Earth System Model Evaluation Tool (ESMValTool)

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ESMValTool
Earth System Model eValuation Tool

What is the ESMValTool?

- **Community diagnostics and performance metrics tool** for the evaluation of Earth System Models
- **Development in multiple projects** (e.g. APPLICATE, CMIP6-DICAD, CRESCENDO, C3S-MAGIC, ESA CMUG, PRIMAVERA, IS-ENES3)
- Encompass 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**

What main problems does the ESMValTool want to solve?

- **Reproduceability** with respect to Earth system model evaluation
- **Efficiency** by providing standard diagnostics without the need to do recoding
- **Sustainability** by incorporating community contributions into a larger framework
- Ensure **provenance** for the output data files and plots
- Freedom for diagnostic developers to **code in** their **preferred language** by supporting multiple languages (currently Python, R, NCL, Julia)

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ESMValTool Development Community

- **Core Development Team**

Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Physik der Atmosphäre, Germany (PI)

Alfred Wegener institute (AWI), Germany (overseeing EU Horizon 2020 APPLICATE and TRR181 ESMValTool work)

Barcelona Computing Center (BSC), Spain (overseeing EU Horizon 2020 PRIMAVERA ESMValTool work)

Netherlands e-Science Center (NLeSC), The Netherlands

Ludwig Maximilian University of Munich, Germany (overseeing EU Horizon 2020 CRESCENDO ESMValTool work)

University of Reading, United Kingdom

ESMValTool Development Team

>30 Institutions

Regular workshops, see https://www.esmvaltool.org/meetings.html

Diagnostics and metrics included in version 1.1.0

Porting to version 2 is ongoing

Physics
- Clouds
- Cloud regime error metric (CREM)
- Diurnal cycle of convection
- Evapotranspiration
- Madden-Julian Oscillation (MJO)
- Performance metrics for essential climate parameters
- South Asian monsoon
- Southern Hemisphere
- Standardized precipitation index (SPI)
- Tropical variability
- West African monsoon
- Extreme events (in progress)
- Regional diagnostics (in progress)

