AIRS ASSIMILATION AT MSC

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AIRS R&D at MSC

Topics:

- Assimilation of clear radiances. Pre-processing work completed. 3D-var cycles just started with 123 channels.

- Assimilation of cloudy radiances: new scheme for cloud height and emissivity determination + 1D-var assimilation tests. See poster B28.

- Inter-channel correlation: main topic of this talk.

AIRS Processing

- Cloud inference

  * Uses model T profile guess + ch 787 (10.9 μ)
    (Garand and Nadon, 1998, considers surface inversions)
  * Uses NESDIS cloud amount < 5% in daytime

- Cloud top HT and cloud fraction (emissivity) CF

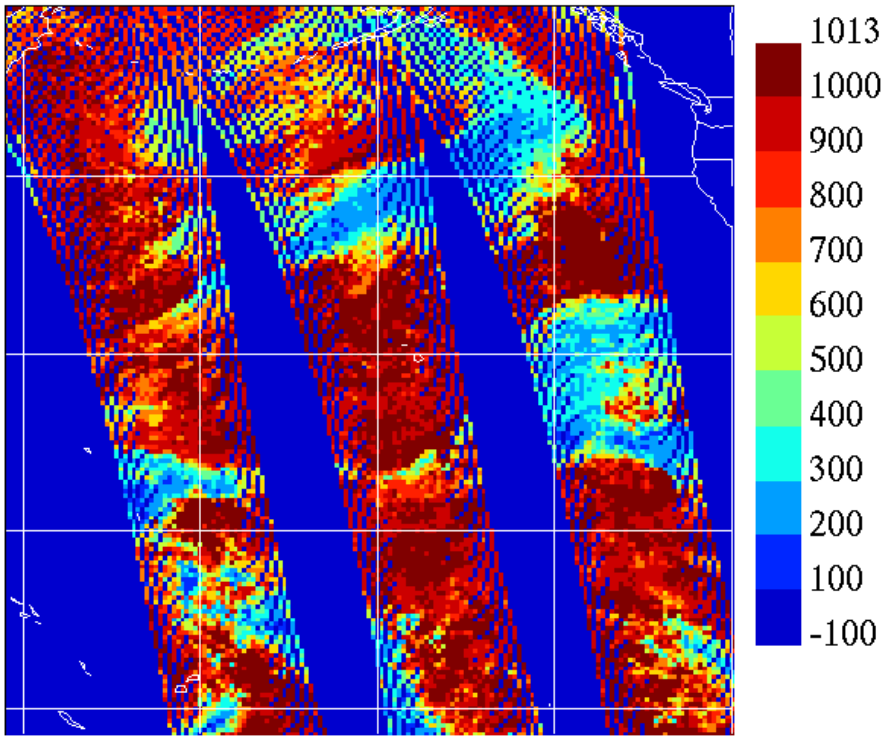
  * Uses CO2 slicing (CS) technique with 12 pairs (13th
  * Requires STD(HT) among 12 to be below 50 mb
  * Uses equivalent height from ch 787 where CS fails

- Cloud free criterion required for assimilation

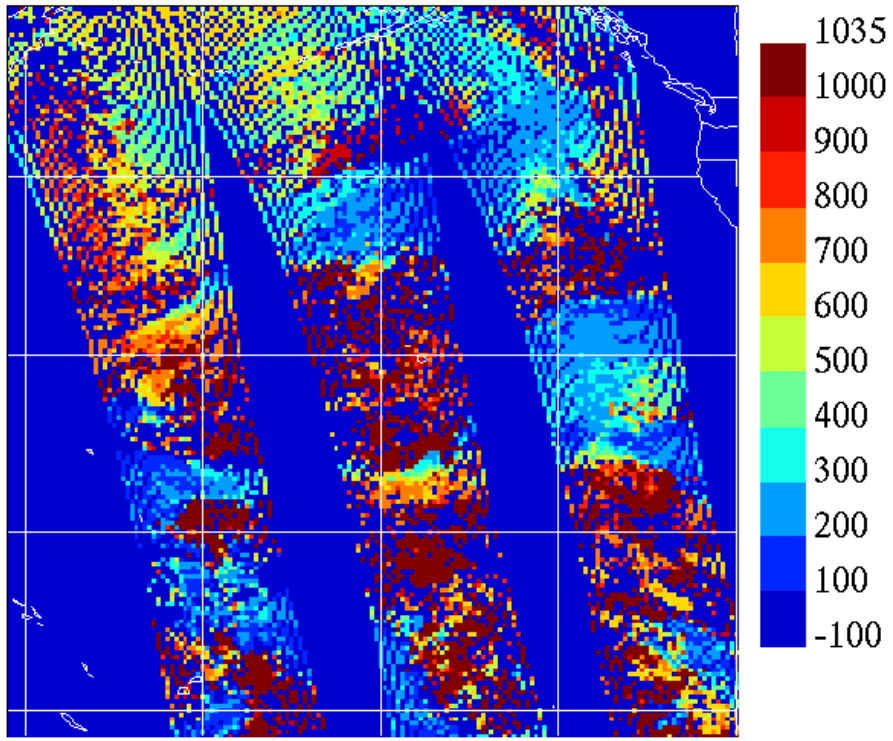
  * Channel assumed cloud free if its local response function dTau/dp obtained from RT model (RTTOV-7) is “safely” above cloud top

Assimilation allowed for channels not sensitive to lower clouds

Cloud top from CO2 slicing



Equivalent height from ch 787



CO2 slicing height consensus

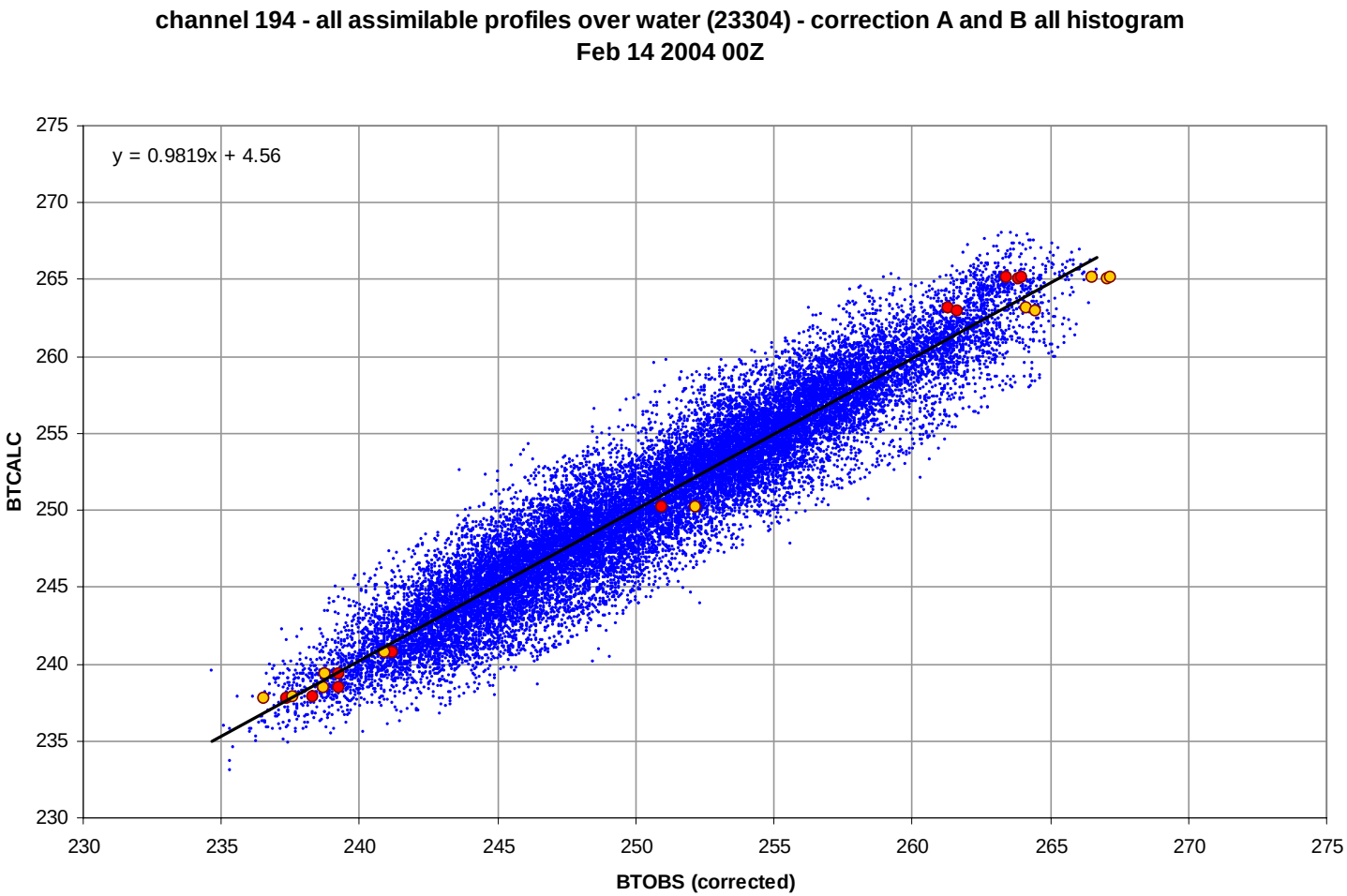
CO2 slicing detects higher tops associated with grey clouds

