Quality Control and Monitoring of *in situ* SSTs for satellite Cal/Val

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Use of in situ SSTs at NESDIS

Active satellite SST Projects

- ✓ Current: POES (AVHRR), GOES (Imager), MSG (SEVIRI)
- ✓ Future: NPOESS (VIIRS), GOES-R (ABI)

Use of in situ SST for satellite Cal/Val

- ✓ CAL: Derive regression coefficients / Perform bias correction
- ✓ VAL: Monitor accuracy of satellite SST against ground-truth

Near-Real Time NCEP GTS *Data*

- ✓ Global Telecommunication System data available in NRT
- ✓ Quality non-uniform & suboptimal ➔ Significant effect on Cal/Val
- ✓ QC not available in GTS ➔ Simplistic *ad-hoc* QC applied
- ✓ Only Drifting & Tropical Moored Buoys employed
  (No Ships/Coastal Moorings)

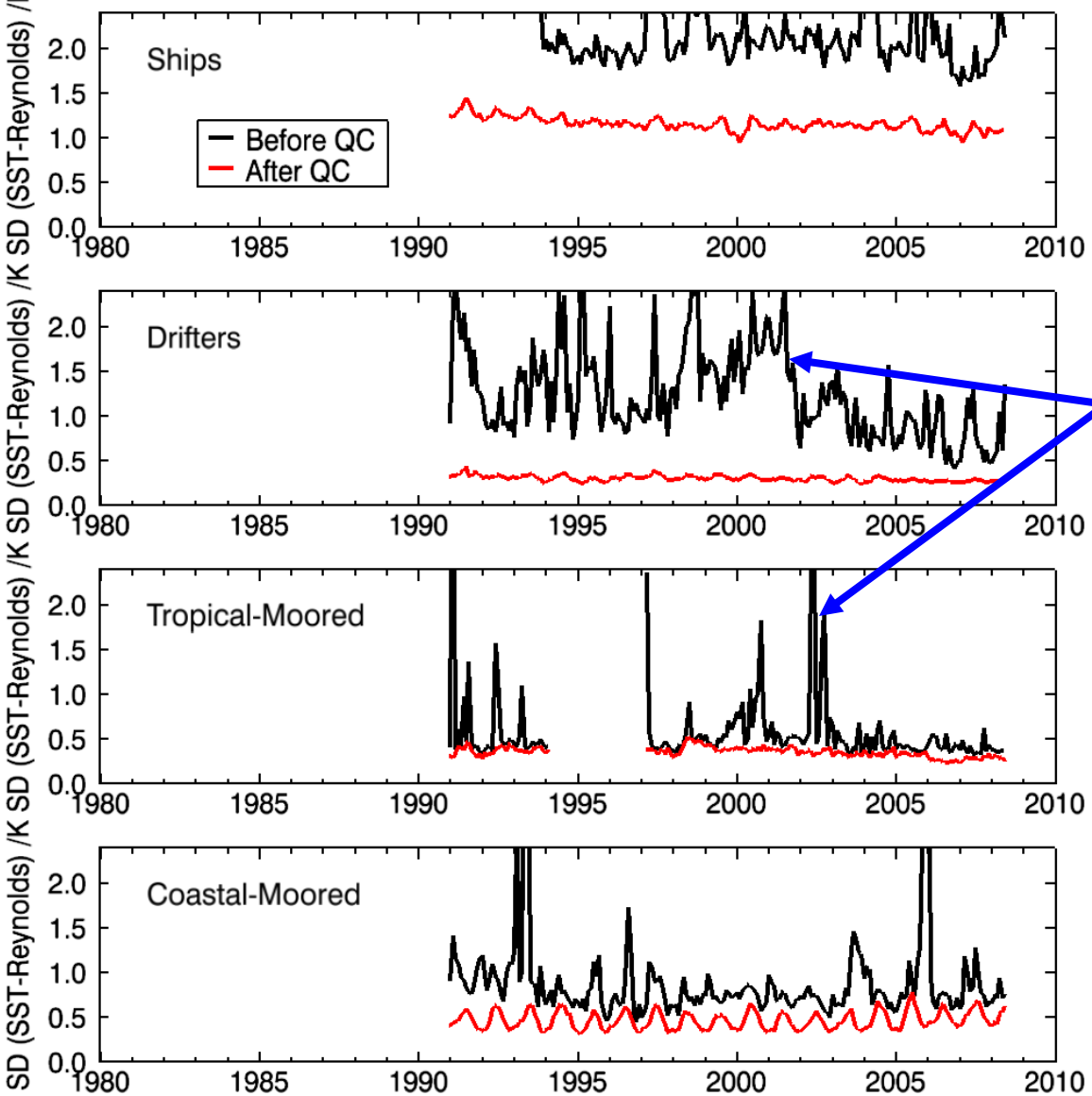
Objective of this study

In support of ongoing SST developments at NESDIS: Review & Improve current operational practices for handling *in situ* SSTs in satellite Cal/Val.

