Testing satellite SST capability to capture thermal features and diurnal warming on the Great Barrier Reef

Xiaofang Zhu, Peter Minnett, Ray Berkelmans, Helen Beggs, Leon Majewski, George Kruger

- Coastal satellite SST versus open ocean SST, difference and similarities, possible difficulties for retrieval
- Goal of this work:
  - Validate satellite skin SST from MODIS, AVHRR and MTSAT-1R against coastal station temperatures (at depth) on the reef
  - Test how well satellite skin SST captures diurnal warming features on the reefs

Study Region and In-situ Measurements

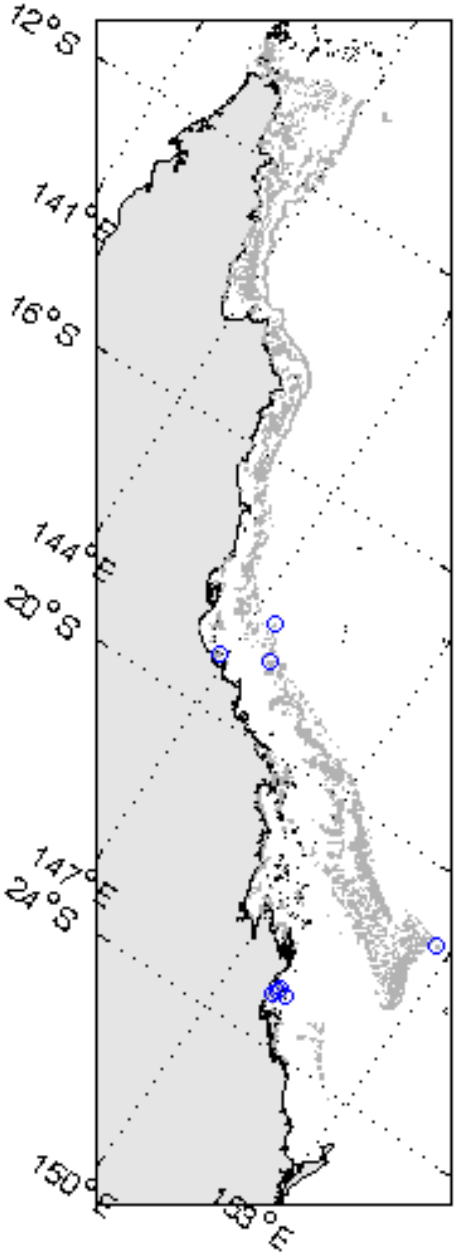
Study period: 120 days 1 Jan to 30 Apr 2010.

In-situ dataset includes 9 stations in the middle and southern end of Great Barrier Reef, with depths ranging from just below lowest low tide to over 10 m in depth. The temperature measurements are bottom measurements.

In-situ stations	Latitude	Longitude	depth (m)
Davies Reef	18.807	147.669	4.4/9
Myrmidon Reef	18.258	147.382	7/19
Cleveland Bay	19.122	146.880	0
BARRSL1	23.158	151.071	9
ELUSIVEFL1	21.104	152.765	2
ELUSIVESL1	21.104	152.765	10
HALAWS	23.154	150.938	6.5

Middle stations, with wind data

Southern stations

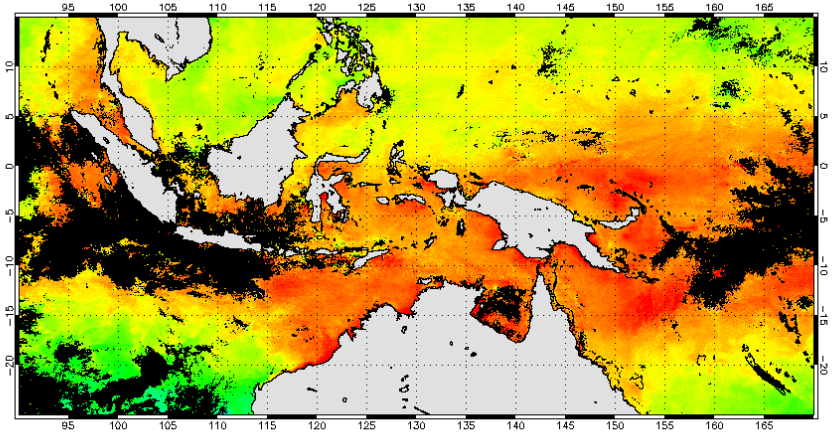


Satellite SST dataset

- 1km MODIS Aqua and Terra L2 SSTskin
- 0.02° IMOS fv01 AVHRR L3C SSTskin (NOAA-17/18/19)
- 0.05° ABoM MTSAT-1R hourly L3 SSTskin

The IMOS HRPT AVHRR and ABoM MTSAT-1R SST data are derived from regression algorithms using drifting buoy matchup datasets, separate from our GBR in-situ data. The data are part of the TWP+ dataset available for January to April in 2009 and 2010 (https://www.ghrsst.org/ghrsst/tags-and-wgs/dv-wg/twp/).

