THE IMPORTANCE OF SALINITY MEASUREMENTS IN THE HEAT STORAGE ESTIMATION FROM TOPEX/POSEIDON

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OUTLINE

Heat storage anomaly (HS') is derived from altimeter data through the relation between thermosteric variations in the upper layer and variations in the sea surface height.

This study compares in situ and satellite heat storage estimates. The discrepancies between the two estimates are mostly related to haline effects.

The objectives of this study are:

1. to investigate if a haline height correction significantly improves the satellite derived heat storage anomaly signal, and
2. if this correction should be based on in situ salinity measurements or climatological estimates.

HEAT STORAGE

The in situ heat storage is

$$HS = \rho C_p \int_{-h}^{0} T(z)dz$$

HS' from the altimeter data is estimated from the filtered height anomaly (η) according to a linear relation:

$$HS' = \frac{\rho C_p}{\alpha}(\eta + \eta_h)$$

ρ	density	T	temperature
C_p	specific heat at constant pressure	α	thermal expansion coefficient
h	sub–thermocline depth	η	filtered height
		η_h	haline correction

ρ, C_p and α are estimated from the WOA94 climatology as a function of x, y and t. α is weight–averaged by temperature and layer thickness.

$\eta_h(x, y, t)$ is estimated by the integral of the product of the climatological haline contraction coefficient, β, and the salinity anomaly (residual after subtracting the annual mean) profiles from the surface to a depth h

$$\eta_h = \int_{-h}^{0} \beta \Delta S dz$$

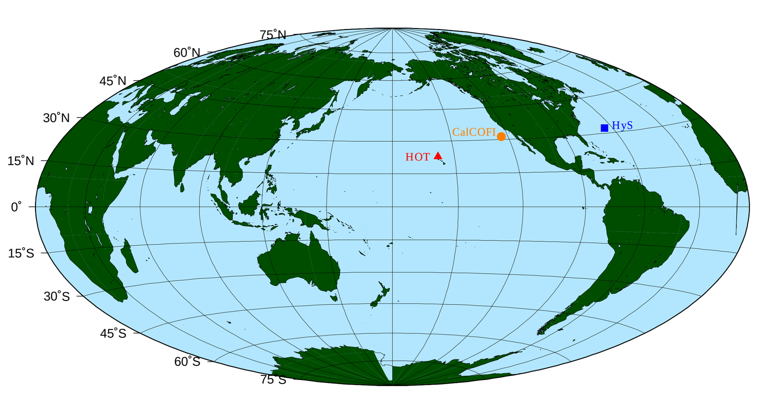
SEA SURFACE HEIGHT

The TOPEX/Poseidon (T/P) sea surface height anomaly is decomposed using 2D finite impulse response filtering as

$$\eta_o = \eta_t + \eta_w + \eta_r = \eta + \eta_r$$

- η_t is the basin–wide non-propagating variability, mostly due to **seasonal** heating and cooling and **advection** by the broad oceanic currents.
- η_w is composed mainly of first–mode baroclinic **Rossby** waves, with periods of 24, 12, 6, 3 and 1.5 months.
- η_r includes a variety of signals among them equatorial **Kelvin** waves and meso-scale **eddies** variability.
- The small–scale, non–propagating signals are **filtered out**.

LOCATION OF THE STATIONS



- Hydrographic sections from the California Cooperative Oceanic Fisheries Investigations (**CalCOFI**) cruises at the California coast;
- The hydrostation ALOHA from the Hawaii Ocean Time series Program (**HOT**) in Hawaii;
- The hydrographic time series in Bermuda (**HyS**) in the western Atlantic.

