The Atmospheric Control Knobs of WAIS Climate

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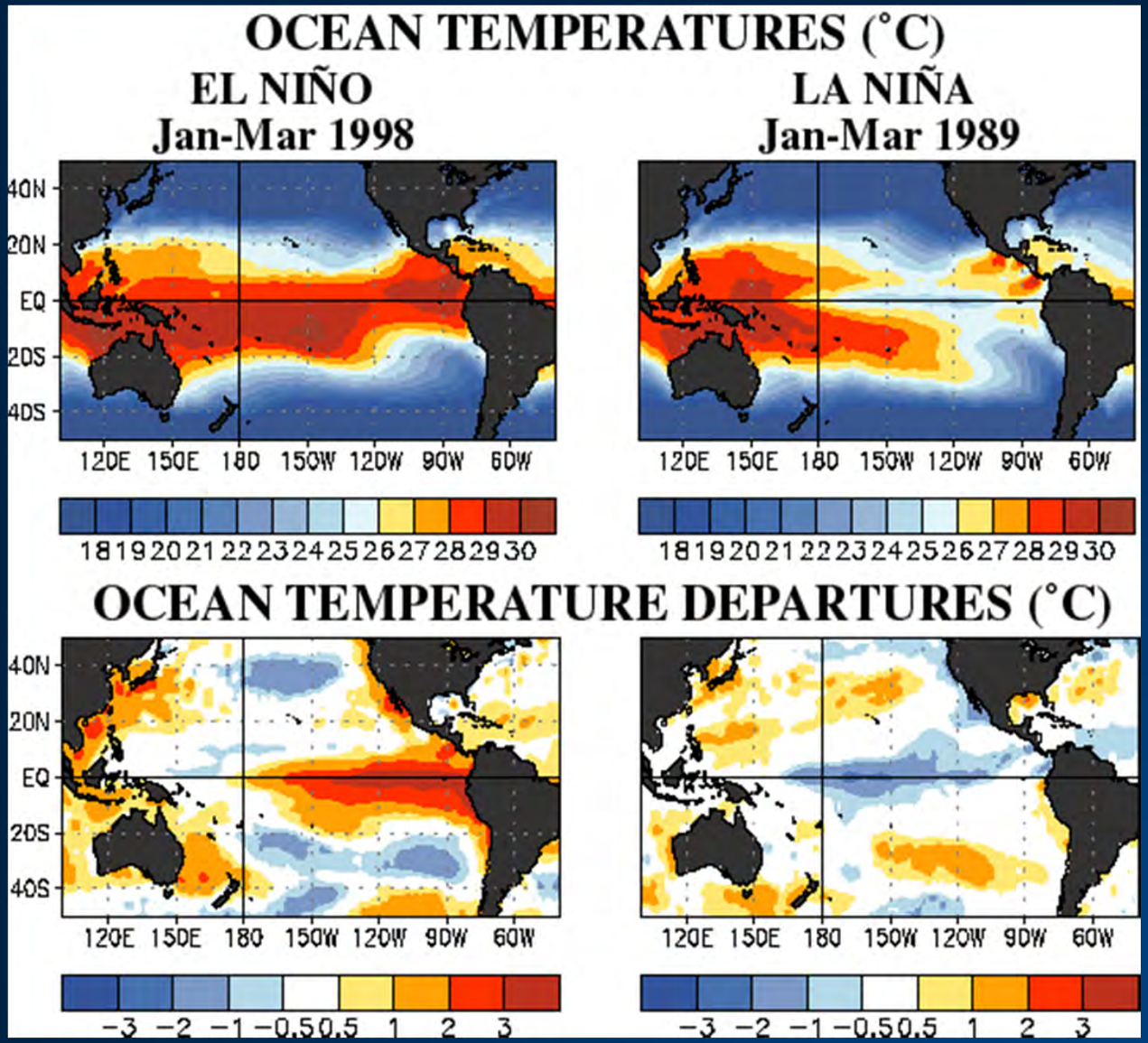
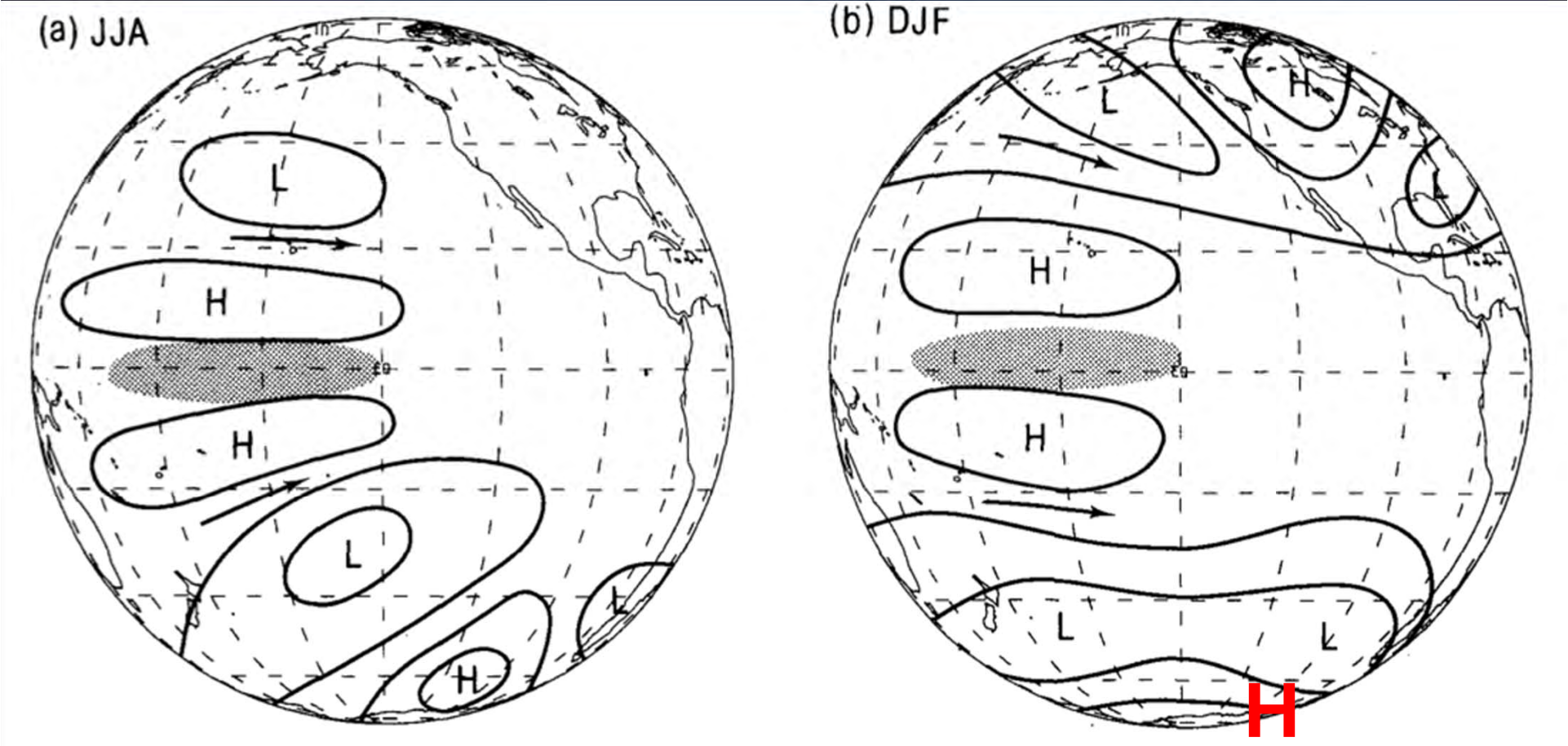
Outline

- Key Players in WAIS Climate
  - ENSO (or, forcing from the tropics)
  - SAM
  - Amundsen – Bellingshausen Seas Low
  - Individual cyclones
- Influence is complex and only recently starting to be better understood
- ‘State of the Climate’ reports

ENSO

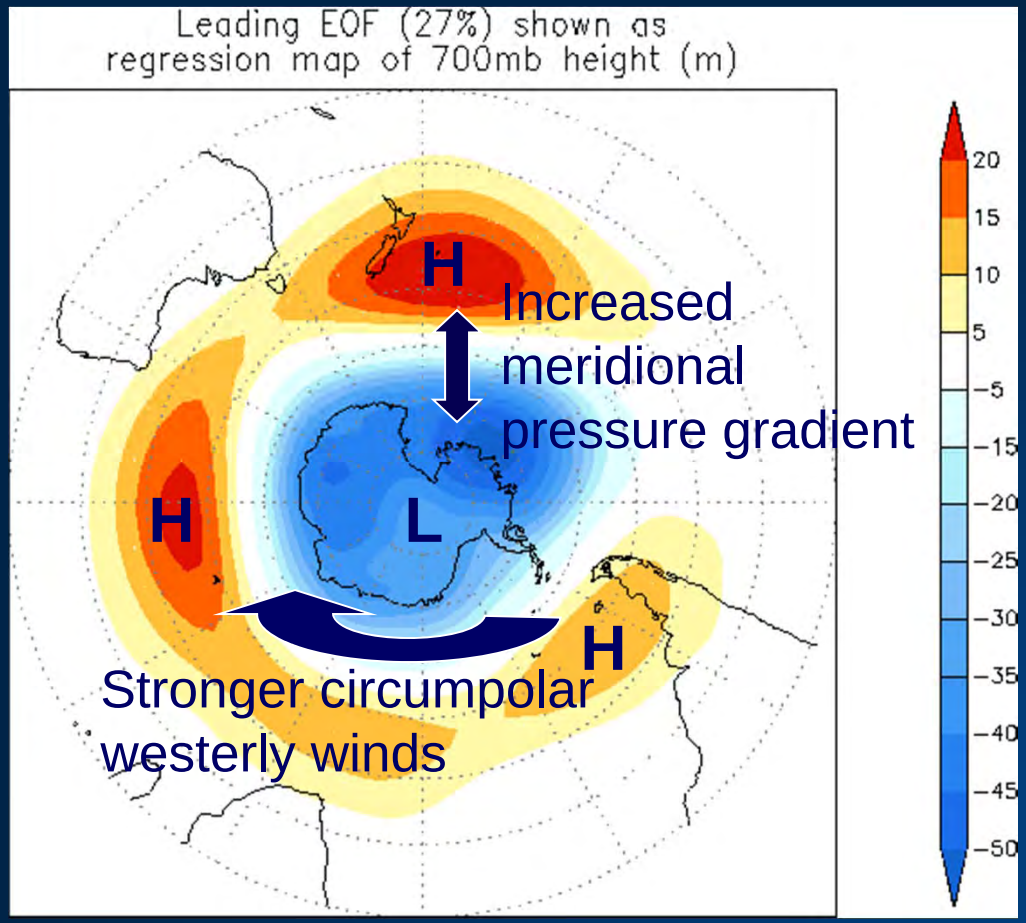

OCEAN TEMPERATURES (°C)
EL NIÑO
Jan-Mar 1998
LA NIÑA
Jan-Mar 1989
40N
20N
EQ
20S
40S
120E 150E 180 150W 120W 90W 60W
18 19 20 21 22 23 24 25 26 27 28 29 30
OCEAN TEMPERATURE DEPARTURES (°C)
−3 −2 −1 −0.5 0.5 1 2 3

Rossby Wave: Teleconnections



Karoly (1989)

The Southern Annular Mode (SAM)



SAM positive phase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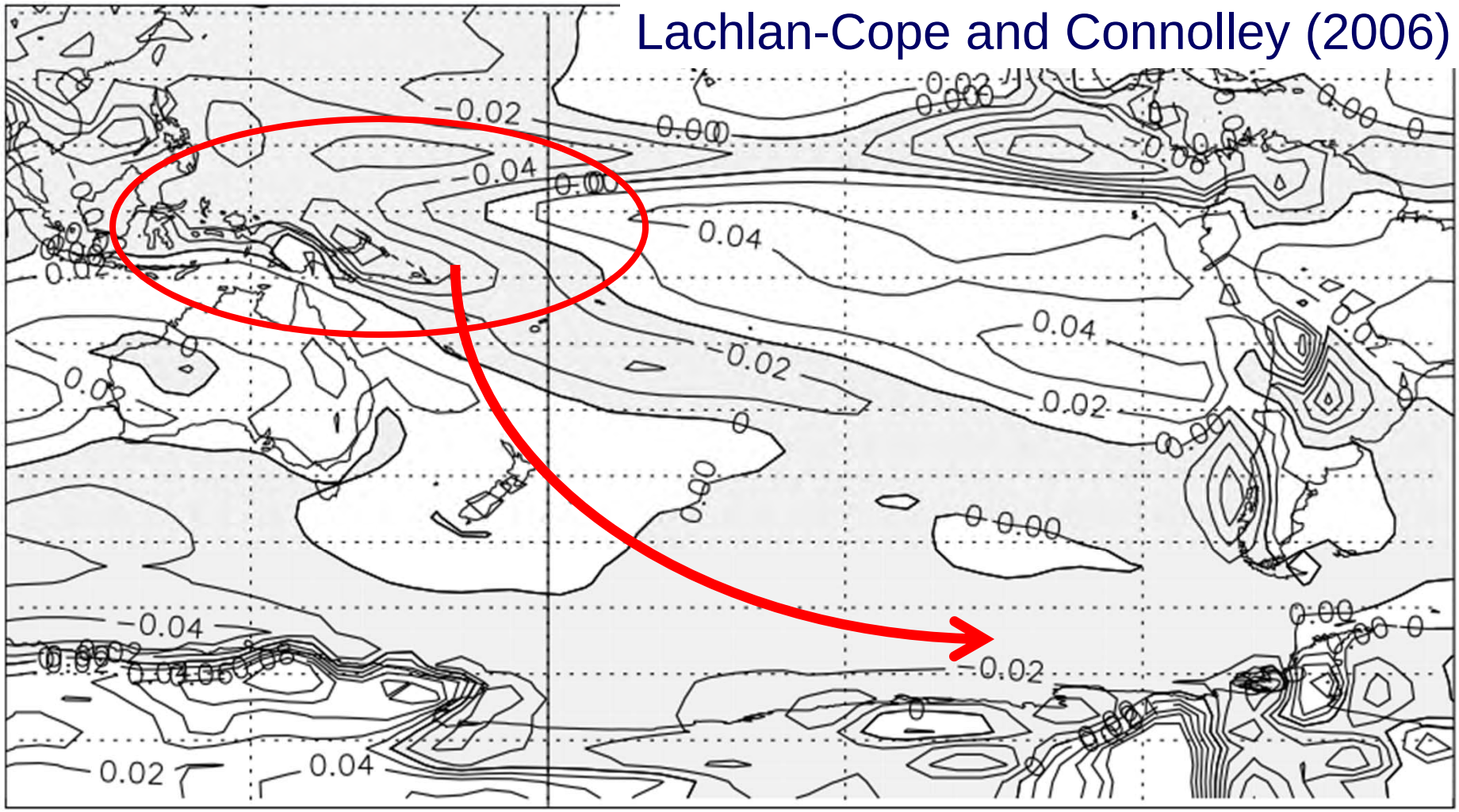
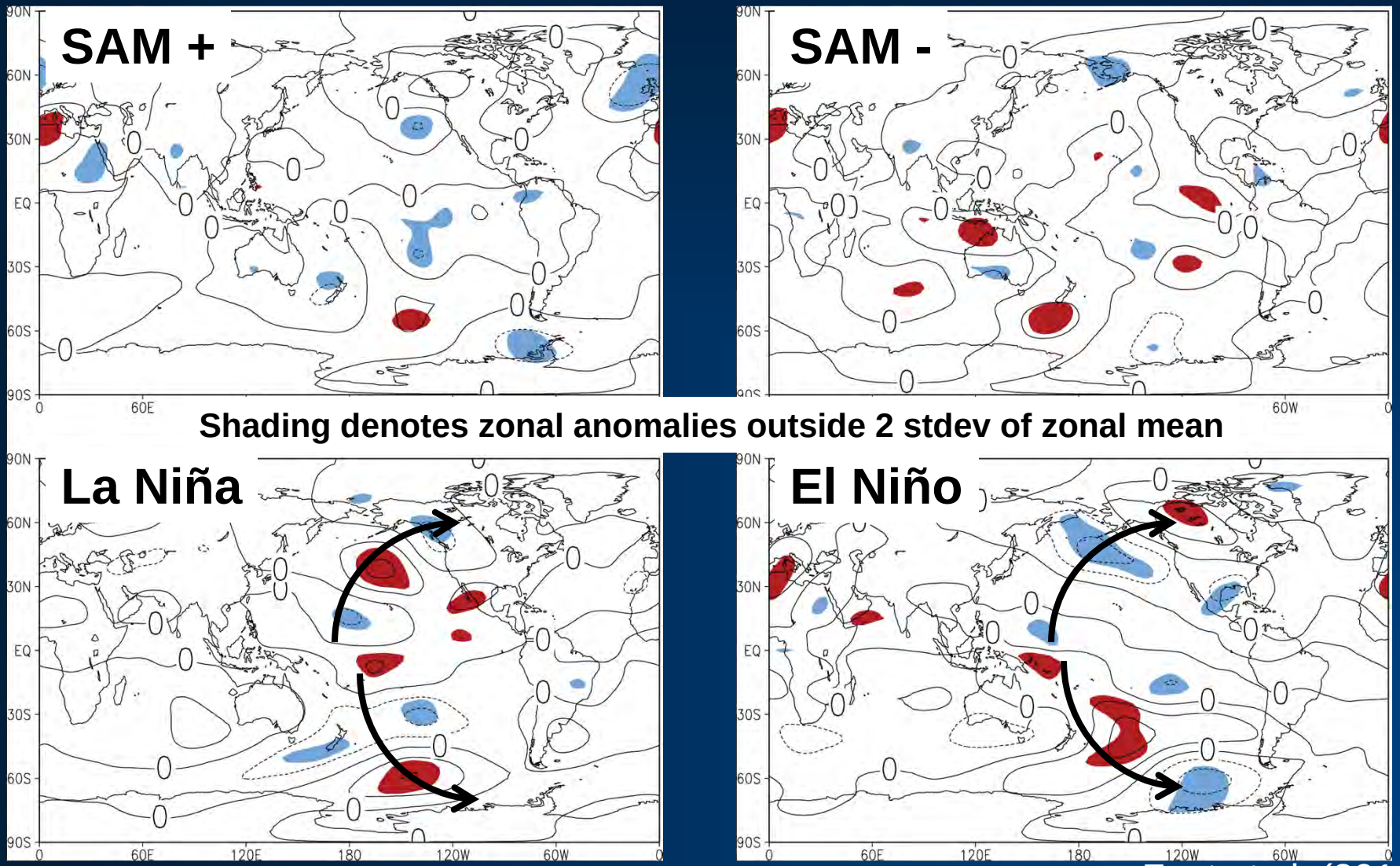
"But, to be fair, there's a fifty-percent chance of just about anything."

