EFFECT OF EMISSIVITY ON SHIPBOARD SEA SURFACE SKIN TEMPERATURE MEASUREMENTS

Minglun Yang, Lei Guan, Kailin Zhang and Liqin Qu

Ocean Remotes Sensing Institute
Department of Marine Technology, College of Information Science and Engineering
Ocean University of China, Qingdao, 266100, China

Introduction Sea surface temperature (SST) is an essential variable for numerical weather prediction and global climate modeling. In situ measurement of sea surface skin temperature (SSTskin) is important for validation of satellite SST observations, and several radiometers have been developed by different research groups. The infrared SST autonomous radiometer (ISAR), a self-calibrating instrument, is designed for in situ SSTskin measurements with an accuracy of 0.1 K. An ISAR has been deployed on the research vessel Dong Fang Hong II of Ocean University of China and continuously operating in the China Seas since 2009. To measure SSTskin accurately, ISAR obtains both the sea surface radiance and the downwelling atmosphere radiance which are calibrated by two reference blackbody cavities. The accuracy of measured SSTskin depends on both the self-calibration process and the correction for sky reflection, which is strongly influenced by the estimate of sea surface emissivity. A small change approximately 0.01 on sea surface emissivity has a significant effect on the derived SSTskin. A constant emissivity value is used in the ISAR SSTskin retrieval algorithm which is not considered about the wind-roughened sea state. In this study, Masuda et al. model is applied to calculate sea surface emissivity which is used in the ISAR SSTskin retrieval process and the effect of wind speed dependent emissivity is analyzed.

Data & Method In Masuda et al. model, sea surface emissivity was given by a function of view angle, wavelength and surface wind speed. The seawater emissivity data tabulated by Masuda et al. at view angle between 0° and 60° are interpolated to a set of emissivity values. The dependence of emissivity on wavelength and surface wind speed for view angle of 45° is shown in Fig 1. The spectral response function for the infrared detector, i.e. KT15.85 used in the ISAR is also shown in Fig 1.

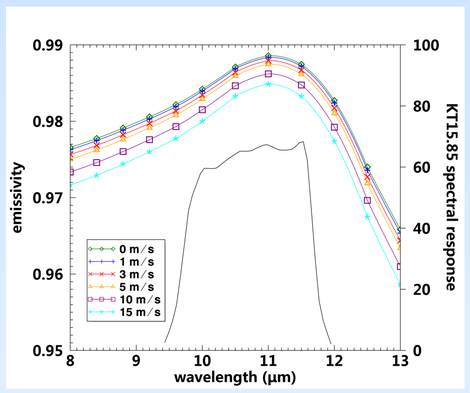

Figure 1 Sea surface emissivity as a function of wavelength and wind speed for view angle of 45°. The spectral response of KT15.85 (the black solid line) is also shown

The appropriate emissivity value should be integrated across the spectral bandwidth for the ISAR ranging from 9-12 μm and weighted by the normalized response function of KT15.85. Fig 2 shows the calculated emissivity dependency on surface wind speed.

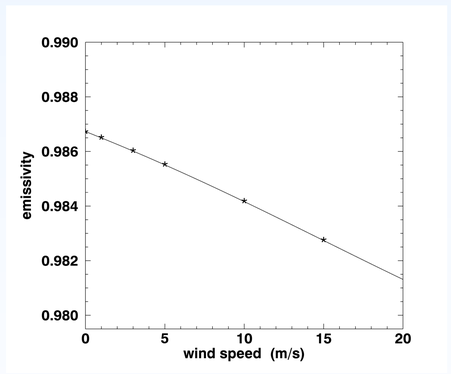

Figure 2 Wavelength weighted averaged sea surface emissivity as a function of wind speed

The surface wind data used in this study are collected by vessel manage system (VMS) of R/V Dong Fang Hong II. The ISAR data used in following analyses were collected during four cruises in 2013 and 2014 of R/V Dong Fang Hong II.

Results The calculated wind speed dependent emissivity is used in the ISAR SSTskin retrieval algorithm. Through matching up the VMS wind speed time and the time of ISAR measurements, SSTskin is derived using emissivity under different wind speed conditions. The SSTskin retrieved using constant emissivity value of 0.987 is also calculated for comparison. Fig 3 shows the difference of retrieved SSTskin between wind speed dependent emissivity and constant emissivity for the cruises mentioned in Table 1. The mean and standard deviation of differences are also tabulated in Table 1.

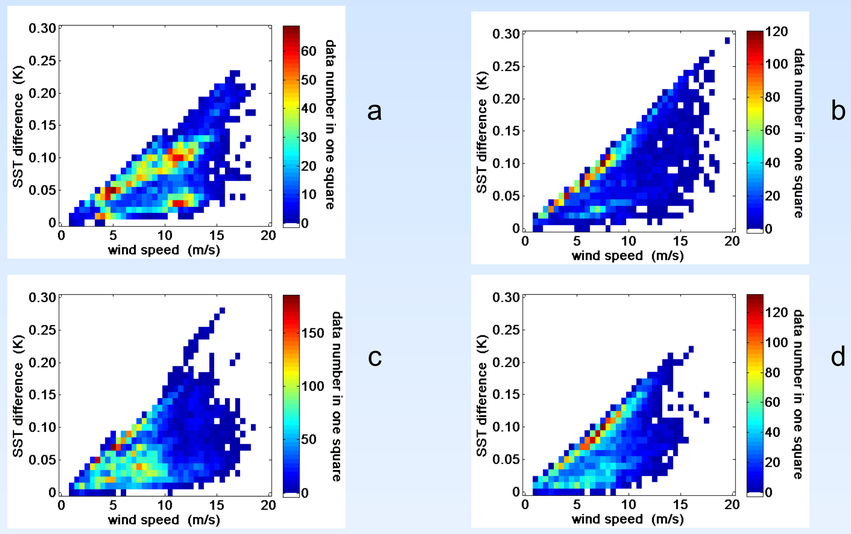

Figure 3 Difference of SSTskin retrieved from two sets of emissivity for the four cruises

Cruises Dates	Mean	Standard Deviation
10 Oct. - 4 Nov. 2013 (a)	0.07 K	0.04 K
4 Nov. - 27 Nov. 2013 (b)	0.08 K	0.05 K
27 Nov. - 22 Jan. 2013 - 2014 (c)	0.06 K	0.04 K
16 Mar. - 23 Apr. 2014 (d)	0.07 K	0.04 K

Table 1 The mean and standard deviation of differences of SSTskin retrieved from two sets of emissivity for the four cruises in 2013 and 2014

Discussion The dependency on surface wind speed in Fig 3 shows that under high wind speed conditions, approximately higher than 10 m/s, the difference of SSTskin can reach a magnitude of 0.1 K to 0.2 K. Comparing to the requirement of 0.1 K accuracy of ISAR, the effect of wind-roughened sea surface emissivity on SSTskin measurements should be considered. It is important to estimate appropriate wind-roughened sea surface emissivity using an accurate emissivity model for the ISAR SSTskin measurements.

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