NOAA SST Quality Monitor (SQUAM)

www.star.nesdis.noaa.gov/sod/sst/squam/

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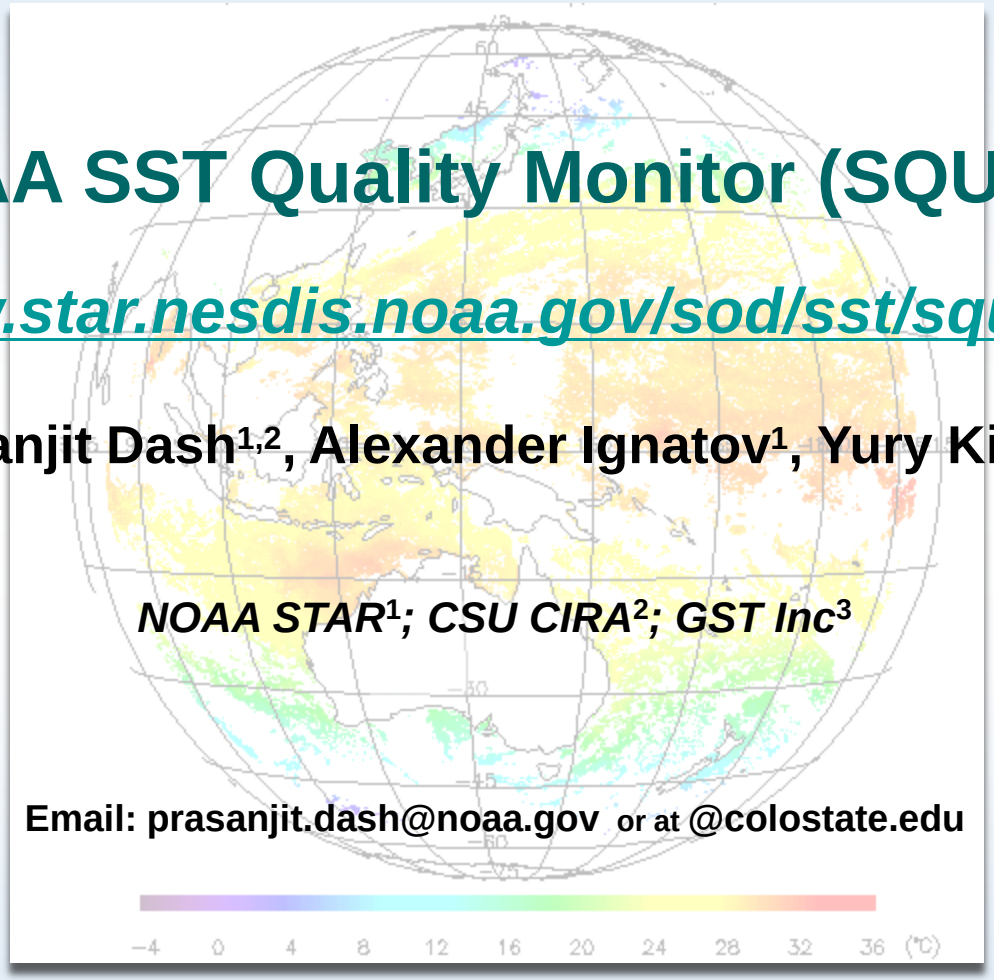


Acknowledgments

Level-2 SST: VIIRS/AVHRR/MODIS

- NOAA ACSPO Team : *ACSPO (NOAA GAC, Metop FRAC, S-NPP VIIRS, Terra/Aqua MODIS)*
- H. Roquet, P. LeBorgne : *O&SI SAF Metop-A FRAC*
- D. May, B. McKenzie : *NAVO SEATEMP, NAVO VIIRS*
- S. Jackson : *IDPS (NPP)*
- C. Merchant, O. Embury : *L2P ARC* (preparation for the Sentinel-3 SLSTR)
- Y. Kurihara, M. Kachi : *L2P Himawari 8 AHI, JAXA*
- A. O'Carroll : *L2P Metop-A IASI, EUMETSAT, S3VT*

Level-3 SST: AVHRR/(A)ATSR:

- K. Casey, R. Evans, J. Vazquez, E. Armstrong: *PathFinder v5.0*

Level 4 SSTs:

- D. Surcel-Colan, B. Brasnett : *Canadian Met. Centre, 0.2° foundation*
- H. Beggs : *ABoM GAMSSA*
- M. Chin, J. Vazquez, E. Armstrong : *JPL MUR*
- E. Fiedler, M. Martin, J. Jones : *OSTIA foundation, GMPE, OSTIA Reanalysis*
- R. Grumbine, B. Katz : *RTG (Low-Res & Hi-Res)*
- V. Banzon, R. Reynolds : *OISSTs (AVHRR & AVHRR+AMSRE)*
- D. May, B. McKenzie : *NAVO K10*
- J.-F. Piollé, E. Autret : *ODYSSEA*
- E. Maturi, A. Harris : *Geo-Polar Blended*
- Y. Chao : *JPL G1SST*
- J. Hoyer : *DMI OISST*

Definitions of levels:
L2: swath projection (satellite)
L3: gridded with gaps (satellite)
L4: gap-free gridded analysis

GHRSST support: Peter Minnett, Craig Donlon, Alexey Kaplan

EUMETSAT VS support: Kenneth Holmlund, Anne O'Carroll (also GHRSST)

Major SST data providers:

Projects and international groups

A few keywords …

- **ACSPO – Advanced Clear-Sky Processor over Oceans**
  - NOAA SST system that generates SST from multiple geo and polar platforms, in real time and reprocessing mode
- **SQUAM – SST Quality Monitor**
  - NOAA automated system for monitoring and validation of SST products
  - Diagnostics/results are made available online, with ~2-3 days latency
- ***i*Quam – *in situ* SST Quality Monitor**
  - NOAA system that provides quality controlled *in situ* data (drifters, moorings, ships; + ARGO floats in recent version 2)

My contribution (and today's talk) is about SQUAM – The SST Quality Monitor

- **STAR (**Center for Satellite Applications and Research**): NOAA Satellite Science Arm**
- **OSPO (**Office of Satellite and Product Operations**): NOAA Satellite Operations 24/7**

Outline

1. SST satellites and NOAA ACSPO products overview

2. SST Quality Monitor (SQUAM): Why? What? How?
   - Consistency as a 'key requirement' in multi-mission inter-comparison
   - Example Monitoring & Validation: Maps, Histograms, Time series *etc.*

3. Expanding to new modules: Geostationary (Himawari-08)

4. Uncovering issues in products: Examples

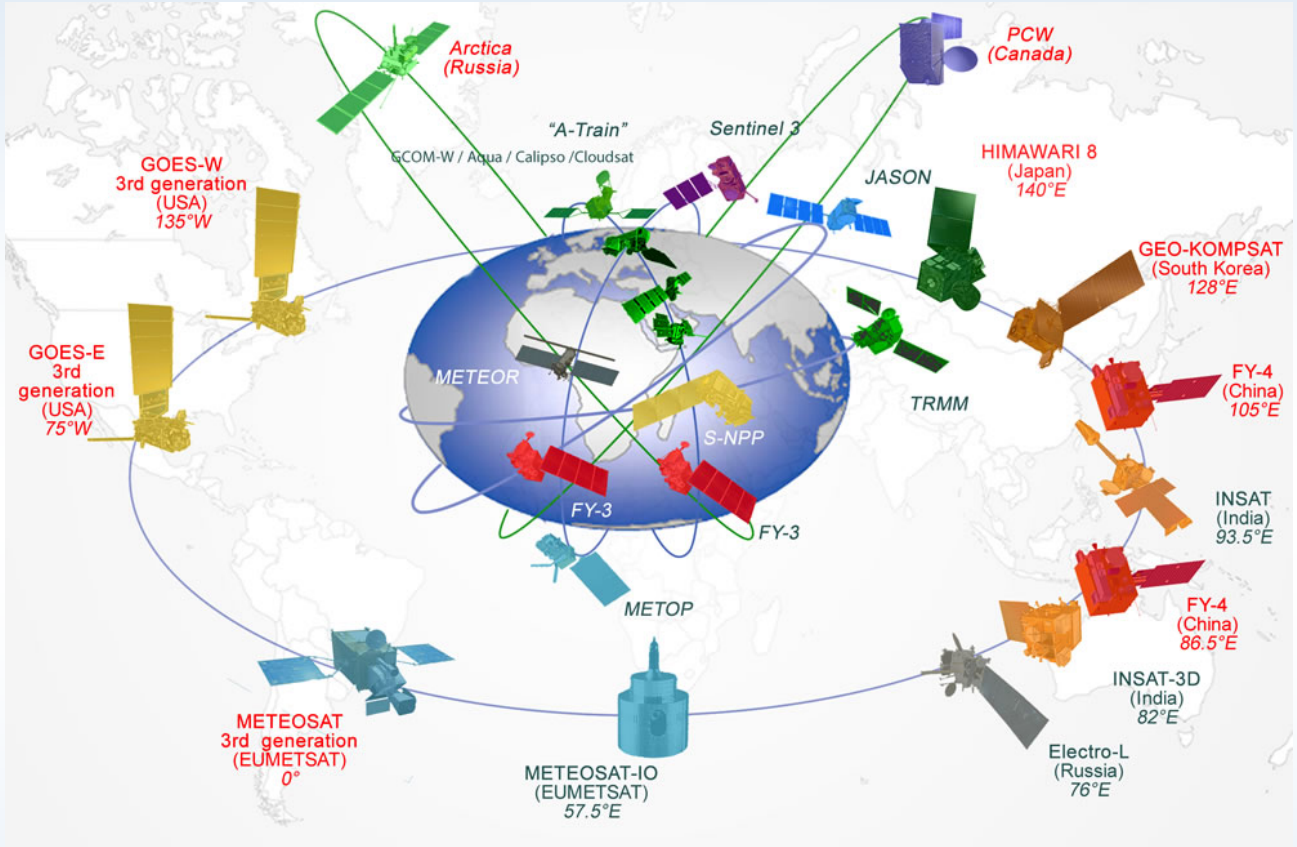
5. Expansion potential beyond the current framework
   - Characterization of collocation effect
   - Estimation of internal error by Triple Collocation Method (3-way)

