METEOROLOGY

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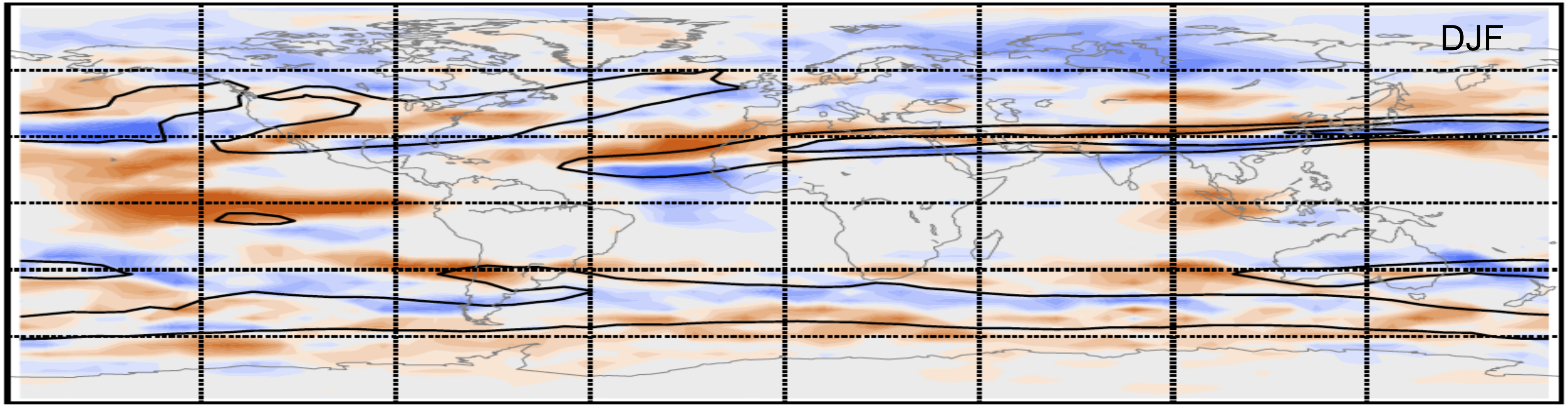
TRENDS IN UPPER TROPOSPHERIC JETS



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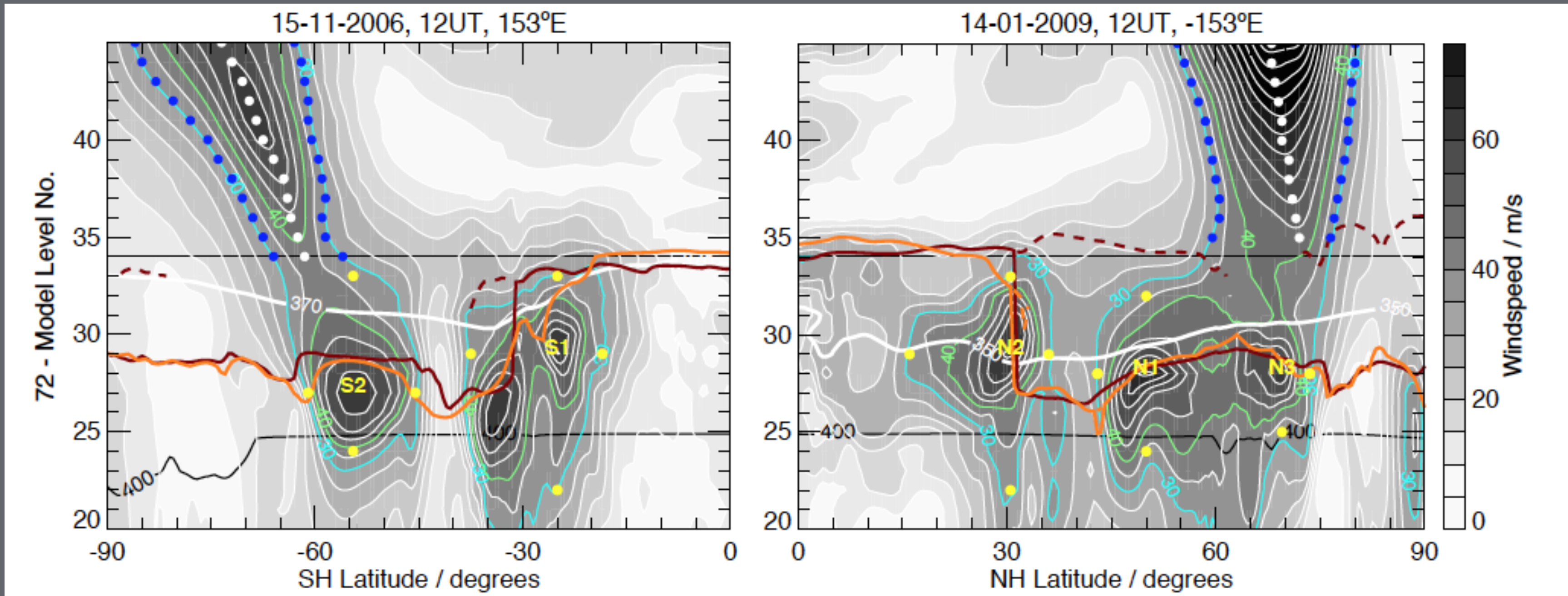
IMPORTANCE OF UPPER TROPOSPHERIC JETS

- The upper tropospheric (UT) jet streams are a key component of the atmospheric circulation, linked with weather and climate phenomena
  - storm tracks
  - precipitation
  - extreme events.
- Changes in UT jet streams are expected to lead to changes in regional weather patterns and climate impacts.
- A range of trend studies using different observations and models, and also different jet characterization methods show conflicting results
  - tropical Hadley cell width trends
  - polar versus subtropical jet trends
- We have revisited this topic using a new jet characterization method applied to five modern reanalyses (1979-2014).

