NASA Sounder Science Team Meeting
October 13-16, 2015
Greenbelt, Maryland

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

Bomin Sun[1,2], Tony Reale[2], Frank Tilley[1,2], and Mike Pettey[1,2]

1 I. M. Systems Group, Inc., Rockville, Maryland
2 NOAA/NESDIS/STAR, College Park, Maryland

Background & Goal

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. T**o 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.

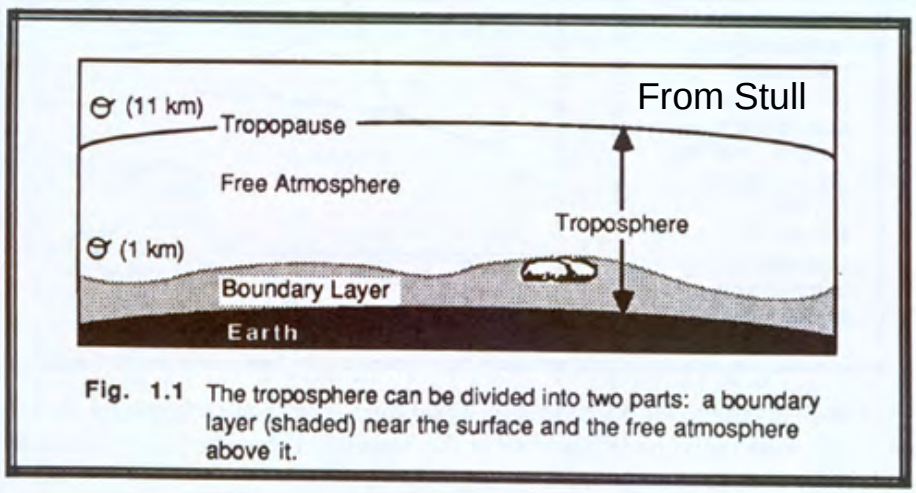
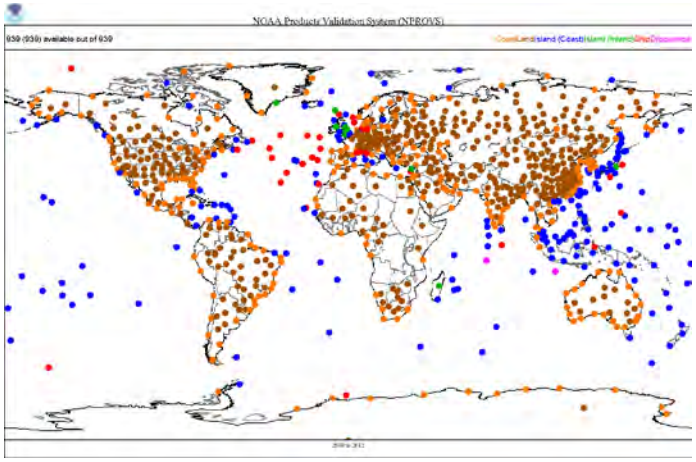


Fig. 1.1 The troposphere can be divided into two parts: a boundary layer (shaded) near the surface and the free atmosphere above it.

Data

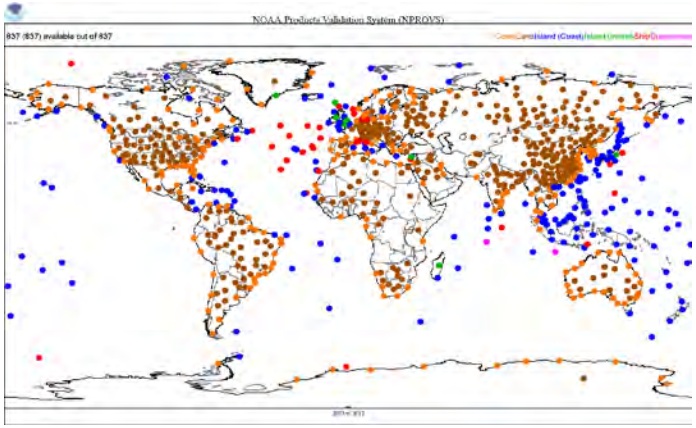
- MetOp-A Infrared Atmospheric Sounding Interferometer (IASI) L2 sounding product developed by NOAA NESDIS.
- RAOB-NOAA IASI collocations (2010-2012) collected via the NOAA satellite Products Validation System.
- Only *qc-accepted* IR+MW IASI retrieval profiles are used.

Collocations within 6-hr & 50-km



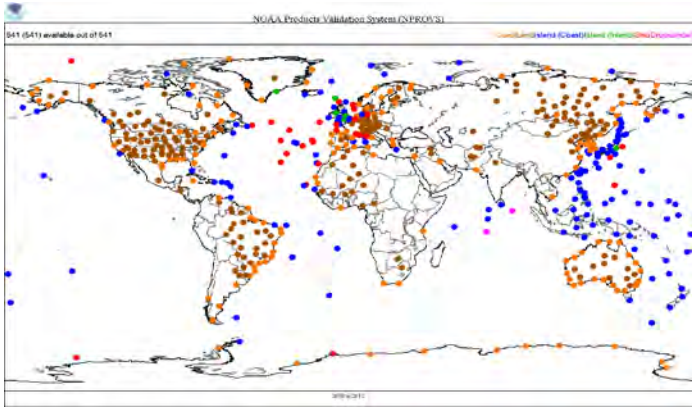
Sample: 550,500 (939 sites)

Collocations within 3-hr & 50-km



Sample: 313,500 (837 sites)

