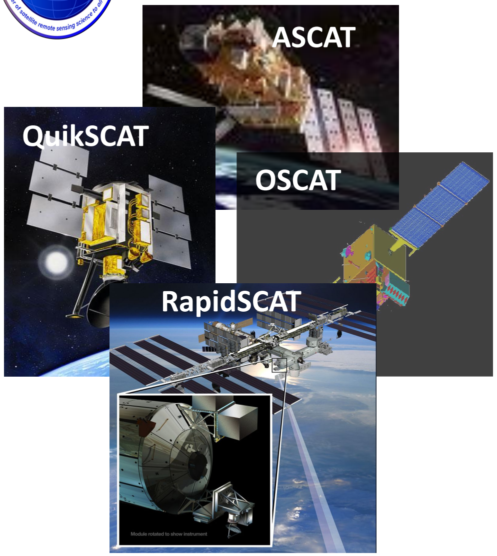
NESDIS STAR Ocean Winds Experiment

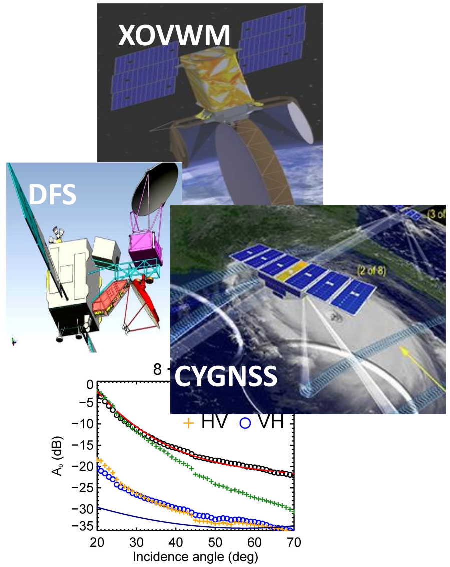
Paul Chang[1], Zorana Jelenak[1,2], Joe Sapp[1,3], Jim Carswell[4],
Casey Shoup[1,3], Qi Zhu[1,3], Steve Frasier[5], Steve Guimond[6]

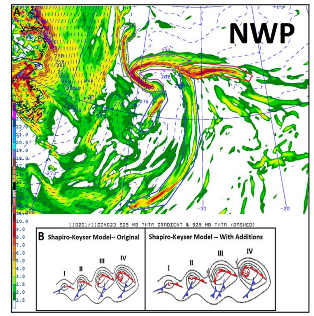
[1]NOAA/NESDIS/STAR/SOCD; [2]UCAR; [3]Global Science & Technology, Inc.;
[4]Tomorrow.IO, [5]UMass Amherst, [6]UMBC & NASA/GSFC

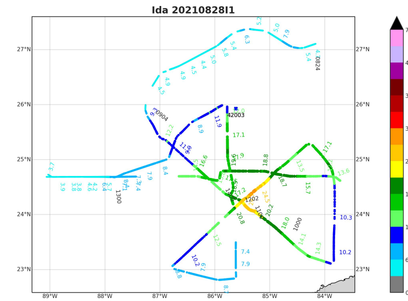
March 9th, 2022

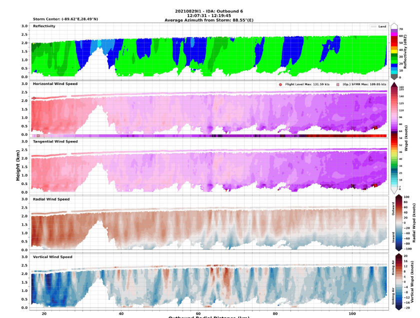
NESDIS Ocean Winds Experiment Goals and Achievements











Calibration, validation and product improvements of current scatterometer and radiometer satellite measurements

New instrument design and risk reduction for future satellite instruments

New insights into physics of hurricane force winds within extratropical storms

Providing NRT SWH and 3D winds into operations

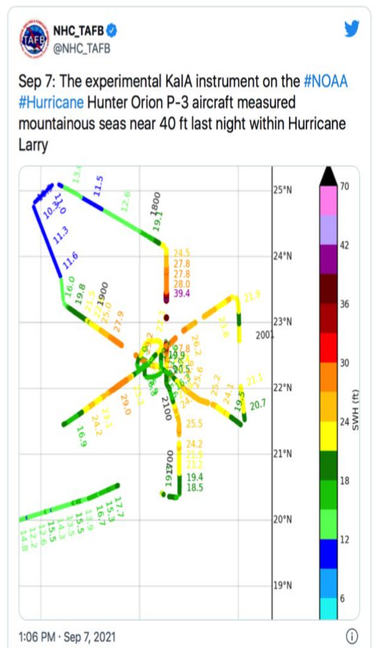
NESDIS Ocean Winds Experiment Instrumentation and Data Products

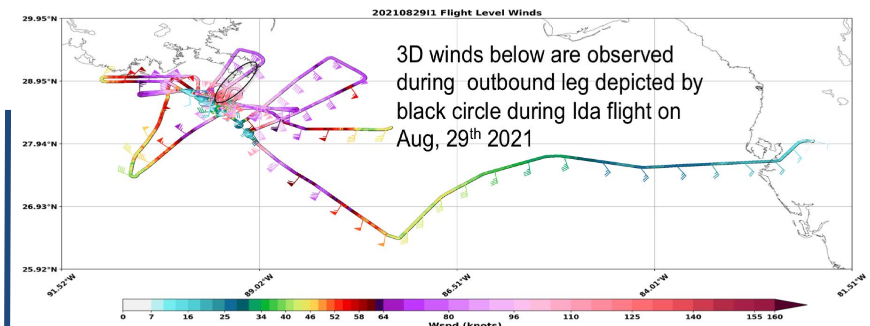
KaIA- Ka-band Interferometric Altimeter (developed by RSS (Tomorrow.IO)

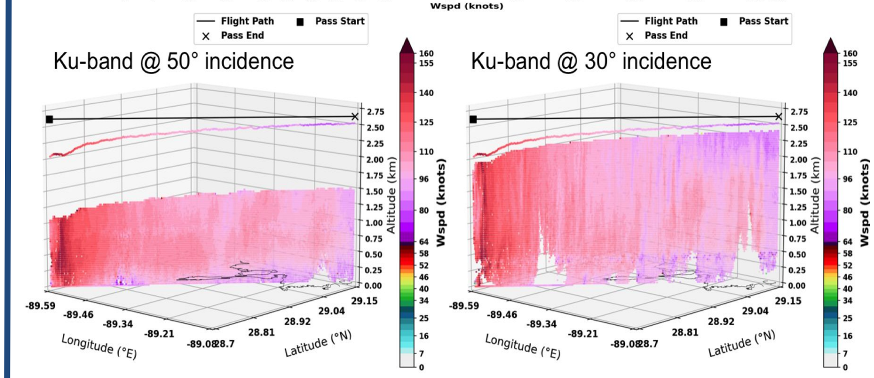
IWRAP-Imaging Wind and Rain Airborn Profiler (UMASS/NESDIS)

- Providing continuous real-time significant wave height and ocean surface winds and fine resolution real-time Doppler velocity and reflectivity profiles below the aircraft to just above the surface

