

Updates on WGSIP Extremes, Ocean Prediction and Temperature Trends Projects

WGSIP 24
27-29 March 2023
ECMWF, Reading UK

WGSIP Extremes project

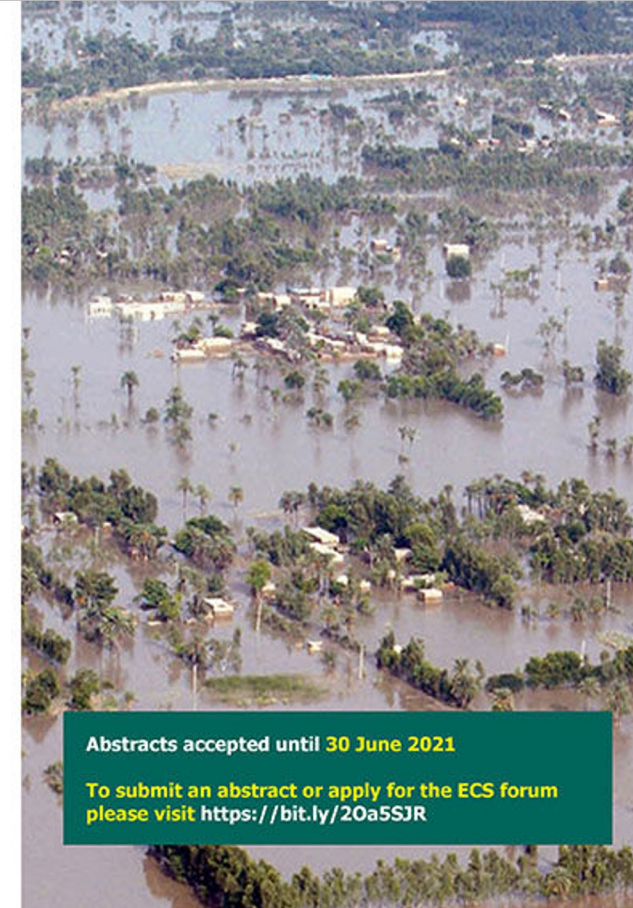
Objectives

- To **quantify the risks of extremes** for a range of phenomena, over different regions and timescales, **using large ensembles of initialised climate model simulations**
- **Assess current capability** of climate models **to predict extreme events**, highlighting opportunities for operational prediction
...by exploiting CHFP and S2S databases, other sources including ESGF and C3S

WCRP Workshop on Extremes in Climate Prediction Ensembles (ExCPEns)

- **Online from APEC Climate Center
25-27 October 2021**
- **Early Career Scientist training and
discussion forum
27-28 October 2021**

Sponsored by



Abstracts accepted until **30 June 2021**

To submit an abstract or apply for the ECS forum
please visit <https://bit.ly/2Oa5SJR>

Extremes Workshop follow up

S2S Newsletter

No. 18

Dec 2021

Meeting report in S2S Newsletter

WCRP Workshop on Extremes in Climate Prediction Ensembles
Bill Merryfield^a, June-Yi Lee^b, and Sangwon Moon^c
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^bResearch Center for Climate Sciences, Pusan National University, Busan, South Korea
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Weather and climate extremes have enormous impacts on society and are becoming more severe and frequent as the world warms. Associated risks of heat waves/dry spells, droughts/floods, wind and other extremes are continually evolving in response to climate variations superimposed on forced climate changes. By providing many realizations of climate-system evolution from observational to decadal and longer-term prediction ensembles offer a powerful tool to better quantify these risks, delineate possibilities for unprecedented extremes, and understand the underlying physical mechanisms and attribution of such events.

The WCRP Workshop on Extremes in Climate Prediction Ensembles (ECPEs) was held 25-27 October 2021 to provide a focal point for current research aimed at applying subseasonal, seasonal, annual to decadal and longer-term prediction ensembles to improve the prediction and understanding of extreme weather and climate events.

Following a 1-year postponement due to the COVID-19 pandemic, ECPEs was hosted as a fully online workshop by the APCC Climate Center (APCC), Research Center for Climate Sciences at Pusan National University and Institute for Basic Science Center for Climate Physics (ICCP), with support from the Asia-Pacific Network (APN) for an Early Career Scientist (ECS) event held on 27-28 October in conjunction with the workshop. These events were co-organized by the WCRP Working Group on Subseasonal to Interdecadal Prediction (WSIP), WCRP Grand Challenge on Weather and Climate Extremes, and S2S, which was represented on the organizing committee by S2S co-chair Frédéric Vitart.

ECPEs featured 44 oral and 31 poster contributions representing every populated continent, organized into six sessions:

1. **Characterization of extremes in observations and climate prediction ensembles** examined aspects of extremes such as their spatiotemporal footprints, cataloging of particular classes of simulated and observed extremes, their characterization in climate prediction ensembles, combining information from decadal predictions and multi-decadal projections, and verification of forecasts of local heatwave indices.
2. **Physical mechanisms of extremes in observations and climate prediction ensembles** considered the origins and impacts of phenomena such as rare Antarctic sudden stratospheric

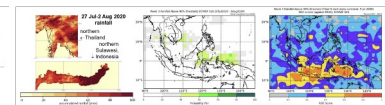


Fig. 1: Rainfall events exceeding the 90th percentile (hatched) during the week of 27 July to 2 August, 2020 (left); Week 3 outlook from the ECMWF S2S system showing elevated probabilities for rainfall above the 90th percentile during the same week (center); corresponding ROC scores from 2020-2023 reforecasts (right), indicating that advance warning supported by reforecast skill was provided for the extreme rainfall in Sulawesi but not Thailand. (Thea Turkington, ASMC/S2S-S2S Pilot Project.)

