ENSO amplitude uncertainty under global warming in CMIP5 models

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Session CL4.20 - Thursday, 07 May 2020, 14:00-15:45
ENSO and Tropical Basins Interactions: Dynamics, Predictability and Modelling

Definitions

ENSO amplitude:	Uncertainty:
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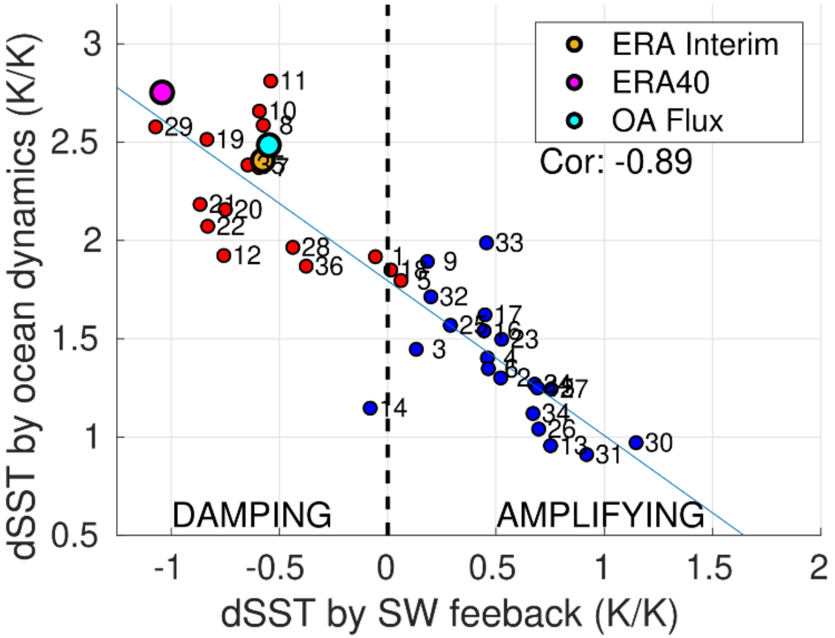
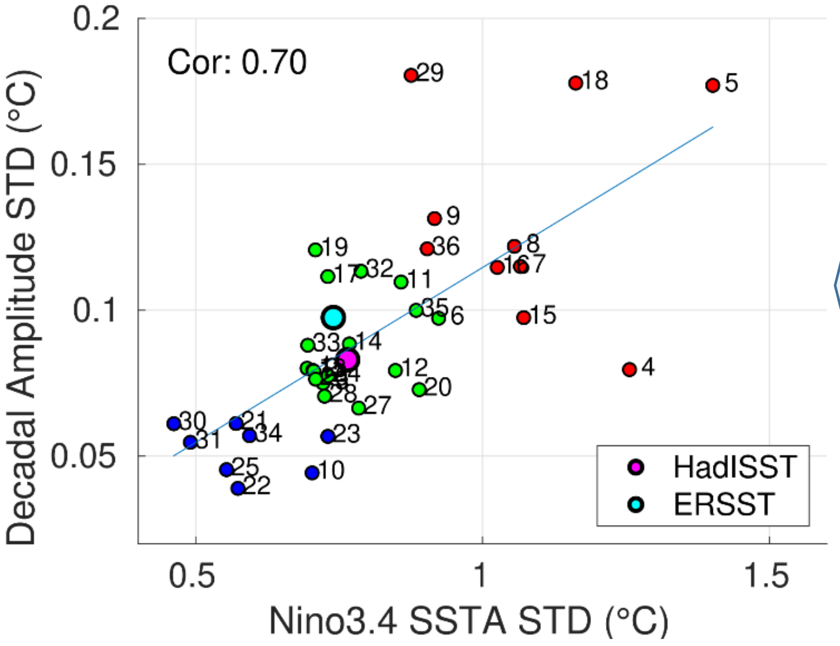
Data:

