COMPOSITE ANALYSIS OF EL NINO SOUTHERN OSCILLATION EVENTS ON ANTARCTICA

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Outline

- Background on ENSO and SAM interactions in the Antarctic
- Data
  - European Center for Medium-Range Weather Forecasting(ECMWF) reanalysis(ERA)-Interim
- Composites
  - Oceanic Nino Index Composites (ONI)
  - Including SAM information
- Discussion/Conclusions
- Future work

ENSO Interactions

- ENSO positive events induce a Pacific South American (PSA) pattern.

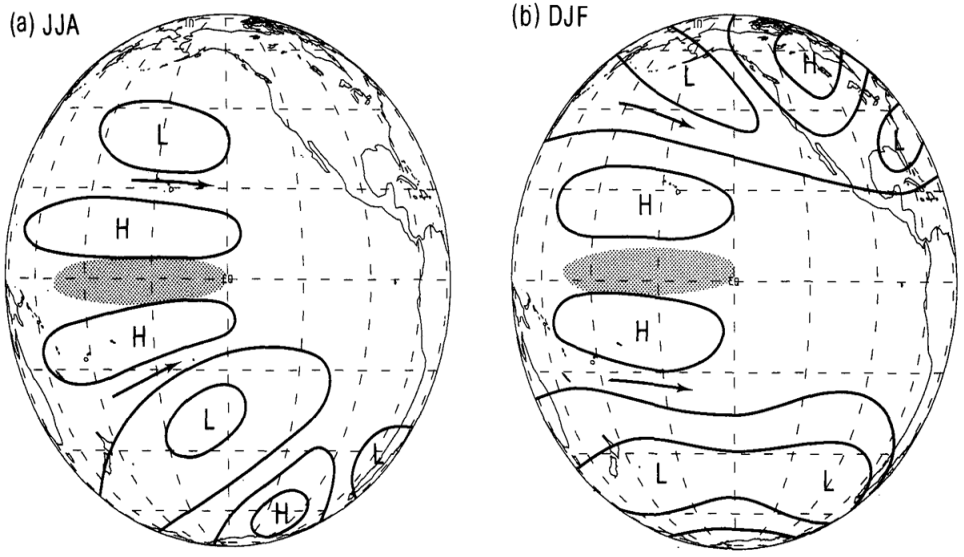
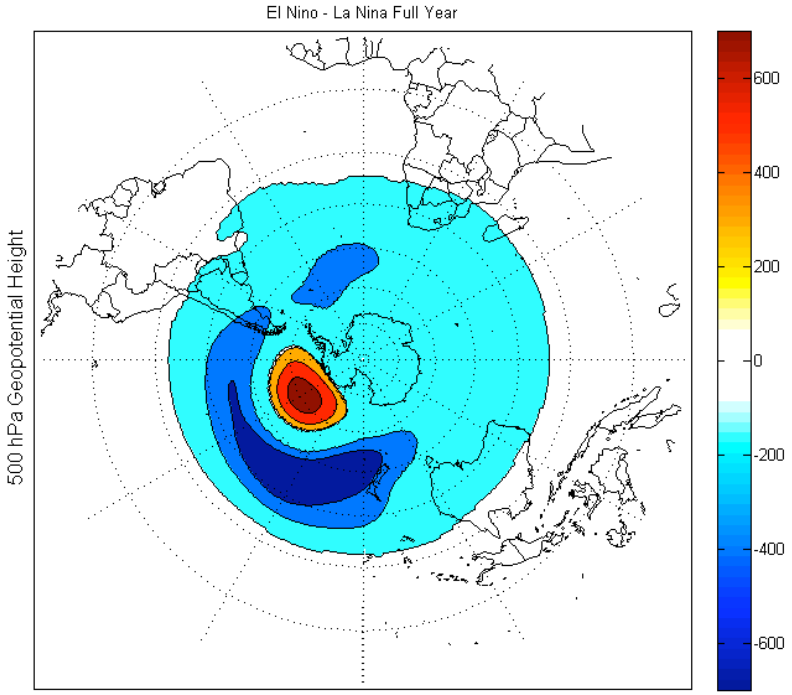
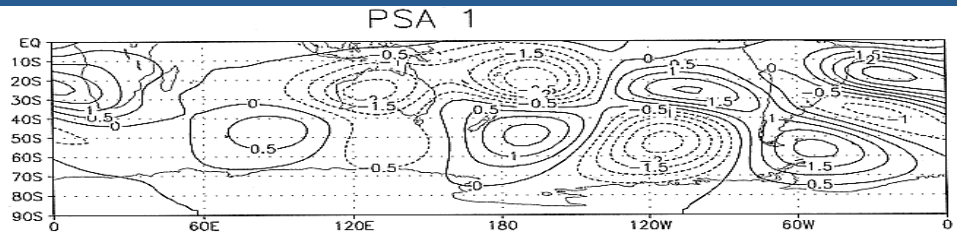


