Modifications to the Water Vapor Continuum in the Microwave Suggested by Ground-based 150 GHz Observations

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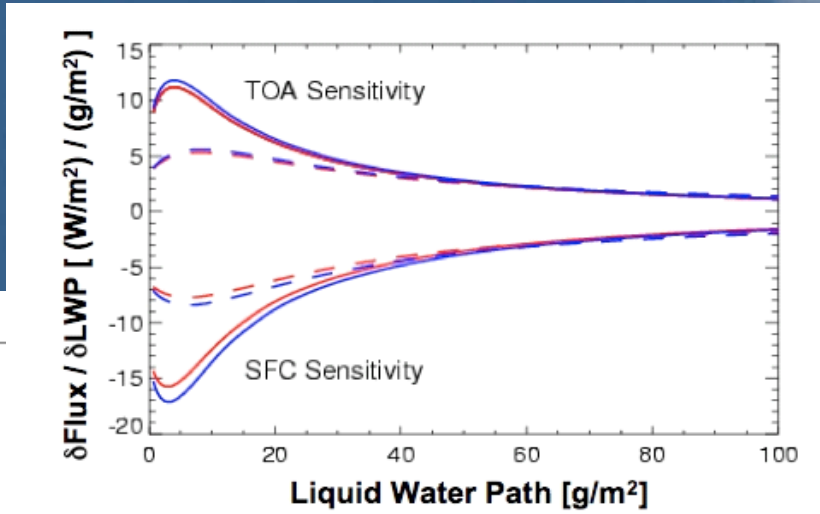
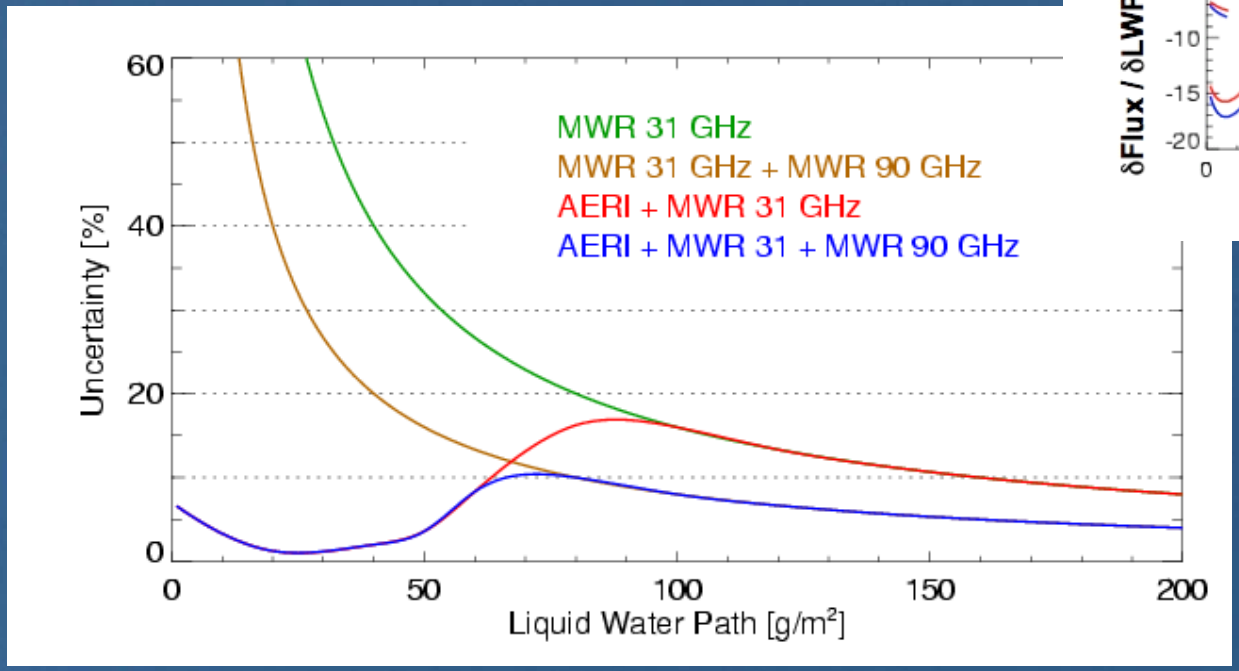
ARM Atmospheric Radiation Measurement Program