Land
- Catchment analysis

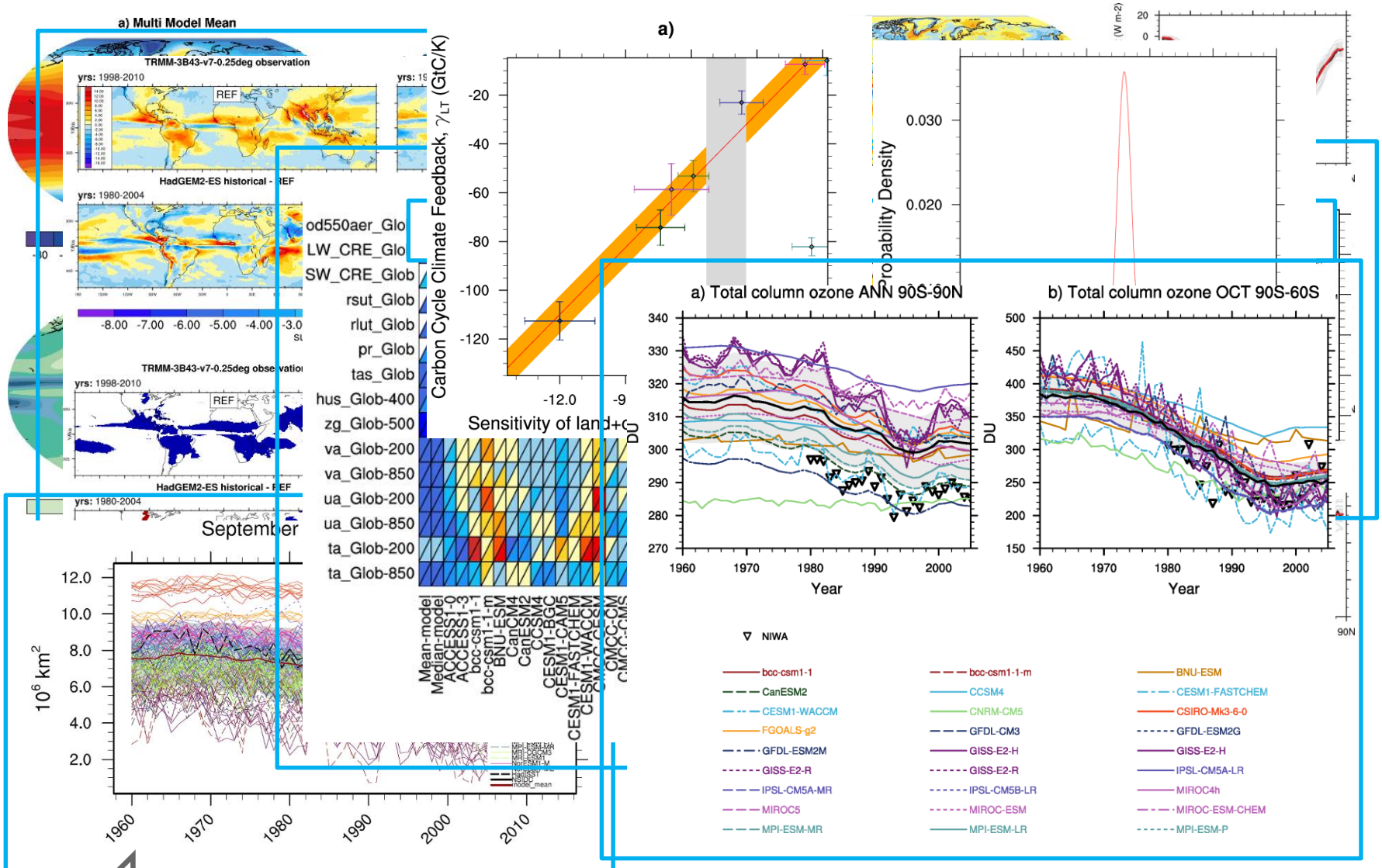
Atmospheric composition
- Aerosol
- Land and ocean components of the global carbon cycle
- Emergent constraints on carbon cycle feedbacks
- Ozone and associated climate impacts
- Ozone and some precursors

Ocean
- Marine biogeochemistry
- NCAR climate variability diagnostics package (CVDP)
- Southern Ocean

Cryosphere
- Sea ice

General
- IPCC AR5 chapter 9 and 12 (in progress)