3. **Regional climate extreme information relevant to impacts, vulnerability and adaptation** considered aspects of particular socioeconomic relevance including codeveloped communication of probabilistic forecasts of extremes for sectoral applications, using observed large-scale climate variations as predictors to estimate future flood economic loss risk, and identification of impactful future changes in rainfall extremes in climate projection ensembles.

4. **Prediction and predictability of large-scale climate variability relevant to extreme events** focused on using climate prediction ensembles to examine how phenomena such as tropical cyclones and the Indian Summer Monsoon are influenced by climate variability patterns and warming trends on subseasonal to multi-decadal time scales, and to what degree skill in predicting large-scale patterns enables skillful prediction of local extremes.

5. **Prediction and predictability of specific extreme events (>10 day)** featured presentations on the prediction of heat waves, hydrological and hydrometeorological extremes, tropical cyclones, monsoon low pressure systems, and lightning by means of S2S and other subseasonal ensemble prediction systems (e.g. Figure 1), including applications of machine learning for post-processing to enhance skill.

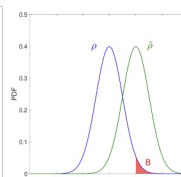


Fig. 2: Schematic illustration of importance sampling of a tail (B) of the original ensemble probability distribution r , followed by weighted drawing of rejections in the tail in order to create a new distribution \tilde{r} providing a much larger sample of rare events. From: Rogues, F., Mouton, L., & Bouvier, F. Comparison of extreme heat waves in climate models using a large deviation algorithm. Proc. Natl. Acad. Sci. USA 115, 26-29 (2018).

6. **Quantifying current and future risks of climate extremes** focused on extracting information about current and future probabilities of weather and climate extremes, including unprecedented extremes, from climate prediction and projection ensembles and high-resolution simulations. Innovative methods applied include the UNEDM approach whereby large seasonal and decadal prediction ensembles are used as a "multiplier" of the single observed record of climate variability, and rare event algorithms that enhance sample sizes in the tails of distributions (Figure 2).

The ECS event immediately followed the ECPEs workshop, and consisted of a discussion and networking forum for ECS from APN member developing countries, followed by a series of ECS training lecture and discussion sessions open to all 58 ECS registrants. The networking forum centered on breakout sessions matching ECS small groups with experienced scientists. Two questions that

were discussed by all of the groups and some responses from the ECS were:

- **What are the most important scientific challenges for predicting weather and climate extremes, and how can we tackle them?**
 - Some challenges are posed by modeling limitations such as limited resolution and imperfect parameterizations, leading to errors in representing teleconnection patterns and limitations for providing information at local scales.
 - Additional challenges result from the limited length of the modern observational record and the rareness of some extreme events leading to insufficient samples for forecast calibration and verification.
- Possible solutions include application of machine learning to improve model parameterizations and correct model errors through post-processing, longer hindcast periods to increase the sample of rare events and better understand climate change impacts on predictability and skill; and downsampling of global model outputs to better represent small-scale processes and orographic effects contributing to extremes.

What are the difficulties faced by ECS in your countries, and what are some possible solutions?

- Among the barriers discussed were lack of state of the art computational facilities and difficulties with data accessibility in ECS home countries, lack of training opportunities for keeping up with rapidly changing technology and scientific developments and for scientific communication, and above all, limited opportunities for finding relevant employment after graduation.

WCRP and other international organizations could help by providing or connecting ECS to training courses covering scientific developments, basic climate dynamics and academic writing, and by providing fellowships or other ways facilitating postdoctoral employment for ECS from developing countries. The six lectures and accompanying question and discussion periods focused on detection, attribution

and prediction of weather and climate extremes, and on use and implications of the recently published Working Group 1 contribution to the IPCC Sixth Assessment Report:

- Detection of extreme events using Machine Learning (Soekyoung Kim, PACC)
- Extreme event attribution (Megan Kirchmeier-Young, ECC)
- Predictability of extreme events in S2S time scale (Frederic Vitart, ECMWF)
- How to use the AR6 WG1 Interactive Atlas for climate change studies (in-to-You, GIST)

and prediction of weather and climate extremes, and on use and implications of the recently published Working Group 1 contribution to the IPCC Sixth Assessment Report:

- Change of extremes assessed in AR6 WG1 Chapter 13 (Juebin Zhang, ECC)

Overall, ECPEs organizers and participants felt it was a successful event despite the limitations and challenges posed by remote participation and differing time zones, although the ECS event in particular could have been even more valuable had in-person participation been possible.

Summary article in APN Science Bulletin

Special issue in APJAS

<https://doi.org/10.30852/sb.2022.1977>

APN Science Bulletin
2022, Volume 12, Issue 1, 141-153, e-ISSN 2522-7971

Supporting regional and international cooperation in research on extremes in climate prediction and projection ensembles: Workshop summary



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Volume 59, issue 1, February 2023
9 articles in this issue

EDITORIAL

Extreme Weather and Climate Events: Dynamics, Predictability and Ensemble Simulations

Christian L. E. Franzke^{1,2} · June-Yi Lee^{1,2,3} · Terence O'Kane⁴ · William Merryfield⁵ · Xuebin Zhang⁶

Published online: 14 February 2023
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Microphysical Structures of an Extreme Rainfall Event Over the Coastline Metropolitan City of Guangdong, China. Observation Analysis and Parameterization Study
Original Article | Published: 12 August 2022 | Page 2 - 16

