Scatterometer-Derived Operational Winds and Surface Pressures

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http://manati.wwb.noaa.gov/quikscat/ (NOAA/NESDIS near real time products)
http://coaps.fsu.edu/scatterometry/ (all COAPS scatterometry activities)

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LONG-TERM GOALS

Enhanced products based on satellite-derived ocean surface winds will be distributed to Navy and commercial vessels, and civilian forecasters, with improved accuracy and much greater ease of interpretation. Two additional products, based on these improved observations, will also improve the ease and speed of interpretation and ocean modeling. A third product will provide an improved alternative for ocean modeling. The technology will be transferred to NOAA/NESDIS for routine use and distribution.

OBJECTIVES

(1) Currently observations that are suspected of being associated with rain events are flagged and ignored. This practice discards many useful observations. An improved flag will be developed to flag only the relatively small fraction of observations where rain has a substantial adverse impact. The improved product will be validated.
(2) The ease and speed of interpretation of the observations will be improved for operational activities (civilian, military, and commercial) by processing the data in a manner that highlights the meteorological features of interest. Objective (3) contributes to this goal.
(3) Surface pressures will be derived from the improved wind products. Surface pressures are routinely used by weather forecasters, whereas, surface winds require considerably more effort to interpret. Furthermore, the surface pressure can be compared to weather prediction products to identify large scale errors in the forecasts.
(4) Surface stresses will be determined directly from the signals observed from the satellite. These are ideal for ocean modeling. They can also be used to improve estimates of wind-related ocean spray, which is of tactical interest.
(5) Surface winds and stresses will be gridded for operational ocean modeling at relatively fine spatial resolution.
(6) Transition of technology to NOAA/NESDIS.

APPROACH AND WORK PLAN

The team members working on the specific aspects of our plan (discussed below) are indicated by their names in bold print.

Ocean vector wind data from QuikSCAT have been available in near real-time from NOAA/NESDIS [**Chang**] to the operational forecasting community since early 2000. The near real-time classification for QuikSCAT implies ocean vector wind product availability within 3 hours of scatterometer measurements of the ocean surface. QuikSCAT transmits data back to ground stations only once per orbit, so approximately 102 minutes of the 3 hour time budget is consumed in data collection alone. These data are automatically retrieved at COAPS [**O'Brien** and **Bourassa**], processed, and forwarded to operational users [**Bernstein**, **Clancy**, and **Hawkins**]. These operational centers forward the data products to the end users, gather feedback, and return it to COAPS for improvement of the products.

Currently, all winds vectors coincident with suspected rain events are flagged as rain contaminated. A theory-based model and observations (**Weissman** et al. 2002, 2003; [**Weissman** and **Bourassa**]) indicate that for many rain events the wind signal is only slightly altered by rain. A tropical cyclone-related application (Sharp et al. 2001) supports this finding. Theory suggests that rain contamination will be a serious problem only when the rain rate exceeds a wind speed dependent threshold. We will use existing proxies for rain rate (Jones et al. 2000a,b; **Weissman** et al., 2002, 2003). In areas of rain contamination, we will estimate wind speed and direction through our pressure fields (for which rain has little impact). The partners in this collaboration are unique in their ability to develop rain impact flags.

NAVOCEANO [**Rigney**] will provide ship observations for validation of our products. COAPS has considerable experience in processing research vessel observations (Smith et al. 2001), and in using these observations for validation of scatterometer winds (**Bourassa** et al., 1997, 2003).

Surface pressures will be determined [**O'Brien** and **Bourassa**] from the satellite winds through the technique of Hilburn et al. (2003). This approach blends forecast pressures with wind observations, to create an improved pressure product. This product will be validated with ship and buoy observations.

Stresses will be calculated directly from scatterometer backscatter [**Weissman** and **Bourassa**], similar to the technique of **Weissman** and Graber (1999) for a previous instrument, without making assumptions required for wind-derived stresses. Scatterometers respond to the short water-waves, which respond more directly to stress than to wind speed. Historically, scatterometers have been calibrated to 10m wind speeds due to the relative paucity of stress observations. A SeaWinds stress algorithm is being developed by **Weissman**.

