CGMS

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Ocean Surface Vector Winds: NOAA Operational Satellite Ocean Surface Vector Winds Requirements Workshop Report

NOAA-WP-26 is the executive summary report from a workshop held June 5-7, 2006 at the Tropical Prediction Center (TPC)/National Hurricane Center (NHC) in Miami, FL. The workshop documented (1) the utilization and impact of presently available satellite OSVW data in the production and use of operational marine weather analyses, forecasts and warnings at NOAA, (2) the OSVW operational requirements within NOAA based on actual experience and phenomena observed, and (3) a preliminary exploration of sensor/mission concepts that would be capable of meeting requirements. Seven years after NOAA first began routinely utilizing satellite OSVW data, the Nation still has no plans for an operational OSVW data stream that addresses the present and future satellite OSVW requirements of NOAA. Although satellite ocean surface vector wind (OSVW) data are revolutionizing operational marine weather warnings, analyses, and forecasts, critical but solvable gaps in OSVW capability remain, leaving life and property at risk.

The workshop findings are summarized below:

1) QuikSCAT vector wind measurements are fully integrated, and heavily used, in the routine workflow of the national centers and coastal forecast offices.

2) Nearly eight years of operational experience with satellite vector wind data has highlighted the need for product improvements in the following areas to support the present needs of NOAA operational forecasters and centers:

a) Measurement accuracy and quality
b) Measurement spatial and temporal ("revisit") resolution, and latency
c) Data product provisioning and training

3) The workshop participants focused on the essential vector wind product requirements.

Establishing an operational satellite OSVW data stream and closing the OSVW capability gaps will result in more accurate warnings, watches and short-term forecasts; improved analyses, model initializations, and atmospheric forcing of ocean models; and a better understanding of coastal and oceanic phenomena. This will yield significant improvements in NOAA's operational weather forecasting, warning and analyses capabilities.

Ocean Surface Vector Winds: NOAA Operational Satellite Ocean Surface Vector Winds Requirements Workshop Report

EXECUTIVE SUMMARY

The operational use of satellite ocean surface vector wind (OSVW) observations has advanced considerably over the past 10 years. OSVW are now depended upon and utilized daily by operational weather centers around the world. Within the NOAA's National Weather Service (NWS) the use of OSVW encompasses the warning, analysis and forecasting missions associated with tropical cyclones, extra-tropical cyclones, fronts, localized coastal wind events (i.e., gap winds), surf, and swell. With oceans comprising over 70% of the earth's surface, the impacts of these data have been tremendous in serving society's needs for weather and water information and in supporting the Nation's commerce with information for safe, efficient and environmentally sound transportation and coastal preparedness. The satellite OSVW experience that has been gained over the past decade by users in the operational weather community allows for realistic operational OSVW requirements to be properly stated and justified for the first time.

NOAA workshop was held June 5-7, 2006 at the Tropical Prediction Center (TPC)/National Hurricane Center (NHC) in Miami, Florida. The workshop gathered meteorologists from the U.S. public and military operational weather forecasting community to assess the operational utilization and impact of satellite ocean surface wind speed and direction measurements and define NOAA operational OSVW requirements. While their operational roles and responsibilities were diverse, they unanimously agreed that satellite ocean surface vector wind data were extremely valuable to their operational day-to-day responsibilities. It was also clear that a gap exists between NOAA's actual OSVW requirements and those being provided by current and planned satellite missions. It was the strong consensus of the workshop participants that closing this gap was required to continue improvements in weather forecasting and warning capabilities

Two research surface vector wind (SVW) missions are currently operating and providing timely data products for operational utilization at NOAA. QuikSCAT/SeaWinds and Coriolis/WindSat employ different microwave remote-sensing techniques to retrieve the SVW. However their distinctions are not pertinent in defining NOAA's present operational SVW requirements. QuikSCAT features most prominently in the following examples and experiences due in part to the near real-time availability of QuikSCAT products since February 2000. WindSat near real-time SVW data only become available in the beginning of 2006.

