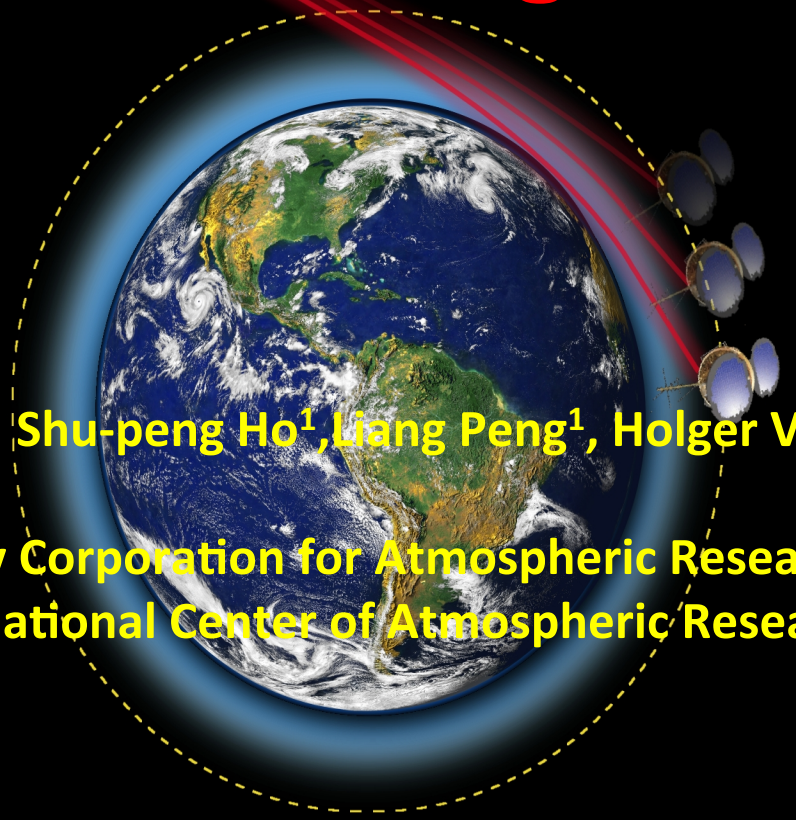
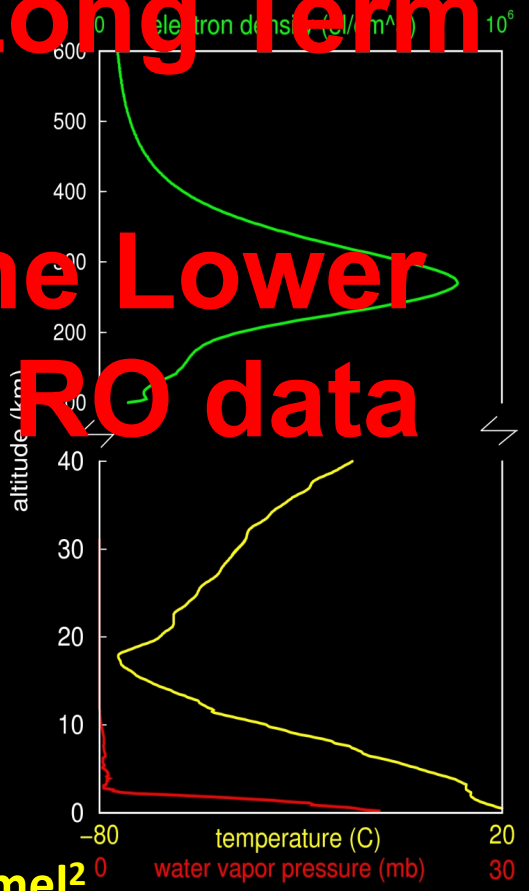
Characterization of the Long Term Variation of Radiosonde Temperature Biases in the Lower Stratosphere using GPS RO data





Shu-peng Ho[1],Liang Peng[1], Holger Vömel[2]

[1]University Corporation for Atmospheric Research/COSMIC, USA
[2]National Center of Atmospheric Research, USA

Motivation:

Can we use RO data to identify uncertainty of stratospheric temperature trends from satellite data and radiosondes ?

Challenges and Objective

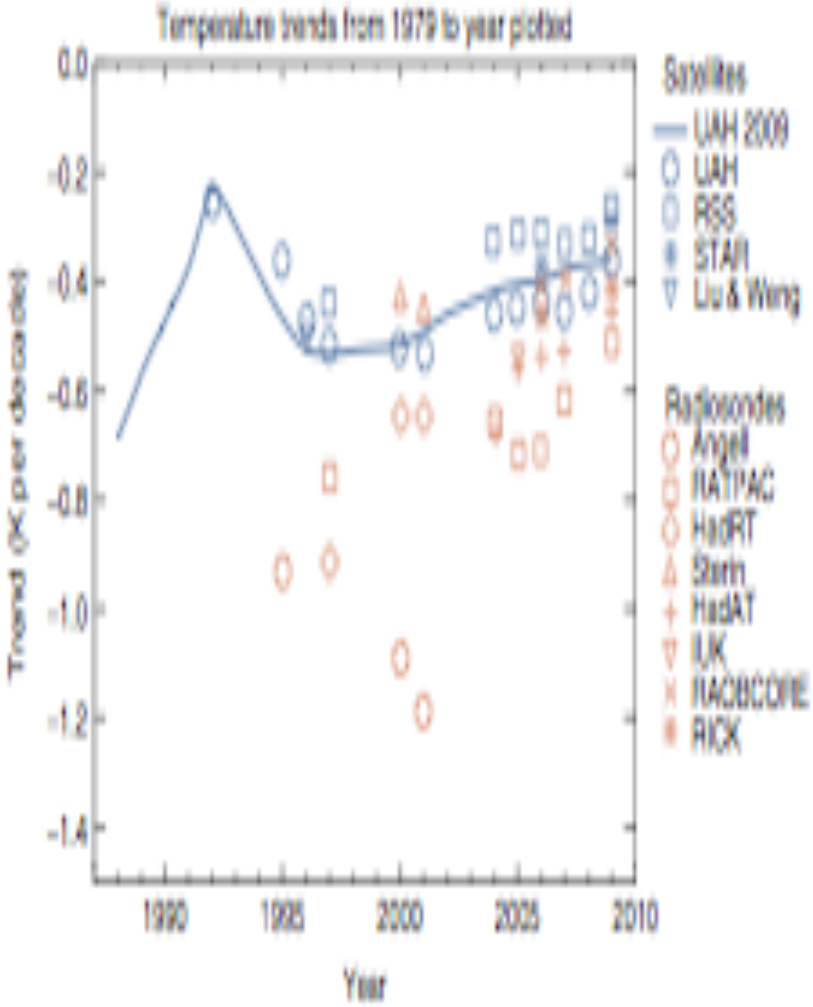
-Radiosonde sensor characteristics can be affected by the changing environment, its measurement accuracy varies considerably in times and locations for different sensor types

- Changes with instrument types

-**Using RO temperature profiles to identify temperature biases from radiosonde, where sensor characteristics vary considerably in times and locations for different sensor types**

Outlines :

- **Approaches**
- **Results, global, time series, trends**
- **Conclusions and Future Work**

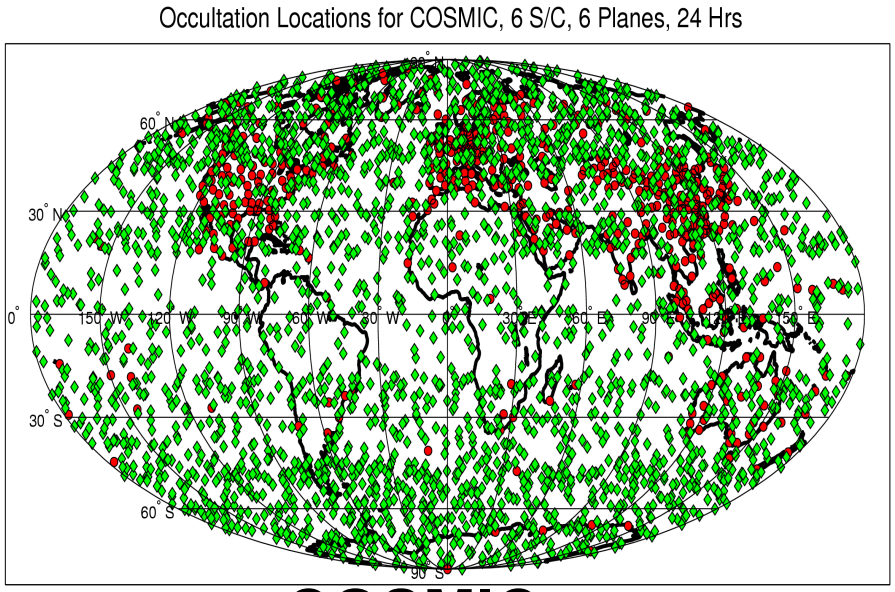


Dian J. Seidel et al., Stratospheric temperature trends: our evolving understanding, *WIREs: Clim Change* 2010.