Specific Objectives

- ✓ Establish accurate and flexible QC for *in situ* SSTs, maximally consistent with wider communities
- ✓ Establish online *in situ* Quality Monitor (*iQuam*) http://www.star.nesdis.noaa.gov/sod/sst/iquam/
  - ✓ Provide summaries of *in situ* SSTs in NRT (stratified by ships, drifters, tropical & coastal moored; and for individual platforms)
  - ✓ Serve QCed *in situ* SST data online for wider community
  - ✓ Include ship and coastal moored data in *iQuam*, to explore their potential use in satellite Cal/Val

Why QC of in situ SSTs is needed?

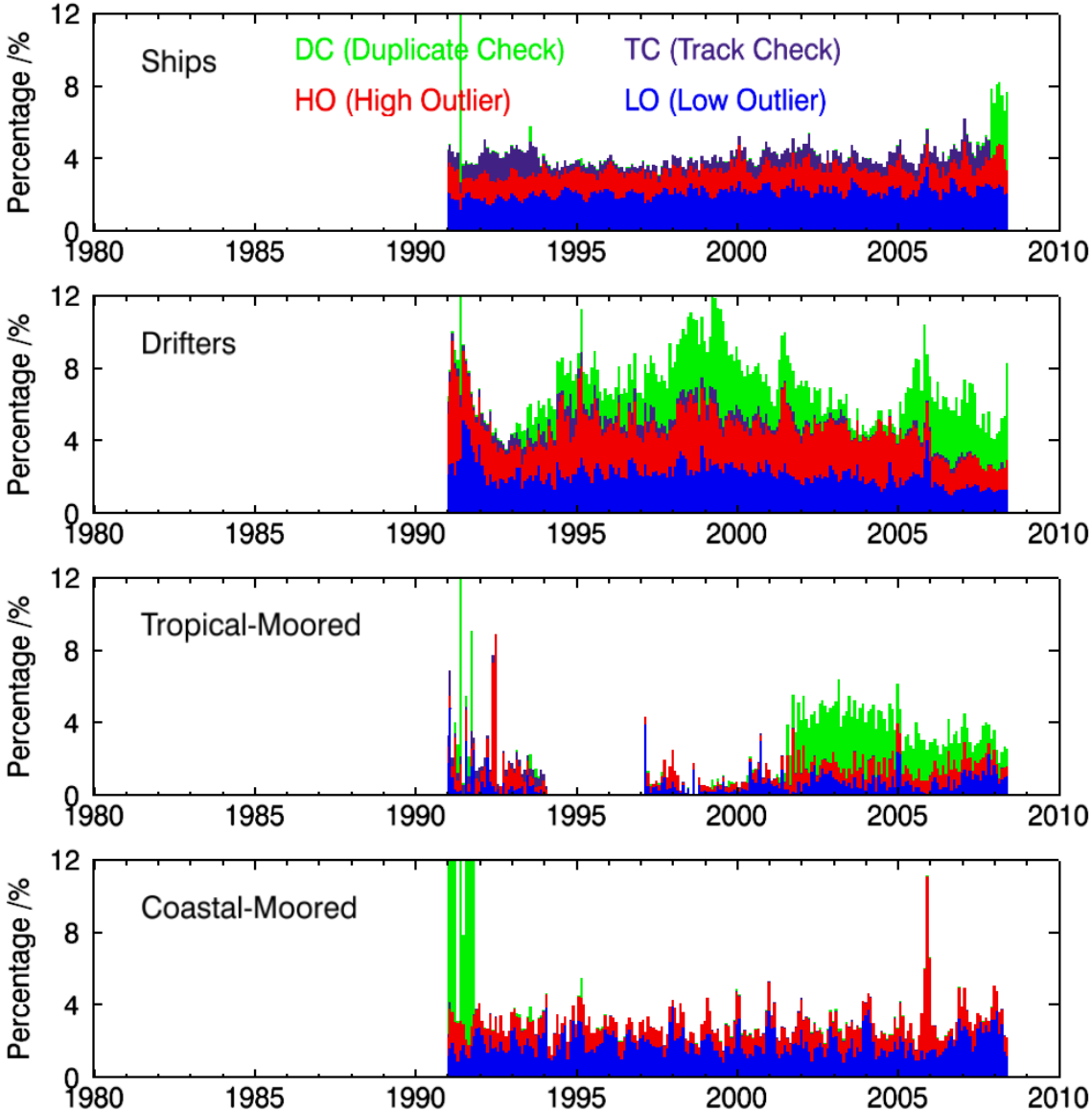


SD of "In Situ – Daily Reynolds SST" stratified by in situ data types

All SSTs are strongly contaminated by outliers. Drifters affected most. QC is strongly needed.

NB: Heritage NESDIS QC

Why QC of in situ SSTs is needed? (Cont'd)



Percent of in situ data excluded by QC

<10% outliers significantly degrade global statistics of in situ SSTs.

Percent of outliers is largest in drifter data used in Cal/Val – this is where QC is needed most.

