平成 **26** 年度

三重大学大学院　生物資源学研究科

修士論文

Overland local weather induced by a leeward meso-cyclone in the Ise Bay

伊勢湾の存在が及ぼす冬季の平野部の局地気象

～海水温が駆動する伊勢湾小低気圧～

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ABSTRACT

This study verified the effect of the difference between sea surface temperature of the Ise Bay and air temperature in winter gives to local weather around by using regional meteorological model and observed data. We conducted sensitivity experiments that sea surface temperature of Ise Bay was set 5°C higher than the reality by using regional meteorological model. Upward sensible heat and latent heat flux is many release by increasing the virtually sea surface temperature of Ise Bay. Furthermore, sea level pressure on the Ise Bay became cyclone tendency. Wind system of plains around Ise Bay had been changed by this cyclone. Relationship that the larger difference between SST in the Ise Bay and temperature, the more prone to cyclone tendency was indicated by the observed data. These results indicate that the local weather around Ise Bay is varied by cyclone occurs on the Ise Bay when large difference between SST in the Ise Bay and temperature in winter. From the above, we concluded that the presence of Ise Bay is to determine the wind around Ise Bay.

Contents

1. Introduction

Studies have been many in the past about the local weather of central Japan, including the around Ise Bay in winter. For example, Kawamura (1966) indicated that atmospheric pressure in synoptic scale is affecting surface wind by relationship of the pressure distribution and wind system.

Ise Bay around has plains, Mountains so as to surround the plains are continuous. It is known that there is a strong wind “Suzuka-oroshi” by the mountains. “Suzuka-oroshi” has been reported that there is different generation mechanism by wind direction (Komatsu and Tachibana, unpublished).

These studies indicate that the impact on the local weather is the synoptic scale field and terrain. However, Ise Bay plays a role of heat source, because sea surface temperature of the Ise Bay is about 15°C higher air temperature (see Appendix 1). Thus, Ise Bay is considered large impact on the atmosphere. However, studies that wind changed by the influence of the Ise Bay located leeward, and affecting the local weather despite blowing strong wind from overland in winter are not almost.

Thus, this study is intended to clarify the effects of the difference between sea surface temperature of the Ise Bay and air temperature in winter gives to local weather around.

2. Data and Methods

2.1 Model configuration

This study used Weather Research and Forecasting (WRF) model Version 3. 4. 1 (Michalakes et al. 2001). Calculating area is shown Fig.1. The outermost domain (d01) had horizontal resolution of 27km. The second outside domain (d02) had horizontal resolution of 9km. The third outside domain (d03) had horizontal resolution of 3km. The innermost domain (d04) had horizontal resolution of 1km. All domains included 27 vertical layers. Using parameters is shown table 1. Cumulus Parameterization (cu_physics) used only d01 and d02. The initial and lateral boundary conditions of the atmosphere used the National Centers for Environmental Prediction (NCEP) Final Analysis (FNL) data with horizontal resolution 1.0° × 1.0°. The initial and lateral boundary conditions of sea surface temperature (SST) used high-resolution, real-time, global, sea surface temperature (RTG_SST_HR) data with horizontal resolution 0.083° × 0.083°. Calculation period was about 2 months, from 1200 UTC 31 November 2005 to 0000 UTC 1 February 2006.

Calculation results using the above data is referred to as control run (CTL). Calculation results to increase 5°C the SST in the Ise Bay is referred to as SST run (see Appendix 2). SST of the Ise Bay was 2.5°C lower than the average year in December 2005 of the calculation period. In contrast, warm year than the average year SST in the Ise Bay was 2.5°C high (see Appendix 3). Thus, that is realistic to increase 5°C the SST in the Ise Bay and this calculation results indicates that SST in the Ise Bay is warmer situation than usually.

We verified by comparing the both of calculation results that difference between SST and air temperature affects overland local weather.

2.2 Analysis by AMeDAS and reanalysis data

The analysis period was from December 2004 to February 2013 for December-January-February.

Observed value of SST in the Ise Bay used the area averaged data in the range of Ise Bay of Japan Coastal Ocean Predictability Experiment 2 (JCOPE2) data (Miyazawa et al. 2009). Temperature data used Japanese 55-year Reanalysis Project (JRA-55) data (Kobayashi et al. 2015) and using value was nearest grid of Mie prefecture. Atmosphere pressure and wind data used Automated Meteorological Data Acquisition System (AMeDAS) data of Japan. Using atmosphere pressure data is daily average value of sea level pressure (SLP). Using wind data is daily average wind speed and most frequent wind direction in the day.

We had anomaly of difference between SST in the Ise Bay and temperature as follows. Daily climate value of difference between SST in the Ise Bay and temperature of Mie prefecture was created by averaging the difference between both data for each day. Anomaly data was created by subtracting the above daily climate value from difference between SST in the Ise Bay and temperature of Mie prefecture.

To obtain the SLP data, we were area average at the point of AMeDAS to be included within from 135.6°E to 137.4°E and from 33.8°N to 36.2°N (see Appendix 4.a). Furthermore, we have daily SLP variation by determining the anomaly from the area average using the average of Tsu and Irako.

Wind data around Ise Bay used the north-south component of the wind of Obata and Minamichita and we confirmed the wind shear between the two points (see Appendix 4.b). We were standardization in both point to remove a specific wind at each observation point. After that, we subtracted Obata from Minamichita to confirm the circulation on Ise Bay. If the above data took a positive value, we assume that around Ise Bay is cyclonic flow into a depression.

We examined the relationship between anomaly of difference between SST in the Ise Bay and temperature and the SLP or wind.

3. Result

3.1 Calculation results of the model

In this section, we verified by subtracting the CTL run from SST run that difference between SST and air temperature affects atmospheric field.

Monthly mean upward sensible heat and latent heat flux is shown Fig.2. Sensible heat and latent heat flux were positive anomaly on the Ise Bay in December and January. This result indicated that the heat flux is emitted to the atmosphere from the sea surface.

Monthly mean of SLP is shown Fig.3. SLP was cyclone anomaly on the Ise Bay (see Appendix 5). Furthermore, cyclone anomaly extended plain around Ise Bay.

Fig.4 shows monthly mean of 10m wind and monthly accumulated precipitation. 10m wind shows only over the wind speed 0.1m/s. Wind converged toward Ise Bay. Precipitation increased in convergence zone. In January, wind direction was change (see Appendix 6), and precipitation increased in overland plain.

3.2 Analysis results by AMeDAS and reanalysis data

Fig.5 shows scatter diagram of anomaly of difference between SST in the Ise Bay and temperature and anomaly of SLP. The horizontal axis is anomaly of difference between SST in the Ise Bay and temperature, and the vertical axis is anomaly of SLP. Anomaly of difference between SST in the Ise Bay and temperature shows only over the 1σ. A straight line is regression line. We found that there is a tendency that the anomaly of difference between SST in the Ise Bay and temperature becomes larger as the cyclone anomaly.

Fig.6 shows scatter diagram of anomaly of difference between SST in the Ise Bay and temperature and wind shear of north-south component. The horizontal axis is anomaly of difference between SST in the Ise Bay and temperature, and the vertical axis is wind shear of north-south component. Anomaly of difference between SST in the Ise Bay and temperature shows only over the 1σ. A straight line is regression line. We found that there is a tendency that the anomaly of difference between SST in the Ise Bay and temperature becomes larger as wind of cyclonic flow into a depression.

