Error Assessment and Validation of the IASI Temperature and Water Vapor Profile Retrievals

Validation by Radiosonde Correlative Measurements

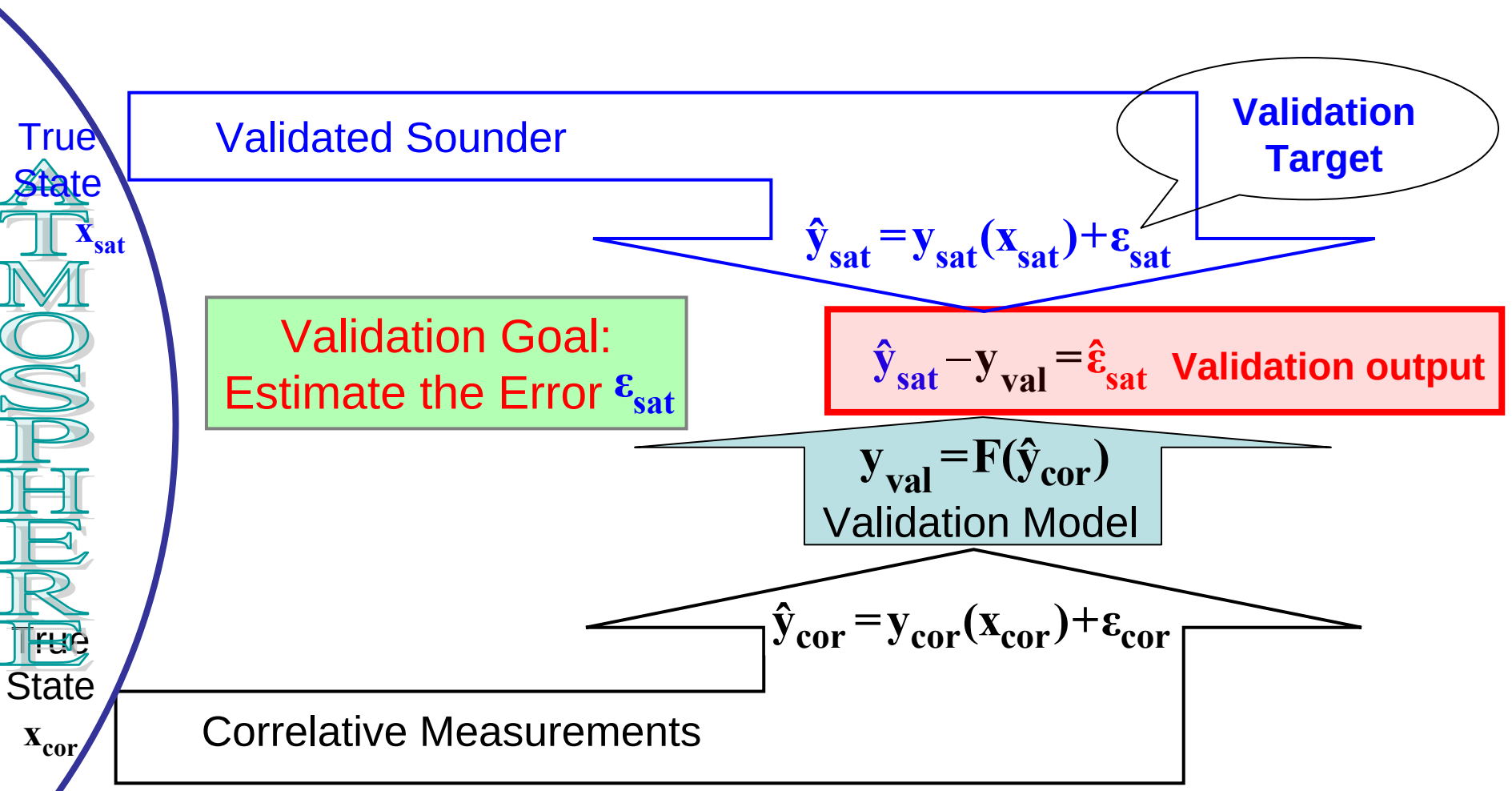
N. Pougatchev, T. August, X. Calbet, T. Hultberg, P. Schlüssel, B. Stiller
K. St. Germain and G. Bingham

ITSC-16 Angra dos Reis
May 7, 2008

Objectives

- Scientific/Methodological – Testing of NPP CrIS Validation Assessment Model by its application to validation of IASI L2 data against radiosondes
- Scientific/Utilitarian – Assessment of the IASI Temperature and Water Vapor retrieval errors in the form that can be utilized by the community – regionally specific Covariance and Bias

Validation by Correlative Measurements



Validation Issues

Why do We Need Validation Model

Why We Can NOT Use Correlative Data As Is

- Characteristic Difference– validated sounder and correlative measurements sample atmosphere differently.
- State Non-Coincidence – correlative measurements are at different time and location.

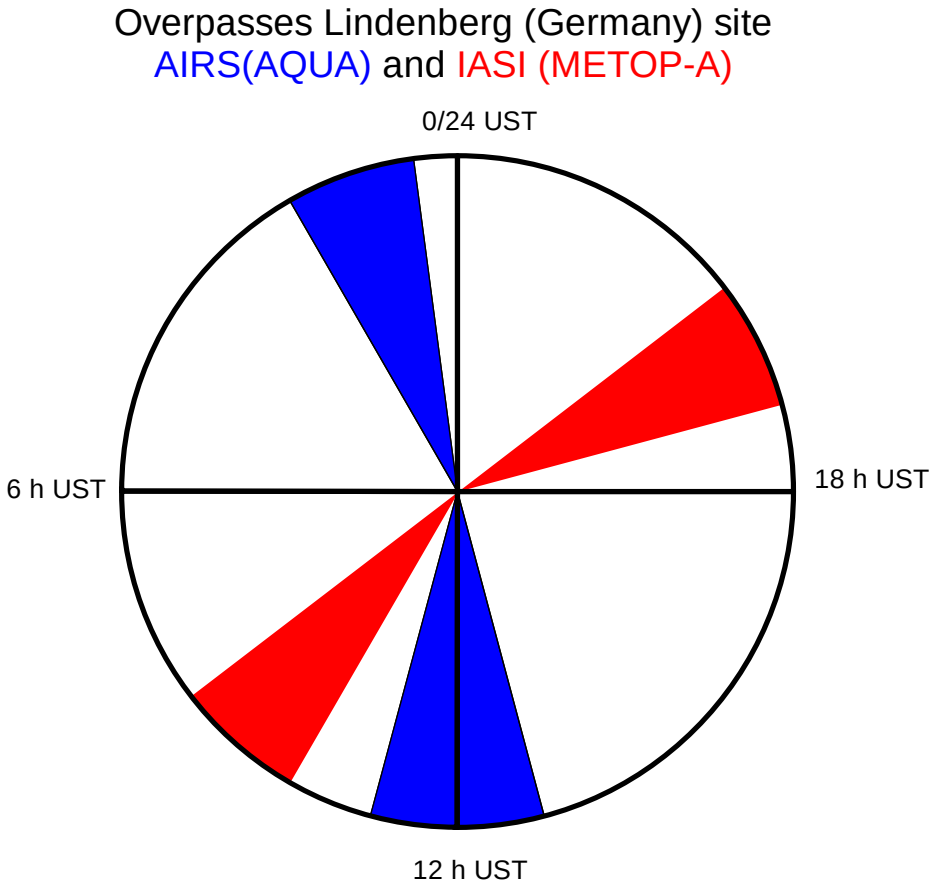
Validation Model reconciles the issues by modeling best linear estimate of the satellite measurements and assessing the errors

$$\mathbf{y}_{val} = \mathbf{B}\hat{\mathbf{y}}_{cor} = \mathbf{y}_{sat}(\mathbf{x}_{sat}) + \boldsymbol{\varepsilon}_{val}$$

