PHYSICALLY BASED LEVEL 2 OBTAINED FROM IASI OBSERVATIONS COLLECTED DURING THE JAIVEX FIELD EXPERIMENTS

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Outline

- general considerations on UWPHYSRET;
- application of UWPHYSRET to IASI data collected during JAIVEx
  - ➢examples of Level 2 Products;
  - ➢surface emissivity retrievals;
  - ➢use of PCA noise filter for Level 2 Product validation;
  - ➢generation of Level 2 products from PCA noise filtered data;
- general conclusions;
- future development.

General considerations on UWPHYSRET

UWPHYSRET

- Attempt to build a *reference* physical retrieval package;
  - Based on Clive Rodger's methodology (Bayesian approach);
- Simultaneous retrieval of Temperature, Water Vapor, Ozone, CO_2, Surface Temperature, Surface Emissivity, Inflation Factor;
- Designed to run with different instruments:
  - S-HIS;
  - IASI;
- Designed to run with different forward models:
  - LBLRTM 11.6;
  - SARTA;
- Implemented in matlab and runs with octave;

Solution

- Iterative solution (Gauss-Newton):

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

- Y is the observation vector (radiances);

- F(x) is the calculated observation vector (radiances); $Y=F(x_n)+noise$

- K is the Jacobian Matrix; $Y = K_n(x_n-x_a)+noise$

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

- S_e is the covariance matrix of the Instrument noise;

Open Issues

- Error covariance matrix characterization should be improved;
  - ➢Forward model errors should be accounted for;
- A-priori covariance matrix characterization should be improved;
  - ➢Trace gas climatology not accurate;
- Regularization of covariance matrices should be improved;
- Test for convergence is to be changed;
- Software should be optimized for speed.

Current applications

- Evaluation of level 2 product accuracy;
- Estimation of PCA noise filtering impact on level 2 products;
- Investigation of the role of Noise Covariance Matrix on retrieval accuracy;
- Investigation of the role of Climatology Covariance Matrix on retrieval accuracy;
- Surface Emissivity Retrieval;
- Estimation of Stability Indices from retrieved profiles;

Examples of Level 2 products

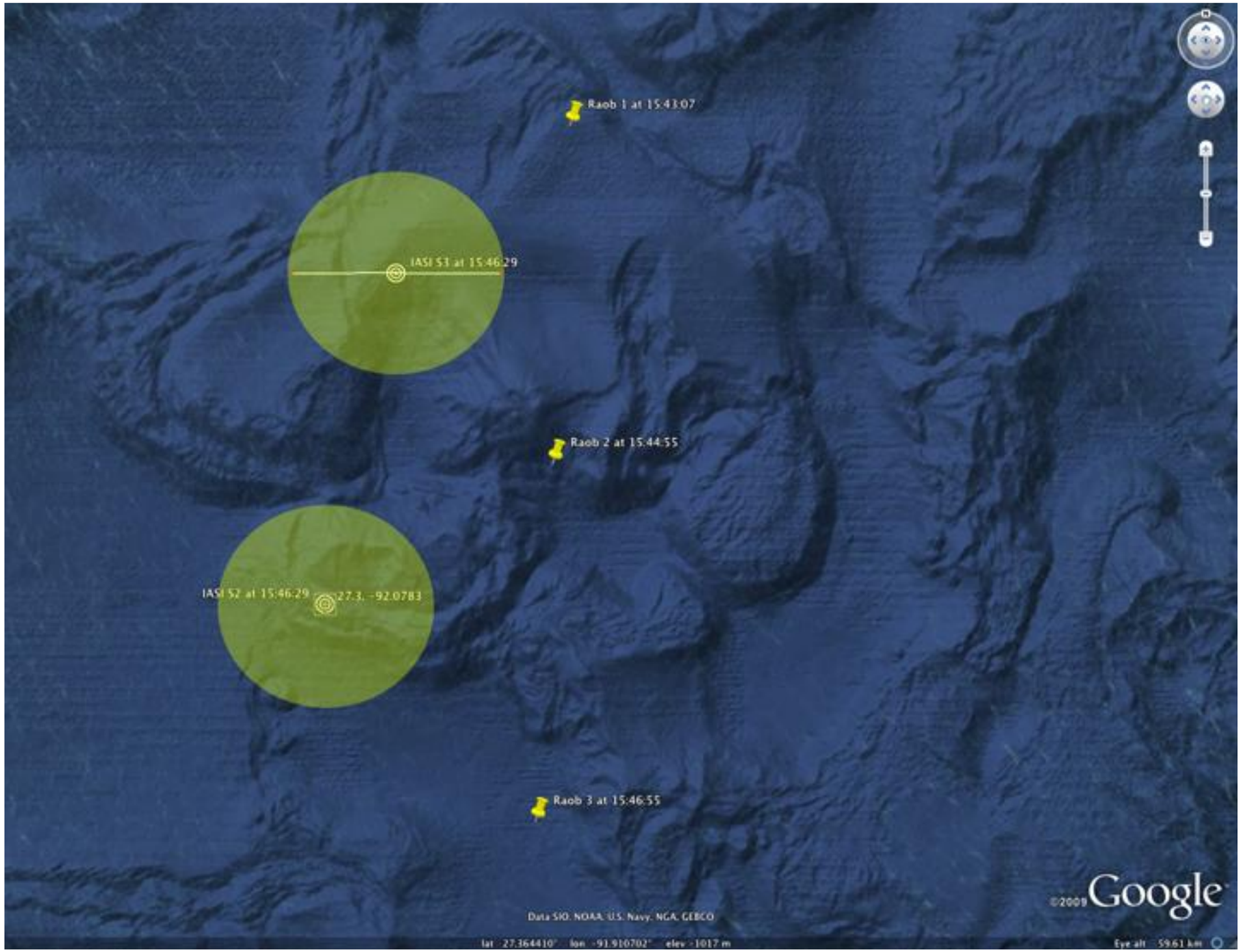
EUMETSAT

SSEC

Retrieval characteristics

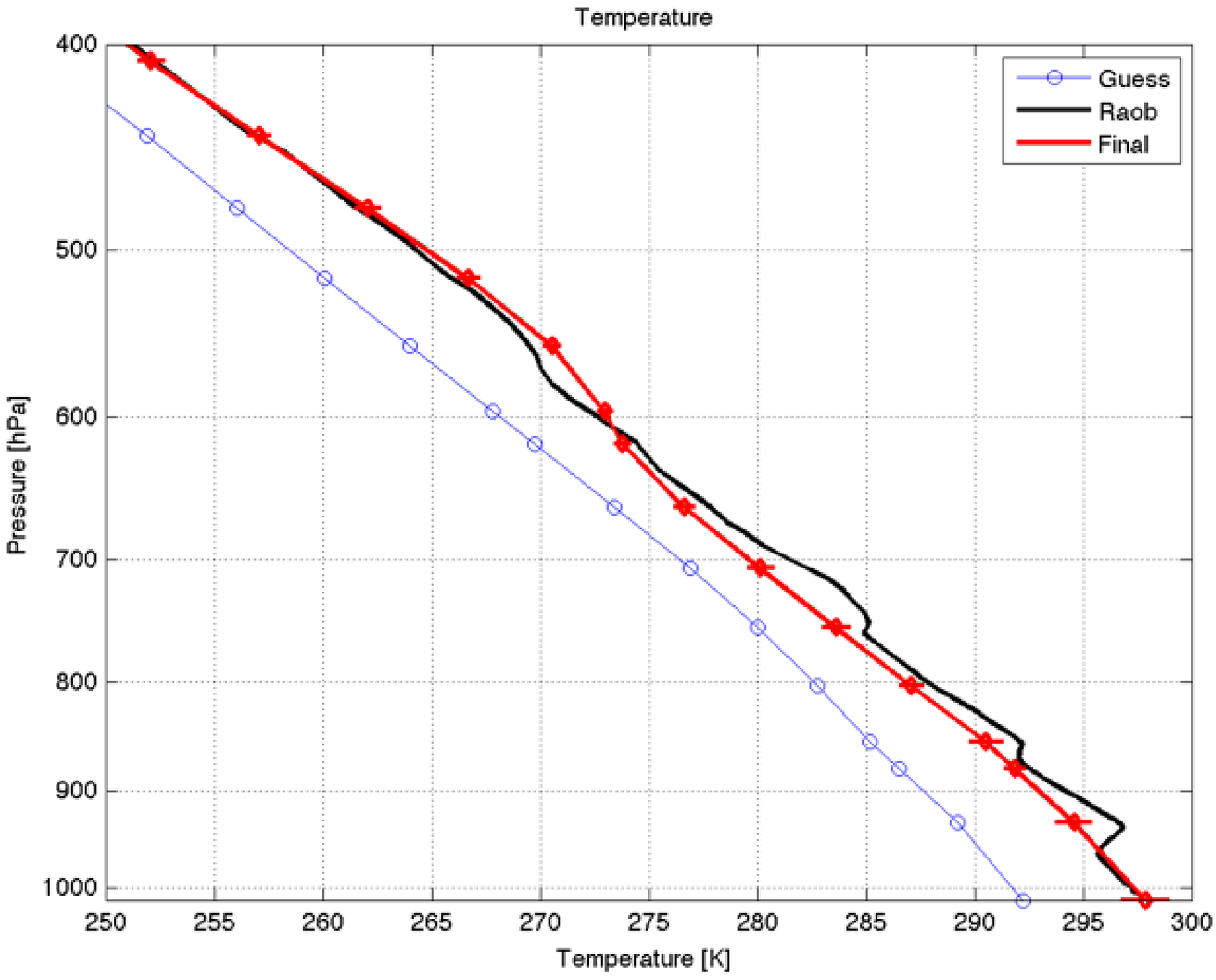
- IASI retrievals were obtained from IASI apodized radiances;
- Noise used to characterize the error covariance matrix was the square actual instrument noise estimates provided by CNES increased from 0% to up to 70%;
- Retrieval was performed in simultaneous mode for T, WV, O3, CO2, SKT, and SE;
- Retrieval for JAIVEx data was done for:
  - IASI data;
  - S-HIS data;
  - NAST-I data convolved at S-HIS resolution;
  - IASI data convolved at S-HIS resolution;

