2 Climatology of Air-Sea Interaction and Atmospheric Convection over the Kuroshio in the East China Sea

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1. Introduction

The Kuroshio, one of the most energetic western boundary currents has a large impact on the surface water characteristics of East China Sea (ECS) - Fig.1) and greatly influences the atmospheric conditions in this region. Series of studies by AMTEX (Air-Mass Transformation Experiment) during 1970’s found out that the increased convective transfer of heat and moisture for air-mass transformation was related to the Kuroshio. The observational data they used were mainly from aerological, surface, upper-air and marine stations in a very limited period of time. But now, with the recent advance of ocean satellite technology, satellite data provide us more opportunities to study air-sea interaction and atmospheric convection over the Kuroshio.

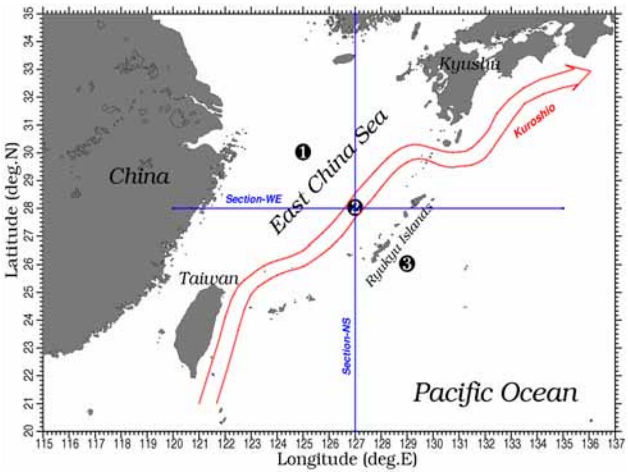

Fig.1. Study area and typical mean path of the Kuroshio. The vertical and horizontal lines indicate the section line of data analysis, and the positions marked ❶, ❷, ❸ are selected as a reference points for air-sea interaction comparison.

This paper investigates the effect of the strong warm ocean current Kuroshio in the air-sea interaction in the ECS. The main objectives are: (1) To show the climatology of seasonal differences of convective process utilizing the monthly mean data of ocean surface and atmospheric parameters; (2) To examine the relationship among these parameters in the air-sea interaction and atmospheric convection.

2. Datasets and Analysis

All the datasets were downloaded through internet (Table 1), extracted and processed for the purpose of this study area (Fig.1). These parameters are the sea surface temperature (SST), wind, precipitation and cloudiness derived from different satellite observations about recent ten (10) years, along with the objectively analyzed heat flux datasets provided by ship observations obtained from empirical bulk formula. The climatological monthly mean of each datasets is computed by simply averaging the original datasets. By using the monthly mean data, we can analyze more about a typical feature of convective phenomena in the Kuroshio region in ECS. The data analysis were made using the view points of convection as illustrated in Fig.2 referring the available datasets used along with their corresponding platform satellites and data source. The methodology analysis used are the following :(a) Contour Map Analysis, (b) Space-Time Diagram (Latitude/Longitude-Time plots), (c) Scatterplots and Correlations, and (d) Time Series Analysis.

Table 1. List of Datasets used in the study

Internet Address	Database (Satellite)
Remote Sensing System (RSS) www.remss.com	@ SST (TRMM) @ Surface Wind (TRMM, QSCAT) @ Atmospheric Water Vapor @ Cloud Liquid water @ Rain Rates (TRMM)
PODAAC,NASA http://podaac.jpl.nasa.gov	@ SST (NOAA)
Weather Home, Kochi University http://weather.is.kochi-u.ac.jp	@ Brightness Temperature IR1, IR2, IR3,VIS (GMS)
National Oceanography Centre, Southampton University www.noc.soton.ac.uk	@ Sea Surface Heat Flux (Bulk formula estimation with COADS dataset)