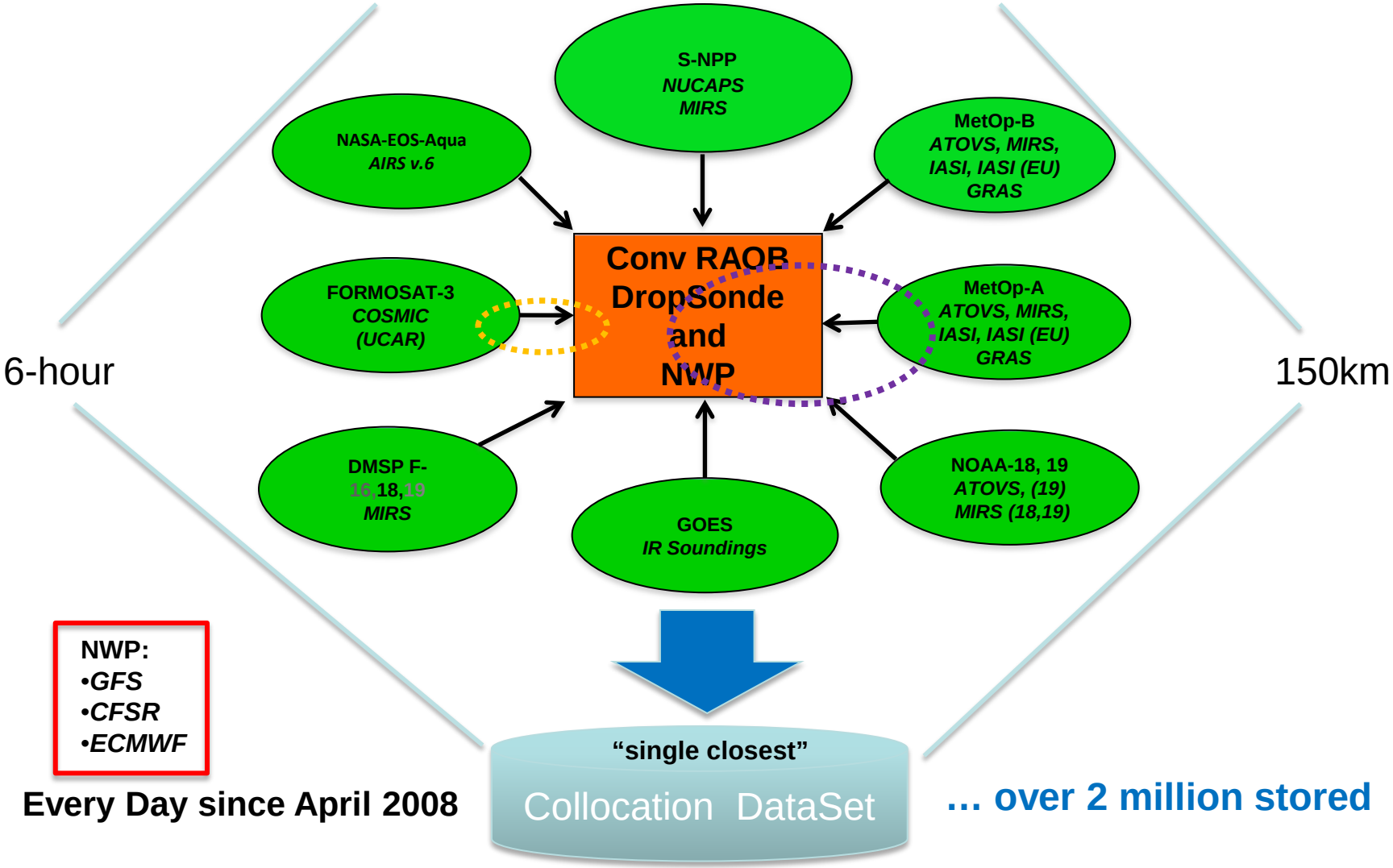
Collocations within 1-hr & 50-km



Sample: 99,000 (541 sites)

NOAA Products Validation System (NPROVS)