KaIA SWH Data being provided to NHC





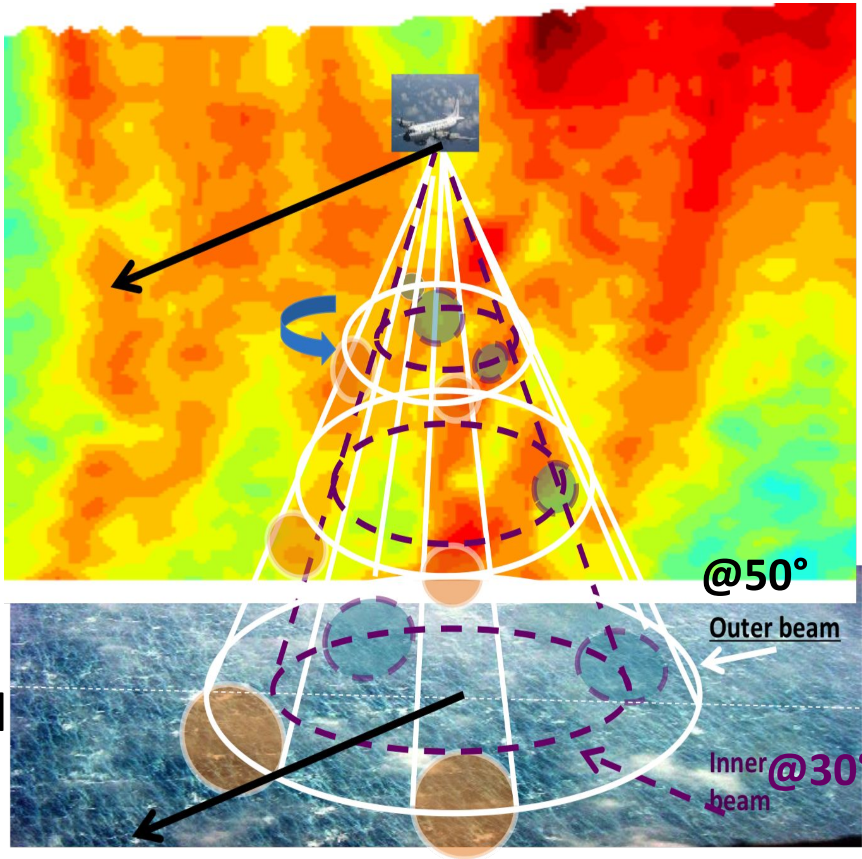


IWRAP Doppler wind profiles connecting the flight level and surface winds through the hurricane boundary layer and revealing very fine scale wind structures in the HBL

https://manati.star.nesdis.noaa.gov/datasets/AircraftData.php

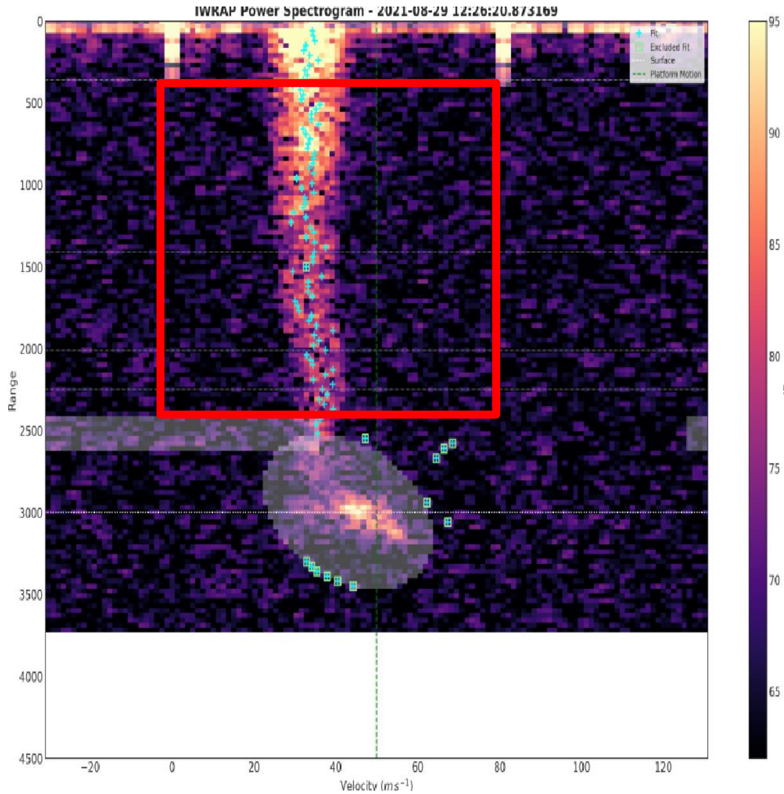
Imaging Wind and Rain Airborne Profiler – IWRAP 2021 Season Configuration

- The IWRAP is a downward-pointing, conically scanning, dual-frequency, dual-polarization Doppler radar capable of measuring surface backscatter and intervening volume reflectivity and Doppler velocity at 30 m range resolution.
- 2021 configuration:
  - Conically scanning Ku and C-band radars
  - V-pol measurements acquired at 30° and 50° incidence angles
  - Outer beam profiles from 1.5km below the aircraft up to 30m from the surface
  - Inner beam profiles from 120m below the aircraft up to 30m from the surface
- 3D wind and reflectivity profiles retrieved along the nadir at 30m vertical and 150m along track resolution
- Maximum possible swath width of ~2–3 km at typical flying altitudes