IASI S2: 04 May 2007

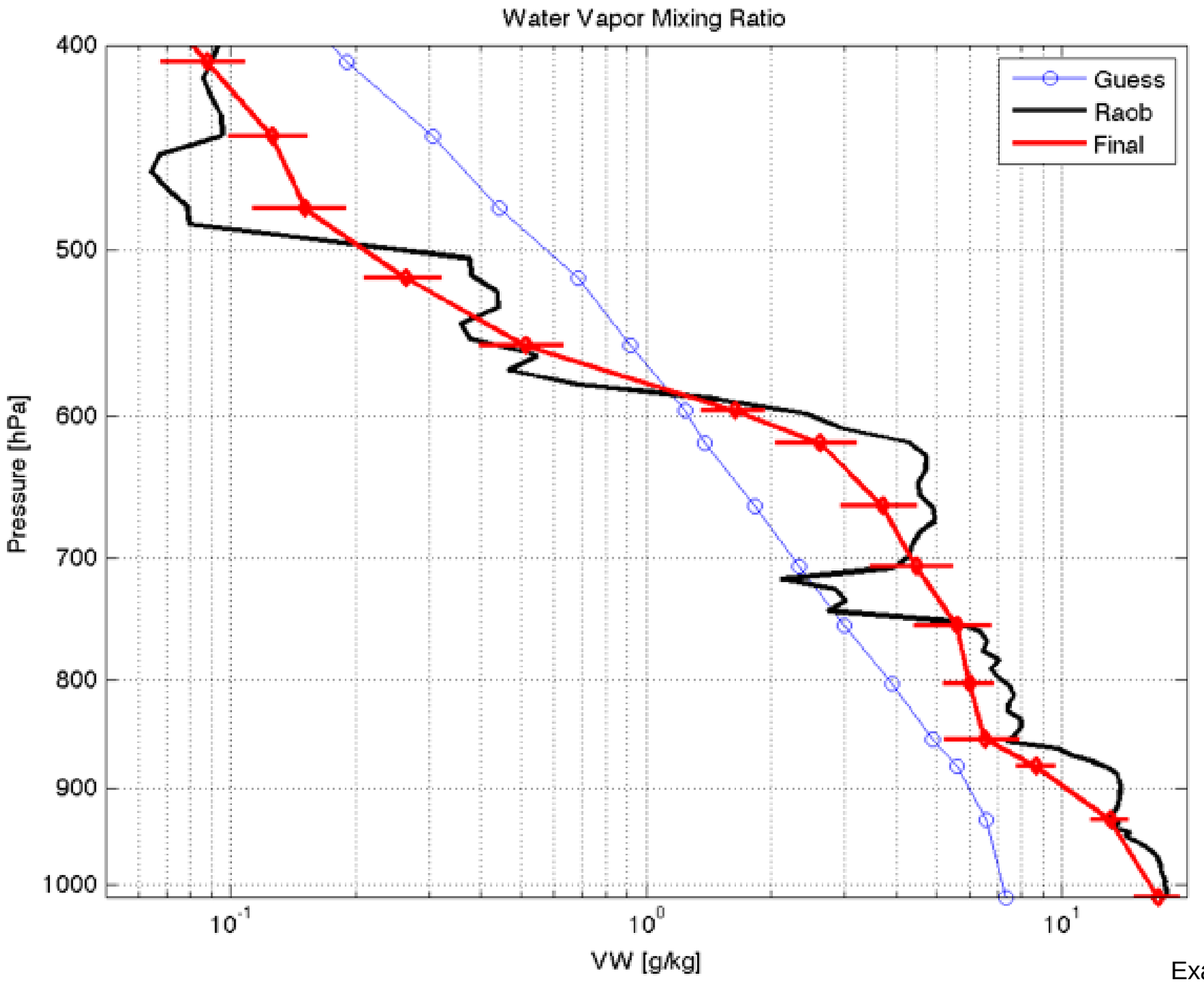


Examples of Level 2 Products

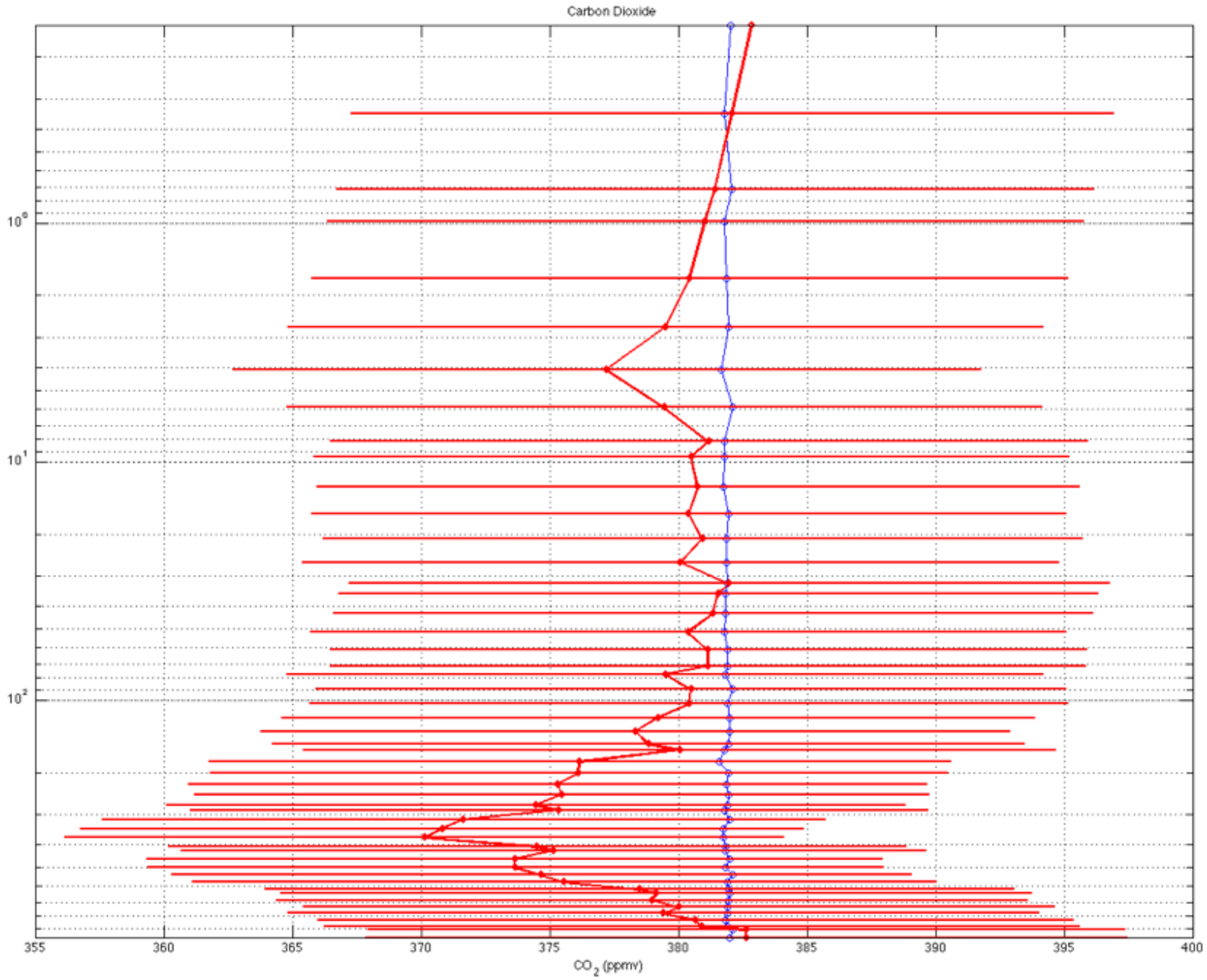
S3: Temperature Retrieval



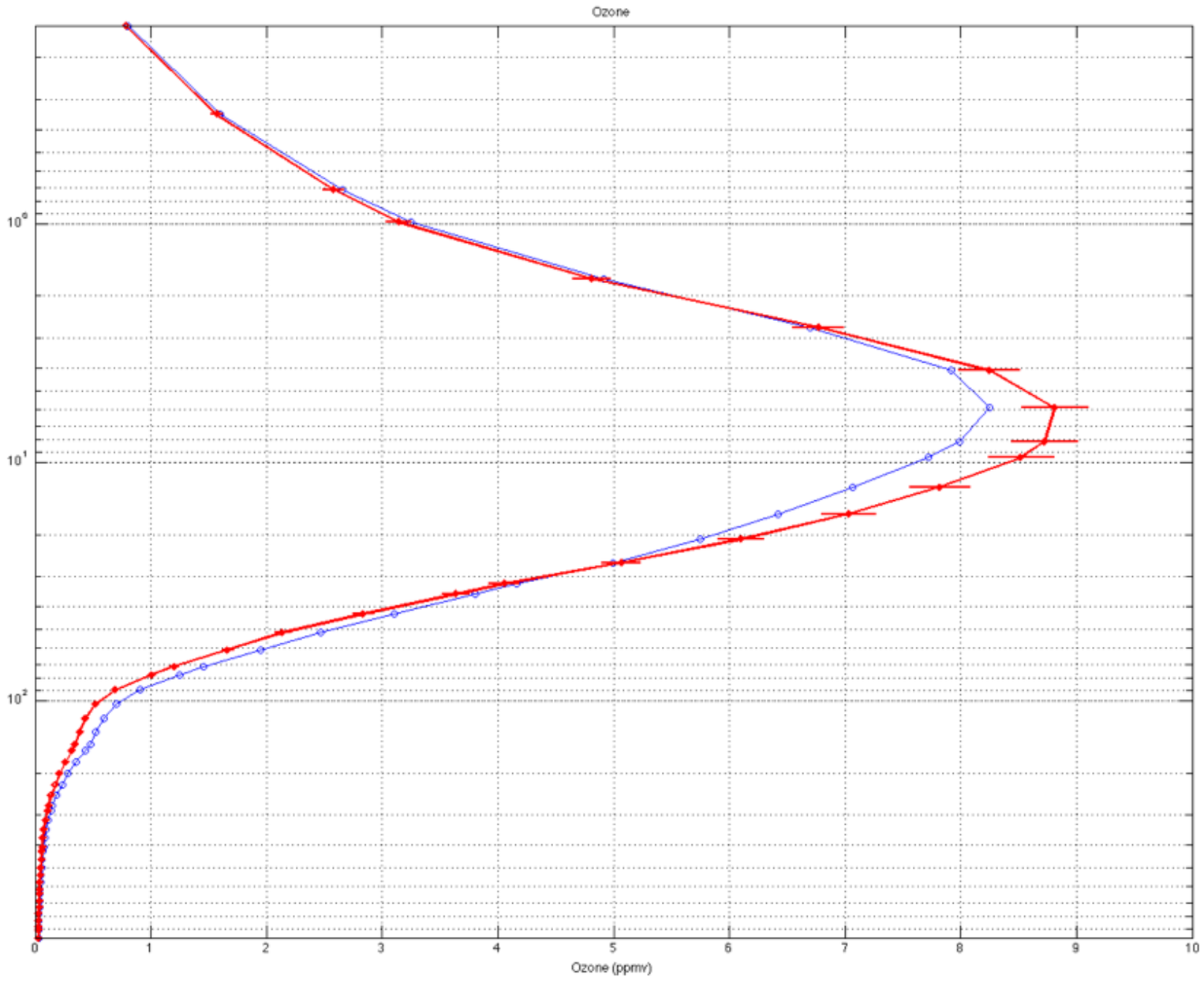
S3: Water Vapor Mixing Ratio



S3: Carbon Dioxide



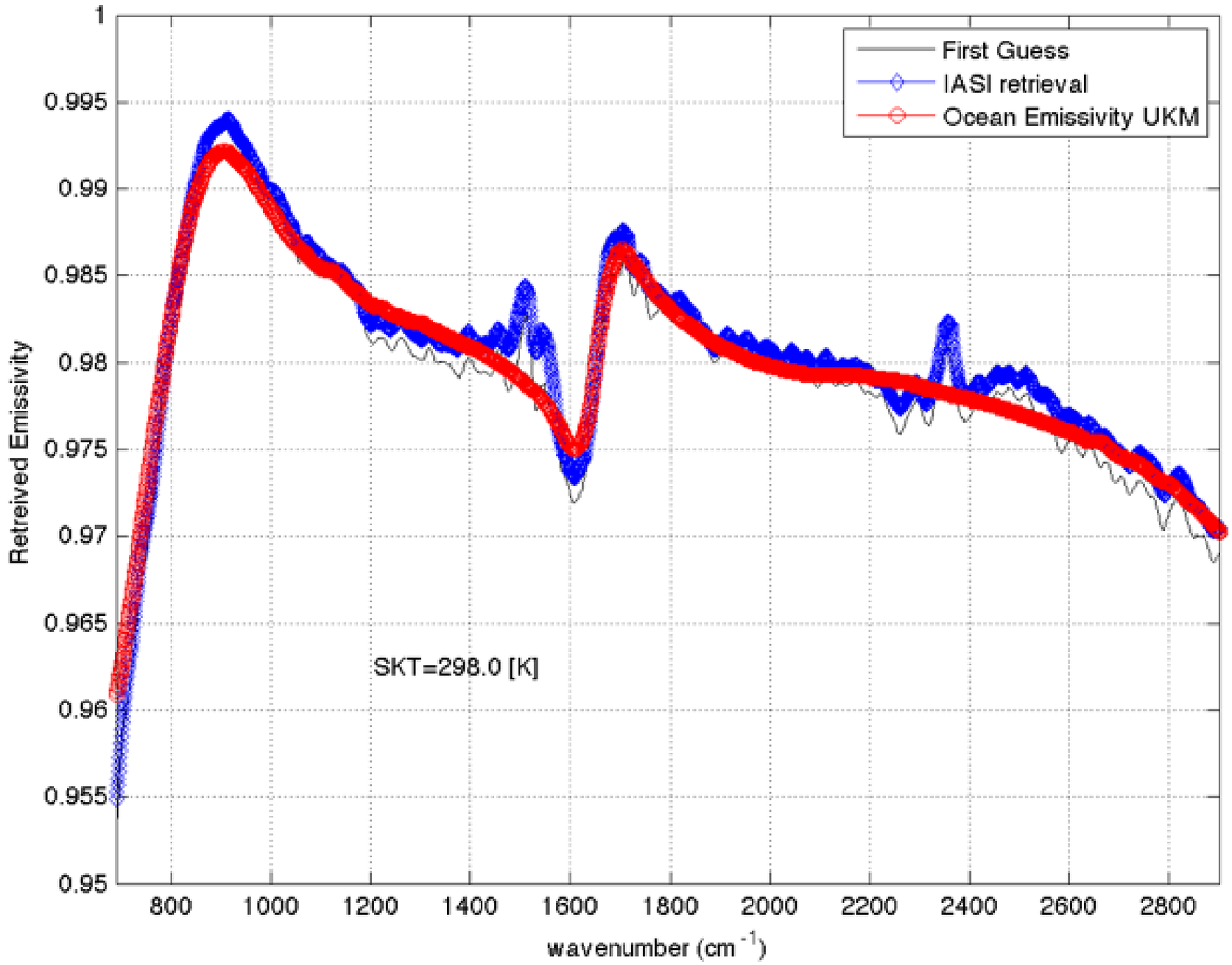
S3: Ozone



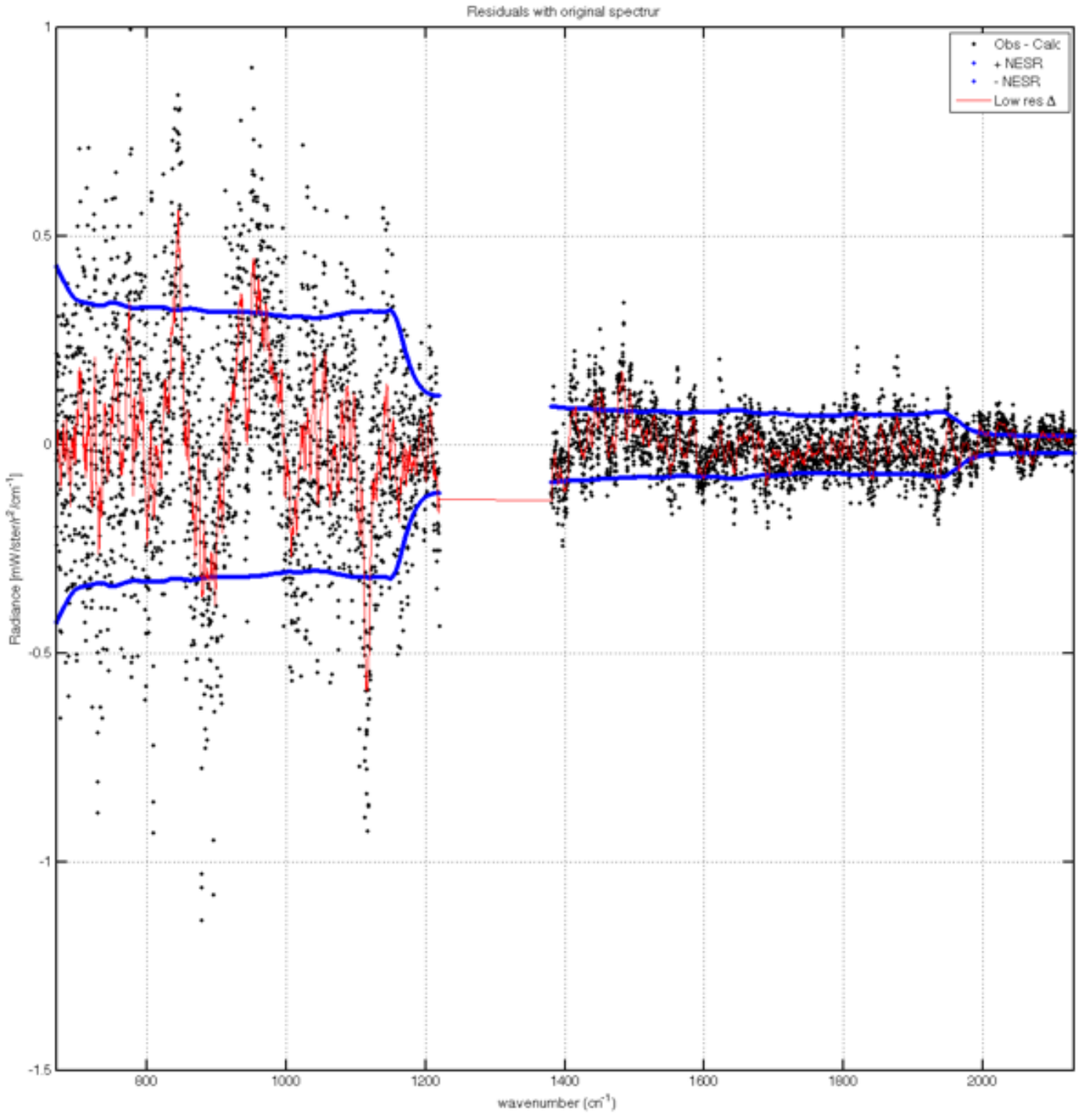
S3: Surface Emissivity and Surface Temperature

