Supporting Climate Science through Robust Model Evaluation and Community-Driven Strategies

Felicity Chun

The Australian Earth System Simulator
National Research Infrastructure (ACCESS-NRI)

Model Evaluation and Diagnostics

Felicity.chun@anu.edu.au

ACCESS-NRI
Model evaluation and diagnostics (MED)

Building an Australian community framework for Evaluation of Earth System Models

Model evaluation

Data including discovery and accessing

Expertise - software optimization, HPC, training

ACCESS-NRI MED TEAM:

Building an Australian community framework for Evaluation of Earth System Models

Romain Beucher

Rhaegar Zeng

Marc White

Felicity Chun

Max Proft

Owen Kaluza

Charles Turner

Climate Models

A model is a simplified representation of a natural system.

Models **advance climate science**, revealing the impact of human activity on the Earth's climate.

Underpinned climate policy decisions on national and international scales.

Models range from simple energy balance models **to complex** Earth System Models (ESMs) requiring state of the art **high-performance computing**

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Model Evaluation

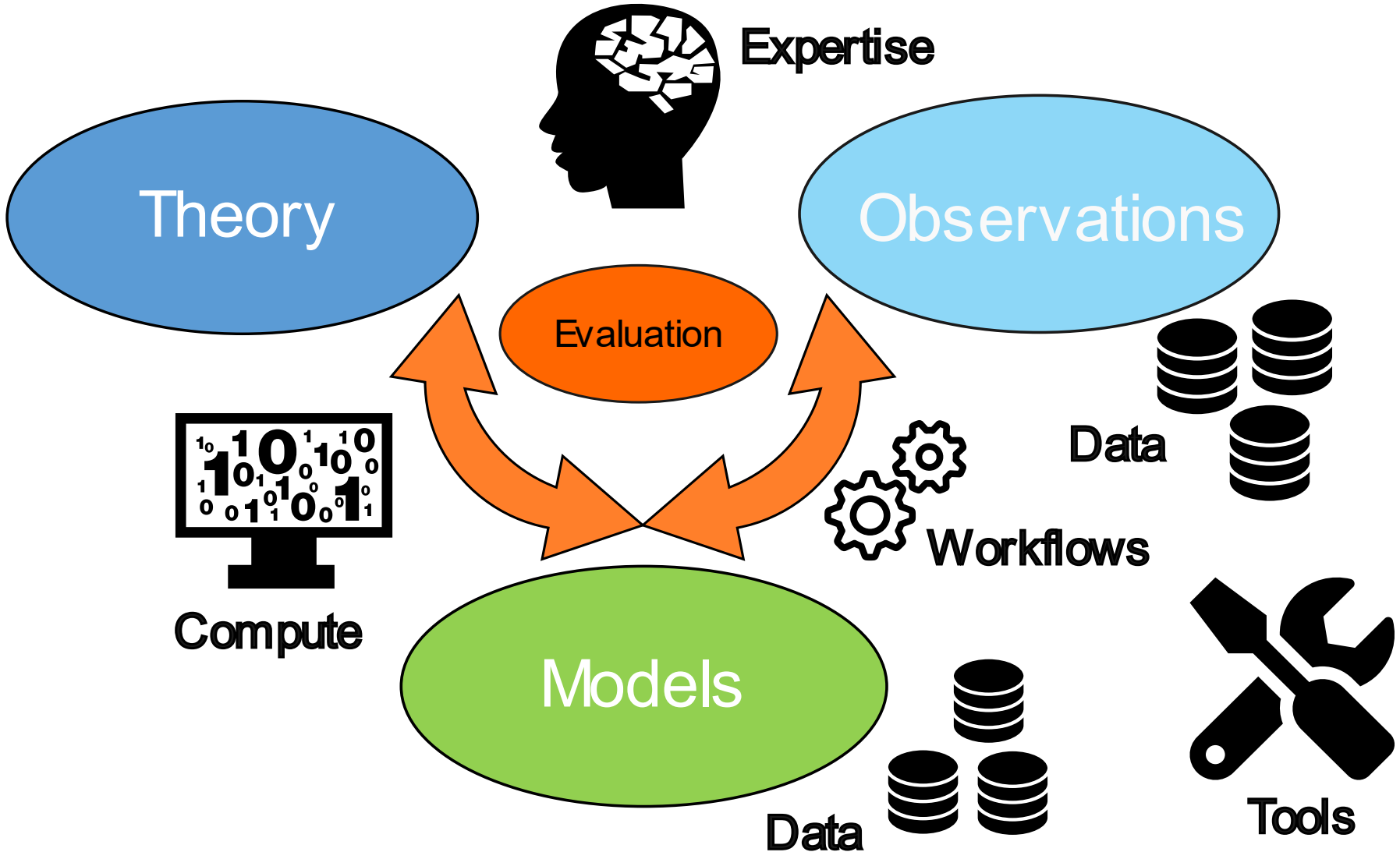
Model Evaluation: What for?

- Facilitates assessment of the **strengths** and **weaknesses** of climate models.
- Evaluate **how realistic** the models are in **simulating the recent past**.
- **Understand** some of the factors responsible for **differences in model projections**.

- Support **development** and identify strategic focus areas.

