NASA CYGNSS Satellite Constellation for Tropical Cyclone Observations

Chris Ruf[1], Scott Gleason[2], Aaron Ridley[1], Randy Rose[2], John Scherrer[2]

1. University of Michigan, Ann Arbor, MI
2. Southwest Research Institute, Boulder, CO

CYGNSS Mission Overview

- The NASA Cyclone Global Navigation Satellite System (CYGNSS) Mission consists of 8 microsatellites, each with a 4-channel GPS bi-static radar receiver
  - Mission lead/Science Ops (University of Michigan)
  - Spacecraft/Integration/Mission Ops (Southwest Research Institute)
- The driving science objective is rapid sampling of ocean surface winds in the inner core of tropical cyclones
- CYGNSS uses a new measurement technique and a new satellite mission architecture
  - Measure the distortion of GPS signals scattered from the ocean surface to determine ocean surface roughness and wind speed
  - Use small satellites so many can be flown to improve sampling

GPS
Satellite

Direct
Signal

CYGNSS
Observatory

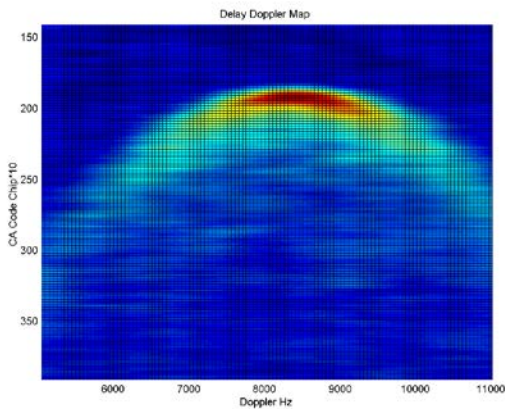CA Code Chip

Doppler Hz

Specular
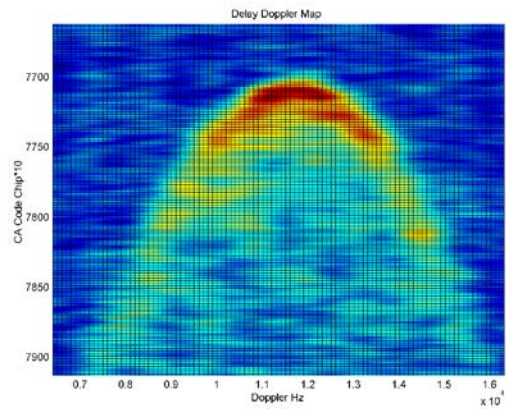Point

Ruf, CYGNSS Mission, TCORF/IHC
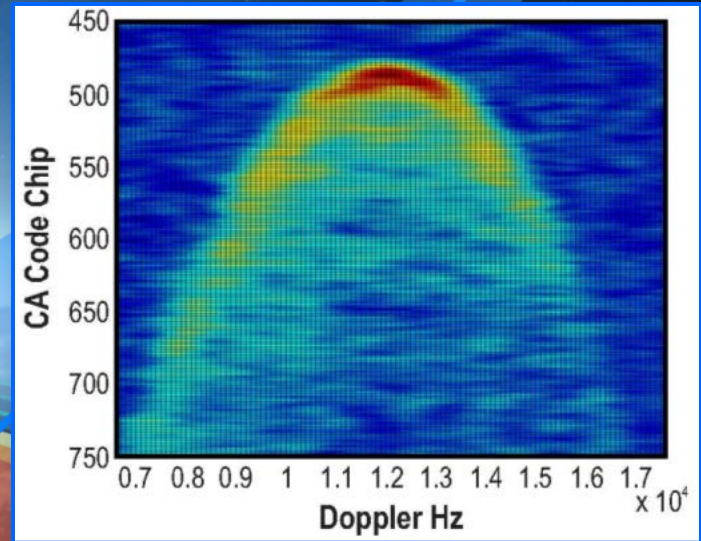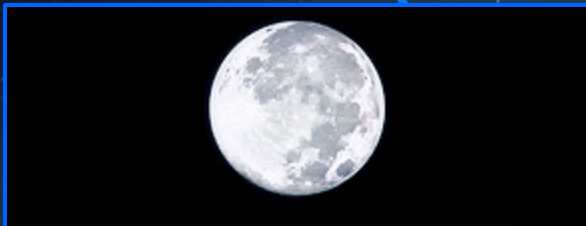
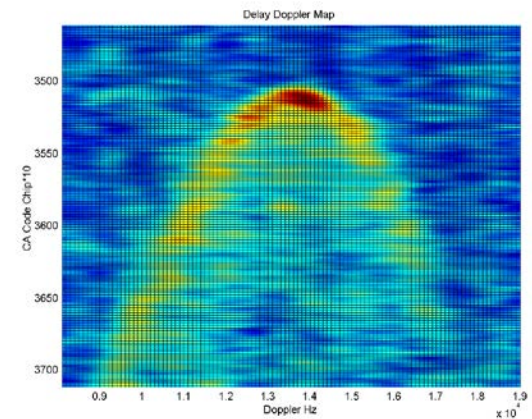# Spaceborne Empirical Demonstration of Ocean Wind Speed Retrievals by GNSS-R