TWP+ dataset 2010-02-14 MTSAT-1R



Data platform and processing level	Temporal resolution	Spatial resolution
MODIS Aqua level 2	Twice a day. Satellite overhead time (SOT) is at about 1:15 and 13:40 local time (LT)	1km
MODIS Terra, level 2	Satellite overhead time (SOT) is at about 10:50 and 22:10 UTC	1km
NOAA17, level 3	SOT is about at 9:20 and 21:00 LT.	0.02°
NOAA18, level 3	SOT is about at 1:45 and 13:55 LT.	0.02°
NOAA19, level 3	SOT is about at 2:00 and 14:40 LT.	0.02°
MTSAT-1R	Every hour	0.05°
In-situ loggers	10 minutes (30 for Cleveland Bay)	n/a

• Methods and Numbers of Match-ups

For each in-situ station

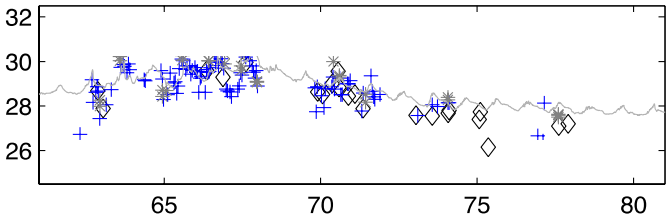
▪ IMOS AVHRR SST: Pixels with latitudes and longitudes ≤ 0.02° from nearest pixel were examined and used if available. Quality flag ≥ 4 (5 is best).

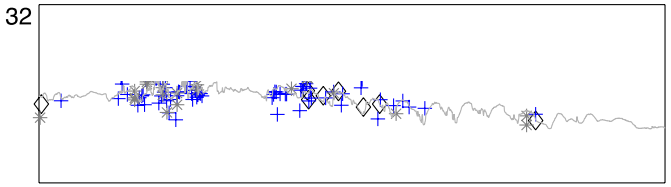
▪ MTSAT-1R: SST from the nearest pixel is used if available. Proximity flags = 5 (best quality clear sky pixel)

▪MODIS L2 swath data: SST was extracted for the in-situ data if there was a pixel within 0.01° both in latitude and longitude from the in-situ station. Quality flag <=1 (0 is best)

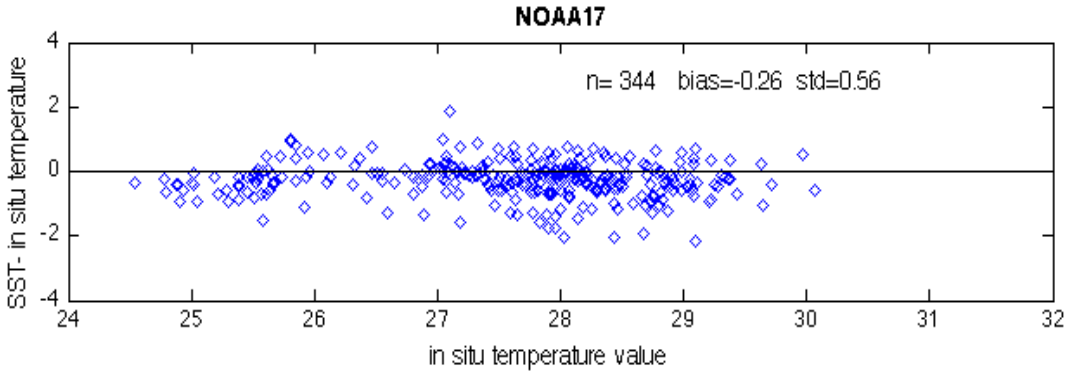
In-situ stations	**Number of SST data points for the 4-month/120-day period**					
	NOAA 17	NOAA 18	NOAA 19	MODIS Aqua	MODIS Terra	MTSAT-1R
Davies Reef	**47**	**45**	**30**	**67**	**72**	**433**
Myrmidon Reef	**42**	**36**	**32**	**43**	**89**	**380**
Cleveland Bay	**14**	**11**	**7**	**0**	**0**	**448**
BARRSL1	**50**	**64**	**49**	**26**	**35**	**361**
ELUSIVEFL1	**43**	**55**	**49**	**86**	**67**	**454**
ELUSIVESL1	**43**	**55**	**49**	**86**	**67**	**454**
HALAWS	33	**39**	**35**	**48**	**42**	**251**
NKEPPSL1	**31**	**48**	**43**	**7**	**11**	**274**
PELFL1	**41**	**61**	**46**	**66**	**55**	**232**
Total for each satellite	**344**	**414**	**340**	**429**	**438**	**3287**