JET CHARACTERIZATION

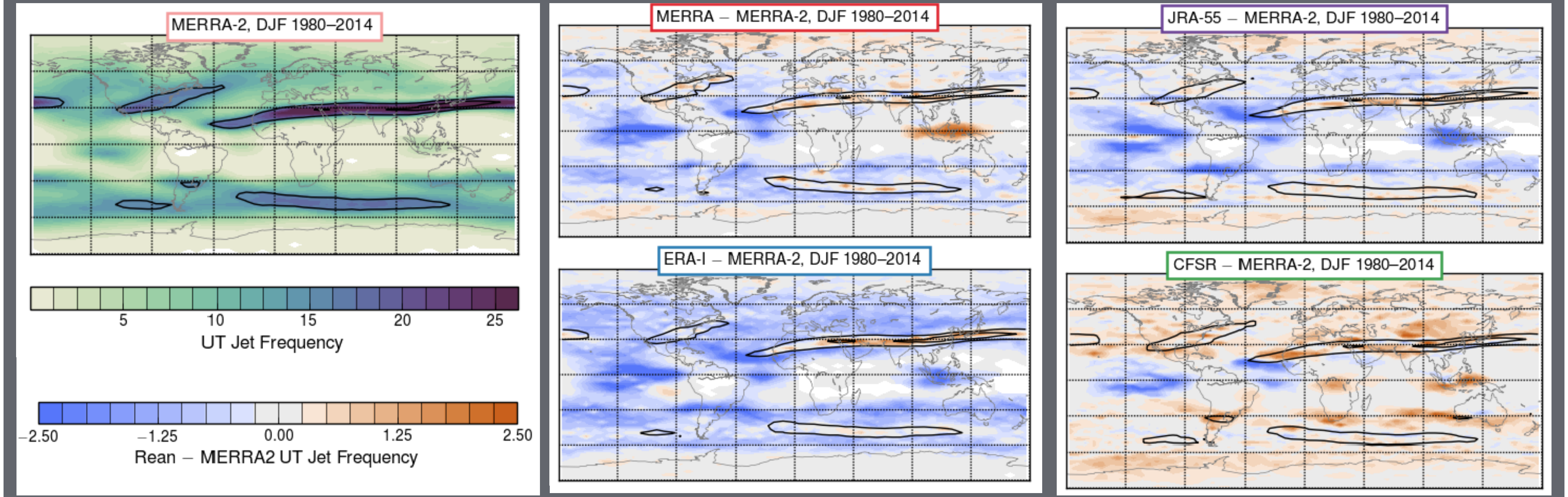
Manney, G. L., M. I. Hegglin, et al., *ACP 2011*
Manney G. L., M. I. Hegglin, et al., *J. Clim. 2014*
Manney G. L. and M. I. Hegglin, *J. Clim. in press*



- Focuses on 3D-character of UT jets (longitude, latitude, height).
- Identifies jet cores (windspeed maxima > 40 m s^{-1}) and jet boundaries (30 m s^{-1}).
- Subtropical jet (STJ) is identified by tropopause height on equatorward side of > 13 km and tropopause drop across jet of at least 2 km.
- Polar jet is strongest westerly jet poleward of STJ (or poleward of 40° if no STJ).

