Effects of GPS/RO refractivities on IR/MW retrievals

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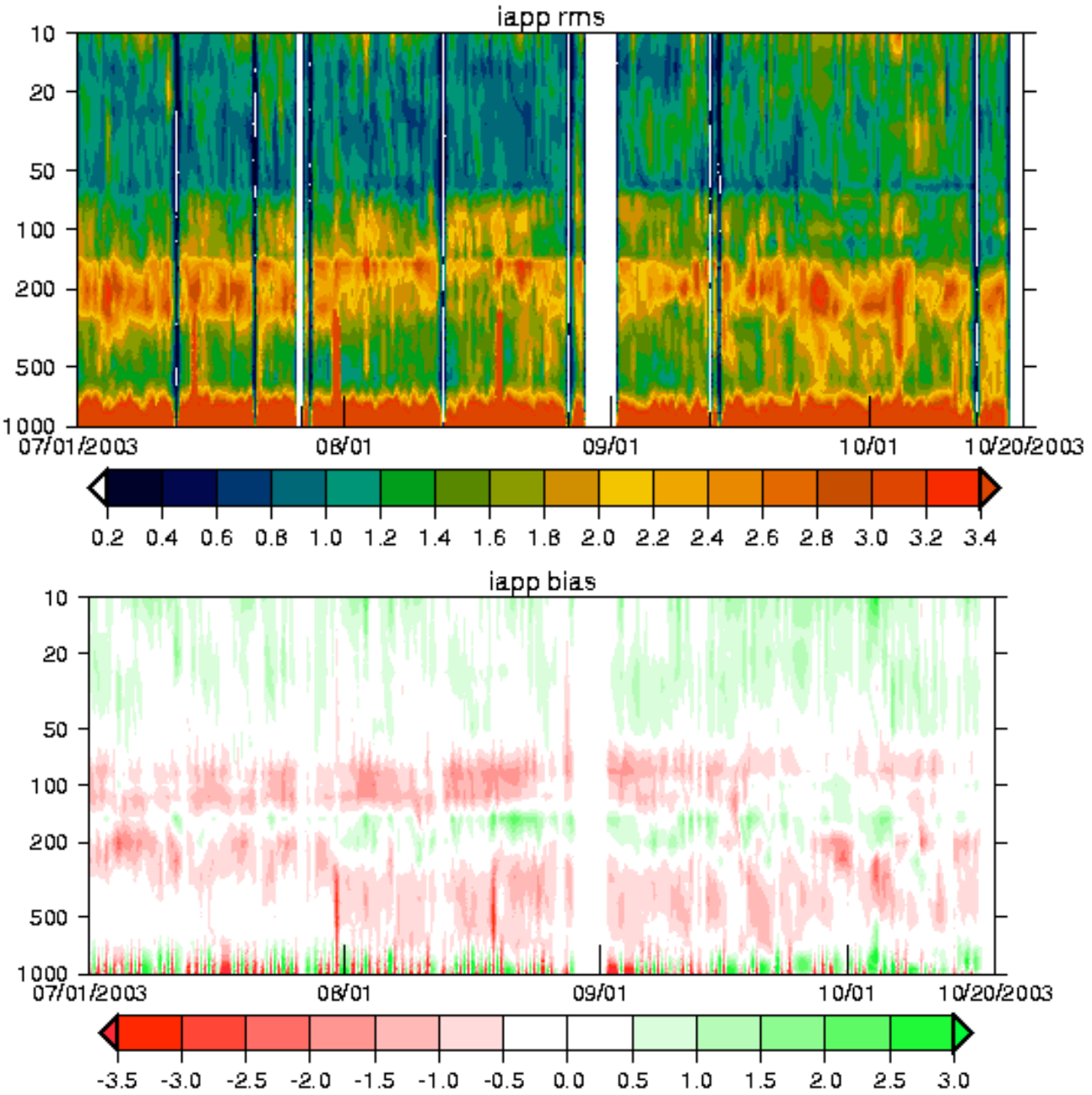
Outline

- Motivation
- Characteristics of the two types of systems
- Simulation approach
- Results of simulation studies
- Preliminary results with real data
- Summary, Future plans

