

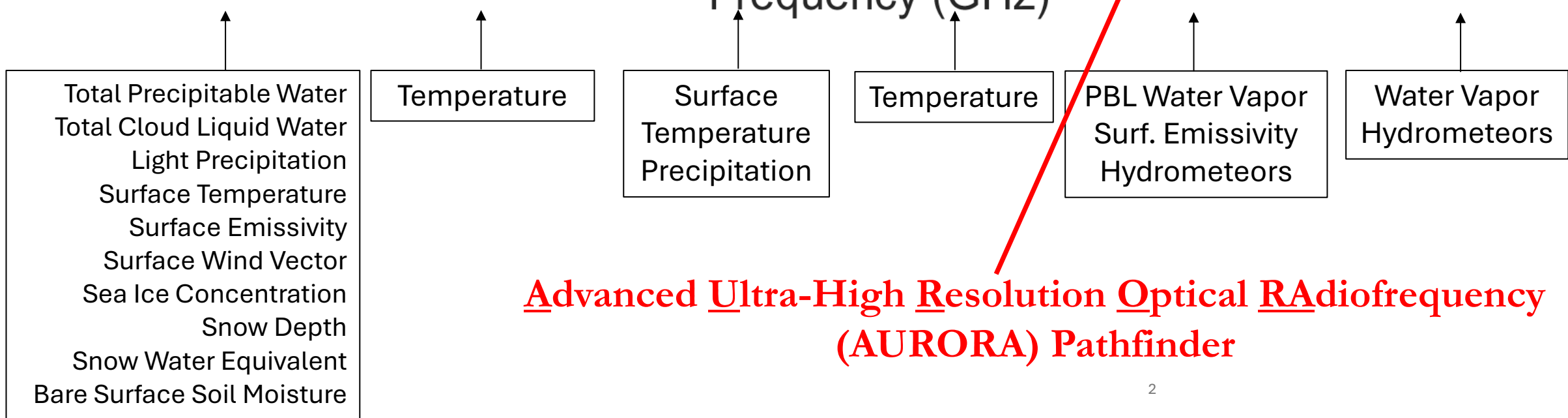
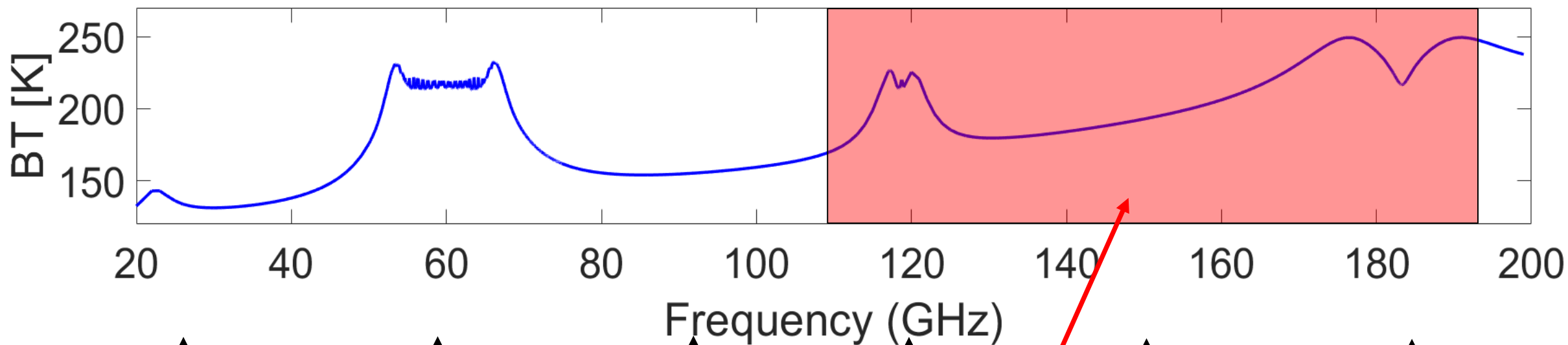
Advancements in Satellite-based Hyperspectral Microwave Sounding at NASA GSFC

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Eumetsat Meeting, Lyon, France, September 19th, 2025

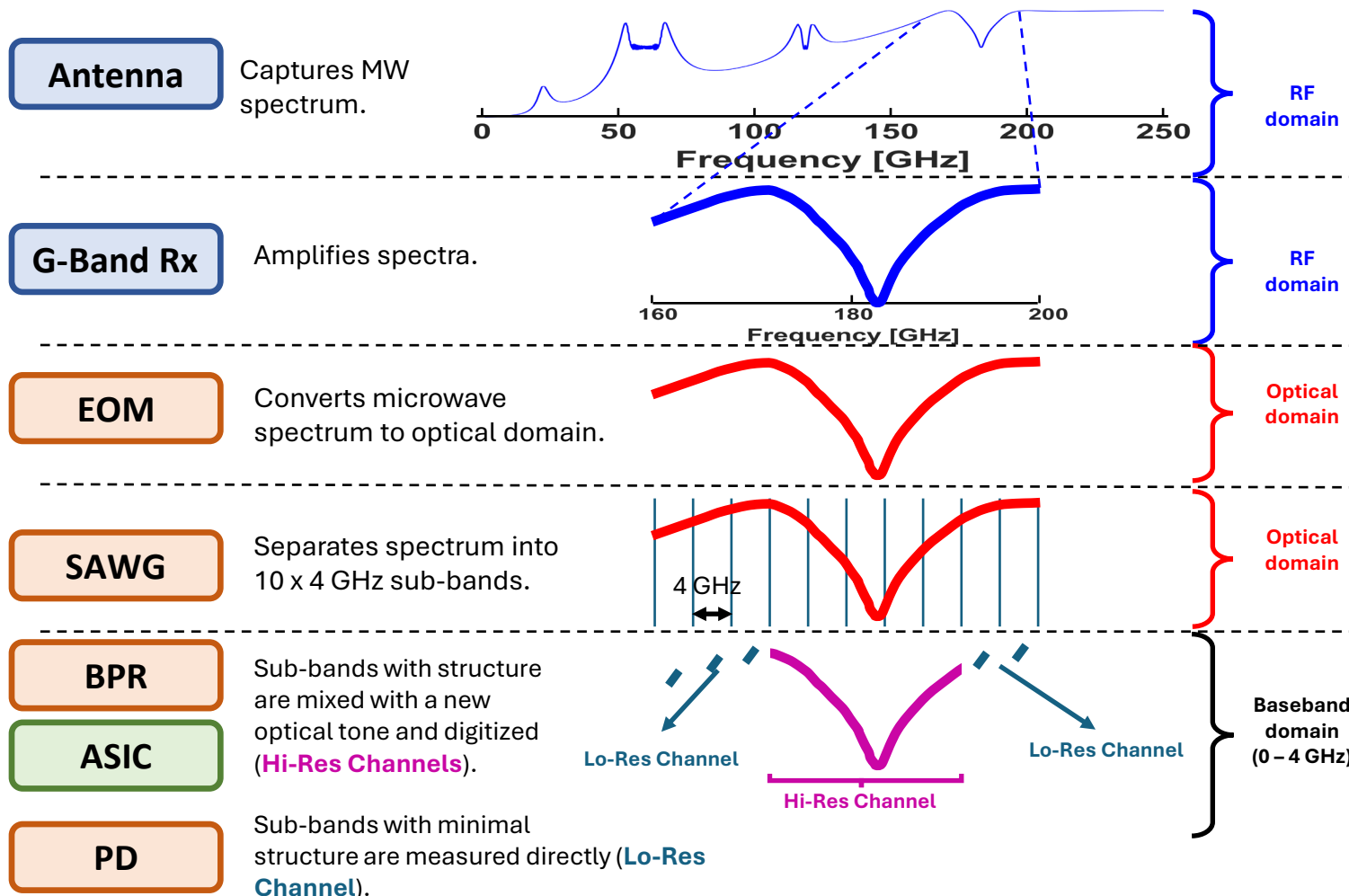
1. NASA Goddard Space Flight Center;
- 1.2 NASA Goddard Space Flight Center, University of Maryland Baltimore County, CRESST II
- 1.3 NASA Goddard Space Flight Center, University of Maryland College Park, ESSIC
- 1.4 NASA Goddard Space Flight Center, SSAI, Inc.
- 1.5 NASA Goddard Space Flight Center, SAIC, Inc.
- 1.6 NASA Goddard Space Flight Center, ASRC Federal System Solutions

