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Monthly Variation of Sea-Air Temperature Differences in the Korean Coast

HYO CHOI[1,2]* and YUAN HANG ZHANG[2]

[1]*Department of Atmospheric Environmental Sciences, Kangnung National University, Kangnung 210-702, Korea*
[2]*State Key Joint Laboratory of Environmental Simulation and Pollution Control, College of Environmental Sciences, Peking University, Beijing 100871, China*

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Monthly variations of sensible heat, latent heat and momentum fluxes and the modification of sea temperature to air temperature were examined at four coastal stations—Sokcho, Kangnung, Ulsan and Chungmu in the path of the East Korea Warm Current from the year of 1981 to 1990, which was one of main migration routes of Japanese common squid. The difference between monthly averaged sea surface and air temperatures at the 10 m height above the sea surface mainly became negative values from April through August, while they had positive ones from September through March. Monthly variability of the temperature differences is significant in both summer and winter, while it is generally small in spring and fall. Negative values of sensible heat fluxes, which indicated a heat gain by the sea through heat conduction across the air-sea interface were found at the four coastal stations from April to August. Minimum values of sensible heat fluxes at Sokcho, Kangnung and Chungmu were in June, except for Ulsan in August. To the contrary, positive sensible heat flux implying a heat loss from sea toward atmosphere occurred from October to February with a maximum in December. Latent heat fluxes due to condensation of moist air over sea surface had small magnitudes from April to August and those due to evaporation of water particles from the sea surface into the lower atmosphere had relatively large magnitudes from October to March. Minimum values of latent heat fluxes also occurred in June except for August in Ulsan. Momentum flux was small from June to August under weak wind in summer, but it was large from December to February under strong wind in winter. Regression equations between sea surface temperature and air temperature at the 10 m height above the sea surface had very high correlation coefficients from 0.92~0.98, except for 0.78~0.84 of Ulsan, which was partially affected by upwelling of cool water from the bottom into the sea surface. Similar to the sea surface, correlation coefficients were over 0.83~0.97 except for 0.70~0.79 for Ulsan at the 10 m depth of sea and were over 0.70~0.95 except for 0.59~0.82 for Ulsan at the 20 m depth.

Keywords:
· Sea temperature,
· air temperature,
· sensible heat flux,
· latent heat flux,
· momentum flux,
· regression equation,
· correlation.

1. Introduction

Through the computation of long-term monthly average values of the surface wind speed and the air-sea differences in temperature and humidity, Budyko (1963) evaluated heat fluxes by a simple bulk aerodynamic formula with a constant transfer coefficient for neutral condition in the surface layer. Further researches on air-sea exchanges of heat and water vapor on the sea surface have been undertaken by many authors (Garratt, 1977; Liu *et al.*, 1979; Steven and Reynolds, 1981; Bunker, 1988; Yamagata and Masumoto, 1989).

Knauss (1998) indicated that sensible and latent heat fluxes mainly combined with radiative fluxes to determine the net air-sea exchange on the ocean. Momentum transfer also play an important role in both wind driven ocean circulation and producing the changes of vertical structure of temperature and salinity in the upper ocean (Gill, 1982; Tso *et al.*, 1990; Choi, 1993; Choi *et al.*, 2000; Seung, 2002). Since Manabe (1957) described the modi-

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* Corresponding author. E-mail: du8392@hanmail.net

fication of air mass over the Sea of Japan (or called the East Sea§ of Korea) in the presence of outburst of cold water, Ninomiya (1972) and Kang (1985) explained heat and water budgets over Japan islands during the period of heavy snow storm and the effect of sea temperature on air temperature over the East Korea Warm Current (EKWC), respectively. However, their estimations on the heat budget remained largely uncertain, due to insufficient sampling data.

Kiyofuji and Saitoh (2003) insisted that Japanese common squid (*Todarodes pacificus*) fishing grounds were mainly found along the east coast of Korea between Cheju and Tsushima Islands, around Yamato Rise, along the coast of Honshu and in northern portions of the Japan/East Sea. From the spatial and temporal variabilities of the Japanese common squid fishing ground, it was verified that two migration routes such as northern migration and southern migration patterns existed. Namely, one of the northern migration patterns was formed along Honshu Island to north and another pattern was along the east coast of Korea (our study region), through Yamato bank to north. Southern migration pattern was almost vice verse of northern migration pattern. Sakurai (2002) and Shin *et al.* (2002) also explained that stock fluctuations for main fisheries species and common squid directly related to climate regime with monthly and seasonal variations of sea temperature shifted in the Japan/East Sea

Main purposes of this research are to investigate the variations of heat and momentum fluxes using monthly averaged meteorological and oceanographic data obtained in the eastern and southern coastal seas of Korea in the path of the EKWC and to predict migration periods of squid in the eastern coastal seas of Korea, revealing the relationship of sea temperatures from air temperatures in the upper ocean layer (from the surface to the 20 m depth of sea water).

