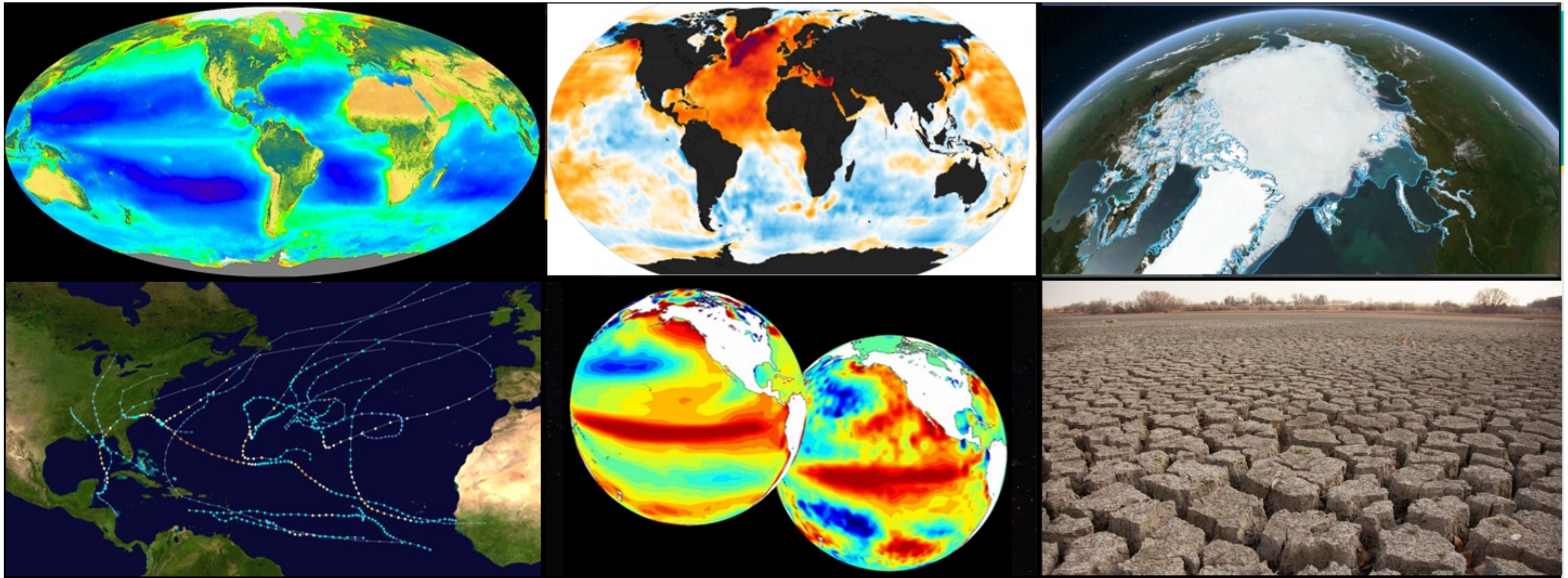


WGSIP Extremes Project

Bill Merryfield, Debbie Hudson

WGSIP 23

November 16, 2021 (online)

WORLD METEOROLOGICAL ORGANIZATION
United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission
International Science Council
WCRP
World Climate Research Programme

Objectives & Activity

- To quantify the risks of extremes for a range of phenomena, over different regions and timescales, using large ensembles of initialised climate model simulations
- Assessment of 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

<u>Activity in 2020-21</u>

- WCRP Workshop on Extremes in Climate Prediction Ensembles (ExCPEns) + ECS event
  > Formulated at WGSIP 21 in Moscow, delayed 1 year by pandemic
  > Co-chaired by June-Yi, session chaired by Hongli, presentations by Asmerom, Debbie, Leon, Bill
  > June-Yi to present debrief
- UNSEEN (using hindcasts to estimate unprecedented events) activity: Leon to present update

