Sea surface temperature retrieval from HY-1D COCTS observations

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Abstract

The Haiyang-1D (HY-1D) satellite is an operational ocean satellite, and the Chinese Ocean Color and Temperature Scanner (COCTS) onboard it can be used for sea surface temperature (SST) observations. In this study, the SST retrieval algorithm was based on atmospheric radiative transfer modelling using 11μm and 12μm channel brightness temperature (BT). Representative ERA5 profiles containing SST and atmospheric state information were selected, which were used as the inputs for the BT simulation by MODerate resolution atmospheric TRANsmission (MODTRAN). The COCTS BT were inter-calibrated with the Visible Infrared Imaging Radiometer Suite (VIIRS) BT before applying to the SST retrieval algorithm. The cloud detection was performed using COCTS visible and infrared channel data, retrieved COCTS SST, and the reference SST. The global COCTS SST in May 2021 was retrieved in this study. The comparisons between the COCTS SST and the in situ SST were carried out. The bias was -0.18 ℃, the standard deviation was 0.55 ℃, the median was 0.15 ℃, the robust standard deviation was 0.51 ℃.

Introduction to HY-1D COCTS

Figure 1. HY-1D satellite (http://www.nsoas.org.cn/news/node_44.html)

HY-1D satellite was launched on June 11, 2020. The time of the descending node is 1:30±30min in the afternoon.

Table 1. HY-1D COCTS spectrum specifications

Channel	Band Range (μm)
1	0.402 ~ 0.422
2	0.433 ~ 0.453
3	0.480 ~ 0.500
4	0.510 ~ 0.530
5	0.555 ~ 0.575
6	0.660 ~ 0.680
7	0.730 ~ 0.770
8	0.845 ~ 0.885
9	**10.30 ~ 11.30**
10	**11.50 ~ 12.50**

The nadir resolution of COCTS is less than 1.1 kilometers, and the scanning width is greater than 2900m.

Satellite and reanalysis data

Table 2. The Satellite and reanalysis data used in this study

Data		resolution	source
HY-1D/COCTS L1B data	11μm、12μm channel BT satellite zenith angle longitude latitude …	1.1km	NSOAS (National Satellite Ocean Application Service)
ERA5	skin temperature sea-ice cover Land-sea mask temperature specific humidity ozone mass mixing ratio …	0.25°	ECMWF (European Centre for Medium-Range Weather Forecasts)
OSTIA	OSTIA SST OSTIA sea ice fraction	0.05°	CMEMS (Copernicus Marine Environment Monitoring Service)

Selection of representative atmospheric profiles

In order to obtain a high-precision SST retrieval algorithm, the representativeness of the atmospheric profiles used to fit the retrieval coefficients is very important. The representativeness refers to the large differences between the atmospheric profiles, including the temperature, specific humidity and ozone mass mixing ratio. The time range of ERA5 data was 0, 6, 12, and 18h on the 1st and 15th of each month in 2020.

The process of profiles choosing is shown in Figure 2. Figure 3 is the spatial distribution of 11μm and 12μm channel BT difference of choosing profiles.

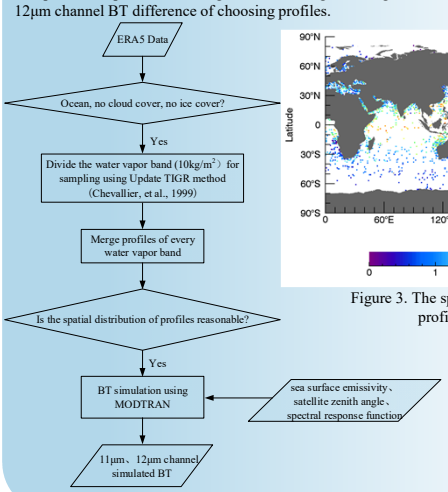


Figure 2. The process of profiles choosing

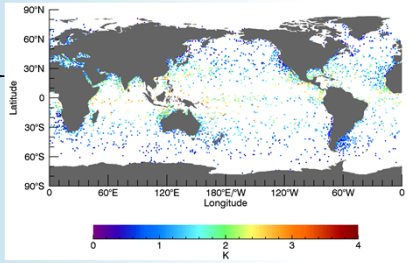


Figure 3. The spatial distribution of choosing profiles (BT difference)

SST retrieval algorithm

Based on the obtained simulated BT and ERA5 skin temperature, the coefficients of the retrieval algorithm at every latitude band were obtained. The latitude bands were: 90°S ~40°S, 40°S~20°S, 20°S~0, 0~20°N, 20°N~40°N, 40°N~90°N. The algorithm model we used was NLSST (Walton, et al., 1998). The formula is:

$$SST = a_1 + a_2 T_{sfc}\left(T_{11} - T_{12}\right) + a_3\left(BT_{11} - BT_{12}\right)\left(\sec\theta_v - 1\right) + a_4$$

where SST is the retrieved SST, T_{sfc} is the estimated value of SST, MCSST was used in this study, θ_v is the satellite zenith angle, and a1~a4 are the coefficients of the SST retrieval algorithm.

