Using JAVIEX data to evaluate Impact PCA Noise Filtering on the High Spectral Resolution Physical Retrieval Algorithm

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ITSC-16 Angra dos Reis, 7-13 May 2008

PCA and hyperspectral IR data (as I know it …..)

- Introduced in the 90s for HIS regression based inversion of hyperspectral data

- Applied to HIS, NAST-I, simulated ITS data compression in late 90's

- Used as Noise Filtering Tool on S-HIS, NAST-I and AIRS data 2004

- Extended to Noise Characterization Tool on S-HIS and AIRS data 2005

- Used to instrument monitoring S-HIS, AIRS, IASI 2007

- Introduced in AAPP for IASI data processing (noise filter properties) 2008

- Impact of Noise Filtered Radiances in Physical Retrievals, S-HIS 2008

Outline

- UWPHYSRET

- JAIVEX

- Retrieval Validation

- Effect of Noise Filtering

- General Consideration on Instrument Noise Covariance Matrix

- Conclusion

- Future work

UWPHYSRET

- Attempt to build a *reference* physical retrieval package;

- Based on Clive Rodger's methodology (Bayesian approach);

- Simultaneous retrieval of Temperature, Water Vapor, Ozone, Surface Temperature, Surface Emissivity;

- Uses LBLRTM 11.3;

- Analitical Jacobians are updated at every iteration;

- Slow, flexible, accurate;

- Implemented in matlab

Solution

- Iterative solution (Gauss-Newton):

$$x_{n+1} = x_a + (K_n^T \bullet S_e^{-1} \bullet K_n + S_a^{-1})^{-1} \bullet K_n^T \bullet S_e^{-1} \bullet ([Y - F(x_n)] + K_n \bullet (x_n - x_a))$$

- x is the state vector (*a* stands for a-priori, *n* is the iteration number);

- K is the Jacobian Matrix;

- S_a is the covariance matrix of the a-priori knowledge;

- S_e is the covariance matrix of the Instrument noise;

- Y is the observation vector (radiances);

- F(x) is the calculated observation vector (radiances);

JAIVEx

- **Joint Airborne IASI Validation Experiment**

- The Joint Airborne IASI Validation Experiment is an international cal/val campaign in support of the NPOESS and MetOp series of operational satellites.

- The focus of JAIVEx is on the validation of radiance observations and meteorological products from the Infrared Atmospheric Sounding Interferometer, IASI.

- IASI measures radiation emission from the surface and atmosphere in the 645 - 2760 cm-1 (i.e., 3.6-15.5 μm) spectral band with high spectral resolution (i.e., 8461 spectral channels with a spacing of 0.25 cm-1).

- The aircraft being employed are the NASA WB-57 and the FAAM BAe 146.