4. Discussion and conclusion

This study verified by sensitivity experiments using the WRF regional meteorological model that how do alter the meteorological fields when large difference between SST in the Ise Bay and temperature in winter. Furthermore, we verified the relationship between the difference between SST and temperature and weather around Ise Bay in reality by using the observed data.

Sensible heat and latent heat flux emitted to the atmosphere is increased by a large difference between SST in the Ise Bay and temperature (Fig. 3). Therefore, cyclone occurs (see Fig. 4 and Appendix 7). Wind system around Ise Bay is varied by the influence of cyclone that occurred (Fig. 5). The above process was indicated by results of regional meteorological model.

Relationship that the larger difference between SST in the Ise Bay and temperature, the more prone to cyclone tendency was indicated by the observed data (Fig. 6 and Fig. 7). This result was indicated consistency with the results of regional meteorological model.

However, result of observed data was not indicate a strong relationship. The reason can be considered two. First, the method of this study may not able to remove the influence of synoptic scale field. Second, is the possibility that was different from the actual scale of cyclone on the Ise Bay. We thought that it is necessary to solve these problems.

However, result of this study suggest that the difference between SST and temperature in leeward affect overland local weather, which was not seen in the study of the conventional local weather.

Acknowledgements

I extend grateful thanks for Prof. Yoshihiro Tachibana who is my supervisor. Prof. Tachibana taught me the amusingness to research for meteorology or climate and he gave me a chance to innovative research, irreplaceable meteorological knowledge and technics for analysis.

I extend special thanks to Dr. Kunihiko Kodera and Dr. Koji Yamazaki for their very helpful discussions. Members of Climate and Ecosystem Dynamics Laboratory provided some advices for my research. I would like to thank for them.

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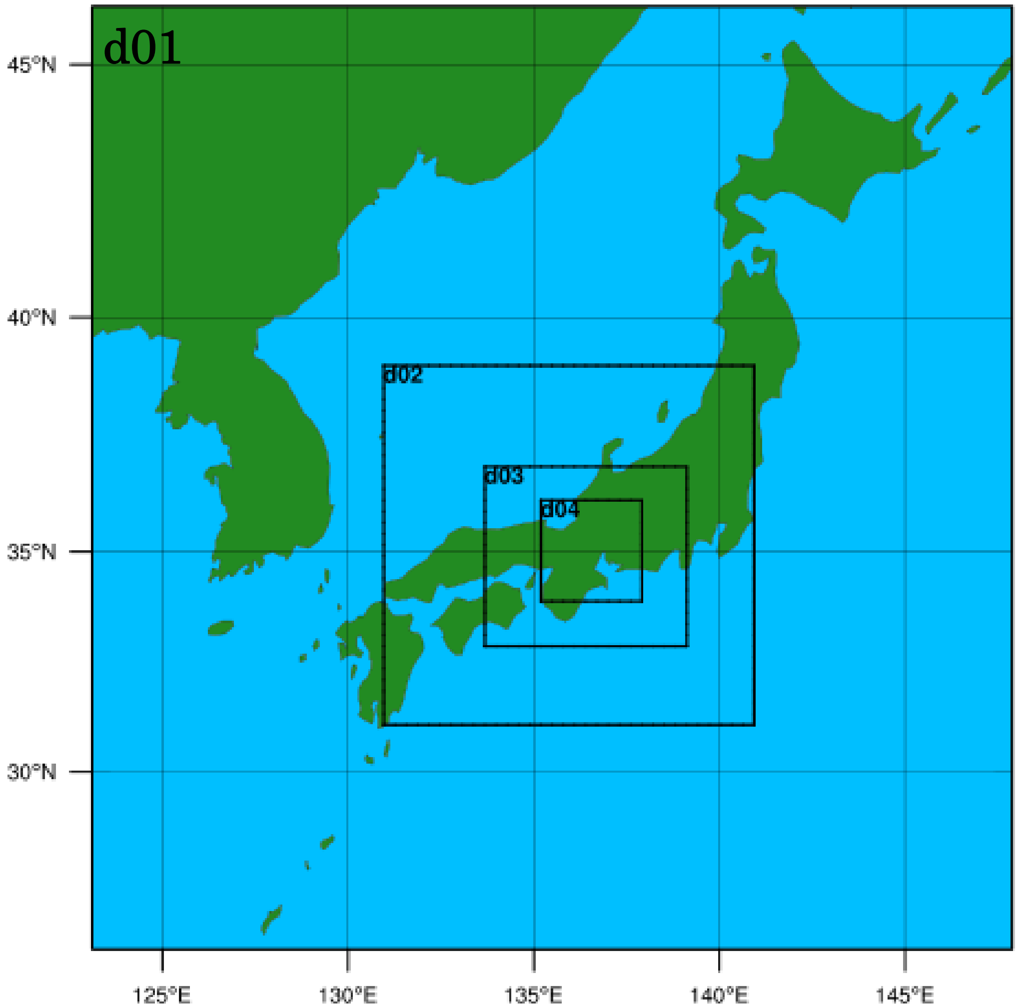


Fig. 1 Domains of regional meteorological model.

Table 1 Using parameters of regional meteorological model

	CTL_Run	SST_Run
Domain	4	4
Horizontal Resolution	27km,9km, 3km,1km	27km,9km, 3km,1km
Vertical Layers	27 Layers	27 Layers
Nesting	1way	1way
The initial and lateral boundary conditions	NCEP FNL data RTG_SST_HR	NCEP FNL data RTG_SST_HR (Only change SST of Ise Bay of domain 4)
Initial time	2005/11/30 12:00	2005/11/30 12:00
Microphysics	WDM6	WDM6
Cumulus Parameterization	Kain-Fritsch	Kain-Fritsch
Planetary Boundary Layer	MYNN2	MYNN2

