Multi-year variation of ENSO forecast skill since the late 1800s

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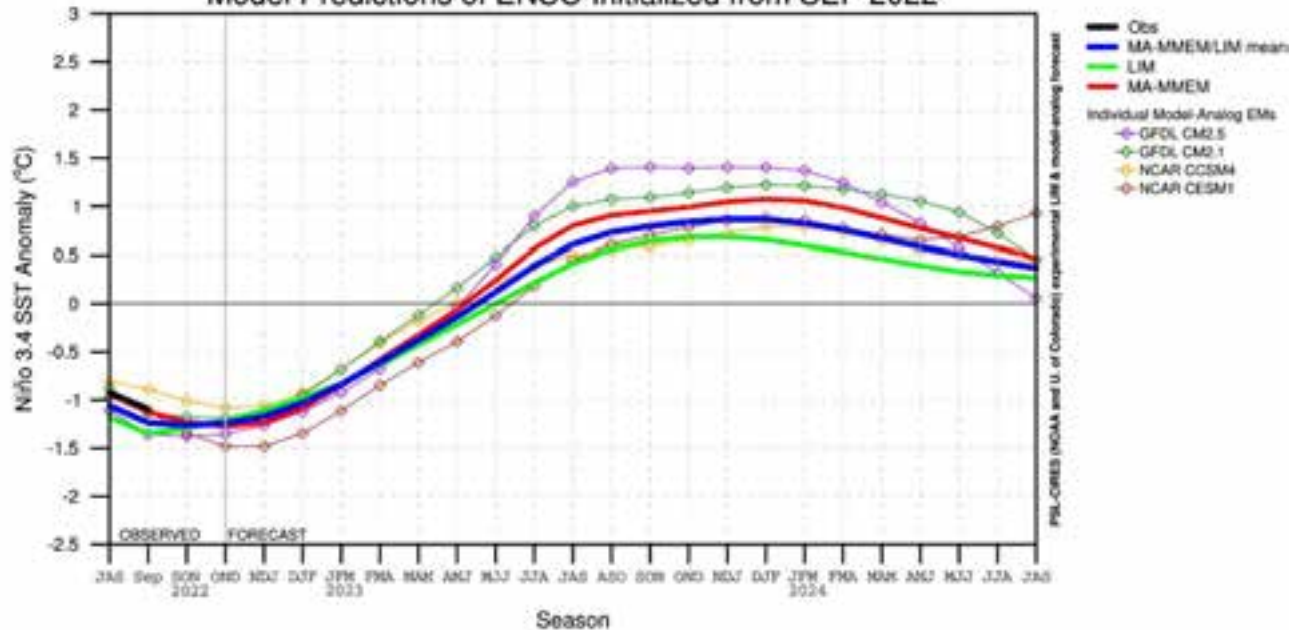
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Motivation: Multi-year ENSO prediction and predictability

Screenshot: The real-time seasonal ENSO predictions made by linear inverse model (LIM) and model-analog technique.

