Understanding Upper-Air Climate Change:

Part I. Changes in the Vertical Temperature Profile

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Goals

Advance understanding of changes in the vertical temperature profile by:

- Improving data quality through attention to temporal homogeneity
- Extracting useful climate-scale information from radiosonde records
- Building on ARL's historical leadership in using radiosonde data

Why?

1. Controversy about tropospheric temperature trends and their relation to those at the surface.

2. Stratospheric temperature changes affect the ozone layer, and possibly surface climate.

3. Changes in profile can be used for detection/attribution.

Approaches

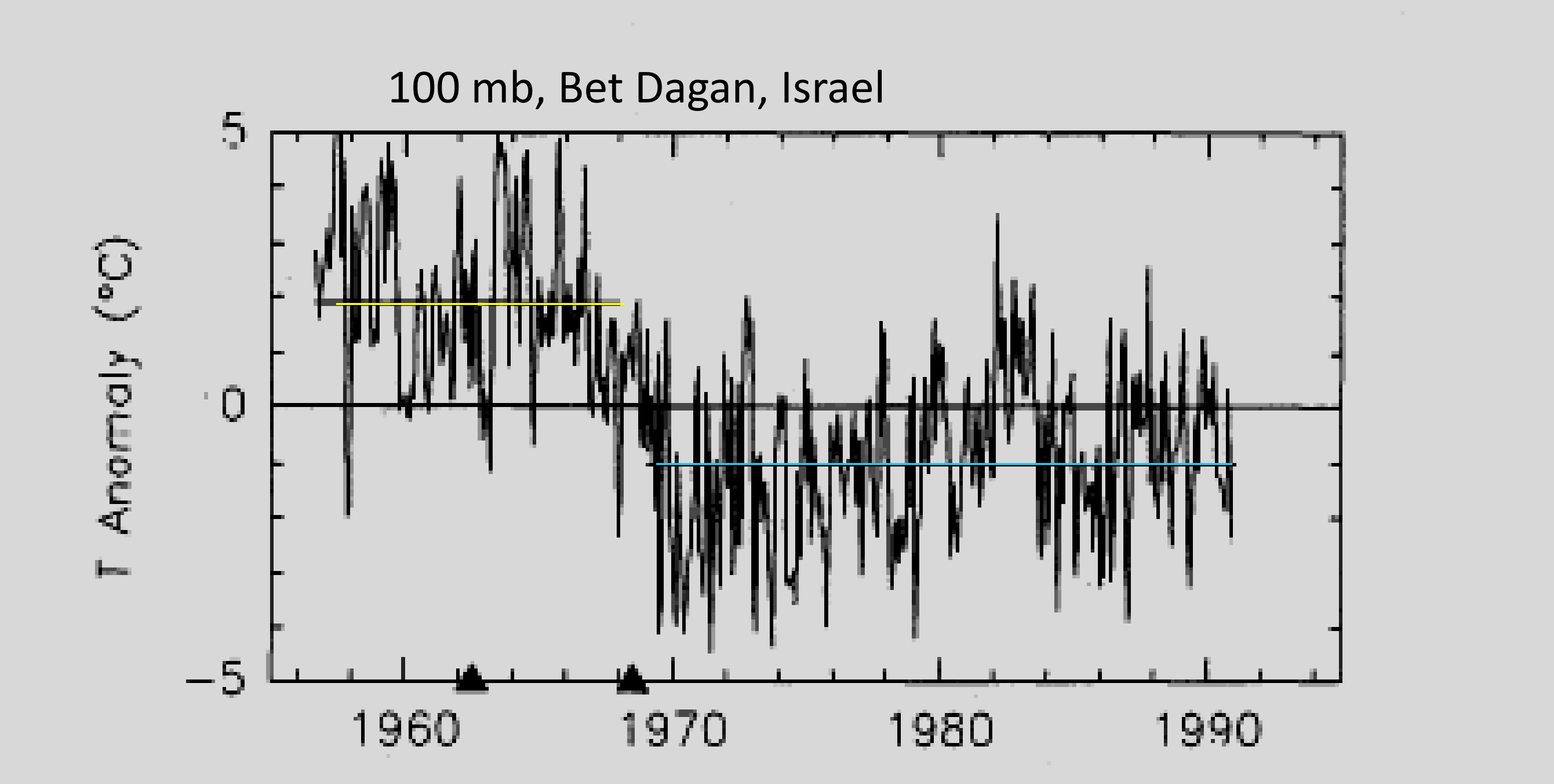
1. Creating climate data records using radiosondes

