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San Francisco, February 12-16, 2007

A multi-model evaluation of systematic errors of the tropical seasonal cycle in IPCC AR4 20th century simulations.

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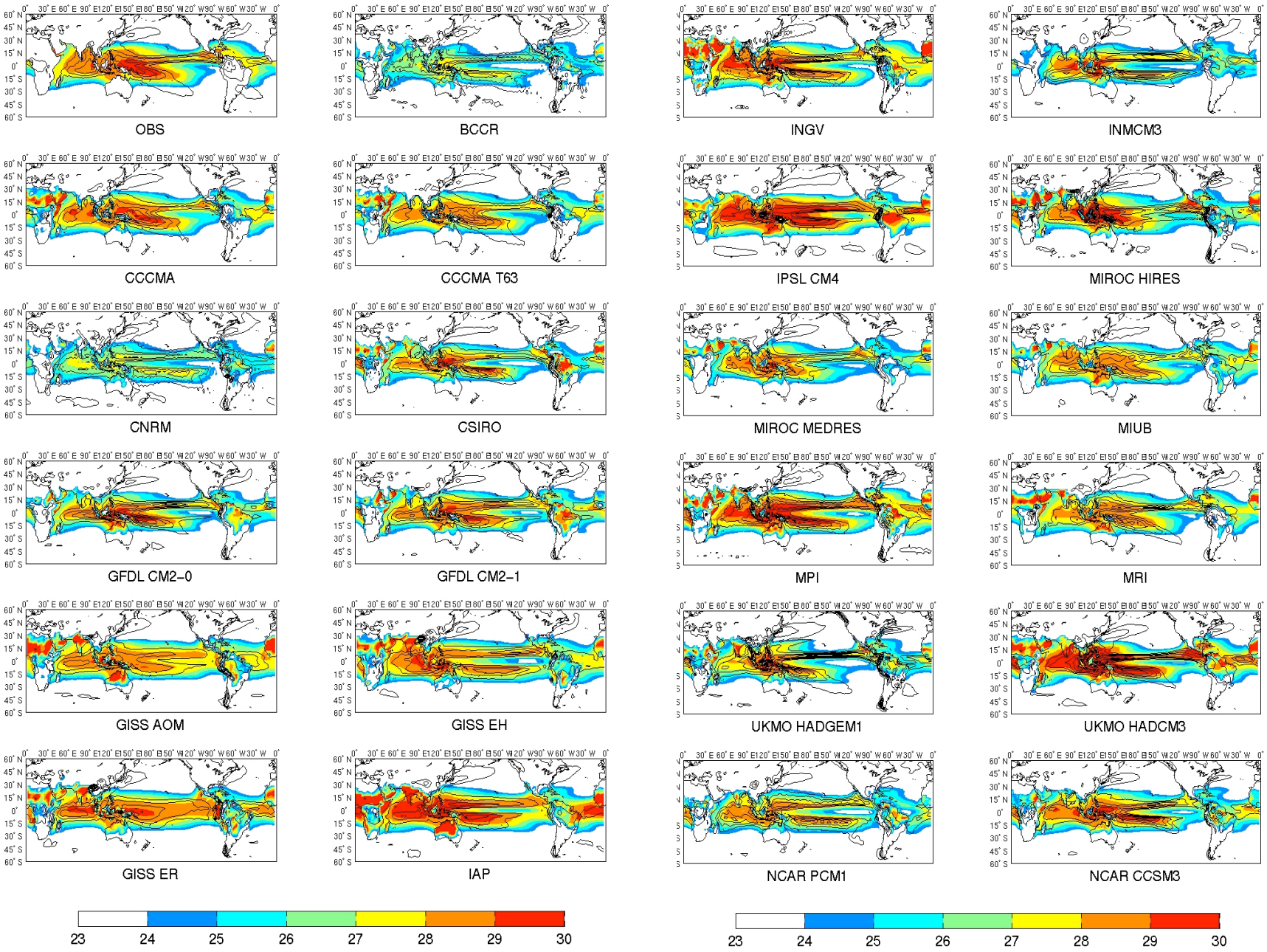
Aims and Methods

• Aim of this work is to highlight the main biases affecting the tropical climate in last generation CGCMs using the full set of AR4 20c3m simulations, with specific focus on the Indo-Pacific region.

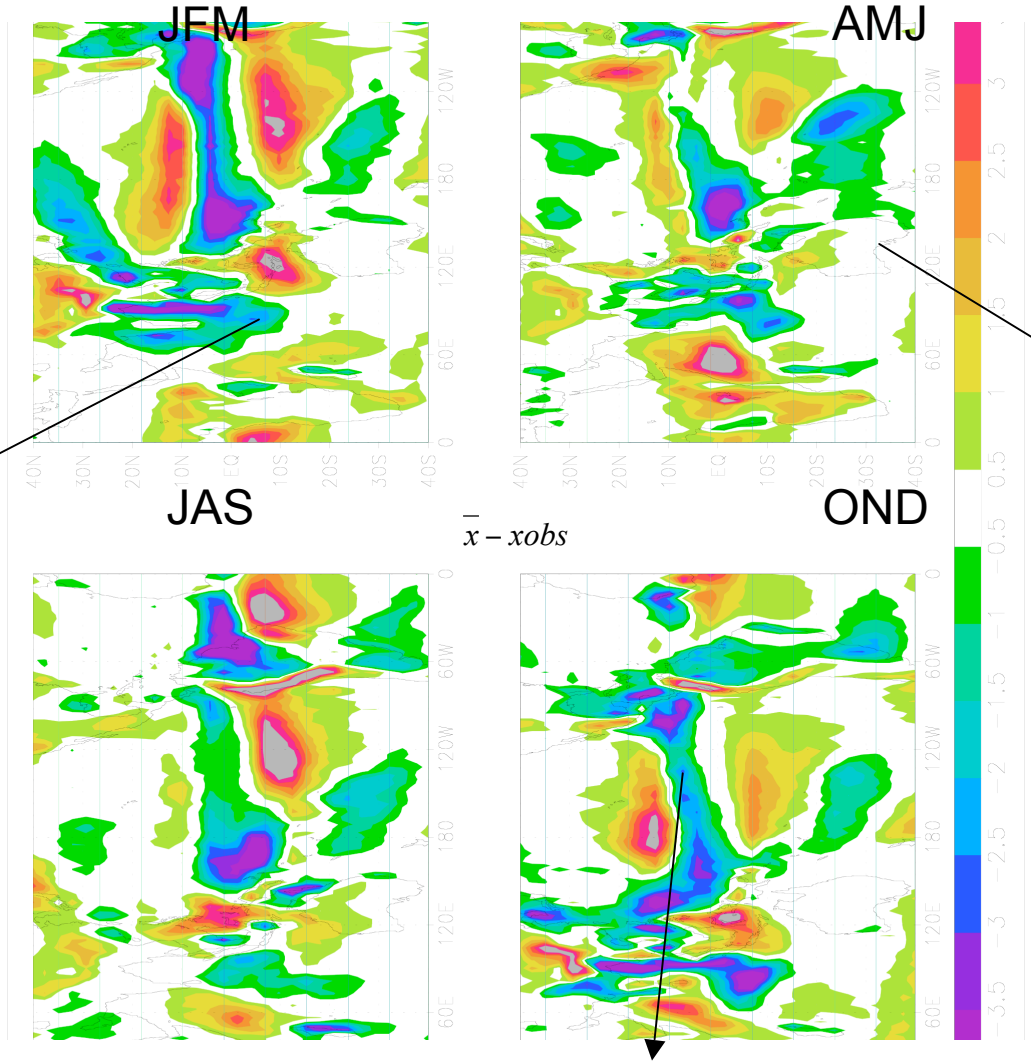
• The assessment process was initiated using standard techniques for a sub-set of the full set of AR4 models, within the framework of the EU ENSEMBLES Project.

• In addition to a more traditional approach, we define several error indices quantifying model biases (e.g., double ITCZ, anomalous westward extension of the cold tongue, etc.) and relate them to the model ability in reproducing specific processes.

