Estimation of Ocean Surface Salinity in the Indian Ocean using Satellite Observations

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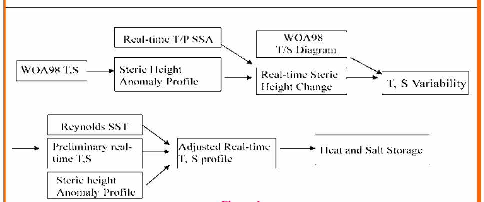
❖ Objectives

This work involves two new techniques:

(1) Estimate heat and salt storage in the Indian ocean using a combination of sea-level anomalies derived from TOPEX/Poseidon (T/P) altimetry and *in-situ* hydrographic data (World Ocean Atlas, WOA98). In this study we calculated heat and salt storages by integrating synthetic temperature and salinity, calculated from altimeter, in the upper 1000m to study the monsoonal circulation.

(2) Retrieval of sea surface salinity (SSS) from space-borne satellite measurements of Outgoing Longwave Radiation (OLR) through the "Effective Oceanic Layer (EOL)". A preliminary assessment of deriving SSS from OLR is presented for the Bay of Bengal.

❖ Estimation of Heat and Salt Storage


Real-time T/P SSA

WOA98 T,S

Steric Height Anomaly Profile

WOA98 T/S Diagram

Real-time Steric Height Change

T, S Variability

Reynolds SST

Preliminary real-time T,S

Steric height Anomaly Profile

Adjusted Real-time T, S profile

Heat and Salt Storage

Figure 1

❖ Comparison of Heat & Salt Storage with the WOCE I1 Section

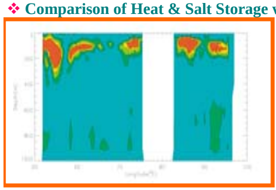


Figure 2. Error in temperature estimation between WOCE and T/P

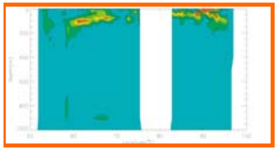


Figure 3. Error in Salinity estimation between WOCE and T/P

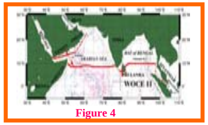


Figure 4

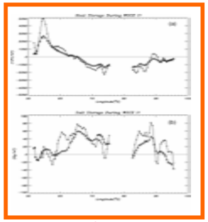


Figure 5. Comparison of heat & Salt Storage derived from T/P altimetry (+ symbol) and WOCE (Δ symbol).

❖ Sea surface steric height anomaly vs Heat & Salt storage

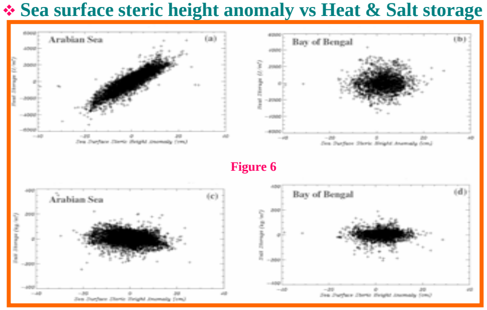


Figure 6

Figure 6 Shows:

- ❖ In the Arabian Sea a quasi-linear relationship was found between the heat storage and the sea surface steric height (SSSH) anomaly. This was as expected since in the Arabian Sea the thermal variability dominates the computation of density and hence SSSH anomaly.
- ❖ The scatter plot of the salt storage and the SSSH anomaly in the Arabian Sea also indicates that SSSH is inversely proportional to the total salt storage, which means that the SSSH is dominated by the heat storage change.
- ❖ In the Bay of Bengal, the scatter plots indicate that the variability of heat storage is as important as the variability of the salt storage, thus the typical quasi-linear relationship between the heat storage and the SSSH variability is not valid in this region. This implies that it is necessary to remove the effects of salt storage variability on the SSH when we compute the heat storage in the Bay of Bengal.

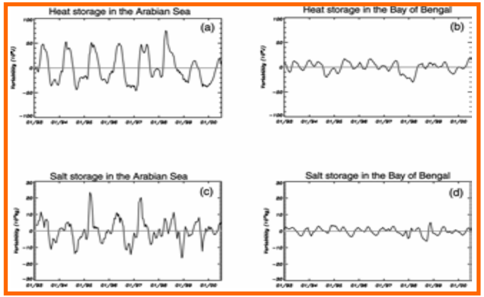


Figure 7. Total heat & Salt storage variability north of 8.5°N

❖ Estimation of Ocean Surface Salinity from OLR

This study is based on the idea that intense convection over the ocean is associated with warmer surface temperatures maintained by low surface salinities formed due to large riverine input and compounded by convection-induced precipitation. A preliminary assessment of deriving ocean surface salinity from OLR is presented for the Bay of Bengal. It is envisaged that the salinity estimated in this way may be useful in improving the existing climatologies in those parts of the world's ocean where intense convection is the regular feature, such as the tropical Indian and Pacific Oceans.

