Advanced Microwave Scanning Radiometer-2 (AMSR2) All-Weather Wind Speed

***Suleiman Alsweiss*[1,2], *Zorana Jelenak*[1,3], *Paul S. Chang*[1]**

[1] *NOAA/NESDIS/STAR*

[2] *Global Science & Technology, Inc. (GST)*

[3] *University Corporation for Atmospheric Research (UCAR)*

IOVWST-2022

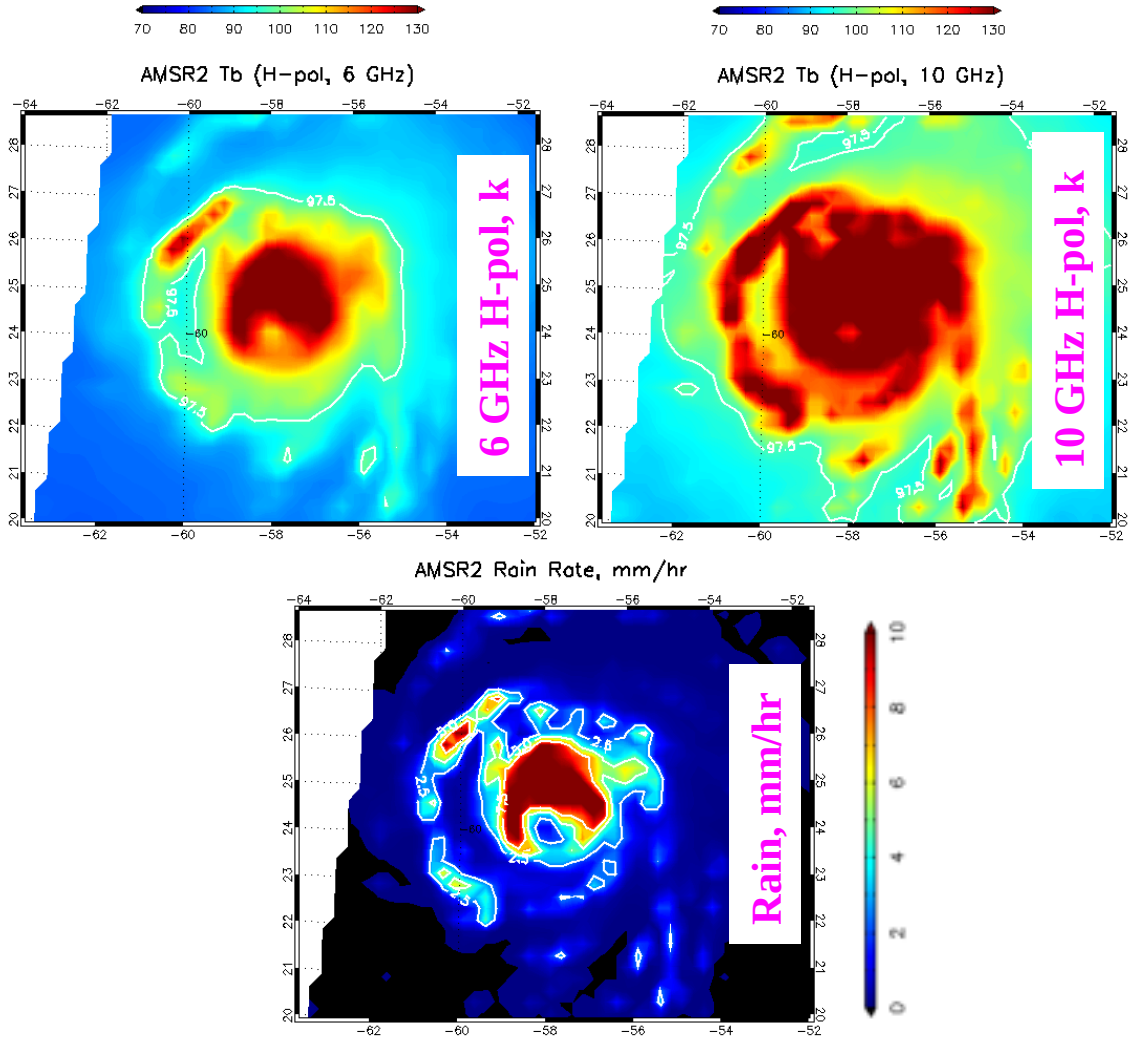
Introduction

- The Ocean Surface Winds Team at NOAA provides a suite of oceanic environmental data records (EDR) derived from AMSR2 measurements
  - SST, SSW, TPW, CLW, Precipitation, SST anomaly, TPW percentage normal
    - Sampled at 0.1° similar to AMSR2 L1B
- An all-weather wind speed (AWS) product will be added to the collection of AMSR2 EDRs offered by NOAA
  - Provides wind speeds in normal and extreme weather conditions with minimal flagging and excellent accuracy
- A near-real-time demonstration of NOAA's AMSR2 EDRs is available for users
  - https://manati.star.nesdis.noaa.gov/datasets/GCOM2Data.php

Problem Statement: Rain Contamination

- Rain contamination increase measured Tbs
  - Raindrops are more effective emitters than sea surface
  - This problem is particularly noticeable at the tropics where rain-layers are deep
- Rain contamination leads to erroneous retrievals
  - Sea surface winds (SSW) retrievals from radiometers can be within ~1 m/s accuracy but tend to degrade rapidly in the presence of rain

AMSR2 pass over Hurricane Teddy (09/19/2020)



Rain heavily contaminates Tbs observed by AMSR2

AMSR2 Overview

- AMSR2 on board the Global Change Observation Mission-Water (GCOM-W) was launched in May 2012 by the Japanese Aerospace Exploration Agency (JAXA)
  - Passive remote sensing instrument that acquires microwave emission from the Earth's surface and atmosphere at **6.9, 7.3, 10.65, 18.7, 23.8, 36.5, & 89.0 GHz**
  - Conically scans Earth's surface at a nominal **incidence angle of 55°** which results in a wide **swath of 1450** km

Freq. (GHz)	6.9	7.3	10.6	18.7	23.8	36.5	89
Polarization	Vertical & horizontal						
Along-track IFOV width (km)	62	58	42	22	26	12	5
Cross-track IFOV width (km)	35	34	24	14	15	7	3

