Near Surface Temperature and Salinity Variations and Diurnal Cycles in the Tropical Ocean

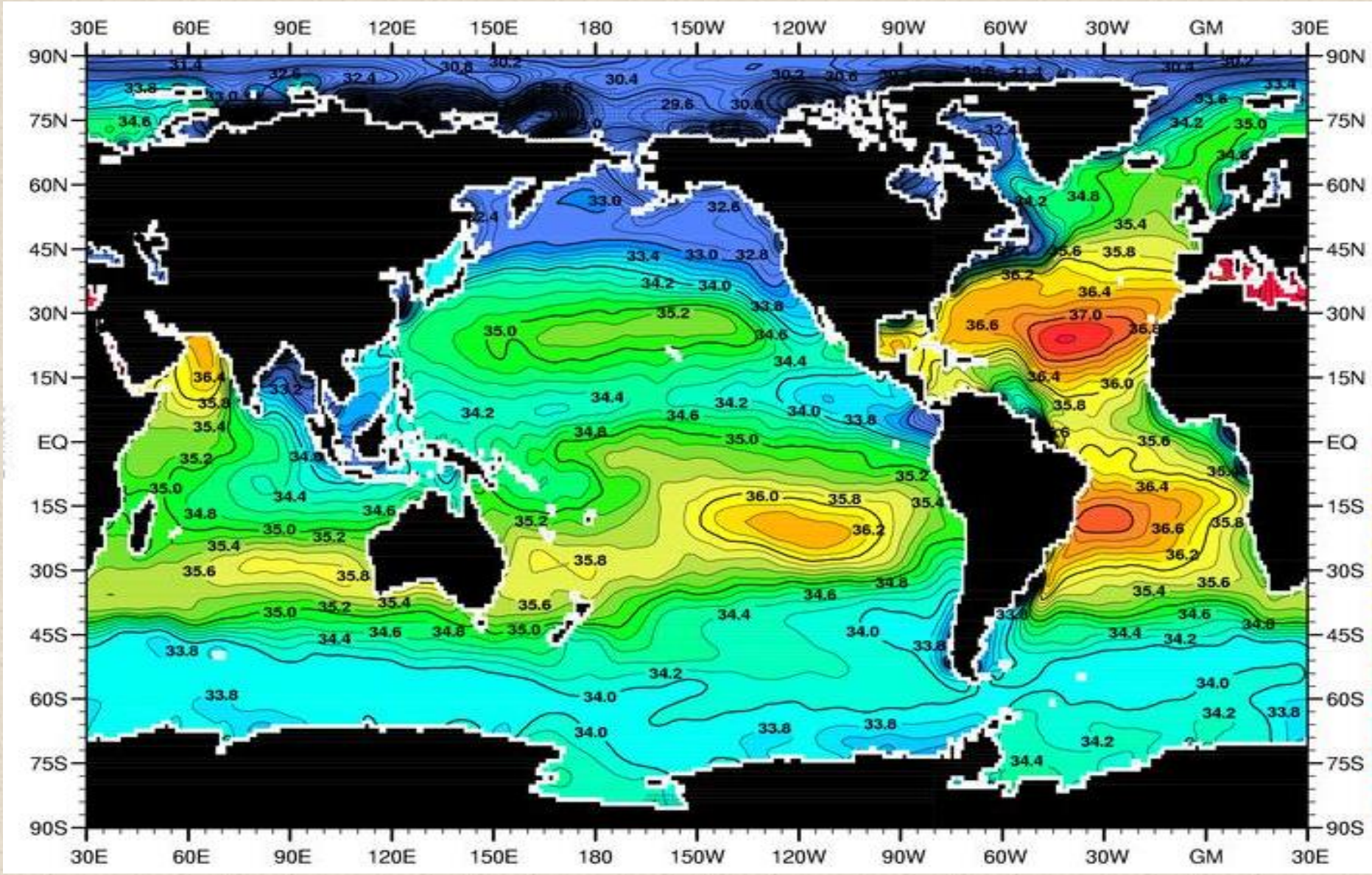
Stephen Riser
Jessica Anderson

University of Washington

riser@ocean.washington.edu

8th Aquarius/SAC-D Science Meeting, Buenos Aires
November 14, 2013

[Acknowledgements to NASA, NOAA, NSF, ONR]



The annual mean global sea surface salinity (PSU)

$$S = \frac{M_S}{M_S + M_W}$$

classical definition of salinity

$$\frac{\partial S}{\partial t} + \underset{\sim}{u}_H \cdot \nabla S + w\frac{\partial S}{\partial z} = \text{sources} - \text{sinks} + \text{mixing}$$

average this over a surface mixed layer of thickness *h* :

"ocean rain gauge"

$$h\frac{\partial S}{\partial t} = -\langle \underset{\sim}{u} \rangle h \cdot \nabla \langle S \rangle - \nabla \cdot \int_{-h}^{0} \underset{\sim}{u} S \, dz - \left(\langle S \rangle - S_{-h} \right) \left(\frac{\partial h}{\partial t} + \underset{\sim}{u}_{-h} \cdot \nabla h + w_{-h} \right) + \left(E - P \right) S_o + \text{SSM}$$

advection of vertically-averaged salinity by the average flow

advection of salinity by the sheared part of the horizontal flow

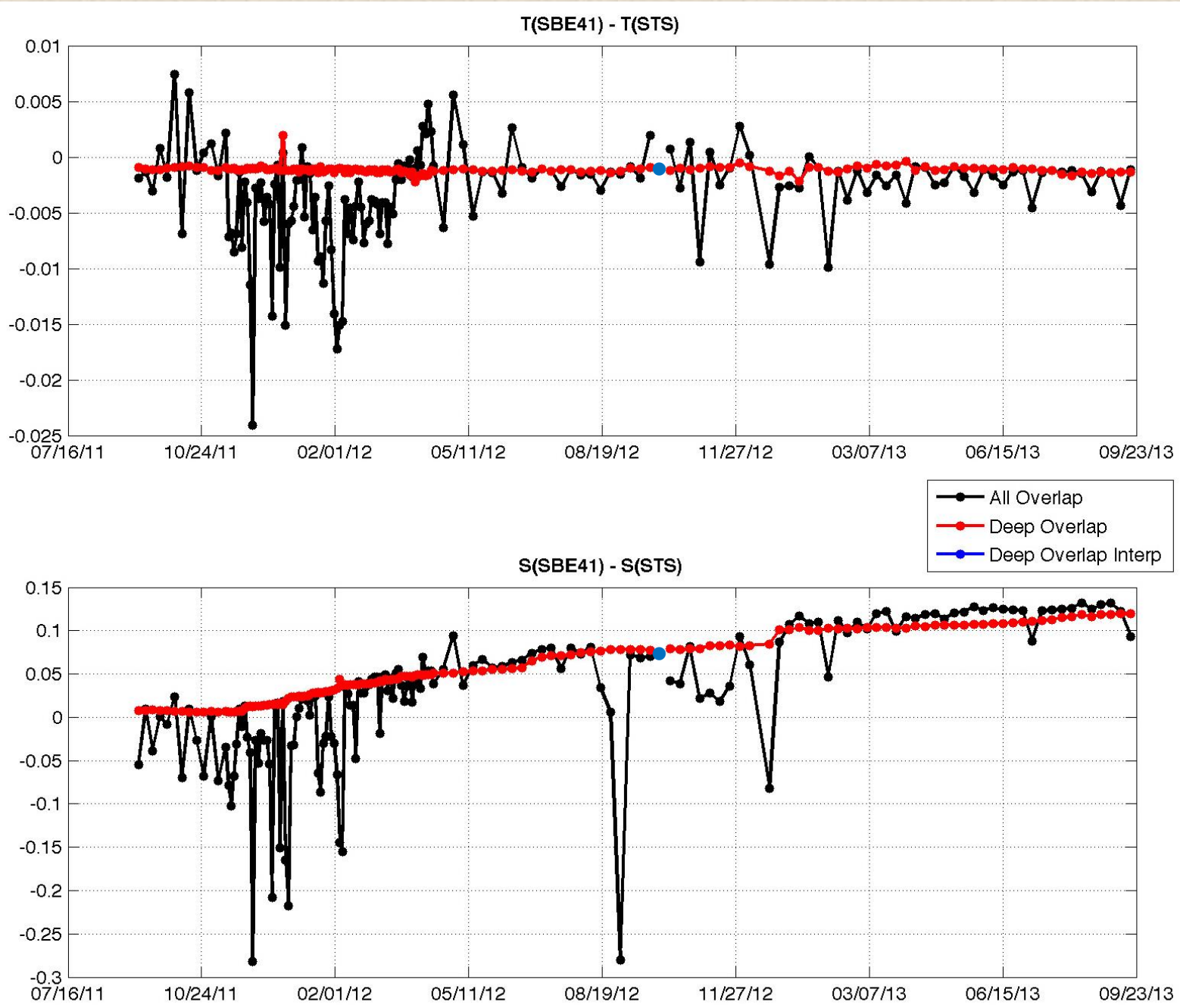
entrainment/detrainment and/or obduction/subduction of salinity through the base of the mixed layer