6. What we at NOAA/STAR can potentially offer for EUMETSAT products?
   - Examples of (A)ATSR Reprocessing for Climate (ARC) data in SQUAM
   - Examples of IASI in SQUAM (this visit; preliminary)

7. (Online demo |connectivity)

8. Summary

RS satellite missions (present/near-future)



Source: WMO

SST: many projects, missions, teams, agencies.
NOAA SST enterprise **ACSPO** system is used with multiple SST platforms/sensors

ACSPO – Advanced Clear-Sky Processor for Oceans
Products overview

NOAA Enterprise Sea Surface Temperature (SST) System

Operational/Experimental Products

- Polar: Operational with AVHRR (NOAA/GAC and Metop- A and B /FRAC); S-NPP/JPSS VIIRS; Experimental with Terra/Aqua MODIS
- Geo: Experimental with Himawari-8 AHI (launched Oct'2014); To be operational with H8 AHI and GOES-R ABI (to be launched Oct'2016)

Two Reanalysis (RAN) efforts underway

- AVHRR GAC RAN (NOAA-15, 16, 17, 18, 19, Metop-A, -B (2002 – pr)
- S-NPP VIIRS (Jan 2012 – pr)

Data availability (GHRSST, GDS2)

- NOAA NCEI
- PO.DAAC

Further info about ACSPO

- Alex.Ignatov@noaa.gov (STAR, PI)
- John.Sapper@noaa.gov (OSPO, PI)

NOAA ACSPO produces >10 different products

There are also NASA, NAVO, OSI SAF products

Essentially, SST community is data rich!

What Products are available? What is retrieval the domain? How they compare? Perform? *(mind your own business only does not work if we were to know the relative performances)*

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SST Quality Monitor (SQUAM)

- **Why**
  - Evaluate the retrieval domain and performance in near-real time
  - Was initially created for ACSPO, now additionally monitors other products in the spirit of "community"

- **What**
  - Automated, ~Near-Real Time (2-3 days), Global, Online
  - Monitoring; Validation (*vs. in situ*); Consistency Checks (*vs.* L4s)
  - Adaptable to other products, e.g., Ocean Color, Salinity, LST
  - URL: Google "SQUAM SST" or "NOAA SQUAM"

- **How**
  - Analyzed are deviations from a set of references: $\Delta T_S = T_S - T_{REF}$
  - Gaussian? Centered at ~0? Narrow? No outliers?
  - Two types of T_{REF}
    1. *i*Quam *in situ* ("Validation"): Data may be sparse, non-uniform in space & in accuracy/precision (even after QC), and subject to geographical biases
    2. Global L4 analyses ("Consistency Checks"): L4 products have complete global coverage & more uniform accuracy/precision. The much larger (by 3-4 orders of magnitude) "match-up data sets" allow a quick global snapshot of L2/3 products

Current SST Datasets in SQUAM

Level 2/ Level 3

Polar
- AVHRRs (ACSPO, NAVO, O&SI SAF…)
- VIIRS, MODISs, ATSRs (ACSPO, ARC…)
- Sentinel-3 SLSTR (Eumetsat, 2016) *and more*

Geostationary
- GOES (NOAA, NAVO, O&SI SAF)
- SEVIRI (NOAA, O&SI SAF)
- MTSAT (NOAA, JAXA)
- Himawari-8 (NOAA, JAXA, ABoM?)
- GOES-R ABI (ACSPO, 2016)

In situ (iQuam)

QC, Monitoring, Data Access
- *www.star.nesdis.noaa.gov/sod/sst/iquam/*

Platforms
- Drifters, Moorings, Ships, ARGO Floats,..

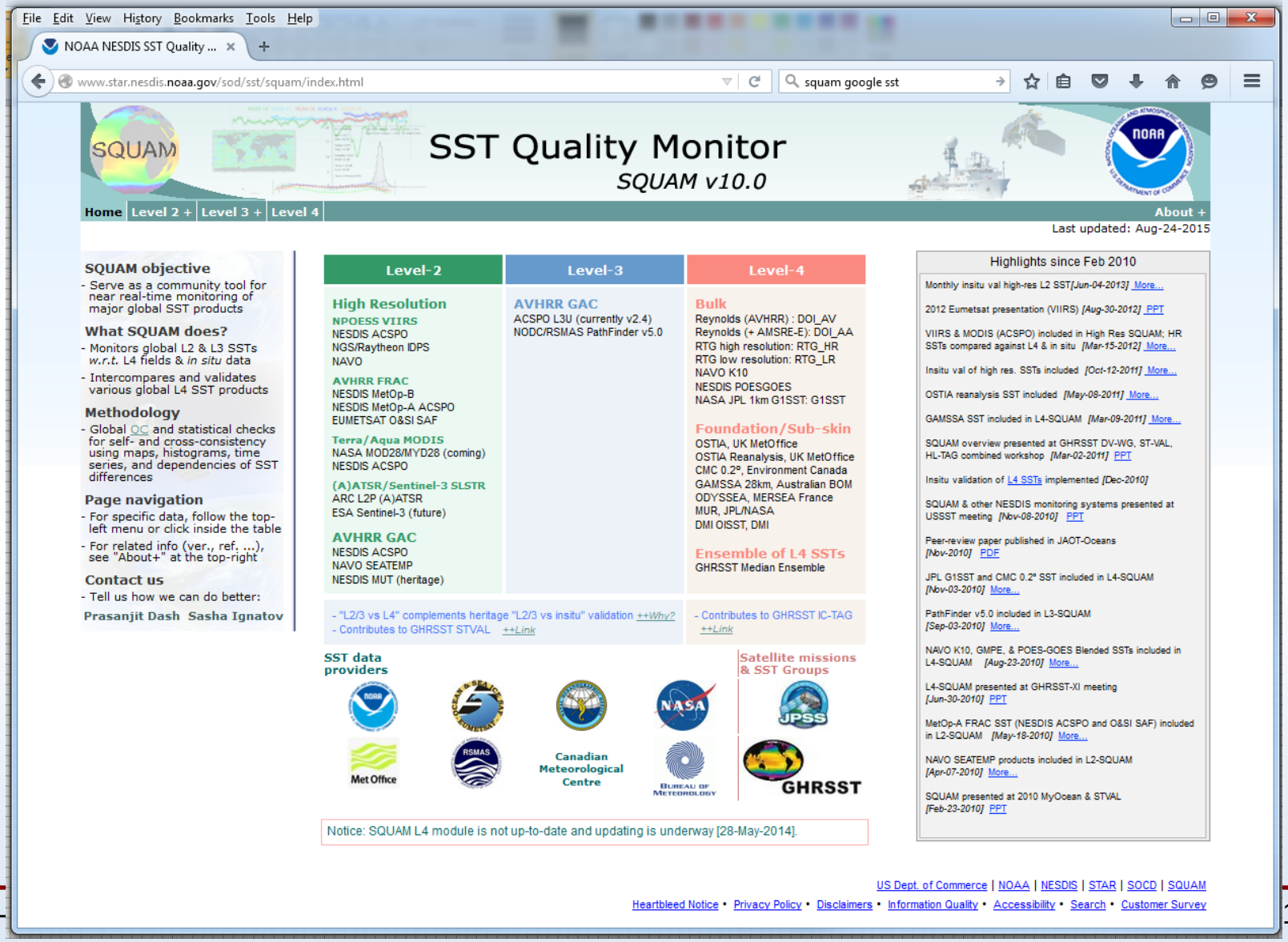
Sources
- GTS, ICOADS, GODAE/FNMOC, ..

