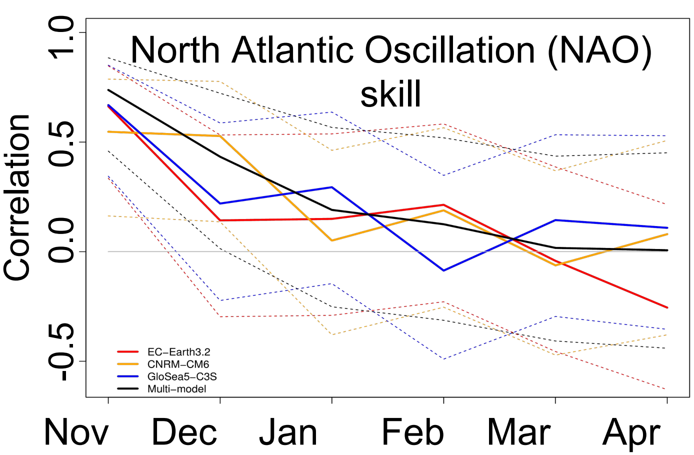
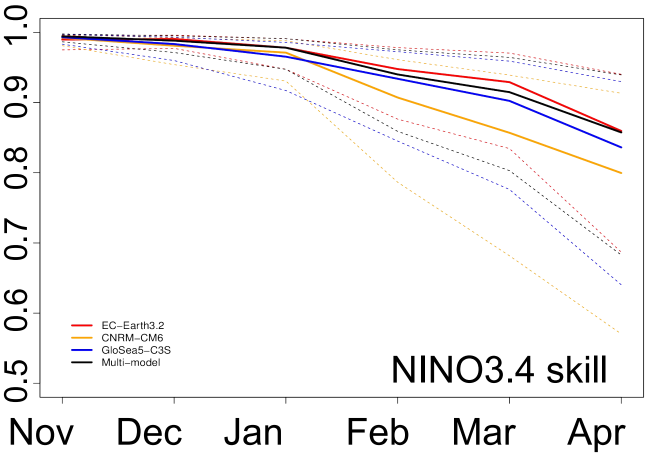
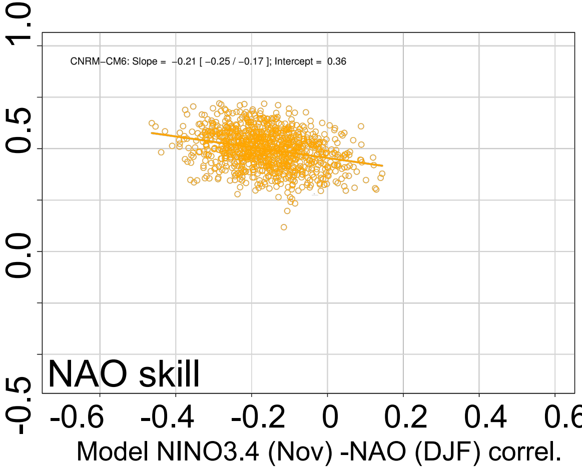
Northern hemisphere winter forecasts in current climate prediction systems

Juan C. Acosta Navarro, Pablo Ortega, Verónica Torralba, Etienne Tourigny, François Massonnet, Francisco J. Doblas-Reyes, Doug Smith, Lauriane Batté







- The sets of members in CNRM-CM6 with larger anticorrelation between NINO3.4 (November) and NAO (DJF) tend to have a more skill in the NAO predictions.
- In ERA-Interim the NAO-NINO3.4 correlation coefficient is -0.25. The 1880-2015 (HadiSST1 & Jones et al. 1997) correlation is -0.05. Neither one is statistically significant at 95% confidence.

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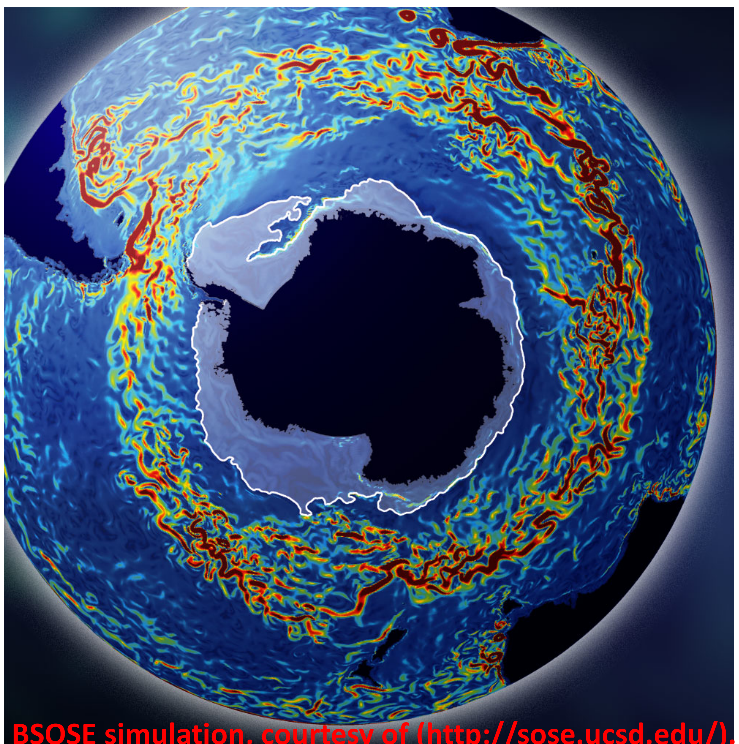
PRIMAVERA

A framework for understanding the quality of Southern Ocean circulation in coupled climate and Earth System Model simulations

Rebecca L. Beadling (Beadling@email.arizona.edu)
Joellen L. Russell, Ronald J. Stouffer, Paul J. Goodman, Matthew Mazloff

SOCCOM



BSOSE simulation, courtesy of (http://sose.ucsd.edu/).

Conclusions

(1) Relative to CMIP3, there have been significant model improvements in the simulation of the ACC and parameters associated with its flow.

(2) Models are grouped based on their ability to simulate important observationally-based metrics:

- ✔ **PUSH**: accurate zonally-averaged maximum westerly wind stress
- ✔ **PULL**: accurate total wind stress curl over Drake Passage latitudes
- ✔ **DENSITY**: reasonable full-depth and zonally-averaged density gradient across the ACC
  - (1) Reasonable ACC for approximately the right reasons (8 models)
  - (2) Accurate simulation of metrics but weak ACC (6 models)
  - (3) Accurate wind stress forcing with errors in density gradient (10 models)
  - (4) Errors in wind stress forcing but accurate density gradient (6 models)
  - (5) Errors in wind stress forcing and errors in density gradient (1 model)

(3) Early CMIP6 analysis suggests improvements in the ACC simulation for several models.

Evaluation of CMIP6 climate models in predicting monsoon rainfall based on bias corrected clustering approach

*Swati Bhomia and C. M. Kishtawal

*swatibhomia10@gmail.com, Space Applications Centre, ISRO, Ahmedabad, India

CMIP6 Model Analysis Workshop, 25-28 March 2019, Barcelona, Spain

Objective

The aim of the present work is to develop a bias corrected cluster (BCC) approach using CMIP6 climate model simulations. With this approach improvement over simple mean and the participating models is expected.

Data & Methodology

Data Selection
CMIP6-Model & ERA-Interim Data: Zonal wind (ms^{-1}), Meridional wind (ms^{-1}) and Specific humidity (kg kg^{-1}) at archived pressure levels

→

Study Area & Period
Spatial coverage (the Indian Ocean)
Temporal Resolution (June-September, 1991-2010)
Spatial Resolution (2.5^{o}x2.5^{o})

↓

Computation of Monthly VIMFs
Using the wind and specific humidity integrated Zonal and Meridional VIMF (kgm^{-1}s^{-1}) were computed for each Model & ERA

←

Bias Correction
Using ERA data and CMIP6 historical run from 1991-2000 bias for each model for each summer monsoon month was computed

↓

Computation of SM & BCC
During the testing period viz. 2001-2010, SM & BCC (by restoring the cluster with higher members) were computed at each grid

→

Validation of SM & BCC
Skill of the SM & BCC has been assessed with respect to the ERA-interim using Pearson's correlation, vector correlation & SD of error

Acknowledgement: The authors are thankful to the CMIP6 & ERA data team for providing the necessary data. Thanks to the CMIP6 Model Analysis Workshop organizers for providing this wonderful opportunity. We are also thankful and indebted to WMO for providing the financial support for attending this workshop. This work is a part of DST/SERB sponsored project under N-PDF Scheme (PDF/2017/002075).

Results & Conclusions

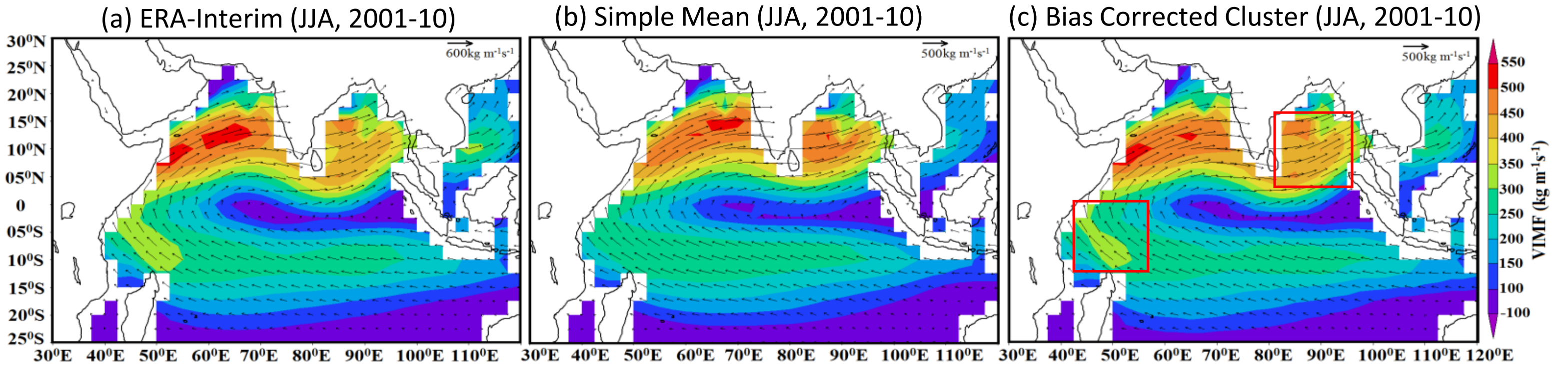


Figure 1: Vertically Integrated Moisture Flux (VIMF) has been shown from (a) Era-Interim, (b) Simple Mean (SM) and (c) Bias Corrected Cluster (BCC) Mean, for seasonal mean JJA (June-to-August) for the testing period 2001-10.

- It can be seen in the figure, that the spatial pattern of the simple mean and bias corrected cluster (BCC) derived VIMFs fields, are matching well with the ERA-Interim VIMFs fields over almost all the regions viz., Somali coast, Arabian Sea and Bay of Bengal.
- Based on the verification scores BCC approach was found to be performing better compared to simple mean and the member models with higher correlation coefficient and lower error.
- BCC was found to have higher vector correlation (r=0.96) compared to simple mean (r=0.92).

Future Perspective

✓ In future more models will be incorporated in the present clustering approach, as more confidence will be placed on the BCC approach once we will have higher number of data points.

