K-Band Spectrum Survey Demonstration

Team: O. Egbert, J. Batra, D. Orthel, J. Tang, D. Baatarkhuyag, A. Zainaddin
Advisor: Prof. Albin J. Gasiewski
University of Colorado Boulder Electrical Engineering

BACKGROUND

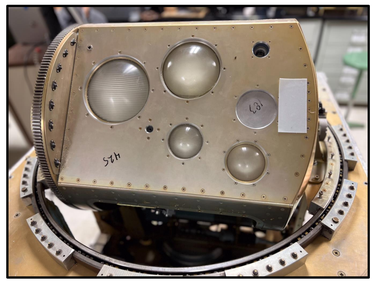

Figure 1. PSR Scanhead

Figure 2. Mobile Platform

The K-Band Spectrum Survey Demonstration addresses the issue of understanding radio frequency interference (RFI) at the ground level which is disruptive to weather forecasting and other scientific applications. By integrating the CET polarimetric scanning radiometer (PSR) into a mobile platform, the project demonstrates the measurement of RFI heat maps in a range of environments: urban, suburban, and rural.

The resonance of water vapor at 22.235 GHz provides a critical capability for accurate and reliable satellite measurements used for weather forecasting. The upper wing of the resonance falls in an internationally protected radio band from 23.6 to 24.0 GHz. This band is allocated for the Earth Exploration-Satellite Service (EESS). RFI can corrupt water vapor measurements and therefore disturb weather forecasts. It is critical to understand the current level of RFI to develop the next generation of NOAA weather satellites [1].

The PSR instrument has historically been used onboard NASA aircraft to collect microwave emission data at frequencies from C-Band through G-Band (6-200 GHz). The unique challenge for this project was to adapt the instrument for operation on a ground-based mobile platform.

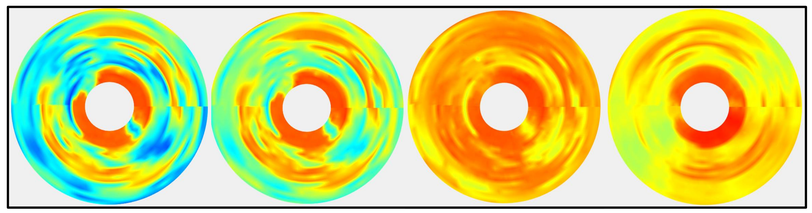

Figure 3. O-Records displaying brightness temperature channels 18.7, 23.0, 50.3, 89.0 vertical polarization (GHz, left to right)

LOCAL EXCURSION

Figure 5. O-Records of radiometric data collected during local excursion

The DenvEx24 local excursion objective was to perform a local survey of potential emissions in the 23.6-24.0 GHz frequency band. Beginning at CU in Boulder, brightness temperatures were observed along US-36, Baseline Reservoir, Standley Lake, Federal Blvd, and W. Colfax Ave.

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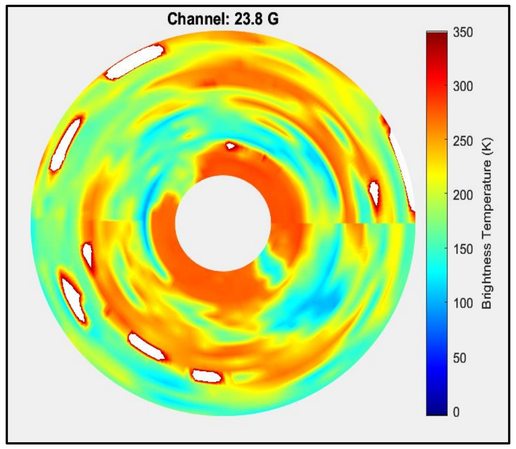
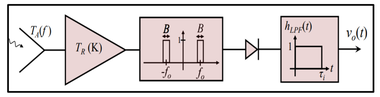


Figure 6. O-Record consisting of 15 revolutions of conical scan

The PSR instrument scanned in conical mode at a beam angle of 83 degrees from Zenith. The O-record in Fig.6 is comprised of 15 conically scanned rasters which provide a convenient means of displaying near planned position indicator (PPI) brightness temperature data. The off-scale data (white) represent potential anthropogenic emission in the EESS allocated band.

INSTRUMENT CHARACTERIZATION



$$\mathbf{P = kTB}$$

Measure of Intensity from RF Source

P	Power measured
k	Boltzmann's constant
T	Brightness temperature
B	Bandwidth

$$\Delta T_{RMS} = \frac{\sigma_{v_o}}{\frac{\partial \langle v_o(t) \rangle}{\partial T_A}} = \frac{T_{SYS}}{\sqrt{B\tau_i}}$$

ΔT_{RMS}

Fundamental Limit of Radiometer Sensitivity

T_{SYS}	$T_{\mathrm{Antenna}} + T_{\mathrm{Receiver}}$
B	Bandwidth
τ_i	Integration time

[2]

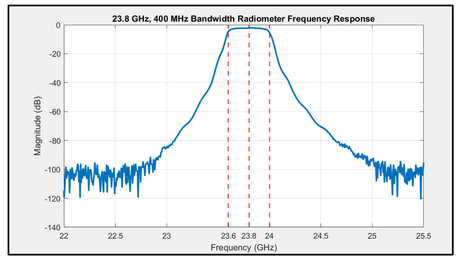


Figure 7. Passband filter response for 23.6-24.0 GHz EESS channel illustrating out-of-band filter response

Condition	Temperature (K)	⟨Voltage⟩ (V)	σ (mV)
Ambient	290	-0.794	1.335
Liquid Nitrogen	77	-0.362	1.204

$\Delta T_{RMS} = 0.6\ K$
Gain $= 2$ mV/K

Figure 8. In-lab measurement data identifying gain and sensitivity of instrument

CONCLUSION

The project demonstrates the feasibility of a land-based RFI study of K-Band emissions. Filter bank radiometer characteristics shown in Figure 7 indicate the need for higher certainty in brightness temperature measurements. Full implementation of the survey across United States will upgrade the 24 GHz radiometer with hyper-spectral digital spectrometer.

ACKNOWLEDGEMENTS

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REFERENCES

[1] National Research Council. *Spectrum Management for Science in the 21st Century*. Washington, DC: The National Academies Press, p. 80-85 (2010), https://doi.org/10.17226/12800.
[2] A. Gasiewski. (2022) ECEN 5254 [Powerpoint Slides]