# Validation of Aquarius Sea Surface Salinity Data with In Situ Measurements from the SPURS Field Experiment

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Data provided by:

Tom Farrar (WHOI Mooring)

Dave Fratantoni and Ben Hodges (WHOI Wave Gliders)

Luca Centurioni (SIO/UCSD Drifters)

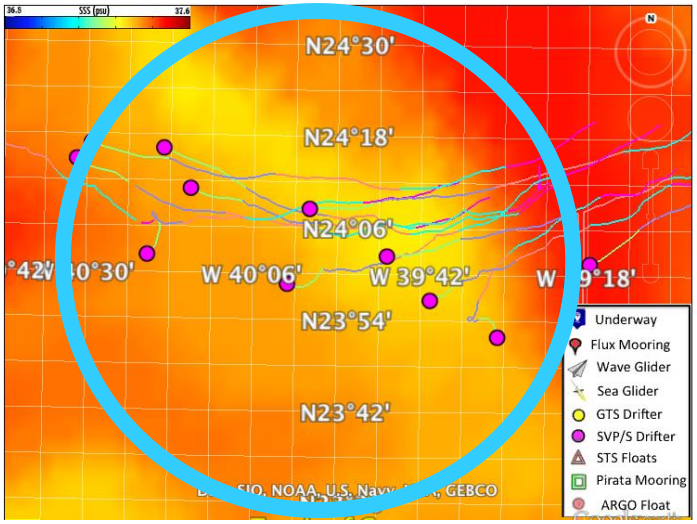
Thanks to:

SPURS Data Management: Frederick Bingham (UNCW)

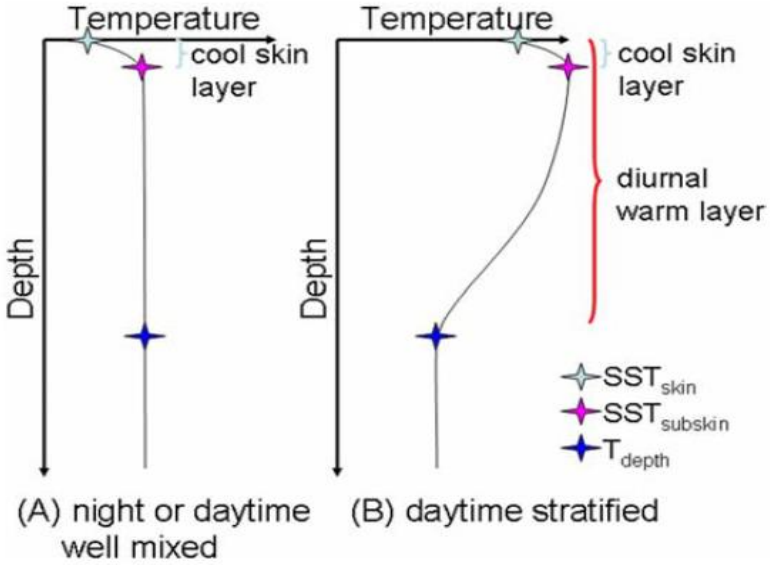
Aquarius Project, JPL PODAAC, SPURS Science Teams

