



South Eastern Australian Climate Initiative


Expansion of the Southern Hemisphere Tropics

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 **MURRAY-DARLING**
BASIN AUTHORITY

Introduction



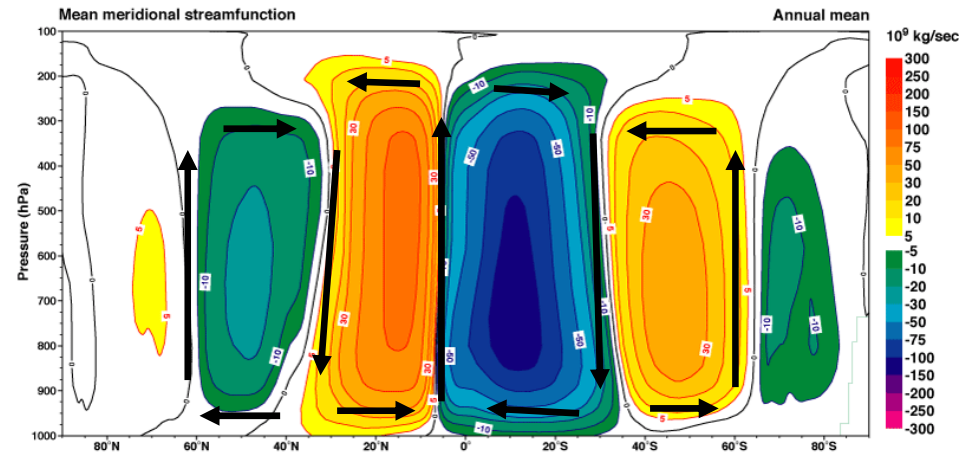
- Improve understanding of nature and causes of climate variability and change in SE Australia (SEA)
- Our project examines the dynamics of rainfall decline in SEA (and other subtropical regions)
- Relate observed changes in mean meridional circulation (MMC) to this decline
 - Comprehensive review paper

What is the MMC?



