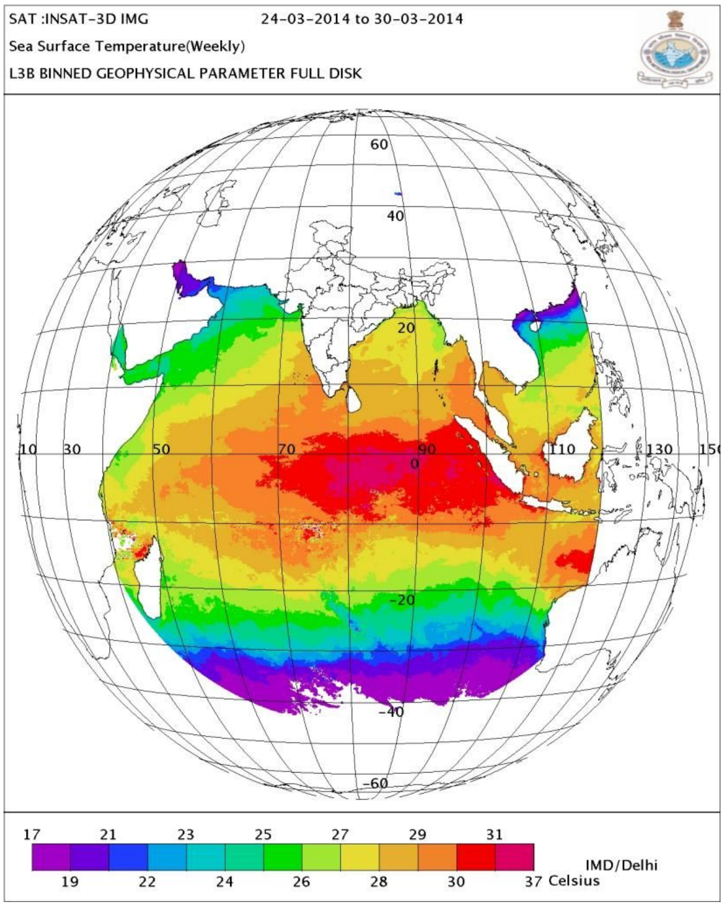
SAC/EPSA/AOSG/SR/32/2015

Validation Report on Sea Surface Temperature from INSAT-3D Imager observations



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Space Applications Centre (ISRO), Ahmedabad

&

India Meteorological Department, New Delhi

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8	Originating Unit	Space Applications Centre, Ahmedabad * IMD, Delhi
9	Abstract	In the present study, INSAT-3D SST derived for the duration of one year(July 2014– June 2015) using thermal split window channels (TIR-1 and TIR-2) data for every half an hourly acquisition has been validated with near simultaneous skin temperature as obtained from Moderate Resolution Infrared Spectro-radiometer (MODIS) onboard TERRA and AQUA satellites. Analysis of the preliminary validation with MODIS-SST indicates that bias corrected root mean square difference (STD) of INSAT-3D SST is ~1 K and ~1.3 K during daytime and nighttime respectively on instantaneous basis. In general, INSAT-3D SST is having a cold bias($SST_{INSAT3D}$ – SST_{MODIS}) which is comparatively more (~0.8K) in morning while afternoon and evening times have lesser (~0.4K) cold biases. Warm bias in higher ranges of SST(> 30º C) is also noticed during this validation period especially in nighttime.
10	Classification	Restricted
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1.0 Summary

The INSAT-3D Sea Surface Temperature (SST) geophysical product (GP), a fast-delivery level-2 product at 0.05º X 0.05º resolution, is being generated operationally for every half an hourly acquisition since the Imager Payload was commissioned on 1st October 2013. In the present study, INSAT-3D SST derived for the duration of one year(July 2014– June 2015) using thermal split window channels (TIR-1 and TIR-2) data for every half an hourly acquisition has been validated with near simultaneous skin temperature as obtained from Moderate Resolution Infrared Spectro-radiometer (MODIS) onboard TERRA and AQUA satellites. Analysis of the preliminary validation with MODIS-SST indicates that bias corrected root mean square difference (STD) of INSAT-3D SST is ~1 K and ~1.3 K during daytime and nighttime respectively on instantaneous basis. In general, INSAT-3D SST is having a cold bias($SST_{INSAT3D}$ – SST_{MODIS}) which is comparatively more (~0.8K) in morning while afternoon and evening times have lesser (~0.4K) cold biases. Warm bias in higher ranges of SST(> 30º C) is also noticed during this validation period especially in nighttime. Higher standard deviations with respect to MODIS SST in night are likely to be attributed to Sun intrusion into the payload and blackbody causing calibration perturbations. In order to avoid erroneous SST retrievals and in-turn improve upon the accuracy, some remedial measures are suggested.

2.0 Introduction

(i) INSAT-3D SST operational retrieval

India on 26th July 2013 successfully launched its advanced meteorological spacecraft INSAT-3D by Ariane-5 launch vehicle from the spaceport of Kourou in French Guiana and parked at 82˚E. INSAT-3D is designed for enhanced meteorological observations, monitoring of land and ocean surfaces, generating vertical profile of the atmosphere in terms of temperature and humidity for weather forecasting and disaster warning. It carries four payloads viz. 6 channel multi-spectral Imager, 19 channel Sounder, Data Relay Transponder (DRT) and Search and Rescue Transponder. For sea surface temperature (SST) measurement, Imager has two split window channels (10.3-11.3 µm and 11.5-12.5 µm) and a mid-IR channel (3.8-4.0 µm) with 4 km ground resolution. As far as SST retrieval algorithm development for INSAT-3D is concerned, pre-launch activities involved developing a comprehensive radiative transfer simulation based database of INSAT-3D thermal channels observations for tropical Indian oceans and atmospheric conditions taking into accountvarious channels characteristics such as central frequencies, bandwidth, sensor response functions and noise equivalent temperatures, developing a suitable SST retrieval algorithms and then extensive testing of SST retrieval algorithm on various observations from similar sensors onboard e.g. FY-2D and FY-2E. Post-launch operations included characterization of various payload instruments for first few months which basically involves checking of consistence accuracy of thermal channels through Global Space-based Inter-calibration System (GSICS). Thermal Imager channels level-1B data was available in October, 2013 after first level of commissioning phase. Since then INSAT-3D level-1B and geophysical parameters data including sea surface temperature are being generated operationally and have been released for internal users.

The INSAT-3D Geophysical Product SST (IMDPS Product Code L2B_SST) is a fast delivery level-2 product designed for use in meteorological studies, which contains skin SSTs in cloud-free 0.05-Deg cells. SST product is being generated in near real time for every half hourly acquisition. Daily, weekly, monthly and seasonal SST products arealso available from India Meteorological Department website (www.imd.gov.in). Some of the products on near real time basis are also available from Meteorological and Oceanic Sciences Data Archival and Dissemination Centre (MOSDAC) website (www.mosdac.gov.in). Cloud detection being very crucial for SST retrievals, has been performed using threshold based and spatial coherence techniques (Coakley and Bretherton 1982).Thresholding technique assumes that over oceans in Indian domain brightness temperature in thermal band(TIR-1) is greatly affected by the presence of clouds, resulting in decreased brightness temperature from cold cloud tops. Spatial coherence method is based on the assumption that SST is homogeneous and warmer than clouds; thus clouds can be identified where the scene brightness temperature has lower mean value or larger standard deviation. Further, the cloud flags generated by cloud mask routine are also used to detect the clouds. The SST retrieval uses IMDPS's pre-launch satellite zenith angle based retrieval coefficient sets, for both day and night (Mathur et al, 2006). SST at each cloud-free pixel is retrieved using the equation

$$SST = A_0 + A_1T_{11} + A_2dT + A_3dT^2 \quad (1)$$

Where A_0, A_1, A_2 and A_3 are coefficients determined by simulation and have satellite zenith angle dependence

$dT = T_{11} – T_{12}$

T_{11} and T_{12} are brightness temperatures for the split-window channels.

In each case i.e. day and night, only TIR-1 and TIR-2 data are used in order to avoid relatively more noisy mid-IR channel (3.6 - 3.9 µm) data and therefore preliminary validation does not include SST retrieval using 3.9µm data. All the SST observations are passed through a stringent check with respect to 20 years weekly climatological SST (Reynolds et al, 2002).A typical weekly SST map generated using INSAT-3D thermal split window channels is shown in Figure 1 and the processing flow chart of SST retrieval is shown in figure 2.

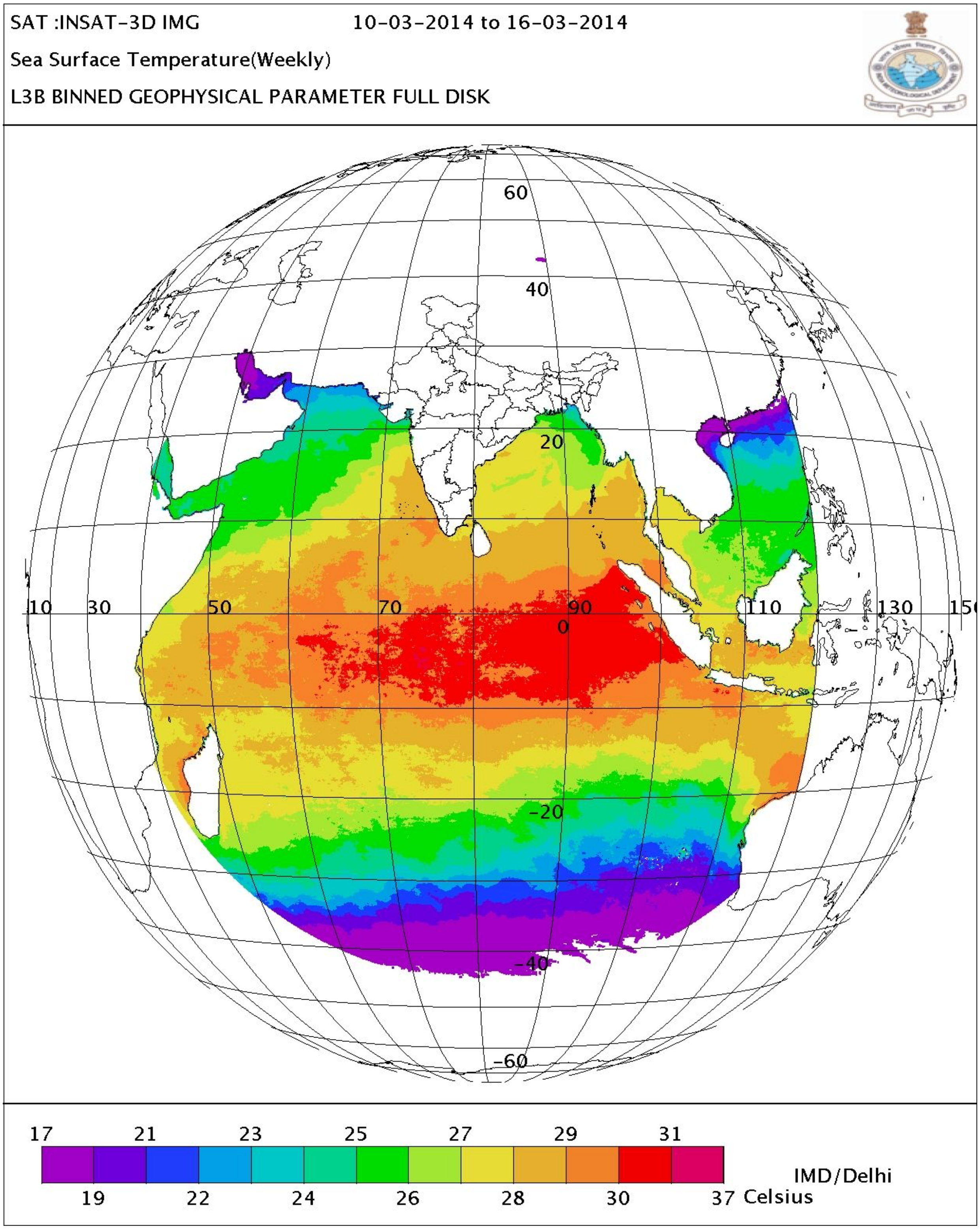


Figure 1: Typical weekly composite of SST derived from INSAT-3D thermal channels.

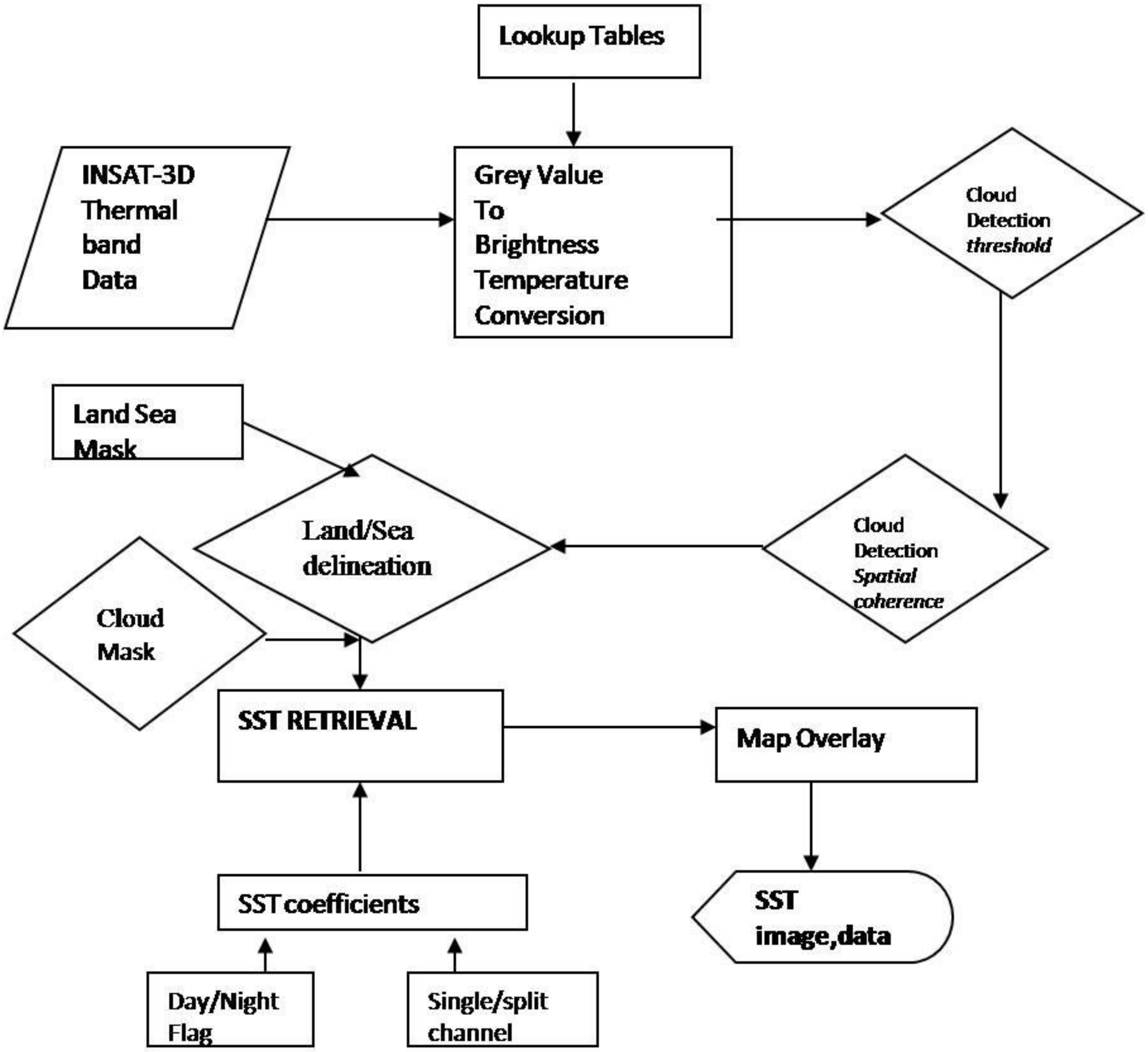


Fig.2 Flowchart of SST processing software for INSAT-3D

(ii) ***AQUA-TERRA-MODIS- Swath SST data***

The purpose of MODIS SST is to provide high quality global measurements of this parameter. MODIS SST is superior to AVHRR SST due to the higher sensitivity and lower signal-to-noise characteristics of the MODIS instrument (Brown and Minnett 1999, Kohtaro et al, 2007). The mid-IR channels are especially useful in the high water vapor, low-latitude regions compared with previous radiometers. They are also less susceptible to aerosol contamination compared to the 11-12 µm channels (Minnett et al, 2004).

The sea surface temperature (SST) product provides sea surface temperature at 1-km (Level 2)

and 4.6 km, 36 km, and 1° (Level 3) resolutions over the global oceans. This product consists of four global SST fields: daytime (D1) and nighttime (N1) SST derived from the 11-micron channel and daytime (D2) and nighttime (N2) SST derived from the 4-micron channel. In addition, a quality-assessment parameter is included for each pixel. The Level 2 product is produced daily and used to generate the gridded Level 3 products daily, 8-day, monthly, and yearly for day and night conditions. A quality parameter is provided for each data set.

Derived from radiance measurements collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments aboard NASA's Terra and Aqua satellites, the sea surface temperature (MOD28) is an estimate of the warmth of the ocean's "skin" (top millimeter). The algorithm uses multiple atmospheric window techniques to estimate the atmospheric parameters that are required to compensate for absorption and scattering of energy radiated and reflected by the ocean. The bulk temperature of the near-surface ocean is the temperature of the upper 10-20 cm to 1 meter as measured by conventional thermometers on buoys and ships. Extensive analysis has been done of satellite and *in situ* data to enable the algorithm to estimate bulk temperature as well as skin temperature.