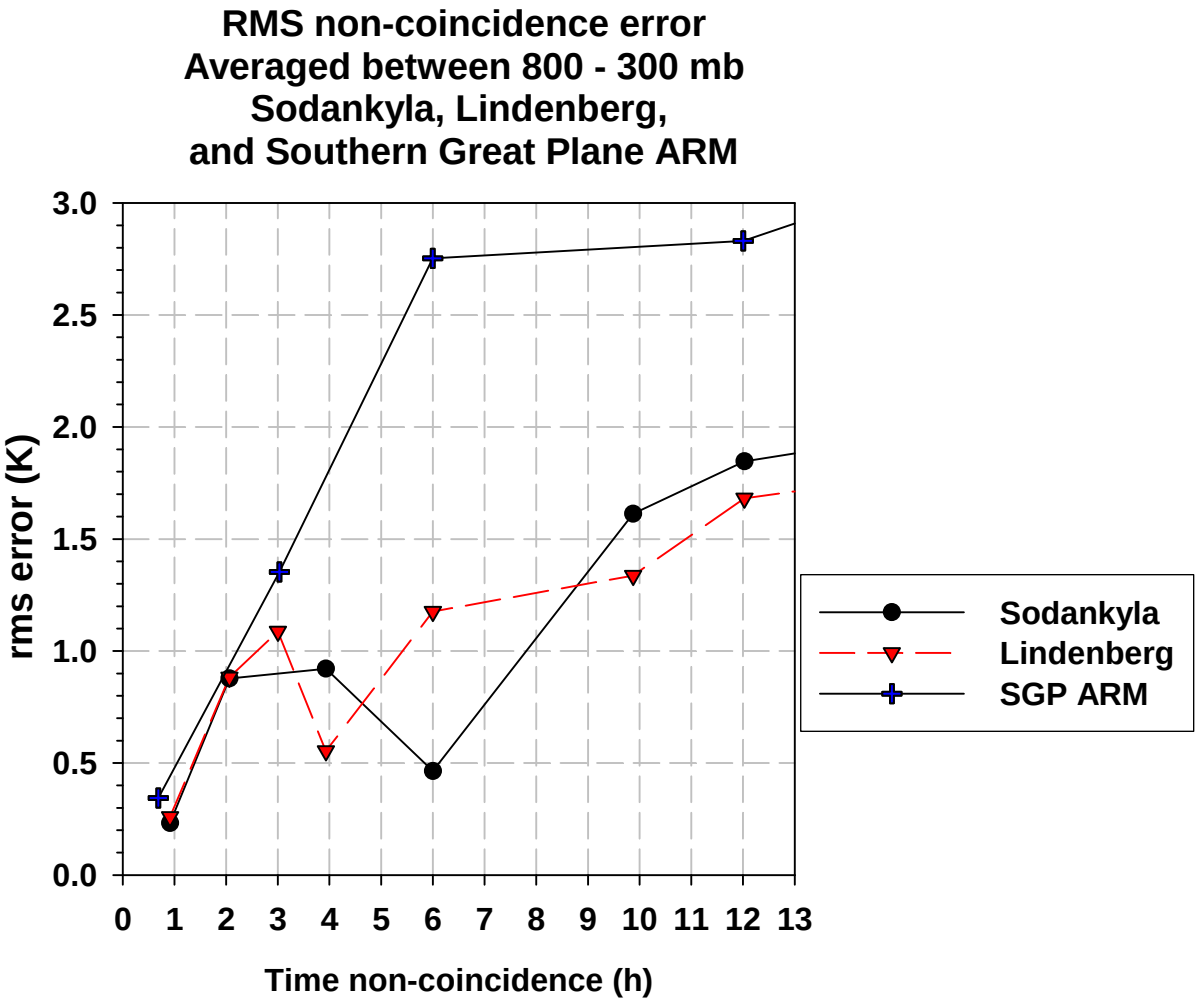
IASI Validation Study

- *Validation Data Set* – radiosondes at Lindenberg (Germany, 52.21° N, 14.12° E, 112 m a.s.l). Dedicated launches 1 hour prior and at the overpass time; and synoptic times (0, 12, 6, and 18 UTC)
- *Validated parameters* – Atmospheric Temperature and Water Vapor Vertical Profiles.
- *Validated System* – IASI characterized by averaging kernels.
- *Validated Data Set* – EUMETSAT v. 4.2 retrievals; cloud clear; $\pm 1^{o}$ Lat. and Long. about Lindenberg