NB: Heritage NESDIS QC

QC Options at NESDIS

For the use in satellite Cal/Val, QC must be

- ✓ Accurate, flexible & scalable
- ✓ Available in near-real time (NRT)
- ✓ Consistent with the community approaches (e.g., UK MET Office)

Option 1: Utilize one of the available QCed datasets

- ✓ ICOADS: Not available in NRT
- ✓ UK Met Office: Publicly accessible?
- ✓ FNMOC: 1998 – on; QC non-uniform; Documentation scarce

Option 2: Implement "in house" QC

- ✓ Access to NCEP GTS data available in NRT
- ✓ Consistent with MET community (Lorenc and Hammon, 1988; Ingleby and Haddleston, 2007) ➔ *Straightforward to implement*
- ✓ Easy to customize to meet flexible Cal/Val needs

Current Implementation of QC

Category	Check	Type of error handled	Physical basis
Preprocessing	Duplicate Removal	Duplicates arise from multiple transmission or data set merging	Identical space/time/ID
Plausibility	Plausibility checks	Unreasonable field value	Range of single fields & Relationships among them
Internal consistency	Tracking	Points falling out of track	Travel speed exceeds limit
	Spike check	Discontinuities in SST time series along track	SST gradient exceeds limit
External consistency	Reference Check	Measurements deviating far away from reference	Bayesian approach (Ref. SST: daily OI SST v2)
Mutual consistency	Cross-platform Check	Mutual verification with nearby measurements (“buddies check”)	Bayesian approach based on space/time correlation of SST field (Correlation model: 2-scale SOAR, Martin et al., 2002)

The need for in situ SST monitoring system for satellite Cal/Val

- Some existing *in situ* monitoring web sites, e.g.
  - JCOMMOPS / DBCP: http://www.jcommops.org/dbcp/data/qc.html
  - UK Met Office: http://www.metoffice.gov.uk/research/nwp/observations/monitoring/marine/ (password needed)
  - Meteo France: http://www.meteo.shom.fr/qctools
  - EUMETSAT OSI SAF METOP SST MDB monitoring: http://saf.met.no/validation/desc_sst_mdb_mon.html
  - NCEP/NCO Quality Assessment Project: http://www.nco.ncep.noaa.gov/pmb/qap/

Many useful elements but not exactly what's needed for global Cal/Val of satellite SSTs at NESDIS, in NRT

- *In situ* SST monitoring system for satellite Cal/Val
  - iQuam - in situ SST quality monitor http://www.star.nesdis.noaa.gov/sod/sst/iquam/

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iQuam

Quality Monitor for *in situ* Sea Surface Temperatures

NOAA / NESDIS / STAR

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- Maps
- Statistics
- Time-series
- Platforms

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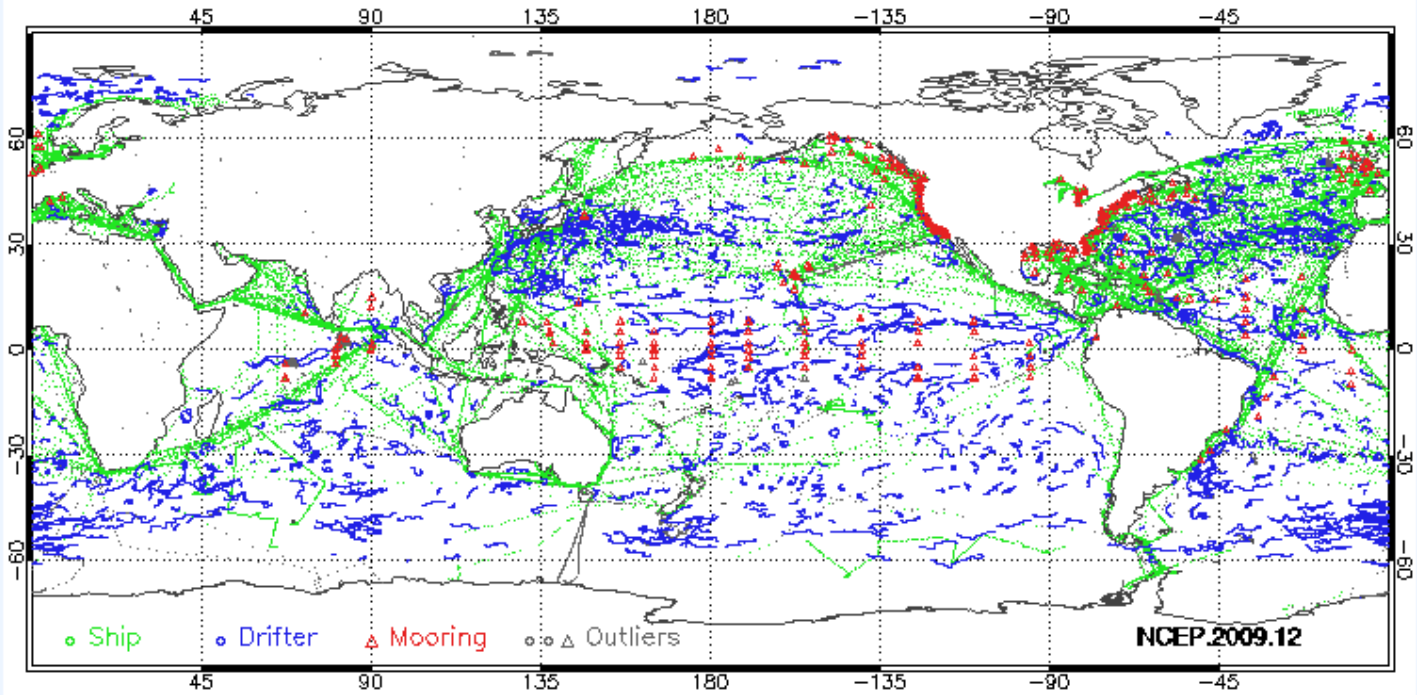
Each symbol stands for one observation. Four types of platforms are shown in different colors, with outliers (erroneous observations) shown in gray.