Centralized RAOB and Satellite Product Collocation

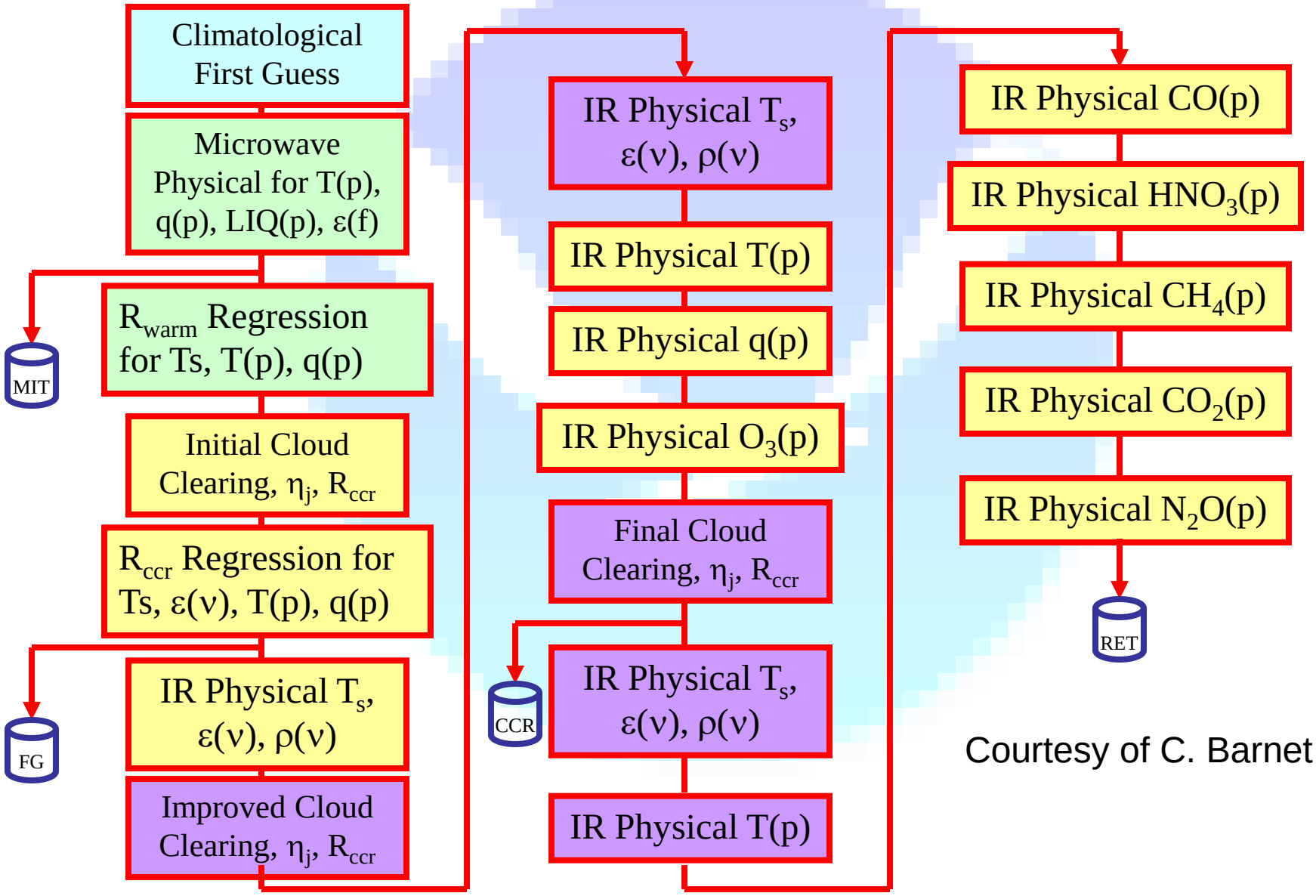


Every Day since April 2008

… over 2 million stored

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

Simplified flow diagram of the NOAA IASI retrieval algorithm



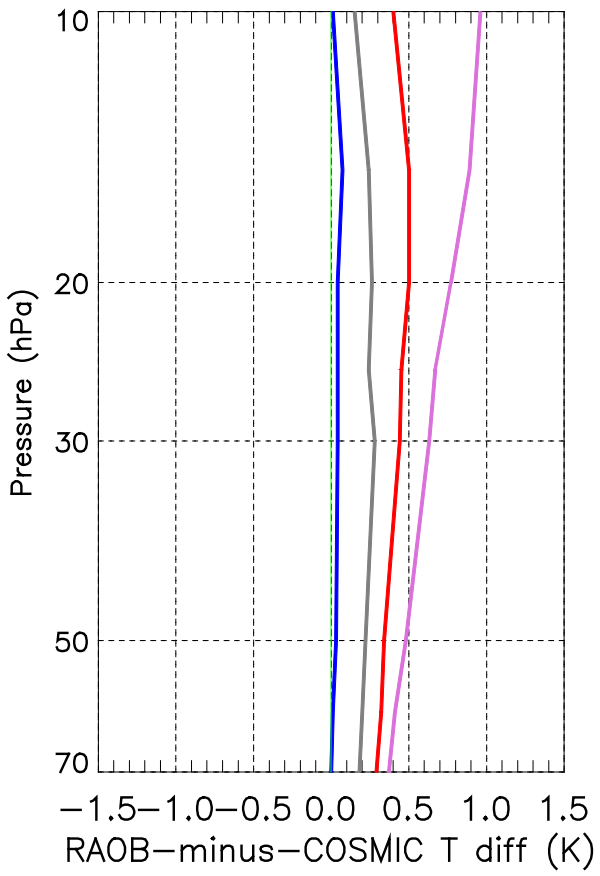
Courtesy of C. Barnet

RAOB Accuracy Impact in Validation

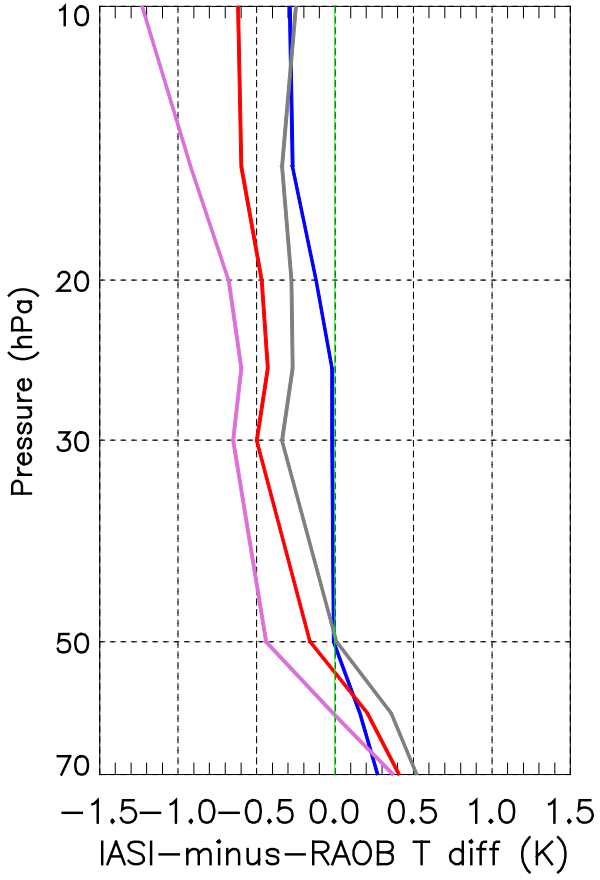
- RAOB measurement accuracy characteristics and impact on satellite validation
  - Temperature
  - Humidity

Errors in RAOB T and Impact in Validation

Radiosonde T error



IASI-minus-RAOB T diff.