Rossby Wave Generation

Lachlan-Cope and Connolley (2006)



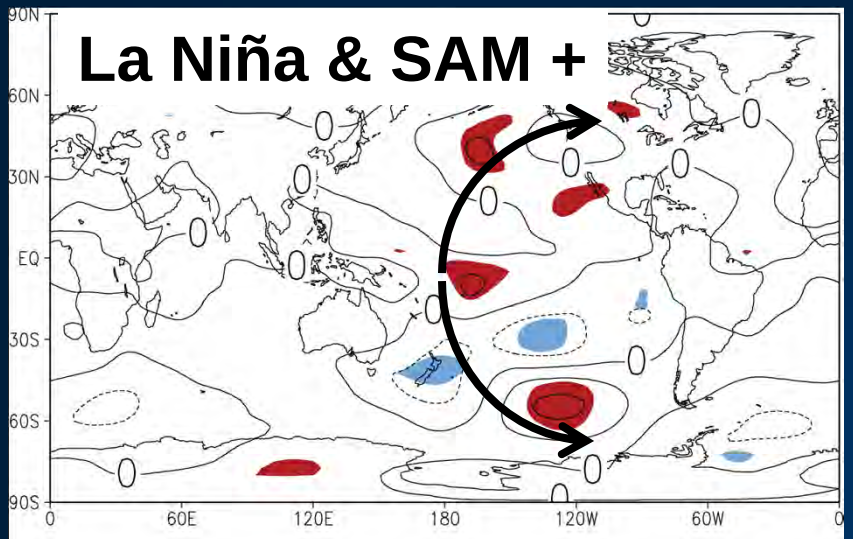
Rossby Wavetrains: 500 hPa Streamfunction zonal anomalies

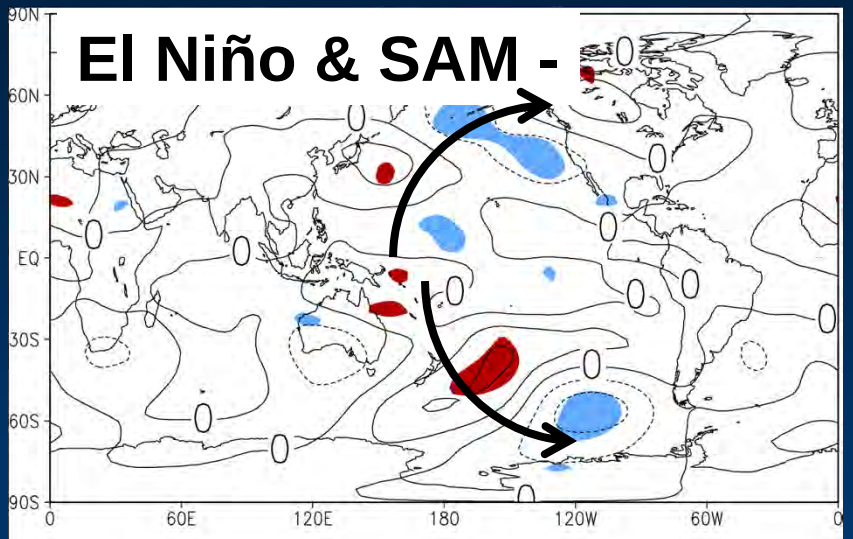


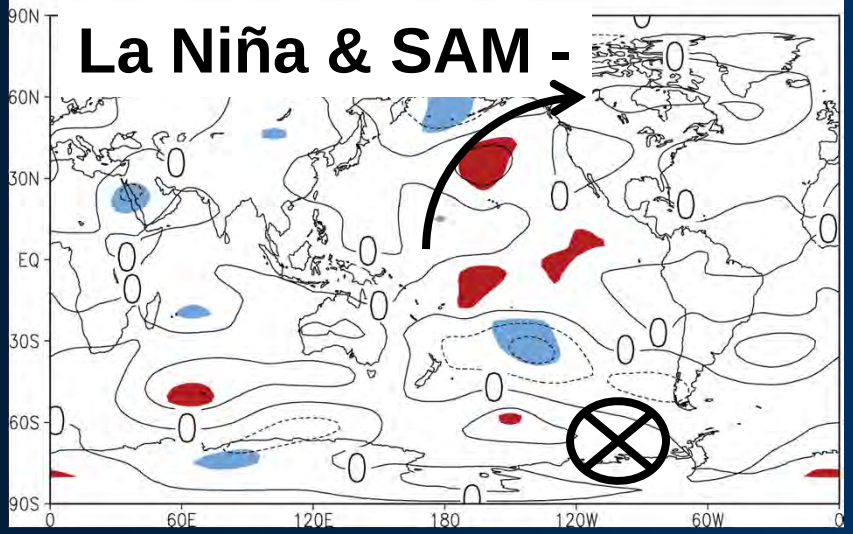
Shading denotes zonal anomalies outside 2 stdev of zonal mean

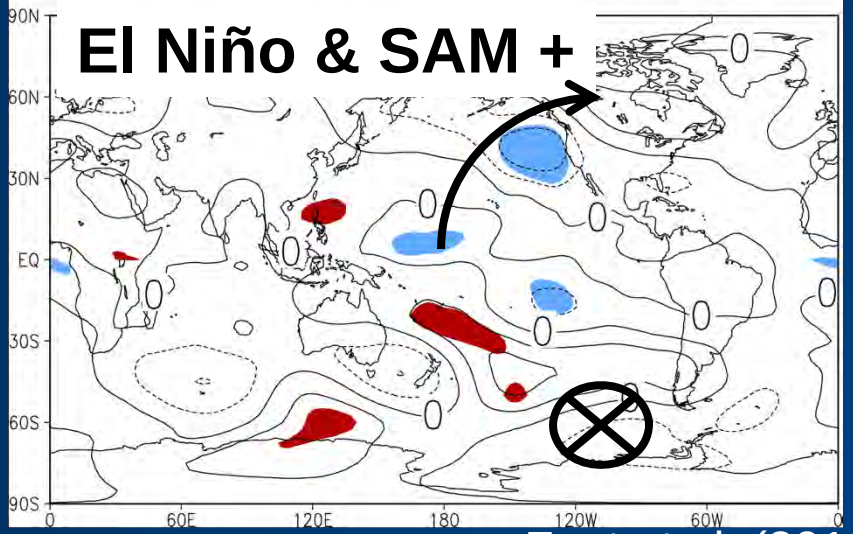
Fogt et al. (2011)

Rossby Wavetrains: 500 hPa Streamfunction zonal anomalies



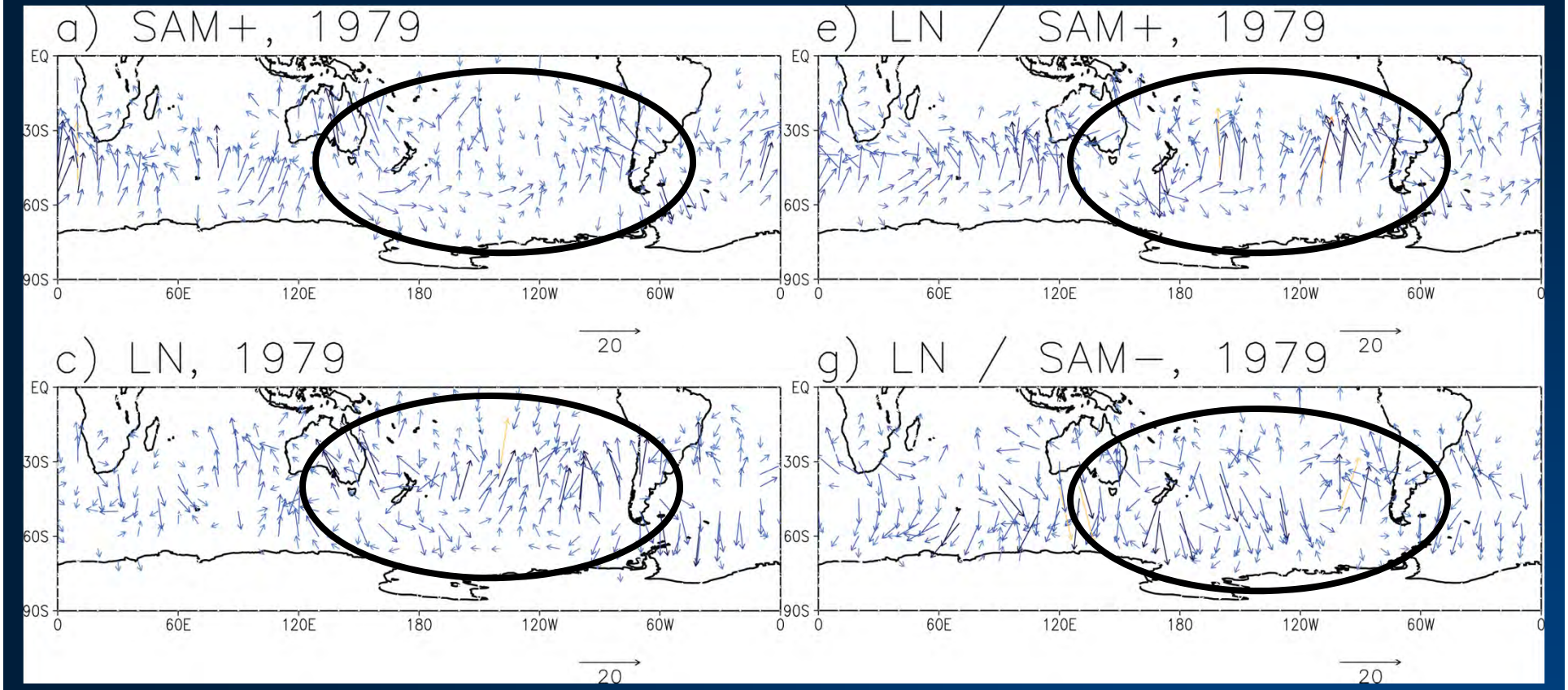






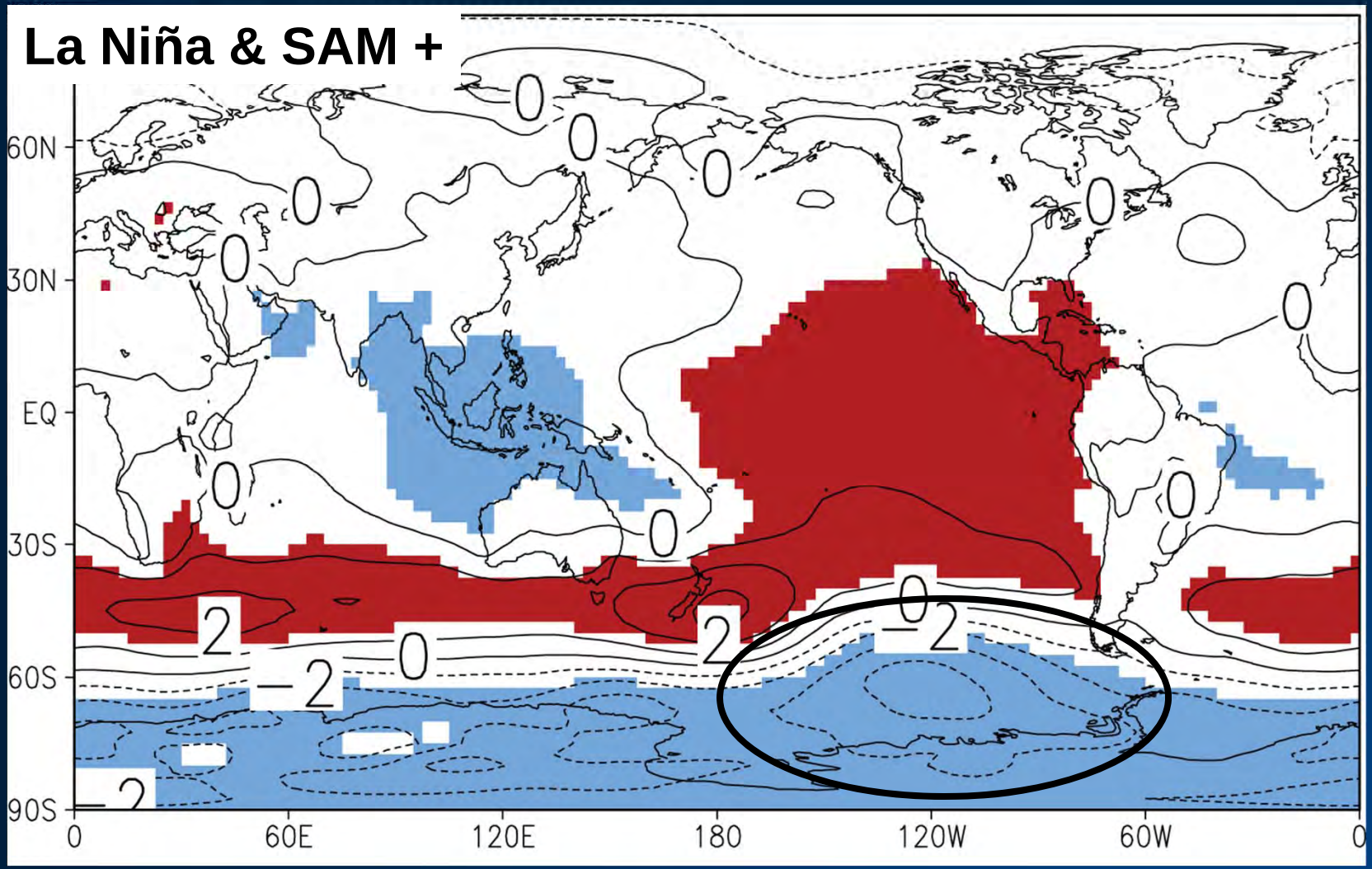
Fogt et al. (2011)

