Characterization of radiosonde temperature biases in the upper troposphere and lower stratosphere using RO data: Assessment of Vaisala RS92, GRUAN RS92, and RS41

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UCAR/COSMIC

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Motivation:

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

Challenges and Objective

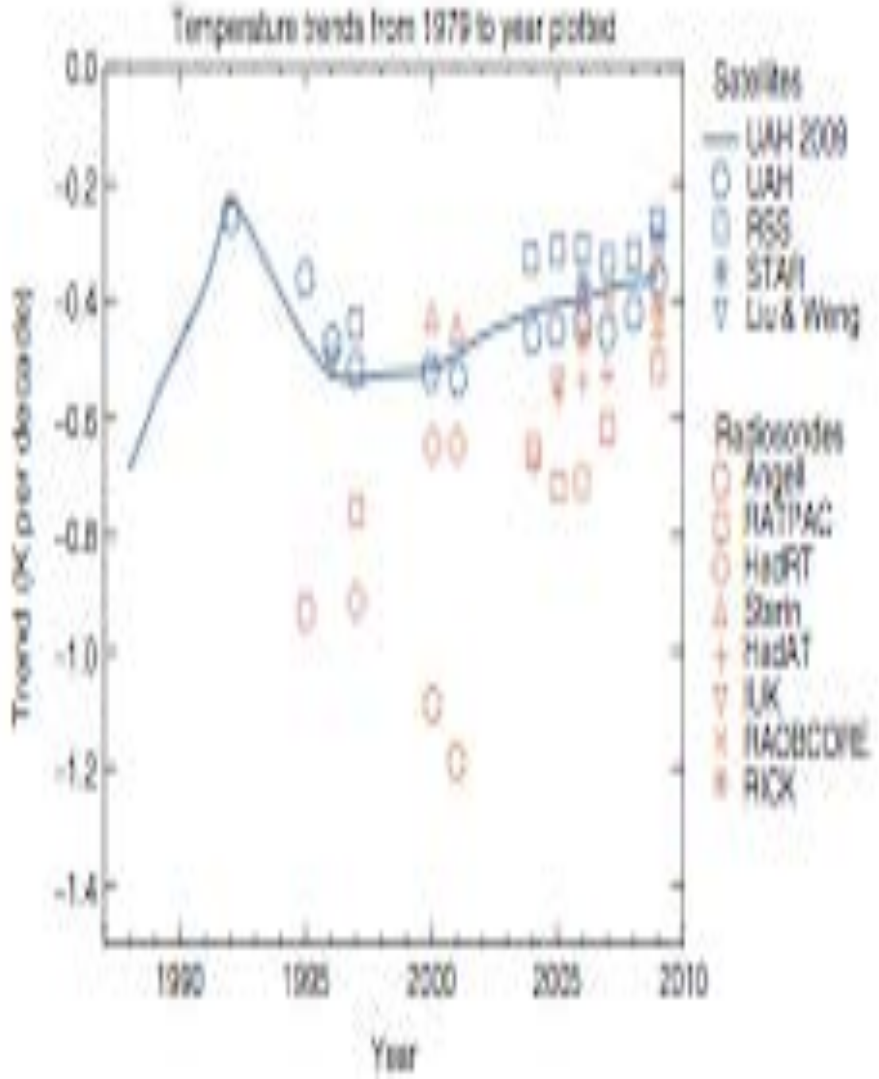
-Radiosonde sensor characteristics can be affected by the changing environment, its measurement accuracy varies considerably in times and locations for different sensor types

- 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.

Outlines

1. Identify global RAOB temperature biases in the UTLS using RO data

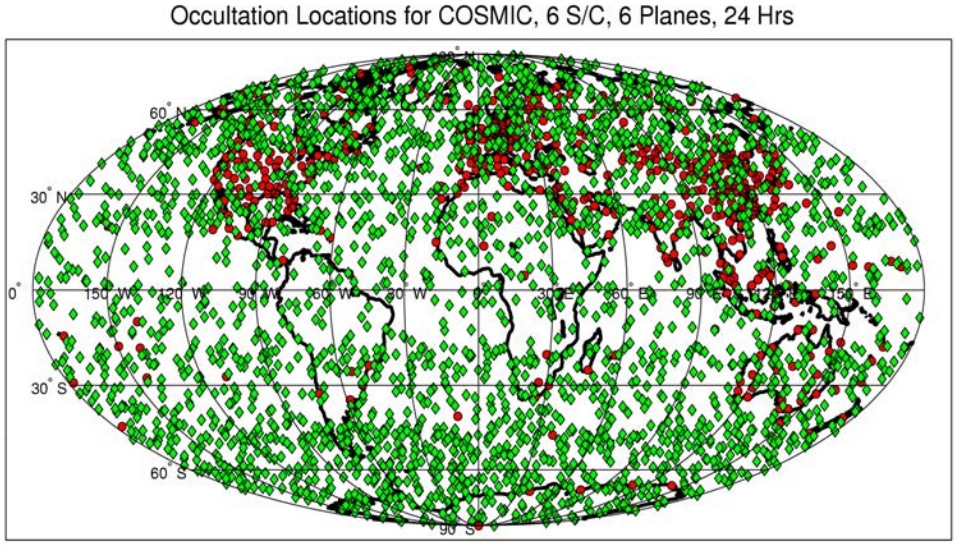
2. Characterize RS92 and RS41 RAOB temperature biases using RO data

