Operational Utilization of High Resolution Ocean Surface Wind Vectors (25km or better) in the Marine Forecasting Environment

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LONG-TERM GOALS

The work proposed here seeks to exploit currently and soon to be available satellite ocean surface vector wind data in the operational weather forecasting environment. This work will build upon an ongoing effort to quantify the impacts of QuikSCAT ocean vector wind data in the operational short-term warnings and forecasts issued by the NWS Ocean Prediction Center (OPC), and extends the effort to include the NWS Tropical Prediction Center and OCENS, Inc, a small company specializing in ocean and weather monitoring tools and services for the commercial and recreational marine users. In addition to the standard 25km wind vector products from QuikSCAT, this effort will also investigate the impacts of higher spatial resolution wind vector products (12.5km and higher) and the wind vector retrieval capabilities of WindSAT, a polarimetric microwave radiometer.

OBJECTIVES

This effort aims to operationally generate and distribute a gridded wind vector analysis and forecast product out of the OPC and TPC to end user participants (US Coast Guard and OCENS Inc.) who will provide feedback on the product impacts and utility. The National Environmental Satellite, Data and Information Service (NESDIS) will generate and provide a gridded wind field product utilizing all available satellite remote sensing data to the MPC and the TPC. These gridded wind field products will cover the areas of responsibility (AORs) for OPC and TPC, and will serve as the basis for the gridded wind vector analysis and forecast products generated by OPC and TPC. We also seek to investigate improvements to the currently available standard wind vector product that will yield positive impacts in its operational utilization. In particular, ambiguity removal processing and quality flagging improvements in adverse weather conditions will be studied along with the potential of retrieving higher resolution (< 25km) wind vector products. While the ADEOS-II satellite mission ended prematurely, we will investigate the utility of having a co-located radiometer with the scatterometer in flagging and potentially correcting rain contaminated data. Also, aircraft scatterometer data collected during the hurricane season experiments on the NOAA P-3 aircraft will be also be used to help quantify the impacts of rain on scatterometer ocean surface measurements. Additionally, the launch of WindSat in January 2003 represents the first polarimetric radiometer in space designed for retrieval of the ocean surface wind vector. After WindSat's calibration/validation period, the ocean vector wind data retrieved from it will be compared and integrated with the scatterometer wind vector products. Attempts will also be made to improve the spatial resolution of WindSat products where it is feasible.

APPROACH AND WORK PLAN

The work proposed here involves exploring the benefits to operational weather forecasting of high-resolution ocean surface wind vector data through an end-to-end operational demonstration project. Existing vector wind products will be utilized, and potential new products will be investigated from current and future satellite sensors. The observations themselves will be gridded by ORA and used by forecasters at the Ocean Prediction Center and the Tropical Prediction Center to regularly issue a gridded high-resolution wind analysis product over their areas of responsibilities (AORs). These gridded products will be provided operationally to the US Coast Guard for use in their Search And Rescue (SAR) mission, and to OCENS, a commercial company specializing in weather, earth and ocean monitoring services (www.ocens.com). Both the Coast Guard and OCENS will provide feedback on the utility of these data.

Specifically,
-Investigate the potential of higher resolution, less than 25km, wind products from QuikSCAT.

-Evaluation of benefits for having a coincident passive sensor with a scatterometer (AMSR and SeaWinds on ADEOSII) in wind retrieval performance and its use as a quality control to maximize impacts in data assimilation. This will be off-line and lower in priority task given the failure of ADEOSII.
-Evaluation of ocean vector wind data from WindSat and integration into operational ocean surface wind vector product stream including investigating higher resolution, less than 30km, wind products.
-Identify the utilization of QuikSCAT wind vector at TPC and quantify its impacts.
-Gridded high resolution surface wind fields over OPC AORs...edited and quality controlled by OPC forecasters as a routine product.
-Operational delivery of gridded winds by OPC to the US Coast Guard for their Search and Rescue (SAR) mission with feedback of utility.
-Operational delivery of gridded winds by OPC to OCENS, Inc. with feedback of utility.