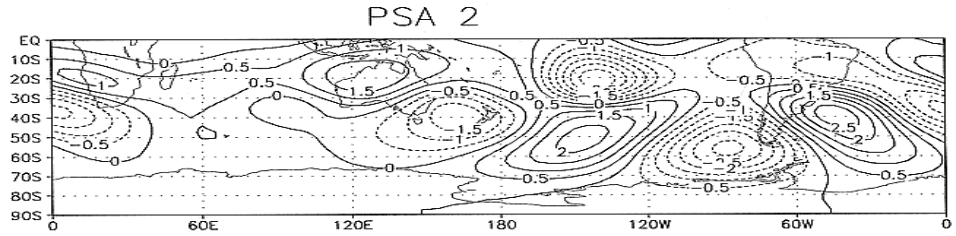
FIG. 11. Schematic illustration of the pattern of upper tropospheric height anomalies over the Pacific Ocean during (a) the early stage of an ENSO event in the SH winter (JJA) and (b) the mature stage of an ENSO event in the SH summer (DJF). The stippling shows the region of enhanced convection over the central equatorial Pacific and the arrows indicate the westerly wind anomalies in the jet streams.

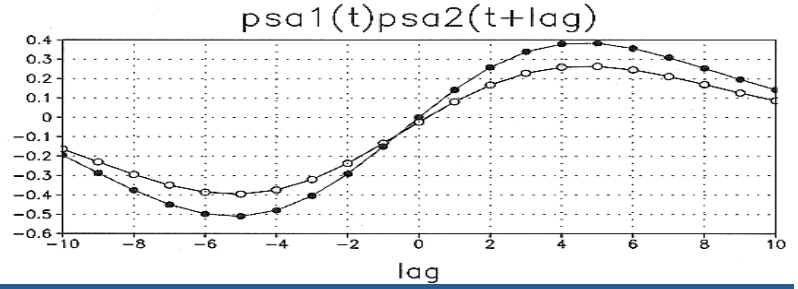
Karoly 1989

ENSO Interactions









Mo and Higgins 1998

ERA-Interim

- Time period of study: **January 1979 – January 2014**
- Upper Level data used: 300 & **500 hPA heights** contoured in 10gpm
- Surface data: **Temperature, and Sea Surface Temperature**
  - Used to both check for physical consistency with upper level and to determine surface effects
  - Sea Surface Temperature used to emphasize differences between El Nino and La Nina
- Used in both composite analysis and point comparisons with AWS stations to ensure the model reproduces ground stations accurately.
- Resolution: 0.75 x 0.75 degrees
- Latitude: 10.5 N – 89.5 S

Composite Analysis

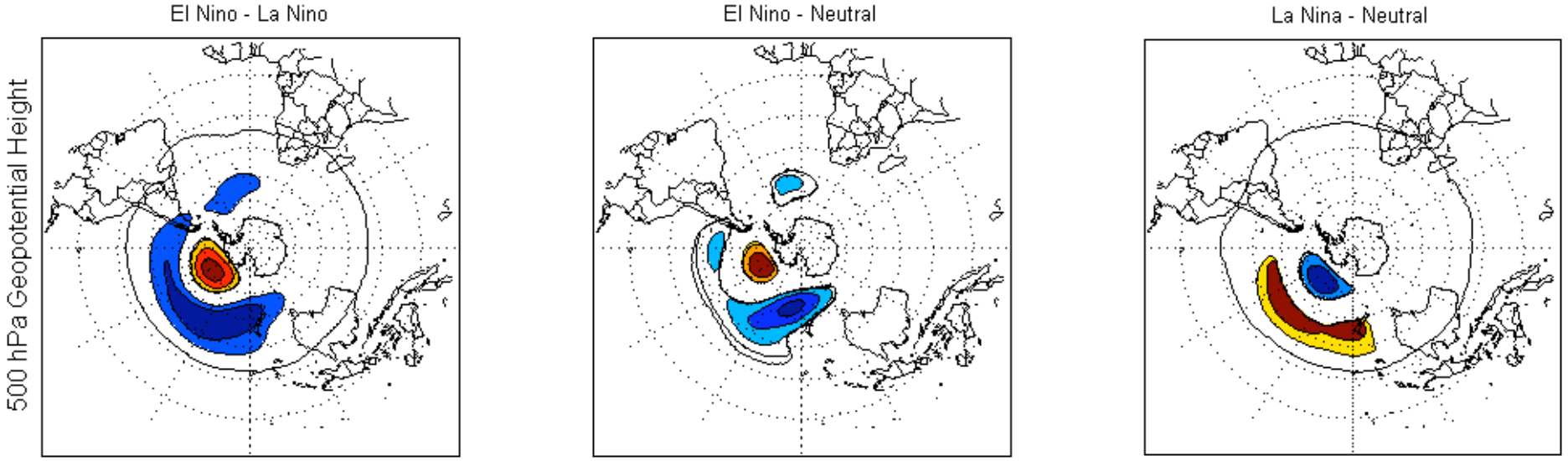
Standard composites have been made of El Nino – La Nina, which is easily compared with regression analysis of the ONI

