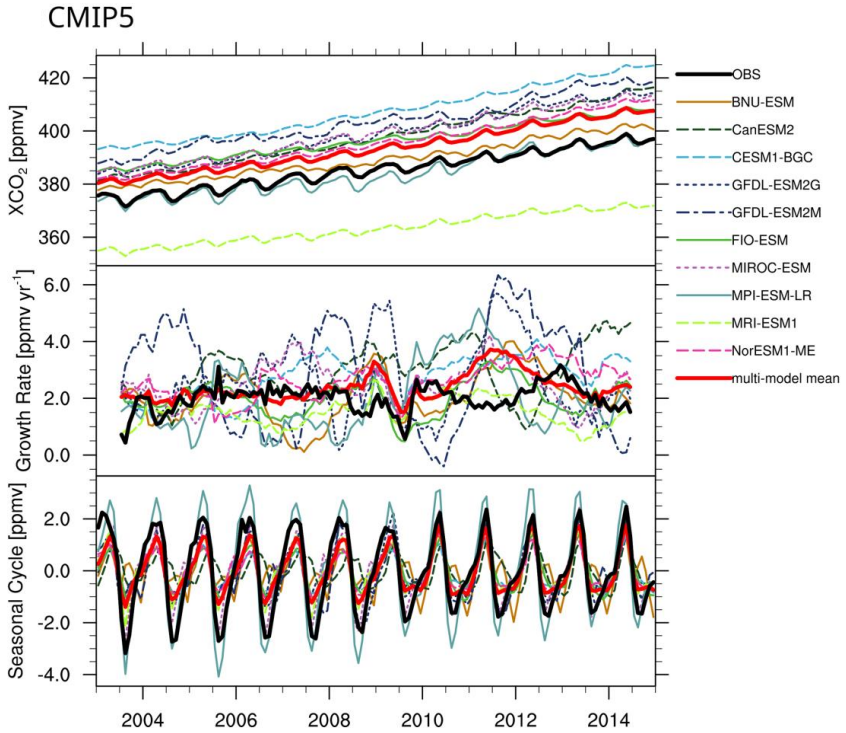
Evaluation of CMIP6 models

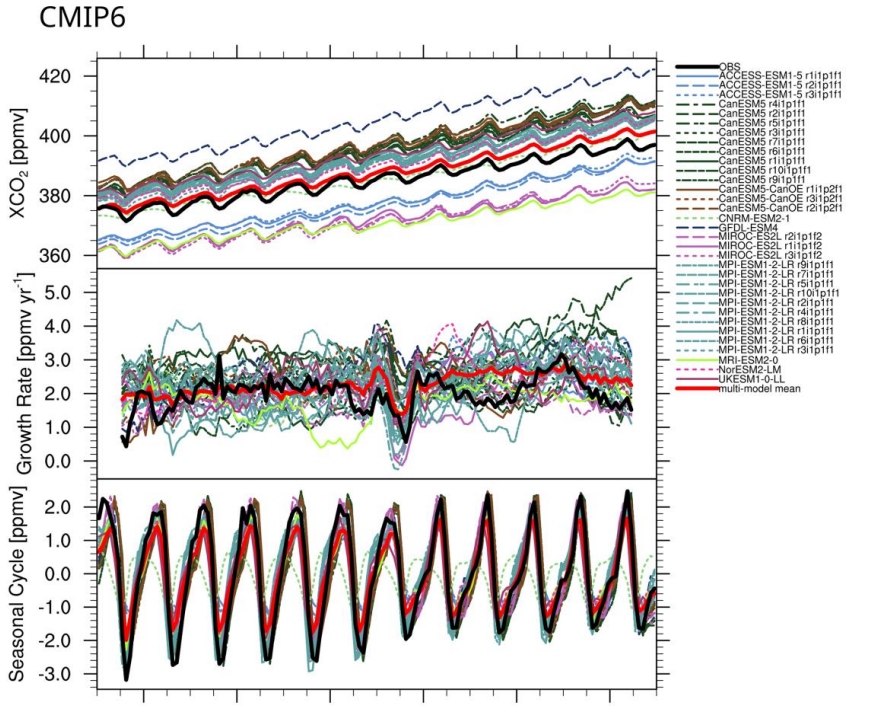
Global average XCO2



From: Gier et al. (2020)

