PCMDI – An Earth System Model Evaluation Project

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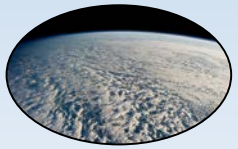
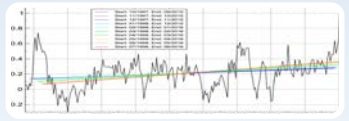
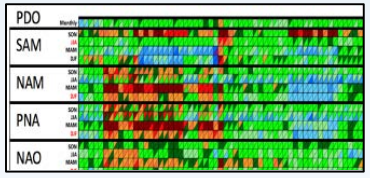
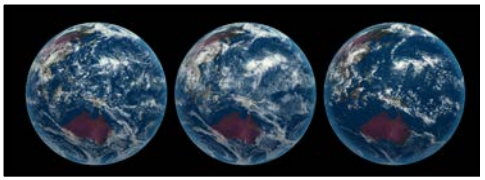
Using model ensembles of today and tomorrow to measure model performance, reduce uncertainties in their predictions, and determine the pathways for their improvement









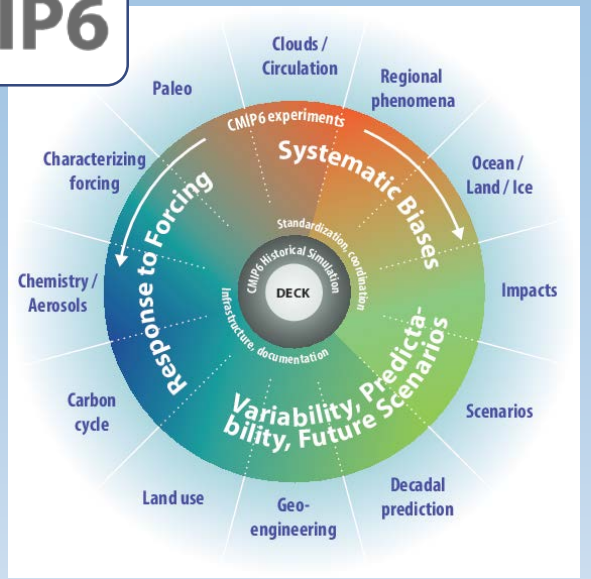
Outline

1. CMIP6
2. Reducing Uncertainties Related to Cloud Feedbacks and Climate Sensitivity
3. Interpreting Recent Changes in Climate to Inform Predictability
4. Measuring Model Performance and Facilitating Community Involvement
5. Engaging with the Convection Permitting Models of Tomorrow

CMIP6: In Full Bloom

Coupled Model Intercomparison Project Phase 6

CMIP6



- PCMDI, together with LLNL ESGF project, has been involved in CMIP6 planning and delivery since 2013
- By the numbers, CMIP6 currently has:
  - 10 PB published (CMIP5: 2 PB), 20-50 PB expected
  - 136 models from 51 institutions (CMIP5: 59 models)
- Improved scientific analyses are facilitated by PCMDI's involvement in the related ***input4MIPs*** and ***obs4MIPs*** efforts, which provide systematization and provenance of datasets used to force and evaluate models

obs4MIPs
Observations for Model Intercomparison Projects

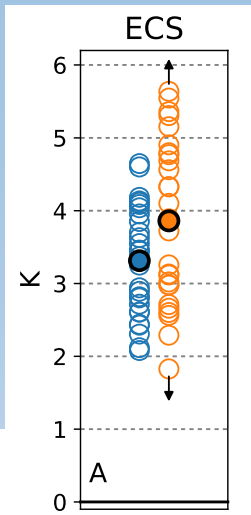
input4MIPs
Input datasets for Model Intercomparison Projects

Taylor, K.E., S. Denvil, P.J. Durack, M. Lautenschlager, M. Stockhause, D. Williams and many others, 2019: A Guide to CMIP6 Participation. https://pcmdi.llnl.gov/CMIP6/Guide/ and https://pcmdi.llnl.gov/CMIP6/ArchiveStatistics/esgf_data_holdings/

