Validation of Aquarius Salinity with Argo: Errors Due to Collocation and Vertical Salinity Stratification

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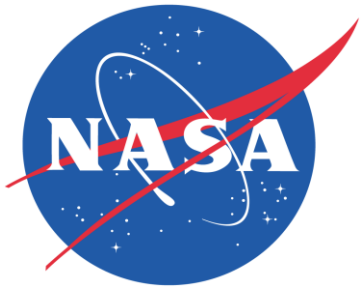
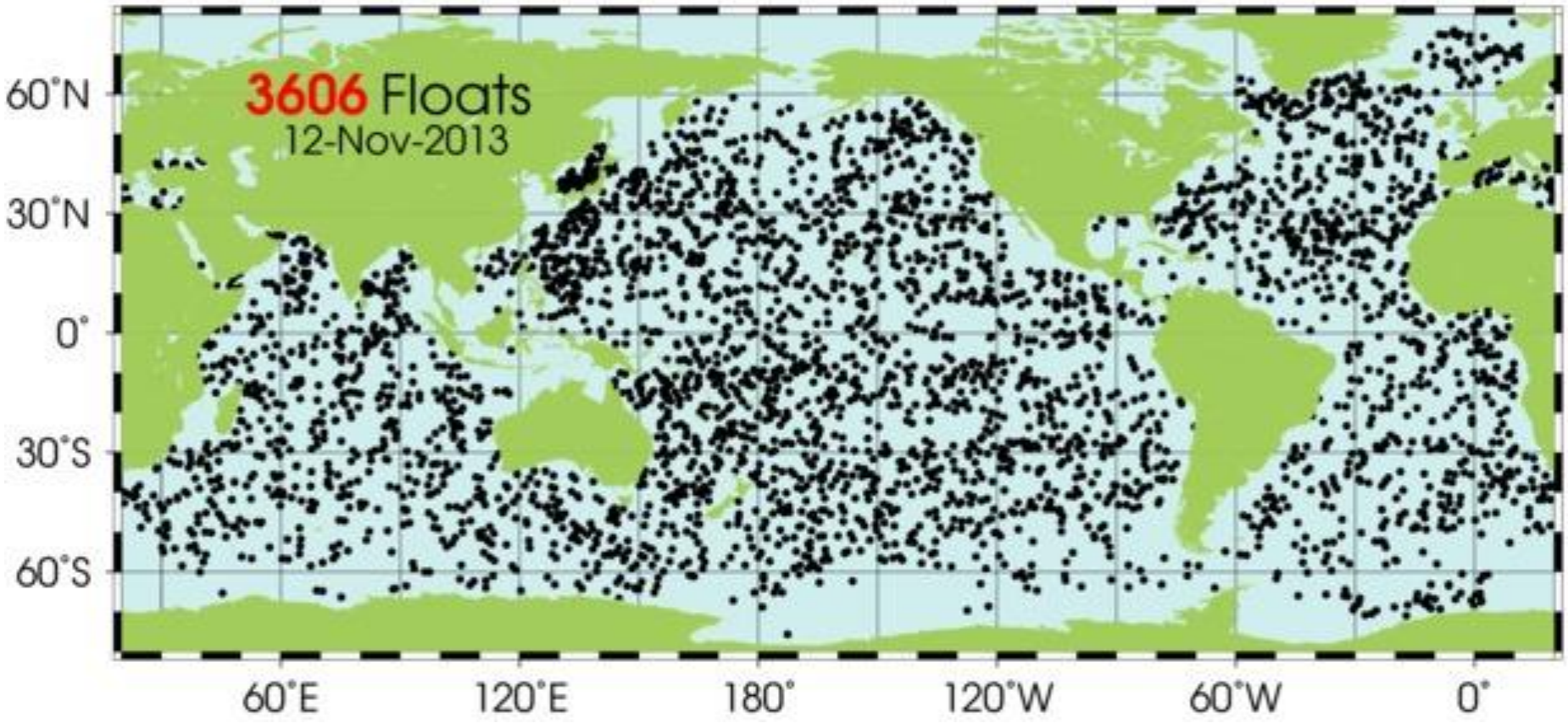
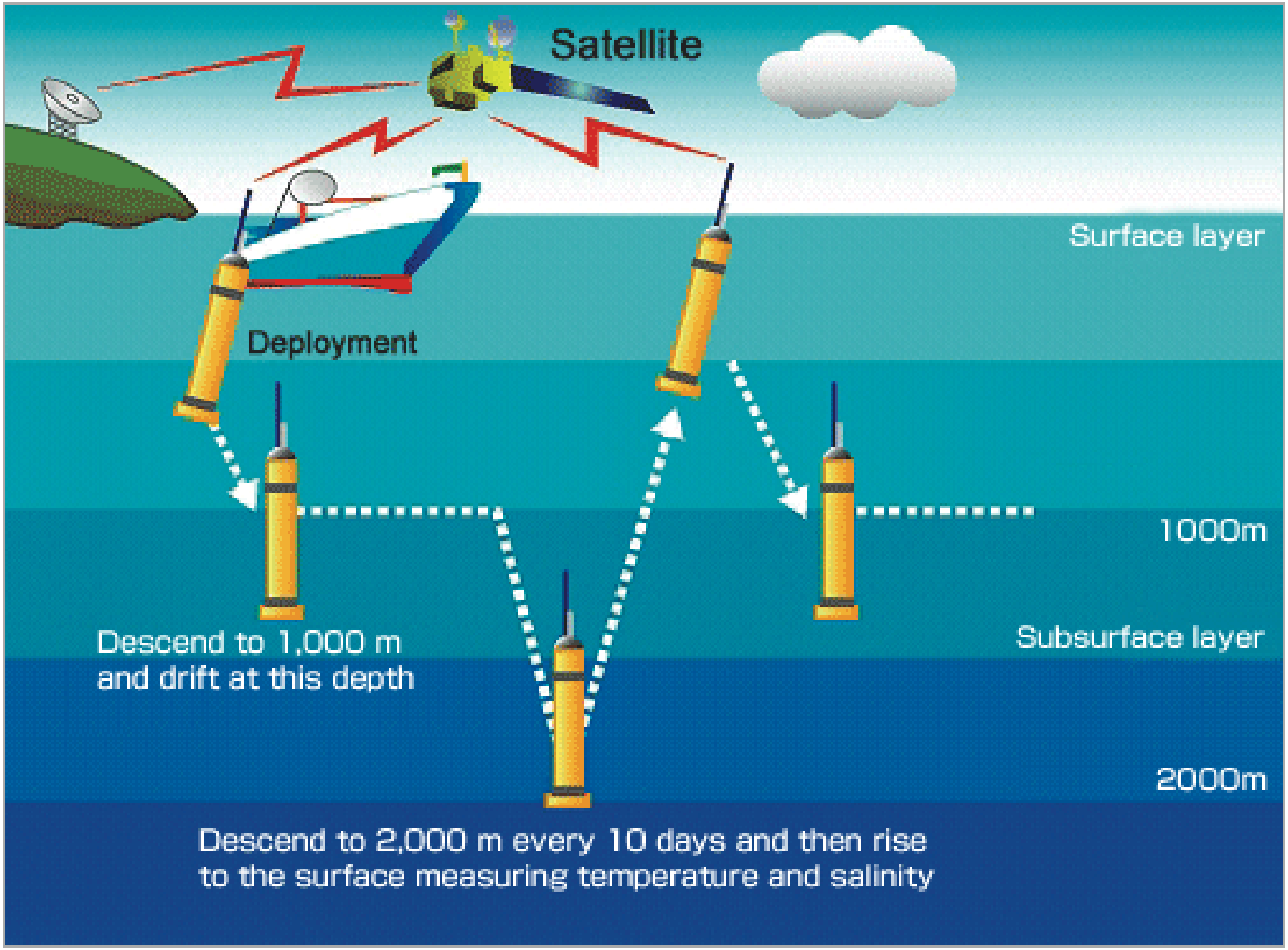


