The Aquarius Radiometers and Radio Frequency Interference: Analysis of RFI at L-Band and its Impact on Salinity Retrieval

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Outline

- Introduction
- Analysis of RFI environment changes
- Conclusions
Undetected RFI is a serious issue because it can unknowingly cause biases in retrieved salinity.

It is usually related to high level RFI but can also appears without it.

Cases of undetected RFI in two different areas of the world (Japan and North Atlantic) will be examined here.
SMOS RFI Probability

- SMOS detected a large increase of RFI over Japan starting September 2011
- Suspected cause: start of operation in frequency band adjacent (above) to Earth Exploration Satellite Service (EECS) primary allocation to passive remote sensing systems
Aquarius RFI and antenna temperature (ascending)

- no change in detected RFI...

- but large change in observed antenna temperature!

(T_{AV} + T_{AH})/2 (after RFI filtering) [K]

same trend is observed in descending tracks (and beams 2,3)
Change is most evident over the island of Kyushu where little RFI had been detected before September 2011, by either SMOS or by Aquarius.
no recognizable change in Aquarius detected RFI...

but definite change in Aquarius observed antenna temperature compared to expected antenna temperature
Analysis over Pacific Ocean, Region P

beam 1, ascending

beam 2, ascending

beam 3, ascending

beam 1, descending

beam 2, descending

beam 3, descending

Analysis of Region P: Aquarius Observations

Analysis over Pacific Ocean, Region Q

beam 1, ascending

beam 2, ascending

beam 3, ascending

Analysis of Region Q: Aquarius Observations

ascending
regions Q1, Q2, Q3 / ascending tracks only

descending
regions Q1, Q2, Q3 / descending tracks only
Discussion

- Aquarius RFI filter is missing most of the RFI emitted by wireless telecommunication systems.
- Quantifying the effect on SSS and soil moisture retrievals is difficult due to the short time range range of RFI-free measurements (4 weeks).
- Effect is very large over land but present, although almost undetectable, over ocean as well.
- Further analysis are mostly confined to the area around Kyushu due to presence of radar systems RFI on other parts of Japan.
Following requests by SMOS, in November 2013 radars part of the North Warning System (formerly DEW Line) adjusted their operating frequency to avoid interference in the 1400 to 1427 MHZ band.

As a result, most antenna sidelobe RFI over the Eastern part of the North Atlantic disappeared starting on November 26, 2013.

An analysis has been performed on selected regions, findings shown here are limited to three of them.
Characteristics of Selected Study Regions

- Regions under study partially overlap “RFI exclusion zone” that is not used for calibration, and include
  - an area moderately affected by RFI emissions from Canada (region A)
  - an area severely affected by RFI emissions from Canada (region B)
  - an area affected by RFI emissions from Europe (region C)
Atlantic Ocean, region B, ascending orbits only

Atlantic Ocean, region B, descending orbits only

Comparison with ARGO SSS

Comparison with ARGO data shows a similar trend.
Year-by-Year Comparison with ARGO SSS

Atlantic Ocean, region A / ascending tracks

Atlantic Ocean, region B / ascending tracks

Atlantic Ocean, region C / ascending tracks

Atlantic Ocean, region A / descending tracks

Atlantic Ocean, region B / descending tracks

Atlantic Ocean, region C / descending tracks
### Estimation of SSS Bias Caused by Undetected RFI

<table>
<thead>
<tr>
<th></th>
<th>region A</th>
<th>region B</th>
<th>region C</th>
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<tbody>
<tr>
<td><strong>ARGO SSS (2) - ARGO SSS (1)</strong></td>
<td>-0.0077</td>
<td>0.0579</td>
<td>-0.0062</td>
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<tr>
<td><strong>AQ SSS (2) - AQ SSS (1)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>asc+desc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>asc</td>
<td>0.1043</td>
<td>0.2593</td>
<td>0.0796</td>
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<tr>
<td>desc</td>
<td>0.1806</td>
<td>0.3423</td>
<td>0.0327</td>
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<tr>
<td><strong>estimated bias</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>in Aquarius SSS</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>asc</td>
<td>0.0358</td>
<td>0.1184</td>
<td>0.1327</td>
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<tr>
<td>desc</td>
<td>0.1883</td>
<td>0.2844</td>
<td>0.0389</td>
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<tr>
<td><strong>caused by undetected RFI?</strong></td>
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1) \(\Rightarrow\) average of (23-Nov-2011 to 23-Aug-2012) and (22-Nov-2012 to 24-Aug-2013)

2) \(\Rightarrow\) (23-Nov-2013 to 24-Aug-2014)

Units are PSU
Conclusions

- Aquarius RFI filter is missing some RFI, need to add a way to detect it?
- possibility of unexpected undetected RFI must be taken into consideration for calibration
- use of SMOS RFI product can help in some analysis