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

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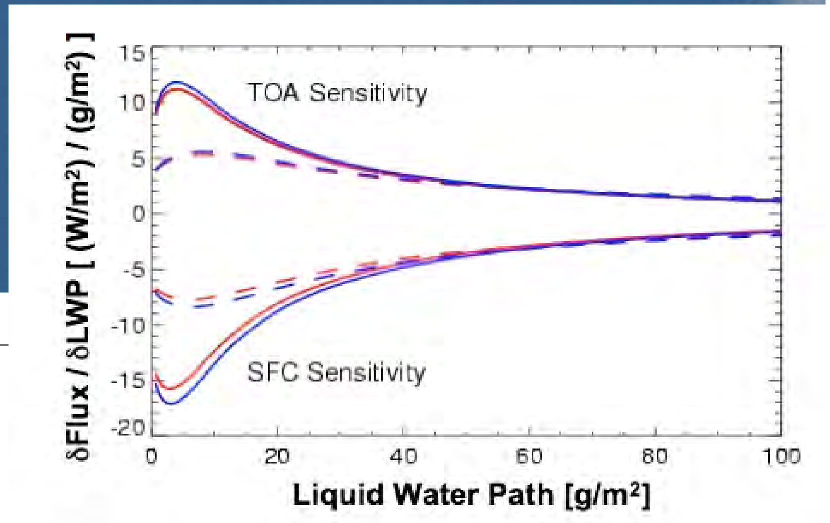
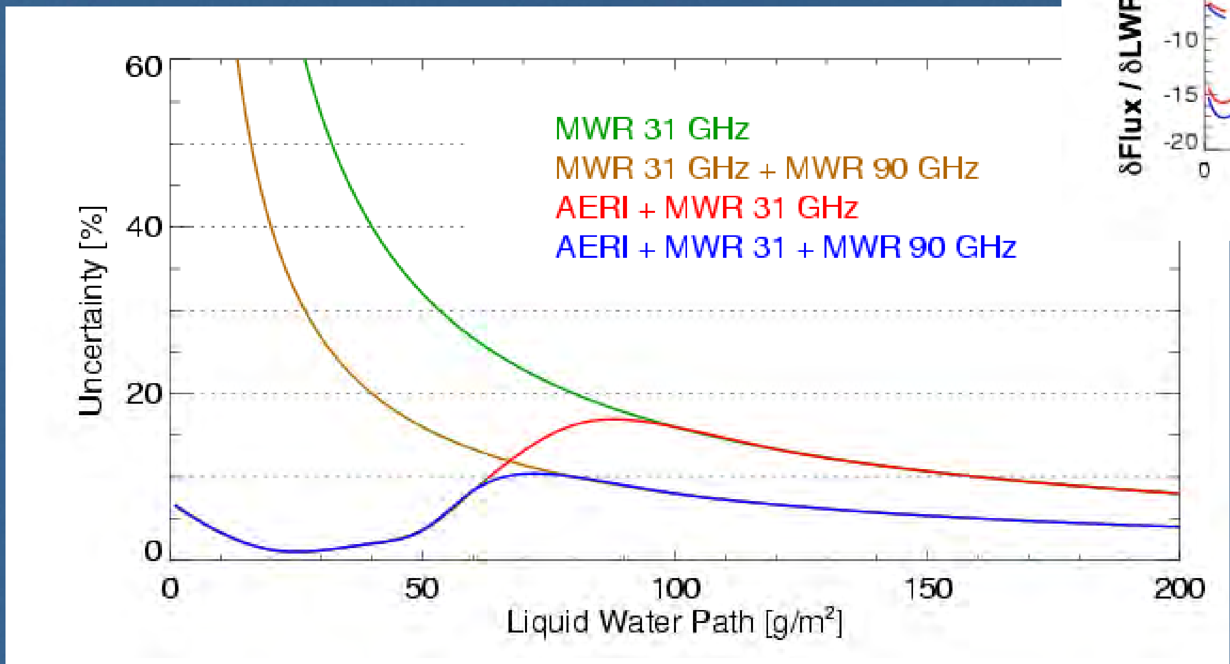
ARM Atmospheric Radiation Measurement Program