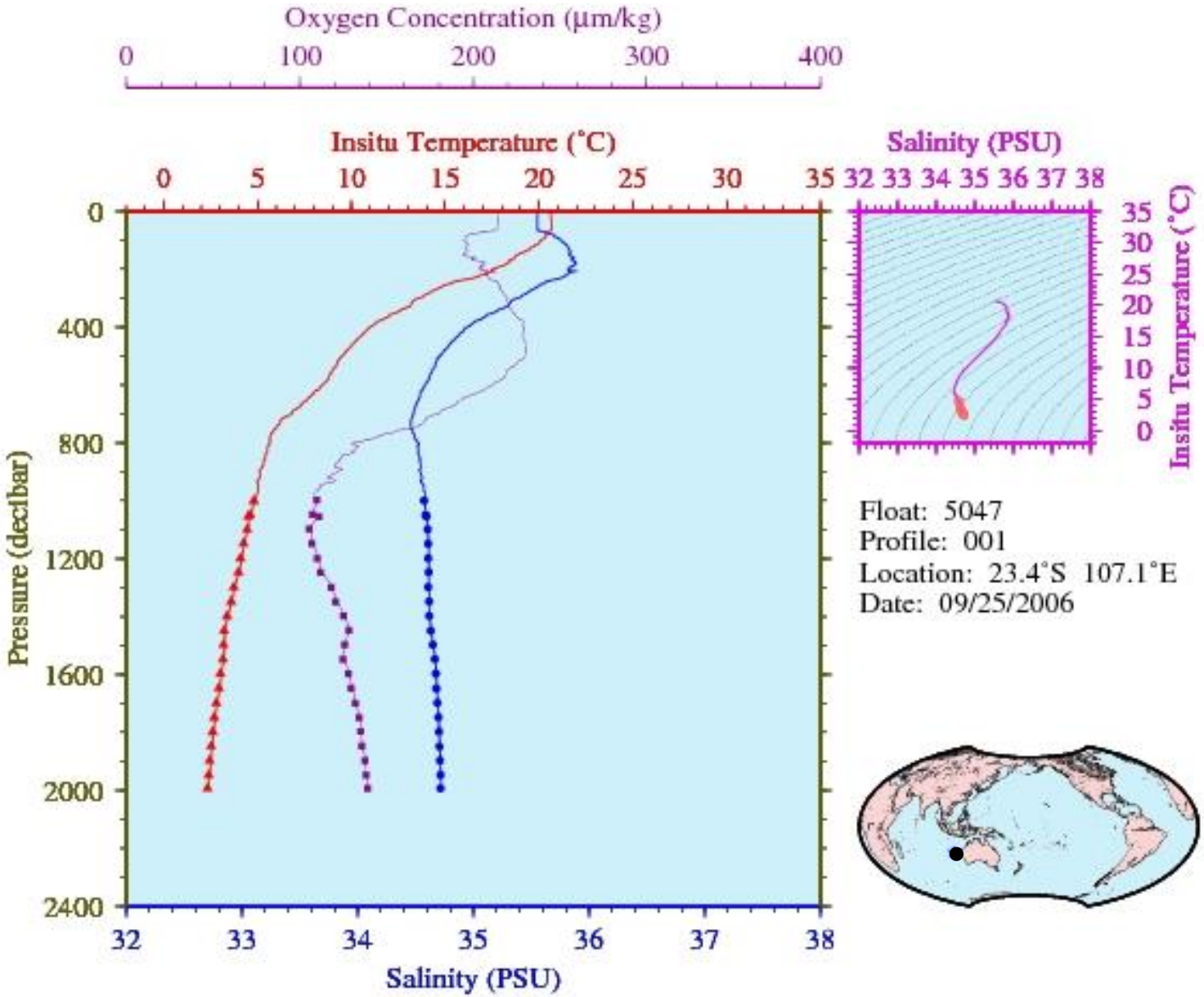
The Argo Float Array



Canonical Argo mission:
0-2000 m; *T*, *S*, *p* **(0.005 °C; 0.01 PSU ; 2.5 dbar)**
Δt = 10 days
5-6 years/200-250 profiles