2. Data

Meteorological and oceanographic data set of air and sea water temperatures, humidity and wind from 1981 to 1990 were analyzed for four coastal stations of Korea from 39.2°N to 34.6°N—Sokcho, Kangnung, Ulsan and Chungmu in the path of the East Korea Warm Current through the Korea Strait toward the East Sea of Korea, as one of main migration routes of squid. The eastern coastal seas are under the influences of both the East Korea Warm Current for whole year and the North Korea Cold Current (NKCC) extended toward Kangung coastal sea for only winter season, and the climate changes at coastal inland sites are largely associated with the characteristics of the adjacent seas, showing partially marine climate aspect (Fig. 1).

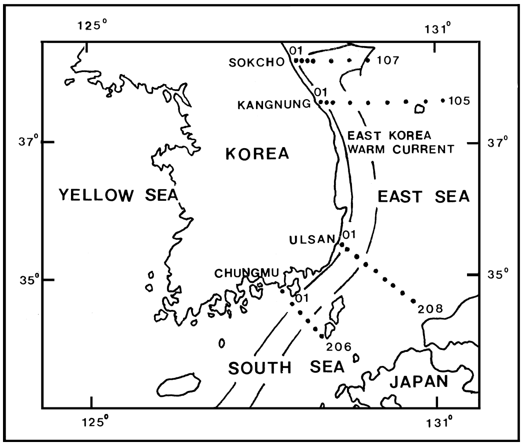

Fig. 1. Location of the serial oceanographic measurement lines and meteorological stations in the path of East Korea Warm Current.

The measured oceanographic variables were acquired every other month (February, April, June, August, October and December) at the closest point away from the coast on each serial oceanographic measurement line established by National Fisheries Research and Development Institute (NFRDI) (1982~1991) and the meteorological ones confined to the same months were obtained by coastal meteorological stations of Korea Meteorological Administration (KMA, 1982~1991). Since the four oceanographic stations are in the path of the EKWC through the Korea Strait and the East Sea of Korea, the closest oceanographic points such as 107-01, 105-01, 208-01 and 206-01, that is, just coast were chosen for investigating the association of sea and air temperatures in the coastal region.

In order to document the temporal variations of heat and momentum exchanges between air and sea in the marine atmospheric boundary layer of the eastern and southern coastal seas and to evaluate the effects which the atmosphere (or the coastal sea) has upon the characteristics of the eastern coastal sea (or the atmosphere) by the both cooling and heating between air and sea, surface heat and momentum fluxes have been sequentially calculated from Sokcho to Chungmu coastal stations.

3. Theoretical Background

According to Bunker (1988) the sensible heat flux is computed by the formula as

$$Q_s = \rho_a C_d C_p V_a (T_o - T_a) \tag{1}$$

where Q_s, ρ_a, C_d, C_p, V_a, T_o and T_a are the sensible heat flux, the air density (=1.2 kgm^{-3}), the drag coefficient for

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§ The Editor-in-Chief does not recommend the usage of the term "East Sea" in place of "Japan Sea".

momentum flux, the specific heat at constant pressure (=1004 $\mathrm{Jdeg^{-1}kg^{-1}}$), the surface wind at the 10 m height above the sea, the sea surface temperature and the air temperature at the 10 m height over the sea surface, respectively (Wallace and Hobbs, 1977).