- This can increase signal visibility in the composites
- Definition of ENSO events is 5 month running mean sea surface temperature deviation of .5 degrees Celsius for at least 6 month in the Nino 3.4 region (Trenberth, 1997) was used for ONI composites

Composite Analysis

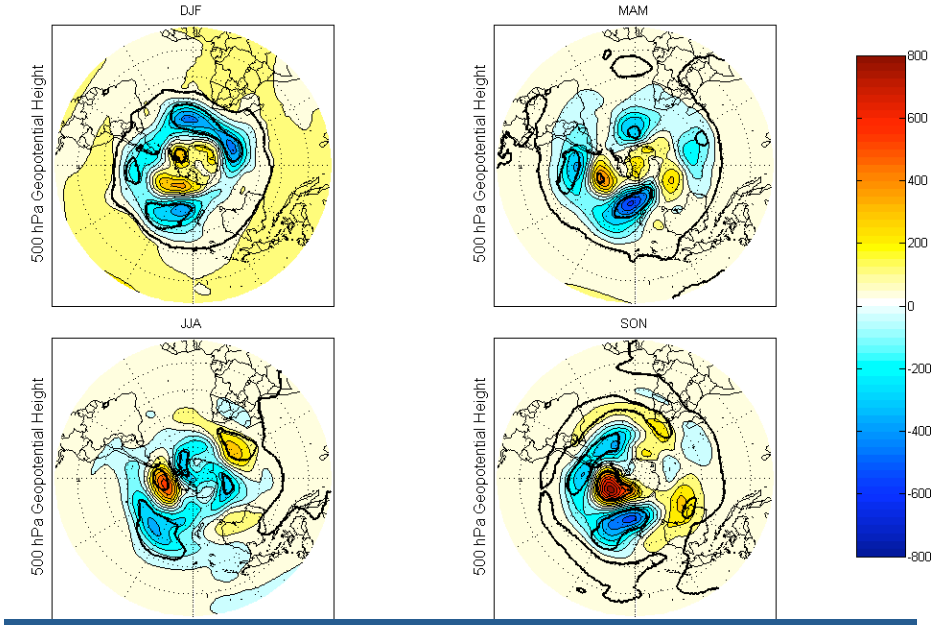
- Pros and Cons
  - Pro:
    - Shows signals associated with La Nina and El Nino as opposed to areas impacted by both in opposite directions
    - Shows seasonal variations
  - Con:
    - Doesn't easily indicate cause of impact
    - Low number of events causes difficulties in statistics.
    - Doesn't factor or account for strength of event

Composite Analysis Techniques



Composite Analysis El Nino

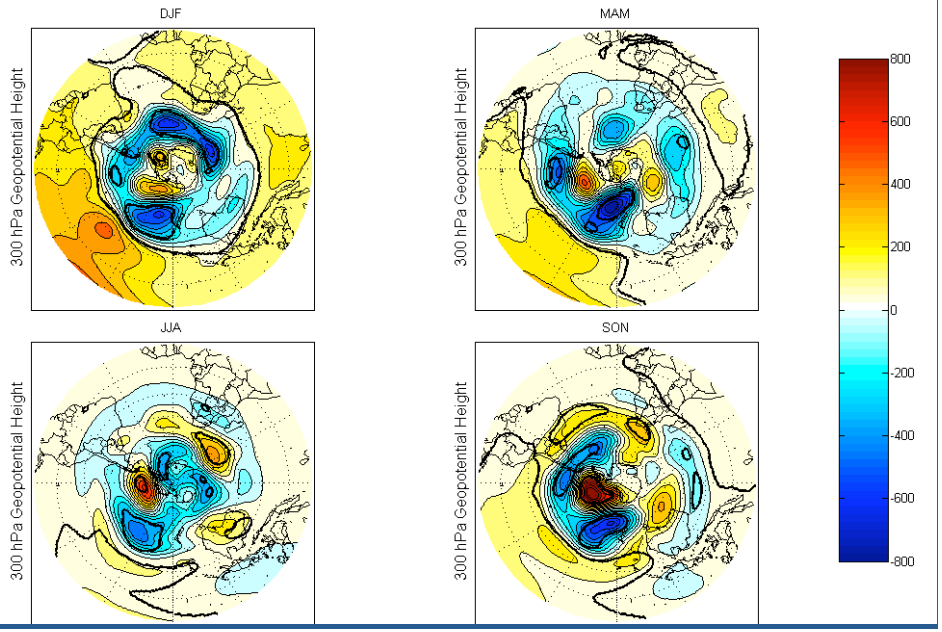
500 hPa Geopotential Height



- Inconsistent Amundsen Bellingshausen Sea Low Variation
- Relatively consistent through depth of atmosphere
- Significant regions shifted toward the Peninsula