20c3m Mean SST and Precipitation



Error on Precipitation (ensemble mean – obs) : $\overline{x} - obs$



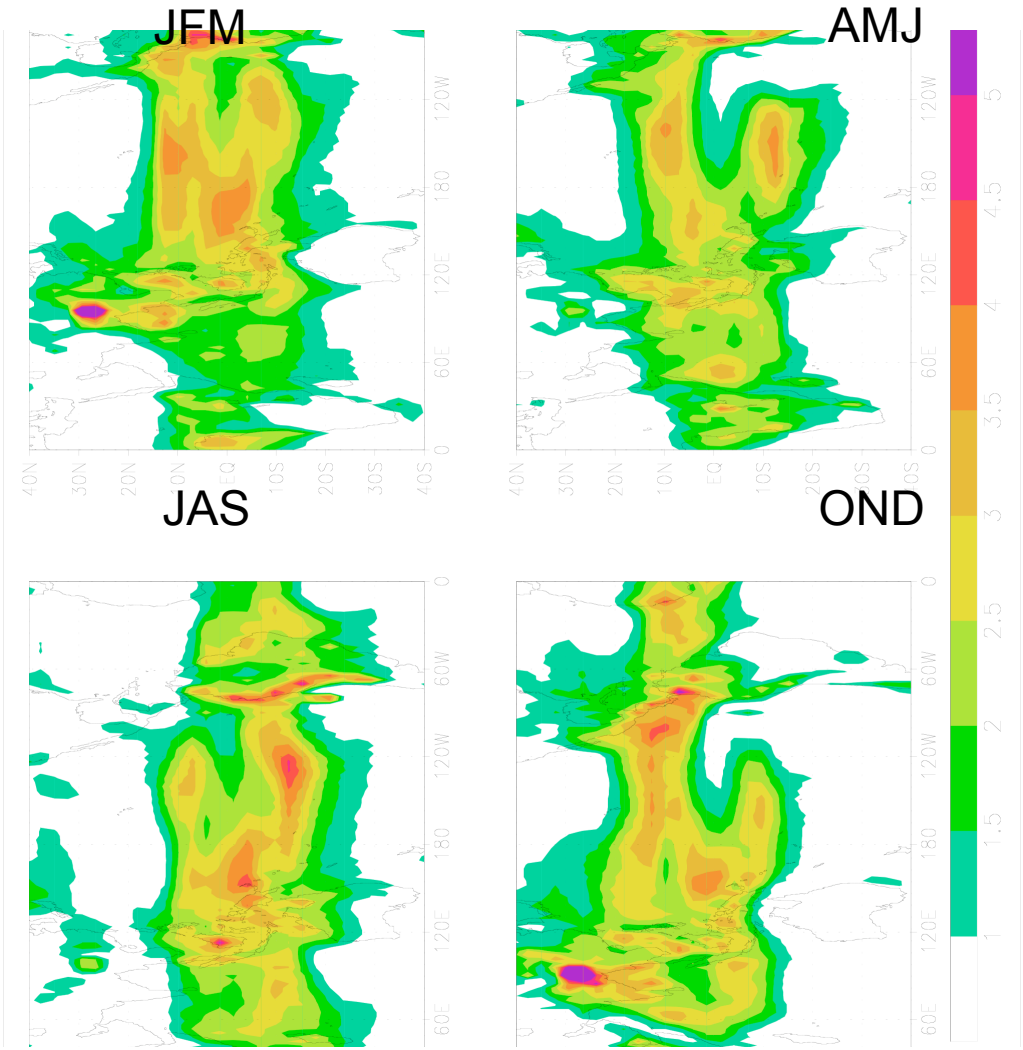
Double ITCZ

Low precipitation in West Equatorial Pacific

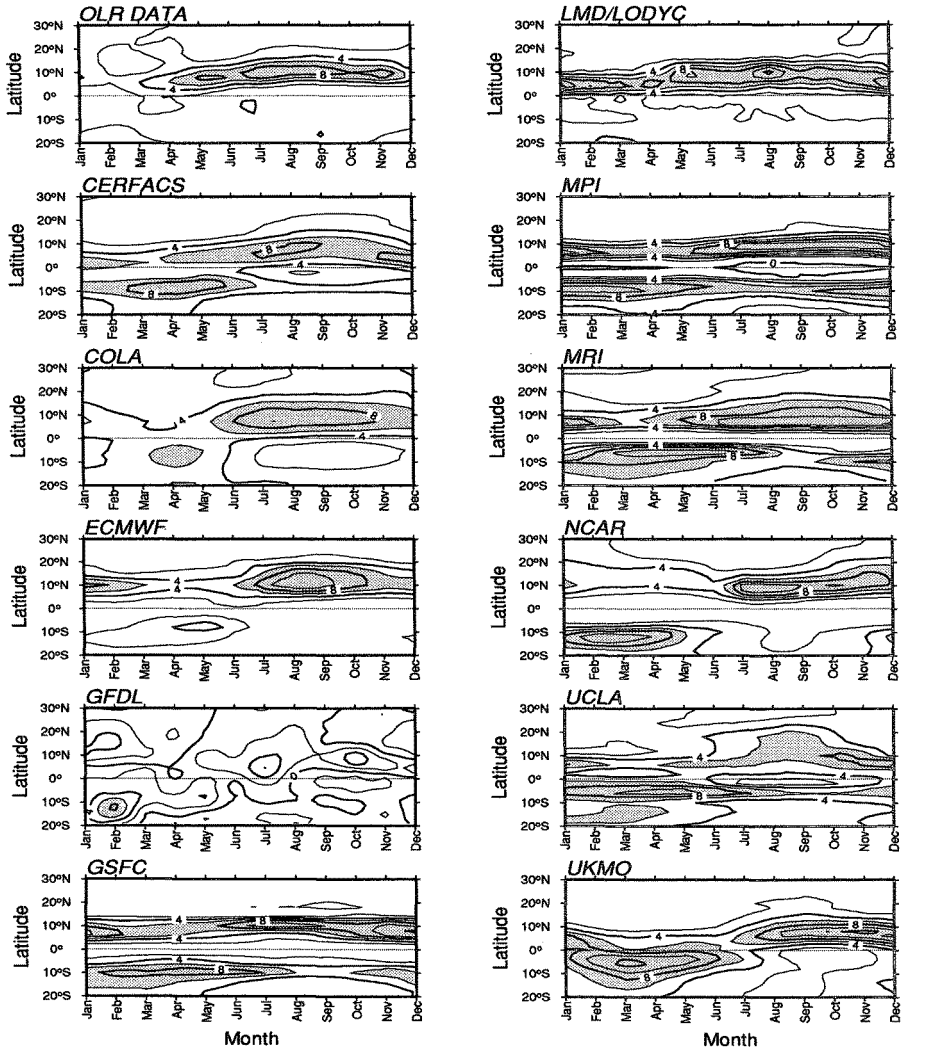
Excess of precipitation on West Indian Ocean

OBS: Xie-Arkin Precip.

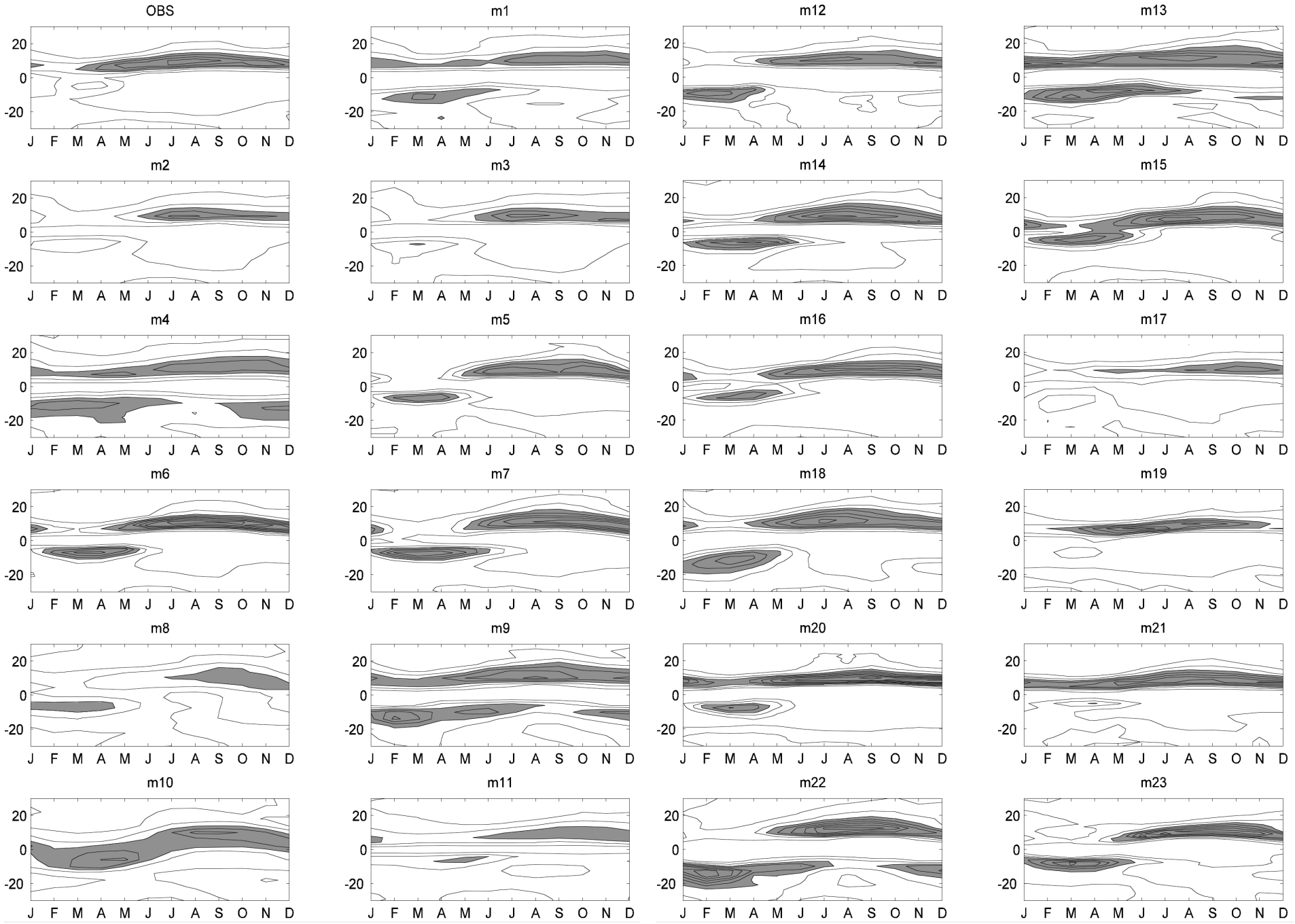
Precipitation : intra-model spread $\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$



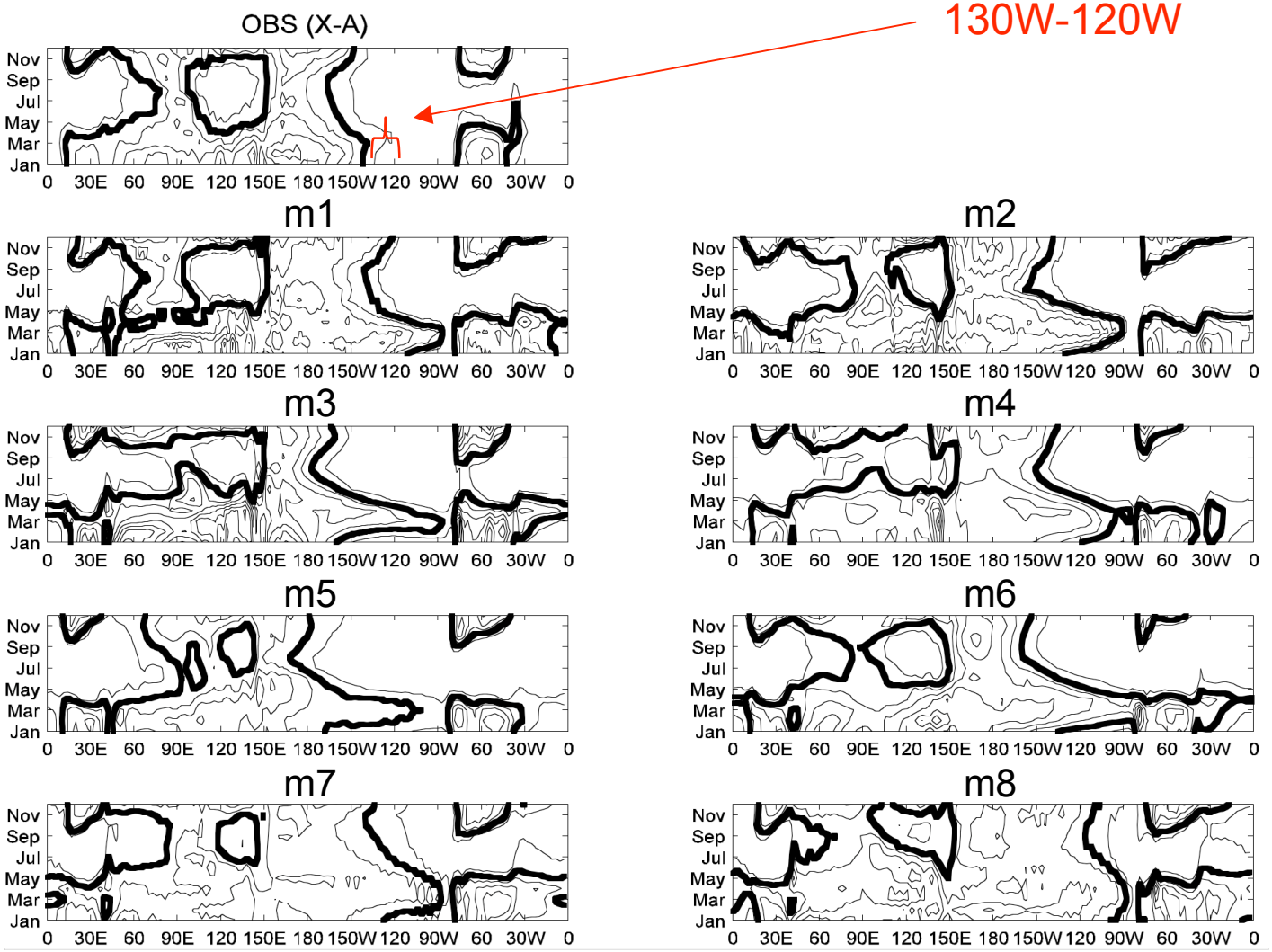
DOUBLE ITCZ: The past….



