Adaptation of community climate evaluation tools for CCI needs (WP5)

DLR

ESMValTool Earth System Model Evaluation Tool

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Aims

- Exploit CCI and CCI+ data for evaluation of earth system models
- Enhance the ESMValTool with additional diagnostics and performance metrics for the evaluation of models with ESA CCI and CCI+ data
- Enhance use of ESA CCI and CCI+ data for climate model evaluation in the Climate Model Intercomparison Project (CMIP)
- Make a substantial contribution to the CMIP Phase 6 (CMIP6)

Science questions

- How well can state-of-the-art ESMs simulate climatological mean, variability and trends in selected ECVs?
- What is the progress achieved in CMIP6 compared with CMIP5 in selected ECVs?
- Are the new ESA CCI data complementing and changing global and regional model evaluation and benchmarking?

Earth System Model Evaluation Tool (ESMValTool)

- 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)
- Was used in supported of production of a subset of figures of the IPCC WGI AR6
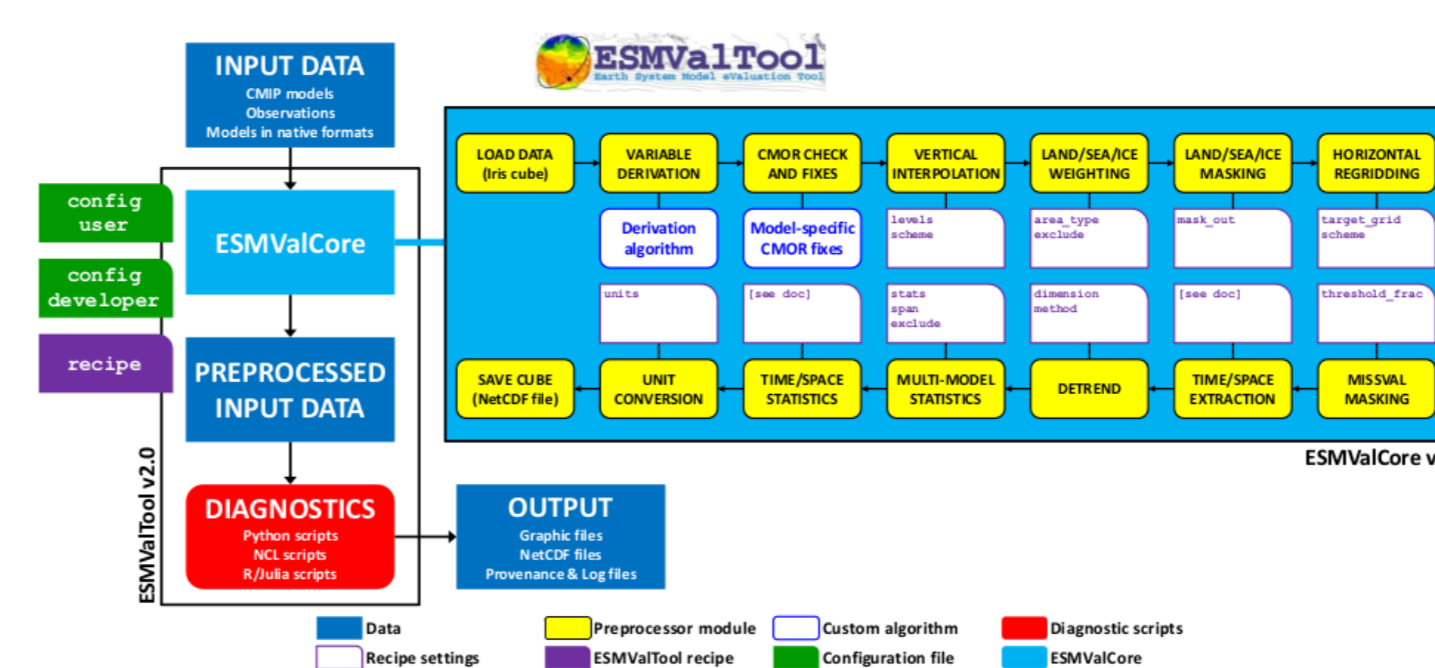

Schematic representation of ESMValTool v2.0. From Righi et al. (2020).