E_u Vectors: La Niña Case



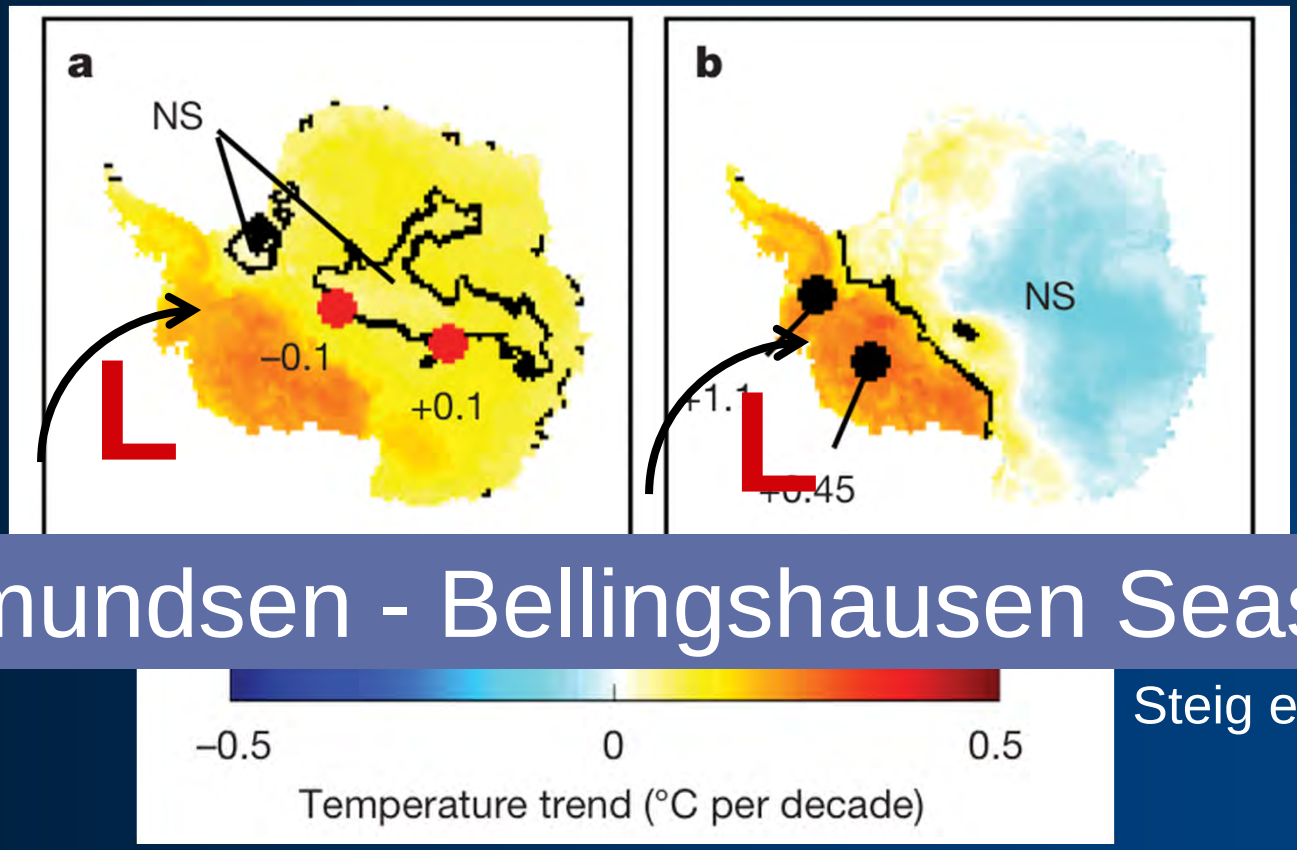
Fogt et al. (2011)

Combined SAM + ENSO Influence



An Important Connection?

Reconstructed Temperature Trends



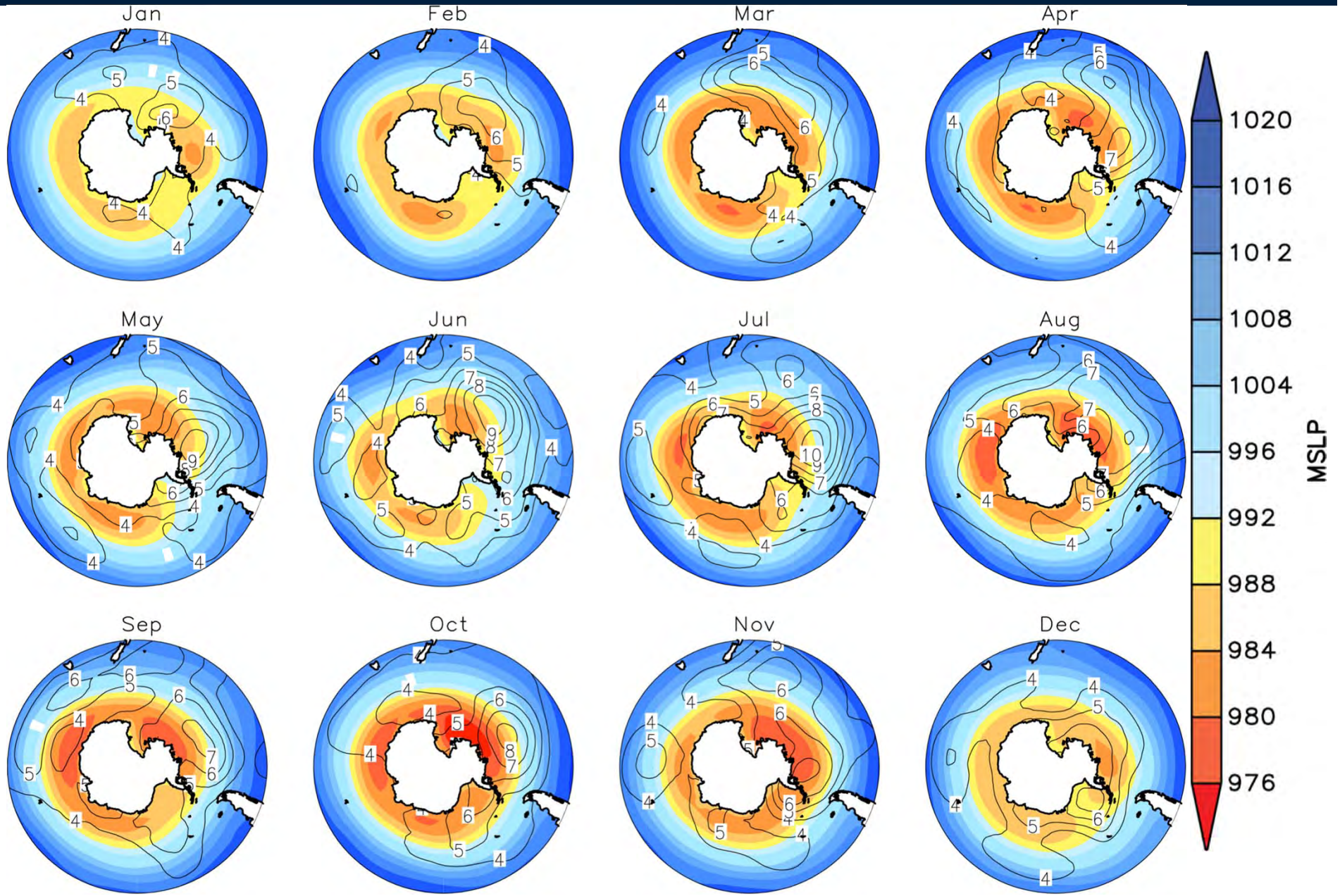
L = Amundsen - Bellingshausen Seas Low

Steig et al. 2009

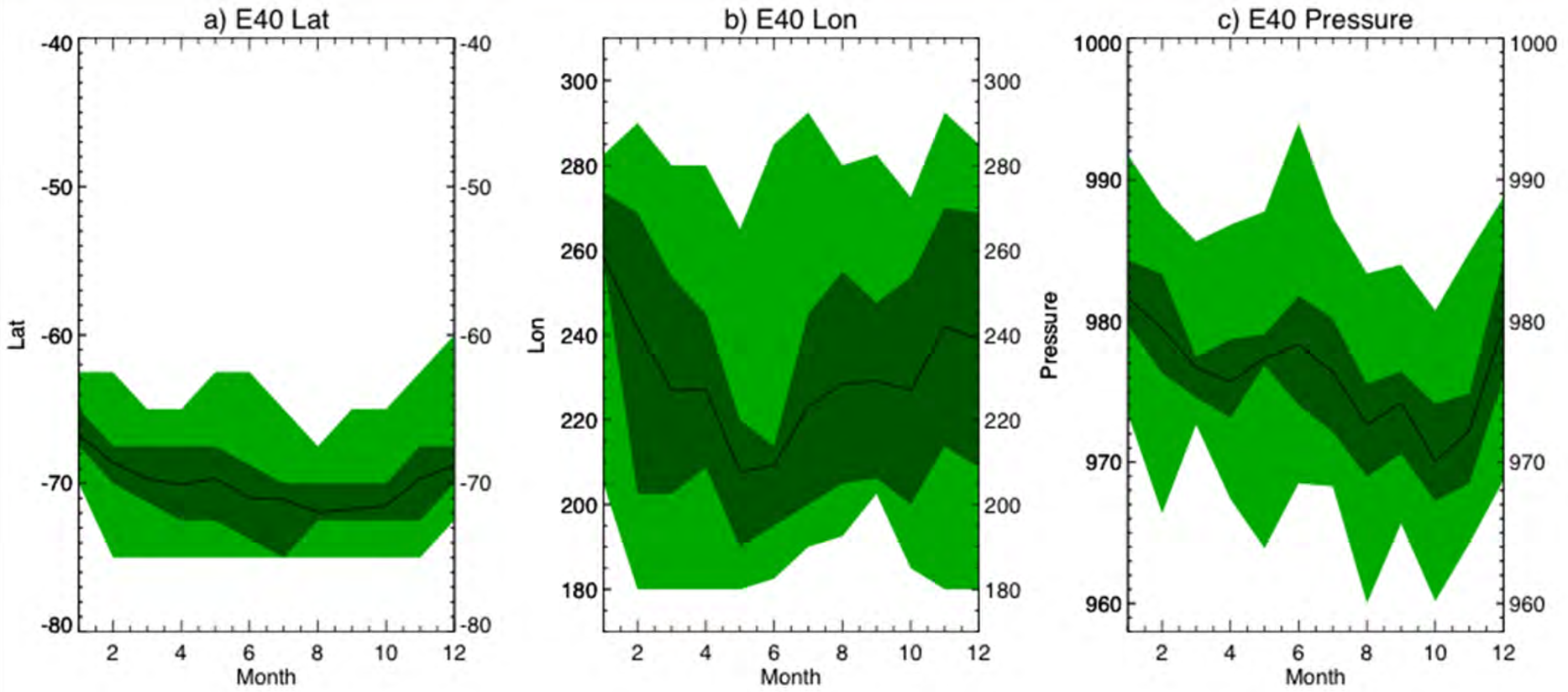
The Amundsen-Bellingshausen Seas Low (ABSL)

- Exists because the Antarctic Peninsula and off-axis nature of the Antarctic topography dynamically influence the atmospheric flow of the region
- Little is understood of the ABSL variations, especially its connection with synoptic activity
  - Necessary first step in order to find any links to the strong regional warming

ERA-40 MSLP Monthly Means, 1979-2001



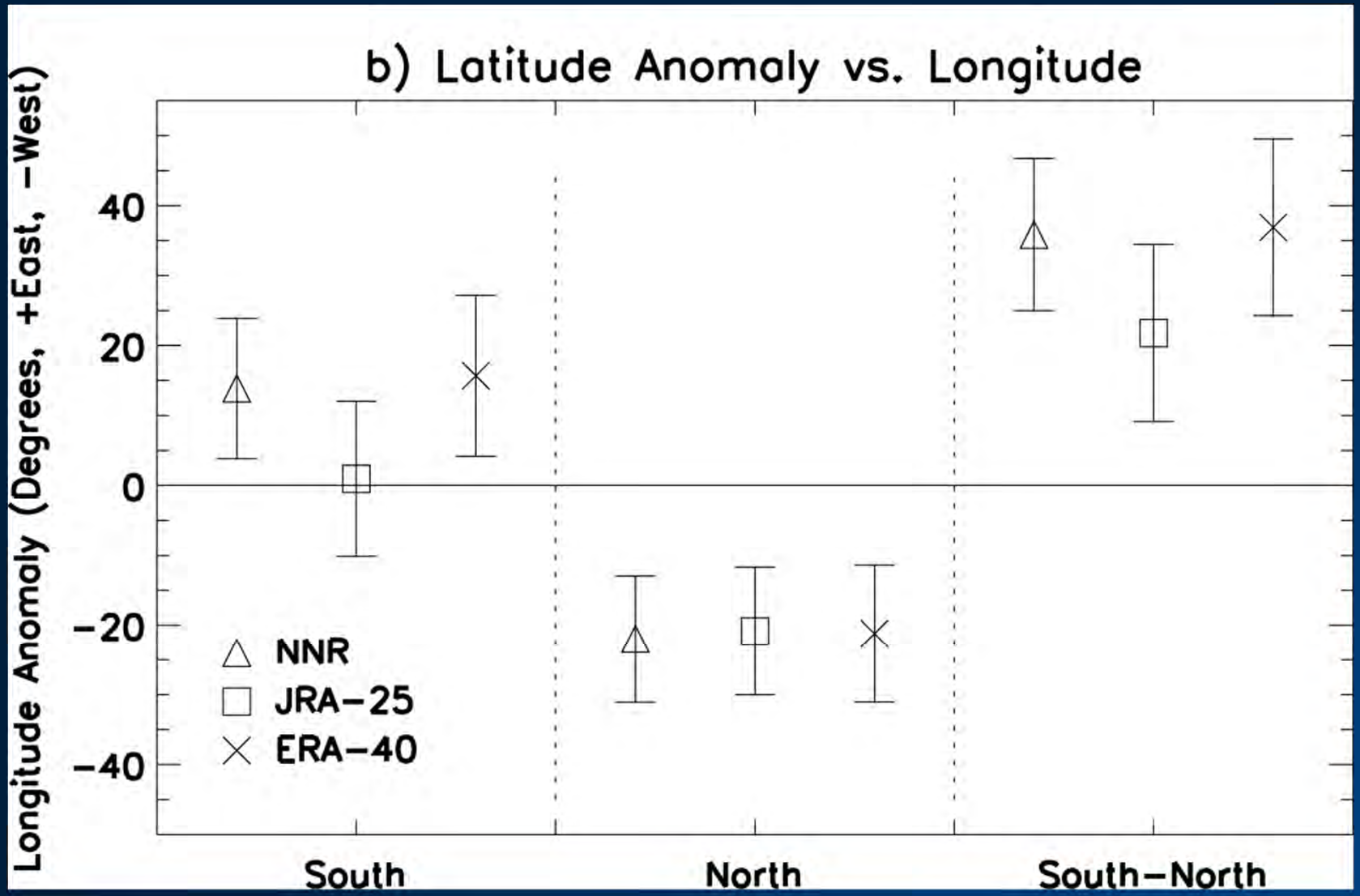
Interannual ABSL Variations (79-01)



