Observations of Large-Scale Depth Perturbations of the Main Thermocline[1]

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ABSTRACT

Three trans-oceanic XBT sections (~5000 km in length) and a shorter one (~2500 km in length) were taken in the central North Atlantic in 1974 to study the distribution of the horizontal scales and amplitudes of mesoscale variability. Few features of the MODE scale (~400 km wavelength) were observed; the most dominant features had space scales of 1000–2000 km and amplitudes of 50–100 m.

1. Introduction

During 1974 the NOAA ships *Oceanographer* and *Researcher* made several traverses along the Trans-Atlantic Geotraverse (TAG) corridor (Fig. 1). This is a standard geophysical section across the central North Atlantic. In addition to geophysical measurements, hourly expendable bathythermographs (XBT's) were taken to study the oceanwide distribution of the amplitudes and scales of depth perturbations of the main thermocline. During MODE, one perturbation was observed to have an amplitude of about 100 m and a horizontal scale of 400 km. At that time, there were conjectures that such features were common and closely-packed.

The majority of the XBT's used were T-7's, which have a depth capacity of 750 m. Only when the supply of these was exhausted were T-4's (450 m probes) used. Except for the first *Oceanographer* section, during which recorder malfunctions caused several gaps in the data, few hourly observations were missed. For the three *Oceanographer* sections, the sampling interval was 28 km (16.5 n mi); for the *Researcher* section, the interval was 23 km. From Bermuda to about 25°W, three of the sections are parallel. In this region it is possible to study temporal as well as zonal variations if it is assumed that the north-south scale of any perturbations is much larger than the distance between the sections.

2. Observations

One feature of these sections is that all the isotherms below ~300 m move up and down coherently, i.e., they have the same vertical displacements. Consequently, for the purposes of this note only the depth of the 12°C isotherm is presented; it is representative of the displacements of the main thermocline. The data have been smoothed (although it was not absolutely necessary to do this) with a Hanning filter that replaces the depth of an isotherm at any spot with a depth that is one-half of the observed value at that spot plus one-fourth of the sum of the values on either side. The effect of the filter is to reduce white noise. Before filtering, missing hourly values were given depths that were linear interpolations of adjacent values.

The dominant feature of all the sections is the east-

[1] MODE Contribution No. 71.

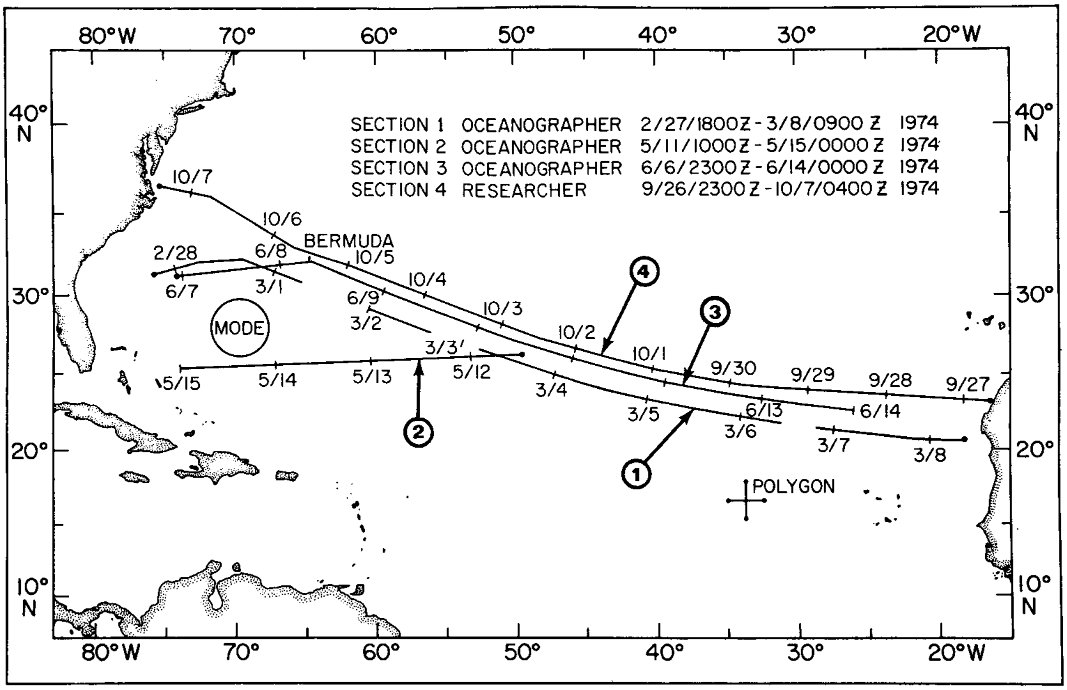

FIG. 1. Locations of XBT sections.

west slope to the thermocline (Fig. 2). Of more interest is the question as to what is the nature of the mesoscale fluctuations on these sections. Visually it can be seen that there are not many perturbations that are of the MODE scale (wavelength ~400 km). To study the perturbations more quantitatively sections 3 and 4 were selected since they are continuous across the full width of the ocean. For these sections the linear trend and mean were removed. From the remaining series the autocorrelation function and spectra were computed.

