Launch: September 21, 2014 on a SpaceX Dragon spacecraft.

Mission duration: 2 years. May extend if Columbus ISS site remains available...Currently until February 2017

Instrument: Dual-polarization, Ku-band pencil beam scatterometer using engineering hardware from the QuikSCAT mission.

Measurement accuracy: QuikSCAT-level accuracy with 25 and 12.5 km spatial resolution (pre-anomaly). Only 12.5km retrievals available post anomaly with some degradation in statistical performance compared to pre-anomaly products.

Measurement swath: ~800 km (varies with ISS altitude)

Data products: near real-time (NRT) data produced by JPL and distributed to operational users around the world, science data distributed through NASA’s Physical Oceanography Data Active Archive Center (PODAAC).

Mission timeline: the instrument was assembled largely from QuikSCAT and new parts, integrated and tested in less than 2 years,
Provided in near real-time for:

- NAWIPS environment for the NWS National Centers
- The JSCDA for data assimilation
- Web portal for NWS WFO’s and broader community

Ana Best Track Intensity
1800 UTC 8 May
45 kt/1000 mb
34-kt wind radii: 100 100 80 100

Higher resolution retrievals show higher winds in general, both in and outside of rain

12.5-km RapidScat

http://manati.star.nesdis.noaa.gov/rapidscat
RapidScat publicly available in NRT via NESDIS/STAR Ocean Winds Manati web page since Dec 1\textsuperscript{st} 2014

- Global images and zoomed in images of selected winds
- Zoomed in images of all ambiguities
- Tropical Storm centered wind vector retrievals
- Tb and u and v-wind component monitoring pages
- Alerts to RapidScat scheduled outages

http://manati.star.nesdis.noaa.gov/datasets/RSCATData.php
NOAA users are currently using ASCAT-A, ASCAT-B, and RapidScat in their operations.

ISS orbit provides swaths cutting SE/NW or NW/SE across the extratropics and tropics.

These orbits cut across ASCAT swaths and help fill gaps in coverage especially at lower latitudes.
RapidScat NRT Monitoring

- Implemented near real-time monitoring of wind retrieval performance and platform attitude (http://manati.star.nesdis.noaa.gov/rapidscat)
  - The relative instability of the ISS platform enhances the need for continuous
  - Attitude knowledge is good and should be accounted for in the wind retrieval processing, but...
  - Allows users to check for any anomalous behavior to aid in interpretation of products

- RapidScat planned outages posted at http://manati.star.nesdis.noaa.gov/rscat_images/monitor/RapidScat_Scheduled_Outages.txt
Monitoring RapidSCAT
Wind Speed and Direction

Non optimal geometry
Post anomaly
Monitoring RapidSCAT Position Information

Daily averaged incidence angle (Sep 15 2015)

Daily averaged roll

Daily averaged yaw

Daily averaged altitude

Non optimal geometry

Post anomaly
Black wind barb indicates flagged for possible rain contamination. Black circle indicates that not all four NRCS measurements were available for the retrieval.
RapidScat Anomaly

• On August 15, 2015 RapidScat experienced a sudden drop in measured power
  • This sudden drop in power resulted in the wind processing system unable to process the RapidScat data to the standard products
  • The anomaly has been isolated to the Scatterometer Electronic Subsystem (SES), basically with the receiver of RapidScat
• The RapidScat project reworked the wind processing system to compensate
  • **RapidScat wind products are now being produced at 12.5km**
    • From statistical analysis some degradation at low winds < 6 m/s
      • More so in direction versus speed
      • Winds above 6 m/s are not significantly affected but statistics for 3-6 m/s are noticeably worse in the middle of the swath
    • Rainflags are not available for the outer edge of the swath
    • Qualitatively there appears to be some overflagging in the center of the swath
Statistical results-Pre anom.

![Graph showing statistical results for GDAS match up between Oct 3rd 2014 and March 23rd 2015, including a 2D contour plot and a 1D line graph. The graphs display the uncorrected wind speed compared to GDAS wind speed, with metrics such as total number of collocated points, correlation coefficient, bias, and standard deviation shown.](image-url)
Statistical results-Post anom.
GDAS MATCH UP--Aug 28-29 2015

