WGSIP Risk of Extremes Project

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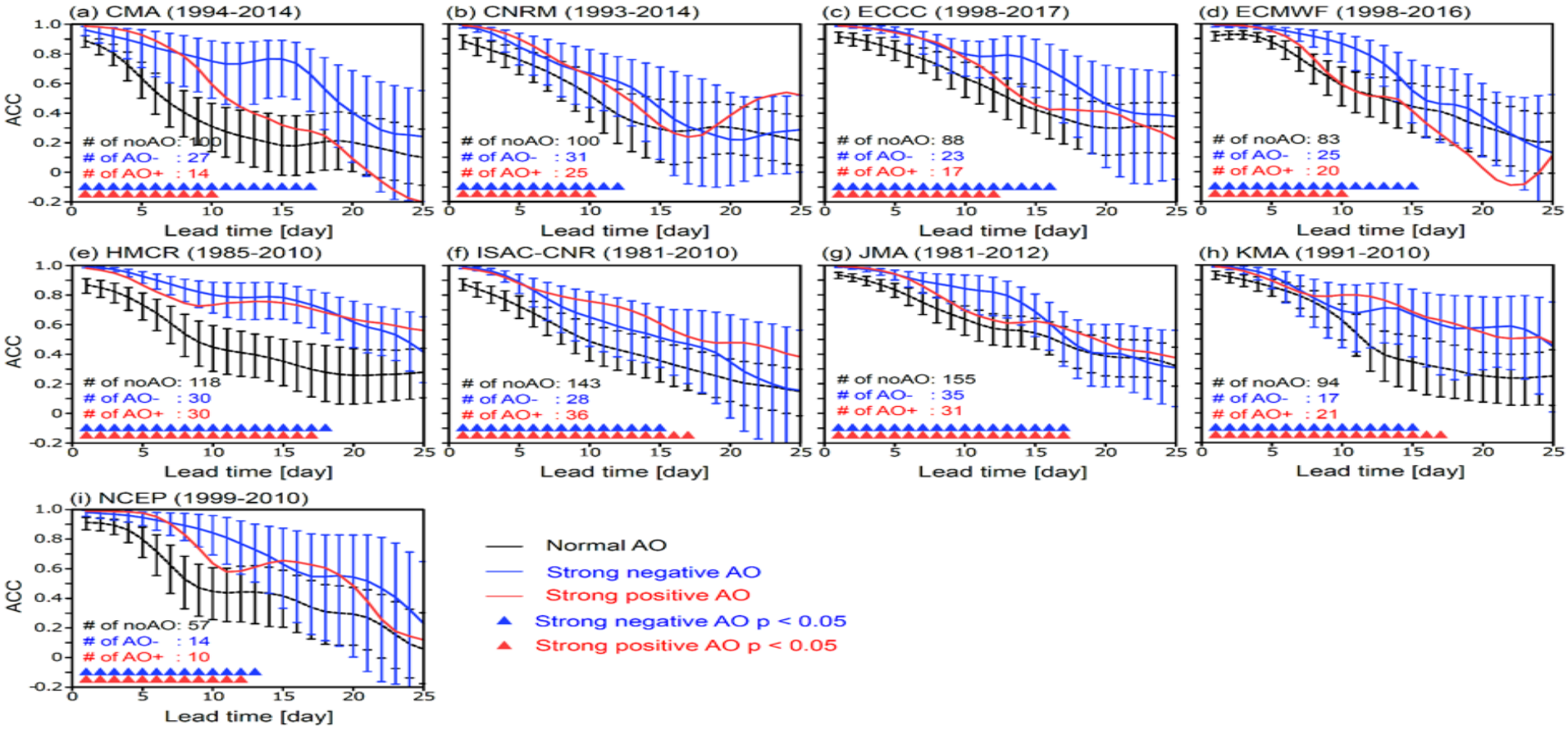
Expected outcomes:

- a series of case studies applying the UNSEEN methodology to a variety of phenomena and regions, potentially including compound events

