Status of the Microwave Barometric Radar and Sounder (MBARS)

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# Current Ocean Surface Pressure Obs.

Pressure drives atmospheric motion.

$$\frac{d\mathbf{V}}{dt} = \mathbf{P}_n + \mathbf{C} + \mathbf{F}$$

Horizontal atmospheric acceleration is from the sum of the **pressure gradient,** Coriolis, and frictional forces.

Measurement of pressure gradients allows retrievals of **horizontal winds.**

Tropical and subtropical **cyclones** are defined by the *location* and *strength* of the associated low-pressure anomaly.

July 10 2015 0000 UTC (6 hour window)
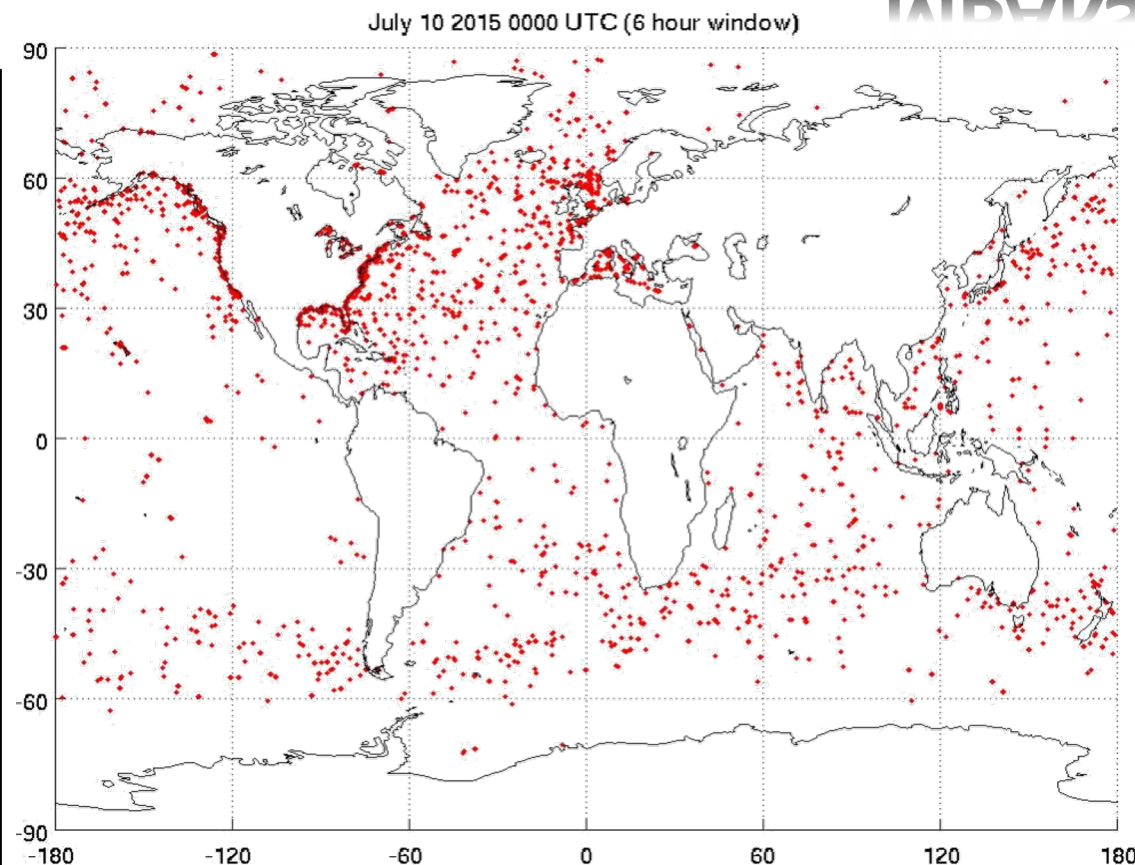
Sea level pressure observations from all sources in a six-hour window (2015, GMAO).
45% of the ocean is >300 km from an observation.

Overview of MBARS

- 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).