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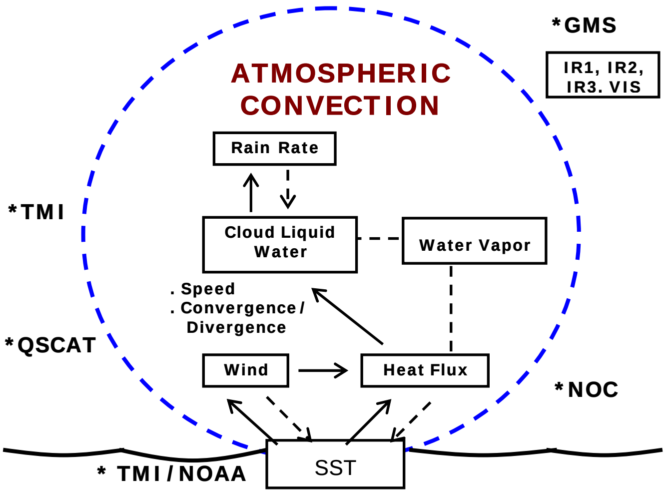

Fig. 2. Basic overview of the convection processes in the air-sea interaction Showing the parameters used and their corresponding satellites platforms/source.

3. Results and Discussion

The climatology of SST exhibits a strong temperature gradient of the warm SST of the Kuroshio front that marked a boundary separating from the warm waters on the northwestern section of ECS especially during winter and spring (Fig.3). The SST variability of the Kuroshio gives significant effect on surface winds. Intensified wind found along the Kuroshio path in Fig.4 are modified and affected by the strong temperature gradient in the wide spread area in ECS. The convergence of wind also found in this area where the location of large amount of heat flux is observed.

The influence of the warm Kuroshio is very remarkable during winter and early spring, and there is a great amount of heat loss advected from the ocean to the atmosphere. It is interesting to note that over the Kuroshio during spring, flux of heat was still manifested in spite all over the surrounding ocean waters heat gain were observed as shown in Fig.5.

Figures 6a and 6b show the variation of cloud liquid water and rain rates over the Kuroshio at point ❷ using their monthly mean variation time series. Higher amount of cloud liquid water corresponds with high precipitation found in late winter until the last month of spring. Cloud liquid water were almost observed over the Kuroshio in ECS as shown in Figs. 7a and 7b. The percentage albedo of cloudiness over this region as inferred by the amount cloud liquid water content is shown in Figs.8a and 8b. More cloud-covered areas are found caused by the enhanced atmospheric convection particularly in winter and spring seasons.

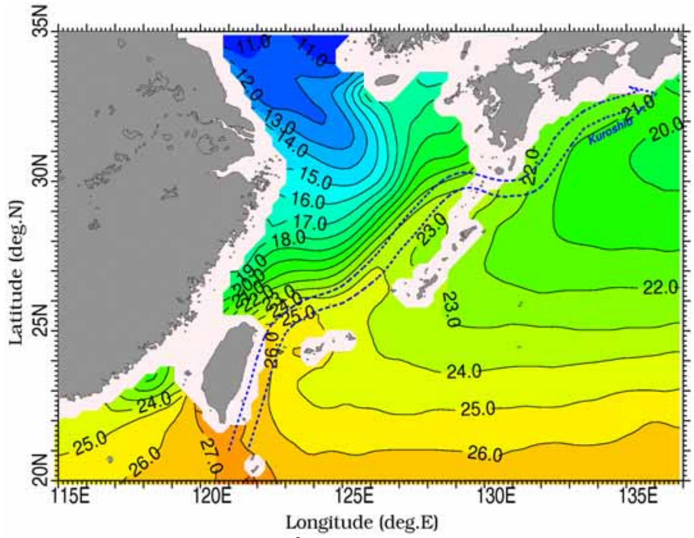

Fig.3. Mean distribution of SST (^{0}C) over the Kuroshio region during SPRING.

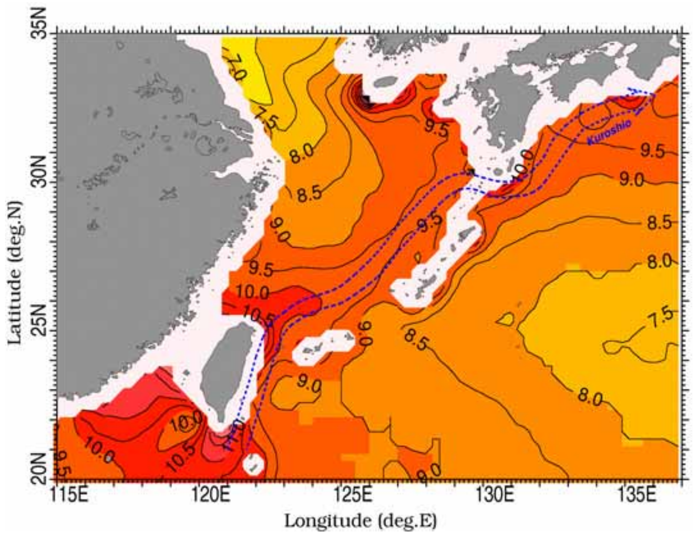

Fig.4. Mean distribution of Surface Wind Speed (m/s) over the Kuroshio region during WINTER.