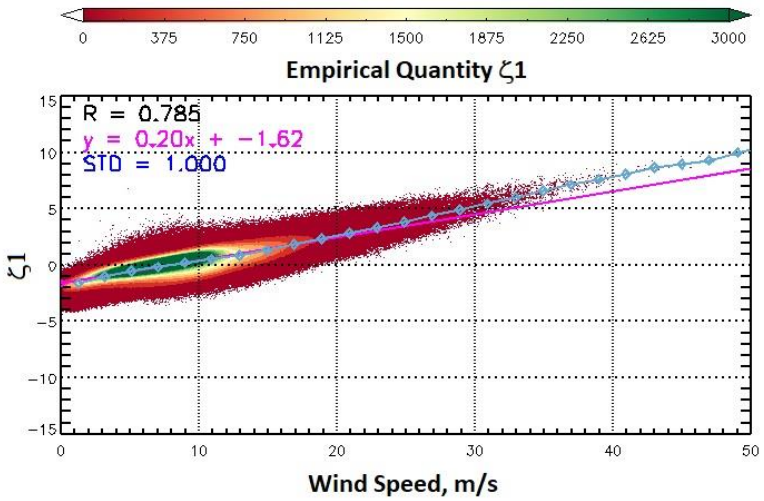
NOAA's AWS Product: Characteristics

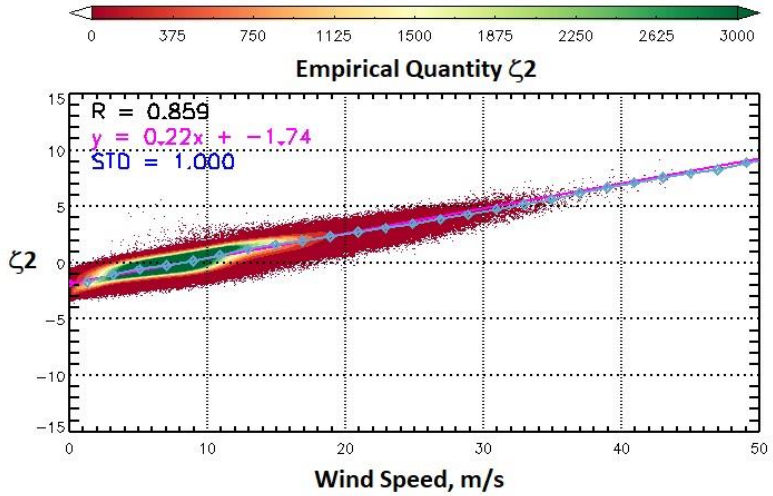
- Sensitive to all wind speed regimes including hurricane force winds
  - Trained with 1000 AMSR2 hurricane overpasses
  - Collocated with high resolution (25 km) GDAS
  - Collocated with HWRF (10 km)
- Less susceptible to rain in all weather conditions
  - Rain contamination can be mitigated via the linear combination of different channels
    - AMSR2 observe dual polarized Tbs at multiple frequencies
- Minimal flagging
  - Salvages majority of points in extreme weather events and/or intense rain

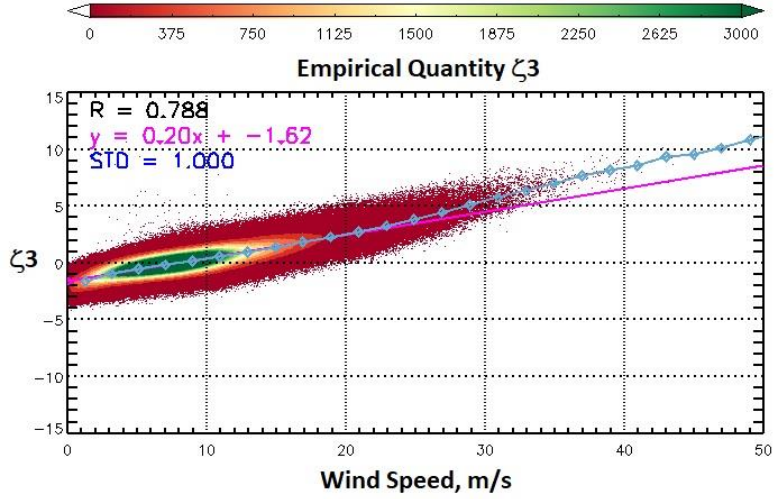
NOAA's AWS Product: Model Development (1)

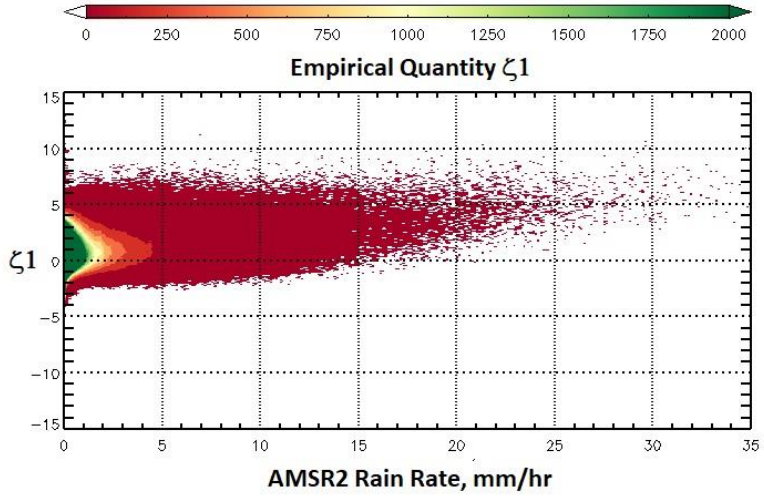
- **AMSR2 AWS** algorithm is **statistical** based that relies on 2-stage multiple linear regression
  - Suitable for all weather algorithms to avoid issues with modeling rain
  - Stage-1 regression coeffs. are a function of SST
  - Stage-2 regression coeffs. are a function of wind speed obtained from stage-1
- The algorithm exploits the linear combination of AMSR2 6, 10, and 18 GHz H- & V-pol channels to derive 3 empirical quantities ($\zeta_1, \zeta_2, \& \zeta_3$)
  - Serve as regression independent variables
  - Less susceptible to rain while maintain sensitivity to wind speed
- Regressions were trained with GDAS & HWRF
  - Interpolated temporally & spatially to AMSR2 measurements' location

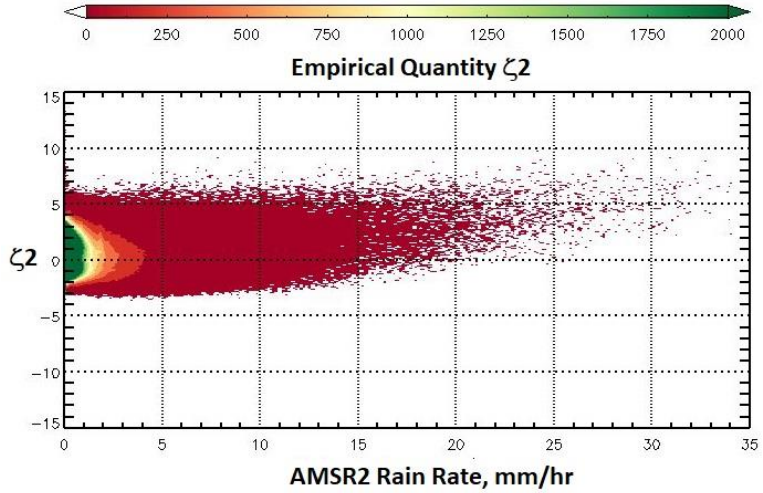
NOAA's AWS Product: Model Development (2)