AIRS Processing

- Surface emissivity
  * ocean: Masuda scheme: depends on view angle and sfc wind
  * land: based on CERES 18 types (global 16 km). Rough spectral interpolation. Considers water fraction.
  * uses info on ice and snow from latest NWP analysis

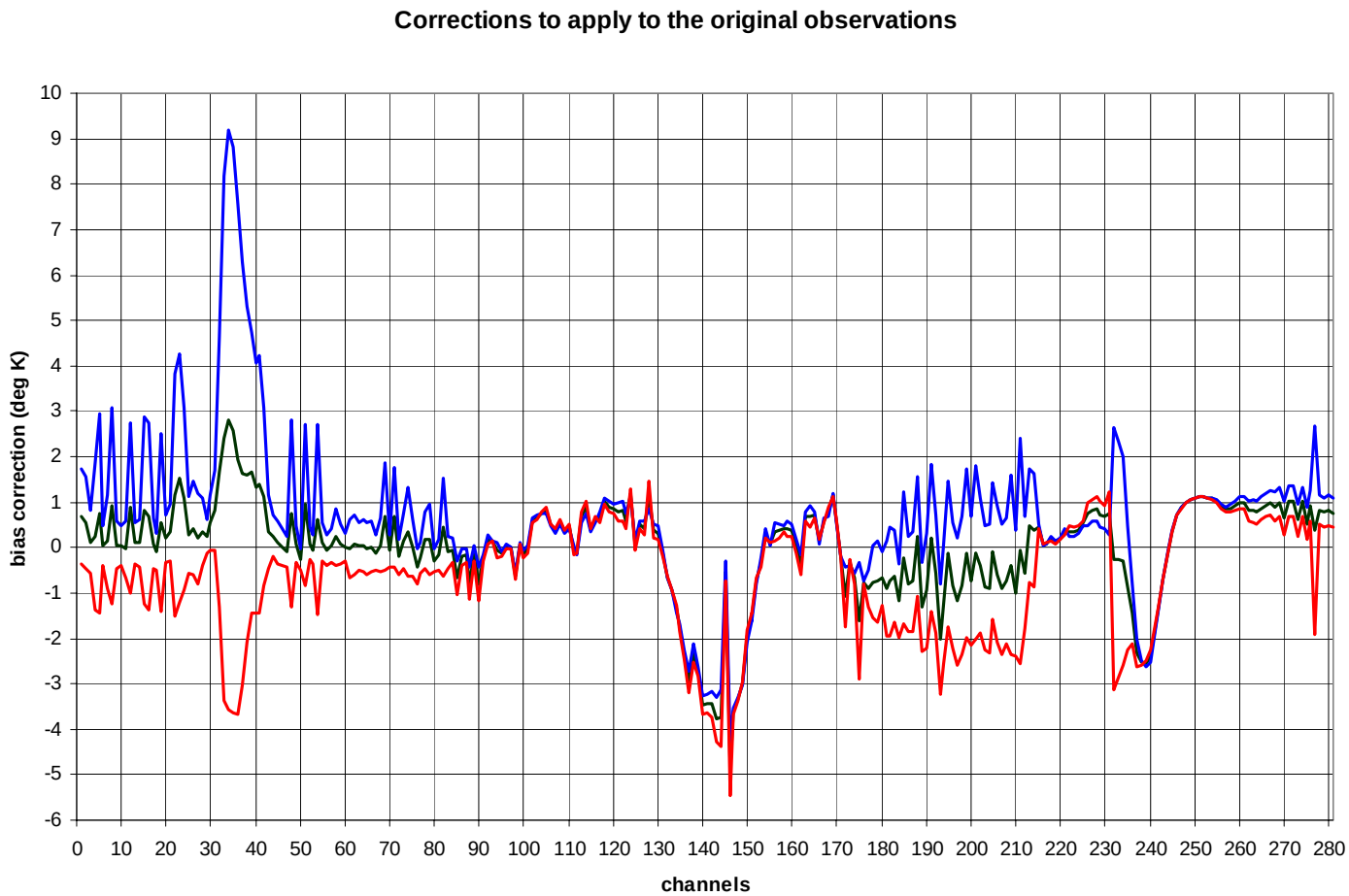
- Brightness Temperature (BT) Bias correction
  * linear form: bias = a BT_{OBS} + b
  * flat bias is also an option
  * real time updating in preparation

Bias correction example for AIRS water vapor channel 1708 (194/281)



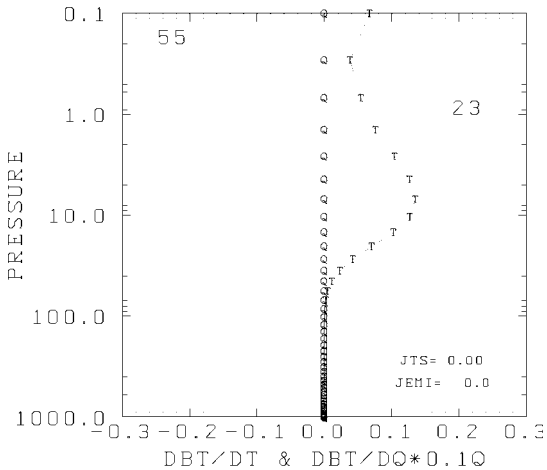
before
after

Bias correction
mean BT (flat), +10 K, -10 K

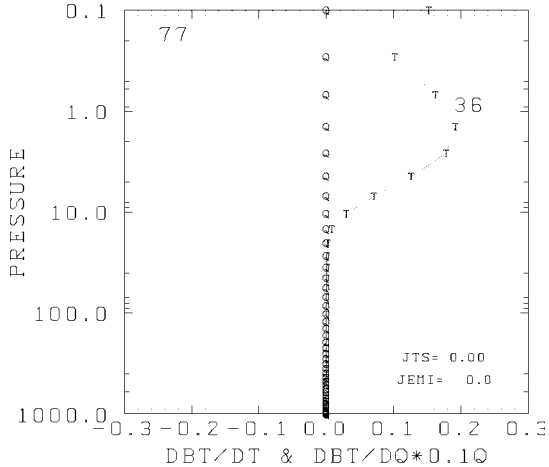


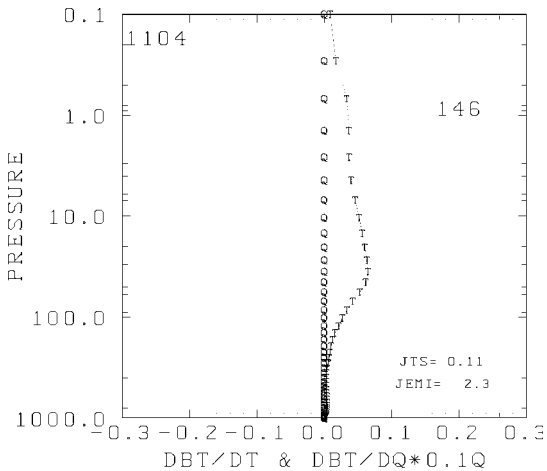
Some rejected channels

above NWP top

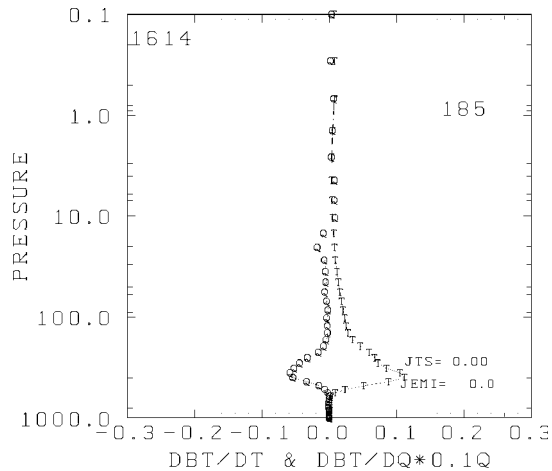


bad RT + above top





O_3, long tail



long tail

Interchannel error correlation: Full R matrix computation

Current practice: diagonal R=(O+F). Is this ok?

