IASI 1DVAR retrievals of temperature and emissivity over sea ice and snow covered land validated by dropsondes

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Collaborators

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- The OBR and FAAM teams that were involved in CLPX-II.

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Met Office

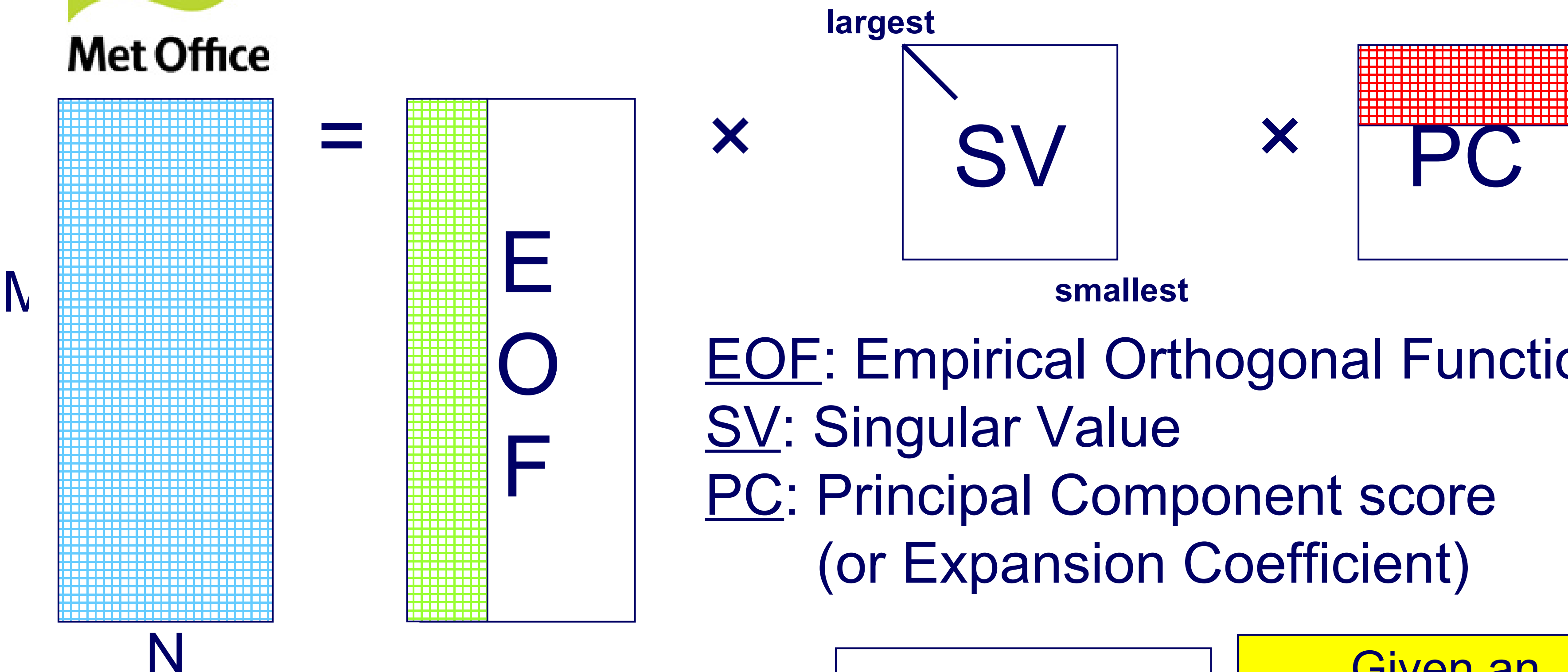
Introduction

Why do IASI 1DVAR with PC radiative transfer?

- Currently Met Office assimilates a small subset of the 8400 channels IASI provides.
  - Computational efficiency reasons.
  - Positive impact on NWP scores
  - Data being thrown out may contain additional useful independent information
- PC RT provides a way to include this extra information at much lower computational cost.
- This talk discusses attempts to retrieve humidity and temperature.

PC Radiative Transfer

HT-FRT – offline calculations



EOF: Empirical Orthogonal Function
SV: Singular Value
PC: Principal Component score
(or Expansion Coefficient)

