ONE TYPE OF EDDY DEVELOPMENT IN THE NORTHEASTERN KUROSHIO BRANCH

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ABSTRACT: Some features of vertical structure of the frontal interaction zone of the warm Kuroshio Current and cold Oyashio Current are known from 1930 from analysis of ship data. Ship data however do not allow carrying out the area detailed survey opposite to satellite infrared (IR) observations which possess by high spatial and temporal resolution. Analysis of NOAA AVHRR IR images demonstrated that process of formation and development of the Kuroshio warm core rings is highly complex. They are formed as a result of development of anticyclonic meanders of the warm Kuroshio waters and spin off them from the current. Joint analysis of thermal infrared images and altimetry data has also indicated that interaction of eddies to the frontal zone plays a crucial role in formation of large eddies moving to the Southern Kuril region.

KEY WORDS: Satellite and altimetry data, anticyclonic and cyclonic eddies, geostrophic velocity anomalies

1. INTRODUCTION

One of exploration trend of Laboratory of Ocean Research by Space Methods of Pacific Research Fisheries Centre is the forecasting of hydrological conditions in investigated areas, marking out of fishery areas. Studying of hydrological conditions in the researched region by satellite information helps to solve the given problem.

2. DATA

The following data were used for our research: Infra – red and TV images from satellite NOAA (obtained from Satellite Monitoring Laboratory) and altimetry data from site AVISO (Archiving, Validation and Interpretation of Satellite Oceanographic data) were used as the main data. Japanese fax charts were used as the secondary data (data of SST for three days). Charts of geostrophic velocities anomalies were created. Data of anomalies of sea level have been used for calculations.

3. RESULTS

In 2004 it was traced the eddy formation as a result of interaction of two Kuroshio warm core rings. Geostrophic current anomalies were calculated in the eddies.

In spring 2004, several anticyclonic eddies were observed in the frontal Kuroshio zone (Figure 1 a, b). The first anticyclonic eddy, (A 24) 150 miles in diameter, was located to the south-east of Hokkaido, the second one (A 25) about 50-60 miles in size likely formed by the Tsugaru Current was at 40°N, 144°E and the third one (A 26), a warm-core ring of the Kuroshio, was at 37-38°N, 142-143°E. The last eddy, a large warm-core ring of the Kuroshio (A 30) 130-miles in diameter, was observed in the southern part of the frontal zone at 151-154°E. (see Figure 1).

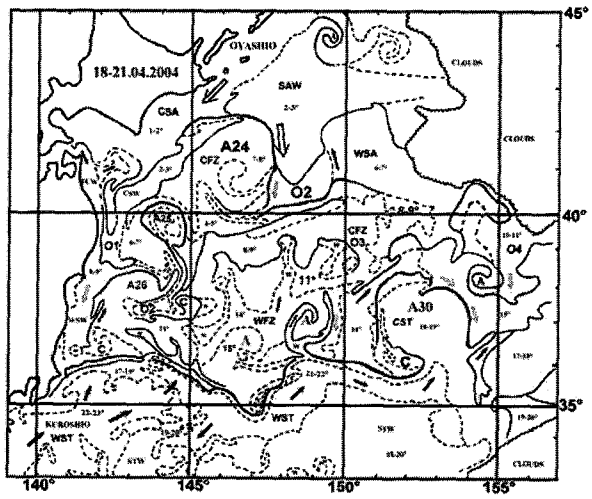
Let's consider interaction of two Kuroshio rings and formation of new eddy. In April within eddy A26, sea surface temperature (SST) ranged between 11 and 13°C, geostrophic velocity anomalies, computed from altimeter data, varied from 0.03 and 0.34 m/s and average geostrophic current anomaly was 0.18 m /s. Within eddy A30, SST was 17-18°C, geostrophic current anomalies was 0.01-0.69 m/s and average geostrophic velocity anomaly was 0.20 m/s.

During 2004, the center of eddy A26 was quickly moving in a anticyclonic path to Honshu. Then in December 2004, it away from the Honshu coast that can be considered as a wave reflection from an obstacle (Figure 2).

Eddy A30 is typical anticyclonic warm Kuroshio core ring (temperature not different from Kuroshio temperature). Kuroshio increased meandering between 150 and 153° in the February 2004. Kuroshio current influence on the movement Kuroshio meander on the east was intense. (Figure. 3). Western currents at the meander edge turned it into anticyclonic eddy. Then the eddy spin off the current. After formation eddy A 30 displaced quickly westward (1-2 miles/day) between 146-148°E in a cyclonic path along the Kuroshio front that can be considered as an opposite wave movement. It and reached 145°E at the end of November 2004. It is know that different planetary waves moved to the westward. Probably, they influence on the movement of the eddy A30 to the westward.