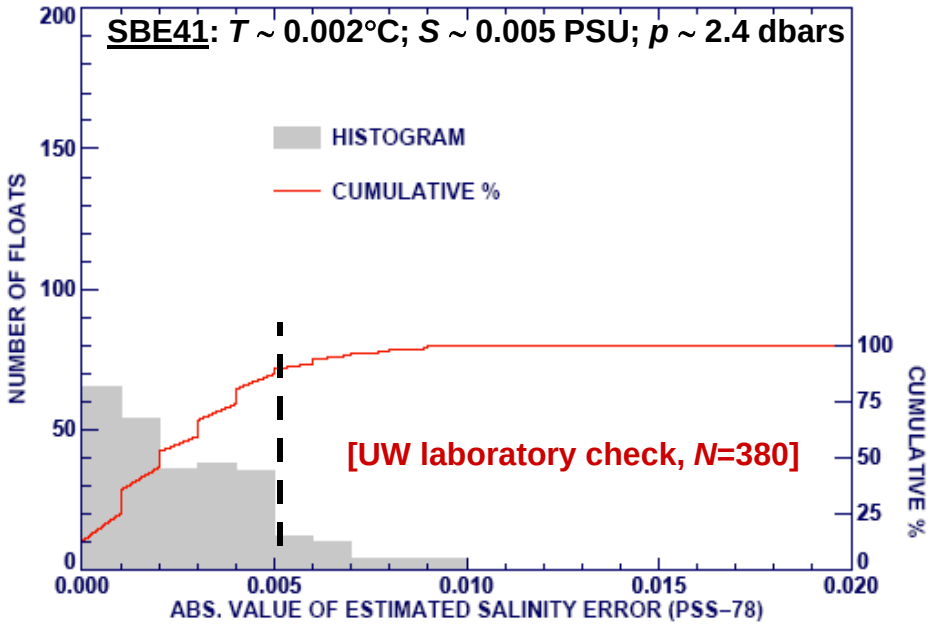


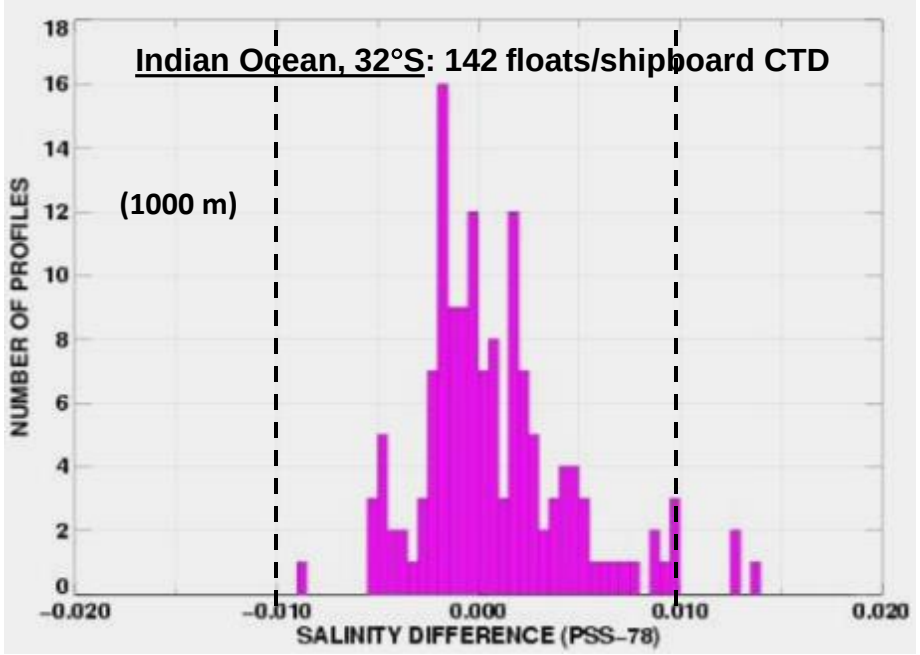
A Typical Argo Mission



An example of a high-resolution Argo profile from the Indian Ocean

SBE CTD performance in Argo: generally excellent





Results from recovered floats

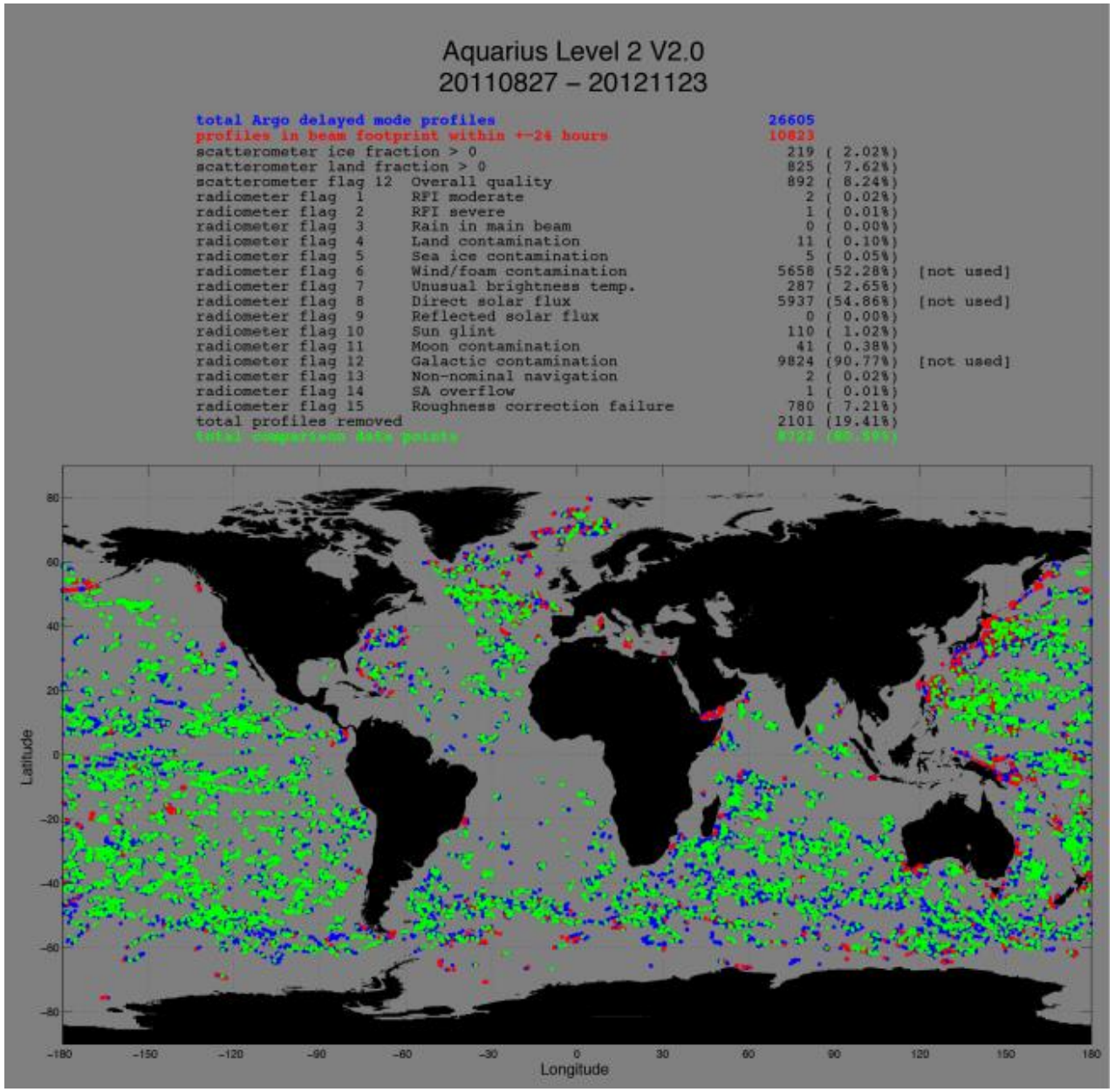
FLOAT	TIME (days)	ΔT (°C)	ΔS (PSS-78)	Δp (decibars)
29045*	840	0.00136	-0.0074	4.68
2900056*	730	0.00158	-0.0074	5.92
29051*	900	0.00100	-0.0125	0.72
41862†	1096	0.00030	-0.0060	0.06