Sea surface temperature determination is based on MODIS-calibrated mid- and far-infrared (IR) radiances (Bands 20, 22, 23, 31, and 32 from MOD02) using an algorithm that exploits the differences in atmospheric transmissivity in the different IR bands to enable highly accurate estimation of the atmospheric effects. A land mask is used to mark non-water pixels while an ice-extent mask limits polar sea coverage. A sequence of spatial and temporal homogeneity tests is applied to validate the quality of the cloud-free observations. Sun glint is a significant source of error in the mid-wave IR bands, so the cloud mask product is critical to identifying glint pixels as is sea surface wind ancillary data that are used to estimate the magnitude of the glint area radiance.

The daytime SST derived from the 4-micron channel (D2) is affected by reflected solar radiation, and therefore the D1 (11 micron) SST is preferable for daytime applications. During the night, the surface ocean is more homogeneously mixed, and thus the skin temperature is more representative of the bulk upper-layer temperature. The N2 has a higher signal-to-noise ratio than N1, but both fields are validated. In the present validation exercise MODIS swath data with 1 km resolution has been used and re-gridded to 0.04 X 0.04 deg to match INSAT-3D pixel resolution.

2.1 *Methodology for match-up database generation*

Before retrieval of SST over any pixel, INSAT-3D brightness temperature data for both the split thermal window channels are checked for land/ocean mask, cloud detection, upper and lower thresholds, differential check, satellite zenith angle and solar zenith angle(presently this check is disabled, but will be used when MIR channel is used for SST retrievals during nighttime). SST thus retrieved undergoes a climatological SST check. The climatological SST dataset is prepared from NOAA-AVHRR and buoy observations of 1981-2001 and is known as Reynolds SST climatology. Since MODIS SST has been very well validated for global oceans and represent best as far as satellite derived ocean skin temperature is concerned, this product was chosen to validate INSAT-3D derived SST. The spatial and temporal collocation criterion for INSAT-3D derived SST at pixel resolution with respect to MODIS-SST was 0.05º and ±30 minutes. Accordingly MODIS-SST swath data was also regridded to 0.05º. Mean bias and Root mean square deviation (RMSD) were calculated as per the following formulae:

$$MeanBias = \frac{1}{N}\sum_{i=1}^{N}\left(SST_{INSAT3D} - SST_{Buoy}\right)$$

$$RMSD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(SST_{INSAT3D} - SST_{Buoy}\right)^{2}}$$

3.0 Results

3.1 Overview of operational retrieval of SST

SST plots of half hourly and daily sea surface temperature from the INSAT-3D product have been produced throughout the validation period. Half hourly SST map for 27 January 2014, 0500 GMT has been shown in Figure 3. As an example the daily averaged SST maps for 7, 13 and 16 October 2014 are shown in Fig. 4-6. Figure 4 shows SST map for 7th October 2014 with normal SST conditions prevailing over north Bay of Bengal and depicting around 30ºC SST. On 12th October 2014 cyclone ‘HUHUD’ hit the Vishakhapatnam coast. Very heavy rainfall and high winds caused coastal Bay of Bengal to cool rapidly. Figure 6 showing the SST map for 13th October 2014 clearly captured such a strong cooling near Vishakhapatnam coast(26ºC as compared to 30ºC on 7th October). Approximately 2-3ºC cooling is also seen in the vicinity of the landfall of the cyclone ‘HUDHUD’ around Andhra and Orissa coast Post cyclone time. On 16th October (Figure 6) SST has been recovered to its normal condition. Cooling in the North Arabian Sea during this time of the year is also clearly visible. Persistent cloud cover on this day over equatorial Indian Ocean also inhibits the SST retrieval.

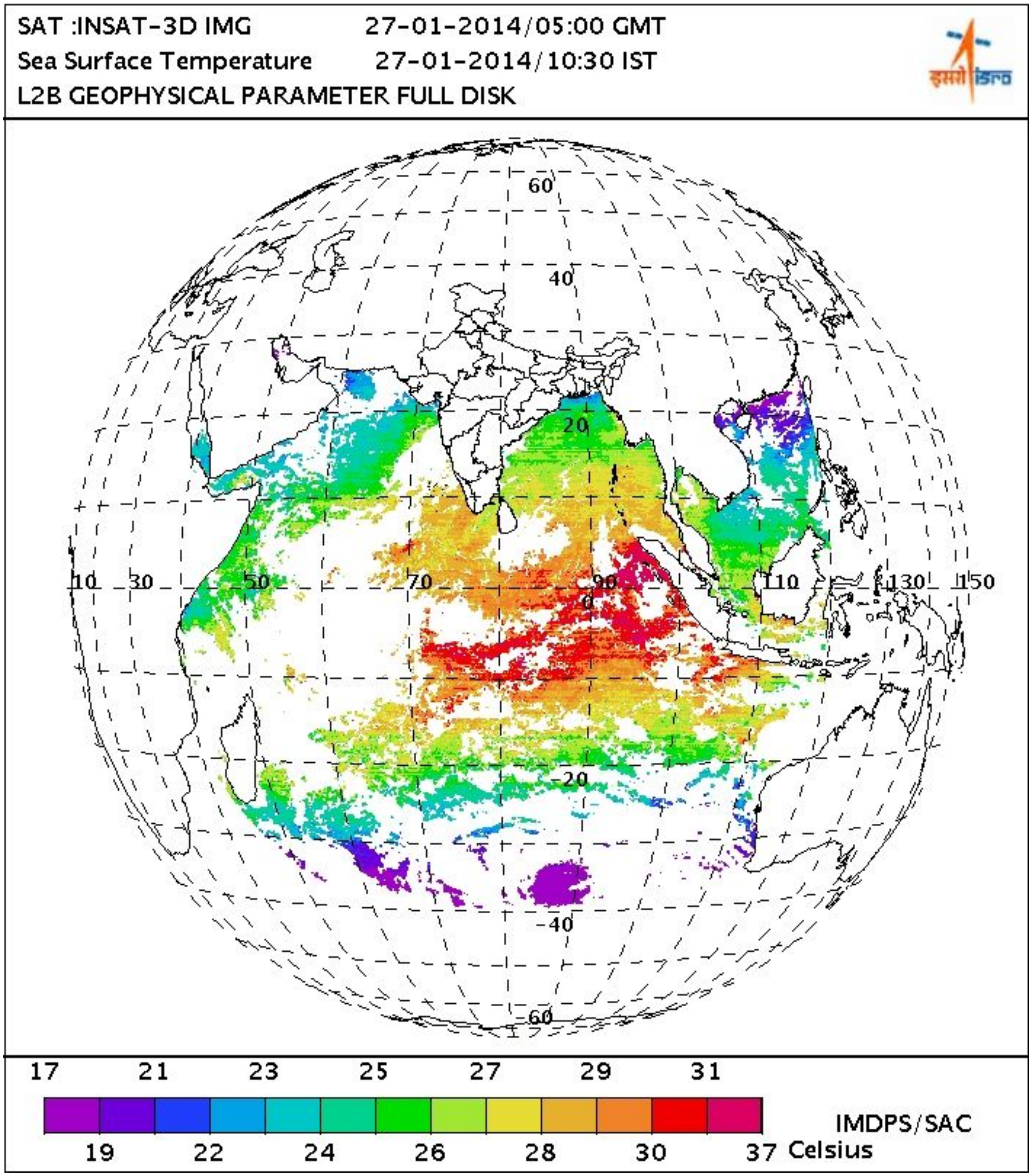


Fig 3: Half hourly SST image from INSAT-3D for 27 January 2014, 0500GMT

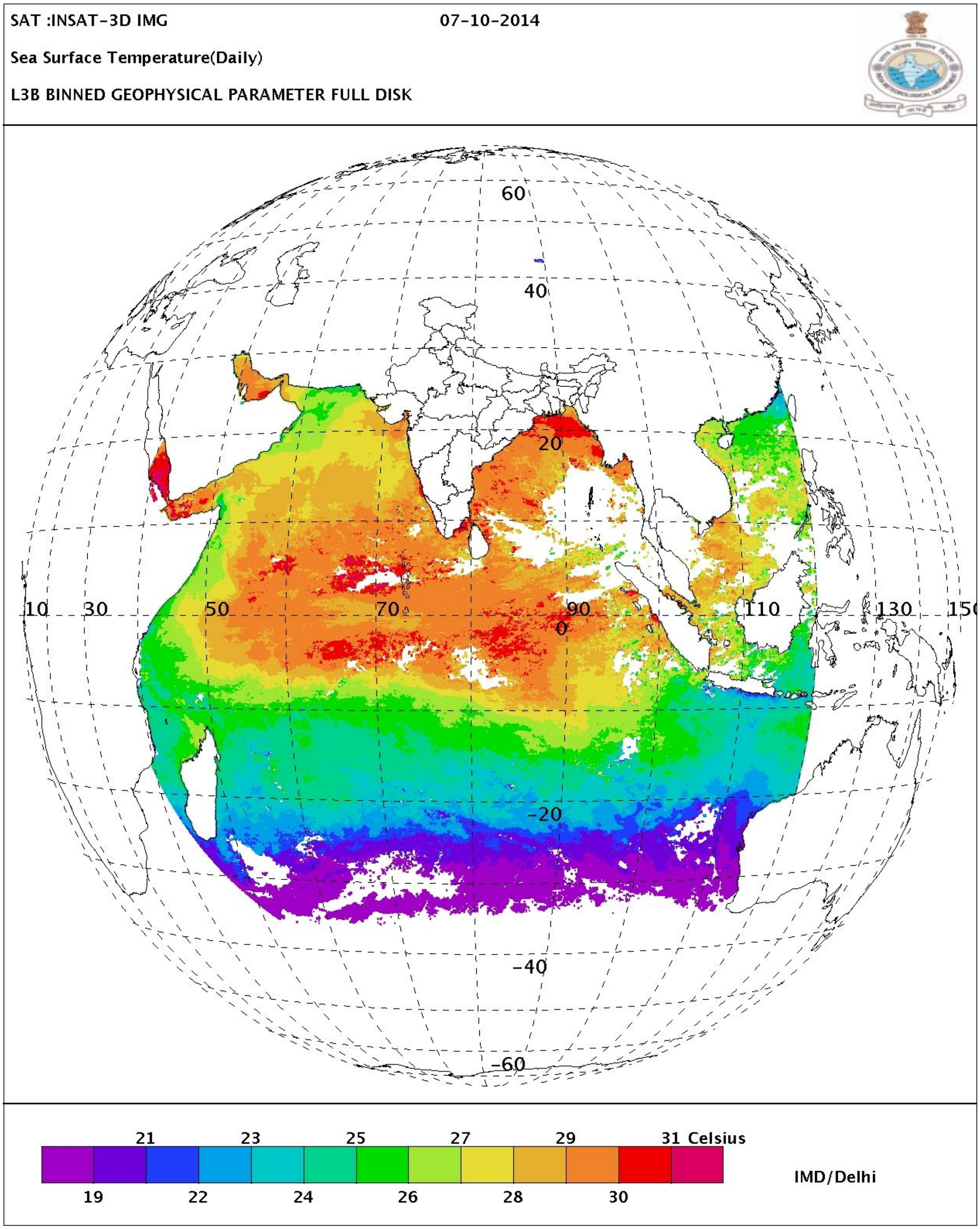


Fig 4: Daily averagedSST image from INSAT-3D for 7 October 2014
(5 days before cyclone 'HUDHUD' landfall)

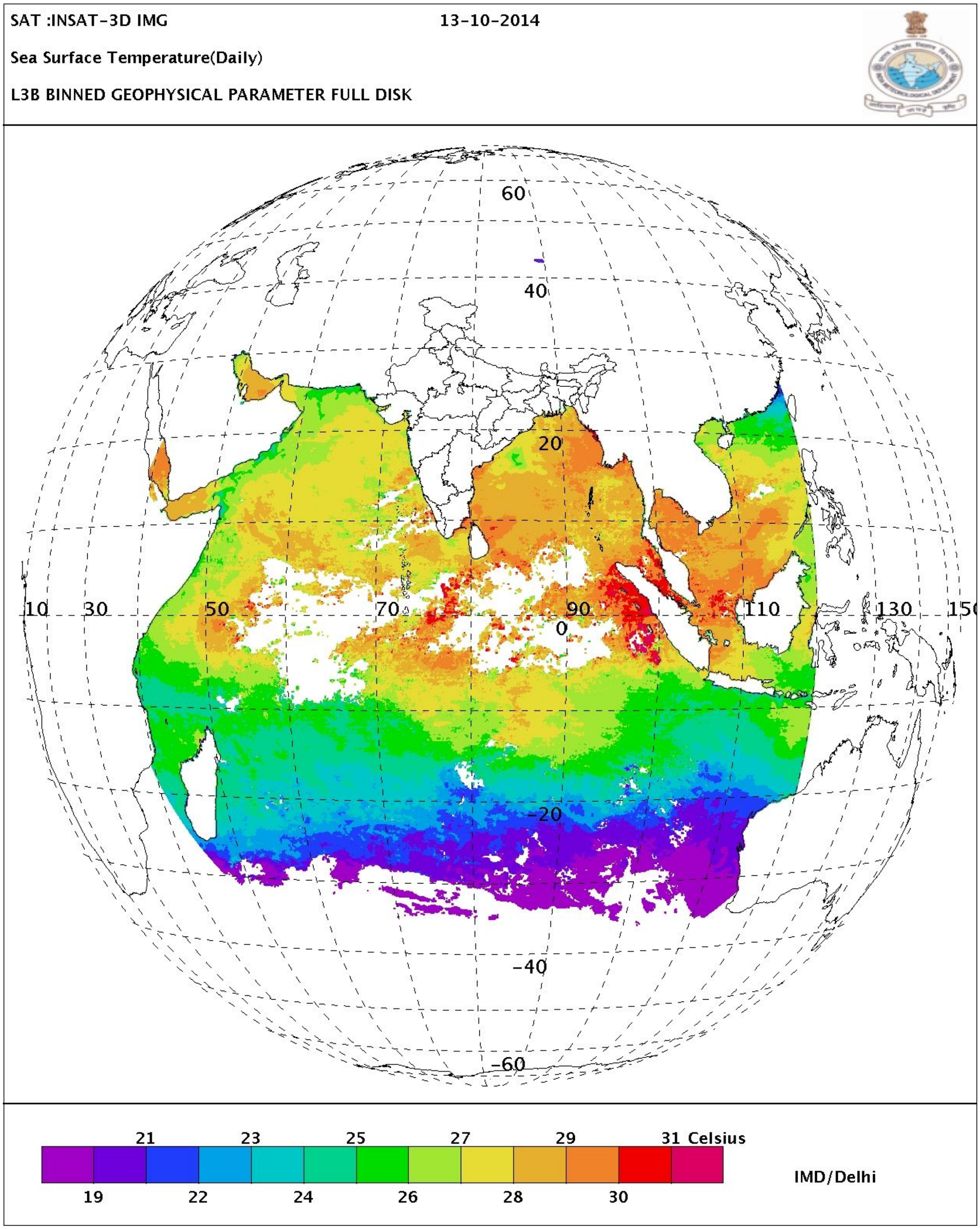


Fig 5: Daily composite SST image from INSAT-3D for 13 October 2014
(One day after cyclone HUDHUD landfall)

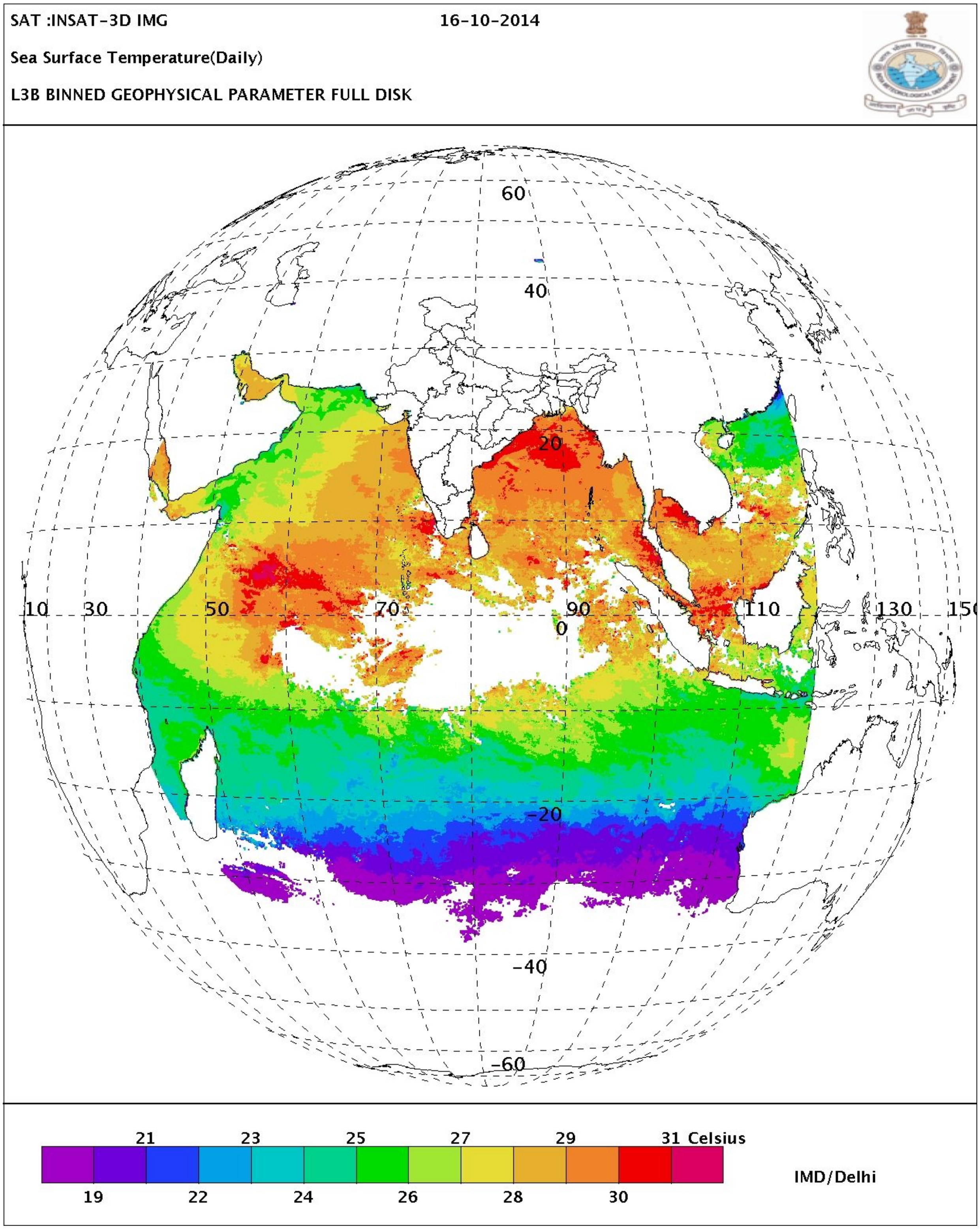


Fig 6: Daily averagedSST image from INSAT-3D for 16 October 2014
(4 days after cyclone HUDHUD landfall)