To accomplish these objectives we established a National partnership among the following organizations. These organizations have demonstrated experience in remote sensing of the ocean surface wind vector, near real-time processing and distribution of this data, application and utilization of these data in the operational environment.

-NOAA/NESDIS/Office of Research and Application - Paul Chang
-NOAA/NWS/NCEP/Ocean Prediction Center - Joseph Sienkiewicz
-NOAA/NWS/NCEP/Tropical Prediction Center - Richard Knabb
-Brigham Young University - David G. Long
-US Coast Guard
-Navy/Naval Research Laboratory - Peter Gaiser
-OCENS, Inc. - Mark Freeberg

The effort proposed here will develop an end-to-end process for the operational utilization of satellite observations, and will address the end-to-end utilization of remote-sensed ocean vector wind data. Ocean vector wind data is currently in available from NASA's QuikSCAT mission and will also be available from future satellite sensors such as WindSat, ASCAT on METOP, and CMIS on NPOESS.

WORK COMPLETED

The standard operational QuikSCAT wind vector product has a spatial resolution of 25km x 25km. However, the measurement methodology of QuikSCAT allows for wind vector retrievals at better spatial resolutions at the cost of a noisier retrieval. ORA worked with QuikSCAT group at JPL to implement 12.5km spatial resolution processing operationally at NOAA. The initial validation results of this wind vector product showed that improvements were required in the ambiguity removal processing and rain flagging, which were subsequently modified. The validation of the new 12.5km wind vector products yielded results acceptable for operational distribution and utilization. Figures 1 and 2 contain plots for an example set of QuikSCAT wind vector retrievals at the standard 25km, the improved 12.5km spatial resolutions. The 12.5km wind vector retrievals clearly show more detail than the standard 25km product. And while the original 12.5km product clearly contained errors in the wind vector retrievals, such as along the swath edges, the improvements made in ambiguity removal and rain flagging clearly yield a quality product as seen in figure 2. The new 12.5km QuikSCAT wind product is in the final stages of operational implementation, and will be available within the operational environment (NAWIPS/NMAP) of the Ocean Prediction Center and the Tropical Prediction Center.

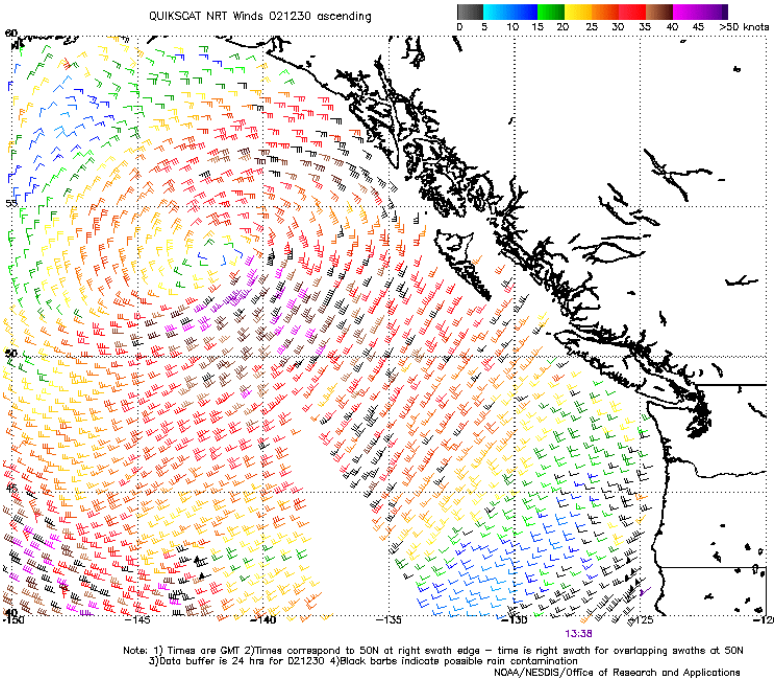

Figure 1: Standard 25km spatial resolution wind vectors from QuikSCAT.

