Seasonal forecasts in a changing climate

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A crucial component of any (seasonal) forecasting system is its retrospective forecasts.

Reforecasts are used for:

- ✓ **Calibration of real-time forecasts**

  e.g., mean-state bias corrections, variance inflations

- ✓ **Skill estimation to assess confidence in real-time forecasts**

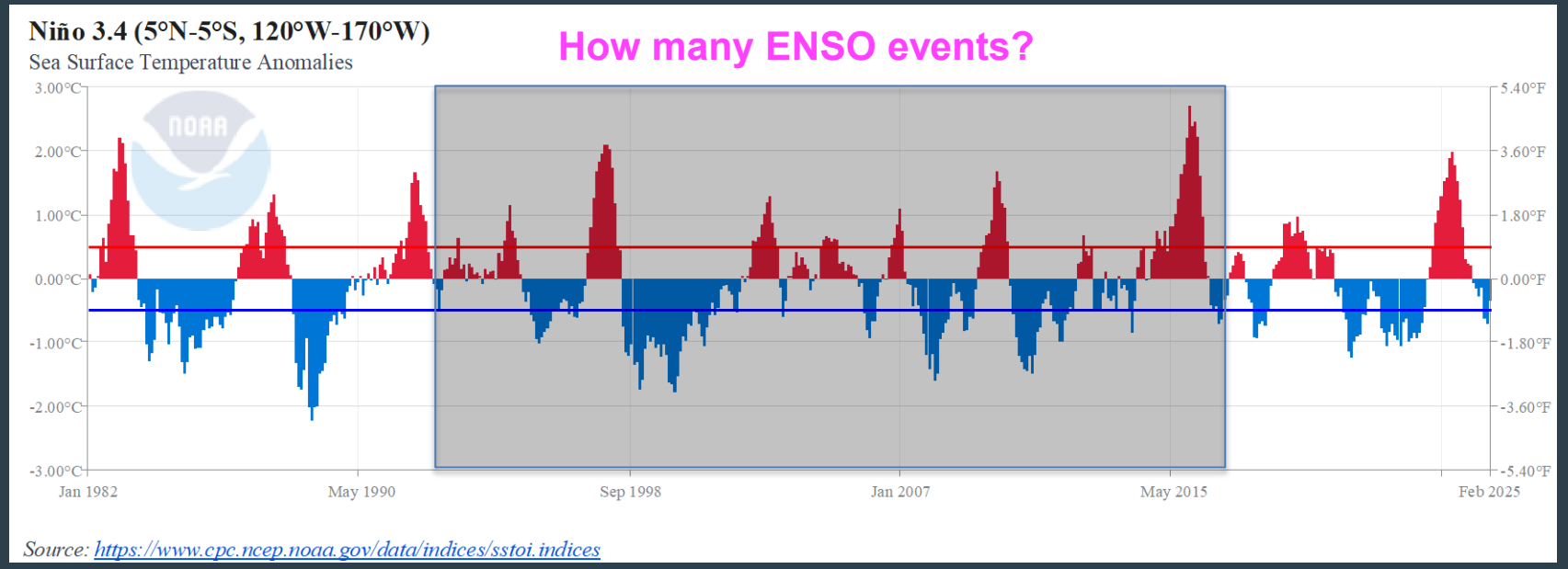
Re-forecasts in C3S cover the 24-year period 1993-2016.

SEAS5 has re-forecasts over the 36-year period 1981-2016.

Limitations of re-forecasts

- **Balance of re-forecast size and computational costs**
- **Uncertainties due to sample size constrain**:

  → evaluation of sporadic natural drivers, e.g., ENSO, MJO, SSW



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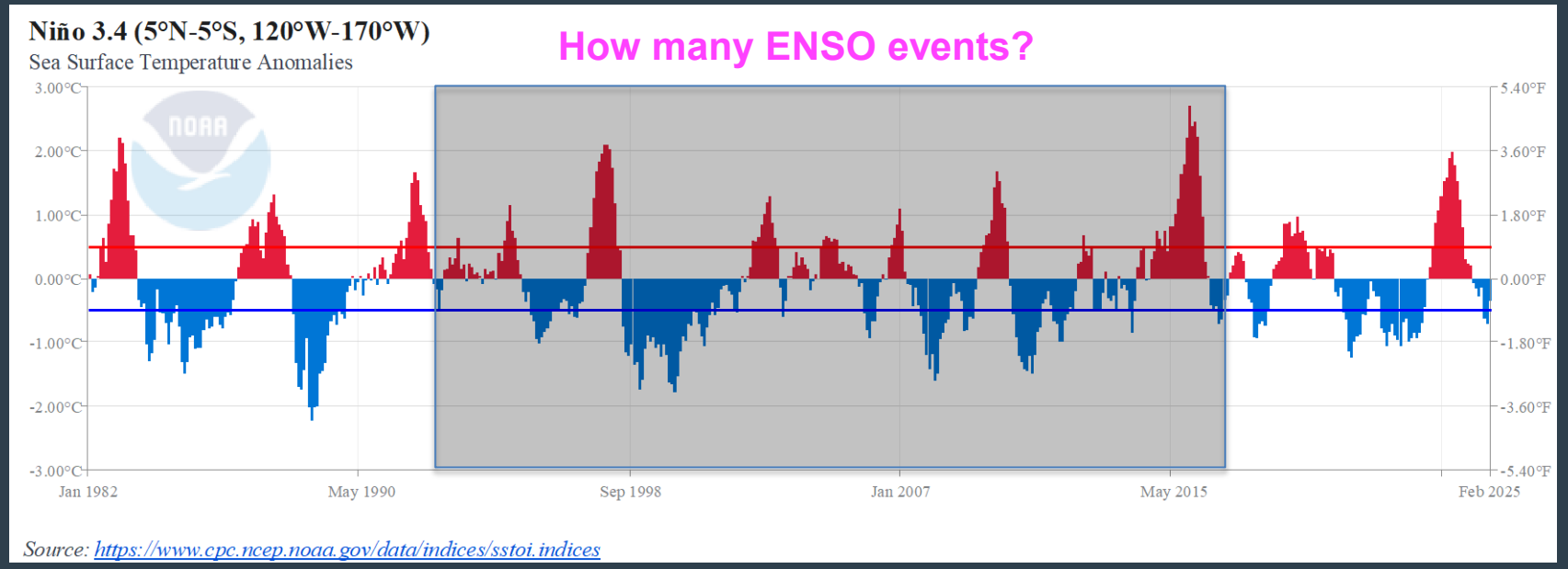
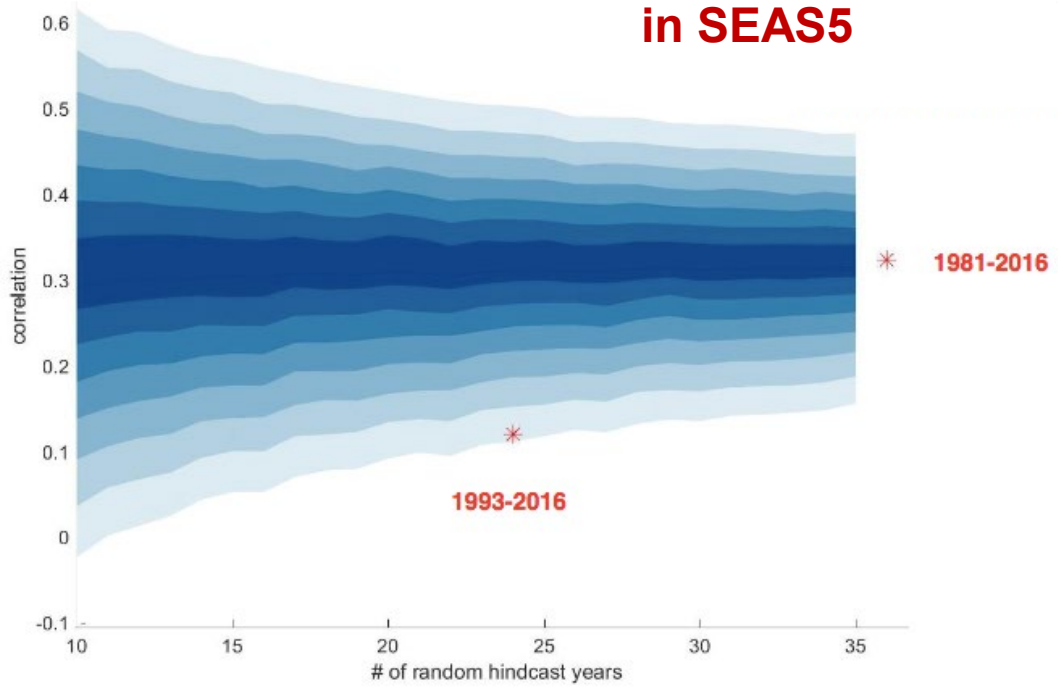