## 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

ESA CCI datasets implemented into the ESMValTool. Datasets and variables highlighted in blue are the latest additions. Resolutions of the original datasets (if different from the ESMValTool implementation) are given in parentheses.
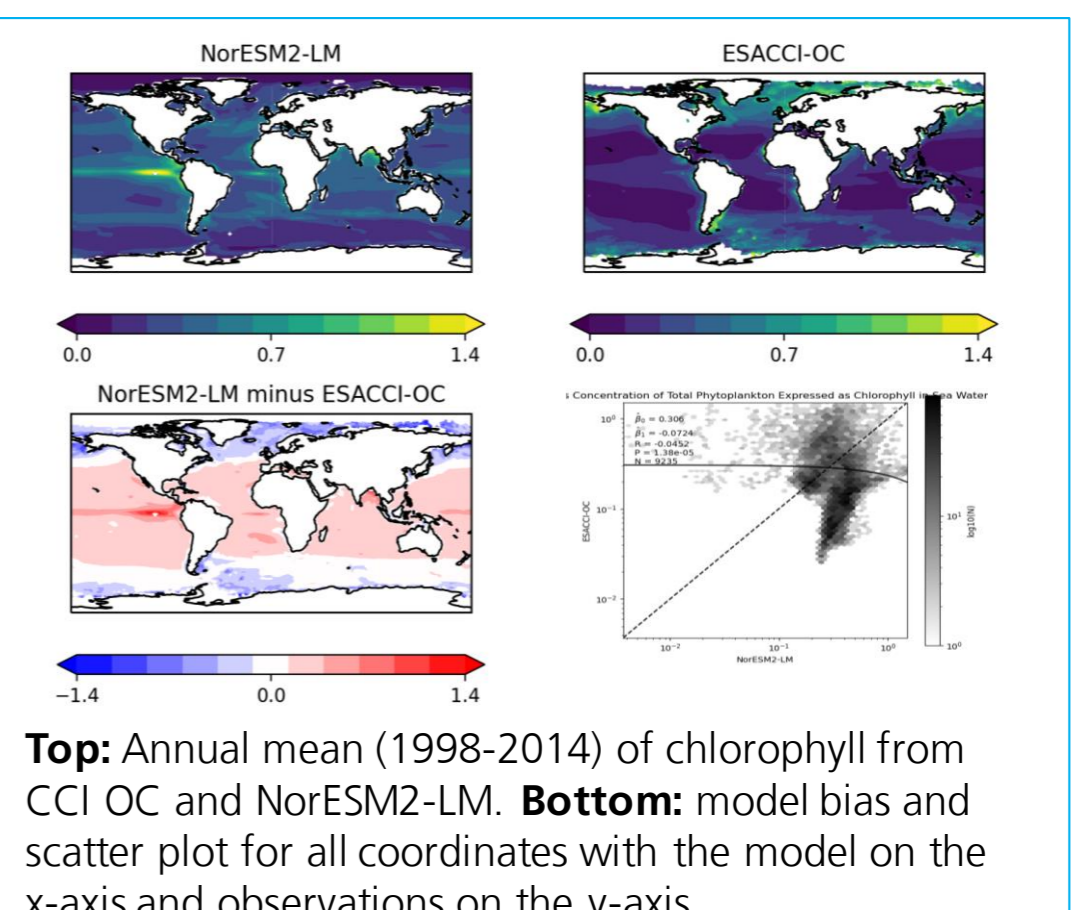
Examples of new diagnostics in ESMValTool
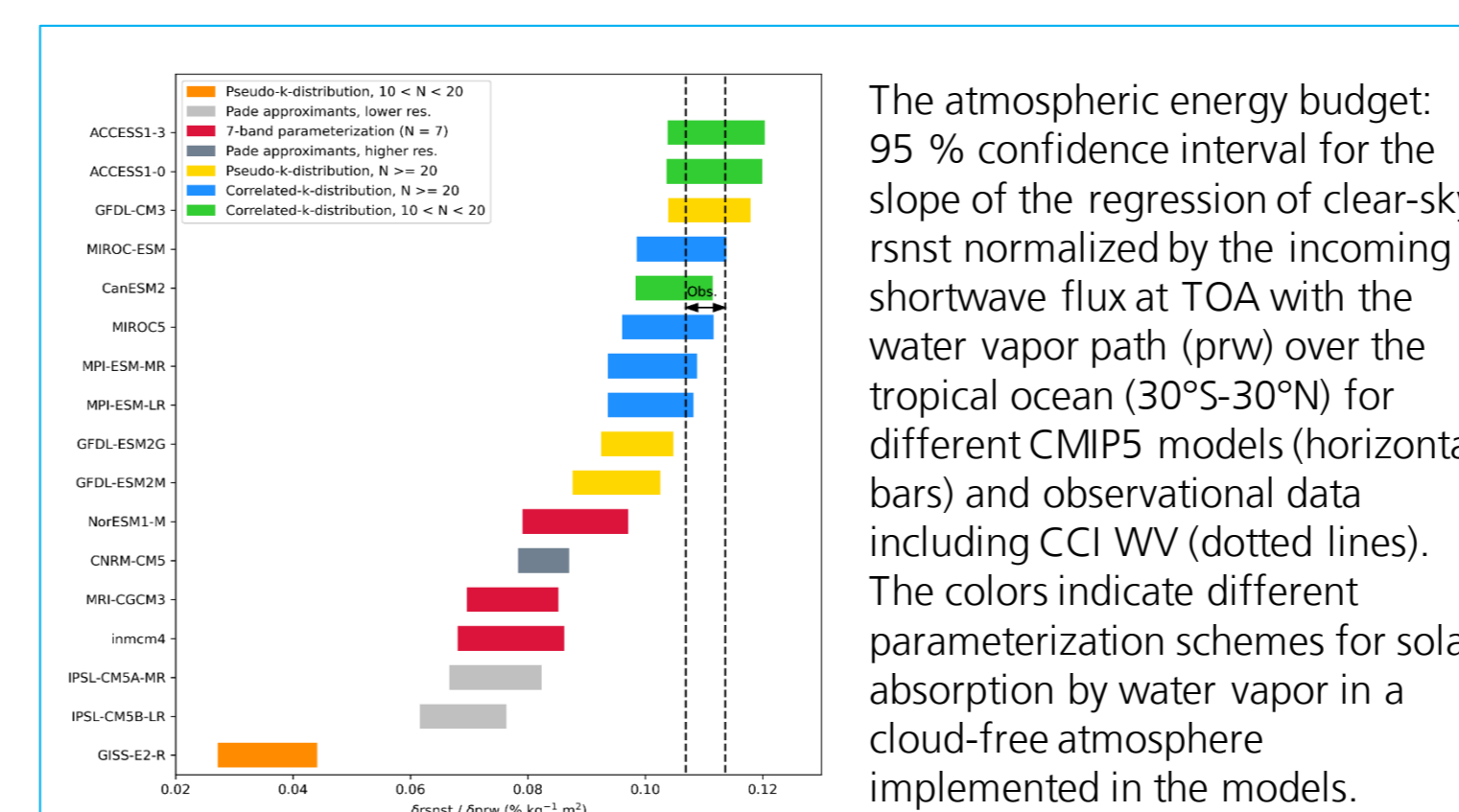
The atmospheric energy budget: 95 % confidence interval for the slope of the regression of clear-sky rsnst normalized by the