Tropical expansion as seen in historical radiosonde data

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The Centre for Australian Weather and Climate Research
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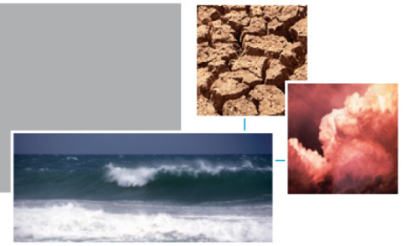
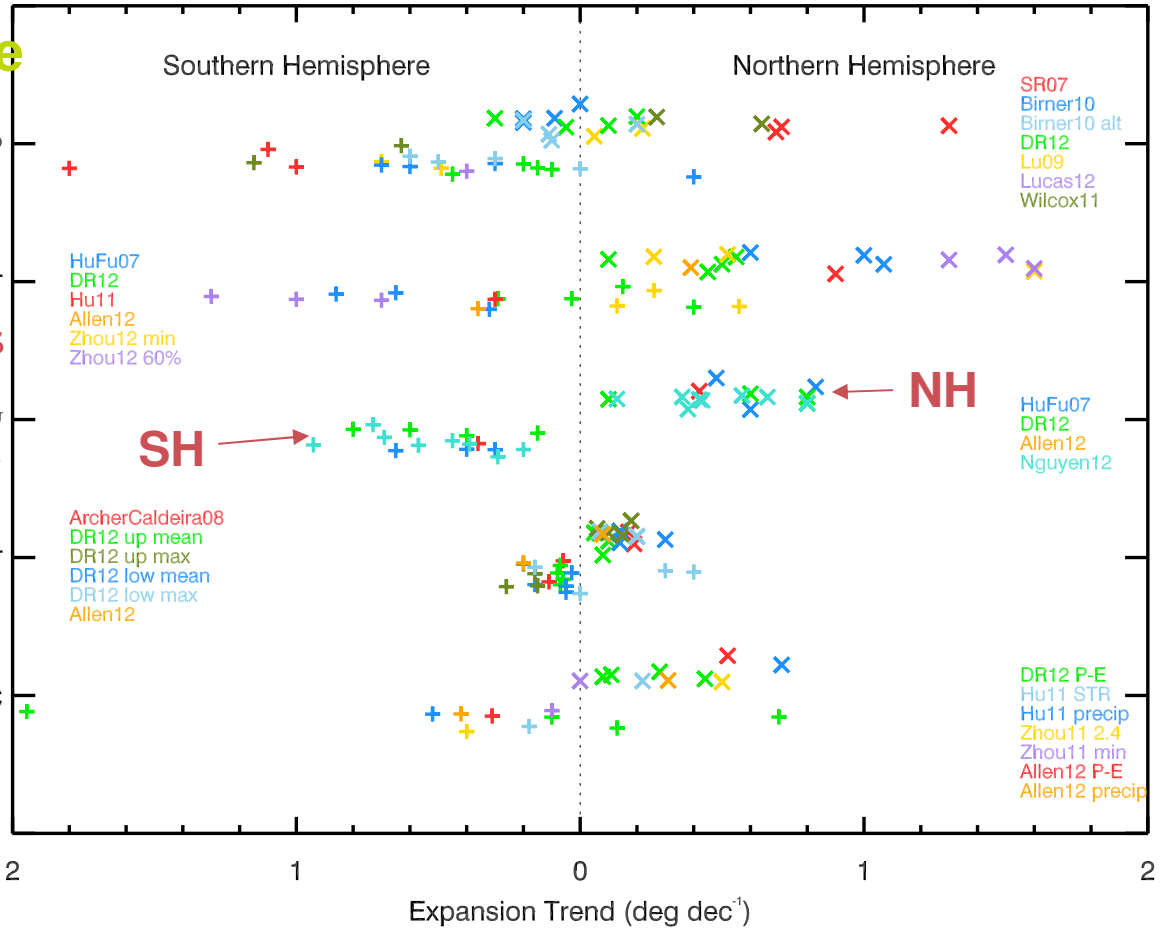
State Government Victoria