Harnessing Improved Atmospheric Content in Hyperspectral Microwave Measurements



Advanced Ultra-High Resolution Optical Radiofrequency (AURORA) Pathfinder

MW Photonics Design



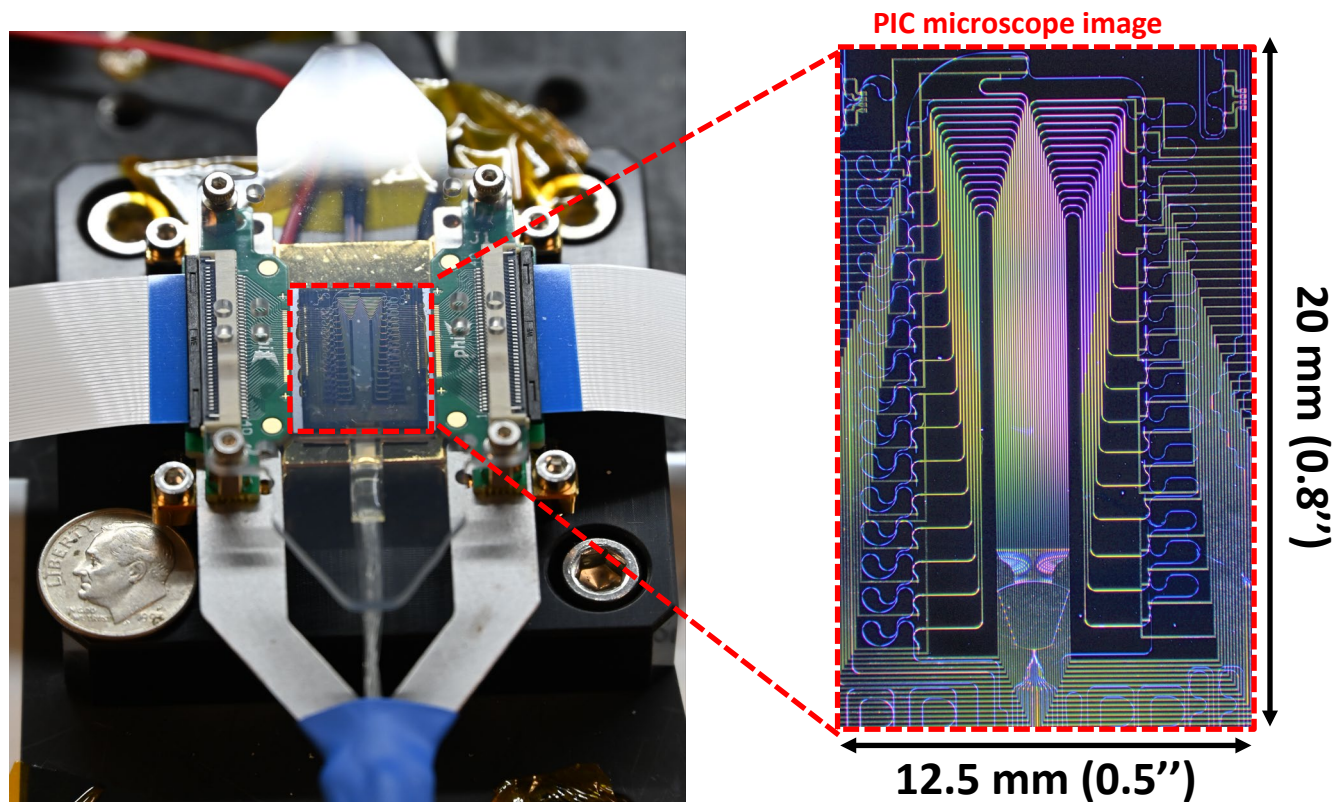
- HyMPI is a modular design, with simultaneous 40 GHz coverage
- Can be applied to multiple parts of the spectrum to obtain full, contiguous coverage of the MW thermal domain
- Paired with ASICs - “PICASIC” - it enables full, contiguous, hyperspectral resolution coverage in entire Earth’s MW thermal domain

US Patent 11852864

Title: “Serial Arrayed Waveguide Grating”

Gambini et al., 2024, <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10380670>

