Compact Ocean Wind Vector Radiometer: Mission Status and Future Constellations

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Naval Research Laboratory, Monterey

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The Aerospace Corporation

and STP-H8 cal/val team

This work was conducted at the Jet Propulsion Laboratory, California Institute of Technology under contract with NASA. Government sponsorship is acknowledged.

STP-H8 Mission

- Space Force mission to demonstrate new low-cost microwave sensor technologies for weather
  - **COWVR: measures ocean surface wind vector, integrated water vapor, cloud liquid water, rain rate**
  - **NASA provided TEMPEST flight spare: measures water vapor profile, convective precipitation**

- Continuous operations since January 7, 2022 **(3.4 years)**
- **Operations secured through August 2025 (extension in discussion with NASA/JAXA/ISS)**

- Science data processing at JPL
- Supports DoD operational weather (JTWC, FNMOC, NRL) with 1-2 hour latency products
- **Data distributed via PO.DAAC (updated daily)**

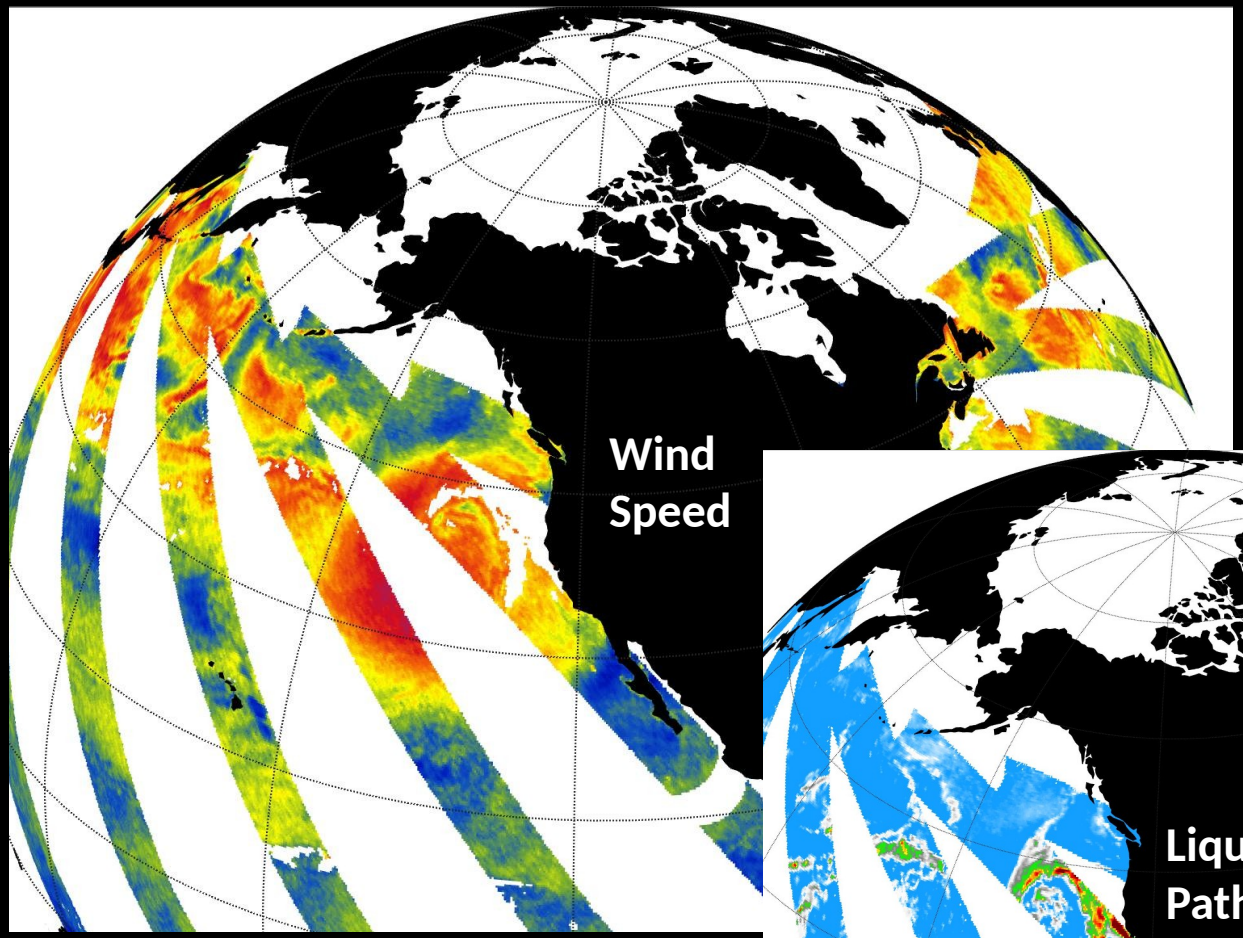
- NASA funding supports ASAP working group for combined COWVR/TEMPEST studies

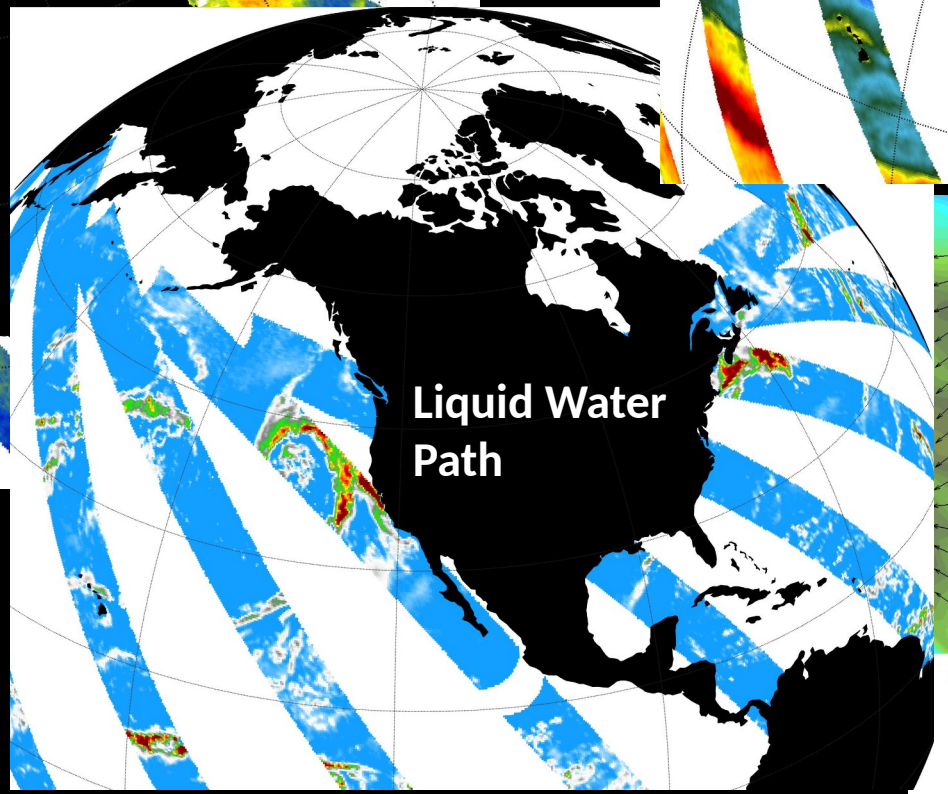
Credit D. Pettit

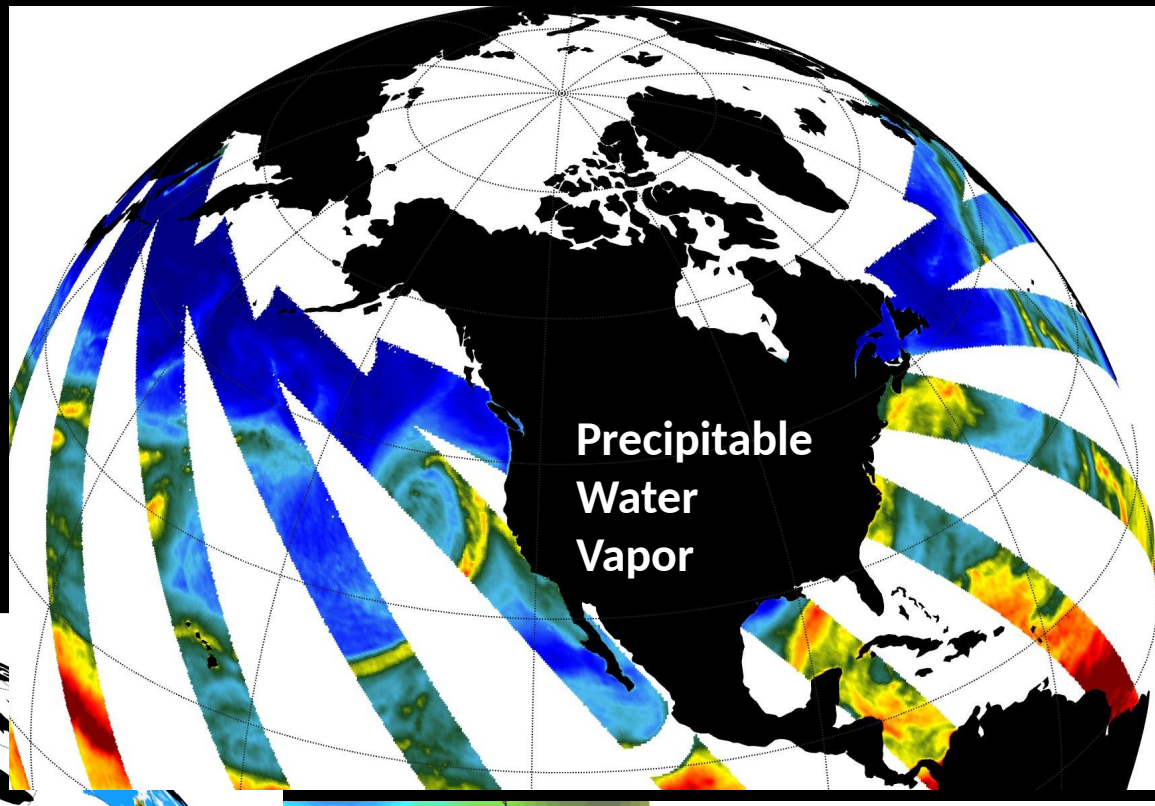
WIND VECTOR VALIDATION RESULTS COWVR V10 (PUBLIC RELEASE)

