Advancing Subtropical Climate Dynamics

Wednesday, 3 August 2022

Understanding the El Niño Southern Oscillation Effect on Cut-Off Lows as Simulated in Forced SST and Fully Coupled Experiments

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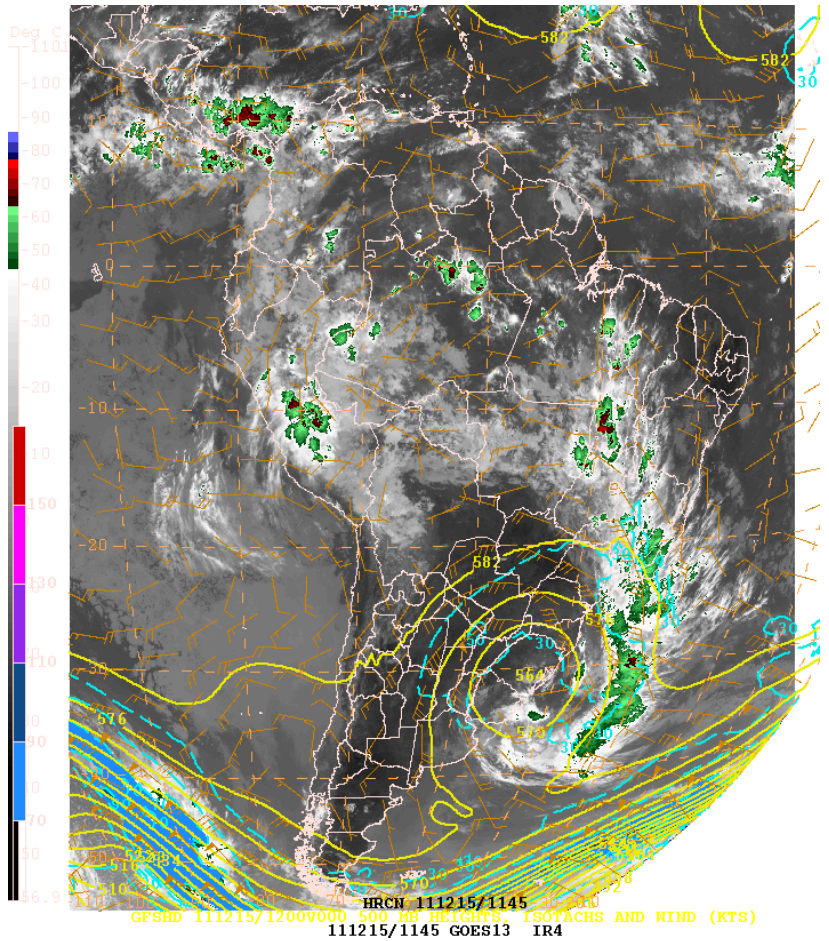
Cut-off Lows (COLs)

- Palmen and Newton (1969): synoptic-scale low pressure system at upper troposphere, which develops from a midlatitude cold trough that extends equatorward.

Motivation

- The effect of ENSO on cut-off lows are uncertain.
- Evaluation of climate models in reproducing ENSO-COL teleconnection.