- Provide the most credible information on regional climate changes, impacts, and risks for **stakeholders and policy-makers**.

Model Evaluation



Evaluation workflow

Model output

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

Observations and reanalyses

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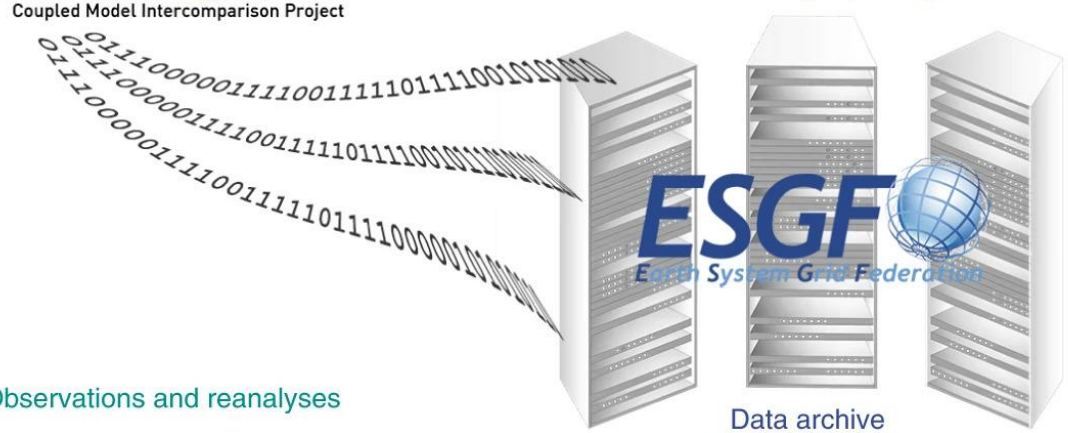
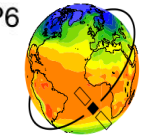
Processing capability



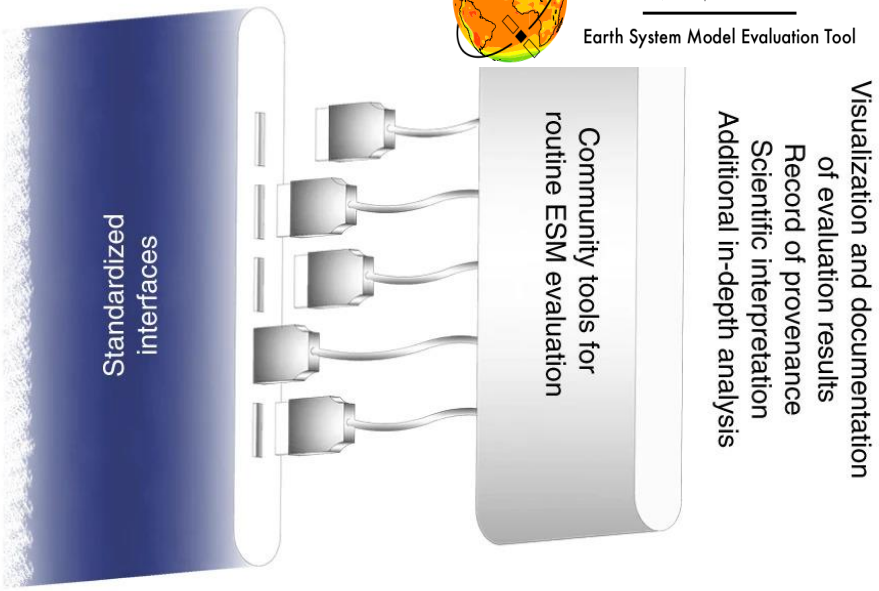
Data archive

Analysis computing environment integrated with the ESGF

Well-established analysis
Sharing of diagnostic codes
Guidance and support from the CMIP panel,
WGNE/WGCM climate model disgnostics and
metrics panel, and CMIP6



ESMValTool
Earth System Model Evaluation Tool



State evaluation of ECVs
(climatology, trends and so on)
Process and phenomena evaluation
Link to projections
(MMM analysis and emergent contraints)
Performance metrics

Modified after Eyring, 2019

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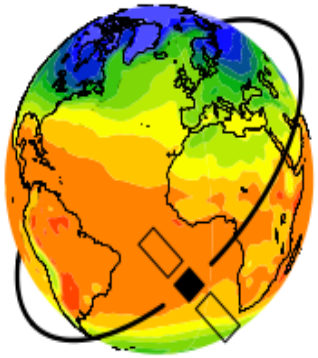
Evaluation Frameworks

- Collection of diagnostics and performance metrics
- Mean state, trends, variability, key physical processes and emergent constraints.
- Capability to reproduce figures from IPCC AR5 and incorporates targeted analysis package



