International Centre for Theoretical Physics, Trieste, Italy, Nov 2012

ENSO, decadal climate variability and climate change in the Pacific

Scott Power,

with G. Kociuba, C. Chung, J. Callaghan, F. Delage, J. Arblaster, I. Smith, G. Roff, H. Rashid, and over 100 other colleagues in the Pacific-Australia Climate Change Science and Adaptation planning Program (PACCSAP)

Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

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Contents

1. Decadal climate variability in the Pacific
   - ENSO
   - Land-falling severe tropical cyclones

2. Climate change in the Pacific
   - Past and future changes in the Walker Circulation
   - Combined, non-linear impact of El Niño and global warming on precipitation
   - *Climate Change in the Pacific* – a major new report available for download

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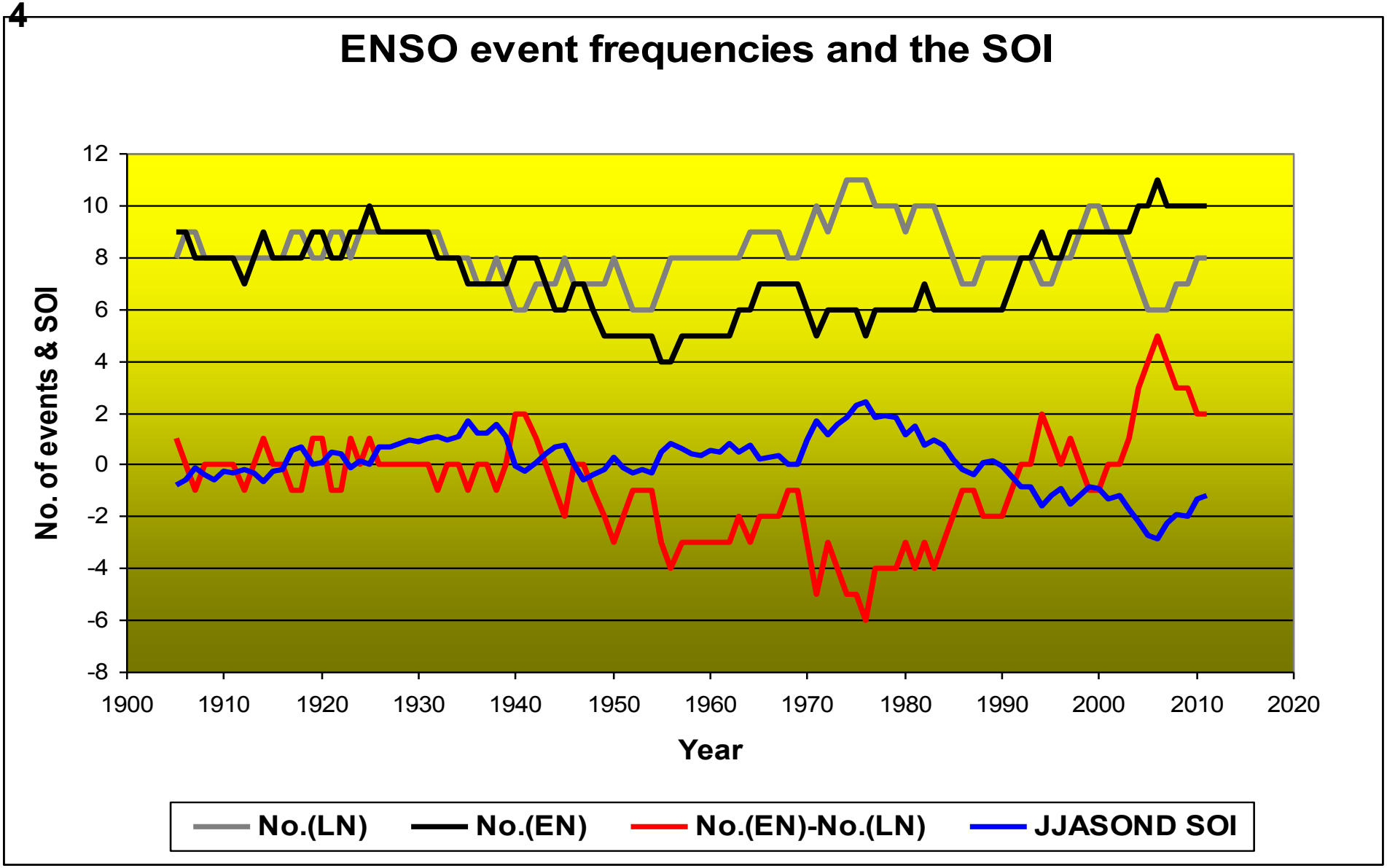


Power and Smith, *Geophys. Res. Lett.*, 2007; updated to 2011

An expensive pile of debris at Hinchinbrook Marina in Cardwell.
Photo: Paul Crock

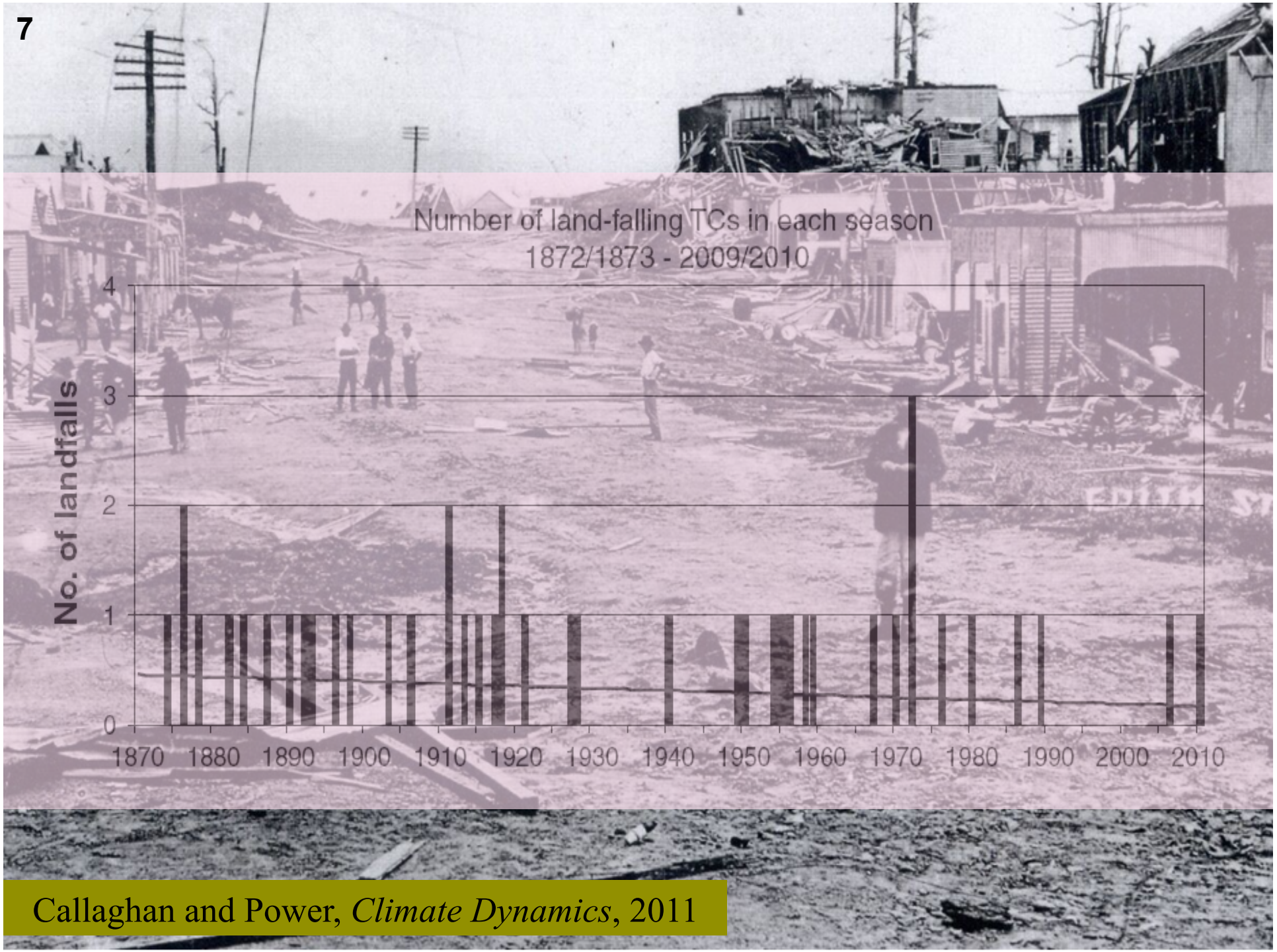
Mackay 1918

To achieve homogeneity we:

•restricted attention to

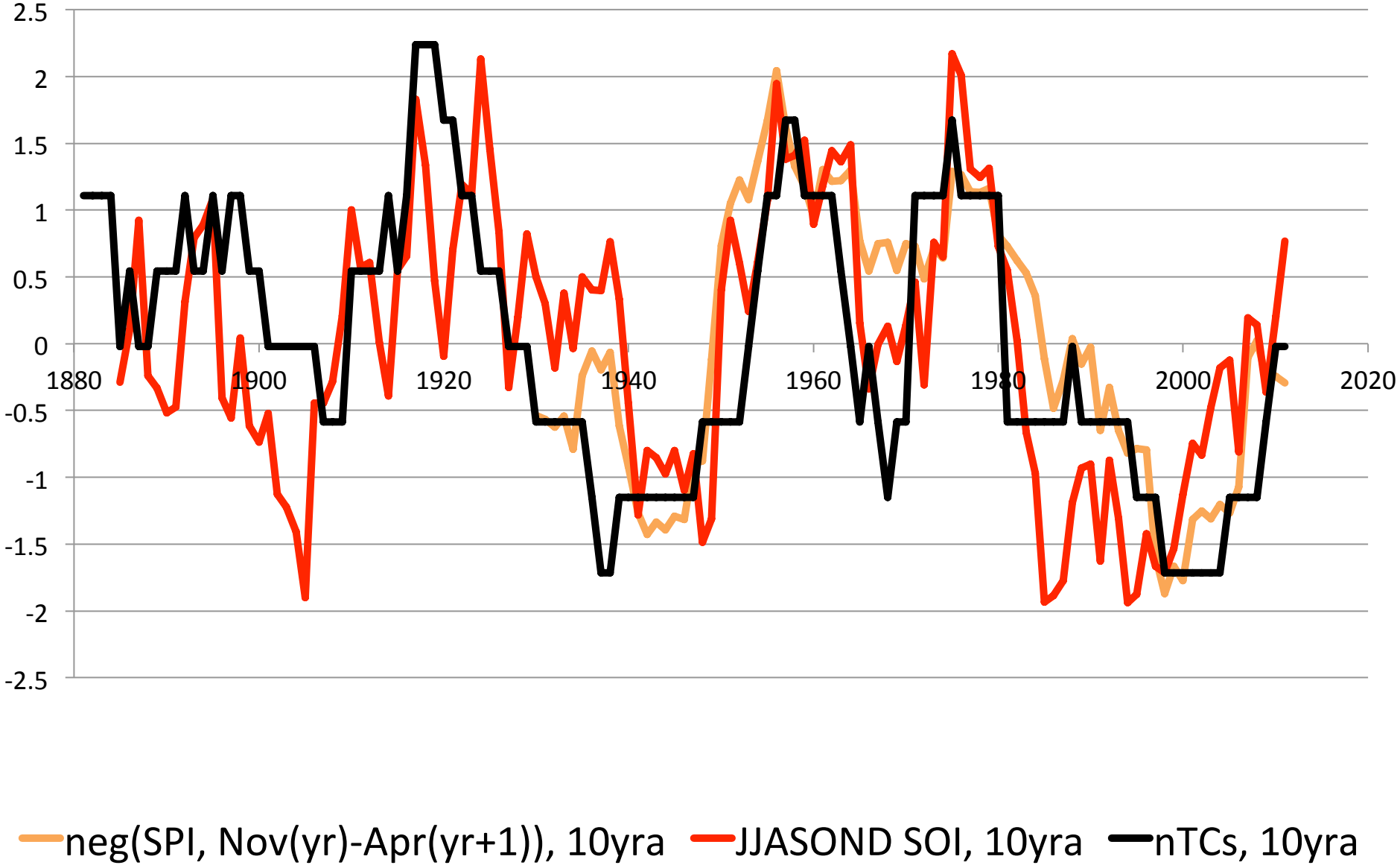
- most populated part of coast
- after 1872

•combined all categories 3-5 into a single ‘severe’ class



Callaghan and Power, *Climate Dynamics*, 2011

10-yr running scaled averages



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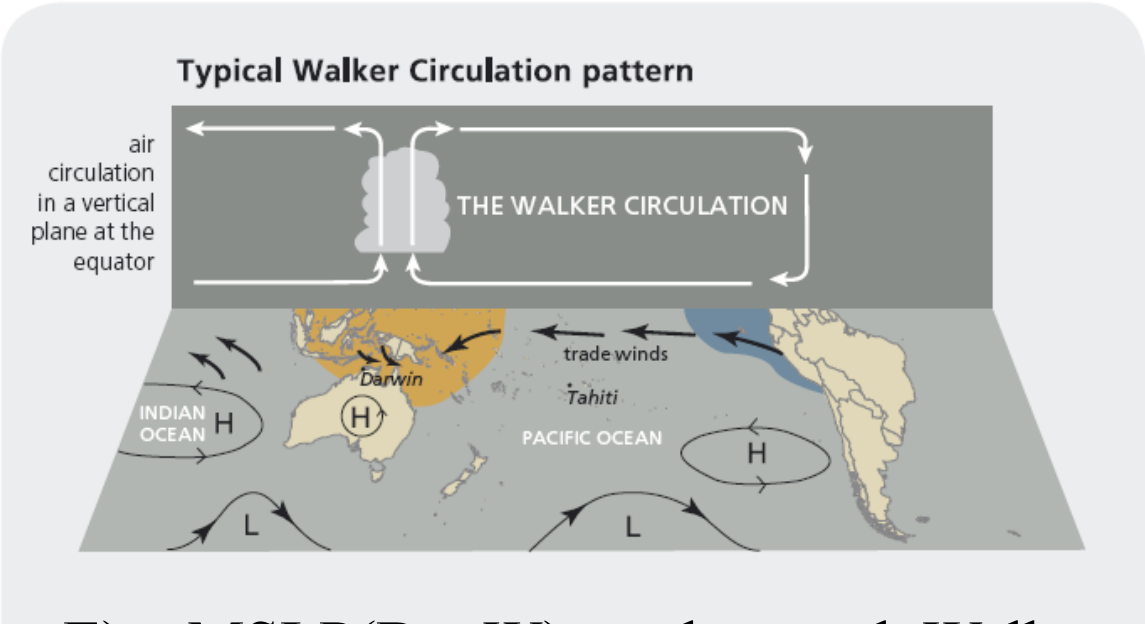
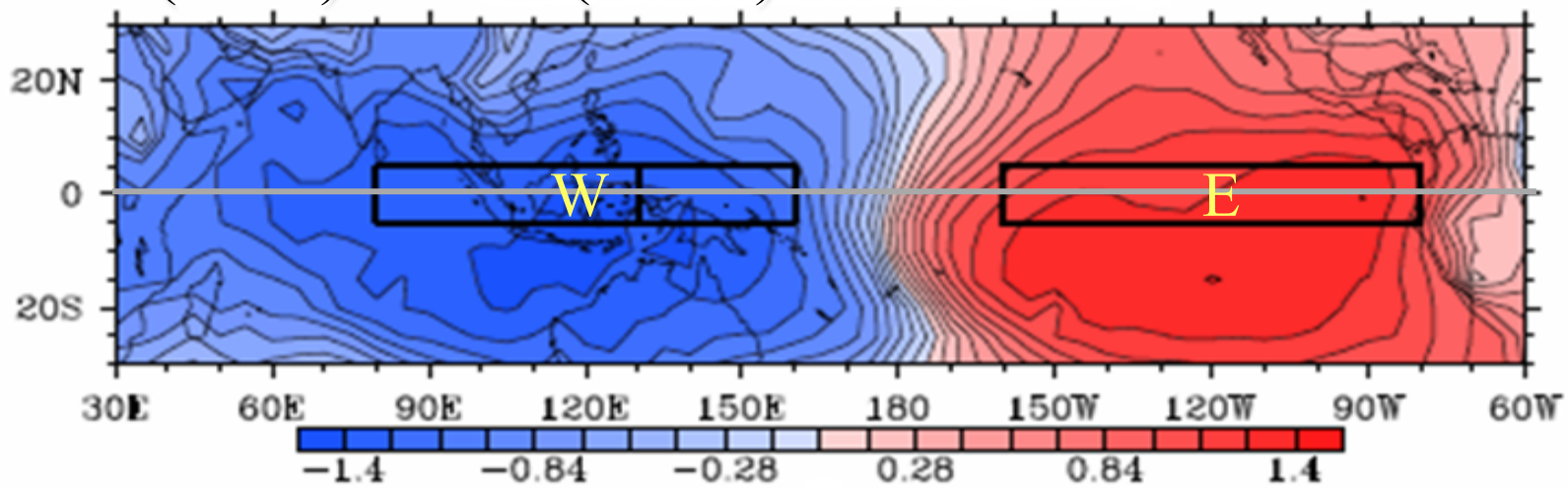
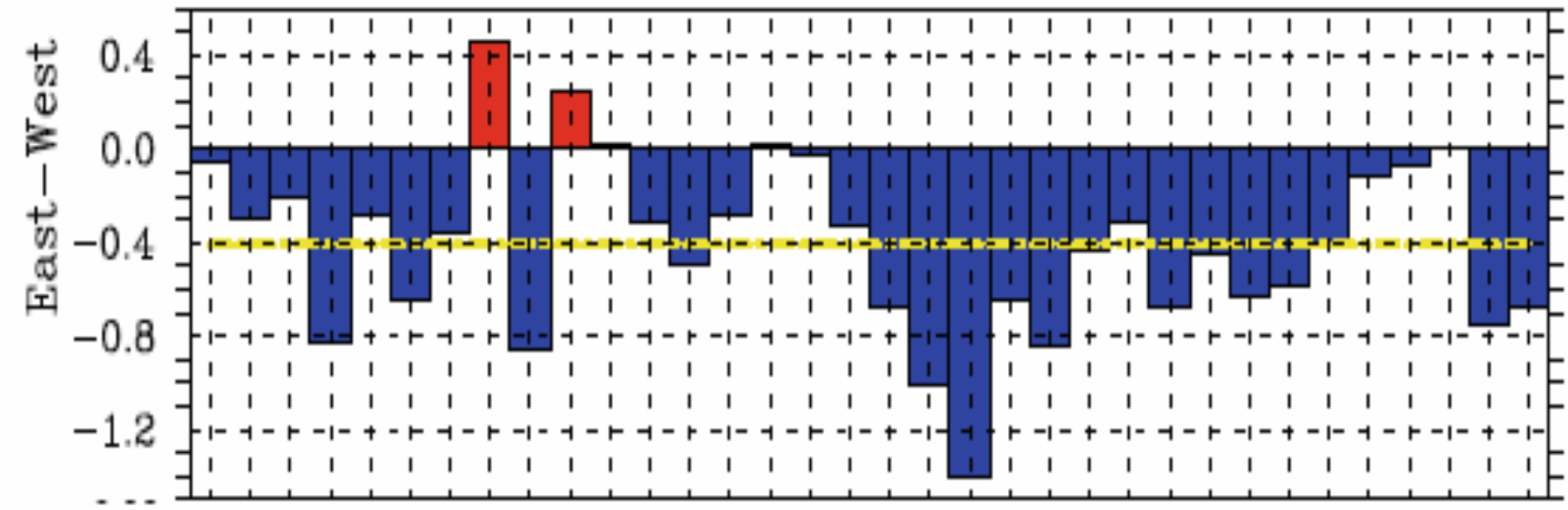
The Walker circulation