Serial Arrayed Waveguide Grating - SAWG

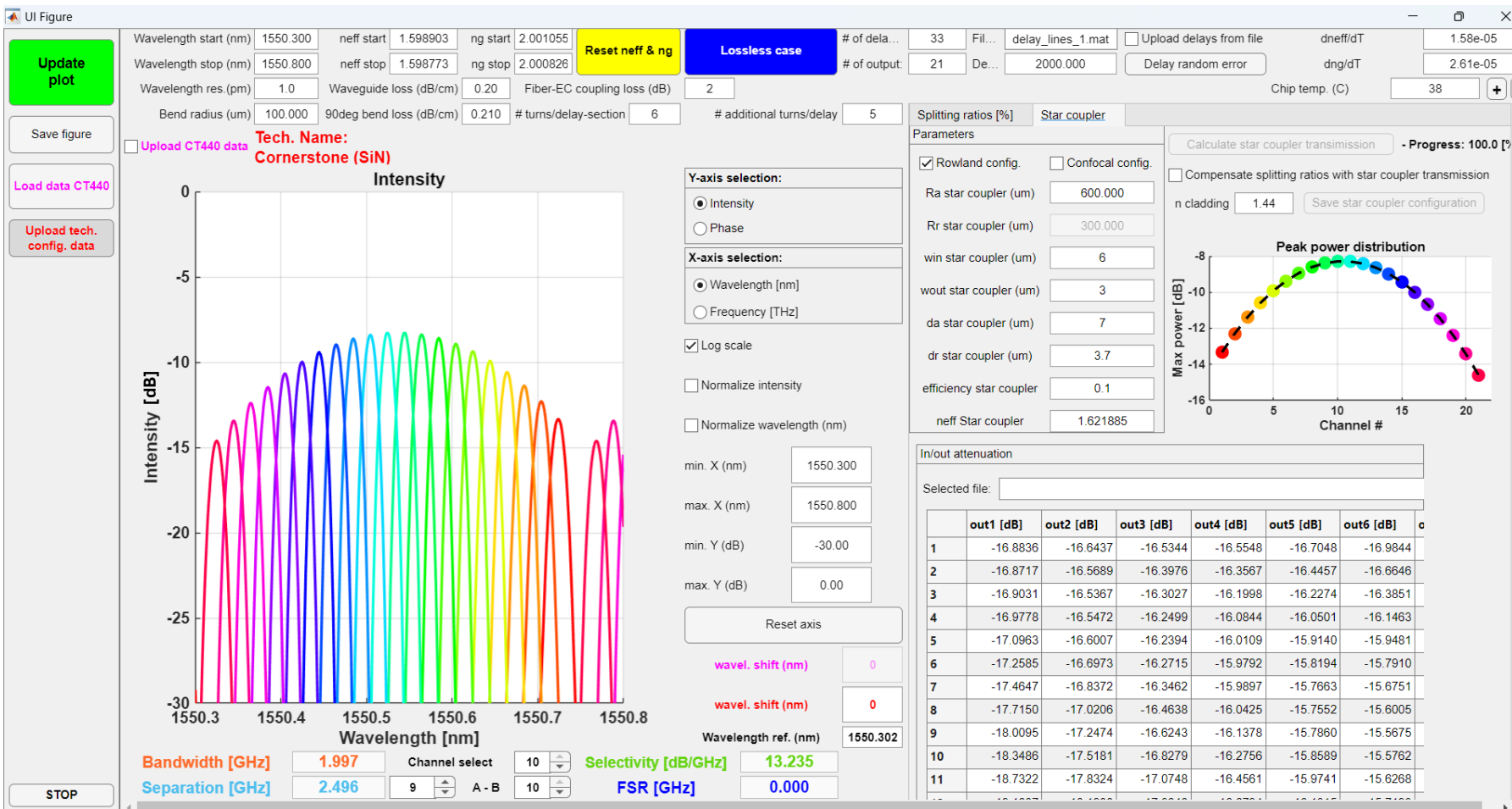


- [US Patent 11852864 – M. Stephen, “Serial Arrayed Waveguide Grating”](#)
- [Gambini et al., 2024, An Ultra-Compact, Narrow-Bandwidth, and High-Density Channel Photonic Integrated Channelizer Based on Serial Arrayed Waveguide Grating Architecture, J. Lightwave Technol. 42, 2908-2916 \(2024\)](#)

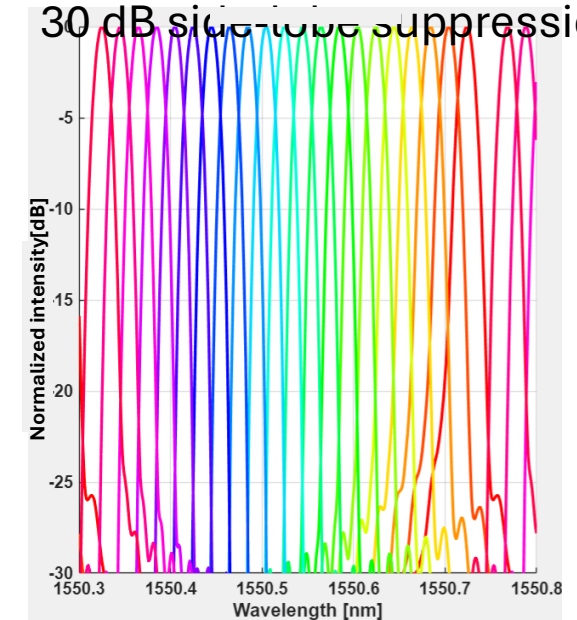
SAWG system model

Optical and geometrical parameters define the frequency response of the filter:

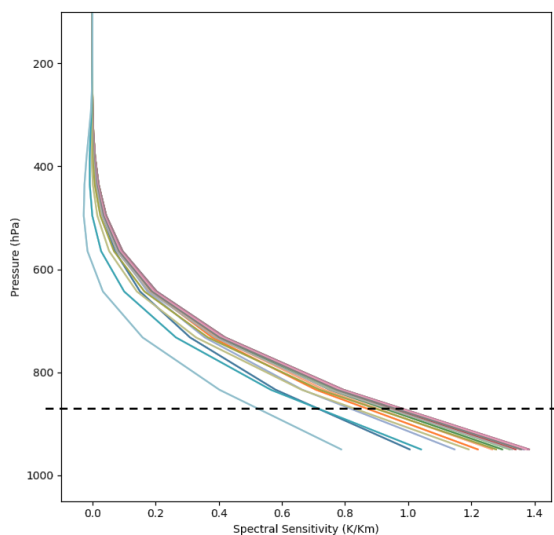
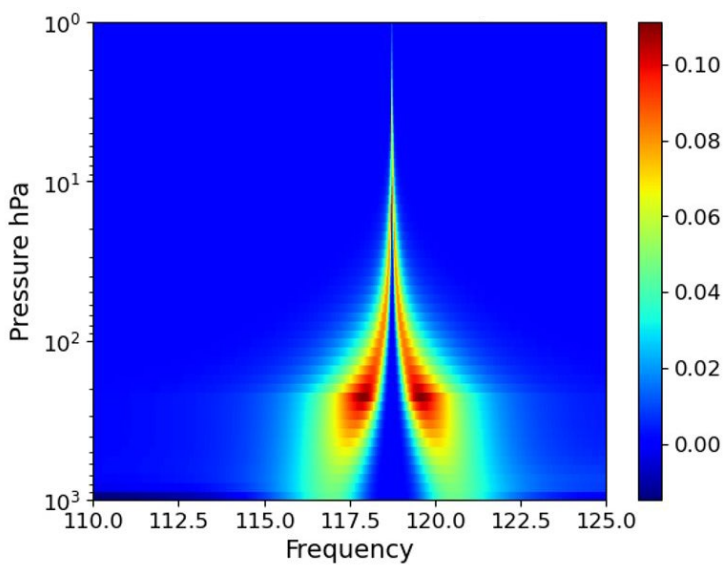
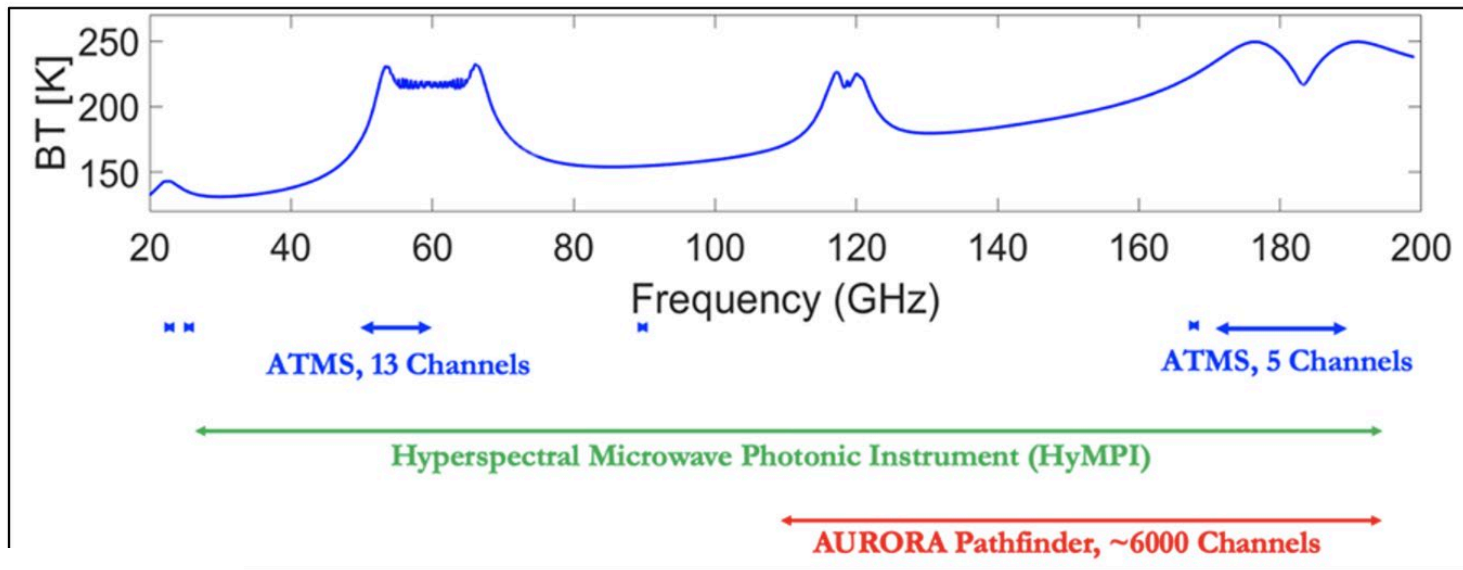
- 33 delay lines
- 21 output channels
- 2.5 GHz channel separation
- 2.0 GHz channel 3dB bandwidth
- 30 dB side-lobe suppression



