

WP7: ESMValTool v2.0 – Analyzing CMIP models made easy

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Knowledge for Tomorrow



ESMValTool – Aim and motivation

The challenge of analysing and evaluating the CMIP6 ensemble

Compared with CMIP5: more models, more experiments, higher model complexity, higher resolution, increased data volume

➤ Easier and faster evaluation of complex Earth System Models

- Easy analysis of CMIP models
- Fast overview due to standard diagnostics, figures and variables
- Easy comparison of new model simulations with already existing runs and observations (e.g. obs4MIPs, ESA CCI)

Development and documentation



GitHub repository allows development with many users



Issue tracking system (GitHub)



Online documentation (readthedocs)

Automated quality control



Automated code checking (Codacy)



Automated testing (CircleCI)

ESMValTool – Aim and motivation

➤ Improved quality standard for model evaluation

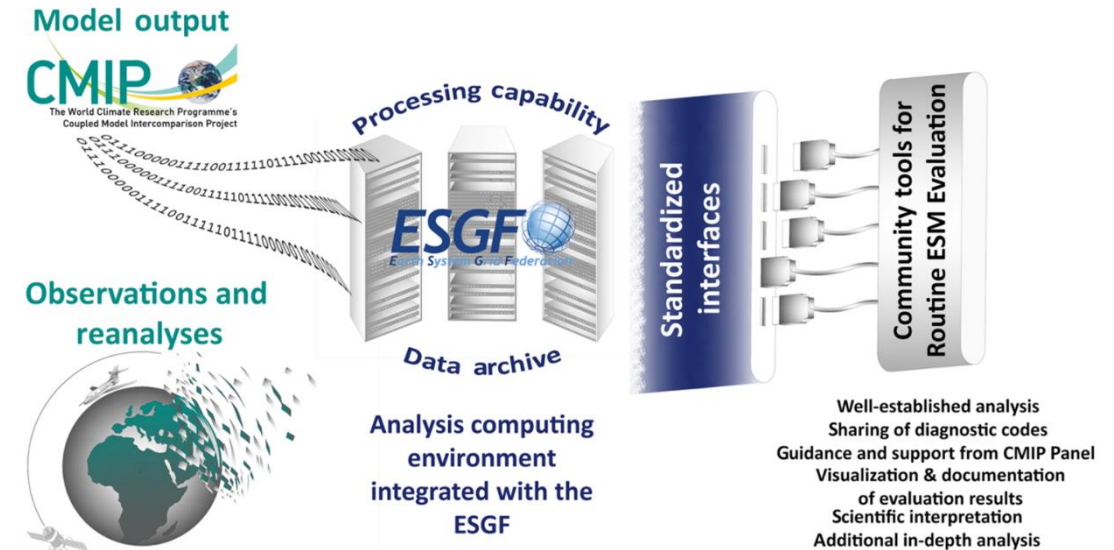
- Growing number of included diagnostics
- Reproduction of special reports or scientific papers with standard „recipes“
- Traceability and reproducibility of results

➤ Easily expandable

- Synergy with other software projects to expand the ESMValTool (e.g. NCAR CVDP)

➤ Coupling to Earth System Grid Federation (ESGF)

- Complete and timely analysis of CMIP simulations with observations



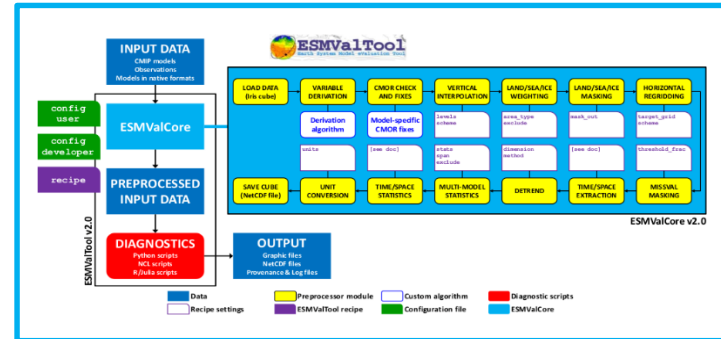
ESMValTool version 2.0

Release v2.0 August 2020

- **Open source community development on GitHub** (> 200 developers, > 60 international institutes)
- **Rapid development** since the first release in 2016 with support of CRESCENDO and other FP7 / H2020 projects
- **Online documentation**
- **Now a well-tested tool** providing end-to-end provenance to ensure reproducibility
- Used in several **IPCC WGI AR6** chapters

