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New Radiosonde Temperature Bias Adjustments for Potential NWP Applications Based on GPS RO Data

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Frank Tilley and Michael Pettey for data collection & processing
Steve Schroeder, Holger Vömel, and Chi Ao for consulting on radiosonde and GPSRO quality

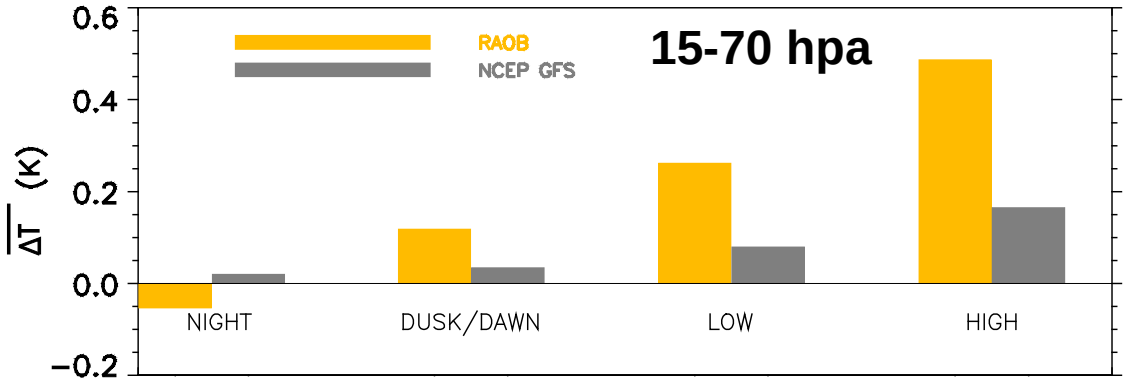
Problems

- Radiosonde temperature observations have biases
  - Errors due to solar and IR radiation
  - Adjustments made at field stations are not adequate, so biases remain

- NCEP radiation correction (RADCOR) method is outdated [Collins, 1999]
  - Based on RS80 as the reference
  - Does not include modern sonde types, such as Vaisala RS92, U.S. Sippican Mark IIA, etc.

Biases in RAOB and GFS forecast relative to COSMIC Tdry

(global average over all stations)
2008.05 – 2011.08



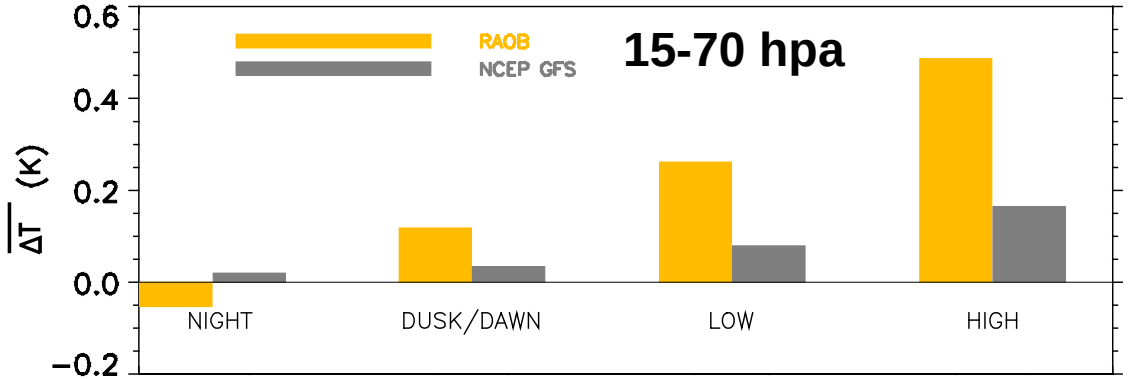
Solar Elevation Categories

- NIGHT (<−7.5 deg)
- DAWN/DUSK (−7.5 – 7.5 deg)
- LOW (7.5 – 22.5 deg)
- HIGH (>22.5 deg)

Sun, B., A. Reale, S. Schroeder, D. J. Seidel, and B. Ballish, 2013: “Toward improved corrections for radiation-induced biases in radiosonde temperature observations”. JGR, Vol 118, 1-13, doi:10.1002/jgrd.50369.

Bias pattern remains stable for different time periods

T difference from COSMIC Tdry (global average over all stations)



2008.05 - 2011.08

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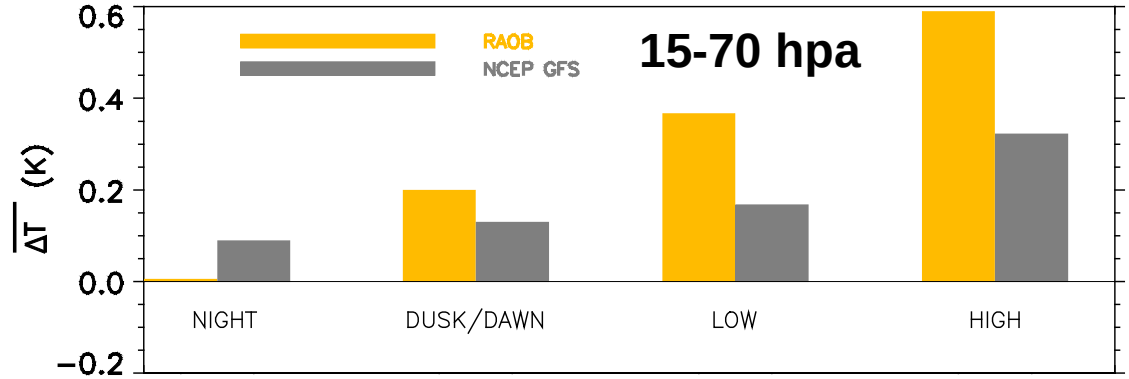
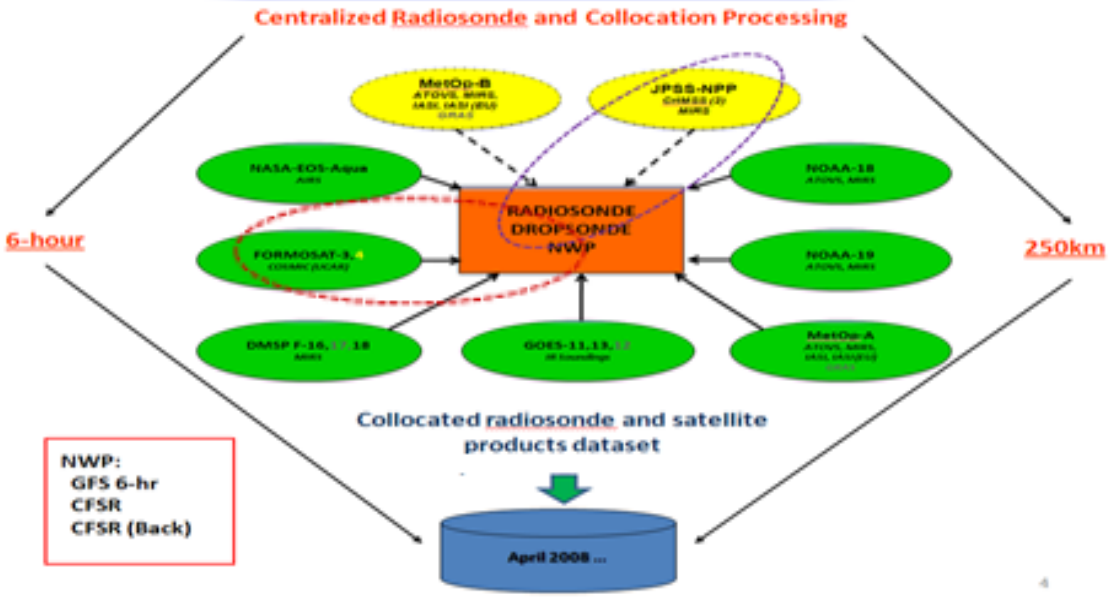


