Clear-Air Forward Microwave and Millimeterwave Radiative Transfer Models for Arctic Conditions

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Motivation for Arctic Forward Model studies

1) Arctic moisture and clouds play a key role in our climate, but are difficult to measure because of small concentrations

2) Conventional instruments (MWR, GPS, radiosondes) show small sensitivity to low Precipitable Water Vapor (PWV) and Liquid Water Path (LWP). Therefore, scaling of radiosondes by PWV (done by ARM) is questionable

3) Radiometers operating at mm- and submm-wavelengths offer greatly-enhanced sensitivity to PWV and LWP

4) To utilize enhance sensitivity to small amounts of vapor and clouds, accurate forward models are imperative

The Arctic Winter Radiometric Experiment
WVIOP2004

PI: E.R. Westwater
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ARM: J. C. Liljegren, B. M. Lesht
Period: March-April 2004
Location: ARM NSA, Barrow, Alaska

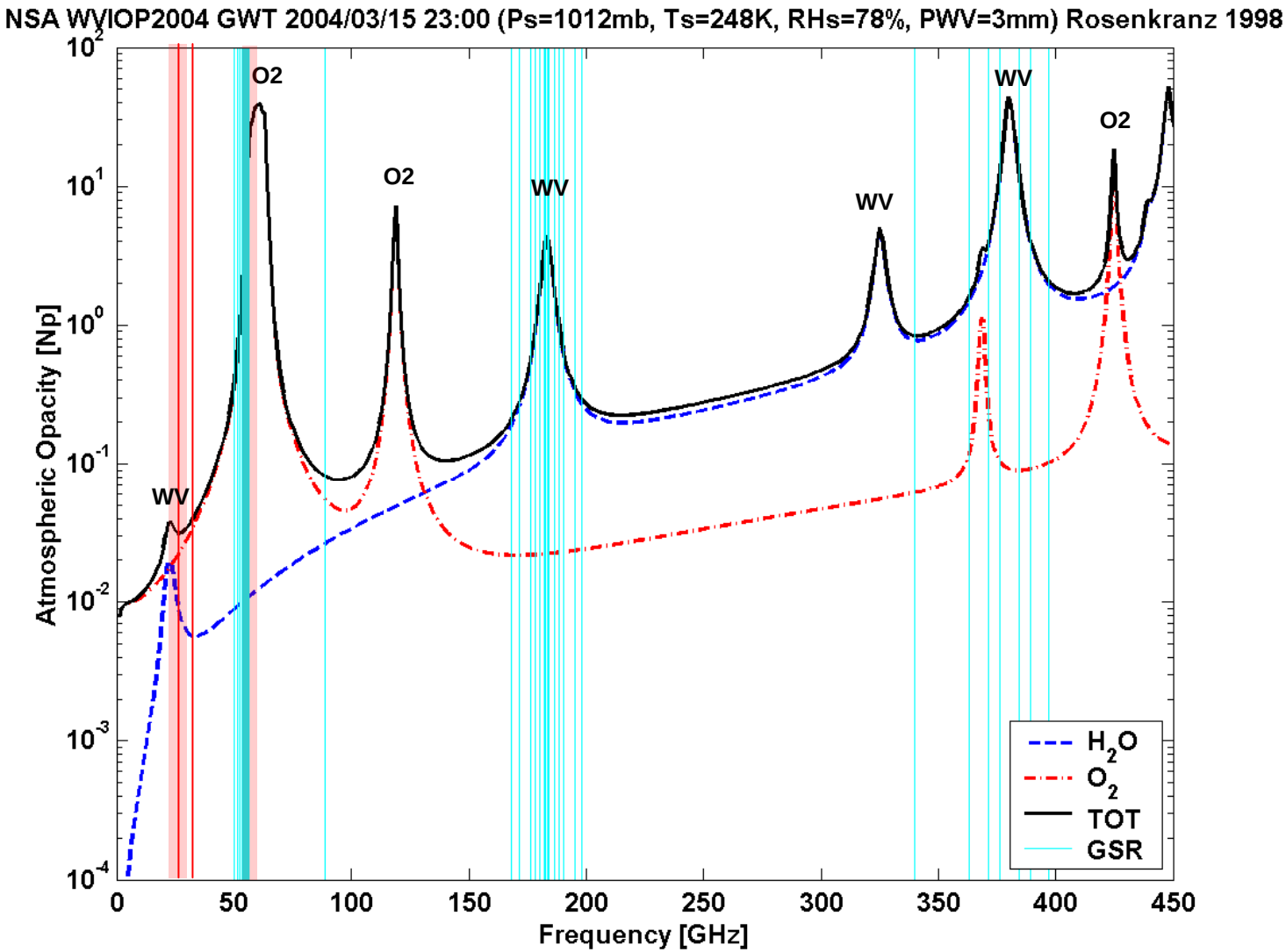
Instruments:

