1D-Variational based Retrieval of SST from INSAT-3D Imager

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1. Abstract

The present paper deals with the retrieval of sea surface temperature (SST) from INSAT-3D Imager observations using statistical regression method, followed by 1D-Variational technique. The accuracy of the retrieved SST shows a significant improvement over the SST retrieved using regression technique alone. A good match is also observed in the diurnal variation of SST when compared with the in-situ SST measurements.

2. Introduction

Sea surface temperature is an essential variable to study the earth's climate projections. It is one of the important parameters required for understanding of various physical oceanic processes. Therefore, the accurate estimation of SST is extremely important. The present study exploits the 1D-Variational method for the improved estimation of SST from INSAT-3D Imager's split-window observations.

3. Data used

- INSAT-3D Imager L1B data products (Brightness Temperatures, geolocation, satellite zenith angle, etc.) from MOSDAC at https://mosdac.gov.in.
- In-situ measurements of SST acquired from IQuaM portal of NOAA available at https://www.star.nesdis.noaa.gov/sod/sst/iquam.
- Moderate Resolution Imaging Spectroradiometer (MODIS) derived SST products acquired from http://oceancolor.gsfc.nasa.gov.
- Forecast SST fields from Numerical Weather Prediction Model: Global Forecasting System (ftp://nomads.ncdc.noaa.gov/GFS/)

4. Methodology

Two-step retrieval: regression + 1D-Variational technique

First step: Regression analysis applied on split-window observations from INSAT-3D Imager as given by Walton et al. (1998)

$$SST = a_0 + a_1 T_1 + a_2 (T_1 - T_2).SST_{guess} + a_3\,(sec\theta - 1).(T_1 - T_2) \quad (1)$$

Where, SST is the satellite derived SST estimate, T_1 and T_2 are the brightness temperatures of INSAT-3D thermal channels (TIR-1 and TIR-2), and SST_{guess} is a first-guess of SST (NWP model forecast).

Second step: Implementation of 1D-Variational technique

$$x_a = x_b + BH^T(HBH^T + R)^{-1}(y - H(x_b)) \quad (2)$$

Where, x_a is the best estimate of desired variable, x_b is the first guess, B is the background error-covariance matrix, R is the observation error covariance matrix, H is the forward operator.

We have used retrieved SST using regression technique as observation (y) and model forecast SST as background (x_b). Since y and x_b are corresponding to the same location, the forward operator H will be an identity operator. Hence, eq. (2) can be rewritten as:

$$SST_a = \left(\frac{R}{B+R}\right) SST_{fcst} + \left(\frac{B}{B+R}\right) SST_{reg} \quad (3)$$

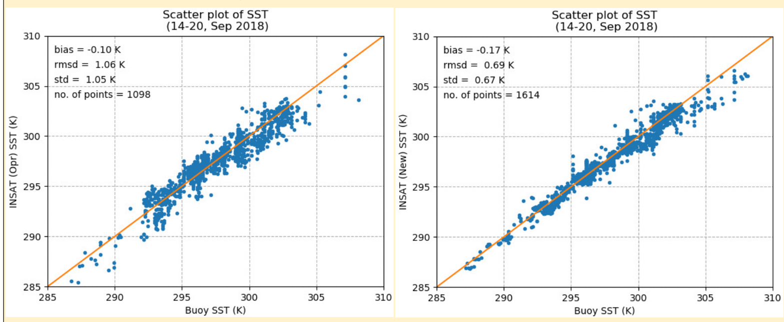
Here, SST_a is the final estimate of SST, SST_{fcst} is the first guess of SST (x_b) taken from NWP model forecast, SST_{reg} is the SST retrieved from equation (1). R and B respectively, are the diagonal elements of the error covariance matrices of the retrieved SST (Regression) and first-guess SST (forecast).

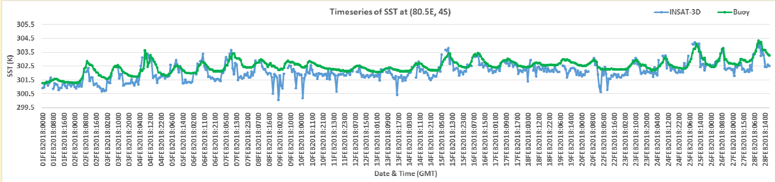
5. Validation

- SST retrieved using equation (3) from INSAT-3D Imager observations and validated with the in-situ observations as well as MODIS derived SST products.
- The matchup dataset has been prepared by collocating both the observations. The collocation criterion: Δx=4 km, Δt=15 minutes

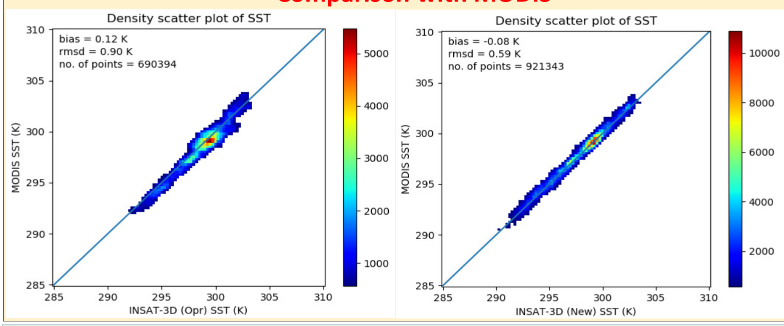
6. Results

Comparison with in-situ observations





Comparison with MODIS



7. Conclusions

- 1D-Variational based retrieval algorithm shows significant improvements over the regression based retrieval.
- A limited validation with in-situ measurements show an accuracy of 0.67K.
- An accuracy of 0.59K in the retrieved SST is observed when validated against MODIS SST.
- The diurnal variation in the retrieved SST is showing a good match with buoy SST, except during the mid-night hours due to calibration problems in GEO satellites .

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Reference

- *Walton, C. C., W. G. Pichel, F. J. Sapper, and D. A. May, (1998), "The development and operational application of nonlinear algorithms for the measurement of sea surface temperatures with NOAA polar orbiting environmental satellites." Journal of Geophysical Research, 103: 27999 – 28012.*

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