SGP ARM Cart Site: 19 Apr 2007 15:32 UTC

S-HIS FOV

WB-57 Position
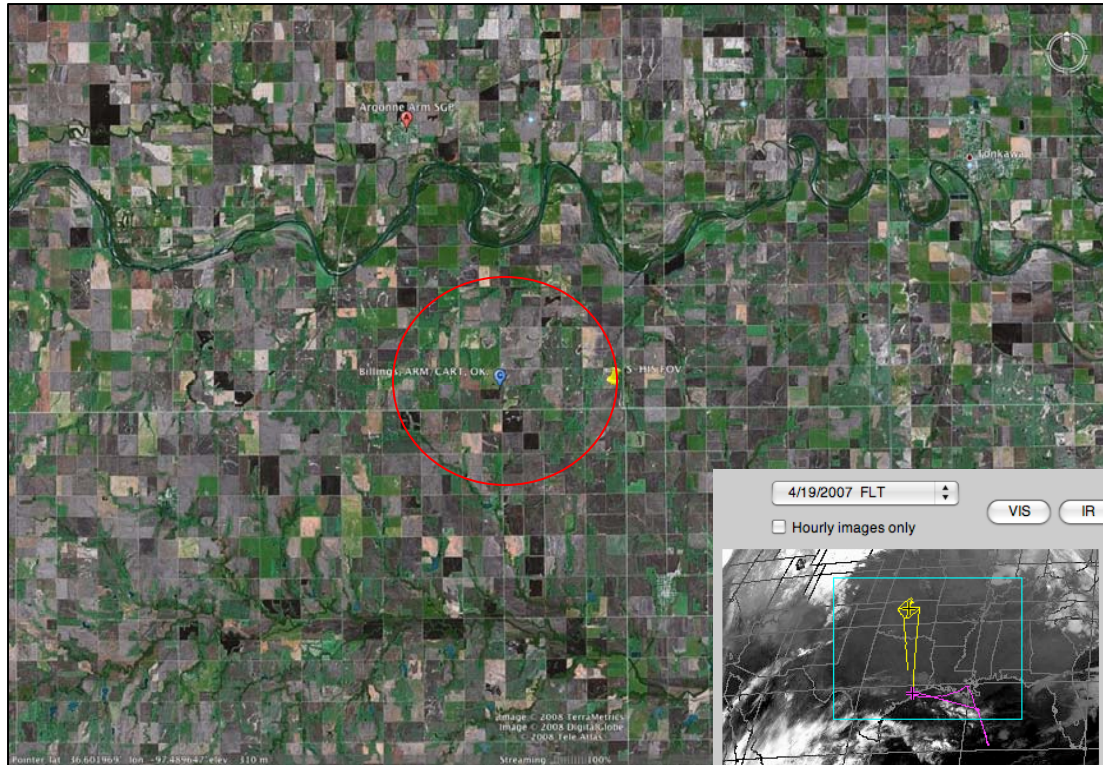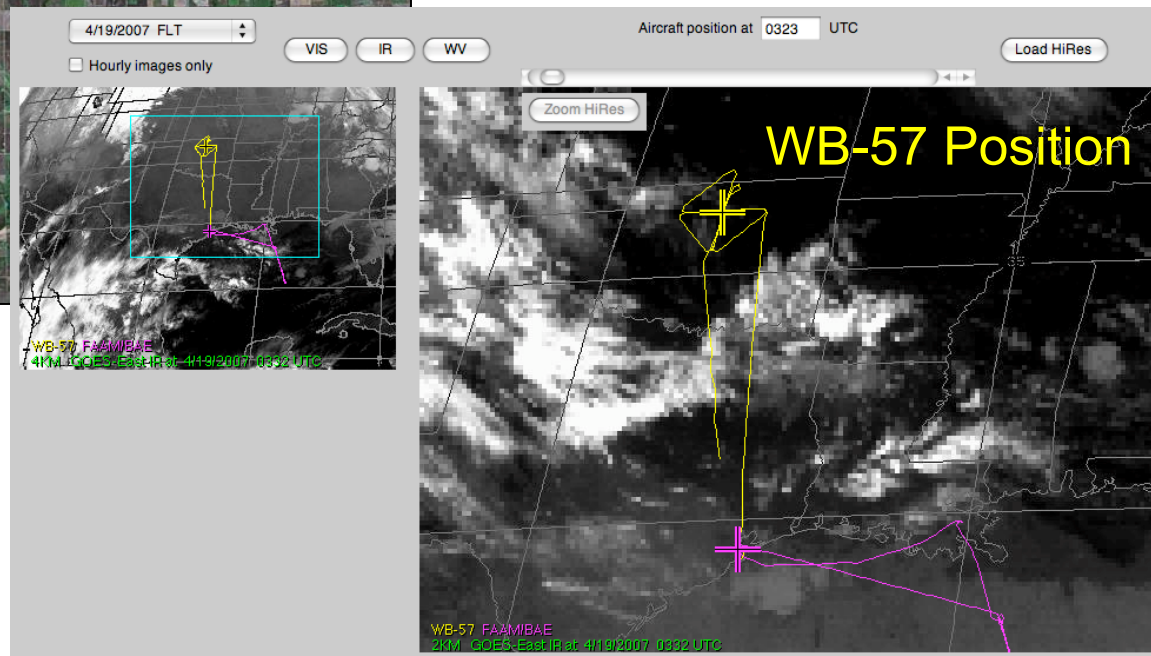
Retrieved Vertical Profiles
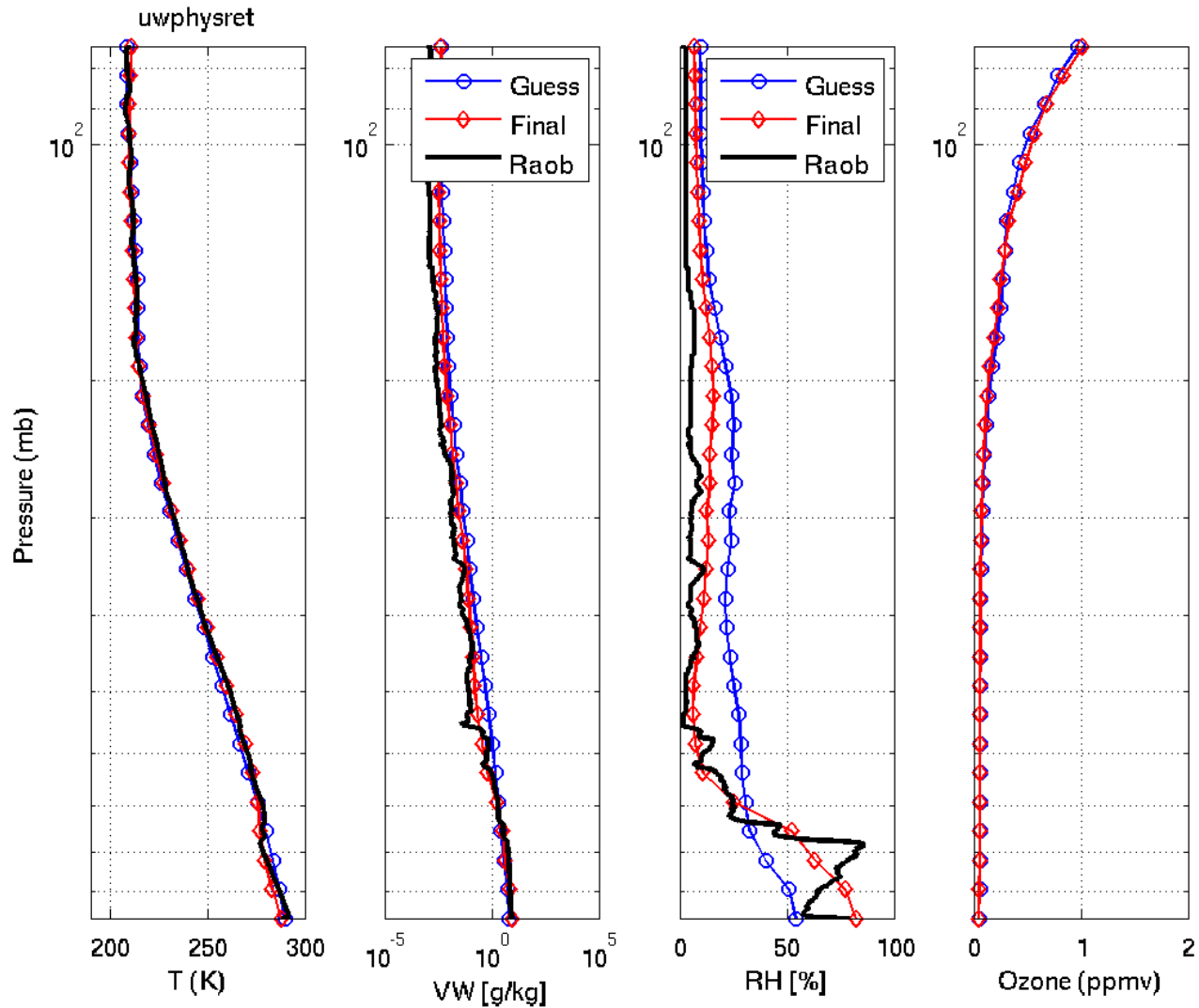
Retrieved Temperature Profile with Errorbars
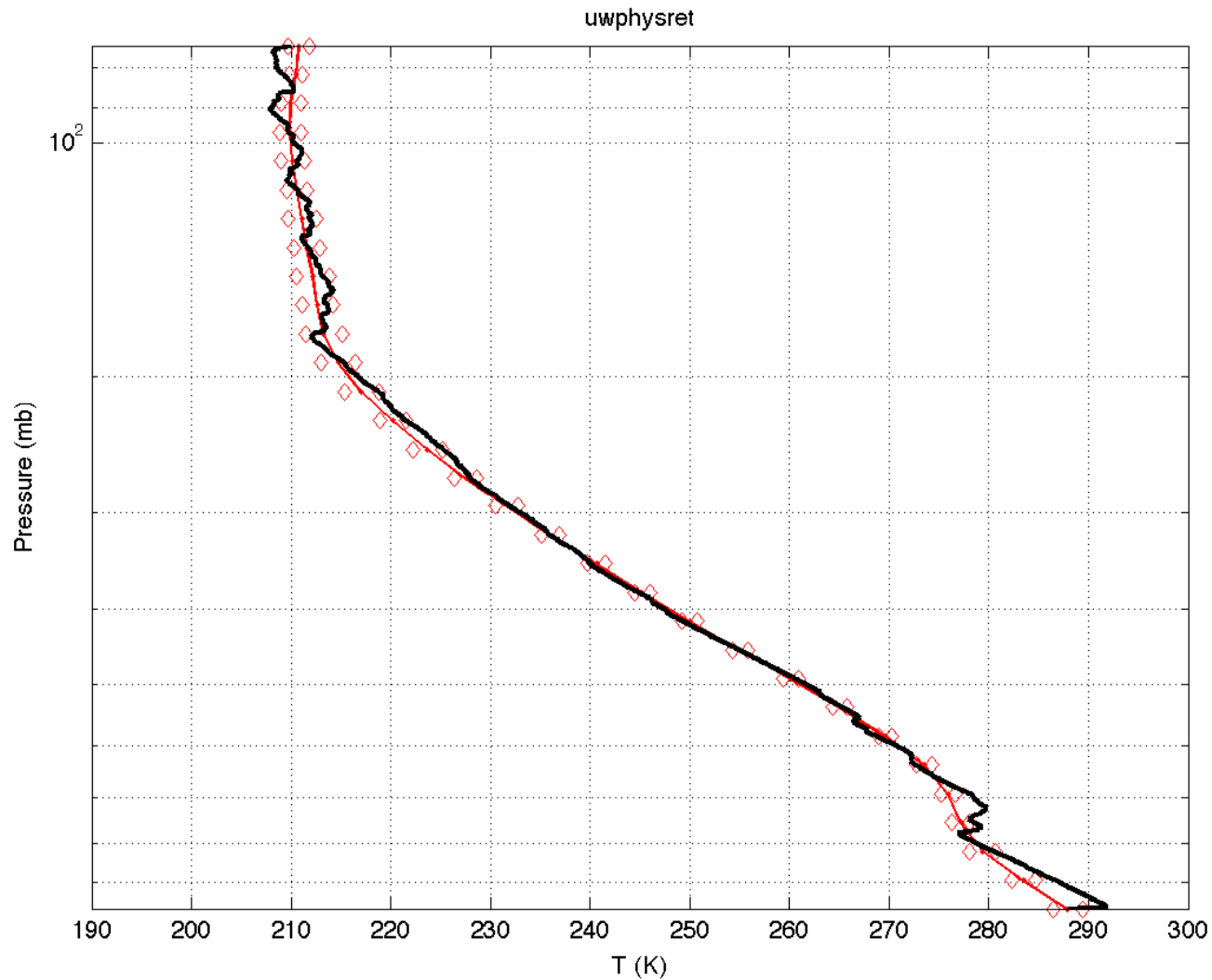
Retrieval Errors
