Status of the Microwave Barometric Radar and Sounder (MBARS)

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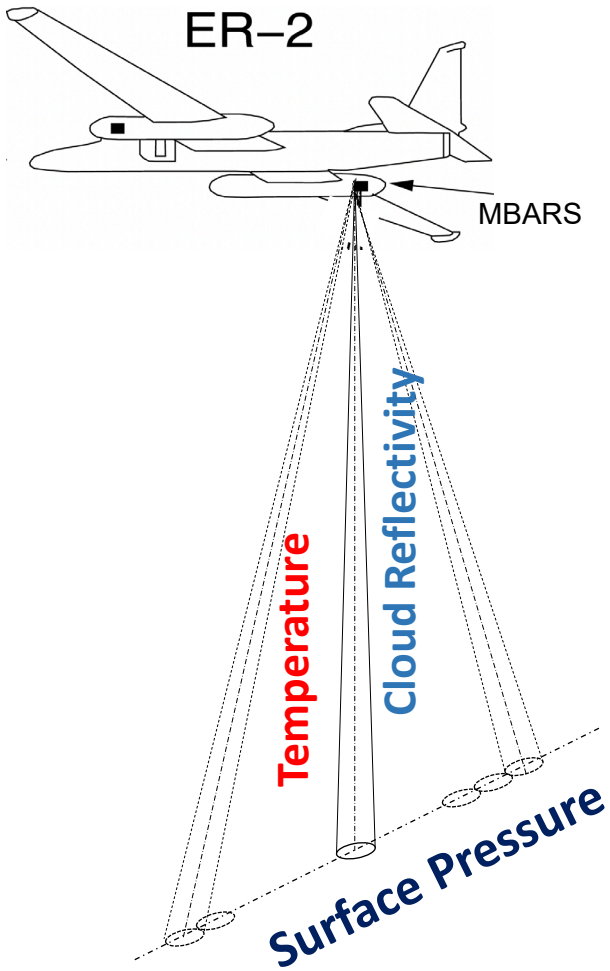
Overview of MBARS

MBARS
Microwave BArometric Radar and Sounder

- Objective is to retrieve **atmospheric pressure** with a combined active/passive microwave instrument at V-band (64-70 GHz).
  - Target of 1-2 hPa surface pressure precision
  - Demonstration planned on NASA ER-2 Fall 2024
- Additional products will be **radar reflectivity** and radiometric **temperature sounding**.
- 3-year project funded through Earth Science Technology Office (ESTO)'s 2021 Instrument Incubator Program (IIP).
- Partnership between NASA/GSFC, NASA/LaRC, Tomorrow.io, Morgan State University.



Current Surface Pressure Obs.

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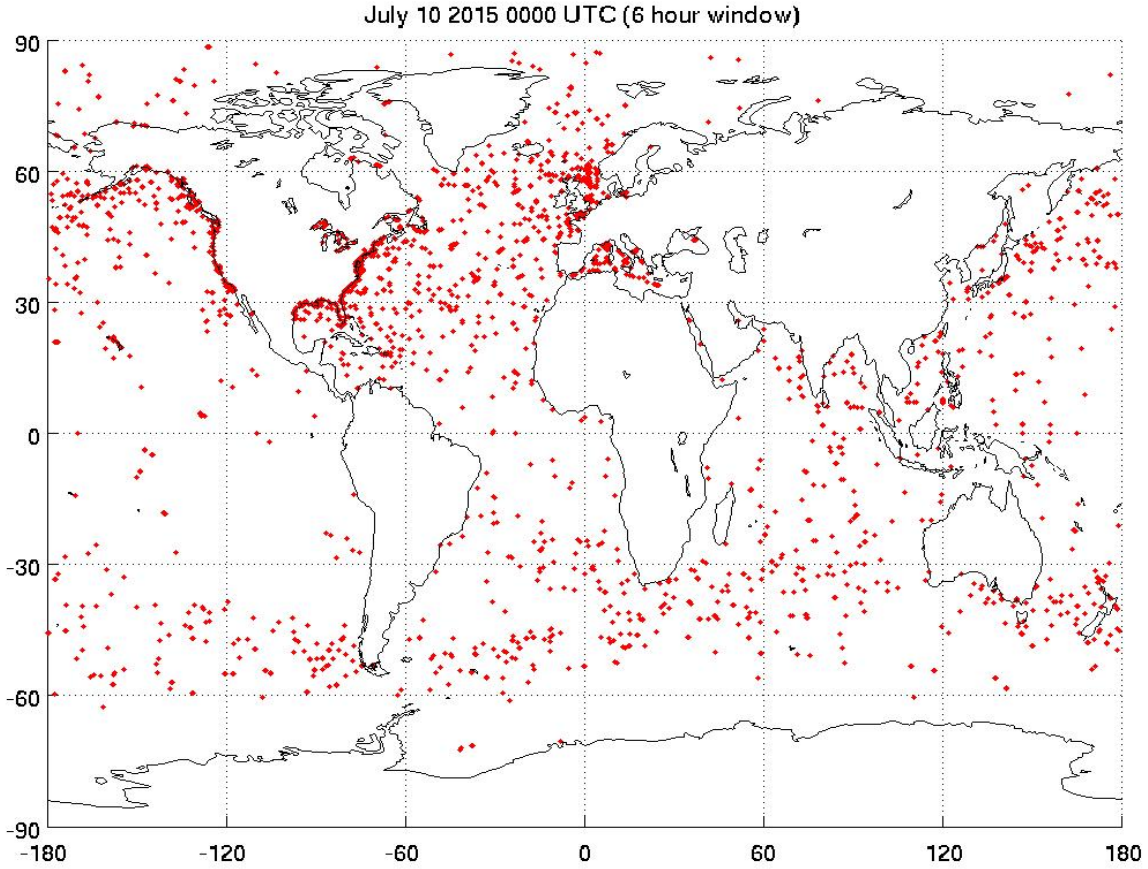