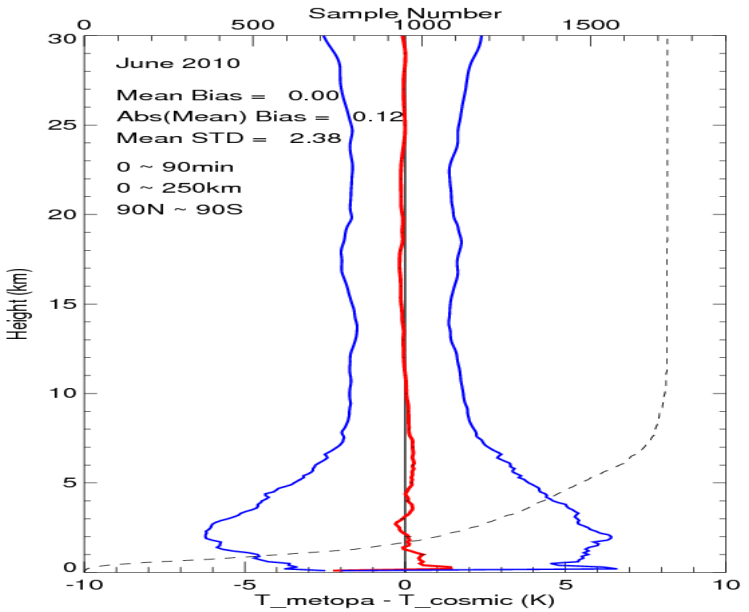
RO data for climate research

- **Measure of time delay: no calibration is needed**
- **Requires no first guess sounding**
- **Not affect by clouds**
- **Uniform spatial/temporal coverage**
- **High precision (<0.05K)** (Ho et al., TAO, 2009)
- **Insensitive to clouds and precipitation**
- **No mission dependent bias** (Ho et al., TAO, 2009)
- **Reasonable structural uncertainty among data processed from different centers (Ho et al., JGR, 2009, 2012)**
- **Short term RAOB vs. RO comparison (He et al., 2009; Sun et al., 2011, 2013)**

Using FM3-FM4 pairs in early mission

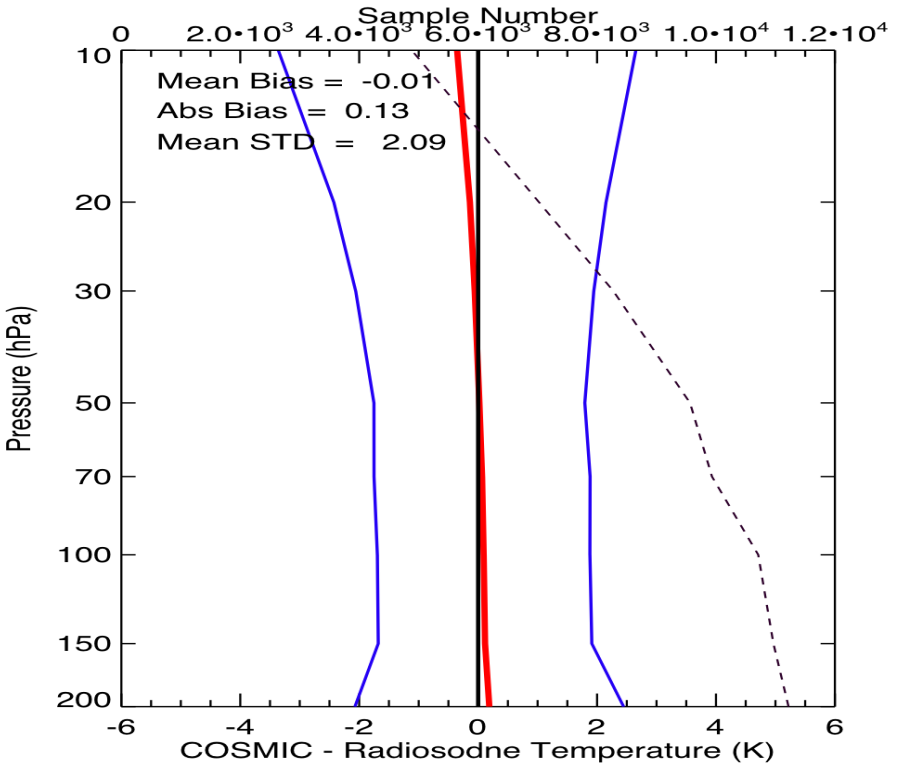


COSMIC

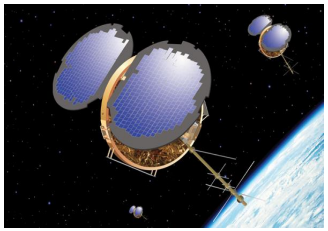


Check the accuracy of the RO temperature

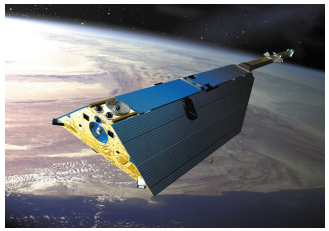
RS 92 vs. COSMIC derived temperature profiles in 2007

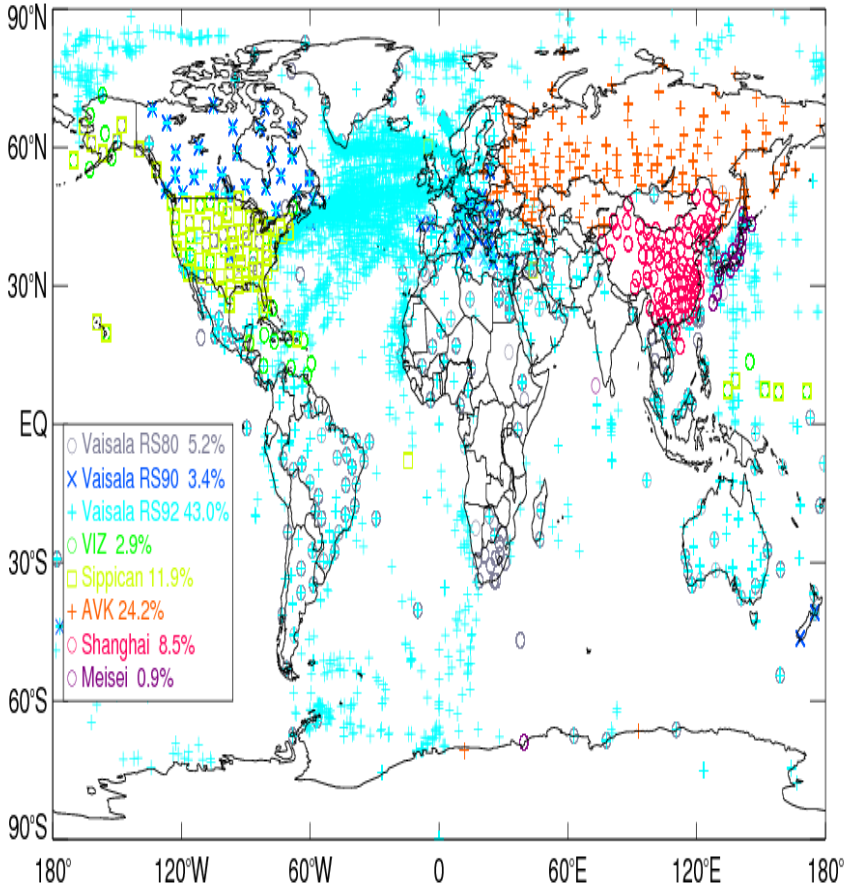


Ho, S.-P., Ying-Hwa Kuo, William Schreiner, Xinjia Zhou (2010), Using SI-traceable Global Positioning System Radio Occultation Measurements for Climate Monitoring [In "States of the Climate in 2009]. *Bul. Amer. Meteor. Sci.*, **91** (7).



