AMS Annual Meeting
21st Conference on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans and Land Surface
Seattle, WA, 22-26 January 2017

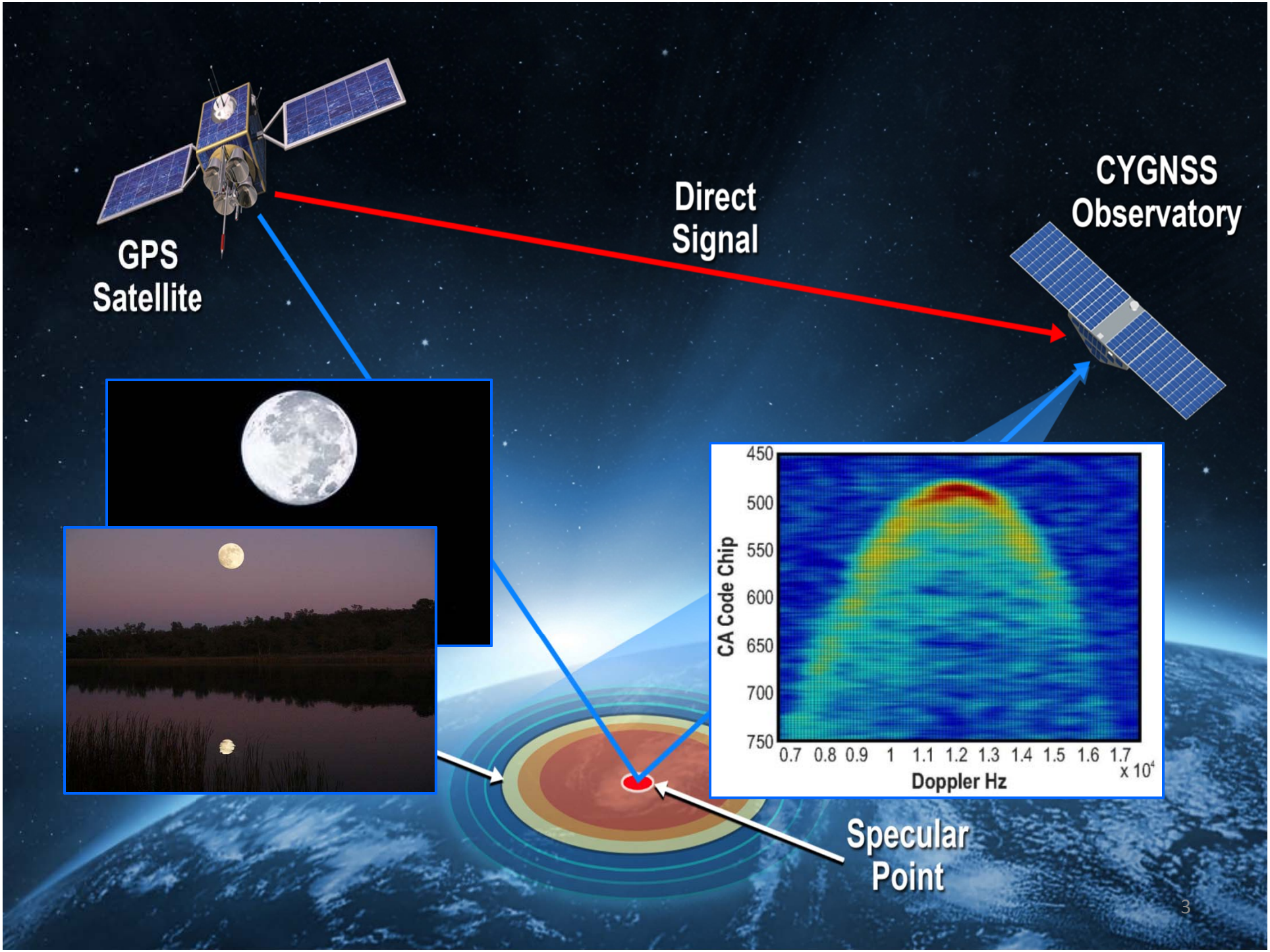
The NASA CYGNSS Satellite Constellation for Tropical Cyclone Observations