Sample time series of SSTskin and in-situ temperature measurements

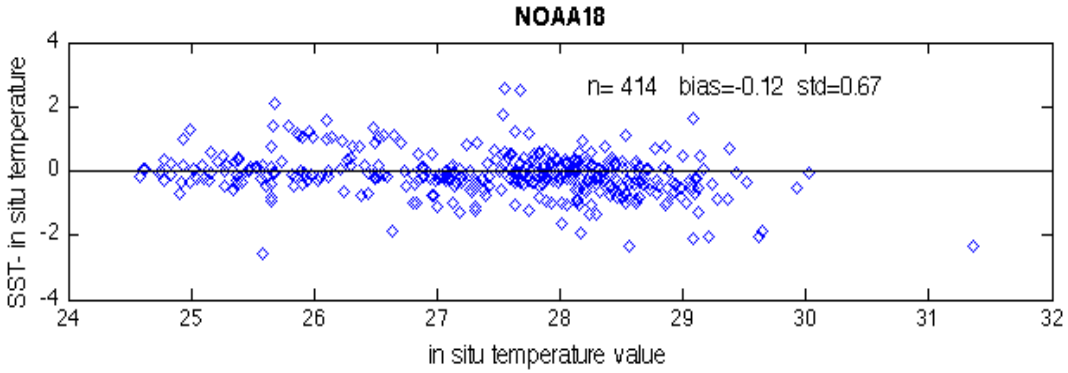




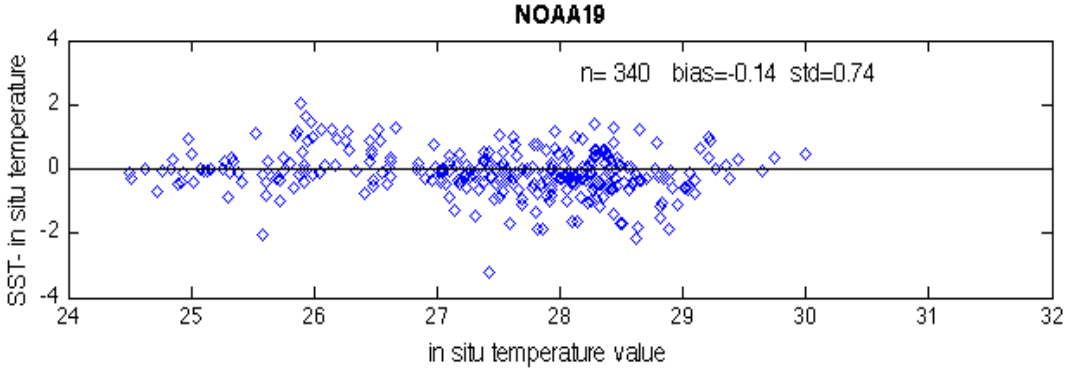
Comparison statistics of SSTskin and in-situ measurements: IMOS AVHRR



NOAA-17 all points:
n=344, bias =-0.26K, std=0.56K
Day points (@9:20):
n=137, bias= -0.46K, std=0.7K
Night points (@21:00):
N=207, bias=-0.14K, std=0.41K