First Guess of SE was derived from ocean emissivity PCs

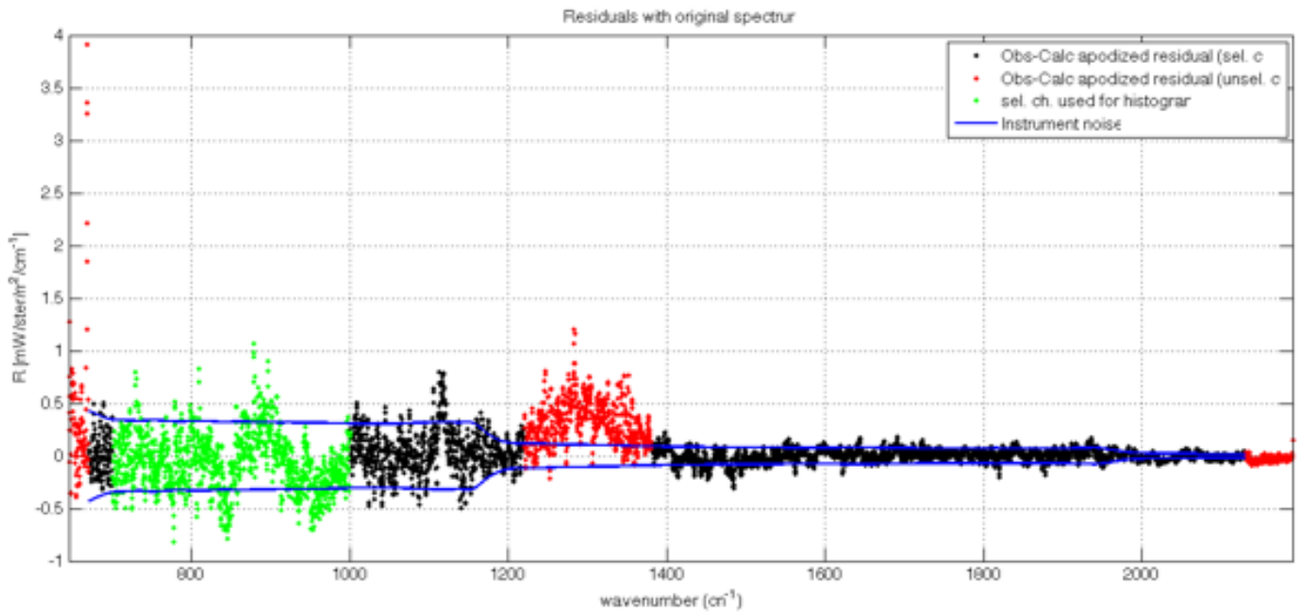
ARIES Estimated ST= 297.4K

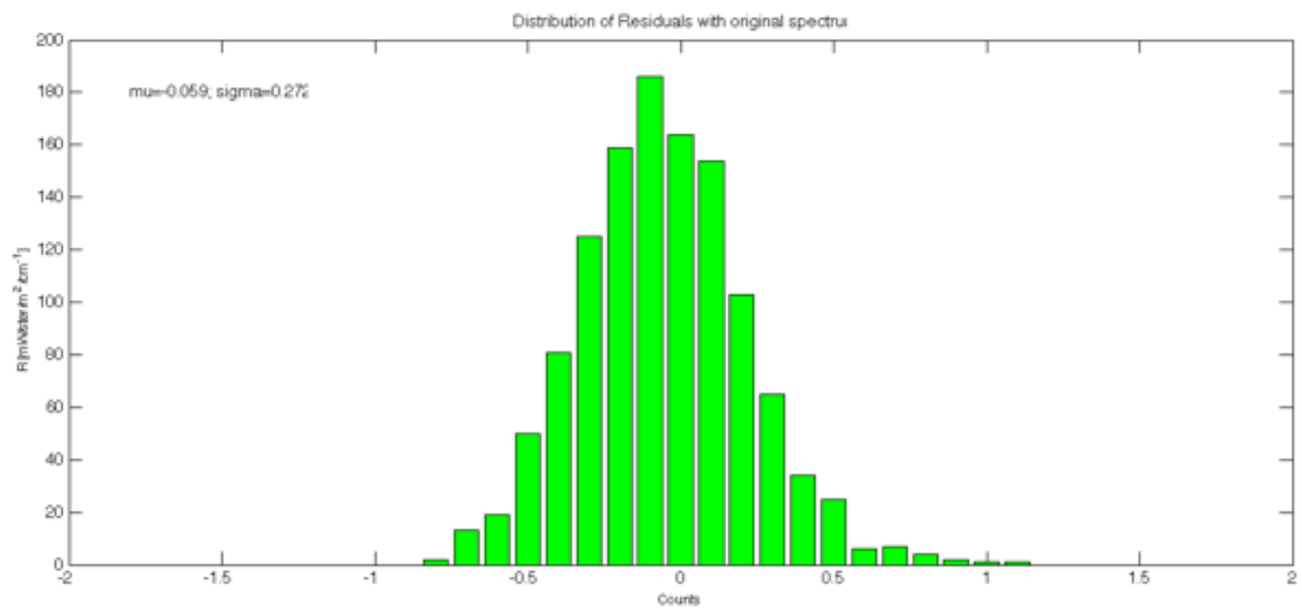


S3: Radiance Residuals

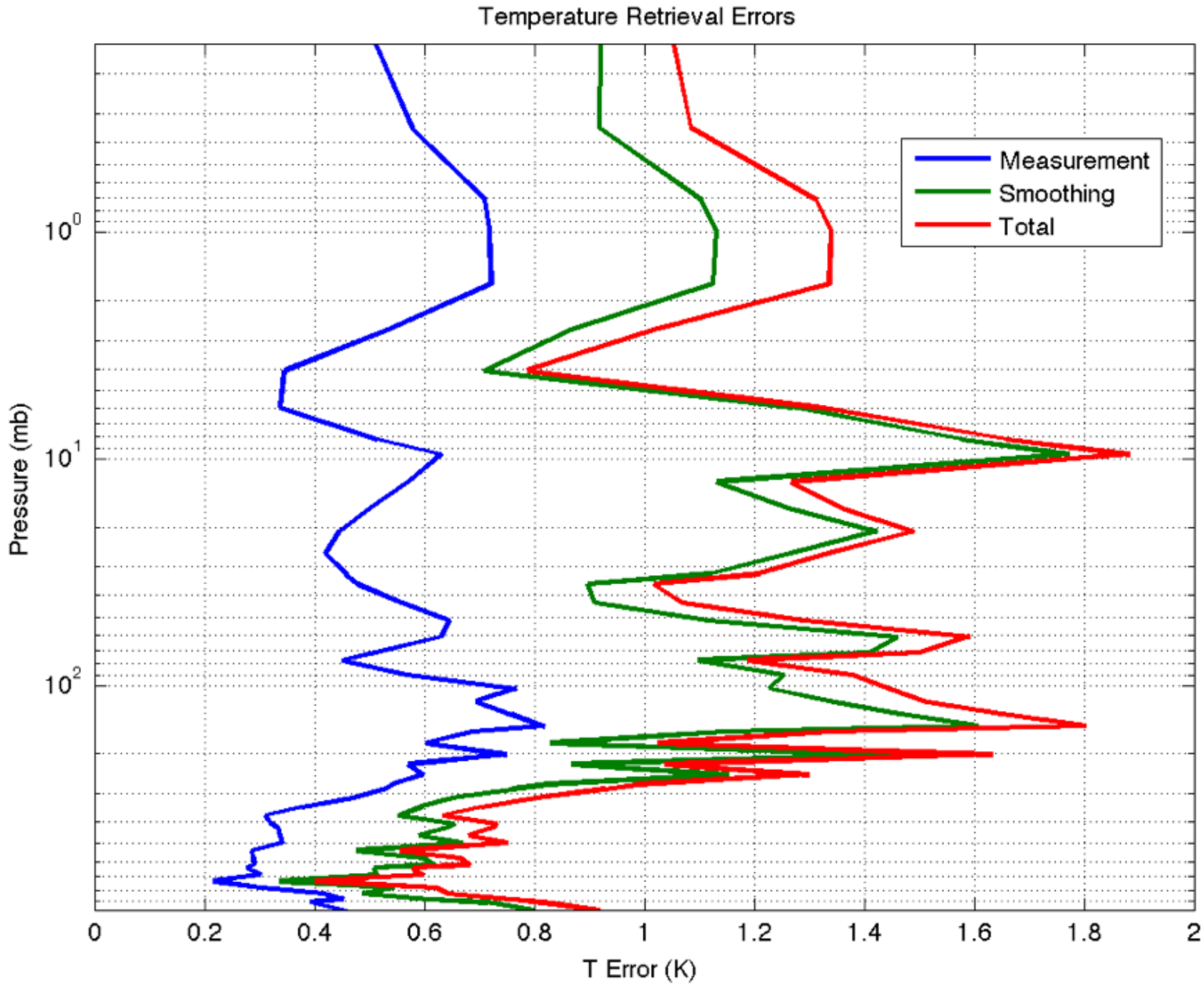


S3: BT residuals

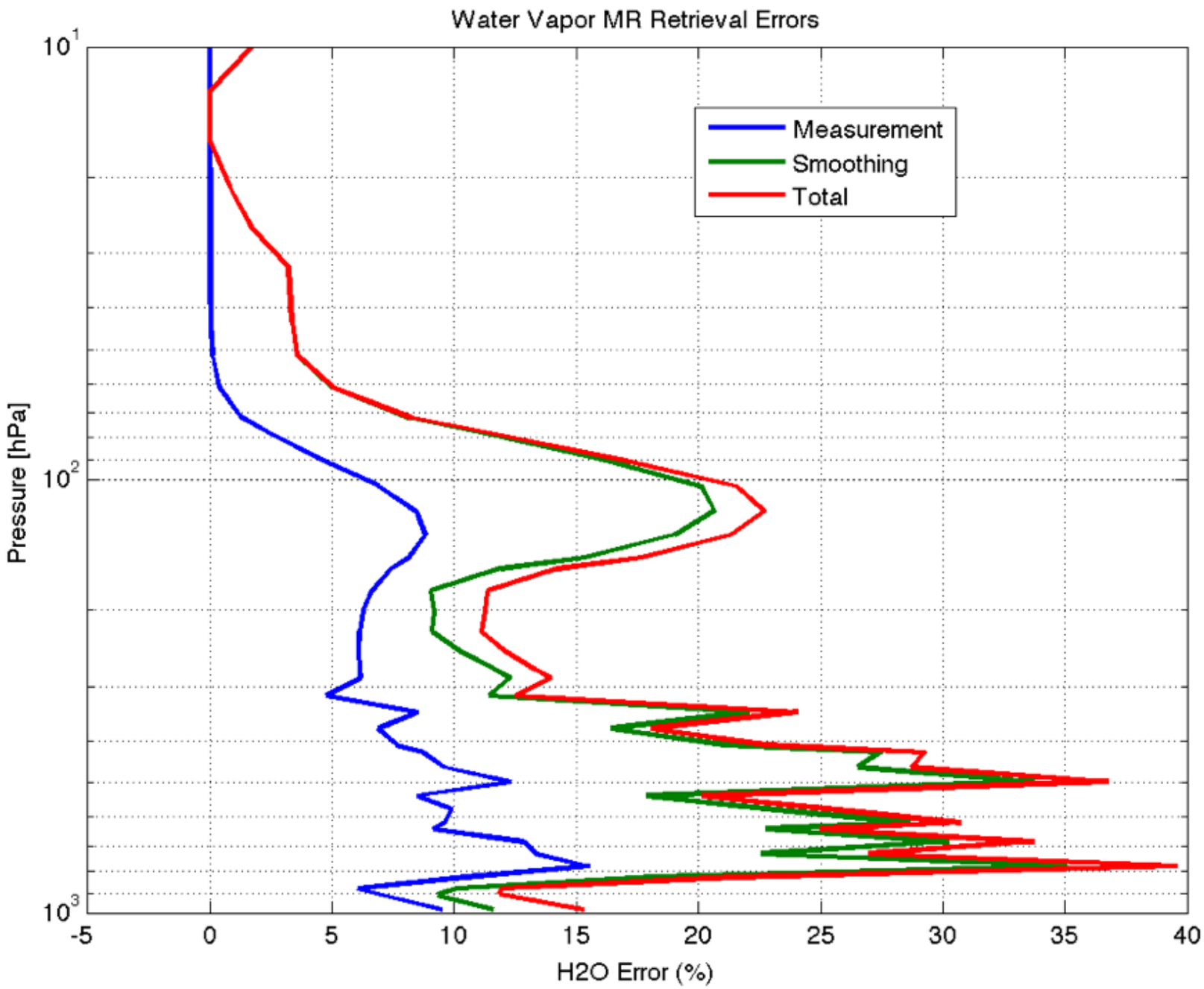




Solution: T Retrieval Errors



Solution: H_2O MR Retrieval Errors



Surface Emissivity Retrieval

- Surface Emissivity is calculated as combination of 6 basis functions (Principal Components) therefore the whole emissivity spectrum is represented by 6 coefficients only;

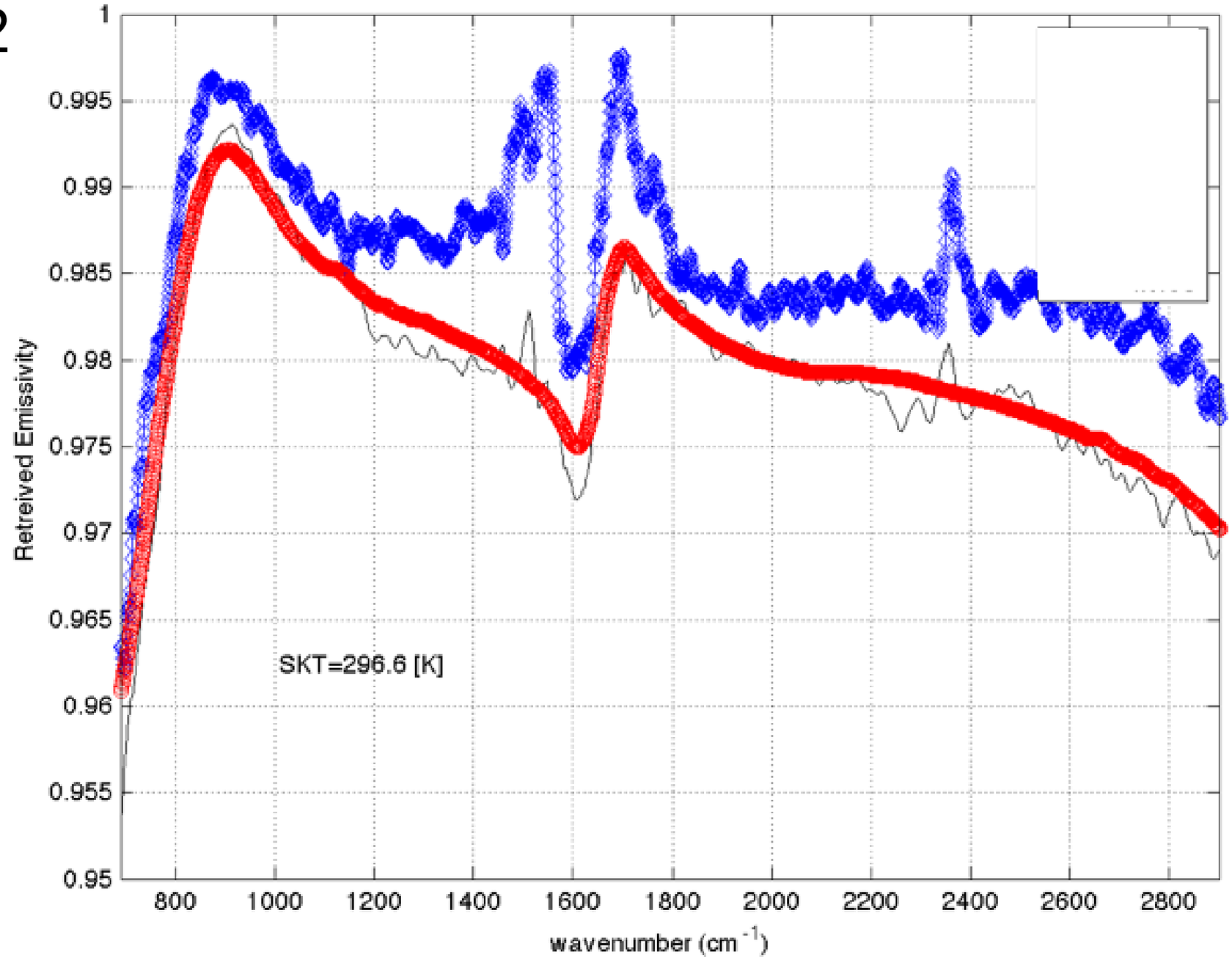
- Basis functions are derived from a predefined set of emissivities through PCA;

- In the current version of the algorithm the emissivity Jacobians K_{emis} is multiplied by the basis functions (interpolated on the selected channel grid) element by element. The product is then used as Jacobian for the emissivity coefficients;
  $K'_{emis} = K_{emis}.*\text{interpolated(PC)}$

- Emissivity is therefore highly dependent on the PC used to represent it;

