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Motivation

• There is tremendous interest in both the operational and research communities in high wind event observations
• However, there exist large disparities in wind intensity estimates between different sensor observations as well as between different wind products from the same sensor and there is a general lack of surface truth
• Disagreements stem from differences in:
  – Measurement resolution
  – Sensor sensitivity to high winds
  – Geophysical model functions
  – Retrieval algorithm approaches
  – Atmospheric and sea state impacts on measurements
• High wind algorithm and product developments led by NOAA STAR Winds Team, RSS, JPL, JAXA, Meteo France, ESA
Remote Sensing Systems: Bringing Consistency into High Wind Measurements with Spaceborne Microwave Radiometers and Scatterometers

Product development based on H*Wind, SFMR, Dropsondes collocated with WindSat. All RSS Radiometer and Scatterometer retrievals calibrated to match WindSat

QuikScat (Ku 2011) vs WindSat
1-hour match-ups 2003 - 2019

RSS ASCAT (V2.1) vs WindSat
2-hour match-ups 2007 - 2017

SMAP vs WindSat
1-hour match-ups 2015 -

Presented by Thomas Meissner IOWVST 2017

BAMS September 2017 issue
http://journals.ametsoc.org/doi/10.1175/BAMS-D-16-0052.1 in print
JPL High Wind Product Development

- Product development based on SFMR, Dropsondes, H*Wind model and best track

Presented by A. Fore (JPL)
High winds Workshop Nov 2016, Exeter

QuikSCAT All weather high wind speed
Presented by B. Stiles
IOVWST 2013
JAXA AMSR-2 High Wind Product

- The product contains wind speeds in the best track of typhoons announced by Japan Meteorological Agency and NOAA National Hurricane Center.
- The wind speeds above 17 m/s retrieved by this algorithm were compared with the maximum wind speeds within 200 km from the center position of the best track or the wind speeds observed by dropsondes.
- Utilizes 6.9- and 10.7- GHz H channels. This algorithm realizes to retrieve the sea surface wind speed more than 70 m/s.

Presented at JAXA/EORC, RESTEC Nov 2015
Developed by Dr Akira Shibata
Calibration, validation and product improvements of current scatterometer and radiometer satellite measurements

New instrument design and risk reduction for future satellite instruments

New insights into physics of hurricane force winds within extratropical storms

NESDIS/STAR Ocean Winds Aircraft Experiment

Marine weather forecasting and warning

R2O

RapidSCAT

ASCAT

NWP Impact

QuikSCAT

OSCAT

AMS-2

DFA

XOVWM

CYGNSS

NWP

R2O

Drifting Buoy

Radiosonde

Uoropsonde

GAP Wind

RapidSCAT Wind

ASCAT Wind

AMS-2UA

Land Surface MODIS Wind

WRF

Aircraft ATMS Ship ARPS IASI

MIP CYS NEXRAD Wind HRRR SEVIRI

GOES Profiler Wind

Impact per Observation (J/kg)
NOAA ASCAT Scatterometer High Wind Product

- Geophysical model function developed using airborne IWRAP scatterometers and SFMR radiometer measurements
- Satellite GMF tuned to match SFMR and dropsonde measurements in ETC
- Utilized in operations since 2011
  - Considered to have best high wind retrievals within ETC by operational community

International Satellite High Wind Workshops

Recommendations

• Two high wind validation workshops held in 2015 (Miami/NOAA) and 2016 (Exeter/ESA)
  – Agreed that dropsondes WL150 wind speeds will be our standard for truth.
  – SFMR winds will be the transfer mechanism from dropsondes winds to satellite winds.

• Intercalibration of multiple-datasets by analyzing differences and similarities between the Passive and Active MW measurements.
  – Two wind regimes of strong interest:
    • overlap range between L-band, C- and Ku-band : 15-32 m/s
      – Extratropical cyclones ideally suited for ensuring consistency between scatterometer and radiometer observations
    • high wind regime > 33 m/s

• Recommendations:
  – Improve calibration by starting where products are similar and moving to higher wind speeds as sufficient comparison data exist.
  – Attempt to develop model function that also accounts for sea state and heavy rain (if found to be important)
  – Possible dependence on storm motion, SST, latitude, wave directions ? We suggest to use radii at 34Kts (18m/s), 50Kts (25.7) and 64Kts (33m/s) as this is relevant to the forecasters.
  – We can also look at EKE, integrated power dissipation
    • look at other indices to help understand the tropical winds (quick ways to compare data sources)
Novel Approach for Satellite High Wind Validation: Comparison of ETC Wind Field Structures

- All currently operational scatterometers and radiometers have adequate spatial resolution to observe high winds in extratropical cyclones
  - Winds in extratropical cyclones span up to 40m/s in most mature storms over the area of 100-1000km

- Satellite observations of extratropical cyclones
  - ASCAT-A: KNMI, NOAA and RSS
  - Microwave Radiometer wind products:
    - SSMIF16, SSMIf17, WindSat, AMSR-E, GMI (RSS)
    - AMSR-2 (NOAA, JAXA, RSS)

- RSS high wind products based on H*wind model and SFMR high wind measurements

- SMAP JPL based on SFMR TC measurements

- JAXA AMSR-2 dropsondes and best track max wind

- NOAA ASCAT high wind gmf based on SFMR/IWRAP observations of extratropical cyclones
Extratropical Storm Life Cycles
(adapted from Shapiro – Keyser Cyclone Model)
Storm track file

Read HF Cyclone Info.