Temperature NOAA17

NCEP Model minus ATOVS IAPP retrieval

Jul 01 to Oct 20 2003



Characteristics of the two types of systems

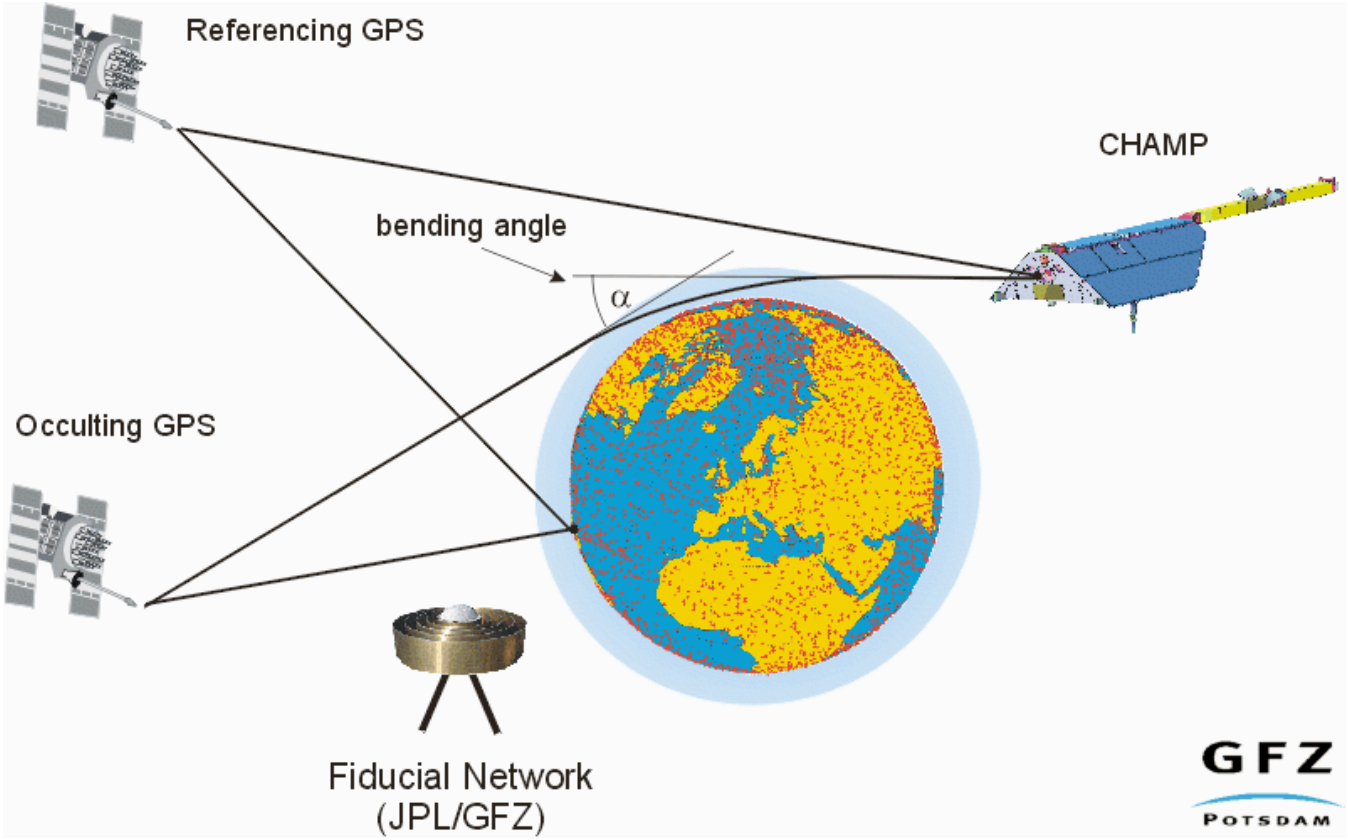
GPS/RO

- 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
- little information around the tropopause

Geometry of radio occultation



$$N = 77.6\frac{P}{T} + 3.73*10^5\frac{P_w}{T^2} + 4.03*10^7\frac{n_e}{f^2} + 1.4W$$

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Statistical regression retrieval method

NOAA88 data set (training 90 %)

(Forward Models)

Simulated Brightness Temperatures, Refractivities, SFC

(BT, N, T_{sfc}, W_{sfc}, BT^2, N^2, T_{sfc}^2, W_{sfc}^2)

Regression Coefficients

Temp and Humidity Retrievals (NOAA88 – test 10 %)

Simulation of data

ATOVS/CrIS brightness temperatures:

- model called **PFAAST** (pressure layer fast algorithm for atmospheric transmittances)
- 42 pressure level from 0.1 to 1050 hPa
- **Noise:** NedT + 0.2 K forward model noise
- 39 ATOVS channels, 393 selected CrIS channels

GPS/RO refractivity profiles:

- 1 km vertical resolution between 6 and 28 km (23 levels)

$$N(z) = c_1 \frac{P(z)}{T(z)} + c_2 \frac{P_w(z)}{T^2(z)}$$

- Vertically correlated measurements errors

(Healy & Eyre, 2000; Kursinski et al., 1997)

Surface temperature: $T_{sfc} = T_{lowest} + noise(0.5K)$ (Kelvin)

Surface mixing ration: $w_{sfc} = w_{lowest} + noise(10\%)$ (g/g)

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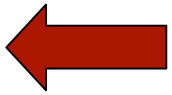
- **Results of simulation studies** 
  - Impact of different sources of information
  - Impact of GPS noise
- **Preliminary results with real data**
- **Summary, Future plans**

Impact of different sources of information

Retrievals from different combinations of satellite data (IR, MW, and GPS/RO) are compared to radiosonde profiles

RTVL(IR) RTVL(GPS) RVL(IR + SFC) RTVL(IR +GPS)

RTVL(IR +AMSU + SFC) …….

