Earth System Model Evaluation Tool (ESMValTool)

A. Lauer and the ESMValTool development team

cmug
cci

What is ESMValTool?

The **Earth System Model Evaluation Tool** (ESMValTool) is a community diagnostics and performance metrics tool for the evaluation and analysis of Earth System Models (ESMs).

➤ **Community effort** open to both users and developers

➤ **Wide scope:** includes many diagnostics and performance metrics covering different aspects of the Earth system

➤ **High flexibility:** new diagnostics and more observational data can be easily added

➤ **Multi-language support:** Python, NCL, R, Julia (other open-source languages are possible)

➤ **Reproducibility** of the results (provenance)

➤ **Well-documented** source code and diagnostics

➤ **Online tutorial** for easy introduction for new users

➤ **Governance** structure in place

github.com/ESMValGroup

docs.esmvaltool.org
tutorial.esmvaltool.org

www.esmvaltool.org

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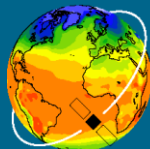
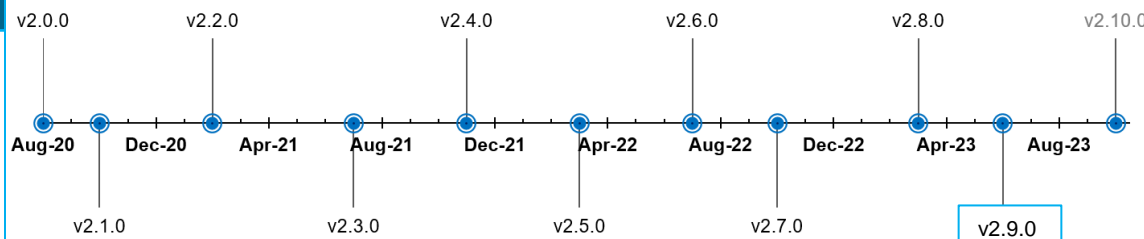**ESMValTool**
Earth System Model Evaluation Tool

- Community diagnostic and performance metrics tool for **evaluation and analysis of Earth system models**
- **Open source community development on GitHub** (> 200 developers, > 60 international institutes)
- Used in several chapters of the **Assessment Report 6** of the IPCC's WG1
- Release of v2.0.0 in August 2020, currently at v2.9.0

Timeline:
- v2.0.0 — Aug-20
- v2.1.0
- v2.2.0
- v2.3.0
- v2.4.0
- v2.5.0
- v2.6.0
- v2.7.0
- v2.8.0
- v2.9.0
- v2.10.0

Axis: Aug-20, Dec-20, Apr-21, Aug-21, Dec-21, Apr-22, Aug-22, Dec-22, Apr-23, Aug-23