- assessment of current capability of climate models to predict extreme events

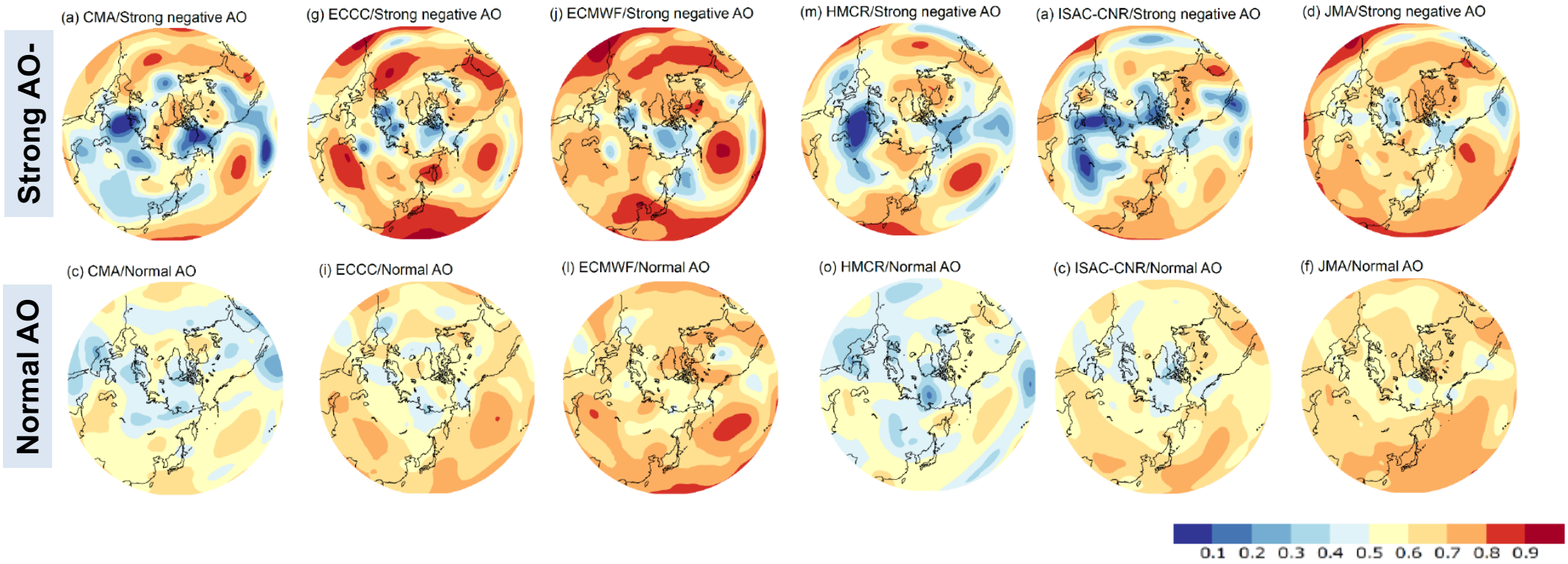
S2S predictability of the AO

Skill is higher for strong AO cases



S2S predictability of the AO

Correlation skill improved for strong negative AO cases

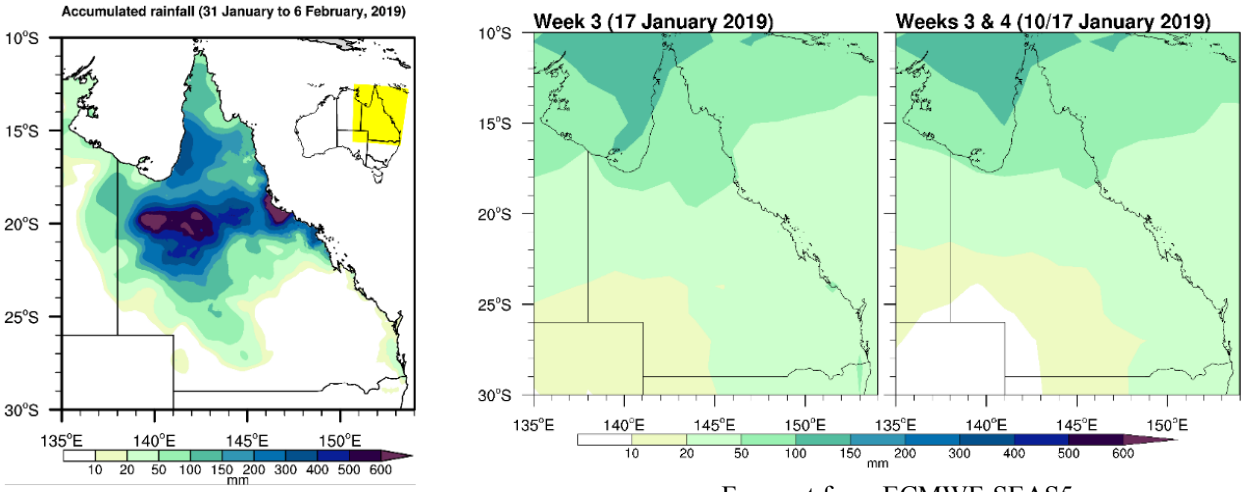


Underlying atmospheric dynamics are also discussed in Minami and Takaya (2020).

