Shipboard measurements of Sea Surface Skin Temperature in the Northwest Pacific

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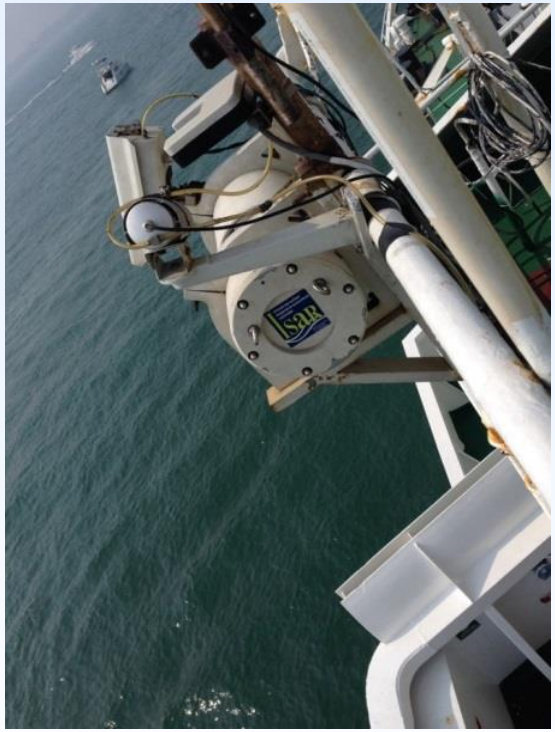
College of Information Science and Engineering
Ocean University of China

- Shipboard measurements of the skin SST
- Evaluation of satellite SST
- Summary

ISAR-5C
made by University of Southampton

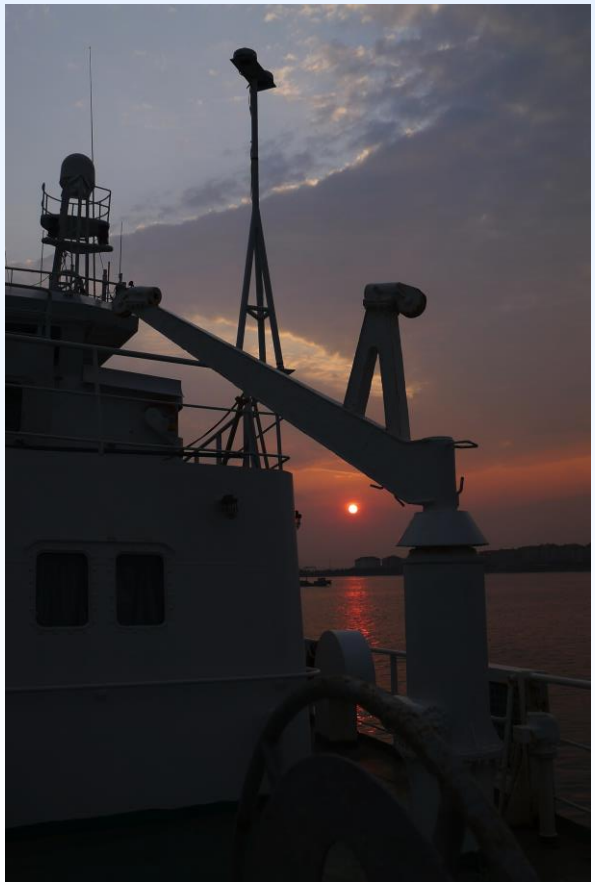
Oct, 2007, Qingdao

Dong Fang Hong II is a research vessel of Ocean University of China (OUC).This vessel is 96 m long and 15 m wide, with a draught of 5.5 m



ISAR on the compass deck

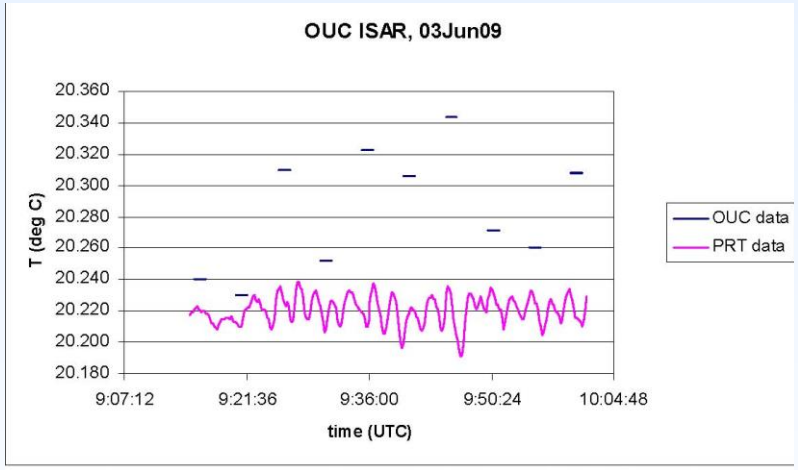
Data logging system in the lab



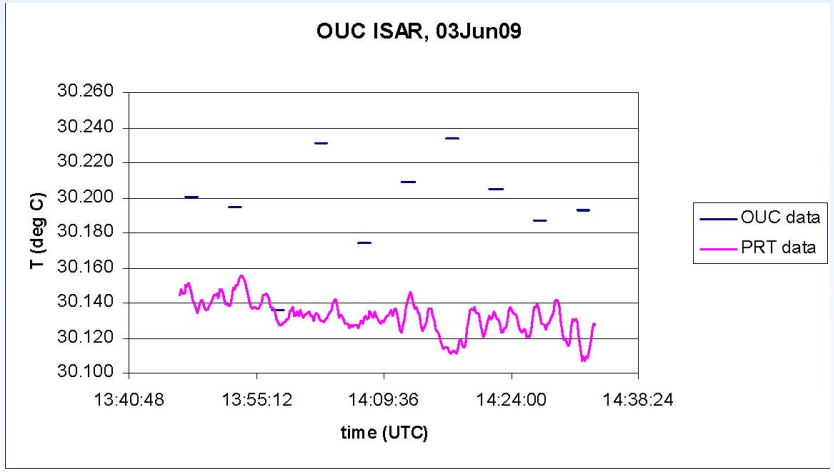
Parameter	Sensor
Shortwave radiation	Kipp & Zonen CMP 21
Longwave radiation	Kipp & Zonen CGR 4
Net radiation	Kipp & Zonen CNR 4
SST_{2m}	SBE 48
SST_{5m}	SBE 37 / SBE39

Ancillary data collections

CEOS comparison of Infrared radiometry in support of satellite calibration and validation for measuring SST for studies of climate change, Jun 2009



<ISAR – BB> =0.064 K



<ISAR – BB> =0.048 K

(Theocharous et. al., NPL Report OP3, 2010)

Measurements of the skin SST by ISAR

- 1st cruise, 21 Sept. 2009
- 61st cruise, 9 Jun 2017

Specification table:

Spectral Range	500 to 5000 cm^{-1}
Effective Emissivity	>0.9998
Temperature Range	-40C° to +65C°
Radiance uncertainty	<±0.005 K
Temperature Display Resolution	(as per controller BC-231)
Temperature Stability	0.03C° over 120 sec.
Temperature Gradient	<0.35C
Temperature Setting Resolution	0.001C°
Temperature knowledge	± 0.01℃ Absolute
Aperture diameter	2,75 inch
Voltage	110/230Vac, 50 or 60 Hz
Power consumption (1 source)	30W

BB-ASSIST II LR TECH INC

BB Controller, LR TECH INC

Date and time retention

Duration: *One month if powered at least 30 min.*

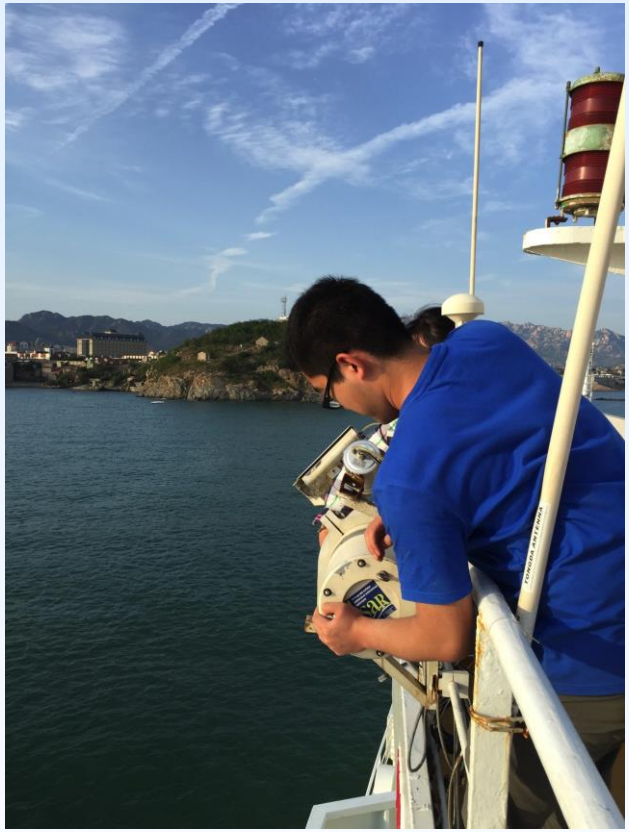
Temperature probe inputs

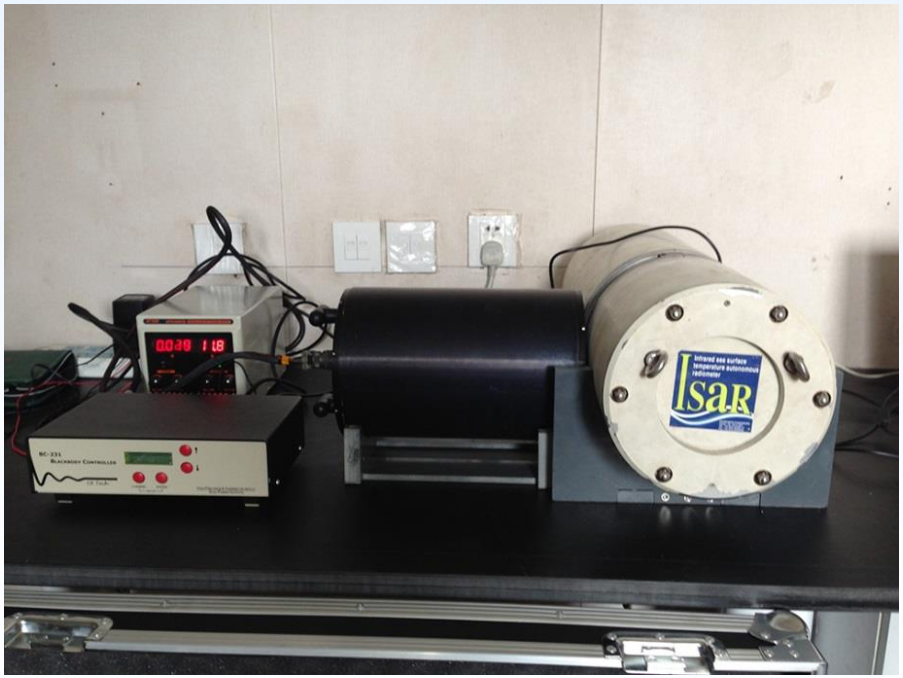
Probe type: *NTC thermistor 10kOhms at 25°C*
Maximum impedance of any probe: *50kOhms*
Maximum total impedance: *125kOhms*
Calibration: *Automatic*
Range of measure: *10°C to 65°C*
Resolution of measure: *0.001°C*

