Aparna Radhakrishnan[1],Ryan Abernathey[6], Sasha Ames[10], V. Balaji[4], Julius Busecke[5], Forrest Hoffman[10], Phil Kershaw[7], David Neelin[8], Jessica Liptak[2], John Krasting[2], Kristopher Rand[3], Ag Stephens[7], Hans Vahlenkamp[9]

American Geophysical Union 2023
Session: CF and NetCDF: 30 Years of Wide Open Science

Every fraction of a degree of warming has grave consequences.

IPCC

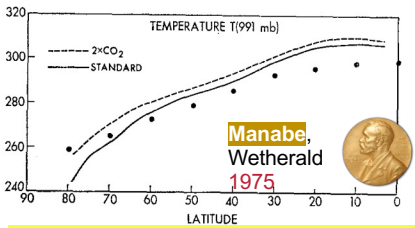
Cyclone Michaung, Chennai, India.
Dec 5th, 2023

Acknowledging the Climate and Forecast conventions, A.Radhakrishnan et al AGU 2023

Every fraction of a degree of warming has grave consequences.

IPCC

Cyclone Michaung, Chennai, India.
Dec 5th, 2023



Manabe, Wetherald 1975

3 models in Charney's report

THE WCRP CMIP3 MULTIMODEL DATASET 2007

A New Era in Climate Change Research

BY GERALD A. MEEHL, CURT COVEY, THOMAS DELWORTH, MOJIB LATIF, BRYANT MCAVANEY, JOHN F. B. MITCHELL, RONALD J. STOUFFER, AND KARL E. TAYLOR

Open access to an unprecedented, comprehensive coordinated set of global coupled climate model experiments for 20th and 21st century climate and other experiments is **changing the way researchers and students analyze and learn about climate**

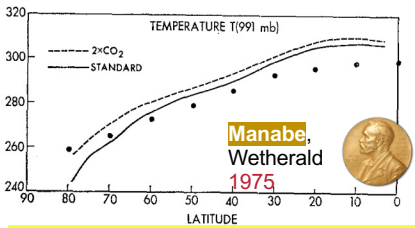
CMIP6 design, 2016

≈ 120 models

CMIP5 design,2012

≈ 60 models

≈ 25 models all over the world



3 models in Charney's report

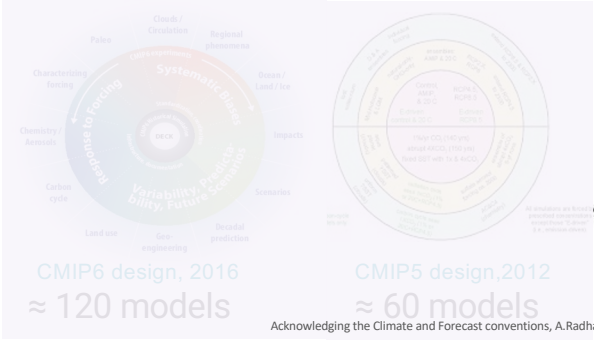
THE WCRP CMIP3 MULTIMODEL DATASET 2007

A New Era in Climate Change Research

BY GERALD A. MEEHL, CURT COVEY, THOMAS DELWORTH, MOJIB LATIF, BRYANT MCAVANEY, JOHN F. B. MITCHELL, RONALD J. STOUFFER, AND KARL E. TAYLOR

Open access to an unprecedented, comprehensive coordinated set of global coupled climate model experiments for 20th and 21st century climate and other experiments is **changing the way researchers and students analyze and learn about climate**

≈ 25 models all over the world

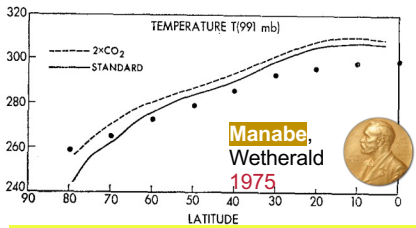


CMIP6 design, 2016

≈ 120 models

CMIP5 design,2012

≈ 60 models



3 models in Charney's report

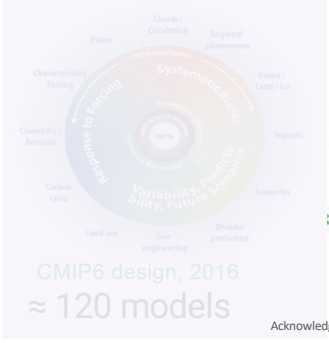
THE WCRP CMIP3 MULTIMODEL DATASET 2007

A New Era in Climate Change Research

BY GERALD A. MEEHL, CURT COVEY, THOMAS DELWORTH, MOJIB LATIF, BRYANT MCAVANEY, JOHN F. B. MITCHELL, RONALD J. STOUFFER, AND KARL E. TAYLOR

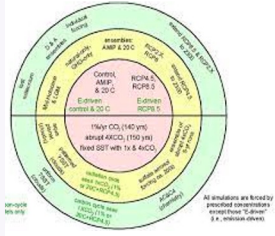
Open access to an unprecedented, comprehensive coordinated set of global coupled climate model experiments for 20th and 21st century climate and other experiments is **changing the way researchers and students analyze and learn about climate**

