The 20th International TOVS Study Conference (ITSC)
October 28 – November 3, 2015
Lake Geneva, Wisconsin

Characteristics of Radiosonde Observations and their Impact in Satellite Sounding Product Validation

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Goals

1. What are the RAOB error characteristics & how they are reflected in satellite retrieval validation
   - Temperature
   - Humidity

Coarse-layer averaging statistics:
~1 km for AVTP and ~2 km for AVMP

2. To what extent that satellite retrieval can detect atmospheric structures shown in RAOBs
   - Atmospheric boundary layer
     - Surface-based inversion
     - Unstable boundary layer
   - Tropopause

100-lvl retrieval profiles are utilized.

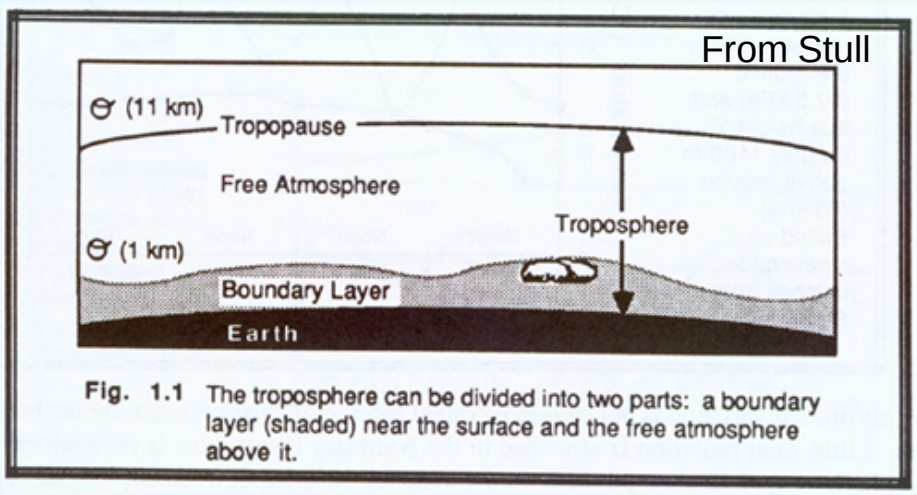
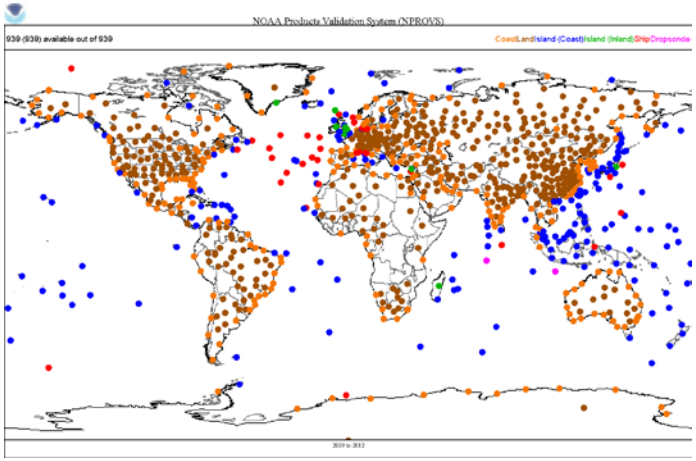


Fig. 1.1 The troposphere can be divided into two parts: a boundary layer (shaded) near the surface and the free atmosphere above it.

Data

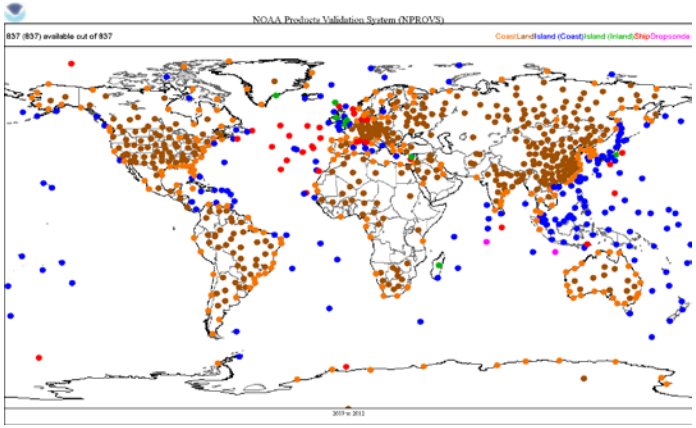
- **MetOp-A IASI L2 sounding product developed by NOAA NESDIS.**
- **Three-yr (2010-2012) RAOB-IASI collocations collected via NPROVS.**
- **qc-*accepted* IR+MW IASI retrieval profiles.**

Collocations within **6-hr** & 50-km



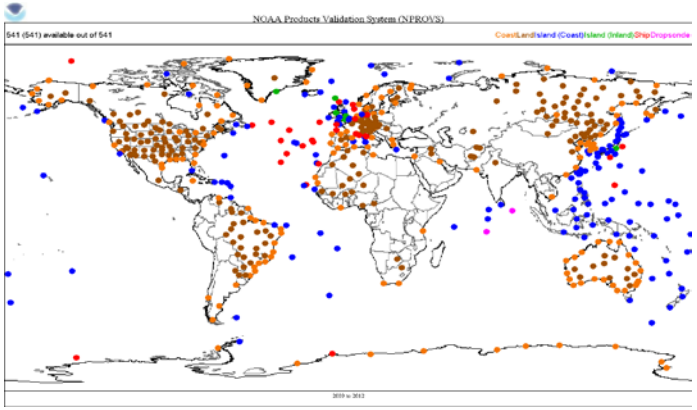
Sample: 550,500 (939 sites)

Collocations within **3-hr** & 50-km



Sample: 313,500 (837 sites)