https://www.psl.noaa.gov/forecasts/seasonal/
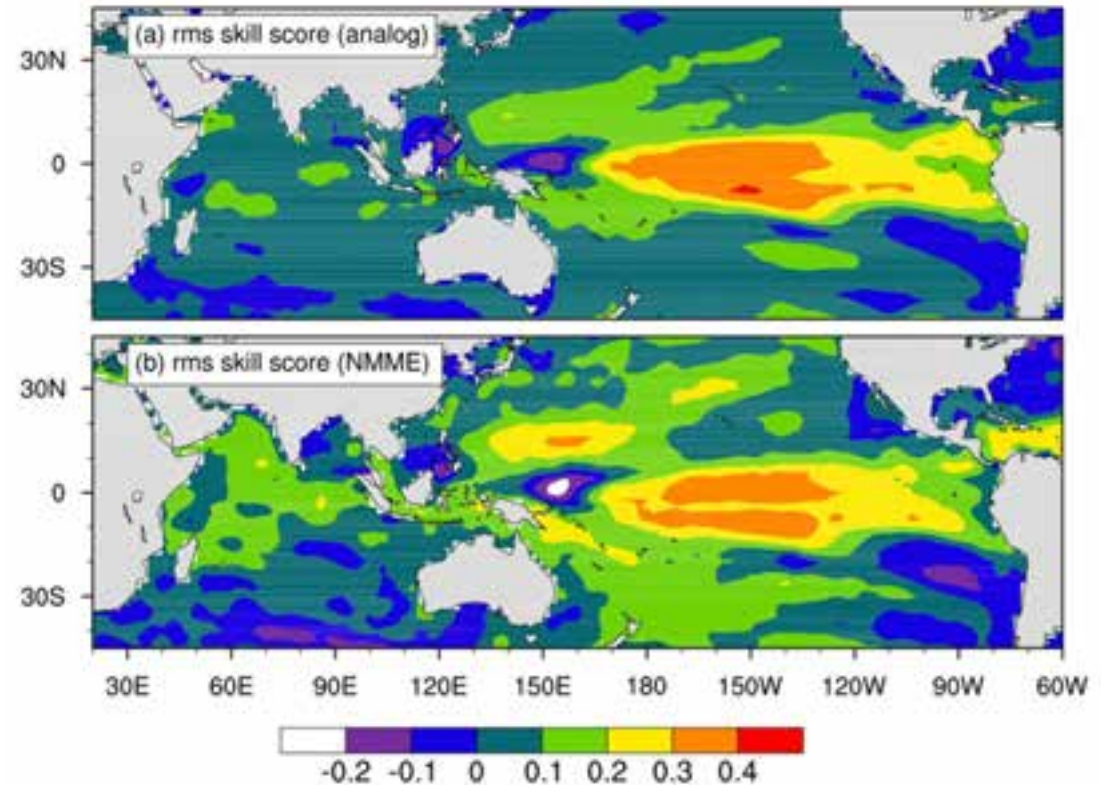
Ding et al. (2018; J Clim.)

Figure: Model-analog and NMME hindcast skills of monthly SSTa at 6-month forecast lead for the period of 1982-2015.

Multi-year variation of ENSO forecast skill since the late 1800s by using model-analog technique

Analog: if two atmospheric states resemble each other rather closely, each of the state can be viewed as equivalent to the other state plus reasonably small perturbations (Lorenz 1969).

Figure: Schematic of a model-analog forecasting system
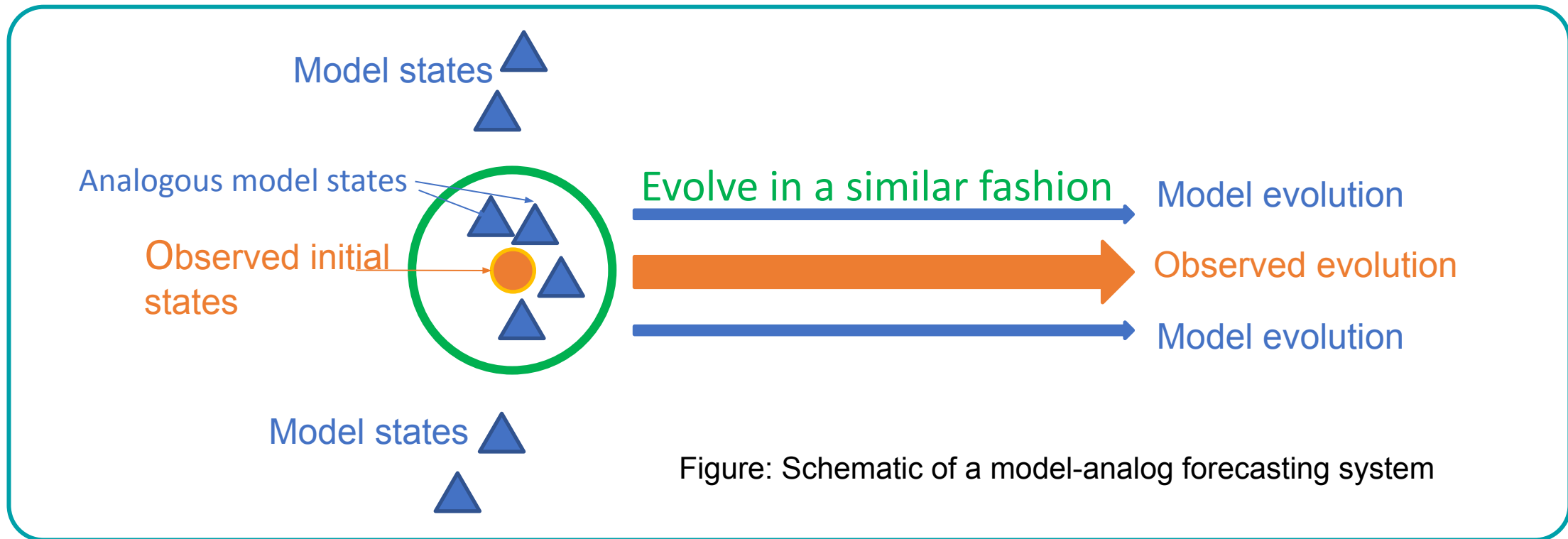
Advantages:
- **Construct model-analogs to estimate its own state (no initialization shock)**
- **forecasts with no additional integration needed (computationally cheap)**