The latent heat flux is obtained from

$$Q_e = \rho_a C_d L V_a [E_s(T_o) - HE(T_o)](0.622/P_a) \qquad (2)$$

where Q_e is the latent heat flux; L the latent heat (=2.49 × 106 $\mathrm{Jkg^{-1}}$); P_a the atmospheric pressure and H the relative humidity, based upon Yamagata and Masumoto (1989). Similarly, the evaluated monthly values of P_a at the four coastal sites under the influence of the almost same pressure of the high pressure system or the low pressure system passing through the Korean peninsula toward the East Sea of Korea and H near the coastal sea surface, through our coastal experiment were 1008 hPa and 0.8. The saturated vapor pressure E_s can be given by the following formula (Masumoto and Yamagata, 1988; Tso *et al.*, 1990);

$$E_s(T) = 10^{(9.405-(2353/T))}. \qquad (3)$$

As positive and negative temperature differences between air and sea exist from spring to winter, a linear regression method is adopted to estimate sea temperature from air temperature (vice verse) for two classifications of air temperature higher than sea surface temperature ($T_a > T_o$) and vice verse ($T_a < T_o$),

The momentum flux represented by the magnitude of the surface wind stress, τ is evaluated from the bulk aerodynamic equation (Liu *et al.*, 1979; Large and Pond, 1981, 1982; Philander *et al.*, 1987). Wind stress in the Cartesian coordinate, which influences sea surface current speed and direction by

$$\tau_x = \rho_a C_d |\boldsymbol{V}| u$$

$$\tau_y = \rho_a C_d |\boldsymbol{V}| v \qquad (4)$$

where τ, τ_x and τ_y, $\boldsymbol{V}$, u and v are wind stress $\{\tau = (\tau_x^2 + \tau_y^2)^{1/2}\}$, wind stress in the x and y directions, wind velocity $\{\boldsymbol{V} = (u^2 + v^2)^{1/2}\}$. As hourly wind speed without considering wind direction was used for the calculation of momentum flux, wind stress was evaluated using the formula of $\tau = \rho_a C_d \boldsymbol{V}^2$. As drag coefficient, C_d is a function of wind speed at 10 m height above the sea, sea surface temperature, T_o and air temperature, T_a at 10 m height over the sea, it varies by atmospheric stability such as unstable, neutral and stable conditions due to the temperature contrast between T_o and T_a. So its magnitude depends upon thermal distribution near sea surface for day or night and summer or winter.

Through the coastal experiment in the East Sea of Korea by Choi (1993), following formula with a function of wind speed and atmospheric stability based on the difference between T_o and T_a in the marine atmospheric boundary layer was suggested

$$C_d = \{1.0 + 0.06 \times \boldsymbol{V}/10(T_o - T_a)\} \times 10^{-3} \qquad (5)$$

and the values of C_d were in the range of 0.82×10^{-3}~1.19×10^{-3}, similarly to Garratt (1977) and Trenberth *et al.* (1990). He insisted, in general, greater value of drag coefficient in winter than in summer.

4. Results

Daily and monthly variations of air temperatures in the coastal region should be strongly affected by the sea surface temperature and the vertical structures of sea temperatures in the upper ocean layers, which are controlled by both short and long wave radiations during the day and night and intrusion of warm ocean current into the eastern coastal sea in summer and cold ocean current in winter (Fig. 2(a)). On the reverse, the sea surface temperature and vertical profile of sea temperature are also under the influence of the air. Due to the decrease of solar radiation and the southward extension of North Korea Cold Current along the eastern coasts, both monthly mean air and sea surface temperatures for the ten years at Sokcho, Kangnung, Ulsan and Chungmu in the southern and eastern coastal seas began to drop in September and decrease fast with the maximum cooling rates of –13.5°C and –6.8°C per month in December (KMA, 1982~1991; NFRDI, 1982~1991). It means that the maximum cooling rate of air near the sea surface was much greater than that of sea.

Under the increase of solar radiation and the intrusion of East Korea Warm Current in the eastern coastal seas, to the contrary, the air and sea surface temperatures also started to increase in April and had the maximum heating rates of 7.3°C and 5.8°C per month in August during the period of one year. However, the monthly variations of differences between sea surface and air temperatures were different from the monthly variations of each sea surface and air temperatures.

As shown in Fig. 2(a), the difference between sea surface and air temperatures (sea temperature–air temperature) depicted two peak points with a maximum value of 12.5°C in December and a minimum one of –4.6°C in June, except for July and August in Ulsan, whose coastal sea was in the cool water pool area due to upwelling of cool sea water from the bottom into the sea surface, with sea surface temperature relatively 2°C~3°C lower than outside area in July (NFRDI, 1982~1991). Seung (1974) explained a dynamic consideration on the temperature distribution in the east coast of Korea in August, show-

