Quantifying the Tropical Upper Troposphere Lapse Rate Feedback Using Radio Occultations

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Outline

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Objectives

1. Understand how ROs could complement climate research?

2. What new physics information could we get from GNSS signals?

Introduction (Climate Feedbacks)

CLIMATE FEEDBACK DEFINITION:

The climate feedback for a variable, λ_x, can be expressed as the product of two terms [e.g., *Soden et al.*, 2008]:

$$\lambda_x = \left(\frac{\partial R_x}{\partial X}\right) \cdot \left(\frac{dX}{d\overline{T}_s}\right)$$

A) One of the radiative transfer

B) One of the climate response

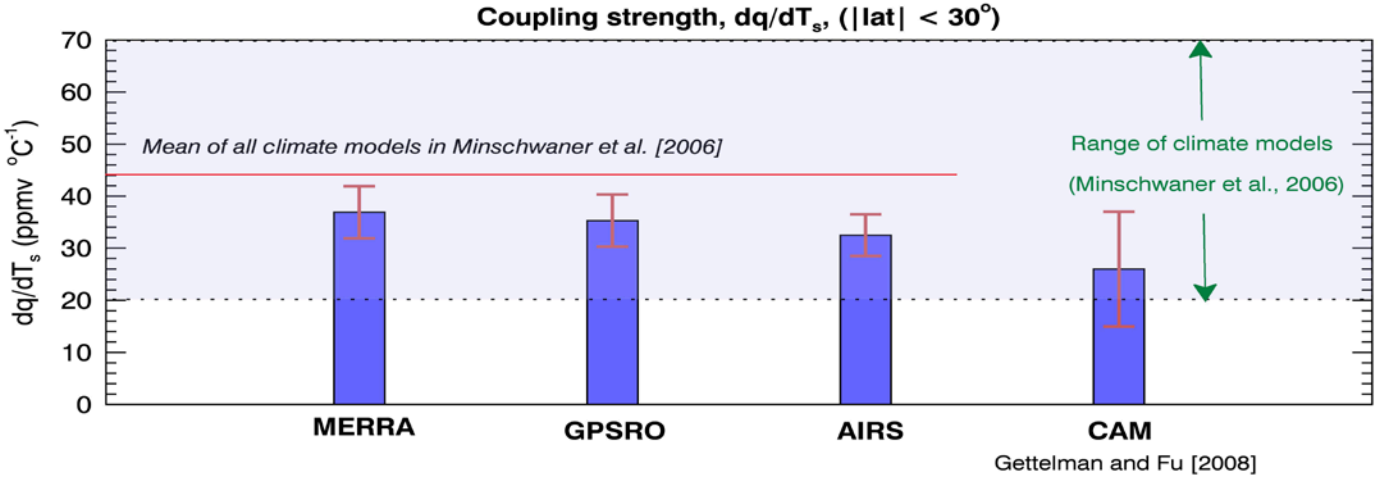
Where *R* is the net top of the atmosphere (TOA) flux; *X* is a climate variable (e.g., T, q, A, C); and T_s is the surface temperature.

Introduction (Climate Feedbacks)

RO-BASED WATER VAPOR FEEDBACK [*Vergados et al.*, 2016]

$$\frac{dq}{dT_s} = 621.9907 \cdot \frac{P}{\left(P - e^2\right)^2} \cdot \frac{T^2}{b} \cdot \left[\frac{dN}{dT_s} + \frac{1}{T} \cdot \left(2N - \frac{aP}{T} \right) \cdot \frac{dT}{dT_s} \right]$$

q is the specific humidity, N is the refractivity, T is the atmospheric temperature, T_s is the surface temperature, e is the partial pressure of water vapor, and a and b are constant values.



