The WindSat Passive Microwave Radiometer: Forecaster Applications

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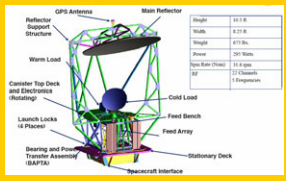
WindSat Polarimetric Radiometer:

Objective: Ocean surface wind vectors via polarimetric microwave radiometry

Purpose: Risk reduction for NPOESS CMIS sensors

Channels: 10.7, 18.7, 37.0 GHz Fully polarimetric

6.8, 23.8 GHz Dual polarimetric



Launch: January 6, 2003

Altitude: 830-km

LTAN: 1759

Spacecraft: Coriolis

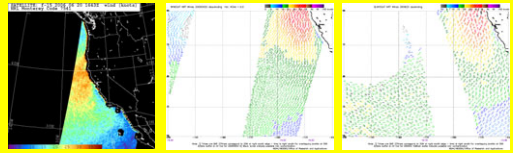
Freq, GHz	Channels	NEDT (1)	FOV, km
6.8	v, h	0.48	40x60
10.7	v, h, ±45, lc, rc	0.37	25x38
18.7	v, h, ±45, lc, rc	0.39	16x27
23.8	v, h	0.55	12x20
37.0	v, h, ±45, lc, rc	0.45	8x13

SSM/I, WindSat, QuikScat Comparisons

SSM/I Wind Speed — 20 June 2006 1452 UTC

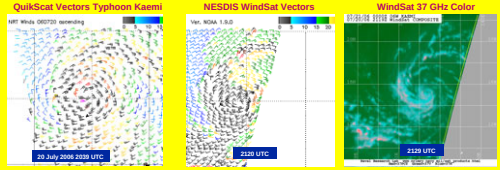
NESDIS WindSat — 20 June 2006 1643 UTC

NESDIS QuikScat — 20 June 2006 1338 UTC

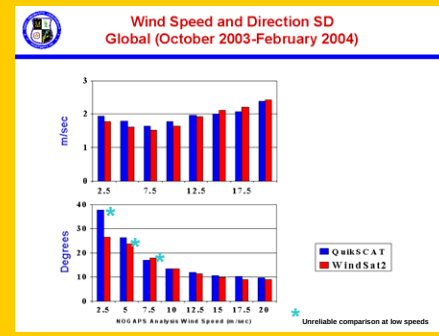


SSM/I shows speed-only depiction (left), but WindSat and QuikScat show wind vector retrievals. All depict fast winds off the Central California Coast (red/orange coloration).

QuikScat Vectors Typhoon Kaemi — NESDIS WindSat Vectors — WindSat 37 GHz Color



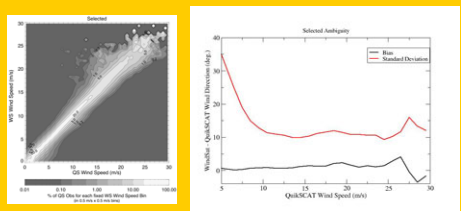
Black shows rain-flagged retrievals in Typhoon. QuikScat (left) gives reasonable center of Circulation. WindSat center of circulation (center) is less accurate compared to image (right).



QuikScat and WindSat retrievals were both compared to NOGAPS surface winds for conditions without rain from 0 to 20 m/s. While not ground truth, NOGAPS is a good comparison standard. WindSat and QuikScat have similar departures from NOGAPS except for directions at low speeds where the comparison is not reliable.

Interpreting WindSat Products

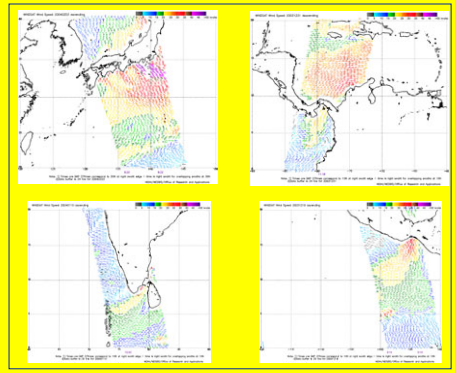
- Retrievals are based on radiometer measurements, similar to Special Sensor Microwave (SSM/I) and Special Sensor Microwave Imager Sounder (SSMIS)
- In contrast with SSM/I and SSMIS (speed only), retrievals include wind direction
- WindSat valid speed range is from 3 – 25 m/s (6 – 50 kts)
- Direction retrievals are degraded in regions of low speeds, below about 7 m/s
- Retrievals are significantly degraded in regions of precipitation or heavy cloudiness
- No retrievals are possible within about 75 km of coastlines
- 50 Km horizontal cell size, though data are output at 13 km
- 1000 Km swath width



Left Side: QuikScat wind speeds vs. WindSat wind speeds. Correspondence is good up to about 25 m/s. Right Side: QuikScat directions vs. WindSat directions. Large differences in direction below 10 m/s indicates degradation of retrievals at low speeds, especially for WindSat. WindSat retrievals are from Bettenhausen et al. 2006.