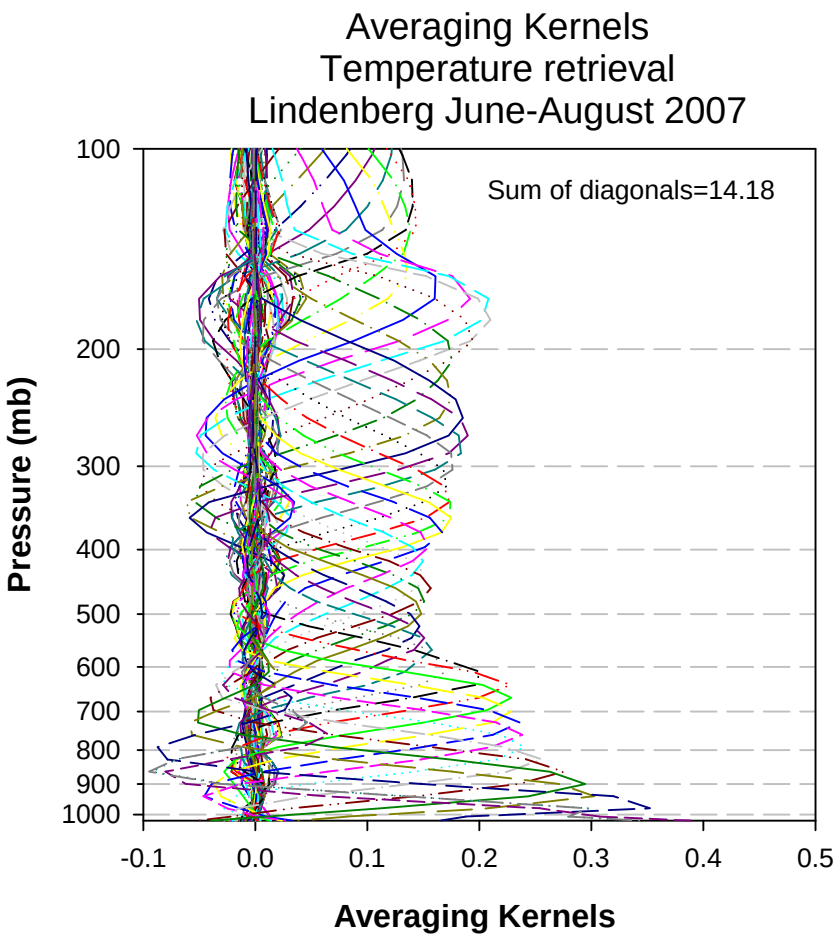
Overpasses and Sonde Launches



Temperature Non-Coincidence Error Free Troposphere



Averaging Kernels Temperature



AvKe_IASI_LND_2007.JNB

Temperature Retrieval Error
Variances/rms

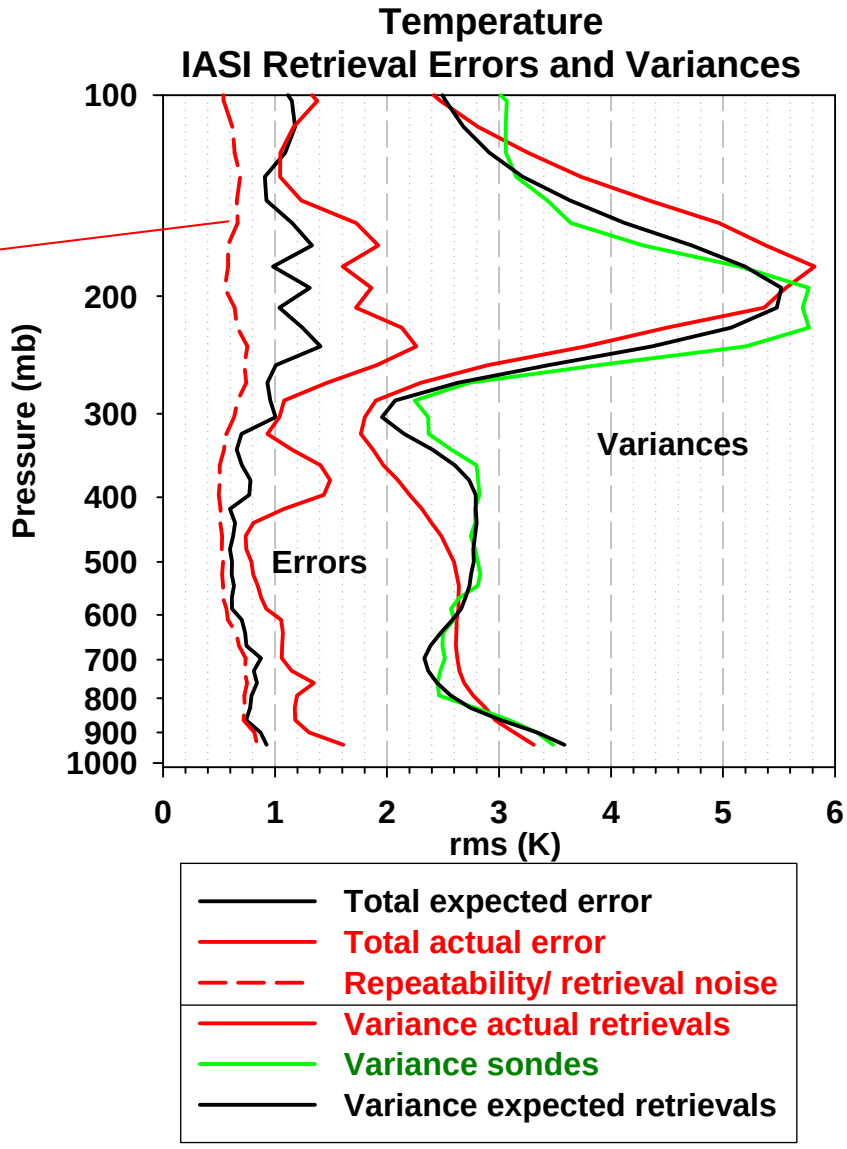
Expected retrieval - $\hat{\mathbf{x}}_{exp}$

$$\hat{\mathbf{x}}_{exp} = \mathbf{x}_a + \mathbf{A}(\mathbf{x}_{true} - \mathbf{x}_a) + \boldsymbol{\varepsilon}$$

Expexted error - $\hat{\mathbf{x}}_{exp} - \mathbf{x}_{true}$

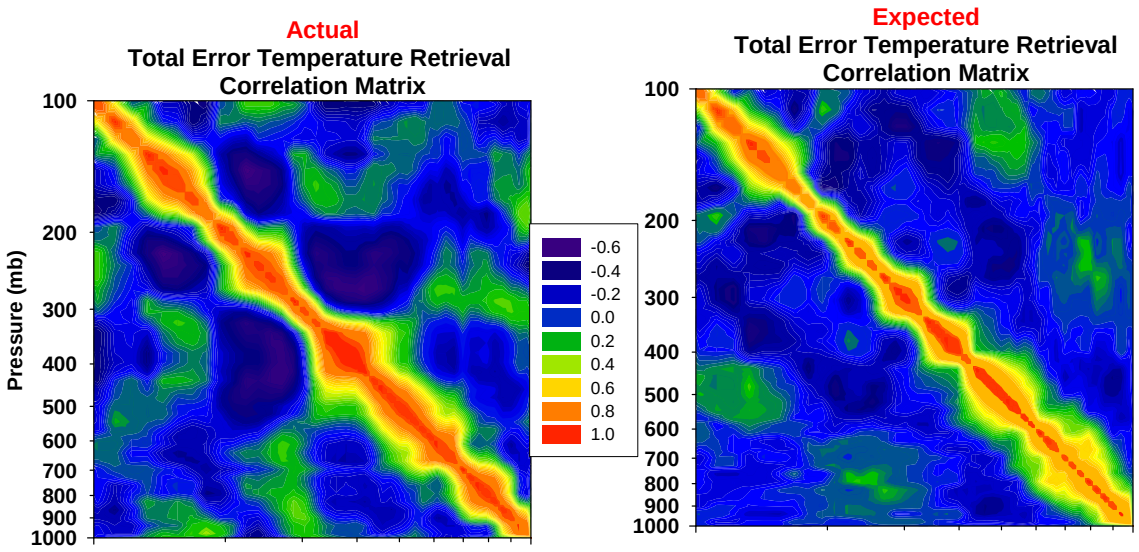
$$\mathbf{S}_{exp} = (\mathbf{I} - \mathbf{A})\mathbf{S}_x(\mathbf{I} - \mathbf{A})^T + \mathbf{S}_\varepsilon$$