MSLP(BoxE) – MSLP(BoxW) used to track Walker circulation



Walker circulation weakens during 21st century in CMIP3 models under A2 scenario – very robust

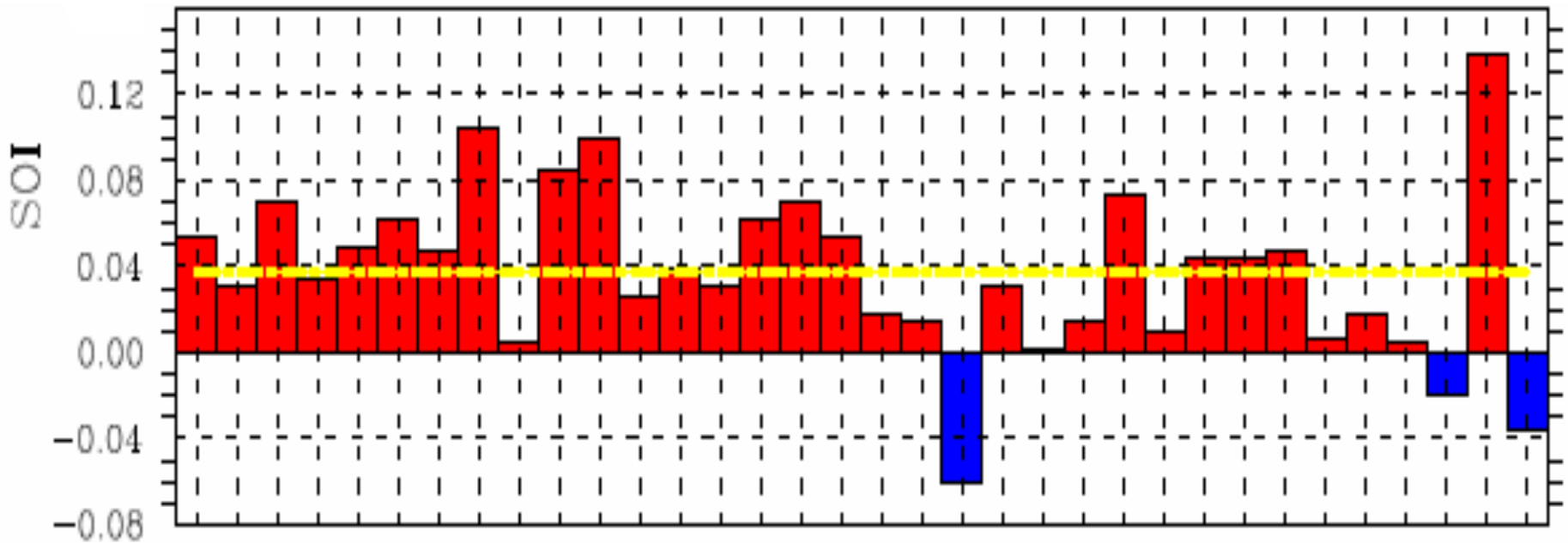


What will happen to the Southern Oscillation Index (SOI)?

- SOI < 0 during El Niño/when the Walker circulation weakens
- SOI > 0 during La Niña/ when the Walker circulation strengthens

- As the Walker circulation circulation is projected to decline during the 21st century, the projected SOI will obviously decline

21st century trends in SOI, A2



The SOI actually increases during the 21st century!

The SSOI increases - very robust.

The Walker circulation weakens – very robust.

How can this be??

Power and Kociuba, *Climate Dynamics*, 2011

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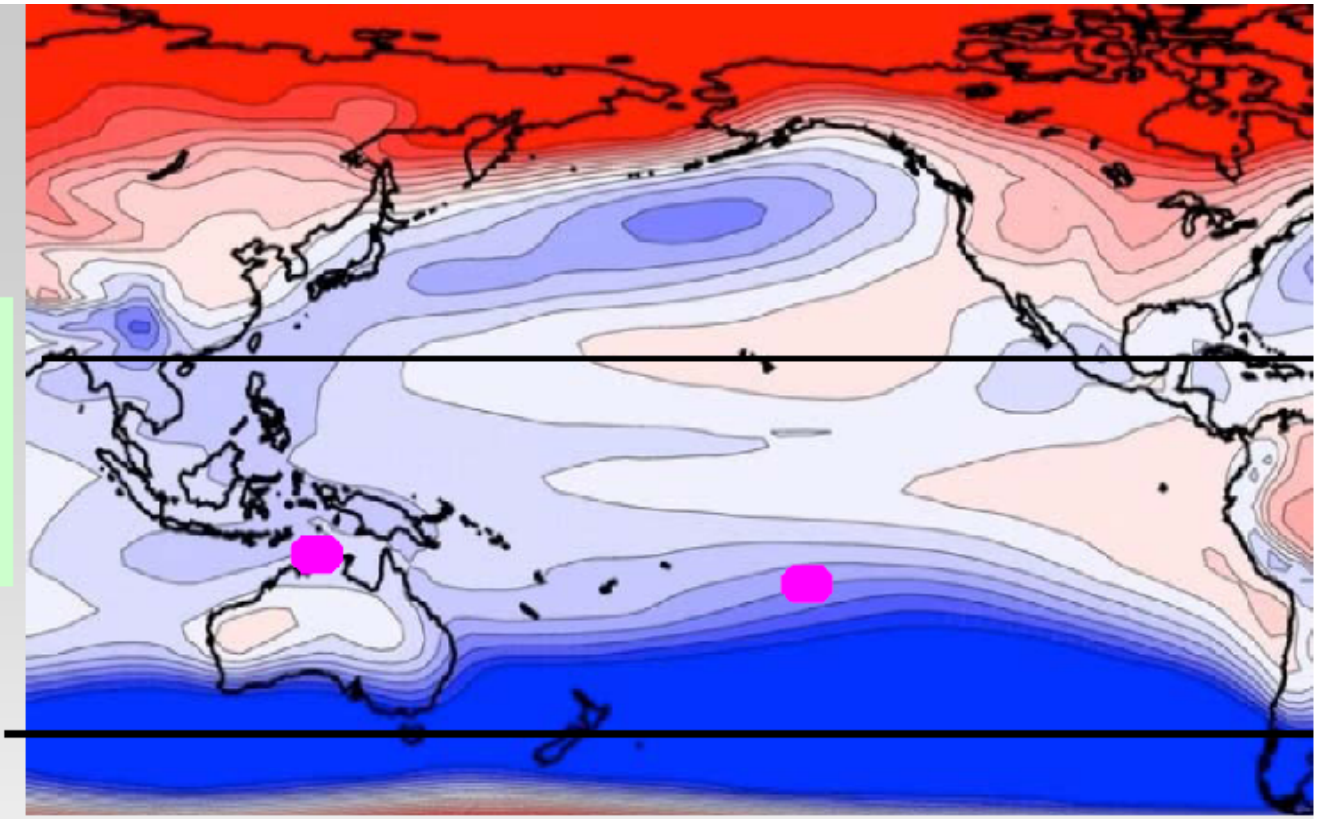
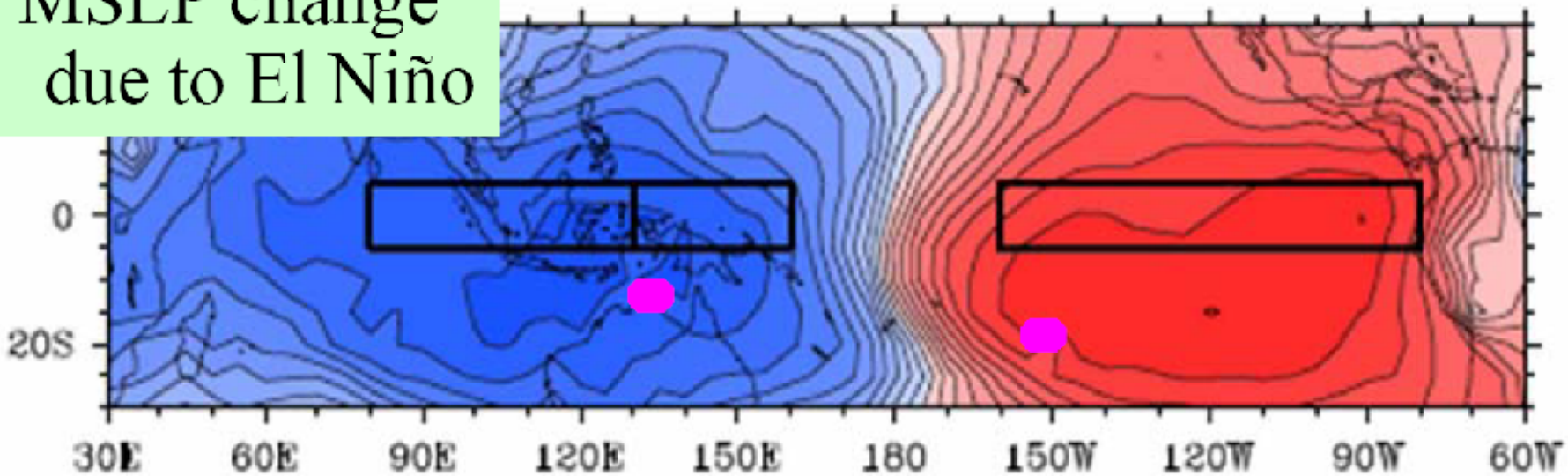
21st C MSLP change due to global warming



MSLP change due to El Niño



- Glaring example in which use of El Niño as an anlaogue for climate change breaks down