Interquartile Range

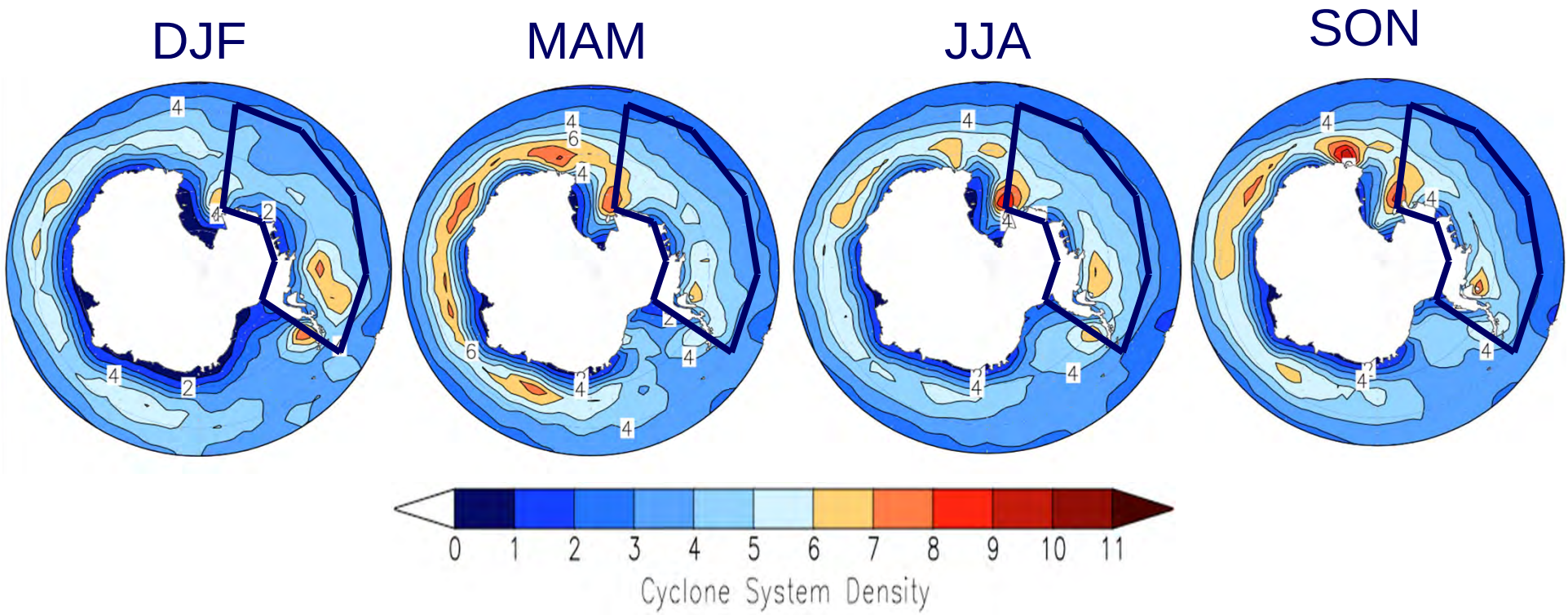
Overall Range

Position Relationship



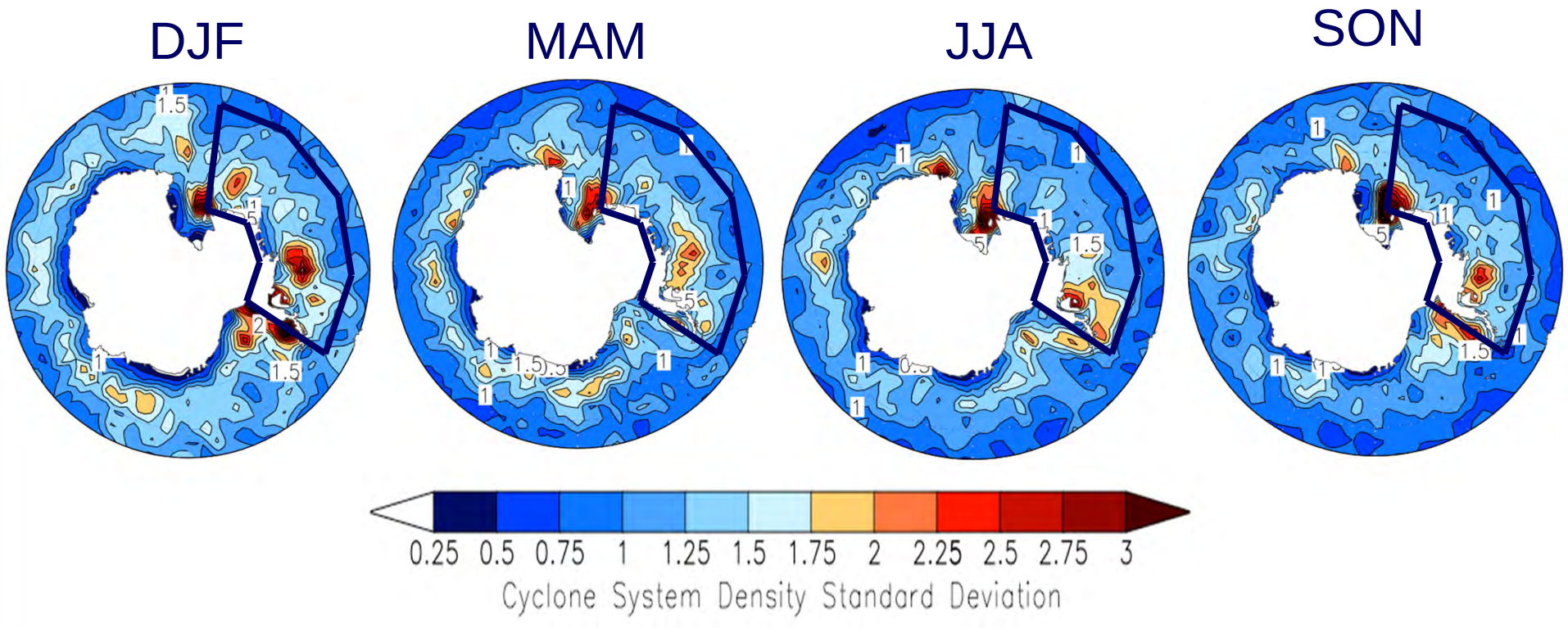
The Weather-Climate Connection: Individual Cyclones

ERA-40 Seasonal Cyclone System Density, 1979-2001



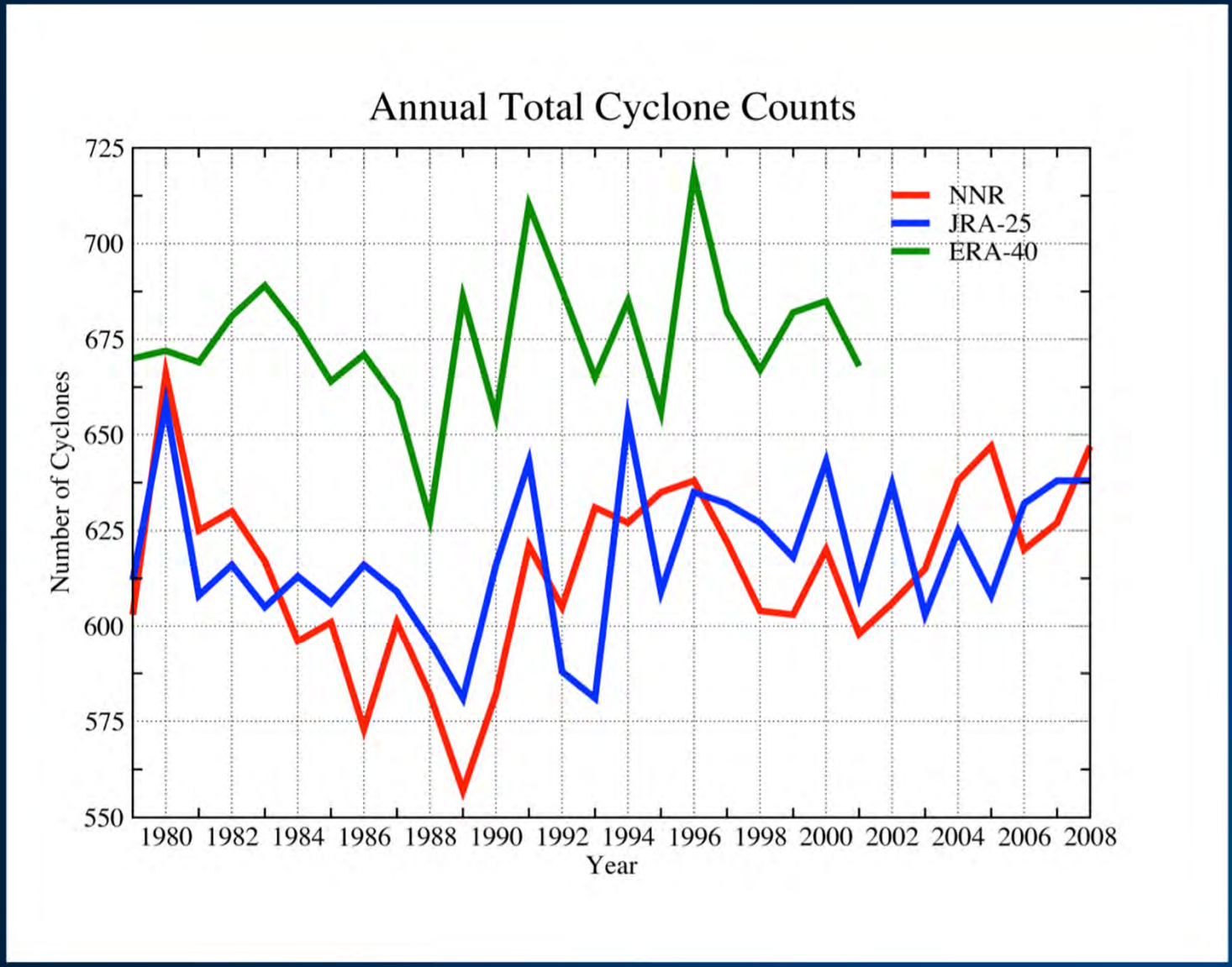
University of Melbourne Automated Cyclone Tracking Scheme
Simmonds et al. (2003)

ERA-40 System Density Standard Deviation, 1979-2001

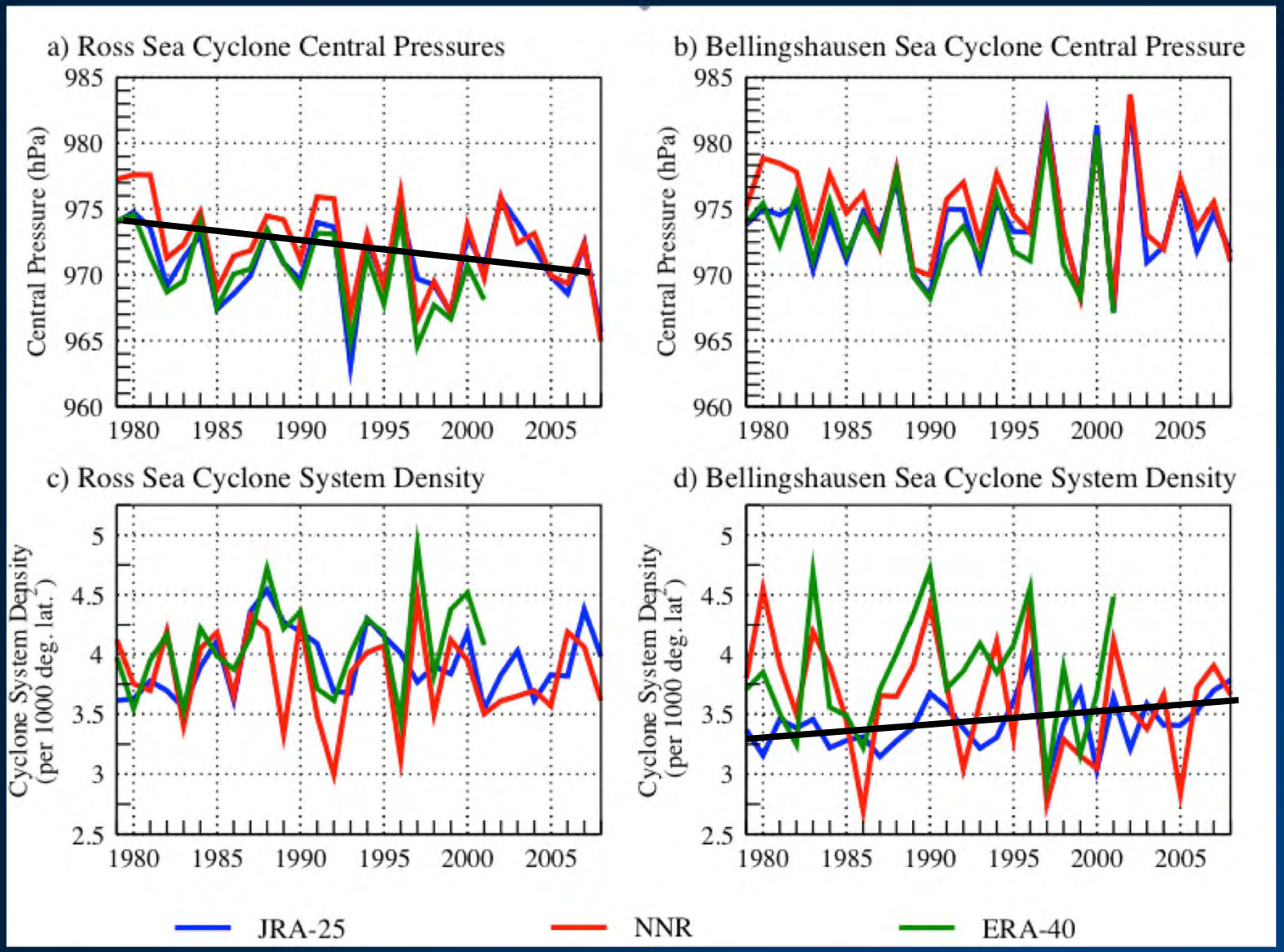


University of Melbourne Automated Cyclone Tracking Scheme
Simmonds et al. (2003)