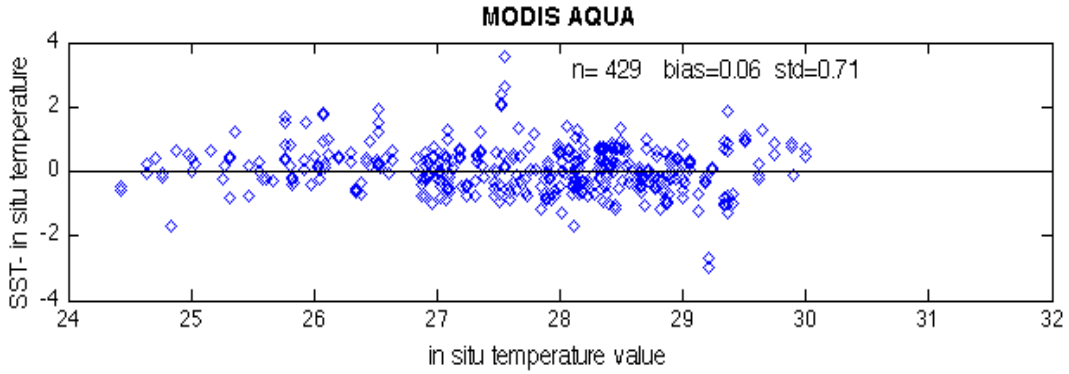
NOAA-18 all points:
n=414, bias =-0.12K, std=0.67K
Day points(@1:45):
N=218, bias= -0.14K, std=0.87K
Night points(@13:55):
N=196, bias=-0.09K, std=0.37K



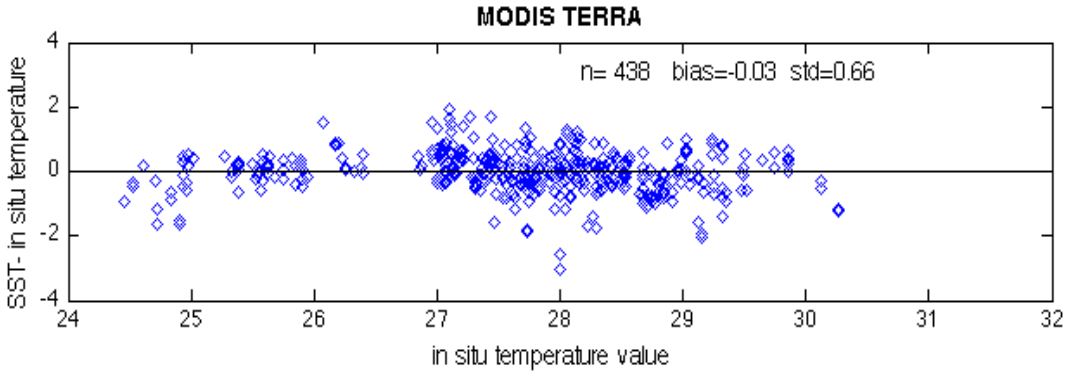
NOAA-19 all points:
n=340, bias =-0.14K, std=0.74K
Day points (@2:00):
N=209, bias= -0.13K, std=0.87K
Night points (@14:40):
N=131, bias=-0.16K, std=0.47K

Note: Add 0.17K to all biases to convert AVHRR SSTskin to SSTsubskin

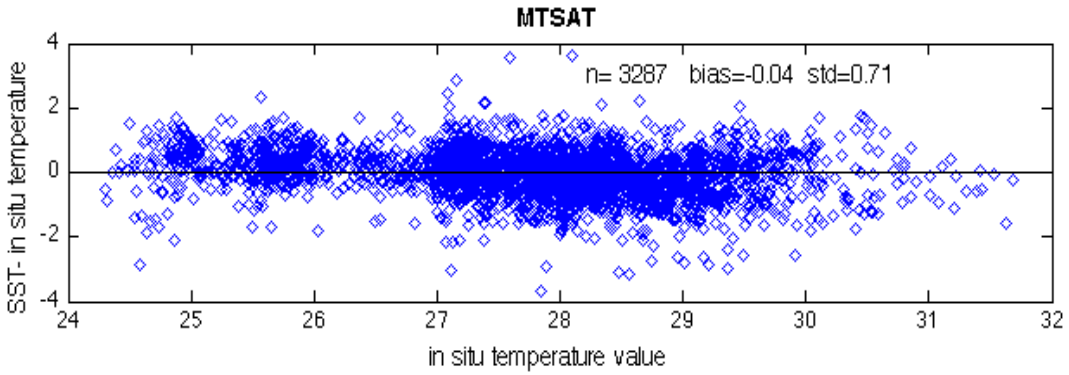
Comparison statistics of SSTskin and in-situ measurements: MODIS + MTSAT-1R



MODIS Aqua all points:
n=429, bias =0.06K, std=0.71K
Day points(~1:15):
N=226, bias= 0.28K, std=0.78K
Night points(~13:40):
N=203, bias= -0.18K, std=0.53K