Diagnostics – IPCC AR5 chapter 9



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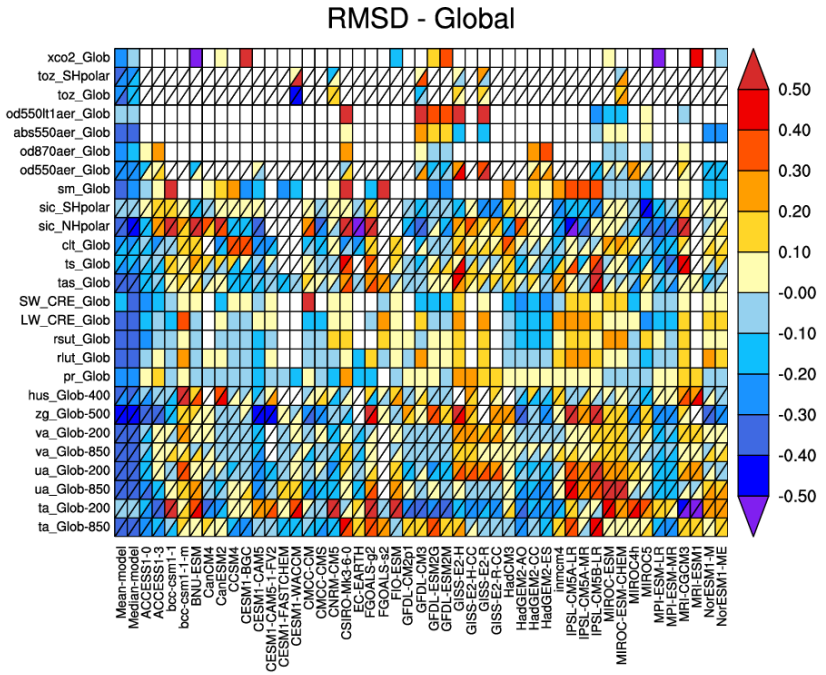
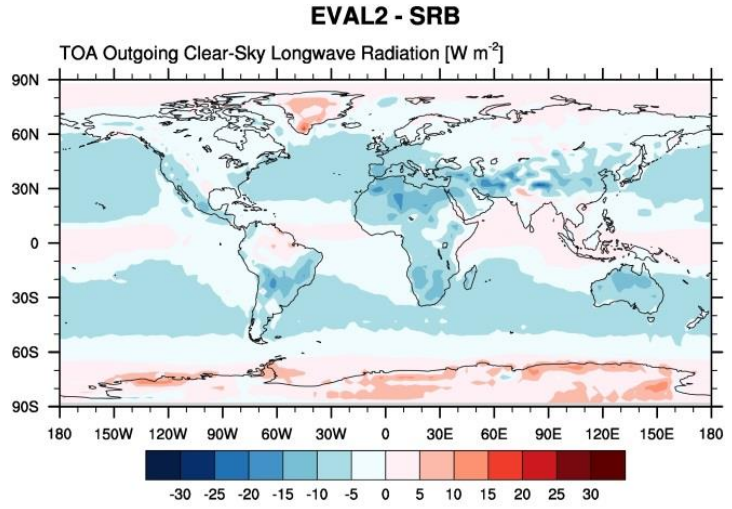
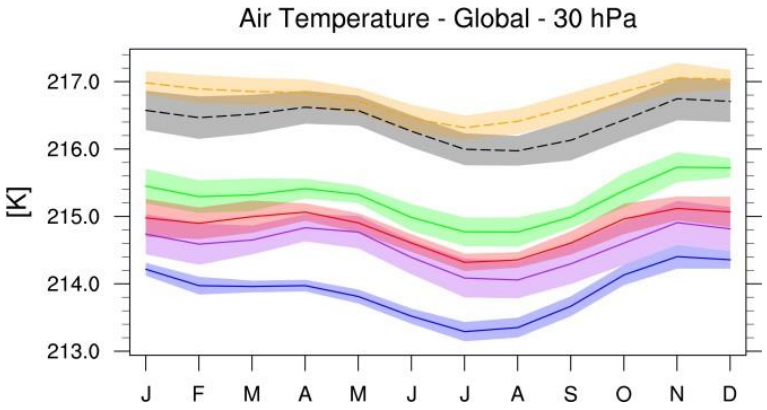
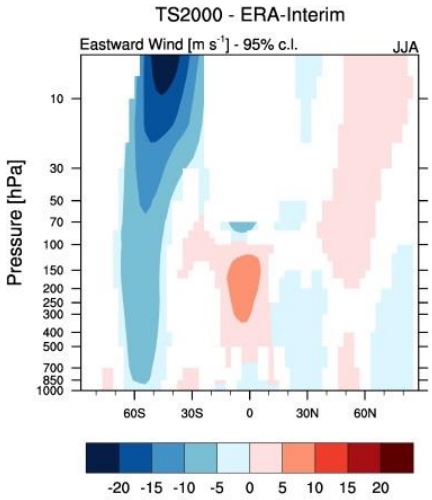
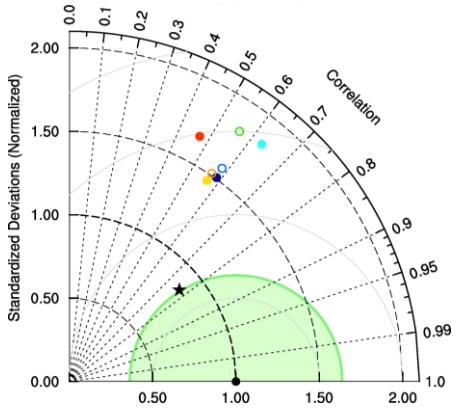
Diagnostics – Performance metrics