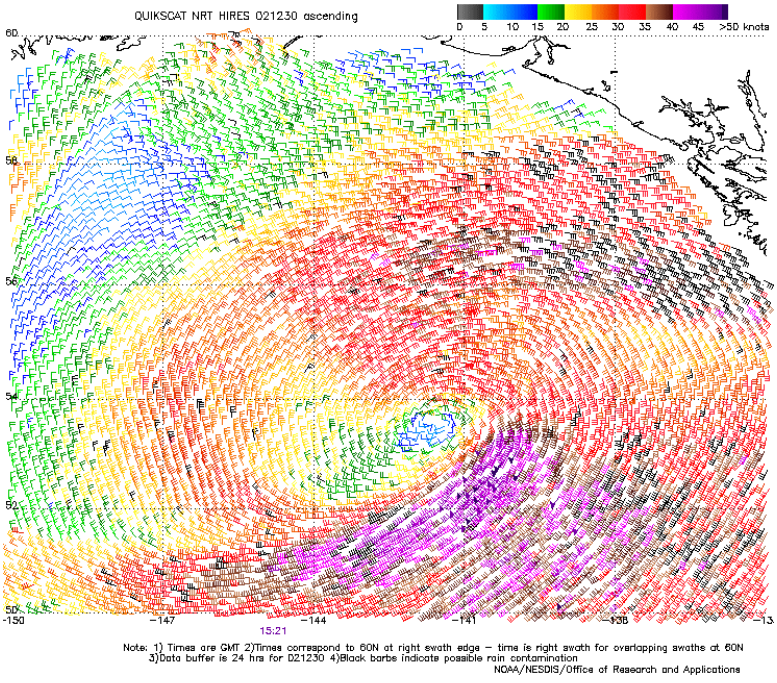

Figure 2: Improved 12.5km spatial resolution wind vectors from QuikSCAT.

Even higher spatial resolutions products from QuikSCAT are being pursued by the Center for Remote Sensing at BYU. The spatial sampling of the QuikSCAT backscatter measurements can support reconstruction of finer scale backscatter values which can then be used to estimate the near surface wind vector field at an ultra high-resolution (pixel spacing of 2.5km). The ultra-high resolution wind

retrievals have been implemented in the operational QuikSCAT processing stream for storm specific regions similar to the high resolution normalized radar cross-section (nrcs) product.