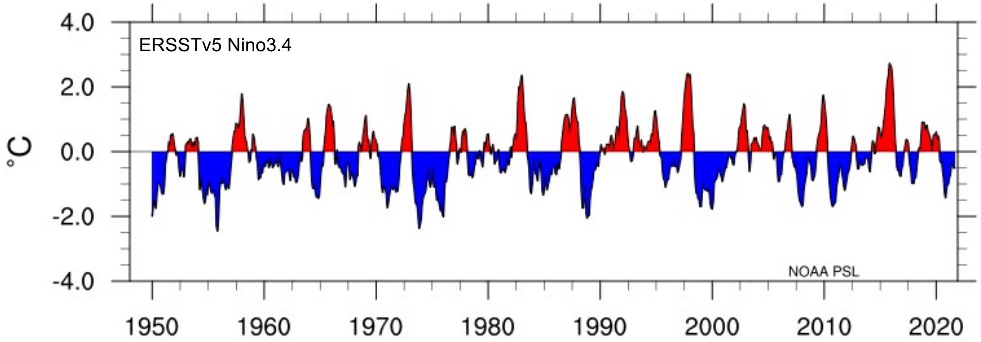
Extreme ENSO events in Copernicus seasonal hindcasts*

- Knowledge about potential ENSO extremes is limited by having only one realization of the modern observational record →

- Climate prediction ensembles potentially can greatly multiply the number of realizations if sufficiently realistic

- This motivates examining ENSO extremes in hindcasts of the Copernicus Climate Change Service (C3S) seasonal prediction ensemble, which currently has 184 ensemble members across 8 models

- We ask: **How frequently do El Niño/La Niña events stronger than any yet observed occur in the C3S hindcast ensemble?**



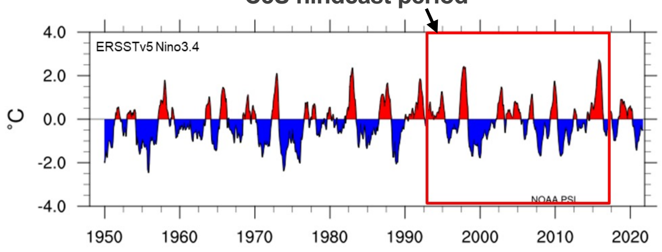
C3S seasonal hindcast contributing systems

Centre/Model	Country	Ensemble size
CMCC SPS3.5	Italy	40
DWD GCFS2.1	Germany	30
ECMWF SEAS5	EU	25
Météo-France System 8	France	25
Met Office GloSea5	UK	28
NCEP CFSv2	USA	16
ECCC CanCM4i	Canada	10
ECCC GEM-NEMO	Canada	10
TOTAL		**184**

*Presented at WCRP Workshop on Extremes in Climate Prediction Ensembles, Oct 25-27 2021

Analysis

- Consider 6-month hindcasts initialized each month during the C3S hindcast period **1993-2016**

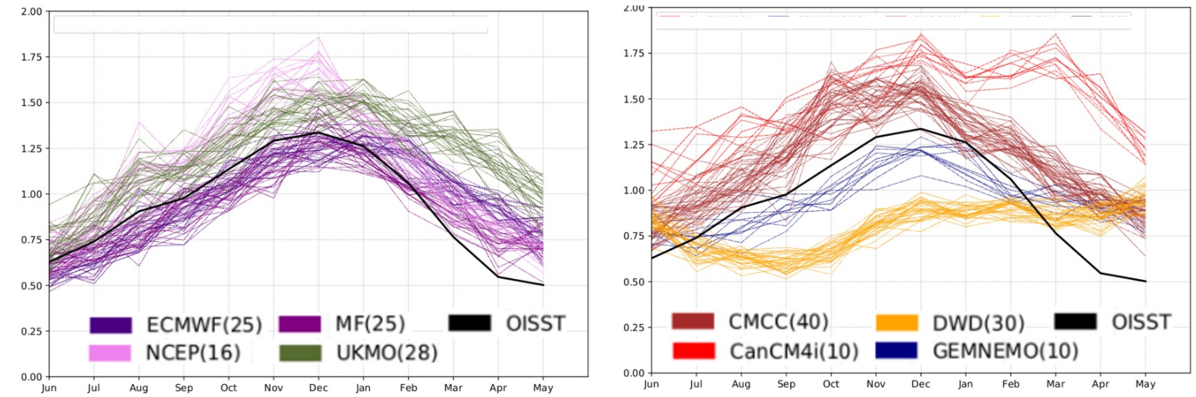


- Focus on hindcast values of the Niño3.4 index in **December** (month of peak Niño3.4 variance) **initialized in July** (**5-month lead** → least constrained by initial conditions)

