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

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The annual mean global sea surface salinity (PSU)
\[ S = \frac{M_S}{M_S + M_W} \]

classical definition of salinity

\[ \frac{\partial S}{\partial t} + u_H \cdot \nabla S + w \frac{\partial S}{\partial z} = \text{sources} - \text{sinks} + \text{mixing} \]

average this over a surface mixed layer of thickness \( h \):

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

- advection of vertically-averaged salinity by the average flow
- advection of salinity by the sheared part of the horizontal flow
- entrainment/detainment 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

“ocean rain gauge”
Argo float with CTD sensor (cuts off at ~3 m)

Float with auxiliary STS sensor and PAL hydrophone
$T$ 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

STS refers to auxiliary high-resolution near-surface T-S measurements funded by NASA.
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

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

ΔT

ΔS

Δρ

[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.