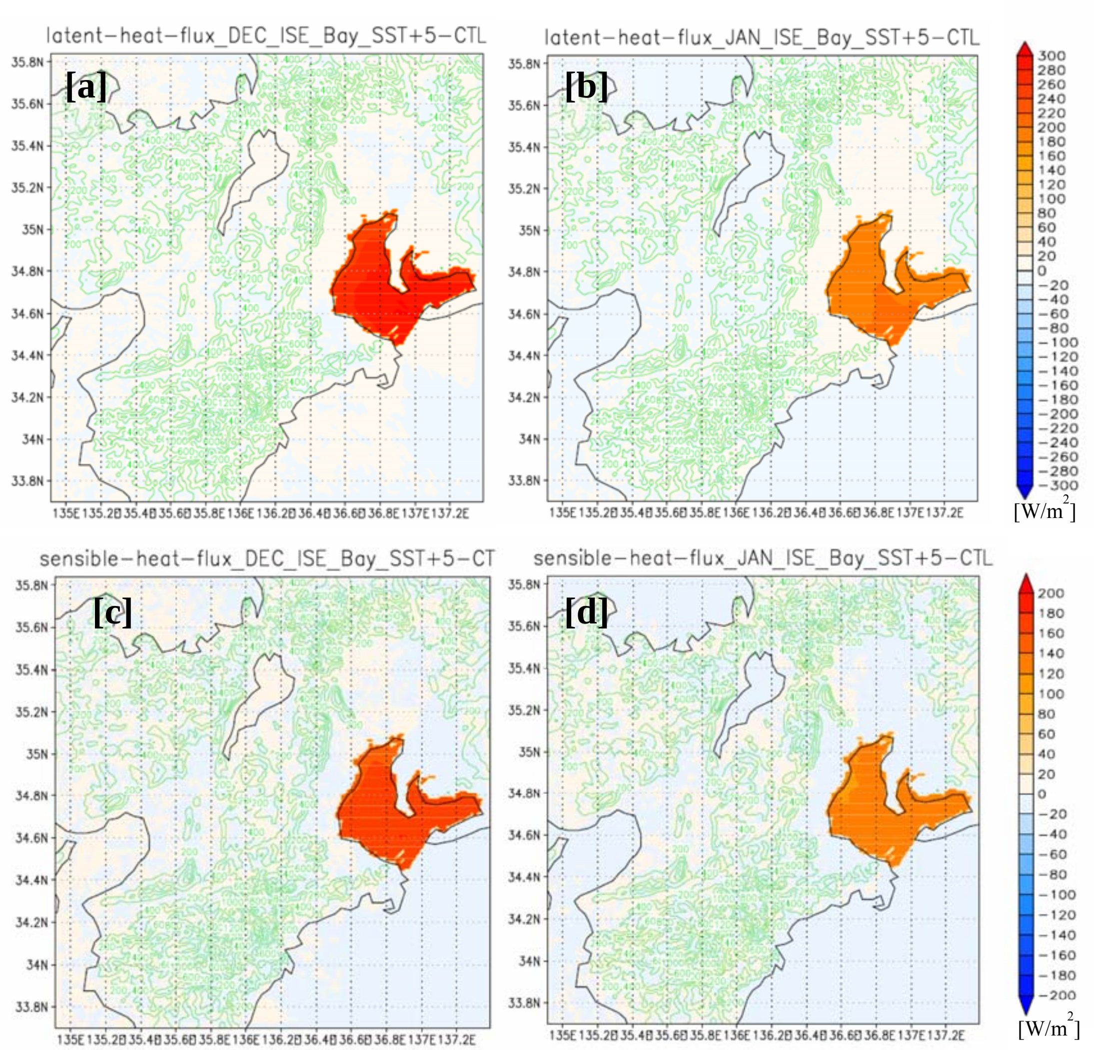


Fig. 2 Difference of CTL run and SST run upward latent heat (upper) and sensible heat (lower) flux in (a), (c) December and (b), (c) January.

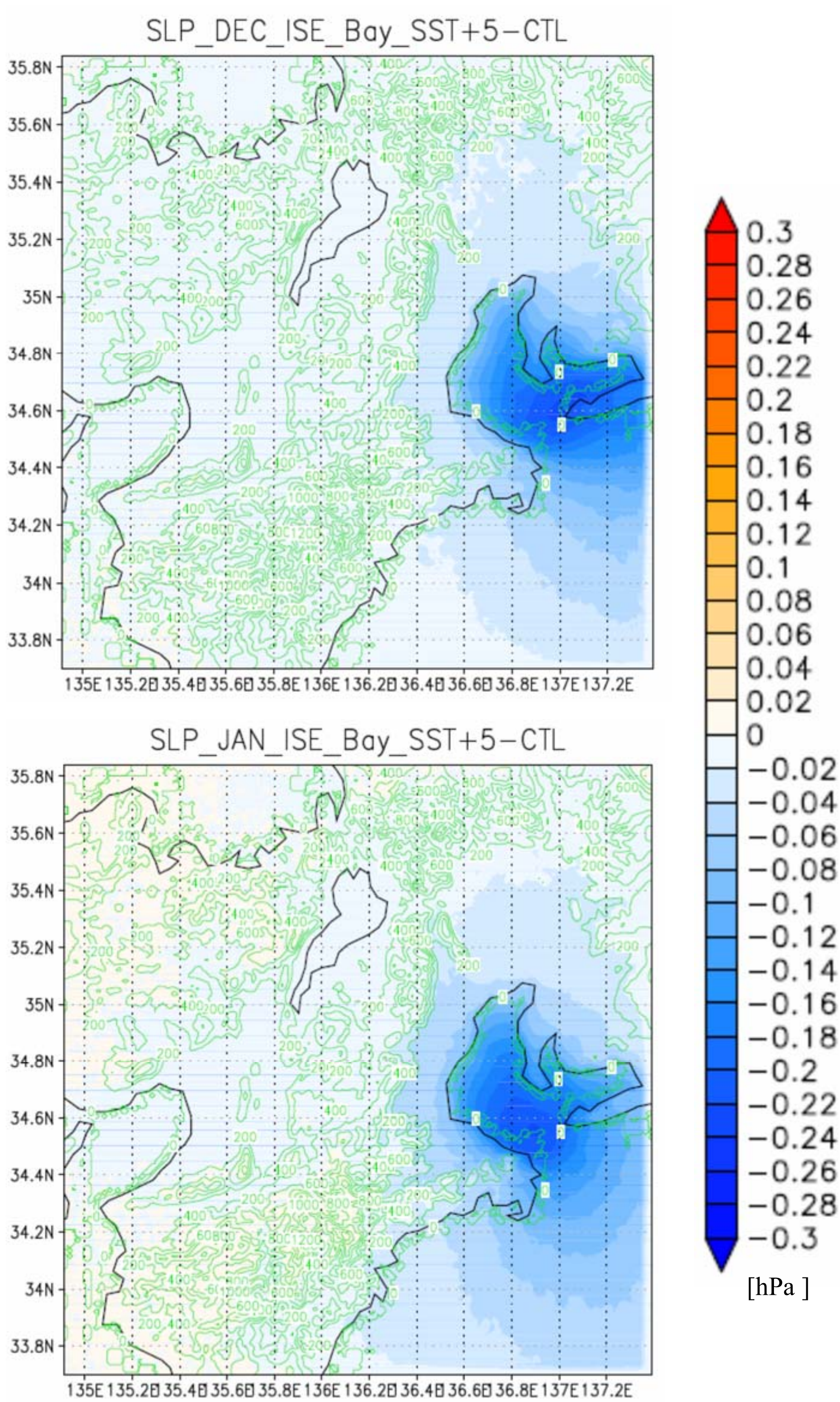


Fig. 3 Difference of CTL run and SST run SLP in December (upper) and January (lower).