3.2Validation Results

As per the collocation criterion described in section 2.1, typical daily collocated SST maps from INSAT-3D (fig 7-Left image) and MODIS(Fig 7-Right image) for 1 June 2014 are shown in figure 3. Latitudinal thermal gradients in MODIS SST image are clearly replicated in INSAT-3D. There are certain regions like north-west Arabian Sea where INSAT-3D SST is slightly cooler than that from MODIS. And in fact, in general, most of the time INSAT-3D shows underestimation with respect to MODIS (figures 20-26). A plausible reason for this could be the difference in pixel resolution of INSAT-3D and MODIS and so poorer resolution leads to more uncertainty in cloud detection specially low level clouds with comparable temperature as of sea surface leading to cloud contamination in INSAT-3D SST pixels. Another reason for large cold bias in INSAT-3D SST around 1600 and 1700 hrs could be the Sun intrusion into the payload and blackbodies inside the spacecraft resulting into the failure of normal calibration coefficients for conversion of gray counts into radiance. Similar impact of Sun intrusion around these times is also seen in bias corrected RMSD (figure 9) where RMSD remains below 1 K in the early morning hours (0100 -1100 hrs GMT) but shoots up higher than 1K later.

Validation with MODIS-AQUA

Figures 8(a) to 13(a) show the mean bias of INSAT-3D SST with respect to MODIS/AQUA for all the half hourly acquisitions for July –November 2014 and March 2015 (0100 GMT bias as shown in graph is actually mean of 0100 and 0130 GMT for the entire month, similarly 0200GMT bias as shown in the graph is the mean of 0200 and 0230 GMT bias). All the graphs show a reasonably less cold bias (below 1K) between 0100 to 1100 GMT but exceeds 1K between 1200-2000GMT. In all the months it is also observed that the bias becomes positive (INSAT-3D SST is warmer than MODIS SST) after 2000 GMT. Figures 8(b) to 13(b) show the bias corrected root mean square deviation(RMSD) between INSAT-3D and MODIS SST. It can be easily concluded from all these figures that RMSD is nearly 1K or less from 0100to 1100 GMT and after that it gradually increases to more than 1.5K at around 2300 Hrs.

Validation with MODIS-TERRA

Inter-comparison of INSAT-3D and MODIS-TERRA SST has been shown in terms of mean Bias and bias corrected RMSD in figures 14(a) to 19(a) for July-November 2014 and March 2015. It is evident from the figures that mean bias is always negative (means INSAT-3D SST is colder than MODIS SST) and it is minimum (~0K) around 1100 and 1200 Hrs but varies between -1K to -2K at other times. For the months of July-September at 0500 hrs GMT there is no bias. As far as bias corrected RMSD is concerned the trend follows that of AQUA-MODIS and the mean RMSD is around 1K from 0100 GMT to 1200 GMT as shown in figures 14(b) to 19(b). The maximum mean RMSD is observed at around 2200 and 2300 GMT Hrs.

Comparison of Daytime and Nighttime Validation

In order to ascertain the difference in the performance of sensor as well as SST retrieval algorithms during daytime and nighttime, all the collocations between INSAT-3D and MODIS observations between 0100 and 1300 GMT were categorized as Daytime and the observations between 1330 hrs and 2330 hrs GMT were categorized as Nighttime. The typical density plots for September-October 2014 and March 2015 for AQUA as well as TERRA have been shown in figure 22-23. The density plots reveal that Daytime SST accuracies are marginally better than Nighttime. Figures 27-32 are the bar-chart drawn to show that for all the months, majority of the points lie in the range where INSAT-3D and MODIS SST have mean difference between -1K to 1K.

Monthly variation of bias and RMSD for one year

The monthly average variation of bias and RMSD(bias corrected) in INSAT-3D SST with respect to MODIS SST onboard AQUA and TERRA for one year(July 2014- June 2015) are shown in Figure 33 and 34. Upper and lower panel of each figure shows the variation for daytime and nighttime respectively. As evident from the figures, daytime RMSD with respect to MODIS-AQUA is ~1K for the entire year while nighttime RMSD reaches ~1.5K in the months of September 2014 and April-June 2015. Comparison with MODIS-TERRA also reveals almost similar trend except that RMSD for daytime is slightly more than that from MODIS-AQUA. Nighttime SST RMSD in this case also is marginally more than daytime RMSD for the entire one year i.e. July 2014 to June 2015.

4.0 Conclusions and Discussion

SST retrieval algorithm for INSAT-3D has been successfully implemented to generate SST maps on half hourly, daily, weekly and monthly time scale. Thermal gradients in INSAT-3D SST images match very well with the corresponding MODIS SST images. Also SST cooling due to ‘HUDHUD’ cyclone in Bay of Bengal has also been revealed through SST images over the affected region. Initial validation of INSAT-3D SST for one year (July 2014-June 2015) with corresponding MODIS skin SST shows that the accuracy of INSAT-3D SST is ~ 1K during daytime i.e. between 0100 and 1100 hrs GMT. The degradation in accuracy(~1.5K) during nighttime is also consistent for the entire one year and possibly it can be attributed to several factors viz. sun intrusion impact on onboard blackbodies and payload, lack of suitable GSICS calibration for conversion of radiance, problem of filtering out the low clouds and the performance of SST retrieval algorithm at the edges of the swath. Geo location errors in TIR-1 and TIR-2 channels can also lead to errors in making the match-up database between INSAT-3D and MODIS. In this validation exercise, satellite scan angle dependent collocation has not been carried out which can also lead to some differences in SST from INSAT-3D and TERRA/AQUA especially at the swath edges of both the satellites. Another difference in INSAT-3D and TERRA/AQUA is due to difference in respective pixel resolutions of the thermal channels. MODIS having 1 km pixel resolution has much better probability of filtering out the cloudy pixels in a FOV of 0.05 X 0.05 deg. In order to improve the cloud detection and in turn homogeneity in INSAT-3D SST fields, attempts are being made to retrieve SST in a FOV of 0.1 X 0.1 deg and initial results show significant improvement in accuracy. Further, during daytime cloud detection can be improved by using visible channel reflectance data. Due to the detector-to-detector non-uniform response in the Imager thermal channels, a horizontal striping impact is seen the TIR-1 as well TIR-2 images. This striping effect is enhanced when the difference of brightness temperatures in TIR-1 and TIR-2 are used as a multiplicative factor in SST retrieval algorithm causing striping in SST images. De-striping of thermal channels is undergoing Testing & Evaluation process and very soon the entire data will be reprocessed to get improved SST images. Therefore, it is strongly suggested that the information regarding the payload and blackbody performance should be incorporated in the operational chain of SST retrieval to check these suitable system parameters before proceeding for SST retrieval operationally. Further, GSICS calibration should be incorporated so as to work well for all the acquisitions in one day and thereby enabling SST retrievals for studying diurnal variation.

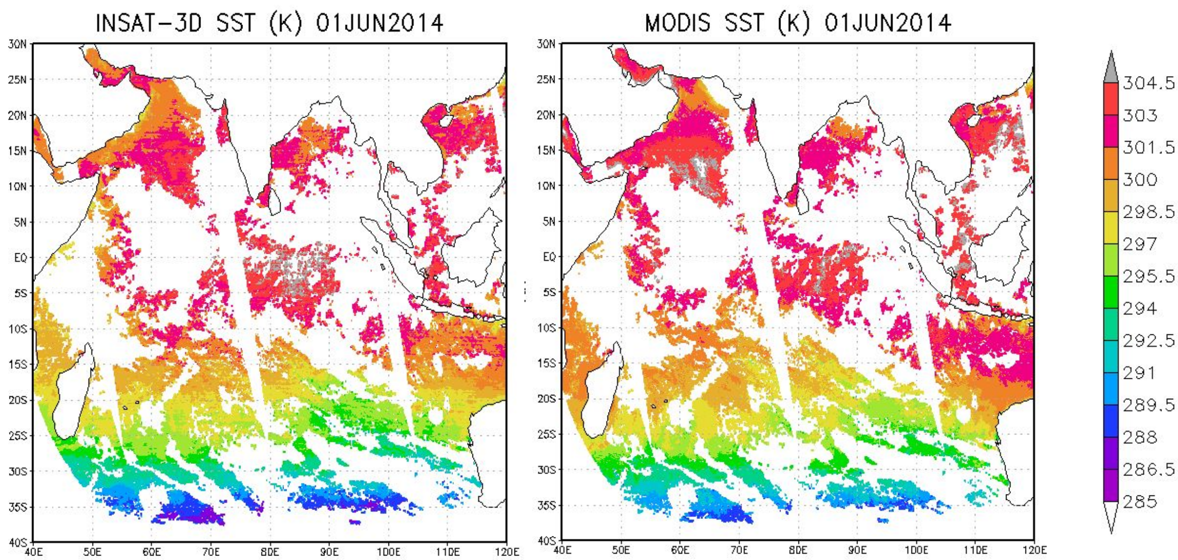


Fig.7: A typical collocated SST map from INSAT-3D and MODIS for 01 June, 2014.

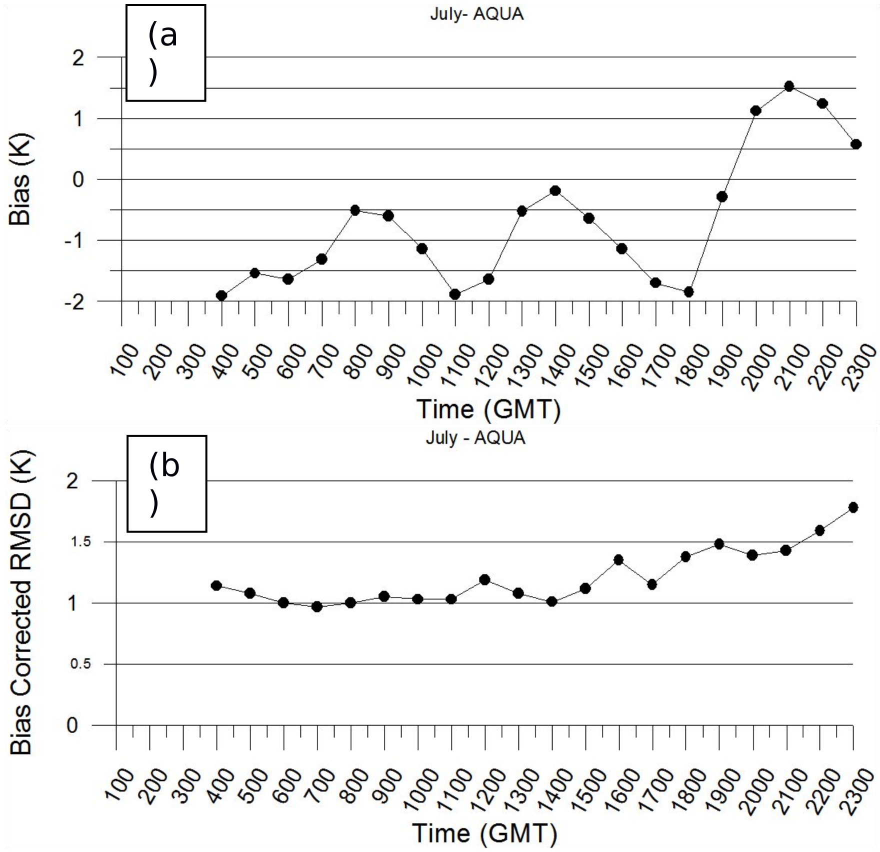
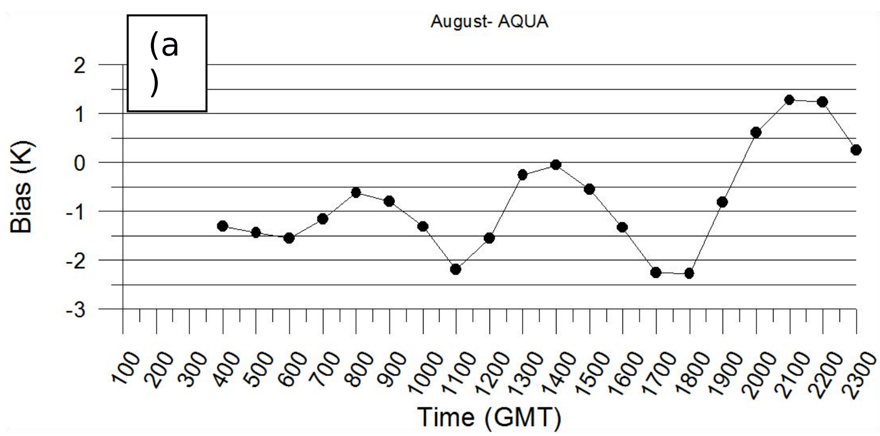


Figure 8: Bias and RMSD(bias corrected) of INSAT and MODIS_AQUA SST for July 2014



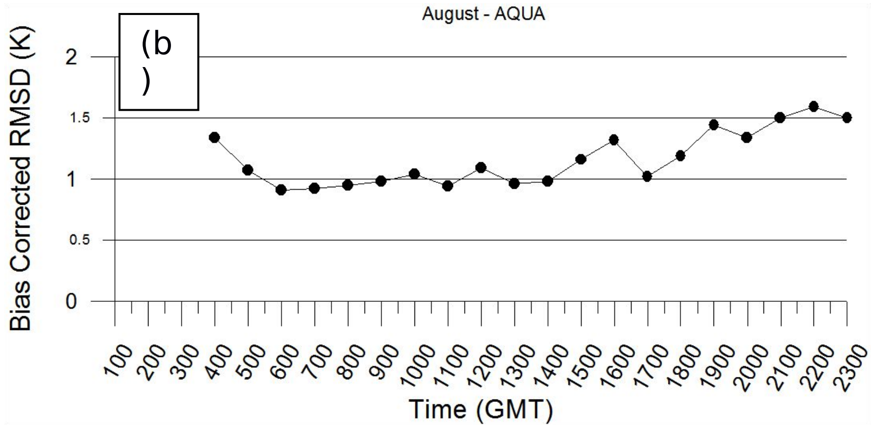
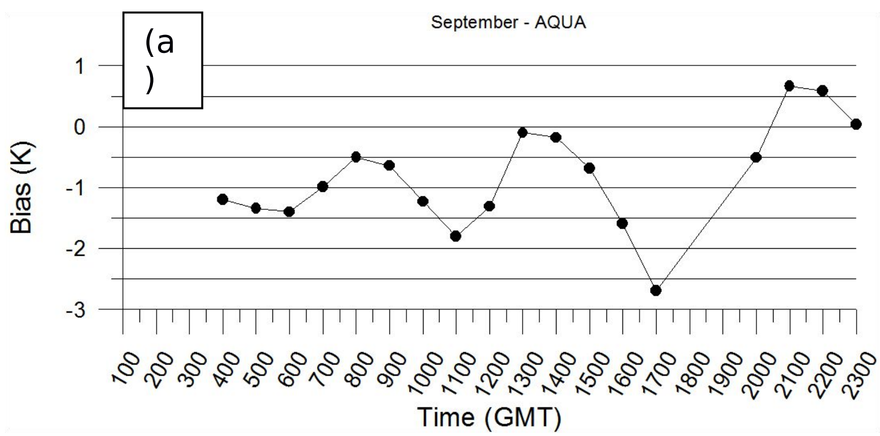