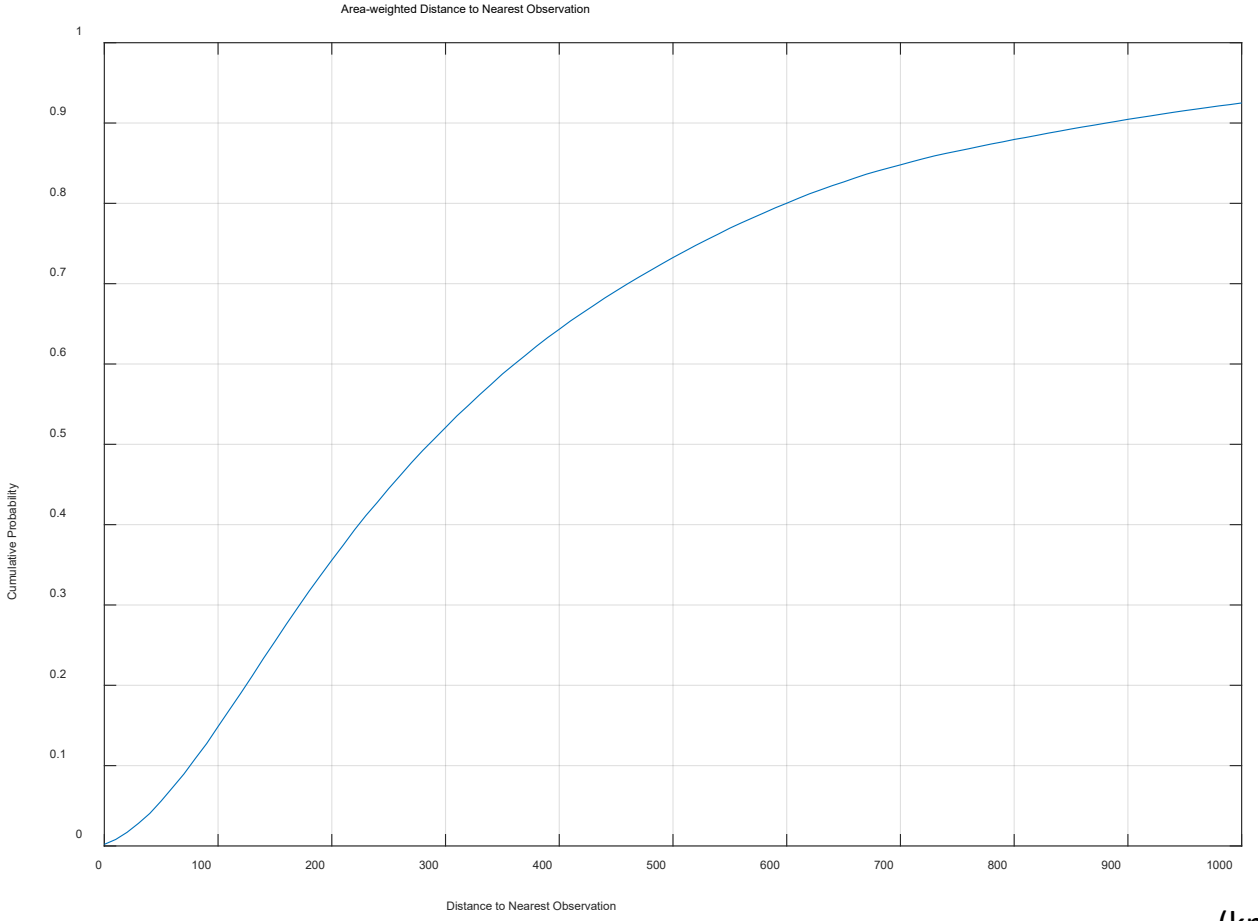

Sea level pressure observations from all sources (platforms, buoys, ships) in a six-hour window (2015, GMAO).

