Preliminary monitoring and study on severe cold shock events in the Taiwan Strait

Student: Tzu-Chun, Hsu
Supervisor : Prof. Zhe-Wen, Zheng
Department of Earth Science, National Taiwan Normal University

Introduction

In the past winter time, there were several severe **cold shock events occurred in the Taiwan Strait (CSTS)**, which led to the ecological damage, e.g. economic fisheries losses and coral bleaching. In addition, the previous studies are focused on the single event analysis of the severe events. There's no holistic definition of an event's area definition and temperature criteria. As a result, in this study, we plan to give a long-term monitoring on all severe cold shock events occurred in the Taiwan Strait (CSTS) in the past 30 years using continuous satellite-based infrared (IR) sea surface temperature (SST) images. Based on related analyses, the spatial and temporal characteristics of CSTS can be elucidated.

Here are few questions we want to clarify:

1. What is the suitable temperature criteria of CSTS ?
2. How many CSTS has happened in past 30 years ?
3. How to distinguish severe CSTS events ?
4. What are the events' temporal and spatial features ?

Previous Studies

To know what are the cold shock events in Taiwan Strait (TS), we read the previous studies first. A study mentioned that the SST variation in the TS is mainly seasonal; there is a clear SST belt occurring between the colder water in the northwestern TS and the warmer water covering the southeastern TS. They also tell us the ENSO events show impact on the wind and SST field in the TS (Kuo and Ho 2004).

Now that we have to know the flow pattern of TS. (**Figure 1.**) This is a schematic diagram of the flow pattern in winter. The bathymetry and Northeast monsoon (NE) are related to the current trend, especially a portion of the China Coastal Water is deflected by the CYR and turns back northeastward (Jan et al. 2002).

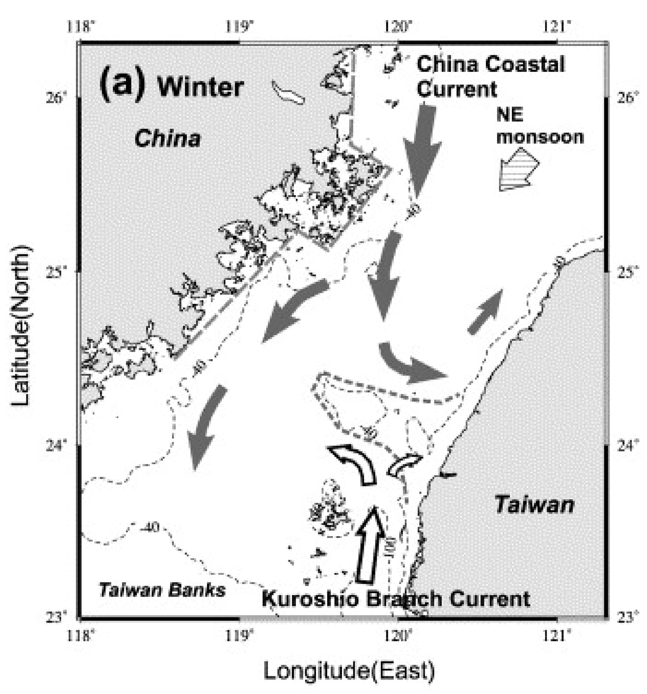

Figure 1. (Jan et al. 2002)

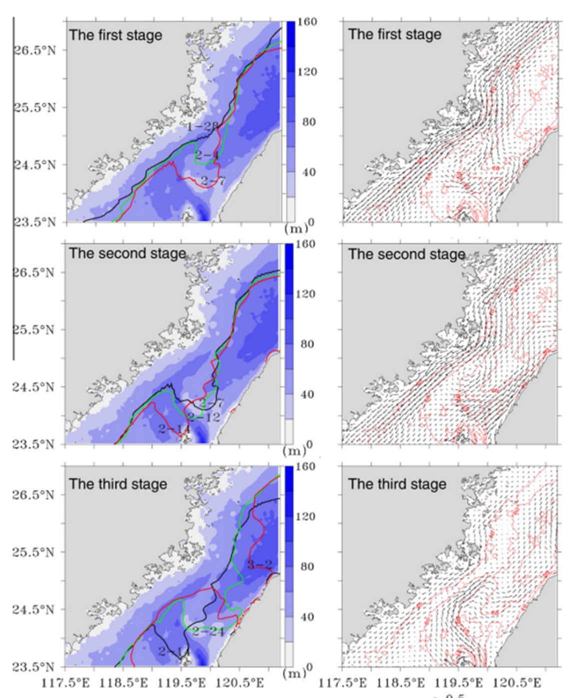

Figure 2. (Liao et al. 2013)

We also wonder whether there's a index can represent the severity of the CSTS. A coolness index has been created which represents a regional average of the relative mass of cold water (Lee et al. 2005). It suggested that the **isotherm line of sea surface temperature 20˚C** might be served as a winter **thermal front boundary index** of China Coastal Current (CCC) and Kuroshio Branch Current (KBC) in the Strait.