History

- Originally **developed by** Climate **Scientists**
- Version 1.0 in 2016 (*Eyring et al., GMD, ESMValTool v1.0, 2016*)
- Apache 2 **Open Source** License
- Due to
  - growing complexity of the code
  - complex diagnostics
  - demands by higher data volumes
  - performance issues
  - not being very user friendly

- a large **refactoring** of the code base and **professionalization was initiated** (v1.0 → v2.0)

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Professionalization of code development

- Move from svn to git (from centralized repository to distributed system)
- “Installability”
- Clean installation with standard tools resolving the dependencies (conda/pip/docker)
- Open/transparent development at GitHub
- Continuous Integration (automated code testing, automated dependency check, configuration management, etc.)
- Auto-generated online documentation (https://esmvaltool.readthedocs.io)
- Code conventions (also tested)
- Version 2 alpha release v2.0a1 in August 2018

Joined development effort among several partners
DLR (Germany), NLESC (Netherlands), BSC (Spain), MetOffice (UK), URead (UK)

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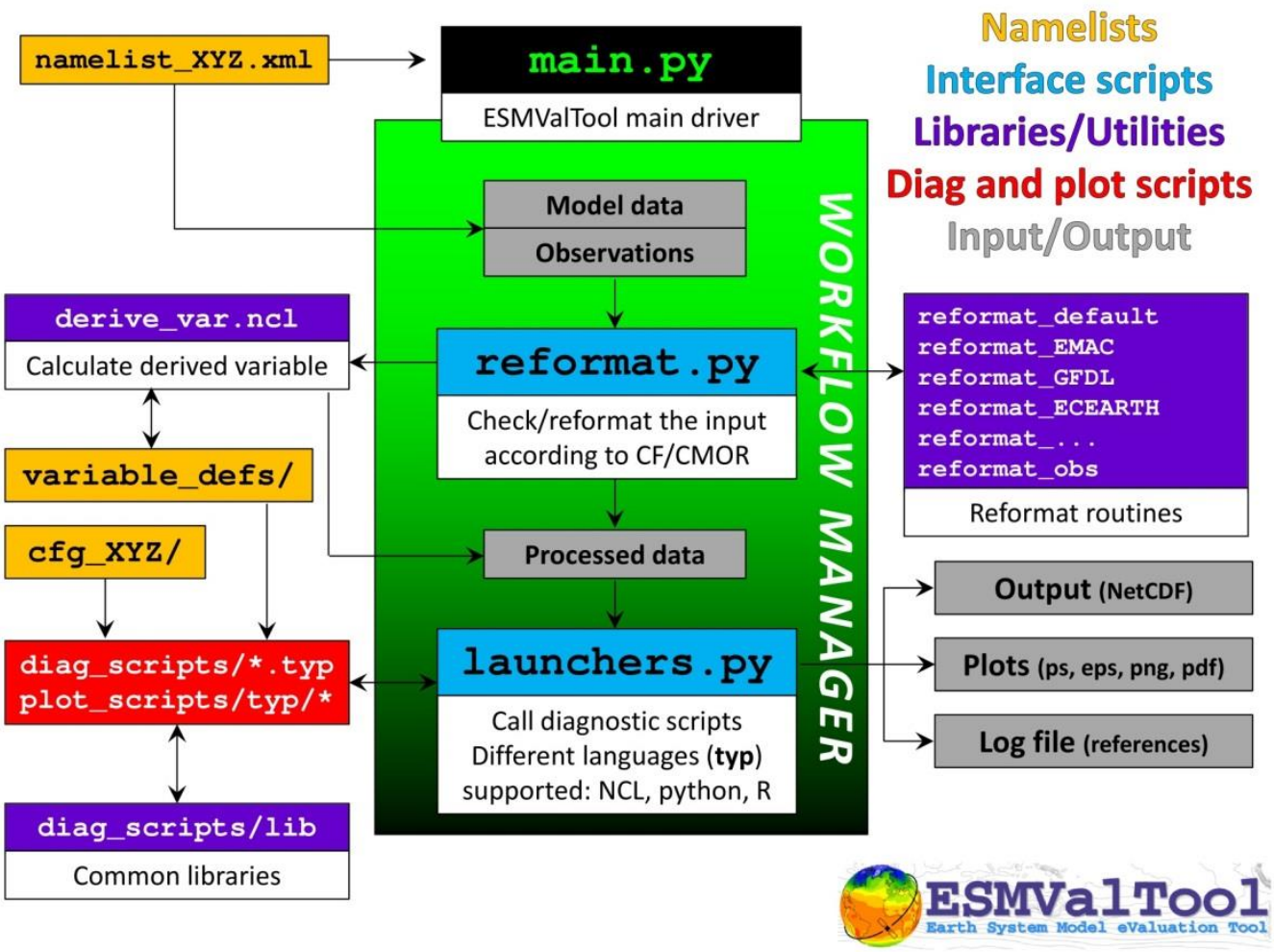
Schematic overview ESMValTool v1.0