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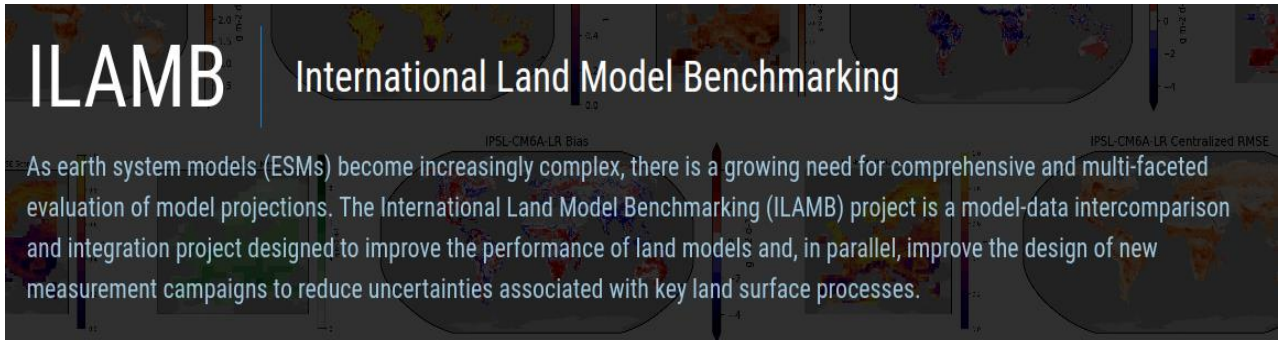
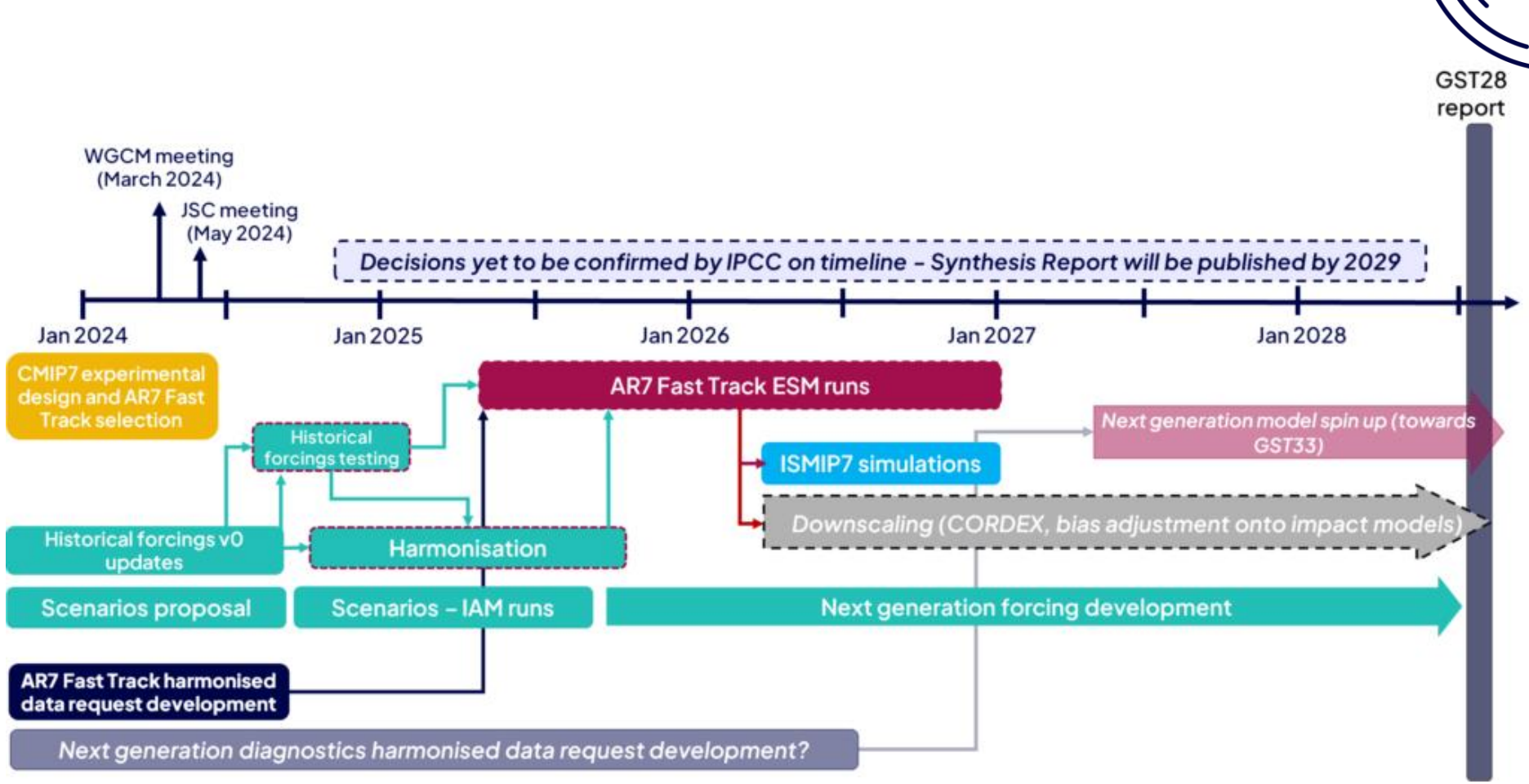