Seasonal cycle over eastern Pacific (avg. 150°-100°W). [Mechoso et al. 1995]

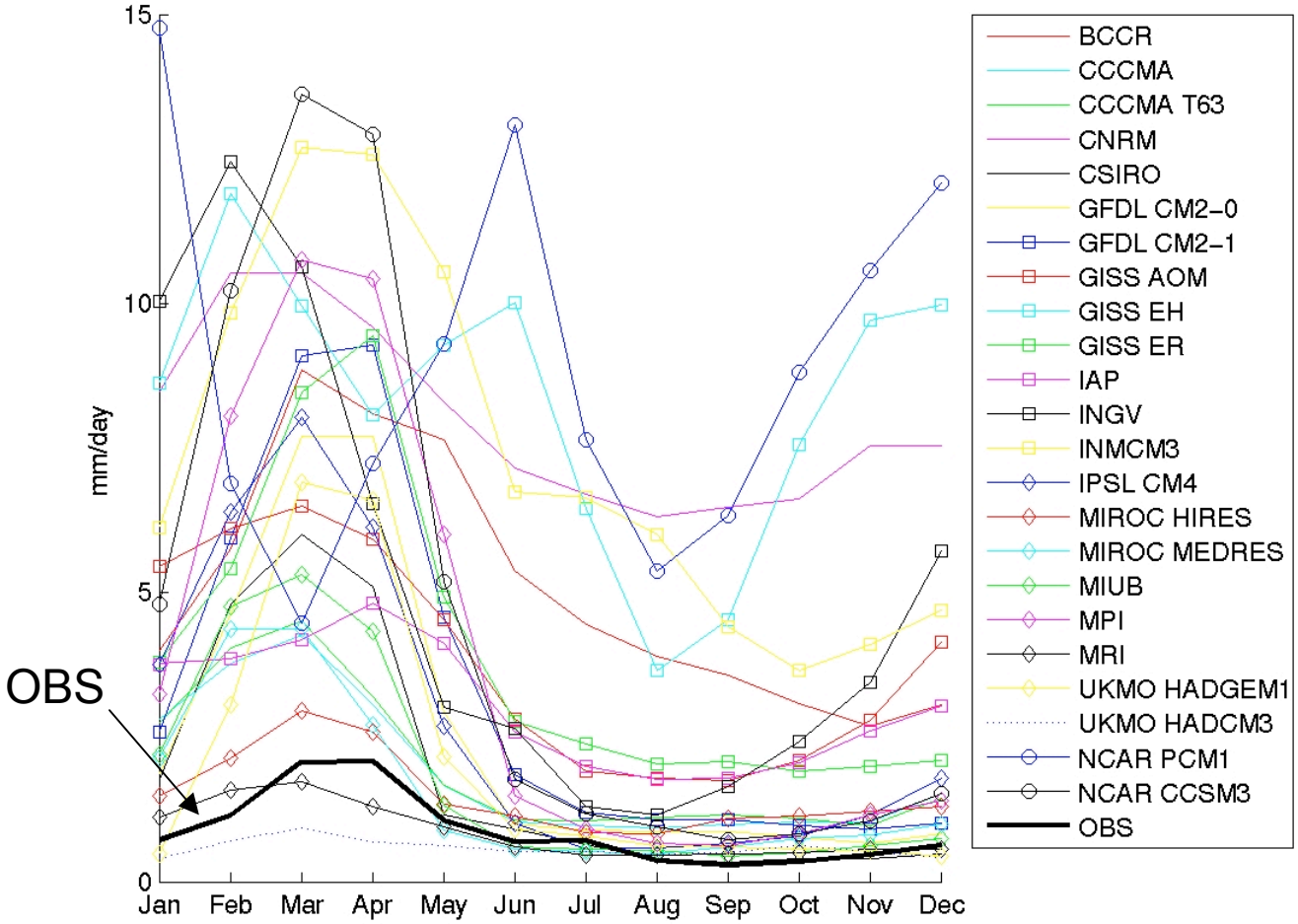

OBS
m1
m12
m13
m2
m3
m14
m15
m4
m5
m16
m17
m6
m7
m18
m19
m8
m9
m20
m21
m10
m11
m22
m23
20
0
-20
J F M A M J J A S O N D

Hovmoller diagram of precipitation avg over [12.5S-7.5S].



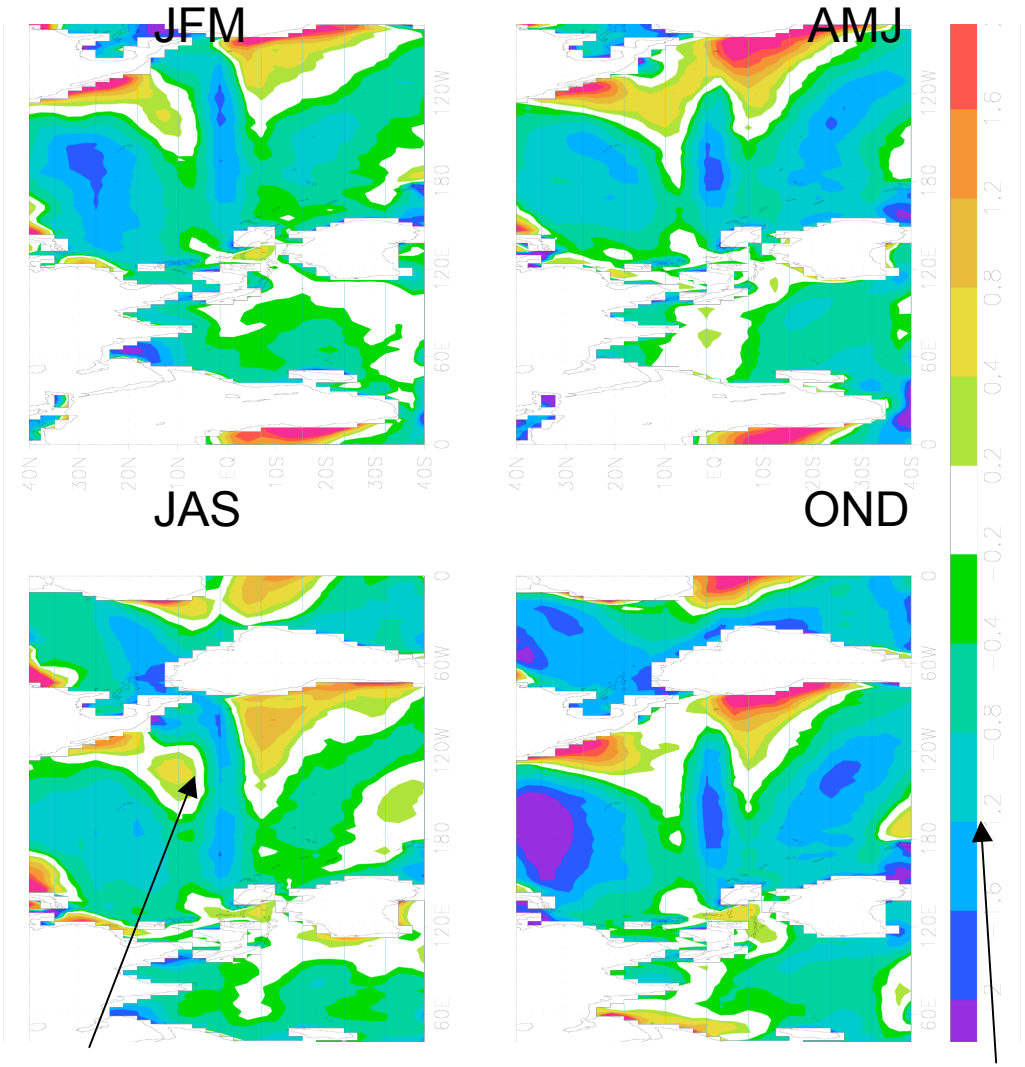
c.i.=2 mm/day black thick line=4 mm/day

Mean seasonal cycle of precipitation in 7.5S-12.5S 120-130W



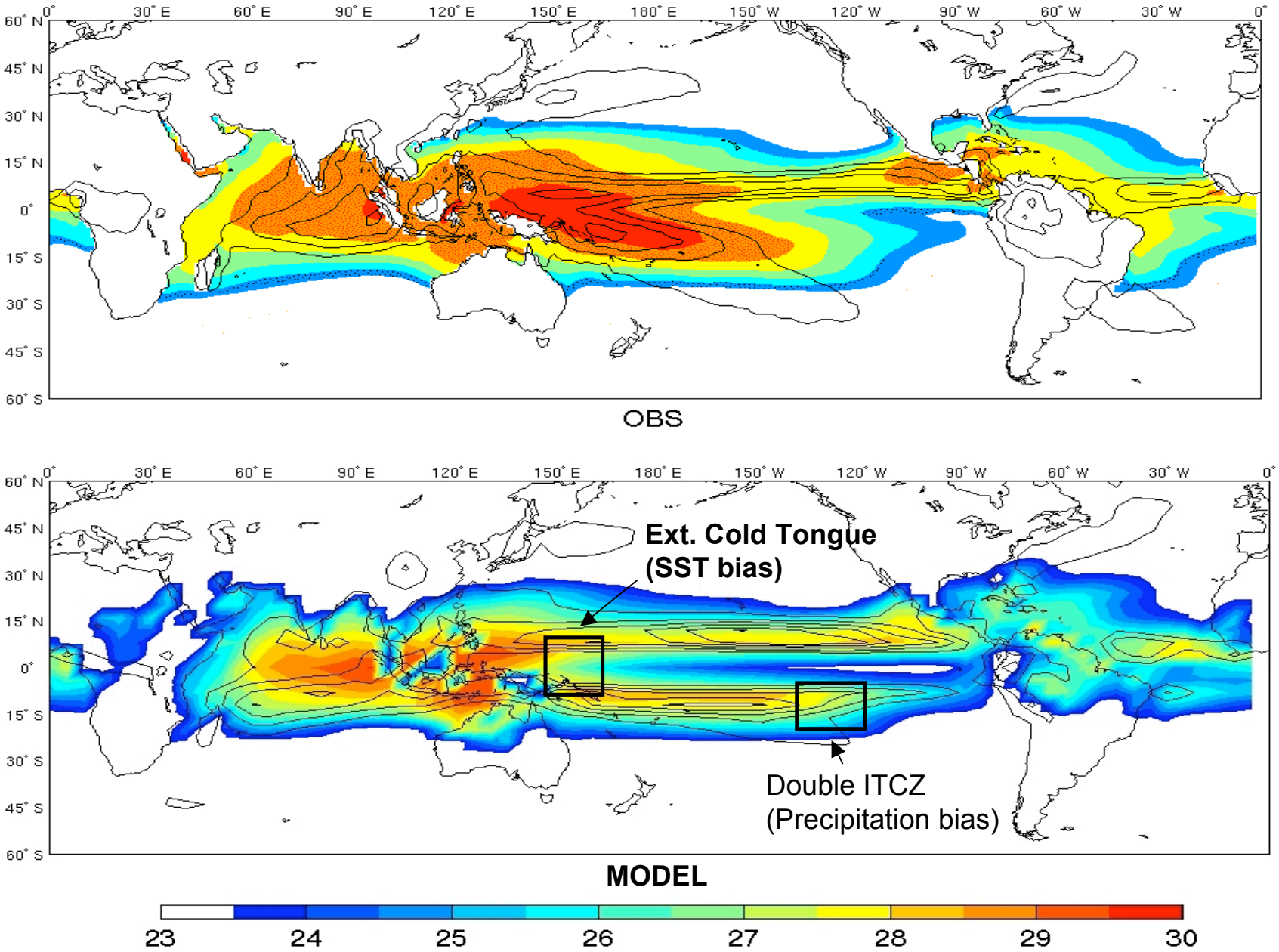
Double ITCZ Index: Mean Precipitation in 7.5S-12.5S 120-130W