Recent research on predicting extremes (BoM)

Extreme rainfall that caused the north-eastern Australia floods in February 2019

Led to the deaths of ~625,000 cattle and ~48,000 sheep, infrastructure damage and flooding of >3000 homes



Forecast from ECMWF-SEAS5

In collaborative S2S paper: Domeisen et al "Advances in the subseasonal prediction of extreme events" (To be submitted to BAMS)

Other extremes research:

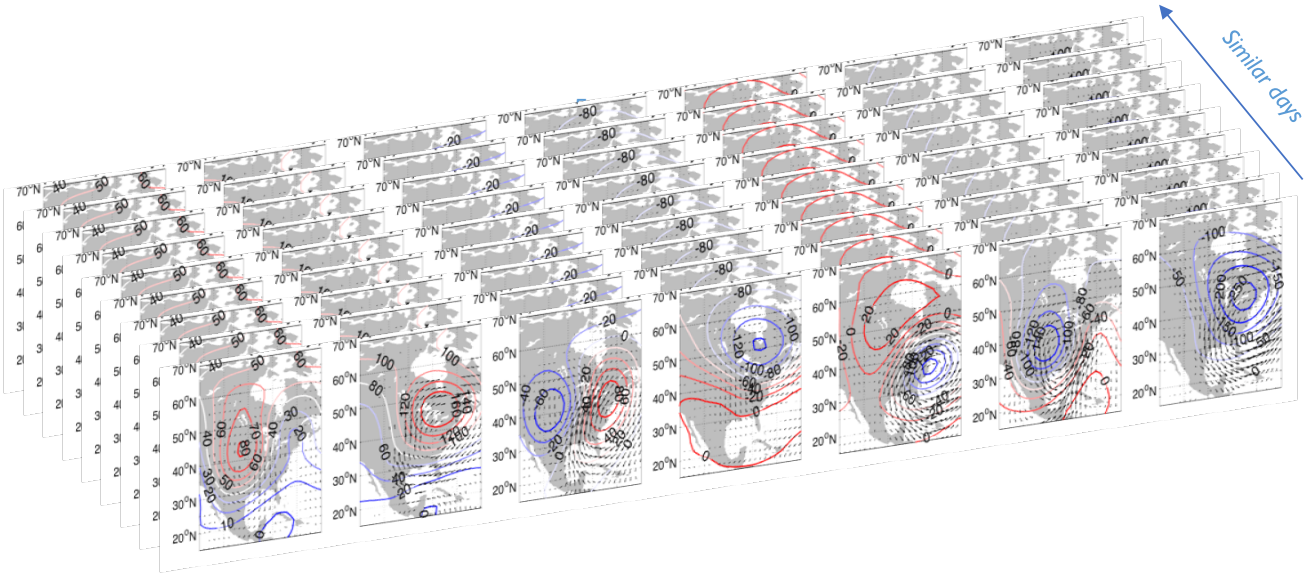
Cowan et al, https://doi.org/10.1016/j.wace.2019.100232 Forecasting the extreme rainfall, low temperatures, and strong winds associated with the northern Queensland floods of February 2019

King et al, QJRMS https://doi.org/10.1002/qj.3789 Sub-seasonal to seasonal prediction of rainfall extremes in Australia

Lim et al, Nature Geoscience https://doi.org/10.1038/s41561-019-0456-x Australian hot and dry extremes induced by weakenings of the stratospheric polar vortex

Wang and Hendon, Clim Dyn. https://doi.org/10.1007/s00382-020-05432-x Impacts of the Madden–Julian Oscillation on wintertime Australian minimum temperatures and Southern Hemisphere circulation

A Flow-Dependent Approach to Process-based Model Diagnostics



Minimize the function:

$$W(P) = \sum_{j=1}^{N} \sum_{x \in C_j} d^2(X, Y_j),$$

- Can we build an integrated diagnostic framework based on weather type spatial patterns and frequencies of occurrence to facilitate the identification of model systematic errors across multiple timescales?

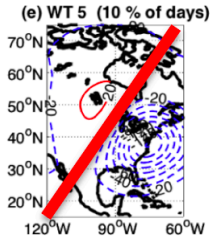
Michelangeli *et al.* (1995); Robertson and Ghil (1999); Robertson *et al.* (2015); Muñoz *et al.* (2015, 2016, 2017; in prep)