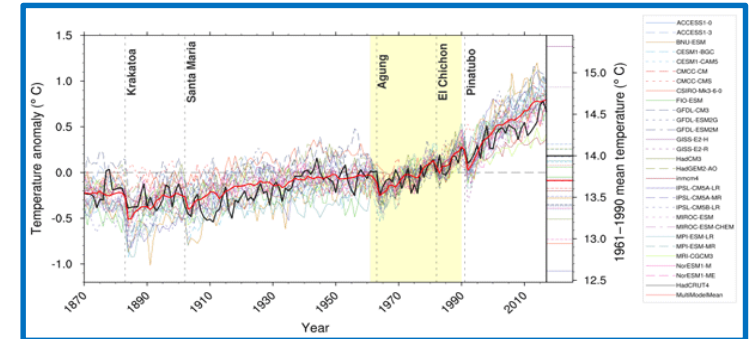
Righi et al., GMD (2020)

Technical overview



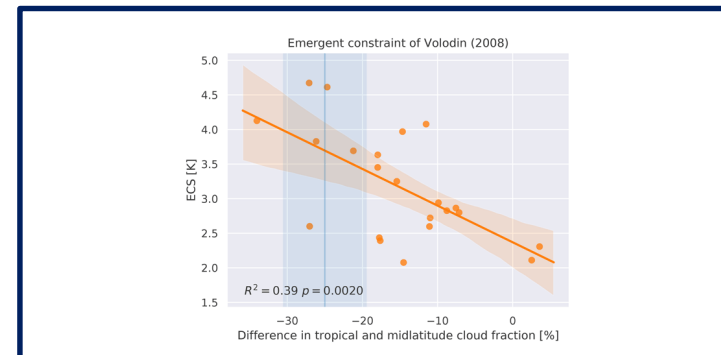
Eyring et al., GMD (2020)

Large-scale diagnostics



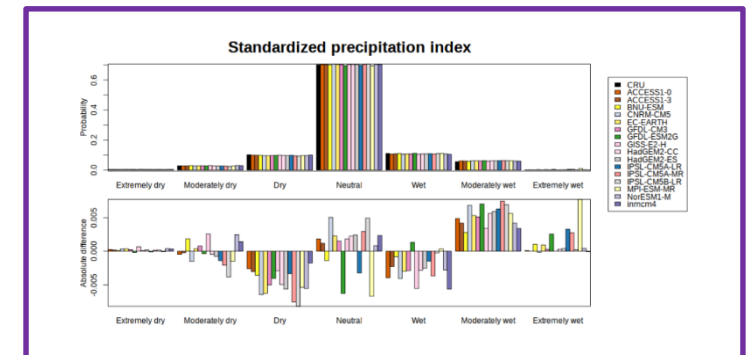
Lauer et al., GMD (2020)

Diagnostics for emergent constraints and future projections



Weigel et al., GMD (in rev.)