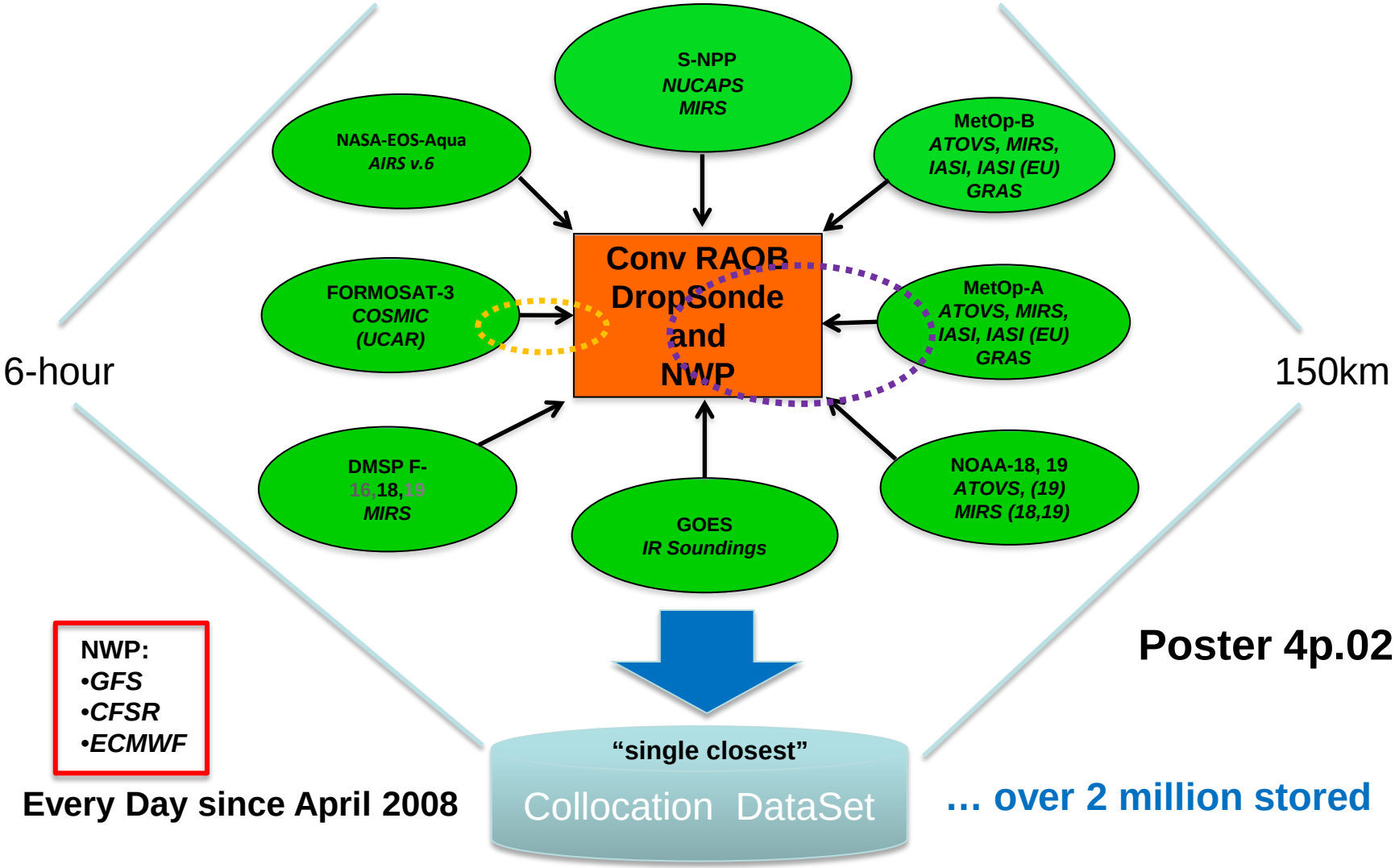
Collocations within **1-hr** & 50-km



Sample: 99,000 (541 sites)

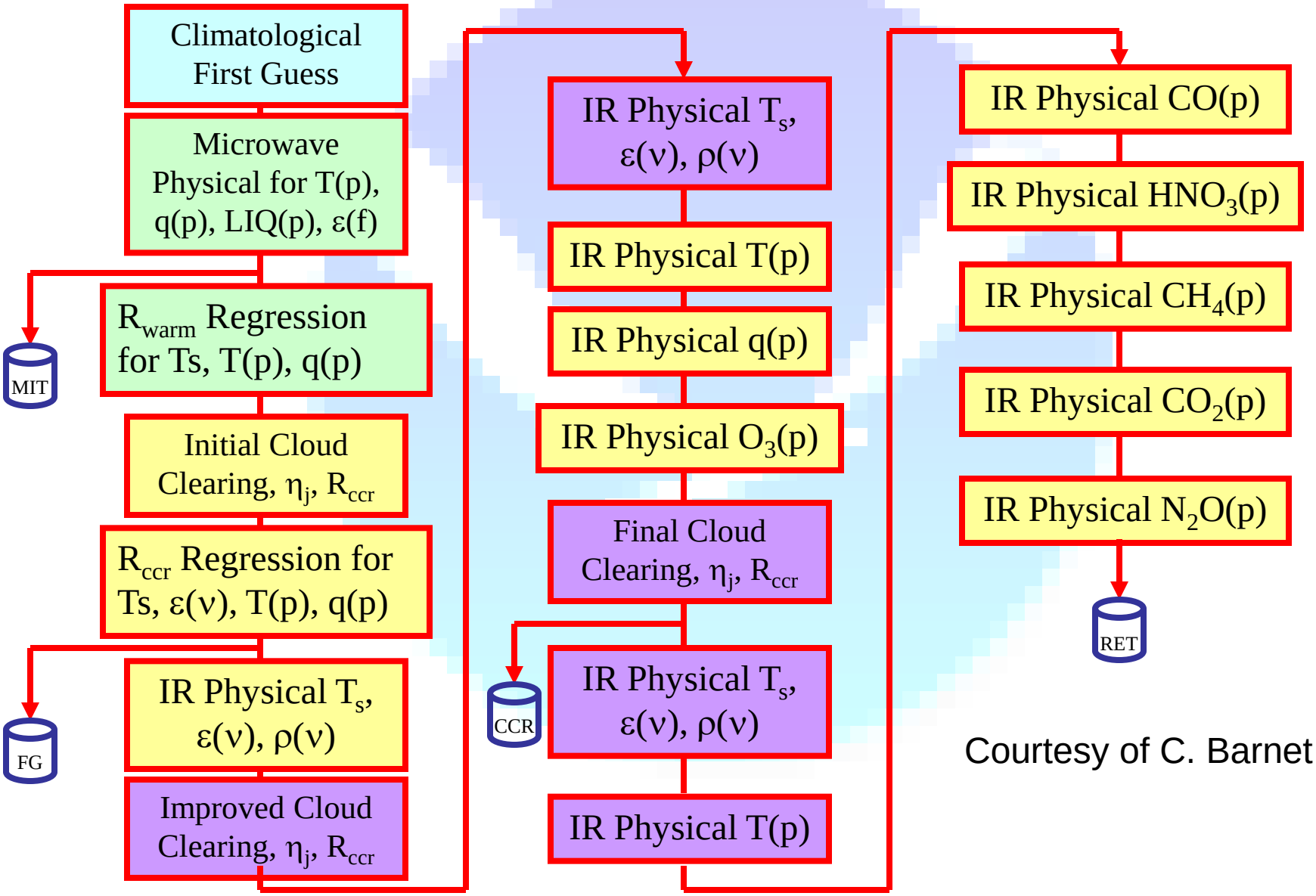
NOAA Products Validation System (NPROVS)