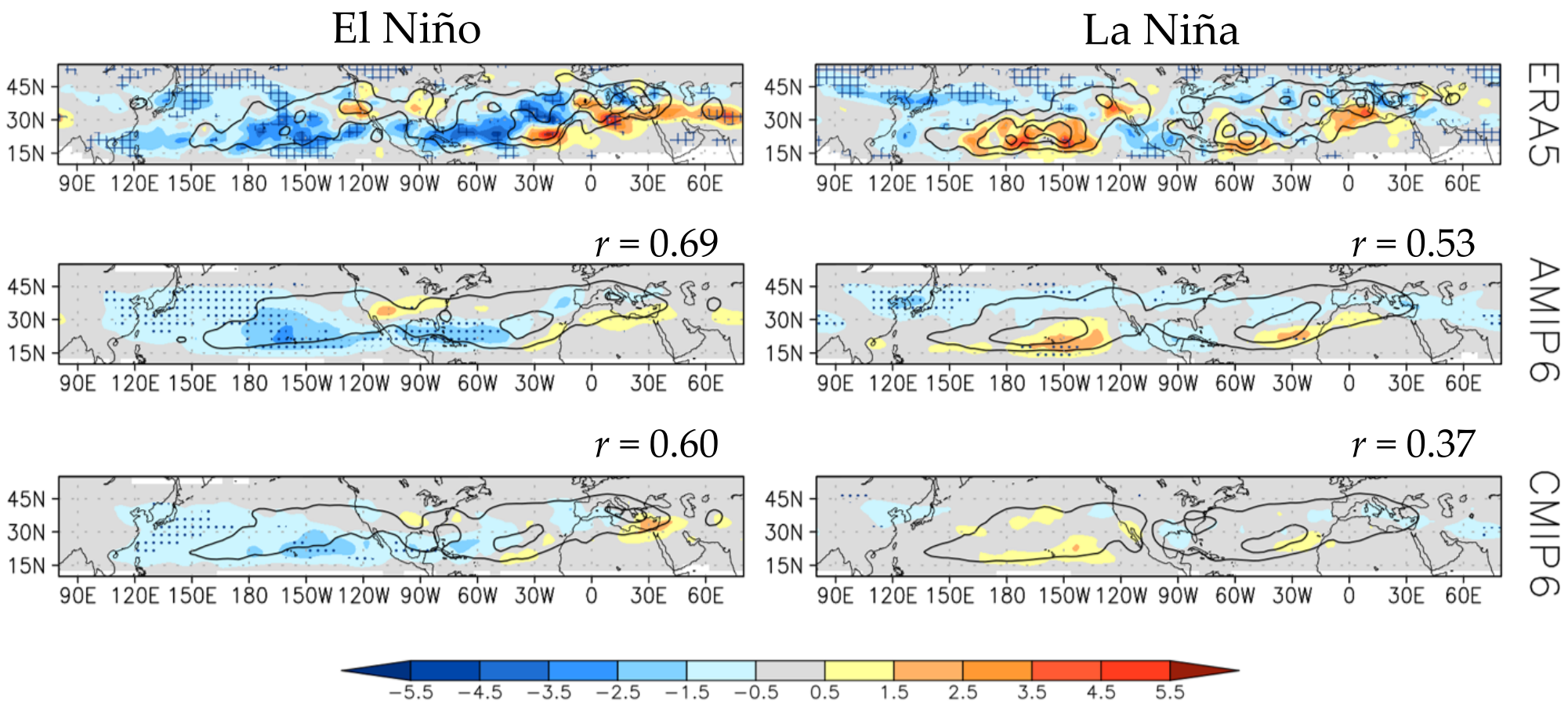
Sistemas meteorológicos atuantes no Brasil, Oficina de textos, Chapter 5.

COL response to ENSO

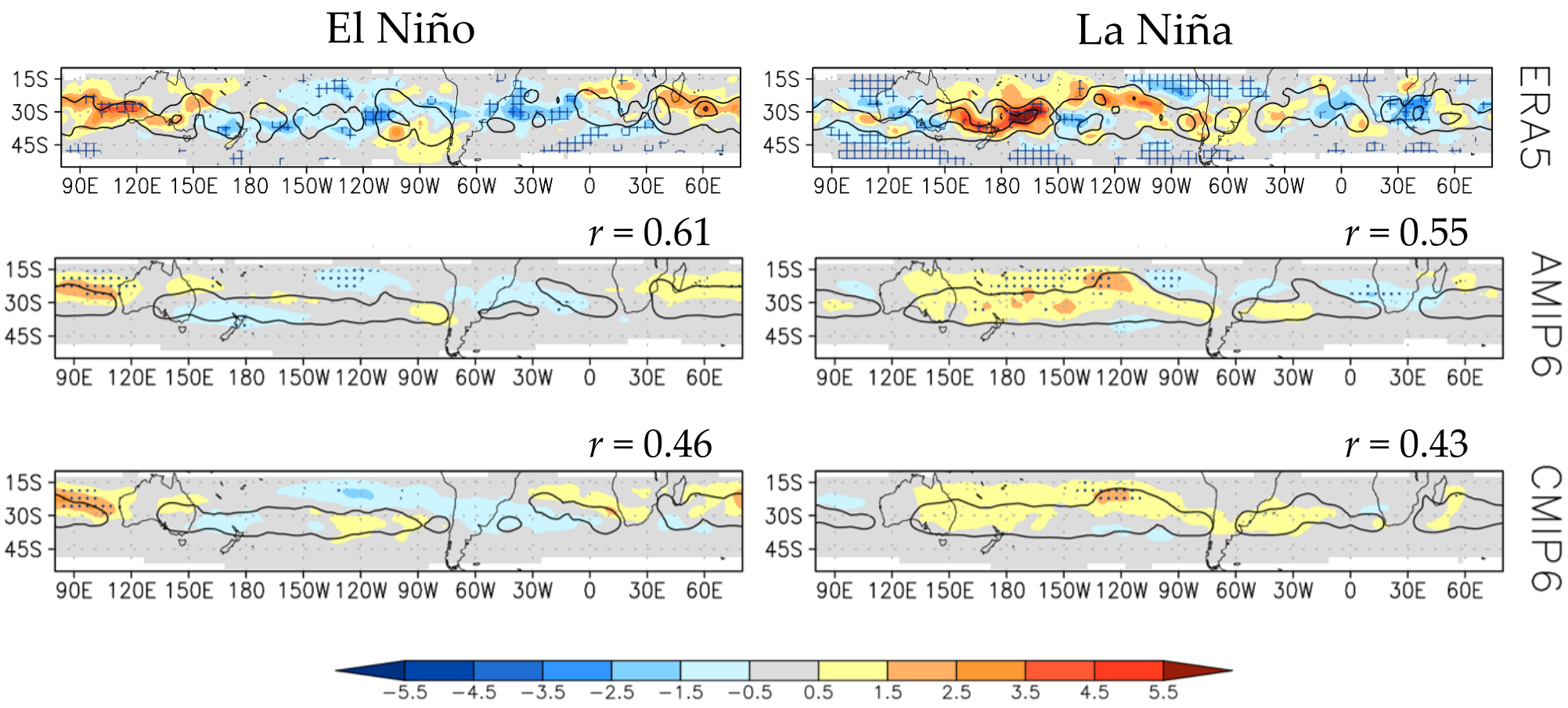
- Data from atmosphere-only (**AMIP6**) and fully coupled (**CMIP6**) simulations for the historical period 1979-2014 (horizontal resolutions range between 100-250km).
- Validation using **ERA5** (approximately 80 km).
- TRACK algorithm (Hodges 1994) is used to identify COLs based on the T42 250-hPa vorticity with a COL detection scheme.
- Niño-3.4 greater than +1.0 C (El Niño) and less than -1.0 C (La Niña) based on the NOAA ONI from the reconstructed SST version 3b (**ERSST.v3b**).

