# Horizontal resolution and seasonal predictability of Tropical Pacific variability

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## Seasonal climate predictions

**Seasonal to Decadal climate prediction** (S2DCP) is a field of research attracting growing interest beyond the scientific community due to its strong potential to guide decision-making in many sectors (e.g. energy production, agriculture) in the face of the pressing dangers of climate change (*Hermanson et al., 2022*).

There are several indications that **higher resolution** versions of the current generation of climate models might improve key air-sea teleconnections, decreasing common biases of global models and improving the skill to predict certain regions at seasonal scales, e.g. in tropical sea surface temperature (*Prodhomme et al. 2016*).

We assess **how the predictive skills change when the horizontal resolution is increased** and how these changes are related to the simulation of physical processes.

We use **two different Climate models** to better understand how the development of model-specific biases can impact predictive skills. We focus on the Tropical Pacific as it is a major source of Seasonal Predictability thanks to the influence of ENSO.

## Experimental approach

We use two different models, EC-Earth3 (*Döscher et al., 2021*) and CNRM-CM6.1 (*Voldoire et al., 2019*) in their Atmosphere-Ocean configurations. We compare their predictions at two different resolutions, standard (SR) and high (HR) resolutions. We performed two sets of seasonal retrospective hindcasts (initialised in Nov. and May) with each resolution configuration. Each set covers the hindcast period **1993-2014**, has **20 members** and a forecast length of **6 and 8 months** for CNRM-CM6 and EC-Earth3 systems respectively. We focus on the May initialisation in this analysis.

| | Components | Resolution SR | HR | Atmospheric initialisation | Oceanic initialisation |
|---|---|---|---|---|---|
| EC-Earth3 | IFS cy36r4<br>NEMO v3.6 — Oasis<br>LIM3 | 80<br>100 | 40<br>25 | ERA5 | in-house reconstruction (NEMO3.6 based) |
| CNRM-CM6.1 | Arpège v6<br>NEMO v3.6 — Oasis<br>Gelato v6 | 130<br>100 | 50<br>25 | ERA-interim<br>ERA5 | Glorys2v4<br>Glorys12v1<br>(NEMO-based) |

**TAB. 1.** Model components (2nd column) and the corresponding horizontal resolution (3rd column) of the two models used, EC-Earth3 and CNRM CM6.1. The respective atmospheric (4th column) and oceanic (5th column) initial conditions used for each prediction system are summarised.

## Impact of the horizontal resolution on the Tropical Pacific prediction skill

Both HR models seem to improve the skill in the central pacific, which manifests in improved skill for Niño3.4 index

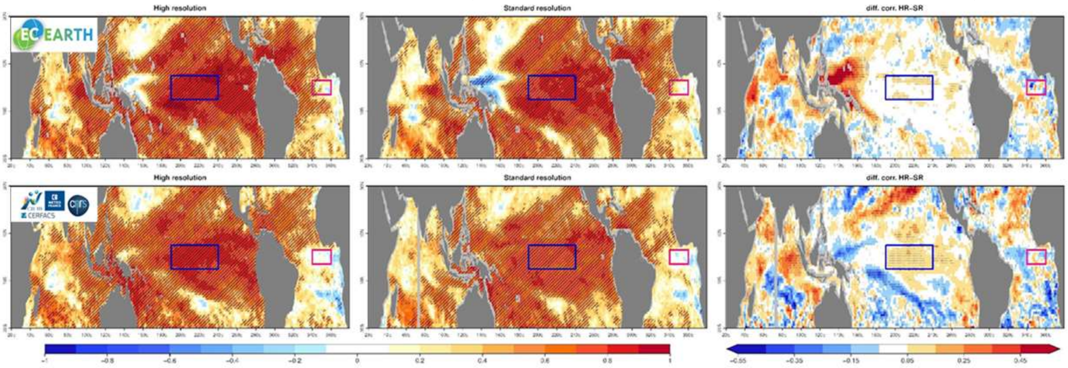


**FIG.1.** Maps of Anomaly Correlation Coefficient (ACC) for the second forecasted season (August-September-October) of sea surface temperatures (SST) for (top) EC-Earth3 and (bottom) CNRM-CM6.1 forecast system initialised in May. The left column corresponds to the HR version of each model, the middle one to the SR version and the right column shows the difference in correlation between HR and SR. In the right column, red indicates an improvement in the skill with increased resolution, blue indicates a degradation of the skill. The reference dataset is ERA5 reanalysis. The ACC has been computed over the 1993-2014 period for each individual grid point after interpolation to a regular 1º grid. Dashes indicate that the values are statistically significant at the 95% level. The blue box is the Niño 3.4 region, the pink box is the Atlantic Niño region.