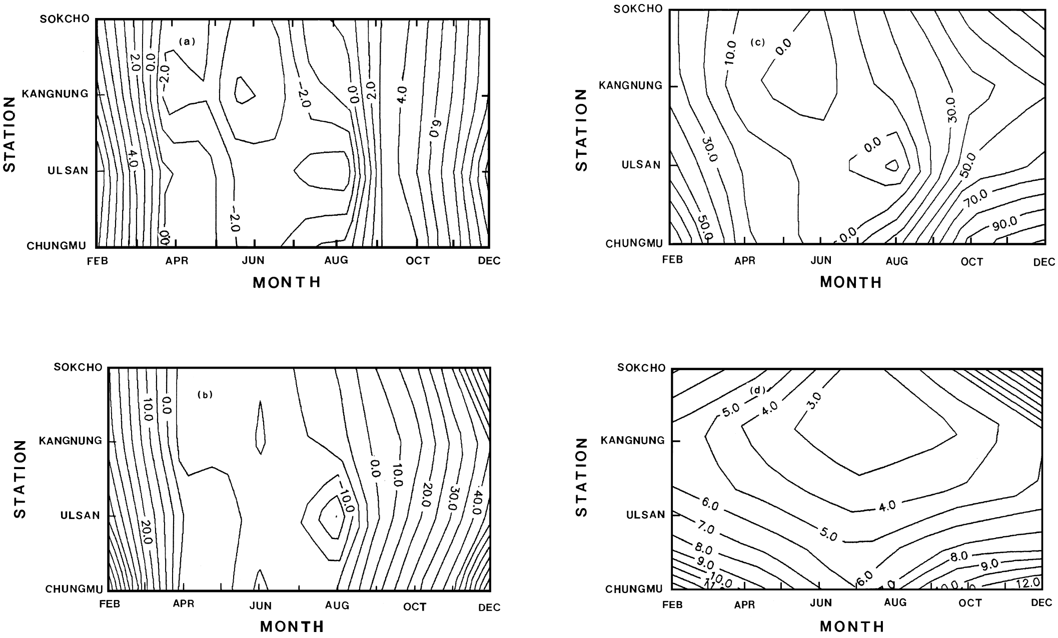

Fig. 2. (a) Monthly variation of sea surface and air temperature differences (°C) at the eastern and southern coastal stations of Korea in the path of the East Korea Warm Current, except for (b) sensible heat fluxes (Wm^{-2}), (c) latent heat fluxes (Wm^{-2}) and (d) momentum heat fluxes (Wm^{-2}).

ing the occurrence of cold water masses. Lee (1978) and Lee (1983) further investigated that cold water masses along the southeast coast of Korea near Ulsan coast frequently appeared during summer and the surface water temperature in this region were usually lower than those elsewhere. The appearance of cold water to the surface in the upwelling region concurred well with the periods of positive *y*-component wind like alongshore components of wind (southerly and southeasterly winds).

The differences between monthly averaged sea surface and air temperatures near the sea surface mainly became the negative values from April through August, which imply the higher air temperature than the sea surface, due to the increase of surface heat fluxes. On the other hand, they had positive values from September through March with the lower air temperature than the sea surface. Figure 2(b) shows the monthly averaged sensible heat fluxes for the ten years at Sokcho, Kangnung, Ulsan and Chungmu.

From April to August the magnitudes of sensible heat fluxes at all of four eastern and southern coastal sites ranged from –20.1 Wm^{-2} to –0.31 Wm^{-2}. The averaged minimum sensible heat fluxes were generally detected in June, except for August in Ulsan. Thus, from April to August the lower atmosphere near the sea surface could transfer the heat into the coastal sea. On the other hand, the sensible heat fluxes from September to March had positive values of 17 Wm^{-2} to 81 Wm^{-2}, showing the maximum value in December. It means that the coastal waters transferred sensible heat to the lower atmosphere during these months.

The modification of air temperature from the sea surface in winter is very important to maintain much higher air temperature in the eastern coastal region of Korea than that in the inland. For instance, the monthly mean temperature of Wonju city in the western inland 100 km away from Kangnung coast is generally 5°C lower in winter than that at Kangnung (KMA, 1982~1991). This is mainly due to the sensible heat transfer from the sea surface into the lower atmosphere in the coastal region under the influence of the EKWC, while at the station in the inland far away from the coast, air masses in the lower atmosphere are not influenced by the relatively warm sea water masses.

