

Supporting CMIP6 Simulations with the ESMValTool

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Projekttreffen CMIP6-DICAD

AWI Bremerhaven

18 April 2018



Knowledge for Tomorrow

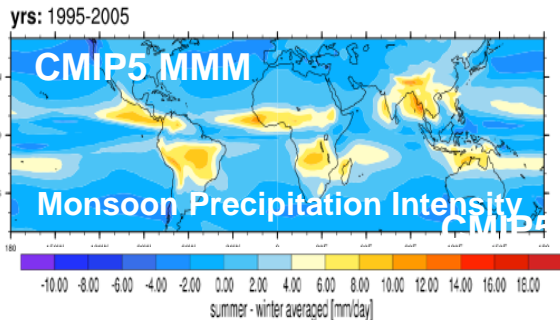


How to characterize the wide variety of models in CMIP6?

- Routine Benchmarking and Evaluation Central Part of CMIP6 -

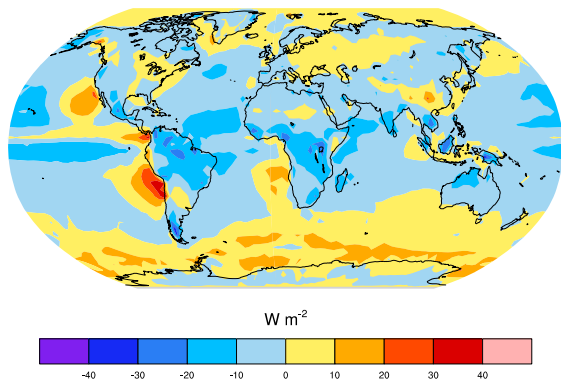
Tools such as the community-developed **Earth System Model Evaluation Tool (ESMValTool, Eyring et al., ESMValTool, GMD (2016b))** that includes other software packages such as the **NCAR CVDP (Phillips et al., 2014)**, and the **PCMDI Metrics Package (PMP, Gleckler et al., EOS (2016))** to produce well-established analyses as soon as CMIP model output is submitted.

Similar to **Figure 9.7 of AR5**



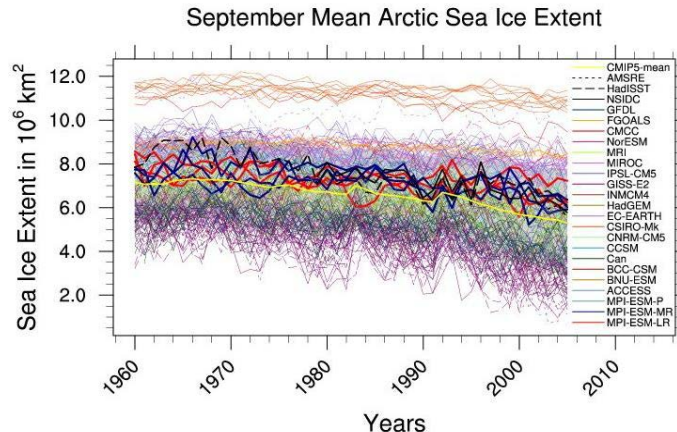
Similar to **Figure 9.5 of AR5**

Net Cloud radiative effect against CERES EBAF

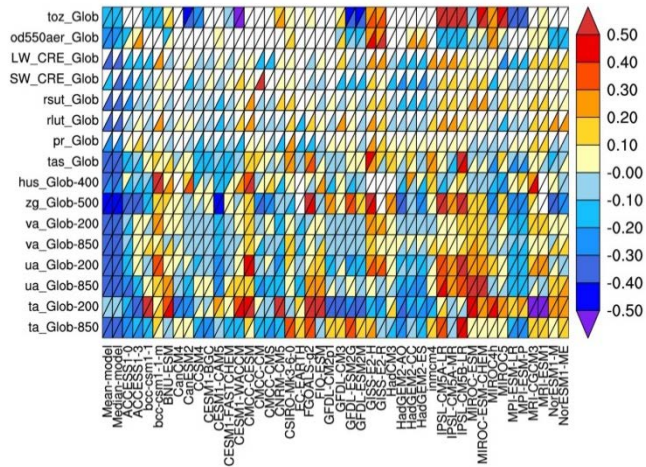


Running alongside the ESGF

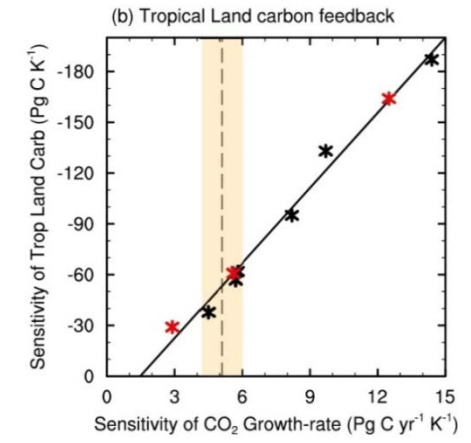
Similar to **Figure 9.24 of AR5**



RMSD - Global



Link to projections



Similar to **Figure 9.24 of AR5**

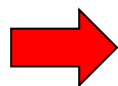
Workflow for Model Evaluation in CMIP5 & CMIP6

Workflow for model evaluation during CMIP5:

- Local download of high volume data => multiple copies at many institutions
 - Time and resource intensive
 - Local archive could quickly get outdated
 - Need to preserve metadata in the final result
- Duplication of efforts by non coordinated development of diagnostic code
- Evaluation by individual scientists (whenever they had time) => delays in the availability of a comprehensive assessment of the CMIP5 ensemble

Envisaged workflow for model evaluation in CMIP6 (Eyring et al., ESD, 2016):