Requires active collaboration with the international community

CMIP7 submission



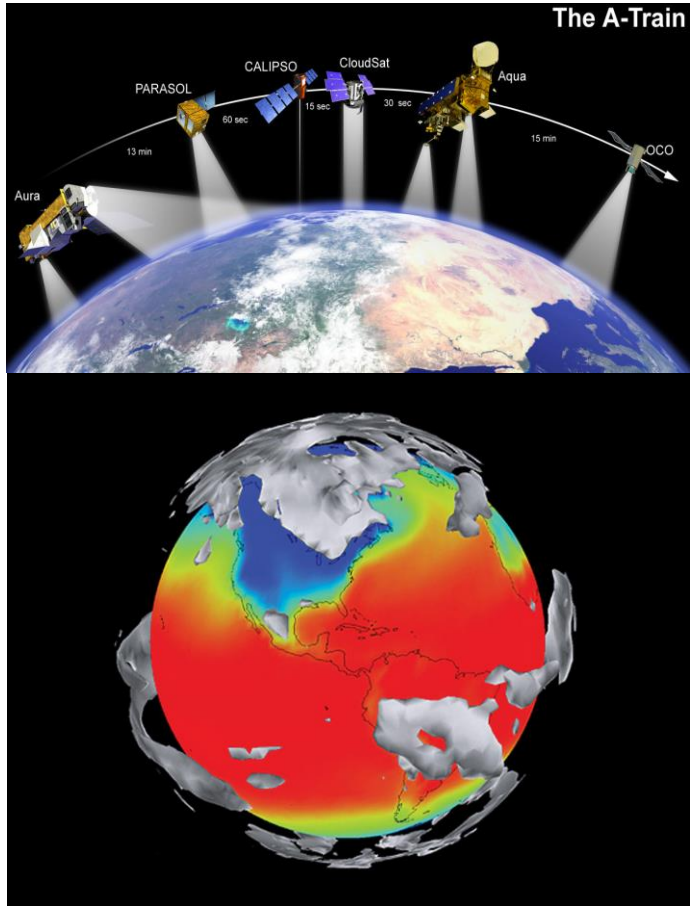
https://wcrp-cmip.org/cmip7/

Data

Integration of the NCI Data Collections

Climate & Weather

- Model simulations
- Satellites data
- Observation/reanalysis data for Australia



Big Data Challenges

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ACCESS-NRI Intake catalog

Easily find and load datastores for a wide range of climate model data on Gadi.

Also provide tools so you can easily build your own datastores

A simple process for getting these added to the ACCESS-NRI Intake catalog

```
import intake

catalog = intake.cat.access_nri
catalog
```

name	model	description	realm	frequency	variable
01deg_jra55v13_ryf9091	{ACCESS-OM2}	{0.1 degree ACCESS-OM2 global model configuration with JRA55-do v1.3 RYF9091 repeat year forcing (May 1990 to Apr 1991)}	{ocean, sealce}	{3hr, 1day, 3mon, fx, 1mon}	{bih_fric_v, sig2_m, ULAT, total_ocean_sens_heat, HTE, frz_onset_m, lprec, area_u, vert_pv, tx_trans_submeso, total_ocean_runoff_heat, total_ocean_evap, sst_m, alvdf_ai_m, wt, total_ocean_calving_...
01deg_jra55v140_iaf	{ACCESS-OM2}	{Cycle 1/4 of 0.1 degree ACCESS-OM2 global model configuration with JRA55-do v1.4.0 OMIP2 interannual forcing}	{ocean, sealce}	{1day, 1mon, fx}	{bih_fric_v, ULAT, mld_max, total_ocean_sens_heat, HTE, vvel, lprec, area_u, vert_pv, bottom_temp, total_ocean_evap, total_ocean_runoff_heat, alvdf_ai_m, wt, total_ocean_calving_heat, vatm_m, tota...
01deg_jra55v140_iaf_cycle2	{ACCESS-OM2}	{Cycle 2/4 of 0.1 degree ACCESS-OM2 global model configuration with JRA55-do v1.4.0 OMIP2 interannual forcing}	{ocean, sealce}	{1day, 1mon, fx}	{bih_fric_v, ULAT, mld_max, total_ocean_sens_heat, HTE, vvel, lprec, area_u, vert_pv, meltb, dvirdgdt_m, bottom_temp, total_ocean_evap, total_ocean_runoff_heat, alvdf_ai_m, wt, vatm_m,