Similarly to the variations of sensible heat fluxes, the latent heat fluxes in the coastal sea were in the range of –12 Wm^{-2} to 34 Wm^{-2} from April to August, and 32 Wm^{-2} to 114 Wm^{-2} from September to March (Fig. 2(c)). The minimum values of latent heat fluxes occurred in June except for August in Ulsan as in the case of the sensible heat flux. The negative values of latent heat fluxes were observed in Sokcho, Kangnung and Ulsan. The general aspects of latent heat fluxes due to condensation of moist air over sea surface had small magnitudes from April to August and due to evaporation of water particles from sea surface into lower atmosphere had relatively large

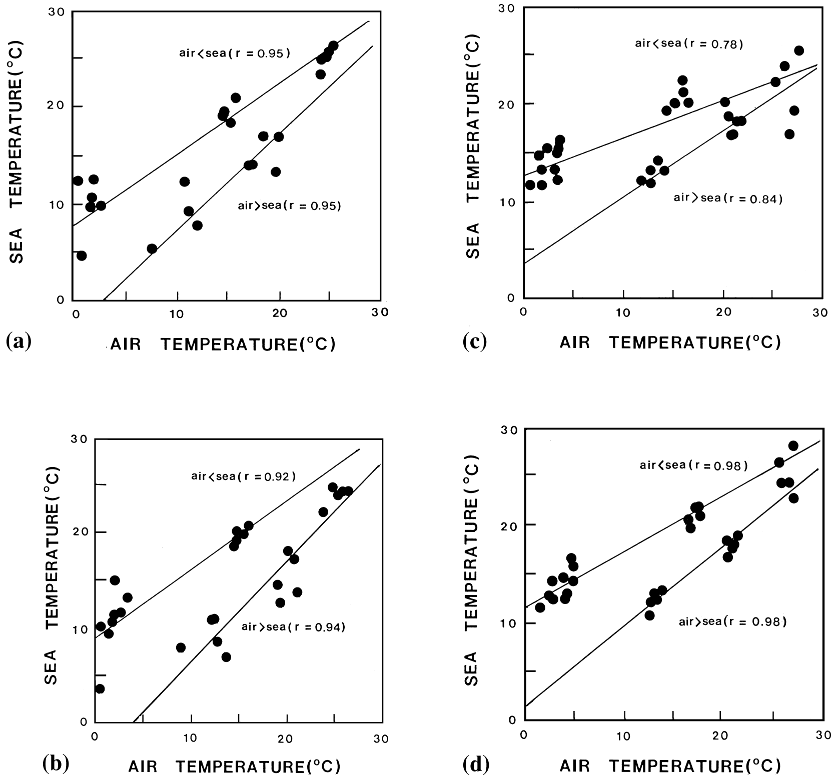

Fig. 3. (a) Relationship between monthly averaged sea surface temperatures and air temperature at the 10 m height above the sea surface in the Sokcho coastal sea (107-01), (b) the Kangnung (105-01), (c) the Ulsan (208-01) and (d) Chungmu (206-01) of Korea (1981~1990). $T_a > T_o$ (or $T_a \leq T_o$) means that air temperature is higher (lower) than sea temperature.

magnitudes from October to March.

Momentum flux called wind stress in the other word was evaluated at the same observation points of coastal seas. The magnitudes of momentum fluxes in December and February were almost three or four times as large as in June and August (Fig. 2(d)). The Asian winter monsoon with strong north-westerly winds during the cold air outbreak affects the formation of relatively strong wind fields in the eastern coastal regions of Korea (Choi, 1993). The strong wind makes a contribution to the cooling of air rather than sea and to the evaporation of water particles, to a great extent, enhancing the large difference of sea and air temperatures.

Consequently, even if an exact amount of quantity for the relationship between momentum flux and both sensible and latent heat fluxes could not be shown up in this study, the increase of sensible heat flux or latent heat flux has a similar tendency to that of momentum flux in spring and summer and vise versa in fall and winter. Sensible and latent heat fluxes should be large in the coastal regions along the path of the East Korea Warm Current, under the strong momentum fluxes over sea surface. Our coastal experiment showed the similar results conducted by Enriquez and Friehe (1984) through the California coastal experiment.

Table 1. Correlations of monthly mean sea surface temperature (*Y*) and air temperature over sea surface (*X*) in the eastern and southern coastal seas of Korea in the path of the East Korea Warm Current (1981~1990). T_a and T_o are air and sea temperatures, respectively.