Relatively fine spatial resolution gridded wind fields are produced as prototypes for operational oceanography [**Bourassa**]. The quality of these fields is indirectly evaluated through the accuracy of the ocean model results for two regions: the Gulf of Mexico [**O'Brien** and **Bourassa**] and the eastern Pacific [**Kindle**].

Enhanced graphics that emphasize the meteorologically-relevant features will be developed [**O'Brien** and **Bourasssa**]. All these products will be generated in near real-time. One product will show pressure fields derived from the scatterometer in addition to modeled pressure fields (analysis and forecast fields interpolated to the time of the scatterometer observations). Another product will using moving vector code (**Bourassa** et al. 1998). The moving vectors highlight meteorologically interesting features without the distracting errors associated with rain contamination and missing data. Pressure and rain graphics will also be included in the second product. These graphics (and identical information in digital form) will be made available to NWS local offices, Marine Prediction Center [**Chang**], FMNOC [**Clancy**], and other operational centers [**Bernstein** and **Hawkins**]. Feed back from these sources will lead to better products, and perhaps to products that are tailored to various applications.

The programs used to create our new products are written in a computer language that that is practical for transfer to NOAA/NESDIS's computer systems [**Bourassa** and **Chang**].

WORK COMPLETED

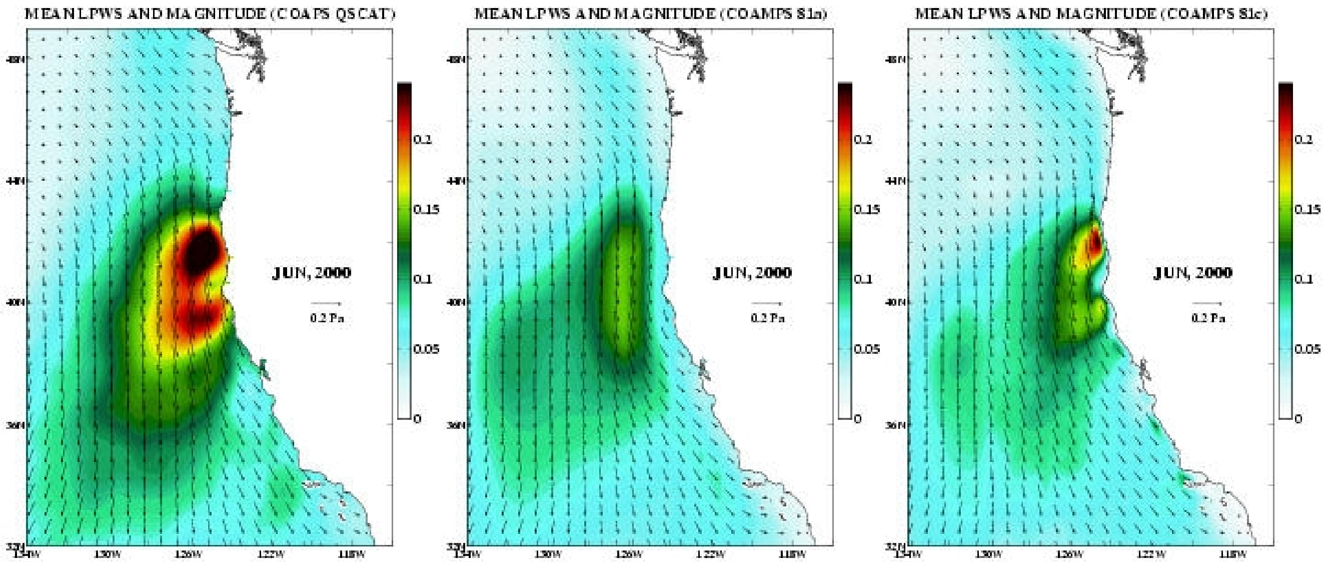

Figure 1 shows a comparison of wind stress for June 2000 using the Large and Pond formulation for the QuikSCAT derived winds (50km resolution, left) and the COAMPS Reanalysis 10m winds at 81km (middle), and 9km (right) resolutions. The observed sea level at Neah Bay, Washington was compared to results of a model forced by the QuikSCAT winds and the COAMPS winds at 81, 27 and 9km resolution. The results reveal that the simulation forced by the QuikSCAT product yields a comparable correlation to the observed sea level and an improved skill score relative to even the high resolution (9Km) COAMPS product.