Better agreement with radiosondes assumed to indicate improved retrievals

Statistics of bias and rms differences calculated

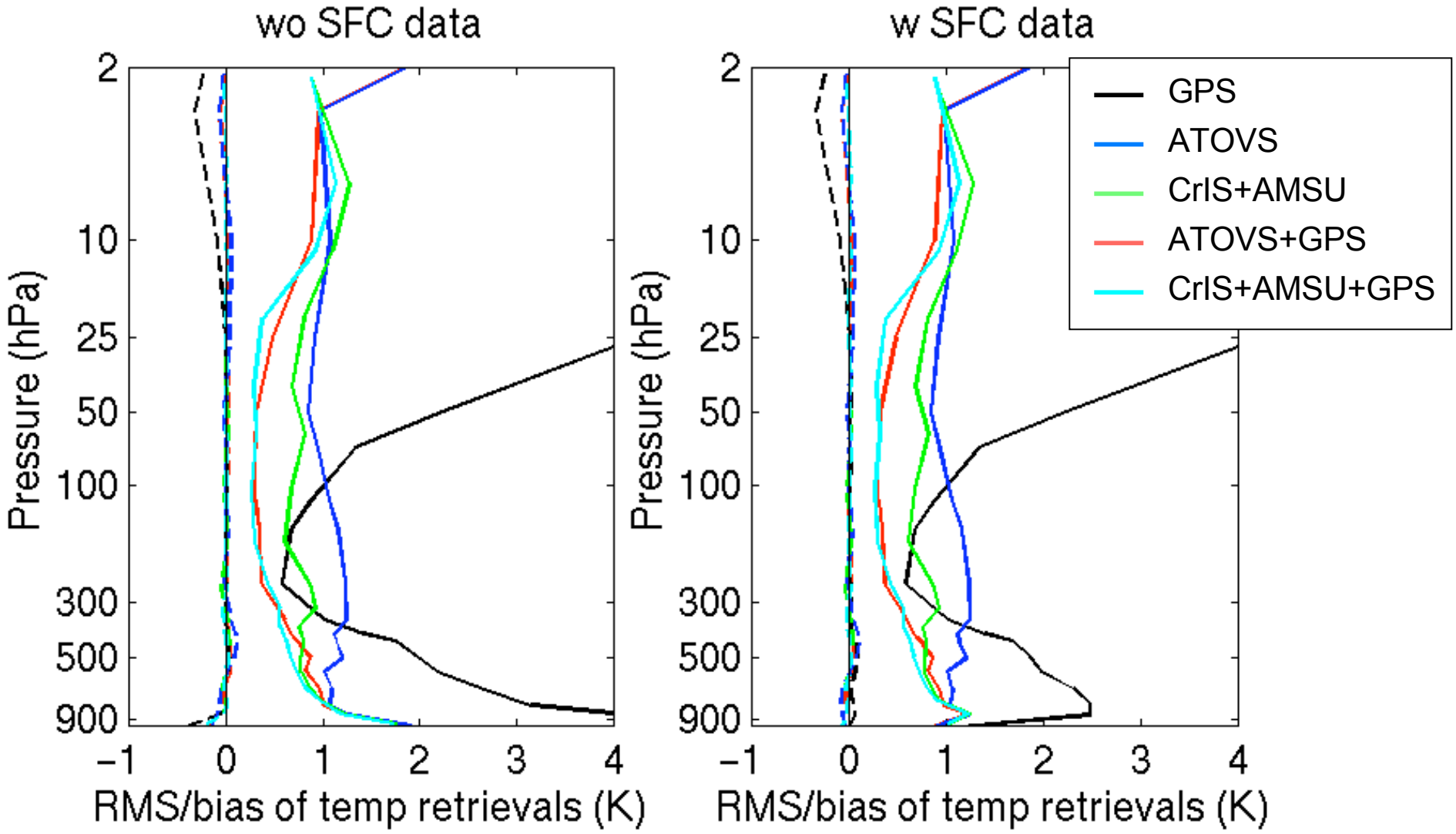
1 km layers of temperature profiles

2 km layers of mixing ratio profiles up to 300 hPa

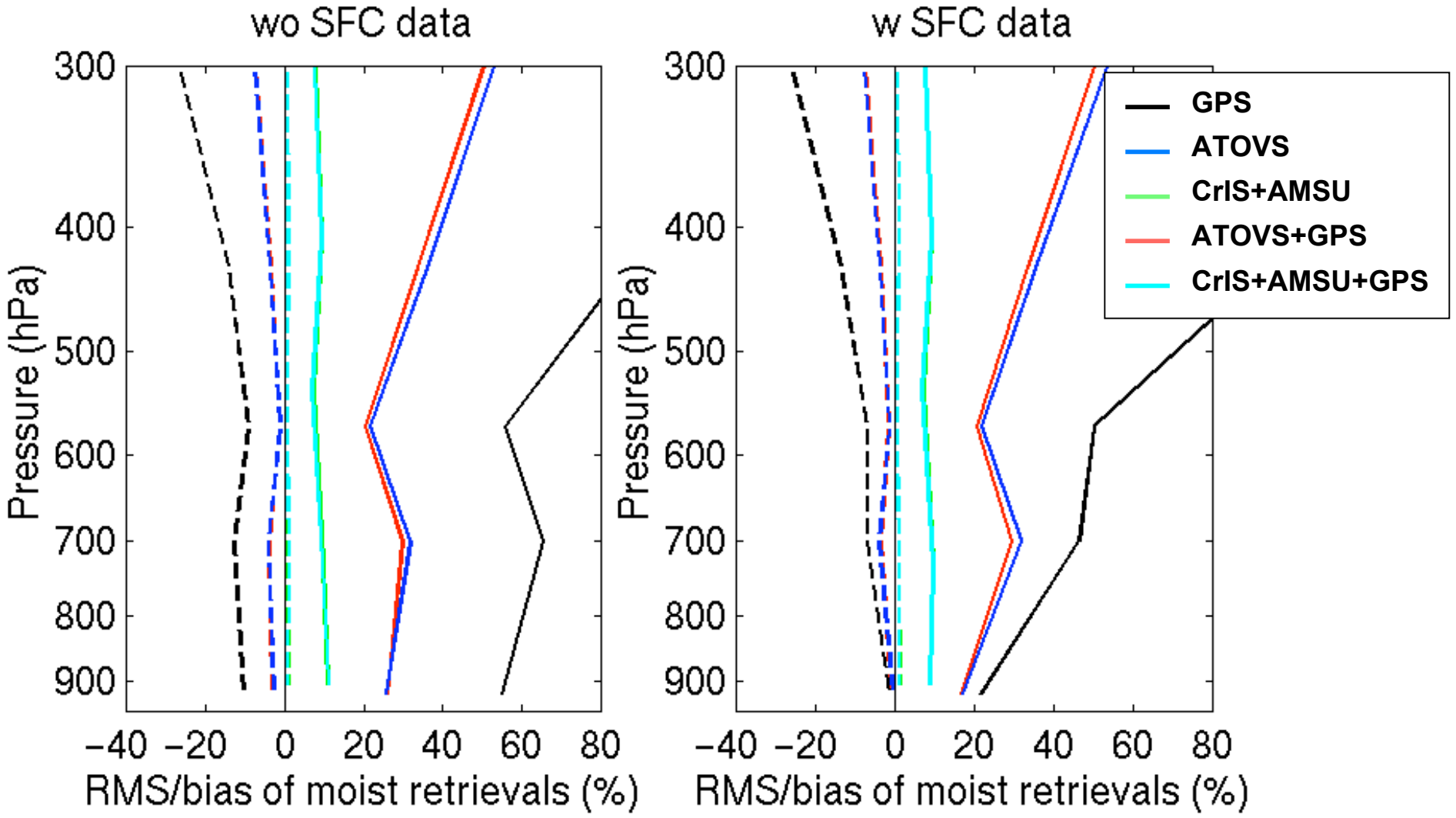
$$BIAS = \frac{1}{n} \sum \frac{w_{true} - w_{retr}}{w_{true}}$$