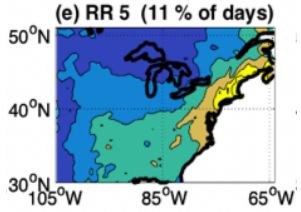
Weather types

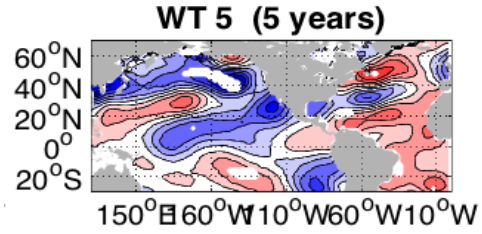
Rainfall patterns

SST patterns

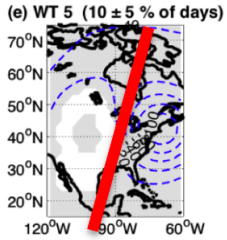
MERRA

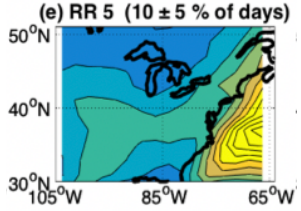


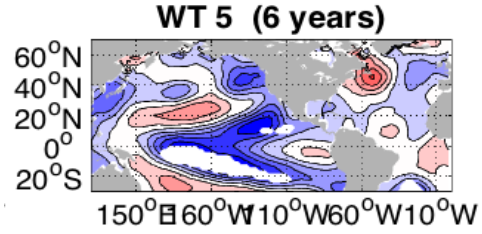




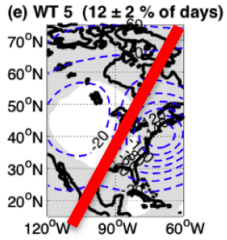
$LOAR_{sst}$

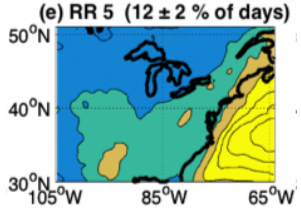


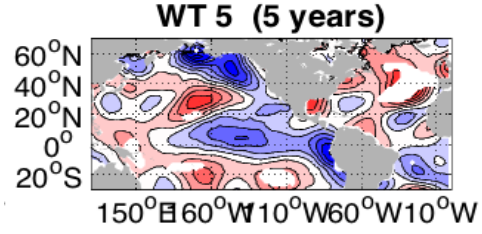




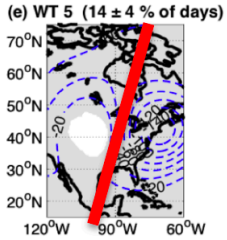
$FLOR_{sst}$