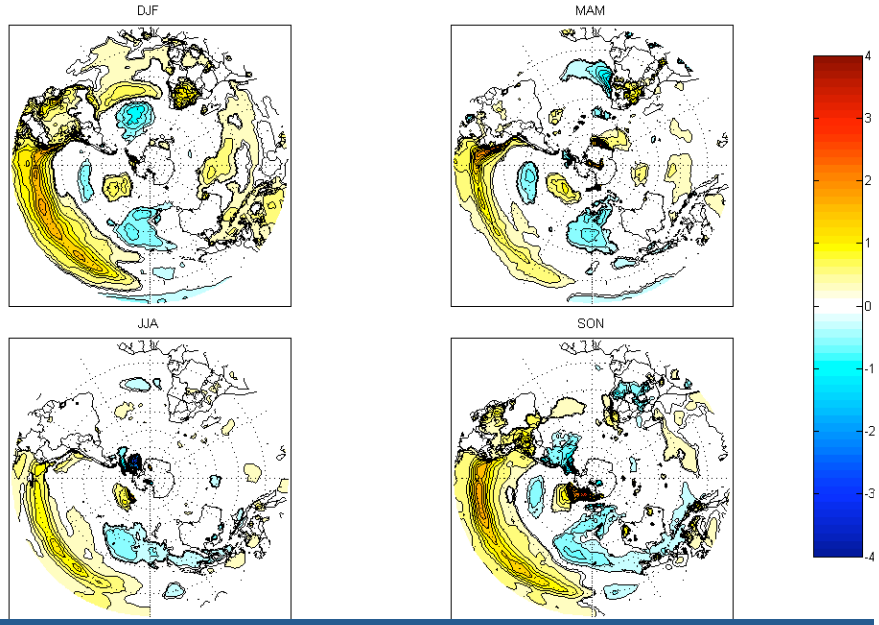
- DJF Looks odd, though this lines up with some seasonal analysis within the literature.