- Use monthly NOAA OISSTv2 as observational reference

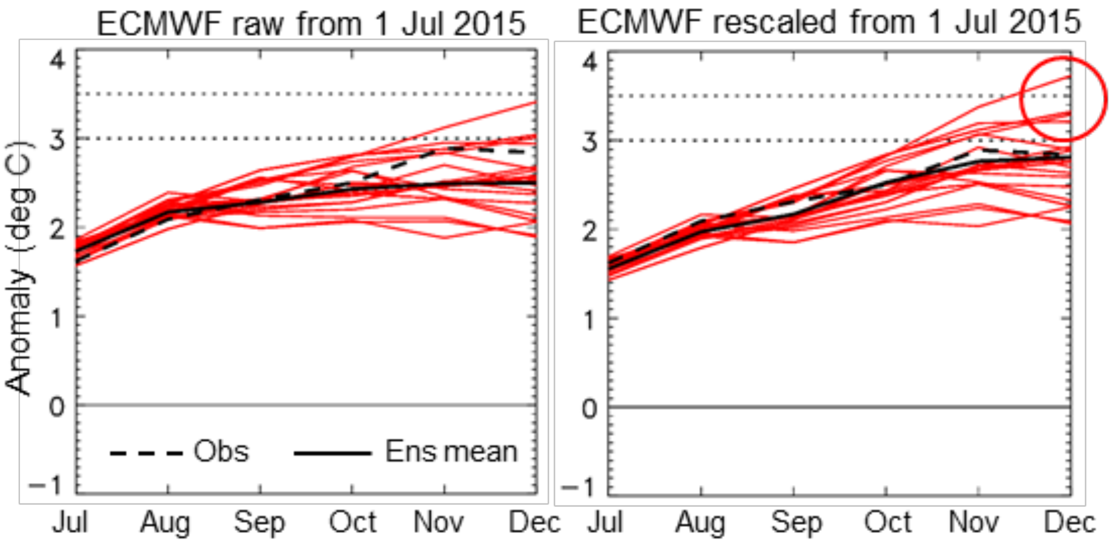
- In addition to correcting the mean bias, ENSO amplitude biases are removed by rescaling Niño3.4 variance for each month and lead time to match observed variance for that month:

Standard deviations of 1993-2016 lead-5 Niño3.4 hindcast anomalies in each calendar month for ensemble members of C3S seasonal prediction models (colours), and observed values to which each model is rescaled (black)