Observational studies of tropical expansion



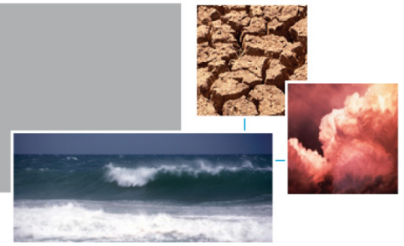
Methodology or Data Source

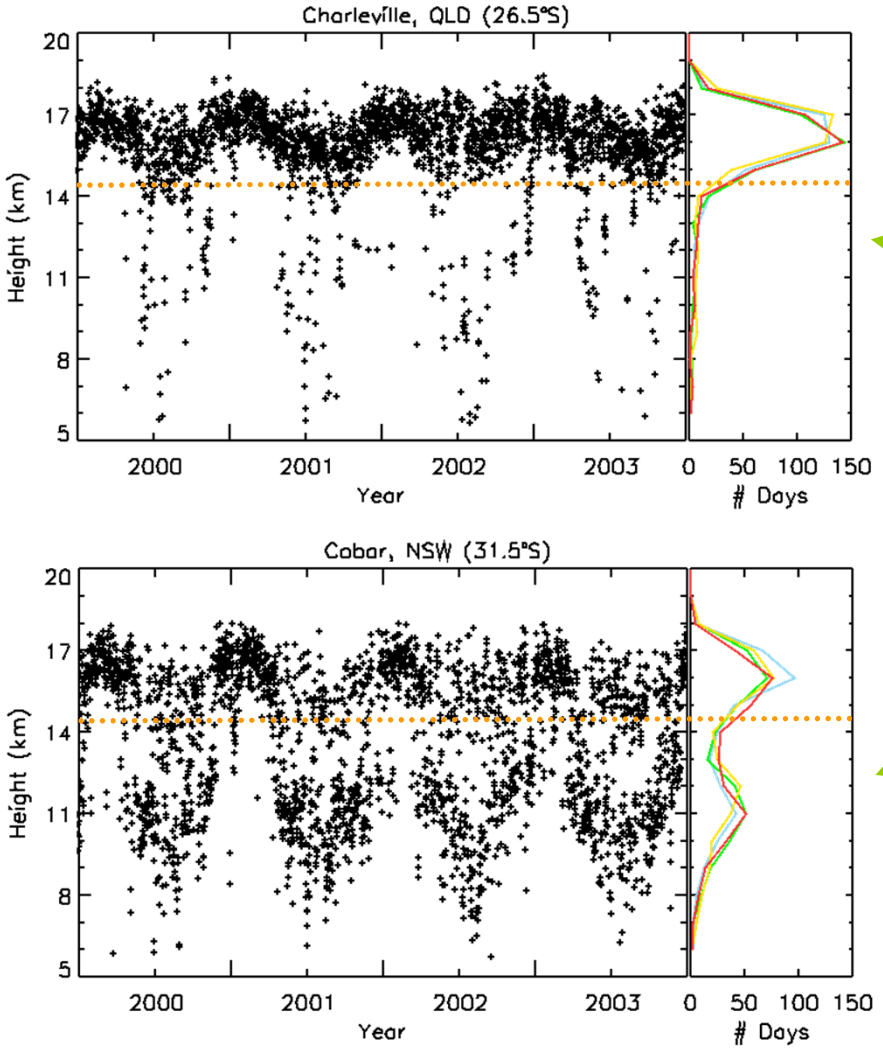
- General consensus on tropical expansion since 1979
- Wide range of estimates
  - More scatter in satellite, less in jet
- Different hemispheric asymmetry
  - Is expansion equal, or does one hemisphere expand more than the other? Which one expands more?
- Consequence of different physics or other data/reanalysis issues?