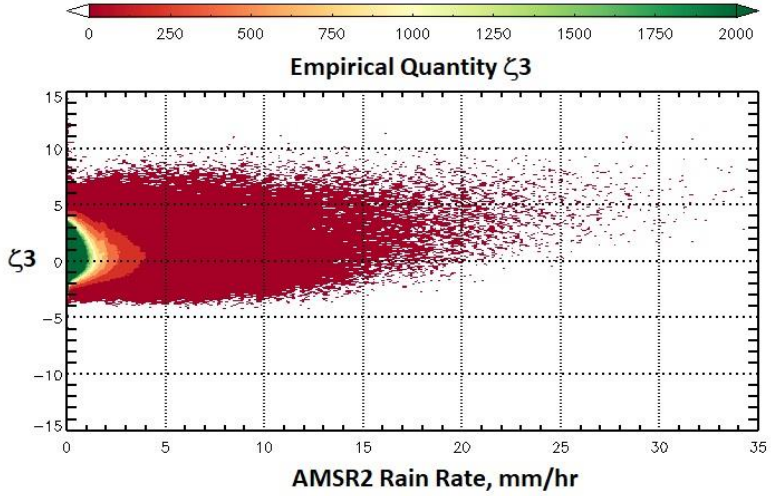






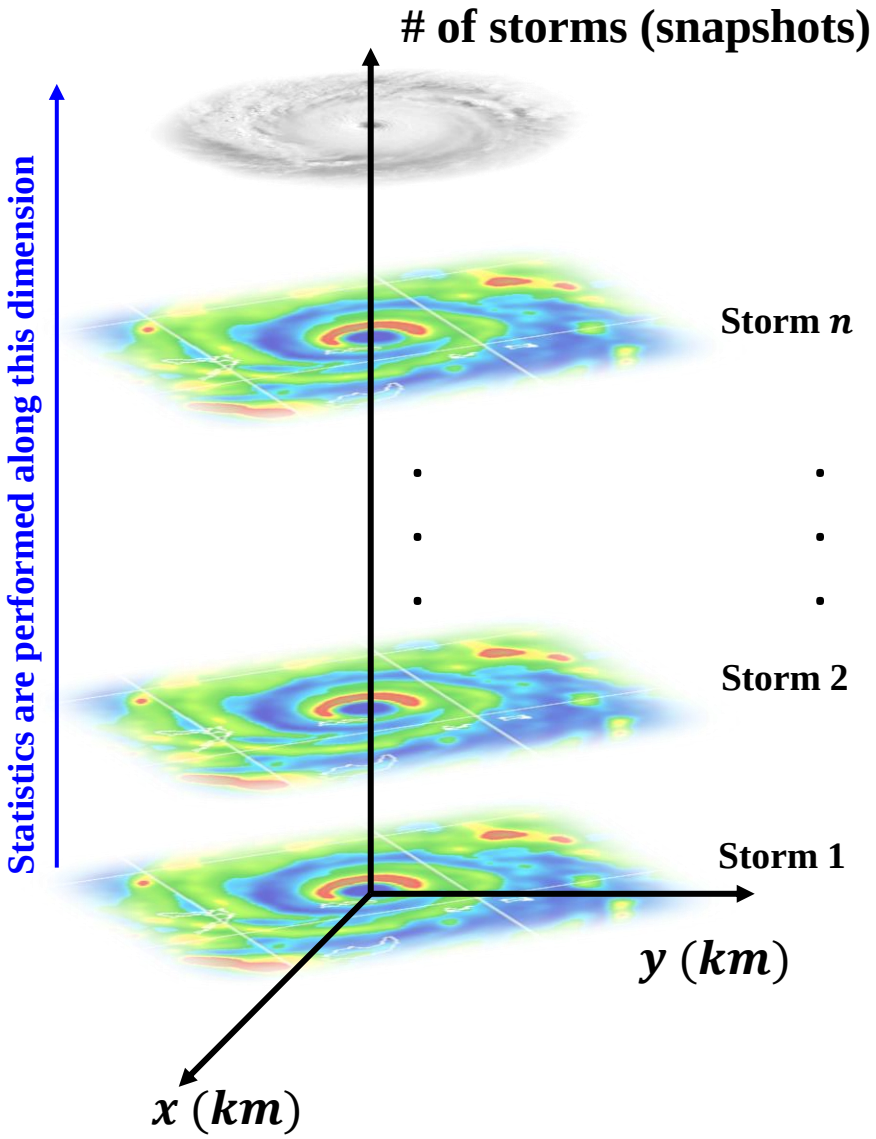




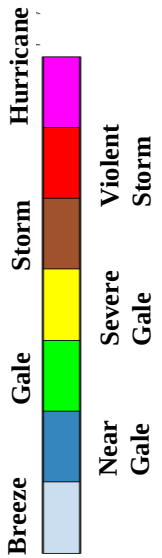


Extreme Winds Validation: Composite Plots

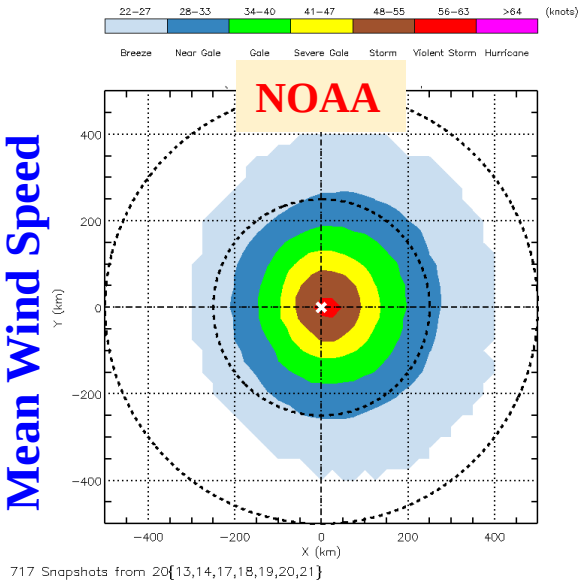
- A composite plot is a compound of several snapshots of wind speed retrievals in storms
  - These snapshots are gathered by defining a circle with a specified radius from the center of a storm
    - A storm centric coordinate system
  - The storm-centric snapshots are stacked with the center point being the storm center
  - Statistical analysis can be performed on the stacked snapshots for validation and comparison
    - Different algorithms and/or sensors