≈ 25 models all over the world



CMIP6 design, 2016

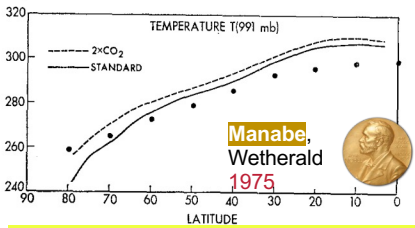
≈ 120 models



CMIP5 design,2012

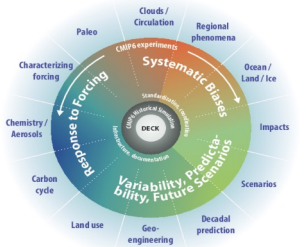
≈ 60 models

Acknowledging the Climate and Forecast conventions, A.Radhakrishnan et al AGU 2023



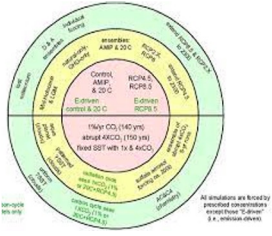
Manabe, Wetherald 1975

3 models in Charney's report



CMIP6 design, 2016

≈ 120 models



CMIP5 design,2012

≈ 60 models

THE WCRP CMIP3 MULTIMODEL DATASET 2007

A New Era in Climate Change Research

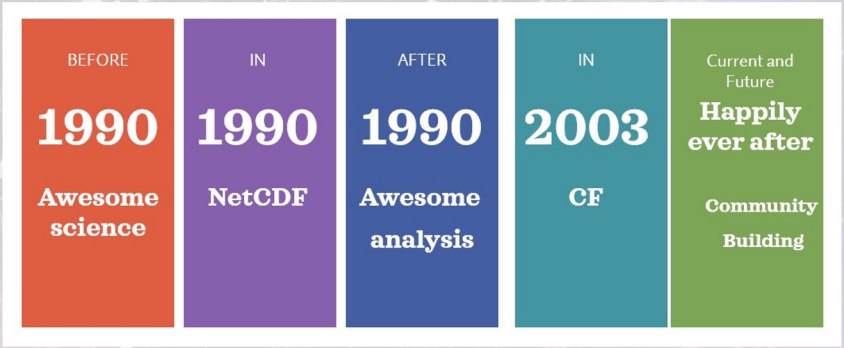
BY GERALD A. MEEHL, CURT COVEY, THOMAS DELWORTH, MOJIB LATIF, BRYANT MCAVANEY, JOHN F. B. MITCHELL, RONALD J. STOUFFER, AND KARL E. TAYLOR

Open access to an unprecedented, comprehensive coordinated set of global coupled climate model experiments for 20th and 21st century climate and other experiments is **changing the way researchers and students analyze and learn about climate**

≈ 25 models all over the world

Acknowledging the Climate and Forecast conventions, A.Radhakrishnan et al AGU 2023

Acknowledging the Climate and Forecast conventions



Data/Metadata standardization efforts

GFDL user analysis suites

Community diagnostics

CF and Climate Model Output Rewriter

GFDL Model Development

Provenance

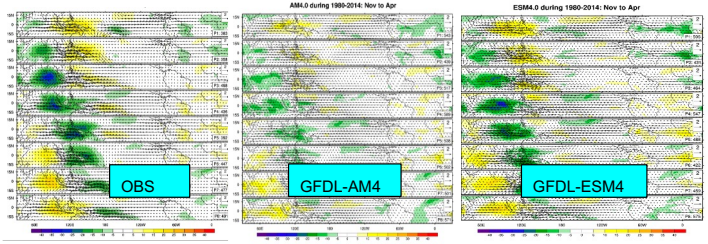
Data publication

GFDL climate modeling workflow

Usable Climate model output

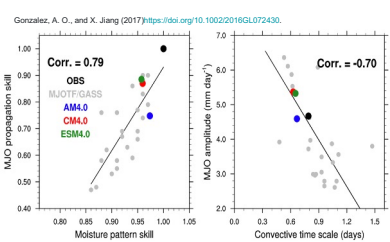
Towards interoperable tools and science

Process Oriented Diagnostics (POD)



Ref. Dong, 2021, UFS webinar, CMIP6 datasets from ESGF.

MJO lifecycle



Maritime continent ***moisture pattern skill*** is correlated with ***MJO propagation skill***; ***Convective timescale*** is correlated with ***MJO amplitude***.

Why does the model behave a certain way?

Deep-dive into the processes, emergent behaviors..