Surface Emissivity and Surface Temperature

S2

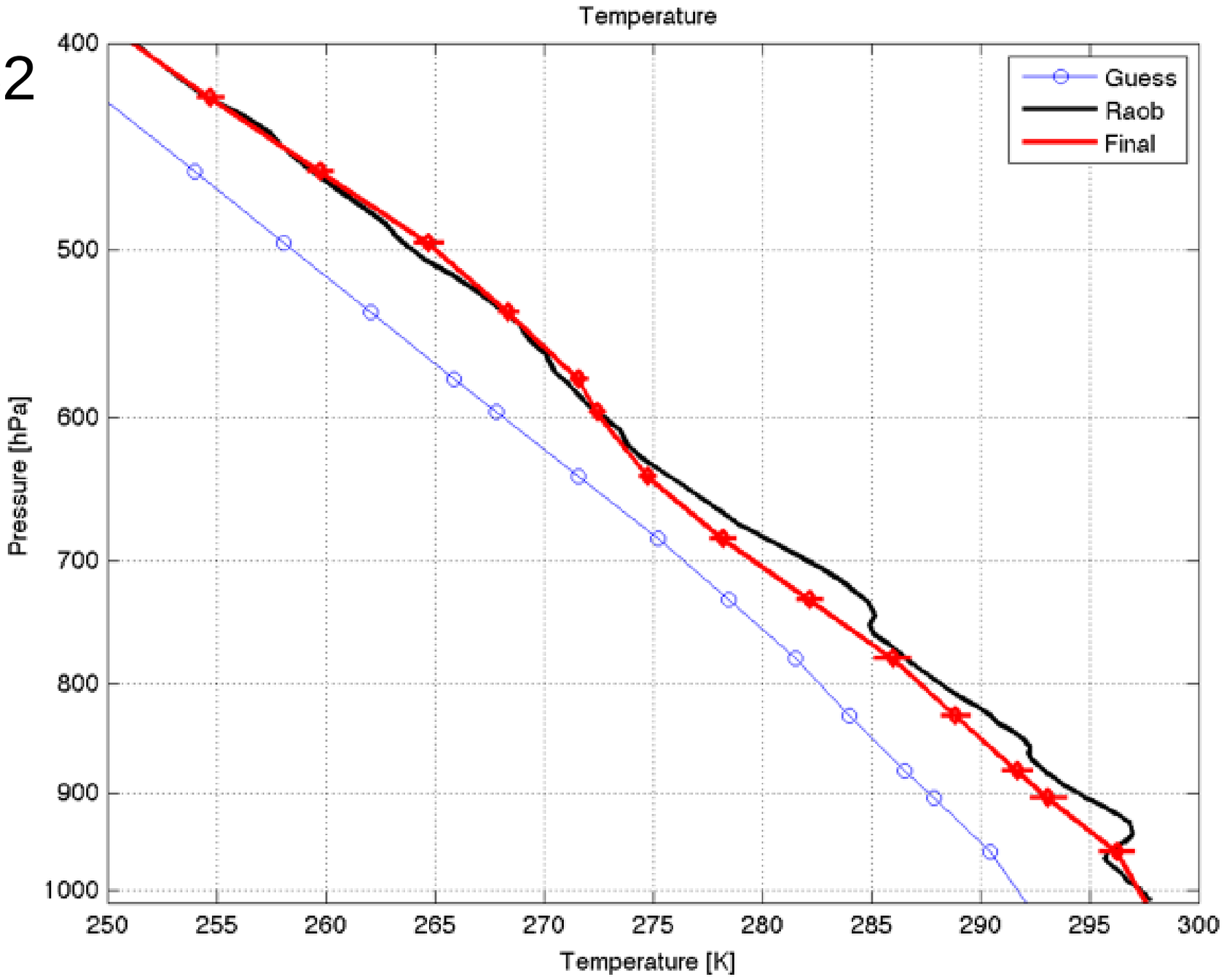


ARIES
Estimated
ST= 297.4K

Surface Emissivity retrieval

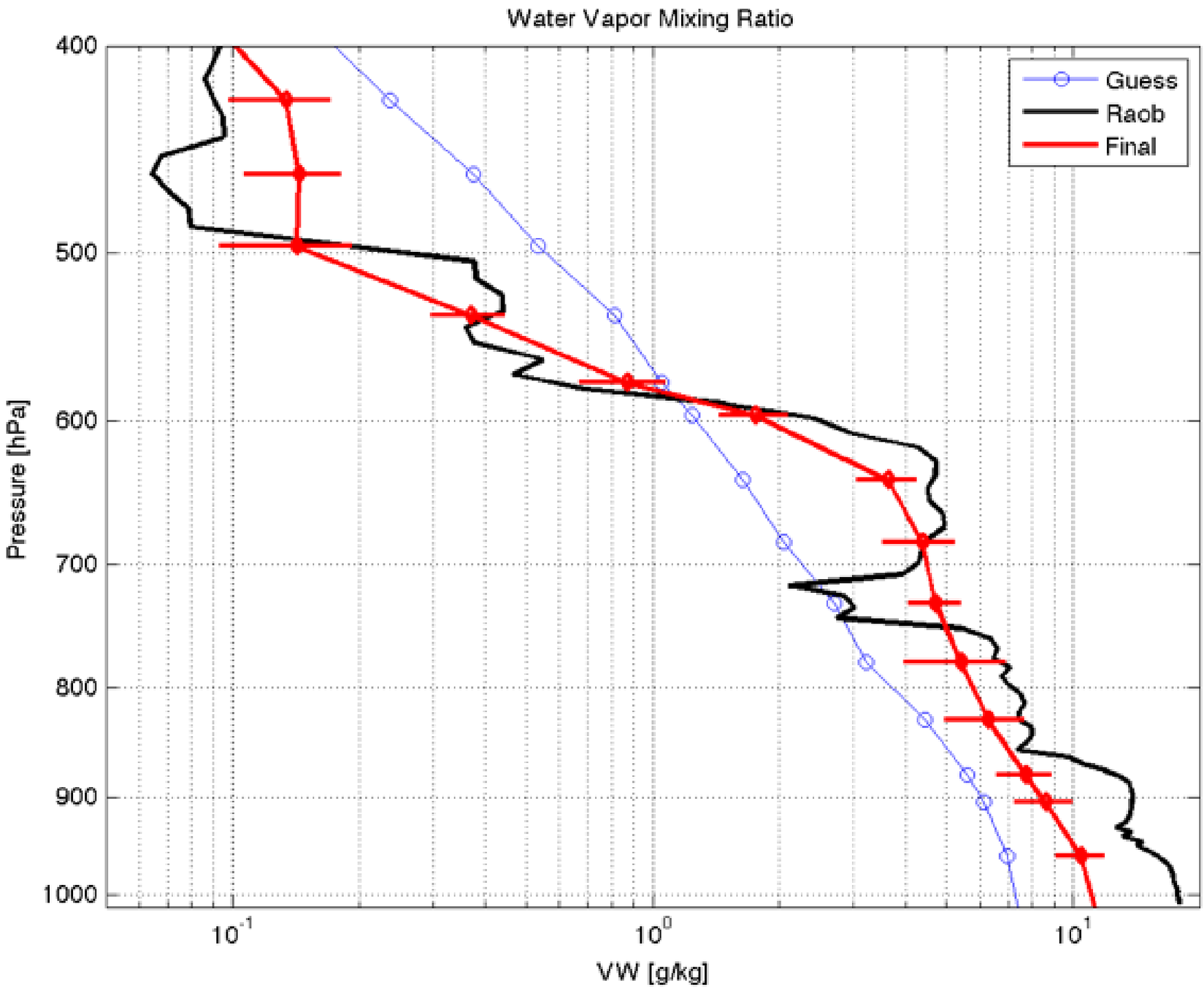
Temperature Retrieval

S2



Surface Emissivity retrieval

Water Vapor Mixing Ratio

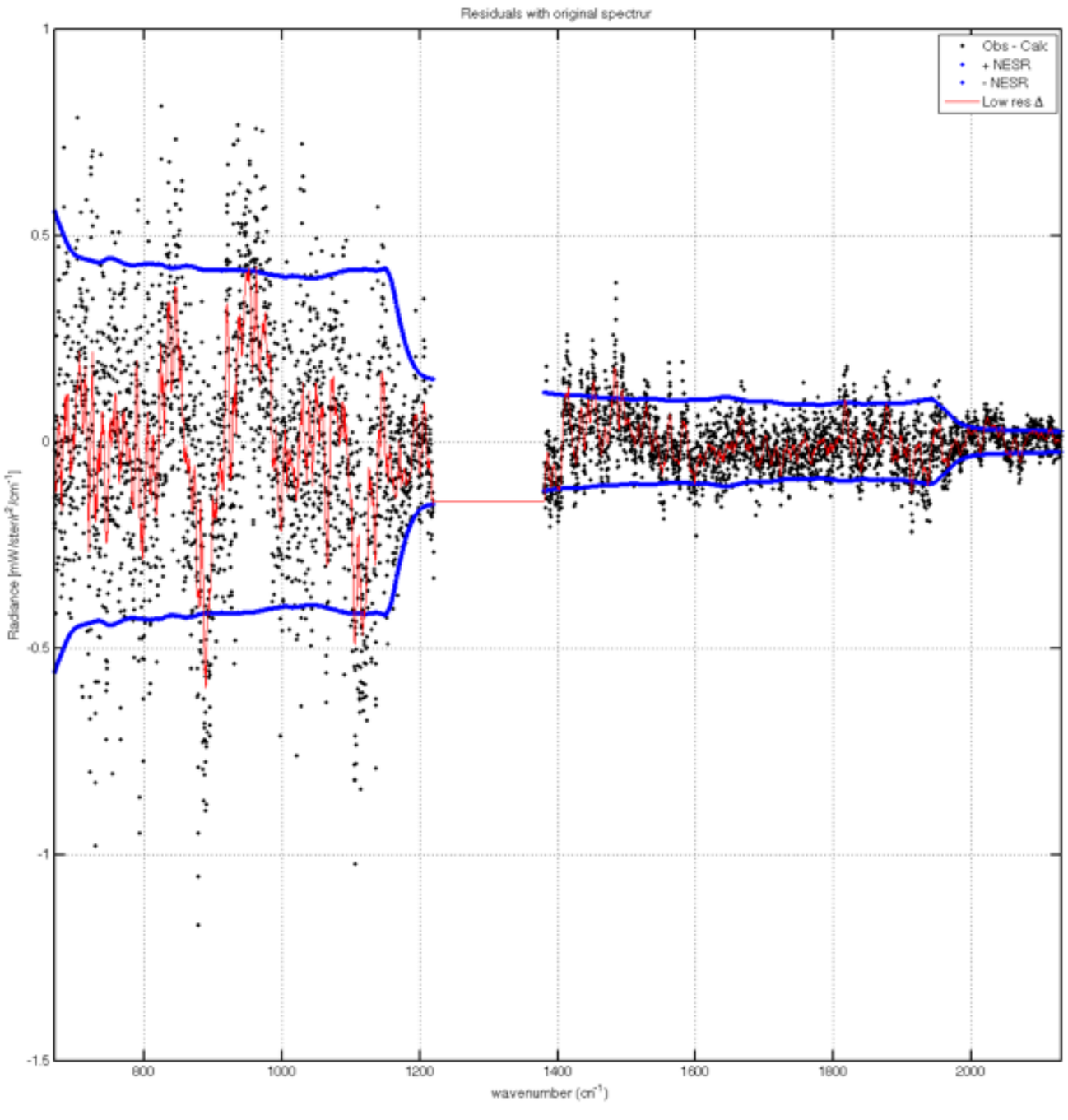


S2

Surface Emissivity retrieval

Radiance Residuals

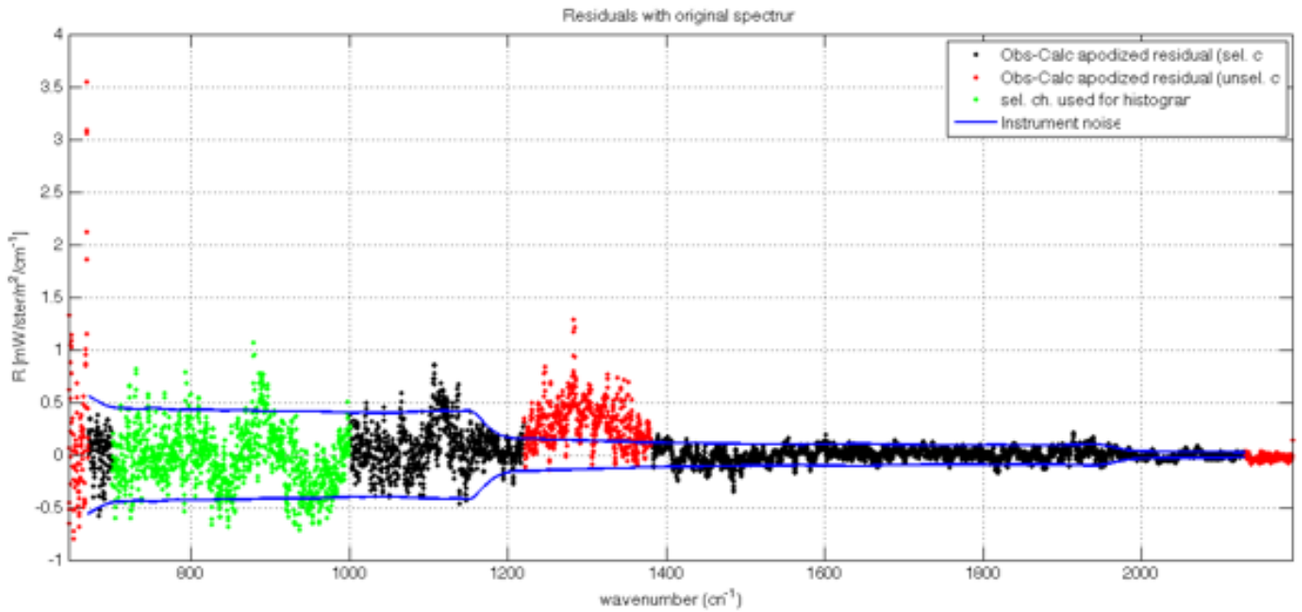
S2

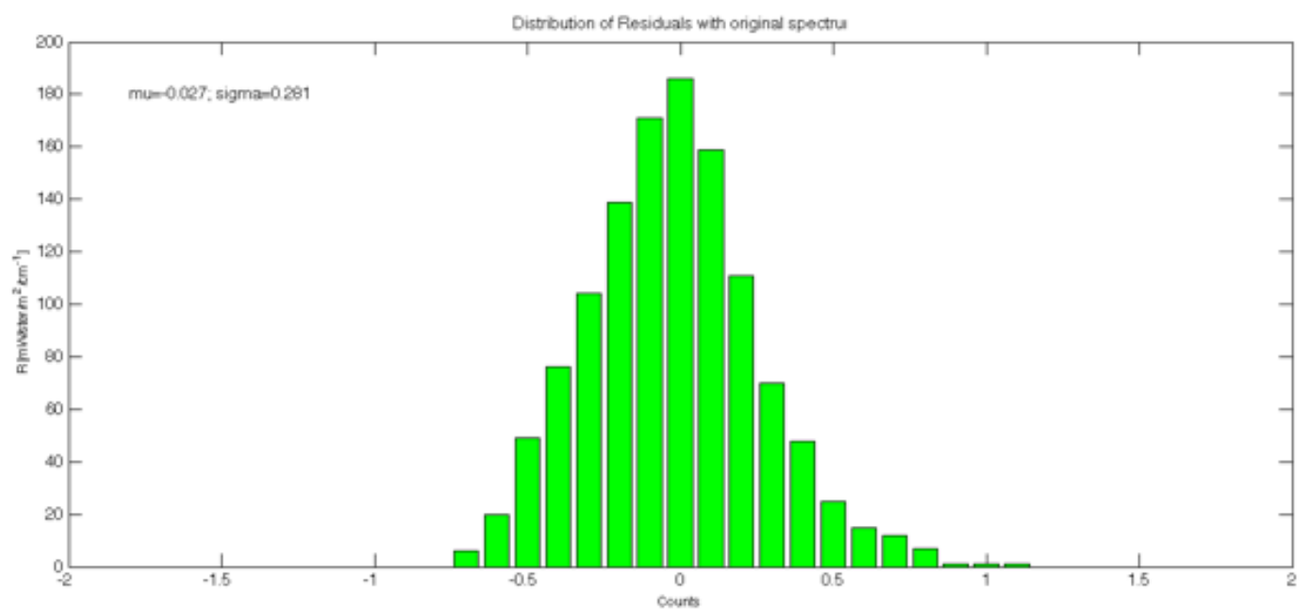


Surface Emissivity retrieval

BT residuals

S2