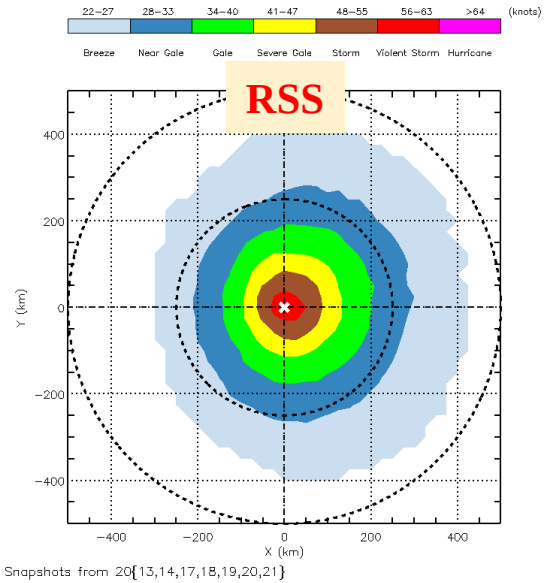
Composite Plots: Mean Wind Speed



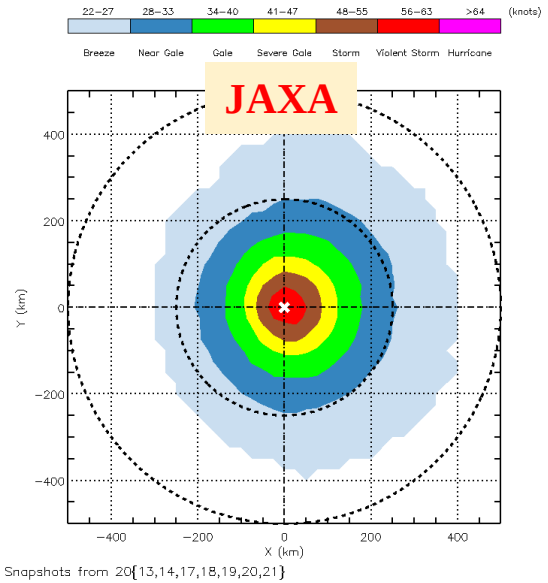
Mean Wind Speed



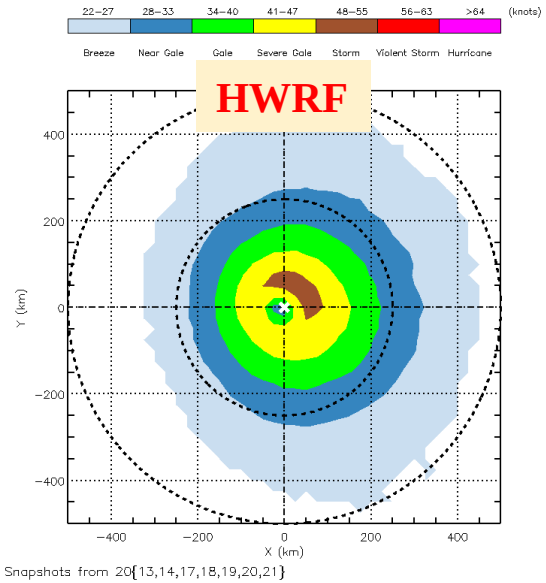
717 Snapshots from 20{13,14,17,18,19,20,21}



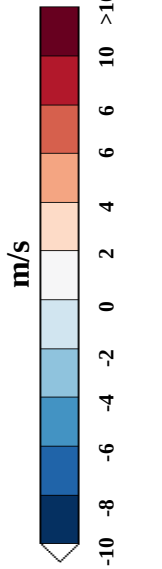
717 Snapshots from 20{13,14,17,18,19,20,21}



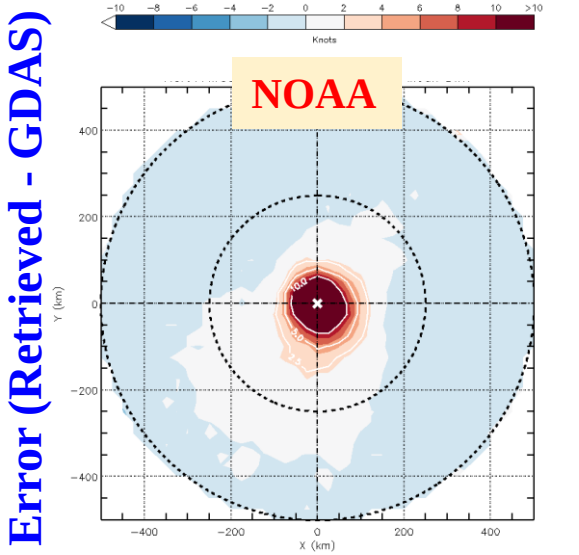
717 Snapshots from 20{13,14,17,18,19,20,21}



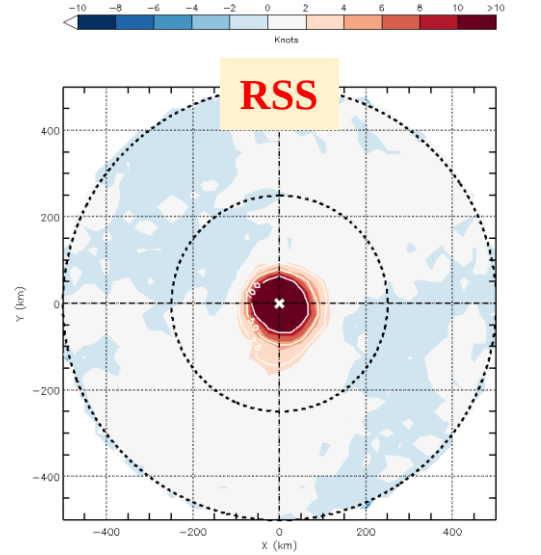
717 Snapshots from 20{13,14,17,18,19,20,21}



