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Relation between the Sea Surface Temperature and the Coastal Climate in Korea

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The oceanic effect on the coastal climate, the air temperature and the humidity, in Korea was studied by using the meteorological and the sea surface temperature data compiled from 1962 to 1981.

The fluctuation of sea surface temperature plays an important role in determining the air temperature and the humidity in the coastal area. The sea surface temperature is higher than the air temperature from September to March in the western coastal area, and from September to April in the southern and the eastern coastal areas. It is found that in March the air temperature begins to surpass the sea surface temperature in the western coastal area, and in April in the southern and the eastern coastal areas. On the basis of the multiple regression analysis it is found that the oceanic effect on the coastal climate, the air temperature and the humidity, in the western coastal area is different that in the southern and the eastern coastal areas.

Introduction

The northward warm current, the Kuroshio, in the Western Pacific Ocean splits into two branches in the East China Sea near Japan. One branch flows along the Pacific coasts of the Japan Islands toward east as the main Kuroshio and the other branch, the Tsushima Warm Current, penetrates into the East Sea. Also, the Yellow Sea Warm Current in the South Sea of Jeju Island flows into the Yellow Sea.

There are four major air masses, the North Pacific, the Siberia, the Yangtze, the Okhotsk air masses in the vicinity of the Korean peninsula. Especially among them, the dry and cold polar continental air mass (Siberia air mass) and the moist and warm tropical maritime air mass (North Pacific air mass) act as the monsoon over the surface of the adjacent seas of Korea. Accordingly, the strong heat exchange between the air and the sea produces a remarkable air mass transformation.

It has been well known that the ocean has a great influence on the coastal climate through the air-sea heat exchange. However, it is difficult to evaluate the interaction between the air and sea quantitatively. Sverdrup(1937, 1951) made studies on the evaporation from the ocean, Jacobs (1942, 1951) also studied on the energy transformation over the oceans, and Laevastu(1960) summarized previons studies and offered the detailed description on the factors affecting the sea temperature. Paulson, Leavitt and Fleagle(1972), Stegan(1973) and Ling and Kao(1976) carried out some model experiments through the direct ocean observation. Wyrtki(1966) computed and discussed the variation of the monthly heat budget in the North Pacific Ocean. Manabe(1957, 1958), Matsumoto and Ninomiya(1966), Ninomiya(1972) calculated the sensible heat and evaporation, and discussed the transformation of the air mass overlying the Japan Sea. Han(1972), Han and Chang (1978) made quantitative analyses of the heat budget in the adjacent seas of Korea.

The Korean Peninsula is surrounded by the seas and its coastal climate is affected by the fluctuation of sea condition. In this study, the relationship between the coastal climate and the sea surface temperature will be investigated based on the meteorological and the sea surface temperature data.

Data and Method

The locations of meteorological stations and light houses used in the present study are presented in Fig. 1. Air temperature and humidity data were taken from the monthly reports of the standard meteorological stations at the inland and coastal areas, and the sea surface temperature data were collected from the observations at the lighthouses. All data were compiled from 1962 to 1981. The monthly mean temperature and humidity were computed and examined.

The differences of temperature and humidity between the coastal and inland areas, and the differences of temperature between the coastal area and the light house were obtained on the basis of the bulk aerodynamic formulas: $Q=K_1(T_w-T_a)W$ and $E=K_2(e_w-e_a)W$, where Q denotes the sensible heat, E evaporation, K_1, K_2 numerical constant, W wind speed, T_a the air temperature at the deck height, T_w the sea surface temperature, e_a and e_w the vapor pressures of the air at the deck height and at sea surface, respectively.

The multiple regression analysis was performed in order to study the relationship between the coastal climate and the sea surface temperature. The accuracy of the multiple regression analysis is evaluated by computing the coefficient of determination and the coefficient of multiple correlation.