# Challenges in Aquarius Validation

## In Situ Platforms

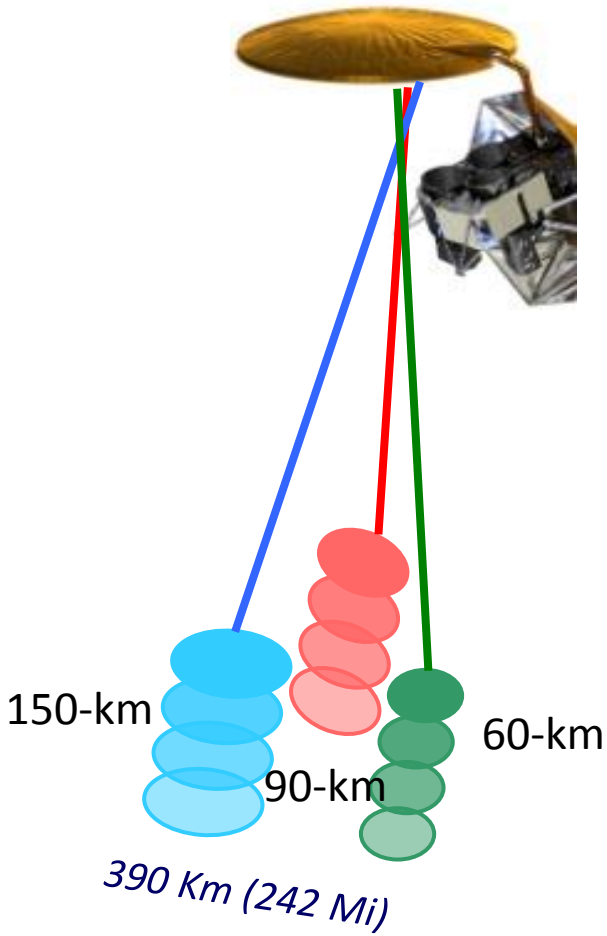



Point measurement




Vertical stratification


## Satellite




weekly

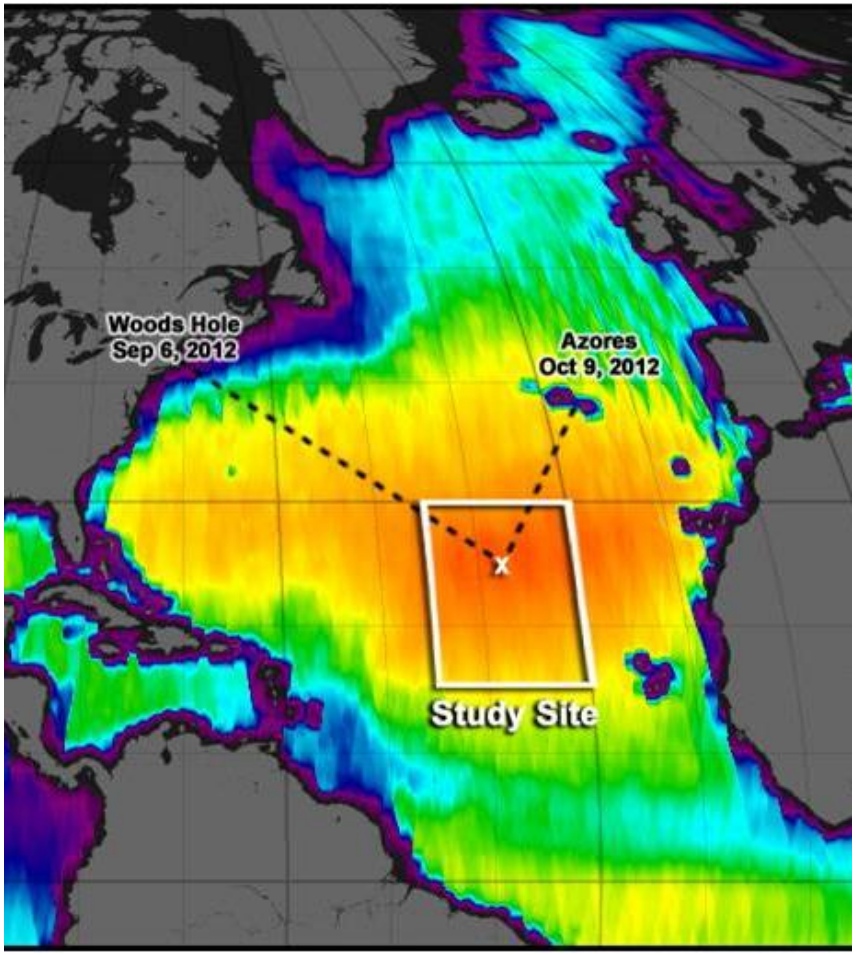
# Questions to be addressed

- What is the Aquarius retrieved data error in the SPURS region?
- What is the ground-truth salinity over 150-km & week?
  - Vertical stratification between the surface skin layer (~ 1 cm) and the near surface layer (~10 m)
  - Variability within the Aquarius footprint (150-km)
  - Variability within the weekly (Aquarius repeat time) time scale?

# Salinity Processes in the Upper Ocean Regional Study (SPURS)

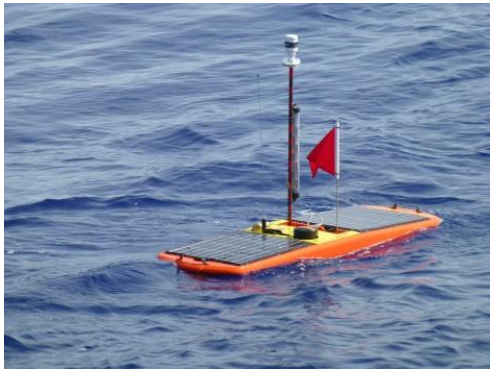
Five (5) cruises during September 2012 – October 2013

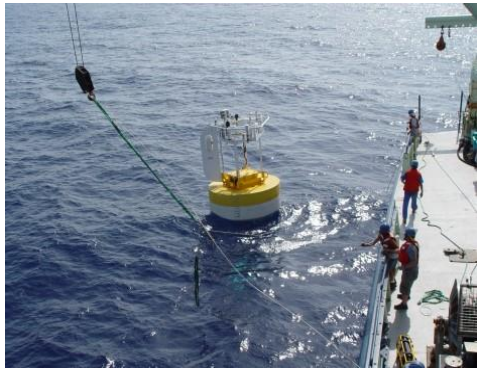
1. Thalassa/Frence-2012 (8/16 - 9/13)
2. Knorr/US-2012 (9/6 – 10/9)
3. Sarmiento/Spain-2013 (3/14 – 4/20)
4. Endeavour/US-2013spring (3/14 – 4/14)
5. Endeavour/US Cruise-2013fall (9/19-10/10)

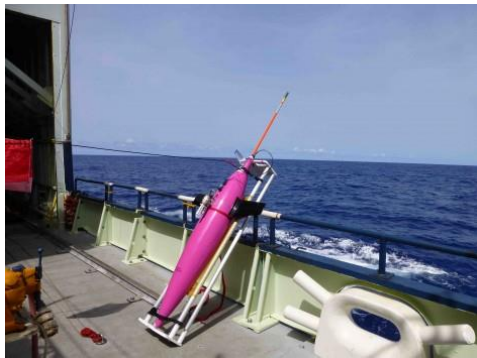


# SPURS Salinity Measurements from Surface to 10 meters Depth

- Waveglider-1: 0.2
- Drifter: 0.5
- WHOI Mooring: 0.75 (2)
  2.1
  5.2
  8.0
- Waveglider-2: 6
- STS Float: 0-3
  3-10
- Seaglider: 0-10