Basically the spectral computations confirmed what is apparent visually. For section 3 there is a small peak at a wavelength of ~200 km. Features of this scale can be seen to occur in figure 2 mostly at the western end of the section from 57°W to 72°W. Section 4 has a small spectral peak at ~600 km. The features that contribute to this are located between 50° and 60°W and around 25°W. Neither of these peaks is significant at the 90% confidence limit. Both sections show significantly more energy at larger wavelengths. In section 3 there is a major feature centered at 66°W. This has a wavelength of ~1000 km and an amplitude of 100 m.

Section 2 has no features at the MODE scale. A large feature is centered at 66°W with an amplitude of over 100 m. The horizontal scale of this is about 800 km. A similar feature was indicated to be present in section 3 at 66°W. This section is about ~700 km to the north of section 2 and was taken about one month later.

All of the sections are remarkably smooth between 55° and 26°W (Fig. 2). However, in this area there are large temporal variations between the sections. These appear to have horizontal scales of 1000–2000 km and amplitudes of 50–100 m. To see if these fluctuations have a clear seasonal time scale, all the hydrographic data that are on file at NODC in the 10° square centered at 25°N, 40°W were examined. These data do not

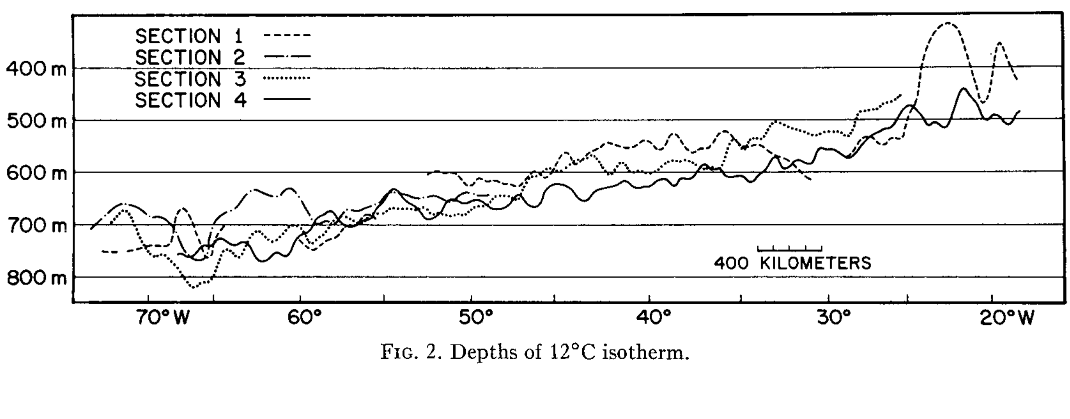

FIG. 2. Depths of 12°C isotherm.

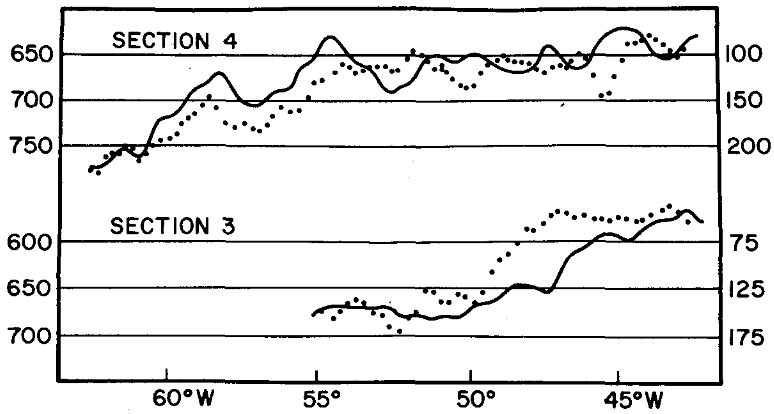

FIG. 3. Comparison between depth (m) of 12°C isotherm (solid line) and thickness change (m) of 18°C water (dotted line). Scale for thickness change is on right-hand side of figure.

show any strong seasonality; however, there was some tendency for standard deviations of the fluctuation of the depth of 12°C isotherm to be greatest during the winter. Since a total of only 117 stations was available, this result is tenuous.

In other areas, the temporal variations are much smaller. For example, between 62° and 55°W each section shows a strong east-west slope. In light of the large variations observed elsewhere, it is surprising how little this slope changes. The slope coincides with the edge of the 18°C water (Worthington, 1959). A convenient measure of the thickness of the 18°C water mass is the distance between the 18 and 20°C isotherms. The change in depth of the 12°C isotherm compensates for thickness changes in the 18°C water (Fig. 3). The thickness change is a combination of a change in depth of both the 20 and 18°C isotherms. Thus the good agreement does not result from the fact that the 12 and 18°C isotherms are almost parallel (as they are to the west of this region).

3. Summary

The purpose of these sections was to look for typical features, such as the MODE eddy, in the central Atlantic. These sections show that at these times there are few features that are characterized by both the MODE horizontal scale and amplitude. This is surprising since the sections pass through or close to the MODE, POLYGON and the proposed POLYMODE areas where such features were thought to be common. Most energetic features of this scale that are present occur on the eastern side of the ocean basin.

The most prominent features that were observed have space scales of 1000–2000 km and amplitudes of 50–100 m. The origin and time scales of these are unknown. Perhaps they are the response of the ocean to large-scale, seasonal variation of the wind field. Their large space scale makes it difficult to distinguish them from the mean circulation. Indeed some apparent variability was shown to be related to the edge of the 18°C water mass.

These results seem to indicate that the eddy field is more complex than envisioned after MODE. The MODE eddy possibly represents one realization of the eddy family. Others of different space scales have already been observed and more no doubt remain to be discovered.

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