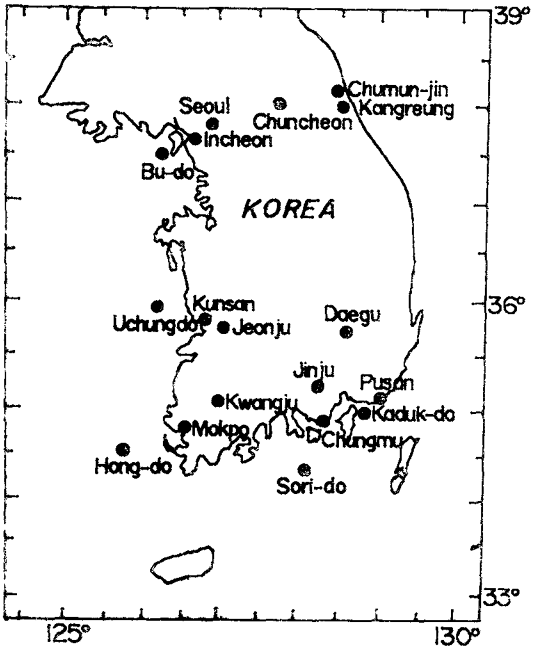

Fig. 1. Location of the stations in the study area

Results and Discussion

1. Temperature

The annual variations of the mean air and sea surface temperature were obtained like Fig. 2. What is evident from the figure is that the air temperature in the coastal area is higher than that in the inland area when the sea surface temperature is higher than the air temperature in the coastal area. Also, the annual range of temperature in the coastal area is smaller than that in the inland area. This may be explained by the fact that the fluctuation of sea surface temperature significantly influences the coastal climate.

As seen in Fig. 2, the sea surface temperature is higher than the air temperature from September to March(about 6 months) in the western coastal area, meanwhile, from September to April(about 5 months) in the southern and eastern coastal areas. As mentioned above, the air temperature in the western coastal area begins to surpass the sea surface