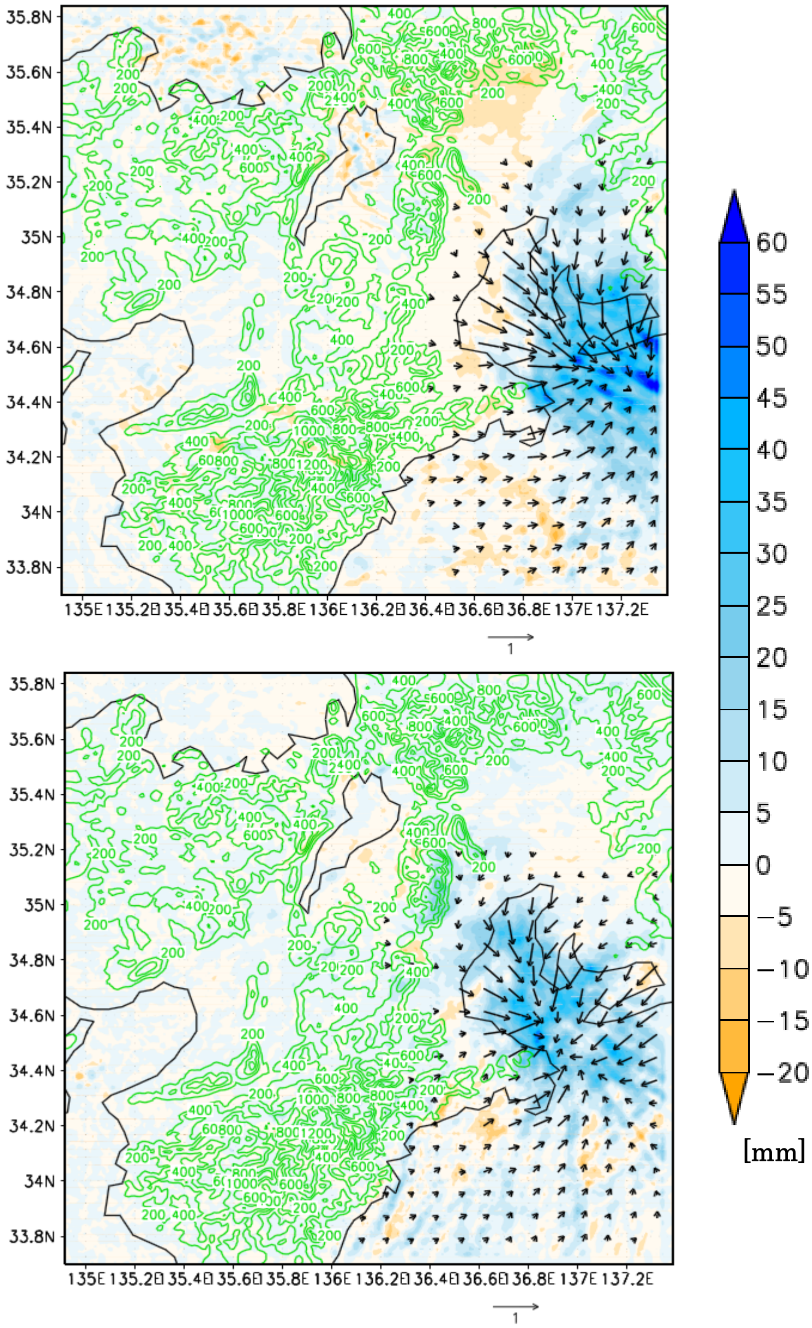


Fig. 4 Difference of the accumulated precipitation [mm] and wind between CTL run and SST run in December (upper) and January (lower). Shade indicates the accumulated precipitation and black arrows indicate wind speed and wind direction.

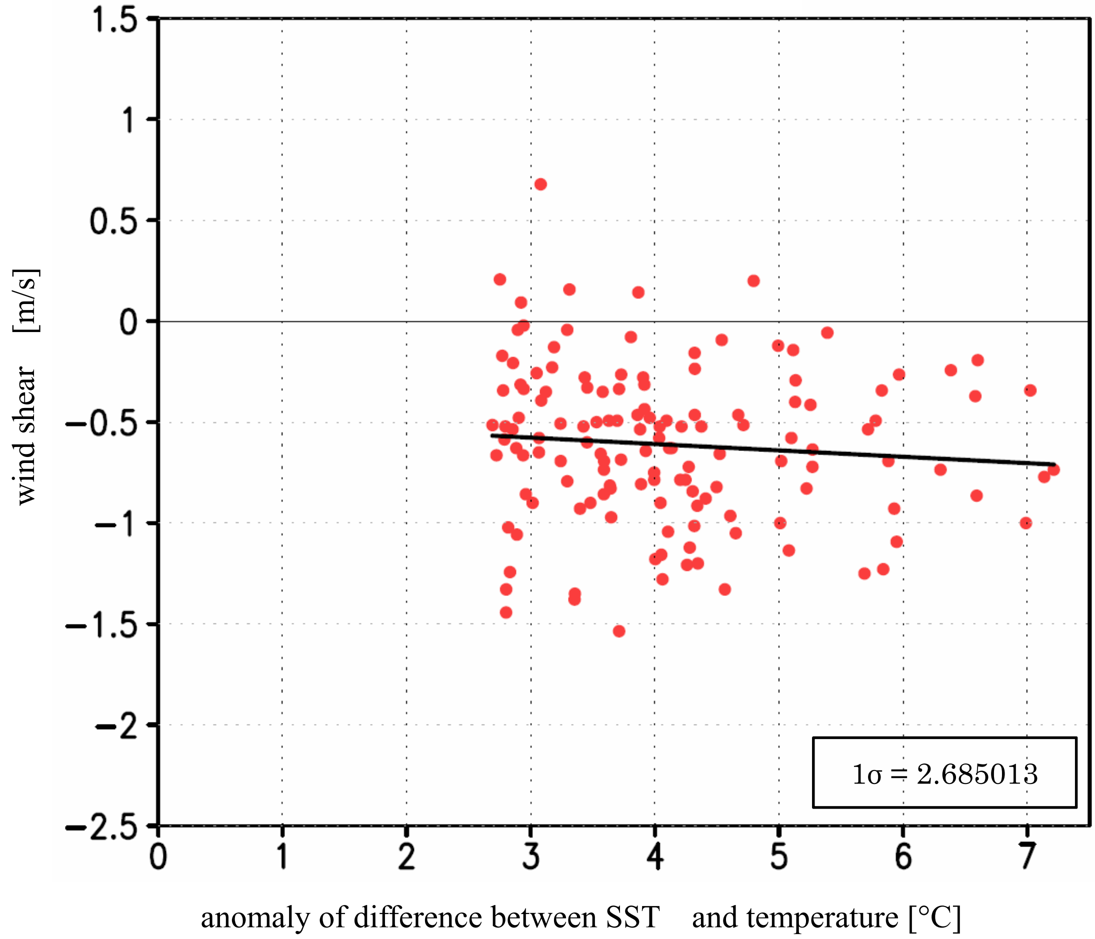


Fig. 5 Scatter diagram of anomaly of difference between SST in the Ise Bay and temperature and anomaly of SLP. The horizontal axis is anomaly of difference between SST in the Ise Bay and temperature, and the vertical axis is anomaly of SLP. Anomaly of difference between SST in the Ise Bay and temperature shows only over the 1σ. A straight line is regression line.