1. Identify global RAOB temperature biases in the UTLS using RO data

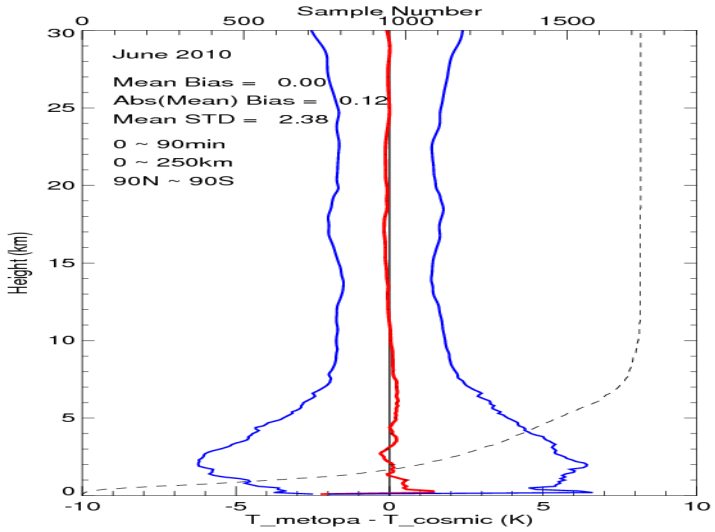
RO data for climate research

- **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)**

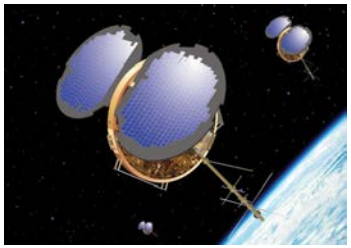
Using FM3-FM4 pairs in early mission



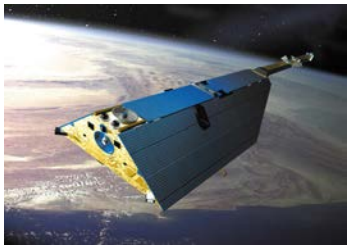
COSMIC

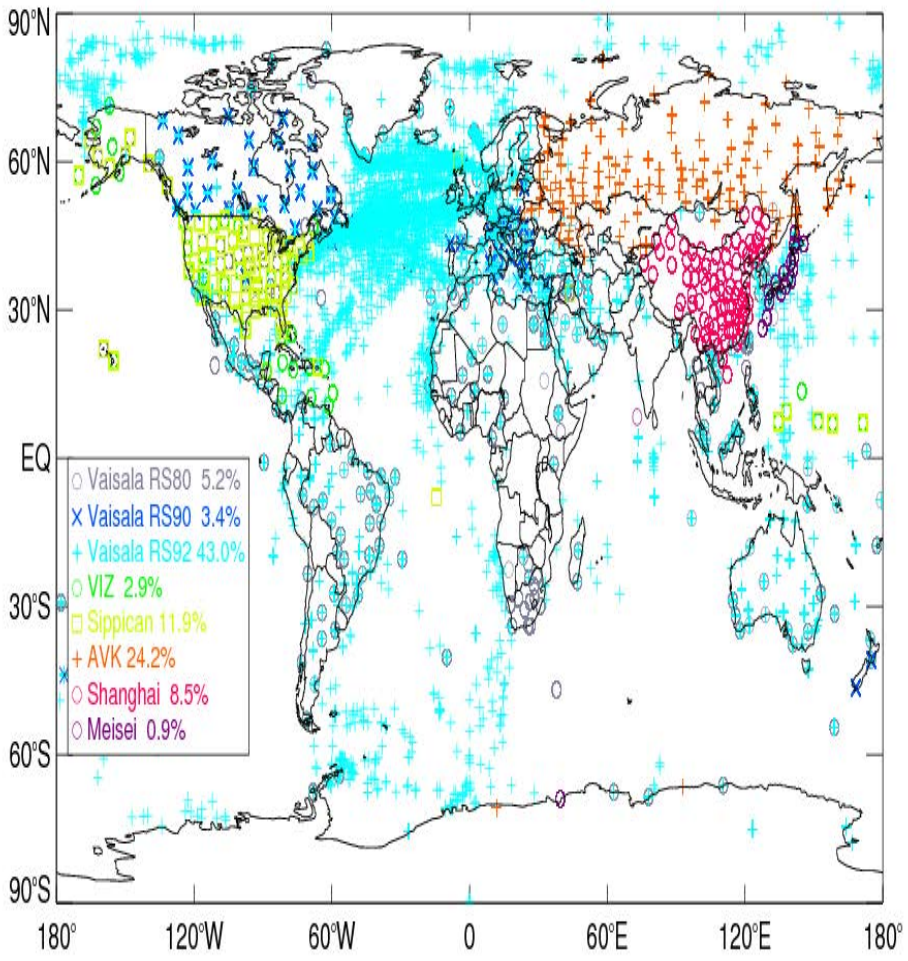


Metop-A – COSMIC



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





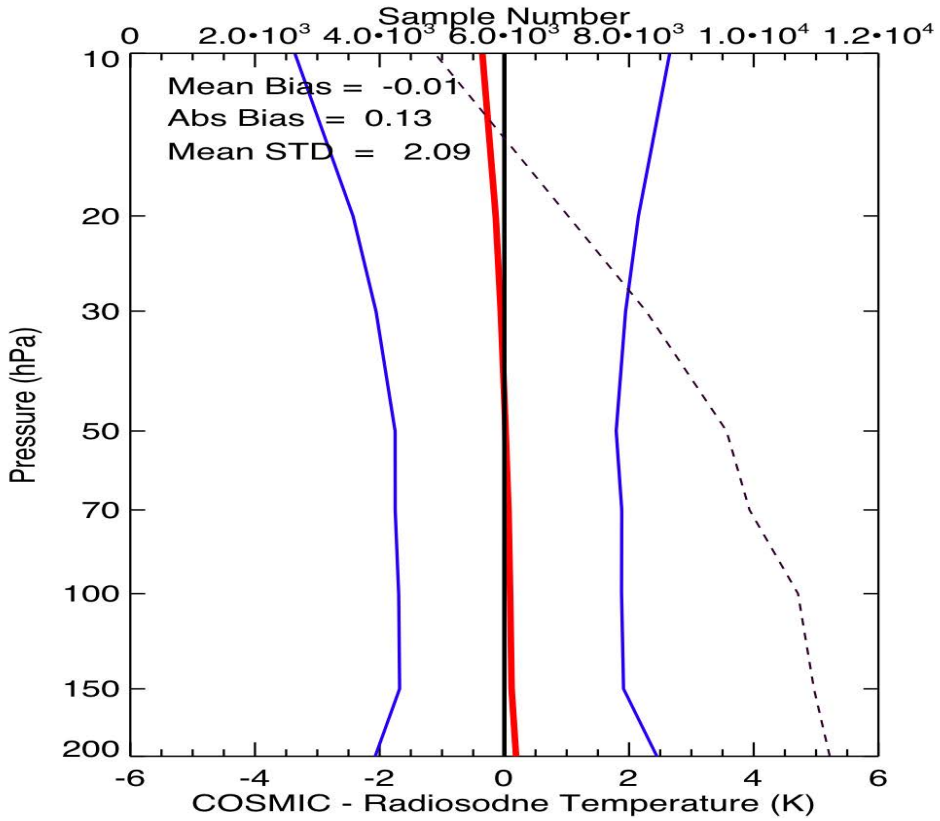
Radiosodne data DS353.4 from NCAR
- originally acquired from NCEP.
- contains the original data values transmitted by stations
- no radiative or other corrections from NCEP are included in this dataset
He et al., (2009 GRL)

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/-B and radiosonde profiles
< 200 km
< 3 hrs

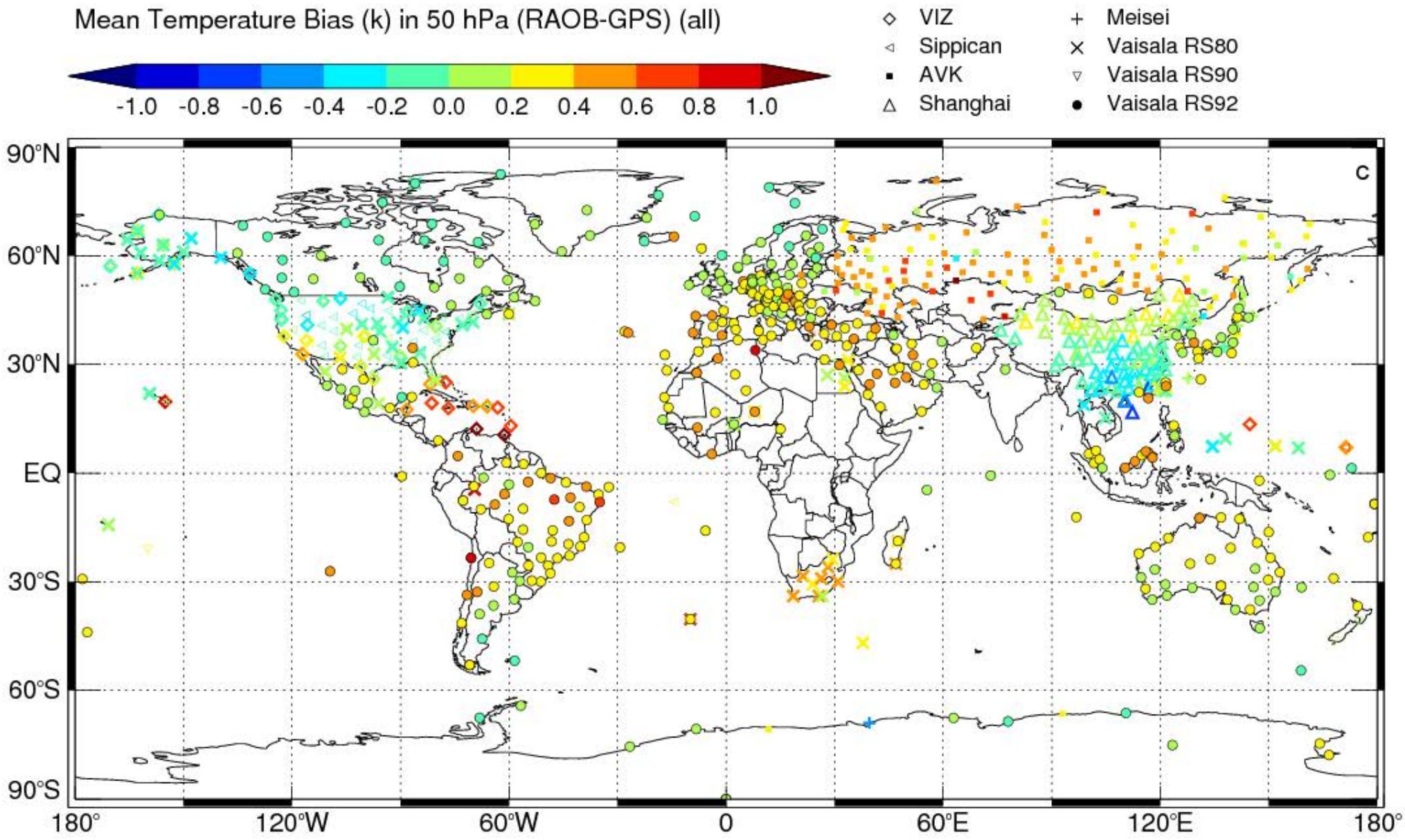
Check the accuracy of the RO temperature

RS 92 vs. COSMIC derived temperature profiles in 2007

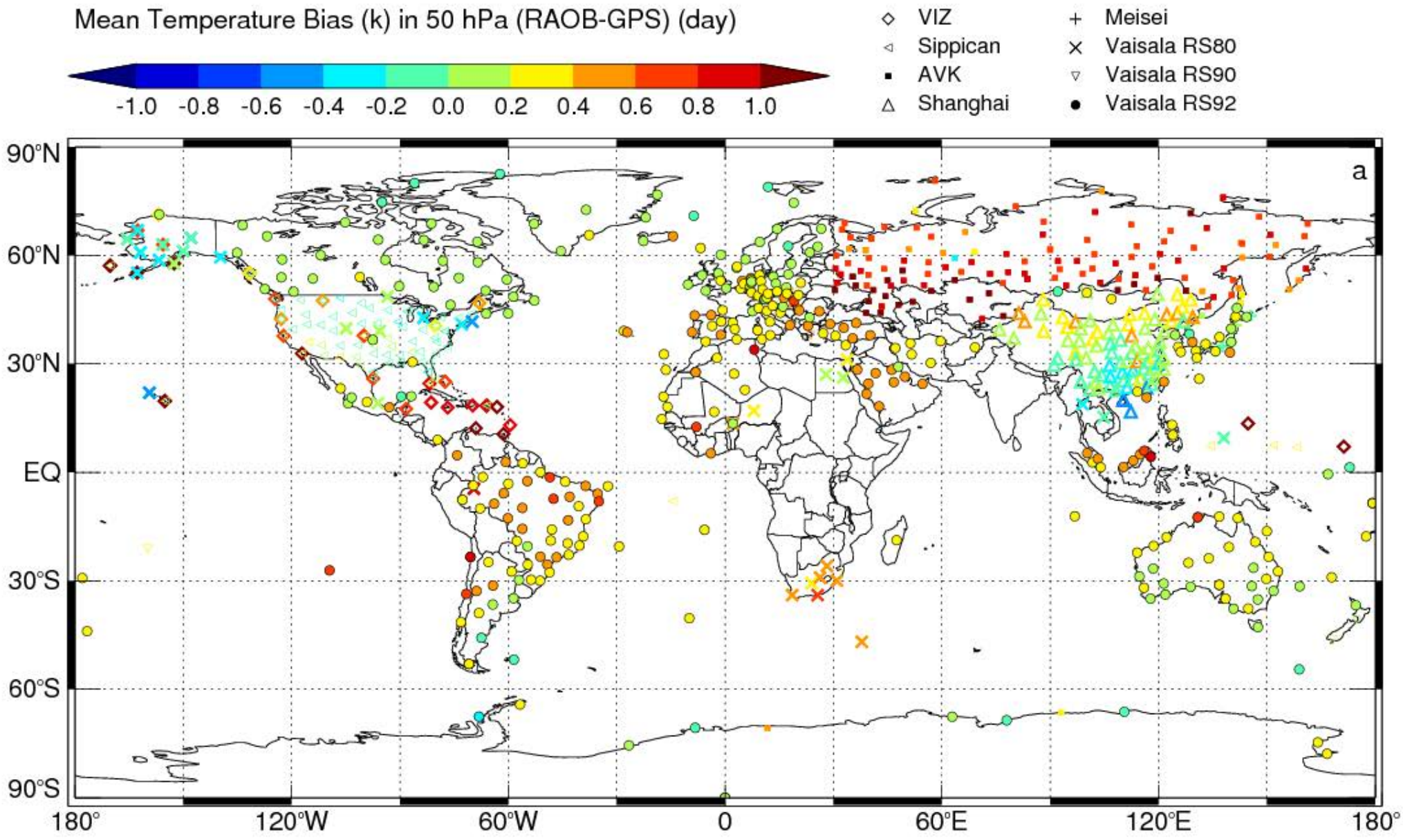


Ho, S.-P., Ying-Hwa Kuo, William Schreiner, Xinjia Zhou (2010), Using SI-traceable Global Positioning System Radio Occultation Measurements for Climate Monitoring [In "States of the Climate in 2009]. *Bul. Amer. Meteor. Sci.*, **91** (7).