Reducing uncertainty in near-term European climate projections

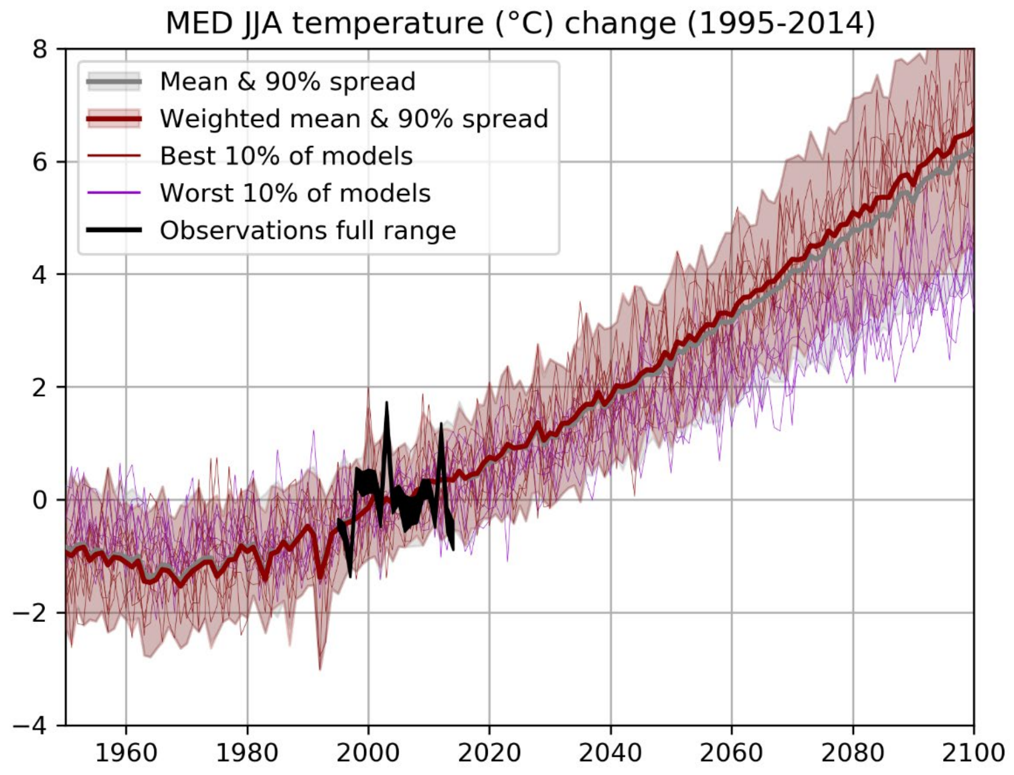
L. Brunner, R. Lorenz, and R. Knutti | Poster 3-P04

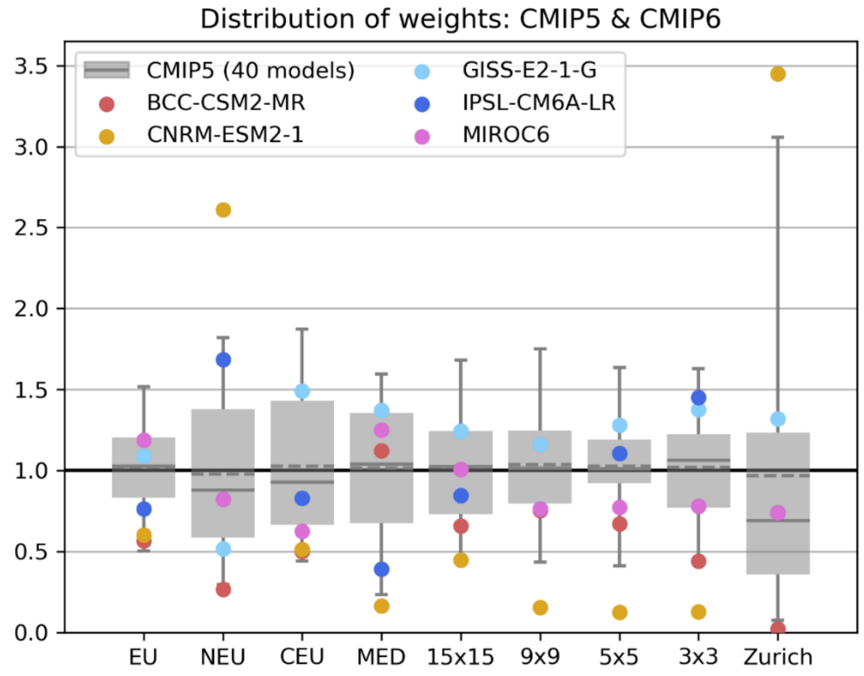
weight of model i

$$w_i = \frac{e^{-\frac{D_i^2}{\sigma_D^2}}}{1 + \sum_{j \neq i}^{M} e^{-\frac{S_{ij}^2}{\sigma_S^2}}}$$

performance weight

independence weight



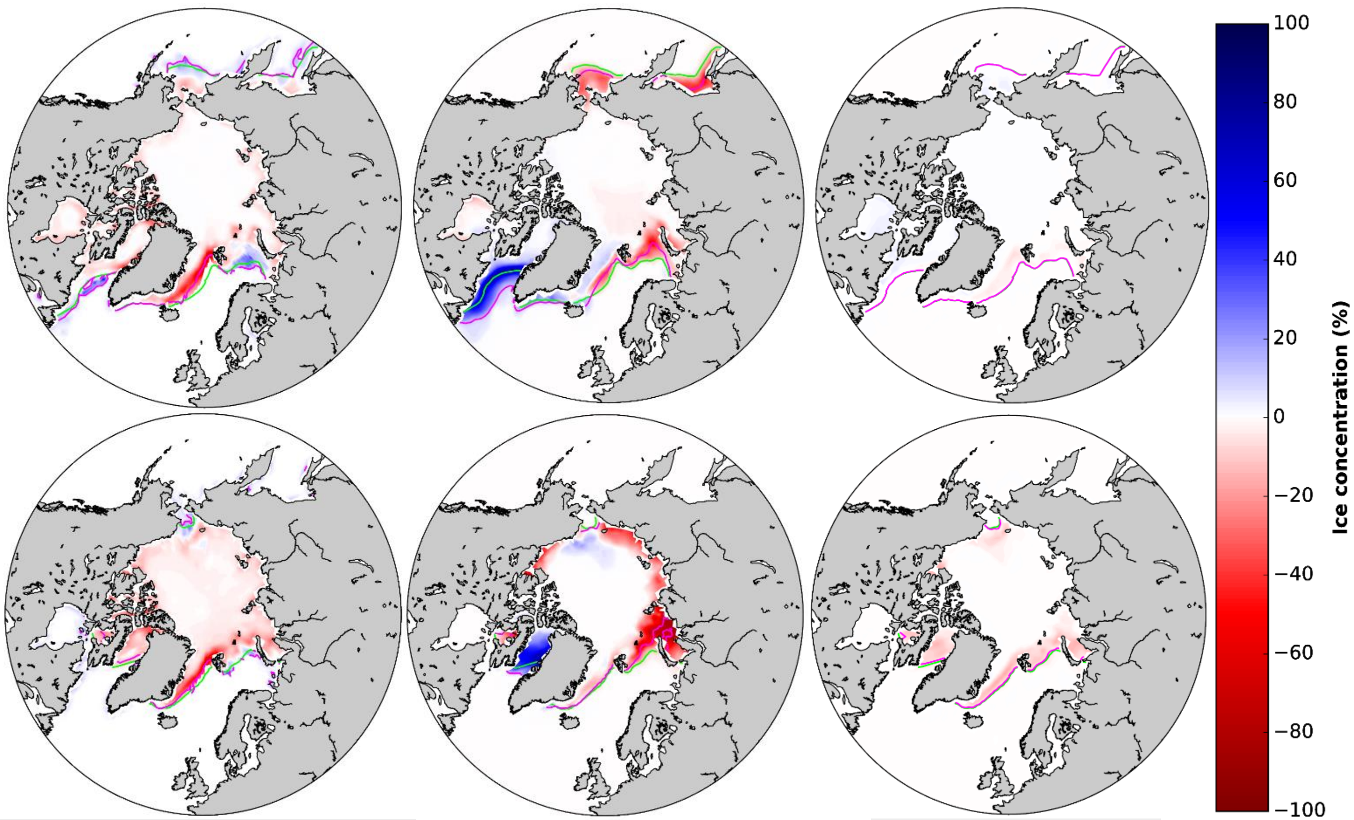


An anatomy of the forecast errors in a seasonal prediction system with EC-Earth

***R. Cruz-García**, P. Ortega, J.C. Acosta-Navarro, F. Massonnet, F.J. Doblas-Reyes*

May 1st

Nov 1st



Initial Conditions Inconsistency

Systematic Error

Forecast Error

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Poster: 3_P05

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RESEARCH ARTICLE
10.1029/2018JD029541

Key Points:
- A perfect-model framework can be useful to determine the achievable

A Framework to Determine the Limits of Achievable Skill for Interannual to Decadal Climate Predictions

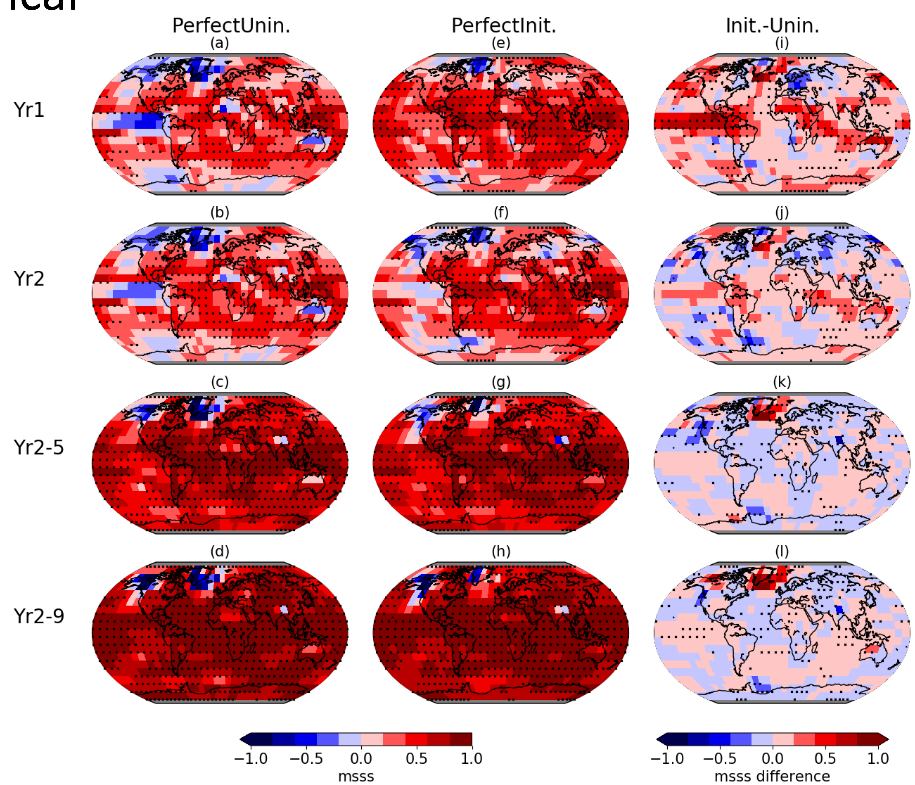
Yiling Liu[1], Markus G. Donat[1,2], Andréa S. Taschetto[1], Francisco J. Doblas-Reyes[3,2], Lisa V. Alexander[1], and Matthew H. England[1]

Current decadal prediction systems are subject to non-ideal initialization
→ What level of skill may be achievable given "perfect" initialization?

Perfect-model predictions (with CESM), consistent set-up to decadal hindcasts:

decadal simulations started from a historical reference run each year 1961-2005
→ How far can the model predict itself, starting from (almost) identical initial conditions?

Compare skill for initialised/uninitialised perfect-model versus real-world predictions



Poster # 3-P06 (Tuesday pm)

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NCAR's Climate Model Assessment Tool

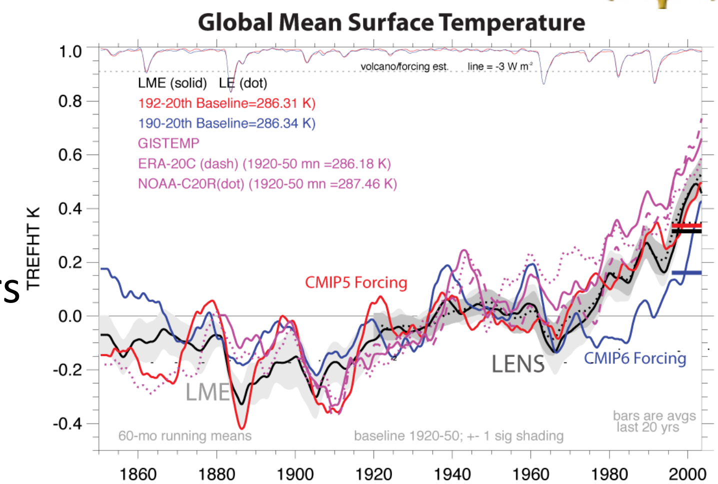
John Fasullo

Model Simulation

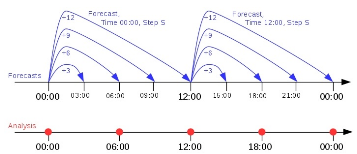
e.g. CESM1.x

Observations

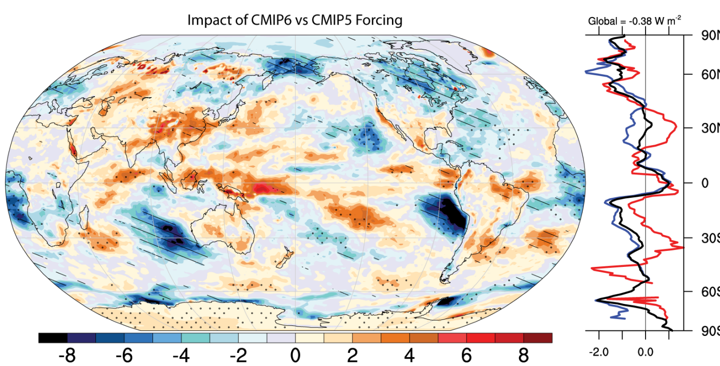
GISTEMP, GPCP, ERA20C
HADCRU, CERES
Ocean Heat Content
Time series / Hovmoëllers



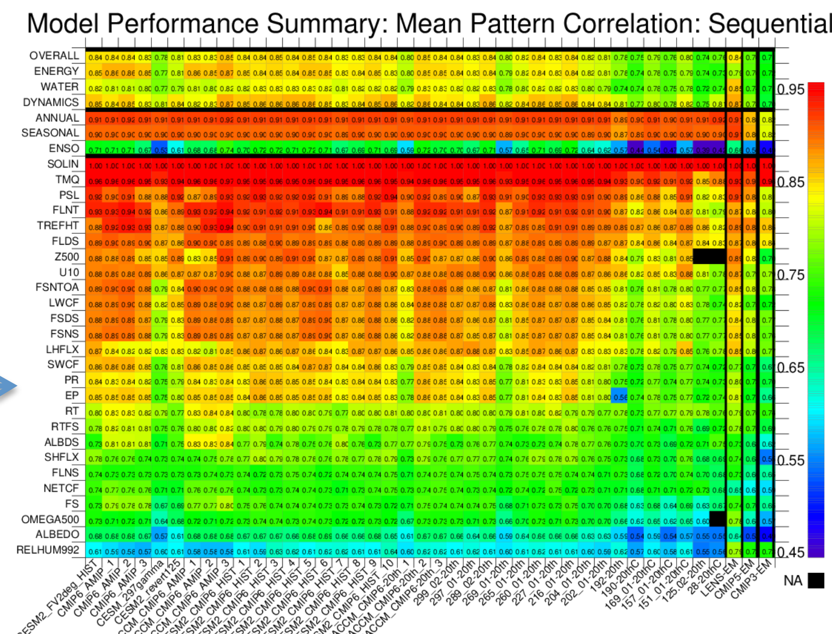
CERES GPCP ERA5 26 Variables



Mean State; JJA-DJF; ENSO Reg.
Pattern Correlations, Satellite Era



Scoring



All differences shown w.r.t. internal var.