Scientific Documentation

Righi et al., GMD, 2020
Technical overview

Eyring et al., GMD, 2020
Large-scale diagnostics

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

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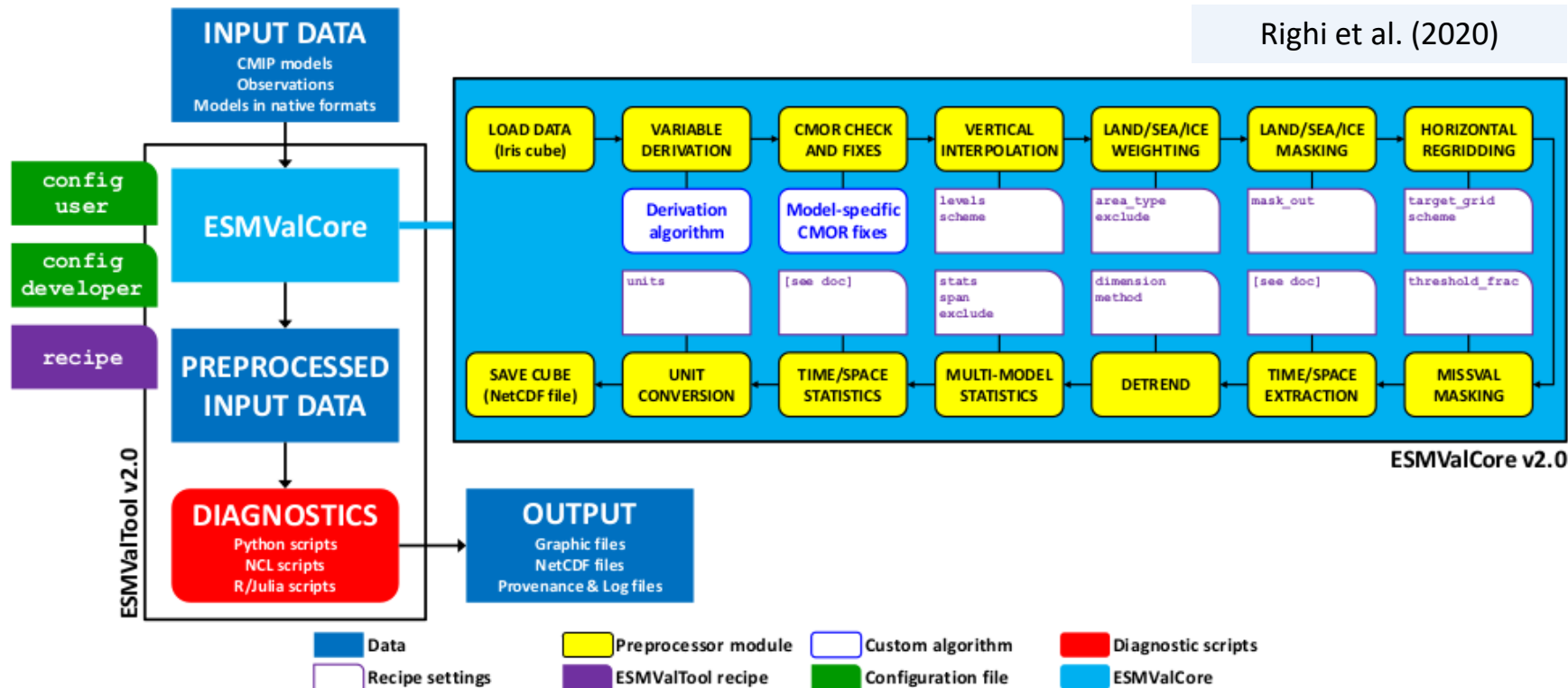**Diagnostics for extreme events, regional and impact evaluation**