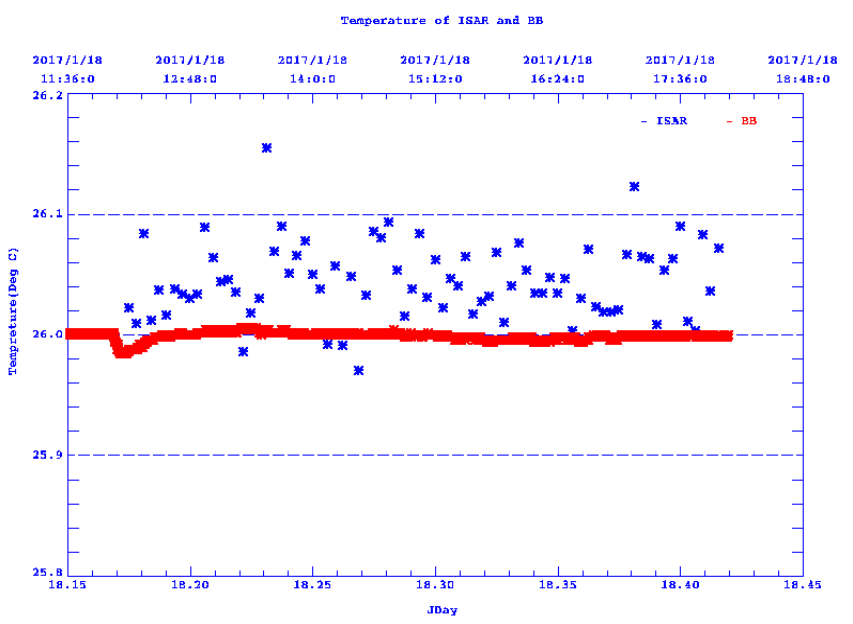
Regulation

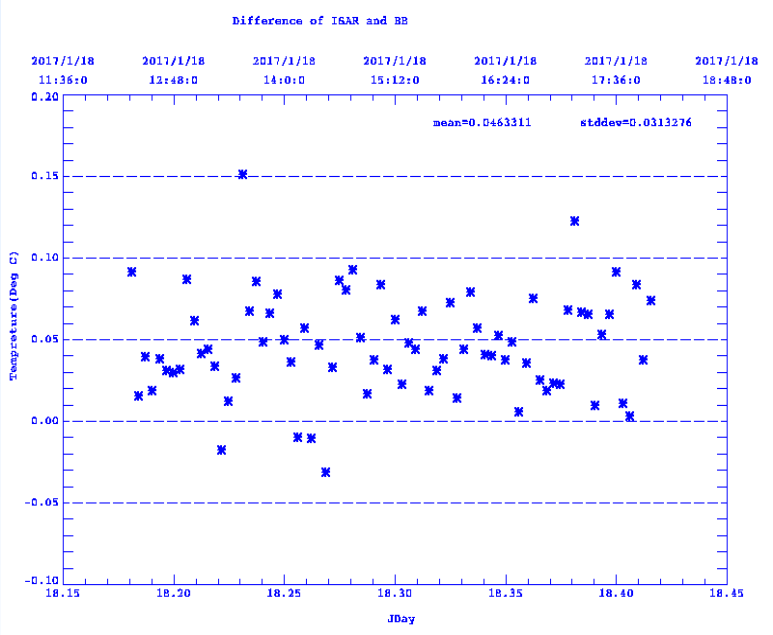
Setpoint: *15°C to 60°C*
Resolution of setpoint: *0.001°C*
Maximum stability at setpoint: *±0.005°C*

*Absolute precision of measure: *better than* 0.005°C *(controller)*
* Absolute precision of measure excludes intrinsic error of the probe, but includes a maximum ambient temperature variation of ±20°C.