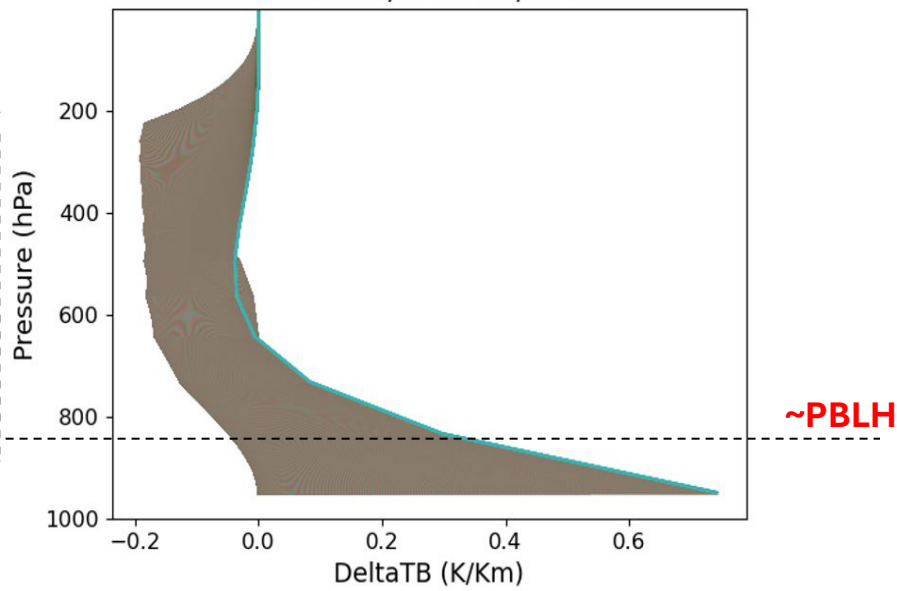
Example of SAWG Matlab model result



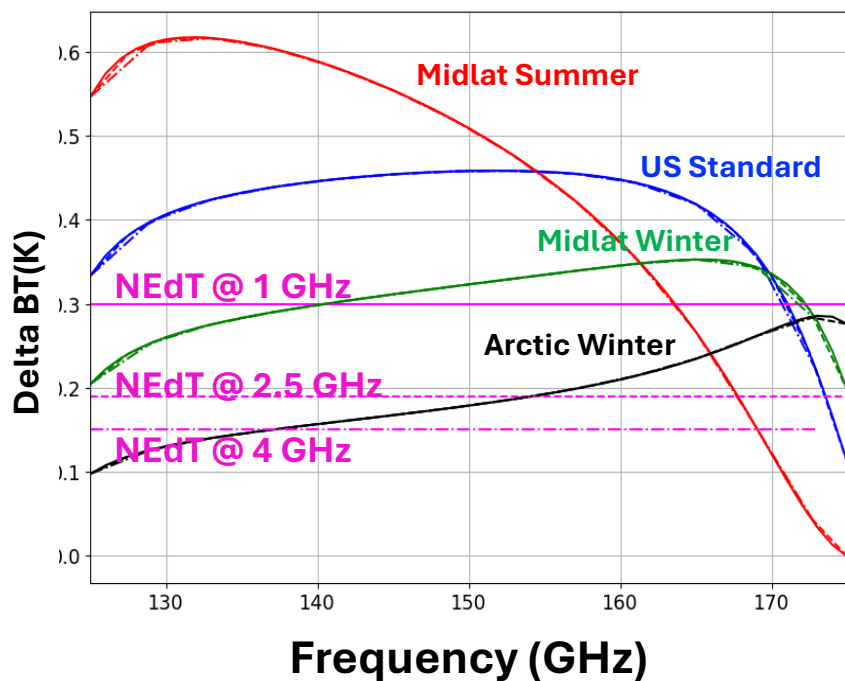
The Advanced Ultra-high Resolution Optical and Radiofrequency (AURORA) Pathfinder