The center of eddy A26 was at 143°E during this period. The distance between the centers of eddies decreased to 90-100 miles and the edges of eddies contacted. Satellite data (IR – red, altimetry) and SST charts confirm this situation. (Figure 4, 5).

A.



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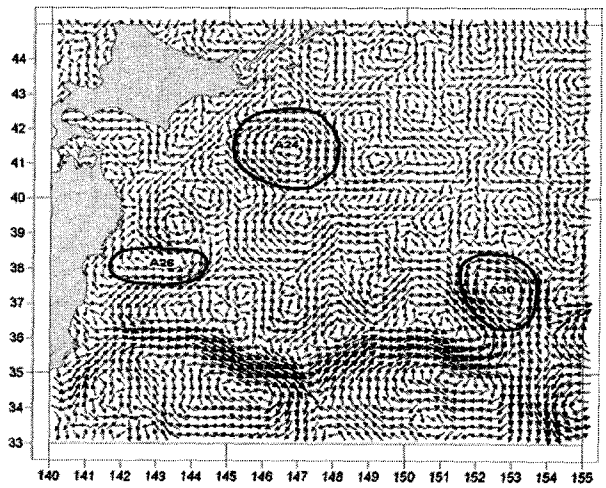

Figure 1. Anticyclonic eddies at the Kuroshio frontal zone in the April 2004.
A - Chart of frontal analyses constructed by analysis of AVHRR IR images taken on 18-21 April 2004. B - geostrophic velocity anomalies for 21 April 2004 computed from altimetry data. SAW - subarctic water; CSA - relatively cold SAW; WSA - relatively warm SAW; STW – subtropical water; FZW – warm frontal zone water; CFZ – relatively cold FZW; WST – the warmest STW, CST - relatively cold STW; WFZ – warm FZW; w – warm section of the water area; A – anticyclonic eddies; C – cyclonic eddies; O 1 and O 2 – Oyashio branches

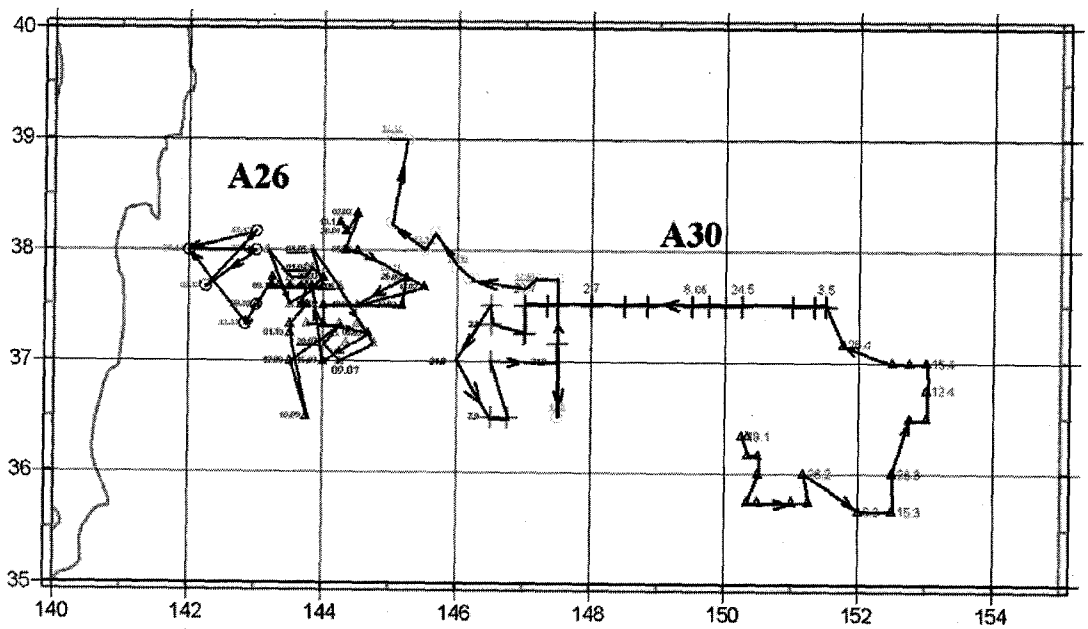

Figure 2. Movement of anticyclonic eddies A26 and A30 during 2004.