- **It help us to contrast the differences between AMIP and CMIP simulations and to identify possible errors in the predicted SSTs by coupled models.**

Track density composites of NH COLs

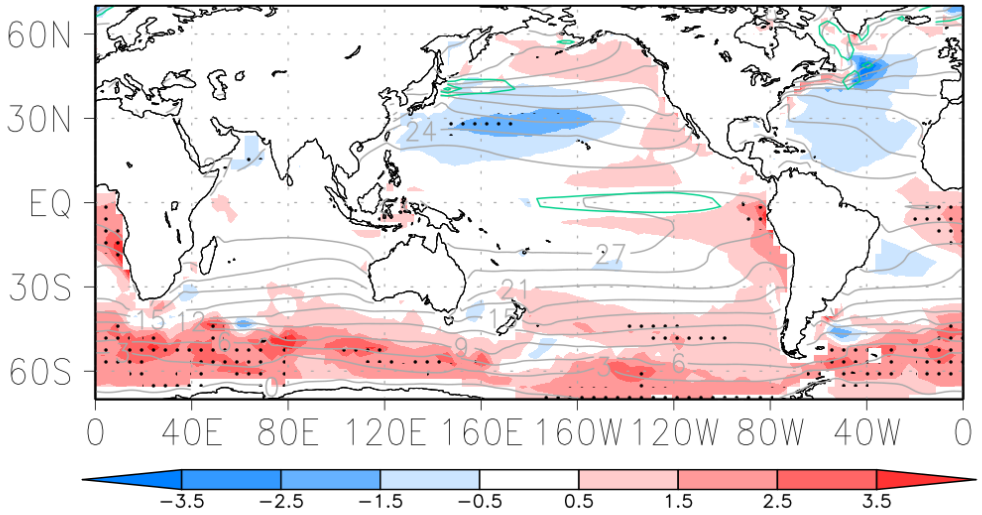


Track density composites of SH COLs



- Which factor should be attributed to the inferior performance of coupled models compared to atmospheric models?

It may be related to inaccurate predicted SSTs…



Annual SST(gray contours), annual mean SST bias (shaded), and annual variance (aqua contours) from CMIP6 multi-model ensemble mean