Level 4

CMC 0.2 (Canada), CMC RAN
OSTIA, Operational + Retro (UKMO)
GAMSSA (Australia BoM)
JPL MUR, JPL G1SST
Reynolds (AVHRR; +AMSR-E)
RTG (Low, High Resolution), GSI
ODYSSEA (France)
GMPE (GHRSST)
NAVO K10
NOAA Geo-Polar Blended
DMISST (Danish Met. Inst.)
NCODA (NRL)
MGDSST (JAXA, Japan)
RSS (MW, MW+MODIS)

Definitions of levels:
L2: at observed pixels (satellite)
L3: gridded with gaps (satellite)
L4: gap-free gridded, time-averaged

SQUAM web-interface



L2-SQUAM (HR SST)

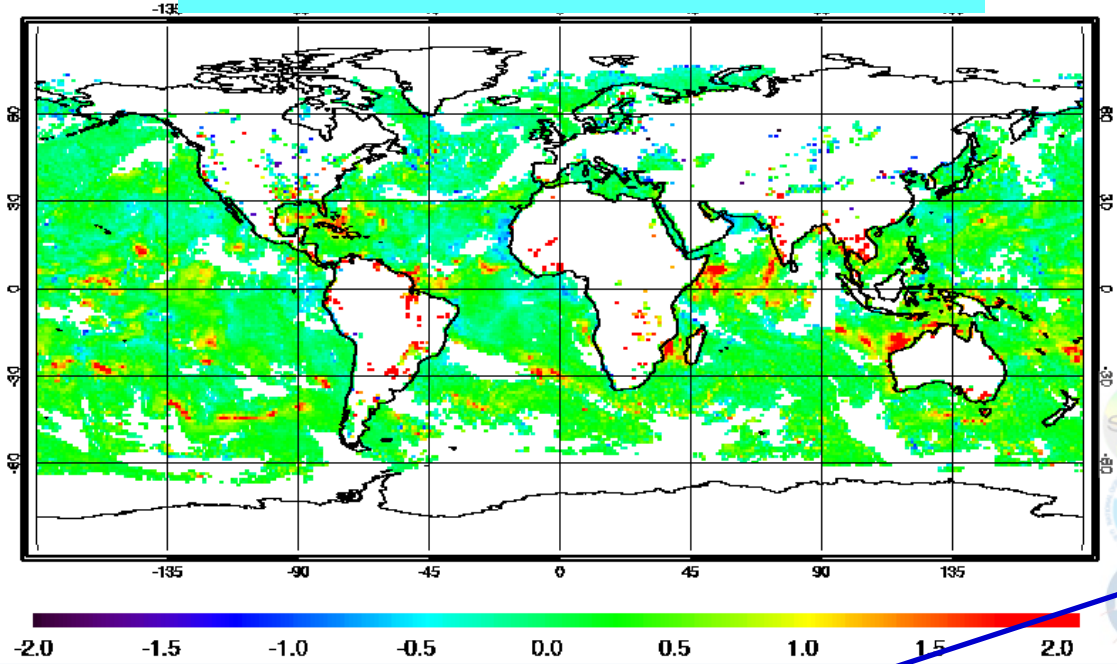
www.star.nesdis.noaa.gov/sod/sst/squam/HR/

- L2 SQUAM comprises high resolution (HR; 1km or better) and low resolution (GAC; 4km) modules
- Here, examples are from the HR module

ACSPO S-NPP VIIRS SST in HR-SQUAM

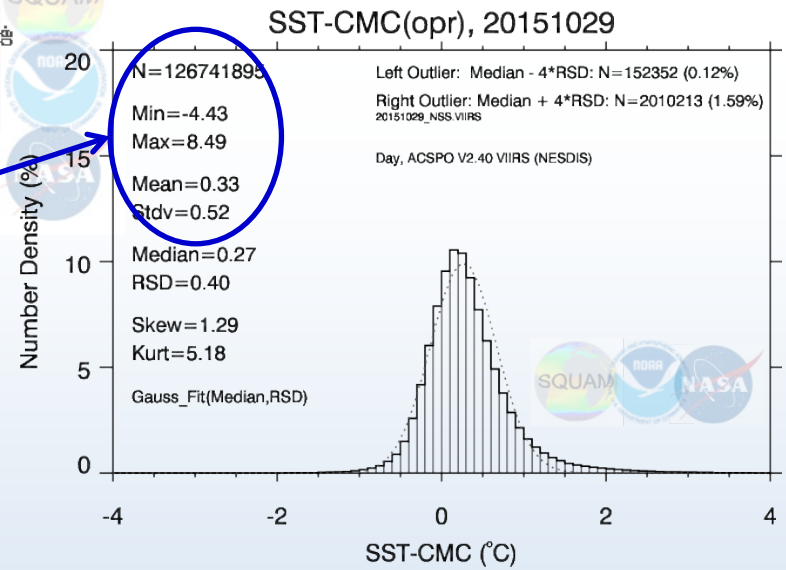
Maps | Histograms | Time-series | Dependencies | Hovmöller

NPP VIIRS (ACSPO, day) – CMC L4



NPP VIIRS & AQUA MODIS (ACSPO)

NPP VIIRS (ACSPO) – CMC L4

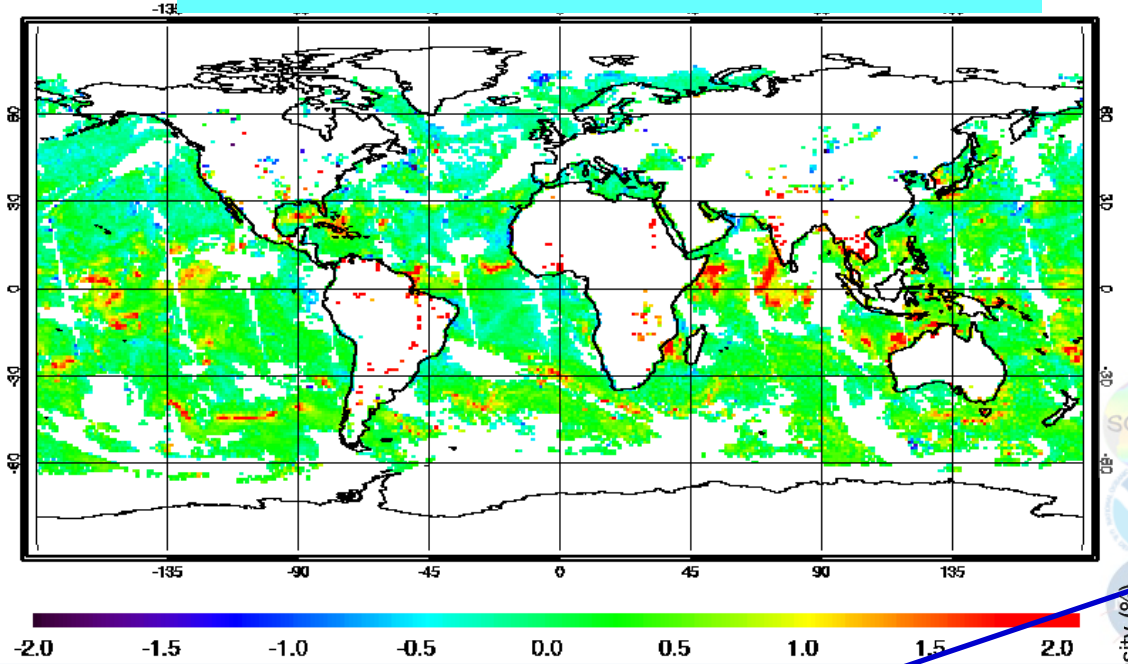


Maps used to check coverage & global product performance (cold – cloud/aerosol leakages, warm – diurnal warming)

ACSPO Aqua MODIS SST in HR-SQUAM

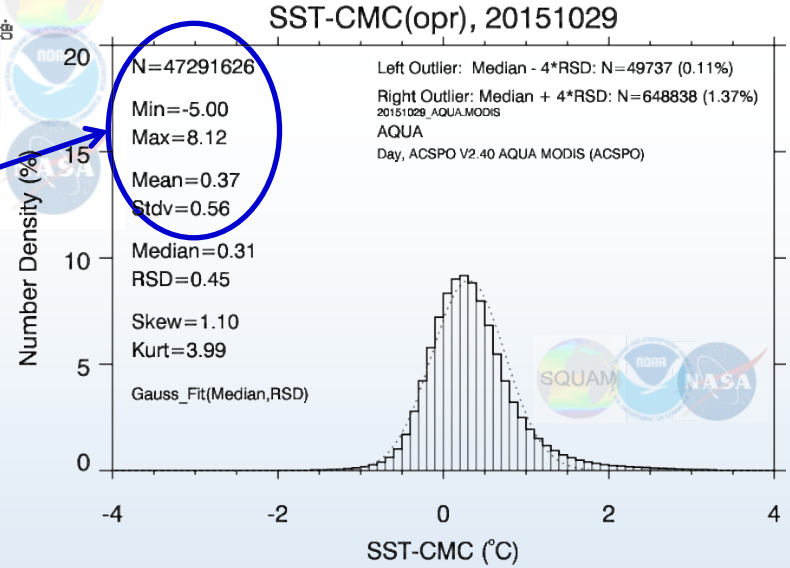
Maps | Histograms | Time-series | Dependencies | Hovmöller