Evaluation of CMIP6 models





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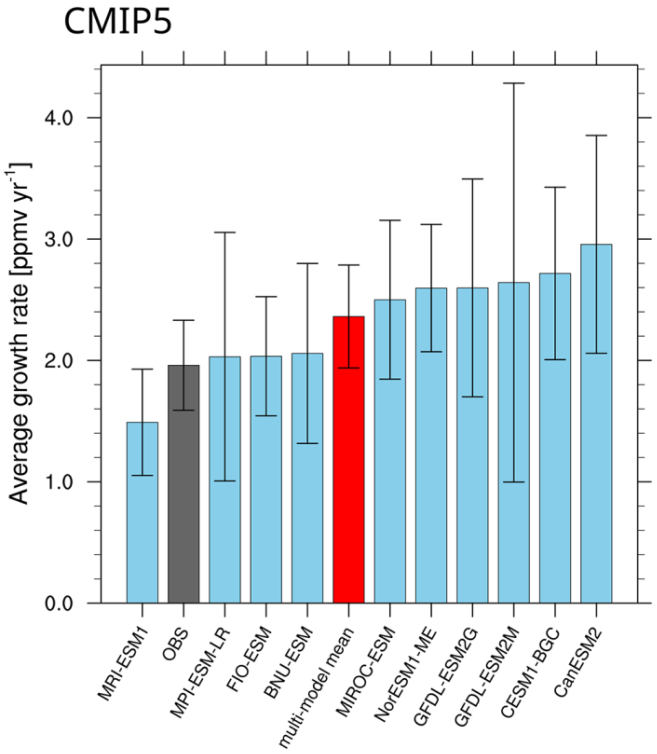
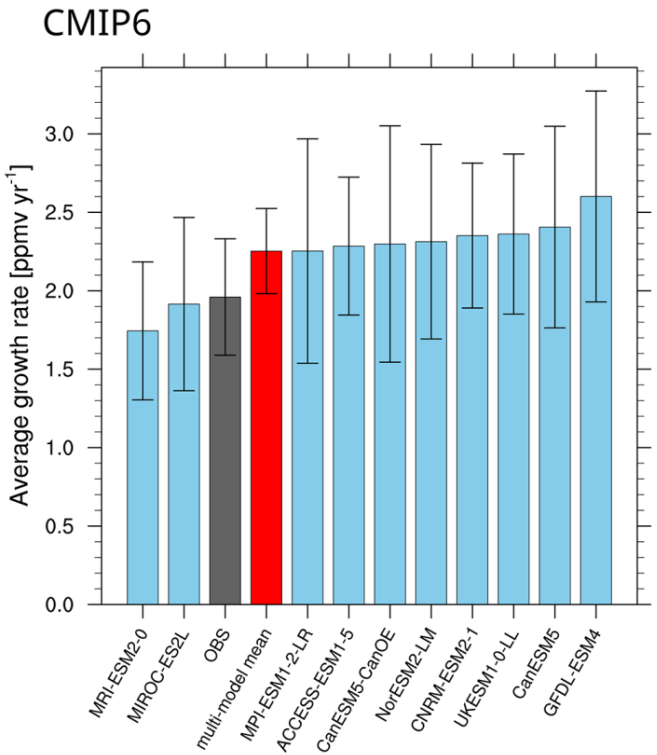
Evaluation of CMIP6 models