From: *Eyring et al., ESMValTool v1.0, GMD, 2016*

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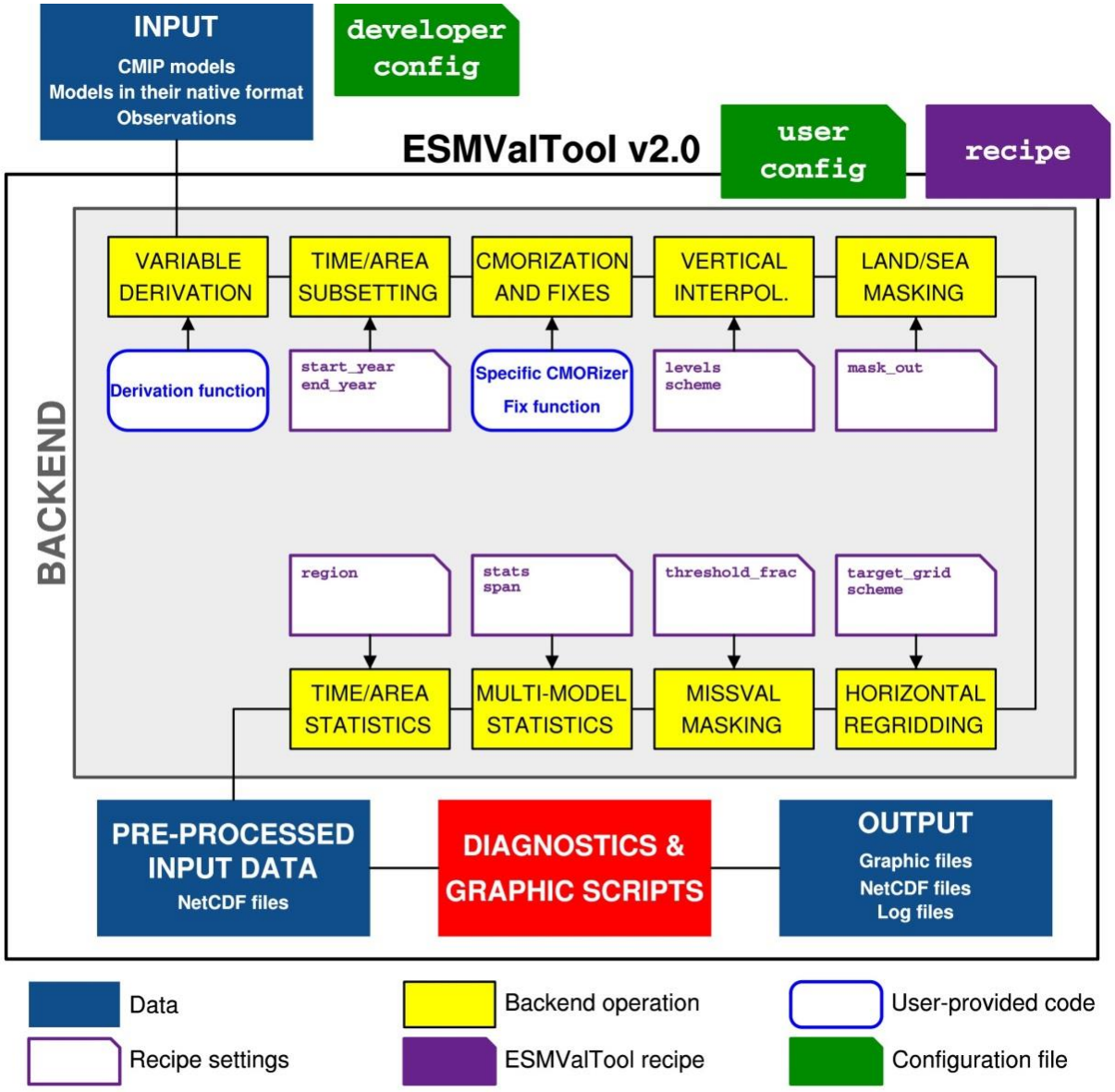
Revised Structure for version 2

