Combining GPS occultations with AIRS infrared measurements for improved atmospheric sounding

Éva E. Borbás*, Elisabeth Weisz*, Jun Li*, Harold M. Woolf*, and W. Paul Menzel**

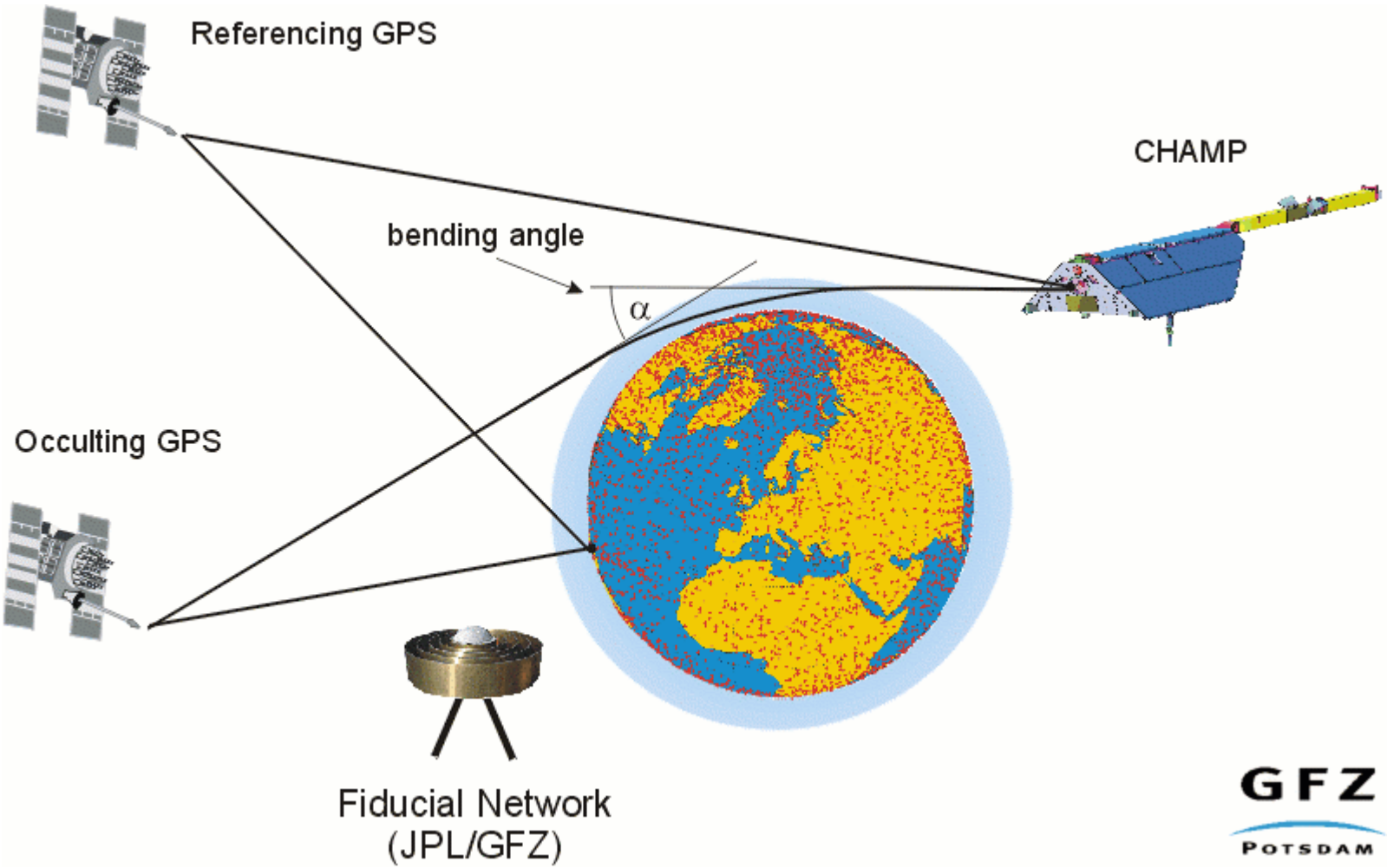
***Space Science and Engineering Center,University of Wisconsin / Madison**

****NESDIS/ Office of Research and Applications**

Outline

- Introduction – Motivation, Reminder
- Input data
- Combined retrieval method
- Results
- Conclusion & Future Plans

Geometry of radio occultation



Motivation

GPS/RO

- –good absolute accuracy
- –very high vertical resolution, poor horizontal resolution
- –information in upper troposphere and stratosphere
- –high accuracy around tropopause
- –“all weather” instrument

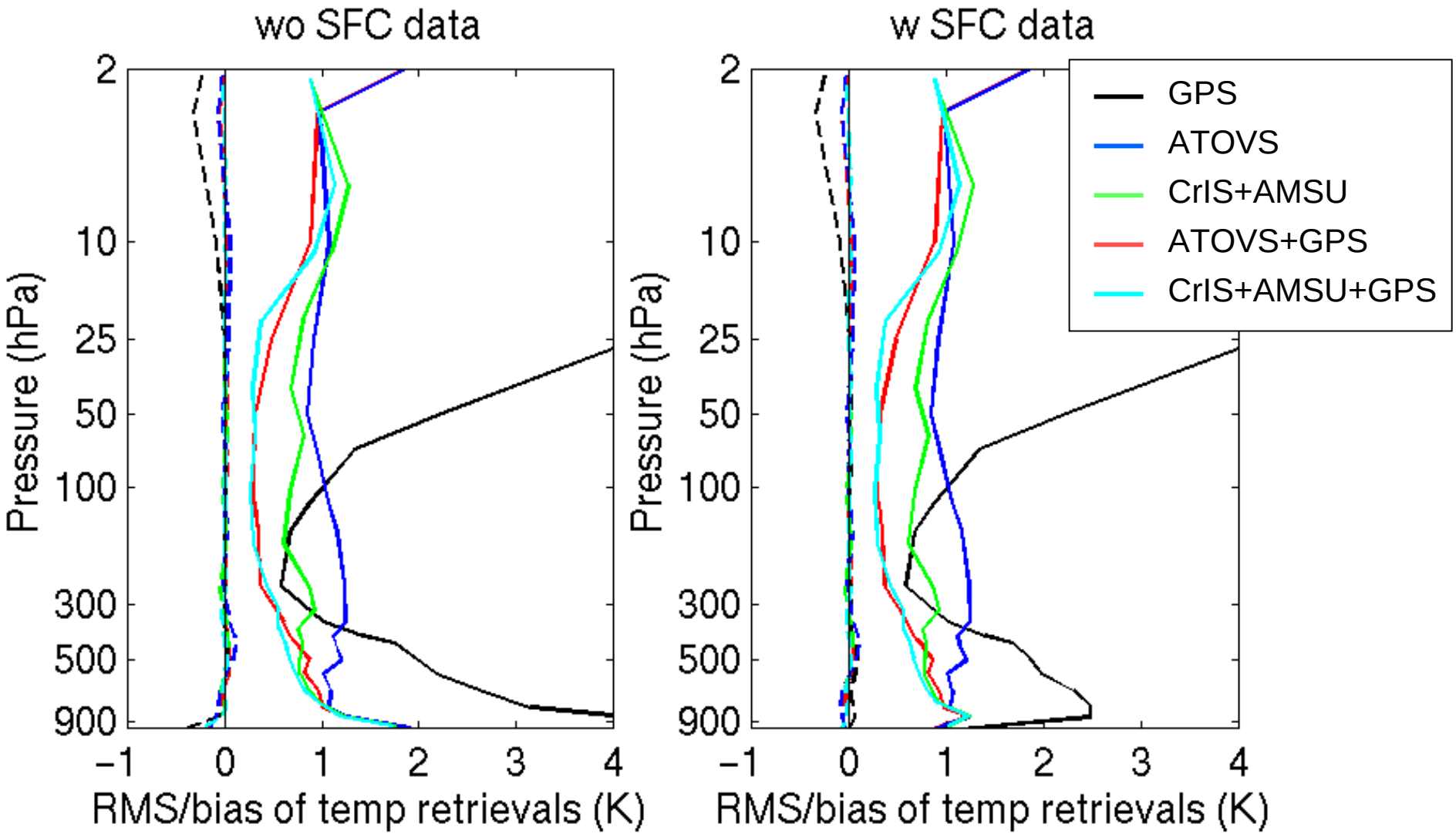
IR and MW (ATOVS)