Tropical moorings include tropical arrays TAO/TRITON, PIRATA, RAMA etc. Coastal moorings are all other moorings except those tropical arrays.

Global map of measurements



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iQuam webpage http://www.star.nesdis.noaa.gov/sod/sst/iquam/

iQuam: Monthly Statistical Summaries

Outliers detected by each QC check

QC Statistics

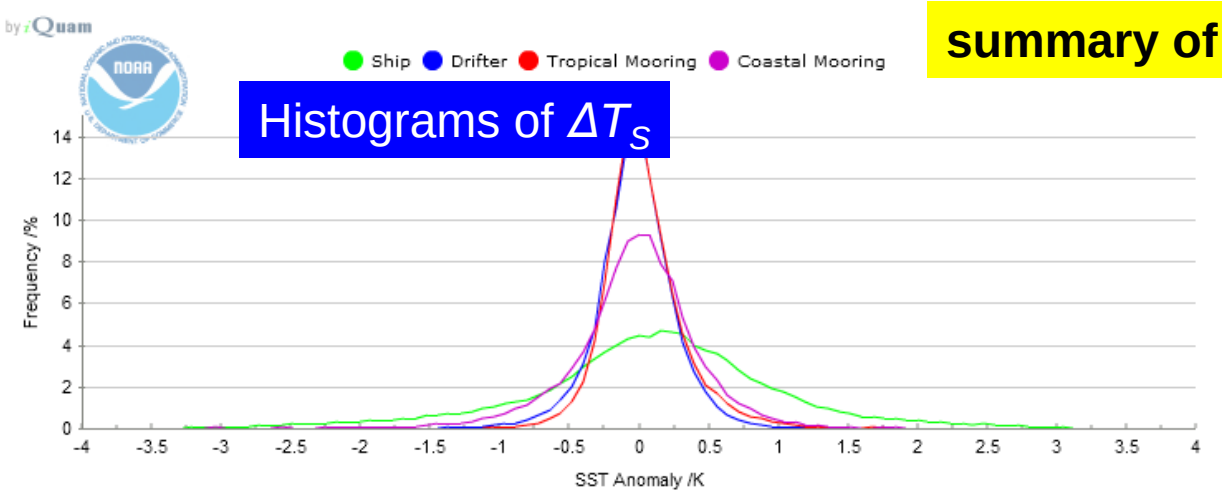
Platform	N_Obs	N_QC	DR	TC	SC	RC	XC
Ship	78,661	66,072	164	7,409	150	11,626	12,087
Drifter	1,048,270	939,558	84,745	3,197	870	15,257	23,878
Tropical Mooring	33,566	32,994	212	140	17	314	351
Coastal Mooring	187,319	174,938	6	1,354	426	6,313	12,180

