Matched Filter Maximum Hurricane Wind Retrievals Using CYGNSS's Special Downlink Modes

Mohammad Al-Khaldi[1], Joel T. Johnson[2], Stephen J. Katzberg[3,4],
Younghun Kang[2] and Ethan Kubatko[2]

[1]University Cooperation for Atmospheric Research, Boulder, CO, USA
[2]The Ohio State University, Columbus, OH, USA
[3]NASA Langley Research Center, Hampton, VA, USA
[4]South Carolina State University, Orangeburg, SC, USA

The estimation of hurricane properties and their evolution is one of the CYGNSS (Cyclone Global Navigation Satellite System) mission's core objectives. CYGNSS is well suited to address this need through its eight satellite constellation facilitating revisits ranging between 3-7 hours and its L-band (1.575 GHz) operation, motivating the use of its delay-Doppler Map (DDM) measurements for the estimation of various storm properties.

This presentation will describe recent developments in a 'matched filter' retrieval approach that uses CYGNSS Full-DDM mode measurements to estimate maximum hurricane winds. Its estimates are based on comparisons of tracks of CYGNSS specular measurements over hurricanes and predictions of the same waveforms over synthetic storm models as their parameters are varied. Storm parameters are retrieved for simulated returns that maximize correlation and minimize root mean square error with measured data. Prior to their use in this process, both measured and simulated waveforms are normalized by their rms amplitude such that retrievals are based on DDM 'shapes' as opposed to their amplitudes, thereby bypassing uncertainties associated with the CYGNSS calibration process. Because properties of the reference waveforms are significantly affected by the choice of synthetic storm model(s), particular emphasis is placed on providing an analysis of the retrieval's dependence on the use of the Willoughby or Generalized Asymmetric Holland parametric storm models. A strategy for their combined use will also be discussed using an extensive record of CYGNSS hurricane 'Full DDM' downlinks spanning 20 storms over the 2017-2020 hurricane seasons.

Because the retrieval approach uses Full DDM downlinks, its usefulness also extends to near-miss tracks, which do not pass through the storms' respective centers, due to their expanded 16 chip maximum delay extent (4 times larger compared to standard CYGNSS downlinks). The potential for further improvements in retrieval performance will also be assessed in the presentation as a function of increased measurement delay extent using CYGNSS's Raw I/F mode downlinks whose use allows for the creation of DDMs with an arbitrary extent in delay.