Centralized RAOB and Satellite Product Collocation



https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs

Simplified flow diagram of the NOAA IASI retrieval algorithm



Courtesy of C. Barnet

RAOB Accuracy Impact in Validation

- RAOB measurement accuracy characteristics and impact on satellite validation
  - Temperature
  - Humidity

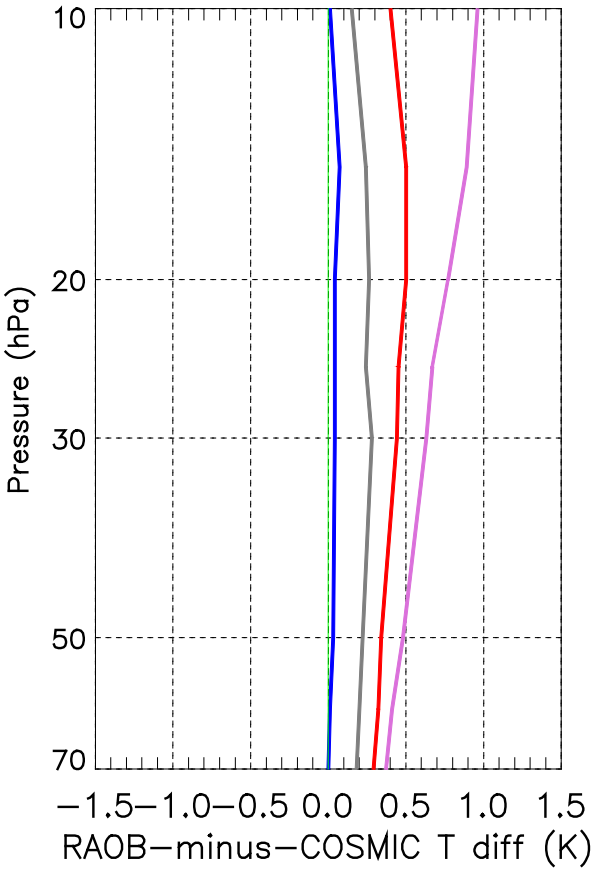
Errors in RAOB T and Impact in Validation

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

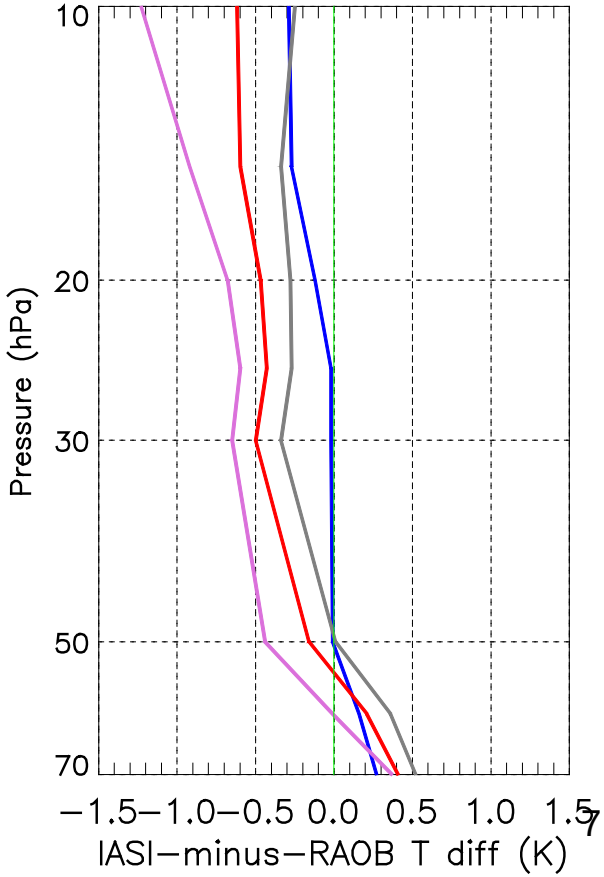
Radiosonde temperature radiation-induced errors (Sun et al.,2013, JGR).

Collaborating with NCEP to improve their radiosonde “RADCOR” in DA.

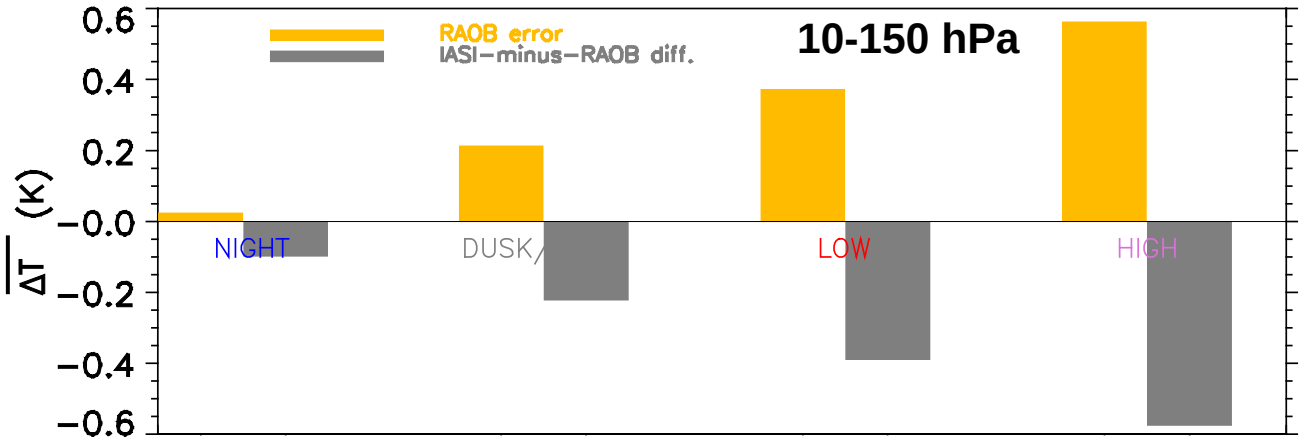
Radiosonde T error



IASI-minus-RAOB T diff.