Expertise

Methods: Assess and Develop

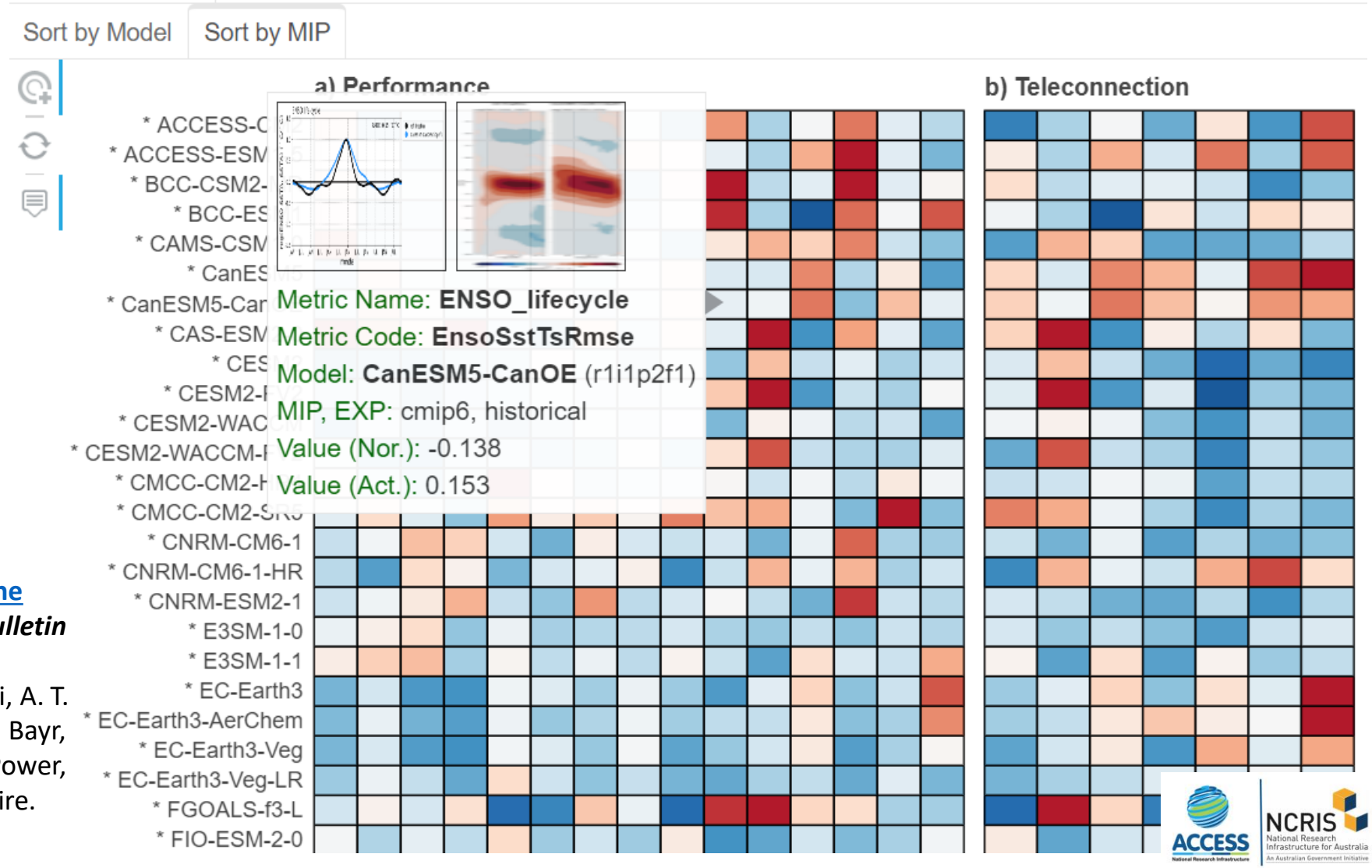
Community needs examples and guidelines on which metrics to use. Also need framework to validate relationship and / or identify spurious relationships.

Evaluation methods depend on application:

- Future projections are mainly interested in mean trends (spatial and temporal).
- Impact studies require regional scale evaluation of seasonal cycles (temperature, precipitation, humidity, wind speeds etc...)

Continuous learning and training is essential for success and growth in your career.
The landscape is constantly evolving, so it's important to stay informed about the latest technologies and trends...

