SEAS5-20C: Biennial (24-month long) hindcasts for the 20th Century

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Motivation

Skill in predicting ENSO in ECMWF's seasonal forecasting system SEAS5 is very high (*Johnson et al., 2018*) which raises the question whether we can predict ENSO beyond the first year. Here, we use ECMWF's reanalyses of the 20th Century ERA-20C, CERA-20C and ORA-20C to initialise 24-month re-forecasts covering the hindcast period 1901 to 2010.

Motivated by previous work on multi-decadal variability of seasonal forecast skill during the 20th Century (*Weisheimer et al., 2017; O'Reilly et al., 2017; Weisheimer et al., 2018*), we will be exploring how the predictability of ENSO varies throughout the hindcast period.

ENSO performance in 1981-2010

mean state

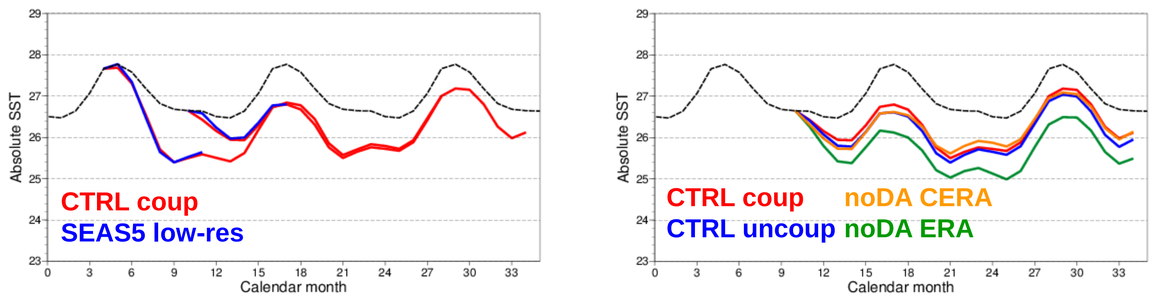

Fig 1: Nino3.4 SST mean states 1981-2010 in SEAS5-20C. Observed SSTs from ERA-20C in black.

- Initial drift in SEAS5-20C is very similar to (low-resolution) SEAS5
- Impact of data assimilation (coupled/uncoupled/no) on drift is small
- Larger cold bias with ERA-20C forcing of the initial ocean state compared with CERA-20C forcing

RMSE and ensemble spread

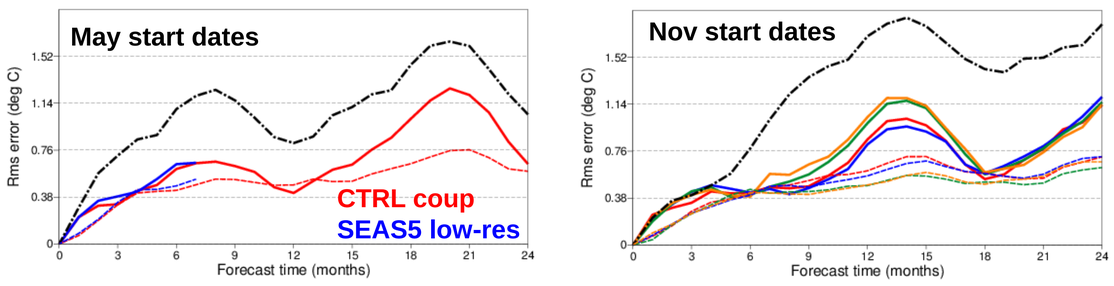

Fig 2: Forecast RMSE (solid) and ensemble spread (dashed) over lead time during 1981-2010. Persistence RMSE in black.

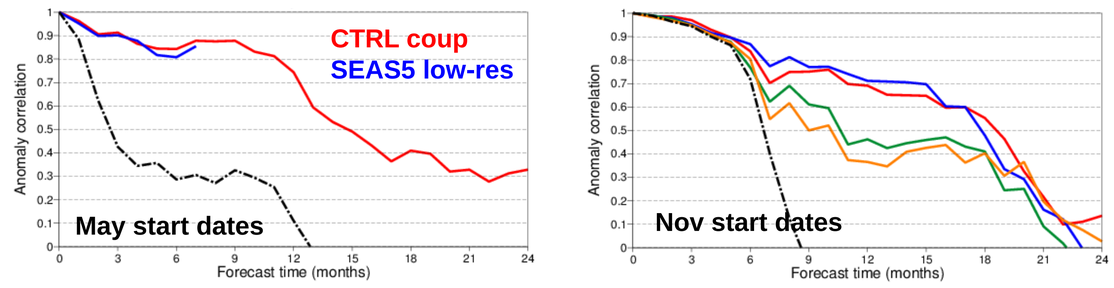

Fig 3: Anomaly correlation over lead time during 1981-2010. Persistence in black.

