ESTF2020

Next Generation GNSS Bistatic Radar Receiver

Presenter: Chris Ruf, University of Michigan

PI: Chris Ruf

Team Members: Roger Backhus, Tim Butler, Chi-Chih Chen, Scott Gleason, Ryan Miller, Andrew O'Brien, Line van Nieuwstadt

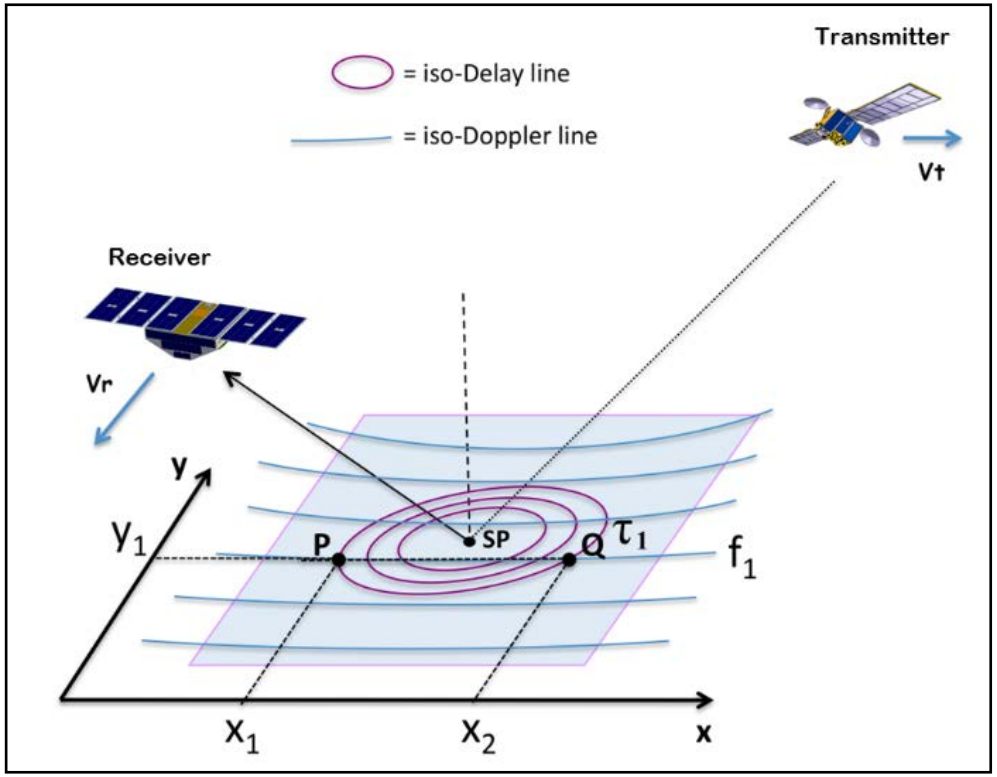
Program: IIP-16

Improved Time & Space Sampling with Low Microwave Frequencies at Low Cost

- Why low microwave frequency remote sensing?
  - Insensitive to gaseous attenuation in atmosphere
  - Propagation through precipitation and vegetation canopy
  - Sub-surface penetration (soil moisture, ice thickness)
- Why high temporal sampling?
  - Resolve short time scale events like tropical cyclone winds, extreme precipitation, flooding
- Why high spatial resolution + low cost are difficult
  - Diffraction limited antenna size, high bandwidth/high power radar
- Why high temporal resolution + low cost are difficult
  - Requires many satellites if in low Earth orbit

Solution – GNSS-R Bistatic Radar

- Use GPS constellation as transmitter half of radar
  - 1.6 GHz, 19 cm wavelength
- Adapt GPS navigation receiver to measure signal scattered from surface back into space
  - Uses very low cost, low power mature commercial technology
  - Radar receivers can be accommodated on small, low cost spacecraft