Annual Cyclone Counts

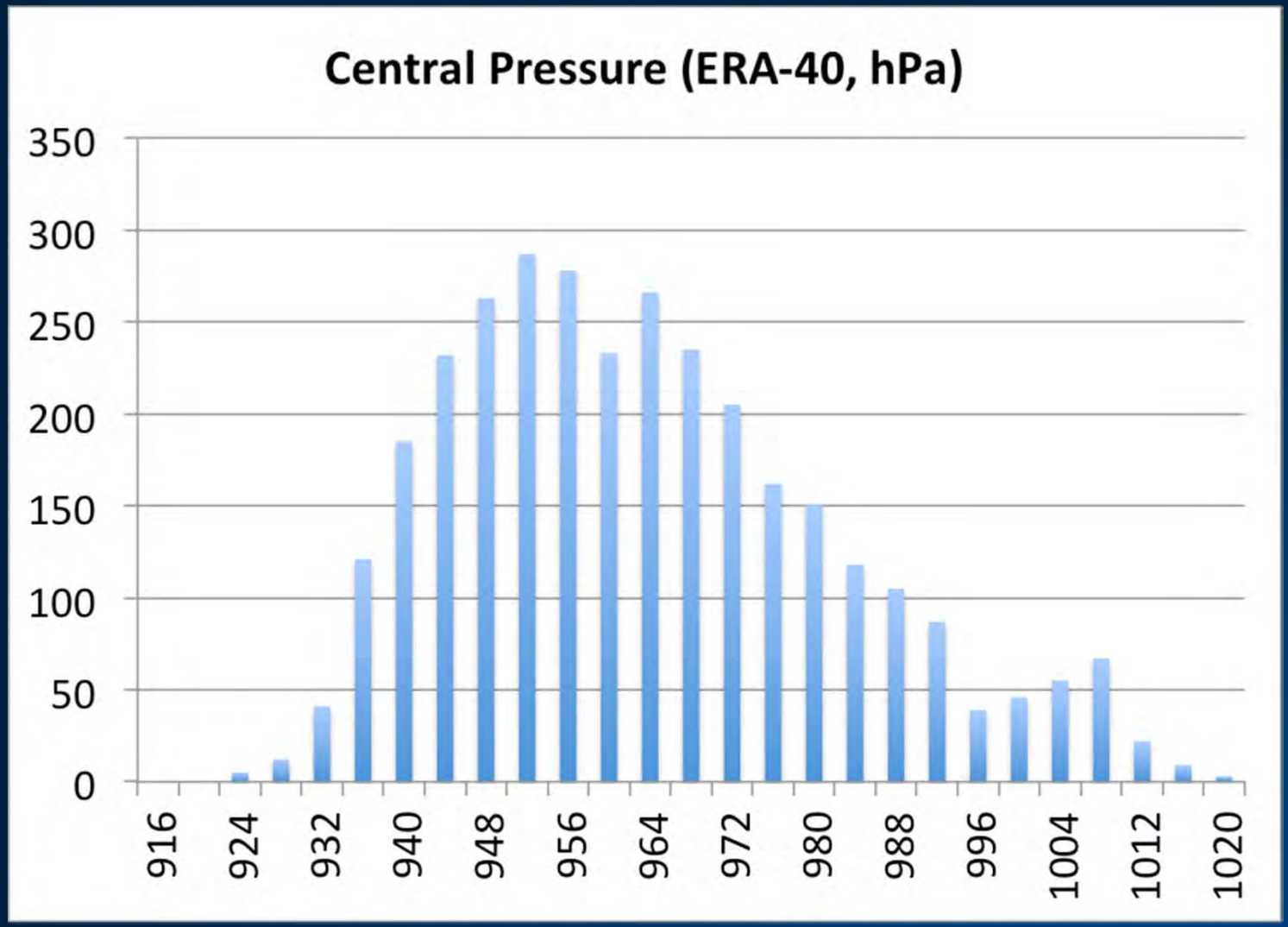


Basin Characteristics

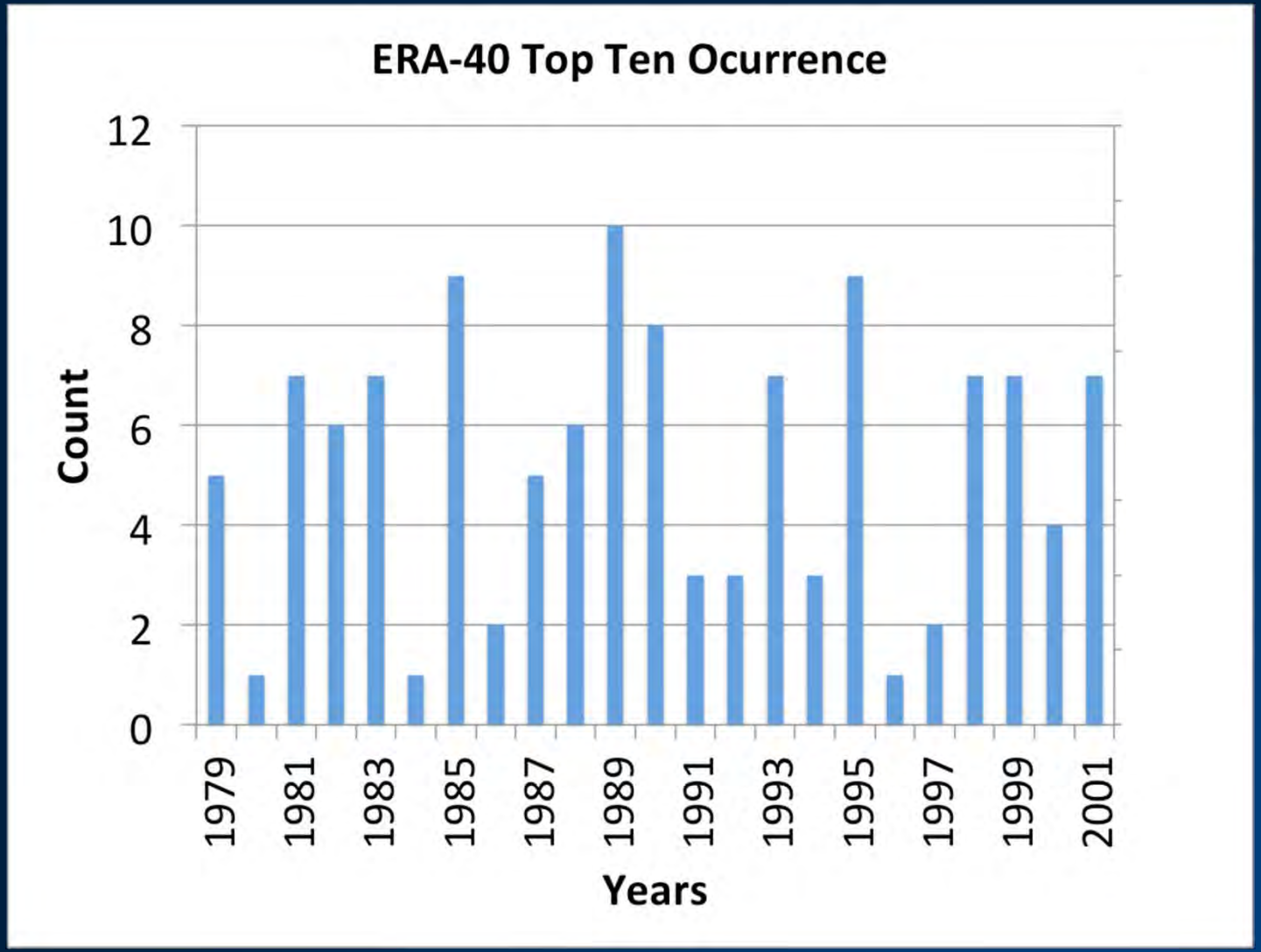


The Biggest Impacts: Ten Strongest Cyclones (by month)

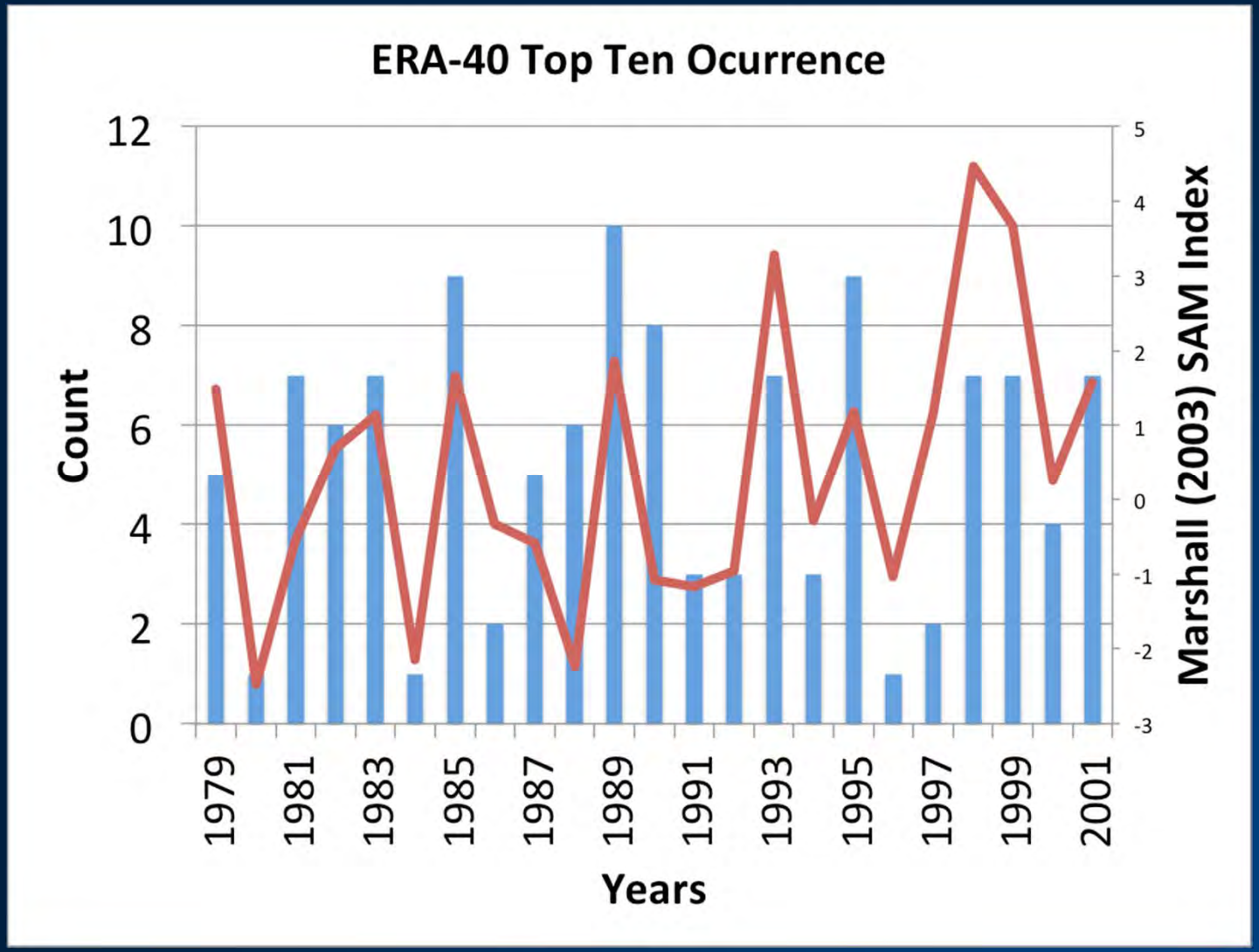
Top Ten Strongest Cyclones



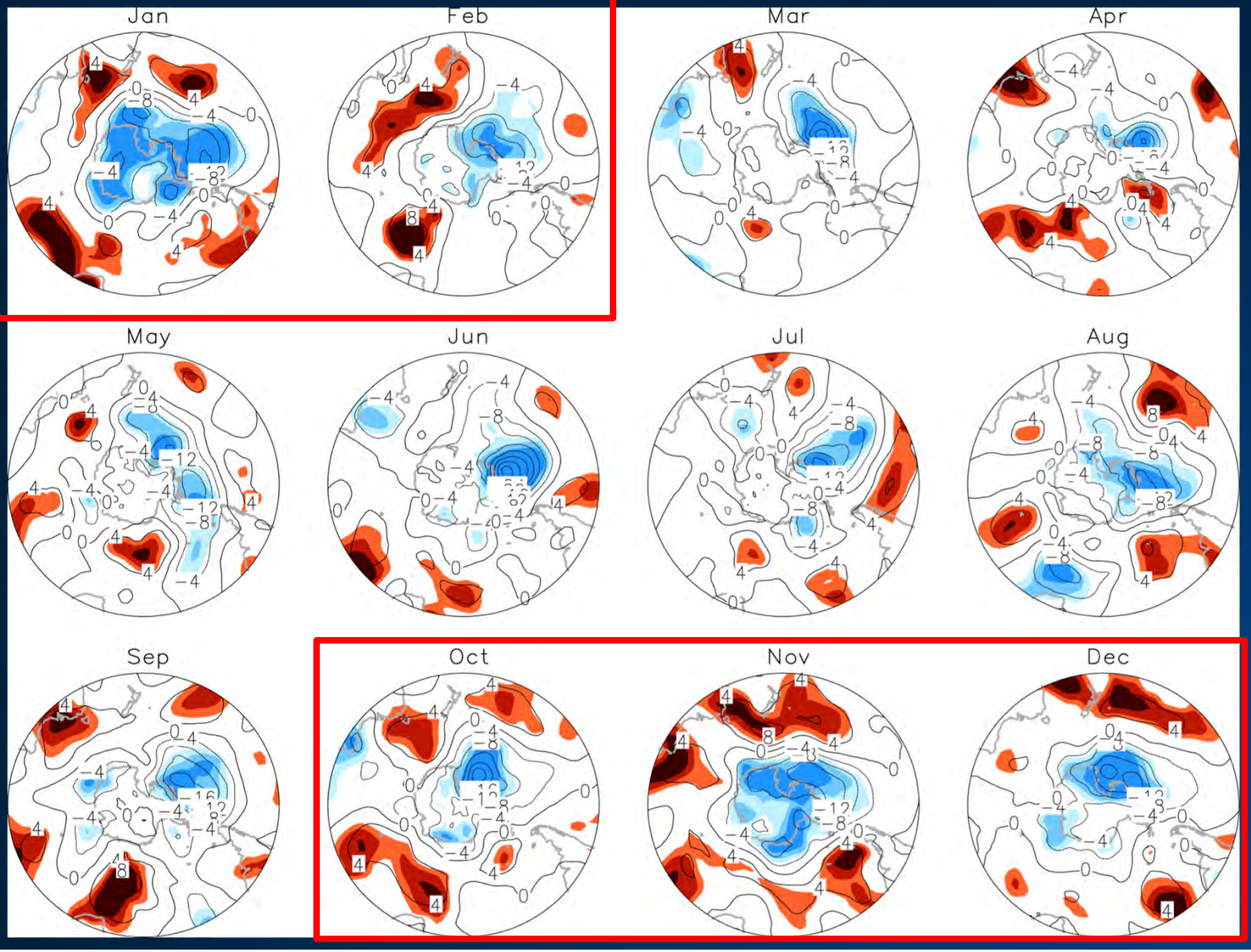
Top Ten Occurrence By Year



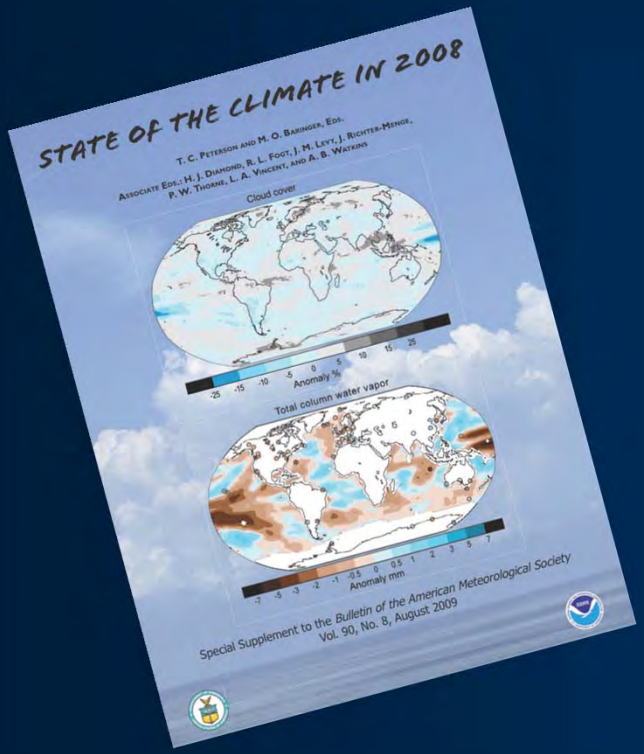
Top Ten Occurrence By Year

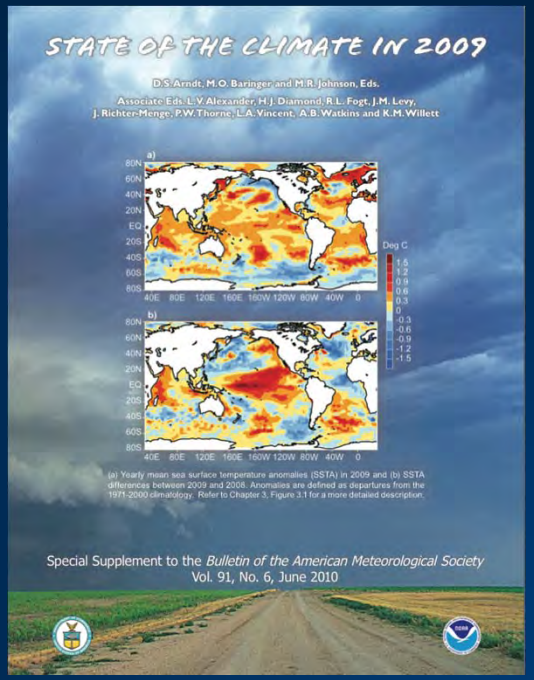


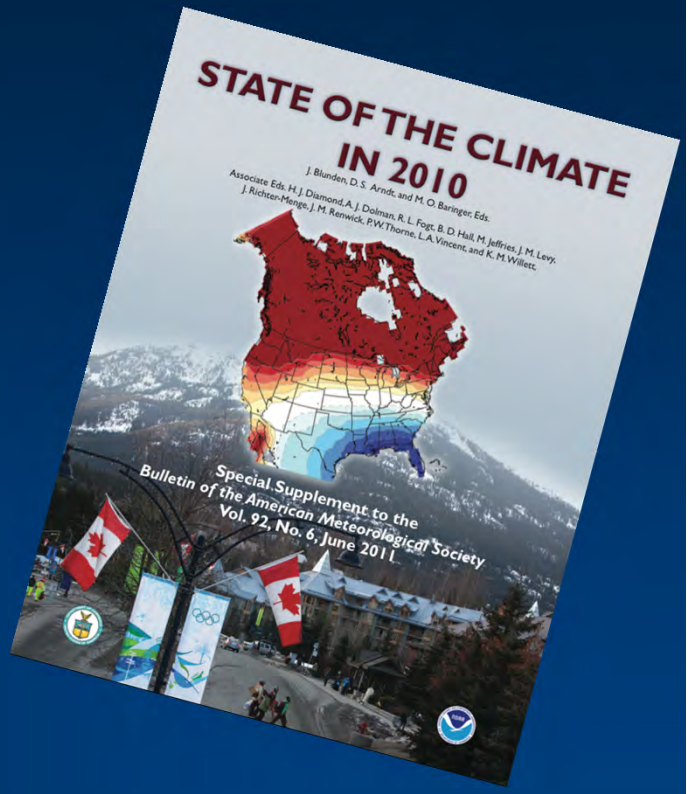
Circulation Anomalies at Cyclone Peak Intensity