Importance of Higher Microwave Frequencies: Improved LWP

Adding 90 GHz obs decreases random error in LWP retrievals by factor of 2 over 23/31 GHz retrievals





Turner, Cadeddu, Löhnert, Crewell, Vogelmann
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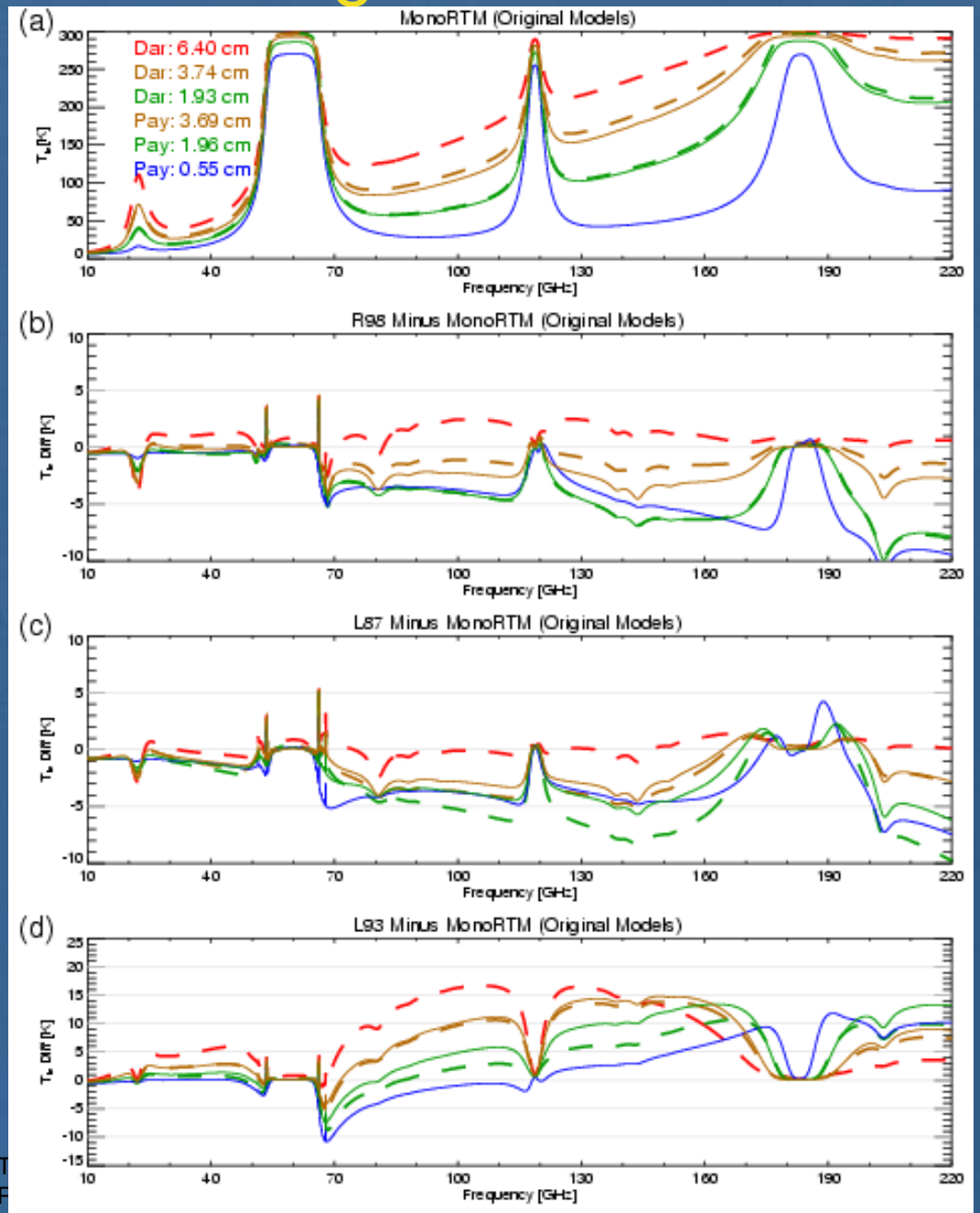
Large Differences Among RT Models