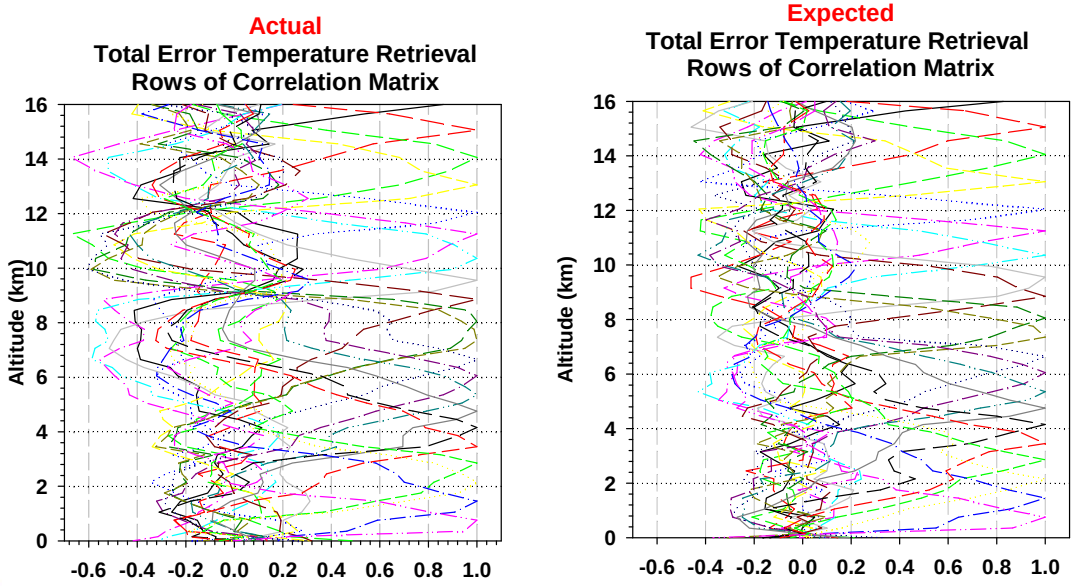
$$\text{Expected covariance} - \mathbf{A}\mathbf{S}_x\mathbf{A}^T + \mathbf{S}_\varepsilon$$