1) Dual channel Microwave Radiometer (MWR):
23.8; 31.4 GHz

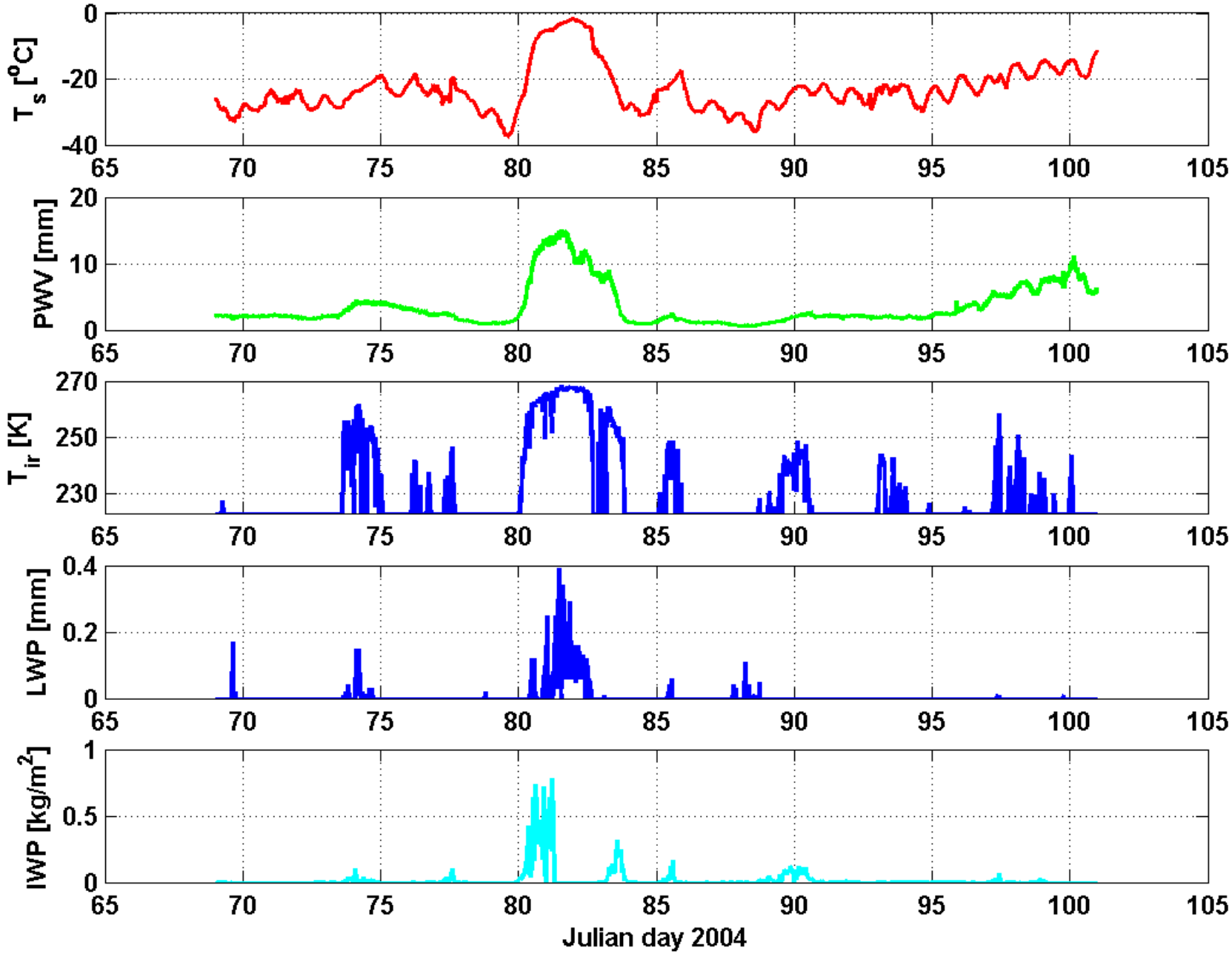
2) 12-channel Microwave Radiometer Profiler (MWRP):
22.235; 23.035; 23.835; 26.235; 30.0 GHz
51.25; 52.28; 53.85; 54.94; 56.66; 57.29; 58.8 GHz

3) 25-channel Ground-based Scanning Radiometer (GSR)
50.2; 50.3; 51.76; 52.625; 53.29; 53.845; 54.4; 54.95; 56.215;56.325 GHz
89 V; 89 H GHz
183.31±0.55; ±1; ±3.05; ±4.7; ±7; ±12; ±16 GHz
340 V; 340 H GHz 380.197±4; ±9; ±17 GHz

Atmospheric Opacity for Arctic Conditions



WVIOP2004 Time series of meteorological variables



Radiosondes launched during the experiment

VAISALA RS90-A

4 times per day at the ARM Duplex (00, 06, 12, 18 UTC)

1 time per day at the ARM "Great White" (00 UTC)

Temperature sensor: F-Thermocap (capacitive wire)
Humidity sensor: Heated twin-sensor H-Humicap

GPS Mark II & Meteolabor "SNOW WHITE" (NASA)

5 at night, 3 during the day

Temperature sensor: VIZ short rod thermistor;

