OUTLINE

• Aquarius GMF
• Stepwise algorithm (inc. current baseline)
• CAP Algorithm
• Performance Comparison
• Summary
PALS and POLSCAT Installation on P-3 for the 2009 High Wind Campaign

- **PALS:** Passive/Active L-band Sensor

- **POLSCAT:** Ku-band scanning radar, providing ocean surface wind observations
Airborne PALS Sigma0 Dependence on Wind direction
All Star Pattern Flight Data
PALS Radiometer TB Dependence on Wind Direction
Circle Flight Data

Diagram showing the relationship between azimuth angle and temperature (TY, TH) for different wind speeds (24 m/s, 14 m/s, 9 m/s). The data points and trend lines illustrate how temperature varies with the azimuth angle.
Aquarius Radiometer GMF
Ascending/Descending

W. Tang
Nov. 17, 2011
Descending
TB vs Wind Speed and Direction

- Matchup with SSMI Wind Speed and NCEP Wind Direction
  - Not quite sufficient matchup samples for >20 m/s wind speed
Sigma0 vs Wind Speed and Direction

- Match up with SSMI wind speed and NCEP Wind direction
Aquarius $\sigma_0$ GMF

- ALOS PALSAR model function to within 1 dB after a constant adjustment of Aquarius sigma0s by a factor of 1.5

- Ocean and land surface sigma0s are within expected range
Aquarius Wind and SSS Retrievals
Stepwise Algorithm

- Wind Speed Retrieval Algorithm (Alex):
  - Retrieve Wind Speed from Scatterometer VV+HH data using the NCEP wind direction as ancillary
  - Select the ambiguity closest to the NCEP wind speed

\[ F_{\text{scat}}(W) = \frac{(\sigma_{0VV} - \sigma_{0VVm})^2}{(k_p \sigma_{0VV})^2} + \frac{(\sigma_{0HH} - \sigma_{0HHm})^2}{(k_p \sigma_{0HH})^2} \]

- TB Correction and Salinity Retrieval:
  - Correct TB using the scatterometer wind speed and NCEP wind direction
  - Flat surface TB=TB-dTB(Scat speed, NCEP direction)
  - Retrieve the salinity

- Accuracy limited by the NCEP Wind Direction Errors for wind speed estimate and directional correction for TB
Contour Plot of Model Sigma0
Alex, 10/18/2011

HH GMF

Not monotonic in speed for some directions!

VV GMF

Ambiguities in speed!
Aquarius Scatterometer Wind Retrieval in good agreement with SSM/I

- Maximize objective function in speed, for a given wind direction.

- Objective Function: \( \text{obj} = - \left( \frac{(s_{0,vv}-\text{gmf}_s0_{vv})}{s_{0,vv}} \right)^2 - \left( \frac{(s_{0,hh}-\text{gmf}_s0_{hh})}{s_{0,hh}} \right)^2 \)

- Standard deviation of scat speed – SSMI speed:
  - Beam 1: 1.6 m/s; Beam 2: 1.5 m/s; Beam 3: 1.4 m/s
  - STD < 2 for all speeds less than 12 m/s

Scat Wind Speed Map

Scat Wind Errors vs. SSMI

2D log histogram

- Beam 1: Bias: 0.329; STD: 1.613
- Beam 2: Bias: 0.214; STD: 1.522
- Beam 3: Bias: -0.060; STD: 1.444
Aquarius CAP Algorithm for SSS and Wind Retrievals

- CAP Algorithm: Retrieve SSS, Wind Speed and Direction Using Combined Passive and Active (CAP) Data
- Select the ambiguity closest to the NCEP winds in direction

$$F_{pol}^{SSS,W,\phi} = \frac{(I - I_m)^2}{2\Delta T^2} + \frac{(\sqrt{Q^2 + U^2} - \sqrt{Q_m^2 + U_m^2})^2}{2\Delta T^2} + \frac{(\sigma_{0VV} - \sigma_{0VV_m})^2}{(k_p \sigma_{0VV})^2} + \frac{(\sigma_{0HH} - \sigma_{0HH_m})^2}{(k_p \sigma_{0HH})^2}$$

$$I = T_{BV} + T_{BH}$$

$$Q = T_{BV} - T_{BH}$$

- Tested the algorithms using the Aquarius V1.1 and V1.2 data

Yueh and Chaubell, IEEE TGRS, in press
Time Series of AQ-CAP SSS and Wind Speed from V1.2 Evaluation