GNSS-R instrument (early version of CYGNSS science payload) deployed on UK-DMC-1 mission, launch 2003

- Winds ~ 2 m/s
- Winds 7 m/s
- Winds 10 m/s

Ruf, CYGNSS Mission, TCORF/IWC 4

Level 1 Baseline Mission Science Requirement

Sci Rqmt #	Requirement
1	3 m/s to 70 m/s at 5 km x 5 km resolution
2	Operation in presence of rain
3a	10% retrieval uncertainty for winds > 20 m/s
3b	2 m/s retrieval uncertainty for winds < 20 m/s
3c	Spatial Resolution of 25 km x 25 km or better
4a	100% duty cycle during science operations
4b	Mean temporal resolution less than 12 hours
4c	24 hour spatial sampling covering 70% or more of the cyclone historical track
5	Calibrate and validate CYGNSS data in individual wind speed bins above and below 20 m/s
6	Support operational hurricane forecast community

CYGNSS Spatial Sampling Over 24 Hours
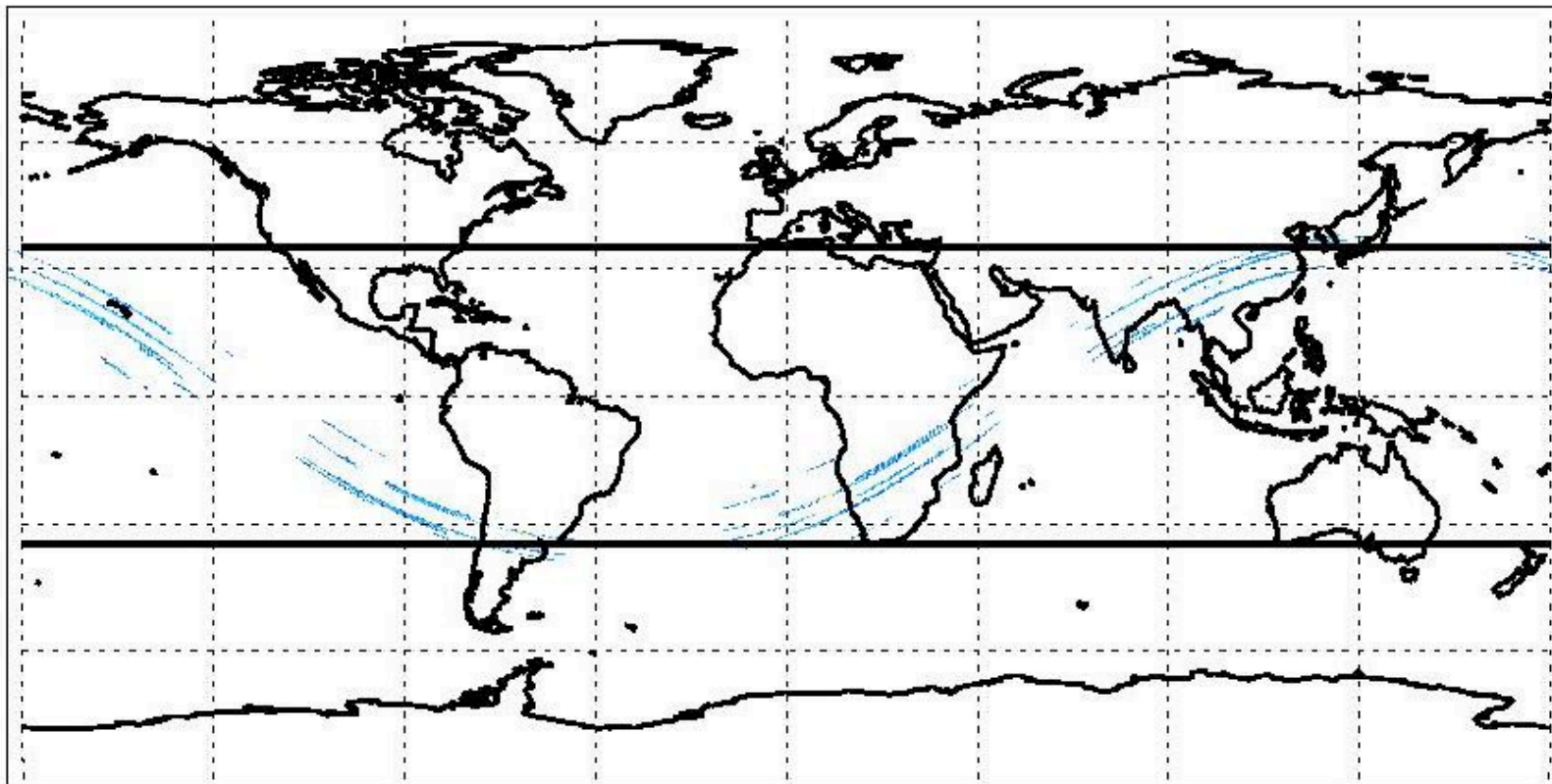
- Revisit time: 2.8 hr (median), 7.2 hr (mean)
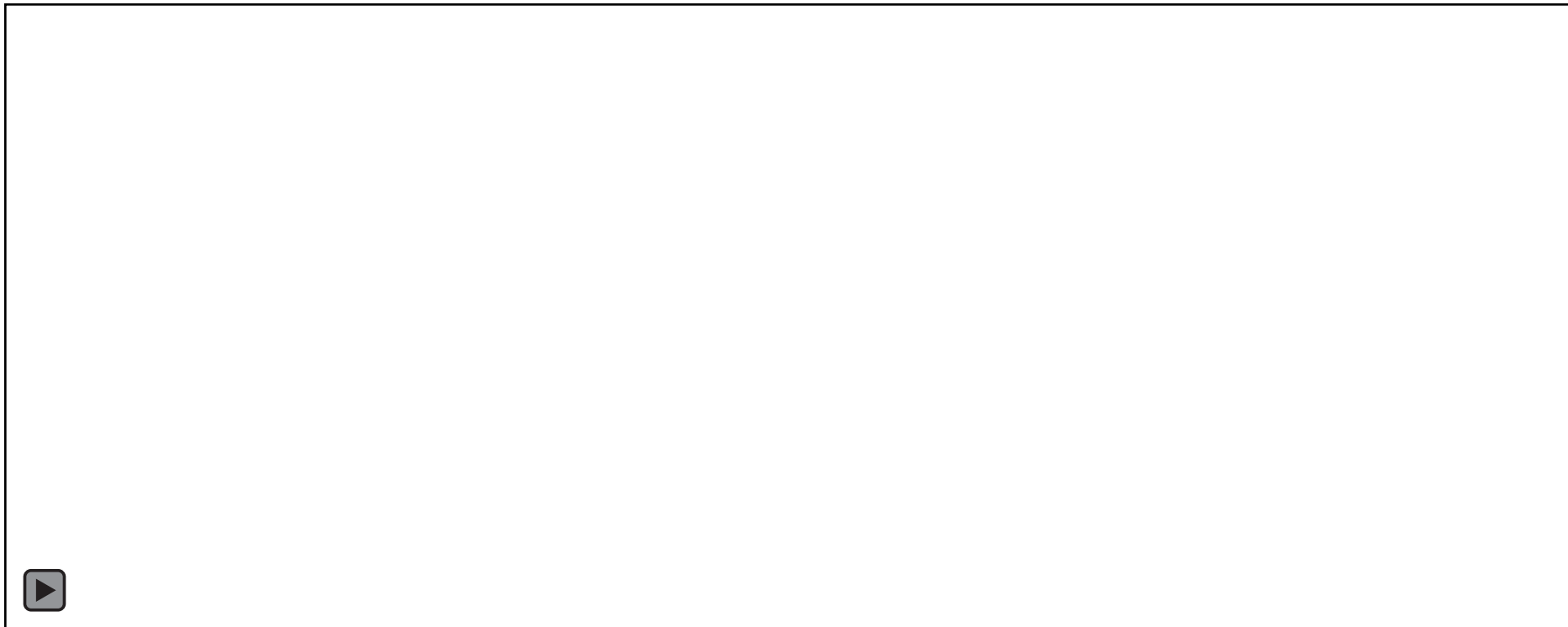
Observatory Fabrication and Testing