Figure 9: Same as figure 4 except for August 2014



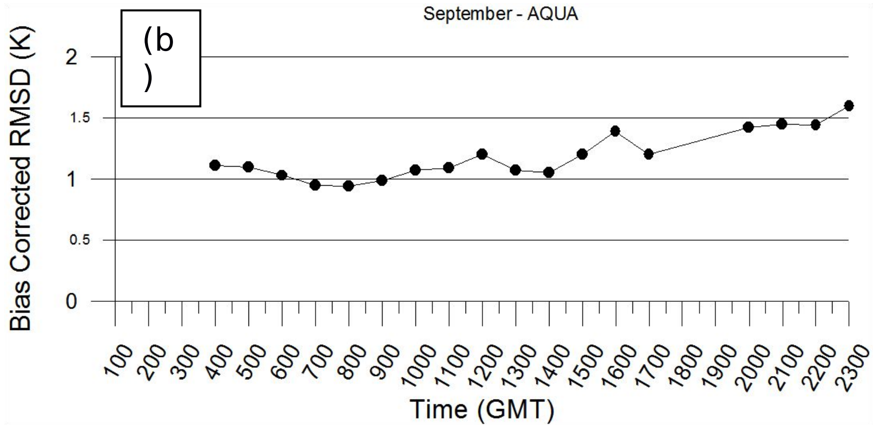
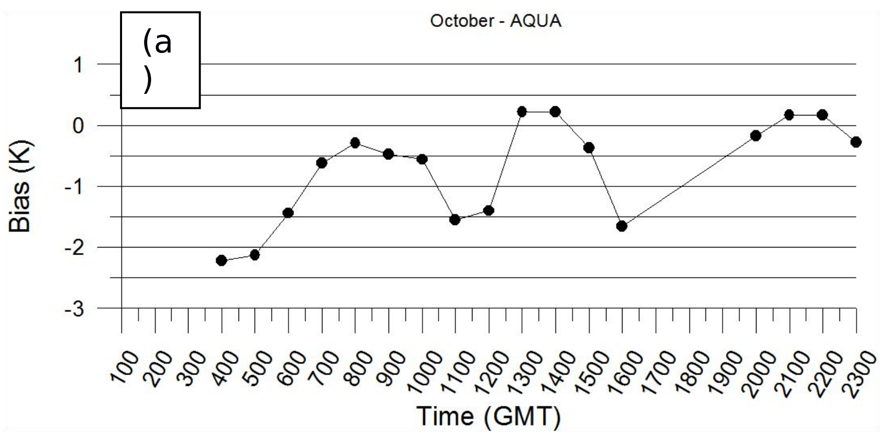


Figure 10: Same as figure 4 except for September 2014



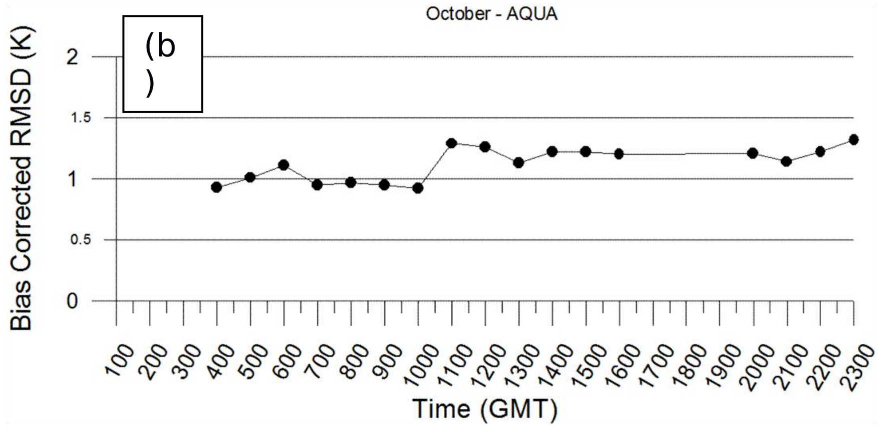
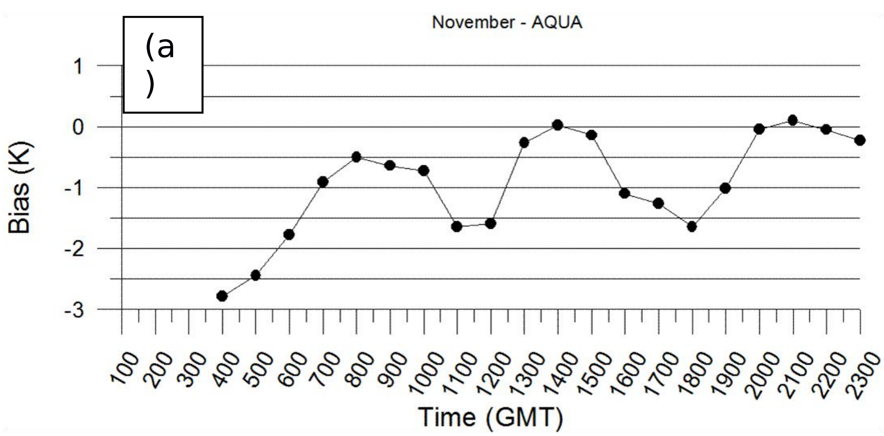


Figure 11: Same as Figure 4 except for October 2014



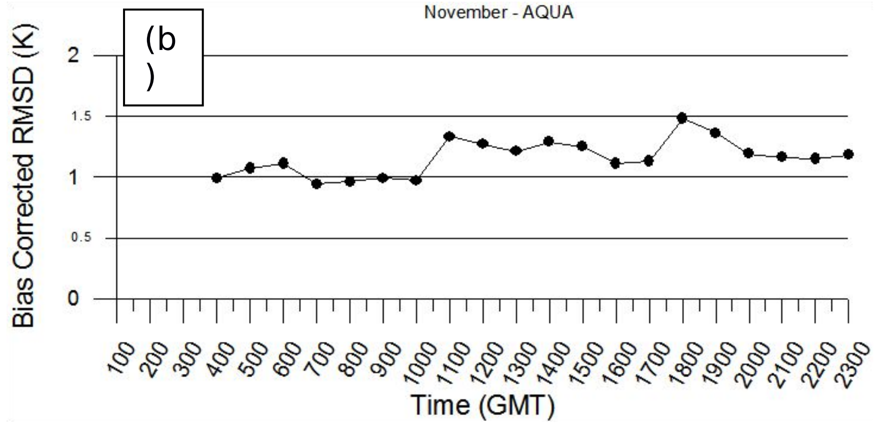


Figure 12: Same as figure 4 except for November 2014

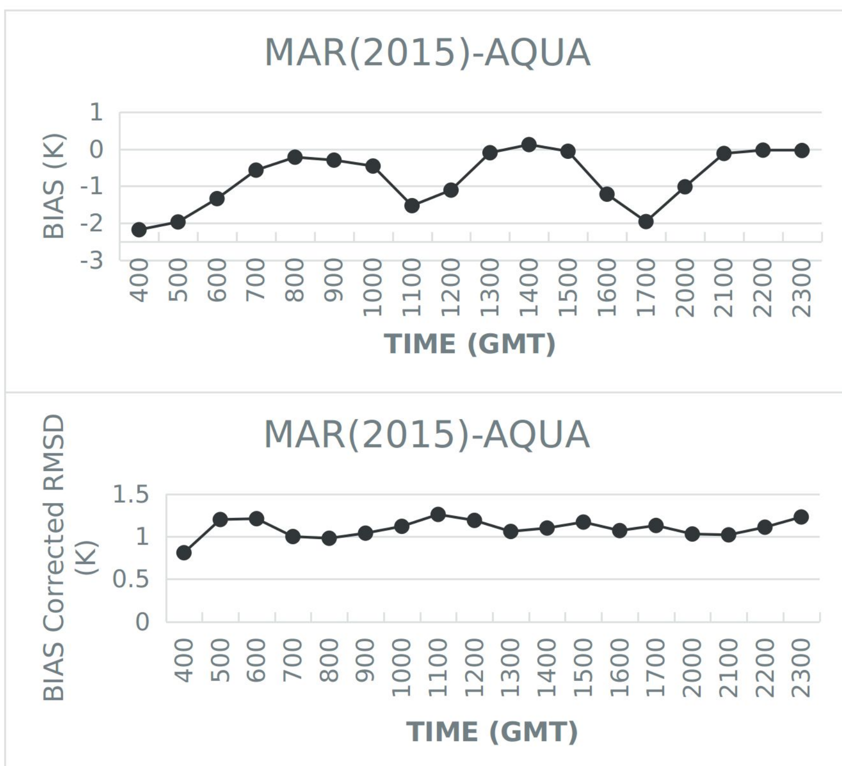


Figure 13: Bias and Bias corrected RMSD between INSAT-3D and MODIS-AQUA SST for March 2015