* Deployed by Japan in the North Pacific † Deployed by the US in the North Atlantic

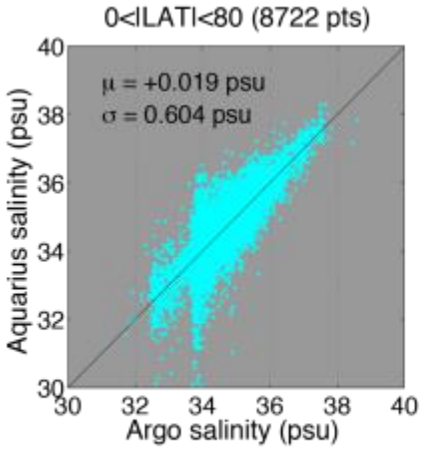
***DMQC results*:**
≤ 10 % adjusted

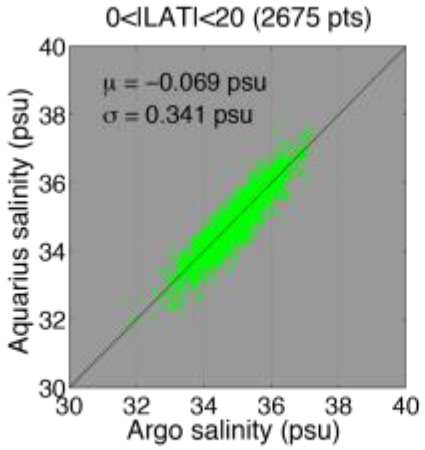
Collocation of Aquarius level-2 SSS and Argo near-surface salinity

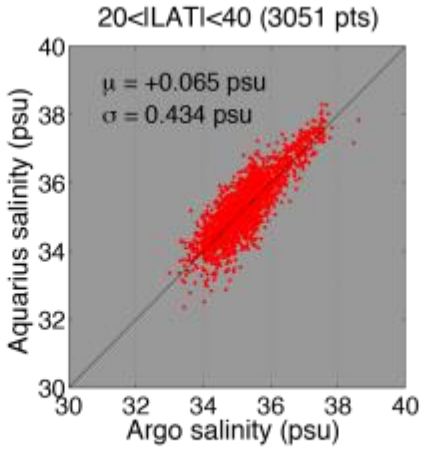
- **26605 delayed mode profiles in 15 months**
- **10823 of these were inside one of the three beam footprints within ±24 h of acquisition.**
- **About 20% of these were flagged for land, ice or other contamination, leaving 8722 collocated data pairs for analysis.**
- **For each data pair, the top Argo salinity sample is recorded. This is usually at a nominal depth of 5 m.**
- **$\Delta S = SSS_{Aquarius} - S_{Argo}$**

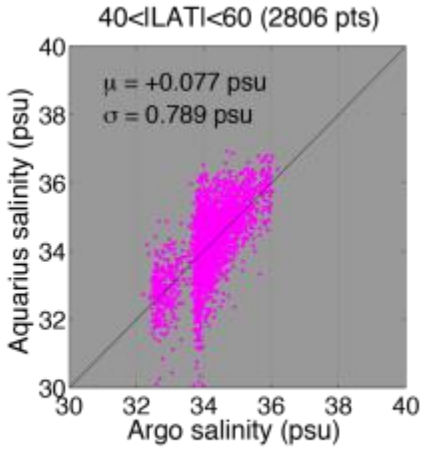


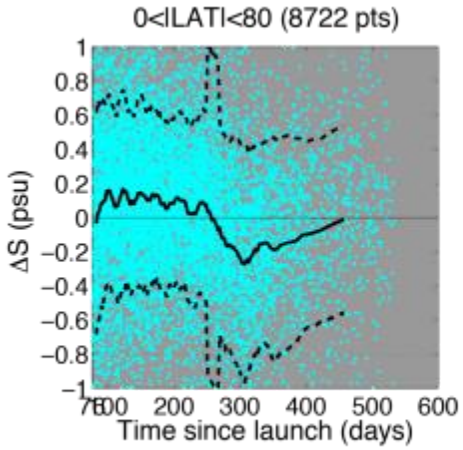
$SSS_{Aquarius} = \alpha S_{Argo} + \mu$