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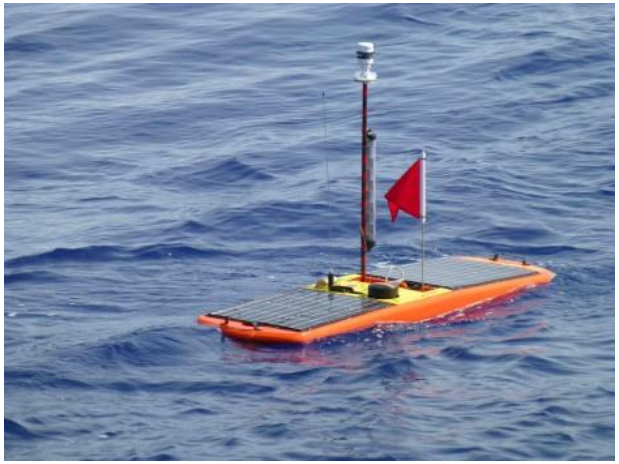
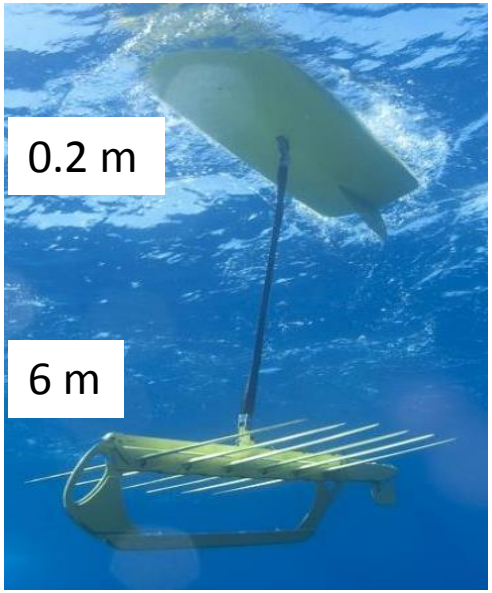
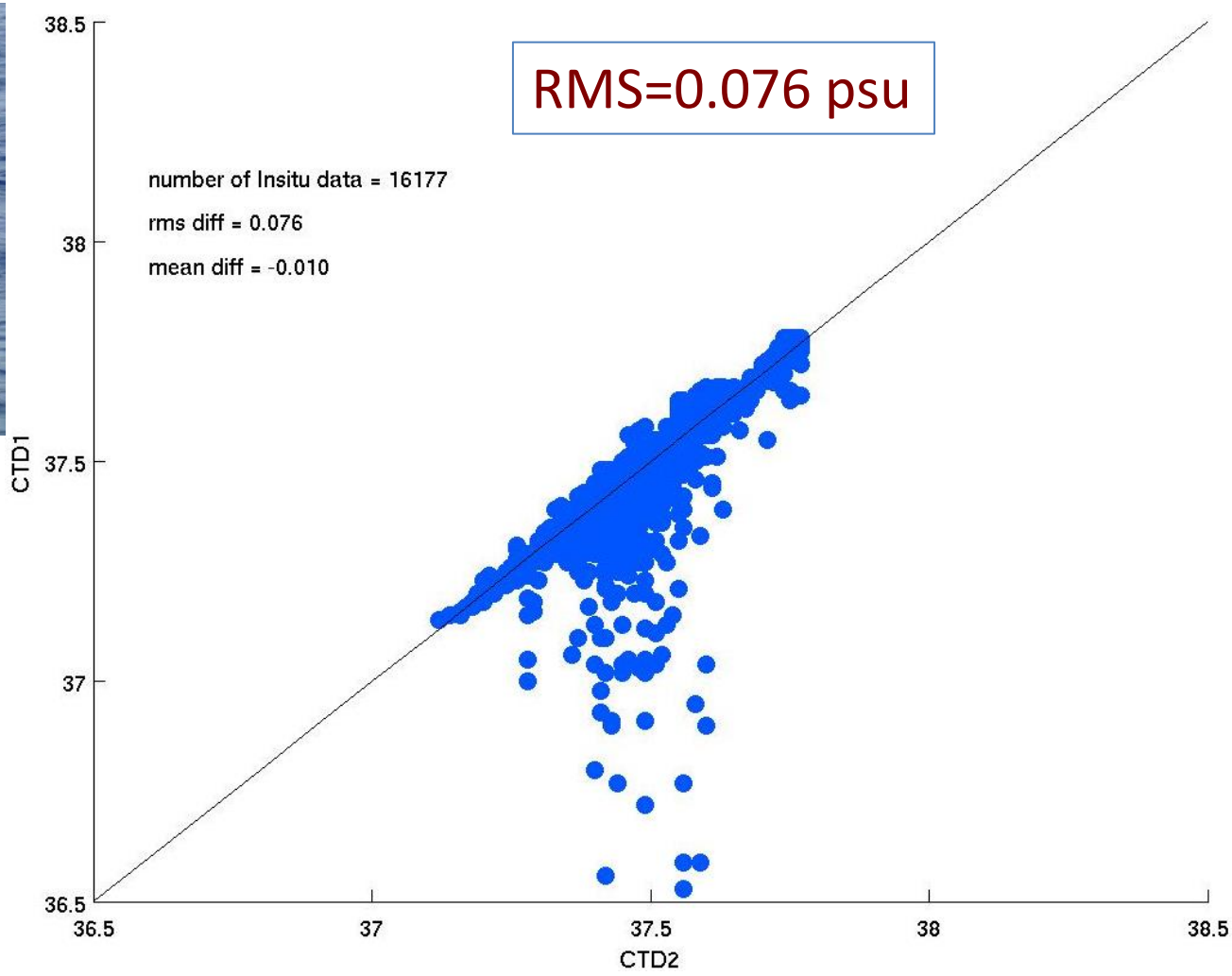
# Vertical Stratification:
# Wave Glider CTD-1(0.2m) vs. CTD-2 (6m)