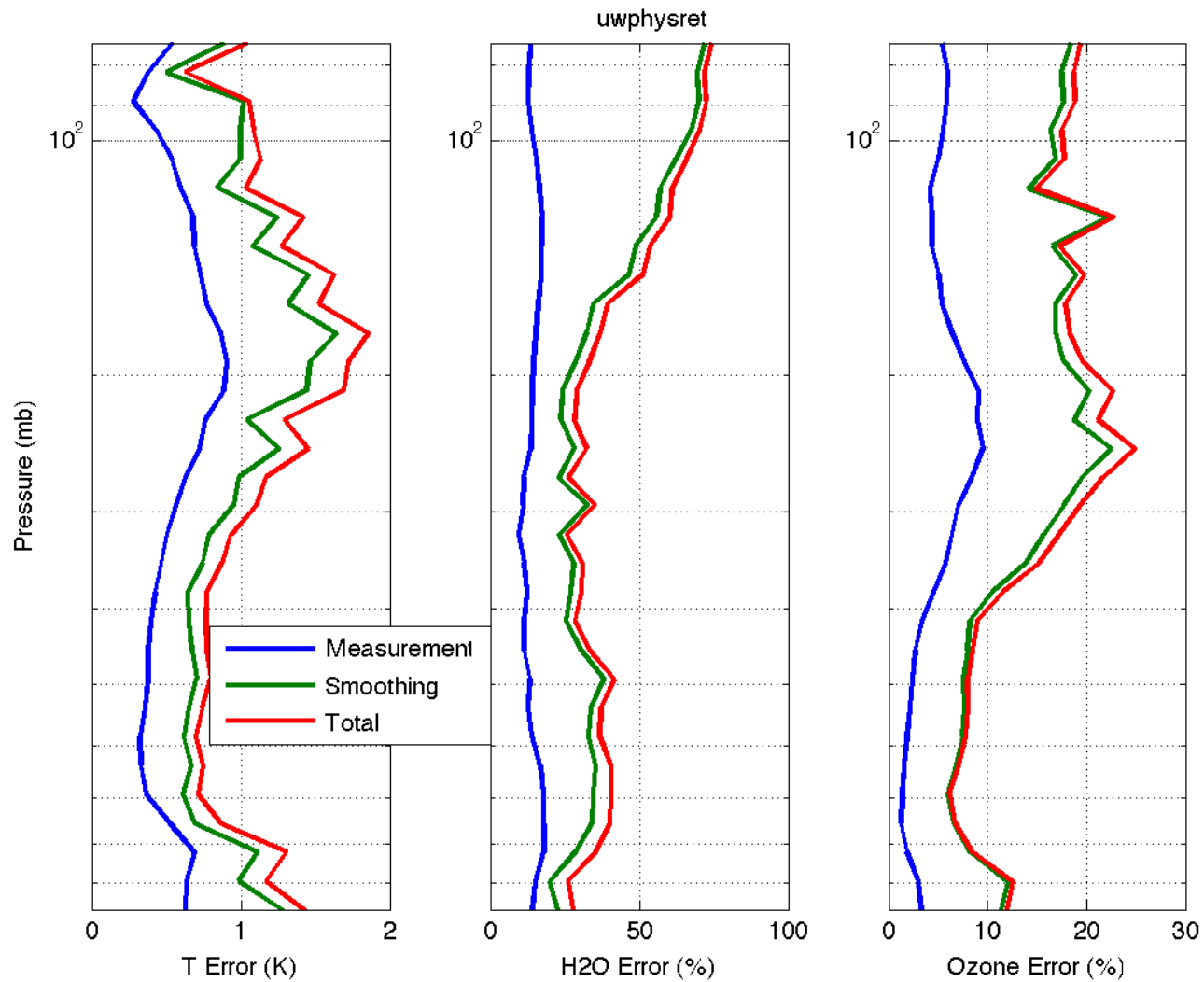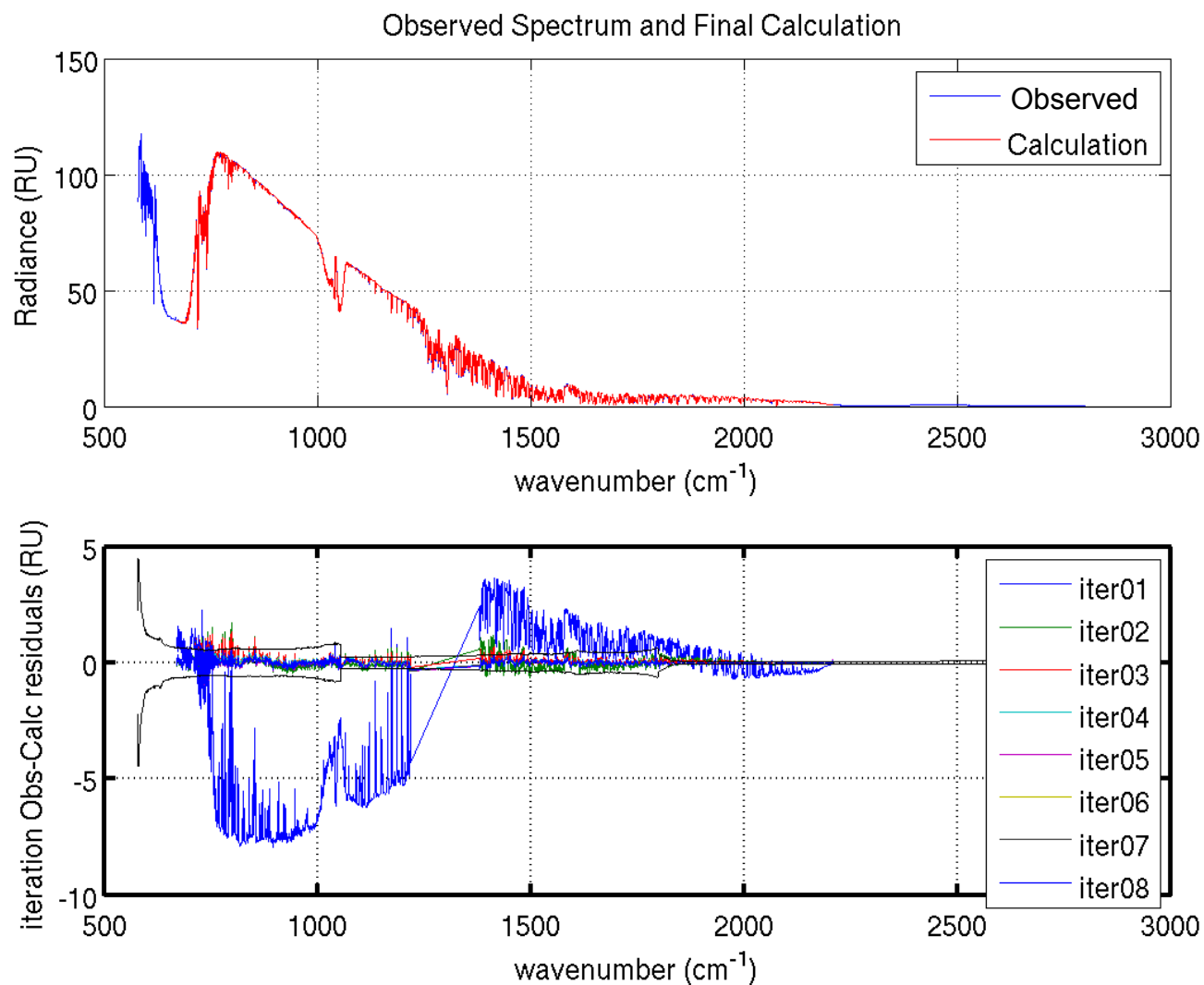
Retrieved Surface Emissivity
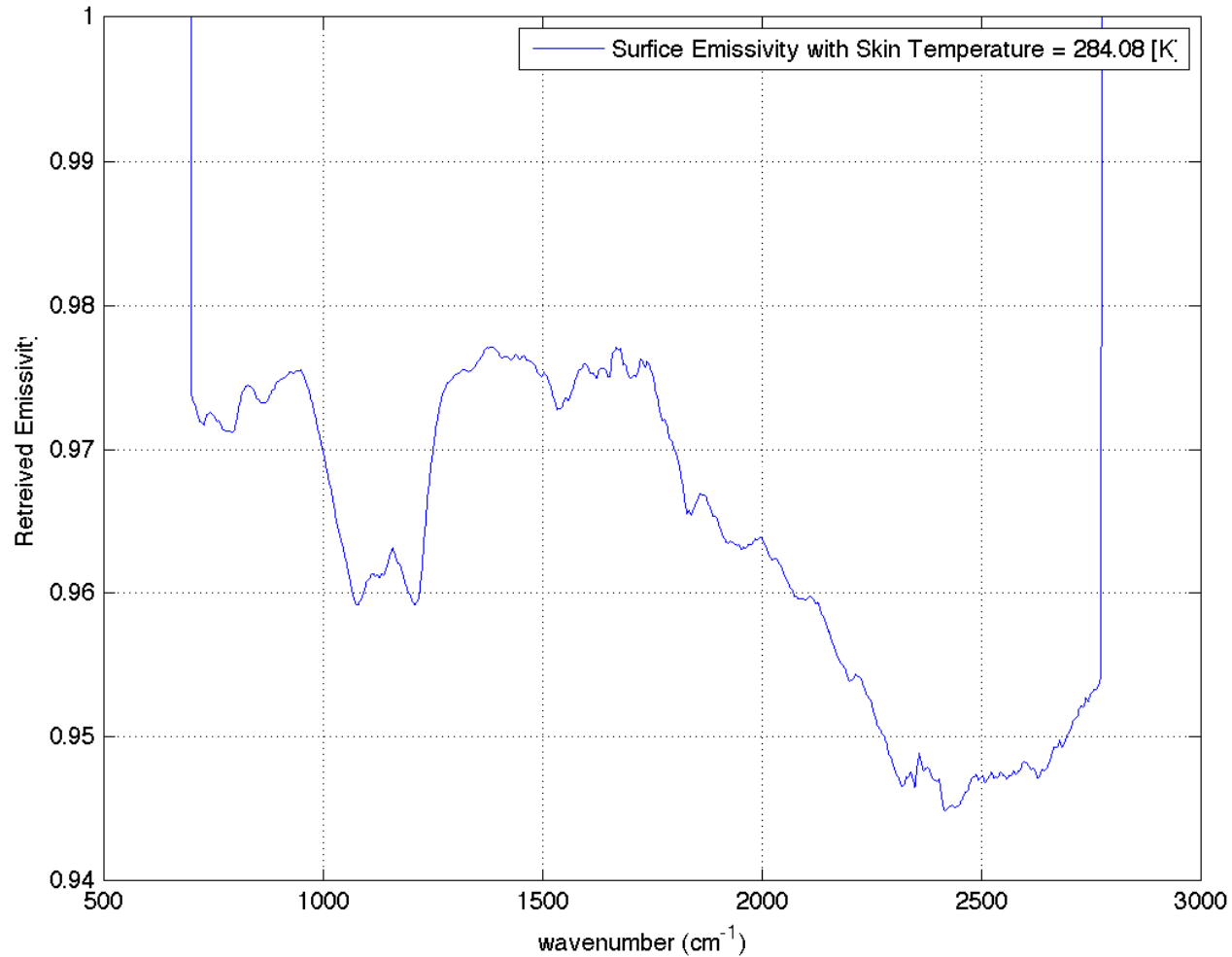
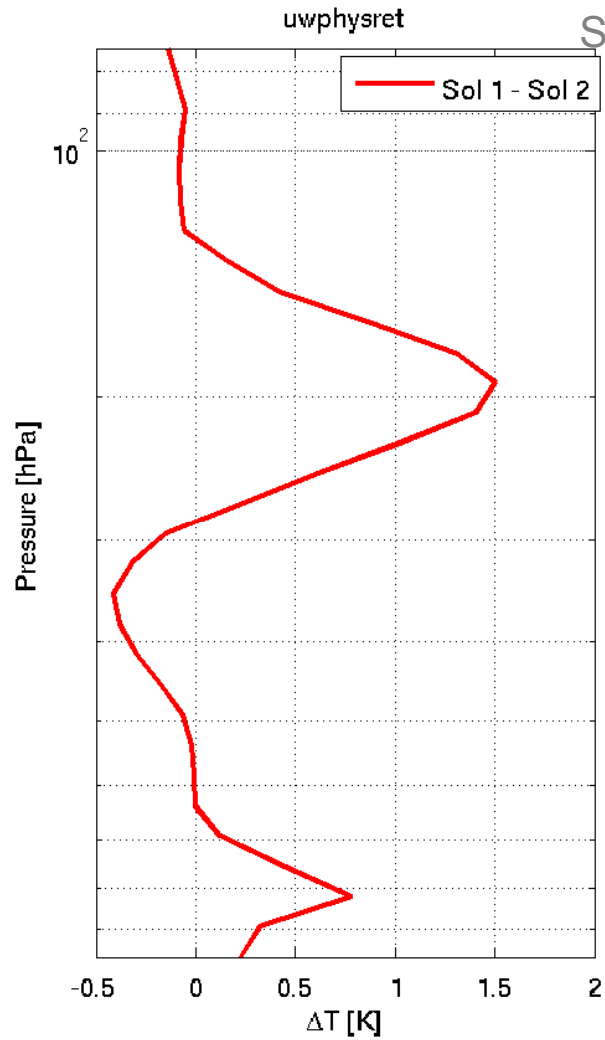# Retrieved Surface Emissivity: Validation with UWEMIS (from MODIS data collection 5)
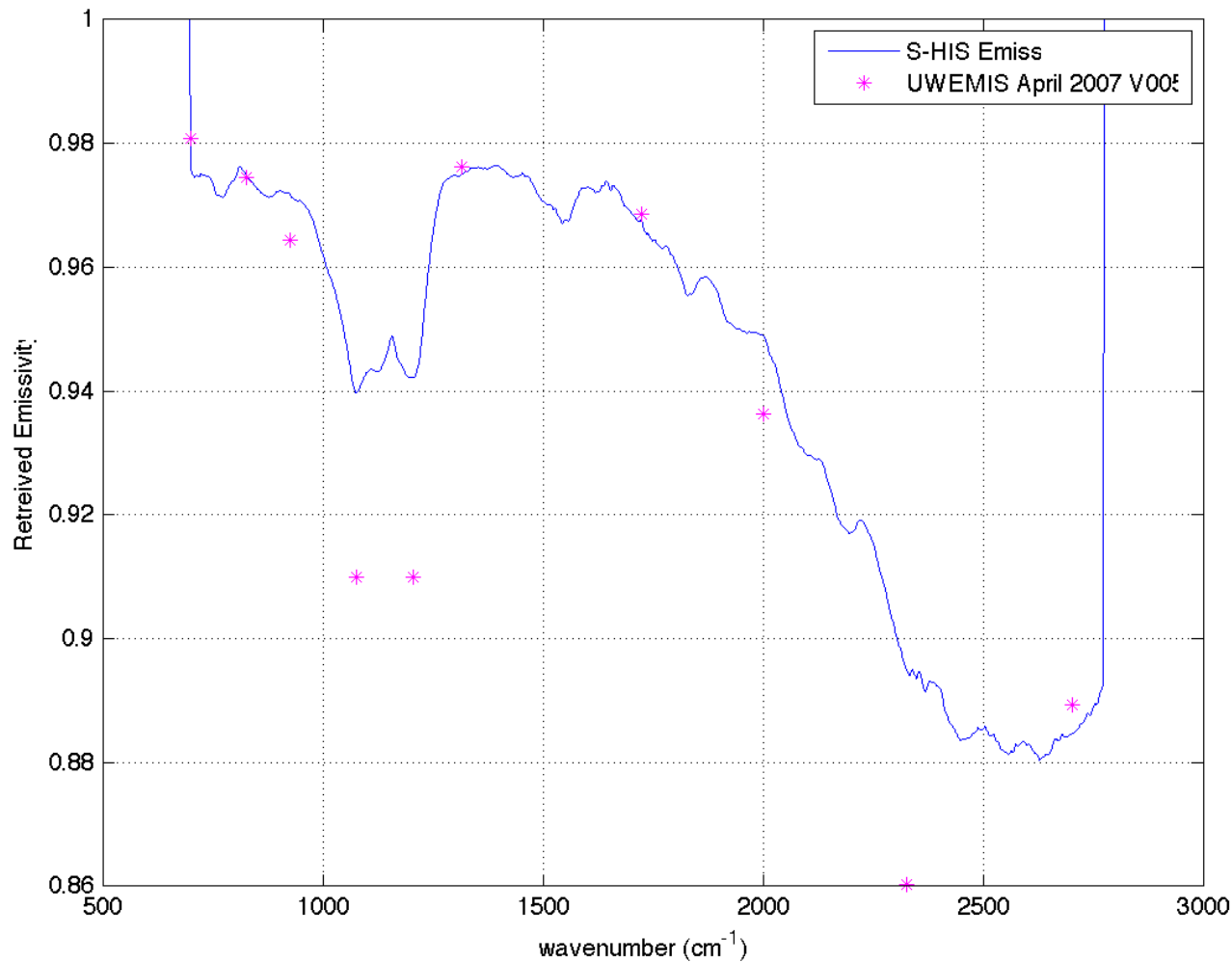
Courtesy of
Eva Borbas