Chris Ruf[1], Robert Atlas[2], Paul Chang[2], Maria-Paola Clarizia[1], James Garrison[3], Scott Gleason[4], Steve Katzberg[5], Zorana Jelenak[2], Joel Johnson[6], Mary Morris[1], Sharan Majumdar[7], Andrew O'Brien[6], Derek Posselt[8], Damen Provost[1], Aaron Ridley[1], Randy Rose[4], Faozi Said[2], John Scherrer[4], Golf Soisuvarn[2], Valery Zavorotny[2]

1. University of Michigan, Ann Arbor, MI; 2. NOAA, College Park, MD; 3. Purdue University, West Lafayette, IN; 4. Southwest Research Institute, Boulder, CO; 5. NASA, Langley, VA; 6. Ohio State University, Columbus, OH; 7. University of Miami, Miami, FL; 8. NASA JPL, Pasadena, CA

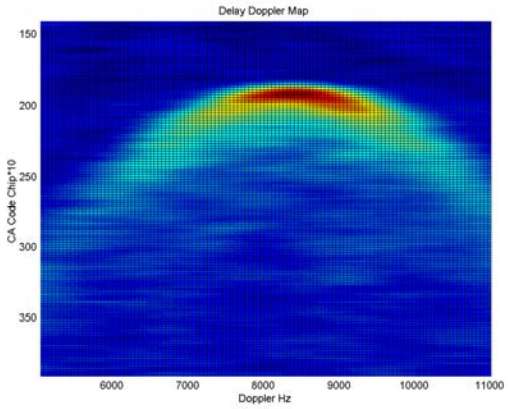
CYGNSS Mission Overview

- 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

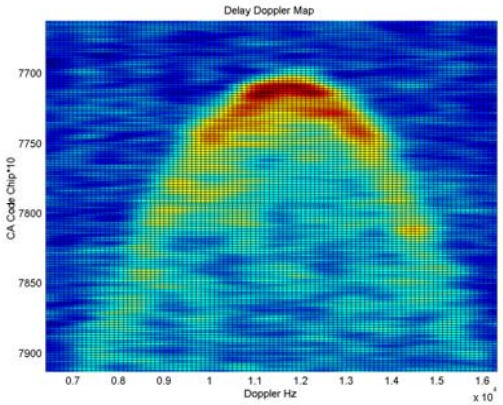

GPS
Satellite
Direct
Signal
CYGNSS
Observatory
CA Code Chip
450
500
550
600
650
700
750
0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7
x 10^4
Doppler Hz
Specular
Point

Spaceborne Empirical Demonstration of Ocean Wind Speed Retrievals by GNSS-R

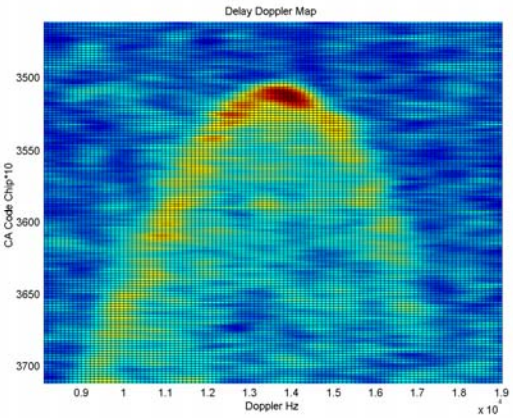
GNSS-R instrument (early version of CYGNSS science payload) deployed on UK-DMC-1 mission, launch 2003