Application of a **big data approach** to constrain projection-based estimates of the **future North Atlantic Carbon Uptake**

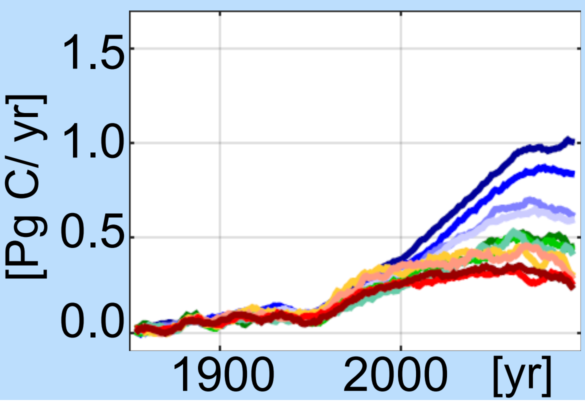
Nadine Goris (nadine.goris@norceresearch.no), Jerry Tjiputra, Klaus Johannsen

-11 CMIP5 models

-RCP8.5

R=0.8

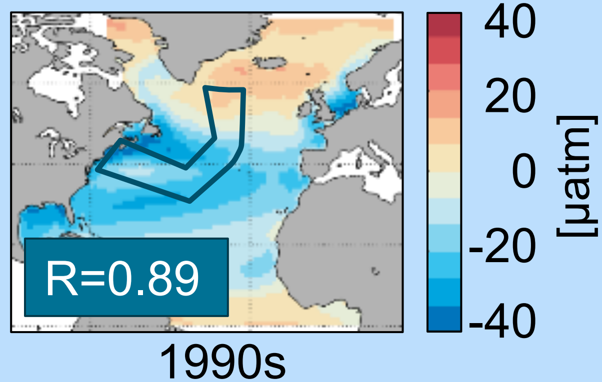
Anthropogenic Carbon Uptake, North Atlantic



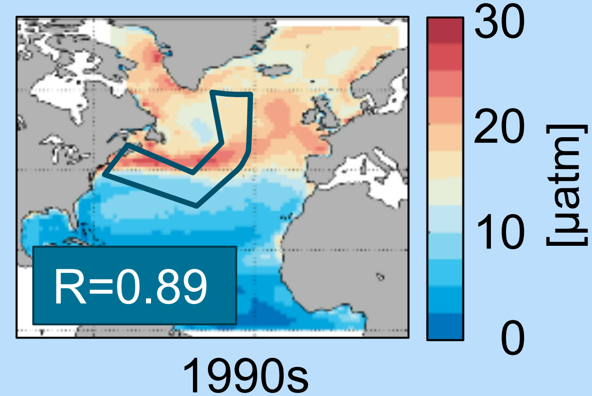
R=0.9

-Model spread relates to the modeled "carbon pump" efficiency

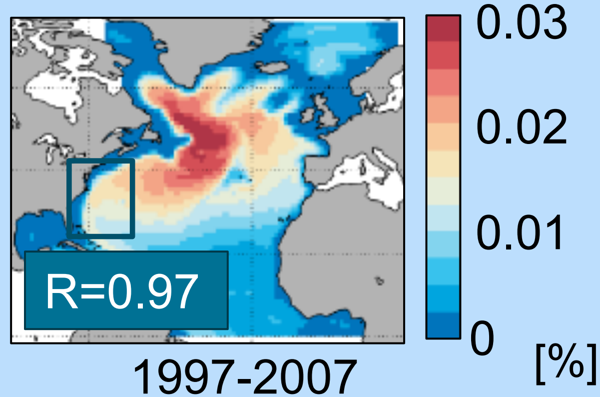
Winter pCO_2^{sea}-anomaly, multi-model (MM) mean



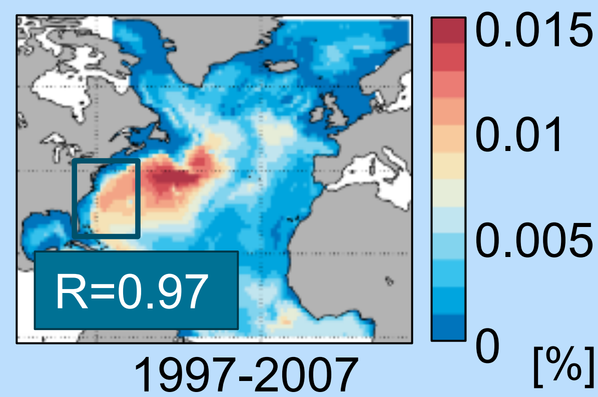
Winter pCO_2^{sea}-anomaly, MM standard-deviation



C_{ant*}-fraction > 1000m, multi-model mean



C_{ant*}-fraction > 1000m, MM standard-deviation



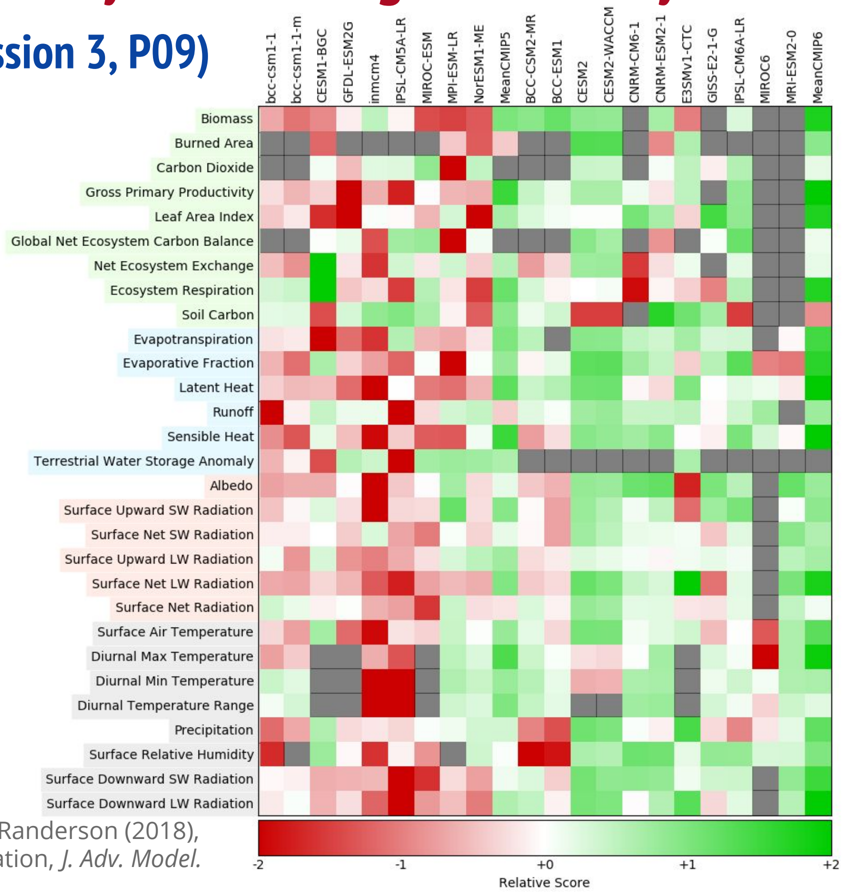
Benchmarking CMIP Terrestrial Carbon Cycle and Biogeochemistry Models with the ILAMB Package (Session 3, P09)

RUBISCO

Forrest M. Hoffman[1,2], Nathan Collier[1], Mingquan Mu[3], Gretchen Keppel-Aleks[4], David M. Lawrence[5], Charles D. Koven[6], Min Xu[1], Cheng-En Yang[2,1], Jiafu Mao[1], William W. Riley[6], James T. Randerson[3]

[1]Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA; [2]University of Tennessee, Knoxville, Tennessee, USA; [3]University of California Irvine, Irvine, California, USA; [4]University of Michigan, Ann Arbor, Michigan, USA; [5]National Center for Atmospheric Research, Boulder, Colorado, USA; [6]Lawrence Berkeley National Laboratory, Berkeley, California, USA

- The International Land Model Benchmarking (ILAMB) Package is an Open Source toolkit for evaluating land biogeochemistry models through comparisons with observations
- ILAMB assesses model fidelity for 29 variables with over 60 observational datasets for biogeochemistry, hydrology, radiation, and climate forcing
- ILAMB scores models based on statistical comparisons (bias, RMSE, phase, amplitude, spatial distribution, Taylor scores) and functional response metrics
- Preliminary relative scores suggest that the CMIP6 suite of models has improved over the CMIP5 suite of models



Collier, N., F. M. Hoffman, D. M. Lawrence, G. Keppel-Aleks, C. D. Koven, W. J. Riley, M. Mu, J. T. Randerson (2018), The International Land Model Benchmarking (ILAMB) System: Design, Theory, and Implementation, *J. Adv. Model. Earth Sy.*, 10(11):2731–2754, doi:10.1029/2018MS001354.

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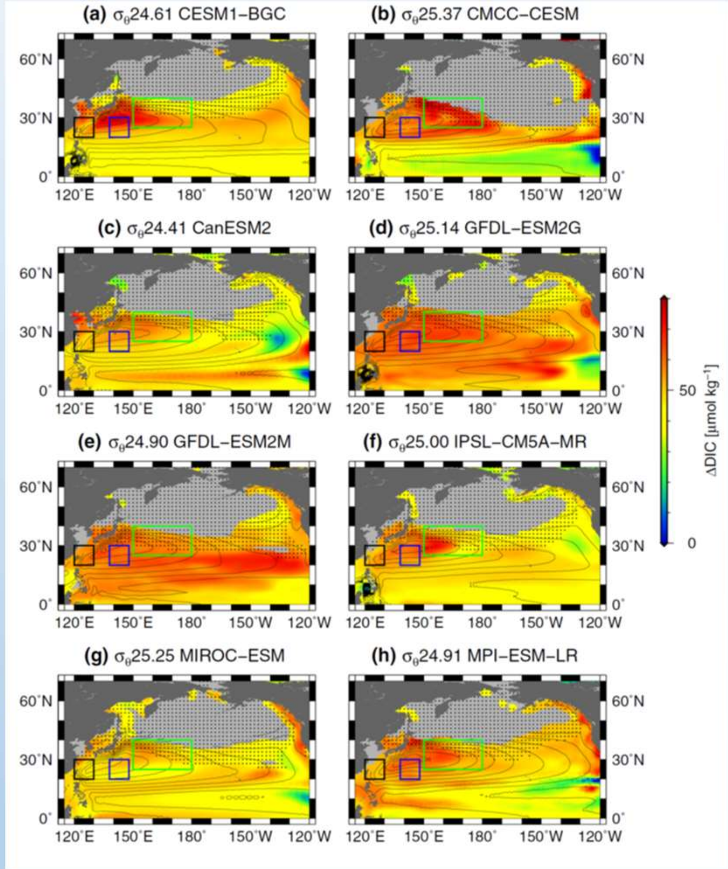
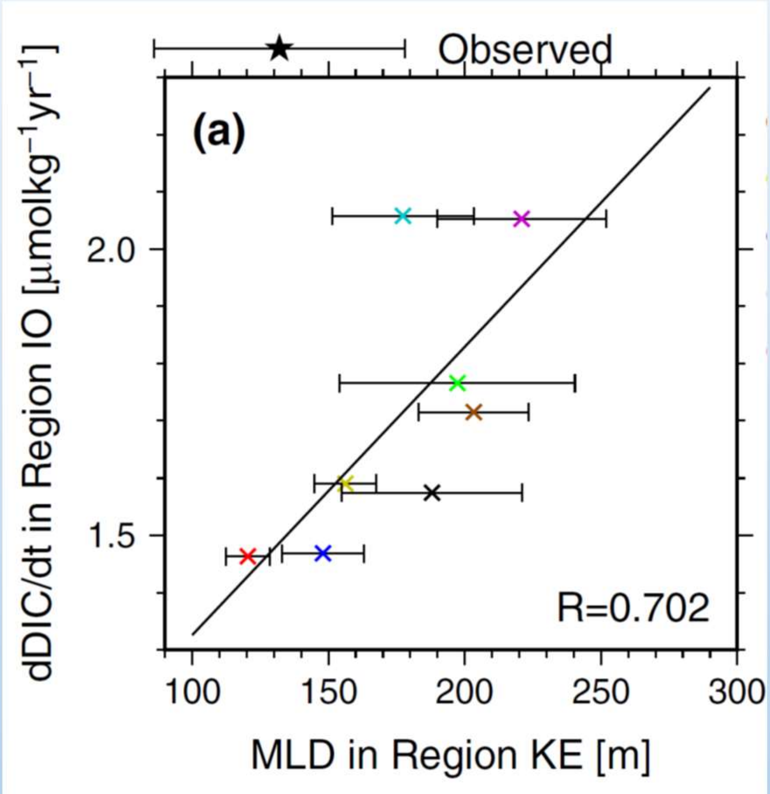
An emergent constraint on ocean acidification in the subsurface layers based on multi-model analysis