Wave Glider



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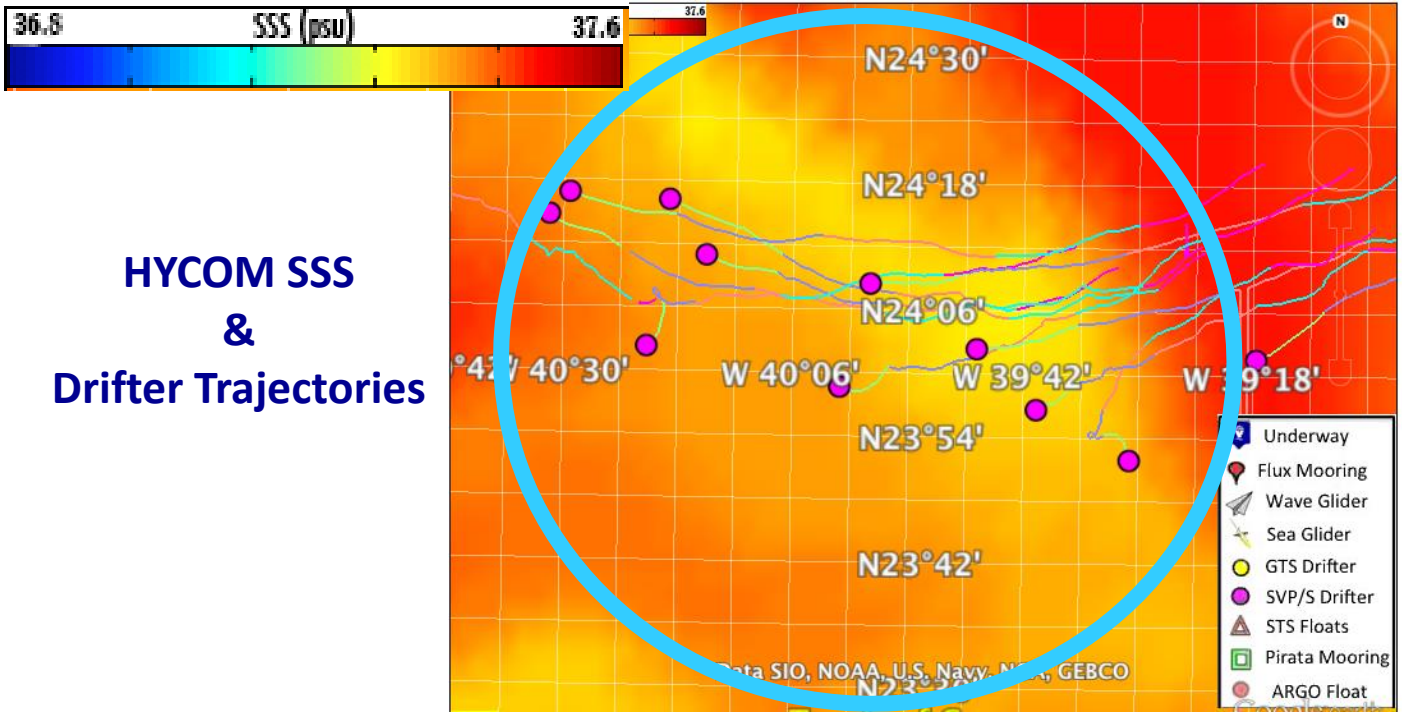
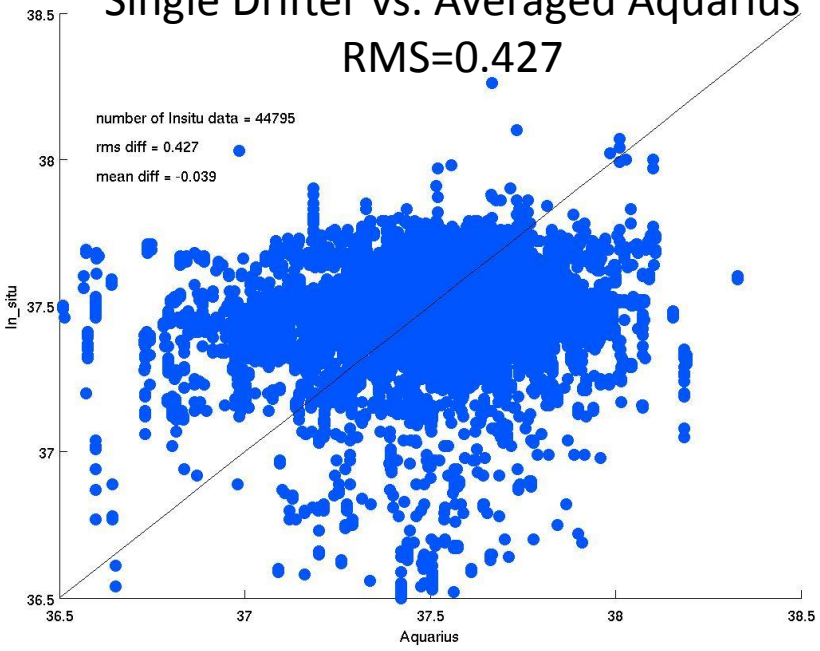
**HYCOM SSS**
**&**
**Drifter Trajectories**

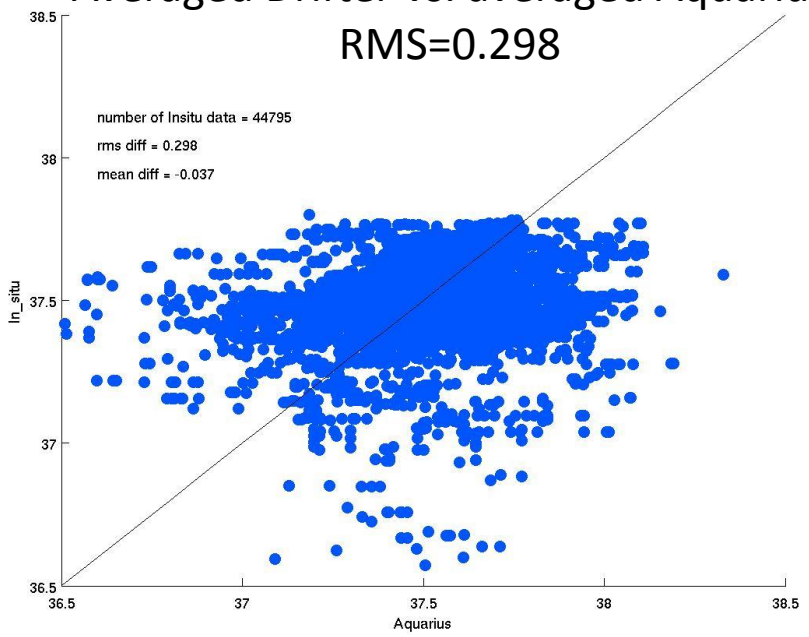



Conclusion: Averaging single-point data significantly improves the agreement with Aquarius (averaged) data