- More coordination of software efforts because over the last several years, **community evaluation tools** have been developed as open source software
- the ESGF nodes have been expanded with **processing capabilities** so that the tools can run **alongside the ESGF** as soon as the output is published
- Evaluation tools will ensure **traceability & reproducibility** of evaluation results



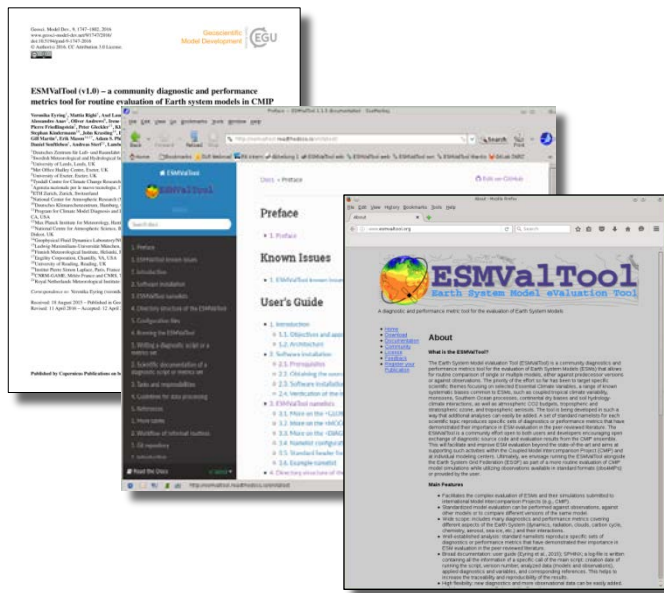
The resulting enhanced systematic characterization of models would identify **strengths & weaknesses** of the simulations **more quickly and openly to the community**, which will also support model development & assessments (e.g. IPCC)



ESMValTool version 1.0

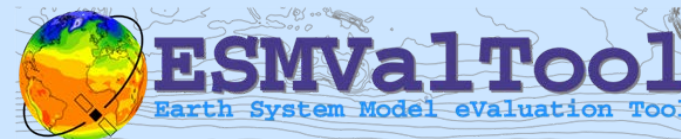
<http://www.esmvaltool.org/>

Eyring et al., *Geosci. Model Dev.*,
2016



GitHub

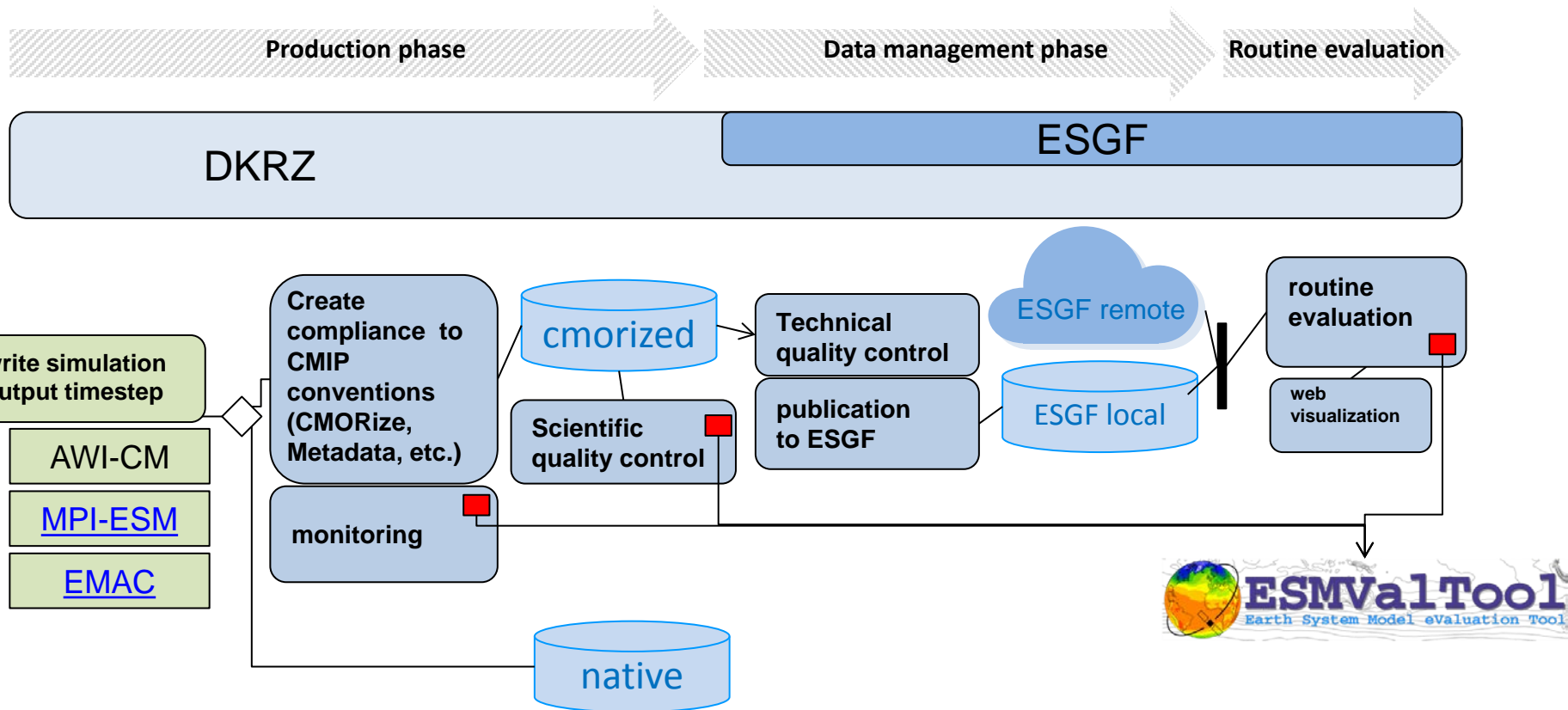
<https://github.com/ESMValGroup/ESMValTool/>



