Comparing Stratospheric Temperature Records from GPS Radio Occultation, MSU/AMSU and Radiosondes

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A R S C l i S y s

INTRODUCTION

Detecting the anthropogenic influence on the climate system requires high-quality observations of the Earth's atmosphere. Upper-air temperature time series exist primarily from radiosondes (since 1958) and from satellite measurements, the latter provided by the (Advanced) Microwave Sounding Unit (A)MSU (since 1979, see Fig. 1). Neither of the instruments was originally intended for climate monitoring. Thus, demanding inter-calibration and homogenization procedures are required to establish a climate record. Uncertainties concerning the magnitude of upper-air temperature trends still remain. The GPS Radio Occultation (RO, Fig. 2) technique is well suited to overcome these problems. It provides relatively new (continuous since ~2001), independent measurements of upper-air parameters with high accuracy, global coverage and high vertical resolution. Additionally it is self-calibrating, avoiding the need of error-prone inter-calibration. These observations are therefore well suited for climate studies and can also be used to asses structural uncertainties in other datasets.

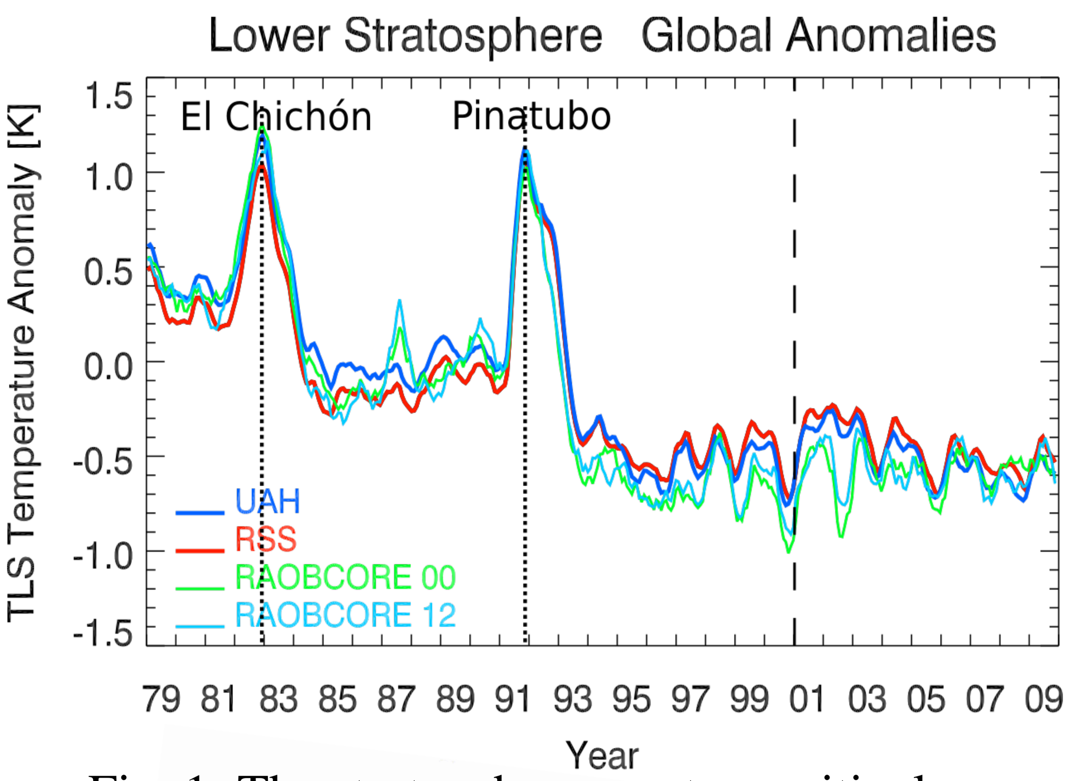


Fig. 1: The stratosphere reacts sensitively to climate change

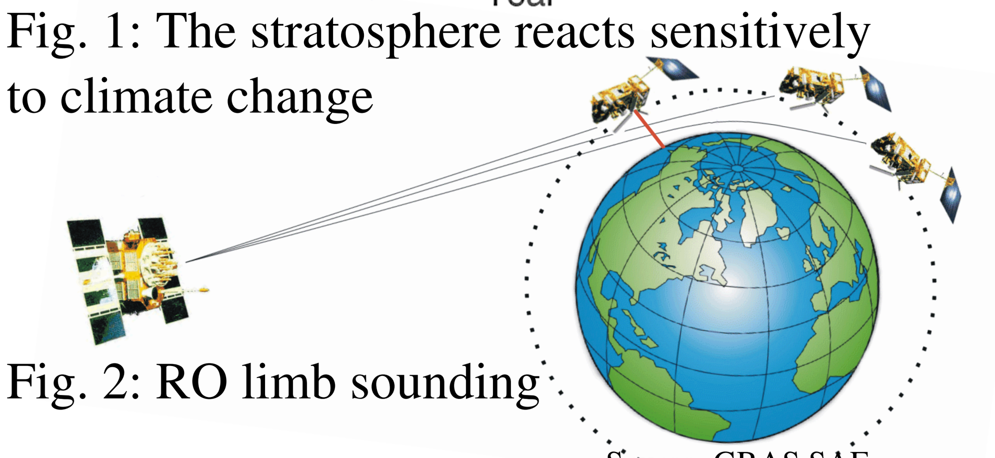


Fig. 2: RO limb sounding

STUDY SETUP

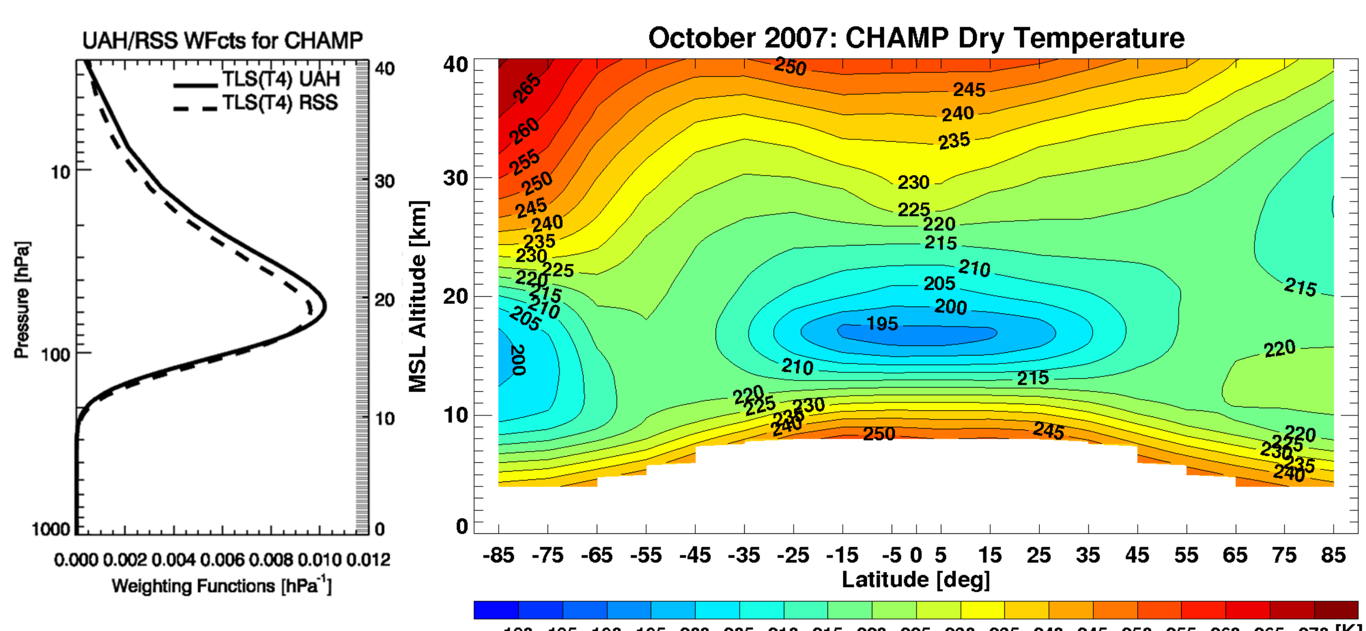


Fig. 3: TLS weighting function describing the relative contribution of the lower stratosphere (left); RO monthly climatology, CHAMP (right)

In this study we compare (A)MSU, radiosonde and RO monthly-mean zonal-mean anomalies for 2001–2009. For reference we also show corresponding ECMWF analyses.