Approach: Using COSMIC and Metop-A re-processed data from 2006 to 2015 to assess the quality of radiosonde data



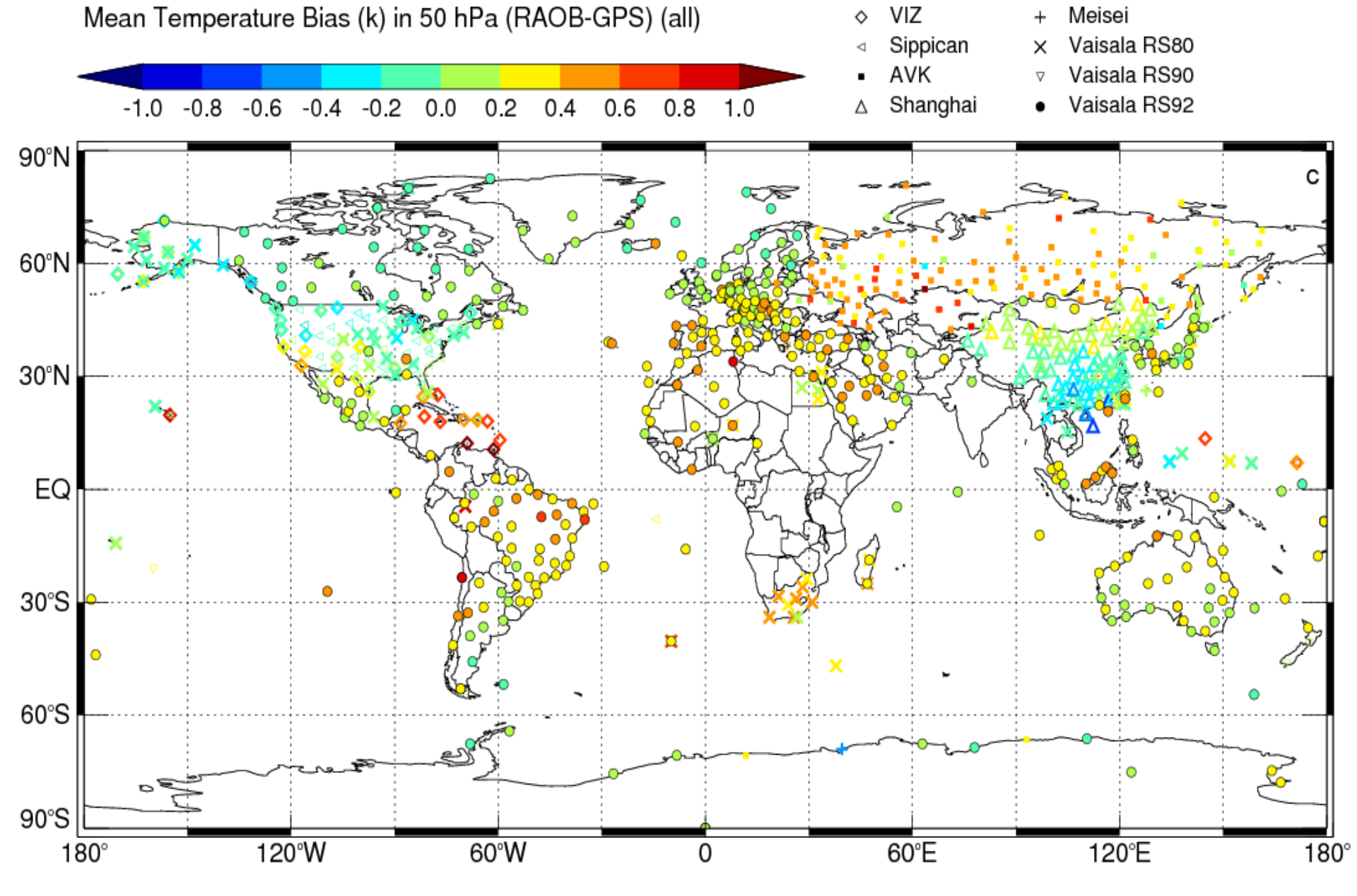


Radiosodne data DS353.4 from NCAR
- originally acquired from NCEP.
- contains the original data values transmitted by stations
- no radiative or other corrections from NCEP are included in this dataset
He et al., (2009 GRL)

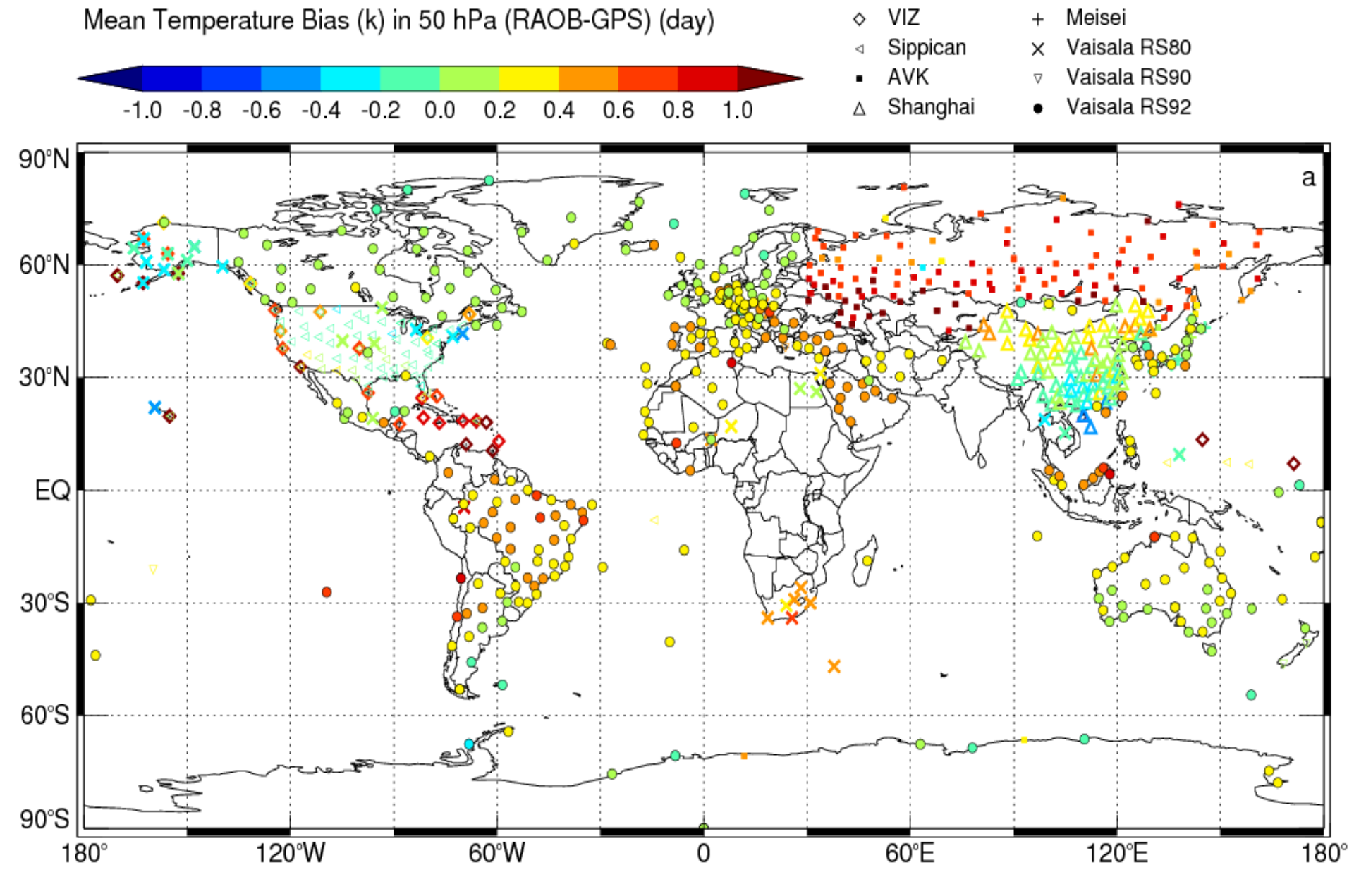
Region	Sonde Type	Matched Sample
Russia	AVK-MRZ	2000 (20%)
China	Shang	650 (6.1%)
USA	VIZ-B2	600 (5.9%)
Others	Vaisala	3140 (30%)