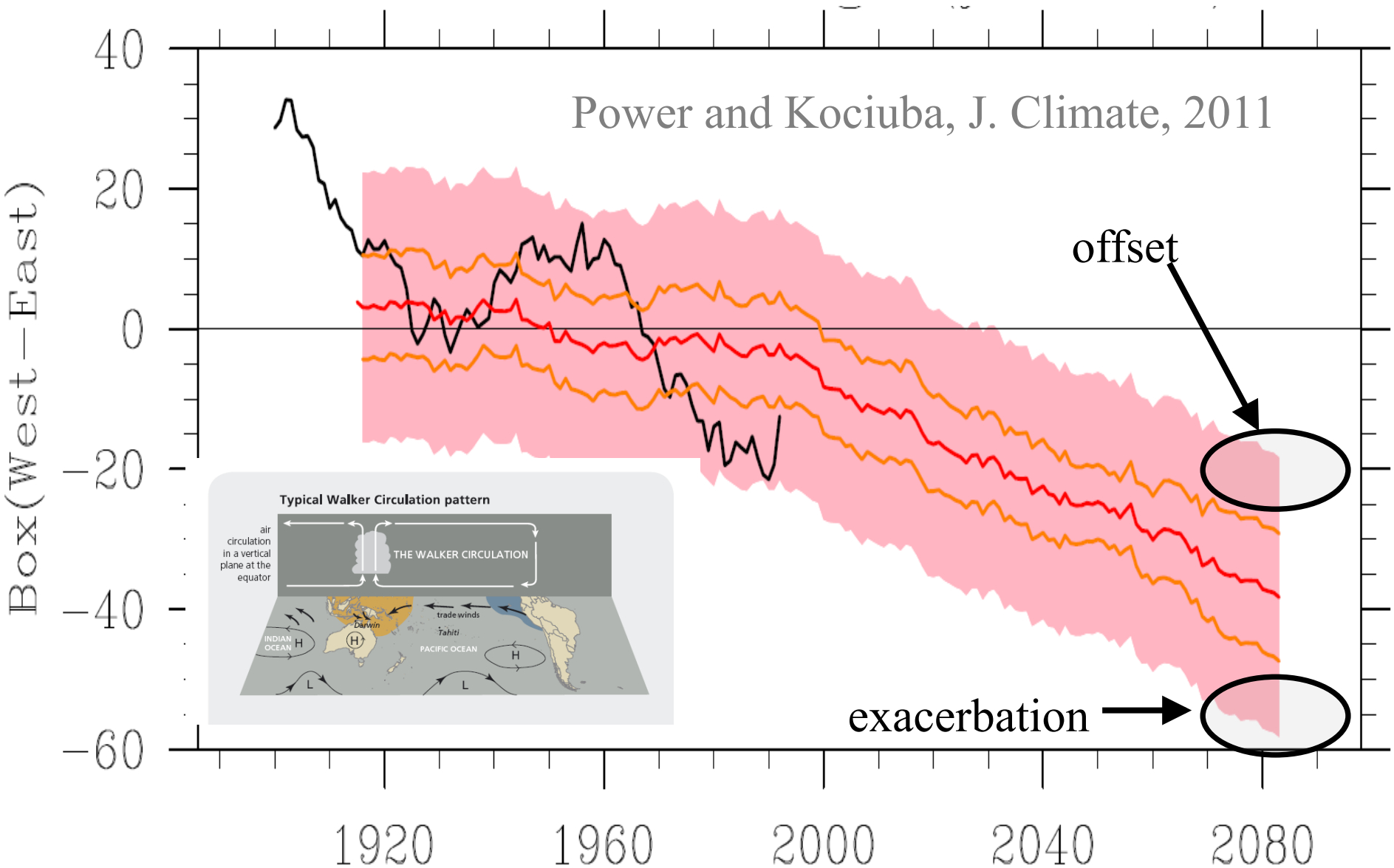
20th C trends in BoxdP

Observed and MMEM trends

Source	Trend (Pa/yr), 1901-1999	% contribution
Obs (Power and Kociuba 2011)	-0.52	100
All models	-0.1	19
"Consistent" models	-0.17	33
Top 6 (van Oldenborgh et al. 2005	-0.26	50
Top 4 (van Oldenborgh et al. 2005)	-0.2	38
GFDL2.1 (Vecchi et al. 2006)	-0.37	71

Power and Kociuba, *J. Climate*, 2011

The Walker Circulation – past and future



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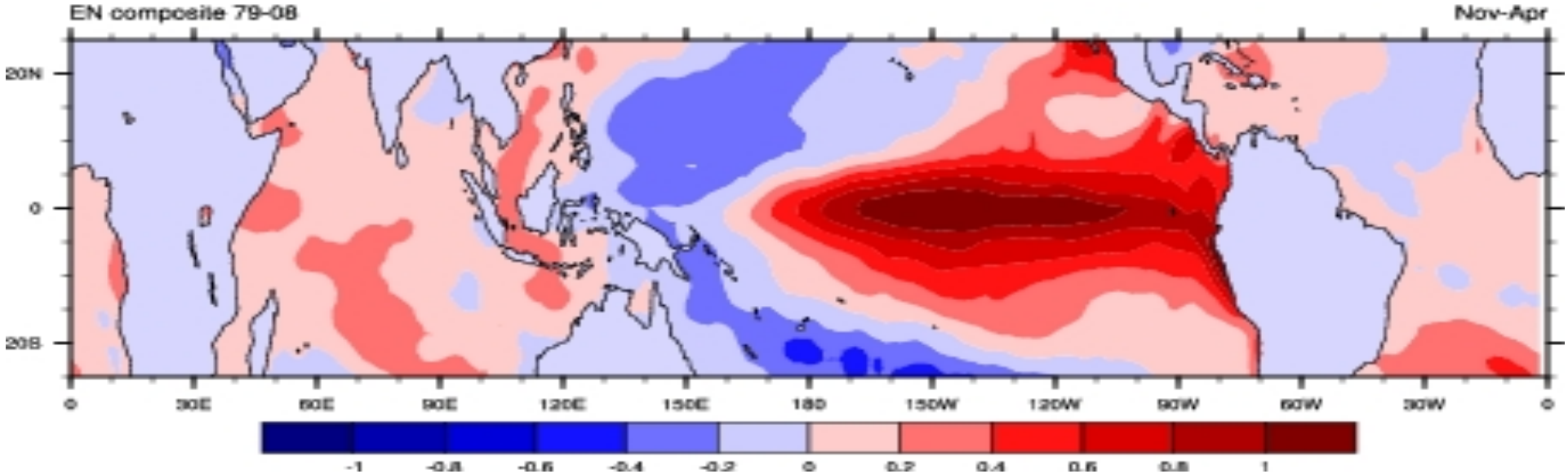
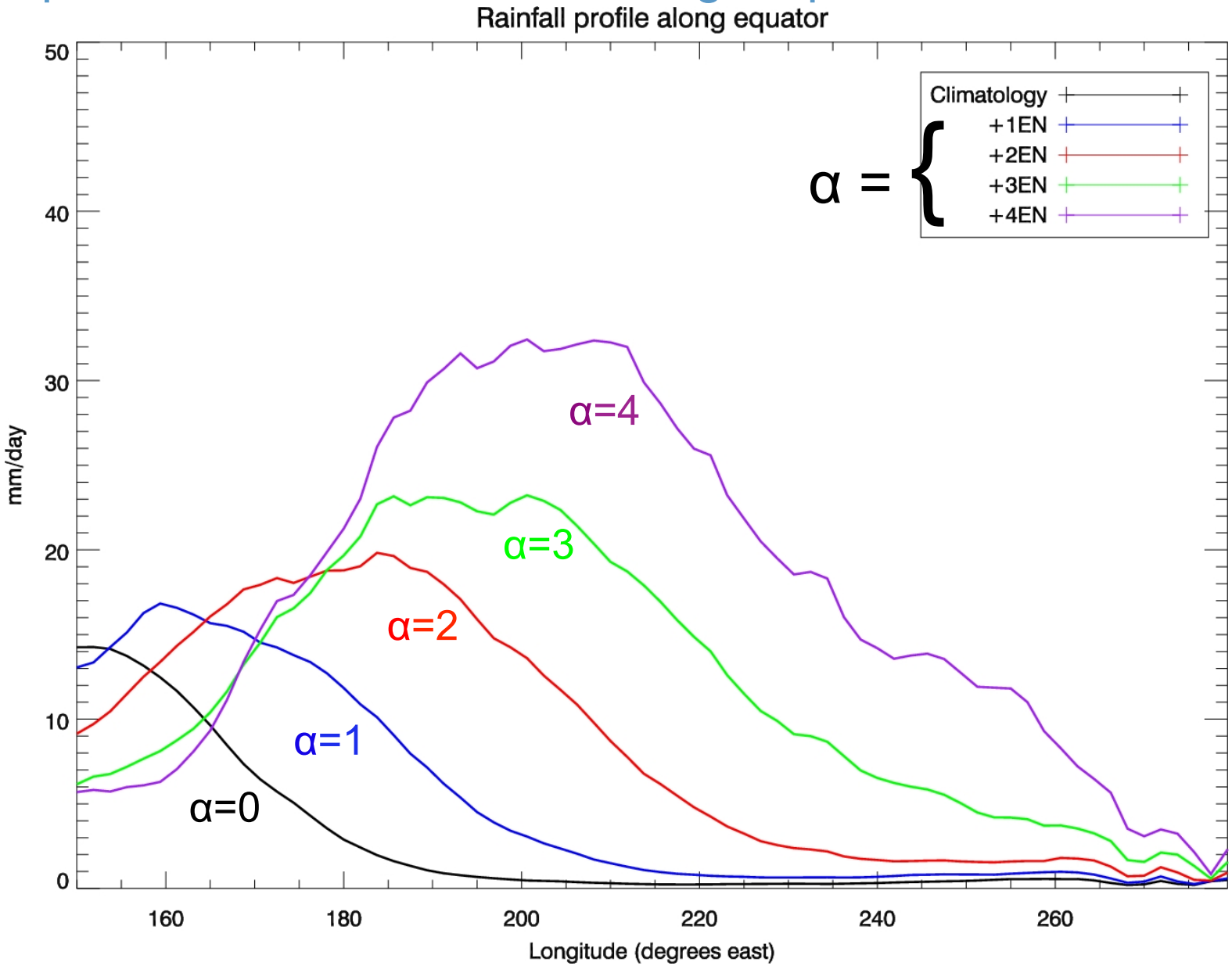
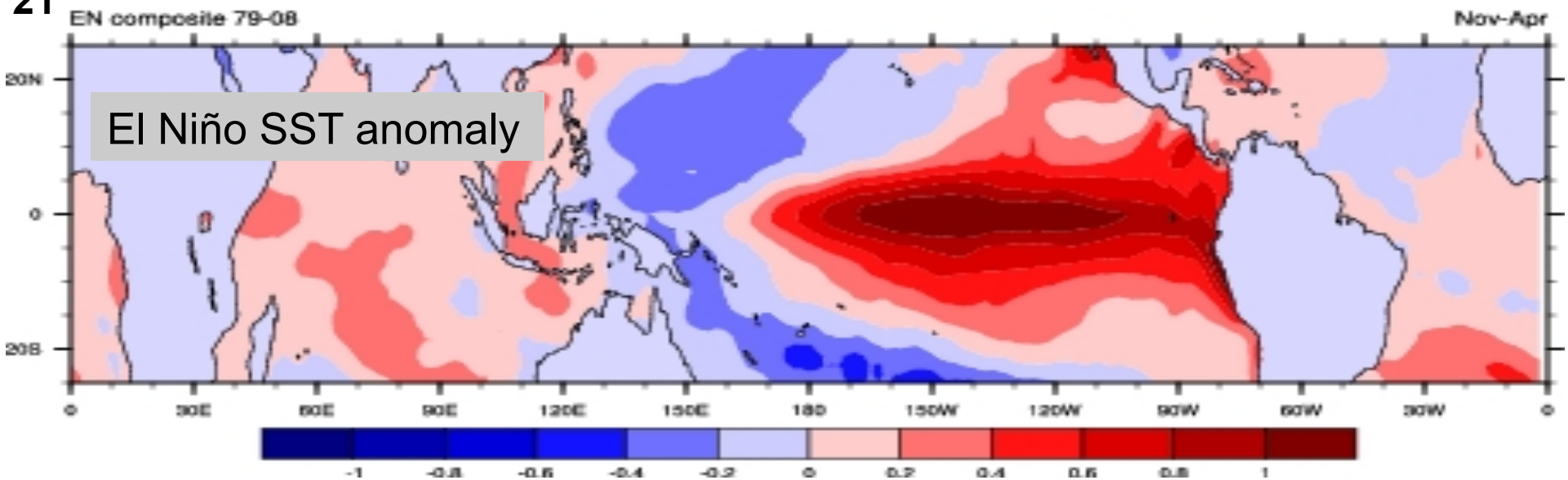
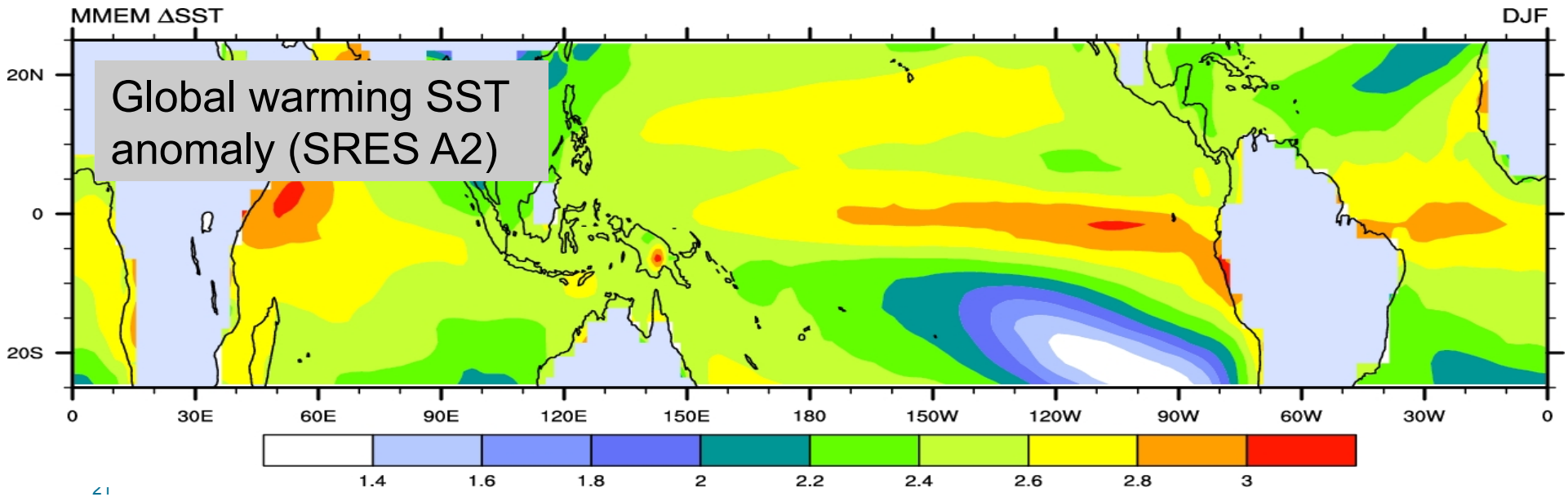
El Niño SST anomaly – same monthly structures used in all experiments