Moments of $\Delta T_S = T_{in\ situ} - T_{Reynolds}$

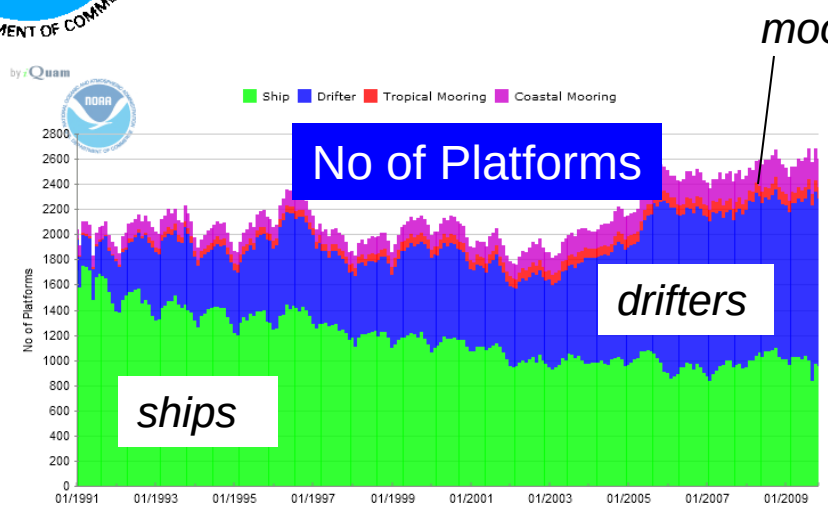
SST Statistics

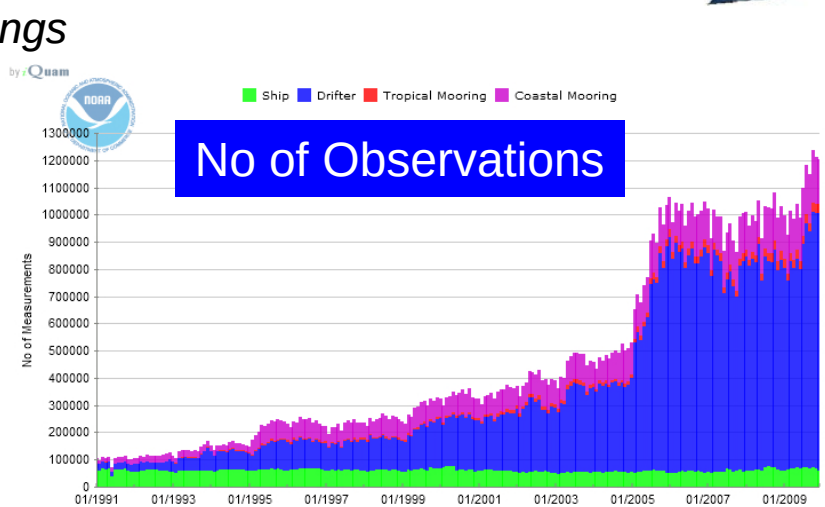
Platform	BIAS	SD	SKEW	KURT	MED	RSD	N_Mtchp
Ship	0.14	0.94	-0.32	1.77	0.17	0.73	60,687
Drifter	0.02	0.29	-0.29	4.43	0.02	0.23	937,136
Tropical Mooring	0.07	0.29	0.79	3.39	0.04	0.22	32,947
Coastal Mooring	0	0.5	-1.24	7.32	0.04	0.35	148,818

summary of statistics

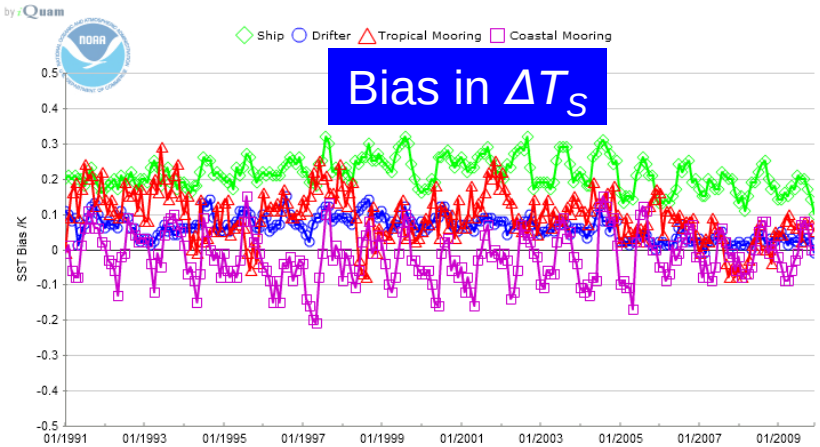


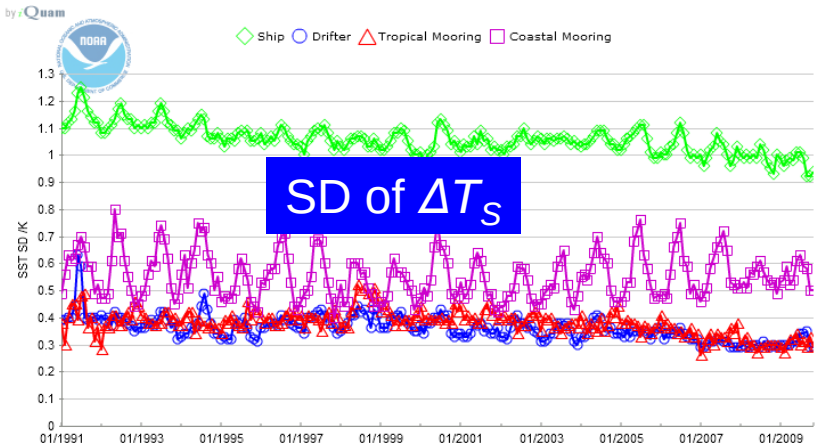
iQuam: Time Series of Monthly Statistics