		RCP 4.5	RCP 6.0	RCP 8.5
1	ACCESS1.0	X		X
2	ACCESS1.3	X		X
3	BCC-CSM1.1	X	X	X
4	BCC-CSM1.1(M)	X	X	X
5	BNU-ESM	X		X
6	CanESM2	X		X
7	CCSM4	X	X	X
8	CESM1(BGC)	X		X
9	CESM1(CAM5)	X	X	X
10	CMCC-CM	X		X
11	CMCC-CMS	X		X
12	CNRM-CM5	X		X
13	CSIRO-Mk3.6.0	X	X	X
14	FGOALS-g2	X		X
15	FGOALS-s2			X
16	GFDL-CM3	X	X	X
17	GFDL-ESM2G	X	X	X
18	GFDL-ESM2M	X	X	X
19	GISS-E2-H	X	X	X
20	GISS-E2-H-CC	X		X
21	GISS-E2-R	X	X	X
22	GISS-E2-R-CC	X		X
23	HadGEM2-CC	X		X
24	HadGEM2-ES	X		
25	INM-CM4	X		X
26	IPSL-CM5A-LR	X	X	X
27	IPSL-CM5A-MR	X	X	X
28	IPSL-CM5B-LR	X		X
29	MIROC5	X	X	X
30	MIROC-ESM	X	X	X
31	MIROC-ESM-CHEM	X	X	X
32	MPI-ESM-LR	X		X
33	MPI-ESM-MR	X		X
34	MRI-CGCM3	X	X	X
35	NorESM1-M	X	X	X
36	NorESM1-ME	X	X	X





36 CMIP5 climate models divided into sub-ensembles:

Feedback strength:

Models with unrealistic positive shortwave feedback (blue dots) are separated from models with realistic ENSO dynamics (**"Strong Feedback Model"**, red shading on the list, red dots on the figure)

ENSO decadal variability:

Models with high/low decadal ENSO amplitude variability (red/blue dots), and with realistic ENSO amplitude (green dots) are included in **"High", "Low" and "Real"** sub-ensembles, respectively

ENSO amplitude projection: long-term trend of the ENSO amplitude estimated with the 2nd order polynomial fit.

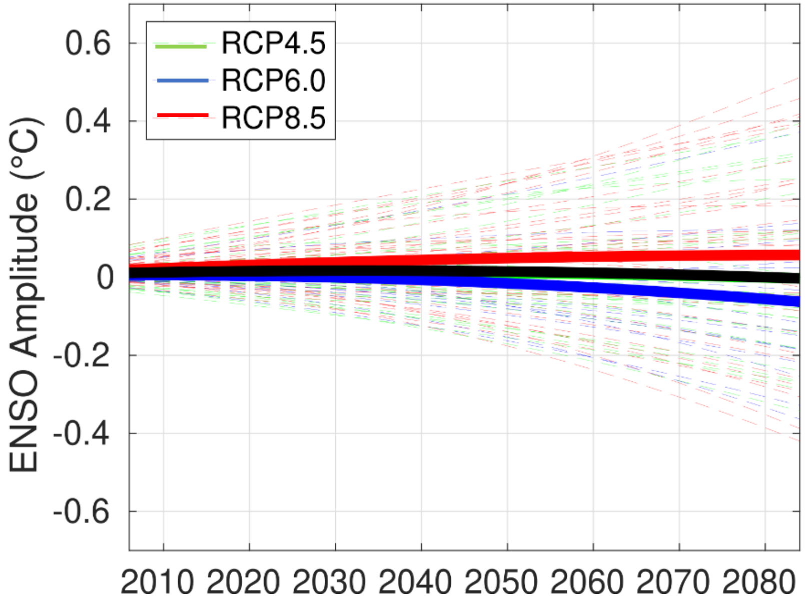
The difference between the ENSO amplitude time series and the polynomial fit is defined as internal (decadal) variability.