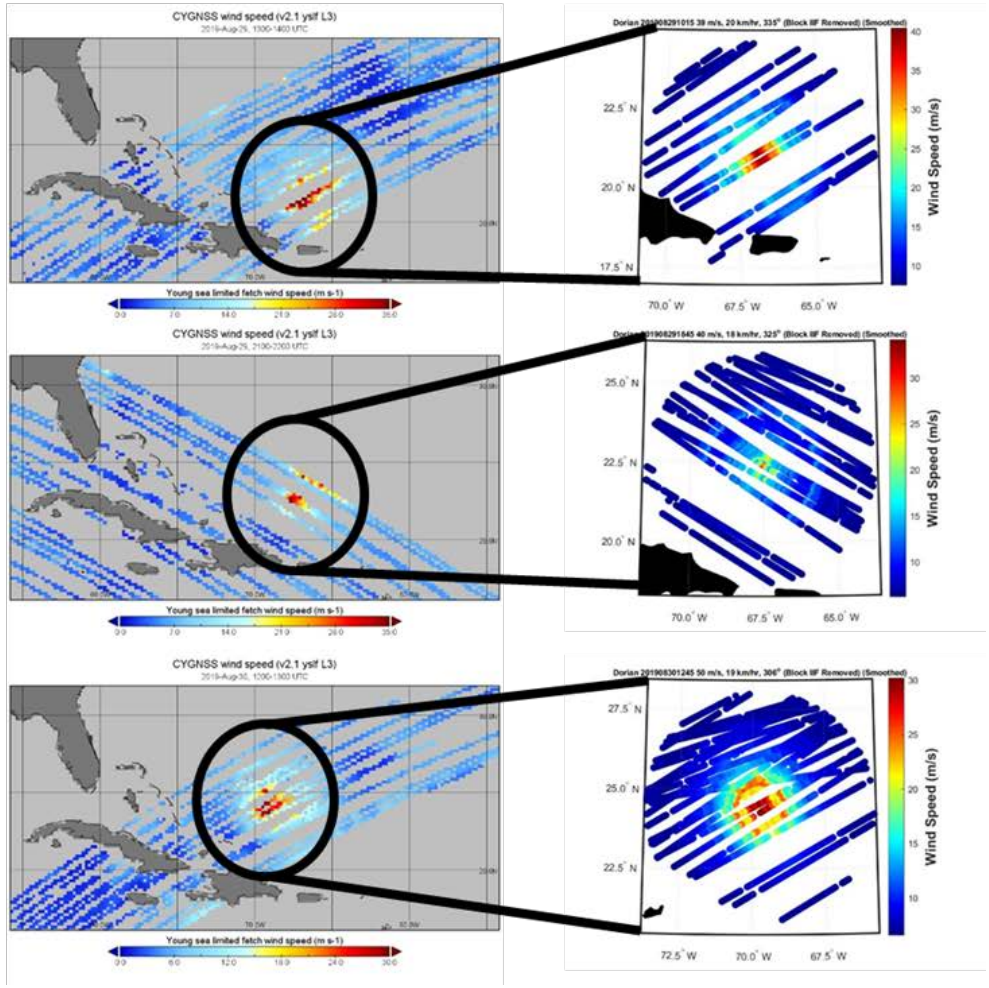


Flight Heritage with CYGNSS Mission

Overpasses of Hurricane Dorian, 2019 Aug 29-30

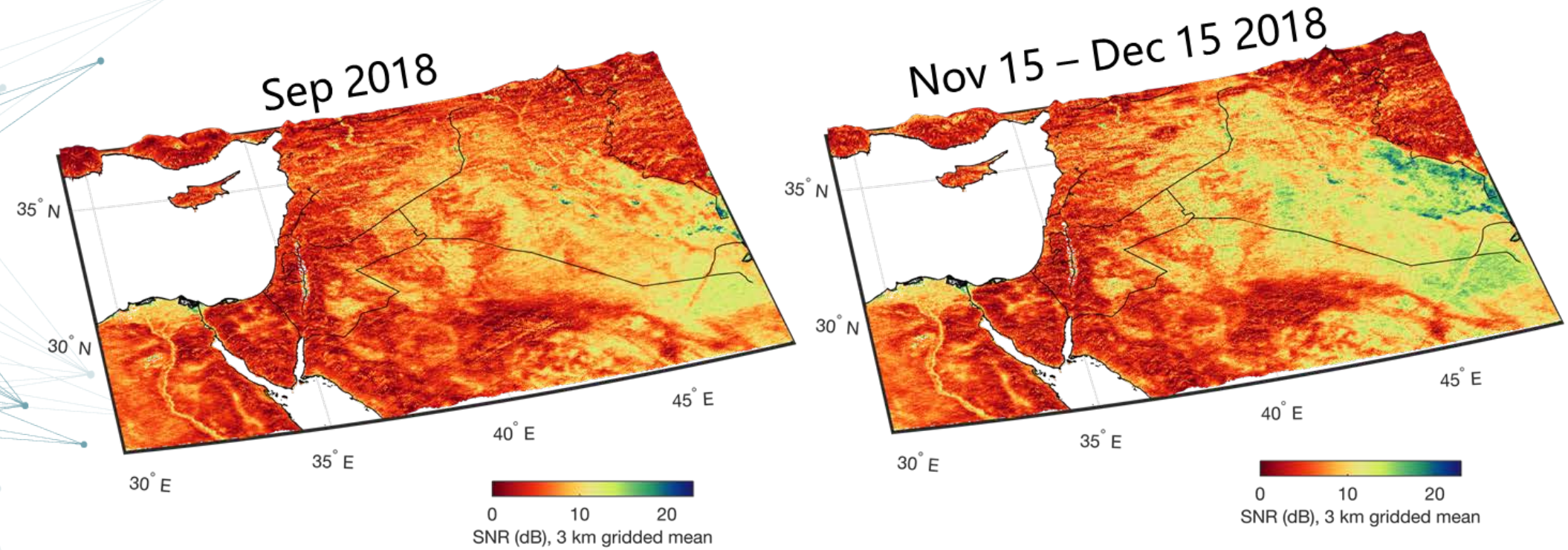
Intensity and storm center **hourly background wind field** **3-hr inner core**

- **2019-08-29, 10:15 UTC**
  - Vmax = 39 m/s
  - Center fix (20.96N, 293.12E)
- **2019-08-29, 18:15 UTC**
  - Vmax = 40 m/s
  - Center fix (22.30N, 292.38E)
- **2019-08-30, 12:45 UTC**
  - Vmax = 50 m/s
  - Center fix (24.43N, 290.26E)



Fight Heritage with CYGNSS Mission (2)

Flood Inundation Mapping



Mapping major flood event in northwest Iraq caused by heavy precipitation in Nov 2018. (left) CYGNSS SNR map for Sep 2018, before flooding. (right) Nov-Dec 2018 map identifies flooded regions by large increases in SNR (yellow-green areas)

Capability Enhancements Enabled by IIP

- CYGNSS Receiver Capabilities
  - GPS L1 C/A signal reception
  - 4 parallel receive channels by digital processor capacity
  - Co-pol only
- Enhanced Capabilities
  - Both GPS and Galileo satellites; Both low (L1/E1) and high (L5/E5) bandwidth signals
  - 20 simultaneous channels
  - Co- and X-pol
- Science Data Product Enhancements
  - More channels = X4 better temporal and spatial sampling
  - Higher bandwidth = X5 better vertical resolution (altimetry)
  - Dual-pol = Radio Occultation & better vegetation canopy correction

Next Steps / Contributions

- New IIP Receiver is being deployed on Air New Zealand commercial aircraft for extended (multi-year) field operations as part of GNSS-R collaboration between NASA and the New Zealand Space Agency to support CYGNSS cal/val activities
- Looking for future spaceflight opportunity