ENSO and tropical Pacific metrics for CMIP5

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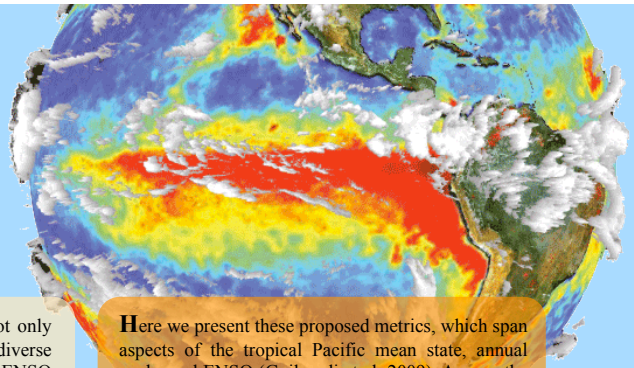


The wide diversity of El Niño simulations in coupled GCMs contributes to large uncertainties in projections of future tropical climate variability and its global impacts (Meehl et al. 2007, Vecchi and Wittenberg, 2009, Collins et al. 2009). This shortcoming – a major issue in the IPCC AR4 – has helped motivate a new chapter in the upcoming AR5 report, dedicated to ENSO and other modes of climate variability.

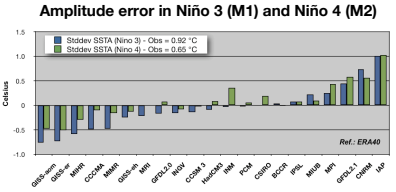
Uncertainty in the future of ENSO arises not only from diverse model biases, but also from the diverse and inconsistent metrics used to evaluate ENSO from study to study. To better coordinate future studies, the CLIVAR Pacific Panel asked a group of ENSO experts to propose a set of standard ENSO metrics, to aid in diagnosing and understanding inter-model differences and assessing simulation quality.

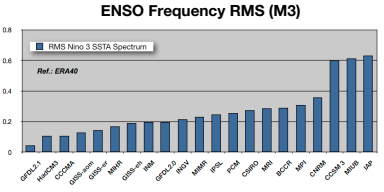
Here we present these proposed metrics, which span aspects of the tropical Pacific mean state, annual cycle, and ENSO (Guilyardi et al. 2009). Among the many metrics proposed these were estimated by a panel of ENSO experts to be the most relevant ones. These metrics are applied to the CMIP3 pre-industrial control simulations.

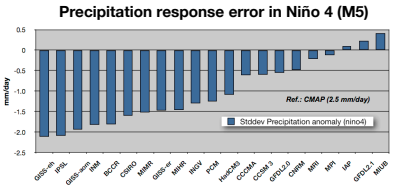
We then devise several "weighting" procedures using these metrics to analyse ENSO amplitude change in CMIP3 scenarios.

The 10 metrics retained:

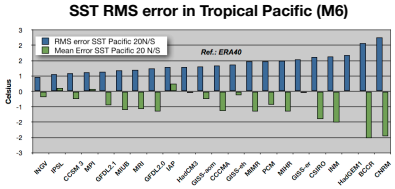
ENSO

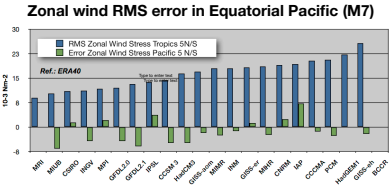


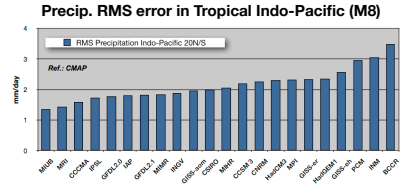


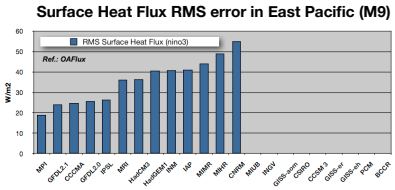


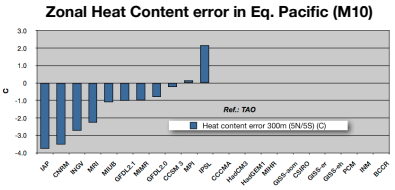
Mean state

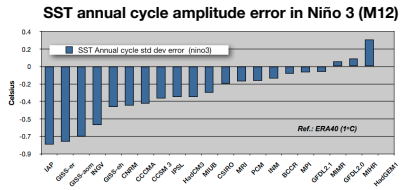












Weighting:

	M1	M2	M3	M5	M6	M7	M8	M9	M10	M12
Thresholds:	Diff	Diff	RMS	Diff	RMS	RMS	RMS	RMS	Diff	Diff
Unit	C	C	C²	mm/day	C	10^{-3} Nm^{-2}	mm/day	Wm^{-2}	C	C
limit - 2 points	-0.6	-0.40	-	none	-	-	-	-	-3	-0.5
limit - 1 point	-0.3	-0.20	-	-1	-	-	-	-	-1.5	-0.2
limit + 1 point	0.3	0.20	0.20	1	1.5	10	1.5	20	1.5	0.2
limit + 2 points	0.6	0.40	0.40	none	2.5	20	2.5	40	3	0.5