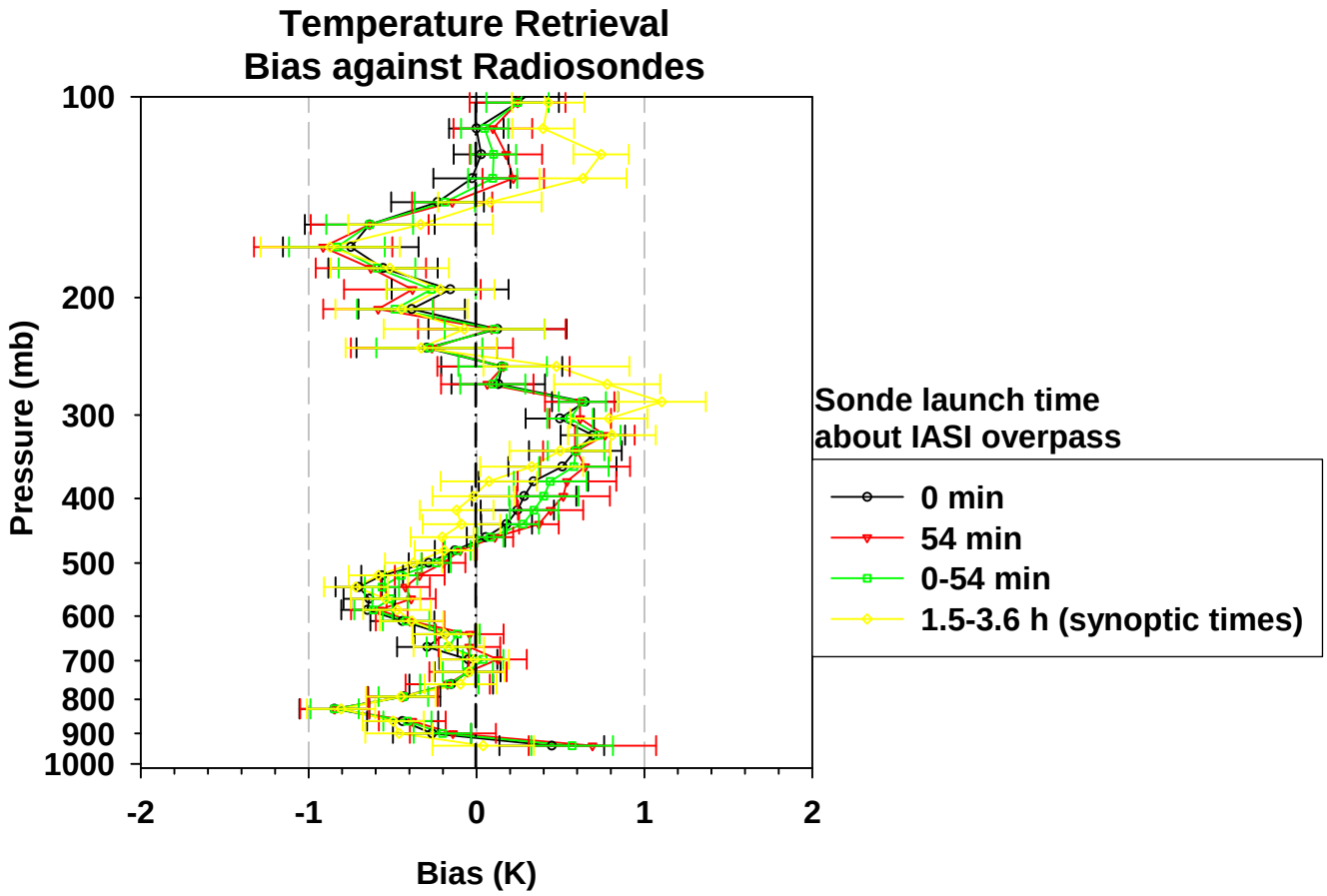
Temperature Retrieval Error

Covariance Matrices

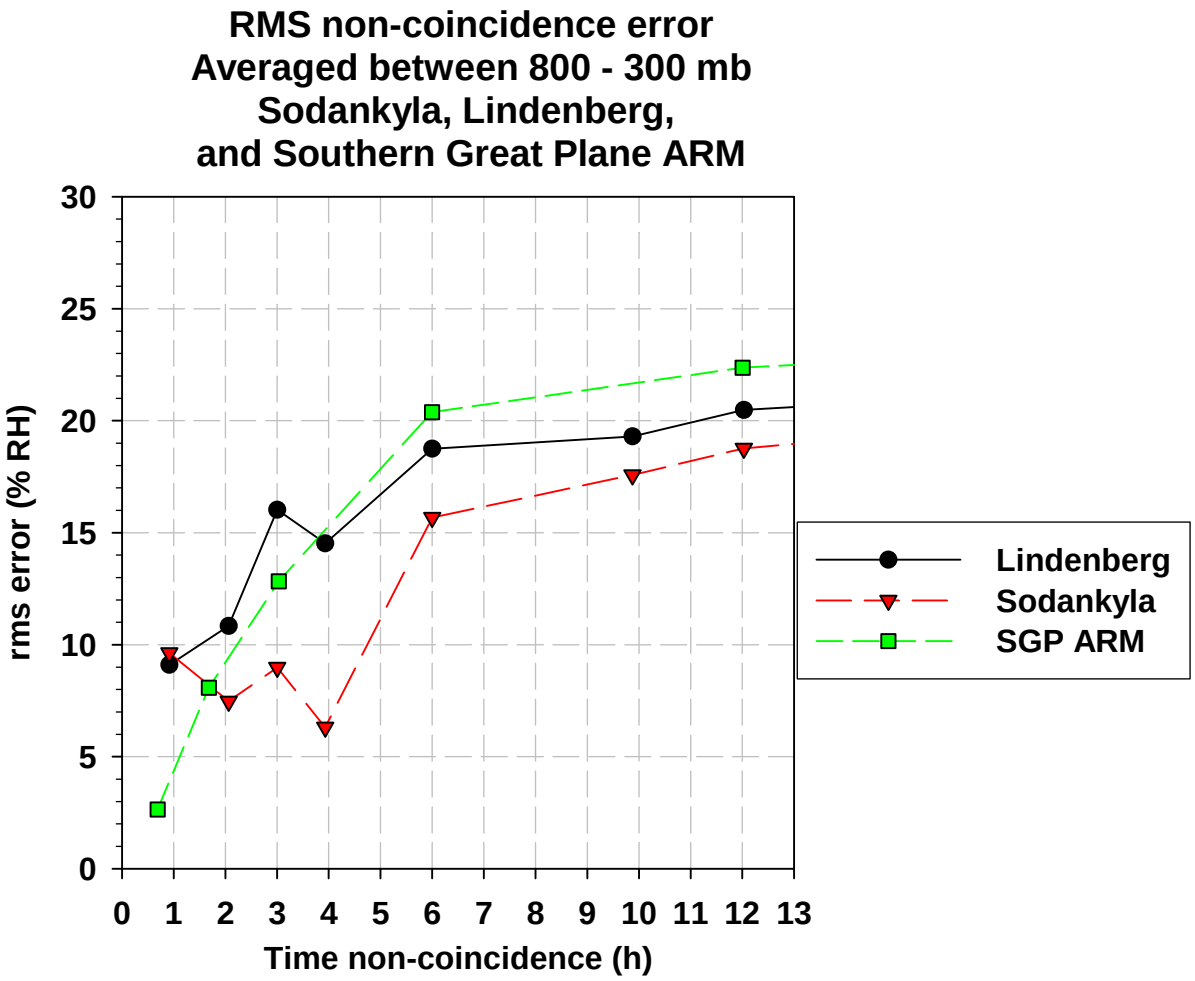




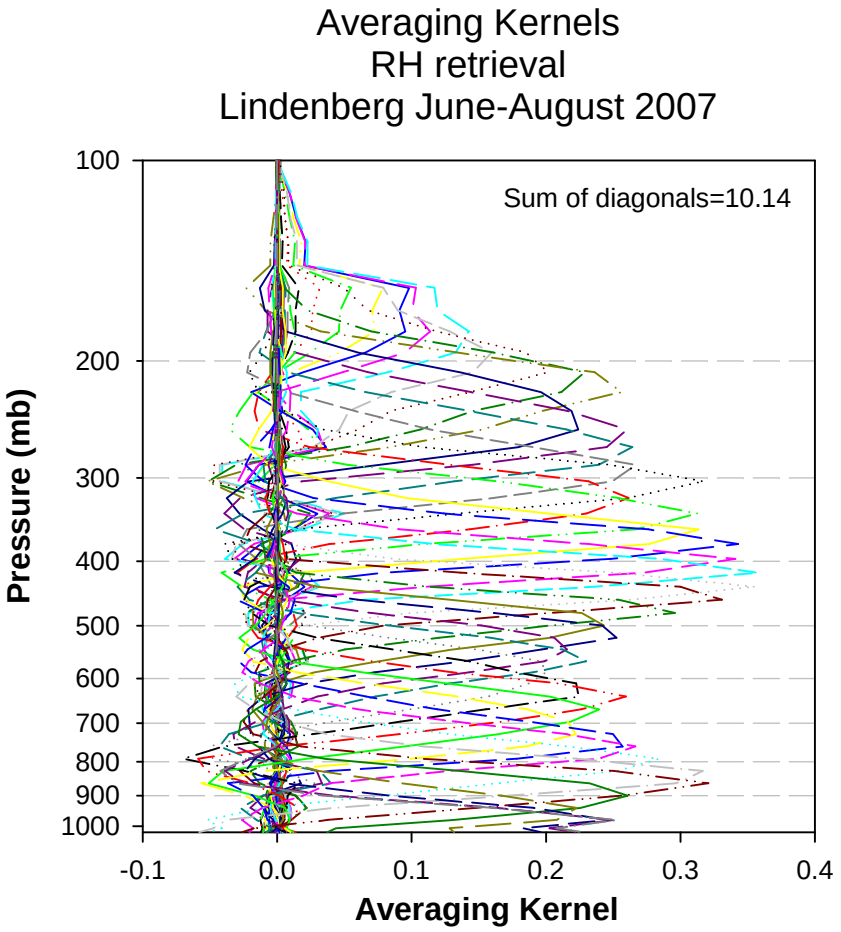
Temperature Retrieval Error
Bias



Relative Humidity Non-Coincidence Error Free Troposphere