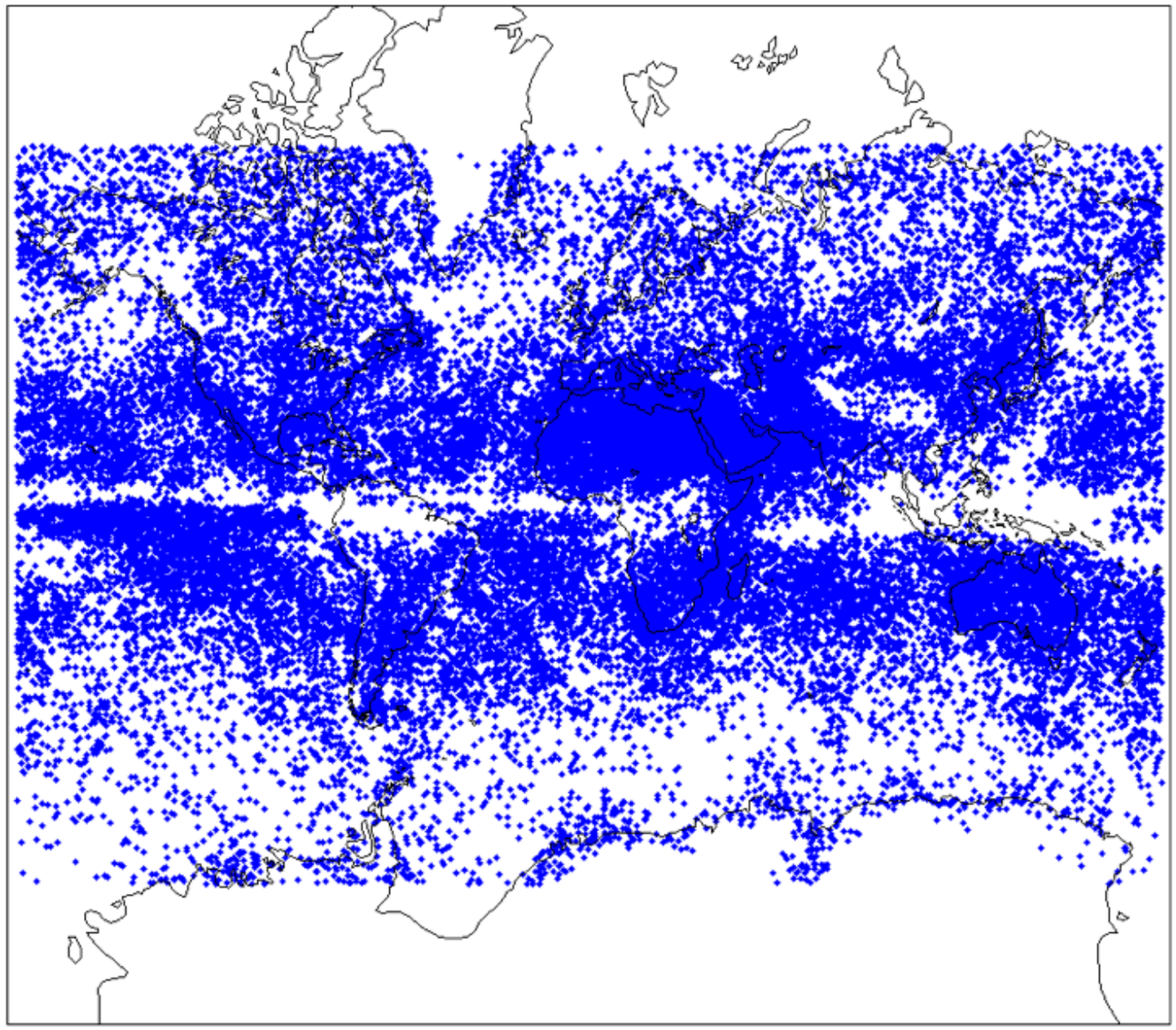


Using PCA noise filter to evaluate Level 2 products

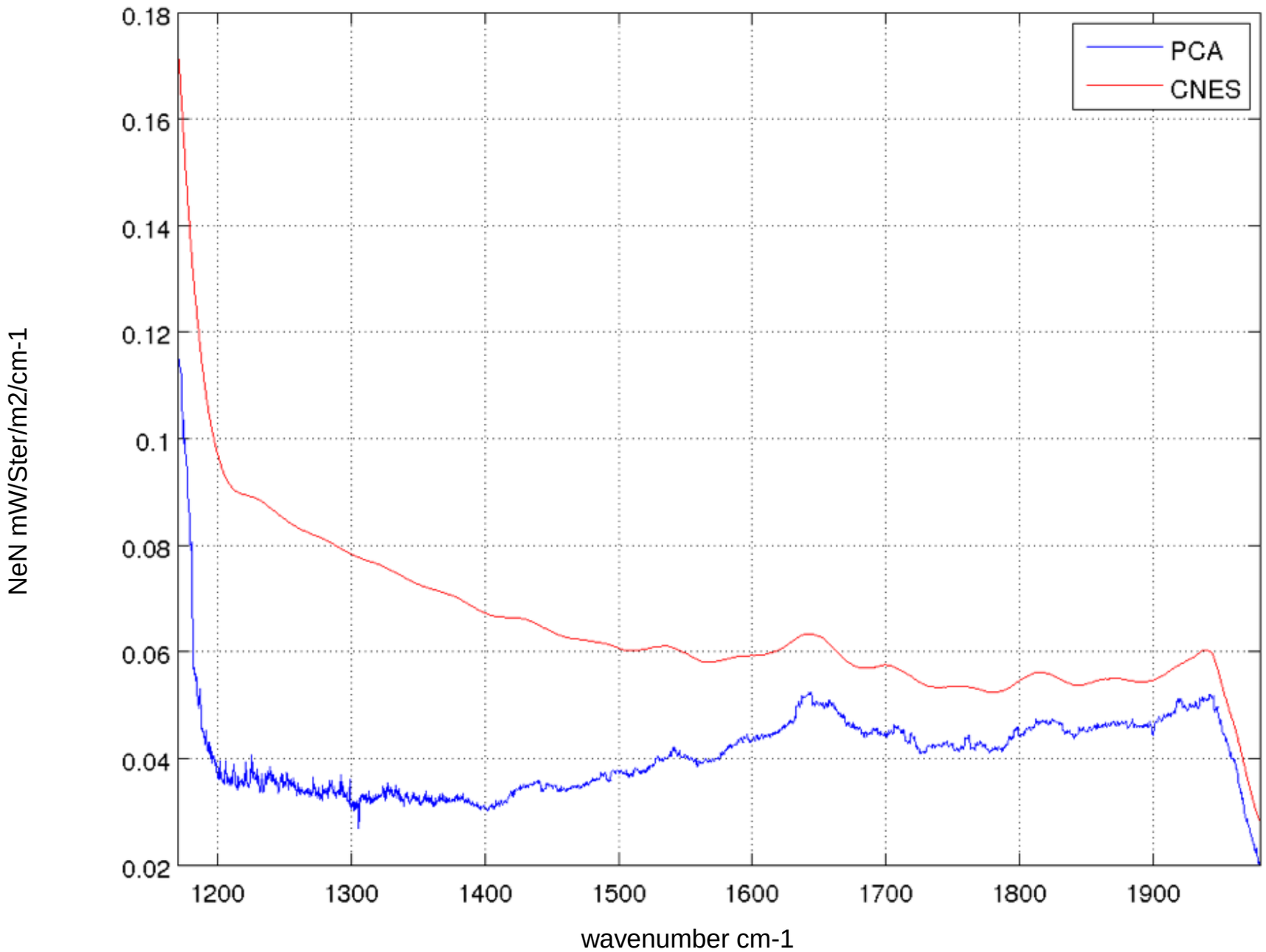
What was done

- Metaiasi (developed by Ray Garcia) was used to generate data sets containing selected IASI observations;
- Training datasets was created
  - ➢ Global Observations, Clear sky, All Angles, All Detectors;
- Principal components were generated for the training dataset and used to:
  - ➢ generate IASI NeN estimates;
  - ➢ noise filter IASI observations to evaluate retrieval residuals;