- Winds ~ 2 m/s



- Winds 7 m/s

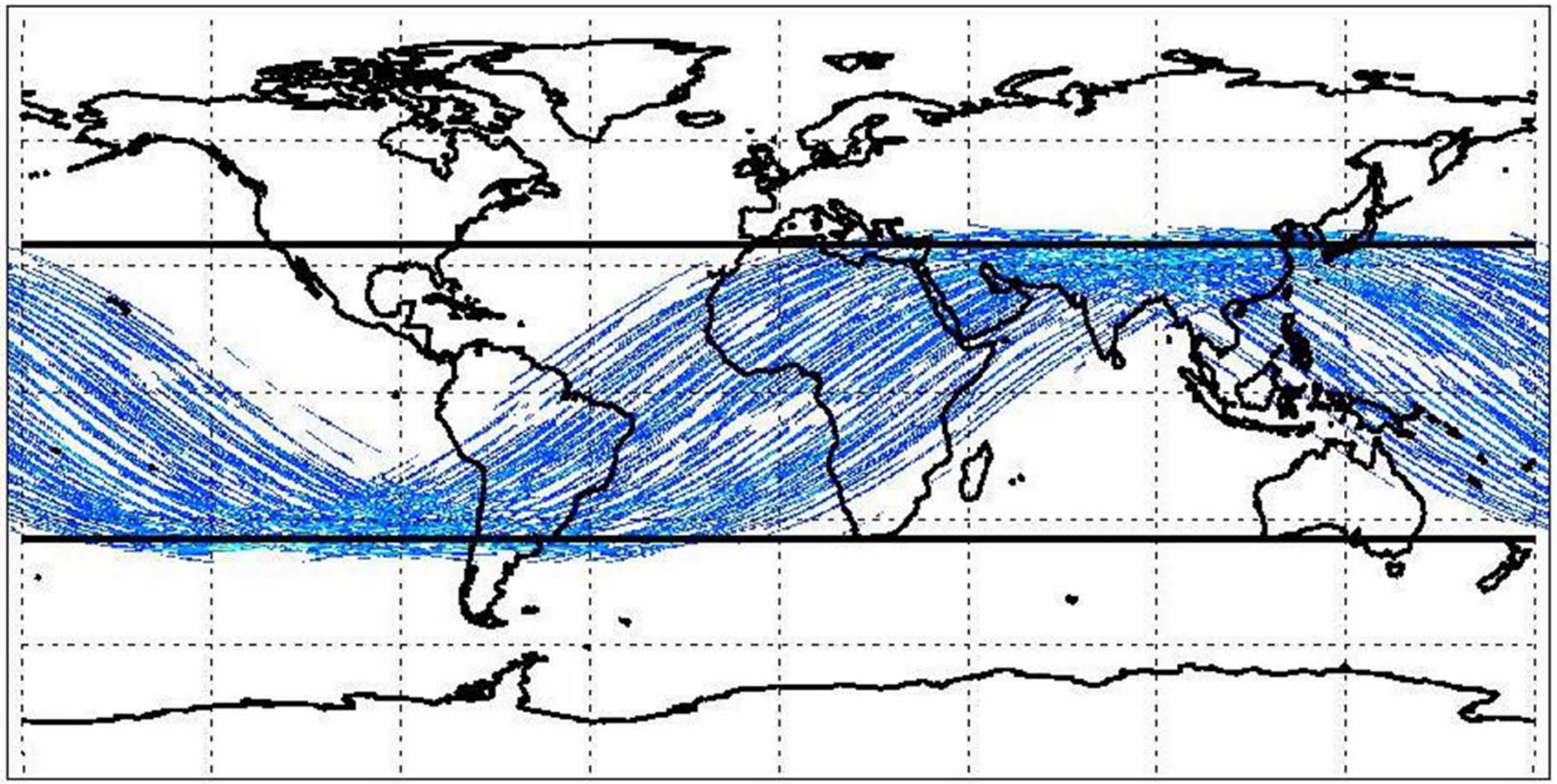


- Winds 10 m/s

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