Michio Kawamiya and Michio Watanabe (JAMSTEC), Contact: kawamiya@jamstec.go.jp



Change in DIC concentration computed as the difference between the decades 2041–2050 and 2006–2016, at depths of ~200m

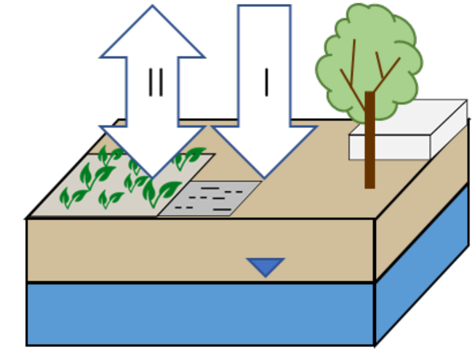


Scatter plots of the DIC trend at depths of ~200m within Izu-Ogasawara region versus MLD in Jan.–Mar. within Kuroshio Extention region averaged over 2006–2015

MLD in the Kuroshio Extension Region acts as an "emergent constrain" for projection of mid-depth acidification.

Long-term Balances and Variabilities of Surface Energy and Water Cycles: Preliminary Results from LS3MIP and GSWP3

*Hyungjun Kim, Gerhard Krinner, Sonia Seneviratne, Bart van den Hurk, Chris Derksen, Taikan Oki, Yukihiko Onuma, Bertrand Decharme and David Lawrence; *hjkim@iis.u-tokyo.ac.jp



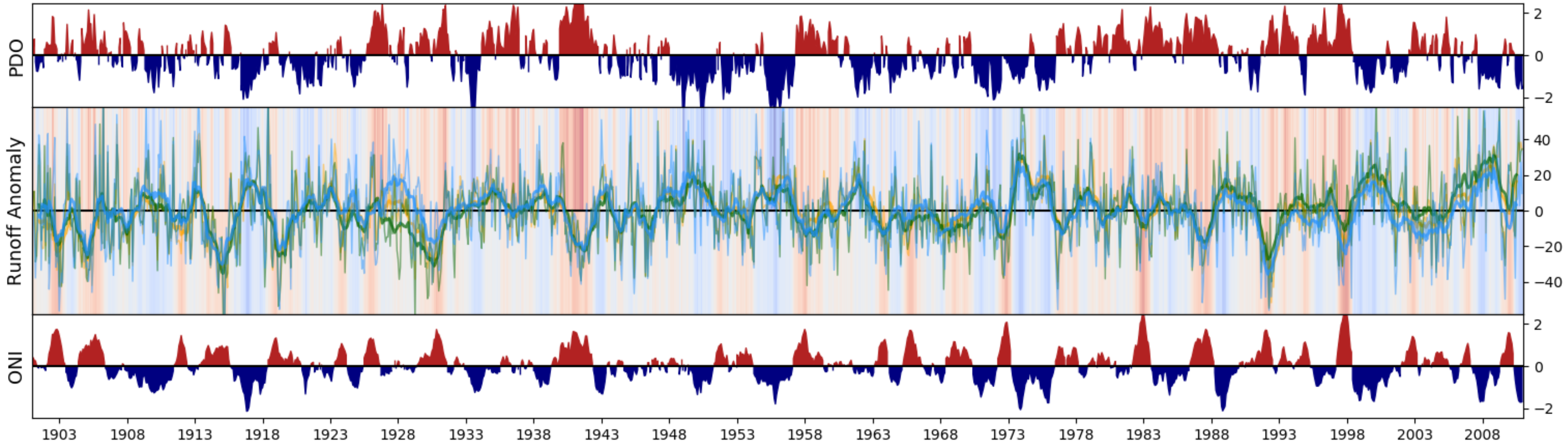
Land Surface, Snow, Soil-moisture MIP (LS3MIP)

to quantify land processes, climate forcings, and their feedbacks in CMIP6

I) land-hist : offline land-only simulations with high-quality climate drivers (here, CLM/CESM2, ISBA/CNRM-CM6, MATSIRO/MIROC6 by GSWP3 forcing data for 1901-2010)

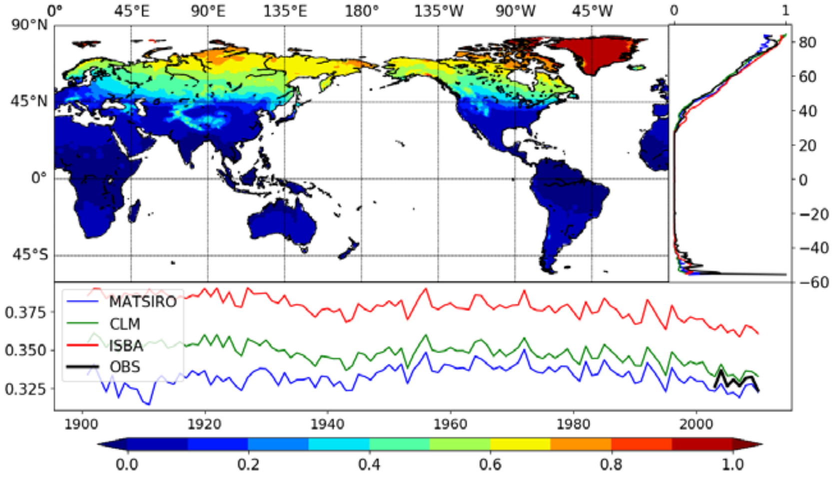
II) lfmip : coupled simulations with snow & soil-moisture nudging

1. First realistic multi-model terrestrial energy/water/carbon cycles for entire 20C



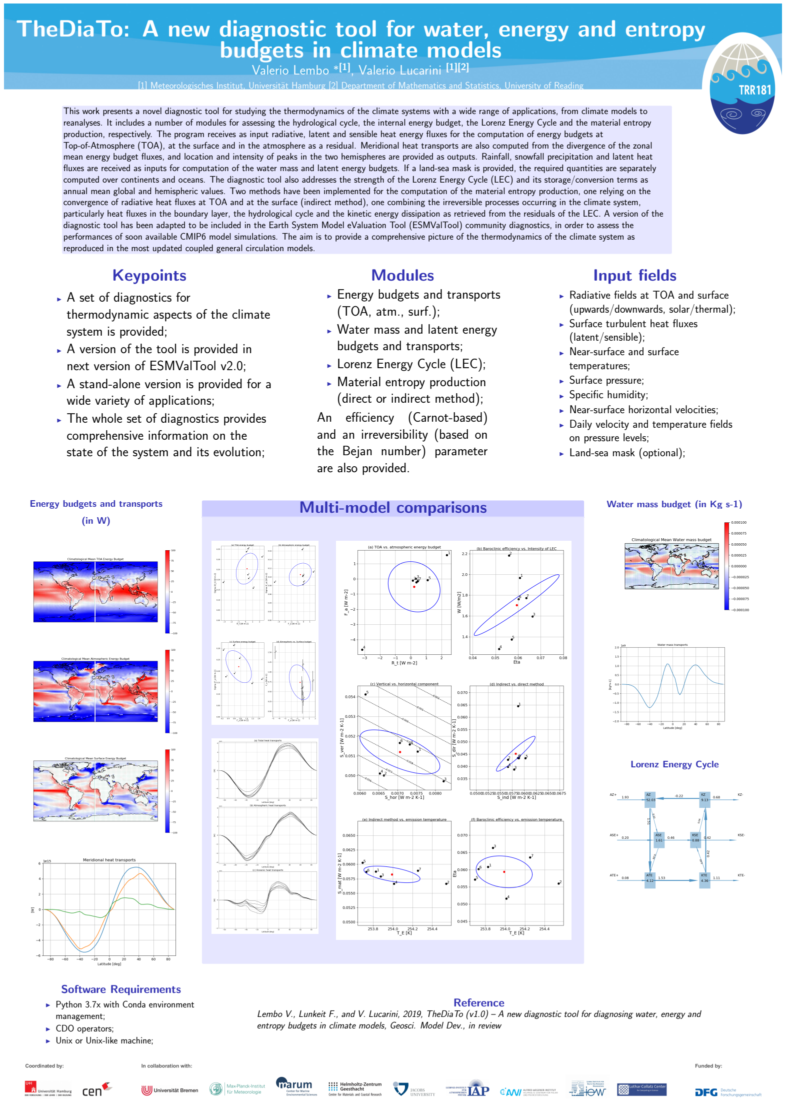
- *Interannual variability of global runoff is significantly modulated by Pacific SST variability (multivariate regression based on ONI and PDO can reproduce ~50% of total variability)*
- *Each model has a similar sensitivity to climate forcing*

2. Evaluation of the land processes



- *All models well-capture the decreasing trend of snow cover extent which has been under-estimated in coupled simulations. (e.g., CMIP5)*

THEDIATO: A NEW DIAGNOSTIC TOOL FOR WATER, ENERGY AND ENTROPY BUDGETS IN CLIMATE MODELS



- The Thermodynamic Diagnostic Tool (TheDiaTo, v1.0) is a collection of metrics for the thermodynamics of the climate system;
- It is designed for being part of the ESMValTool community diagnostics;
- It contains 4 independent modules:
  - Energy budgets and transports;
  - Latent energy/water mass budgets and transports;
  - The atmospheric Lorenz Energy Cycle;
  - The material entropy production;
- A stand-alone version of the tool is being prepared, allowing for comparisons of a wide range of products;

We can provide more info at stand 12!

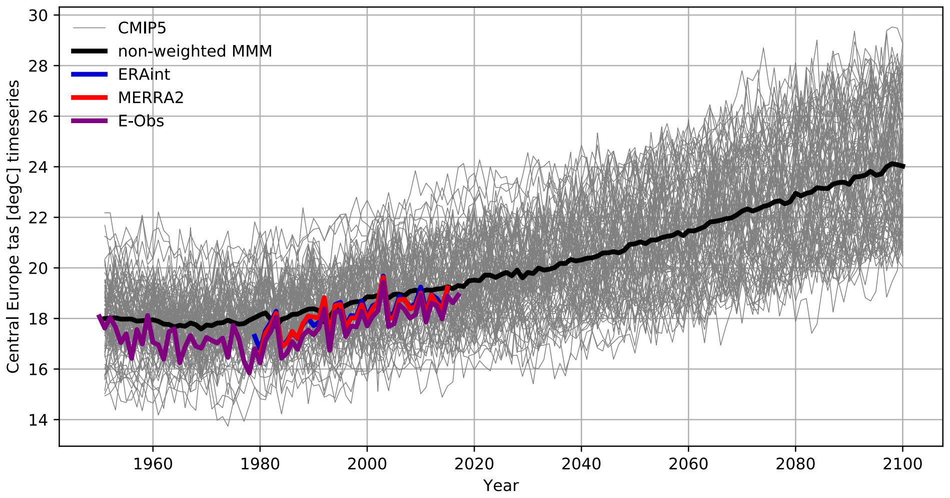
Valerio Lembo, CEN, University of Hamburg, Germany

ETH zürich

Can we beat climate model democracy in ensemble projections?