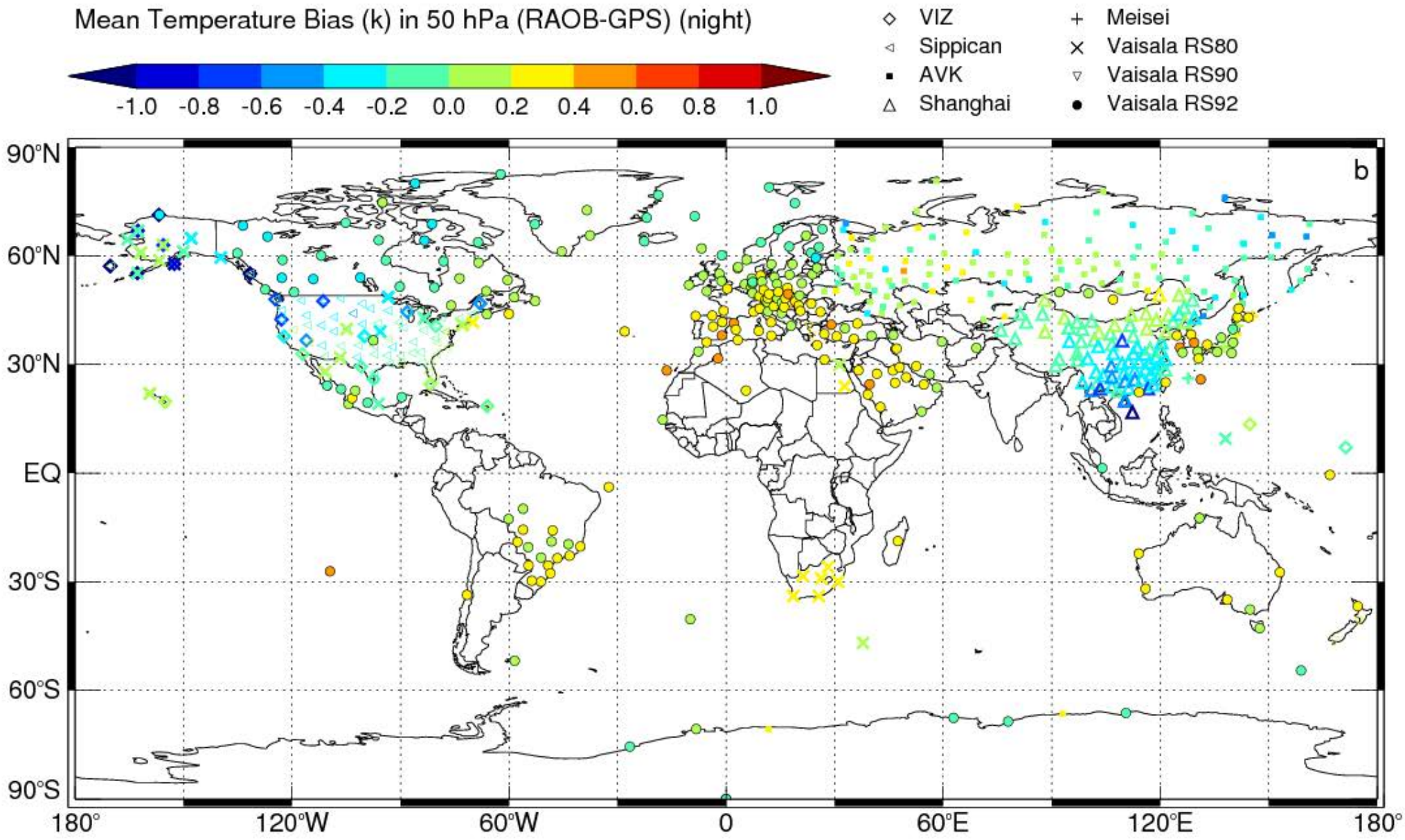
Day time and night time

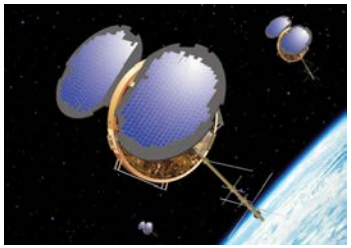


Day time

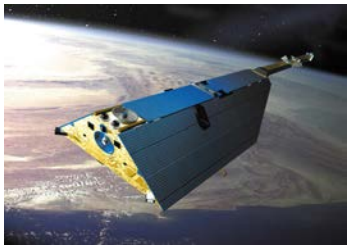

Mean Temperature Bias (k) in 50 hPa (RAOB-GPS) (day)
-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0
VIZ
Sippican
AVK
Shanghai
Meisei
Vaisala RS80
Vaisala RS90
Vaisala RS92
a
90°N
60°N
30°N
EQ
30°S
60°S
90°S
180°
120°W
60°W
0
60°E
120°E
180°

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°



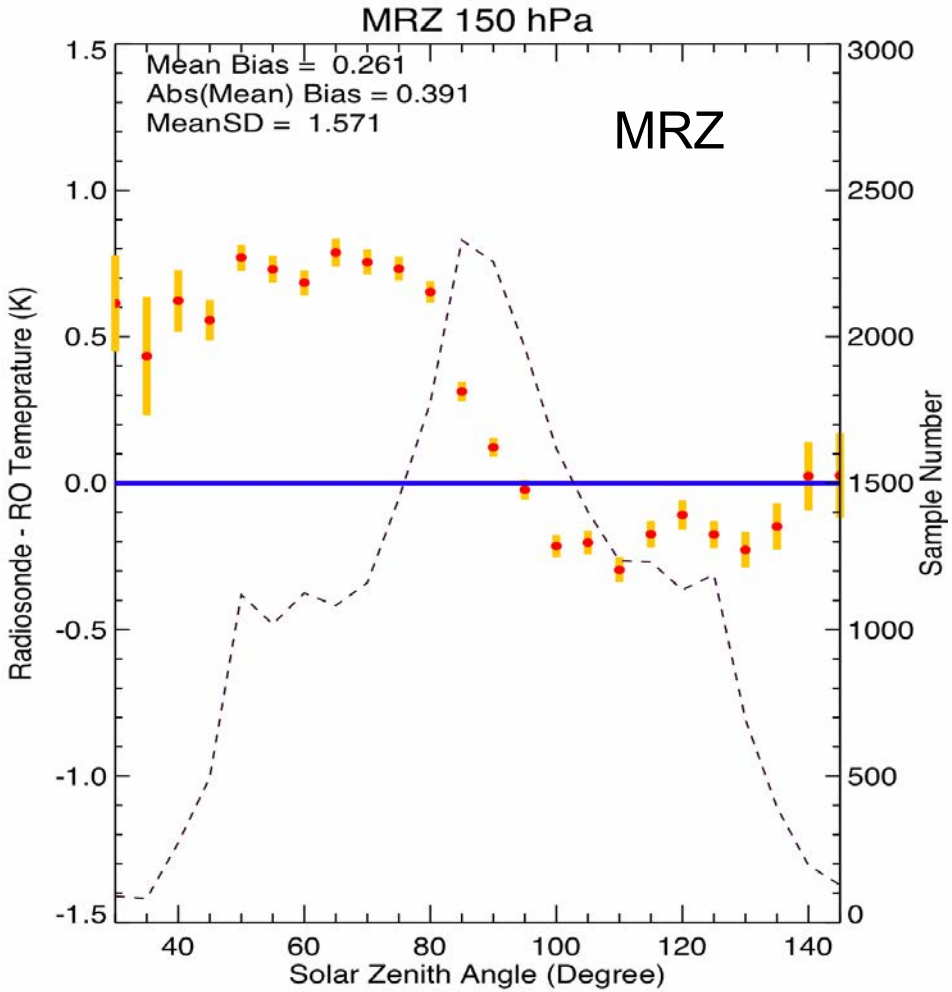
Using RO data to Identify Diurnal variation of Radiosonde Temperature Anomalies

