Aquarius Sea Surface Salinity Retrievals using a Roughness Correction from the CONAE MicroWave Radiometer (MWR)

W. Linwood Jones¹, Yazan Hejazin¹, Maria Jacob² and Monica Rabolli²

1 - Central FL Remote Sensing Lab
Univ. Central Florida
Orlando, FL

2- CONAE
Buenos Aires, AR

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MWR Ocean Roughness Correction

- Pre-launch, ocean roughness correction was considered the dominant error for AQ SSS retrieval
- Baseline SSS retrieval algorithm uses the AQ Scat to provide the roughness correction ($\Delta Tb$)
  - $\Delta Tb$ is correlated with measured radar backscatter
- MWR provides an alternative approach for obtaining an AQ roughness correction
  - MWR measured (top-of-atmos) Tb at Ka-band is used to calculate excess ocean emissivity due to wind speed (and wind direction)
  - Using ocean Radiative Transfer Model, measured Ka-band excess emissivity is translated to L-band $\Delta Tb$
MWR Roughness Correction Status

• At the end of 2014, the MWR roughness correction algorithm reached maturity

• Enabling factors:
  – Completion of MWR counts-to-Tb algorithm
    • Release of MWR L1B V7.0 beta Tb product Nov. 2014
  – Release of AQ L-2 V3.0
V6.0 23H DD biases (MWR-WS)  
July 2012 – Nov 2013

~ 0.25K/mo
V6.0 23H DD biases (MWR-WS)
July 2012 – Nov 2013

B1

B2

B3

B4

V7.0 DD Normalized to WindSat
MWR Roughness Correction Algorithm
Theoretical Ocean Emissivity RTM
L-band Tuning

- \( T_{b\text{\_ocean}} \)
- \( T_{b\text{\_smooth}} \)
- \( \Delta T_{b\text{\_meas}} \)
- \( \Delta T_{b\text{\_model}} \)

Inputs:
- SST
- Salinity
- EIA
- Pol
- Freq
- Wind Speed
- Wind Dir
- Az Look Dir
- Rain rate
- EIA
- Pol
- Freq

Outputs:
- Tune model coeff
Tuning L-band RTM for Wind Speed
Tuning L-band RTM for Wind Direction

Beam 1

Beam 2

Beam 3

V-pol Tb (K)

H-pol Tb (K)

\( \chi \) (deg)

WS = 15 m/s

WS = 8 m/s

WS = 4 m/s

Observed L-band from AQ

Modeled L-band
Theoretical Ocean Emissivity RTM
Ka-band Tuning

\[ T_{b_{\text{ocean}}} + \Delta T_{b_{\text{meas}}} \]

\[ T_{b_{\text{smooth}}} - \]

Specular Emissivity Model

\[ \Sigma \]

SST
Salinity
EIA
Pol
Freq

Wind Speed
Wind Dir
Az Look Dir
Rain rate
EIA
Pol
Freq

\[ \Delta T_{b_{\text{model}}} - \]

CFRSL Emissivity Model

\[ + \]

Model error

\[ \Sigma \]

Calculate MWR Ocean Surface \( T_{b_{\text{ocean}}} \)

XCAL RTM

- MWR TOA \( T_b \)
- WindSat/SSMIS retrievals
- WS, RR, CLW
- NCEP
- Atmos/Ocean pars

Tuning Ka-Band Model (Coefficients)
Tuning Ka-band RTM for Isotropic Wind Speed

Odd Beams (52°)

Even Beams (58°)
Tuning Ka-band RTM for Relative Wind Direction

Odd Beams

- $WS = 10 \text{ m/s}$
- $WS = 6 \text{ m/s}$

Even Beams

- $WS = 10 \text{ m/s}$
- $WS = 6 \text{ m/s}$

Relative Wind Direction

- $T_b \text{ Y-pol}$
- $T_b \text{ H-pol}$
Empirical Roughness Correction Relationship (for Isotropic Winds)
Wind Direction $\Delta T_{b_{WD}}$ Adjustment

- Wind direction effects are removed using NCEP wind directions and corresponding AQ/MWR antenna “azimuth look” geometries
  - Wind direction effects removal are complicated because all IFOV’s (L-band & Ka-band) have different relative wind directions $\chi$

$$\chi = (\text{IFOV azimuth}) - (\text{wind flow direction})$$
Relative Wind Directions are Different for each IFOV

Wind flow direction

Flight Direction

Sub-Satellite Point

\( \chi_i \)

\( \chi_j \)

N
W
E
S
Roughness Correction for Both Methods

AQ Scat - blue & MWR - red

\[
\begin{align*}
\text{V-pol} & \\
\text{H-pol} & \\
\end{align*}
\]
Differences Between Both Roughness Corrections

\[ \Delta T_{b_{\text{MWR}}} \, - \, \Delta T_{b_{\text{Scat}}} \]
The MWR derived L-band roughness correction is applied to the L-2 ocean surface Tb. Resulting Smooth Surface Tb is used to retrieve AQ SSS. The same ADPS SSS retrieval algorithm used as for L-2.
$$\Delta SSS = AQSSS - HYCOM$$

Double Difference = $$(\Delta SSS)_{\text{Scat}} - (\Delta SSS)_{\text{MWR}}$$
ΔSSS for Different Roughness Corrections: Scat, MWR & Avg, for AQ Beam-3, May 2013
### Mean value (psu)

<table>
<thead>
<tr>
<th>Beam 3 (m/s)</th>
<th>0 – 5</th>
<th>5 – 10</th>
<th>10 – 15</th>
<th>15 – 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ</td>
<td>0.05</td>
<td>0.02</td>
<td>0.15</td>
<td>0.17</td>
</tr>
<tr>
<td>MWR</td>
<td>0.11</td>
<td>0.04</td>
<td>–0.05</td>
<td>–0.25</td>
</tr>
<tr>
<td>Avg</td>
<td>0.07</td>
<td>0.02</td>
<td>0.03</td>
<td>–0.05</td>
</tr>
</tbody>
</table>

### Standard deviation value (psu)

<table>
<thead>
<tr>
<th>Beam 3 (m/s)</th>
<th>0 – 5</th>
<th>5 – 10</th>
<th>10 – 15</th>
<th>15 – 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ</td>
<td>0.43</td>
<td>0.44</td>
<td>0.40</td>
<td>0.42</td>
</tr>
<tr>
<td>MWR</td>
<td>0.57</td>
<td>0.53</td>
<td>0.56</td>
<td>0.62</td>
</tr>
<tr>
<td>Avg</td>
<td>0.46</td>
<td>0.45</td>
<td>0.41</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Summary

• A legacy data set of 30 months of MWR data exist for roughness correction for all AQ Beams
  – Release of MWR roughness correction algorithm in Summer 2015

• Validation of \((\text{AQ SSS})_{\text{MWR}}\) was performed using HYCOM for Jan, April & July 2013
  – Also inter-comparison with \((\text{AQ SSS})_{\text{Scat}}\)
  – Result show that MWR roughness correction is very similar to AQ Scat roughness
  – Further improvements may be possible using weighted averages of MWR & Scat roughness
Future Work

• Development of combined Scat & MWR roughness correction and associated AQ L-2 SSS
• Investigation of the differences between Scat & MWR roughness corrections
  – Especially for high WS
• Evaluation of roughness correction during salinity stratification