Two-thirds of the data set was used for fitting, and one-third of the data set was used for validation. The bias of the validation data set was near 0, and the standard deviation was 0.45℃.

The SST retrieval was performed using COCTS 11μm and 12μm channel BT after inter-calibration with VIIRS. During the retrieval, the latitude bands of the pixels were judged, and the SST retrieval algorithm corresponding to the latitude band was used. In order to reduce the discontinuity at the edge of the latitude band, the weighted average of the SSTs of two adjacent latitude bands was used within 2.5° of the latitude boundary.

Cloud detection

The threshold method was used for cloud detection in this study. Figure 4 is the process of cloud detection. Figure 5 is the 11μm channel BT before and after cloud detection on May 4, 2021 .

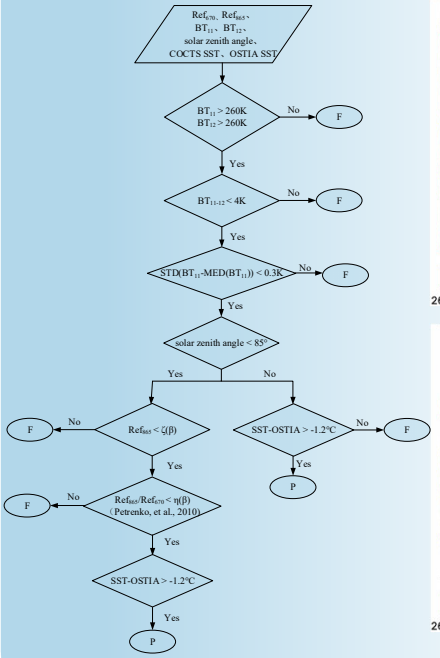
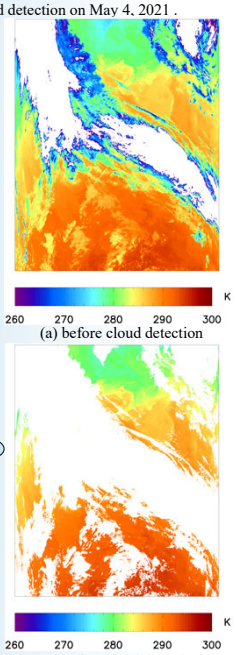


Figure 4. Cloud detection process (P means pass, F means fail)



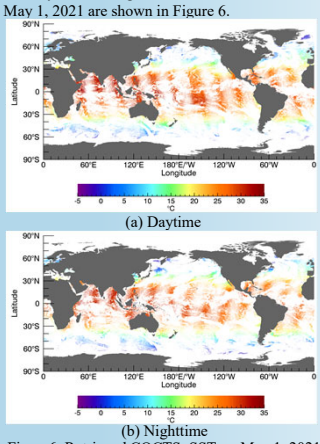
(a) before cloud detection

(b) after cloud detection

Figure 5. 11μm channel BT before and after cloud detection on May 4, 2021

Results and validation

The daytime and nighttime retrieved COCTS on May 1, 2021 are shown in Figure 6.



(a) Daytime

(b) Nighttime

Figure6. Retrieved COCTS SST on May 1, 2021

We compared retrieved COCTS SST with the in situ SST from iQuam data including drifters, high-Resolution drifters, tropical moorings, and Argo floats. The time window was 1 hour and the space window was 0.01°× 0.01°. There were 24963 matchups after removing the matchups greater than three standard deviations. The bias was -0.18 ℃, the standard deviation was 0.55 ℃, the median was 0.15 ℃, the robust standard deviation was 0.51 ℃. The histogram distribution of bias is shown in Figure 7.

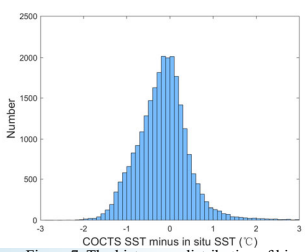


Figure 7. The histogram distribution of bias

Summary and future works

- SST retrieval algorithm has been obtained based on the ERA5 atmospheric profile, and then cloud detection and SST retrieval has been performed using HY-1D/COCTS L1B data.
- Analyze the factors that cause bias and then analyze if there is a possibility of improving the algorithm.
- HY-1D/COCTS SST retrieval for long time series.
- Compare HY-1D/COCTS SST with in situ skin SST .

References

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