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Changes of Local Meteorological Environment in particular Air Temperature at Isahaya Bay Reclamation Area as a Naked Saline Flat Land

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Abstract: Isahaya Bay reclamation area (816 ha) was a flat saline naked land like a new desertificated land. Land reclamation was carried out in Isahaya Bay for two reasons, to increase the amount of flat land and to decrease meteorological disasters. Within several years after salt is eliminated, the reclaimed land will become excellent arable land, and will be available for many uses. It is necessary to perform continued meteorological research on this land, which is intended for agricultural usage after reclamation is complete. The water temperature of the artificial pond increased by the heat of solar radiation during the daytime in summer, and the effect of increased air temperature at Yue and Azuma was obtained when the wind was blowing toward them from the pond.

Keywords: Air temperature, Bank, Isahaya Bay, Meteorological environment, Reclamation

1. Introduction

Isahaya Bay reclamation area was a flat, saline and naked land for these 5 to 10 years. It was like a new desertificated land. So it is necessary to observe and evaluate variations of wind and air temperature for predicting and simulating the new climatic characteristics. The plan for the reclamation of Isahaya Bay was initiated by the Kyushu Agricultural Administration Agency, Ministry of Agriculture, Forestry and Fisheries (MAFF) in 1989. The meteorological observation of wind speed, wind direction, air temperature and precipitation began on Jan. 1, 1989. The construction of reclaimed land in Isahaya Bay was started in Nov. 1992. The reclamation area of Isahaya Bay included an artificial regulation or control pond that was completely and instantaneously separated from Isahaya Bay in the Ariake Sea on a day in Apr. 1997, and work on this part of the project was finished in Mar. 1999. The reclamation project was continued and the reclamation was completed in 2007. The observation results of wind speed and wind direction around Isahaya Bay were presented in a recent paper (Maki, 2007; Maki *et al.*, 2008). The wind speed on the ground surface was slightly decreased by resistance from the Isahaya Bay front bank, and wind direction on the ground surface changed to clockwise by about 20 degrees in the prevailing wind direction.

2. Observational and Analytical Methods of Meteorological Data

Figure 1 shows the satellite image of the topography and meteorological observation of 4 points around the Isahaya reclamation area. Around the Isahaya reclamation area, Azuma and Yue are located at the foot of Unzen (1359 m), and the foot of both

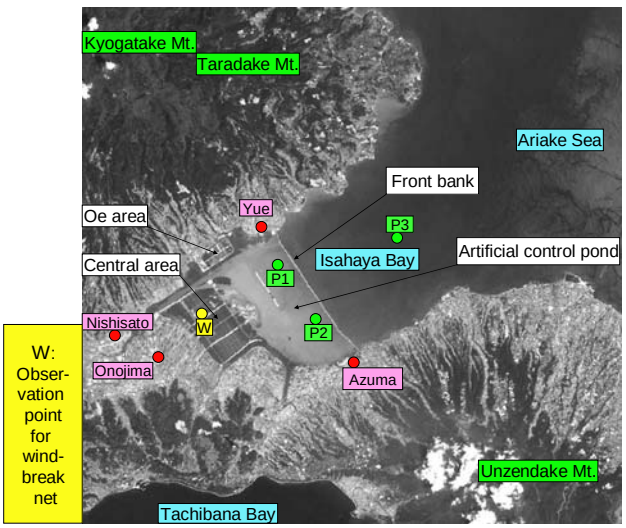

Fig. 1. Topography of the Ariake Sea, Isahaya Bay and the reclamation area in Nagasaki.

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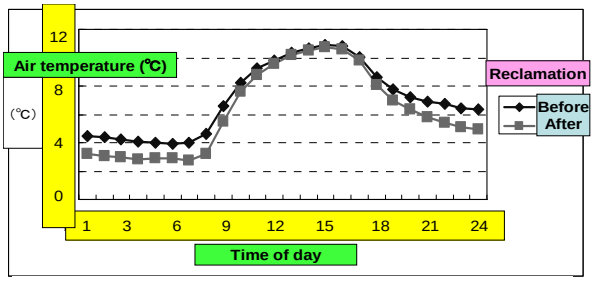

Fig. 2. Variations in air temperature on fine or clear days in winter before and after the reclamation at Yue.

