Designing and Simulating the Next-Generation Ocean Vector Winds Mission

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Winds over the ocean drive the ocean circulation, which redistribute and store a large fraction of the Earth's heat, a key variable in the global climate. Winds are also responsible for the upwelling of nutrients at the coasts, a key source for maintaining viable coastal ecosystems and fisheries. Finally, winds over the ocean can constitute great hazards to both shipping and coastal populations from tropical and extra-tropical cyclones and other high wind events.

The scientific and social importance of ocean vector winds has been recognized by the United States National Research Council (NRC) in its Decadal Review recommendation to NASA and NOAA for the next generation of Earth observing, spaceborne missions. The NRC recognized the importance of the ocean vector wind measurements provided by the NASA QuikSCAT scatterometer and recommended that NOAA launch the next-generation ocean vector winds instrument, which they called the extended Ocean Vector Winds Mission (XOVWM). The improvements relative to QuikSCAT suggested by the NRC for the next generation mission would be addition of all-weather capabilities and improved spatial resolution.

In a parallel effort, NOAA has undertaken an effort to synthesize the needs for the NOAA weather forecasting community. This effort resulted in a series of recommendations for the next-generation ocean vector winds instrument that would meet NOAA's future operational needs. The recommendation of the NOAA user community overlapped the NRC recommendation for all weather capabilities and higher spatial resolution.

NOAA has asked the Jet Propulsion Laboratory (JPL), California Institute of Technology, to design a radar system that could be used as a basis for the next generation winds mission. In this paper we report on the design and simulation methodologies used for the design of the XOVWM and other systems to meet

NOAA's needs. A report of the initial study results can be found in http://podaac.jpl.nasa.gov/WEB_INFO/QFO_MissionConceptReport_JPL_08-18.pdf.

A key challenge in the design of the next generation system was the reconciliation of the competing requirements of higher resolution (which favors a higher frequency) and all weather capabilities (which favor lower frequencies and, possibly, the addition of radiometer channels for rain estimation and correction). JPL has come up with two potential solutions to this design challenge. The first solution, XOVWM, consists of a pencil-beam scanning scatterometer with a rotating 3.5m x 5m antenna which supports scatterometer channels at Ku and C-bands, and an X-band polarimetric radiometer channels. The large antenna size is required for the implementation of SAR processing, which allows a spatial resolution better than 5 kilometers for the Ku-band channel.

The large antenna in the XOVWM system presents an accommodation and cost challenge. In order to provide alternatives that might be easier to implement, JPL has designed a Dual Frequency Scatterometer (DFS), a real aperture pencil beam Ku and C-band scanning scatterometer with a 2m antenna. The system provides all-weather capabilities with a spatial resolution superior to QuikSCAT, but coarser than XOVWM. It is designed to be operated inconjunction with a passive radiometer system, such as AMSR on the JAXA GCOM-W platform.

One of the great challenges in the evaluation of the merits of these systems is the inability to prototype them and collect data over the primary regions of interest: tropical and extra-tropical cyclones and coastal regions. We have overcome this challenge by building a large scale simulation framework which can be used to perform Observing System Simulation Experiments (OSSE's). Our simulation framework relies on the ability of the Weather Research and Forecasting Model (WRF) to generate realistic wind speed and rain fields at resolutions compatible with tropical cyclone dynamics and the resolution capabilities of the proposed instruments. We use the WRF fields (which we have validated with NOAA users at the NOAA National Hurricane Center/Tropical Prediction Center) to generate the truth fields for surface winds and precipitation. We then use high wind speed model functions (based on hurricane radar data collected by NOAA and U. Mass./JPL) and physical radiative transfer solutions to simulate the scatterometer/radiometer observables. Finally, we have developed advanced algorithms for the processing of this multi-frequency data for the retrieval of high accuracy surface vector winds.

In this presentation we review our design and simulation strategies and present results for multiple tropical and extra-tropical cyclones, as well as high speed wind jets in the coastal region. We also summarize the assessment of these results obtained by canvassing NOAA users of ocean vector wind data.