Diagnostics for extreme events, regional and impact evaluation



ESMValTool version 2.0



International ESMValTool development team

- 17 funded projects
- 63 institutions
- 203 developers

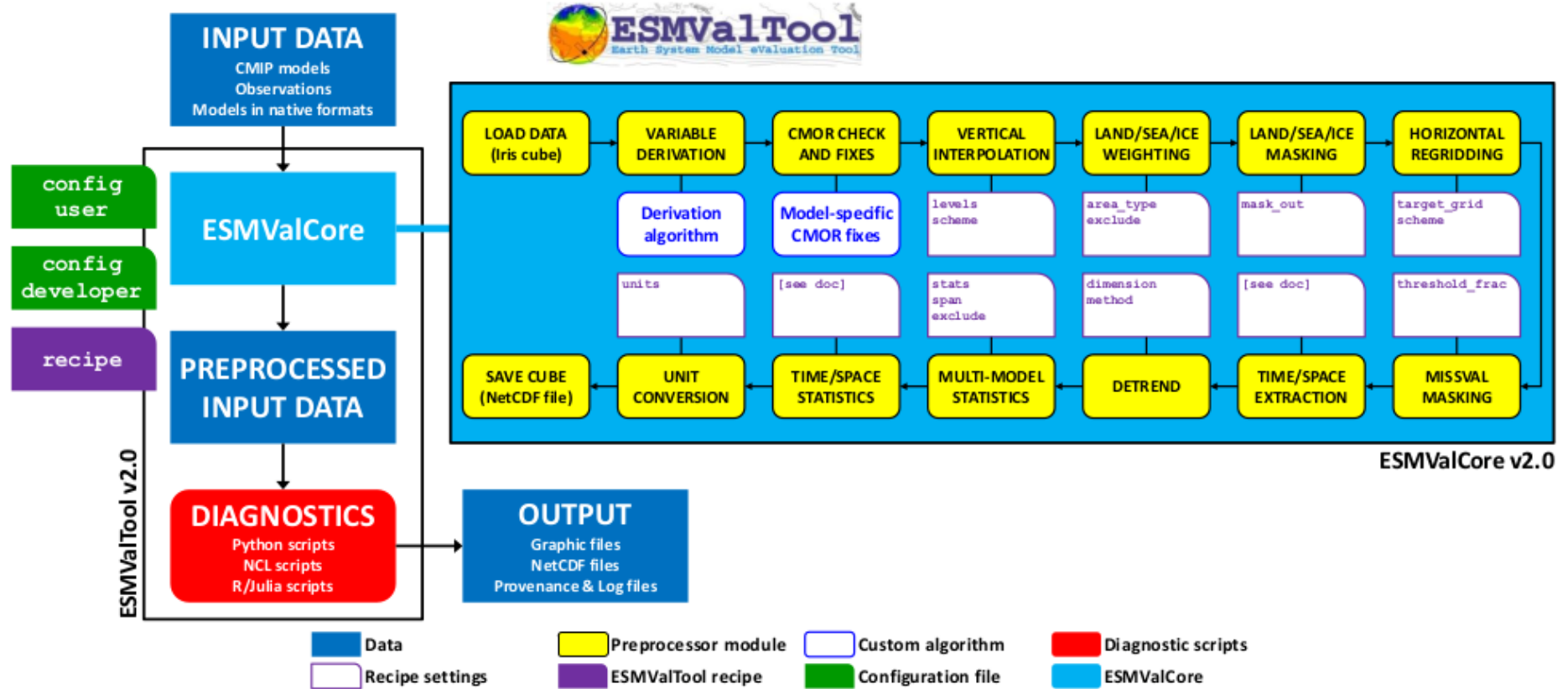
Release v2.0 August 2020

- 3.5 years of work
- 8 coding workshops
- 416 pages documentation
- 776 solved issues
- 1276 merged pull requests
- 1725 files
- 544,971 lines of code



ESMValTool v2.0 – workflow

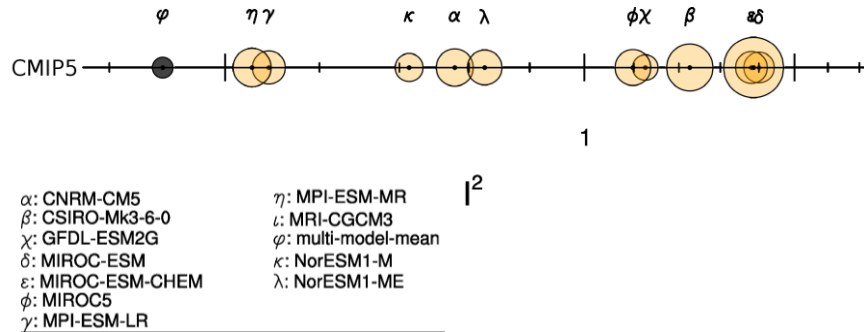
- Core functions completely rewritten in Python 3
- Improved performance and efficiency using state-of-the-art Python libraries (Iris, Dask)
- Greatly improved user friendliness (installation, configuration, documentation)