Table 1: thresholds used to compute demerit points

Discussion:

To devise weights from these metrics, the "demerit points" technique is used (Suppiah et al. 2007). These are computed using metric-dependent thresholds (**Table 1**). The resulting sum of demerit points is used to compute a weighted average of 2xCO2 (ratio 1) and SRESA2 (ratio 2) ENSO amplitude change respectively vs. pre-industrial and 20th century simulations (**Table 2**). Results do not show any clearer evolution of ENSO amplitude in a 2xCO2 climate. Removing the less-able models (more than 12/5/16 demerit points - depending on metrics weighting strategy, see method 2 in Tab. 2) does not change the results. Furthermore and because of the complexity of ENSO processes, a large amount of arbitrary hypothesis (even though they are based on "expert assessments") have been used to devise the present weights.

This calls for caution when using metrics to weight ENSO projection change in scenario simulations.

Model	2XCO2	Pre-Indust	Ratio r1	Ratio r2	Demerit points WSum (A)	WSum (B)	WSum (C)	M1	M2	M3	M5	M6	M7	M8	M9	M10	M12	Rank A	Rank B
(BCCR)		0.95			*8*	*2*	*10*	*0*	*0*	1	1	2	1	2	*1*	0	0		
CCSM3	0.68	0.78	0.87	0.61	6	2	8	0	0	2	0	0	1	1	*1*	0	1	5	4
CCCMA	0.44	0.42	1.05	0.75	9	3	12	2	1	0	0	1	2	1	*1*	0	1	11	10
CNRM	1.68	1.66	1.01	1.09	15	5	20	2	2	1	0	2	2	1	2	2	1	17	15
CSIRO		0.90	*N/A*	1.03	6	3	9	0	1	1	1	1	0	1	*1*	0	0	5	10
GFDL-CM2.0	0.90	0.75	1.20	1.21	3	0	3	0	0	0	0	0	1	1	*1*	0	0	1	1
GFDL-CM2.1	1.58	1.32	1.20	0.88	6	3	9	1	2	0	0	0	1	1	*1*	0	0	5	10
(GISS-AOM)		0.17	*N/A*	*N/A*	*13*	*7*	*20*	3	3	0	1	1	1	1	*1*	0	2		
GISS-EH	0.82	0.86	0.95	1.00	9	2	11	0	1	0	1	1	2	2	*1*	0	1	11	4
GISS-ER	0.19	0.24	0.79	*N/A*	13	7	20	3	3	0	1	1	1	1	*1*	0	2	16	18
HadCM3	0.85	0.77	1.10	1.16	6	1	7	0	0	0	1	1	1	1	*1*	0	1	5	2
(HadGEM1)		0.68	*N/A*	1.10	*9*	*2*	*11*	*0*	*0*	*1*	*1*	1	2	1	2	*0*	*1*		
IAP	1.41	1.93	0.73	0.64	16	6	22	2	2	2	0	1	2	1	2	2	2	18	16
INGV	0.84	0.75	1.11	1.30	6	3	9	0	0	1	1	0	0	1	1	1	2	9	4
INM	0.82	0.88	0.93	0.92	9	3	12	0	2	0	1	1	1	2	2	*0*	0	11	10
IPSL-CM4	0.84	1.00	0.84	1.10	7	2	9	0	0	1	1	0	1	1	1	1	1	9	4
MIROC3.2(hires)		0.35	*N/A*	0.97	11	5	16	2	2	0	1	1	1	1	2	*0*	1	14	15
MIROC3.2(med)	0.46	0.44	1.05	0.86	11	6	17	2	2	1	1	1	1	1	2	*0*	0	14	16
MIUB	1.08	1.14	0.95	0.84	4	2	6	0	0	2	0	0	0	0	*1*	0	1	3	4
MPI	1.50	1.16	1.29	1.14	4	3	7	0	2	1	0	0	0	1	0	0	0	3	10
MRI	0.94	0.70	1.34	1.26	3	1	4	0	0	1	0	0	0	0	1	1	0	1	2
PCM	0.82	0.89	0.92	0.89	8	2	10	0	0	1	1	1	2	2	*1*	0	0	10	4
Ensemble average	0.93	0.85	**1.02**	*0.99*				-0.06	0.08	0.27	-1.02	1.35	16.25	2.14	35.64	-1.28	-0.27		
Ens. av. points					6	2	8	0	0	1	1	0	1	1	1	0	1		
	Method 1: all		Method 2: best																
Metric Weight A	**1.08**	*1.03*	**1.10**	*1.04*				*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*		
Metric Weight B	**1.07**	*1.04*	**1.08**	*1.05*				*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*		
Metric Weight C	**1.08**	*1.04*	**1.10**	*1.05*				*2*	*2*	*2*	*2*	*1*	*1*	*1*	*1*	*1*	*1*		

(model never considered) — models removed

Table 2: combining the demerit points to estimate 2xCO2 ENSO amplitude change. Three weighting strategies are proposed: A (all metrics have same weight), B (use only ENSO) and C (double weight of ENSO metrics vs. mean state) for two groups of models: method 1 (all) and method 2 ("best" models). *Warning: Error bars are not considered.*

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