Estimating Eddy–Induced Heat Transport by Combining Satellite Altimetry, Argo, and TMI Measurements

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1. Introduction

Many studies in the past have investigated the ocean's role in closing the global heat balance and a consensus has emerged that the time-mean ocean circulation plays a critical role in transporting heat from the tropics to the poles. With the ocean being a turbulent medium in which the time-mean circulation is in general much weaker than its time-varying signals, several recent studies have started to look into the transport carried by mesoscale eddies of the ocean (e.g. Holloway 1988; Stammer 1998; Rosenmühl and Gilson 2001; Wunsch 1999).

With new observational ability to measure mesoscale eddy activity becoming available in recent years, we attempt in this study to re-evaluate the eddy heat transport in the North Pacific. In contrast to the studies by Holloway (1988) and Stammer (1998) in which satellite altimetry data were used to derive the statistical properties of the mesoscale eddy field, the satellite SSH data will be used in this study to evaluate the movement and strength of individual mesoscale eddies. In addition to the satellite altimeter data, we also in this study utilize the sea surface temperature (SST) data measured by the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager (TMI) and ancillary data from the global Argo float program (Fig. 1, right). These two data sets have become available recently and, as we will show below, provide us with an effective means to capture the thermal structures of the mesoscale eddies. By combining the concurrent temperature and surface dynamic height measurements, we seek to estimate the eddy heat flux \( F' \) directly.

2. Structures of Mesoscale Eddies

Figures 2b and 2c show the \( T' \) and \( \dd{z} \) profiles measured by Argo float 29033 (See Fig. 2a for its trajectory). Figures 2d and 2e show the \( T' \) and \( \dd{z} \) anomaly profiles after removing the climatological \( T' \) and \( \dd{z} \) anomaly after removing the climatological \( T' \) and \( \dd{z} \) anomaly. These profiles capture the propagation of westward propagating warm- and cold-core eddies (see Fig. 3, right). The eddy-induced temperature anomalies in the western North Pacific suggest an effective depth \( H_c \) may be sought that relates the surface and depth-integrated eddy heat transport values:

\[
H_c = \frac{\Delta T_s}{\Delta T_c} \times \frac{\Delta T_c}{\Delta T_s}
\]

Using this conversion value, Fig. 9 (below) shows the estimated eddy heat transport for each of the eddies. This provides a measure of the eddy heat transport associated with the eddies. The estimated eddy heat transport values for each of the eddies are shown in Fig. 9, below. The eddy heat transport is the difference of baroclinic stability due to the vertical shear of the regional mean zonal flows (Qiu 1999).

3. Eddy Heat Transport in N Pacific

Confinement of eddy heat transport to the seasonal thermocline suggests an effective depth \( H_c \), with the eddy heat transport associated with eddies in the western North Pacific. The eddy heat transport values are shown in Fig. 10, below. The eddy heat transport is the difference of baroclinic stability due to the vertical shear of the regional mean zonal flows (Qiu 1999).

4. Major Findings

- A large poleward eddy heat transport is found in the central North Pacific along the SW-NE lifting band of the Subtropical Front. This high transport band is also found in the study by Rosenmühl and Gilson (2001) and our estimate compares well with the Rosenmühl and Gilson's results using the high-resolution XBT/XCTD transect of San Francisco – Honolulu – Guam – Taiwan (see Fig. 11, below). The eddy heat transport is the difference of baroclinic stability due to the vertical shear of the regional mean zonal flows (Qiu 1999).

References and Acknowledgment

The Argo float data was provided by the USGOOA/Argo Global Data Assembly Center, the TMI data by Remote Sensing Systems, and the merged T/P and ERS-2 altimeter data by the CLS Space Oceanography Division as part of the Environment and Climate Data Center (EEDC) project.

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