300 hPa Geopotential Height



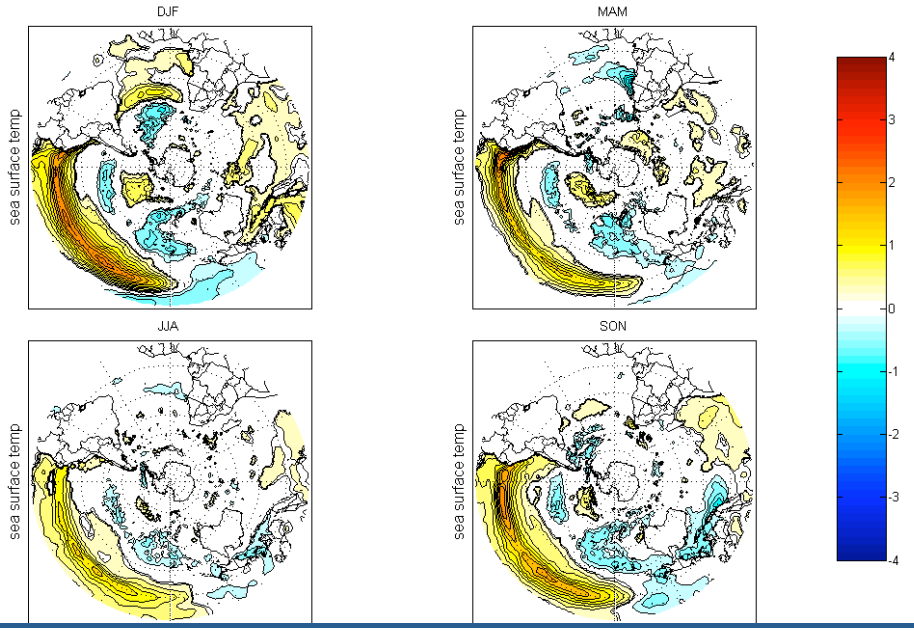
Composite Analysis El Nino

2 Meter Temperature



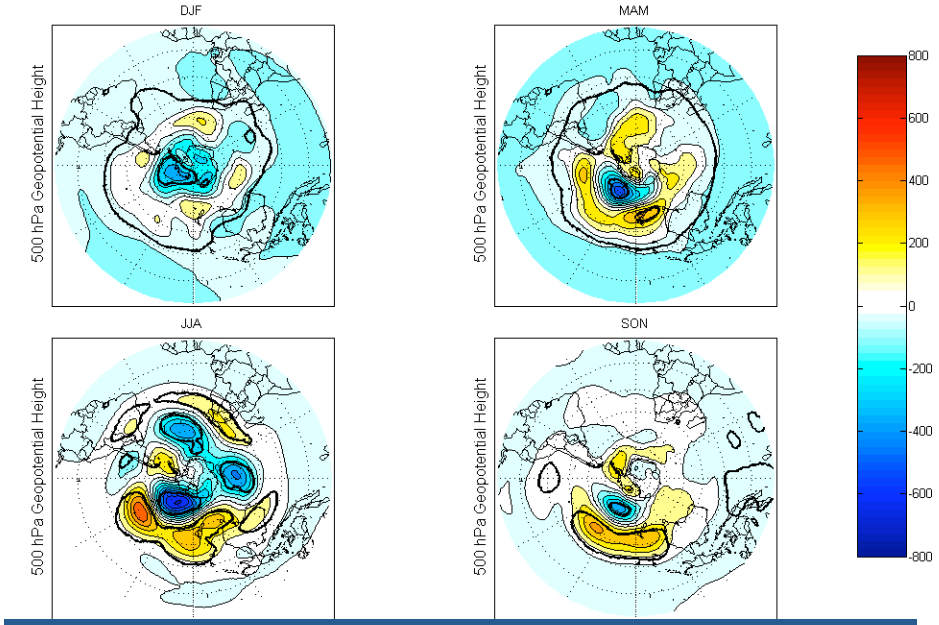
- DJF oddities remain in the 2 Meter Temperatures
- Southern Ocean temperatures and air temperatures remain relatively consistent through time.

Sea Surface Temperature



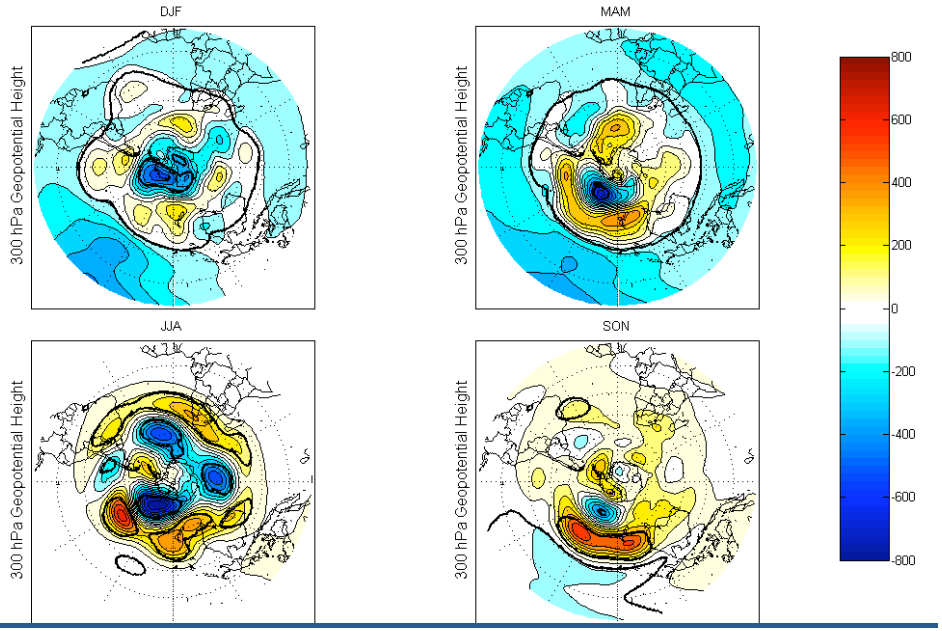
Composite Analysis La Nina

500 hPa Geopotential Height



- Upper air consistently shifted toward Ross Ice Shelf
- DJF period shows significant low height anomaly in East Antarctica
- Other seasons show signal stretching toward East Antarctica, but not statistically significant