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





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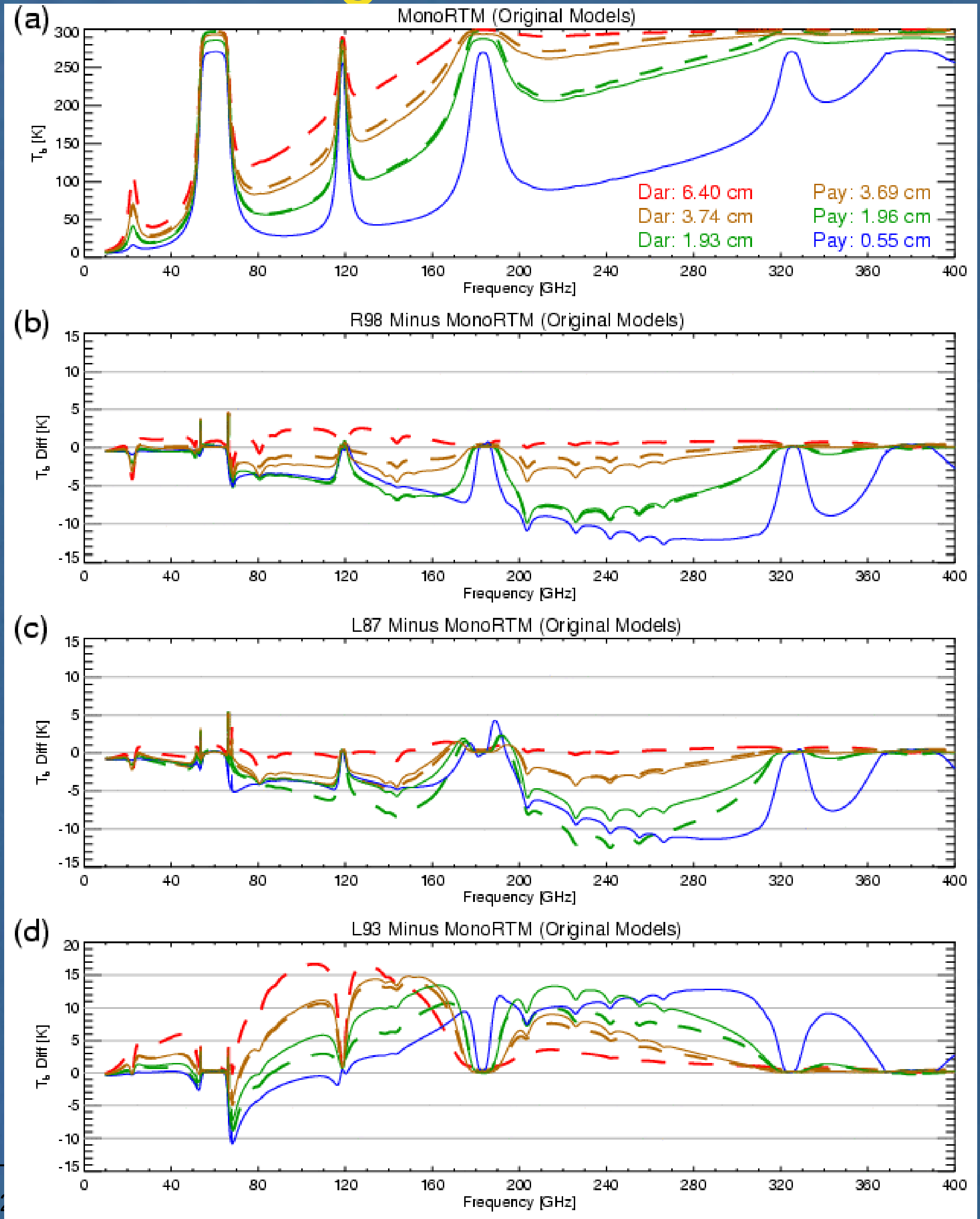
Large Differences Among RT Models