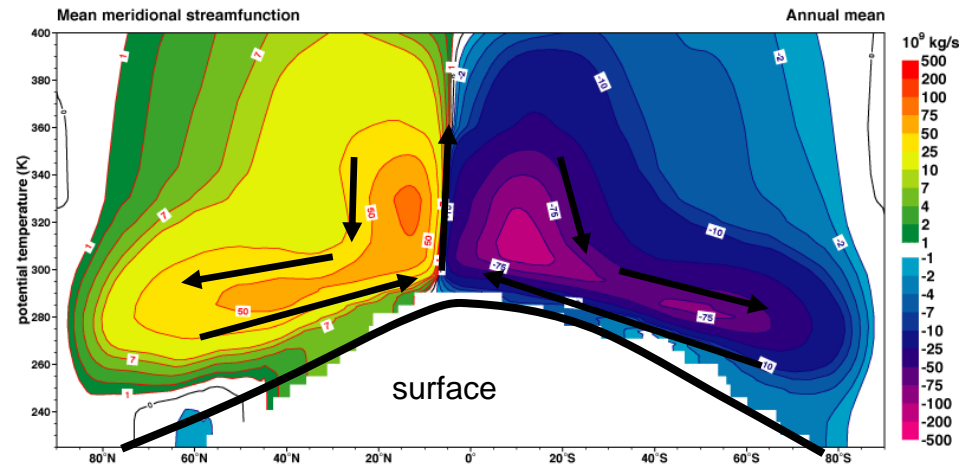
- **Isobaric view**

- ‘Three-cell’ model
- Hadley Cell
- Ferrel, Polar cells



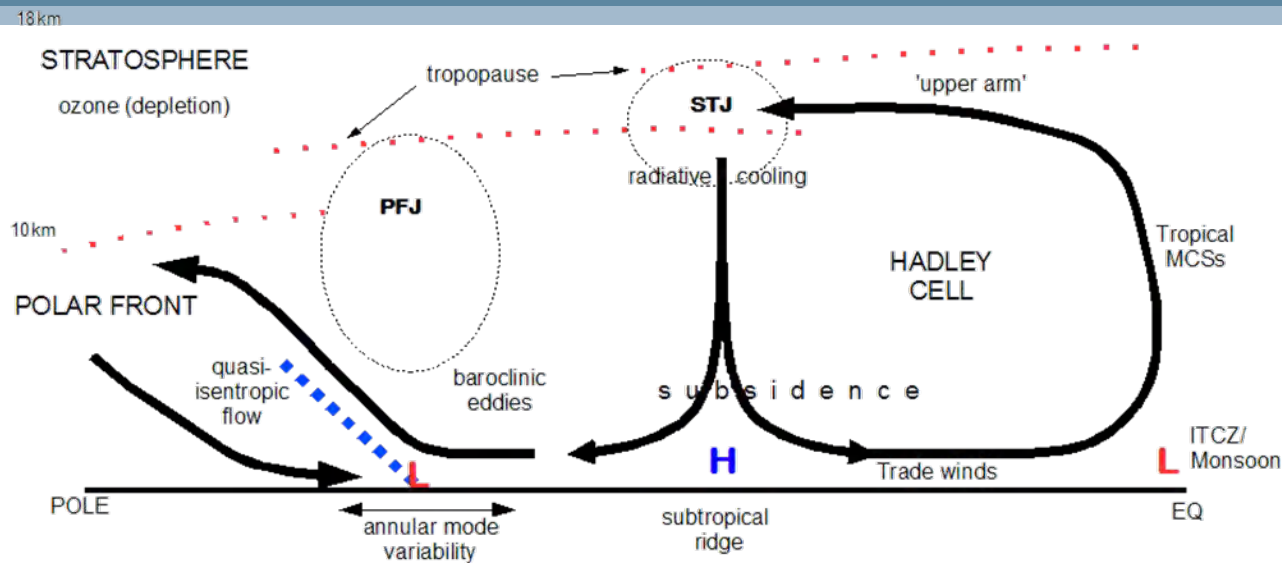
- **Isentropic view**

- Coordinate system tilted in ET
- Single hemispheric circulation
- Extratropics stronger



images: ERA-40 Atlas

Idealized Model of MMC



- Main features : Hadley Circulation and Polar Front
 - Annular mode is variability of polar front
- Subtropics are region of mixing between the two
 - Tropical/extratropical interaction; Baroclinic waves important
- Spatial variability driven by continents, SST, mountains
- MMC not a ‘top-down’ driver; rather represents the cumulative effects of smaller scale processes

Observed Changes to the MMC



- Both the tropical and extratropical portions of the MMC are changing
 - Annular mode increase = mean poleward shift in storm track position
 - Expansion of tropics or a widening of the Hadley Cell
- Idealized model suggests these are related, but exact mechanisms are unclear
 - Baroclinic eddies clearly important
 - Important for subtropics (like SEA)!