Ruf, CYGNSS Mission, TCORF/IHC

# Pegasus Installed on L-1011 Aircraft

Observatory Separation
(simulation)

CYGNSS "First Light" Science Data

- The first CYGNSS science instrument was turned on while spacecraft FM03 was crossing the eastern coastline of Brazil on 4 January 2017.

- First Light Delay Doppler Maps (DDMs) measured during 4 Jan 2017 coastal crossing. CH1-3 are ocean reflections. CH4 is land reflection.
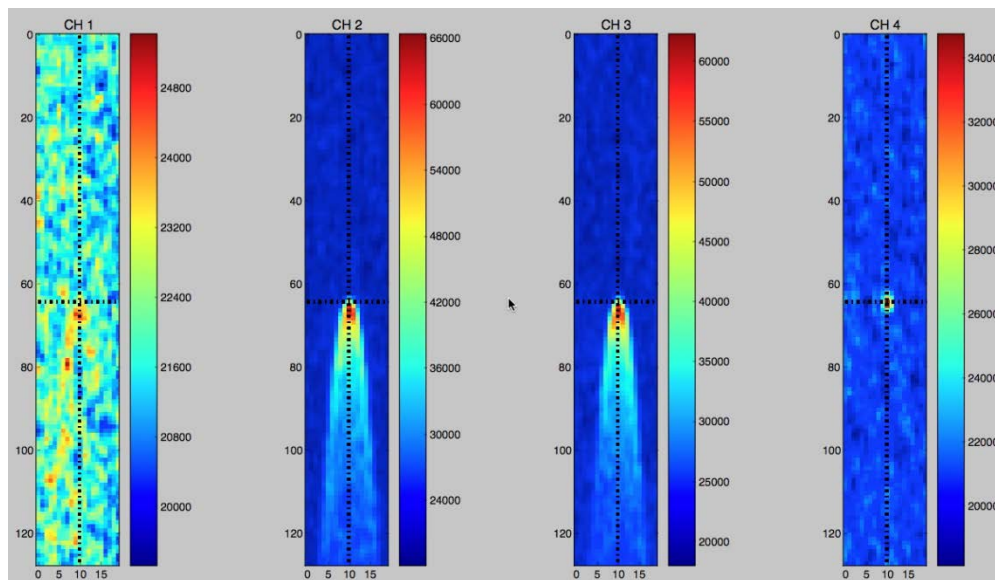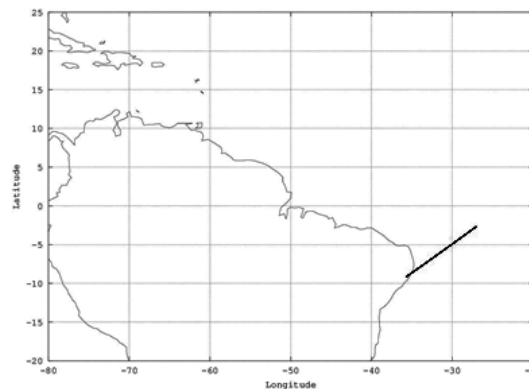
First Ground Truth Matchup (1)
## (FM06 on 21 Jan 2017)