REANALYSES COMPARISON

Manney, G. L., M. I. Hegglin, et al., *ACP 2017.*

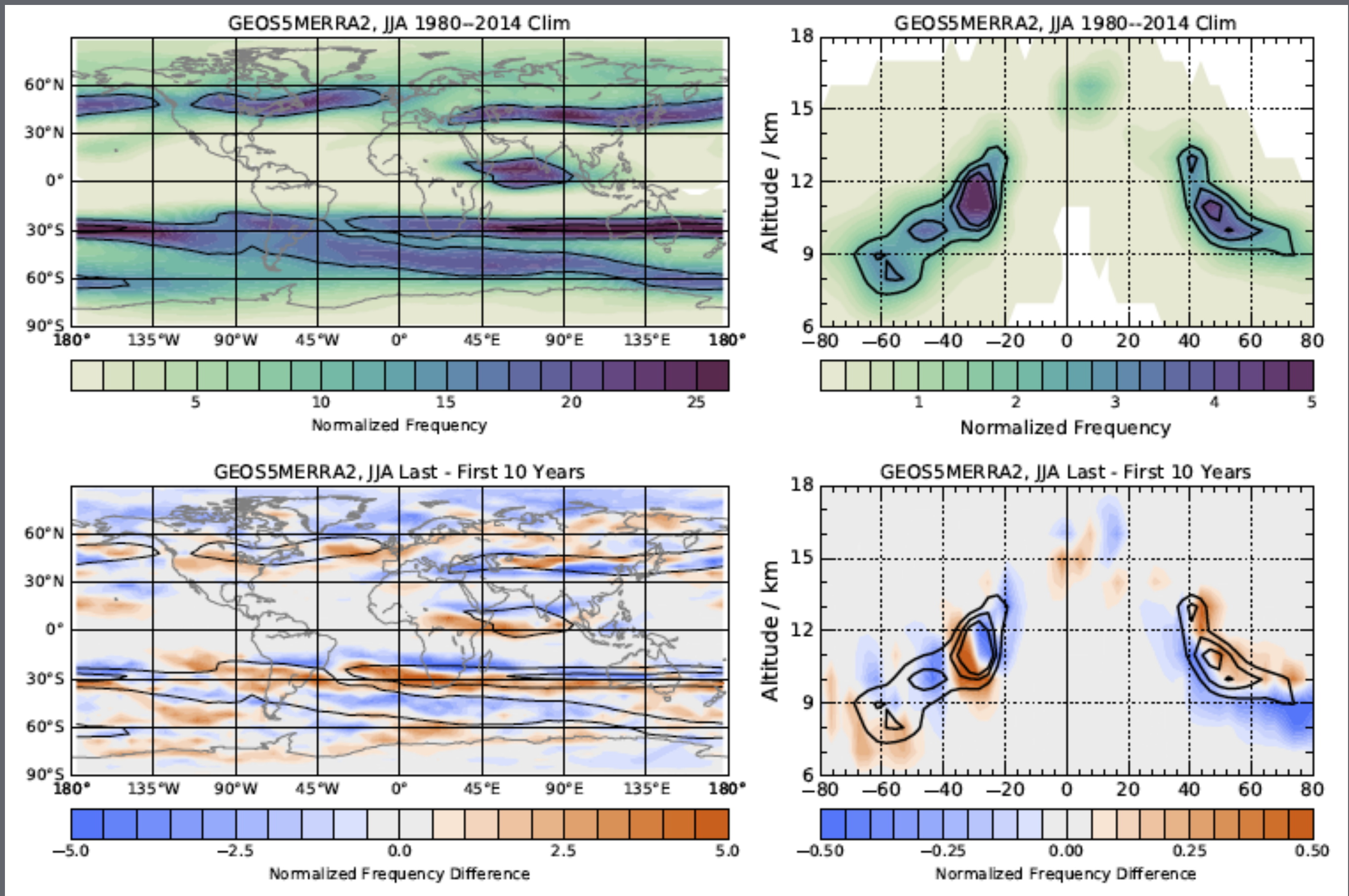


- Very good qualitative agreement in UT jet distributions between reanalyses.
- Largest quantitative differences in SH mid- and high-latitudes in solstice seasons, also in UT jets associated with tropical circulations.
- Quantitative differences mostly explained by differences in model resolutions.
  - ERA-I (CSFR) shows lowest (highest) resolution and low (high) bias in UT jet frequencies.

GLOBAL UT JET TRENDS

Manney, G. L. and M. I. Hegglin, *J. Clim. in press*

- MERRA-2 reveals complex longitudinal structure.
- Poleward shift of SH STJ frequencies across many longitudes.
- Apparent positive altitude shift in UT jets in NH.



Climatology of MERRA-2 UT jet frequencies in JJA (1980-2014).

Trends in MERRA-2 UT jet frequencies between last and first 10 years of climatology in JJA (last-first 10 years).

