ENSO and Trade Wind Charging: a multi-model evaluation
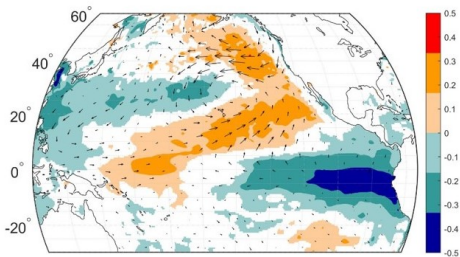
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TWC

The Trade Wind Charging (TWC) consists of North Pacific Oscillation-induced wind-stress anomalies in the northern extratropics.
In the figure to the left (obtained from SODAsi.3 over the interval 1960-2011) one can see the characteristic signature of the westerly anomalies in the central portion of the ocean, north of the Equator.

The questions that guide this project:

- ▶ are state of the art models able to reconstruct the TWC mechanism and its relationship with ENSO?
- ▶ does model resolution have an impact?
- ▶ is this relationship stationary?

Data

HighResMIP
> High Resolution Model Intercomparison Project
> we use the **control-1950** experiment: CO_2 is constant, at
> 1950's concentration, 1950-2050

SODAsi.3
> Simple Ocean Data Assimilation reanalysis, 1871-2011
> (SODA henceforth)

Model ID	ocean res	atmospheric res	
CMCC-CM2-HR4	25km	100km	LR
CMCC-CM2-VHR4	25km	25km	HR
CNRM-CM6-1	100km	100km	LR
CNRM-CM6-1-HR	25km	50km	HR
MPI-ESM1.2-HR	40km	100km	LR
MPI-ESM1.2-XR	40km	50km	HR
ECMWF-IFS-LR	100km	50km	LR
ECMWF-IFS-MR	25km	50km	MR
ECMWF-IFS-HR	25km	25km	HR
EC-Earth3P	100km	80km	LR
EC-Earth3P-HR	25km	40km	HR

Method

The analysis follows 3 steps:

  Seasonal means of zonal wind stress τ_x (NDJF) and SST (NDJ) anomalies (1 year lag)

  EOF analysis to isolate modes of highest variability
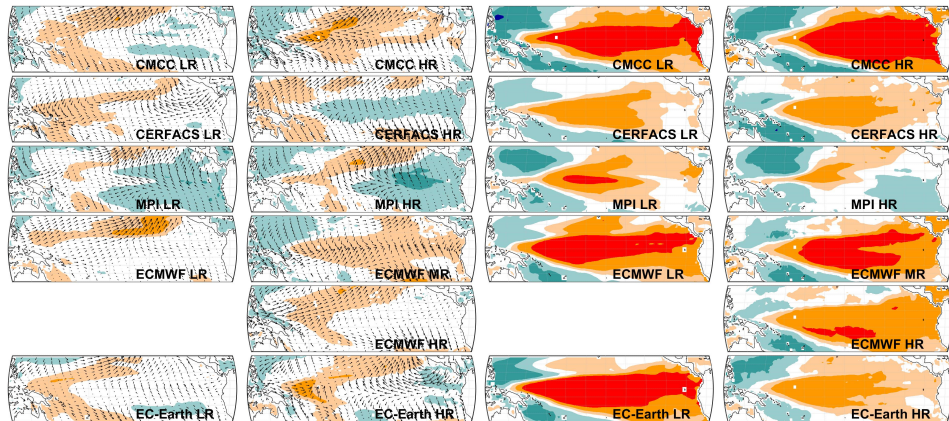
  CCA on a subset of EOF's

First couple of Canonical Variable ($CV^1_{\tau_x}(t-1)$, CV^1_{SST}) captures the most strongly coupled modes of τ_x and succeeding SST.