Humidity sensors: VIZ carbon hygristor;
Meteolabor chilled mirror

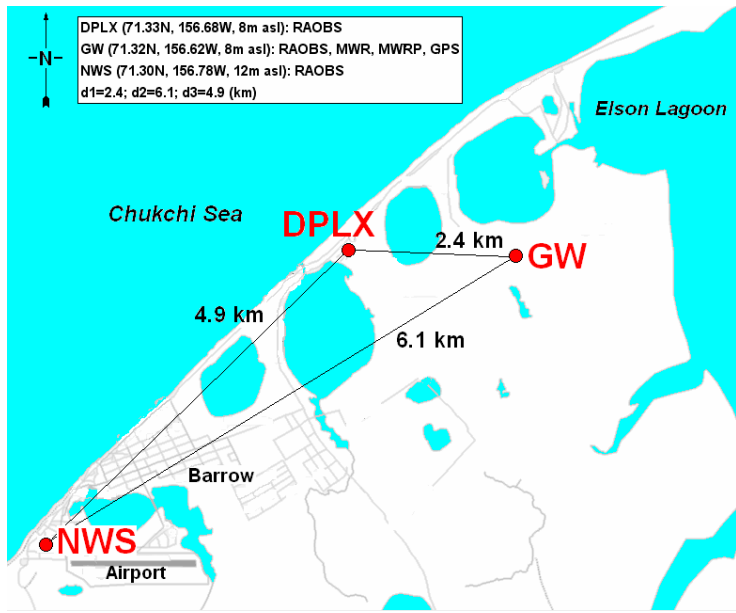
Dual-radiosonde launches: Vaisala RS90 and Sippican Mark II & Meteolabor Snow White

VIZ-B2

(National Weather Service)

2 times per day in Barrow (00, 12 UTC)

Temperature sensor: VIZ long rod thermistor; Humidity sensor: VIZ carbon hygristor



Forward Model And Radiosonde Comparisons

INPUT TO MODELS = T, RH, AND P FROM RADIOSONDES
CLEAR SKIES DETERMINED FROM MWRP IR

Models

- Liebe 1987
- Liebe 1993
- Rosenkranz (1998)
- Rosenkranz (2003)
- Liljegren (2005)

Radiosondes

- Vaisala RS90 (Dplx)
- Chilled mirror
- VIZ (NASA)
- Vaisala RS90 (GW)
- VIZ(NWS)

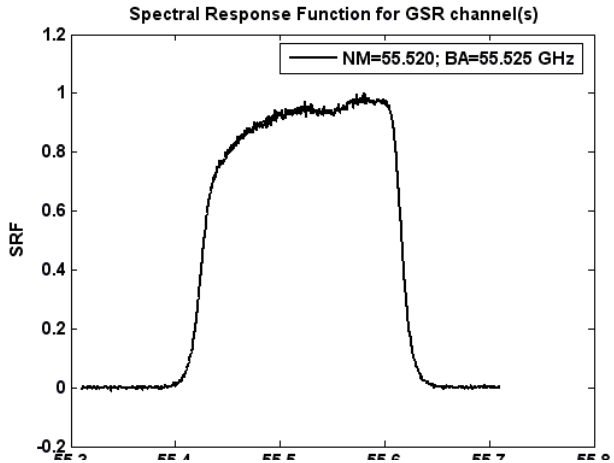
Some Details of Forward Model Comparisons

Radiometer Calibration

Internal Loads (10 ms)

External Blackbody Targets (2 min)

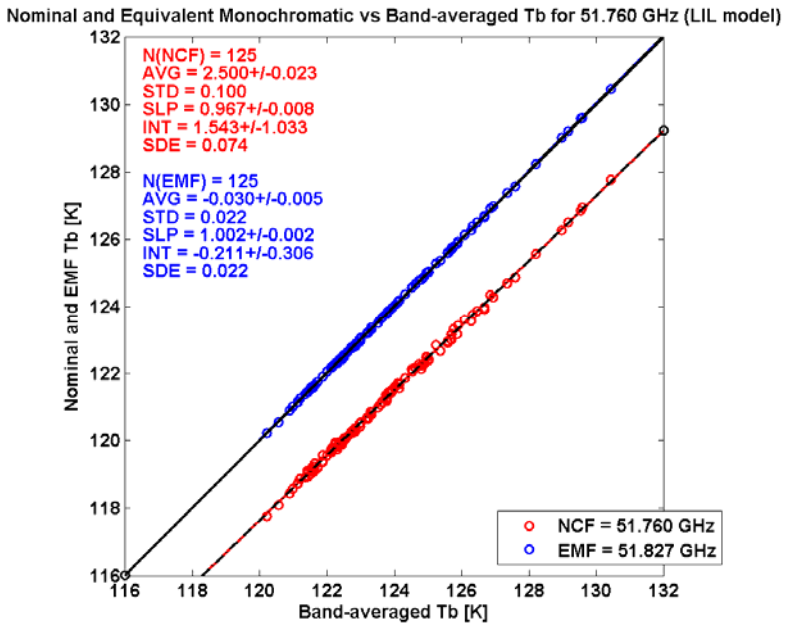
Tip Calibration (Window Channels)



Calculations from Radiosondes

Compute band-averaged Tb

Corrections to Monochromatic up to 2.5 K !