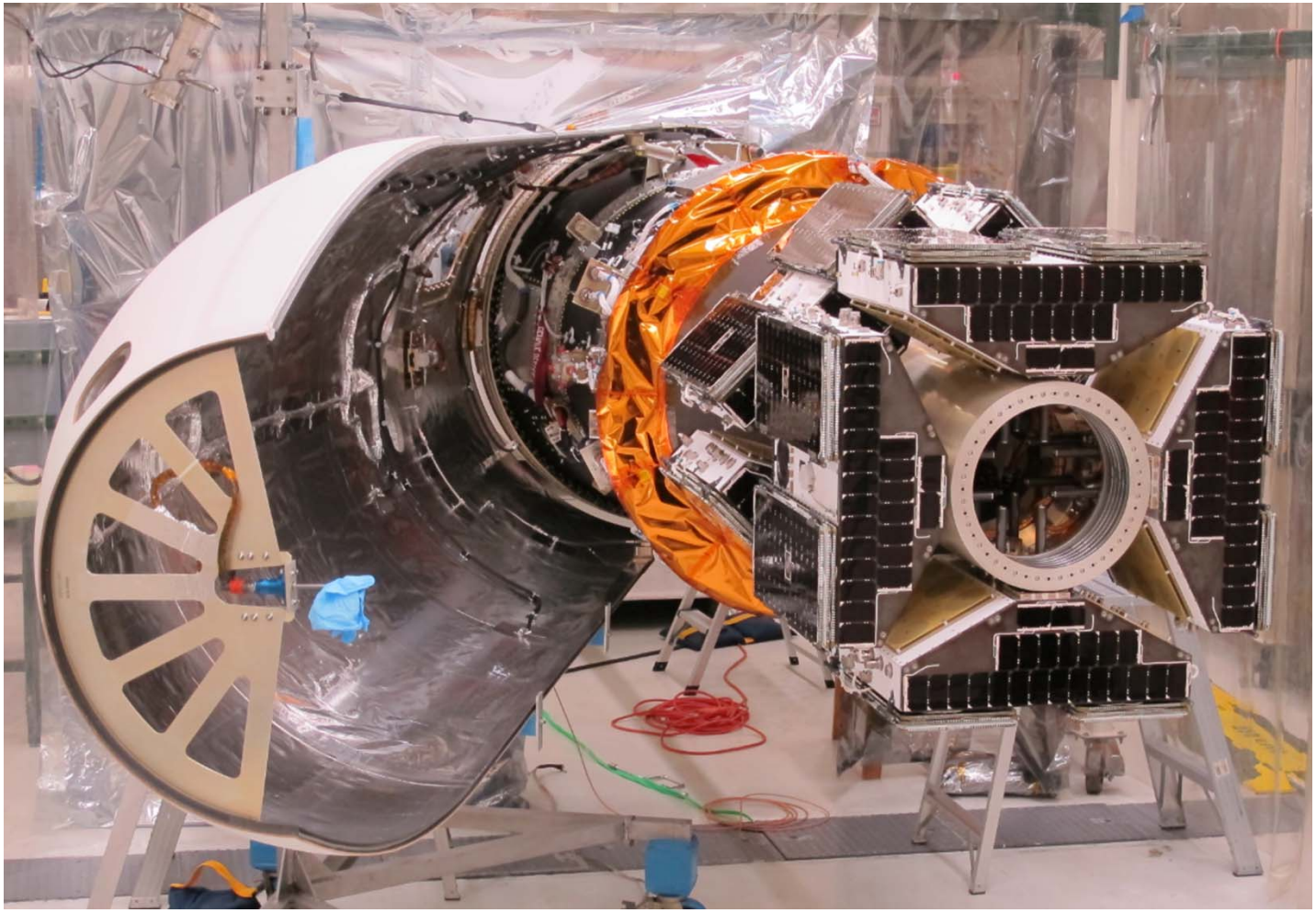
CYGNSS Spatial Sampling Over 24 Hours



- Revisit time: 2.8 hr (median), 7.2 hr (mean)

