

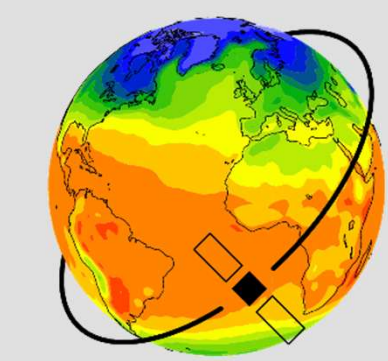
Analyzing and evaluating Earth system model simulations with observations using ESMValTool

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Abstract

The Earth System Model Evaluation Tool (ESMValTool) is a free and open-source community diagnostic and performance metrics tool for the evaluation of Earth system models. Here, we present an overview of the capabilities and features of the software package that can be used to analyze or evaluate results from e.g. CMIP and CORDEX models, reanalysis data or satellite observations. Biases of a model relative to observations can be put into the context of deviations shown by other state-of-the-art models, which greatly helps to assess even a large number of variables. Recently added diagnostics target potential problems such as unrealistic behavior of climate-relevant quantities, insufficient skill in reproducing the observed basic climate state, or violations of physical laws. The latter is particularly important for the emerging class of hybrid machine learning (ML) enhanced ESMs, where data-driven components are integrated with physics-based model formulations.



ESMValTool
Earth System Model Evaluation Tool

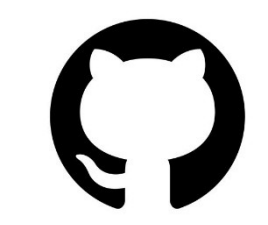
Resources



ESMValTool Website
esmvaltool.org



ESMValTool Documentation
docs.esmvaltool.org



ESMValTool on GitHub
github.com/ESMValGroup/ESMValTool



ESMValTool Tutorial
tutorial.esmvaltool.org



ESMValTool LinkedIn Profile
www.linkedin.com/company/esmvaltool



<https://esmvaltool.org/info>

About ESMValTool

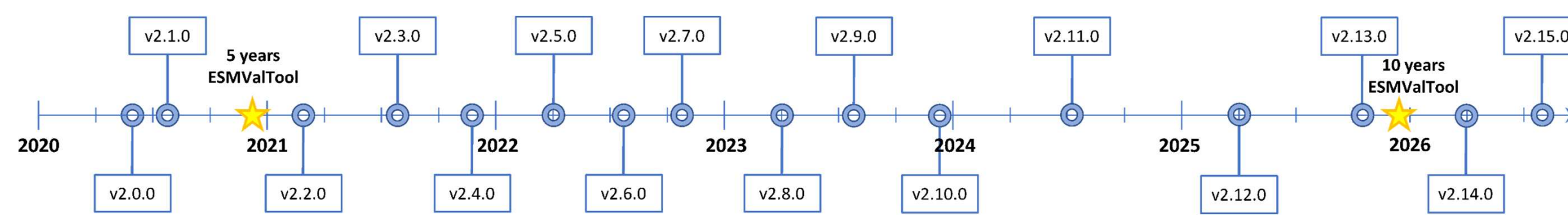
International ESMValTool development team

- 24 funded projects
- 76 institutions
- 274 developers

<i>Righi et al., GMD, 2020</i>
Technical overview
<i>Eyring et al., GMD, 2020</i>
Large-scale diagnostics
<i>Lauer et al., GMD, 2020</i>
Diagnostics for emergent constraints and future projections
<i>Weigel et al., GMD, 2021</i>
Diagnostics for extreme events, regional and impact evaluation
<i>Schlund et al., GMD, 2023</i>
Evaluation of native ESM output
<i>Lauer et al., GMD, 2025</i>
Monitoring and Benchmarking
<i>Schlund et al., GMD, 2025</i>
Optimization and efficiency
<i>Lauer et al., GMD, 2026</i>
Consistency and sanity checks