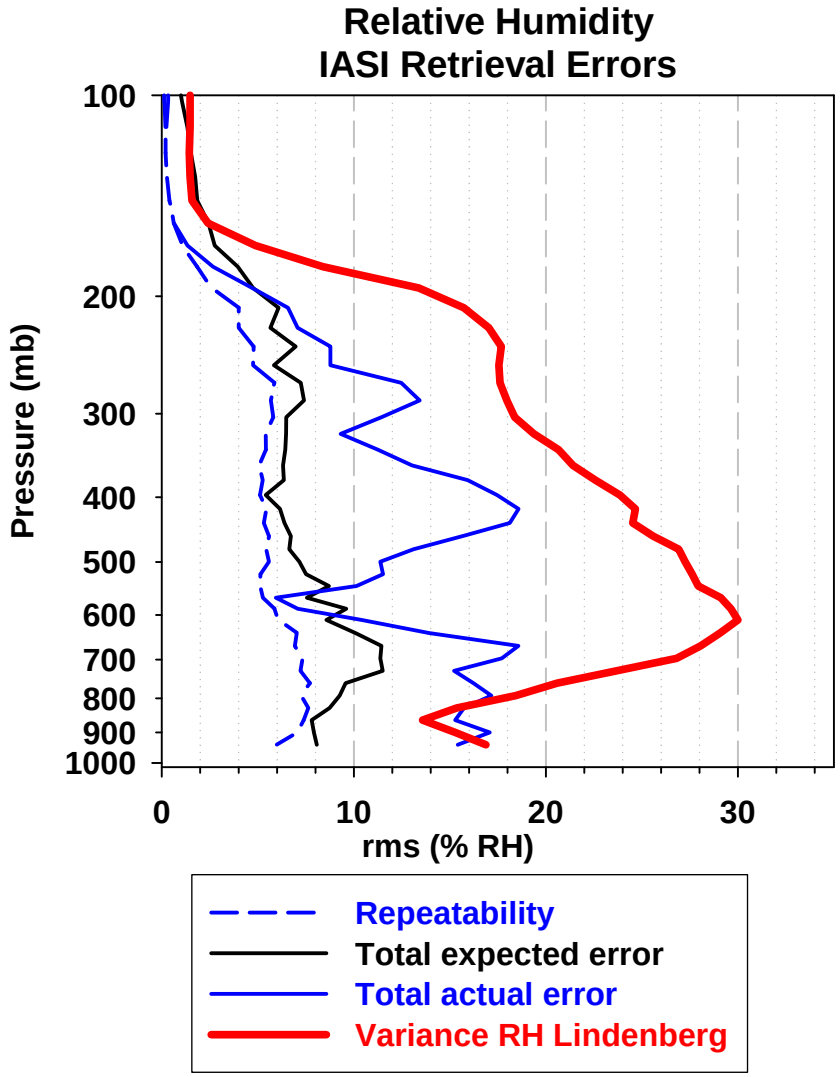


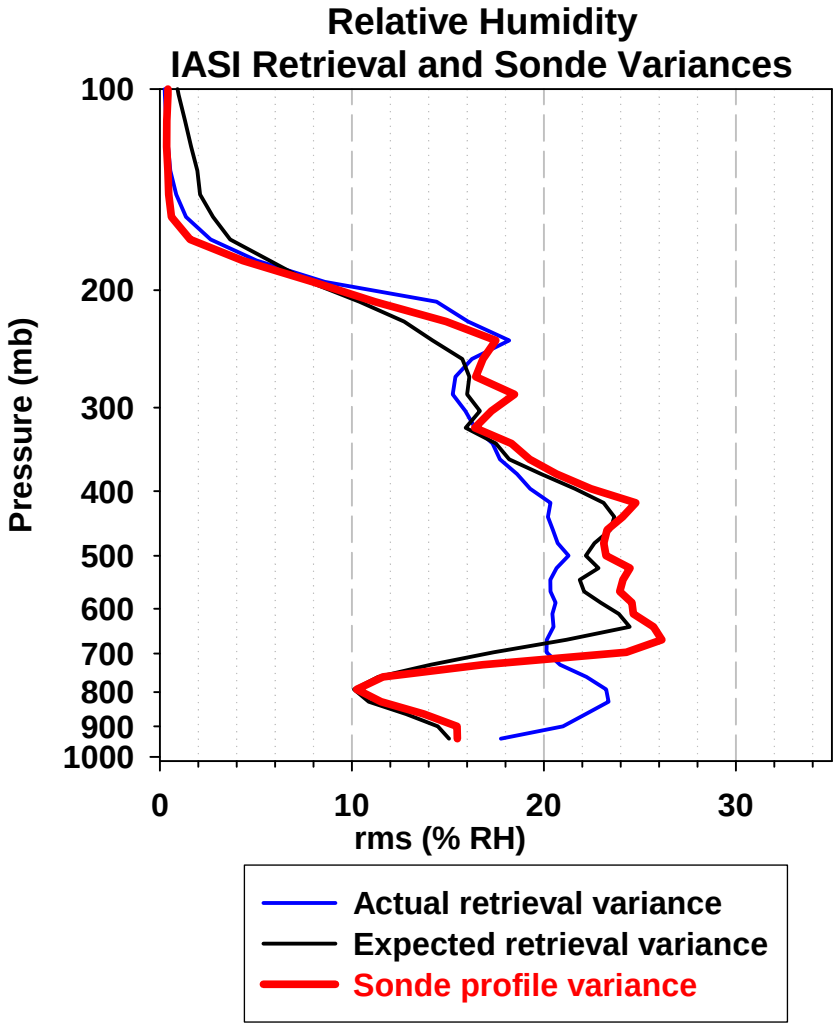
Averaging Kernels Relative Humidity



AvKe_IASI_LND_2007.JNB

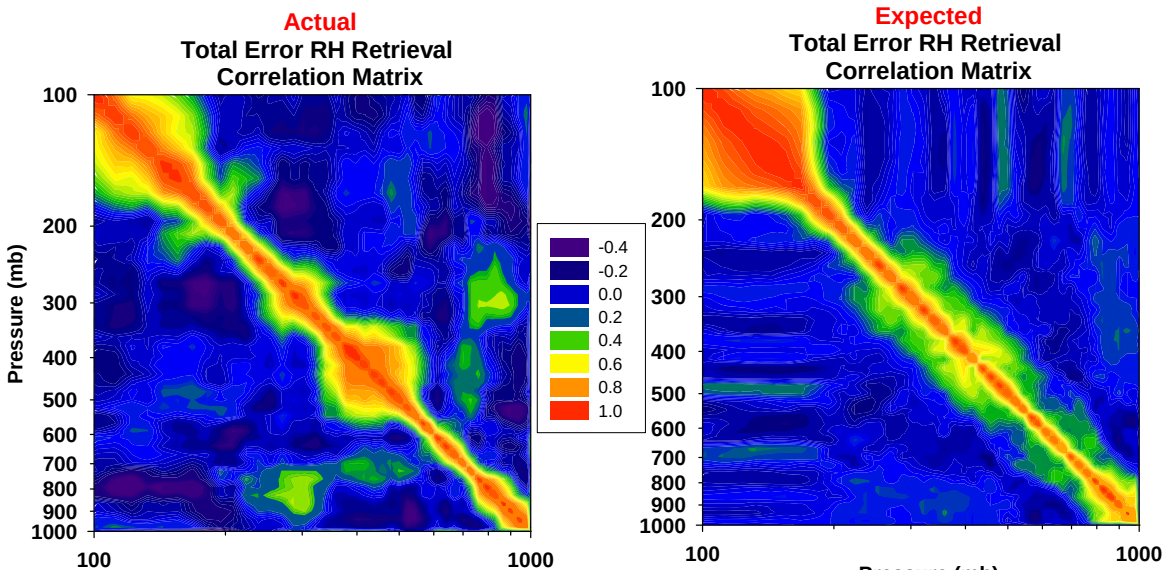
Relative Humidity Retrieval Error
Variances/rms