AQUA MODIS (ACSPO, day) – CMC L4



NPP VIIRS & AQUA MODIS (ACSPO)

AQUA MODIS (ACSPO) – CMC L4

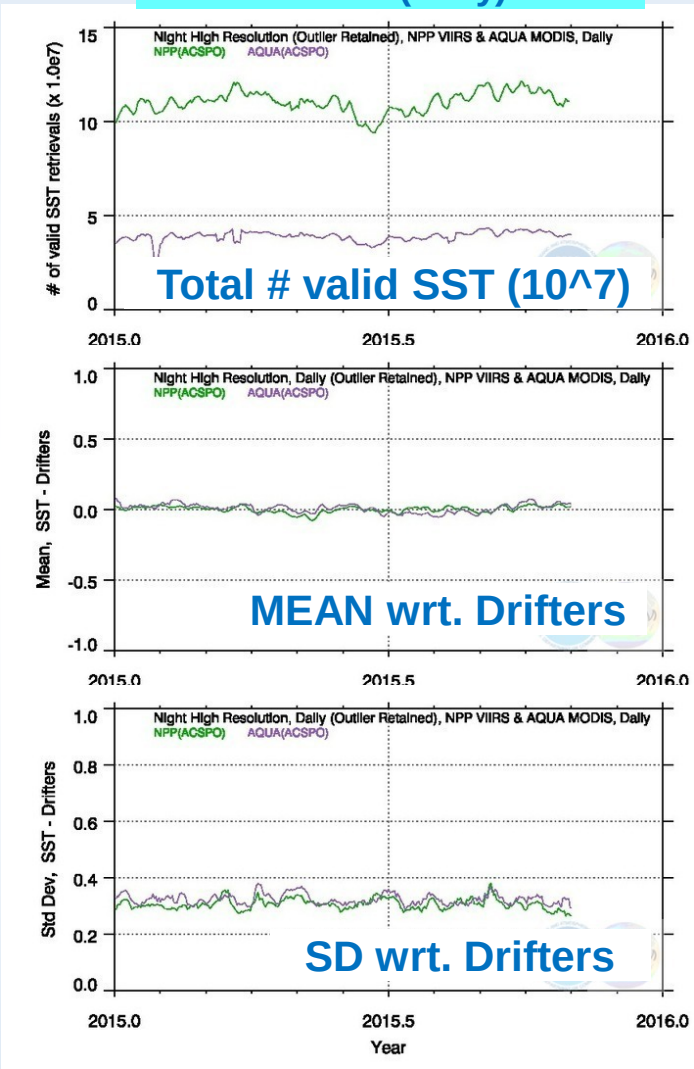


In ACSPO MODIS SST product, there are a factor of 2.7 fewer valid SST pixels compared to VIIRS, and its performance is slightly degraded

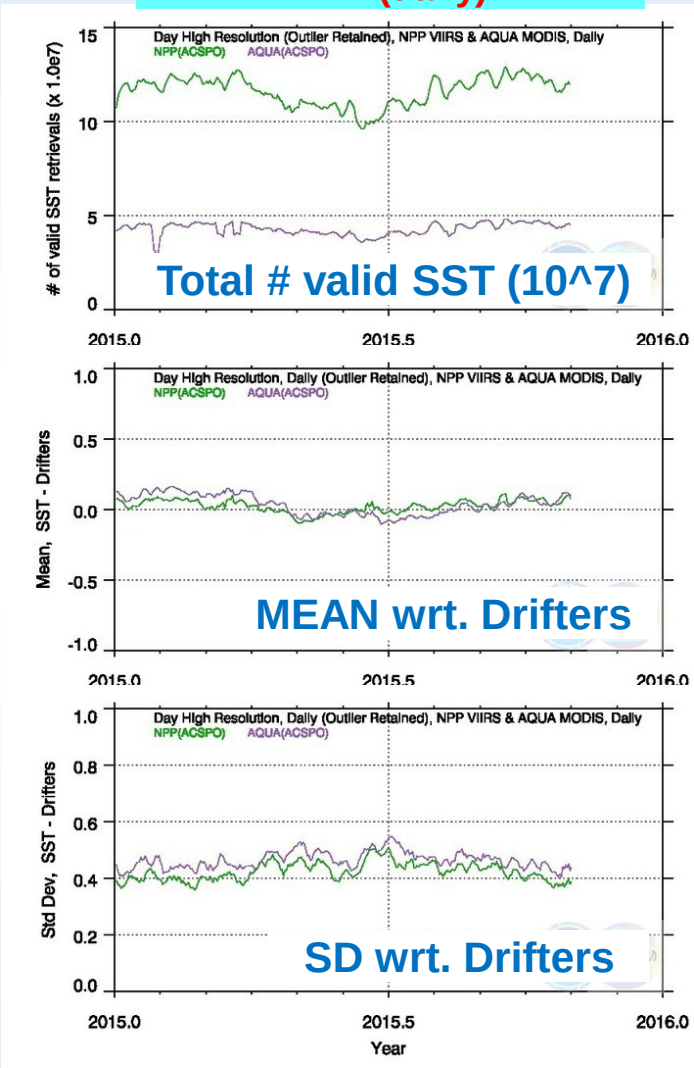
Time series of S-NPP VIIRS & Aqua MODIS SSTs

Maps | Histograms | **Time-series** | Dependencies | Hovmöller

NIGHT (daily)



DAY (daily)



Comparable performances for ACSPO VIIRS & MODIS

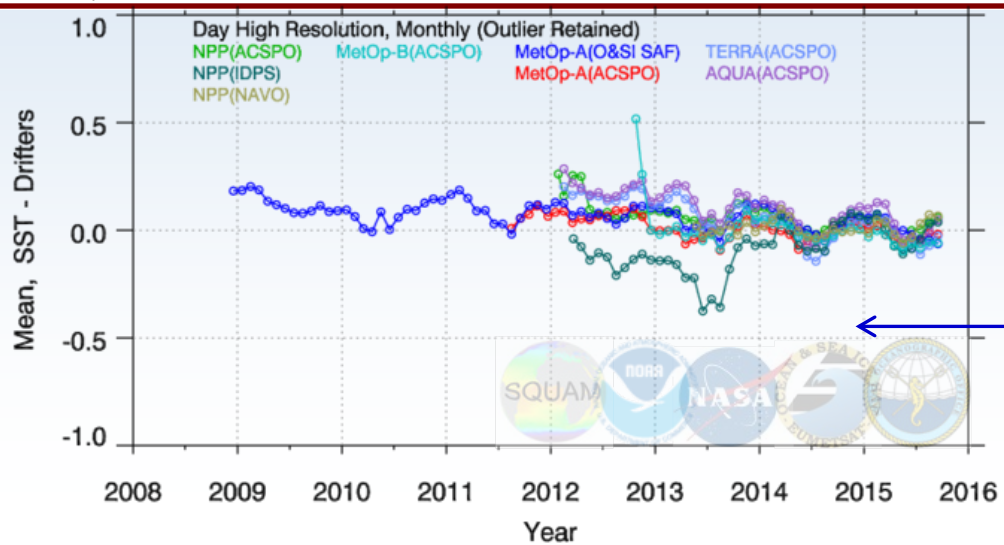
MODIS: less # of obs and slightly degraded SST stats

AQUA and NPP fly close orbits. NPP provides larger coverage; Aqua provides longer history. Currently, ACSPO MODIS is experimental, but if of interest to users, we will consider making it operational in GDS2 format

Similar comparisons are available for major global products in HR-SQUAM (online demo, if possible)

All SST products in HR-SQUAM

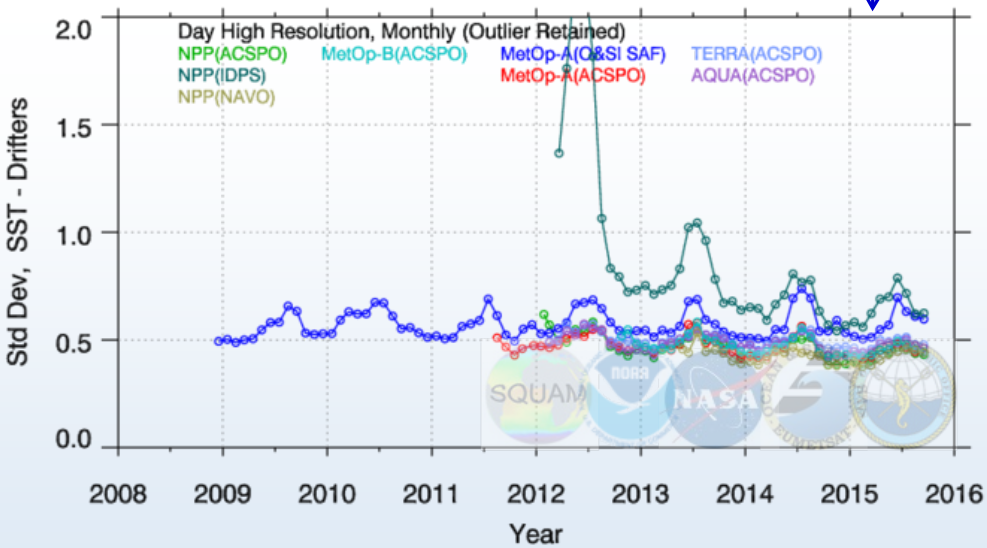
Maps | Histograms | **Time-series** | Dependencies | Hovmöller