- AIRS well suited to study this problem
- Period of 6-h (81,000 profiles) provides enough data

Method of estimation

- Classical Hollingsworth-Lonberg technique
  Based on (O-P) variances vs distance
- Assumes only P errors spatially correlated
- Each element of R matrix fitted individually
- Uses the 281 AIRS channel set
- Results derived from 4 consecutive orbits

Functional form of fit

Simple exponential for MODEL COV:

$COV_M(D) = COV_M(0)\ EXP(-D/L)$

D= distance, L= length scale

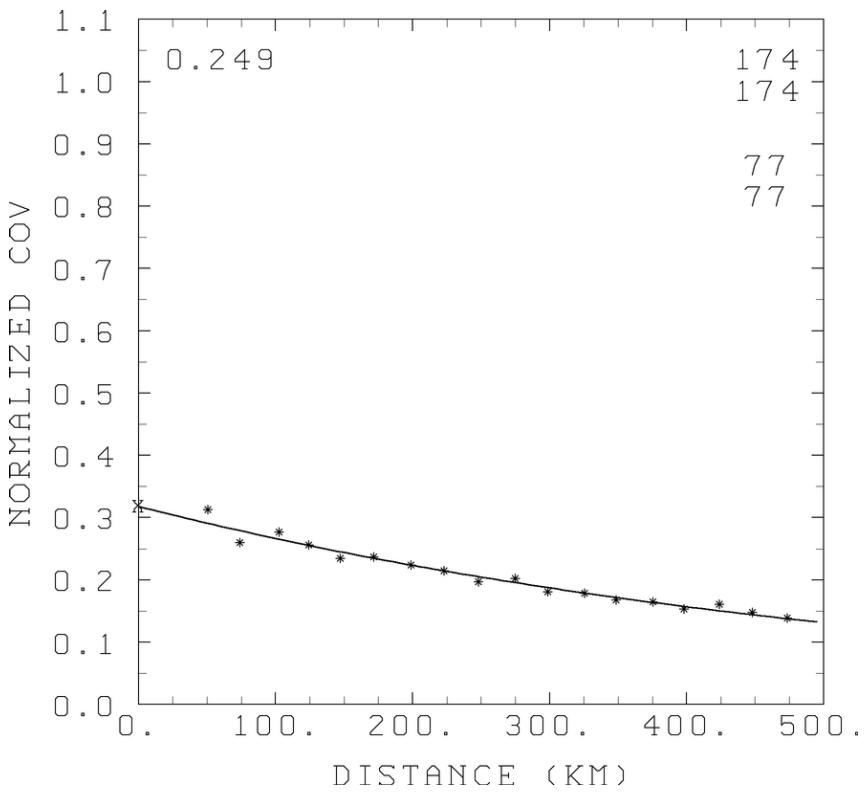
Separation of OBS and MOD errors:

$COV_O = COV_T(0) – COV_M(0)$

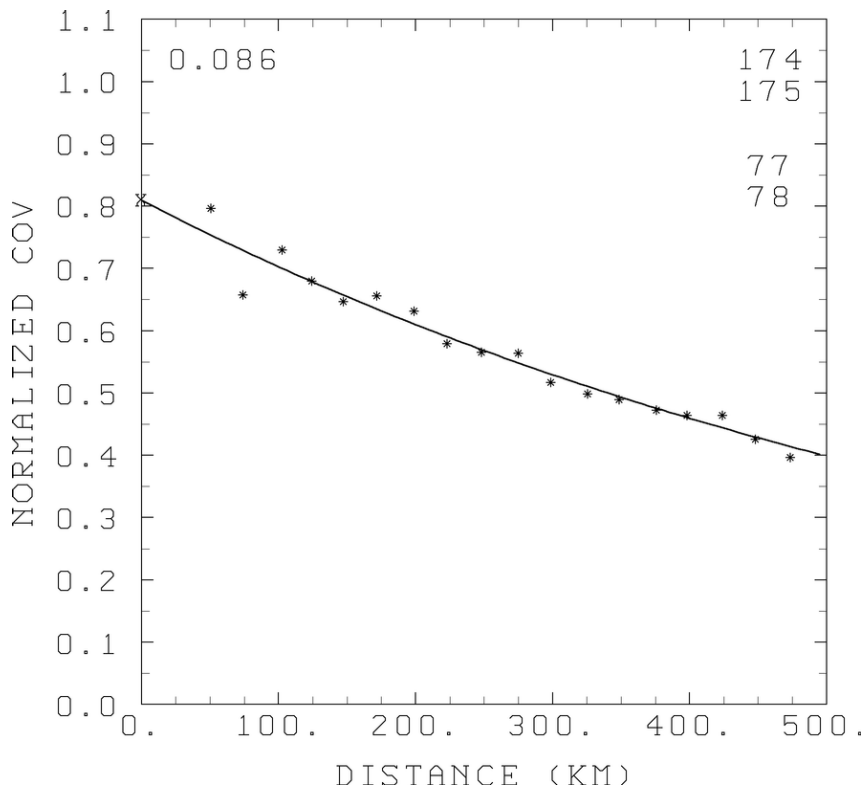
With COV_T = <O-P>

Model error fit for AIRS 174-174 and 174-175

R = 0.170, B = 0.079 K^2



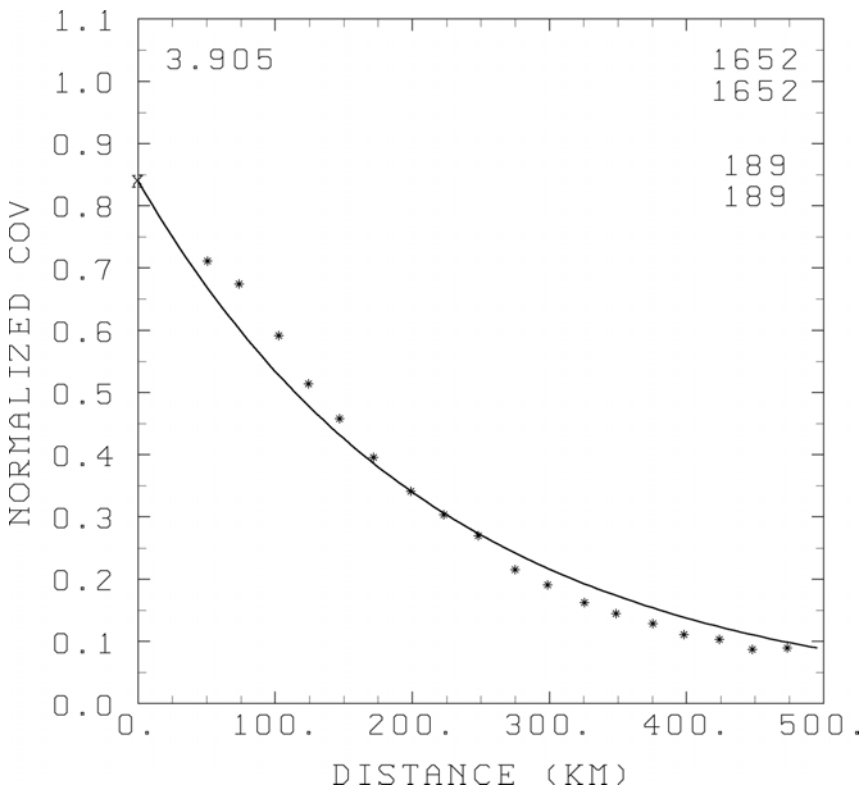
R = 0.016, B = 0.070 K^2



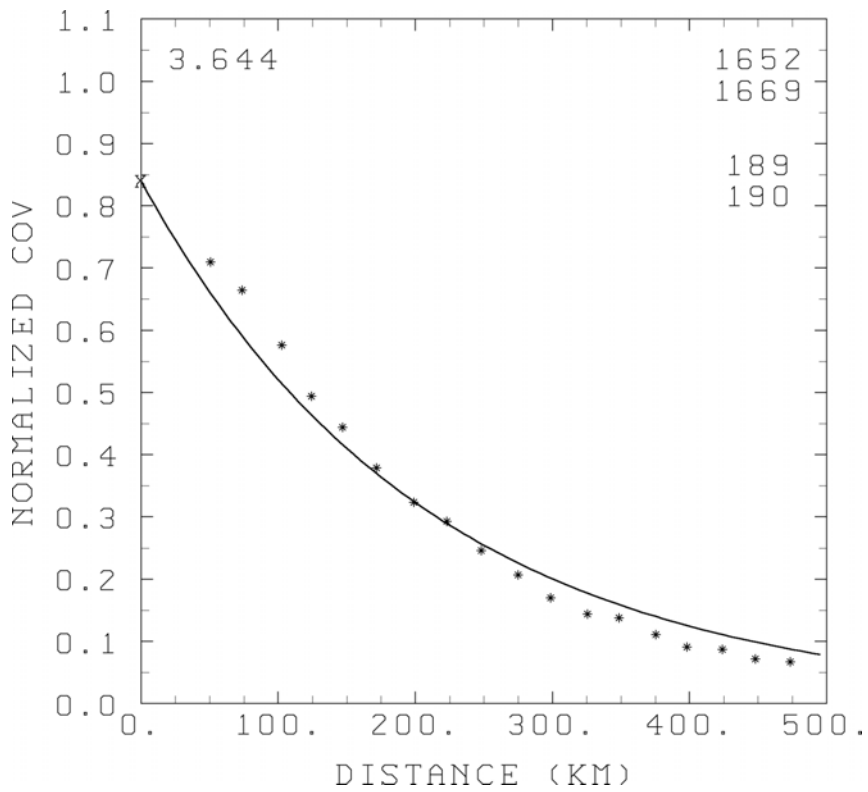
Ch 174: 699.305 cm^{-1}, 14.30 μ, temperature sensitivity