- Forecast performance of SEAS5-20C as good as (low-resolution) SEAS5
- Discernible positive impact of ocean DA from month 6 (after first spring barrier) to month 18 (second spring barrier): reduced forecast RMSE, increases ensemble spread and improves anomaly correlation

References

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Experiments

- Hindcasts with 24-month lead time for the hindcast period 1901-2010, ensemble size: 10 members
- Low-resolution configuration of SEAS5: $T_{co}199L91$ (ca. 50km) in the atmosphere and ORCA1Z42 (1 degree) in the ocean/sea-ice
- ECMWF's 20-th Century reanalyses used to initialise hindcasts:
  - CERA-20C: coupled atmosphere-ocean-land-sea-ice reanalysis (*Laloyaux et al., 2018*)
  - ERA-20C: atmosphere-land reanalysis (*Poli et al., 2016*)
  - ORA-20C: ocean reanalysis *(de Boisseson & Alonso Balmaseda, 2016*)

Experiment	Start dates	Atmospheric ICs	Ocean and sea-ice ICs	Initialisation
CTRL_coup	May and Nov 1901-2010	CERA-20C	CERA-20C	coupled data assimilation
CTRL_uncoup	Nov 1901-2010	CERA-20C	ORA-20C	uncoupled data assimilation
noDA_CERA	Nov 1901-2010	CERA-20C	CERA-20C-forced ocean run	no ocean data assimilation
noDA_ERA	Nov 1901-2010	CERA-20C	ERA-20C-forced ocean run	no ocean data assimilation

Decadal variability of ENSO forecast skill

mean state 1929-1958

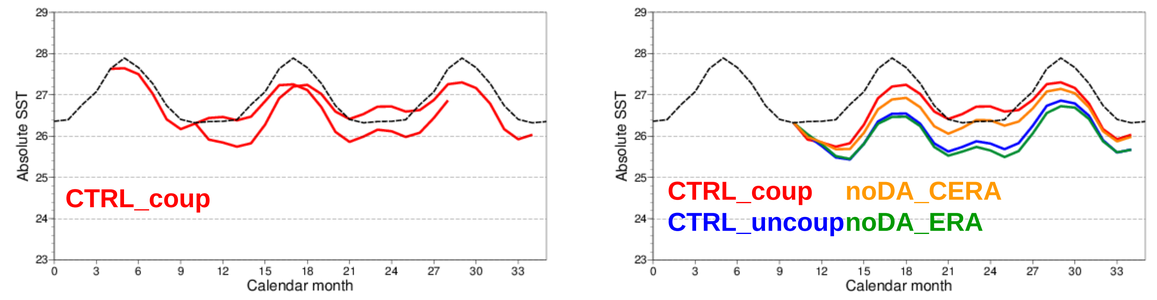


Fig 4: As Fig. 1 but for 1929-1958.

- Reduced cold bias in all model runs compared to 1981-2010 (Fig. 1)
- Larger annual cycle in observations

Varying seasonal forecast skill in the Century (month 2-4 DJF)