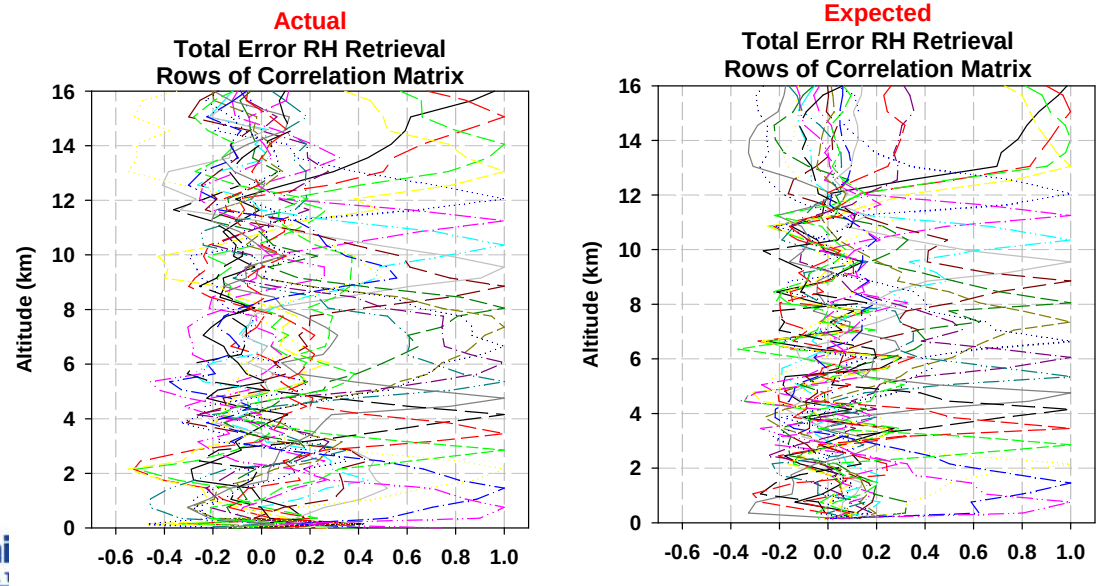




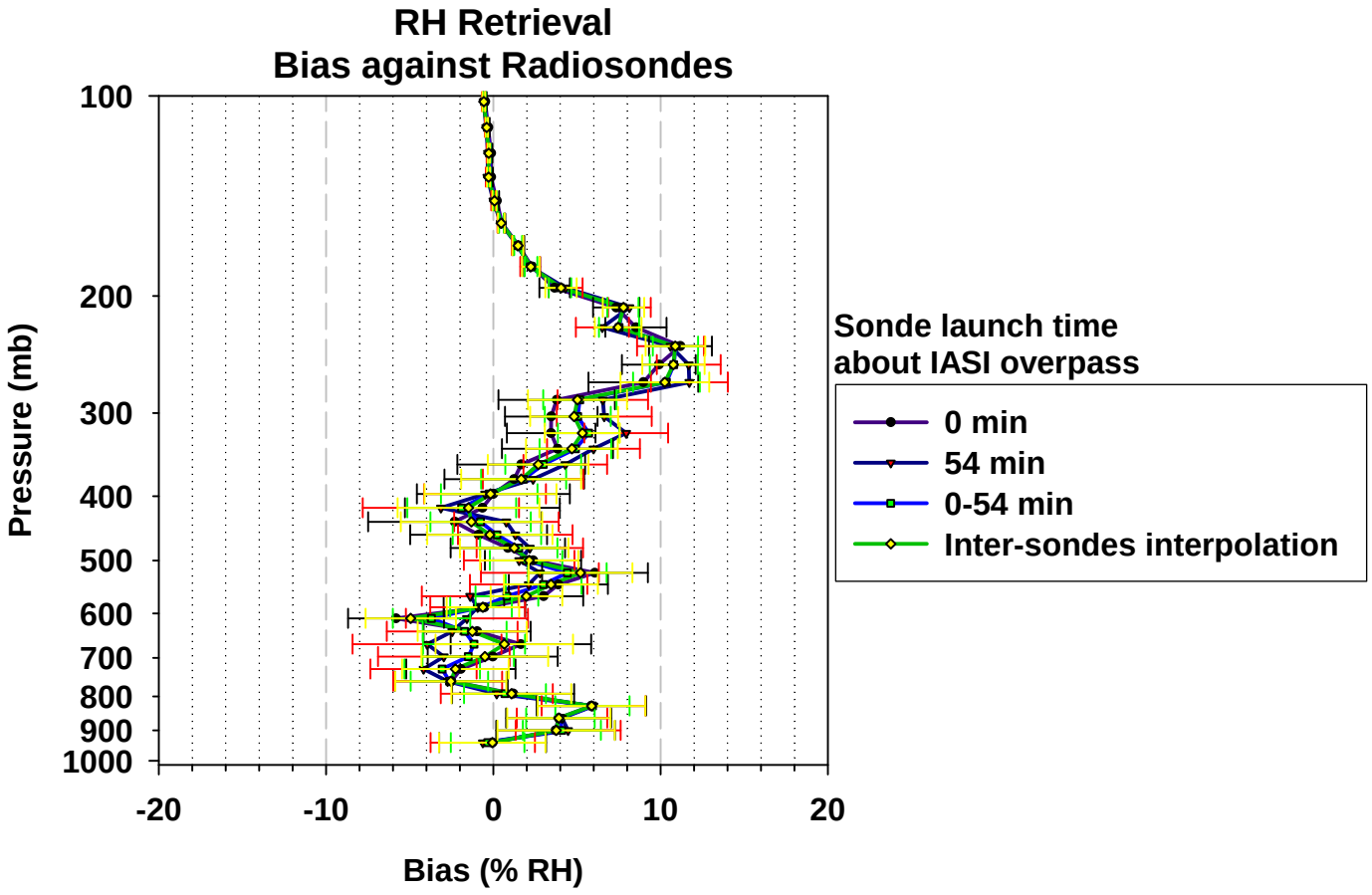
Relative Humidity Retrieval Error

Covariance Matrices





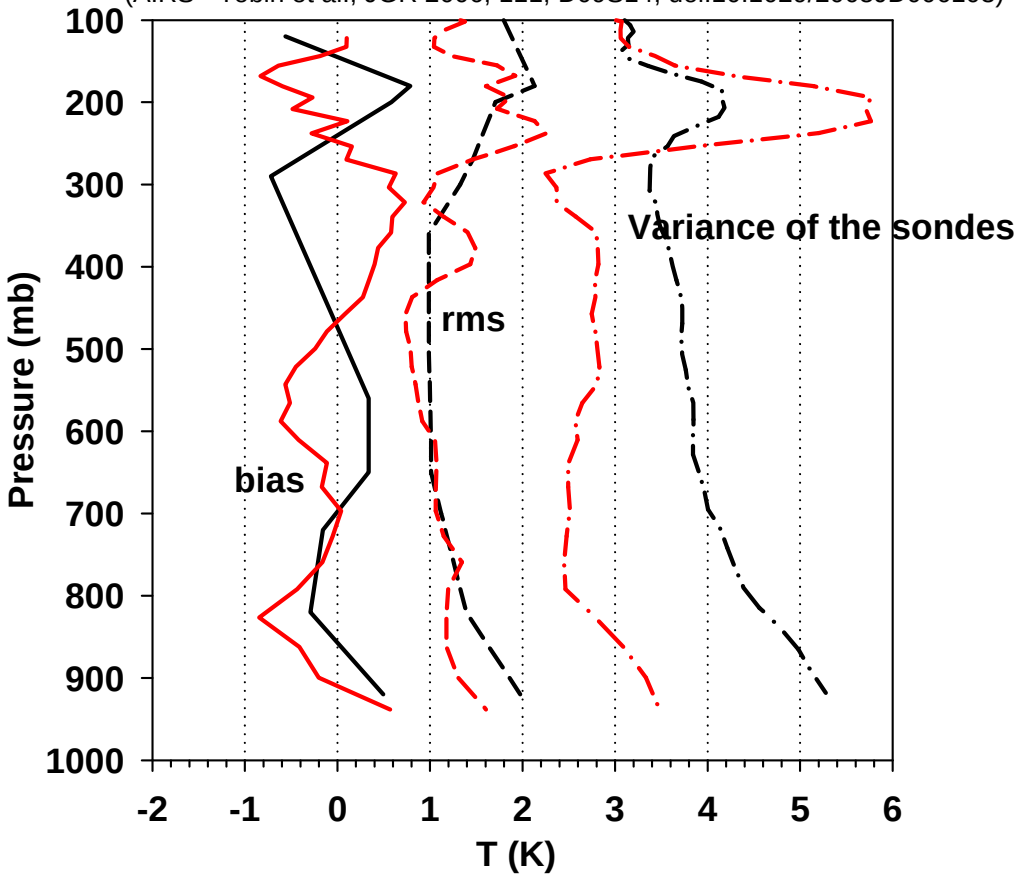
Relative Humidity Retrieval Error
Bias



IASI and AIRS Performance Temperature

Validation T retrievals vs. radiosondes
IASI (Lindenberg) and AIRS (ARM SGP)
IASI - red lines; AIRS - black lines

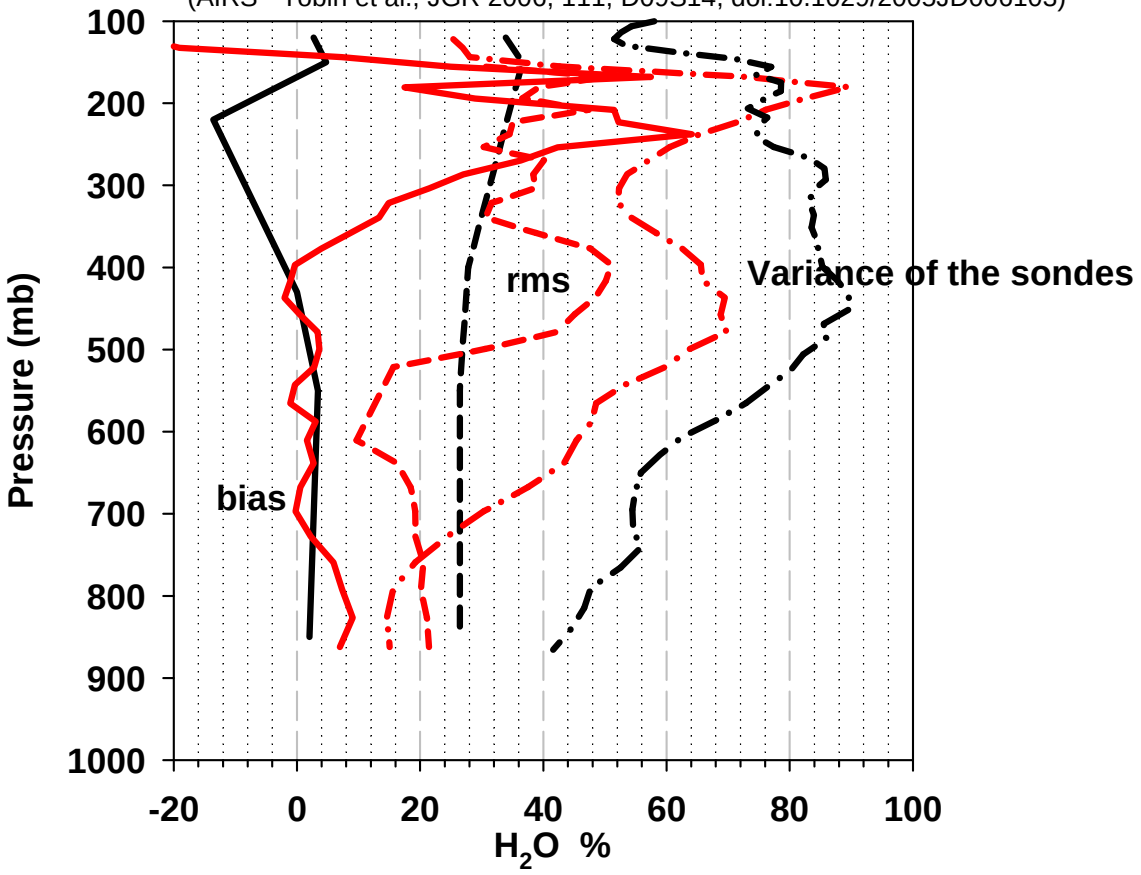
(AIRS - Tobin et al., JGR 2006, 111, D09S14, doi:10.1029/2005JD006103)



IASI and AIRS Performance Relative Humidity

Validation Water Vapor retrievals vs. radiosondes
IASI (Lindenberg) and AIRS (ARM SGP)
IASI - red lines; AIRS - black lines

(AIRS - Tobin et al., JGR 2006, 111, D09S14, doi:10.1029/2005JD006103)



This is NOT Relative Humidity!!!

Conclusions

- At Lindenberg state dependent error dominates the total error for both for Temperature and Relative Humidity. That implies that retrieval errors should be characterized regionally and seasonally specifically.

Conclusions

- Temperature
  - Our Validation Assessment Model and radiosondes allow to account for non-coincidence error and finite vertical resolution of IASI and assess retrieval errors accurately:
  - Variances/rms of a single FOV retrieval are $\leq 1K$ between 800 – 300 mb with increase to 2 K in tropopause and at the surface
  - Bias against radiosondes oscillates within $\pm 0.5K$ between 950 – 100 mb.
  - Actual vertical resolution apparently lower than expected in mid-troposphere and tropopause regions

Conclusions

- Relative Humidity
  - Complex spatial structure of highly variable RH field does not allow to assess retrieval errors accurately:
  - Variances/rms of a single FOV retrieval are between 6 - 18 % RH in 800 – 300 mb with best performance at 600 mb
  - No statistically significant bias was detected between 800 – 300 mb.
  - Actual vertical resolution apparently lower than expected in mid-troposphere region
  - Techniques other than radiosondes, e. g. NAST-I in combination with drop-sondes, are needed for accurate RH retrieval error assessment.

Conclusions

- IASI and AIRS retrieval performance are in reasonable agreement with direct comparison needed for more definitive conclusion
- The Validation Assessment Model analysis of temporal variations of T and RH at Lindenberg and ARM SGP sites reveals that Lindenberg is better for T validation (synoptic time launches can be used) and ARM is better for RH validation.
- This approach can be used for Cal/Val planning through optimal validation tools and sites selection and characterization.