The workshop findings are summarized below:

Remotely-sensed OSVW from satellites are used by forecasters to help make wind warning and forecast decisions related to tropical and extratropical cyclones and other hazardous phenomena. NWS marine wind warnings and forecasts are used directly by mariners engaged in commerce, transportation and recreation to make safe and economically efficient passages. Additionally, tropical cyclone warnings are utilized by emergency managers, government officials, and the general public to prepare for potential impacts from these systems. Remotely-sensed OSVW help to fill the immense gaps inherent in the conventional ocean surface-based observation network. QuikSCAT vector wind measurements are fully integrated, and heavily used, in the routine workflow of the national centers (OPC,

TPC/NHC), JTWC and coastal NWS WFOs. The QuikSCAT data have had major operational impact in the areas of:

Marine warnings and forecasts

- Short-term warnings and forecasts for high seas and offshore waters
- Observational source for surface analyses

QuikSCAT OSVW help to:

- o locate fronts and troughs
- o locate centers of high and low pressure
- o determine the category and extent of wind warning areas (Gale (34-47kt),Storm (48-63 kt) and Hurricane Force (64 kt or greater))

QuikSCAT is the first remote sensing instrument that can consistently distinguish extreme Hurricane Force conditions from less dangerous Storm Force conditions in extratropical cyclones. Due to the availability of QuikSCAT, OPC forecasters are now more likely to anticipate the onset of Hurricane Force conditions. (Fig 1)

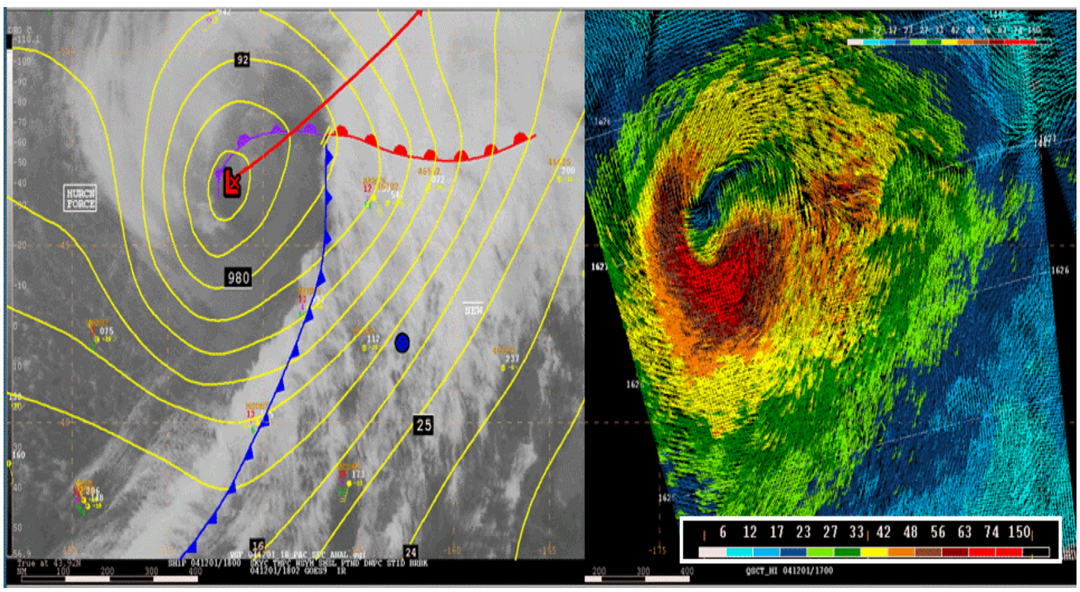


Fig. 1. Two panel figure showing (left) the OPC surface analysis for 1800 UTC 1 Dec 2004 for an intense North Pacific cyclone. Also shown are the GOES IR imagery and available ocean surface observations from ships of opportunity. The right panel displays the QuikSCAT 12.5 km resolution OSVW available to the OPC High Seas forecaster as displayed on the operational N-AWIPS workstations. Red wind barbs indicate wind speeds of Hurricane Force intensity.

Tropical Cyclone Analysis and Forecasting

The mission of Tropical Prediction Center/National Hurricane Center (TPC/NHC) is to save lives, mitigate property loss, and improve economic efficiency by issuing the best watches, warnings, forecasts, and analyses of hazardous tropical weather, and by increasing understanding of these hazards. One of the most significant challenges in accomplishing this mission is the scarcity of data over the oceans. Winds from the QuikSCAT scatterometer have filled in some of these gaps since the data have been available in near real-time and have been integrated into the daily operations of both the NHC and TAFB since 2000.