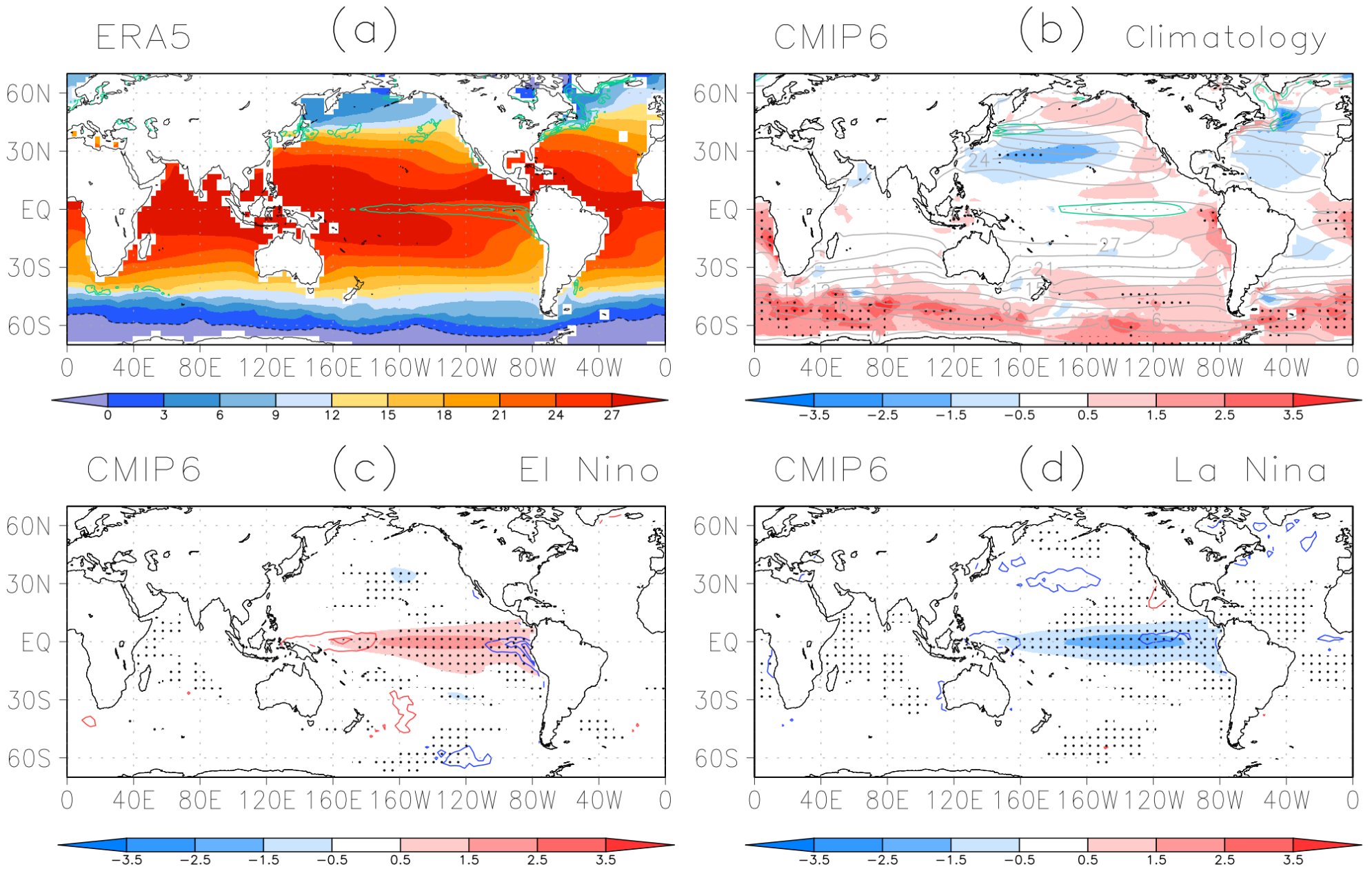