ER–2

MBARS

Temperature

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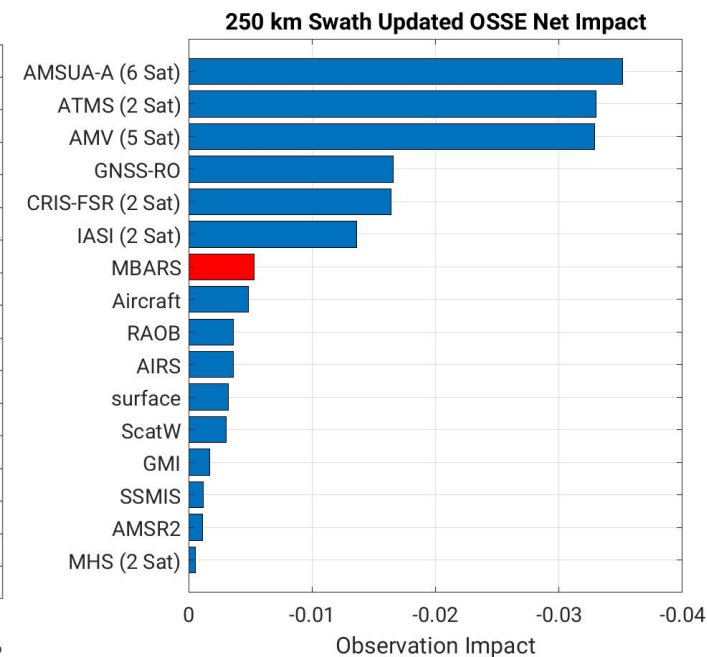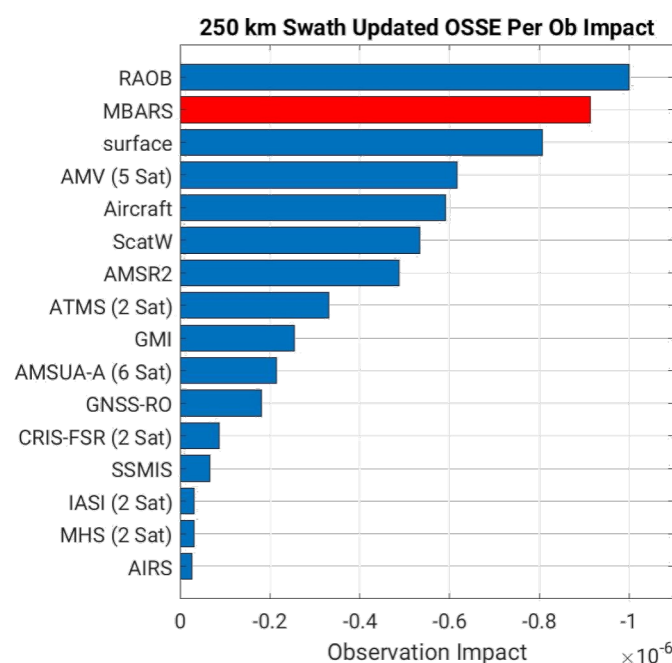
Surface Pressure
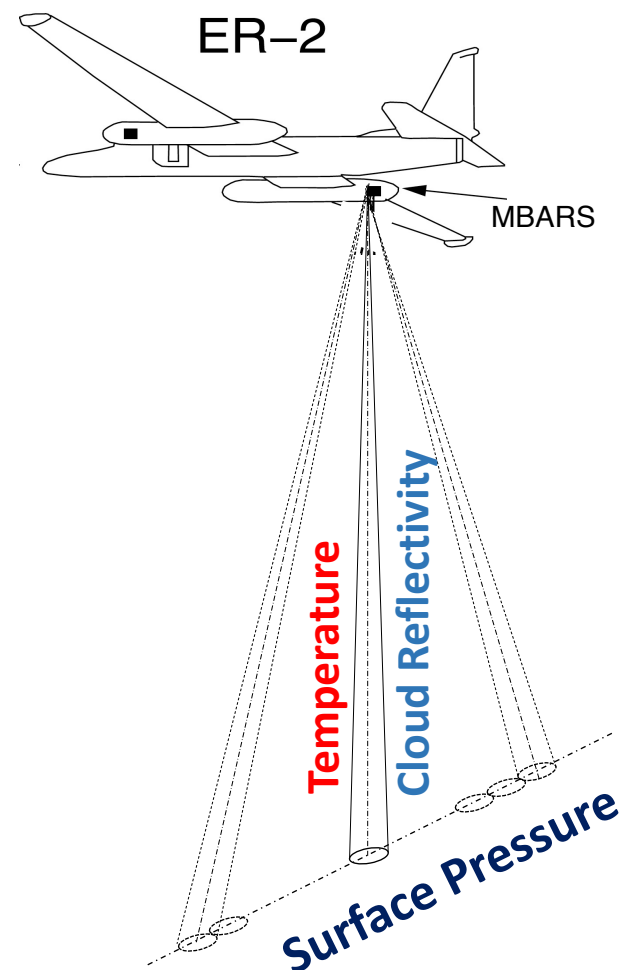