- –high horizontal resolution, poor vertical resolution
- –information from the total atmospheric column
- –more information on lower tropospheric temperature
- –less information around the tropopause

Results of simulation study

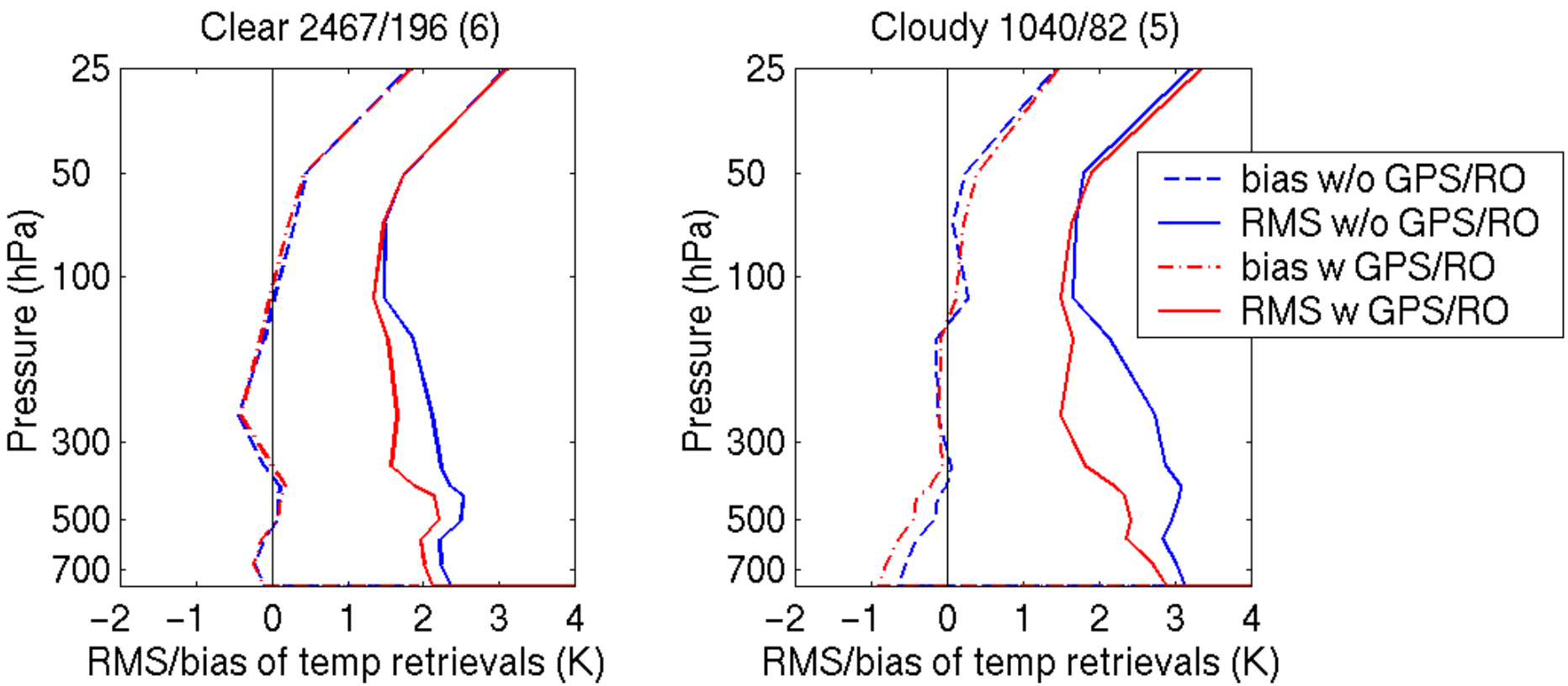
Results of real ATOVS+CHAMP/SACC study

RMS/bias diff of simulated temp retrievals from various systems



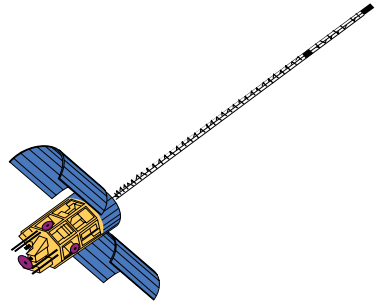
RAOB validation of SACC + ATOVS T(p)

Oct 2001, Jan, Apr and July 2002



GPS/RO (SACC) data improves the radiometric (ATOVS) temp retrievals around the tropopause by 0.5 K (larger impact over the cloudy skies)

Input data



Time period: Sept 2002 – Oct 2003

AIRS+RAOB matchup (**100,266** collocations)

GPS data (SAC-C) July 2001 and Dec 2003: **66,989** occultations

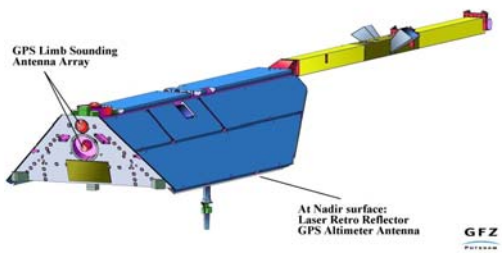
GPS data (CHAMP) May 2001 and Dec 2003: **106,609** occultations