OSSE Retrieval Impacts

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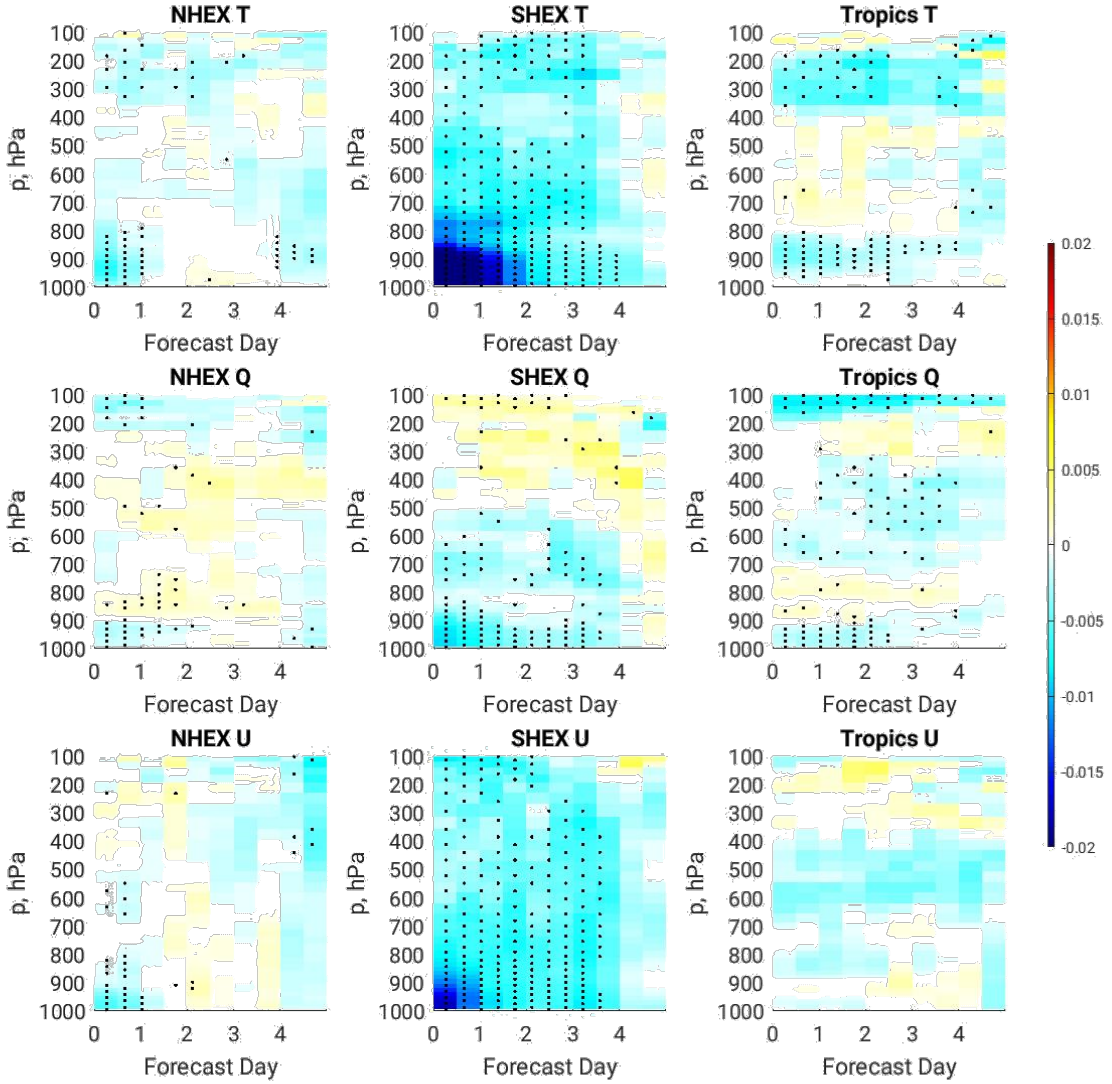
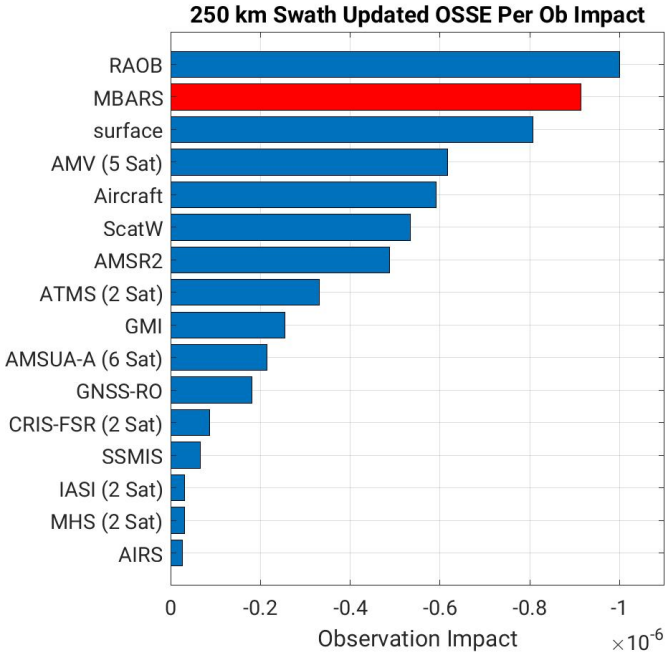
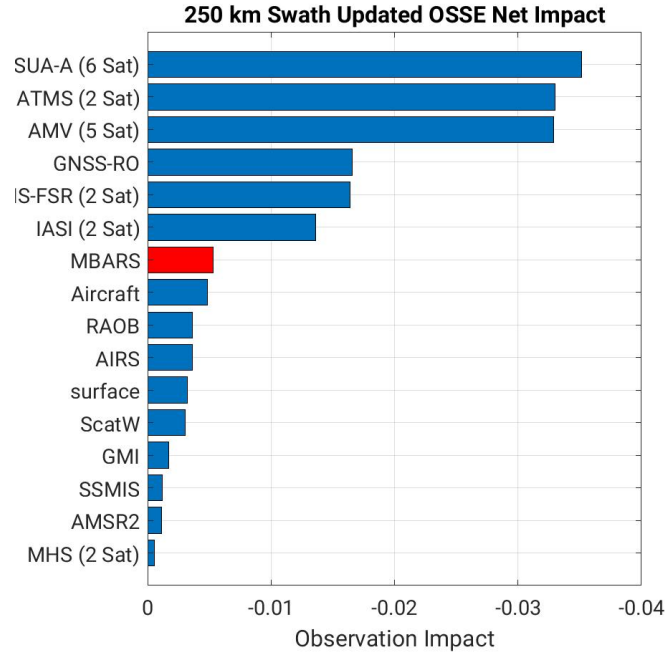