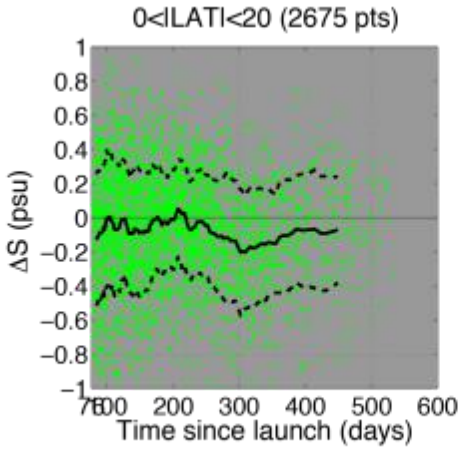


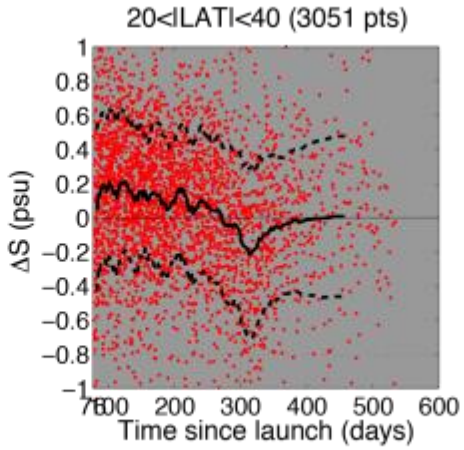


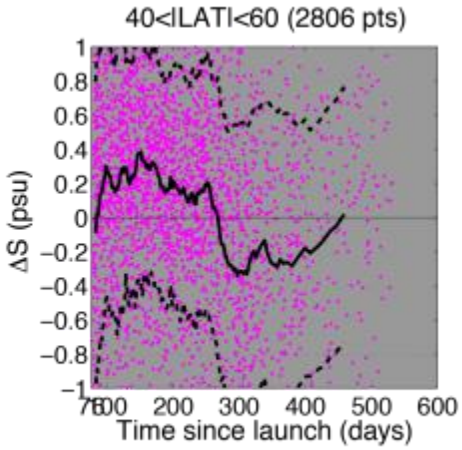






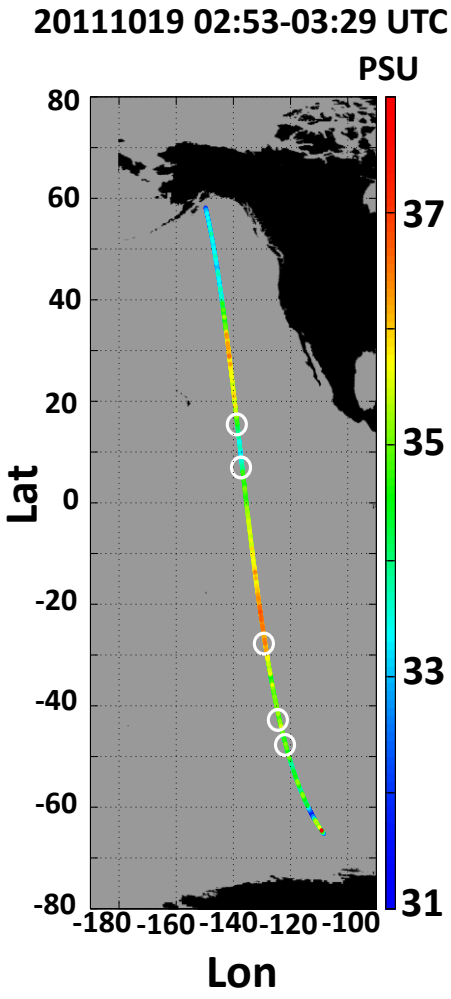


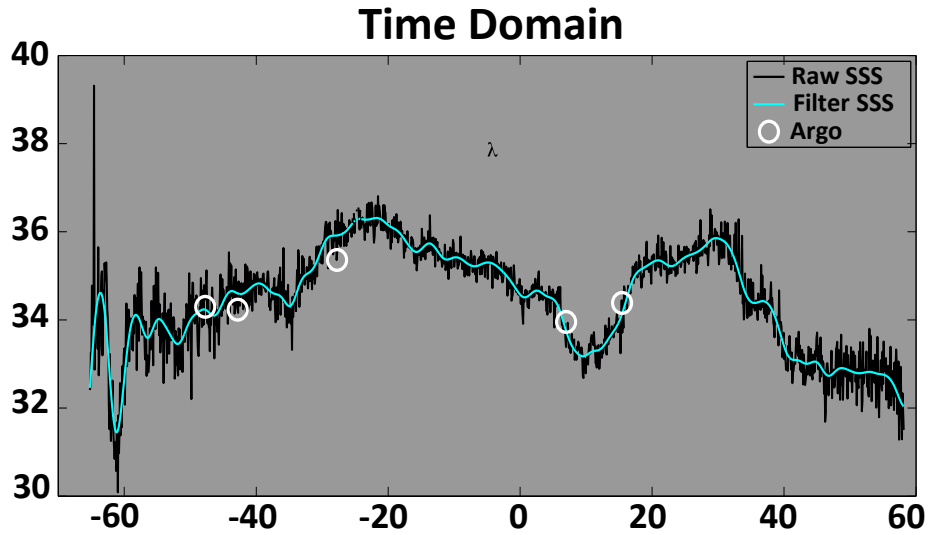


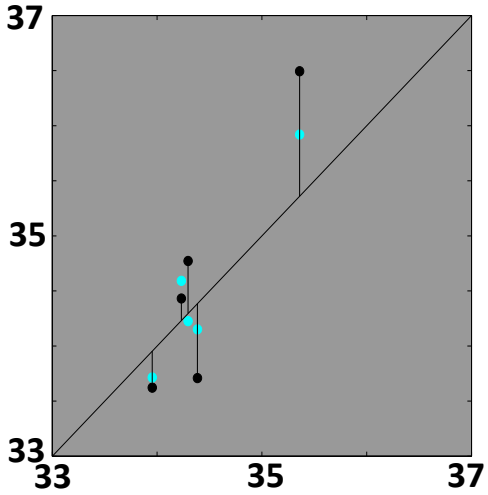


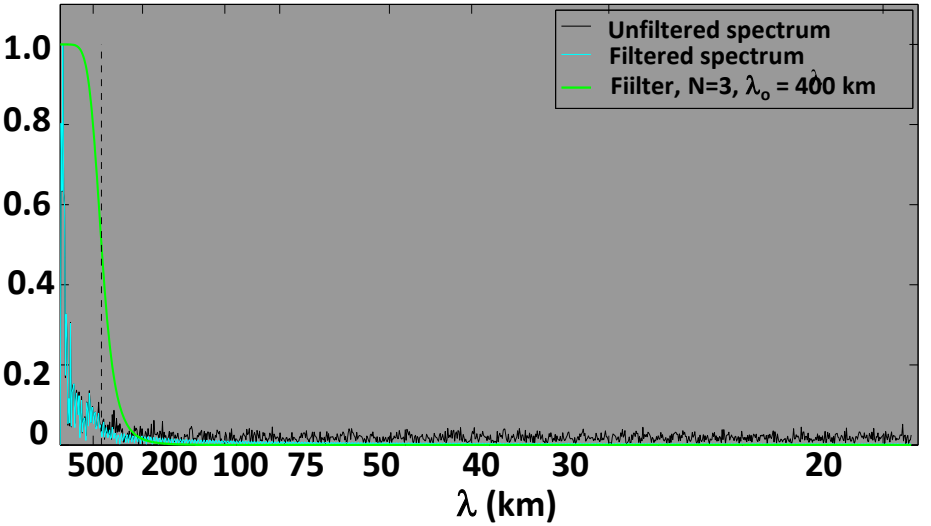
Overall μ < 0.1 PSU for all latitudes to 60°, but σ is large