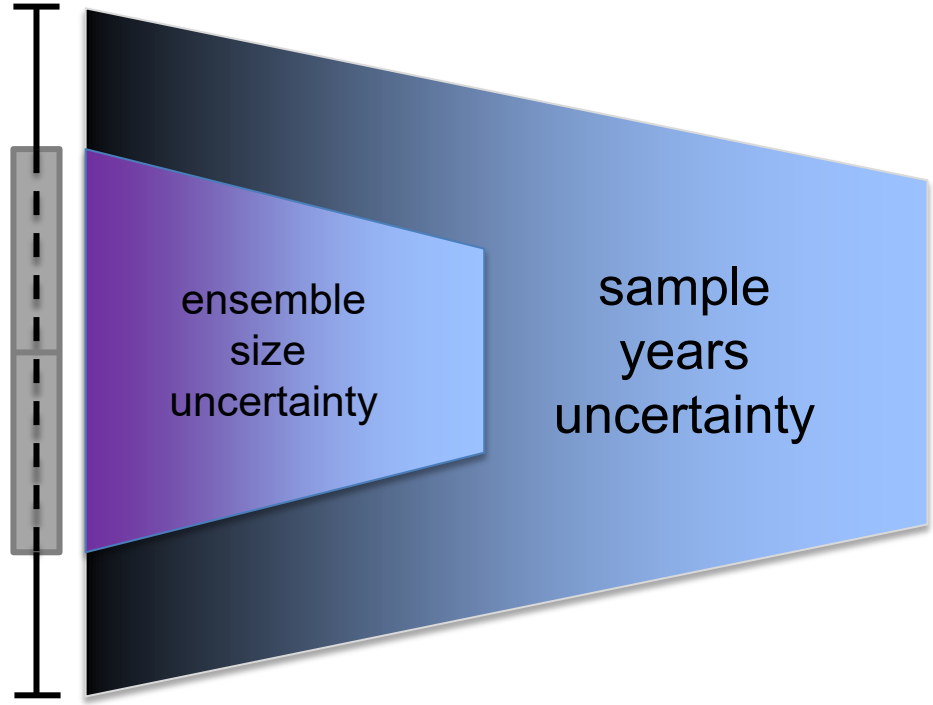
Limitations of re-forecasts

- **Balance of re-forecast size and computational costs**
- **Uncertainties due to sample size constrain:**

  → skill estimation in regions of large interannual variability, e.g., Euro-Atlantic

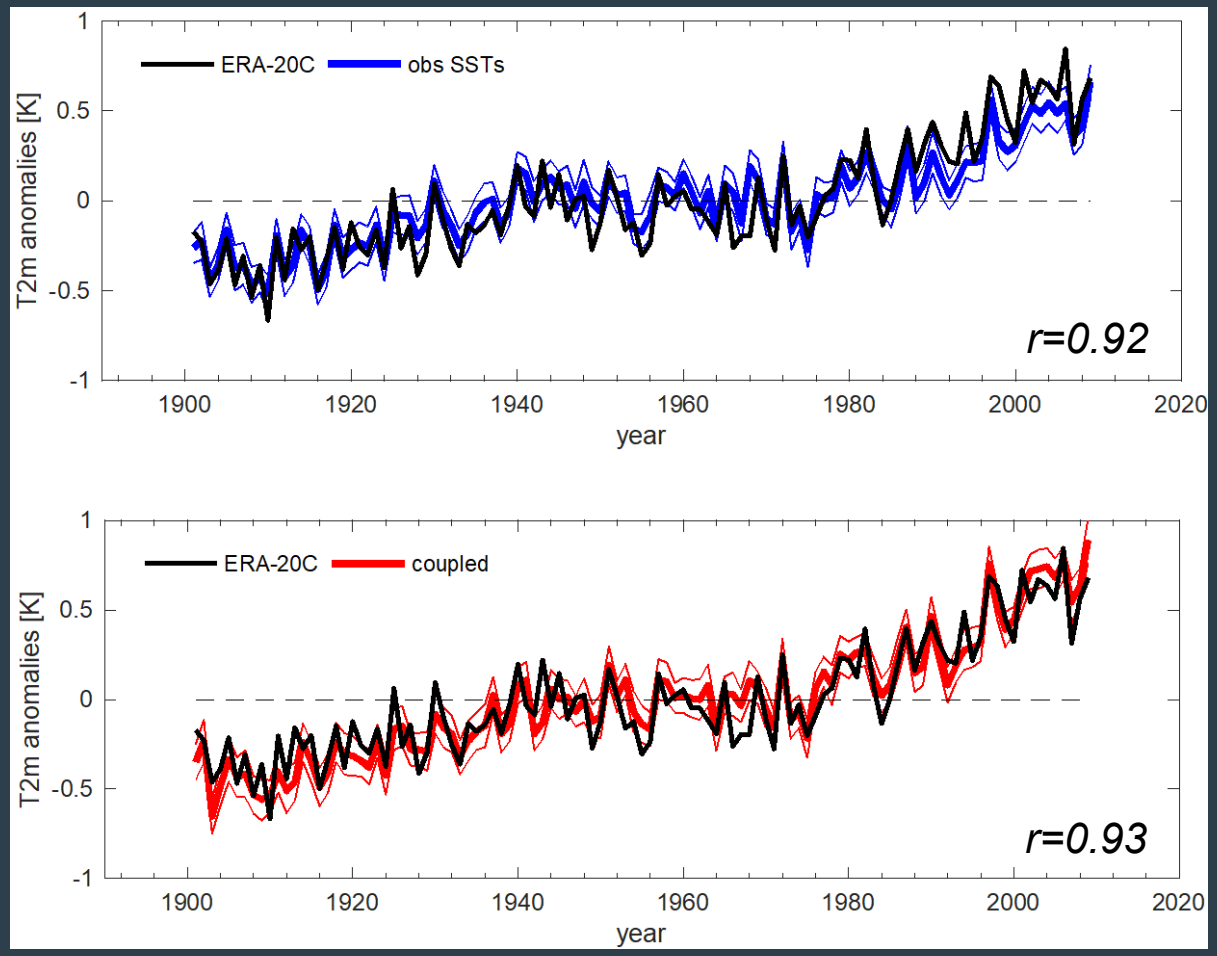
Uncertainty of the NAO forecast skill in SEAS5





Can we overcome the sampling problem by using substantially longer historical re-forecast periods?