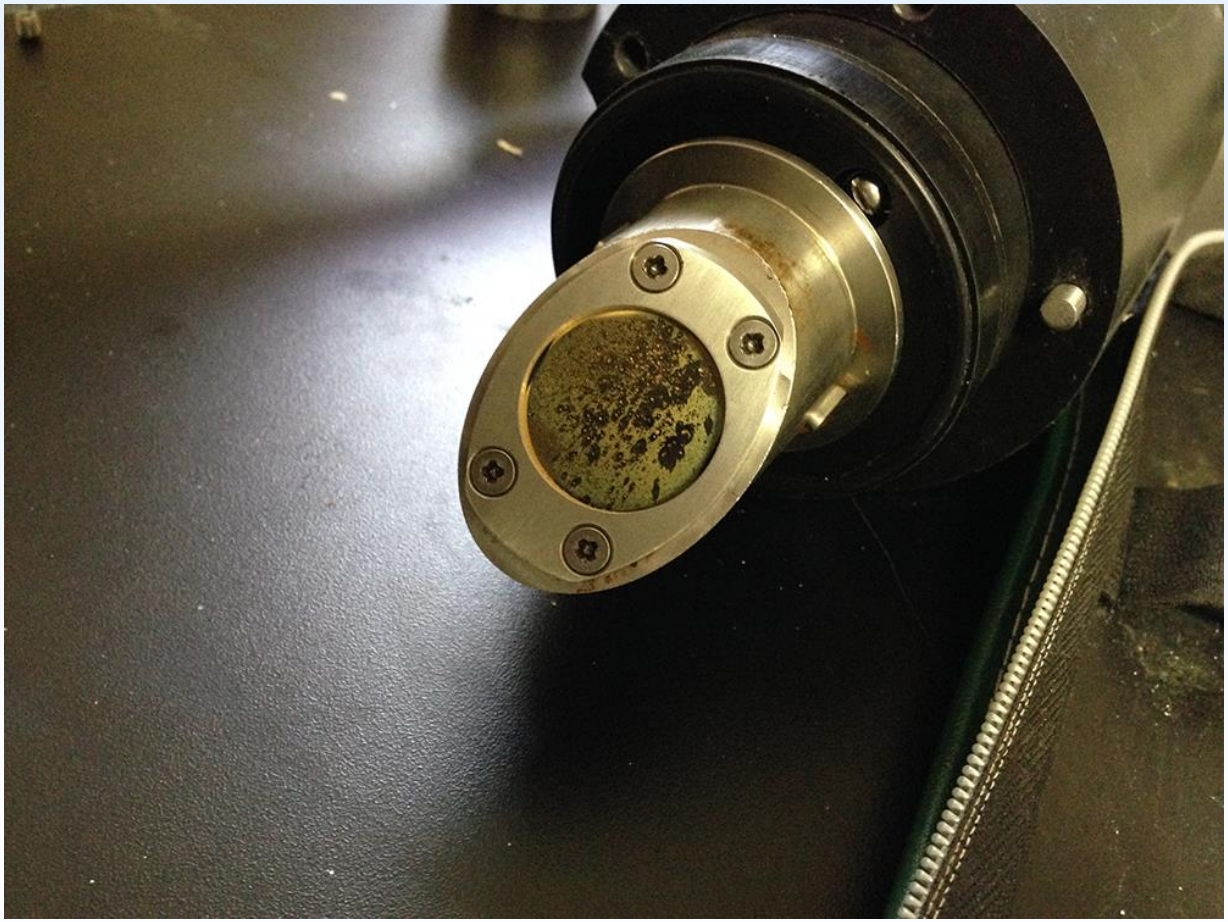

ISAR



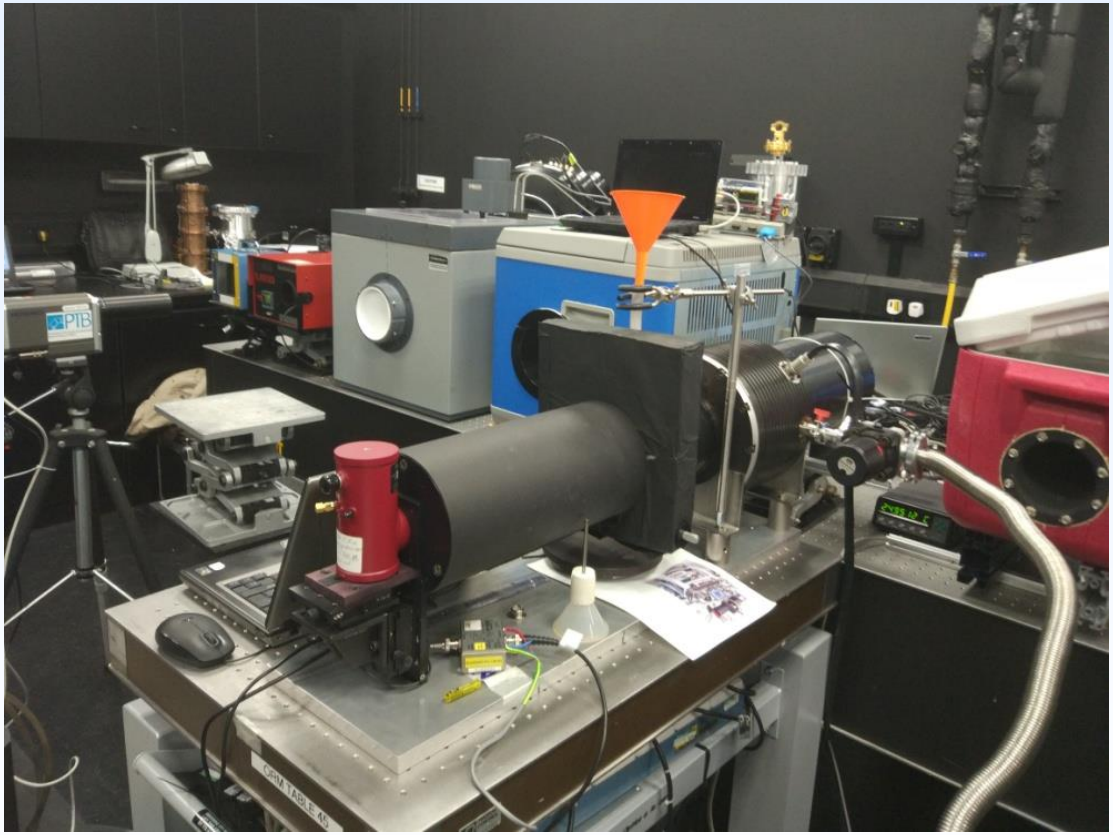


Calibration after 57th cruise（12/27/2016 – 0117/2017）

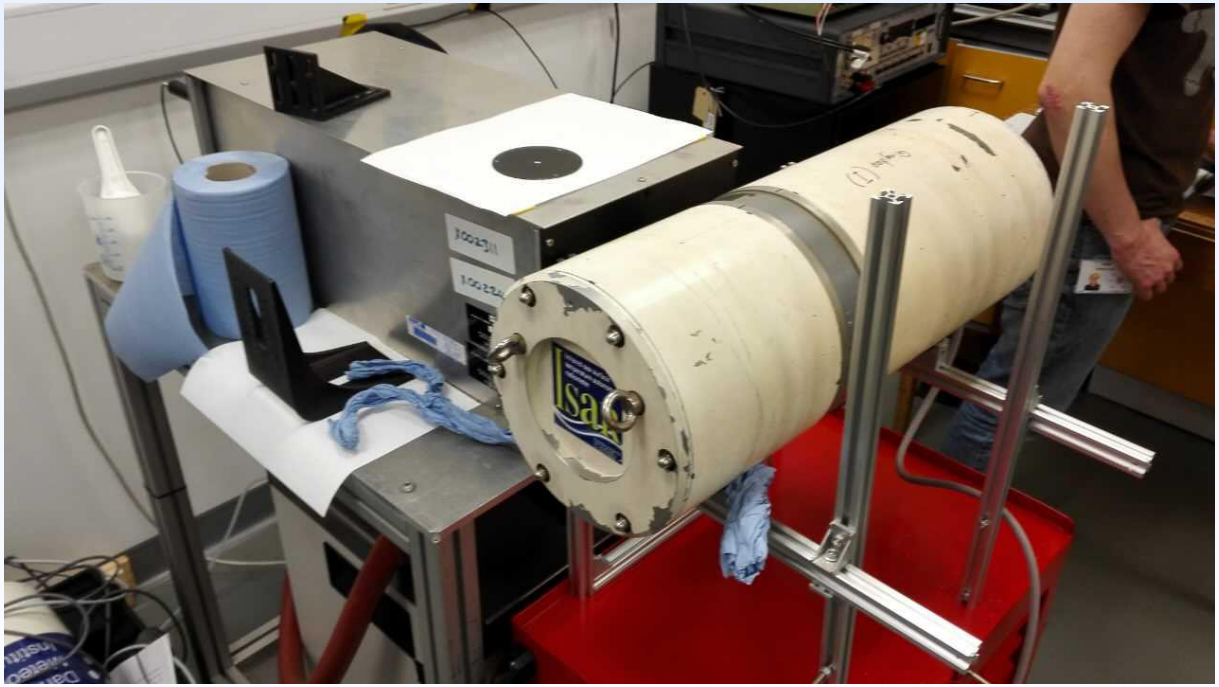
Bias: 0.046 K Std Dev: 0.03 K

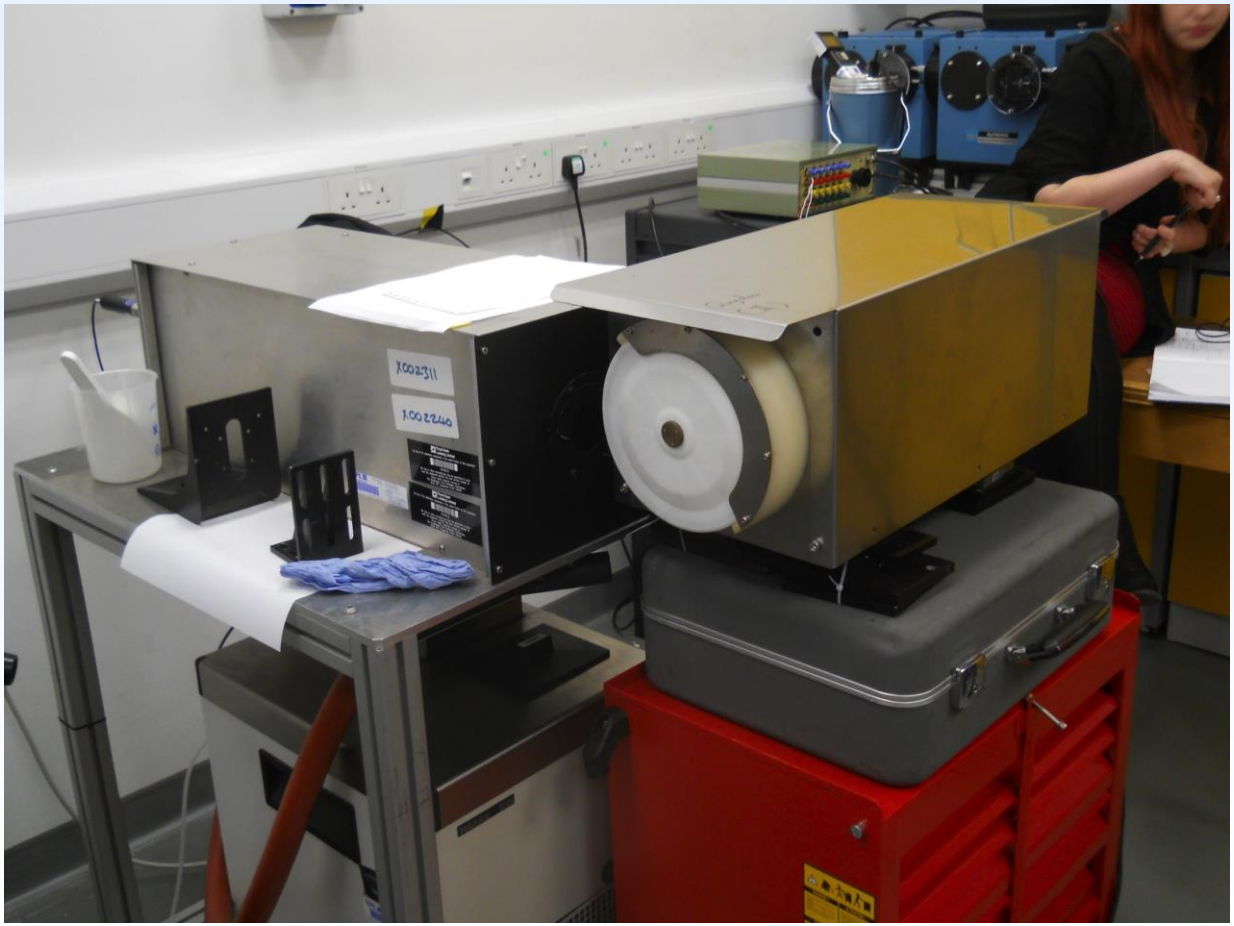


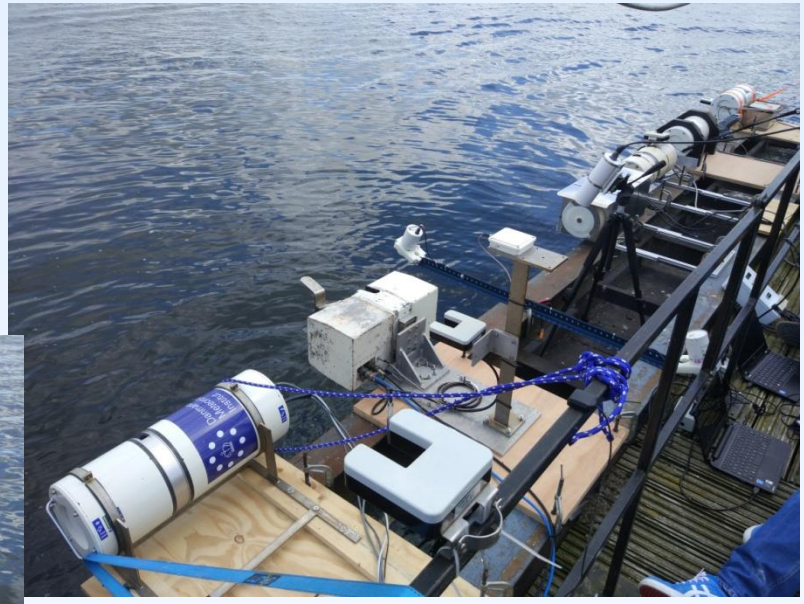

IMO 8887947

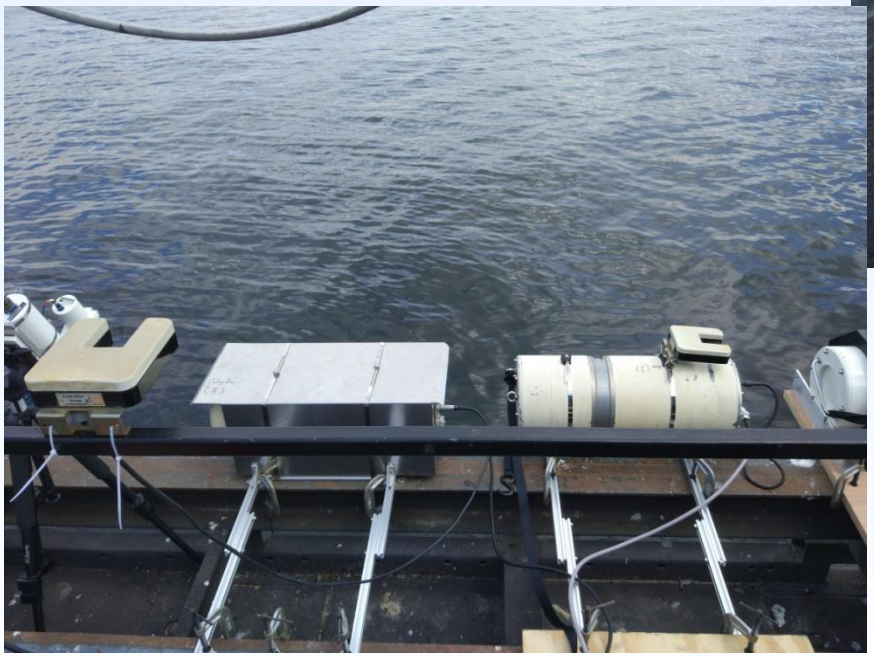


Fiducial Reference Measurements for validation of Surface Temperature from Satellites (FRM4STS), Jun 2016









CEOS comparison of Infrared radiometry in support of satellite calibration and validation for measuring SST for studies of climate change, Jun 2009