6 MONORTM simulations for 2 climatologies, only WV and O_2 considered, 2 overlapping pairs with similar water vapor amount

Rosenkranz '98 - MONORTM

Liebe and Layton '87 - MONORTM

Liebe et al. '93 - MONORTM

Two 90/150 GHz Radiometers

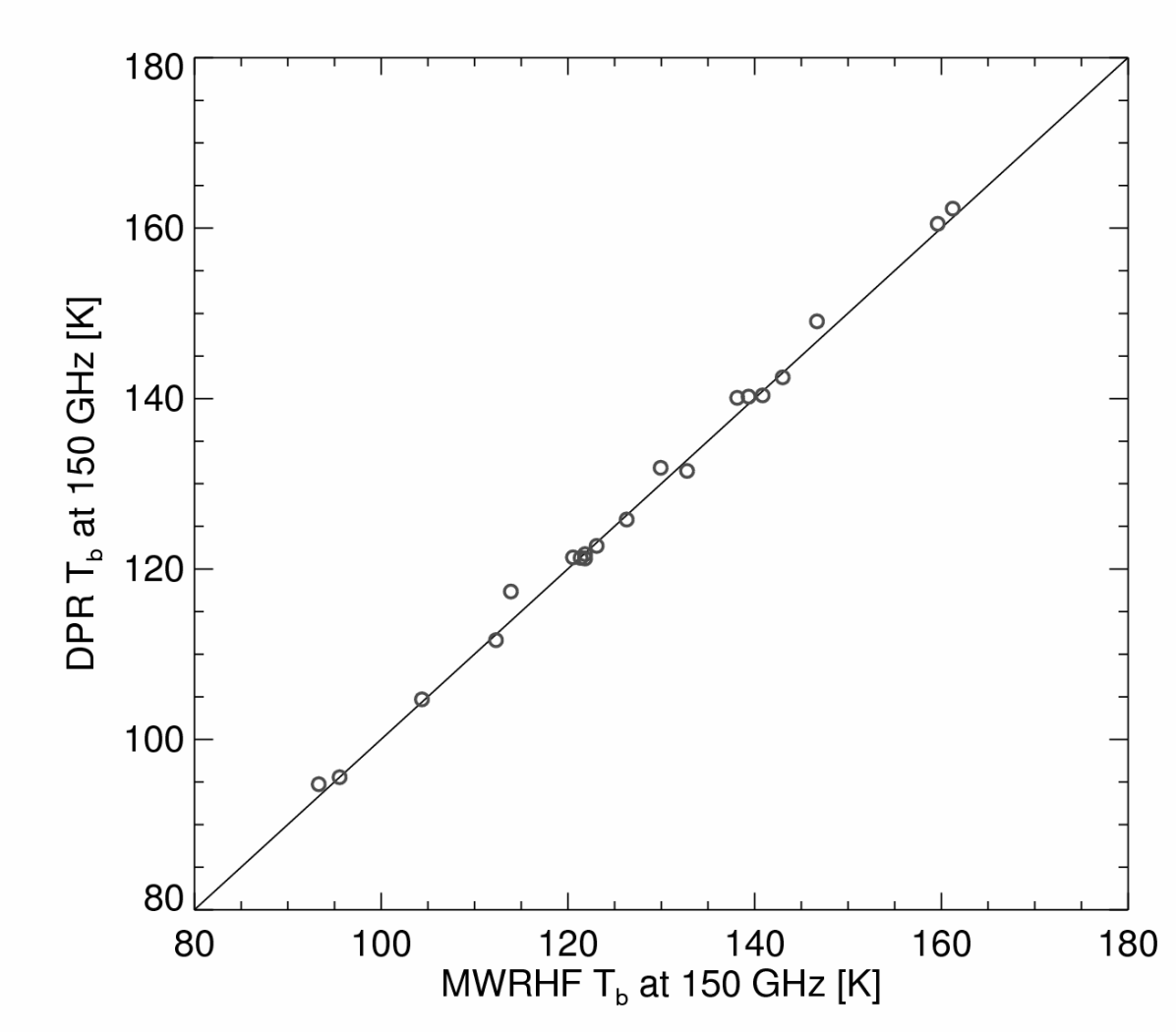
ARM MWRHF