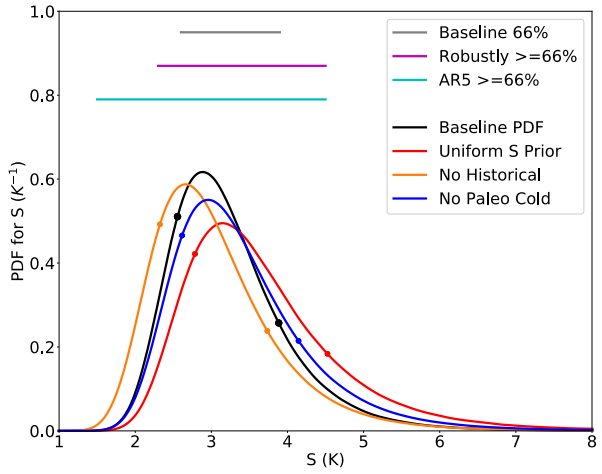
Climate Sensitivity and Cloud Feedbacks

Many CMIP6 models warm more in response to CO_2 – New scientific judgment thinks the highest and lowest sensitivities to be unlikely

- Demonstrated that the higher climate sensitivity (ECS) in many CMIP6 models is due to stronger cloud feedbacks in extra-tropical low clouds
  - Mark Zelinka's feedback estimates are incorporated into the draft AR6 IPCC report
- PCMDI scientists were among the leaders of the World Climate Research Program expert assessment of climate sensitivity which found that climate sensitivity (S) is likely (66% chance) between 2.6 - 3.9 K



Zelinka et al., *Geophys. Res. Lett.* (2020)



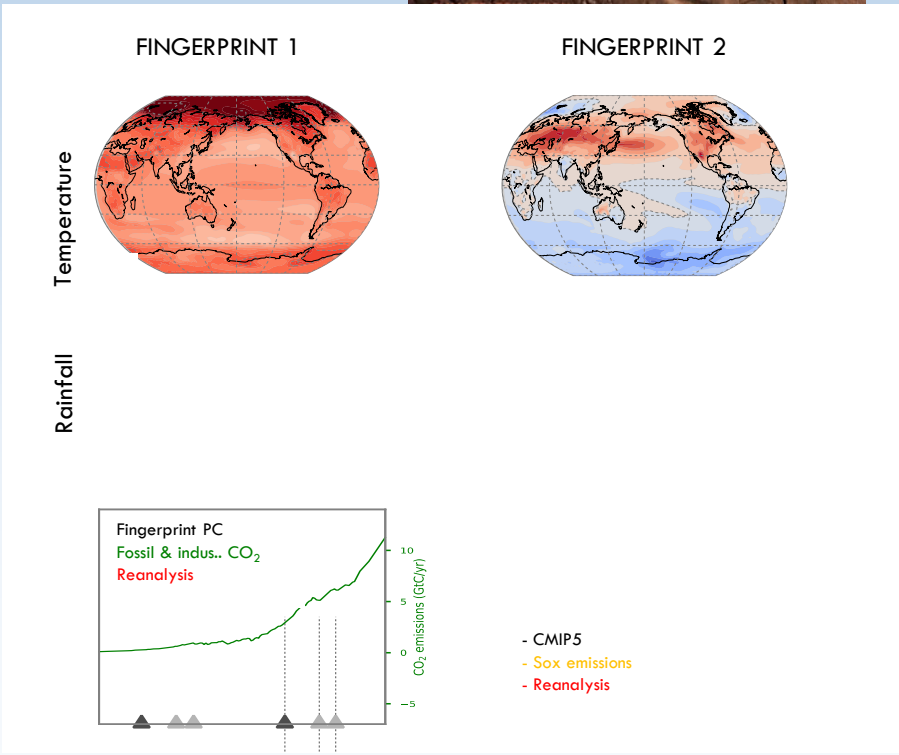
Sherwood, S. et al., *Rev. Geophys.* (2020)

Zelinka, M. D., T. A. Myers, D. T. McCoy, S. Po-Chedley, P. M. Caldwell, P. Ceppi, S. A. Klein, and K. E. Taylor, 2020: Causes of higher climate sensitivity in CMIP6 models. *Geophys. Res. Lett.*, 47, e2019GL085782, doi: 10.1029/2019GL085782.