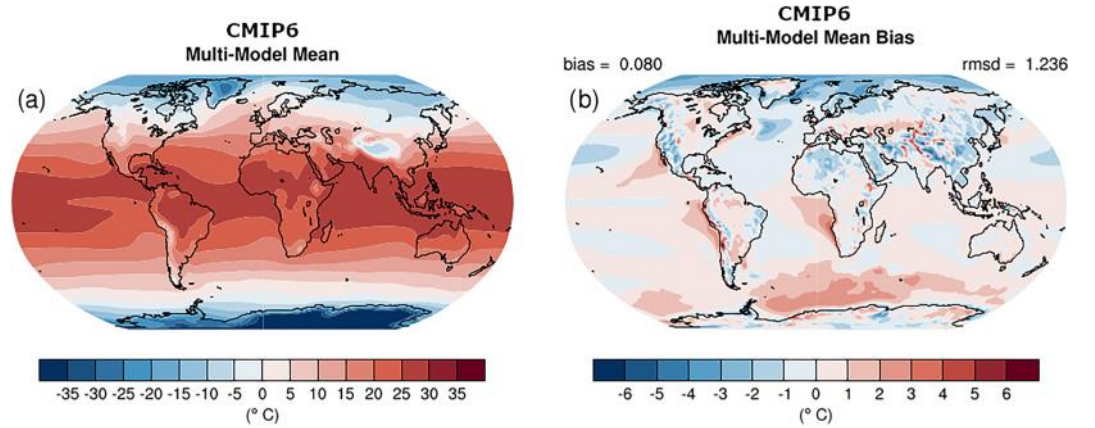
Righi et al., 2020
Technical overview

Examples of new large scale diagnostics (Eyring et al., 2020)

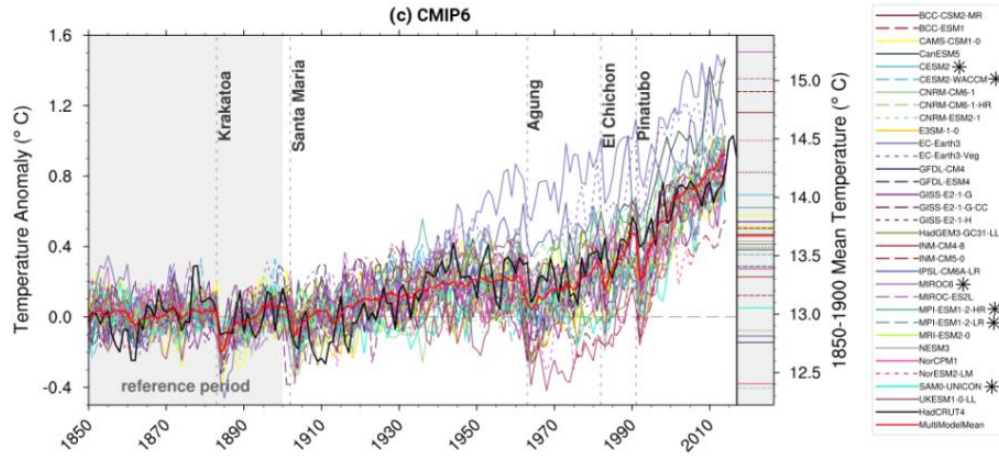
Single Model Performance Index (SMPI)



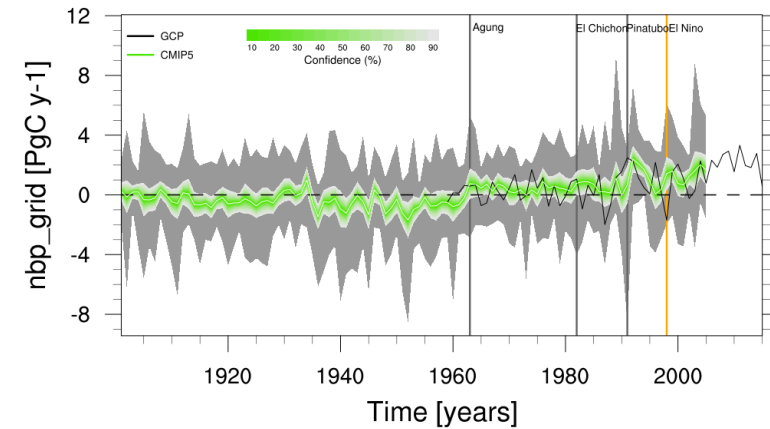
Annual mean 2-m air temperature (Bock et al., 2020)



Global average 2-m temperature anomalies (Bock et al., 2020)