Collocate COSMIC/Metop-A and radiosonde profiles
< 200 km
< 3 hrs

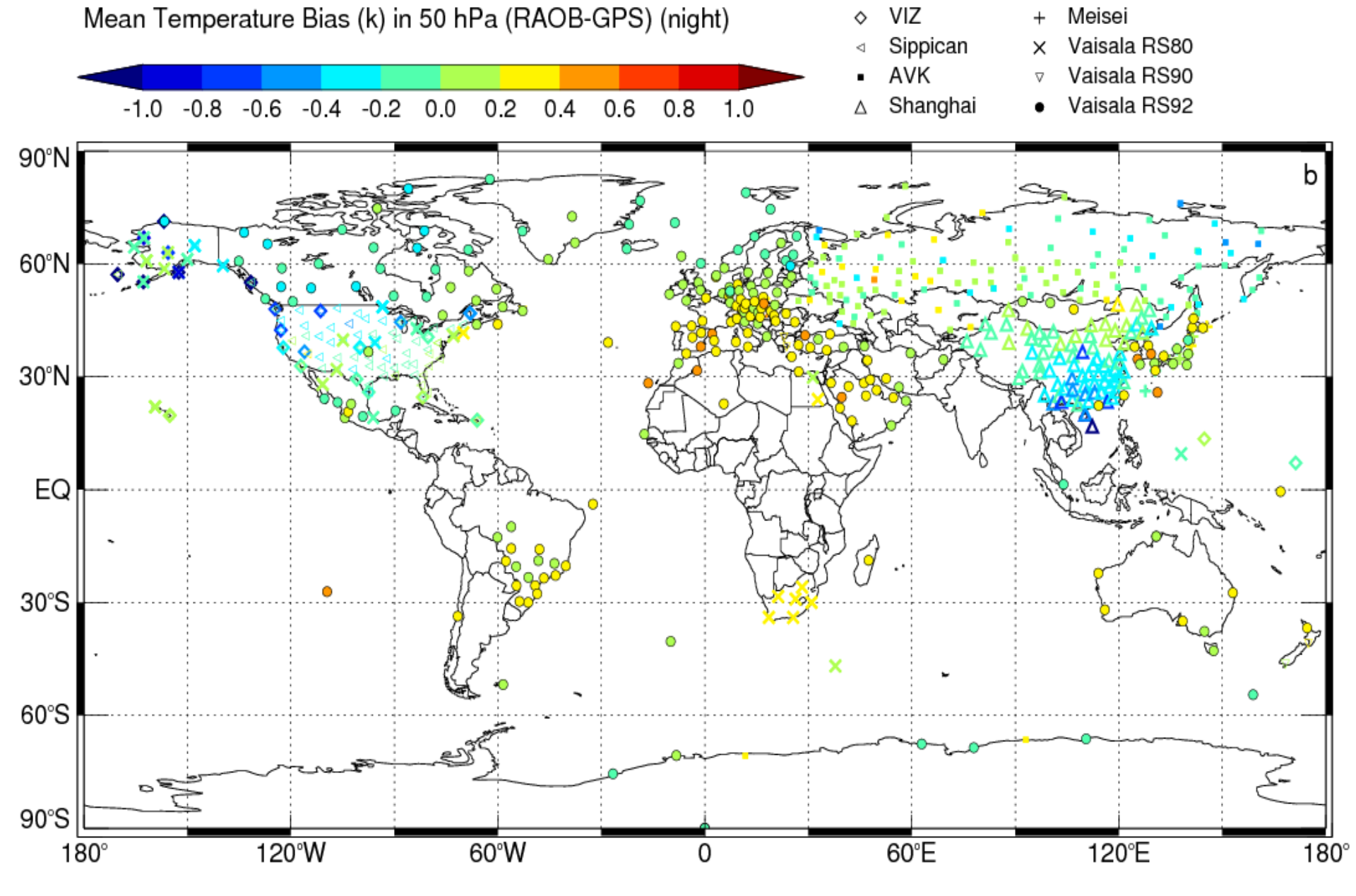
Day time and night time

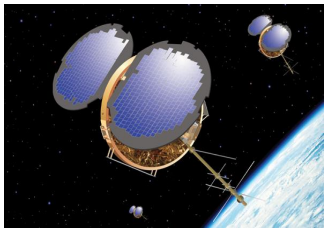


Day time

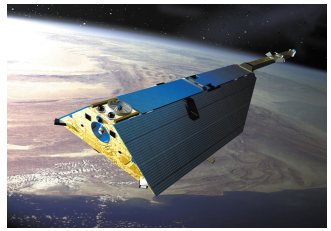

Mean Temperature Bias (k) in 50 hPa (RAOB-GPS) (day)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
VIZ
Sippican
AVK
Shanghai
Meisei
Vaisala RS80
Vaisala RS90
Vaisala RS92
a
90°N
60°N
30°N
EQ
30°S
60°S
90°S
180°
120°W
60°W
0
60°E
120°E
180°

Night time


Mean Temperature Bias (k) in 50 hPa (RAOB-GPS) (night)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
VIZ
Sippican
AVK
Shanghai
Meisei
Vaisala RS80
Vaisala RS90
Vaisala RS92
b
90°N
60°N
30°N
EQ
30°S
60°S
90°S
180°
120°W
60°W
0
60°E
120°E
180°



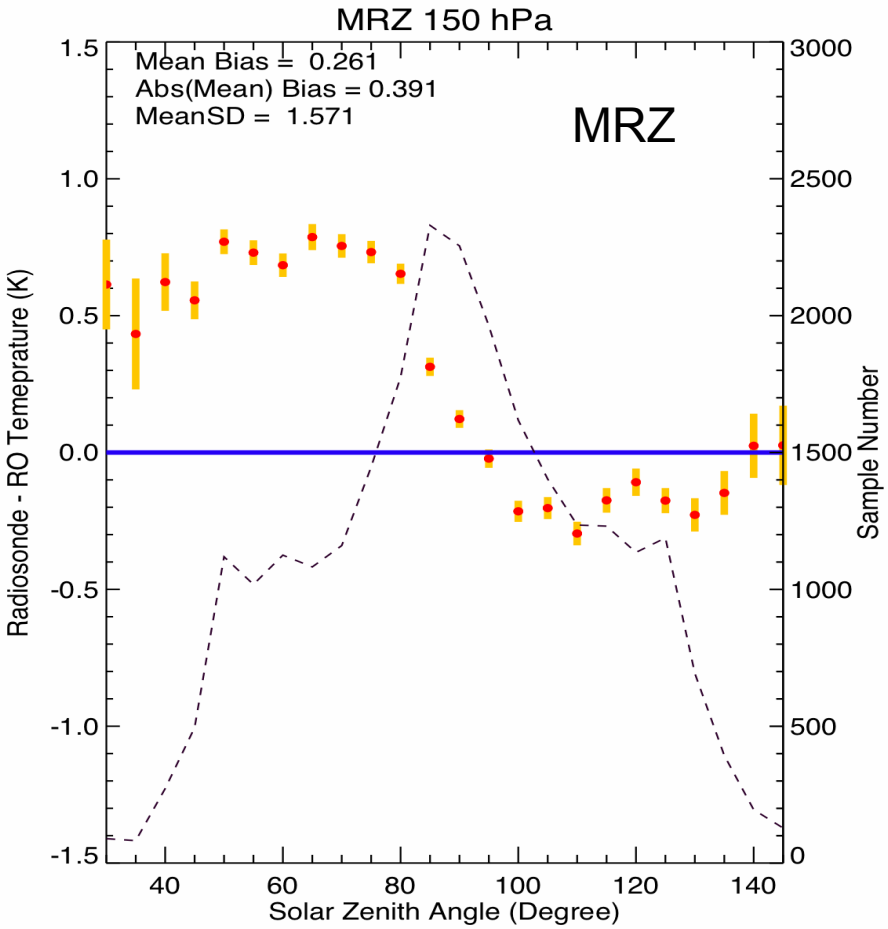
Using RO data to Identify Diurnal variation of Radiosonde Temperature Anomalies

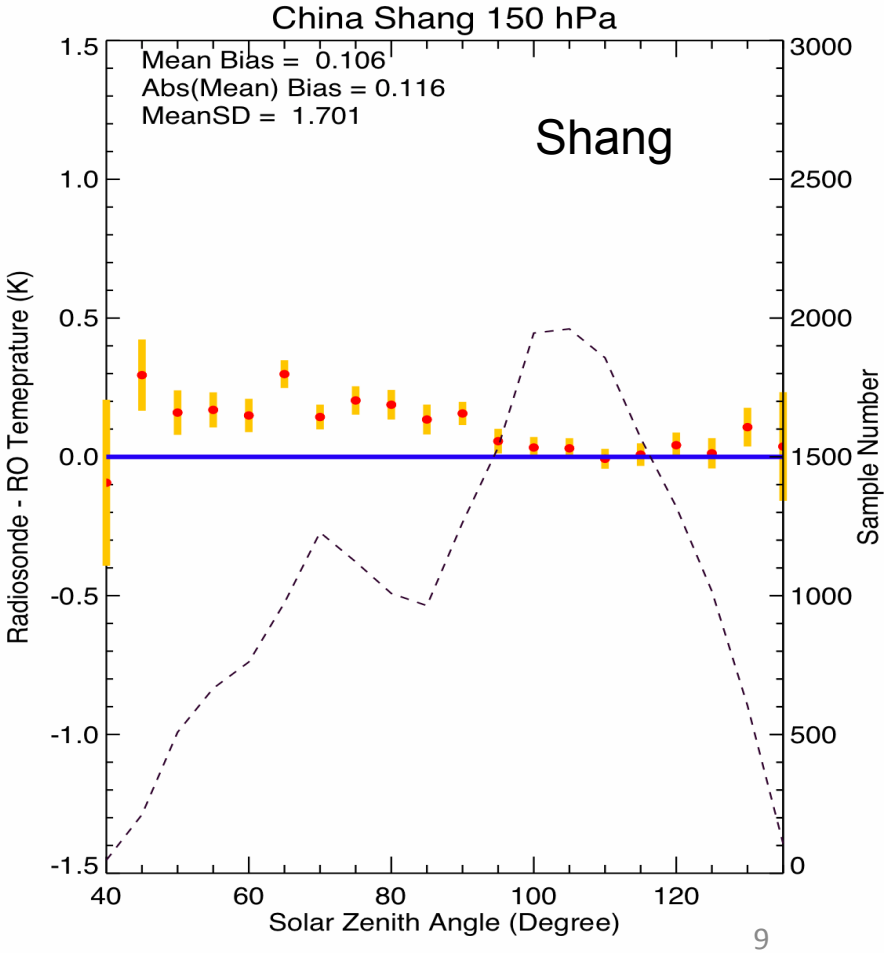


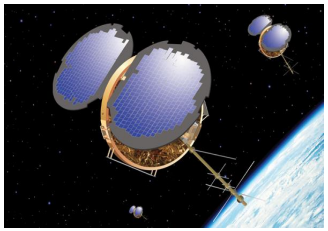
Solar absorptivity = 0.2
IR emissivity = 0.04