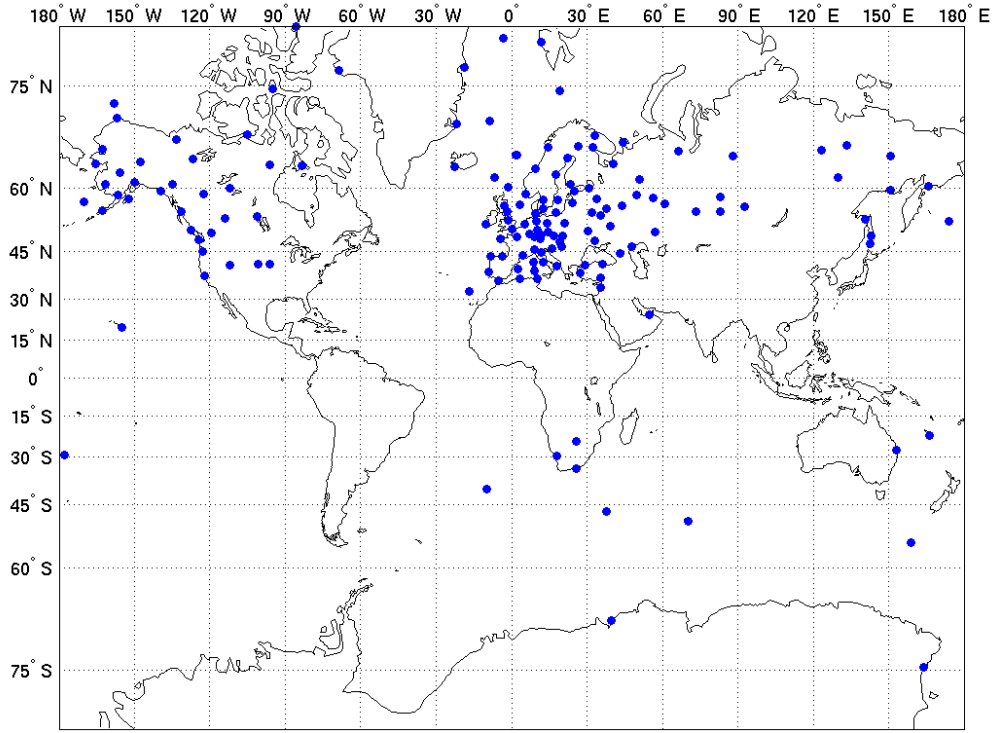
AIRS+RAOB+GPS collocation:

1980 (382 clear sky)

AMSU (AQUA): v3.0.8.0

AIRS level 2: v3.0.8.0





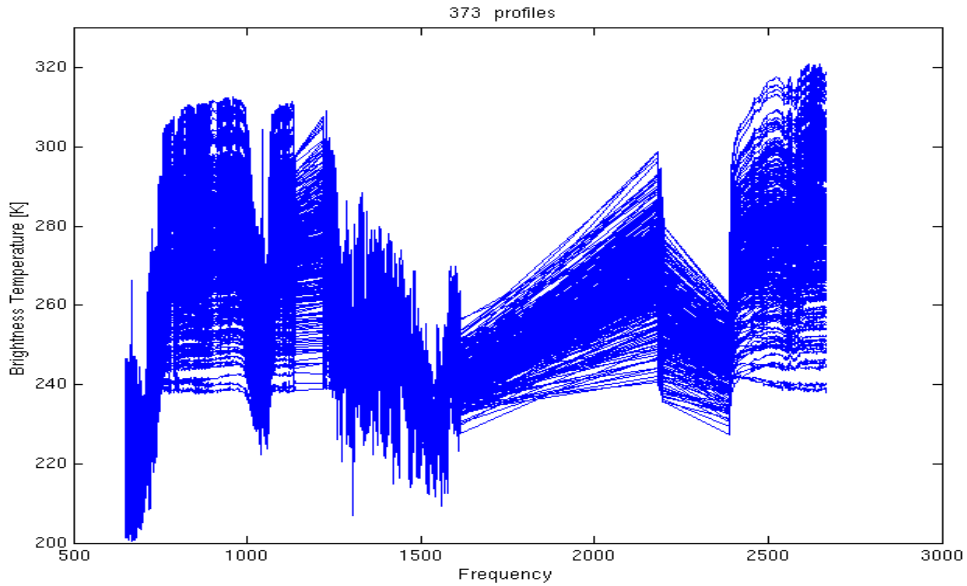
Location of AIRS+AMSU+RAOB+GPS collocations

Method

Test of different cloud masks:

Clear: if BT(obs) –BT(calc) <= 7

for less than 10 selected channels



Test of different set of selected channels and retireval methods:

Clear sky PC statistical regression method

number of PCs:30

6 BT and 11 scan angle classification

with 1688 selected channels

Class	BT@1000 cm^{-1} training	BT@1000 cm^{-1} observations
1	BT ≤ 260	BT ≤ 255
2	250<BT≤270	255<BT≤265
3	260<BT≤280	265<BT≤275
4	270<BT≤290	275<BT≤285
5	280<BT≤300	285<BT≤295
6	290 < BT	295 < BT

AIRS+AMSU+GPS Clear Sky retrieval

Regression Retrieval of T, q, O3, Ts, Ps, and ε_s under clear conditions

Regression Model: $X = C\ Y$

Least squares regression solution: $C = X\ Y^T\ (Y\ Y^T)^{-1}$

X…Atmospheric State,

C…Coefficients,

Y…Measurements: **AIRS & AMSU BTs and GPS refractivity profiles**

Forward Model Calculations

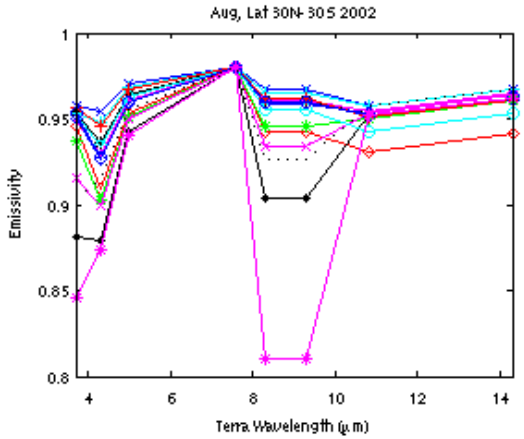
AIRS BTs: SARTA model

AMSU BTs: Paul van Delst's implementation of Liebe MPM line-by-line model (Channels: 6-14)

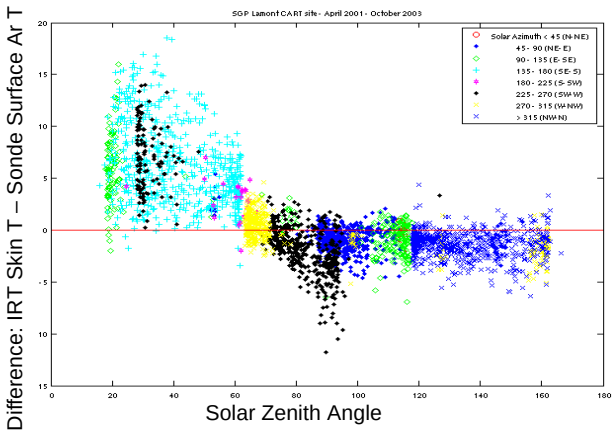
GPS refractivity profiles**:** (Healy & Eyre, 2000) with vertically correlated measurements errors (200m vertical resolution)

POSTER !!!!