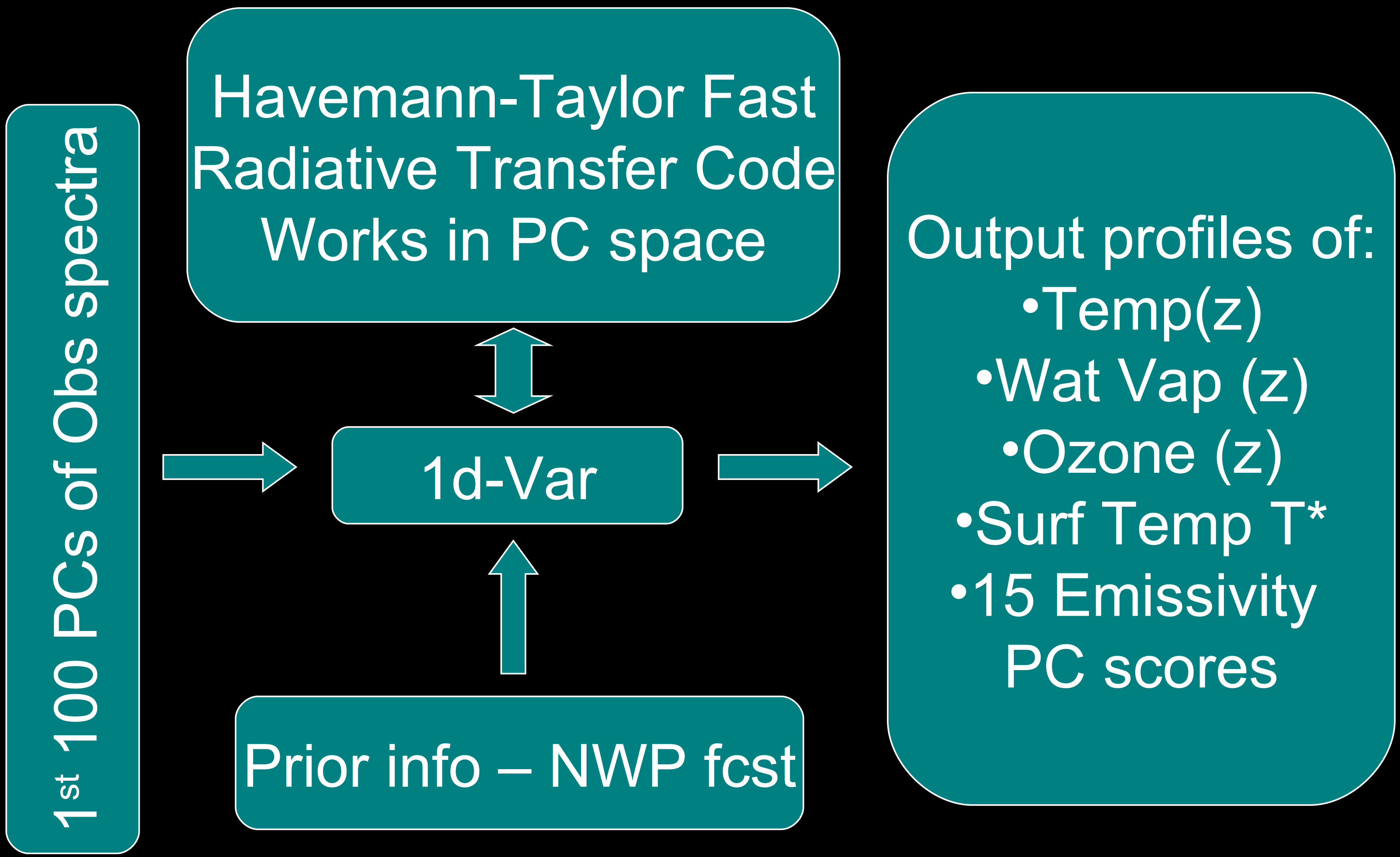
Training spectra
M channels
N profiles

SVD generates
EOF decomposition
of this matrix

Diagonal matrix
of Singular
Values (SV)
sorted
by size
Best 60 used

Given an
observed
spectrum the
EOFS can be
used to generate
PC scores which
are used in RT

Couple HT-FRTC to 1d-Var



1d-Var – minimization of the cost function

x = atmospheric state
T(z), q(z), O3(z), T*, E(PCs)

y = observations
Represented as PCs of the
Radiance spectra

$$J(\mathbf{x}) = (\mathbf{x} - \mathbf{x_0})^T \mathbf{B}^{-1} (\mathbf{x} - \mathbf{x_0}) + (\mathbf{y} - \mathbf{y}(\mathbf{x}))^T \mathbf{R}^{-1} (\mathbf{y} - \mathbf{y}(\mathbf{x}))$$

B = Error covariance
of Background profile
– extended to include a block
matrix with the error covariances
of the surface emissivity
PC scores

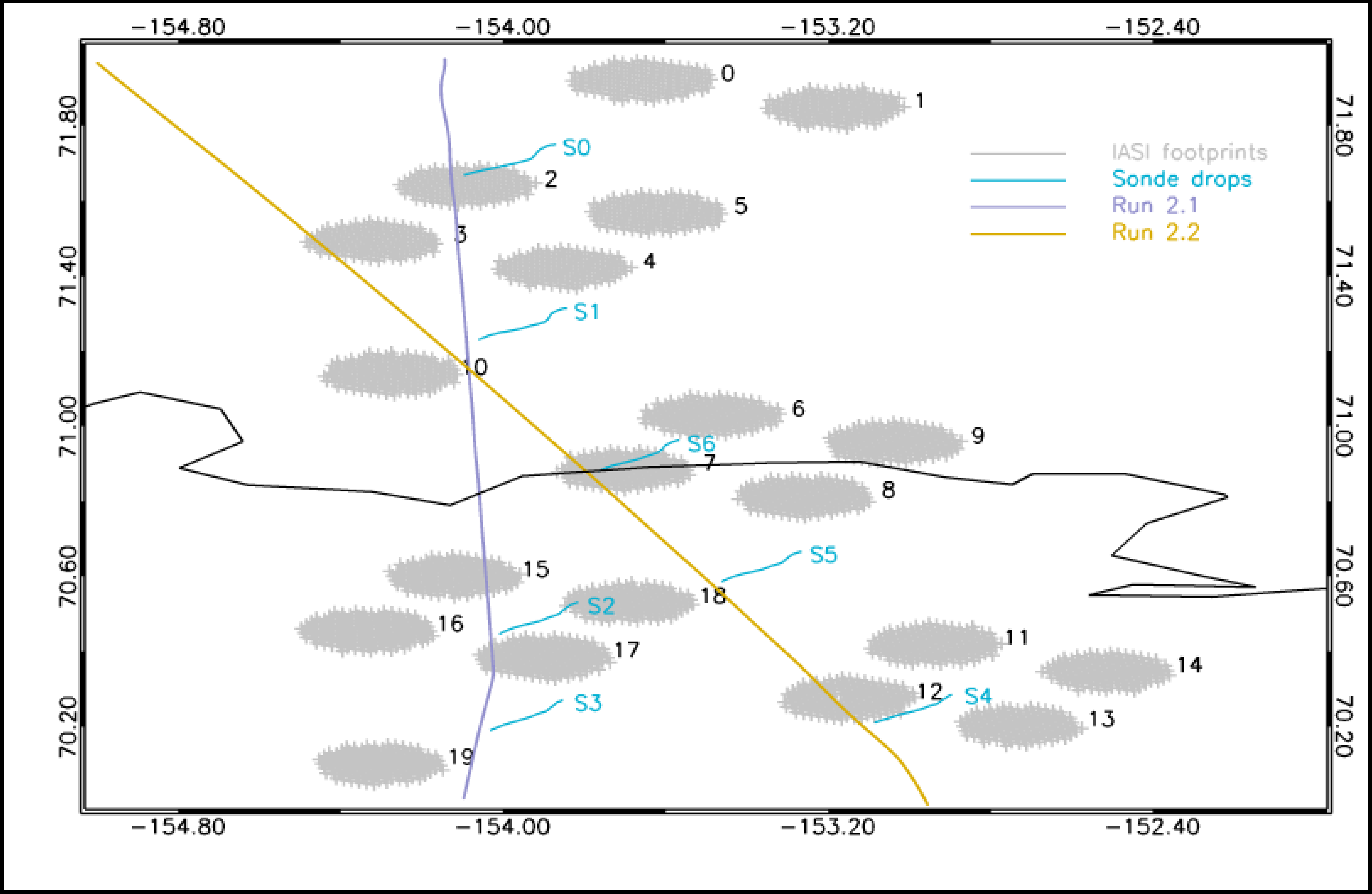
R = Error covariance
of measurements
– extended to include
the error covariances of the sum
of the observational and model
errors in Principal Component
Space