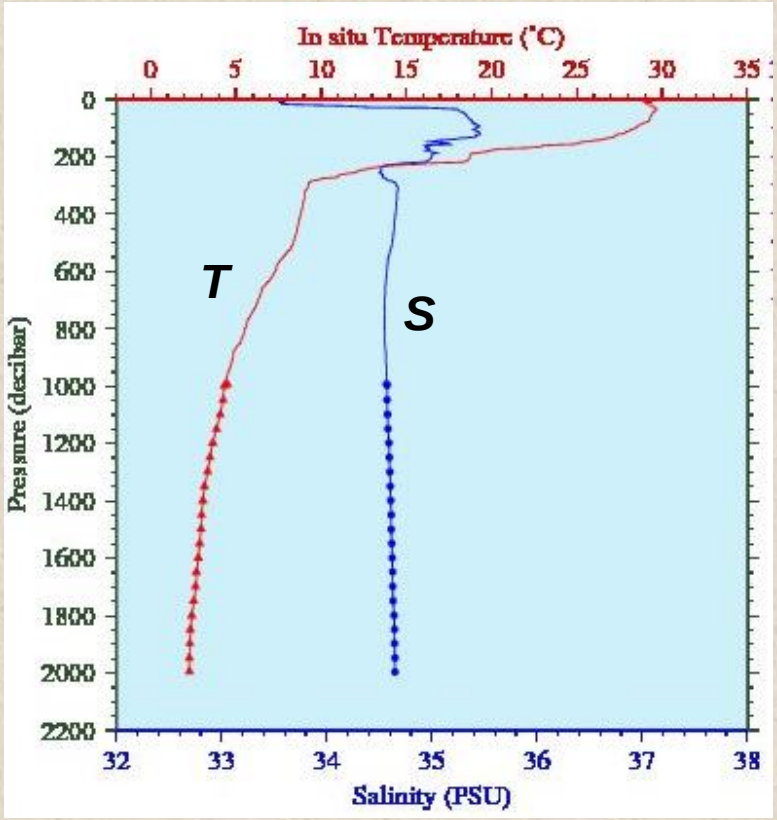
change of salinity at the sea surface through evaporation and/or precipitation

small scale mixing

← Argo float with CTD sensor (cuts off at ~3 m)

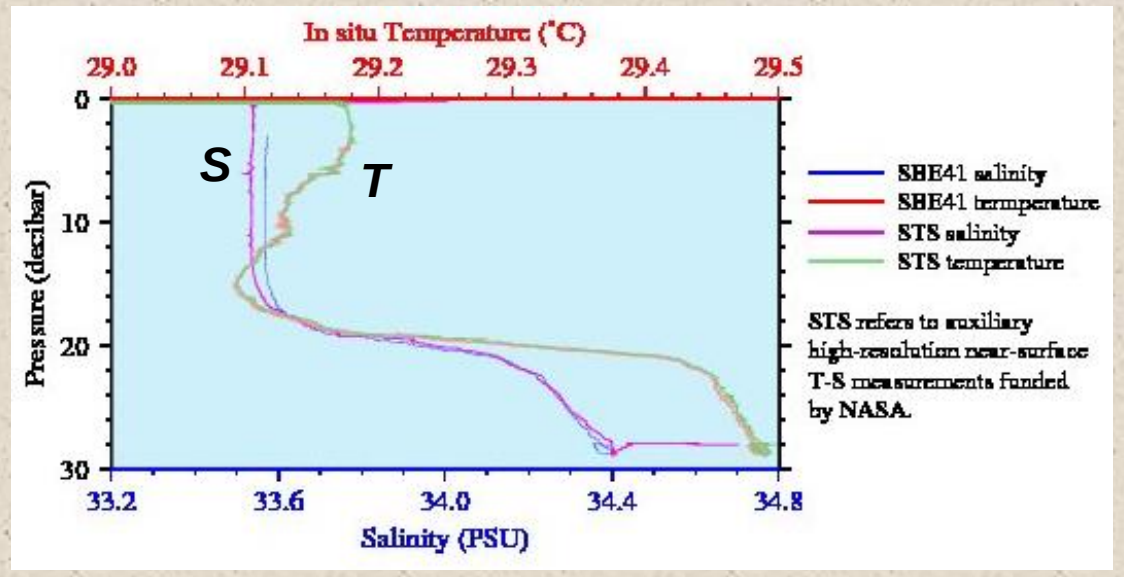
Float with auxiliary STS sensor and PAL hydrophone

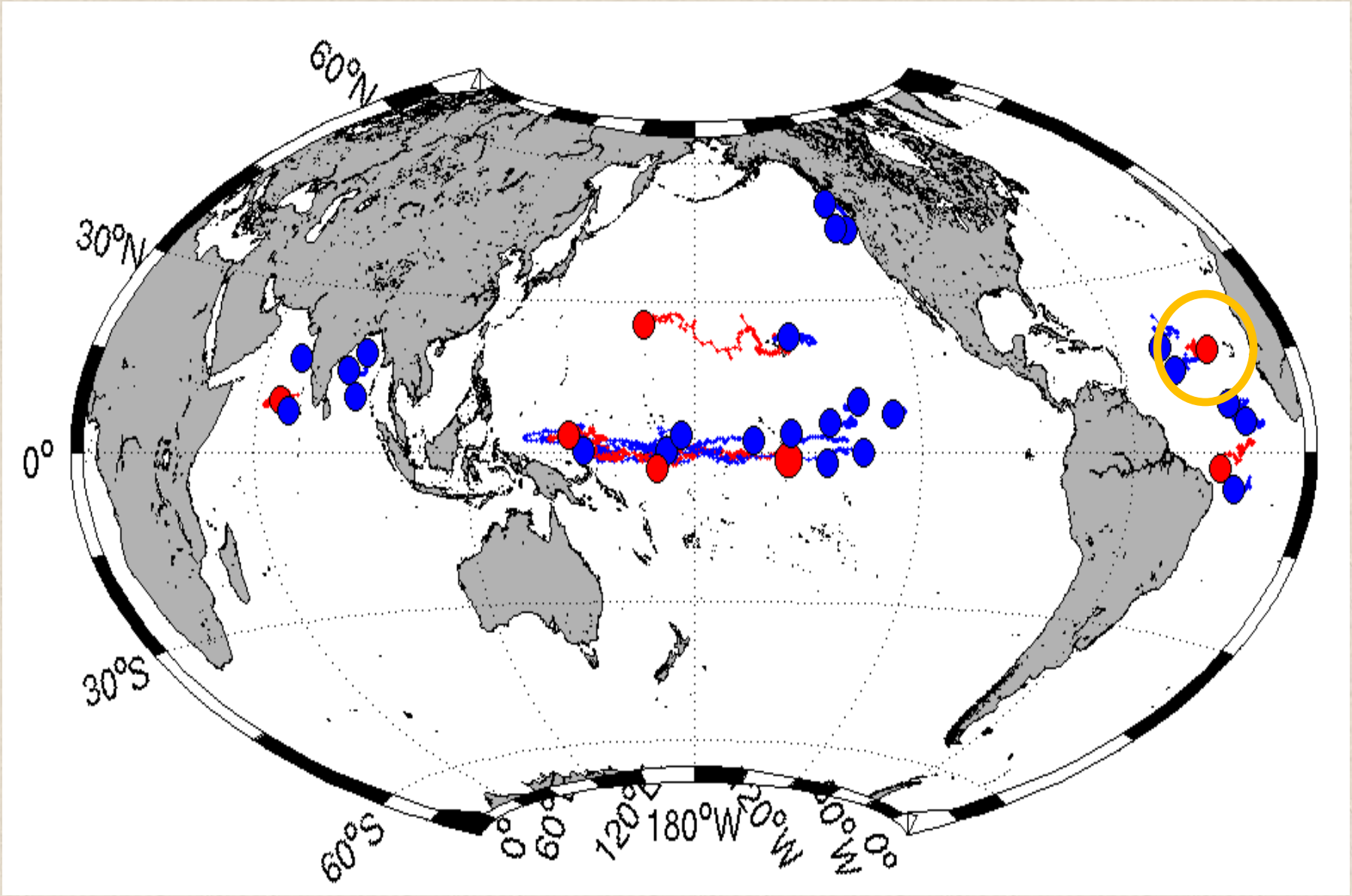

T(SBE41) - T(STS)
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
07/16/11
10/24/11
02/01/12
05/11/12
08/19/12
11/27/12
03/07/13
06/15/13
09/23/13
All Overlap
Deep Overlap
Deep Overlap Interp
S(SBE41) - S(STS)
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
07/16/11
10/24/11
02/01/12
05/11/12
08/19/12
11/27/12
03/07/13
06/15/13
09/23/13