Model error fit for AIRS 1652-1652 and 1652-1669

R = 0.605 , B = 3.300 K^2

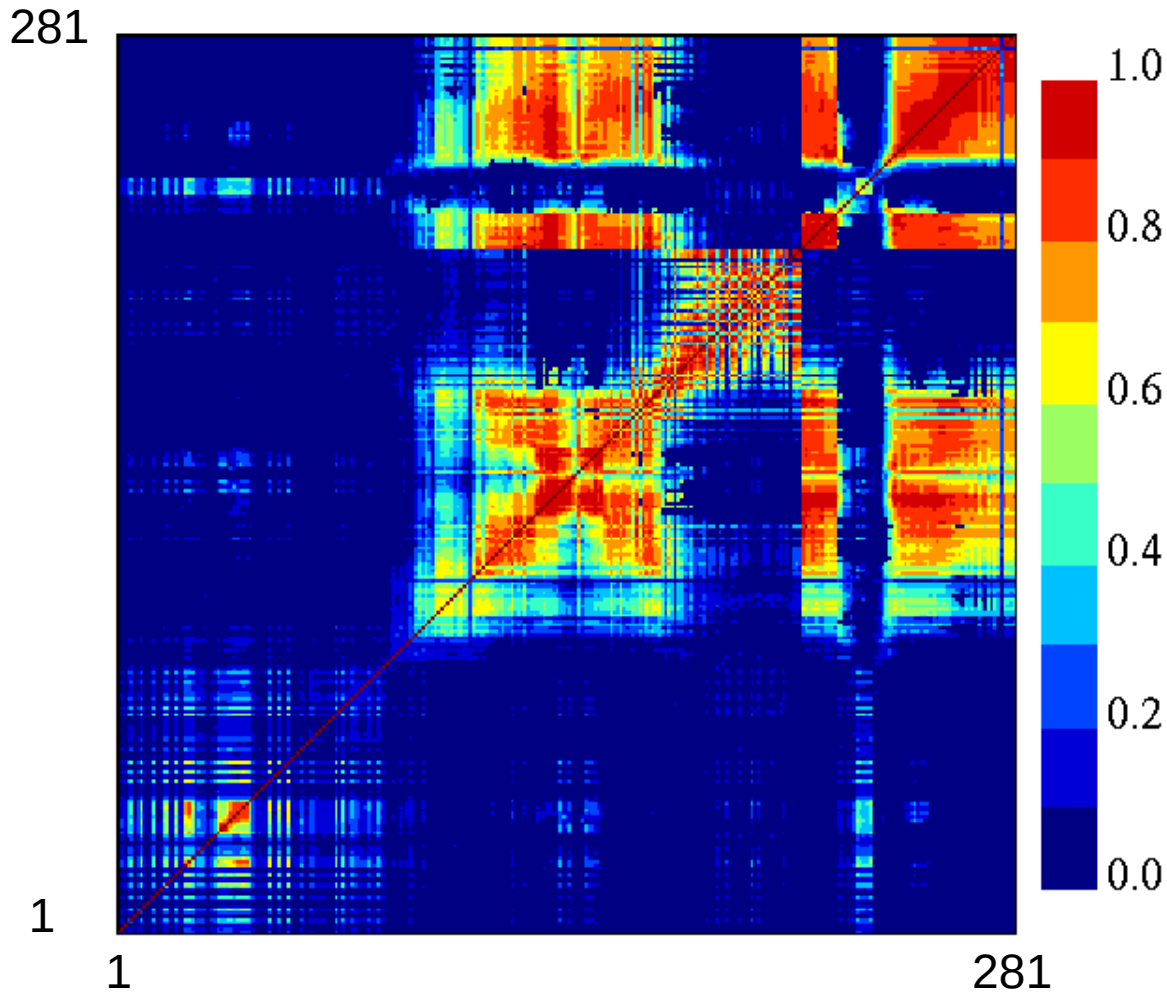


R = 0.565, B = 3.079 K^2



Ch 1652: 1441.728 cm^{-1}, 6.936 μ, water vapor sensitivity

Obs error Correlation matrix 281 X 281



Interchannel error correlation (123 channels)

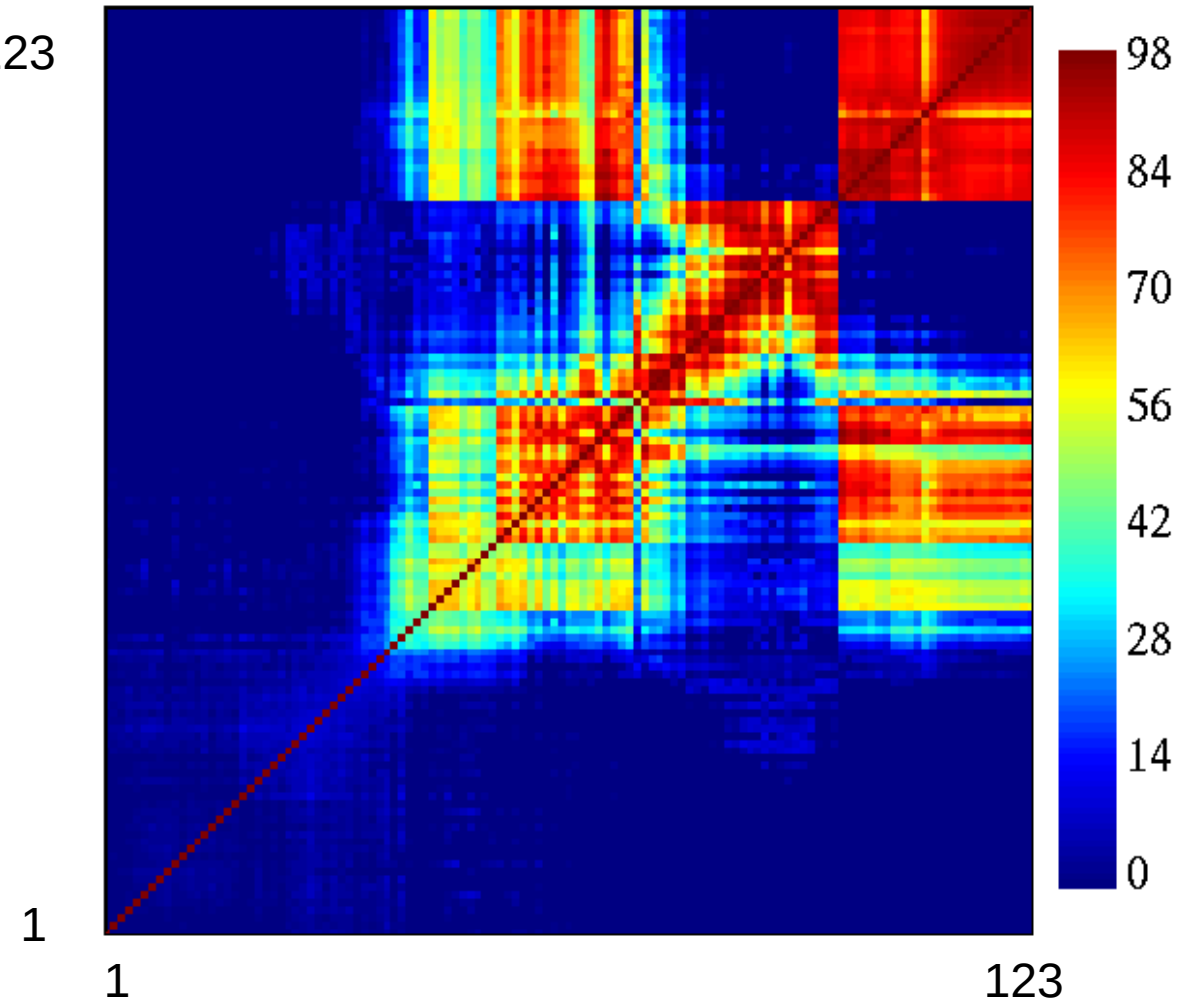
4.50-4.59 μ
1865-2141 (T, T_s)

6.23-7.60 μ
1424-1852 (mid q, T)

7.8-14.0 μ
528-1382 (low T, q; T_s)