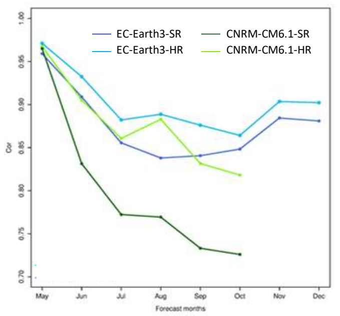


**FIG. 2.** Anomaly Correlation Coefficient (ACC) skill score in the Niño3.4 region as a function of forecasted month for (dark blue) EC-Earth3-SR, (light blue) EC-Earth3-HR, (dark green) CNRM-CM6.1-SR, (light green) CNRM-CM6.1-HR forecast systems. The reference dataset is the ESA SST CCI dataset.

## Is the improvement in ENSO skill coming from the Atlantic Niño teleconnection?

Summer Atlantic Niños favour the development of Pacific Niñas the following winter and vice versa (Rodríguez-Fonseca et al. 2009, Ding et al. 2012).

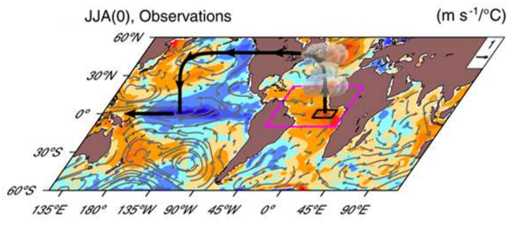


**FIG. 3.** From Cai et al. (2019). Observed 1980-2005 SST and 850 hPa wind anomalies in JJA(0) – before the peak of a La Niña event – regressed onto a basin-wide SST index over the tropical Atlantic (10S-20N, 60W-10E, pink box) in MAMJJA(0).

The correlation between the peak of Atlantic Niños (JJA) and different phase of the development of a Niña event (FIG. 4) is negative in the observations (black), as expected linking warm (cold) summer Atlantic events with the later occurrence of cold (warm) winter ENSO events. The models underestimate the teleconnection strength, some of them don't simulate any teleconnection.

The improvement in the predictive skill in the ENSO region can come either from (1) better skill in ATL3 which impacts the ENSO region without any change needed in the teleconnection itself, (2) a better teleconnection that transfer the predictability from ATL3 into the ENSO region even without changes in skill in ATL3, or (3) both.

FIG. 4 and FIG. 5 suggest that it's the second case for EC-Earth3-HR and none of them for CNRM-CM6.1.

**The better simulation of the teleconnection between the Atlantic Niño/a and the following ENSO event in EC-Earth3-HR can partly explain the improvement in ENSO predictive skill in this model.**

*Due to an improved ATL3-Niño teleconnection?*

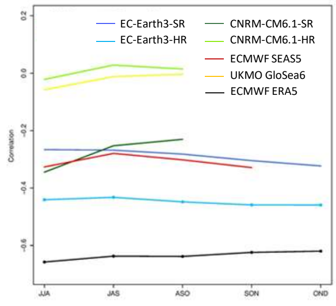


**FIG. 4.** Correlation between Atlantic Niño (3S-3N, 20W-0) SSTA in JJA and Niño3.4 SSTA for 3 forecast months running mean for (dark blue) EC-Earth3-SR, (light blue) EC-Earth3-HR, (dark green) CNRM-CM6.1-SR, (light green) CNRM-CM6.1-HR, (red) ECMWF SEAS5 and (orange) Met Office GloSea6 forecast systems. The black line is ECMWF ERA5 reanalysis.

*Due to improved ATL3 skill?*

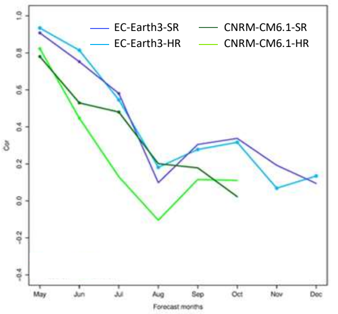


**FIG. 5.** Anomaly Correlation Coefficient (ACC) skill score in the Atlantic Niño region as a function of forecasted month for (dark blue) EC-Earth3-SR, (light blue) EC-Earth3-HR, (dark green) CNRM-CM6.1-SR, (light green) CNRM-CM6.1-HR forecast systems. The reference dataset is the ESA SST CCI dataset.

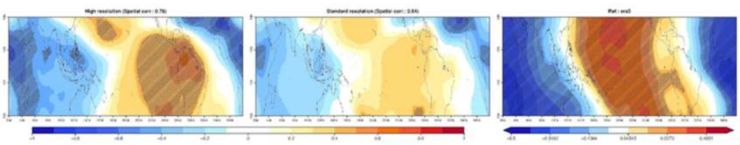

**FIG.6.** Correlation pattern between the JJA Atlantic Niño/a region index and the JJA velocity potential at 200 hPa for (left) EC-Earth3-HR, (middle) EC-Earth-SR and (right) the reference dataset, ERA5. Dashes indicate that the values are statistically significant at the 95% level.

**Stay Tuned**

Upcoming release of a multi-year (3 years) climate prediction system with EC-Earth3:

- Nov init.: 1960-2021, SR and HR, 20 and 15 members
- May init.: 1980-2021, SR and HR, 20 and 15 members

## References

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