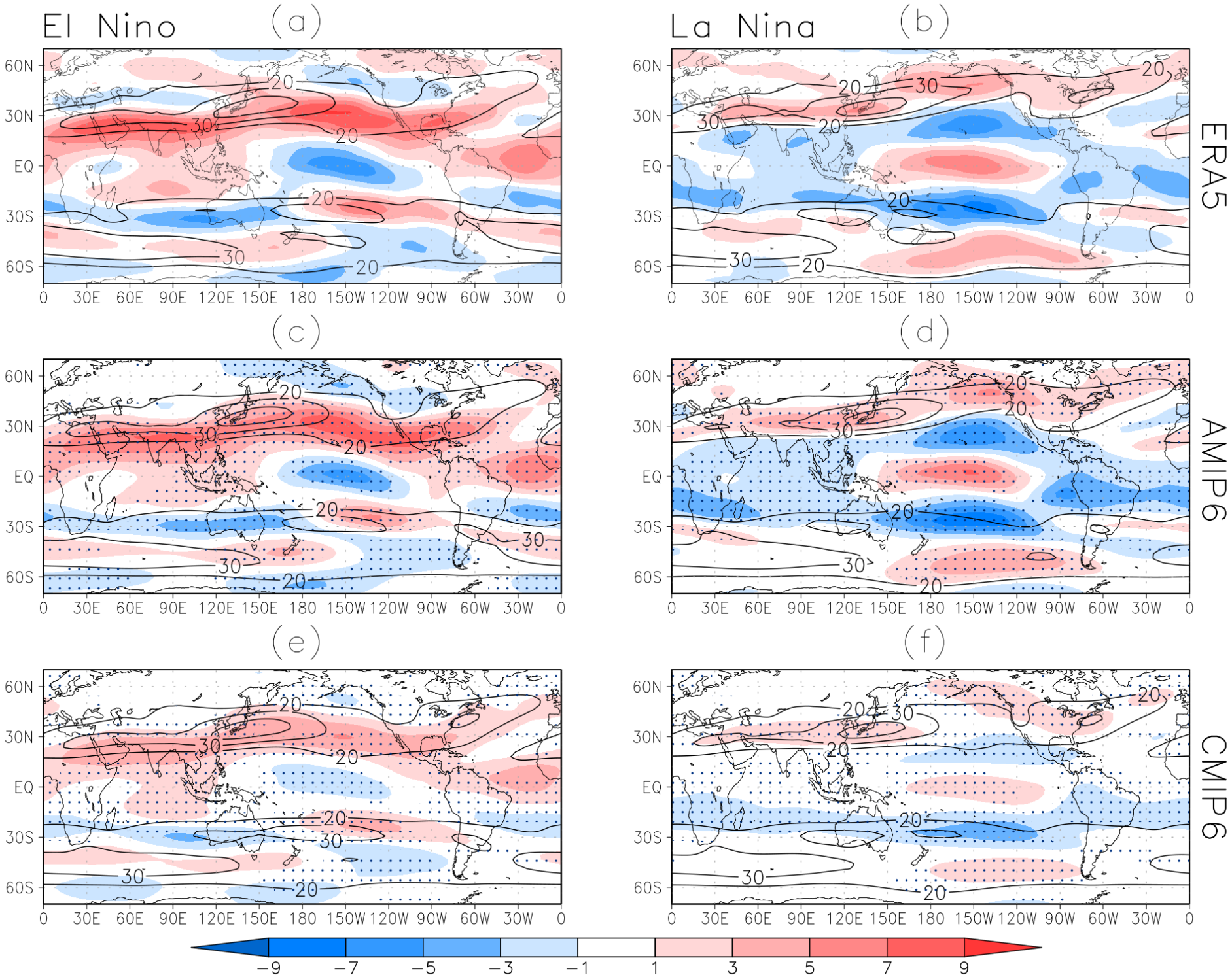
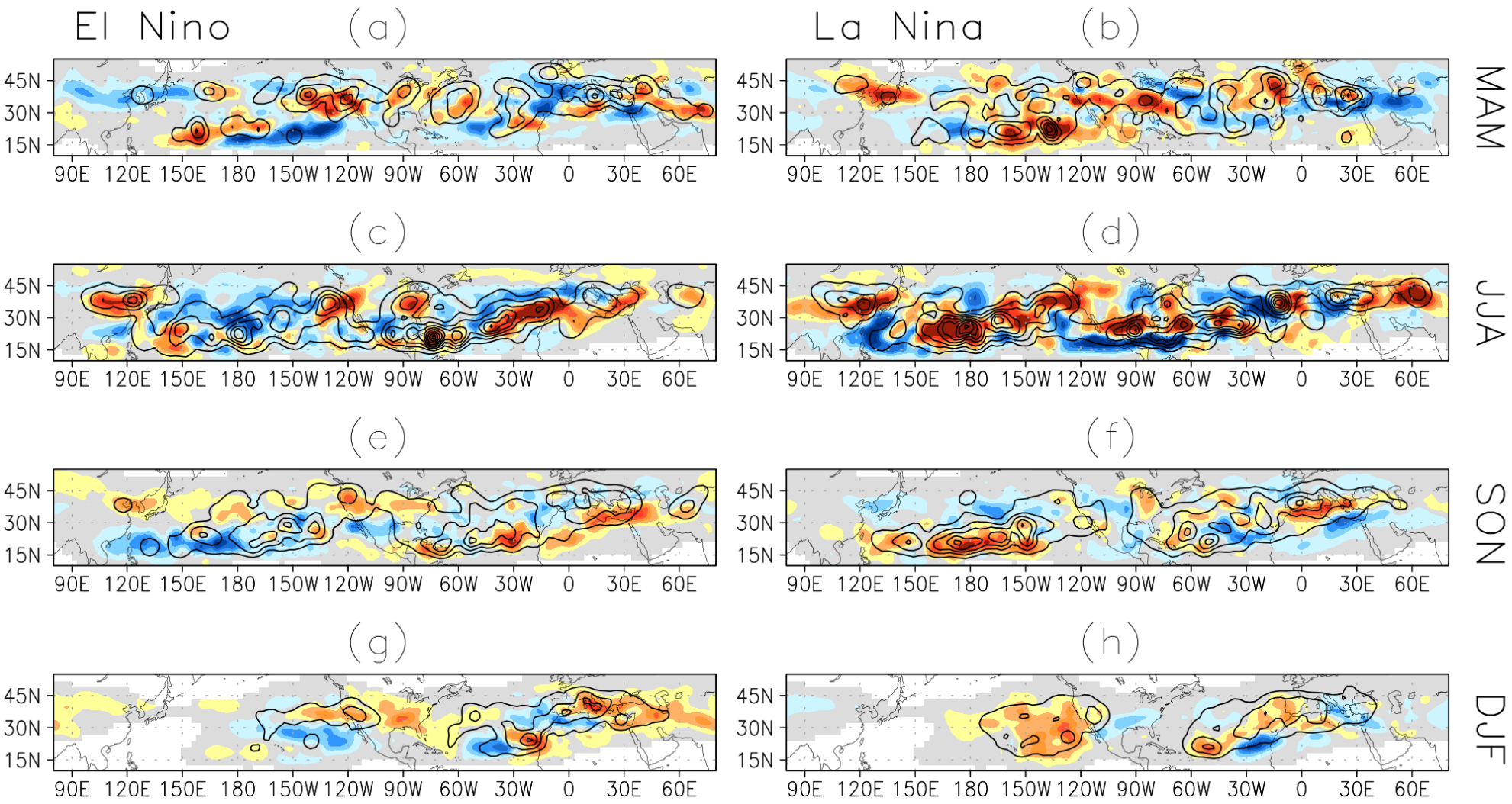