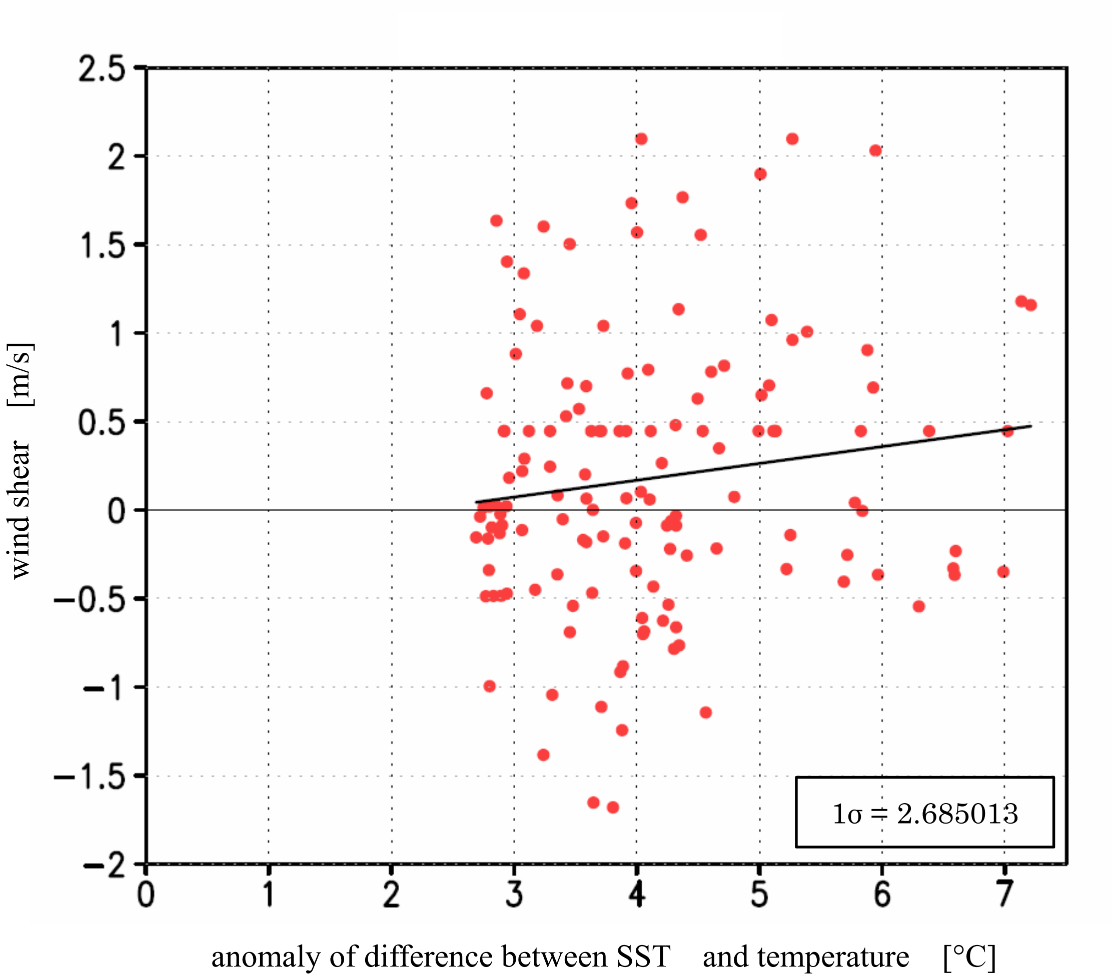
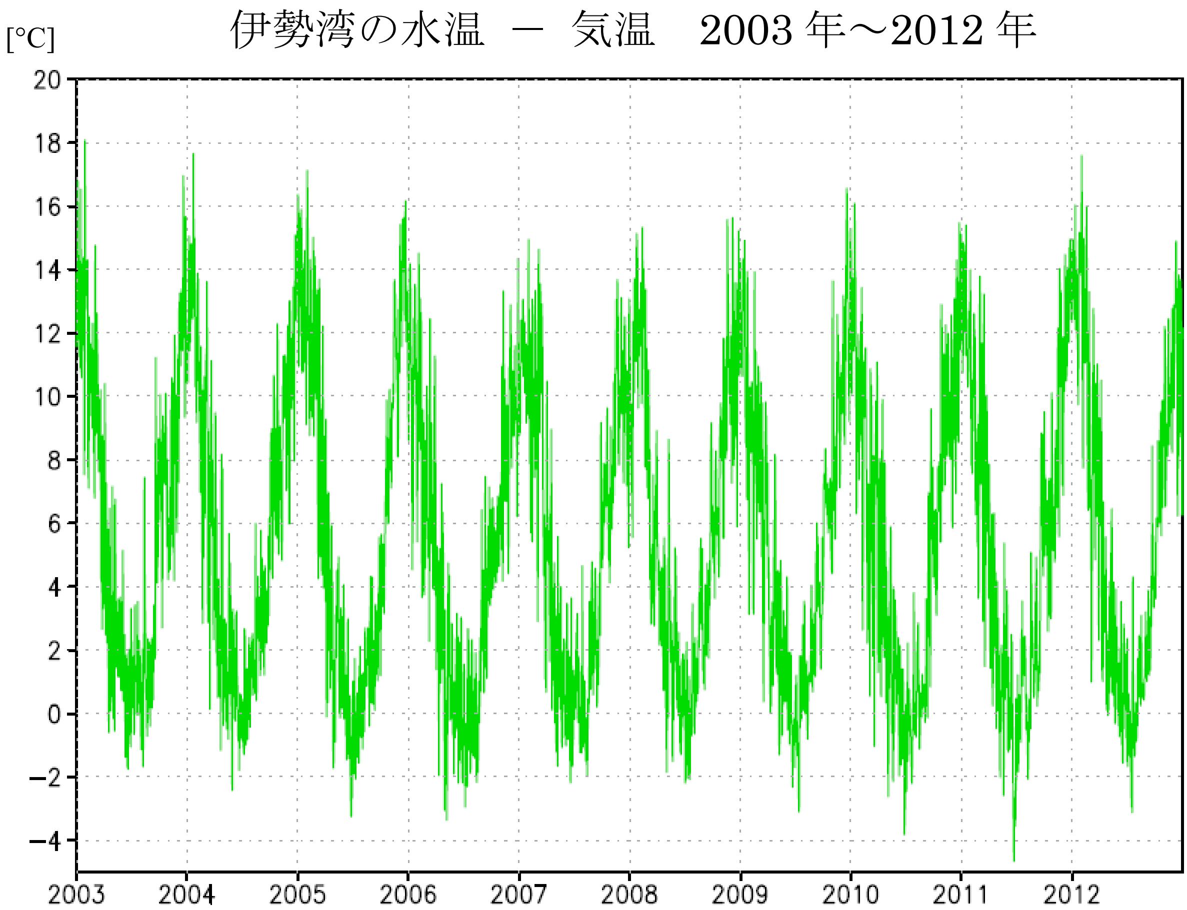
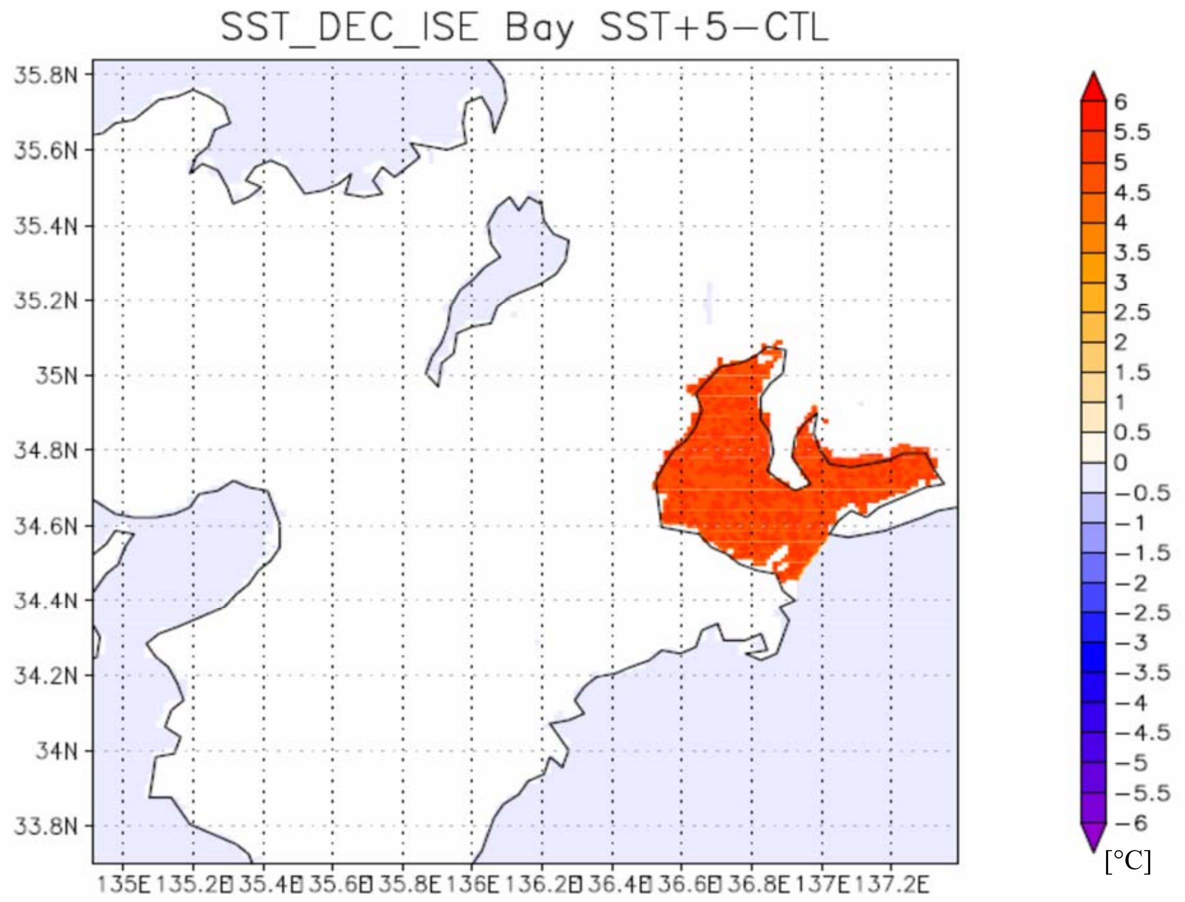