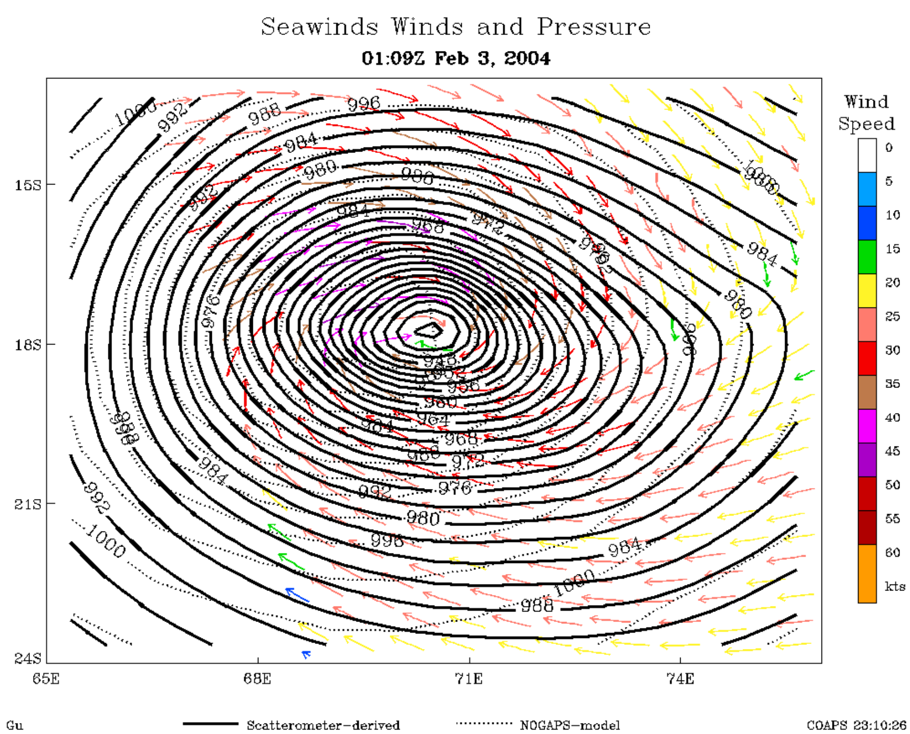

Fig. 2. Regions of scatterometer-derived surface pressures are now centered on the center of storms. This approach is more useful to forecasters. Future goals include the use of wind barbs rather the vectors, and objectively determined density of pressures.

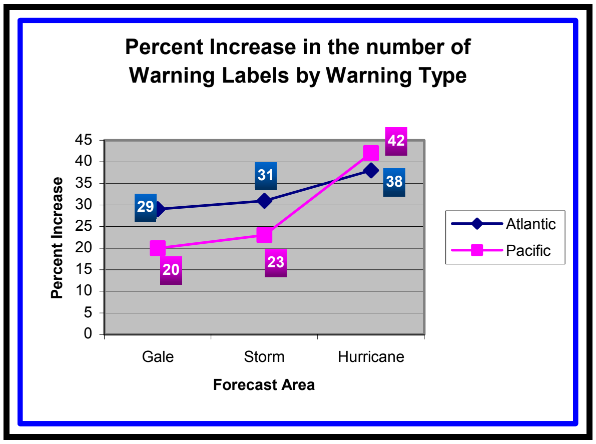

Fig. 3. During the fall of 2002 and spring of 2003 studies were conducted to quantify the effects of QuikSCAT wind vector data on the issuance of short-term marine wind warnings in the Ocean Prediction Center. An analysis of the data according to warning category indicated that using QuikSCAT winds had a greater impact with the more significant warnings in both oceans. The number of Hurricane Force warnings increased by 38% in the Atlantic and by 42% in the Pacific.