2. Studying climate effects of volcanic eruptions

3. Investigating effects of ENSO on stratospheric temperatures

1. Creating climate data records using radiosondes

Example of the problem:



From Gaffen, JGR (1994)

Effect of instrument change—Metox to VIZ

RATPAC = Radiosonde Atmospheric Temperature Products for Assessing Climate

NOAA Team:

ARL: Melissa Free, Dian Seidel

GFDL: John Lanzante

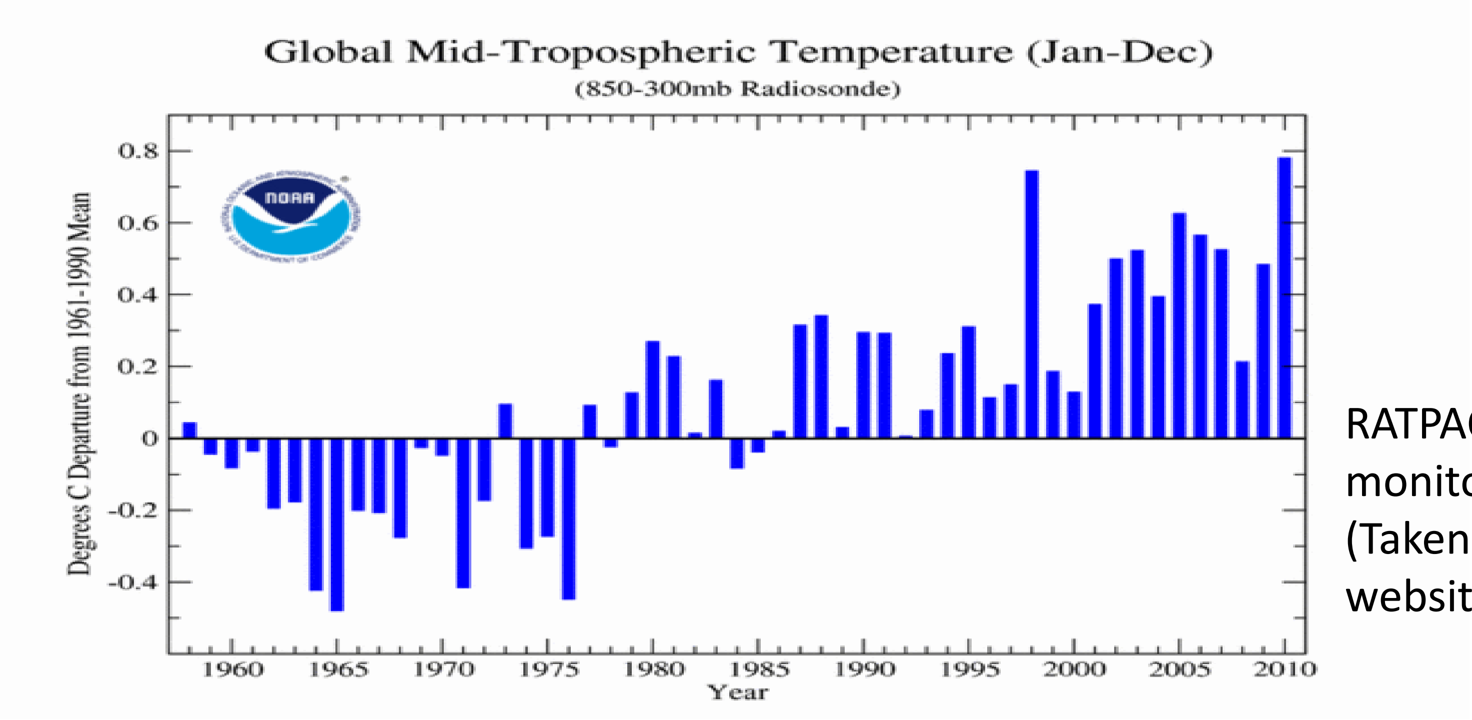
NCDC: Imke Durre, Tom Peterson

Philosophy:

- Adjust data without satellite or other reference data (to maintain independence)
- “First do no harm”—Avoid overadjustment
- Carefully selected set of stations

RATPAC Accomplishments:

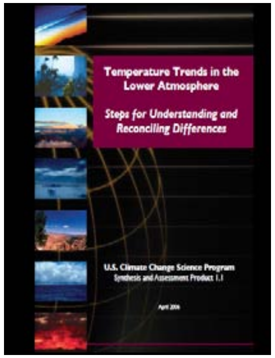
- Regional and monthly mean adjusted radiosonde temperature dataset
- First radiosonde temperature dataset homogenized without the use of satellite data.
- Only NOAA upper-air adjusted radiosonde dataset, transferred to NCDC for monthly operational updating.



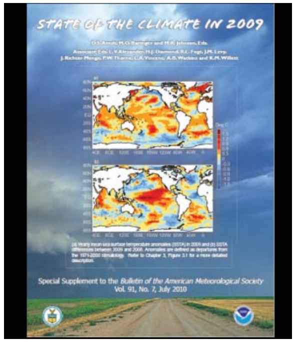
RATPAC used by NCDC for monitoring
(Taken from NCDC website)

RATPAC Indicators of Success:

- Used for assessments (IPCC, BAMS State of Climate Reports)