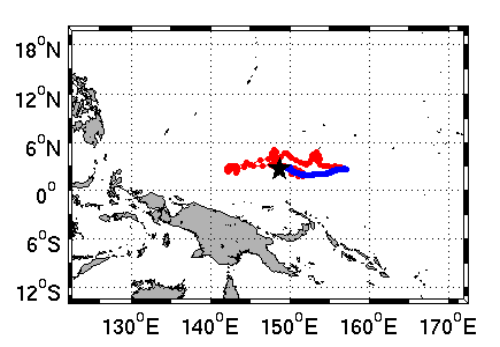
***T* and *S* profiles (0-2000 m) from UW float 6117, in the western equatorial Pacific**

***T* and *S* profiles (0-30 m) from the same float**

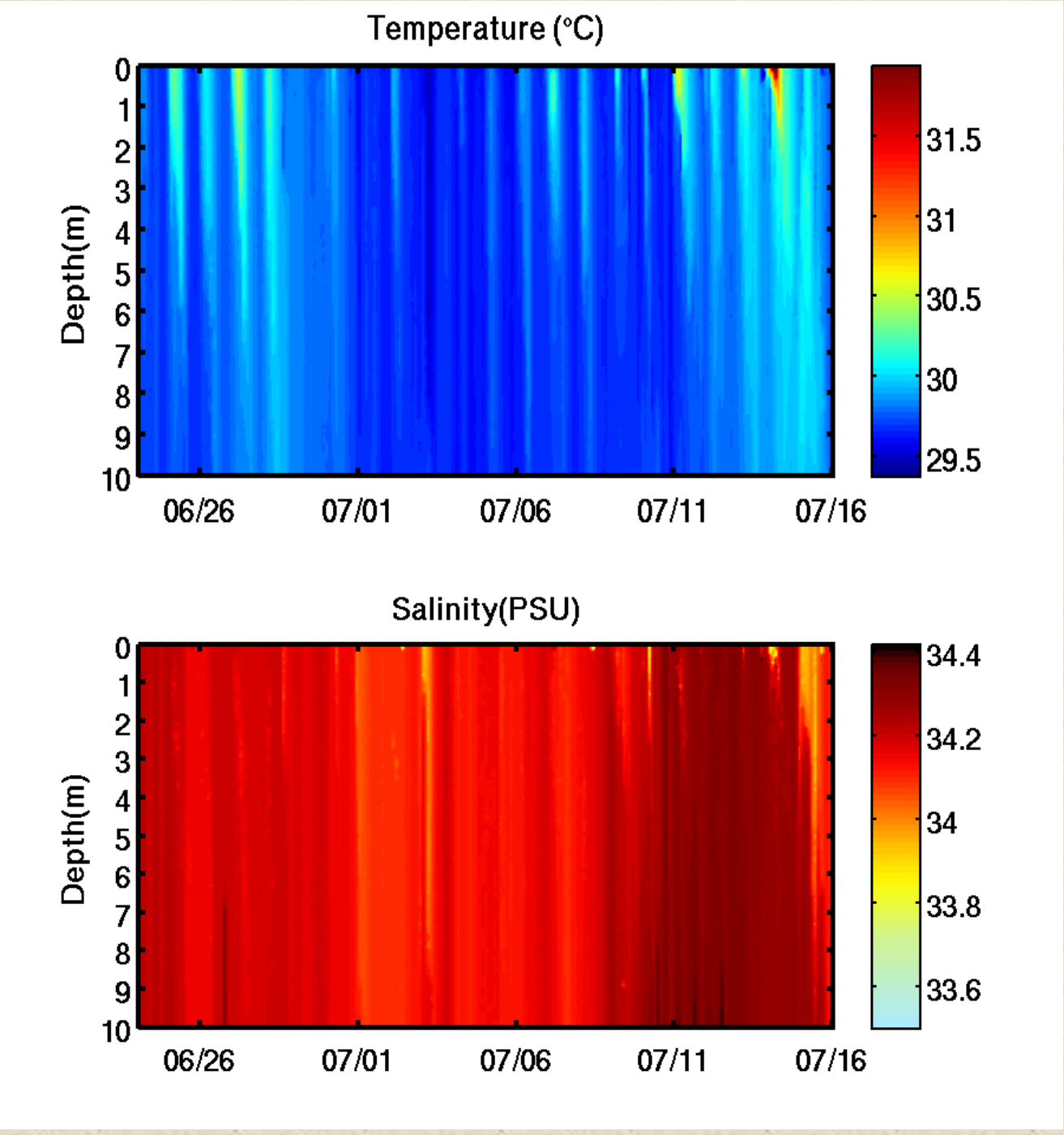




Locations of 69 UW floats equipped with STS sensors



***T* and *S* from the upper 10 m of the ocean from float 6117 during a 3 week period when it was profiling 0-200 m at intervals of 2 hours**