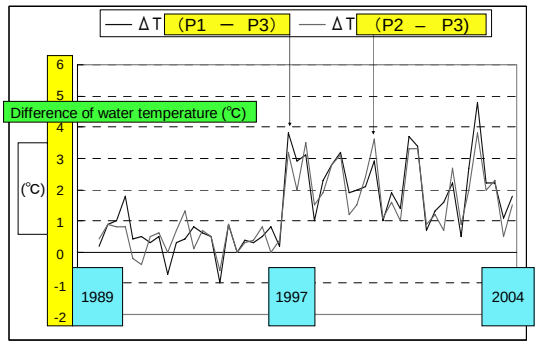

Fig. 3. Variations in differences of water temperatures inside and outside the artificial pond.

Tara (983 m) and Kyoga (1076 m), respectively, and face Isahaya Bay. Onojima and Nishisato are located in an inland area.

The meteorological data were obtained by the Kyushu Agricultural Administration Agency, MAFF from 1989 to 2007. Shimabara, Ohmuta, Taimei and Misumi AMeDAS data as representative data of the area around the Ariake Sea were used for the analyses and were compared to the air temperature at Azuma, Onojima and Yue. Nishisato data were not used because of the urban effect caused by buildings and roads. The analytical data were collected from Jan. 1, 1989 to Dec. 31, 2005.

The data from 1990 to 1996 and the data from 1999 to 2005 are the data in the period before and after the construction of the front main bank, for **Figures 2 to 5**, respectively. The hourly meteorological data are wind speed, wind direction, air temperature and precipitation. Annual averaged temperatures of the daily maximum, mean and minimum air temperatures, and the differences of 3 averaged temperatures were analyzed.

3. Observation Results and Their Considerations

3.1. Diurnal variation in air temperature on fine or clear winter days at Yue

Figure 2 shows the variations in air temperature (3000 data) on fine or clear days in winter before and after the reclamation in 6 years at Yue. Yue is selected as the place that properly effected by northern winds at night and by southern winds at daytime in winter. The air temperature after the reclamation was lower than that before the reclamation showing in **Figure 3**. The temperature difference is especially large from late afternoon to early morning and is slight during the daytime. The difference is a maximum of about 1 ˚C. The extension of reclamation most likely affected the temperature at Yue during the winter nights because of strong radiation cooling on the naked reclamation land. The low-temperature northern wind blows during the cold winter half year and the land breeze or mountain wind comes from Tara at night.

On the other hand, the air temperature increased after the reclamation particularly in winter at Azuma during the period of northern wind. The northeast wind curved by Tara is a sea breeze that blows fairly frequently compared to the mountain wind from Unzen (Maki *et al.*, 2008). However, it seemed at Azuma that the effect by reclamation just after the period from 1997 to 2001 was large, but after 2002 the effect was small. As Onojima is located in a flat area and far from mountains and the pond, it is little affected by mountain winds or sea breezes. And it was not affected greatly by reclamation; the cooling in winter was not large in this case.

At Yue during the daytime in summer, the water temperature increased because the pond was enclosed by the front bank, because the air temperature increased in response to the sunshine, and because high humidity was brought by a sea breeze into the inland area. But at Onojima, a high-temperature, high-humidity air mass does not enter such an inland area and the effect is not found. These phenomena clearly affected on air temperature.

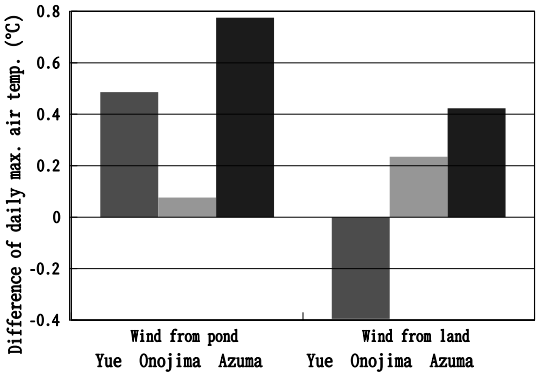

Fig. 4. Variations in difference of daily maximum air temperature before and after reclamation.