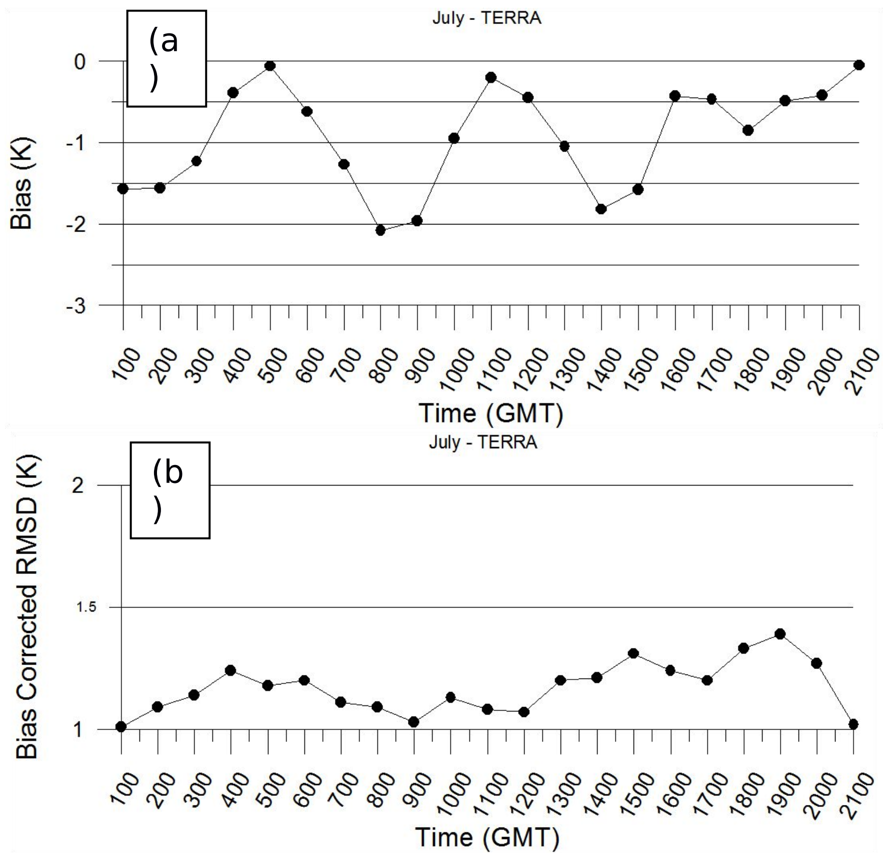


Figure 14: Same as figure 4 except for TERRA

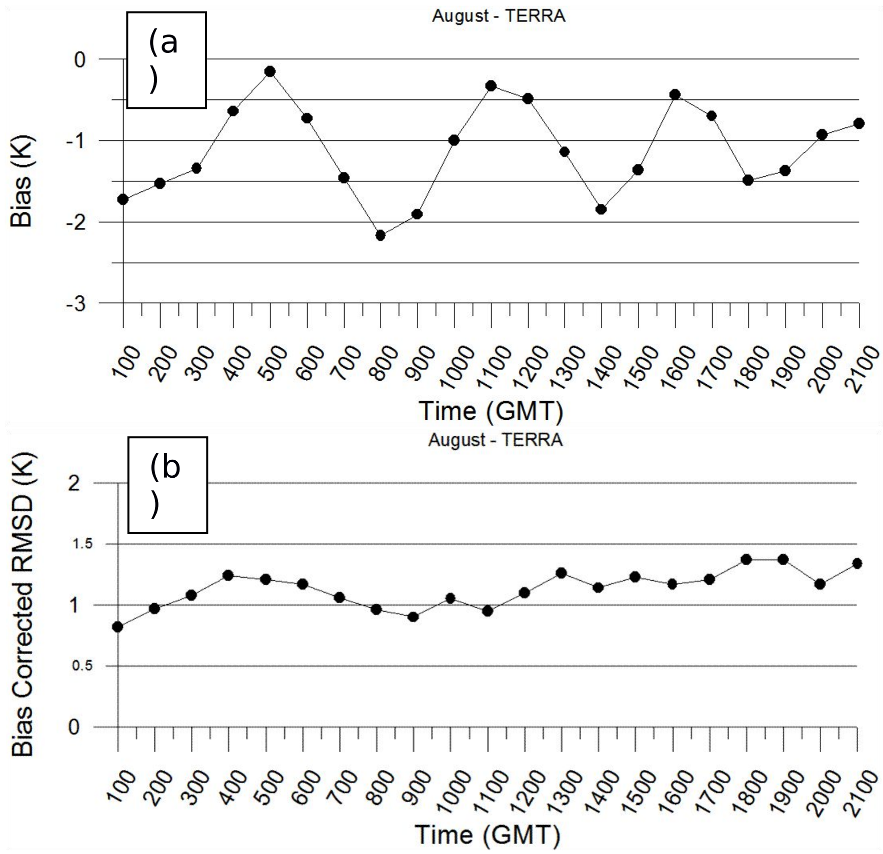


Figure 15: Same as figure 5 except for TERRA

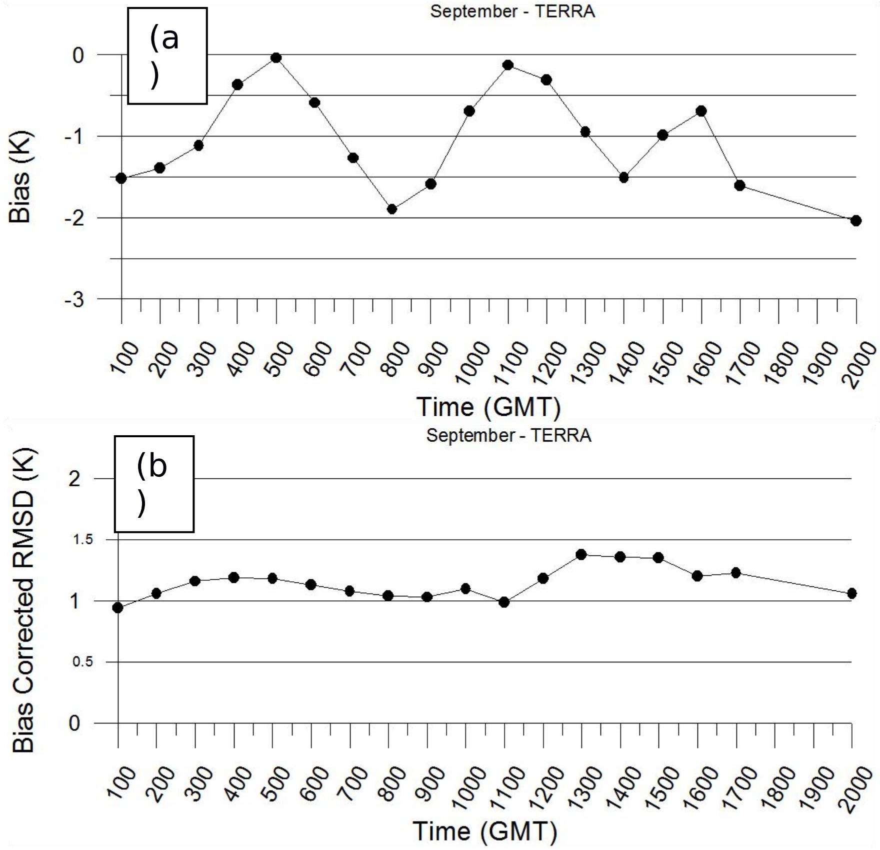


Figure 16: Same as figure 6 except for TERRA

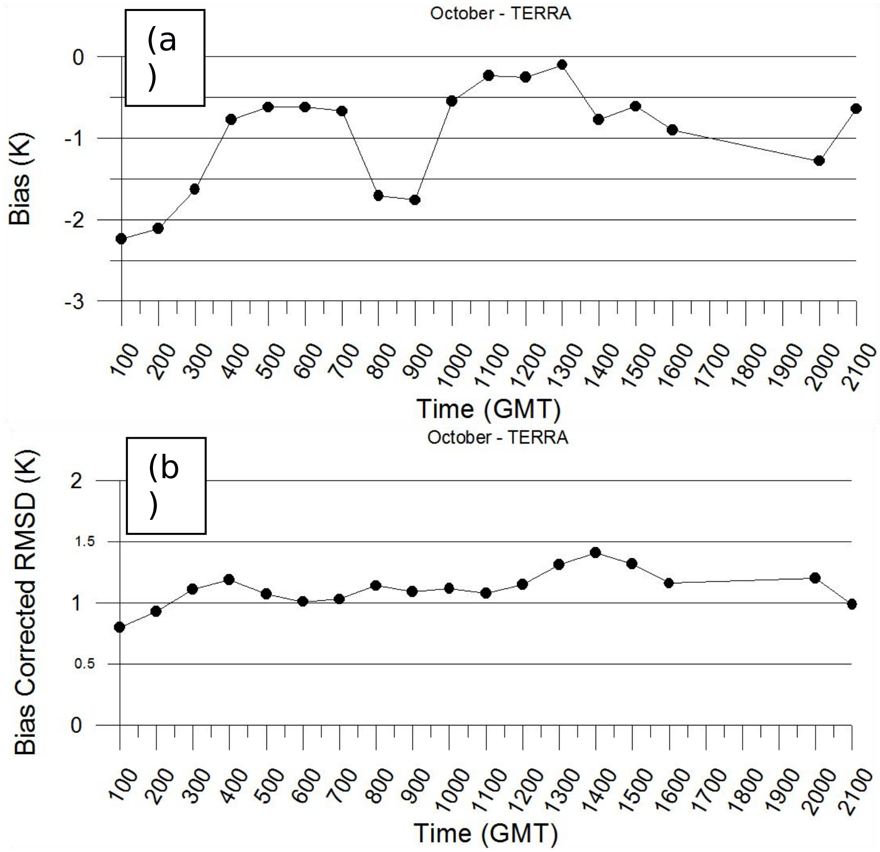


Figure 17: Same as figure 7 except for TERRA

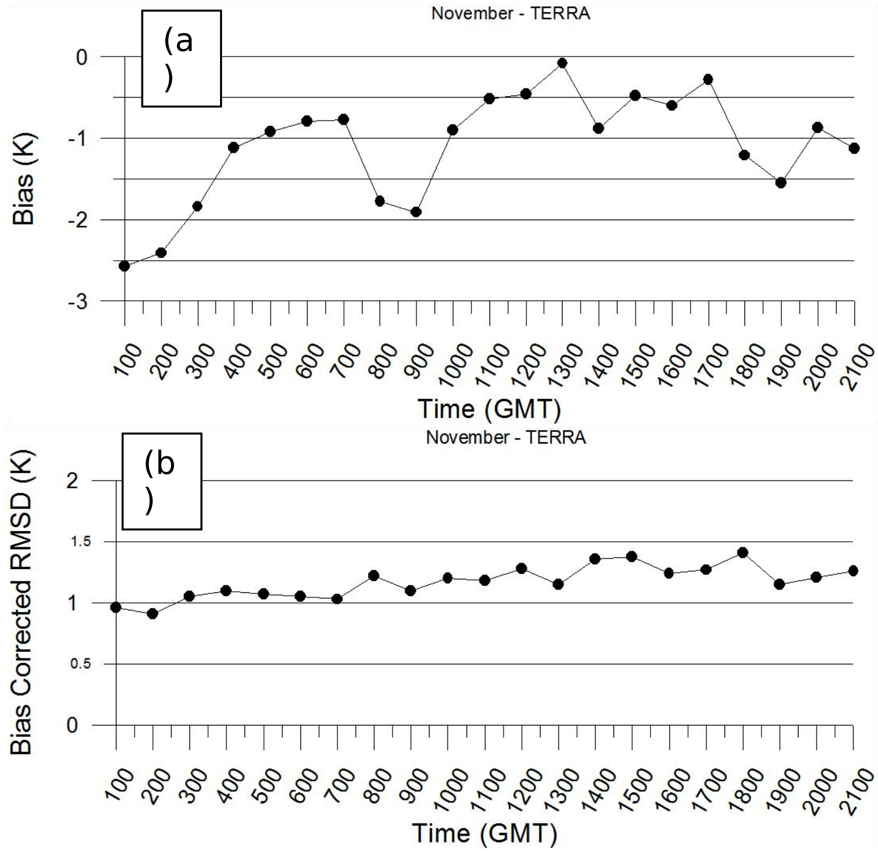
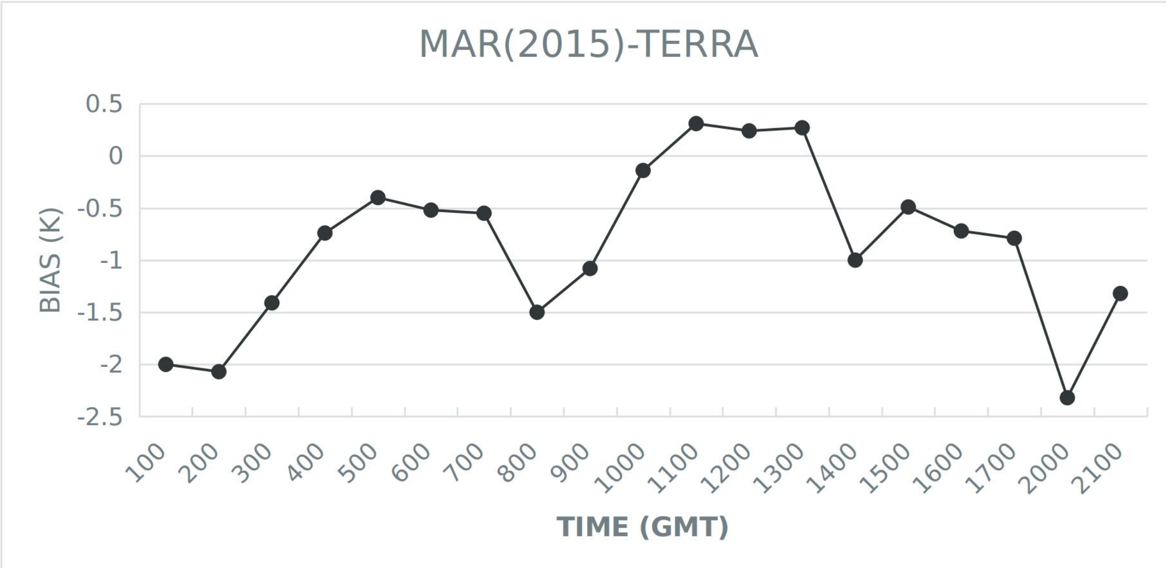


Figure 18: Same as figure 8 except for TERRA



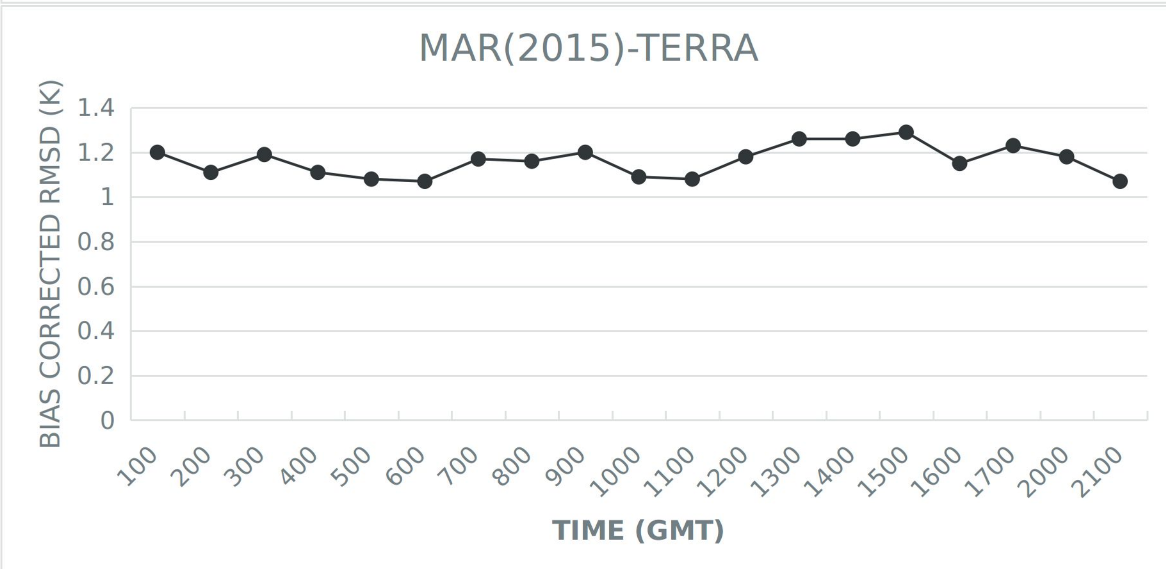


Figure 19: Bias and Bias corrected RMSD between INSAT-3D and MODIS-TERRA SST for March 2015

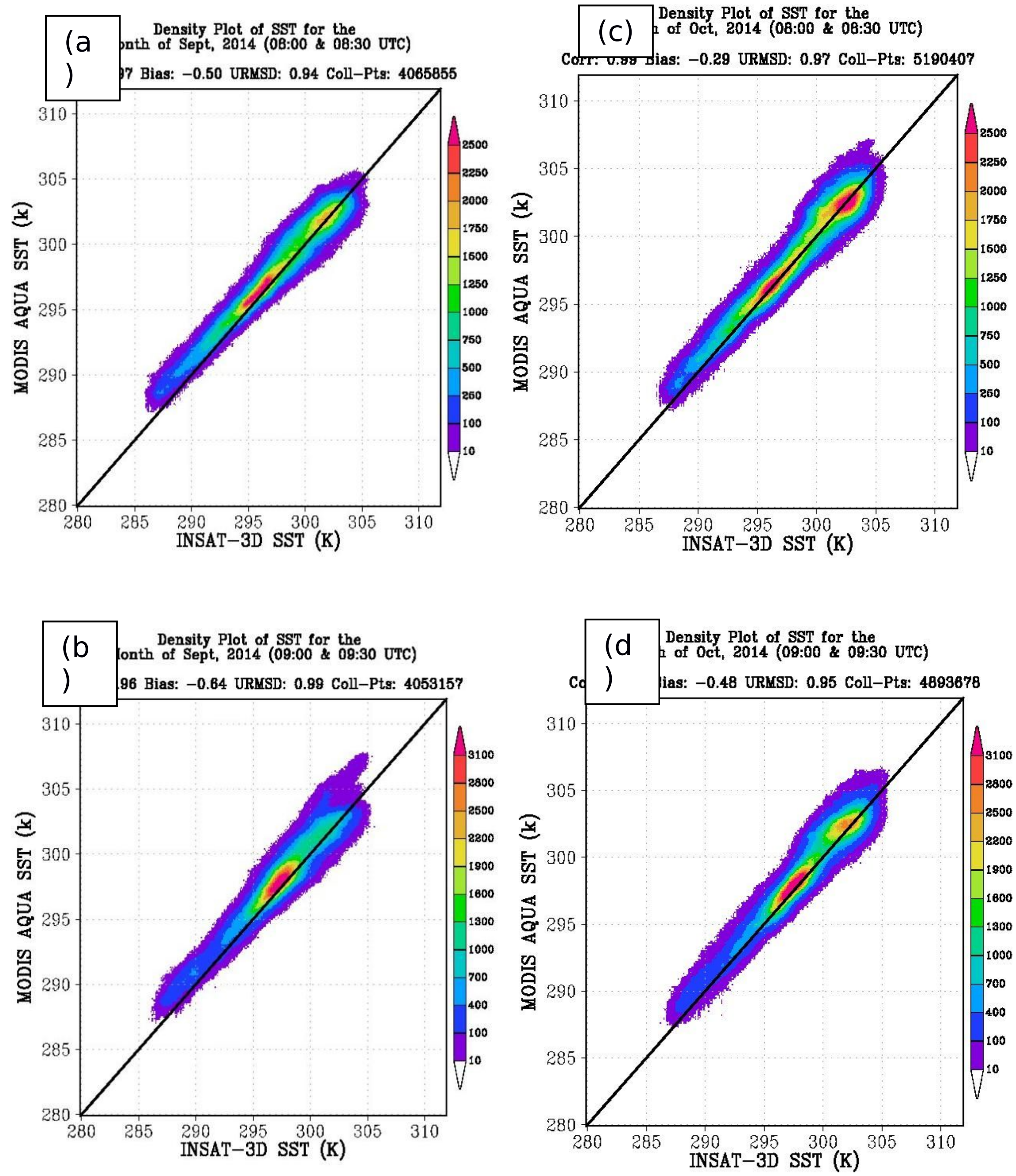


Fig.20: Density plots of INSAT-3D and AQUA -MODIS SST for (a) 0800 & 0830 GMT, September 2014 (b) 0900 & 0930 GMT, September 2014 (c) 0800 & 0830 GMT, October 2014 and (d) 0900 & 0930 GMT, October 2014.

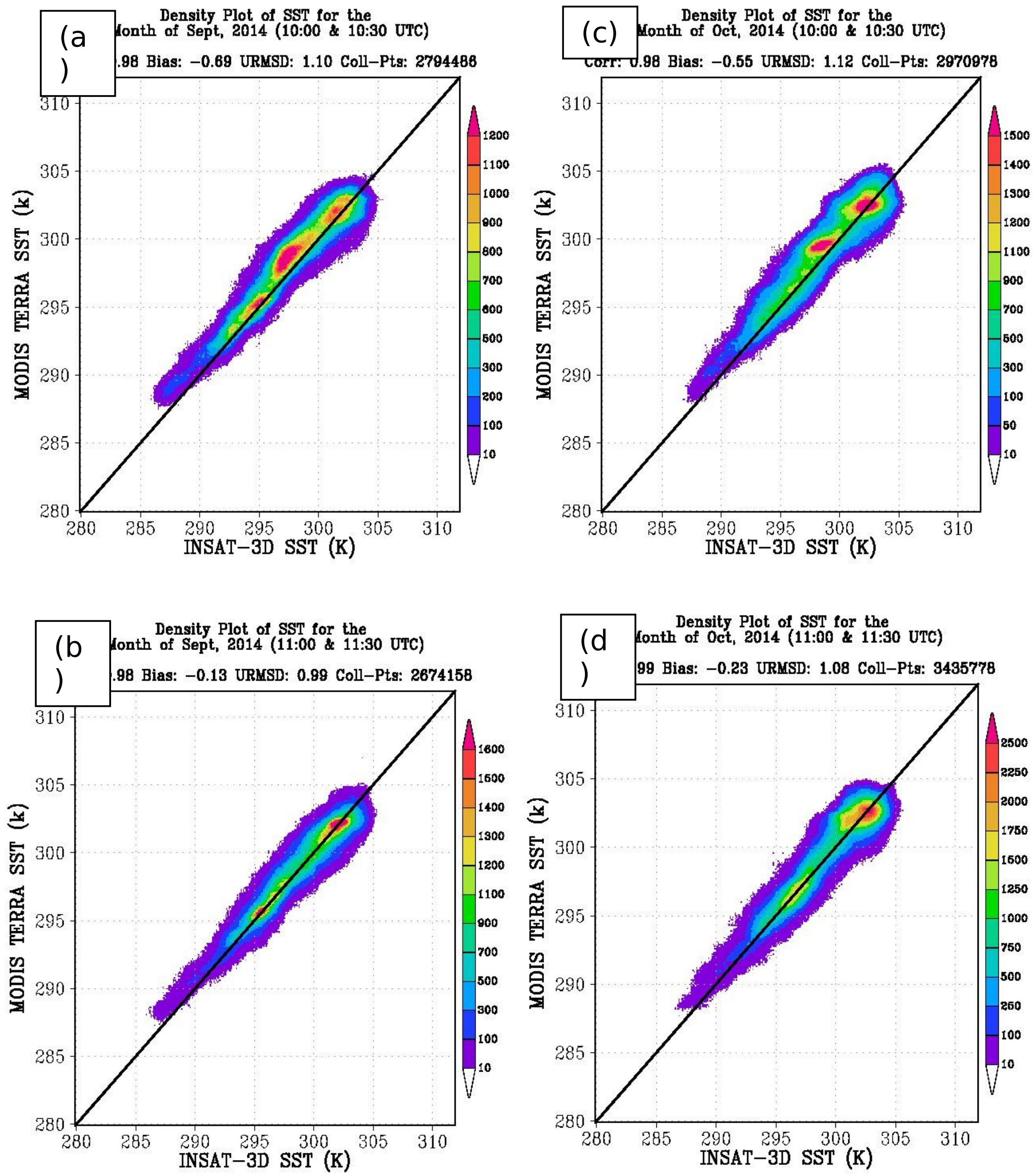


Fig.21: Density plots of INSAT-3D and TERRA -MODIS SST for (a) 1000 & 1030 GMT, September 2014 (b) 1100 & 1130 GMT, September 2014 (c) 1000 & 1030 GMT, October 2014 and (d) 1100 & 1130 GMT, October 2014.

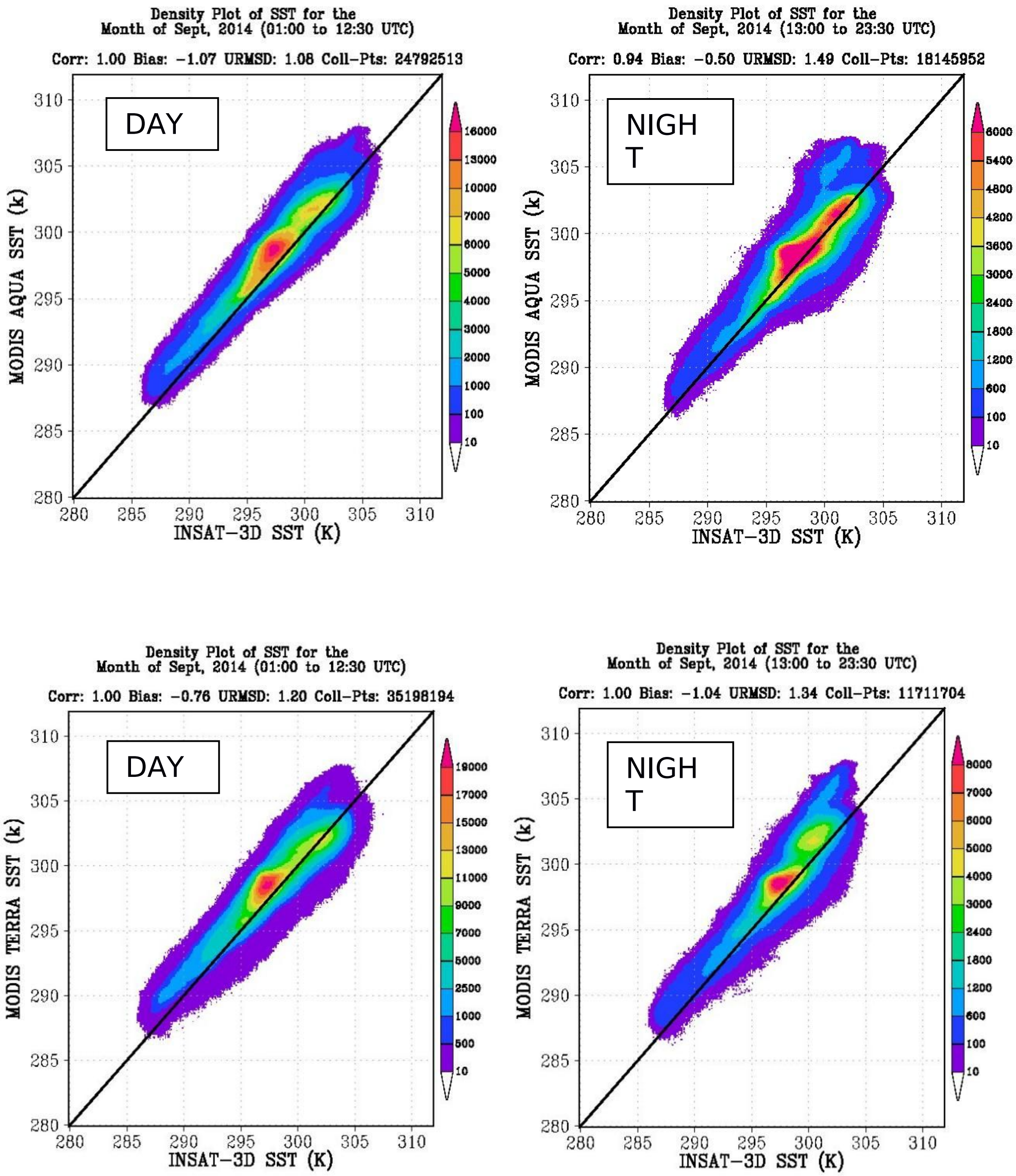


Fig.22: Density plot of INSAT-3D and AQUA–MODIS Day-Night SST(Upper panels) and TERRA-MODIS Day-Night SST (Lower panels) for September, 2014 including all the acquisitions.