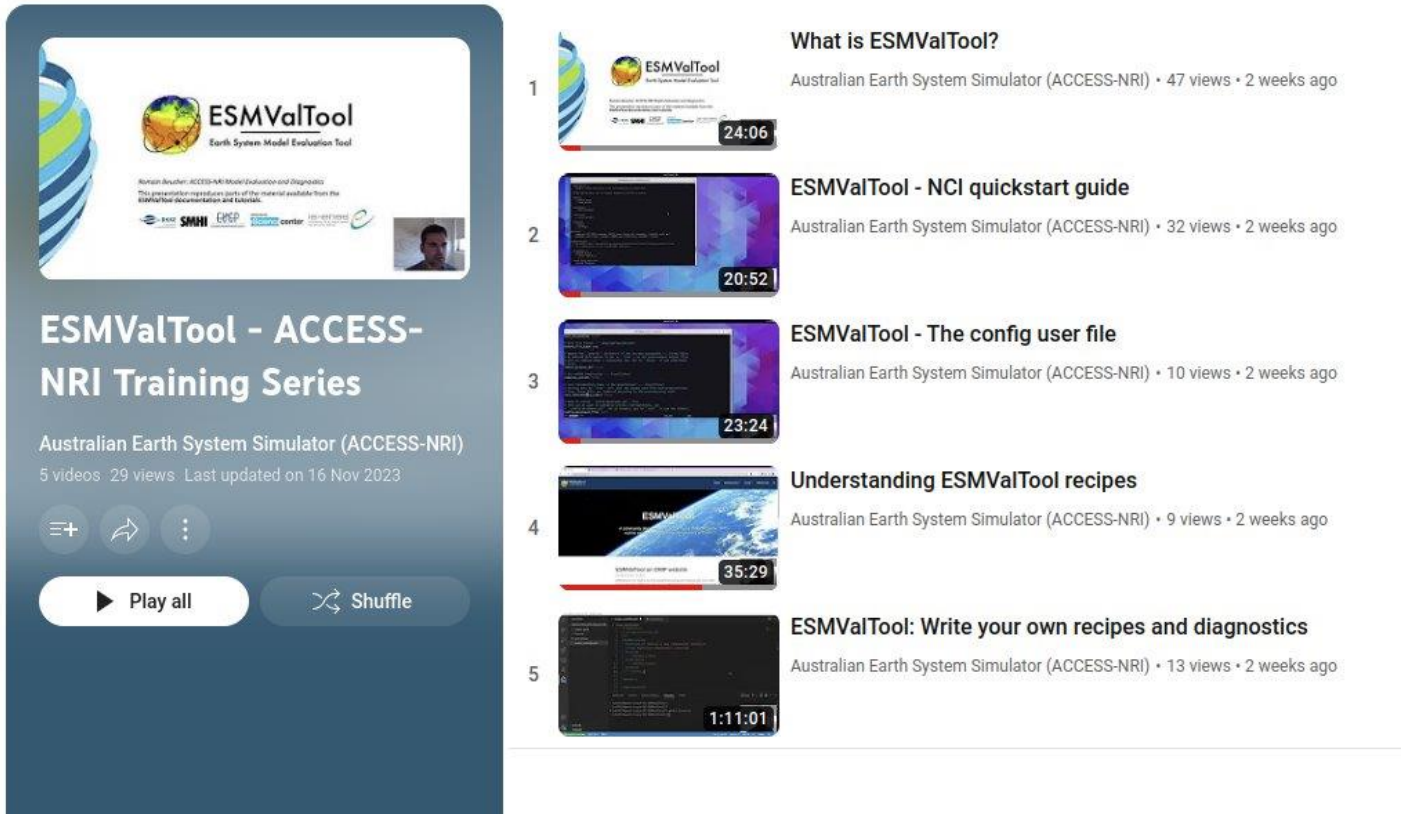
ENSO Collaboration



[Evaluating climate models with the CLIVAR ENSO metrics package](), ***Bulletin of the American Meteorological Society***, by Planton, Y., E. Guilyardi, A. T. Wittenberg, J. Lee, P. J. Gleckler, T. Bayr, S. McGregor, M. J. McPhaden, S. Power, R. Roehrig, J. Vialard, and A Voldoire. (2021)

Training & Resources

- YouTube videos
- Web tutorials
- GitHub example repositories
- Documentation



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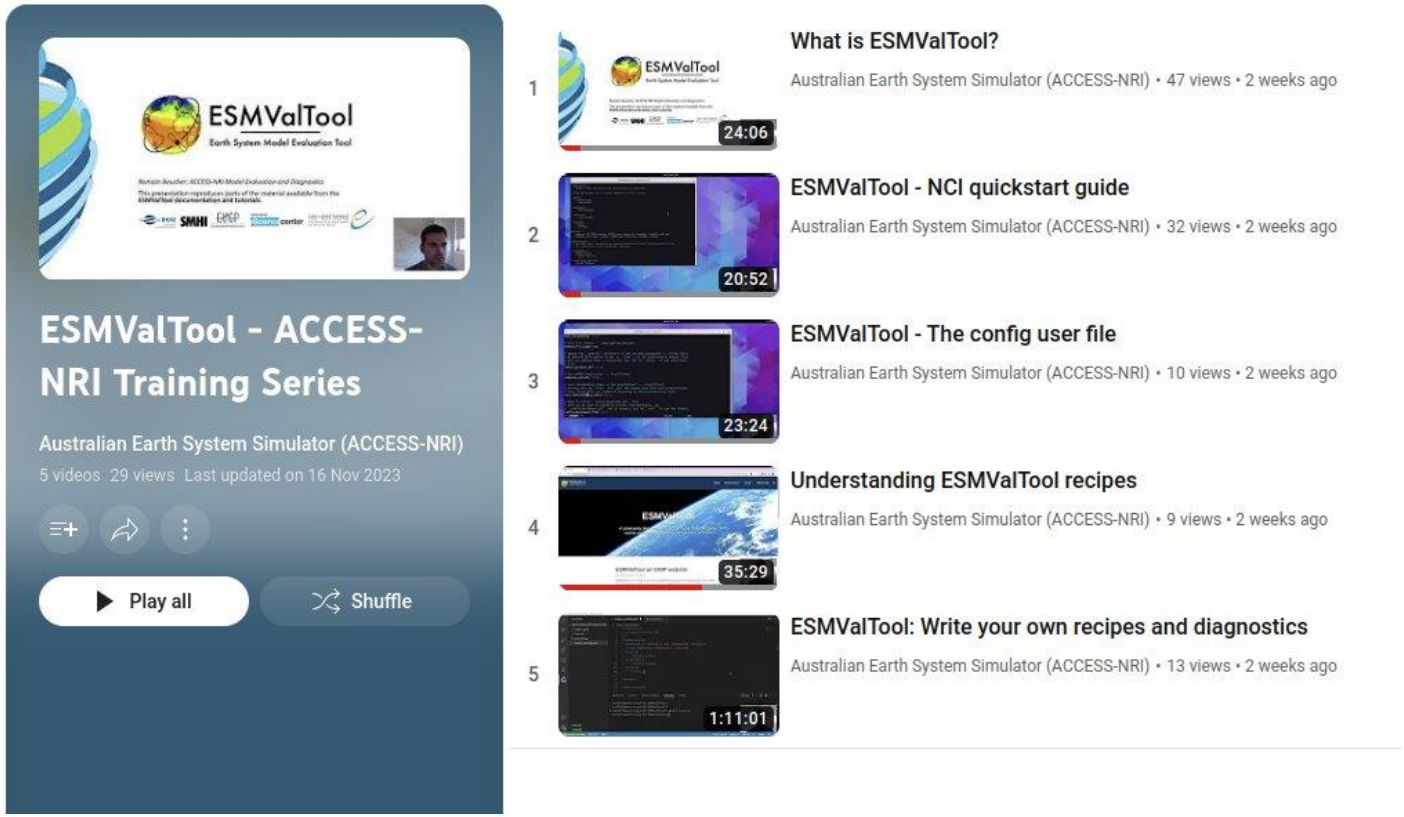