τ and SST anomalies regressed against CV^1's

$$CV^1_{\tau_x}(t-1) \qquad\qquad CV^1_{SST}(t)$$

τ and SST anomalies regressed against CV^1's

The plots on the right-hand side clearly share strong resemblance to the pattern of a characteristic positive ENSO.
The left-hand side instead shows the state of the ocean 1 year before the positive ENSO state. In the central extra-tropics, in the Northern Hemisphere, one can see different flavors of the TWC westerly anomalies that we showed in the SODA reconstruction.
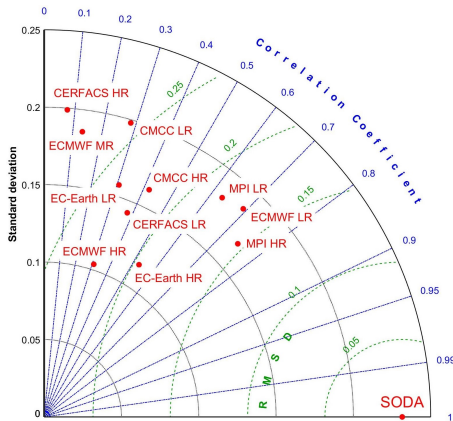
Taylor Diagram

Figure: Taylor diagram of the zonal component of TWC (TWC_x) over the region [5N - 20N][165E - 240E]. The point of reference is TWC_x of SODA for the interval 1960-2011.
Correlation for CERFACS HR, ECMWF MR not significant at $\alpha = 0.05$.
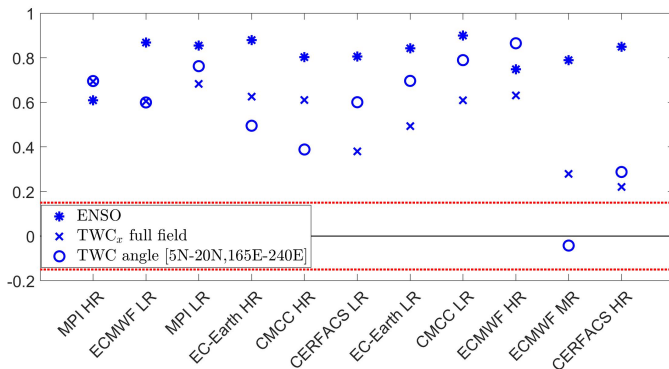
Further Indicators

Figure: On the x-axis, models and resolutions ranked according to the Taylor Diagram of the zonal component of TWC (TWC_x) over the region [5N - 20N][165E - 240E]. Along the y-axis, correlations against SODA 1960-2011. In red, the interval of significance.
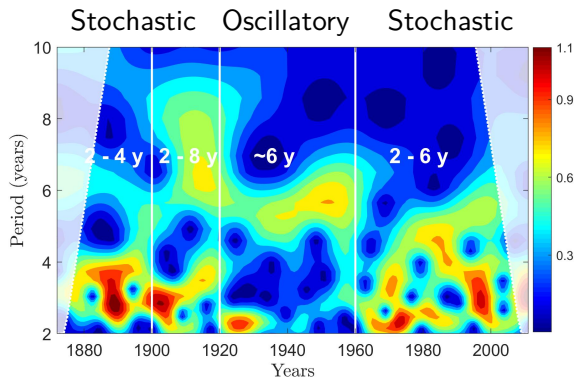
Internal Variability of ENSO

Figure: Continuous Wavelet Transform on the Niño 3.4 index of SODA 1871-2011. We identified intervals, longer than 10 years, that present different frequency patterns. The analysis is repeated for all models and resolutions and summarized in the following table.

Internal Variability

Model ID	res	2-4 y	4-6 y	2-6 y	2-8 y	single freq band
SODA	-	✓		✓	✓	$\sim$ 6 y
CMCC	LR	✓		✓		$\sim$ 4 y
	HR	✓		✓		
CERFACS	LR	✓				$\sim$ 3 y
	HR	✓		✓		$\sim$ 3 y, $\sim$ 5 y
MPI	LR	✓	✓	✓	✓	
	HR	✓			✓	$\sim$ 6 y
ECMWF	LR			✓	✓	$\sim$ 3 y
	MR	✓		✓	✓	
	HR	✓		✓		
EC-Earth	LR			✓		
	HR	✓		✓	✓	$\sim$ 5 y

Preliminary conclusions:

► Most models analyzed thus far are able to reconstruct TWC

► The different resolutions do not appear to play an important role in the models' ability to reconstruct TWC

► The ENSO signal has a non-stationary oscillation in most experiments

Forthcoming step:

► Understand whether the non-stationarity of ENSO's oscillation is reflected in its coupling with TWC, as seen in SODA