<u>All models:</u>
- Strong **disagreement** on ENSO amplitude projection with the mean signal close to zero (black thick line)
- Individual projections for the change in amplitude by the end of the 21st century disagree in a range from -0.4 to +0.5

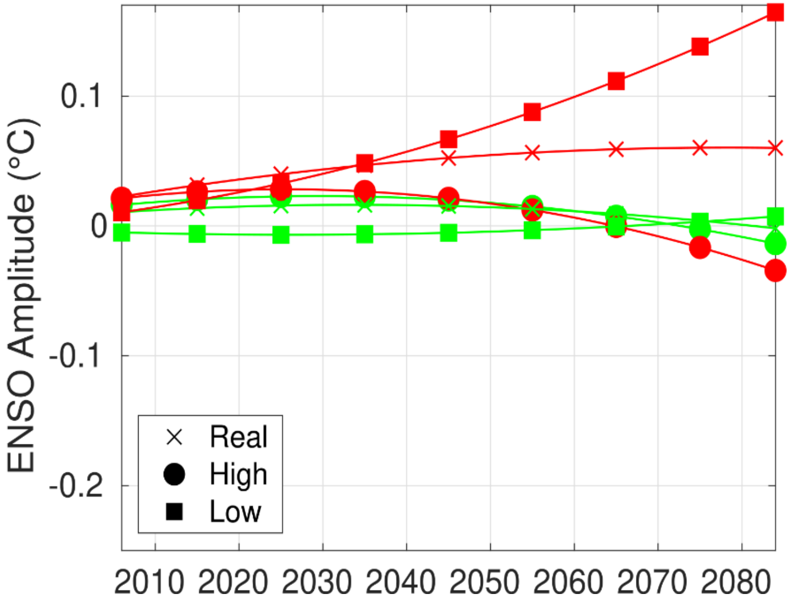
<u>Amplitude Sub-ensembles:</u>
- **Disagreement** for High, Low and Real sub-ensemble members using RCP4.5 scenario
- Low and Real sub-ensemble means project an **increase** of the ENSO amplitude for the RCP8.5 scenario

<u>Strong Feedback Sub-ensemble:</u>
- Low and Real sub-ensemble means project an **increase** of the ENSO amplitude
- The High sub-ensemble mean projects a **decrease**
- Both cases are **consistent** with RCP4.5 and RCP8.5 scenarios