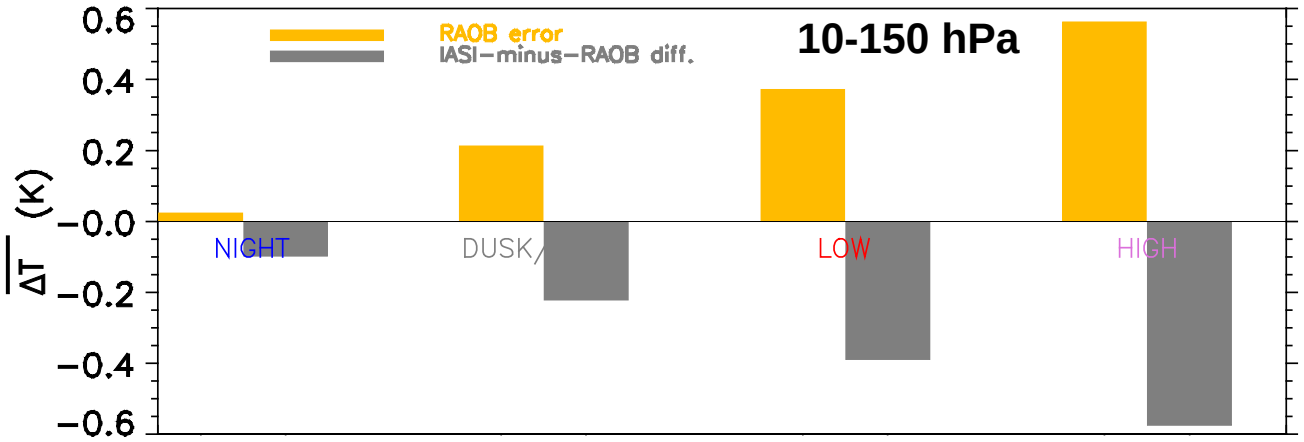
Solar Elevation Categories

- 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).

Collaboration with NCEP to improve their RADCOR in assimilation & forecasting.

RAOB Temperature error impact in validation



Solar Elevation Categories

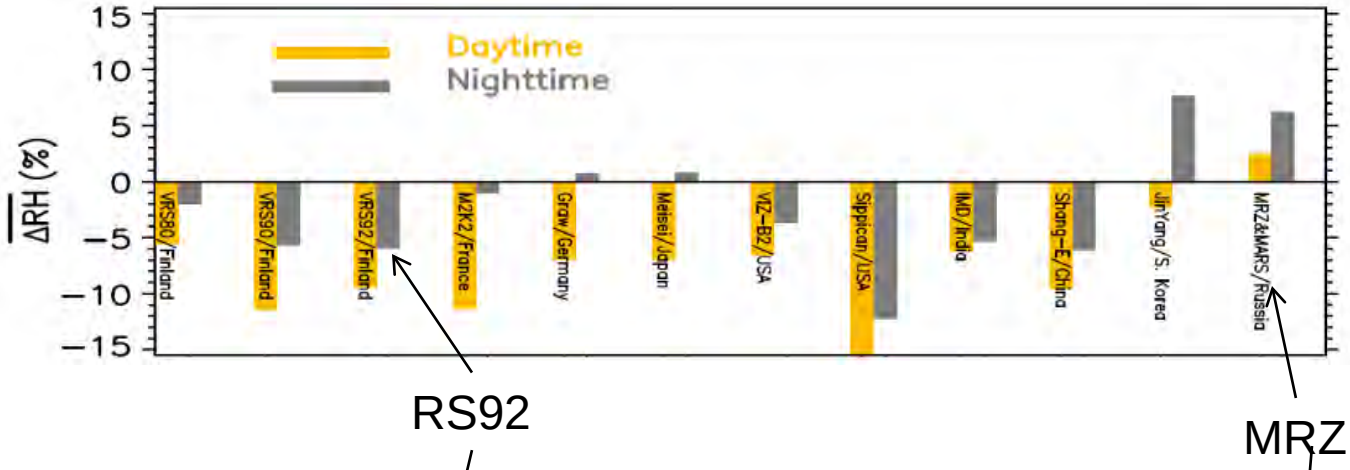
- NIGHT (<−7.5 deg)
- DAWN/DUSK (−7.5 – 7.5 deg)
- LOW (7.5 – 22.5 deg)
- HIGH (>22.5 deg)