Reduction of σ by filtering



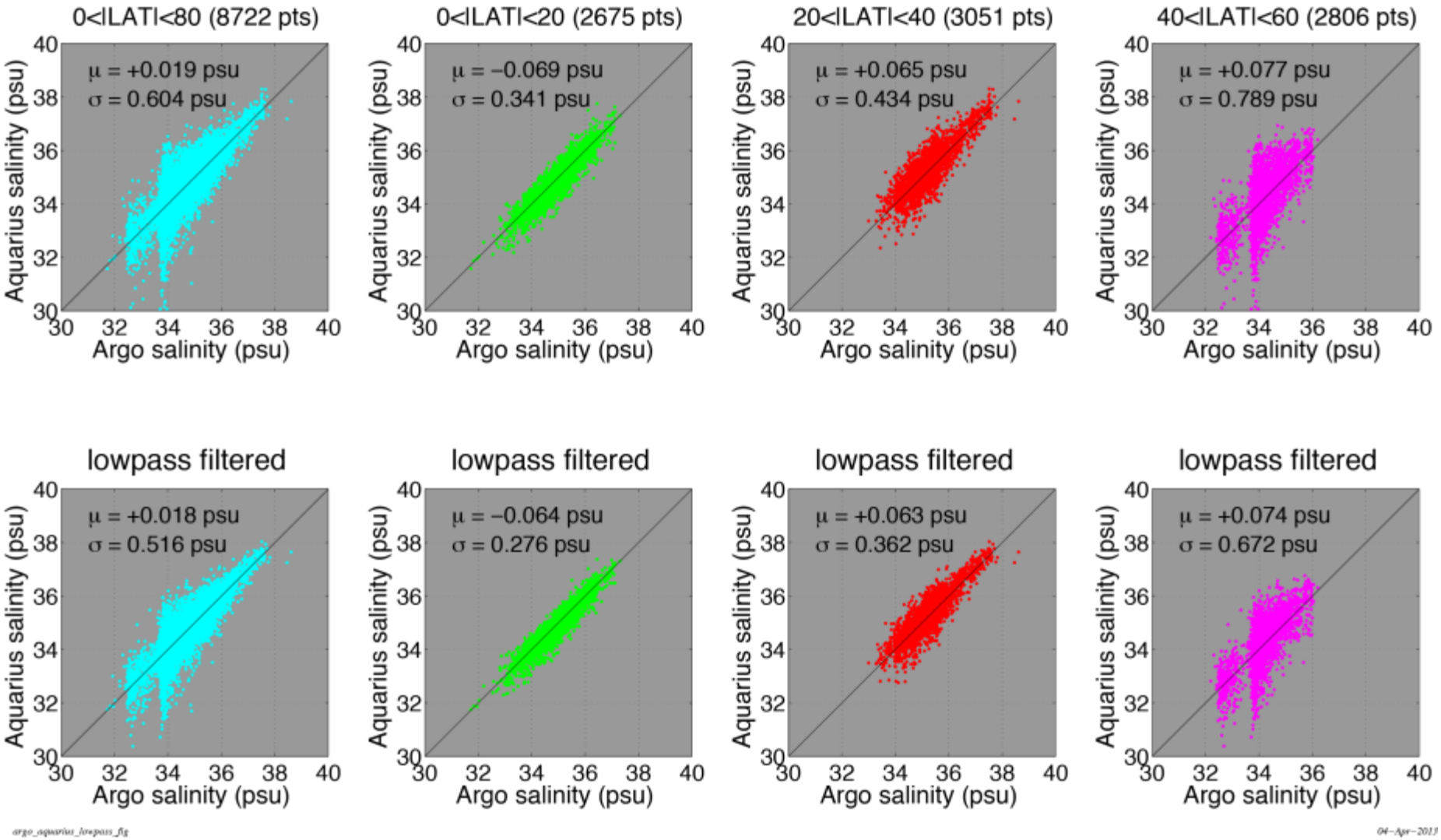






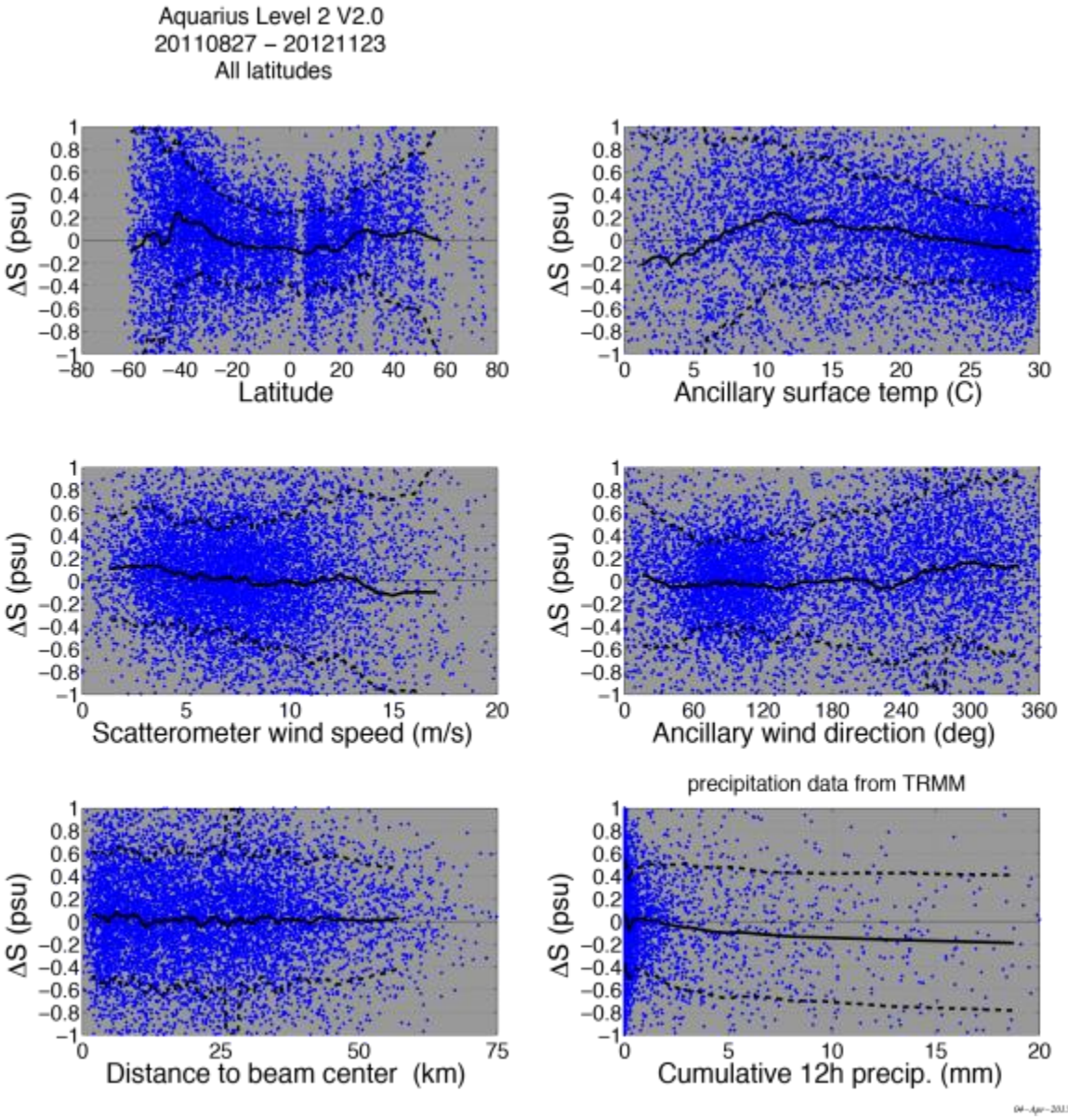
La	Lo	d(km)	dt(h)	dS	ds (filt)
-49	-122	26	44	0.40	-0.70
-43	-124	60	32	0.20	0.36
-28	-129	44	-4	1.13	0.56