Single Drifter vs. Averaged Aquarius
RMS=0.427




Averaged Drifter vs. averaged Aquarius
RMS=0.298



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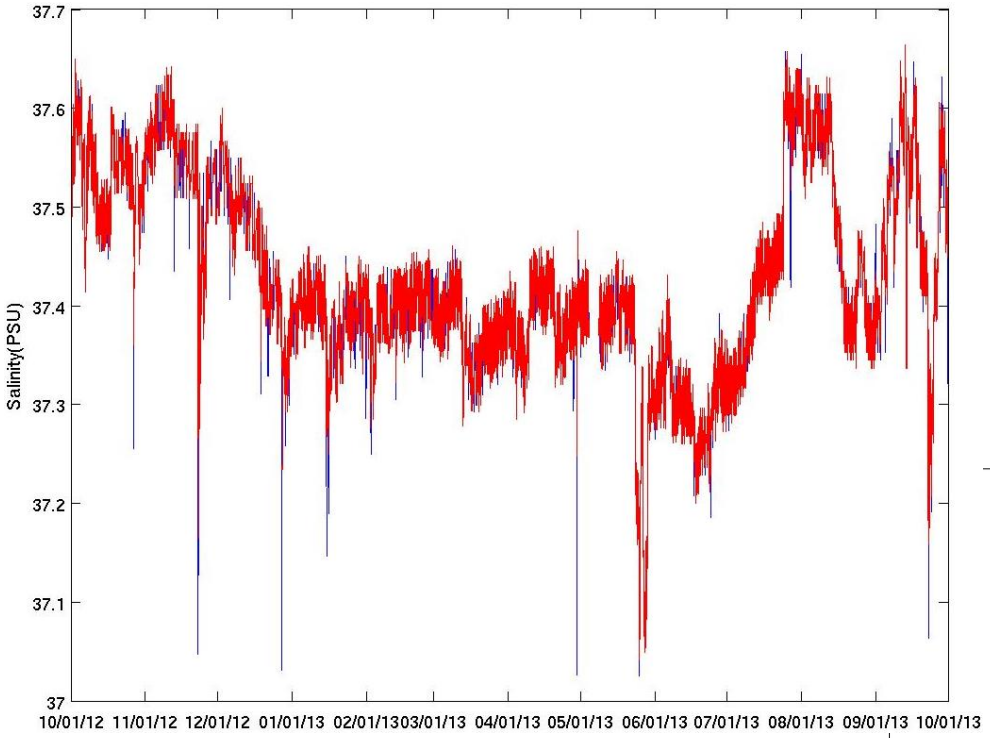
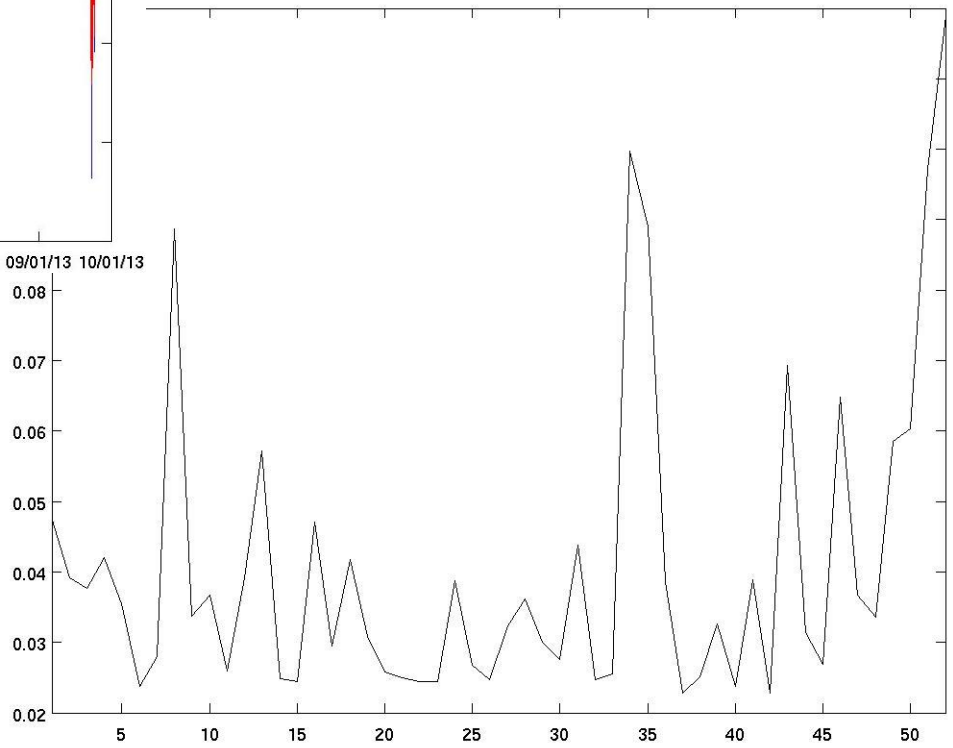
# Sub-weekly variations from WHOI mooring