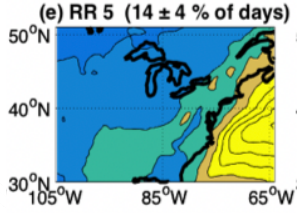


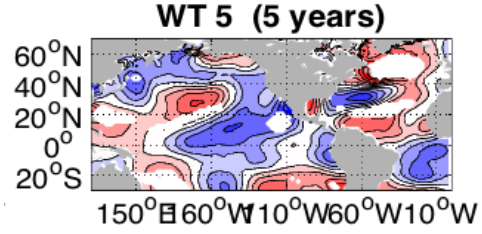


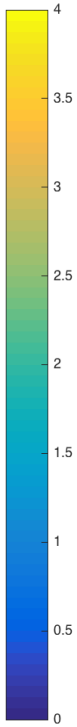


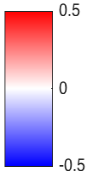
$FLOR_{sst+strat}$









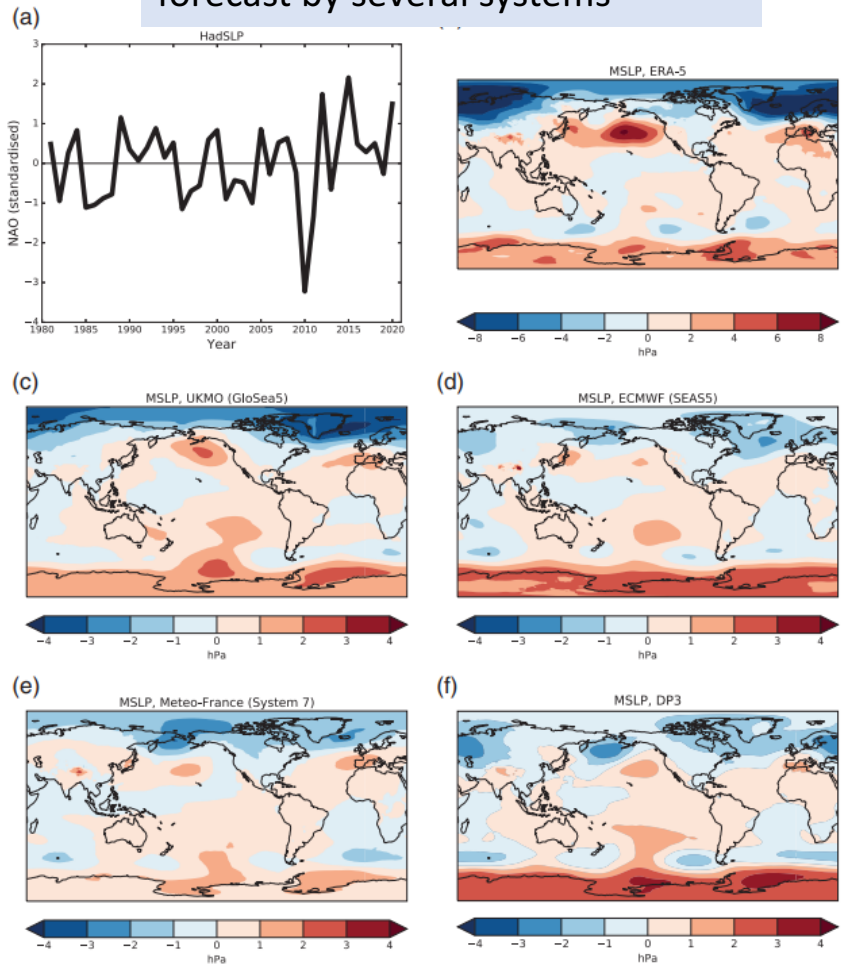


Improved skill by taking into account errors in the modelled representation of weather types and associated rainfall and SST patterns

Muñoz *et al* (2017; in prep)

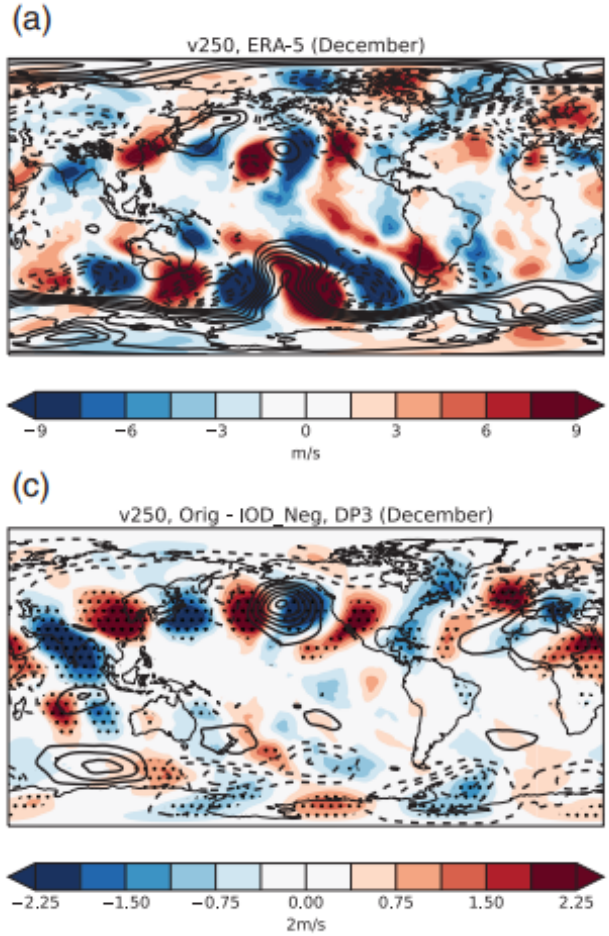
Predictability of European winter 2019/20