Example of variance rescaling

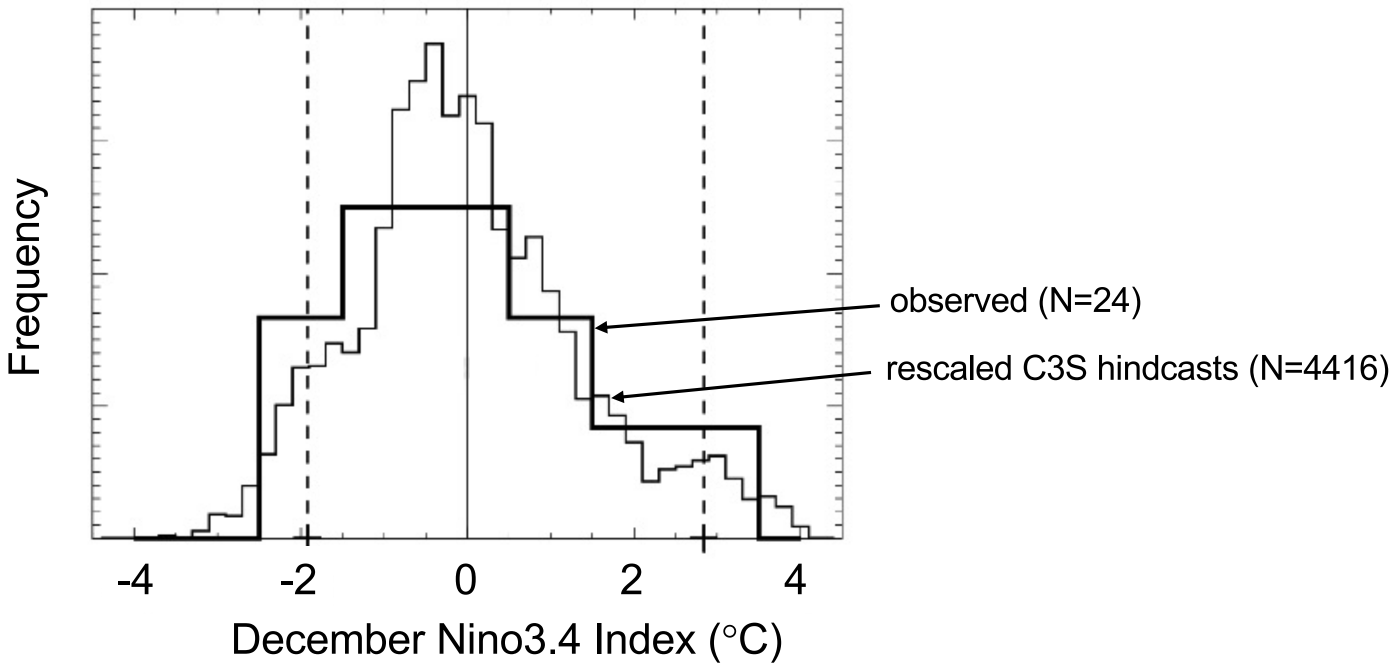
- These plots show the ECMWF Niño3.4 plume initialized 1 July 2015, based on raw values (left) and rescaled to match observed variances (right)



→ *Even with variance rescaling, December Nino3.4 anomalies exceed 3 or even 3.5 degrees for several ensemble members*

