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CYGNSS Spaceborne Constellation for Ocean Surface Winds: Mission Design and Sampling Properties

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The NASA Earth Venture Cyclone Global Navigation Satellite System (CYGNSS) is a spaceborne mission scheduled to launch in October 2016 that is focused on tropical cyclone (TC) inner core process studies. CYGNSS is specifically designed to address the inadequacy in observations of the inner core that result from two causes: 1) much of the inner core ocean surface is obscured from conventional remote sensing instruments by intense precipitation in the eye wall and inner rain bands; and 2) the rapidly evolving (genesis and intensification) stages of the TC life cycle are poorly sampled in time by conventional polar-orbiting, wide-swath surface wind imagers.

CYGNSS measurements of bistatic radar cross section of the ocean can be directly related to the near surface wind speed, in a manner roughly analogous to that of conventional ocean wind scatterometers. The technique has been demonstrated previously from space by the UK-DMC mission in 2005-6. CYGNSS will advance the wind measuring capability demonstrated by the experimental payload on UK-DMC to a more mature ocean science mission.

The CYGNSS constellation is comprised of 8 observatories in 500 km circular orbits at a common inclination angle of 35°. Each observatory contains a Delay Doppler Mapping Instrument (DDMI) which consists of a multi-channel GPS receiver, a low gain zenith antenna and two high gain nadir antennas. Each DDMI measures simultaneous specular scattered signals from the 4 GPS transmitters with the highest probable signal-to-noise ratio. The receivers coherently integrate the received signals for 1 ms, then incoherently integrate on board for an additional one second. This results in 32 wind measurements per second.

CYGNSS has spatial and temporal sampling properties that are distinctly different from conventional wide-swath polar imagers. Spatial sampling is marked by 32 simultaneous single pixel “swaths” that are 25 km wide and, typically, 100s of km long. They can be considered roughly analogous to the sampling that would result from 32 simultaneous hurricane hunter aircraft making measurements of the wind speed directly below each aircraft. The temporal sampling is best described by a probability distribution of the revisit time at each location within the +/- 35o latitude coverage area. The median value of the revisit time is ∼2 hours and the mean revisit time is ∼6 hours.
The bistatic radar cross section of the ocean surface at the specular reflection point between a GPS transmitter and a CYGNSS receiver is measured in the form of Delay-Doppler Maps (DDMs). Wind speed is estimated from the DDMs using a minimum variance (MV) estimator. The MV estimator is a composite of wind estimates obtained from different observables that can be derived from the DDMs. Regression-based wind retrievals are developed for each observable using geophysical model functions that relate an observable to the surface wind speed. The MV estimator exploits the partial decorrelation that is present between residual errors in each individual wind retrieval.

The EGU 2014 presentation will include a summary of the current mission design, including the DDMI science payload, the spacecraft, the constellation orbital architecture, the mission concept of operations. The spatial and temporal sampling properties, and retrieval uncertainty, of the CYGNSS ocean surface wind measurements will also be presented.