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

Rosen98 - MonoRTM

Liebe87 - MonoRTM

Liebe93 - MonoRTM

Two 90/150 GHz Radiometers

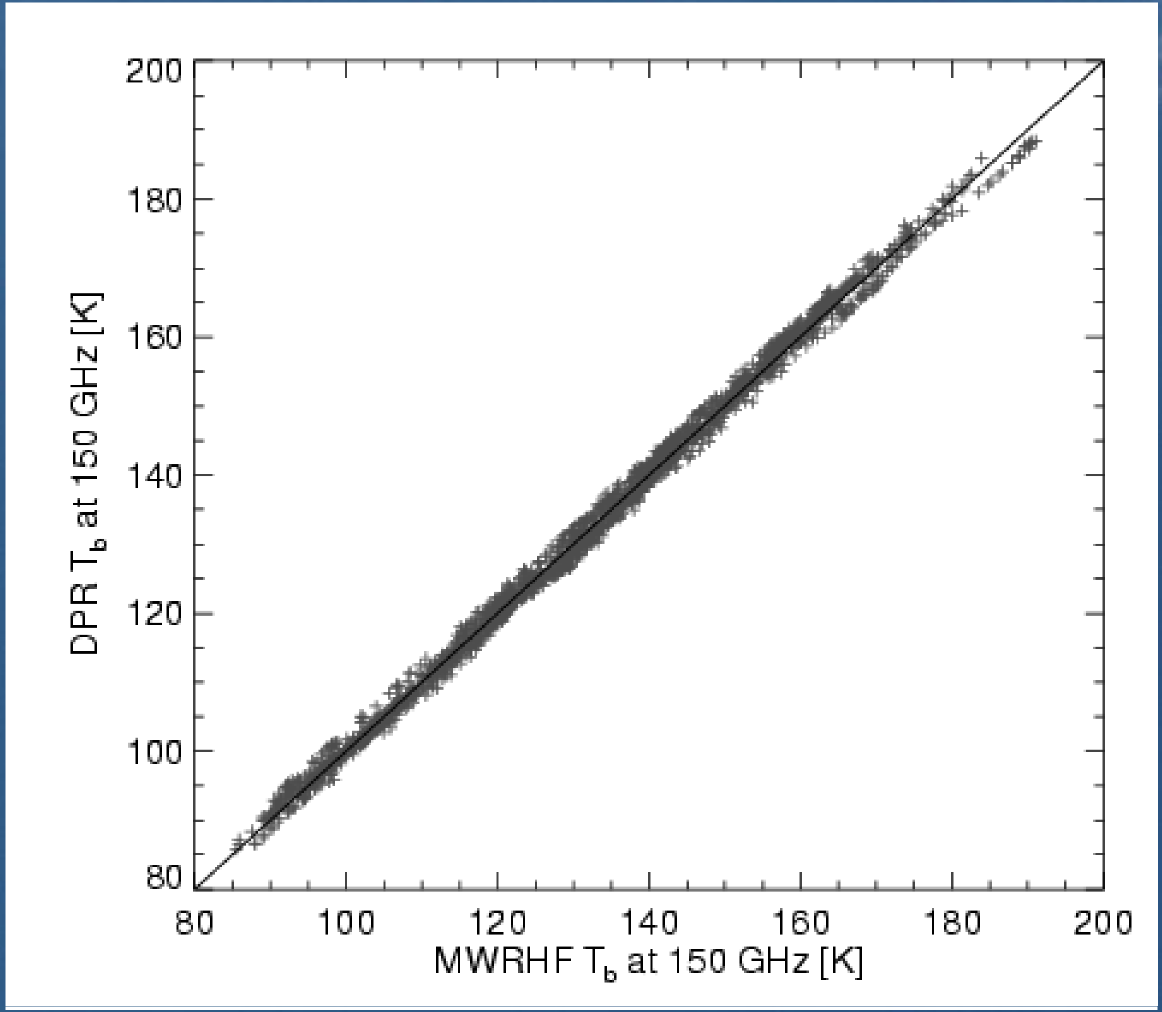
ARM MWRHF

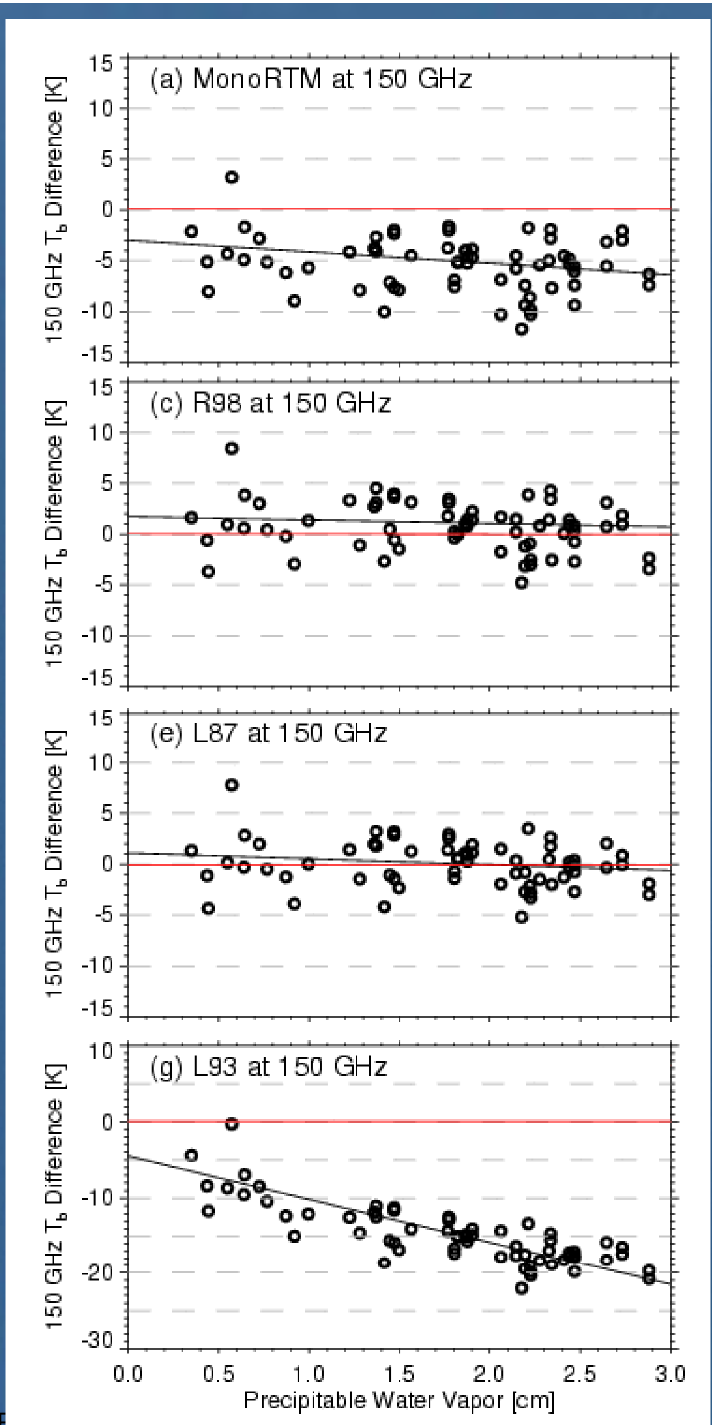
University of Munich DPR

- 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
- 2122 clear sky cases from 24 different days
- Bias: -0.12 K
- RMS: 1.29 K
- Slope: 0.998 K/K
- Correlation: 0.998





Absorption Model Evaluation at 150 GHz

- 71 clear-sky cases with coincident radiosonde and DPR or MWRHF obs
- Scaled radiosondes to match PWV retrieved from MWR's 23.8 GHz obs
  - Needed in order to remove diurnal sonde humidity bias
- Only able to compare with 150 GHz obs, as 90 GHz obs could not be calibrated
- Significant differences btwn obs and calc, especially for the MonoRTM and Liebe93 models

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Water Vapor Continuum Formulation