University of Munich DPR

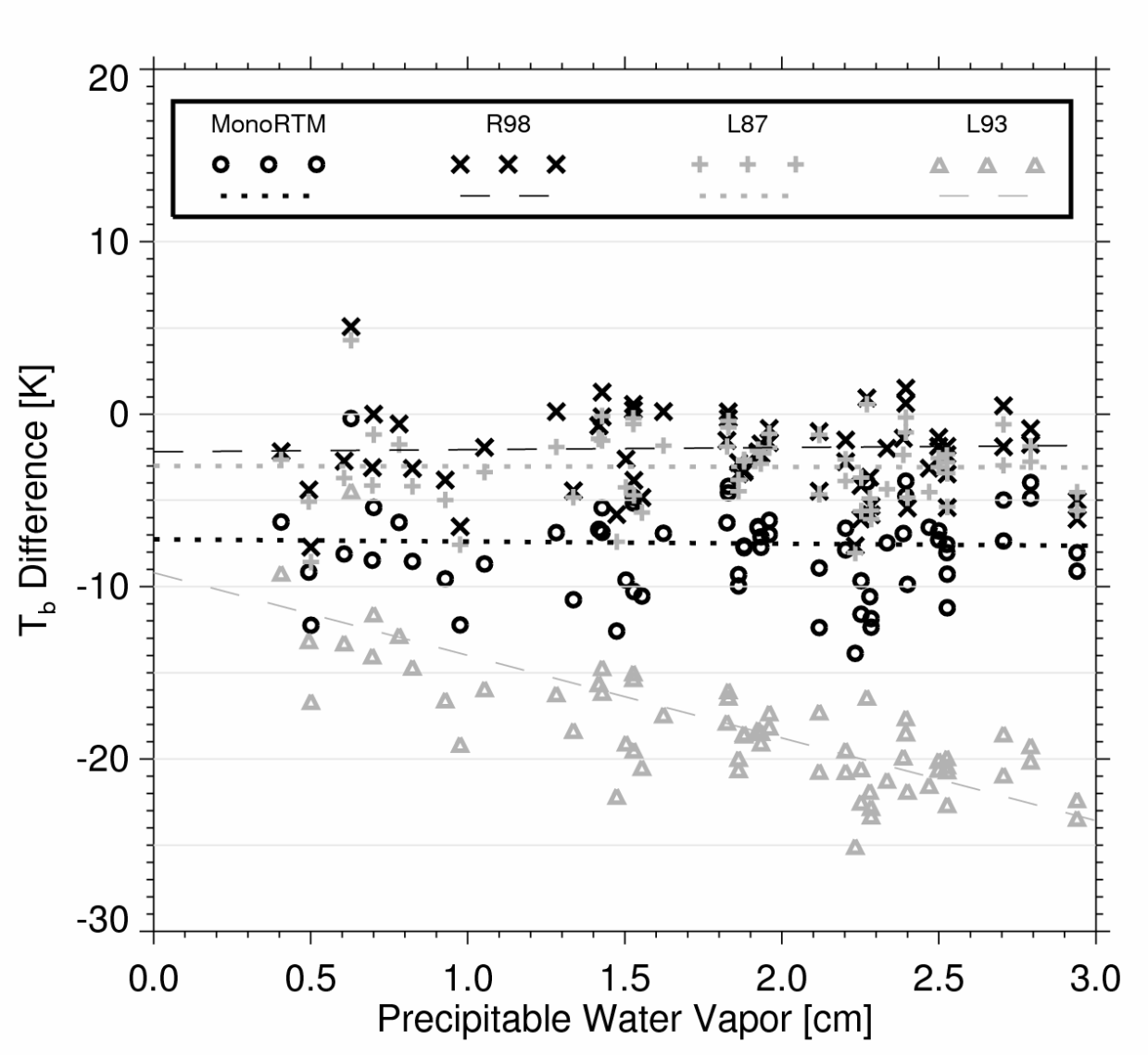
- Built by same manufacturer; similar “insides”
- Both calibrated with LN_2; 90 GHz also used tip curves
  - Dew on radome & clouds contaminated most tip curves
  - LN_2 calibration procedure was different for two instruments