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**

Radiosonde type relative humidity (RH) bias

RAOB 300 hPa RH bias



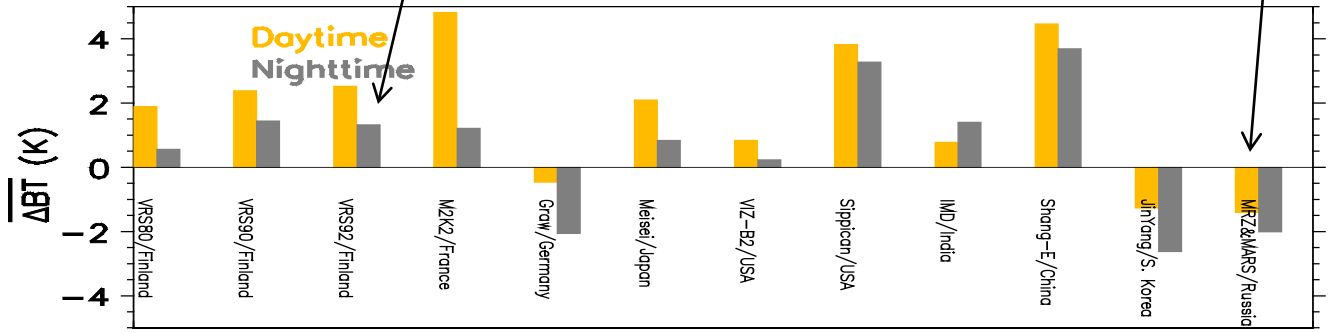
RS92

MRZ

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

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

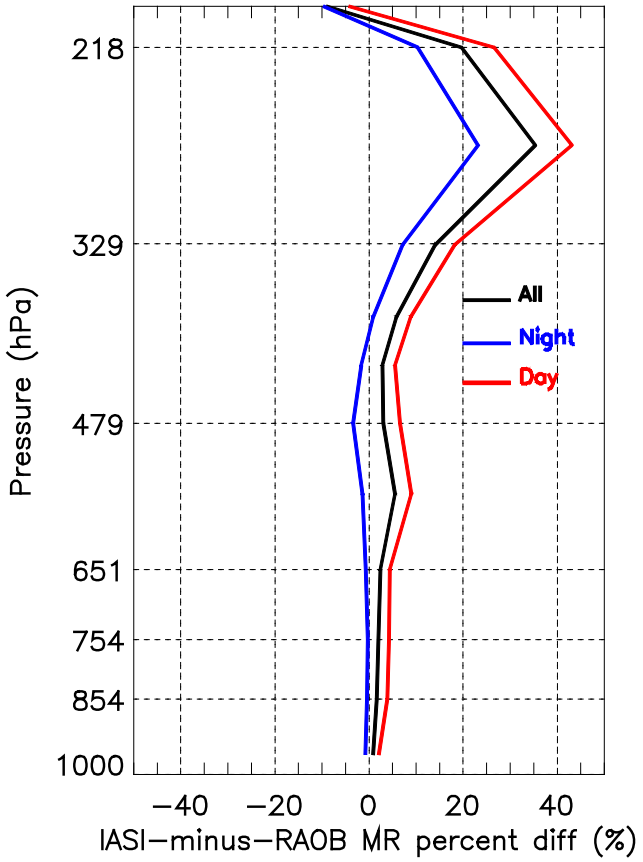
Calculated RAOB BT -minus-satellite observed BT for 183+/- 1 GHz



Sun et al. (2010, JGR)

RAOB humidity error impact in validation

IASI-minus-RAOB water vapor mixing ratio diff.



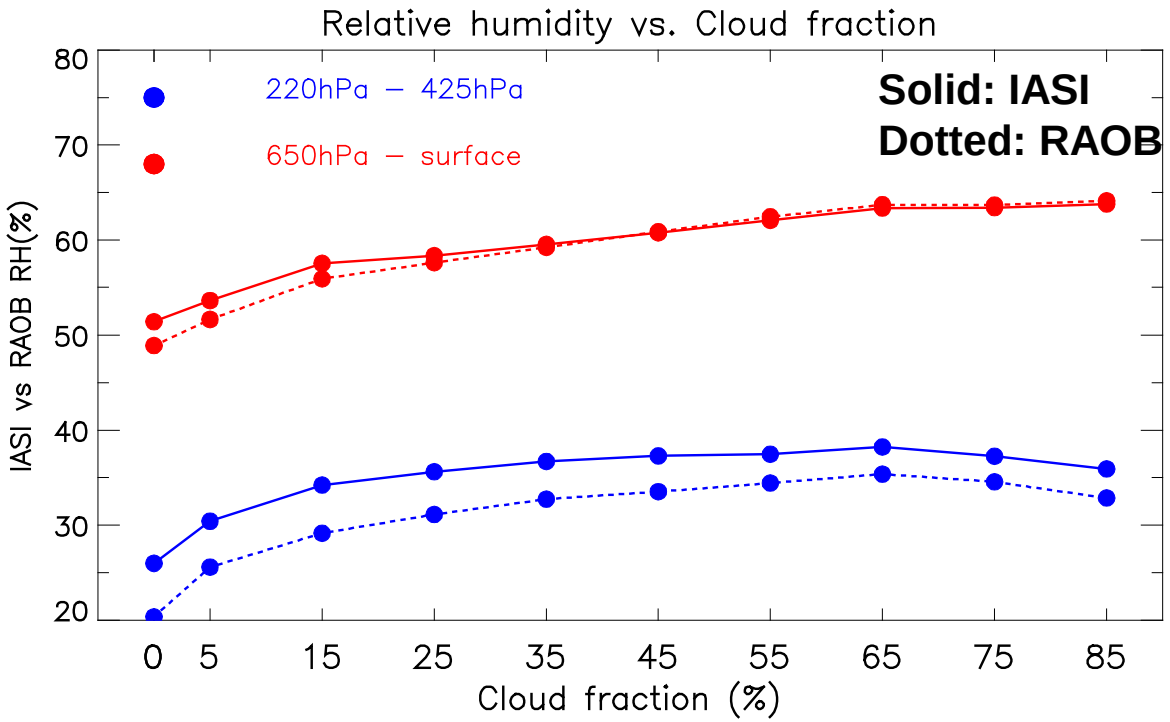
RAOB humidity tends to have a dry bias particularly at the upper level during daytime.