Strong positive NAO unusually well forecast by several systems

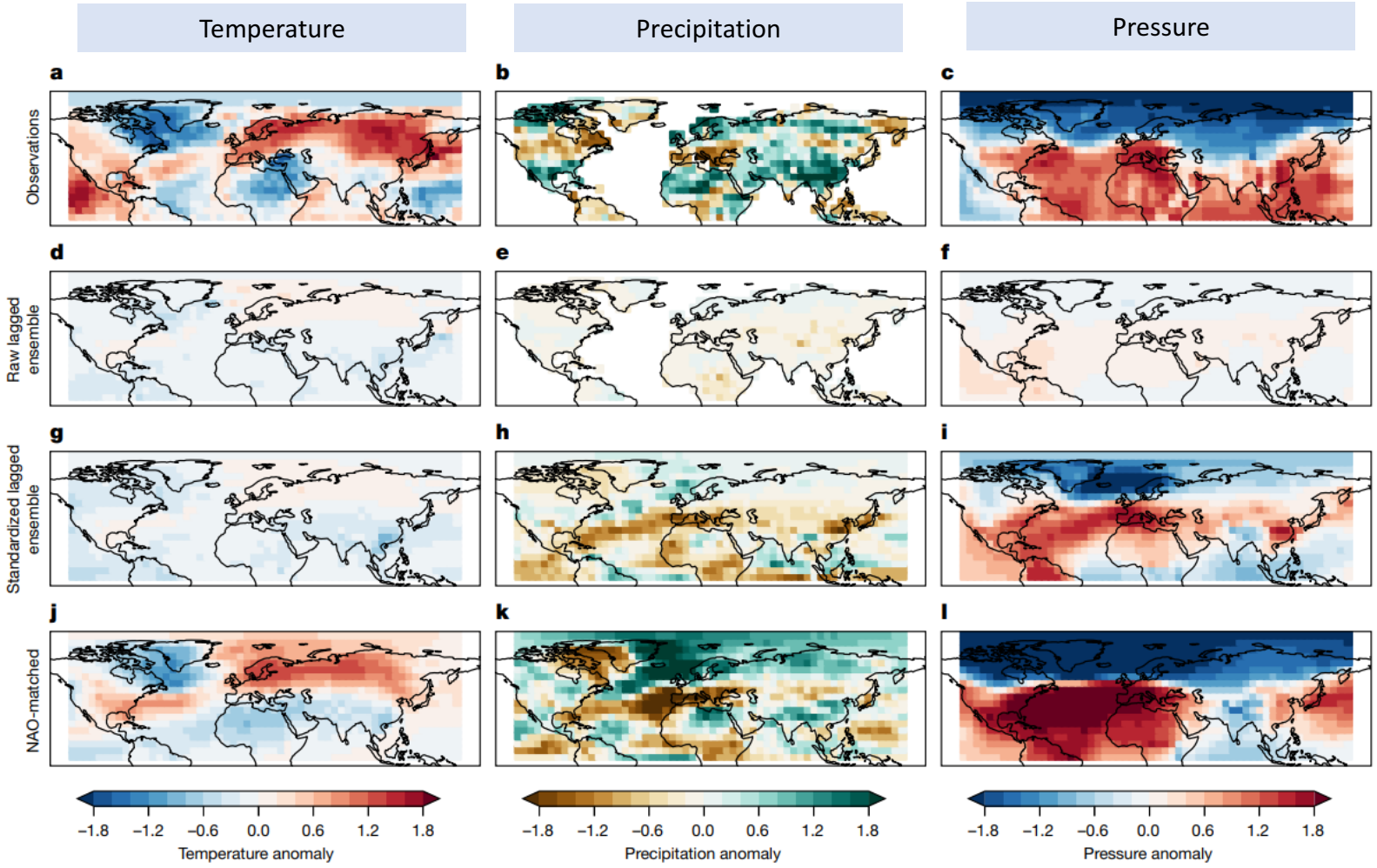


Hardiman et al 2020

Rossby waves caused by extreme Indian Ocean Dipole



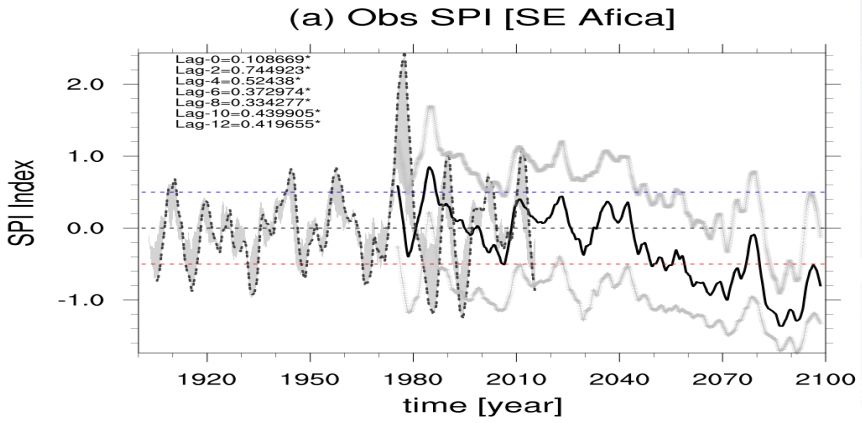
Decadal prediction of extreme NAO

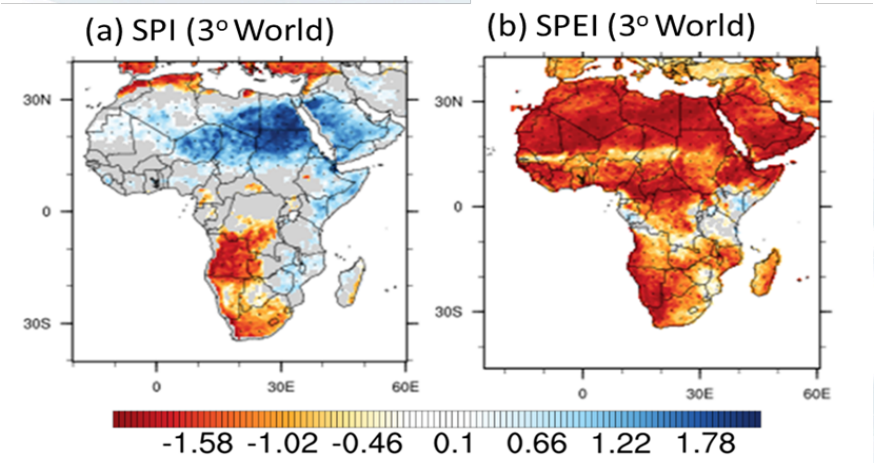


- Extreme positive NAO decade
- Raw model forecasts underestimate the predictable signal (“signal to noise paradox”)
- Scaling improves the NAO
- But impacts of the NAO still not captured
- Additional post-processing required (“NAO-matching”)

Smith et al 2020

African drought