MODIS Terra all points:
n=438, bias =-0.03K, std=0.66K
Day points (@10:50)
N=204, bias= 0.17K, std=0.56K
Night points(@22:10)
N=234, bias=-0.22K, std=0.7K

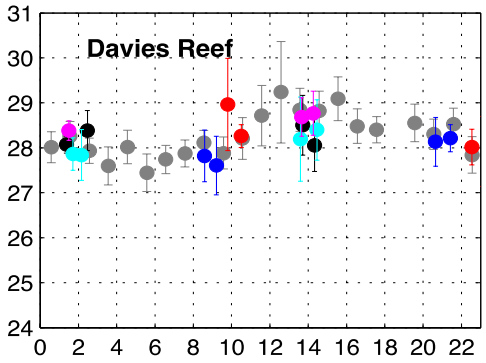


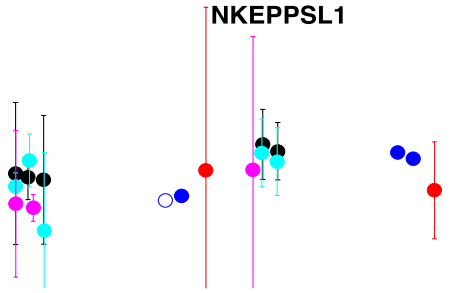
MTSAT-1R all points:
n=3287, bias =-0.04K, std=0.71K

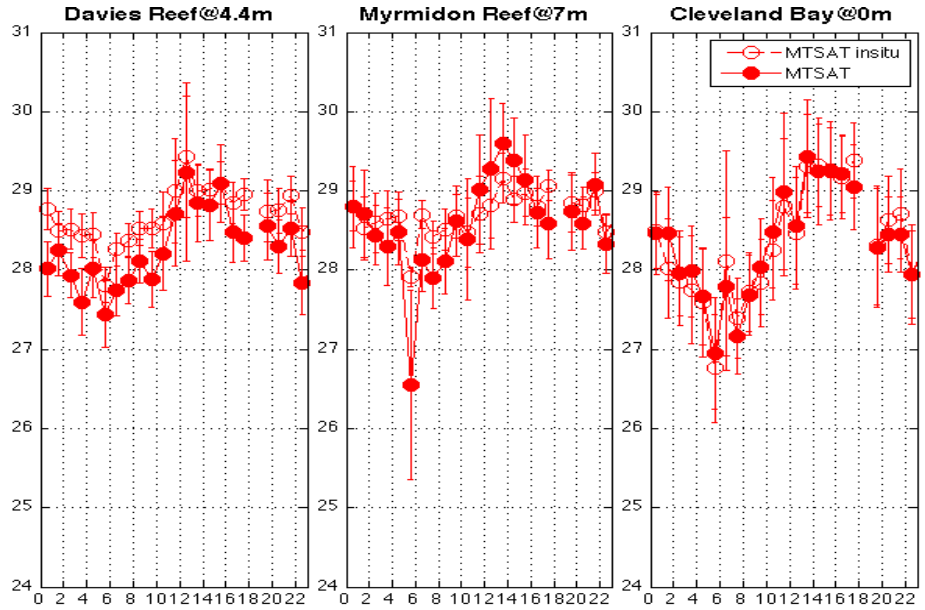
Other coastal validation works:
Park et al 2014 AVHRR at Japan Sea Std=0.8-0.85K
NOAA IQUAM coastal moorings compared with Reynolds SST std=0.5-0.6K, much larger datasets