Unique Characteristics of IWRAP

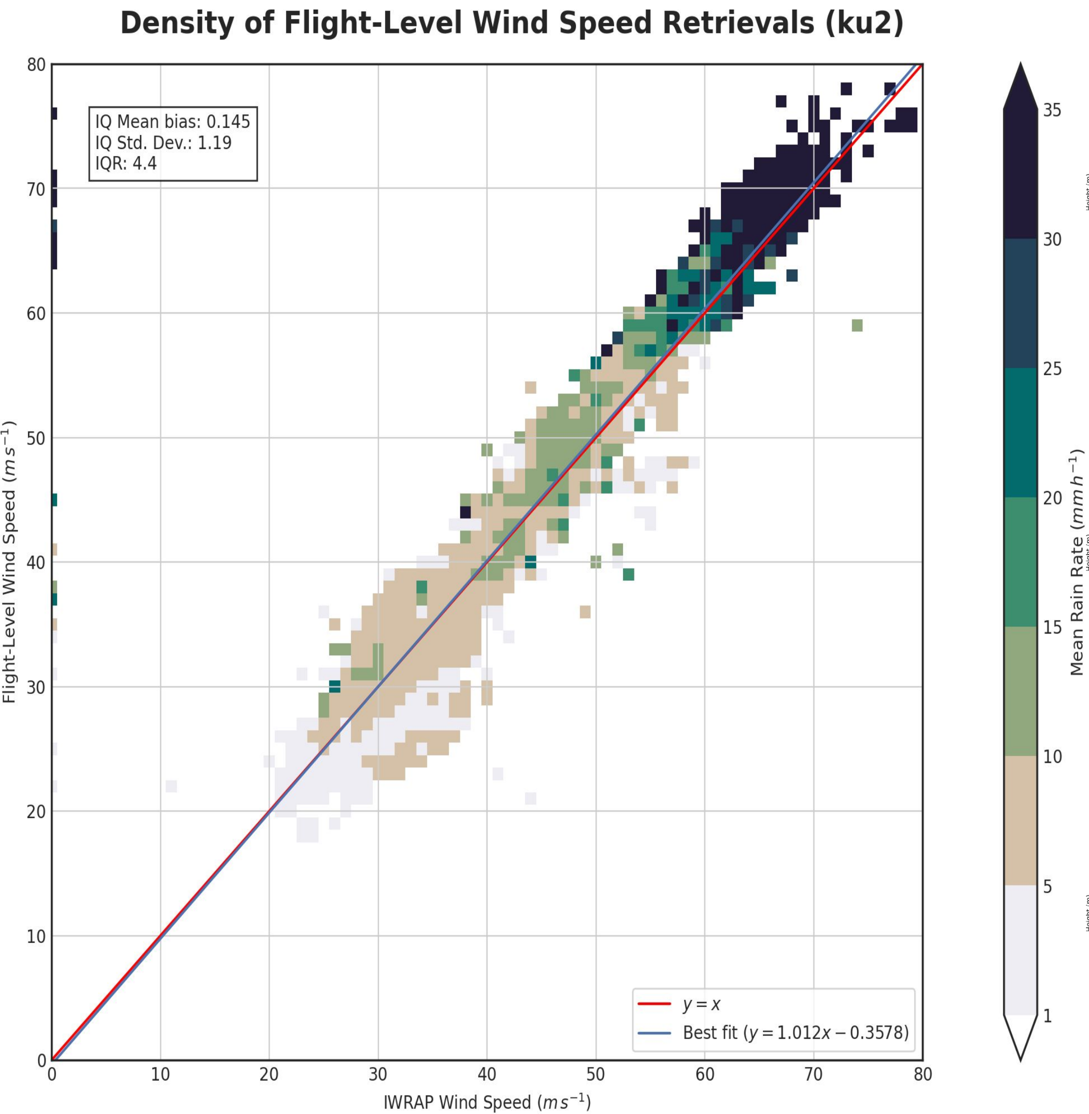
- Traditionally IWRAP wind and reflectivity profiles have been obtained by utilizing the pulse-pair processing algorithm and covariance method widely used in Doppler weather radars
  - This allows for accurate retrievals down to 300-500m above the surface
  - At lower altitudes precipitation volume backscatter is contaminated by the 1) nadir reflection from the surface backscatter and the 2) surface backscatter at the range gates closer to the ocean.
- Most unique aspect of IWRAP radar is in its advanced radar control and data acquisition system
  - This allows for spectral processing technique to be employed
- 2021 NRT processing utilized traditional pulse pair approach
  - Post season spectral processor applied on all data collected during 2021 season

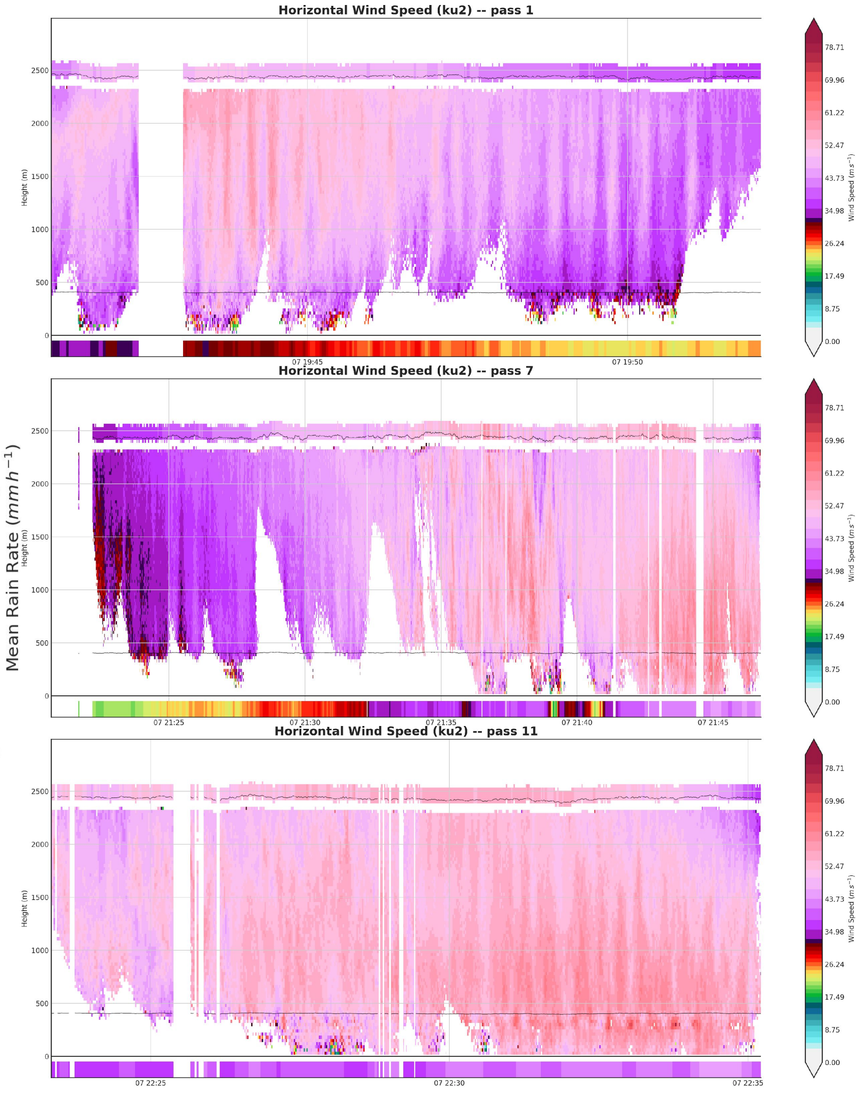


Data Validation

- Validation of IWRAP measurements utilized
  - Aircraft flight level wind measurements
    - Comparison done with highest level (120m bellow the aircraft) inner beam measurements vs flight level
  - Tail Doppler Radar wind profiles along the track
    - Along-track (1.5-km spacing) vertical profile with 150-m vertical grid spacing
    - Effectively an average wind over a 10-km wide swath across the flight track
  - Stepped Frequency Microwave Radiometer
    - SFMR wind retrievals referenced at 10m height
    - Comparison approach
    - Direct comparisons between SFMR and lowest level IWRAP winds
    - Assuming logarithmic wind decay within lowest 10m SFMR winds translated to IWRAP heights