150 hPa

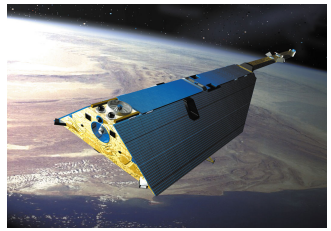
Solar absorptivity = 0.15
IR emissivity = 0.85





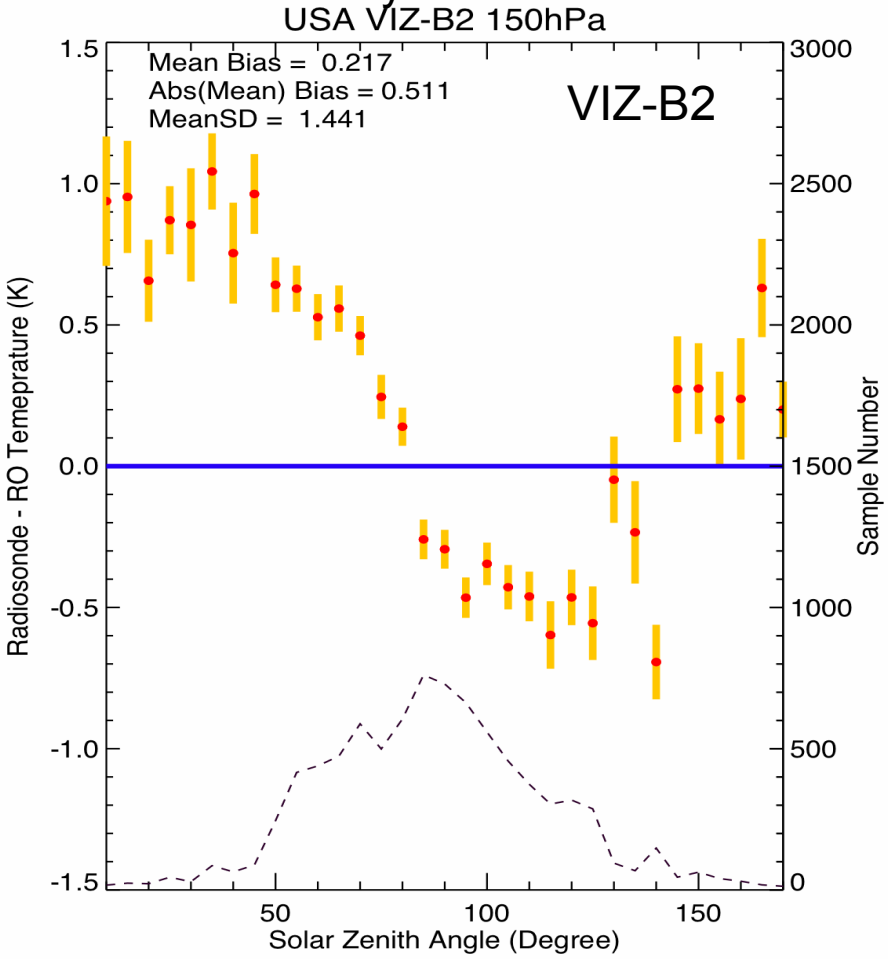


Using RO data to Identify Diurnal variation of Radiosonde Temperature Anomalies

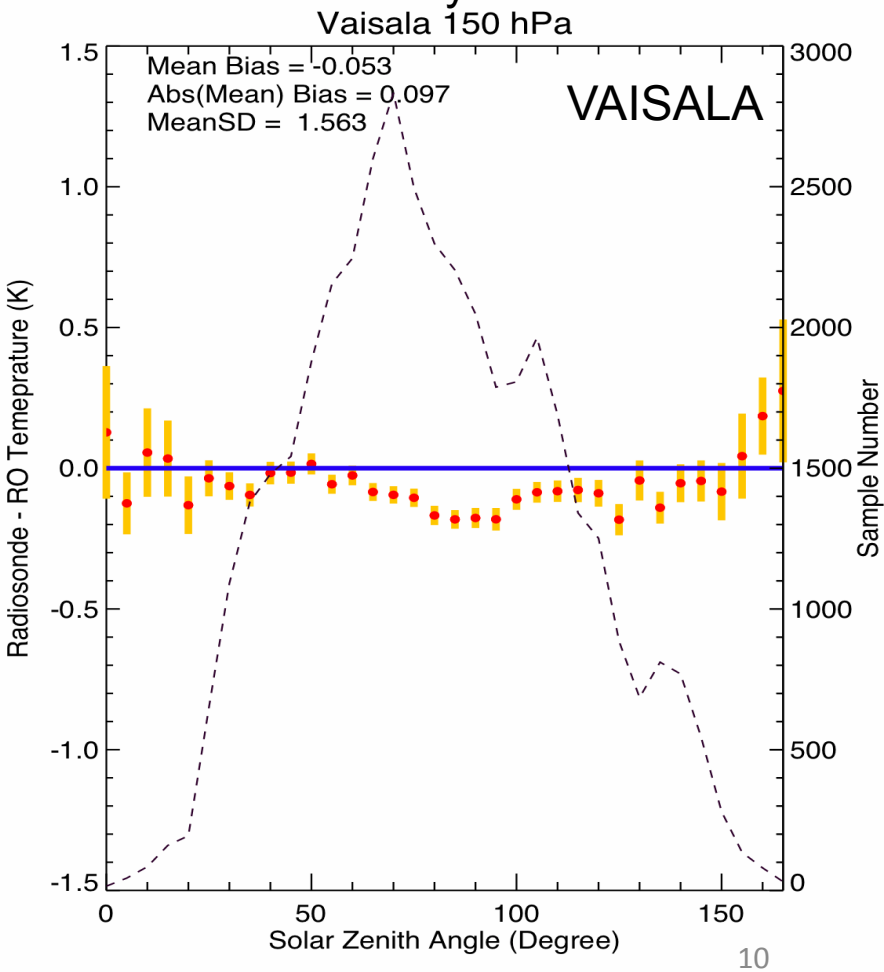


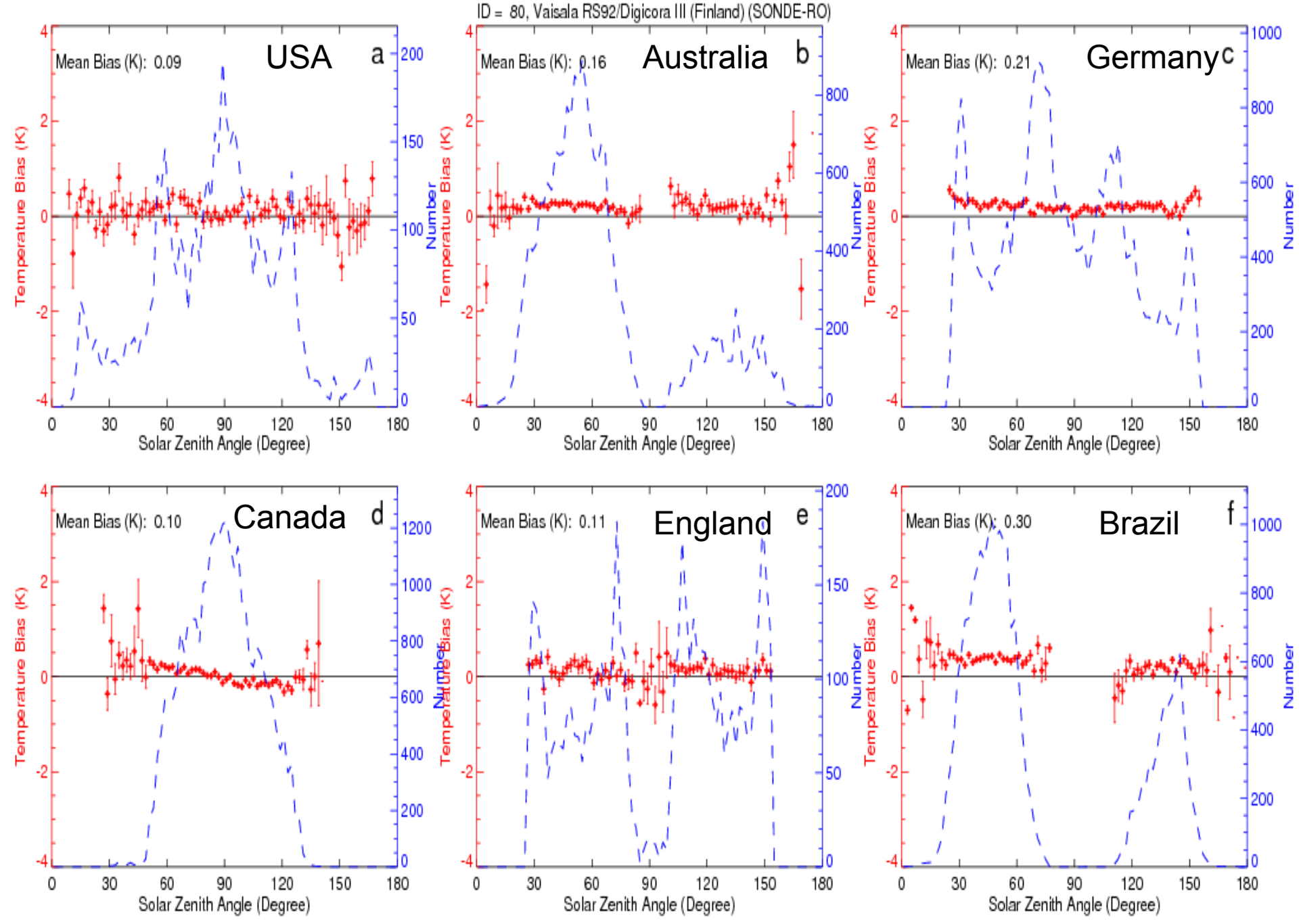
Solar absorptivity = 0.15
IR emissivity = 0.85