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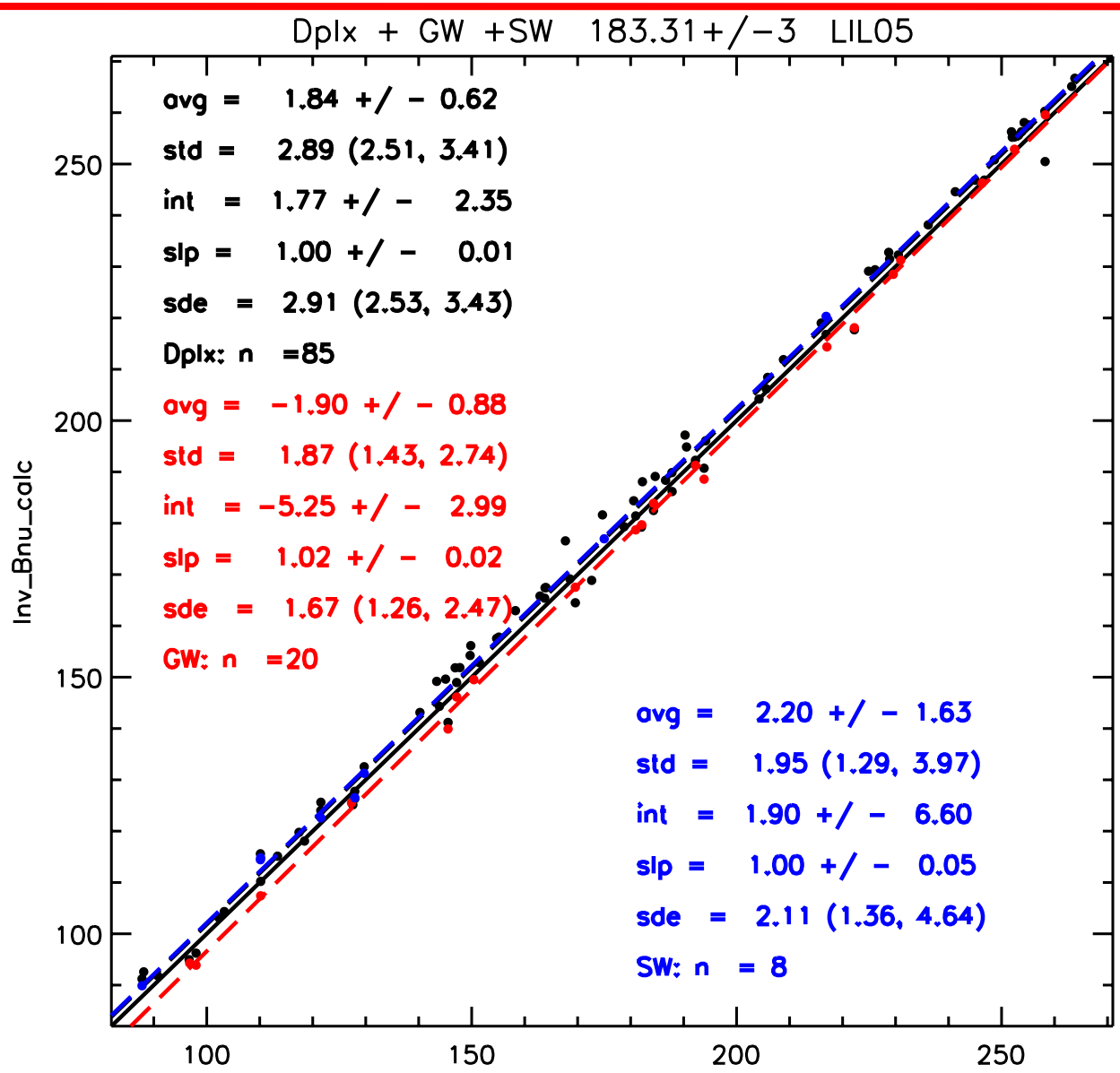
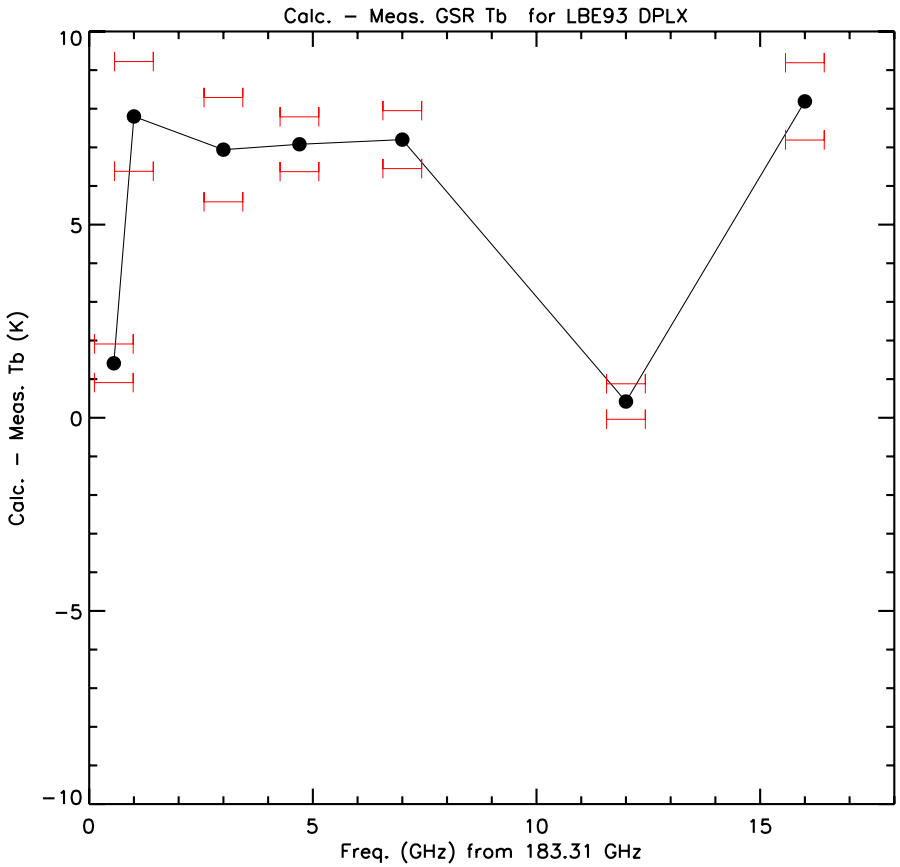
Typical results of Forward Model Analysis Near 183 .31 GHz