Widening of the Tropics



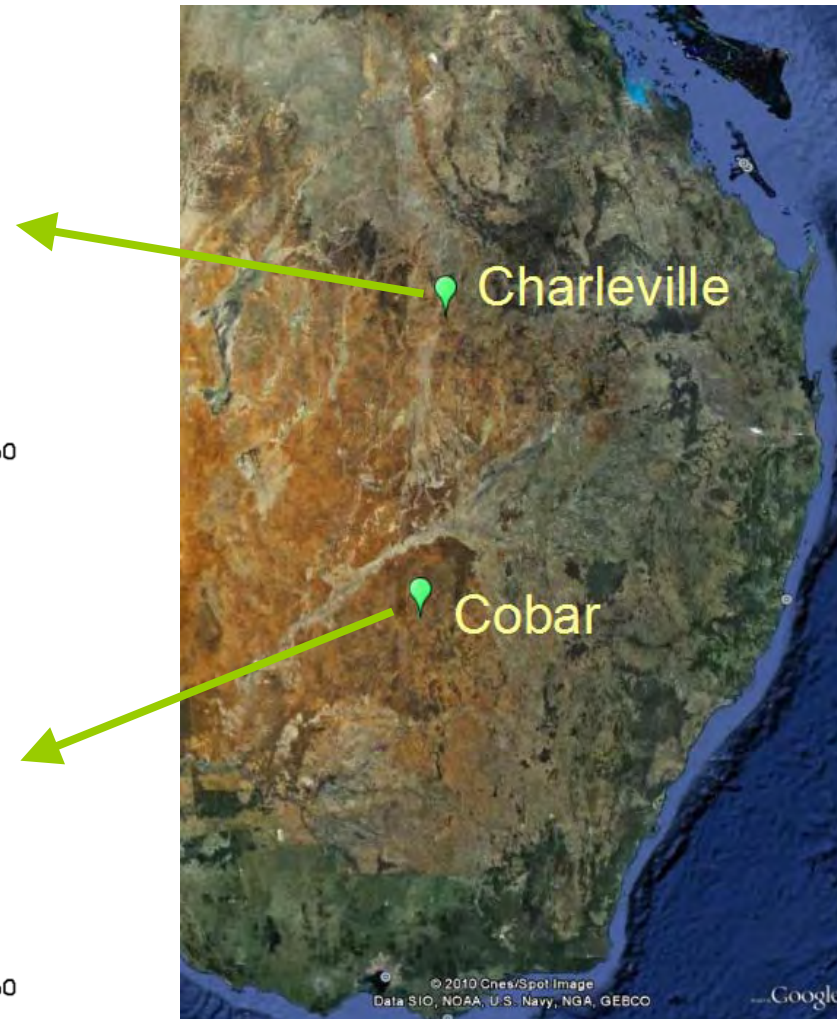
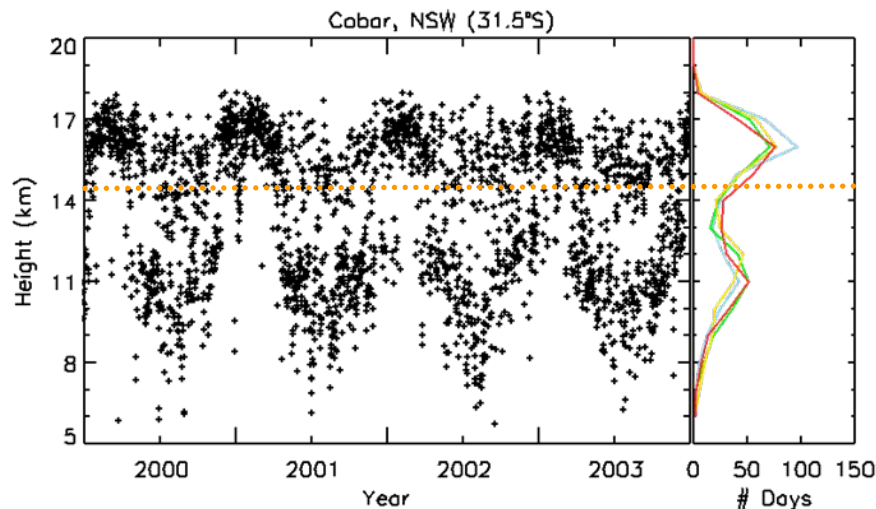
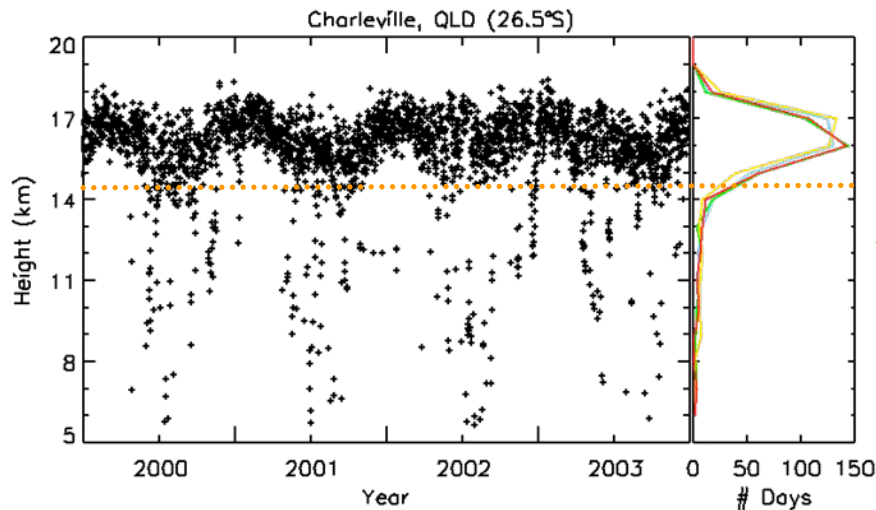
- Variety of studies have identified a global expansion of the tropics in multiple data sources
 - Ozone (Hudson 2006)
 - Satellite temperature trends and OLR (Fu et al. 2006; Hu and Fu 2007)
 - **Reanalysis**: jet streams trends (Archer and Calceira 2008), streamfunction trends (Hu and Fu 2007), tropopause height frequency (Seidel and Randel 2007; Birner 2010)
- More widening in SH
- Typically, SH trends of 0.5 to 1.0 degrees per decade since 1979, some higher