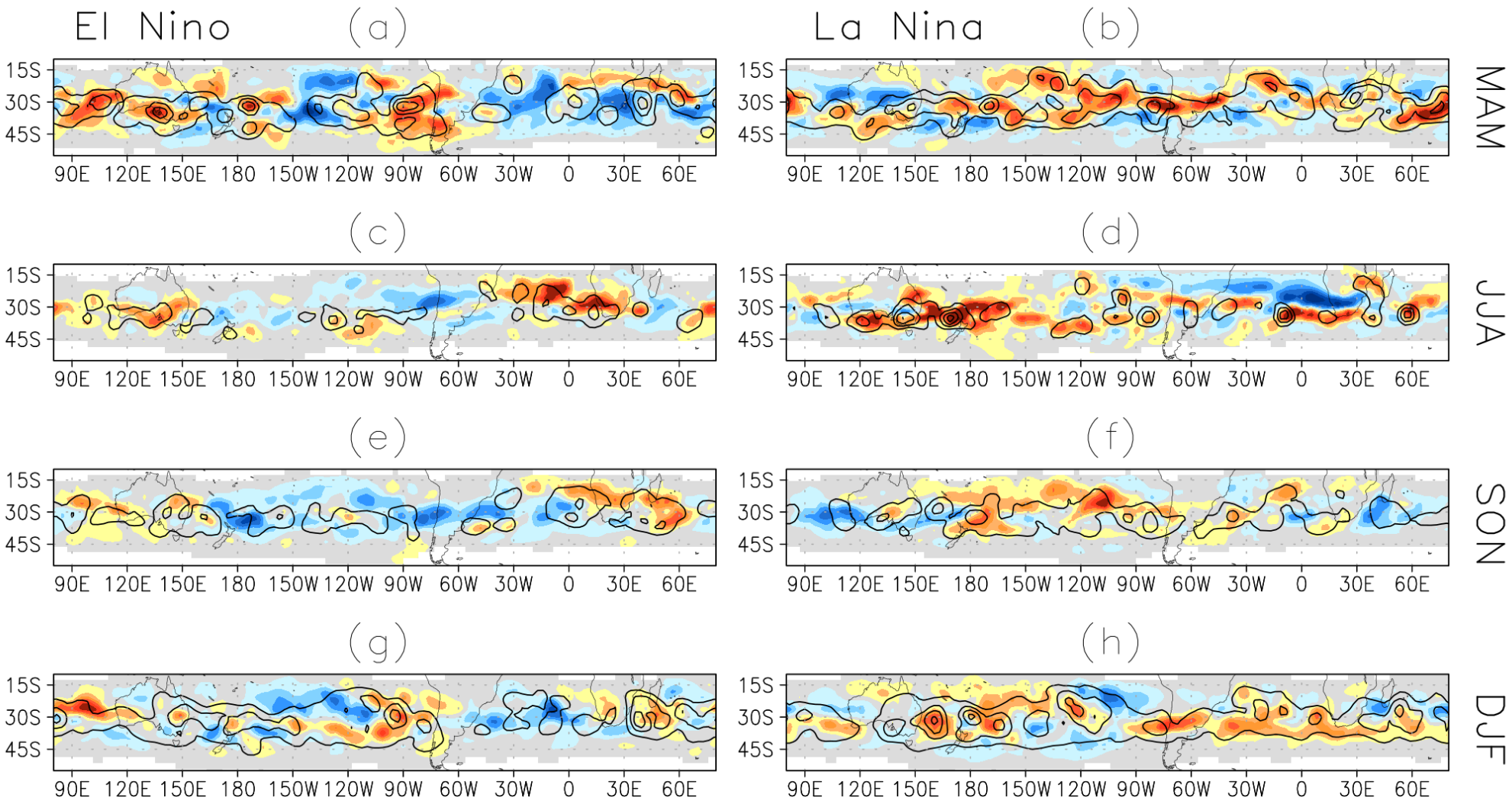