Methodology

COMPONENTS OF SOFTWARE

DATA	METHODOLOGY	ANALYSIS
Data • JPL, GPS-RO • ERA-Interim • Aqua/AIRS v6.0 • MERRA v2.0	**Analysis** • Monthly zonal means • 9–year long time series • Interannual anomalies • 300 – 200 hPa	**Retrieve** • Compare GPS-RO series with ERA-Interim, AIRS, and MERRA data sets. • Assess linear trends, seasonal variabilities, their anomalies, and quantify dT/dSST. • Assess the GPS-RO performance on short-term temperature time series.
↓	↓	
Set Up • 01/2007–12/2015 • 30ºS–30ºN • Tropical Zones	**Statistics** • Mean climatologies • Difference & Std. Dev. • Monthly variabilities • Seasonal/Annual Trend	

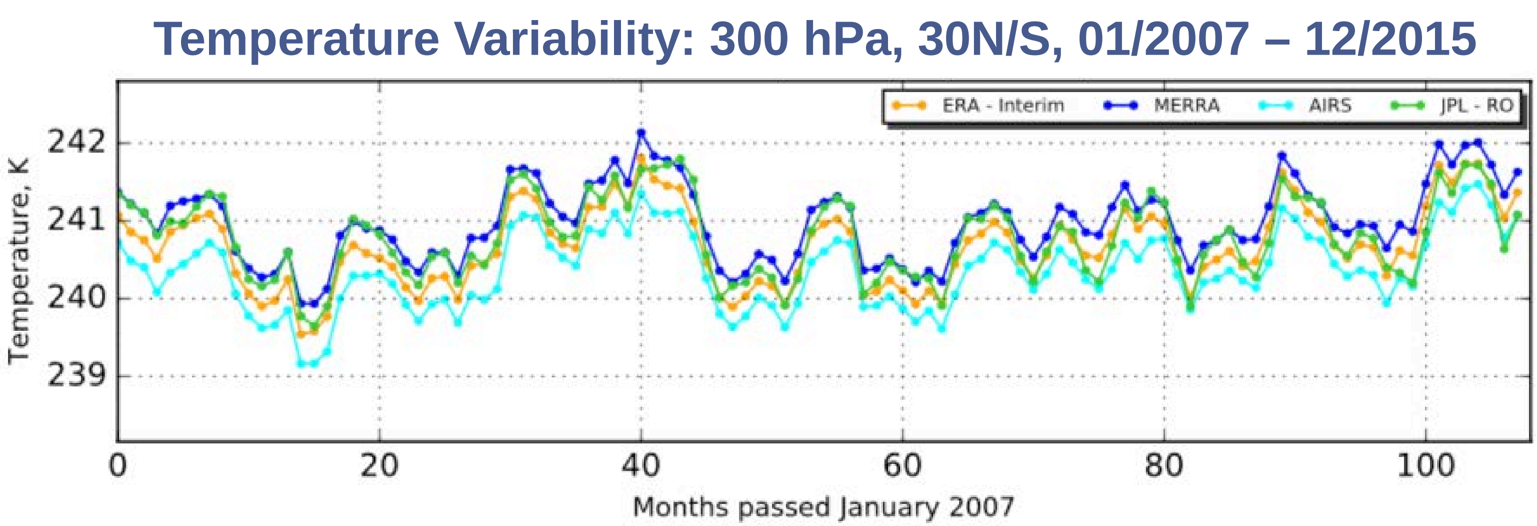
ERA-Interim
European Center for Medium-Range Weather Forecasts Re-Analysis Interim