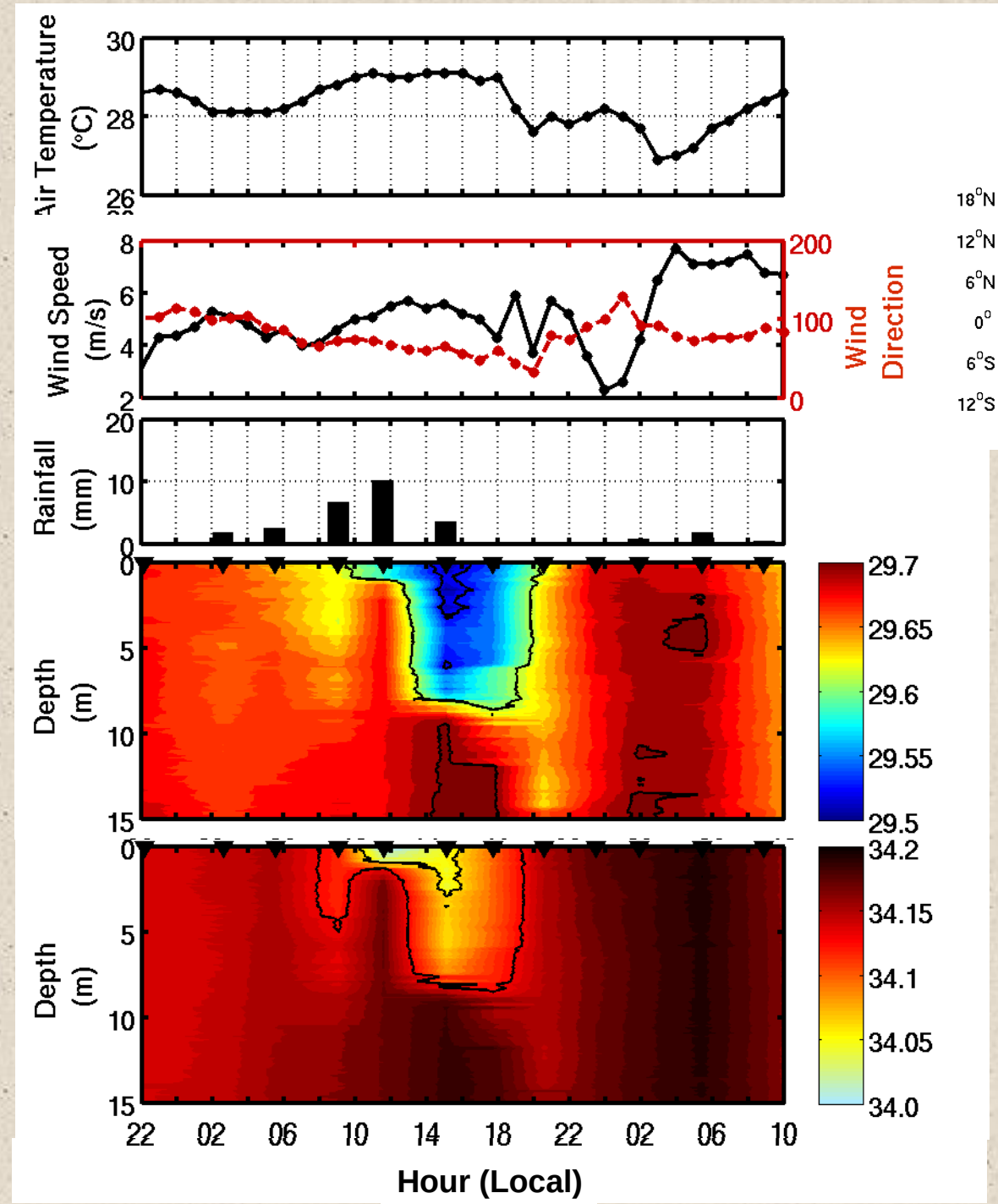
Float 6117

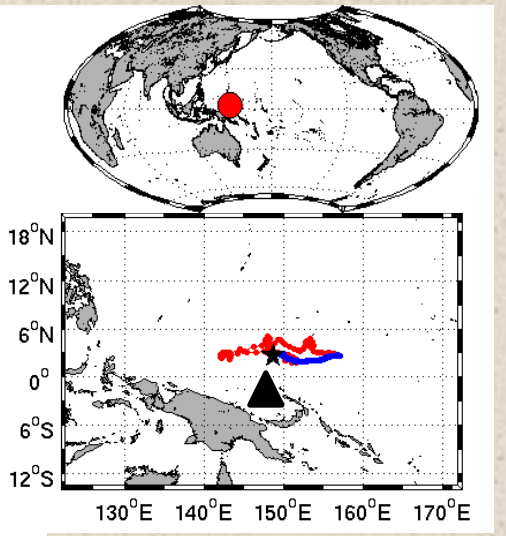
TAO mooring
2°N, 147°E

TRMM
(3 hourly)