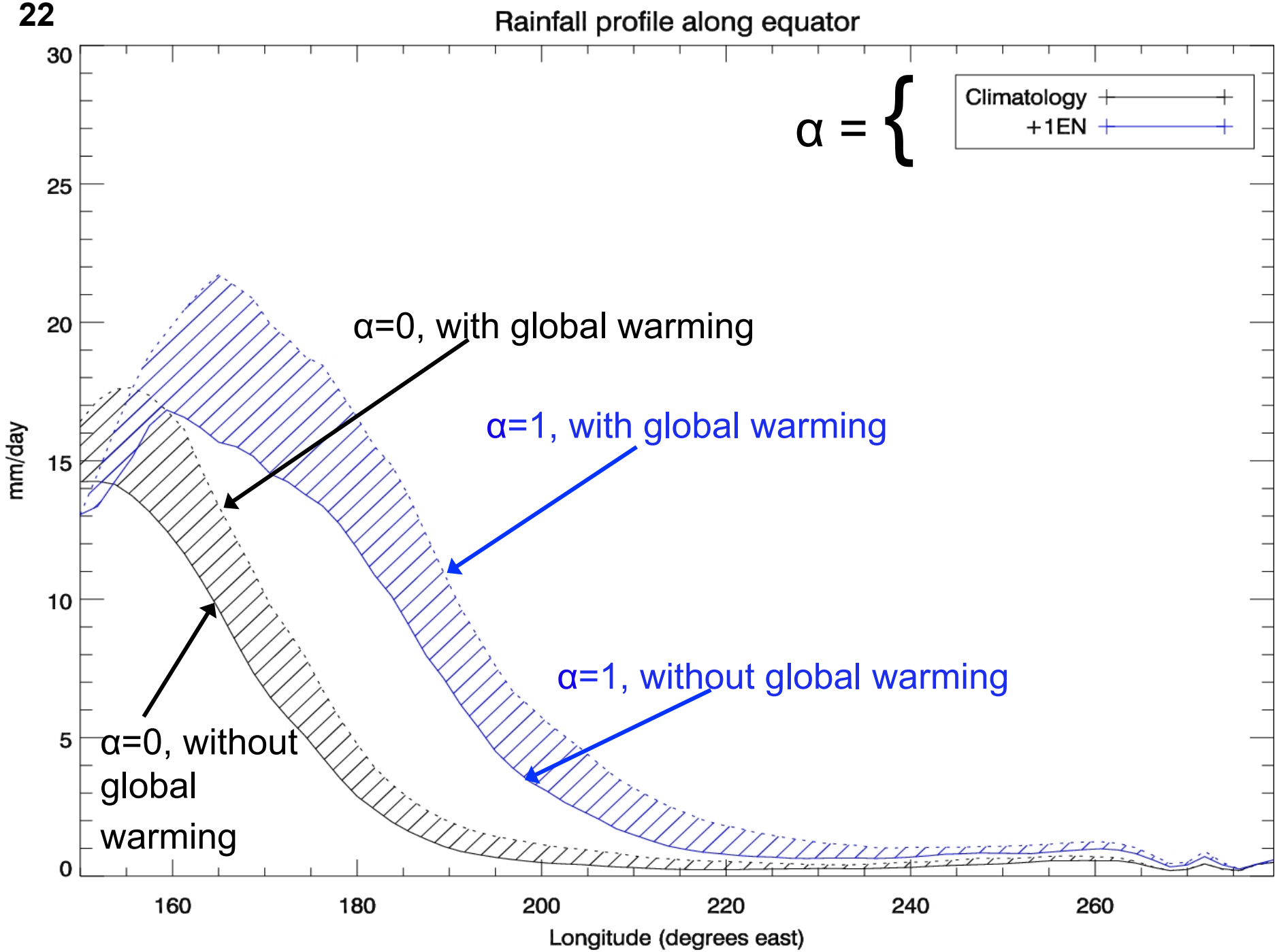


Impact of unchanging El Niño SSTA pattern on equatorial rainfall with increasing amplitude