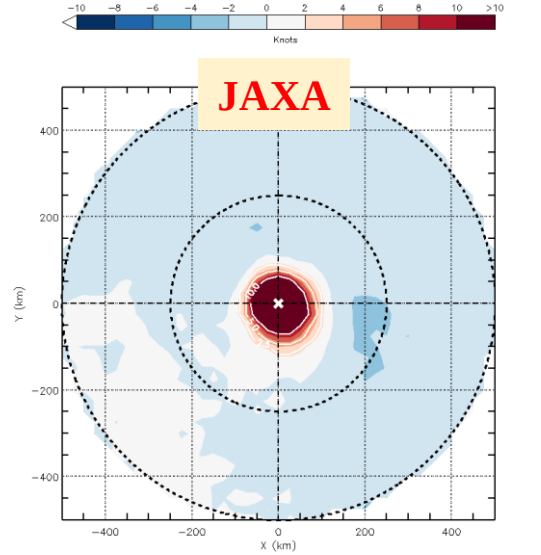
Error (Retrieved - GDAS)



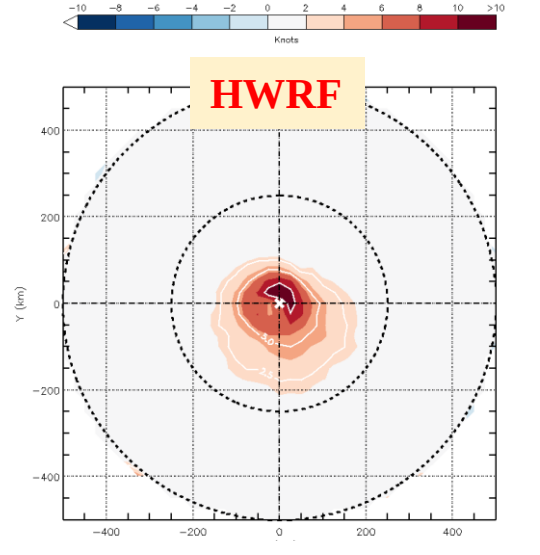
717 Snapshots from 20{13,14,17,18,19,20,21}



717 Snapshots from 20{13,14,17,18,19,20,21}



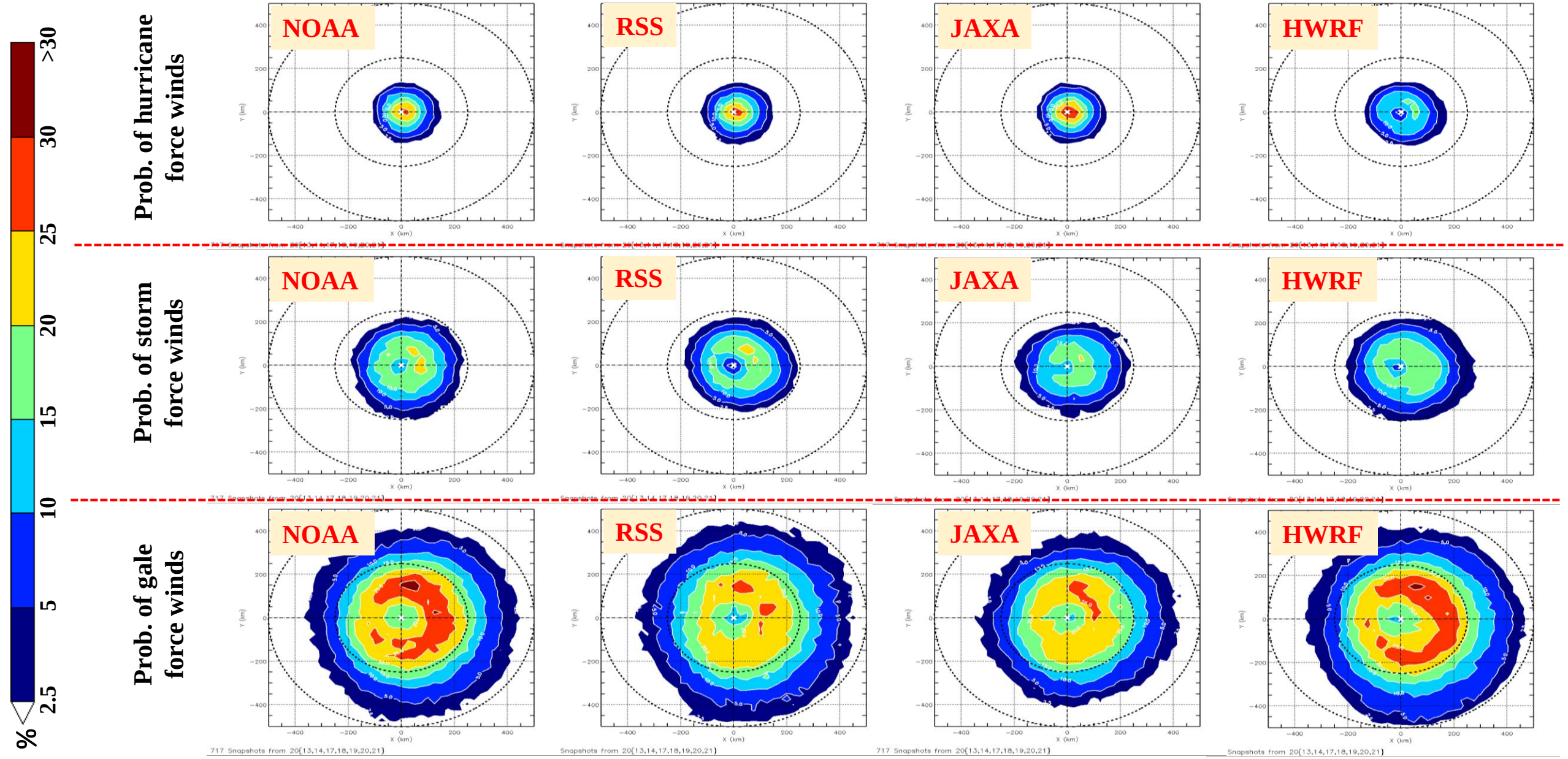
717 Snapshots from 20{13,14,17,18,19,20,21}