incoming shortwave flux at TOA with the water vapor path (prw) over the tropical ocean (30°S-30°N) for different CMIP5 models (horizontal bars) and observational data including CCI WV (dotted lines). The colors indicate different parameterization schemes for solar absorption by water vapor in a cloud-free atmosphere implemented in the models.
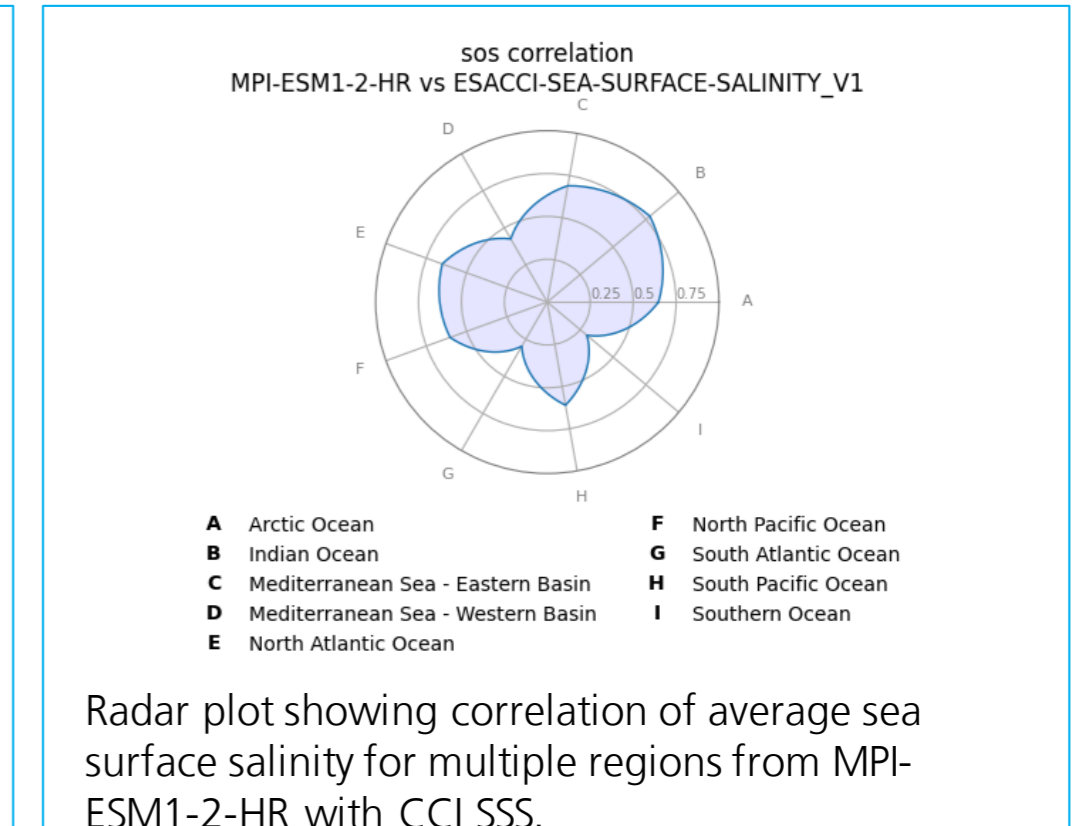
Radar plot showing correlation of average sea surface salinity for multiple regions from MPI-ESM1-2-HR with CCI SSS.
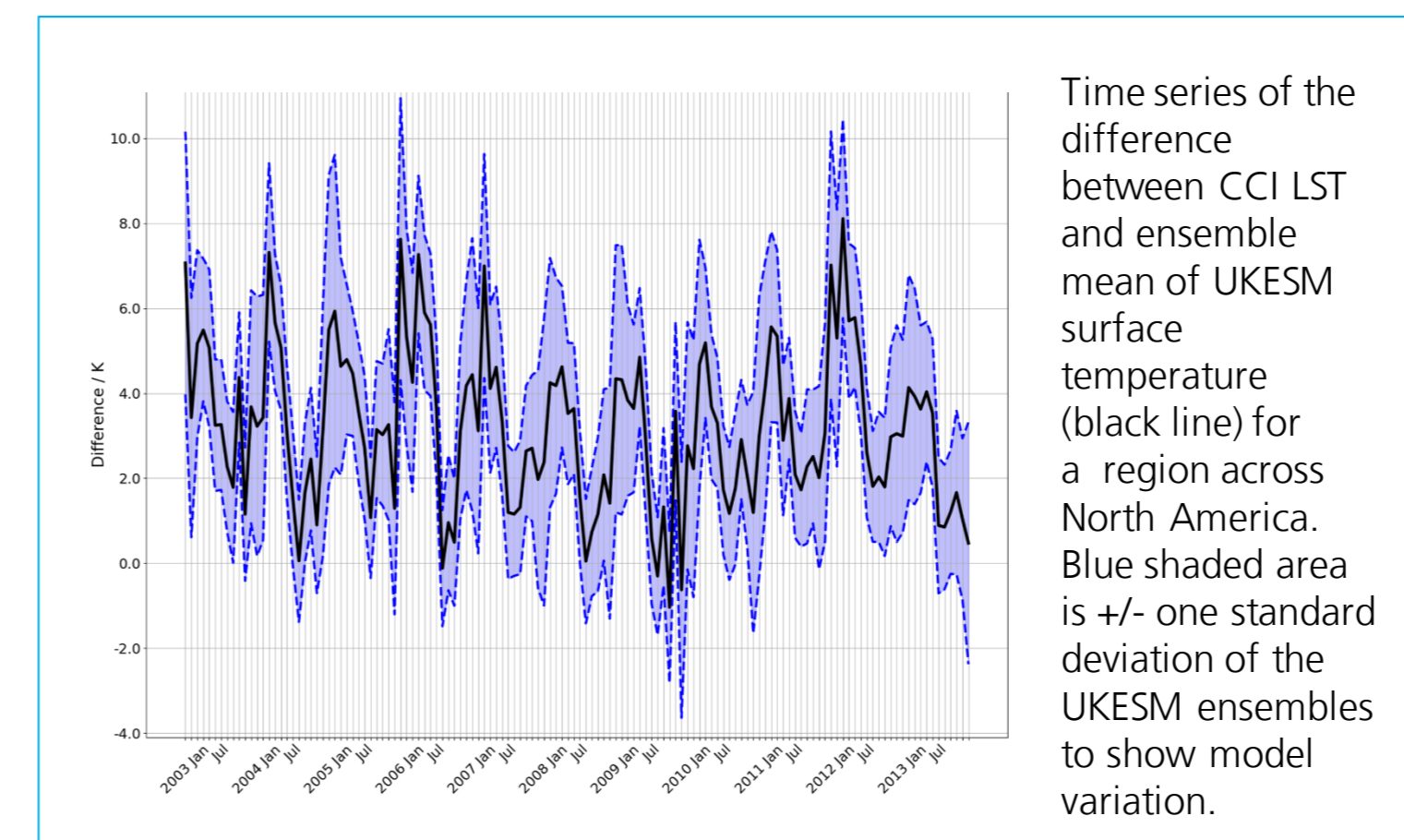