Model-analog skill is comparable to skill from initialized model (ECMWF SEAS-5) since 1900

CMIP6 **model-analog** forecasts

Initialized seasonal hindcast experiments for the 20th century, produced using a version of the ECMWF's Integrated Forecasting System (IFS). [Weisheimer et al. (2022; GRL)]
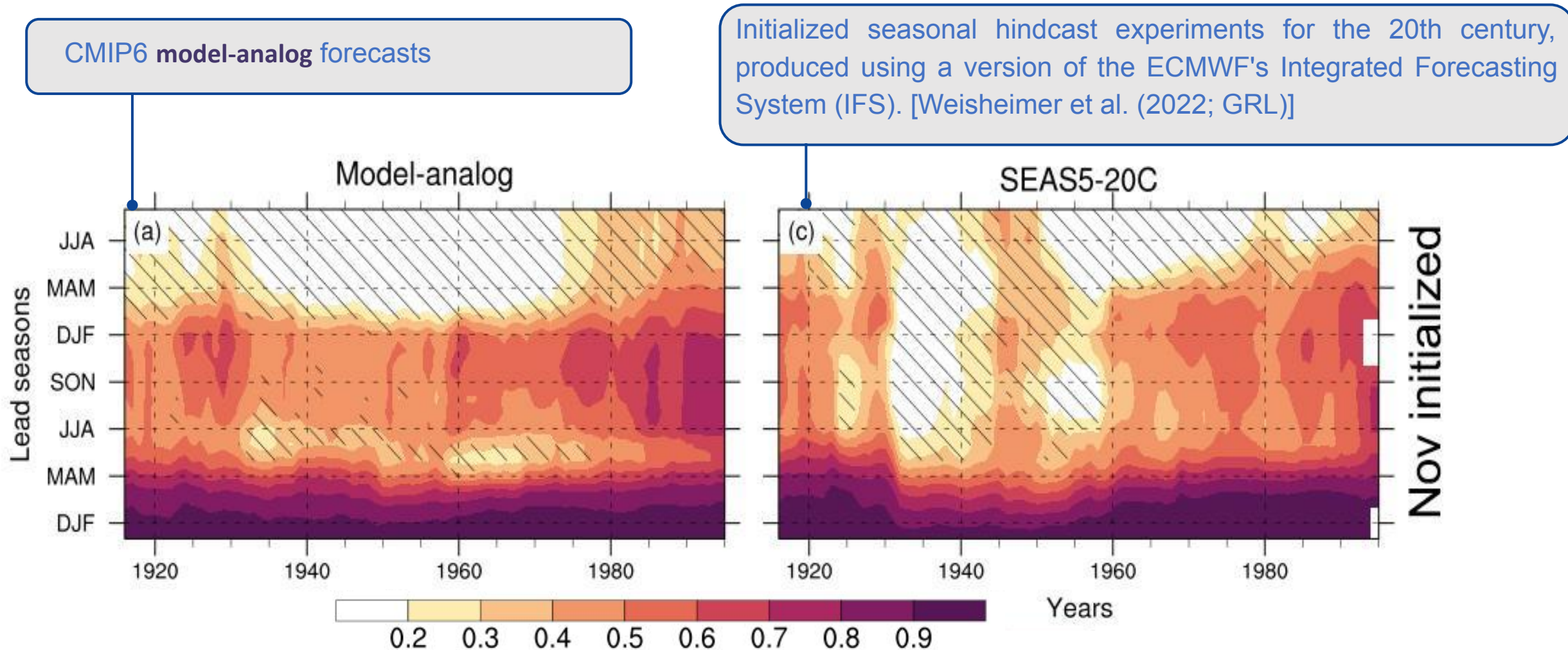