Flight level winds vs IWRAP Ku @30° incidence

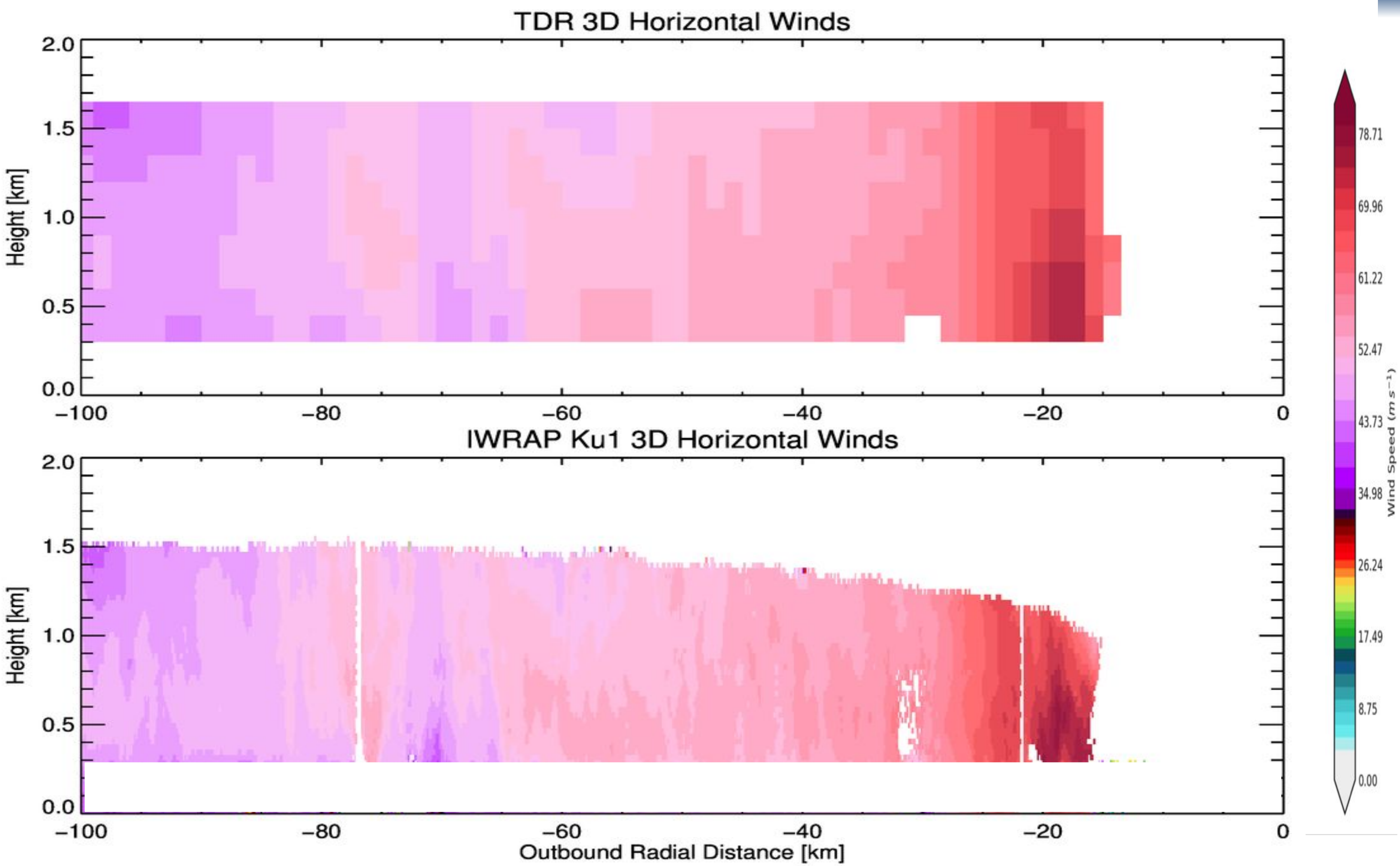




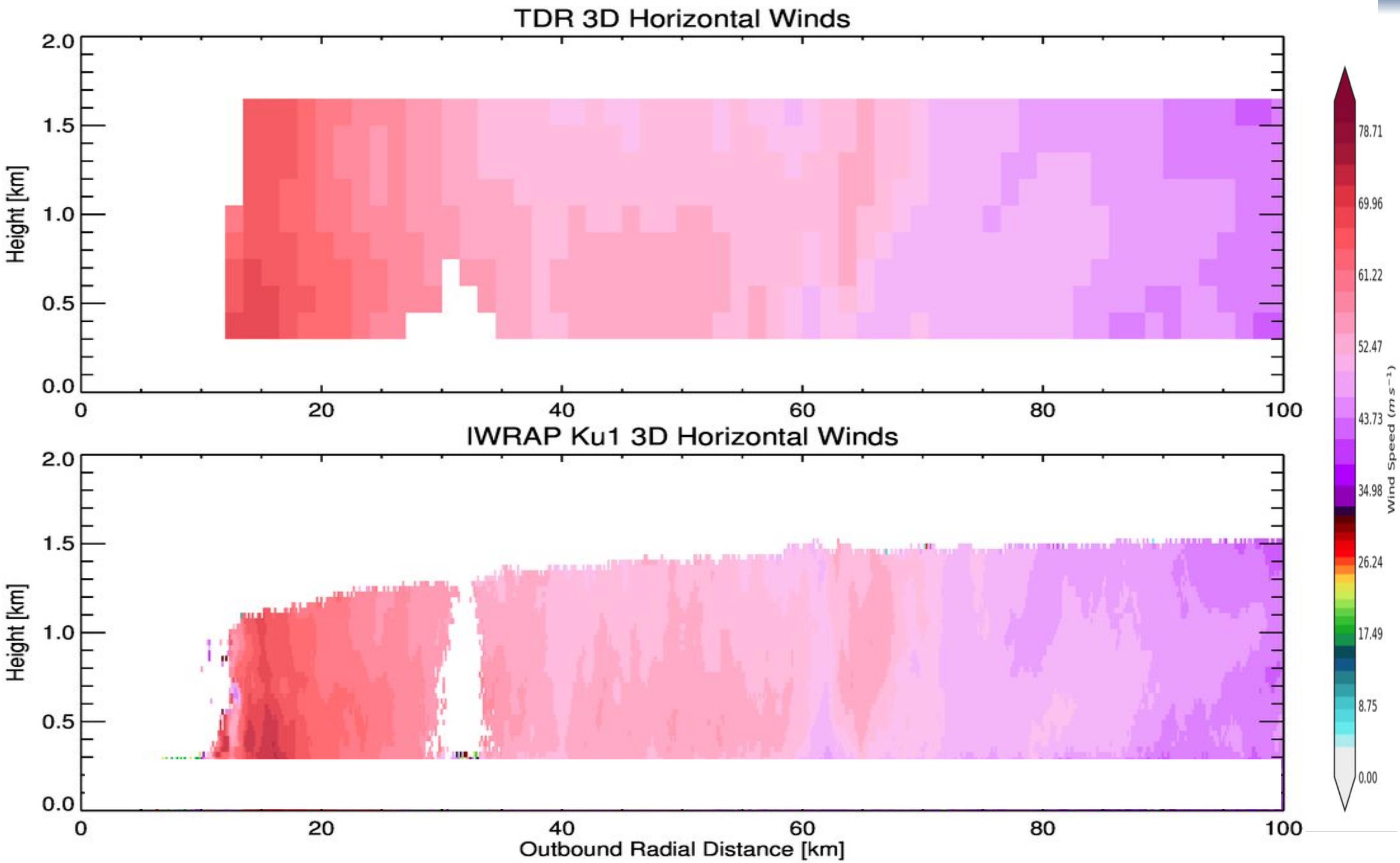
TDR vs IWRAP Comparisons

IWRAP Ku @50°

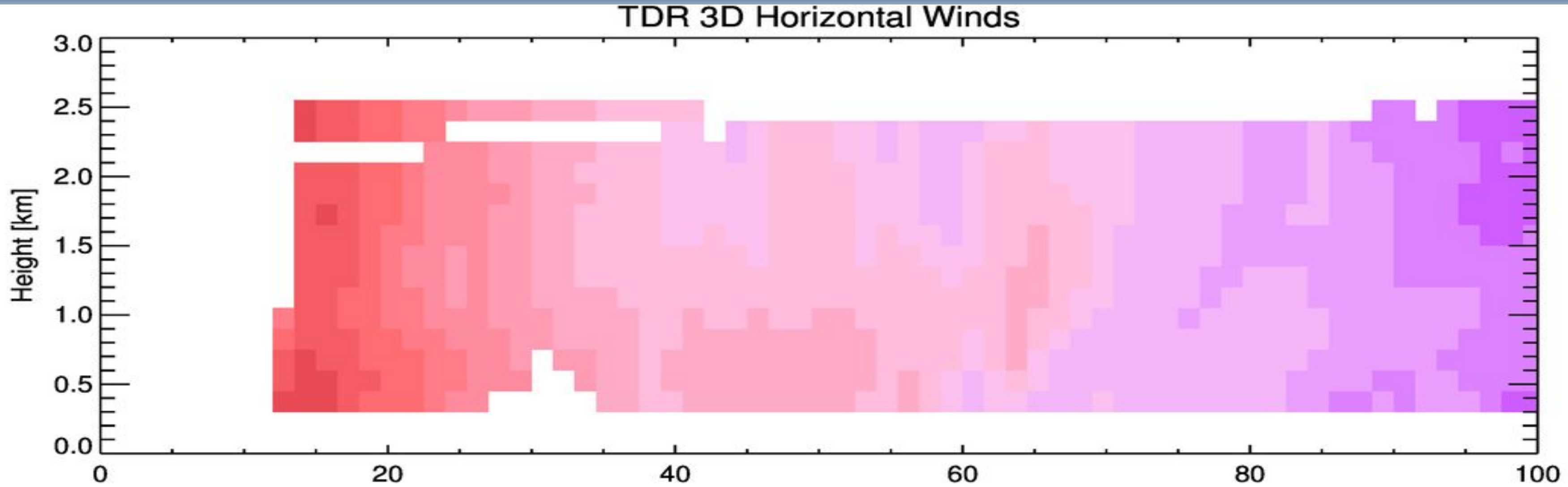