RESULTS

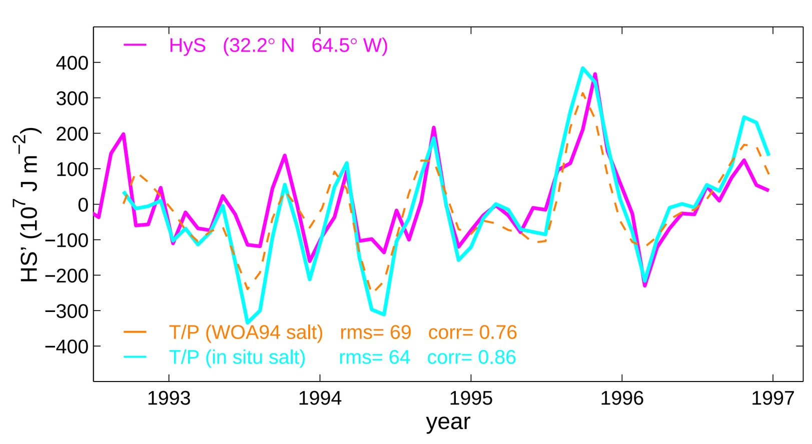
The in situ HS is calculated from temperature profiles integrated between the surface and a depth **below the main thermocline**.

For each time series the long–term mean is computed with the maximum number of complete years of data. The in situ HS' is estimated by removing this mean.

To evaluate the role of η_h in determining the T/P HS', three cases are studied:

- no salinity,
- climatological (WOA94) salinity,
- in situ salinity.

Bermuda



This time series has on average one measurement every 15 days and the HS' from both sources were interpolated to one month resolution.

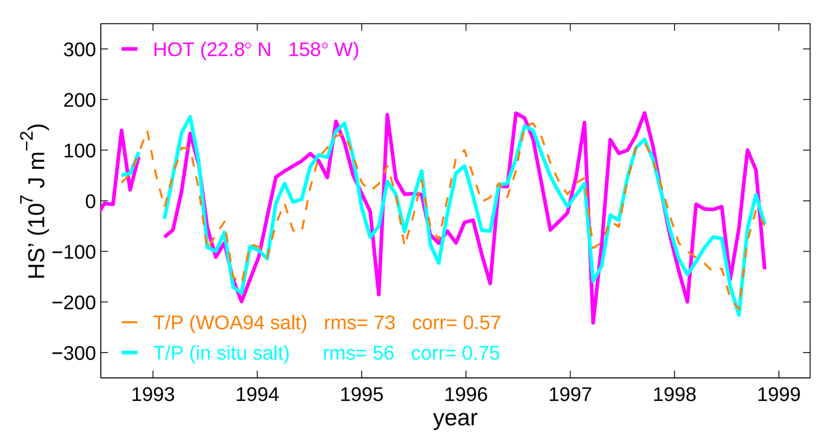
The T/P HS' is in better agreement (lower rms difference and higher correlation) with in situ HS' when the haline correction is based on in situ rather than climatological salinity.

When the salinity is not used, the rms difference and correlation are about the same as when the climatological salinity is used.

Results are better after 1995 as the dominant signal in the heat storage spectrum shifts from semi–annual to annual. Lower rms difference and higher correlation (52×10^7 J m^{-2} and 0.90) are obtained for the 1995–97 period compared to 1993–94 (75×10^7 J m^{-2} and 0.80).

This station coincides with a T/P cross–over latitude where the zonal spacing between samples is maximum and approximately twice the wavelength of the local semi–annual Rossby waves. This results in spatial aliasing and degradation of the correlation.

