Model evaluation expectations of European ESM communities: first results from a survey

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IS-ENES3 WP3 T4

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Context: climate model evaluation tools

ESMValTool
Earth System Model Evaluation Tool

… to coordinated development
Since 2010s

CMEC
PMP

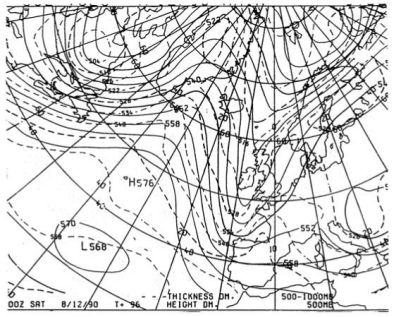
Standardization 2000s-2010s

ESGF
Earth System Grid Federation

(outputs, experiments, file format, metadata)

From individual efforts…

1970s-1990s



Cullen (1993)

Context: community tool vs in-house solution

- Community
  - Reduce duplication of effort on often repeated tasks
  - Promote standardisation and enable meaningful cross comparisons, eg between ESMs, ESMs and data
  - Critical mass to create a support and collaboration community in institutions and between institutions ➔ sustainability of the tool
  - More efficient use of resources (funding, staff)

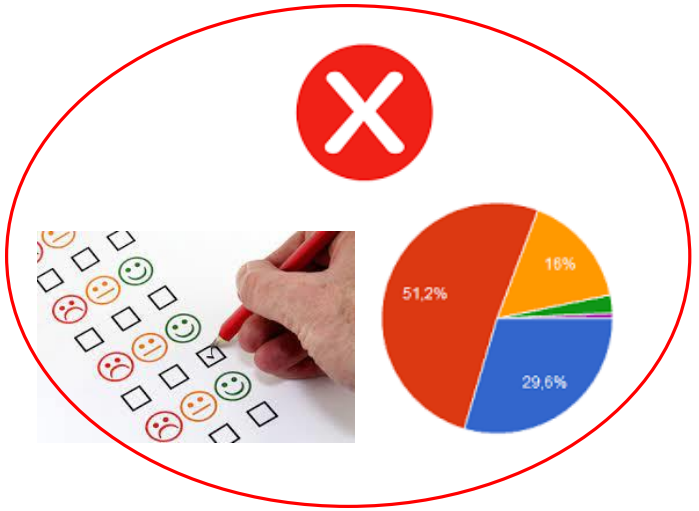
- In-house
  - Freedom: Scientists like to do things their own way and need to be convinced to use "off-the-shelf" tools
  - Heritage: Force of habit and previous investment prevent convergence on common tools

The roots of the survey

- In 2018 (writing of the IS-ENES3 project), different evaluation tools were moving forward as potential solutions for the modelling groups
- One front runner supported by the European community with IS-ENES3: the ESMValTool
- Good practice: if we want to develop tools for the community, give a chance to the potential users to say what they need
- Why a survey?
  - Going beyond the lobby discussion
  - A context to favour freedom of speech
  - Possibility to understand peoples choices

ASSIMILA

Survey: the process

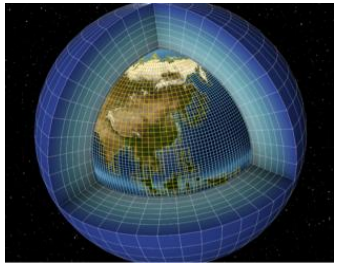


- An investigation
  - Open-ended questions ➔ interest/experience of the interviewees are paramount
  - Not a 'box ticking' survey with final statistics on items
  - Not designed to be a representative statistical sample with a clear answer

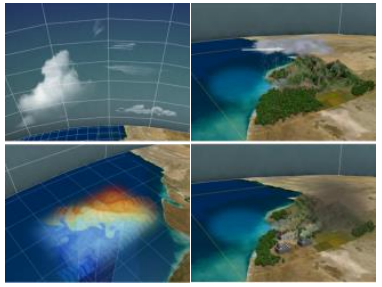
- The interpretation is partly subjective: hard to keep an un-biased eye on the content of the interviews

Who was interviewed?