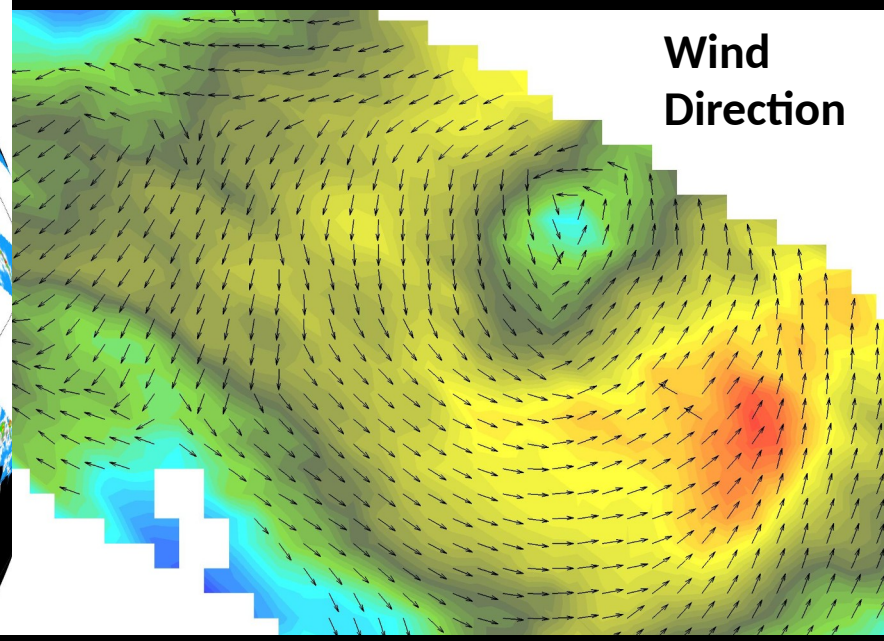
Credit NASA

COWVR Products

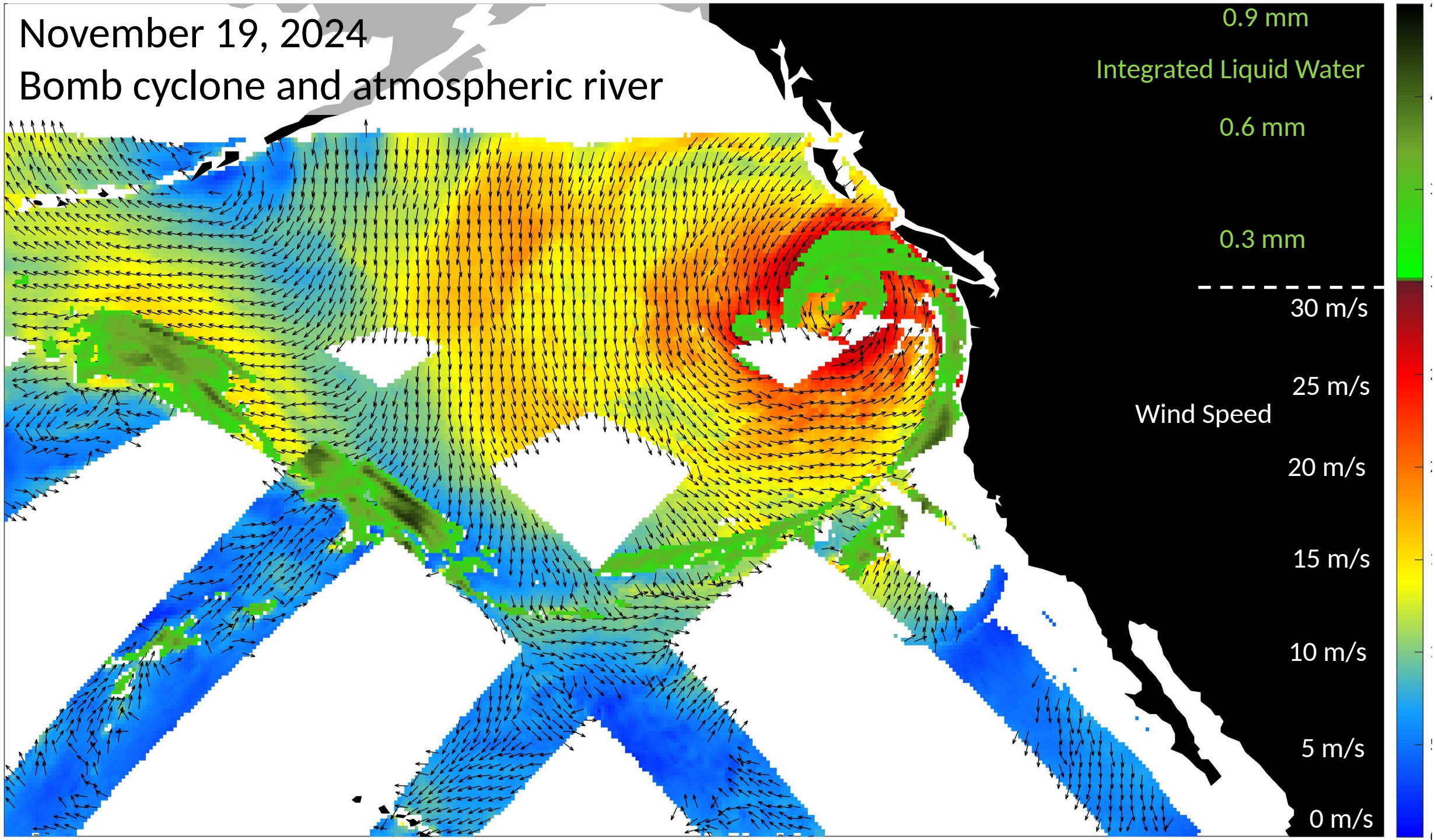


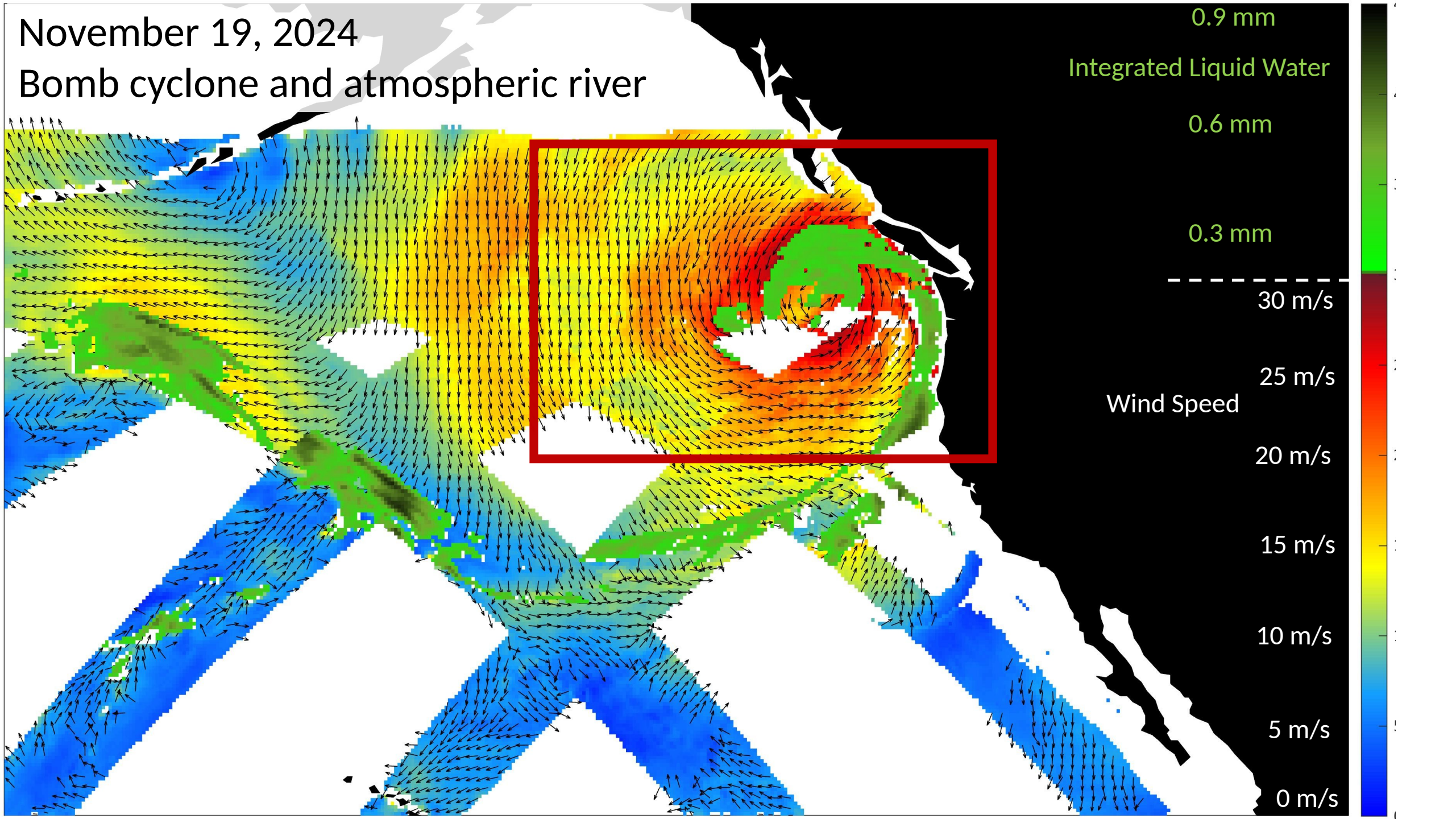






30km spatial resolution
900km swath


November 19, 2024
Bomb cyclone and atmospheric river
0.9 mm
Integrated Liquid Water
0.6 mm
0.3 mm
30 m/s
25 m/s
Wind Speed
20 m/s
15 m/s
10 m/s
5 m/s
0 m/s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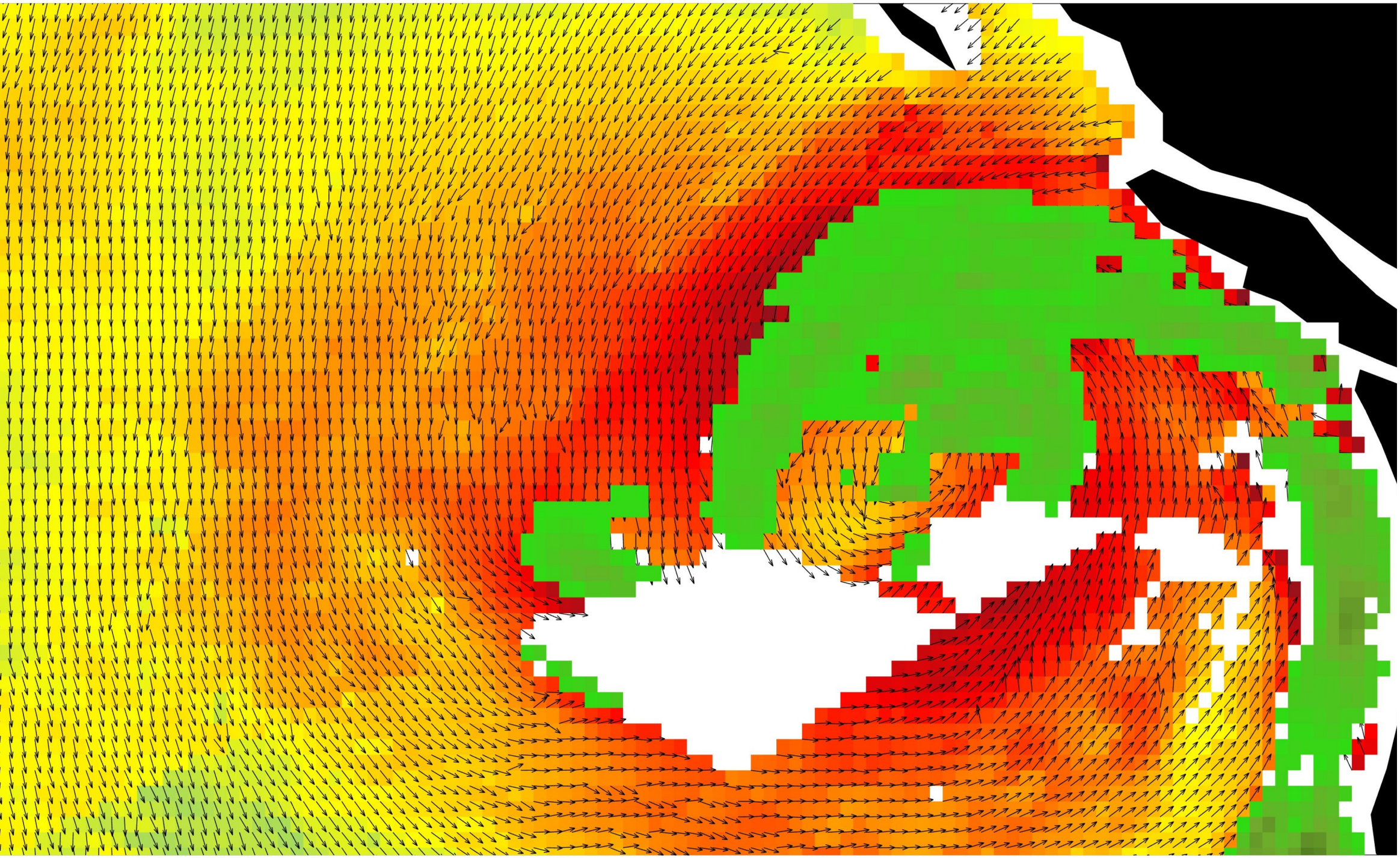
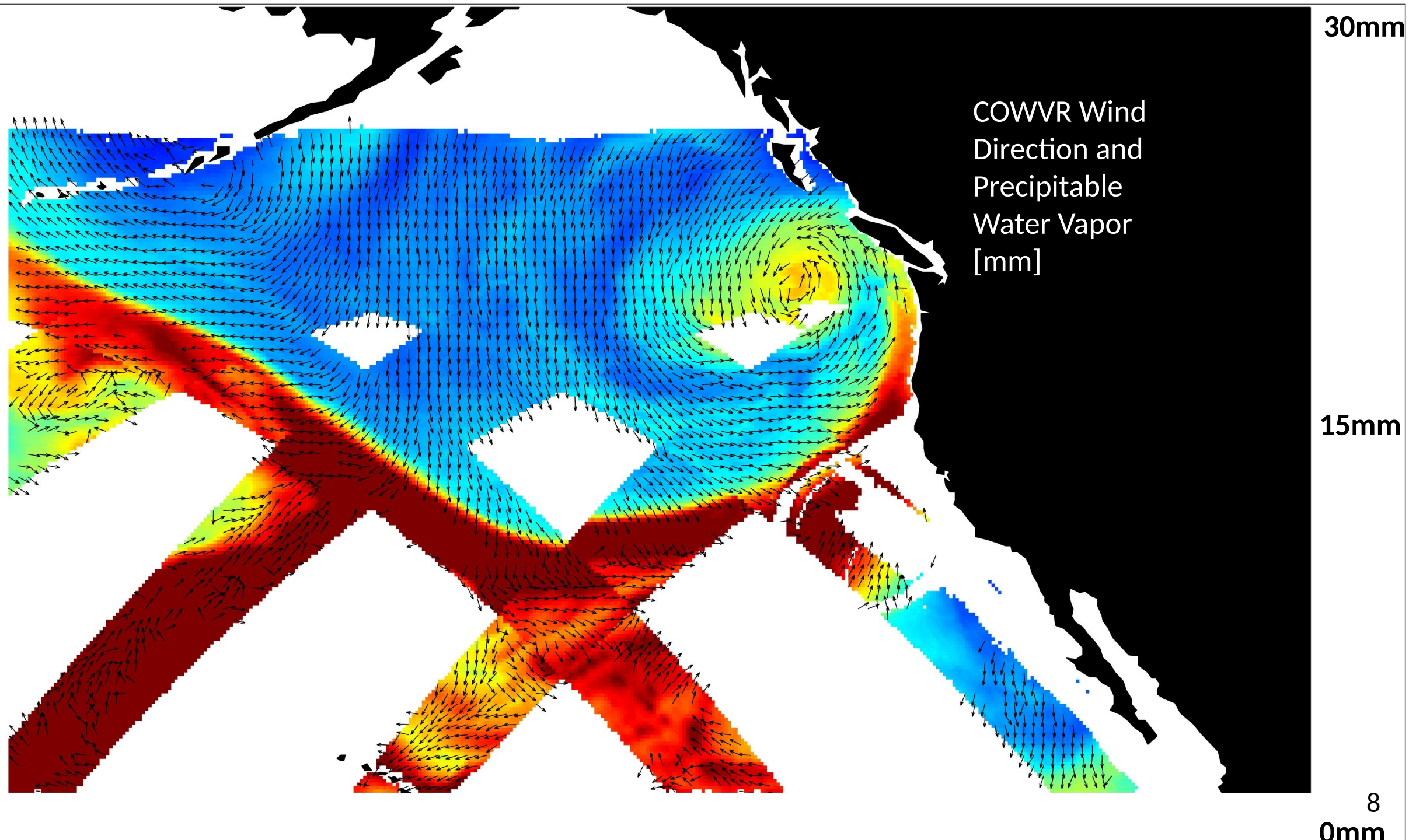
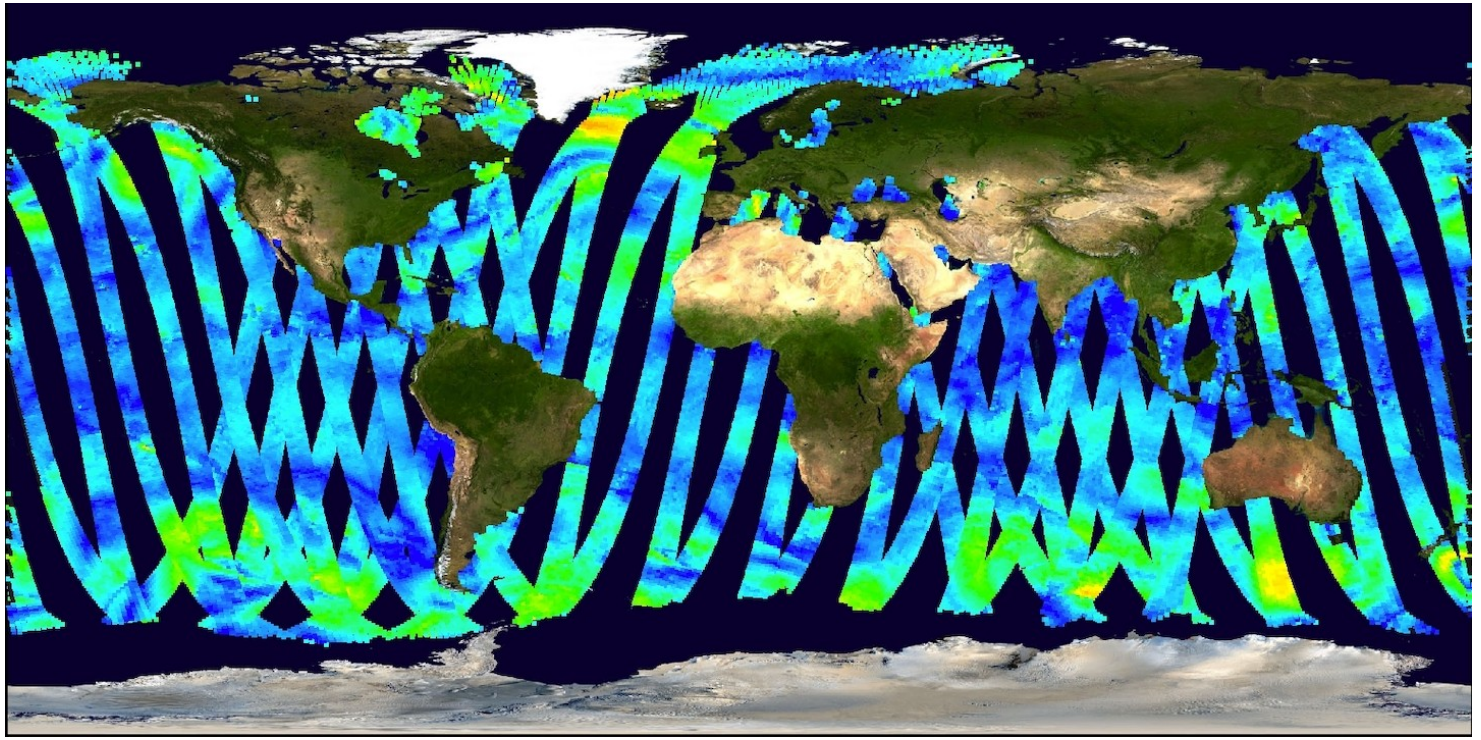



COWVR Wind Direction and Precipitable Water Vapor [mm]
30mm
15mm
0mm
30
25
20
15
10
5
0

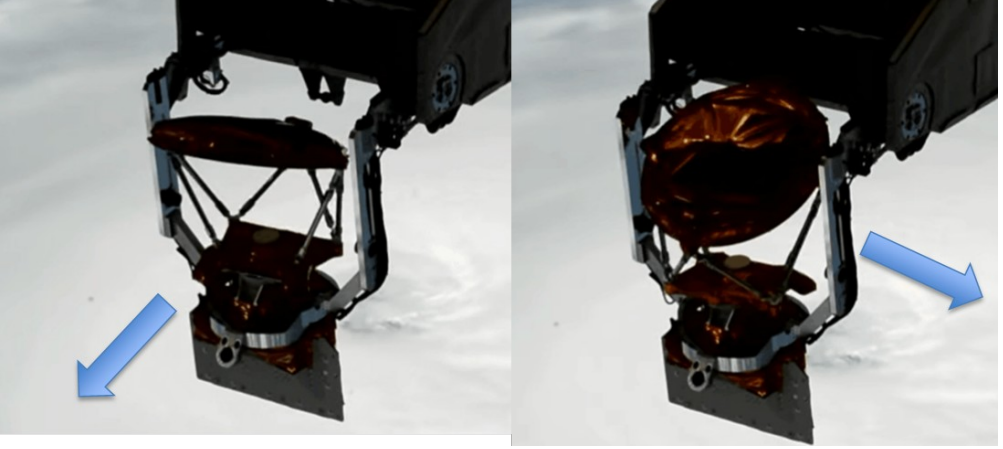
COWVR and MetOp-B/C KNMI ASCAT Intercomparison

- COWVR matched with co-incident observations from the Advanced Scatterometer (ASCAT) on MetOp-B/C
- Match-ups defined as <25km spatial and ± 30 mins temporal
- Both COWVR and ASCAT product quality flags applied, but no other filtering



EUMETSAT/OSI SAF, KNMI, 2019-11-15, MetOp-C ASCAT Level 2 25.0km Ocean Surface Wind Vectors

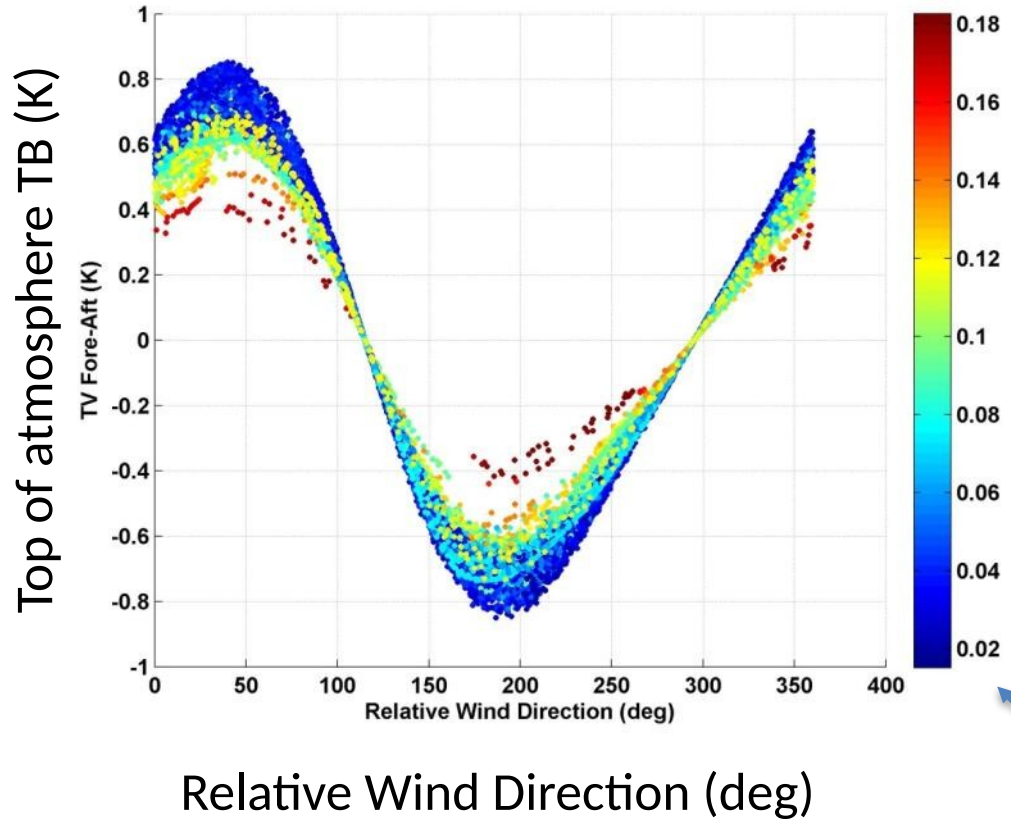
COWVR 2-Look Retrieval Algorithm



- COWVR designed for full 360° un-blocked conical scan

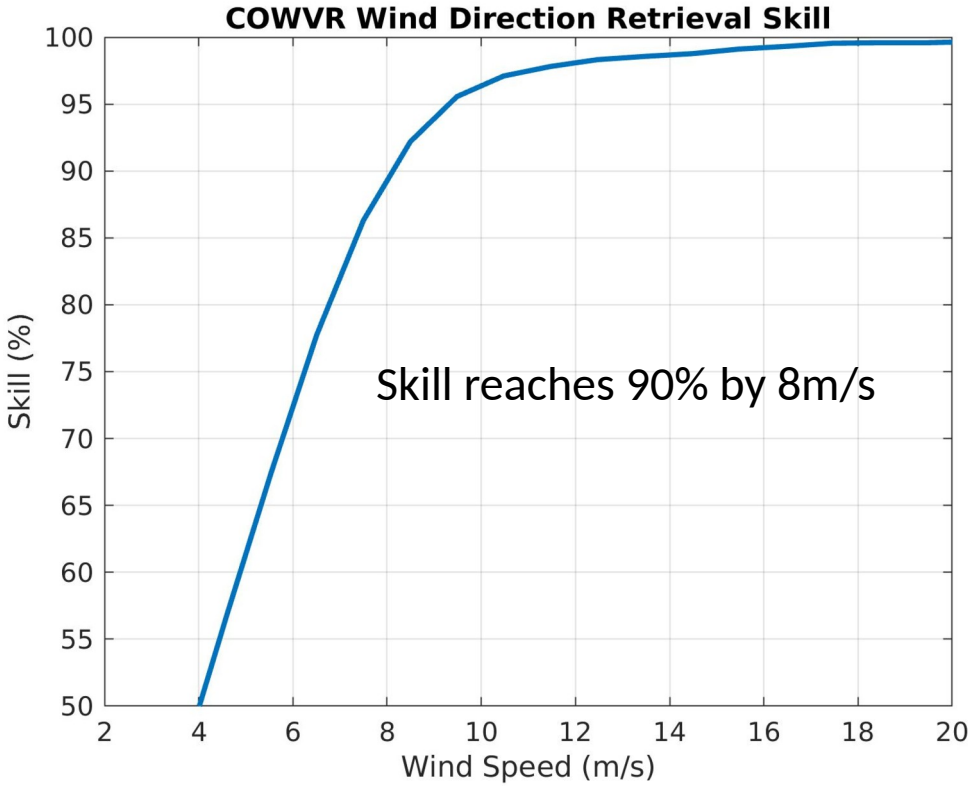
- Using fore and aft looks:
  - Isolates wind direction signal in V/H-pol channels which are otherwise dominated by atmosphere, **significantly improving signal to noise**
  - **Reduces number of ambiguities** by having samples at two relative wind directions

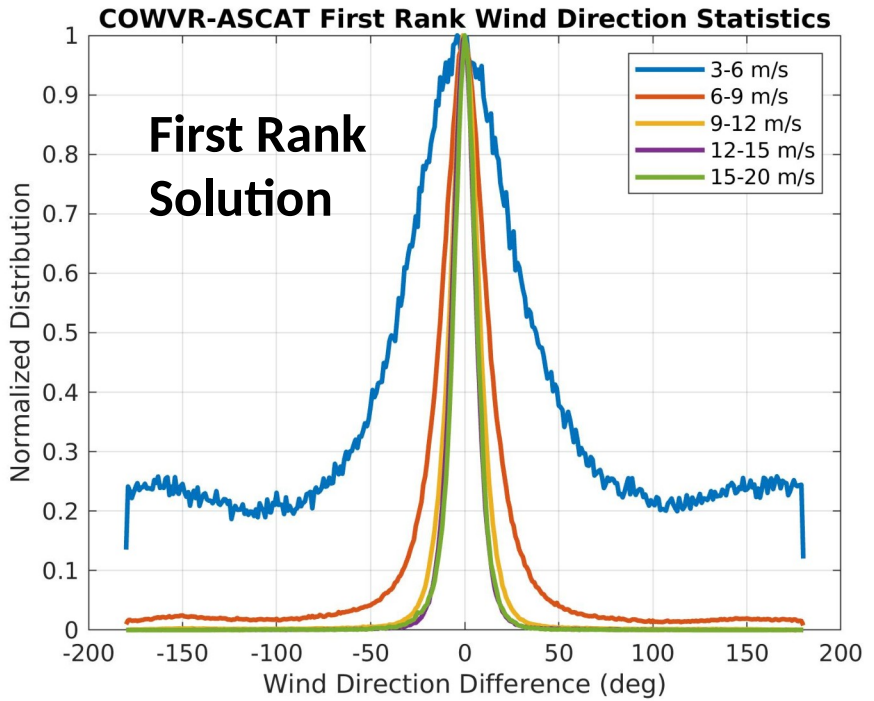
- COWVR algorithm adapted from WindSat (Brown et al., 2006)