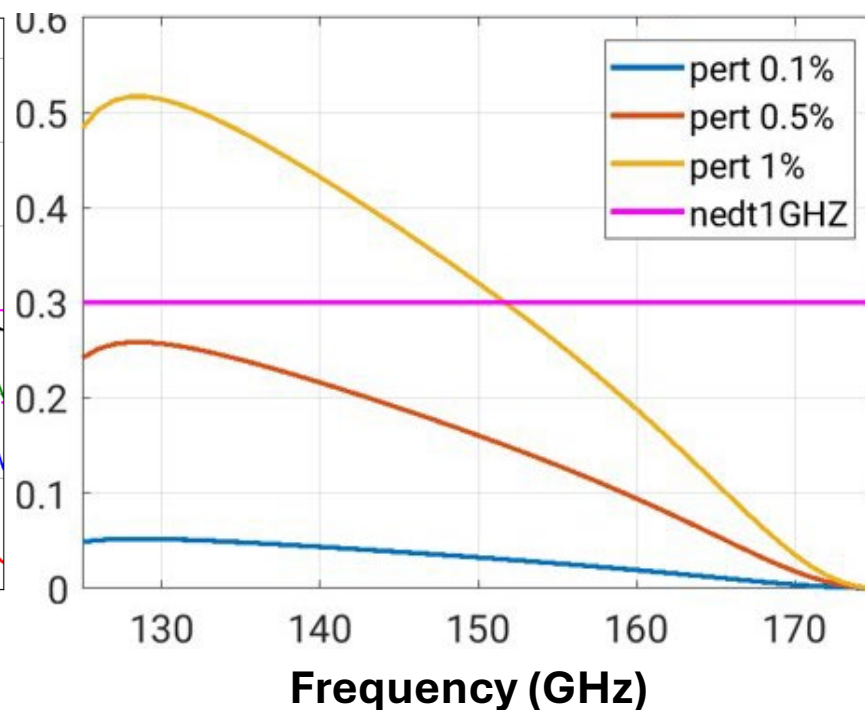
- Channels
- 125.0 GH
- 127.5 GH
- 130.0 GH
- 132.5 GH
- 135.0 GH
- 137.5 GH
- 140.0 GH
- 142.5 GH
- 145.0 GH
- 147.5 GH
- 150.0 GH
- 152.5 GH
- 155.0 GH
- 157.5 GH
- 160.0 GH
- 162.5 GH
- 165.0 GH
- 167.5 GH
- 170.0 GH
- 172.5 GH



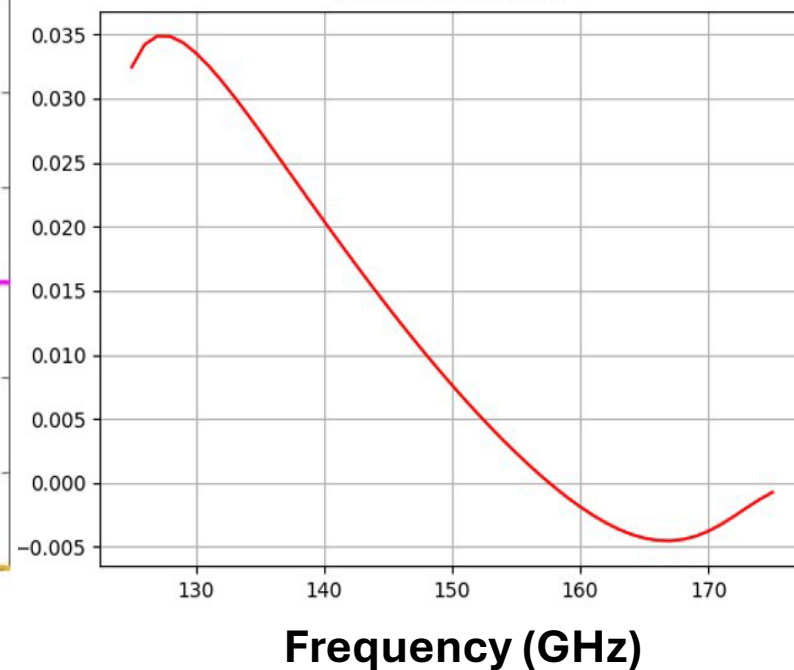
10% Delta Water Vapor @ 850hPA



Midlat Sum: Surf. Emissivity Perturbation

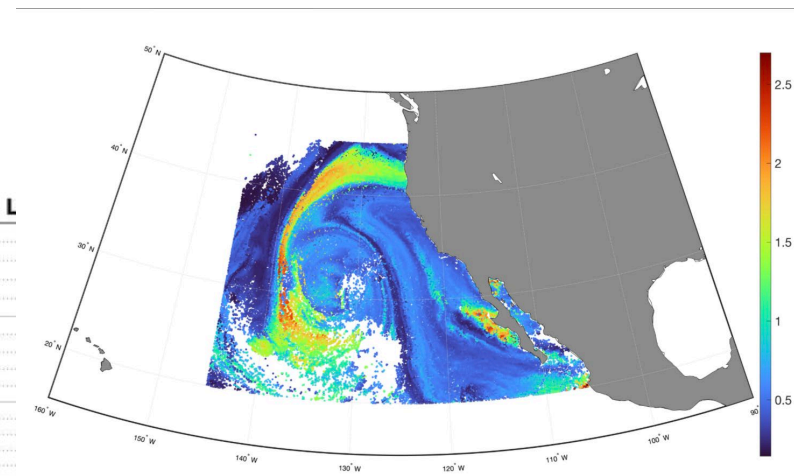
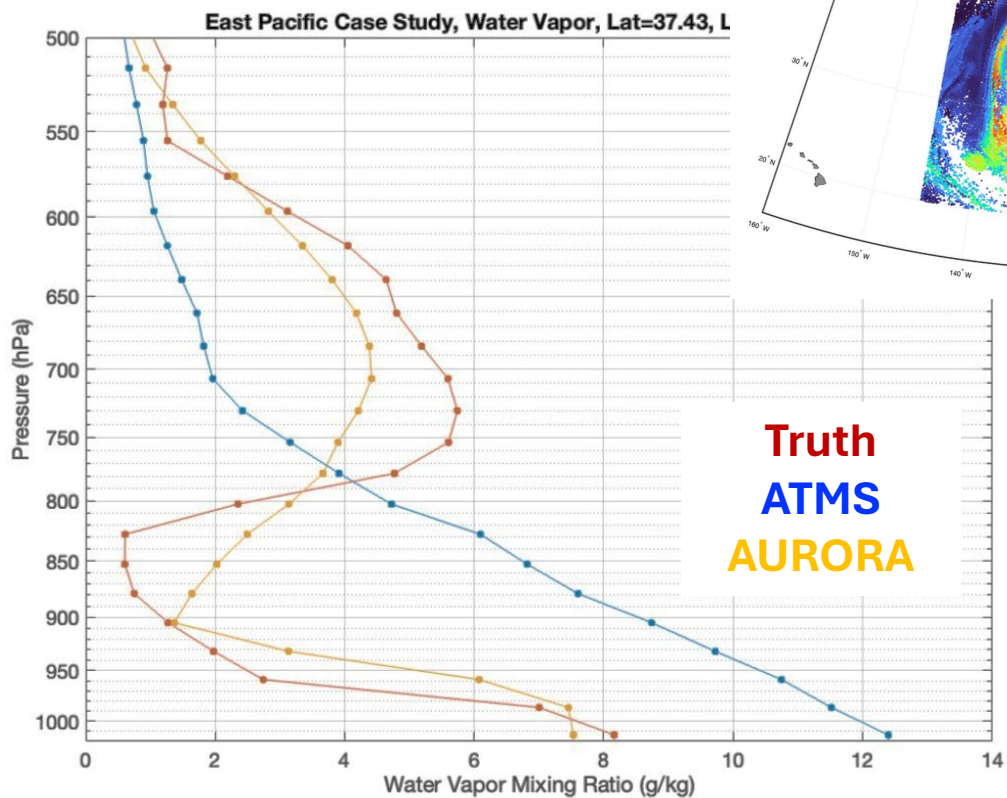
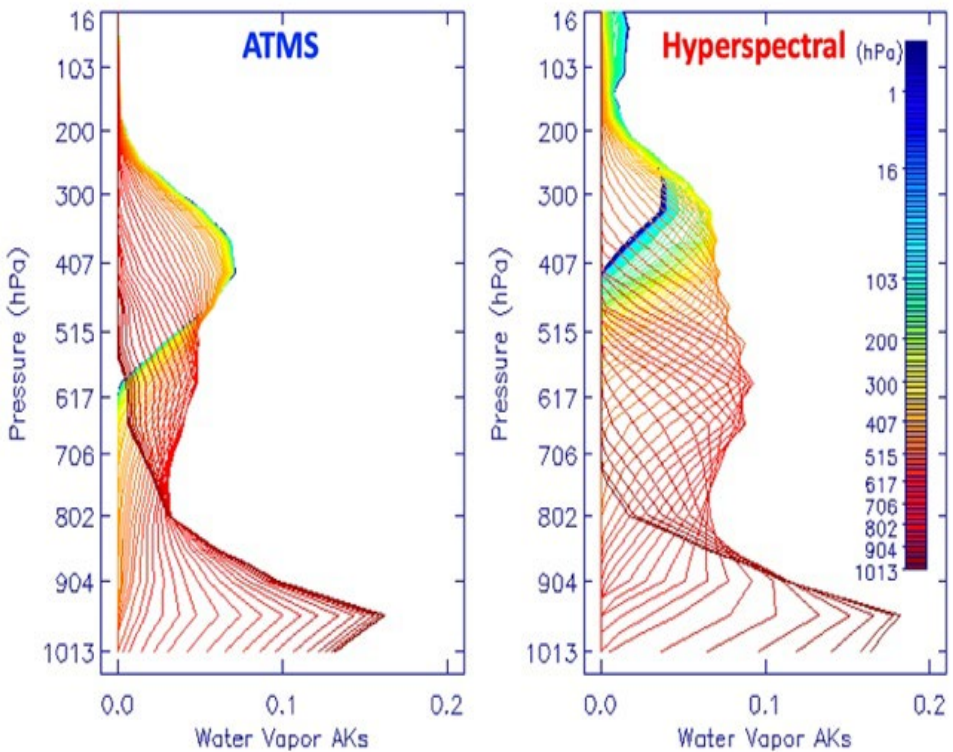