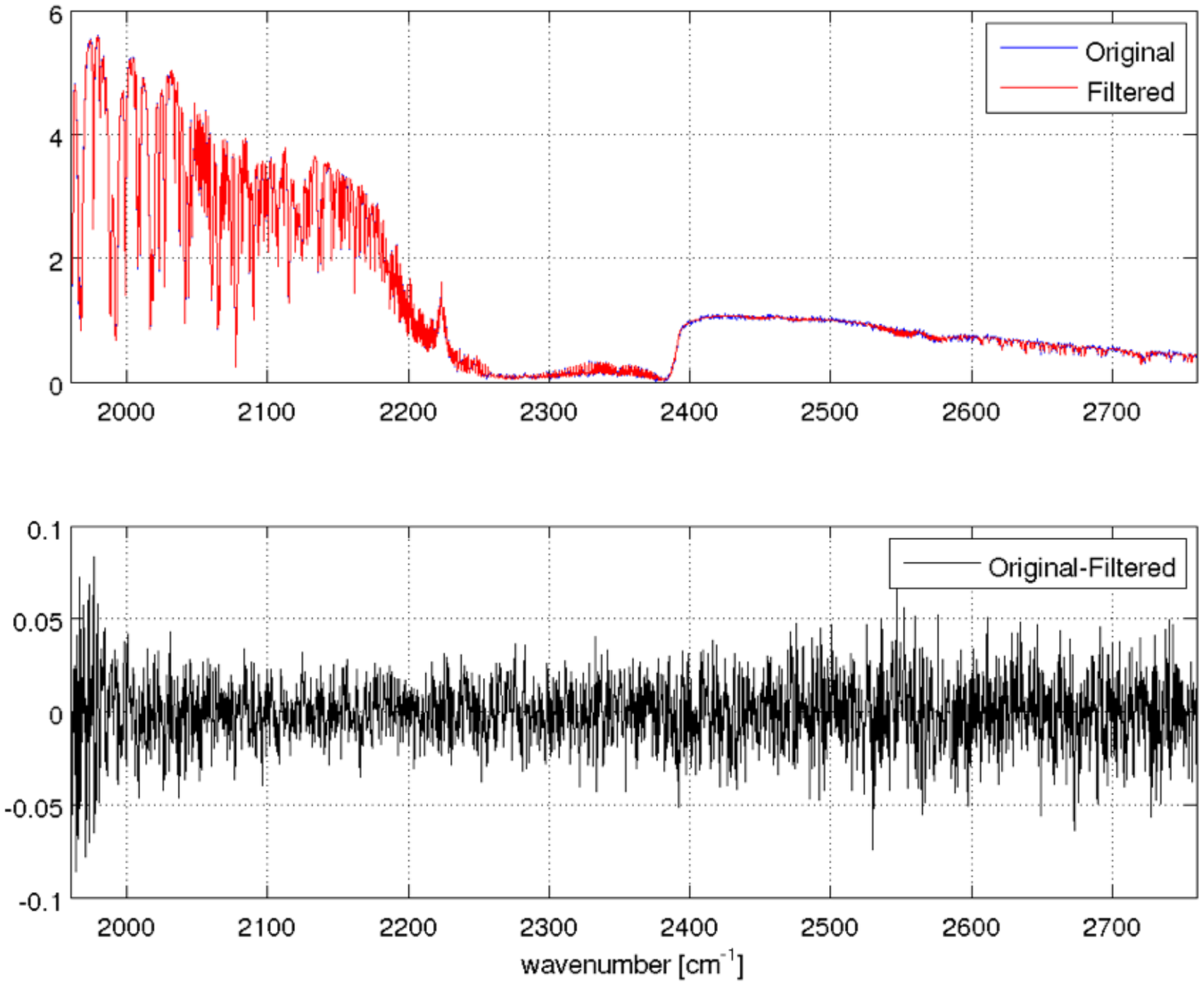
Training Observation Distribution



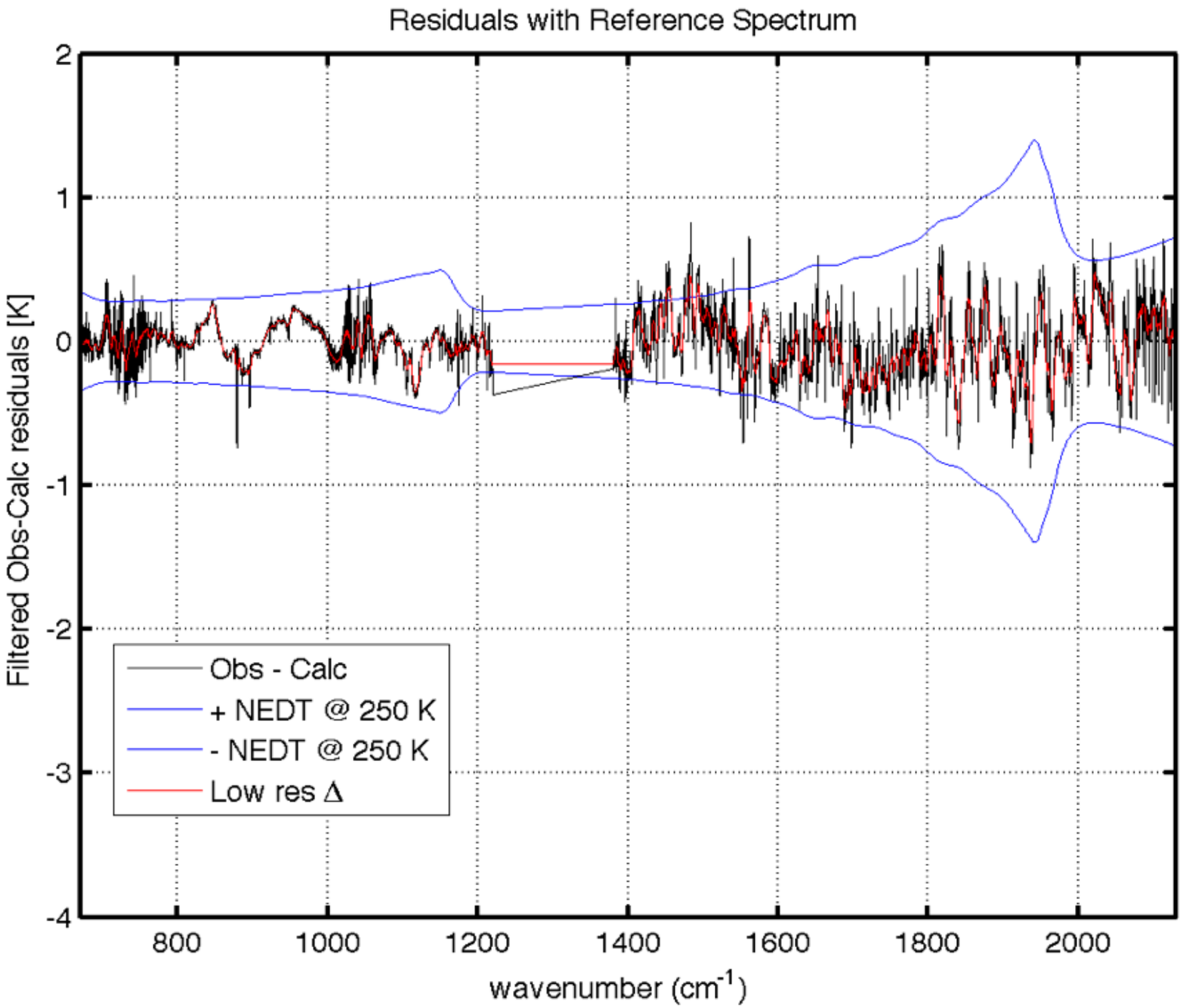
PC based noise estimation



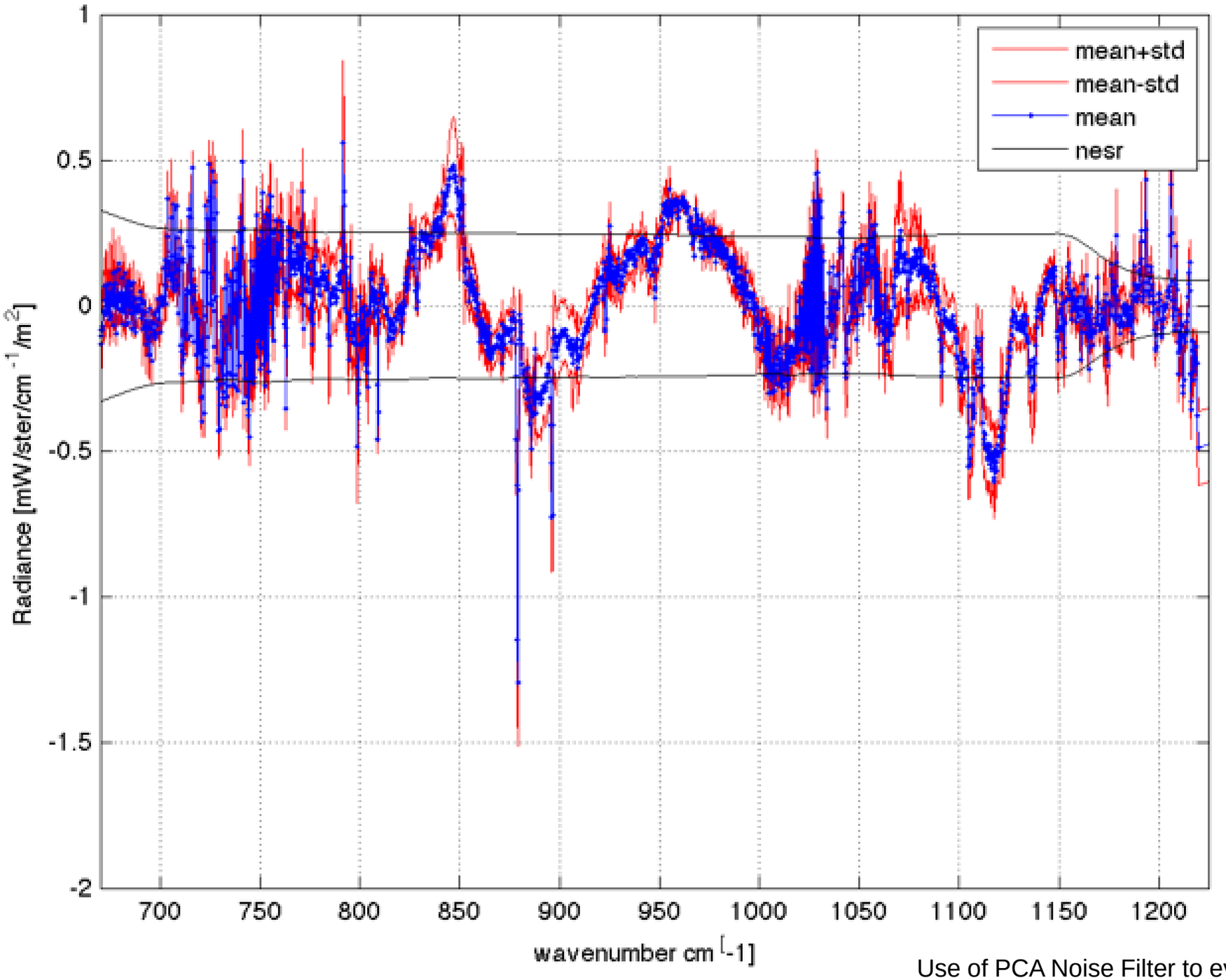
Filtered - Unfiltered



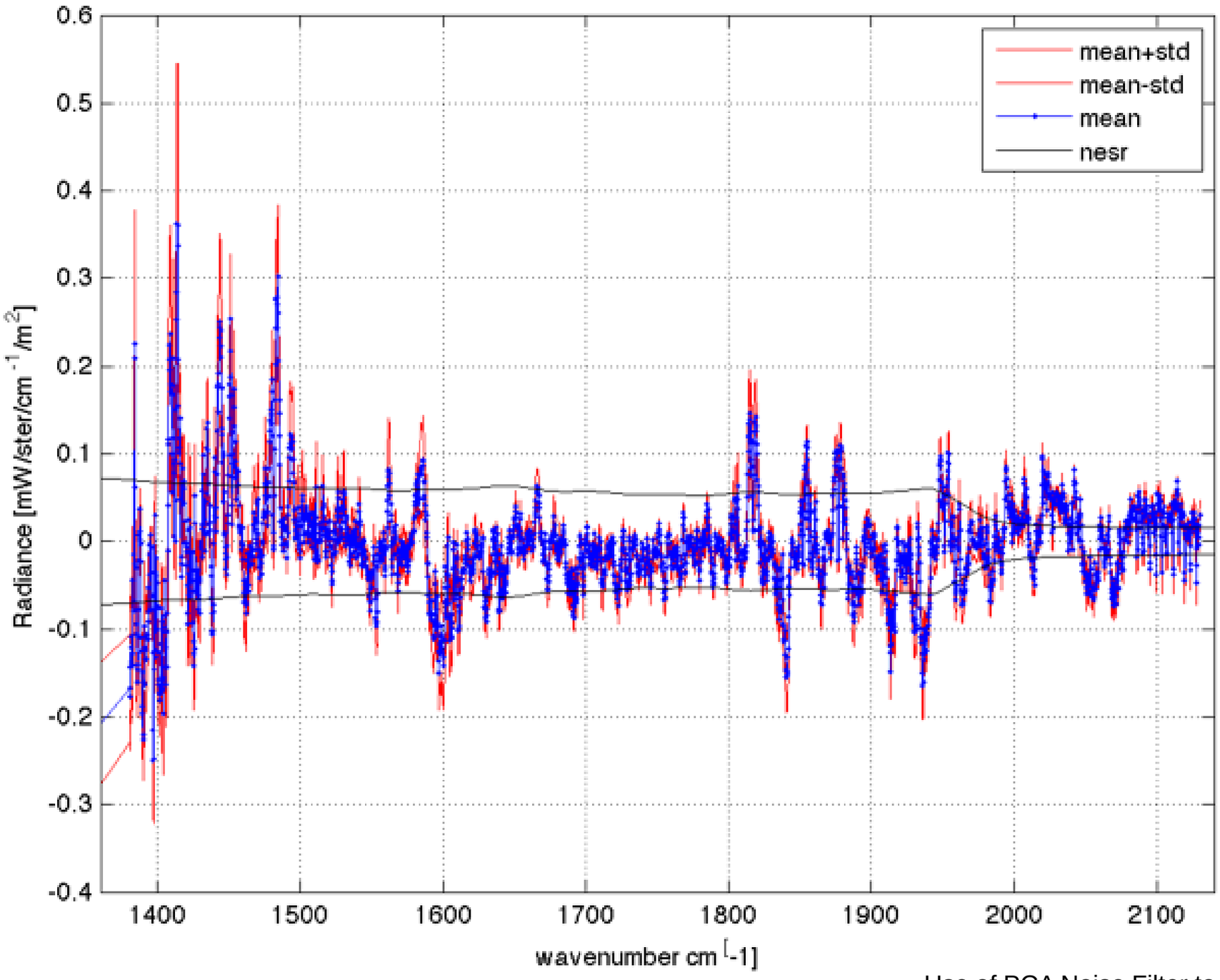
S3 Unfiltered/Filtered BT Residuals



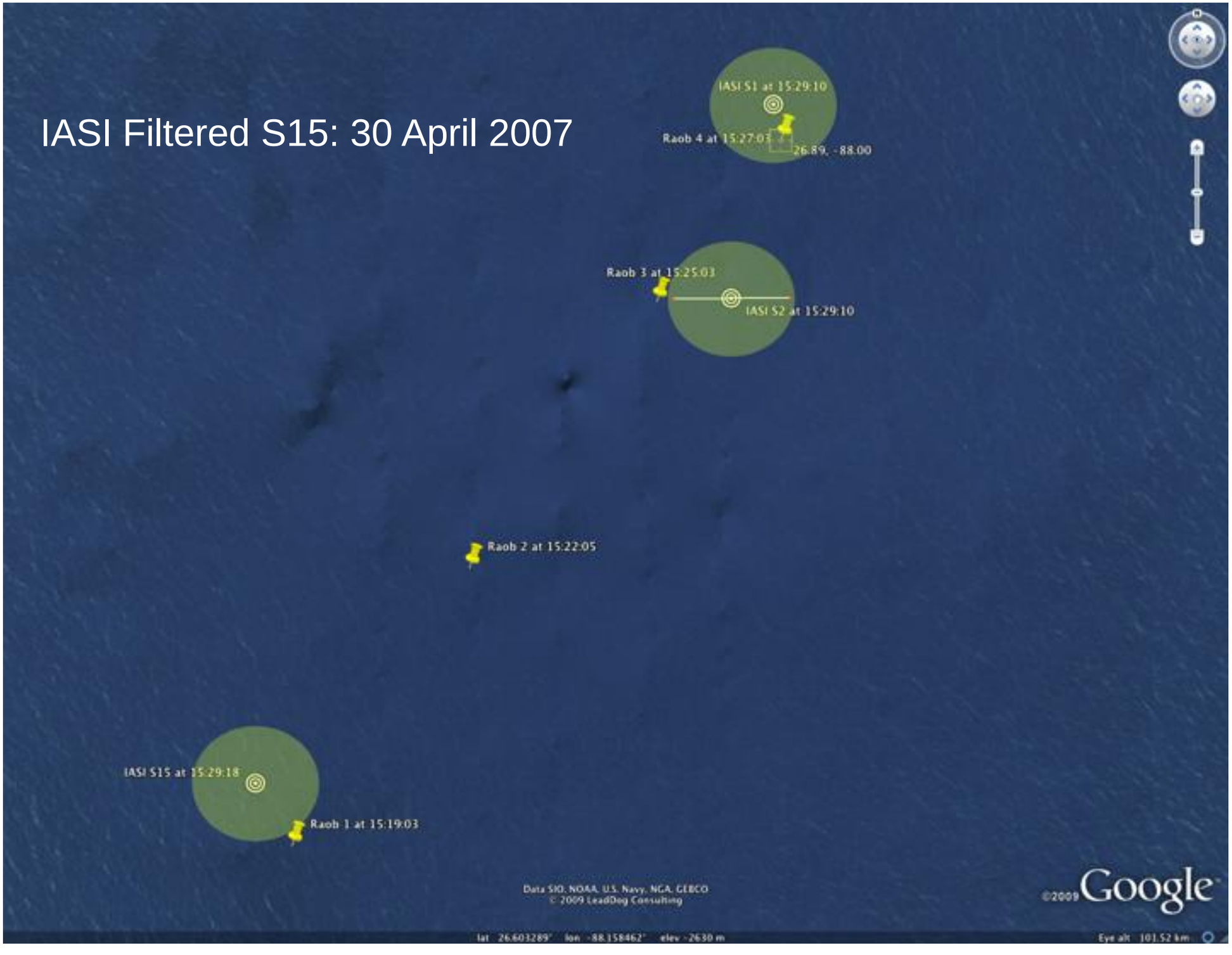
Mean and Std LW residuals (filtered data) for 5 cases



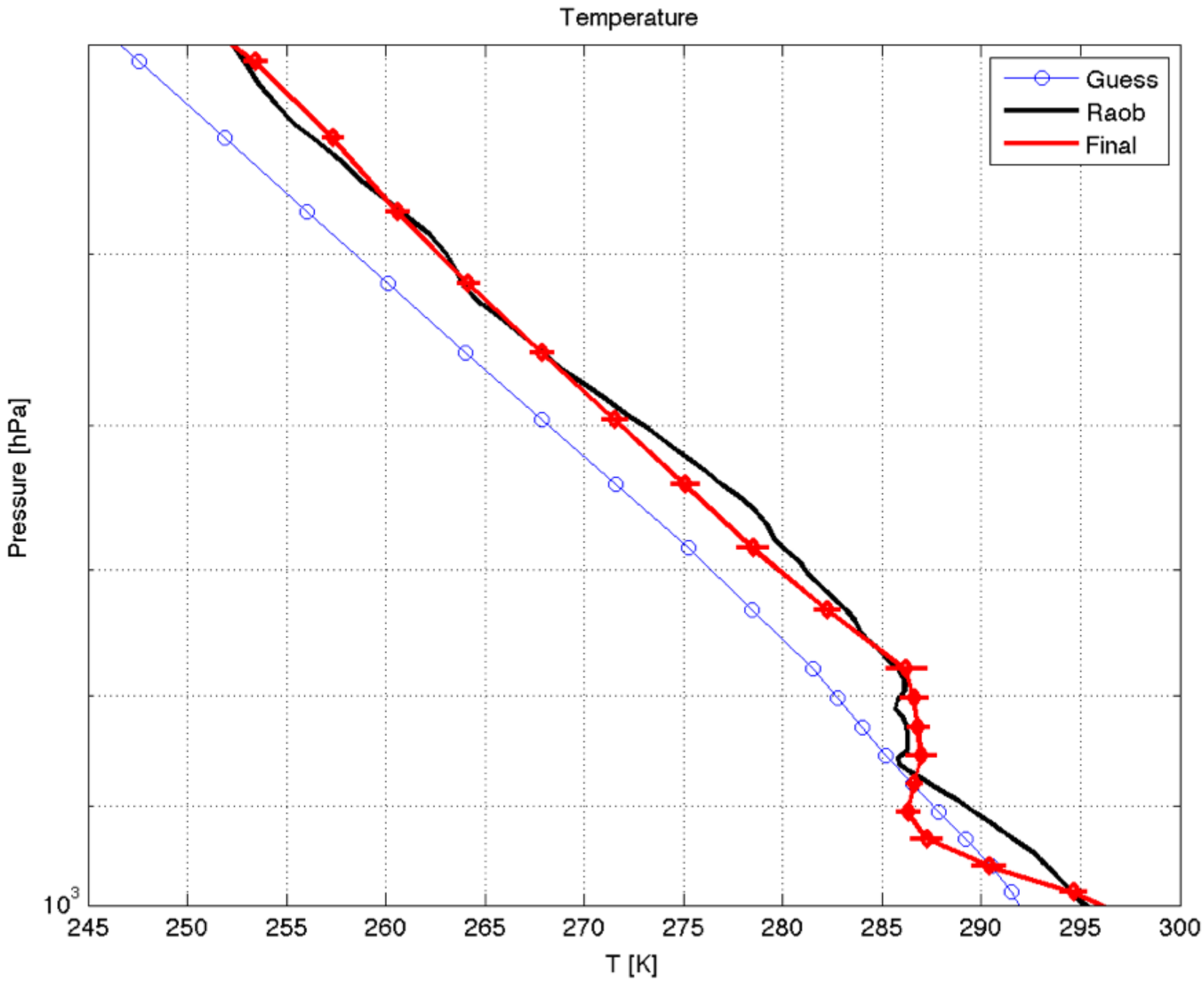
Mean and Std MW/SW residuals (filtered data) for 5 cases