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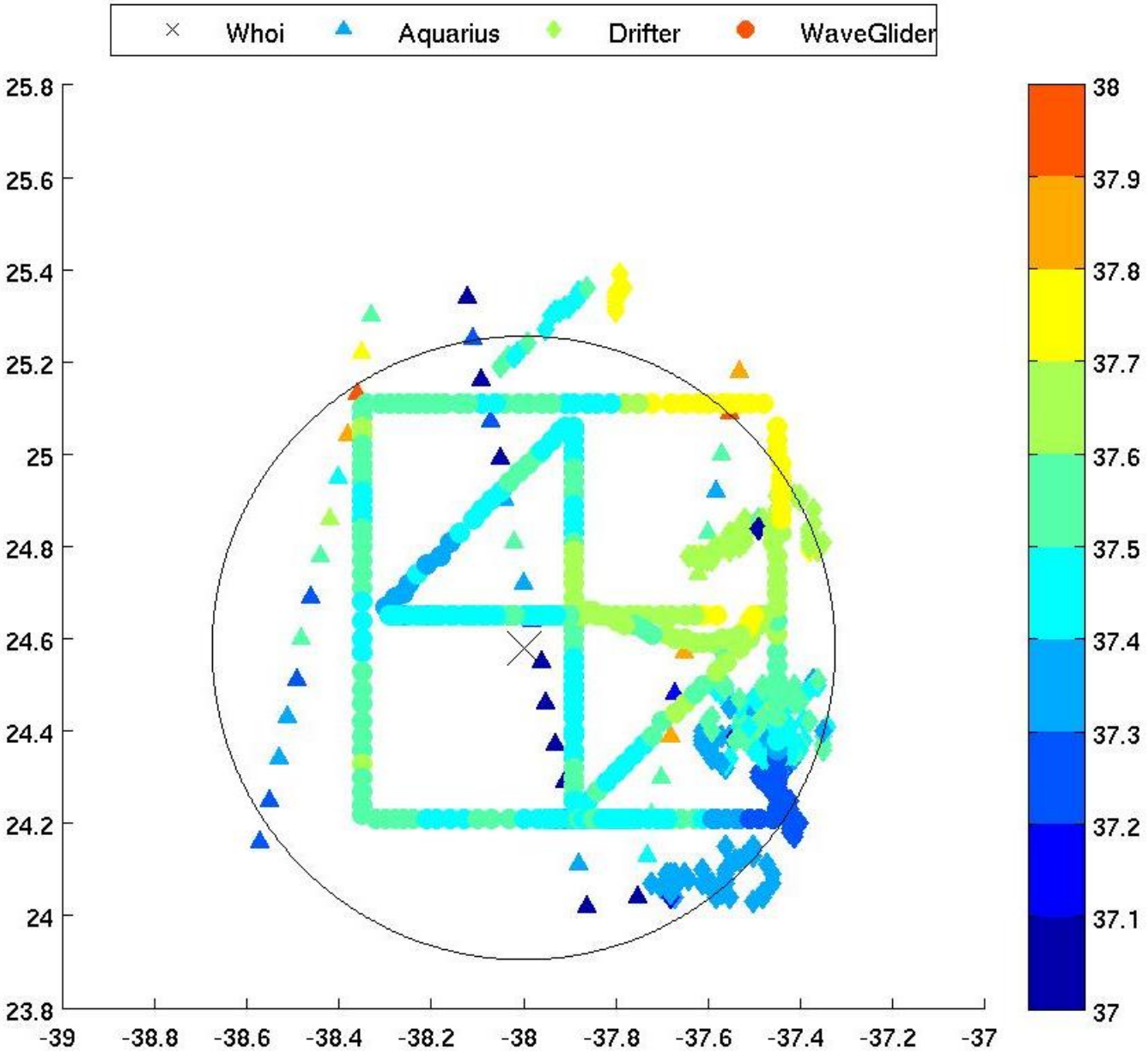
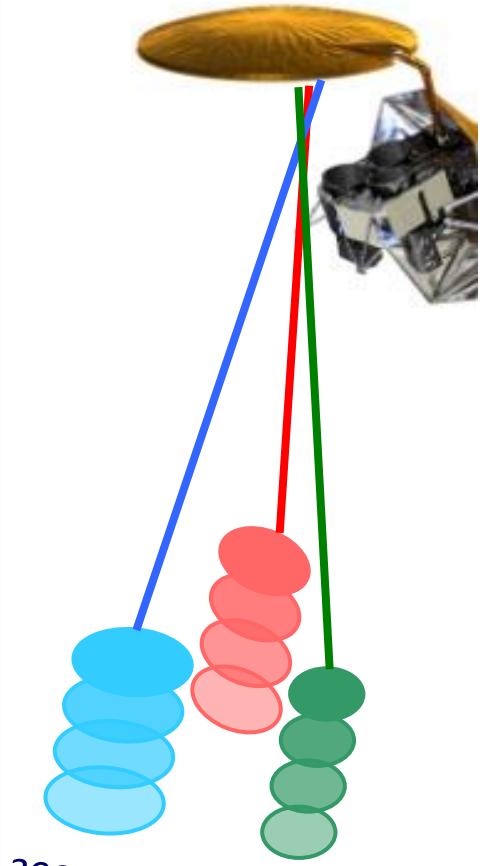
# SPURS In Situ Measurements