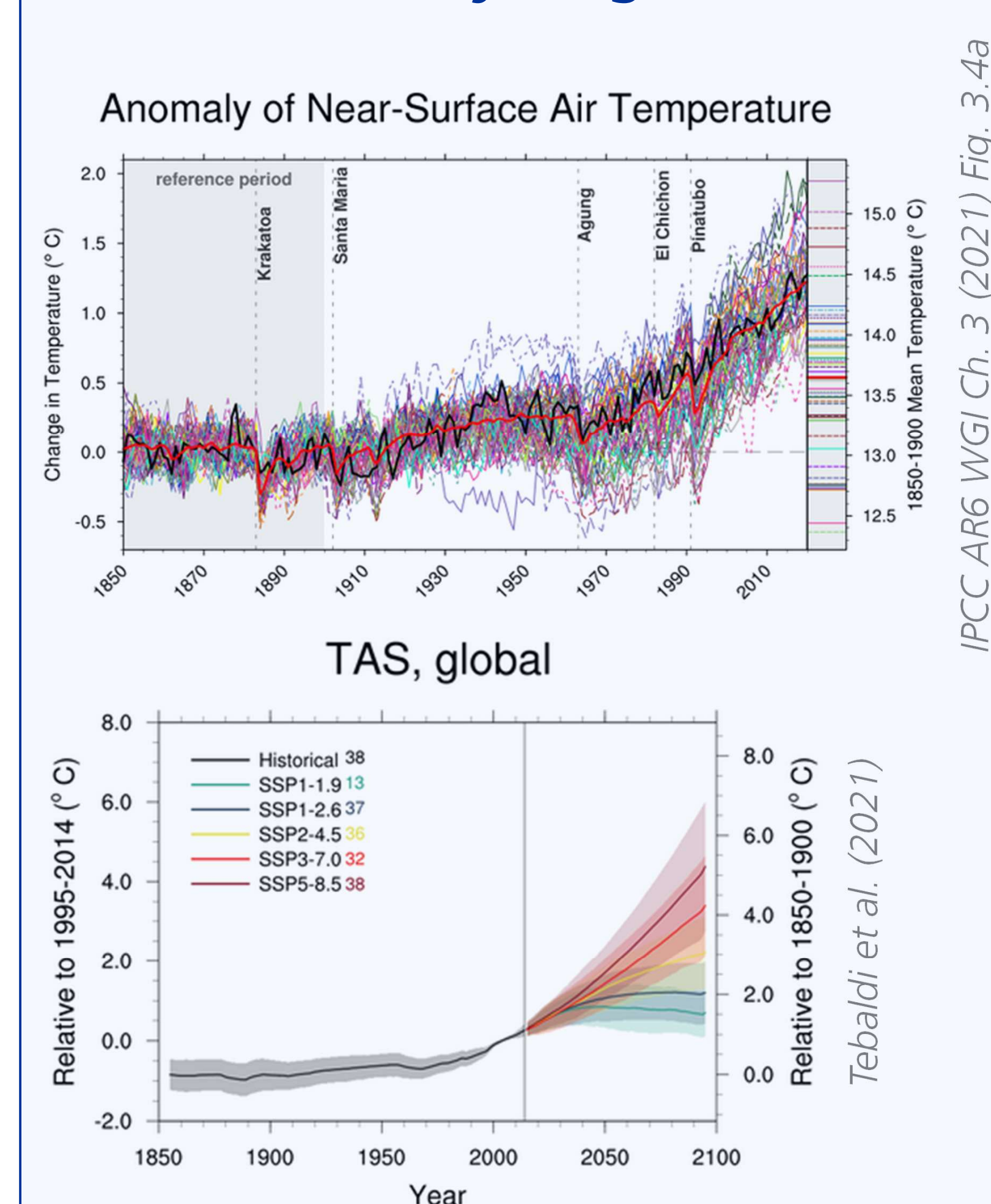
- Open source community-developed tool for fast and easy comprehensive **evaluation and analysis** of Earth system models including provenance records for all results (**traceability and reproducibility**)
- Used in several chapters of the **Assessment Report 6** of the IPCC's WG1
- One of the model benchmarking and evaluation tools selected by the **CMIP7 Model Benchmarking Task Team**
- Contribution to **Rapid Evaluation Framework (REF)**, which aims at evaluating CMIP7 model output in near-real time as soon as data sets are published