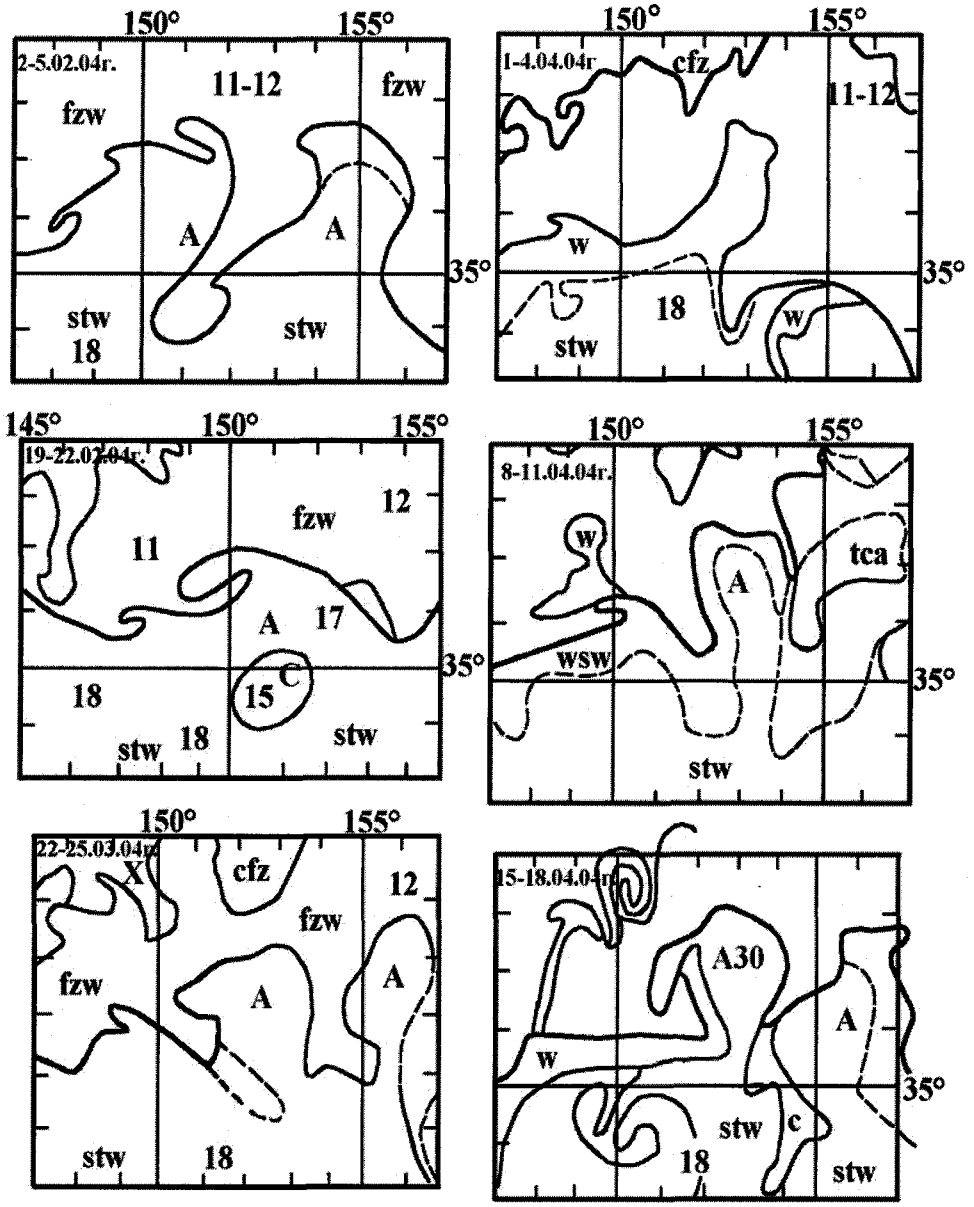

Figure 3. Meandering Kuroshio current during formation of warm core ring A30.
A - Chart of frontal analyses constructed by analysis of AVHRR IR images taken on 18-21 April 2004. B - geostrophic velocity anomalies for 21 April 2004 computed from altimetry data. SAW - subarctic water; CSA - relatively cold SAW; WSA - relatively warm SAW; STW – subtropical water; FZW – warm frontal zone water; CFZ – relatively cold FZW; WST – the warmest STW, CST - relatively cold STW; WFZ – warm FZW; w – warm section of the water area; A – anticyclonic eddies; C – cyclonic eddies; O 1 and O 2 – Oyashio branches

In the middle of December 2004, a new anticyclone 100 miles in diameter was formed at 145°E likely due to interaction of direct wave and wave reflecting from Honshu.