Time series of the difference between CCI LST and ensemble mean of UKESM surface temperature (black line) for a region across North America. Blue shaded area is +/- one standard deviation of the UKESM ensembles to show model variation.


Top: Annual mean (1998-2014) of chlorophyll from CCI OC and NorESM2-LM. **Bottom:** model bias and scatter plot for all coordinates with the model on the x-axis and observations on the y-axis.

Comparison of the global mean monthly mean time series of CCI XCH4 (red line) and emission-driven simulations of three CMIP6 models.

Examples CMIP6 model evaluation with ESA CCI data and the ESMValTool

Southern Ocean clouds (DJF)
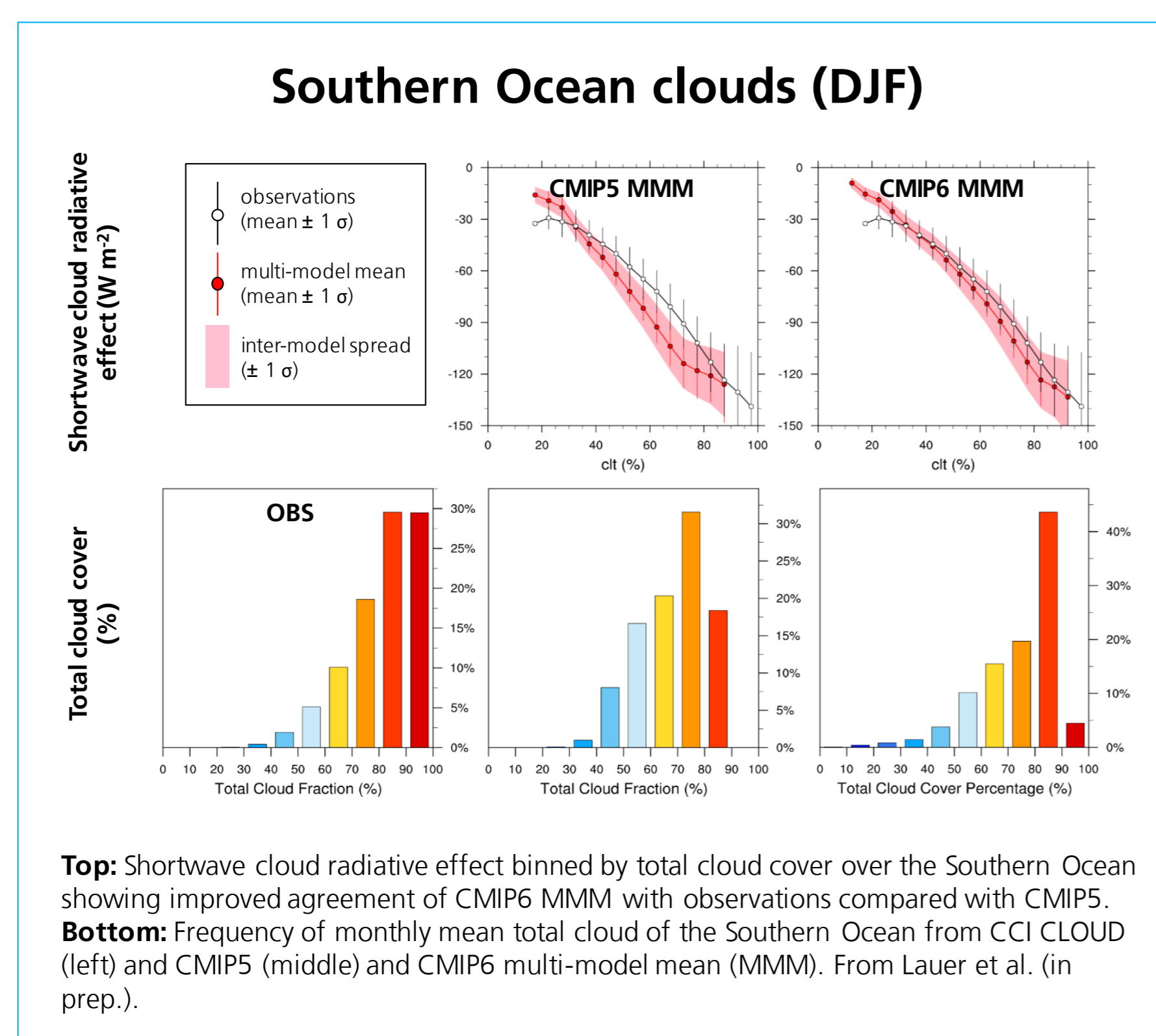
Top: Shortwave cloud radiative effect binned by total cloud cover over the Southern Ocean showing improved agreement of CMIP6 MMM with observations compared with CMIP5. **Bottom:** Frequency of monthly mean total cloud of the Southern Ocean from CCI CLOUD (left) and CMIP5 (middle) and CMIP6 multi-model mean (MMM). From Lauer et al. (in prep.).