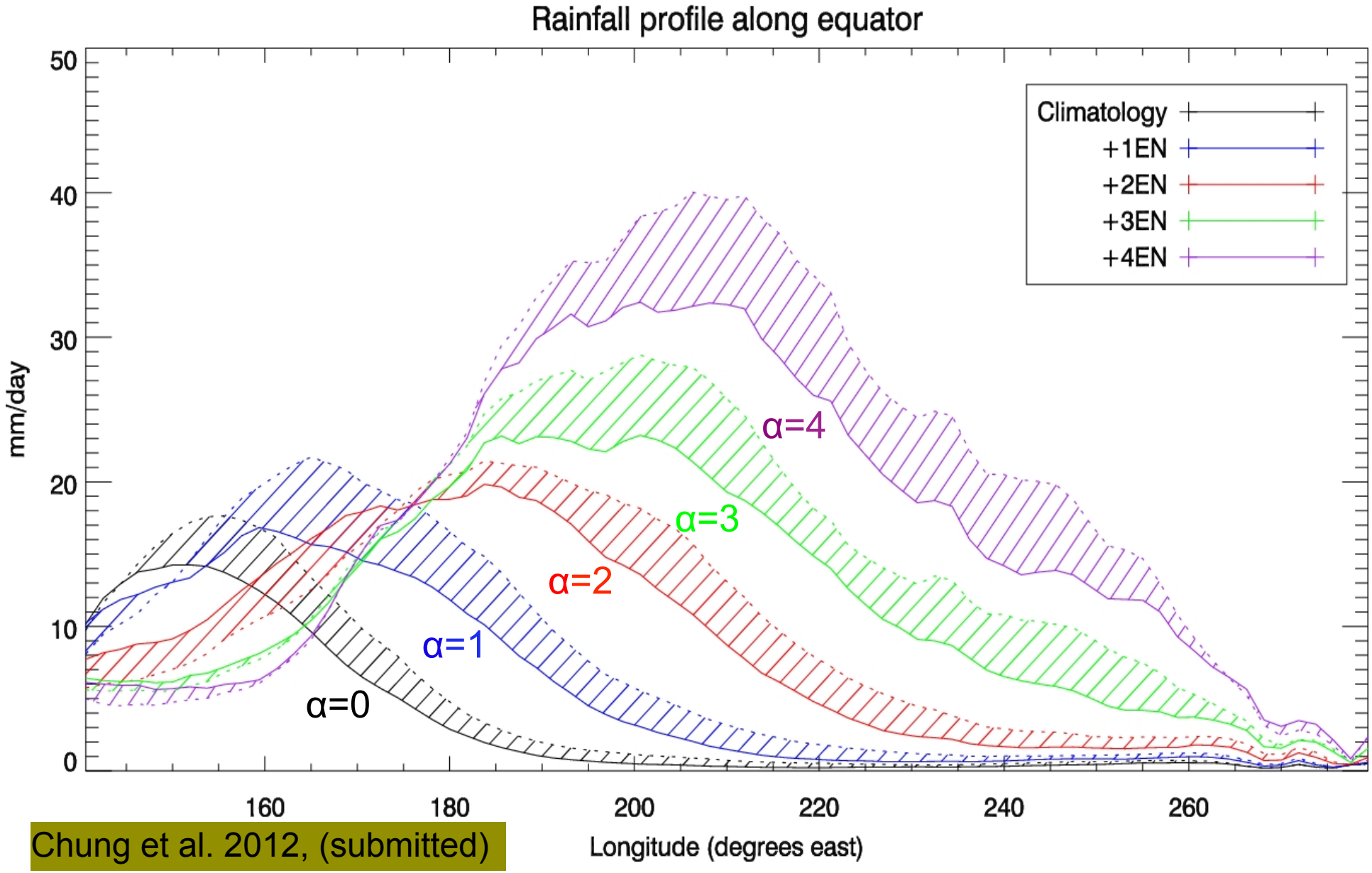



EN composite 79-08
Nov-Apr
El Niño SST anomaly
20N
0
20S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


MMEM ΔSST
DJF
Global warming SST anomaly (SRES A2)
20N
0
20S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3


Rainfall profile along equator
α = {
Climatology
+1EN
α=0, with global warming
α=1, with global warming
α=1, without global warming
α=0, without global warming
mm/day
30
25
20
15
10
5
0
160
180
200
220
240
260
Longitude (degrees east)

Combined effect of global warming and El Niño



Chung et al. 2012, (submitted)

Combined effect of global warming and El Niño

- Rainfall response depends non-linearly on El Niño_SSTA
- Impact of global warming varies with magnitude of El Niño event
- Rainfall in tropics is a non-linear function of SSTA_EN and SST_GW

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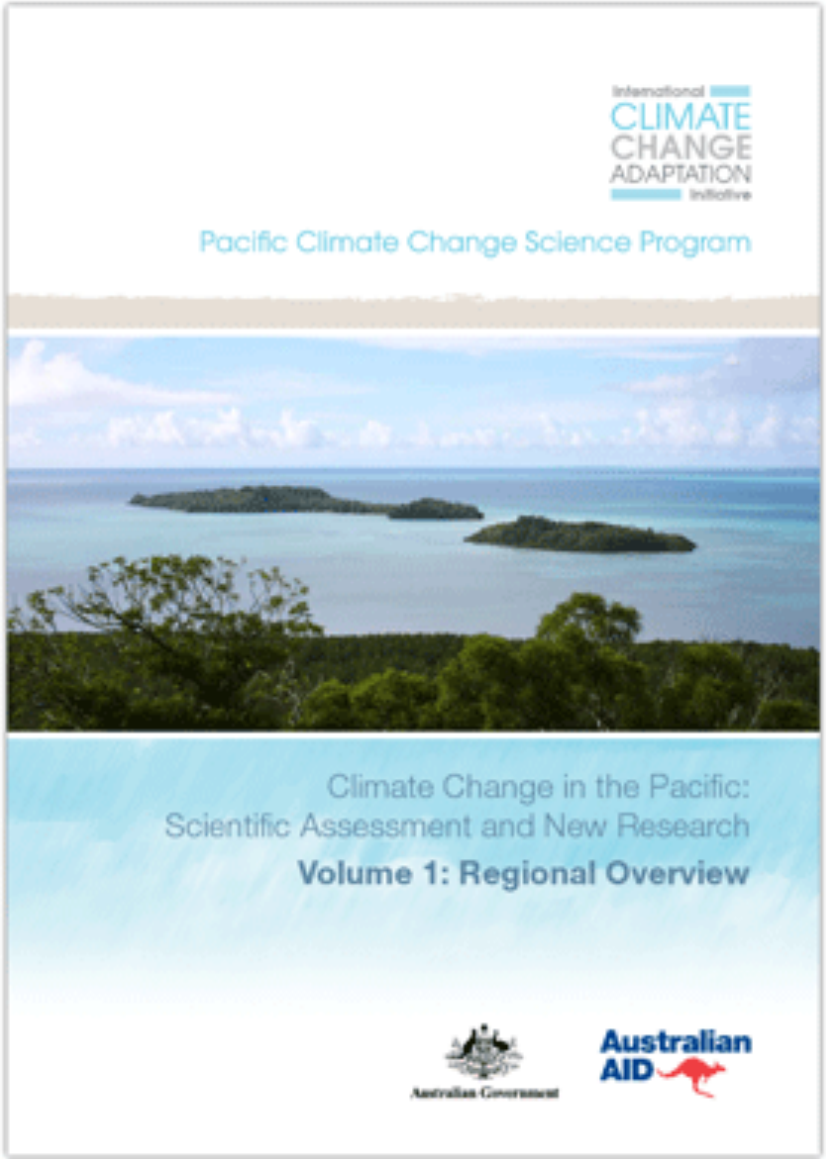
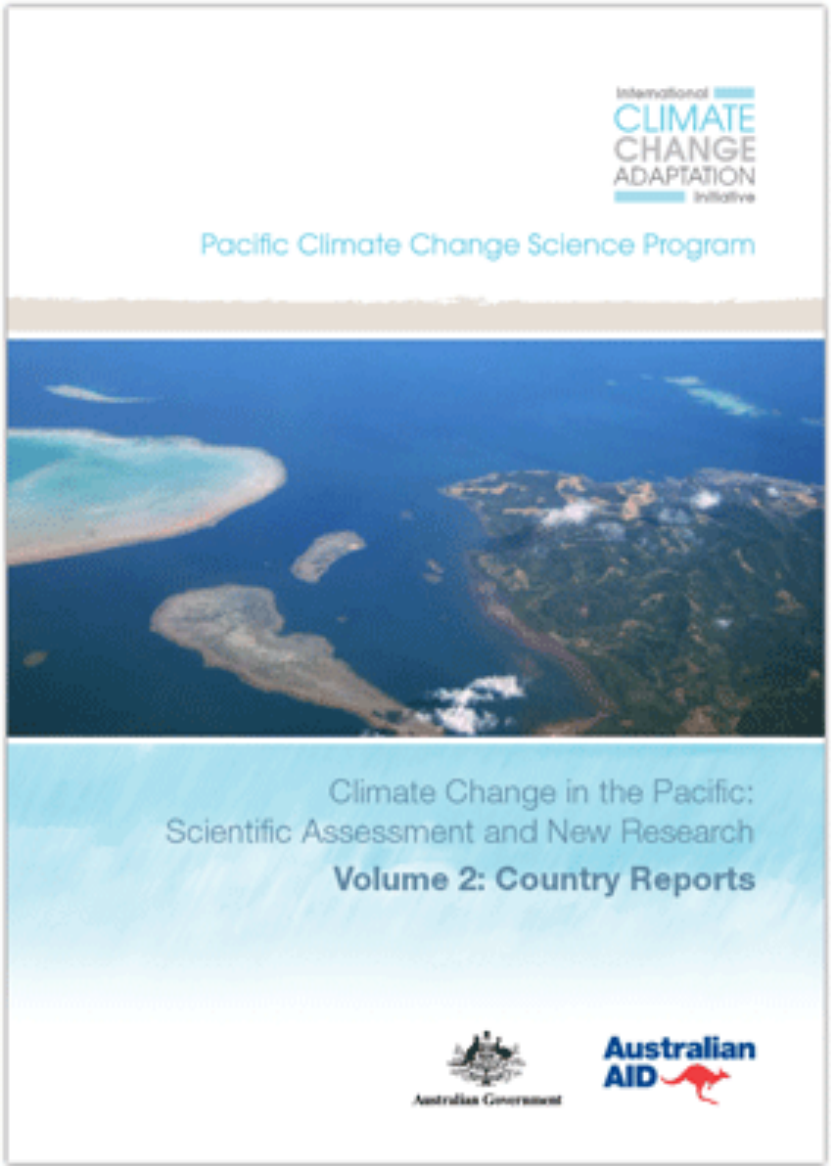
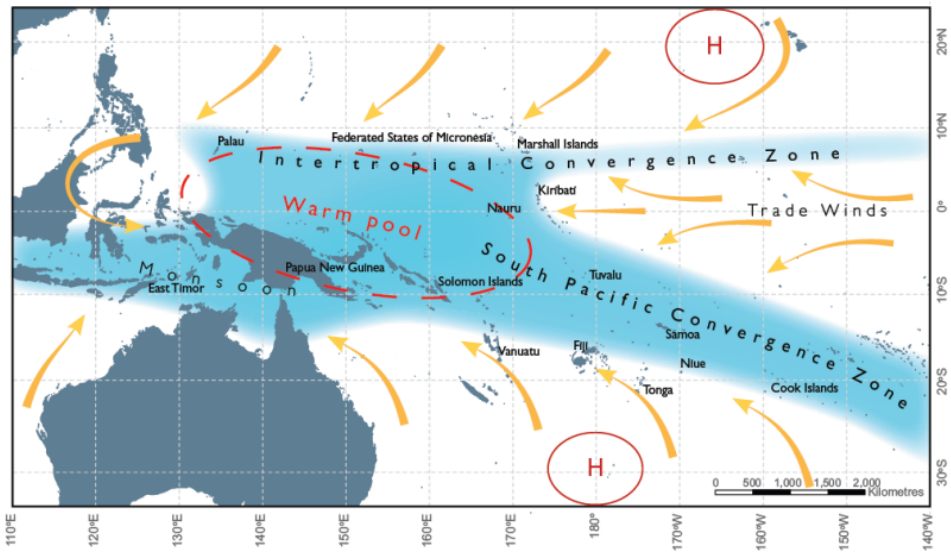
Climate Change in the Pacific: Scientific Assessment and New Research