Training Data

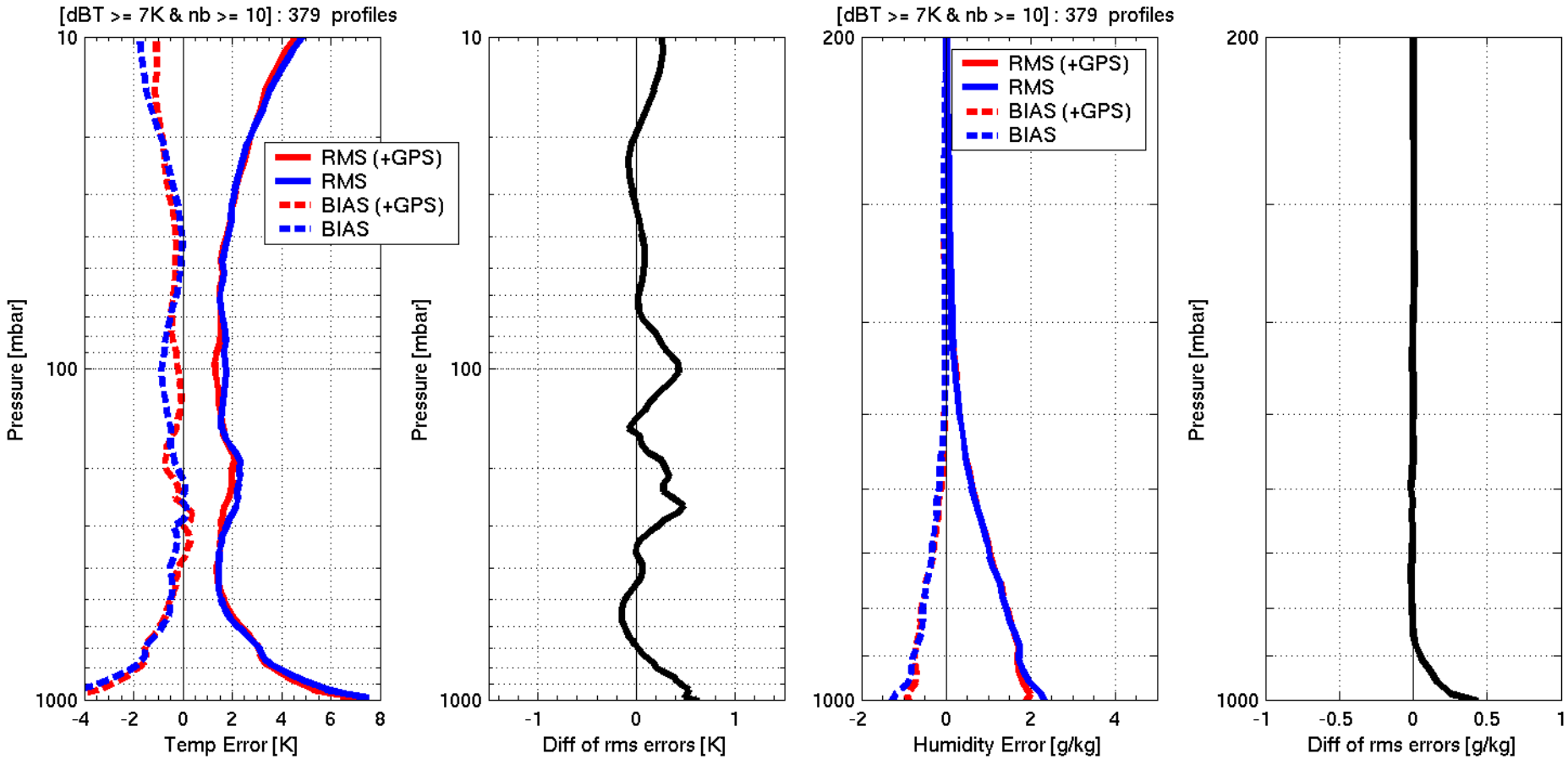


- 12,245 global atmospheric profiles
- Profiles are taken from the
  NOAA-88, ECMWF training set, TIGR-3, ozonesondes, desert radiosondes
- All with saturation checks and other QC
- New Surface Skin Temperature assigned to profiles
- New ecosystem-based Surface Emissivity assigned to profiles