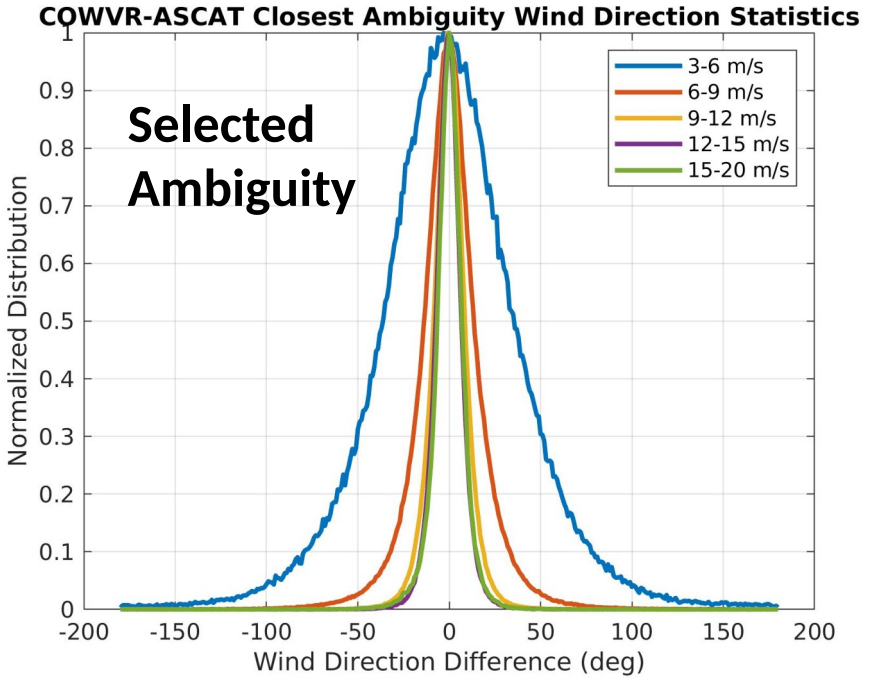


2-look algorithm Skill and Ambiguities (COWVR-ASCAT)

- Very little “nudging” required above 6m/s wind speed
- Algorithm produces 2 solutions on average, typically separated by 180^{o}
- Still some room for improvement at lower winds to reach noise limited simulated performance

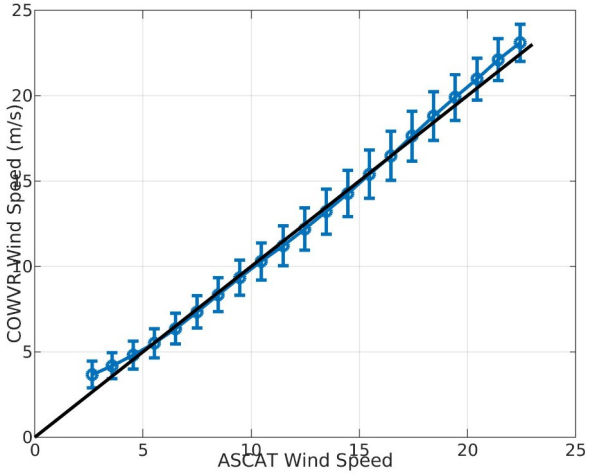


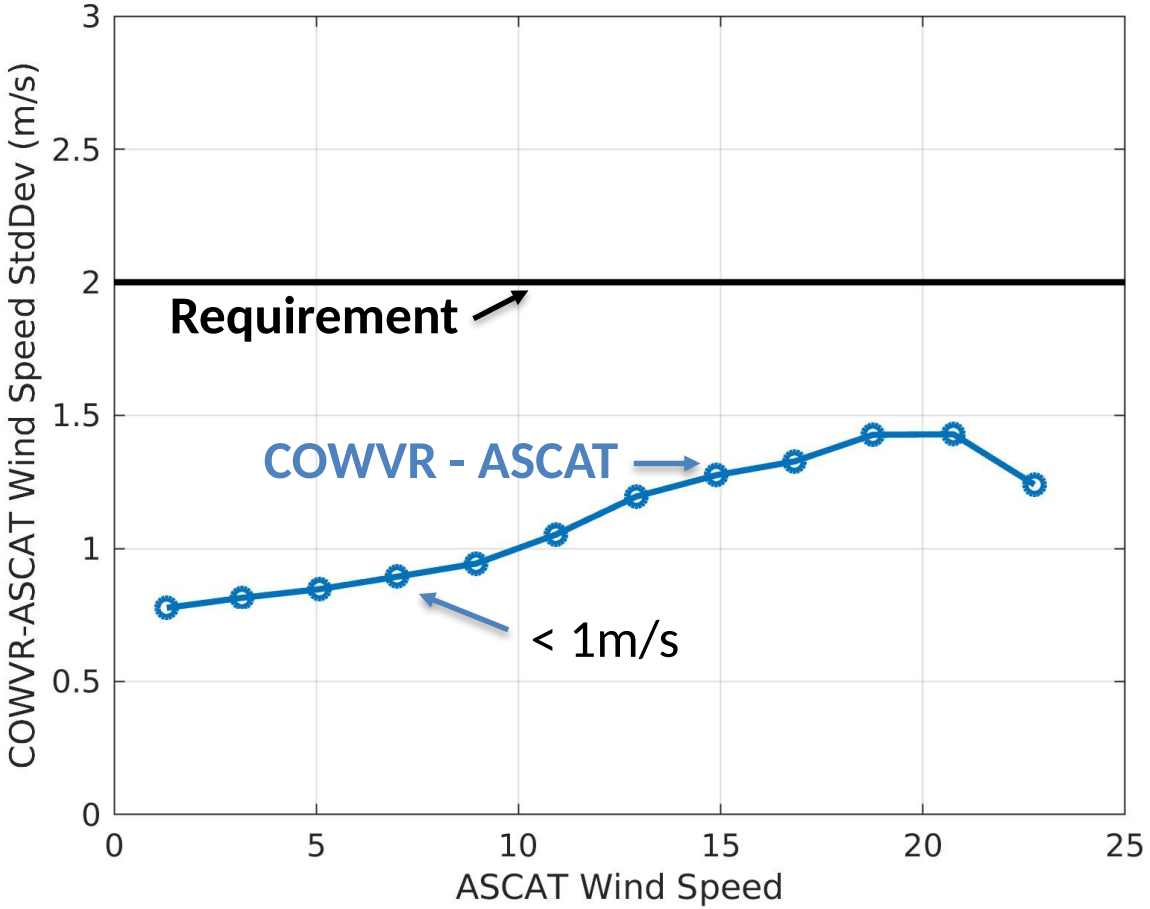




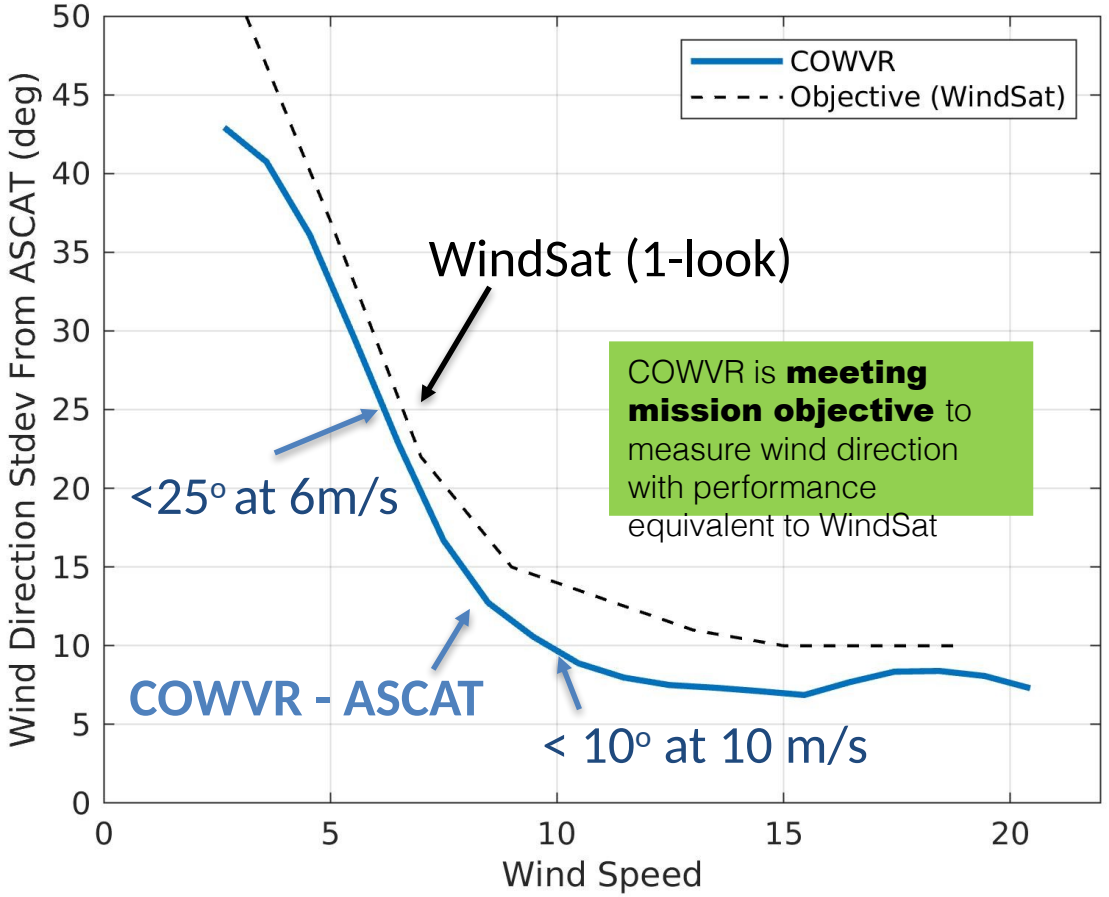
Wind Vector Comparison (COWVR-ASCAT statistics)

Wind speed uncertainty less than 1m/s globally, consistent performance with other operational microwave sensors

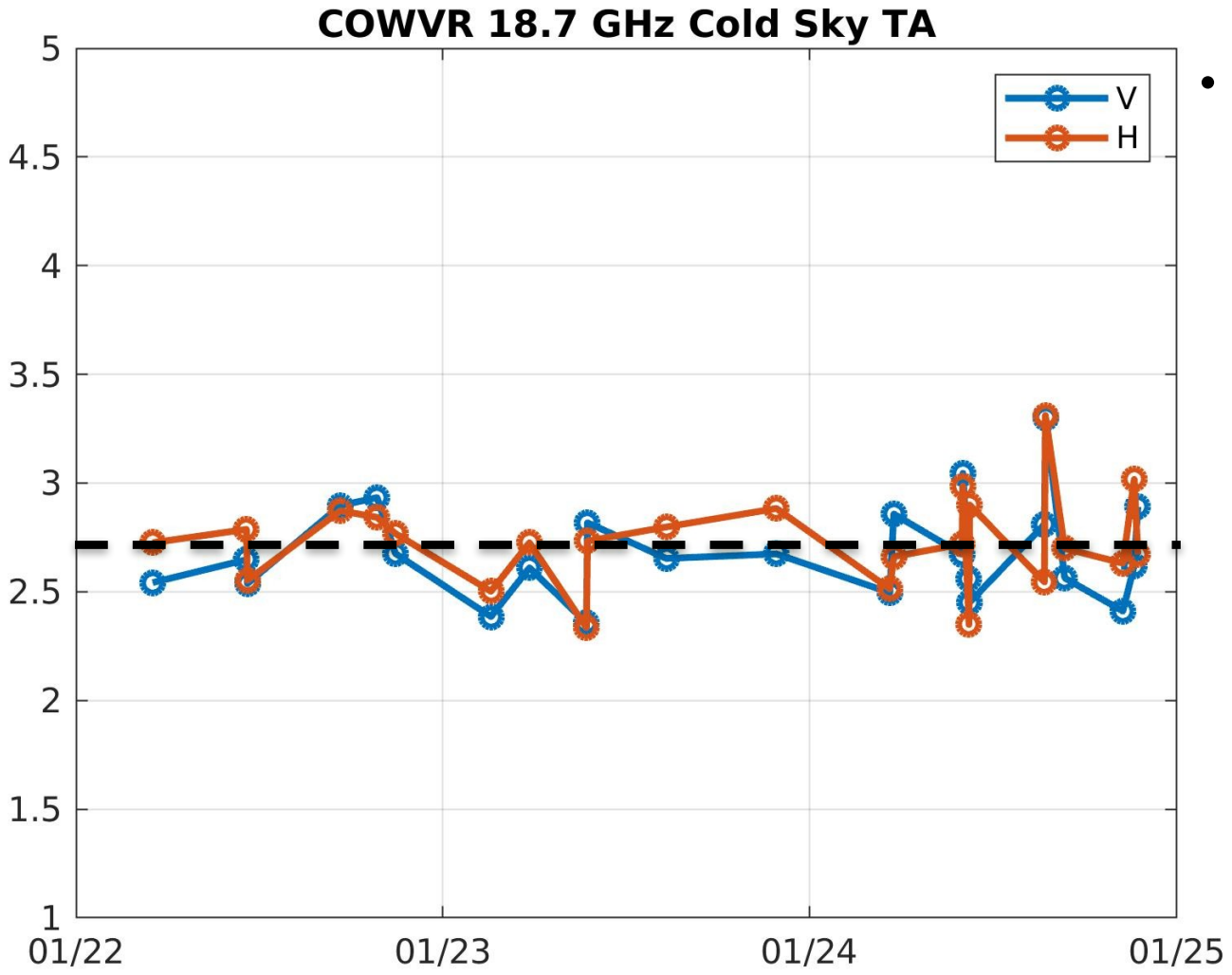




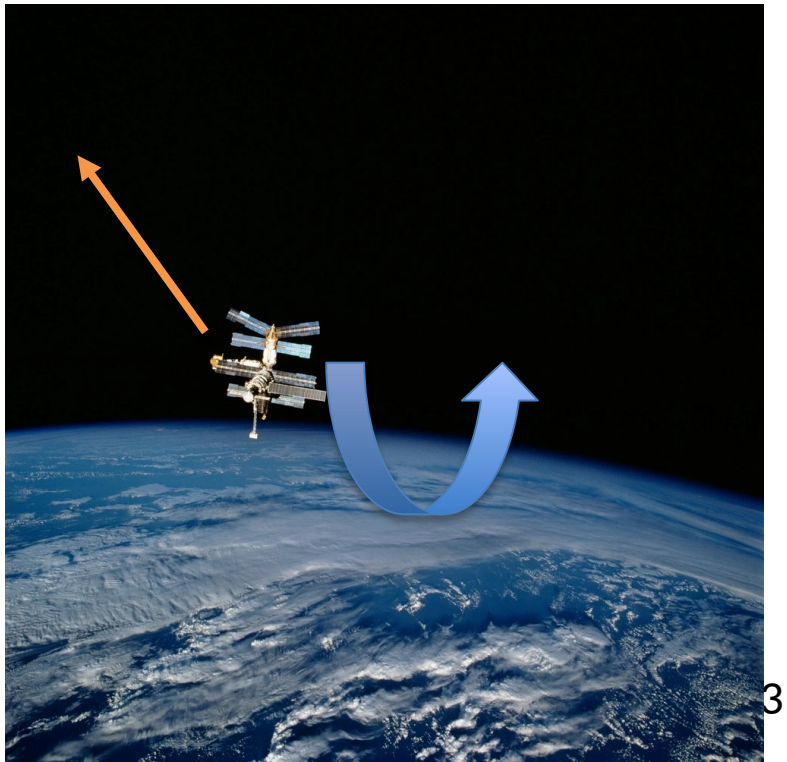
Wind direction uncertainty < 25° globally, better than WindSat (1-look)



Long-term Calibration and Stability

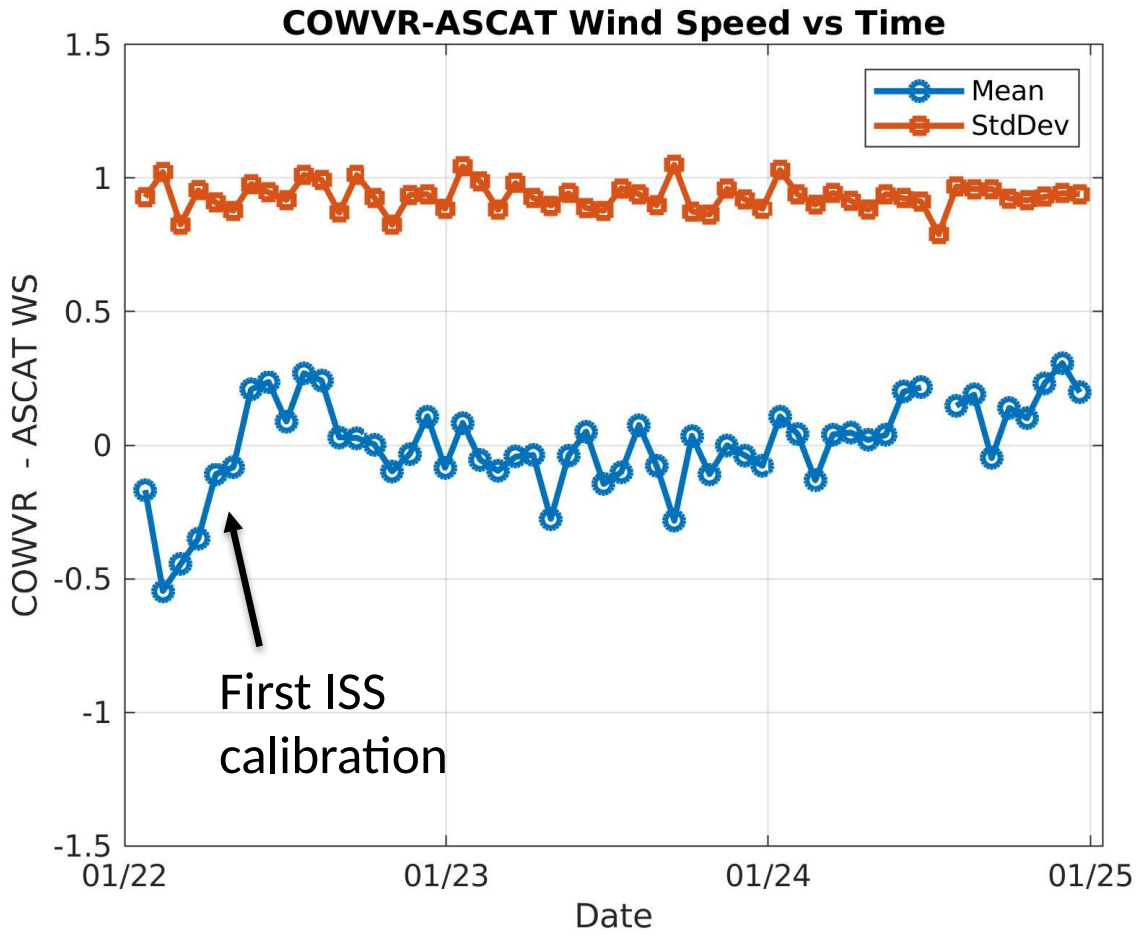


- COWVR is demonstrating electronic calibration sources for an operational conical imager
- Long-term calibration stabilized using periodic views of cold sky during ISS upward pitch maneuvers