Observing System Simulation Experiment (OSSE) shows that 1-2 hPa uncertainty pressure observations improve forecasts, particularly over the data-starved oceans.





Observation Impact: 24 hour total wet energy 30-60S

Differential Absorption Radar

MBARS
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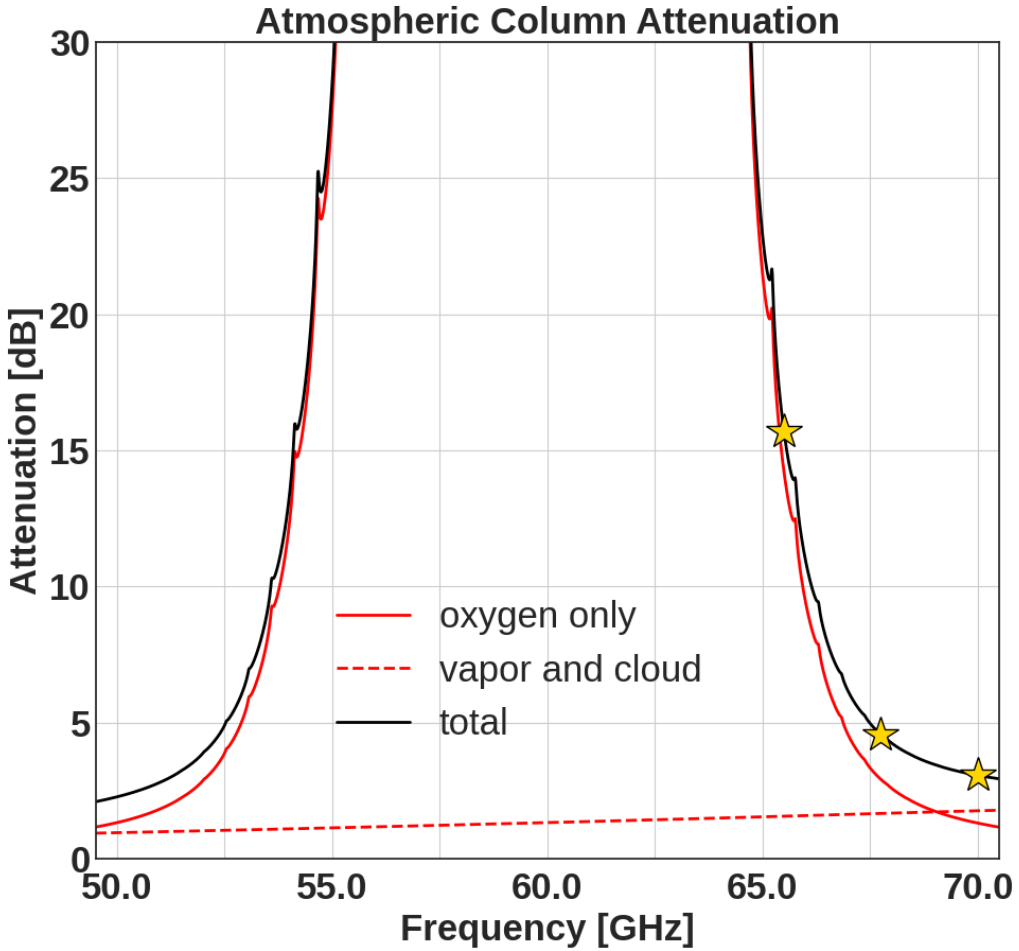
Use radar and a temperature profiler to estimate the **total column oxygen** content using differential backscatter from the surface.