Retrieval from PCA Noise Filtered Radiances

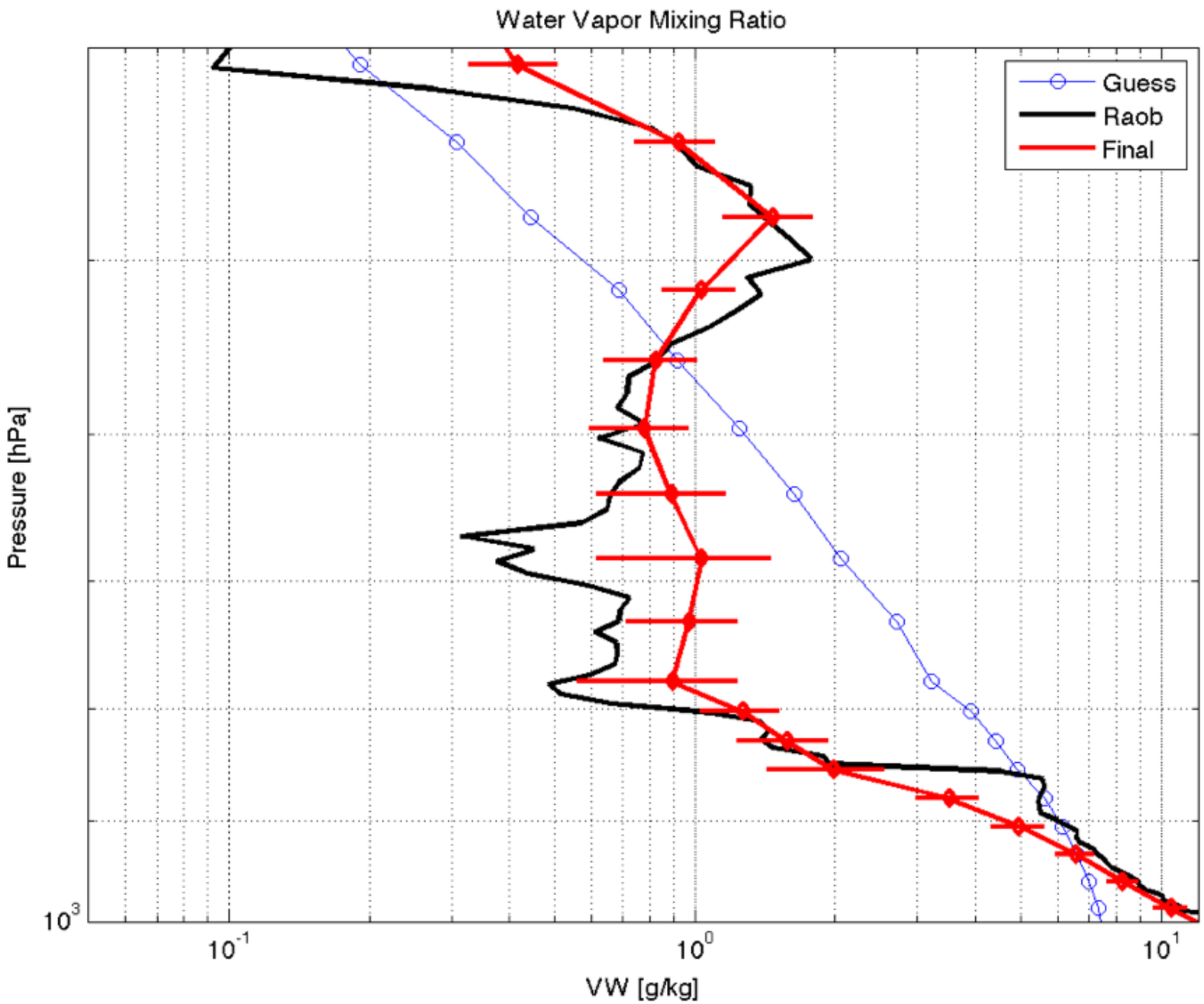


Filtered (S15) Temperature Retrieval



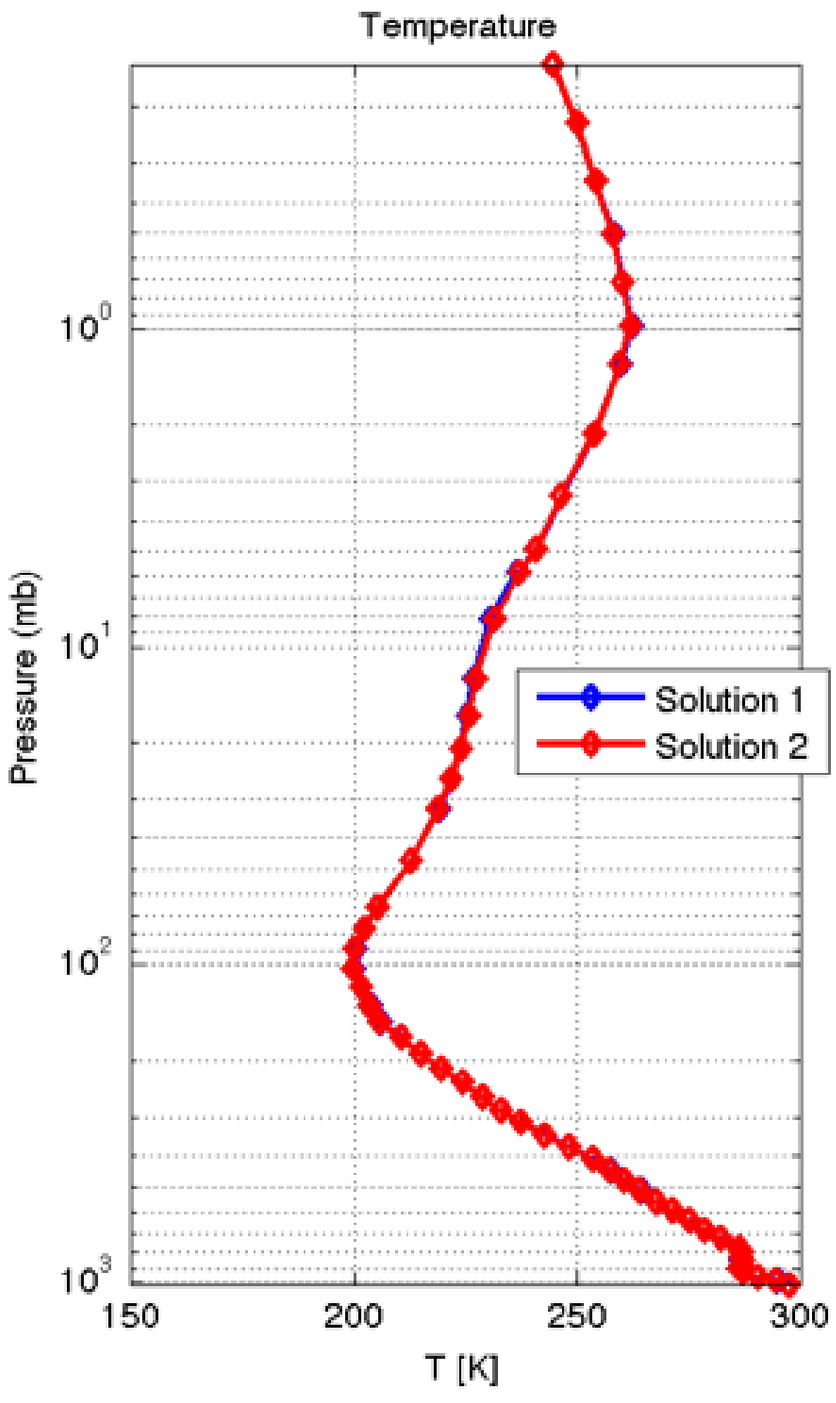
Retrieval from PCA Noise Filtered Radiances

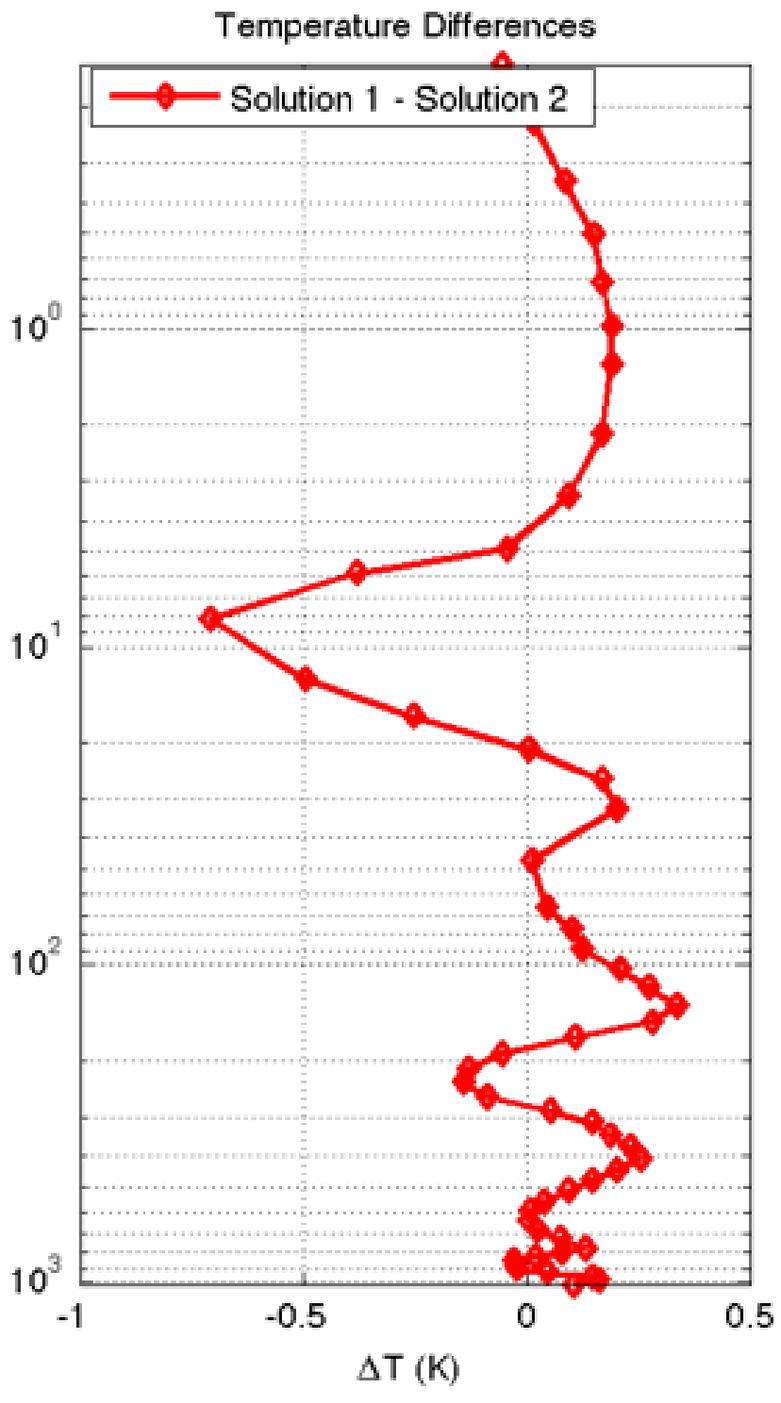
Filtered(S15) Water Vapor Mixing Ratio



Retrieval from PCA Noise Filtered Radiances

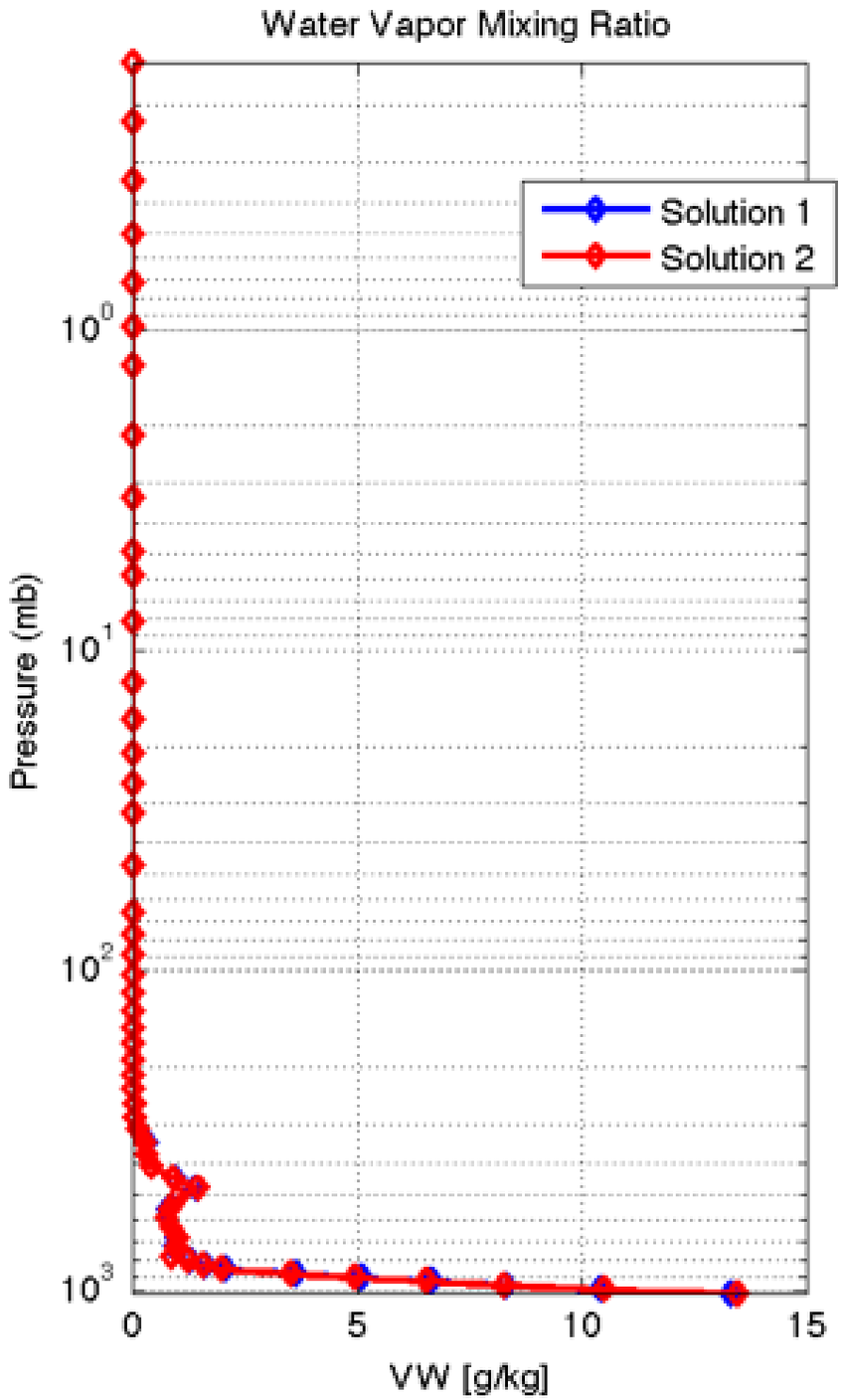
Unfiltered/Filtered T retrieval differences