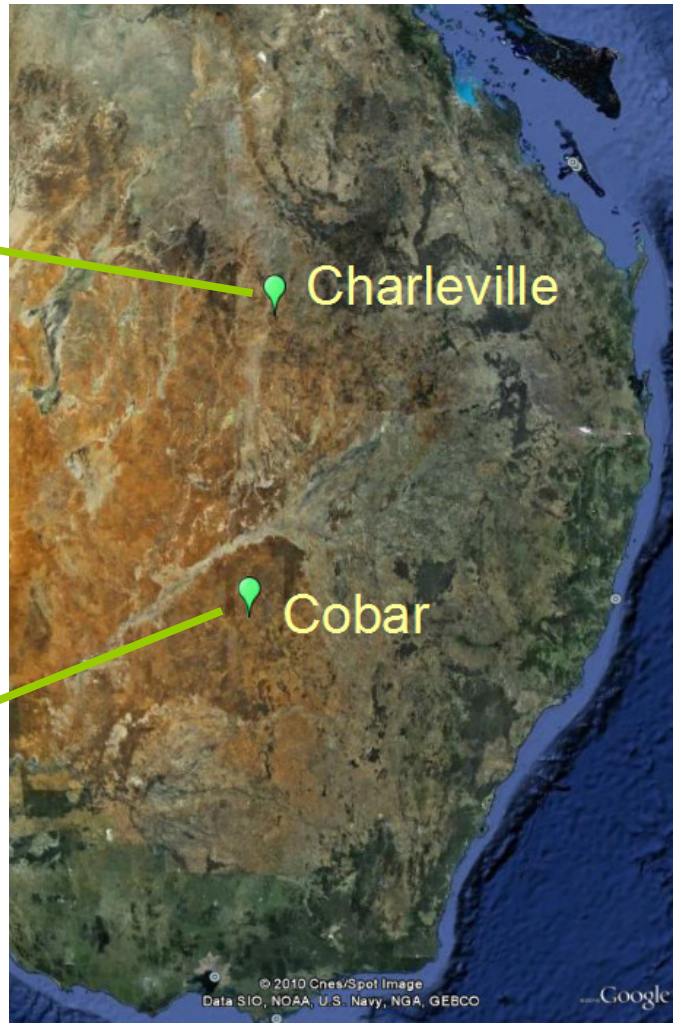


Trends units are degrees latitude per decade

The Edge of the Tropics

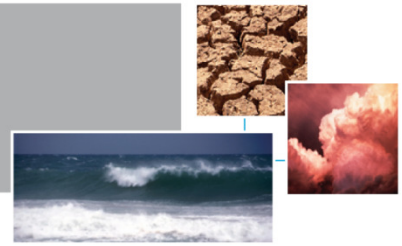






each dot is one observation of the tropopause, bin size = 1 km, centred

Data and methodology



Focus here is on using real observations (not reanalyses) to examine tropical expansion

- Basis for evaluation of reanalyses

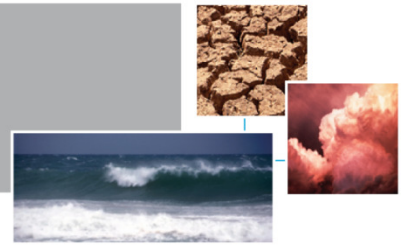
Data used: Integrated Global Radiosonde Archive (IGRA) from NOAA

- Comprehensive global coverage, freely available from web

Methodology thoroughly described in Lucas et al (2012, JGR)

- Use all available data
- Create time/latitude array of tropical tropopause days (TTD) in 'bands'
- 'First difference' compositing technique
- Sampling bias corrections, error estimation
- Contour time/latitude array to estimate trends, use TTD=300,200,100 and 50

Summary of Lucas et al (2012)



Analysis of SH expansion

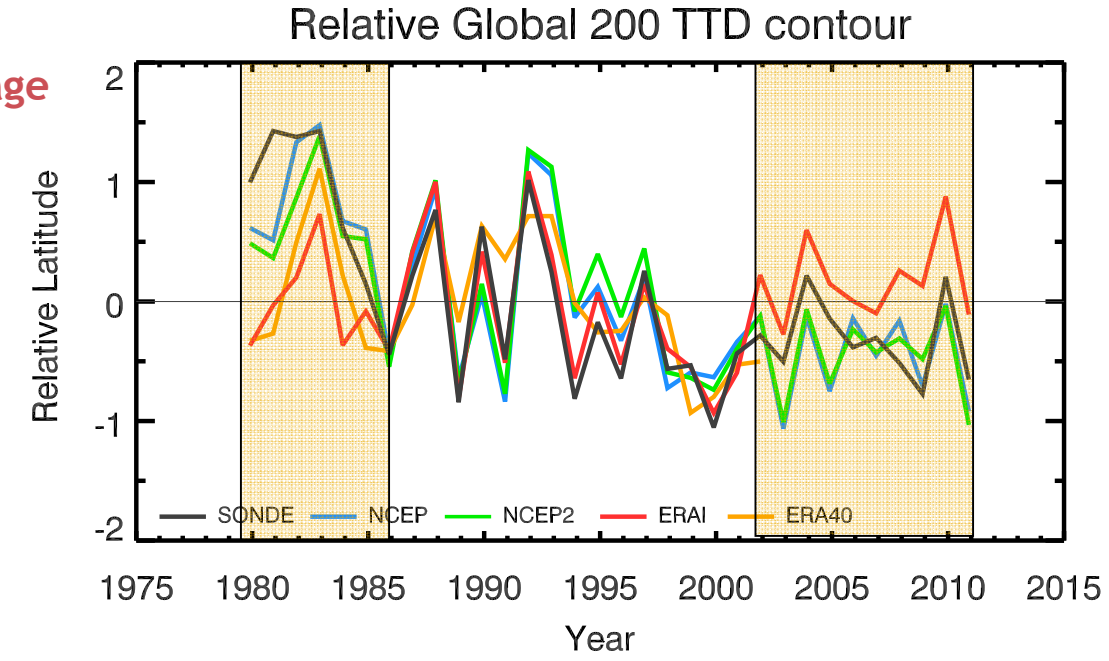
- 3 regions (ANZ, AFR, SA) + average
- Focus on TTD=200 contour

Comparison with four reanalyses

- NCEP, NCEP2, ERA-40, ERA-I
- Same methodology applied
- Reanalysis contours shifted polewards

Trends (SH only)