- Centralized config files
- Redesing of the recipe-format to YAML
- Some „expensive“ operations moved from diagnostic to backend (e.g. multi-model mean)
- Pure Python 3 in the Backend
- Builds on Iris (MetOffice)

Iris



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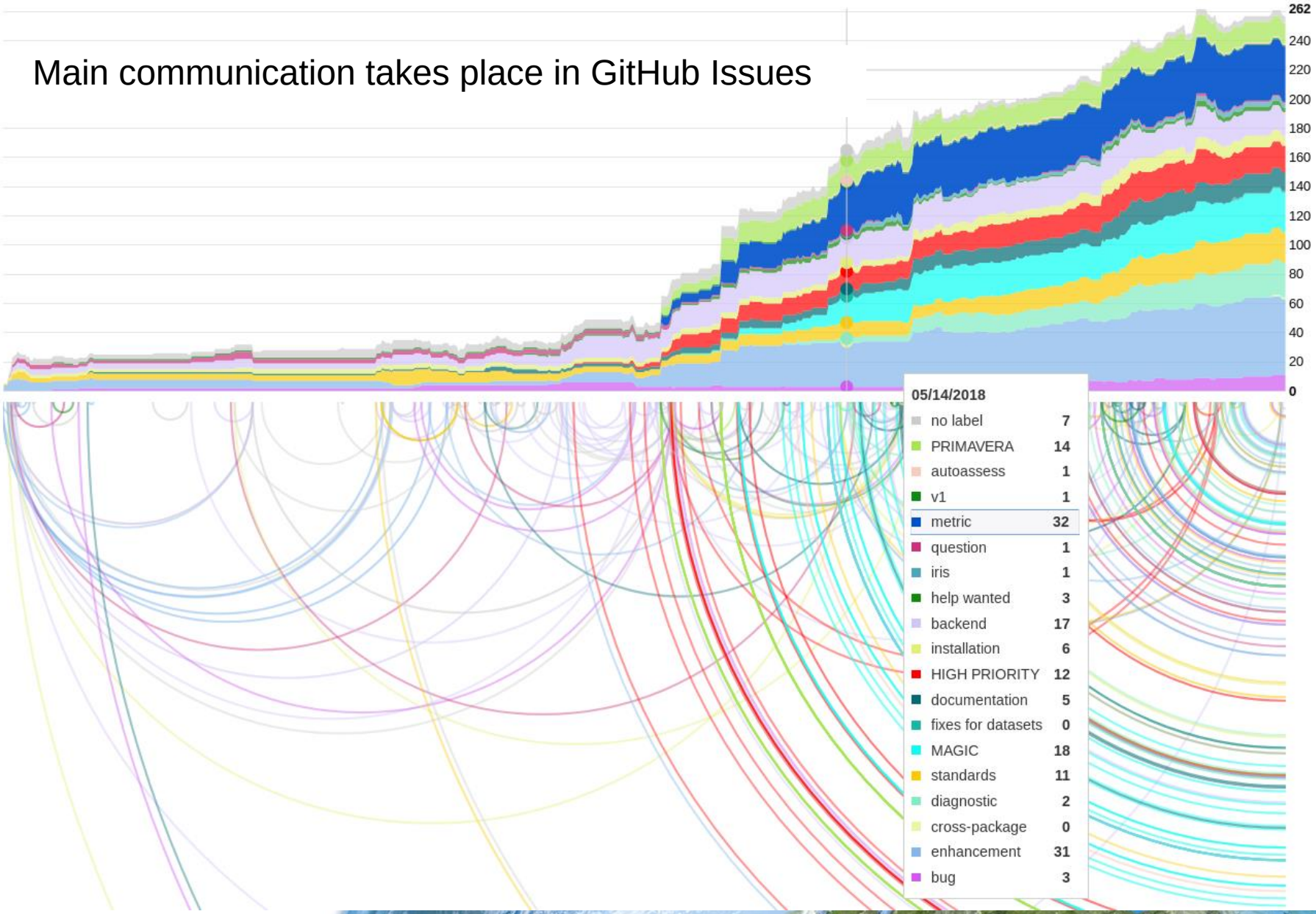
Preprocessor functions