Stations	Correlation coefficient	Regression equation
Sokcho	$r = 0.95\ (T_a > T_o)$	$Y = 0.99X - 2.80$
	$r = 0.95\ (T_a < T_o)$	$Y = 0.72X + 7.84$
Kangnung	$r = 0.94\ (T_a > T_o)$	$Y = 1.07X - 4.31$
	$r = 0.92\ (T_a < T_o)$	$Y = 0.73X + 8.94$
Ulsan	$r = 0.84\ (T_a > T_o)$	$Y = 0.68X + 3.67$
	$r = 0.78\ (T_a < T_o)$	$Y = 0.39X + 12.59$
Chungmu	$r = 0.98\ (T_a > T_o)$	$Y = 0.84X + 1.25$
	$r = 0.98\ (T_a < T_o)$	$Y = 0.58X + 11.38$

In order to investigate the relationship between air temperature at the height of 10 m above the sea surface and sea temperatures from the surface to the 20 m depth of sea water the regression lines were evaluated on the air temperature to the sea temperature at the surface, the 10 m and 20 m depths of coastal waters, respectively. At

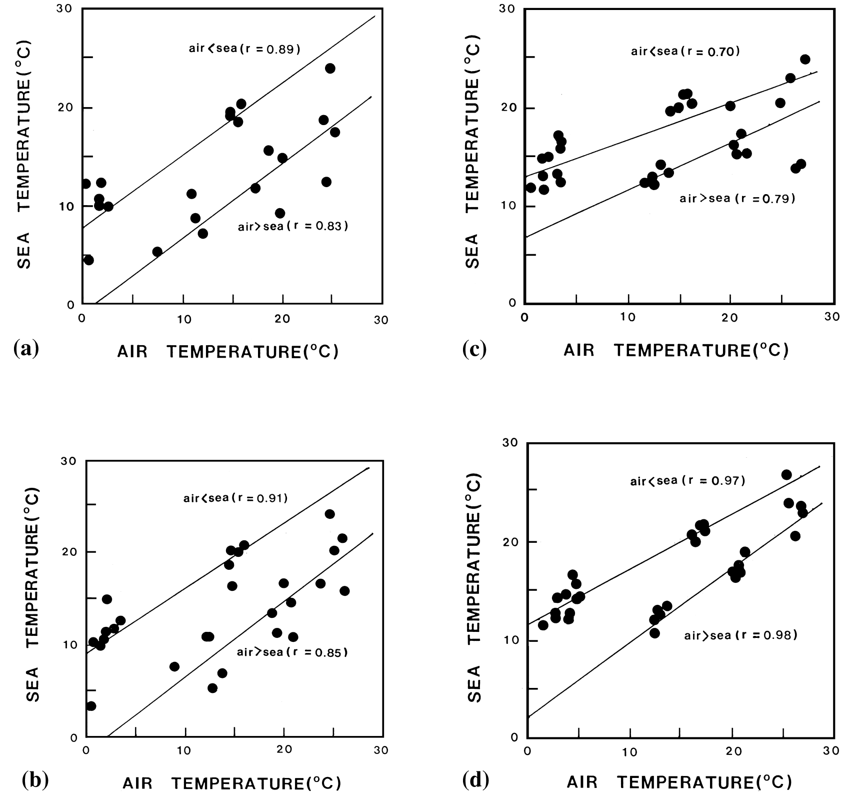

Fig. 4. (a) As shown in Fig. 3 except for the 10 m depth and air temperature at the 10 m height above the sea surface in the Sokcho coastal sea (107-01), (b) the Kangnung (105-01), (c) the Ulsan (208-01) and (d) Chungmu (206-01) of Korea (1981~1990). $T_a > T_o$ (or $T_a \le T_o$) means that air temperature is higher (lower) than sea temperature.

the Sokcho coast, the correlation coefficients between sea surface and air temperature were 0.95, when the air temperature was higher than the sea temperature ($T_a > T_o$) and also 0.95, when the air temperature was lower than the sea temperature ($T_a < T_o$) (Table 1 and Fig. 3(a)). The correlation coefficients were 0.94 ($T_a > T_o$) and 0.92 ($T_a < T_o$) at the Kangnung, 0.84 ($T_a > T_o$) and 0.78 ($T_a < T_o$) at the Ulsan, and 0.98 ($T_a > T_o$) and 0.98 ($T_a < T_o$) at the Chungmu, respectively (Figs. 3(b), (c) and (d)).

Thus, sea temperature at whole stations was highly correlated to air temperature, but the correlation coefficient at Ulsan station was relatively lower than other three stations. It has generally been reported that upwelling phenomena were detected in the Ulsan coastal sea under the influence of southerly alongshore wind bound for north in the summer season. Relative low correlation between them may be mainly due to the formation of cool pool of waters uplifted from the bottom into the sea surface, with sea surface temperature relatively lower than outside area, like open sea of the East Sea (Lee, 1983).