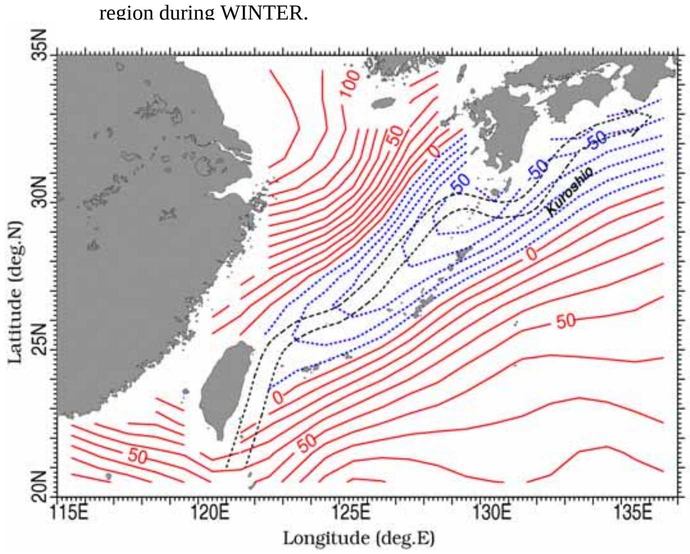

Fig.5. Mean distribution of Sea Surface Net Heat Flux (w/m^2) over the Kuroshio region during SPRING. Positive (negative) heat gain (loss) by the ocean surface is indicated by solid (broken) lines.

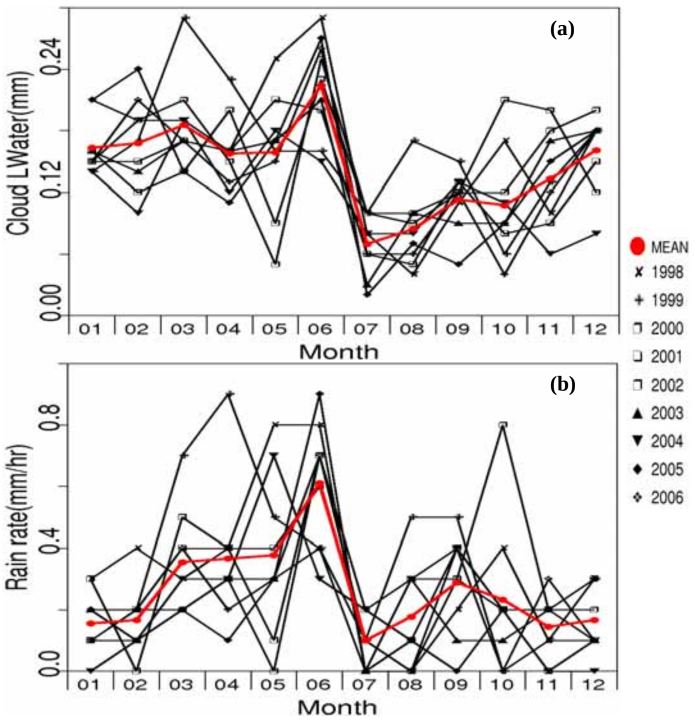

Fig.6. Monthly mean variation time series of (a) Cloud Liquid Water (mm) and (b) Rain Rates (mm/hr) over the Kuroshio region at point ❷. The red thick line denotes the yearly average for each month