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

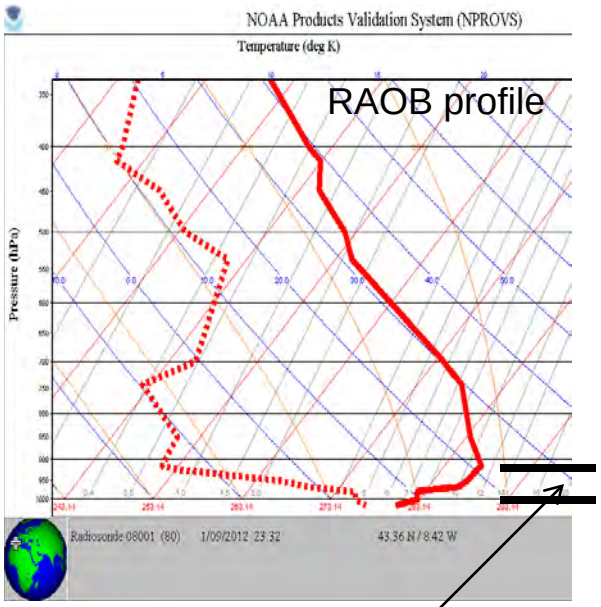
Consistency among cloud, temperature and humidity in the IASI retrieval system



RAOB *vs.* IASI atmospheric structure

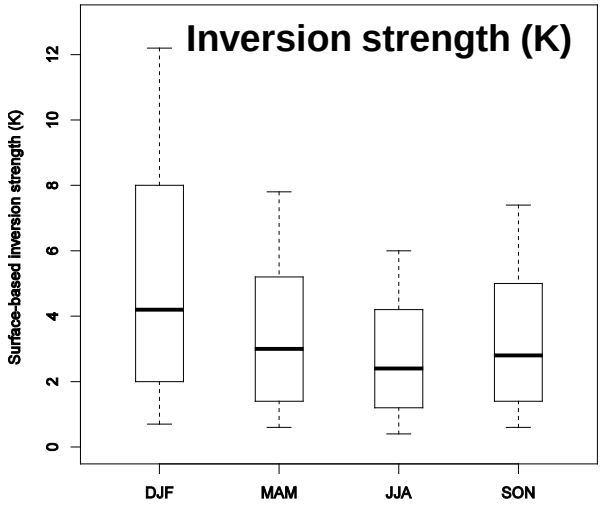
- Atmospheric structure features in RAOB *vs.* IASI retrieval profiles
  - Surface inversion
  - Unstable boundary layer (surface-based inversion cases excluded)
  - Tropopause

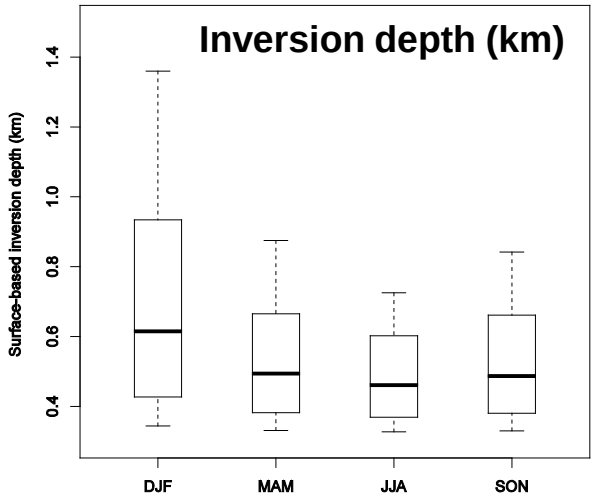
Surface-based temperature inversion in RAOBs



Surface inversion layer
Depth: 876 m
Strength: 6.2 K

Based on 3-yr global data. Sample: 445,000





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

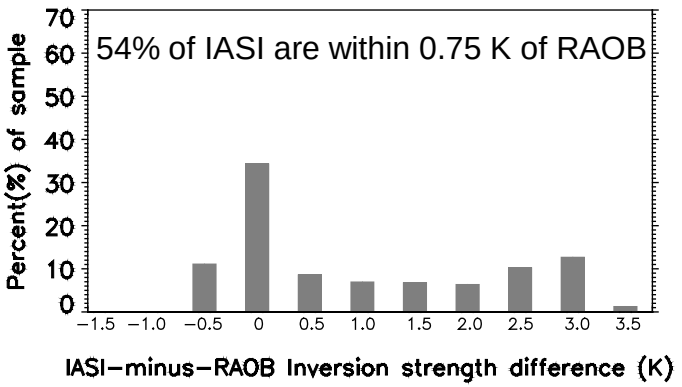
Surface-based inversion statistics: RAOB *vs*. IASI

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

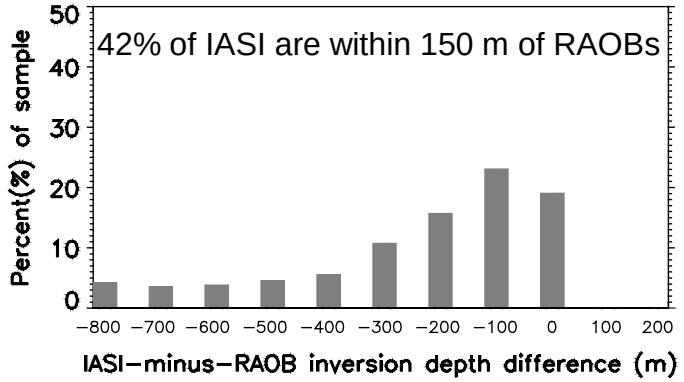
RAOB Inversion YES (11455) → IASI Inversion YES (51%)