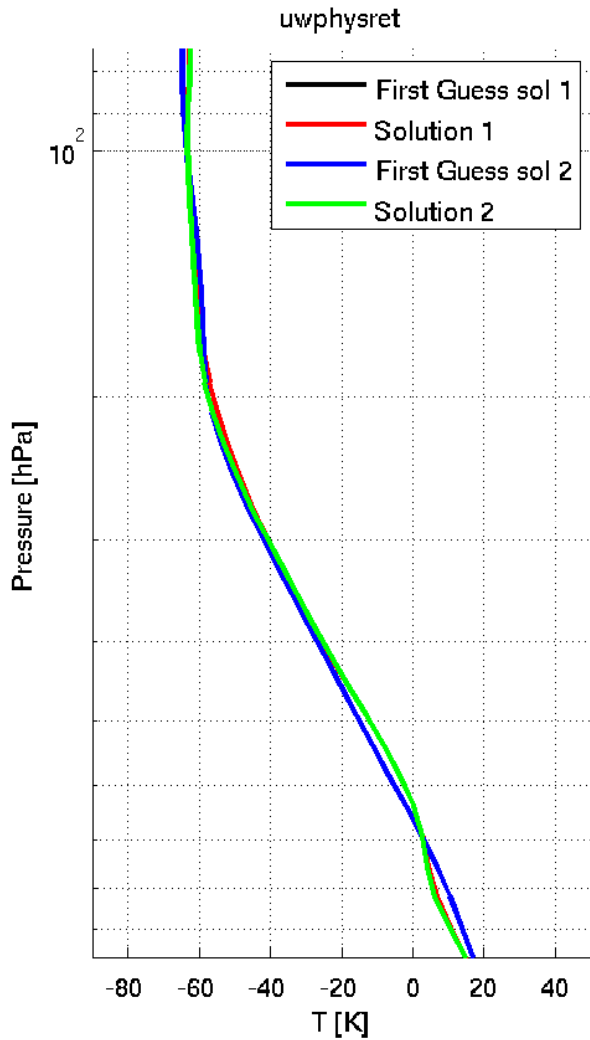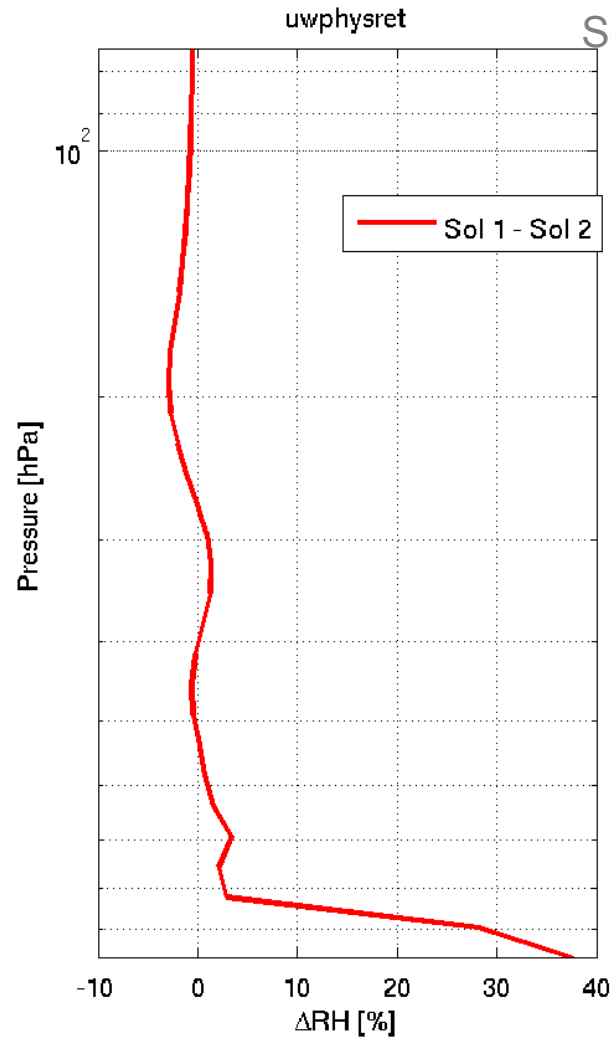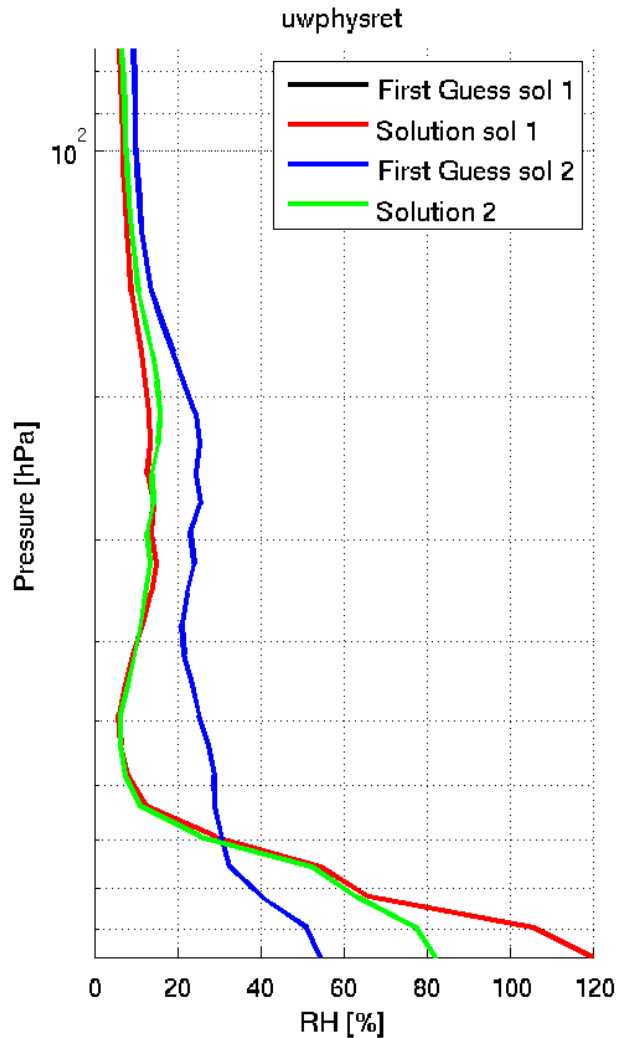# Retrieval Conversion: Iteration by Iteration