Error on SST (ensemble mean – obs) : $\overline{x} - obs$



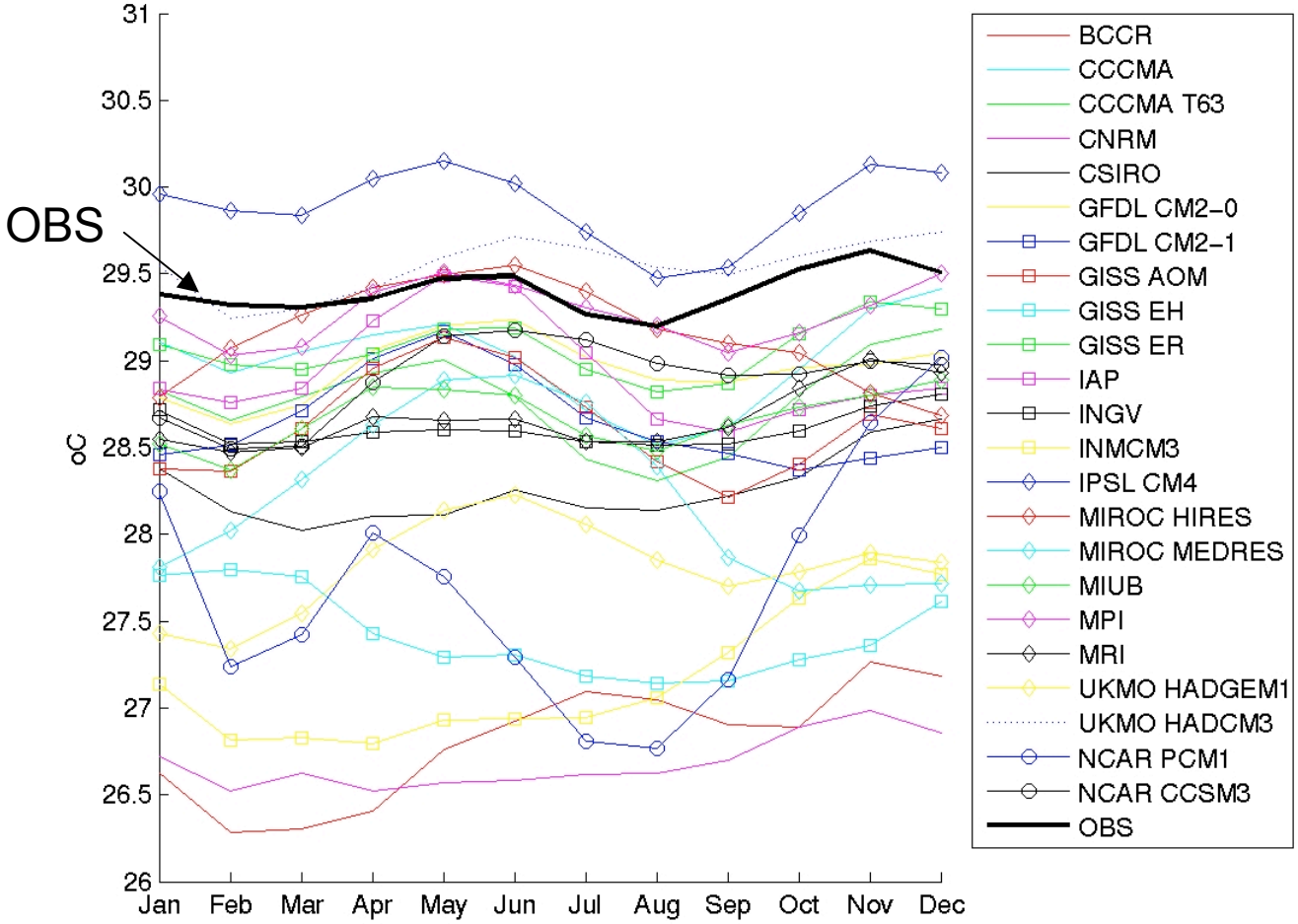
anomalously cold West Pacific
(westward extended cold tongue)

anomalously warm East Pacific

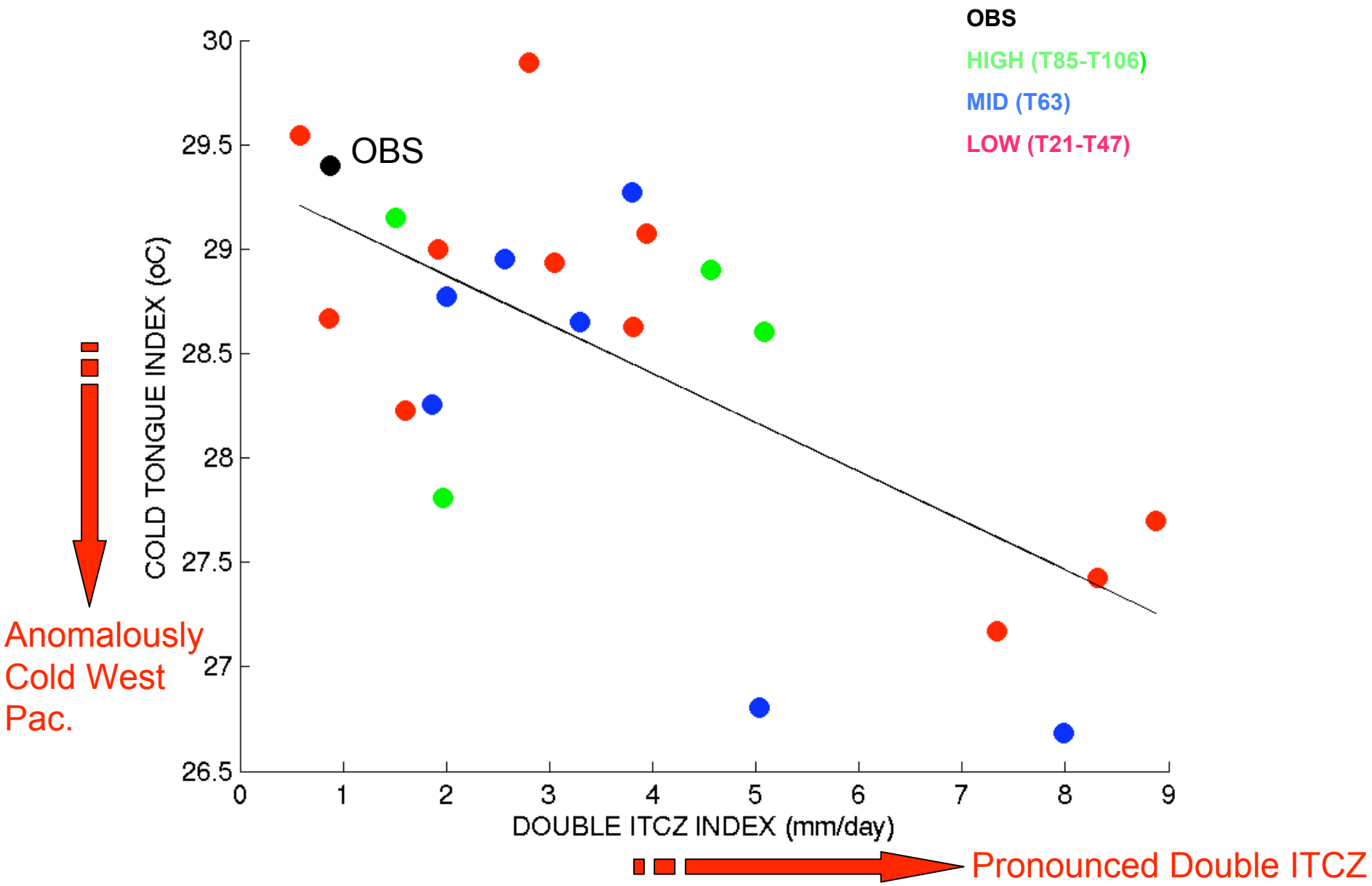


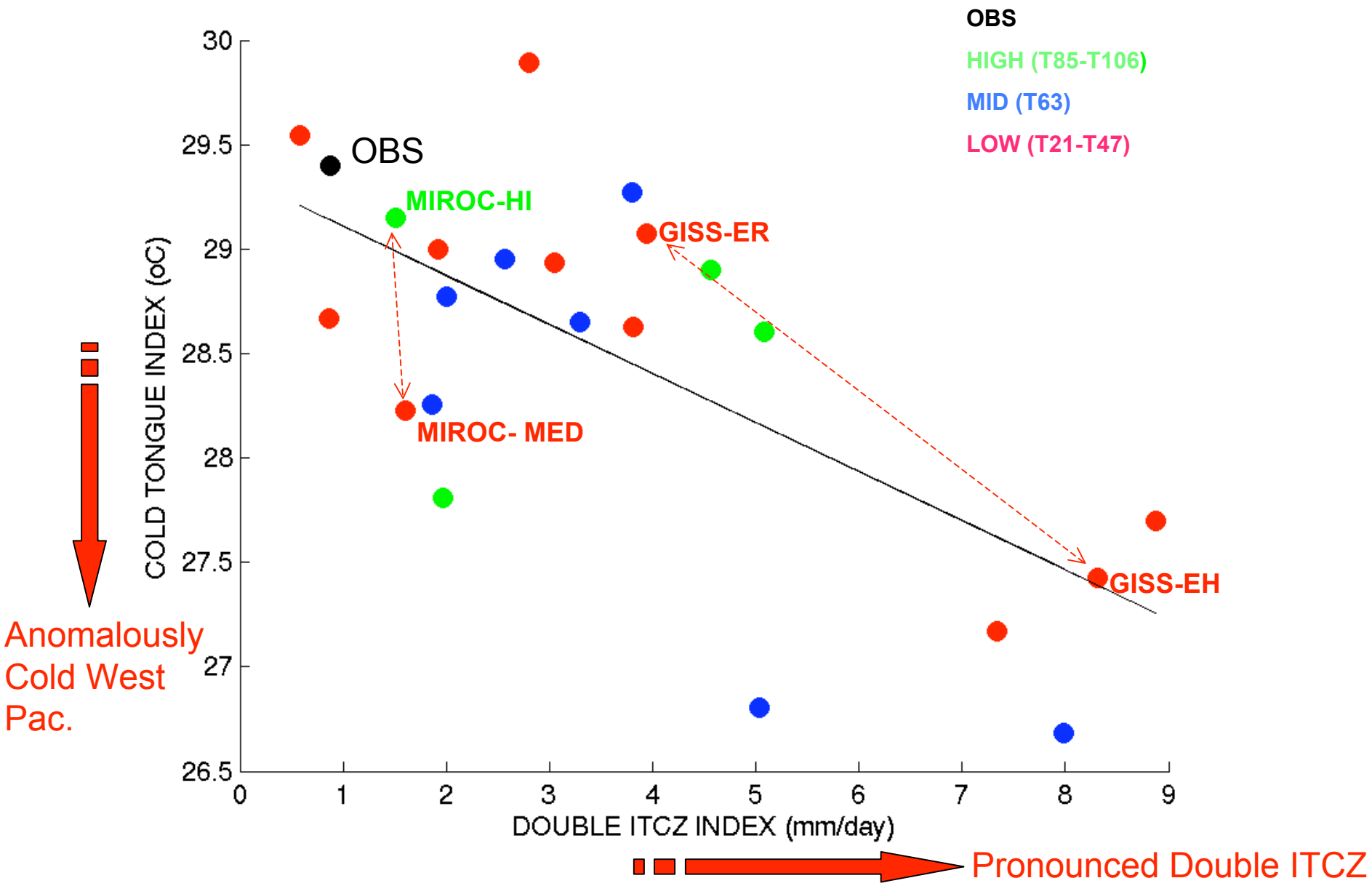
Color shading: skin temperature. Contour: precipitation (c.i.=2 mm/day)