$$RMS = \sqrt{\frac{1}{n} \sum \left(\frac{w_{true} - w_{retr}}{w_{true}} \right)^2}$$

RMS/bias diff of simulated temp retrievals from diff systems



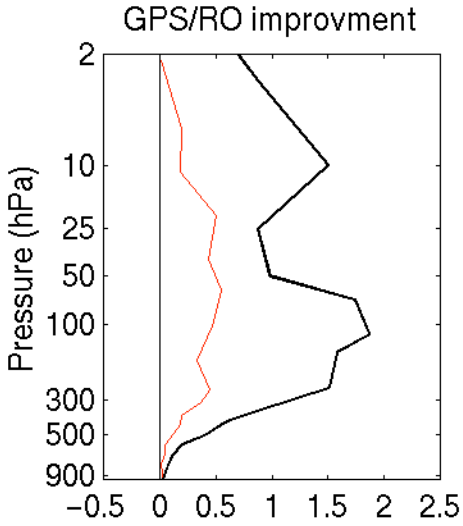
RMS/bias diff of simulated moist retrievals from diff systems

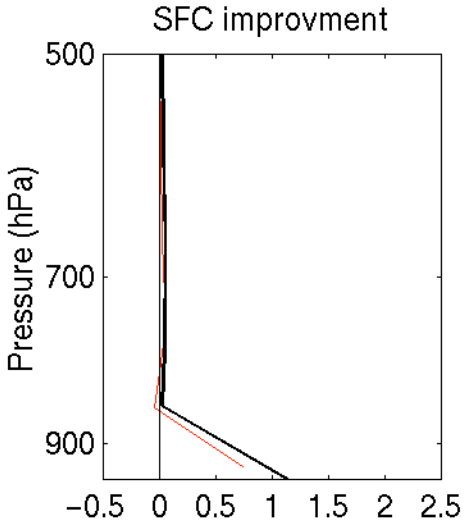


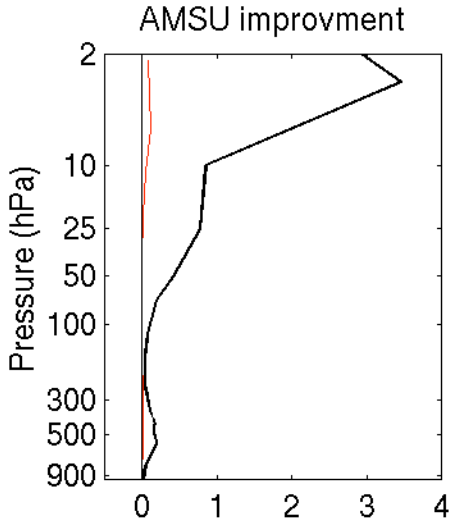
RMS difference of simulated temperature retrievals (K)