Relative model performance and pattern correlations
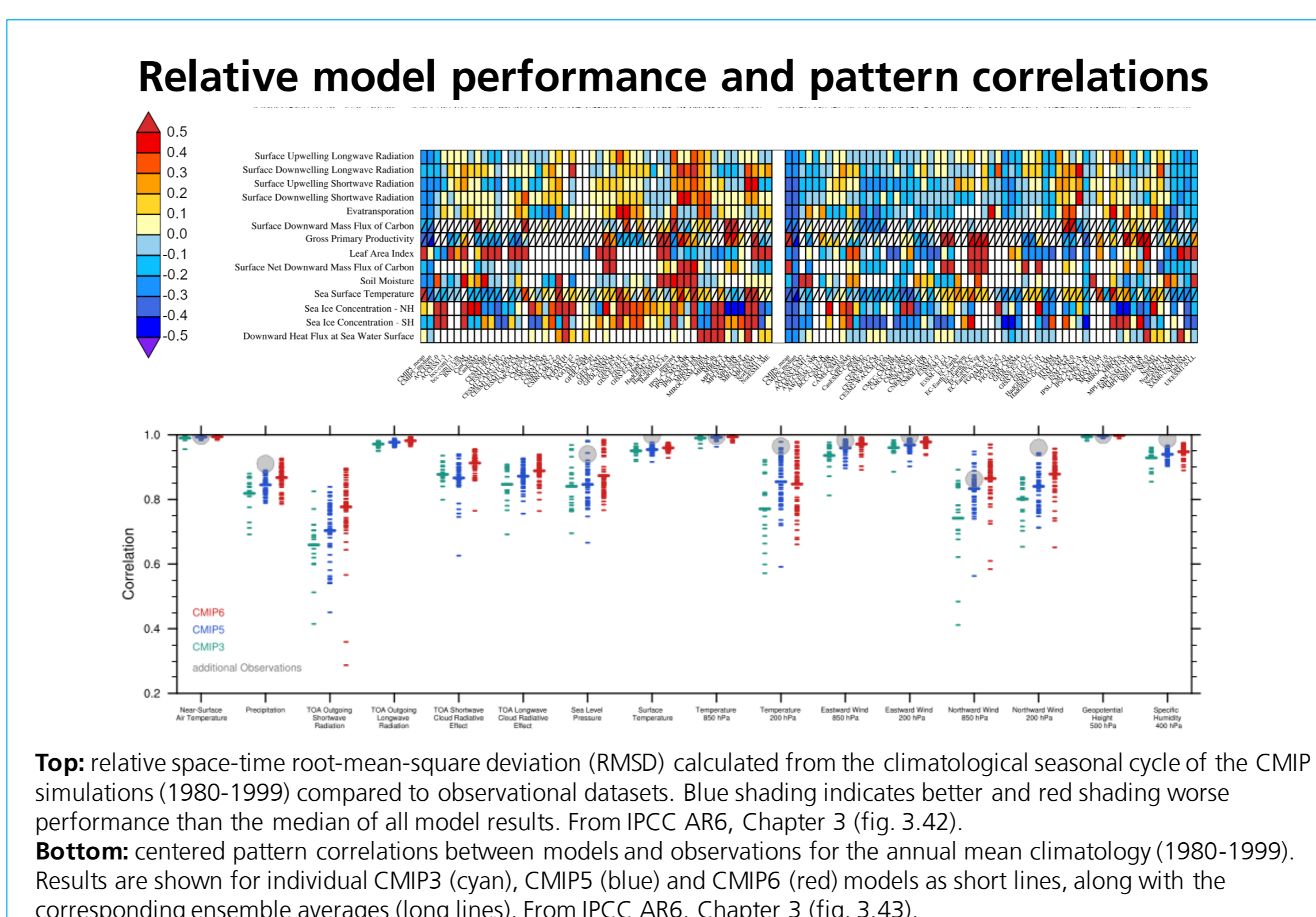
Top: relative space-time root-mean-square deviation (RMSD) calculated from the climatological seasonal cycle of the CMIP simulations (1980-1999) compared to observational datasets. Blue shading indicates better and red shading worse performance than the median of all model results. From IPCC AR6, Chapter 3 (fig. 3.42). **Bottom:** centered pattern correlations between models and observations for the annual mean climatology (1980-1999). Results are shown for individual CMIP3 (cyan), CMIP5 (blue) and CMIP6 (red) models as short lines, along