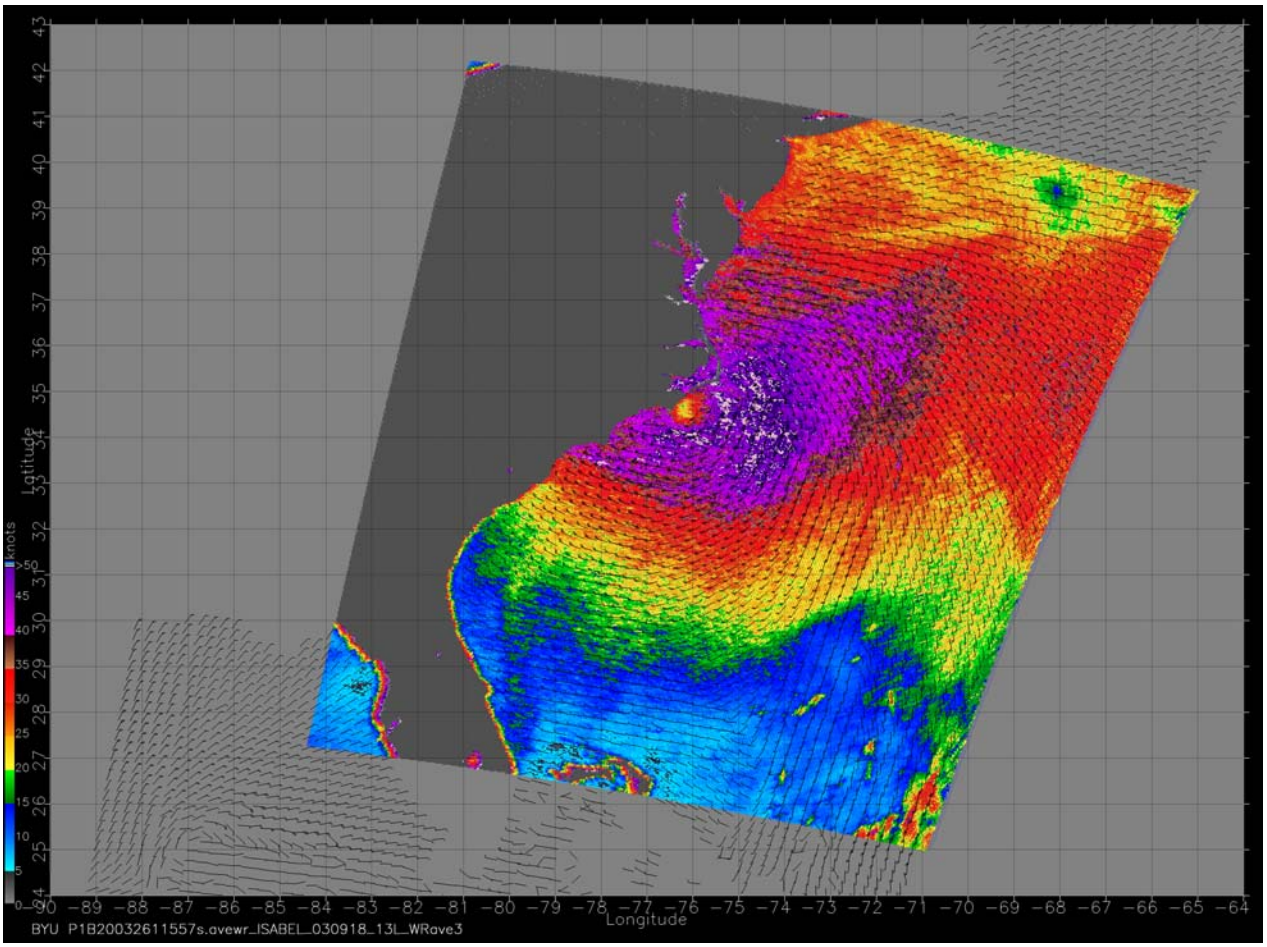

Figure 3: Ultra high resolution wind speed retrievals from a QuikSCAT pass over Hurricane Isabel

The OPC has developed a gridded wind field product using a nine-hour time composite on a one-third degree latitude-longitude grid every hour based on QuikSCAT wind vector data. These data files contain the U and V components of the wind field along with time stamps and quality flags, and are formatted in the GRIB1 and GRIB2 format. The incentive for using GRIB format is compatibility with most display and weather routing software packages used by mariners. An example of the GRIB formatted wind vector plots is shown in figure 4. OCENS is one company that provides ocean and weather monitoring tools and services to mariners and has been working closely with OPC in the development and distribution of their gridded wind field product. OPC has been providing the wind field GRIB files to OCENS Global Marine Networks (GMN) since November 2003. OCENS is in the process of modifying and developing viewer software for their customers to be able to fully utilize the new GRIB files. Market surveys performed by OCENS during 2003 indicate a high interest in reliable ocean surface wind data and a general lack of confidence in currently available wind information. OCENS is targeting to be ready for beta-testing the GRIB wind product for the Newport to Bermuda race and the Pacific cup race from San Francisco to Hawaii this summer.