On the Pacific Decadal Oscillation Simulations in CMIP6 Models: A New Test-Bed from Climate Network Analysis
Original Article | Open Access | Published: 18 August 2022 | Page: 17 - 28

The East Asian Summer Monsoon Response to Global Warming in a High-Resolution Coupled Model: Mean and Extremes
Original Article | Open Access | Published: 23 August 2022 | Page: 29 - 45

Extreme, Strong Western Pacific Subtropical High in May 2021 Following a La Niña Event: Role of the Persistent Convergence Zone over the Indian Ocean
Original Article | Published: 17 October 2022 | Page: 47 - 58

Outbreak of a Tornado with Tropical Cyclone Yara (2021) Formed over the Bay of Bengal
Original Article | Published: 27 October 2022 | Page: 59 - 67

Sub-Seasonal Entrainment (SubSE) Model-based Assessment of the Prediction Skill of Recent Multi-Year South Korea Rainfalls
Original Article | Open Access | Published: 02 December 2022 | Page: 69 - 82

Challenges in Attributing the 2022 Australian Bushfires to Climate Change
Original Article | Published: 20 December 2022 | Page: 83 - 94

Exceptionally persistent Eurasian cold events and their attribution
Original Article | Open Access | Published: 13 January 2023 | Page: 95 - 111

Extreme ENSO events in Copernicus seasonal hindcasts

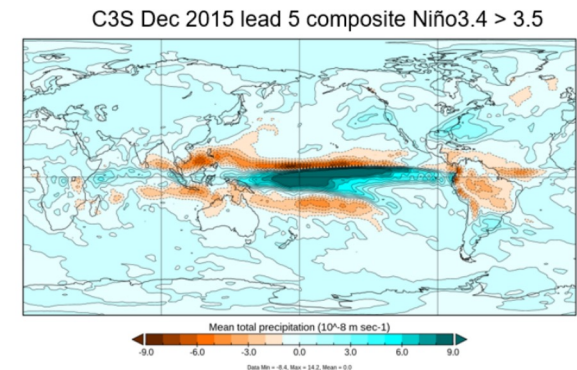
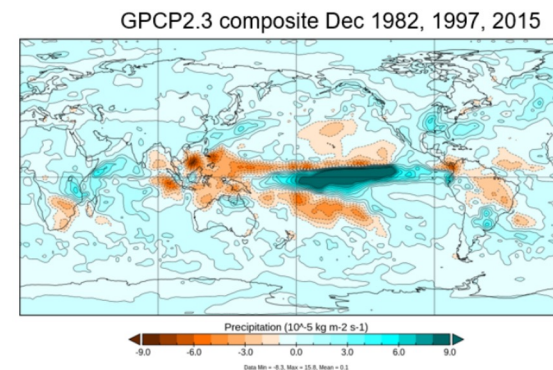
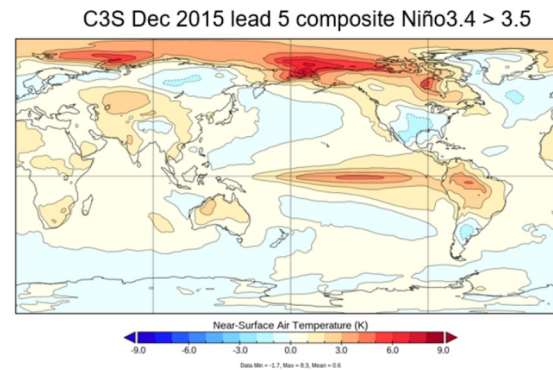
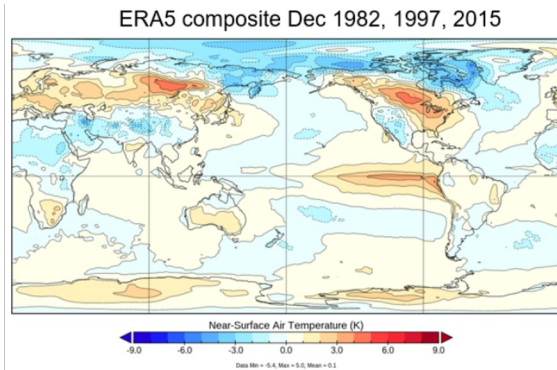
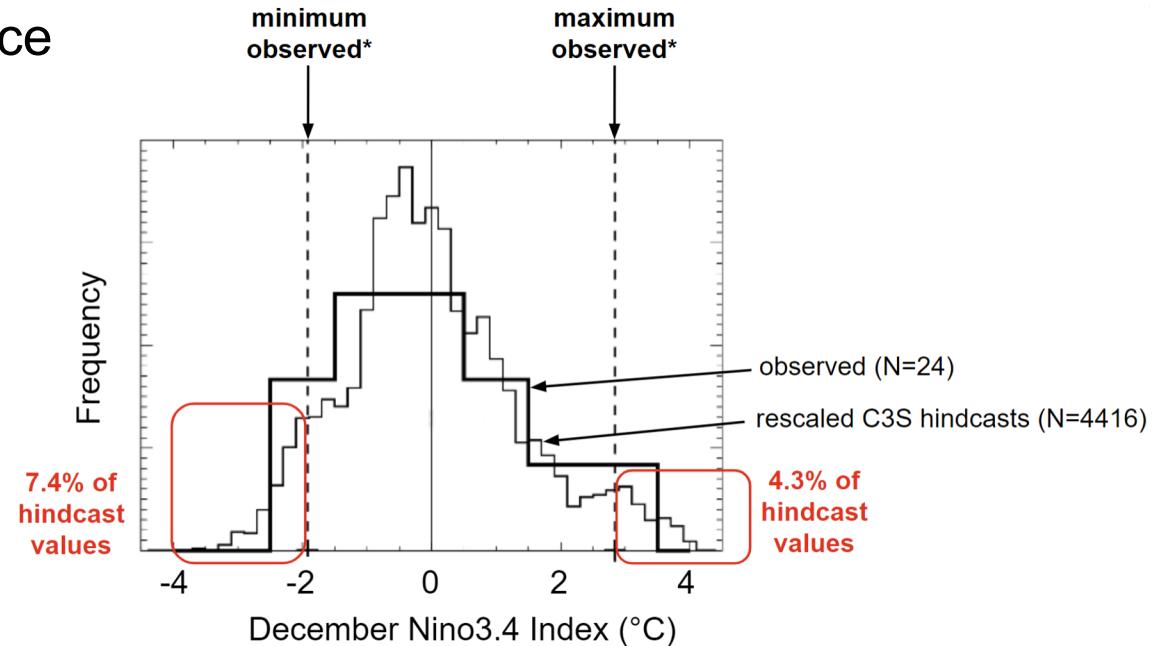
(Revised W. Merryfield & W.-S. Lee submission under review with APJAS)