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

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

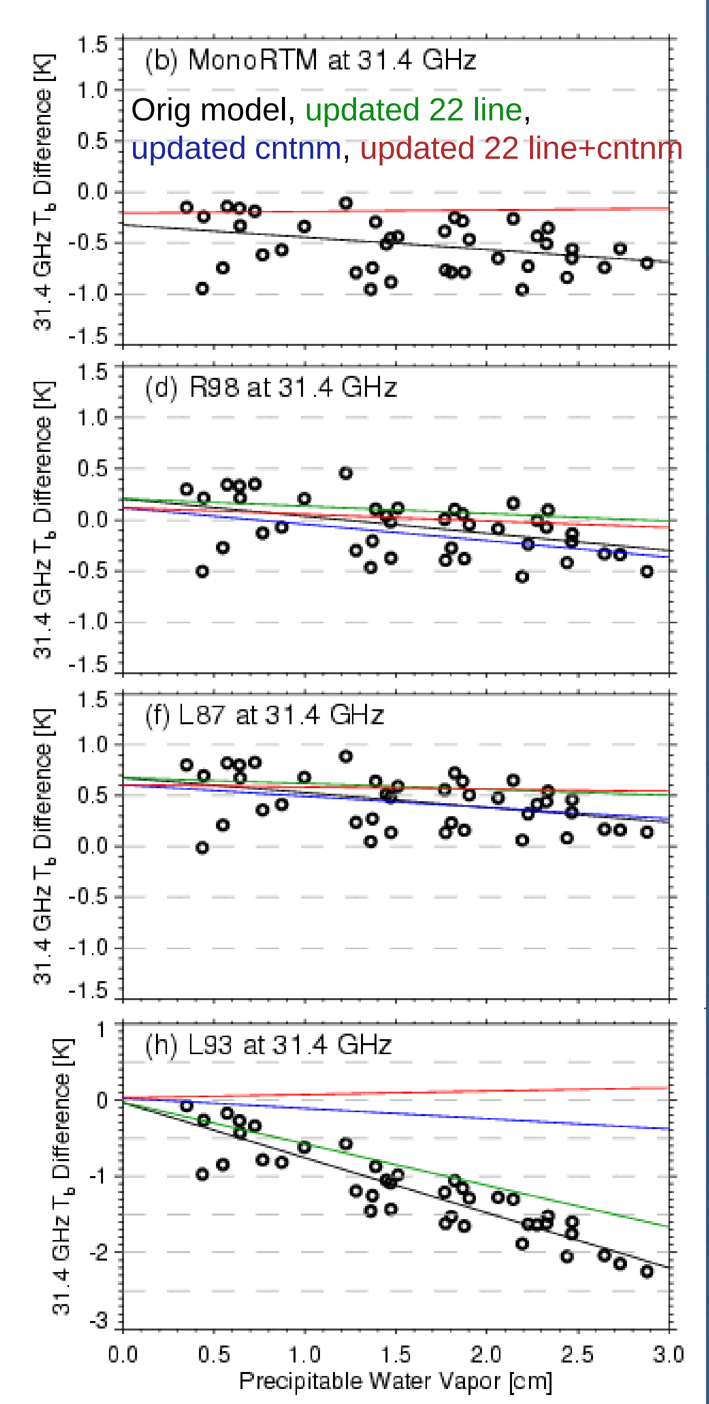
MonoRTM formulation

Model	C_f multiplier	C_s multiplier
Rosen98	1.105 ± (0.098, 0.030)	0.79 ± (0.17, 0.06)
MonoRTM	0.835 ± (0.073, 0.018)	1.44 ± (0.29, 0.09)
Liebe87	1.090 ± (0.124, 0.038)	0.80 ± (0.20, 0.07)