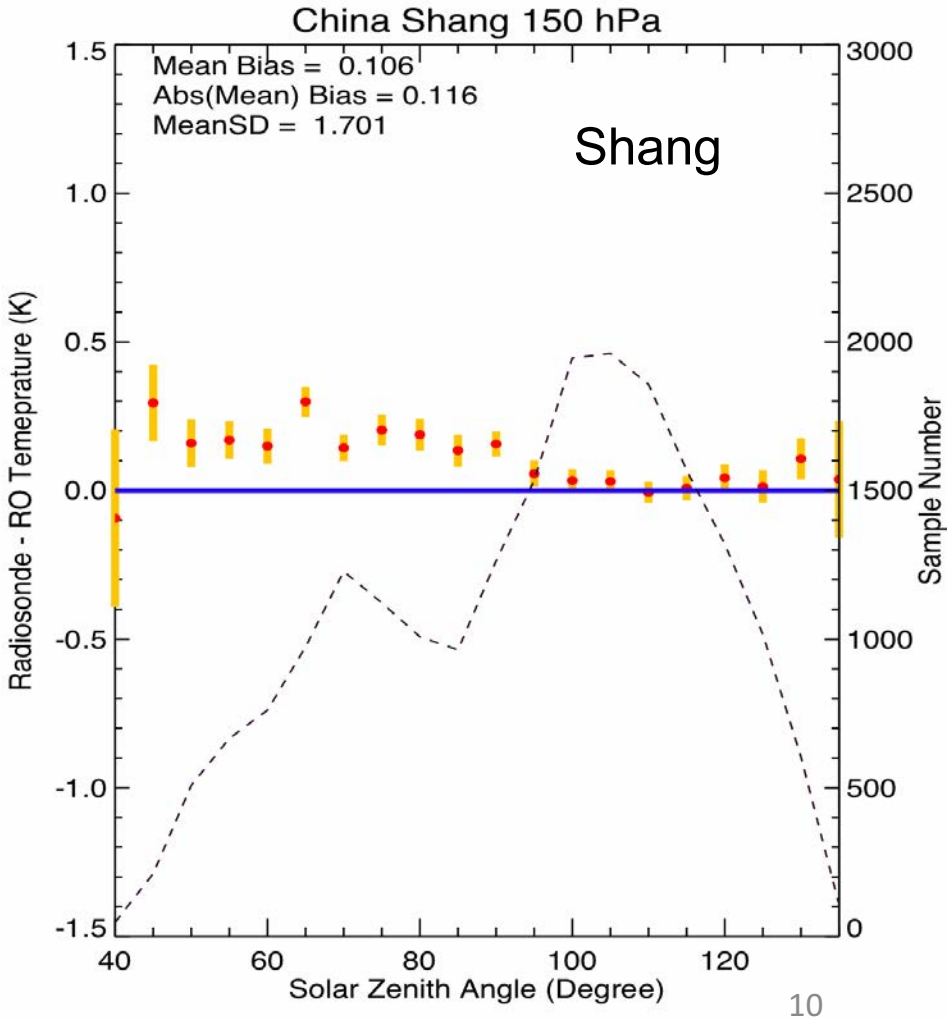


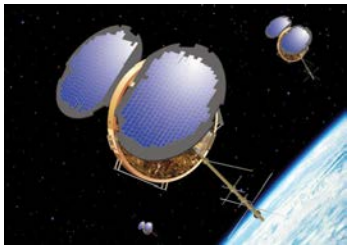
Solar absorptivity = 0.2
IR emissivity = 0.04

150 hPa

Solar absorptivity = 0.15
IR emissivity = 0.85







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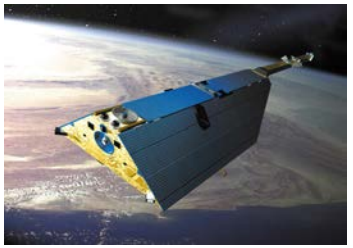
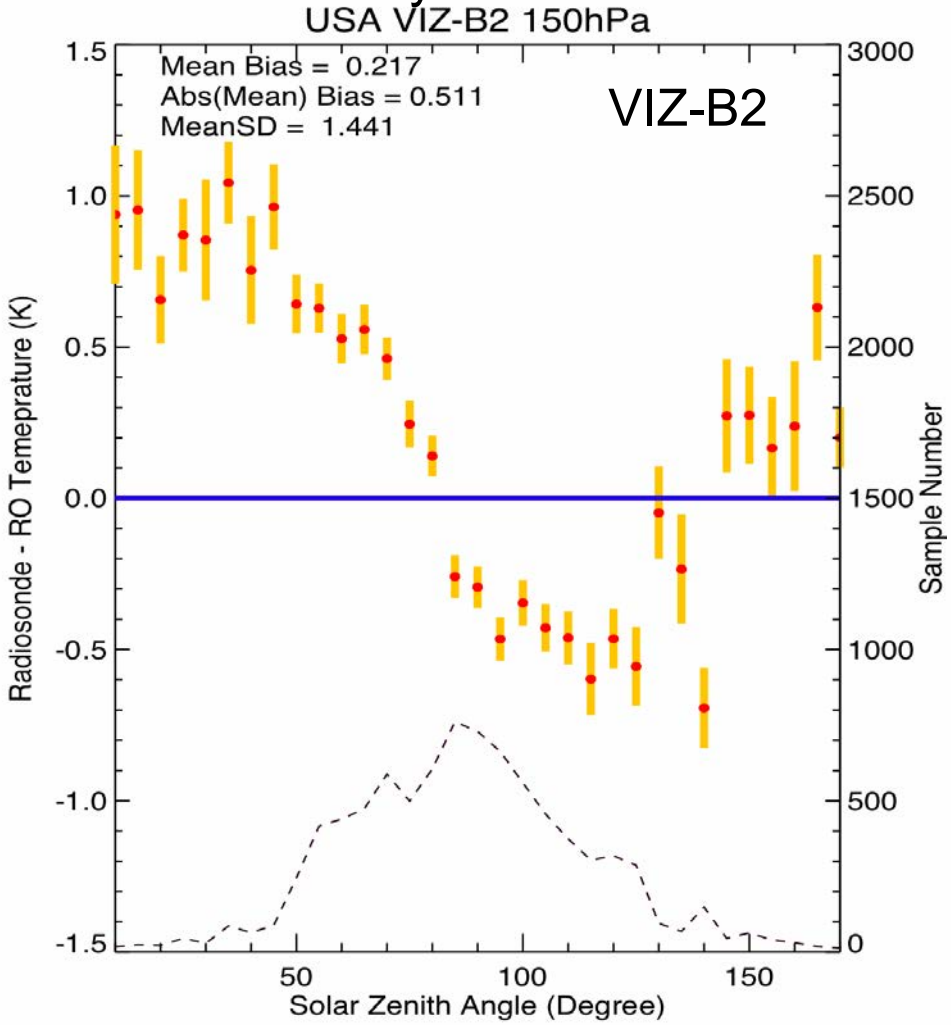
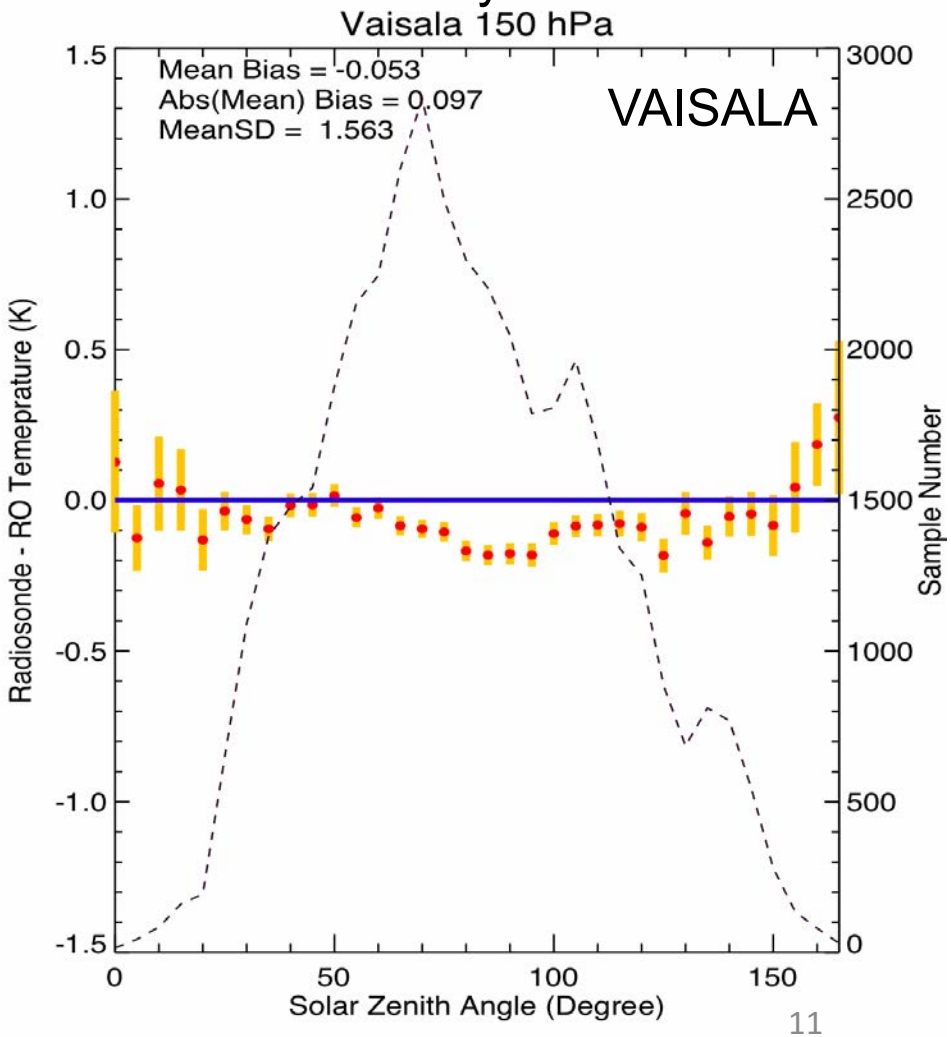


