Outline

• Non-spinning QuikSCAT
• GMF fitting procedure
• Consistency with Ku2011
  – Ku2011 was used for QuikSCAT v3 retrievals
• Comparison with NSCAT2
• JPL OSCAT retrievals

GMF development utilizes data from multiple sources, ensuring that GMF will yield consistent winds between Oceansat-2 and the QuikSCAT climate data record.

A: Develop GMF fitting procedure and validate it against Ku2011

B: Use validated GMF fitting procedure to develop GMF for OceanSAT-2 data
Current status of QuikSCAT

• QuikSCAT stopped spinning on November 23, 2009
• Since then, we have obtained single azimuth data from a variety of incidence angles and polarizations
• Data being used to
  – Develop geophysical model functions at alternate incidence angles, e.g. for Oceansat-2
  – Retrieve accurate wind speed profiles on a narrow (30 km) swath
  – Calibrate cryosphere products for Oceansat-2
Non-spinning QuikSCAT

• Non-spinning QuikSCAT sigma0s
  – Average 50 consecutive footprint (egg) measurements to produce a ~30km by 30 km backscatter measurement
    • Slice processing is not done because it would require extensive recalibration and accurate attitude knowledge
    • Footprints move ~3.8 km on ground during averaging
Here we compare a 1000-km long non-spinning wind speed profile (bottom) with a similar profile (top) obtained when QuikSCAT was spinning.

Both profiles are compared with co-located ECWMF and SSM/I wind speeds. Rainy data is omitted.
Spinning vs. non-spinning sigma0 profiles

Spinning QuikSCAT (9/2008)

ECMWF Speed [m/s]

WindSat rain [mm/hr]

Distance [km]

Latitude

Longitude

Non-spinning QuikSCAT (9/2010)

ECMWF Speed [m/s]

WindSat rain [mm/hr]

Distance [km]

Latitude

Longitude
### QuikSCAT operating modes since 2009

<table>
<thead>
<tr>
<th>Revs</th>
<th>Dates</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 54315</td>
<td>Up to 23 Nov 2009</td>
<td>Wind Obs. Nominal; antenna freeze during orbit 54315</td>
</tr>
<tr>
<td>54316-55960</td>
<td>23 Nov 2009 – 18 Mar 2010</td>
<td>How do we make this thing work???</td>
</tr>
<tr>
<td>55961-56321</td>
<td>18 Mar 2010 – 12 Apr 2010</td>
<td>QSCAT outer beam, nominal point; 374 good data revs</td>
</tr>
<tr>
<td>56333-56337</td>
<td>13 Apr 2010</td>
<td>ISRO outer beam point; 1553 lockup shortly afterward</td>
</tr>
<tr>
<td>56378-57675</td>
<td>16 Apr 2010 – 16 Jul 2010</td>
<td>ISRO outer beam point; bad config after 1553 anomaly recovery, no good data</td>
</tr>
<tr>
<td>57676-58317</td>
<td>16 Jul 2010 – 30 Aug 2010</td>
<td>ISRO outer beam point, good configuration (643 good data revs)</td>
</tr>
<tr>
<td>58347-60967</td>
<td>1 Sep 2010 – 4 Mar 2011</td>
<td>ISRO inner beam point, 2614 good data revs</td>
</tr>
<tr>
<td>60969-62351</td>
<td>4 Mar 2011 – 9 June 2011</td>
<td>ISRO outer beam point, good configuration</td>
</tr>
<tr>
<td>62354-62820</td>
<td>9 Jun 2011 – 12 July 2011</td>
<td>QSCAT nadir point, outer beam</td>
</tr>
<tr>
<td>62822-63819</td>
<td>12 Jul 2011 – 20 Sep 2011</td>
<td>QSCAT nadir point, inner beam</td>
</tr>
<tr>
<td>63822-65658</td>
<td>20 Sep 2011 – 27 Jan 2012</td>
<td>QSCAT high-incidence angle on inner beam (θ ~ 62.5° for H-pol)</td>
</tr>
<tr>
<td>65660-66443</td>
<td>27 Jan 2012 – 22 Mar 2012</td>
<td>QSCAT high-incidence angle on outer beam (θ ~ 62.5° for V-pol)</td>
</tr>
<tr>
<td>66446-present</td>
<td>22 Mar 2012 – present</td>
<td>ISRO outer beam point (check OSCAT calibration drift)</td>
</tr>
</tbody>
</table>

**QSCAT2012 data summary**

<table>
<thead>
<tr>
<th>Type</th>
<th>Revs</th>
</tr>
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<tbody>
<tr>
<td>OSCAT outer beam</td>
<td>2020 revs</td>
</tr>
<tr>
<td>OSCAT inner beam</td>
<td>2614 revs</td>
</tr>
<tr>
<td>QuikSCAT outer beam</td>
<td>812 revs</td>
</tr>
<tr>
<td>QuikSCAT inner beam</td>
<td>974 revs</td>
</tr>
</tbody>
</table>
Step 1: Gather data for GMF