- 184 realizations of 1993-2016 ENSO variability at 0-5 month lead time
- Bias correct Niño3.4 for mean and interannual variance
- Key results:

☐ Many of the 4416 simulated months at lead 5 exceed observed +/- Dec Niño3.4 extremes

☐ Suggests possibility of unprecedented ENSO extremes, e.g. Niño3.4 > 3.5 every ~100 years ↓

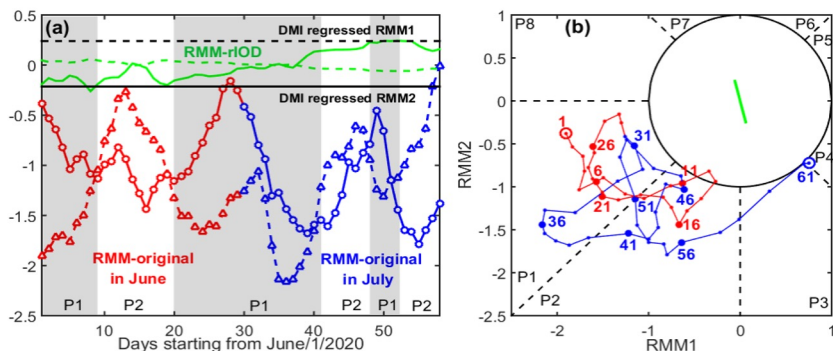
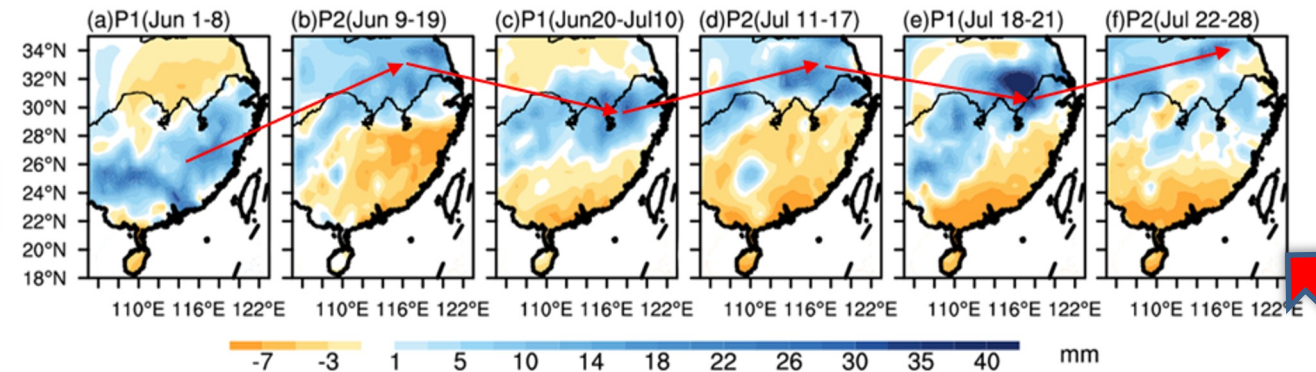
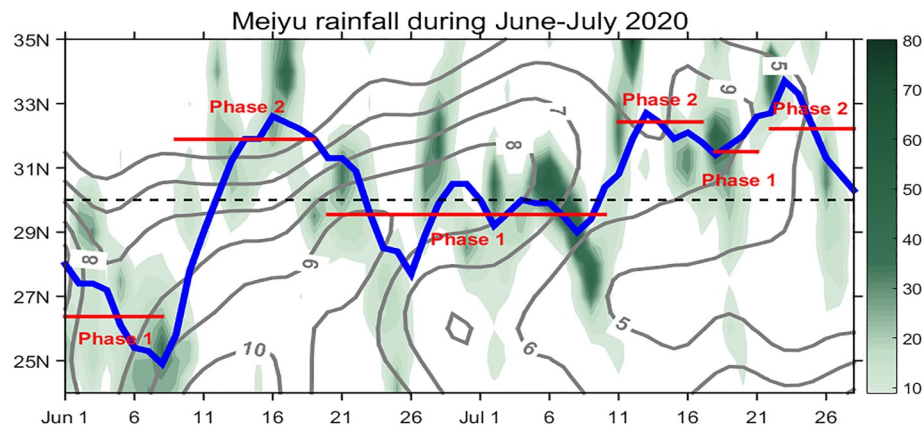
☐ ENSO amplitude biases vs model & lead time strongly correlated with cold tongue bias