Solar absorptivity = 0.15
IR emissivity = 0.85

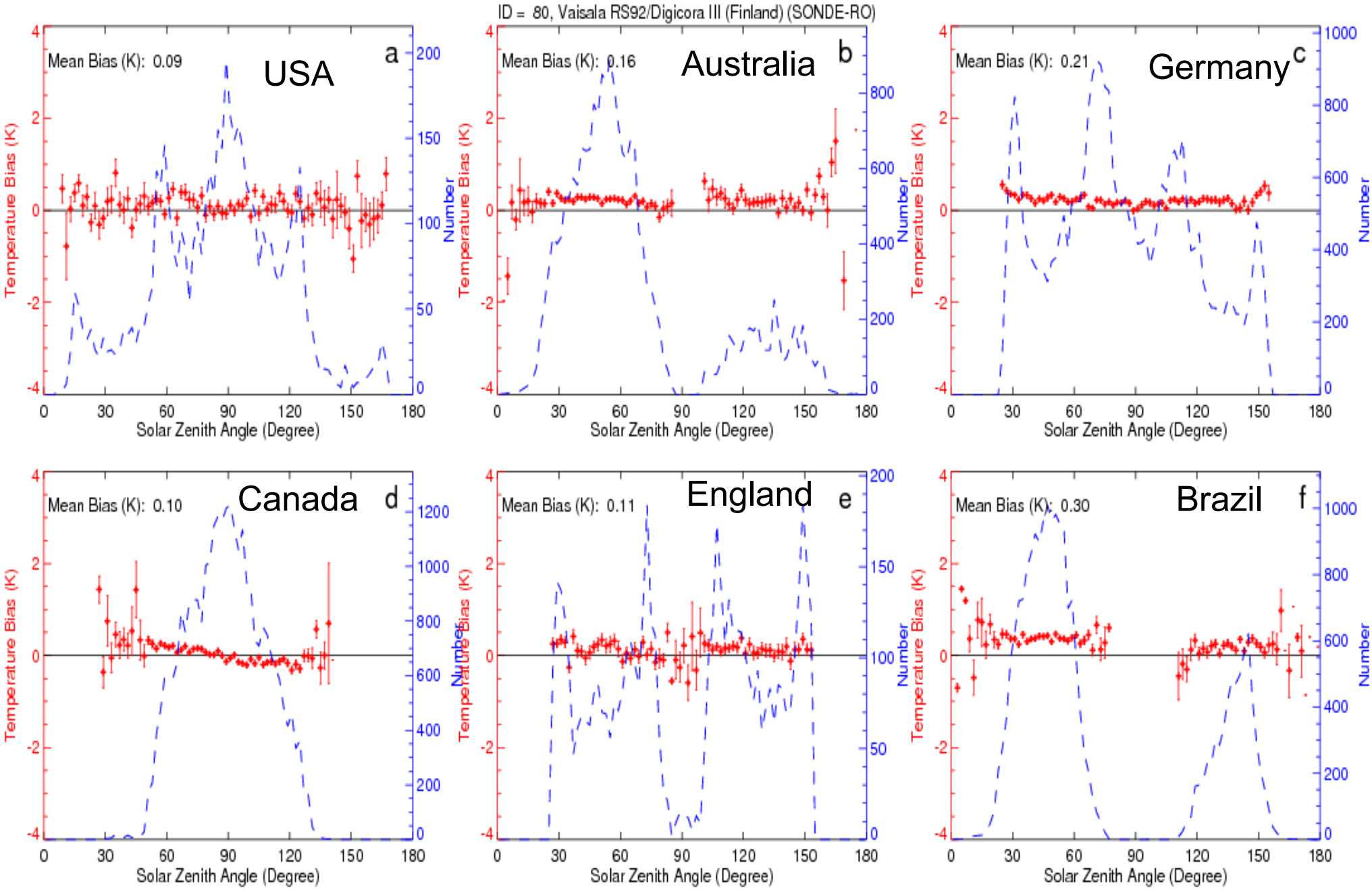
150 hPa

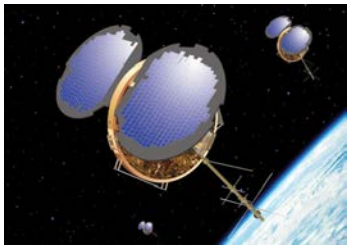


Solar absorptivity = 0.15
IR emissivity = 0.02

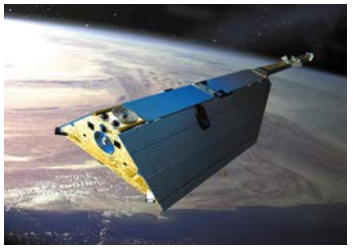


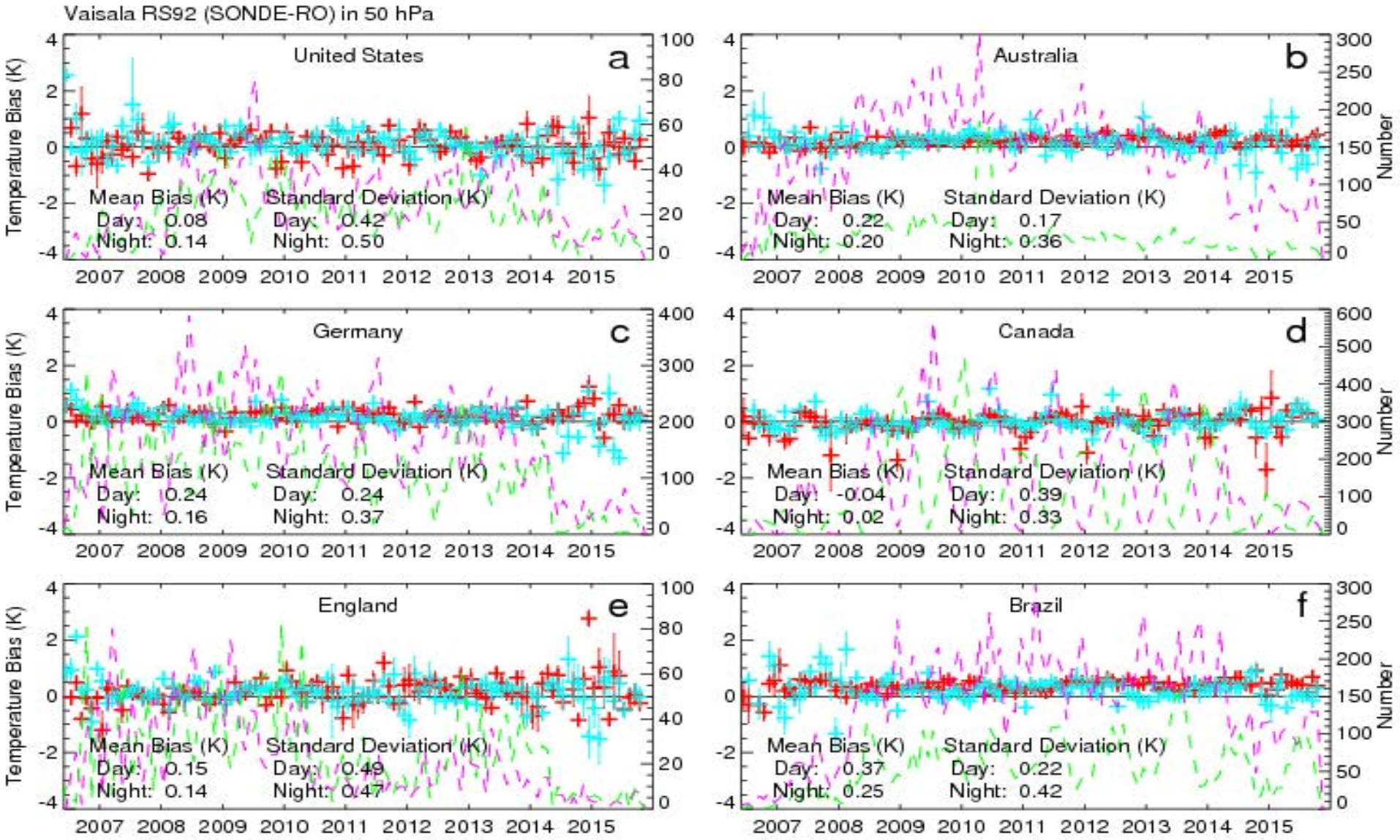
The RS92 temperature biases over different countries may vary depending on when and how the radiative corrections are applied.

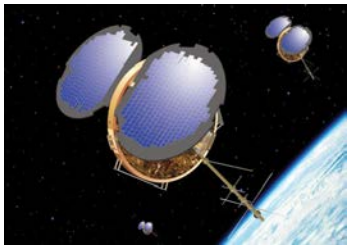




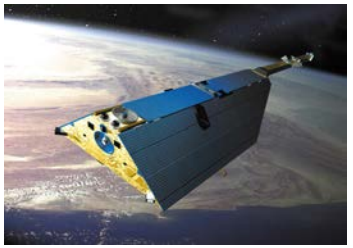
Using RO data to identify Inter-seasonal Temperature Biases Vailsala RS92