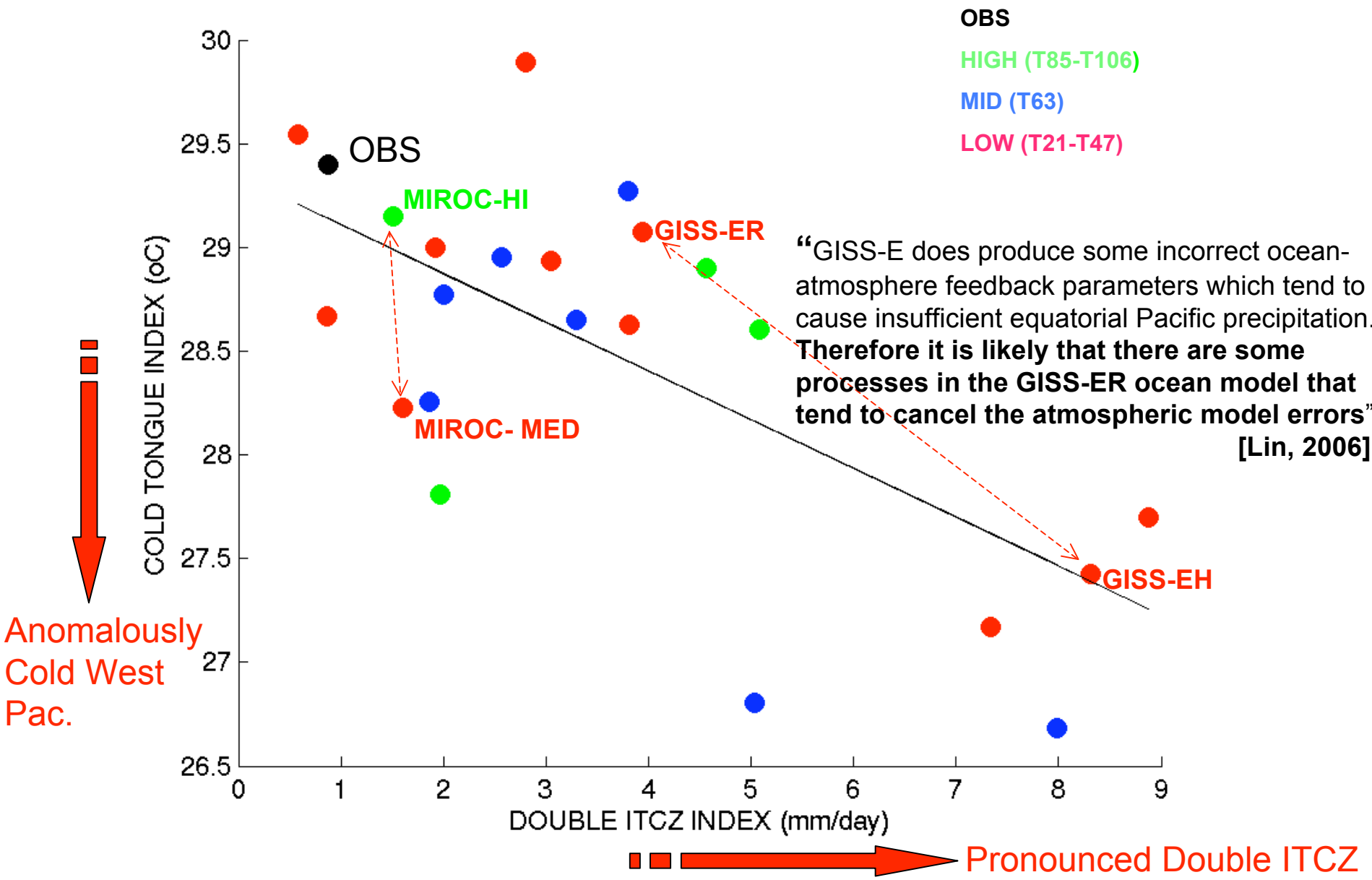
Mean seasonal cycle of SST in 5S-5N 150-160E (Warm Pool)



Cold Tongue Index: Mean SST in 5S-5N 150-160E

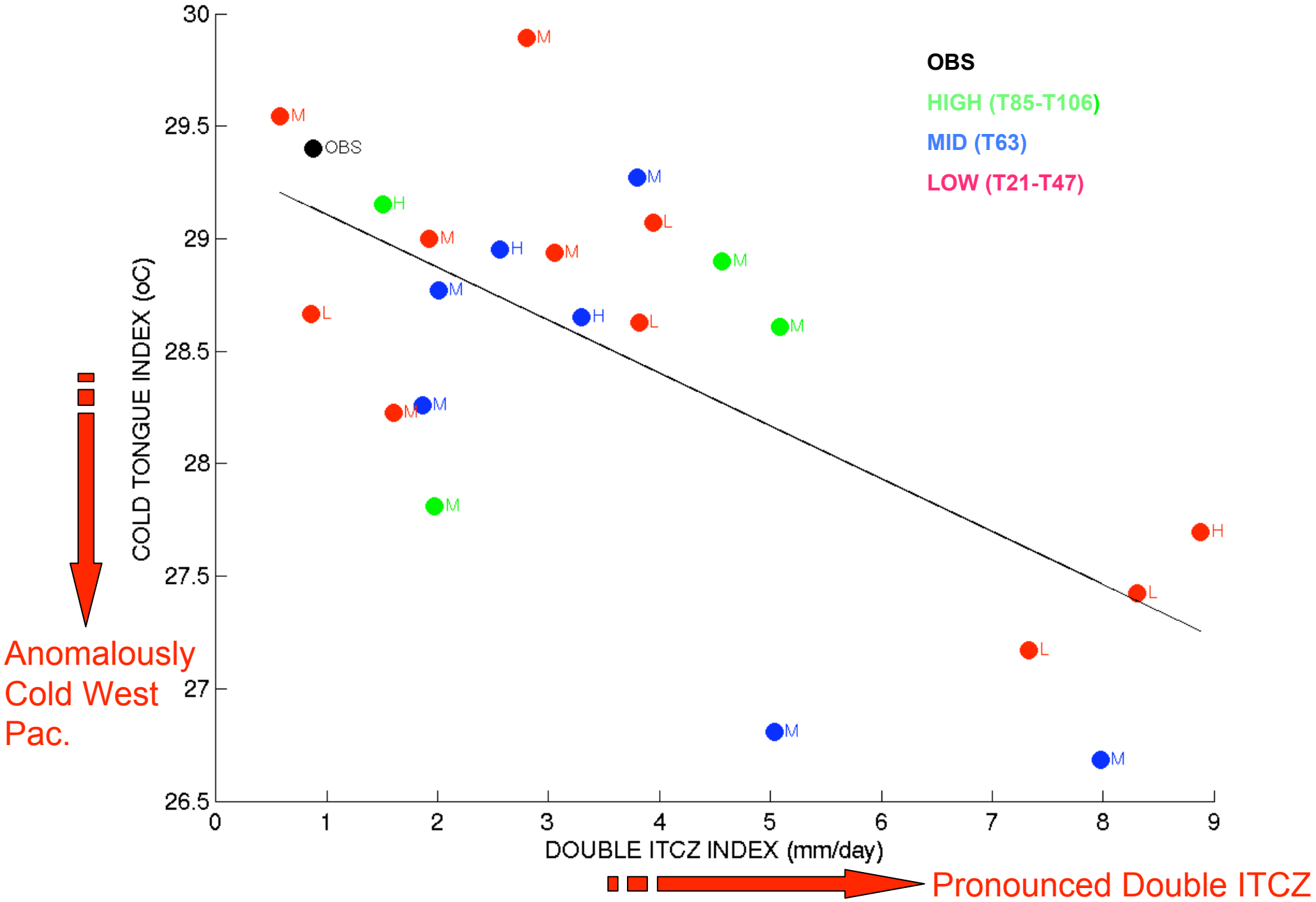

OBS
HIGH (T85-T106)
MID (T63)
LOW (T21-T47)
OBS
COLD TONGUE INDEX (oC)
30
29.5
29
28.5
28
27.5
27
26.5
0
1
2
3
4
5
6
7
8
9
DOUBLE ITCZ INDEX (mm/day)
Anomalously Cold West Pac.
Pronounced Double ITCZ


OBS
HIGH (T85-T106)
MID (T63)
LOW (T21-T47)
OBS
MIROC-HI
GISS-ER
MIROC- MED
GISS-EH
COLD TONGUE INDEX (oC)
DOUBLE ITCZ INDEX (mm/day)
30
29.5
29
28.5
28
27.5
27
26.5
0
1
2
3
4
5
6
7
8
9
Anomalously Cold West Pac.
Pronounced Double ITCZ

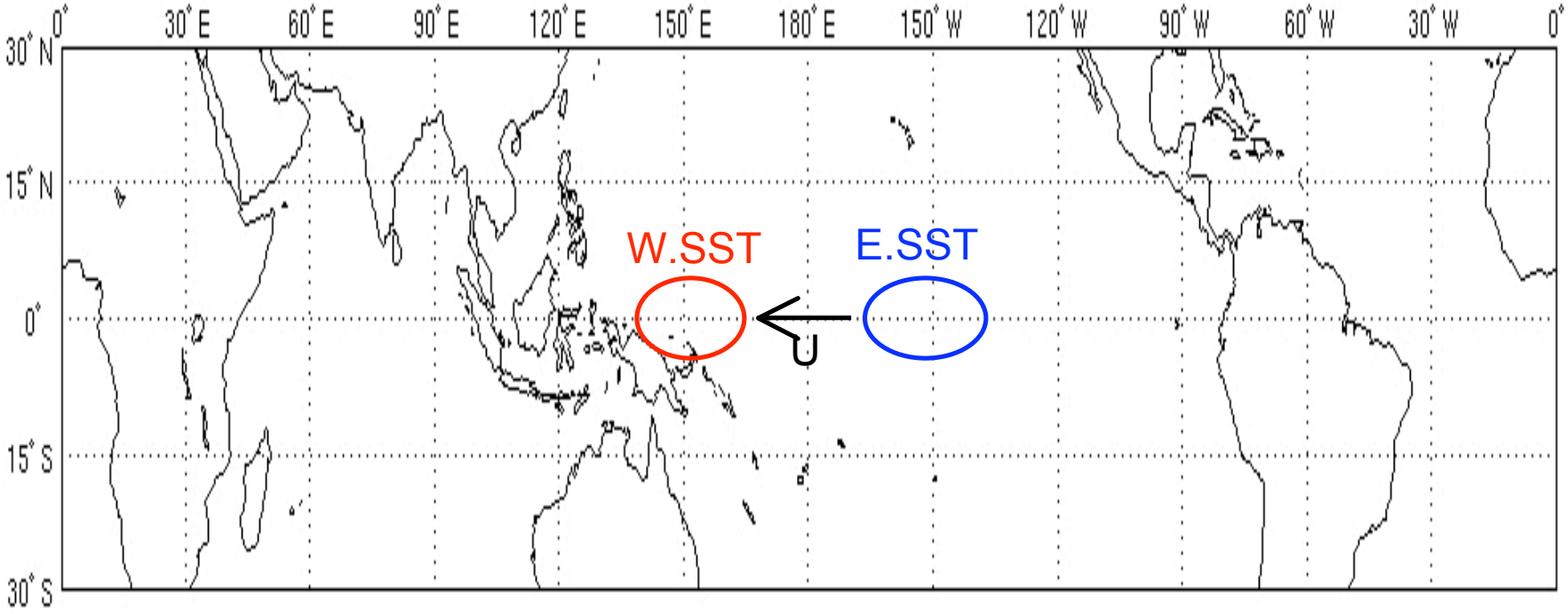


"GISS-E does produce some incorrect ocean-atmosphere feedback parameters which tend to cause insufficient equatorial Pacific precipitation. **Therefore it is likely that there are some processes in the GISS-ER ocean model that tend to cancel the atmospheric model errors**".