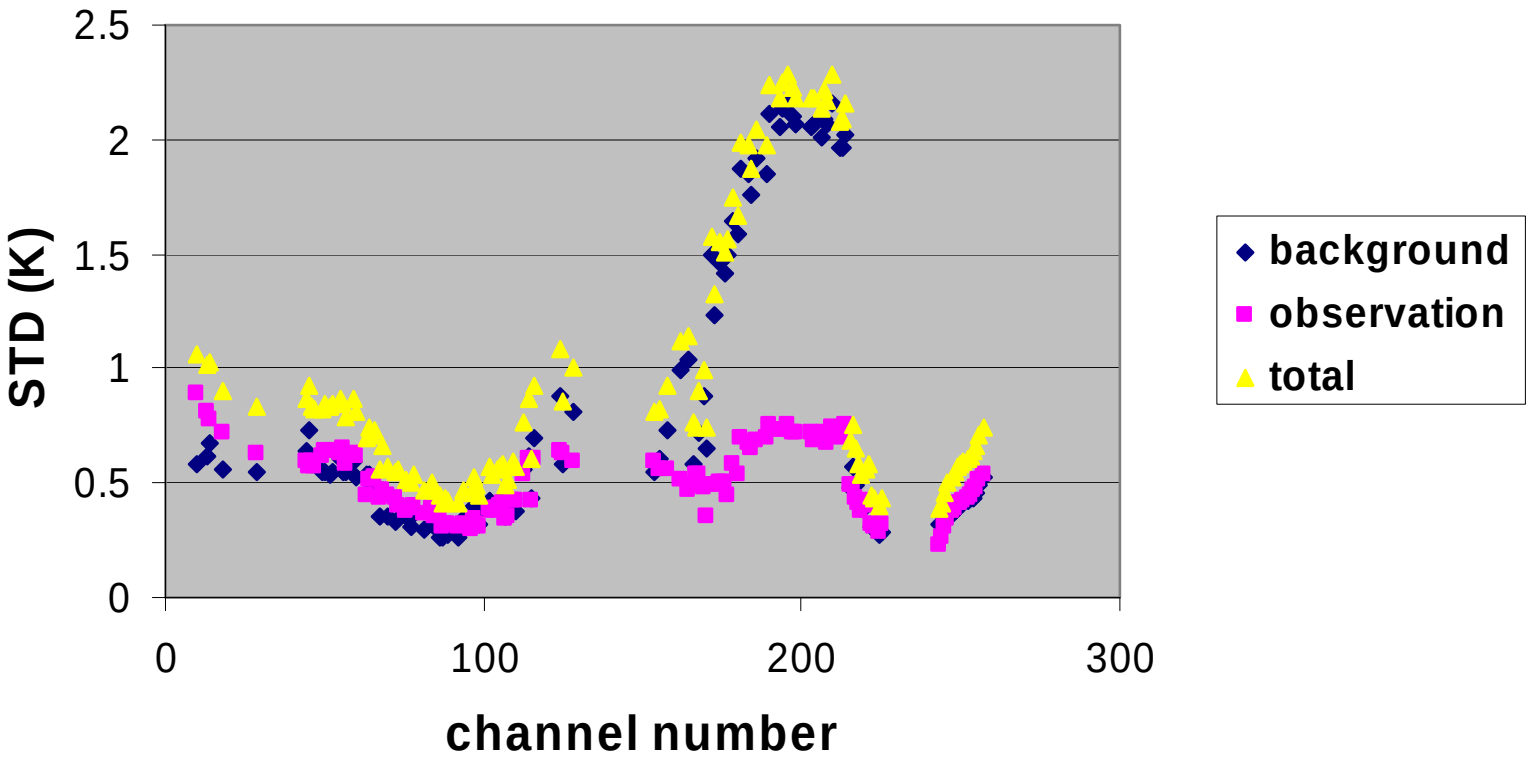
221-362 (200-800 mb T)

14.1-15.1 μ
21-215 (10-500 mb T)

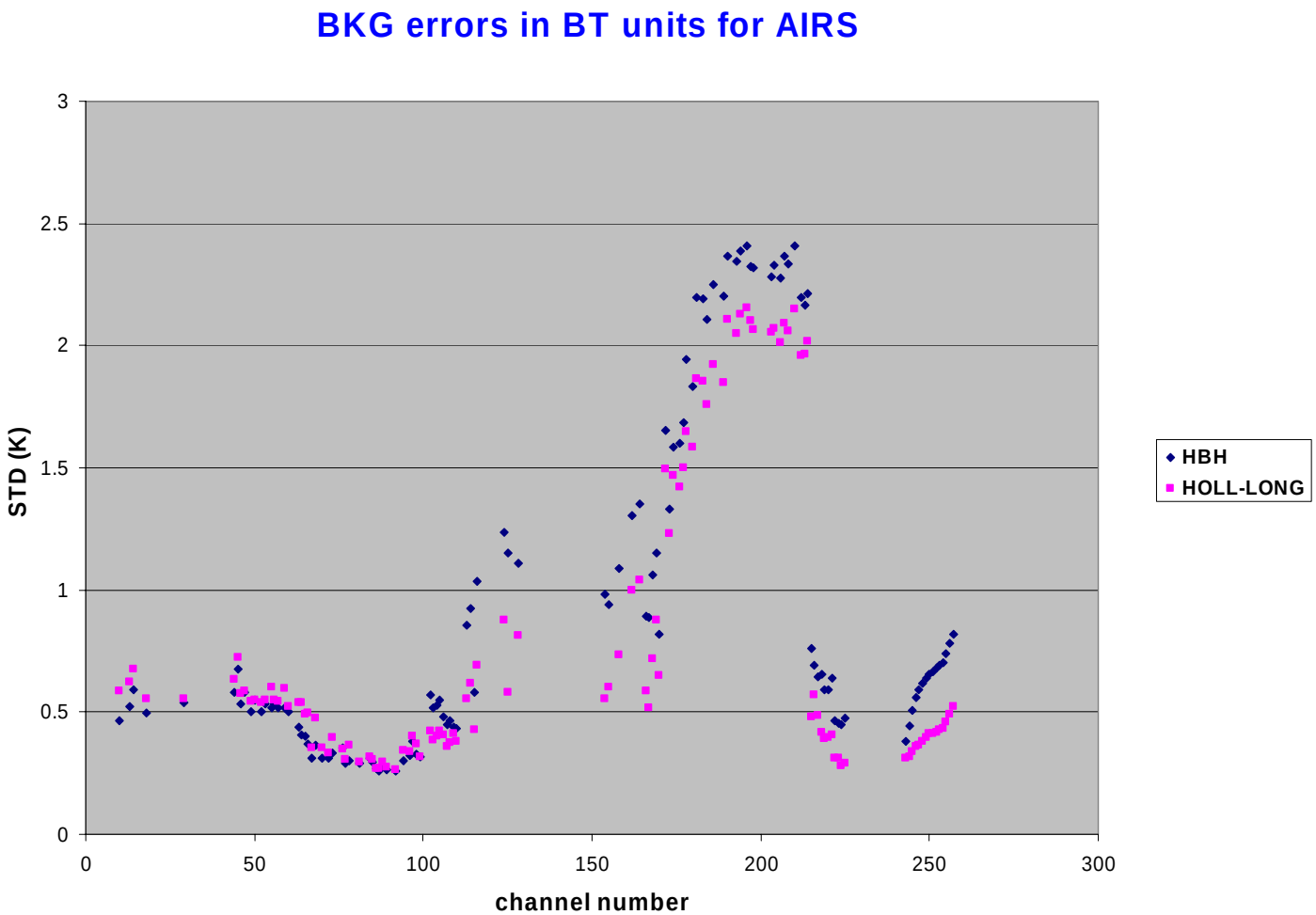


Separation of Total, Obs and Background errors

BT errors for AIRS



Comparing background error from H-L technique and from HBH^T (both using same data)



H-L works well for AIRS; our B matrix overestimates H_2O errors

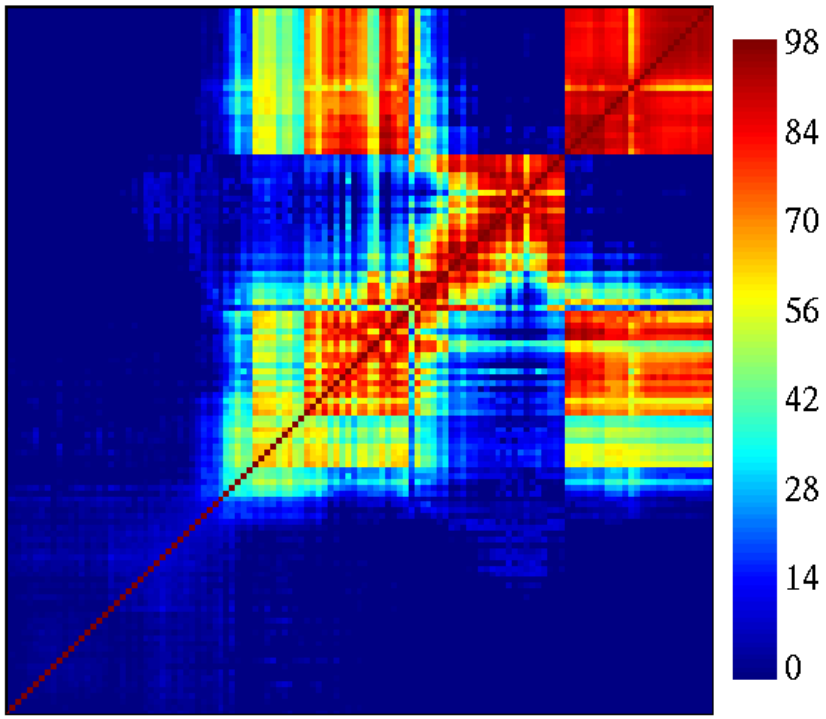
Making R positive definite

Problem: R not positive definite due to methodology of fitting (with some error) each component individually