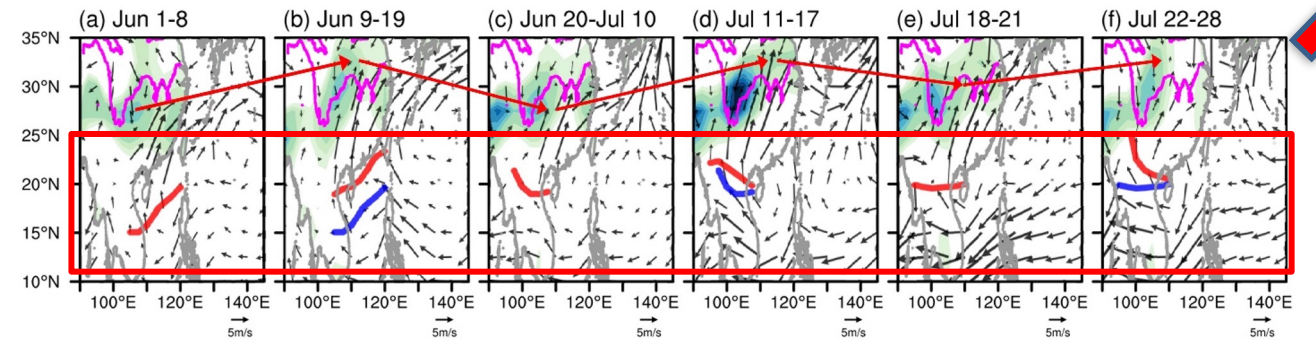
MJO Phase swings modulate the recurring latitudinal shifts of the 2020 extreme summer-monsoon rainfall around Yangtse

Wang, Y., H.-L. Ren*, et al. 2022: *Journal of Geophysical Research: Atmospheres*, **127**(6), <https://doi.org/10.1029/2021JD036011>

- The extreme rainfall episodes in June–July of 2020 manifest as recurring latitudinal shifts around Yangtse river;
- The north-south shifts of 2020 Meiyu rainfall shows a high correspondence with the recurring MJO Phase 1–2 swings;
- The MJO modulates the latitudinal shifts of Meiyu rainfall mainly through changing the westward extended ridge line of WNP anticyclone.



MJO phase variations between 1 and 2



WNP anticyclone ridges shift latitudinally

WGSIP Ocean Prediction project

Objectives

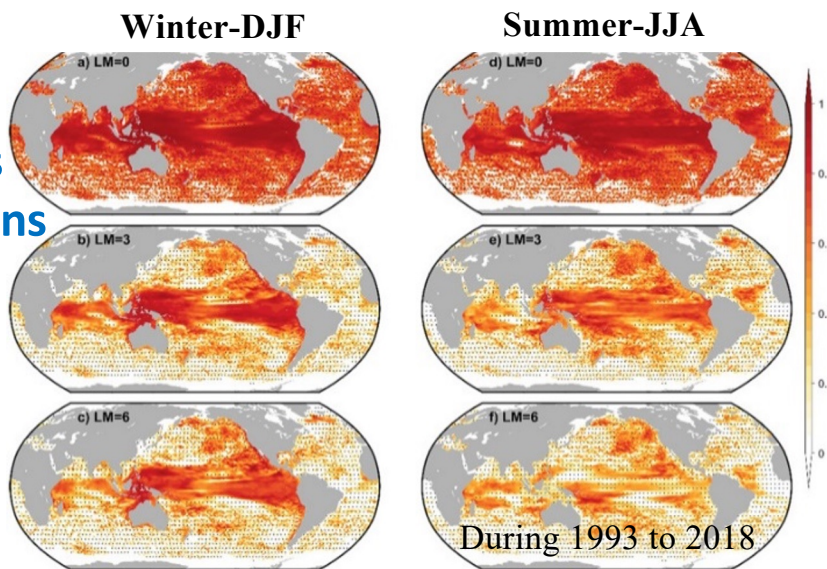
- Systematically **evaluate prediction capabilities for ocean variables besides SST** across time scales and for multiple climate prediction systems
- Assess **performance of individual prediction systems** in relation to their initialization, resolution, etc.
- Assess **multi-model performance gains**
- Assess **properties and suitability of different verification datasets**, utility of multi-product verification
- Assess **sources of predictability** and ability of models to represent them
- Facilitate useful **real-time forecasting of ocean properties** having societal impacts

Main focuses so far: sea surface height (SSH), mixed-layer depth (MLD)

Seasonal predictions of sea surface height in BCC-CSM1.1m and their modulation by tropical climate dominant modes

Wang, G.J., H.-L. Ren*, et al. 2023: Atmospheric Research, 281:106466. <https://doi.org/10.1016/j.atmosres.2022.106466>