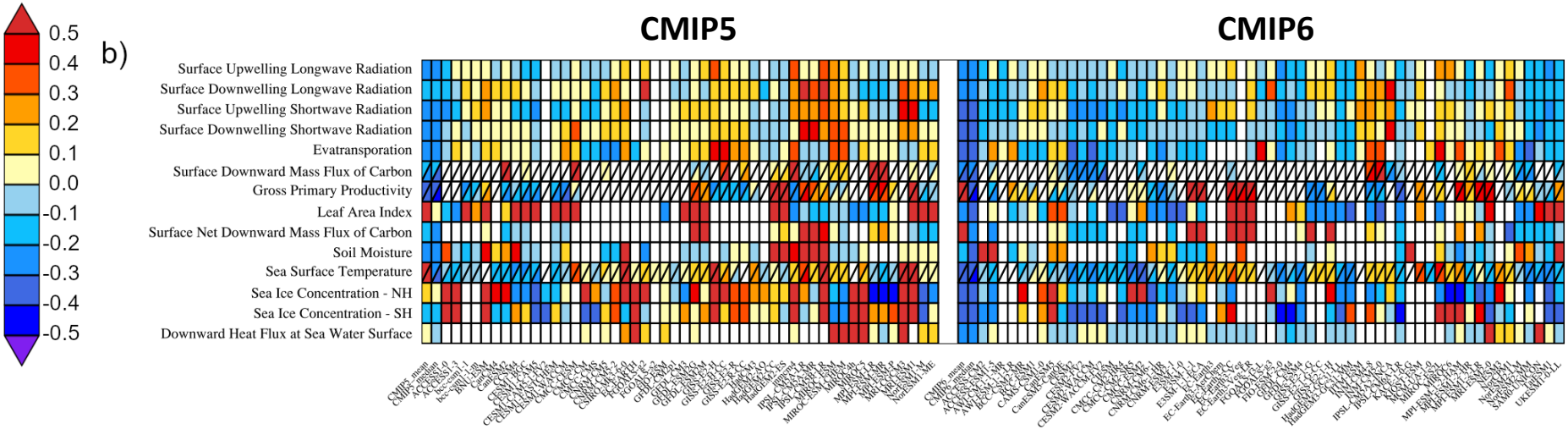




From: Gier et al. (2020)

Evaluation of CMIP6 models

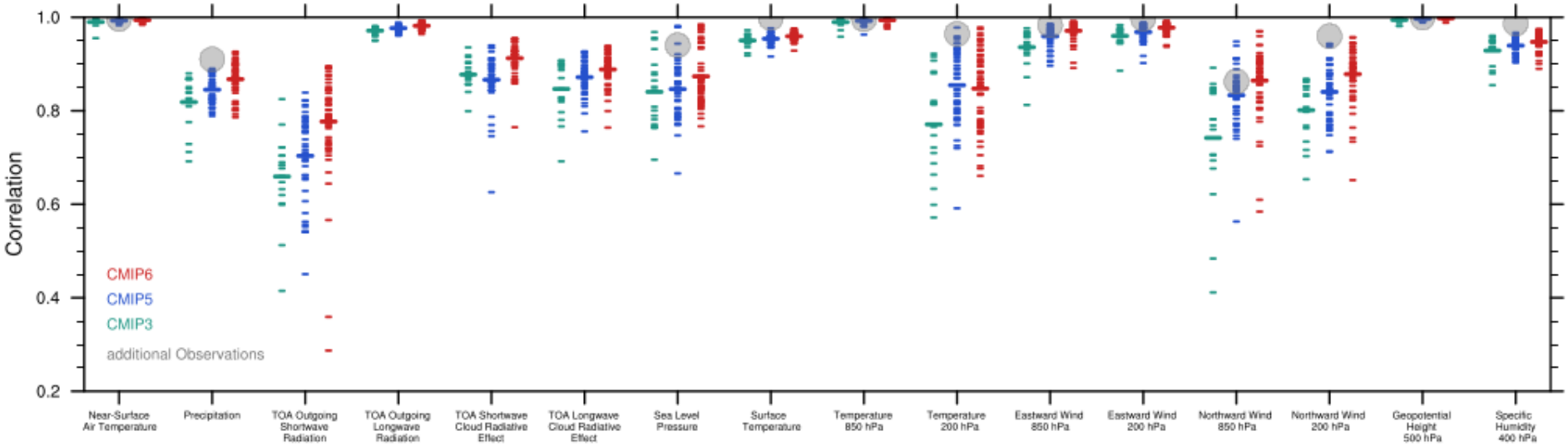
Relative model performance (RMSD)