STS
Temperature

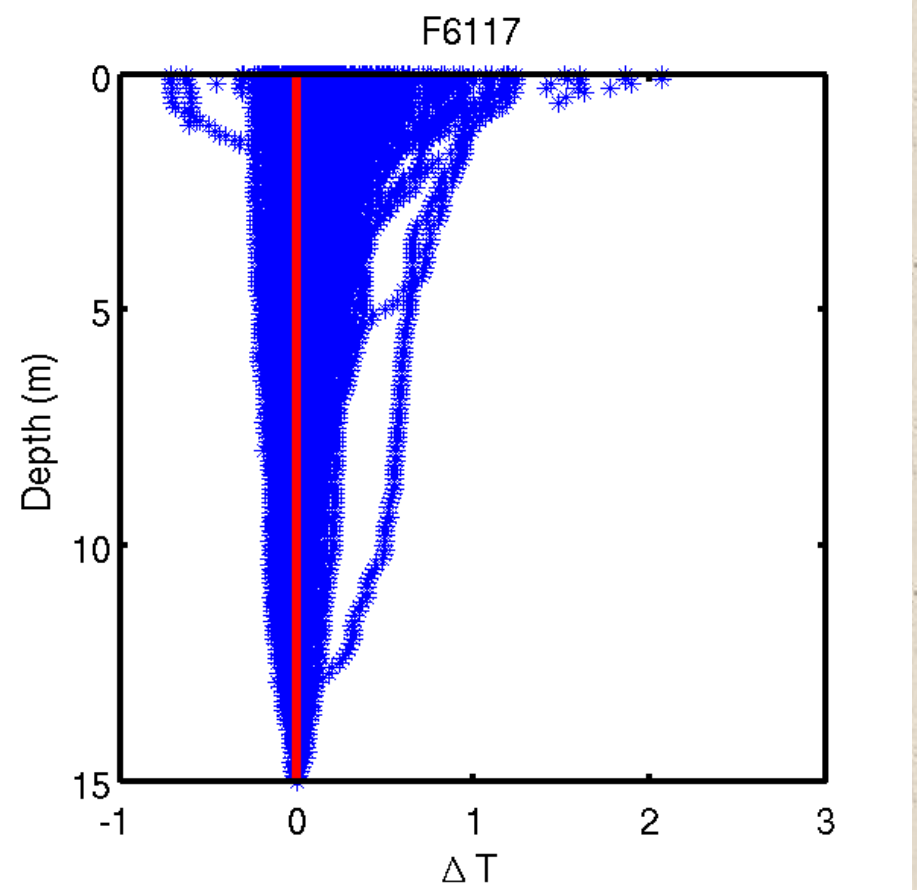
STS
Salinity

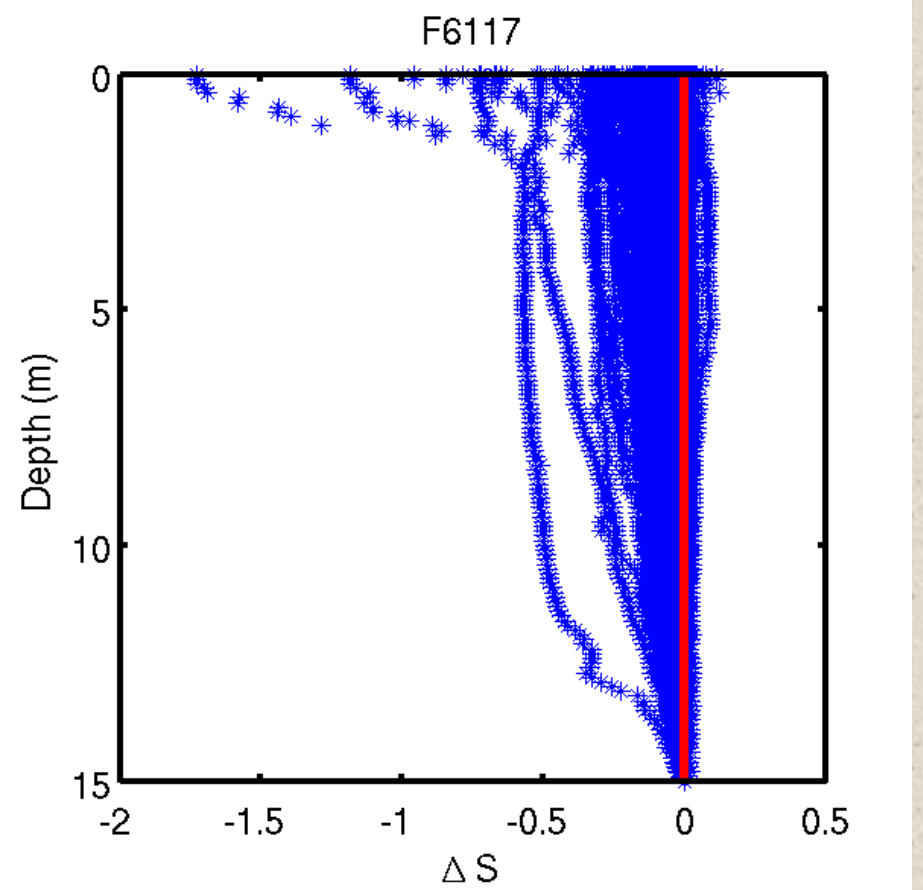




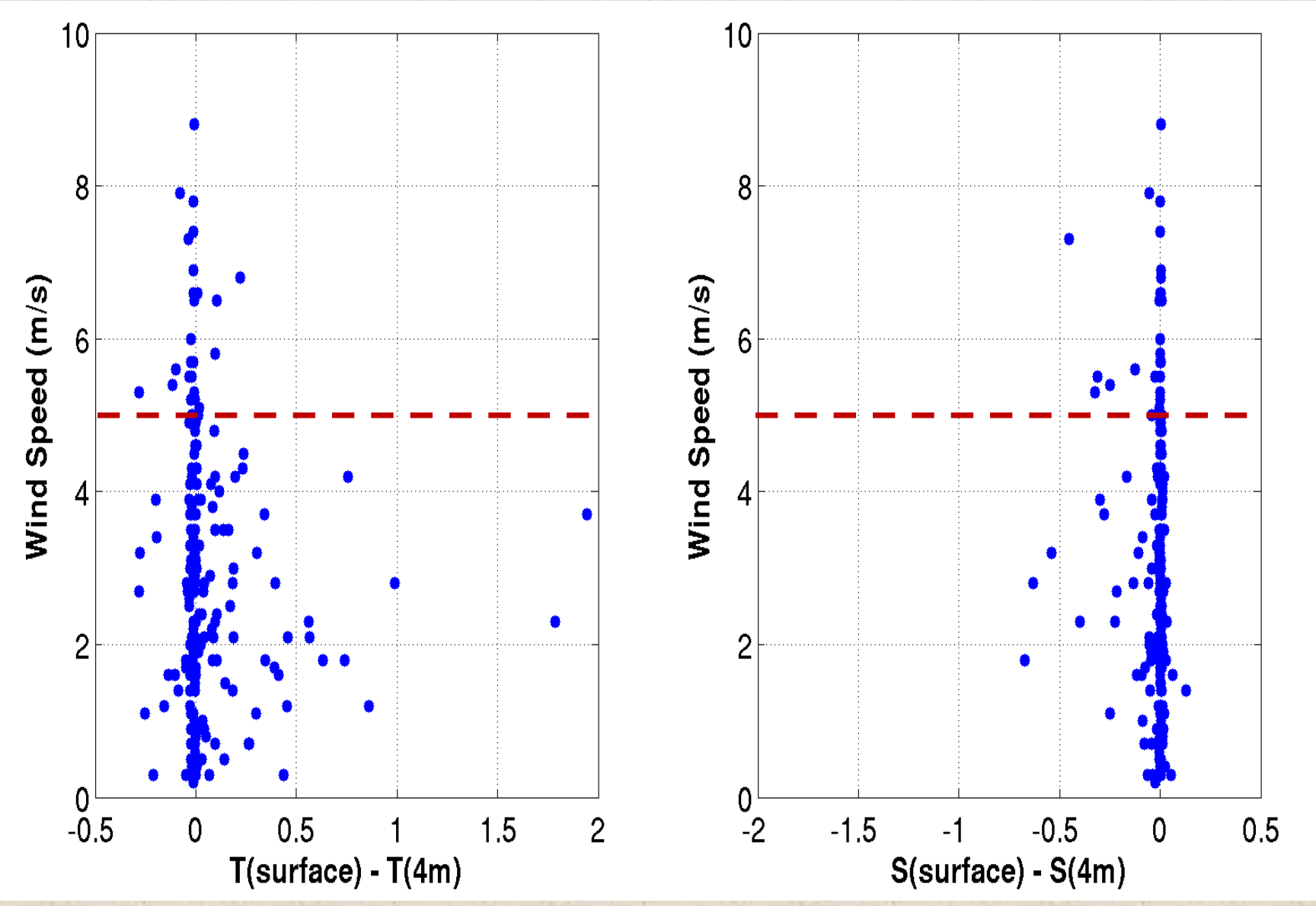
7/3/2009

Rainfall:	**25 mm**
ΔS :	**0.15 PSU**
ΔT :	**0.18 ˚C**

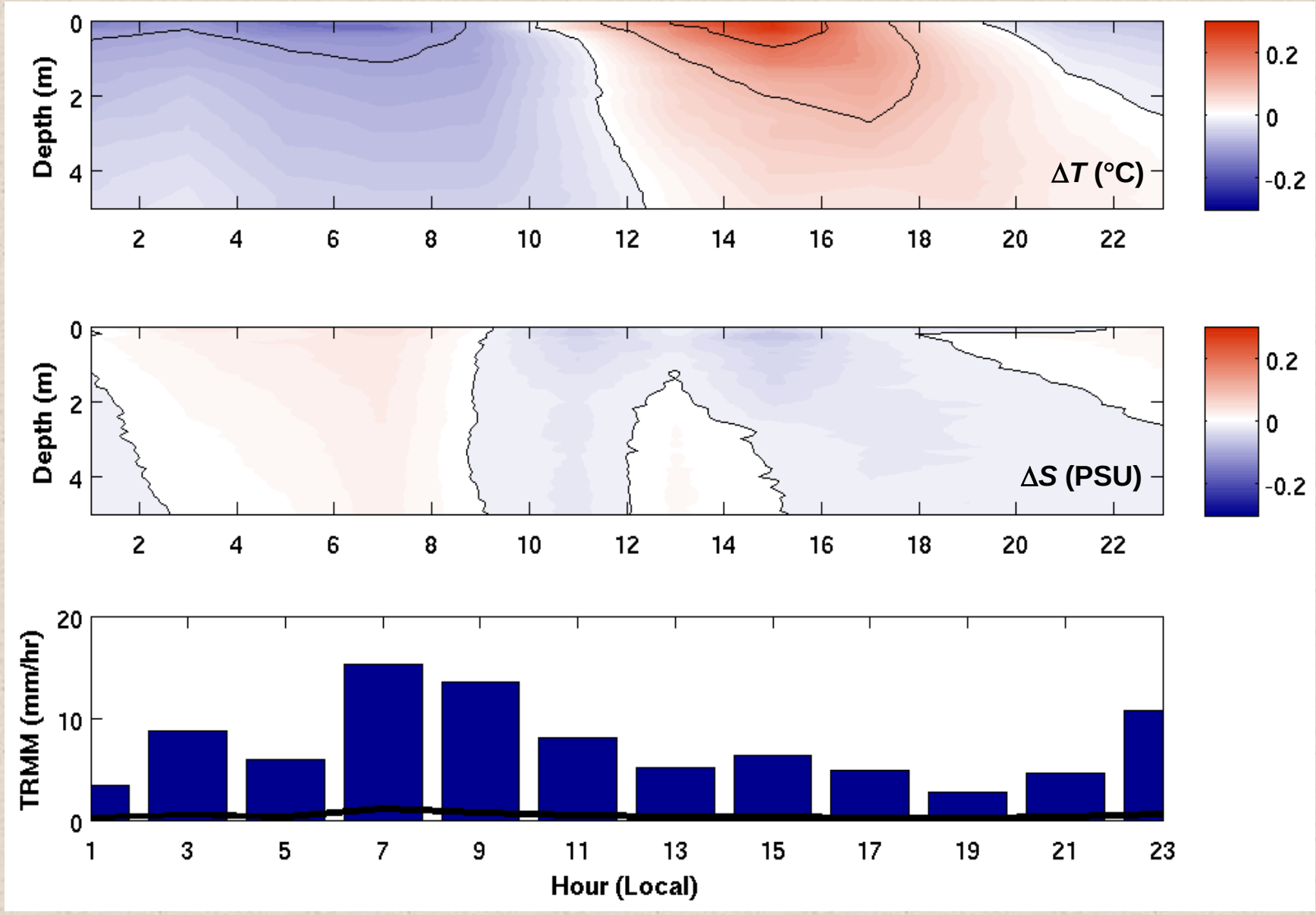




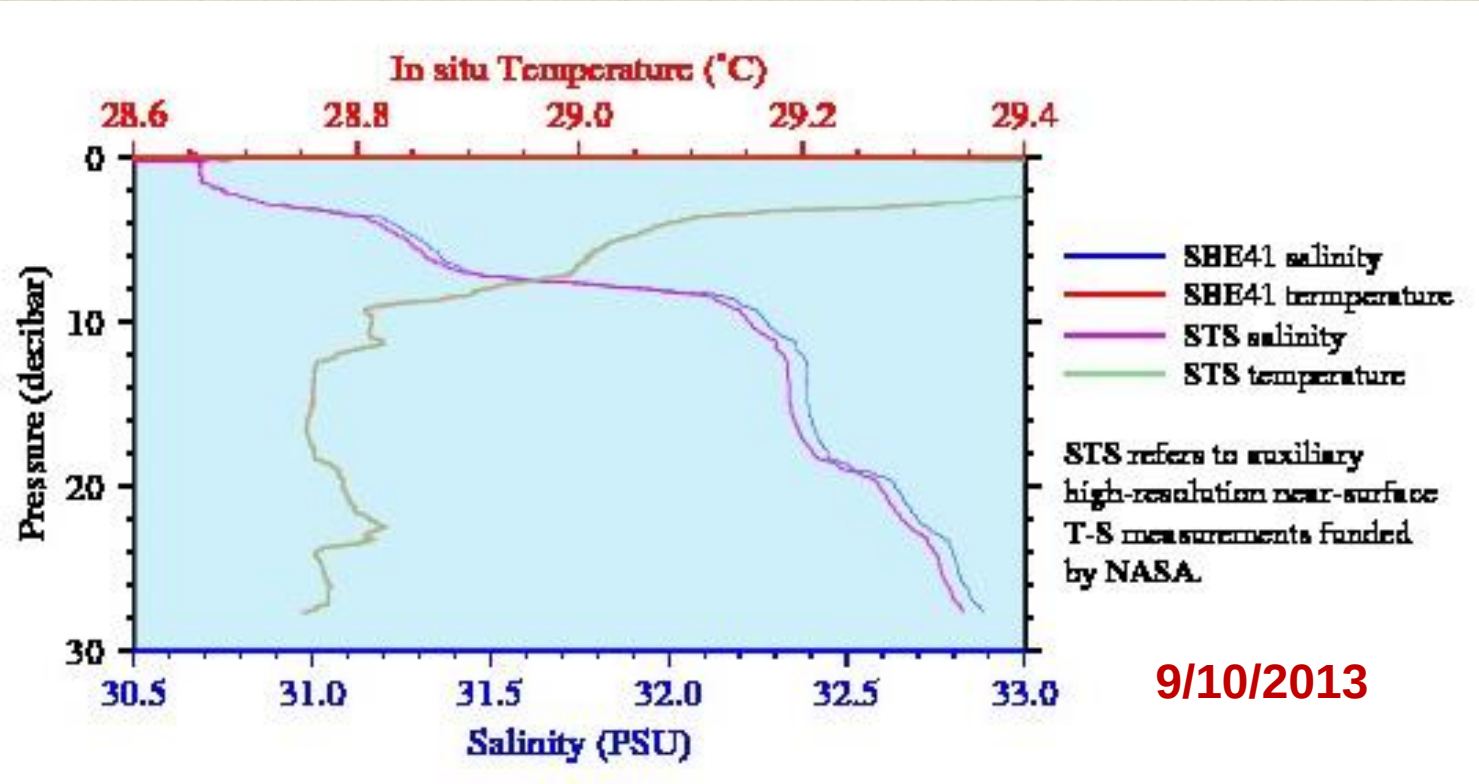
Comparisons of *T* and *S* (sea surface minus 15 m value) for the fast cycle period of float 6117 in the western equatorial Pacific