OSSE Retrieval Impacts
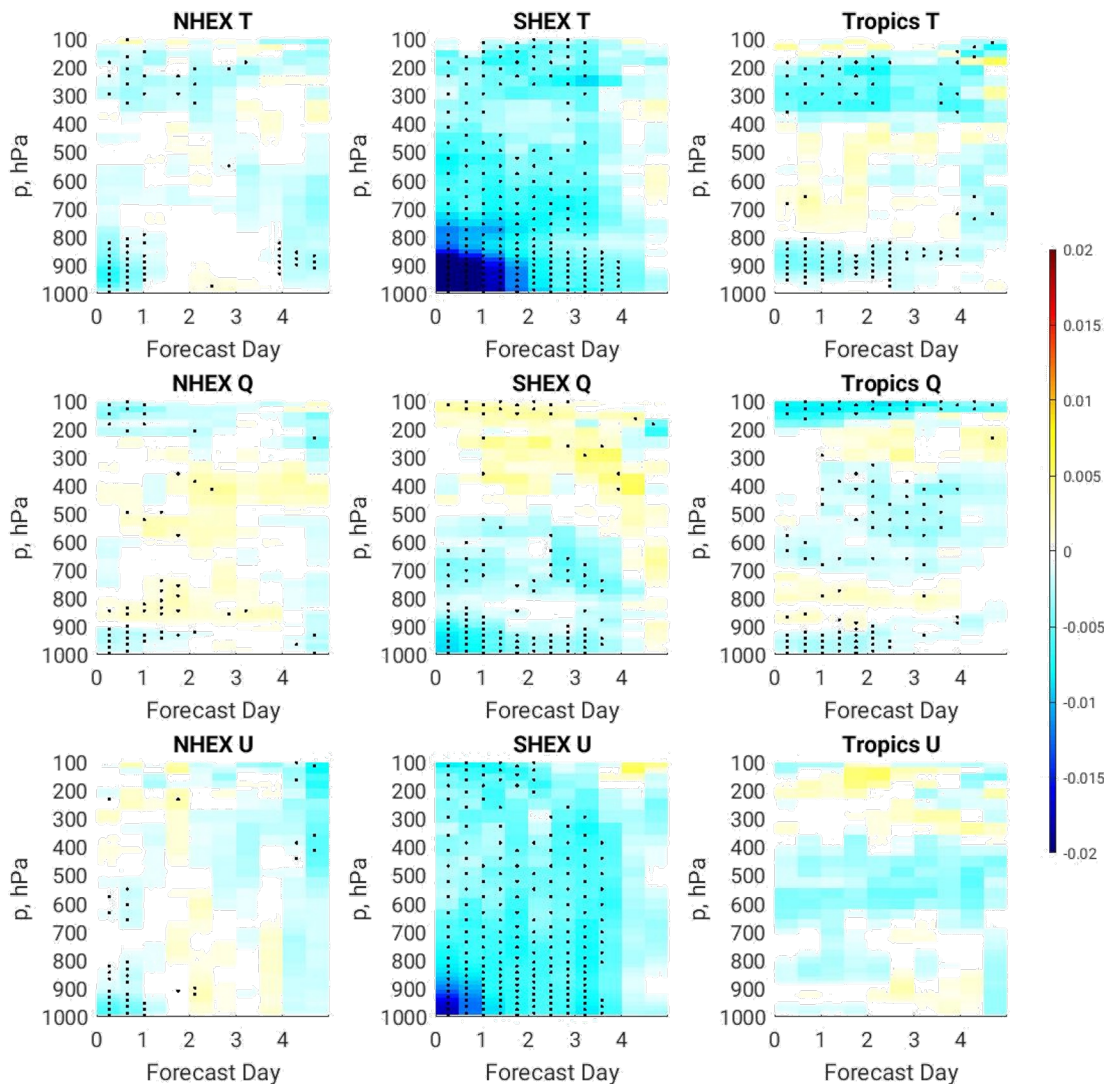
Observing System Simulation Experiment (OSSE) shows that 1-2 hPa uncertainty pressure observations improve forecasts, particularly over the data-starved oceans.

