# The Aquarius Salinity Retrieval Algorithm Beyond Version 3.0

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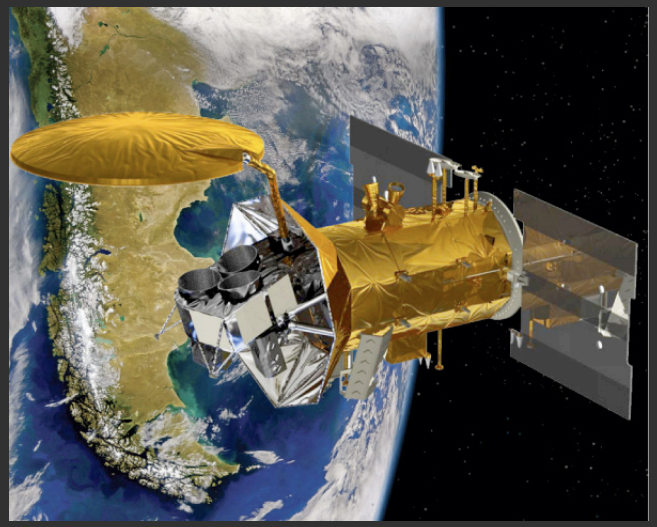

**2014 Aquarius / SAC-D Science Team Meeting**

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Seattle. Washington, USA

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# Outline

1. Short Review: V2.0 → V3.0

2. Going Forward: V3.0 → V4.0 → Future

# Aquarius Version 3.0

## Released June 2014

### ADPS V2.0

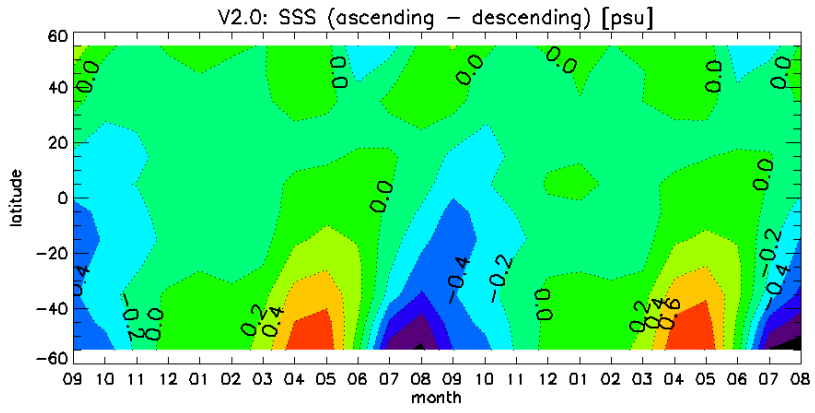
- Surface Roughness Correction
  - Based on NCEP wind speeds and scatterometer sigma-0.
- Reflected Galaxy
  - Physical model:
    Ocean surface modelled as ensemble of tilted facets:
    Geometric Optics
- Antenna Pattern Correction based on GRASP 2012 computer antenna simulations

### ADPS V3.0

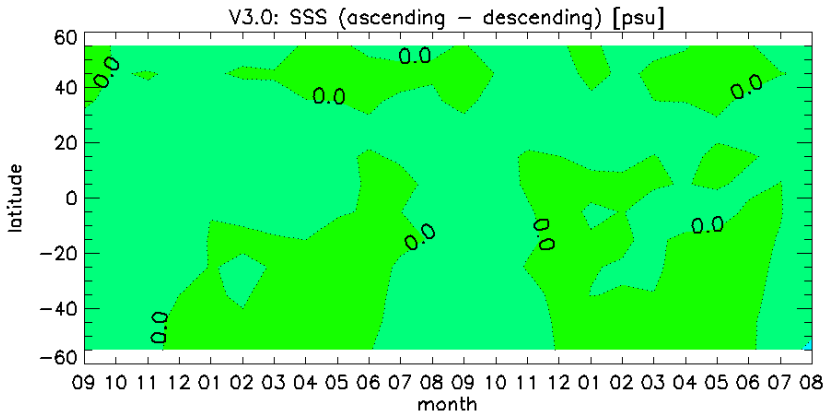
- Surface Roughness Correction
  - Based on Aquarius wind speeds
  - HH-pol scatterometer + H-pol radiometer
- Reflected Galaxy
  - Geometric Optics (about 90%)
  - Symmetrization between ascending and descending swaths
- Antenna Pattern Correction
  - Reduced biases over land + ice
  - Reduced biases in 3rd Stokes
- Q/C and RFI flagging
- d_SSS(SST) bias adjustment