- **Community diagnostics and performance metrics tool** for the evaluation of Earth System Models
- **Standardized model evaluation** can be performed against observations, against other models or to compare different versions of the same model
- 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
- Well-established analysis based on **peer-reviewed literature**
- Ensuring **traceability and provenance** (e.g. input data, metadata, diagnostics (incl. citation), tool version, doi)
- Currently **≈ 110 scientist** from >30 institutions part of the development team and **> 120 users**
- **Development in several projects** (e.g. KliSAW, APPLICATE, CRESCENDO, C3S-MAGIC, PRIMAVERA)



Example for integration of the ESMValTool into the CMIP6 Workflow at the DKRZ



Integration for routine evaluation

Routine evaluation by combining synda and the ESMValTool
(final integration step next week at DKRZ)

- Synda acts as a daemon listening for changes on the ESGF
- Upon a successful replication step the ESMValTool will be called from synda to act on the new data

Data CMIP3, CMIP5 and CMIP6

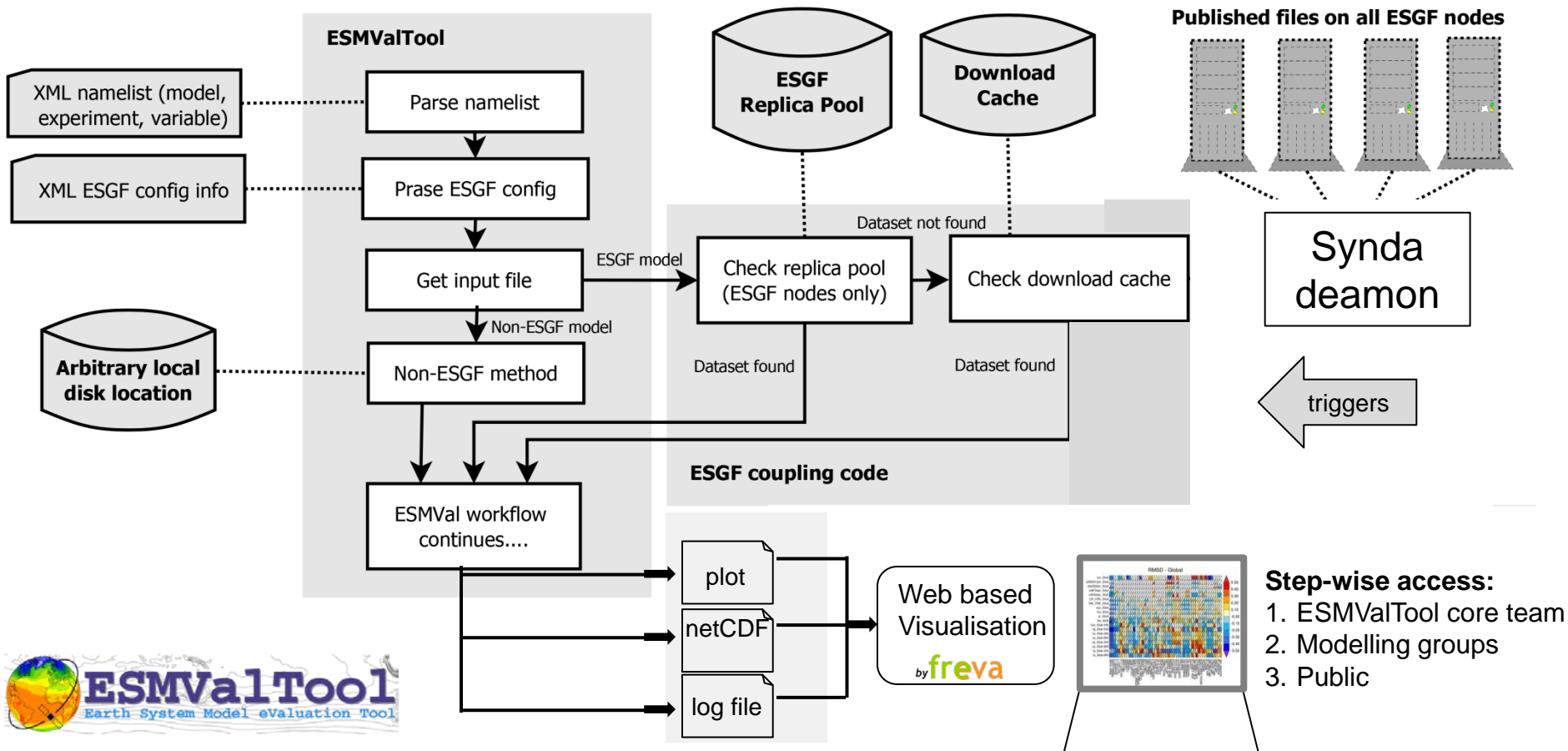
- /work/kd0956/
CMIP5, CORDEX, OBS4MIPS, PMIP3,..
- Current volume: 1.3 PByte

Observational Data

- /work/kd0956/OBS/bk1020 (group 1020)
- Current volume: 0.5 TB
Tier1, Tier2, Tier3



ESMValTool Workflow for routine evaluation at the ESGF (CMIP6-DICAD)



