Retrieval of Sea Surface Temperature from HY-1C COCTS

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Introduction

The Haiyang-1C (HY-1C) satellite was launched in September 2018, operated by the National Ocean Satellite Application Center (NSOAS) of China. HY-1C satellite is the successor satellite for HY-1A and HY-1B, with the greater measurement accuracy of global ocean color parameters and sea surface temperature (SST). The Chinese Ocean Color and Temperature Scanner (COCTS) on board the HY-1C has 2 thermal infrared bands centered near 11 μm and 12 μm used for measuring SST, with a spatial resolution of 1.1 km at nadir. The inter-calibration of COCTS infrared channels with IASI was conducted in our previous study. In this research, the Bayesian cloud detection and optimal estimation (OE) SST retrieval were applied to COCTS data. The retrieved COCTS OE SSTs were compared with iQuam in situ SST.

Bayesian cloud detection

In this study, the Bayesian cloud detection algorithm of HY-1C COCTS have been developed, based on the Bayes' theorem and COCTS simulation results. The MODerate resolution atmospheric TRANsmission (MODTRAN) are used for simulation of COCTS brightness temperature (BT). The prior vector, including SST and total column water vapor (TCWV), are obtained from ERA5 data. Fig. 1 (a) and (c) are the regional COCTS 11 μm BTs in fronts on 3 July 2019 before and after cloud detection, respectively, and Fig. 1 (b) is the corresponding RGB figure of reflectance channels. The figures show that the cloudy detection is giving plausible results, and it works well in ocean fronts. We will also validate the cloud mask performance using the retrieved SST evaluation results in the following part.

Fig. 1. Bayesian cloud detection results on 10 July, 2019: (a) COCTS 11 μm scene BT on before cloud detection; (b) RGB image of reflectance channels; COCTS 11 μm scene BT after cloud detection. The gray in (a) and (c) represents land and white in (c) represents cloudy sky.