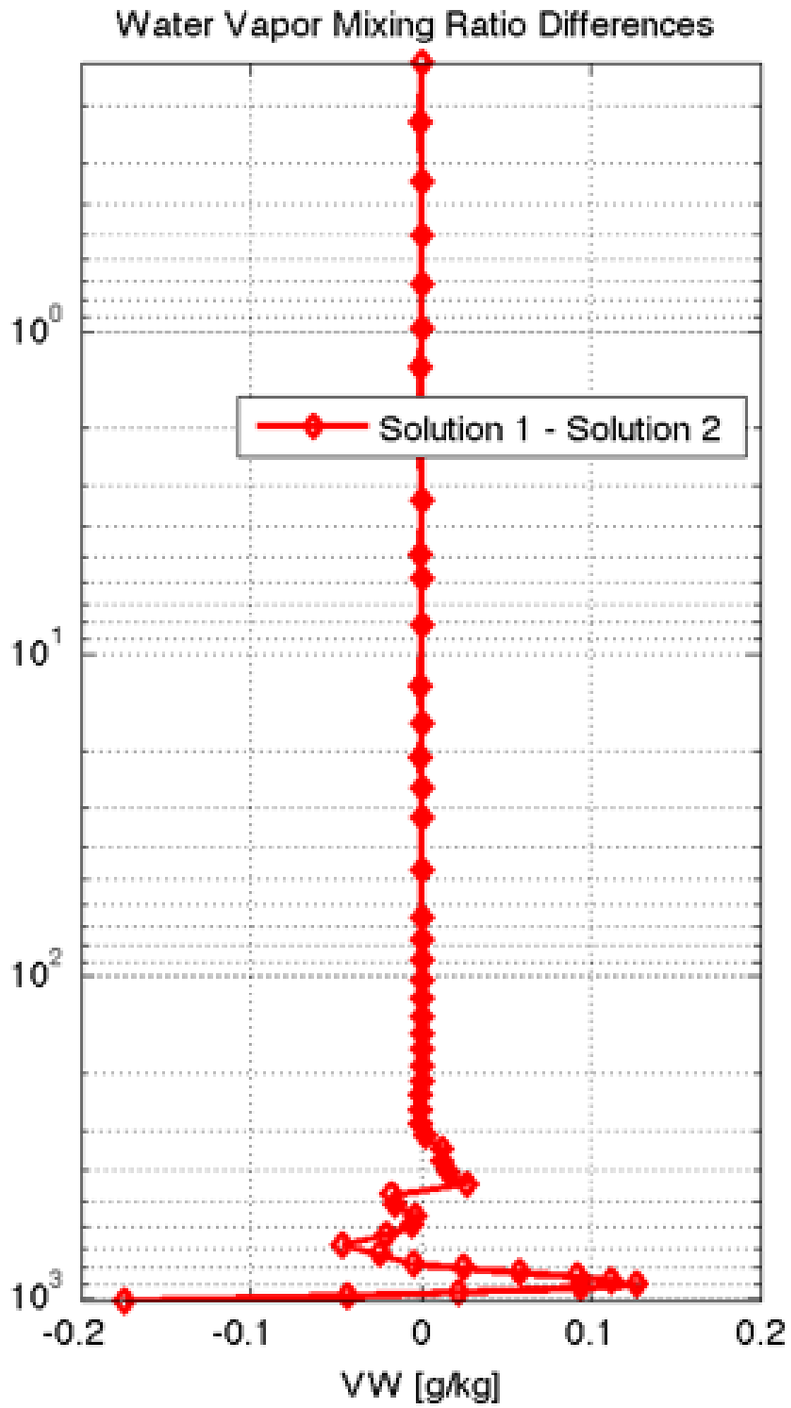




Retrieval from PCA Noise Filtered Radiances

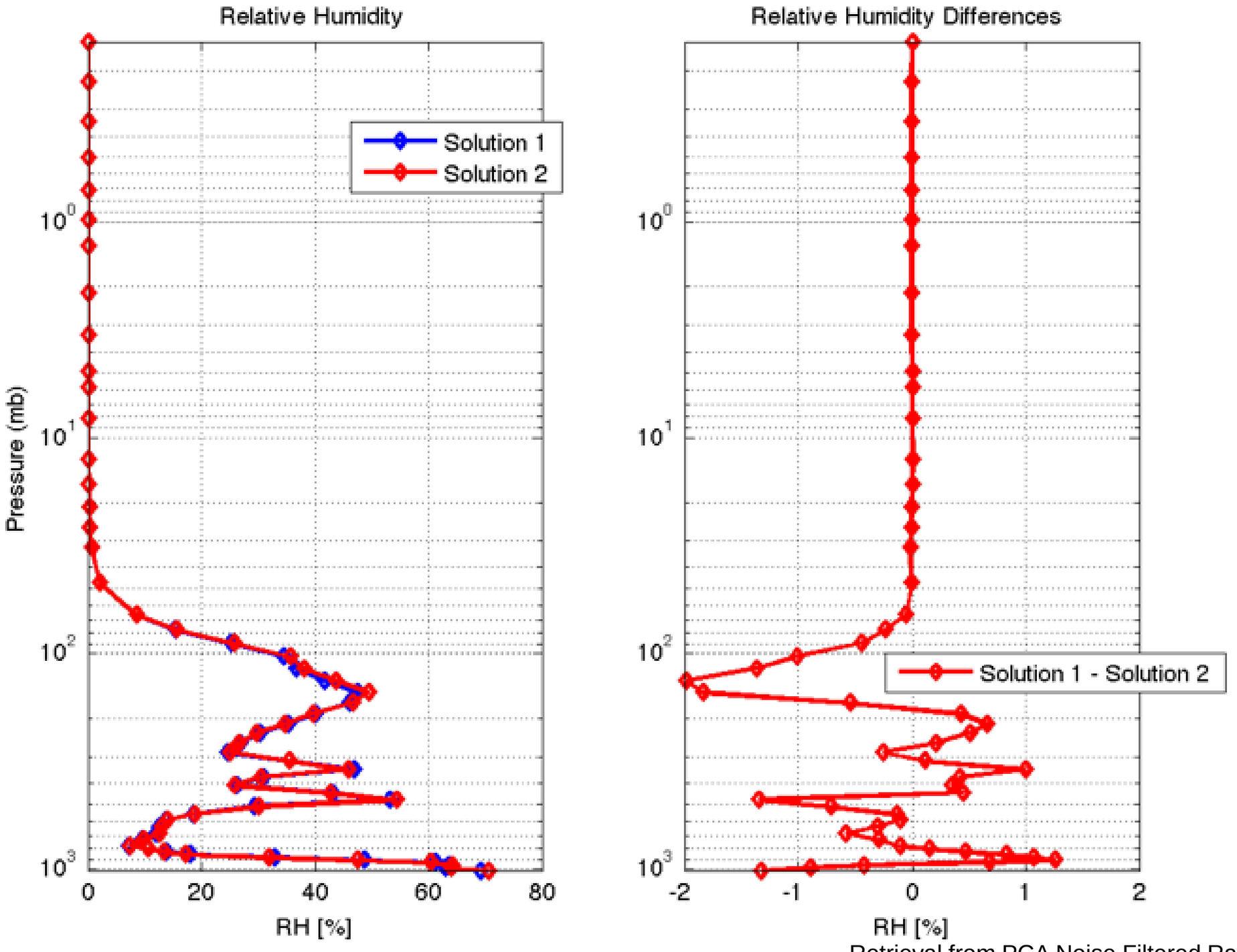
Unfiltered/Filtered MR retrieval differences





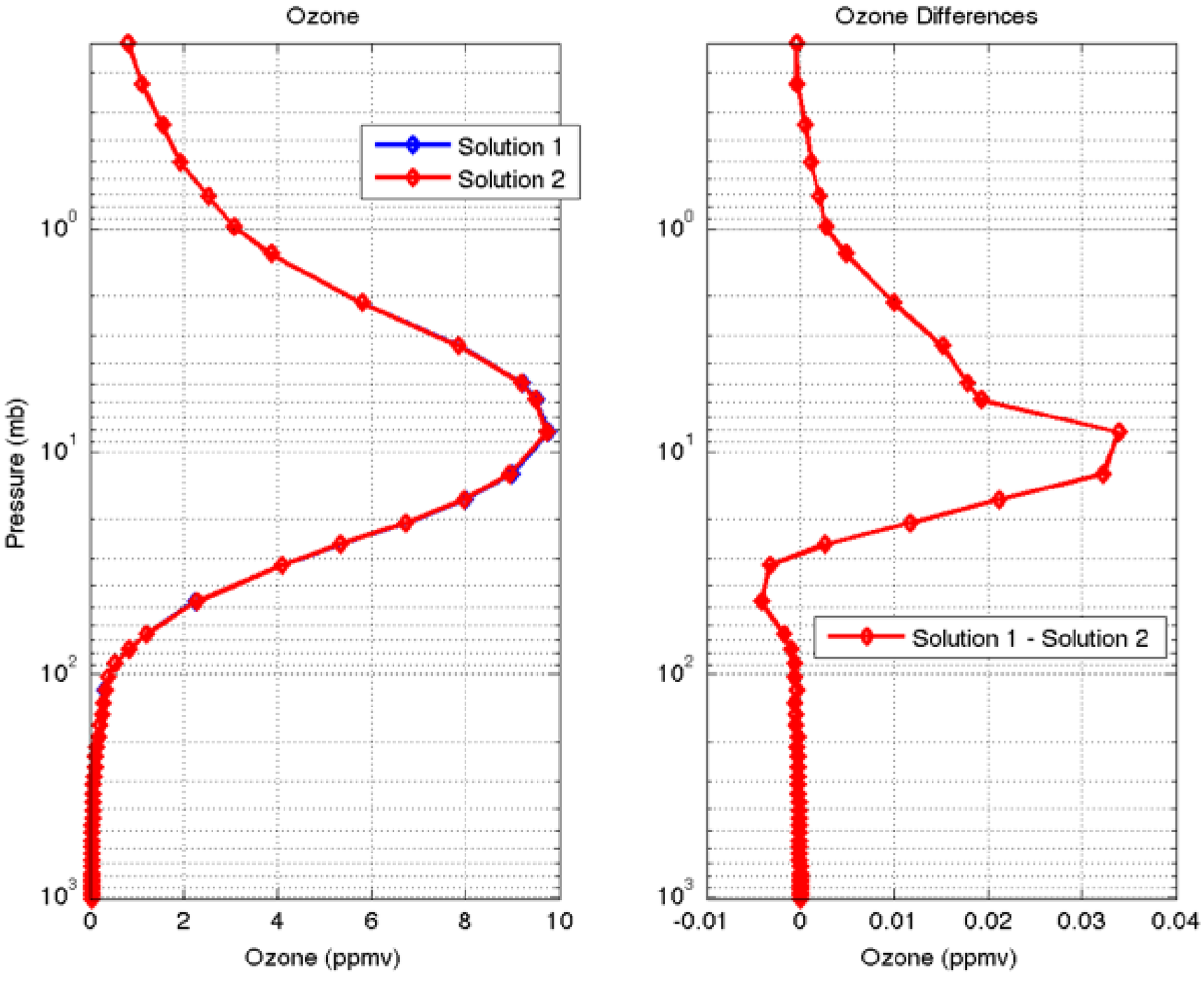
Retrieval from PCA Noise Filtered Radiances

Unfiltered/Filtered RH retrieval differences



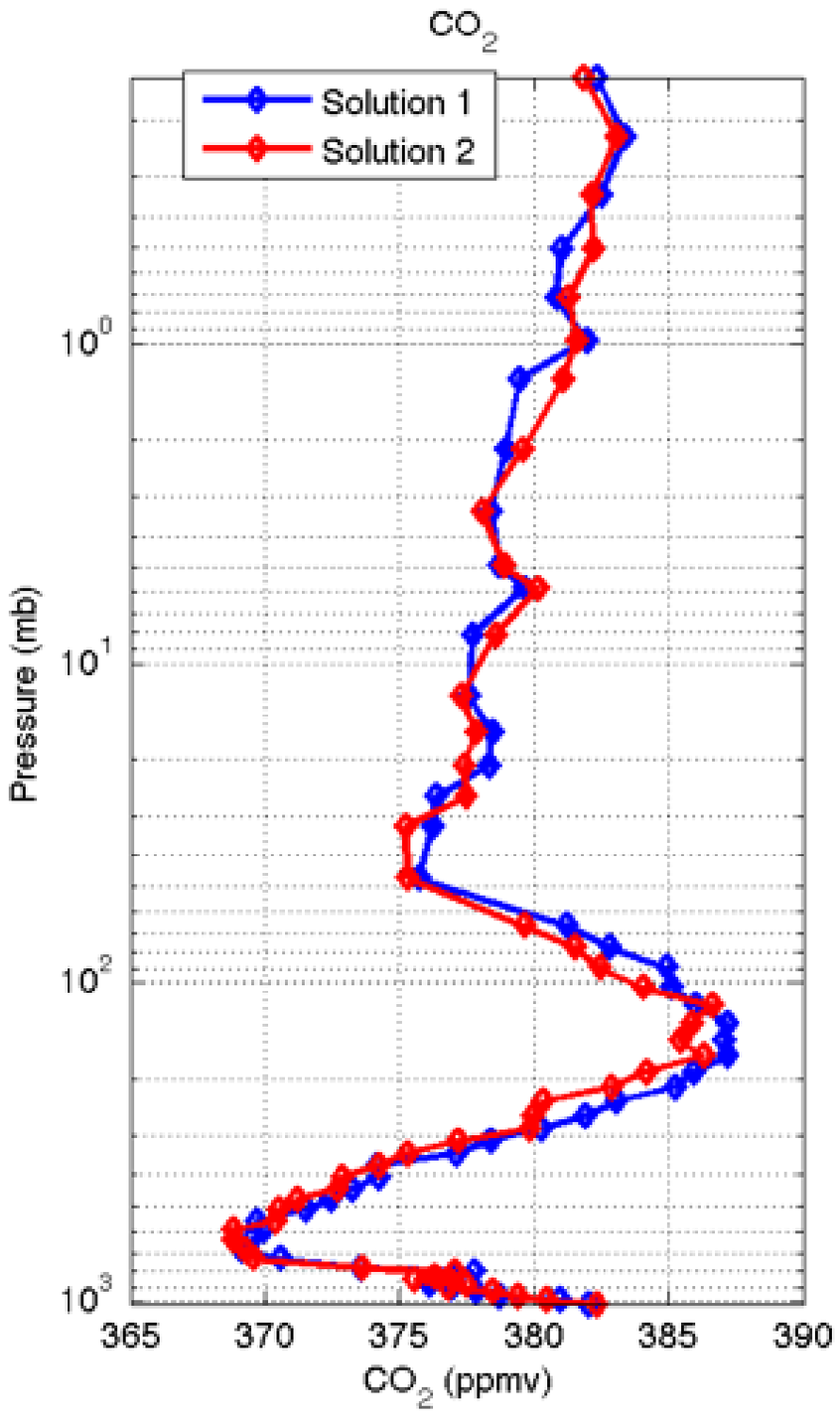
Retrieval from PCA Noise Filtered Radiances

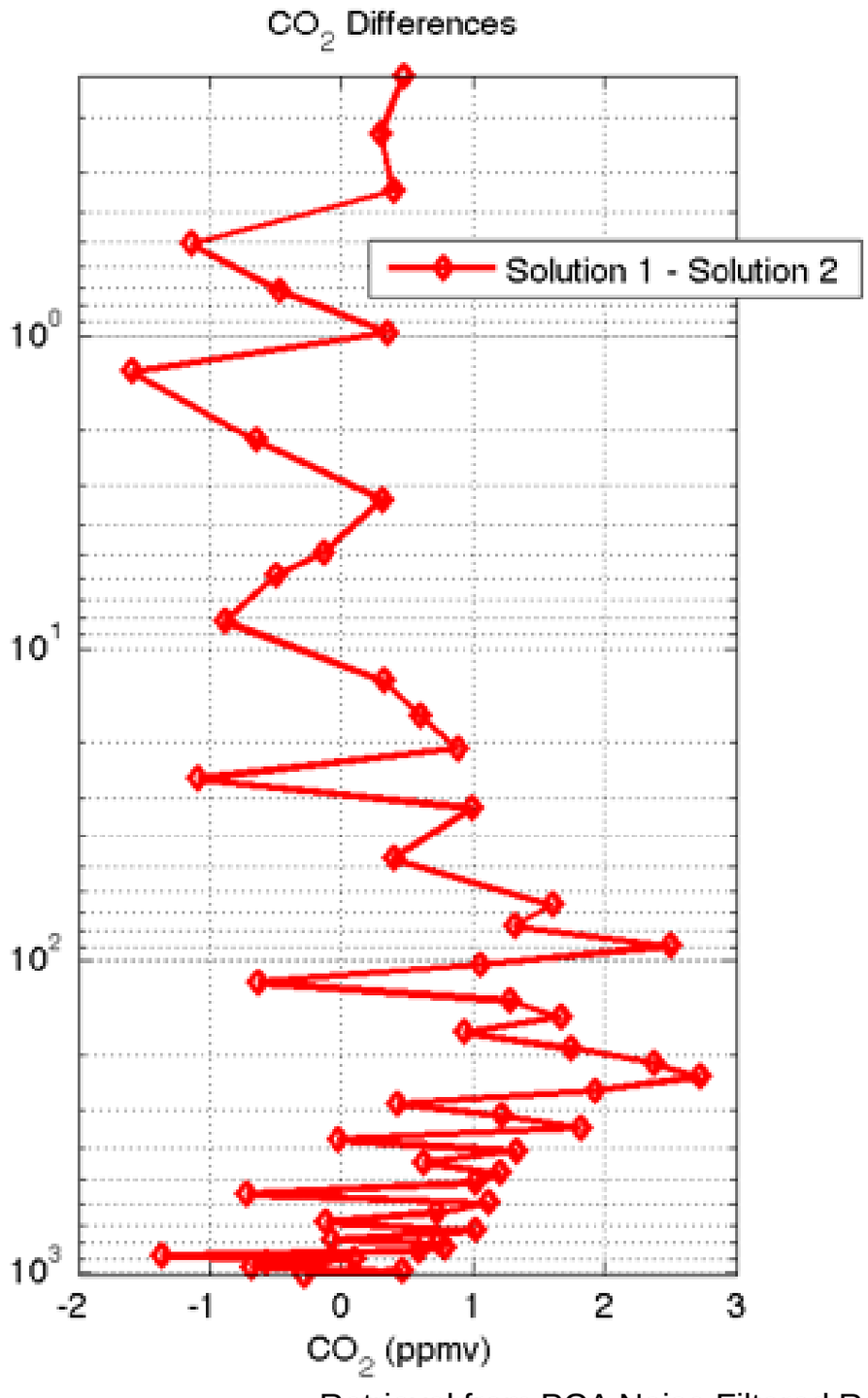
Unfiltered/Filtered Ozone retrieval differences



Retrieval from PCA Noise Filtered Radiances

Unfiltered/Filtered CO_2 retrieval differences





Retrieval from PCA Noise Filtered Radiances

Conclusions on UWPHYSRET

- Attempt to build a *reference* physical retrieval package based on Clive Rodger's methodology (Bayesian approach);
- currently uses LBLRTM 11.6 or SARTA but is going to be extended to other fast models (OSS);
- provides common framework to:
  - ➢ compare retrievals obtained from different instruments;
  - ➢ compare retrievals obtained with different forward models;
- UWPHYSRET is currently used to:
  - ➢ assess impact of PCA compression (and/or noise filtering) on level 2 products;
  - ➢ assess accuracy of level 3 products derived from IASI observations;

Conclusions on UWPHYSRET applied to JAIVEx

- Use of JAIVEx data provided valuable indication on the general accuracy of Level 2 products derived with UWPHYSRET;

- PCA noise filtering of retrieval residual was found useful in identifying spectral structures in retrieval residuals and has the potential to be used to evaluate retrieval biases;

- Preliminary results obtained from PCA noise filtered radiances indicated that PCA causes variation in the tropospheric part of retrieved profile within .3 K in temperature and .2 g/kg in water vapor mixing ratio (about 1% in RH);

  ➢PCs were derived in the simplest way with no quality control on input radiances;

Some references

- C. Rodgers 2000: Inverse Methods for Atmospheric Soundings. World Scientific.

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