Sherwood, S. and 24 co-authors including S. A. Klein and M. D. Zelinka, 2020: A combined assessment of Earth's climate sensitivity. *Rev. Geophys.*, doi: 10.1029/2019RG000678.

Disentangling the Causes of Observed Changes in Temperature, Precipitation, and Drought

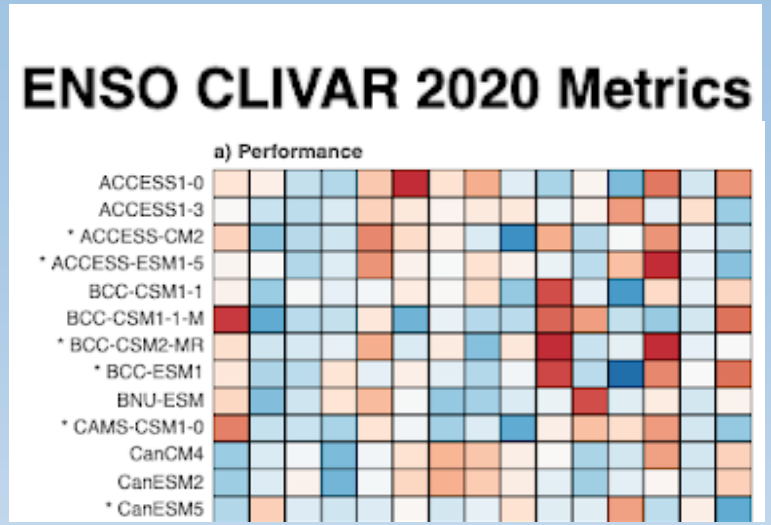
- Using a fingerprint method accounting for the complex time evolution of forcings, we demonstrated that greenhouse gas emissions and aerosols have influenced regional drying around the globe in two distinct ways since the 1950s
- Models with a more complete representation of aerosol effects better match observations

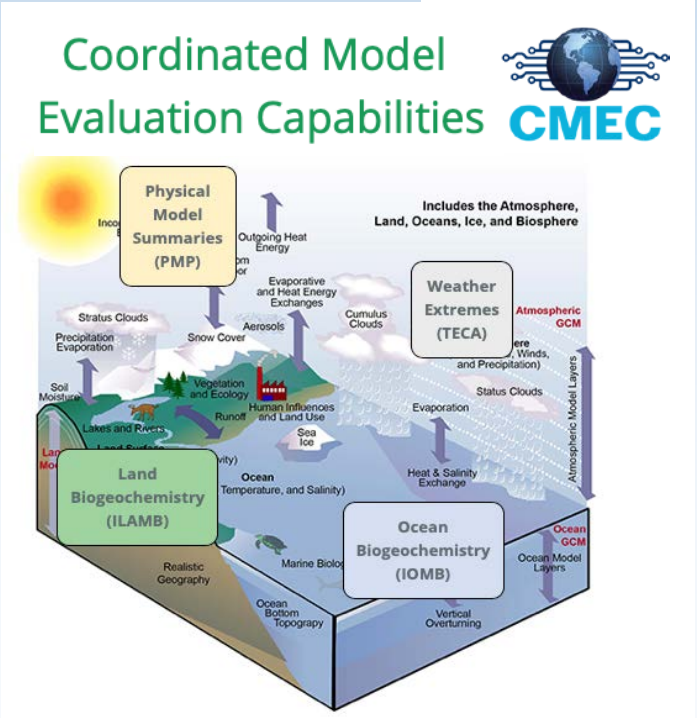


Bonfils, C., B. D. Santer, J. Fyfe, K. Marvel, T. Phillips, S. Zimmerman, 2020: Human influence on joint changes in temperature, rainfall, and continental aridity. *Nature Climate Change*, https://doi.org/10.1038/s41558-020-0821-1.