Case study: B345

Constraints on 1DVAR

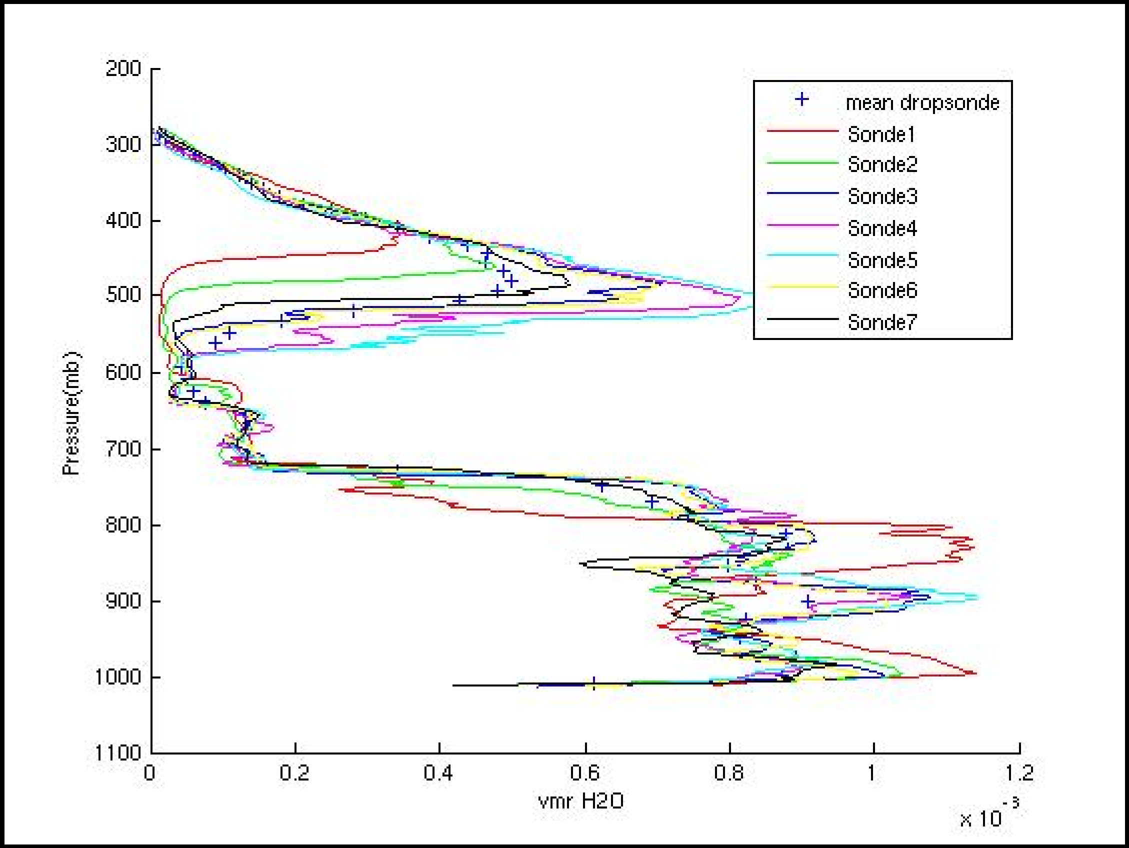
- ECMWF model fields taken as background.
  - 0.5° X 0.5° resolution
- AVHRR Channel 4 used as an estimate of the background surface temperature.
- B matrix for ECMWF model
  - Spatially invariant
  - Independent of flow conditions
- Sondes a local measurement
  - Provide a best estimate of the “truth”