(A)MSU data, provided by the University of Alabama (USA) and Remote Sensing Systems (USA), is given in layer-average brightness temperatures, described by weighting functions (Fig. 3; TLS stands for the lower stratosphere channel). For RO temperature profiles, we use a radiative transfer model (RTTOV) to compute comparable MSU TLS equivalents, and for the radiosonde data MSU TLS equivalents are provided by the University of Vienna (Austria).

Dataset	Version	Time Period	Sampling (per day)
RO CHAMP	WEGC OPSv5.4	Sep2001–Sep2008	~ 150
RO GRACE	WEGC OPSv5.4	Mar2007–Dec2009	~ 150
RO COSMIC	WEGC OPSv5.4	Aug2006–Dec2009	~ 2000
RO SAC-C	WEGC OPSv5.4	Sep2001–Nov2002	~ 150
(A)MSU	RSSv3.2 UAHv5.3	Jan1978–Dec2009	~ 30000 (TLS)
Radiosondes	RAOBCOREv1.4	Jan1957–Dec2009	> 1000 stations
ECMWF	T42L60 T42L91	Sep2001–Jan2006 Feb2006–Dec2009	co-located to RO profiles

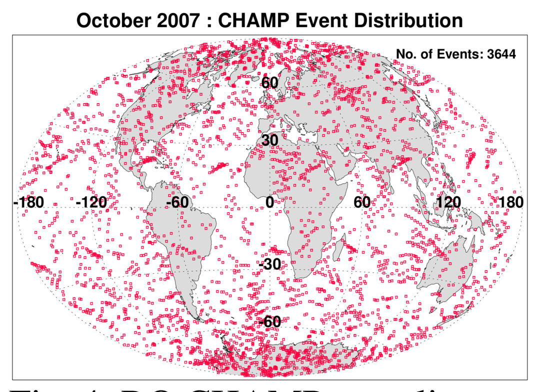


Fig. 4: RO CHAMP sampling

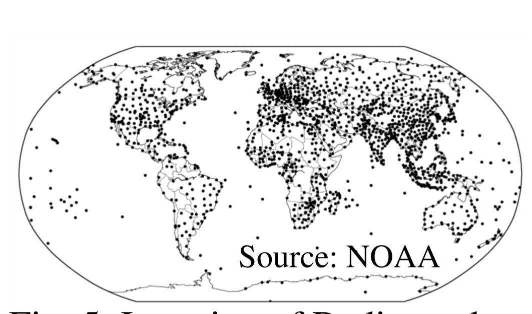


Fig. 5: Location of Radiosonde stations

RESULTS

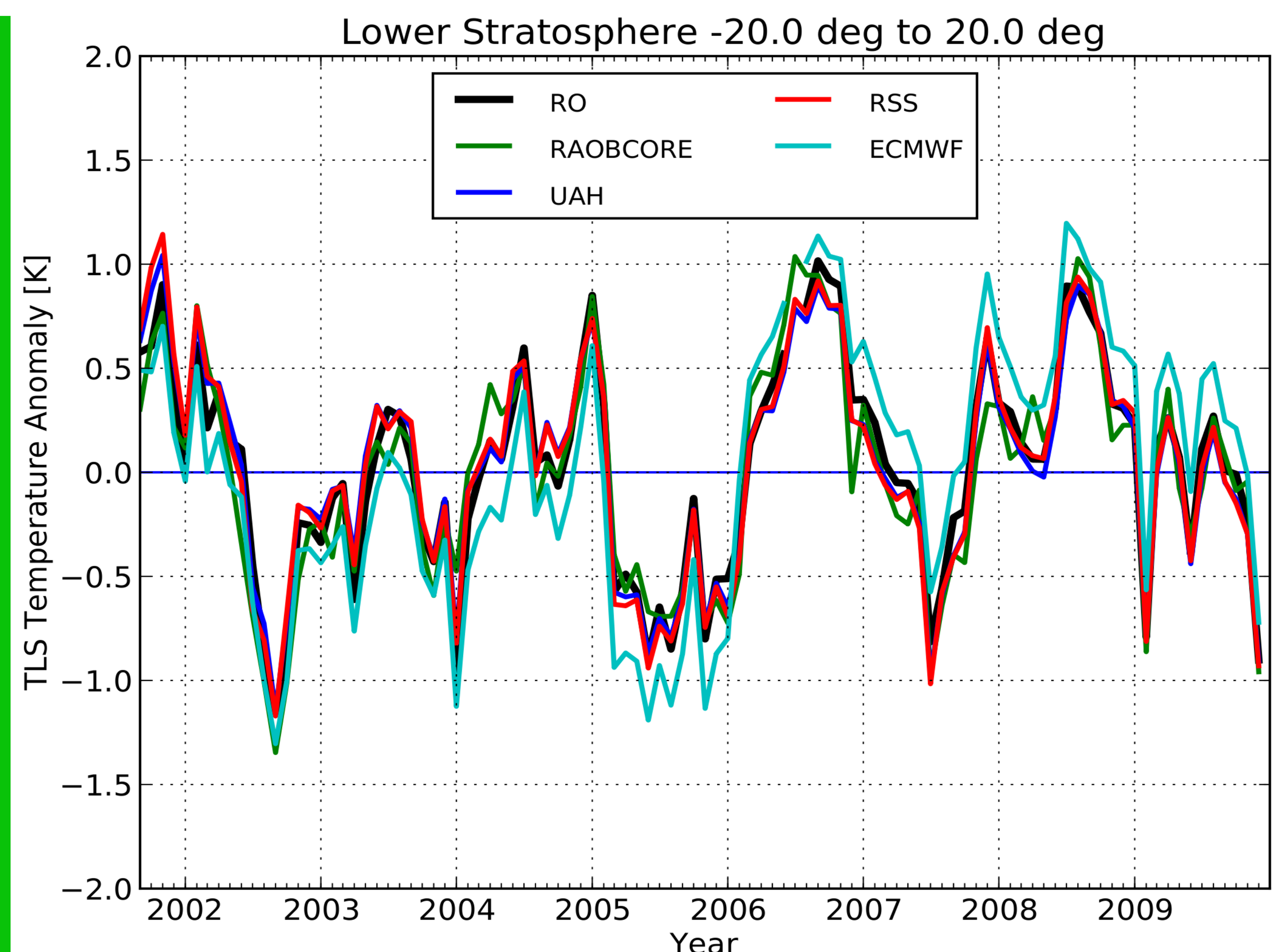
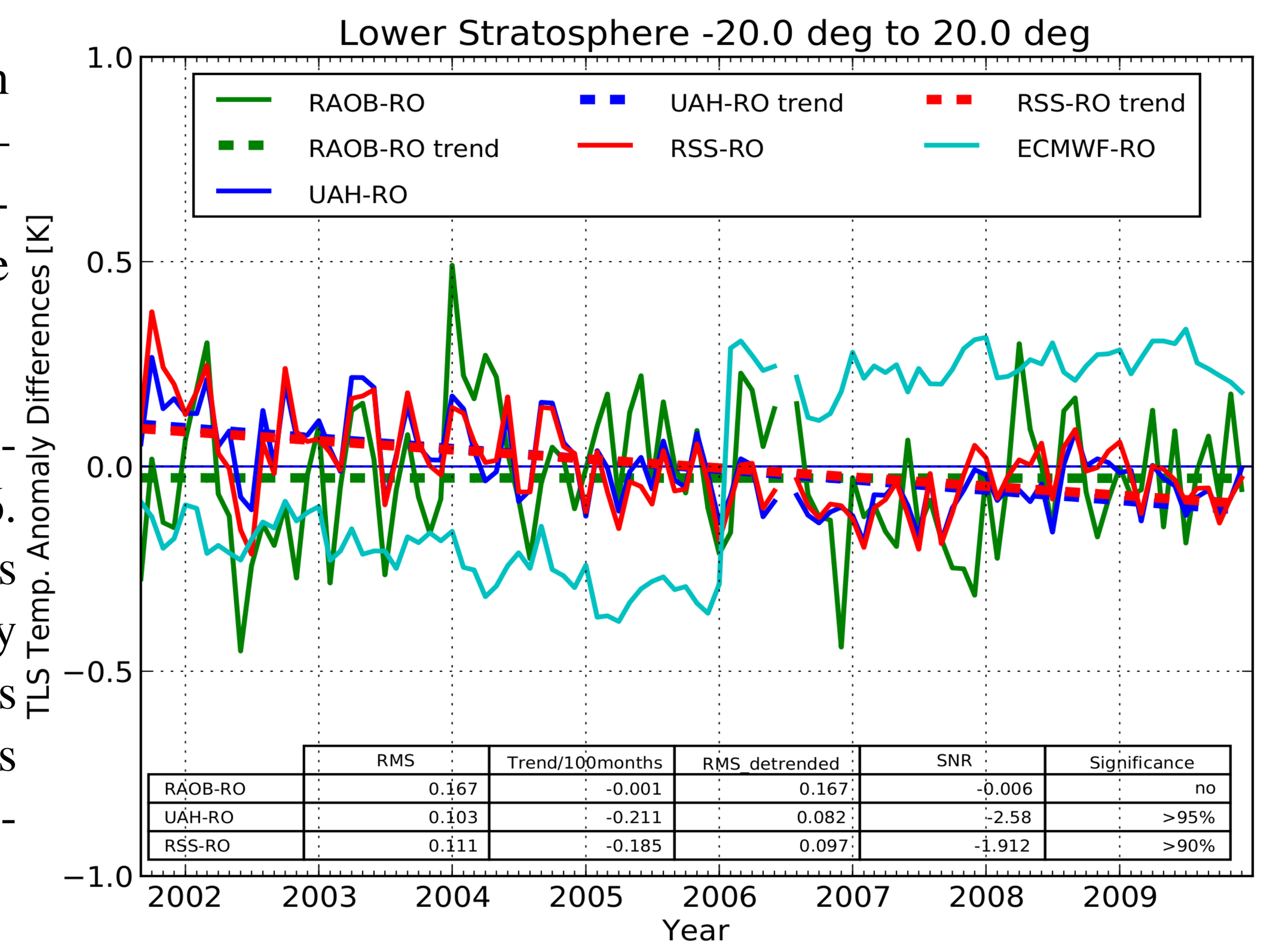


Fig. 6 (left): Monthly-mean anomalies relative to 2002–2009 for the tropics. By looking at monthly anomalies the data is de-seasonalized.

Fig. 7 (right): Differences between the anomalies of Fig. 6. By looking at the differences the climatological variability common to both datasets is removed, isolating differences due to measurement and processing.



	RMS	Trend/100months	RMS_detrended	SNR	Significance
RAOB-RO	0.167	-0.001	0.167	-0.006	no
UAH-RO	0.103	-0.211	0.082	-2.58	>95%
RSS-RO	0.111	-0.185	0.097	-1.912	>90%

- Significant differences in Radio Occultation and (A)MSU lower stratospheric temperature records can be observed (Fig. 7). The two datasets clearly show a temporal drift to each other.
- The change of resolution of the ECMWF analysis in Feb2006 is clearly visible as a shift in the anomaly time series.
- The known error sources for RO cannot explain the observed difference (high-altitude initialization drifts, dry/physical temperature difference, mean sampling error are about one magnitude smaller than the detected trend differences.
- More work is needed to assess the consistency of upper-air temperature records.