State of the Climate Reports







Snapshot of Climate in Comparison with Observational Records

2008

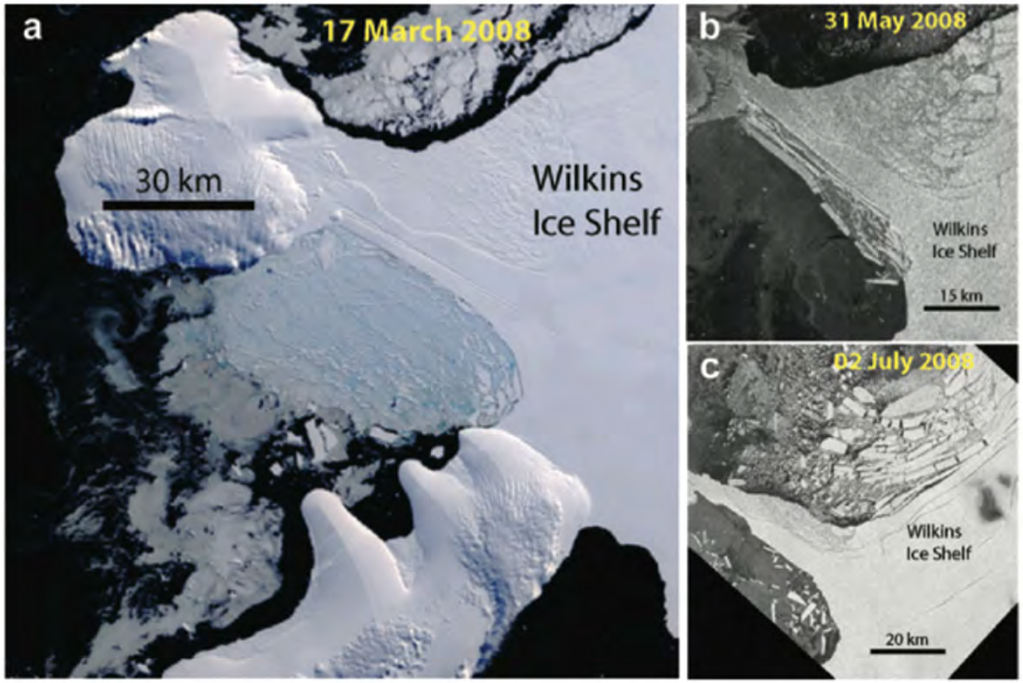
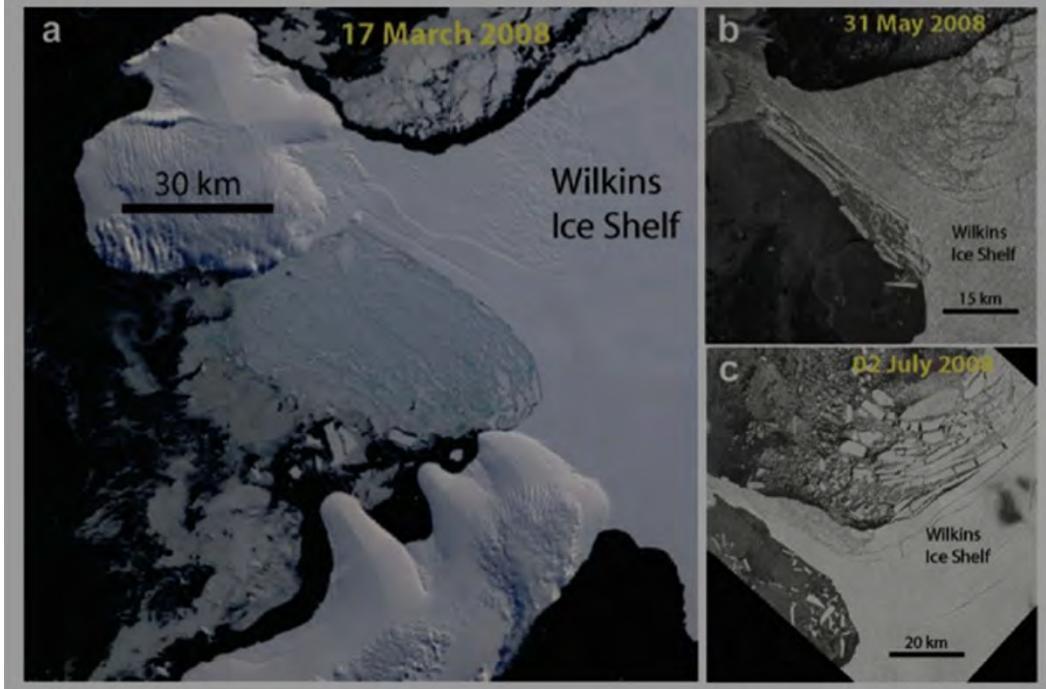


FIG. 6.1. Wilkins Ice Shelf breakup events of 2008. (a) MODIS band 1 image 10 days after the end of the first event; (b) *Envisat* ASAR image during the second event; (c) *Envisat* ASAR image during the third event. (*Envisat* ASAR images © European Space Agency.)

1. Break-up of the Wilkins Ice Shelf

2008



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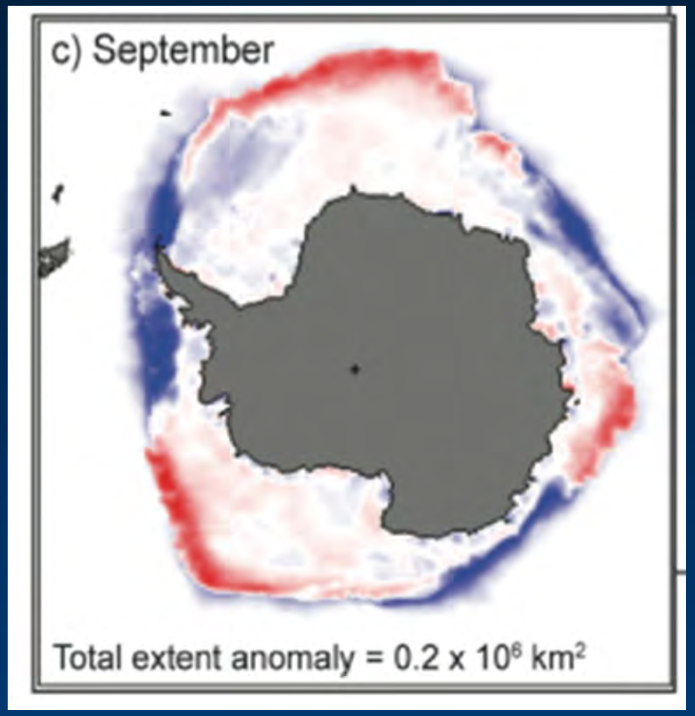
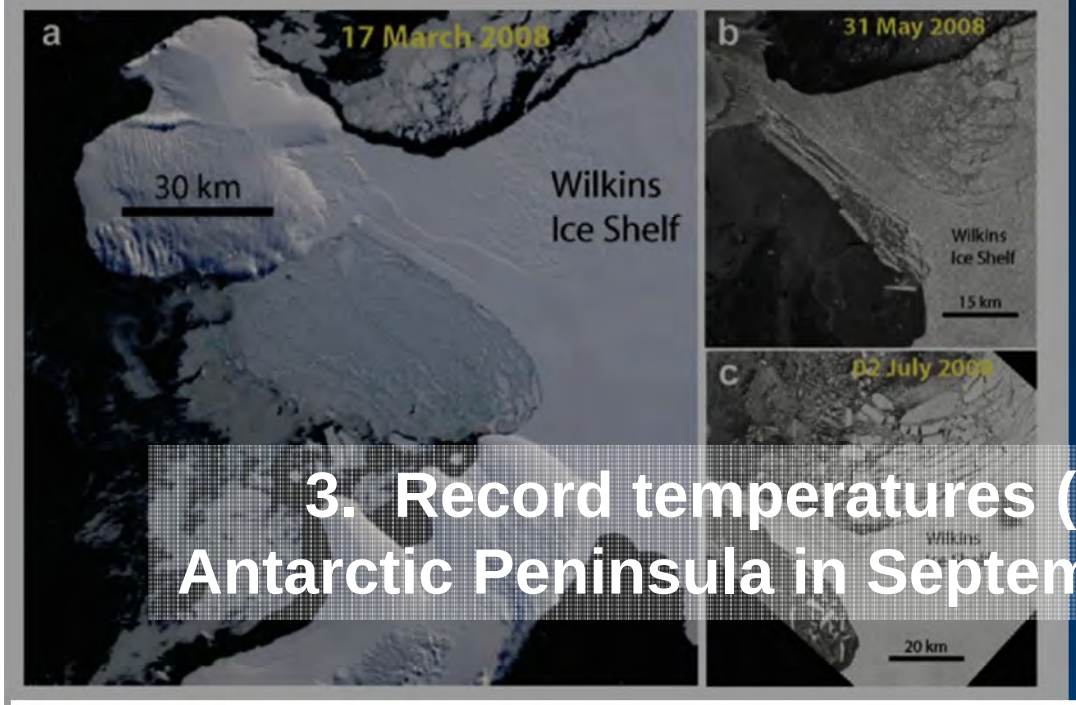
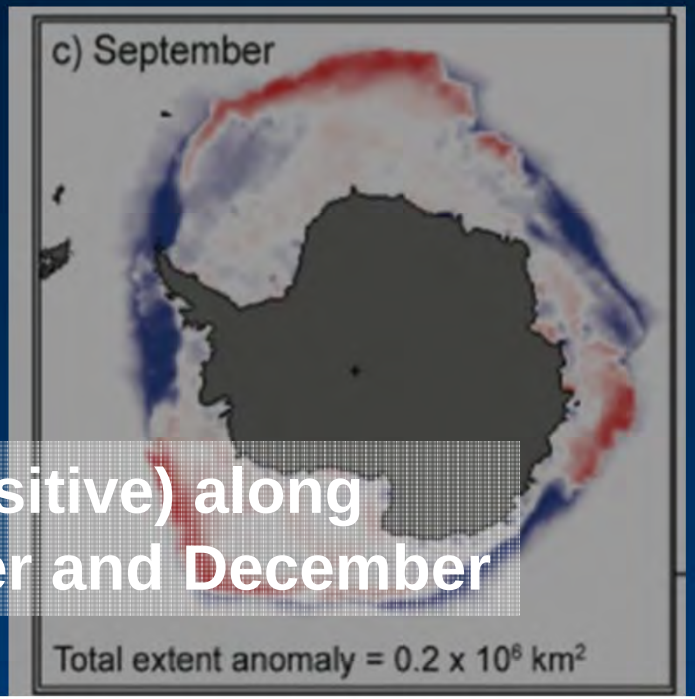


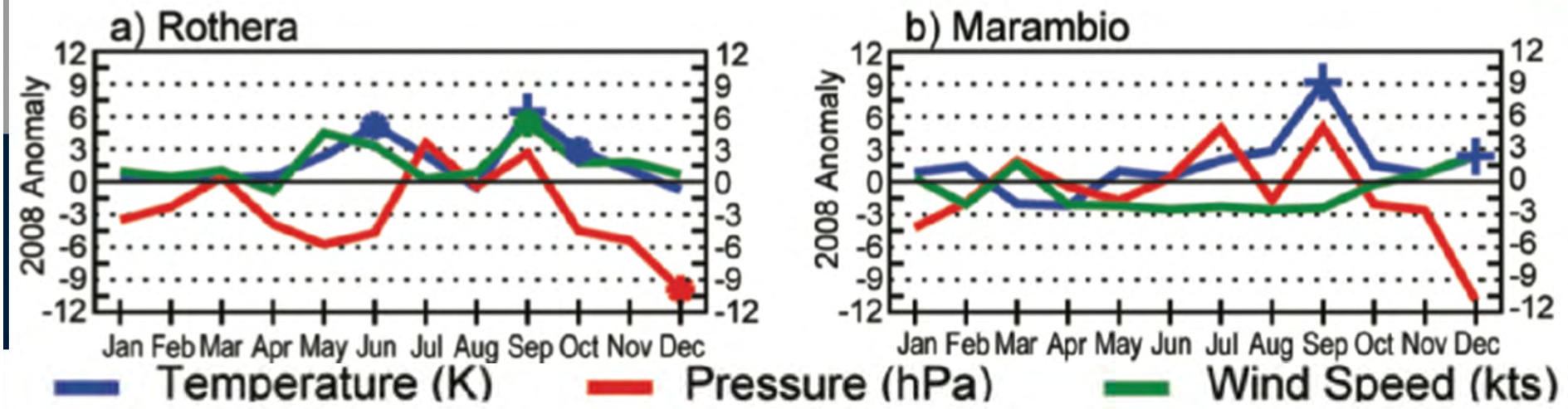
2. Continued Ice Loss in the Amundsen-Bellingshausen Seas