B345 Coincidence between Dropsondes and IASI footprints



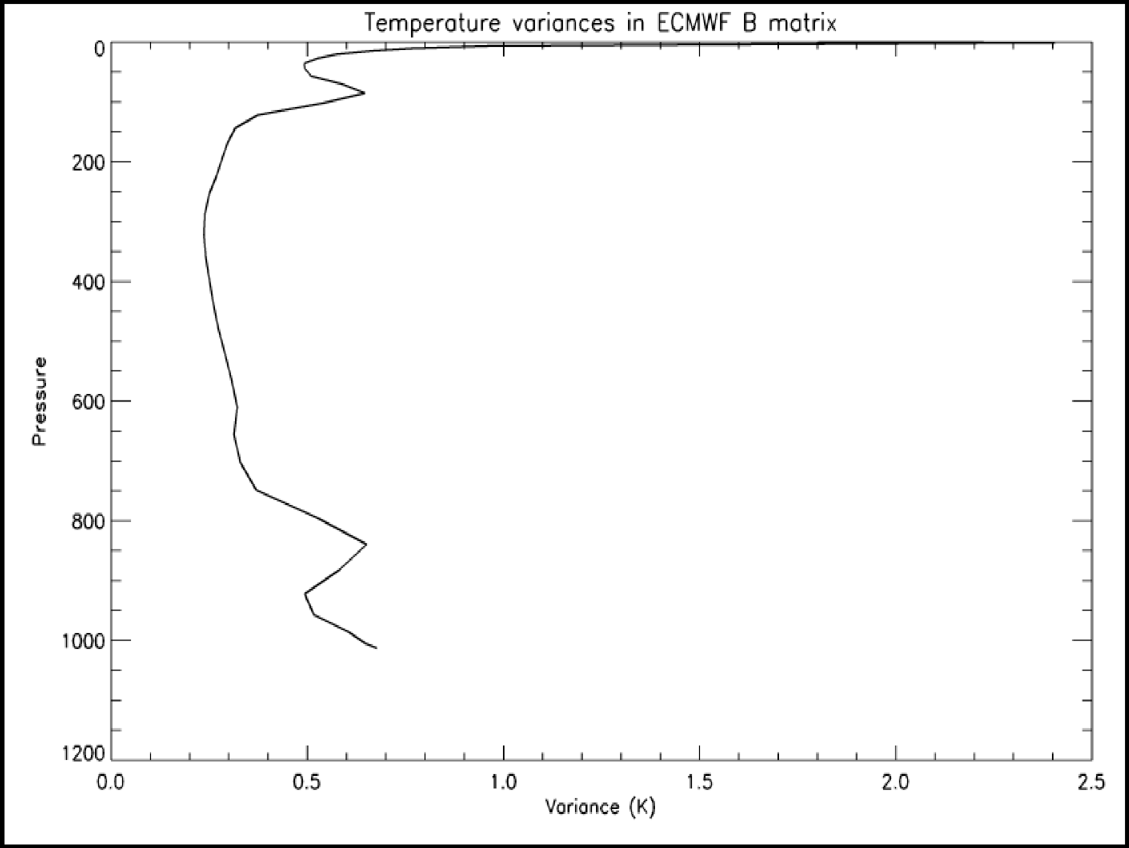
Dropsonde data

- Sonde humidity quite variable
- STD q= 5.7e-5 kg/kg
- STD rh= 7.9 %
- STD temp= 0.73 K