Global mean 2m temperature forecasts for DJF

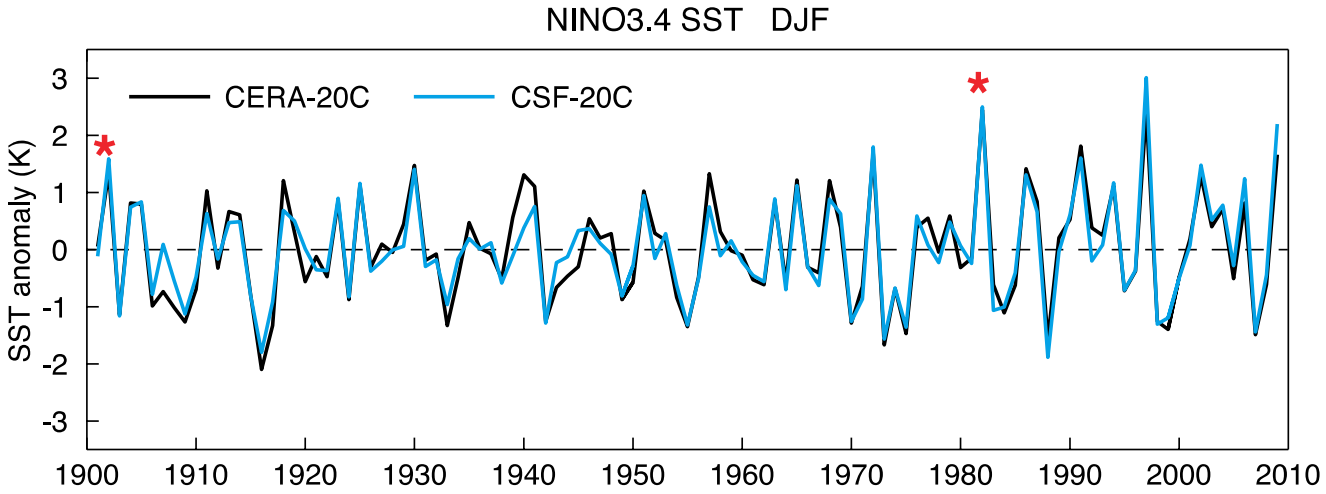


Seasonal forecast of the 20th Century

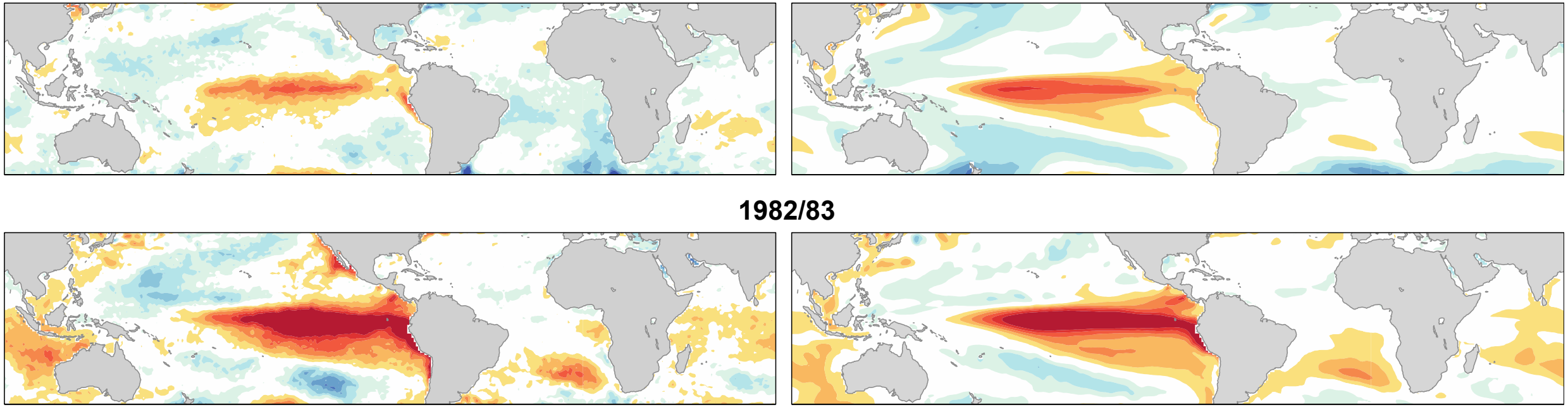
- Re-forecasts over the period 1900-2010
- Initialised from ERA-20C/CERA-20C
- Atmosphere-only and coupled forecasts
- System 4-like model version in low resolution
- Large ensembles (51 members)

Weisheimer et al. (QJ2017, QJ2019, BAMS2020)