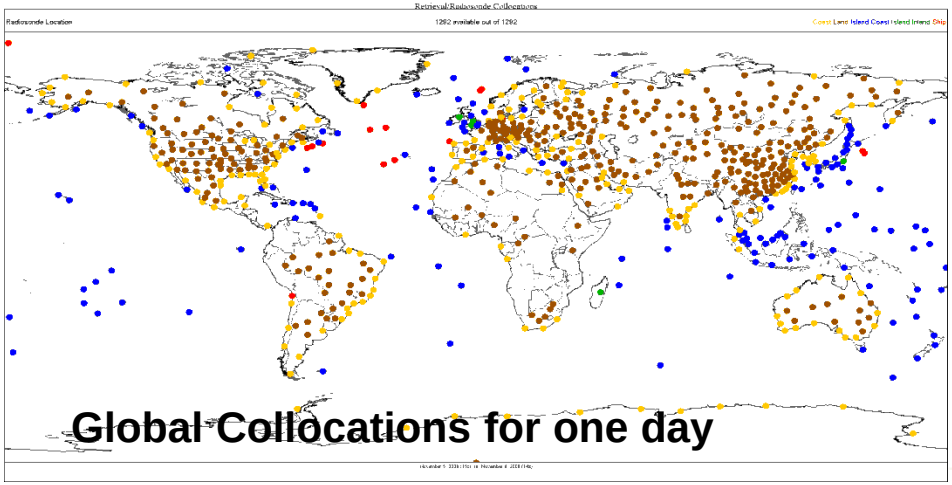
2012.01 - 2013.12

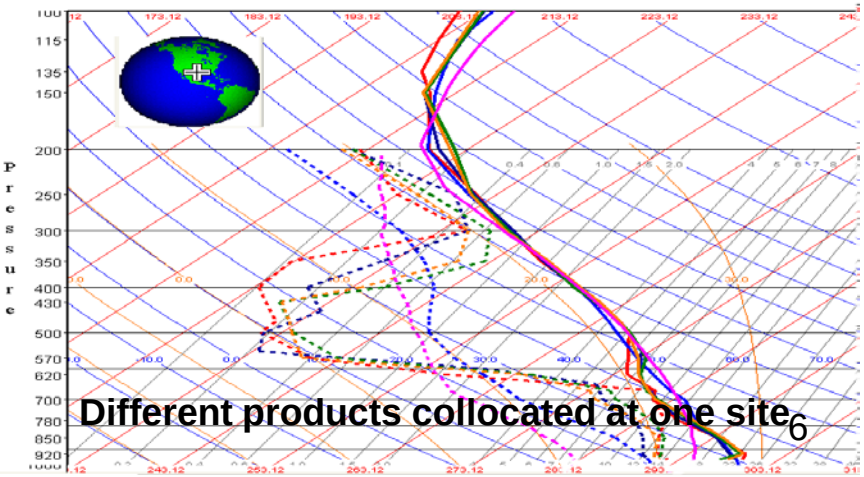
Outline

- Use GPS RO Tdry retrievals as a reference to quantify radiosonde T errors and develop new RADCOR
  - For all individual sonde types for different heights and solar angles
  - Based on the RAOB-COSMIC collocation data of 2008.05 – 2011.08
- Compare our new RADCOR with existing NCEP RADCOR
  - Radiosonde temperatures observation (OB) minus the NCEP GDAS background (BG)
  - Based on data of 2012.09 – 2013.08

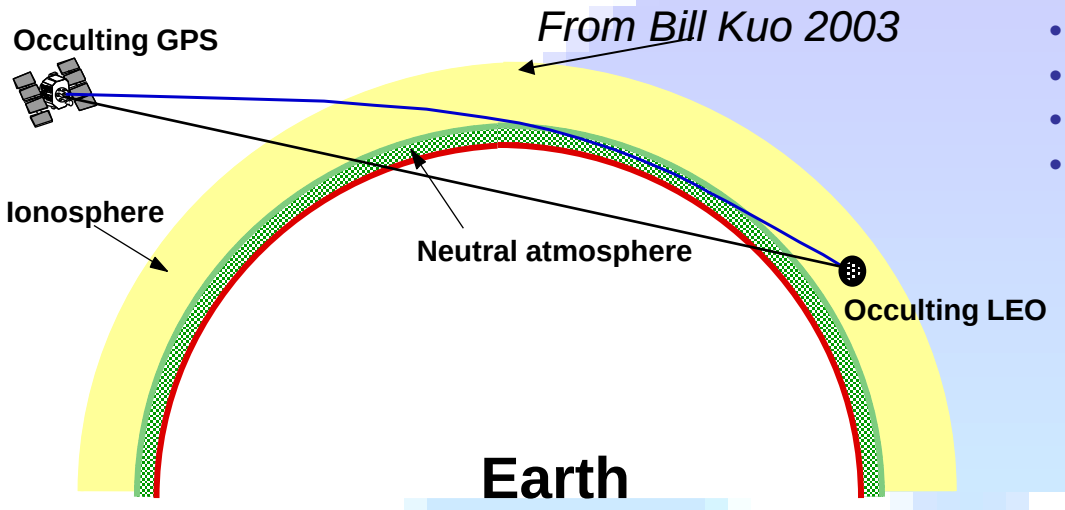
NOAA Products Validation System (NPROVS)