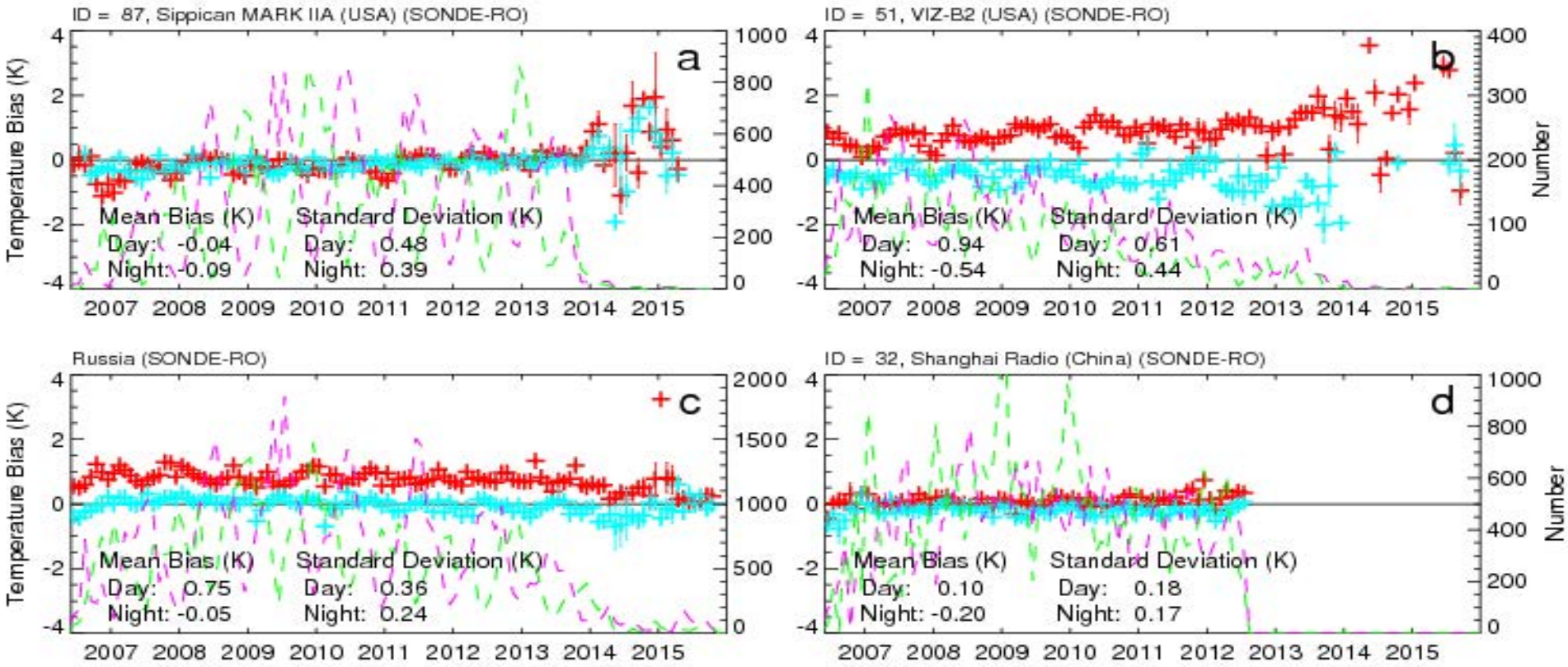






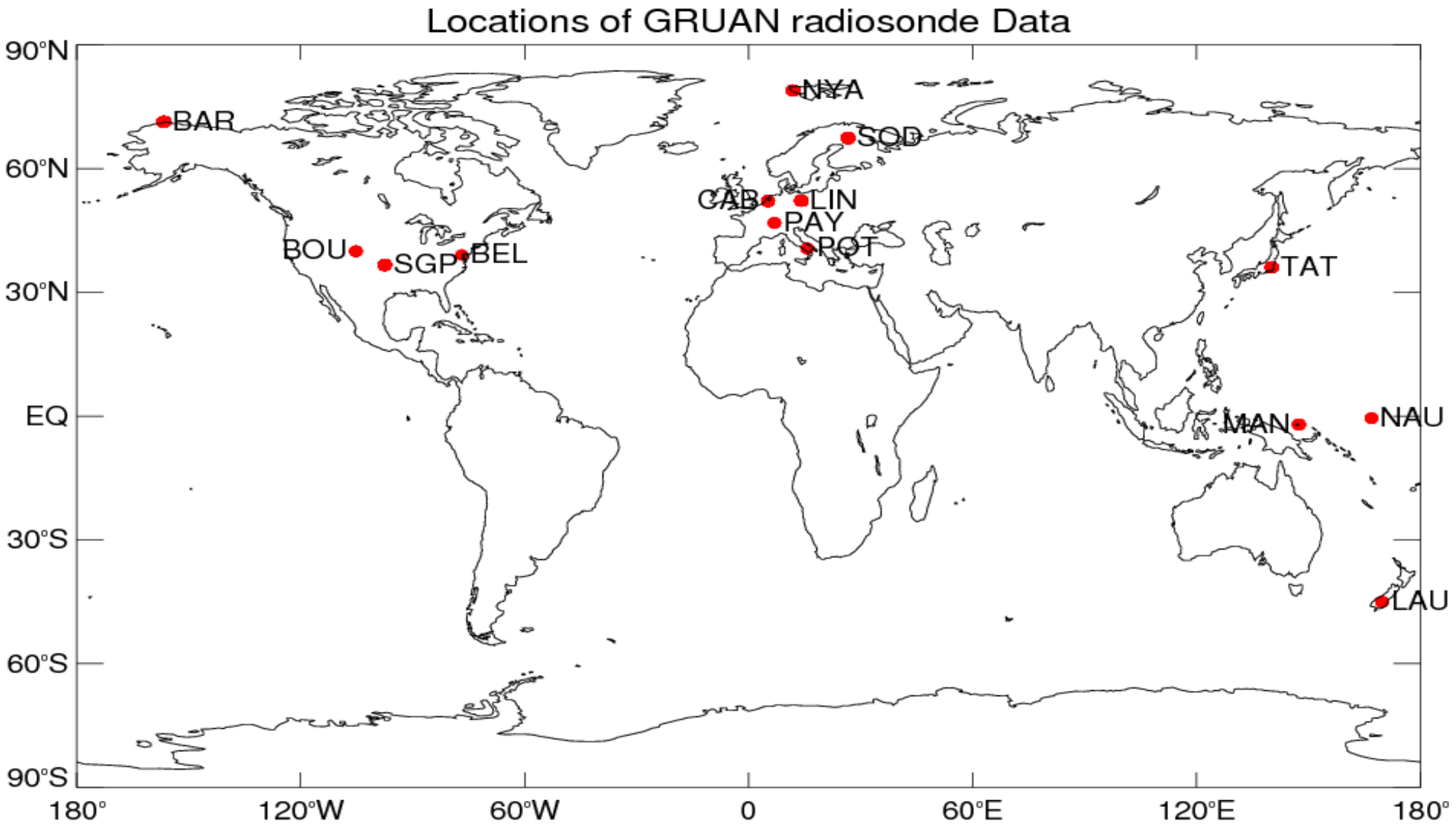
Using RO data to Identify Inter-seasonal Temperature Biases



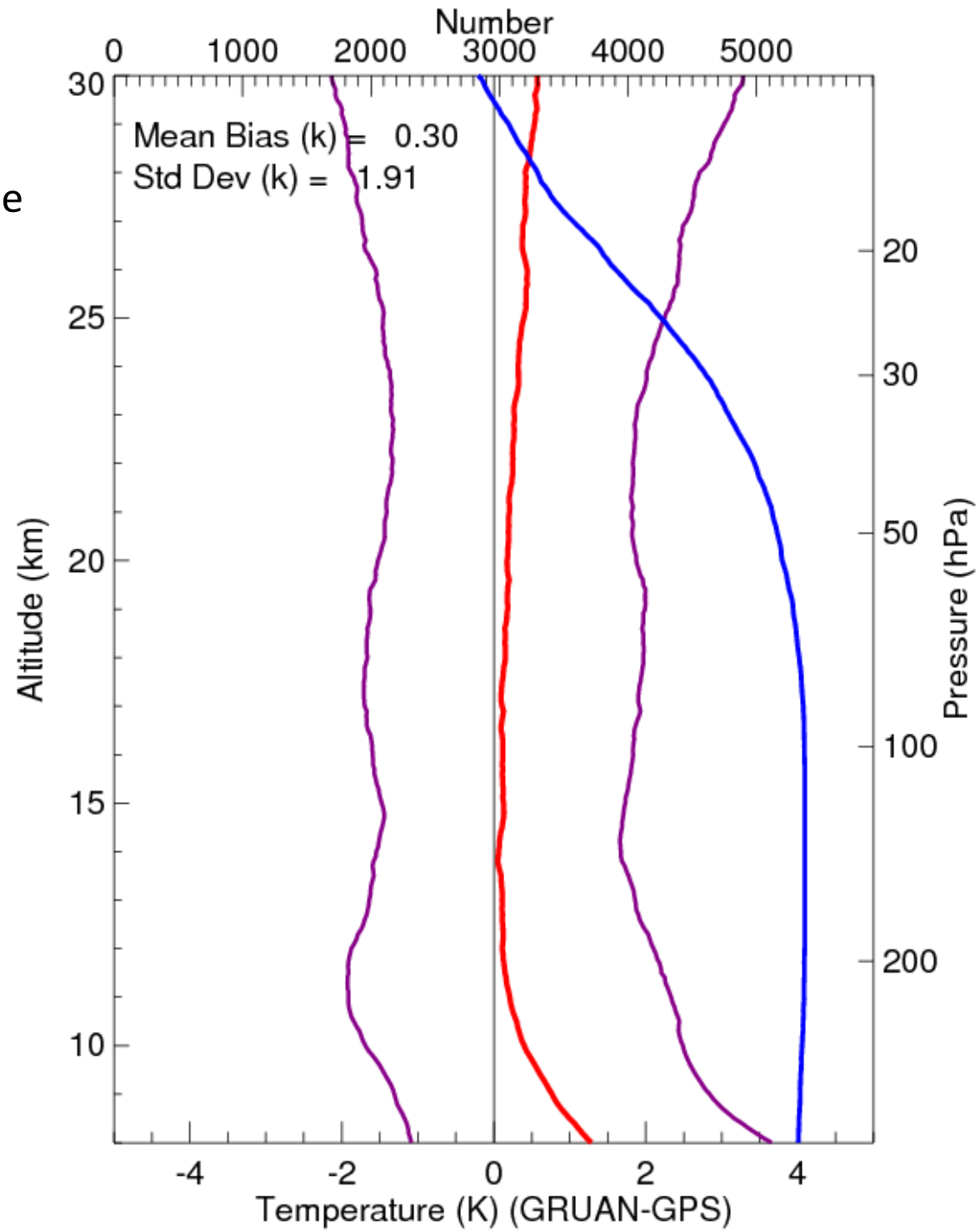


Ho, S. -P., L. Peng, and H. Voemel, 2017: Characterization of the long-term radiosonde temperature biases in the upper troposphere and lower stratosphere using COSMIC and Metop-A/GRAS data from 2006 to 2014. *Atmospheric Chemistry and Physics*, **17**, 4493-4511, doi:10.5194/acp-17-4493-2017.