RAOB Temperature error impact in validation



Solar Elevation Categories

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

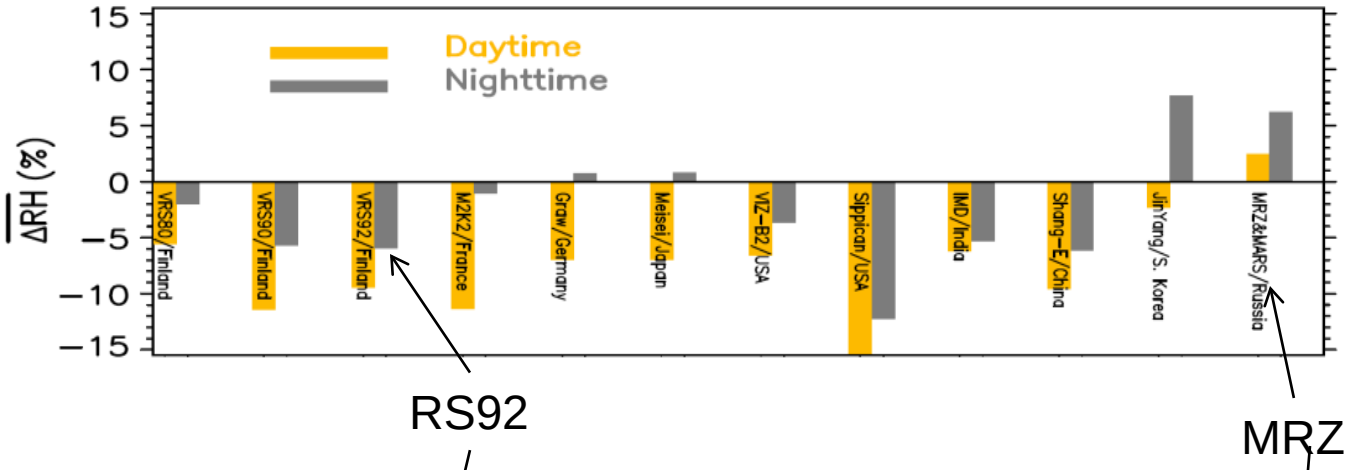
For 10-150 hPa

	All-day	**Daytime (Low+High)**
RAOB temperature error:	**0.27 K**	**0.49 K**
IASI-minus-RAOB difference:	**-0.32 K**	**-0.50K**

“Cold bias” in IASI-minus-RAOB at UTLS is largely due to warm bias in RAOB

Radiosonde type relative humidity (RH) bias

RAOB 300 hPa RH bias



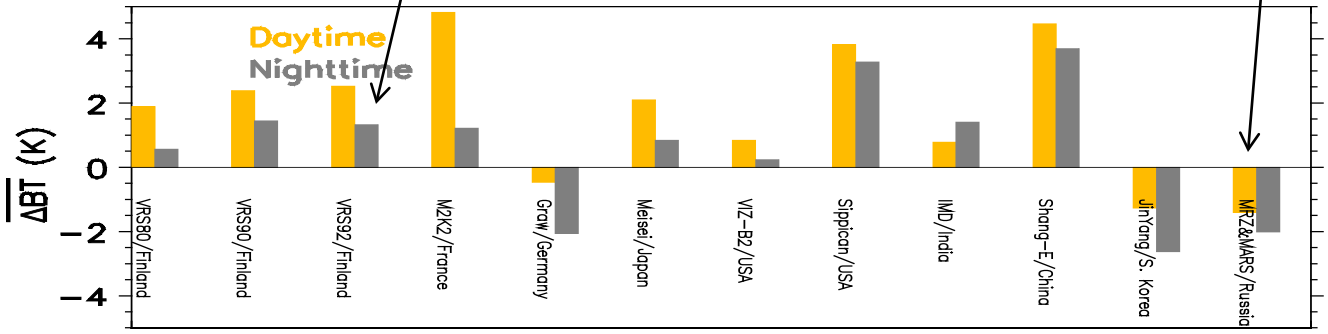
RS92

MRZ

Most sonde types have a dry bias at upper levels particularly during daytime

Russian sonde is one of the few exceptions, showing a wet bias.

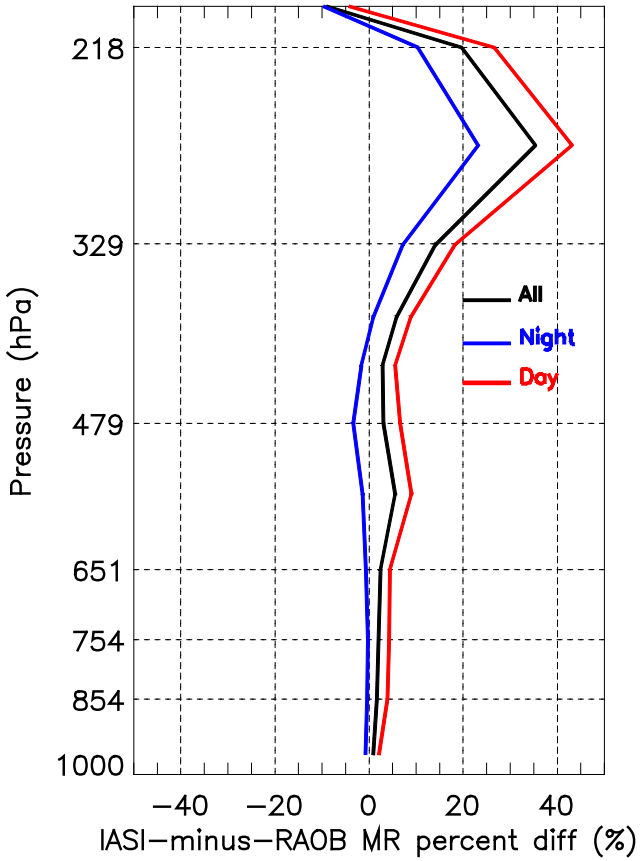
Calculated RAOB BT -minus-satellite observed BT for 183+/- 1 GHz



Sun et al. (2010, JGR)

RAOB humidity error impact in validation

IASI-minus-RAOB water vapor mixing ratio diff.