Learn, share, improve

NOAA's Model Diagnostics Task Force, funded by NOAA MAPP

Task Force Lead: D. Neelin (UCLA)

What We Have Done:

- Established community of >90 diagnosticians
- Leverages CF and CMOR conventions
- Built a Python-based framework
- Collaboration with DOE on Earth System Metrics and Diagnostics Standards
- Prepared extensive documentation & tutorials
- Moved to an open-development environment
- Ability to do multi-model comparisons
- Robust Testing

Where We are Going:

- Major "data processor" redesign for an agile framework for ALL.
- Expand to more Earth system components
- Explore more weather-scale phenomena
- Model workflow integration
- Align with GFDL/NOAA objectives while collaborating with other community partners

Connect model development efforts with expertise in the academic and private sectors to evaluate and improve model performance and process representation

A.Radhakrishnan, MDTF, WCRP OSC 2023

Data/Metadata standardization efforts

GFDL user analysis suites

Community diagnostics

CF and Climate Model Output Rewriter (CMOR)

GFDL Model Development

Provenance

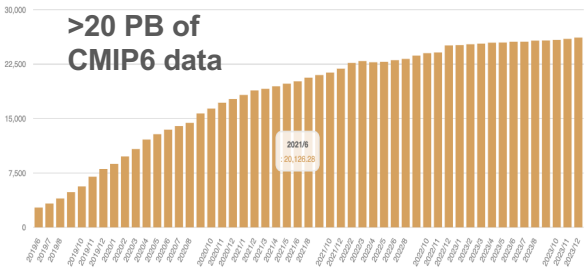
Data publication

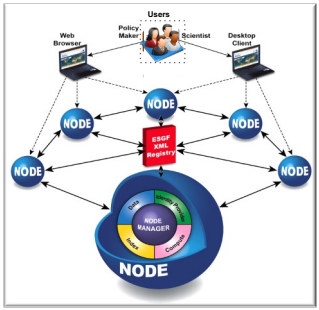
GFDL climate modeling workflow

Usable Climate model output

Towards interoperable tools and research

Earth System Grid Federation





Adapted from https://esgf.github.io/

- Where CMIP6 data access is made possible
- Modular Infrastructure for data publication
- Compliance to CF and CMOR
- Towards cloud-based quality assurance
- Many more..

The Earth System Grid Federation (ESGF) is an international collaboration for the software that powers most global climate change research, notably assessments by the Intergovernmental Panel on Climate Change (IPCC).

Acknowledging the Climate and Forecast conventions, A.Radhakrishnan et al AGU 2023

Data/Metadata standardization efforts

GFDL user analysis suites

Community diagnostics

CF and Climate Model Output Rewriter (CMOR)

GFDL Model Development

Provenance

Data publication

GFDL climate modeling workflow

Usable Climate model output

Towards interoperable tools and research

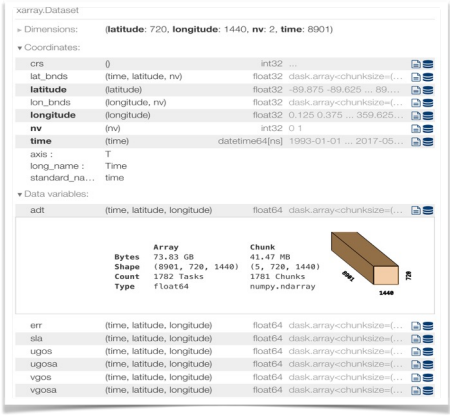
Usable data?

Bringing analysis to the data!

- Intuitive Data exploration
- Analysis-ready [Cloud-optimized] Datasets! (ARCO)
- Scalable analytics

Diverse audience, diverse stakeholders

Analysis-Ready, Cloud-Optimized Data (ARCO)



xMIP

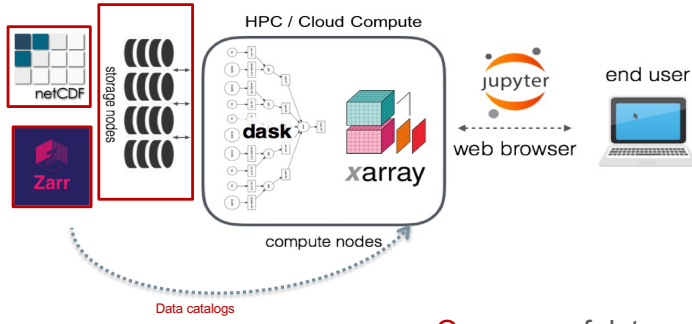
PANGEO FORGE

Preprocess to clean the data inline to make intercomparison seamless

Easy ARCO data generation

Acknowledging the Climate and Forecast conventions, A.Radhakrishnan et al AGU 2023

A cloud-native scientific data analytics ecosystem



Data proximate analysis

One copy of data and MANY ways to analyze by MANY DIFFERENT people

Acknowledging the Climate and Forecast conventions, A.Radhakrishnan et al AGU 2023

PANGEO

References

How to request for additional CMIP6 data in the cloud?
https://pangeo-data.github.io/pangeo-cmip6-cloud/requesting_data.html

Contact:

aparna.radhakrishnan@princeton.edu

xMIP https://cmip6-preprocessing.readthedocs.io/en/latest/?badge=latest

CMIP6 Controlled Vocabulary https://github.com/WCRP-CMIP/CMIP6_CVs

Pangeo and data catalogs
https://pangeo-data.github.io/pangeo-cmip6-cloud/
intake-esm https://intake-esm.readthedocs.io/en/latest/
Intake-esgf https://github.com/ESGF2-US/intake-esgf

MDTF https://github.com/NOAA-GFDL/MDTF-diagnostics