Revaluating Passive Ocean Vector Winds: WindSat Retrievals

Michael H. Bettenhausen, Ian S. Adams and Peter W. Gaiser
Remote Sensing Division, Naval Research Laboratory

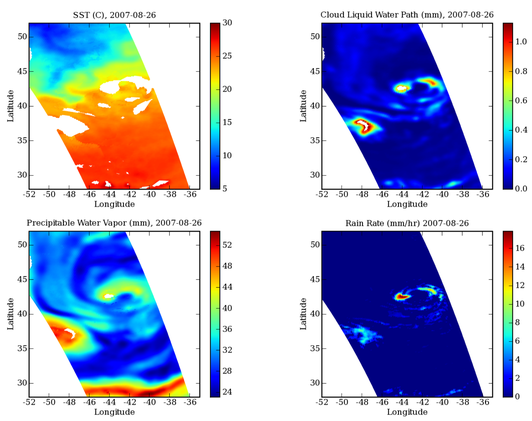
WindSat Description

- WindSat has demonstrated ocean surface vector wind (OSVW) measurement capability with polarimetric microwave radiometry.
  - Algorithms continue to improve
- Jointly Sponsored by US Navy and the NPOESS Integrated Program Office; Designed and build by the Naval Research Laboratory (NRL)
- Launched 2003-01-06 on STP's Coriolis satellite bus into sun-synchronous orbit
- More than 71 months of data collected
- Risk reduction for NPOESS Microwave Imager / Sounder (MIS)
- WindSat Special Issue, IEEE TGRS, March 2006.

WindSat OSVW Retrieval Algorithms

- NRL
  - Optimal estimation algorithm
  - Near-real-time and archive data available
  - Continues to improve (see details right)
- NOAA/NESDIS
  - Regression algorithm (uses sensor data records from NRL algorithm v. 1.9.0)
  - Initial six-month global data set released 2004 (NESDIS-1)
  - Near-real-time retrievals with updated (2006) algorithm (NEDIS-2); data available in N-AWIPS
- Other research algorithms (see references)

Other Ocean EDRs



WindSat Ocean Data Utilization and Availability

Utilization

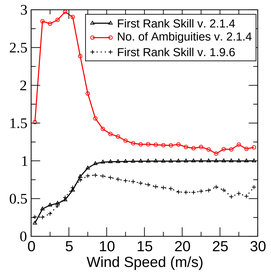
- Near real-time processing of imagery and ocean EDRs (NRL v. 1.9.6) at US Navy Fleet Numerical Meteorological and Oceanographic Center (FNMOC)
- Tropical cyclone monitoring and forcasting
  - NRL-Monterey, FNMOC, Joint Typhoon Warning Center and National Hurricane Center
- Data assimilation into numerical weather prediction models
  - operational use (NRL v. 1.9.6) by Navy (NAVDAS/NOGAPS), U.K. Met Office, NOAA NCEP GFS
  - in testing for ECMWF

Data availability

- Near real-time data (NRL v. 1.9.6) on shared processing network (NESDIS, NAVO, NRL-Monterey, AFWA, CSU/CIRA)
- Archive data set
  - ocean EDRs (NRL v. 2.1) and brightness temperatures (SDRs) (v. 2.1): http:www.cpi.com/datacenter
- Near real-time wind images (NRL v. 2.1) at http://nrl.navy.mil/windsat
- Near real-time data in N-AWIPS (NESDIS algorithm)

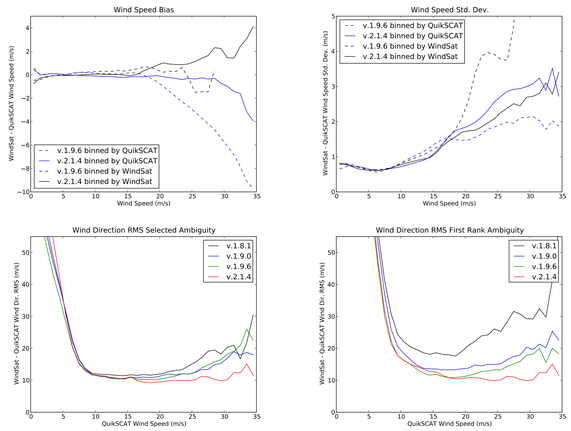
NRL WindSat OSVW Retrieval Algorithm - Chronology