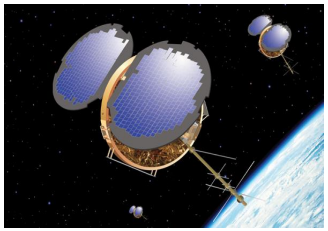
150 hPa



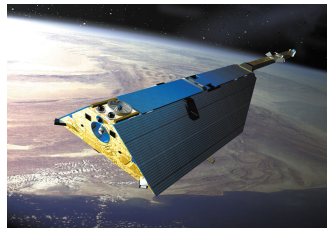
Solar absorptivity = 0.15
IR emissivity = 0.02

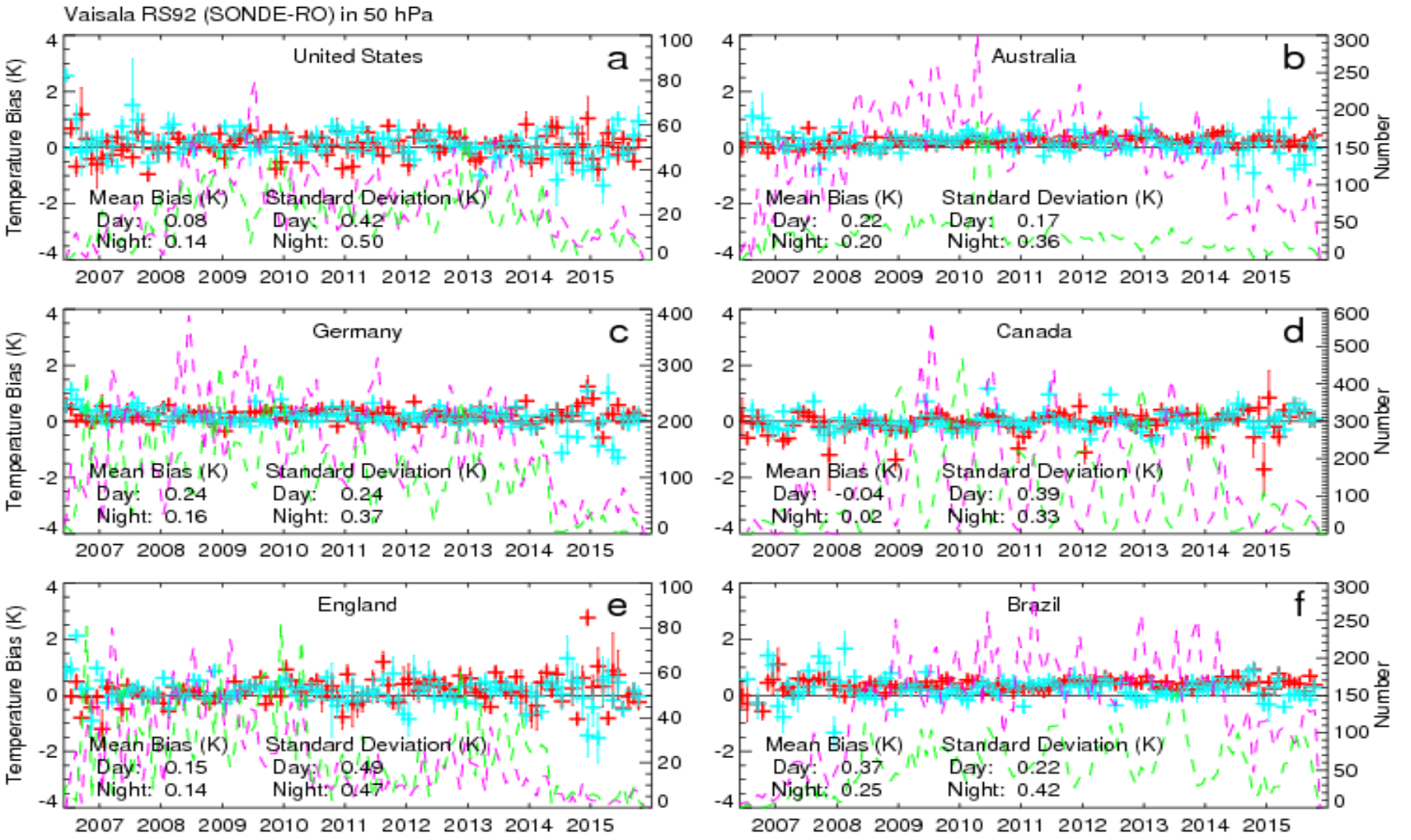



ID = 80, Vaisala RS92/Digicora III (Finland) (SONDE-RO)
Mean Bias (K): 0.09
USA
a
Mean Bias (K): 0.16
Australia
b
Mean Bias (K): 0.21
Germany
c
Mean Bias (K): 0.10
Canada
d
Mean Bias (K): 0.11
England
e
Mean Bias (K): 0.30
Brazil
f
Temperature Bias (K)
Number
Solar Zenith Angle (Degree)