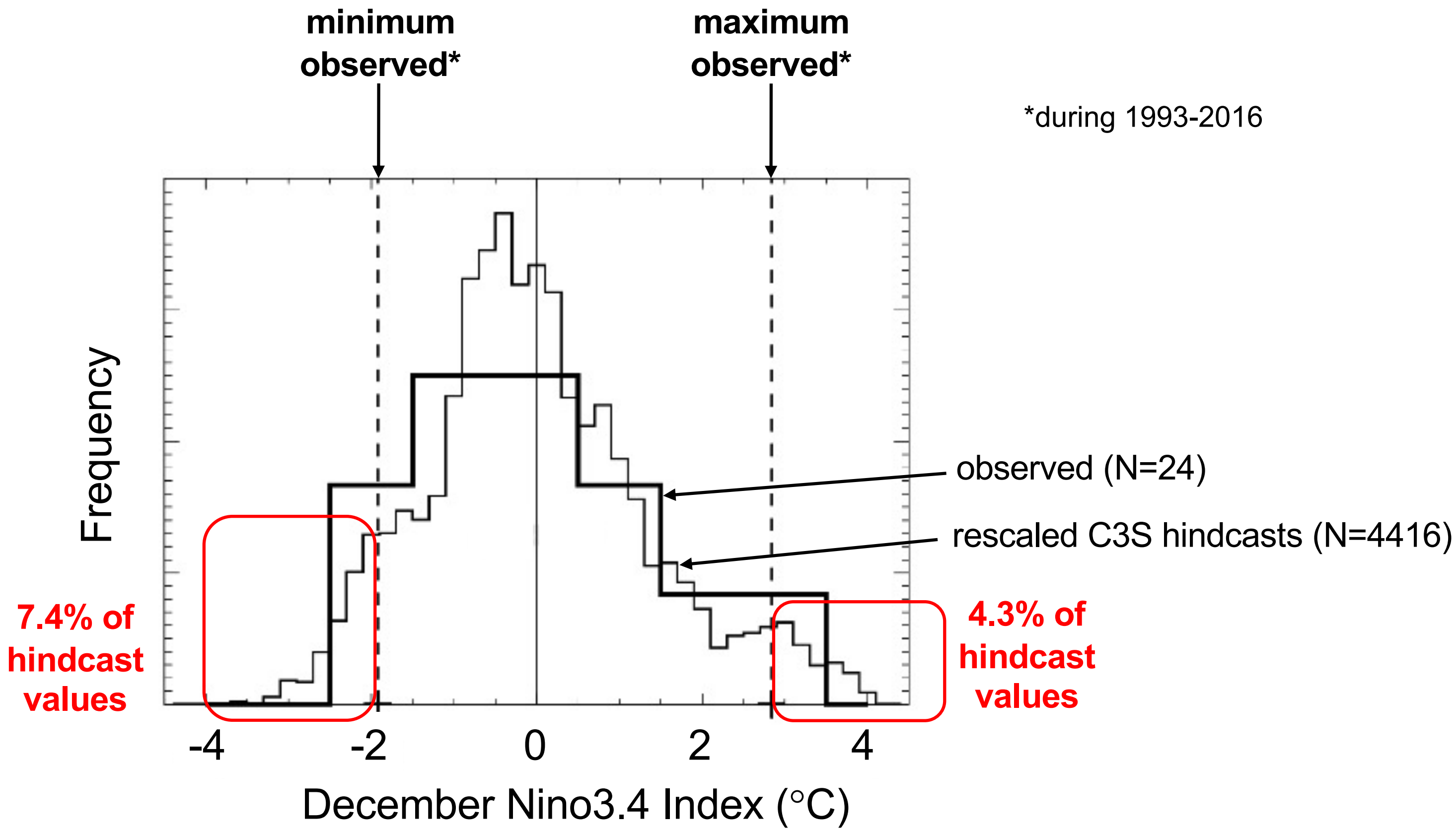
C3S vs observed Nino3.4 distributions

5-month lead, 1993-2016



→ distribution is realistic according to two-sample Cramér–von Mises test (also for individual models, other lead times after rescaling)

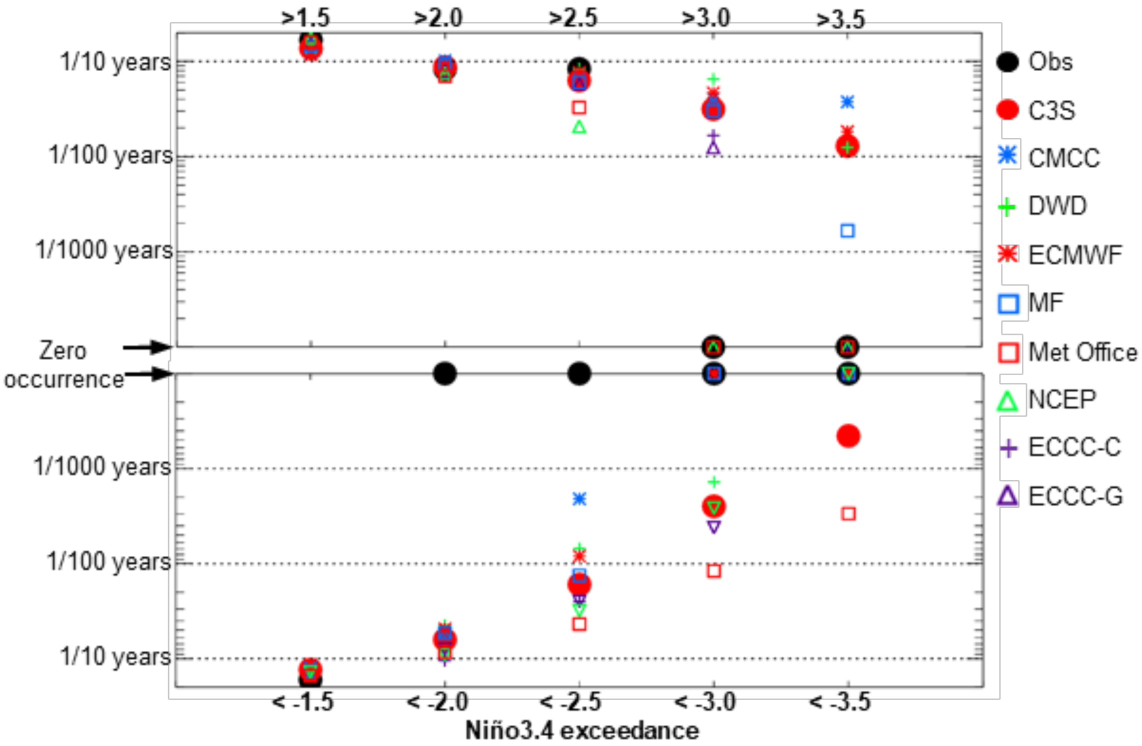
What does this imply about ENSO extremes?



