Note on the Thermosteric Anomaly*

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Abstract: The simplified method for the computation of dynamic height anomaly proposed by MONTGOMERY and WOOSTER (1954) and by KLEIN (1955) is examined for about 250 stations over the north Pacific. The present study indicates that the integrated pressure terms for the dynamic height anomaly, surface over 1000 db, can be evaluated in terms of temperature only at 600 m level with sufficient accuracy. The errors introduced by this replacement are found less than 1 dyn. cm for various areas of different water masses.

According to the usual procedure for numerical computation, the dynamic height anomaly is given (for example, SVENDRUP et al.: The Oceans, p. 58, 409, 1946) by

$$ΔD=∫_0^{ρ}(Δth+δth+δtp+δthp)dp.$$ 

MONTGOMERY and WOOSTER (1954) called the first term in the parenthesis of the above expression thermosteric anomaly and the last three pressure terms, and made several discussions on them. Their result based on the Carnegie data suggests that the pressure terms may be neglected for the computation of the dynamic height anomaly in the Pacific. KLEIN (1955) and J. REID*** found that the correction for the neglect of the pressure terms can be made for the dynamic height anomaly 0 over 1000 db by an empirical equation. This correction equation has been proved valid with errors less than 2 dynamic centimeters.

The validity of the correction equation has been confirmed by the present authors also for the entire North Pacific especially in Kuroshio region and even in boundary regions between different water masses. If we write after KLEIN $ΔD'=∫_0^{1000}Δthdp$, the correction to

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be applied is $\Delta D-\Delta D'$, which is plotted against $\Delta D'$ for each station (Fig. 1). The linear relationship between $\Delta D-\Delta D'$ and $\Delta D'$ which is drawn by eye in the figure is:

$$\Delta D-\Delta D' = 0.05 \Delta D' - 0.02.$$

The errors are again less than 2 dyn. cm for most of all cases, so that this method of correction is certainly useful. However, there are certain indications from our result that the correction must depend somewhat signifi-

![Graph showing the relationship between $\Delta D-\Delta D'$ and $\Delta D'$](image)

Fig. 2. Correction for the integrated pressure terms in terms of temperature at 600 m.

Symbols used in the figure are same as in Fig. 1.

more upon temperature and salinity at greater depths than those at shallower. Combined with other observed facts that the dependence of the terms on salinity is almost negligible compared with that on temperature and also that the spatial variations in temperature are decidedly greater at depths of upper hundred meters than at greater depths, it is expected that the correction terms might be represented in terms of temperature at a certain intermediate depth. In fact, the non-integrated pressure terms for individual standard level reveal the maximum variance at a depth of 500 m or 600 m. Based on these indications, the correction terms $\Delta D-\Delta D'$ computed for each station are plotted against temperature at 600 m, $T_{600}$, for the corresponding station. As shown in Fig. 2, the fit is remarkable. The stations* were selected to cover a sufficient variety of situations from various areas and seasons (NORPAC, over the north Pacific, summer 1955; Equatorial waters; California waters). Out of about 250 stations examined, which were selected in somewhat arbitrary

* The data for the stations were taken from the following sources: (1) NORPAC hydrographic data records prepared by the Scripps Institution of Oceanography; Pacific Oceanographic Group; Pacific Oceanic Fisheries Investigation; Hokkaido University; Japanese Hydrographic Office; Tokyo University of Fisheries; Central Meteorological Observatory, Tokyo; Tokai Regional Fisheries Research Laboratory, Tokyo; and Kagoshima University; (2) Mid-Pacific Oceanography, parts II-IV; (3) Hydrographic Bulletin, Special Numbers, nos. 10, 14 & 15, Japan.
manner though, all except only one fall within 1 dynamic centimeter. This single exception is, as a matter of fact, due to an abnormal distribution of temperature or might be due to any error or disturbance, so that this might not be considered significant at all. It is rather surprising that temperature at 600 m level could give the value of integrated pressure terms within an accuracy of 1 dyn. cm or probably less for various areas of different water masses. As far as the pressure terms for the dynamic height anomaly, surface over 1000 db, are concerned, this accuracy is considered sufficient. Certainly, the validity might be somewhat limited owing to the fact that the cases examined here are still limited.

The correction for the dynamic height anomaly at other levels over 1000 db is also of interest. That for 200 db level over 1000 db is examined and yields the success with the same order of accuracy. One might think more accuracy is required for the correction to the anomaly at lower levels, but further increase in accuracy would not be much significant owing to the increasing uncertainties for lower levels due to such as the choice of the reference level. As a whole, the correction should be significant, considering that possible errors due to titration, interpolation, temporary disturbances, variations or acceleration, and to somewhat arbitrary choice of reference level would amount to several dynamic centimeters. The method for adjusting $\Delta Y'$ to $\Delta D$ as described in the present note seems to give much simplified means for obtaining the dynamic height anomaly with sufficient accuracy. Of course, discussions concerning those errors due to various other sources should be important, but they are tentatively placed out of the scope of the present work.

References

KLEIN, HANS T., 1955:
"A new technique for processing physical oceanographic data". (Scripps Institution of Oceanography; manuscript.)