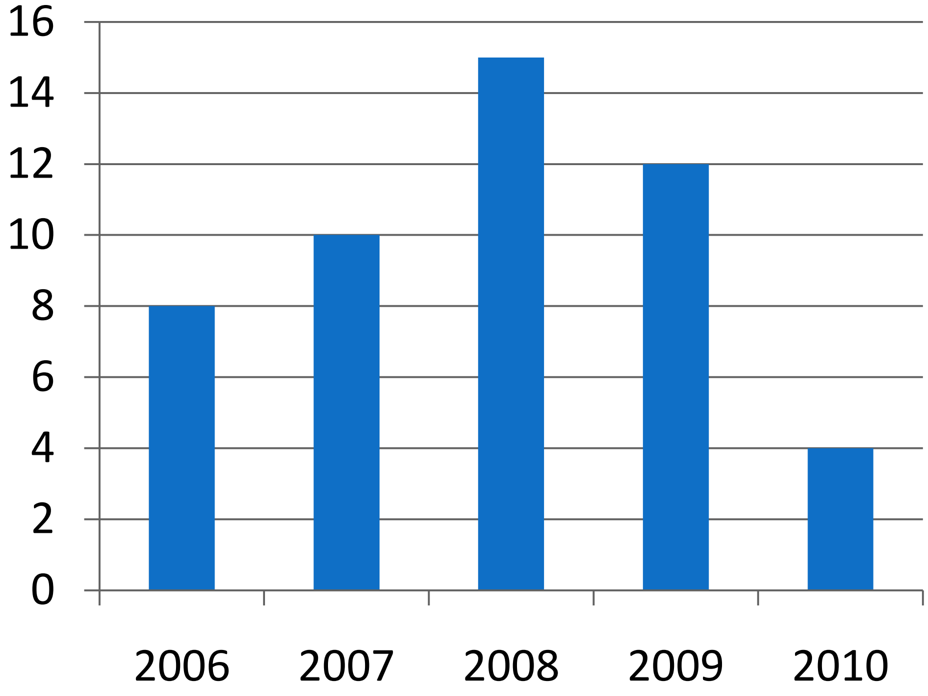


- Used by numerous other scientists.
- NOAA Bronze Medal 2007



- RATPAC paper referenced by many others

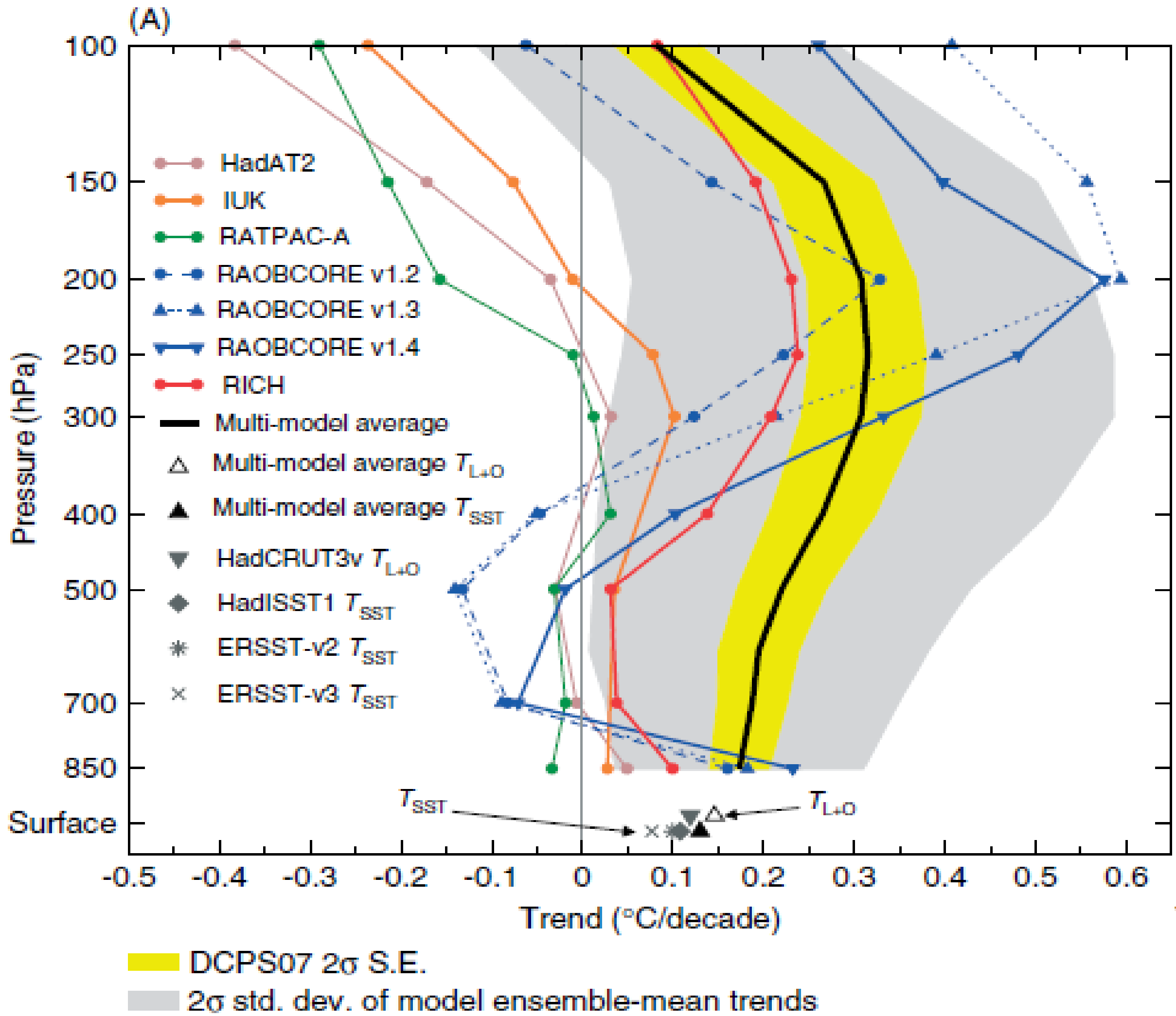
Number of publications* referencing RATPAC, by year