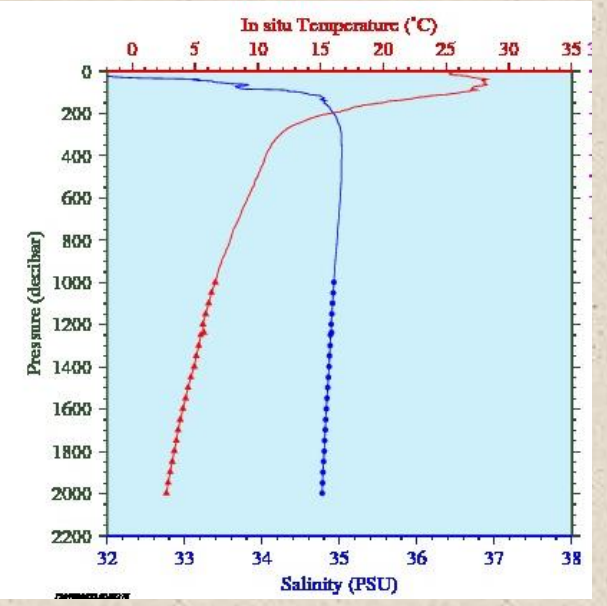
***T* and *S* differences between the sea surface and a depth of 4 m from float 6117, plotted as a function of wind speed measured at a nearby TAO mooring**



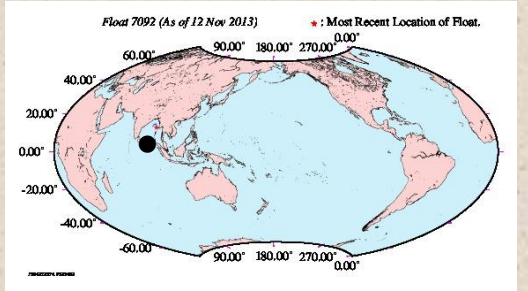
Binned *T* and *S* anomalies as a function of local time, shown with binned colocated rainfall from TRMM. Diurnal cycles in *T* and *S* are clearly present.