Timeline

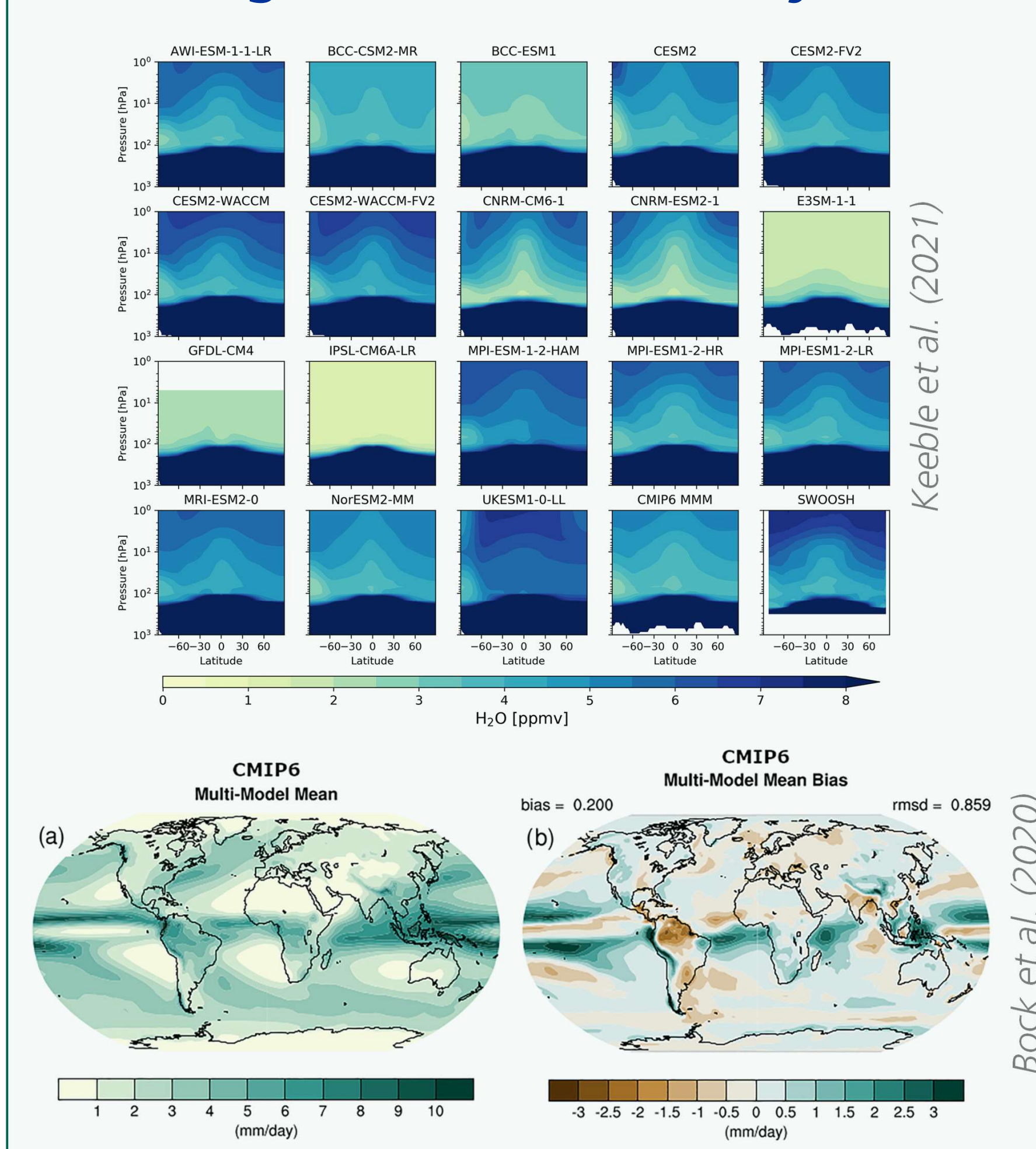


Examples of ESMValTool diagnostics and metrics