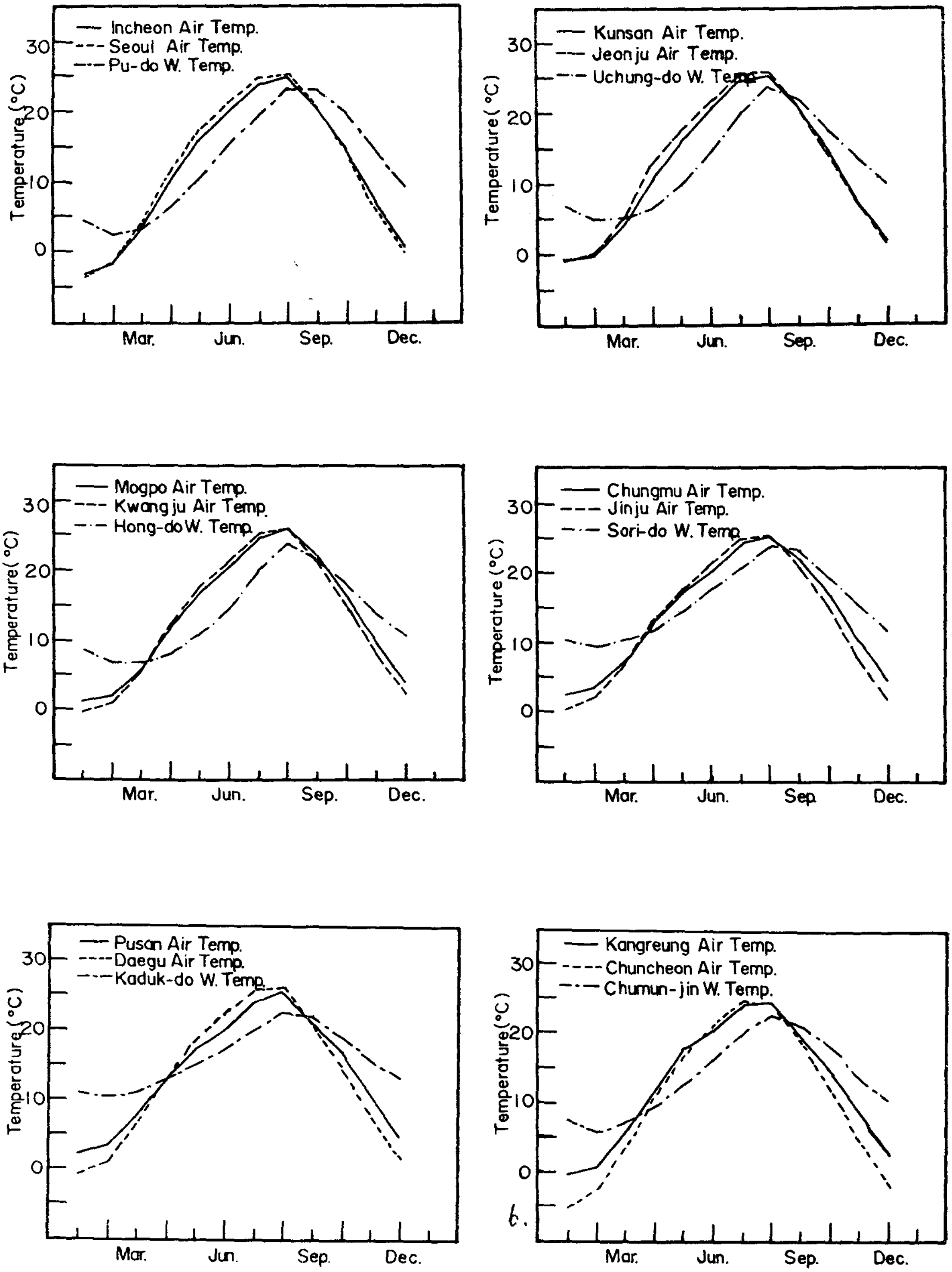

Fig. 2. Annual variations of the mean air and sea surface water temperature during 1962-1981