RESULTS

1) A technique has been developed to force the geophysical model functions for each polarization to be internally consistent. This is a new approach in the development of geophysical model function (for converting radar observations into vector winds or stresses). The improved internal consistency leads to better solutions.

2) A preliminary retrieval algorithm has been developed for surface turbulent stress. This stress is what forces the ocean – not winds. Insufficient information (a lack of wave data) introduces uncertainties in the conversion from wind to stress. This direct result bypasses these problems. Further issues remain regarding refinement of this methodology, and regarding calibration at low wind speeds.

3) The physically-based model has been developed for rain impacts on backscatter. This is the first detailed examination of the physics of rain impacts on the QSCAT retrievals, where the results of the model have been compared to rain observations from NEXRAD and TRMM.

IMPACT AND APPLICATIONS

National Security

The pressure and enhanced graphics can be of use for tactical planning, ship routing, and marine (including marine aviation) safety in general. The gridded winds and stresses are extremely useful for modeling near surface currents, and the drift of objects due to these currents. The near real time gridded winds have already been shown to be effective for search and rescue activities, in collaboration with a NOPP project led by Gary Lagerloef.

Economic Development

There should be considerable increased efficiency in response to open ocean and coastal severe weather. The products produced in this study have been shown to be useful in evaluating critical biases in the forecasts from weather prediction models. Improvements in these areas will lead to less loss of work related to Nor'Easters and landfalling tropical cyclones. It will also help in the more efficient routing of ships.

The TeraScan users can obtain QuikSCAT wind data from SeaSpace free of charge. The data added to TeraScan user's existing sources of other satellite products and model analyses, and help achieve better analyses of weather systems. Providing this added service to TeraScan users has a positive impact on SeaSpace's business development.

Quality of Life

The extremely high quality near-surface currents modeled in the Gulf of Mexico should be of great help in increasing our knowledge of physical oceanography related to the Gulf's ecosystem and coastal resource management. Many organizations receiving the QuikSCAT wind data are involved in the areas of coastal resource management and public information service. Such users include 11 national weather service organizations, four commercial weather service organizations, and four national oceanographic and fisheries organizations. It is particularly beneficial that QuikSCAT data provide large-scale information over the water surface where the conventional observations are not available.

Science Education and Communication (Delete this section if there are none)

Animations based on the results from the Gulf of Mexico model are used, in a university course, to demonstrate important physical concepts.

TRANSITIONS

National Security

The QuikSCAT derived wind data are being incorporated into SeaSpace Corporation's developmental programs. It adds a new component to SeaSpace's product lines.

The satellite-derived surface stresses and enhance graphics are being made available to the Navy for operational activities. The products were made available at the end of the reported period: details of the use are not available at this time.

Economic Development

These products are being made available to forecasters so that they can better evaluate model forecasts in the context of severe weather, for which the consequences of forecast quality can have tremendous impacts in lost work and damage mitigation.

RELATED PROJECTS

1) Analysis, Modeling and Science for NSCAT, SeaWinds, ADEOS Vector Winds (OSU, NASA): Scatterometer winds are validated, gridded, and used for many science applications
http://coaps.fsu.edu/scatterometry/ (all our scatterometry activities)

2) Numerical Modeling of Cross-Shelf Exchange Processes in the Gulf of Mexico (NASA):
The circulation of the Gulf of Mexico is examined, with emphasis on the on transport to and from the shelf regions. Fine resolution scatterometer wind fields are used to force the model.

3) Quality-Evaluated Meteorological Data from Research Vessels (NOAA/OGP)
http://www.coaps.fsu.edu/RVSMDC/index.shtml (Research Vessel Data for Calibration)

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