RAOB Inversion NO (77725) → IASI Inversion NO (88%)

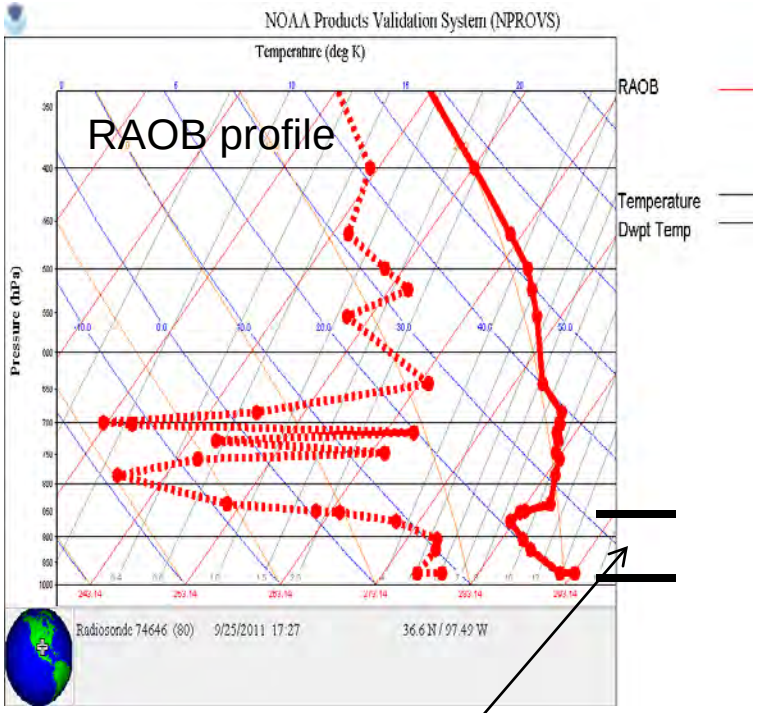
Diff. in inversion strength



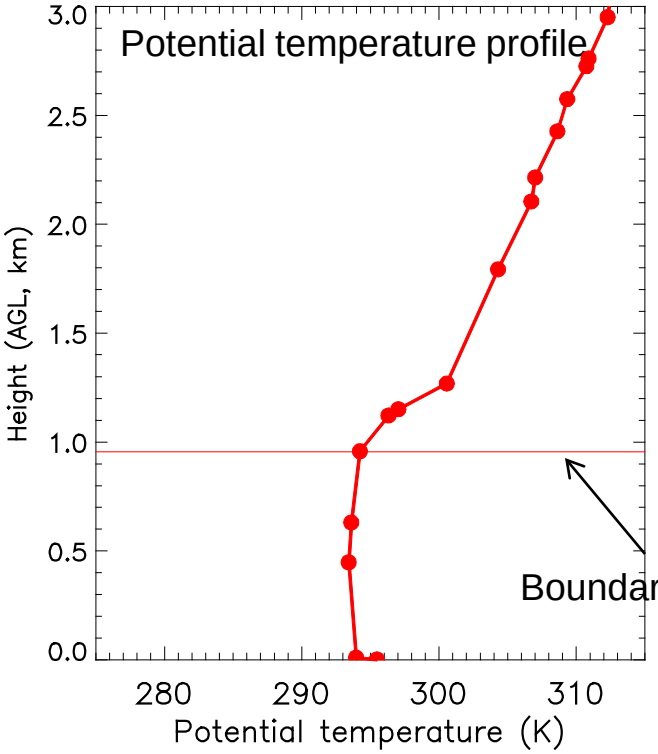
Diff. in inversion depth



Detection of unstable boundary layer

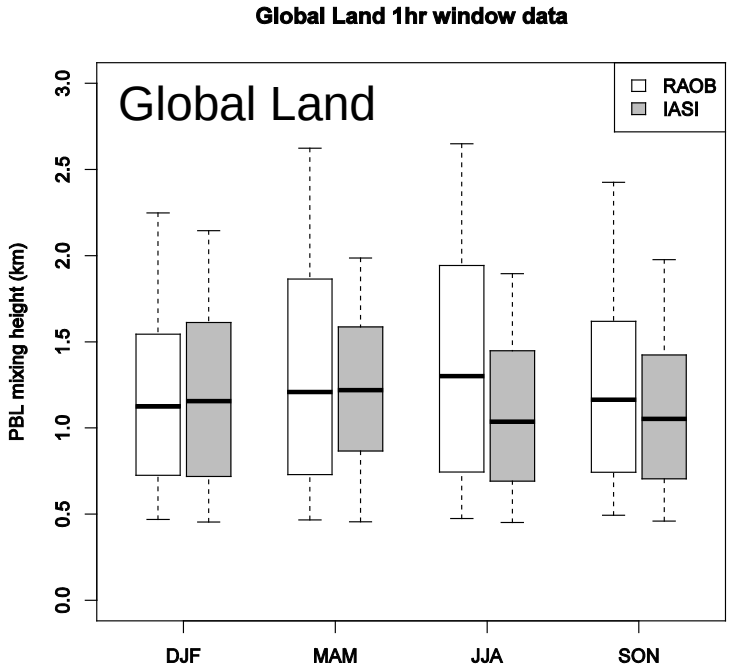


Unstable boundary layer

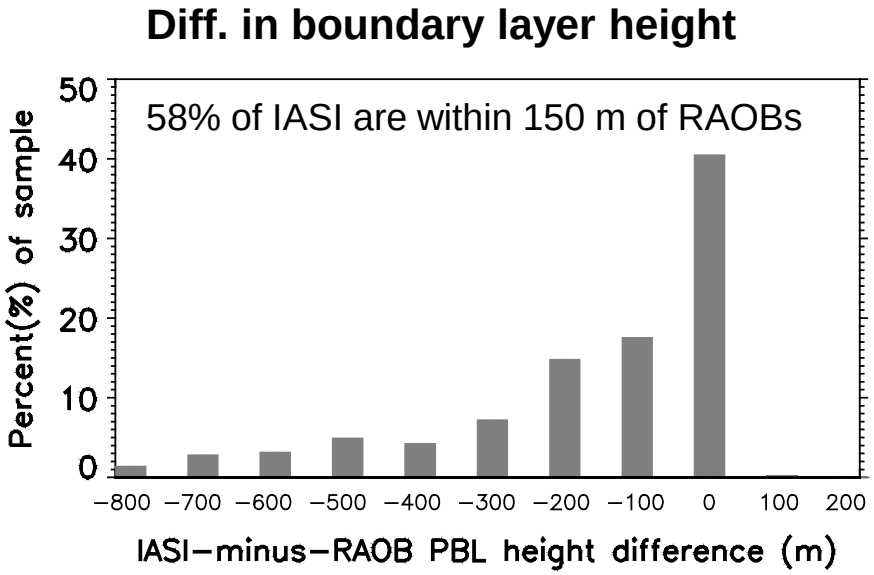


Boundary layer height

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



Sample 2905 4018 5199 3710



Box-and-whisky
90th
75th
50th
25th
10th

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%

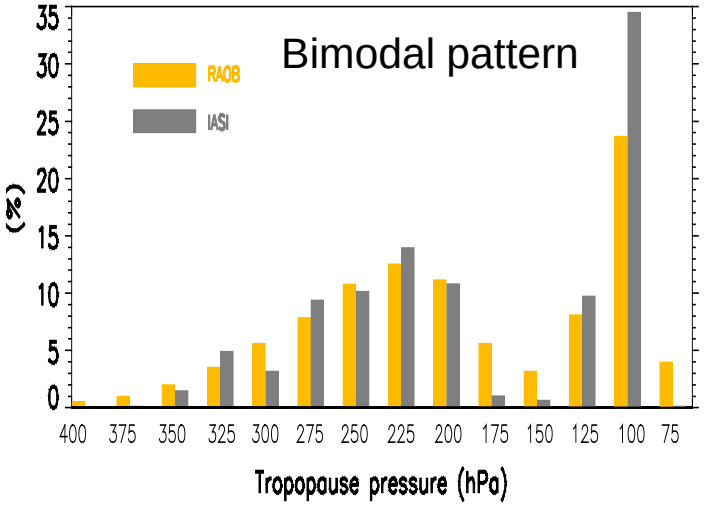
Unstable boundary layer height

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

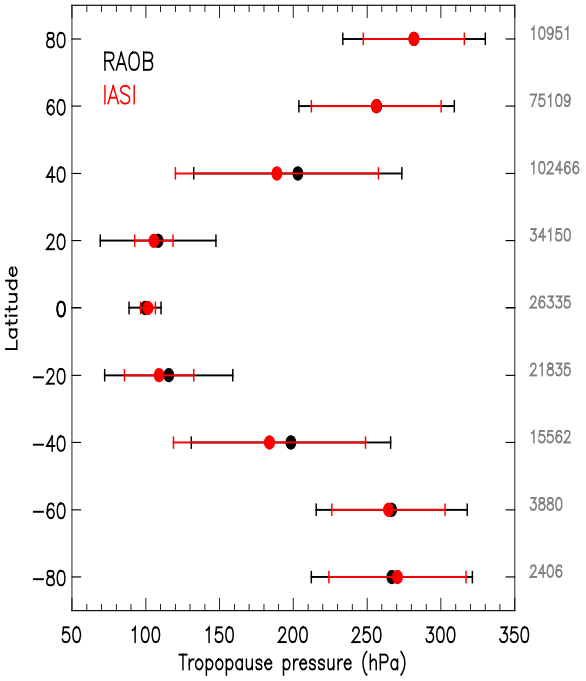
RAOB and IASI within 0.5-hr or less?