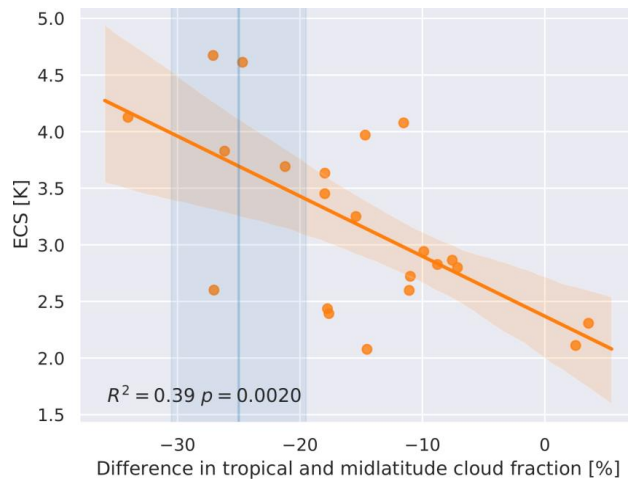


Global land-atmosphere CO₂ flux

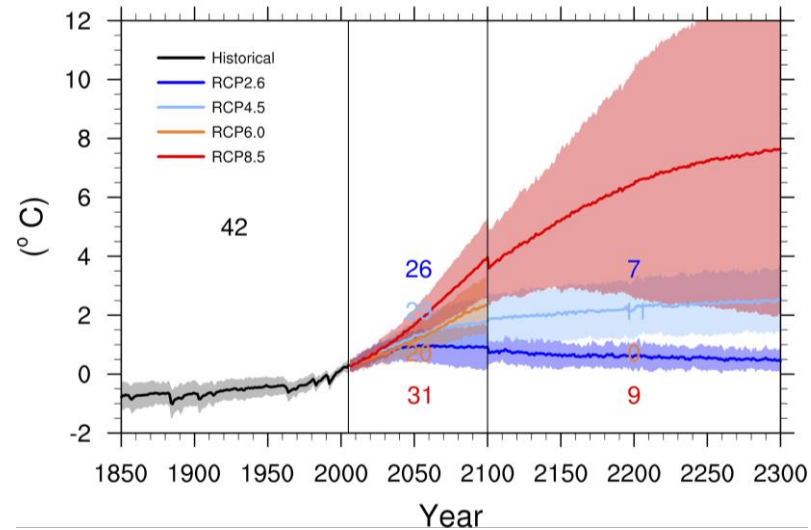


Examples of new diagnostics for emergent constraints and analysis of future projections from ESMs (Lauer et al., 2020)

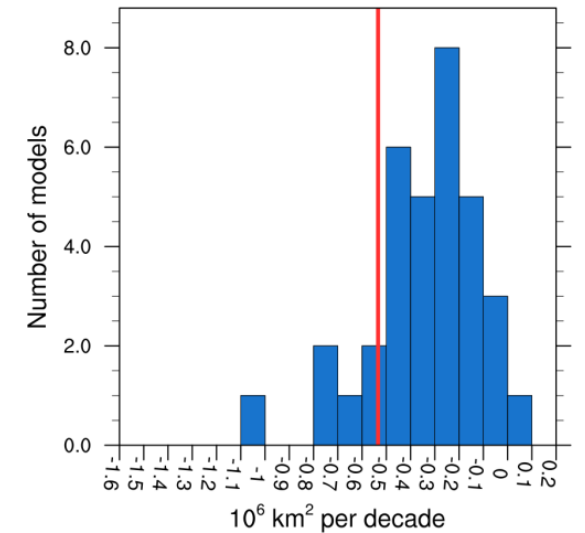
Emergent Constraint for ECS (Volodin, 2008)