SEASONAL ST JET TRENDS SH

Manney, G. L. and M. I. Hegglin, et al., *J. Clim. in press*

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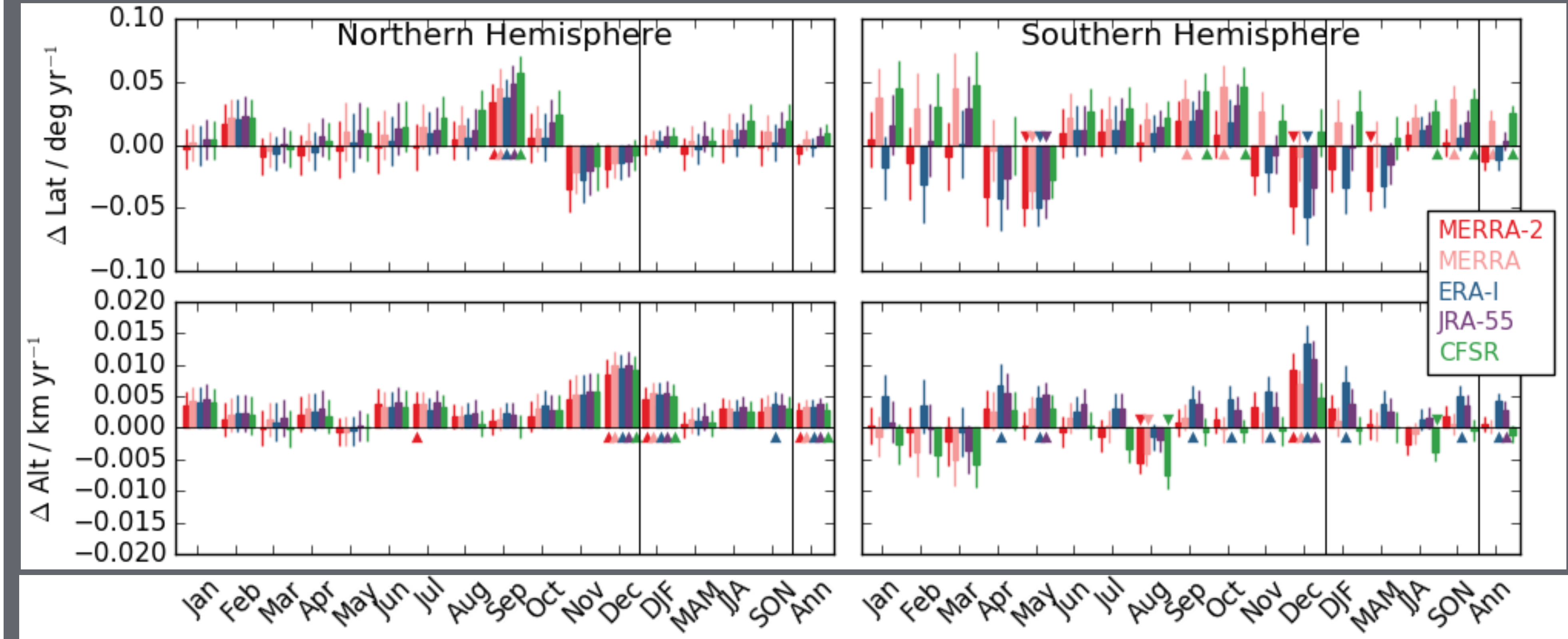
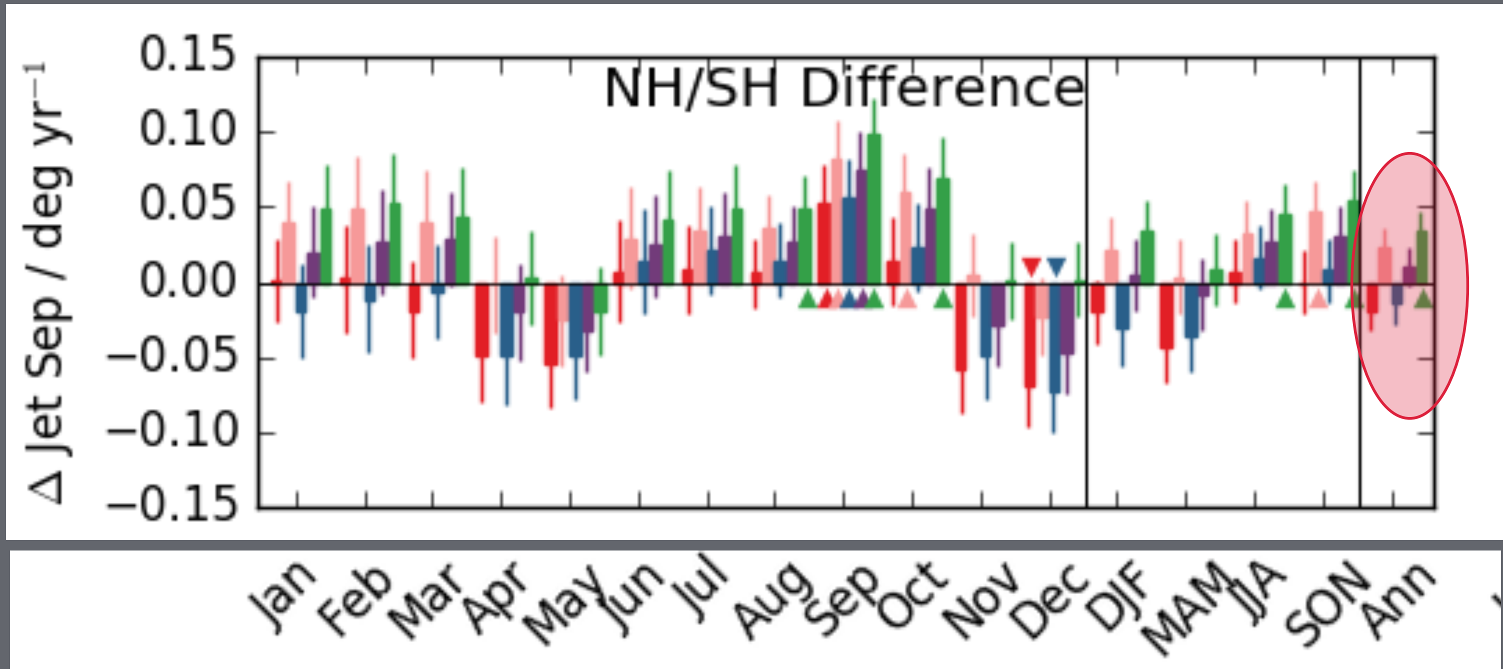
- Trends in STJ latitudes show strong seasonal variations, which are not robust across reanalyses, nor on an annual basis.
- Altitude shifts however are robust across the reanalyses through most of the year in NH, and also statistically significant on an annual mean basis.