Bias increase
RapidScat Post Anomaly Example
✧ Tropical Cyclones
✧ Gulf of Mexico Storm/Gulf of Tehuantepec
✧ Extratropical Cyclones
RapidSCAT Use for Tropical Cyclone Observations
Over the Atlantic ASCAT provides coverage between 22 and 03Z, useful for the 03Z TC advisory package over the central and eastern Atlantic, and for the 09Z package over the western part of the basin.
RSCAT fills in the gap nicely between 04Z and 09Z, cutting across the ASCAT swaths in the tropical and subtropics, helpful for the 09Z package over central and eastern parts of the basin.
ASCAT coverage is optimized for the 15Z TC advisory package over the central and eastern Atlantic.
RSCAT provides coverage over much of the Atlantic that can be useful for the 21Z TC advisory package.
Gulf of Mexico Storm Event
March 5-6 2015
Borderline Gale/Storm Force Tehuantepec Event

Nov 26th, 2014 14:20Z

RapiScat around 1420Z showed an area of 40-45 kt winds over a 50-60 n mi area.
ASCAT-B around 1540Z showed a much larger area of gale and 40+ kt winds, but about the same peak.

Which one should forecaster believe?
Note: 1) Times are GMT 2) Times along bottom correspond to measurement at 15N 3) Data buffer is 22 hrs from 20141126 4) Black circles indicate possible contamination

NOAA/NESDIS/Office of Research and Applications
Higher resolution products are ‘noisier’ however they are providing further details that sometimes results in warning category change.
Tehuantepec High Wind Events Climatology from Scatterometer Observations

Gale and Storm Force Tehuantepec Events 1999-2013
Through 3 April 2013

- 12.5-km QSCAT available Jan. 2003
- QSCAT failed Nov. 2009
- ASCAT available at NHC
- OSCAT available in NAWIPS at NHC Jan. 2011
Tehuantepec Event Trends

✧ 25-km QuikSCAT era (1999-2002)
  ➢ 15.6 total events per year – 13.3 gale, 2.3 storm

✧ 12.5-km QuikSCAT era (2003-2009, including ASCAT since 2007)
  ➢ 19.4 total events per year – 11.3 gale, 8.1 storm

✧ Post-QuikSCAT era (2009-2013)
  ➢ 21 events per year – 15.8 gale, 5.3 storm

✧ Gale force wind events increased in post-QuikSCAT era relative to storm force events
  ➢ Is this due to sensor differences?

Pro. 3. QuikSCAT pseudo-wind stress (vectors in m s⁻¹) and Ekman pumping velocity (shade in 10⁻⁴ m s⁻¹) climatology: (a) annual mean, (b) Jan-Apr, and (c) Jul-Oct. Land orography (km) is plotted in color shading.
RapidScat Observations
Tehuantepec: October-November

QuikSCAT observation times
ASCAT/OSCAT observation times
RapidScat Observations
Tehuantepec: December-January

QuikSCAT observation times
ASCAT observation times
Synoptic Setup
Strong Cold Front Moving into the
Gulf of Mexico

18Z 5 March 2015

00Z 6 March 2015

06Z 6 March 2015
Late Morning ASCAT Pass Showed Gale Conditions

1545 UTC
5 March 2015
Gale not seen in ship/buoy obs, but indicated by 40 kt ob at Tampico (MMTM)
Early Evening RapidScat Pass Showed Storm Conditions

2215 UTC
5 March
2015
**UPDATED FOR STORM WARNING IN GULF OF MEXICO BASED ON RAPIDSCAT**

**GULF OF MEXICO STORM WARNING...**

.COLD FRONT FROM 30N86W TO 26N92W TO 19N96W. W OF FRONT S OF 26N NW TO N WINDS 30 TO 40 KT. SEAS 8 TO 14 FT. W OF FRONT N OF 26N N WINDS 20 TO 30 KT. SEAS 8 TO 12 FT IN N SWELL.

.04 HOUR FORECAST COLD FRONT FROM 30N83W TO 24N93W TO 18N94W. S OF 20N W OF 95W **NW WINDS 40 TO 55 KT**. SEAS 10 TO 13 FT.

ELSEWHERE S OF 26N W OF 94W NW TO N WINDS 30 TO 40 KT. SEAS 11 TO 17 FT. REMAINDER AREA N OF FRONT W OF 86W N TO NE WINDS 20 TO 30 KT WITH HIGHER GUSTS. SEAS 8 TO 12 FT IN N TO NE SWELL...EXCEPT 10 TO 15 FT S OF 28N W OF 93W.
### Storm Conditions Observed at Sacrifice Island near Veracruz (SACV4)