Table 2. Correlations of monthly mean sea temperature at the 10 m depth (Y) and air temperature over sea surface (X) in the eastern and southern coastal seas of Korea in the path of the East Korea Warm Current (1981~1990). T_a and T_o are air and sea temperatures, respectively.

Stations	Correlation coefficient	Regression equation
Sokcho	$r = 0.83$ ($T_a > T_o$)	$Y = 0.75X - 0.89$
	$r = 0.89$ ($T_a < T_o$)	$Y = 0.73X + 7.69$
Kangnung	$r = 0.85$ ($T_a > T_o$)	$Y = 0.80X - 1.52$
	$r = 0.91$ ($T_a < T_o$)	$Y = 0.70X + 8.85$
Ulsan	$r = 0.79$ ($T_a > T_o$)	$Y = 0.47X + 6.81$
	$r = 0.70$ ($T_a < T_o$)	$Y = 0.37X + 12.79$
Chungmu	$r = 0.98$ ($T_a > T_o$)	$Y = 0.75X + 2.21$
	$r = 0.97$ ($T_a < T_o$)	$Y = 0.57X + 11.47$

On the air temperature to the sea temperature at the 10 m depth of the coastal sea the correlation coefficients were 0.83 ($T_a > T_o$) and 0.89 ($T_a < T_o$) at the Sochok coastal station, 0.85 ($T_a > T_o$) and 0.92 ($T_a < T_o$) at the Kangnung, 0.79 ($T_a > T_o$) and 0.70 ($T_a < T_o$) at the Ulsan, and 0.97 ($T_a > T_o$) and 0.97 ($T_a < T_o$) at the Chungmu (Table 2, Figs. 4(a), (b), (c) and (d)). Here, at the Chungmu coast in the southern sea of Korea, correlation coefficient between sea temperature and air temperature is still very

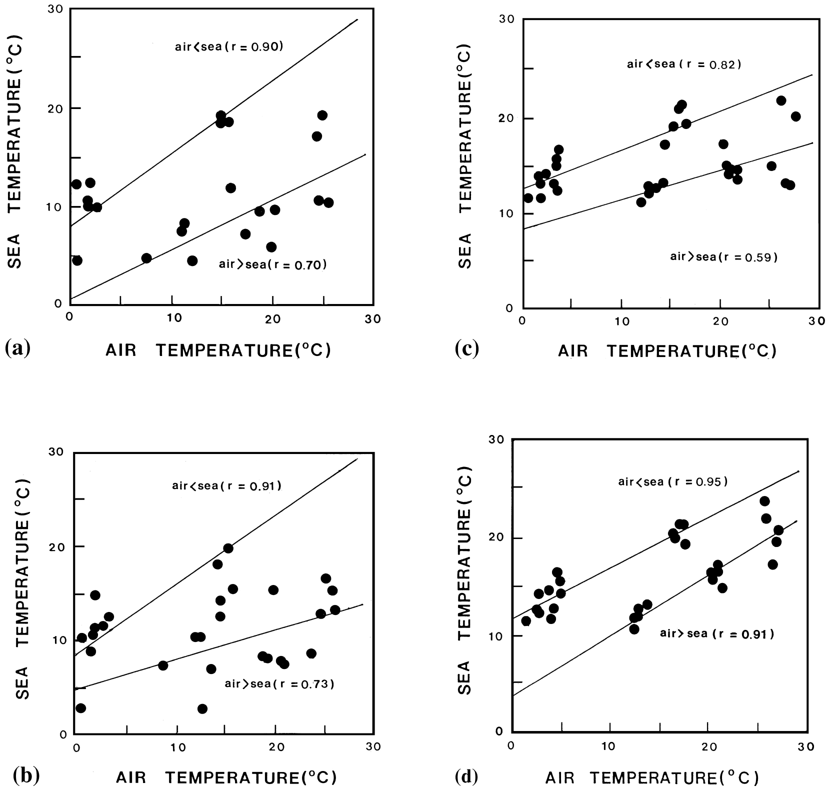

Fig. 5. (a) As shown in Fig. 3 except for the 20 m depth and air temperature at the 10 m height above the sea surface in the Sokcho coastal sea (107-01), (b) the Kangnung (105-01), (c) the Ulsan (208-01) and (d) the Chungmu (206-01) of Korea (1981~1990). $T_a > T_o$ (or $T_a \le T_o$) means that air temperature is higher (lower) than sea temperature.

high and the sea temperature directly affected the air temperature. On the other hand, at the Ulsan coast in the East Sea of Korea the correlation between sea temperature and air temperature became worse than that at the surface.