TROPICAL WIDTH TRENDS

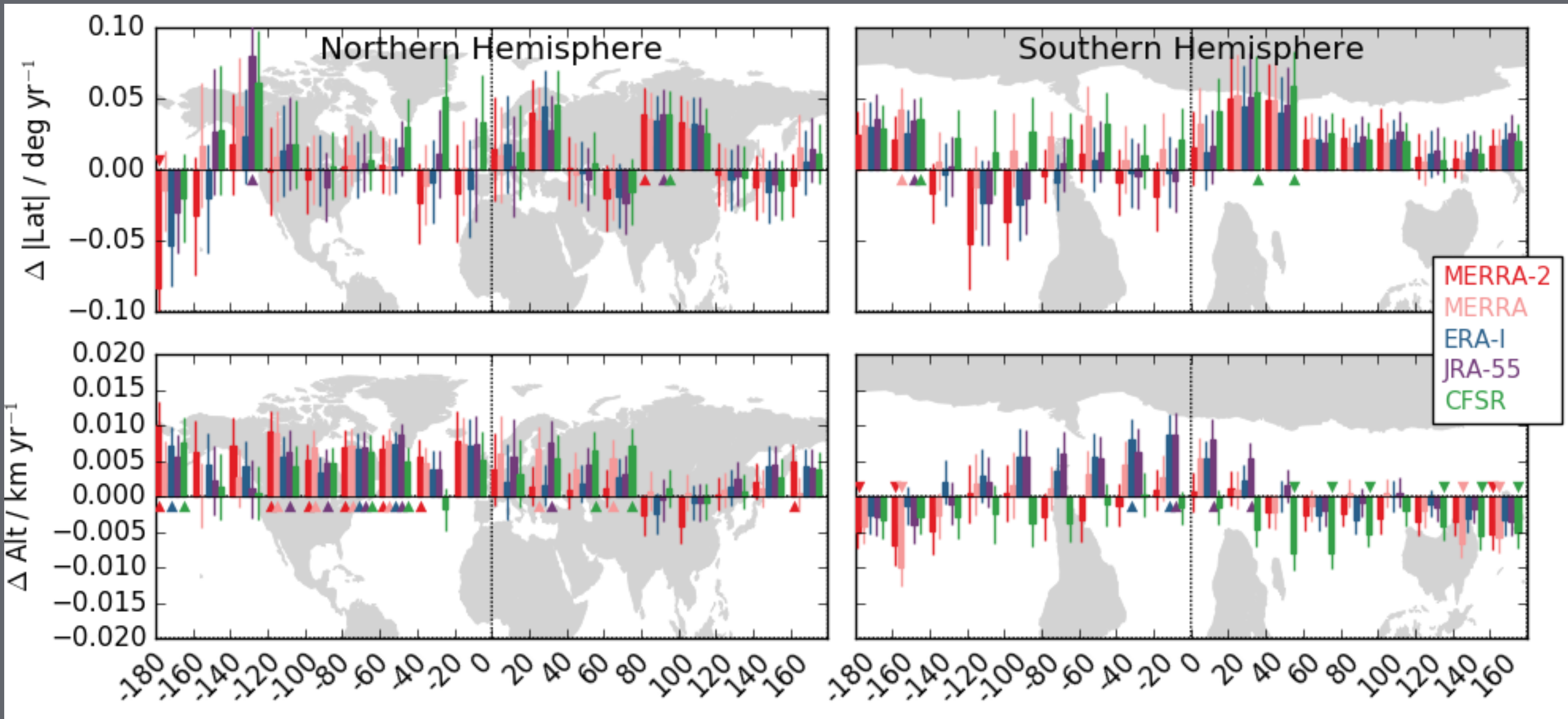
Manney, G. L. and M. I. Hegglin, *J. Clim. in press*



- No robust trend in tropical width across the different reanalyses on an annual basis.
- Seasonally, robust and statistically significant widening is seen in September and October only. A narrowing of the tropical width is found in December.
- Zonal averaging may, however, mask strong longitudinal signals!

LONGITUDINAL STJ TRENDS (JJA)

Manney, G. L. and M. I. Hegglin, *J. Clim. in press*

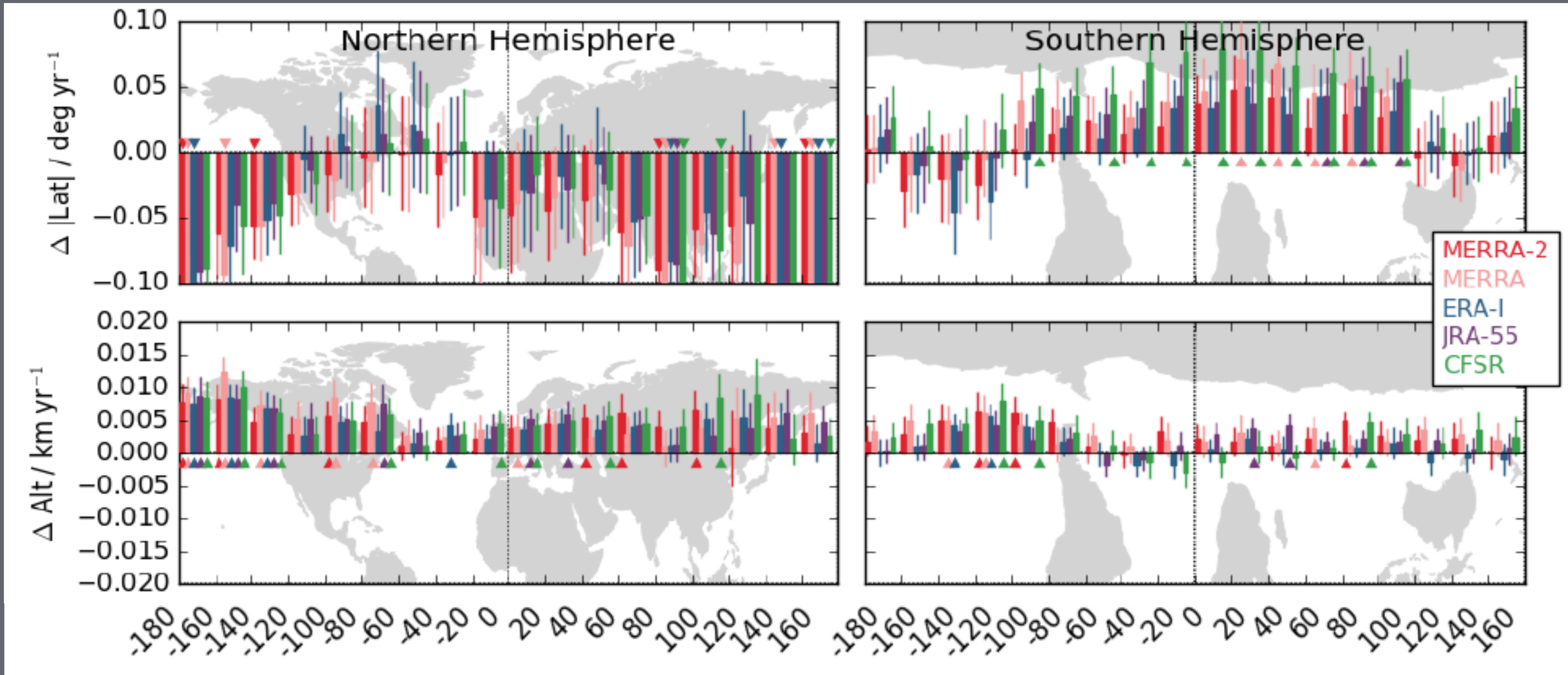


- Subtropical jet shows longitudinally strongly varying trends, especially in the NH.
- A clear poleward shift is found in the SH between 20E-160W.
- NH jet altitudes have increased.