Observed Spectrum and Final Calculation

Retrieval difference for Unfiltered and Filtered Data: Temperature

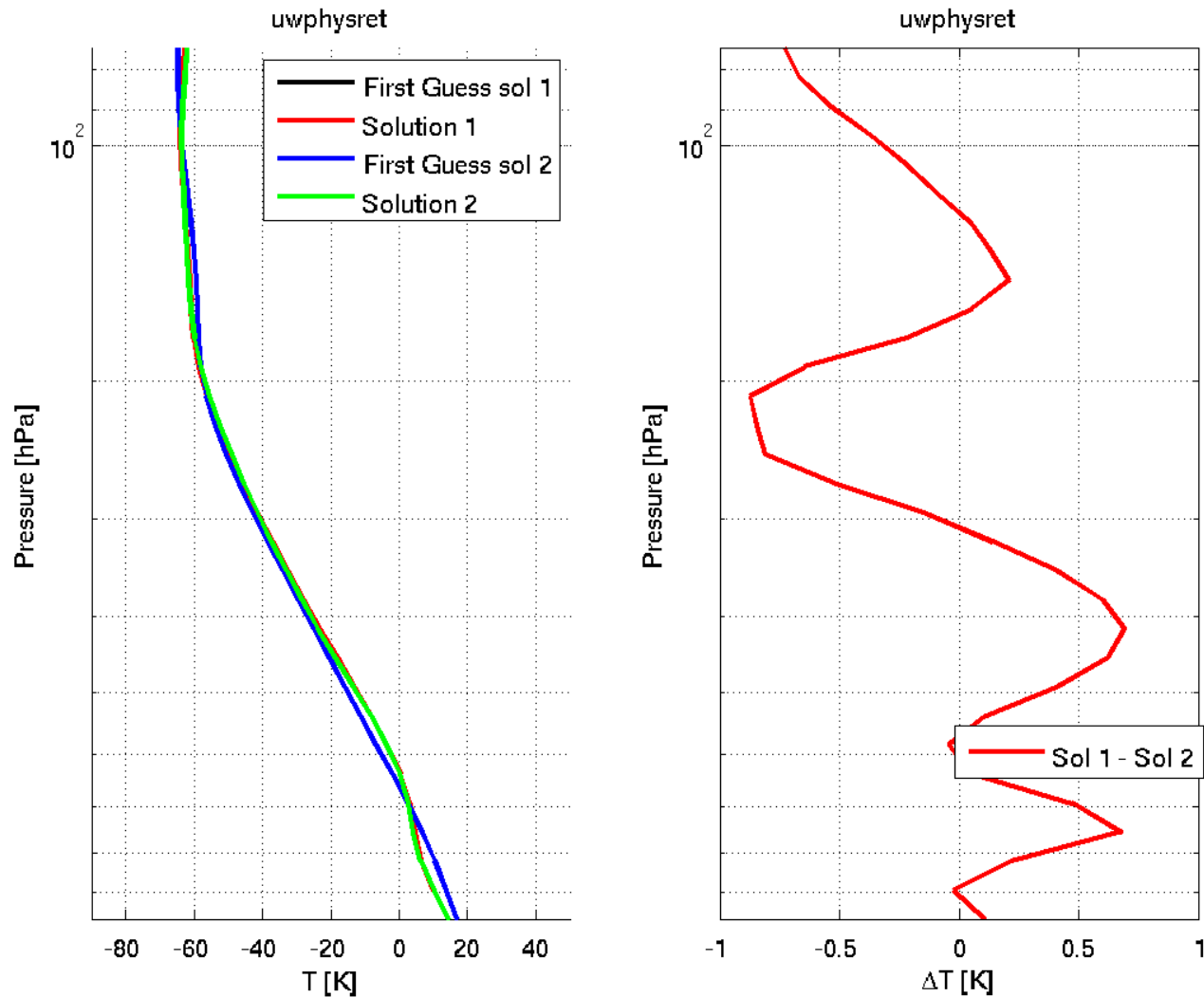Solution 1 == Unfiltered Data
Solution 2 == Filtered Data

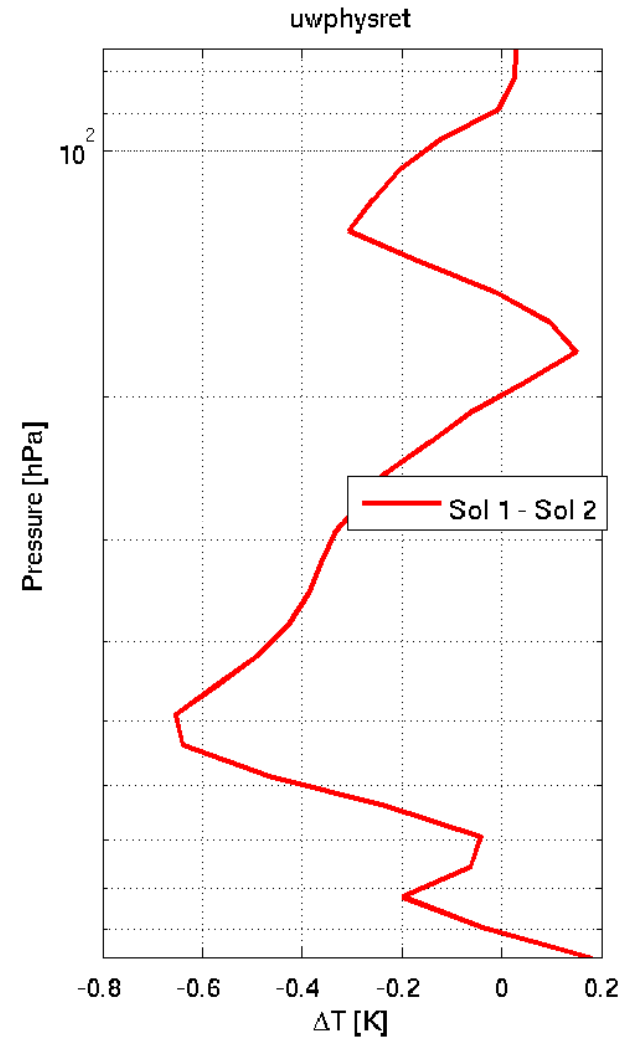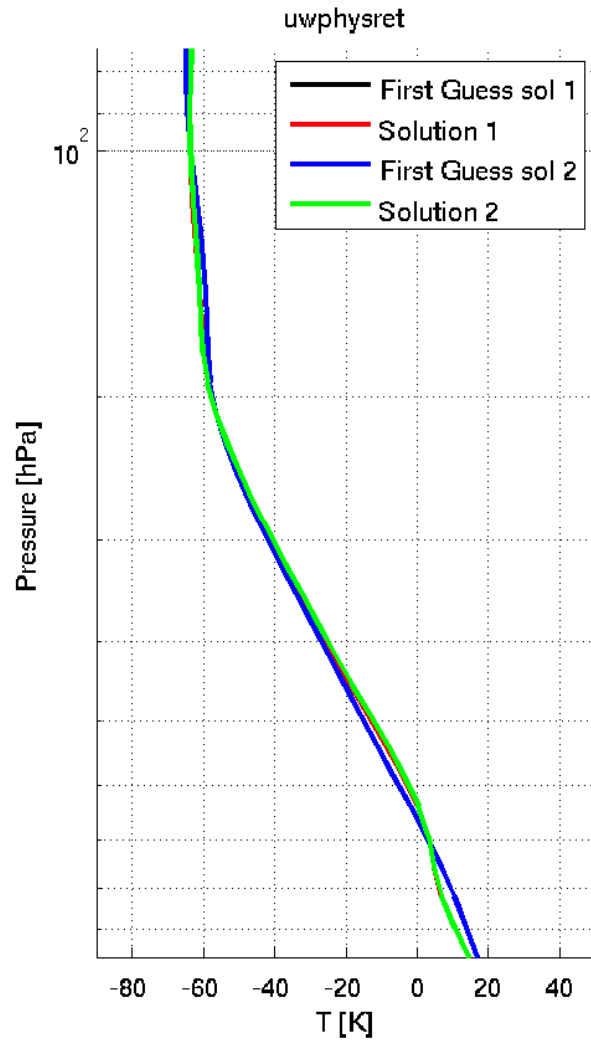# Retrieval difference for Unfiltered and Filtered Data: Relative Humidity