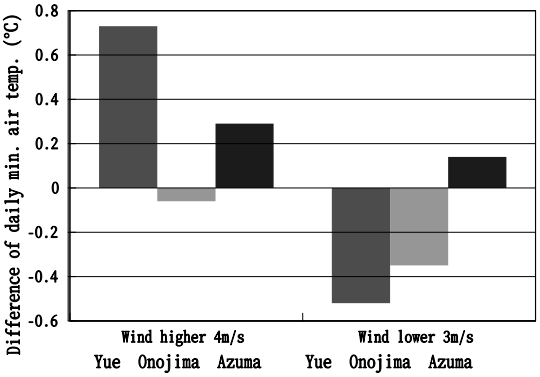

Fig. 5. Variation in daily minimum air temperatures at3 points on fine or clear days in winter before and after the reclamation under 3 m/s and over 4 m/s.

3.2. Variation in water temperatures inside and outside of the artificial pond

Figure 3 shows the seasonal variations in differences of water temperatures inside (P1, P2) and outside (P3) the artificial pond. The temperature difference has increased over 2 ˚C since 1997. Before shutting of the gate of front bank, the temperature difference between outside and inside was not large and also the scale of yearly variation was small, but it became large after 1997. The average maximum water temperature and variation difference are very large, 3 to 4 ˚C. Because the outside sea water does not enter the artificial pond and the depth and volume of the pond are smaller than the outside sea, the water temperature is easily increased by sunshine. For period of about one year, in 2003, the difference of water temperature decreased to 1 to 2 ˚C and returned close to the temperature before the reclamation. This occurred because at the time there was a short-term opening of the front bank for the purposes of exchanging from fresh water to sea water and investigating the current water, salinity concentration, ecology and so on. It is interesting that the exchange of water affected the water and air temperatures.

3.3. Variation in daily maximum air temperature in summer when the wind blows from the pond

From June to August, the wind from the artificial pond is from the WNW to NNW at Azuma, N to E at Onojima and SSE to SW at Yue. The wind from the inland is from the SW to SE at Azuma, WNW to SE at Onojima and NW to NNE at Yue. It was obtained that wind speed on the ground surface decreased a little because of resistance of the front bank of Isahaya Bay, and wind direction of the prevailing wind direction on the ground surface also changed to clockwise about 20 degrees (Maki, 2007; Maki *et al.*, 2008).

The variations in difference of daily maximum air temperature (3000 data) before and after reclamation at 3 points are shown in Figure 4. When the wind came from the direction of the pond at Azuma and Yue during the daytime in summer, the difference of maximum air temperature significantly increased, because the surface water temperature of the small artificial pond with its small amount of water was raised more by the sunshine than was the water temperature of the Ariake Sea. There seems to be more wind from the pond at Azuma and Yue because of the higher water temperature. This creates an area of low pressure, that is, the air is sucked from the outside. However the maximum air temperature at Onojima did not increase, because Onojima is located inland and far from the pond and is not affected with regard to the maximum air temperature.

At Azuma and Onojima, the maximum air temperature increased when there was wind from inland. However at Yue, it is interesting that the maximum air temperature decreased significantly, and the wind is from the NW to NNE. It is probably a downwind from Tara, which is a woodland as air high humidity and low temperature.

3.4. Variation in daily minimum air temperature of weak wind on fine or clear winter days after the reclamation

The analytical conditions in winter from December to February are as follows: Before reclamation is 1991 to 1996, while after is 1999 to 2004. The selected data are the days of weak wind, fine or clear, no clouds and dry air condition, that is, daily mean wind speed is under 3 m/s, sunshine duration is over 7 h per day and daily precipitation is 0 mm.