- sondes: 0.4 deg dec^{-1} (expansion)
- NCEP, NCEP2: 0.3 - 0.5 deg dec^{-1}
- ERA-I: no trend

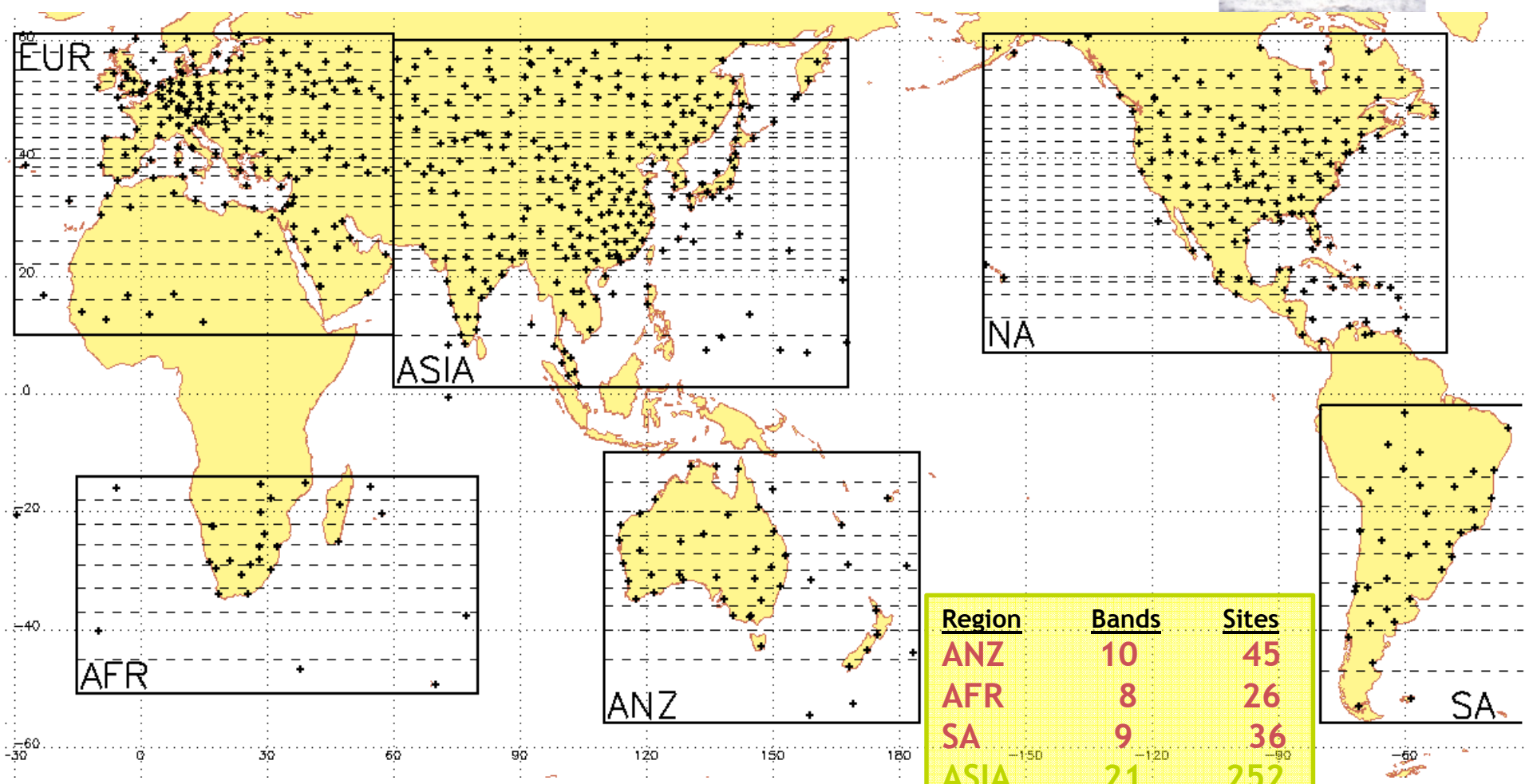


Two periods of notable difference

- post-2002 -- better satellite observations improving ERA-I, creates inhomogeneity
- pre-1985 - ??