Retrieval difference for Unfiltered and Filtered Data: Surface Emissivity and Temperature
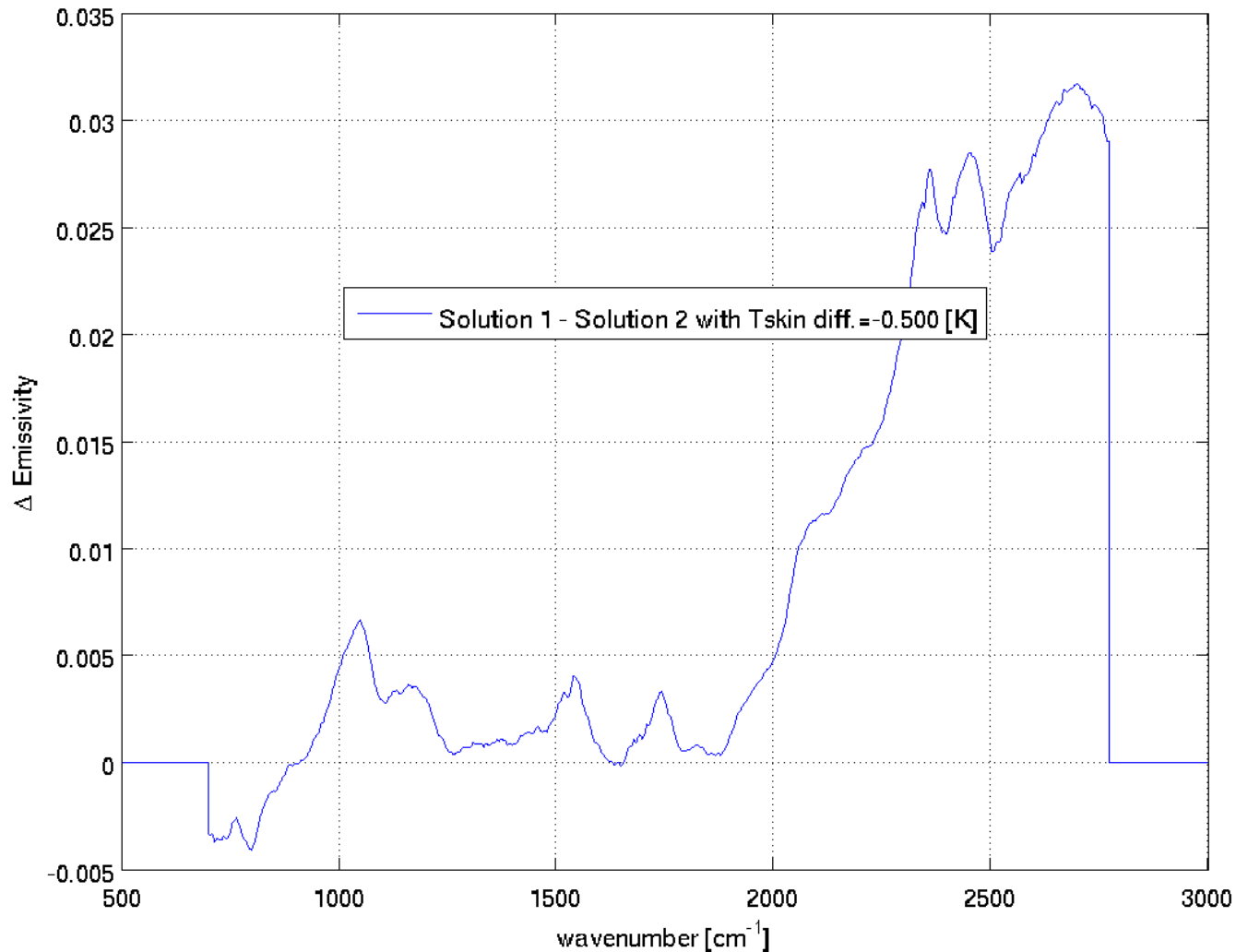
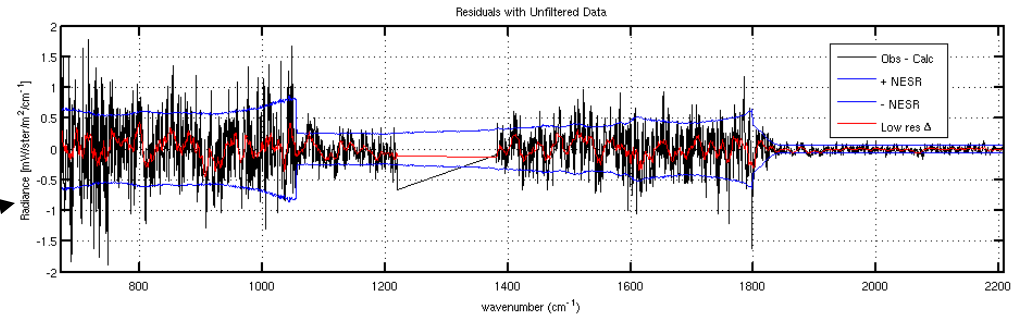# Retrieval difference for Apodized and Non-Apodized Data: Temperature
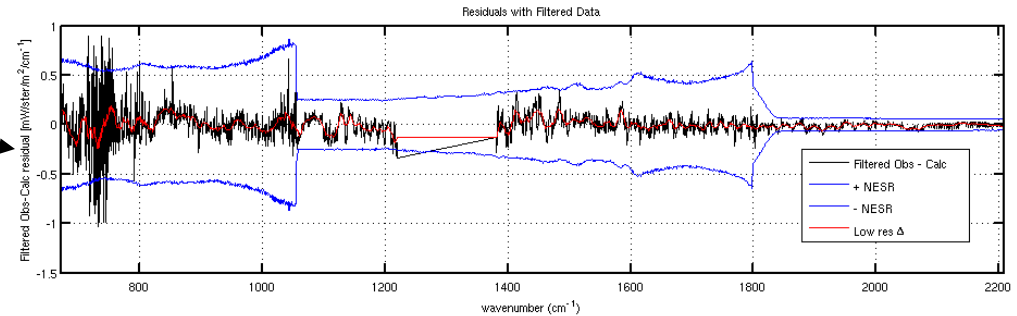
LBLRTM 10.4 - LBLRTM 11.3 (Temperature)

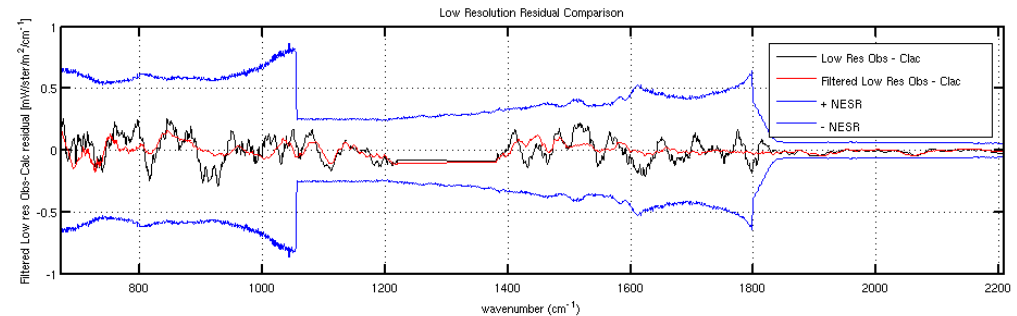# Retrieval off Unfiltered Data: Residuals in radiance Units
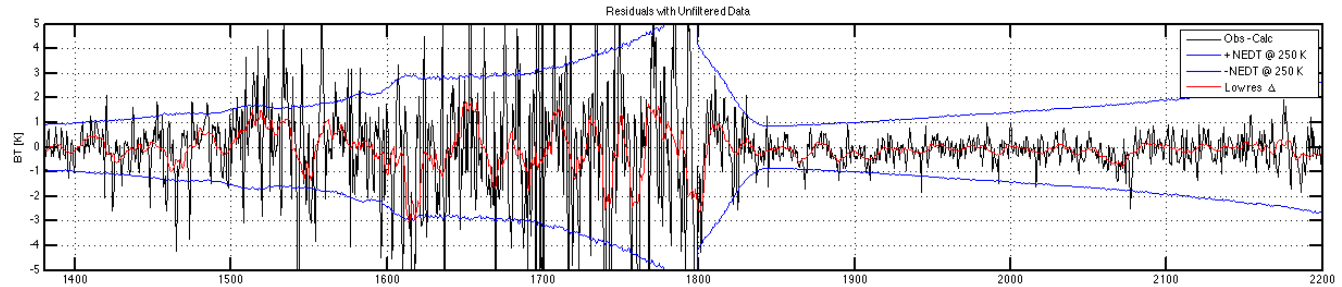

Unfiltered Obs - Calc

Filtered Obs - Calc

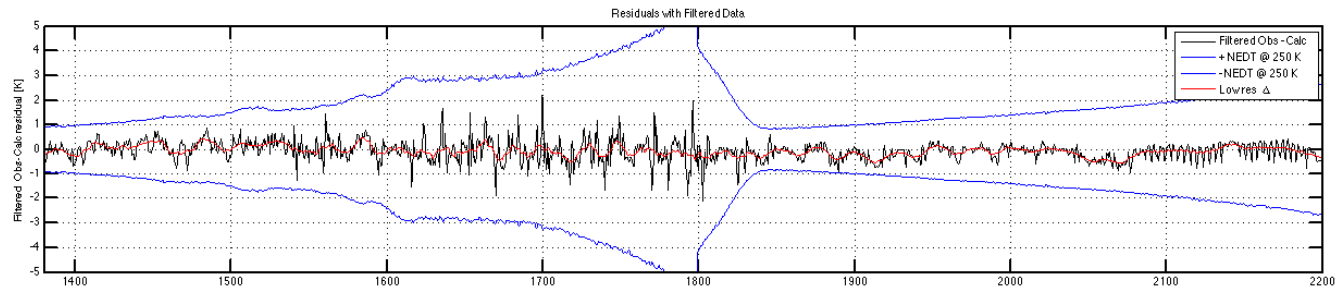•Retrieval off Unfiltered Apodized Data;
•Nominal Noise (diag COV matrix).
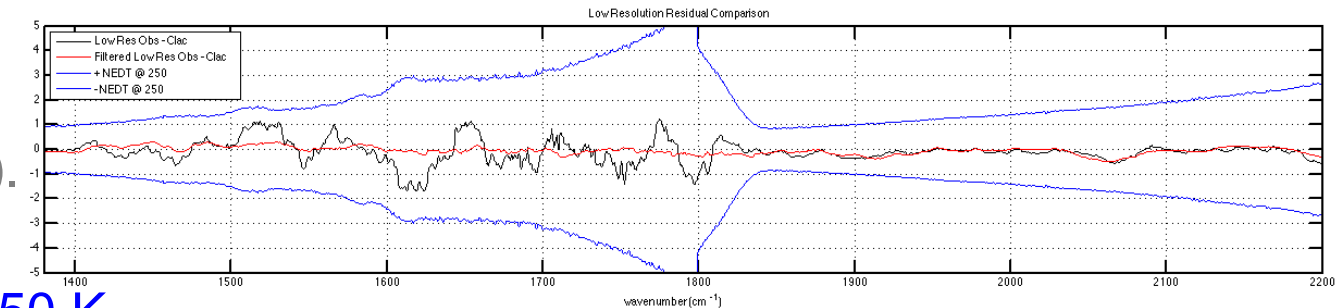
NESR