Schlund et al., GMD, 2023
Evaluation of native ESM output

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

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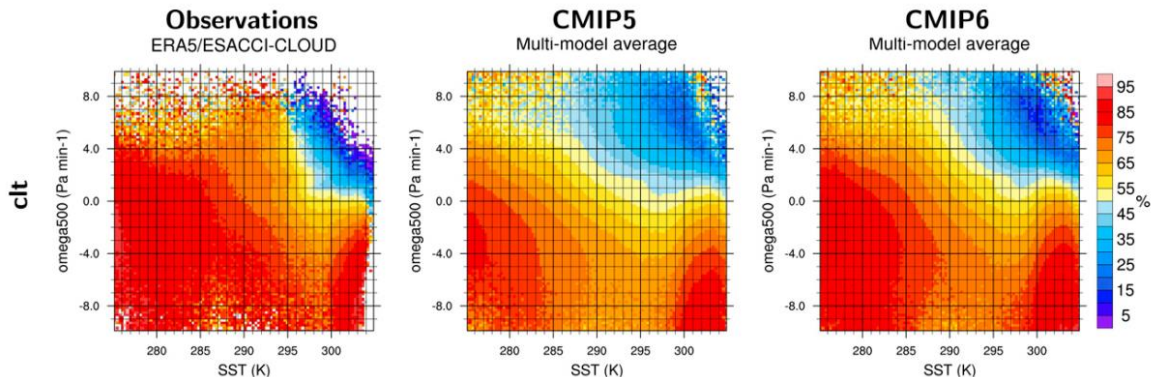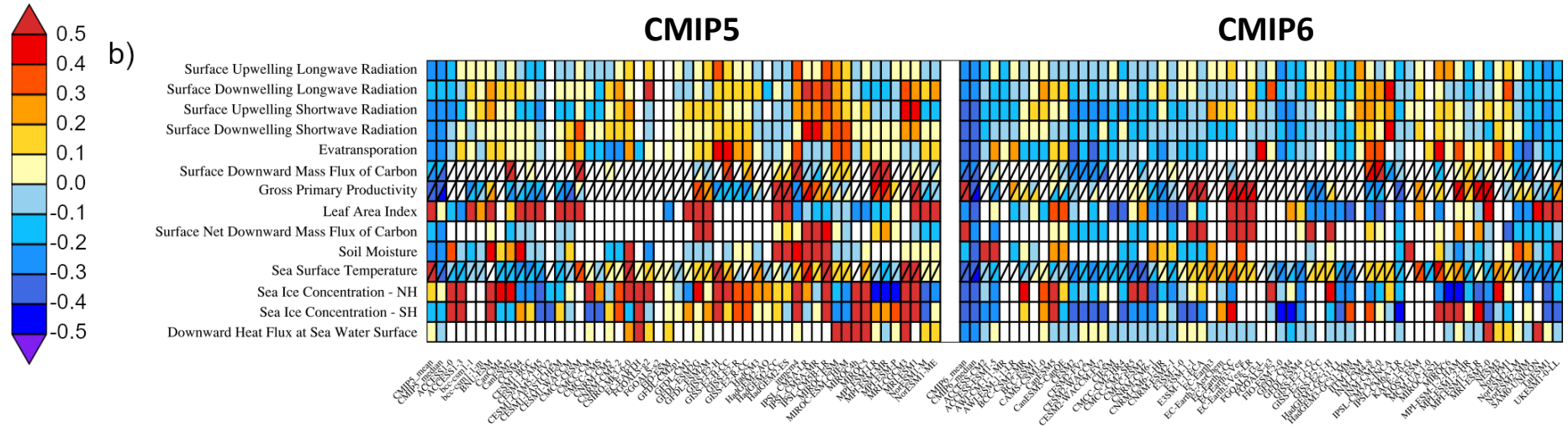
Evaluation of clouds

Lauer et al. (2023)
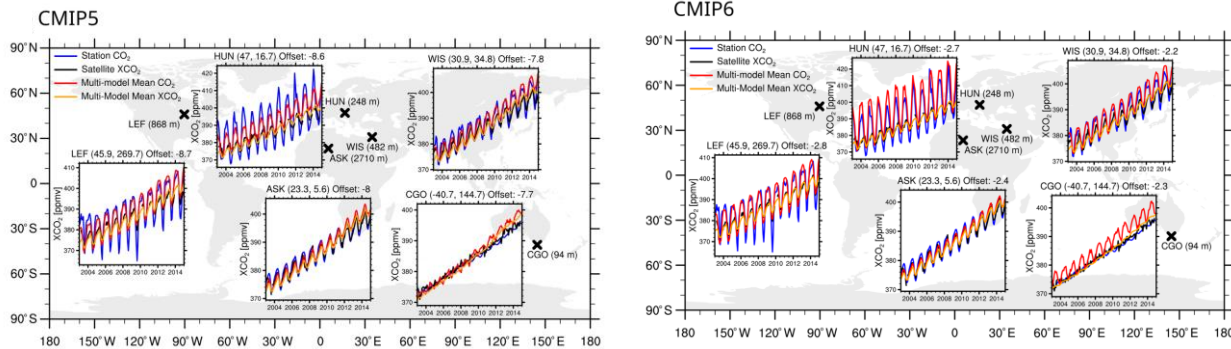
Evaluation of XCO$_2$

Gier et al. (2020)

Relative model performance (RMSD)

From: IPCC AR6, Chapter 3, Fig. 42

ESMValTool development in CMUG

ESMValTool
Earth System Model Evaluation Tool

- Exploit ESA CCI and CCI+ data in the context of **Earth system model (ESM) evaluation** with ESMValTool

- **Enhance the ESMValTool** with additional diagnostics and metrics enabling analysis of models with ESA CCI and CCI+ data

- Implementation of **new CCI datasets and corresponding diagnostics** into the ESMValTool and **updating existing datasets** where needed

- Explore possibilities to **take advantage of the uncertainty information** provided with the CCI datasets for model evaluation