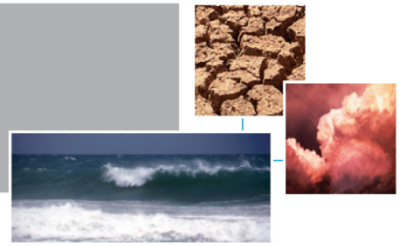
Repeat this methodology for the NH, compare with SH results

Study regions illustrated



Region	Bands	Sites
ANZ	10	45
AFR	8	26
SA	9	36
ASIA	21	252
EUR	19	178
NA	20	136

TTD contours from ASIA

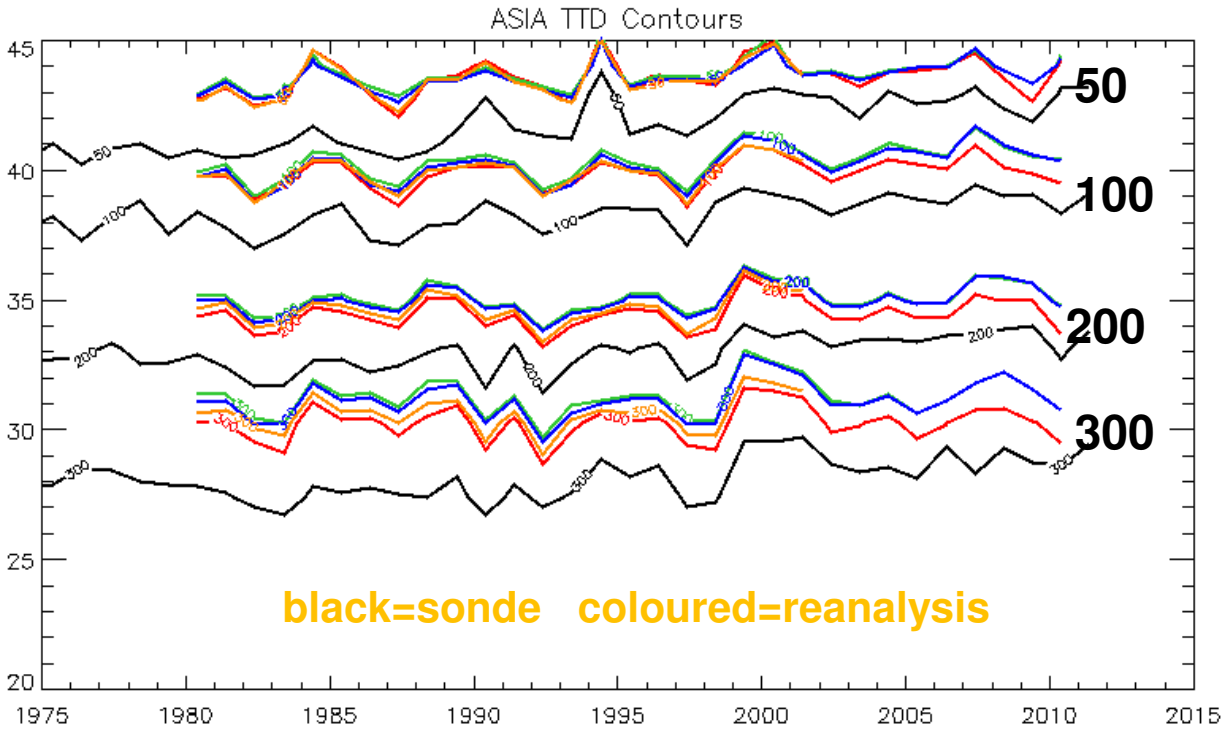


Good match for interannual variability

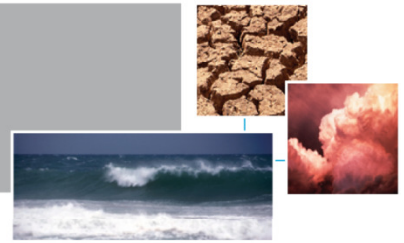
General shift poleward of reanalysis contours