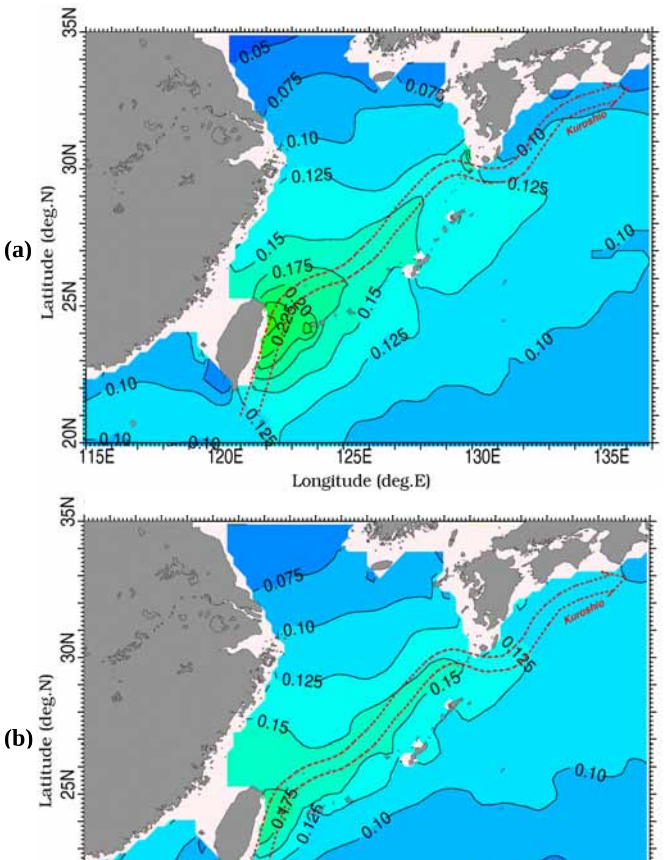

Fig.7. Mean distribution of Cloud Liquid Water (mm) over the Kuroshio region during (a) WINTER and (b) SPRING.

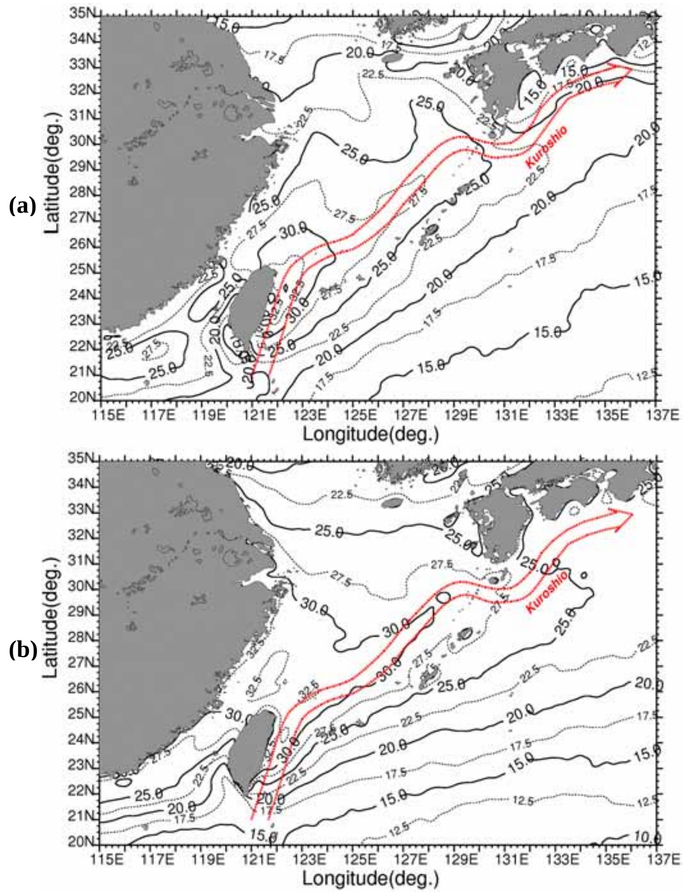

Fig.8. Mean distribution of Visible Albedo (%) over the Kuroshio region during (a) WINTER and (b) SPRING.

4. Concluding Remarks

This study shows the climatology of seasonal variations about the air-sea interaction and atmospheric convection over the Kuroshio in ECS using mainly various satellite observed datasets. The Kuroshio is almost stationary along the edge of the continental shelf of ECS and simple monthly spatial mean successfully obtained for some component of convective phenomena related to the Kuroshio. Though the typical convective time scale of air-sea interaction over the Kuroshio were several weeks shorter than one month, the climatological monthly mean provided us some sort of conditionally sampled feature observed in this area showing the concentration over the Kuroshio. It also gives us the opportunity of better analysis for the general pattern and characteristics of a typical air-sea interaction phenomena observed over this region.