Figure: Seasonal mean AC skill of NINO3.4 predictions as a function of hindcast period on the horizontal axis and forecast lead time on the vertical axis.
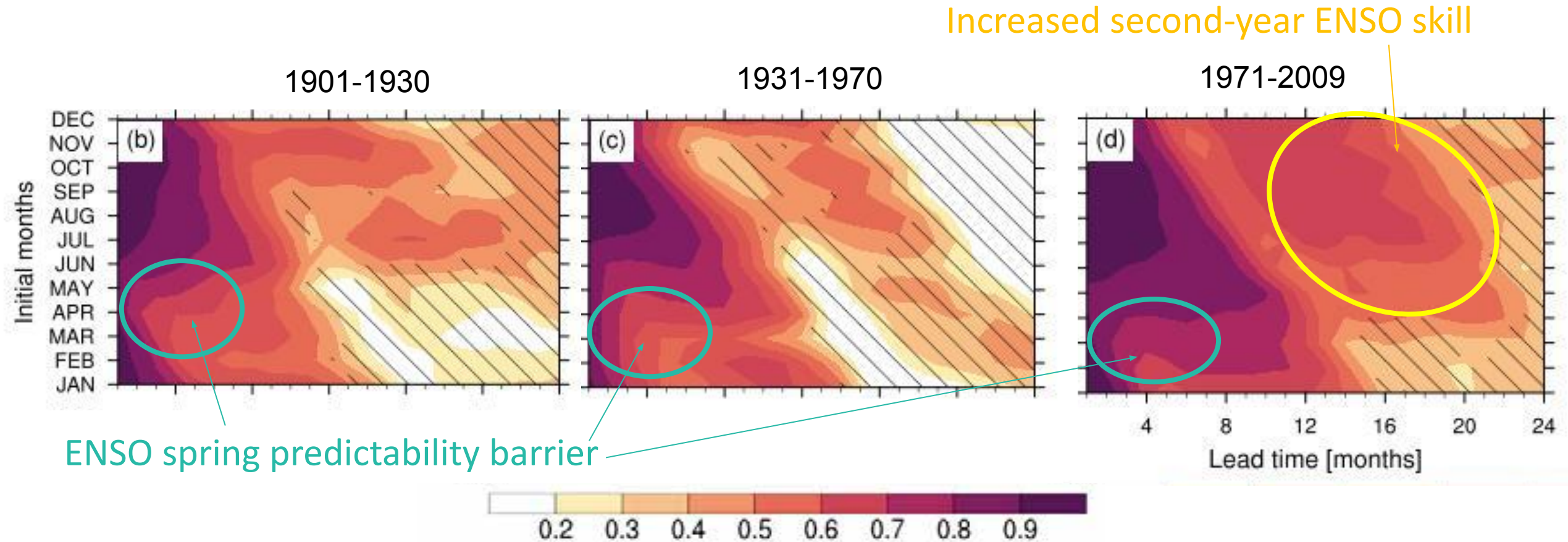
ENSO skill underwent seasonal variation

Figure: AC skill of NINO3.4 predictions as a function of lead times on the horizontal axis and initial months on the vertical axis for three subperiods of 1901-1930, 1931-1970, and 1971-2009, respectively.