with the corresponding ensemble averages (long lines). From IPCC AR6, Chapter 3 (fig. 3.43).
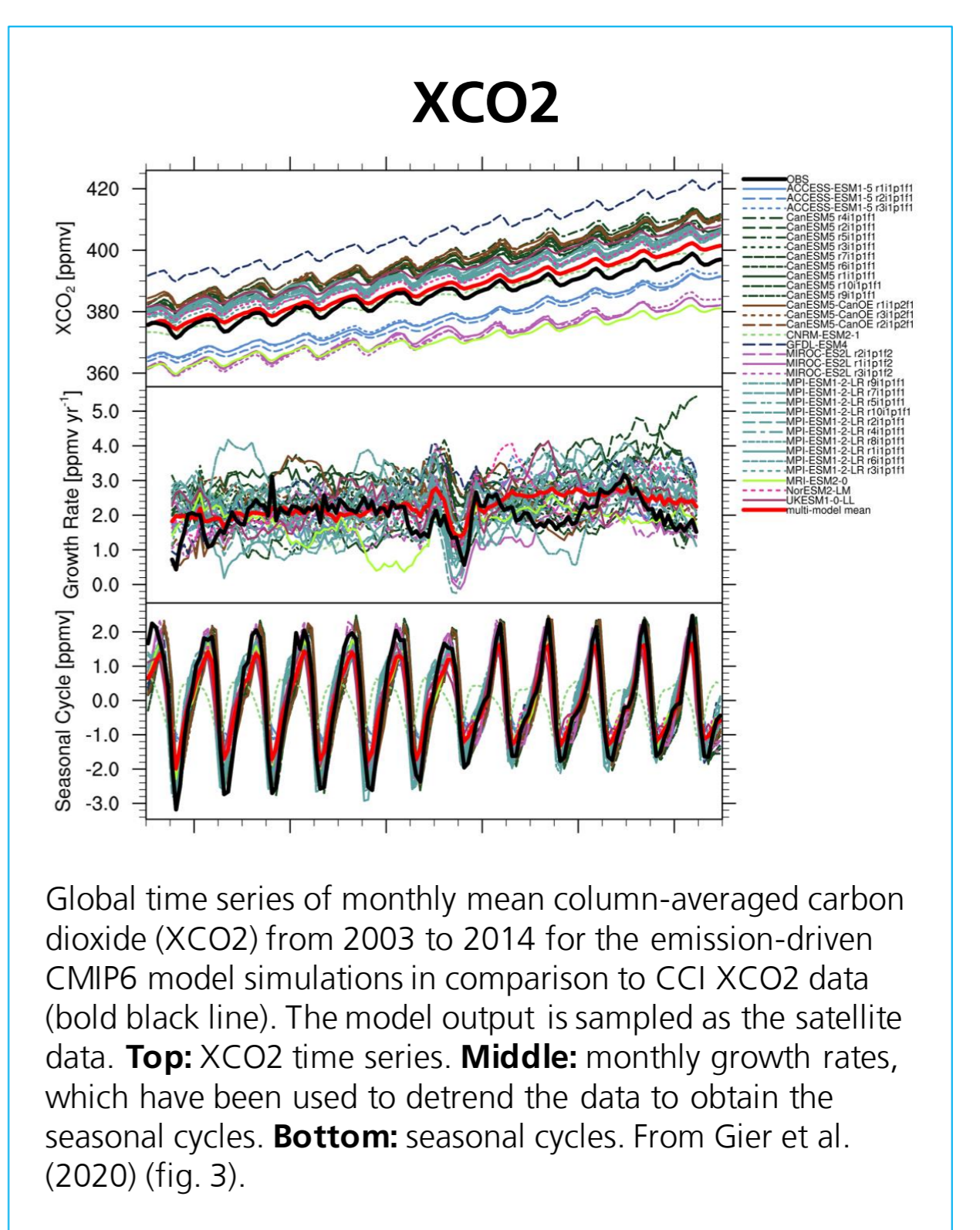
XCO2

Global time series of monthly mean column-averaged carbon dioxide (XCO2) from 2003 to 2014 for the emission-driven CMIP6 model simulations in comparison to CCI XCO2 data (bold black line). The model output is sampled as the satellite data. **Top:** XCO2 time series. **Middle:** monthly growth rates, which have been used to detrend the data to obtain the seasonal cycles. **Bottom:** seasonal cycles. From Gier et al. (2020) (fig. 3).

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