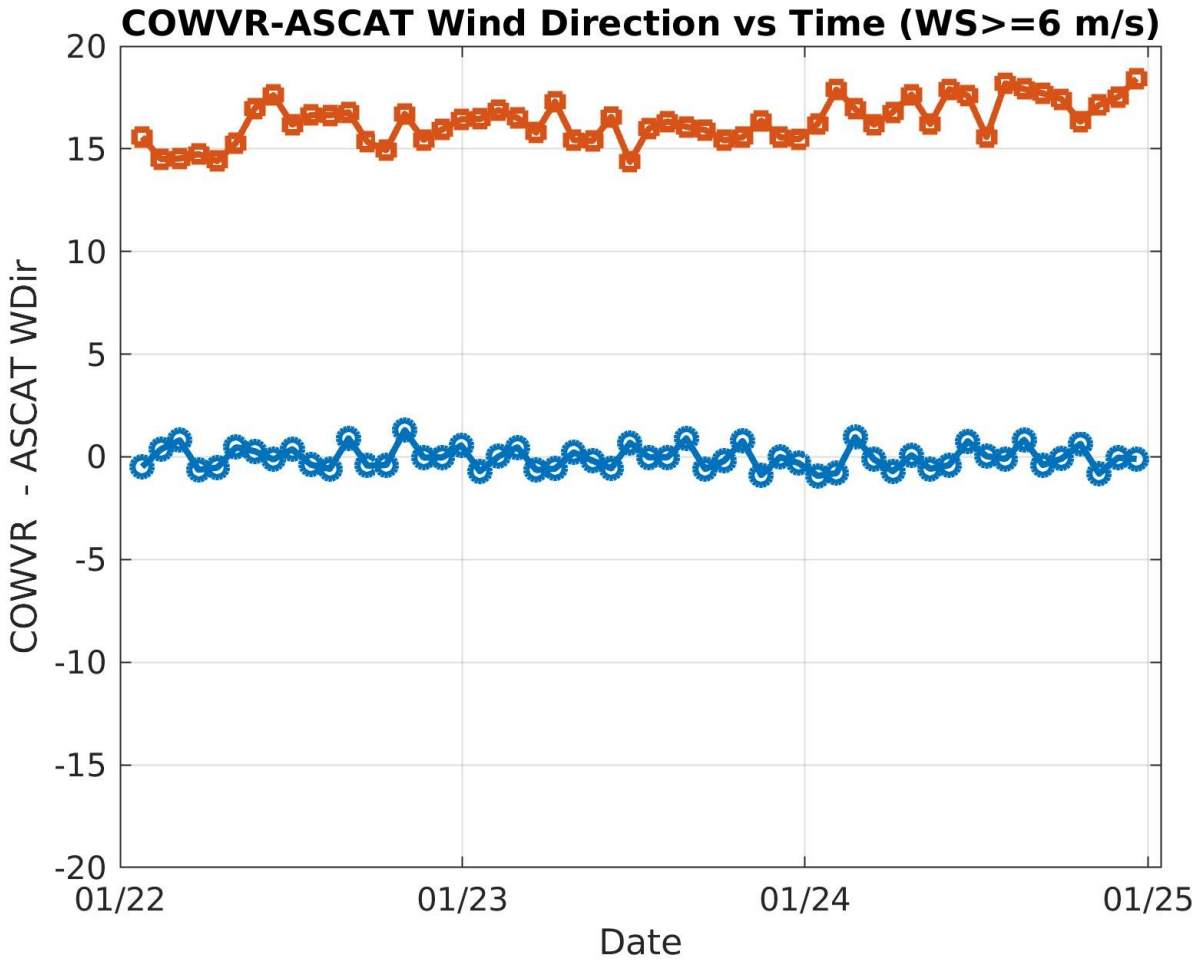


Wind vector validation statistics stable in time relative to ASCAT

Wind Speed (COWVR-ASCAT)



Wind Direction(COWVR-ASCAT)
WS>6m/s & > ± 90° outliers removed



Data Access via PO.DAAC

Free Text Search

Enter search text

COWVR

Perform Search | Reset

Temporal Search

Start Date

Stop Date

Capabilities Filter | Download | Clear Filter

Filter by Text

Found 3 matching dataset(s)

LIST | TABLE

COWVR STP-H8 Surface Wind Vector and Column-Integrated Atmospheric Water Measurements Version 10.0

(COWVR_STPH8_L2_EDR_V10.0)

WATER VAPOR INDICATORS | SURFACE WINDS | PRECIPITATION PROFILES

Information | Coverage | Data Access | Documentation | Citation

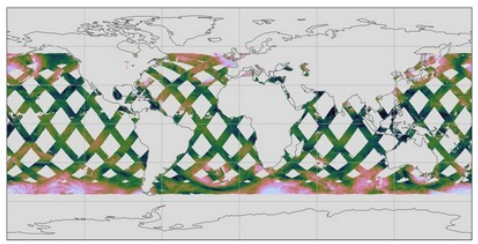
Version: 10.0

Processing Level: 2

Start/Stop Date: 2022-01-08 to Present

Description:

This dataset includes satellite-based observations of geolocated surface wind vectors, precipitable water vapor, and integrated cloud liquid water, as well as the microwave brightness temperatures used to derive them. Theses measurements make up the environmental data record (EDR) from the COWVR (Compact Ocean Wind Vector Radiometer) sensor aboard the international space station (ISS), beginning in January 2022 with forward-streaming to PO.DAAC. Data over the satellite swath are available in HDF5 format with roughly one file per hour (the ISS orbit period is ~90 minutes), and coverage shown in the thumbnail is for a full day. Spatial resolution is roughly 35... Show More



Status: ACTIVE

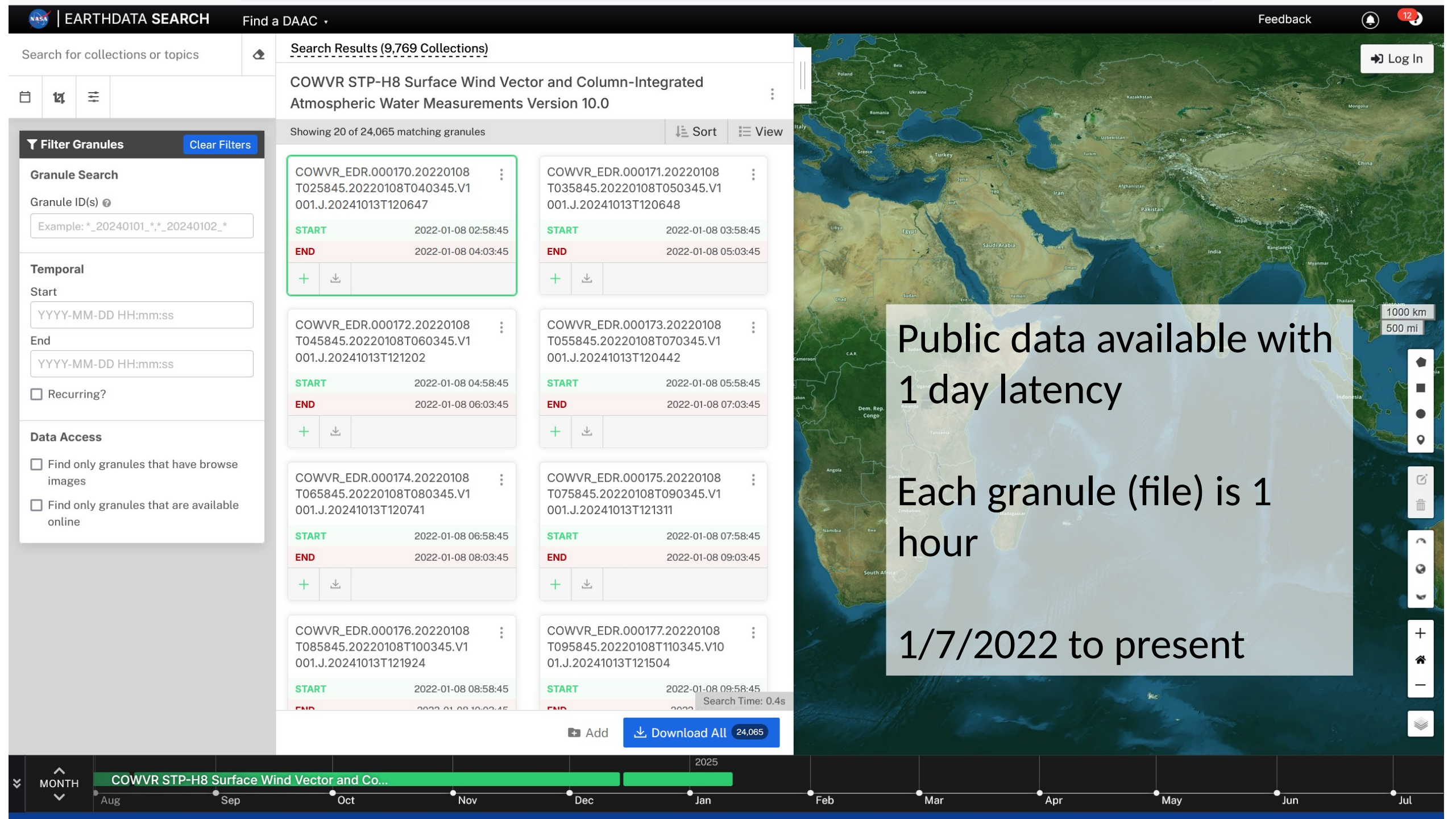
Short Name:
COWVR_STPH8_L2_EDR_V10.0

Collection Concept ID:
C3237678855-POCLOUD

Spatial Coverage:
N: 61° **S:** -61°
W: -180° **E:** 180°

Access:
- Browse Granule Listing
- Search Granules

Capabilities:


EARTHDATA SEARCH
Find a DAAC
Feedback
12
Search for collections or topics
Search Results (9,769 Collections)
COWVR STP-H8 Surface Wind Vector and Column-Integrated Atmospheric Water Measurements Version 10.0
Showing 20 of 24,065 matching granules
Sort
View
Filter Granules
Clear Filters
Granule Search
Granule ID(s)
Example: *_20240101_*,*_20240102_*
Temporal
Start
YYYY-MM-DD HH:mm:ss
End
YYYY-MM-DD HH:mm:ss
Recurring?
Data Access
Find only granules that have browse images
Find only granules that are available online
COWVR_EDR.000170.20220108T025845.20220108T040345.V1001.J.20241013T120647
START 2022-01-08 02:58:45
END 2022-01-08 04:03:45
COWVR_EDR.000171.20220108T035845.20220108T050345.V1001.J.20241013T120648
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END 2022-01-08 06:03:45
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COWVR_EDR.000177.20220108T095845.20220108T110345.V1001.J.20241013T121504
START 2022-01-08 09:58:45
Search Time: 0.4s
Add
Download All 24,065
Log In
1000 km
500 mi
Public data available with 1 day latency
Each granule (file) is 1 hour
1/7/2022 to present
MONTH
COWVR STP-H8 Surface Wind Vector and Co...
2025
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul

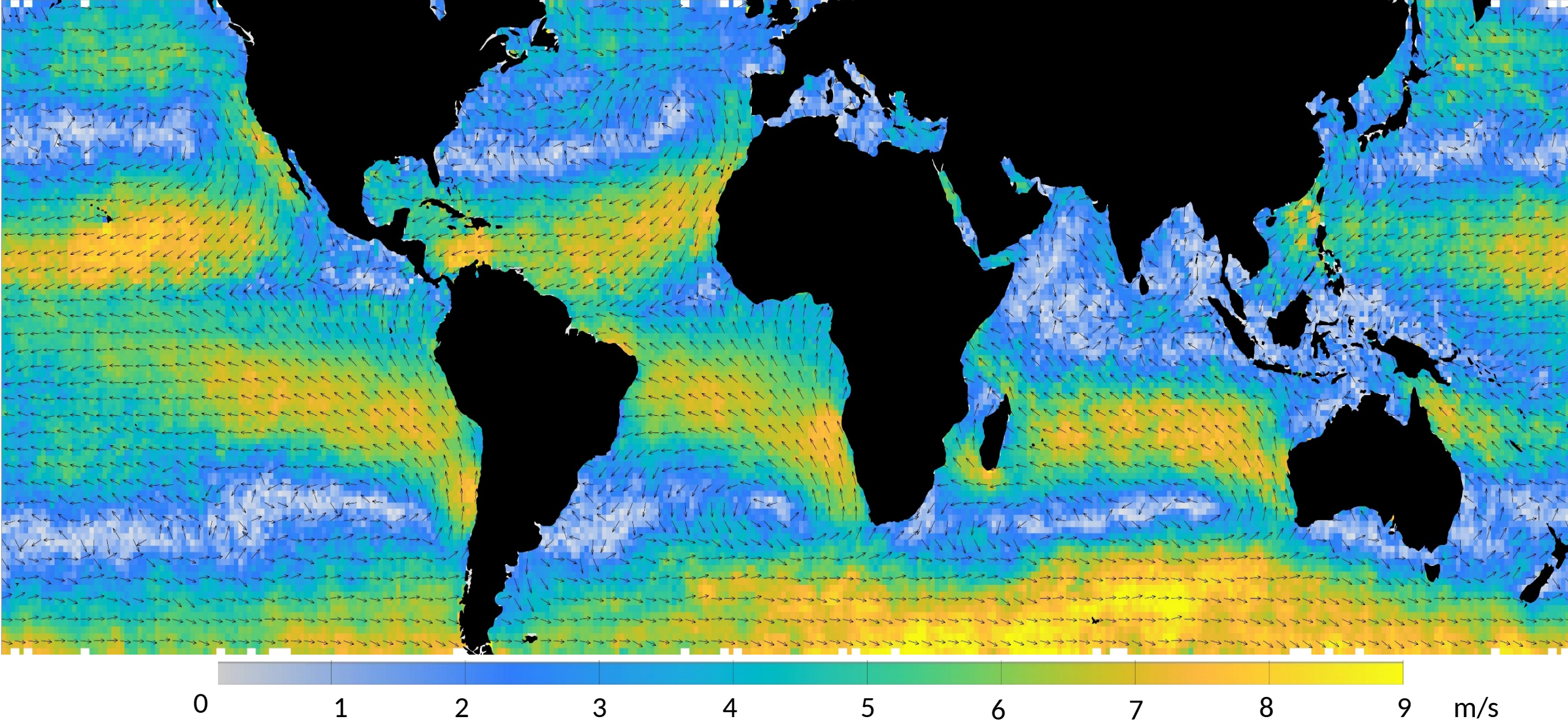
Compact Ocean Wind Vector Radiometer (COWVR) Environmental Data Record (EDR) Quick-start Users Guide

Prepared by: Shannon Brown (shannon.t.brown@jpl.nasa.gov), Mary Morris
Jet Propulsion Laboratory, California Institute of Technology
Date: 9/25/2024
Version 1.0

- Quick start user guide available on PO.DAAC
- Short document to get acquainted with data fields, flagging, ISS considerations, etc.

Unique COWVR Sampling from ISS

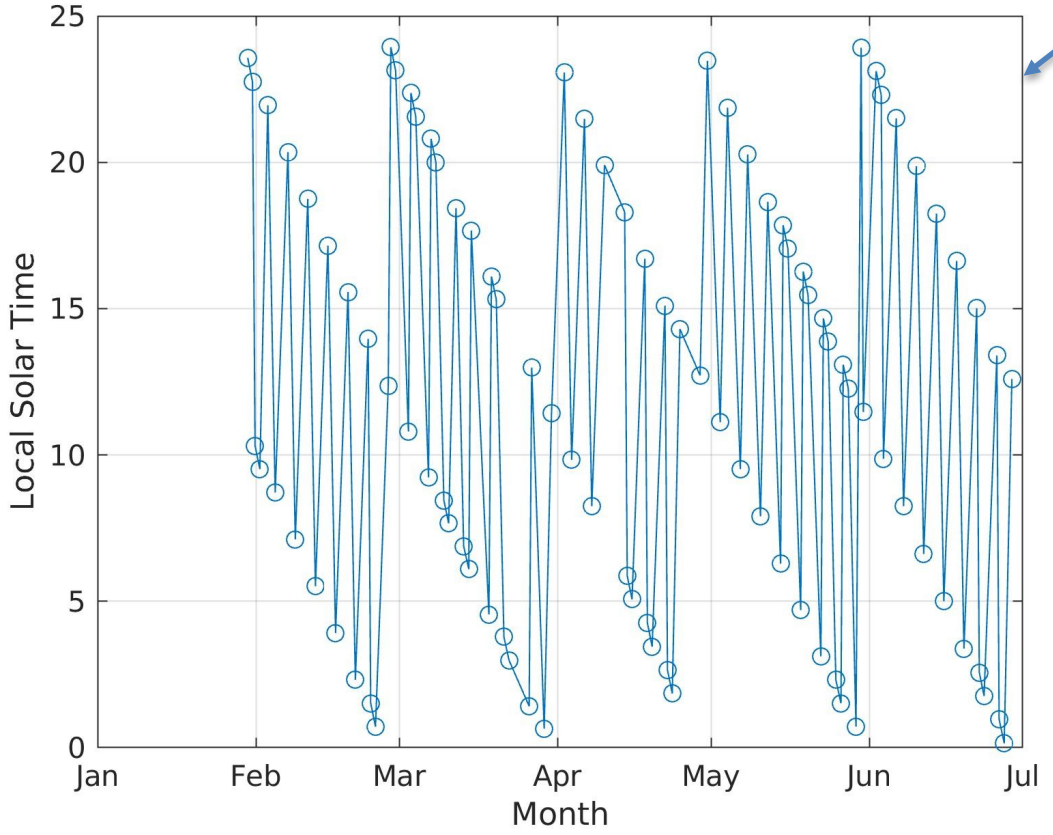
Credit D. Pettit



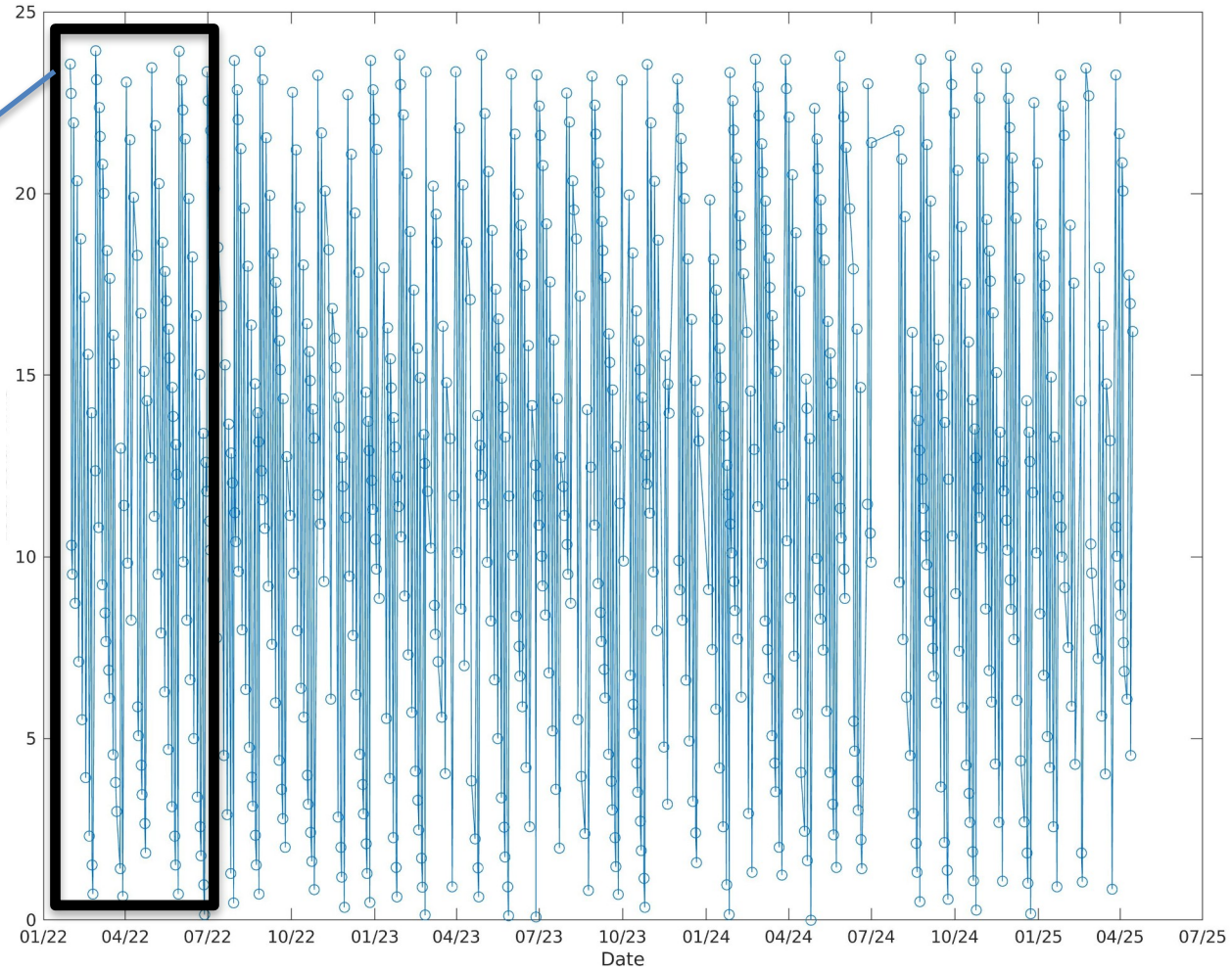
COWVR 3.5-Year Annual Mean Wind Speed and Direction