With the assumption that oxygen is well mixed, this provides the **dry-air surface pressure.**

Add **water vapor mass** to achieve total surface pressure.

Using three-frequencies (65.5, 67.75, 70 GHz) allows mitigation of confounding variables such as water vapor and fog.



For more information on this concept, please see:

Lin, B. and Hu, Y.: Numerical simulations of radar surface air pressure measurements at O2 bands, *IEEE T. Geosci. Remote,* 2, 324–328, 2005.

Millán, L., Lebsock, M., Livesey, N., Tanelli, S., and Stephens, G.: Differential absorption radar techniques: surface pressure, Atmos. Meas. Tech., 7, 3959–3970, 2014.

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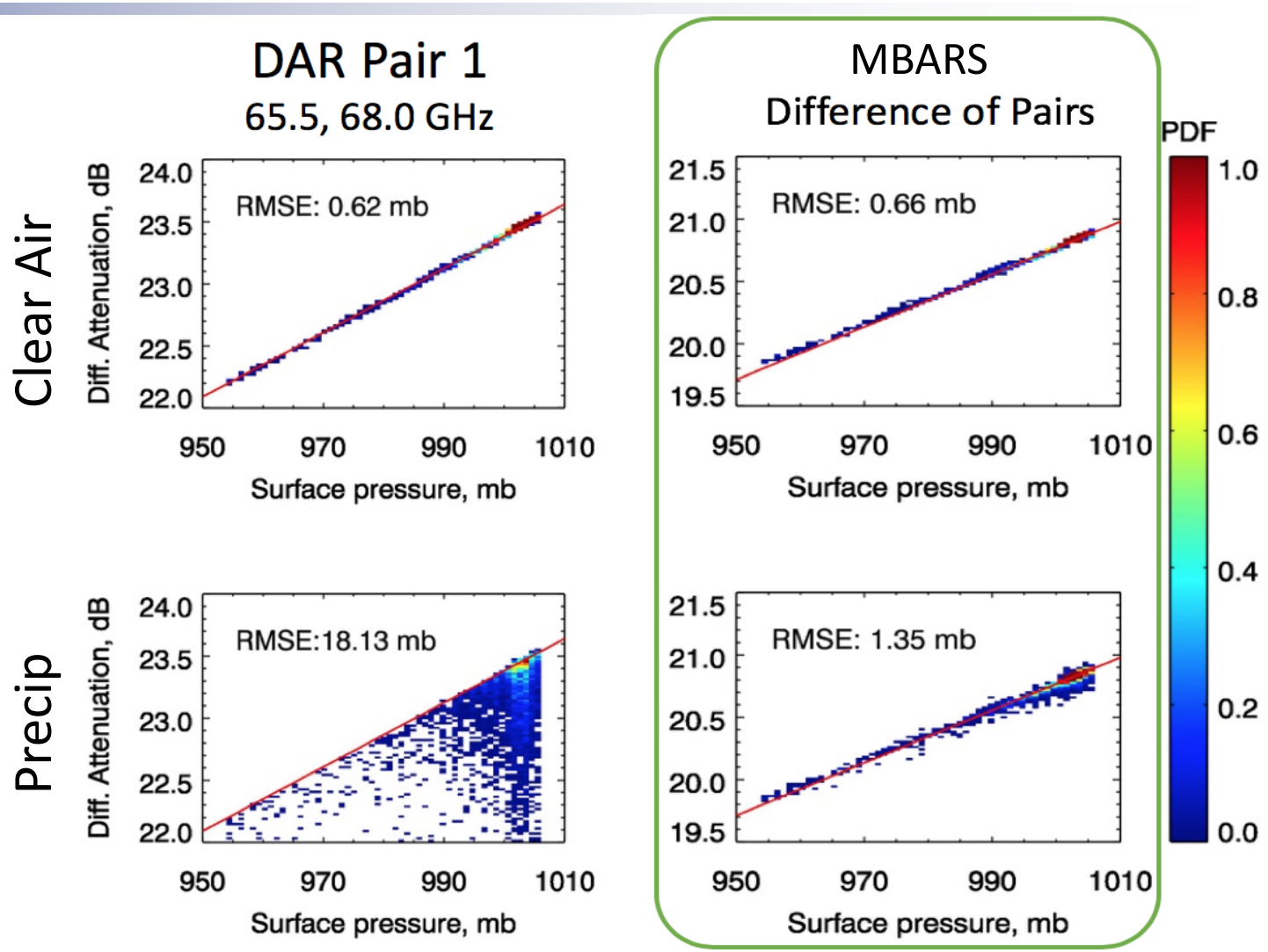


Temperature Sounding

Temperature profiles from radiometric sounding extends the DAR surface-pressure to a vertical atmospheric pressure retrieval.