- Southern Africa moisture stress worsened since 2000 (shown by standardised precipitation index SPI)
- Models capture some of the inter annual variability (r=0.74)
- Model projections under business as usual scenario (RCP8.5) show continued decline to extreme unprecedented conditions by 2100
- Projections even more severe when water loss due to potential evapotranspiration is taken into account (Standardised Precipitation-Evapotranspiration Index SPEI).

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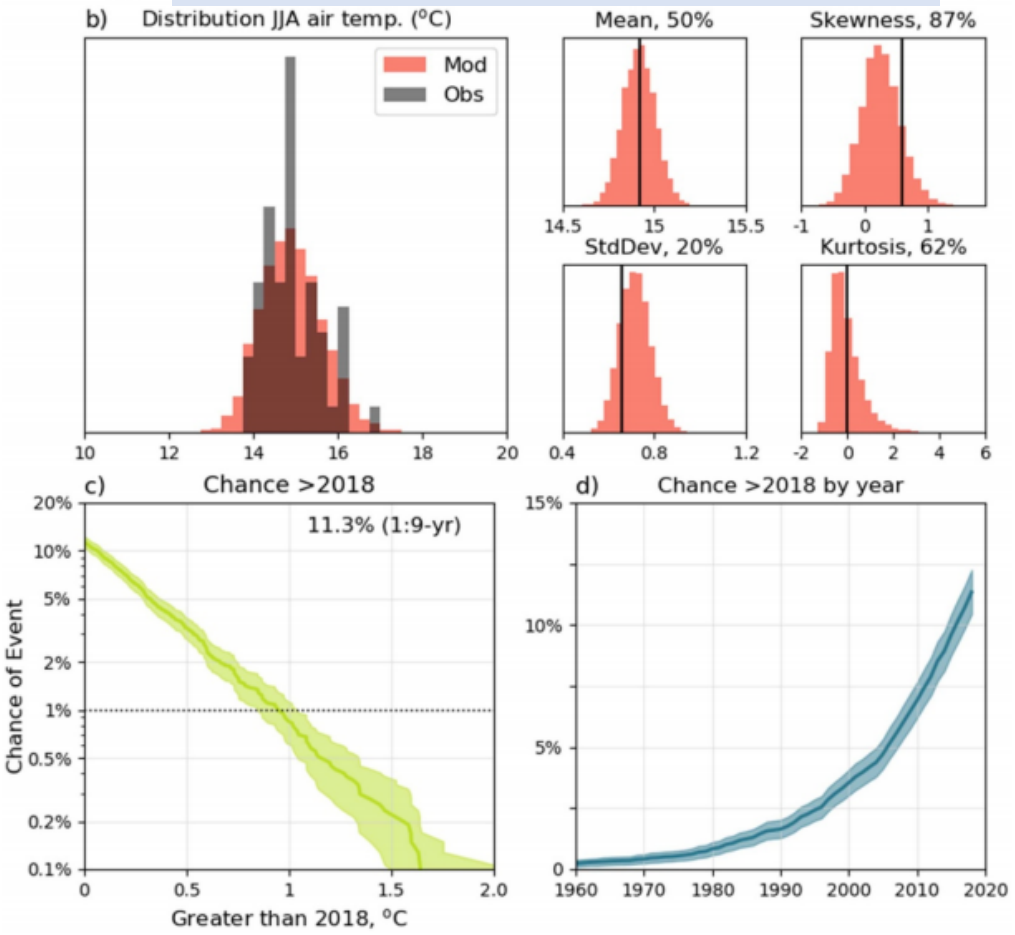
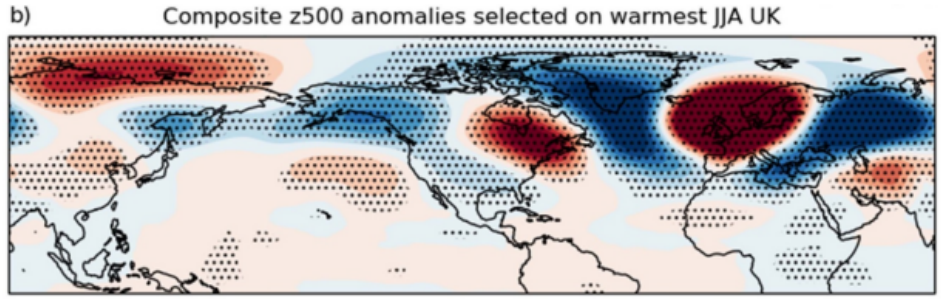
Risk of unprecedented hot UK summer