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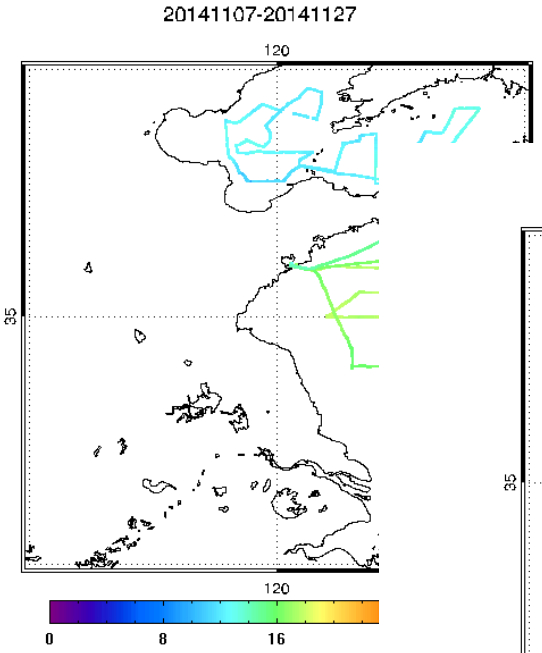
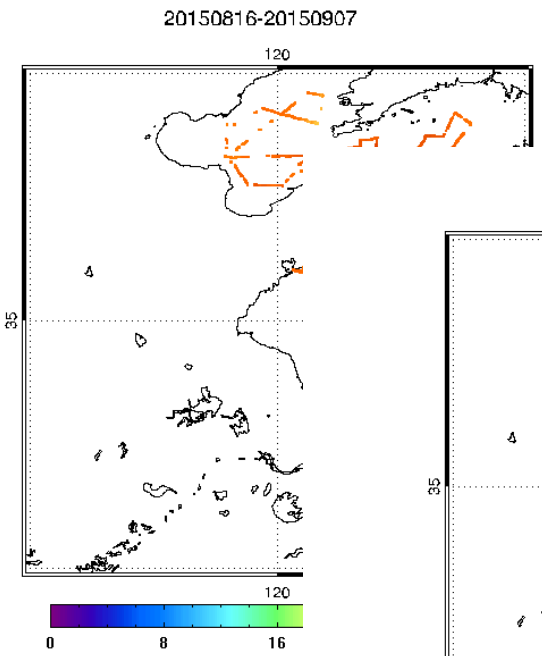
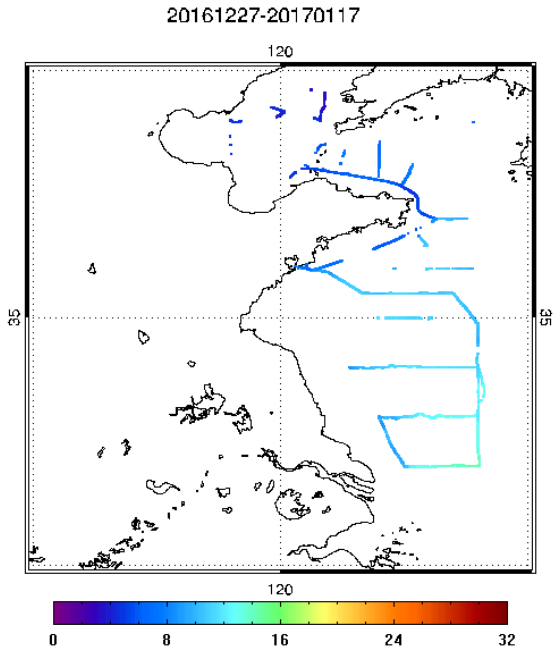
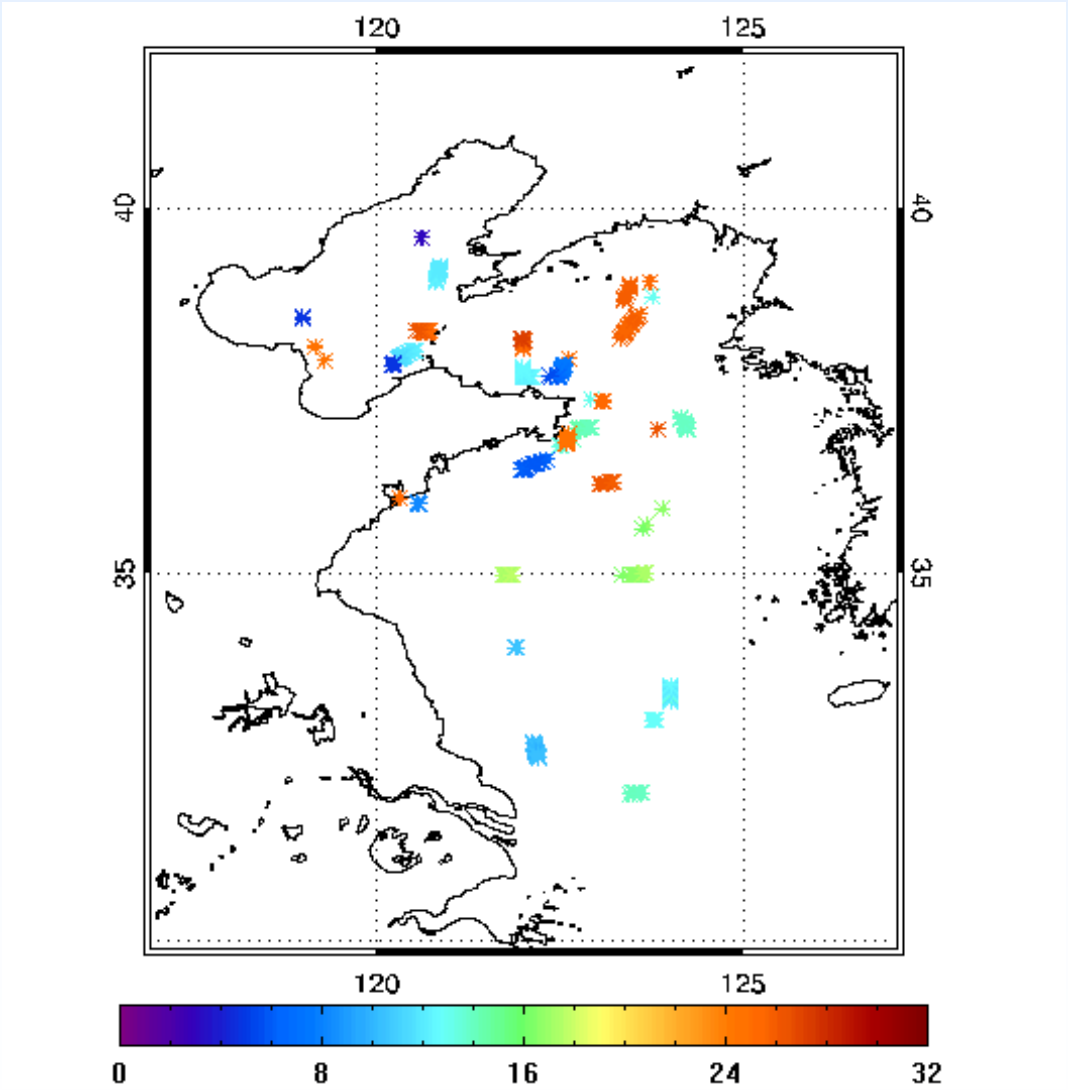
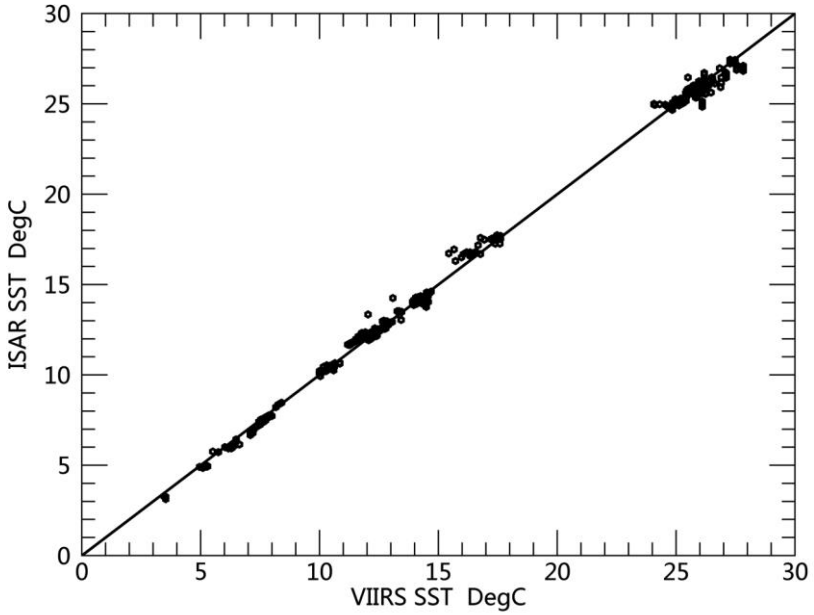
Comparison VIIRS SST with ISAR measurements








120
125
40
35
120
125
0
8
16
24
32



Temporal window: 1 hour
Spatial window: 0.01°
No. of Matchup: 493
Bias: 0.14 ℃, Std. Dev.: 0.35 ℃

High quality
No. of Matchup: 122
Bias: 0.09 ℃, Std. Dev.: 0.21 ℃

Sea surface temperature products are operationally produced from Fengyun satellites and Haiyang satellites observations in China

- Haiyang (HY) Series Satellite

National Ocean Satellite Application Center (NSOAS) of the State Oceanic Administration of China (SOA) is responsible for development of ocean satellite series and satellite ocean applications. (http://www.nsoas.gov.cn)

- Fengyun (FY) Series Satellite

National Satellite Meteorological Center (NSMC) of China Meteorological Administration (CMA) is responsible for development of meteorological satellite series and satellite meteorological applications. (http://http://www.nsmc.cma.gov.cn)

Evaluation of Sea Surface Temperature from FY-3C VIRR Data in the Arctic

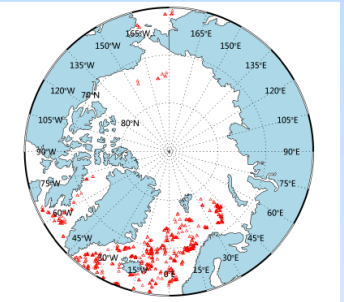


Fig.1 Matchup Locations

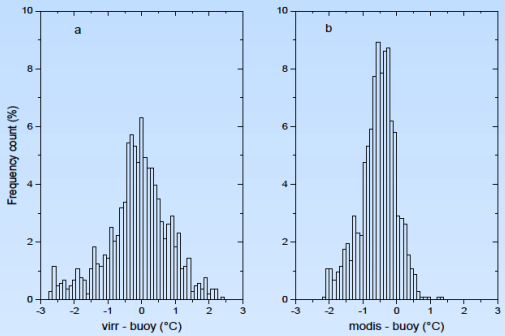


Fig. 2 Histograms of SST difference

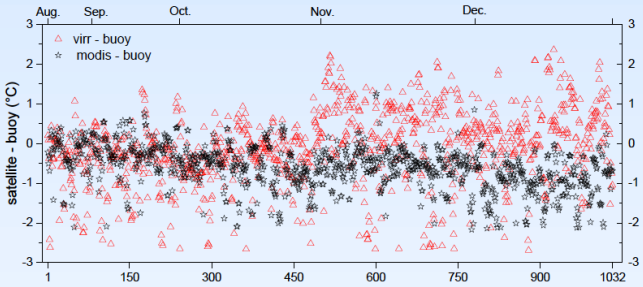


Fig. 3 Time series of SST difference between satellite and buoy data

	N	Bias(°C)	Std(°C)	Median(°C)	RSD(°C)	P(±0.5°C) (%)
VIRR – buoy	1032	-0.12	0.93	-0.06	0.76	49

Wang, H, L. Guan and G. Chen, 2016: Evaluation of sea surface temperature from FY-3C VIRR data in the Arctic. *IEEE Geoscience and Remote Sensing Letters*, **13** (2), 10.1109/LGRS.2015.2511184

✧HY-1 Series Satellites

Chinese Ocean Color and Temperature Scanner (COCTS)

- HY-1A, 15 May 2002
- HY-1B, 17 April 2007

✧HY-2 Series Satellites

Scanning Microwave Radiometer

- HY-2A, 16 August 2011

HY-1 Chinese Ocean Color and Temperature Scanner (COCTS)