RAOB humidity tends to have a dry bias particularly at the upper level during daytime.

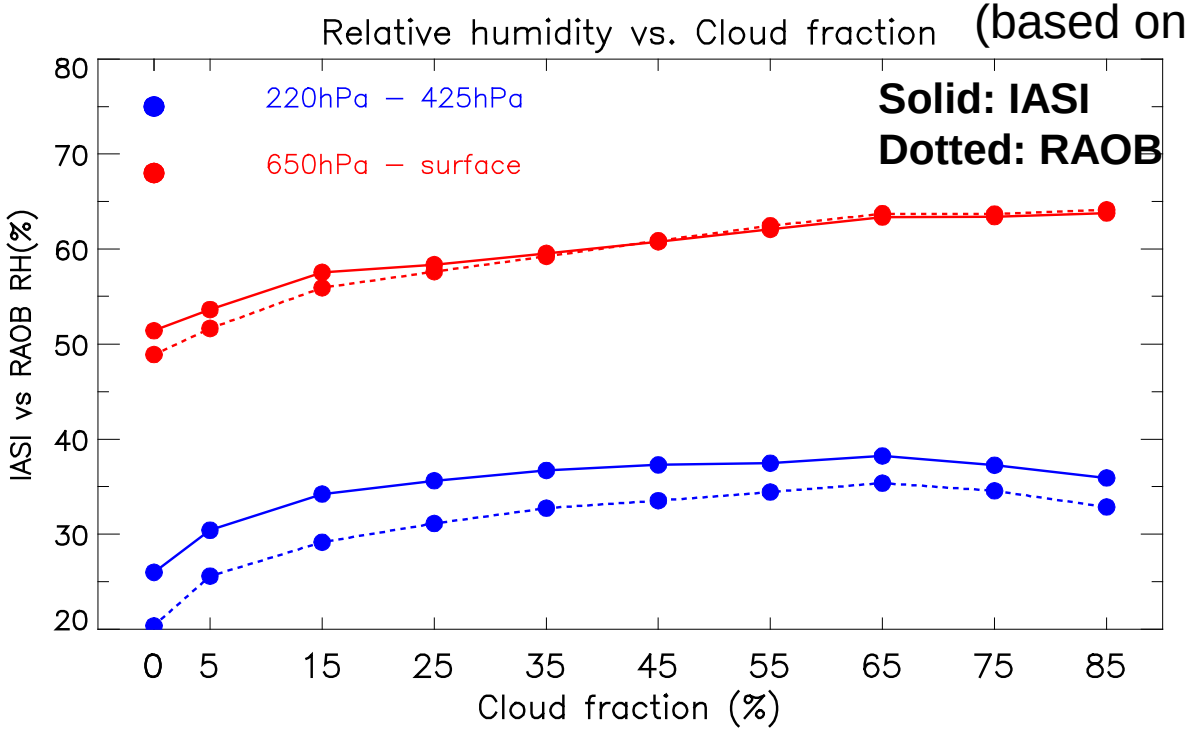
This bias largely leads to a “wet bias” in satellite data validated.

Recommend: use nighttime data

However, conventional RAOBs are useful in satellite product validation

An example: as the independent data source verifying the consistency among cloud, temperature and humidity in the IASI retrieval system

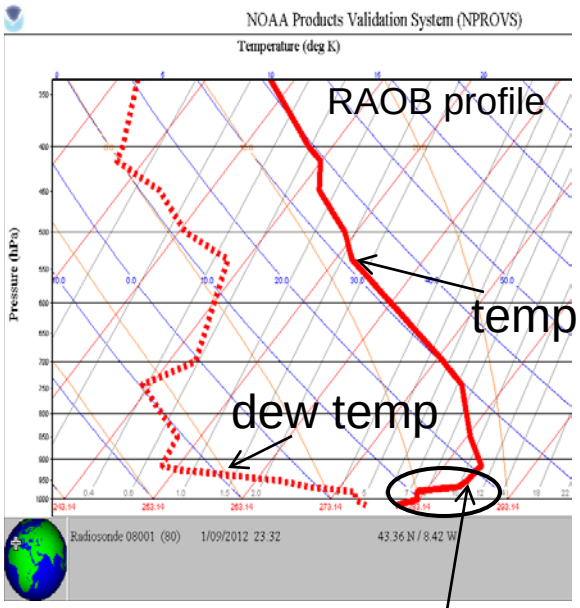
(based on 3-yr data)



RAOB *vs.* IASI atmospheric structure

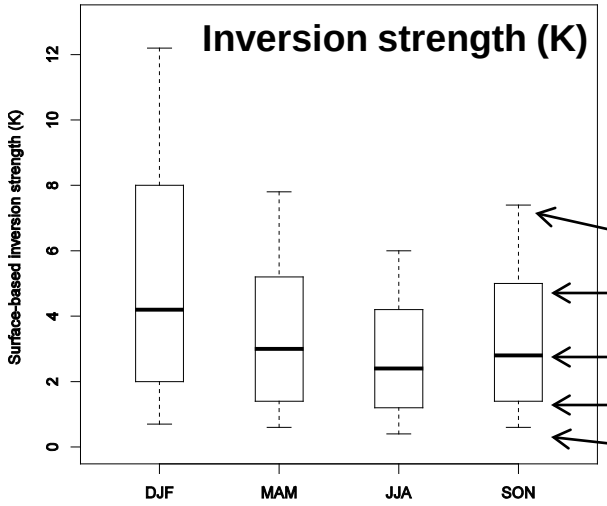
- Atmospheric structure features in RAOB *vs.* IASI retrieval profiles
  - Surface inversion
  - Unstable boundary layer (surface-based inversion cases excluded)
  - Tropopause