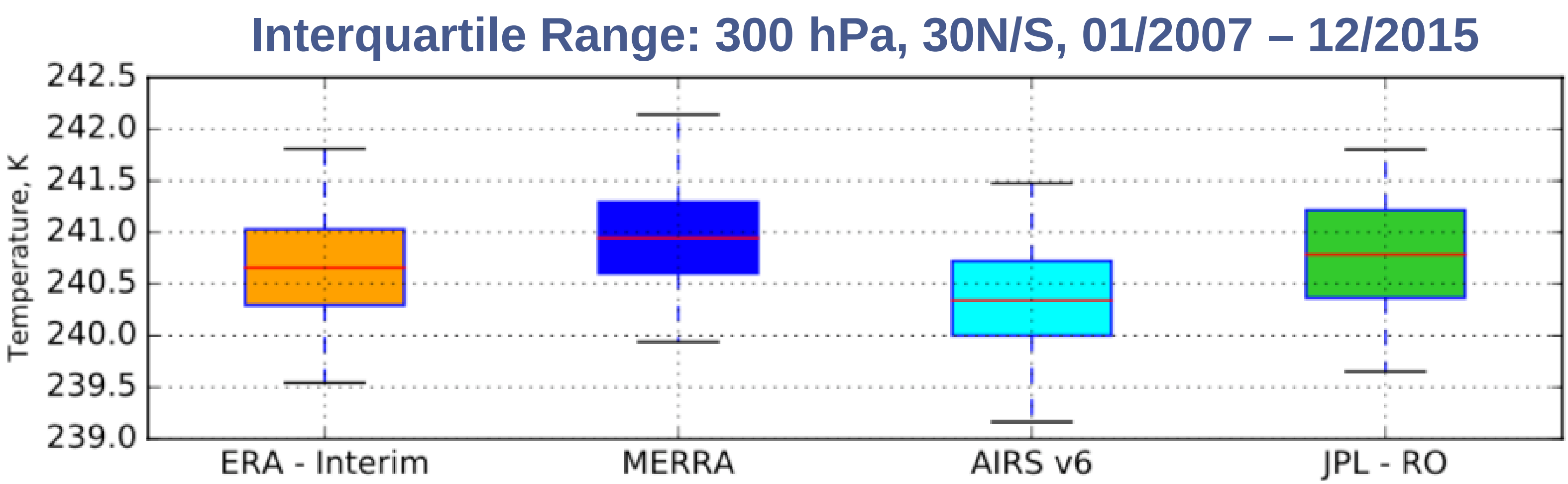
Aqua/AIRS
Atmospheric Infrared Sounder

MERRA
Modern-Era Retrospective Analysis for Research and Applications

Results (1/6) (± 30º, 300 hPa)

Temperature Trends (300 hPa)