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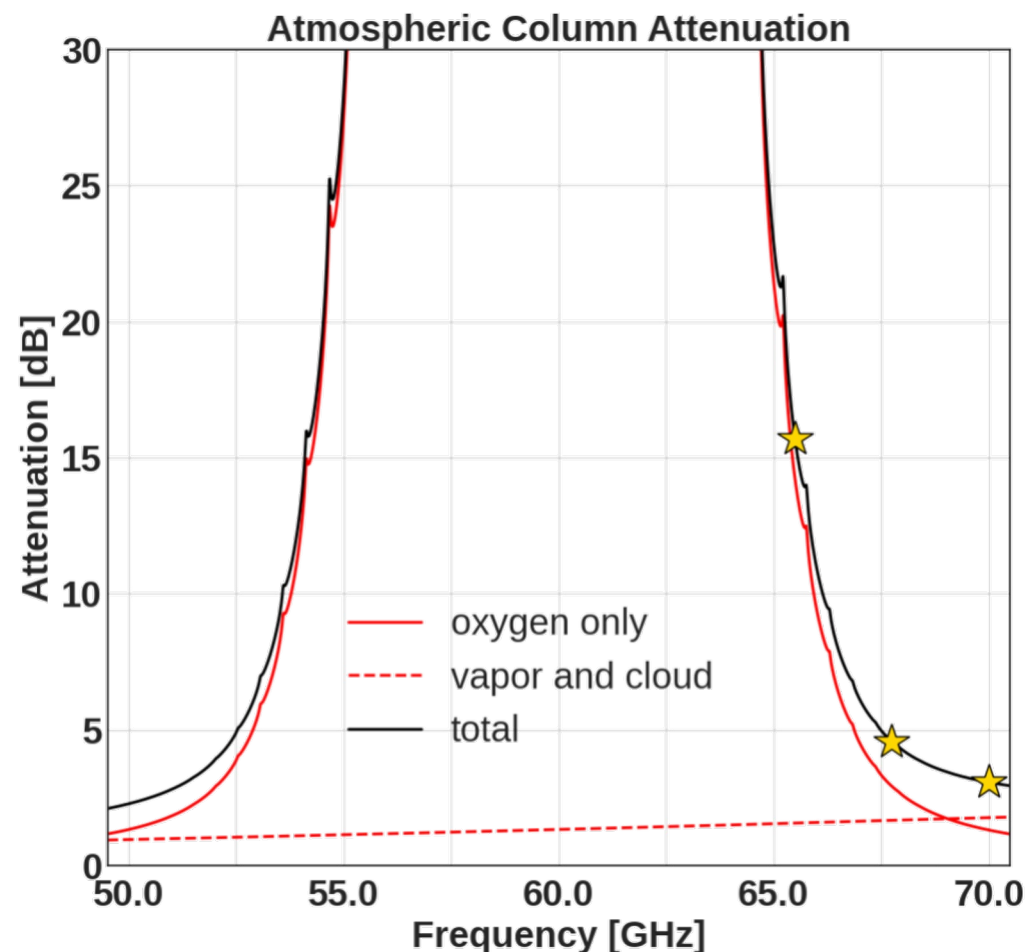
Differential Absorption Radar

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.