Gap Winds of the World using WindSat

NOAA NESDIS Algorithm

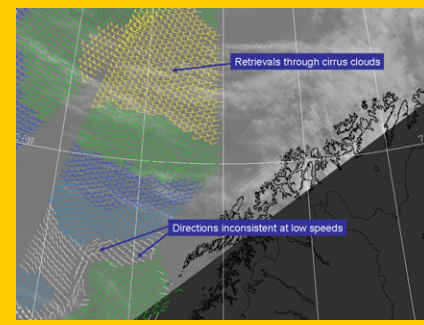


Upper Left: Japan; Upper Right: Panama; Lower Left: India/Sri Lanka; Lower Right: Mexico (Tehuantepec Gap)

Directions at Low Speeds

7/24/2006 WindSat overlayed on NOAA-15 IR

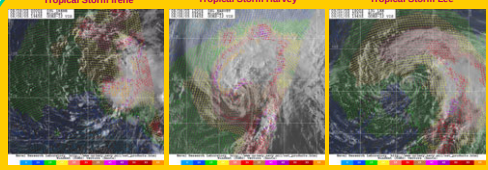
Norwegian Coast is shown



Wind vectors using the Naval Research Laboratory algorithm (Bettenhausen et al. 2006) off Norway. Notice that most winds are horizontally consistent with one another. But directions in the light wind region (cyan and white) vary considerably.

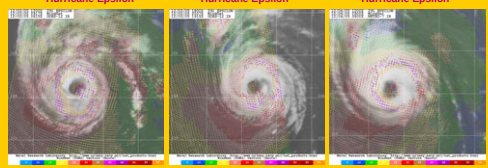
WindSat Wind Vectors

Tropical Storm Irene — Tropical Storm Harvey — Tropical Storm Lee



WindSat wind vectors overlain on coincident GOES-12 visible imagery for three Atlantic tropical storms. Examples readily depict WindSat's ability to monitor surface wind fields for heavily sheared systems. Exposed low-level circulations and their highly asymmetric wind fields can be mapped in non-rain areas. Note dramatic discontinuities in wind speed with Irene and Lee both exhibiting winds < 10 kt in the SW quadrant and gale force winds in the NE. All winds are from the operational WindSat algorithm at FNMOC (Bettenhausen, et al., 2006) and no attempt has been made to refine the rain flag algorithm or modify values if they are rain contaminated (small circle at base of wind barb tail). Rain flagged data should be used with caution.

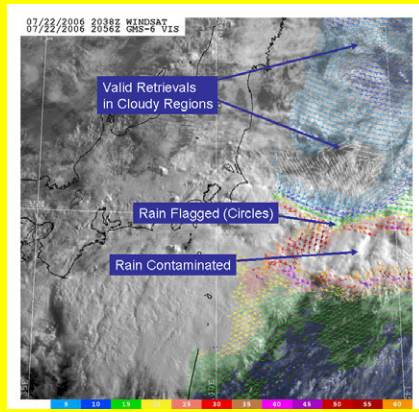
Hurricane Epsilon — Hurricane Epsilon — Hurricane Epsilon



WindSat wind vectors overlain on GOES-12 and Meteosat-7 IR for three overpasses of Hurricane Epsilon (Atlantic basin), each twelve (12) hours apart. Note: 1) large rain-free eye permits retrieval attempts in huge eye, 2) consistent high wind speed asymmetry in SW quadrant, 3) 1025-km swath can infrequently provide multiple views/day and supplement QuikSCAT and ERS-2 data in Atlantic basin. Typical temporal coverage is less optimal.

WindSat Retrievals off of Japan

Most clouds don't affect retrievals



Naval Research Laboratory (NRL) retrieval (Bettenhausen et al. 2006) showing retrievals in cloudy regions, rain-impacted regions of reduced accuracy (circles on the barbs), and significant rain (no retrievals overlaid). Fortunately, clouds do not interfere with the retrievals of most vectors.

Conclusions

- WindSat has demonstrated that the surface wind vector can be retrieved from space.
- Winds are valid from about 3 to 25 m/s.
- Wind directions are degraded at slow speeds.
- WindSat vectors can be retrieved through most clouds.
- Winds are degraded (flagged) or contaminated (not shown) in regions of heavy clouds or precipitation. The WindSat radiometer design makes this determination straightforward.
- Though affected by precipitation, QuikScat retrievals are less affected by the atmosphere.
- NPOESS will have an operational conical scanning passive radiometer. Specifications of this new instrument are being finalized. It may have a similar wind vector capability as WindSat.

Reference:

Bettenhausen, M. H., C. K. Smith, R. M. Bevilacqua, N. Wang, P. W. Gaiser, and S. Cox, 2006, A nonlinear optimization algorithm for WindSat wind vector retrievals. Volume 44, IEEE Trans. of Geosci. Rem. Sensing, (WindSat special Issue).

Training through COMET

http://meted.ucar.edu/npoess/ocean_winds/index.htm

Acknowledgments:

The authors are grateful to the support of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Integrated Program Office (IPO). The support of the research sponsors, the Oceanographer of the Navy through the program office at the PEO C4I&Space/PMW-180, under program element PE-0603207N and the Office of Naval Research under program element PE-0602435N is also gratefully acknowledged.