LONGITUDINAL PJ TRENDS (DJF)

Manney, G. L. and M. I. Hegglin, *J. Clim. in press*

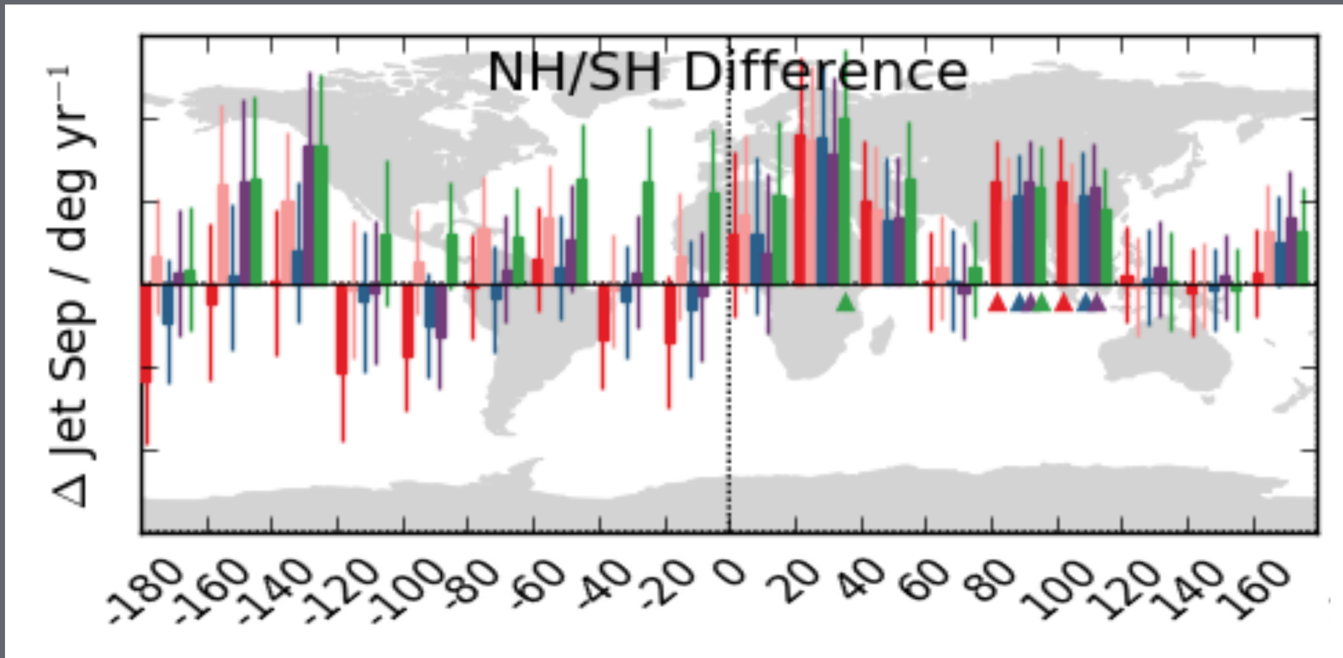
DJF



- Polar jet shows a clear equatorward shift in the NH DJF (and JJA, not shown).
- Not separating polar and subtropical jets properly will obscure/compensate jet trends!

LONGITUDINALLY RESOLVED TROPICAL WIDTH TRENDS (JJA)

Manney, G. L. and M. I. Hegglin, *J. Clim. in press*



- Changes in subtropical jet position yield a robust widening of the tropical width over Africa and South-East Asia in JJA.