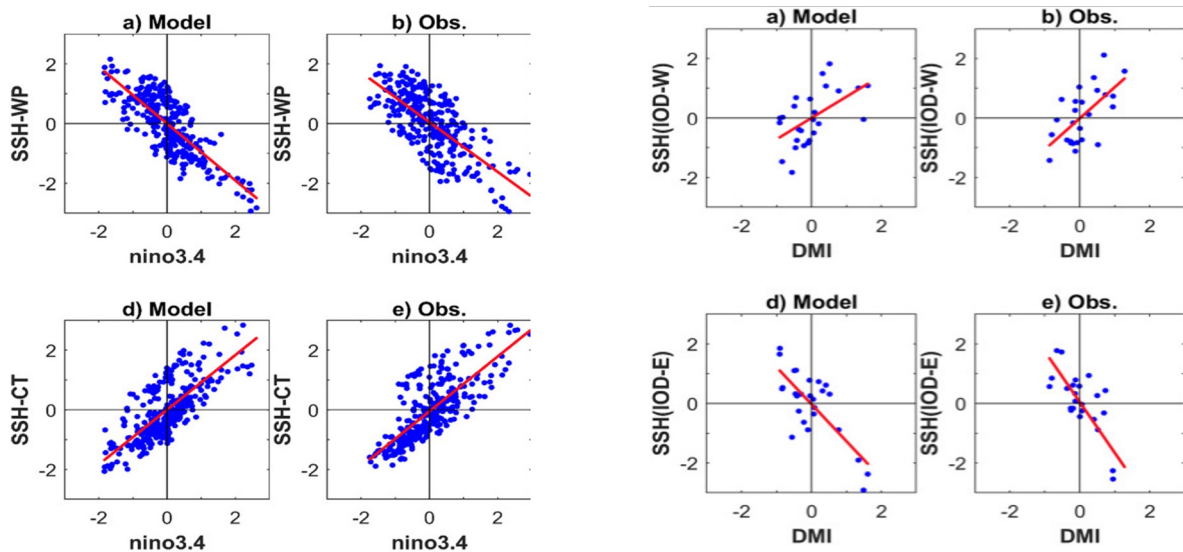
TCC scores distributions



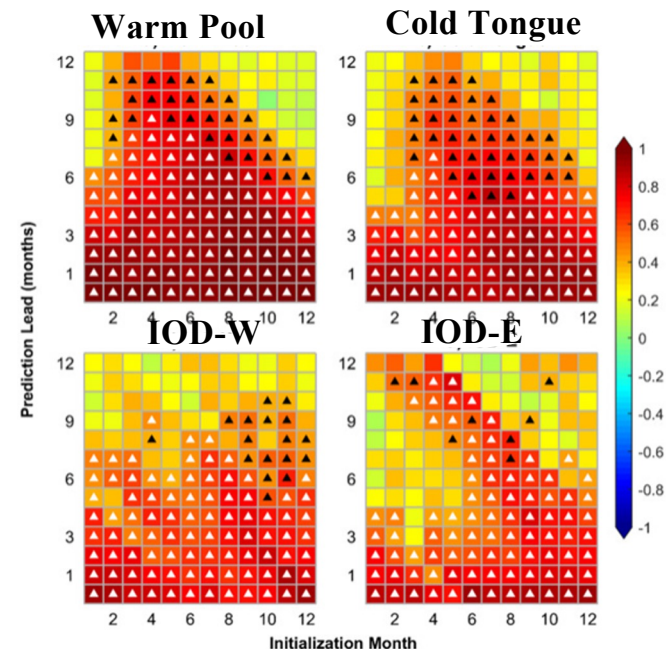
- Prediction skills of SSH in BCC-CSM1.1m are overall higher during boreal winter than summer.
- ENSO/IOD is the main source of predictability for SSH over tropical Pacific/Indian Ocean.

Warm Pool (WP):
Cold Tongue (CT):
western IOD (IOD-W) :
eastern IOD (IOD-E) :

Relationship between regional SSH variations and ENSO and IOD →



TCC scores as a function of initial month and prediction lead months →



Ocean prediction poster cluster at OSC23



WORLD CLIMATE
RESEARCH PROGRAMME
**OPEN SCIENCE
CONFERENCE**
23 - 27 OCT. 2023 | RWANDA
Advancing Climate Science
for a Sustainable Future

Poster Cluster 15: Ocean Predictability and Prediction on Subseasonal to Decadal Timescales



Convenors

William Merryfield, Environment and Climate Change Canada

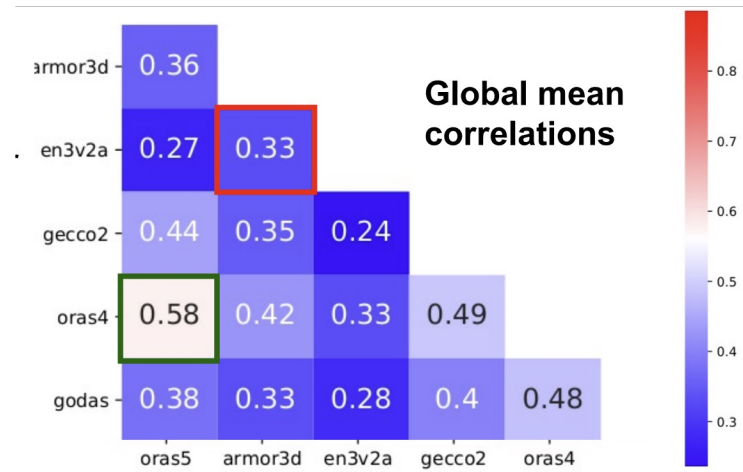
Charlotte Demott, Colorado State University (USA)