2008





3. Record temperatures (positive) along Antarctic Peninsula in September and December



2009

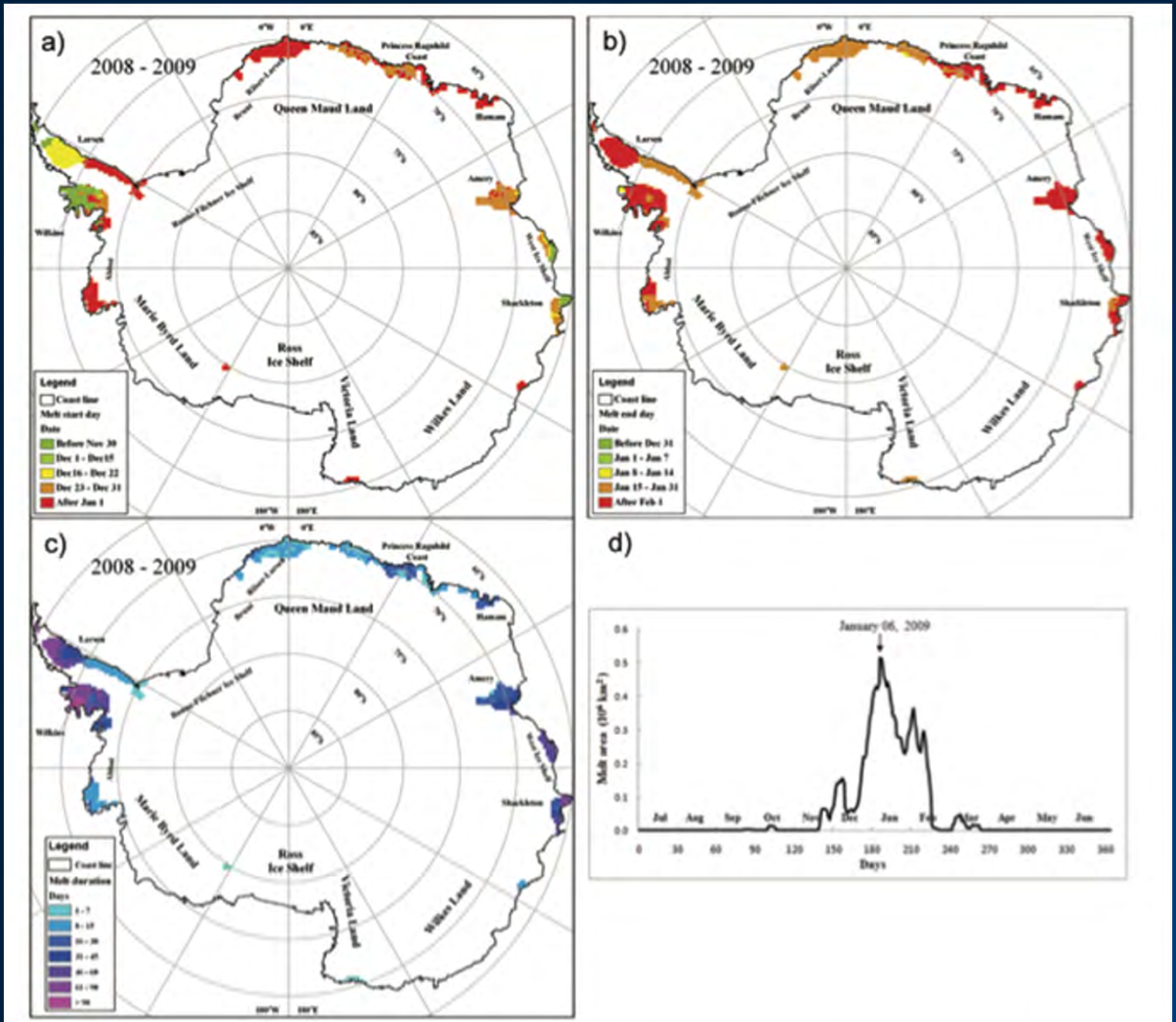
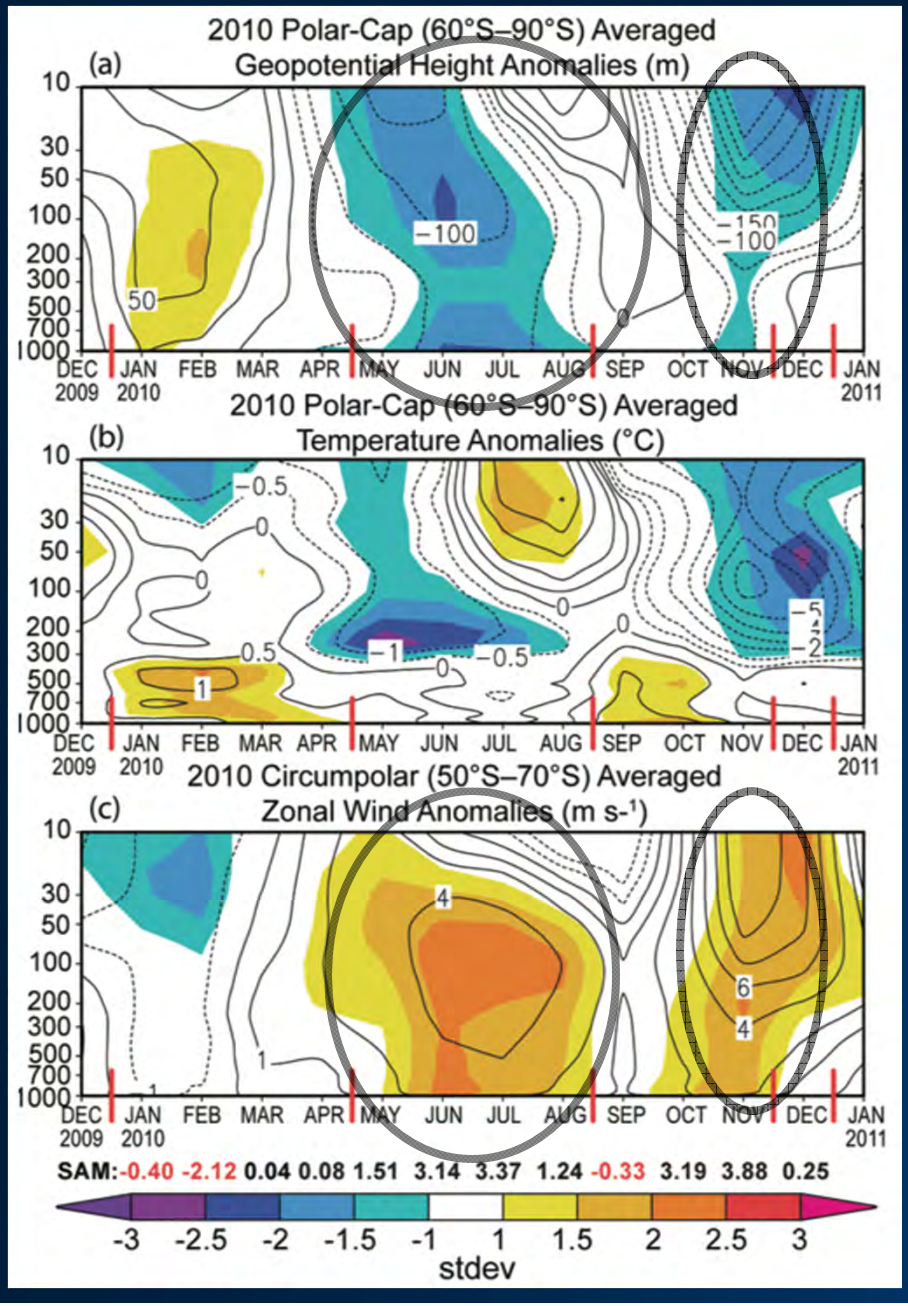
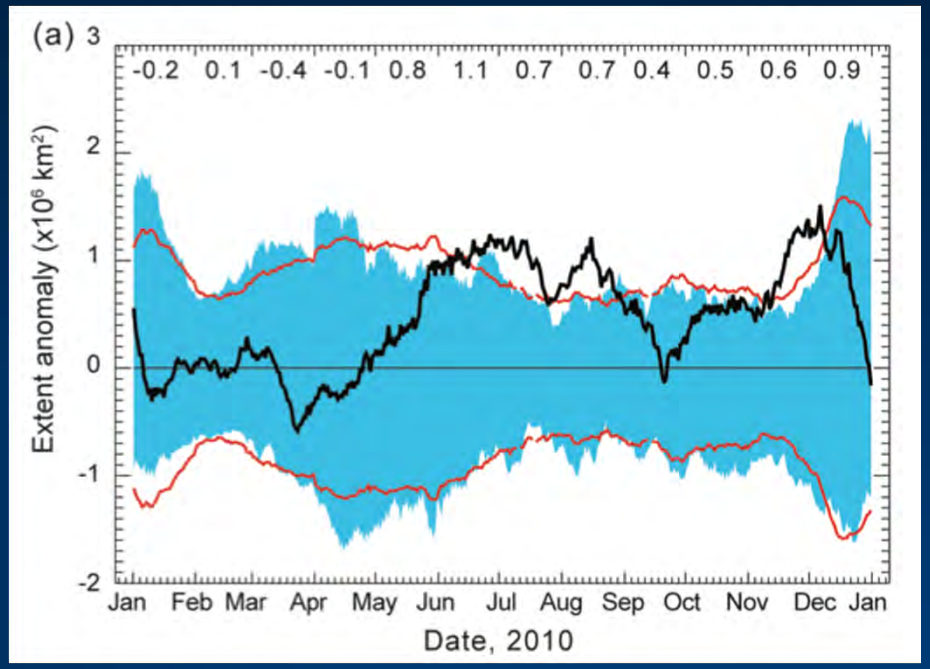


FIG. 6.6. Surface snow melt (a) onset date, (b) end date, (c) duration, and (d) melt area for the austral summer 2008/09 melt season.

Austral summer 2008-2009 was lowest melt year on record. No melt detected on Ronne Filchner or Ross Ice Shelves.

2010





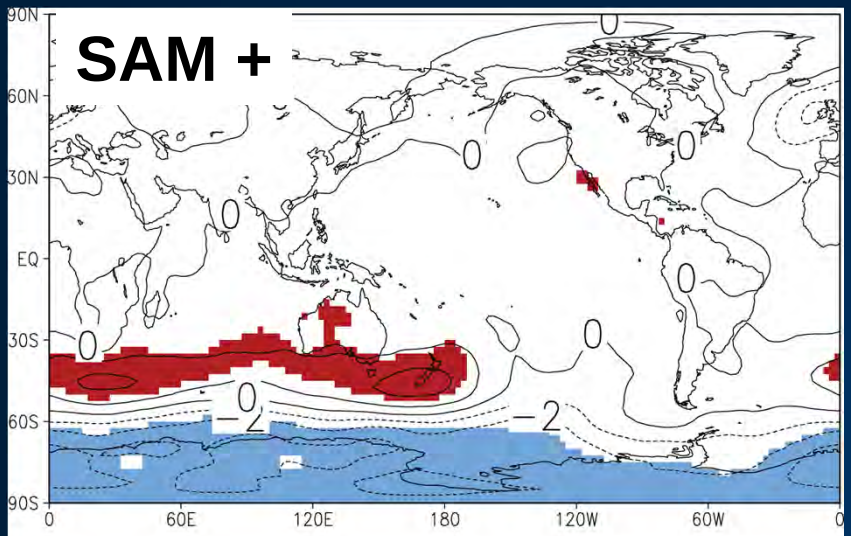
Record positive SAM and sea ice extent in winter and late November – early December

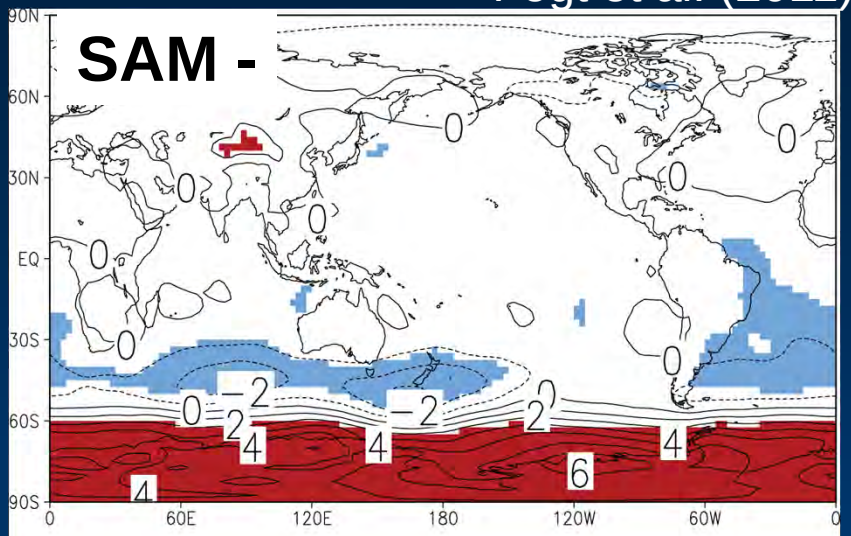
Conclusions

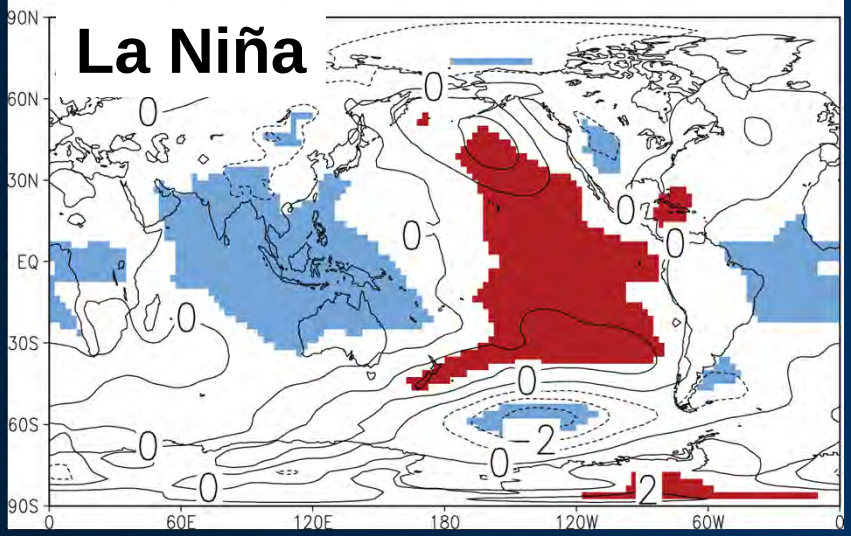
- WAIS climate is influenced by complex interactions from SAM and tropical forcing
- Variations in the ABSL are a key player in WAIS climate
- Understanding the weather-climate connection here is necessary, but challenging due to high interannual variability
- Over the last 3 years, there have been many important regional climate records, which also have important WAIS climate implications

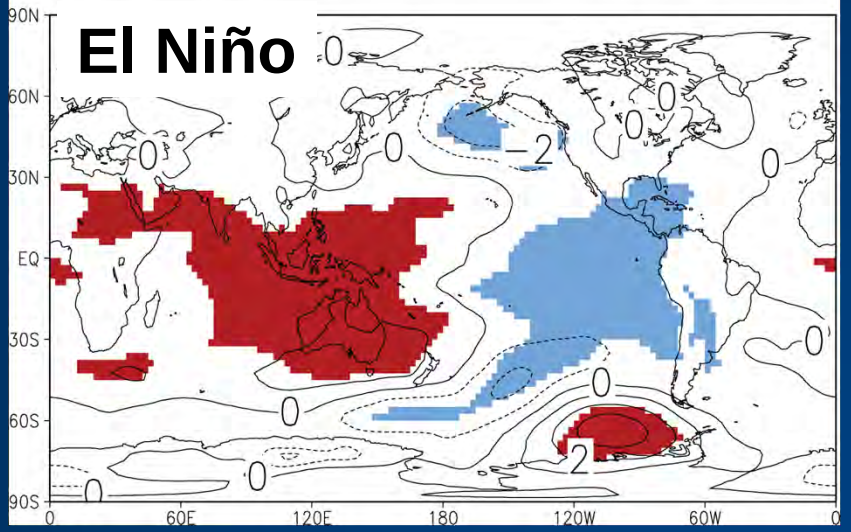
NCEP MSLP Composites

Fogt et al. (2011)