Surface-based temperature inversion statistics in RAOBs

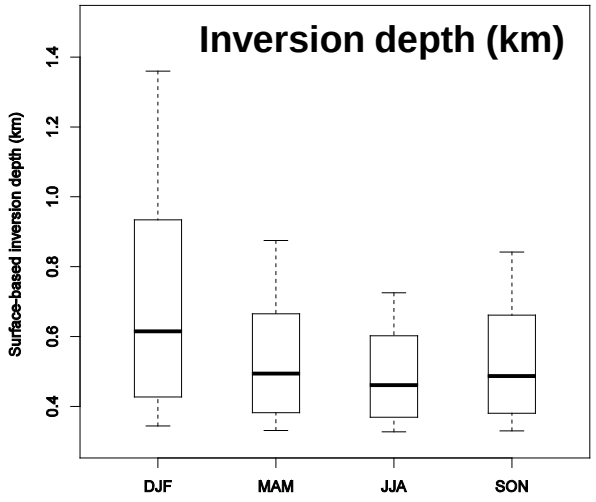


Surface inversion layer
Depth: 876 m
Strength: 6.2 K

Based on 3-yr global data (445,000 profiles)



Box-and-Whisky:
90th
75th
50th
25th
10th

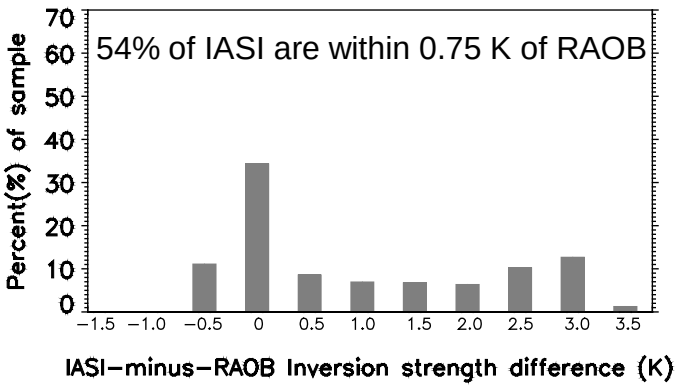


Surface-based inversion statistics: RAOB *vs*. IASI

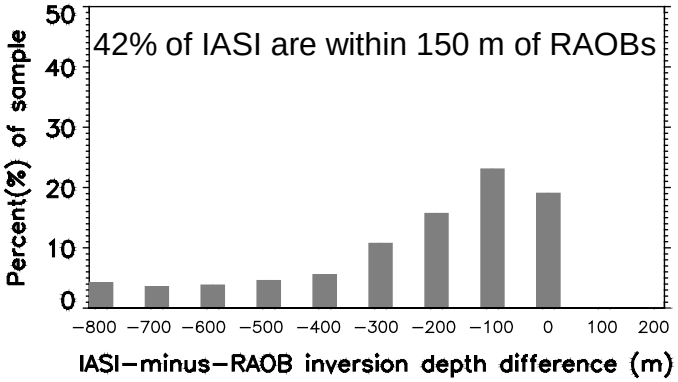
Based on 3-yr RAOB-IASI collocations within 1-hr window

RAOB Inversion		IASI Inversion
YES (100)	→	YES (51)
RAOB Inversion		IASI Inversion
NO (100)	→	NO (88)