access-hive.org.au
Jasmeen Kaur
User training team poster

Workshops

CSIRO

climate extremes
ARC centre of excellence

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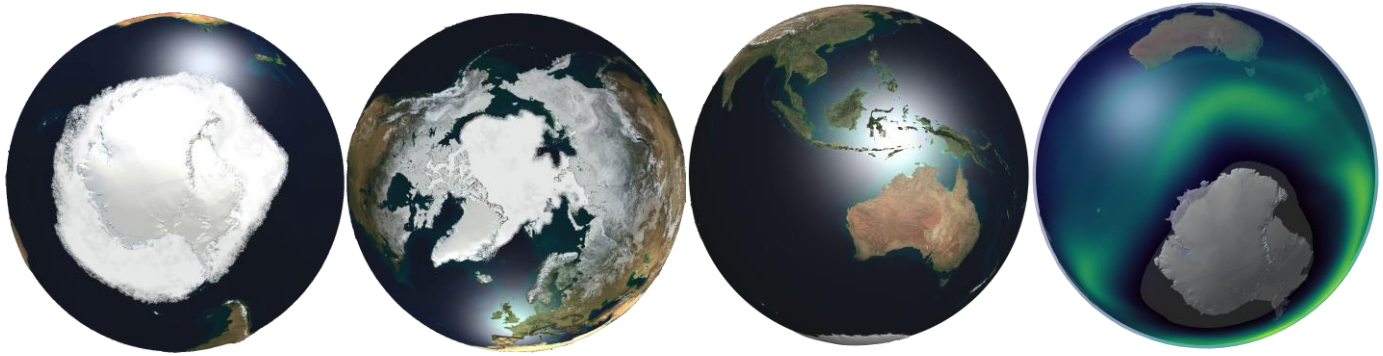
Visualisation tools



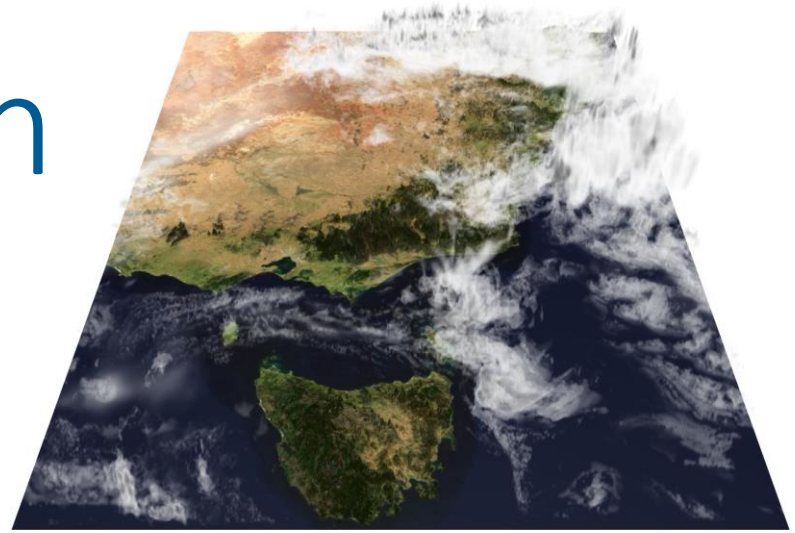
Provide vis tools for analysing complex data sets, viewing data in context and communicating research

Jupyter notebook based 3D / 4D vis tools

- Easily rendering high quality images and movies
- Integrate with existing research tools
- Python library: https://github.com/ACCESS-NRI/ACCESS-Vis
- Tutorial notebooks for 3D visualisation training: https://github.com/ACCESS-NRI/ACCESS-Visualisation-Recipes
- Integration with other ACCESS-NRI tools, including data catalogues and evaluation tools