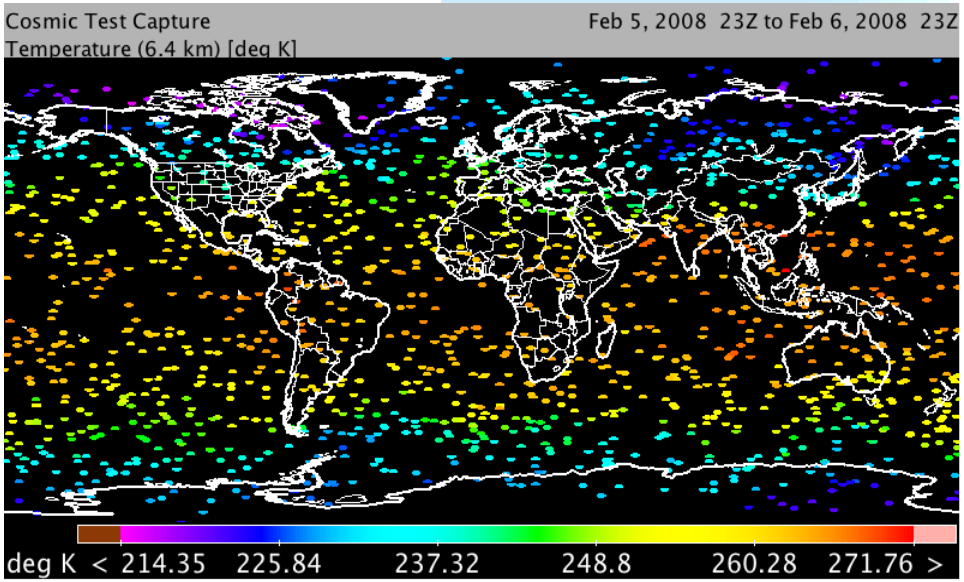


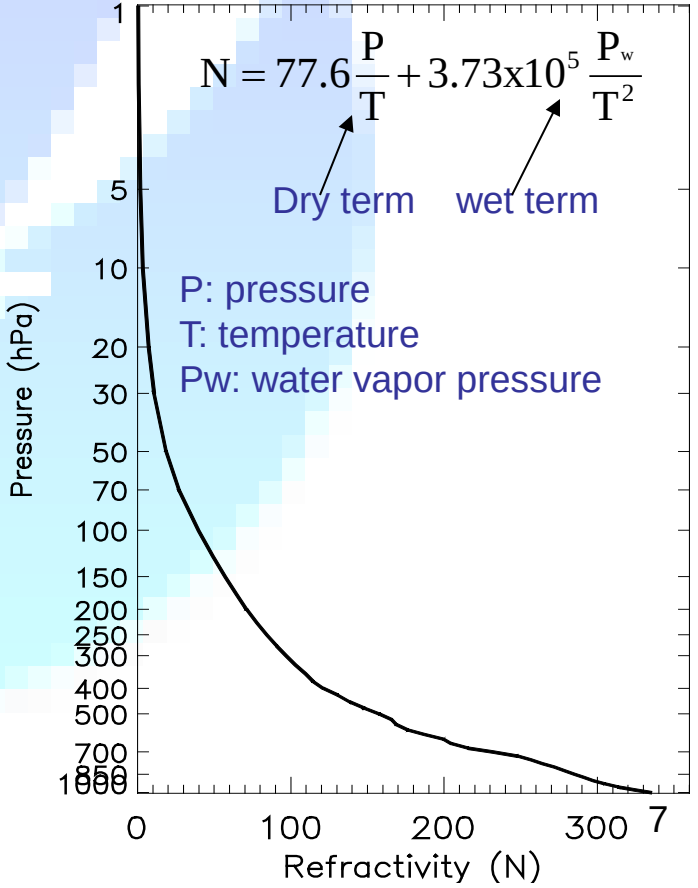


Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC)



- All-weather sounding capability
- High vertical resolution
- No calibration issues
- Good spatial and temporal distribution





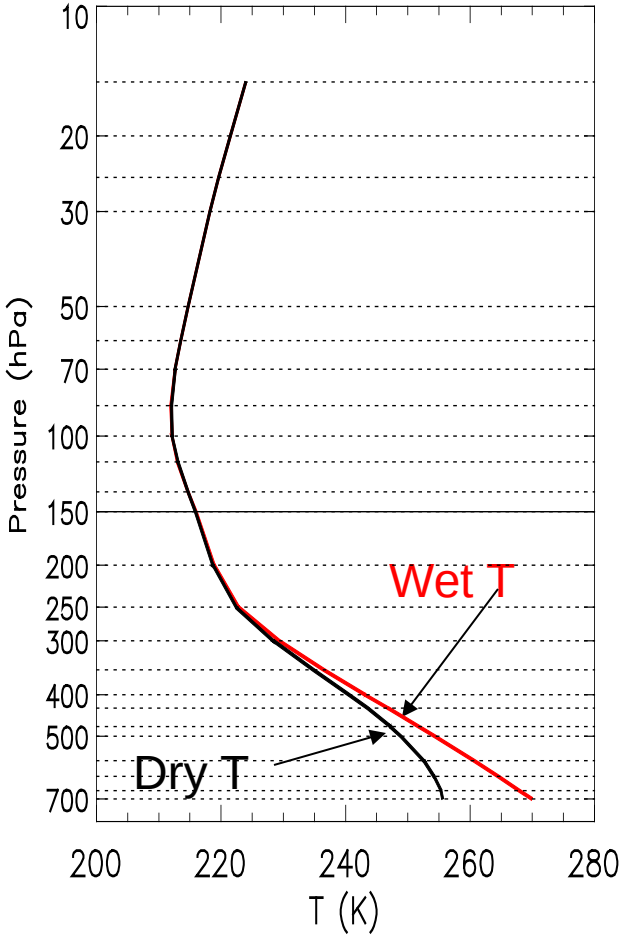
COSMIC "dry" T and "wet" T

- Dry temperature: derived by neglecting the water vapor term in refractivity (N)

