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Retrieval of the air temperature over the sea based on the satellite data

B. H. Kwon (1), G. M. Hong (1), Y. S. Kim (2)

(1) Department of Environmental Atmospheric Science, Pukyong National University (bhkwon@mail1.pknu.ac.kr), (2) Department of Satellite Information Science, Pukyong National University

The ocean actively exchange heat, water and momentum with the atmosphere through the ocean surface. Since the exchange and transporting processes are essential components of the global climate, it is quite important to estimate these fluxes between the atmosphere and the ocean and of transports by ocean and atmospheric circulation to understand the mechanism of the global. However, it is difficult to estimate those fluxes and transports globally using in-situ observation data from ships and buoys, since such data are extremely sparse in time and space. By contrast, we can obtain extremely homogeneous data with high resolution using analysis and satellite data. Due to the temporal and spatial simultaneity and the high-frequency repetition, the data set retrieved from the satellite observation is considered to be the most desirable ones for the study of air-sea interaction. With rapidly developing sensor technology, satellite-retrieved data has experienced improvement in the accuracy and the number of parameters. Nevertheless, since it is still impossible to directly measure the heat fluxes between air and sea, the bulk method is an exclusive way for the evaluation of the heat fluxes at the sea surface. In order to get the accurate fluxes using the bulk method, it is necessary to derive the relievable marine meteorological parameters such as SST, atmosphere temperature, air pressure, wind speed and specific humidity. The simple estimation methods of air temperature and specific humidity at the sea surface are investigated using the buoy and satellite data. Air temperature and specific humidity obtained by the regression equations are validated through the comparison with sea truth data.

Latent heat and sensible heat fluxes are globally estimated using a bulk formula for satellite data, which includes several kinds of physical variable, and the estimation

of turbulent heat fluxes is complex. For this estimate, wind speed, specific humidity, and saturated specific humidity are necessary for latent heat, and wind speed, air temperature, and sea surface temperature (SST) are needed for sensible heat flux. In these necessary variables, specific humidity and air temperature are not easily obtained from satellite data compared with other data. Schlüssel *et al.* (1995) proposed an algorithm for estimating specific humidity from satellite data. Some studies proposed a method for estimating the surface level air temperature by satellite sensors (Jones *et al.*, 1999). However, satellite-derived specific humidity and air temperature are not yet so accurate as to be satisfactory for the estimation of latent and sensible heat fluxes. In particular, air temperature is one of the most important elements of the climate parameters.

The sparsity of observation data in time and space over the Korean Peninsula marginal seas has forced one to use climatological means of statistical methods to obtain information of the surface heat flux. Furthermore, most of the studies on the heat budget were limited to the East/Japan Sea area due to the relative abundance of observations. Equivalent information of the sea surface flux over the East/Japan Sea are limited in numbers reported over the Yellow Sea and East China Sea. We used data from buoys around the Korean Peninsula and the East Sea operated by KMA, JMA: #22101, #22102, #22103, #22104, # 22105, #21002, #21004, and #22001. Bias of air temperature with MCSST is 0.28° with 1.5° RMSE and 0.98 correlation coefficient. Specific humidity estimated indirectly using buoys data shows also fairly good result in terms of -1.42 g kg^{-1} BIAS and 1.75 g kg^{-1} RMSE, correlation coefficient 0.97. The statistic results for sensible and latent heat fluxes calculated using the marine meteorological elements, which are derived by the present method, are comparable with those of previous studies.

It was noted that the large deviation of air temperature in the winter season by the linear regression despite good correlation coefficients. We propose a new algorithm based on the Fourier series with which the SST and the air temperature are written:

$$SST(t) = A_0 + \sum_{n=1}^{N-1} \{\sqrt{A_n^2 + B_n^2}\sin(\tfrac{2n\pi}{N}t + \theta_{SST})\}$$
$$AT(t) = a_0 + \sum_{n=1}^{N-1} \{\sqrt{a_n^2 + b_n^2}\sin(\tfrac{2n\pi}{N}t + \theta_{AT})\}$$

We found that the mean of air temperature a_0 is a function of the mean of SST with the monthly gradient of SST ($GradSST(t) = -0.55\sin(\pi/6) - 0.85$) inferred from the latitudinal variation of SST and the spectral energy of air temperature is related linearly to that of SST ($\sqrt{a_n^2 + b_n^2} = 0.62\sqrt{A_n^2 + B_n^2} + 0.034$). An algorithm to obtain the air temperature over the sea was completed with a proper analysis on the relation between of air temperature and of SST. This algorithm was examined by buoy data and therefore the air temperature over the sea can be retrieved based on just satellite data.

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References

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