Note: Add 0.17K to biases to convert MODIS and MTSAT-1R SSTskin to SSTsubskin

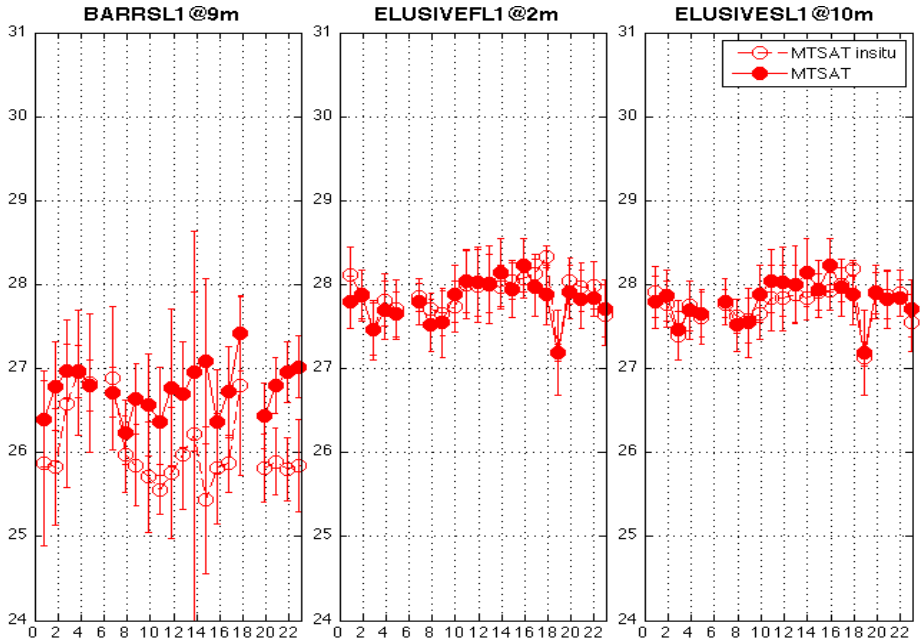
Local specific diurnal warming features shown in SST measurements

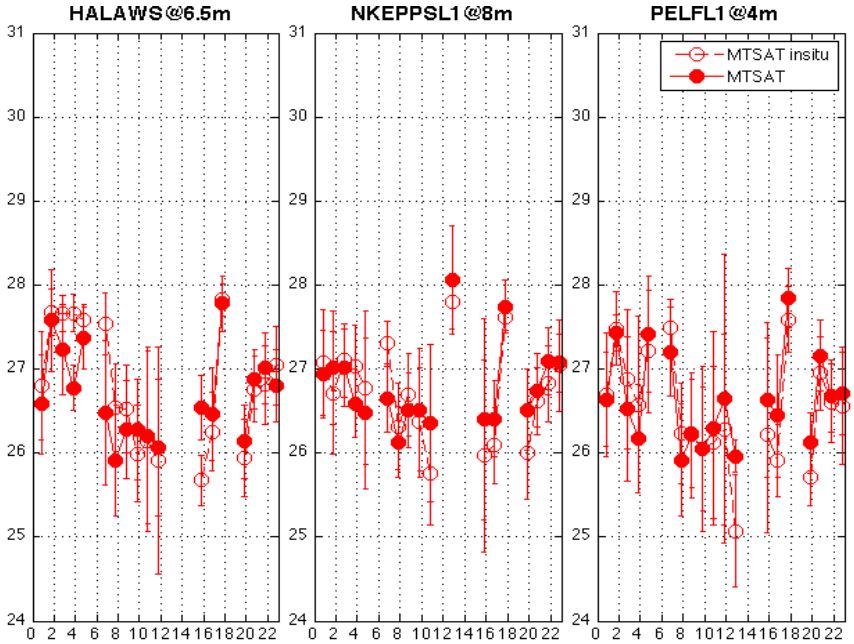






Similar features could be seen in in-situ data for each station





Summary of statistics

Satellite Sensor and Processing Level		Bias	Standard Devn.	N
Aqua MODIS, level 2	All	0.06K	0.71K	429
	Day	0.28K	0.78K	226
	Night	-0.18K	0.53K	203
Terra MODIS, level 2	All	-0.03K	0.66K	438
	Day	0.17K	0.56K	204
	Night	-0.22K	0.70K	234
NOAA17 AVHRR, level 3	All	-0.26K	0.56K	344
	Day	-0.46K	0.70K	137
	Night	-0.14K	0.41K	207
NOAA18 AVHRR, level 3	All	-0.12K	0.67K	414
	Day	-0.14K	0.87K	218
	Night	-0.09K	0.37K	196
NOAA19 AVHRR, level 3	All	-0.14K	0.74K	340
	Day	-0.13K	0.87K	209
	Night	-0.16K	0.47K	131
MTSAT-1R, level 3	All	-0.04K	0.71K	3287

Summary

- Objective is to assess the accuracy with which satellite-derived SSTs can represent the temperature at the depth of the corals, including diurnal fluctuations.
- Comparison of coastal polar-orbiting (AVHRR, MODIS) and geostationary (MTSAT) SST with coral top temperatures show good agreement, with bias and standard deviation similar or better than similar studies.
- Diurnal warming pattern (both timing and amplitude) shown in in-situ temperature are captured well by SST data. The geostationary SST are especially useful in studying the daily warming.
- Some regional bias corrections are needed to improve SST retrievals.
- Satellite SST is a good indicator of the temperature at the coral depth, but the two are not equal. A more accurate relationship between the two requires use of models.