QuikSCAT data have had a major impact in TC forecasting by providing estimates of:

a) determination of tropical cyclone (TC) 34-knot and 50-knot wind radii (Fig 2);
b) tracking of TC center location, including the initial identification of TC formation;

Experience has shown that while automated wind direction solution from QuikSCAT selected wind vectors is sometimes misleading, manual analysis of QuikSCAT ambiguities (alternative wind solutions) can often be used to identify early-stage closed circulations (Fig. 3) and to locate the centers of mature cyclones to precisions of a few tens of kilometres

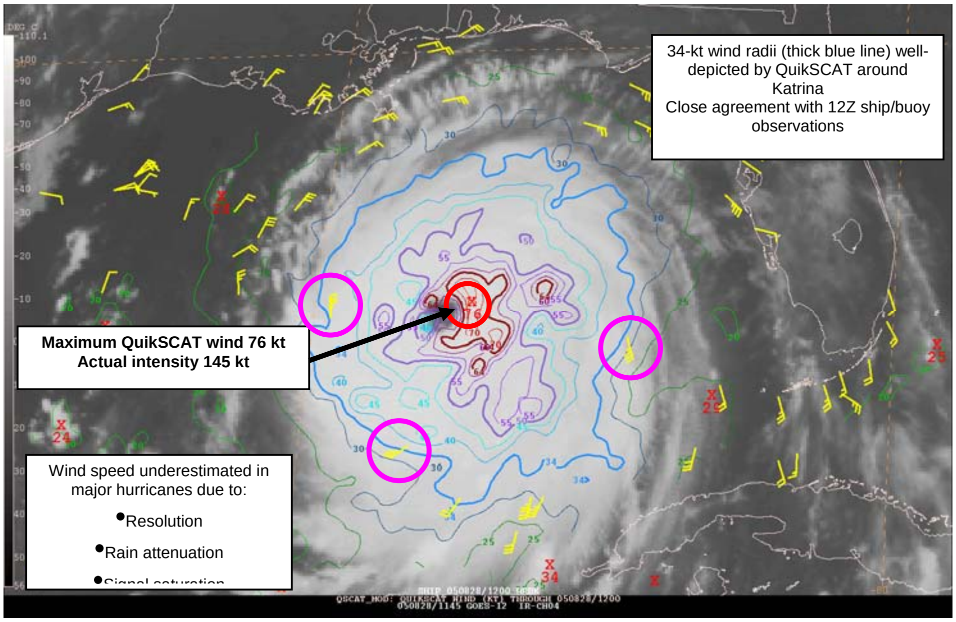
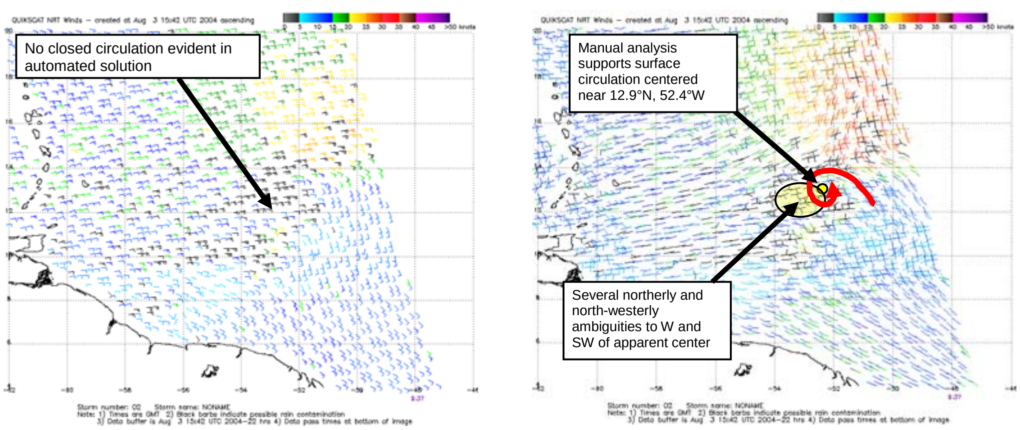