Observatory Fabrication and Testing

All 8 Observatories Integrated with Pegasus Launch Vehicle

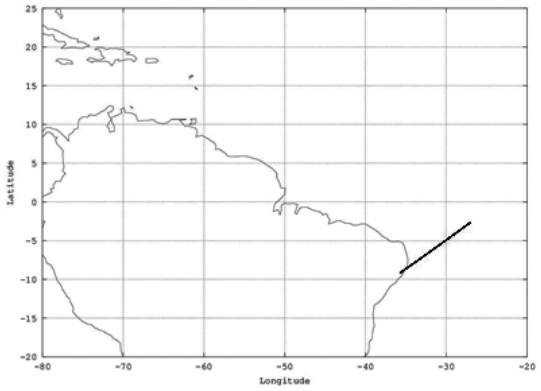


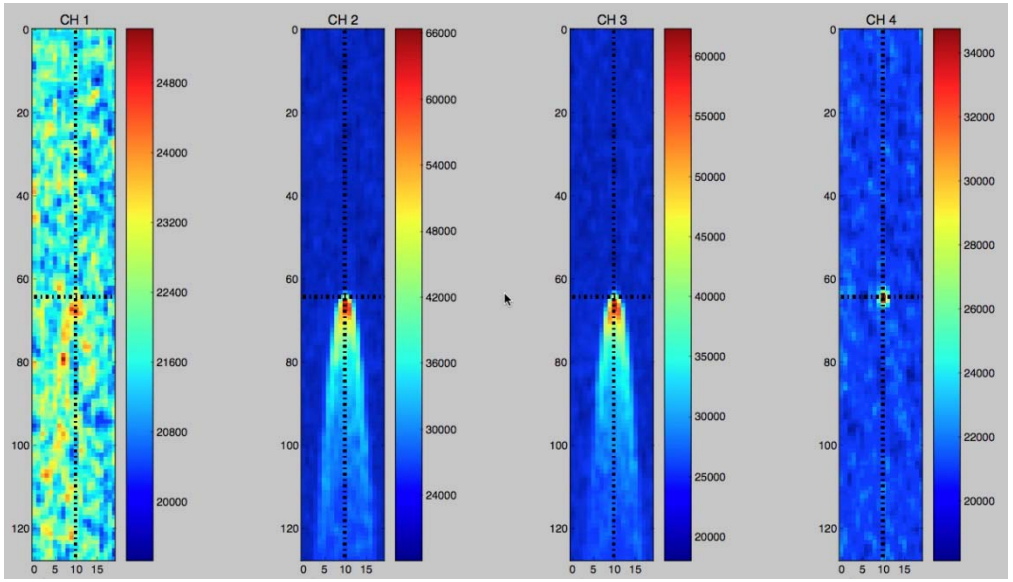
Pegasus Installed on L-1011 Aircraft

Observatory Separation
(simulation)