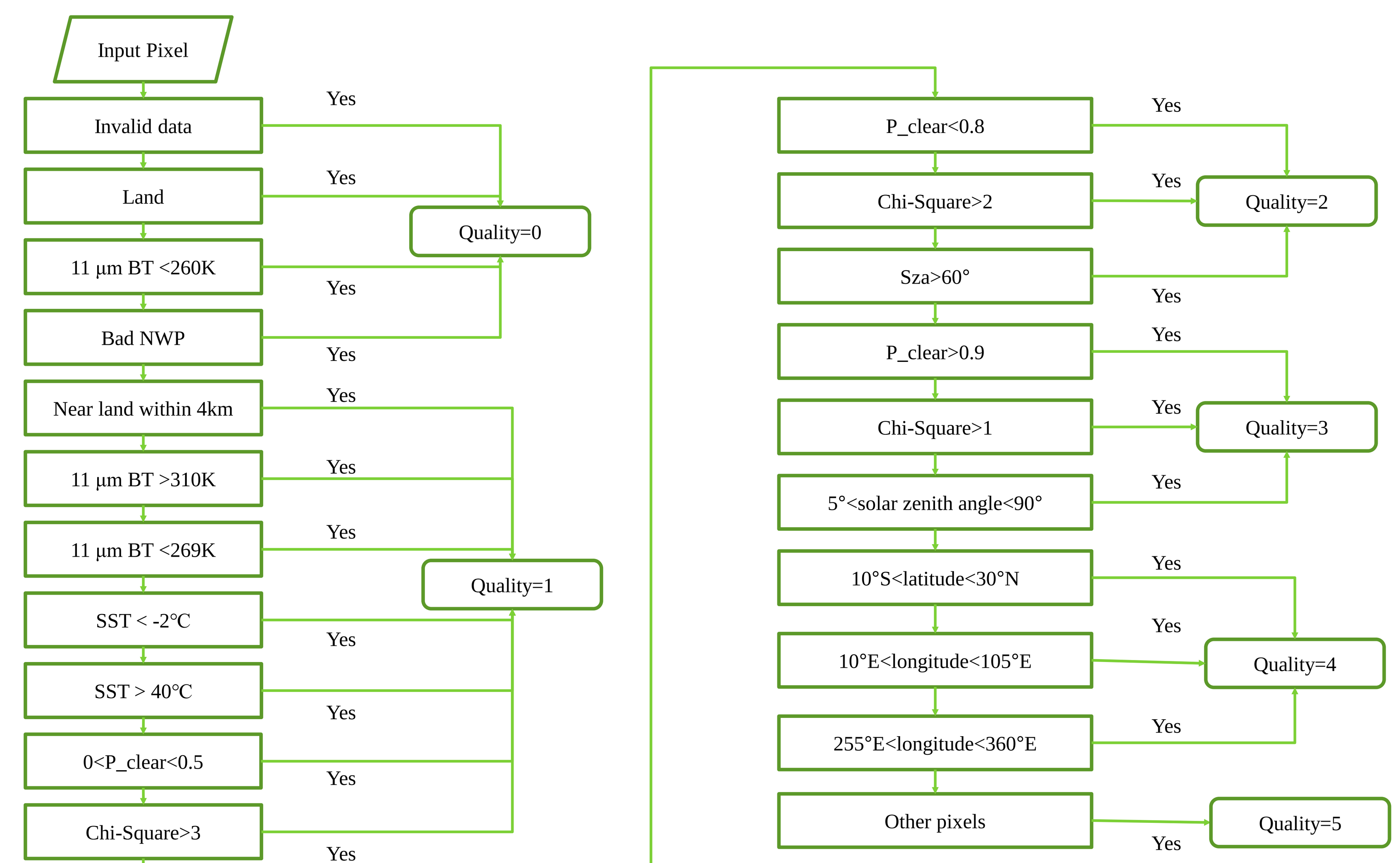

Fig. 2. Logic and thresholds for assigning pixel quality level to COCTS OE SSTs.

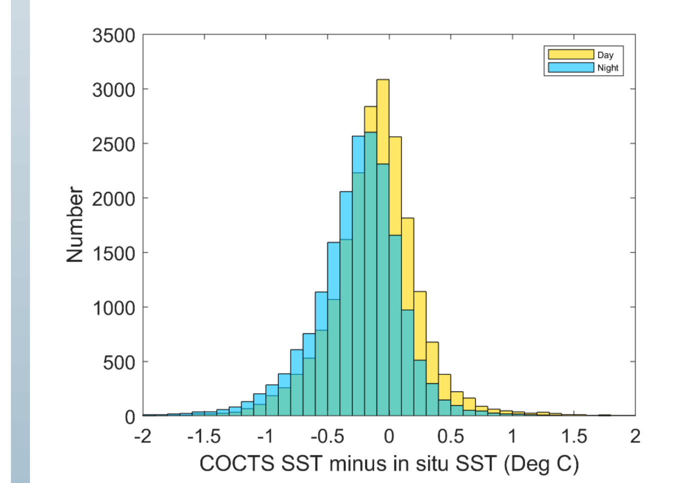

Fig. 3. The distribution of COCTS minus in situ SST difference

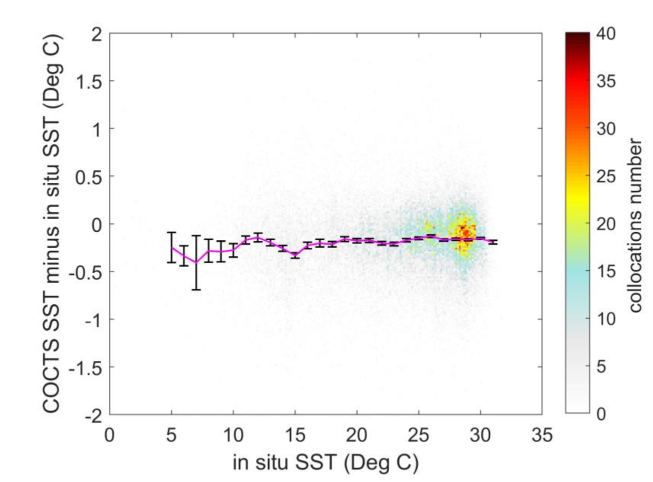

Fig. 4. The variations of COCTS minus in situ SST difference against in situ SST.