Fig. 2 QuikSCAT pass over Hurricane Katrina at 1130Z 28 August 2005 highlights strengths and weaknesses of QSCAT in tropical cyclones



0937 UTC 3 August 2004 Advisories initiated on TD#2 (later Bonnie) partly based on this analysis. TC Discussion: "IT IS DIFFICULT TO ASCERTAIN IF THE SYSTEM...AN ESPECIALLY FAST MOVING ONE...HAS A CLOSED CIRCULATION WITHOUT DATA FROM A RECONNAISSANCE PLANE. YOU COULD MAKE THE CASE THAT A SMALL CIRCULATION EXISTS USING QUICKSAT AMBIGUITY ANALYSIS."

Fig. 3 Early identification of a tropical depression using QuikSCAT ambiguity analysis

Public forecasts and warnings

- Remotely-sensed ocean surface winds used as a diagnostic tool

Improved knowledge of upstream conditions over the oceans (lows, highs, wind maxima, fronts) gives both coastal and inland forecasters the ability to diagnose numerical model analyses and forecast fields for both coastal and land falling events. This often results in changes of warning criteria and the forecast timing of the onset of hazardous conditions.

- Coastal jets in the lee of caps and points

Prior to QuikSCAT, the extent and impact of orographically induced jets and lee wakes were not well known (Fig 4).

- Identification and warning of coastal gap

QuikSCAT winds have greatly improved the monitoring and forecasting of gap wind events as well, particularly in the Gulf of Tehuantepec. Prior to the advent of QuikSCAT, the extent and magnitude of many of these high wind events was unknown due to a lack of observations.

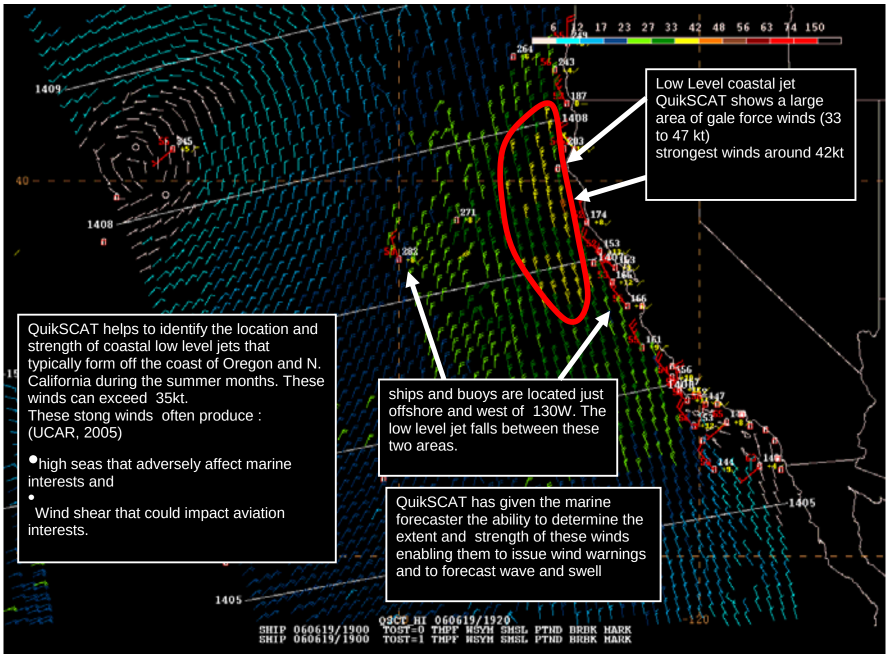


Fig. 4 Example of Coastal Low Level Jet off the California coast as observed using the 12.5 km QuikSCAT pass from 1400 UTC 19 June 2006

- Improved surf/swell forecasts

Detailed ocean surface winds give forecasters a detailed view of swell generation areas and the ability to better diagnose the quality of numerical wave model guidance. This supports the NWS's increased focus on rip current forecasting.