- 11.3% chance of unprecedented event
- Strongly increasing as climate warms



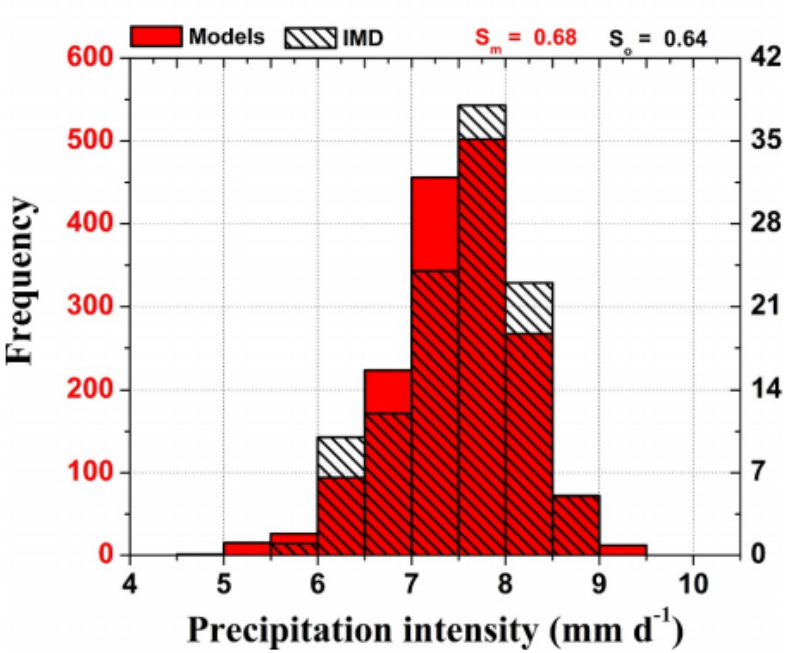
- Associated with Rossby waves
- Can be driven by tropical rainfall
- Also sea ice anomalies in Barents Sea and Sea of Okhotsk



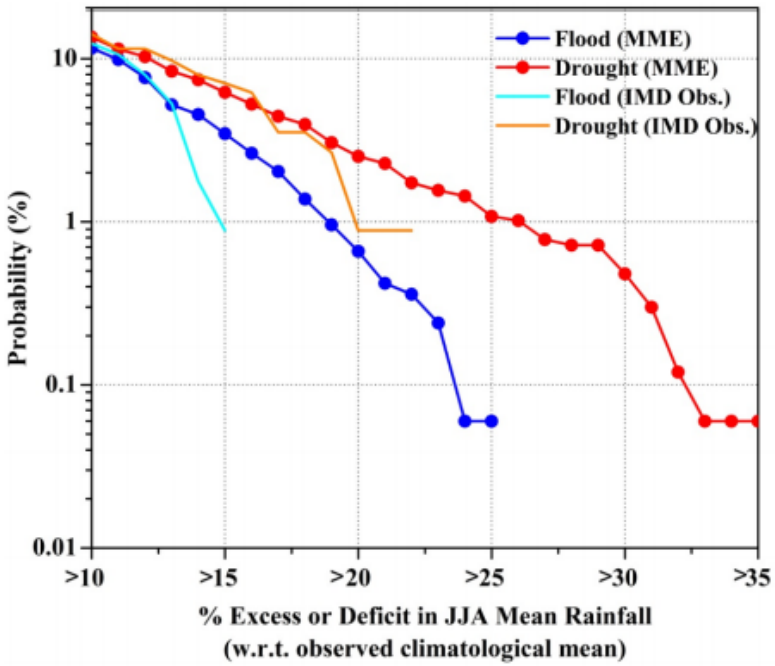
Kay et al 2020

Risk of unprecedented Indian monsoon rainfall

CHFP seasonal hindcasts simulate the observed frequency distribution of Indian monsoon rainfall



Probability of droughts and floods



- 1.6% (2.6%) chance of unprecedented drought (flood)
- Drought more likely than flood due to ENSO asymmetry
- 30% drought deficit once in 2 centuries

Jain et al 2020