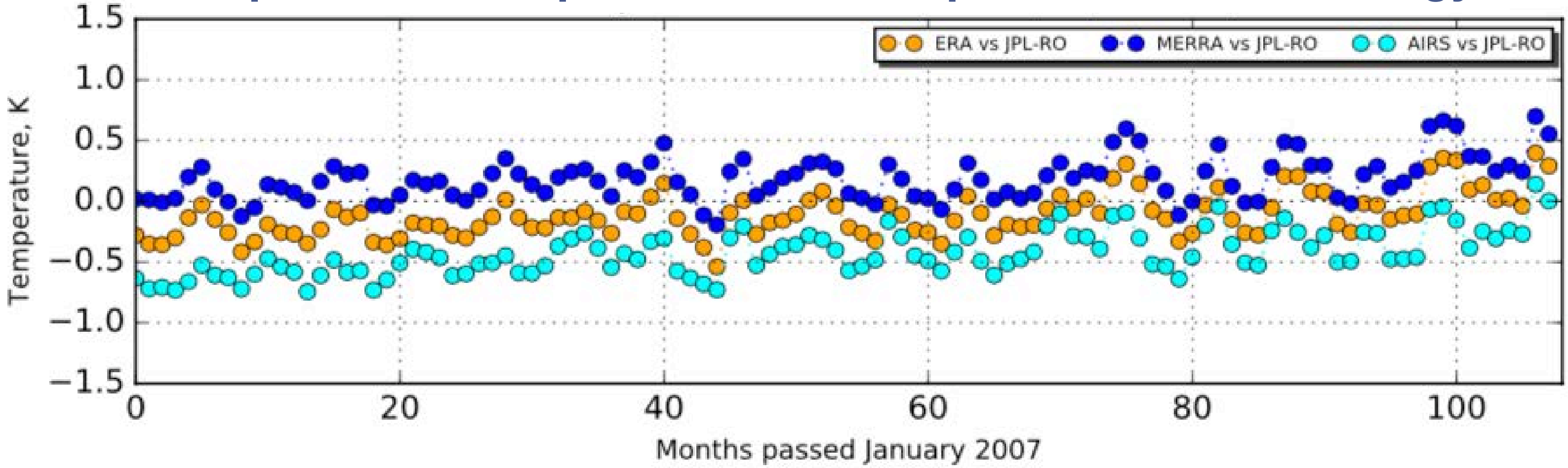




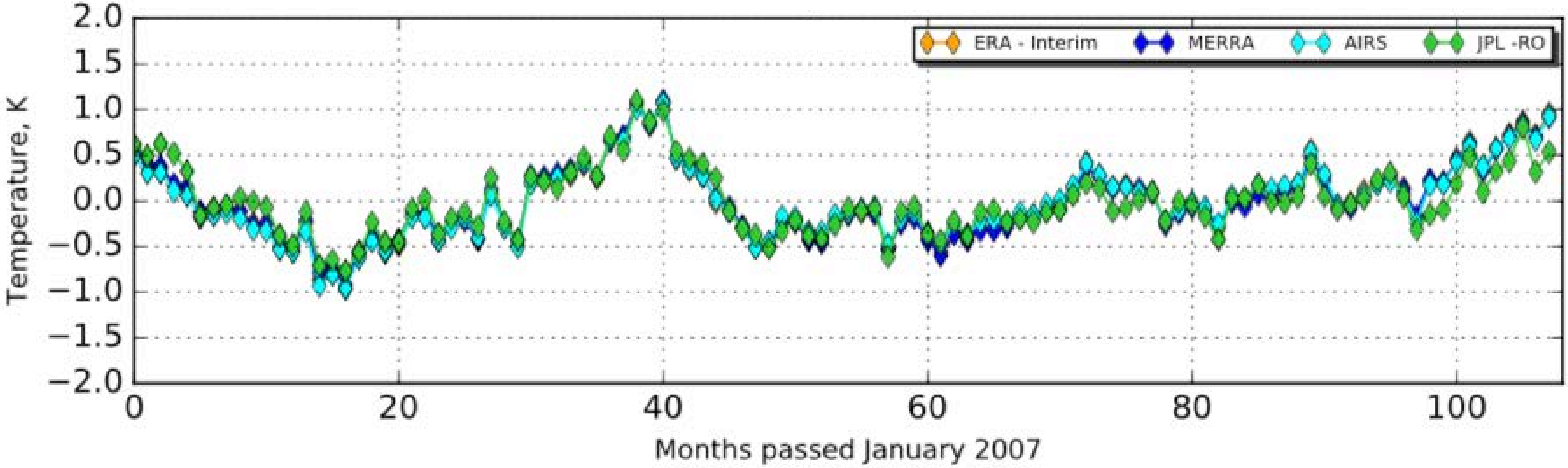
Results (2/6) (± 30°, 300 hPa)

Temp. comparisons (300 hPa)