Atmospheric Column Attenuation
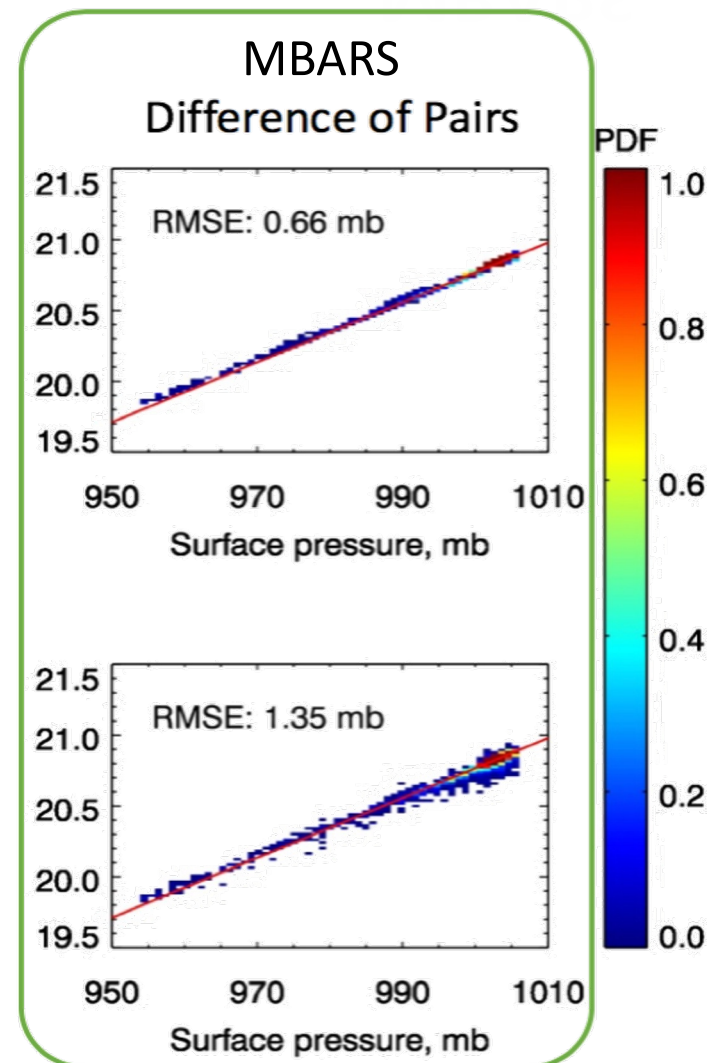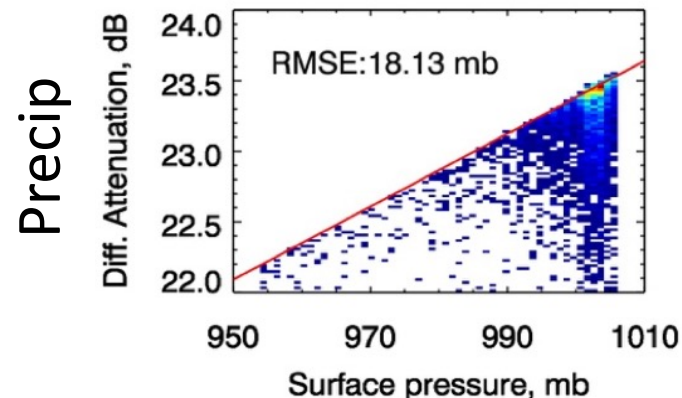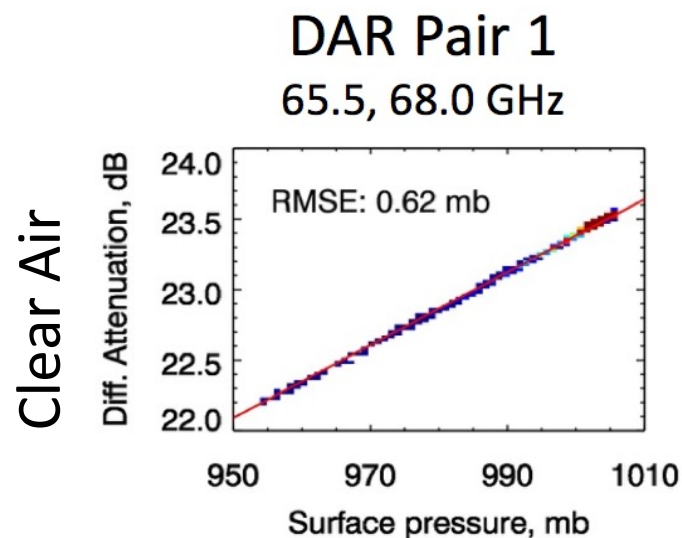
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DAR Pair 1
65.5, 68.0 GHz