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aerosol cci

update to Swansea ATSR (v4.33) and SLSTR / 3A (v1.12) OR ensemble (ATSR v3.0 and SLSTR / 3A v2.2) v6.1

permafrost cci

implement MODISLST_CRYOGRID-AREA4_PP-fv03.0

biomass cci

implement L4-AGB-MERGED-100m-2018-fv3.0

snow cci

implement multi-sensor.multi-platform.MERGED.2-0.r1

cloud cci

v3.0 AVHRR AM+PM
add L3U data (daily)

soil moisture cci

update to version v7.1

land cover cci

update to v2.0.7/v2.1.1

sst cci

add daily values
update v3.0 once available

land surface temperature cci

v3.00, MODIS EOS Aqua
add daily values

water vapour cci

v3.1 TCWV-global (COMBI)
add daily values

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- Available **uncertainty information** will be implemented into the ESMValTool alongside already existing ECVs from ESA CCI datasets

- In order to make **scientific use** of this uncertainty information, possibilities to propagate uncertainty information to the spatial and temporal scales used by the models will be investigated.

- As a **starting point**, work done on implementing uncertainty information for the CCI LAND SURFACE TEMPERATURE (Mittaz et al., 2019) will be used.
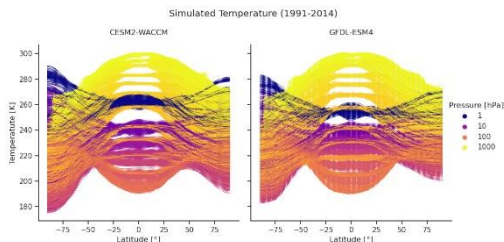
Starting point (Mittaz et al., 2019)

- Uncertainty propagation equations using matrices

- Generic platform for the propagation dependent on the error covariance matrix

- This approach is expected to work for LST and SST.

- It will then be investigated in a case-by-case study if an extension to selected other ECVs is possible.
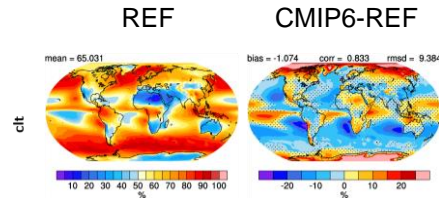
Diagnostics and datasets

- High-level interface to Python data visualization library *seaborn*

- CMIP6 evaluation (e.g. Lauer et al., 2023) and climate projections (e.g. Tebaldi et al., 2021)

- IPCC AR6 diagnostics

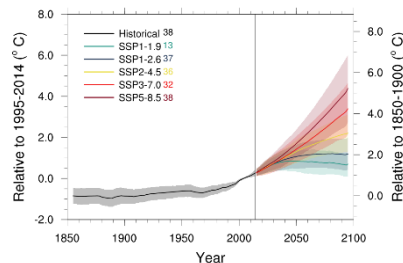- New observational and reanalysis datasets
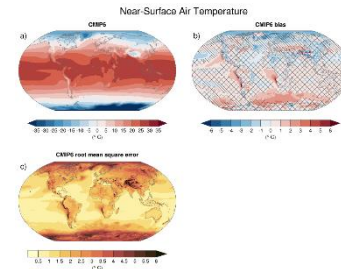