IR=HIRS

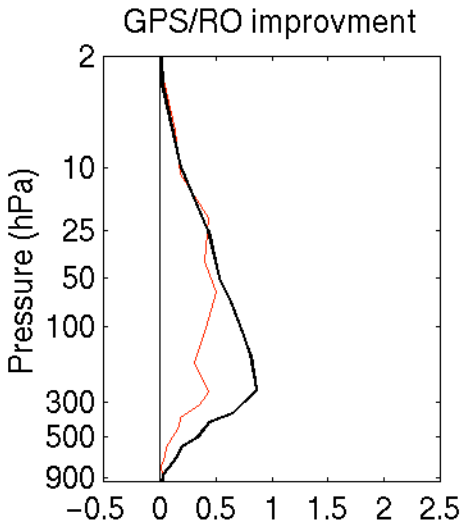
IR=CrIS

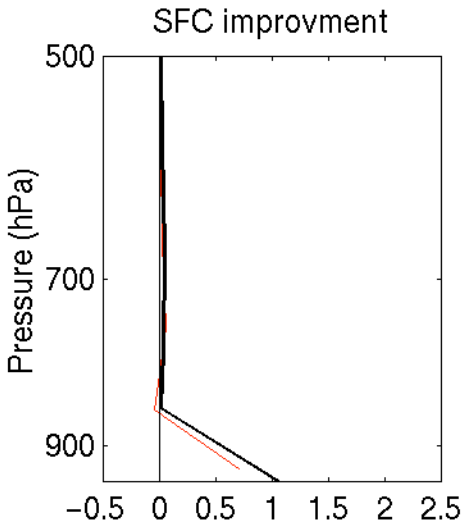


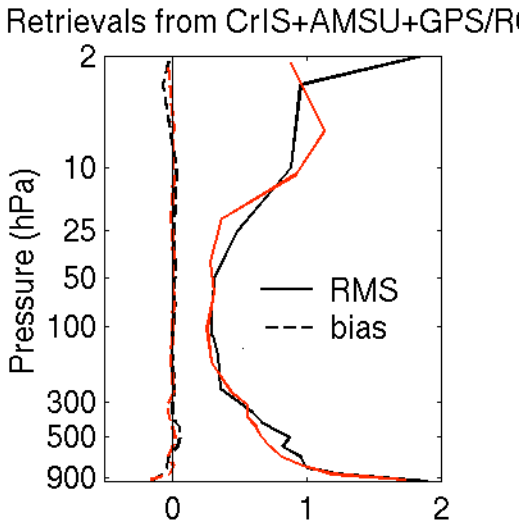




IR + AMSU



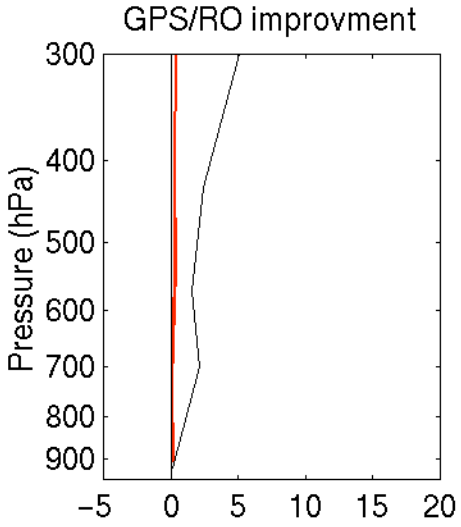


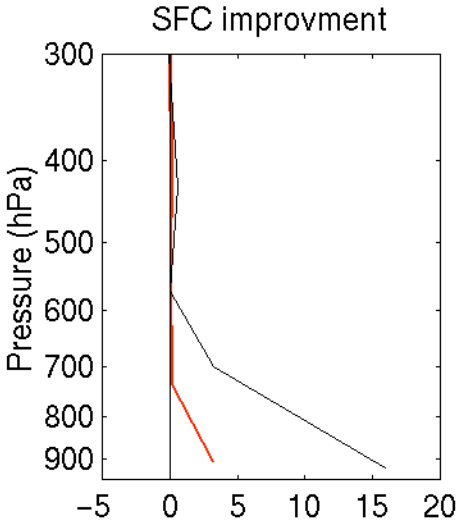


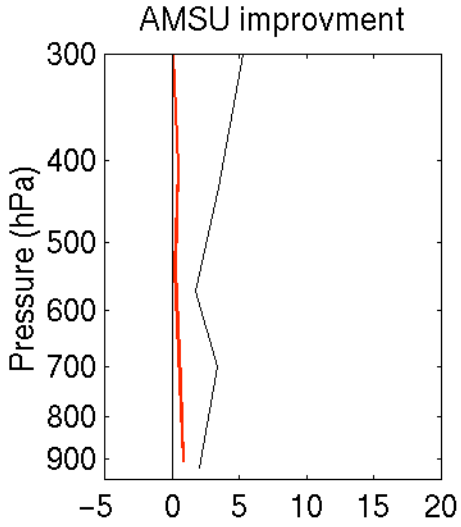
RMS difference of simulated moisture retrievals (%)