Numerical Weather Prediction

Satellite surface wind data improve numerical weather prediction (NWP) model forecasts in several ways. OSVW data

- contribute to the improved analyses of the surface wind field, and, through the data assimilation process, of the atmospheric mass and motion fields in the free atmosphere above the surface.
- provide important verification data for NWP model forecasts
- drive ocean models and surface wave models, to calculate surface fluxes of heat, moisture and momentum, and to construct surface climatology.

QuikSCAT Product Limitations

Eight years of operational experience with the satellite vector wind data has highlighted the need for product improvements in the following areas to support the present needs of NOAA operational forecasters and centers:

d) Measurement accuracy and quality
   - Rain contamination, leading to inaccurate retrievals in rainy conditions and an inability to measure maximum winds near the centers of tropical and extratropical (i.e., mid-latitude) cyclones.
   - Ambiguity removal (wind directional uncertainty) degrading the analysis of cyclone center locations.
   - Arbitrary limitations in retrieval algorithms, leading to maximum reported speeds of 50 m/s (100 knots).

e) Measurement spatial and temporal ("revisit") resolution, and latency
   - 12.5- and 25-km resolution products cannot resolve important specific small-scale, high wind speed features near the centers of storms and cyclones, or small-scale gap winds near islands such as the Aleutians.

- The present 30-km land mask (designed to avoid land contamination of wind measurements) eliminates data within the critical near shore areas of responsibility of most coastal WFOs.
- Insufficient revisit frequency from a single (albeit broad-swath) polar orbiting instrument, leads to the unavailability of timely (within 3-6 hour) wind data during some forecast cycles.
- Inadequate data timeliness during rapidly changing meteorological conditions (the QuikSCAT "near-real-time" requirement of 180 minutes from data acquisition to product availability, developed prior to launch, has been found through operational experience to be too long).

f) Data product provisioning and training
   - Lack of user documentation for NOAA operational satellite wind products
   - Limited training materials available for NOAA operational forecasters.

New NOAA OSVW Requirements

After much discussion, the workshop participants focused on the essential vector wind product requirements

- All-weather retrievals (i.e. accurate retrievals in rain)
- Accuracy levied upon the selected 10-meter 1-minute sustained wind as defined by operational requirements
  - 0–165kt wind speed range
    - 10–165kt: speed +/- 2kt and direction +/- 10 degrees (2 sigma)
    - 4–10kt: speed +/- 2 kt and direction +/- 20 degrees (2 sigma)
    - 0–4kt: speed +/- 2kt
- Revisit time interval (defined as the time interval between measurements at a particular point on the ocean surface): every 6 hours (1–3 hour goal)
- Reduced product latency: 45–60 minutes from measurement to product availability (15 min goal)
- 2.5 km x 2.5 km grid spacing which is defined as the spacing between unique wind vector retrievals (1 km x 1 km goal)
- Unique wind vector grid cells to within 2.5 km of the coast (1 km goal)
- Wind fields must be delivered into the operational environment and data assimilation systems
- Product documentation / tutorial / training

These refined requirements:

a) ensure accurate measurements in the presence of extreme wind conditions such as those found in intense storms and cyclones by extending the upper wind speed limit to 165 kt, (in the category 5 hurricane range), and requiring accurate measurements in the presence of rain;
b) increase the spatial resolution (decrease the characteristic dimensions) of individual measurements to allow definition of small-scale features in synoptic and mesoscale systems, provide accurate vector wind measurements closer to the coast, and allow estimation of the required 1 minute sustained wind speed from the instantaneous spatially averaged wind measured by the spaceborne instruments; and
c) emphasize the overall operational requirement for an observing system (likely multi-platform) that satisfies revisit frequency requirements for measurements at every open-ocean location.

Workshop participants from the research community noted that the above refined operational requirements would result in data products that would significantly enhance the present research applications of the oceanographic, meteorological, and climate research communities.

Eight years after NOAA first began utilizing QuikSCAT OSVW for operational use, and more than three years after the launch of WindSat, the nation still has no firm plans for operational acquisition of adequate OSVW data. Now is the time to develop and execute a plan that addresses NOAA's present and future operational satellite ocean surface vector wind requirements.

Reference:
NOAA Operational Satellite Ocean Surface Vector Winds Requirements Workshop Report
http://manati.orbit.nesdis.noaa.gov/SVW_nextgen/SVW_workshop_report_final.pdf