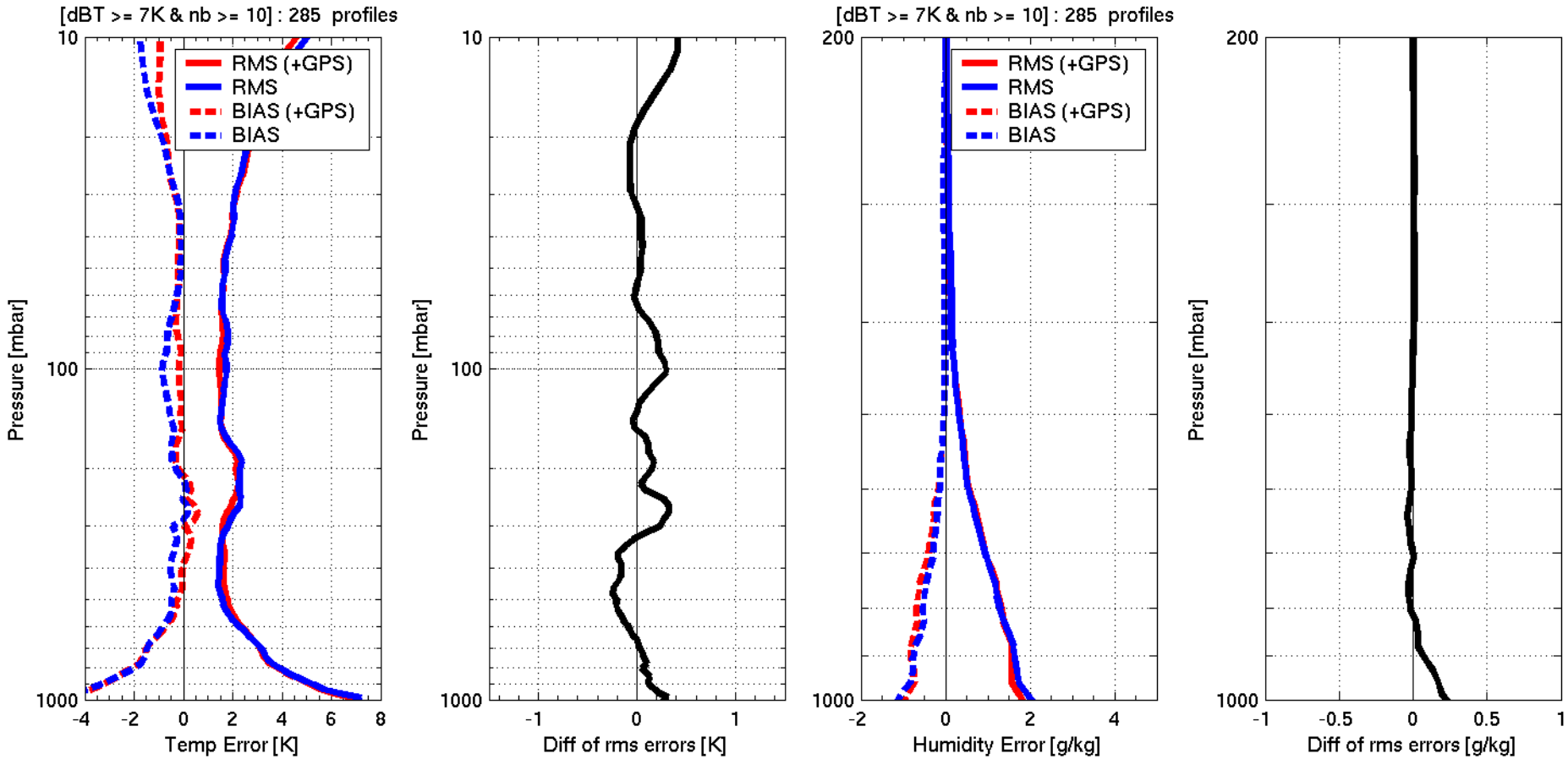
Electrochemical concentration cell (ECC) Ozonesondes weekly launches, 1997 to present at 8 sites through the Climate Monitoring and Diagnostics Laboratory (CMDL)