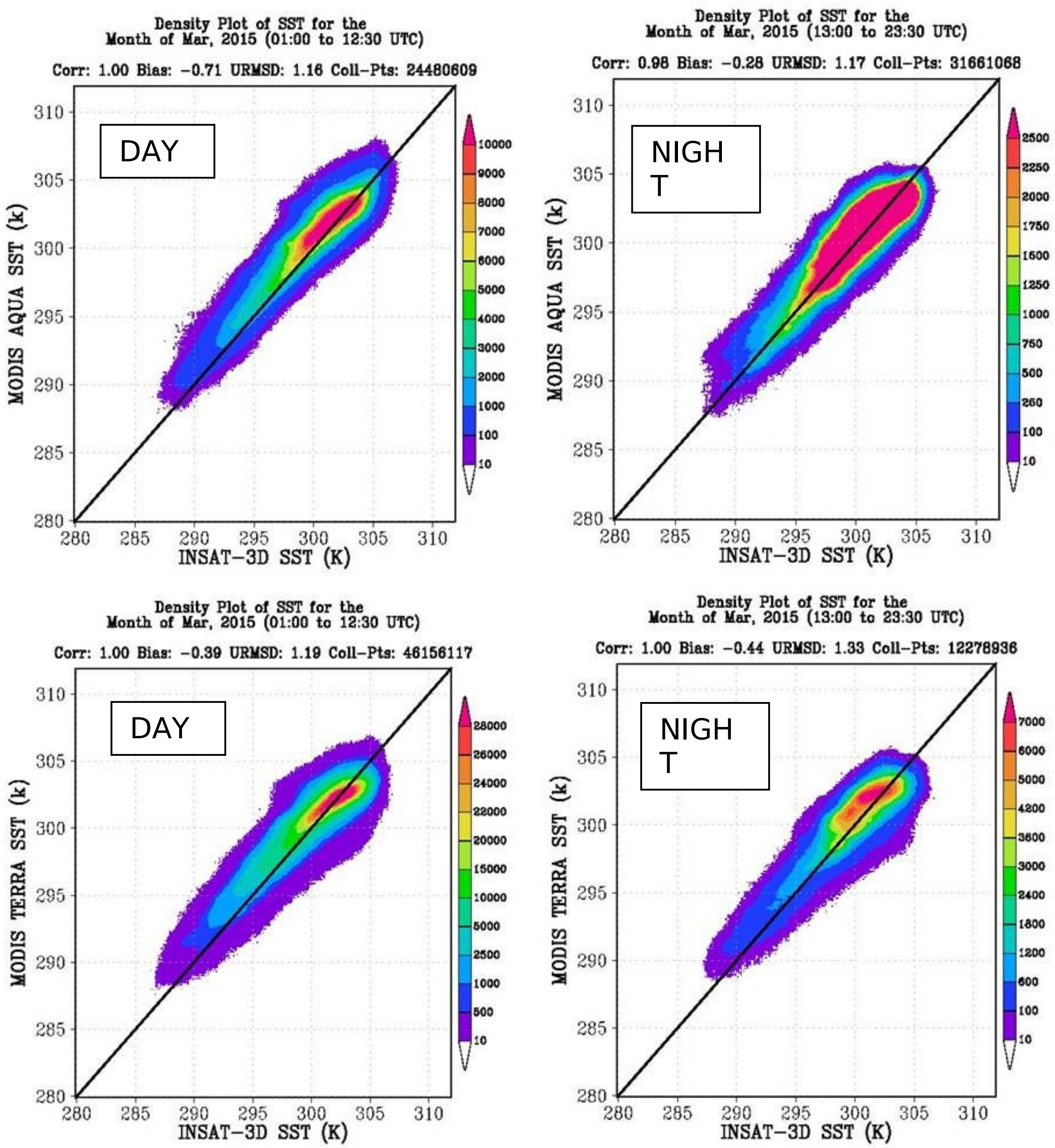


Fig.23: Density plot of INSAT-3D and AQUA–MODIS Day-Night SST (Upper panels) and TERRA-MODIS Day-Night SST (Lower panels) for March, 2015 including all the acquisitions

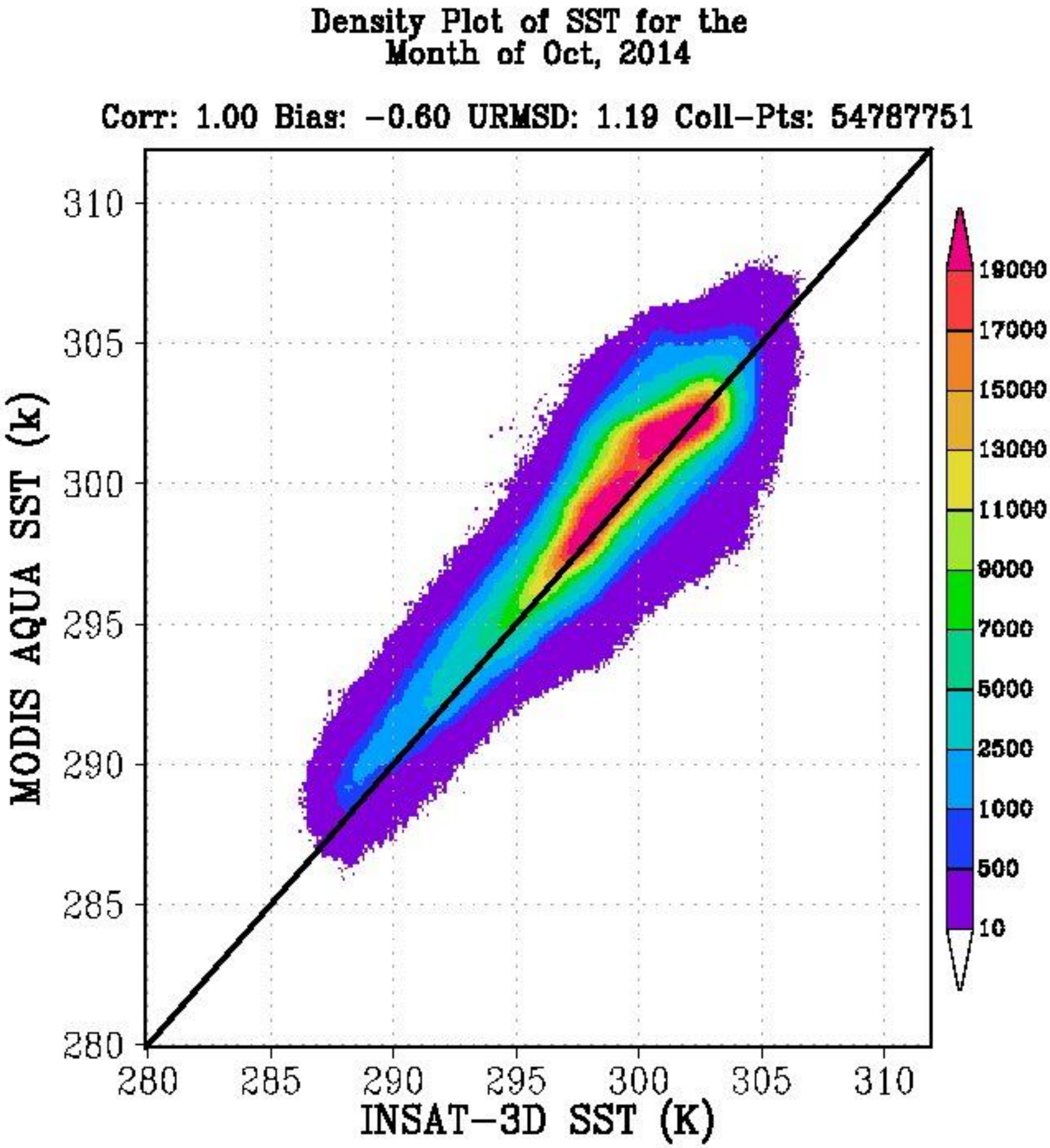


Fig.24: Density plot of INSAT-3D and AQUA -MODIS SST for October, 2014 including all the acquisitions.

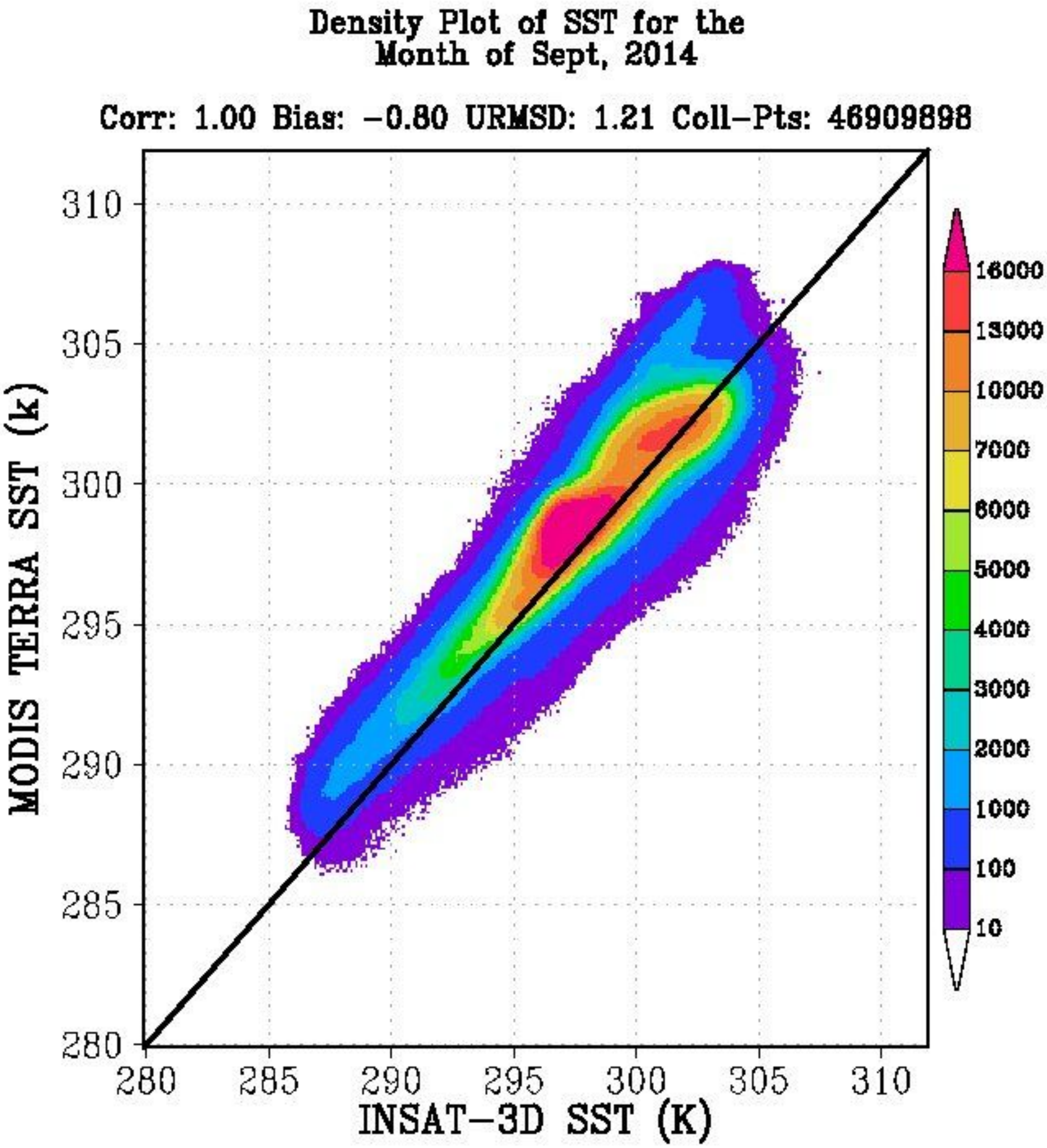


Fig.25: Density plot of INSAT-3D and TERRA -MODIS SST for September, 2014 including all the acquisitions.

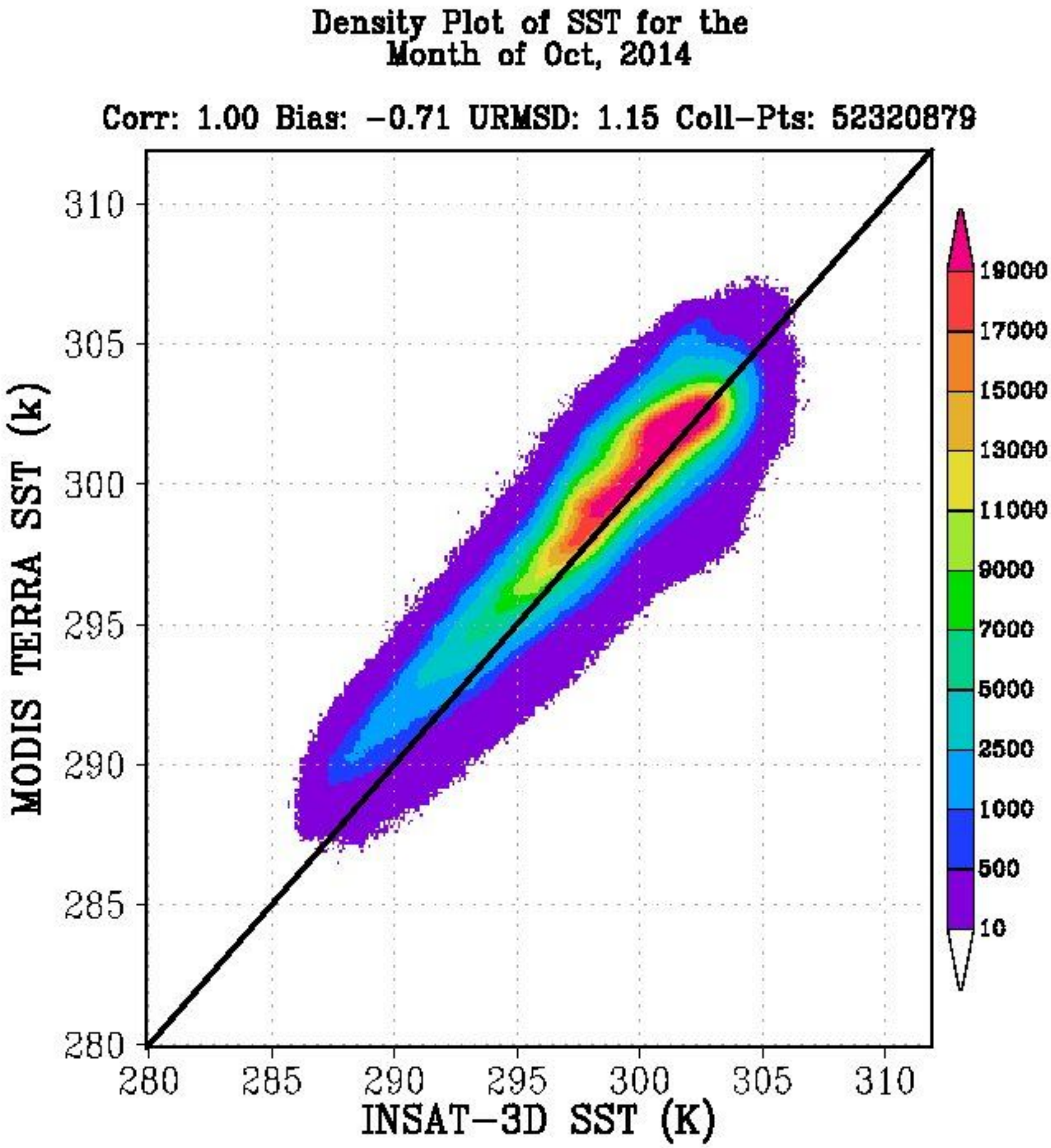


Fig.26: Density plot of INSAT-3D and AQUA -MODIS SST for October, 2014 including all the acquisitions.