Diurnal Sampling

Good sampling over diurnal cycle each month

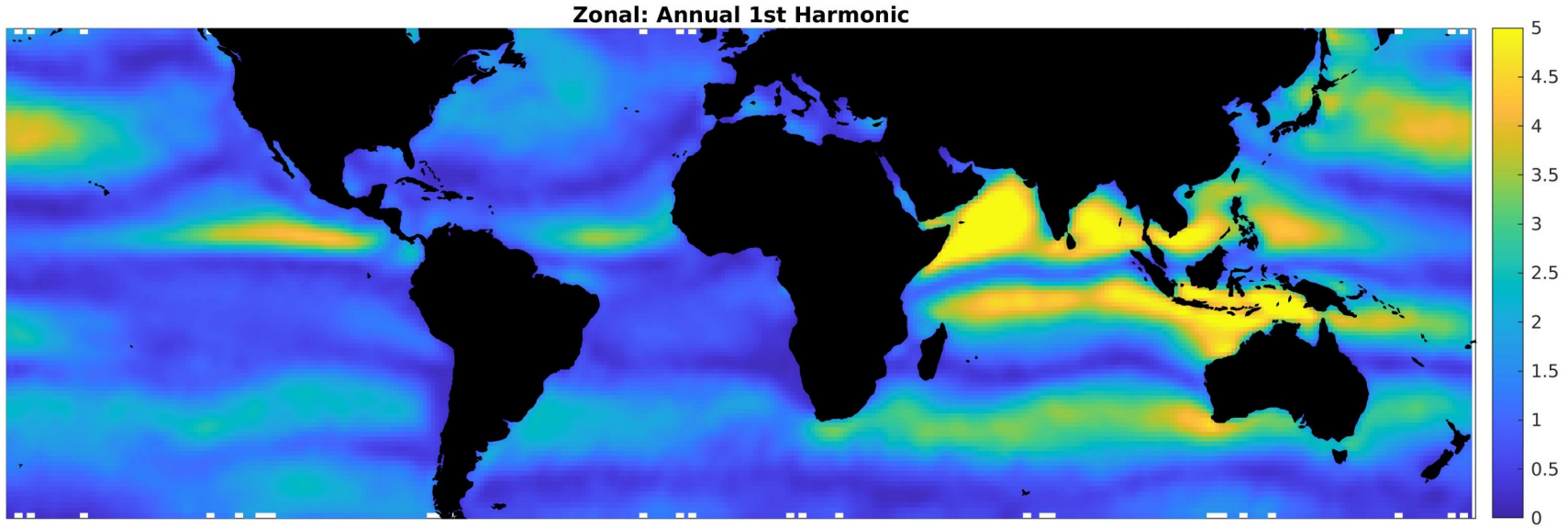


Diurnal Sampling Near Equator



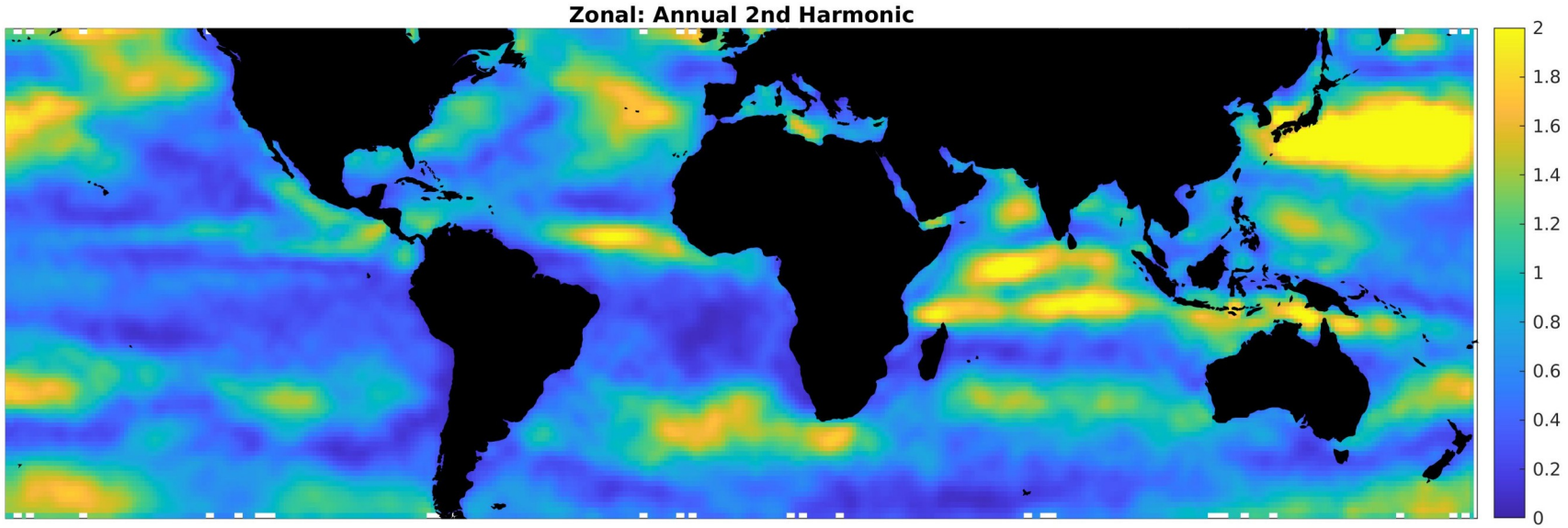
2022 - 2025

Annual Harmonic Amplitude (Zonal)



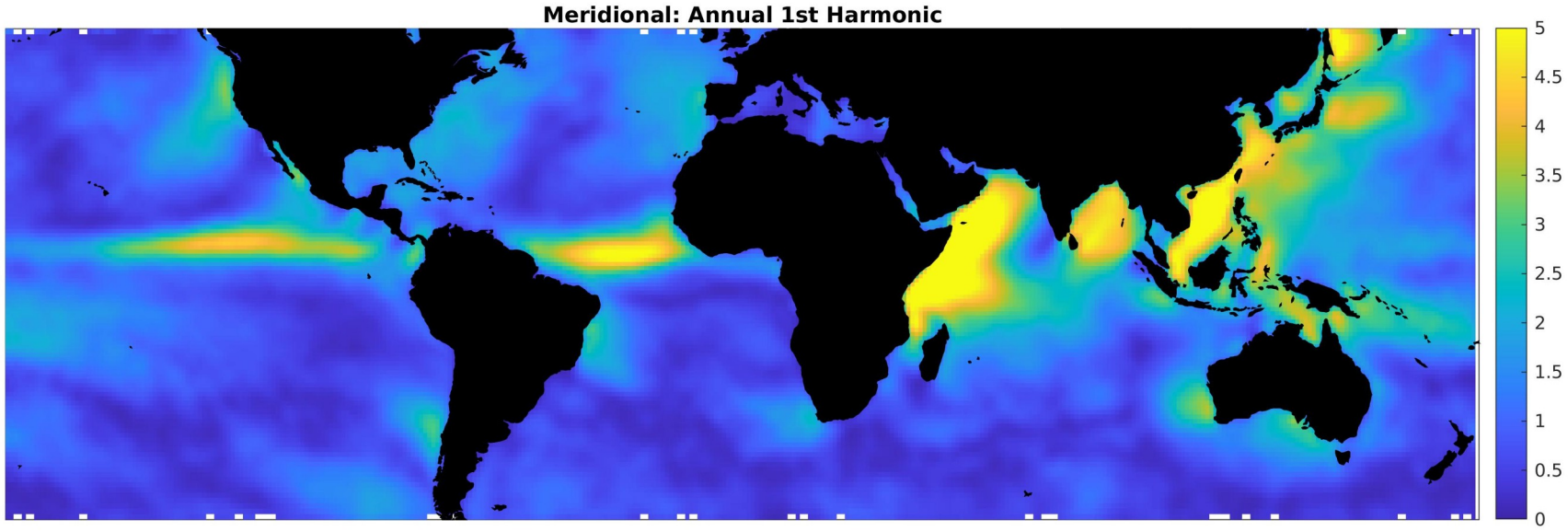
1st Harmonic

W → E



2nd Harmonic

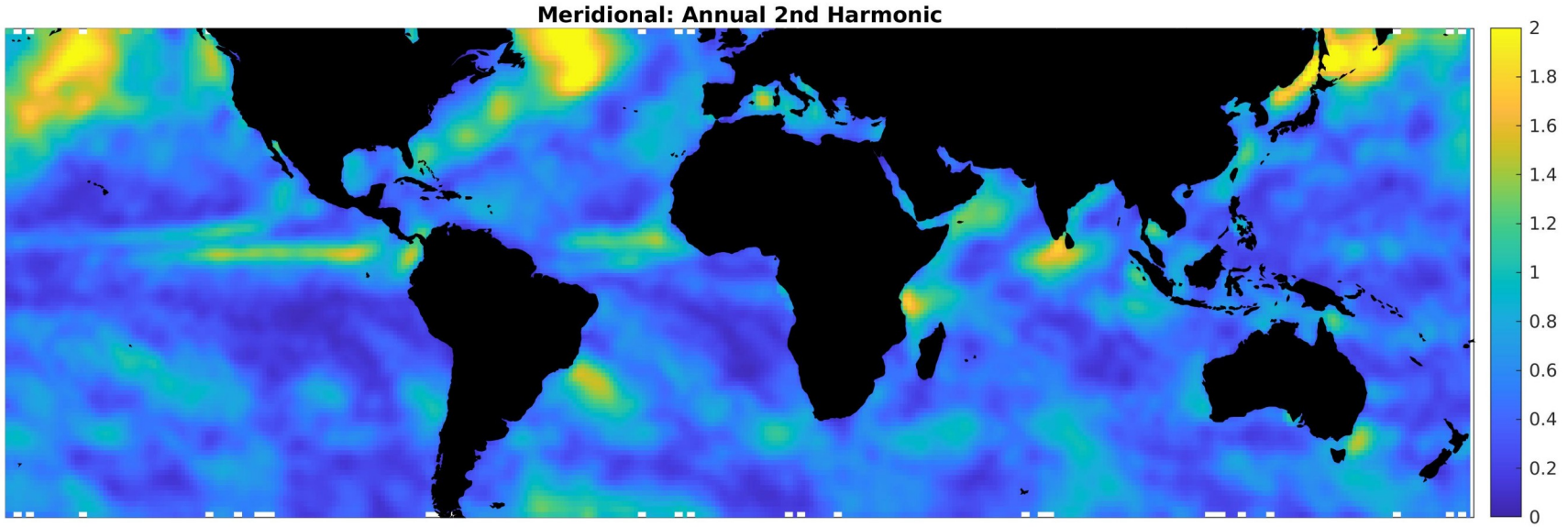
Annual Harmonics Amplitude (Meridional)



1st Harmonic

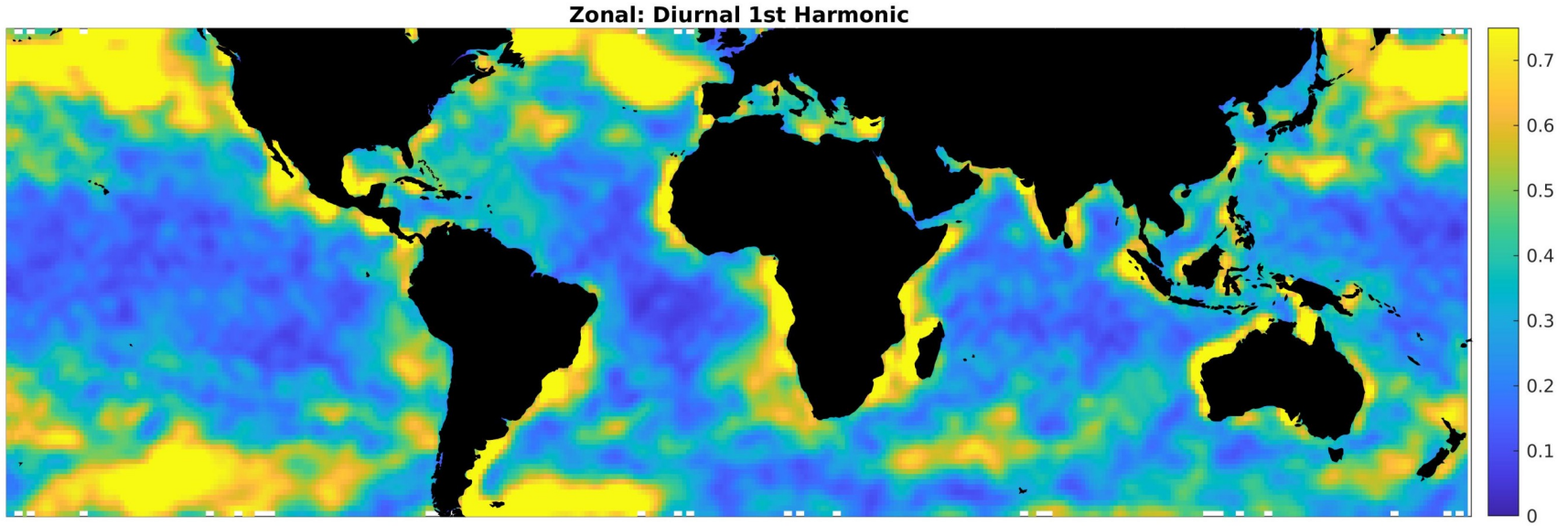
N

S



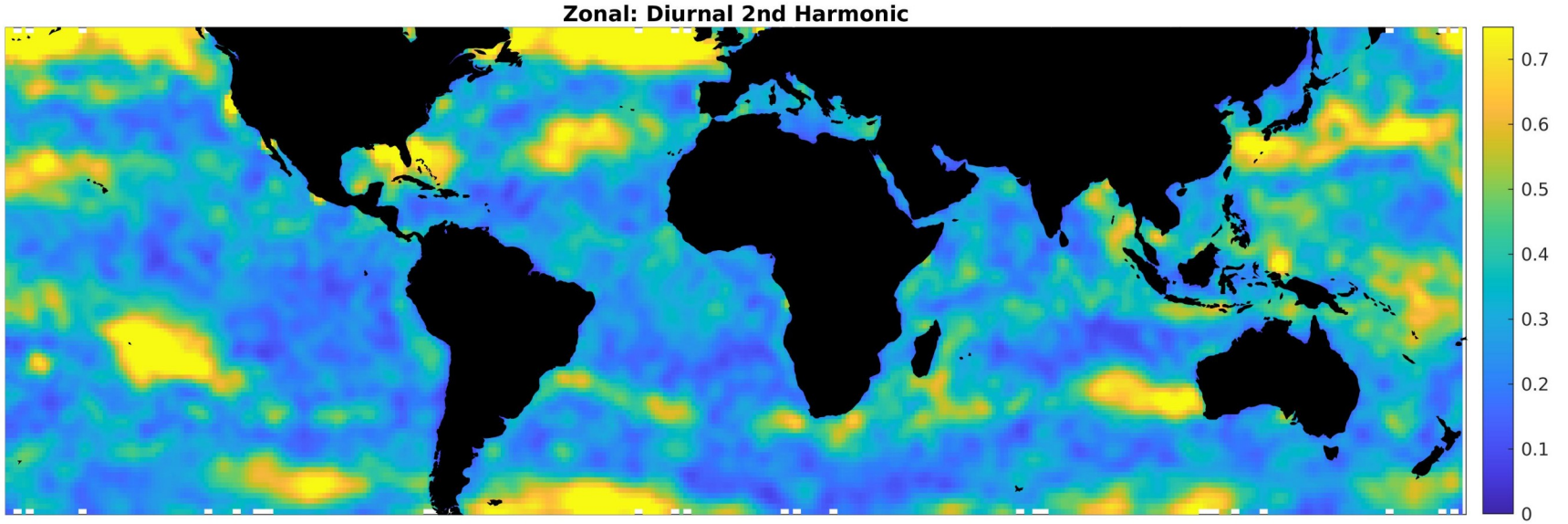
2nd Harmonic

Diurnal Harmonic Amplitude (Zonal)