# Symmetrization of Galaxy Reflections

**GO (V2.0)**



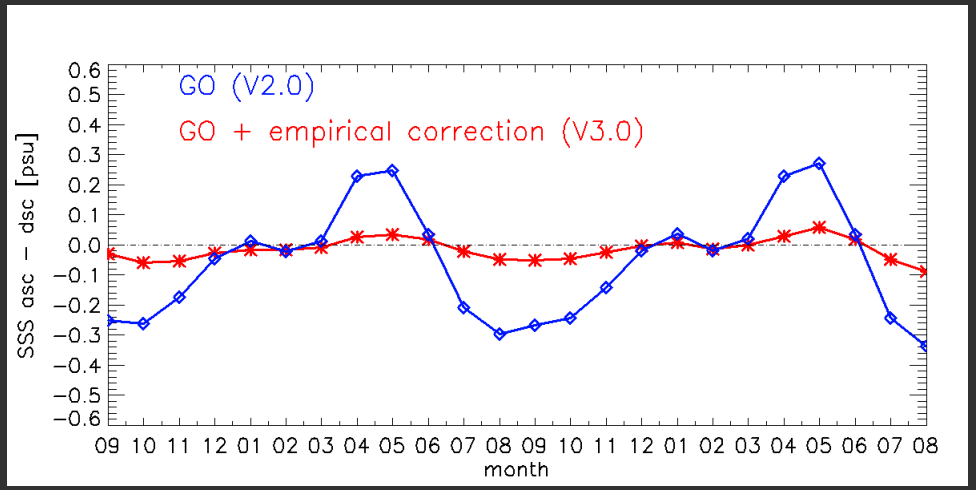

**GO + empirical adjustment (V3.0)**




Latitude

Month

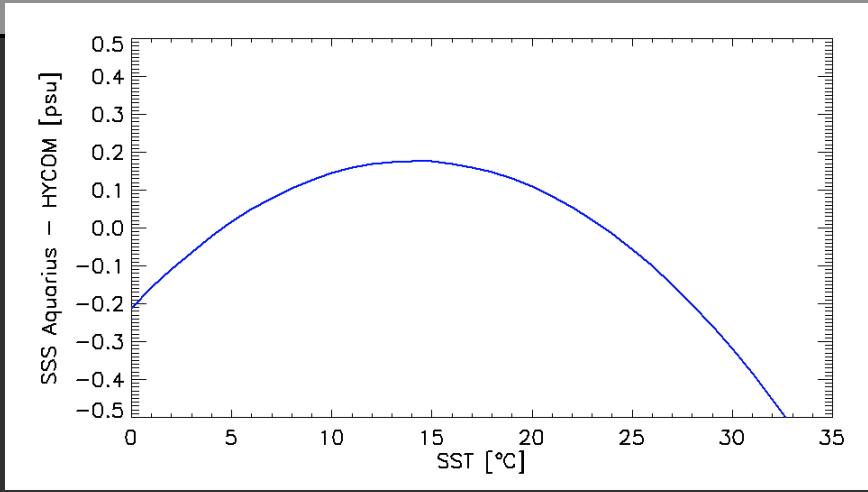
Ascending Minus Descending Salinity Differences



# SST Dependent Biases

## Post-hoc Correction

- Caused by SST dependent biases in GMF
  - 0.1 K uncertainty in GMF is 0.2 psu uncertainty in SSS
  - Dielectric constant of seawater
  - Oxygen absorption (non-resonant continuum)
  - Surface roughness model
  - Most likely a combination of such
  - See talk T. Meissner
- "Bias adjusted" SSS product is provided in V3.0 in addition to standard product
  - Derived after filtering out rain