MBARS shares the DAR receiver with a V-band (64-70 GHz) microwave temperature profiler capable of hyperspectral sounding.

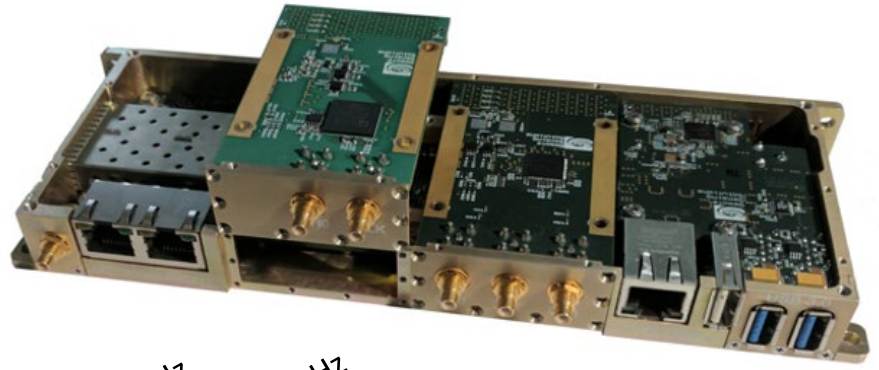
While MBARS will be capable of hyperspectral sounding, we will target atmospheric pressure at three levels using conventional radiometer channels:

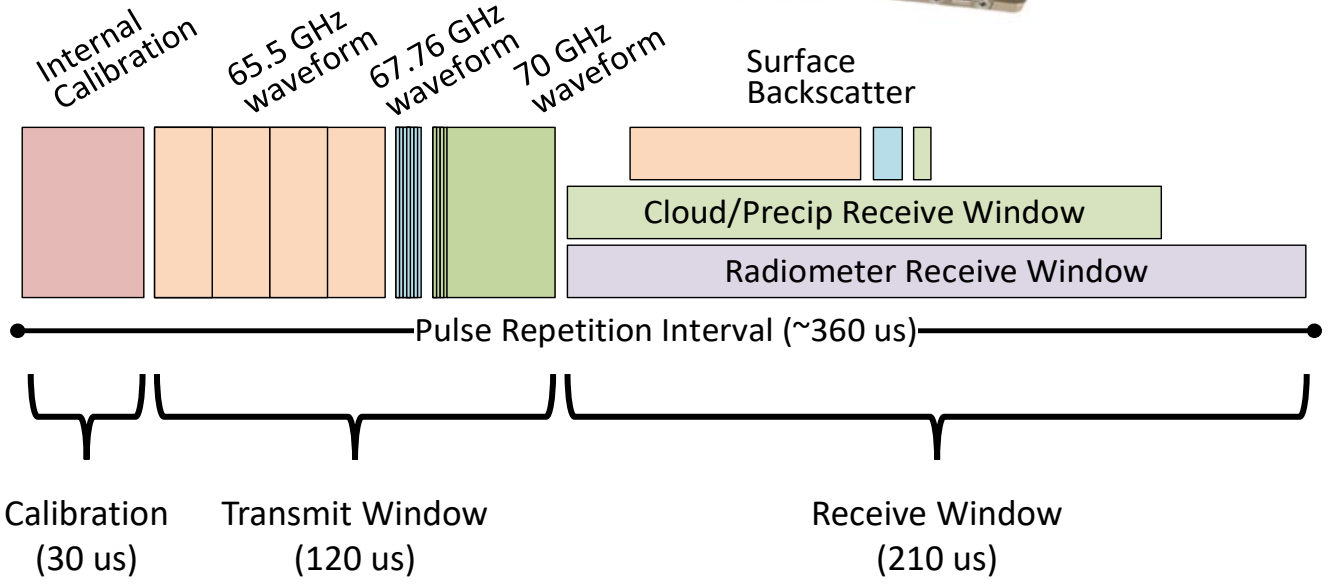
- Surface
- Mid-Troposphere (~500 hPa geopotential heights)
- Upper-Troposphere (~250 hPa geopotential heights).

Technical Challenges

MBARS
Microwave BArometric Radar and Sounder

- The pressure radar concept is experimental, so there ~~may~~ **will** be unexpected challenges.
- Target of 0.02 dB (0.5%) precision requires many (50,000+) independent samples assuming positive signal-to-noise ratio (SNR).
  - Same precision requirement soil moisture radiometry, but in a radar.
  - 16x frequency-hopped radar subchannels will provide multiple independent samples per pulse repetition interval.
  - Strict receiver linearity and internal calibration path requirements
- Receiver will use digital processing to separate radar and radiometer returns.
- First-of-its-kind instrument and retrieval algorithm.