ERA5
(a)
CMIP6
(b)
Climatology
CMIP6
(c)
El Nino
CMIP6
(d)
La Nina
60N
30N
EQ
30S
60S
0
40E
80E
120E
160E
160W
120W
80W
40W
0
3
6
9
12
15
18
21
24
27
−3.5
−2.5
−1.5
−0.5
0.5
1.5
2.5
3.5

Table 1. List of CMIP6 models used in this study, including the model-developing institution, the horizontal and vertical resolution of the atmospheric component, and the number of ensembles for the AMIP6 and CMIP6 simulations with respect to the 250 hPa horizontal winds and sea surface temperature in parentheses. The resolution of spectral models is first indicated by the truncation type (T—triangular truncation, TL—triangular linear truncation, R—rhomboidal truncation, C—cubed-sphere finite volume, N—number of Gaussian grid points, F—finite volume grid), followed by the truncation number, dimension of the model output on a Gaussian grid (in parentheses), and the approximate nominal resolution (in km). The resolution of the grid point models is indicated by the grid dimension.

Model Name	Model Expansion	Institution	Atmospheric Resolution		No. of Ensembles	
			Horizontal	Vertical	AMIP	Historical
ACCESS-CM2	Australian Community Climate and Earth System Simulator (ACCESS) with U.K. Met Office Global Atmosphere (GA)	Centre for Australian Weather and Climate Research (CAWCR), Australia	N96 (192 × 144)	85	3	1 (1)
ACCESS-ESM1-5	ACCESS with HadGEM2 (version 1.1)		N96 (192 × 144)	38	3	3 (3)
BCC-CSM2-MR	Beijing Climate Center (BCC) Climate System Model version 2, medium resolution	BCC, China	T106 (320 × 160)	46	3	1 (1)
IPSL-CM6A-LR	L'Institut Pierre-Simon Laplace (IPSL) Coupled Model, version 5, coupled with the Nucleus for Model for Interdisciplinary Research on Climate (MIROC), version 6	IPSL, France	N96 (144 × 143) (320 × 160)	79	9	10 (10)
MIROC6		MIROC, Japan	T85 (256 × 128)	81	10	9 (9)
MIROC-ES2L	MIROC Earth System (version 2) Long-term simulations		T42 (128 × 64)	40	3	3 (3)
MRI-ESM2-0	Meteorological Research Institute (MRI) Earth System Model, version 2.0	MRI, Japan	TL159 (320 × 160)	80	3	5 (3)
NorESM2-LM	Norwegian Earth System Model, version 2, medium resolution	Norwegian Climate Centre (NCC), Norway	144 × 96	32	1	2 (1)


El Nino
(a)
La Nina
(b)
(c)
(d)
(e)
(f)
ERA5
AMIP6
CMIP6
60N
30N
EQ
30S
60S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
20
30
−9 −7 −5 −3 −1 1 3 5 7 9


El Nino
(a)
La Nina
(b)
(c)
(d)
(e)
(f)
(g)
(h)
MAM
JJA
SON
DJF
45N
30N
15N
90E 120E 150E 180 150W 120W 90W 60W 30W 0 30E 60E


El Nino
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(g)
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MAM
JJA
SON
DJF
15S
30S
45S
90E 120E 150E 180 150W 120W 90W 60W 30W 0 30E 60E