Retrieval off Unfiltered Data: Residuals in BT

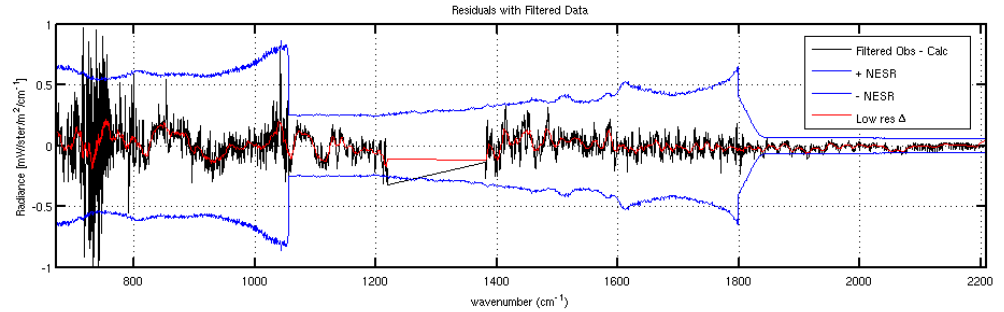
Unfiltered Obs - Calc

Filtered Obs - Calc

- Retrieval off Unfiltered Apodized Data;
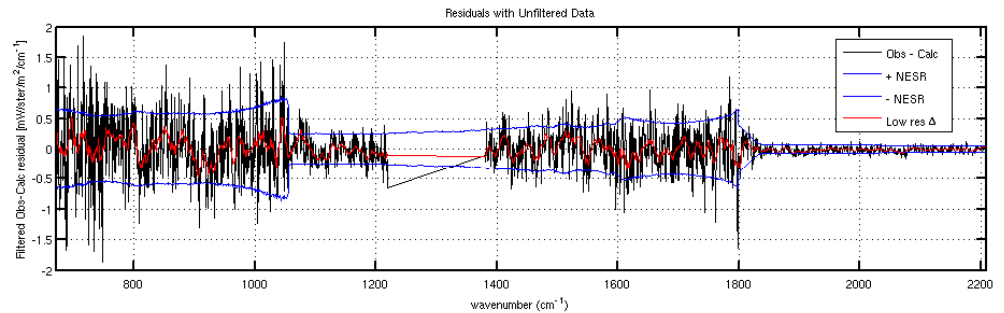- Nominal Noise (diag COV matrix).

NEDT @ 250 K
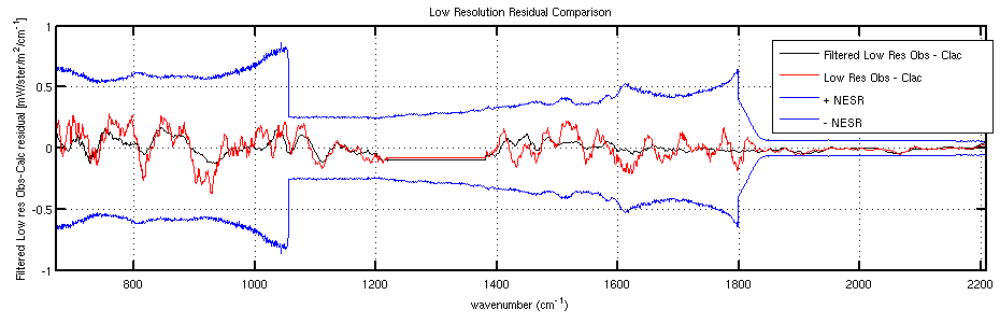
Retrieval off Filtered Data: Residuals in radiance Units
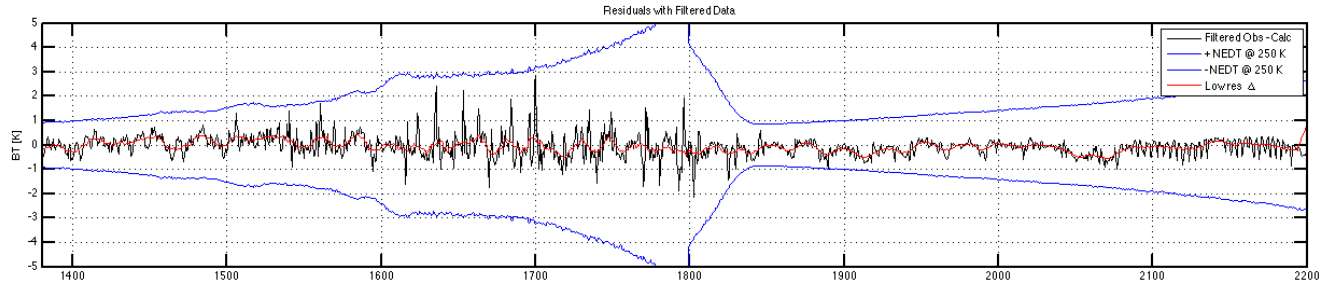
Unfiltered Obs - Calc

Filtered Obs - Calc

•Retrieval off Unfiltered Apodized Data;
•Nominal Noise (diag COV matrix).
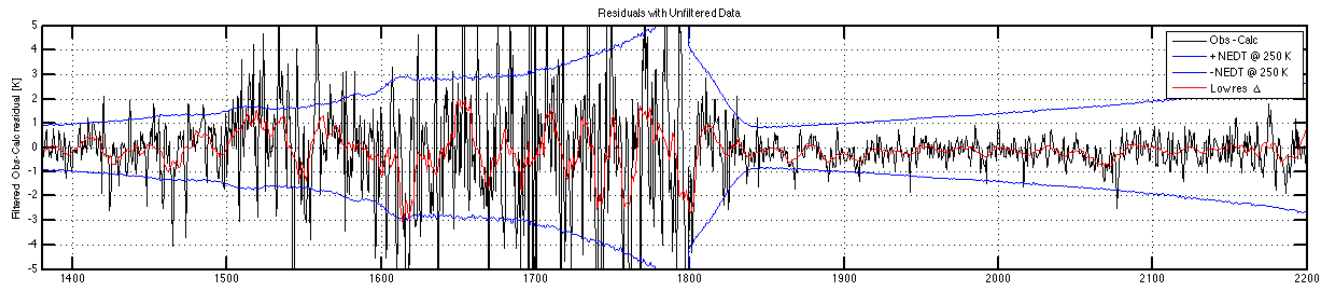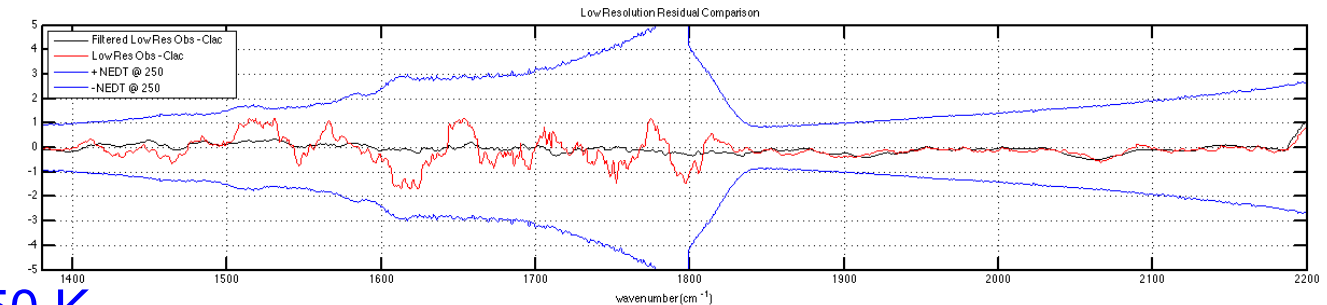
NESR

Retrieval off Filtered Data: Residuals in BT

Filtered
Obs - Calc

Unfiltered
Obs - Calc
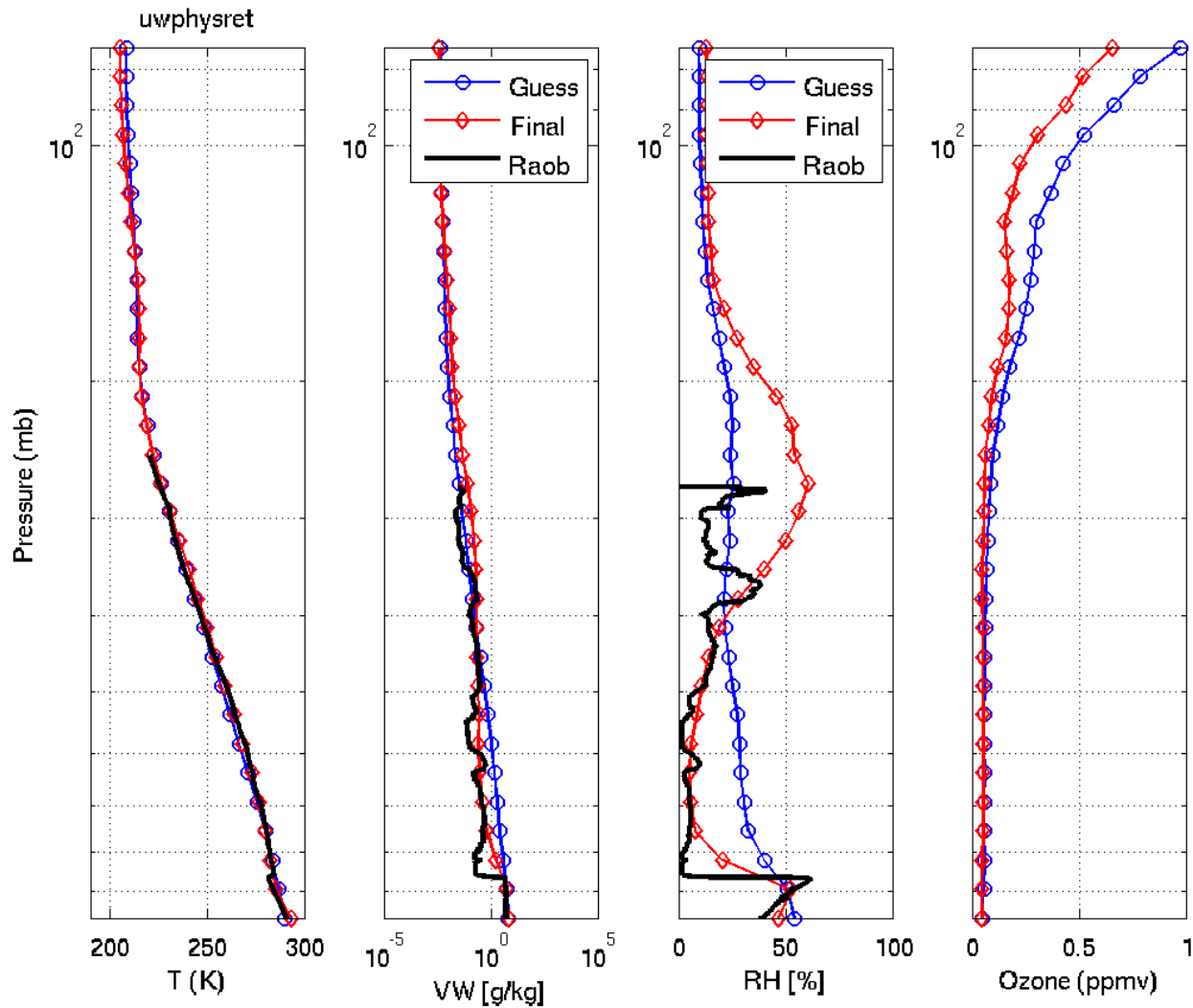
•Retrieval off Filtered
Apodized Data;
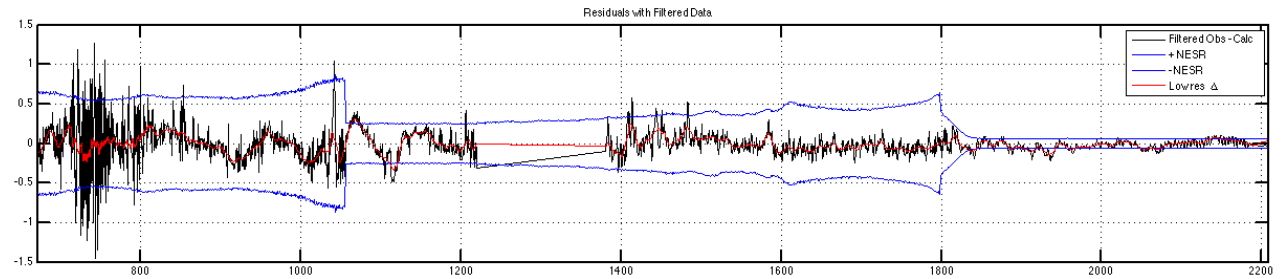•Nominal Noise
(diag COV matrix).