IR=HIRS

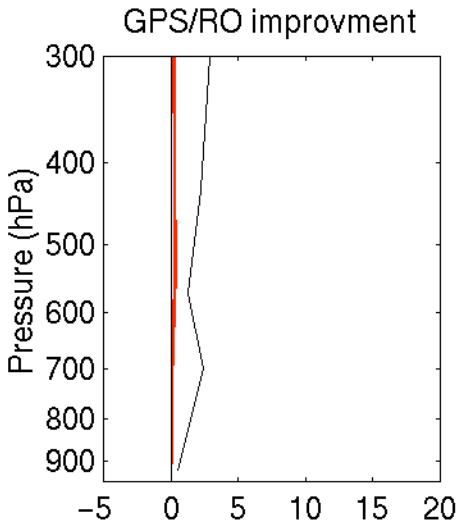
IR=CrIS

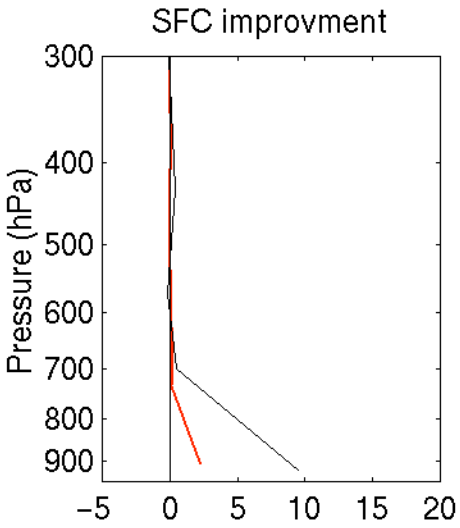


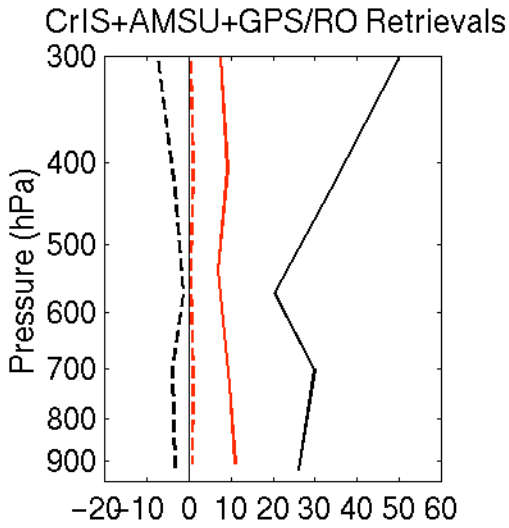




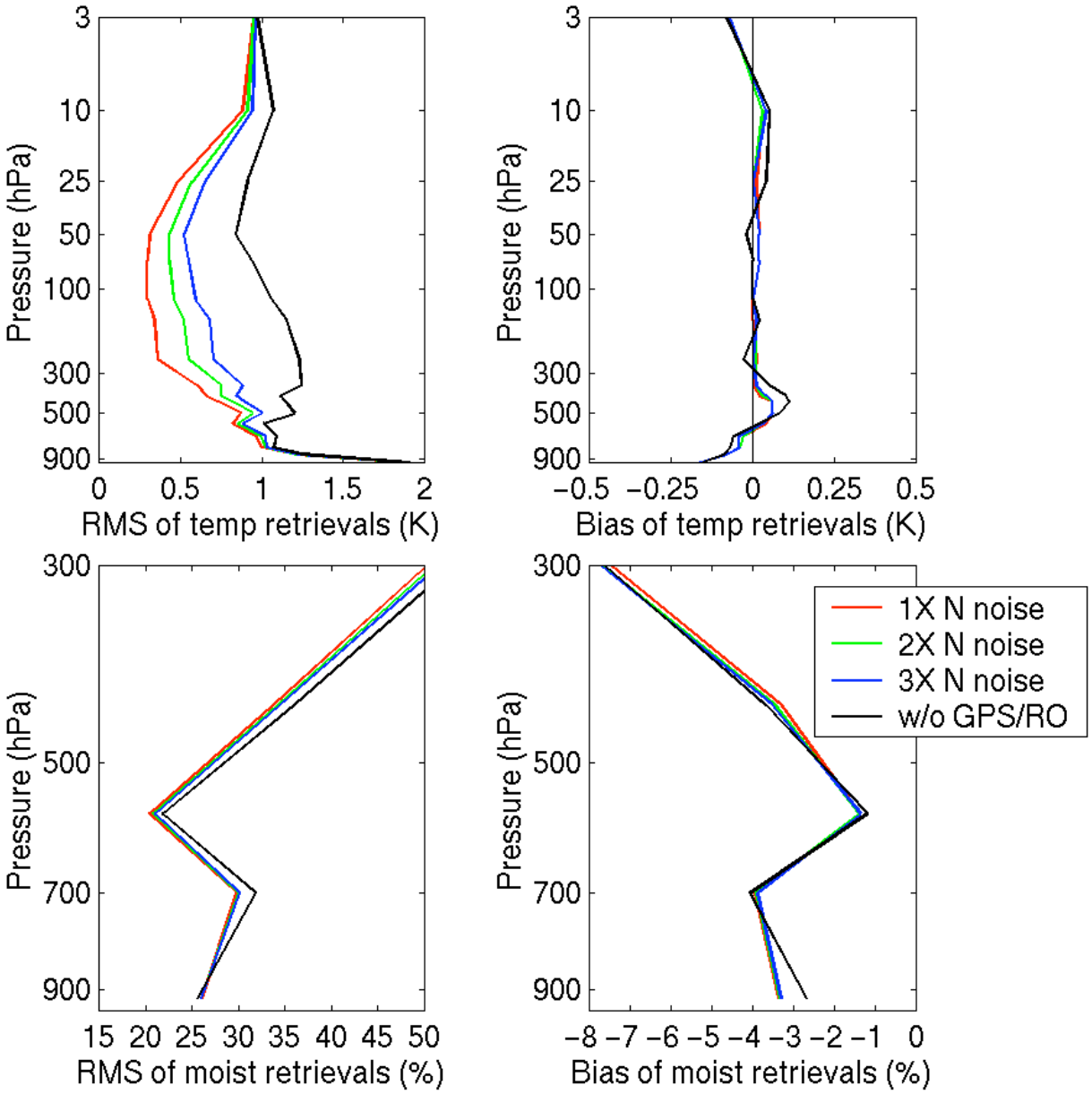
IR + AMSU







Impact of GPS/RO noise



Summary of simulation studies

GPS/RO improves:

HIRS (GOES) temp retrievals

from the tropopause by 1.8 K down to 450 hPa by 0.5 K. (Wu et al., 1998)

between 10 hPa and the tropopause by about 0.8 K

ATOVS (AMSU plus HIRS) **temp** retrievals

around the tropopause level by 0.8 K.

between 30 hPa and the tropopause by about 0.5 K.