- Version 1.8.1 (March 2005)
  - Used for first NRL archive data release in March 2005
  - Description in [Bettenhausen; 2006]
- Version 1.9.0 (Feb. 2006)
  - Second archive data release in Feb. 2006
  - New sea surface emissivity model which includes V-pol and H-pol directional signals – improves wind direction performance.
- Version 1.9.6 (June 2007)
  - Current operational version
  - Improved interpolation and footprint matching of WindSat measurements. Most important near clouds or coastlines.
  - Rain rate added (based on GPROF algorithm)
  - First-order correction to mitigate thermal gradients in the warm calibration load.
  - Improved quality control (sea ice, land contamination, etc.)
- Version 2.1.4 (April 2009)
  - Current archive data set
  - Improved modeling for high winds ($>$ 20 m/s)
  - Three resolutions:
    - Low: 50 km x 71 km (available in all releases)
    - Medium: 35 km x 53 km (2008 and later)
    - High: 25 km x 35 km (2008 and later)
  - Improved ambiguity selection skill and reduced influence of NWP wind field used for initialization (nudging)
  - Improved rain and RFI flags



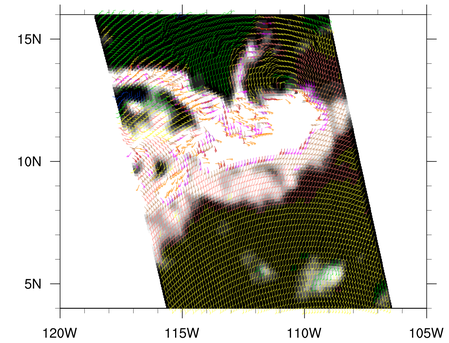
Statistical Evaluations of WindSat OSVW Retrievals

- Several statistical evaluations of WindSat retrieval performance
  - Freilich and Vanoff, 2006: based on NESDIS-1 and NRL v. 1.8.1
  - Monaldo, 2006: based on NESDIS-1
  - Atlas, et al, 2007: based on NRL v. 1.8.1 and v. 1.9.0
  - Bi, et al, 2007: based on NESDIS-2 and NRL v. 1.9.6
  - Candy, et al, 2008: based on NRL v. 1.9.6
- We use method similar to that of Monaldo to compare the versions of the NRL WindSat wind retrievals
  - Compare to nearest QuikSCAT wind retrieval within 25 km and within one hour of the WindSat measurement
  - Six-month data set: 2003-09 through 2004-02
  - Exclude rain (cloud liquid water (CLW) retrieval $>$ 0.2 mm), land and sea ice contamination
- Results below show:
  - Wind speed and direction performance at high wind speeds is substantially improved in the current version. (Wind speed performance for v. 1.8.1 and v. 1.9.0 is similar to v. 1.9.6.)
  - First rank performance has improved substantially – reduced importance of the initialization field (NWP) used for the median filter



Tropical Depression

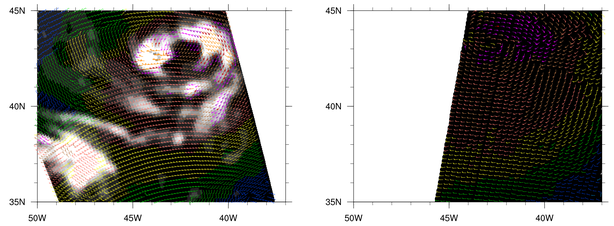
- 2006-07-11 at 0116 UTC, Tropical Depression 3-E
- Brennan and Knabb (2007) evaluated NESDIS WindSat wind retrievals
- Below we show NRL v. 2.1.4 medium res. WindSat retrievals
  - Circulation center indicated at 13N, 111W versus the NHC best track position of 13.3N, 110.4W
  - Sharp wind direction shifts along cloud liquid water (CLW) gradients noted by Brennan and Knabb are not present
  - Wind retrievals are sensitive to rain but not CLW $<$ 0.2 mm
  - Peak wind speeds outside raining regions is 30-35 knots WSW of circulation center agrees well with QuikSCAT



WindSat 2006-07-11 at 0116 UTC, v.2.1.4 medium res.