Temperature Comparisons with respect to JPL climatology



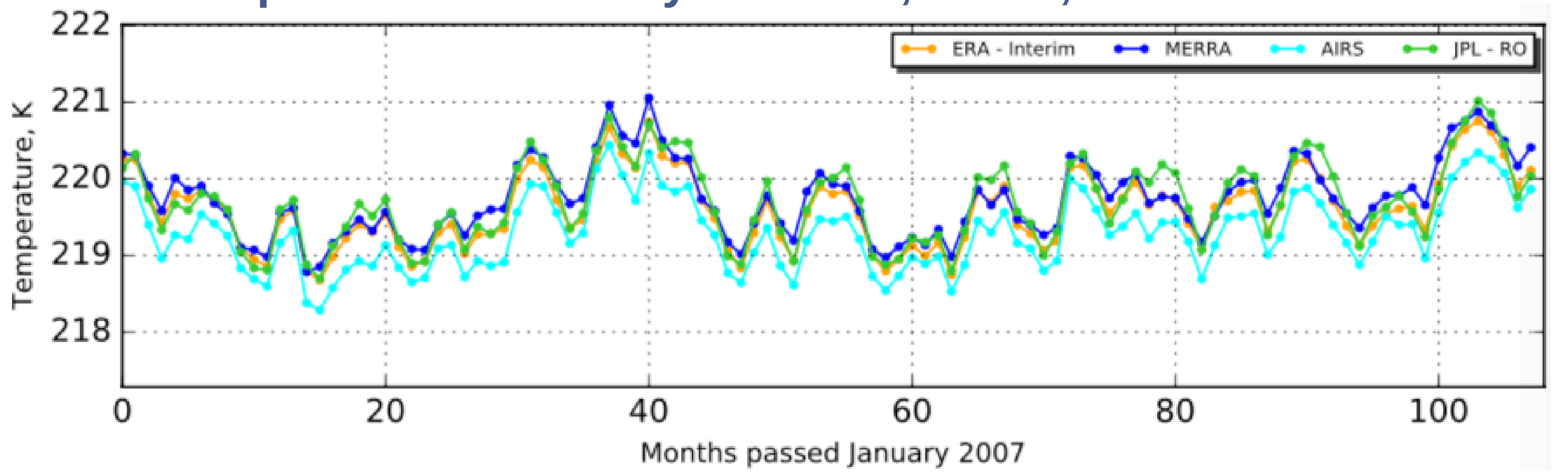
Temperature Anomalies Time Series



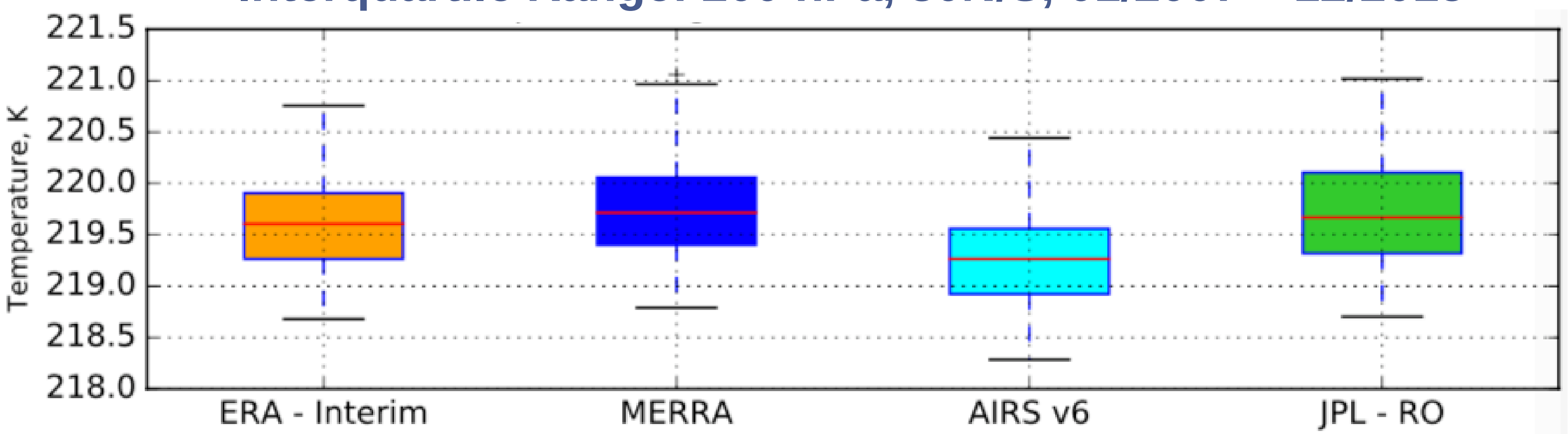
Results (3/6) (± 30º, 200 hPa)

Temperature Trends (200 hPa)

