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COMPUTATIONAL PROCEDURE FOR ESTIMATING THE EFFECTS OF SEA SPRAYS ON TEMPERATURE FIELDS OVER THE SEA SURFACE

Ayumi Saruwatari[1] and Nobuhiro Abe[2]

We propose a procedure to calculate the latent heat of vaporization of sea sprays in the meteorological model in order to investigate the effect of sea sprays on the air temperature field above the sea surface in this study. Local air temperature are found to decrease 0.1–0.5°C when we consider the latent heat flux due to the sprays comparing with results without sprays. The numerical experiments varying 'Spray Generation Function' (SGF) found that sprays with radii of O(10–100μm) have most influence on the temperature field. This suggests that the local meteorological field around the surf zone, where the number of sprays of O(10–100μm) is known to be greater than that above the open ocean, can be greatly affected by the presence of sprays.

Sea sprays are one factor that determines the meteorological field over the ocean since they affect air-sea heat/moisture fluxes through the vaporization process. Sea sprays are known to be generated due to 'bursting bubbles' on the sea surface or 'spume droplets' torn off from wave crests by wind in open ocean as well as breaking and overtopping waves in the surf zone. De Leeuw (1999) observed that the number density of sea sprays with a size of O(10-100μm) in the surf zone is 1-2 orders of magnitude larger than that in the open ocean as the spray generation mechanism differs between the zones. Since the sea sprays of O(10-100μm) have been found to significantly contribute to the air-sea heat/moisture exchange (Andreas, 1992), relationships between the shapes of the spray size spectrum and air-sea heat flux should be reasonably evaluated for accurately predicting the coastal meteorological field.

The proposing procedure computes the latent heat of sea sprays and applies the latent heat flux for a meteorological model, WRF (Weather Research and Forecasting model), as a boundary condition on the sea surface. Temperature, pressure, humidity, wind velocity and the SGF that represents the number and size of the sprays generated from the sea surface are used as parameters to compute the latent heat. There is no reasonable model to estimate SGF in the surf zone although a number of SGF models for the open ocean have been proposed. In this study we performed numerical experiments to investigate response of the meteorological fields above the sea surface. SGFs based on open ocean conditions were used.

Latent heat by sea sprays computed under various conditions in the present study was compared with the corresponding results by Andreas (1992) (Fig. 1 (a)). We confirmed that both results were of the same order of magnitude and the trend of response of the latent heat to the temperature, humidity and wind velocity coincides with each other.

We confirmed that wind velocity is more important to determine the latent heat of sea sprays than temperature and humidity by performing sensitivity analysis. Latent heat was also found to be strongly influenced by SGF which is known to be mainly dominated by wind velocity.

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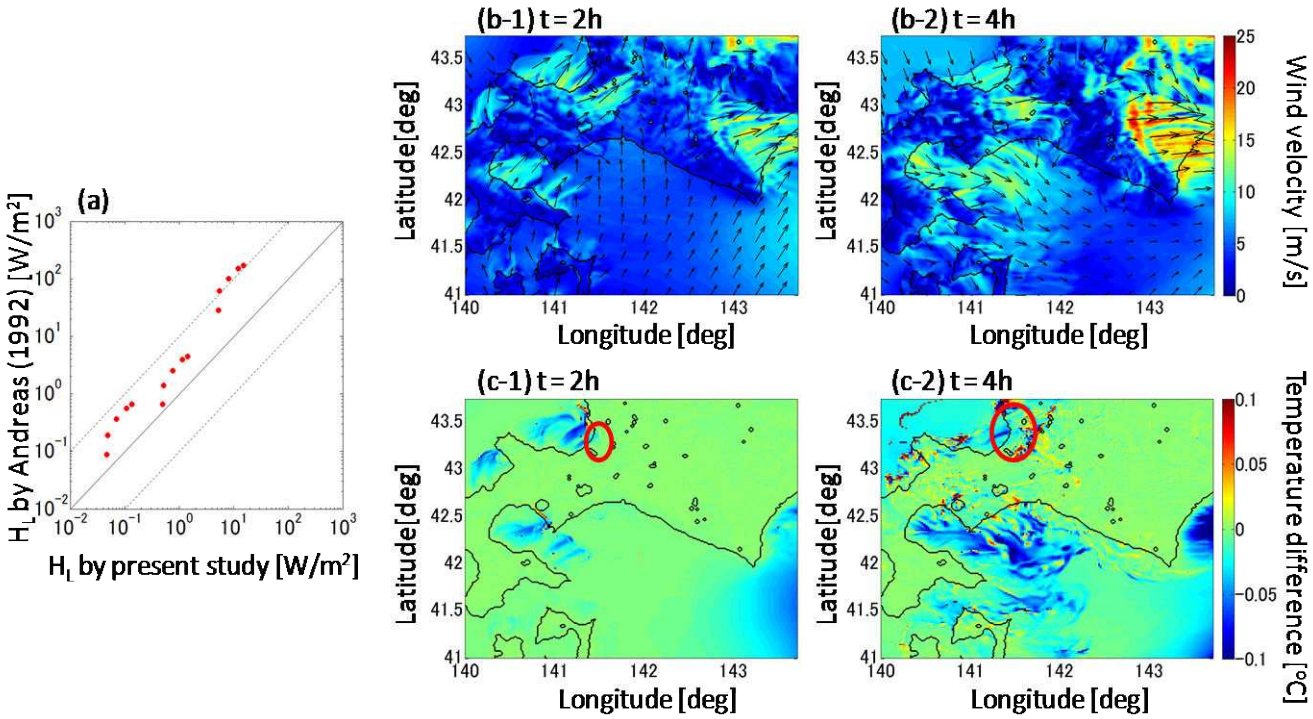

Figure 1 (a) Comparison of latent heat flux H_L due to sea sprays computed in the present study and Andreas (1992). Wind velocity (b) temperature difference (c) appeared due to the latent heat of sea sprays.

Figure 1 (b), (c) shows typical temperature differences found by considering latent heat of sea sprays and corresponding wind velocity fields. A temperature difference of 0.1-0.5°C was found depending on the wind velocity above the sea surface in the computational conditions of this study. A temperature difference was also found in the coastal land area with landward wind (circled in Fig. 1 (c)).

We confirmed that sprays with O(10-100μm) especially affect the temperature above the sea surface by comparison of the temperature fields computed with various SGF where generation of sprays of O(0.1μm), O(1μm), O(10μm) and O(100μm) were used. In a numerical experiment where SGF of O(10-100μm) is increased by a factor of 100 difference in wind velocity field as well as temperature field could be found. Since sprays of this size are known to increase in the surf zone (de Leeuw, 1999) the local meteorological field around coastal region is expected to be substantially influenced by sea sprays.

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