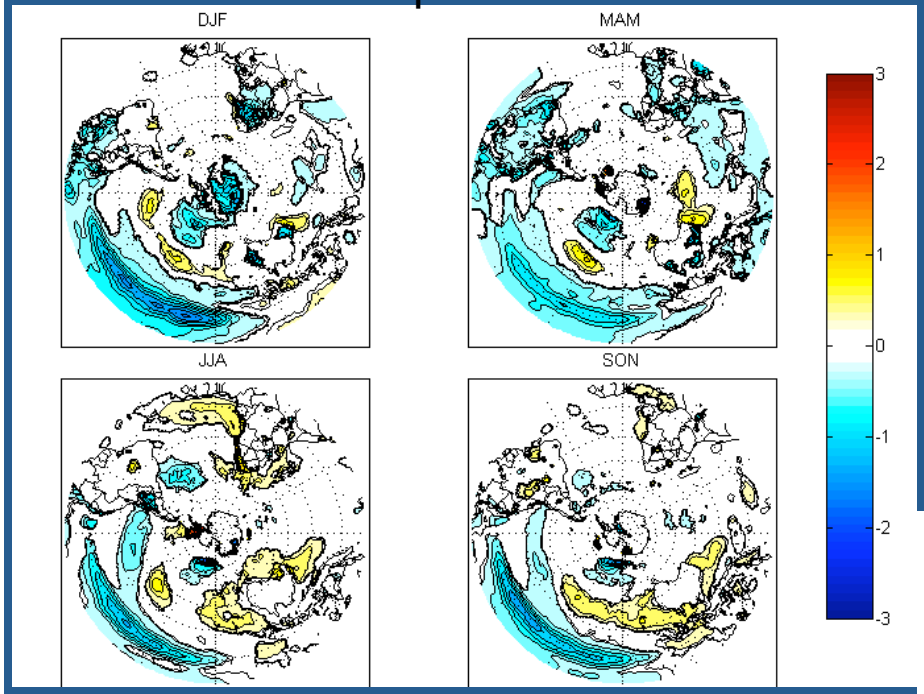
300 hPa Geopotential Height



- While SON was the season of primary importance for El Nino DJF is far more impactful for La Nina

Composite Analysis La Nina

2 Meter Temperature



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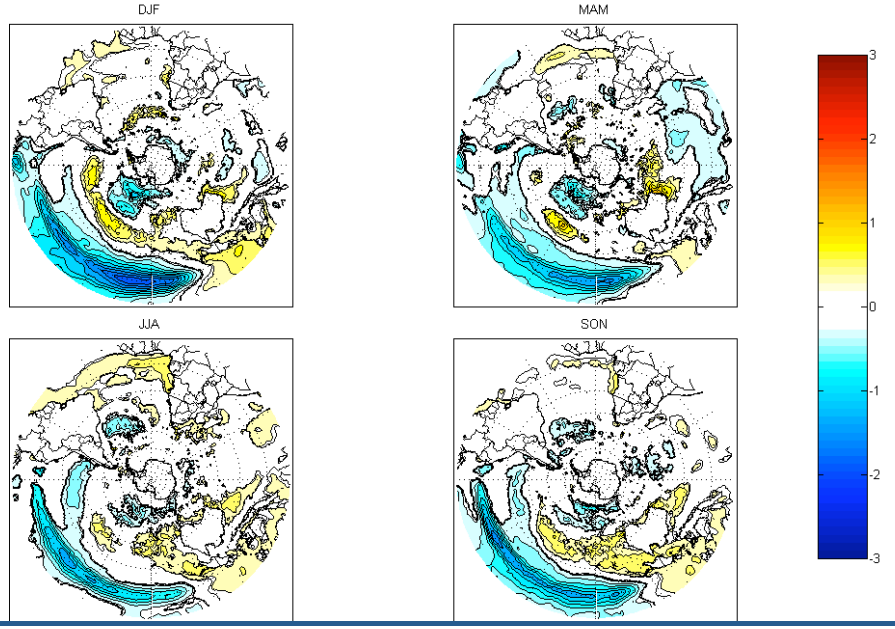
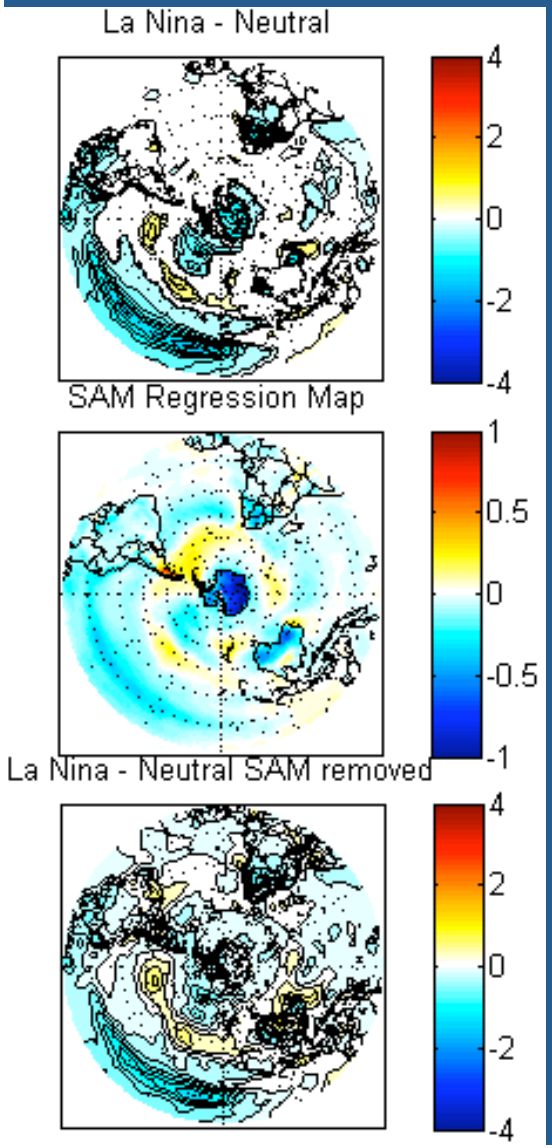
Sea Surface Temperature