- Location of specular point shown
- Color coded by coincident GDAS wind speed
- Dynamic range of wind speed over the interval is 4-12 m/s
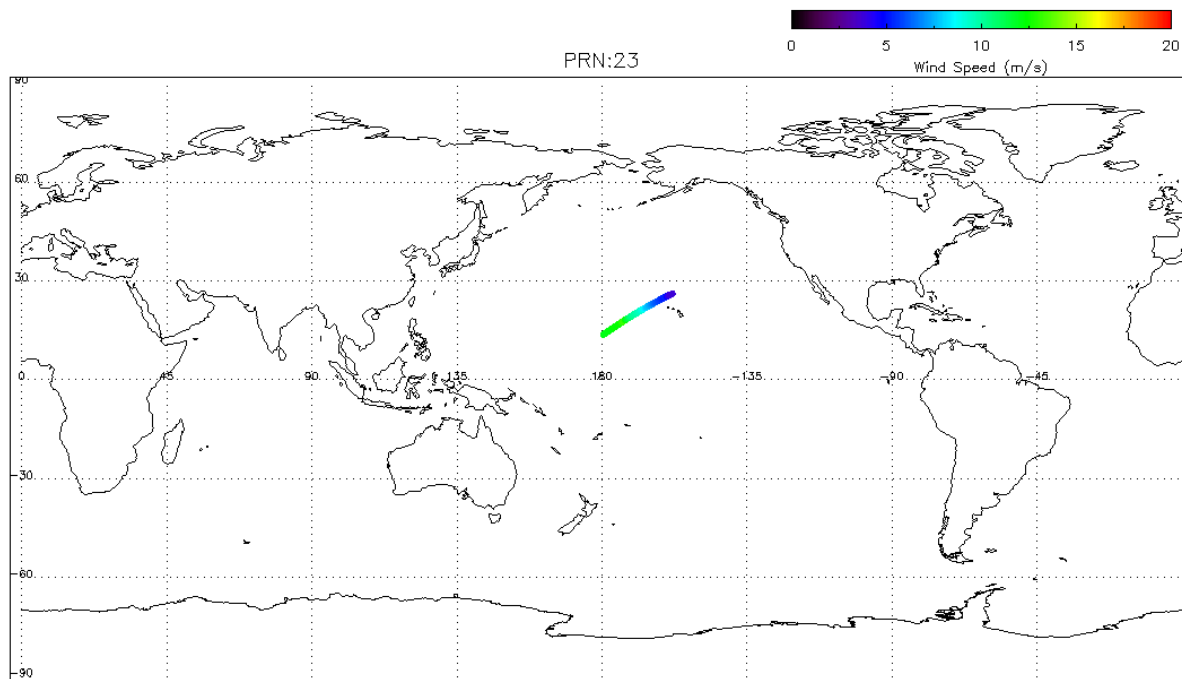
First Ground Truth Matchup (2)
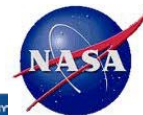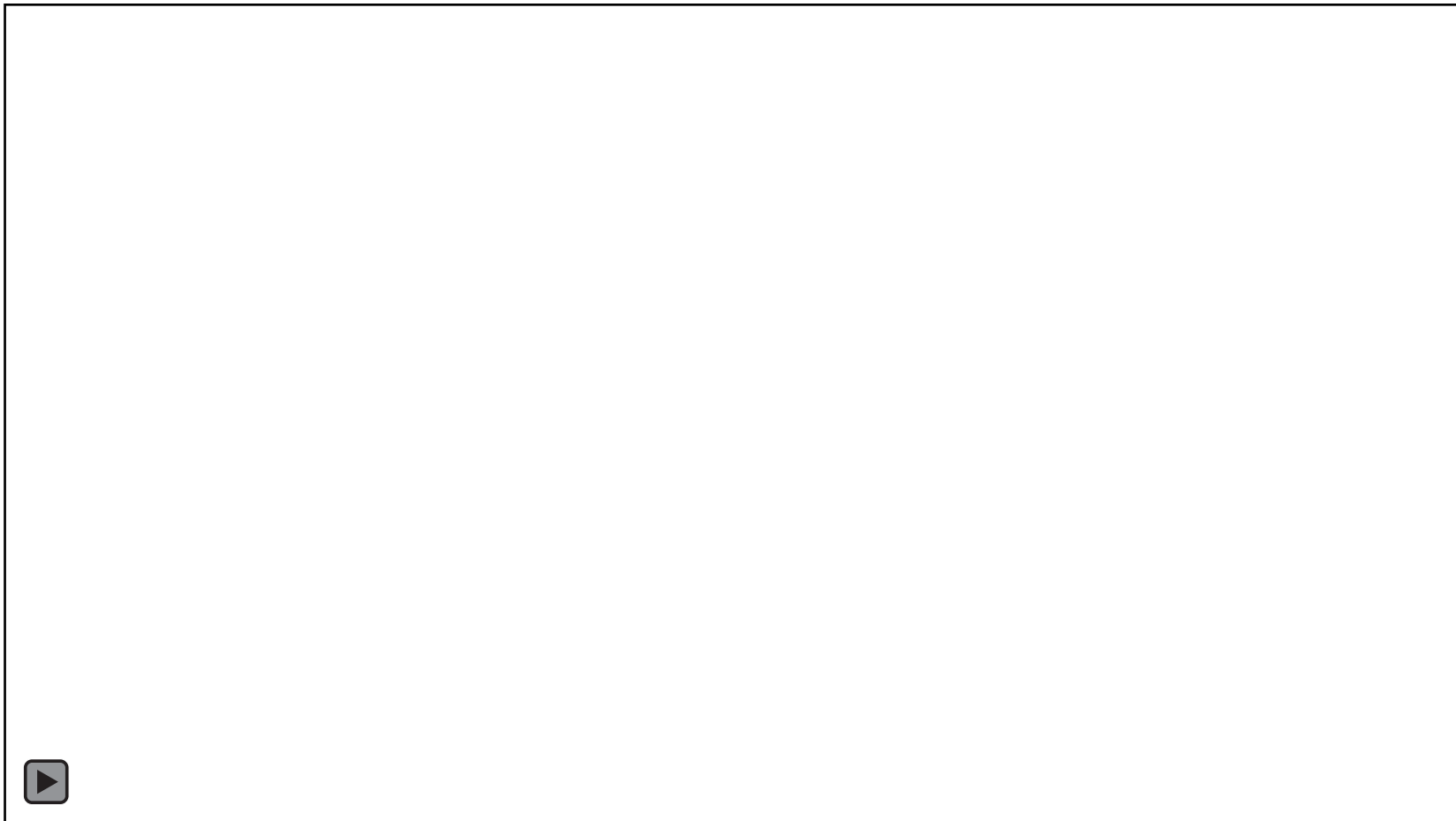# (FM06 on 21 Jan 2017)