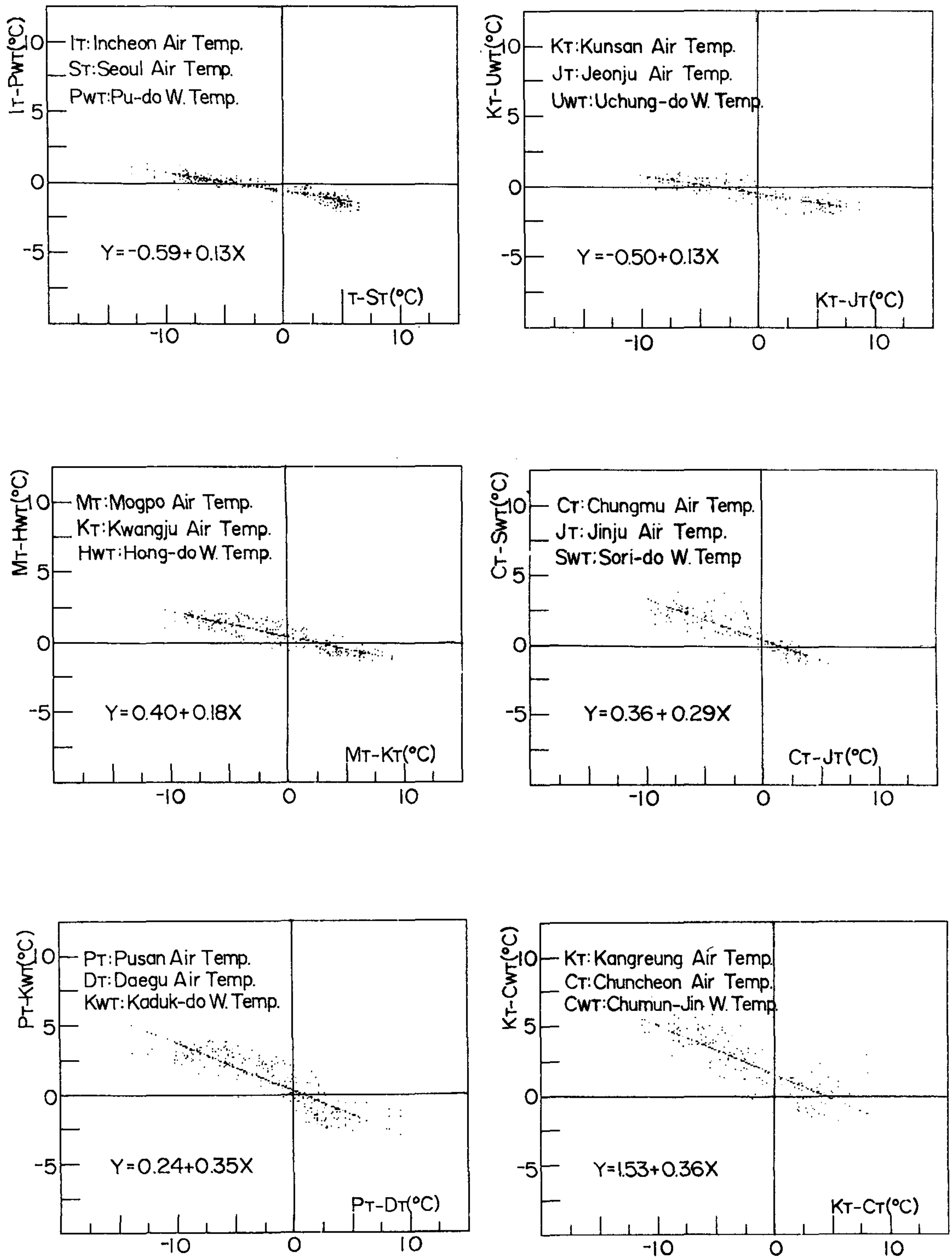

Fig. 3. Correlations in terms of the temperature difference between the coastal area and the ocean station and that between the coastal and the inland areas during 1962-1981

Table 1. Results of multiple regression analysis

(Temperature)

	Multiple regression equation	Coefficient of determination	Coefficient of multiple correlation
Pusan	$Y= -0.604+0.334X_1+0.710X_2$	0.992	0.996
Incheon	$Y= -0.661+0.133X_1+0.879X_2$	0.998	0.999
Mogpo	$Y= -0.119+0.201X_1+0.831X_2$	0.998	0.999
Kangreung	$Y= -1.731+0.226X_1+0.727X_2$	0.990	0.995
Kunsan	$Y= -0.912+0.163X_1+0.873X_2$	0.999	0.999
Chungmu	$Y= -0.169+0.275X_1+0.749X_2$	0.996	0.998

temperature in March, meanwhile, in April in the southern and eastern coastal areas. Such discordance can be explained by citing the description by Dietrich *et al.* (1980). That is, the annual amplitude of sea water temperature is relatively large in shallow waters, because continental influences control the heat transfer as in the Yellow Sea with the amplitude greater than 9°C. Accordingly, we can easily infer that the sea water temperature in the Yellow Sea increases or decreases more rapidly than that in the South and East Seas. However, for its detailed interpretation, the distribution of the vertical sea water temperature associated with the overlying air mass must be studied in future.

The correlation in terms of the temperature difference between the coastal area and the light house and also that the coastal and the inland areas are shown in Fig. 3. In Fig. 3, the X-axis denotes the air temperature difference between the coastal and the inland areas, and Y-axis the difference between the coastal air temperature and the water temperature at the light house. In each regression equation in Fig. 3, as a whole, the coefficients of the variable X(0.29~0.36) in the southern and eastern coastal areas were larger than those (0.13~0.18) in the western coastal area.