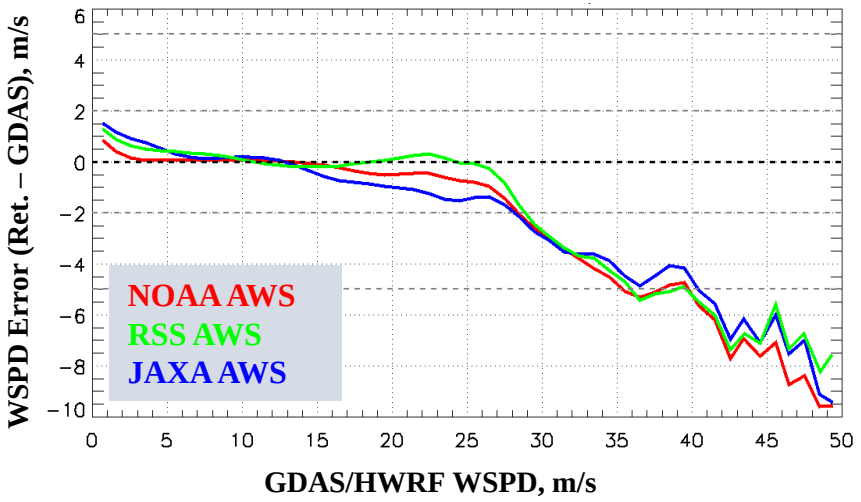
717 Snapshots from 20{13,14,17,18,1

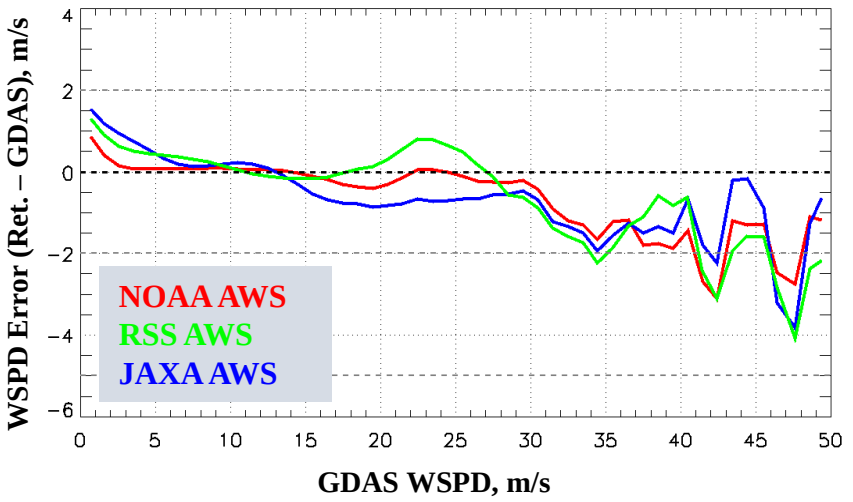
700 snapshots used

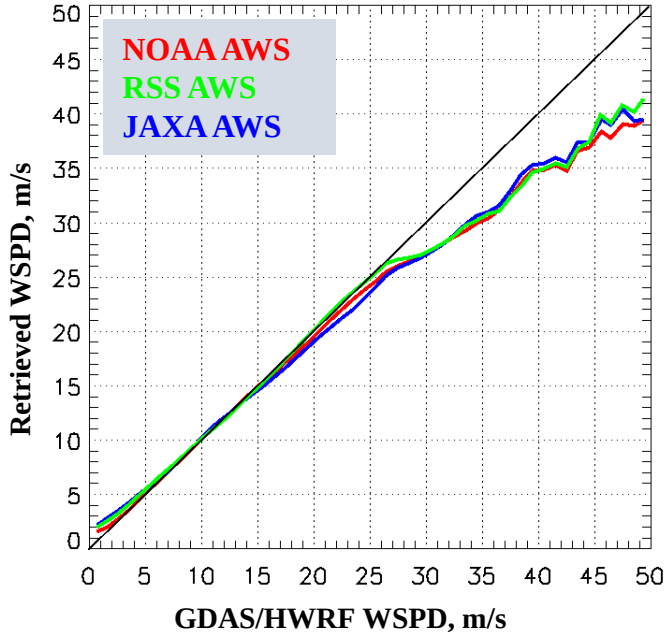
Composite Plots: Prob. of Extreme Winds

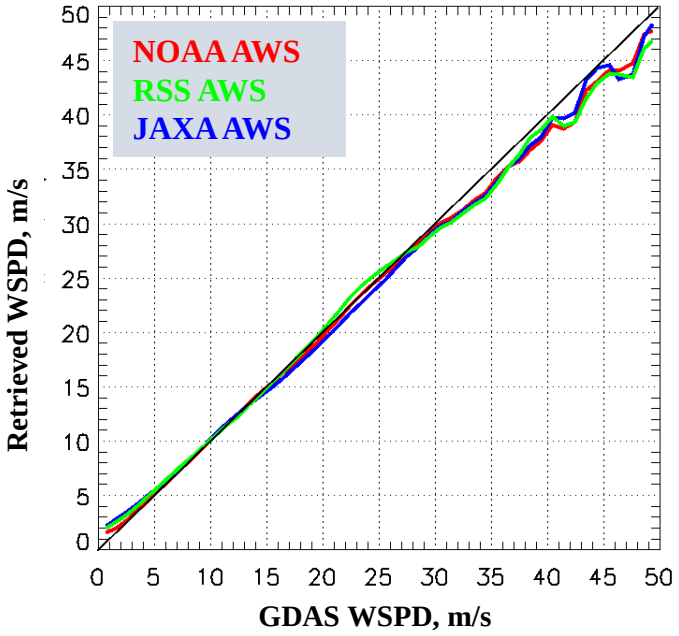


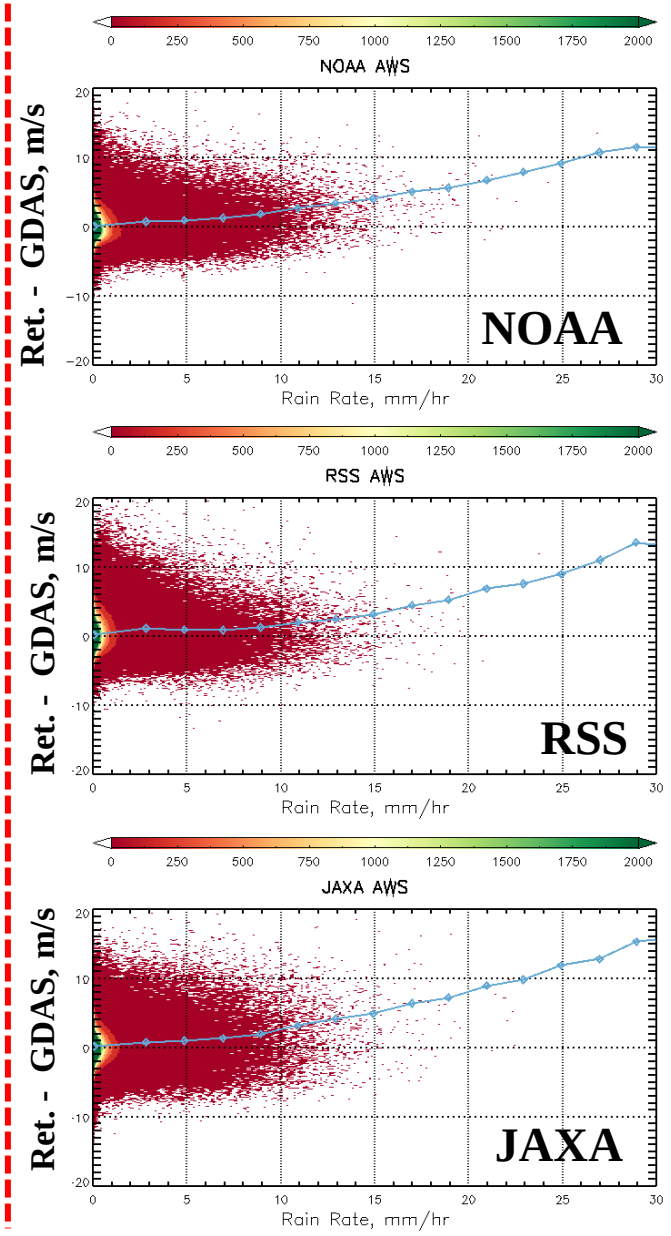
Standard Validation



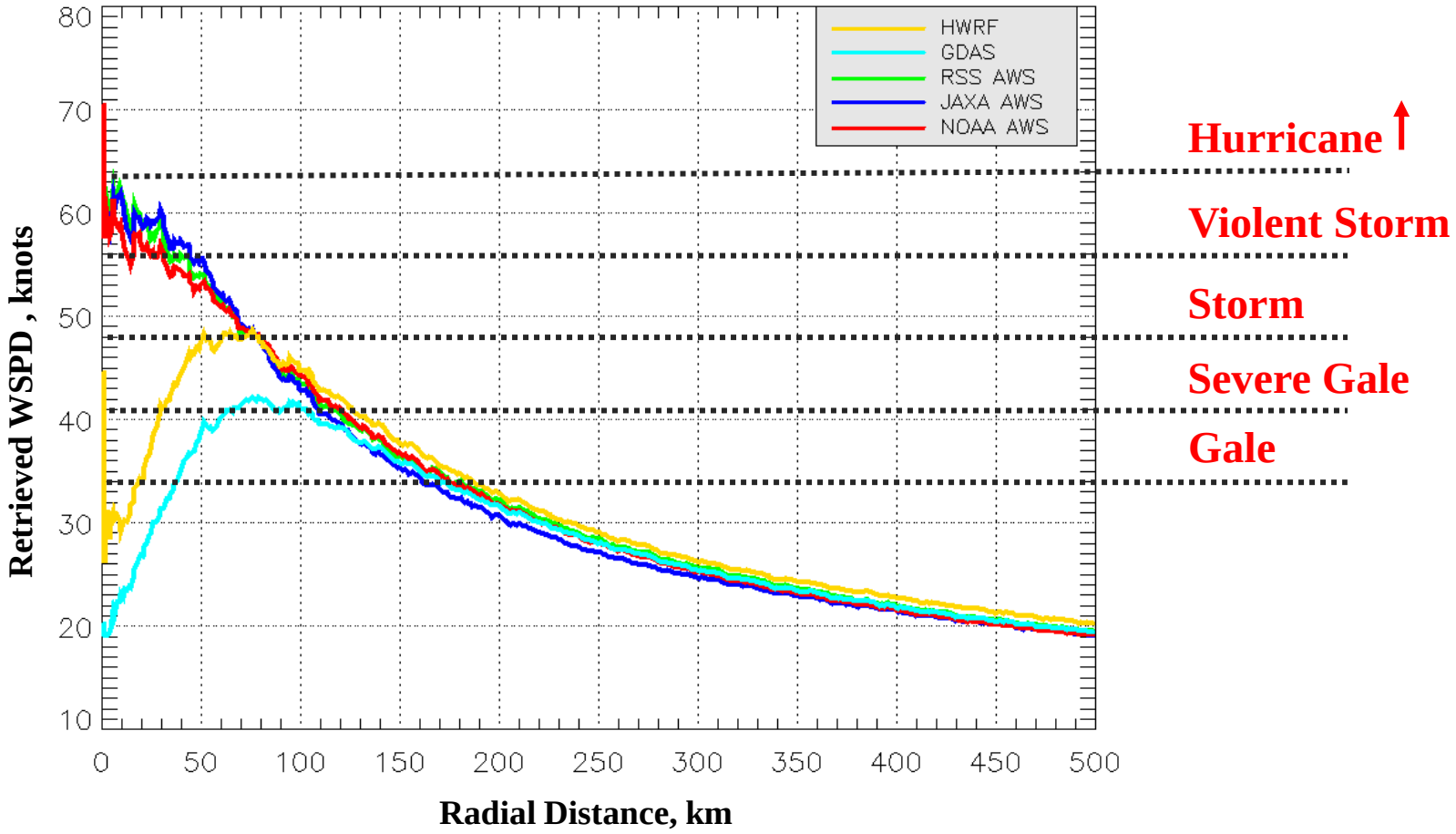


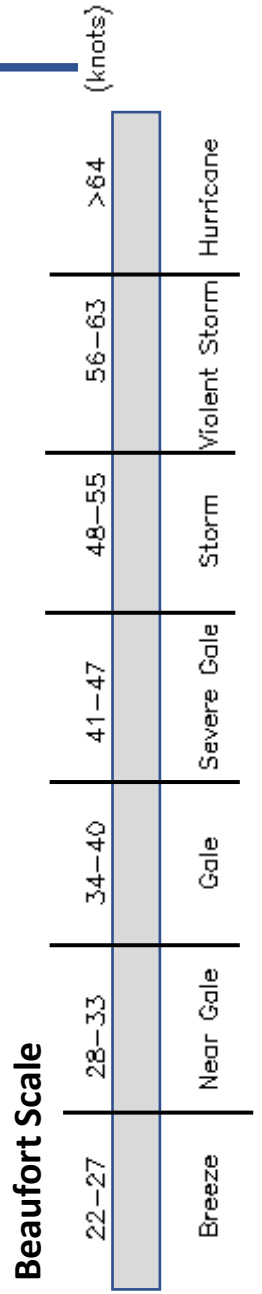






Radial Wind Speed Comparison



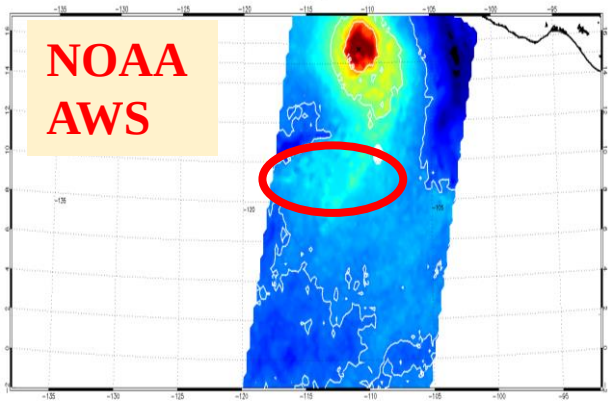