MBARS Airborne Demonstrator

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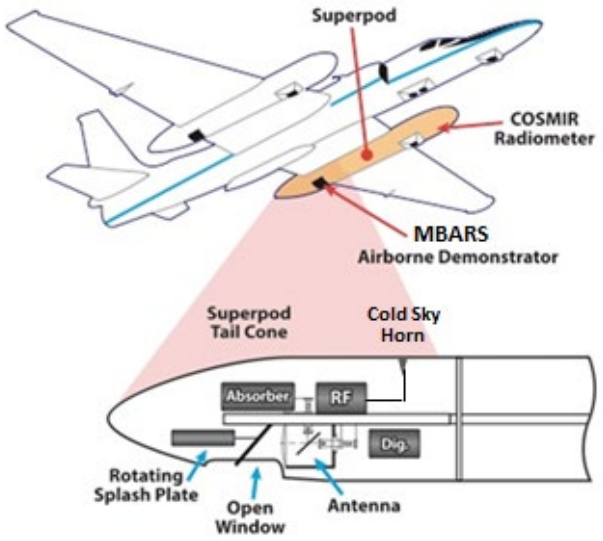
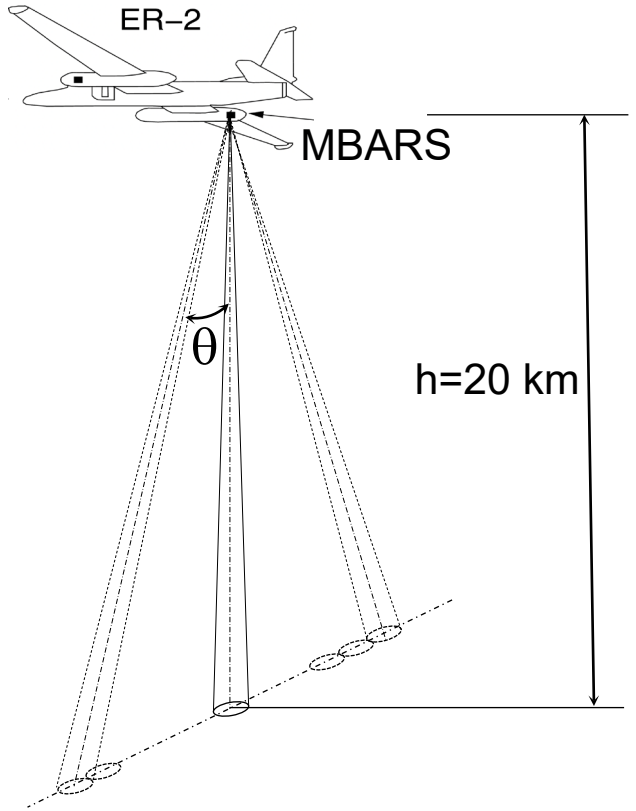


NASA ER-2, Image Credit NASA/Carla Thomas



Parameter	Target ER-2 MBARS Performance
Scan Pattern	Cross-Track
Transmit Power	5 Watts
Horizontal Resolution	1-4 km
Precision (Surface Pressure)	1-2 hPa
Swath	10 km
Altitude	20 km
Sensitivity (Radar Reflectivity)	-20 dBZ