Temperature Variability: 200 hPa, 30N/S, 01/2007 – 12/2015



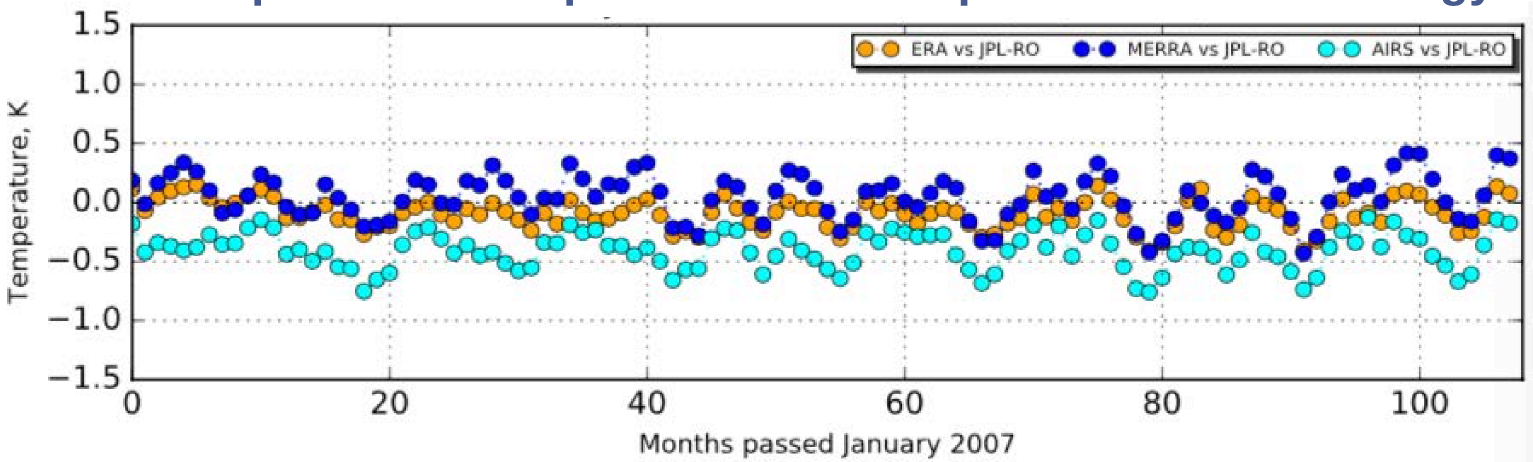
Interquartile Range: 200 hPa, 30N/S, 01/2007 – 12/2015



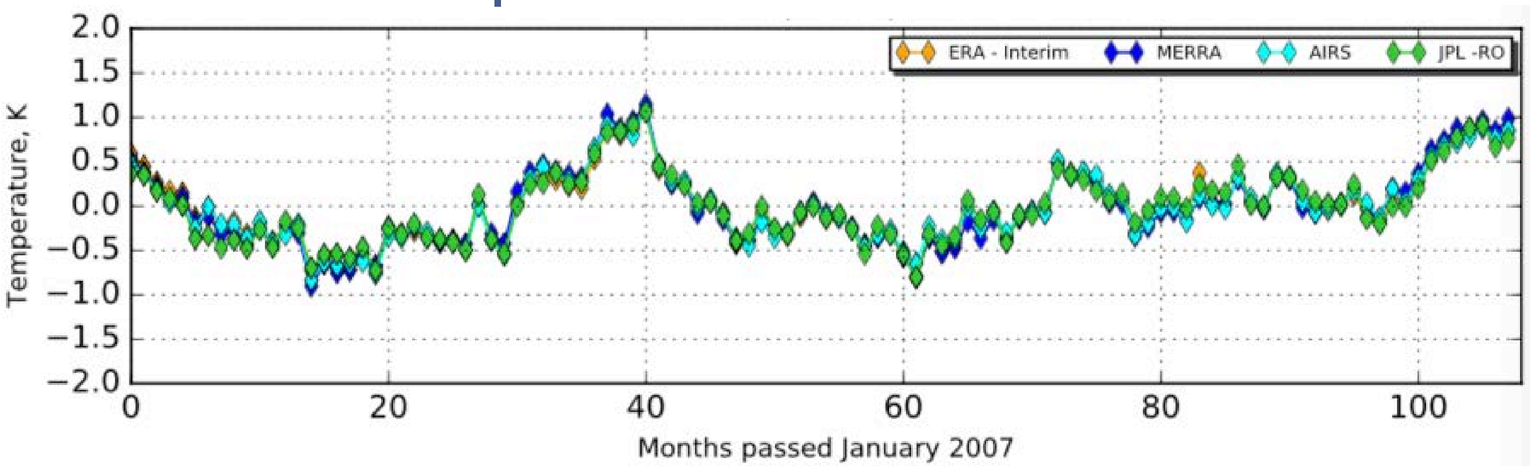
Results (4/6) (± 30º, 200 hPa)