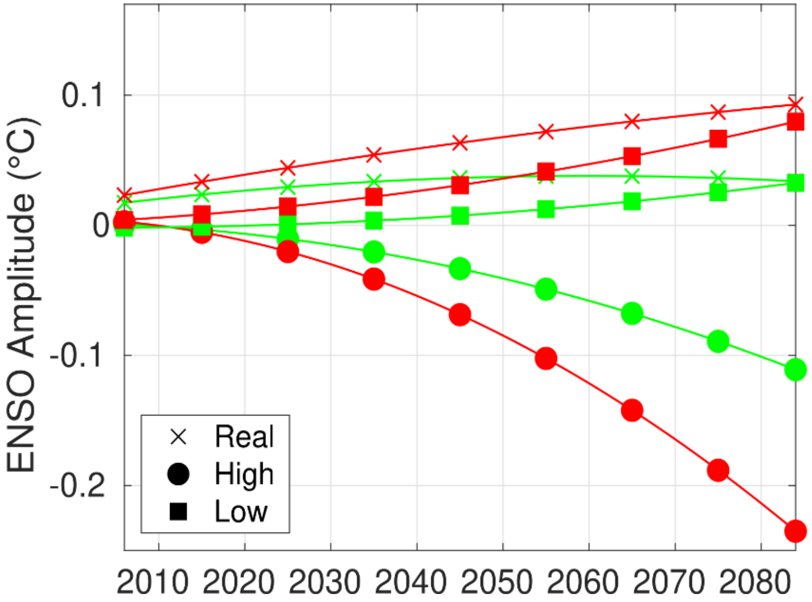
36 MODELS

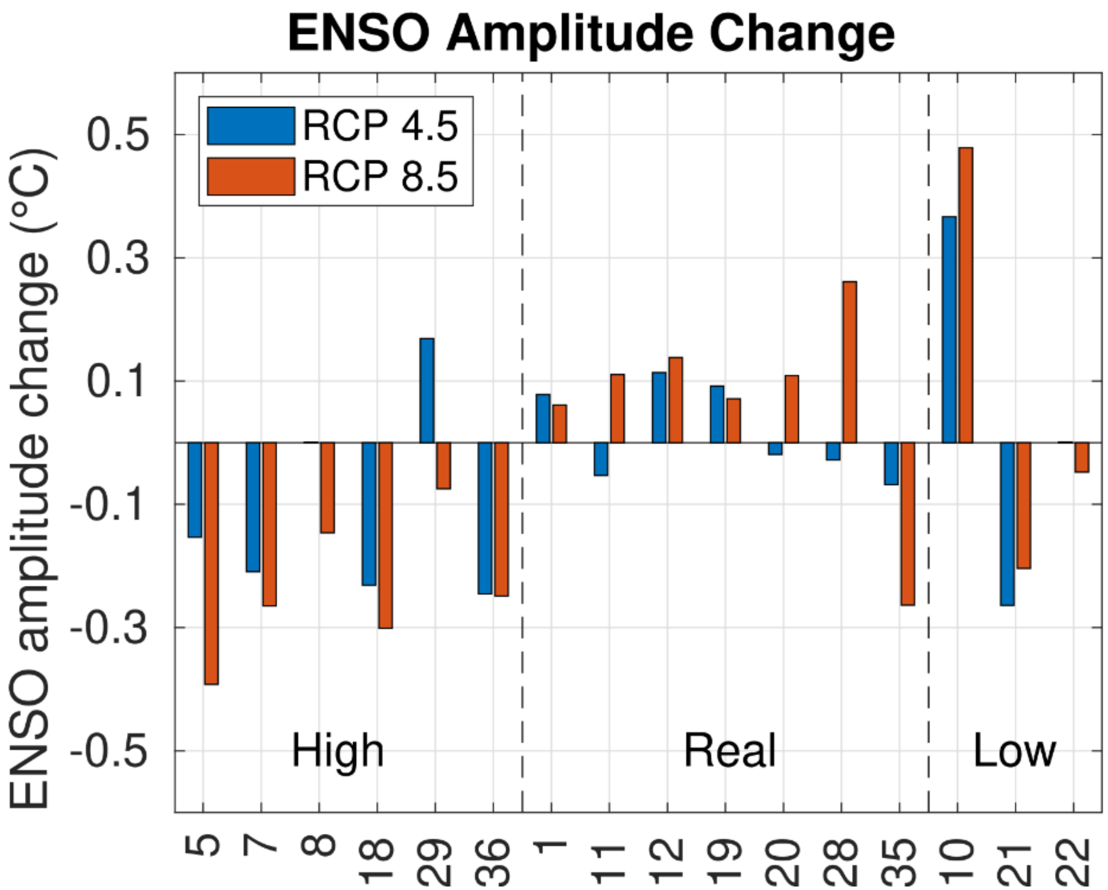


36 MODELS IN 3 SUB-ENSEMBLES



STRONG FEEDBACK SUB-ENSEMBLE IN 3 SUB-ENSEMBLES





Relatively strong **agreement** for realistic ENSO dynamics models and High/Real sub-ensembles on representing the change of the ENSO amplitude (between the end of the 21st century and 2005):

- General agreement between high decadal ENSO variability and realistic ENSO dynamic models, projecting a **decrease** of the ENSO amplitude

- General agreement between realistic ENSO amplitude and dynamic models, projecting an slight **increase** of the ENSO amplitude

ENSO amplitude (x) depends on the scenario (s), climate model (m) and time (t):