# Impact on Performance

## Local Biases

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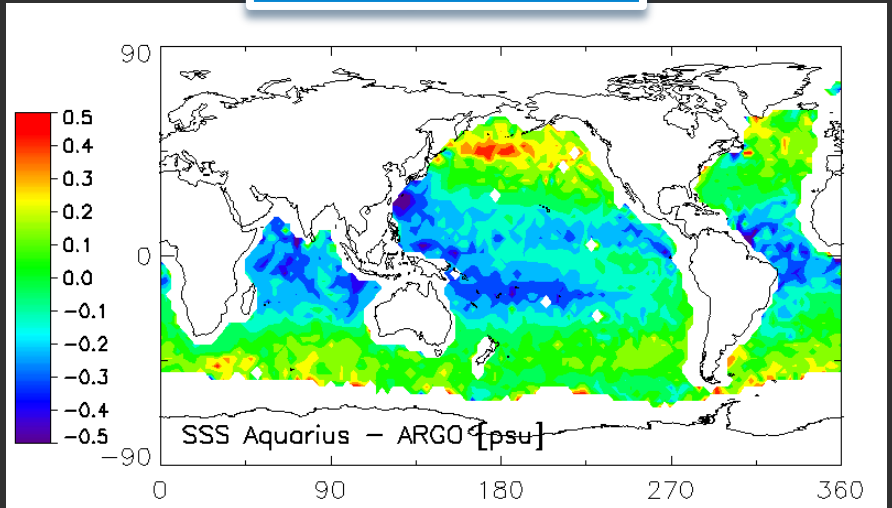
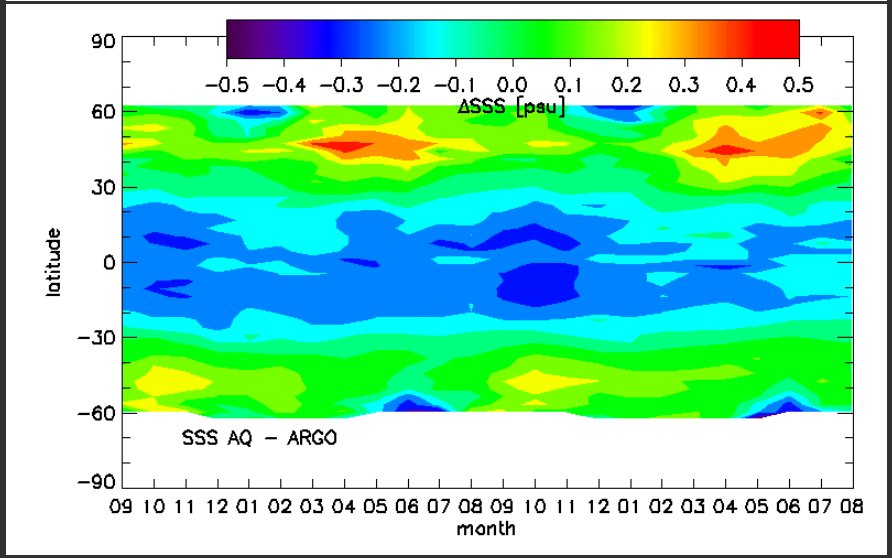
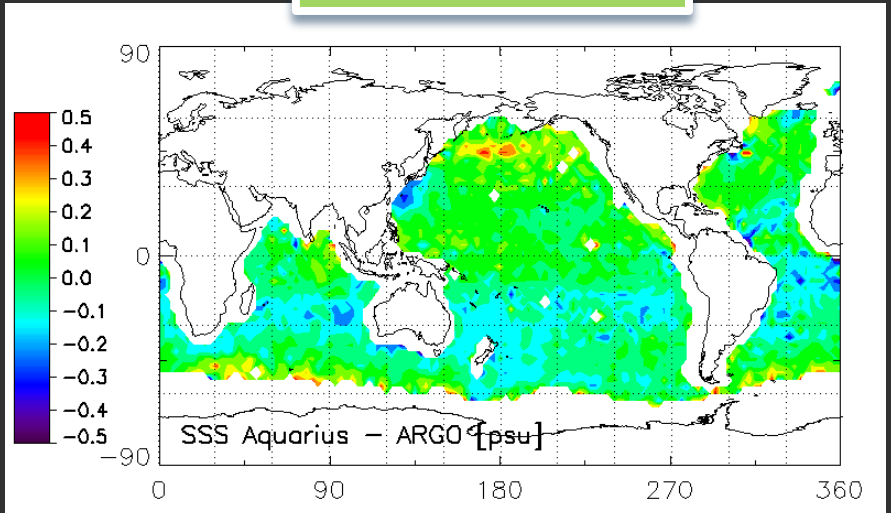
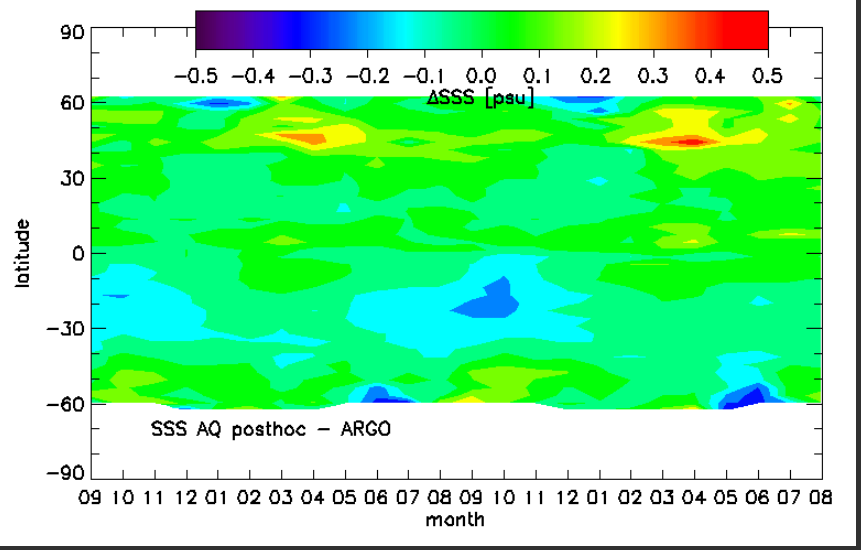
V3.0
no adjustment