• Non-spinning QuikSCAT sigma0s
• ECMWF collocation
  – Interpolate analysis field in space and time
• NCEP collocation
  – Interpolate analysis field in space and time
• SSM/I collocation
  – Time difference within 60 minutes
• WindSat collocation
  – Time difference within 60 minutes
Step 2: Filter for data consistency

- **Wind speeds are consistent**
  - NCEP, ECMWF, SSM/I, WindSat all have valid winds
  - $\text{abs}(\text{ECMWF} - \text{SSM/I}) < 2 \text{ m/s}$
  - $\text{abs}(\text{ECMWF} - \text{NCEP}) < 2 \text{ m/s}$
  - $\text{abs}(\text{ECMWF} - \text{WindSat all weather}) < 2 \text{ m/s}$

- **Wind directions are consistent**
  - ECMWF and NCEP directions are within 20°

- **Rain is not present**
  - SSM/I rain rate and WindSat rain rate are both 0

- **Data is timely**
  - Time difference within 60 minutes (i.e., +/- 60 min)
    - Between SSM/I and QuikSCAT
    - Between WindSat and QuikSCAT
GMF_OSCAT: Inner beam data

Data location histogram

Sigma0 histogram

Bin size = 0.5°

White X = Mean sigma0 as a function of wind speed
Red circle = mean wind speed as a function of sigma0
(Means were taken in linear units with negative sigma0s kept)
Negative sigma0s are in the lowest bin

6/27/2012
Step 3: Fit iteratively, removing outliers

Truth: WindSat low frequency speed (consistent with Ku2011) and ECMWF direction

1. Fit the coefficients $A_0$, $A_1$, $A_2$ (least squares fit)
2. Remove outliers
   - For each 20° azimuth bin, trim top and bottom 10% of data, estimate mean and standard deviation, and remove points that are 3*sigma away from previous iteration’s model fit
3. Refit the coefficients
4. Repeat steps 2 and 3 until all three coefficients change by less than 1%

\[
\sigma^0 = A_0 + \sum_{n=1}^{N} A_n \cos(n\chi)
\]

Inner beam
Speed = 8.00 (±0.15) m/s
30831 points (discarded 3100 after 3 iterations)
Coeffs: 0.00407506 0.00172133 0.00194878
Step 4: Spline fit across speed bins

- Create smoothly varying $A_0$, $A_1$, and $A_2$ coefficients by using spline fit
  - Least squares cubic spline with constraints on the shape of the final function
- To maintain consistency, spline parameters were chosen by comparing GMF_QS to Ku2011 – the same spline parameters were then used for GMF_OSCAT
- Spline fits were performed using “SLMtools”, a freely available toolbox for MATLAB (requires Optimization toolbox).

http://www.mathworks.com/matlabcentral/fileexchange/24443
Spline fit example

Ku2011
Spline fit
Fit coefficients (size of marker indicates number of data points)

GMF_QS: VV

GMF_OSCAT: VV

Cubic spline
Gray lines are knots

Concave up over [0, 5]
Linear over [15, 100]

Must be (0, 0)
Compare GMF_QS to Ku2011 (HH)
Compare GMF_QS to Ku2011 (VV)
Step 5: Correct A0 bias with Ku2011

- Calculate correction factor: \[ A_{0\text{corr}} = \frac{A_{0\text{Ku2011}}}{A_{0\text{GMF\_QS}}} \]
- Apply correction factor to GMF\_ISRO
- No corrections for A1 or A2
QSCAT2012 with Oceansat-2 data

Wind retrieval using 99 revs from Jan 2012

Retrieval performance

Speed bias [m/s]

Speed RMS [m/s]

Direction RMS [deg]

Cross-track distance [km]
Summary

• Nonspinning QuikSCAT data
  – Low noise
  – Potential for investigating model deviations
  – JPL plans to make this data available soon
• New GMF suitable for OSCAT incidence angles
  – Similar to NSCAT2
• GMF is extrapolated outside of 3-12 m/s
• QSCAT2012 combines OSCAT angle GMF with RSS’s Ku2011
  – But directional modulation is different!
• Future plans
  – Improve directional modulation consistency with Ku2011
  – Develop GMF at 62° for future applications
APPENDIX
GMF_OSCAT: Outer beam data

Data location histogram

Sigma0 histogram

Bin size = 0.5°

White X = Mean sigma0 as a function of wind speed
Red circle = mean wind speed as a function of sigma0
(Means were taken in linear units with negative sigma0s kept)
Negative sigma0s are in the lowest bin
RAW FIT COEFFICIENTS
(GMF_OSCAT)
GMF_OSCAT: raw fit coefficients
GMF_OSCAT: raw fit coefficients

![Graphs showing wind speed vs. HH A0, HH A1, HH A2, and Sigma0 vs. Relative azimuth for different wind speeds.]