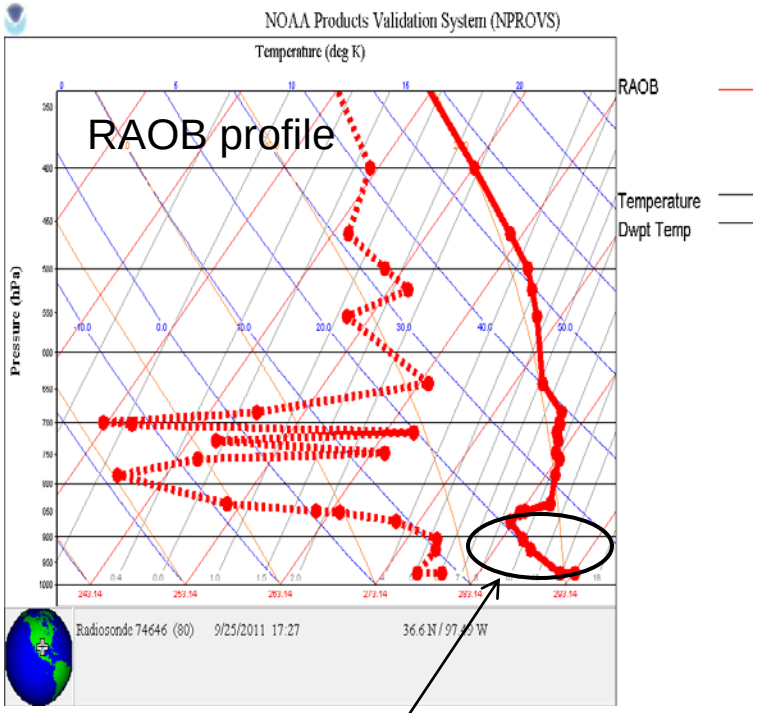
Diff. in inversion strength



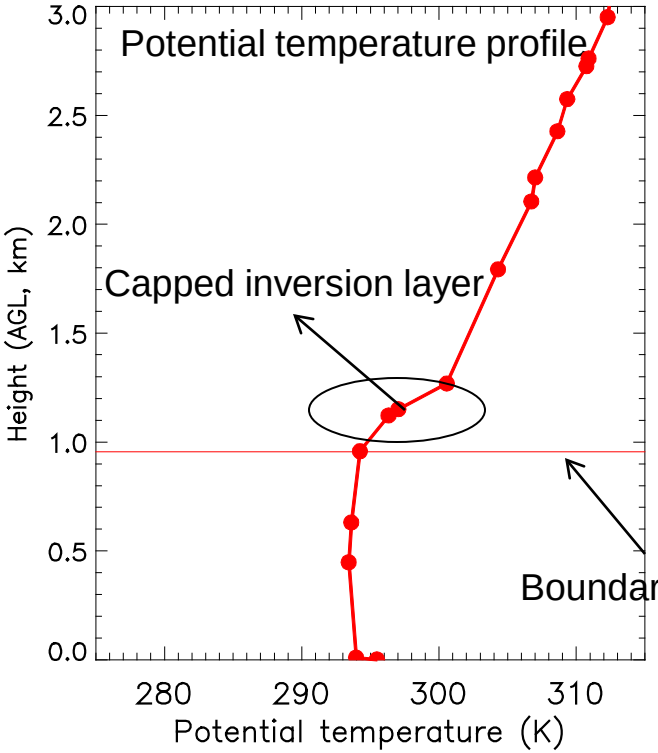
Diff. in inversion depth



Detection of convective/unstable boundary layer

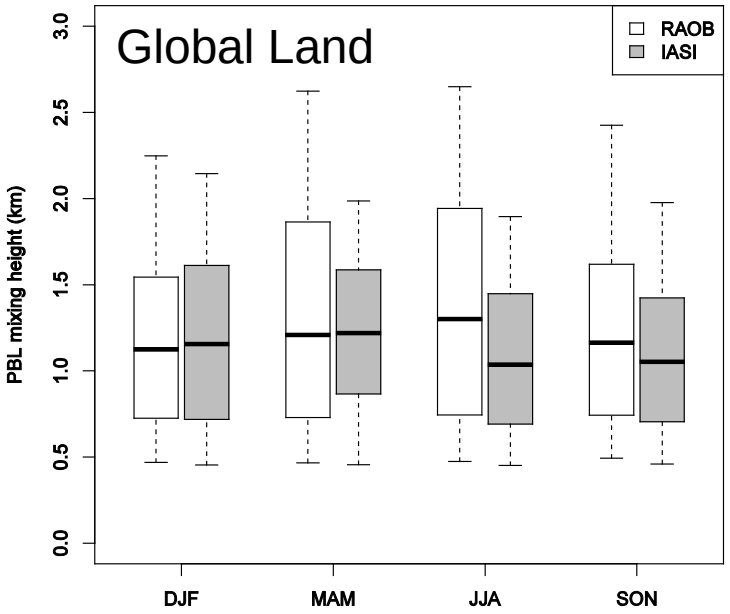


Unstable boundary layer



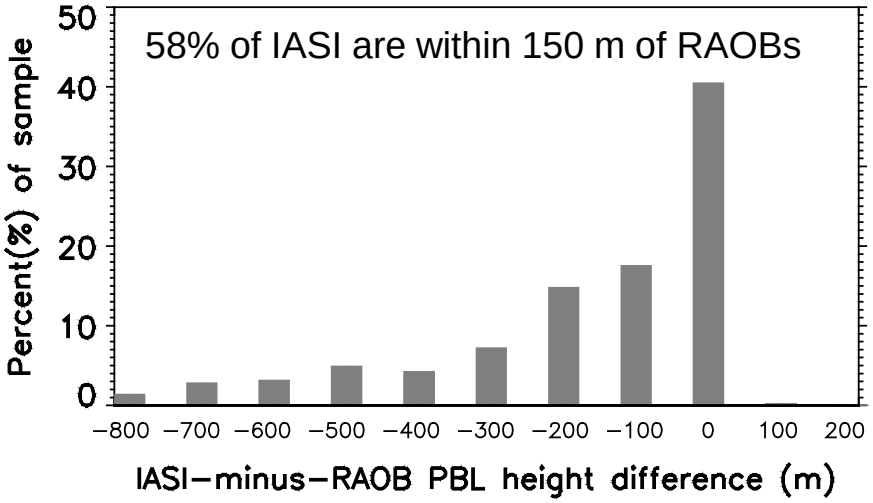
RAOB *vs*. IASI unstable boundary layer height (with surface inversion cases excluded)

boundary layer height statistics



Sample	2905	4018	5199	3710

Diff. in boundary layer height



RAOB and IASI Time Difference Matters in boundary layer detection comparison

RAOB and IASI within 3-hr diff.

RAOB Inversion → IASI Inversion

YES (33829) → YES 42%

Unstable boundary layer height

RAOB median height is 1241 m, higher than IASI by 239 m.

RAOB and IASI within 1-hr

RAOB Inversion → IASI Inversion

YES (11455) → YES 51%

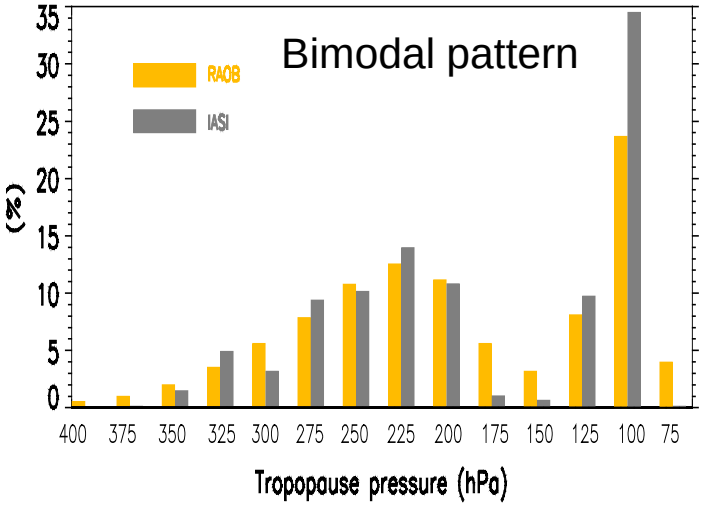
Unstable boundary layer height

RAOB median height: 1203 m, higher than IASI by 80 m.