Except the **20˚C**, there's other boundary called **'cold tongue' (<17 ˚C)** (Chang et al. 2009). It was suggested to be a portion of the China Coastal Water deflected by the Chang-Yuen Ridge and turns northeastward, which was mentioned in the **Figure 1**. They also say that the SST & ONI have similar variation trend.

In addition, we want to know how the CSTS evolve. **(Figure 2.)** This is a research about the 2008 cold disaster in the Taiwan Strait. They organize the three stages of depth-averaged currents movements, they were **off-shore extension**, **southwestward intrusion**, and **northeastward retreat** sequentially. (Liao et al. 2013)

Data selection and comparison

In order to use continuous satellite-based infrared (IR) sea surface temperature (SST), we have to compare different datasets' properties. The data should be daily data and its temporal coverage must reach at least 30 years. After comparison, the **Copernicus Climate Data Level-4 (L4)** can be served as the research material. This dataset is a spatially complete global SST product based on data from multiple sensors. Its resolution is 0.05˚*0.05˚. Our selected time will be January, February, March and December from 1991 to 2020.

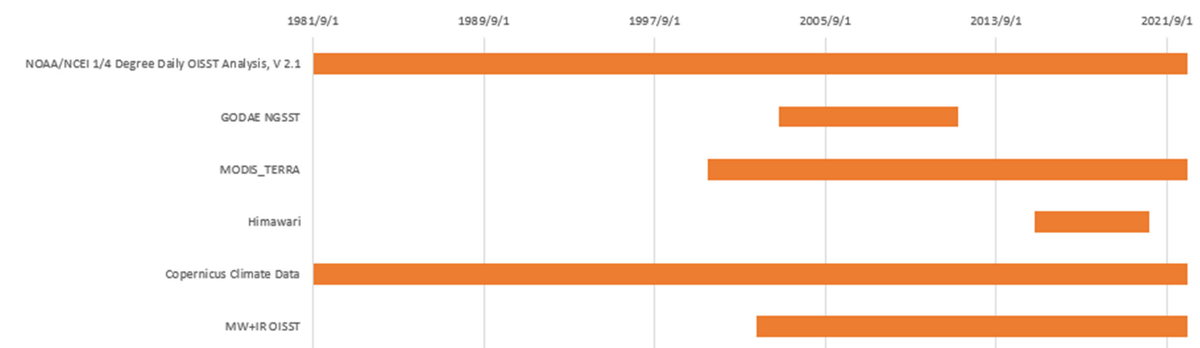

Figure 3. datasets time coverage comparison

Methodology

To get the area temperature variation trend, we specify a certain area (longitude: 118˚E~121˚E latitude: 23˚N~25˚N, as **Fig 6.** solid line area shown) for average temperature calculation which omitted the NaN value, due to the bathymetry and the extra portion of the cold water that both can affect the mean temperature. Thus, we get a time series of mean temperature variation (**Fig 4.**). Next, we set different criteria of continuous days and boundary temperature to get reasonable continuous event. The validation of the criteria is that it should include the severe cold shock events in the past , such as 2000, 2008, and 2011.

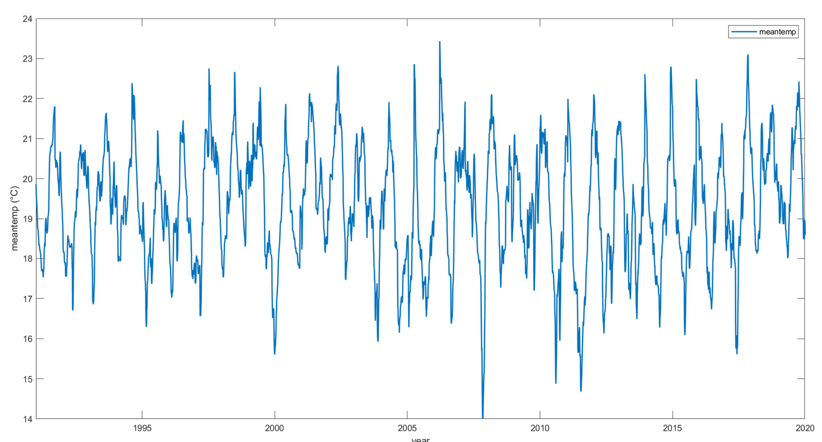

Figure 4. time series of mean temperature variation

Result

After comparison and consideration, we get **10 events** form the analysis by using the criteria of **'14 days & 17.5 ˚C '** in the designated area **(Figure 5.)**. We discover that despite the event of 2008 is the most severe one, but the event of 2012 last longest. We conclude that **strong cold shock events don't need to last long. (Figure 6.)** This figure shows a typical pattern of the 10 events, which is the events' mean composite SST map.