Fig. 6 Scatter diagram of anomaly of difference between SST in the Ise Bay and temperature and wind shear of north-south component. The horizontal axis is anomaly of difference between SST in the Ise Bay and temperature [°C], and the vertical axis is wind shear of north-south component [m/s]. Anomaly of difference between SST in the Ise Bay and temperature shows only over the 1σ. A straight line is regression line.

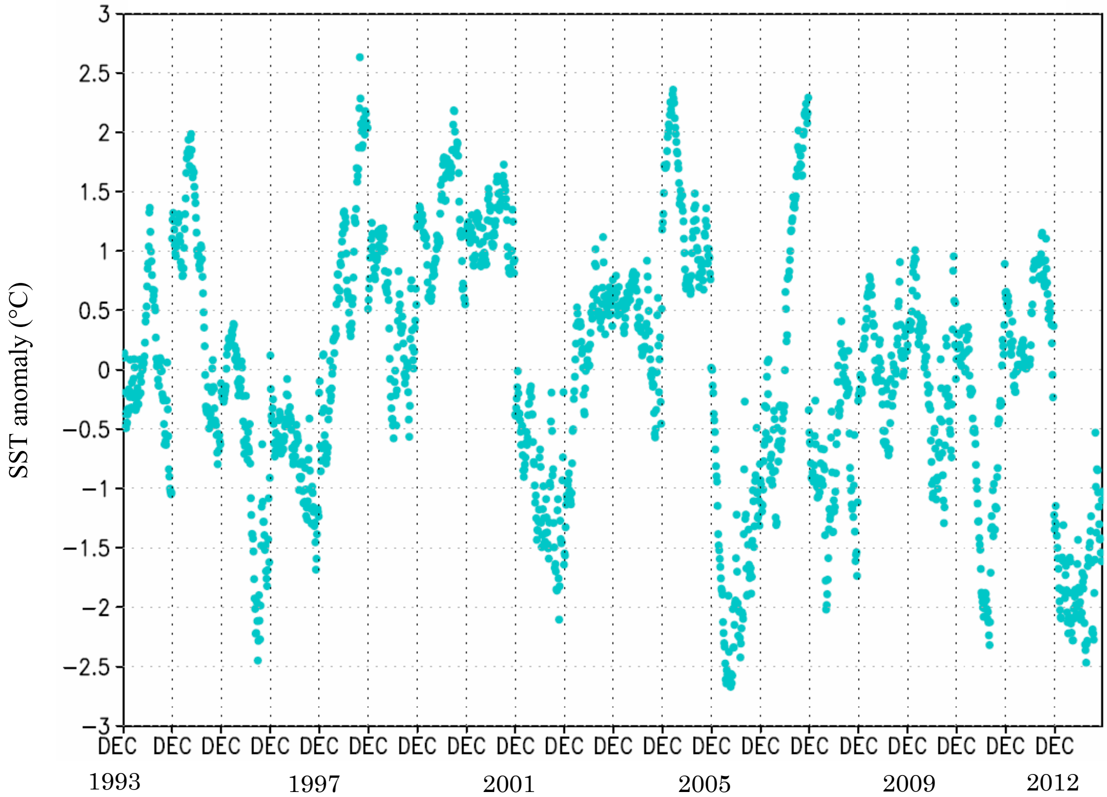
Appendix



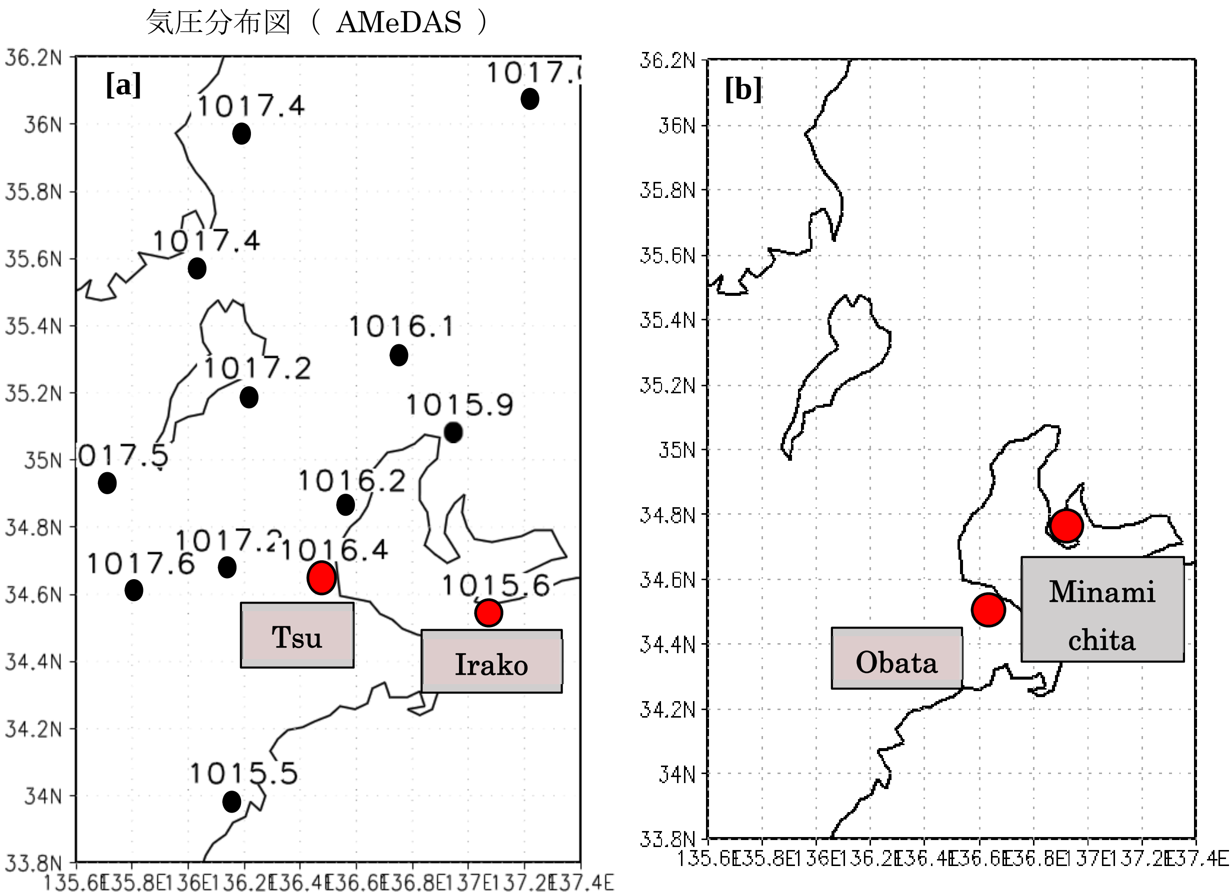
Appendix 1 Time series of difference of SST and air temperature.



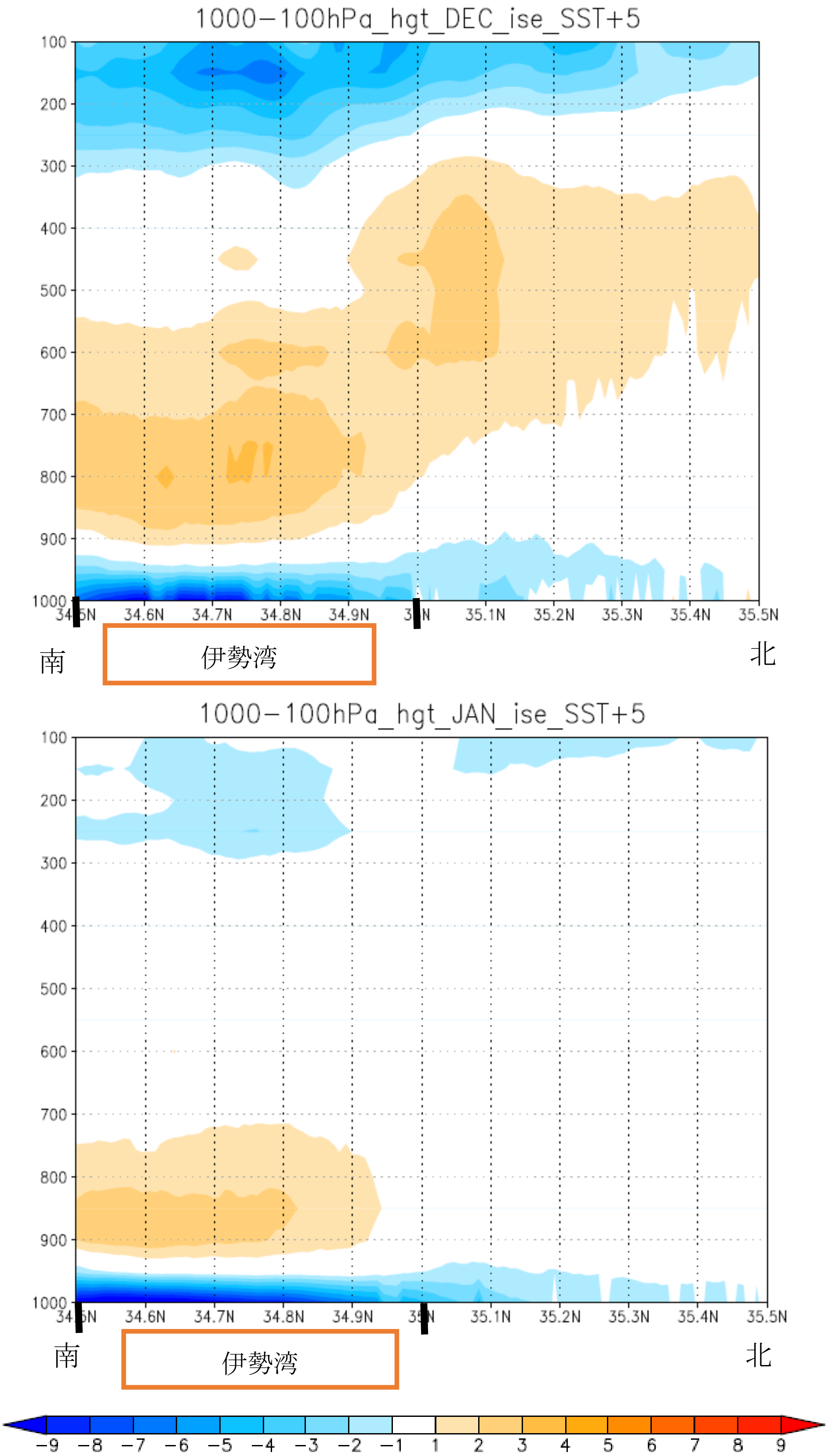
Appendix 2 Difference of CTL run and SST run SST.



