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CENTRE EUROPÉEN DE RECHERCHE ET DE FORMATION AVANCÉE EN CALCUL SCIENTIFIQUE

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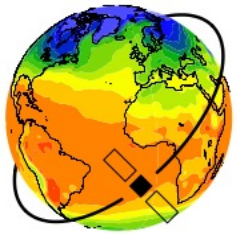
My Internship on



ESMValTool

Earth System Model Evaluation Tool

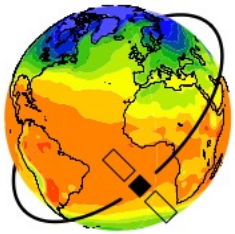
Introduction

What is ESMValTool?

- Community tool for diagnostics
- Reliable interface to analyze and evaluate
- Comprehensive and systematic evaluation of ESMs

Who might be interested?

- Community of climate modelers
- Developers and users of models



ESMValTool

Earth System Model Evaluation Tool

Outline

- Getting started with ESMValTool
  - Available diagnostics
  - And how to use them
  - (Dis-)advantages of ESMValTool
- Developing new utilities
  - Producing systematic analysis of model output
  - Browsing interface (Atlas)

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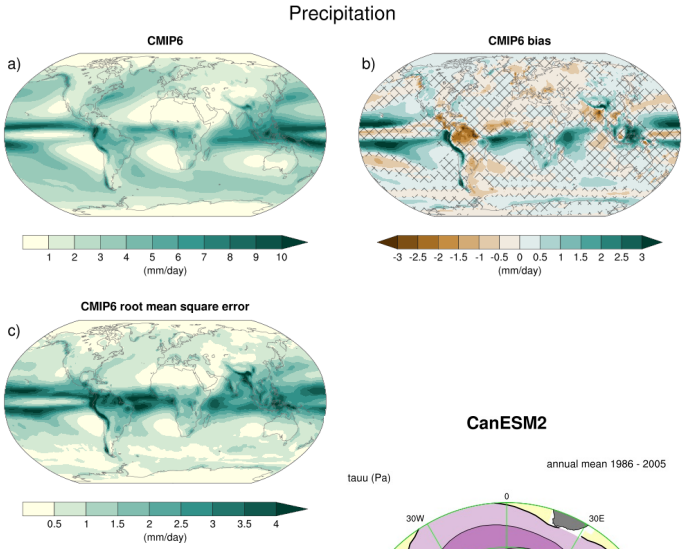
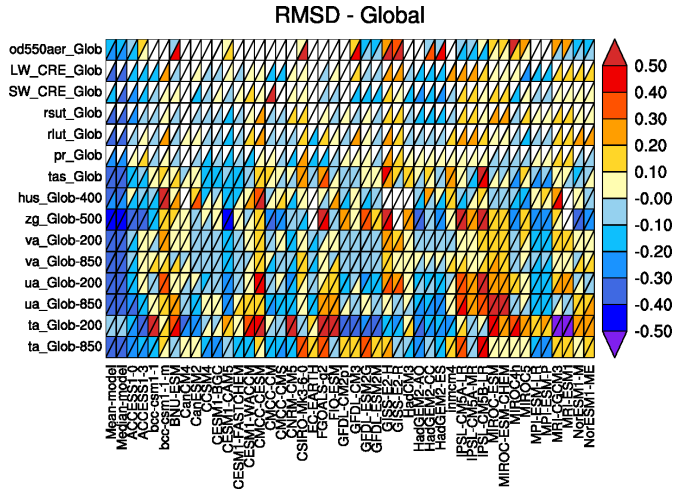
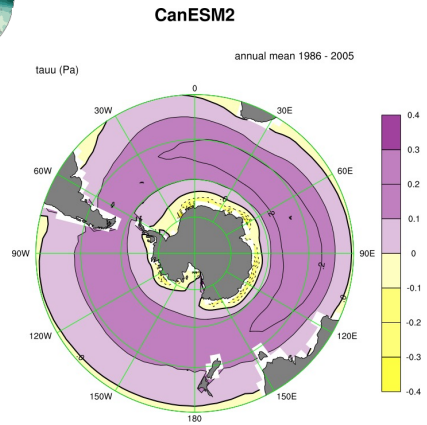
Getting started with ESMValTool