08292021I1 Inbound 12:36z

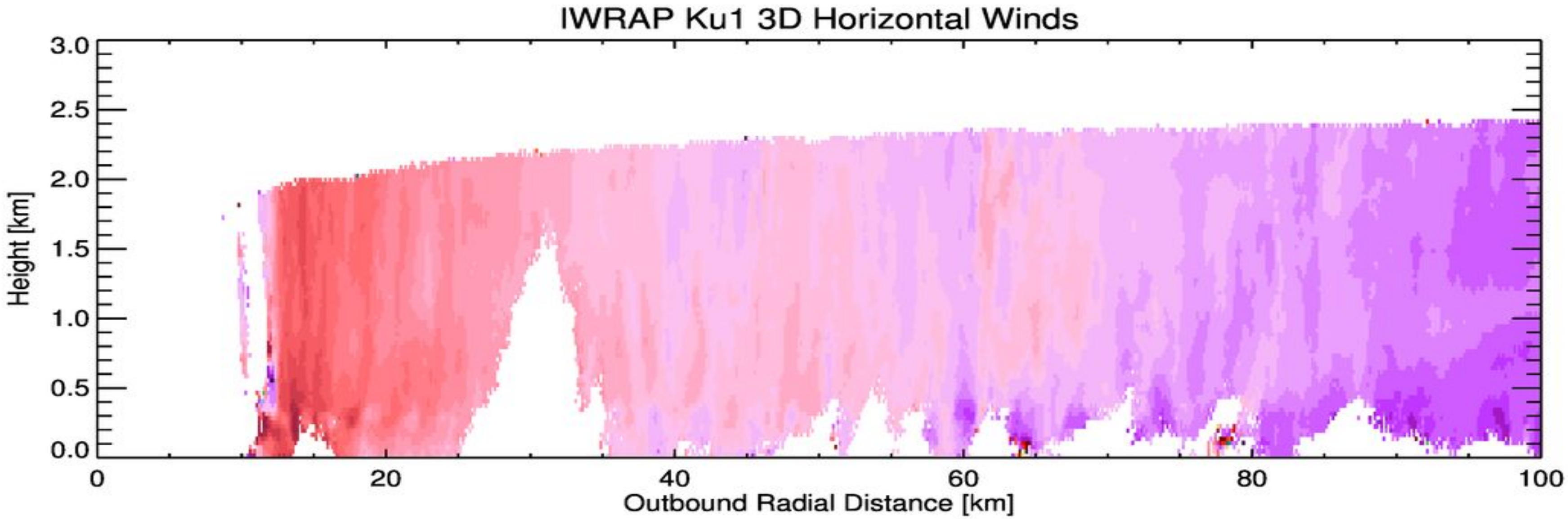


08292021I1 Outbound 12:03z
TDR vs IWRAP @50°

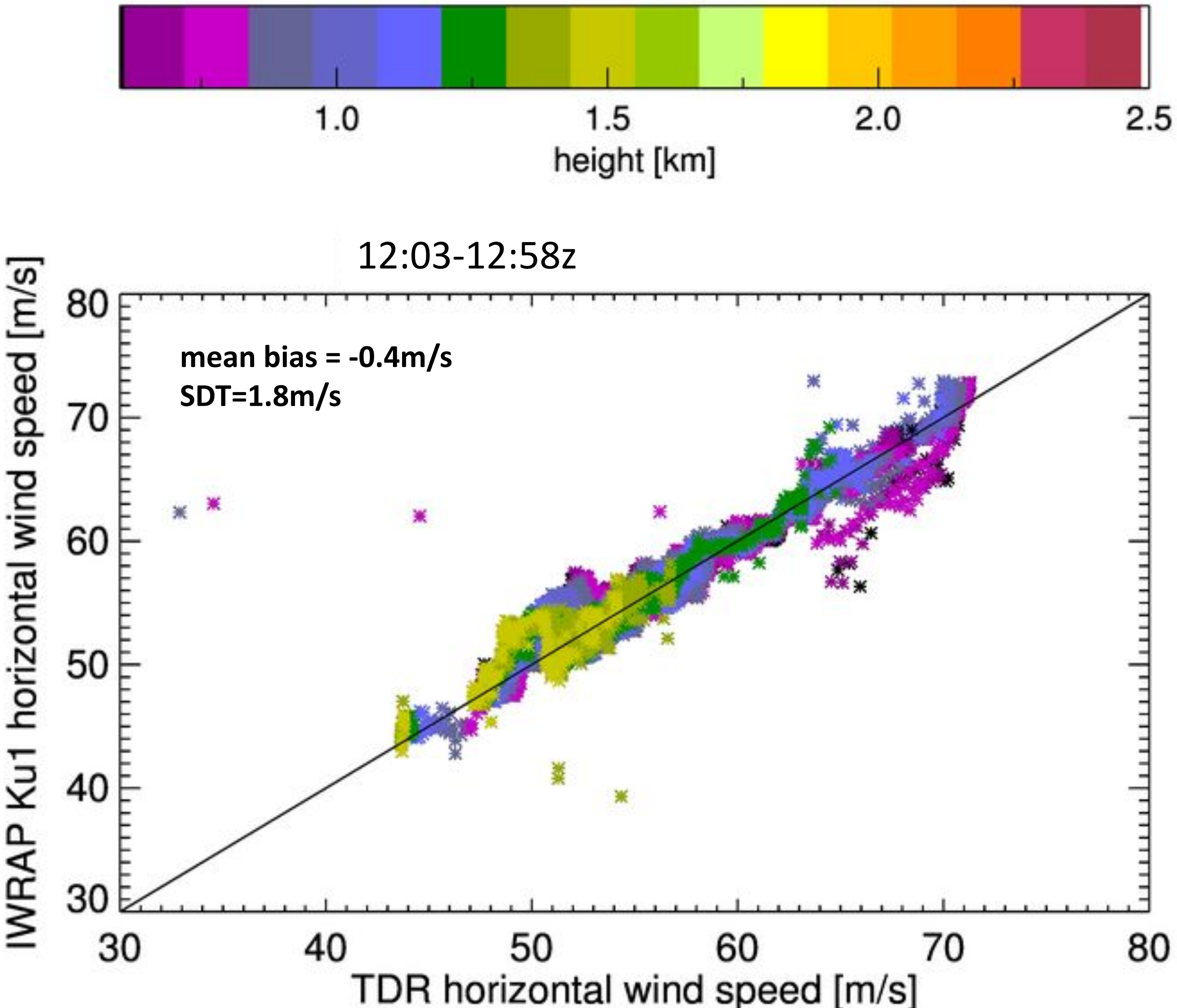


08292021I1 Outbound 12:03z
TDR vs IWRAP @30°