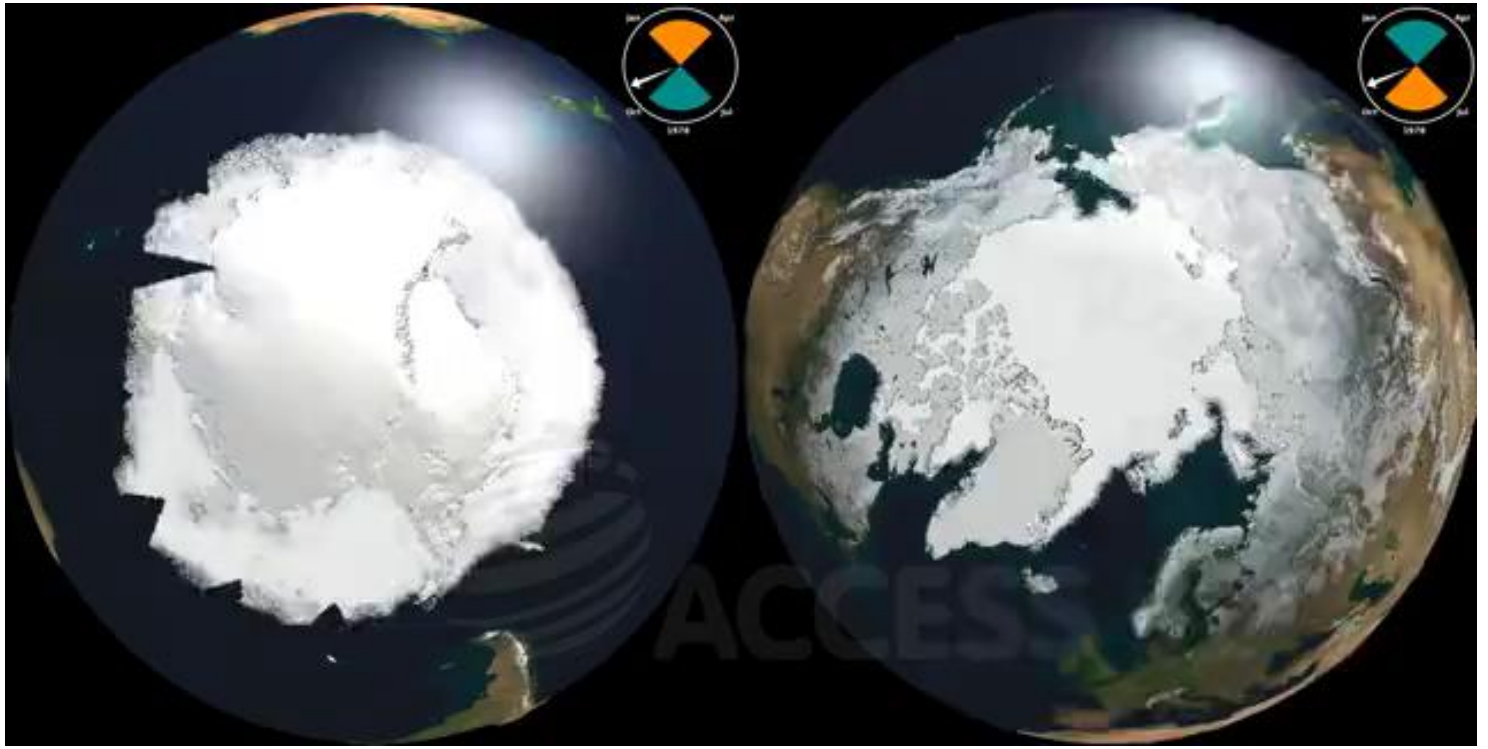
Owen Kaluza

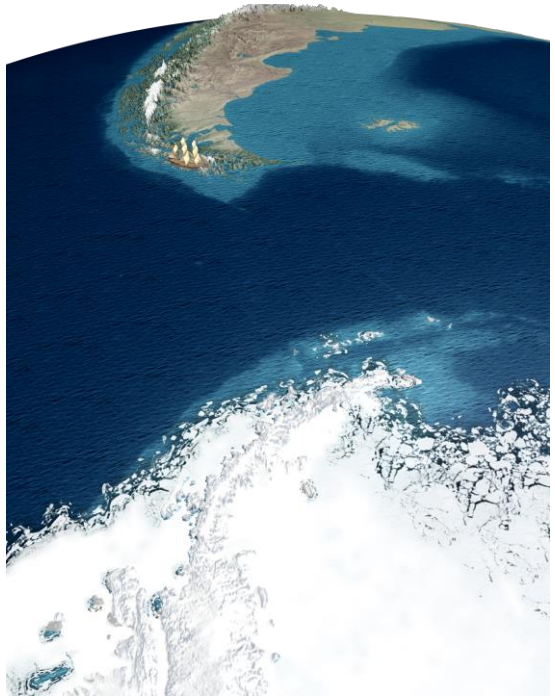
Advanced Visualisation



Release visualisations highlighting ACCESS-NRI data and tools

Some visualisation releases and work in progress:
https://vimeo.com/accessnri





CONCLUSION

- **Developing and maintaining software for analysing and comparing model outputs.**

- Facilitate access to **observational datasets** and community experiments.

- **Generate diagnostics and evaluate models/configurations** at any stage of model development.

- Help **establish community guidelines and standards**.

- **Support international efforts.**

ACCESS-NRI Strategic Plan:

Andy Hogg. (2022). Strategic plan for ACCESS-NRI (2022-2027) (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7196783

ACCCESS-NRI National Collaborators:

ACCCESS-NRI International Collaborators:

Australia's climate simulator