Analysis of Tropical Expansion



- Examine SH widening of tropics **directly from radiosonde data** using a regional perspective
- Data from Integrated Global Radiosonde Archive
 - Australia/ New Zealand – high data quality
 - South America – marginal data quality
- Time period: 1989 – 2009
- Use data to accumulate tropopause statistics
 - height, pressure, temperature
 - WMO ‘lapse rate’ definition
- Annual tropopause height frequency

The Edge of the Tropics

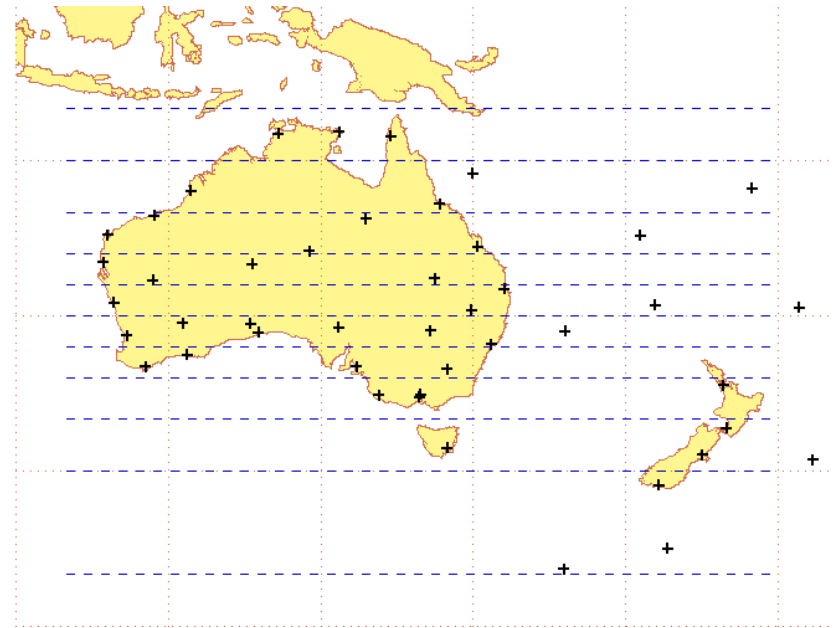


each dot is one observation of the tropopause, bin size = 1 km, centred

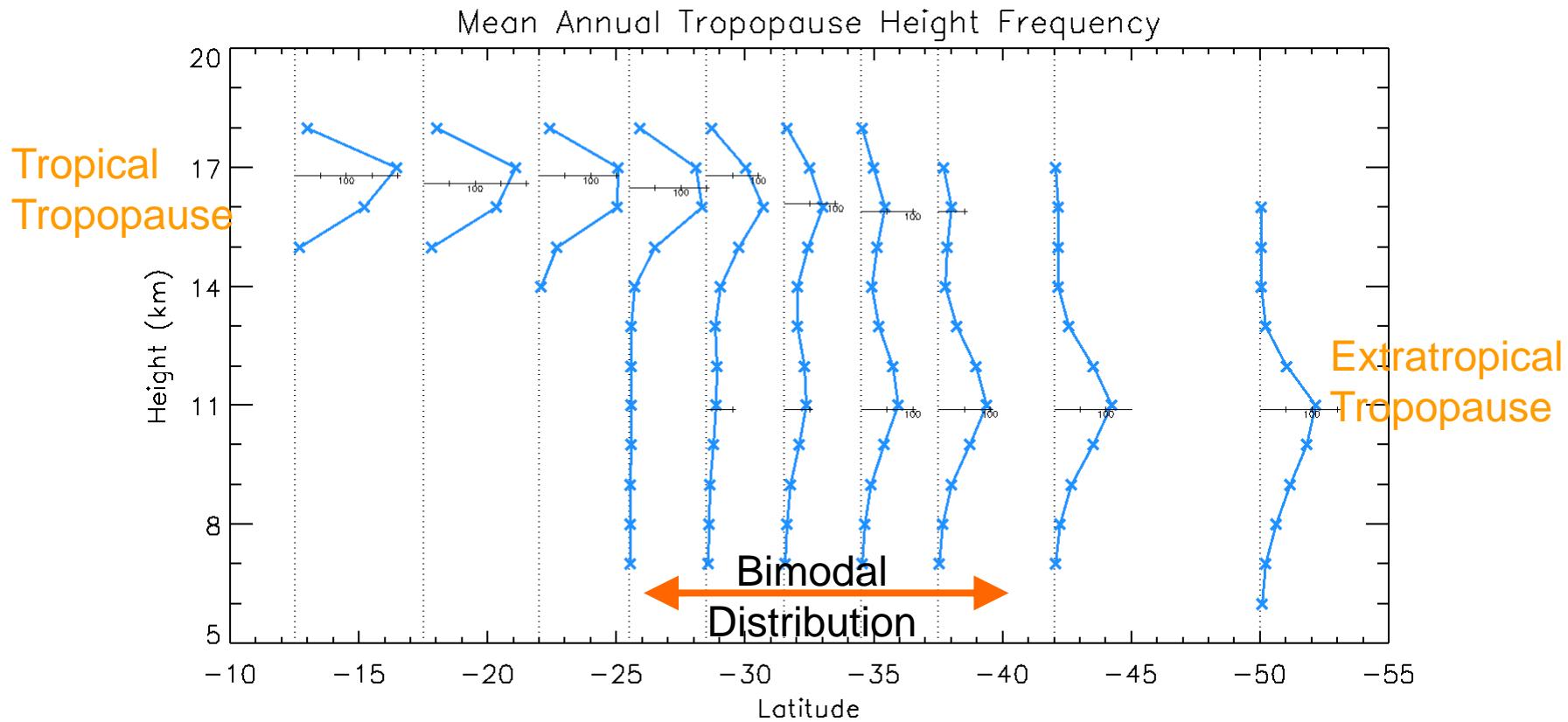
Analysis Method



- Calculate time series of number of days with 'tropical' tropopause at each station
- Average into zonal bands, generally 3-5 degrees. Nine bands in ANZ
- Contour number of days per year in latitude/time
- Slope of contours indicates trends