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

Liebe93 treats WV cntnm as a pseudo-line…

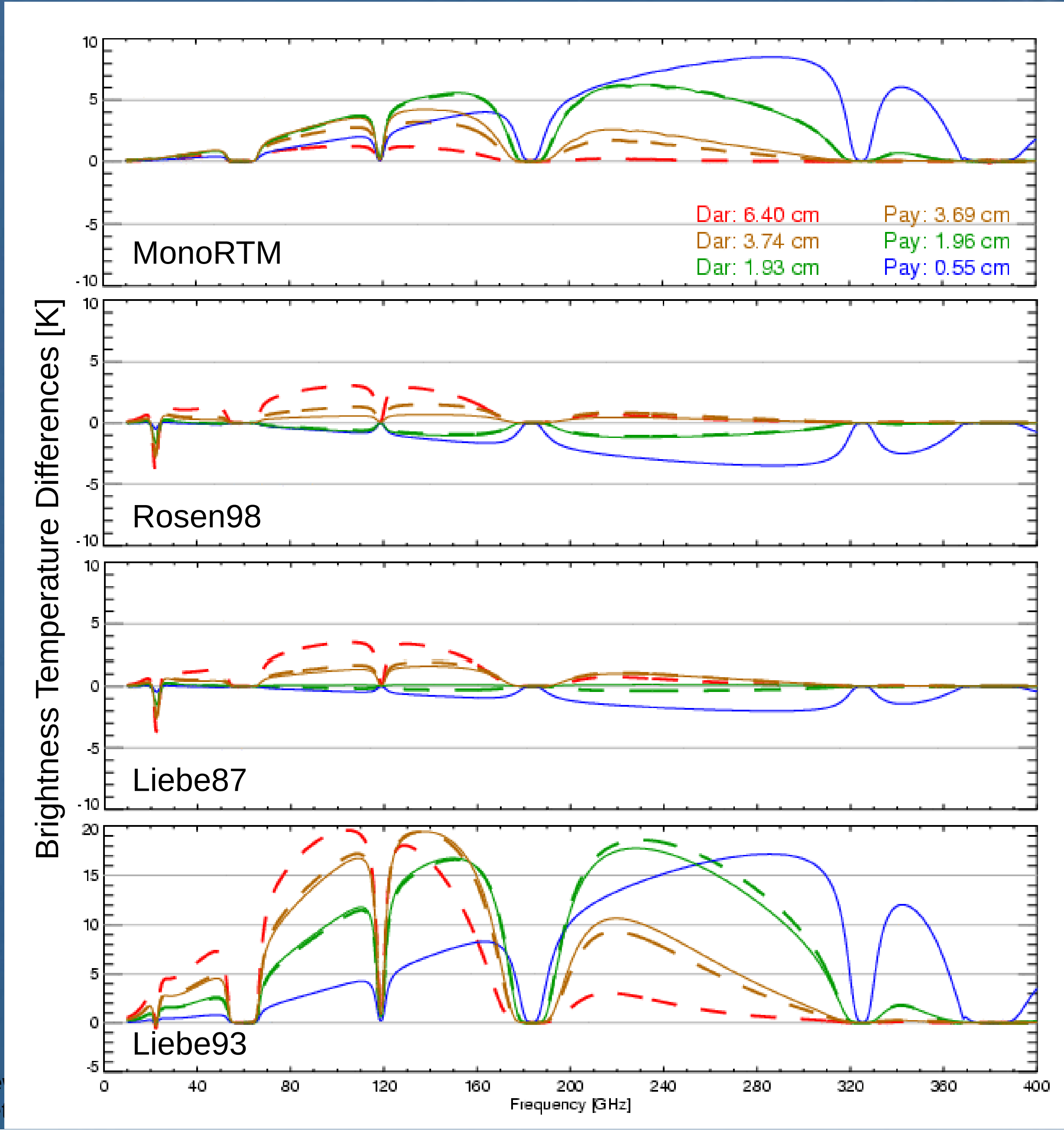


Evaluation at 31.4 GHz

- Comparisons made with the 31.4 GHz MWR observation
- Used same 71 cases for evaluation
- MonoRTM and Liebe93 results show significant improvement due to WV cntnm update
- Rosen98 and Liebe87 models show small improvement with updated cntnm
- Updating Rosen98, Liebe87, and Liebe93 models to have better 22.2 GHz line parameters improved all three models