Total publications to date = 51

*From Web of Science

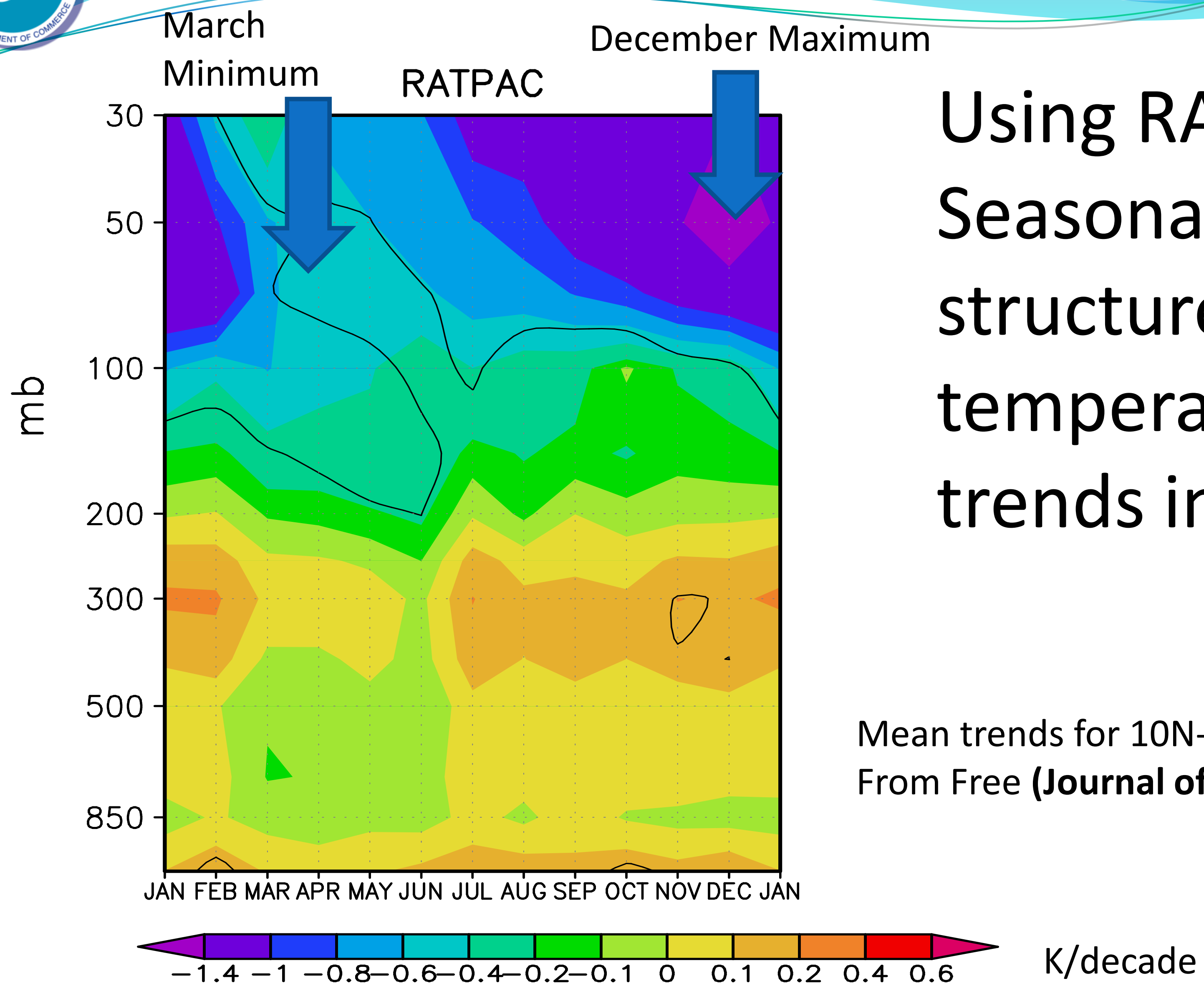
Using RATPAC: Comparing observed trends with models



Trends for 1979-1999 in tropics from sondes and models

Santer, Thorne, Haimberger, Taylor, Wigley, Lanzante, Solomon, **Free**, Gleckler, Jones, Karl, Klein, Mears, Nychka, Schmidt, Sherwood, and Wentz, **Int. J. Climatol. (2008)**