X (s,m,t)

X is divided into the long-term trend (2nd order fit, x_f) and internal (decadal) variability ($\boldsymbol{\varepsilon}$) :

$$X\,(s,m,t) = x_f(s,m,t) + \boldsymbol{\varepsilon}\,(s,m,t)$$

Uncertainty is computed as the model spread (standard deviation):

Model uncertainty:

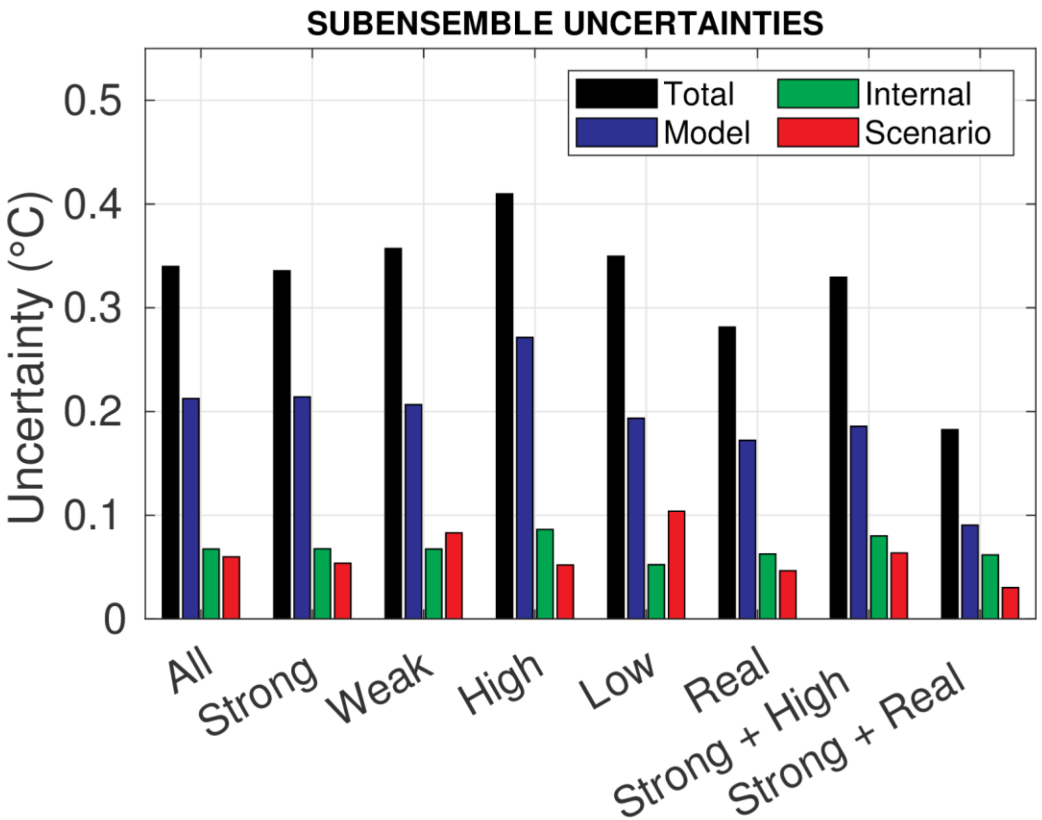
$$M\,(t) = \frac{1}{N_s}\sum_s std_m(\,x_f(s,m,t))$$