Comparison of Two Systems at 150 GHz

- Independently calibrated systems
- 20 clear sky cases with radiosonde launched
- Bias: -0.5 K
- RMS: 1.3 K
- Slope: 1.005 K/K
- Correlation: 0.998



Absorption Model Evaluation at 150 GHz



- 71 cases
- Scaled radiosondes to MWR's 23.8 GHz obs
  - Diurnal sonde bias
- Only able to compare with 150 GHz obs, as 90 GHz obs could not be corrected

Water Vapor Continuum Formulation

$$\alpha_f = \nu \tanh\left(\frac{h\nu}{2k_B T}\right)\left(\frac{(n - n_\nu)}{n_0}\right) n_\nu C_f(\nu)$$

$$\alpha_s = \nu \tanh\left(\frac{h\nu}{2k_B T}\right)\left(\frac{n_\nu}{n_0}\right) n_\nu C_s(T, \nu)$$

MonoRTM formulation

Model	C_f multiplier	C_s multiplier
Rosen98	0.87 ± 0.09	1.22 ± 0.15
MonoRTM	0.65 ± 0.07	2.26 ± 0.26
Liebe87	0.77 ± 0.11	1.34 ± 0.17

Multipliers derived to make:

- abs (slope of residuals at 150 GHz vs. PWV) < 0.1 K/cm
- abs (bias of residuals at 150 GHz) < 0.1 K

Uncertainties assumed 1.5 K bias error in obs

Evaluation at 31.4 GHz

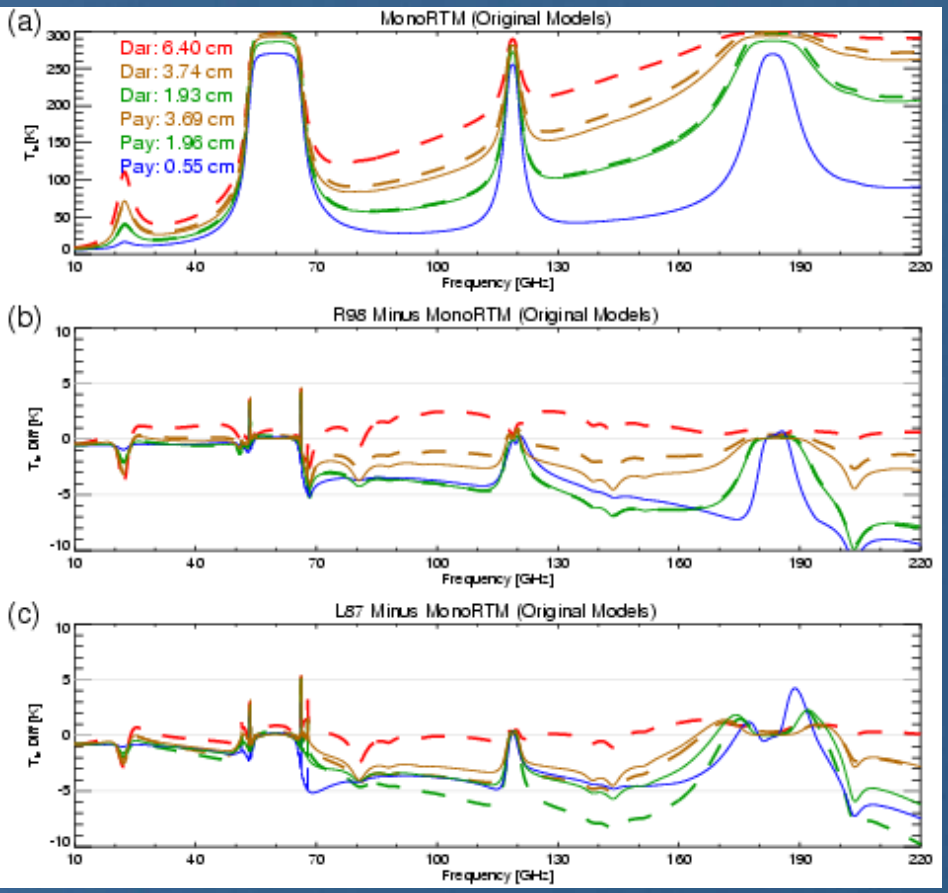
- Comparisons made with the 31.4 GHz MWR observation
- Used same 71 cases for evaluation
- Rosen98 and MonoRTM results show improvement