As another method of studying the role of the sea in the coastal climate, the multiple regression analysis was attempted, and its results are in Table 1, where the variable Y denotes the air temperature in the coastal area, X_1 the sea surface temperature at the light house and X_2 the air temperature in the inland area. As shown in Table 1, the coefficients of variable X_1(0.23~0.33) in the southern and eastern coastal areas were larger than those (0.13~0.20) in the western coastal area. Judged from the results of Fig. 3 and Table 1, it may be noticed that the oceanic effect on the coastal climate is more remarkable in the southern and eastern coastal areas than in the western coastal area. In addition, the coefficients of the determination and the multiple correlation were more than 0.99.

2. Humidity

In order to investigate the role of the sea on the variation of humidity in the coastal area, the annual variations of sea surface temperature and humidity in the coastal and inland areas were drawn as Fig. 4. As is readily noticed in Fig. 4, as a while the humidity in the coastal area is high in comparison with that in the inland area.

Fig. 5 shows the correlations between the temperature difference(X-axis) in the coastal area and the light house and the humidity difference(Y-axis) in the coastal and the inland areas. As shown in *Fig. 5, the change in the humidity difference* between the inland and coastal area was related to the difference between the sea surface temperature and the coastal air temperature. The results of multiple regression analysis, Y the humidity in the coastal area, X_1 the temperature at the light house and X_2 the humidity in the inland area, are shown in Table 2. As shown in Table 2, similarly in case of the temperature in Table 1, the coefficient of X_1(0.03~0.06) in the western coastal area is relatively smaller than that (0.14~0.20) in the southern and eastern coastal areas. The coefficients of determination and multiple correation were more than 0.98.