Using RATPAC: Seasonal structure of temperature trends in tropics



Mean trends for 10N-10S 1979-2009
From Free **(Journal of Climate 2011)**

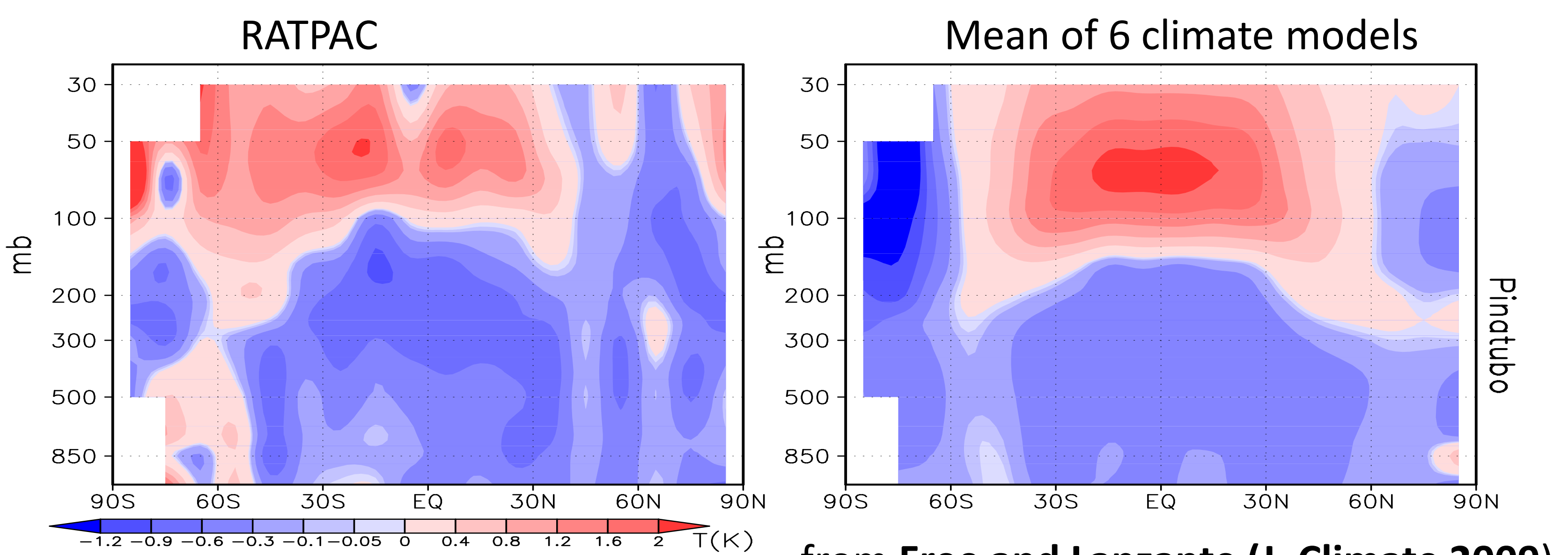
2. Climate effects of volcanic eruptions

Many papers on surface effects, fewer on upper air

Previous work mostly looked at layer mean temperatures or used satellite or reanalysis data.

Instead we:

- Examine effects on vertical temperature profile using radiosonde data.
- Carefully separate volcanic effects from other short-term variations.
- Compare to results from climate models.



from **Free and Lanzante (J. Climate 2009)**

Accomplishments:

Comparing volcanic signals in radiosonde data to those in climate models

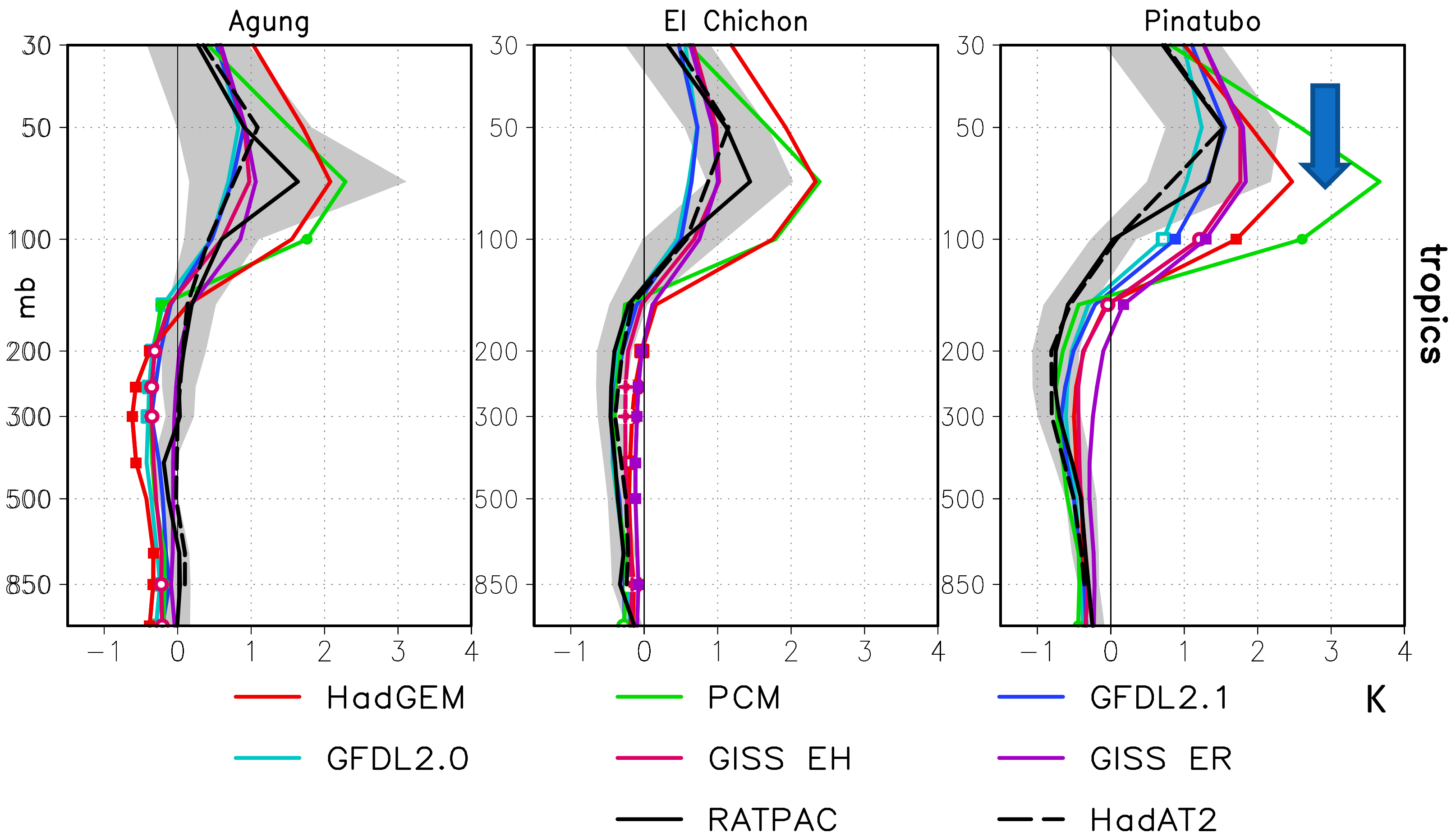


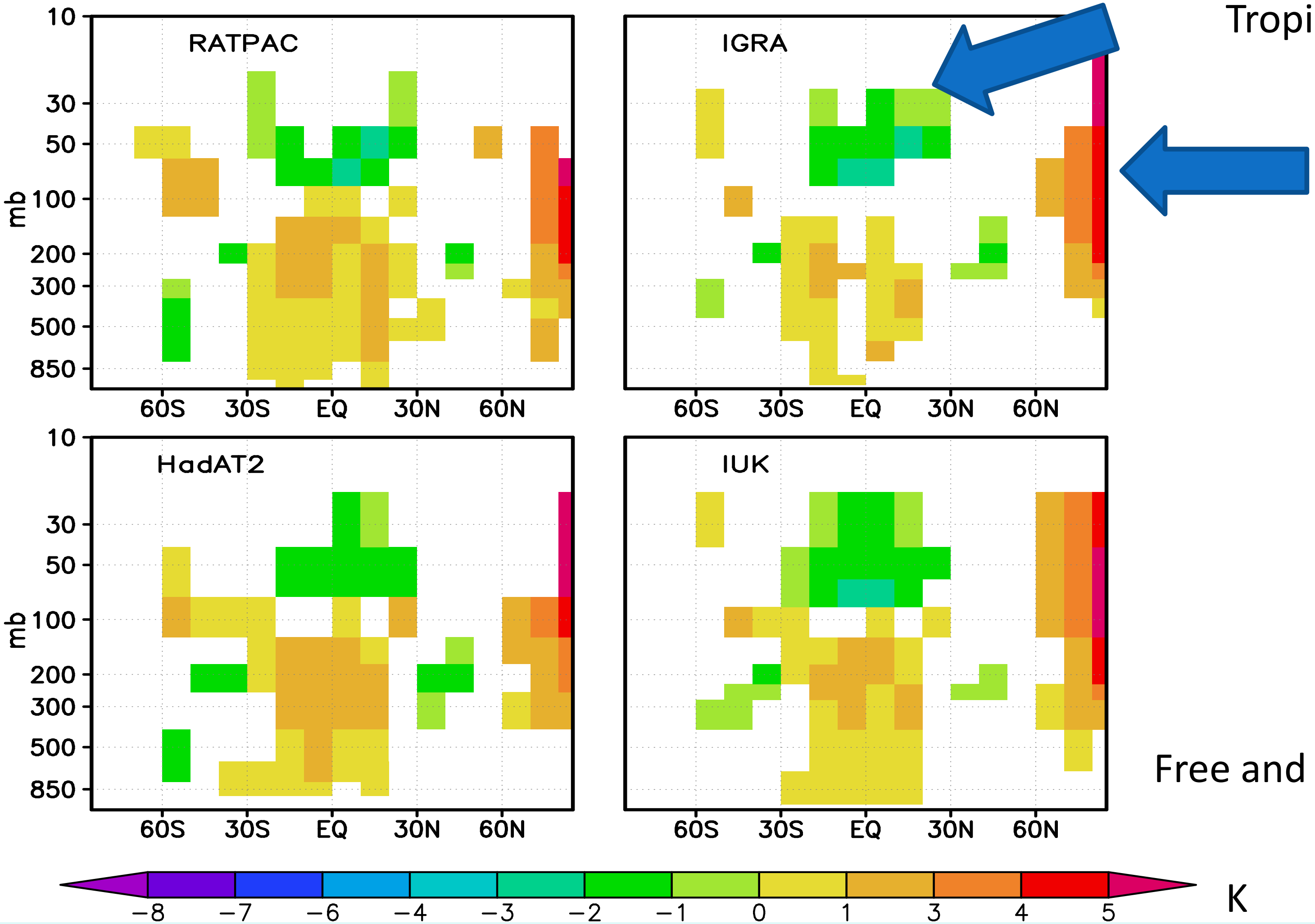
Fig. 4b from **Free and Lanzante (J. Climate 2009)**