In the same regression technique the correlation coefficients at the 20 m depth were evaluated with the magnitudes of 0.70 ($T_a > T_o$) and ($T_a < T_o$) at the Sokcho coast, 0.73 ($T_a > T_o$) and 0.91 ($T_a < T_o$) the Kangnung, 0.59 ($T_a > T_o$) and 0.82 ($T_a < T_o$) at the Ulsan, and 0.91 ($T_a > T_o$) and 0.95 ($T_a < T_o$) at the Chungmu (Table 3, Figs. 5(a), (b), (c) and (d)). Sea temperatures from the sea surface to the 20 m depth of the coastal seas were highly correlated to the air temperature with correlation coefficients of 0.70~0.98 except for Ulsan at 20 m depth. In the eastern and southern coastal seas in the path of the East Korea Warm Current, there were good correlations at the sea surface, 10 m and 20 m depths of waters expect the case at 20 m depth for Ulsan, respectively. In July, there were the occurrences of cold water masses near the sea surface induced by the upwelling phenomena in the coastal sea of Ulsan.

Even if there is the strongest solar heating of the year on waters of the Ulsan coastal sea, it is expected that the sea water masses could not be sufficiently heated by the solar radiation due to the inflow of cold water masses from the bottom layer to the sea surface. Thus, the correlation coefficients of the air to the sea temperatures could be much lower in Ulsan than in any other stations (Tables 1, 2 and 3).

Table 3. Correlations of monthly mean sea temperature at the 20 m depth (Y) and air temperature over sea surface (X) in the eastern and southern coastal seas of Korea in the path of the East Korea Warm Current (1981~1990). T_a and T_o are air and sea temperatures.

Stations	Correlation coefficient	Regression equation
Sokcho	$r = 0.70\ (T_a > T_o)$	$Y = 0.52X + 0.53$
	$r = 0.90\ (T_a < T_o)$	$Y = 0.76X + 7.78$
Kangnung	$r = 0.73\ (T_a > T_o)$	$Y = 0.31X + 5.08$
	$r = 0.91\ (T_a < T_o)$	$Y = 0.70X + 8.85$
Ulsan	$r = 0.59\ (T_a > T_o)$	$Y = 0.32X + 8.22$
	$r = 0.82\ (T_a < T_o)$	$Y = 0.41X + 12.52$
Chungmu	$r = 0.91\ (T_a > T_o)$	$Y = 0.64X + 3.56$
	$r = 0.95\ (T_a < T_o)$	$Y = 0.53X + 11.60$

In winter, air temperature was greatly influenced by warm water in the coastal region such as Kangnung city in the path of the East Korea Warm Current and due to the exchanges of heat fluxes between cold air and warm sea, it was much higher in Kangnung coastal city than Wonju city in the western inland. To the contrary, the air temperature over the coastal sea becomes relatively lower than that over the inland in summer.

5. Conclusions

From analyzing monthly meteorological and oceanographic data for ten years at four coastal stations in the path of the East Korea Warm Current passing, sensible heat fluxes from April to August had negative values with a minimum magnitude in June except for August in Ulsan, which means the heat gain by the sea resulted from heat conduction across the air-sea interface. Positive values from October to February with a maximum in December mean the heat loss by the sea.

The magnitudes of latent heat fluxes decrease from April to August, but increase from October to February. Latent heat fluxes in the coastal seas due to condensation in summer and evaporation in winter showed similar tendencies of monthly variations of sensible heat fluxes, with partial disagreement. The distributions of monthly average momentum fluxes showed very small magnitudes from June to August, but large magnitudes from December to February. It seems that the momentum fluxes depended upon wind speed and atmospheric stability with a function of wind stress, air and sea temperatures over the sea surface can affect the variations of sensible and latent heat fluxes in the lower atmosphere of the study area. The prediction of sea temperature is very significant to understand both migration route and catching period of squid in the East Sea. During the period of coastal investigation, sea temperatures from the sea surface to the depth of 20 m in the coastal seas were highly correlated to the air temperature with high correlation coefficients and the devised formula in this study could be useful to determine fishing time and place on squid.

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