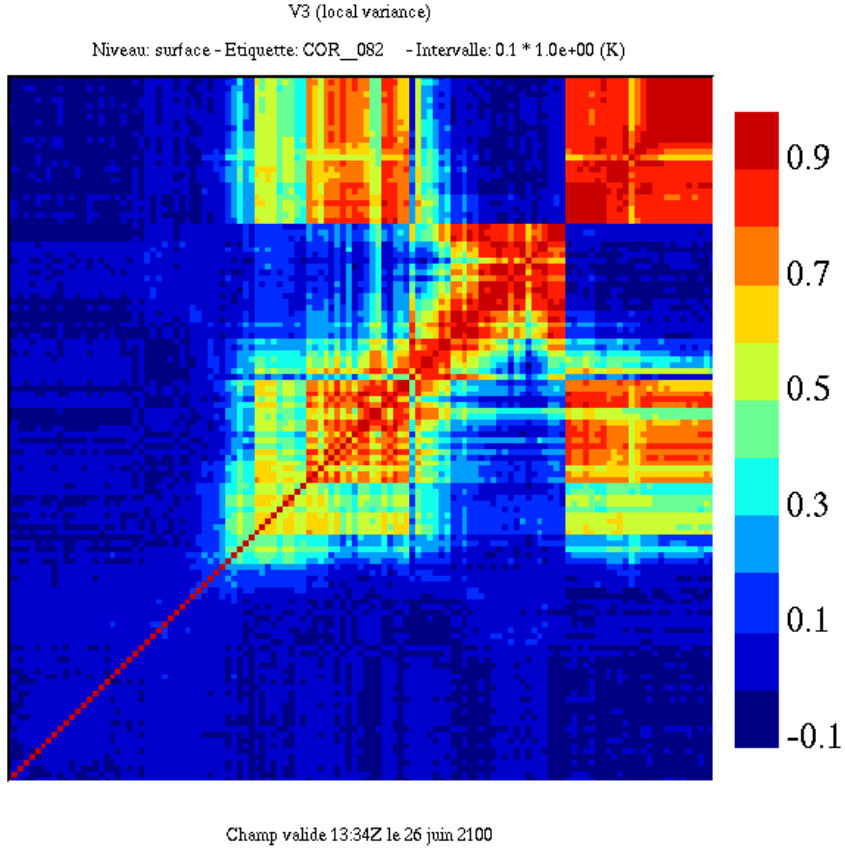
Solution: Eliminate negative eigenvalues + small positive ones (up to half the smallest eigenvalue of the diagonal R). Reconstruct that filtered R. Correlation may change by few percent (max 12 %) compared to unfiltered.