7	-137	48	17	-0.33	-0.24
15	-139	20	40	-0.68	-0.23

Lowpass filtering of Aquarius SSS signal reduces σ by ~ 15-20%



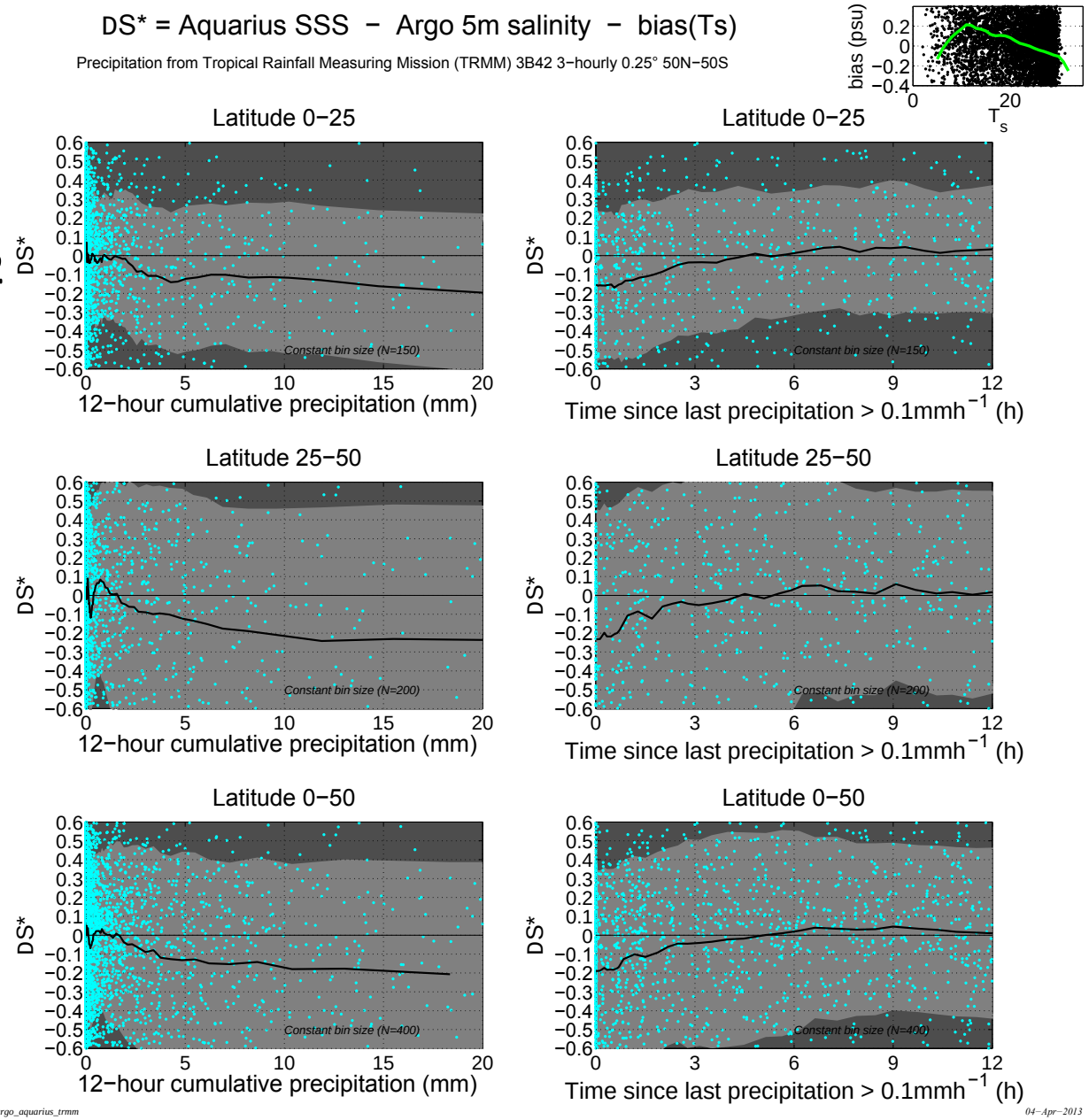
How does ΔS depend on oceanographic variables?