Measuring Model Performance and Facilitating Community Involvement

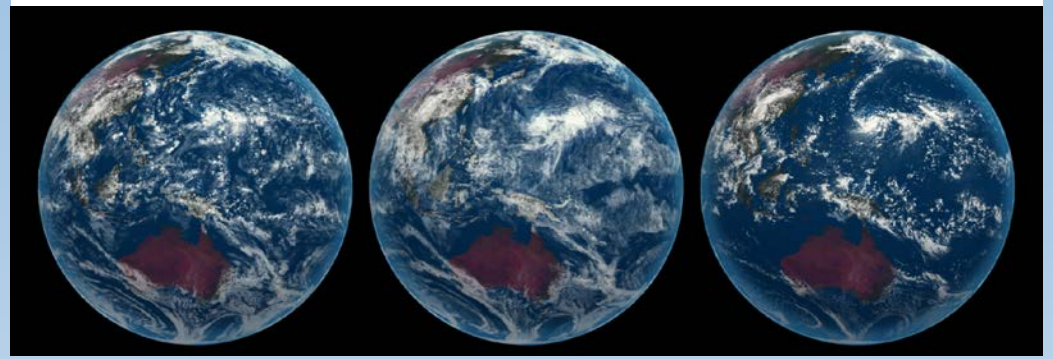
- Metrics (mean state, ENSO, precipitation, …) of CMIP5/6 model performance presented in interactive web pages
- Precipitation benchmark metrics (intensity distribution, intermittency, diurnal cycle, ...) were determined through the DOE-led 2019 Precipitation Workshop
- Prototyping the ***Coordinated Model Evaluation Capabilities*** (lead: P. Ullrich, UC Davis) – a platform to facilitate community involvement in the development and application of repeat-use diagnostics for models





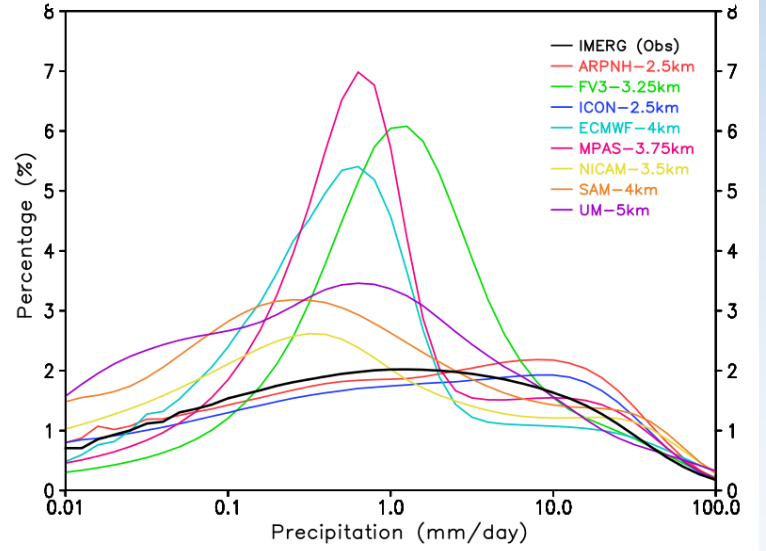
Engaging with Convection Permitting Models

