CYGNSS SMALLSAT MISSION DESIGN, ENGINEERING PERFORMANCE AND SCIENCE RESULTS

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ABSTRACT

The eight smallsat CYGNSS constellation was launched into low Earth orbit on 15 Dec 2016. Each satellite carries a four channel bistatic radar receiver which measures GPS signals scattered from the Earth surface, from which surface roughness and wind speed are determined over ocean and soil moisture and inland flooding are determined over land. The mission architecture and satellite design are presented and related to the resulting science data products and their applications. Examples are presented of early on-orbit engineering commissioning, calibration and validation of the science data products, and some recent scientific results and applications.

Index Terms— CYGNSS, GNSS-R, small satellites.

1. INTRODUCTION

Each CYGNSS Observatory consists of a microsatellite (microsat) platform hosting a GPS receiver modified to measure surface reflected signals [1]. Each Observatory simultaneously tracks scattered signals from up to four independent transmitters in the operational GPS network. The number of Observatories and orbit inclination are chosen to optimize the TC sampling properties. The result is a dense cross-hatch of sample points on the ground that cover the critical latitude band between ±35°. Each observatory uses a single-string hardware architecture with functional and selective redundancy included in critical areas. The microsat was designed for ease of manufacture, integration, and test to provide a low-risk, cost-effective solution.

The microsat structural requirements are driven by physical accommodation of the science antennas and solar arrays and by launch configuration constraints. The microsat's shape is configured to allow clear nadir and zenith fields of view for the science and GPS navigation antennas. The "flight stack": of all eight microsats, positioned as they were during launch, is shown in Fig. 1 undergoing final vibration testing.

Figure 1. The eight CYGNSS observatories in the "flight stack" configuration, mounted concentrically around a central deployment module, undergoing vibration testing.

2. ON-ORBIT COMMISSIONING

The CYGNSS constellation was launched on 15 Dec 2016. Engineering commissioning of the eight satellite buses was conducted during the first month on-orbit, followed by functional testing and commissioning of the science payloads (the GNSS-R GPS radar receivers) during Jan-Mar 2017 [2].

3. OCEAN WIND SPEED OBSERVATIONS

CYGNSS began making continuous science observations in Mar 2017. The primary scientific focus of the mission is on measurements of near-surface wind speed in the inner core of tropical cyclones and hurricanes [3]. The large number of satellites in the constellation has a significant impact on the temporal resolution of those measurements, with short time scale processes such as the rapid intensification phase of a storm able to be resolved [4]. Examples of these sampling properties are shown in Figs 2-3. Fig 2 is a composite of the ocean surface wind speed measurements made globally over a 24 hr period on 28 Sep 2018. The highlighted portion of the globe south of Japan denotes the location of Typhoon Trami on this day. Fig. 3 includes 4 sub-plots showing the wind speed measurements made every 6 hr on this day on the vicinity of Trami. Three of the four panels show significant sampling of the wind field, as an illustration of the rapid refresh time sampling made possible by the constellation.

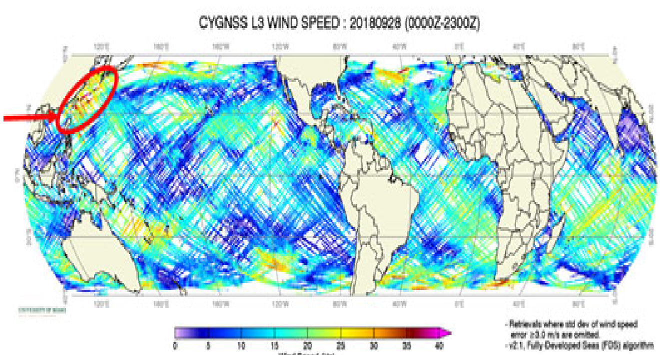

Figure 2. 24 hr global wind speed distribution measured by CYGNSS on 28 Sep 2018; Typhoon Trami circled in red.

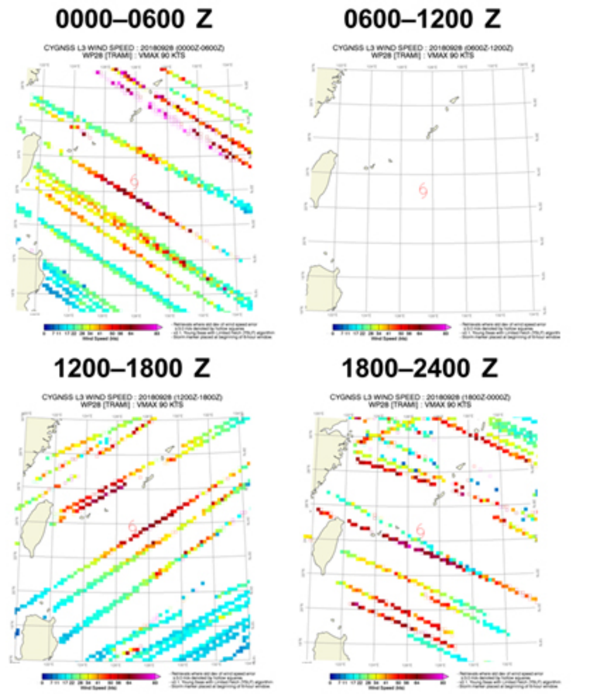

Figure 3. CYGNSS wind speed every 6 hours during overpasses of Typhoon Trami. JTWC storm center noted.

4. CONCLUSIONS

Since the launch of CYGNSS, the constellation has been successfully commissioned and is now in continuous science data-taking mode. Level 1-3 science data products are available to the public at <https://podaac.jpl.nasa.gov/CYGNSS>.

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