The variation in daily minimum air temperature (1000 data) at 3 points on fine or clear days in winter before and after the reclamation at the period of weak wind under 3 m/s and over 4 m/s is shown in Figure 5. The variation in air temperature coincides with differences in wind speed. At Yue and Onojima, the air temperature decreased on a weak wind day based on radiation cooling, but at Azuma the air temperature increased a little. The reason is mainly that the wind at Azuma in winter is a prevailing northern wind, that is, the sea breeze comes from the sea or the artificial pond, and the air temperature of the sea breeze in winter is rather higher than that of the land breeze. It is interesting that the difference is found that the topography of north and south places at Azuma and Yue around Isahaya Bay.

A decrease in air temperature was found on weak wind days, but when wind speed was high, the phenomenon was destroyed and air temperature increased. The reason seemed to be radiation cooling resulting from the area being surrounded by a bank. On a strong wind day over 4 m/s, the general wind mainly affects the air temperature, *i.e.*, the high and low air pressure mainly affect the air temperature, but in keeping with the local wind, *i.e.*, the effect of the disturbance is large in winter, so air temperature could be increased by a small amount of radiation cooling, a phenomenon that occurs in western Japan in winter. On the other hand, when there was a strong wind over 4 m/s at Yue, Azuma and Onojima, the difference of minimum air temperature increased, in particular at Yue and a little at Azuma, for the reasons mentioned above. It seemed like based on the wind by disturbance. Because Onojima is inland, there is very little increase in air temperature. In this case, the small amount of radiation cooling from strong winds and increase of air temperature at disturbance are balanced. Then, it is a rare case in the lowlands in Western Japan, but it was sometimes observed that temperatures could reach -7 ˚C inside a flat field like a basin field surrounded by a bank on fine or clear calm days in winter based on radiation cooling.

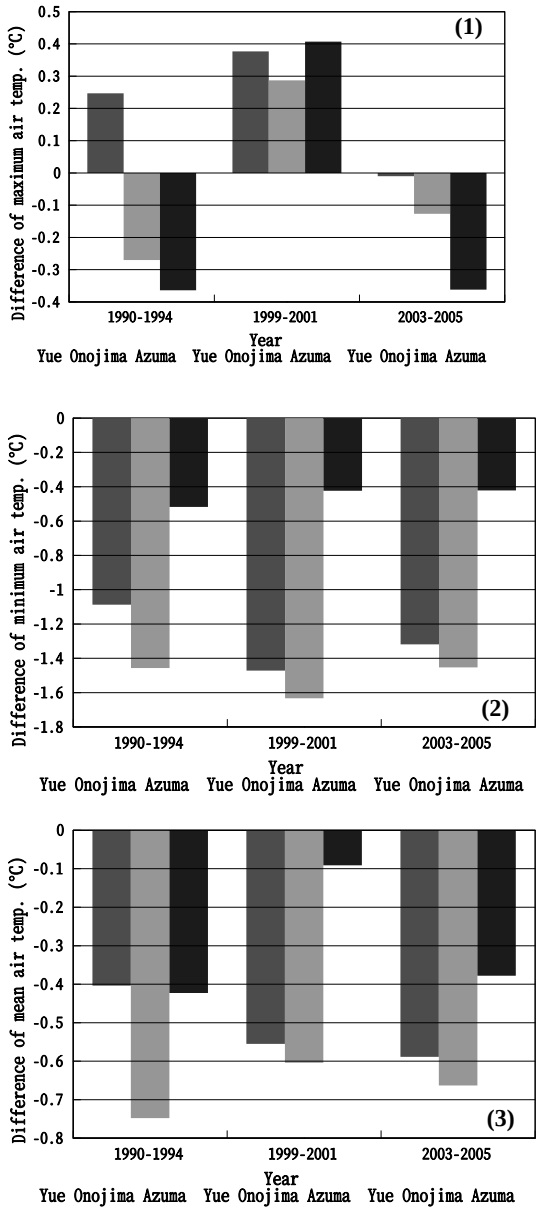

Fig. 6. Difference of the air temperature from 4-point mean air temperature around the Ariake Sea.