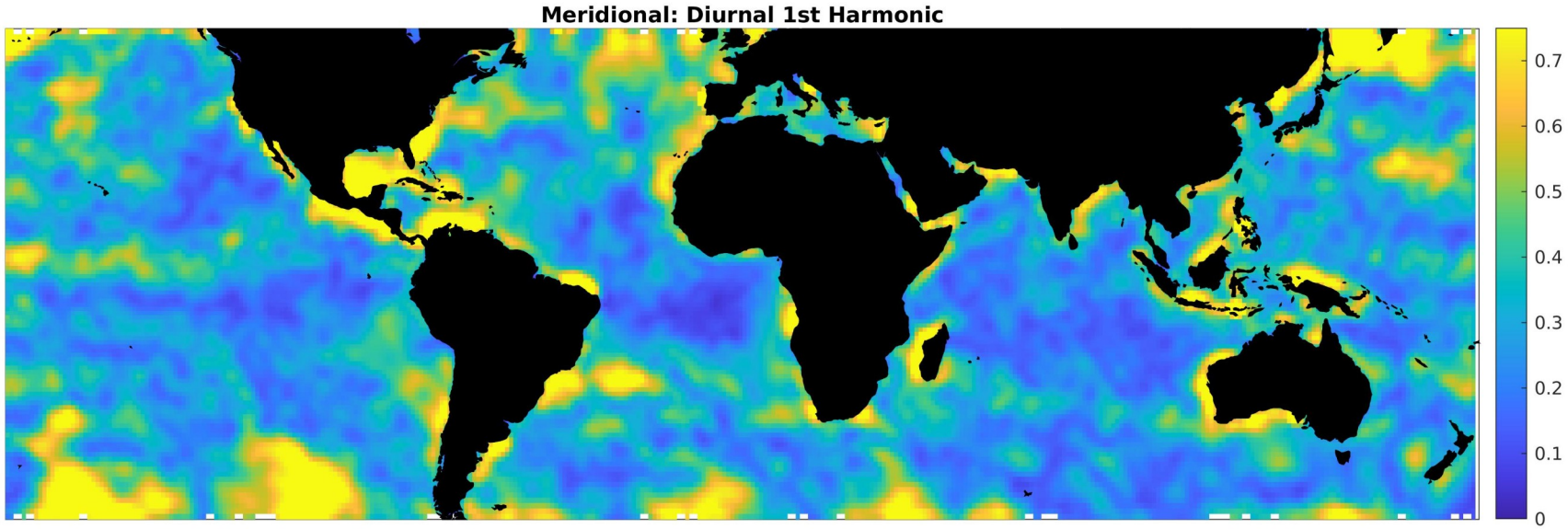
1st Harmonic

W → E



2nd Harmonic

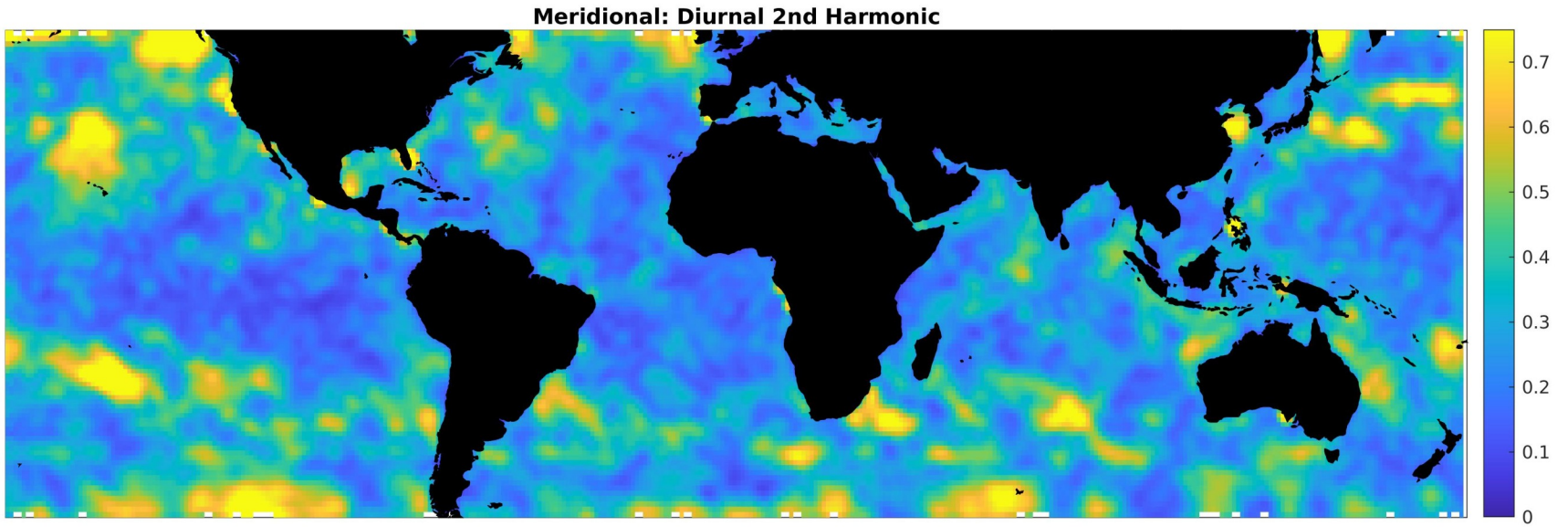
Diurnal Harmonic Amplitude (Meridional)



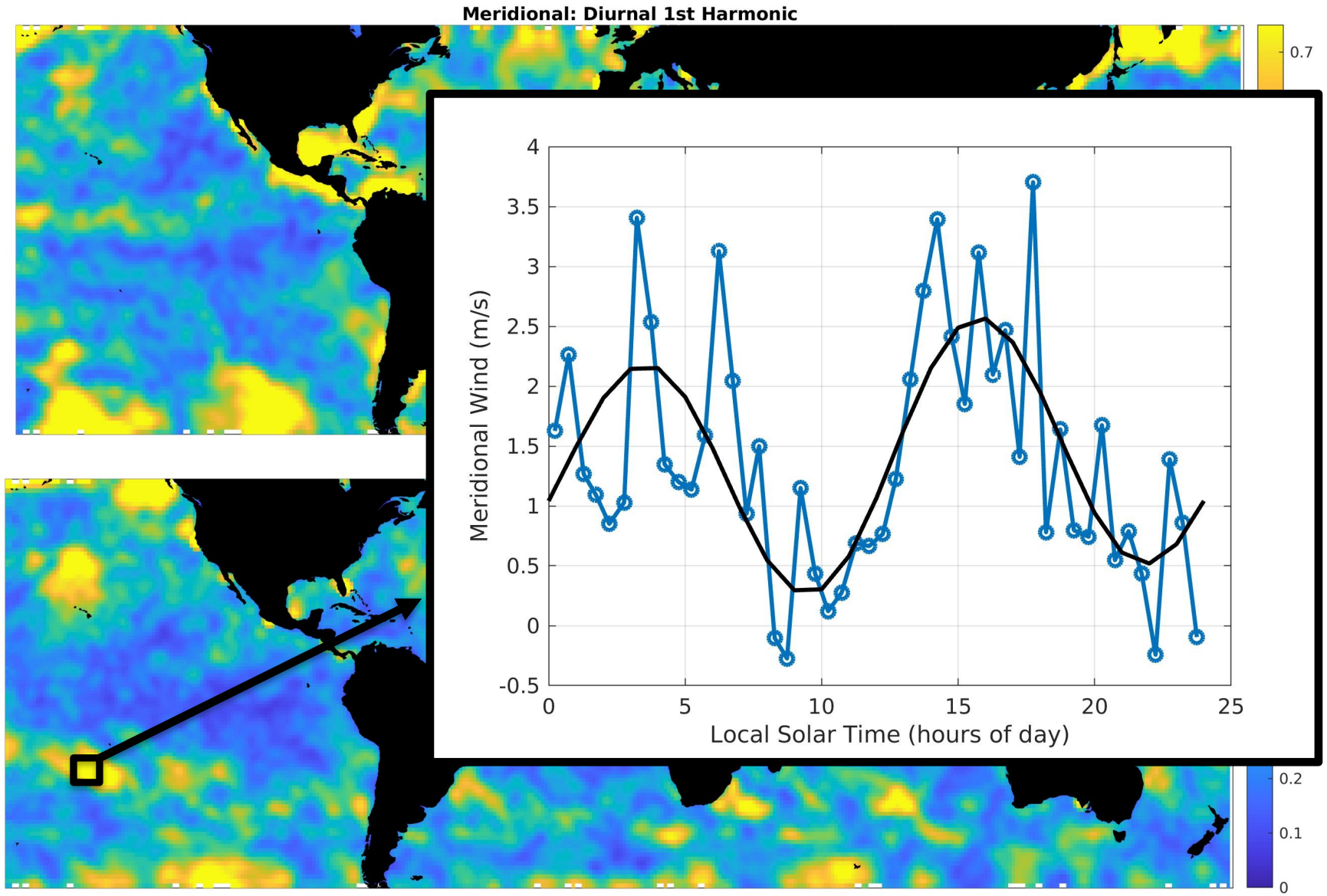
1st Harmonic

N

S



2nd Harmonic


Meridional: Diurnal 1st Harmonic
0.7
0.2
0.1
0
Meridional Wind (m/s)
Local Solar Time (hours of day)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0
5
10
15
20
25

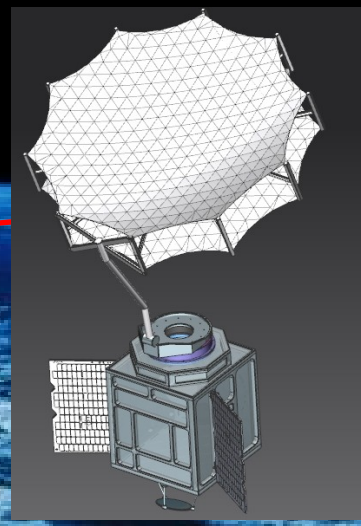
N

S

Jet Propulsion Laboratory
California Institute of Tech

Compact Ocean Wind Vector Radiometer (COWVR) technology demonstrated:

Enables a low-cost constellation for rapid revisit ocean vector wind measurement and microwave imaging supplementing operational scatterometer constellation in SSO orbits



+C/X-band configuration

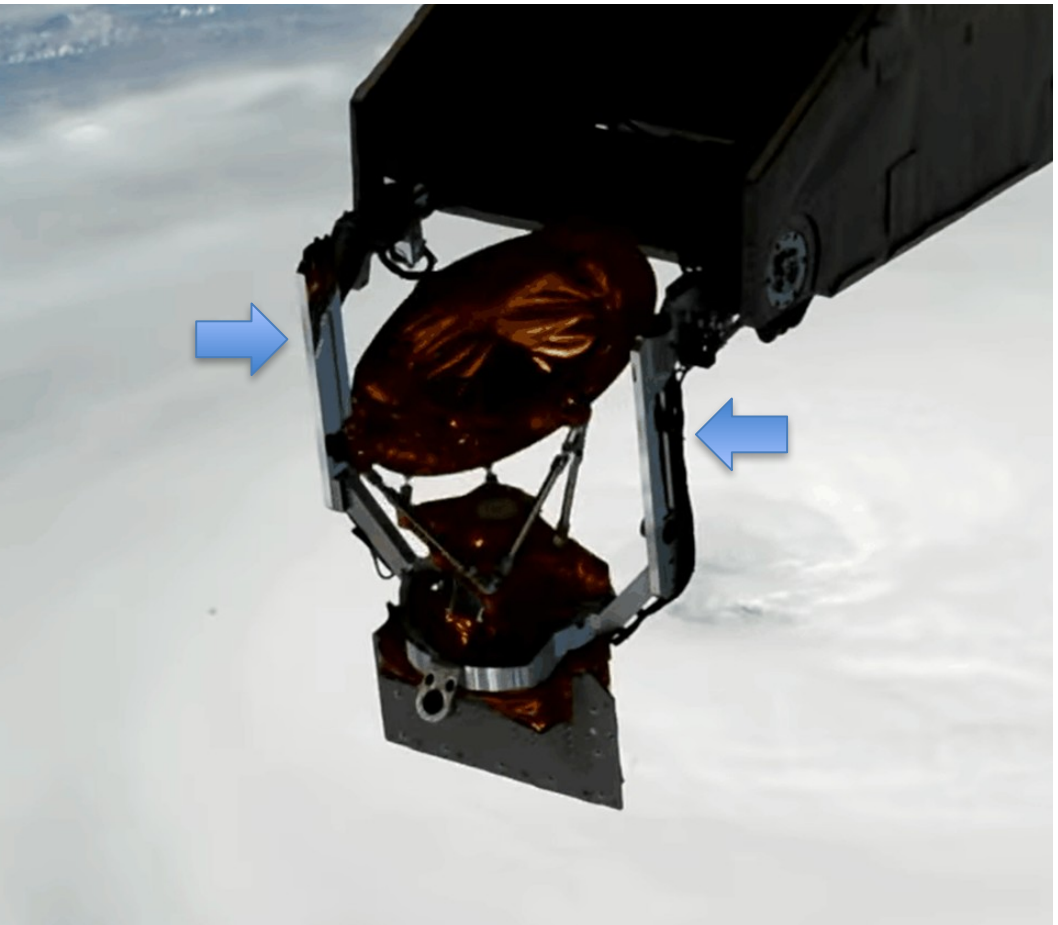
Mission Status

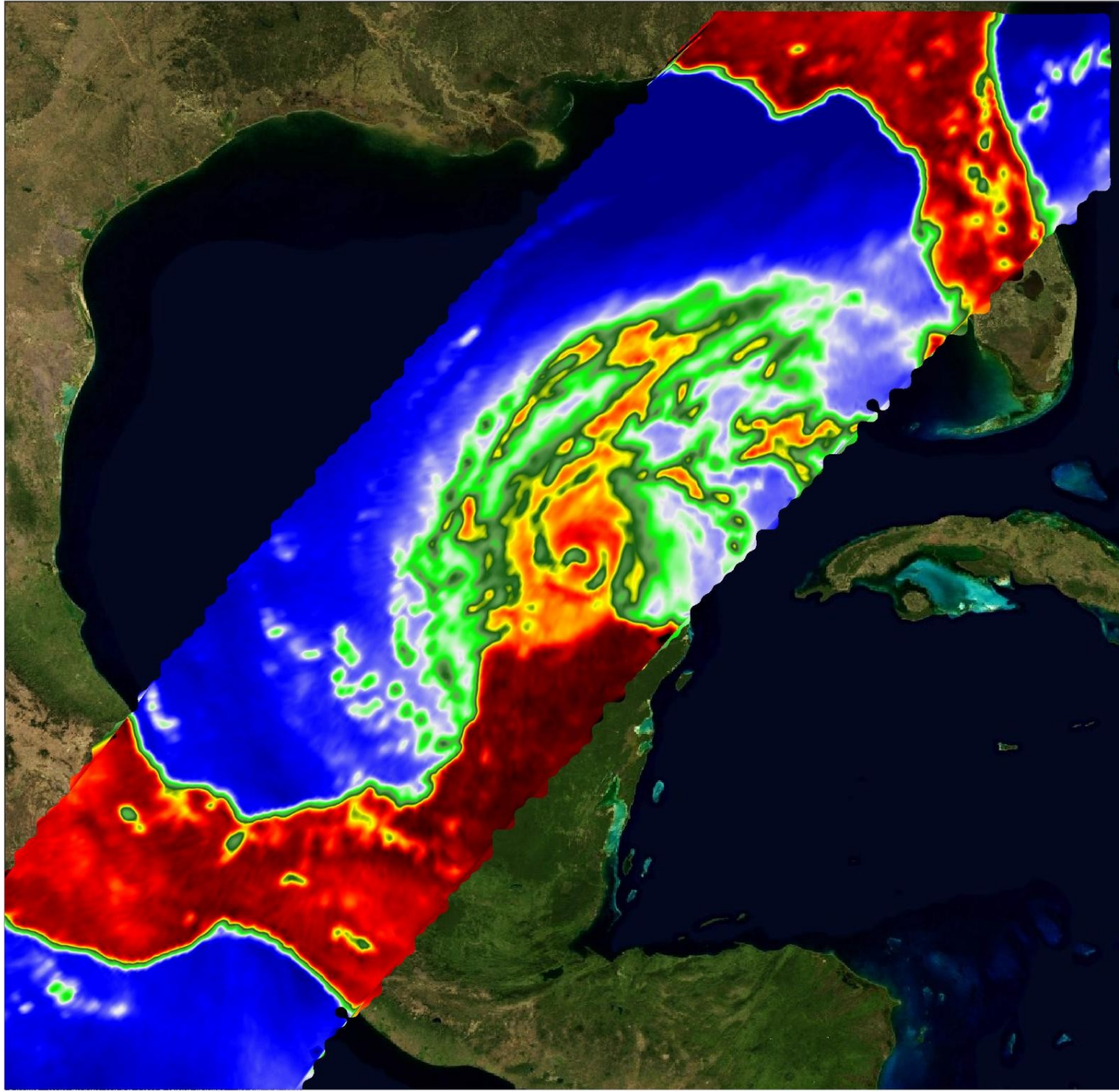
- **COWVR design is validated** for precision microwave imagery and retrievals
- **Paves way for new class of small-satellite conical microwave imagers (NASA AOS, DoD, NOAA)**
- **Uniquely** samples winds combined with atmosphere **over diurnal cycle**
- Providing **low-latency (~2 hour) operational data** since September 2022
- All COWVR and TEMPEST data, including L2 (EDRs), are **available on NASA Earth Data through PO.DAAC** (search COWVR)
- **COWVR will remain operational on ISS through at least August 2025 and may continue into 2026**

Small Satellite Conical Microwave Imagers Are Ready!

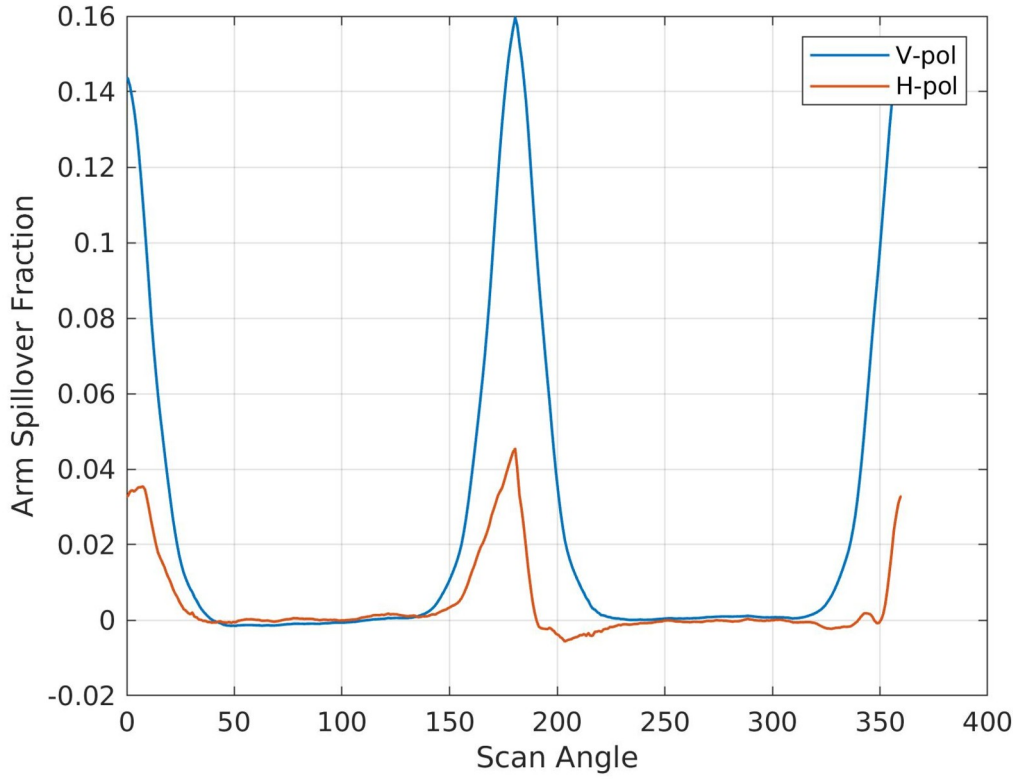
Backup

Support arm blockage correction implemented in ATCF imagery **starting November 2024 adding extra 40% to swath**