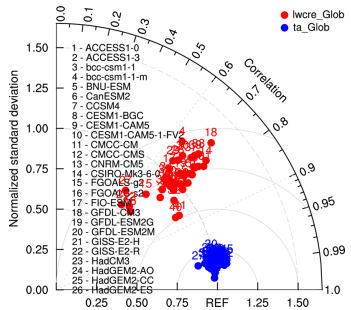
Collection of available diagnostics

- 75 diagnostics
- Atmosphere
- Land
- Ocean
- Climate Metrics
- Future projections
- IPCC

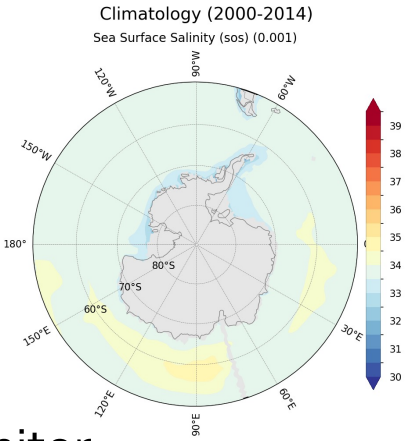




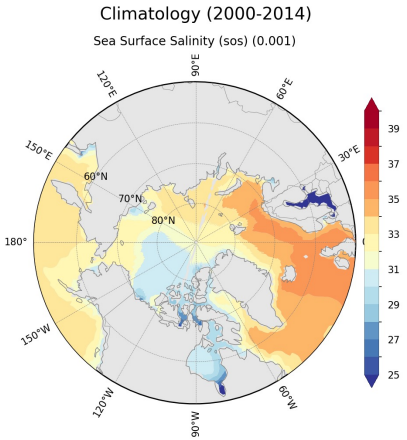


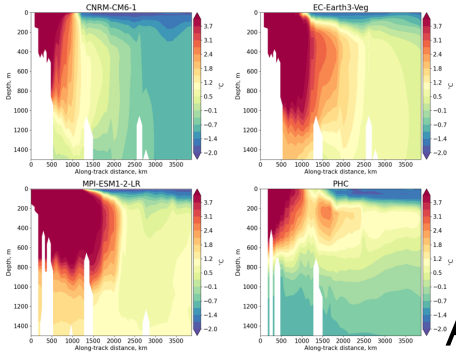


Diagnostics plots



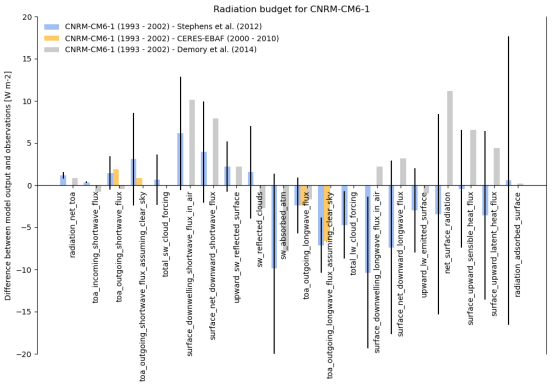
Monitor



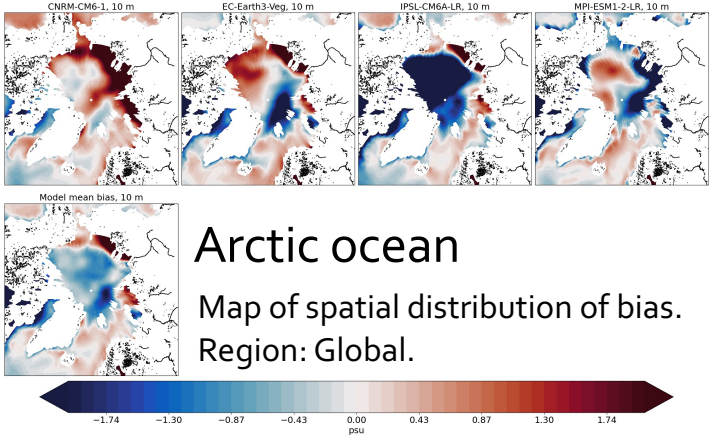


Vertical transect.
Region: AWpath

Arctic ocean

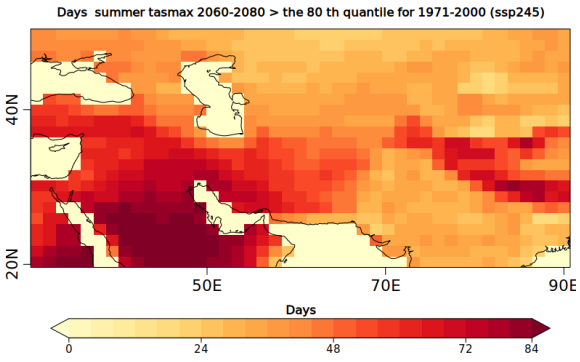


Radiation budget



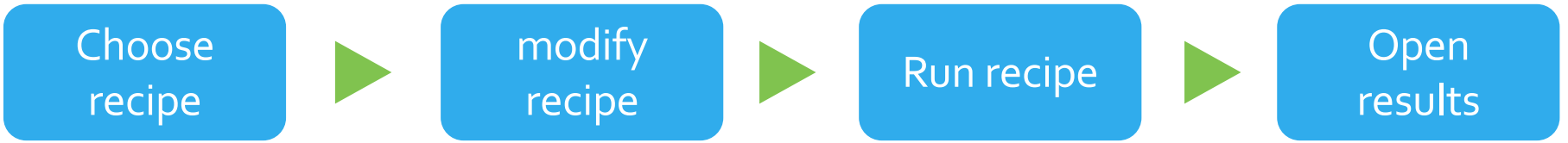
Arctic ocean

Map of spatial distribution of bias.
Region: Global.



Heatwaves

How to produce diagnostics with ESMValTool?



Search through available recipes on ESMValTool documentation or the DKRZ page

Get the recipe you want by
`esmvaltool recipes get recipe_name.yml`

Open recipe and configure it to your liking: e.g. model, member, timerange

Run recipe by `esmvaltool run path/to/recipe` or job file

Make configurations on whether to search ESGF or define output directory

Have a look at the output, open result browser `index.html` in the `recipe_name_date_time` directory

The Recipe

Set of instructions to reproduce certain diagnostics on different sources of data

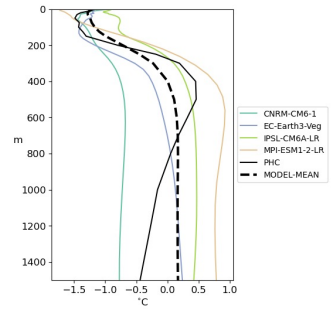
```
#recipe_name.yml
documentation:


datasets:


preprocessors:


diagnostics:
```

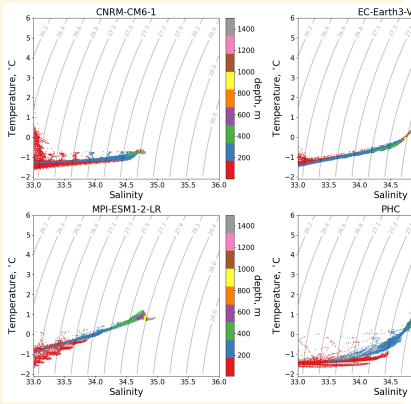
- **General and citation information on the recipe**
- Define the **datasets** that should be analyzed (according to the project key, different facets may be applicable)
- **Preprocessors** (chaining different operators)
- List variables with detailed info on applied **diagnostics** and preprocessors

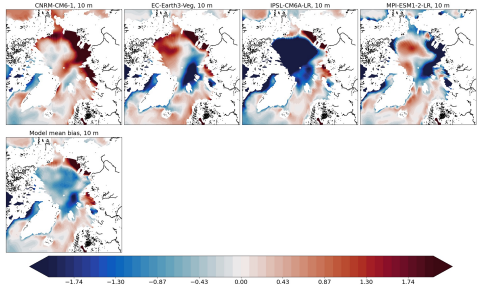
Arctic ocean recipe

```yaml
datasets:
  - {dataset: CNRM-CM6-1, grid: gn, ensemble: r1i1p1f2}
  - {dataset: IPSL-CM6A-LR, grid: gn}
  - {dataset: MPI-ESM1-2-LR, grid: gn}
  - {dataset: EC-Earth3-Veg, grid: gn}

diagnostics:

  arctic_ocean:
    description: Derive ocean variables
    variables:
      areacello:
        project: CMIP6
        exp: historical
        mip: Ofx
        ensemble: r1i1p1f1
        additional_datasets:
          - {dataset: PHC, project: OBS6, mip: fx, tier: 2, type: clim, version: 3}
      thetao: &variable
        mip: Omon
        project: CMIP6
        exp: historical
        ensemble: r1i1p1f1
        start_year: 1980
        end_year: 2005
        additional_datasets:
          - {dataset: PHC, project: OBS6, mip: Omon, tier: 2, type: clim, version: 3, start_year: 1950, end_year: 1950}
      so: *variable
    scripts:
      arctic_ocean_main:
        script: arctic_ocean/arctic_ocean.py
```