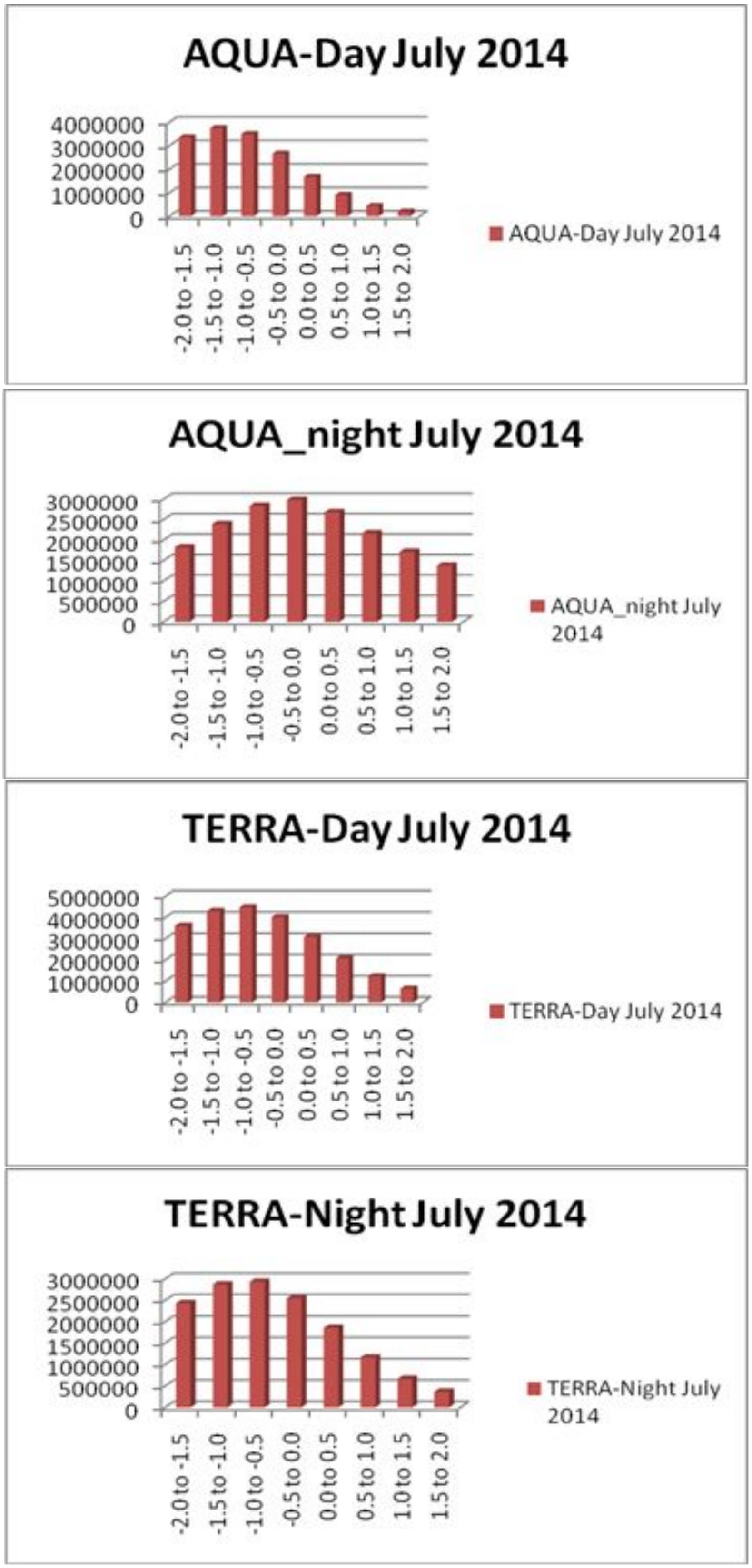
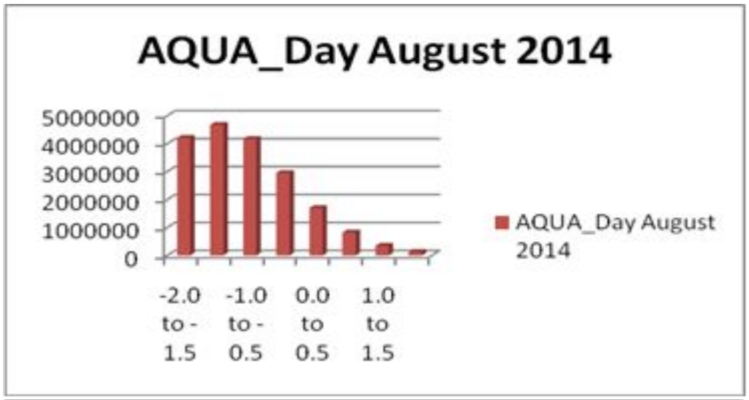
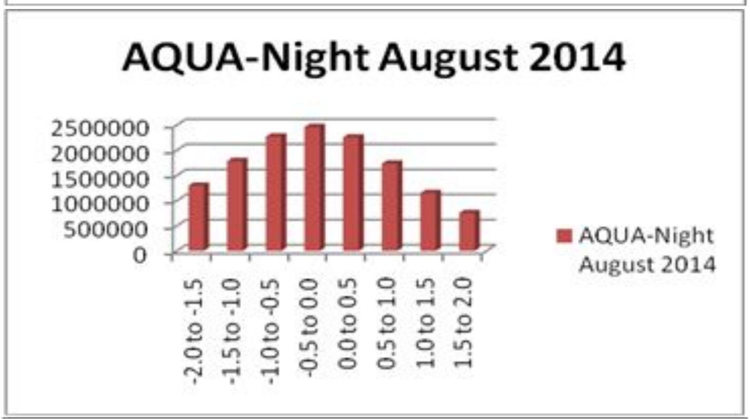
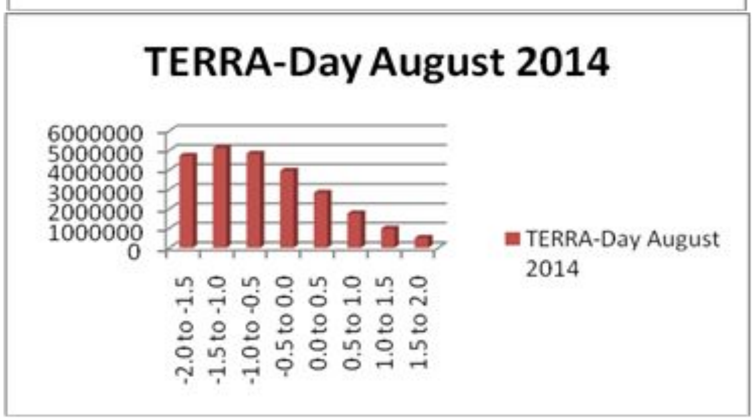


Figure 27: Bar Chart for the comparison of INSAT-3D and MODIS SST for July 2014


AQUA_Day August 2014
5000000
4000000
3000000
2000000
1000000
0
-2.0 to - 1.5
-1.0 to - 0.5
0.0 to 0.5
1.0 to 1.5
AQUA_Day August 2014


AQUA-Night August 2014
2500000
2000000
1500000
1000000
500000
0
-2.0 to -1.5
-1.5 to -1.0
-1.0 to -0.5
-0.5 to 0.0
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
AQUA-Night August 2014


TERRA-Day August 2014
6000000
5000000
4000000
3000000
2000000
1000000
0
-2.0 to -1.5
-1.5 to -1.0
-1.0 to -0.5
-0.5 to 0.0
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
TERRA-Day August 2014

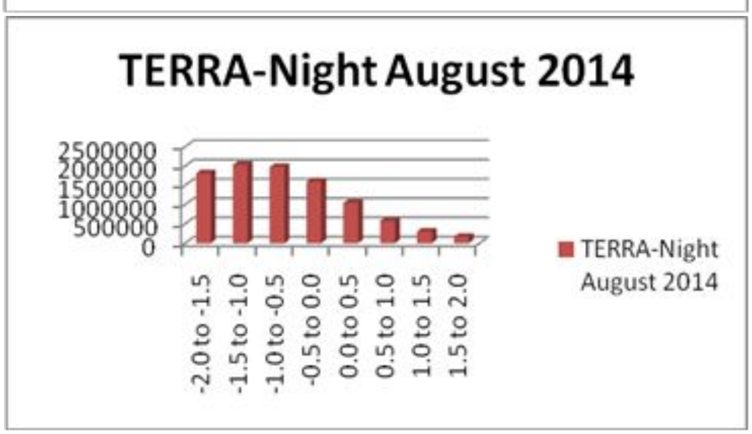
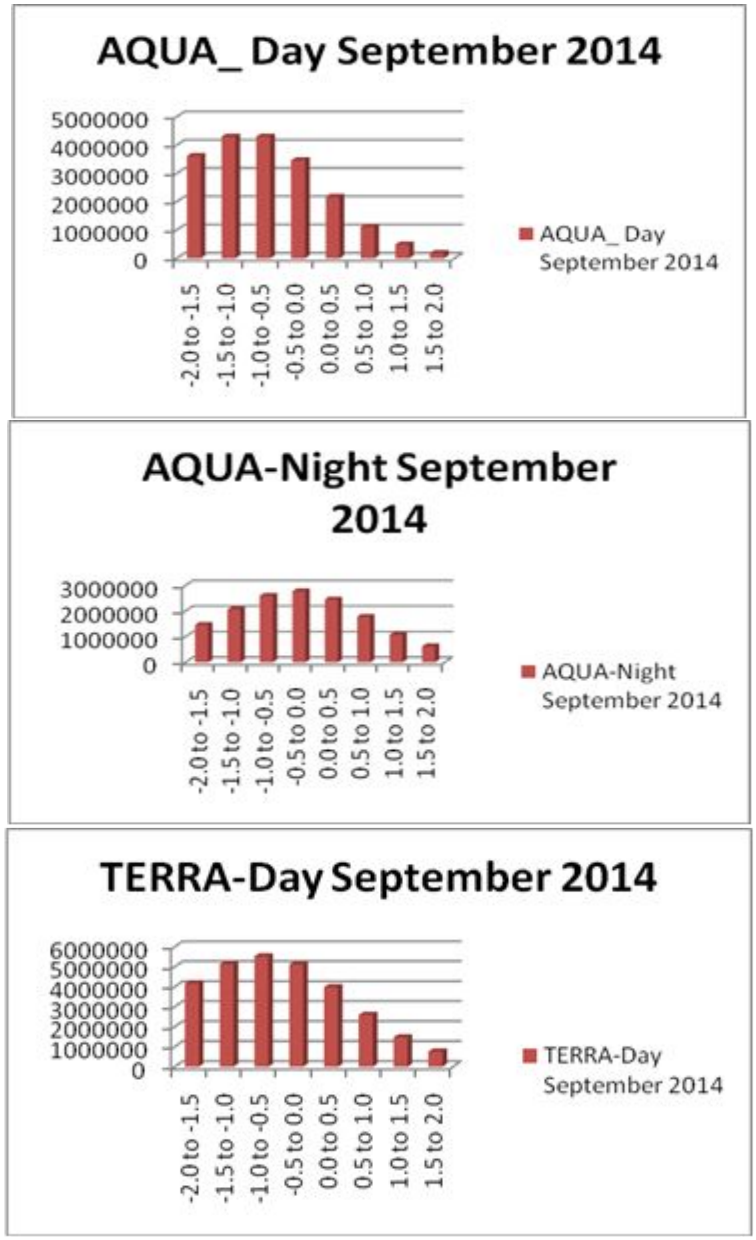

TERRA-Night August 2014
2500000
2000000
1500000
1000000
500000
0
-2.0 to -1.5
-1.5 to -1.0
-1.0 to -0.5
-0.5 to 0.0
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
TERRA-Night August 2014

Figure 28: Bar Chart for the comparison of INSAT-3D and MODIS SST for August 2014



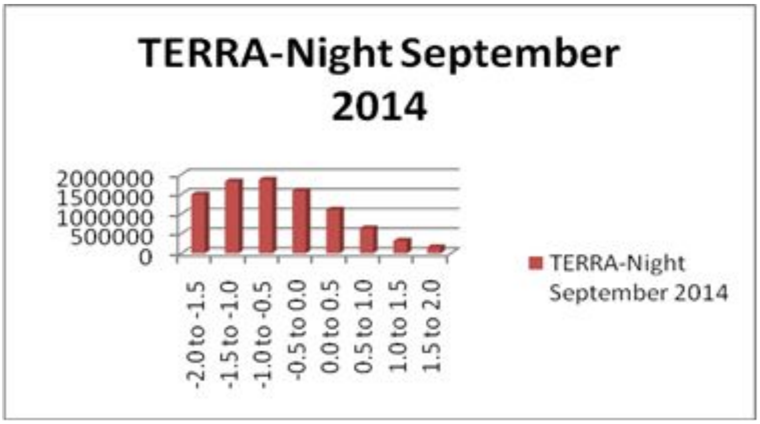
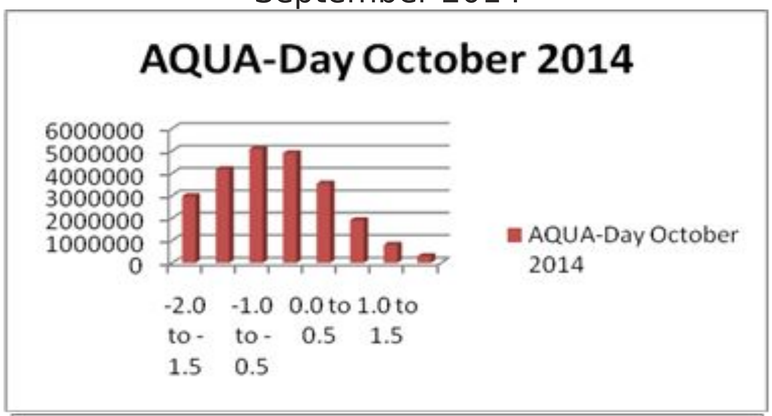
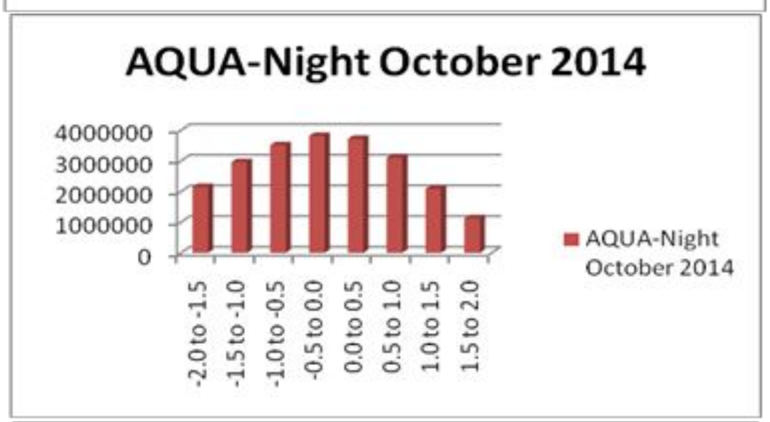
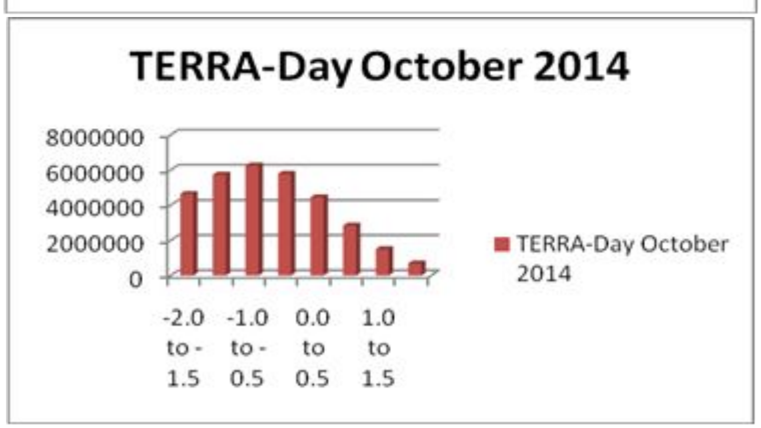


Figure 29: Bar Chart for the comparison of INSAT-3D and MODIS SST for September 2014







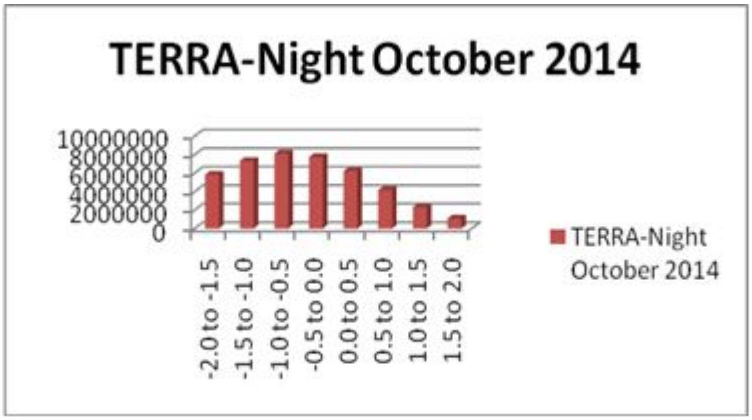
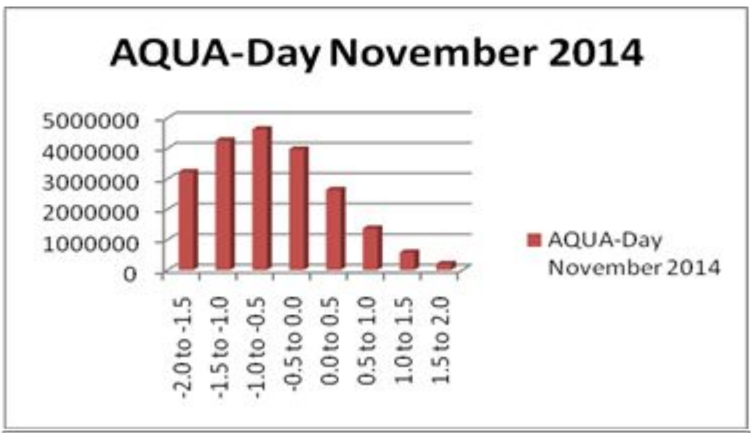