MBARS Development Status

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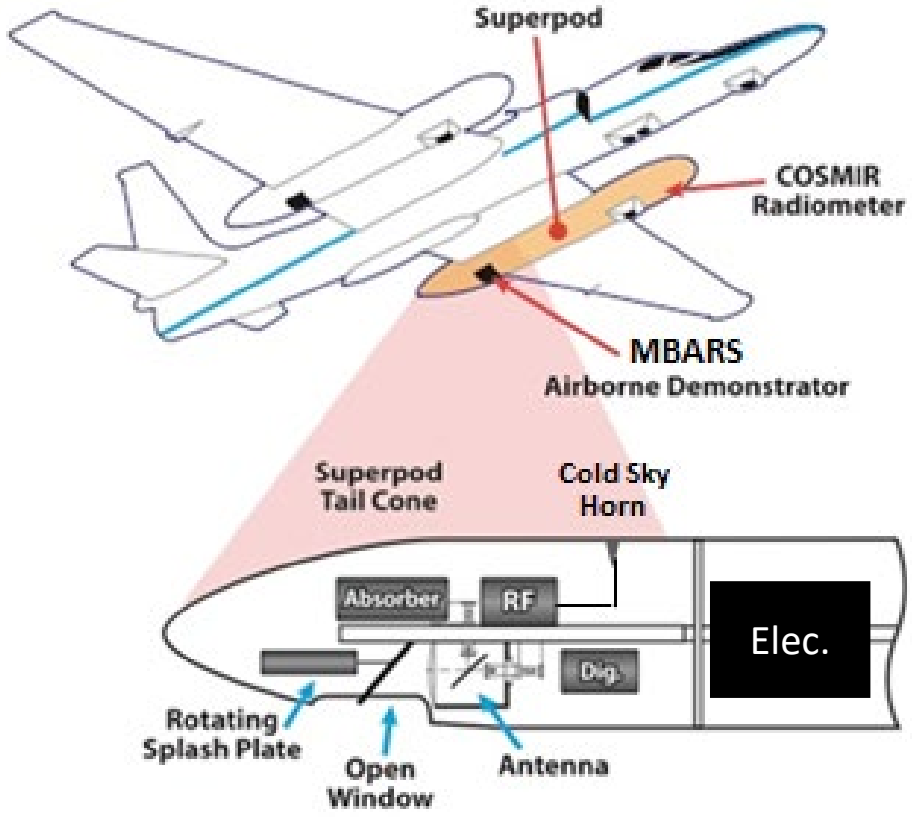
- The MBARS airborne instrument is being assembled, with major procurements completed.
  - **RF Electronics** are housed in a hermetic enclosure in the unpressurized superpod aft-body. Transceiver leverages an SBIR-developed solid-state power amplifier.
  - **IF Electronics, Digital Electronics, and Power Distribution** are housed in the pressurized superpod mid-body.
  - The **Antenna** is a 12” dual-frequency (V+W)-band lens aft-pointing to a splash plate, enabling pitch compensation and cross-track scanning.
    - W-band is to share the superpod with the Cloud Radar System (CRS).
  - The **Scanning Mechanism** is a two-axis (rotation + pitch) stepper motor assembly with a flat splash plate.



MBARS Test Flights

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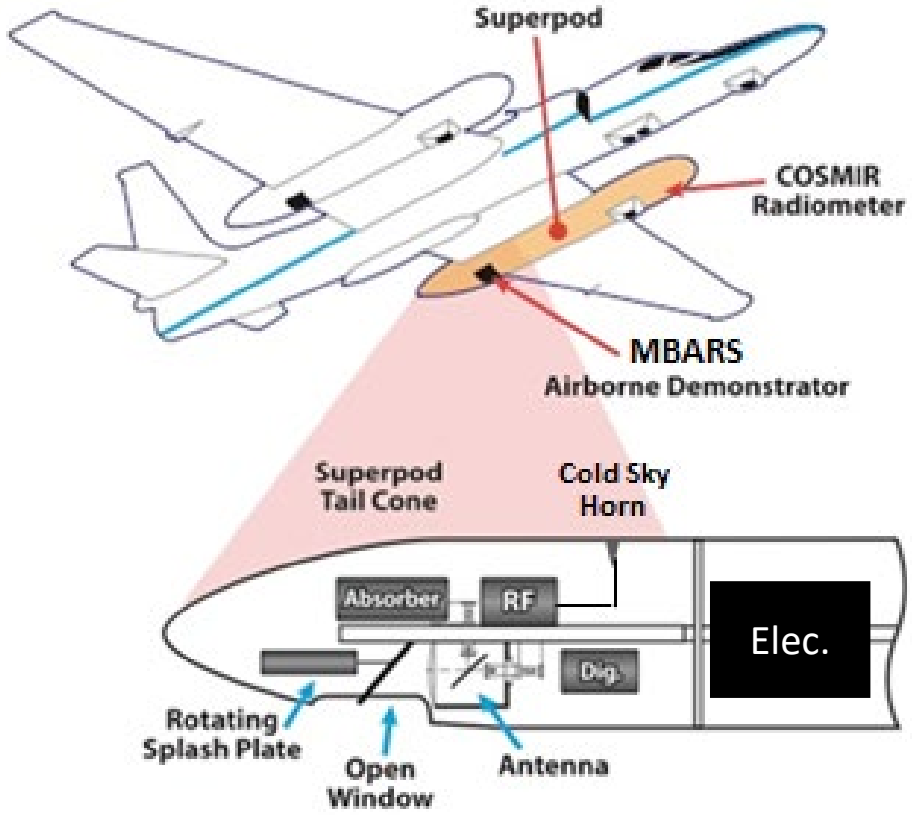
- MBARS has two flight campaigns planned for summer & fall of 2023
  - MBARS is coordinating with the Conical Scanning Millimeter-wave Imaging Radiometer – Hyperspectral (COSMIR-H), PI: Rachel Kroodsma.
    - COSMIR-H is an ESTO Decadal Survey Incubator (DSI) project.
  - Engineering test flights in summer
  - Fall field campaign funded by NOAA to test hyperspectral radiometer technology.
  - Flights will be primarily over the Pacific Ocean, based out of Palmdale, CA.



Thank you!

Questions?