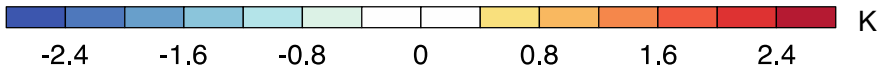
ENSO



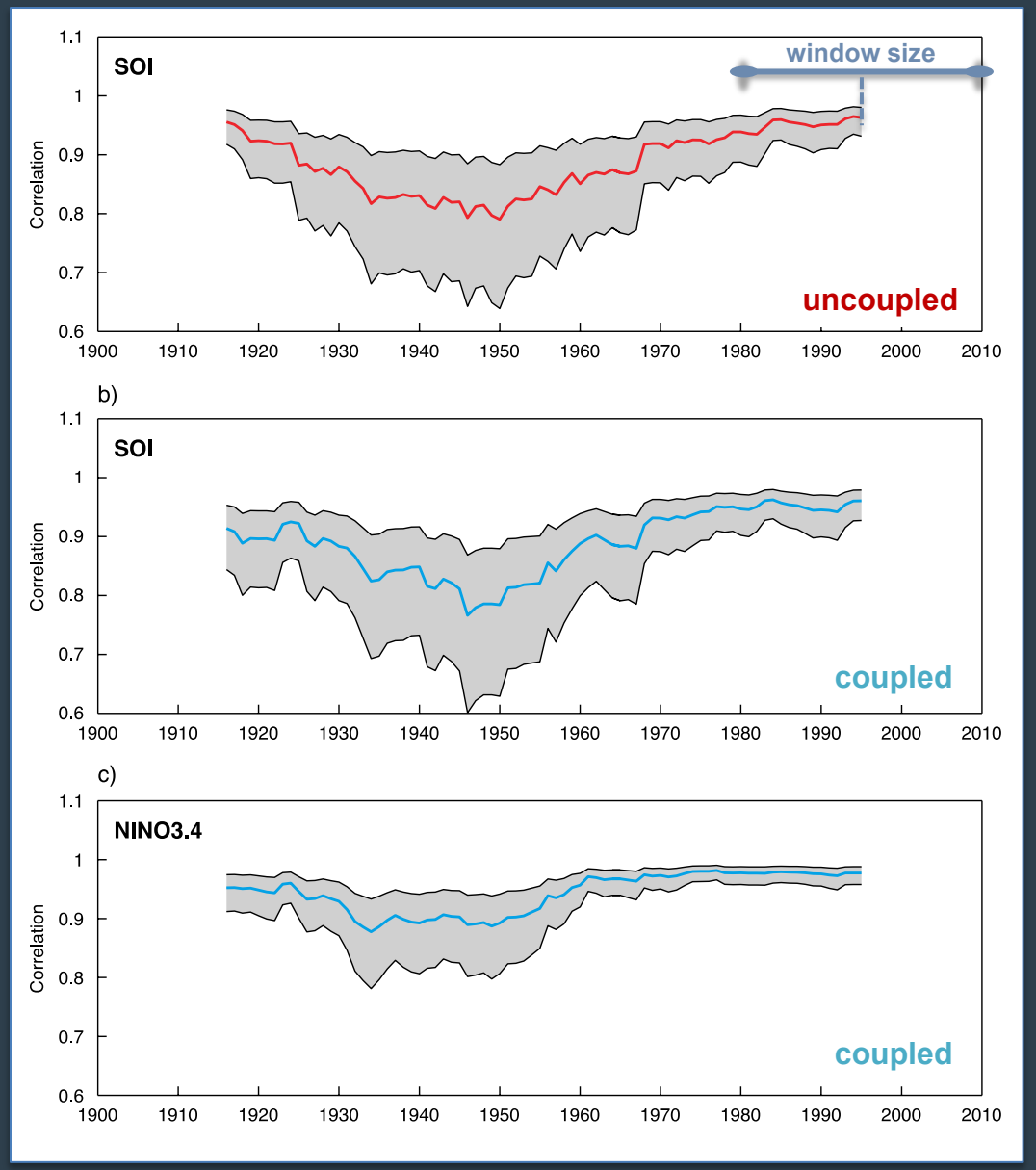
CERA-20C **1902/03** **CSF-20C**



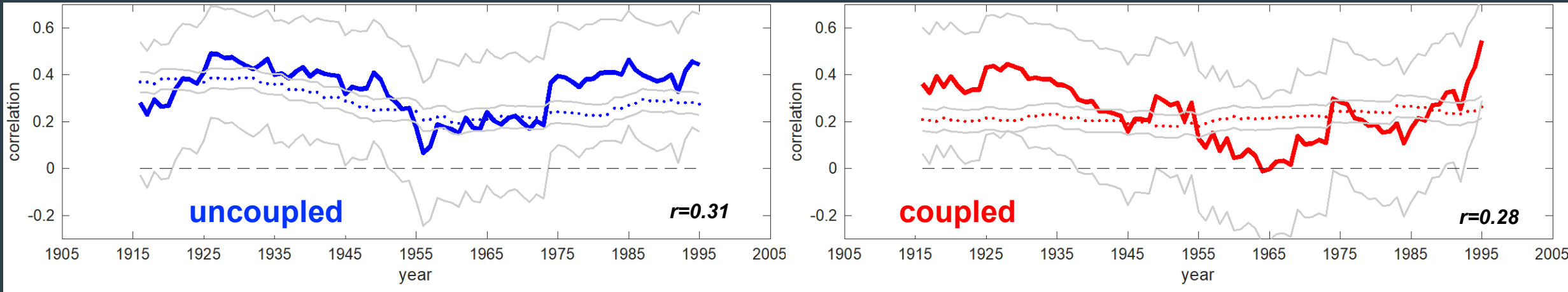
1982/83



ENSO forecast skill throughout the 20th Century

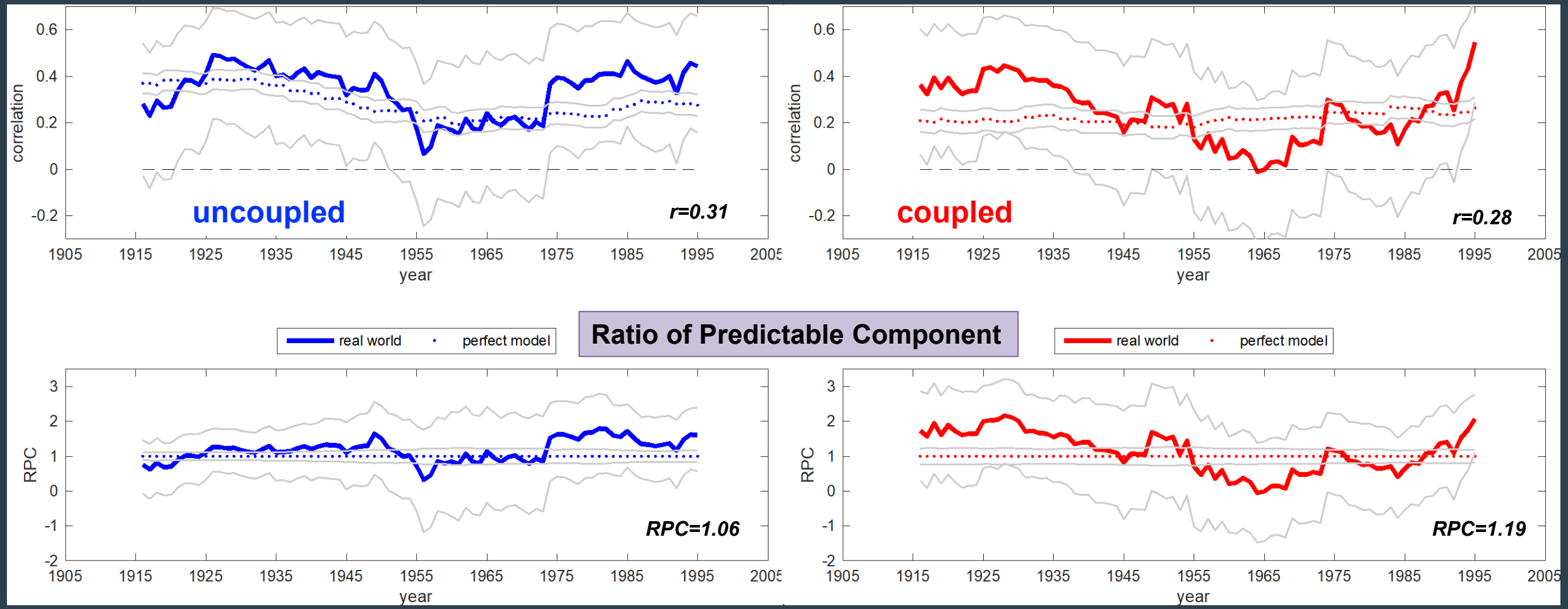


Multi-decadal variability of winter NAO forecast skill



Pronounced multi-decadal skill modulations throughout the 20th century.