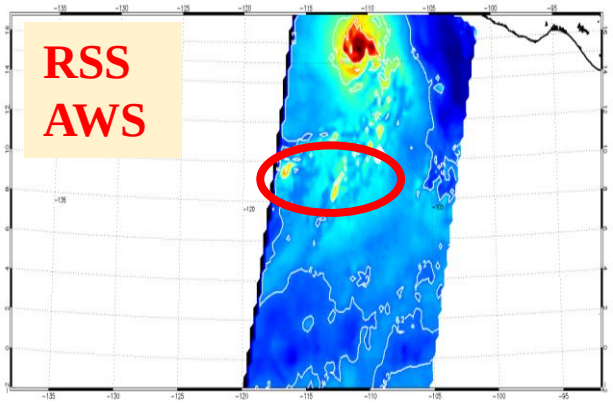
Examples

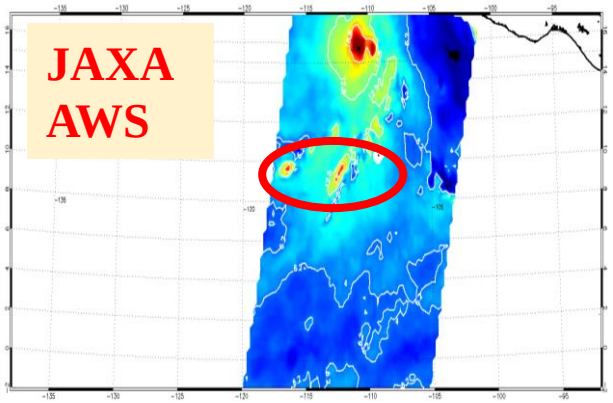
0 5 12 15 20 25 (m/s)

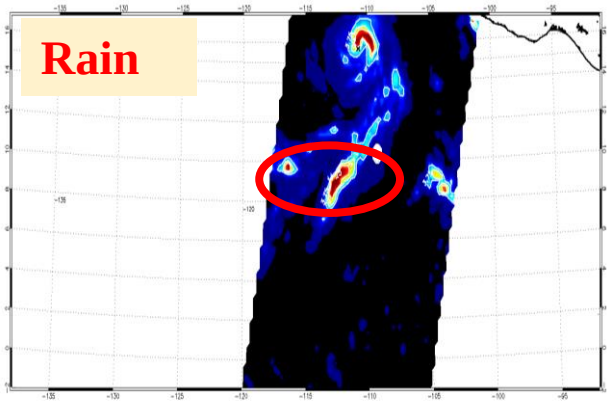
(mm/hr) 0 2 4 6 8 10 12 14

Example 1

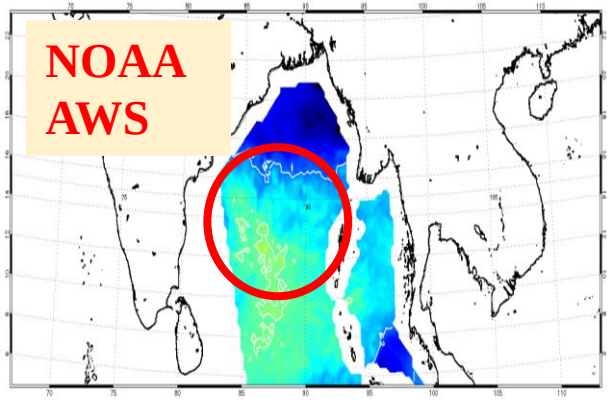


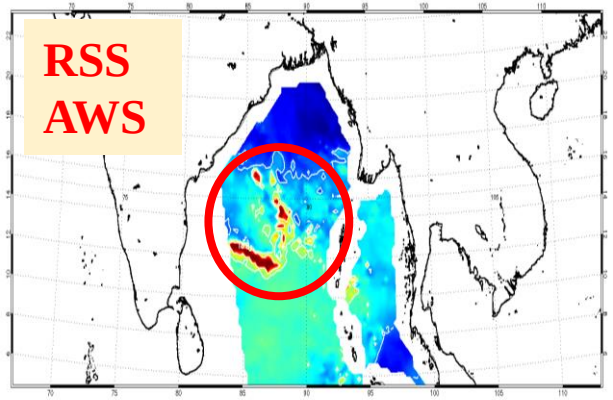


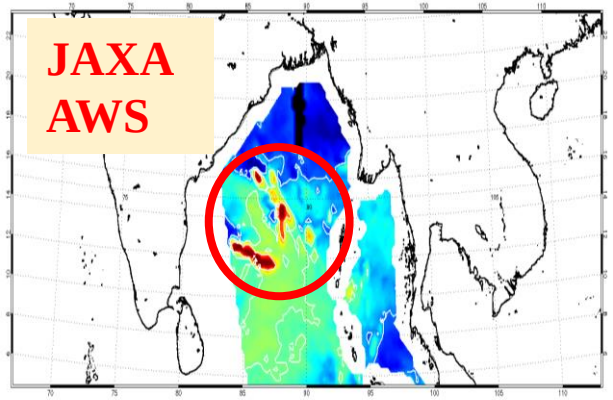


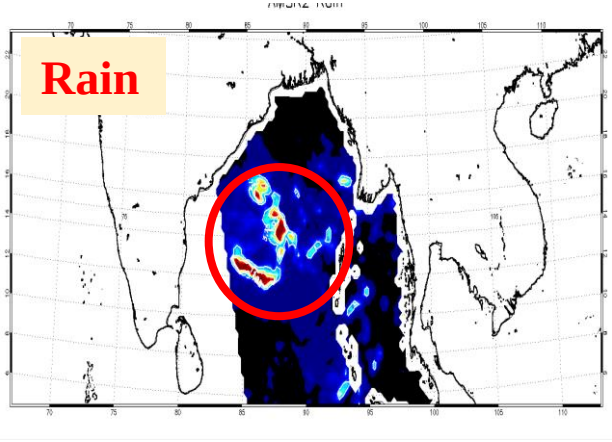


Example 2









Conclusions & Future Work

- **NOAA's AMSR2 AWS** product was briefly described and evaluated
  - Statistical based trained using **1000** AMSR2 orbits from 2013–2021
  - It complements the set of AMSR2 standard satellite data products
  - Global & runs in near-real-time
- Validation results from independent data demonstrated the efficacy of the retrieval algorithm under different wind speed regimes
  - 0 m/s mean bias and < 2 m/s RMS error when compared to numerical weather models
  - Mitigates rain effect under normal and extreme wind events
- **Next …**
  - Validation with other wind speed retrievals from satellites and SFMR