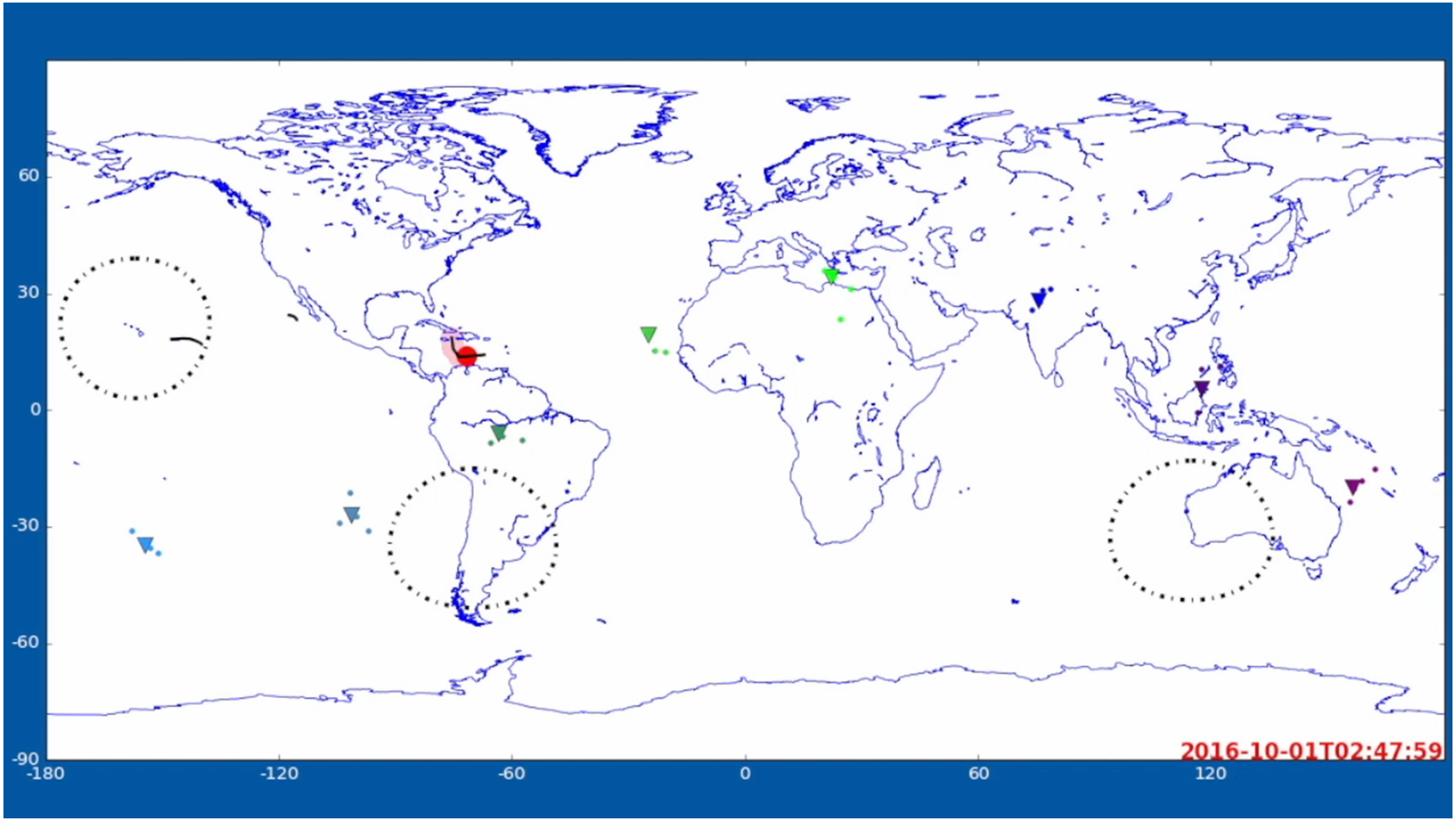
CYGNSS "First Light" Science Data

- 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.





Storm Intersection Forecast Tool
Hurricane Matthew Simulation



CYGNSS Mission Status and Plans

PAST

- 5 Dec 2016 at 08:37 EST: Launch
  - Observatories in "safe mode", sun-pointed with only essential systems powered on
- 16-23 Dec 2016 : Transition to "Engineering Mode"
  - Non-essential systems tested (including navigation portion of science payload), still sun-pointed

PRESENT

- Transition to nadir-pointed engineering mode underway
  - First light science data 4 Jan 2017
  - Two observatories currently nadir-pointed; two sun-to-nadir transitions planned for week of 23 Jan 2017

FUTURE

- Mid Feb 2017: begin "Science Mode" with continuous DDM data taking
- Feb – Apr 2017: Initial cal/val of Level 1 DDM calibration and Level 2 wind speed retrieval algorithms
- Mid Apr 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

More CYGNSS at AMS Annual 2017

Tuesday 24 Jan

Regional Observing System Simulation Experiments (OSSEs) for Hurricanes

Location: 607 (Washington State Convention Center)

- **10:30 AM** 5.1 Creating Vector Winds from Simulated CYGNSS Ocean Surface Wind Speed Retrievals Using Variational Analysis, Mark Leidner
- **10:45 AM** 5.2 Impact of Simulated CYGNSS Ocean Surface Winds on Tropical Cyclone Analyses and Forecasts in a Regional OSSE Framework, Bachir Annane
- **14:30** NASA Hyperwall - CYGNSS

Wednesday 25 Jan

- **10:15** NASA Hyperwall - CYGNSS
- **2:30-4:00pm**, Poster Session 1
  - 1000 Assessing CYGNSS Tropical Cyclone Wind Field Products Before Launch, Mary Morris
  - 1001 Assimilation of CYGNSS Ocean Surface Winds in HWRF, Mark Leidner
  - 1002 Using CYGNSS to Observe Convectively Driven Near-Surface Winds in Tropical Precipitation Systems during Madden-Julian Oscillation Events, Tim Lang
  - 1003 Utilizing CYGNSS Near Surface Winds to Improve Surface Sensible and Latent Heat Flux Estimates, Juan Crespo
  - 1431 Assimilation of CYGNSS and GPM satellite data for improving hurricane forecasting, Zhaoxia Pu

Thank You

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

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