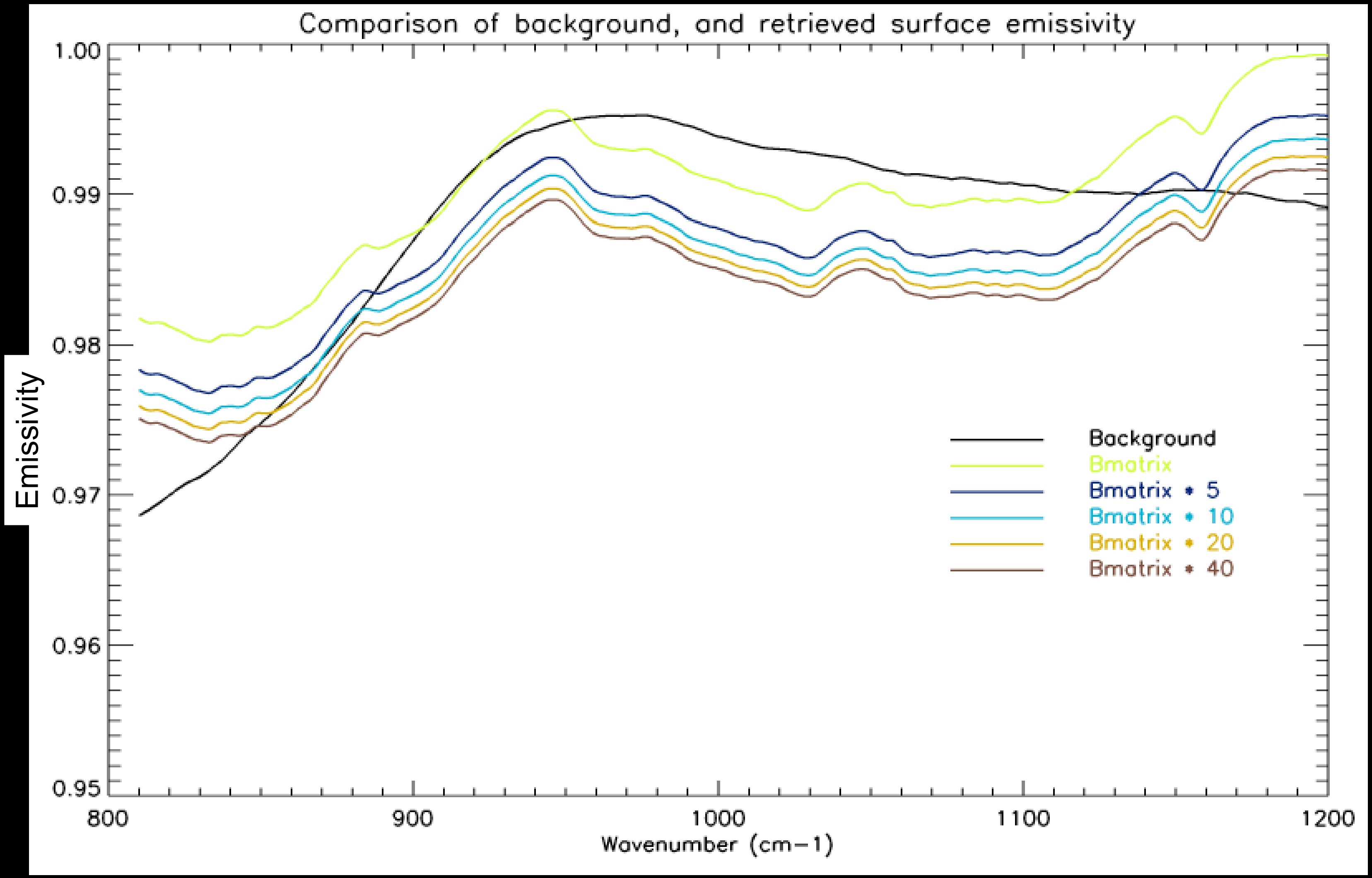


Dropsonde data

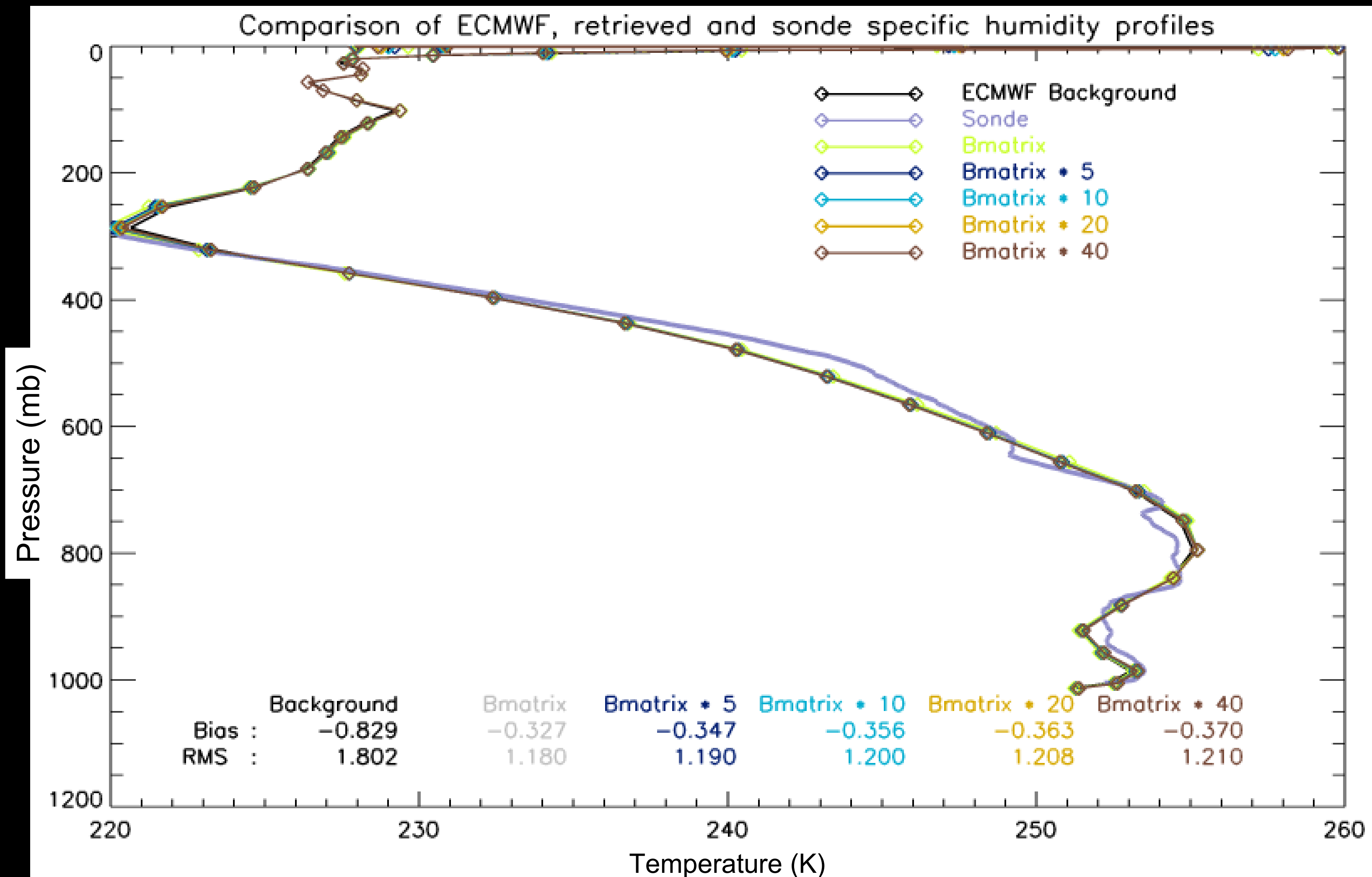
- Sonde humidity quite variable
- STD q= 5.7e-5 kg/kg
- STD rh= 7.9 %
- STD temp= 0.73 K
- Height and temp of trop inversion uncertain/variable
    - Not reflected in B matrix but expected in nature.