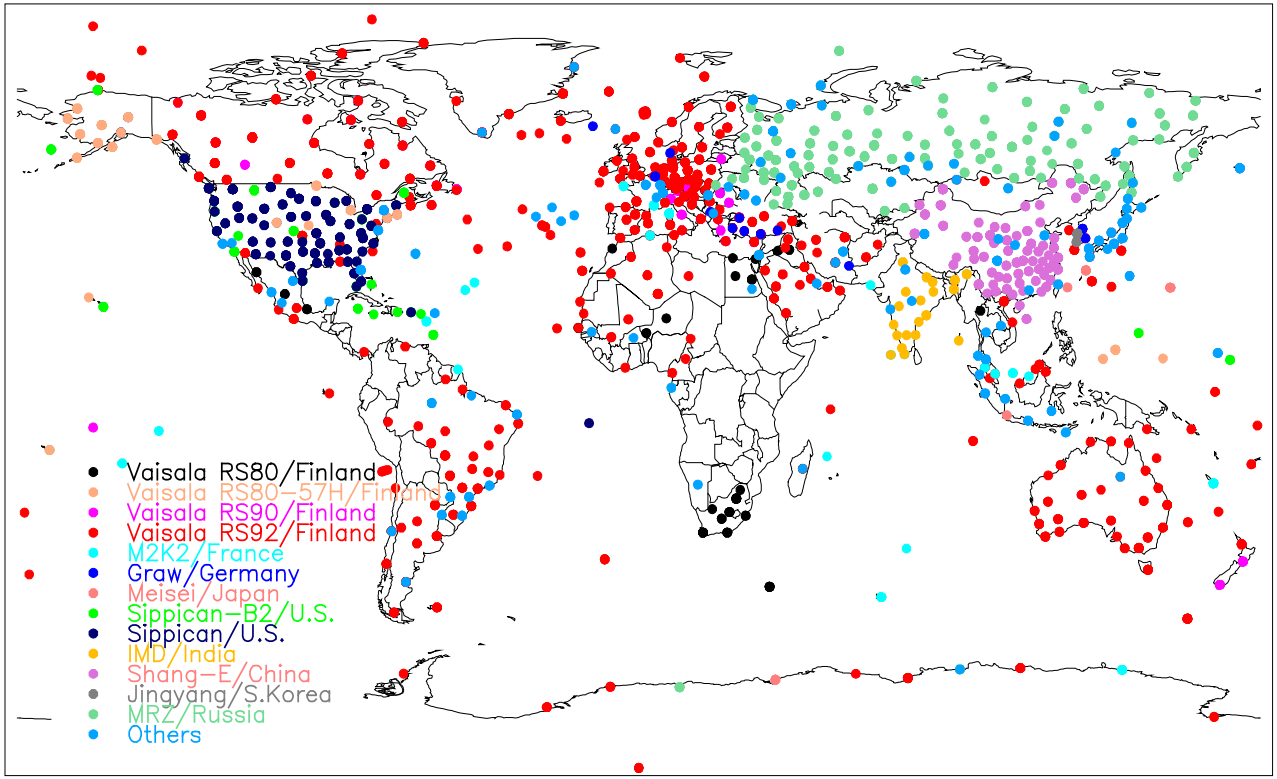
- **Wet temperature: 1DVar initialized with NWP forecast**

For This Study

- Dry T (at or above 150 hPa) + Wet T (below 150 hPa) … *serve as "Reference" to assess raob temperature biases*



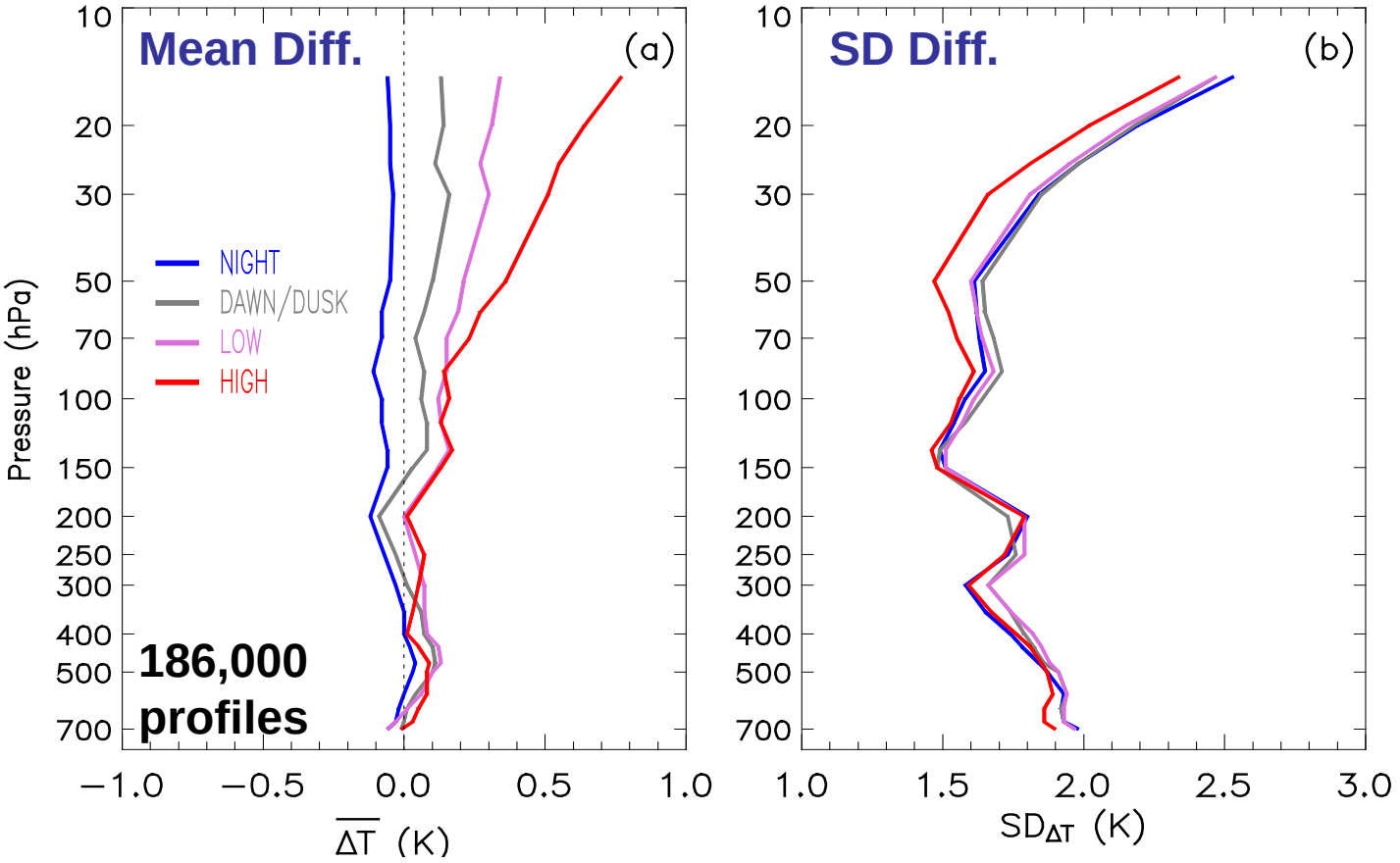
Sonde types flown in global operational network (2008-2011)



