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.
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

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.
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**

**Objective**

- 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 ($r = 0.92$).

**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 NPDF Scheme (PDF/2017/002075).
Reducing uncertainty in near-term European climate projections

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

\[ w_i = \frac{\frac{d_i^2}{\sigma_i^2}}{1 + \sum_{j \neq i}^{M} \frac{s_{ij}^2}{\sigma_j^2}} \]

MED JJA temperature (°C) change (1995-2014)

Distribution of weights: CMIP5 & CMIP6
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

**Initial Conditions Inconsistency**

**Systematic Error**

**Forecast Error**

**Poster: 3_P05**
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)
NCAR’s Climate Model Assessment Tool
John Fasullo

Model Simulation
e.g. CESM1.x

Observations

CERES, GPCP, ERA5
26 Variables

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

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

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

Global Mean Surface Temperature

Model Performance Summary: Mean Pattern Correlation: Sequential
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

**Anthropogenic Carbon Uptake, North Atlantic**

**Winter $pCO_2^{\text{sea-anomaly}}$, multi-model (MM) mean**

-1900 to 2000

**Winter $pCO_2^{\text{sea-anomaly}}$, MM standard-deviation**

-1900 to 2000

**$C_{\text{ant}^*}$-fraction > 1000m, multi-model mean**

-1997-2007

**$C_{\text{ant}^*}$-fraction > 1000m, MM standard-deviation**

-1997-2007

- Model spread relates to the modeled “carbon pump” efficiency

*R=0.8
R=0.89
R=0.9
R=0.97
Benchmarking CMIP Terrestrial Carbon Cycle and Biogeochemistry Models with the ILAMB Package (Session 3, P09)

Forrest M. Hoffman¹², Nathan Collier¹, Mingquan Mu³, Gretchen Keppel-Aleks⁴, David M. Lawrence⁵, Charles D. Koven⁶, Min Xu¹, Cheng-En Yang²¹, Jiafu Mao¹, William W. Riley⁶, James T. Randerson⁷

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

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

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

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

2. Evaluation of the land processes

- 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

- All models well-capture the decreasing trend of snow cover extent which has been underestimated in coupled simulations. (e.g., CMIP5)
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!
Can we beat climate model democracy in ensemble projections?

Ruth Lorenz, Lukas Brunner and Reto Knutti

Increases weight if distance to observations is small

Decreases weight if model is similar to others

\[ W_i = e^{-\frac{D^2}{\sigma_D^2}} \left( 1 + \sum_{j \neq i} e^{-\frac{S_j^2}{\sigma_S^2}} \right) \]
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

Jiafu Mao1,*, Xiaoying Shi1, Daniel M. Ricciuto1, Forrest M. Hoffman2, Peter Thornton1, and Min Xu2

1Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN, USA
2Computer 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

VOLCADEC

European Climate Prediction system

Eeneko Martin¹, Roberto Bilbao¹, Martin Menegoz¹ ², Pablo Ortega¹
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

Ding et al (2019) GRL

Niño3.4 Months 1-12 Skill, 1961-2015

Poster: 3_P18
Uncertainty in Earth System Models: Benchmarks for Ocean Model Performance and Validation

O. Ogunro¹, S. M. Elliott², N. Collier¹, O. Wingenter³, C. Deal⁴, W. Fu⁵, F. M. Hoffman¹
¹CCSI, Oak Ridge National Laboratory, ²COSIM, Los Alamos National Laboratory, ³New Mexico Tech, ⁴IARC, University of Alaska, ⁵UC Irvine

MOTIVATION

● About one quarter of anthropogenic CO₂ emissions end up in the ocean.
● Life in the ocean increases the efficiency of marine environments to take up more CO₂ 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 CO₂.

International Ocean Model Benchmarking (IOMB)

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

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
Predictability Horizons in the Global Carbon Cycle

Is atmospheric CO$_2$ concentration predictable?

Peters et al. 2017

Aaron Spring and Tatiana Ilyina, P21
Development of a new climate model emulator based on CMIP6 multi-model ensemble
Junichi Tsutsui, Central Research Institute of Electric Power Industry

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)

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?

52 available flask stations with at least 10 years of continuous CO$_2$ measurements