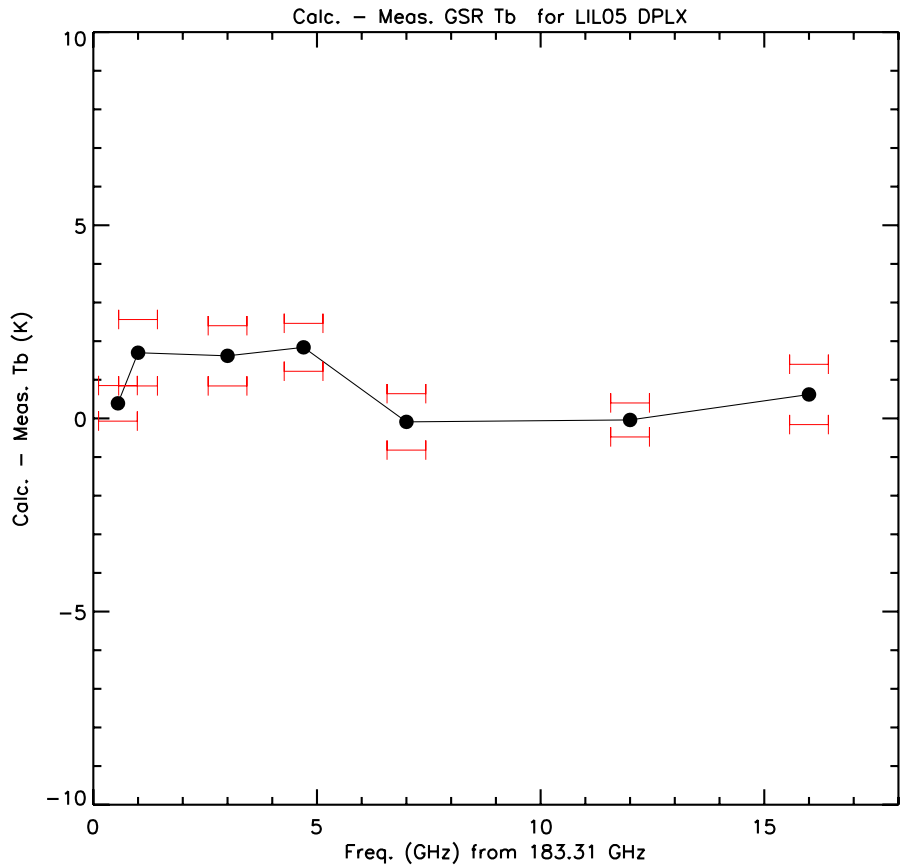


Forward model comparisons near 183.31 GHz

LBE93

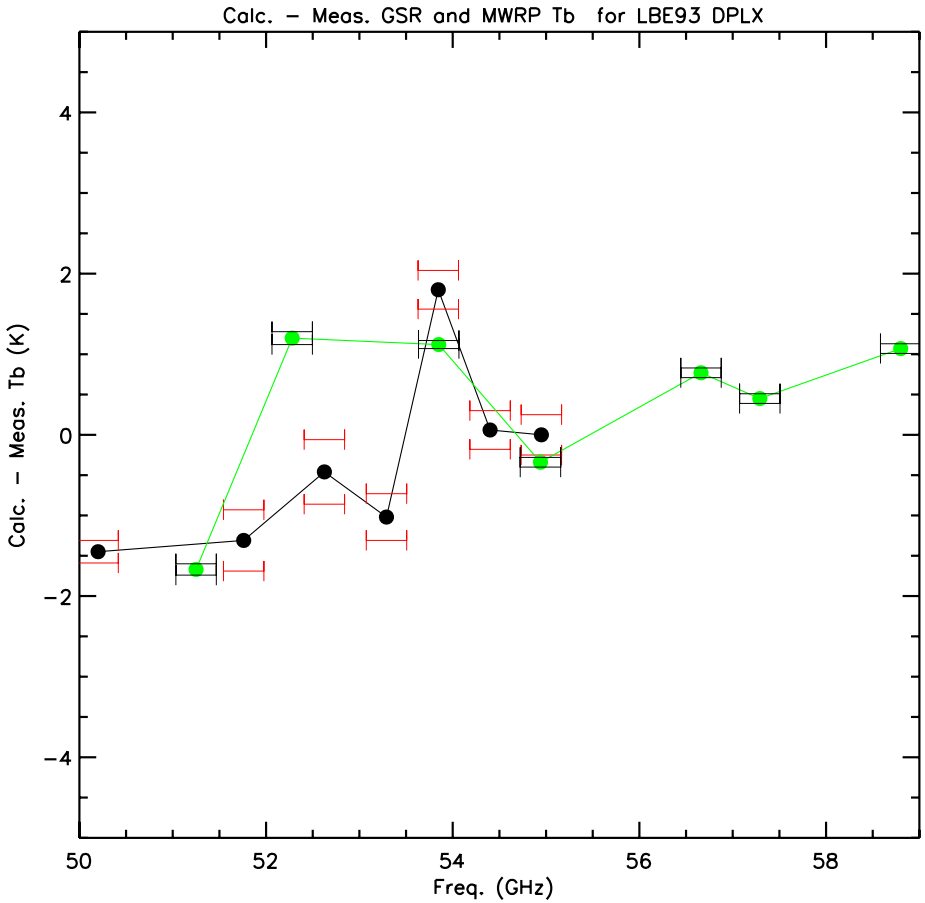


LIL05

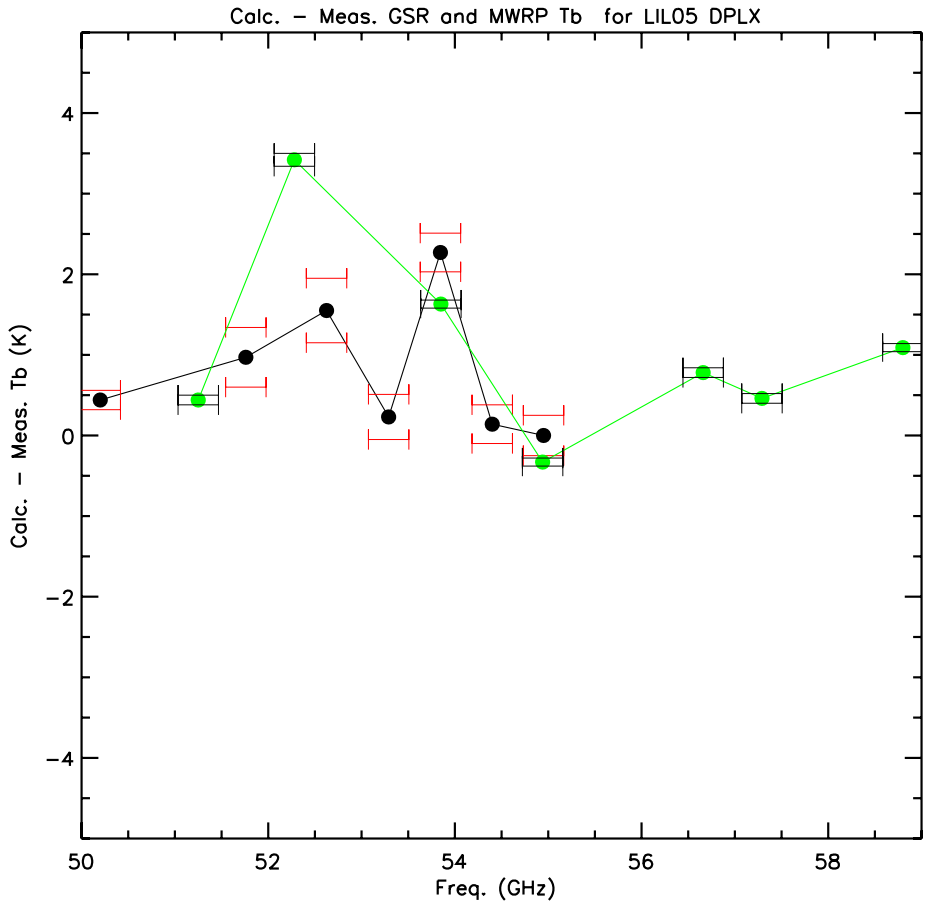


Forward model comparisons near 50-60 GHz For MWRP and GSR

LBE93

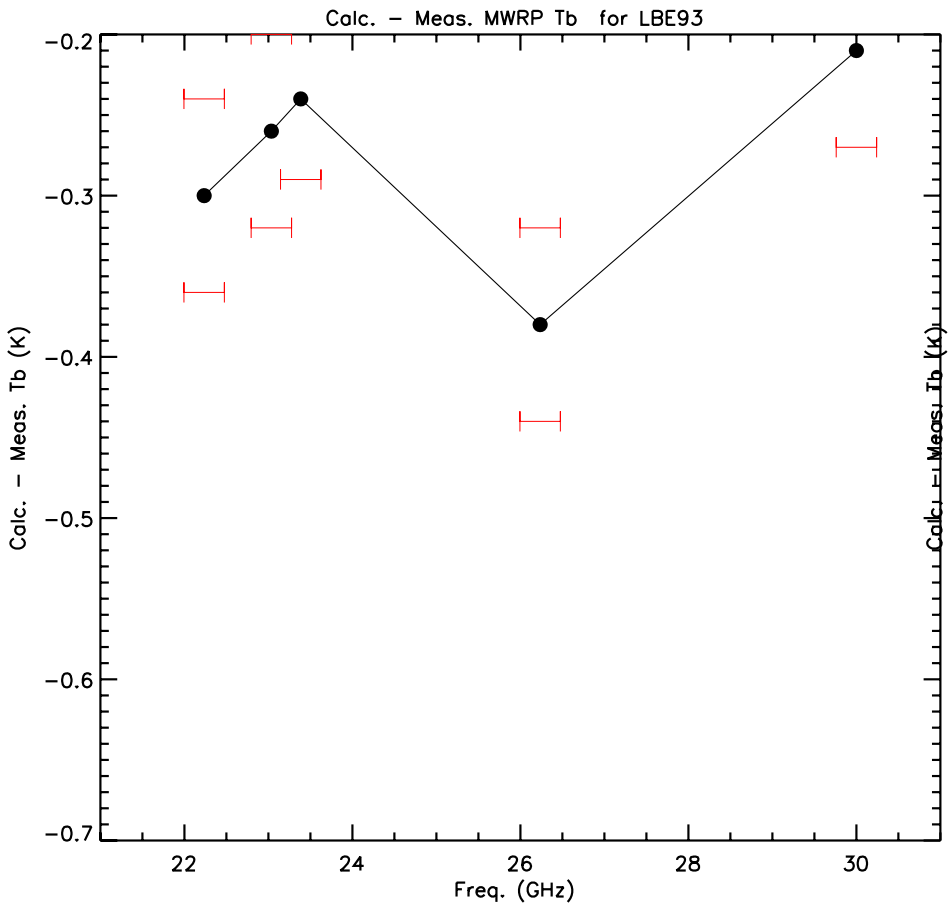


LIL05

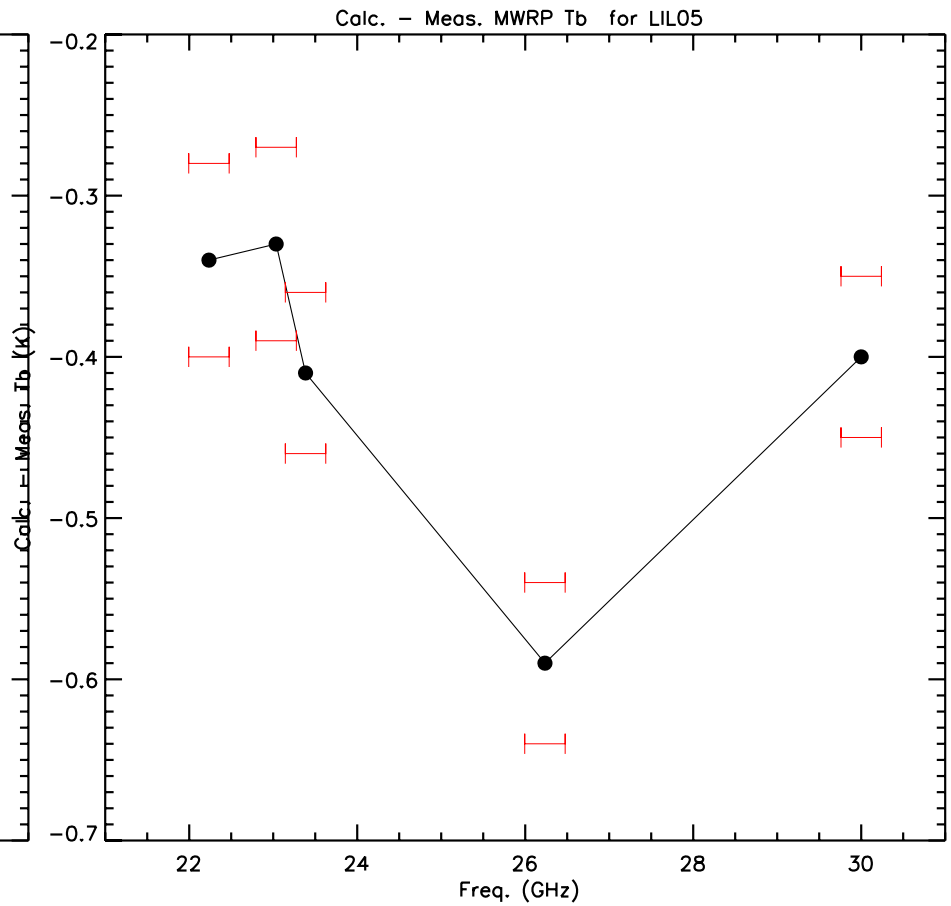