Derived from: Eyring et al., ESMValTool v1.0, GMD, 2016



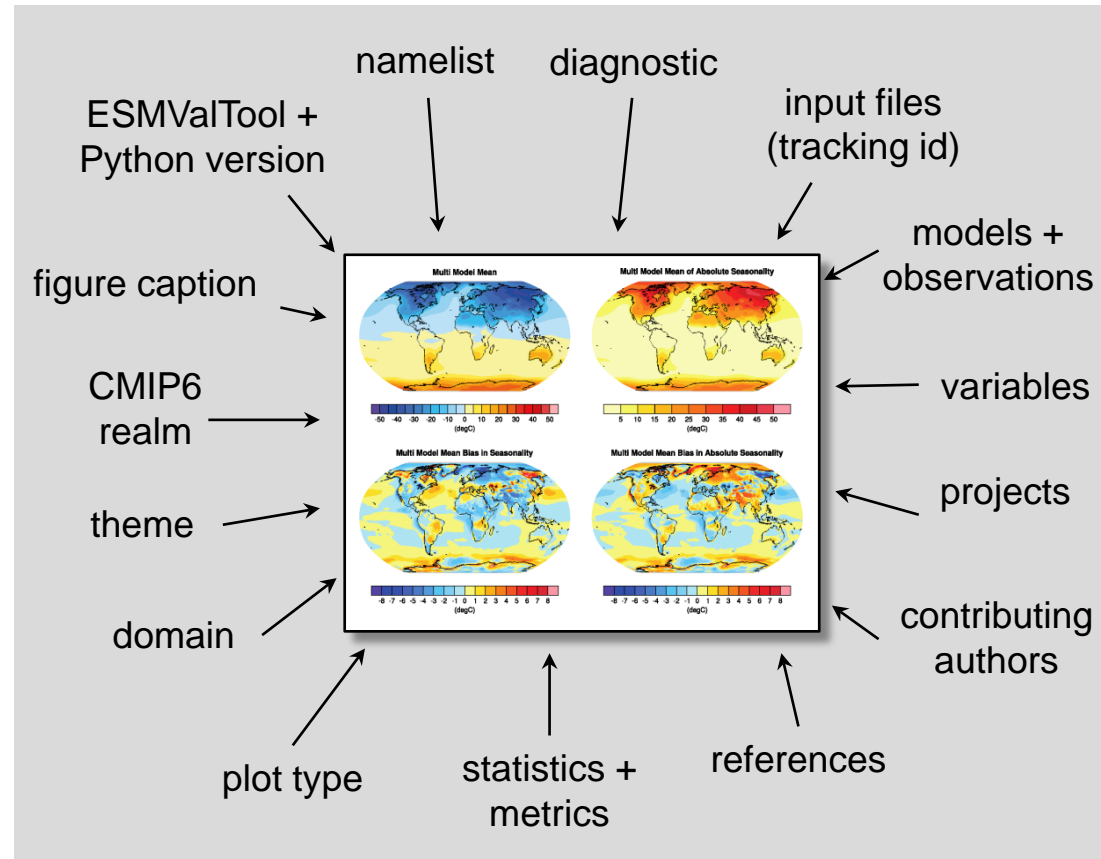
Enhancement of the ESMValTool

1. Improved provenance – traceability and reproducibility

Log-files

- Creation date
- Host and user
- Version number of the ESMValTool
- List of namelists / diagnostics run
- Variables and models processed
- List of all model files that have been used including + Tracking ID (read from metadata if available)
- Patches applied to model data (if any)
- List of all observations used including references
- Contributing authors and acknowledgement of projects

Tagging: meta data attached to image files



Visualization with FREVA

Cooperation with FUB in BMBF CMIP6-DICAD project for routine evaluation of CMIP6 models (including EMAC) as soon as output is submitted to the ESGF

<http://cmip-esmvaltool.dkrz.de/>

ESMValTool namelists (27)

Projects (4)

CMIP6 Realms (7)

Themes (16)

Domain (6)

Plot Type (16)

Statistics (14)

References (23)

Variables (83)

Models (392)

Results [5000]

Search ESMValTool namelists name

| | | | |
|--|---|-------------------------------------|-------------------------------------|
| namelist_CVDP [305] | namelist_DiurnalCycle_box_SFCflux [224] | namelist_DiurnalCycle_box_pr [32] | namelist_DiurnalCycle_harmonic [12] |
| namelist_ECS [23] | namelist_Evapotranspiration [120] | namelist_GlobalOcean [26] | namelist_SAMonsoon [87] |
| namelist_SAMonsoon_AMIP [83] | namelist_SAMonsoon_daily [45] | namelist_Sealce [10] | namelist_WAMonsoon [59] |
| namelist_WAMonsoon_daily [54] | namelist_aerosol_CMIP5 [2019] | namelist_anav13jclim [71] | namelist_collins13ipcc [21] |
| namelist_eyring13jgr [64] | namelist_flato13ipcc [114] | namelist_lauer13jclim [17] | namelist_lauer17rse [925] |
| namelist_mjo_daily [23] | namelist_mjo_mean_state [2] | namelist_perfmetrics_CMIP5 [451] | namelist_righi15gmd_Emmons [45] |
| namelist_righi15gmd_tropo3_CMIP5 [115] | namelist_wenzel14jgr [10] | namelist_williams09climdyn_CREM [1] | |

Filter by

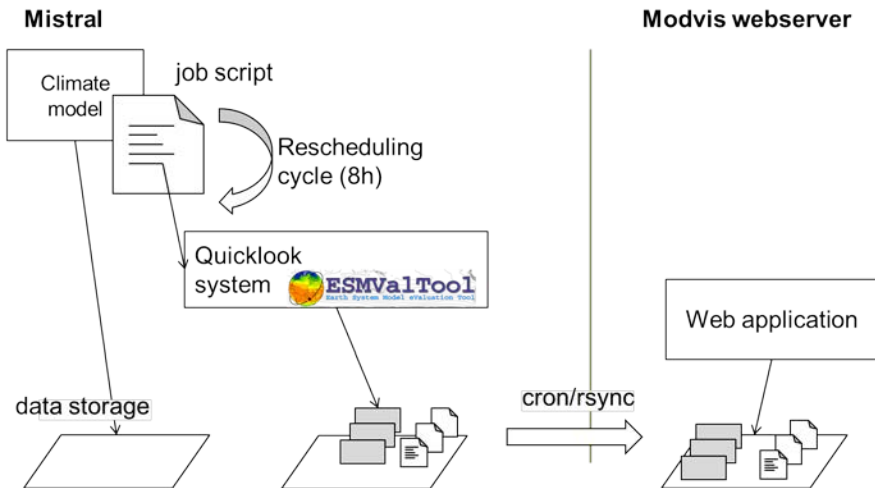
- namelist
- theme
- variable
- model
- reference
- etc.