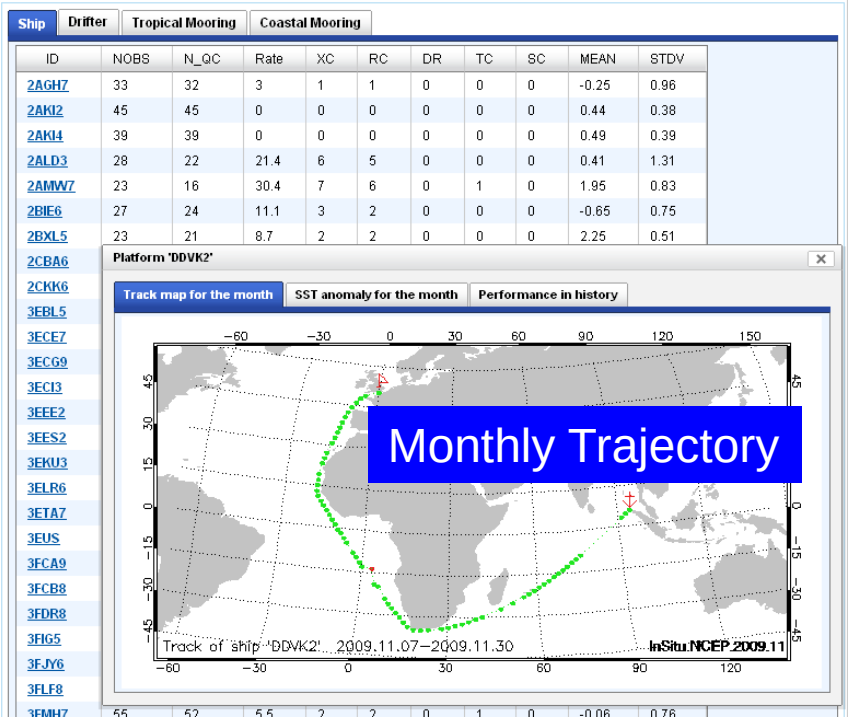
Historical Trends



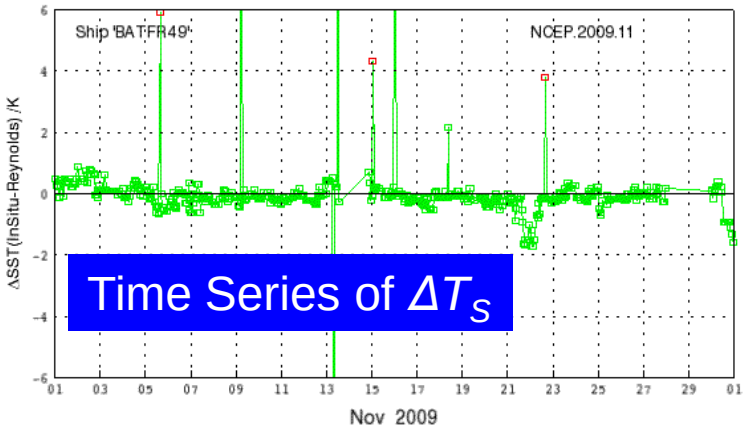


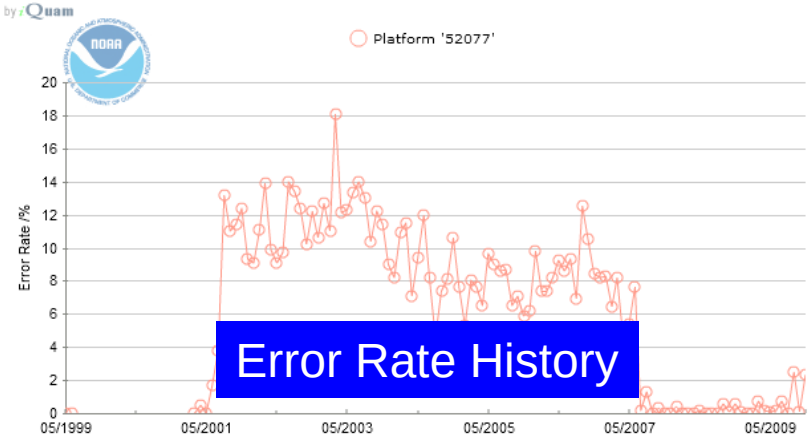
iQuam: Monitoring of individual platforms

List of platforms & individual statistics



ID	NOBS	N_QC	Rate	XC	RC	DR	TC	SC	MEAN	STDV
2AGH7	33	32	3	1	1	0	0	0	-0.25	0.96
2AKI2	45	45	0	0	0	0	0	0	0.44	0.38
2AKI4	39	39	0	0	0	0	0	0	0.49	0.39
2ALD3	28	22	21.4	6	5	0	0	0	0.41	1.31
2AMW7	23	16	30.4	7	6	0	1	0	1.95	0.83
2BIE6	27	24	11.1	3	2	0	0	0	-0.65	0.75
2BXL5	23	21	8.7	2	2	0	0	0	2.25	0.51
2CBA6										
2CKK6										
3EBL5										
3ECE7										
3ECG9										
3ECI3										
3EEE2										
3EES2										
3EKU3										
3ELR6										
3ETA7										
3EUS										
3FCA9										
3FCB8										
3FDR8										
3FIG5										
3FJY6										
3FLF8										
3FMH7	55	52	5.5	2	2	0	1	0	-0.06	0.76





Individual Platforms Monitor

iQuam: QCed Data for download

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iQuam

Quality Monitor for *in situ* Sea Surface Temperatures

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HDF with Quality Flags

Data are in self-describing HDF 4.2 format. Refer to global and data layers attributes for more information.