Snapshots of Clouds in 3 DYAMOND Models

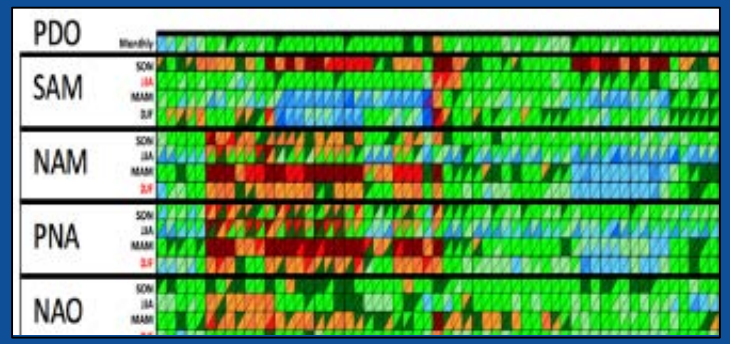


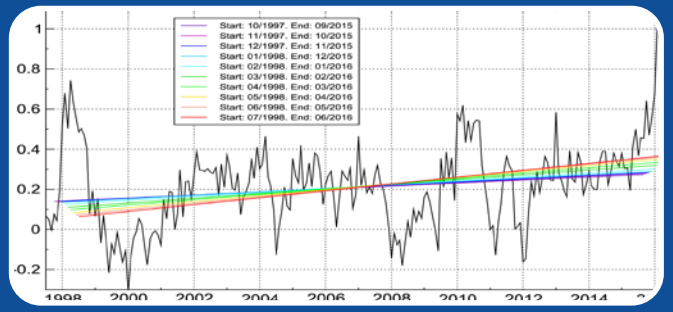
- DYAMOND is the first intercomparison project of global models with horizontal resolution models < 5 km
  - A 40-day simulation was performed by 9 models
- First-looks suggest significant achievements (e.g. extreme daily precipitation) and also significant model diversity
- Challenges will remain (e.g. warm bias over warm season continents) but these models hold significant promise for many high-frequency convection, cloud and precipitation phenomena

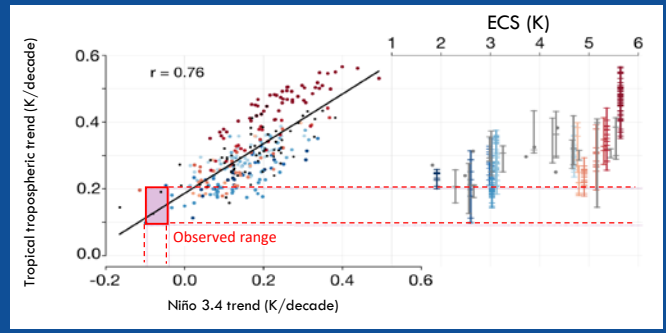
PDF of Daily Precipitation in Tropical Regions



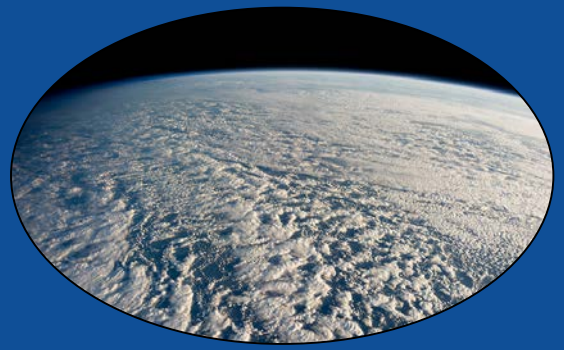
DYAMOND project: https://www.esiwace.eu/services/dyamond

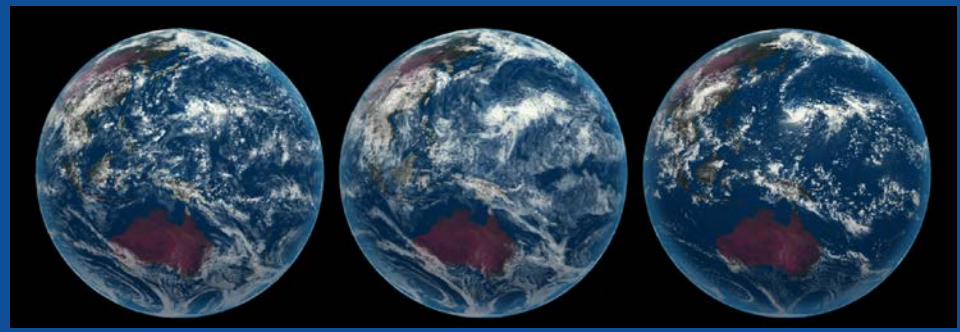






Thanks for your attention!





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