Enhancement of the ESMValTool

2. EMAC monitoring with the ESMValTool

ESMValTool Quicklook System @ DKRZ



```
module use -a /pf/b/b309070/tools/sw/Modules/modulefiles/  
module load esmvaltool
```

```
$ quicklooks --help  
Usage: quicklooks [OPTIONS]
```

```
quicklooks -- Command line interface for the ESMValTool Quicklook System
```

```
Options:
```

```
--model [EMAC|MPI] Name of Model  
--rid TEXT String that identifies a single simulation run  
--project TEXT DKRZ project on which the quicklook jobs shall be  
charged  
--inpath TEXT Path to input files (output files of the simulation run)  
--help Show this message and exit.
```

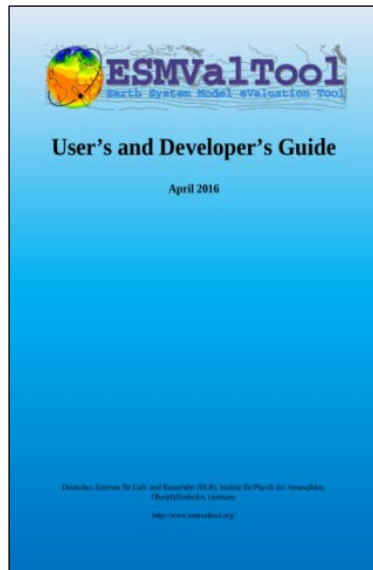
Status:

- System implemented and installed at dkrz
- Demo: <https://modvis.dkrz.de/bd0854/quicklooks/demo/mpi>
Username: demoCMIP6
Password: QuicklookCMIP6
- Application delayed due to problems occurring during integration



Enhancement of the ESMValTool

3. Automatization of creating User's and Developer's Guide: Sphinx based documentation system



Sphinx-based documentation

- Conversion to *reStructuredText* Format (.rst)
- Possibility of **in-code documentation**
- All source code files available in GitHub repository and can be edited directly on the GitHub website
- Automatic generation of html and pdf via **Read the Docs**
- Documentation available online at <http://esmvaltool.readthedocs.io/en/latest/>

Word document →
generating pdf → manual
upload to GitHub repository,
no web-based docu



Enhancement of the ESMValTool

The screenshot displays the ESMValTool documentation website. The top navigation bar includes the ESMValTool logo and a search bar. The left sidebar lists various documentation sections, with '1. Preface' at the top. The main content area shows the 'Preface' page, which includes a list of sections: '1. Preface', 'Known Issues', and 'User's Guide'. The 'User's Guide' section is expanded, showing sub-sections like '1.1. Objectives and approach', '1.2. Architecture', '2. Software installation', '3. ESMValTool namelists', and '4. Directory structure of the ESMValTool'. A red arrow points from the 'v: latest' dropdown menu in the bottom left corner of the page to the '1. ESMValTool known issues' link in the 'Known Issues' section.

ESMValTool

latest

Search docs

1. Preface

1. ESMValTool known issues

1. Introduction

2. Software installation

3. ESMValTool namelists

4. Directory structure of the ESMValTool

5. Configuration files

6. Running the ESMValTool

1. Writing a diagnostic script or a metrics set

2. Scientific documentation of a diagnostic script or metrics set

3. Tasks and responsibilities

4. Guidelines for data processing

5. References

1. More tables

2. Workflow of reformat routines

1. Git repository

1. Introduction

Read the Docs v: latest

Docs » Preface [Edit on GitHub](#)

Preface

- 1. Preface

Known Issues

- 1. ESMValTool known issues

User's Guide

- 1. Introduction
 - 1.1. Objectives and approach
 - 1.2. Architecture
- 2. Software installation
 - 2.1. Prerequisites
 - 2.2. Obtaining the source code
 - 2.3. Software installation
 - 2.4. Verification of the installation
- 3. ESMValTool namelists
 - 3.1. More on the <GLOBAL>-tag
 - 3.2. More on the <MODELS>-tag
 - 3.3. More on the <DIAGNOSTICS>-tag
 - 3.4. Namelist configuration file
 - 3.5. Standard header for the namelist
 - 3.6. Example namelist
- 4. Directory structure of the ESMValTool