- esmvaltool API

GitHub Issues

Main communication takes place in GitHub Issues



Development status and open issues

- Current open issues: https://github.com/ESMValGroup/ESMValTool/issues
- We have defined a #RoadToRelease through 4 git-projects with increasing priority
  - Finalization of recipe_perfmetrics_CMIP5.yml: https://github.com/ESMValGroup/ESMValTool/projects/6
  - Release of v2.0-alpha: https://github.com/ESMValGroup/ESMValTool/projects/2
  - Release of v2.0-beta: https://github.com/ESMValGroup/ESMValTool/projects/3
  - Release of v2.0: https://github.com/ESMValGroup/ESMValTool/projects/4
- Most urgent issues are marked with the HIGH-PRIORITY label: https://github.com/ESMValGroup/ESMValTool/issues?q=is%3Aissue+is%3Aopen+label%3A%22HIGH+PRIORITY%22

Observational data required

Currently a private data repository of observational data needed for the evaluation tasks is curated at the DLR.

Data sets are grouped into 3 classes

- Tier 1: Data sets from the obs4MIPs and ana4MIPs archives (https://www.earthsystemcog.org/projects/obs4mips/ https://www.earthsystemcog.org/projects/ana4mips/)
- Tier 2: Other freely available data sets
- Tier 3: Restricted data sets (e.g., license agreement required)

Development status revised ESMValTool Backend

Implemented and tested

- Revised backend infrastructure, now fully based on **python** and the **IRIS** library (MetOffice)
- Time extraction, CMORization, vertical & horizontal regridding, masking
- New highly-flexible namelist format based on YAML to replace previous XML format
- Revised workflow, including input data handling and parallelization capabilities
- Functionalities for **multi-model statistics** (mean and median) and variable derivation
- Improved interface for the communication between workflow/backend and diagnostic scripts (including **multi-language support**)
- Centralized and **simplified configuration** options (ESMValTool main recepies as single configuration point)
- **Ongoing**
- Revised Provenance workflow

First tests show a factor 10-20 improvement in processing time!