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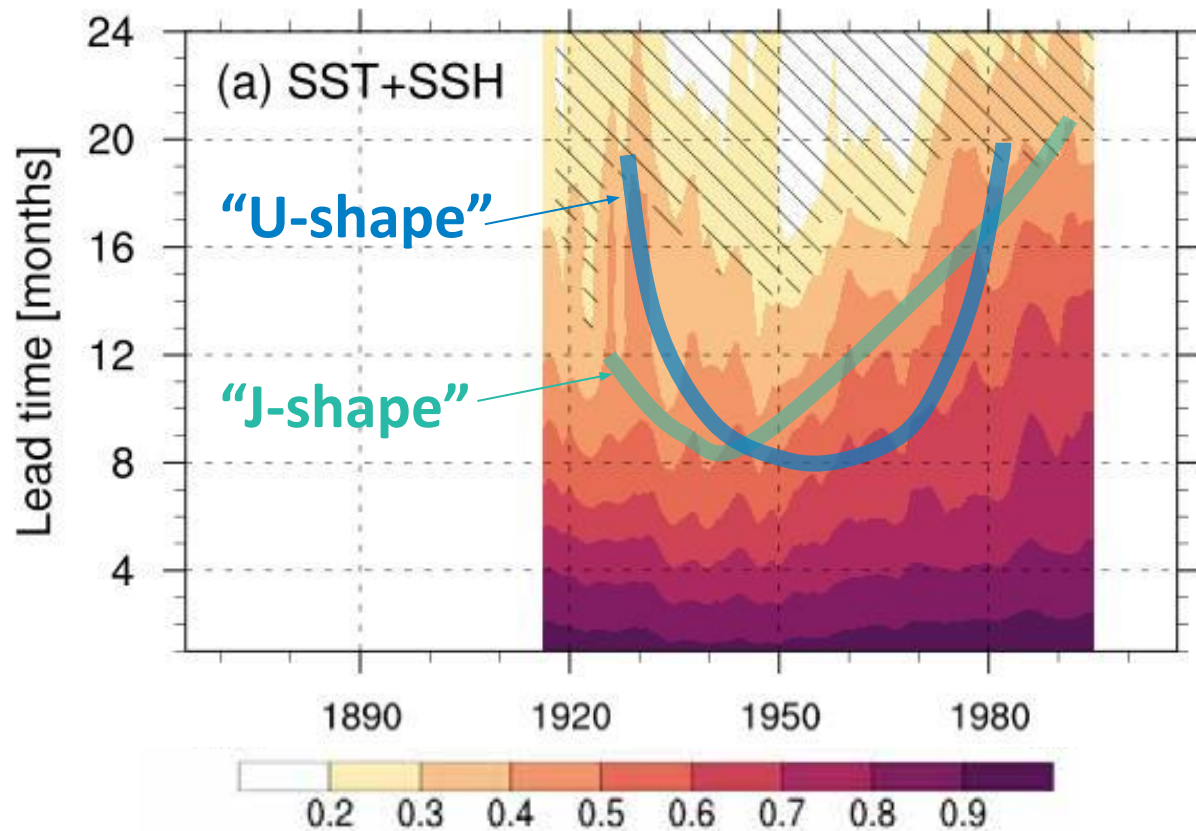# AC skill of ENSO predictions underwent multi-decadal variations

Figure: AC skill evolution of NINO3.4 predictions as a function of lead times and hindcast periods.
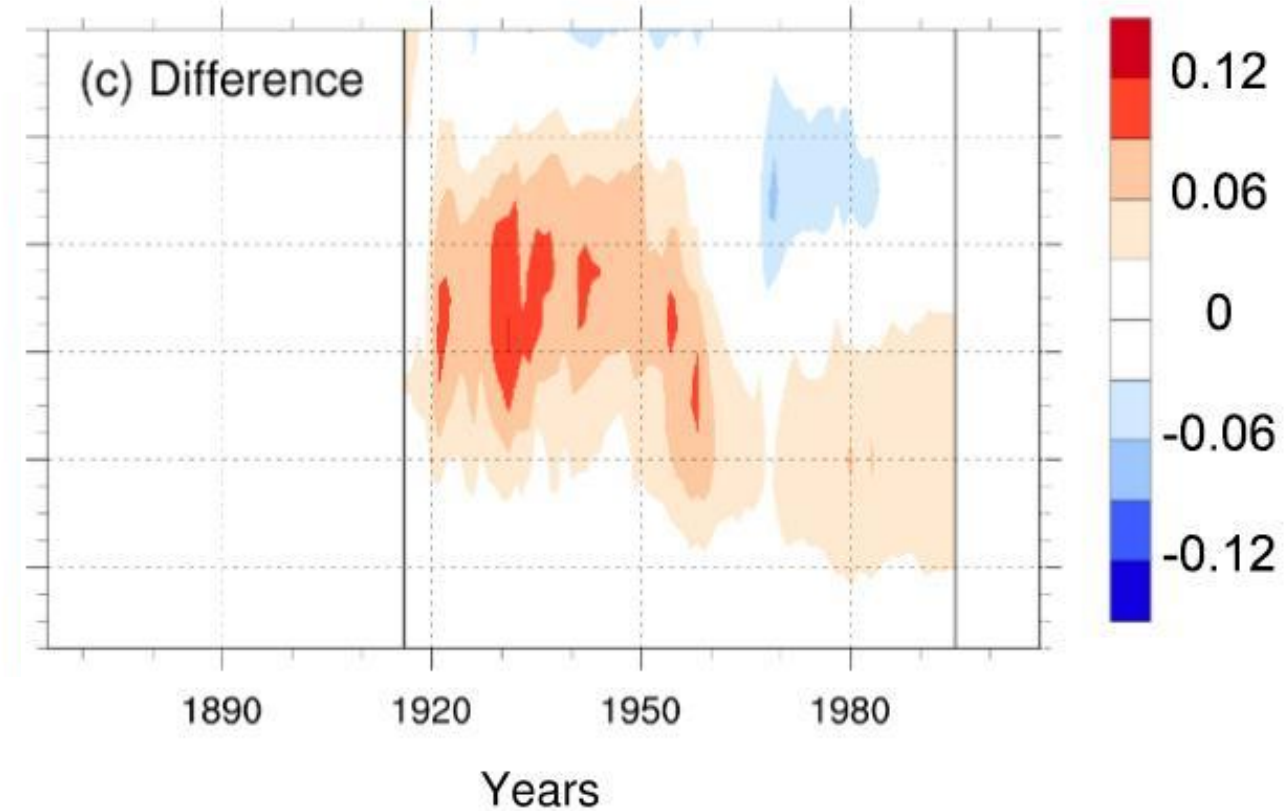
Figure: AC skill difference between SST+SSH experiment and SST-only experiment.