CrIS+AMSU temp retrievals

between 10 hPa and the tropopause by about 0.4 K (Collard and Healy, 2003)

HIRS (GOES) moist retrievals

at 250 hPa by 5 % and at 700 hPa by about 2 %.

ATOVS moist retrievals

from 250 to 780 hPa by about 2.5 %.

Tripling GPS/RO N noise lowers the ATOVS temperature improvement

by 0.5 K from 85 to 350 hPa → real studies !!!!

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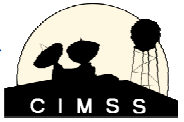
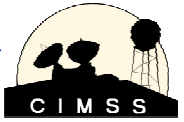


Data

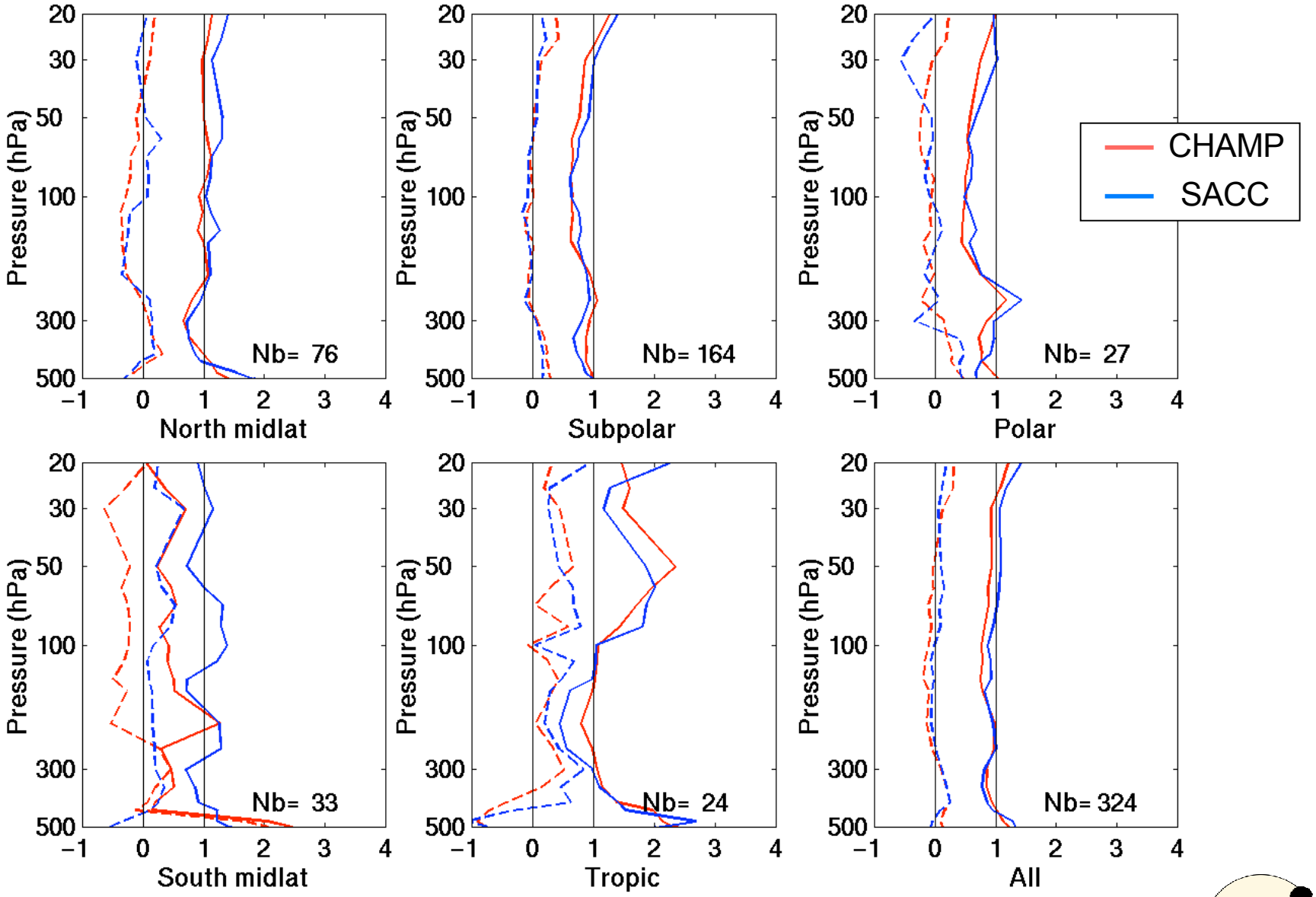
GPS/RO data	CHAMP and SACC (from GFZ & JPL) May 2001 to July 2002 1 km vertical resolution between 8 and 30 km (~350 to 10 hPa) excluding polar regions
IR/MW data:	NOAA-16 ATOVS BT (processed by IAPP at CIMSS) 16 HIRS + 12 AMSU-A + 4 AMSU-B 3X3 HIRS FOVs mean of the clear sky FOVs / all 9 cloudy FOVs
RAOB	
NWP	AVN / NCEP analyses (00, 06, 12, 18 UTC)
Collocations:	interpolation to GPS/RO measurements (11 km altitude) vertical interpolation to ATOVS pressure levels within 3 hour , 300 km for multiple ATOVS FOVs choose clearest and closest in time