2. Characterize GRUAN RS92 and RS41 RAOB temperature biases using RO data

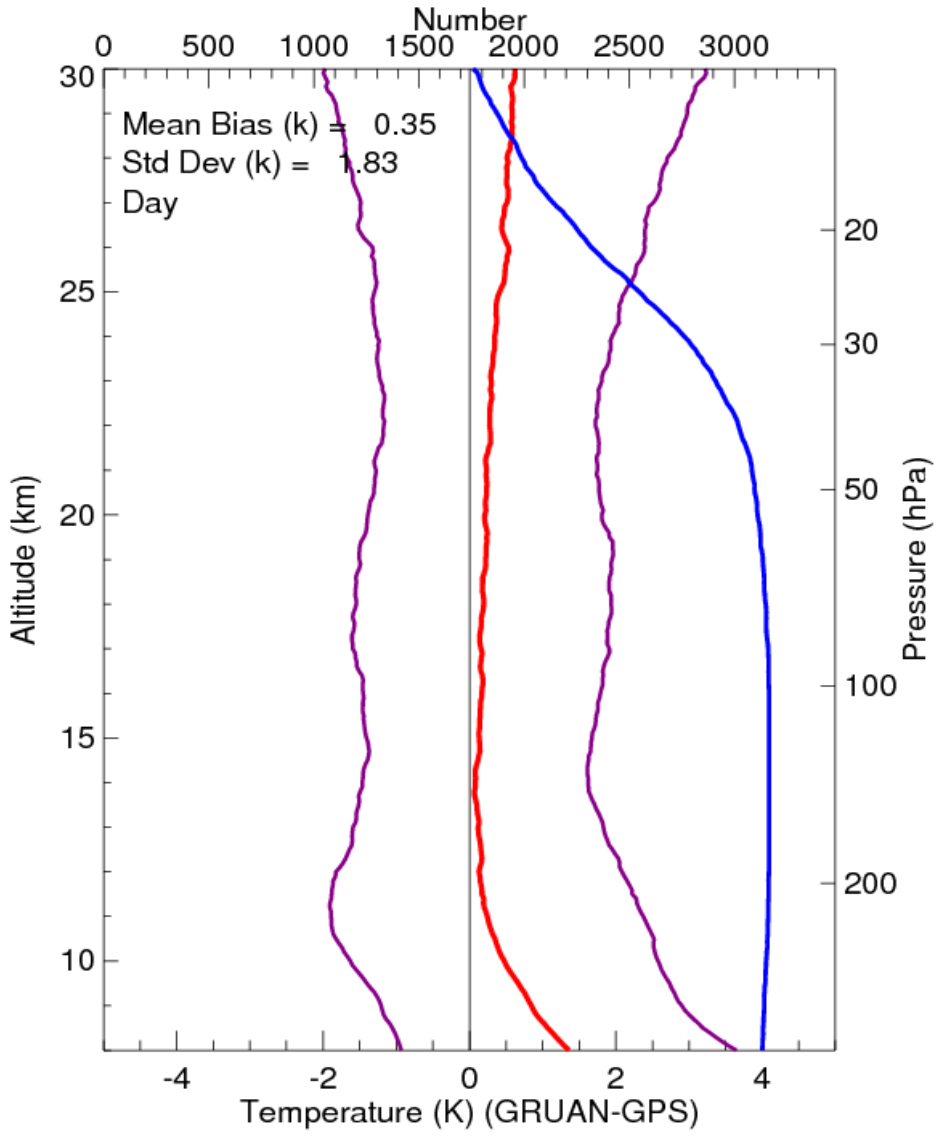


The GRUAN radiosonde temperatures and COSMIC dry temperatures are interpolated into a common 100-meter vertical grid.