Suggested usage of the 16-bit quality flags (QF) are:

- *for general applications, use data with the lowest bit cleared (QF AND 0x0001 == 0);*
- *for high-accuracy applications, use only data with the lowest two bits cleared (QF AND 0x0003 == 0);*
- *for advanced usage of individual QC checks, refer to the definition of individual QFs.*

All data can be directly accessed at here.

NAME	HDF
IQUAM.NCEP.1991.01.HDF	Download
IQUAM.NCEP.1991.02.HDF	Download
IQUAM.NCEP.1991.03.HDF	Download
IQUAM.NCEP.1991.04.HDF	Download
IQUAM.NCEP.1991.05.HDF	Download
IQUAM.NCEP.1991.06.HDF	Download
IQUAM.NCEP.1991.07.HDF	Download
IQUAM.NCEP.1991.08.HDF	Download
IQUAM.NCEP.1991.09.HDF	Download
IQUAM.NCEP.1991.10.HDF	Download
IQUAM.NCEP.1991.11.HDF	Download
IQUAM.NCEP.1991.12.HDF	Download
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IQUAM.NCEP.1992.02.HDF	Download
IQUAM.NCEP.1992.03.HDF	Download
IQUAM.NCEP.1992.04.HDF	Download
IQUAM.NCEP.1992.05.HDF	Download
IQUAM.NCEP.1992.06.HDF	Download
IQUAM.NCEP.1992.07.HDF	Download
IQUAM.NCEP.1992.08.HDF	Download
IQUAM.NCEP.1992.09.HDF	Download

QCed data in HDF format available for download

Summary

- *In situ* SSTs must be QCed before they are used in satellite Cal/Val. Result of Cal/Val is critically sensitive to the QC used.

- QC was implemented at NESDIS. Bayesian approach for external & mutual consistency follows the UK Met Office (Lorenc and Hammon, 1988; Ingleby and Haddleston, 2007).

- NRT online *in situ* Quality Monitor (iQuam) was implemented http://www.star.nesdis.noaa.gov/sod/sst/iquam/
  - Reports summaries by data types (ships, drifters, tropical and coastal moored) and for individual platforms
  - Serves QCed data to outside users

Future work

- Test out the QC for satellite Cal/Val. Fine tune/Revisit QC & *iQuam* as needed. Document.

- Work with SST community through the Group for High Resolution SST. Seek consensus on the QC & usage of *in situ* SST for satellite Cal/Val.

- Explore data from all major *in situ* platforms (ships, drifters, tropical and coastal moored buoys) in satellite Cal/Val.

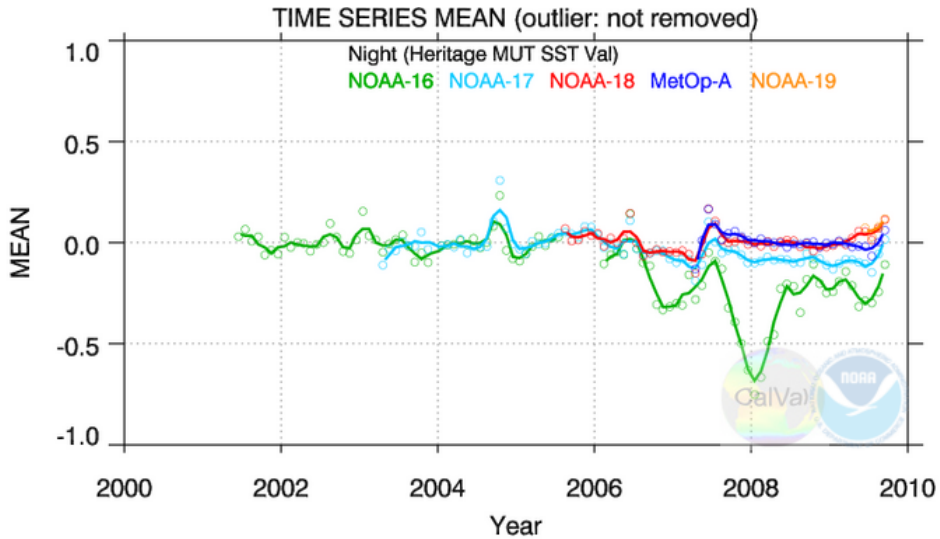
- Estimate error budget in *in situ* SST (e.g., three-way analysis). Estimate effect of *in situ* errors on Cal/Val results.

