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Abstract. In this paper, the response of the upper ocean to typhoon Megi is analyzed and studied by using the sea surface temperature (SST), 500hPa height field and wind field of NCEP reanalysis data and Argo buoy data. The results show that sea surface temperature (SST) will decrease significantly after typhoon, and on the right side of typhoon path cooling is more obvious than the left; the temperature changes dramatically on the right side of Megi path, and correspondingly the depth variation in mixed layer is also intense, and the distance between buoy and the center of the typhoon will also affect the severity of the temperature variation, the salinity may increase or decrease after typhoon, it depends on the evaporation and precipitation or other relevant factors in this area.

1. Introduction
The tropical cyclone (TC) is a strong low pressure phenomenon that occurs in the tropical or subtropical oceans and is a very strong and wide range of tropical weather system, its energy is mainly provided through the upper ocean [1]. Not only its own rotation, but also moves forward at a fast pace, TC may have great effects on the surrounding sea or land. When the TC passes by, the sea surface wind will increase rapidly, which makes the cold water at the bottom of mixed layer upwelling, mixing with the upper warm water, and further leads to the temperature of mixed layer decreasing and the depth of mixed layer increasing at the same time [2]. Liu Zenghong and Xu Jianping use the data of Argo to analyze the depth variation of mixed layer after TC, and obtain preliminary results about upper ocean response to tropical cyclones in the Pacific Northwest, they consider that the depth of mixed layer increases in more than 50% observed profile after TC passes by, and about 78% mixed layer temperature decreases, the decreasing maximum value reaches 5 degrees, and there is a close relationship between the decreasing temperature and the TC path; in addition, they also find that more than half of the mixed layer salinity slope will decrease [3]. Prie (1981) points out that the most significant phenomenon that the response of the upper ocean to typhoon is the decreasing SST, and the research shows that it is cooler on the right of the typhoon path than the left, SST is an important factor that cause s typhoon and impacts the intensity variation of typhoon[4]; Emanuel (1983) points out that typhoon intensity has a strong correlation with SST[5]. In this paper, we attempt to use the information of SST and sea surface temperature anomaly, NCEP reanalysis data and Argo buoy data to analyze the response of the upper ocean to typhoon Megi on the basis of previous studies, and look for the variation regulars of oceanic elements in the upper ocean after typhoon.
2. Data selection and methods

In this paper, we will study the variation of the SST, salinity and the depth of the mixed layer in the upper ocean due to the impact of typhoon. The SST and temperature anomaly are the daily average value which are from the United States Earth System Research Laboratory (ESRL), the grid resolution is 0.25°x 0.25°; The Argo buoy data is from the U.S. Global Ocean Data Assimilation Experiment Center (USGODAE), combining with the information of typhoon Megi that China typhoon Meteorological Bureau provides, the typhoon center in every moment is the origin, and 4 buoys are screened within the range of longitude, then processing the buoy data selected to draw corresponding change graphs about SST, salinity, the depth of mixed layer when typhoon passes by, to find out the main factors in the variation.

2.1. NCEP reanalysis data

The NCEP reanalysis data is exploited to map out the SST daily changes around typhoon Megi path. By comparing the variation to find out the relationship between SST and the typhoon path, and from the graph of daily temperature anomalies can see more intuitive and precise about variation values and the specific range of the SST [6]. By contrasting the upper wind field data and the height field data, we can find reasons for typhoon steering.

2.2. Argo buoy data

All Argo buoy data used is selected in a specific latitude and longitude range of the sea area after typhoon, due to the large scope of the typhoon path, so we consider several buoy data within a certain longitude range as the same record. The selected buoy should satisfy: (1) the distance between the location of the typhoon center and the position of buoy should be in four longitude range; (2) buoy should record information for 5-10 days before and after the typhoon comes; (3) the selected Argo buoy data should have been processed [7,8]. In the definition about the depth of the mixed layer, one definition: the temperature in the lowest depth of the mixed layer is 0.5 °C colder than the SST, $|T(z) - T(0)| < 0.5$, we consider $z$ as the depth of mixed layer (Sprintall and Tomczak, 1992) [9]; the other definition: mixed layer is defined the part above the pycnocline, so in this paper we select the density gradient is not less than 0.015 kg/m$^{-4}$ as the depth of mixed layer (The specification for oceanographic survey data processing, 1992) [10]. The Argo buoy data has a high accuracy, and the thermocline also has certain thickness, in order to reduce the error and ensure the calculated depth of mixed layer more accurate, we select the meridional gradient is less than 0.1 °C • dbar as the depth of mixed layer that buoys survey.