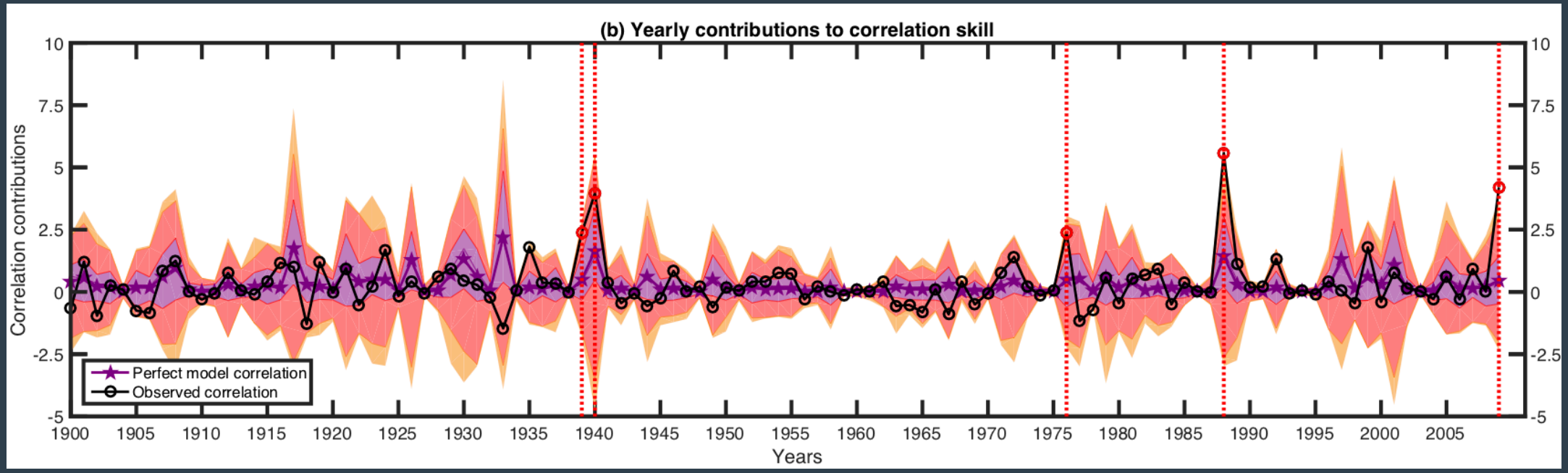
Multi-decadal variability of winter NAO forecast skill

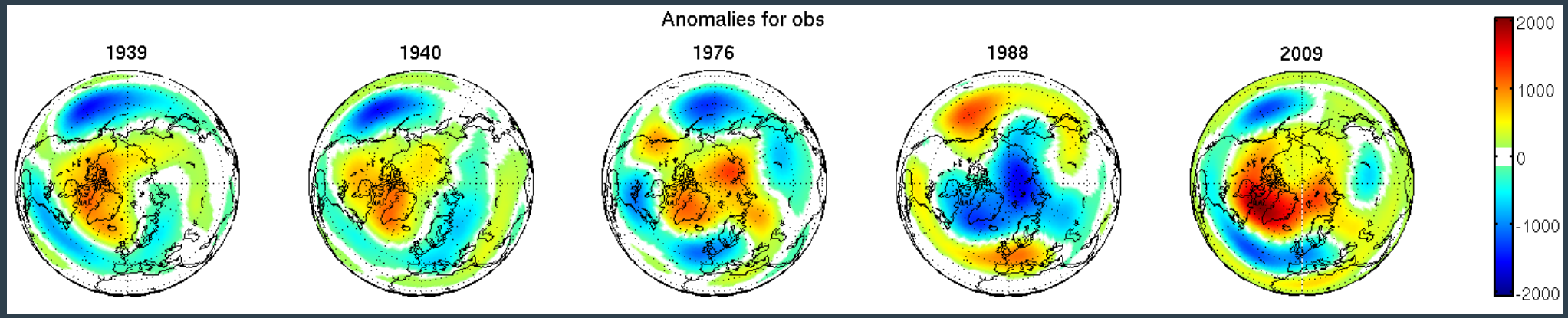


Pronounced multi-decadal skill modulations throughout the 20th century.

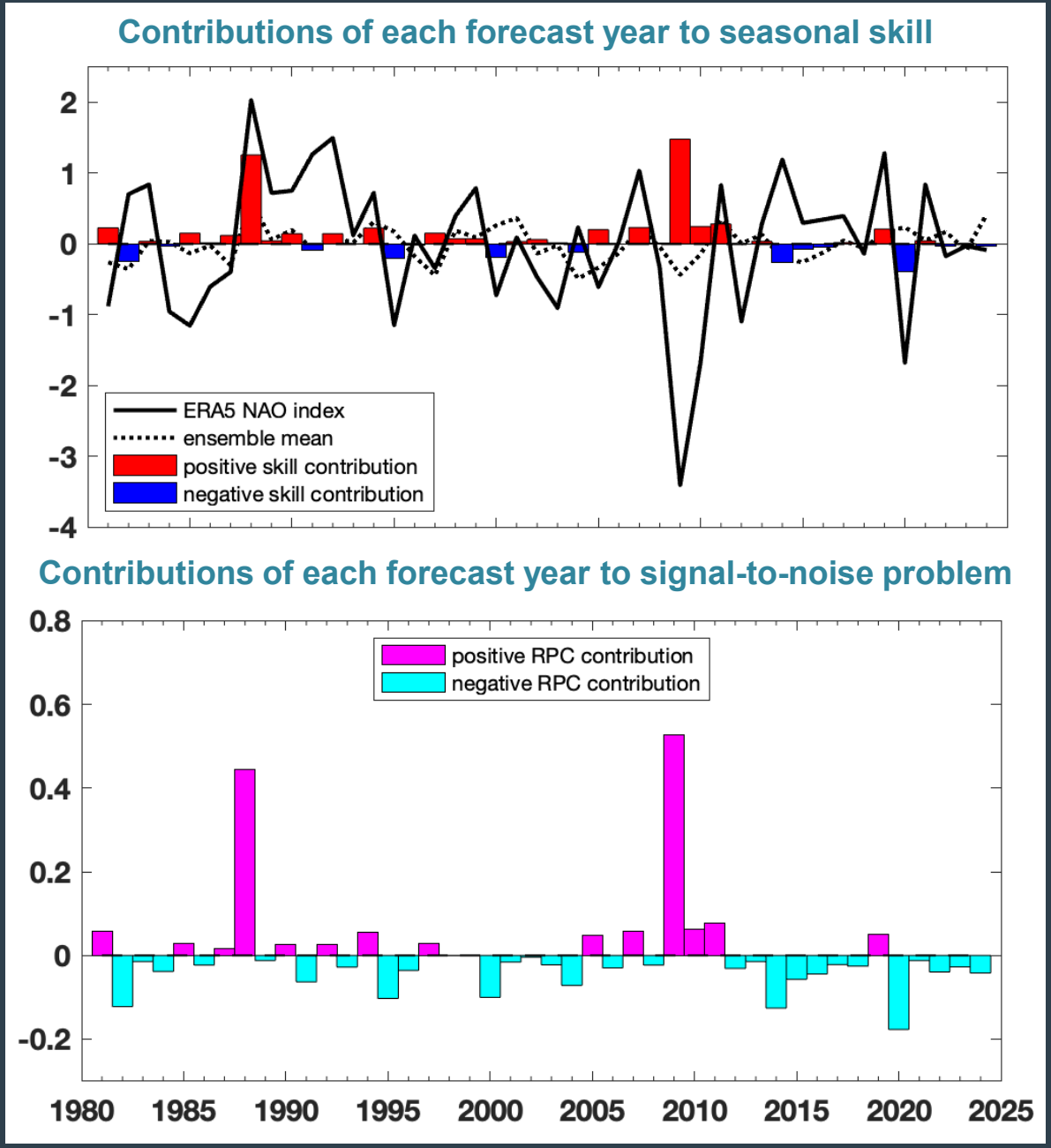
Intermittency of winter NAO forecast skill

Covariance contribution to skill: $$r = \frac{1}{N\,\sigma_{obs}\sigma_{mod}} \sum_1^N x'_{obs} x'_{mod}$$