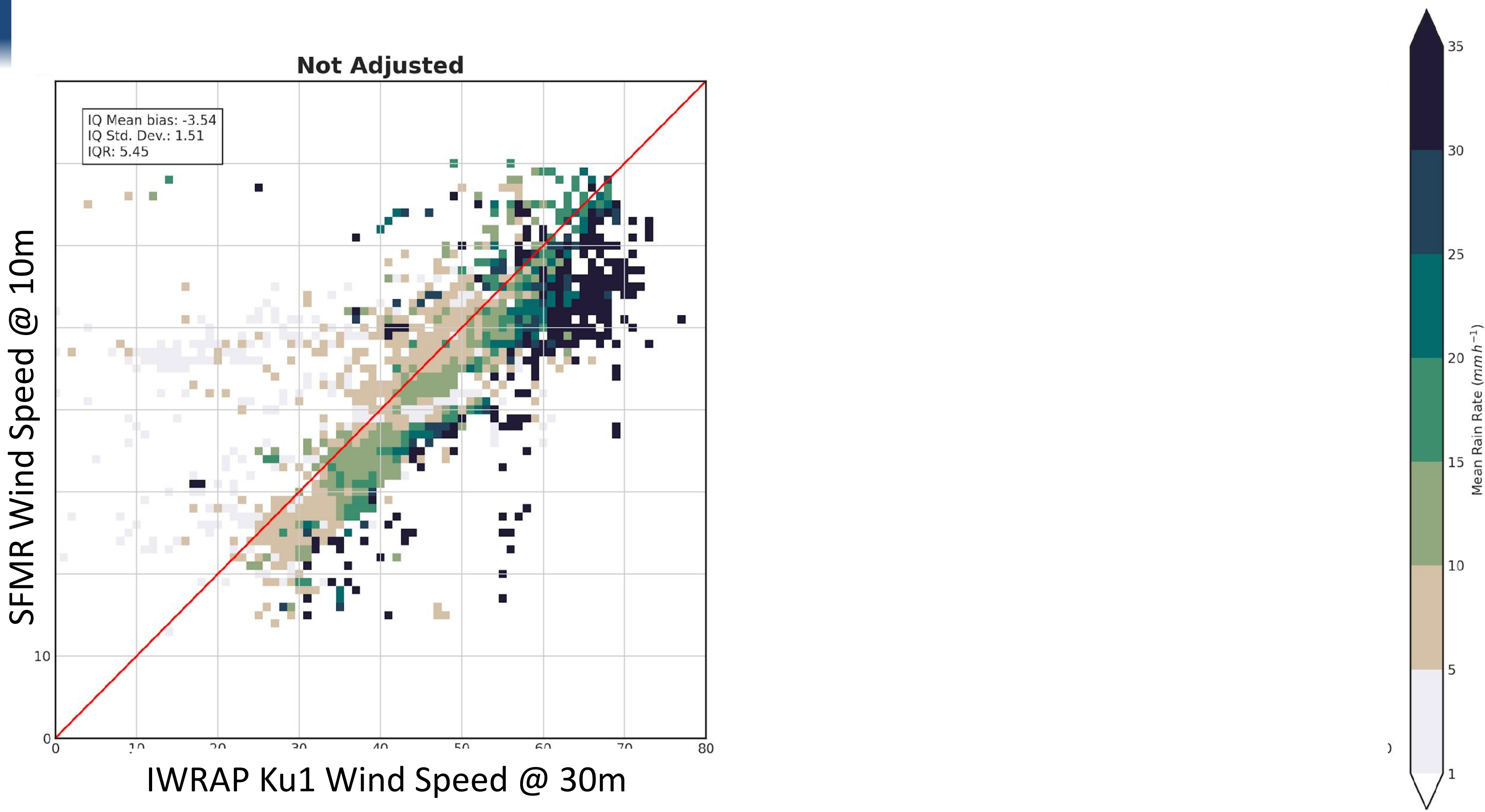


TDR vs IWRAP @50deg Comparison
Ida 08292021I1 12:21-12:58z



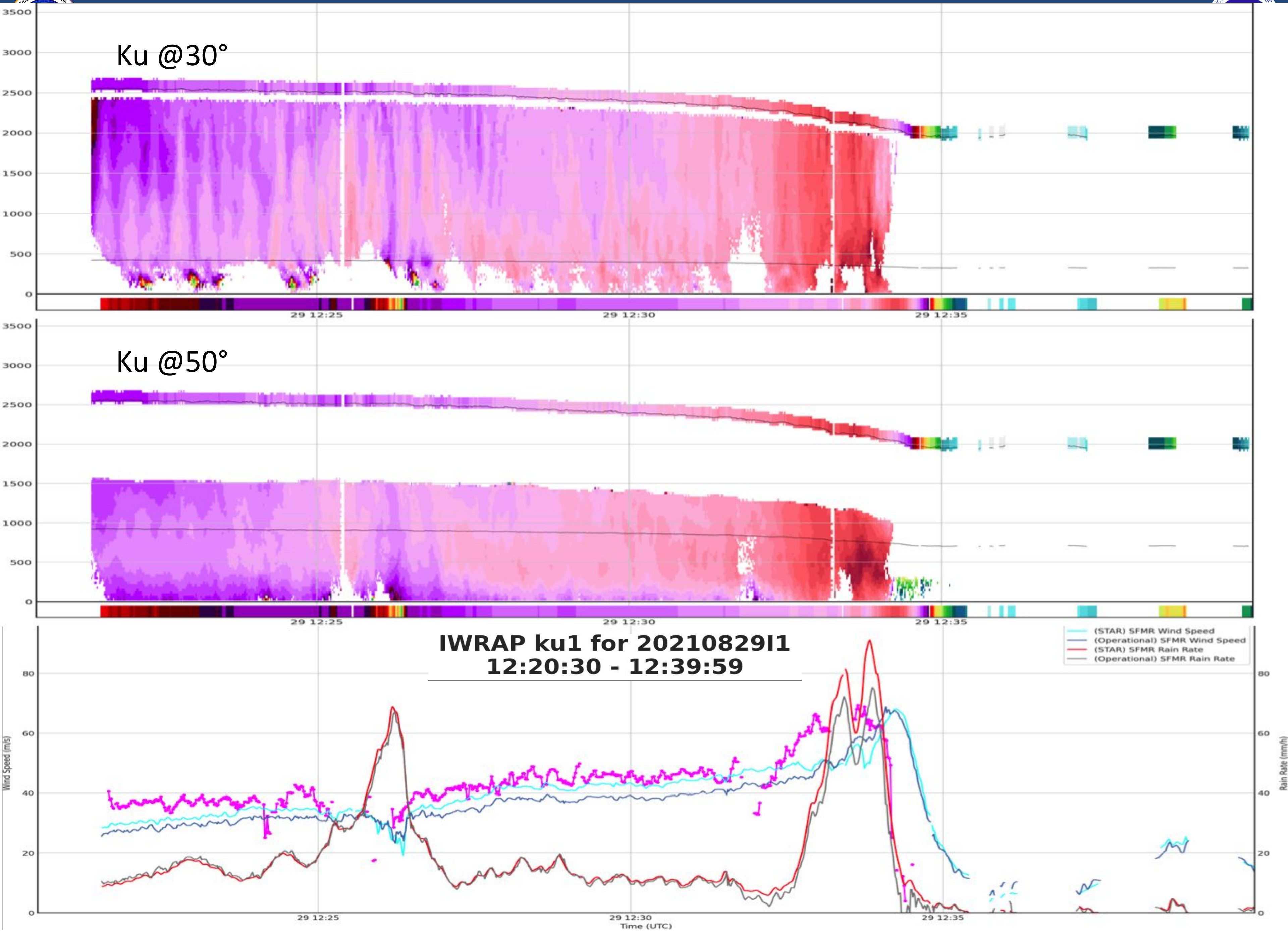
IWRAP vs SFMR
Ku @50°

Density of Surface Wind Speed Retrievals (ku1)