Ruth Lorenz, Lukas Brunner and Reto Knutti

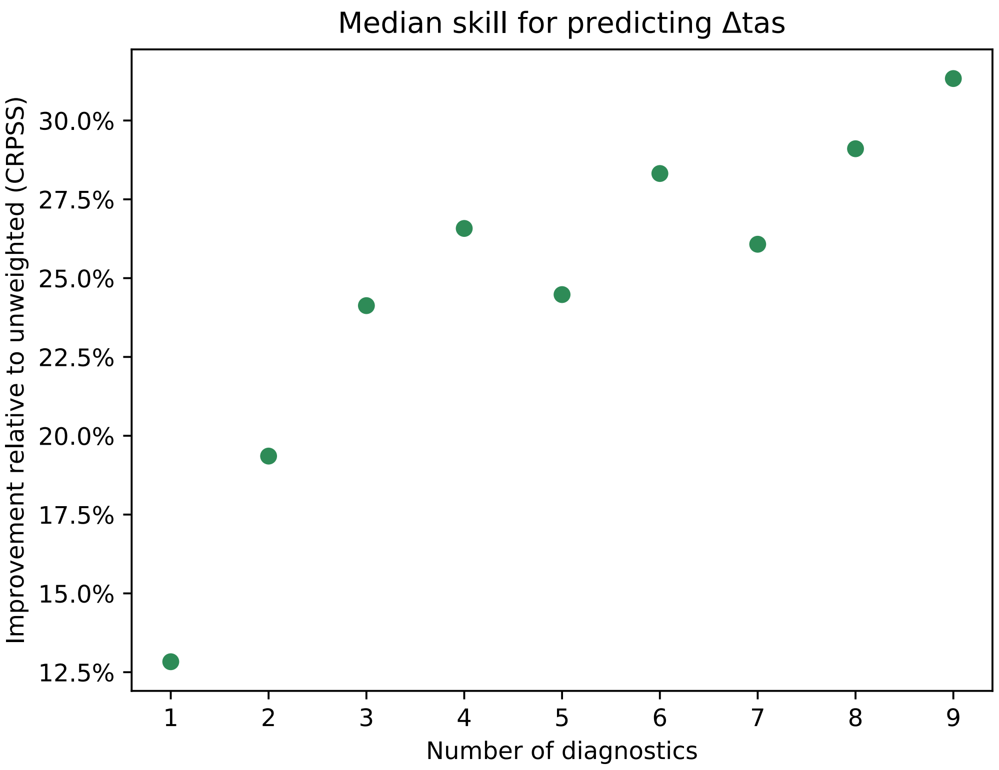
P13



$$w_i = e^{-\frac{D_i^2}{\sigma_D^2}} \Bigg/ \left(1 + \sum_{j\neq i}^{M} e^{-\frac{S_{ij}^2}{\sigma_S^2}}\right)$$

Increases weight if distance to observations is small

Decreases weight if model is similar to others

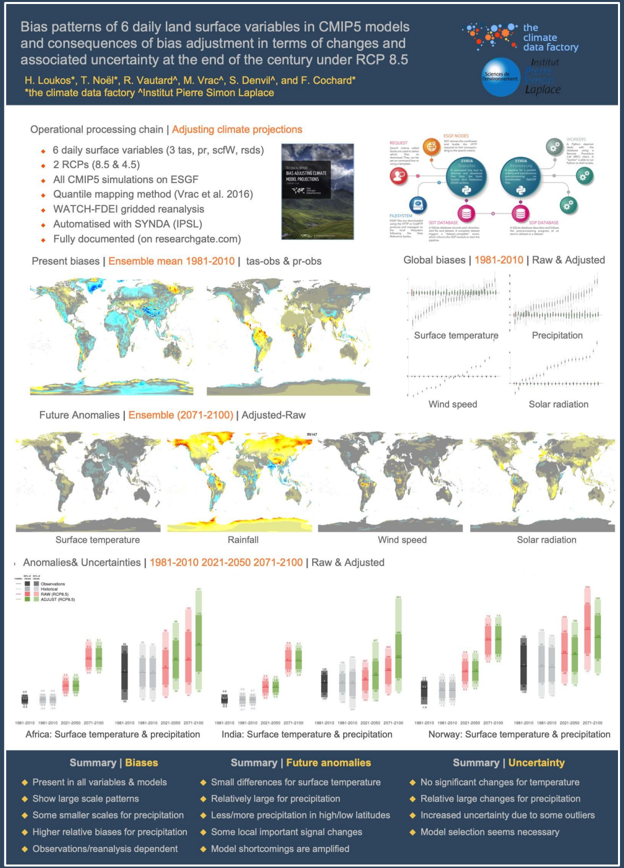


CRESCENDO

Bias patterns of 6 daily land surface variables in CMIP5 models and consequences of bias adjustment in terms of changes and associated uncertainty at the end of the century under RCP 8.5

H. Loukos*, T. Noël*, R. Vautard^, M. Vrac^, S. Denvil^ and F. Cochard*
*the climate data factory ^Institut Pierre Simon Laplace

Tuesday - Session 3 - Poster 14



WHAT WE DID

Compared interpolated and statistically downscaled CMIP5 projections

6 surface variables (3 tas, pr, sfcWind, rsds)

At 0.5°x0.5° (WFDEI reanalysis)

Daily values (1951-2100)

All models (first member)

RCP 8.5

QUESTIONS & ANSWERS

Any large biases in the ensemble mean compared to reanalysis?

Any large differences in the ensemble mean anomalies in 2071-2100?

Any differences in the associated uncertainties?

In short: Temperature YES, NO, NO - Precipitation 3x"YES"

Simulations and evaluations of version 1.0 of E3SM Land Model (ELM) for the LS3MIP

Oak Ridge National Laboratory

Jiafu Mao[1,*], Xiaoying Shi[1], Daniel M. Ricciuto[1], Forrest M. Hoffman[2], Peter Thornton[1], and Min Xu[2]

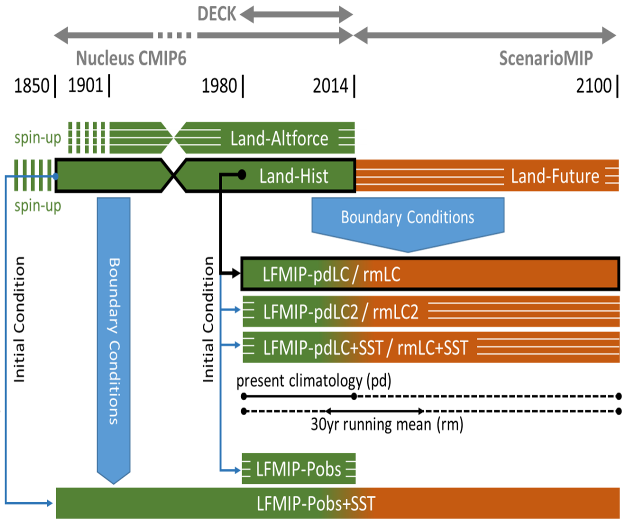
U.S. Department of Energy — Office of Science

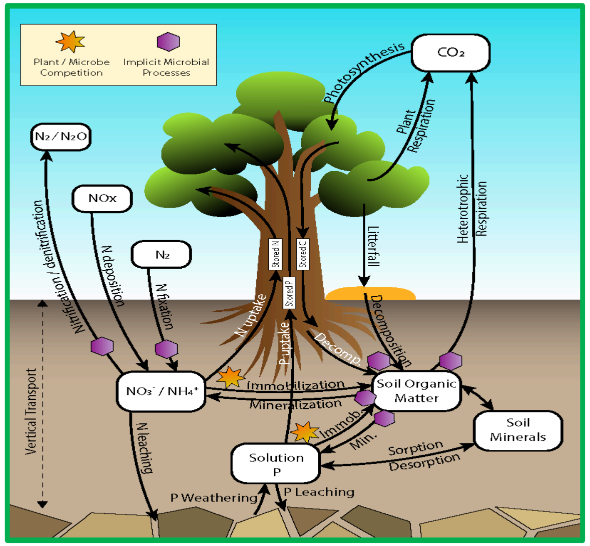
[1]Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA

[2]Computer Science and Mathematics Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA

SCHEMATIC OF LS3MIP :

LS3MIP diagnoses interactions between land and atmosphere and assesses the land components of the CMIP6 ESMs. One of the key components of the LS3MIP is to conduct offline land model experiments driven by common observational drivers, attributing the causes behind model differences to the driver or structural deficiencies. With iLAMB package, we investigate and present comprehensive benchmarking results of the ELMv1.0 against best available observations like the means states and multiyear variations of land surface energy, water, and biogeochemical budgets (B. Van den Hurk et al., 2016).



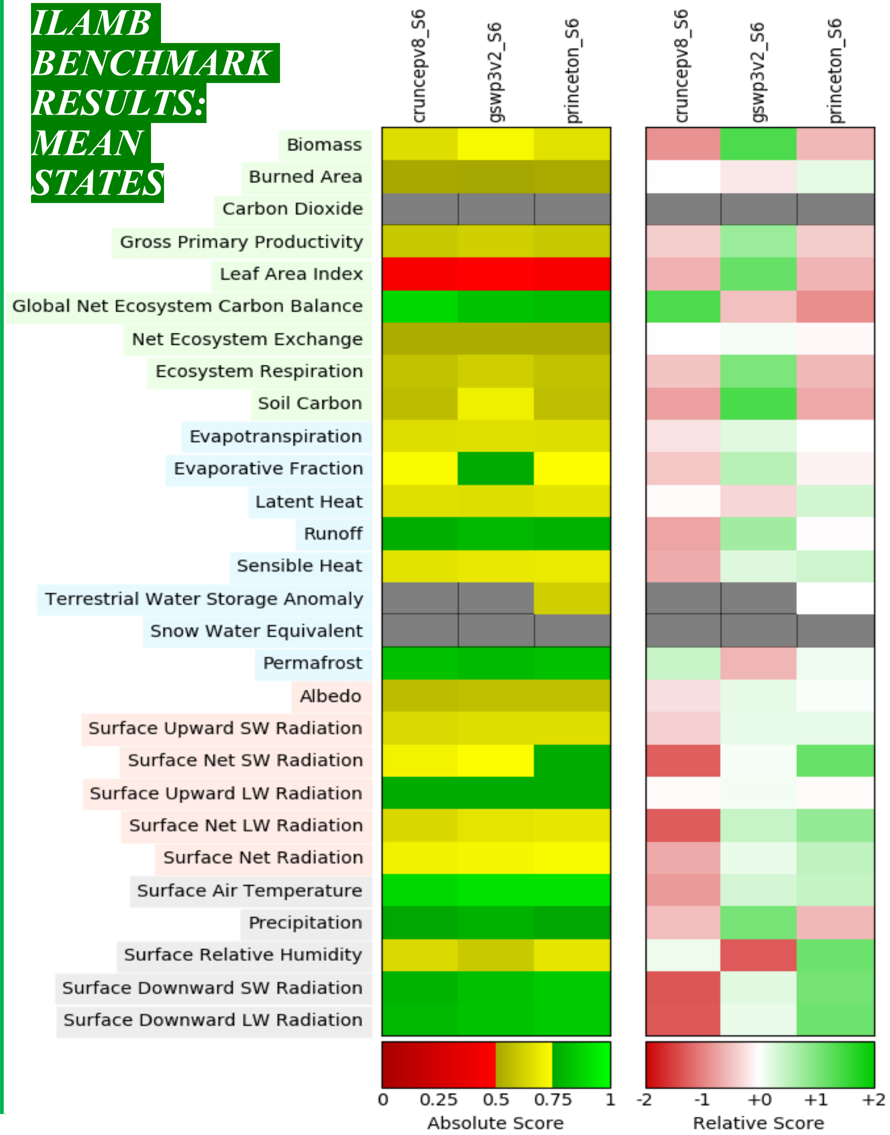


SCHEMATIC OF ELMv1.0:

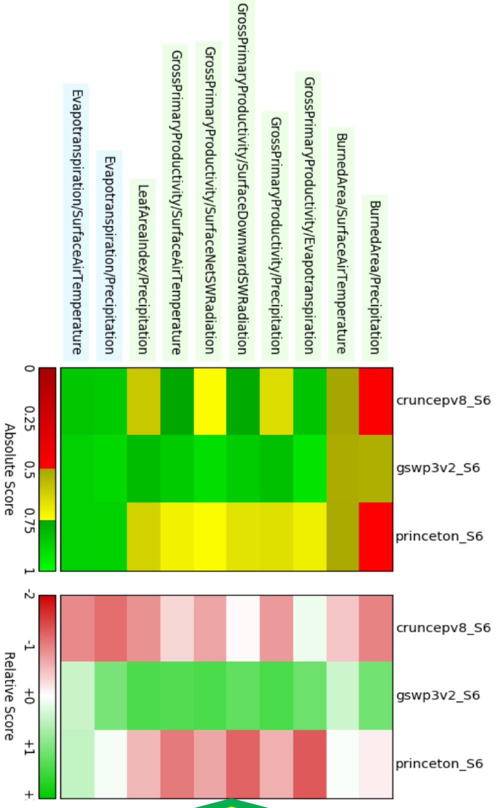
- Built from the Community Land Model Version 4.5 (CLM4.5);
- Introduce prognostic phosphorus cycle and C-N-P interactions;
- Characterize dynamic storage pools for C, N and P;
- Produce global P maps for model initialization;
- Simulate the competition between plants and microbial process for available soil N and P;
- Include many other new developments, evaluations and applications;