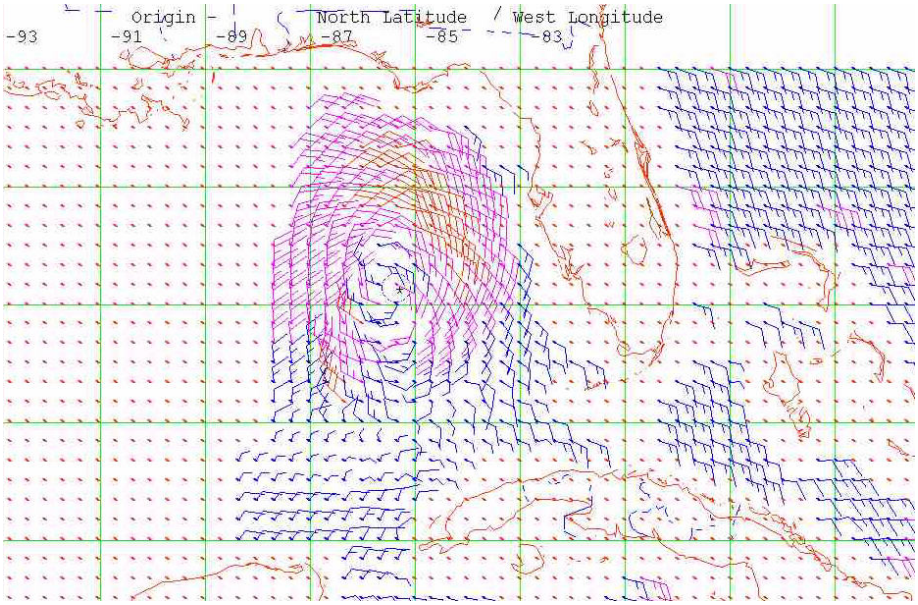

Figure 4: GRIB formatted QuikSCAT wind field example.

TPC has commenced an effort to determine how QuikSCAT wind vector data are currently being used at TPC, and how to best quantify the impacts of this data type in TPC's mission. In the course of this effort, deficiencies in the currently available data are also being identified and addressed where possible by working with the other NOPP partners and the ocean vector wind remote sensing community in general. TPC's approach to determining the utilization of these data and quantifying the impacts of this data is similar to that taken by OPC as part of another NOPP project. A carefully constructed log/survey sheet was distributed to each forecast desk, with the forecaster on duty filling it out as part of his/her daily routine during the period of 15 November 2003 to 15 December 2003.

WindSAT is a polarimetric microwave radiometer launched by the Navy on the Coriolis mission. WindSAT is a first of its kind sensor launched into space on 06 January 2003 to demonstrate and better understand the wind vector retrieval capabilities of a polarimetric radiometer versus those from scatterometers such as QuikSCAT. WindSAT is a risk reduction mission for the CMIS sensor, which will be responsible for meeting the Nation's ocean wind vector retrieval requirements in the NPOESS era. WindSAT is currently in the midst of its calibration and validation period which should be completed during the summer of 2004. At which time ocean vector wind data from WindSAT will also be brought into this NOPP effort to be evaluated and integrated into the operationally available data streams.

RESULTS

A high quality 12.5km wind vector product from QuikSCAT was developed and validated, and is currently being put into operational production.

Ultra high-resolution (2.5km) wind speed retrievals from QuikSCAT were demonstrated to be possible and have been implemented in the operational processing stream
Initial wind vector product in GRIB format was demonstrated and is being routinely generated at OPC

OCENS developed a prototype viewer for the GRIB wind vector product which will be ready for beta testing in several races this summer.

First TPC QuikSCAT wind vector data use survey completed by forecasters
- QuikSCAT data is used during the forecast cycle about 75% of the time
- When QuikSCAT data changed the wind analysis/forecast the winds were adjusted higher about 65% of the time
- It was also helpful in identifying front, trough and ridge locations and confirming wind areas
- The major shortcoming identified was lack data over areas of interest due to no coverage or data latency issues.

IMPACT AND APPLICATIONS

National Security

Any improvements in short-term warnings and forecasting in the marine environment through utilization of satellite ocean vector wind data would certainly benefit any Naval operations and thus National Security or Homeland Defense.

Economic Development

Commercial interests in remotely-sensed ocean surface wind vector data do exist, and initial surveys conducted by OCENS, Inc. show that high quality ocean surface wind data is lacking but desired by commercial and recreational users in the marine environment.

Quality of Life

Any improvements in short-term warnings and forecasts through utilization of satellite ocean vector wind data would benefit commercial and private interests in the marine environment.

TRANSITIONS

RELATED PROJECTS

Scatterometer-derived Operational Winds, Surface Pressures and Rain,
- Principle Investigator J. O'Brien, FSU, funded by the NOPP
- identify utilization of QuikSCAT data at OPC and quantify the impacts of this data at OPC.