- **HH A0, HH A1, HH A2** as functions of wind speed [m/s] with fit coefficients for NSCAT2 and GMF_OSCAT.
- **Sigma0** as functions of relative azimuth [deg] for wind speeds of 2.0 m/s and 4.0 m/s.
GMF_Oscat: raw fit coefficients

- Graph showing \( x \times 10^{-3} \) vs. wind speed [m/s] for HH A0 [linear], HH A1 [linear], HH A2 [linear], along with fits for NSCAT2 and GMF_Oscat.
GMF_OSCAT: raw fit coefficients
GMF_OSCAT: raw fit coefficients

Graphs showing the relationship between wind speed and VV A0, VV A1, VV A2, Sigma0 [dB] vs. relative azimuth for different wind speeds.
GMF_OSCAT: raw fit coefficients

- VV A0 vs. Wind speed [m/s]
- VV A1 vs. Wind speed [m/s]
- VV A2 vs. Wind speed [m/s]

- Sigma0 vs. Relative azimuth [deg]

Legend:
- NSCAT2
- GMF_OSCAT fits
- GMF_OSCAT

6/27/2012
GMF_OSCAT: raw fit coefficients

![Graphs showing fit coefficients for GMF_OSCAT](image)

- **VV A0 [linear]**
- **VV A1 [linear]**
- **VV A2 [linear]**

Wind speed [m/s] vs. 
Relative azimuth [deg] for different wind speeds:
- **6.0 m/s**
- **8.0 m/s**

Graphs compare NSCAT2 fits with GMF_OSCAT fits.
GMF_OSCAT: raw fit coefficients

[Graphs showing the relationship between wind speed and VV A0, VV A1, VV A2, Sigma0, and relative azimuth for GMF_OSCAT and NSCAT2 datasets.]
RAW FIT COEFFICIENTS (GMF_QS)
GMF_QS: raw fit coefficients

Graphs showing the relationship between wind speed and HH A0, HH A1, HH A2, Sigma0 for different wind directions and speeds.

- NSCAT2
- QSCAT1
- Ku2011
- GMF_QS fit coeffs
- GMF_QS

Wind speed [m/s]: 0, 5, 10, 15
Relative azimuth [deg]: 0, 45, 90, 135, 180

Sigma0 [dB]: -24, -26, -28, -30

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GMF_QS: raw fit coefficients

- HH A0 [linear]
- HH A1 [linear]
- HH A2 [linear]

Wind speed [m/s]

Sigma0 [dB]

Relative azimuth [deg]

- NSCAT2
- QSCAT1
- Ku2011
- GMF_QS fit coeffs
- GMF_QS

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GMF_QS: raw fit coefficients

Wind speed [m/s]

HH A0 [linear]

HH A1 [linear]

HH A2 [linear]

Sigma0 [dB]

Relative azimuth [deg]

6.0 m/s

8.0 m/s

NSCAT2
QSCAT1
Ku2011
GMF_QS fit coeffs
GMF_QS

6/27/2012
GMF_QS: raw fit coefficients
GMF_QS: raw fit coefficients
GMF_QS: raw fit coefficients

- **VV A0 [linear]**
  - x $10^{-3}$
  - Wind speed [m/s]

- **VV A1 [linear]**
  - Wind speed [m/s]

- **VV A2 [linear]**
  - Wind speed [m/s]

- **Sigma0 [dB]**
  - Relative azimuth [deg]
  - 2.0 m/s
  - 4.0 m/s

Legend:
- **NSCAT2**
- **QSCAT1**
- **Ku2011**
- **GMF_QS fit coeffs**
- **GMF_QS**
GMF_QS: raw fit coefficients

Wind speed [m/s]

VV A0 [linear]

VV A1 [linear]

VV A2 [linear]

Sigma0 [dB]

Relative azimuth [deg]

NSCAT2
QSCAT1
Ku2011
GMF_QS fit coeffs
GMF_QS

6/27/2012
GMF_QS: raw fit coefficients

- VV A0 [linear]
- VV A1 [linear]
- VV A2 [linear]

Graphs showing the relationship between wind speed [m/s] and Sigma0 [dB] for different datasets:
- NSCAT2
- QSCAT1
- Ku2011
- GMF_QS fit coeffs
- GMF_QS

Wind speed range: 10 to 15 m/s
Sigma0 range: -18 to -14 dB