Implied frequencies of extremes

El Niño extremes

La Niña extremes

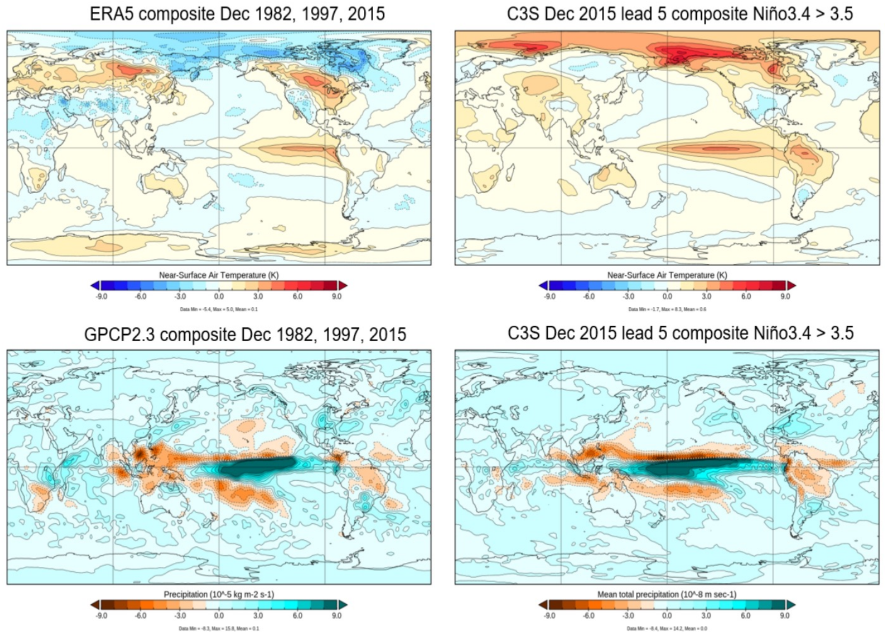


→ C3S distribution implies **Dec Niño3.4 > 3.0 every ≈30 years** **Dec Niño3.4 < -2.5 every ≈60 years** in 1993-2016

Dec Niño3.4 > 3.5 every ≈80 years **Dec Niño3.4 < -3.0 every ≈400 years**

Conclusions

- Results suggest ENSO extremes exceeding those in observed record are realizable, leading to unprecedented impacts →