Operational raobs are used for the analysis. Data for most of the sonde types already experienced radiation corrections at the field sites using schemes provided by vendors, etc.

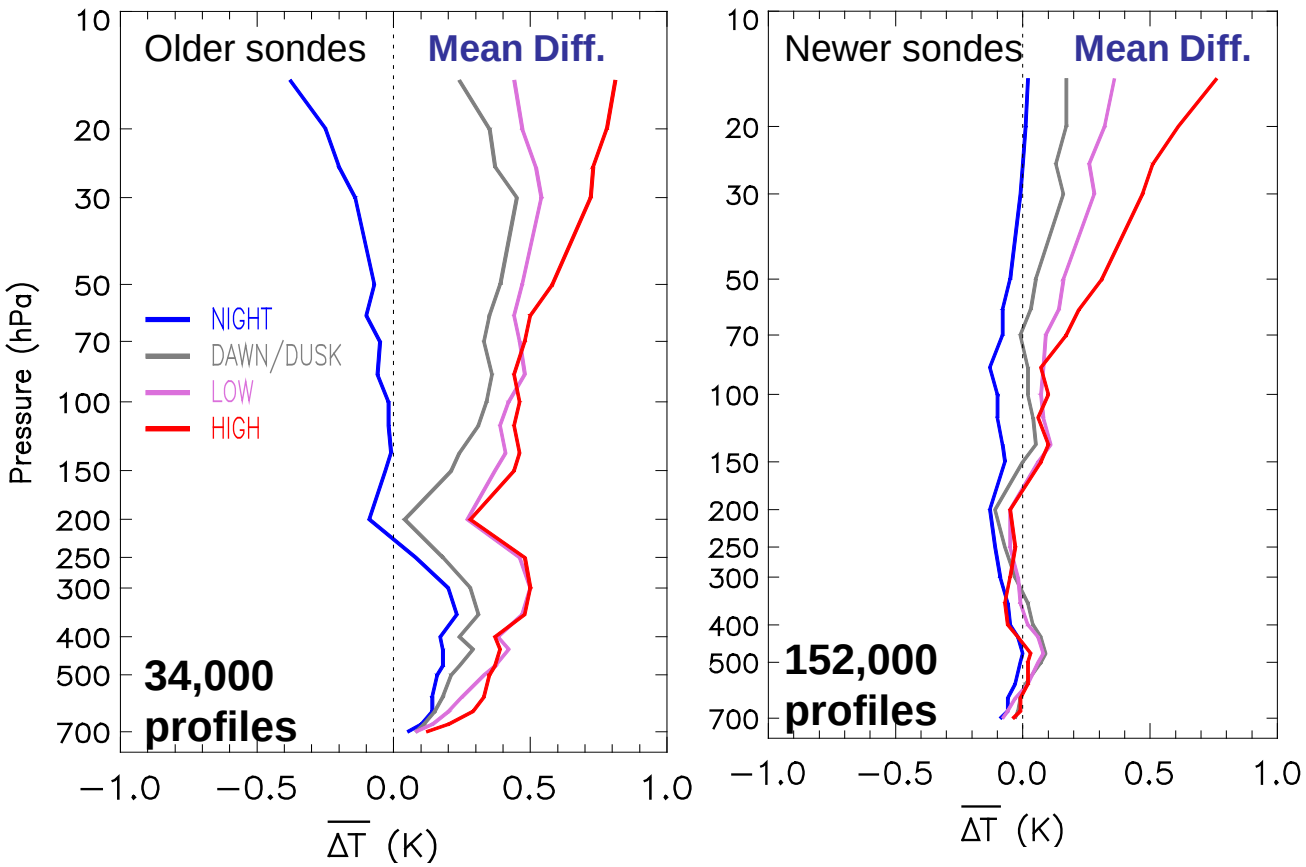
Global sondes

RAOB-minus-COSMIC



Global sondes (older vs. newer)