- Time series
Time Series of AQ-CAP and SSMI Winds

- Aquarius CAP winds agree well with SSM/I
Comparison of Wind Speed Retrievals with SSM/I

- Aquarius CAP winds agree well with SSM/I

  - Standard deviation of speed difference < 1.5 m/s for 0-15 m/s
  - Standard deviation of direction difference < 20 deg for mid-to high winds
• The AQ CAP Wind Speed is essentially unbiased against the SSMI winds
Wind Direction Comparison with NCEP

- The scatter of the closest ambiguity reduces with wind speed
Comparison of Wind Speed Retrievals with NCEP

• Aquarius CAP winds agree well with NCEP
  – Use the latest GMF from V1.2 and Meissner-Wentz dielectric model
  – Standard deviation of speed difference < 1.5 m/s for 0-15 m/s
  – Standard deviation of direction difference < 20 deg for mid-to high winds
Comparison of Wind Speed Retrievals with NCEP

- Aquarius CAP winds agree well with NCEP
  - Use the latest GMF from V1.2 and Klein-Swift dielectric model
  - Standard deviation of speed difference < 1.5 m/s for 0-15 m/s
  - Standard deviation of direction difference < 20 deg for mid-to high winds
Comparison of SSS Retrievals with HYCOM vs. Widn Speed

- Aquarius CAP SSS has the best agreement with Hycom
  - 20 to 50 percent better than L2 SSS (V1.2) or three-step algorithms (V1.2) for > 15-20 m/s
  - V1.2 SSS bias varies significantly over wind speed
  - CAP SSS is nearly unbiased from 0-20 m/s.
Aquarius CAP SSS has the best agreement with Hycom
- 20 to 50 percent better than L2 SSS or three-step algorithms under 10 deg C
- CAP SSS Bias is near zero
- All retrievals have a systematic dependence
  - Bias in the dielectric model?
Sensitivity to Dielectric Model
Meissner-Wentz vs Klein-Swift

- The standard deviations are about the same
- Neither is unbiased
- KS has a positive bias for <5 deg C, while MW has a negative bias
- KS bias varies less than MW for 15 to 30 deg C
BIAS and Standard Deviation VS Time

- CAP s.d. is smaller by about 25%
  - 0-50 m/s, >0 deg C, 50>CAP speed>0, and SSS > 0
  - Aquarius V1.2: 0.92 psu (no average); 0.88 psu (4 blocks)
  - CAP: 0.8 psu (no average); 0.7 psu (4 blocks)
BIAS and Standard Deviation VS Time

- MW and KS have similar daily global averaged biases and s.d.
- CAP s.d. is smaller by about 25%
  - 0-50 m/s, >0 deg C, 50>CAP speed>0, and SSS > 0
  - Average over 4 blocks

MW

KS
Comparison of SSS Retrievals with In Situ

- Aquarius CAP SSS has better agreement with In Situ
  - In particular, the scatter for red and purple clusters has reduced.

![Aquarius (V1.2) vs Insitu SSS Days 240 To 246 All Points](image1)

![CAP vs Insitu SSS Days 240 To 246 All Points](image2)
Aquarius SSS vs. HyCom

- CAP removes many large biases, which are probably caused by the regional errors in the NCEP winds.
• Systematic large biases in descending SSS in southern ocean
Summary

• CAP can produce consistent SSS and wind retrievals
• CAP SSS is more accurate by about 25% on average and 50-100% for high winds
• CAP SSS is nearly unbiased vs SST, while V1.2 SSS bias varies significantly over SST
• CAP wind direction accuracy is better than 20 deg for mid-high winds, and can reach as low as 10 degrees
• CAP wind speed is nearly unbiased against SSMI wind speed
Future Work

• Improve the GMF for high winds
• Improve SSS retrieval using improved dielectric model (particularly for low and high SSTs)
• Develop a better ambiguity selection approach