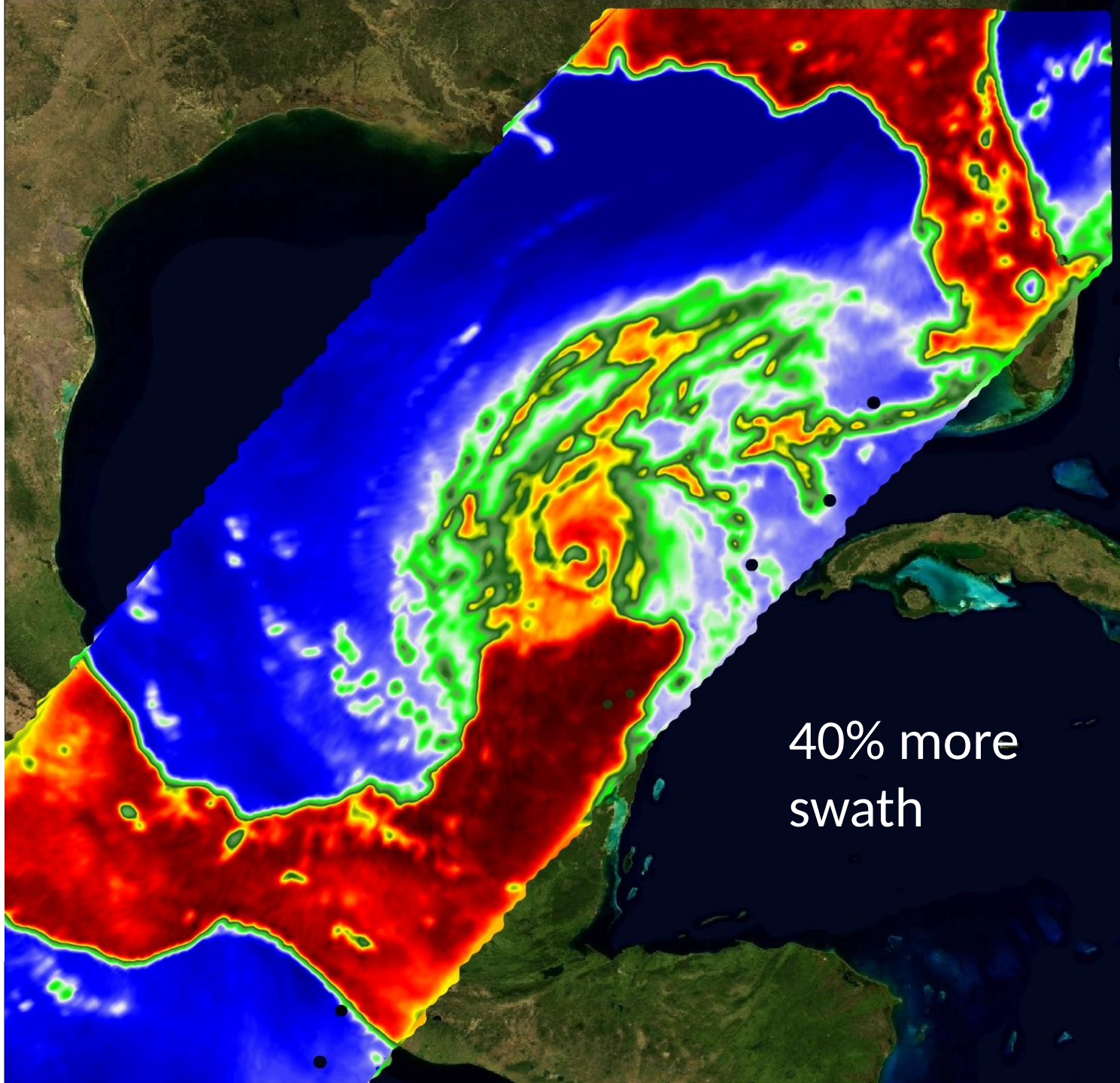


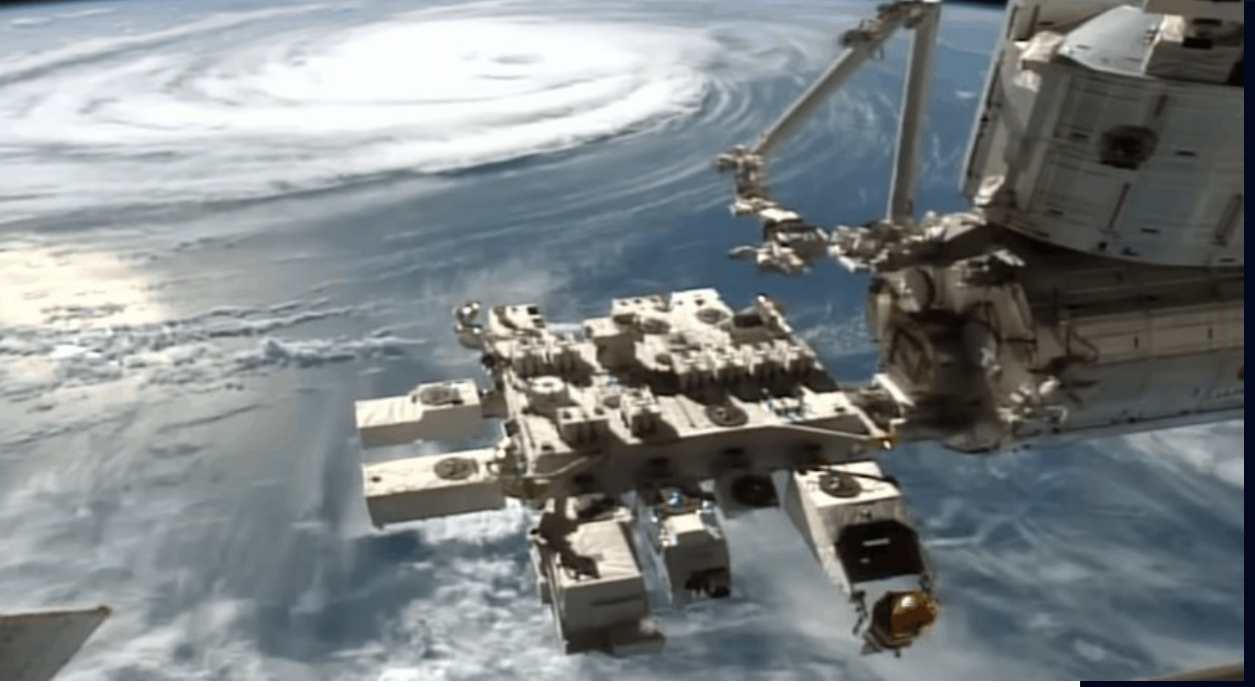


Support arm blockage correction implemented in ATCF imagery **starting November 2024 adding extra 40% to swath**

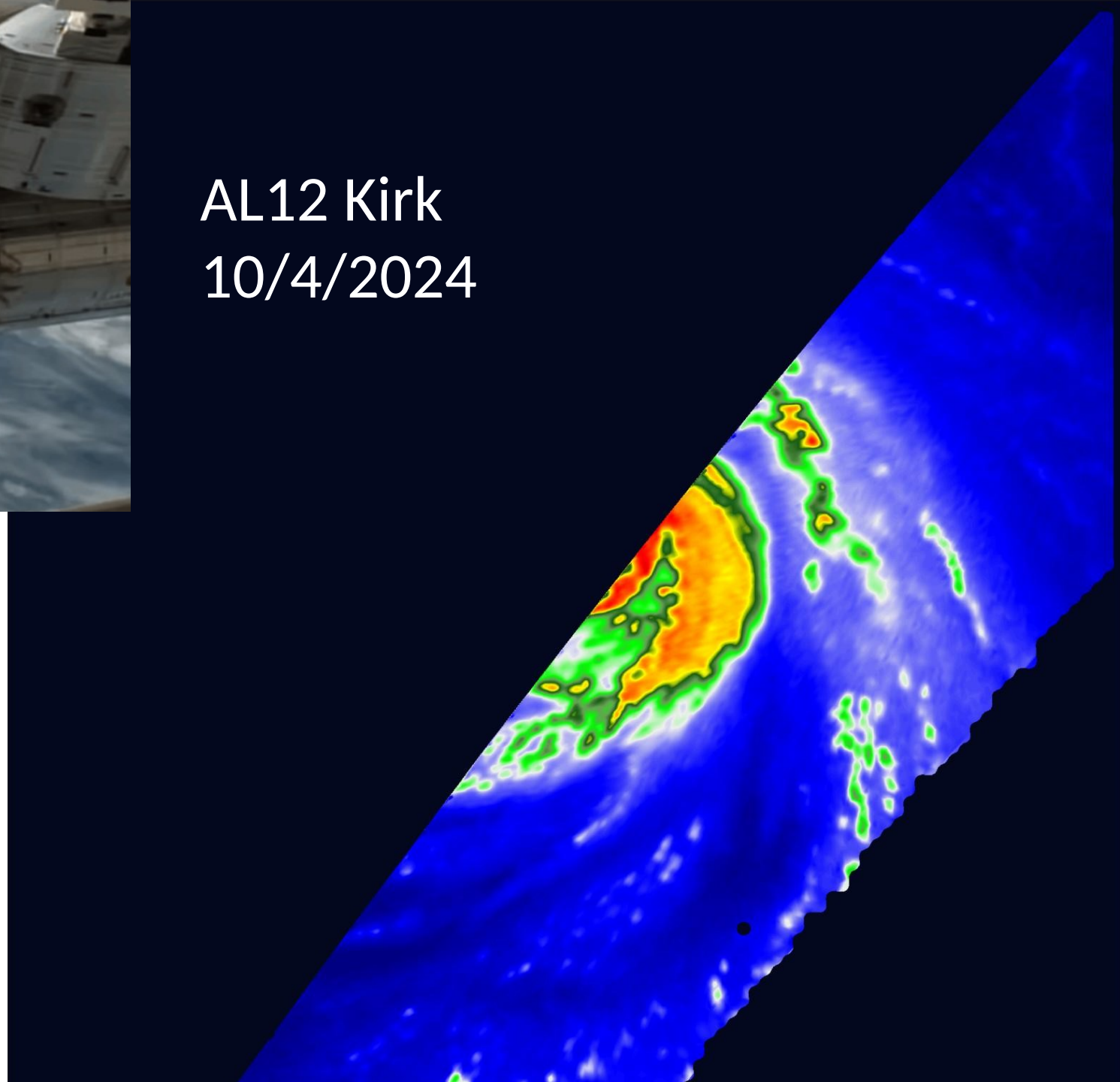


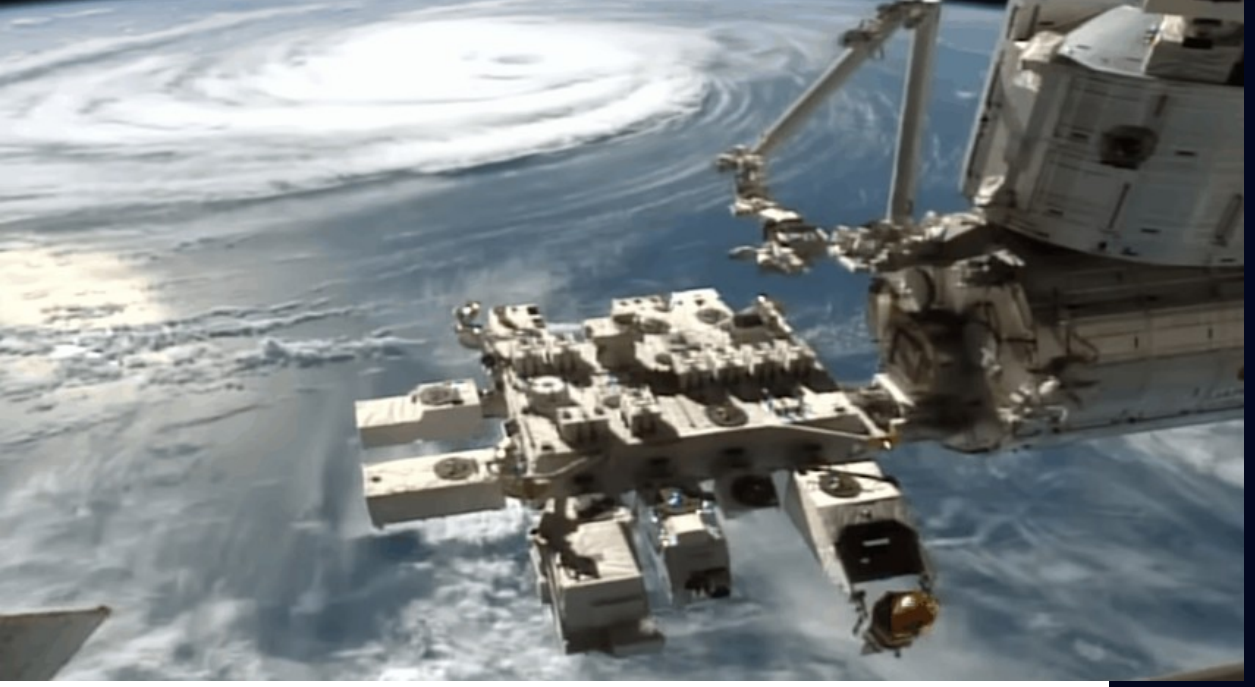
Applied as an angle dependent spillover correction





AL12 Kirk
10/4/2024





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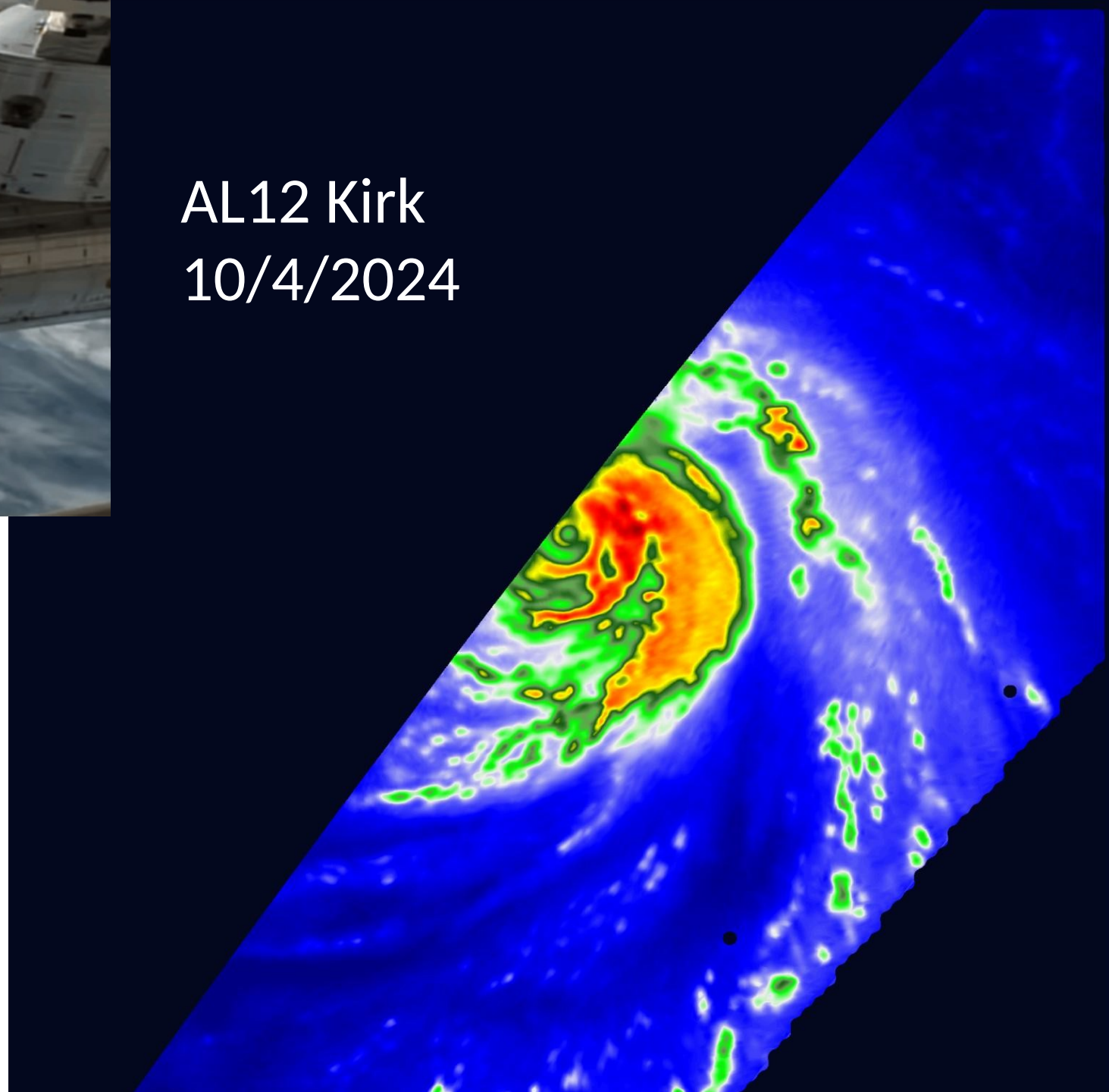
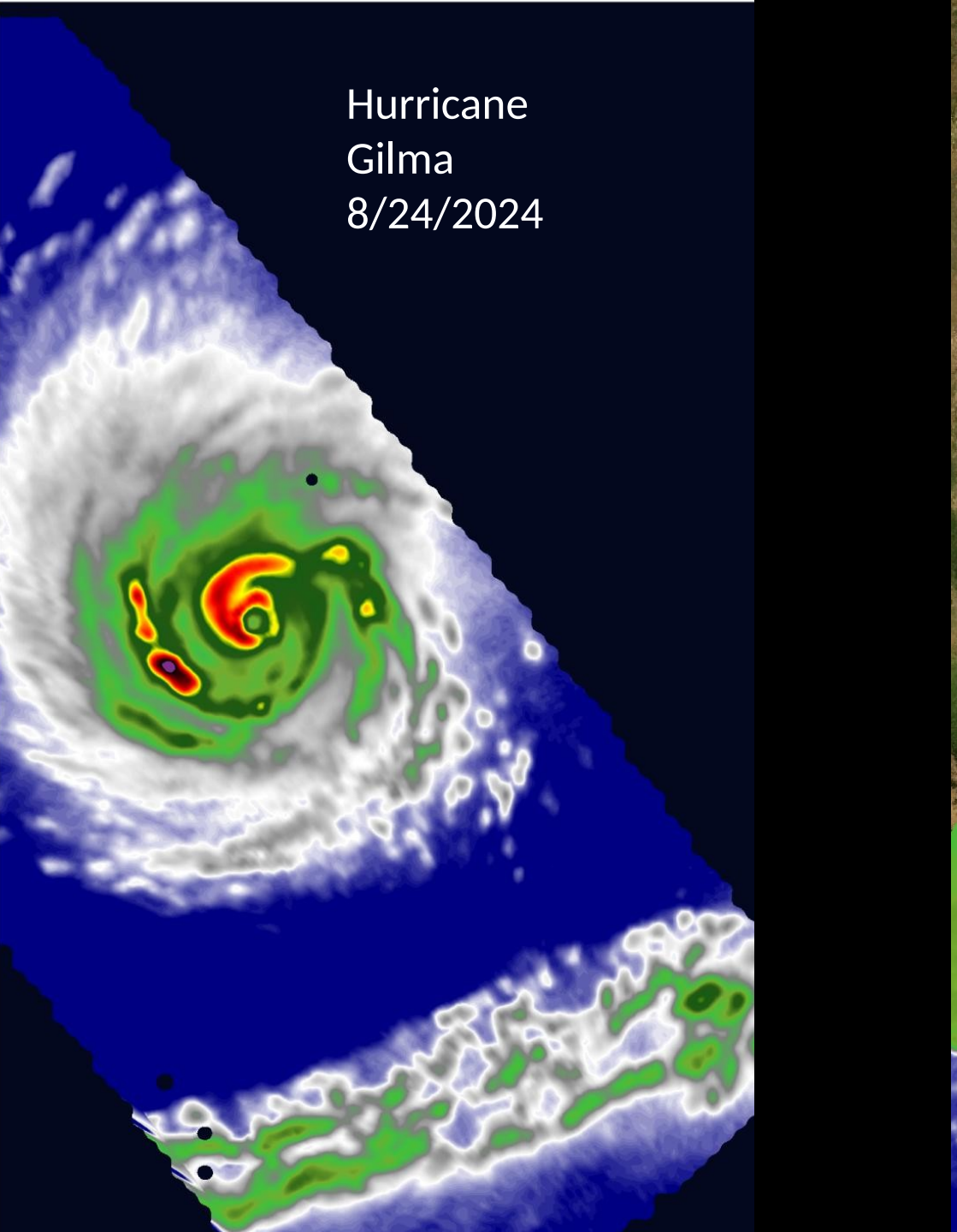
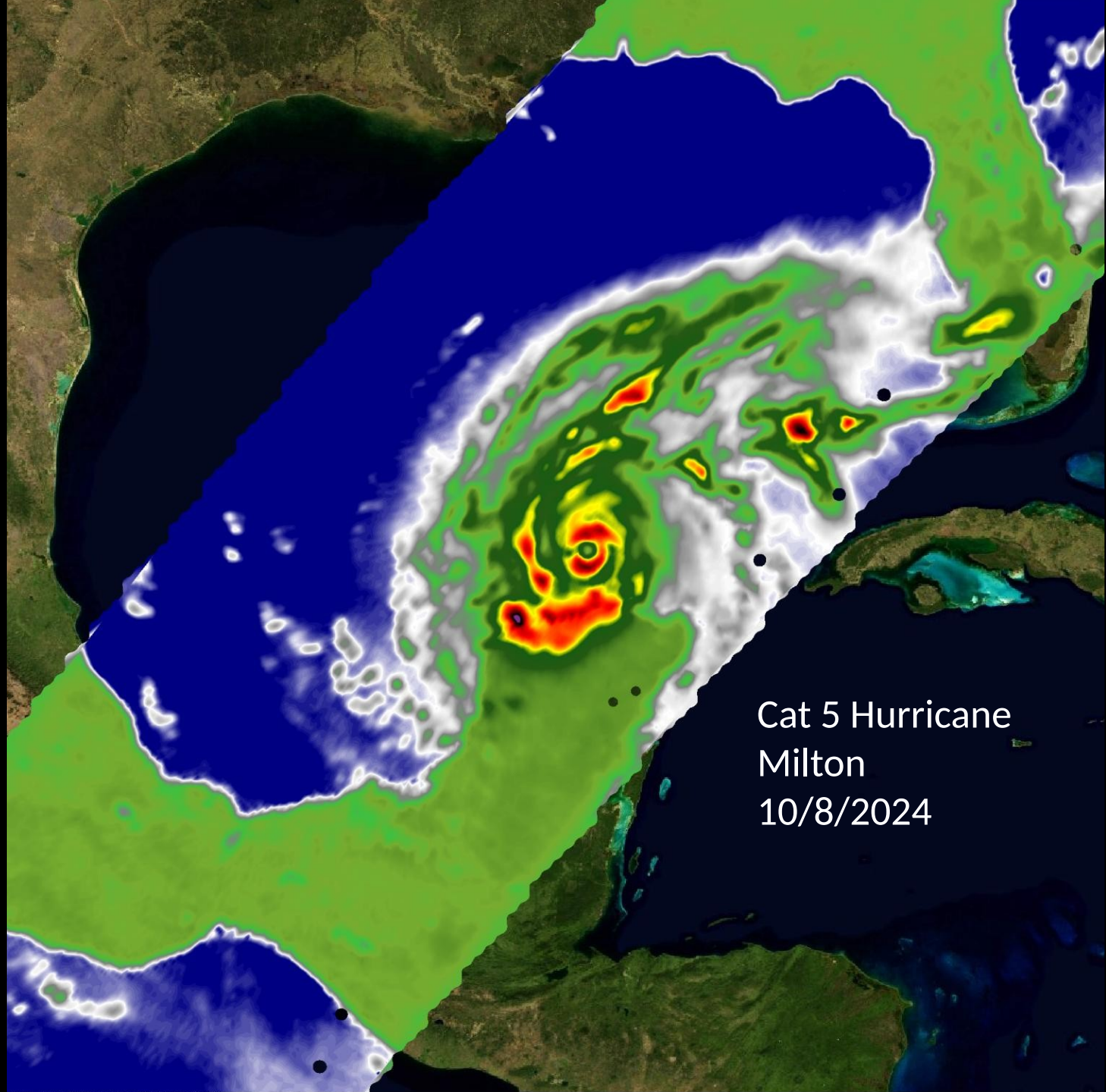
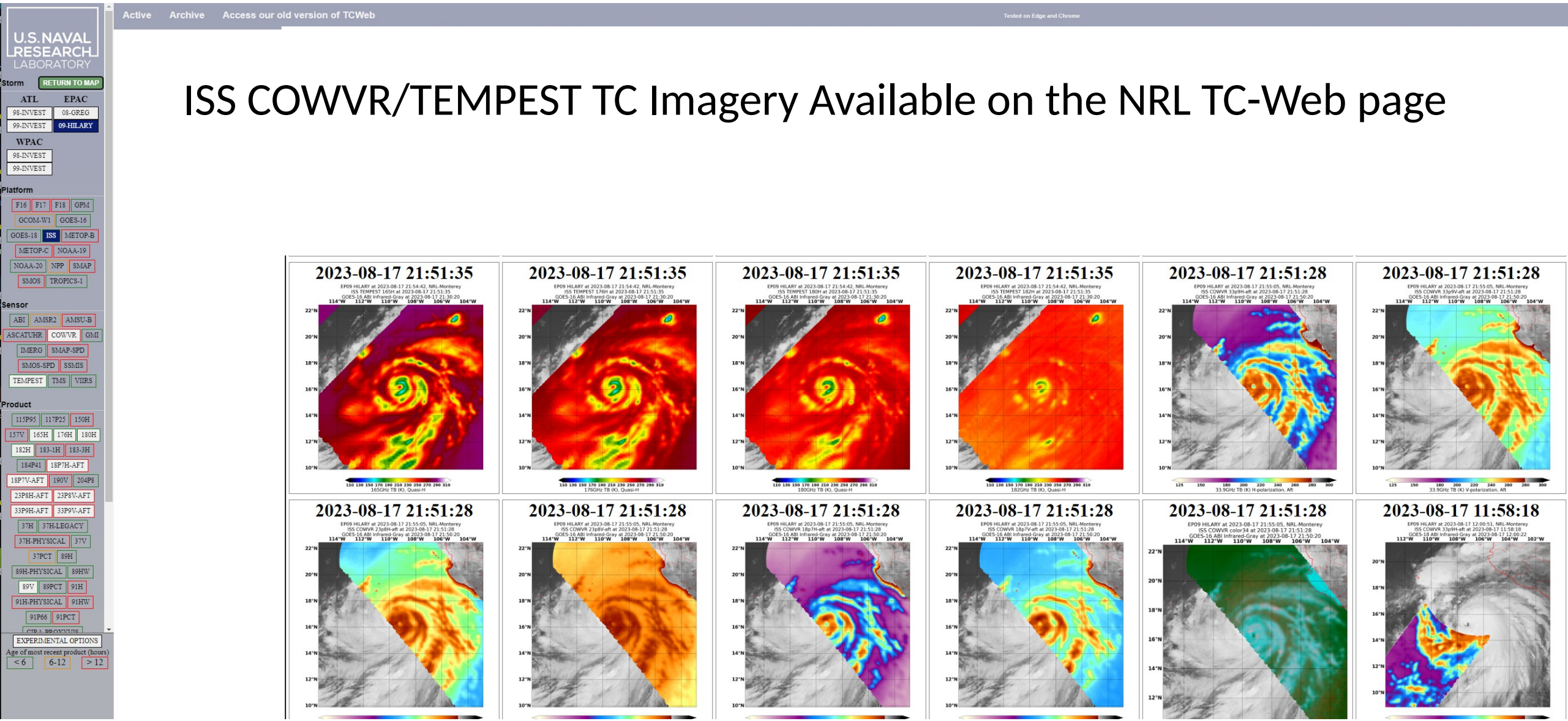
10/4/2024




