Statistical Validation Assessment Model for Advanced Sounding Products

N. Pougatchev T. August, X. Calbet, T. Hultberg, O. Oduleye P. Schlüssel, B. StillerK. St. Germain and G. Bingham

> Hyperspectral Workshop Darmstadt September 16, 2008



Motivation Why Statistical?

- Sounding products errors must be in the form that can be utilized by the users Regionally specific **Covariance** and **Bias.**
- Sounding occurs in turbulent atmosphere which is characterized statistically
- Retrievals are tuned statistically



Outline

- Methodology Sounding and Validation are complimentary parts of remote sensing.
- Validation Assessment Model brief description.
- Practical example IASI Level 2 Error Assessment and validation against radiosondes Lindenberg campaign.



Remote Sensing and Validation by Correlative Measurements



Validation Issues Why do We Need Validation Assessment 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 Assessment Model reconciles the issues by modeling best linear estimate of the satellite measurements and assessing the errors

"Validation of Atmospheric Sounders by Correlative Measurements" N. S. Pougatchev, App. Opt., v. <u>47</u>, 2008



State Non-Coincidence

Correlation Between True States No measurements involved at this point



$$\mathbf{B}_{\mathbf{x}}(\mathbf{x}_{\mathbf{cor}} - \bar{\mathbf{x}}_{\mathbf{cor}}) = Best \ estimate = Expected\{\mathbf{x}_{\mathbf{sat}} - \bar{\mathbf{x}}_{\mathbf{sat}} | given \mathbf{x}_{\mathbf{cor}} - \bar{\mathbf{x}}_{\mathbf{cor}}\}$$



Characteristic Difference

Correlation Between Measurements (two different systems measure the same state)



 $B_{\hat{x}}A_2(x-\bar{x}) = Best \ fit \text{ to } A_1(x-\bar{x}) \text{ over ensemble with covariance } S_x$



IASI Validation Study

- Validation Data Set radiosondes at Lindenberg (Germany, 52.21° N, 14.12° E, 112 m a.s.1). 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. 4.3 retrievals; cloud clear; ±1^o Lat. and Long. about Lindenberg



Averaging Kernels – Vertical Resolution Temperature





Temperature Non-Coincidence Error Free Troposphere



RMS non-coincidence error Averaged between 800 - 300 mb Sodankyla, Lindenberg, and Southern Great Plane ARM





Temperature Retrieval Error and Bias IASI -- "True profile"



www.spacedynamics.org

Averaging Kernels – Vertical Resolution Water Vapor





Relative Humidity Non-Coincidence Error Free Troposphere





Relative Humidity Retrieval Error and Bias IASI – "True profile"





Log(vmr) Retrieval Error and Bias IASI -- "True profile"





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: Expected and Assessed Errors are in good agreement.
- Error variances/rms of a single FOV retrieval are <1K between 800 300 mb with increase to $\sim 1 K$ in tropopause and $\sim 2 K$ at the surface possible cause: wrong surface property and undetected clouds/haze.
- Bias against radiosondes oscillates within $\pm 0.5K$ between 950 100 mb.



Conclusions

- Water Vapor RH
 - Estimated RH error variances/rms of a single FOV is higher than expected and in the free troposphere it is between 10 13 % RH
 - Possible causes may be:
 - Expected linear estimate of the error is not correct due to strong nonlinearity of the retrieval
 - Spectroscopy knowledge is not accurate enough
 - Complex spatial structure of highly variable moisture field does not allow to assess retrieval errors accurately – WE DON'T HAVE GOOD VALIDATION SOURCE
 - Combination of techniques other than radiosondes, e. g. high accuracy airborne sounders (NAST-I) with drop-sondes, are needed for accurate RH retrieval error assessment.



This is THE END

T. August, X. Calbet, T. Hultberg, O. Oduleye P. Schlüssel, B. StillerK. St. Germain and G. Bingham