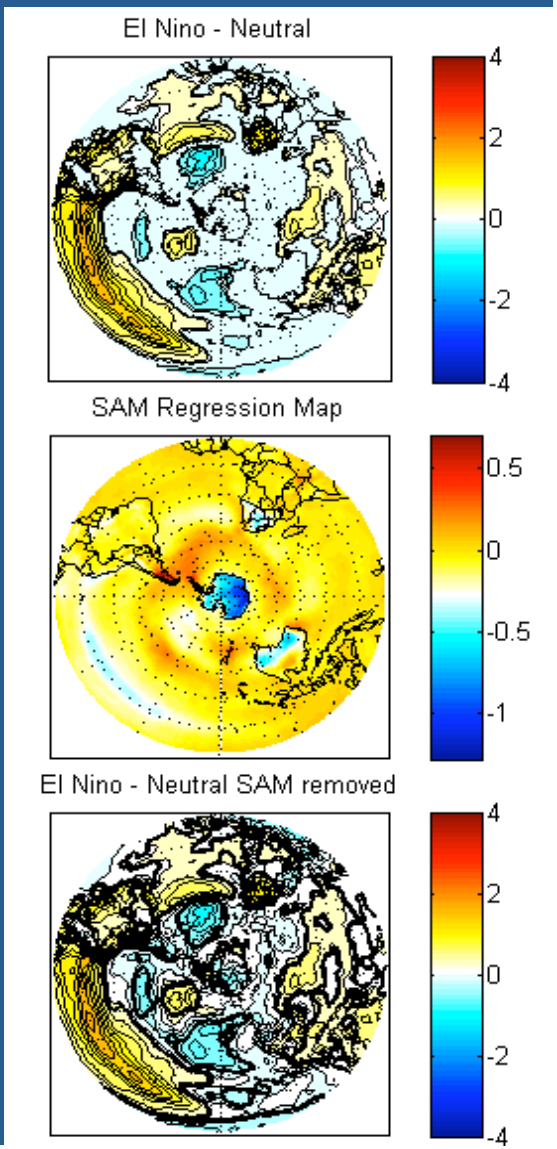


- Sea Surface temperatures match well in ABS region, but don't match well in East Antarctic coastal region.