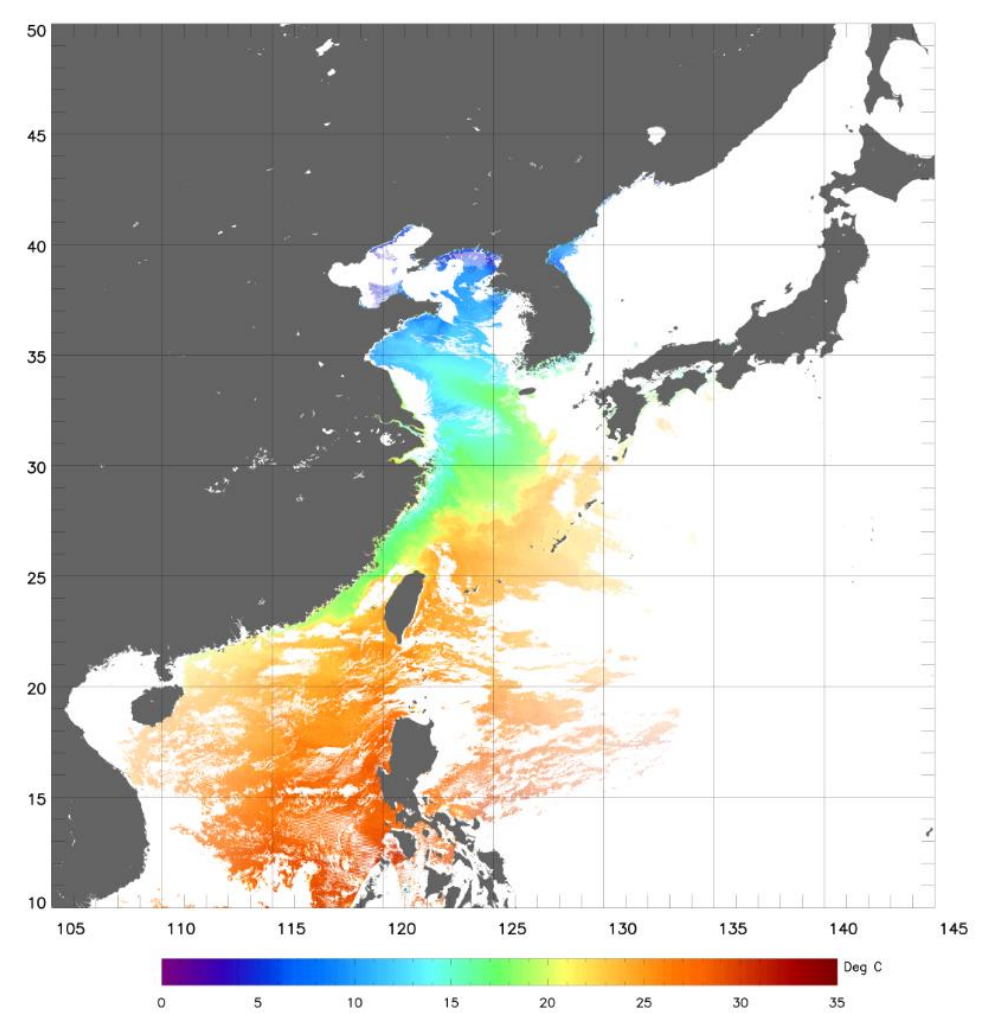
Table 2: Specification of the COCTS instrument

Spectral range (μm)	SNR	Dynamic range (%)	Observation objective
0.402 - 0.422	440	40	Yellow substance, water pollution
0.433 - 0.453	600	35	Absorption of chlorophyll
0.480 - 0.500	590	30	Chlorophyll, sea water optics sea ice Pollutants, shallow sea topography
0.510 - 0.530	560	28	Chlorophyll, water depth, Sediment of low concentration
0.555 - 0.575	525	25	Chlorophyll, sediment of low concentration
0.660 - 0.680	390	20	Peak of fluorescence, sediment of high concentration, pollution, atmospheric correction, aerosols
0.730 - 0.770	400	15	Sediment of high concentration, atmospheric correction
0.845 - 0.885	415	15	Atmospheric correction, water vapor
10.30 - 11.40 (TIR)	NEΔT = 0.2 K (at 300 K)		SST (Sea Surface Temperature), sea ice, temperature of cloud top
11.40 - 12.50 (TIR)	NEΔT = 0.2 K (at 300 K)		SST, sea ice, temperature of cloud top

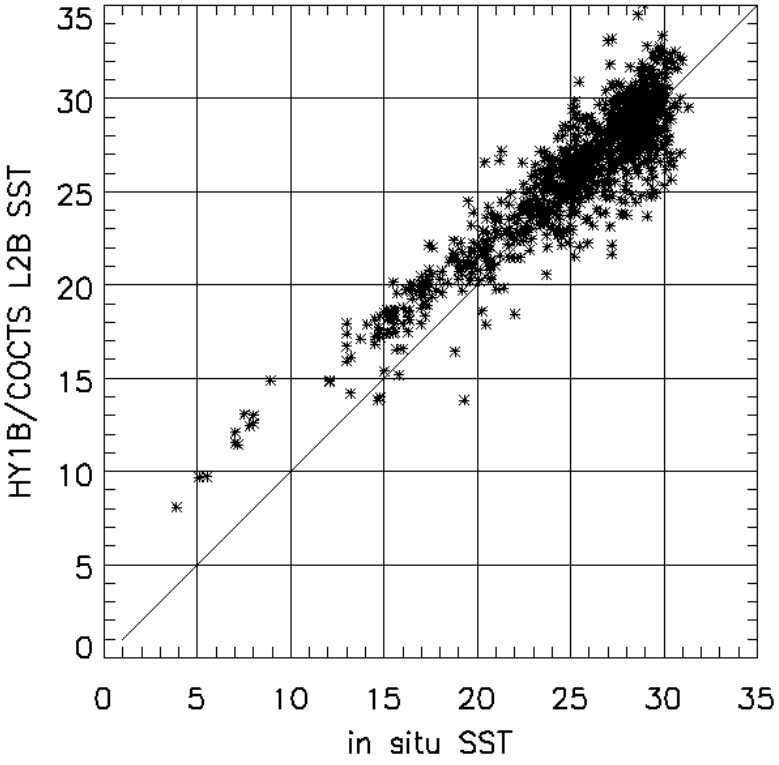
✧ HY-2 Series Satellites
Scanning Microwave Radiometer

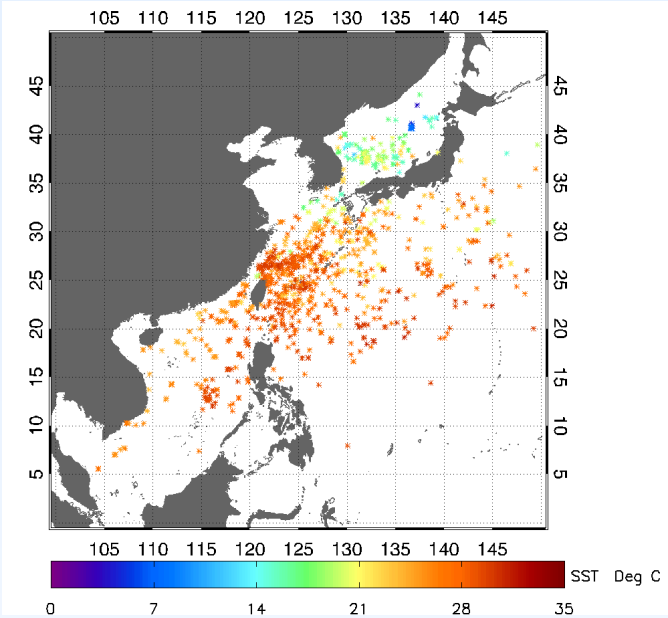
Center frequency (GHz)	6.6	10.7	18.7	23.8	37
RF bandwidth (MHz)	350	250	250	400	1000
Polarization	V,H	V,H	V,H	V	V,H
Brightness temperature sensitivity (K)	0.5	0.5	0.5	0.5	0.8
Calibration precision	1 K @ 180~320 K				
Swath width	1600 km				
Ground resolution (km)	100	62	36	30	18
Dynamic range (K)	3~350				
Receiver linearity	> 0.999				
Main beam coefficient	> 95%				
Scanning mode	Conical scanning				

Evaluation of Sea Surface Temperature HY-1B COCTS



HY-1B COCTS L2B SST on 11 February 2009



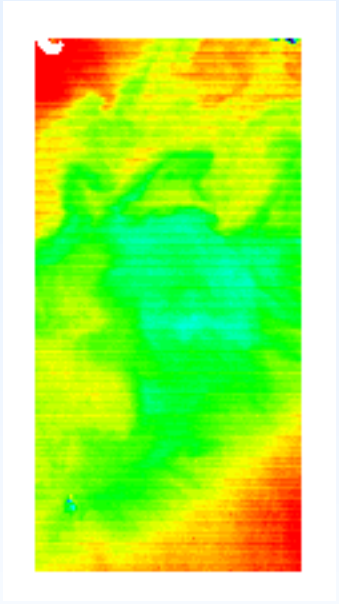


1356 daytime HY-1B L2B SST products during 2008-2010

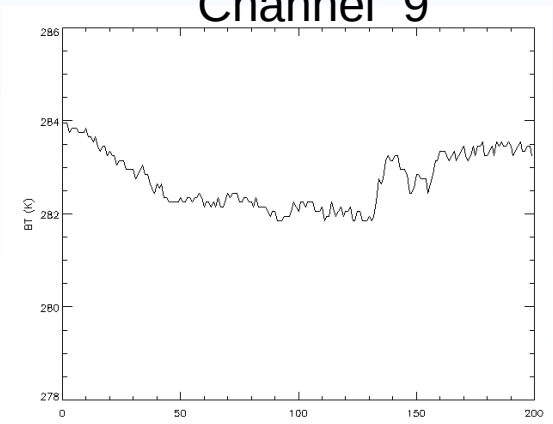
Temporal window: 1 hour
Spatial window: 0.01°
No. of Matchup: 1097

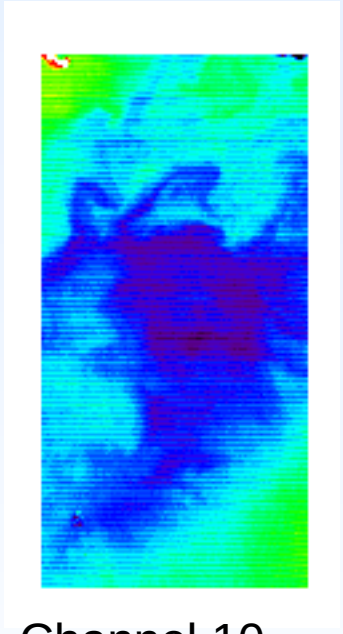
Bias: 0.72 ℃, Std. Dev.: 1.82 ℃
Median：0.80 ℃