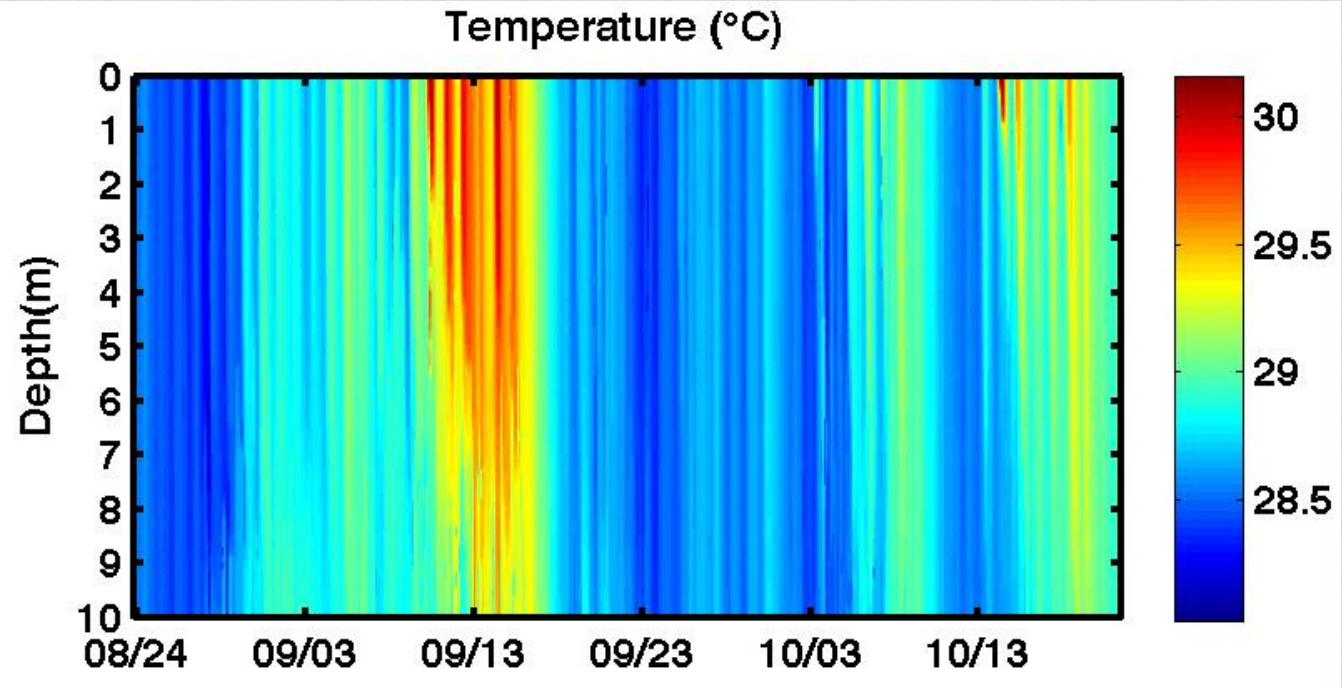
9/10/2013

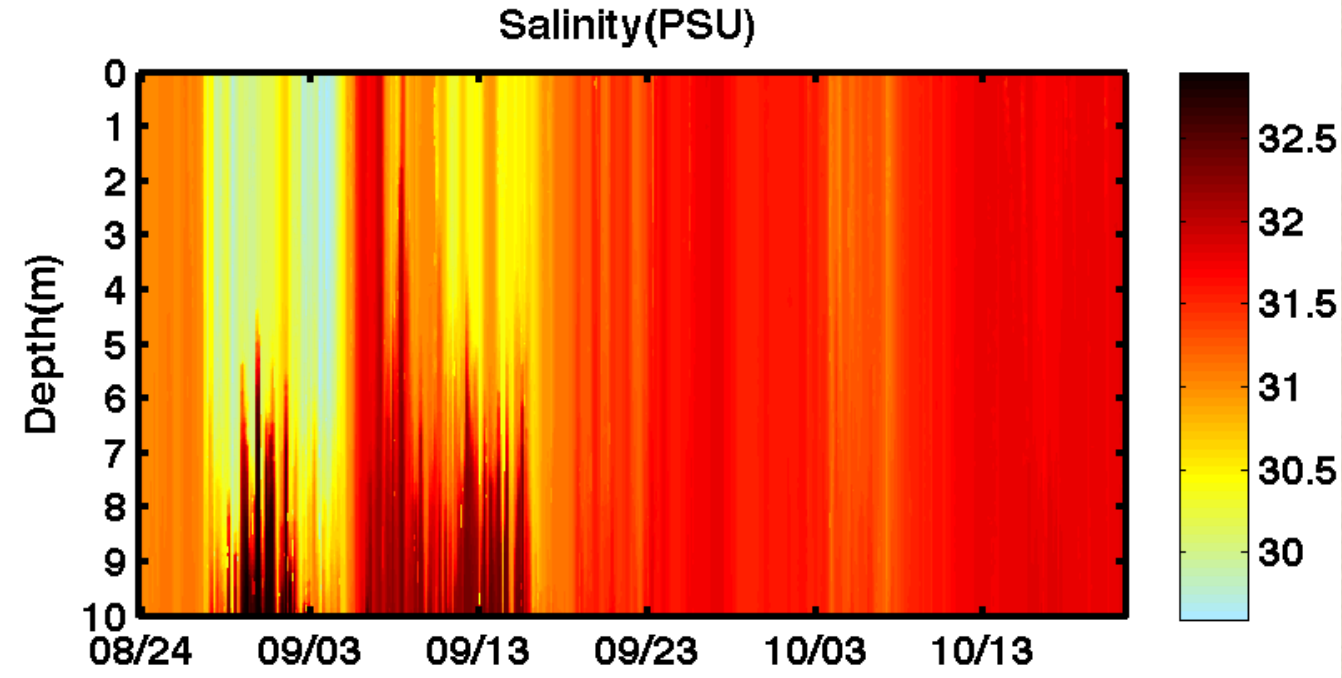


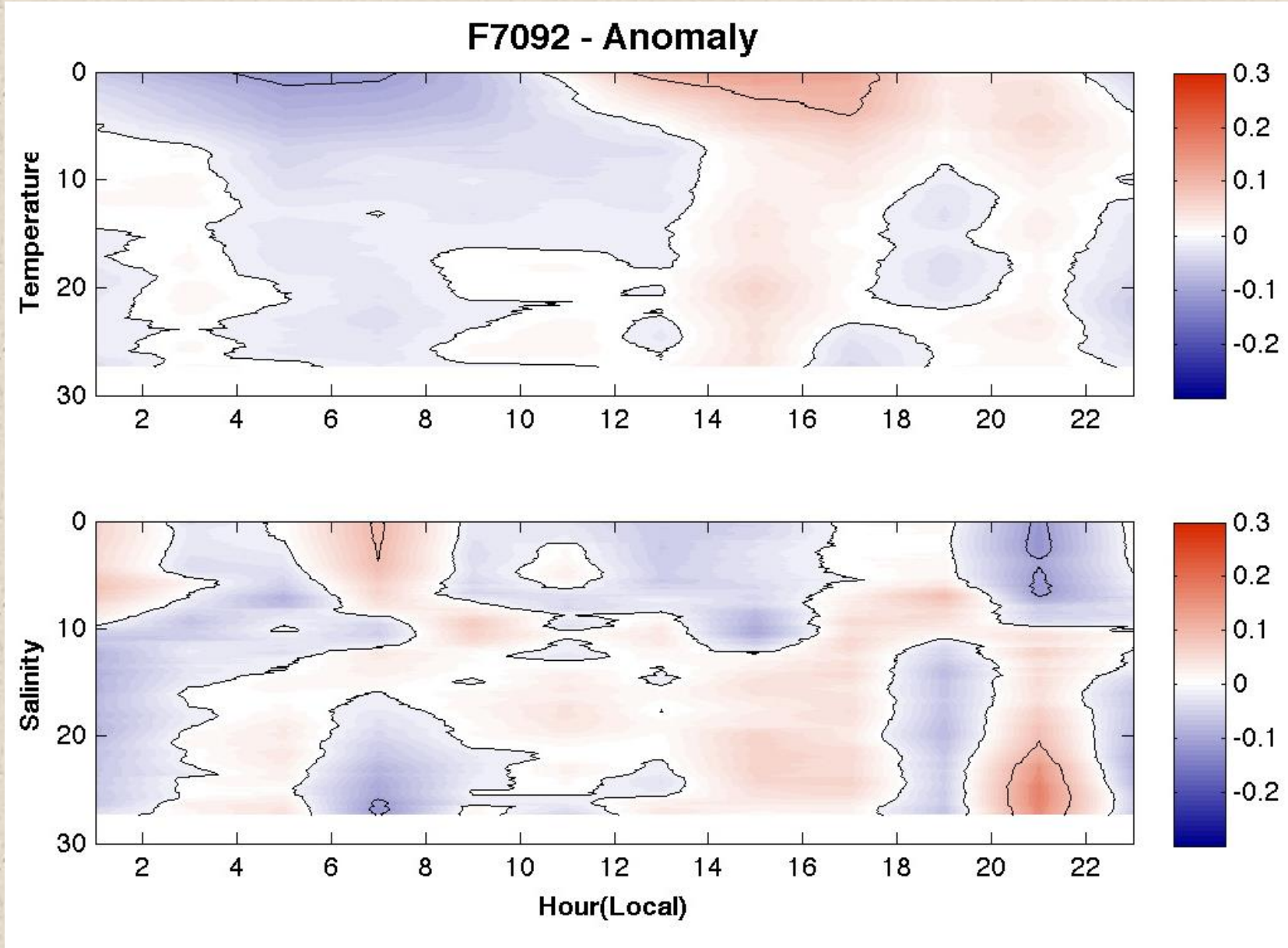
UW float 7092 (WMO 5903747) from the northern Bay of Bengal, shows a marked freshening near the surface (a barrier layer), induced by rain during the southwest monsoon.



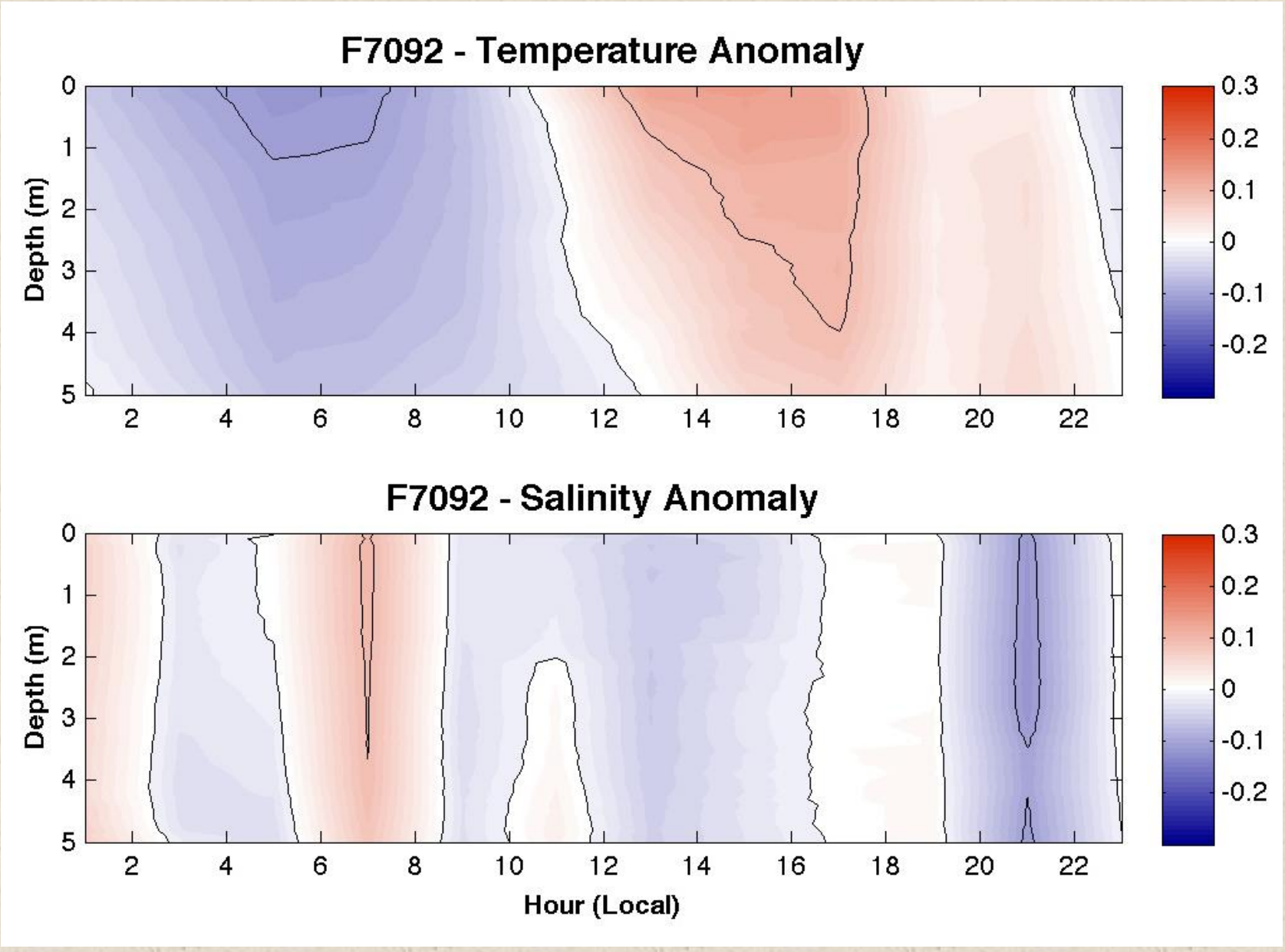
Strong rain events in *T* and *S*, and diurnal cycles, can be seen in both *T* and *S* in the northern Bay of Bengal