Monthly validation of 8 different hi-res SST products in HR-SQUAM (against QC'ed drifters from NOAA *i*Quam)

Mean (day)

Std Dev (day)



Other statistical parameters and interactive plots are also available (will show later in the demo)

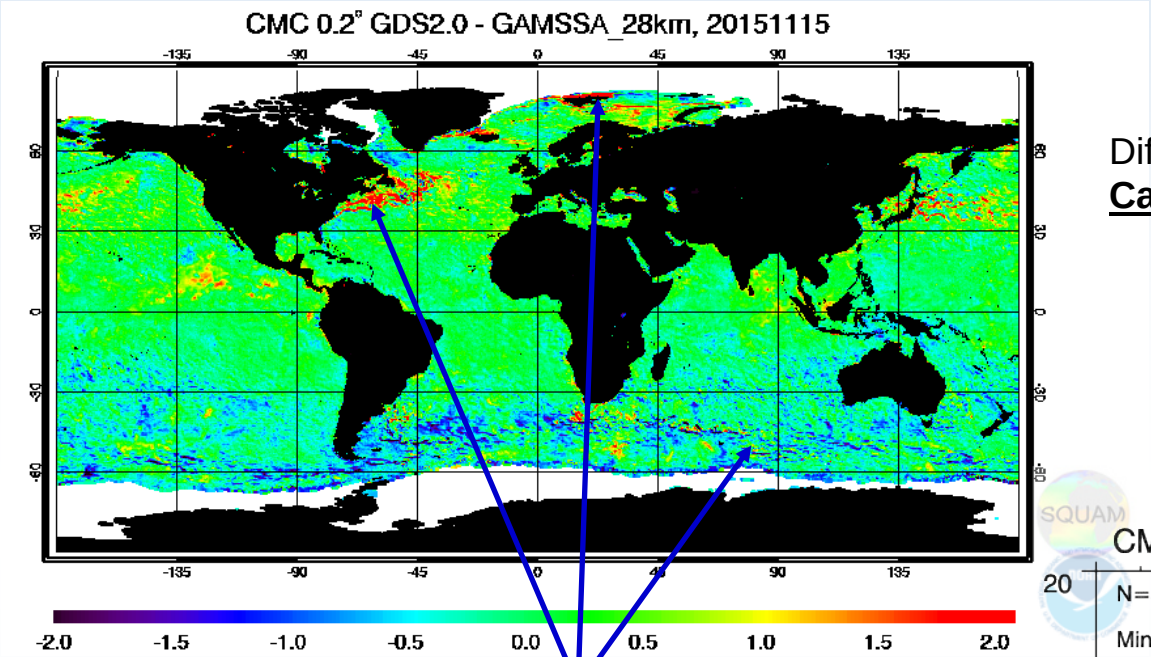
L4-SQUAM

www.star.nesdis.noaa.gov/sod/sst/squam/L4/

- Inter-compare ~15 L4 SSTs (Maps, Histograms, time series …)
- Validate consistently against QCed *in situ* data

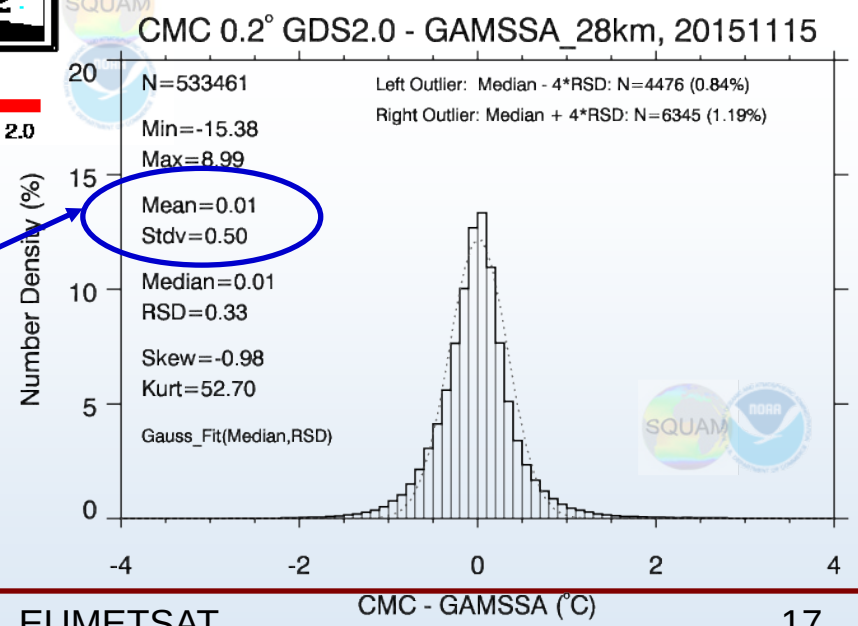
Level-4(L4) SQUAM

Maps Histograms Time-series Hovmöller



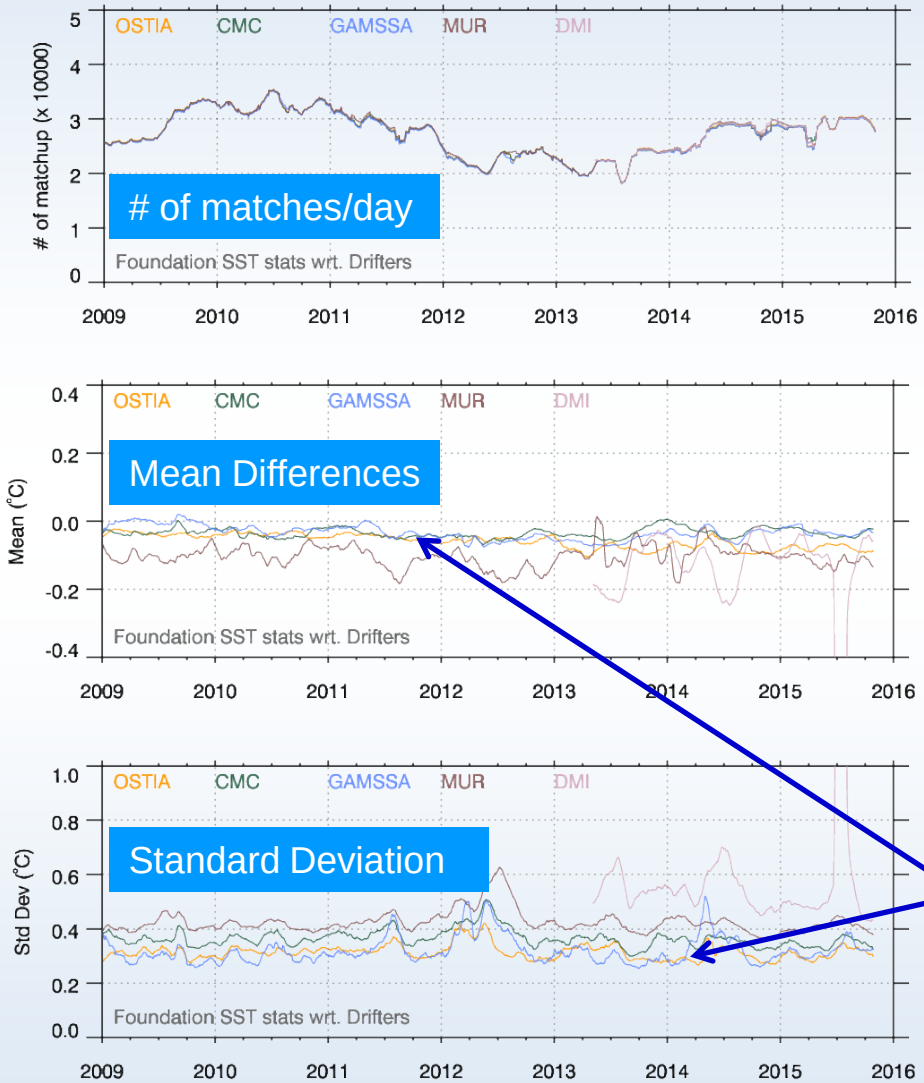
Difference between two foundation SSTs,
Canadian Met Centre 0.2 - ABoM GAMSSA

On average, the differences are close to zero but may be prominent in the dynamic, icy and/or cloudy regions



Level-4(L4) SQUAM

Maps Histograms **Time-series** Hovmöller



Validation of L4 Foundation SSTs wrt. *i*Quam drifters

Globally, GAMSSA and OSTIA closely track each other in terms of Mean Differences and Standard Deviation (note that drifters are assimilated in both)