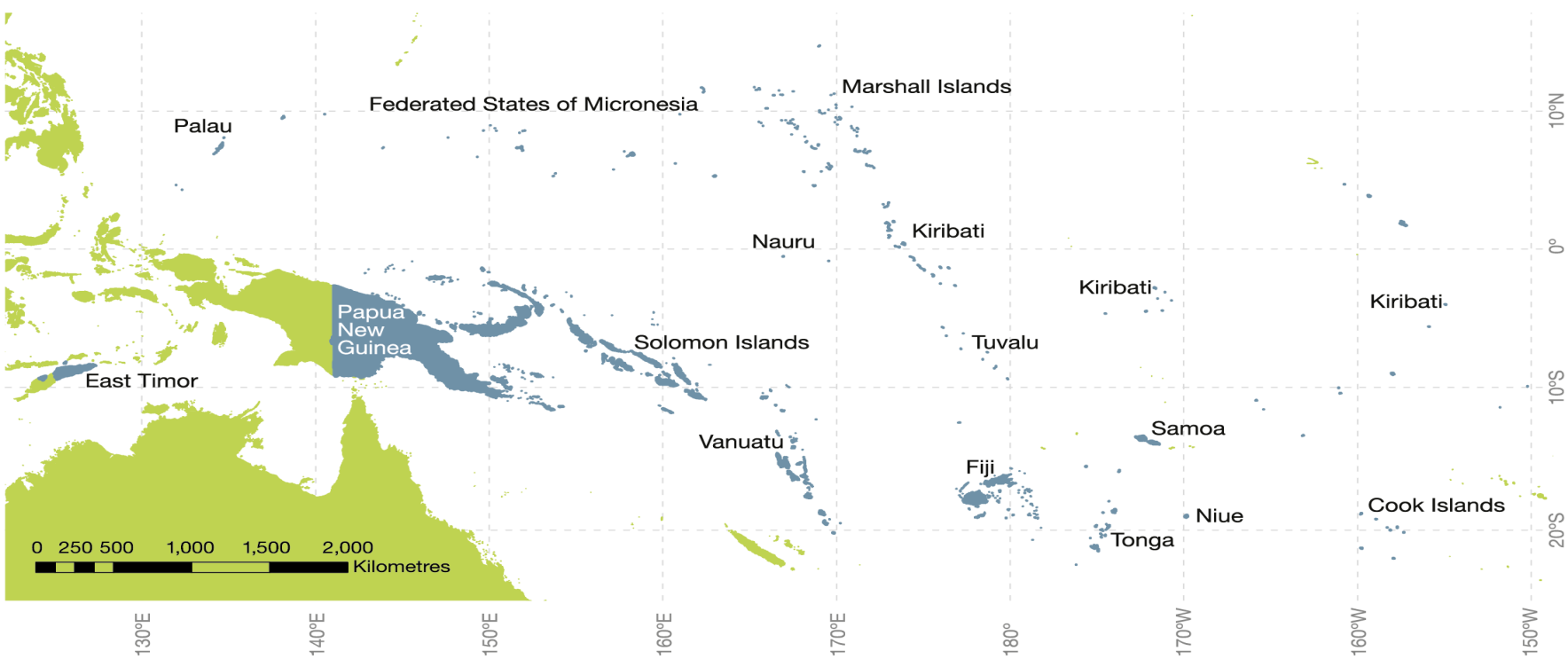


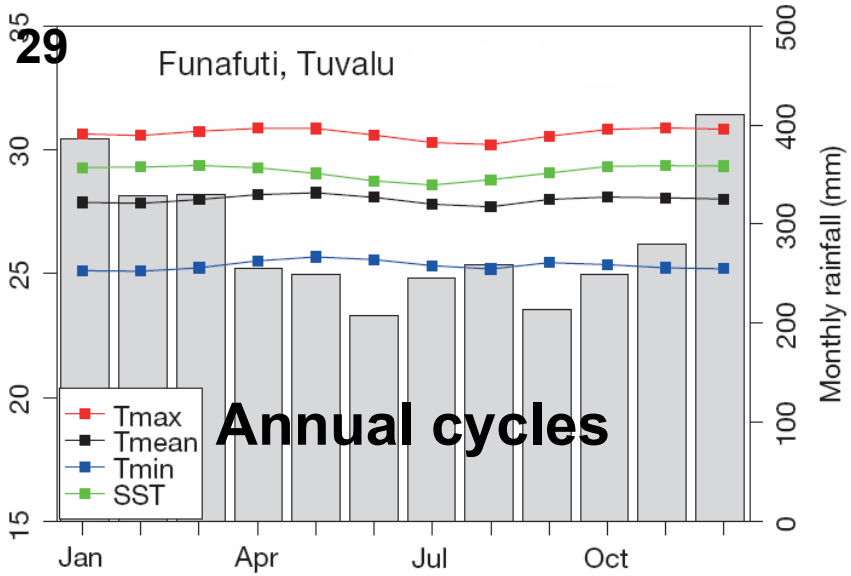




- Volume 1:
  - 530 pages
  - Over 100 contributors
  - Hundreds of references
  - New research
  - Reviews
  - Numerous magnificent photos and diagrams

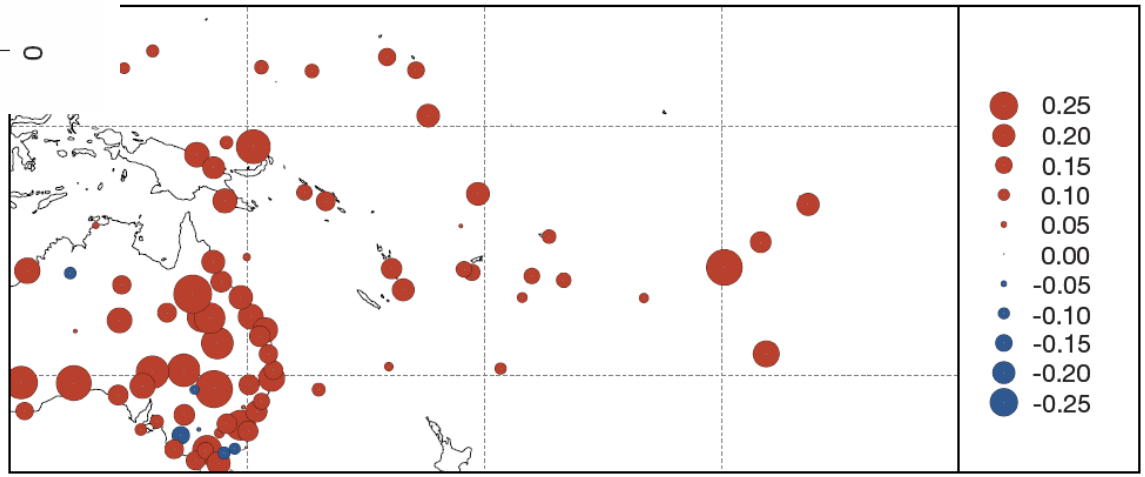
http://www.pacificclimatechangescience.org

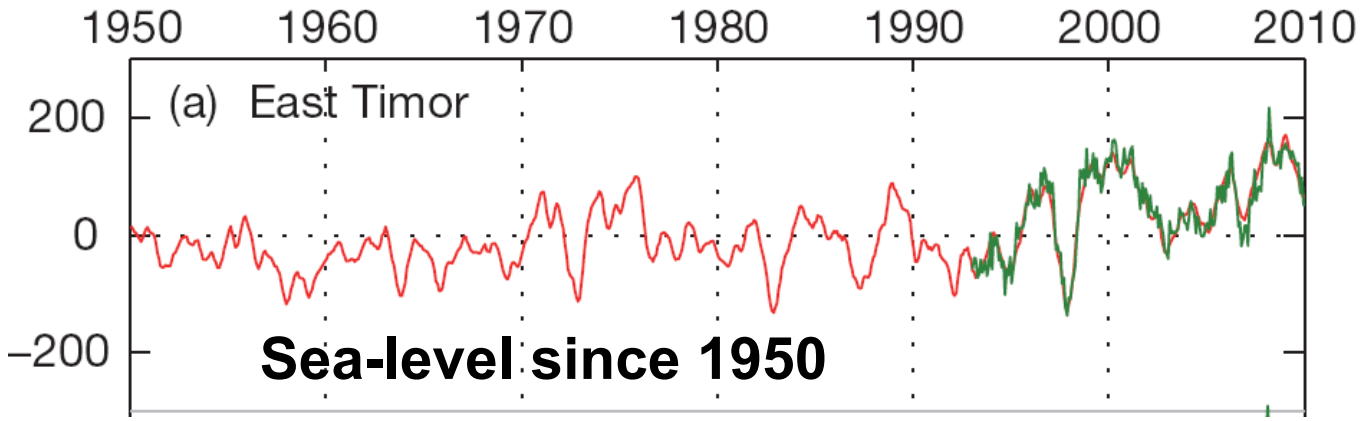

Palau
Federated States of Micronesia
Marshall Islands
Nauru
Kiribati
Kiribati
Kiribati
Papua New Guinea
Solomon Islands
Tuvalu
East Timor
Vanuatu
Samoa
Fiji
Niue
Cook Islands
Tonga
0 250 500 1,000 1,500 2,000
Kilometres
130°E
140°E
150°E
160°E
170°E
180°
170°W
160°W
150°W
10°N
0°
10°S
20°S