Comparisons of HY-1B COCTS L2B SST products and buoy SST data

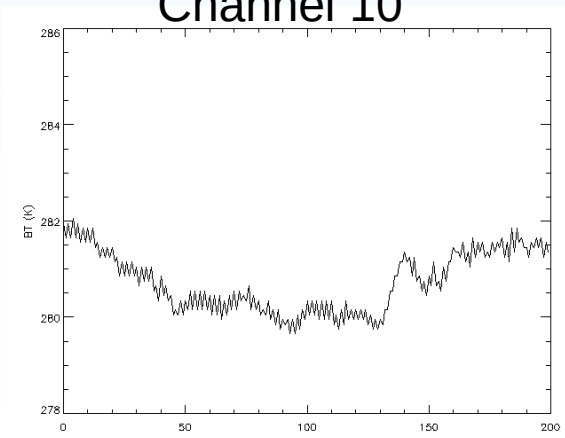


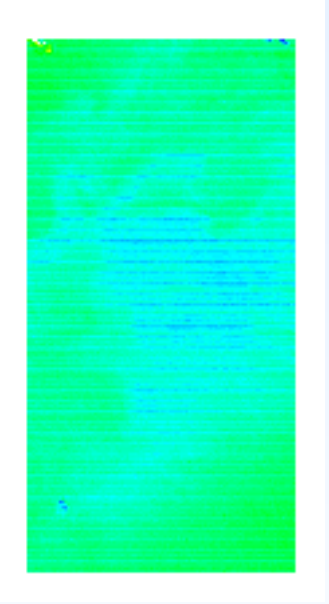
Channel 9



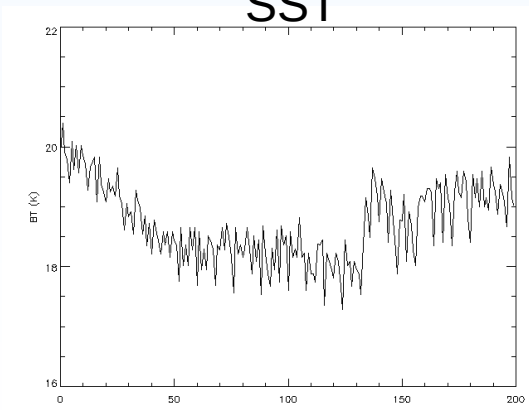


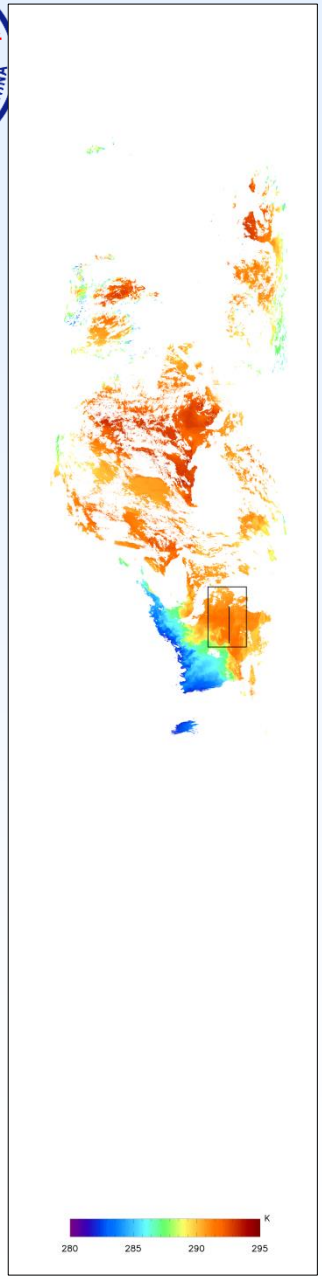
Channel 10

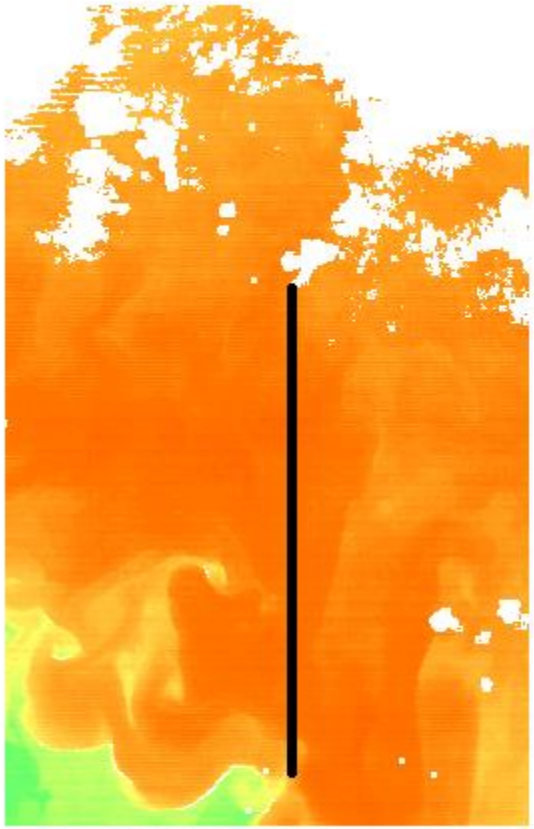


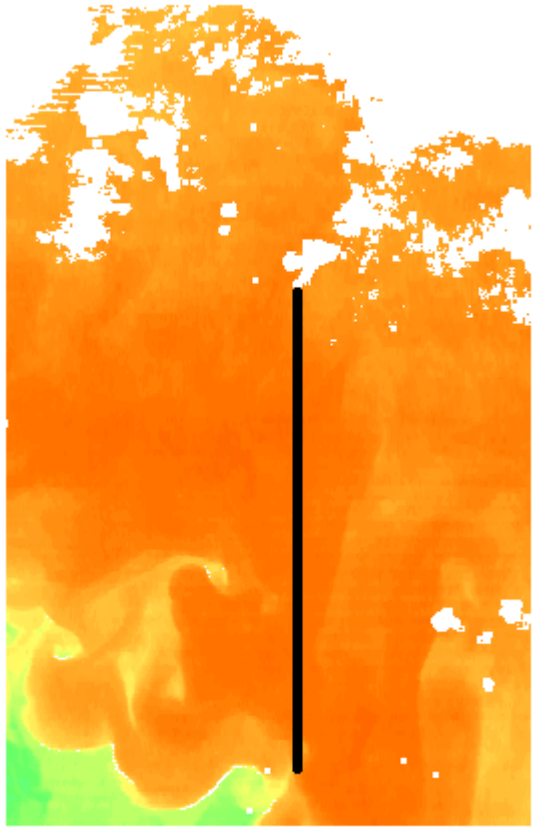


SST



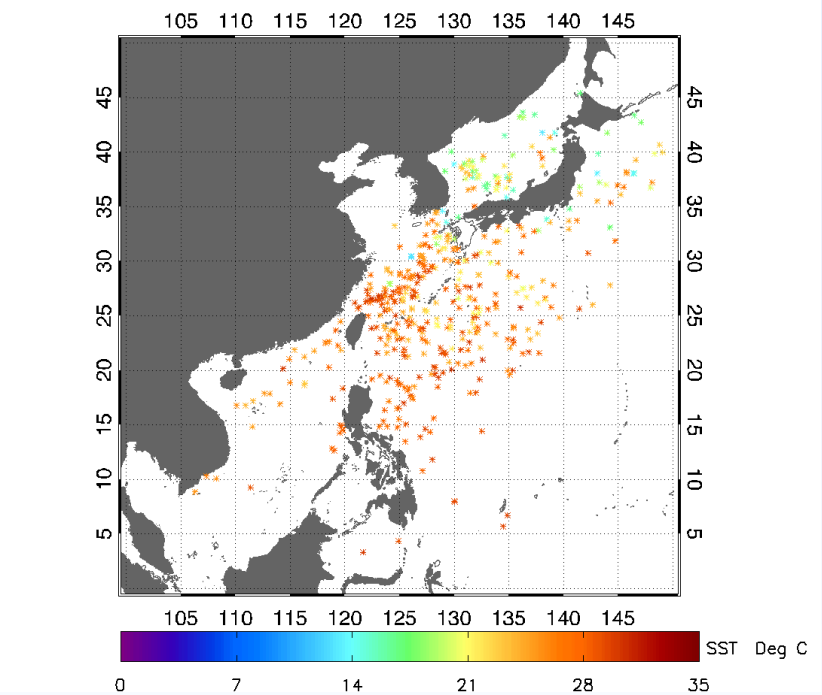






Destriping Algorithm: using a unidirectional variational Model*

*(Bouali and Ignatov, 2013)



1374 daytime HY-1B L1B products during 2009-2011

Temporal window: 1 hour
Spatial window: 0.01°

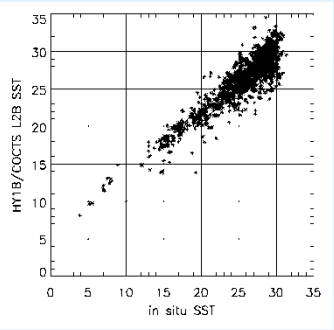
No. of Matchup: 1374 - Total
916 - Regression
458 - Validation

$$NLSST = a_0 + a_1 \times T_9 + a_2 \times T_{sfc} \times (T_9 - T_{10}) + a_3 \times (T_9 - T_{10}) \times (\sec\theta_{saz} - 1)$$

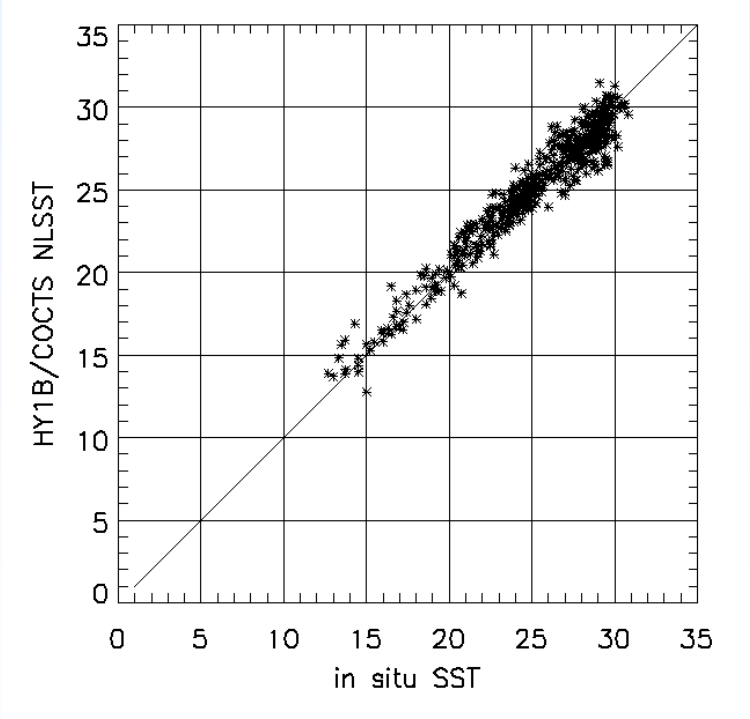
$$MCSST = b_0 + b_1 \times T_9 + b_2 \times (T_9 - T_{10}) + b_3 \times (T_9 - T_{10}) \times (\sec\theta_{saz} - 1)$$