Modellers



Process scientist



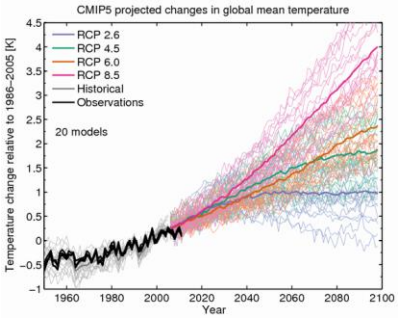
Software developers

ESMValTool
Earth System Model Evaluation Tool

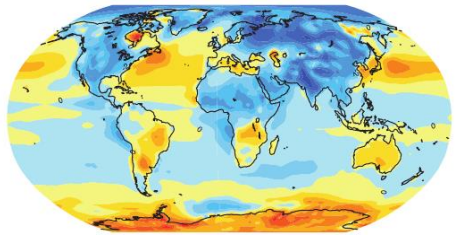
CliMAF
Sharing – Simplifying – Optimizing

NCAR UCAR | CGD's Climate Analysis Section
Climate Variability Diagnostics Package

Scientists /analysts



Evaluation



Data scientists

ESGF
Earth System Grid Federation

Impact community

- Senior scientists/professors, postdocs, industry representatives
- Working scientists with direct hands-on interests and those with strategic interests
- France, Germany, Spain, Sweden, UK, USA

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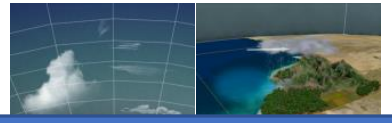
Who was interviewed?

Modellers

Process scientist

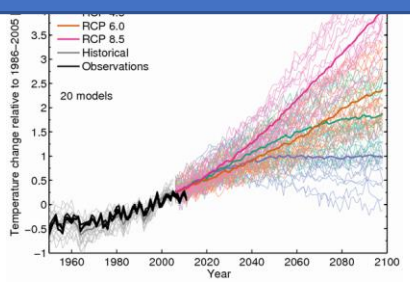


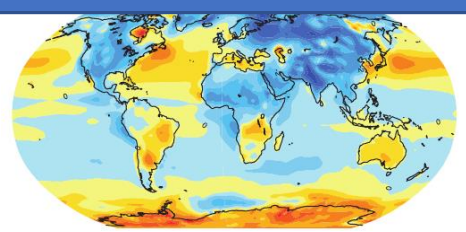
Software developers

ESMValTool

CliMAF

- 41 requests for interviews issued by Steering Group and Assimila
- 20 interviews held
- + 5 email exchanges





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Tools reported by the interviewees

- Study showed a range of “ESM evaluation tools” in use, including:

Diagnostic packages and frameworks

Auto-assess

PMP

CliMAF
Sharing – Simplifying – Optimizing

ESMValTool
Earth System Model Evaluation Tool

Model Diagnostics Task Force
Diagnostic Package

freva

Data operators:

- Climate Data Operator (CDO) (Max Planck Institute), NCO (NetCDF Climate operators), Ncl (NCAR), Python libraries: Xarray, Iris

Consulting existing results

- “Toolboxes” in ESA’s Climate Change Initiative and Copernicus Climate Change Service

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Results: ways to use a community evaluation tool

- Take it as it is: standard model evaluation, benchmarking – model development, collection of IPCC diagnostics ➔ minimum technical effort to use the scientific content
- Adopt the tool and extend its use for evaluation: science of model evaluation, process studies ➔ dive deeper in the technical aspects
- Take the core and use it do your own science ➔ adopt the technical solution (“wish I had this during my PhD”)
- Consulting the results – impact studies – decision making ➔ visualization / access to the results

Results: scientific content – user needs

- From context specific (general, ENSO, etc.) certified core set of diagnostics…
  - Providing "standard" evaluations at end of model runs to provide mark of quality
  - Approved diagnostics for specific questions