V3.0
bias adjusted



# Antenna Pattern Correction: V2.0 → V3.0

- About 1.5% reduction in spillover
  - Spillover values η from scale model AP
  - Cross pol values χ from GRASP 2012 AP
- Adjustment in the 3rd Stokes couplings
- Change in the V/H asymmetry of spillover values of horn 2 and horn 3
- A big improvement over V2. Ocean, land, cold space more consistent (4 K for land).
- Clear and straightforward documentation (RSS Tech. Report 05192014 and the Revised ATBD).

# Impact on Performance

## Triple Colocation Statistics
## Global. Rain Filtered

| AQ – HYCOM – ADPRC ARGO Differences σ [psu] 3° monthly averages | | | |
|---|---|---|---|
| | AQUARIUS – HYCOM | AQUARIUS – ARGO | HYCOM – ARGO |
| V3.0 | 0.29 | 0.31 | 0.25 |
| SST Bias adjusted | 0.24 | 0.27 | 0.25 |

| Estimated Individual Errors σ [psu] AQ – HYCOM – ADPRC ARGO σ [psu] 3° monthly averages (1.5° monthly averages) | | | |
|---|---|---|---|
| | AQUARIUS | HYCOM | ARGO |
| V3.0 | 0.24 (0.27) | 0.16 | 0.19 |
| SST bias adjusted | 0.18 (0.22) | 0.16 | 0.19 |

# Upcoming and Future Work

## Version 4.0

- Replace dSSS(SST) correction with Updated Geophysical Model
- Replacement for MWR Rain Flagging and Correction