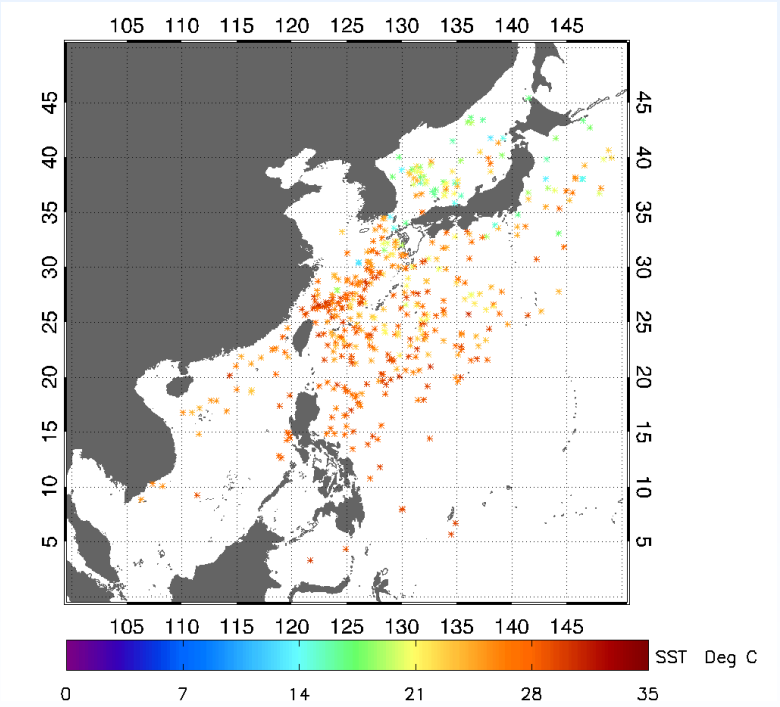
Generation of the new NLSST retrieval coefficients

Bias: 0.72 ℃
Std. Dev.: 1.82 ℃

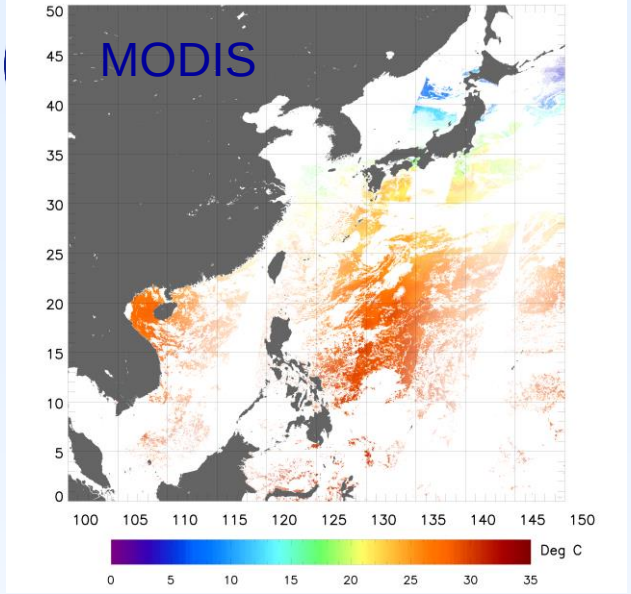


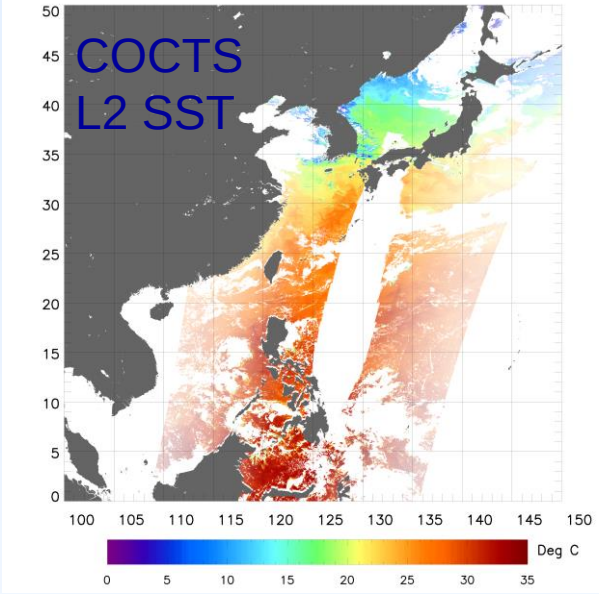
Bias: -0.02 ° C , Std. Dev.: 1.01° C

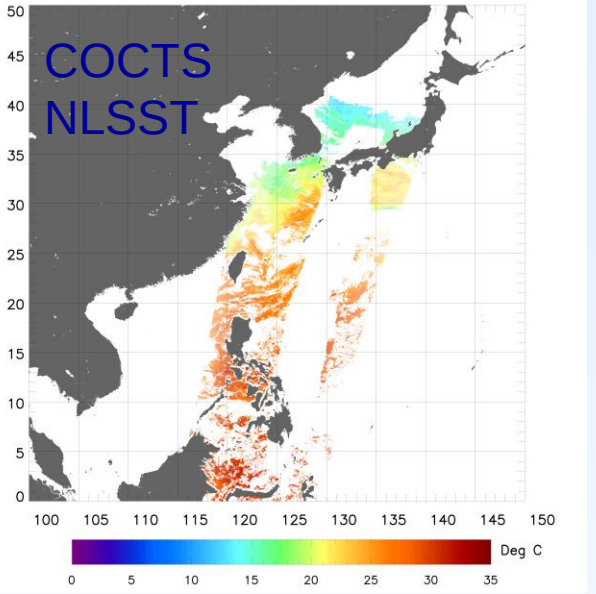


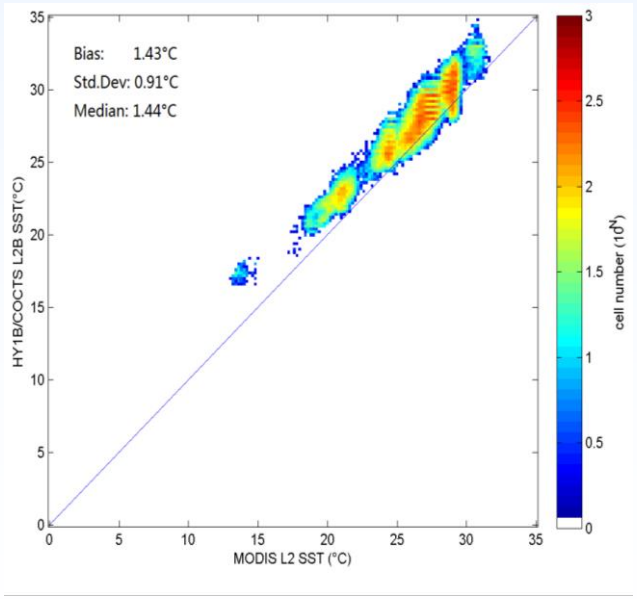


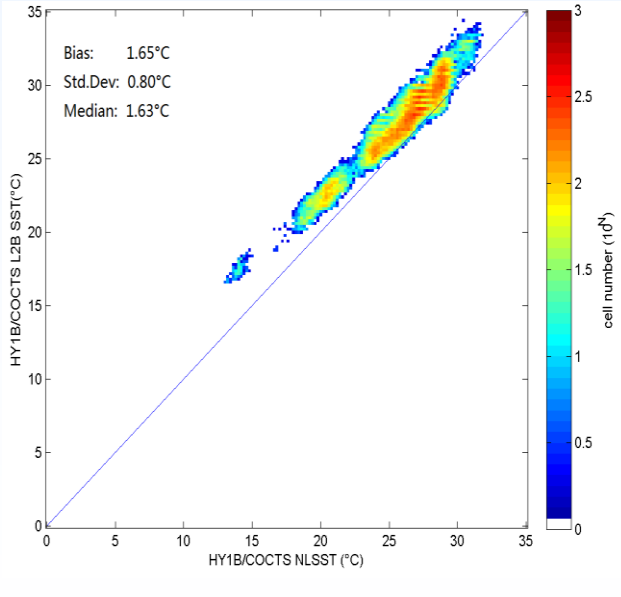
Evaluation of the new SST retrieval coefficients