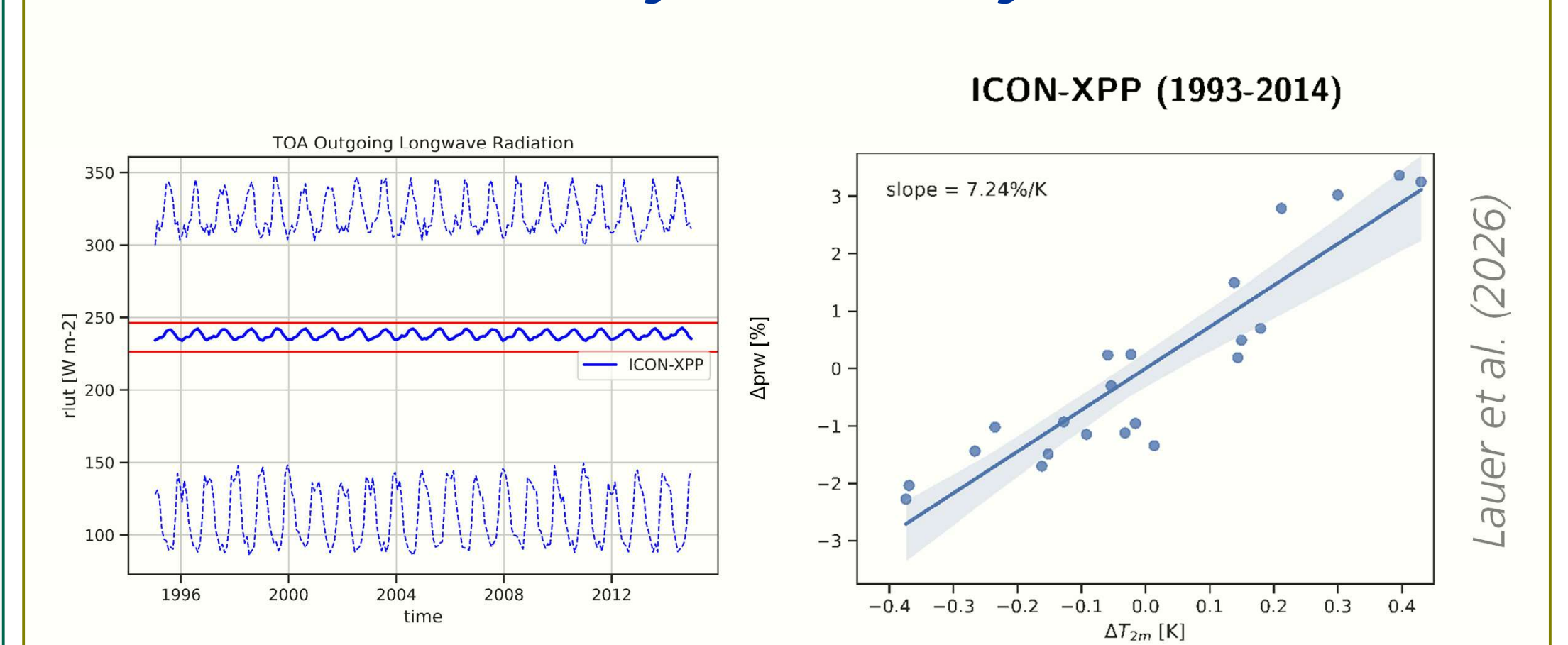
IPCC-style figures



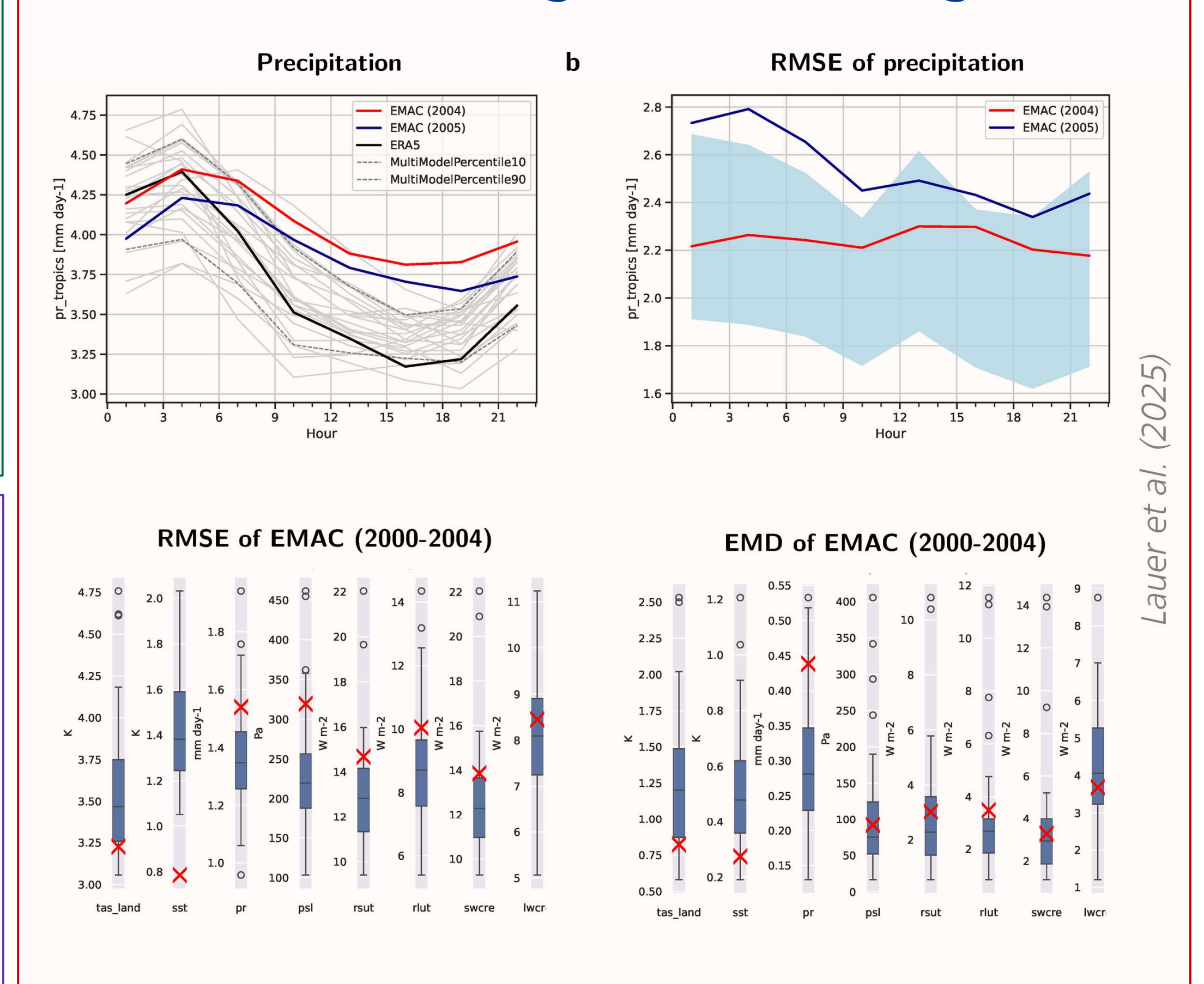
Single/multi model analyses



Consistency and sanity checks



Benchmarking and monitoring



ML-based diagnostics, causal inference