- Sequence of DDMs of Bistatic Radar Cross Section (BRCS)
- Matchup with coincident GDAS winds shown below (in black)
- Decreasing wind speed (from left to right) coincides with increase in BRCS, as expected
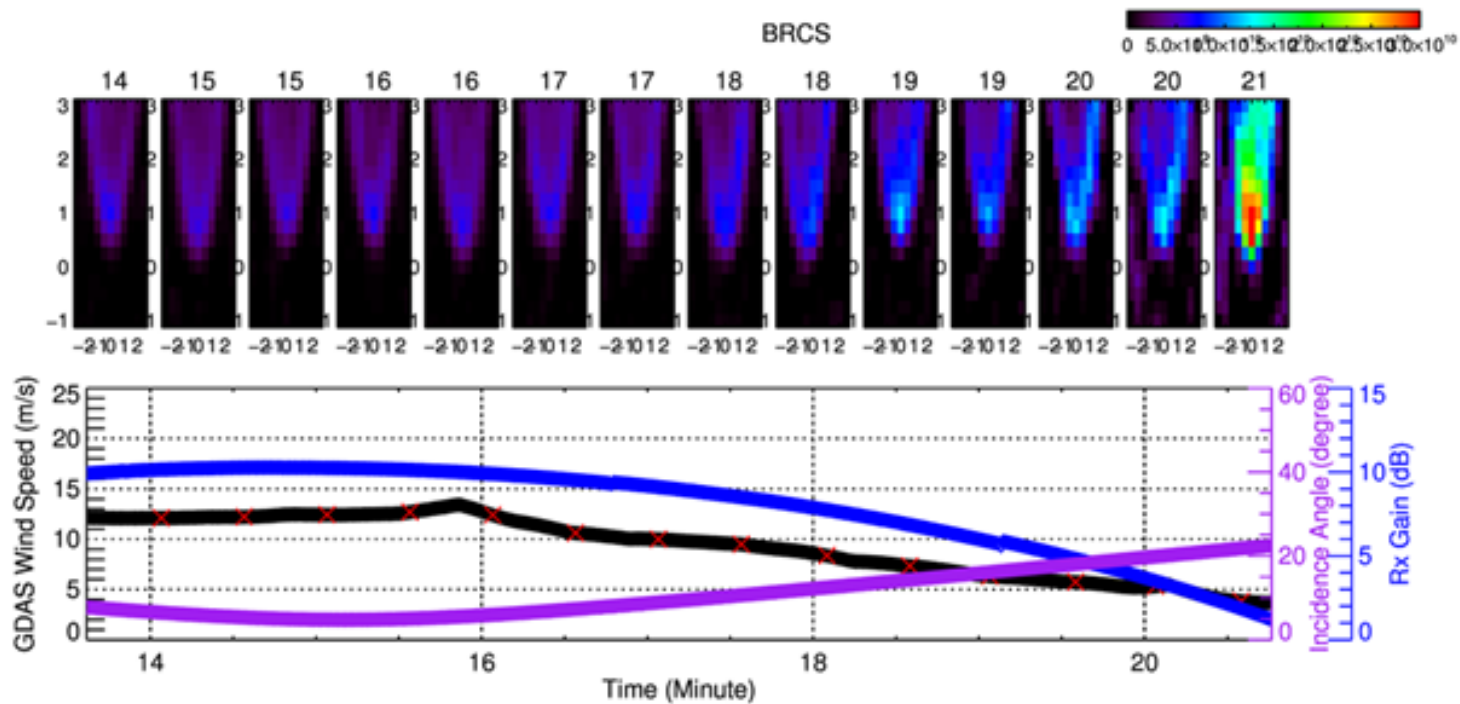
Storm Intersection Forecast Tool
Hurricane Matthew Simulation

CYGNSS Mission Status and Plans

PAST

- Launch 15 Dec 2016 at 08:37 EST
  - Observatories in "safe mode", sun-pointed with only essential systems powered on
- Transition to nadir-point and turn on science instruments

FUTURE

- Mar 2017: complete engineering commissioning
- Apr – May 2017: Initial validation of Level 1 DDM calibration and Level 2 wind speed retrieval algorithm
- Mid May 2017: First public release of DDM and wind speed data products to NASA PO.DAAC
- Dec 2017 – Feb 2018: Cal/Val with 2017 Atlantic hurricane season ground truth

Thank You

for more information visit **http://cygnss-michigan.org**

or contact Chris Ruf, **cruf@umich.edu**