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4. Uncovering issues in products: examples

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   - Examples of IASI in SQUAM (this visit; preliminary)

7. (Online demo |connectivity)

8. Summary

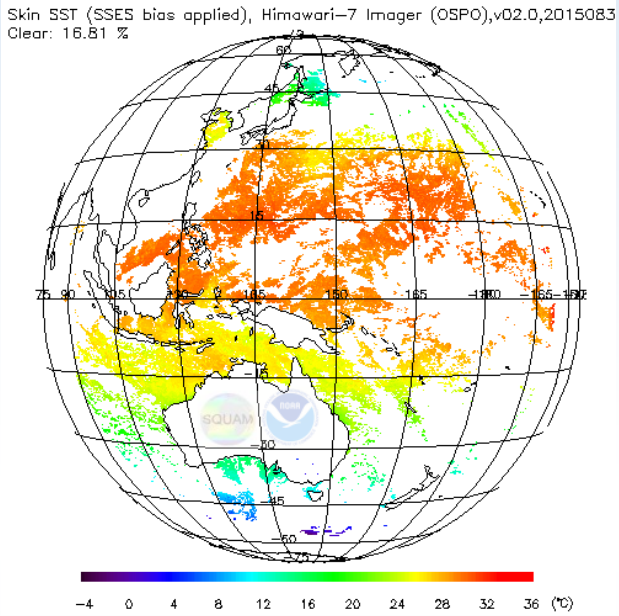
L2-SQUAM (GEO) new

www.star.nesdis.noaa.gov/sod/sst/squam/GEO/

- Himawari-7 (MTSAT-2) and Himawari-8 AHI (ACSPO and JAXA)
- Work in progress (preliminary results)
- In collaboration with JAXA (Misako, Yukio)

GEO-SQUAM

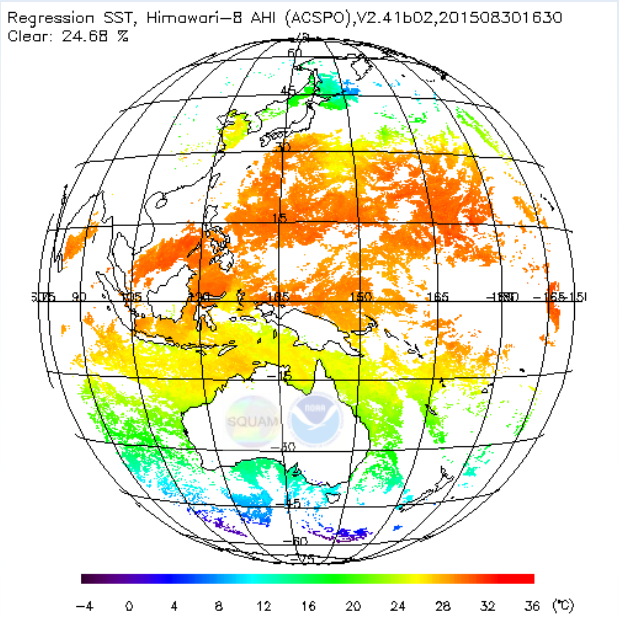
Maps Histograms Time-series Dependencies Hovmöller



Himawari-7/MTSAT2 (NOAA OSPO)

Clear sky coverage = 16.6%

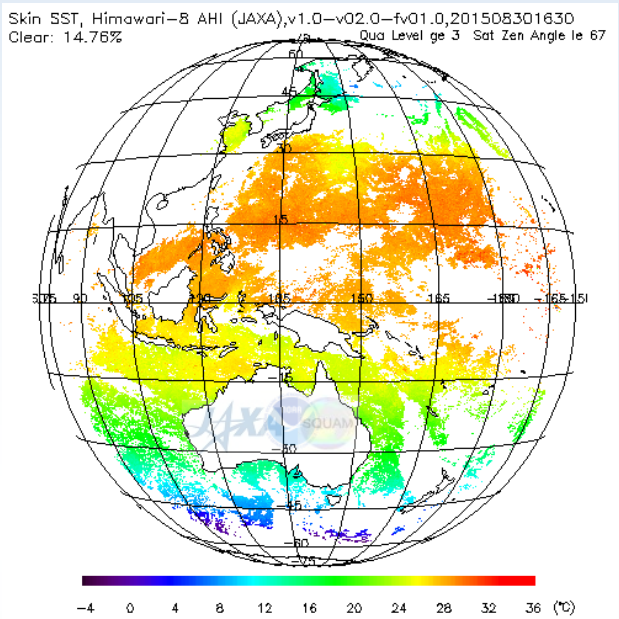
(Probabilistic cloud determination - Bayesian)



Himawari 8 (NOAA ACSPO)

Clear sky coverage = 24.7%

(ACSPO Clear-Sky Mask, Petrenko et al., JTech, 2010)



Himawari 8 (JAXA)

Clear sky coverage = 14.8%

(Bayesian cloud mask; contact Misako/Yukio for more info)

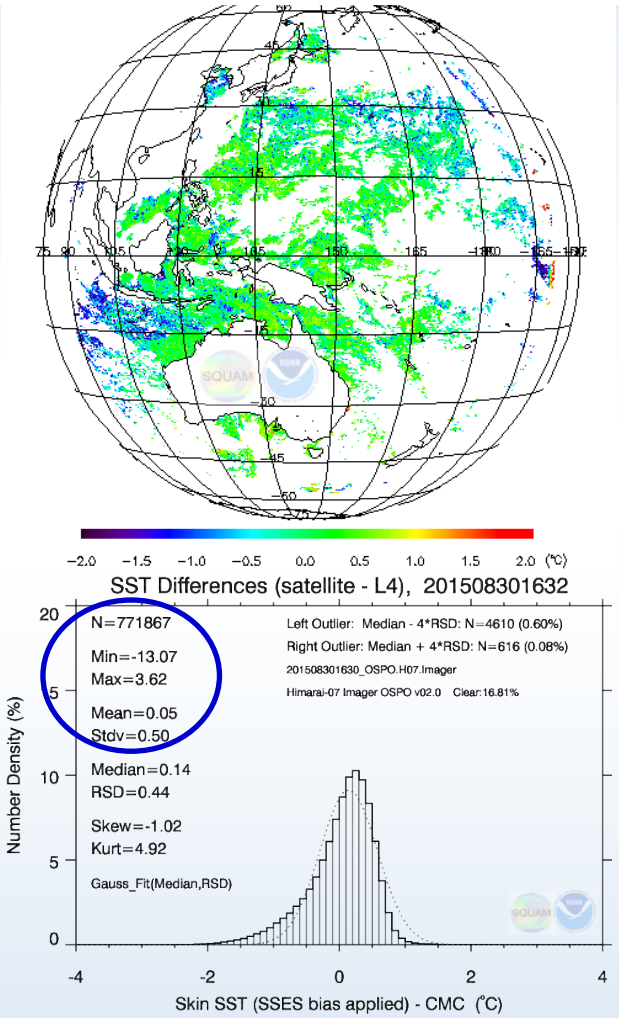
SST maps are useful to check for coverage and large image quality issues.

For product performance, SQUAM checks the residuals wrt. L4s (as shown earlier)