Forward model comparisons from 22.235 to 30.0 GHz for MWRP

LBE93

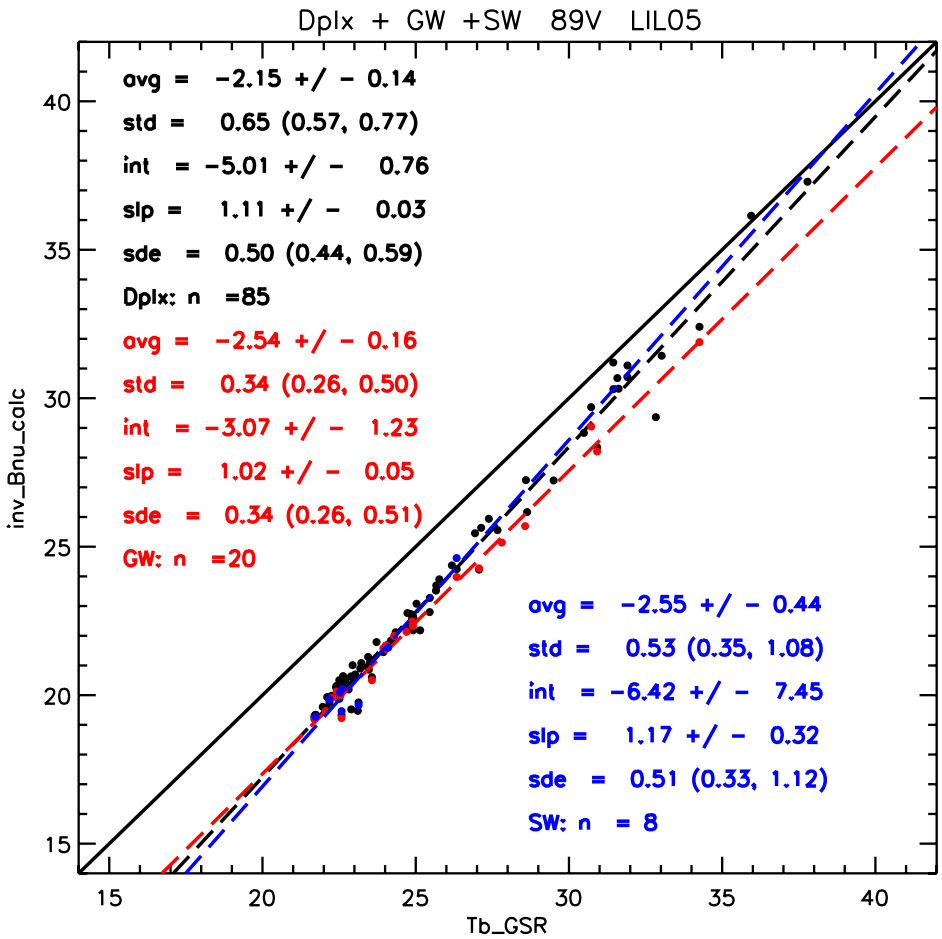


LIL05

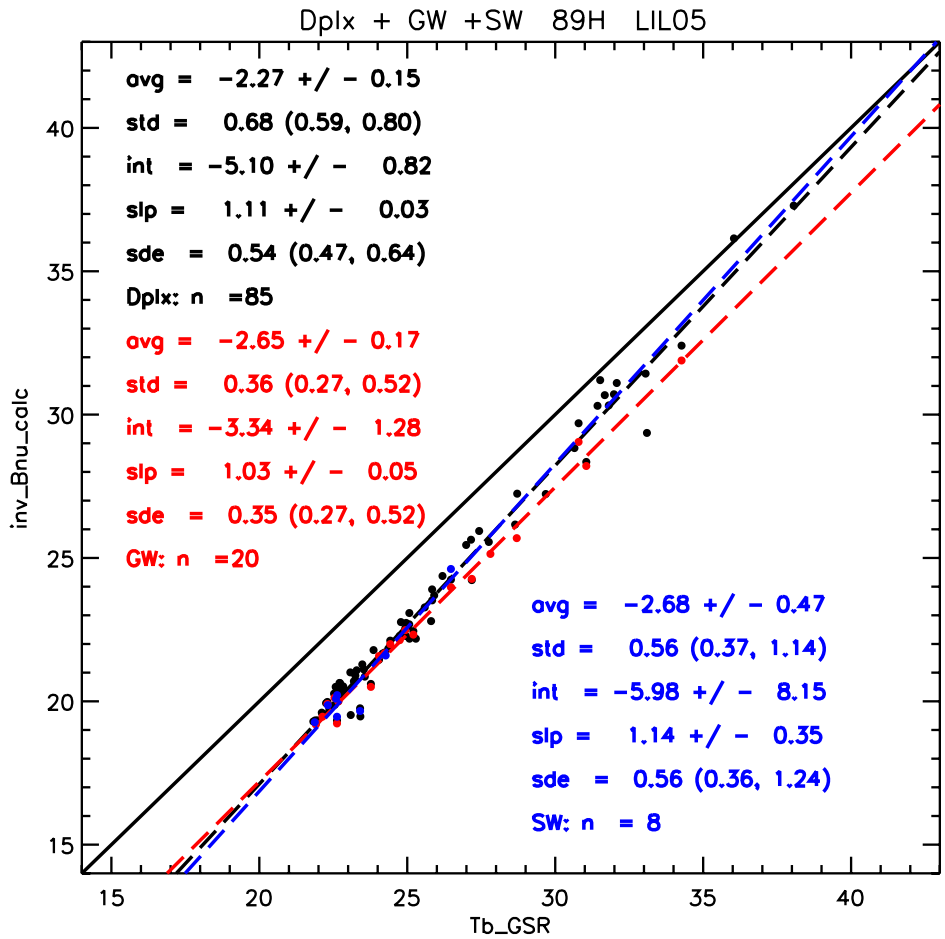


Forward model comparisons at 89 GHz for the GSR: A Puzzle

89V:LIL05



89H:LIL05



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Conclusions

- OVER A WIDE RANGE OF FREQUENCIES, THE LILJEGREN MODEL WORKS AS WELL OR BETTER THAN THE OTHER FIVE MODELS SHOWN

- MWRP AND GSR MEASUREMENTS AT TWO NEARLY COINCIDENT FREQUENCIES AGREE WITH EACH OTHER BUT NOT WITH ANY OF THE MODELS: TEMPERATURE DEPENDENCE OF O2 MODELS?

- UPWARD-LOOKING, MULTI-FREQUENCY RADIOMETERS ARE AN EXCELLENT TOOL FOR CLEAR-AIR FORWARD MODEL STUDIES

Work in Progress

- RETRIEVALS FROM BOTH MWRP AND GSR USING OPTIMAL ESTIMATION
- ANOTHER WINTER EXPERIMENT WILL BE CONDUCTED IN FEB.-MAR 2007

Thank you very much for your attention

International TOVS Study Conference, 15th, ITSC-15, Maratea,Italy, 4-10 October 2006
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2006.