online
version

pdf
version
available



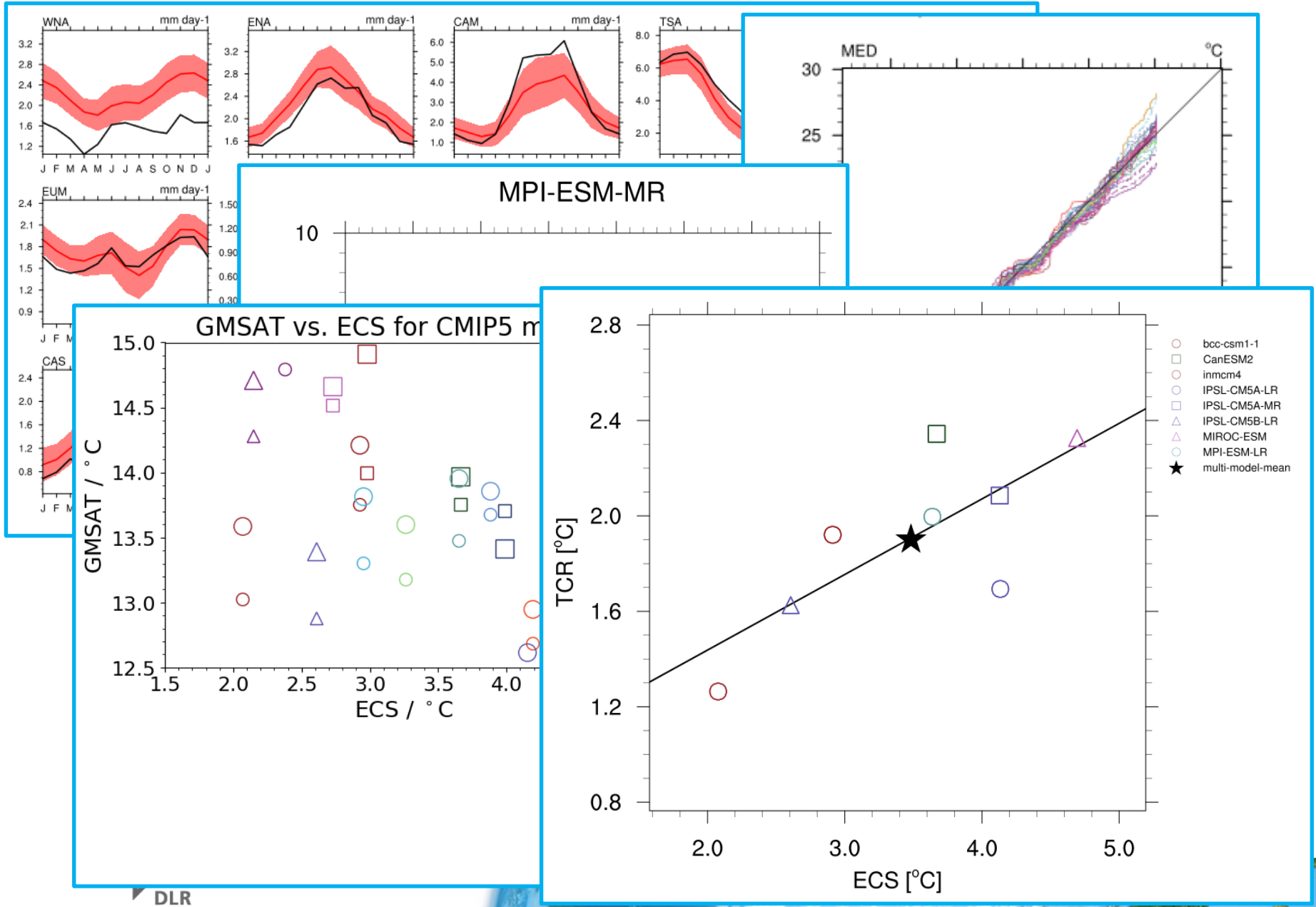
Enhancement of the ESMValTool

4. Examples of new diagnostics

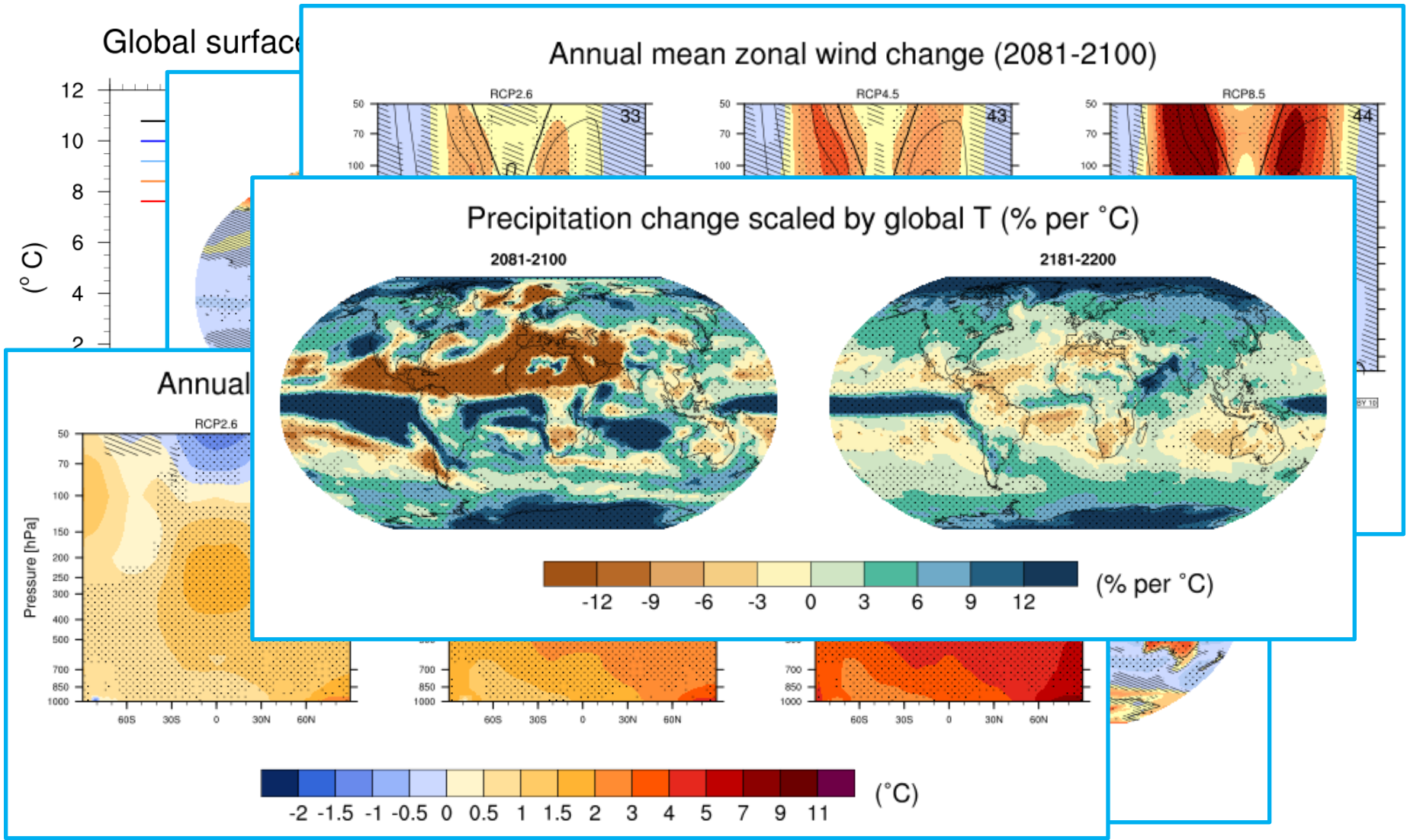
- **New diagnostics from IPCC AR5 chapter 9**
- **IPCC AR5 chapter 12 diagnostics:** analysis of long-term climate change projections
- **ESA CCI diagnostics** (published in Lauer et al., Remote Sensing of Environment, 2017): observational uncertainty, new ECVs
- **Equilibrium Climate Sensitivity and emergent constraints** (for climate sensitivity)