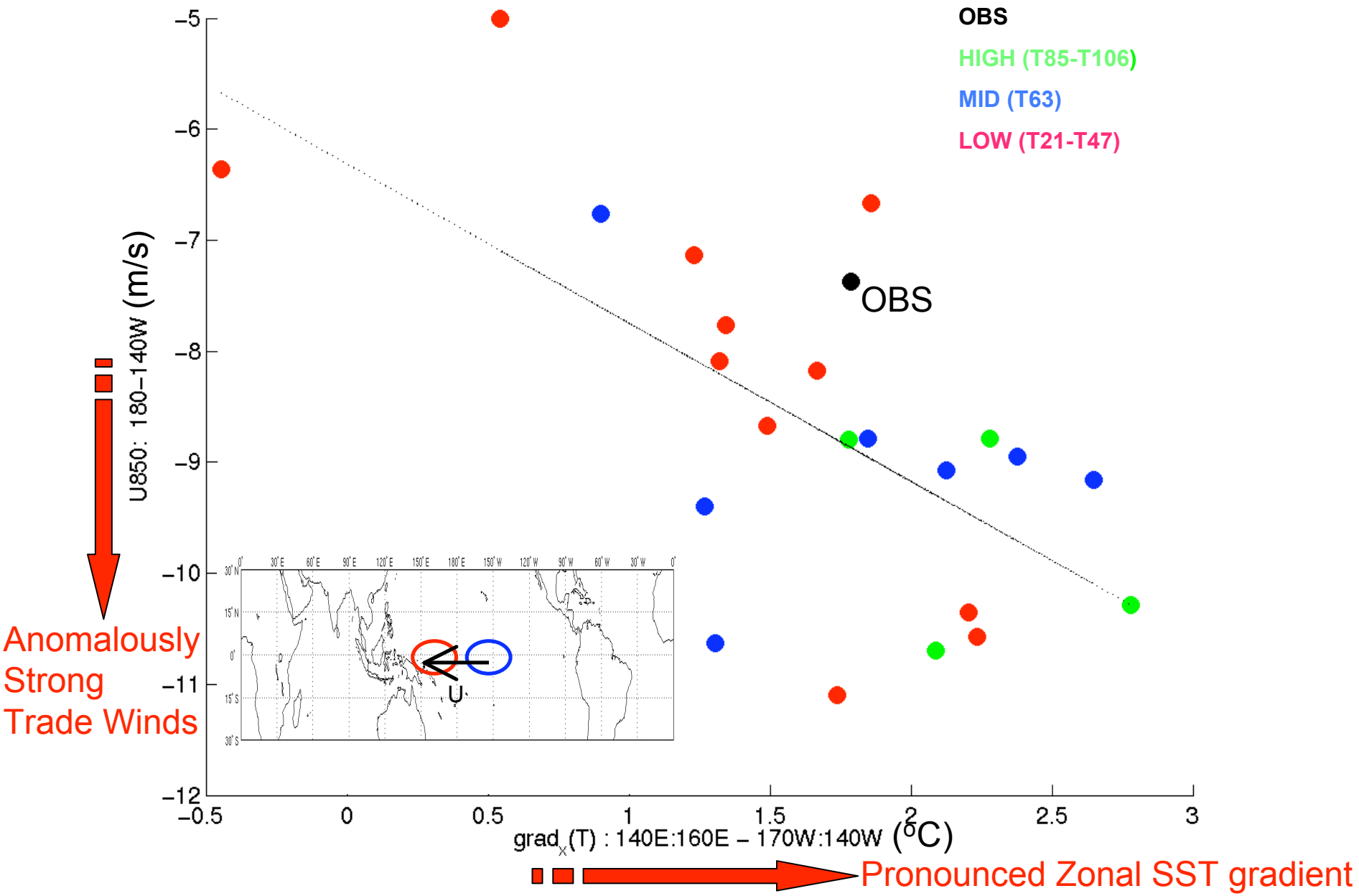
[Lin, 2006]


OBS
HIGH (T85-T106)
MID (T63)
LOW (T21-T47)
COLD TONGUE INDEX (oC)
DOUBLE ITCZ INDEX (mm/day)
30
29.5
29
28.5
28
27.5
27
26.5
0
1
2
3
4
5
6
7
8
9
Anomalously Cold West Pac.
Pronounced Double ITCZ

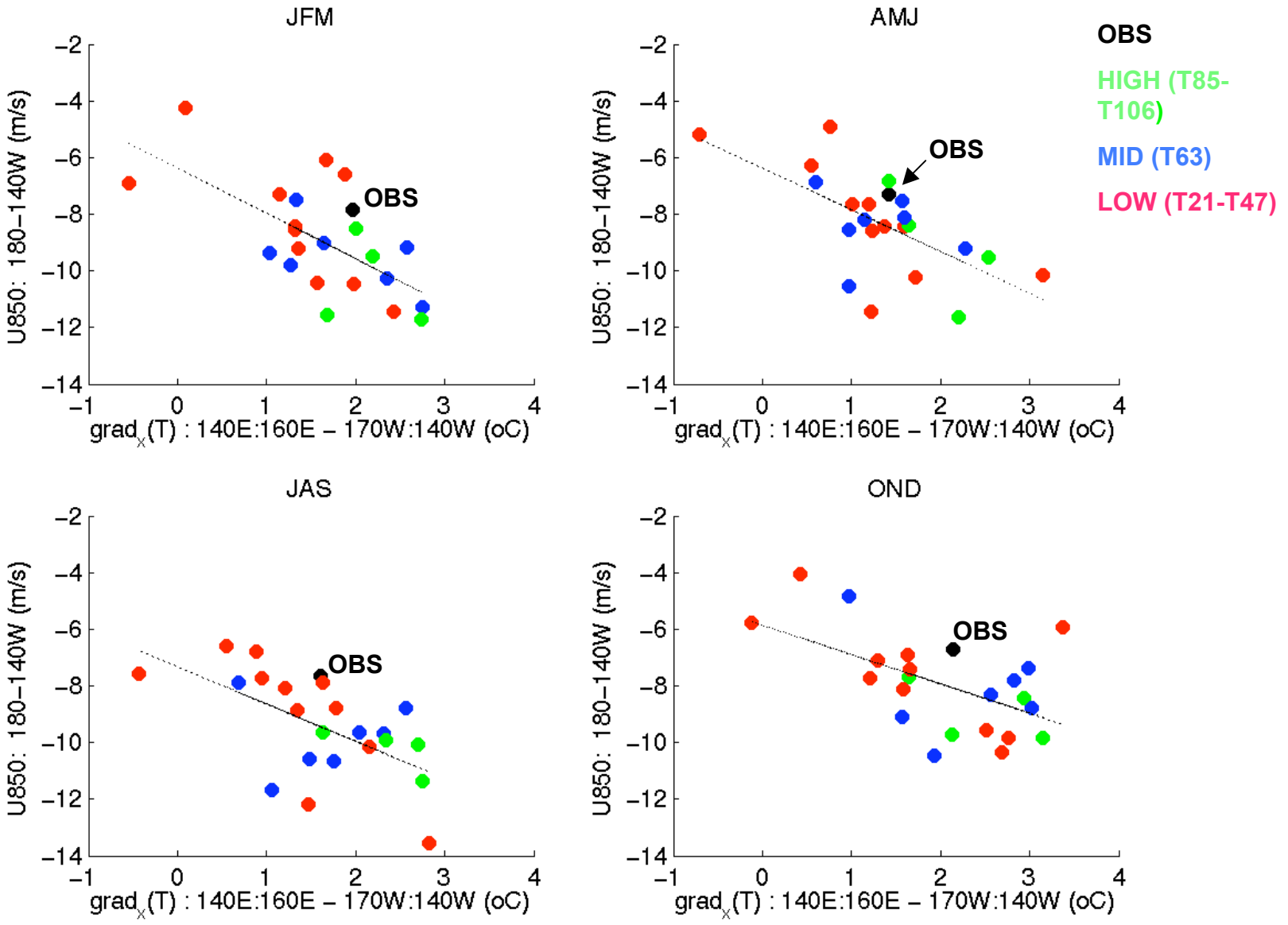
Large scale zonal SST gradient vs U Wind @850mb in the equatorial Pacific



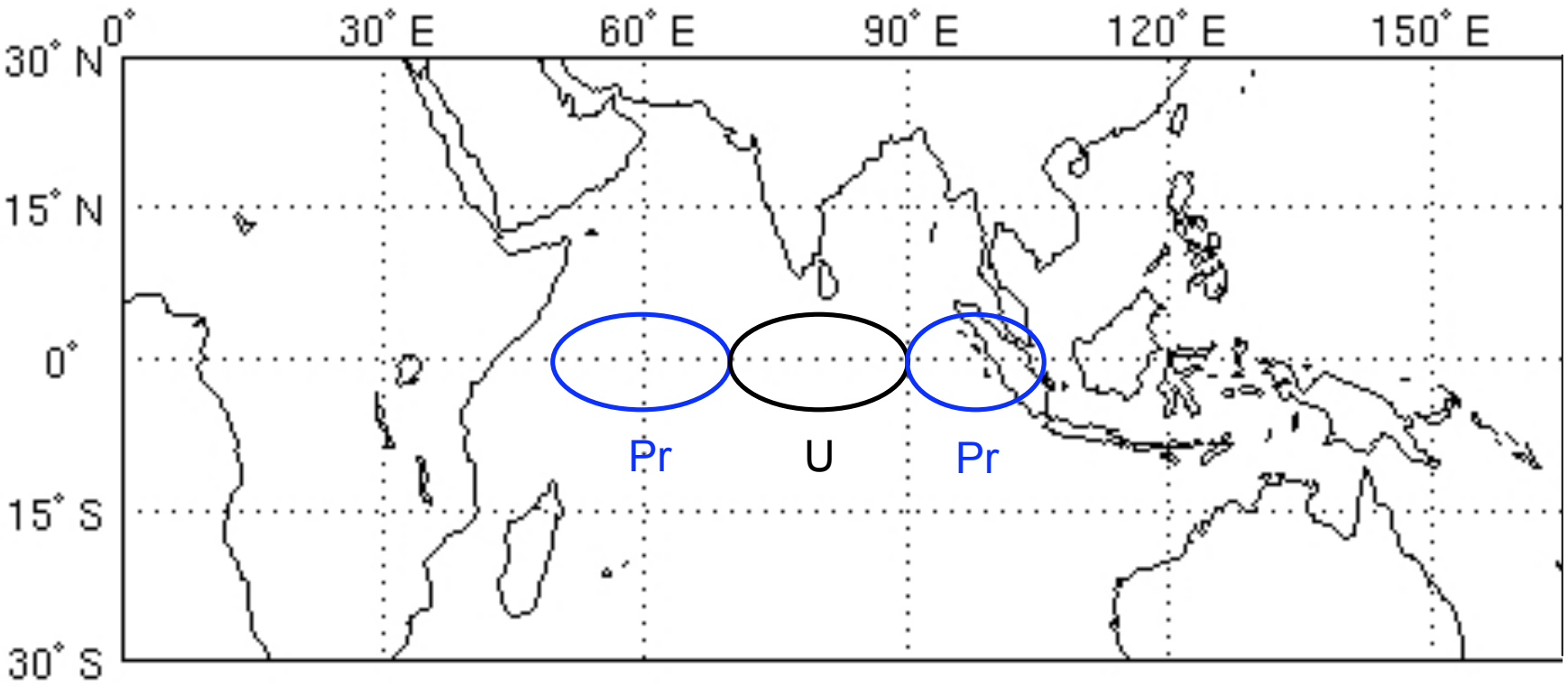
Large scale zonal SST gradient vs U Wind @850mb in the equatorial Pacific



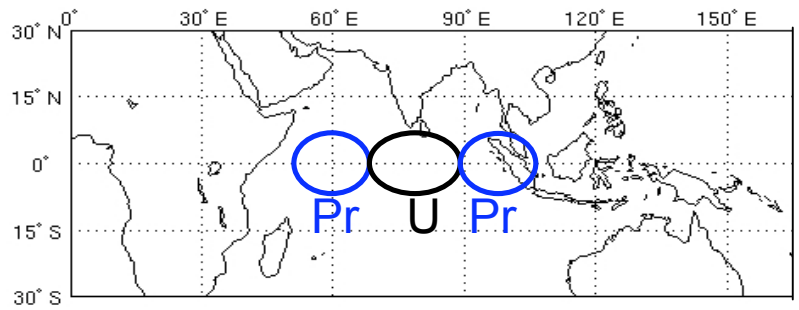
Large scale zonal SST gradient vs U Wind @850mb in the equatorial Pacific