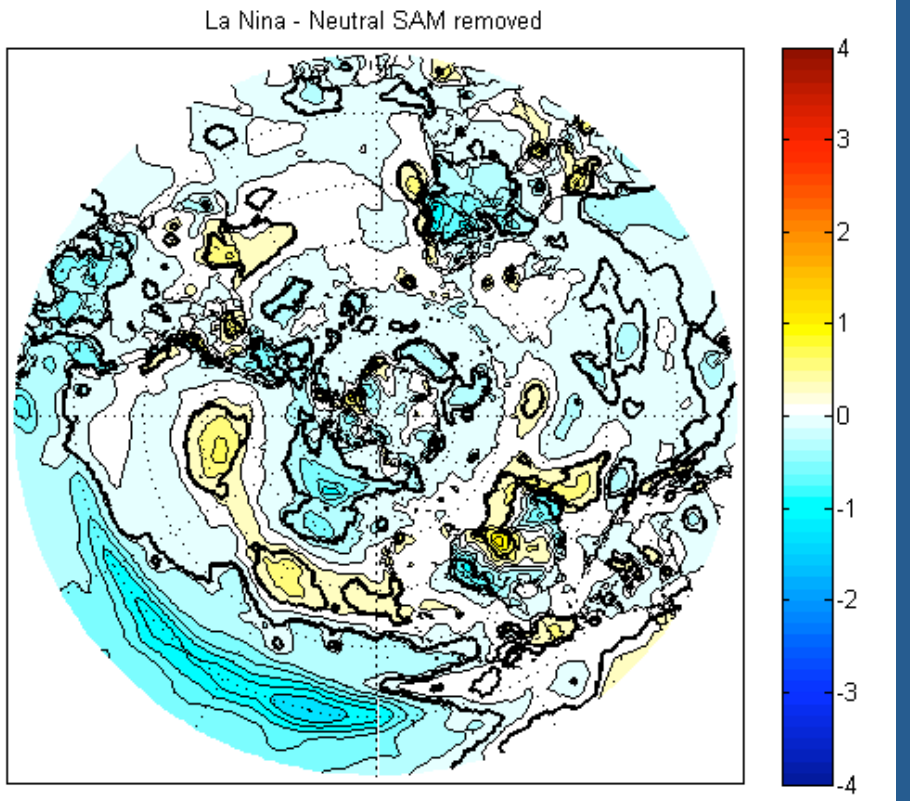
SAM Removal

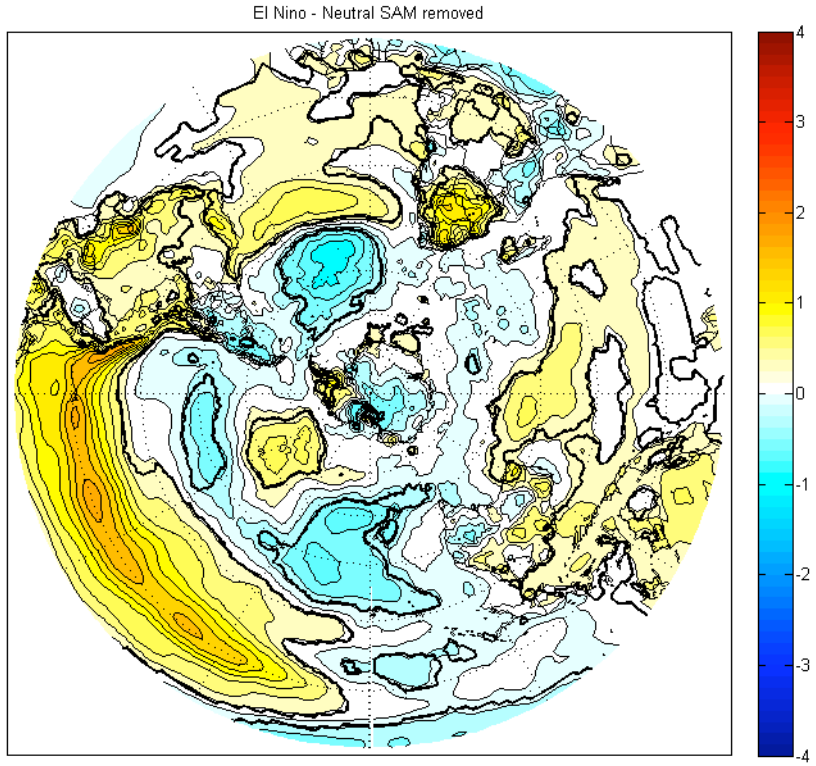


- SAM regression removed
- Only during DJF, though others looked at
- La Nina region of cold air is reduced heavily, but small region of significant cold remains in region consistent with other months
- El Nino shows cooling in the Ross Ice shelf and warming in the Peninsula
- Must be used/interpreted carefully
- DJF period chosen due to trends in SAM.



SAM Removed, Continued





Discussion/Conclusions

- Composites seem to indicate El Nino and La Nina have different regional signals
  - Seasonality varies between La Nina and El Nino, with El Nino peaking in SON while La Nina seems to peak in DJF
  - El Nino impacts shifted toward the Peninsula
  - La Nina impacts shifted toward the Ross Ice Shelf with some impacts in East Antarctica
- Surface effects seem to be largely dependent on the location of the upper level signal, which in turn seems related to regions of strongest temperature variance in the tropical SST.
- Reasons for the difference in location of signal warrants further investigation
  - Uncertain how to explore mechanisms further with this technique

Acknowledgements

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Citations

- Automatic Weather Stations from the University of Wisconsin-Madison (http://amrc.ssec.wisc.edu)
- Bromwich, D. H. and R. L. Fogt, 2004: Strong trends in the skill of the ERA-40 and NCEP–NCAR reanalyses in the high and middle latitudes of the Southern Hemisphere, 1958–2001. J. Climate, 17:4603–4619
- Fogt, R. L., and D. H. Bromwich, 2006: Decadal variability of the ENSO teleconnection to the high latitude South Pacific governed by coupling with the Southern Annular Mode. J. Climate, 19, 979-997.
- Karoly, D. J., 1989: Southern Hemisphere circulation features associated with El Niño–Southern Oscillation events. J. Climate, 2:1239–1
- Kållberg, P., A. Simmons, S. Uppala and M. Fuentes: The ERA-40 archive. [Revised October 2007] September 2004
- Mo, K. C. and R. W. Higgins, 1998: The Pacific–South American modes and tropical convection during the Southern Hemisphere winter. Mon. Wea. Rev., 126:1581–15
- Renwick, J. A., 1998: ENSO-related variability in the frequency of South Pacific blocking. Mon. Wea. Rev, 126:3117–3123
- Trenberth, K. E., 1997: The definition of El Niño. Bull. Amer. Meteor. Soc, 78:2771–2777
- Turner, J., 2004: Review: The El Niño-Southern Oscillation and Antarctica. Int. J. Climatol, 24:1–31.
- Wolter, K., and M.S. Timlin, 1993: Monitoring ENSO in COADS with a seasonally adjusted principal component index. Proc. of the 17th Climate Diagnostics Workshop, Norman, OK, NOAA/NMC/CAC, NSSL, Oklahoma Clim. Survey, CIMMS and the School of Meteor., Univ. of Oklahoma, 52-57.