3.5. Difference of the air temperature from 4-point mean air temperature around the Ariake Sea

The periods of meteorological data were divided into 3 patterns, *i.e*., 1990-1994; before the reclamation, 1999-2001; after the reclamation without vegetation and 2003-2005; after recovered vegetation. The effect of reclamation was found in 1999-2001, in that there was no vegetation under the dry, high salinity conditions compared to the condition before the reclamation in 1990-1994. The vegetation almost recovered on the reclamation area from 2003-2005. The effects of reclamation to the air temperatures were almost negated by the recovering of vegetation.

The difference of the air temperature from 4-point mean air temperature around the Ariake Sea is shown in **Figures 6(1)-(3)**.

The differences of the maximum air temperature (Fig. 6(1)) increased significantly due to the increase of the inland grade with the effects of the naked land and artificial pond from 1999-2001 at Azuma and Onojima compared to the original condition of no reclamation. After the vegetation recovered, the difference of maximum values at Azuma and Onojima returned back pretty well, but Yue was also found the effect of reclamation land in 1999-2001. The difference value decreased significantly after the vegetation recovered, the effect of vegetation became to be larger than that before at Azuma and Onojima because of a fairly recovering.

The differences of the minimum air temperature (Fig. 6(2)) at 3 locations Azuma, Onojima and Yue decreased by radiation cooling based on the increment of inland grade, but the recovering grade at Onojima and Yue is pretty large in 2003-2005. The mean air temperature increased at Azuma based on the increase of the maximum air temperature that the recovering reason of air temperature at Azuma and Onojima with the periods from 1999-2001 to 2003-2005, because of mainly recovering of vegetation, but not for Yue on maximum air temperature because of the vegetation of the Oe reclamation area.

The differences of mean air temperature (Fig. 6(3)) were not significantly changed by the maximum and minimum air temperatures, except in 1999-2001 at Azuma.

The differences of the maximum air temperature increased significantly by the increase of reclamation land in Azuma, Onojima and Yue that was heated during the day by sun. As the vegetation recovered in 2003-2005, the values at Azuma and Onojima almost recovered. The difference of the minimum air temperature decreased by the radiation cooling of Azuma, Onojima and Yue in 1999-2001, but the values at Onojima and Yue recovered in 2003-2005.

4. Concluding Remarks

The results were obtained by the meteorological data from Azuma, Onojima and Yue near the area:

(1) Wind speed on the ground surface decreased a little because of resistance of the front bank of Isahaya Bay, and wind direction of the prevailing wind direction on the ground surface also changed to clockwise about 20 degrees.

(2) The water temperature of the artificial pond was increased by the heat of solar radiation during the daytime in summer in the area isolated when Isahaya Bay was closed off by a bank, and the maximum air temperature at Yue and Azuma was increased when the wind was blowing toward them from the pond. But at Onojima, the change of air temperature was very small because Onojima was more inland, the distance from the pond was large and the effect of a local pond was small.

(3) The minimum air temperatures on winter nights on clear or fine days under 3 m/s at Yue and Onojima decreased after completion of the reclamation at Isahaya Bay because of radiation cooling of the flat surface land.

(4) The differences of the maximum air temperature increased significantly by the increase of reclamation land of Azuma, Onojima and Yue by the daytime heating in 1999-2001. As the vegetation recovered in 2003-2005, the values at Azuma and Onojima almost recovered. The difference of the minimum air temperature decreased by the radiation cooling of Azuma, Onojima and Yue in 1999-2001, but the values at Onojima and Yue were recovered in 2003-2005.

References

Maki T. (2007): Merit and demerit of Isahaya reclaimed land and front bank. *Global Environ. Read by Winds*, Kokonshoin, 101-116.

Maki T., Urayama K., Wakimizu K. (2008): Variations of meteorological environment at Isahaya Bay reclamation area of Nagasaki in Japan. *Proc. of CIGR*, Brazil, CD 1-6.