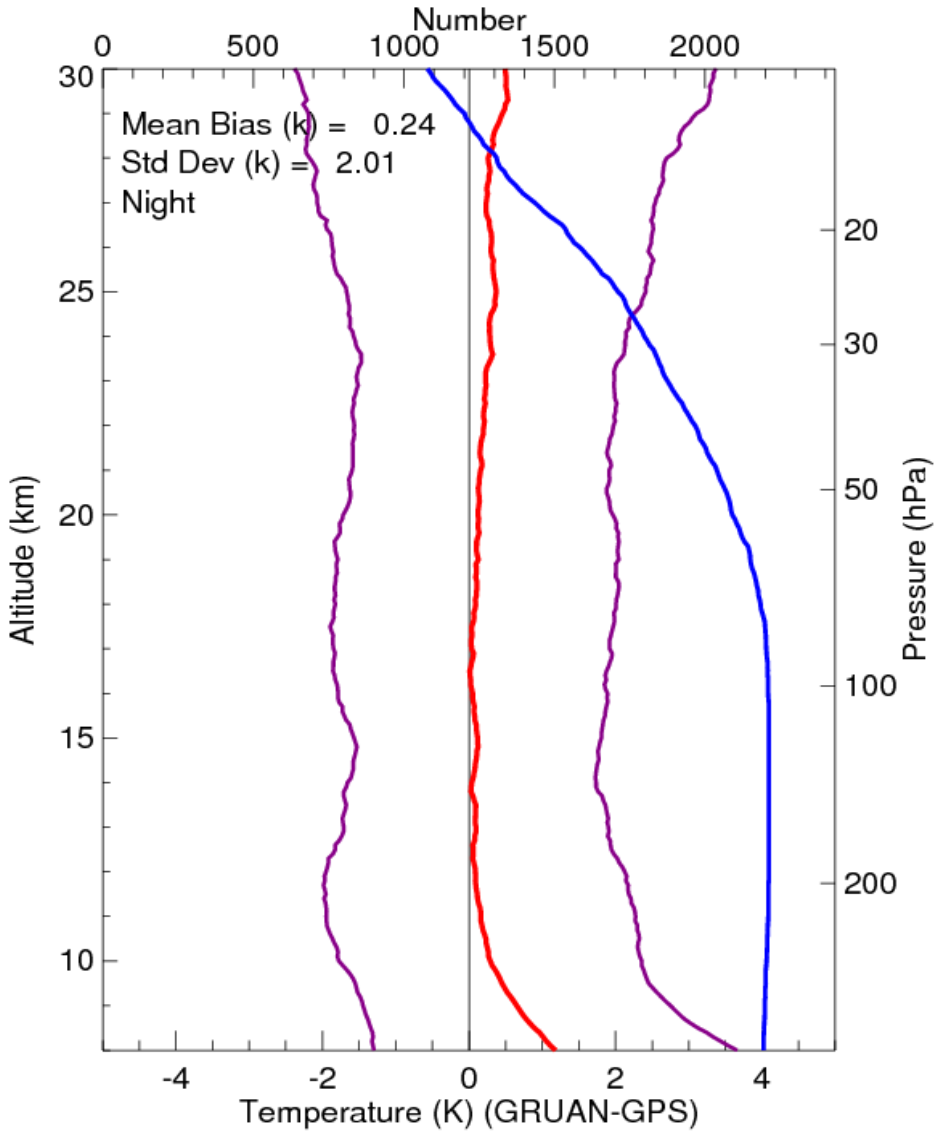


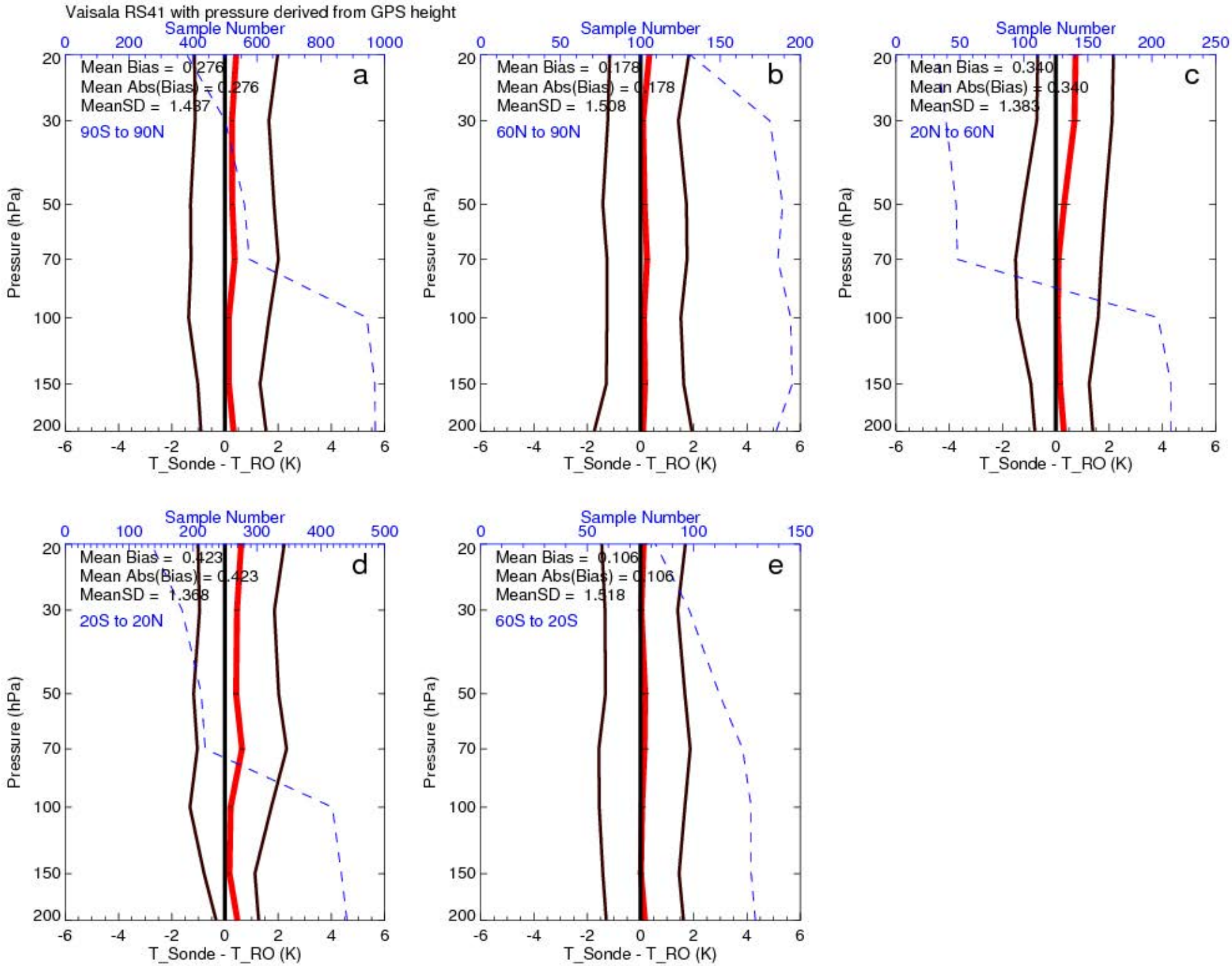
Mean GRUAN pressure

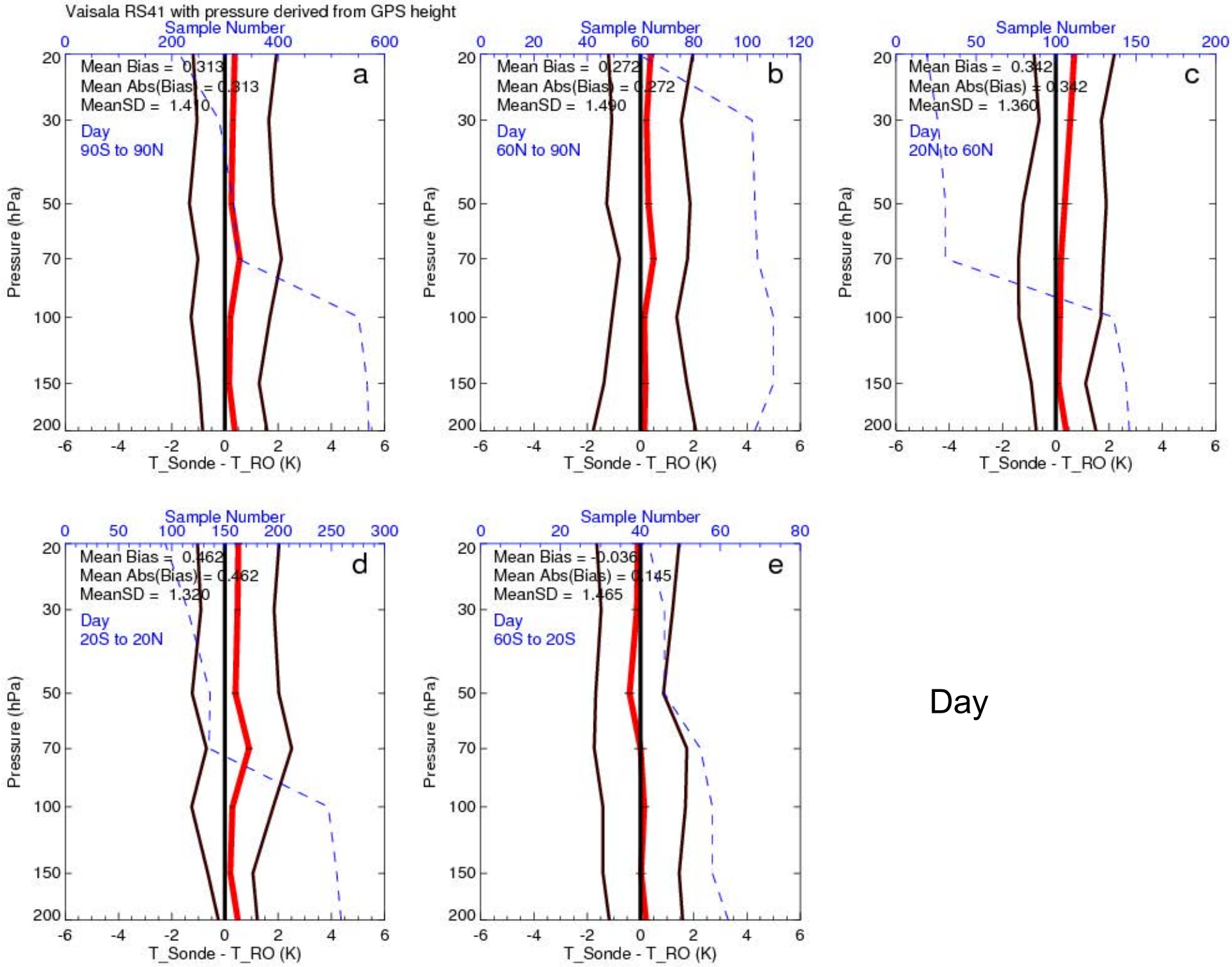
Daytime

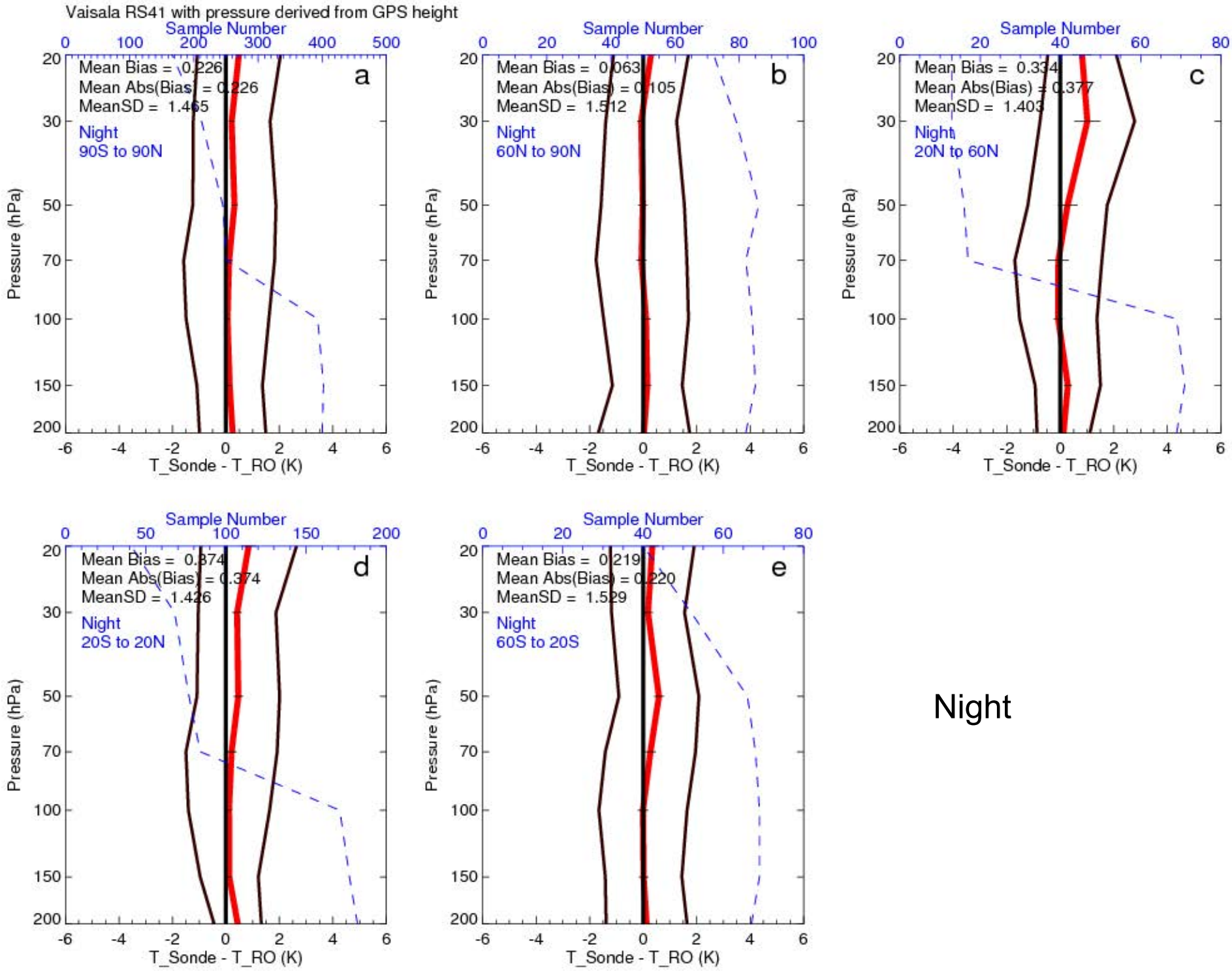


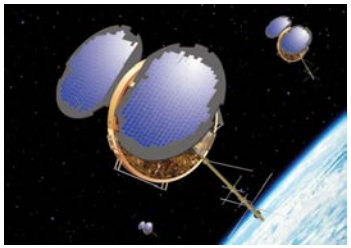
Night time



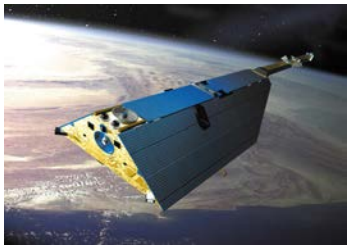

Vaisala RS41 with pressure derived from GPS height
Sample Number
Mean Bias = 0.276
Mean Abs(Bias) = 0.276
MeanSD = 1.437
90S to 90N
a
Mean Bias = 0.178
Mean Abs(Bias) = 0.178
MeanSD = 1.508
60N to 90N
b
Mean Bias = 0.340
Mean Abs(Bias) = 0.340
MeanSD = 1.383
20N to 60N
c
Mean Bias = 0.423
Mean Abs(Bias) = 0.423
MeanSD = 1.368
20S to 20N
d
Mean Bias = 0.106
Mean Abs(Bias) = 0.106
MeanSD = 1.518
60S to 20S
e
Pressure (hPa)
T_Sonde - T_RO (K)


Vaisala RS41 with pressure derived from GPS height
Sample Number
Mean Bias = 0.313
Mean Abs(Bias) = 0.313
MeanSD = 1.410
Day
90S to 90N
a
Mean Bias = 0.272
Mean Abs(Bias) = 0.272
MeanSD = 1.490
Day
60N to 90N
b
Mean Bias = 0.342
Mean Abs(Bias) = 0.342
MeanSD = 1.360
Day
20N to 60N
c
Mean Bias = 0.462
Mean Abs(Bias) = 0.462
MeanSD = 1.320
Day
20S to 20N
d
Mean Bias = -0.036
Mean Abs(Bias) = 0.145
MeanSD = 1.465
Day
60S to 20S
e
Pressure (hPa)
T_Sonde - T_RO (K)
Day


Vaisala RS41 with pressure derived from GPS height
Sample Number
Mean Bias = 0.226
Mean Abs(Bias) = 0.226
MeanSD = 1.465
Night
90S to 90N
a
Mean Bias = 0.063
Mean Abs(Bias) = 0.105
MeanSD = 1.512
Night
60N to 90N
b
Mean Bias = 0.334
Mean Abs(Bias) = 0.377
MeanSD = 1.403
Night
20N to 60N
c
Mean Bias = 0.374
Mean Abs(Bias) = 0.374
MeanSD = 1.426
Night
20S to 20N
d
Mean Bias = 0.219
Mean Abs(Bias) = 0.220
MeanSD = 1.529
Night
60S to 20S
e
Pressure (hPa)
T_Sonde - T_RO (K)
Night



Conclusions and Future Work



- **Geo-location independent COSMIC RO data are useful to assess the quality of radiosonde temperature in the higher troposphere and lower stratosphere**
- **These results suggest that COSMIC 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**