- Multi-model diagnostic with observation
- 25 figures
- Originally optimized for CMIP5







Advantages of ESMValTool

- Provides reproducibility (e.g. IPCC)
- Convenient analysis of different model components
- Simplified execution of routine tasks
- Finding, downloading, checking, fixing CMIP data
- Model and observation comparison
- Good documentation
- Good support team with quick and helpful answers (GitHub discussions)

Weaknesses and Limitations of ESMValTool

- Vocabulary/syntax and general logic of the tool need to be learned
- A lot of debugging/ error fixing -> needs time to get the drill
- Not designed for customizing plots, but possible

- No interface for browsing a large collection of figures !

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Developing new utilities

ESMValTool code structure

- Based on two components

ESMValCore

- key functionalities
- CMORization
- Pre-processors

ESMValTool

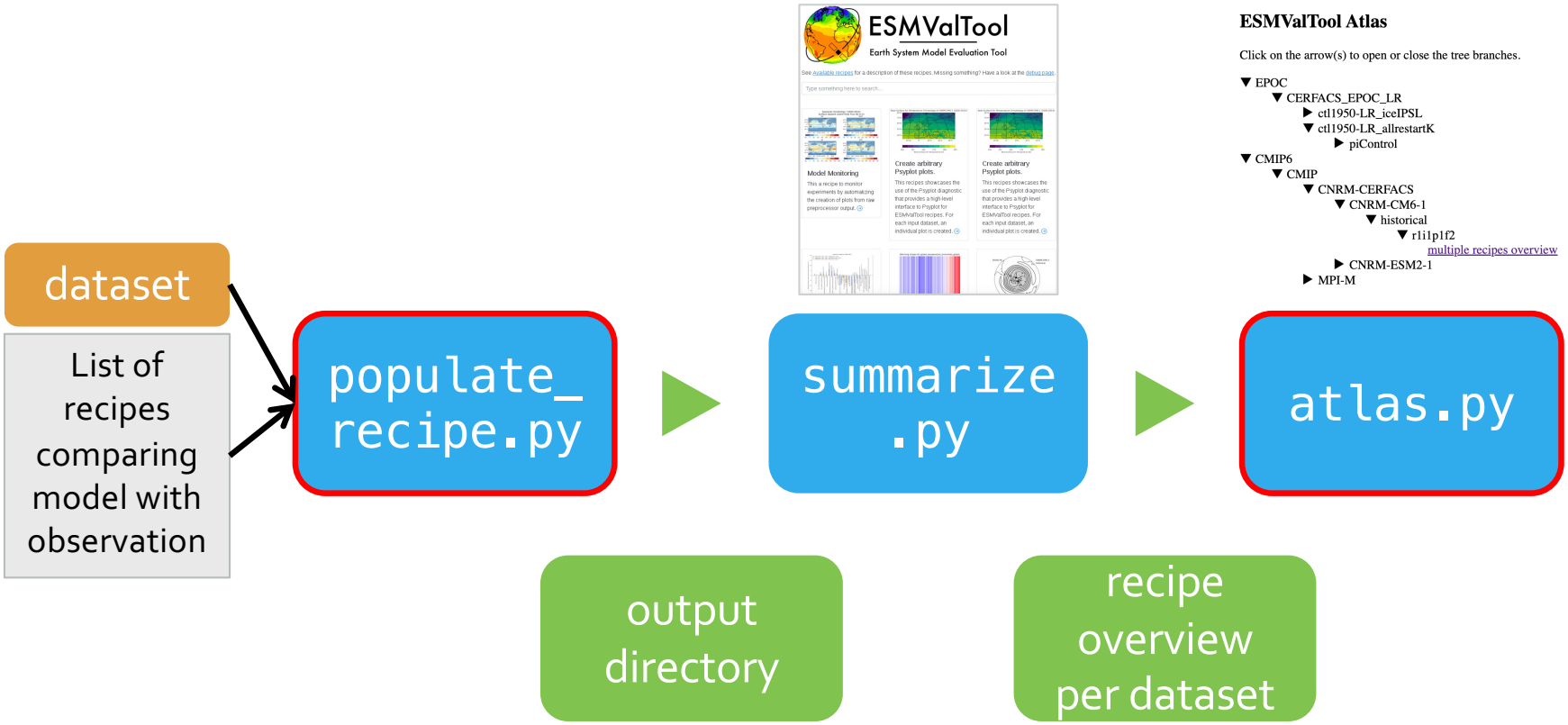
- Diagnostic part
- Recipes
- utilities

- CMOR - Climate Model Output Rewriter

Goal

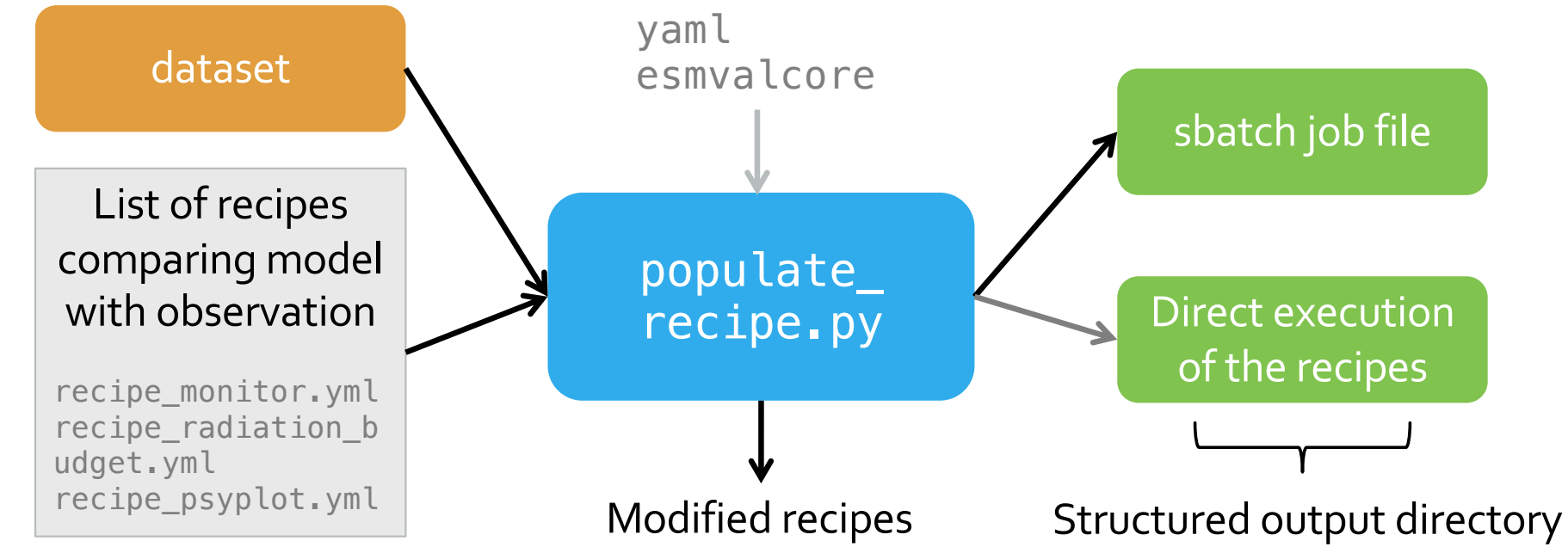
- **Monitoring/evaluating** several simulations from different projects