Intermittency of winter NAO forecast skill: SEAS5 1981-2024



Confidence in future seasonal forecast skill is challenged by

- **Pronounced multi-decadal variability in skill**
  - Working hypothesis: driven by natural mechanisms
  - Observational coverage and quality don’t seem major drivers
  - Risks future degradation of skill if not better understood
- **Strong intermittent behaviour**
  - Most years are not important, only a very few key years dominate
  - Opens up opportunities for focussed and cost-effective research to improve model

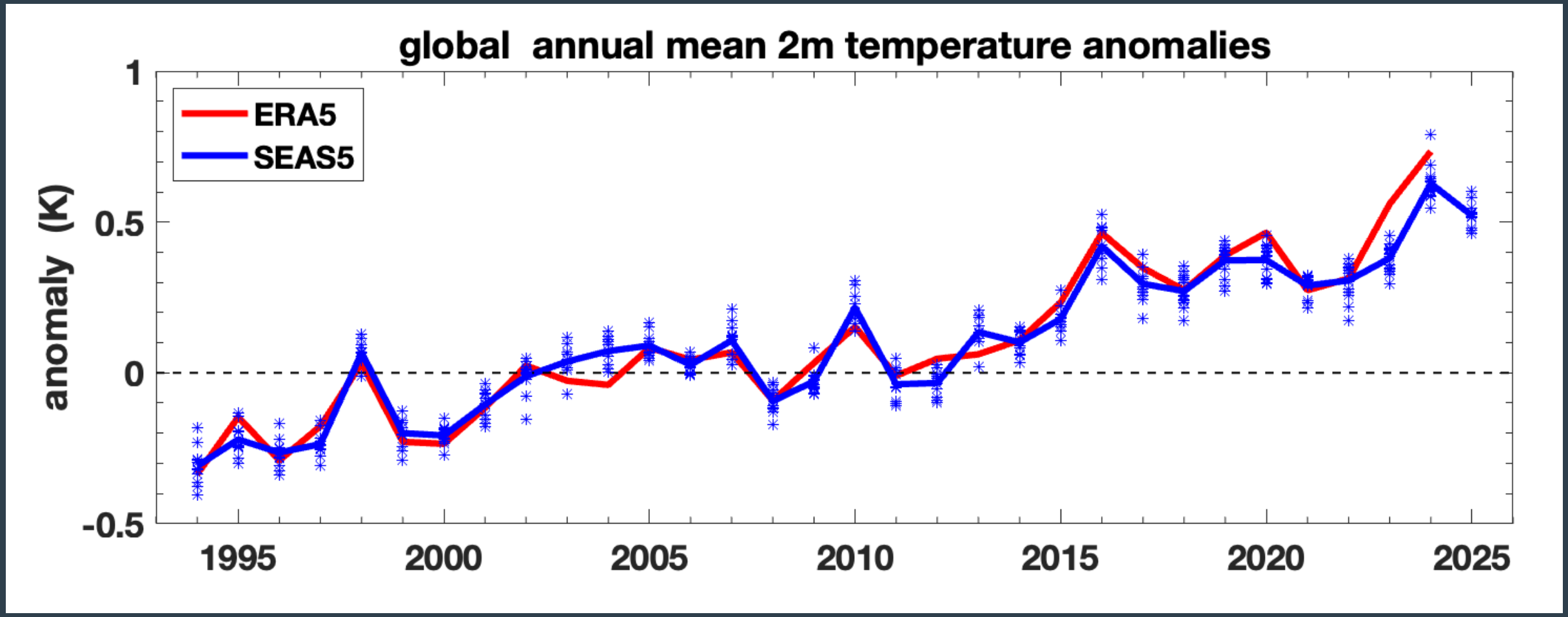
Seasonal forecasts at the interface between weather and climate

Seasonal forecasts have clearly benefited from weather forecasts.

Can seasonal forecasts be of benefit for climate problems?

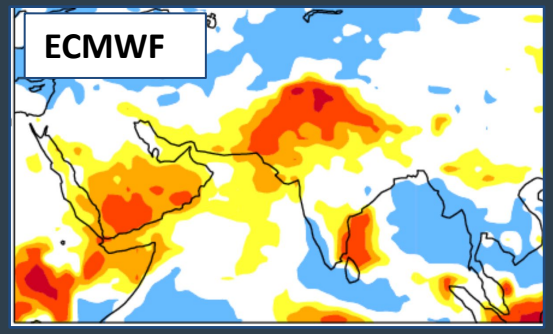
Climate change and SEAS5 forecasts

How well can SEAS5 predict the global mean temperature for the next year?



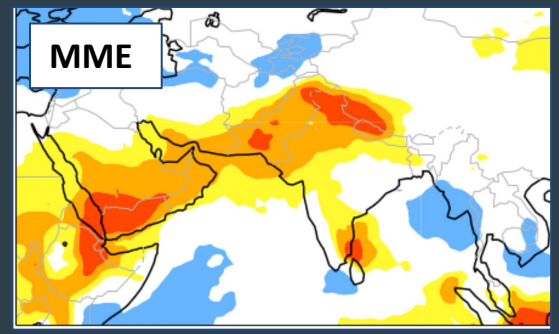
An extreme seasonal rainfall event: Pakistan summer 2022

Upper quintile probability of 1st May 2022 forecasts:



6 out of 8 models predicted a very strong and anomalous rainfall signal for Pakistan

Climate Change Service
climate.copernicus.eu



More than 1,700 people lost their lives and amost 13,000 were injured

A role for climate change?

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How Pakistan floods are linked to climate change

2 September 2022

Climate change

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By Georgina Rannard

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Scientists predict that the average rainfall in the Indian summer monsoon season will increase due to climate change, explains Anja Katzenberger at the Potsdam Institute for Climate Impact Research.

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Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan

Friederike E L Otto, Mariam Zachariah, Fahad Saeed, Ayesha Siddiqi, Shahzad Kamil, Haris Mushtaq, T Arulalan, Krishna AchutaRao, S T Chaithra, Clair Barnes, Sjoukje Philip, Sarah Kew, Robert Vautard, Gerbrand Koren, Izidine Pinto, Piotr Wolski, Maja Vahlberg, Roop Singh, Julie Arrighi, Maarten van Aalst, Lisa Thalheimer, Emmanuel Raju, Sihan Li, Wenchang Yang, Luke J Harrington and Ben Clarke ▲ Hide full author list