Regression retrievals

- Statistical regression (similar as simulation studies)
- Two sets: with and without GPS/RO data
- Training data: AVN/NCEP analyses
- Validation data: RAOB collocations (excluded from training data)
- Four months (representative of four seasons)
- Classify by clear/cloudy & sea/land
- In cloudy conditions only MW channels are used
- QC: if deviation from RAOB >10 %, then temperature retrieval is rejected

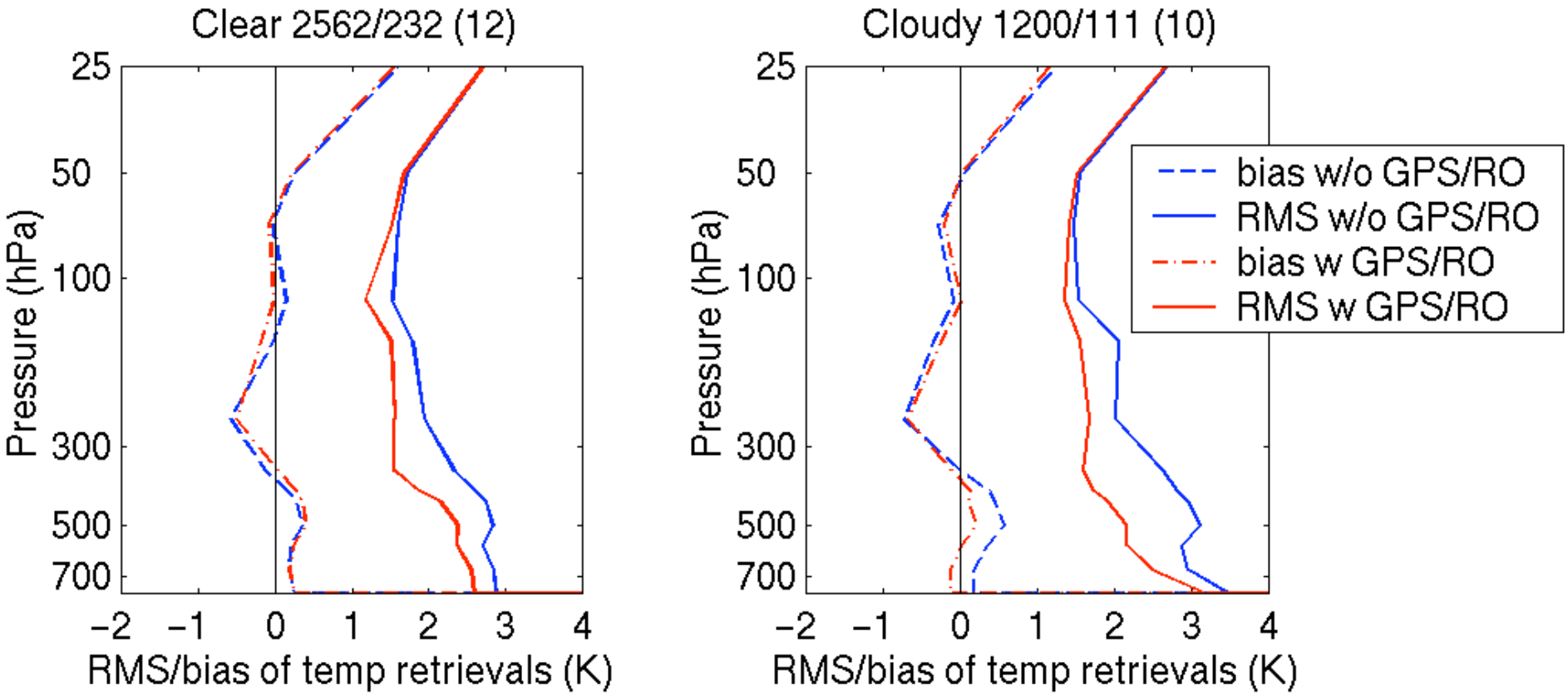


RAOB validation of CHAMP/SACC refractivities for April 2002



RAOB validation of CHAMP + ATOVS T(p)

Oct 2001, Jan, Apr and July 2002



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

Summary

- Simulation studies showed GPS/RO improve radiometric temperature retrievals
- Refractivity data are most different in the tropics and most alike in the sub polar region; refractivity data are most different above 100 hPa
- Quality of SAC-C and CHAMP refractivity data within 1% overall
- GPS/RO refractivity data improves the radiometric (ATOVS) temp retrievals around the tropopause by 0.5 K (larger impact over the cloudy skies)

Future plans

- Conduct similar studies with a high resolution IR data (AIRS)

International TOVS Study Conference, 13th, TOVS-13, Sainte Adele, Quebec, Canada, 29 October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.