Clear Air — RMSE: 0.62 mb

Precip — RMSE:18.13 mb

MBARS
Difference of Pairs

Clear Air — RMSE: 0.66 mb

Precip — RMSE: 1.35 mb

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:
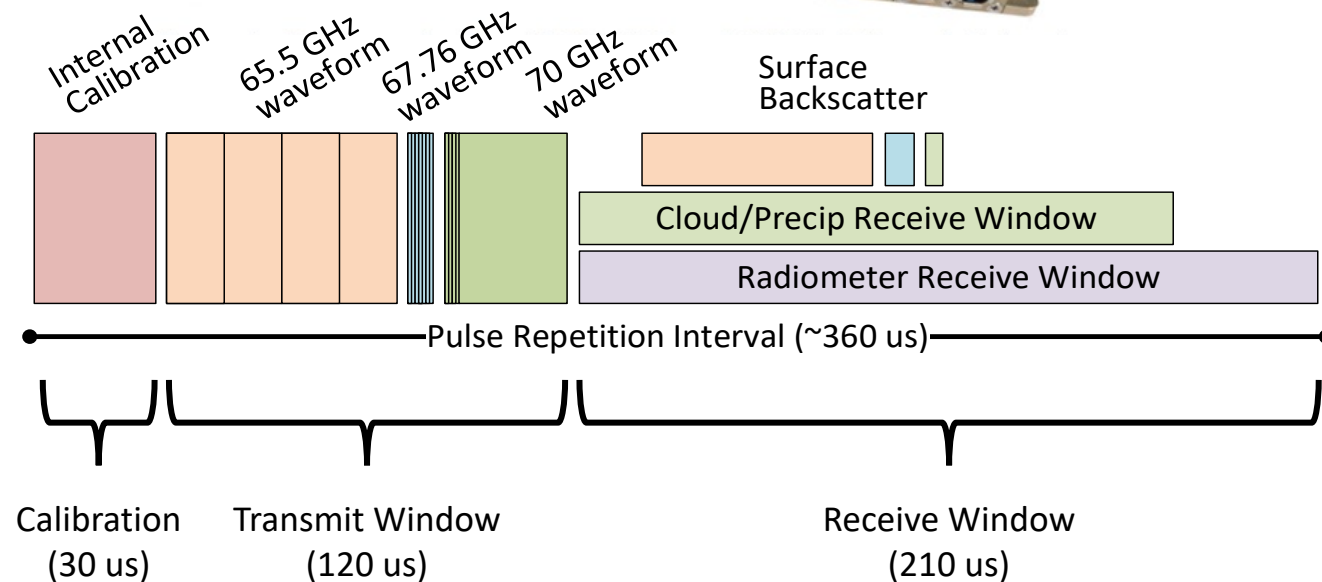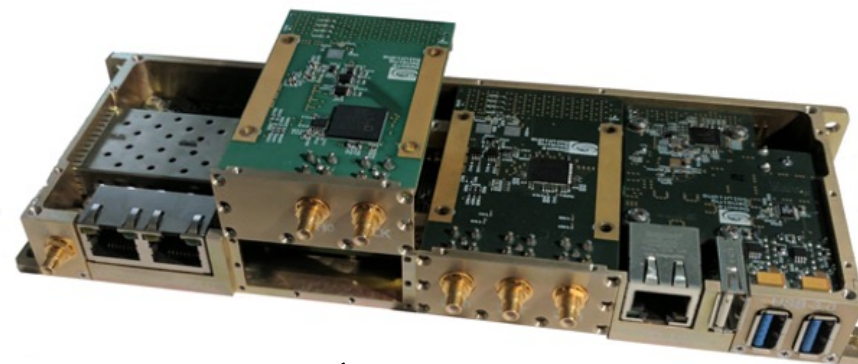
- Surface

- Mid-Troposphere (~500 hPa geopotential heights)