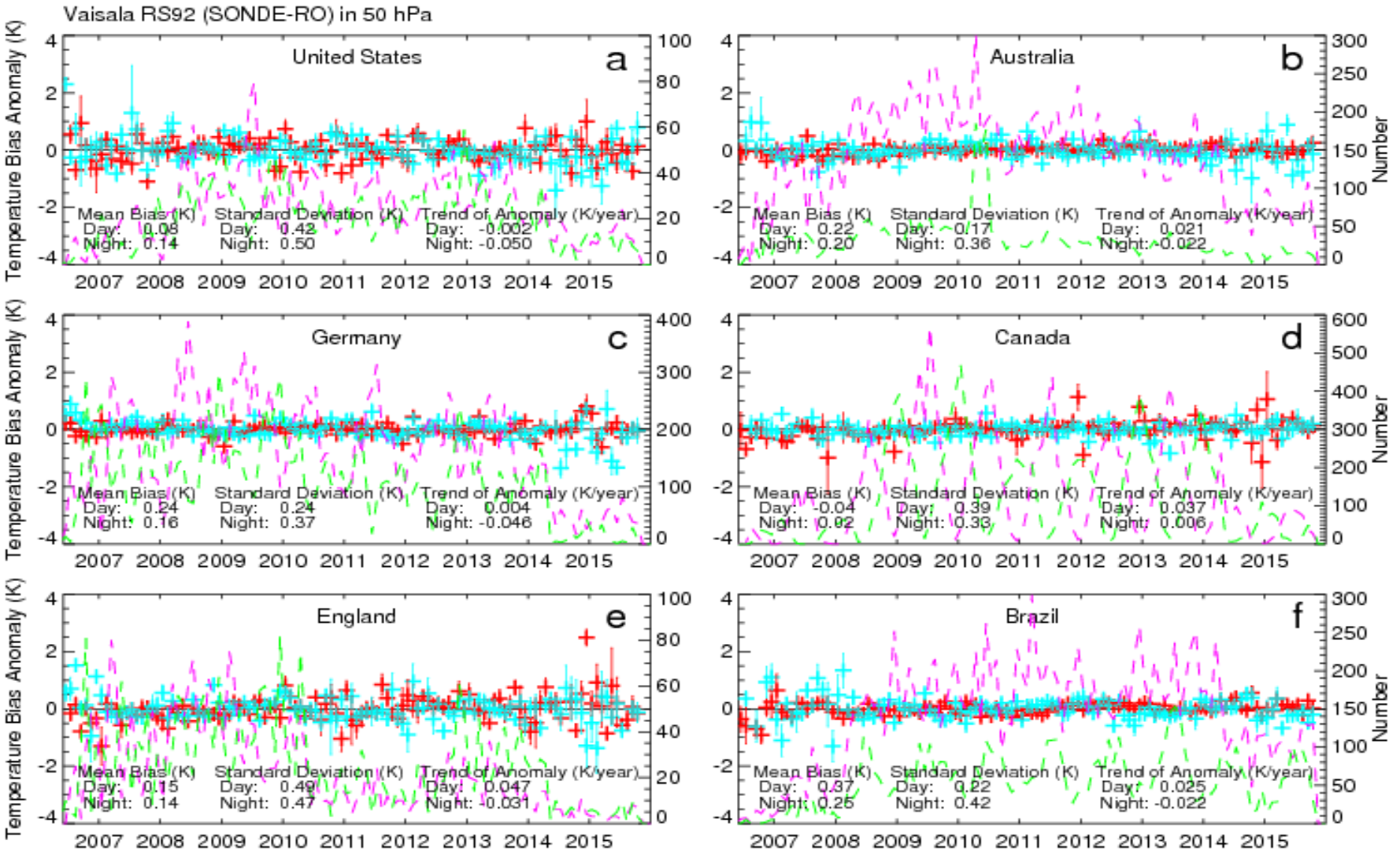


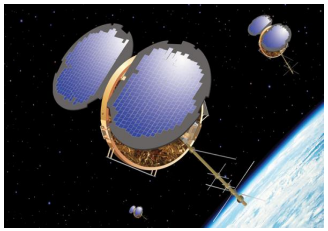
Using RO data to identify Inter-seasonal Temperature Biases Vailsala RS92



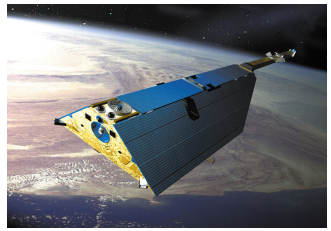


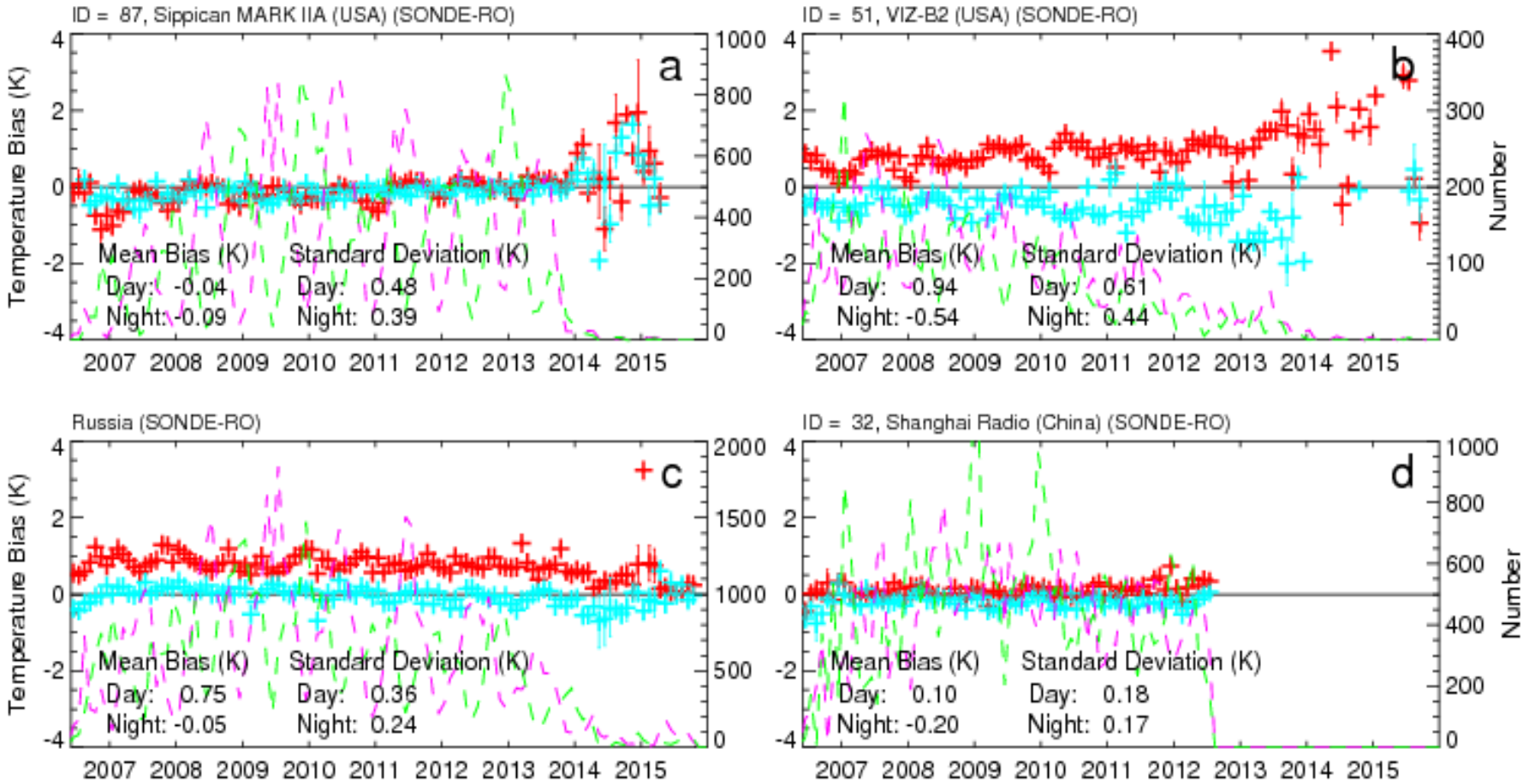
Removing the seasonal cycle
Detection of the drifting of ROAB – RO temperature bias