Kigali, Rwanda, 23-27 October 2023, in-person and online

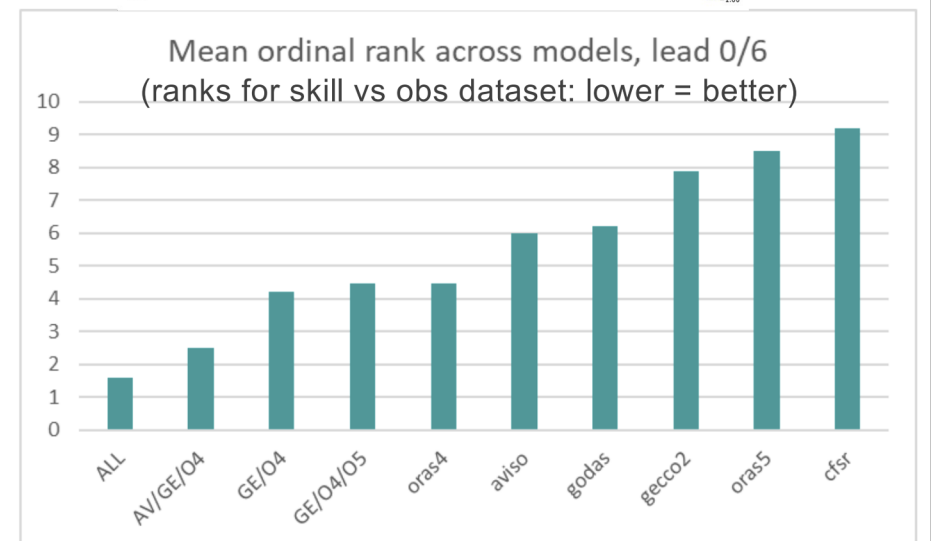
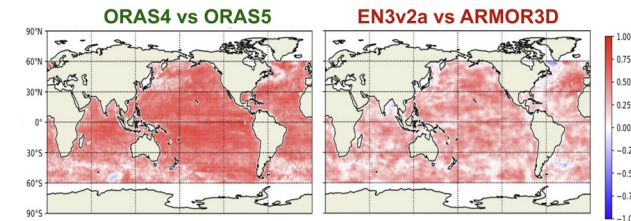
- 14 abstracts received, including W. Merryfield & W.-S. Lee, “Prospects for seasonal prediction of mixed-layer depth”

MLD prediction results & plans

- MLD is important for ecosystems, atmosphere-ocean interactions
- Intercompare multiple verification products (done) →
- Assess skill of 5 CHFP models & combinations thereof
- Assess utility of **multi-product verification**, as for SSH →
- Paper discussing skills, efficacy of verification datasets, potential utility of seasonal MLD predictions



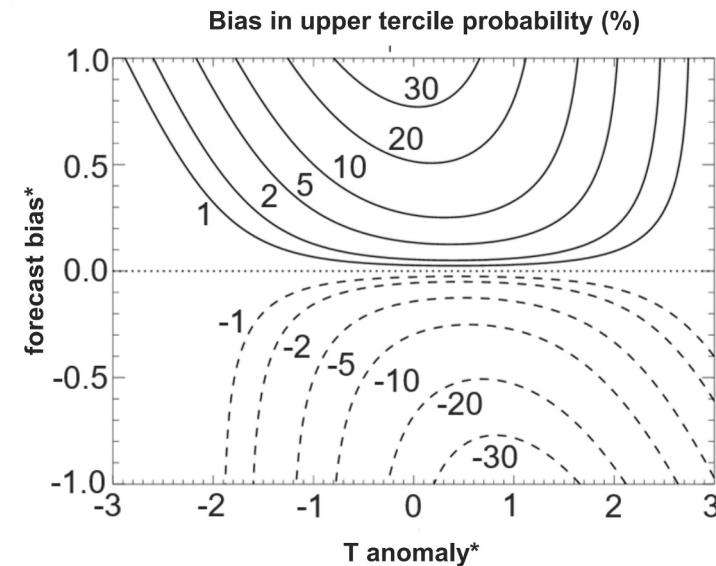
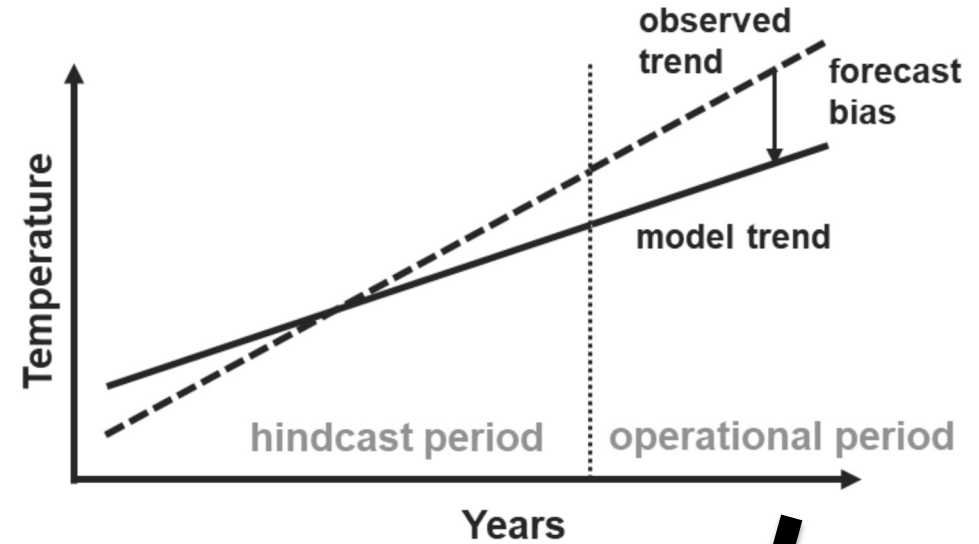
Anomaly correlations 1993-2010