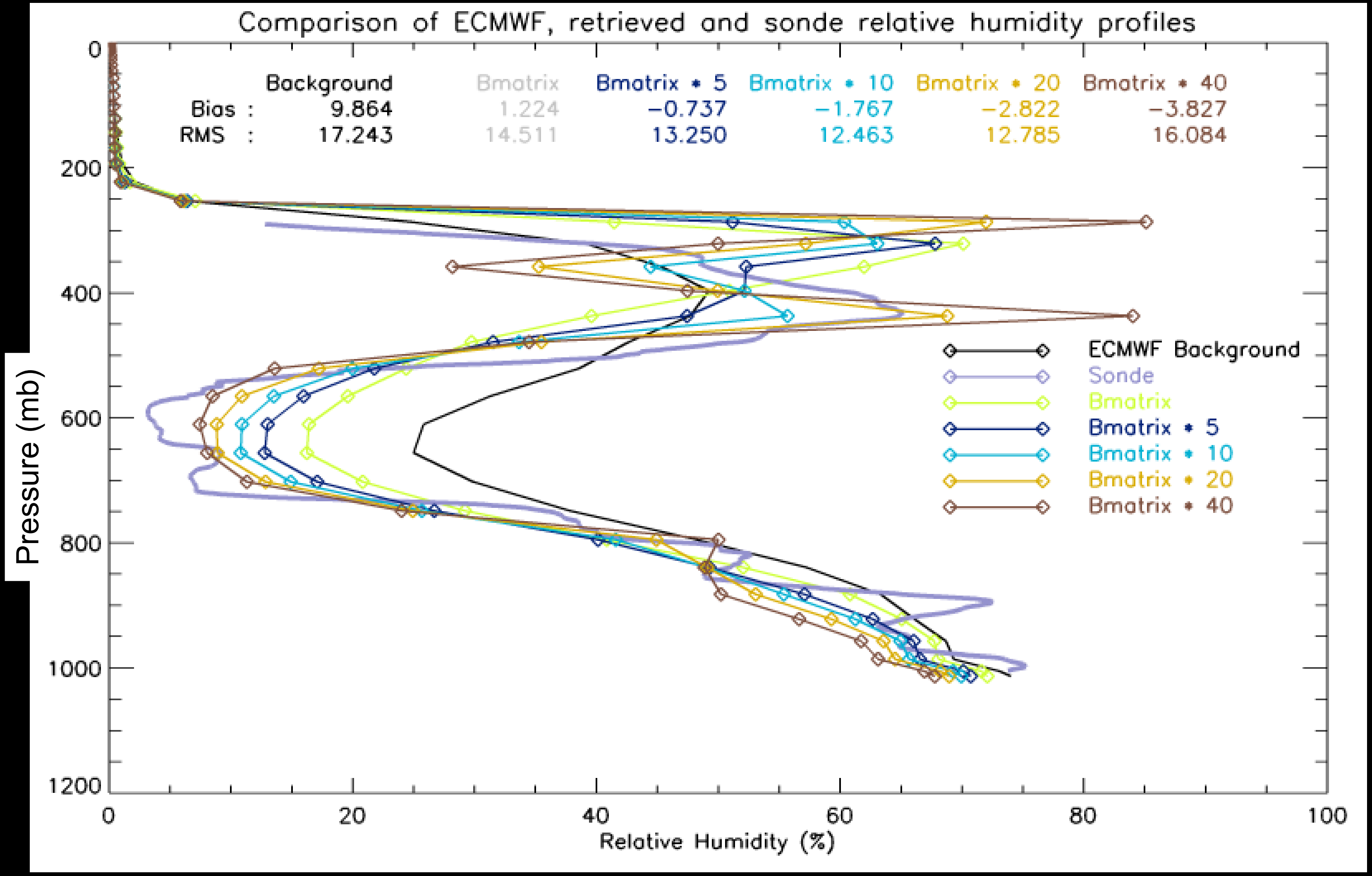
Retrieved surface emissivities



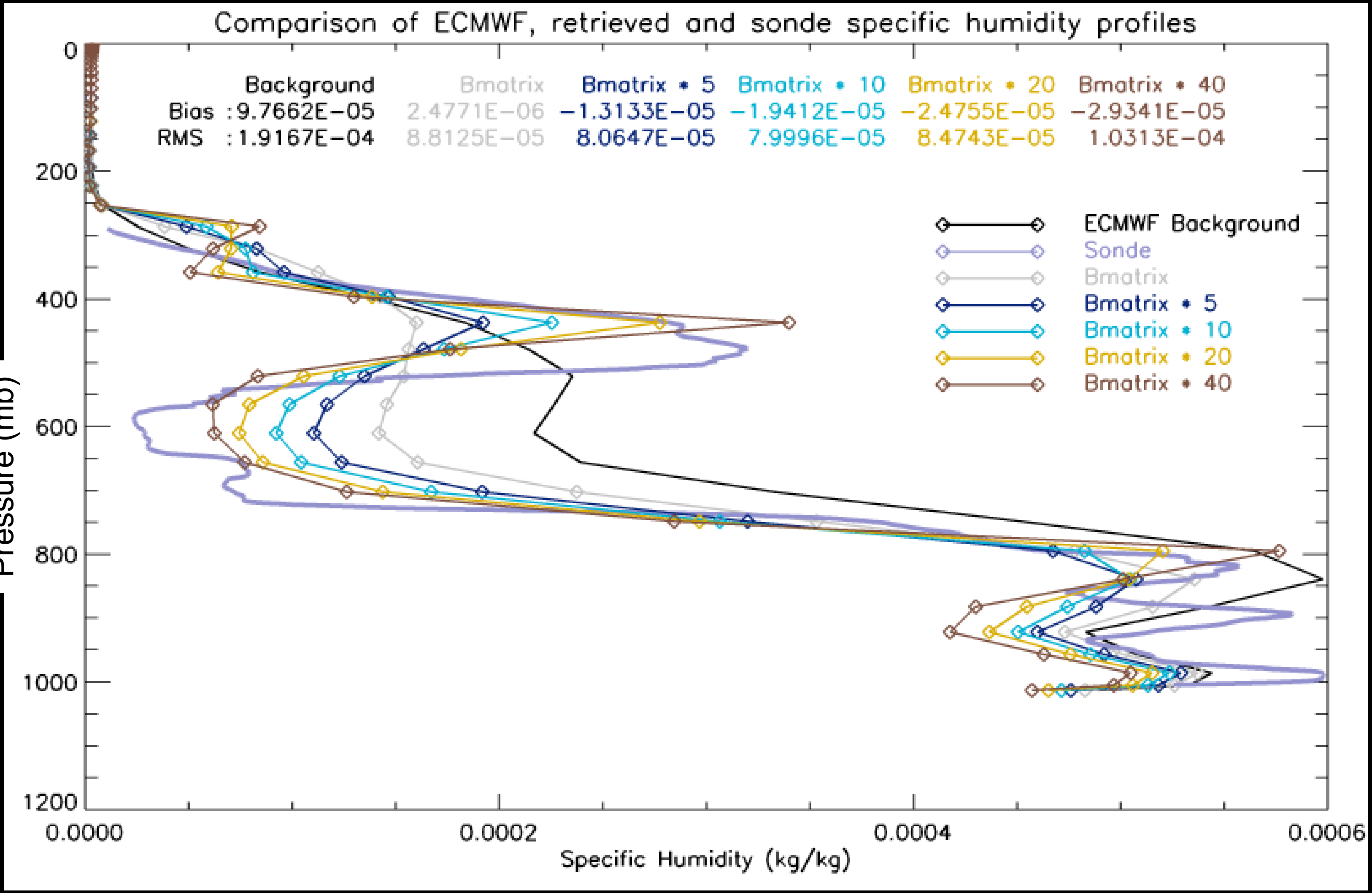
Met Office


Comparison of ECMWF, retrieved and sonde specific humidity profiles
ECMWF Background
Sonde
Bmatrix
Bmatrix * 5
Bmatrix * 10
Bmatrix * 20
Bmatrix * 40
Pressure (mb)
0
200
400
600
800
1000
1200
220
230
240
250
260
Temperature (K)
Background Bmatrix Bmatrix * 5 Bmatrix * 10 Bmatrix * 20 Bmatrix * 40
Bias : −0.829 −0.327 −0.347 −0.356 −0.363 −0.370
RMS : 1.802 1.180 1.190 1.200 1.208 1.210