Original vs reconstructed COR matrix

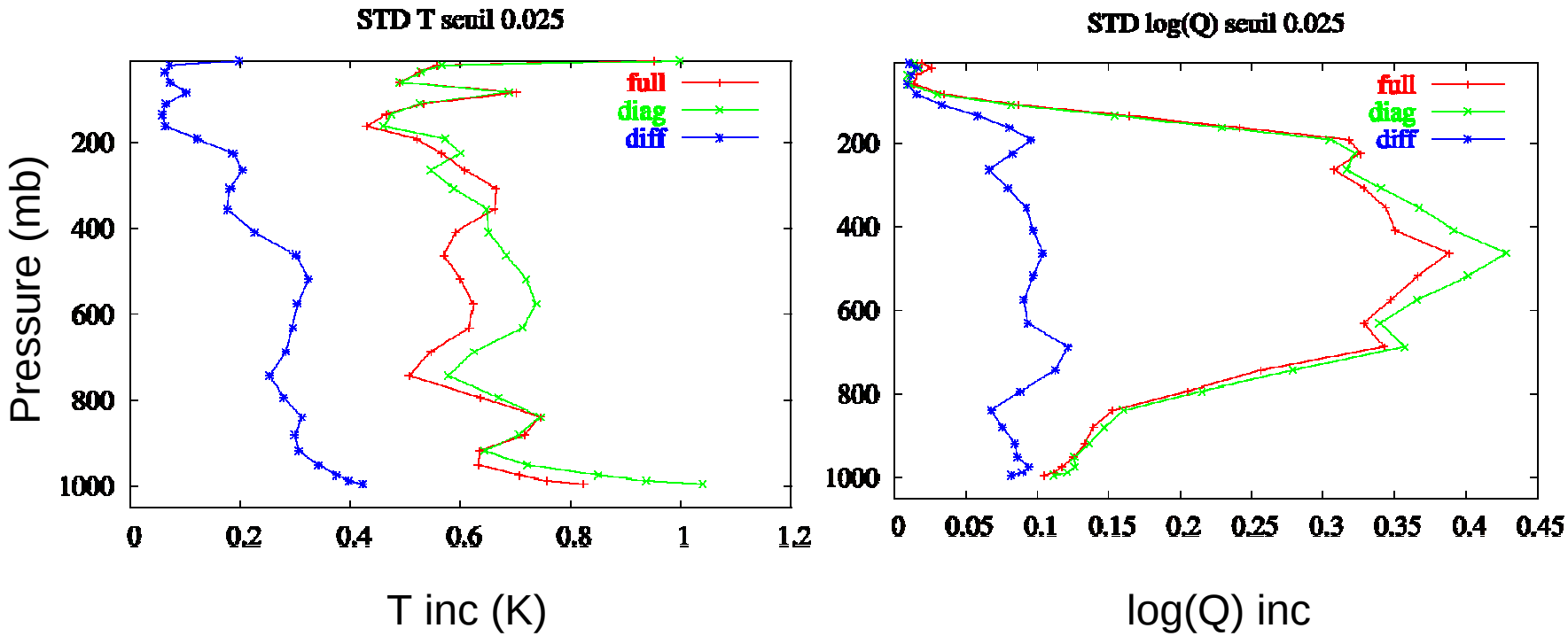
Original



Recontructed with 82/123 components

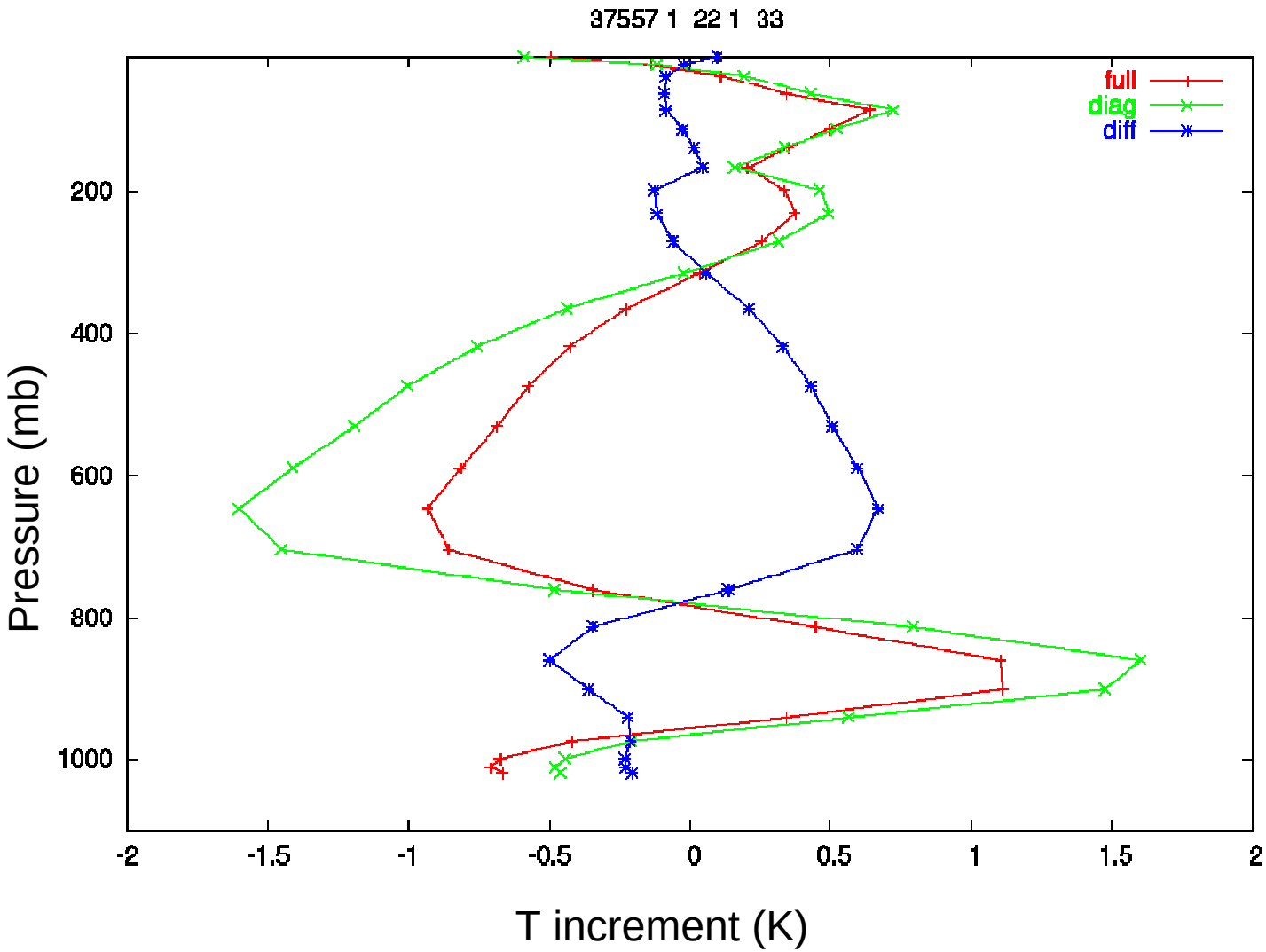


Increment magnitude (full/diag) & difference

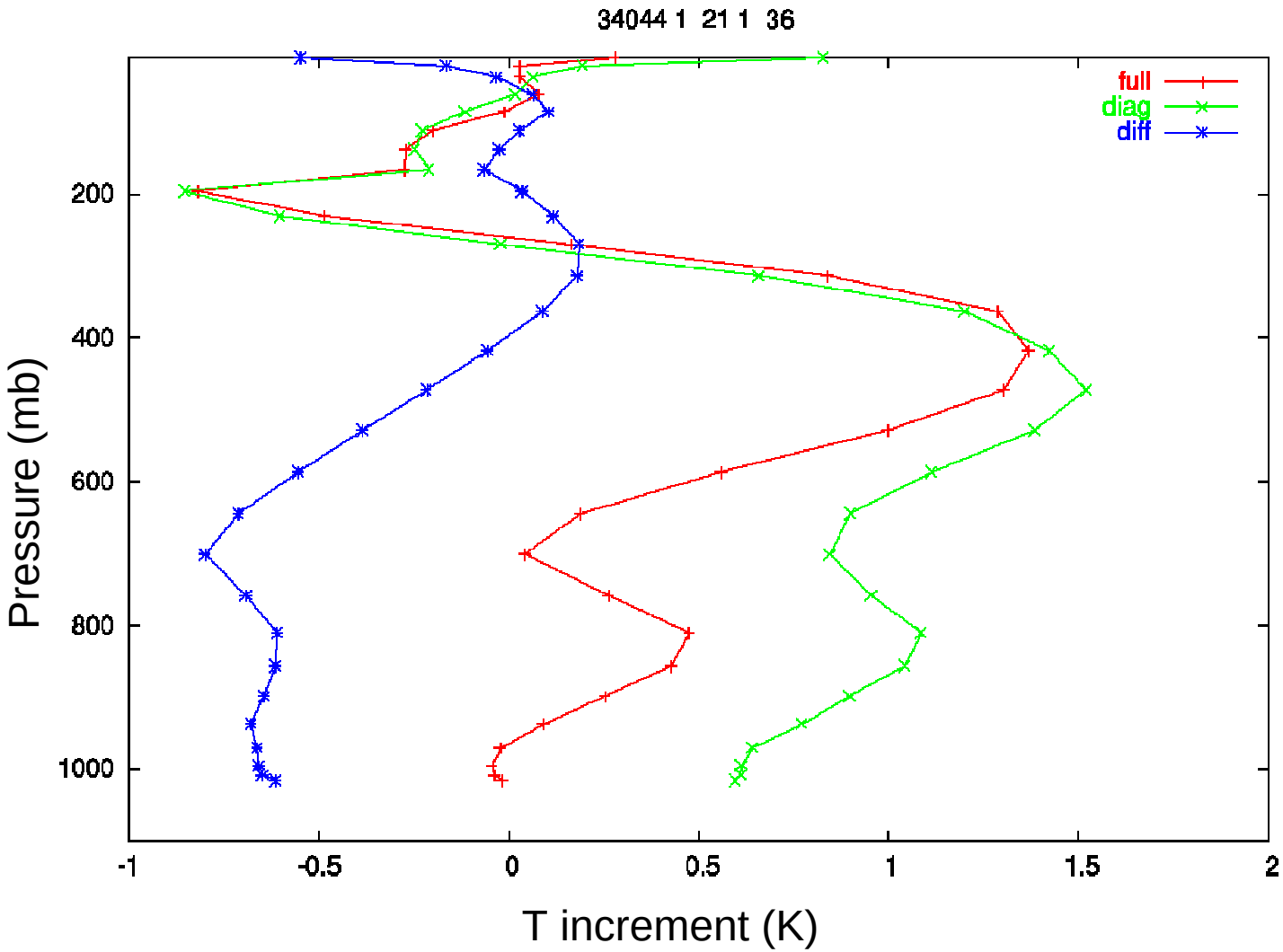


82/123 components, stats derived from 387 1Dvar retrievals. Clear skies.

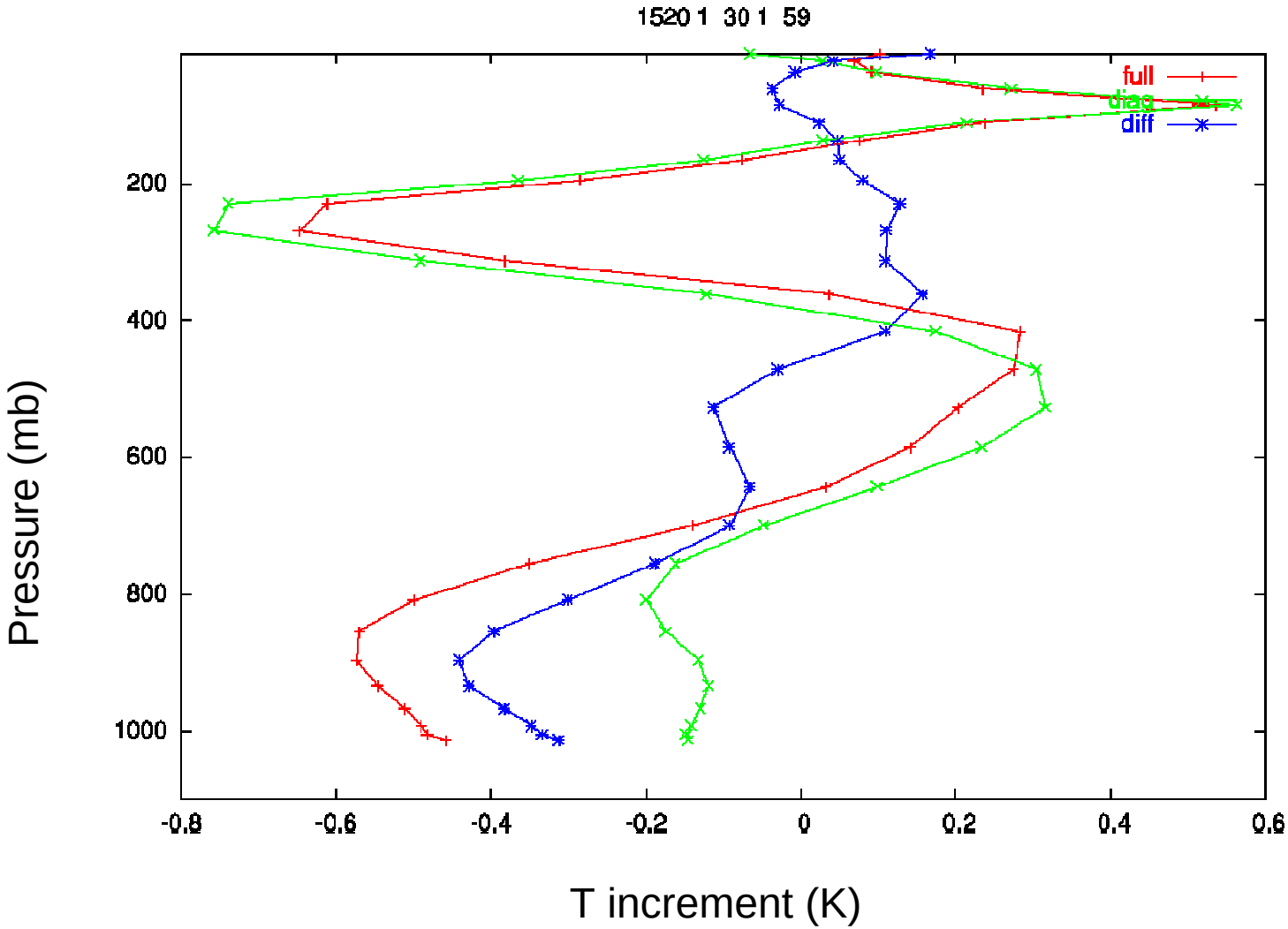
1Dvar T increment (full diag diff)