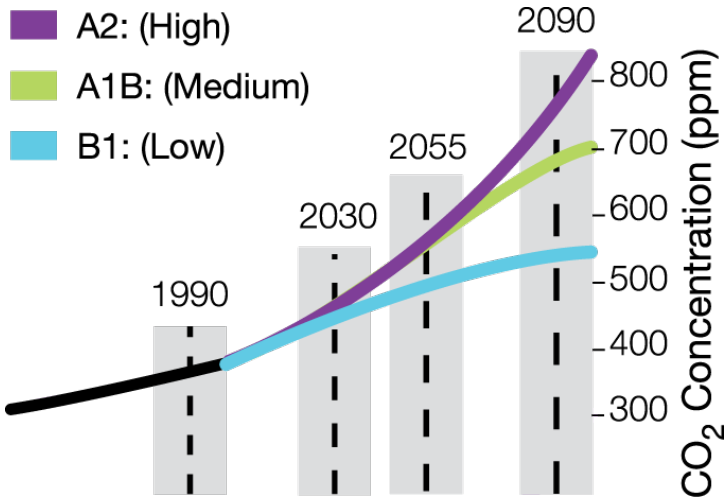
Annual cycles

Air temperature trends 1960-2009 (˚C/decade)





Sea-level since 1950



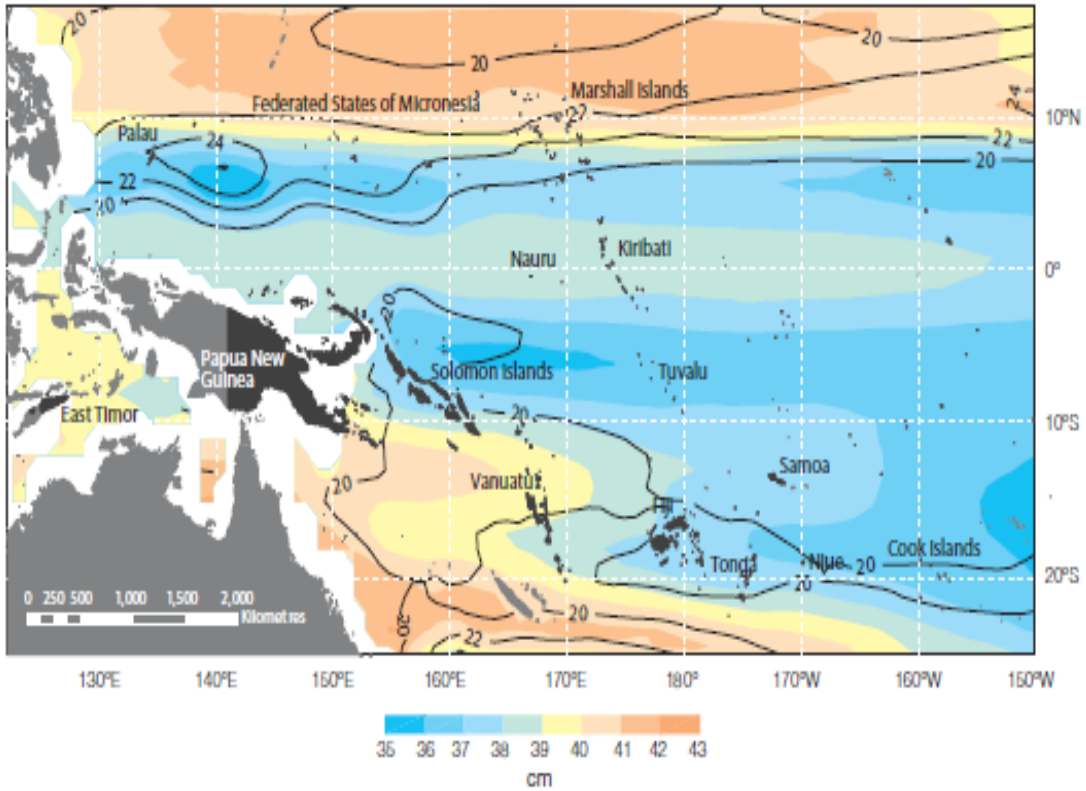


Figure 6.28: The sea-level projections (in cm) for the A1B (medium) emissions scenario in the PCCSP region for 2081-2100 relative to 1981-2000 are indicated by the shading, with the uncertainty indicated by the contours. The distribution of the projections of sea-level change are estimated by combining the global average sea-level projections, the dynamic ocean departure from the global average and the regional changes associated with the changing mass distribution in the cryosphere.

Summary

- Substantial decadal variability in ENSO and ENSO impacts, including severe land-falling TCs

- The Walker circulation:
  - 20th C weakening has both natural and anthropogenic components, but much less clarity on relative contribution than previously thought
  - There has been a recent strengthening
  - Projected to weaken in 21st century, yet SOI projected to increase
  - Glaring example of limitations of using El Niño as an analogue for climate change

- Non-linear interaction between ENSO and global warming

- New report available on Climate Change in the Pacific

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Thanks for listening!

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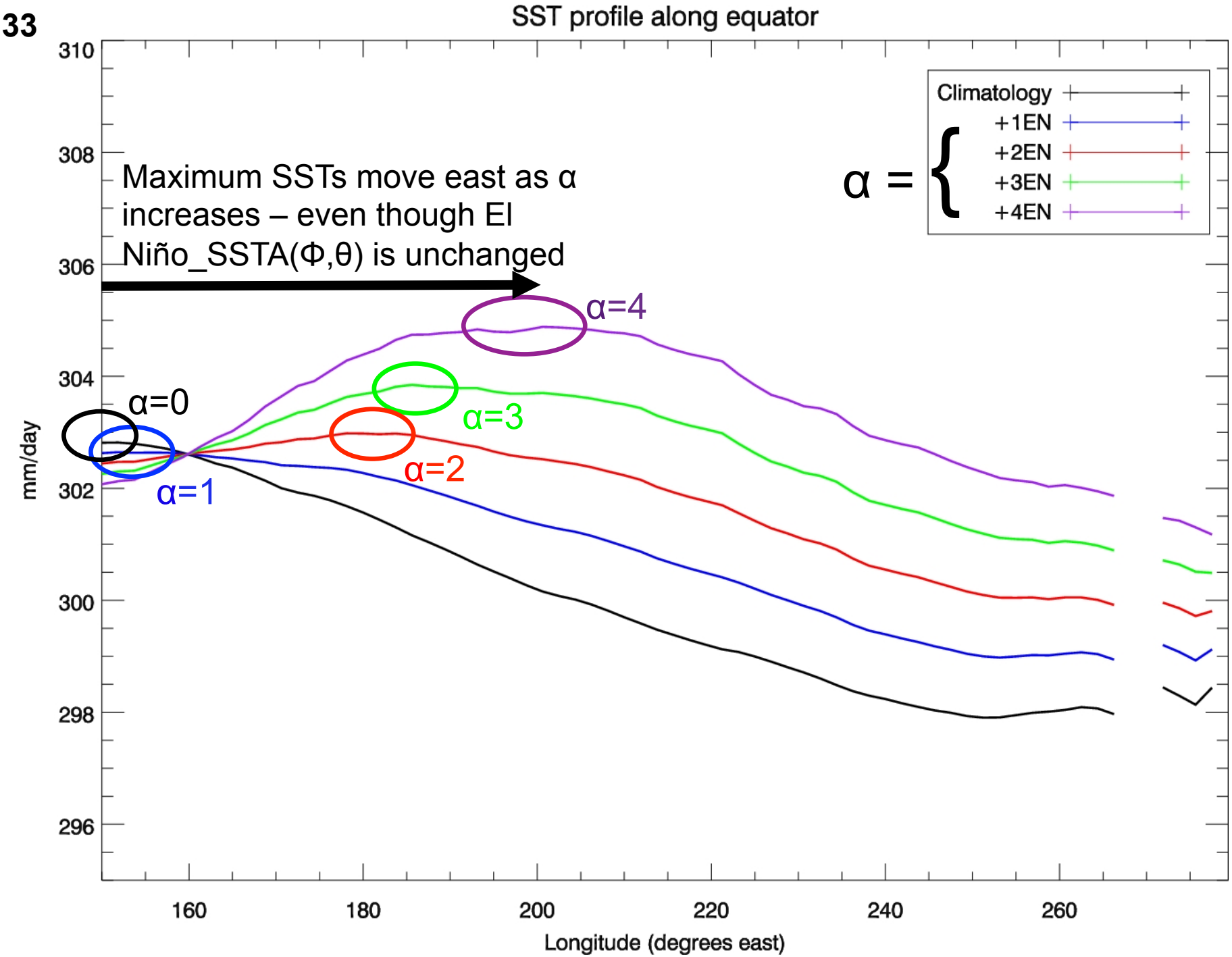
SST profile along equator
Maximum SSTs move east as α increases – even though El Niño_SSTA(Φ,θ) is unchanged
α =
Climatology
+1EN
+2EN
+3EN
+4EN
α=0
α=1
α=2
α=3
α=4
mm/day
310
308
306
304
302
300
298
296
160
180
200
220
240
260
Longitude (degrees east)