RAOB validation of AIRS+AMSU retrievals with and without GPS data



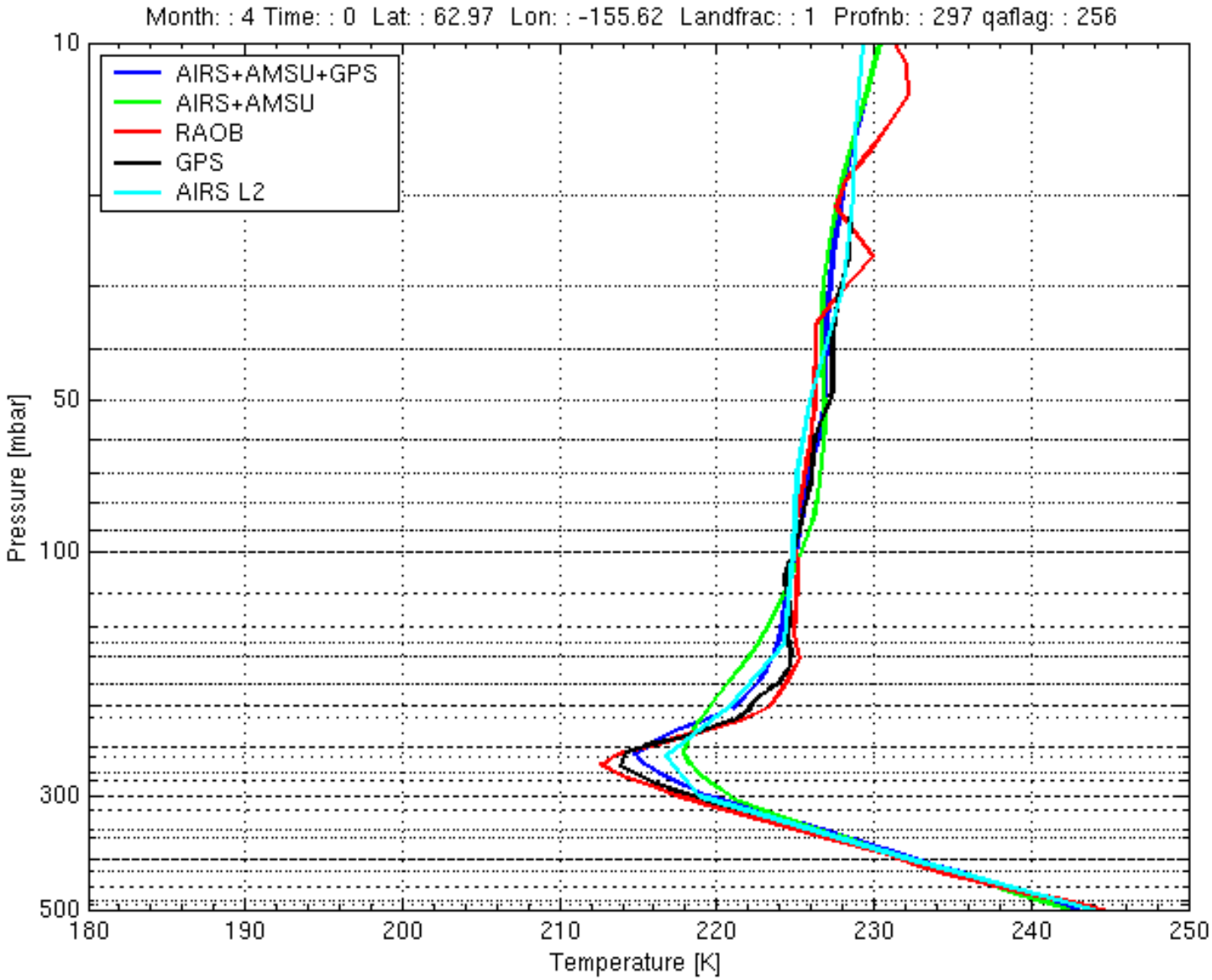
GPS between 8 and 26 km

RAOB validation of AIRS+AMSU retrievals with and without GPS data

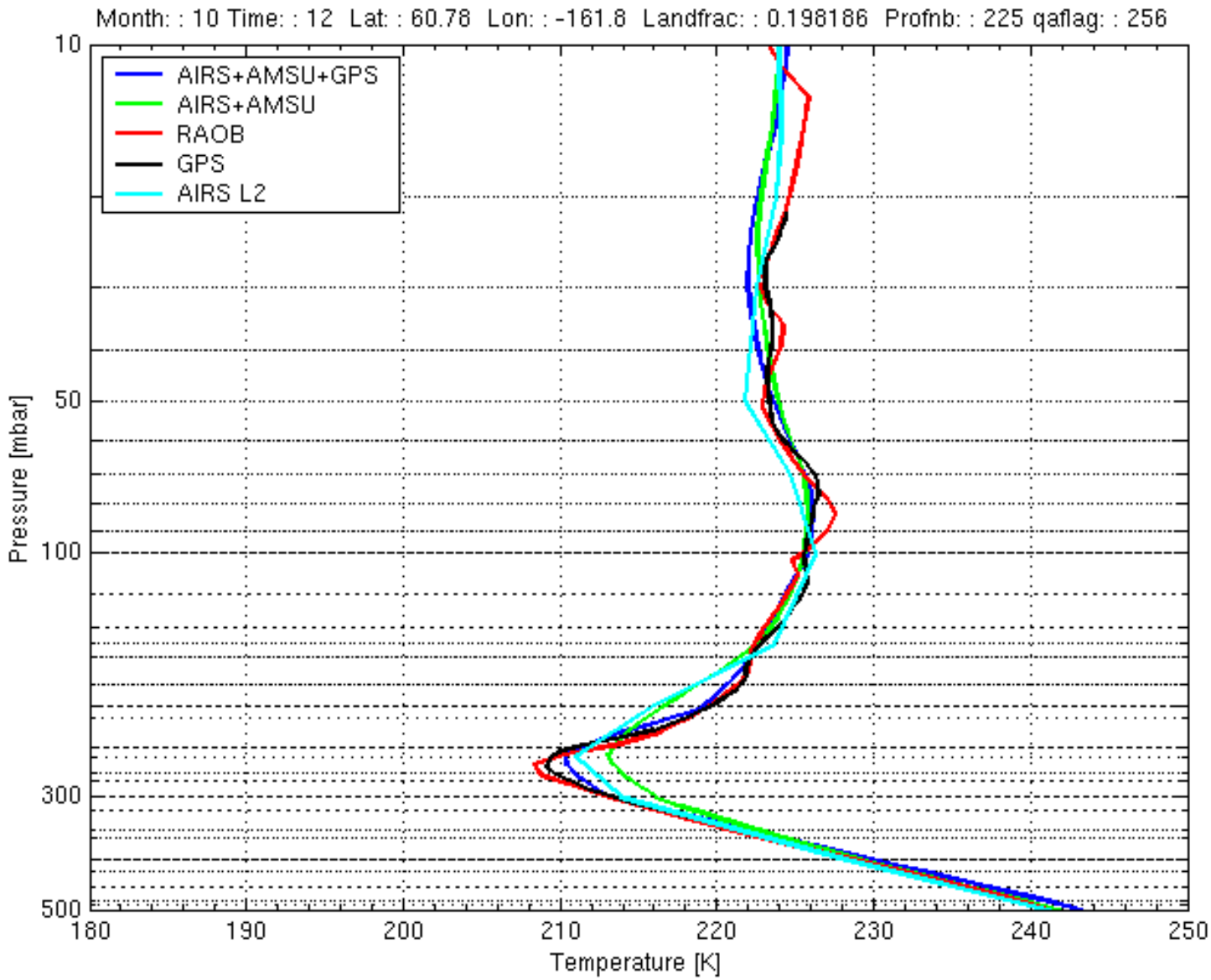


GPS between 1 and 26 km (3Xσ3Xnoise)