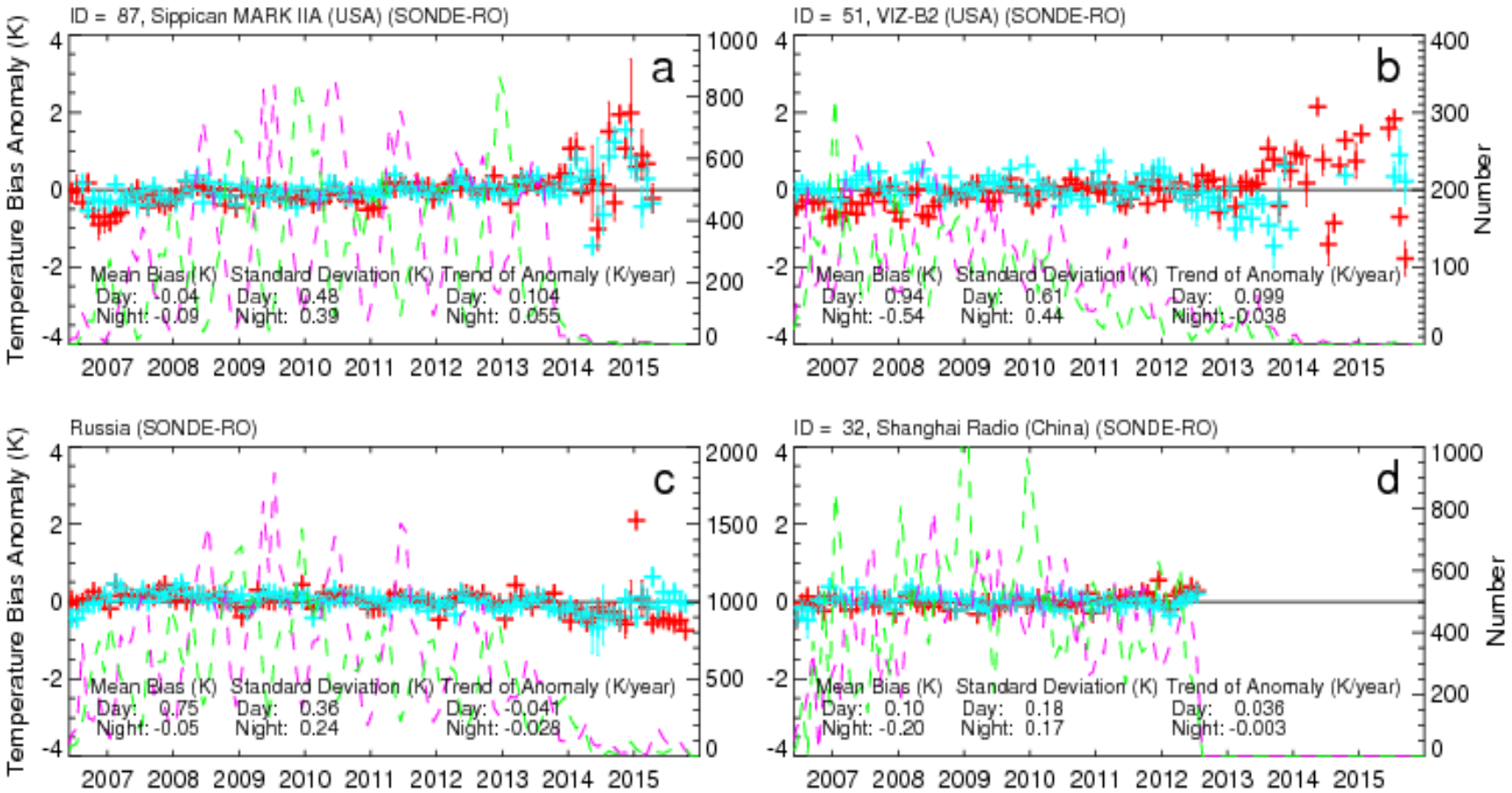


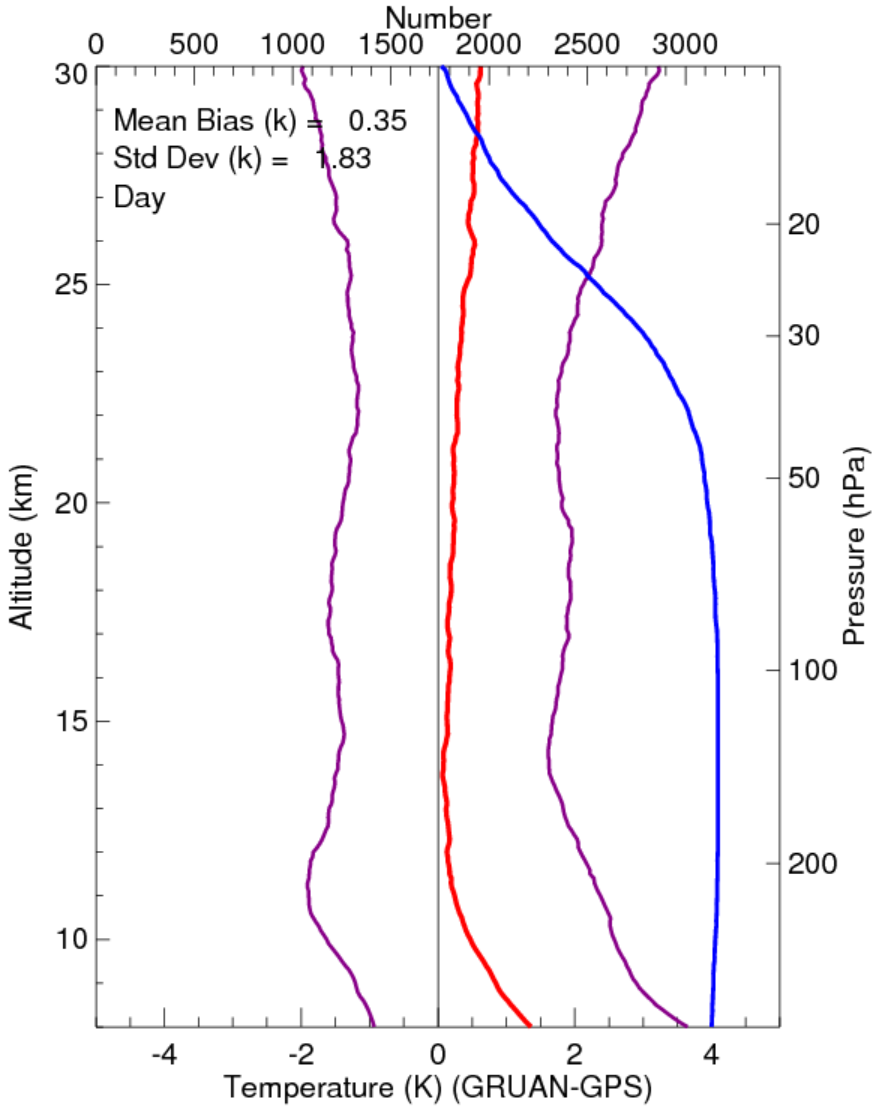
Using RO data to Identify Inter-seasonal Temperature Biases

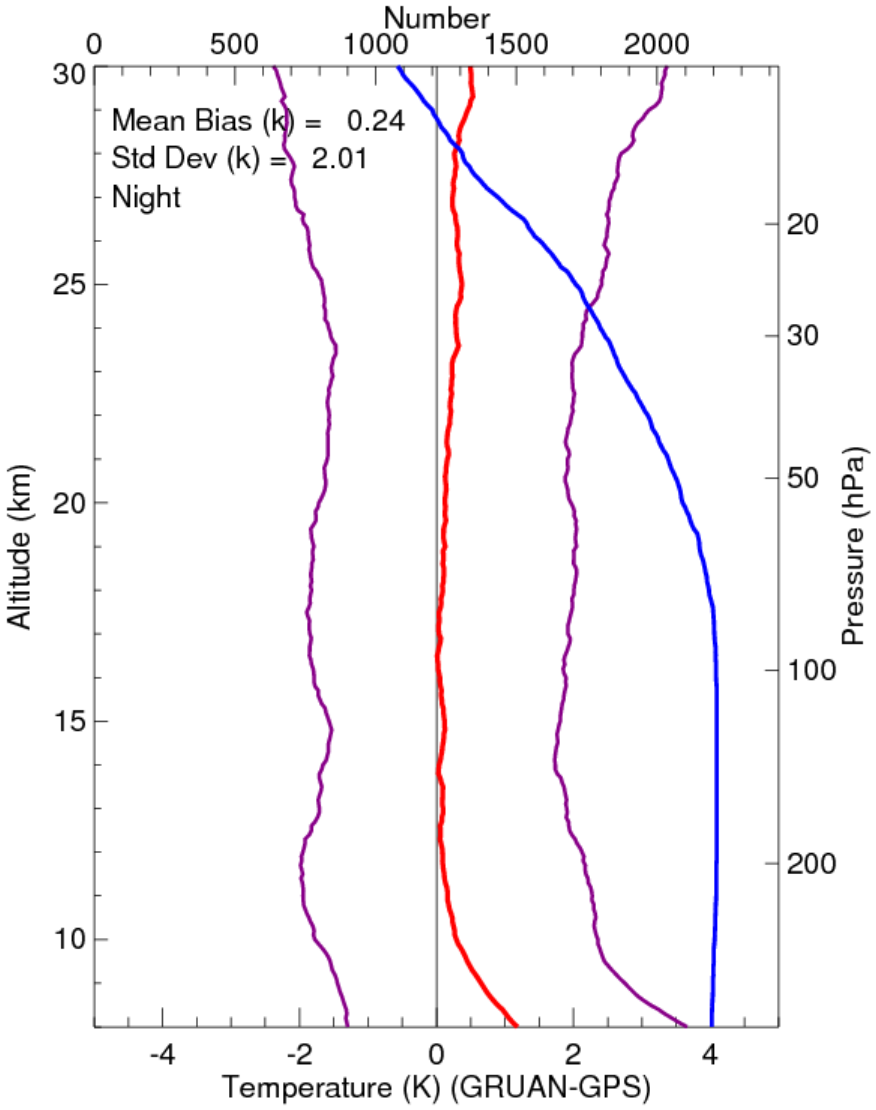




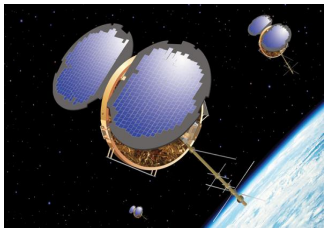
Removing the seasonal cycle
Detection of the drifting of ROAB – RO temperature bias



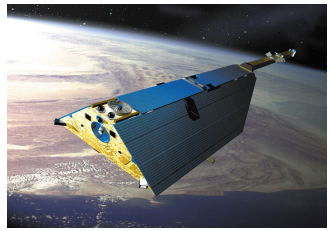




Comparison for Day and Night for all data



Conclusions and Future Work



- **Geo-location independent RO data are useful to assess the quality of radiosonde temperature in the higher troposphere and lower stratosphere**
- **These results suggest that RO temperature observations are extremely useful as benchmark observations for differentiating radiosonde temperature errors resulting from instrument characteristics and identifying the variation of inter-seasonal biases.**
- **MRZ (RUSSIA) contains warm temperature bias during the day but seems consistent with RO temperature during the night**
- **COSMIC-2 is coming**