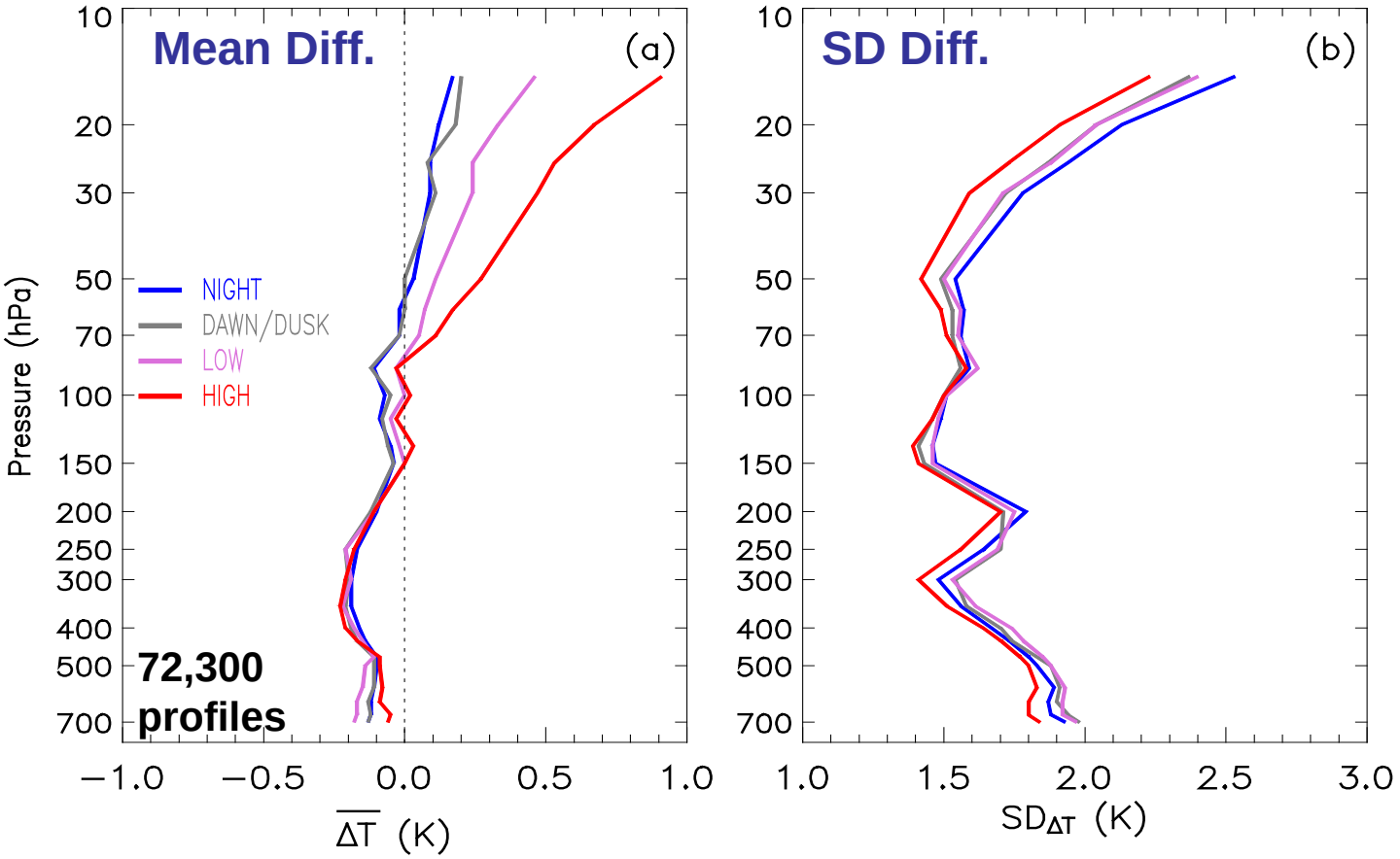
RAOB-minus-COSMIC



- Older sondes: already flown prior to 2000 and are still in use
- Newer sondes: started being flown after 2000