Subtropics – Dry atmosphere

Temperature Comparisons with respect to JPL climatology



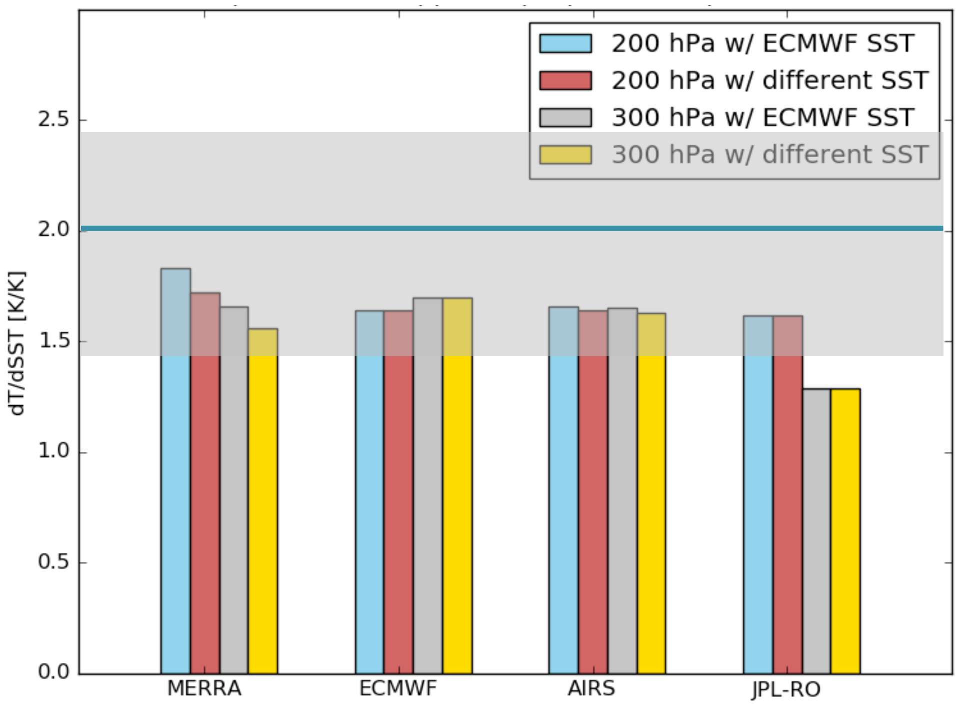
Temperature Anomalies Time Series



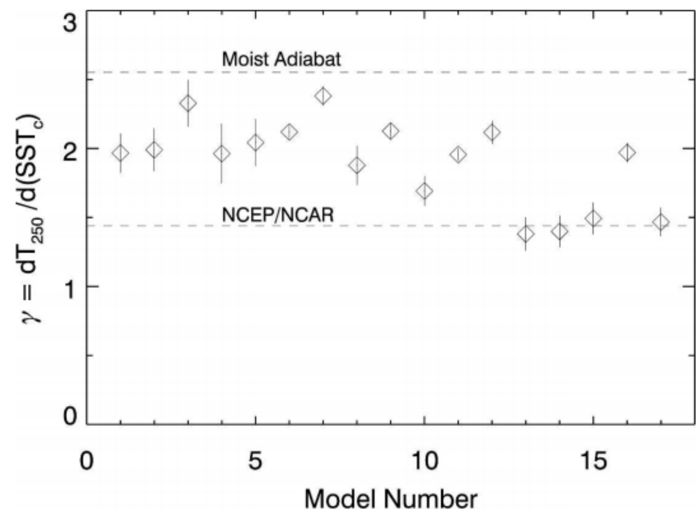
Results (6/6)

Climate Response of the Tropical UT Lapse Rate Feedback

Climate Response of UT temperature feedback



Multi-model Analysis
($\pm$ 20º, 250 hPa, 1980-2000)
[*Minschwaner et al.*, 2006]



The majority of the climate models show dT/dSST at 250 hPa to have a wide range of values, fluctuating between 1.5 K/K and 2.5 K/K [*Minschwaner et al.,* 2006]

Conclusions

1. All data sets, within their error uncertainty, agree on the temperature variability.
2. The variability captured in the inter-annual anomalies of all data sets are the same.
3. At 200 hPa, all data sets show the same dT/dSST response to surface warming.
4. At 300 hPa, all data sets agree with one another – except from GPS/RO showing 30% weaker signal.
5. All data sets fall within the model range (gray area) and are systematically smaller than the multi-model mean.