| MM DD | TIME (CST) | WDIR | WSPD | CST | WHT | DPF | APD | MWD | PRES | PTDY | ATMP | WTMP | DEWP | SAL | VIS | TIDE |
|-------|-------------|------|------|-----|-----|-----|-----|-----|------|------|------|------|------|-----|-----|-----|------|
| 03 06 | 11:00 am    | N     | 27.0 | 29.9 | -   | -   | -   | -   | 30.34 | +0.02 | 60.8 | -57.0 | -    | -    | -   | -    |
| 03 06 | 10:00 am    | N     | 24.1 | 27.0 | -   | -   | -   | -   | 30.34 | +0.04 | 61.3 | -56.3 | -    | -    | -   | -    |
| 03 06 | 9:00 am     | N     | 28.0 | 33.0 | -   | -   | -   | -   | 30.33 | +0.08 | 59.9 | -58.5 | -    | -    | -   | -    |
| 03 06 | 8:00 am     | N     | 28.9 | 32.1 | -   | -   | -   | -   | 30.32 | +0.05 | 59.9 | -56.8 | -    | -    | -   | -    |
| 03 06 | 7:00 am     | N     | 31.1 | 35.0 | -   | -   | -   | -   | 30.30 | +0.04 | 59.7 | -56.5 | -    | -    | -   | -    |
| 03 06 | 6:00 am     | NNW   | 31.1 | 34.0 | -   | -   | -   | -   | 30.27 | +0.02 | 60.6 | -57.2 | -    | -    | -   | -    |
| 03 06 | 5:00 am     | N     | 29.9 | 35.9 | -   | -   | -   | -   | 30.26 | +0.02 | 60.4 | -57.7 | -    | -    | -   | -    |
| 03 06 | 4:00 am     | N     | 29.9 | 35.9 | -   | -   | -   | -   | 30.26 | +0.01 | 61.7 | -57.2 | -    | -    | -   | -    |
| 03 06 | 3:00 am     | N     | 35.0 | 40.0 | -   | -   | -   | -   | 30.25 | +0.01 | 61.9 | -56.1 | -    | -    | -   | -    |
| 03 06 | 2:00 am     | N     | 38.1 | 42.0 | -   | -   | -   | -   | 30.24 | +0.02 | 62.4 | -56.5 | -    | -    | -   | -    |
| 03 06 | 1:00 am     | N     | 38.1 | 42.0 | -   | -   | -   | -   | 30.25 | +0.04 | 62.4 | -56.8 | -    | -    | -   | -    |
| 03 06 | 12:00 am    | N     | 40.0 | 46.0 | -   | -   | -   | -   | 30.24 | +0.02 | 62.2 | -57.6 | -    | -    | -   | -    |
| 03 06 | 11:00 pm    | N     | 47.0 | 55.0 | -   | -   | -   | -   | 30.22 | +0.05 | 61.9 | -56.7 | -    | -    | -   | -    |
| 03 06 | 10:00 pm    | N     | 49.0 | 59.1 | -   | -   | -   | -   | 30.21 | +0.09 | 62.1 | -58.3 | -    | -    | -   | -    |
| 03 05 | 9:00 pm     | N     | 48.0 | 53.0 | -   | -   | -   | -   | 30.22 | +0.15 | 61.5 | -57.9 | -    | -    | -   | -    |
| 03 05 | 8:00 pm     | N     | 48.0 | 55.0 | -   | -   | -   | -   | 30.17 | +0.14 | 61.7 | -56.5 | -    | -    | -   | -    |
| 03 05 | 7:00 pm     | N     | 48.0 | 54.0 | -   | -   | -   | -   | 30.12 | -    | 61.7 | -60.1 | -    | -    | -   | -    |
| 03 05 | 6:00 pm     | N     | 51.1 | 56.9 | -   | -   | -   | -   | 30.07 | +0.06 | 63.1 | -58.8 | -    | -    | -   | -    |
| 03 05 | 5:00 pm     | N     | 45.1 | 52.1 | -   | -   | -   | -   | 30.03 | +0.03 | 65.1 | -58.5 | -    | -    | -   | -    |
| 03 05 | 4:00 pm     | N     | 48.0 | 55.0 | -   | -   | -   | -   | 30.01 | +0.05 | 66.0 | -61.9 | -    | -    | -   | -    |
| 03 05 | 3:00 pm     | N     | 48.0 | 55.0 | -   | -   | -   | -   | 30.01 | +0.05 | 66.0 | -61.9 | -    | -    | -   | -    |
| 03 05 | 2:00 pm     | N     | 42.9 | 51.1 | -   | -   | -   | -   | 30.01 | +0.03 | 66.4 | -65.5 | -    | -    | -   | -    |
| 03 05 | 1:00 pm     | N     | 44.1 | 49.9 | -   | -   | -   | -   | 29.99 | +0.02 | 67.8 | -67.3 | -    | -    | -   | -    |
Tropical Cyclone Ana
May 7th – 10th, 2015
Percentage of NHC Tropical Cyclone Discussions Mentioning QuikSCAT, ASCAT, or OSCAT 2000-2014