Midlat Sum: CLW 10% Perturbation

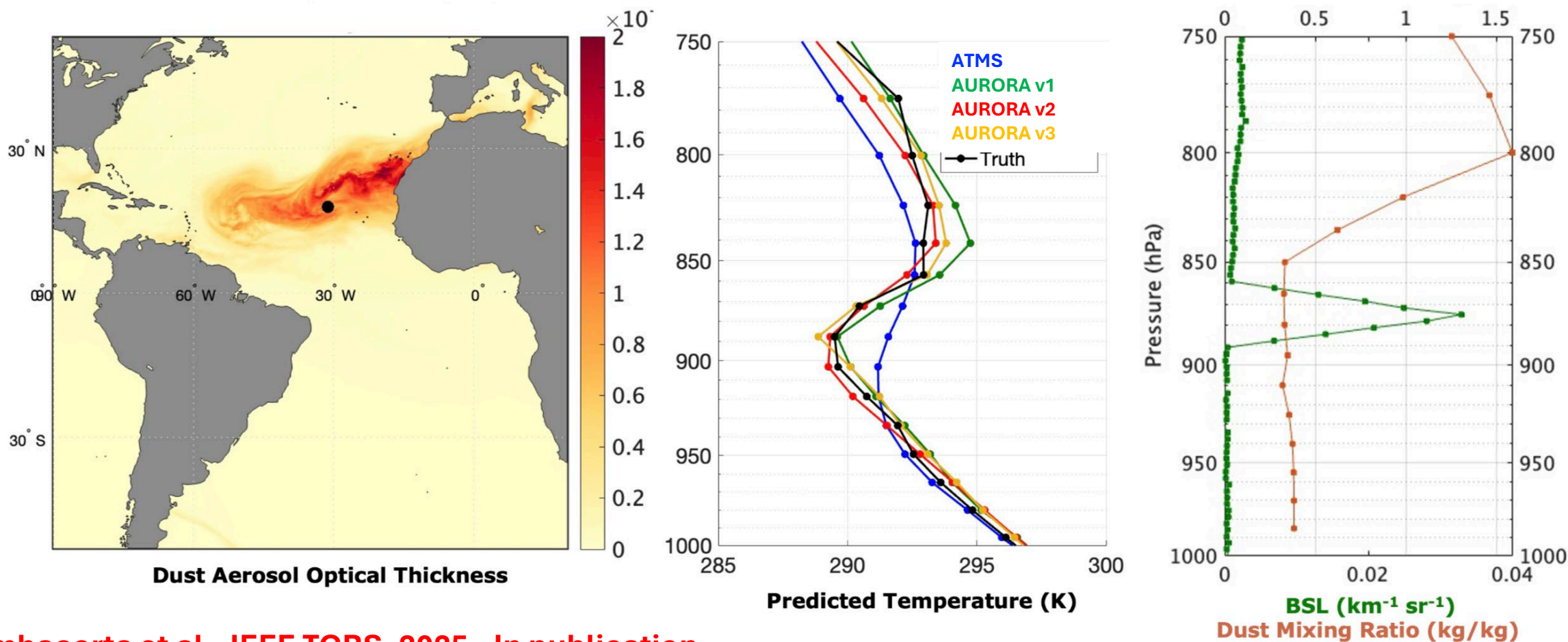


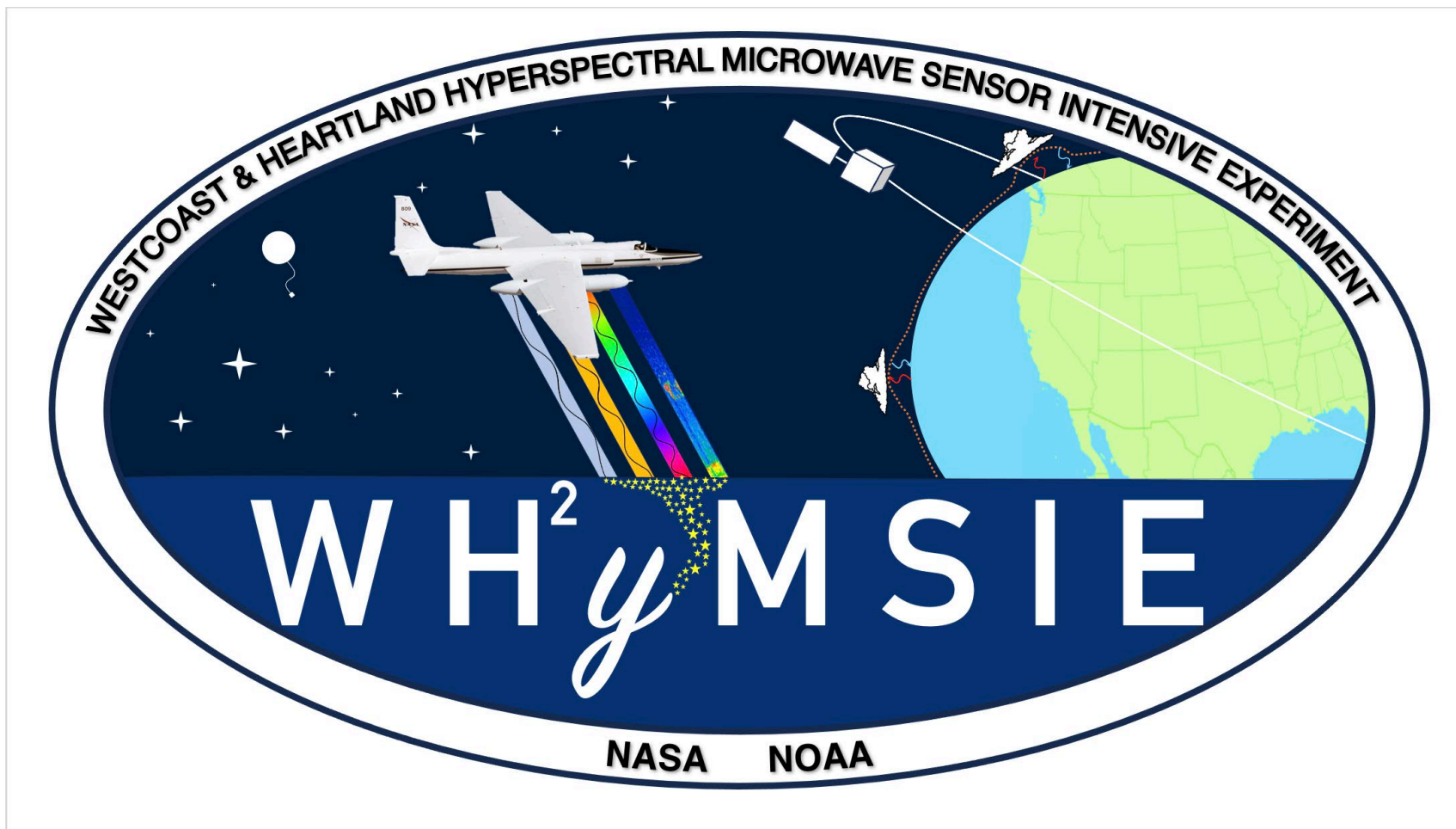
Aurora Pathfinder = Sounder + Imager

Applications: AURORA Pathfinder Will Enable Improved Sounding under Extreme Weather Measurements

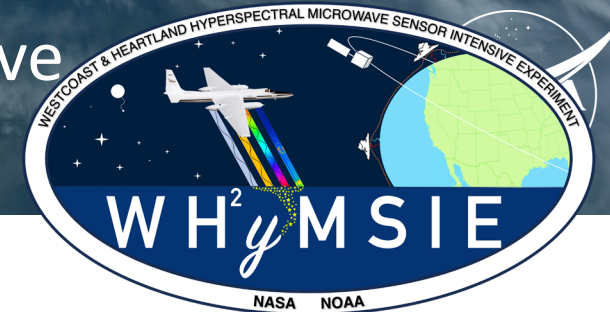


Truth
ATMS
AURORA





<https://earth.gsfc.nasa.gov/climate/campaigns/WHyMSIE>



Objectives

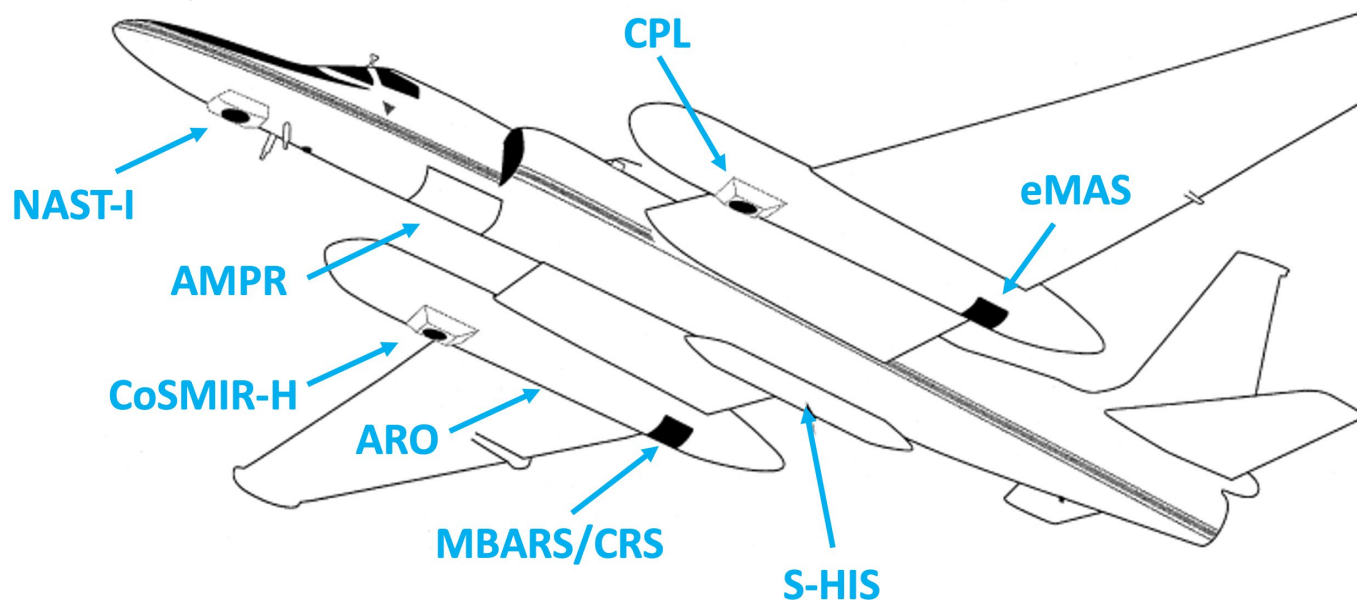
Demonstrate the capabilities of CoSMIR-H

- Maximize sampling of ocean clear sky environments and under fly various POR satellites equipped with microwave instruments (ATMS, AMSU/MHS)

Capture a wide variety of atmospheric states that contribute to variability in PBL and surface emissivity over land (e.g. convective/non-convective)

- Maximize validation opportunities and overflights of ground based PBL-focused networks (e.g. SGP, NCAR Boulder, G-III dropsondes)

Challenge the capability of the combined remote sensing payloads (ER-2 + G-III) by sampling baroclinic zones (T/q gradients) and cloudy environments (e.g. marine stratocumulus)