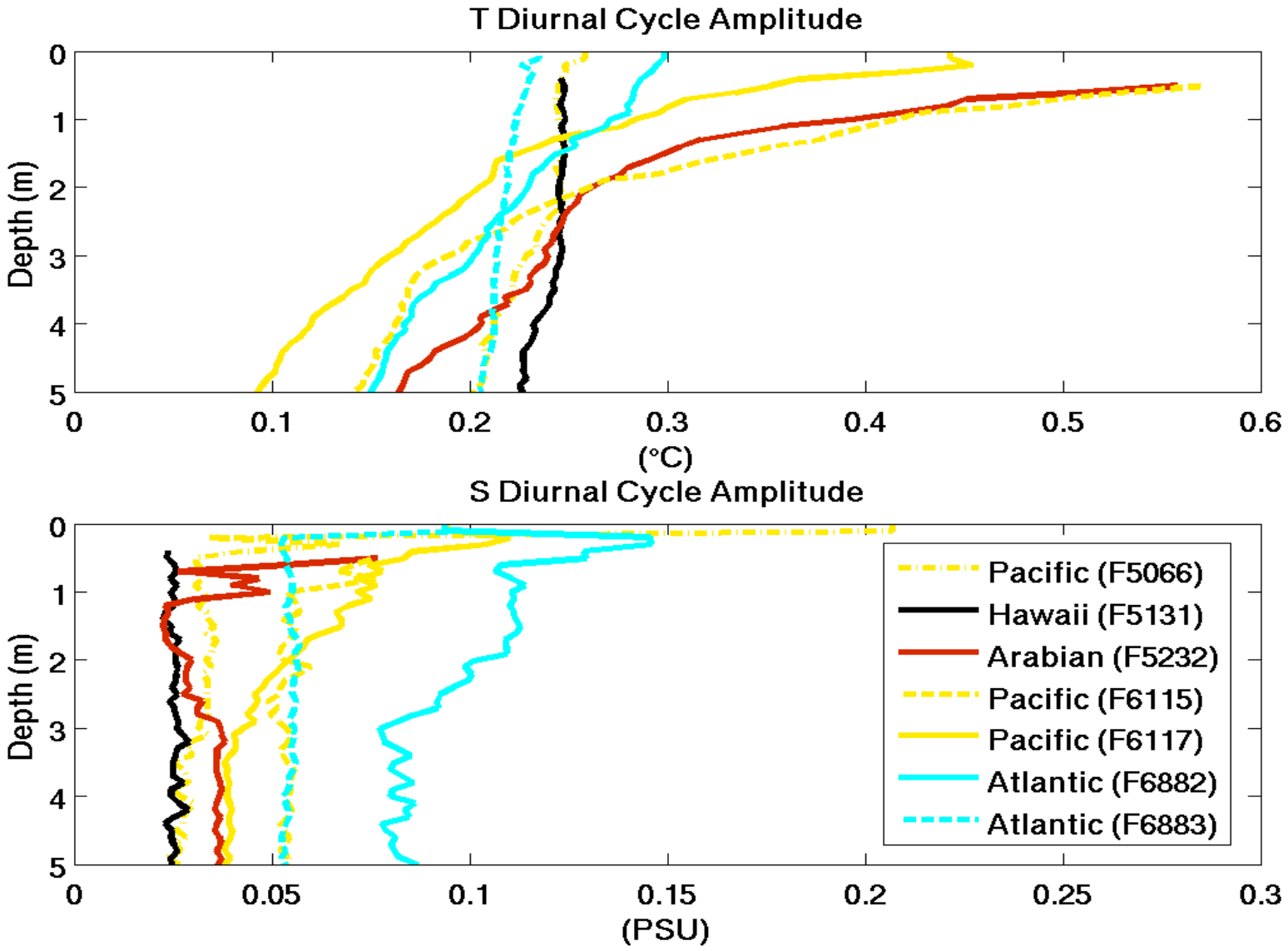




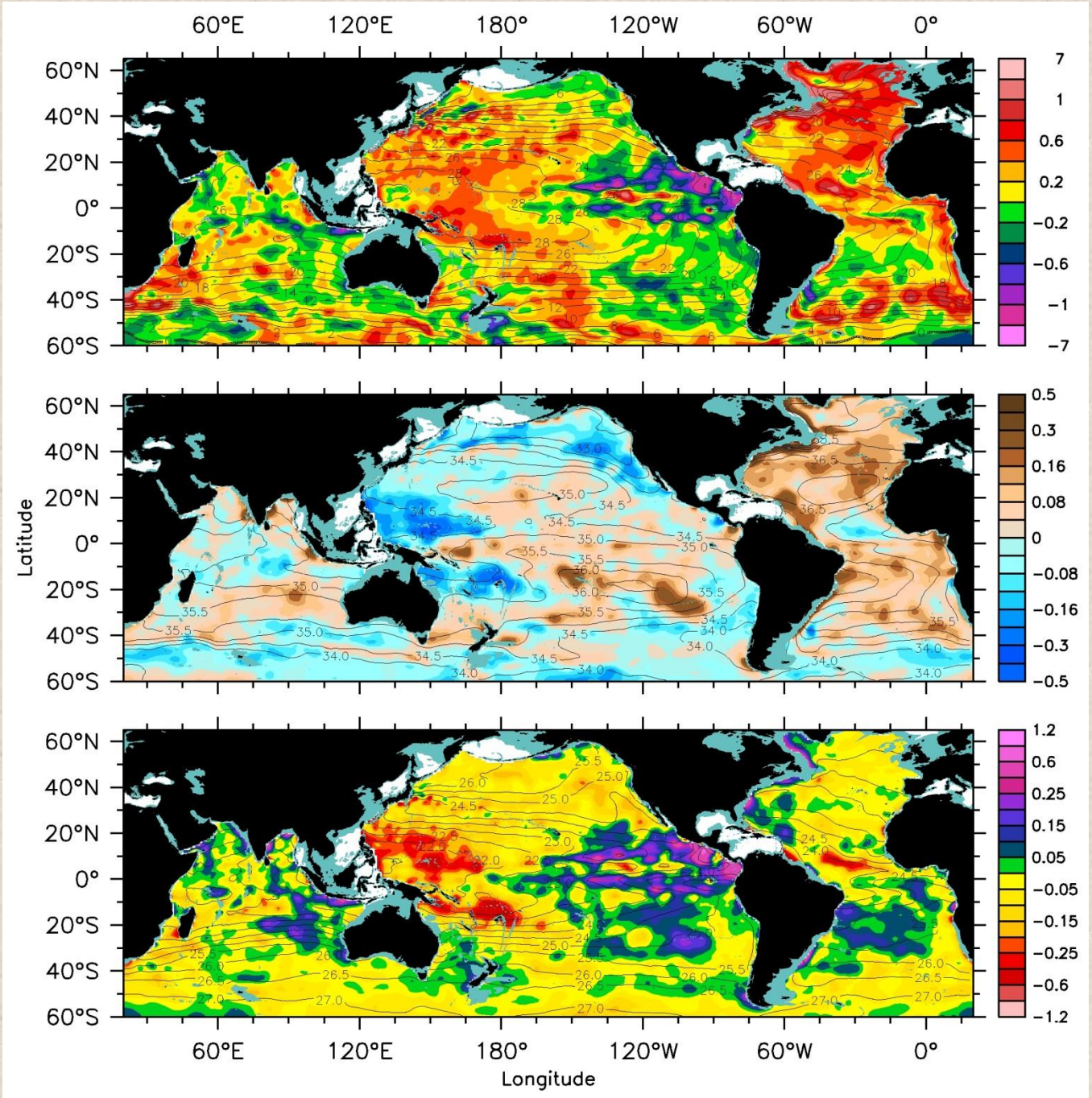
Binned *T* and *S* anomalies as a function of local time. Diurnal cycle in *T* is clearly present, with *S* less evident.



Binned *T* and *S* anomalies as a function of local time (upper 5 meters only). Diurnal cycle in *T* is clearly present, with *S* less evident.



Global variability in the amplitude of *T* and *S* diurnal cycles from all STS floats



ΔT

ΔS

$\Delta \rho$

Upper ocean (~250 m), changes in the past 25 yr

[Roemmich and Gilson, 2009]

Summary

Data from auxiliary STS sensors on some Argo floats, has been used to examine the variability in *T* and *S* very near the sea surface on short time scales. The data can also be used in Aquarius/SAC-D validation exercises.

Many storm events can be seen in the data, lasting several hours, changing the upper ocean temperature and salinity.

There are measureable diurnal cycles in both *T* and *S* in the observations; *T* variability is clearly tied to diurnal heating in the atmosphere; *S* variability is related to diurnal signals in rainfall.

Estimates of decadal-scale variability are only beginning; the longer that programs like Argo and Aquarius continue, the more we will understand long-term variability in the hydrological cycle and the ocean's role in climate.