- Build **automatic workflow** to execute a set of recipes
- Build interface to **browse through the results** in an organized and comprehensive way
- Reusing ESMValTool's build-in functionalities

Workflow


dataset
List of recipes comparing model with observation
populate_recipe.py
ESMValTool
Earth System Model Evaluation Tool
summarize.py
ESMValTool Atlas
Click on the arrow(s) to open or close the tree branches.
▼ EPOC
▼ CERFACS_EPOC_LR
▶ ctl1950-LR_iceIPSL
▼ ctl1950-LR_allrestartK
▶ piControl
▼ CMIP6
▼ CMIP
▼ CNRM-CERFACS
▼ CNRM-CM6-1
▼ historical
▼ r1i1p1f2
multiple recipes overview
▶ CNRM-ESM2-1
▶ MPI-M
atlas.py
output directory
recipe overview per dataset

Recipe population

Idea: monitoring a model



Output directory structure

Default

```
recipe_esacci_oc_20230503_133157
recipe_esacci_oc_20230503_134220
recipe_heatwaves_coldwaves_20230426_083434
recipe_heatwaves_coldwaves_20230426_091140
recipe_heatwaves_coldwaves_20230426_094648
recipe_ipccwg1ar6ch3_atmosphere_20230503_120006
recipe_psyplot_20230601_145145
recipe_psyplot_20230602_131036
recipe_psyplot_20230602_132311
recipe_psyplot_20230602_132638
```

- Flat directory
- Not able to distinguish output by input dataset(s)