NEDT @ 250 K

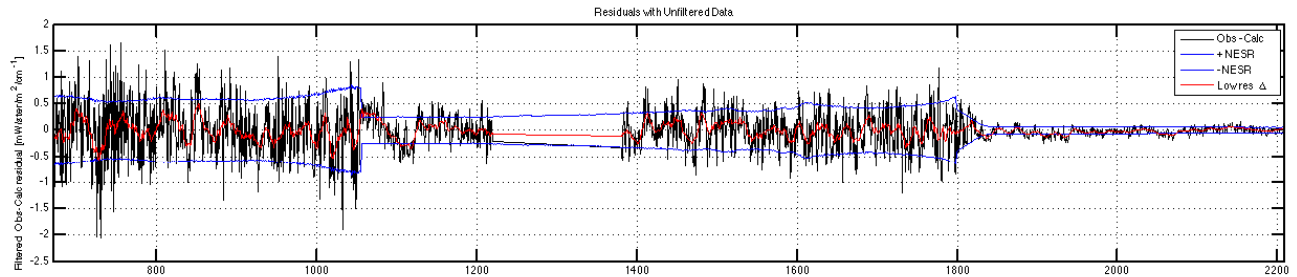# 16 Apr 2007: Retrieved Vertical Profiles

Retrieval off Filtered Data: Residuals in radiance Units
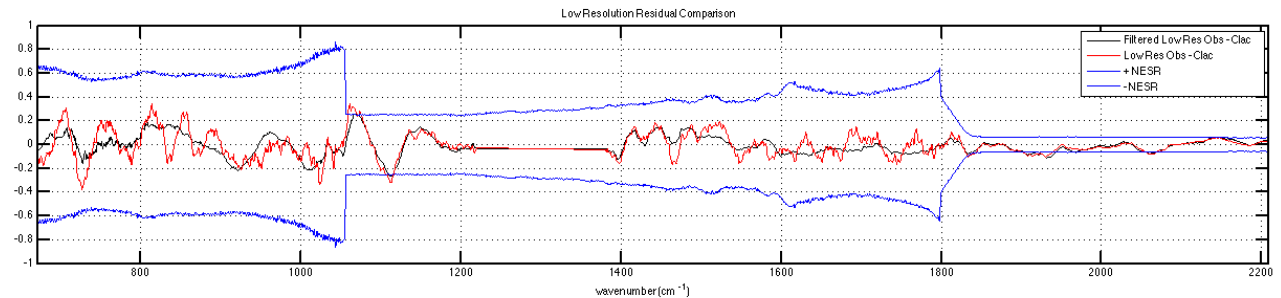

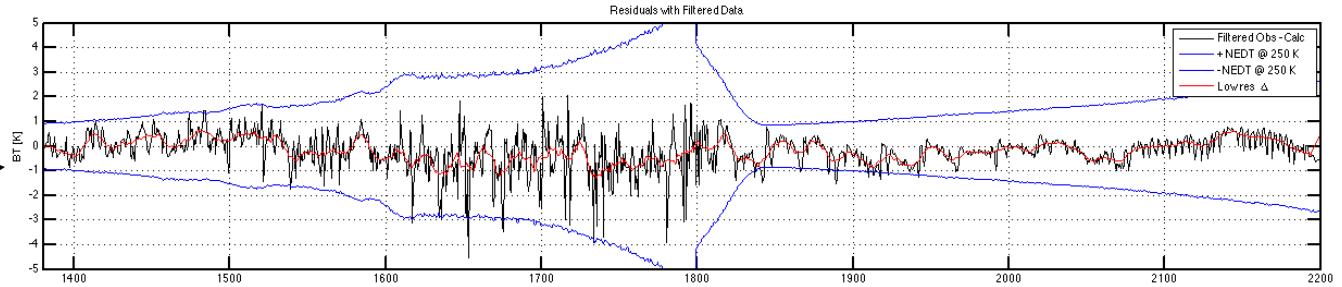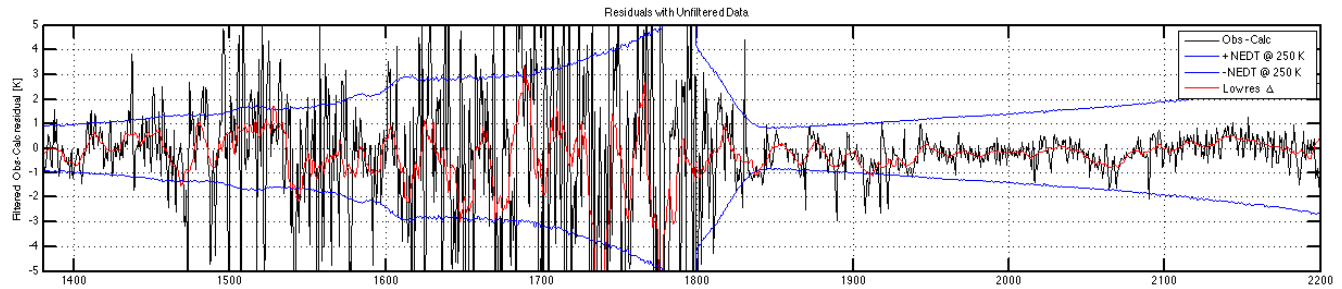
Filtered
Obs - Calc

Unfiltered
Obs - Calc
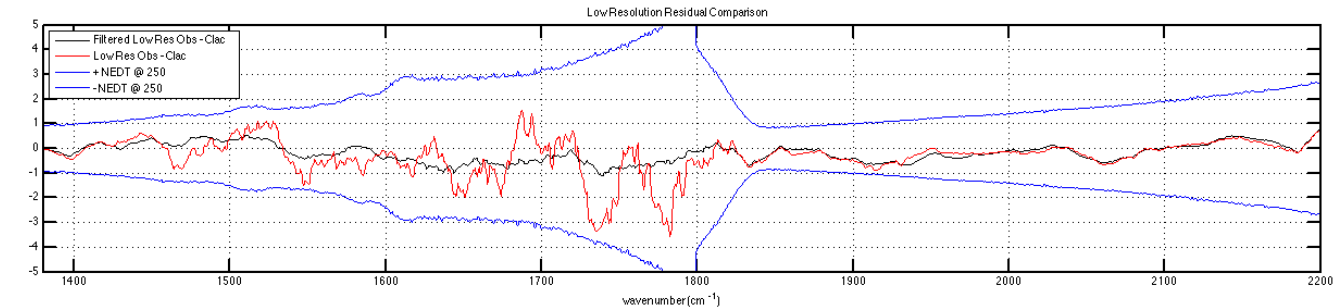
NESR

Retrieval off Unfiltered Data: Residuals in BT

Filtered
Obs - Calc

Unfiltered
Obs - Calc

NEDT @ 250 K

Conclusions

- UWPHYSRET was built as *reference* retrieval system and relies on lblrtm accuracy to allow research on PCA noise filter impact on retrievals

- Redefinition of a stable non singular full covariance matrix (considering apodization, PCA noise filtering, correlations due to the sensor, and forward model error, has not been achieved yet;

- PCA noise filtering effects obtained without redefinition of the noise Covariance matrix produces changes in the range of:

  - [0.5 - 1] K in temperature;

  - [10 - 30] % in lower atmospheric RH;

- These changes are of similar magnitude to those induced by apodization or lblrtm updates;

- Under the approximations used in this study, PCA noise filtered data allows for:

  - better representation of the retrieval residual and for estimation of potential FWM biases

  - retrieval convergence when using more accurate representation of the noise covariance

Future Work

- Re-definition of a stable invertible full instrument noise covariance matrix;

- Application of the current system to IASI data;

- Development of a sequential scheme for retrievals (T-->WV-->Surf T-->Surf Emiss-->Minor Spices);

- Evaluation of the impact of different representation of a-priori information on final retrieval;

Dominant PC of the whole talk

Thank you