New diagnostics – IPCC AR5 chapter 9 diagnostics



New diagnostics – IPCC AR5 chapter 12 diagnostics



WP 6100 Enhancement of the ESMValTool

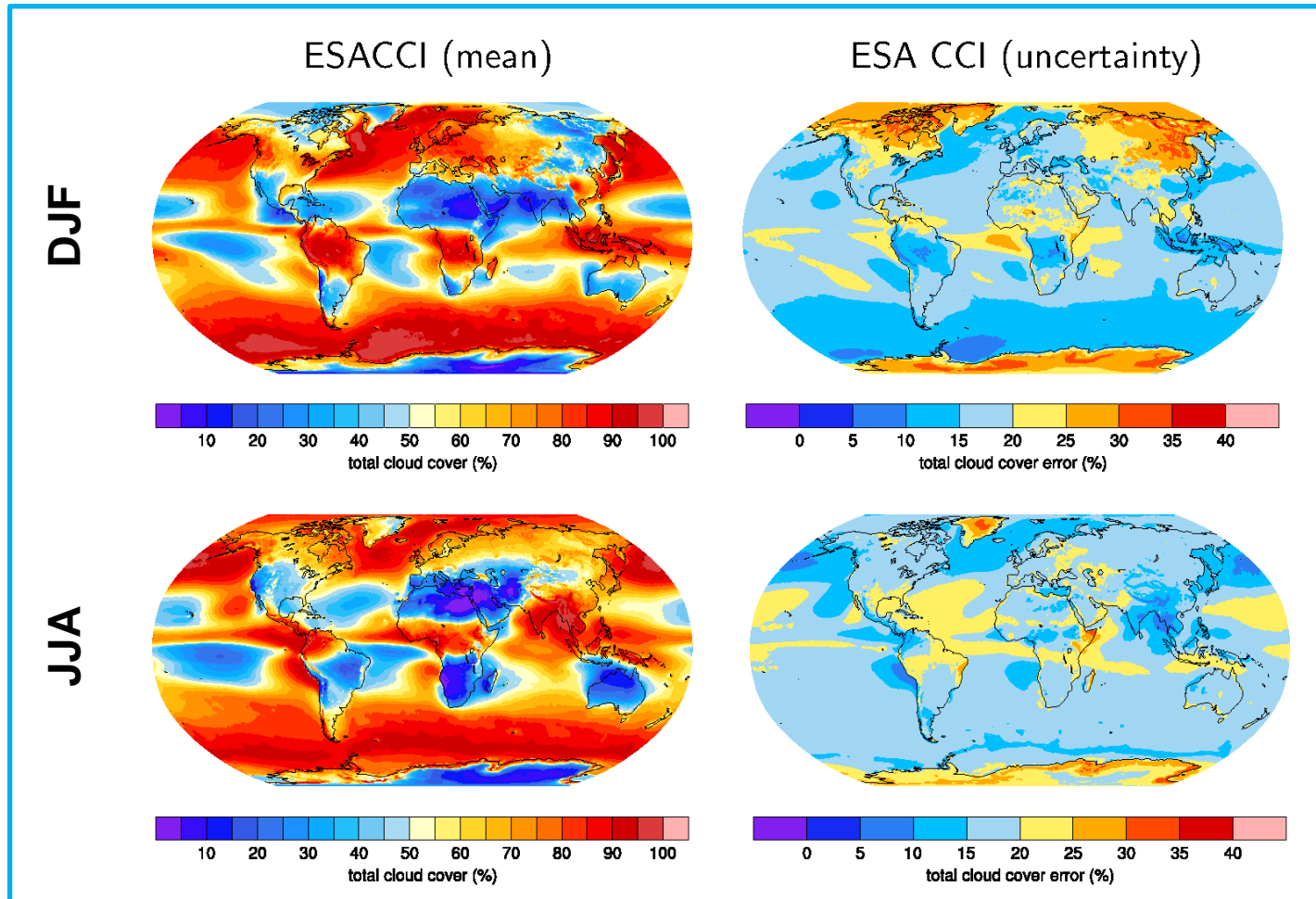
5. Examples of new observational data sets implemented into ESMValTool