- **QSCAT Failure**
- **ASCAT-A**
- **OSCAT**
- **ASCAT-B**
- **OSCAT Failure**

**Year**

- **2000**: 4.9
- **2001**: 6.2
- **2002**: 9.0
- **2003**: 10.5
- **2004**: 11.3
- **2005**: 16.2
- **2006**: 18.8
- **2007**: 21.1
- **2008**: 25.6
- **2009**: 26.4
- **2010**: 15.2
- **2011**: 17.5
- **2012**: 19.2
- **2013**: 23.2
- **2014**: 14.8

**Percentage**

- **Atlantic**
- **E Pacific**

- **ASCAT-A**: 30.7
- **QSCAT Failure**: 28.8
- **OSCAT**: 26.2
- **ASCAT-B**: 25.1
- **OSCAT Failure**: 25.1
Ana’s Lifecycle
Ambiguities show elongated center.
Rain inflated retrievals consistent with Wilmington, NC WSR-88D radar data

Likely rain blocking and rain inflation here
Subtropical Storm Ana

Ana Best Track

1800 UTC 8 May

45 kt/1000 mb

25-25 km

RapidScat

High rain - flagged wind retrievals (50-55 kt) in deep convection southeast of center

GCOM-W1 AMSR

Rain rates > 5 in./hour

5/21/15
Subtropical Storm Ana
RapidScat Pass 1840 UTC 8 May

Ana Best Track Intensity
1800 UTC 8 May
45 kt/1000 mb
34-kt wind radii: 100 100 80
100

Higher resolution retrievals show higher winds in general, both in and outside of rain

12.5-km RapidScat
Subtropical Storm Ana
RapidScat Pass 1840 UTC 8 May

Ana Best Track Position
1800 UTC 8 May
31.6°N 77.4°W

Center is quite apparent in ambiguities and in weaker winds

25-km Ambiguities
Ana Best Track Position 1800 UTC 8 May
31.6°N 77.4°W

Center is quite apparent in ambiguities (31.7°N 77.4°W)

Rain blocking of ambiguities seen east of center where southerly flow is expected

25-km Ambiguities
RapidSCAT Use for Extratropical Cyclone Observations
**Warning Categories**

**Pre-QSCAT**
1. GALE 34-47 kt
2. STORM ≥ 48

**QSCAT Era**
1. GALE 34-47 kt
2. STORM 48-63 kt
3. HURCN FORCE ≥ 64 kt

**Improvements**
- 12.5 km QuikSCAT available May 04
- 25 km QuikSCAT available in N-AWIPS Oct 01
- ASCAT available in N-AWIPS
- QuikSCAT ceased operations
- ASCAT-B available in N-AWIPS
- Improved wind algorithm and rain flag Oct 06

**Graph**
RapidScat reveals HF winds at the northern part from storm center low on November 28\textsuperscript{th}, 2014 at its 10:39Z pass. OPC upgraded its 12Z warning to hurricane force.
12/10/2014 RapidScat confirms hurricane force winds (brightest reds) in w/sw quadrants of Pacific low pressure
01/03/2015 12Z ~
13Z RSCAT & 15Z ASCAT winds within rapidly intensifying Atlantic low
March 9th, 2015 12Z OPC Analysis

OPC issued HF wind warning
Both ASCAT (10:37Z) and RSCAT (10:44Z) passes confirm small area of HF winds
“...Low just offshore is expected to explosively intensify next 24-36 hrs, develop hurricane force winds + seas ≈40 FT...”
April 15th, GFS 18Z run
forecast to deepen 42mb next 24 hours...
“....Atlantic low has deepened 43mb past 24hrs, easily exceeding criteria for "rapid intensification" or “bombogenesis...”
...very dangerous conditions -- winds to 75KT, phenomenal seas to 44FT -- continue this eve beneath intense 963mb low...

April 16th, 2015

Massive, intense wind field detected by the RapidScat

SEVIRI RGB Airmass image of intense, dangerous hurricane force low across the Atlantic
RapidSCAT captures rapidly intensified low (bombogenesis) across the Atlantic, that generated hurricane force winds + seas>30FT April 20th, 2015
✧ OSVW data are deeply integrated into NOAA’s National Weather Service (NWS) marine, tropical and extratropical cyclone operations

✧ RapidScat is providing near real-time ocean surface vector wind data

✧ Quality comparable to that of QuikSCAT (pre-anomaly)

✧ 12.5km products are available in the NWS NAWIPS/NMAP environment and are being used to support the forecasting and warning process at NOAA

✧ The ISS orbit provides a unique opportunity to cross-calibrate satellite scatterometers and characterize the diurnal variability of OSVW.