There was no significant difference between probabilistic predictions of El Niño vs. La Niña events.

ROC score: hit rate vs. false alarm rate

ROC score = 1   Perfect score
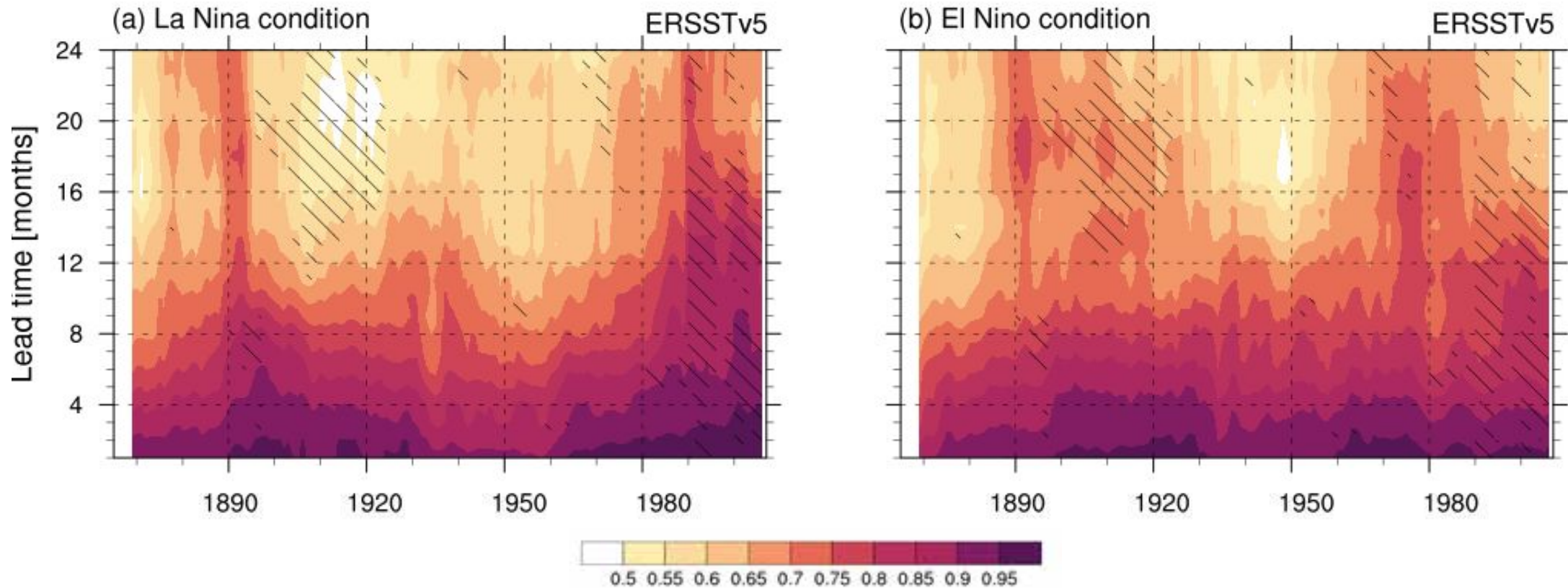ROC score < 0.5   No skill

Figure: Predictive relative operating characteristic (ROC) area evolution for (a) La Niña condition and (b) El Niño condition based on NINO3.4 time series over the 30-year moving hindcast windows.