- **Mean and variance depend on latitude, surface temperature, wind speed /direction, and rain**
- **No dependence on spatial or temporal proximity of Argo and Aquarius samples**
- **Some sources of error not yet explored (galactic, solar/lunar, etc.)**



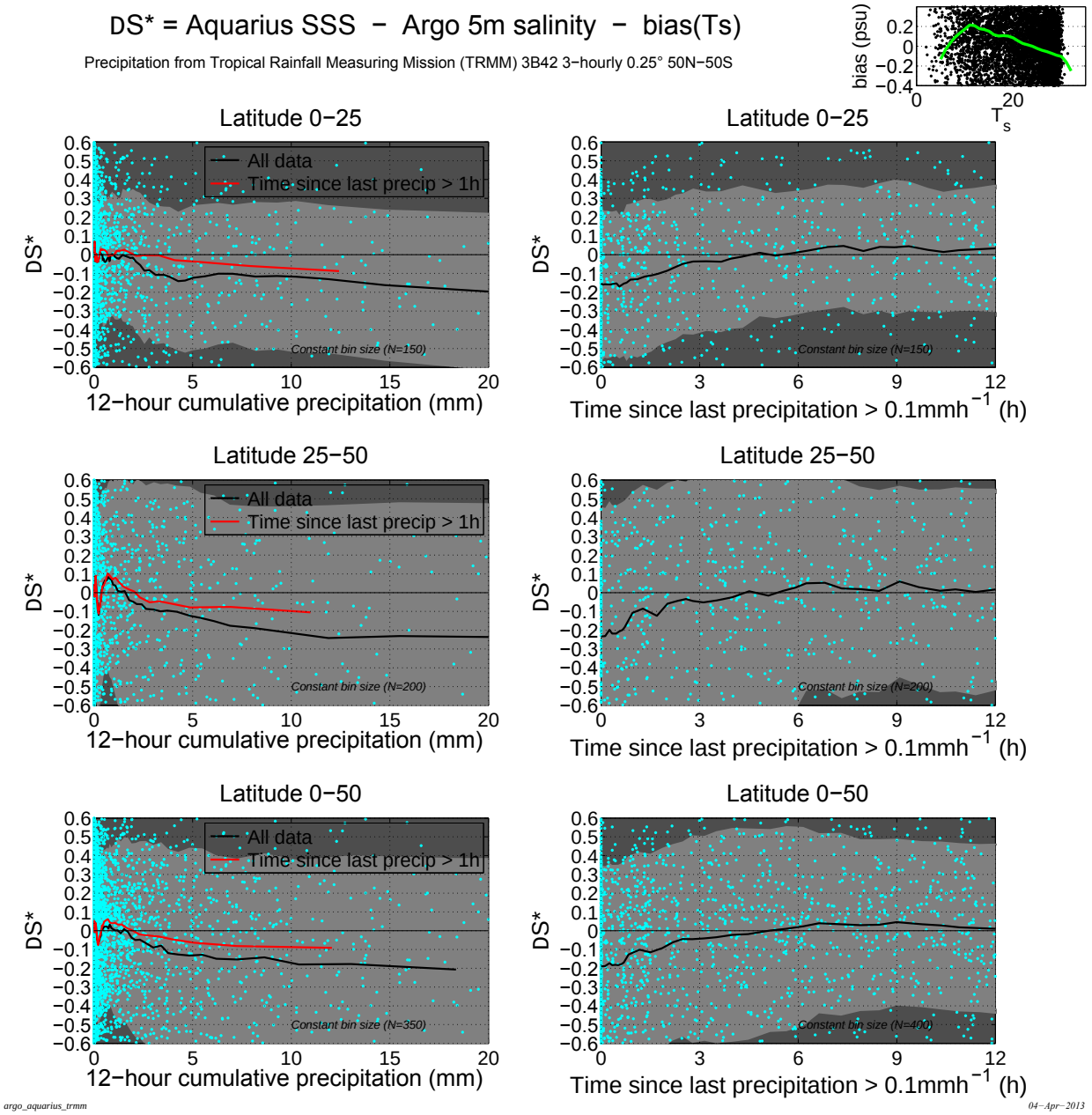
Dependence on precipitation

- **Surface freshening trend with precipitation: ΔS decreases by about 0.2 PSU for P_{12h} > ~ 10 mm**
- **Freshening decreases rapidly with time: bias disappears within ~ 6 hours.**
- **No dependence on Δt , suggesting initial salinity stratification due to freshening at the surface, then mixing**



Dependence on precipitation (2)

Removal of t_{last}< 1 h reduces bias by about half. Possible effects of rain in the beam (i.e., atmospheric or surface roughening) and initial stratification, followed by mixing



Conclusions

- **Mean difference of Level-2 SSS and Argo near-surface salinity is about ± 0.07 PSU for all latitudes less than 60°, varying with latitude.**
- **Seasonal variation ± 0.3 PSU .**
- **Signal is noisy: σ ≈ 0.4 to 0.8 PSU (increasing with latitude). Low-pass filtering reduces σ by 15-20%.**
- **Variables related to bias and variance include surface temperature, wind, and rain.**
- **For collocations of 0-70 km and ±24 h, both bias and variance do not depend on spatial/temporal proximity of Argo and Aquarius.**
- **Moderate to heavy rain causes a differential freshening of about –0.2 PSU. This is short-lived (<6 h) and reduced by about half when current precipitation (t < 1 h) is excluded.**

Further Work

- **Better understanding of salinity stratification in the upper 5 m is needed in order to use the global Argo network for validation**
- **In-situ data from STS floats, SPURS, etc will help**
- **Better collocated precipitation data needed: STS floats with PAL acoustic sensors, improved satellite rain measurement**
- **High-frequency measurements to study small scale temporal and spatial salinity variability**