- Upper-Troposphere (~250 hPa geopotential heights).
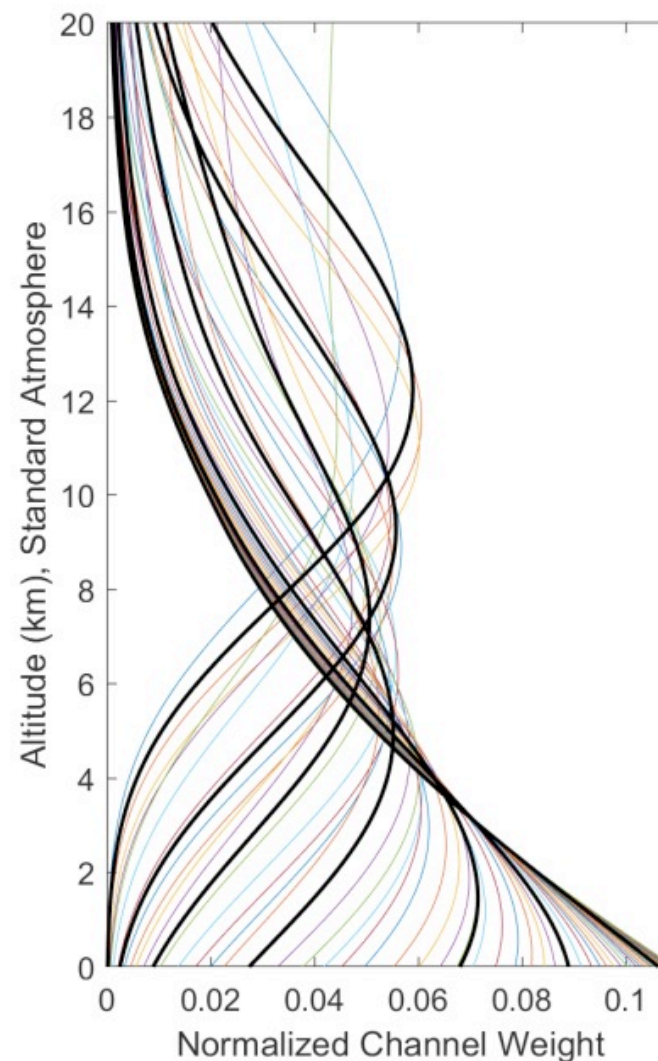
Technical Challenges

- 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).

  - Precision requirement comparable to soil moisture radiometry.

  - 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.

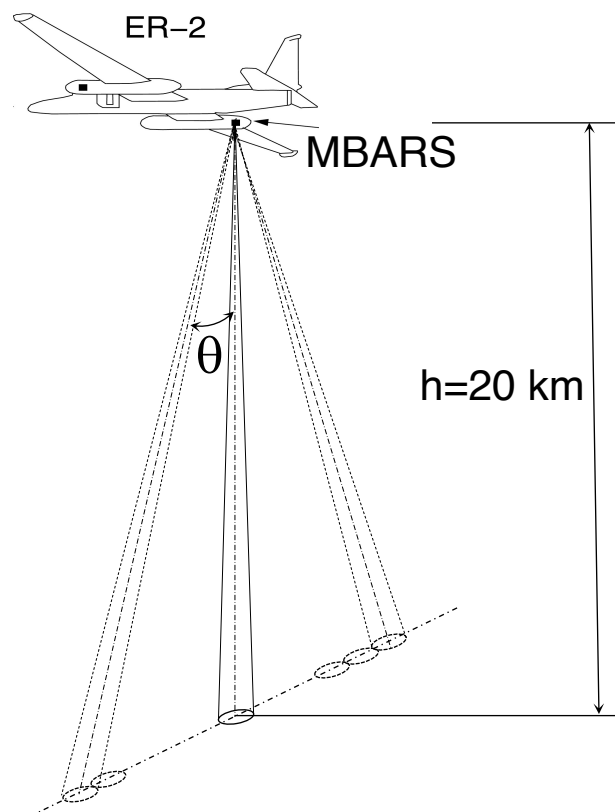- First-of-its-kind instrument and retrieval algorithm.