From: IPCC AR6, Chapter 3, Fig. 42

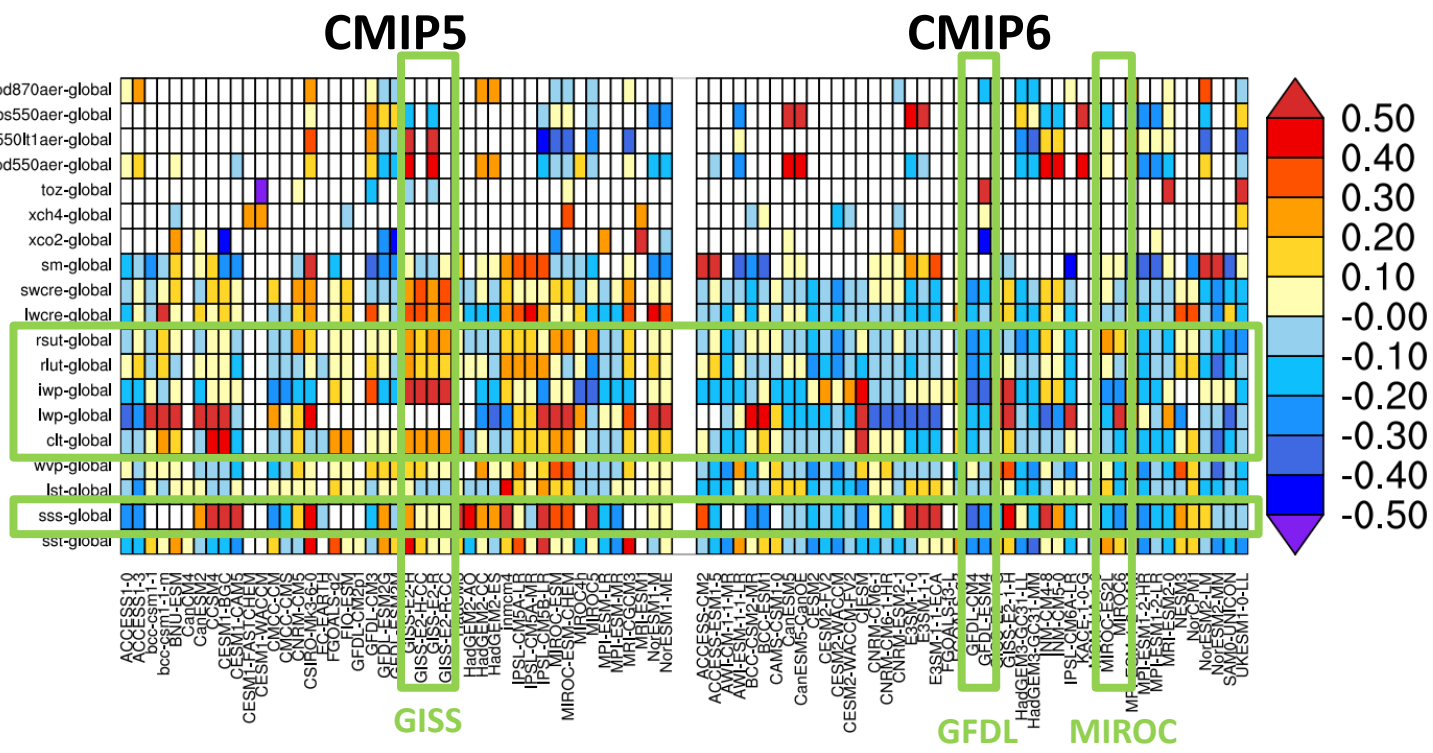
Evaluation of CMIP6 models

Pattern correlations



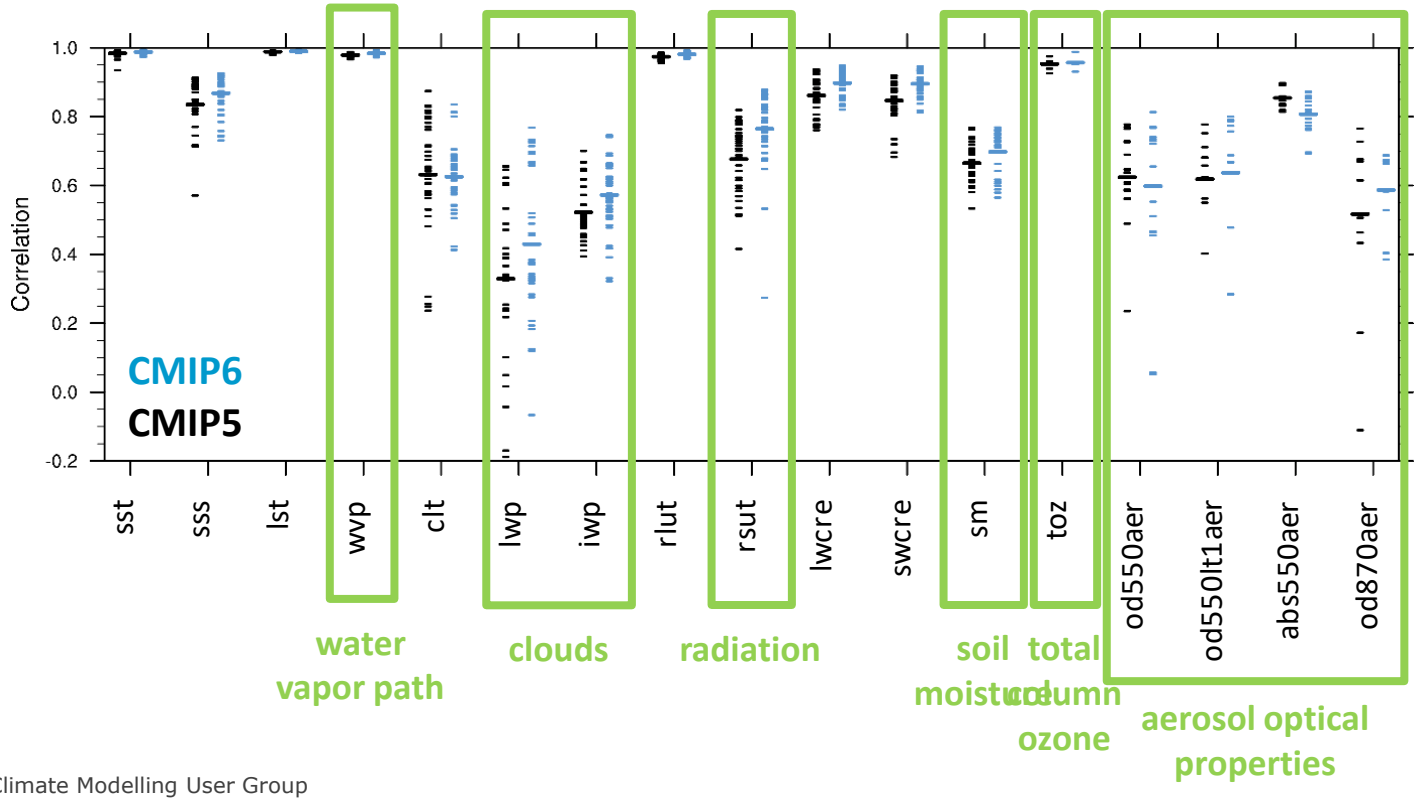
From: IPCC AR6, Chapter 3, Fig. 43

Evaluation of CMIP6 models



Relative space–time root-mean square error (RMSE) calculated from the 1986-2005 climatological seasonal cycle of the CMIP5 (left block) and CMIP6 (right block) historical simulations. A relative performance is displayed, with blue shading indicating performance being better and red shading worse than the median of all model results. White boxes are used when data are not available for the given model and variable.

Evaluation of CMIP6 models



Cantered pattern correlations between models and observations for the annual mean climatology over the period 1986–2005. For the observations the 20-year period (or longest available period if less than 20 years are available) with the biggest overlap with the model period is used.

Summary

- **ESMValTool:** tool for fast and easy evaluation and analysis of Earth system models including provenance records for all results (traceability and reproducibility)
- ESMValTool coupled to ESGF provides a systematic, rapid and comprehensive **performance assessment** that can also enhance quality control
- **Publicly** available and developed in an international **community** effort
- **Diagnostics:** more large-scale diagnostics, emergent constraints and future projections diagnostics, extreme events and regional and impact diagnostics available than before
- Supported production of a subset of figures of **IPCC WGI AR6**
- **ESA CCI data** used for model evaluation and analysis