## Future

- Continue TB Modeling Research into Causes of Salinity Anomalies
- SST Impact Comparison Study
- Estimate of Error (Cold water, land, galaxy)
- Improved Land Correction: (Hybrid Antenna, Land Emissivity Model)
- Reflected Galaxy (Harmonic Analysis based on SMAP)

# Improved Geophysical Model

- Small errors (0.1K) in model for L-band TOA TB are likely the cause for regional SSS errors of order 0.2 psu.
  - Dielectric constant of seawater
  - Oxygen absorption (non-resonant continuum)
  - Surface roughness model
  - Most likely a combination of such
  - See talk T. Meissner

# Rain Flagging and Correction

- NCEP Cloud Water is currently being used for rain flagging and correction
- NCEP does a poor job of locating and quantifying rain
- NCEP was intended as just a placeholder for MWR, which is great for rain flagging
- Alternatives: CMORPH, MW Imager Array
- CMORPH has the advantage of always available
- Listen to Thomas Meissner Talk

**The Rain Splashing Effect**

Any splashing effect seems to be removed by the wind correction algorithm
Aquarius winds may have error, but SSS seem OK
Hence no additional correction is required

# SST Comparison Study

- SSS retrievals required that SST be specified:
  - TB(SSS,SST, wind, etc.)
  - 0.5C = 0.2 psu, but not constant
  - Currently using NCEP daily SST product (Reynolds)
- Previous studies on the choice of SST product were limited
  - Early (more noisy) versions of SSS
  - Looking for large obvious errors
  - Only 2 products were consider
- We will do a more careful and extended impact analysis of choice of SST product
  - Approximately 5 SST products: MW only, IR, Hybrid
  - Coordinate with NASA SST Science Team
- Will provide an estimate of error in SSS retrieval due to uncertainty in SST
- May result in a change in ancillary SST product for Version updates after V4.

# Provide Users with Estimate of SSS Retrieval Error

- The SSS retrieval error is a dynamic quantity
  - Larger in cold water: fairly easy to model using dTB/dSSS
  - High winds will degrade retrievals
  - Biasing close to land
  - Areas of RFI
- This is Becoming a Standard Requirement
- Formal Approach based on partial derivatives
- Empirical Approach based on cal/val experience
- RSS experience with MW imagers: a complex problem
- But, Aquarius is simpler

# Improved Land Correction

- Quick Review of Current Land Correction
  - Done at the TA Level
  - Really an Antenna Side-lobe Correction
- New Hybrid Antenna Pattern for the Simulation
  - Following approach of Emmanuel Dinnat: Remove power from the back-lobe and put it into main lobe.
  - 1.5% reduction in spillover
- New Land TB model based on Aquarius Observations

# Side-Lobe Correction

$$\bar{T}_{BE,toa} = \frac{\int_{3dB\ footprt} T_{BE,toa}\left(\bar{\theta}_i\right) dA}{\int_{3dB\ footprt} dA}$$