Vaisala RS92

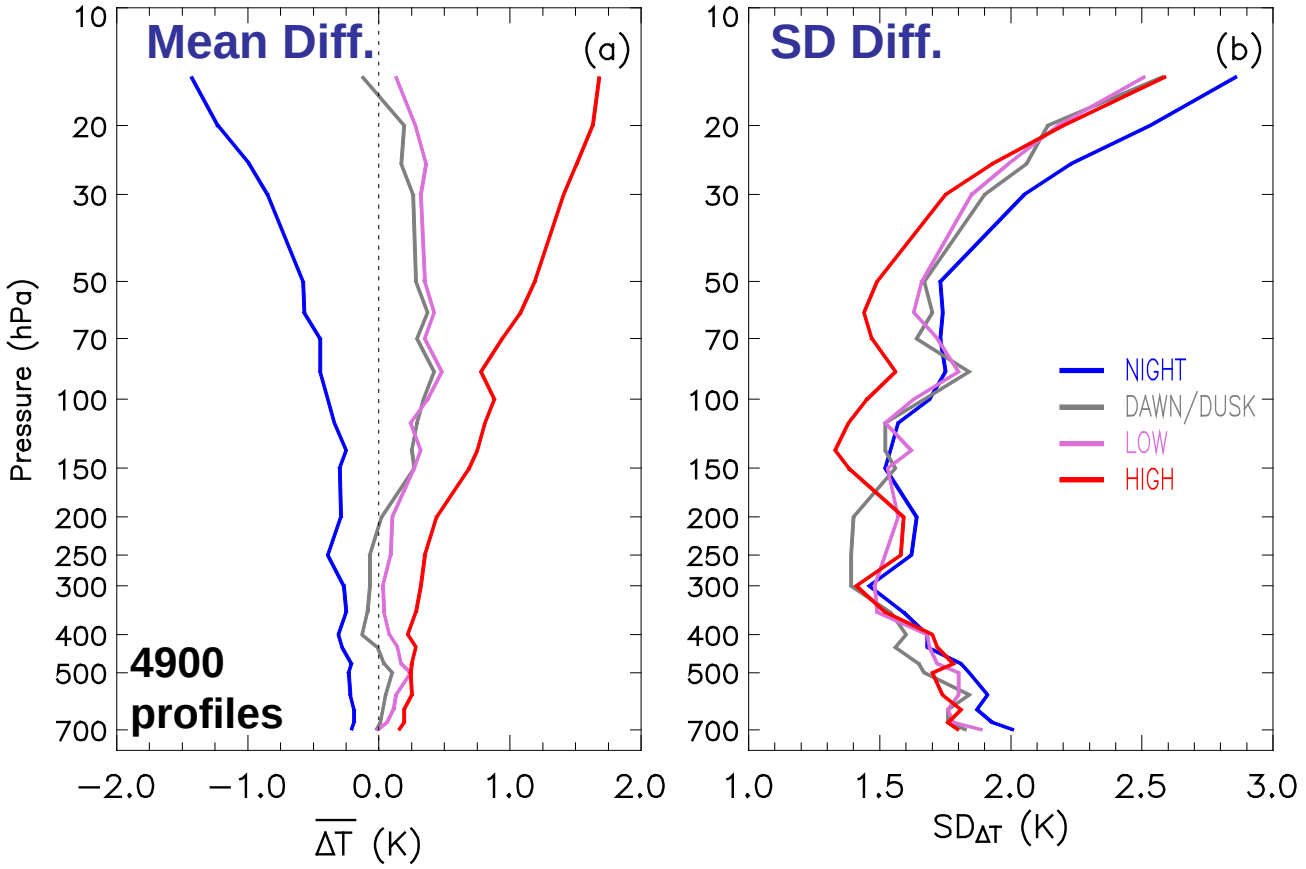
RAOB-minus-COSMIC



… also of primary interest to GCOS GRUAN

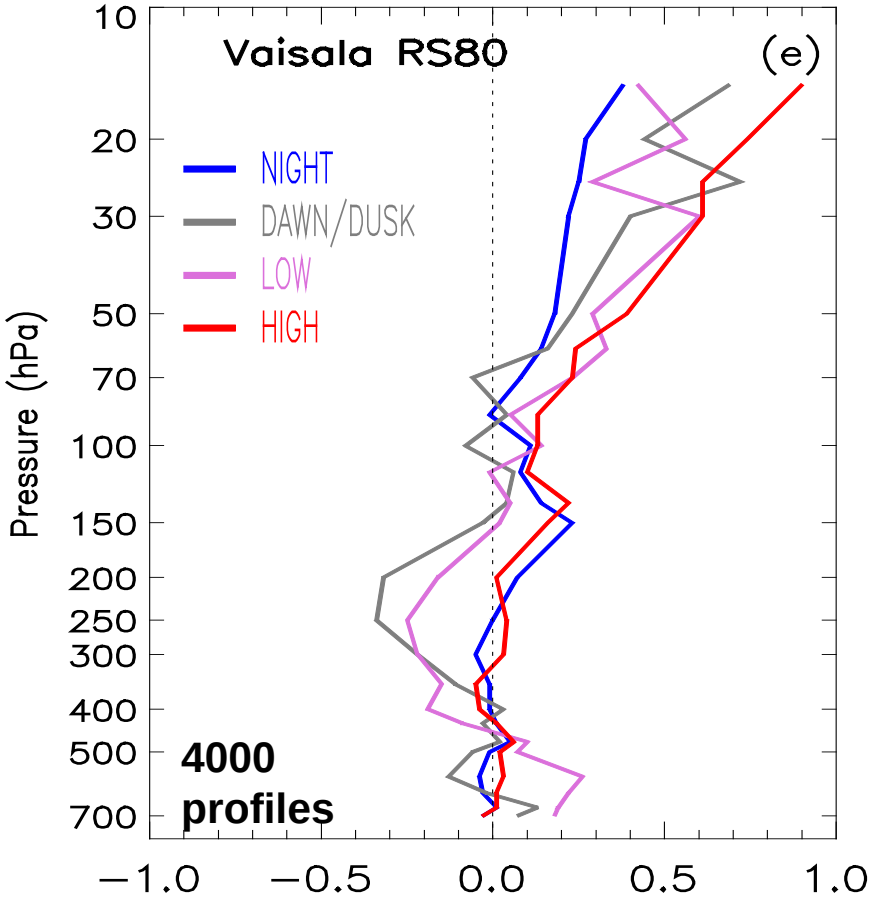
Sippican B2 (no correction done at field stations)