https://e3sm.org/model/e3sm-model-description/v1-description/v1-land/

ILAMB BENCHMARK RESULTS: MEAN STATES



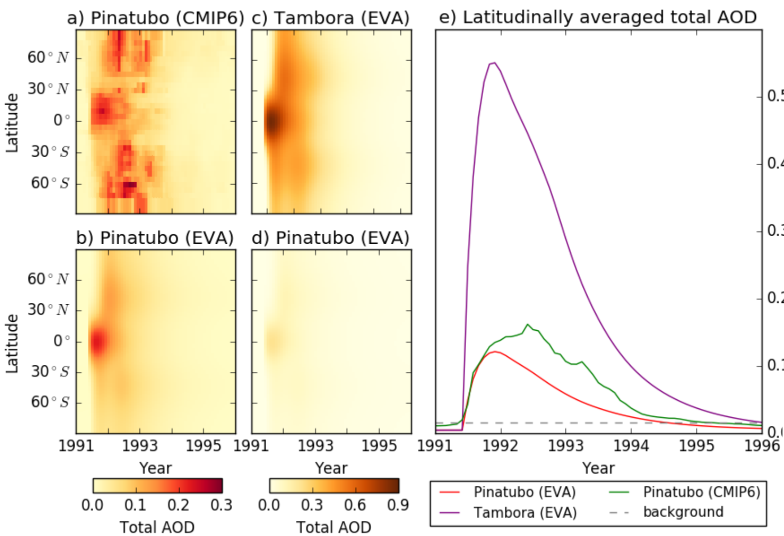
ILAMB BENCHMARK RESULTS: RELATIONSHIP



Tuesday, P15
Jiafu Mao

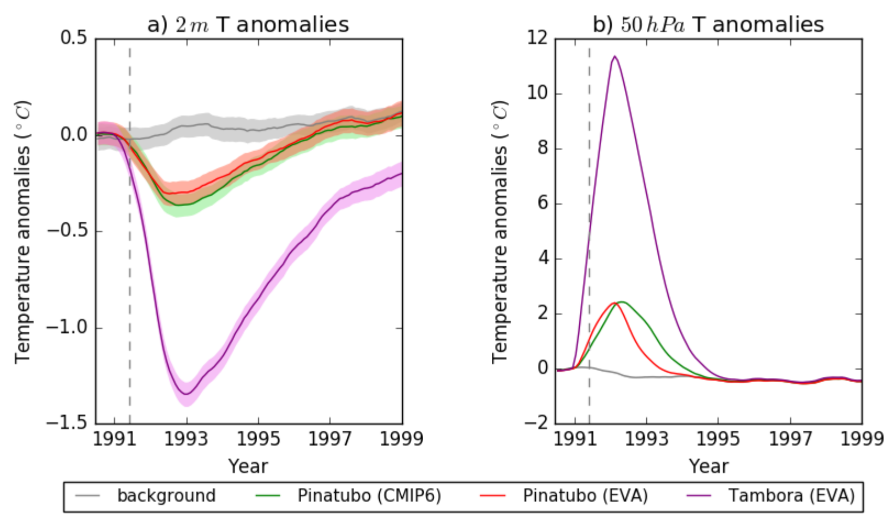
Climate response to the Pinatubo and Tambora eruptions in EC-Earth3.2

Idealised forcing



EC-Earth3.2

Climate response



European Climate Prediction system

VOLCADEC

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Eneko Martin[1], Roberto Bilbao[1], Martin Menegoz[1,2], Pablo Ortega[1]
1 : Barcelona Supercomputing Center (BSC)
2 : Institut des Géosciences de l'Environnement

Estimating the Uncertainty in Climate Projections

Sebastian Milinski, John C. Fyfe, Jochem Marotzke

- How can we quantify uncertainties in future projections?
- Can we reduce some of the uncertainties?

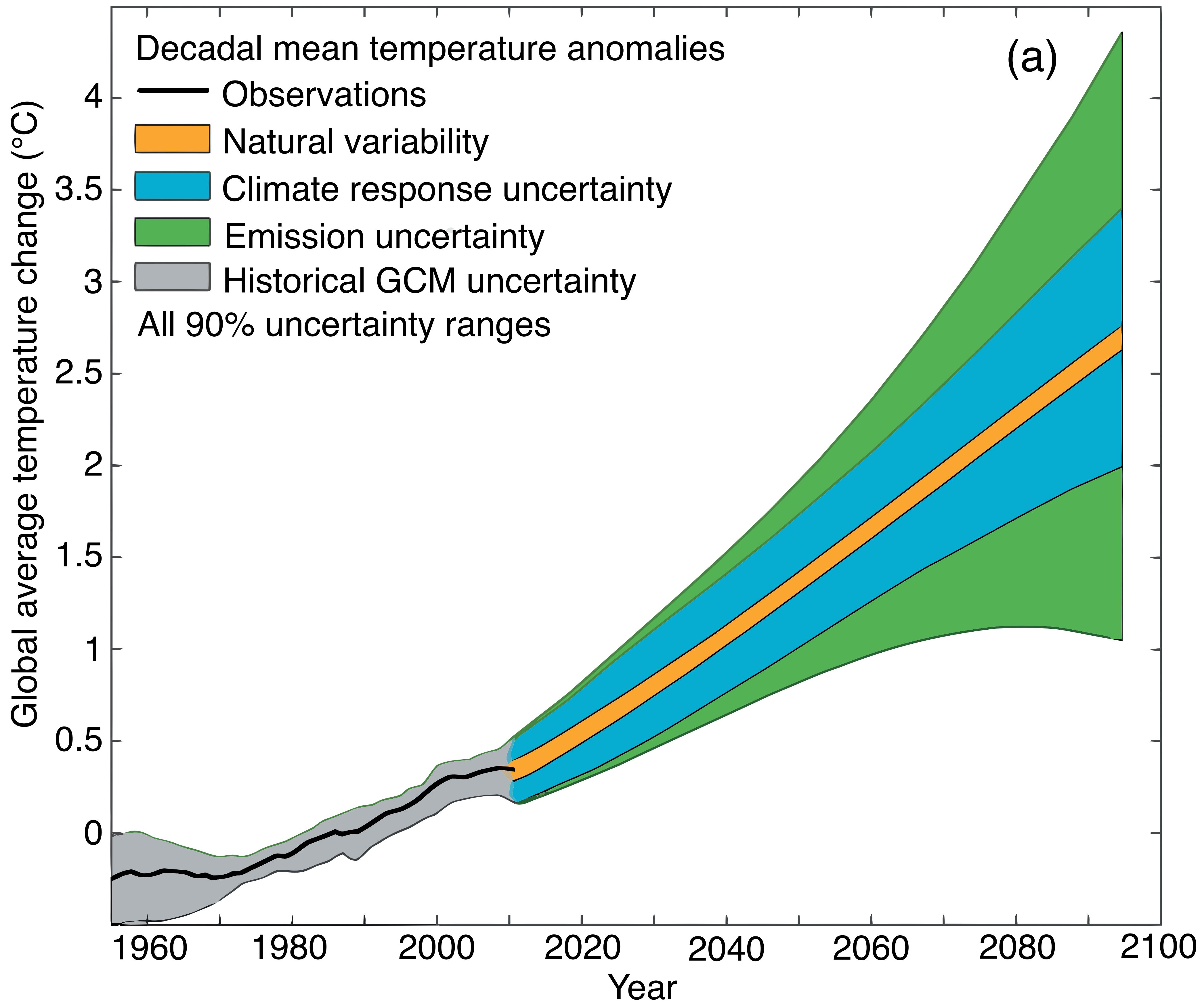
Our approach:

Internal variability

- Isolate internal variability in single-model large ensembles

Response uncertainty

- Emulate forced response range for different ECS values



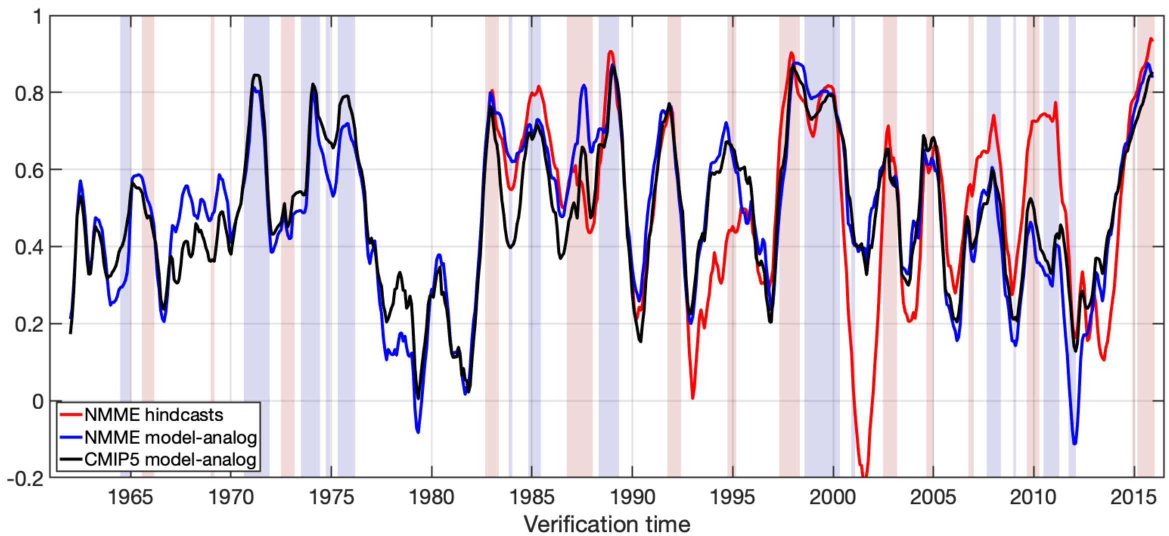
IPCC AR5, FAQ 1.1, Figure 1a

CMIP5/CMIP6 model-analog seasonal forecast skill: a metric for model evaluation of ENSO dynamics

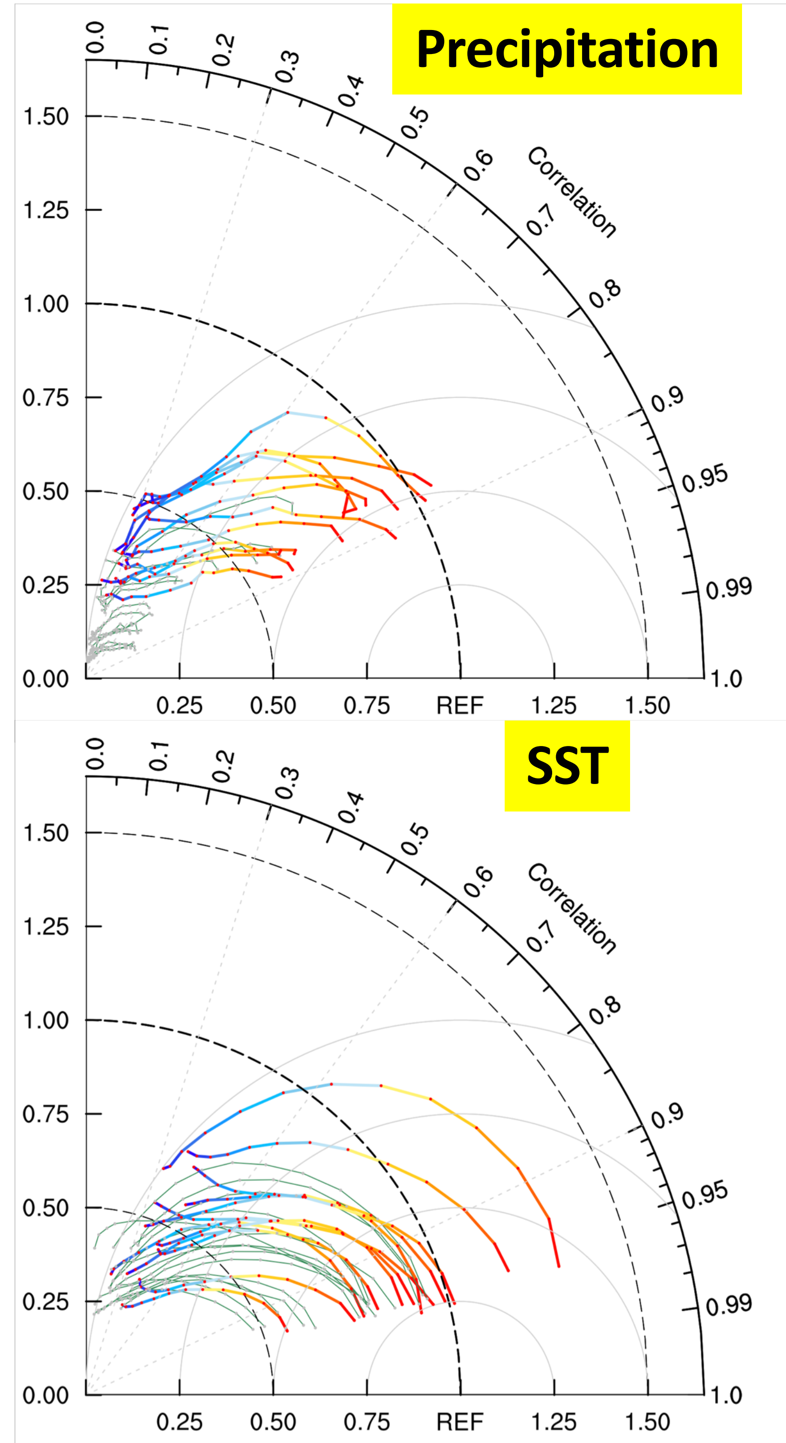
Turn every model into a forecast model

Find analog ensembles within long model simulations to determine both perfect model and real-world skill of tropical SST, SSH, & precipitation forecasts for leads of 1-12 months.