There was no significant difference between probabilistic predictions of +eqSOI vs. -eqSOI.

Sea level pressure (SLP) being an independent validation of our model-analog forecasts
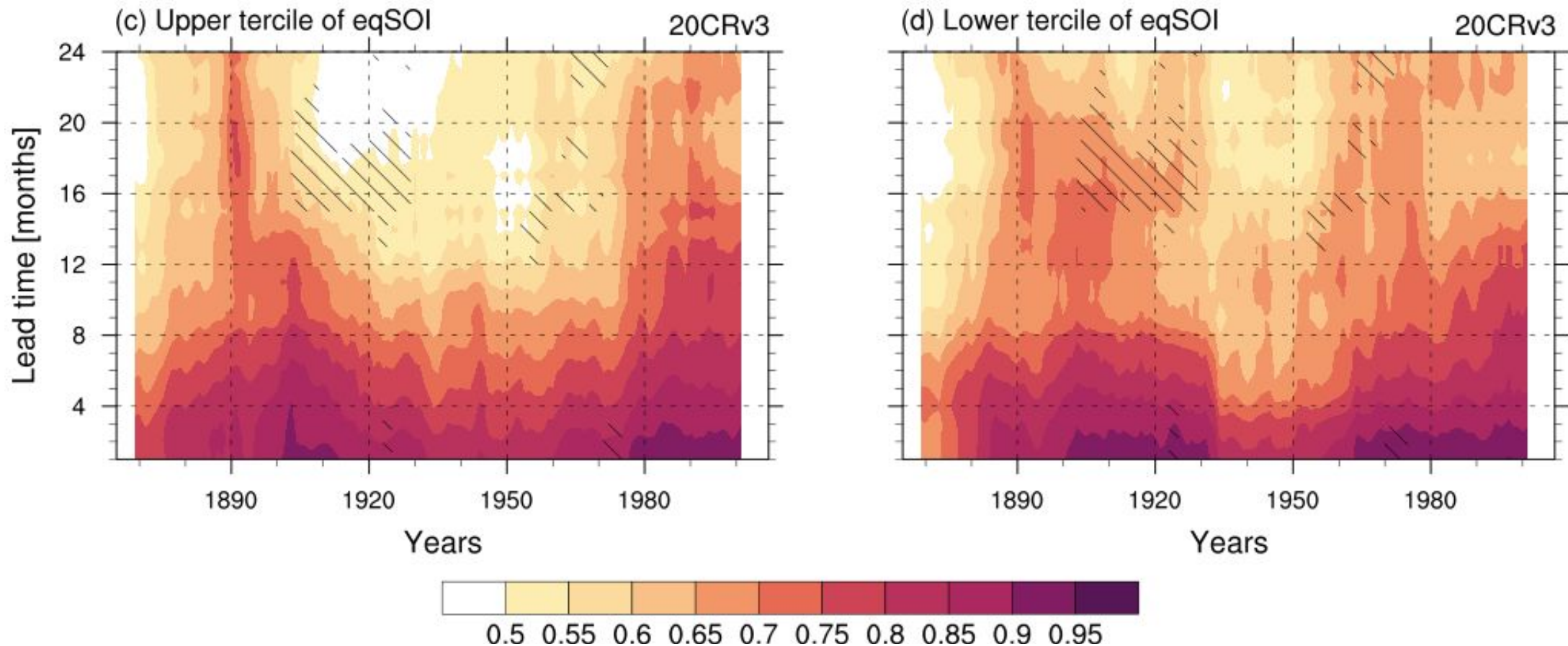

Figure: Predictive relative operating characteristic (ROC) area evolution for (a) La Niña condition and (b) El Niño condition based on equatorial SOI time series over the 30-year moving hindcast windows.

Summary

Conclusions:

- Seasonal ENSO forecast skill made by model-analog technique is **comparable** to traditionally assimilation-initialized hindcasts made twice-yearly by the ECMWF SEAS5 forecast system.
- ENSO forecast skill underwent **multi-decadal variations** with the minimum skill in the middle of 20th century;
- There was **no long-term skill trend** of ENSO predictions since the late 1800s;
- There was **no significant difference** between probabilistic predictions of El Niño vs. La Niña events.

Ongoing work:

- Understanding what caused the increased second-year ENSO skill in the late 20th century.