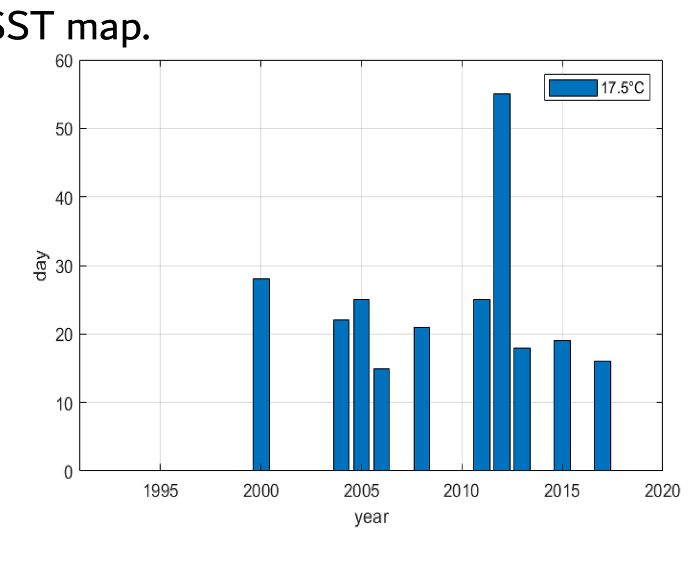

Figure 5. events' statistical result

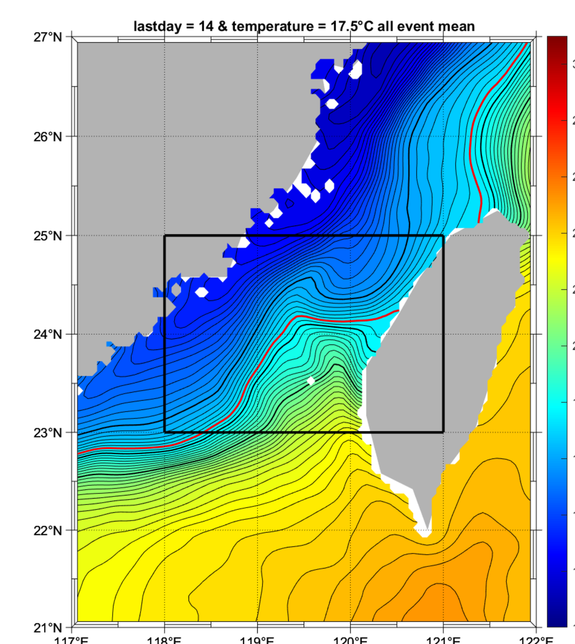

Figure 6. typical pattern of 10 events

In the future, we aim to clarify the relationship between the CSTS and environmental factors(e.g. wind forcing, PGF, SLH, ENSO). Besides, the further result will be examined by the statistical method. In addition to the analytic results of observed based data, next, we plan to use the numerical model to elucidate possible mechanism(s) therein.

Reference

1. Chang, Y., Lee, K. T., Lee, M. A., & Lan, K. W. (2009). Satellite Observation on the Exceptional Intrusion of Cold Water in the Taiwan Strait. Terrestrial, Atmospheric & Oceanic Sciences, 20(4).
2. Jan, S., Wang, J., Chern, C. S., & Chao, S. Y. (2002). Seasonal variation of the circulation in the Taiwan Strait. Journal of Marine Systems, 35(3-4), 249-268.
3. Kuo, N. J., & Ho, C. R. (2004). ENSO effect on the sea surface wind and sea surface temperature in the Taiwan Strait. Geophysical research letters, 31(13).
4. Liao, E., Jiang, Y., Li, L., Hong, H., & Yan, X. (2013). The cause of the 2008 cold disaster in the Taiwan Strait. Ocean Modelling, 62, 1-10.
5. Lee, M. A., Chang, Y., Lee, K. T., Chan, J. W., Liu, D. C., & Su, W. C. (2005, July). A satellite and field view of the winter SST variability in the Taiwan Strait. In Proceedings. 2005 IEEE International Geoscience and Remote Sensing Symposium, 2005. IGARSS'05. (Vol. 4, pp. 2621-2626). IEEE.