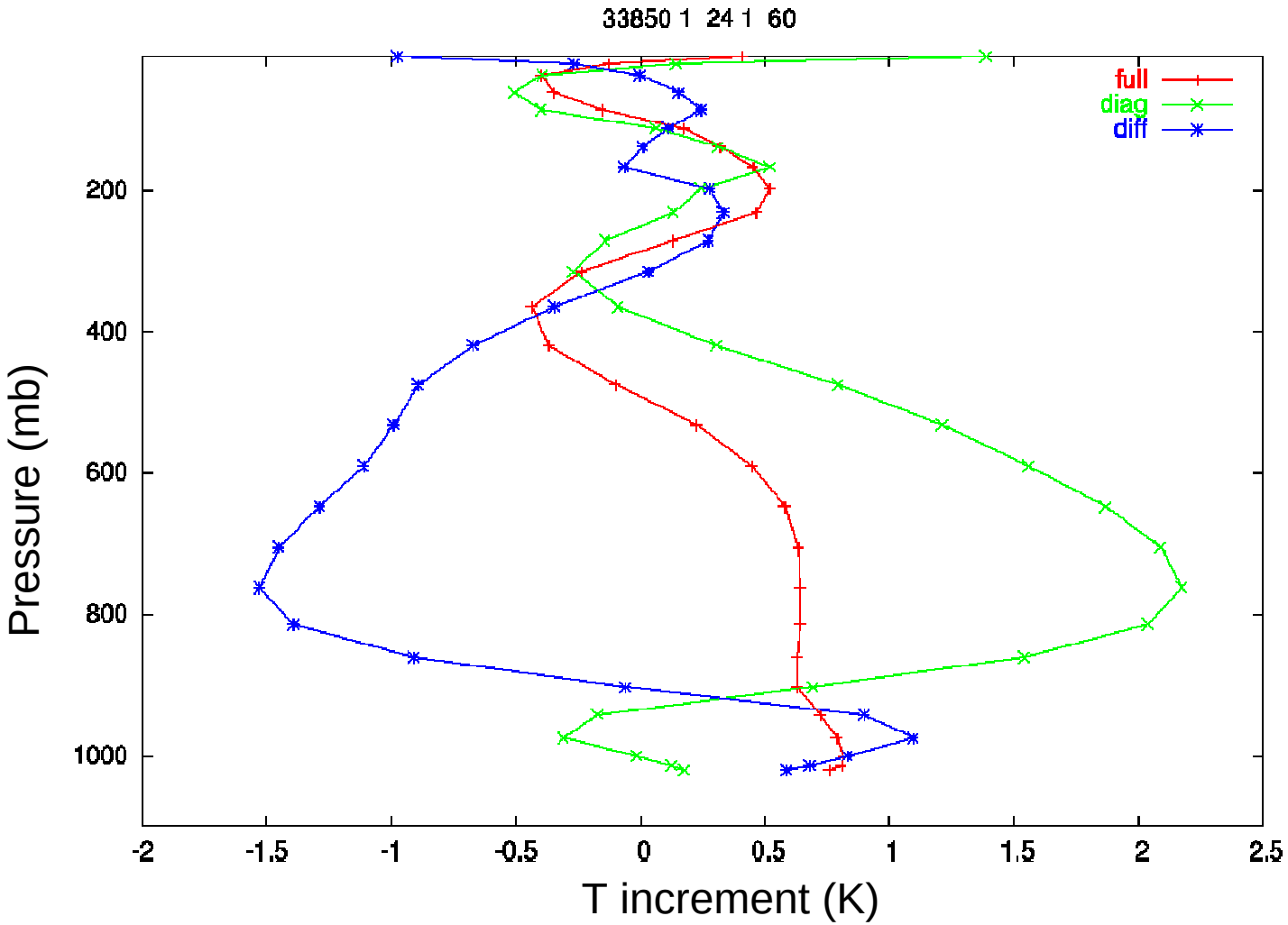
1Dvar T increment (full diag diff)



1Dvar T increment (full diag diff)

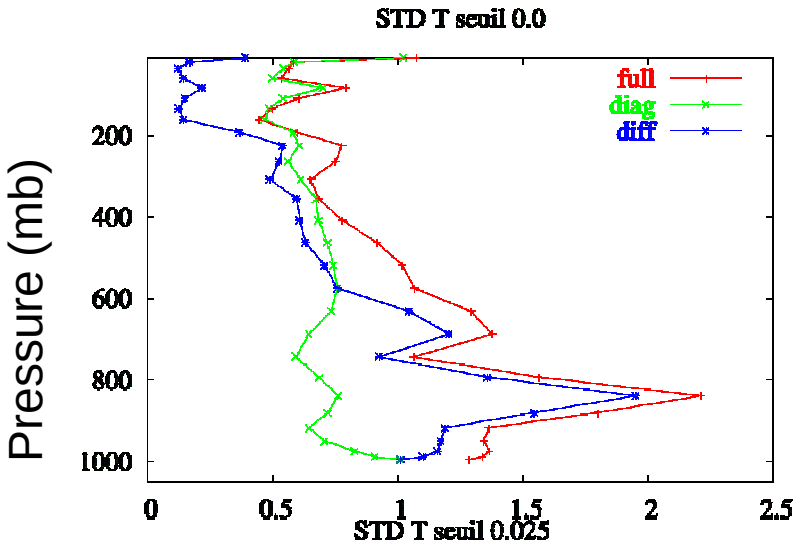


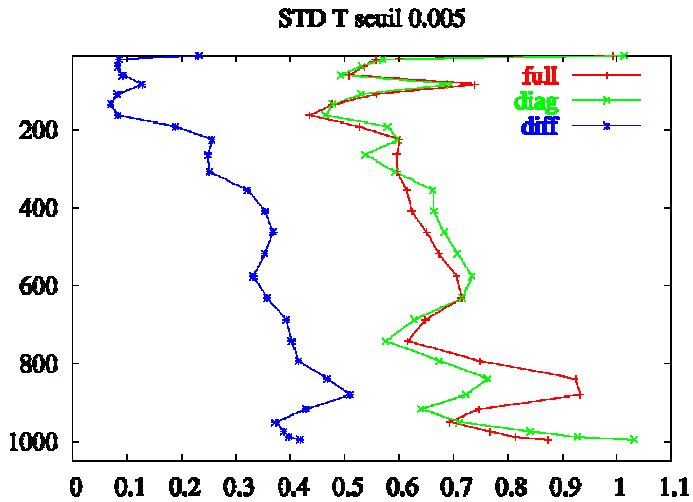
1Dvar T increment (full diag diff)

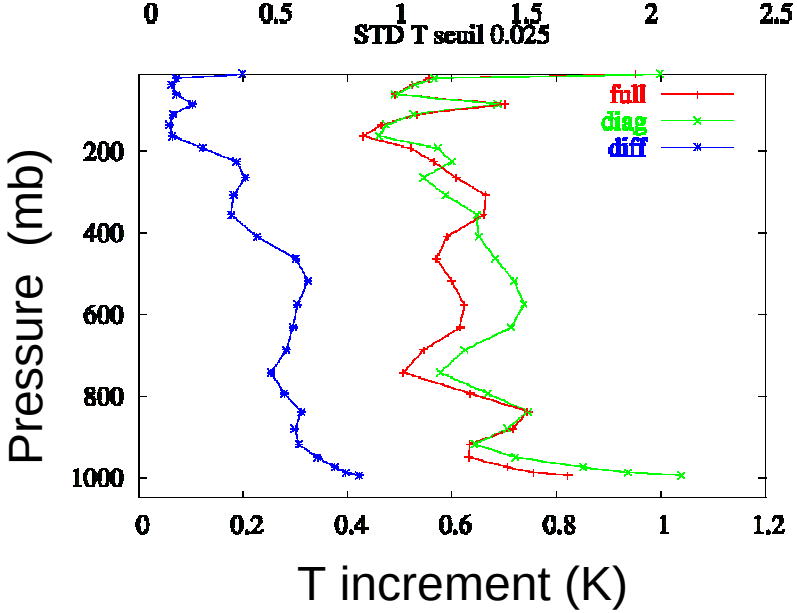


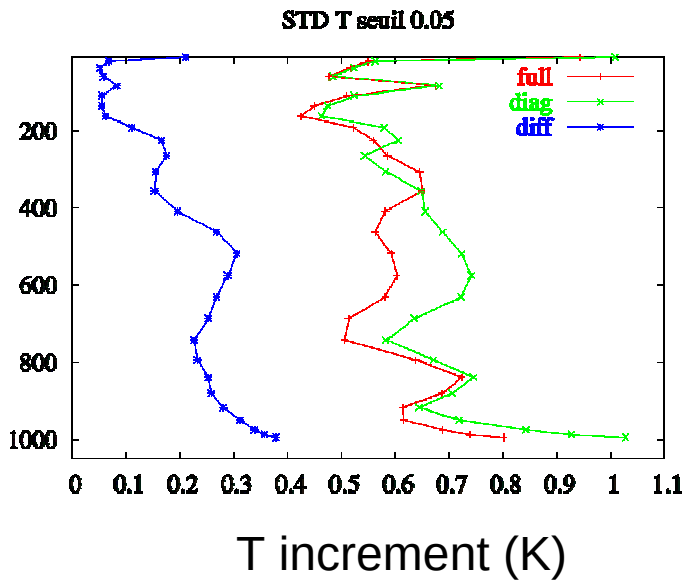
Influence of reconstruction threshold

(105, 100, 82, 70 components)









Conclusions on inter-channel study

- Inter-channel correlation is
  - very low for channels within 14-15 μ CO_2 band
  - often high between H_2O and surface channel

- 1Dvar results:
  - Significant impact: Magnitude of T increment differences (full/diag) is ~50% that of T increment themselves.
  - Some filtering of R is required to get robust results.
  - Slightly lower weight of obs vs background with full R.
  - Faster convergence rate with full matrix (by 50-100%).

- Implementation issue:
  - need to compute R^{-1} locally since the number of channels varies.