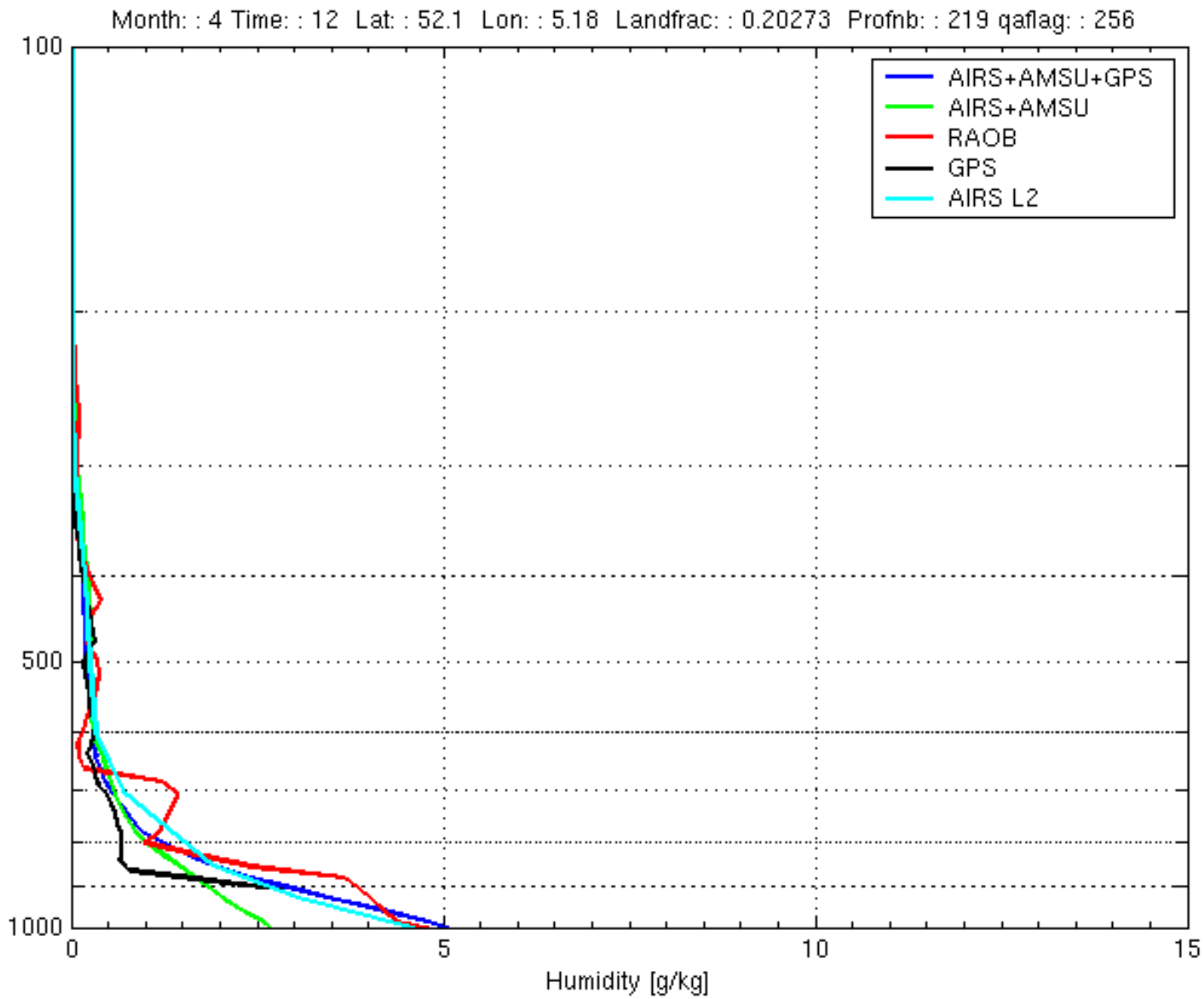
Comparison of temperature profiles



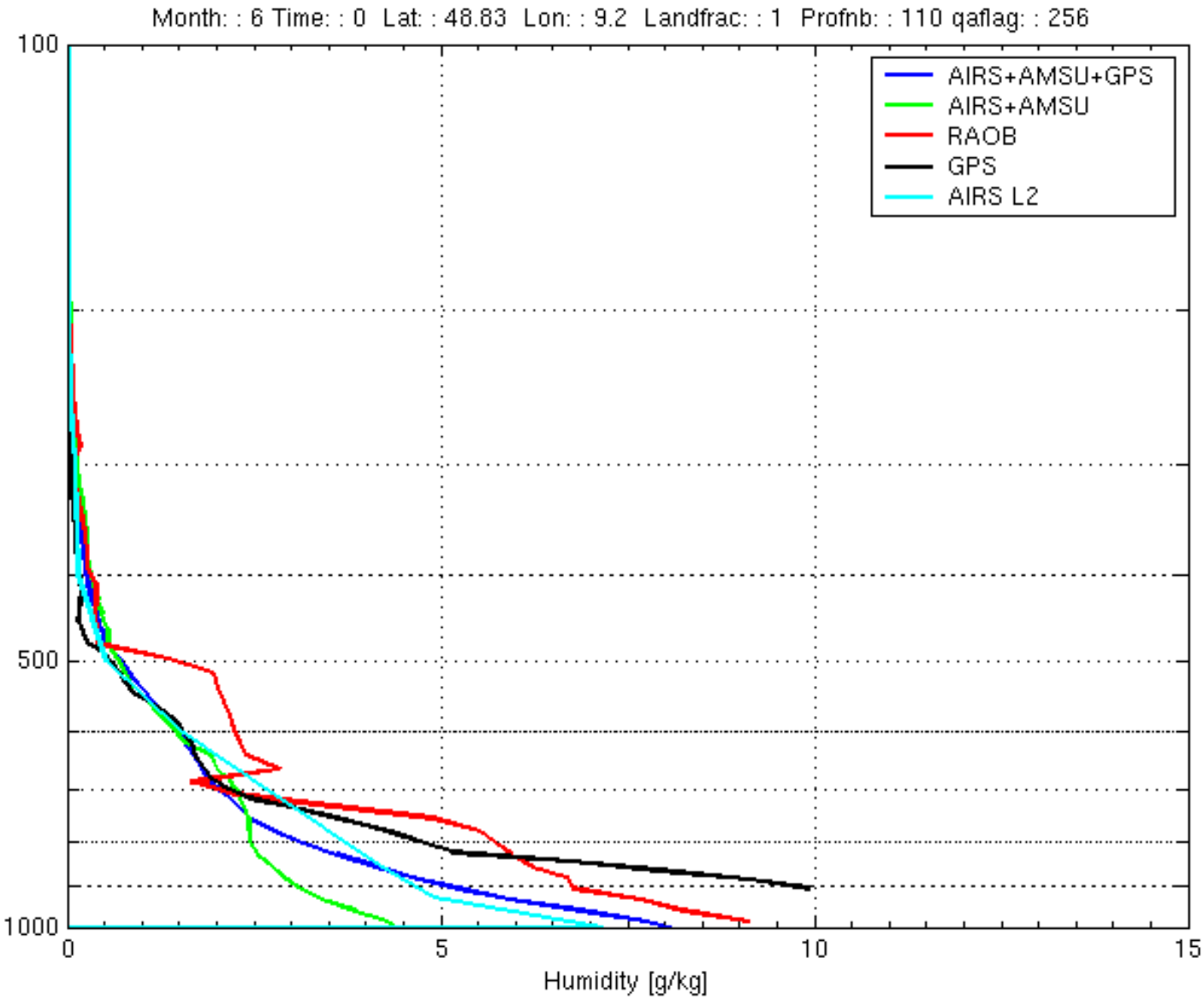
Comparison of temperature profiles



Comparison of moisture profiles



Comparison of moisture profiles



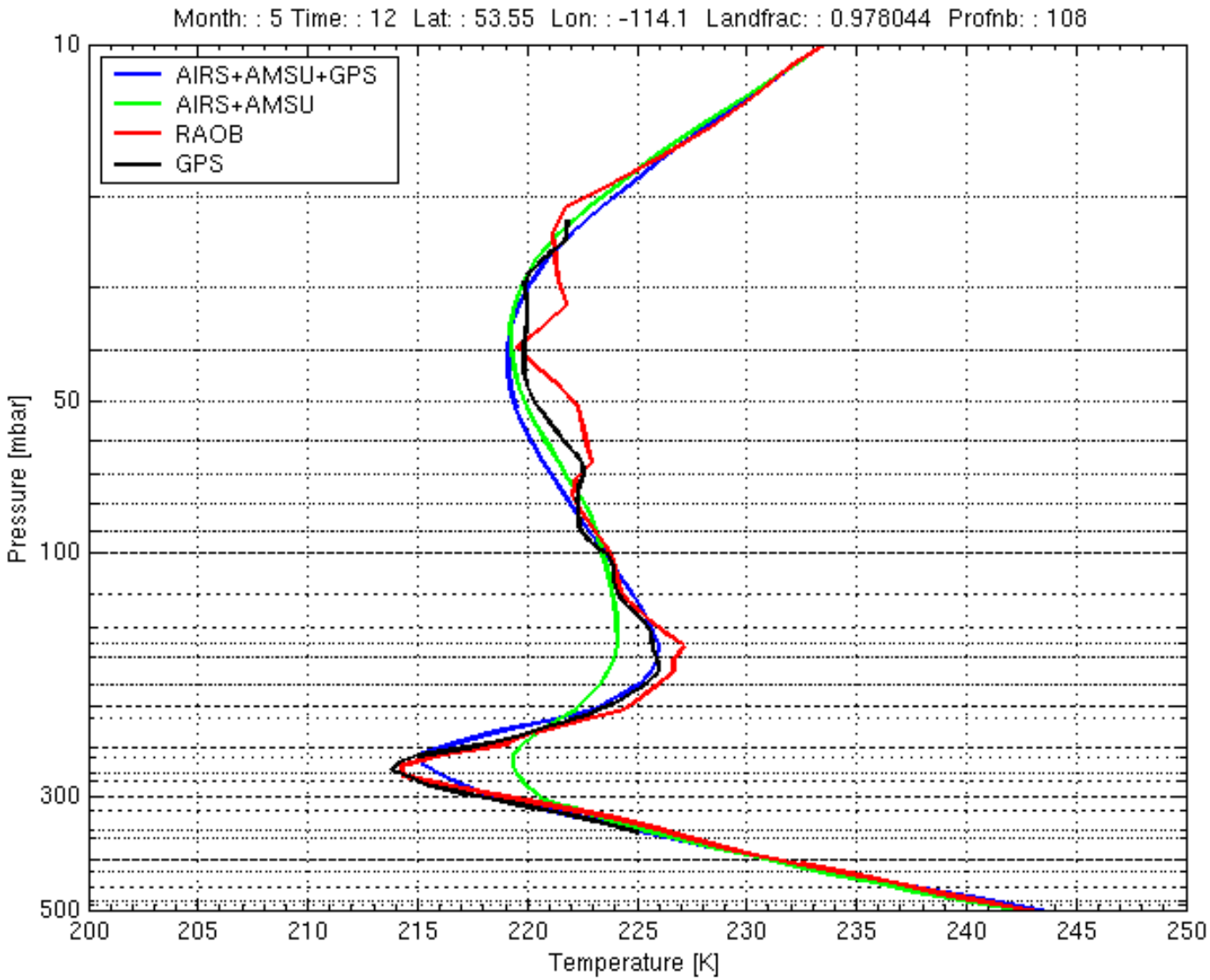
Conclusions

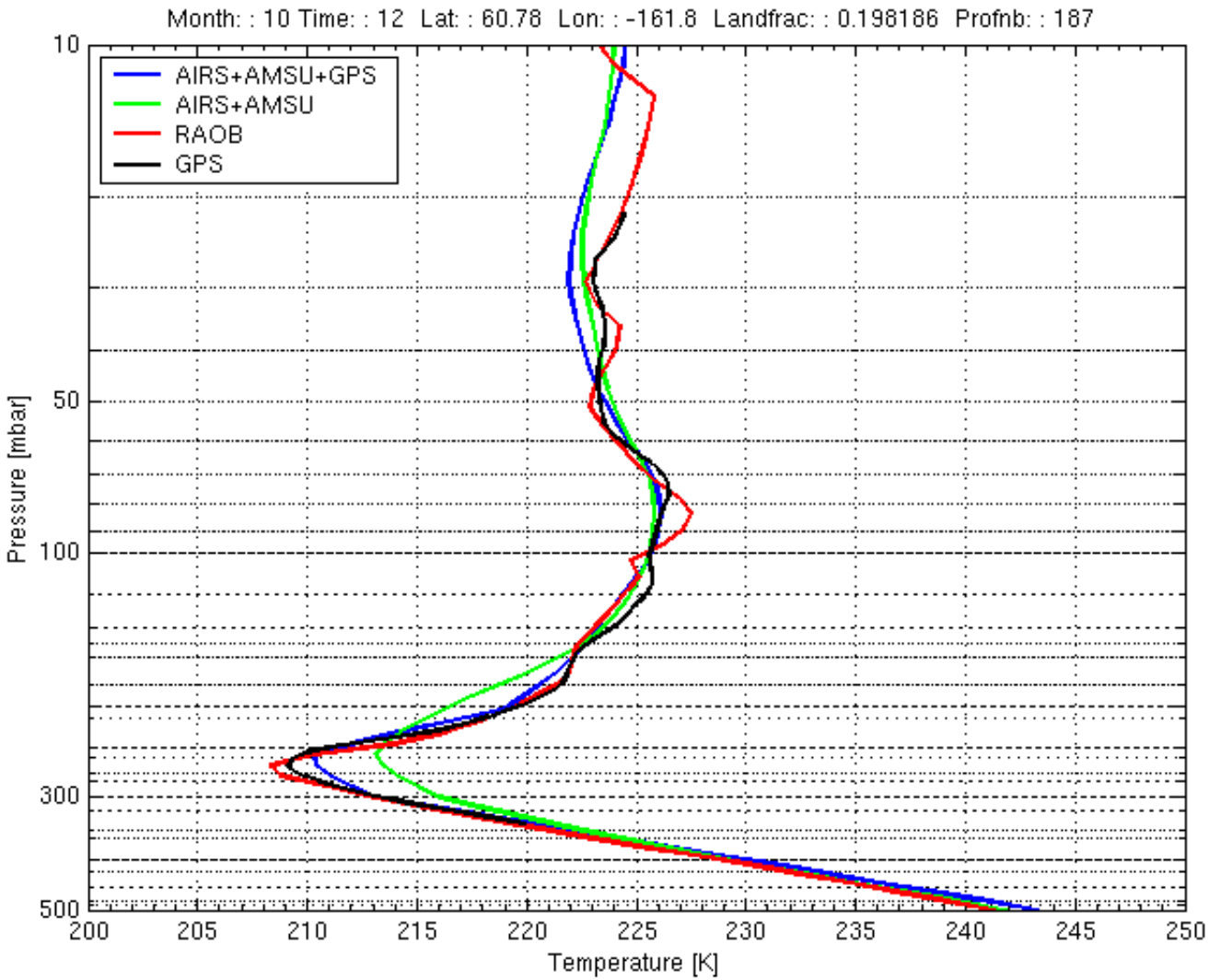
In clear sky conditions, AIRS L2 v3 temperature retrievals perform better than AIRS+AMSU regression retrievals but worse than AIRS+AMSU+GPS. The part of the atmosphere that shows the greatest improvement from inclusion of GPS is the tropopause.

For moisture, AIRS L2 is the best, followed by AIRS+AMSU+GPS and last is AIRS+AMSU (without GPS)

Future Plans

- Expand the dataset with more collocations
- Investigate the lower troposphere more
- Compare with operational AIRS L2 retrievals when v4 is available
- Use v4 software to integrate GPS (if source code becomes available)
- Integrate GPS data in cloudy retrievals


Month: : 5 Time: : 12 Lat: : 53.55 Lon: : -114.1 Landfrac: : 0.978044 Profnb: : 108
AIRS+AMSU+GPS
AIRS+AMSU
RAOB
GPS
Pressure [mbar]
10
50
100
300
500
200
205
210
215
220
225
230
235
240
245
250
Temperature [K]


Month: : 10 Time: : 12 Lat: : 60.78 Lon: : -161.8 Landfrac: : 0.198186 Profnb: : 187
AIRS+AMSU+GPS
AIRS+AMSU
RAOB
GPS
Pressure [mbar]
10
50
100
300
500
200
205
210
215
220
225
230
235
240
245
250
Temperature [K]

International TOVS Study Conference, 14th, ITSC-14, Beijing, China, 25-31 May 2005. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2005.