Spectral Impact of the Modification

Original model minus modified model



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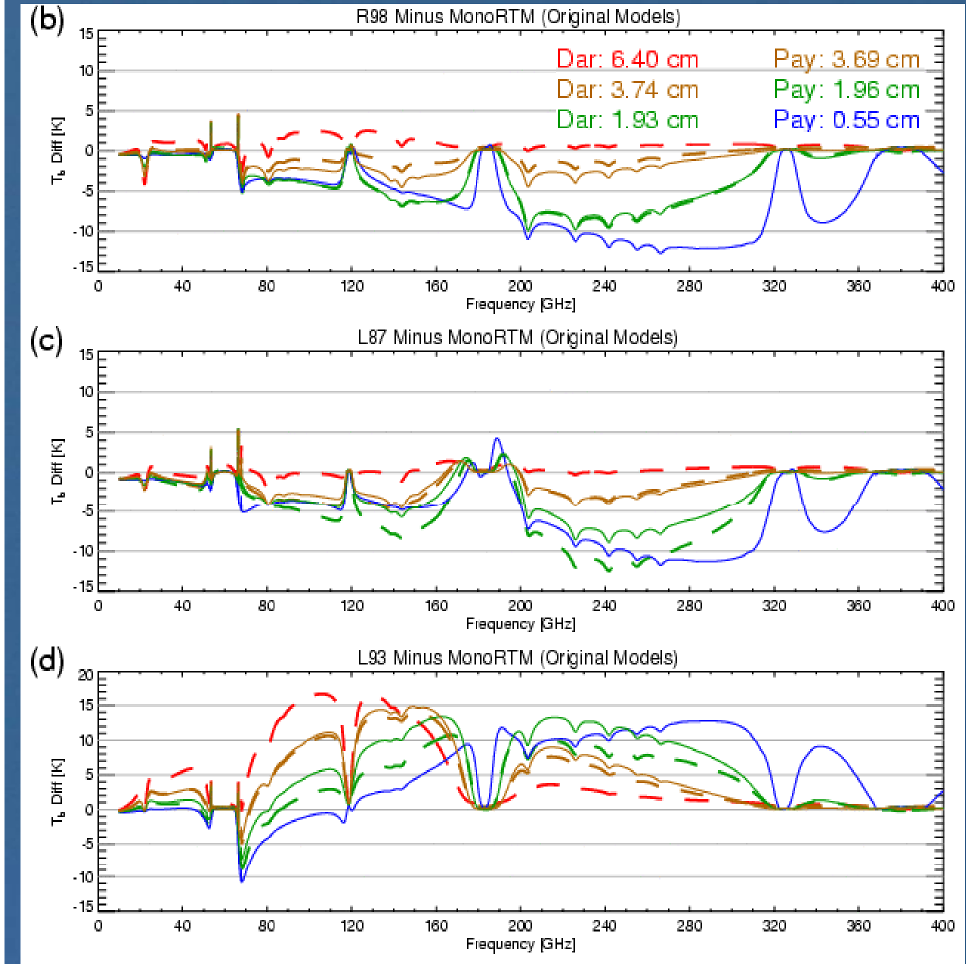
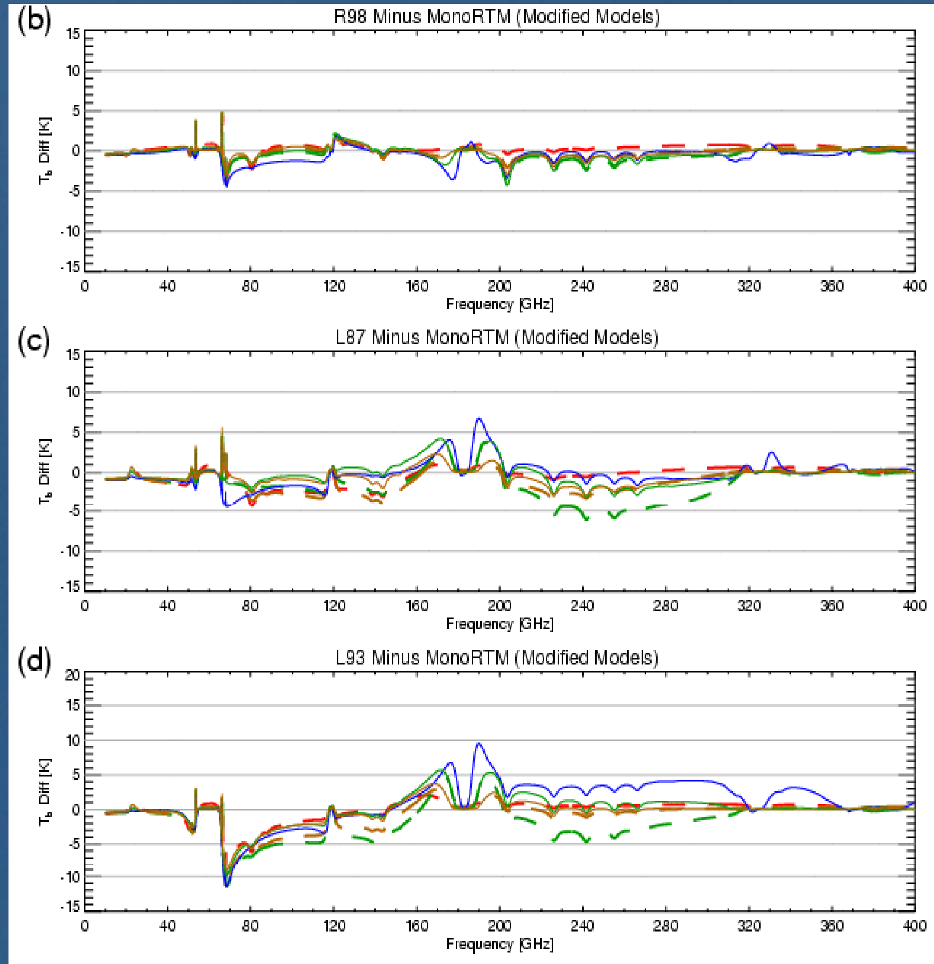
Spectral Impact of Modification Relative to the MonoRTM

Original Model Results | **Modified Model Results**





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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 to used improved 22.2 GHz line parameters
- 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*