Hawai'i

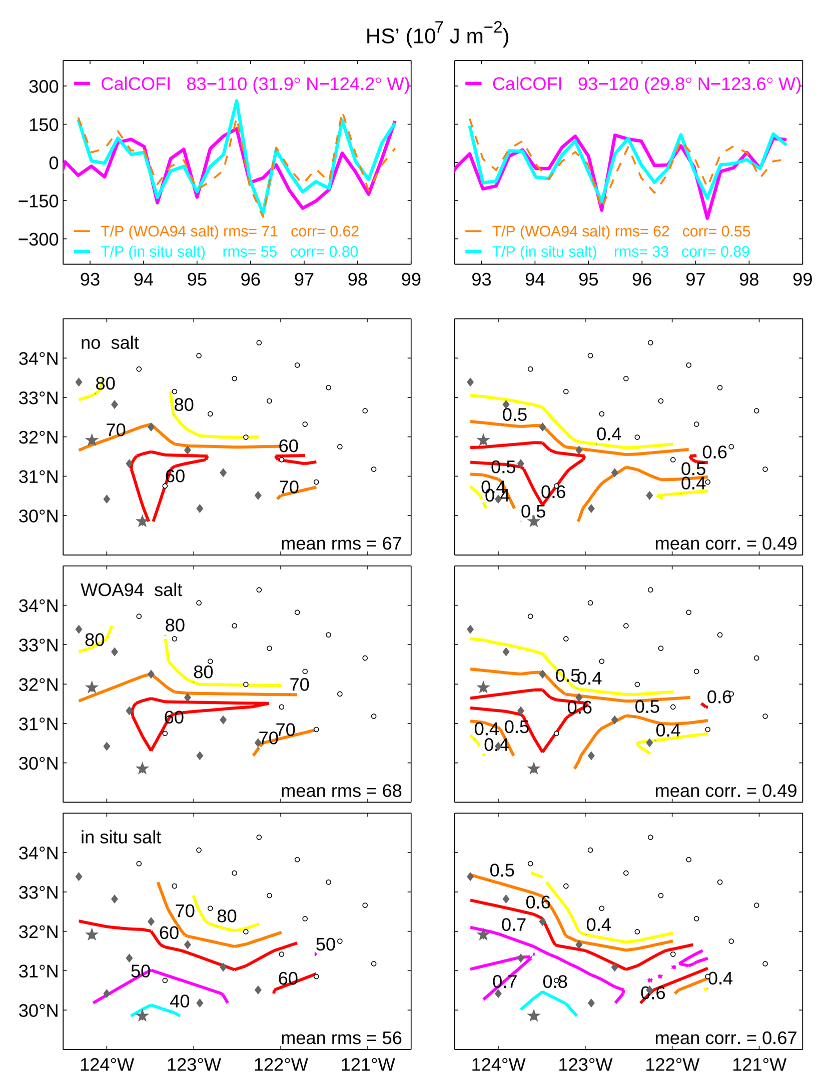


This time series has an average sampling rate of 40 days. Both time series were interpolated to monthly resolution for comparison.

The results when including in situ salinity are significantly better than using the climatology.

In fact, when the salinity is not used, the rms and the correlation are better than using climatology.

California



The CalCOFI array time series has a temporal resolution of 90 days. The T/P time series was interpolated to match this resolution.

Satellite measurements of the sea surface height degrade near the coast due to local tides that are inadequately removed from the T/P data and spread westward by the filter. Thus, correlations decrease and rms differences increase toward the coast. Only eleven stations west of this gradient were considered.

The top row shows comparisons for two stations. The inclusion of salinity effects from in situ measurements improved significantly the T/P estimates. As observed in other regions the inclusion of a climatological salinity correction is detrimental to the results.

CONCLUSIONS

Source	No sal.		WOA94		in situ	
	rms	corr.	rms	corr.	rms	corr.
CalCOFI	67	.49	68	.49	56	.67
HyS	71	.75	69	.76	64	.86
HOT	65	.63	73	.57	56	.75

- The use of in situ salinity estimates significantly augmented the correlations (up to 0.18) and decreased the rms differences (up to 17×10^7 J m^{-2}) in the HS' estimates from in situ and satellite measurements.
- The corrections based on climatological salinities are **equal or worse** than not including haline effects at all.
- These results stress the importance of having salinity measurements concurrent with satellite altimeter measurements to study sub–surface processes.
- Although in situ salinity measurements are sparse the lack of a relatively small haline correction does not preclude the use of altimeter data for oceanic heat storage estimation.

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