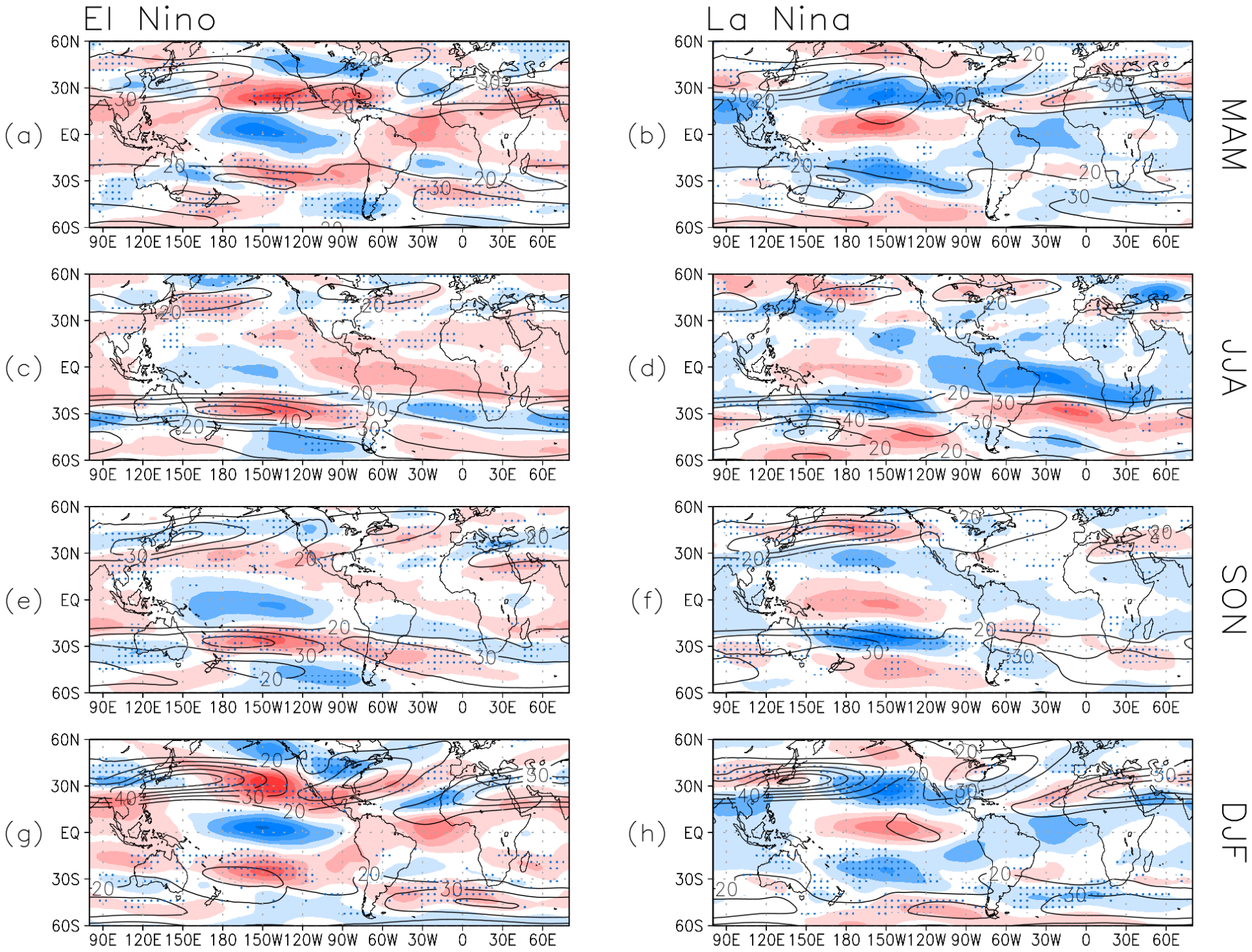
El Nino
La Nina
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
MAM
JJA
SON
DJF
60N
30N
EQ
30S
60S
90E 120E 150E 180 150W 120W 90W 60W 30W 0 30E 60E

Table 2. Number of COL tracks identified in each season and ENSO phase. The percentage of tracks with respect to seasonal values is given in parentheses.

Period	Northern Hemisphere		Southern Hemisphere	
	Niño	Niña	Niño	Niña
DJF	0.0 (0.0)	9.8 (11.2)	−8.9 (−6.1)	9.9 (6.8)
MAM	−13.3 (−10.9)	6.0 (4.9)	−7.0 (−5.4)	−7.7 (−5.9)
JJA	−8.0 (−4.0)	4.5 (2.2)	−8.8 (−12.9)	0.2 (0.2)
SON	−12.0 (−7.2)	−8.5 (−5.1)	−14.0 (−15.0)	−2.3 (−2.4)