ER-2		
Instrument	Measurement Type	Spatial Scale
Conical Scanning Millimeter-wave Imaging Radiometer - Hyperspectral (CoSMIR-H)	Hyperspectral Microwave	1 km
Microwave Barometric Radar and Sounder (MBARS)	Doppler Radar	1-4 km
Cloud Radar System (CRS)	Doppler Radar	300 m
Cloud Physics Lidar (CPL)	Backscatter Lidar	125 m
Scanning High-resolution Interferometer Sounder (S-HIS)	Infrared	2 km
National Airborne Sounder Testbed - Interferometer (NAST-I)	Infrared	2.5 km
Advanced Microwave Precipitation Radiometer (AMPR)	Microwave	0.64 – 2.78 km
MODIS/ASTER Airborne Simulator (MASTER)	Visible-Infrared	50 m
Airborne Radio Occultation (ARO)	GPS Radio Occultation	~125 km
G-III		
High Altitude Lidar Observatory (HALO)	Differential Absorption Lidar	6-12 km x 315 m
Aerosol Doppler Wind Lidar (AWP)	Doppler Lidar	~ 2 km
Dropsondes	In Situ	~ 20 km

WH²yMSIE Over Land Objectives and Ground-Based Support

- Capture wide range a surface types to develop improved surface emissivity models critical for future PBL-relevant microwave retrievals of temperature and water vapor
- Observe PBL dynamics over different surface types (dessert, grasslands, etc.) at different times of day to capture diurnal variability

Land Flight Overview

- 4 science flights
- 27 radiosondes
- Clear sky
- NOAA-21, EarthCare

WH²yMSIE Over Water Objectives and In Situ Validation Support

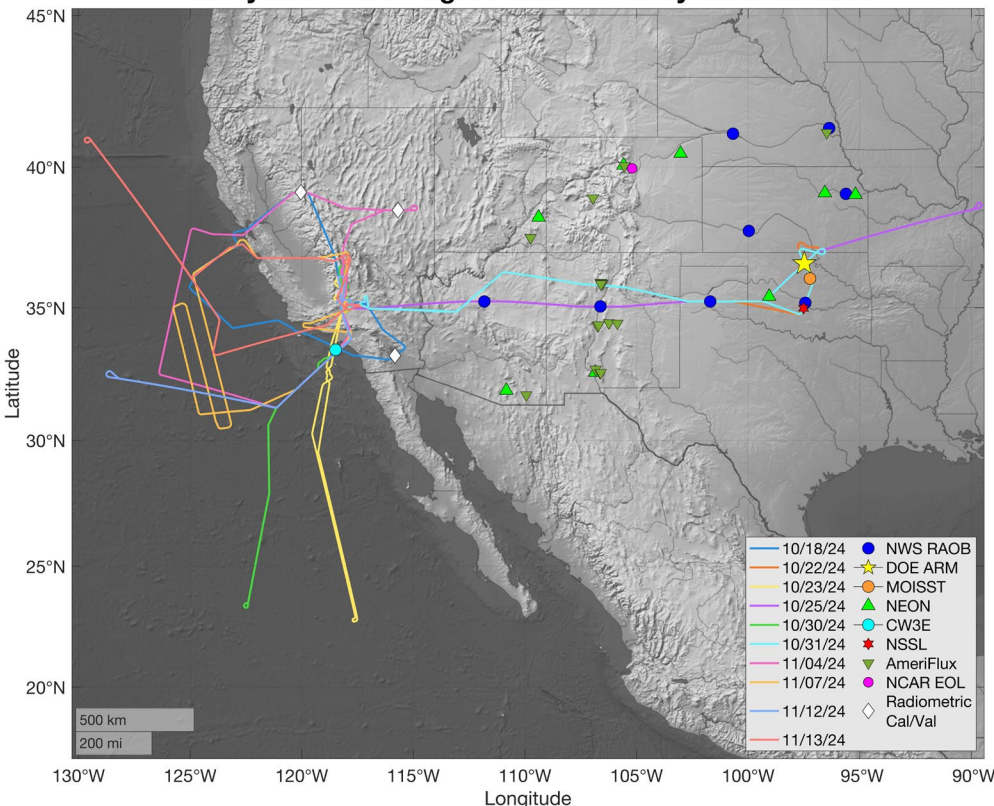
- Maximize clear sky data points and under fly POR satellite instruments for future MW and IR cal/val comparisons
- Observe a variety of marine PBL environments in clear and cloudy conditions

Ocean Flight Overview

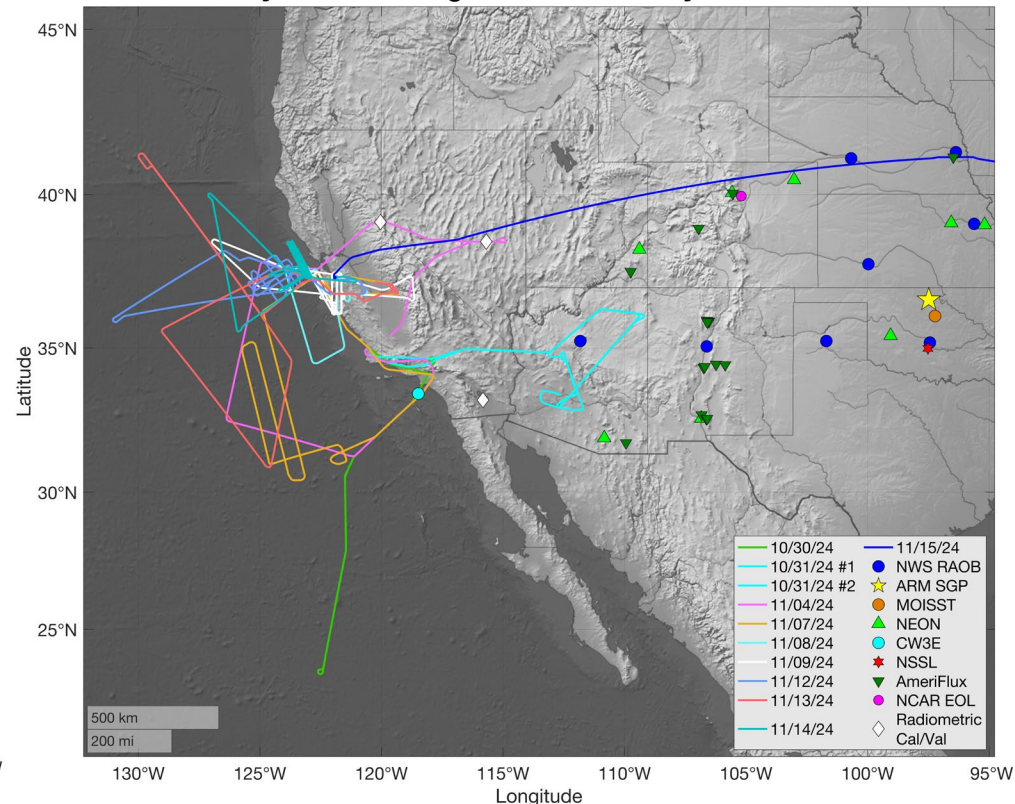
- 6 science flights
- 40 dropsondes
- Mix of clear and cloudy scenes
- NOAA-21, Arctic Weather Satellite (AWS), EarthCare



WH²yMSIE ER-2 Flight Paths + Priority Ground Sites



WH²yMSIE G-III Flight Paths + Priority Ground Sites



WH²yMSIE Data Archive is located at <https://www-air.larc.nasa.gov/>