Scenario uncertainty:

$$S\,(t) = std_s(\frac{1}{N_m}\sum_m(\,x_f(s,m,t))$$

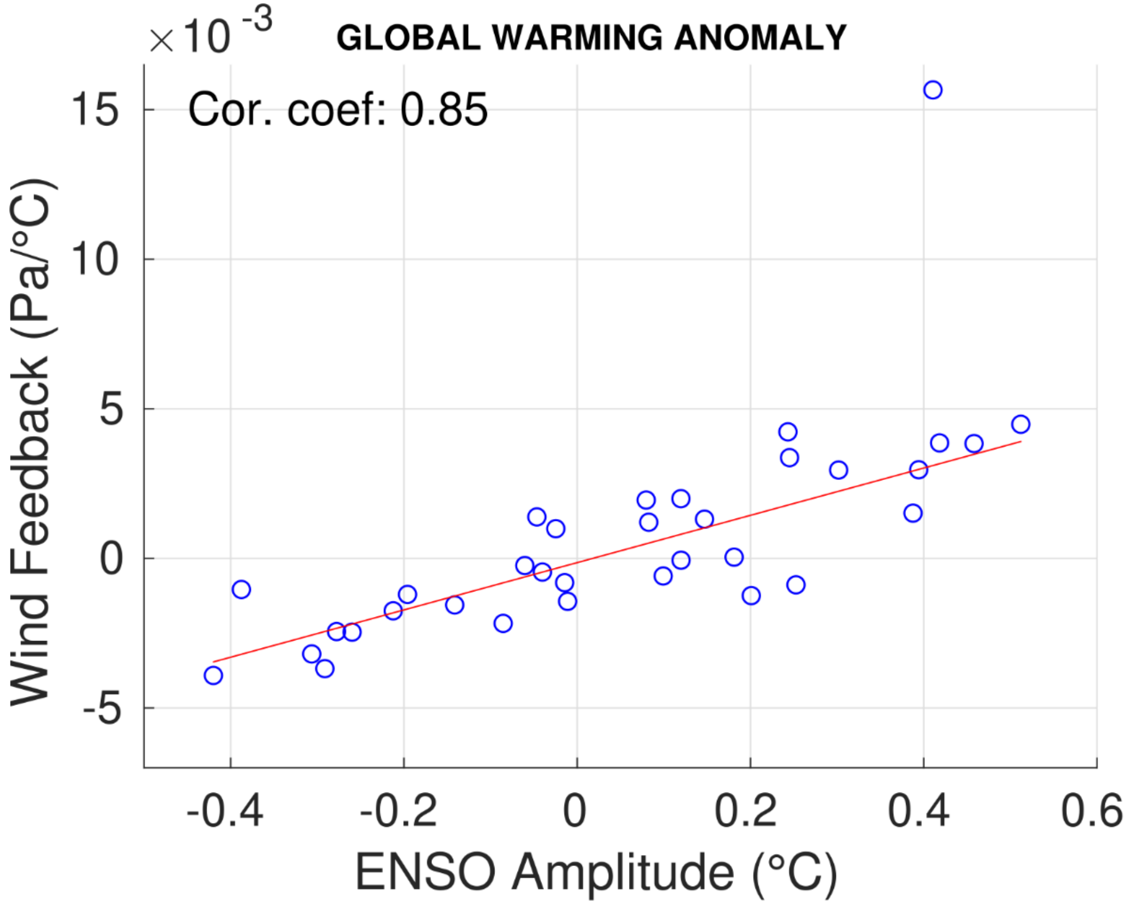
Internal variability uncertainty:

$$I = \frac{1}{N_s}\sum_s \frac{1}{N_m}\sum_m std_t\ (\boldsymbol{\varepsilon}(s,m,t))$$



- **Model uncertainty** (blue) is the dominant source of total uncertainty (black) at the end of the 21st century

- Uncertainties are greatly reduced with realistic ENSO dynamic models and realistic ENSO amplitude models (**Strong + Real**)



- The inter-model relationship between the long term trend of the wind-SST feedback and ENSO amplitude shows a **strong correlation** (0.85) for the RCP4.5 scenario

- The **wind-feedback** is a **potential source** for strong inter-model disagreement when representing the global warming signal of ENSO amplitude

- The result **is confirmed** by the other two scenarios: RCP6.0 and RCP8.5

- It is important to understand the wind-SST feedback change in order to achieve an improvement of the ENSO amplitude predictions under global warming

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