Original Model Results **Modified Model Results**

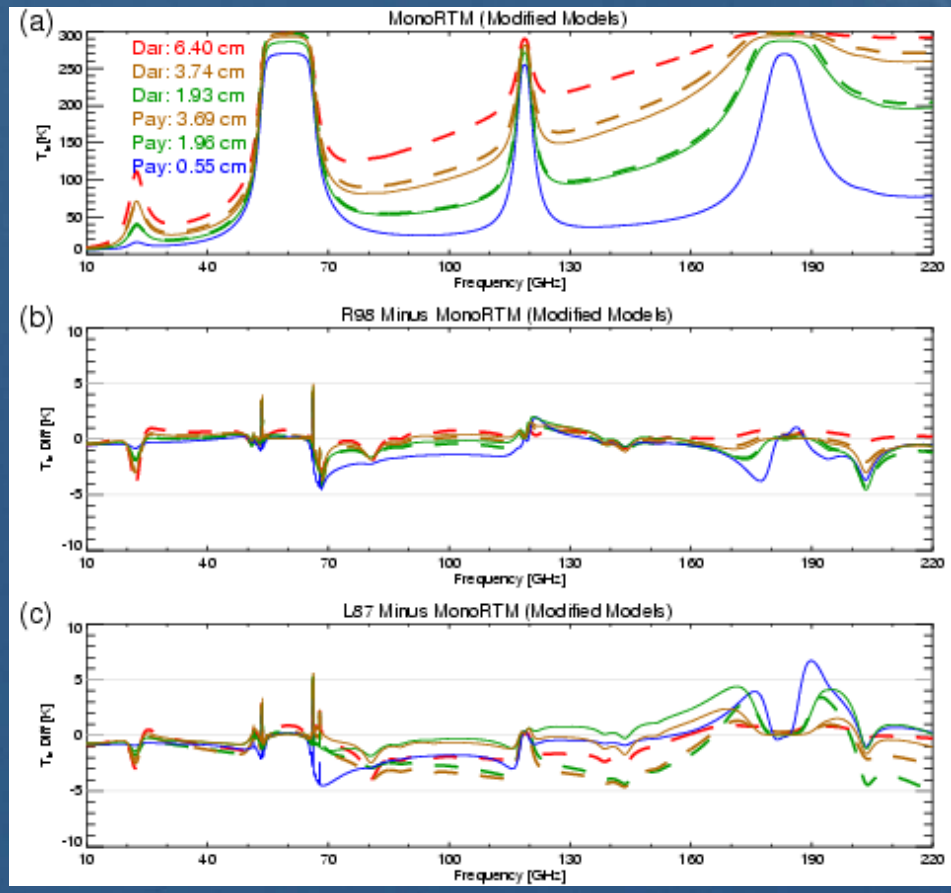
Model	Slope [K / cm]	Intercept [K]	Bias [K]	RMS [K]	RMS_{BR} [K]
Rosen98	-0.205	-0.01	-0.42	0.06	0.02
	-0.196	0.11	-0.29	0.04	0.02
MonoRTM	-0.130	-0.59	-0.84	0.18	0.01
	-0.027	-0.23	-0.32	0.04	0.01
Liebe87	-0.175	0.44	0.09	0.02	0.01
	-0.142	0.59	0.31	0.04	0.01
Liebe93	-0.743	-0.29	-1.67	0.69	0.06
	N/A	N/A	N/A	N/A	N/A

Spectral Impact of Modification

Original Model Results



Modified Model Results



Conclusions

- Evaluated microwave RT models using new observations at 150 GHz during AMF/COPS
- Results suggest WV continua need adjustment:
  - Decrease in foreign-broadened component
  - Increase in self-broadened component
  - Adjusted models in much better agreement with each other
- Better agreement with obs at 31.4 GHz
  - Possible bias in MWR obs is complication
- Need more observations at larger PWV and other atmospheric temperatures
- Inability to reprocess 90 GHz data was disappointing, but vendor has worked with us to allow this to happen in the future
- Manuscript submitted to *IEEE TGRS*