RAOB-minus-COSMIC



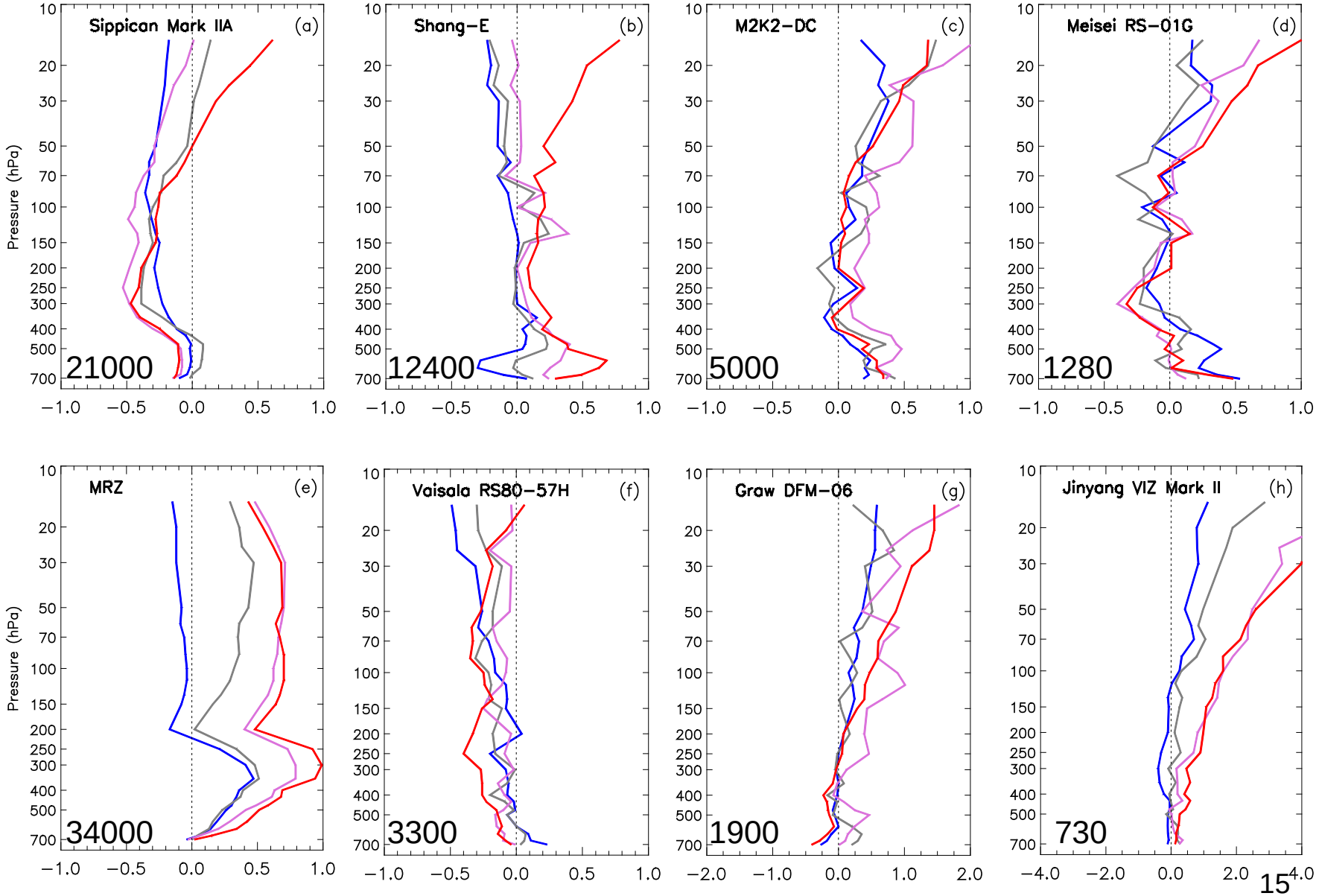
Vaisala RS80

RAOB-minus-COSMIC



RS80 was the reference sonde in the NCEP RADCOR development

Sonde T difference from COSMIC T



New RADCOR tables

- Created for all individual sondes

radcor table example

Press	Night	Low	Med	High
15	-0.06	0.13	0.34	0.77
20	-0.05	0.14	0.31	0.64
25	-0.05	0.11	0.27	0.55
30	-0.04	0.16	0.30	0.51
50	-0.05	0.10	0.21	0.36
60	-0.08	0.07	0.19	0.27
70	-0.08	0.04	0.15	0.23
85	-0.11	0.07	0.15	0.14
100	-0.08	0.06	0.12	0.16
115	-0.08	0.08	0.13	0.13
135	-0.06	0.08	0.16	0.17
150	-0.06	0.03	0.12	0.13
200	-0.12	-0.09	0.00	0.01
250	-0.07	-0.03	0.04	0.07
300	-0.03	0.01	0.07	0.05
350	0.00	0.06	0.07	0.03
400	0.00	0.07	0.08	0.01
430	0.02	0.10	0.12	0.05
475	0.04	0.11	0.13	0.09
500	0.03	0.10	0.10	0.08
570	0.00	0.04	0.06	0.08
620	-0.02	0.01	0.01	0.05
670	-0.03	0.00	-0.03	0.03
700	-0.06	-0.01	-0.06	-0.01

Correction on radiosonde measurements:

Positive values: subtracted from
Negative values: added to

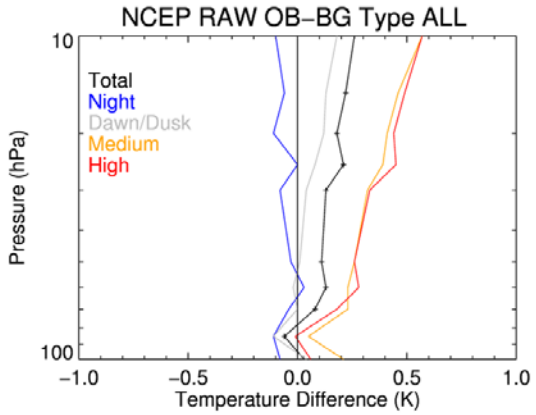
Evaluate our new RADCOR
using 2012.09-2013.08 data

- Statistics of RAOB (OB) -minus-Background (BG)
  - Unadjusted RAOB (corrected at site)
  - Adjusted RAOB (using NCEP RADCOR)
  - Adjusted RAOB (using our new RADCOR)

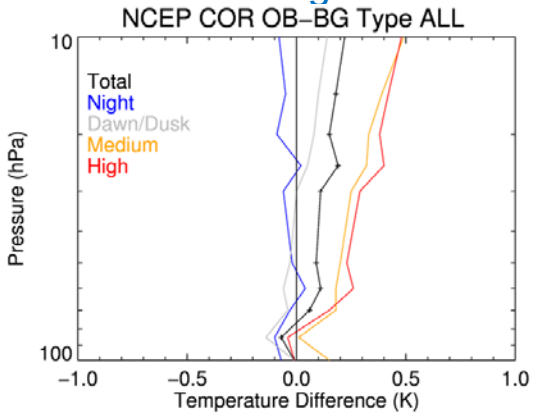
    - The BG was from existing operations which assimilated NCEP RADCOR RAOB … preliminary evaluation

OB-minus-BG for Global

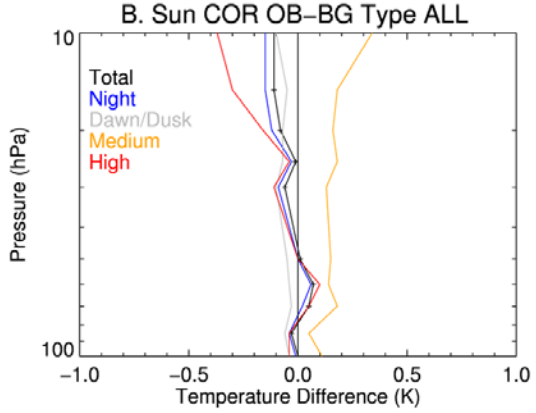
Unadjusted RAOB-minus-Background



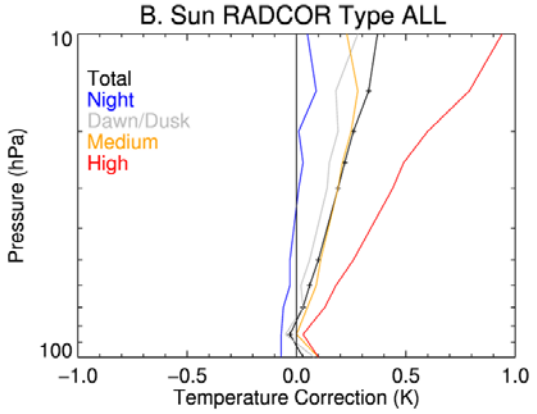
Adjusted RAOB (NCEP RADCOR) -minus-Background



Adjusted RAOB (New RADCOR) -minus-Background



New RADCOR (raob-minus-cosmic)



Summary

- Radiation biases in global operational radiosonde temperature data (2008.05-2011.08) are examined by using collocated GPSRO data
  - The data on average show a nighttime cold bias and a daytime warm bias with daytime bias increasing with altitude and solar elevation angle
  - New RADCOR varying with solar angle and height was developed for individual sonde types

- The stats of OB – BG (2012.09-2013.08) suggest that the RAOB temperature corrected using our new RADCOR fits the model background better than using NCEP RADCOR or without adjustment.

- NPROVS that collects the RAOB-GPSRO collocations for creating the new RADCOR runs everyday and (with pending COSMIC-2) is source of routine monitoring and updating of RADCOR (i.e., for new sondes, etc)
  - ongoing NOAA's Quantitative Observing System Assessment Program (QOSCAP) activity…NWS, NESDIS, and OAR

- **We are ready/waiting for the NWP testing!**