Figure 30: Bar Chart for the comparison of INSAT-3D and MODIS SST for October 2014



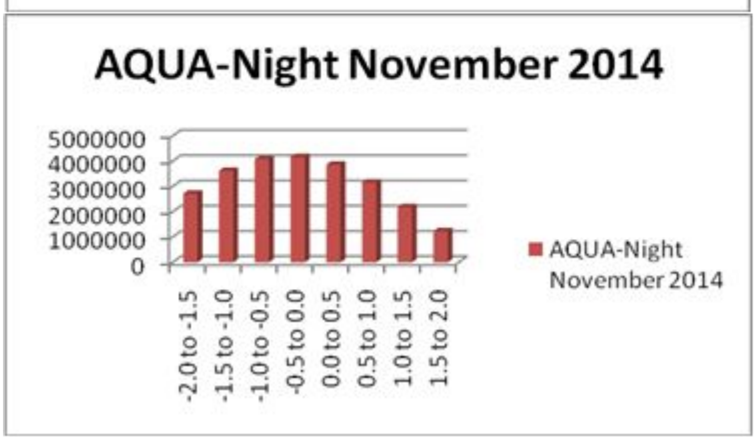
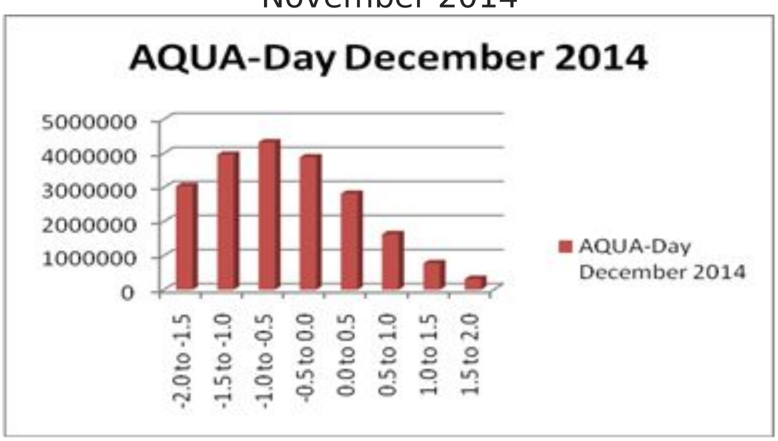


Figure 31: Bar-Chart for the comparison of INSAT-3D and MODIS SST for November 2014



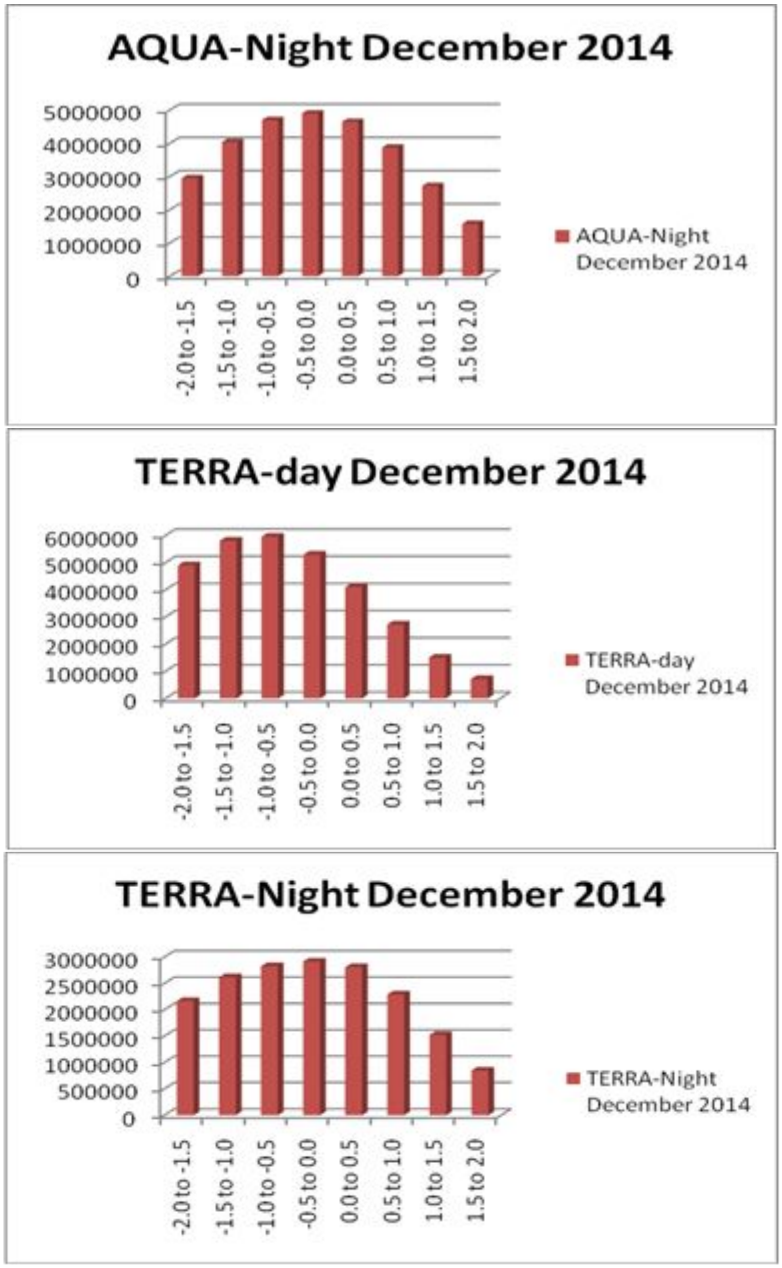
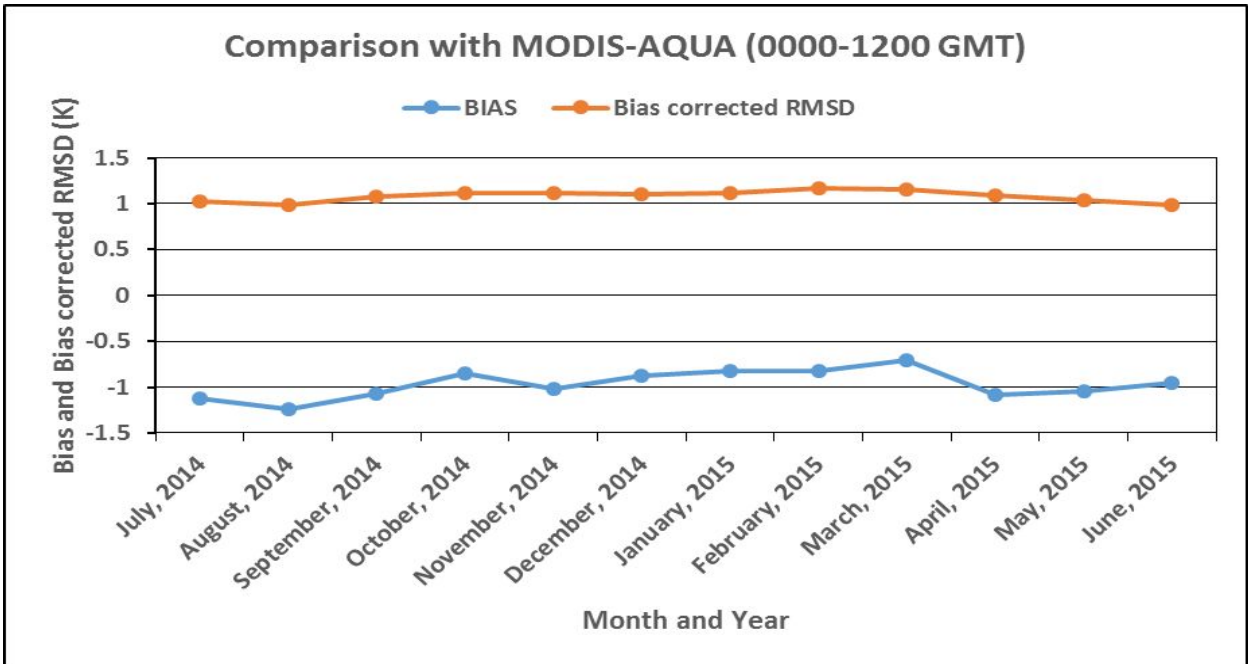


Figure 32: Bar-Chart for the comparison of INSAT-3D and MODIS SST for December 2014



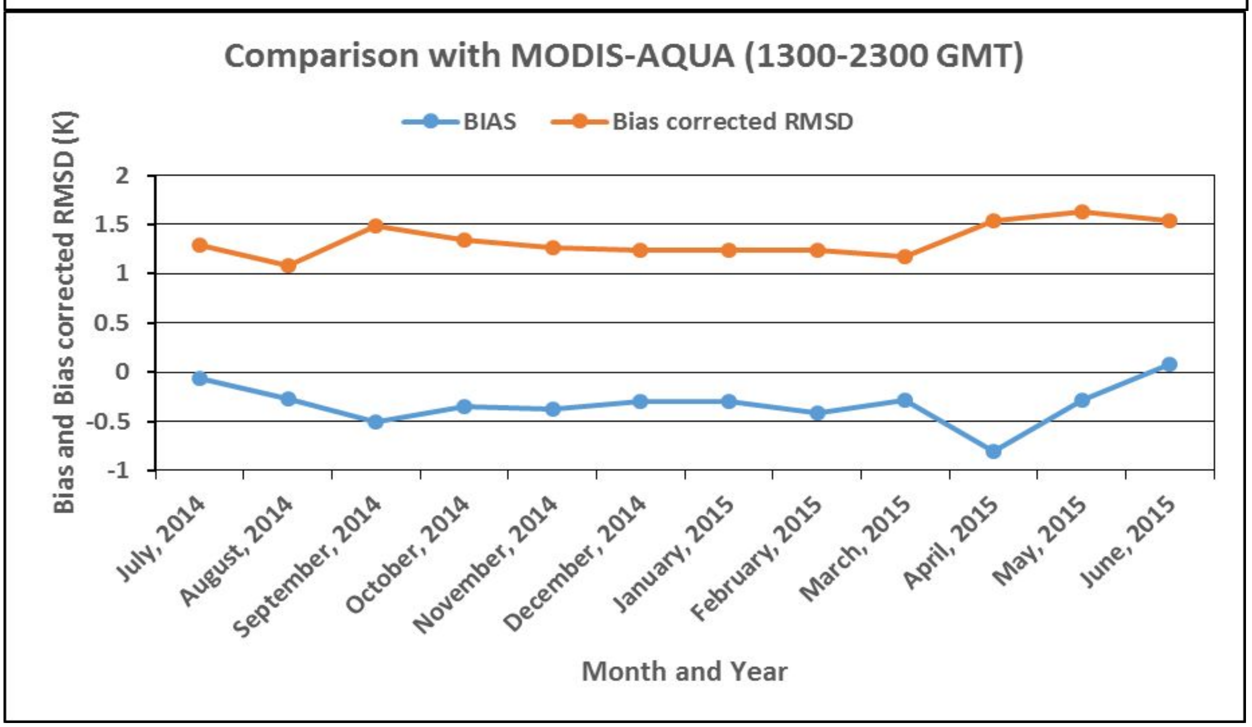
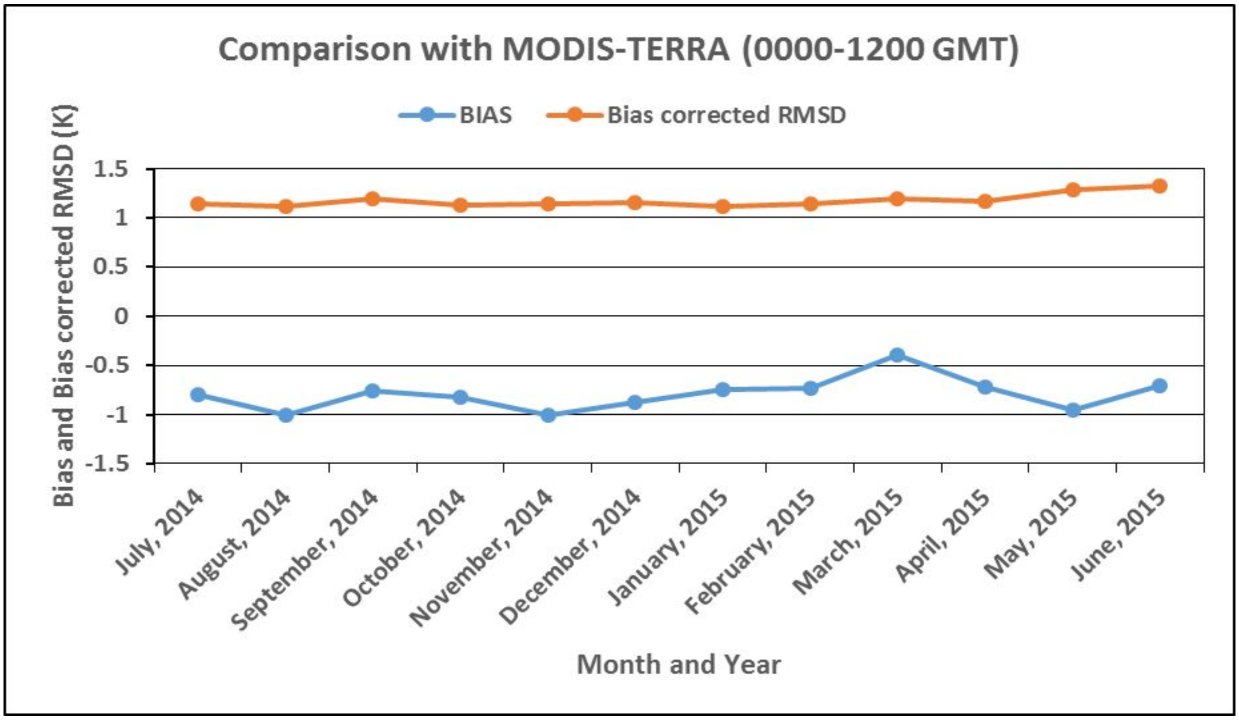


Fig 33: Monthly Time series of Bias and Bias corrected RMSD between INSAT-3D and MODIS-AQUA SST for Day and Nighttime for one year (July 2014- June 2015)



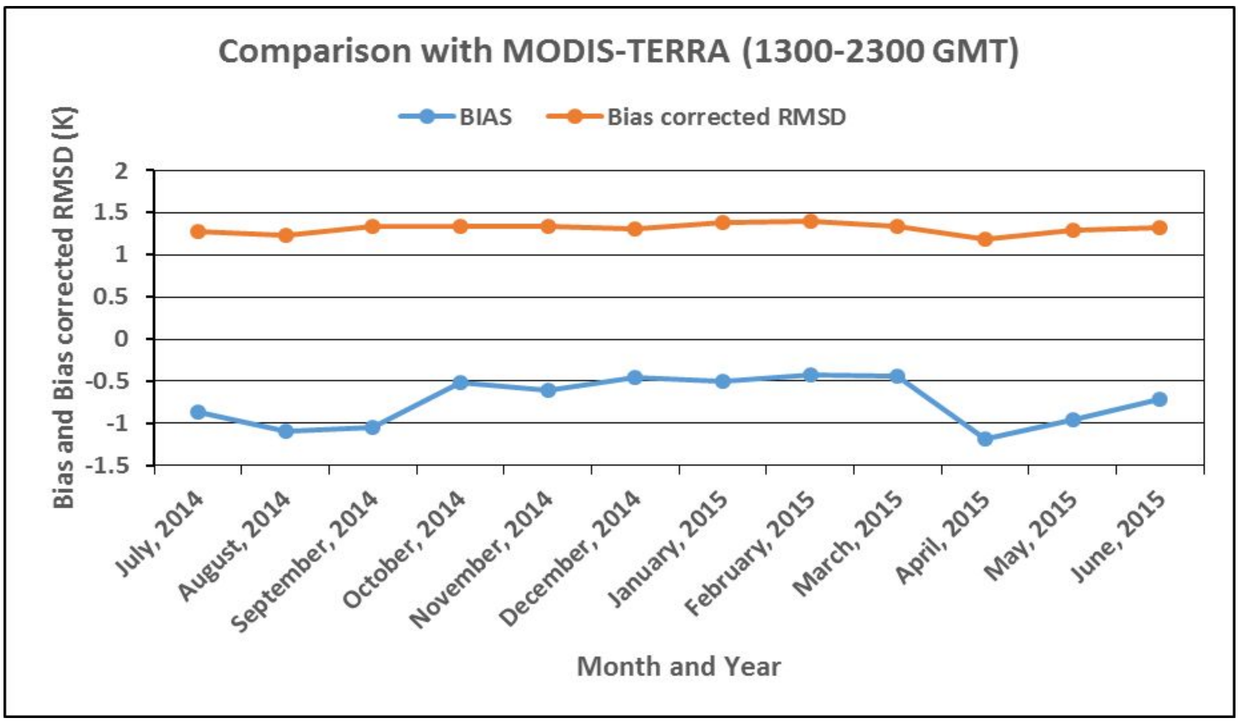


Fig 34: Monthly Time series of Bias and Bias corrected RMSD between INSAT-3D and MODIS-TERRA SST for Day and Nighttime for one year (July 2014-June 2015)

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