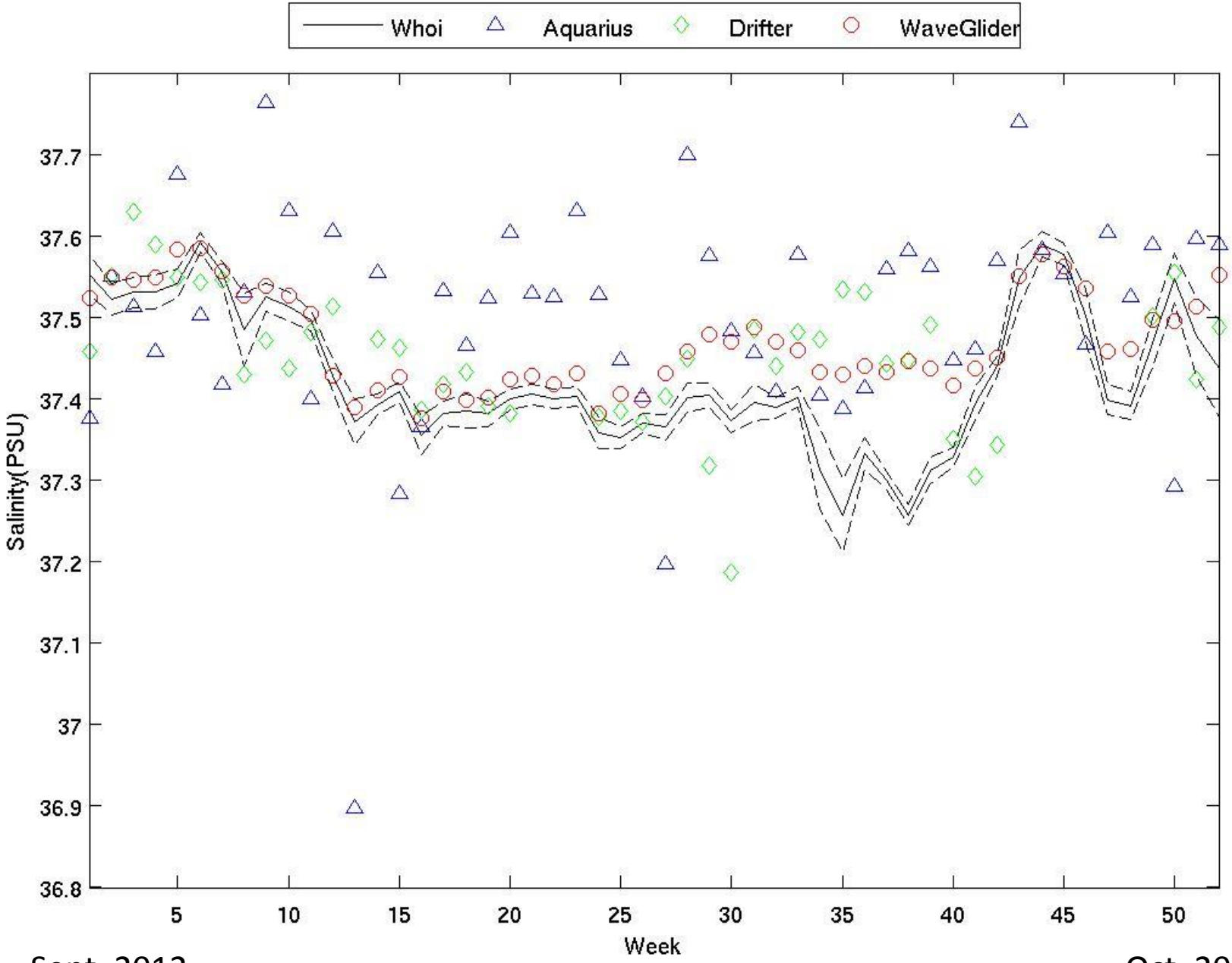

# Aquarius



390 Km (242 Mi)

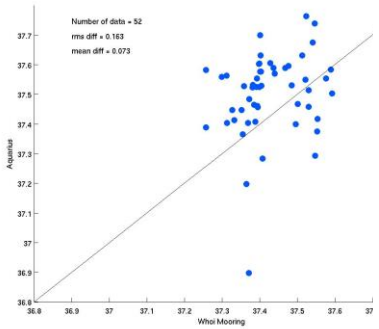
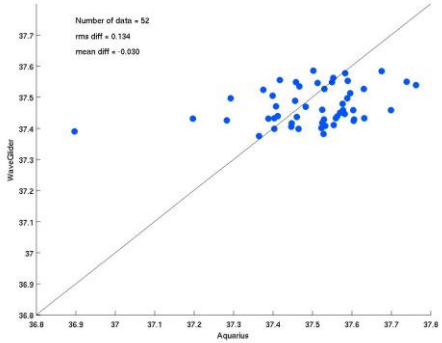
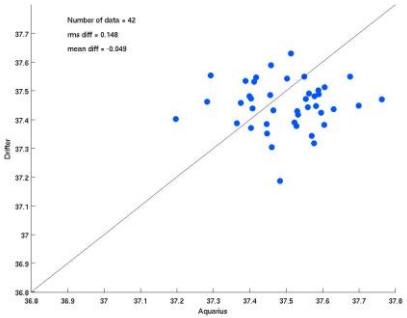
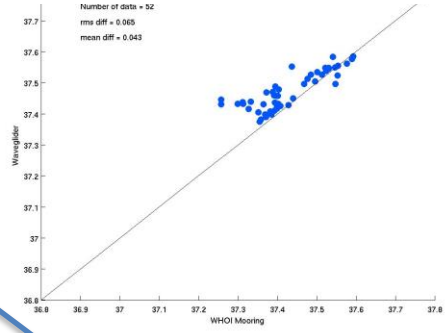
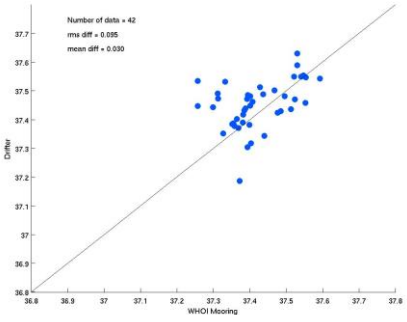
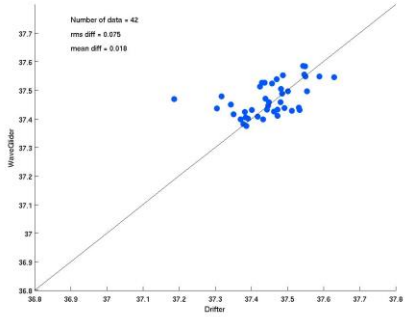
Weekly

# Aquarius & SPURS In Situ SSS (150-km, weekly)




Sept. 2012

Oct. 2013

| RMS (psu) | Aquarius | WHOI Mooring | Wave Glider | Drifter |
|---|---|---|---|---|
| Aquarius | |  |  |  |
| WHOI Mooring | 0.163 | |  |  |
| Wave Glider | 0.134 | 0.065 | |  |
| Drifter | 0.148 | 0.095 | 0.075 | |

# Triple-Point Analysis

**Formulation:**

$S_A = S \pm e_A$
$S_1 = S \pm e_1$
$S_2 = S \pm e_2$

**If $e_A$ and $e_1$ are uncorrelated, then**

$\langle \Delta S_{A\text{-}1}^2 \rangle = \langle e_A^2 \rangle + \langle e_1^2 \rangle$
$\langle \Delta S_{A\text{-}2}^2 \rangle = \langle e_A^2 \rangle + \langle e_2^2 \rangle$
$\langle \Delta S_{1\text{-}2}^2 \rangle = \langle e_1^2 \rangle + \langle e_2^2 \rangle$