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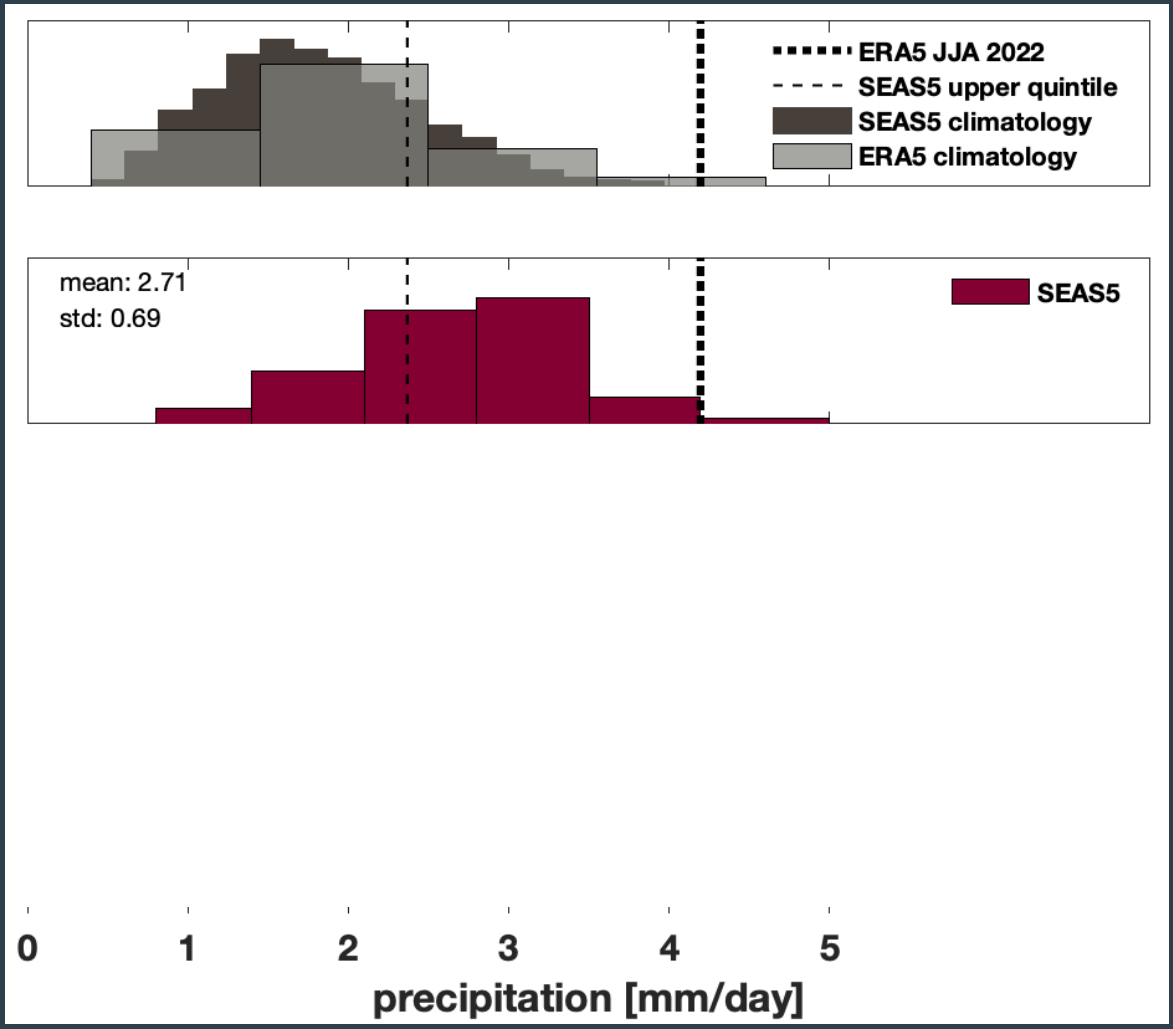
Counterfactual simulations with SEAS5: pre-industrial and future conditions



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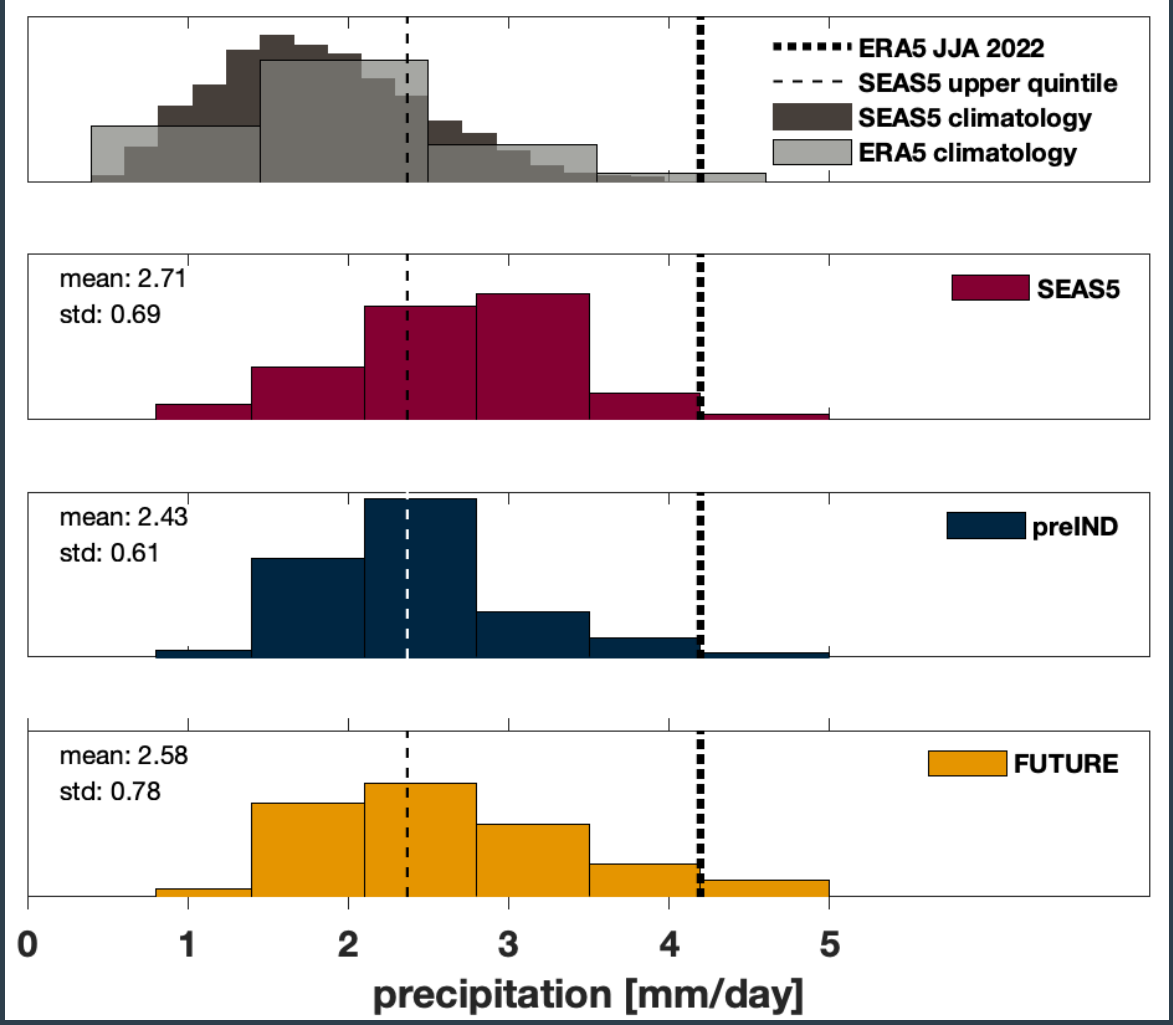

The SEAS5 extreme rainfall forecasts for JJA 2022 is not very sensitive to CO_2 and global SST levels.