Hurricane
Gilma
8/24/2024


Cat 5 Hurricane
Milton
10/8/2024

ISS COWVR/TEMPEST TC Imagery Available on the NRL TC-Web page



https://www.nrlmry.navy.mil/tcweb/active/?stormId=EP072023&platform=iss

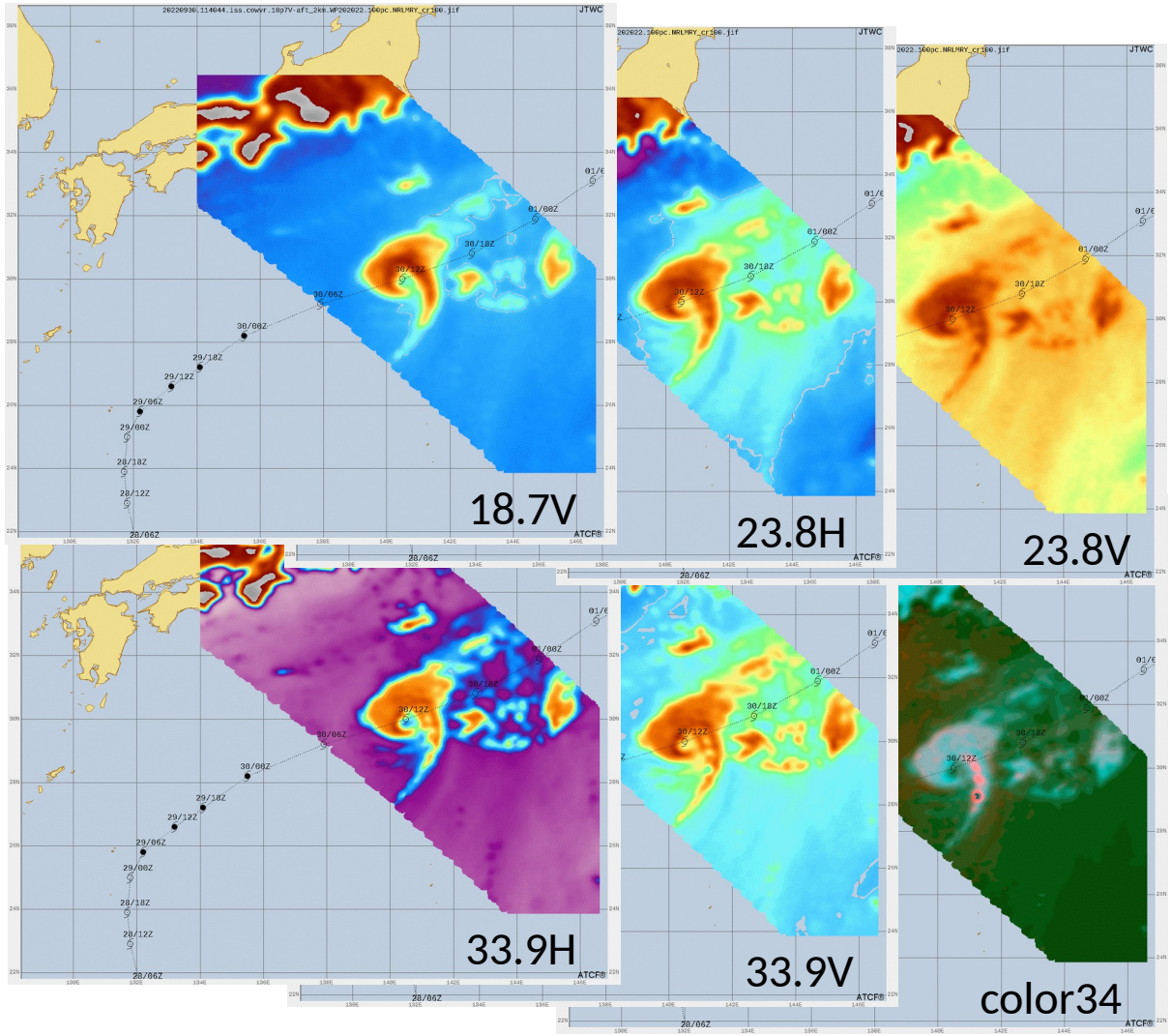
Credit NRL

COWVR Imagery Available in Automated Tropical Cyclone Forecasting System (ATCF)

TS 20W (ROKE) - 30 Sep / 114044Z

Latency typically 2 hours

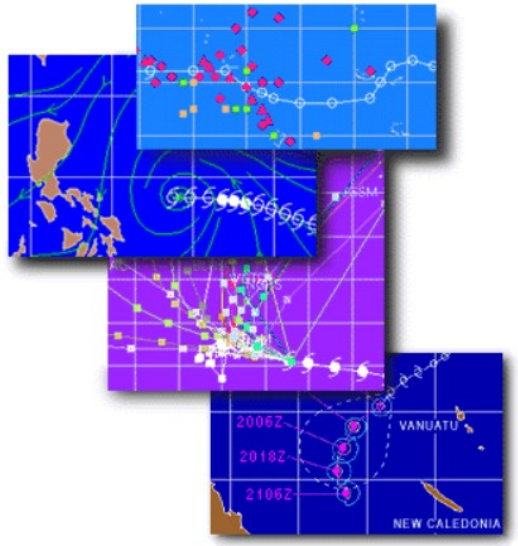
COWVR (aft-look)



Credit NRL

ATCF®

About ATCF | ATCF Support | TC Imagery

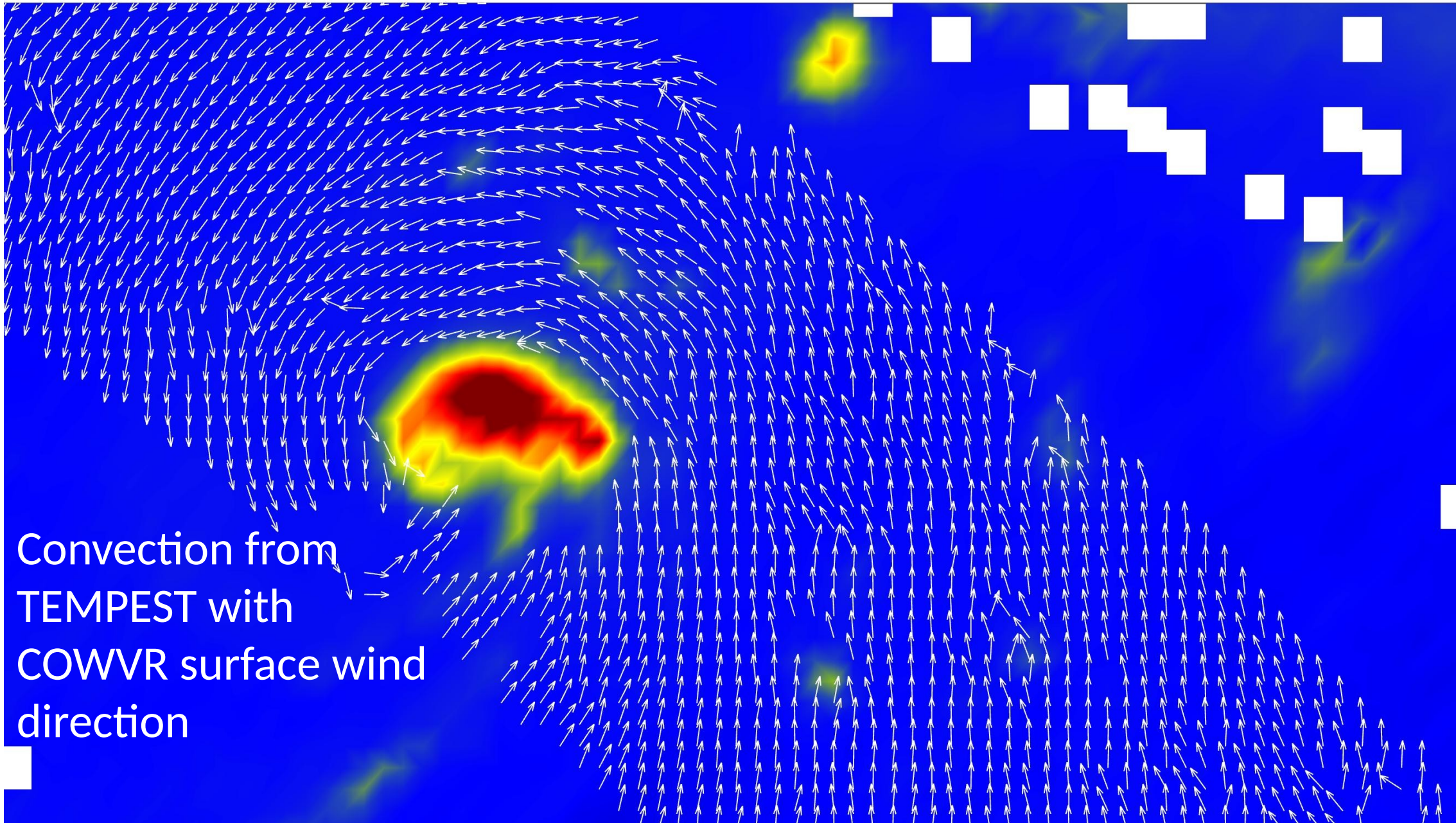


The Automated Tropical Cyclone Forecasting System (ATCF®) developed by NRL Monterey is a computer based application designed to automate and optimize the forecasting process at operational U.S. Department of Defense and National Weather Service tropical cyclone warning centers.

Operational Users

- The Joint Typhoon Warning Center
- The Naval Pacific Meteorology and Oceanography Center
- The Naval Atlantic Meteorology and Oceanography Center
- The National Hurricane Center
- The Central Pacific Hurricane Center

COWVR/TEMPEST Synergy (July 20, 2024, Central Atlantic)



JPL Compact Ocean Wind Vector Radiometer

Small-sat Compatible Design

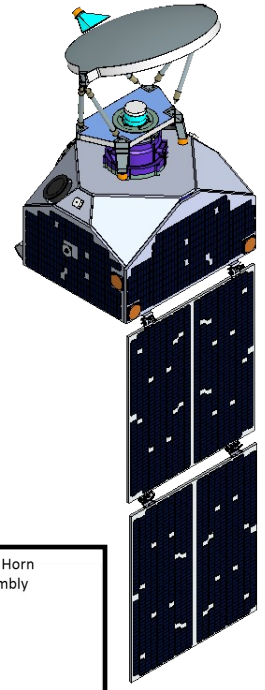
Only reflector rotates

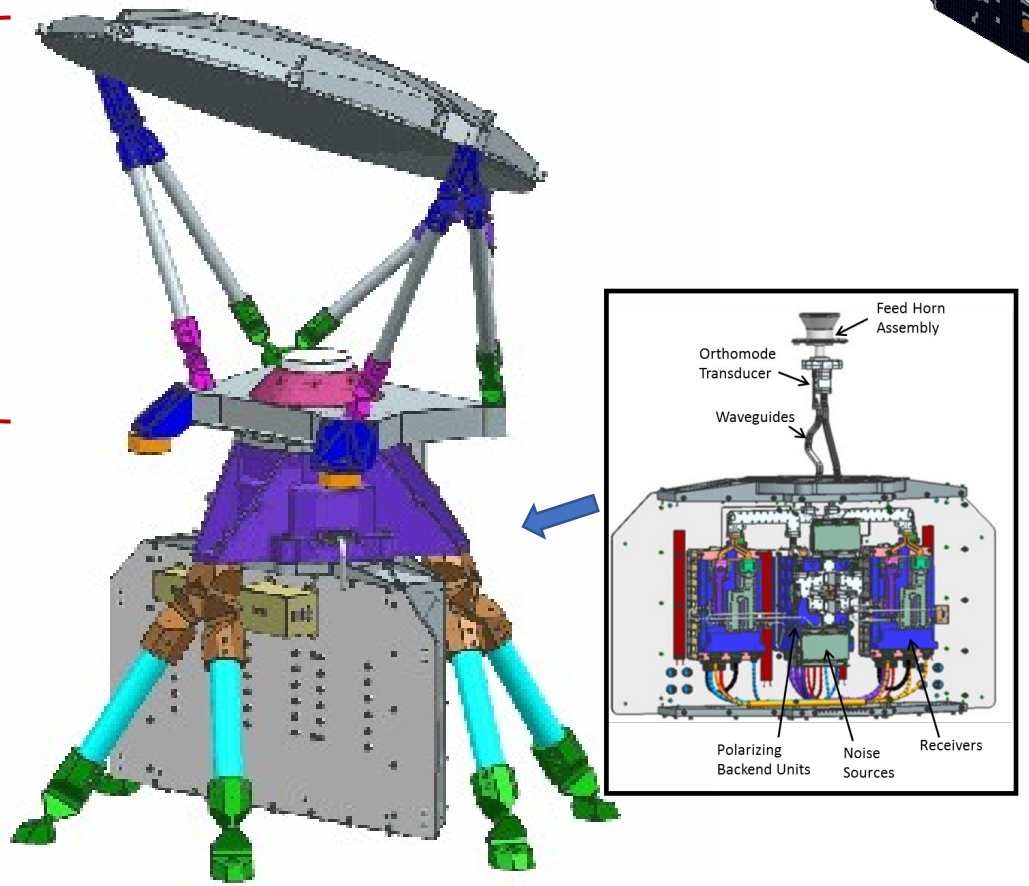
Simple spin mechanism

Single broadband feed horn

Fully polarimetric

360° Conical Scan (fore/aft)





Built for 20% of the cost of a traditional microwave imager, with 100% of the data quality