INFLUENCE OF ENSO ON JET POSITION

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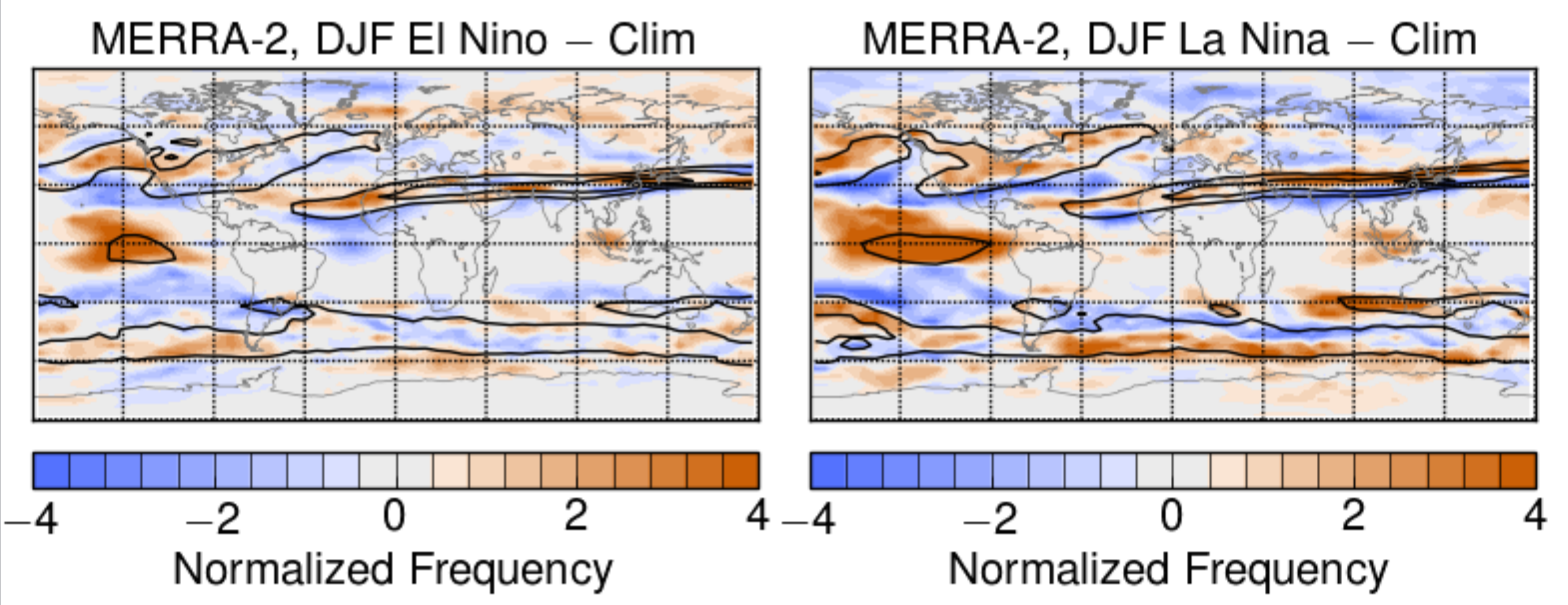
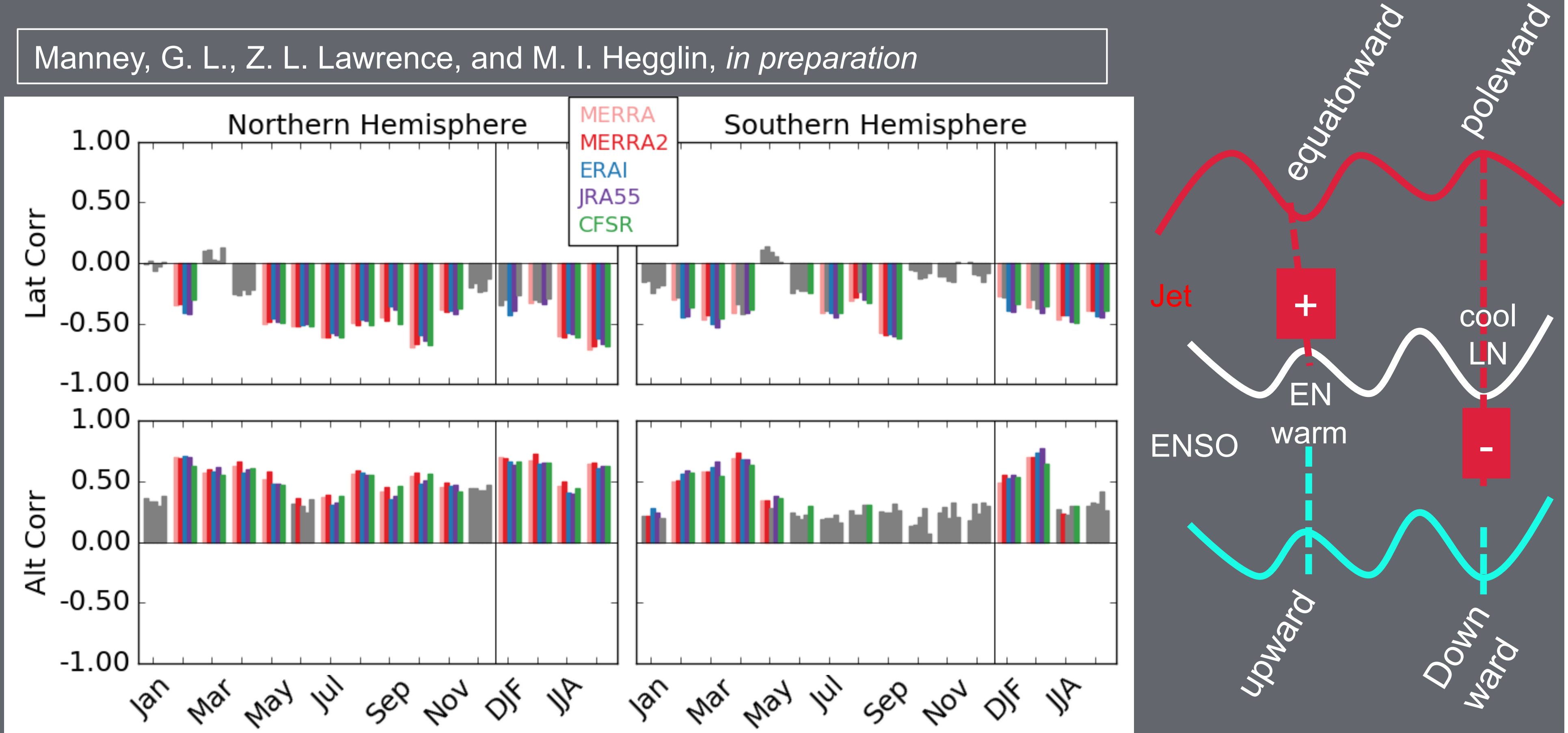
Manney, G. L., Z. L. Lawrence, and M. I. Hegglin, *in preparation*