Part of A26 eddy's water remained near the Honshu. The size of the formed eddy called A28 did not exceed 40-50 miles. (See Figure 4)

In the beginning of December within A 28, SST was 18-20°C, geostrophic velocity anomalies varied from 0.04 to 0.30 m/s and average geostrophic current anomaly was 0.15 m /s.

The eddy's centre moved quickly northward to 40°N, 145°E and then occupied a stationary position.

Eddy A 28 begun moving along oceanic trench northward in spring 2005. In summer 2005, eddy A28 determined the conditions in the southern Kuril region.

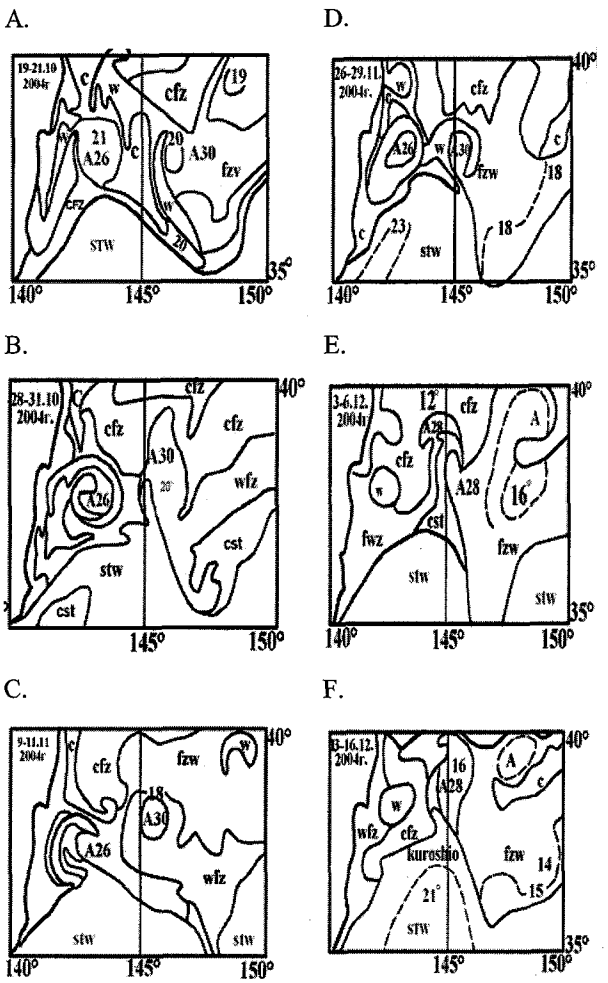

Figure 4. Interaction of anticyclonic eddies in the Kuroshio frontal zone and formation of eddy A 28 in October - December 2004. Legend see in Figure 1.

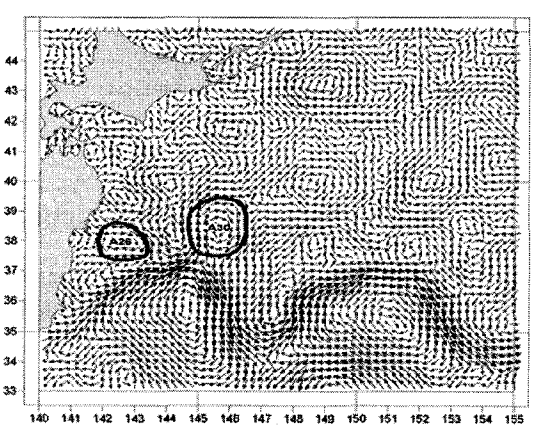

Figure 5. Geostrophic velocity anomalies in December 2004 computed from altimetry data.

4. CONCLUSIONS

1. Following hydrological processes were observed in 2004:
   - Spiral anticyclonic and cyclonic movement of eddies centers.
   - A new anticyclone A28 was formed as a result of the eddies interaction.
2. The eddy A26 movement can be considered as a wave reflecting from an obstacle
3. Fragments of the considered processes of IR images and charts of SST are often observed. But the process of formation, development, interaction of eddy are traced in full infrequently.
4. According to the last years observations the anticyclonic eddies which have been formed from the east Kuroshio meanders moved usually to the north-westward, crossing 40°N between 145°E and 147° E [1]. In the considered case the ring of Kuroshio A 30 first moved up to 145°E to the westward and only after meeting with ring A 26 moved along a deep-water trench to the northward [2, 3].
5. probably the planetary waves influence on the Kuroshio warm rings movement.
6. The given intercommunications of such connections, makes it possible to use these data for the forecasting formation.

5. REFERENCES

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