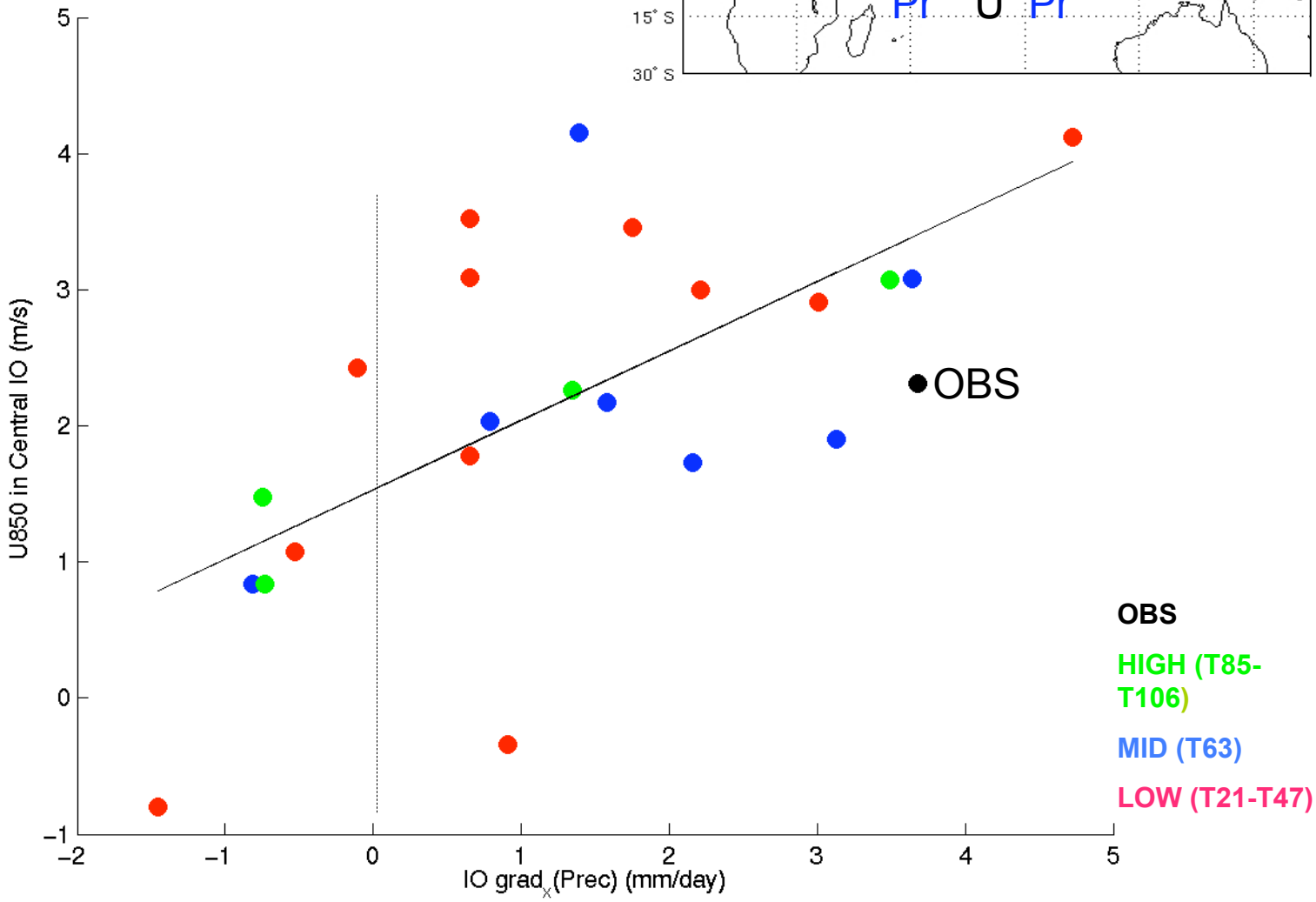


Precipitation vs U850 in the equatorial Indian Ocean

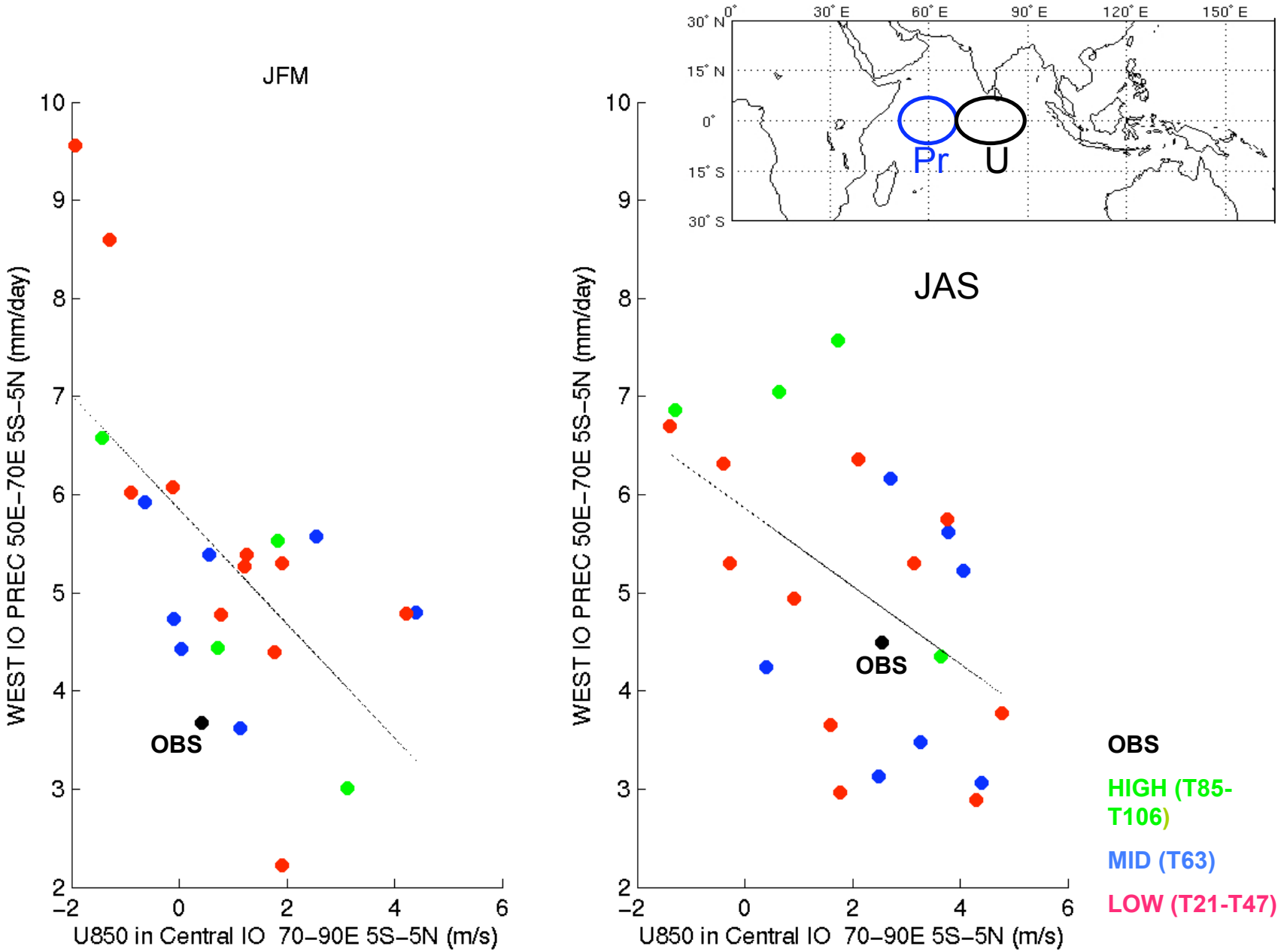


Zonal Precipitation Gradient (E-W) vs U850 In Equatorial Indian Ocean

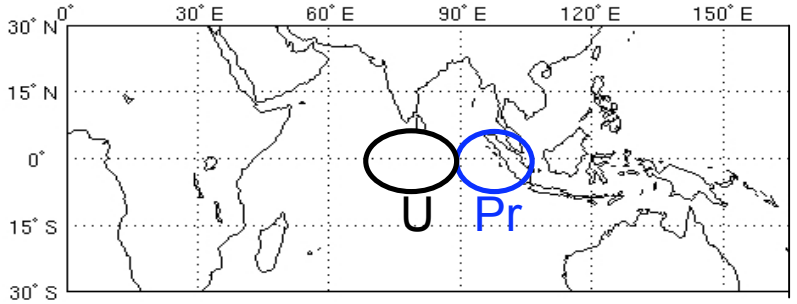


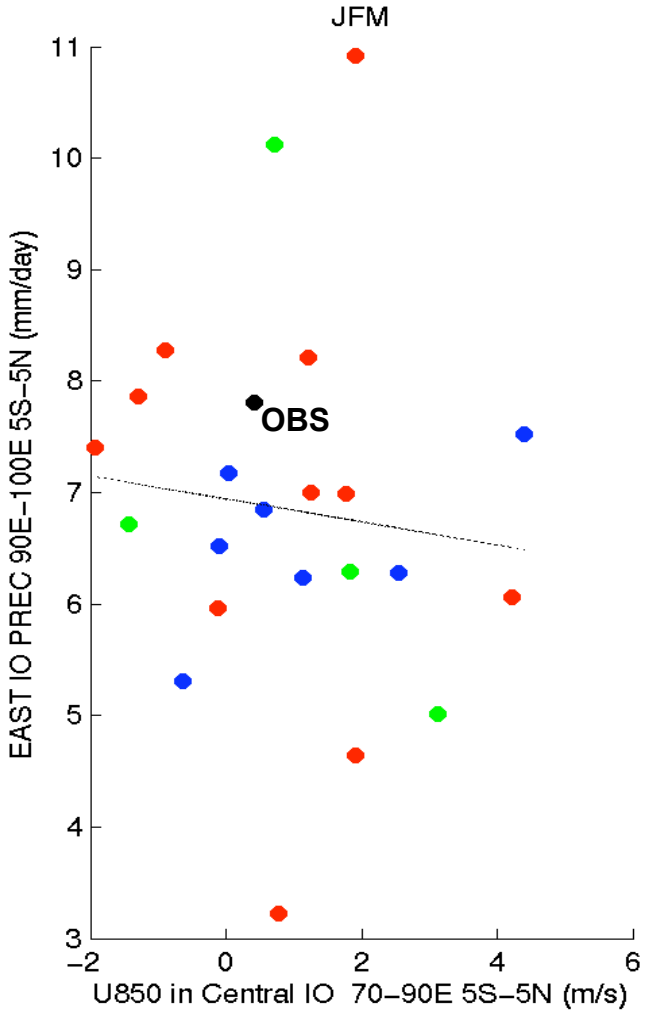


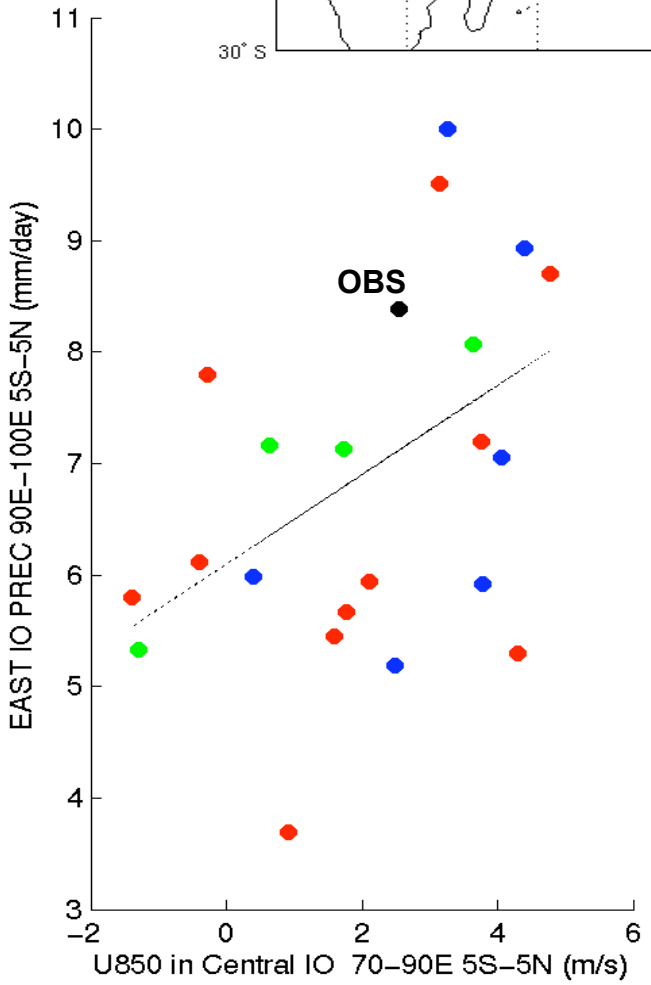
West Indian Ocean



East Indian Ocean







JAS

OBS

HIGH (T85-T106)

MID (T63)

LOW (T21-T47)

Dominant ENSO frequency in AR4 CGCMs.