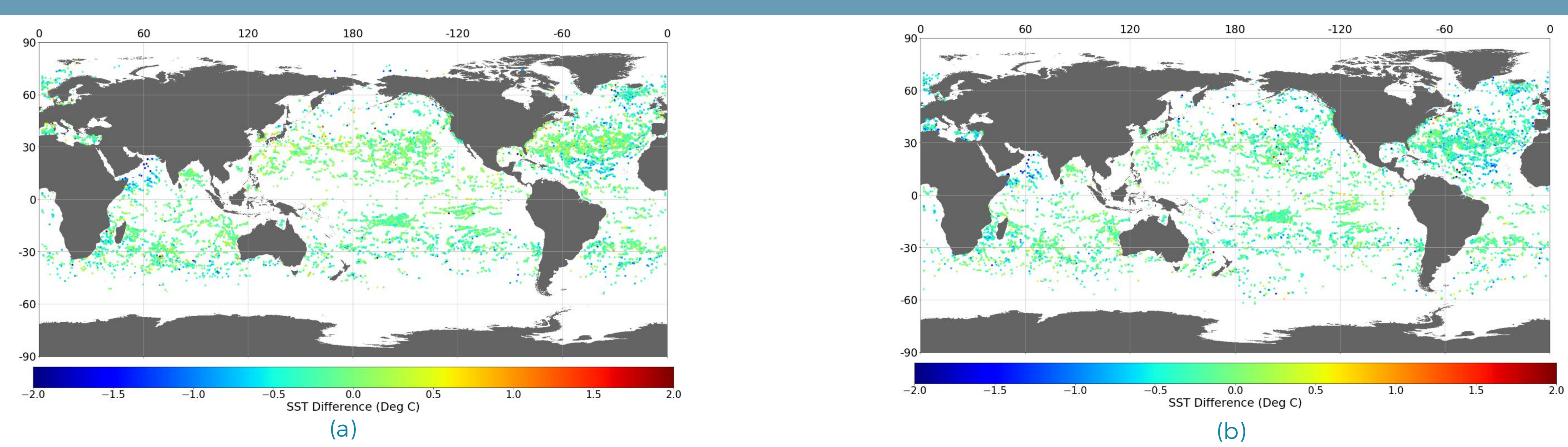

Fig. 5. The geolocation distribution of COCTS minus buoy SST difference: (a) daytime (b) nighttime

Optimal estimation SST retrieval

The COCTS global SSTs are retrieved by OE algorithm from July 2019 to August 2019. OE is the adjustment of the prior SST in the light of the difference between the observed BTs and the BTs that are simulated assuming the prior SST to be correct (Merchant et al., 2008, 2009, 2013). For OE SST retrieval, SST is estimated through a weighted combination of the prior SST and TCWV, and the difference between the observations and the simulated BTs given the prior field. The covariance matrix of prior and satellite observation, as well as the prior information are also necessary for SST estimation. A quality level on a scale 0 to 5 is provided for each SST. Quality level 5 indicates the highest quality. SST with quality levels 4 and 5 should be considered as high-accuracy data. Fig. 2 shows the flow of COCTS QC.

COCTS OE SST validation

In this research, iQuam in situ SSTs are used to validate COCTS OE retrieved SST. Here we select the COCTS OE SSTs that are assigned quality levels of 4 and 5 for detailed validation. COCTS OE SSTs are collocated with iQuam in situ measurements. The temporal window of matchups is set as 1 hour and the spatial window is 0.01°×0.01°. Comparison of COCTS OE SST with in situ SST showed that the COCTS SSTs are cooler than in situ measurements by −0.18 °C on average, and the standard deviation (SD) of differences was 0.38 °C. The median of COCTS minus in situ SST difference is -0.15 °C and the robust standard deviation (RSD) is 0.29 °C. The main reason of the negative SST difference is the observation depth difference between COCTS and buoy. These validation results of COCTS OE SST demonstrated that Bayesian cloud detection and OE SST retrieval algorithm worked well for HY-1C COCTS.

Table I. Comparison results of COCTS minus in situ SST difference

	Bias (°C)	STD(°C)	median(°C)	RSD(°C)	number
Daytime	-0.11	0.37	-0.10	0.28	20593
Nighttime	-0.26	0.37	-0.22	0.29	18798
All	-0.18	0.38	-0.15	0.29	39391