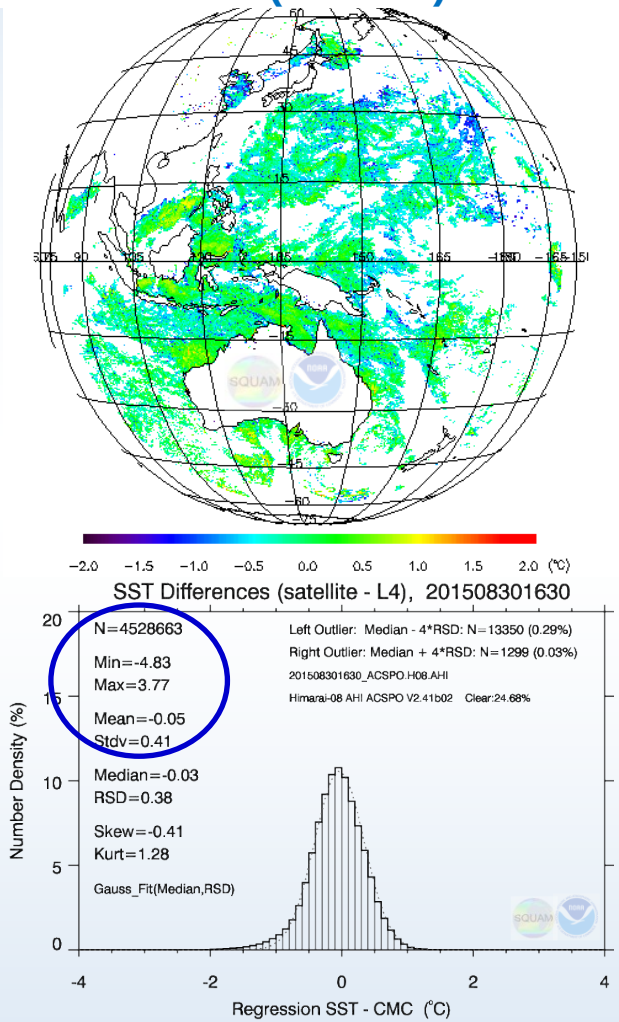
GEO-SQUAM

Maps | Histograms | Time-series | Dependencies | Hovmöller

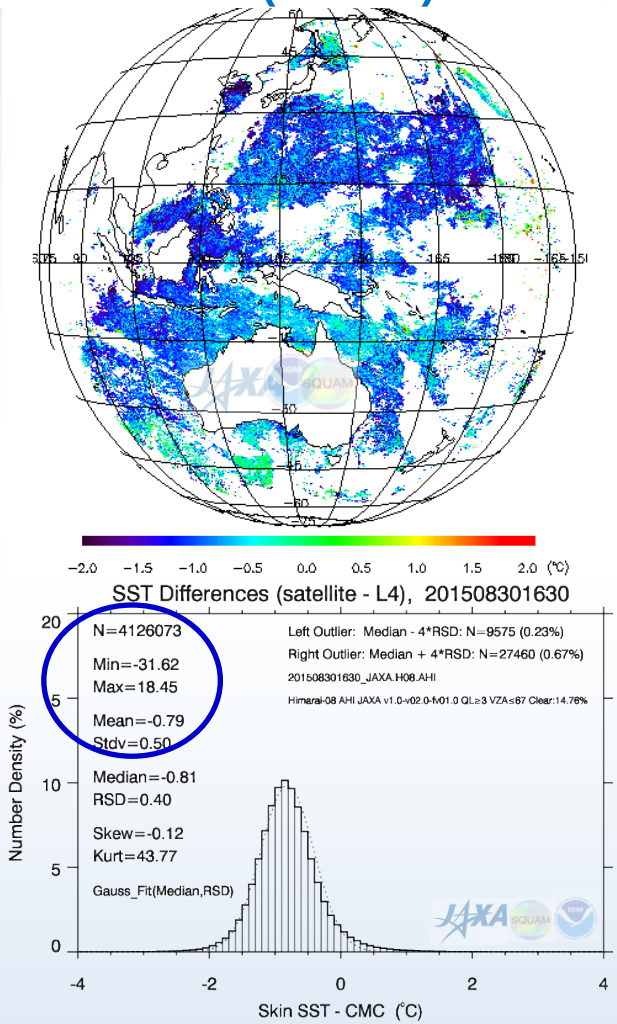
MTSAT 2 - CMC



Himawari-8 (ACSPO) - CMC



Himawari-8 (JAXA**) - CMC



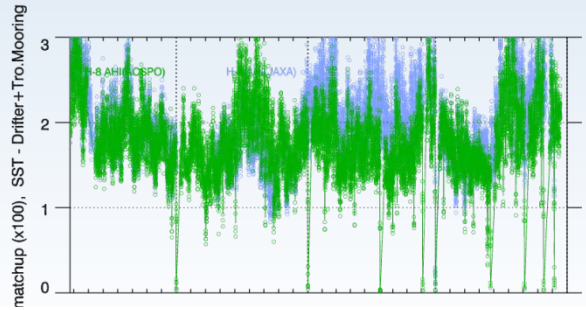
**Please note that JAXA results are preliminary, work is underway with Yukio to resolve

GEO-SQUAM

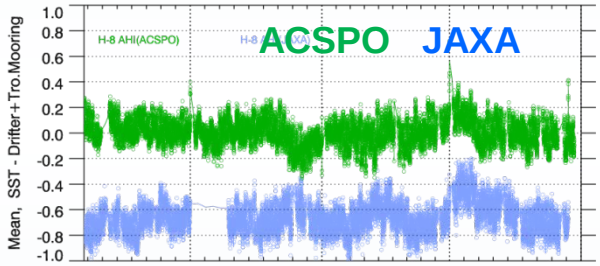
Maps | Histograms | **Time-series** | Hovmöller

Validation of GEO SSTs wrt Drifters + Tropical moorings (from *i*Quam)

Total # matches

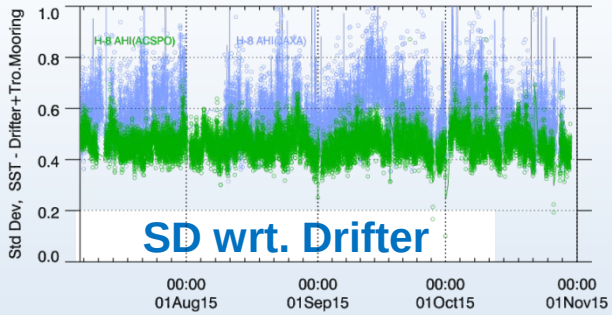


Mean



Persistent cold bias observed in JAXA AHI SST against *in situ* data (same as against CMC).

Std Dev



Standard deviation of JAXA SST is comparable to that of ACSPO AHI SST but somewhat noisier.

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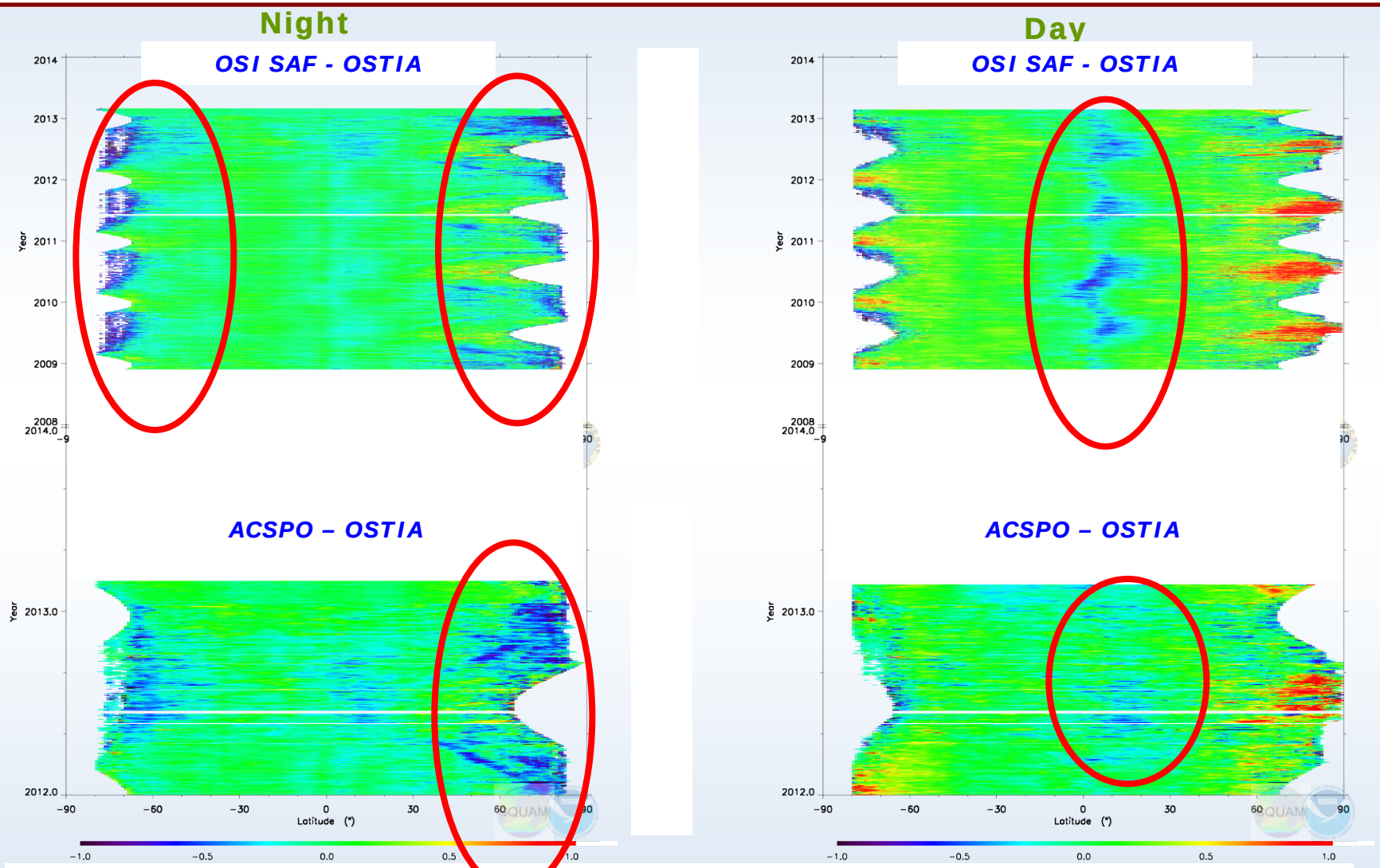
Issues: (1) persistent biases due to cloud or SST algorithms?