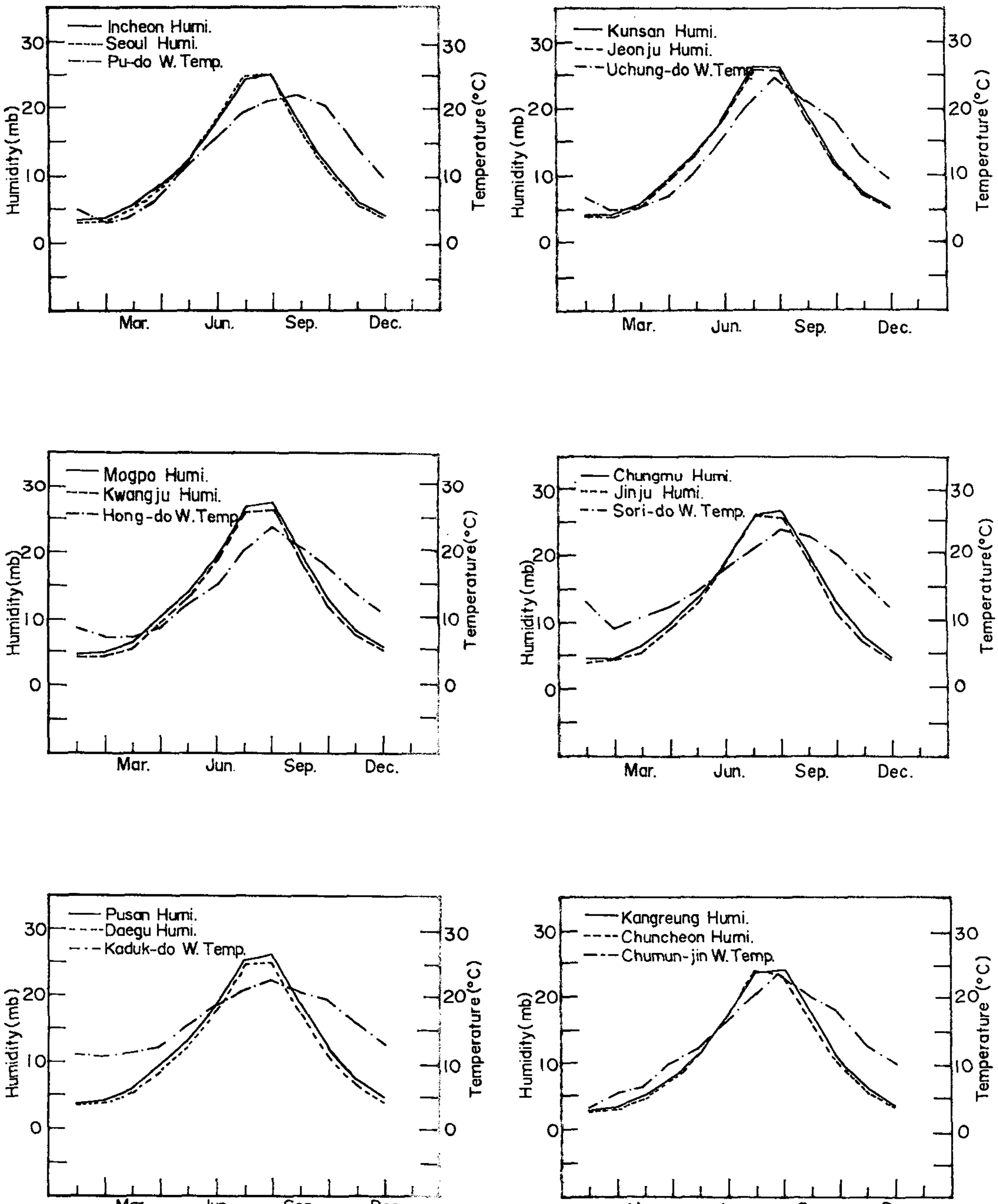

Fig. 4. Annual variations of the mean humidity during 1962-1981

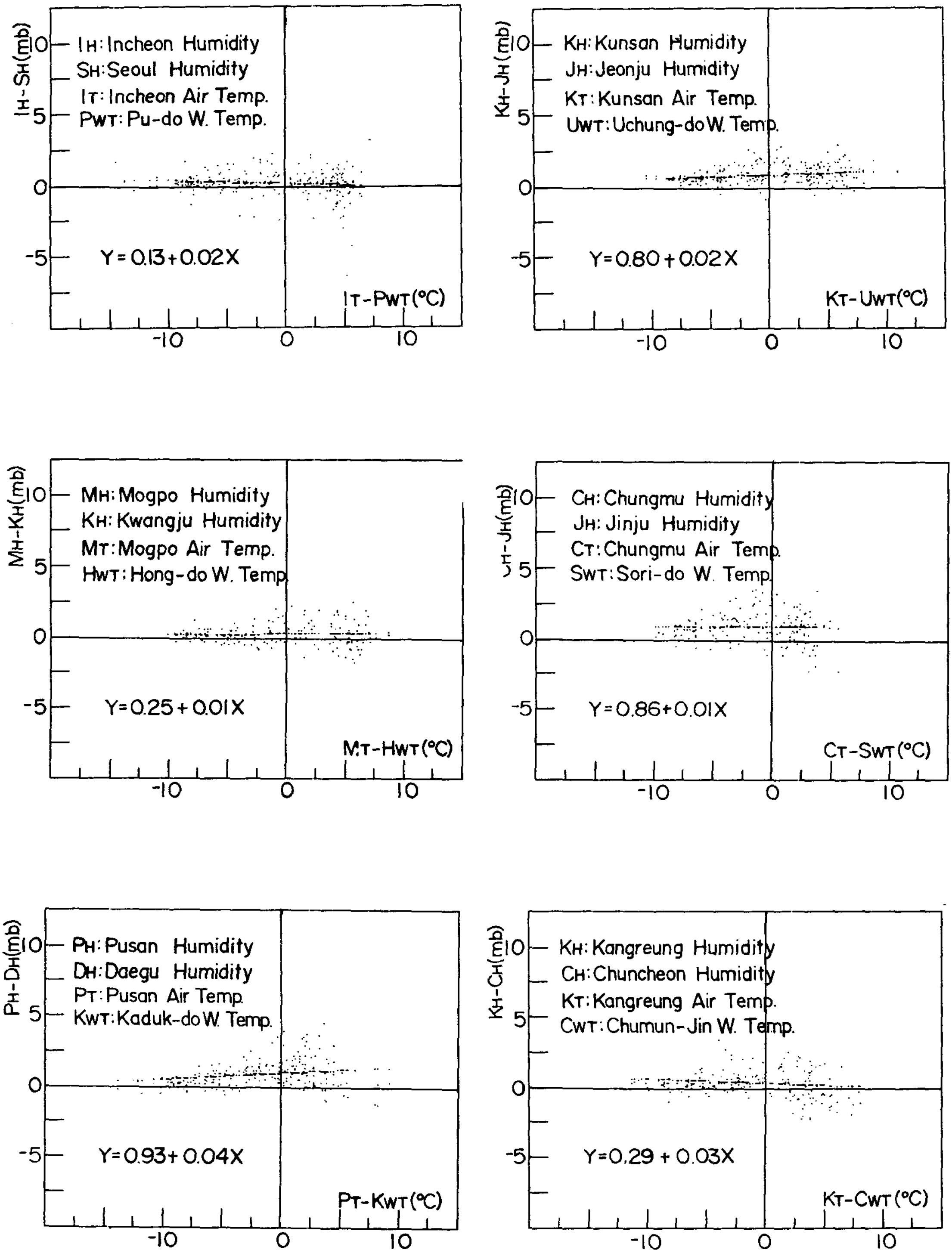

Fig. 5. Correlation between the temperature difference in the coastal area and ocean station, and the humidity difference in the coastal and inland areas during 1962-1981

Table 2. Results of multiple regression analysis

(Humidity)

	Multiple regression equation	Coefficient of determination	Coefficient of multiple correlation
Pusan	$Y = -0.997+0.135X_1+0.944X_2$	0.988	0.994
Incheon	$Y = -0.085+0.059X_1+0.939X_2$	0.989	0.995
Mogpo	$Y = 0.490+0.030X_1+0.989X_2$	0.993	0.996
Kangreung	$Y = -1.099+0.174X_1+0.867X_2$	0.983	0.991
Kunsan	$Y = -0.162+0.047X_1+0.972X_2$	0.991	0.995
Chungmu	$Y = -0.980+0.197X_1+0.845X_2$	0.981	0.990

Conclusion

The oceanic effect on the coastal climate, the air temperature and the humidity, was studied in this paper.

When the sea surface temperature was higher than the air temperature in the coastal area, the air temperature in the coastal area was high in comparison with that in the inland area. The annual range of temperature in the coastal