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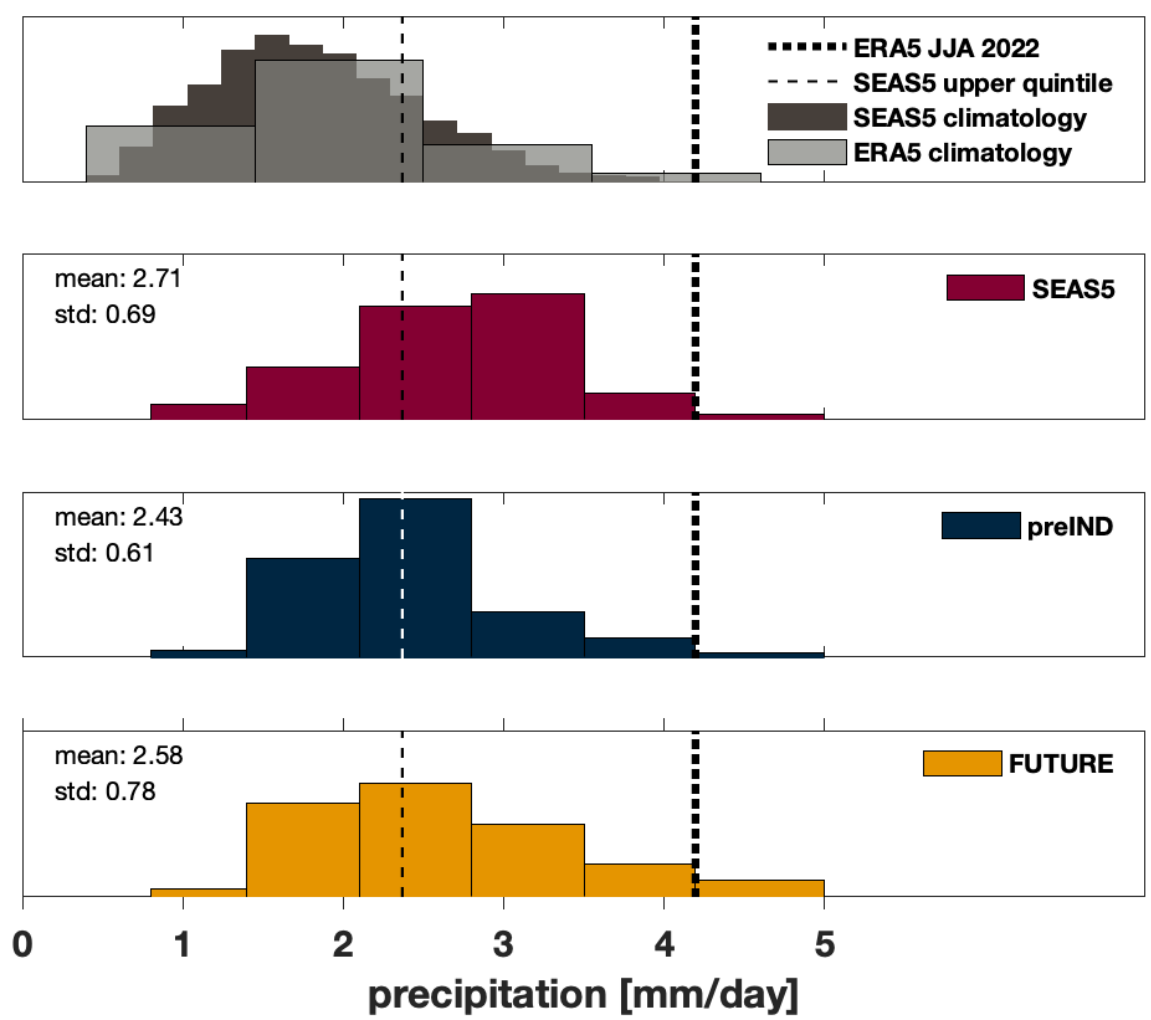

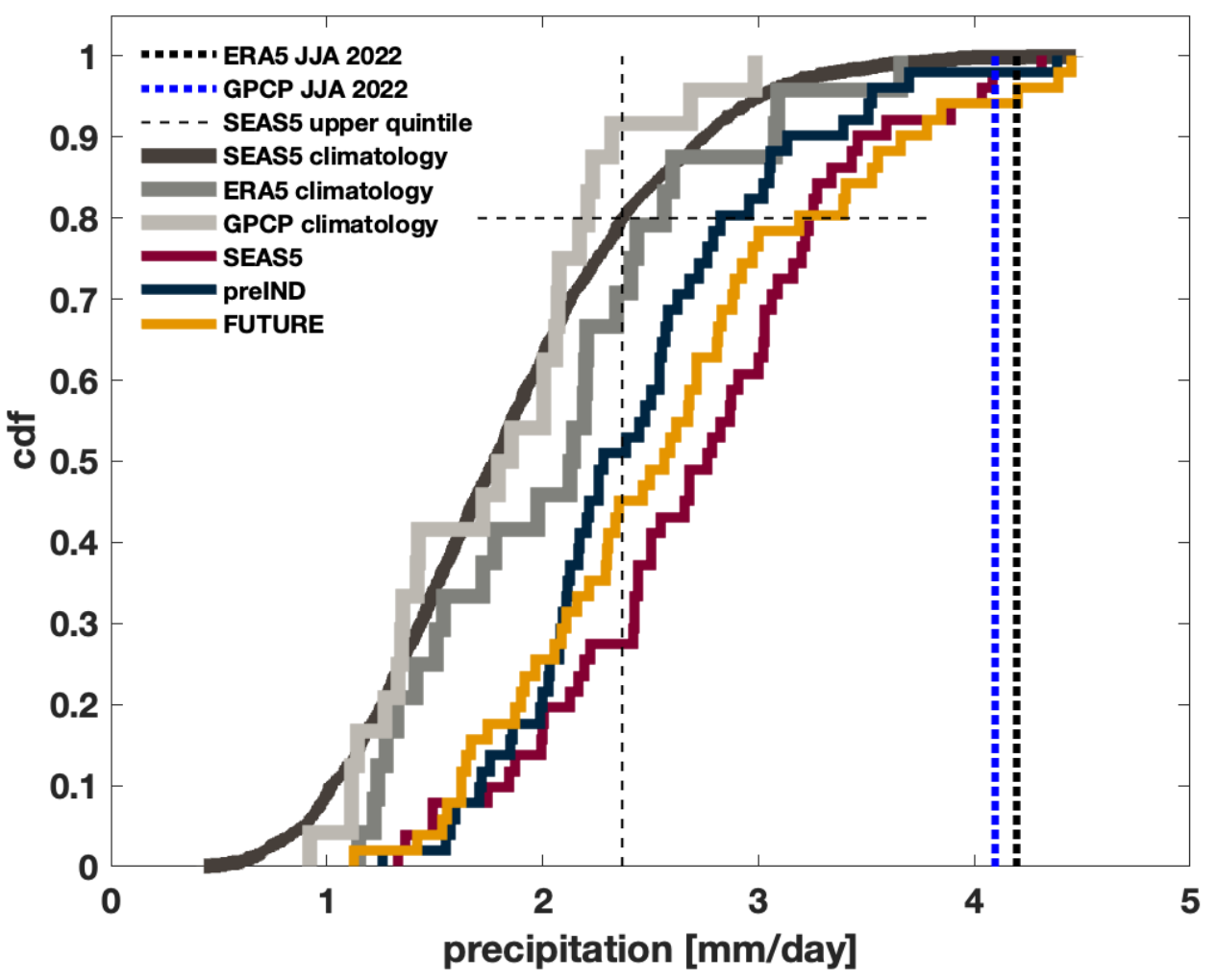

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Outlook

1. **Re-forecasts are very important for calibration, skill assessment and guidance for model developments**
    - Long historical re-forecasts warn us what we might expect in the future
    - We need to put our model to scrutiny test on as many different situations as possible
    - Important characteristics: non-stationarity and intermittency
    - Focus on understanding the key contributing years
2. **Climate change is transforming many aspects of the present climate and weather**
    - We need to embrace the challenge
    - Focus on understanding the mechanisms (explaining and attributing)
    - Lots of opportunities