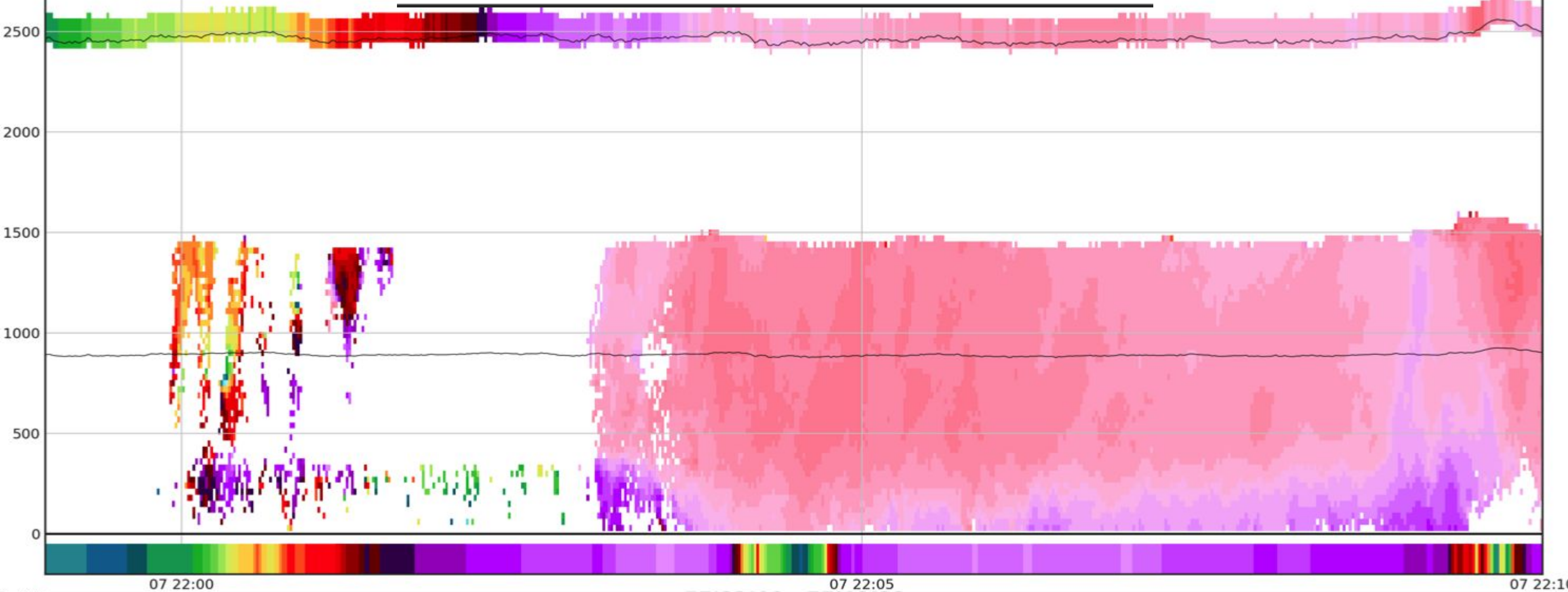
SFMR retrievals dependent on GMF
IWRAP direct Doppler wind measurements

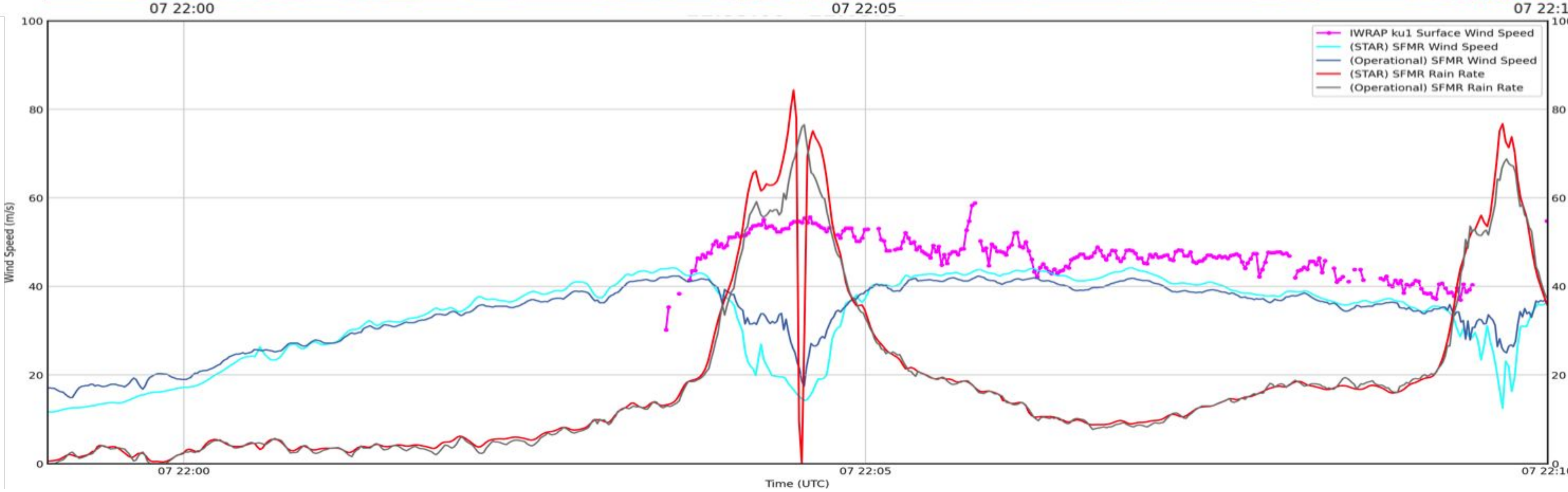
$$u(z_2) = u(z_1)\frac{\ln((z_2 - d)/z_0)}{\ln((z_1 - d)/z_0)}$$