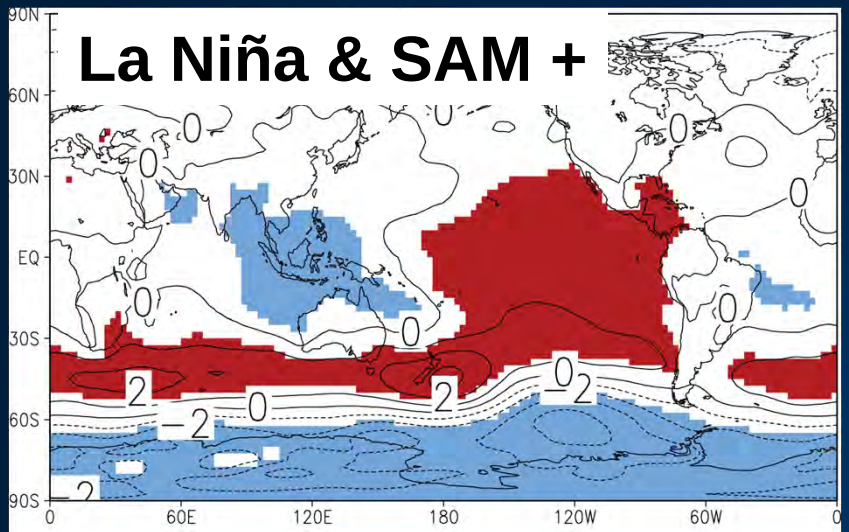


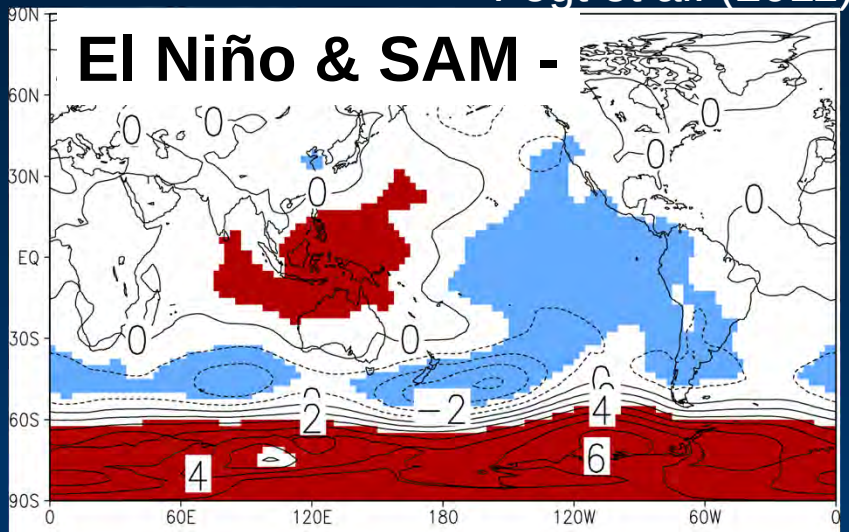


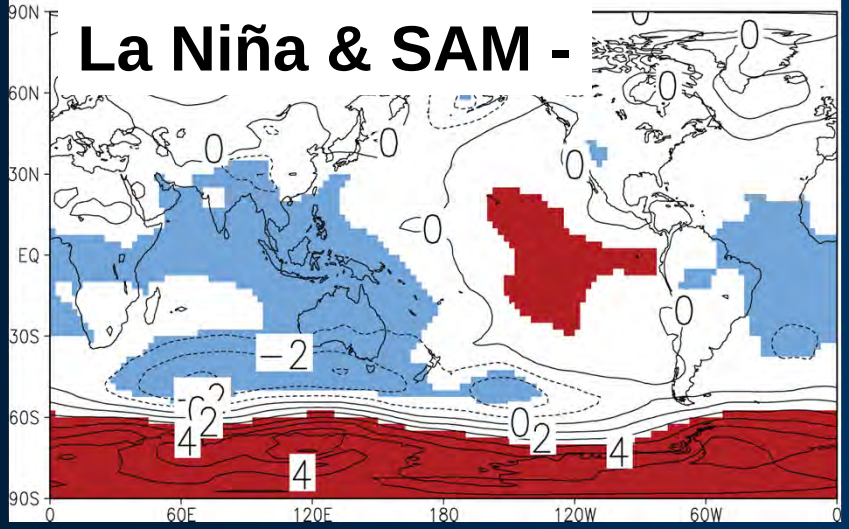


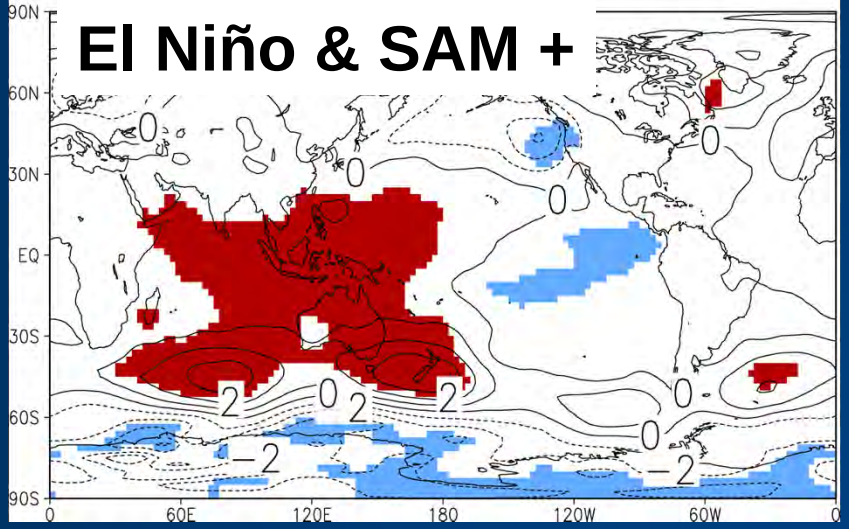
Combined NCEP MSLP Composites

Fogt et al. (2011)

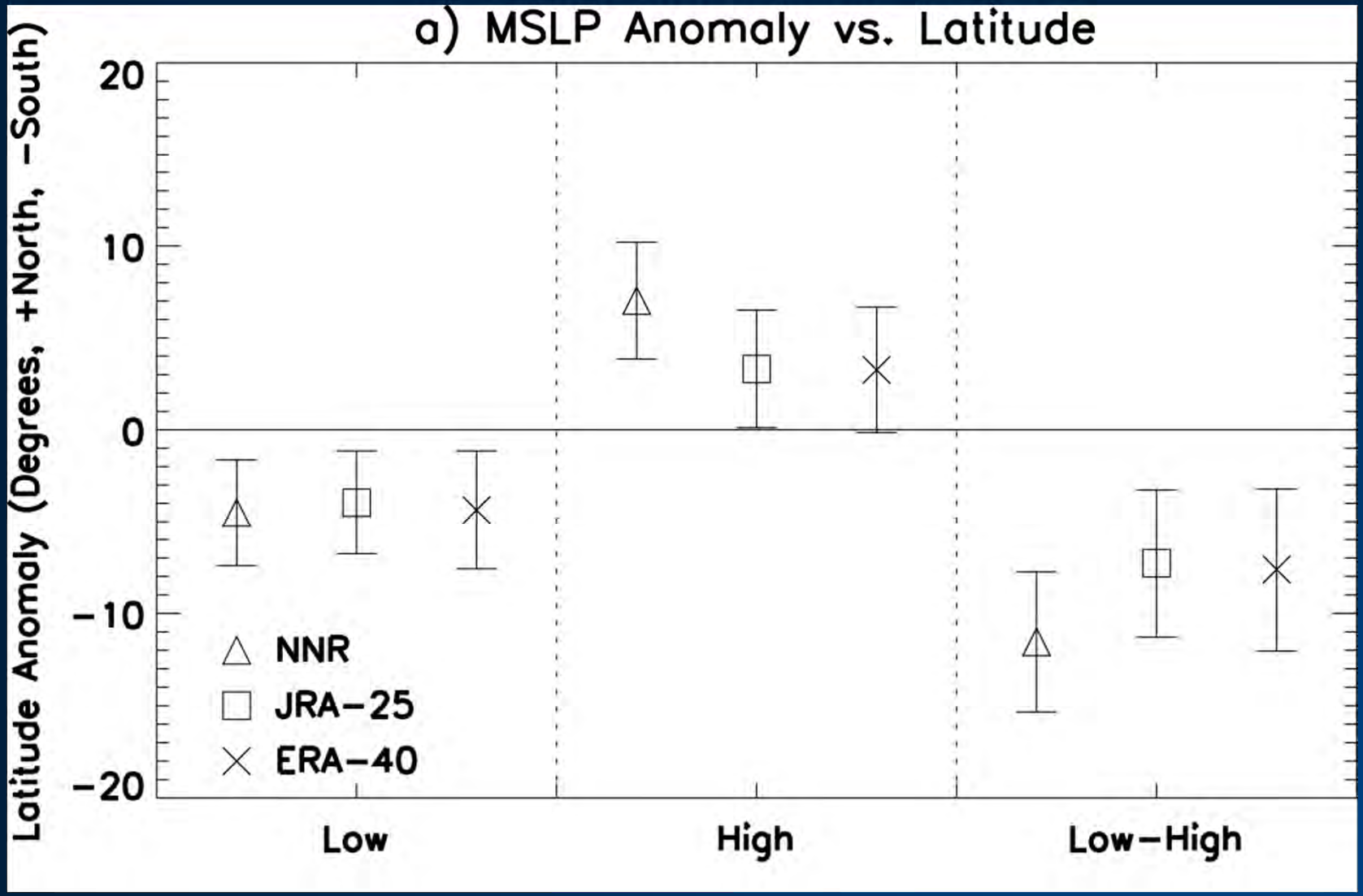




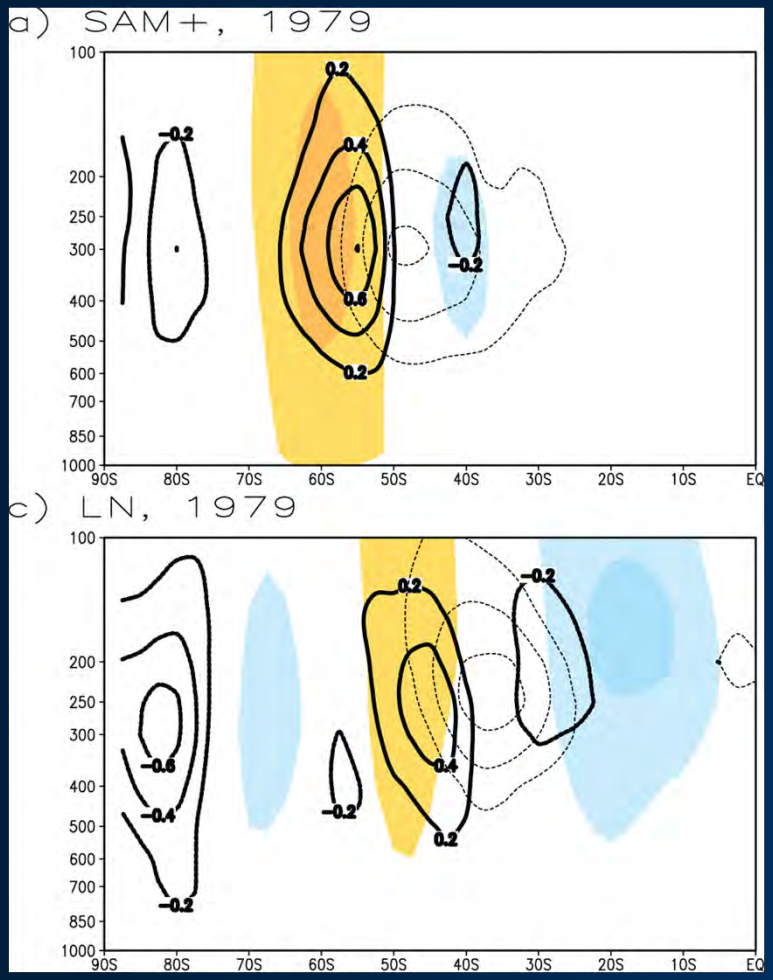




Position Relationships I



Zonal Mean Zonal Wind Composites: La Niña Case

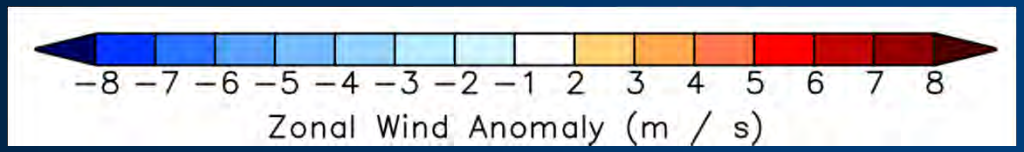


Shading: zonal mean zonal wind anomalies

Thin contours: anomalous meridional transient eddy momentum flux

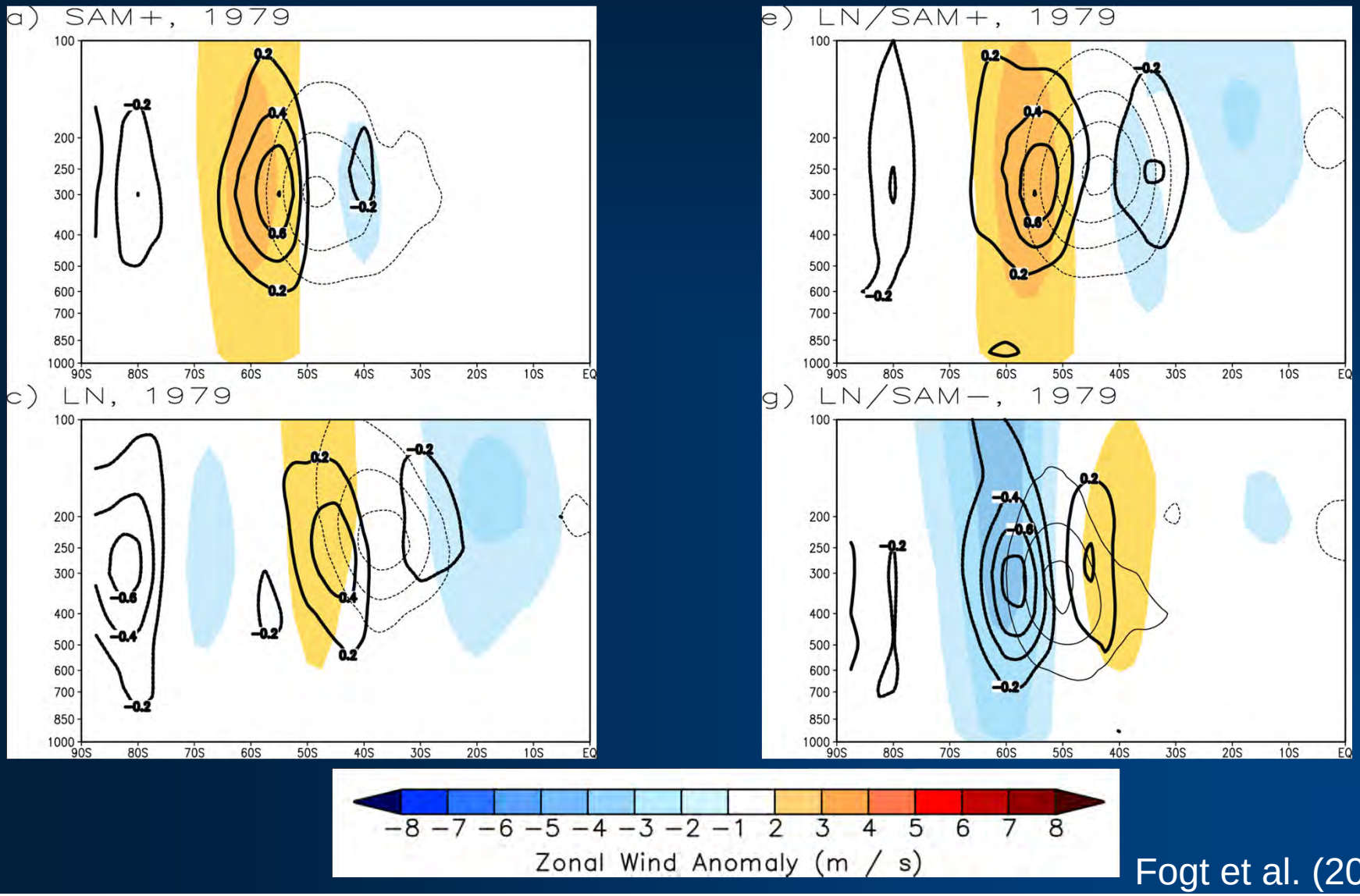
Thick contours: anomalous meridional transient eddy momentum flux convergence

$$\frac{\partial[\bar{u}]}{\partial t} = f_o[\bar{v}] - \frac{\partial[\overline{u'v'}]}{\partial y}$$



Fogt et al. (2011)

Zonal Mean Zonal Wind Composites: La Niña Case



Fogt et al. (2011)