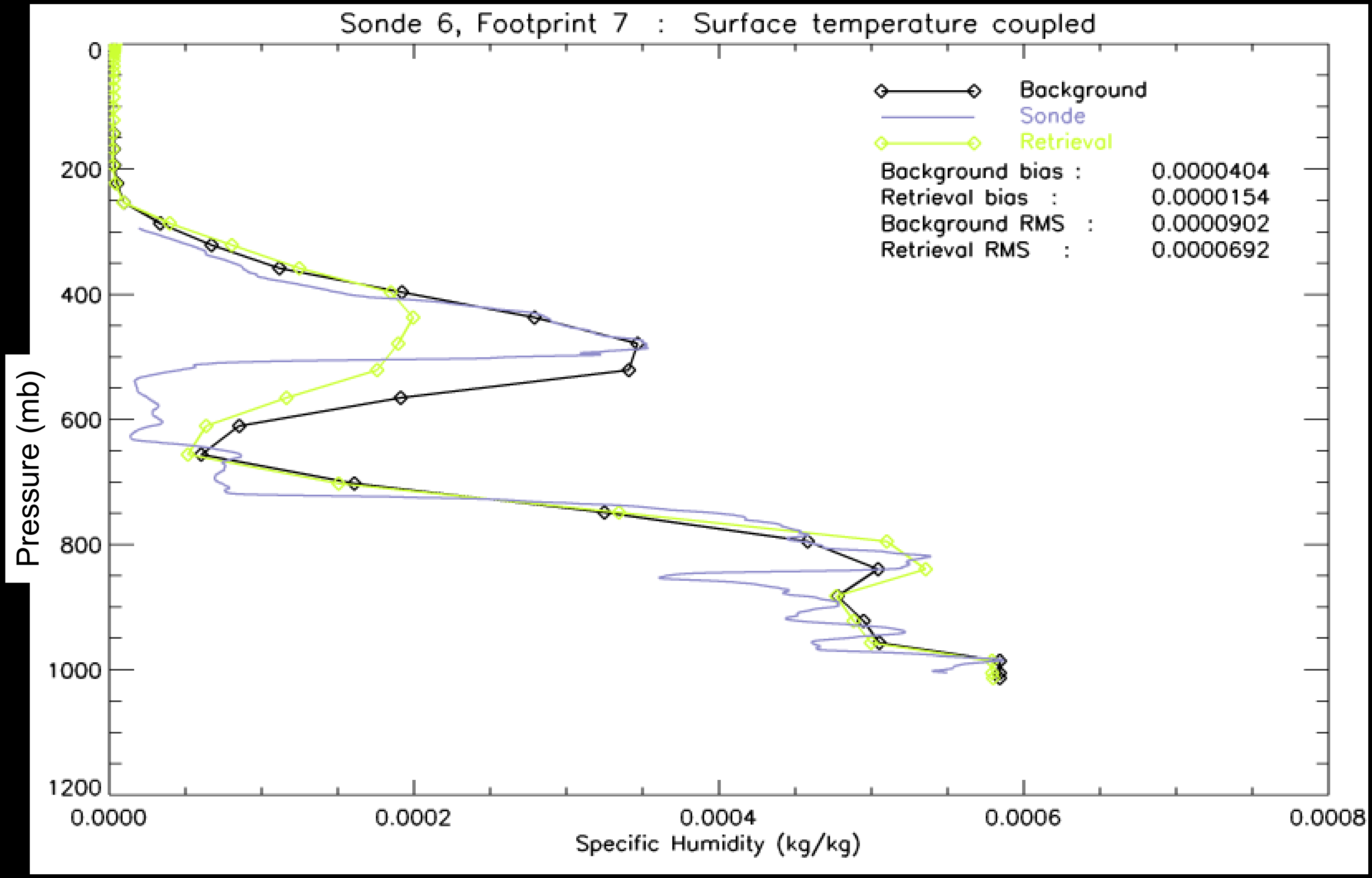
Retrieved relative humidities



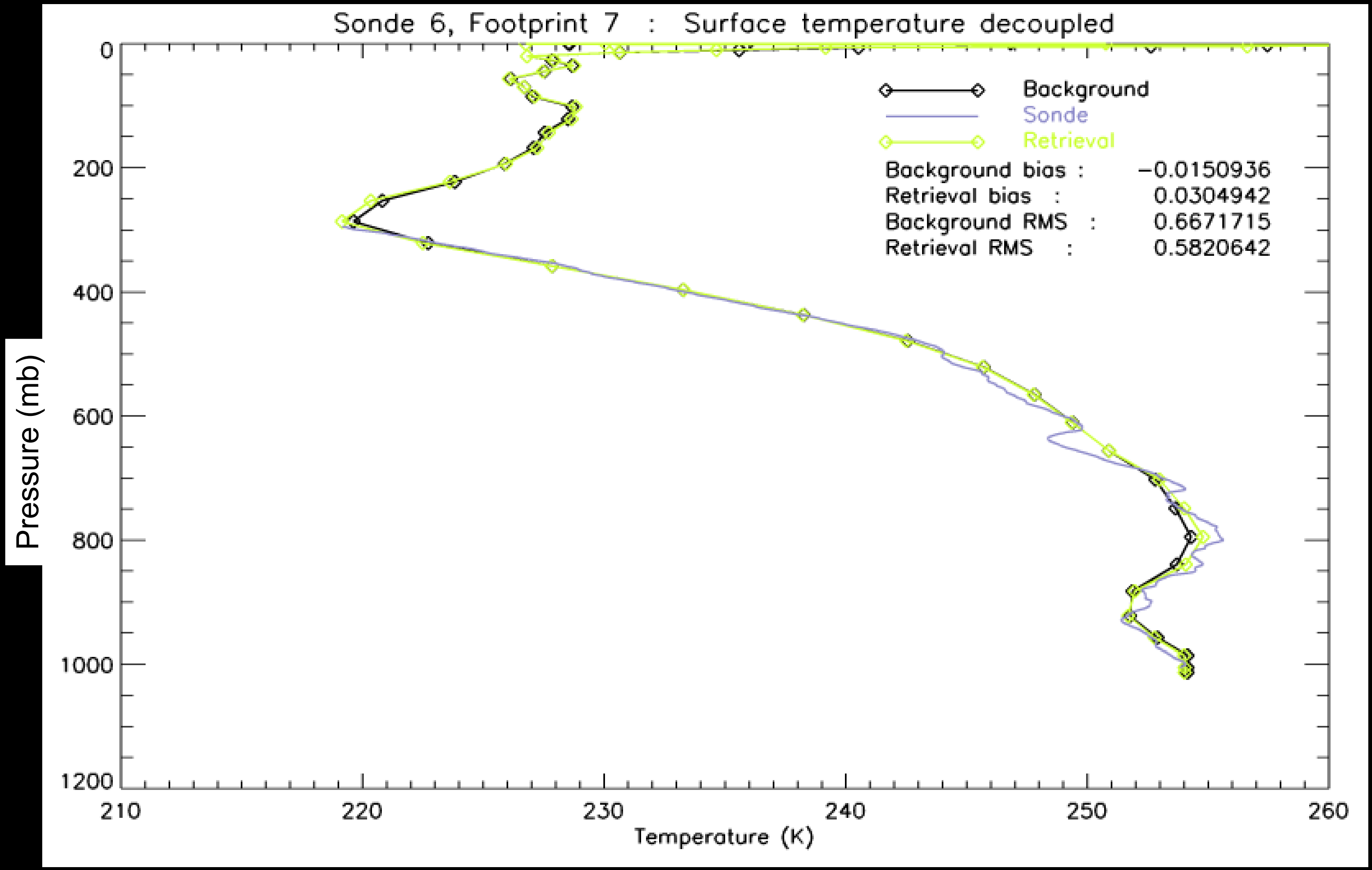
Retrieved specific humidities



Sonde 6, Footprint 7: Good humidity retrieval



Sonde 6, Footprint 7: Thermal coupling



Conclusions

Results

	Temp (K)		RH (%)		SH (kg/kg)*10^6	
	Bgrnd	Retr	Bgrnd	Retr	Bgrnd	Retr
RMSE	1.8	1.2 (best)	17.2	14.5 (12.5) qX10	192	88.1 (80.0) qX10
BIAS	-0.83	-0.33 (best)	9.86	1.22 (best)	97.7	2.5 (best)
Sonde STD	0.73		7.9		57	

Conclusions

- 1DVAR using HT-FRTC retrievals better at matching sonde profiles than background
- However, there is room for even more improvement.
- B matrix is general global quantity
  - Need flow-dependent, local B matrix
- Sub-grid variability in temperature and humidity profiles as well as surface emissivity may be reducing quality of retrievals
- Thermal coupling induced in boundary layer by B matrix
  - Unrealistic in arctic winter conditions.
  - Reduces quality of profile and surface temperatures.
- Retrieval performed over flat, low-lying terrain
  - Expect greater difficulties over complex,elevated terrain.

References

- J.-C. Thelen, S. Havemann, S. M. Newman and J. P. Taylor, “Hyperspectral retrieval of land surface emissivities using ARIES,” *Q. J. Roy. Meteor. Soc.*, vol. 135, pp. 2110-2124, 2009.