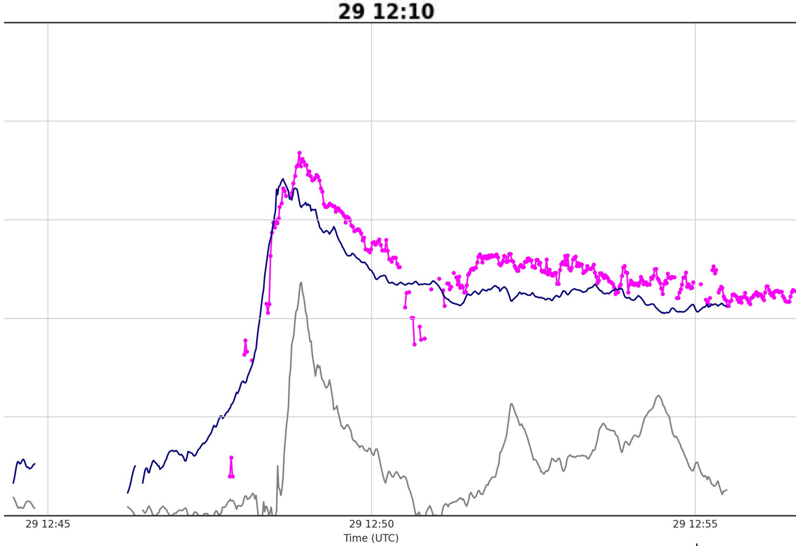
Ku @30°
Ku @50°
IWRAP ku1 for 20210829I1
12:20:30 - 12:39:59
(STAR) SFMR Wind Speed
(Operational) SFMR Wind Speed
(STAR) SFMR Rain Rate
(Operational) SFMR Rain Rate
Wind Speed (m/s)
Rain Rate (mm/h)
Time (UTC)
29 12:25
29 12:30
29 12:35

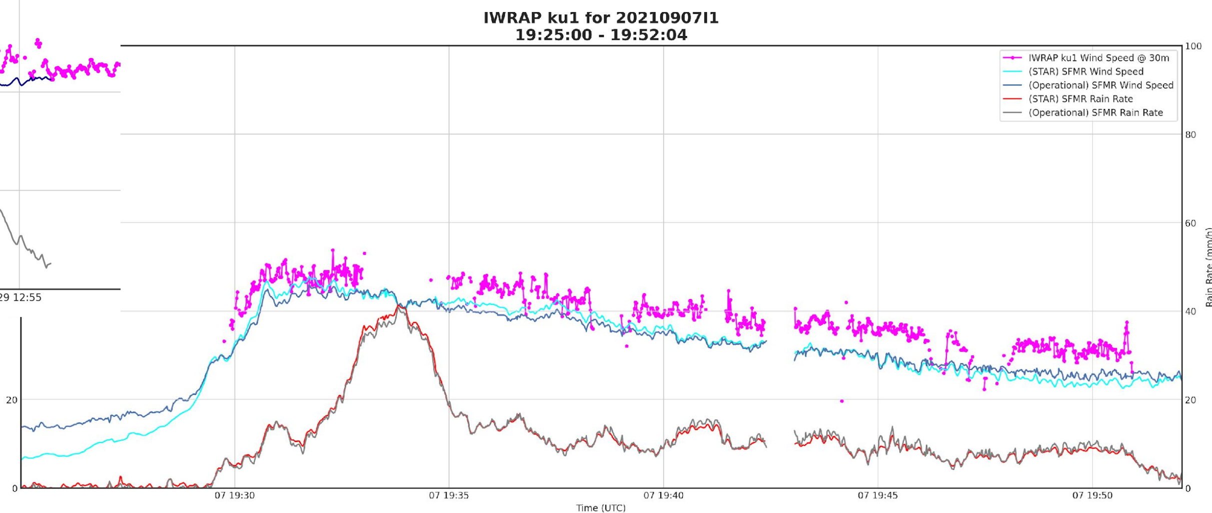
IWRAP ku1 for 20210907I1 21:59:00 - 22:09:59






20210829I1 (Ku-1) - IDA: Outbound 6
12:07:31 - 12:19:45
Altitude Difference (IWRAP-SFMR)
(STAR) SFMR Wspd
Closest IWRAP to SFMR
(STAR) SFMR Rain Rate
Land
Wind Speed (knots)
Altitude Difference (km)
Rain Rate (mm/hr)
175
150
125
100
75
50
25
0
1.0
0.8
0.6
0.4
0.2
0.0
100
80
60
40
20
0
29 12:10
29 12:15


29 12:45
29 12:50
29 12:55
Time (UTC)


IWRAP ku1 for 20210907I1
19:25:00 - 19:52:04
IWRAP ku1 Wind Speed @ 30m
(STAR) SFMR Wind Speed
(Operational) SFMR Wind Speed
(STAR) SFMR Rain Rate
(Operational) SFMR Rain Rate
Rain Rate (mm/h)
07 19:30
07 19:35
07 19:40
07 19:45
07 19:50
Time (UTC)

FY21 Accomplishments/FY22 Plans

- Highest resolution wind and reflectivity profiles measured to date in the lowest levels of the hurricane boundary layer in major hurricanes (from just below the aircraft to up to 30m above the ocean surface)
- Comparison of IWRAP and SFMR wind retrievals points toward errors within SFMR retrieval procedure rather than wind dependence of the emissivity model
- Data from two measurement frequency (Ku and C-band) will allow us to derive corresponding rain rate and dropsize distribution necessary to understand measurement performance further
- 2021 Hurricane Season data availability within next 6 months
  - Development of robust quality control procedures
  - Spectral processing algorithm fine tuning

- 2021 Hurricane Season data availability within next 6 months
  - Development of robust quality control procedures
  - Spectral processing algorithm fine tuning

- 2022 Plans
  - Work with HRD, AOC and NHC on how to best get IWRAP data to NHC
  - Evaluate real-time processing of entire swath
  - Implement real-time processing of surface winds from IWRAP using scatterometry techniques

Thank you! Questions?