Figure1. Graph a to f respectively show the daily temperature anomalies of typhoon Megi from October 17 to October 22, 2010.
3. Upper ocean response to typhoon Megi

3.1. The response of SST to Megi
Synthetically comparing from graph a to f in figure 1, it can be seen SST where the typhoon passes by is obviously lower than other sea area, the lowest value is about 2 °C, therefore, we can infer that the typhoon can reduce SST. Meanwhile, further observation we can see it has a significant cooling area on the southwest side of the typhoon before turning from chart d in figure 1.

3.2. The variation of mixed layer depth
The locations of Argo floats and the typhoon path are drawn in figure 2, we can intuitively see the position of buoy 2901138 is close to the turning point of typhoon Mgei, so we can have a good analysis about information of turning point by using data buoy 2901138 records; on the other hand, buoy 2901123 is on the left side of the typhoon, so the changes of response factors at both sides of typhoon Megi can be compared, while the positions of buoy 2901363 and 2901361 are relatively far from the typhoon, so the change range of response factors are relatively small.

| Float label | Recording date | Latitude° | Longitude° | Depth variation /m |
|-------------|----------------|-----------|------------|--------------------|
| 2901123_159 | 2010.10.13     | 18.887    | 118.923    | 50.10              |
| 2901123_160 | 2010.10.17     | 18.786    | 119.025    | 39.90              |
| 2901123_161 | 2010.10.21     | 18.682    | 118.803    | 90.60              |
| 2901123_162 | 2010.10.25     | 18.723    | 119.012    | 70.50              |
| 2901138_138 | 2010.10.13     | 16.104    | 115.243    | 79.80              |
| 2901138_139 | 2010.10.17     | 16.099    | 115.357    | 50.50              |
| 2901138_140 | 2010.10.21     | 16.045    | 115.667    | 60.50              |
| 2901138_141 | 2010.10.25     | 15.978    | 115.245    | 59.20              |

Figure 2. The chart of typhoon Megi path and buoy position
We know buoy 2901123 is on the right side of the typhoon path, so the change of its temperature amplitude is greater than buoy 2901138, which also shows that SST at the right side of typhoon path has a more obviously cooling than the left around the sea area of typhoon path. We can observe from table 1 the depth variation of mixed layer buoy 2901123 records is particularly intense, the difference between the minimum and the maximum of the depth variations is 50.9m, meanwhile, we have analyzed that SST also has obvious variation from figure 1, by contrast, the depth surveyed by buoy 2901138 has a relatively weak variation.

3.3. The variation of salinity
There are many factors that cause the change of salinity in the mixed layer, such as: precipitation, evaporation of water vapor, mixing intensifies in mixed layer and seawater upwells in the thermocline etc., only the precipitation can reduce the salinity in the above factors, while the other three will increase the salinity. Generally, these processes exist simultaneously; the final change also depends on the strength of the impact of various factors.

![Figure 3](image-url)  
**Figure 3.** The above two graphs show the variation of salinity with the depth by buoy records, the left is buoy 2901123 and the right is buoy 2901138. Different color curves represent the variation of salinity in different days before and after typhoon comes, black line is the 4 days before the typhoon, red is during typhoon comes, the green is the 4 day after typhoon, yellow is the 8 day after typhoon.
According to the data buoy 2901123 records, we can compare the salinity in the same depth before and after typhoon comes from figure 3(left), we can see the salinity firstly increases after typhoon, the increasing maximum value reaches 0.45 in four days after typhoon by contrasting black line to green line in figure 3(left), and then it comes down, but it is still higher than the salinity before typhoon. While the salinity is firstly down after typhoon according to buoy 2901138 in figure 3(right), the decreasing maximum value is 0.2 by contrasting black line to green line in figure 3(right). Because of the salinity data that buoy 2901138 records is close to the turning point of typhoon, this shows that the typhoon causes the precipitation strengthening in the area when turning, which is more than any other influence of several factors, so the salinity decreases.

4. Conclusions
In this article, we draw the SST profile, the depth map of mixed layer and salinity maps by using the data of SST, sea surface temperature anomalies and reanalysis data from NCEP, and combining with information collected by Argo floats, we analyze and compare the variations of the depth in mixed layer, the SST and salinity at left and right sides of typhoon Megi path before and after typhoon comes. We draw the following conclusions:

The SST will significantly decrease after typhoon, and it is cooler on the right side of typhoon path than the left;

It is noteworthy that there will be a significant “cold spot” on the west or southwest side of the typhoon center before turning, which may be helpful to judge when typhoon will turn;

The temperature changes dramatically on the right side of Megi path, and correspondingly the depth variation in mixed layer is also intense. Also the distance that buoy is from the center of the typhoon will also affect the severity of the temperature changes.

The salinity may increase or decrease after typhoon, it depends on the evaporation and precipitation or other relevant factors in this area.

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