Mean Tropopause Height Frequency

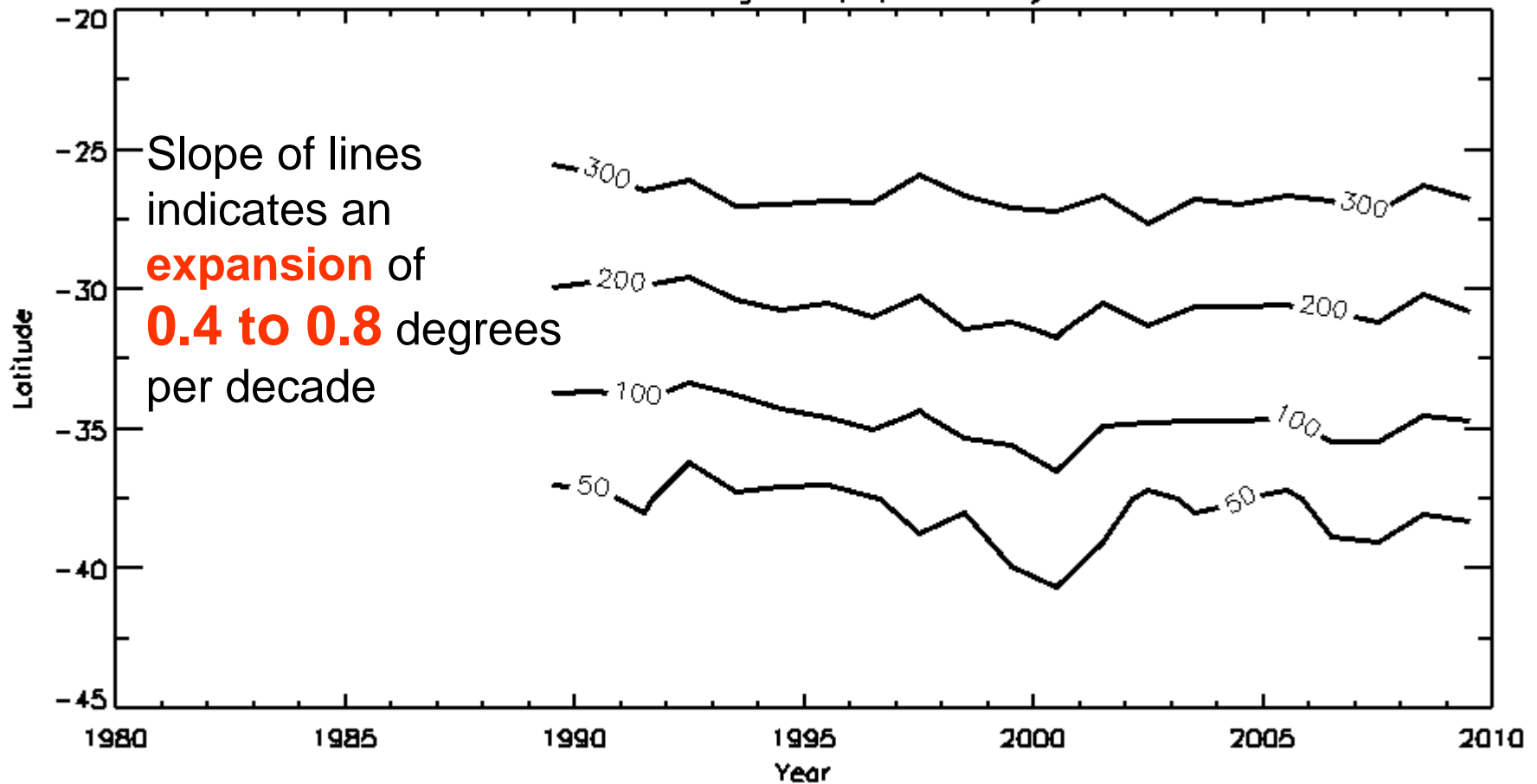


ANZ

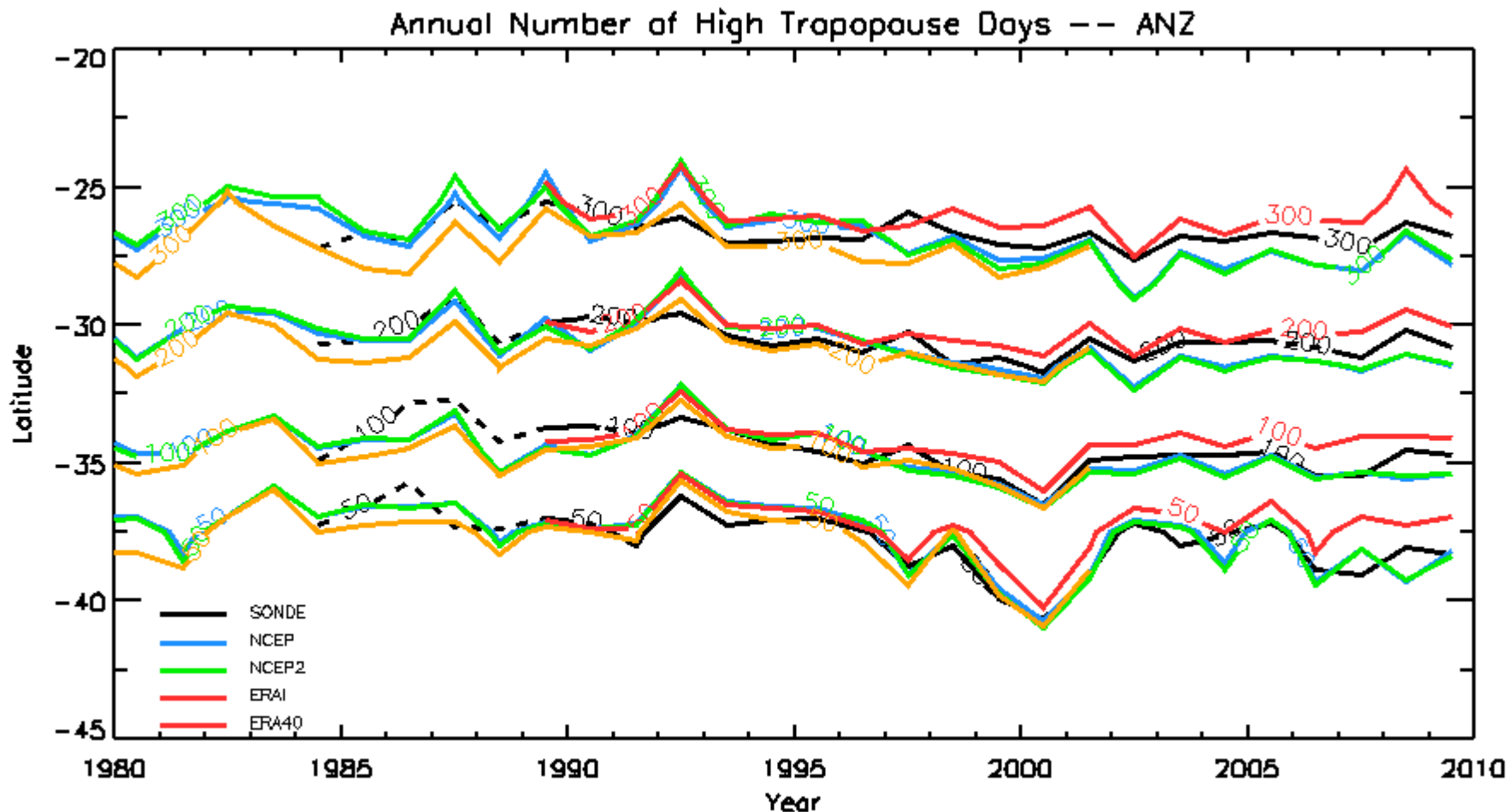
Temporal Variability



Annual Number of High Tropopause Days -- ANZ



Comparison with Reanalyses

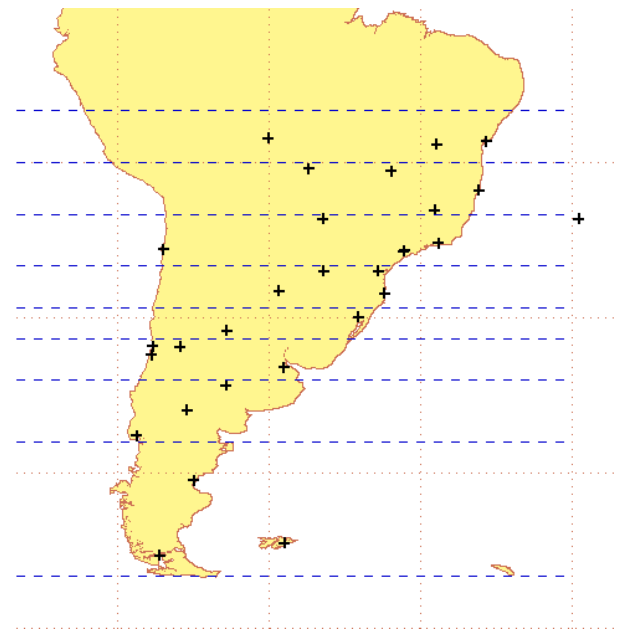


Reanalysis data averaged over same bands and longitudes

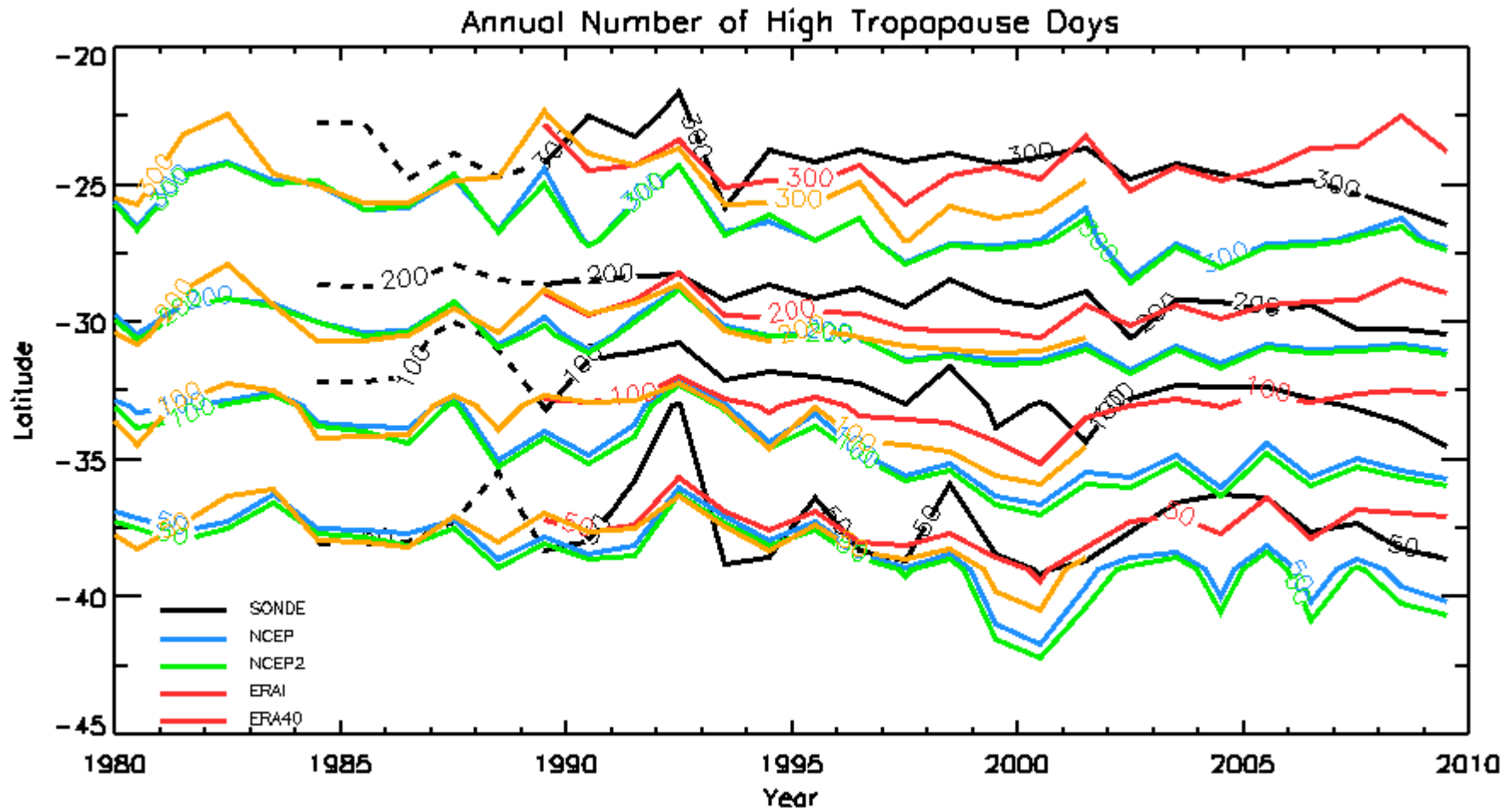
South America



- Similar to ANZ analysis
- Data poorer quality, fewer stations, more missing data
- 8 zonal bands, 3-6 degrees



SA Results and Comparison



sonde results noisy, uncertain...but reanalyses are too...

Suggested expansion greater

Discussion/Conclusions



- Presentation of alternative model of MMC
 - unified hemispheric flow.
 - Subtropics defined by tropical-extratropical interaction
- Regional analysis of tropical expansion from sonde data
 - Total amounts of expansion generally consistent with reported studies
 - Regional differences in expansion, but uncertain
 - Large and different interannual variability
- Understanding regional differences demonstrated in these results could provide useful insights into future climate change, especially on a regional scale.
 - smaller scale processes matter for the larger flow
 - What is role of baroclinic eddies?