OBS:	**3.5 and 5.3**
BCCR:	4.2
CCMA:	3.
CCMA-CGCM3:	5.0
CNRM:	3.4
CSIRO:	2.0
GFDL-0:	3.1
GFDL-1:	5.4
GISS:	3.5
GISS-EH:	4.2
GISS-ER:	2.5
IAP:	3.3
INGV:	4.0
INM:	4.2 and 7.0
MIROC-HIRES:	2.9
MIROC-MEDRES:	8.1
MPI:	3.5
MRI:	2.1
NCAR-CCSM:	2.0
NCAR-PCM1:	2.3
UKMO-HADCM3:	3.0 and 5.3
UKMO-HADGEM1:	4.1

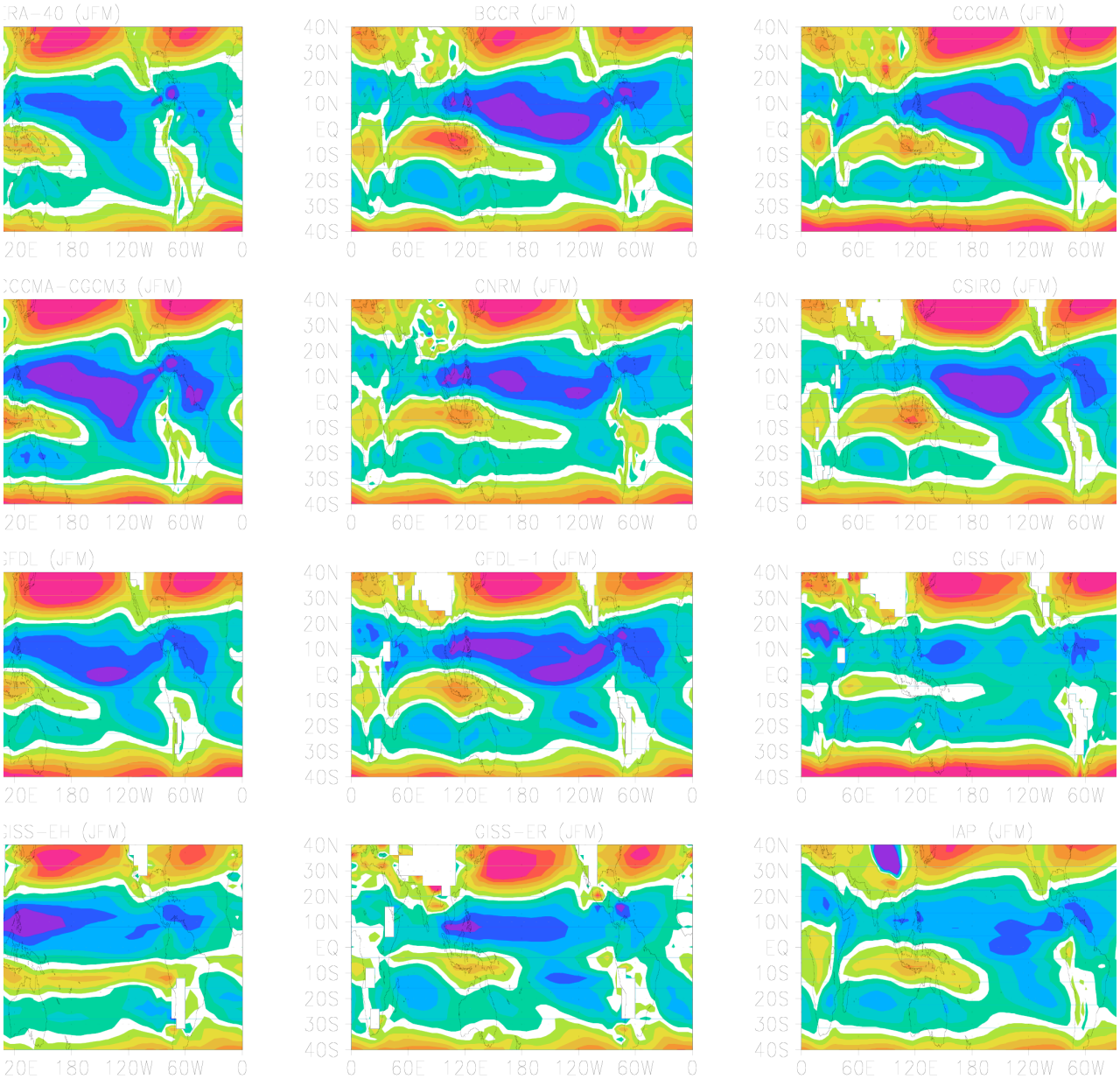
SUMMARY

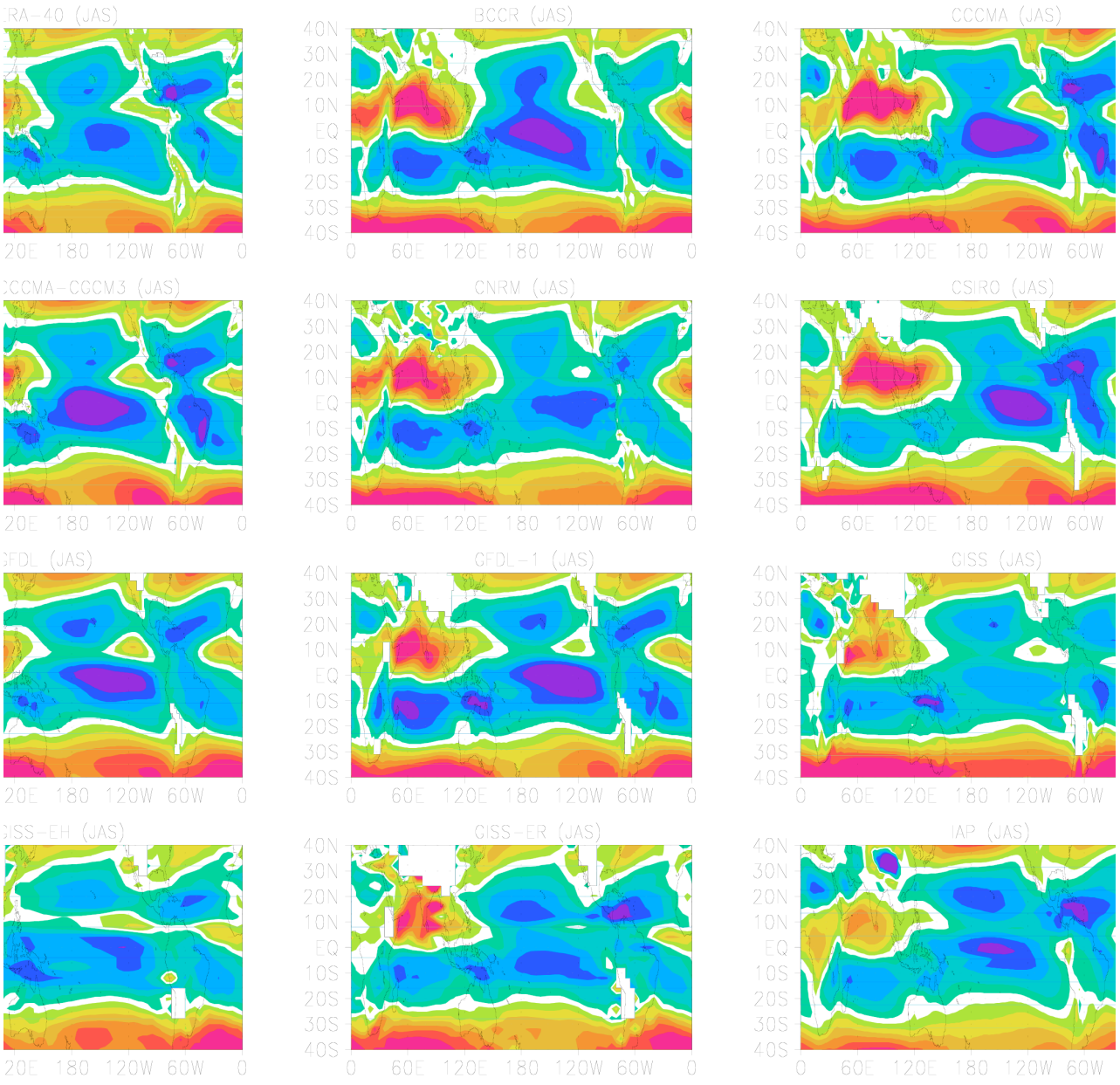
• State-of-the-art CGCMs still present large biases affecting the representation of the 20c3m tropical climate.

• Different model errors appear to be correlated. For example, CGCMs showing a particularly pronounced double ITCZ are generally characterized by an anomalously cold SST in the west equatorial Pacific, typically associated with a an anomalous westward extension of the cold tongue.

• Trade winds in the Pacific sector are largely overestimated, and this is generally associated with a pronounced SST zonal gradient at the equator. There are also indications for an inverse relationship between the intra-model scatter and AGCM resolution.

• Zonal precipitation gradient in the equatorial Indian Ocean is underestimated in most of the CGCMs (with excessive precipitation in WIO, and lower than observed precipitation in EIO). Models exhibiting either a weak or *reversed* (wrt observations) E-W precipitation contrast are generally characterized by a consistently weak zonal wind in central IO.


RA-40 (JFM)
BCCR (JFM)
CCCMA (JFM)
CCCMA-CGCM3 (JFM)
CNRM (JFM)
CSIRO (JFM)
FDL (JFM)
GFDL-1 (JFM)
GISS (JFM)
ISS-EH (JFM)
GISS-ER (JFM)
IAP (JFM)
40N
30N
20N
10N
EQ
10S
20S
30S
40S
0
60E
120E
180
120W
60W
0


RA-40 (JAS)
BCCR (JAS)
CCCMA (JAS)
CCCMA-CCCM3 (JAS)
CNRM (JAS)
CSIRO (JAS)
CFDL (JAS)
CFDL-1 (JAS)
CISS (JAS)
CISS-EH (JAS)
CISS-ER (JAS)
IAP (JAS)
40N
30N
20N
10N
EQ
10S
20S
30S
40S
0
60E
120E
180
120W
60W
0