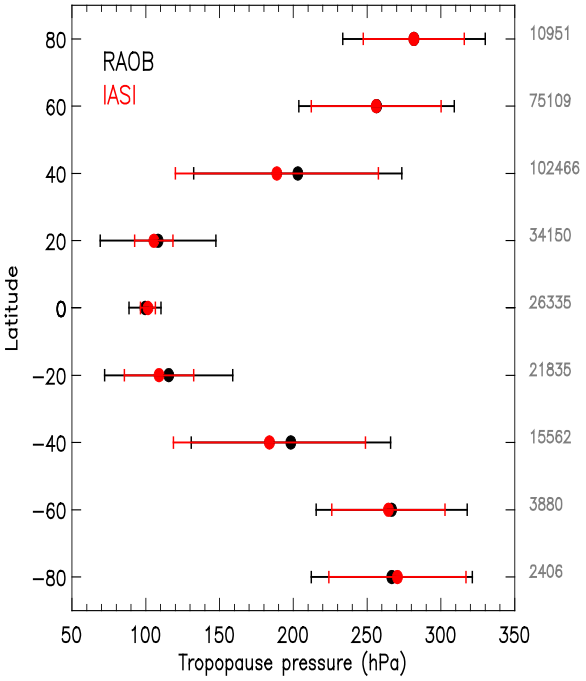
RAOB and IASI within 0.5-hr or less?

RAOB *vs.* IASI tropopause pressure based on 3-yr collocation data

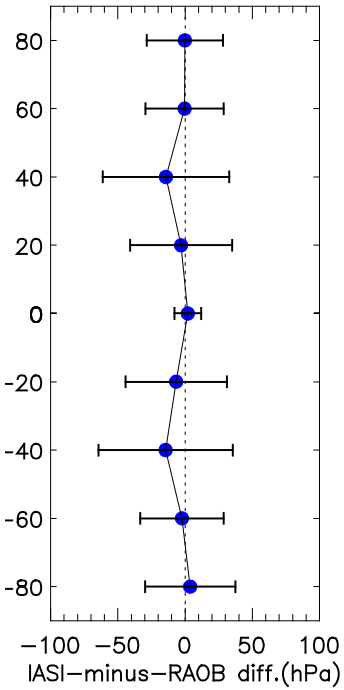
Occurrence probability distribution



Latitudinal variation



IASI-minus-RAOB dif.

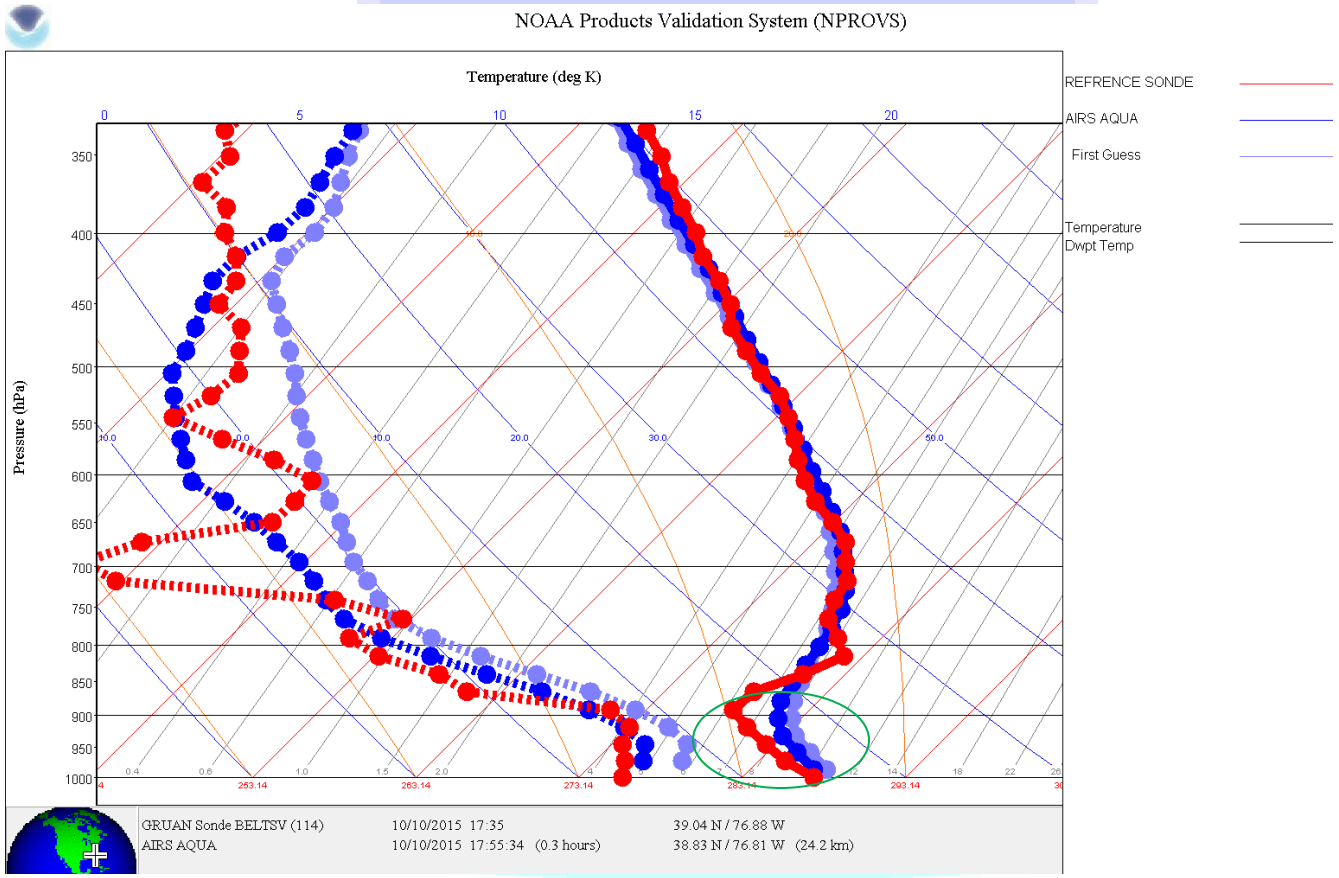


Based on 3-yr data, tropopause in IASI is 6.1 (±42.9) hPa higher than in RAOB.

Summary

- Conventional RAOBs are useful in retrieval product evaluation on individual variables and the physical consistency of different variables as well
- RAOB accuracy issues include T warm bias at UTLS and humidity dry bias in cold & dry environment.
- IASI retrievals can basically capture the climatological characteristics of atmospheric structures (i.e., surface inversion, boundary layer height, and tropopause) shown in radiosonde profiles, but
- Challenge is there for the structure detection on individual profile basis.

Final retrieval and its first-guess *vs*. radiosonde



AIRS overpass 18 minutes after RS92 launch at Beltsville

IASI retrieval *vs.* its first-guess