- 1.5-3.0 degrees here
- Less in NA, EUR

Improvement in ERA-I shift (red lines) at end of period



NH TTD contours by region



Structure of 'subtropics' different in the regions of the NH

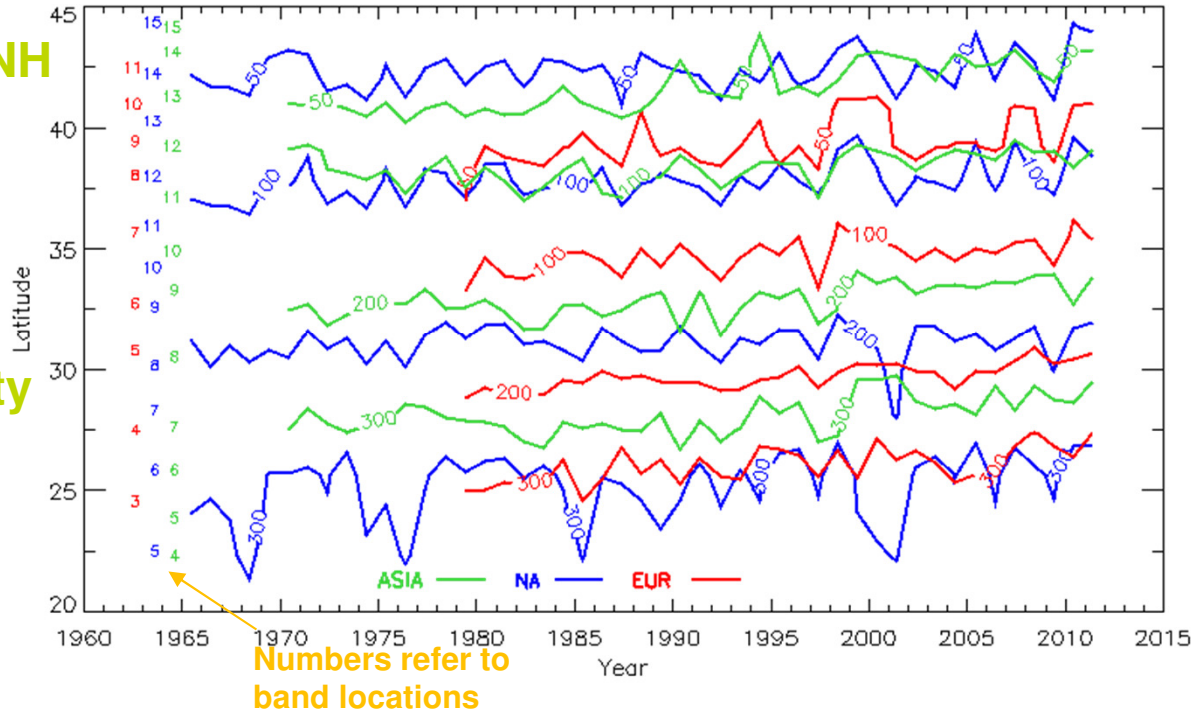
- Less poleward extent in EUR
- 300,200 contours shifted poleward in ASIA
- Thickest in NA

Significantly different variability in NA

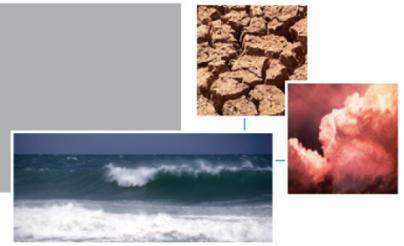
- 'Dips' on 300 contour
- Responses around 2000
- Volcanic response?

Trends (since 1979)

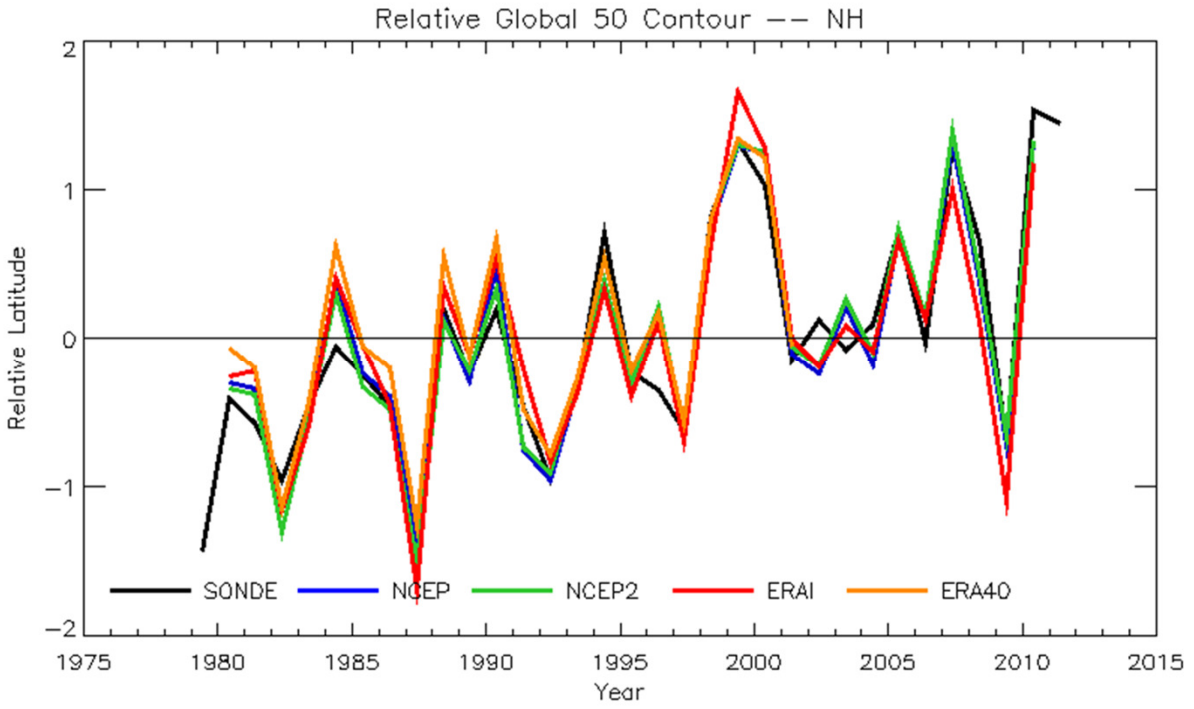
- Largest in ASIA (0.5 - 0.8)
- Insignificant in NA (0-0.3)
- Moderate in EUR (0.4-0.5)