**Solving above equations, then**

$\langle e_A^2 \rangle = \{\langle \Delta S_{A\text{-}1}^2 \rangle + \langle \Delta S_{A\text{-}2}^2 \rangle - \langle \Delta S_{1\text{-}2}^2 \rangle\}/2$

# Triple-Point Analysis

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**Solving above equations, then**

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**Aquarius Data Retrieval Error (psu):**

*[Aquarius, Drifter, Wave Glider]*

0.13

*[Aquarius, WHOI Mooring, Wave Glider]*

0.14

*[Aquarius, WHOI Mooring, Drifter]*

0.14

# Triple-Point Analysis

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**Aquarius Data Retrieval Error (psu):**

*[Aquarius, Drifter, Wave Glider]*

0.13

*[Aquarius, WHOI Mooring, Wave Glider]*

0.14

*[Aquarius, WHOI Mooring, Drifter]*

0.14

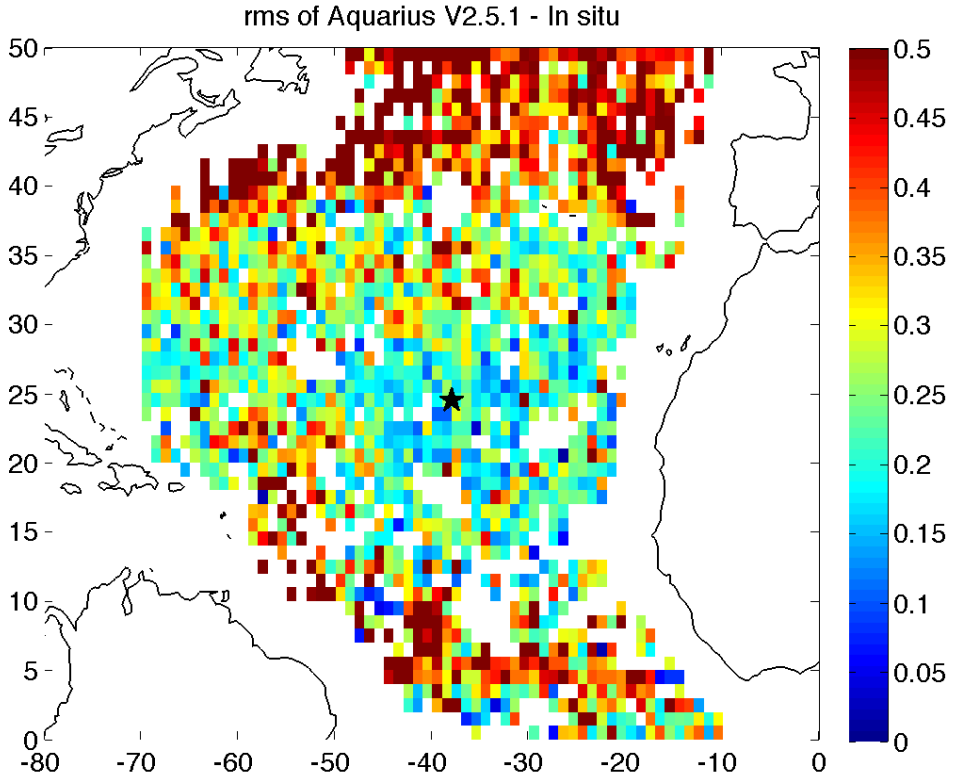
Errors for drifter, mooring and wave glider are 0.072, 0.062, & 0.02 psu, respectively

# Aquarius meets the accuracy requirement in the SPURS region!

Aquarius retrieved weekly data error is 0.13-0.14 psu near 25°N/38°W, & is smaller than the monthly allocation of 0.16 psu at this latitude.

| Latitude Range | Mean Sensitivity ($dT_v/dS$) | Mean # Samples in 28 Days | Baseline Mission Monthly Salinity Error (psu) | |
|---|---|---|---|---|
| | | | Allocation | CBE |
| 0–10 | 0.756 | 10.9 | 0.15 | 0.11 |
| 11–20 | 0.731 | 11.3 | 0.16 | 0.11 |
| 21–30 | 0.671 | 12.1 | 0.16 | 0.12 |
| 31–40 | 0.567 | 13.5 | 0.18 | 0.13 |
| 41–50 | 0.455 | 15.9 | 0.21 | 0.15 |
| 51–60 | 0.357 | 20.3 | 0.24 | 0.17 |
| 61–70 | 0.271 | 30.2 | 0.26 | 0.18 |
| | | Global RMS (psu) | 0.20 | 0.14 |

(Lagerloef et al., 2008)




RMS=0.25 psu (from Hsun-Ying Kao)

# SUMMARY & CONCLUSIONS

- Variability that cannot be resolved by Aquarius and in situ measurements
  - 0.05 to 0.1 psu associated with the vertical stratification (between surface < 1 m and near surface 3-10 m)
  - 0.1 psu associated with sub-footprint (150-km) variations
  - 0.05 psu associated with the sub-weekly fluctuations
- In the SPURS region near 25°N and 38°W, the Aquarius retrieved weekly data error is estimated as 0.13-0.14 psu (smaller than the 0.16 psu allocated for the monthly error), meeting the accuracy requirement!

# FUTURE WORK

- Re-do the analysis with delayed mode data
  - WHOI mooring (redundant sensor at 0.75 m; sensors at 2.1, 5.2, 8.0 meters)
  - UCSD/SIO drifters (CTD sensor drift after 6 months)
- Include data from
  - STS floats (Steve Riser, UW)
  - Seagliders (Craig Lee, UW)
- How can we apply lessons learned from SPURS in the global Aquarius validation?

**Thanks!**

**Questions?**

**Contact Information:**

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626-602-6186