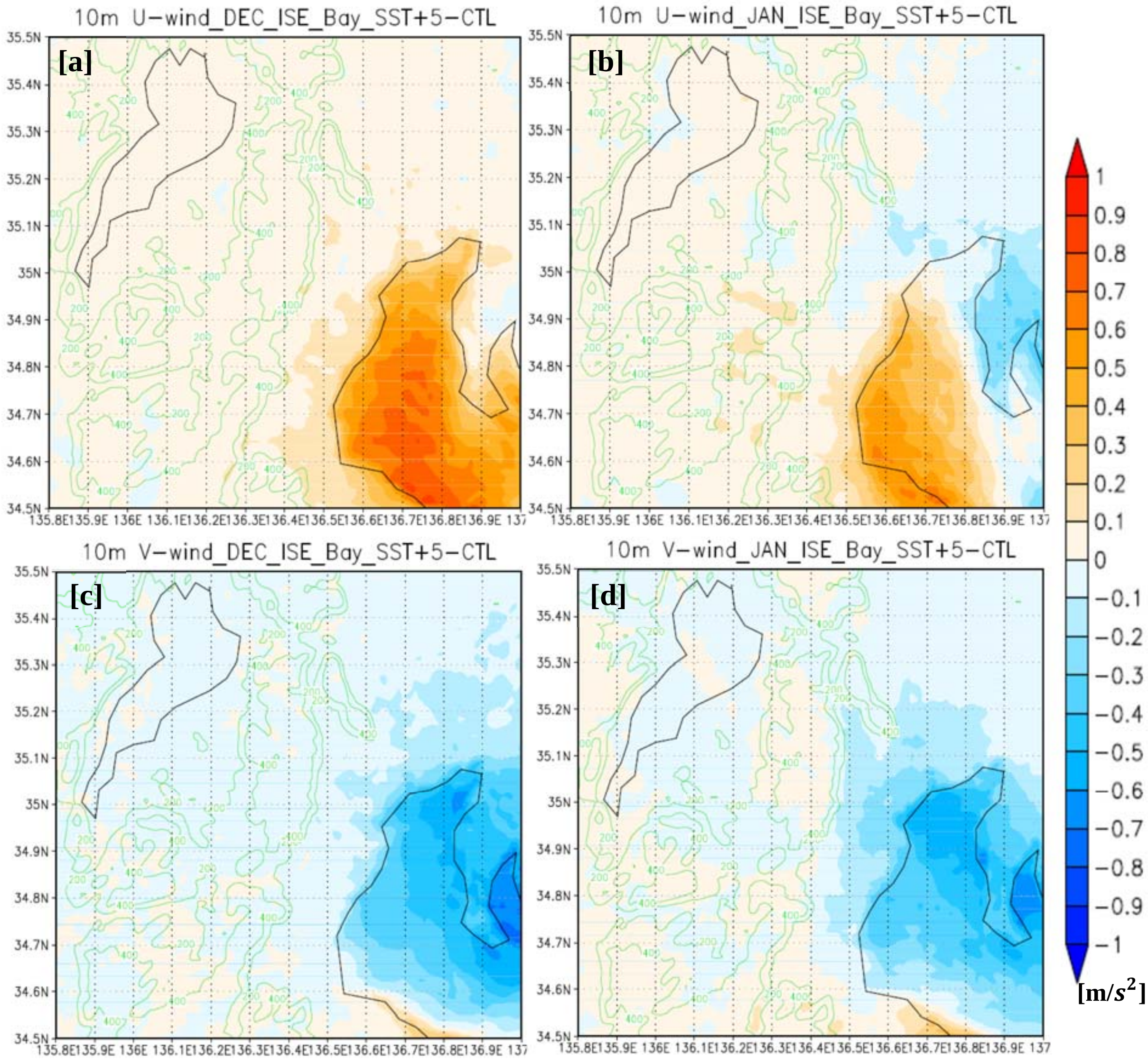
Appendix 3 Time series of anomaly of difference between SST in the Ise Bay and temperature.



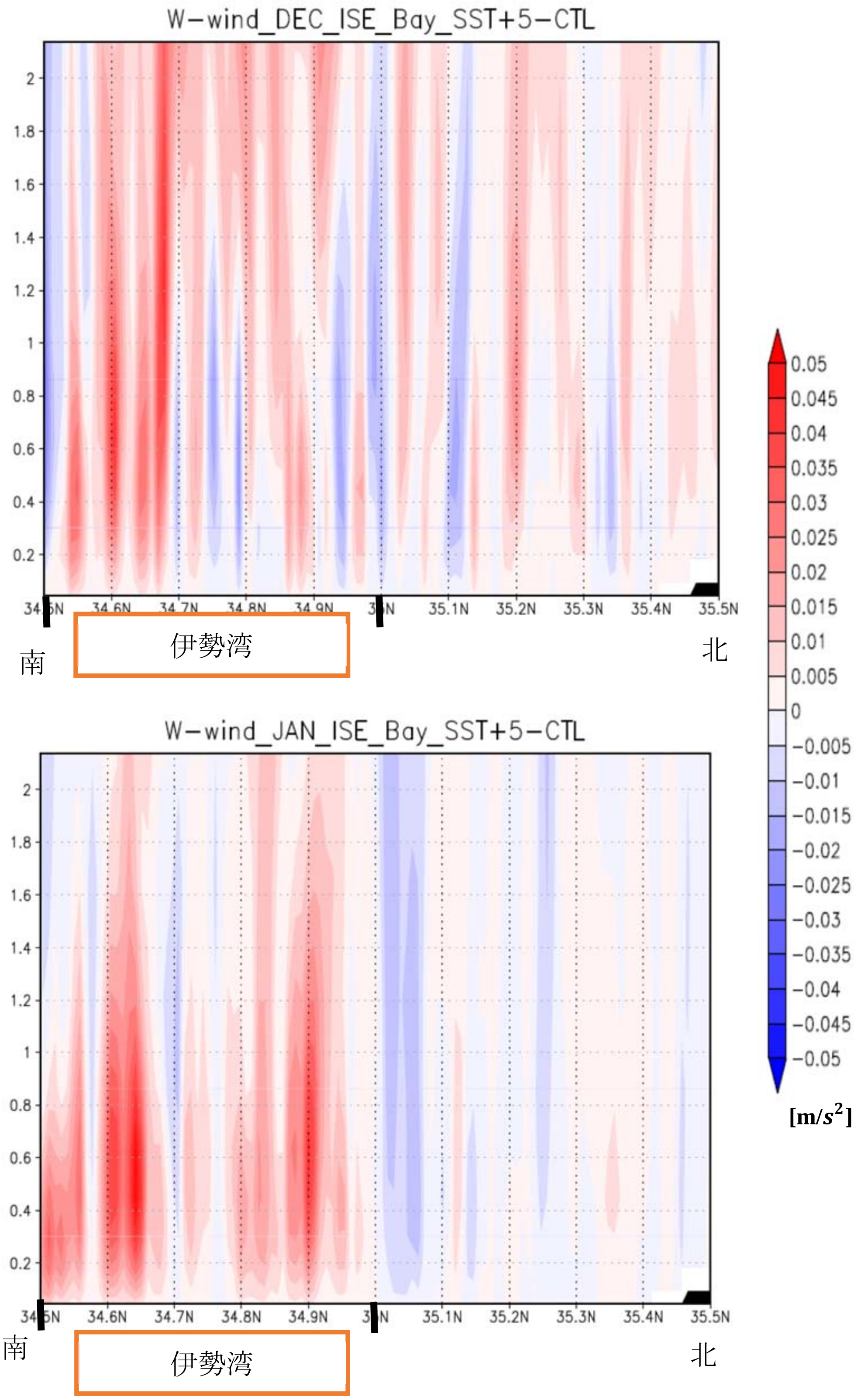
Appendix 4 Using observation station of AMeDAS. [a] using SLP data and [b] using wind data.



Appendix 5 Difference of CTL run and SST run the vertical and latitude of geopotential in (upper) December and (lower) January.



Appendix 6 Difference of CTL run and SST run the zonal (upper) and the meridional component (lower) of the wind in (a), (c) December and (b), (c) January.



Appendix 7 Difference of CTL run and SST run the vertical and latitude of vertical flow in (upper) December and (lower) January.