Extra Tropical Cyclone

- Good agreement between QuikSCAT in the absence of rain
- WindSat CLW helps to explain QuikSCAT retrievals

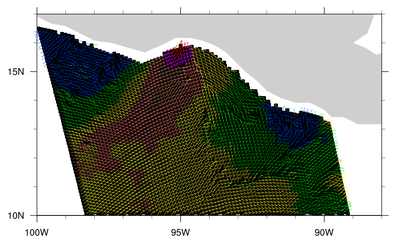


WindSat medium res. 2007-08-26 2020 UTC.

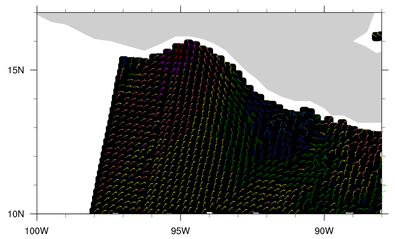
QuikSCAT 25-km 2007-08-26 2049 UTC.

Gulf of Tehuantepec Gap Wind Event

- Comparison of WindSat and QuikSCAT wind retrievals
- Maximum wind speed retrievals for WindSat (48.4 knots) and QuikSCAT (45.7 knots) are collocated to within 10 km
- Spatial distribution of wind speeds agrees well
- Maximum wind speed occurs close to coastline where WindSat low res. is not available
- Maximum WindSat low res. wind speed is 39.8 knots



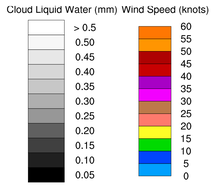
WindSat high res. winds 2007-03-07 0001 UTC



QuikSCAT 25-km winds 2007-03-07 0006 UTC

Graphical Display of WindSat Winds

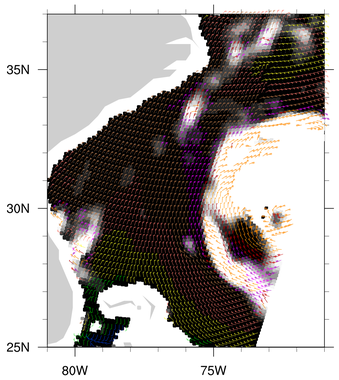
- Current NRL WindSat wind retrievals are sensitive to rain
- Visual interpretation of WindSat retrievals is aided by knowledge of CLW or rain in the scene
- WindSat winds are shown here with a gray-scale background based on WindSat CLW retrieval
- Winds are displayed using colored barbs



Colorbars for WindSat wind retrieval figures.

Hurricane Isabel

- Maximum wind speed retrieved away from rain is 75-80 knots
- Indicated location of the eye agrees with NHC best track at 1200 UTC of 29.7N, 72.5W



WindSat medium res. 2003-09-17 1120 UTC

Conclusions

- Latest NRL WindSat algorithms provide important improvements
  - Accurate wind vector retrievals for high wind speeds
  - Higher resolution retrievals for increased coverage near coastlines and rain
- Current retrievals are sensitive to rain and rain contaminated retrievals should be discounted
- NRL and other groups (see refs.) are working to improve retrievals under rain
- Additional study needed to assess pros/cons of retrievals at different resolutions

References

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Acknowledgements

- The QuikSCAT L2B OWV 25 km swath data were obtained from the Physical Oceanography Distributed Active Archive Center (PO.DAAC) at the NASA Jet Propulsion Laboratory, Pasadena, CA. http://podaac.jpl.nasa.gov.

Mail: bettenhausen@nrl.navy.mil
WWW: http://www.nrl.navy.mil/windsat