General visualization   **CMIP6 evaluation**   **Climate projections**   **IPCC AR6**
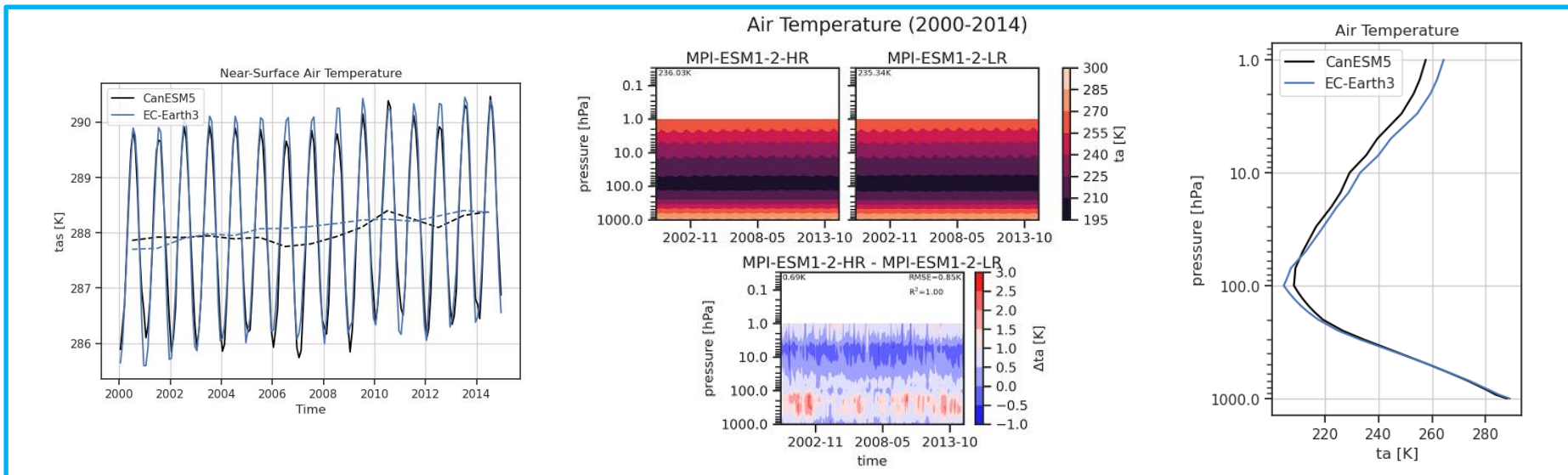
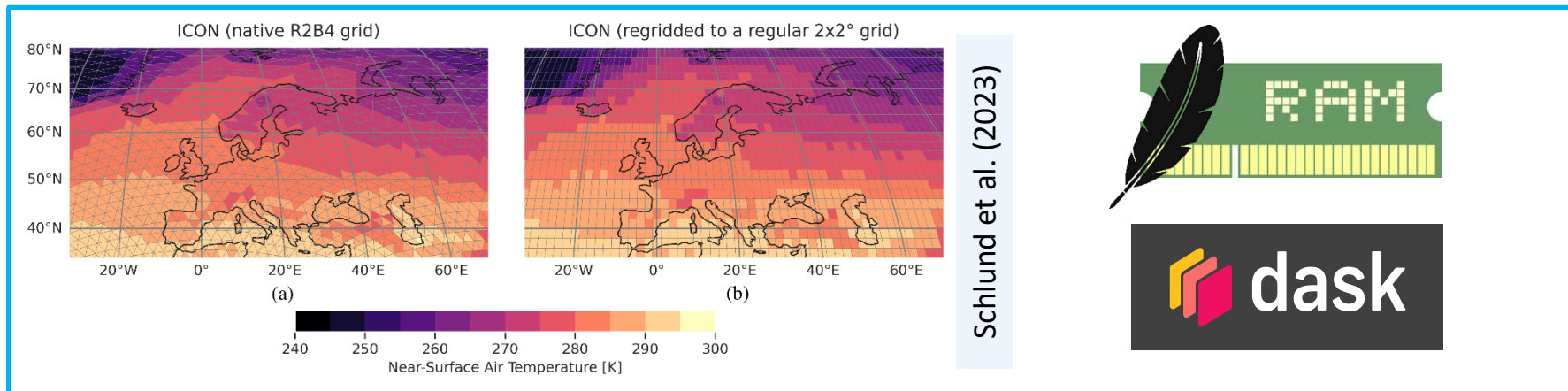European Space Agency

Model development

- Support for processing native model output (e.g. ICON)
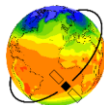
- Monitoring diagnostics

Getting ready for CMIP7

- Improved support for unstructured grids

- Reducing memory footprint: increasing number of lazy functions

- Improved parallel tasking: support for Dask distributed scheduler

Schlund et al. (2023)

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ESMValTool information

1. Github repositories

https://github.com/ESMValGroup/ESMValTool

2. Documentation

https://docs.esmvaltool.org/

3. Tutorial

https://tutorial.esmvaltool.org/

4. Webpage

https://www.esmvaltool.org/

ESMValTool on CMIP website

Posted on October 24, 2023

ESMValTool is now listed as one of the model benchmarking and evaluation tools on the CMIP website. Watch the ESMValTool video from the CMIP Model Benchmarking Task Team available on

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