Tropical Pacific SST Month 6 Skill, 1961-2015



Niño3.4 Months 1-12 Skill, 1961-2015



Ding et al (2019) GRL

Earth System Research Laboratory
Physical Sciences Division

CIRES

Poster: 3_P18

Uncertainty in Earth System Models: Benchmarks for Ocean Model Performance and Validation

O.Ogunro[1], S. M. Elliott[2], N. Collier[1], O. Wingenter[3], C. Deal[4], W. Fu[5], F. M. Hoffman[1]

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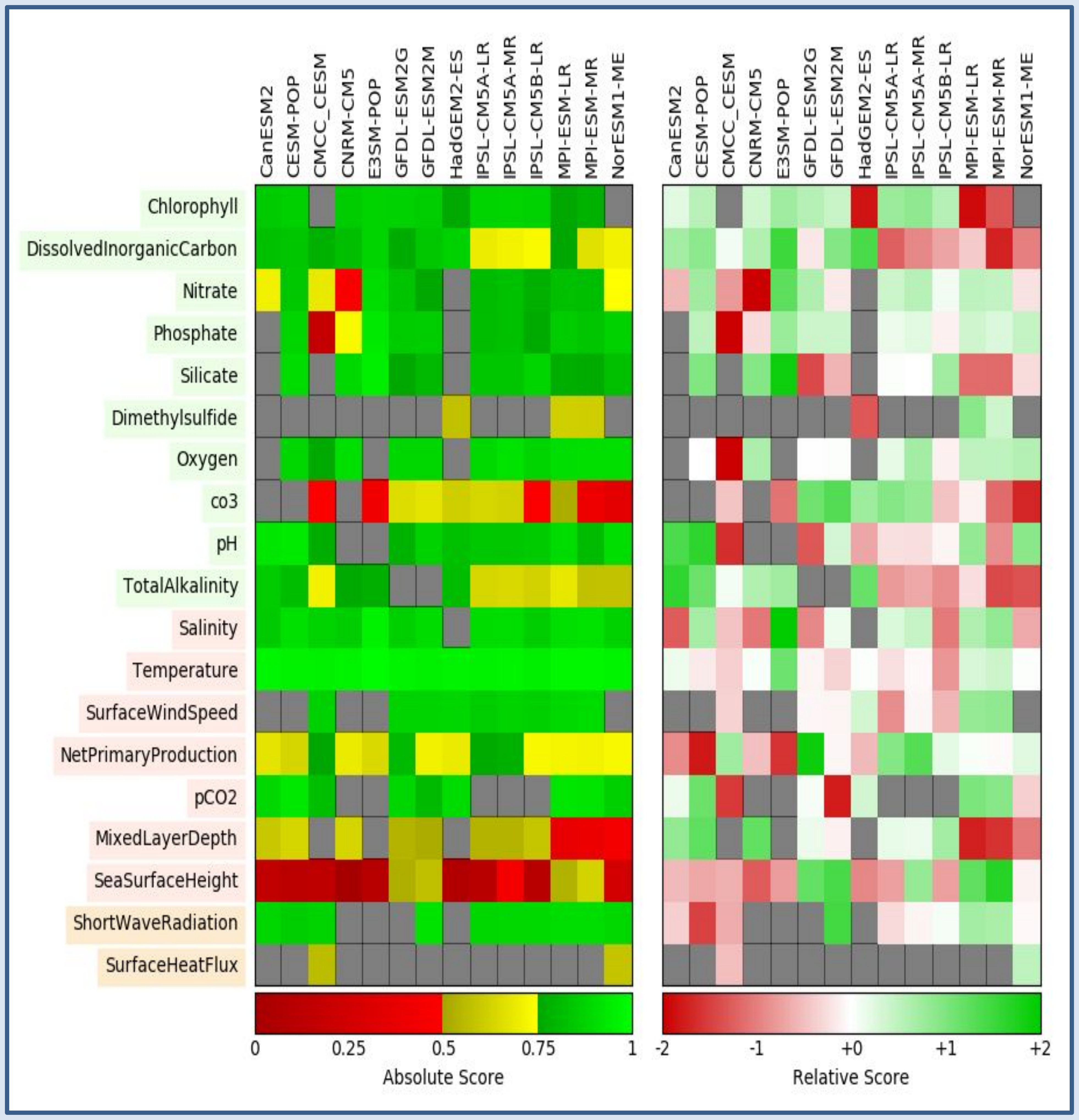
MOTIVATION

- About one quarter of anthropogenic CO_2 emissions end up in the ocean.
- Life in the ocean increases the efficiency of marine environments to take up more CO_2 and reduces the rise in atmospheric concentrations.
- Challenges with appropriate representation of physical and biological processes in Earth System Models (ESMs) undermines the effort to quantify seasonal to multi-decadal variability in ocean uptake of atmospheric CO_2 .

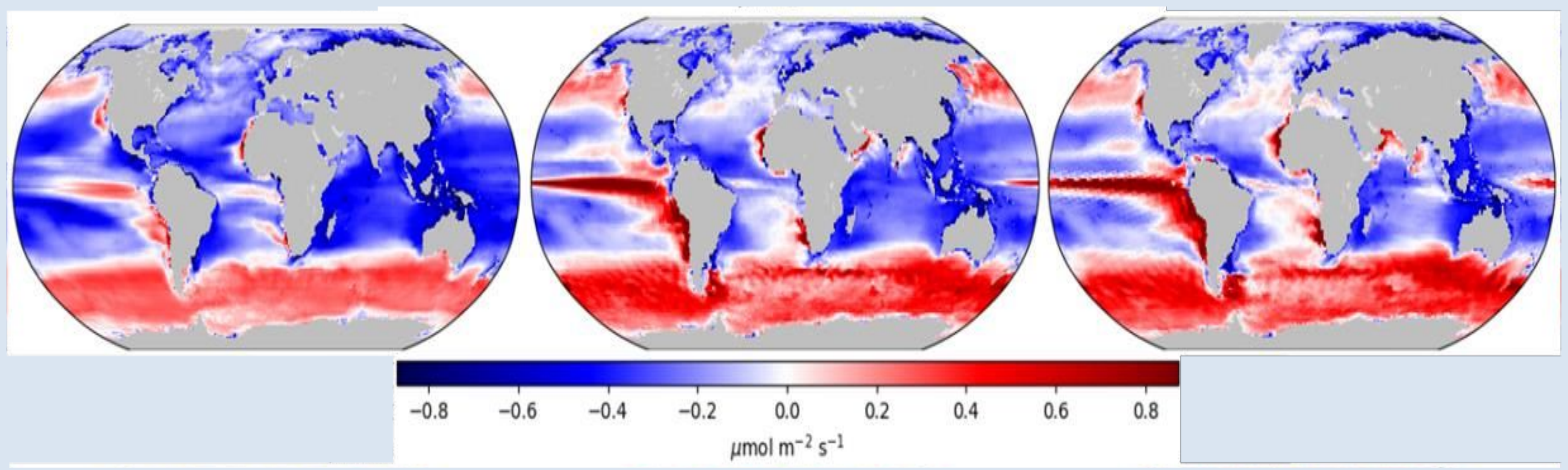
Internationational Ocean Model Benchmarking (IOMB)



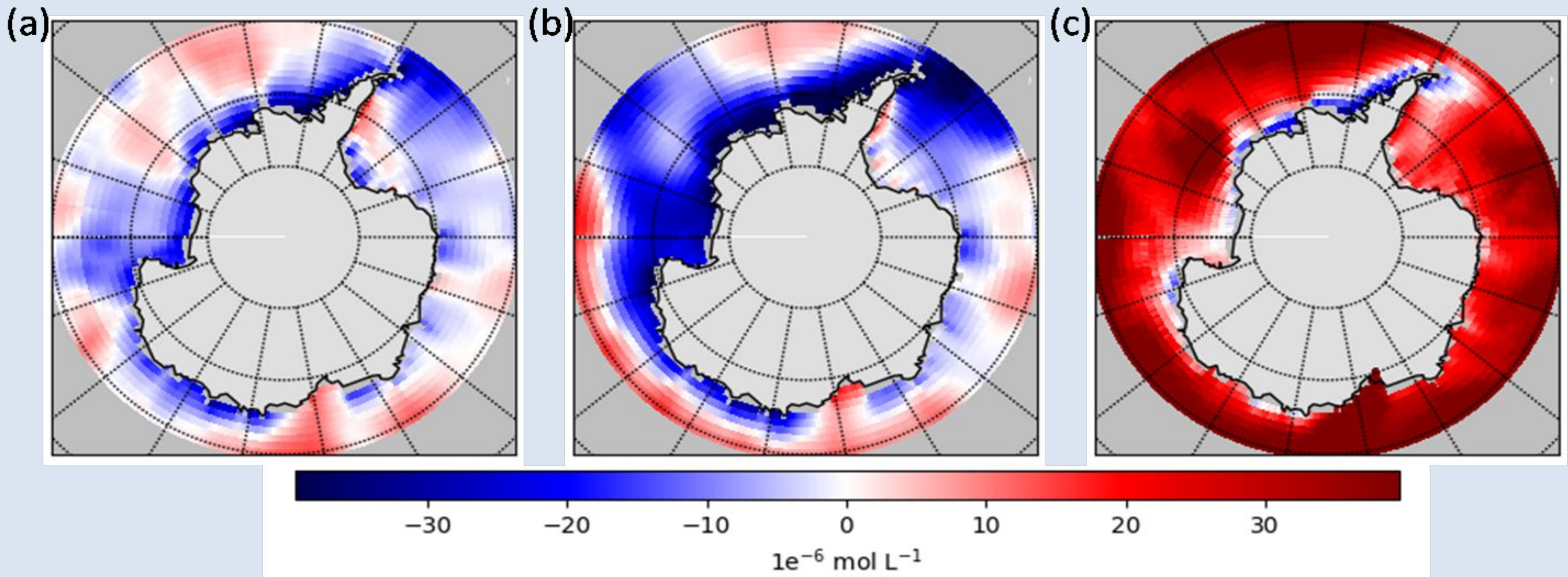
Benchmarking overview for some variables in DOE (E3SM and CESM) and some CMIP5 ESMs

Unique features of IOMB

- Collection of datasets formatted for easy model evaluation
  - https://www.ilamb.org/IOMB-Data/DATA/
- Using high quality observation datasets (global, regional, point, ship tracks) to benchmark ESMs
- Developing observation based metrics to evaluate model performance
- Scores model performance across a wide range of independent benchmark data



Net primary Production : Temporal integrated mean bias (a) Model A (b) Model B (c) Model C



Silicate (SO) concentrations : Temporal integrated mean bias (a) Model A (b) Model B (c) Model C

Take Home Messages

•IOMB is being employed to analyze outputs from ocean models contributing results to CMIP6

•A benchmarking tool for marine biogeochemical results is indispensable as we continue to improve ESM process representations and understand the dynamics of carbon cycle feedbacks from the ocean.