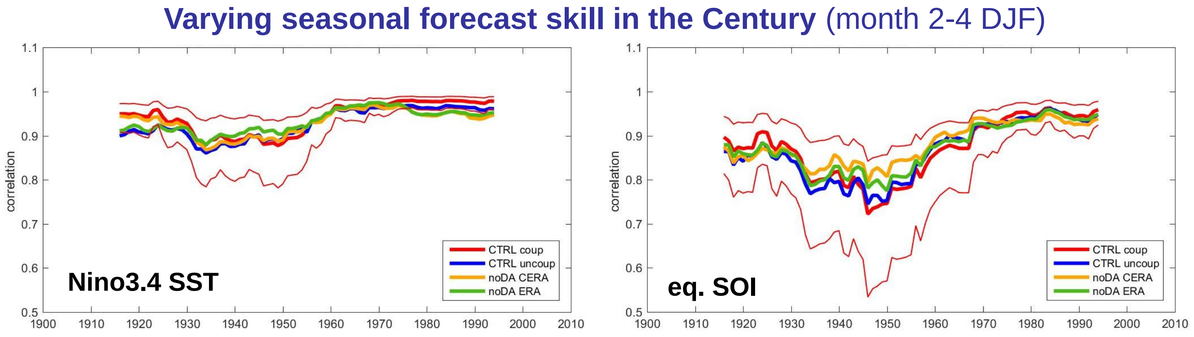
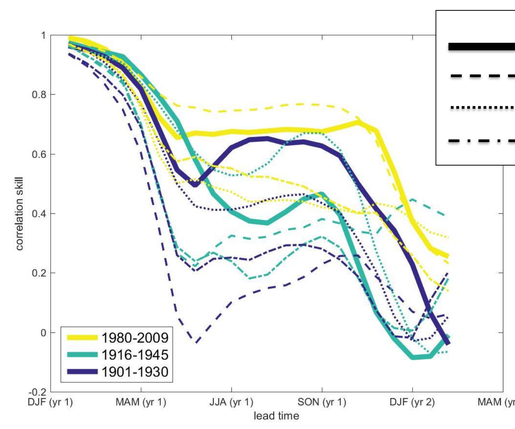


Fig 5: Moving window (30 yrs) anomaly correlation for Nino3.4 SST and the equatorial Southern Oscillation



- Skill during first spring season drops quicker and to lower level in earliest period compared to recent period, recovery to similar levels
- Skill drop for middle periods is slower but reaches significantly lower levels after first spring barrier
- Middle periods overall less skilful after 6 months
- ✓ **Substantial non-monotonic decadal variability of ENSO throughout the 20th Century**
- ✓ **Mid-Century periods shows drastic reduction in skill for a range of lead times**
- ✓ **Similar levels of skill for early and late periods**

Fig 6: Seasonal anomaly correlation of Nino3.4 SST for three different periods (in colours)

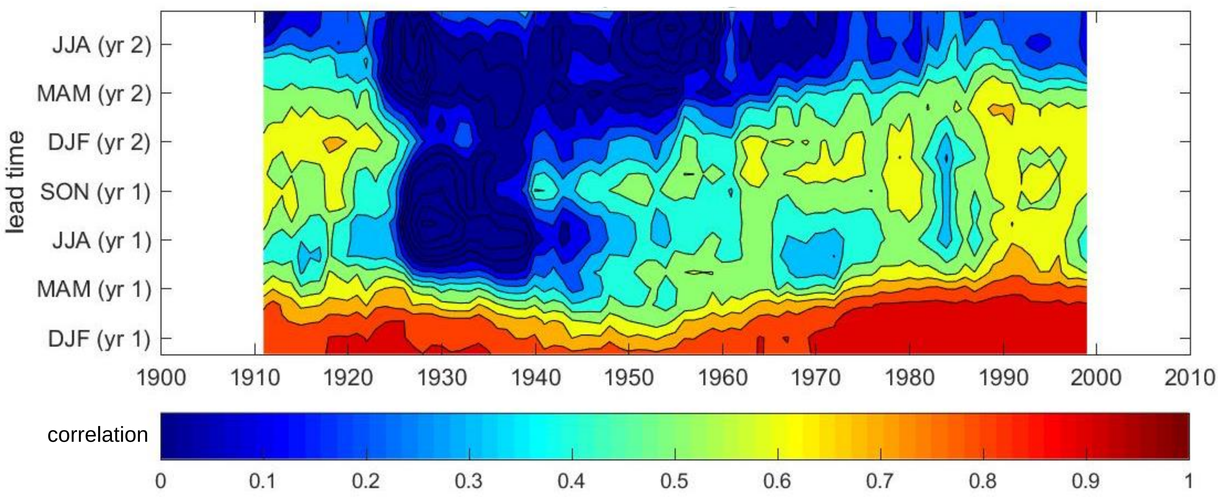


Fig 7: Moving window (20 yrs) anomaly correlation skill to predict the equatorial Southern Oscillation index over the 20th Century and as a function of lead time. Experiment CTRL coup.