MBARS Airborne Demonstrator
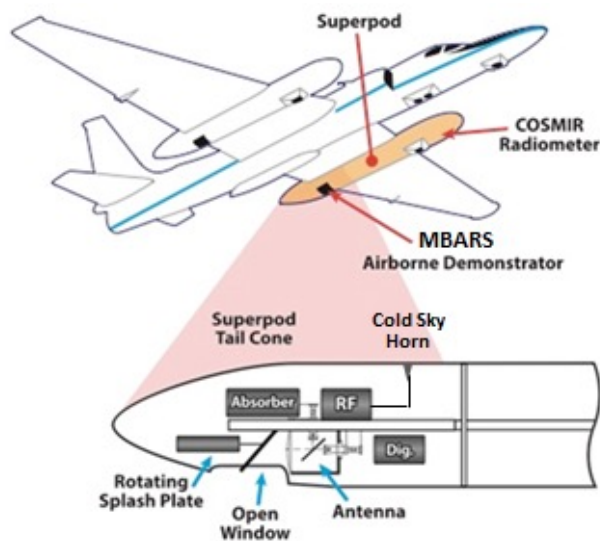
NASA ER-2, Image Credit NASA/Carla Thomas

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

- 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.
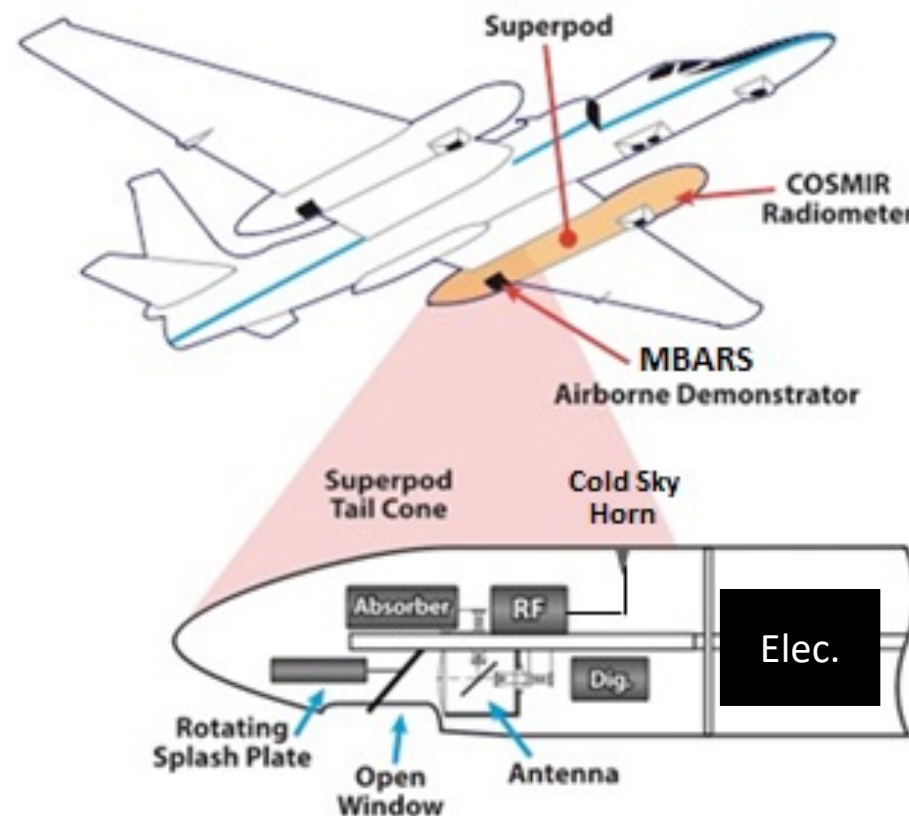
MBARS Test Flights

MBARS has two flight campaigns planned for summer & fall of 2024

- MBARS is coordinating with the Conical Scanning Millimeter-wave Imaging Radiometer – Hyperspectral (COSMIR-H), PI: Rachael Kroodsma.
  - COSMIR-H is an ESTO Decadal Survey Incubator (DSI) project.
- Engineering test flights in summer funded by ESTO
- Fall field campaign funded by NOAA to test hyperspectral radiometer technology.
  - West-coast Hyperspectral Microwave Sensor Intensive Experiment (WHyMSIE), PI Antonia Gambacorta
- MBARS flights will be primarily over the Pacific Ocean, based out of Palmdale, CA.

Thank you!

Questions?