We introduce the EOL parameter that takes into account both the temperature and salinity in the top near-surface stratified layer for linking the convection over the Bay. This stratified layer is mainly due to salinity stratification, and is characterized with a subsurface stability maximum. The EOL is defined as the geopotential thickness (m^2/s^2) of the stratified layer and is computed from: $EOL = \int \alpha \cdot dp$

where α is the mean specific volume anomaly (m^3/kg), The integration is over the depth from surface to the depth (D) of stability maximum. In this study the integration is carried out over a constant depth of 30 m uniformly as the depth of the stability maximum varies between 20 and 40 m in the Bay of Bengal. Figure 8 shows the EOL in the Bay of Bengal.

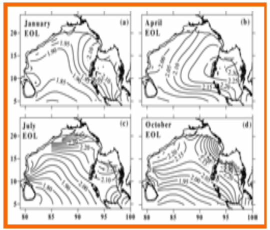


Figure 8. EOL for the representative seasons of (a) northern winter monsoon, (b) northern spring, (c) southwest monsoon and (d) northern fall. The EOL is computed using the monthly Levitus climatologies.

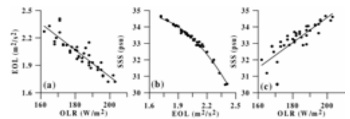


Figure 9

The scatter plots (Figure 9) between OLR vs EOL, EOL vs SSS, and OLR vs SSS for the month of July. These scatter plots indicate highest negative correlation with higher correlation coefficients. The scatter plot between EOL and sea surface salinity (SSS) indicates an increase of EOL with the decrease of SSS. It may be noted that the best-fit line for this plot is the 2-degree polynomial and this is because of temperature and salinity contribution to the specific volume anomaly (or density) in computing the EOL. As expected by definition of EOL, the correlation coefficient of this best fit is also large ($r^2>0.8$). Applying the above computational method and statistical relationship equation the squared correlation coefficients are given in Table. Figure 10 shows SSS during Jul-Sep 98-99.

Month	OLR vs. EOL X=OLR; Y=EOL	EOL vs. SSS X=EOL; Y=SSS	OLR vs. SSS X=OLR; Y=SSS
MAY	$Y = -0.002*X+2.51$ $r^2 = 0.09$	$Y = 25.20+13.19*X-4.43*X^2$ $r^2 = 0.79$	$Y = 0.01*X+30.87$ $r^2 = 0.08$
JUN	$Y = -0.009*X+3.85$ $r^2 = 0.52$	$Y = 35.20+3.14*X-1.95*X^2$ $r^2 = 0.99$	$Y = 0.05*X+23.67$ $r^2 = 0.46$
JUL	$Y = -0.015*X+4.70$ $r^2 = 0.80$	$Y= 20.82+17.76*X-5.69*X^2$ $r^2 = 0.99$	$Y=0.08*X+19.25$ $r^2 = 0.67$
AUG	$Y = -0.013*X+4.72$ $r^2 = 0.44$	$Y = 24.50+14.73*X-5.16*X^2$ $r^2 = 0.97$	$Y = 0.08*X+17.22$ $r^2 = 0.23$
SEP	$Y = -0.002*X+2.51$ $r^2 = 0.01$	$Y = 28.43+10.89*X-4.24*X^2$ $r^2 = 0.98$	$Y = -0.01*X+34.11$ $r^2 = 0.002$
OCT	$Y = 0.006*X+0.74$ $r^2 = 0.16$	$Y = -18.31+57.97*X-5.99*X^2$ $r^2 = 0.95$	$Y = -0.02*X+37.74$ $r^2 = 0.04$
NOV	$Y = 0.002*X+1.51$ $r^2 = 0.05$	$Y = 46.09-6.67*X+0.12*X^2$ $r^2 = 0.91$	$Y = -0.03*X+38.44$ $r^2 = 0.12$

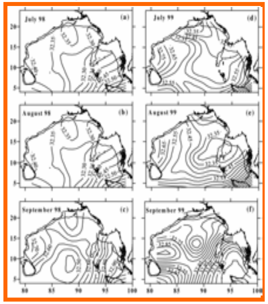


Figure 10. Estimated sea surface salinity during 98-99. The estimations are based on the monthly mean OLR data using the regression equations of each of the month (using Table).

Acknowledgements

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