3. Effects of ENSO on stratospheric temperatures

Previous work used single reanalysis or satellite datasets, and examined limited regions or vertical levels. Our approach differed:

- Applied multiple linear regression to radiosonde data
- Used several datasets to test robustness of results
- Looked at whole atmosphere in zonal mean

Accomplishment: ENSO effect on stratospheric temperature



Tropical cooling

Polar warming

Free and Seidel (JGR 2009)

Summary-Accomplishments:

- Greater understanding of upper-air temperature trends and their uncertainties
- Clearer picture of effects of volcanoes and ENSO on vertical temperature profile

Collaborators:

RATPAC:

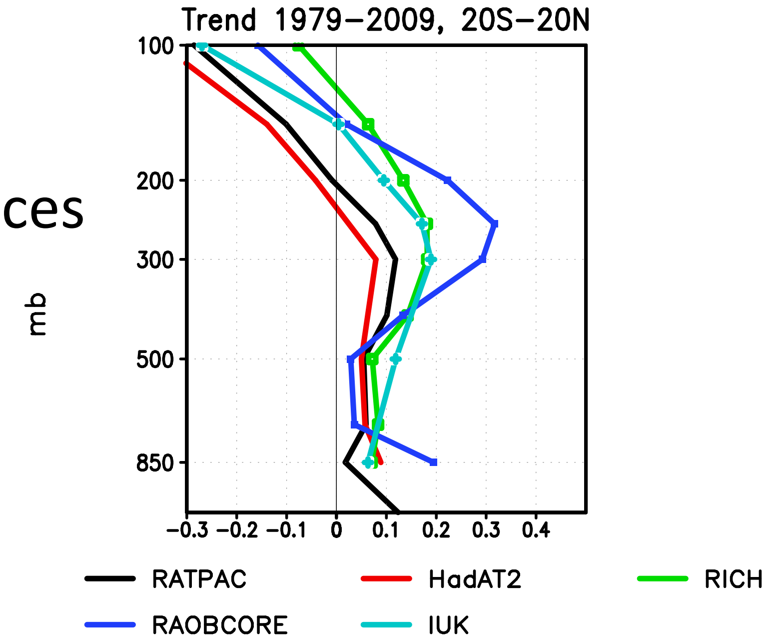
NOAA GFDL: John Lanzante
NOAA NCDC: Imke Durre, Tom Peterson

Volcanic effects on temperature:

John Lanzante, NOAA GFDL

Possible Future Directions

1. Reasons for trend differences



2. Origins of biases

3. Effects on hurricane intensity