area was smaller than that in the inland area due to the influence of the sea. The sea surface temperature was higher than the air temperature for 6 months in the western coastal area, while for 5 months in the southern and the eastern coastal areas. It was also found that the air temperature in the western coastal area began to surpass the sea surface temperature in March, meanwhile, in April in the southern and the eastern coastal areas.

According to the multiple regression analysis, the oceanic effect on the coastal climate, the air temperature and the humidity, in the western coastal area was different from that in the southern and the eastern coastal areas.

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우리나라의 沿岸氣候와 海面水温과의 關係

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1962年부터 1981年까지 氣溫, 濕度, 海面水溫 資料를 利用하여 沿岸氣候에 대한 海洋의 影響을 調査하였다.

海面水溫은 西海岸에서 9月부터 3月까지 約 6個月동안, 東海岸에서는 9月부터 4月까지 約 5個月동안 海岸氣溫보다 높았다.

沿岸氣溫이 海面水溫 보다 높아지는 것은 西海岸에서는 3月, 南海岸과 東海岸에서는 4月로 西海岸이 1個月 정도 빨랐다.

沿岸氣溫과 內陸氣溫, 沿岸氣溫과 海面水溫과의 差, 그리고 沿岸濕度와 海面水溫, 沿岸濕度와 內陸濕度와의 差로 重回歸分析을 한 結果, 沿岸氣候要素(氣溫과 濕度)에 대한 海洋 影響의 係數는 南海岸과 東岸海보다 西海岸에서 弱하게 나타났다.