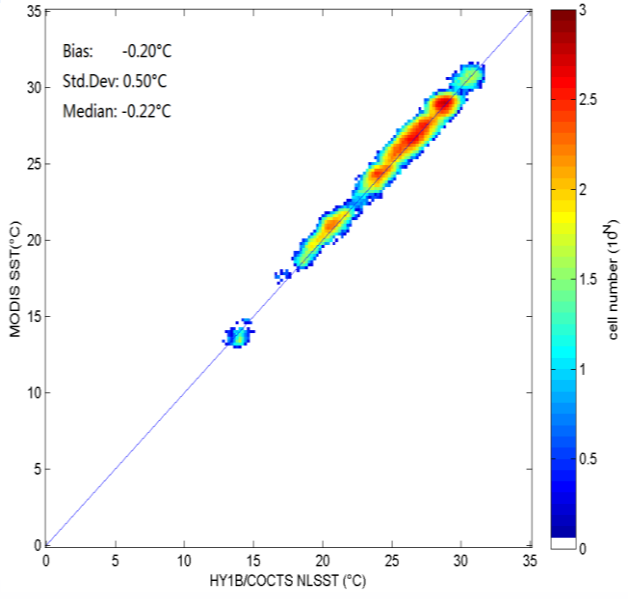






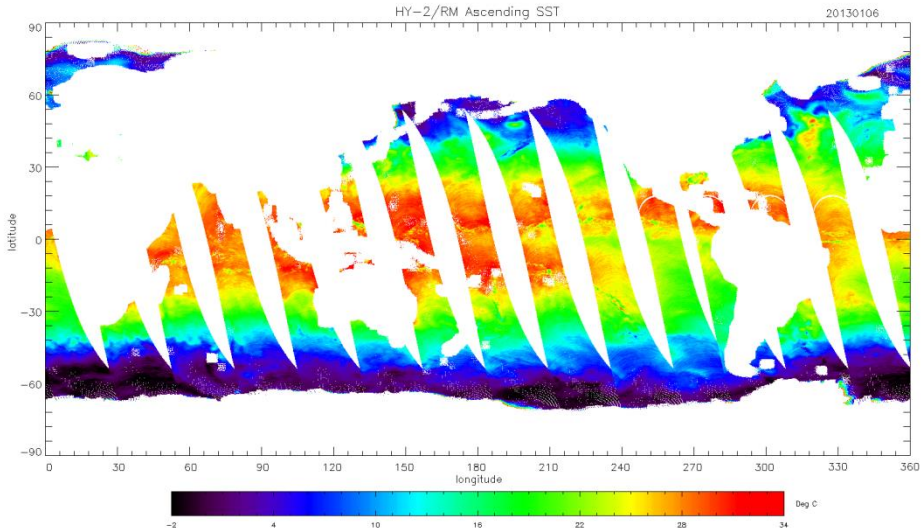


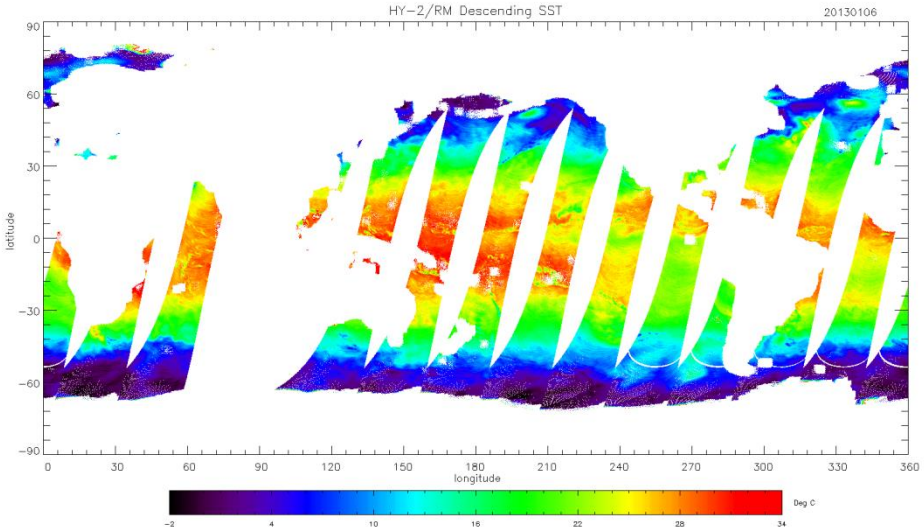


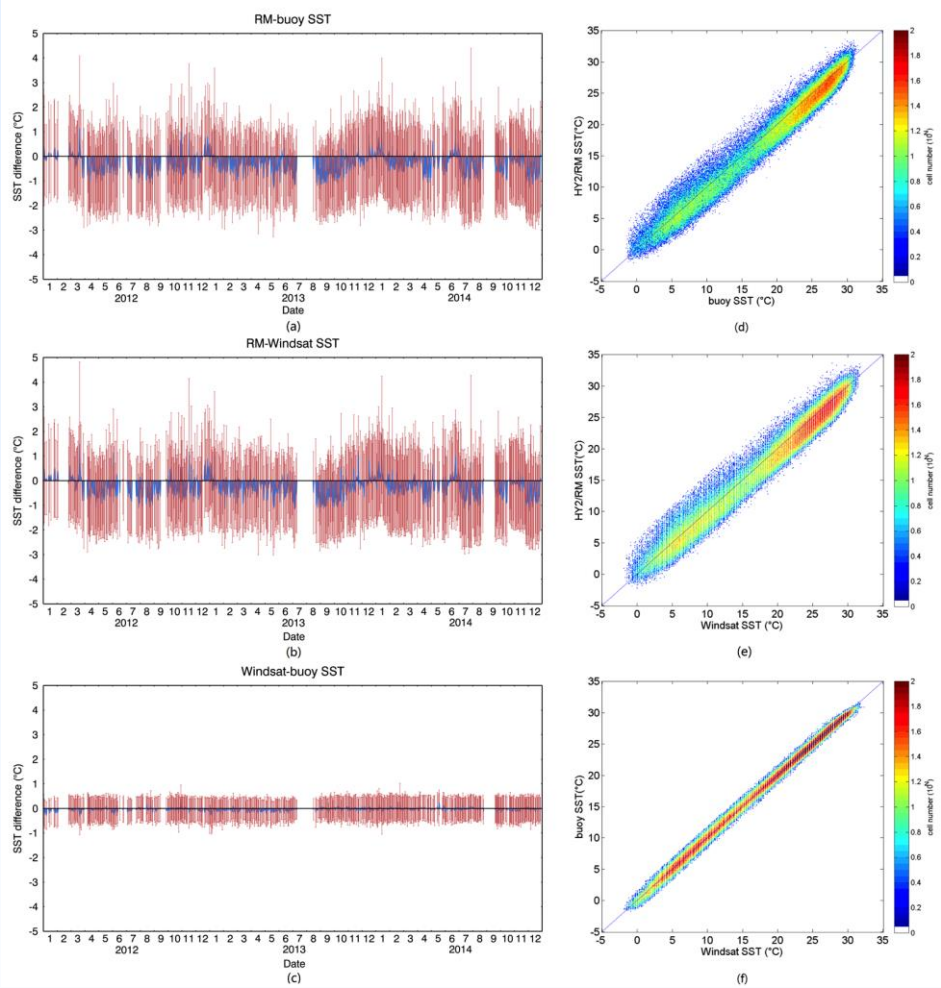


Comparison of the MODIS COCTS L2 SST and NLSST on 14 May 2009

Evaluation of Sea Surface Temperature from HY-2 Scanning Microwave Radiometer



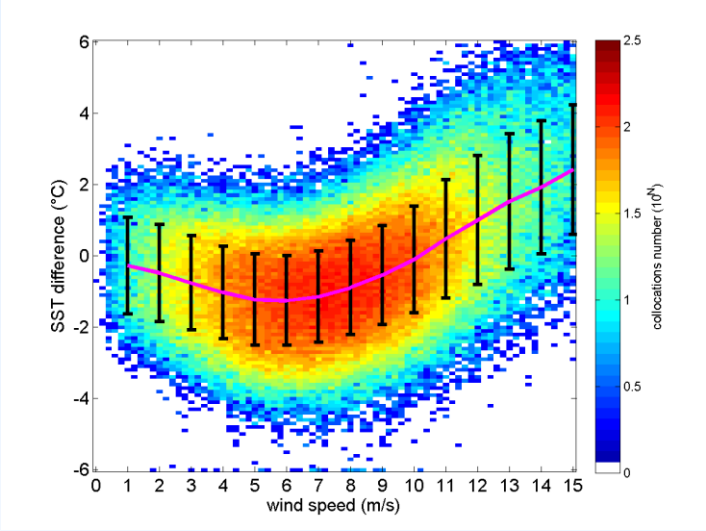


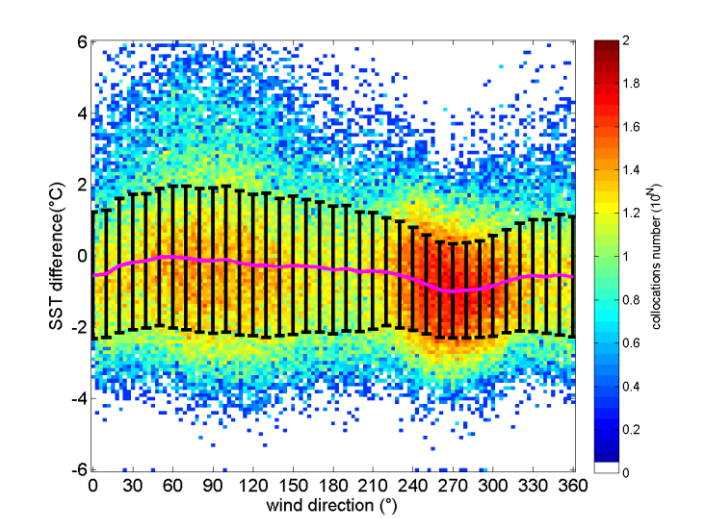


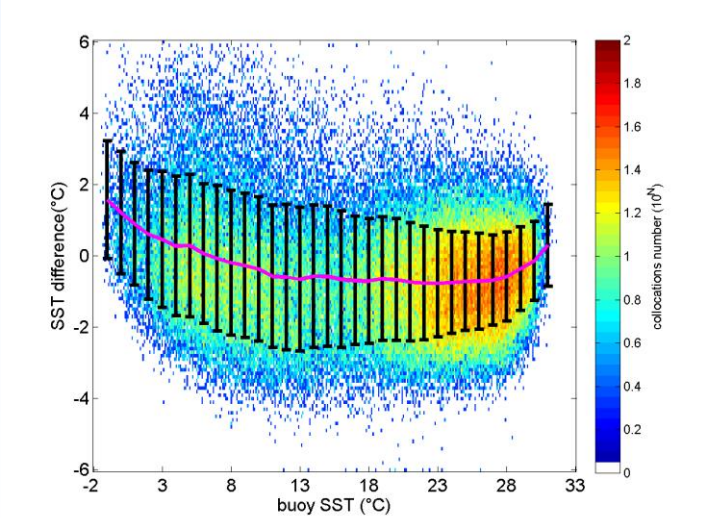
THREE YEAR STATISTICS OF SST DIFFERENCE BETWEEN HY-2 RM, WINDSAT AND BUOY SST DATA FROM JANUARY 2012 TO DECEMBER 2014

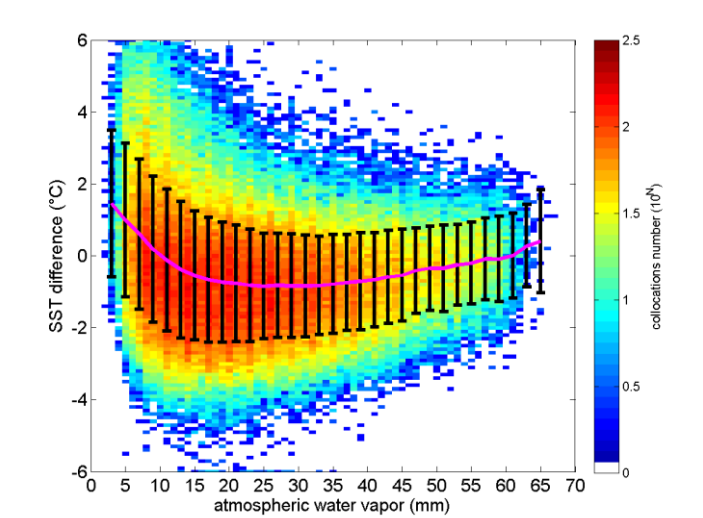
	Number	Bias(°C)	Median(°C)	Std.Dev(°C)	RSD(°C)	P(±0.5°C)(%)	P(±1°C)(%)	P(±2°C)(%)
RM-buoy	166323	-0.45	-0.59	1.73	1.97	22.76	43.23	74.02
RM- WindSat	166323	-0.41	-0.56	1.72	1.97	22.92	43.31	74.48
WindSat -buoy	166323	-0.03	-0.03	0.53	0.59	68.37	92.62	100

Mingkun Liu, Lei Guan, Wei Zhao, and Ge Chen, 2017, Evaluation of sea surface temperature from HY-2 Scanning Microwave Radiometer. *IEEE Transactions on Geoscience and Remote Sensing*, **55**(3), 10.1109/TGRS.2016.2623641


SST difference (°C)
wind speed (m/s)
collocations number (10^4)


SST difference(°C)
wind direction (°)
collocations number (10^4)


SST difference(°C)
buoy SST (°C)
collocations number (10^4)


SST difference (°C)
atmospheric water vapor (mm)
collocations number (10^4)

- Shipboard measurements of the skin SST
- Evaluation of satellite SST
- Summary

Summary

- Shipboard measurements of skin SST

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- The SST products from HY satellites need to be improved

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Thank you