NH ‘global’ summary

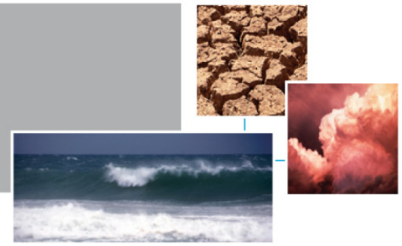


- **Weighted average TTD=200 contour across all regions**
  - Removing mean position accounts for shift
  - Volcanic response more visible in this view
- **Generally good agreement prior to 2002**
  - 1987-88?
- **Significant differences occu after 2002, just as for SH**
  - Suggests inhomogeneity in reanalysis fields
  - Hypothesis: related to significant improvement in satellite instrumentation (AIRS)



BUT…
There appears to be little sign of this poleward of 35 N…data match up very well there

NH/SH 'global' comparison

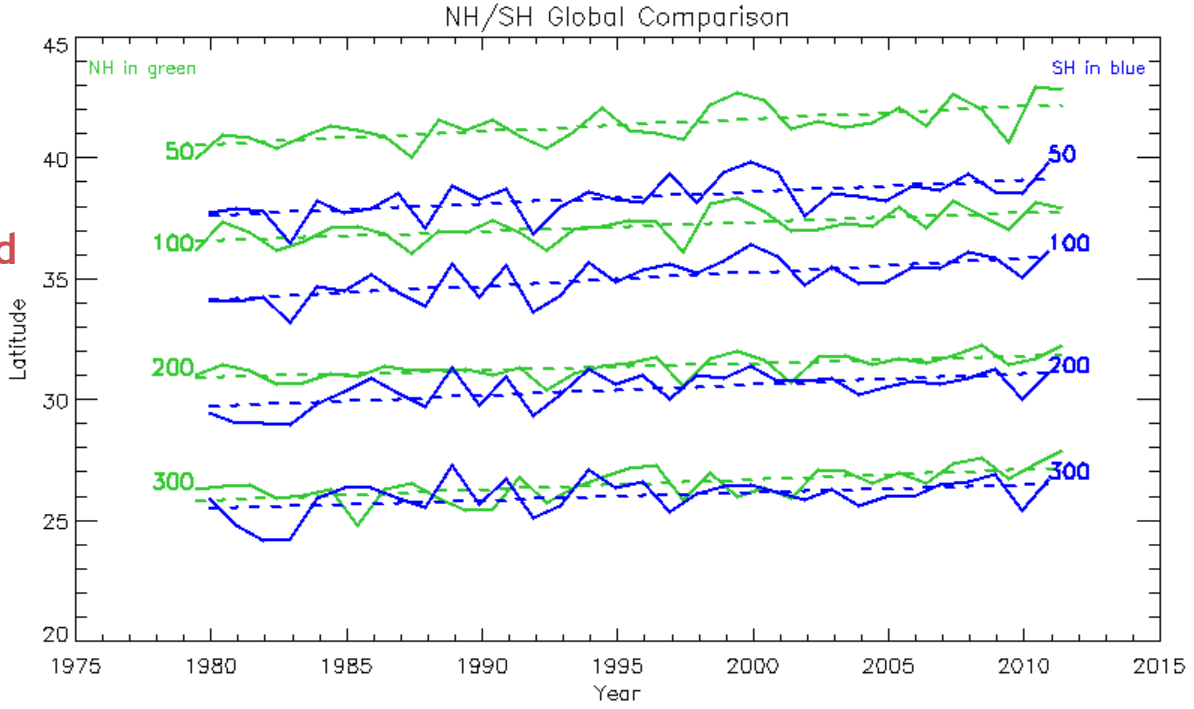


Subtropics in NH are larger compared to SH

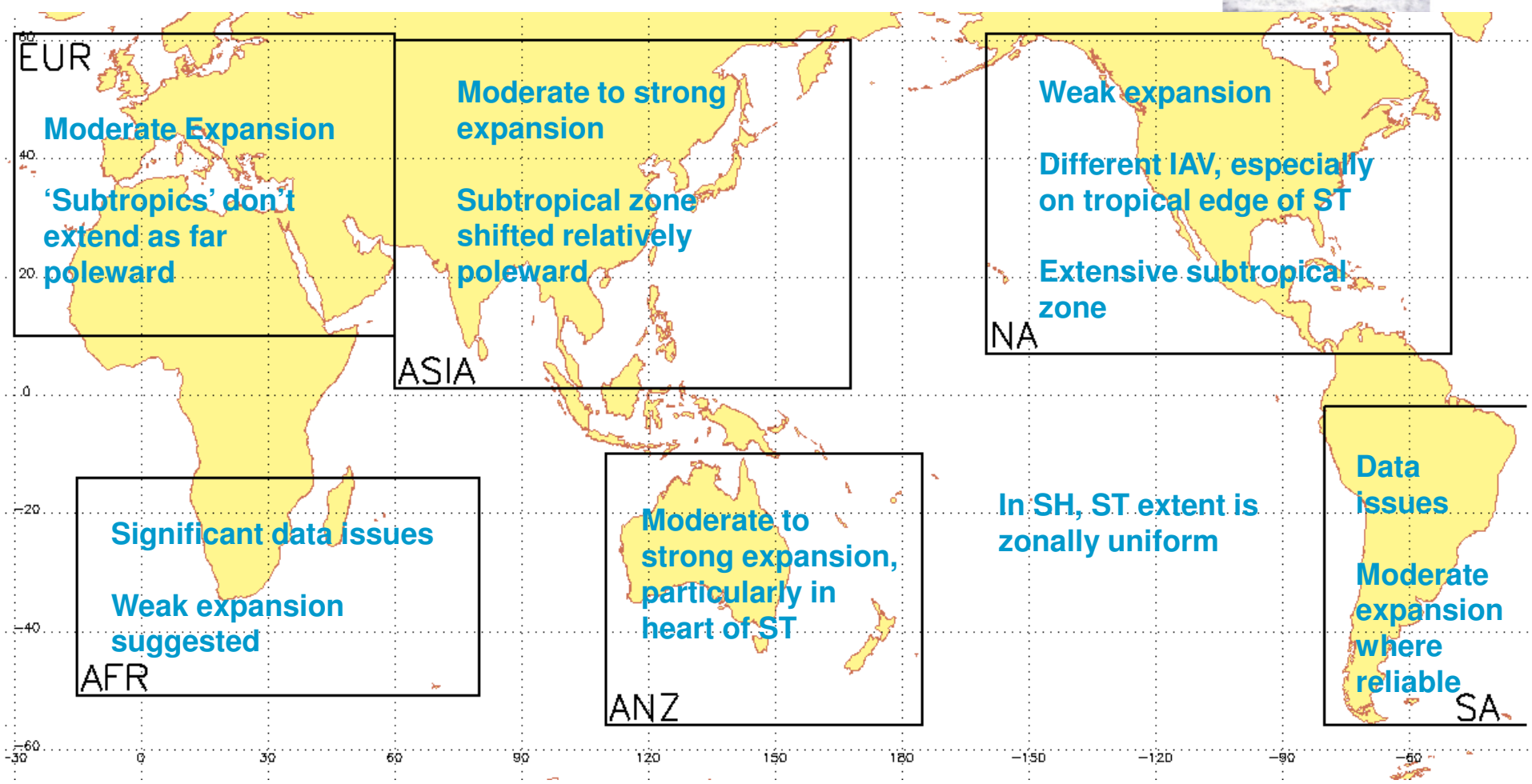
- Start in same place, but extend further poleward
- Likely related to greater land are in NH
- Analogous to finding with other variables (e.g. Ψ)

Is tropical expansion asymmetric?

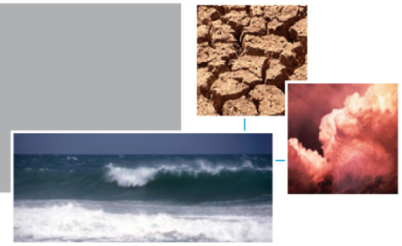
- Trends in SH on 300,100, 50 less reliable (data issues)
- SH trends are larger on 200,100 contours, but not statistically significantly so (about 1-σ difference)



Regional summary



Remarks



- **Historical radiosonde data suggests that, on average, tropical expansion is occurring in both hemispheres at a more-or-less equal rate**
  - Some hints of greater SH expansion, but not statistically significant
- **Strong regional responses are indicated, particularly in the NH**
  - Applies to both rate of expansion and interannual variability
  - Greater land area (and mountains) undoubtedly important
  - What about teleconnection patterns like PNA, NAM/NAO?
- **What about ENSO?**
  - Some evidence of regional signature in SH study
- **What are drivers/climate forcings behind expansion?**
  - In SH, ozone depletion and GHG about equally responsible (plus natural combined with choice of start time…)
  - In NH? Tropospheric ozone/ aerosol forcing? Sea ice loss a possibility??

Thank you.

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State Government Victoria