- … to a rich collection of diagnostics = pick the ones you like
  - Available diversity + possibility to choose
  - Accept you may need to adapt or (re)write code to get the exact diagnostic/plot you need
  - don't let community tools become a dumping ground for everyone's favourite diagnostic

➔ who decides what goes in? Governance / science of model evaluation

Results: identified technical user needs

Flexible: tuned/tunable to wide range of scientific needs

- Model development: Standard diagnostics to compare different versions of a particular model and against observations
- Model analysis, process studies : Tailored, complex diagnostics – for publications

Provide technical solutions

- Finding the data: stop need for data wrangling (model intercomparison)
- Core pre-processing functions
- Growing data volumes (becoming problematic for evaluation): High temporal and spatial resolution simulations
- Use different grids

Efficient execution

- Typically mins/~day

Interoperable with other tools

- I'm not stuck with one tool <-> ways to connect the tools
- Generic/standard (code and output)

Results: experience and trust

Experience

- Good documentation, support, training
  - Make it easy for any particular user to find/get what they want
  - Local support for community tools valued by those who have it
- Transparent and traceable: no “black boxes”, provenance of information easy to track
- Easy to get first result: typically hours/~day to get first plot
- Providing GUIs (cf IS-ENES 3 plans), APIs, click and play, toolbox – not just command line

Trust

- Reliable, tested: certified
- Sustainability: maintained and developed => governance

Feedbacks and implications for ESMValTool

- ESMValTool held in high regard by those interviewed

- "Flexible: tuned/tunable to wide range of scientific needs"
  - Significant progress in making the tool accessible and user friendly over the last few years

- "Good documentation, support, training"
  - Github repo + documentation + training sessions
  - Communication: avoid misunderstanding
  - success stories should be generated to convince the research community

- "Efficient and easy to use"
  - Most recipes run between minutes to hours
  - A couple hours to get first result (if you use conda)

Additional thoughts on community tools

- Need to recognize/acknowledge that we are in a continuous development = this is a journey (and a long one), not a destination!

- There has to be sufficient determination from the user ('stubbornness') to get his/her hands on the tool and overcome the errors: do not give up!

  ➔ Getting the scientists and software developers together!

Take-home points

Community tool

- Range of use cases : from community approved scientific evaluation packages to individual usage
- Technical solution to efficiently serve that range
- Buy in and trust: documentation & traceability, sustainability & governance – long term investment

Discussion is just starting!

Thank you for your attention

Subjects for the long term

- Areas for improvement
  - Machine learning and AI for ESM evaluation
  - On the fly post-processing and diagnostics while the model is running (cf developments at BSC)
  - Geographically distributed computing to eg reduce burden of data transfer
  - Address the data volume problem, eg greater use of cloud computing

About the interviews

- All notes have been checked by the interviewees.
- The notes are confidential to the project review panel and have been made available by the interviewees on the understanding that they will not be circulated further.
- The purpose of the notes is to review the findings of the study and identify key points for the final report.

Notes on governance

- Open source
- Transparent community
- More members, more active/implicated, more animation
- Governance is about the processes, not about the software development. There has to be a strong understanding of why you are doing something and how it will be financially maintained.

Survey: the process

- List of interviewees provided by the steering commitee
- One hour interviews
- A core set of open ended subjects/questions - keeping a lot of freedom in the structure of the interview to favour the expression of opinions and ideas based on interviewee experience and priorities

The questions / subjects

- Context: job description of interviewee
- What are the challenges of model evaluation tools?
- Which model evaluation tool do you use, or contribute to (eg as developer, or data provider)?
  - What is your experience with the ESMValTool?
- Explain how you work (workflow)? How are tools used today? Pros and cons of different approaches
- Most important aspects of these evaluation tools
- What future developments for the tools / challenges?
- Governance of a community tool with particular reference to ESMValTool?
- Other points arising?