Extract Satellite 12.5km Data & Perform QC (land, ice, coast, rain) flags

Generate Mean Wind Fields

Estimate speed & Angle (Heading Vector)

Mean motion

Storm motion

Mean motion

5000km

5000km

Generate Frequency of HF Occurrence per grid fields
ASCAT-A Products Comparison
2007-2015
Spatial Resolution 35-60km

North Atlantic

North Pacific
STAR JPSS Annual Science Team Meeting, 14-16 August 2017

North Pacific

Frequency of Hurricane Force Winds >62kts

Frequency of Storm Force Winds 48-61kts

Frequency of Gale Force Winds 34-47kts
AMSR-2/ASCAT
Wind Products Comparison 2012-2017
Spatial Resolution ~10-60km
AMSR-2/ASCAT
Wind Products Comparison 2012-2017
Spatial Resolution ~10-60km
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Frequency of Gale Force Winds 34-47kts

Frequency of Storm Force Winds 48-61kts

Frequency of Hurricane Force Winds >62kts
ATL ASCAT A/B NOAA - % hur. force winds

NOAA ASCAT

NOAA AMSR-2

JAXA (HW) AMSR-2

RSS AMSR-2

Frequency of Hurricane Force Winds >62kts

ATL ASCAT A/B NOAA - % storm force winds

ATL ASMR NOAA - % storm force winds

ATL ASMR JAXA - % storm force winds

ATL ASMR RSS - % storm force winds

North Atlantic

Frequency of Storm Force Winds 48-61kts

ATL ASCAT A/B NOAA - % gale force winds

ATL ASMR NOAA - % gale force winds

ATL ASMR JAXA - % gale force winds

ATL ASMR RSS - % gale force winds

Frequency of Gale Force Winds 34-47kts
STAR JPSS Annual Science Team Meeting, 14-16 August 2017

**Frequency of Gale Force Winds 34-47kts**

**Frequency of Hurricane Force Winds >62kts**

**Frequency of Storm Force Winds 48-61kts**

North Pacific
AMSR-2 February 6th, 2017
Extratropical Storm Observations
Evaluating Wind Speeds with Respect to Sea State Data Collection

Products:
- 12.5km ASCAT A/B winds
- 12.5, 25km RapidScat winds, including NRCS
- Windsat, GMI, AMSR-2, SSMI-F16/17 from RSS
- AMSR-2 NOAA

Models:
- ECMWF wind
- IFREMER wavewatch (hindcast)

Each collocated (via bilinear interpolation) with

Match up time period: July 1st 2014-Sep 30th 2015
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NOAA AMSR-2

Hs
Wind Sea Hs
First Swell Hs
Whitecap %
NOAA ASCAT-A

Hs

Wind Sea Hs

First Swell Hs

Whitecap %
Second Generation
NOAA AMSR-2 Wind Speed Product

• 2\textsuperscript{nd} Generation Wind Speed Algorithm
  – Uses all 6-36GHz channels
    • Proper channel weighing functions in different atmospheric regimes ensure that higher resolution features are preserved as much as possible
  – New product is all weather wind product
    • Significant improvement of winds in rain is achieved
    • Improved winds within ITCZ zone
    • Improved winds in Southern Hemisphere
  – Winds as close as 25km of the coast
NOAA 1st Delivery

AMSR2 SSW 1st Delivery, m/s
Conclusions

- 1st stage high wind validation performed. We have assessed performance of NOAA AMSR-2 Operational wind speed product performance within extratropical cyclones with respect to NOAA ASCAT, two JAXA wind products and all RSS radiometers
  - Wind field structure from NOAA Operational AMSR-2 product is:
    - On mean close to ASCAT and JAXA high wind product
    - Slightly overestimates storm force wind structure
    - Affected by rain
    - Affected by sea state
    - SFMR, IWRAP and dropsonde database developed and ready to be used for wind validation within tropical cyclones
- 2nd Generation product designed that addresses:
  - Wind retrieval performance in rain
  - High wind estimates overall intensity in rain and southern hemisphere
KNMI, NOAA and RSS ASCAT
High Winds Case Study
Extratropical Storm Feb 1\textsuperscript{st}, 2010
NOAA P3 Flight
Corrected SFMR, RSS ASCAT–A

Wind Speed (m/s)

Hour of Day

Time Difference (Hr.)
RSS

NOAA (CMOD5.h)
200km
40kts
120km
40kts

KNMI (CMOD5.n)
100km
40kts

[knots]