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

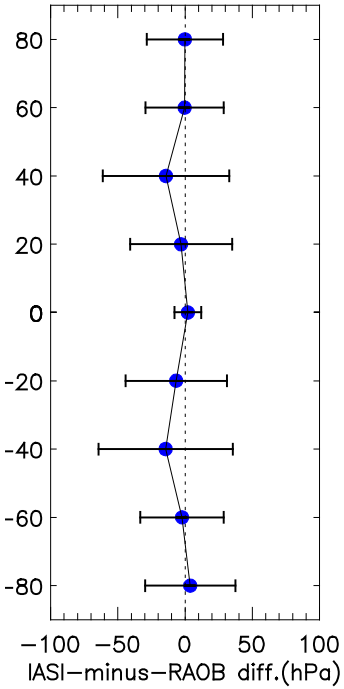
Occurrence probability distribution



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
  - evaluating individual variables in the retrieval product
  - verifying the thermo-dynamic link among cloud, temperature and humidity in the retrieval system

- RAOB accuracy issues including T warm bias at UTLS and humidity dry bias in cold & dry environment.

- NOAA IASI retrievals can catch the climatology of atmospheric structures (i.e., surface inversion, boundary layer, tropopause) as observed by RAOBs.

- NPROVS has been known for its product monitoring capability and it also allows to conduct deep-dive analysis in EDR cal/val and other applications.

IASI retrieval *vs.* its first-guess