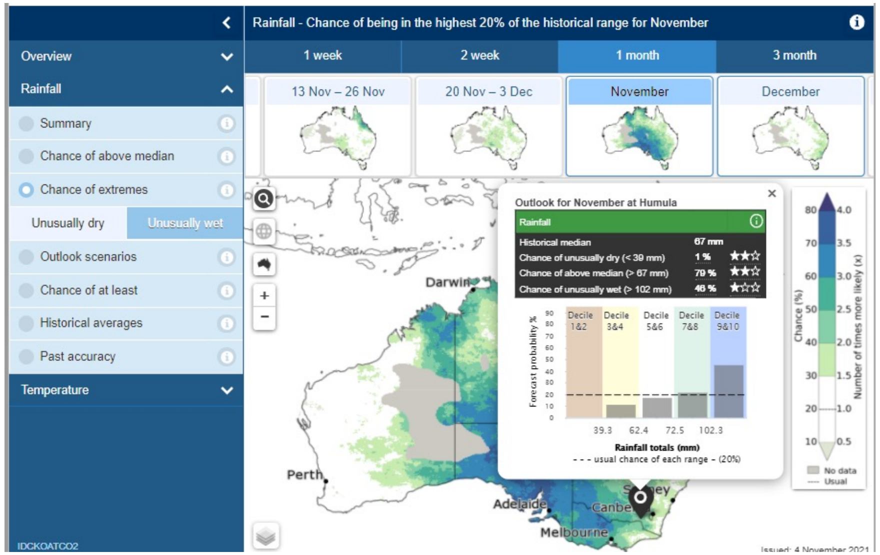


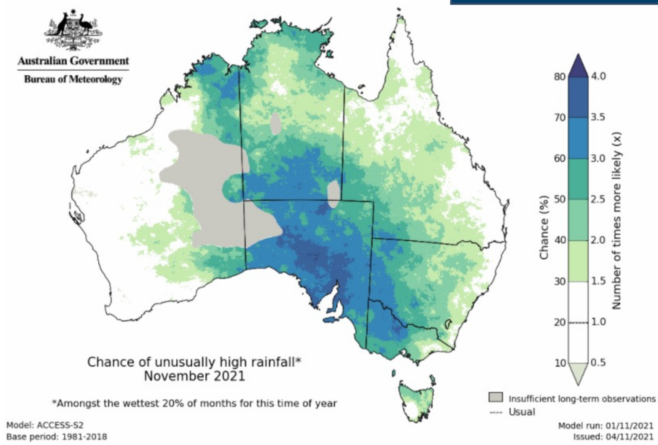
Left: observational composites of Dec temperature anomalies from ERA5 (top) and precipitation anomalies from GPCP2.3 (bottom), during large El Niños of 1982-83, 1997-98 and 2015-16 Right: composites for 9 C3S lead 5 ensemble members having rescaled Dec 2015 Niño3.4 >3.5.

- Caveats include:
  - potential model biases other than for amplitude not accounted for
  - implied occurrence frequencies differ somewhat between models
  - results are specific to 5-month lead realizations of 1993-2016 period
  - future ENSO behavior and impacts likely to be influenced by changing climate

Predicting extremes (BoM)

- A new service (since 1 Nov)
- 'Chance of extreme' outlook maps for upcoming weeks, months, seasons
- For rainfall, maximum/minimum temperature
- Drill down to specific locations
- http://www.bom.gov.au/climate/outlooks





Other extremes research (since WGSIP22):

- **Influence of the Madden-Julian Oscillation on Multiweek Prediction of Australian Rainfall Extremes using the ACCESS-S1 Prediction System**. Marshall et al. 2021. JSHESS., https://doi.org/10.1071/ES21001
- **Tropical forcing of Australian extreme low minimum temperatures in September 2019.** Lim et al. 2021. Climate Dynamics, [https://doi.org/10.1007/s00382-021-05661-8.](https://doi.org/10.1007/s00382-021-05661-8)
- **The 2019 Southern Hemisphere polar stratospheric warming and its impacts**. Lim, et al. 2021. BAMS, https://doi.org/10.1175/BAMS-D-20-0112.1
- **Subseasonal drivers of extreme fire weather in Australia and its prediction in ACCESS-S1 during spring and summer**. Marshall et al. 2021. Climate Dynamics. https://doi.org/10.1007/s00382-021-05920-8
- **A New Operational Seasonal Thermal Stress Prediction Tool for Coral Reefs Around Australia**. Spillman CM and Smith GA, 2021. Frontiers in Marine Science, https://doi.org/10.3389/fmars.2021.687833

For discussion

Ideas for

- further engagement with other groups
- additional WGSIP-driven or coordinated activities
- promoting new approaches for research in this area
- …