$$\Delta T_{BE,toa} = \hat{T}_{BE,toa} - \bar{T}_{BE,toa}$$

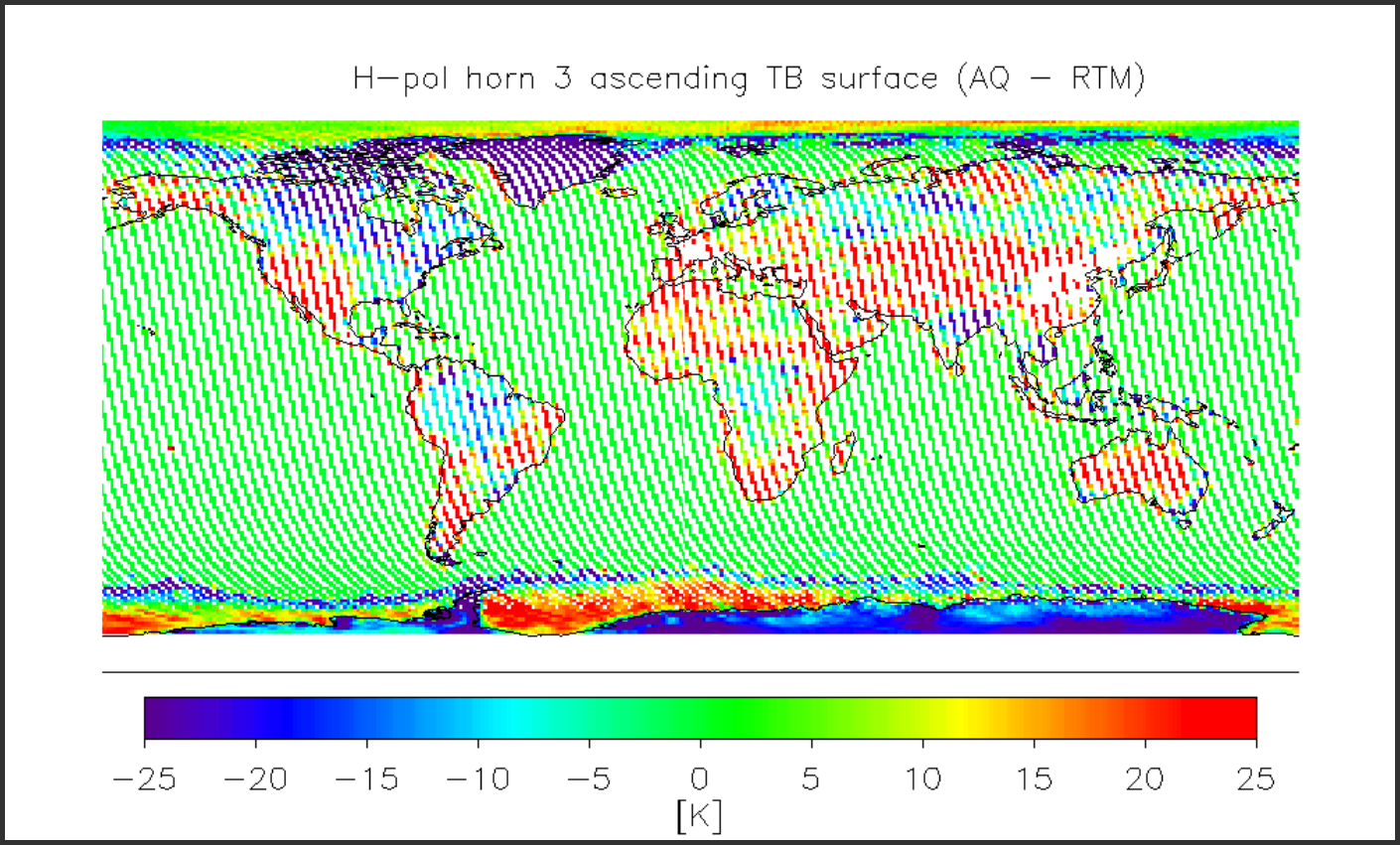
Correction: Table form

Ocean boresight TB

*Exact* TB Integrate over AP

- *Exact* TB is simulated as integral of Earth TB over AP.
- Need land emissivity model to compute Earth TB.
- Correction table is stratified according to the spacecraft nadir longitude, the spacecraft position in orbit, month (climatology), polarization (v-pol, h-pol), and horn (inner, middle, and outer).
- How good is our current land emissivity model?

# Land Emissivity: Aquarius - RTM




- Estimated impact on land correction:
  For land fraction: 0.01
  25 K error in land emissivity → 0.5 psu error in SSS

# Galaxy Reflections

- 1.4 GHz is a protected band because of the Astronomers
- Galaxy glows at 1.4 GHz and we see the reflections from the ocean
- Largest reflections as large as 5 K (10 psu)
- Basic geometric optics (tilted mirror-like facets) used as model
  - Accurate to about 5-10%
  - Residual errors about 0.5 psu
- 4-fold integral used to compute reflected galactic radiation

## New Information and Improvements

- Harmonic Analysis of SMAP Observations
- New Hybrid Antenna Pattern for the Simulation

# Summary

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