- ACCESS-2 (conccnd5, conccnd10)
- Asmi et al. (2011) (aerosol size distrib.)
- CFSR (psl)
- CloudSat (clt)
- **ESA CCI AEROSOL** (od550aer, abs550, od550lt1aer, od870aer)
- **ESA CCI CLOUD** (clt, clwvi, clivi)
- **ESA CCI GHG** (xco2, xch4)
- **ESA CCI OZONE** (tro3, tropoz, toz)
- **ESA CCI SEAICE** (sic)
- **ESA CCI SOILMOISTURE** (sm)
- **ESA CCI SST** (ts)
- ESRL (surface CO₂)
- HadCRUT4 (tas)
- HIPPO (mmrbc)
- HWSD (soil carbon content)
- ISCCP (albiscpp, cliscpp, cltiscpp, cttiscpp)
- JMA-TRANSCOM (CO₂ exchange)
- LAI3g (leaf area index)
- MTE (gross primary productivity of carbon)
- NDP (vegetation carbon content)
- NIWA (toz)
- TOMS (toz)
- WHOI-OAFlux (hfls, hfss)



New observational data sets

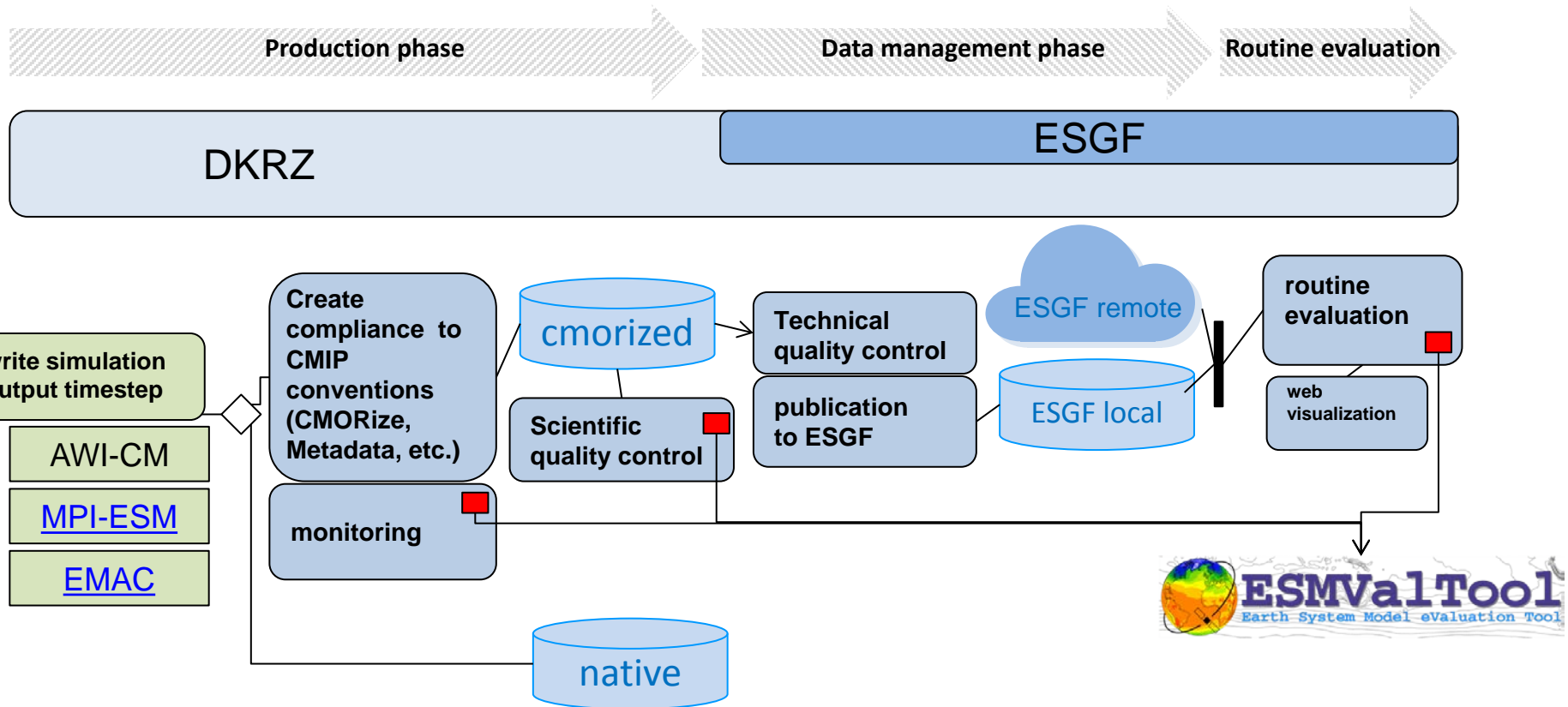
Example: ESA CCI CLOUD (1982-2014)



From: Lauer et al., Remote Sensing of Environment, 2017



Example for integration of the ESMValTool into the CMIP6 Workflow at the DKRZ



ESMValTool Related Milestones in CMIP6-DICAD

- Standardisierte Diagnostiken und Modellevaluation (AP6) -

- **M1: Entwurf mit ausführlicher Spezifikation zum Portal [Monat 6, FUB]**
- **M2: Prototype ESMValTool Version läuft in der ESGF DKRZ Infrastruktur [Monat 9, DKRZ]**
- **M3: ESMValTool steht zur operationellen Laufüberwachung in der DKRZ Infrastruktur zur Verfügung [Monat 12, DLR]**
- **M4: Lauffähiger und getesteter Prototype für das Portal [Monat 15, FUB]**
- **M5: ESMValTool mit erweiterten Diagnostiken auf CMIP5 Modelldaten angewandt [Monat 18, DLR]**
- **M6: ESMValTool mit CMIP6 Modelldaten und Beobachtungsdaten vollständig integriert in der ESGF DKRZ Infrastruktur [neu: Monat 36, DKRZ]**
- **M7: MPI-ESM1/2 und EMAC2 mit erweiterter ESMValTool Version evaluiert und mit anderen CMIP6 Modellen verglichen [neu: Monat 42, DLR]**
- **M8: Produktionssystem des Portals ist installiert [Monat 36, FUB]**



=> Work on time