- Periods with strong El Nino and strong La Nina show distinct differences in jet location and strength, consistent with previous literature.
- Some differences mimic those seen in the trends (e.g., poleward shift of the STJ over Africa, Asia, and the Western Pacific during La Niña)

SEASONAL
STJ / MEI CORRELATION

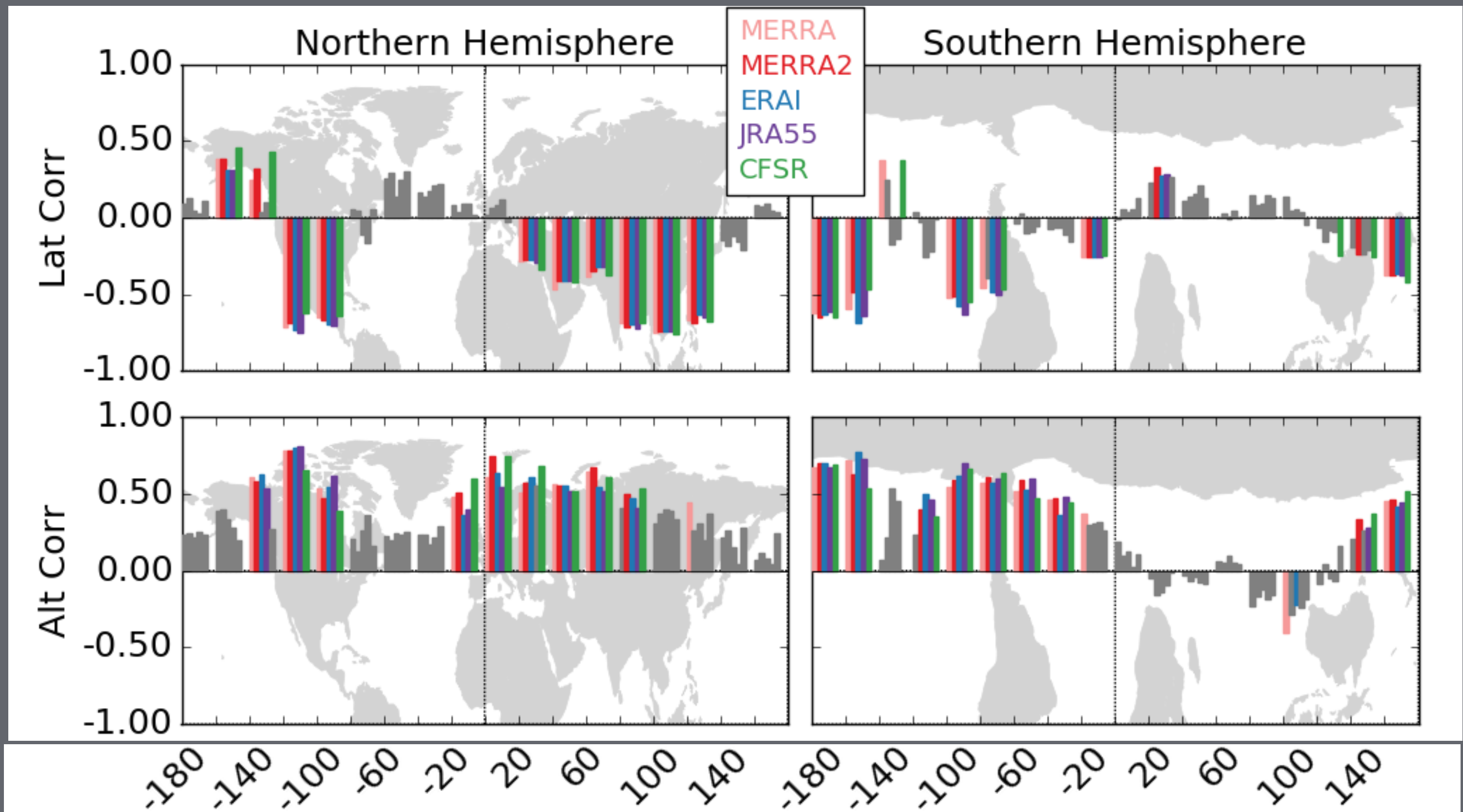
Manney, G. L., Z. L. Lawrence, and M. I. Hegglin, *in preparation*



- The NH STJ shifts equatorward & upward (poleward & downward) during EN (LN) in most seasons.
- The SH jets shift in the same direction, but changes are often weaker and less significant.

LONGITUDINAL STJ / MEI CORRELATION

Manney, G. L., Z. L. Lawrence, and M. I. Hegglin, *in preparation*



- Correlations are not uniform in longitude! A positive correlation is seen e.g. over the Eastern Pacific, the Atlantic, and South Africa.
- The signs of significant correlations nearly always agree for all reanalyses.

SUMMARY AND CONCLUSIONS

- We have presented a new analyses of long-term change in upper tropospheric (UT) jet latitude and altitude using five modern reanalyses.
  - Regional and seasonal variations have been analyzed using daily jet locations at each longitude.
  - Generally good agreement between different reanalyses (with some outliers in the SH).
- Jet shifts show strong regional and seasonal variations, resulting in changes that are not robust in zonal or annual means.
  - Robust changes in the subtropical jets indicate tropical widening over Africa (except during NH spring), and also tropical narrowing over the eastern Pacific in NH winter (not shown).
- The polar (or "eddy-driven") jets have shifted equatorward in the NH.
- A new study finds significant correlations of jet latitude, altitude, and windspeed with ENSO variations (*Manney Lawrence, Hegglin, in prep.)*