Back-Up Slides

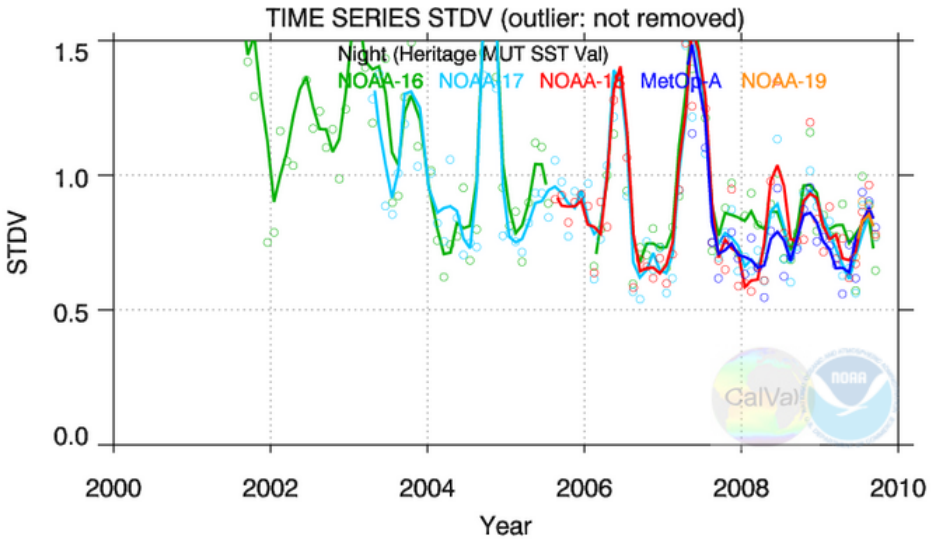
Effect of in situ QC on satellite Cal/Val

NESDIS Heritage AVHRR SST Validation: No QC of match-up data

Global Mean Bias "SAT – In Situ"



Global SD Bias "SAT – In Situ"

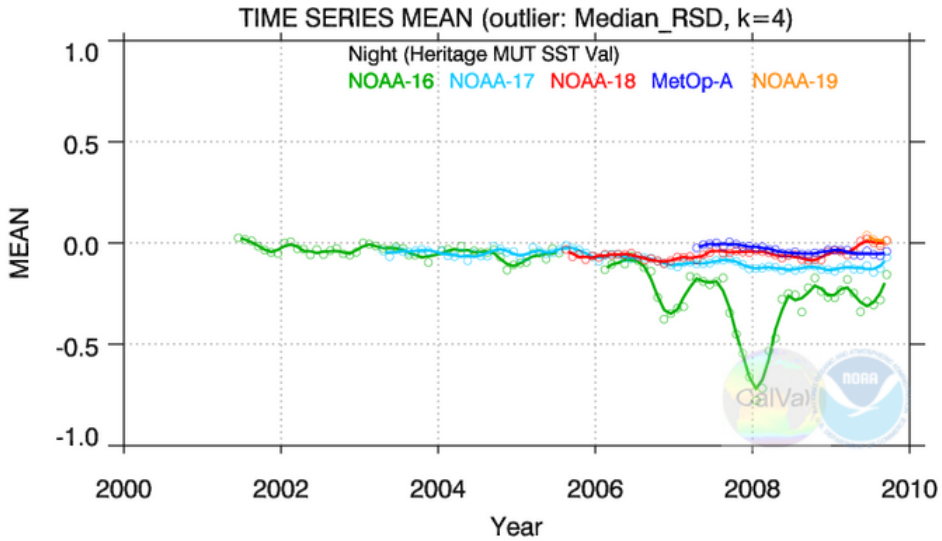


Outliers in in situ data critically affect SST validation statistics.

Courtesy P. Dash, NESDIS/CIRA

NESDIS Heritage AVHRR SST Validation: After QC of match-up data

Global Mean Bias "SAT – In Situ"



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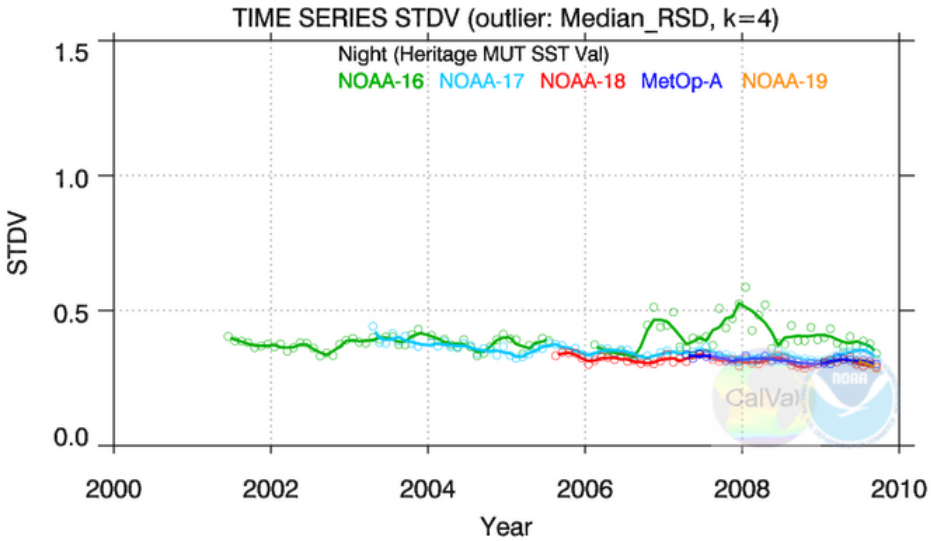

QC improves both moments (most dramatically, affect SD)

Courtesy P. Dash, NESDIS/CIRA