- **Papers on v2.0 (technical and scientific) in preparation**

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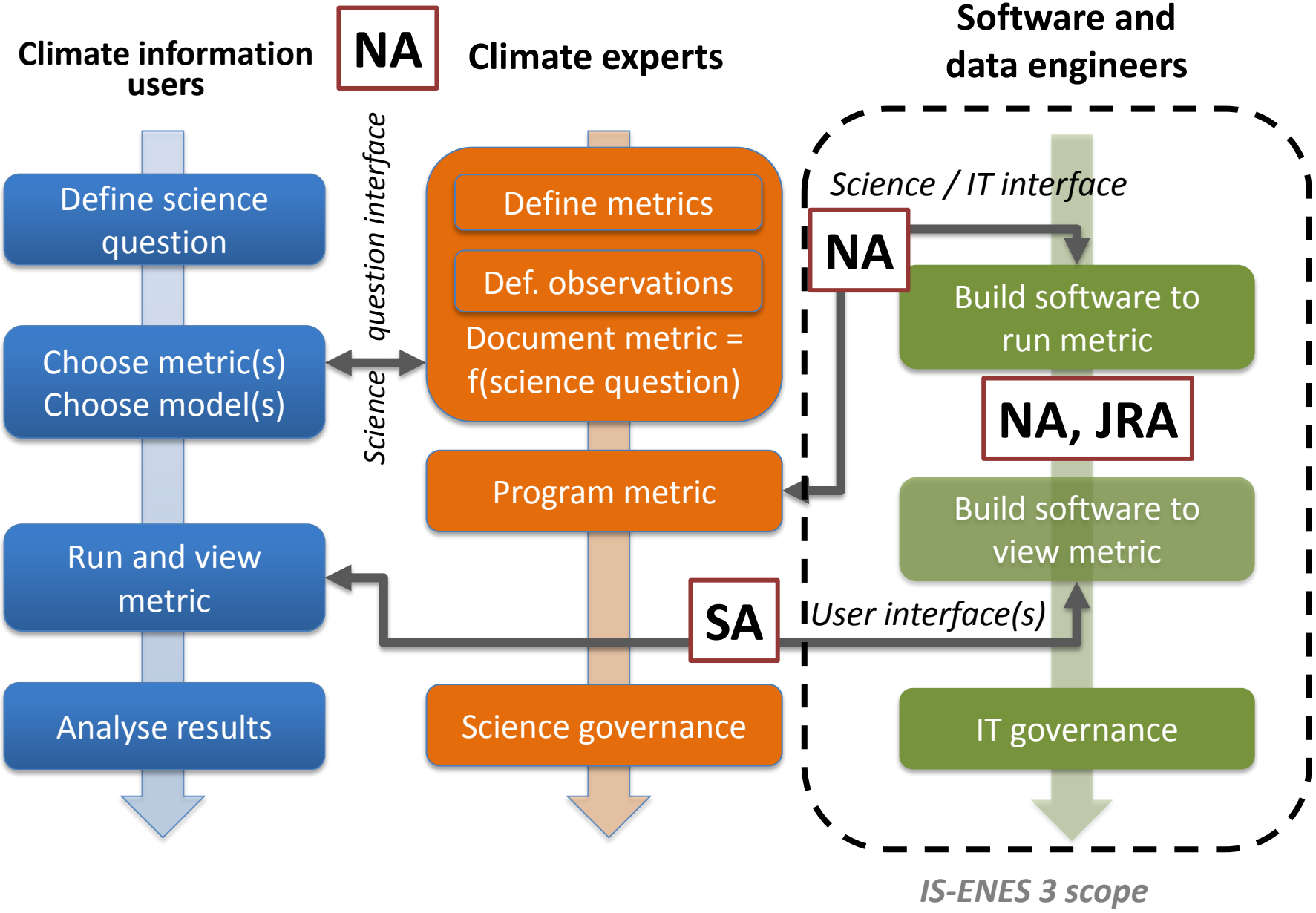
Model evaluation workflow



Thank you !

Breakout group 3 on evaluation; Friday 10h15

https://github.com/ESMValGroup/ESMValTool
https://www.esmvaltool.org/
https://esmvaltool.readthedocs.io

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