Directory structure produced by populate_recipe.py

Project – activity – institute – dataset – experiment – member

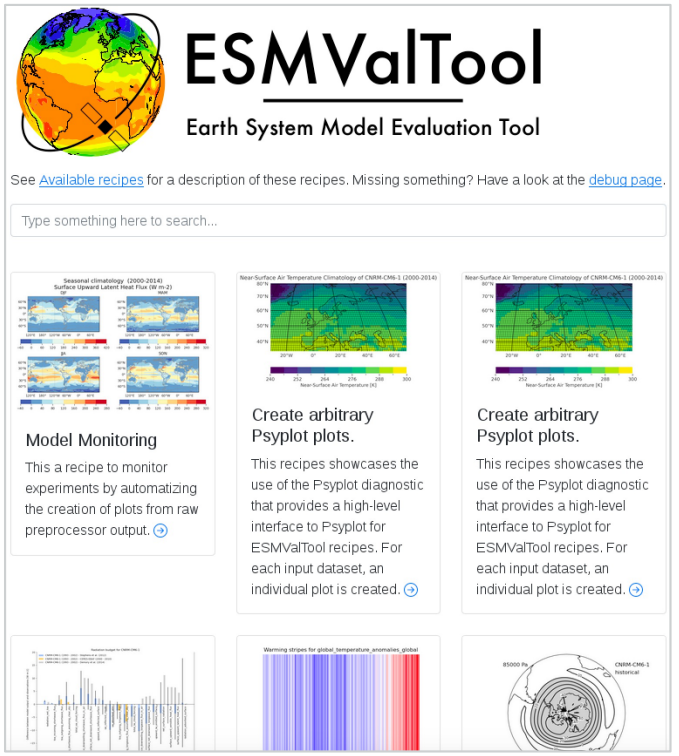
ESMValTools own utilities

- ESMValTool utilities provide summarize.py

Unstructured flat output directory - with html files on the lowest level

summarize.py

`index.html`



- Produces **`debug.html`** page with info about status, runtime and memory usage

ESMValTool Atlas

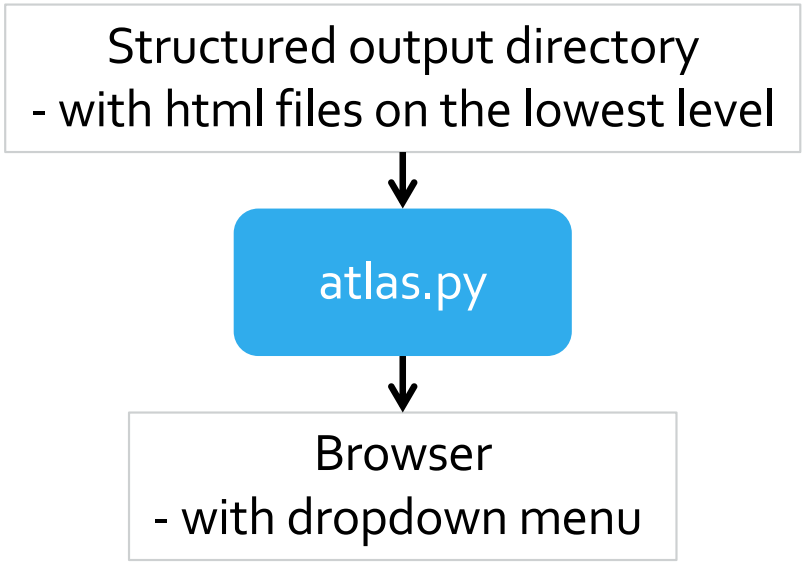
ESMValTool Atlas

Click on the arrow(s) to open or close the tree branches.

- ▼ EPOC
  - ▼ CERFACS_EPOC_LR
    - ▶ ctl1950-LR_iceIPSL
    - ▼ ctl1950-LR_allrestartK
      - ▶ piControl
- ▼ CMIP6
  - ▼ CMIP
    - ▼ CNRM-CERFACS
      - ▼ CNRM-CM6-1
        - ▼ historical
          - ▼ r1i1p1f2
            - multiple recipes overview
      - ▶ CNRM-ESM2-1
    - ▶ MPI-M

http://cerfacs.fr/giec6/ESMValTool/index_esmvaltool.php

Idea/goal: overview of all datasets and its outputs



Further Informations

- ESMValTool Tutorial on Thursday, 2pm at CNRM
- Public GitHub repository
- ESMValTool documentation
- ESMValTool Atlas (cerfacs intranet)