WGSIP Temperature Trends project

Objectives

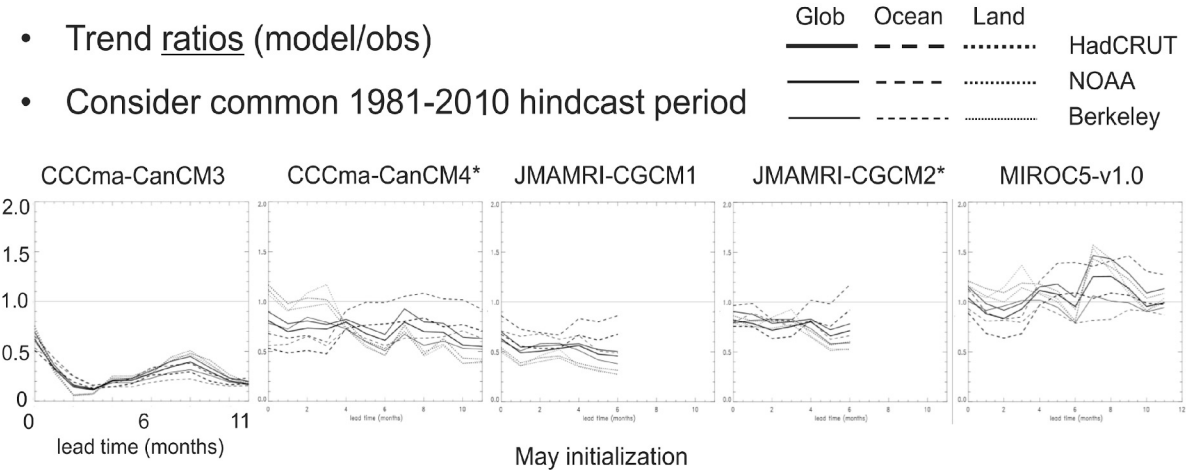
- Assess long-term global and regional **temperature trend errors** as a function of lead time across many seasonal prediction systems
- Assess extent to which temperature trend errors **impact temperature prediction skill**
- Relate trend errors to radiative forcings and initialization methodologies
- Develop a **synthesis** of previous & new results for the community



*in units of standard deviations of the forecast distribution

Results & community activity

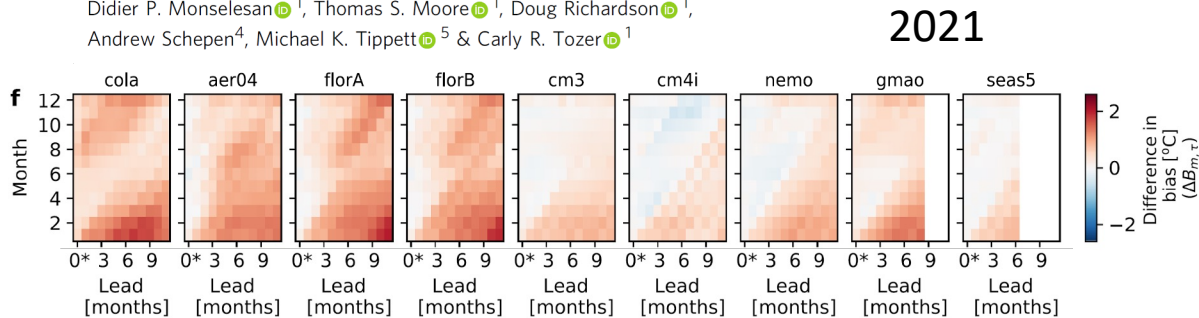
- Temperature trend errors ~20 models have been assessed →
- The issue of how such errors can bias forecasts & skill measures is gaining traction in the community, though not in a coordinated manner ↓



<https://doi.org/10.1038/s41467-021-23771-z> OPEN

Standard assessments of climate forecast skill can be misleading

James S. Risbey^{1,6}, Dougal T. Squire^{1,6}, Amanda S. Black¹, Timothy DelSole², Chiara Lepore³, Richard J. Matear¹, Didier P. Monselesan¹, Thomas S. Moore¹, Doug Richardson¹, Andrew Schepen⁴, Michael K. Tippett⁵ & Carly R. Tozer¹

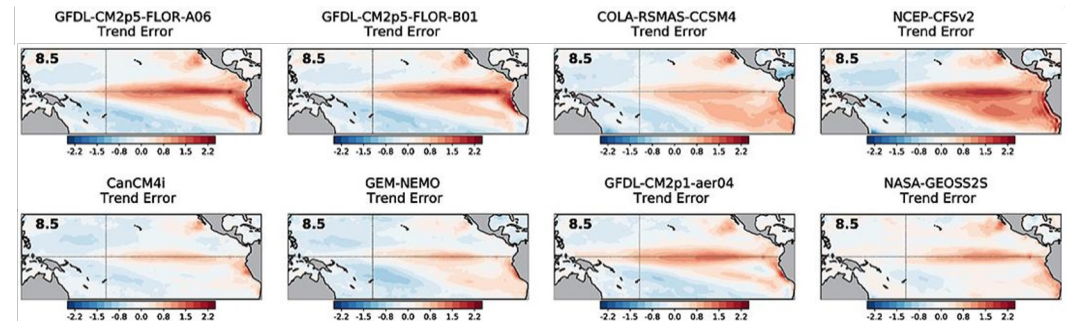


$\Delta(\text{Eq Nino3.4 ST bias}), (1999-2016)-(1982-1998)$

frontiers | Climate

Prediction Challenges From Errors in Tropical Pacific Sea Surface Temperature Trends

Michelle L. L'Heureux^{1*}, Michael K. Tippett² and Wanqiu Wang¹ 2022



SST trend error at 8.5 month lead, 1982-2014

For discussion

Ideas and suggestions for

- Further engagement with other groups
- Additional WGSIP-driven or coordinated activities
- Promoting new approaches for research in this area
- ...