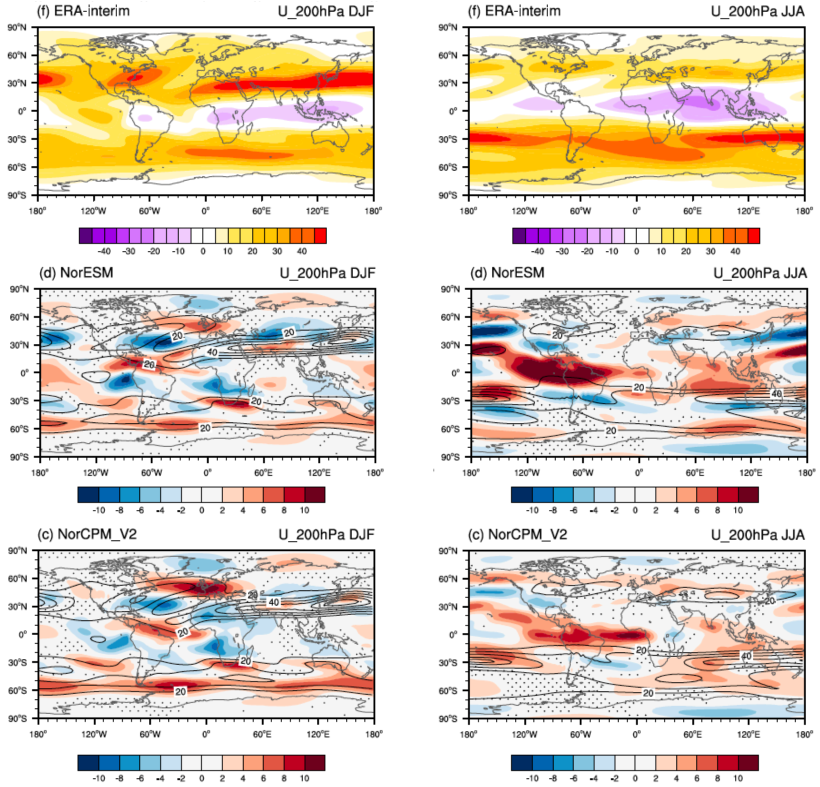
•This tool will help to improve our analysis/understanding of marine biogeochemical feedbacks in large suite of CMIP6 experiments

Tutorial: https://www.ilamb.org/doc/tutorial.html

Tuesday, Session 3: Poster P19

Investigating drivers of midlatitude circulation biases in climate hindcast ensembles

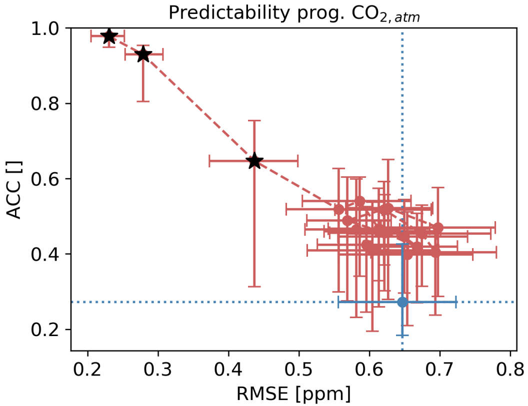
- Key features of midlatitude circulation in ERA-I generally not covered by the ensemble spread (30 members)
- Largest improvements over North Pacific with data assimilation
- Large SST biases persist (>25%); pattern suggests too weak atmosphere-ocean interactions
- Biases are asymmetric in time and space; largest in summer(winter) over North Pacific(North Atlantic)
- However, NAO variability is reasonably well reproduced; though with large spread

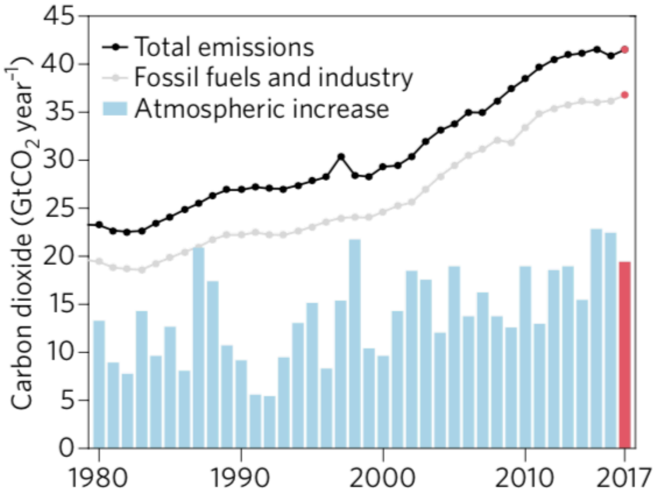


Stefan Sobolowski, Camille Li, Lilan Chen, Fumiaki Ogawa

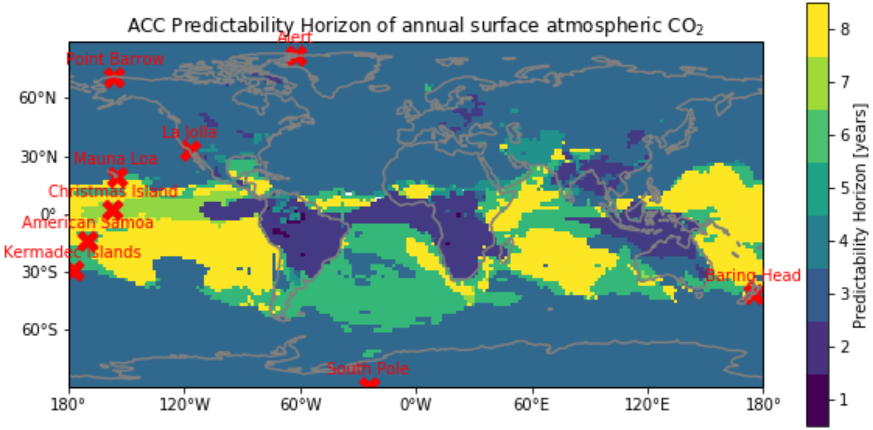
Predictability Horizons in the Global Carbon Cycle

Is atmospheric CO_2 concentration predictable?





Peters et al. 2017



Max-Planck-Institut für Meteorologie

Aaron Spring and Tatiana Ilyina, P21

International Max Planck Research School on Earth System Modelling

Development of a new climate model emulator based on CMIP6 multi-model ensemble

CRIEPI Central Research Institute of Electric Power Industry

Junichi Tsutsui, Central Research Institute of Electric Power Industry

TOUGOU Integrated Research Program for Advancing Climate Models

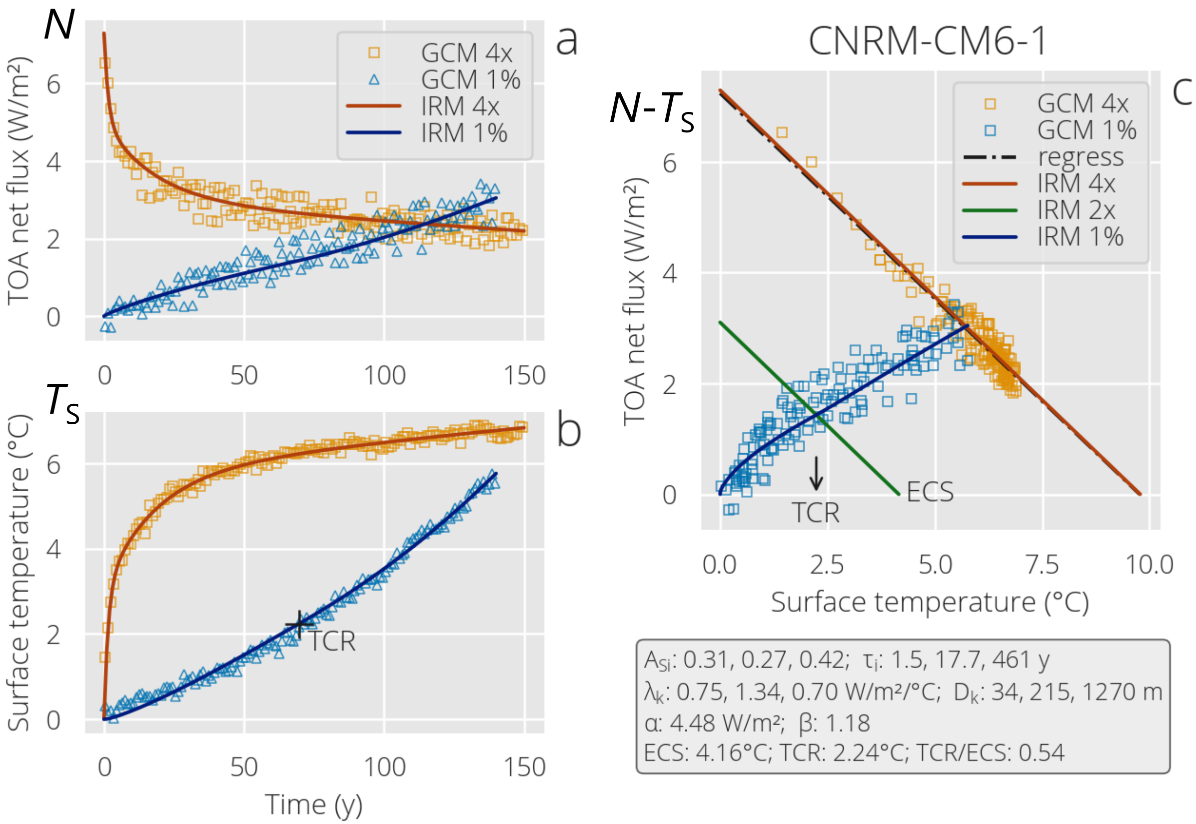


Fig. 1: Example of time series fitting for 4x and 1%/y CO_2 experiments in DECK and N-T_S relation

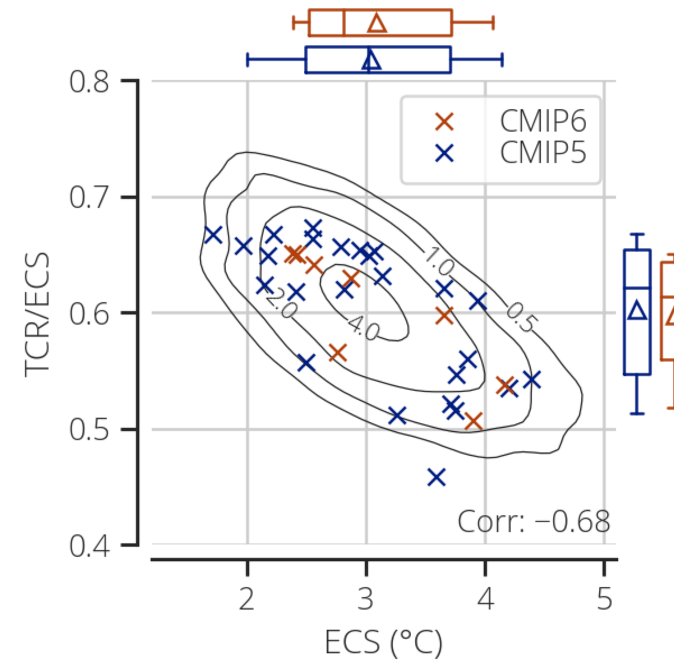


Fig. 2: Equilibrium climate sensitivity (ECS) vs transient climate response (TCR) relative to ECS of multi-model ensemble (MME)

Motivation: To build a climate model emulator reflecting MME for mitigation scenario studies

Method: Curve fitting to DECK time series to estimate forcing-response parameters

Results: The new method provides an improved alternative to the conventional regression (Fig. 1) and a sound basis for probabilistic assessment of the temperature response (Fig. 2)

Benchmarking the simulated global carbon cycle of CMIP6 ESMs using atmospheric CO_2 flask measurements

poster session 3 P23

Samuel Quesada-Ruiz (ECMWF), Philippe Ricaud (CNRM), Séférian, R., (CNRM), David Saint-Martin, (CNRM), Bertrand Decharme, (CNRM), Jerry Tjiputra, (Bergen University), Jörg Schwinger (Bergen University), Tatiana Ilyina (MPI), Thomas Raddatz, (MPI), Tomohiro Hajima (JAMSTEC), Victor Brovkin, (MPI), Vivek Arora (CCCma)

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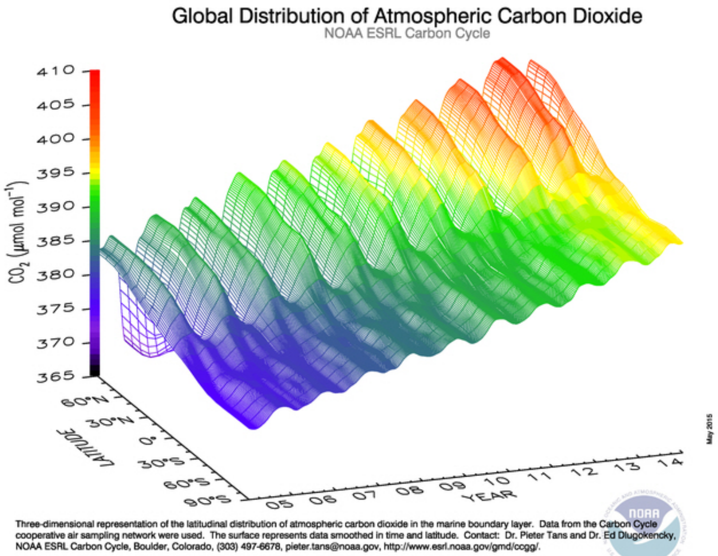

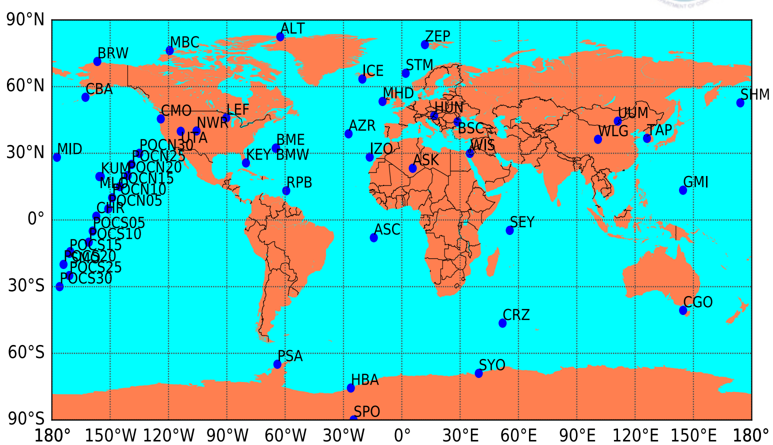

52 available flask stations with at least 10 years of continuous CO_2 measurements

Assessing model results against flask measurements:

- How CMIP6 emission-driven ESMs compare to CMIP5 ESMs ?
- What can be learnt from those simulations in terms of long-term sensitivity ?

CMIP5 CMIP6