Global 2-m temperature change

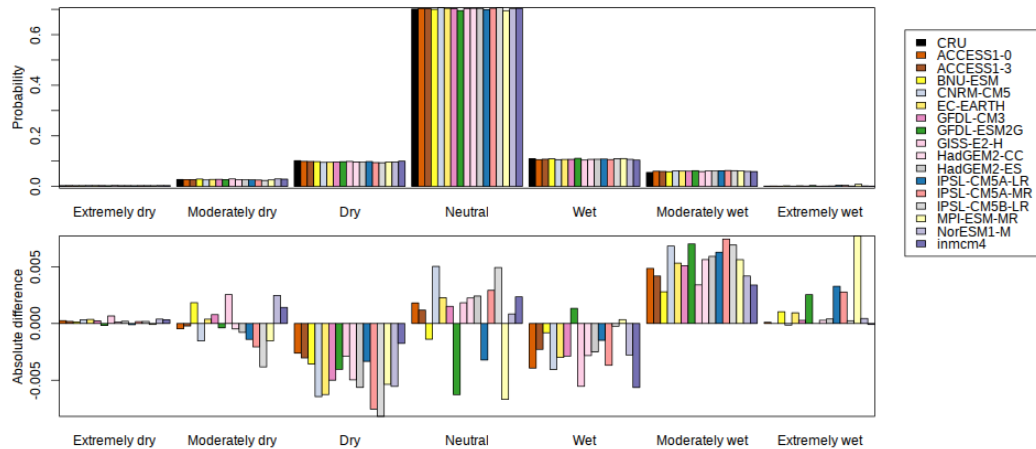


Trends in September Arctic sea ice extent

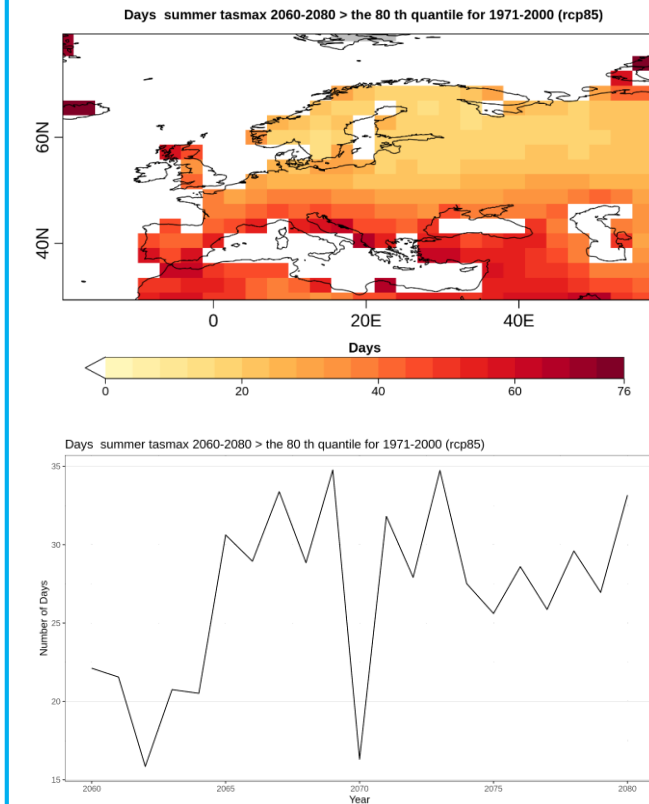


Examples of new diagnostics for extreme events, regional model and impact evaluation and analysis of ESMs (Weigel et al., in review)

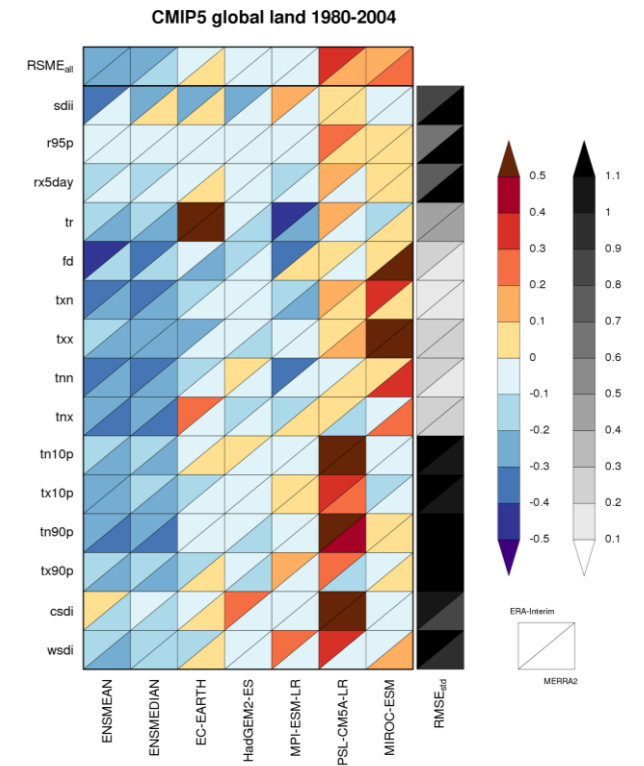
Standardized Precipitation Index (SPI)



Heatwaves



Portrait diagram – temperature and precipitation indices



Summary

- **ESMValTool:** Tool for fast and easy routine 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
- **v2.0 vs v1.0:** clear improvements in core capabilities (pre-processing options), code quality (automatized code checking), and documentation
- **Diagnostics:** more large-scale diagnostics, emergent constraints and future projections diagnostics, extreme events and regional and impact diagnostics available than before
- Supporting production of a subset of figures of the upcoming **IPCC WGI AR6**



Outlook

- ESMValTool development is growing
- Development of the ESMValTool continues beyond the end of CRESCENDO
- Current release: v2.2 (February 2021)

1. Github repositories

<https://github.com/ESMValGroup/ESMValTool>

2. Documentation

<https://docs.esmvaltool.org/>

3. Tutorial

https://esmvalgroup.github.io/ESMValTool_Tutorial/

4. Webpage

<https://www.esmvaltool.org/>