Maps | Histograms | Time-series | Dependencies | **Hovmöller**



ordinate: time *abscissa: latitude* *color-scale: L2-OSTIA*

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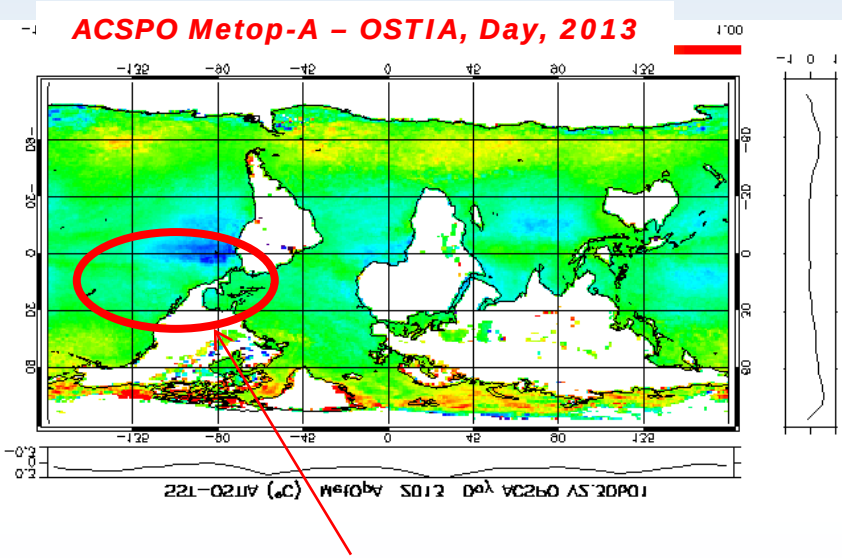
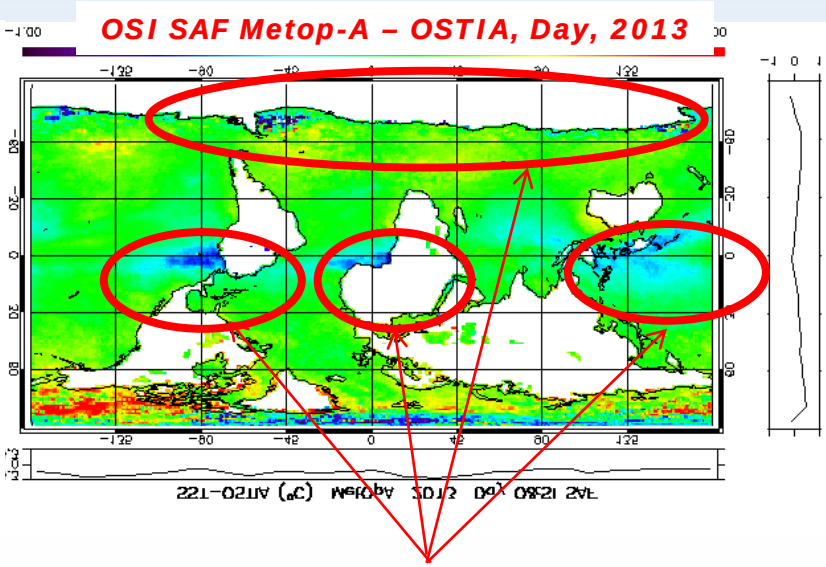
Maps | Histograms | Time-series | Dependencies | Hovmöller



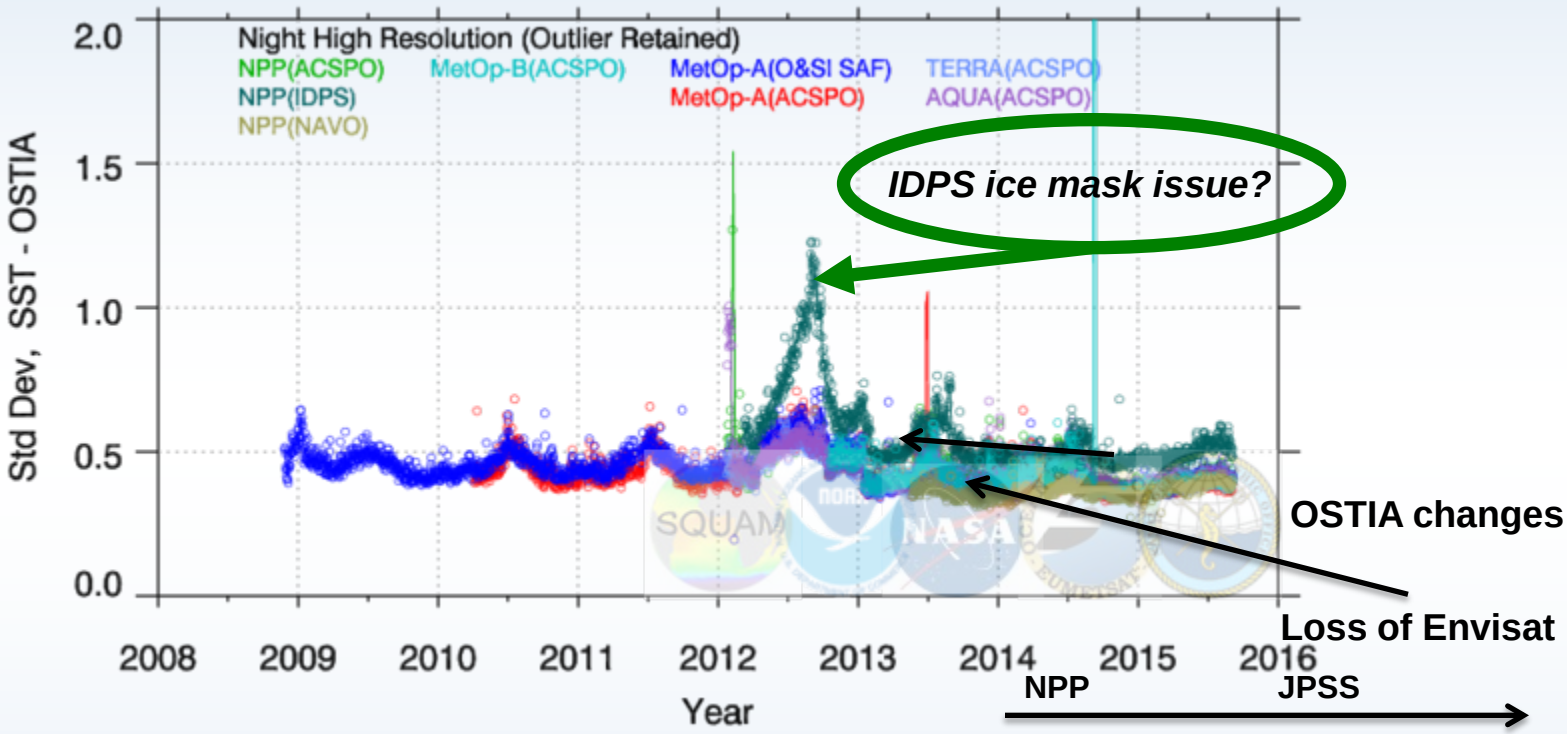


- *Negative residuals possibly suggest cloud/aerosol leakages*

- *More negative residuals possibly suggesting more cloud/aerosol leakages*

Issues: (2) ice mask not updated?

Maps | Histograms | Time-series | Dependencies | Hovmöller

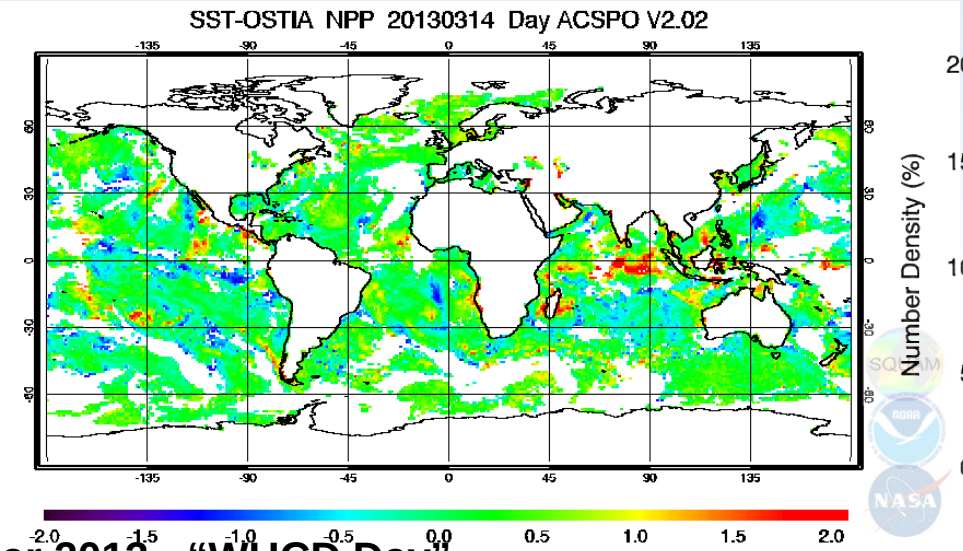


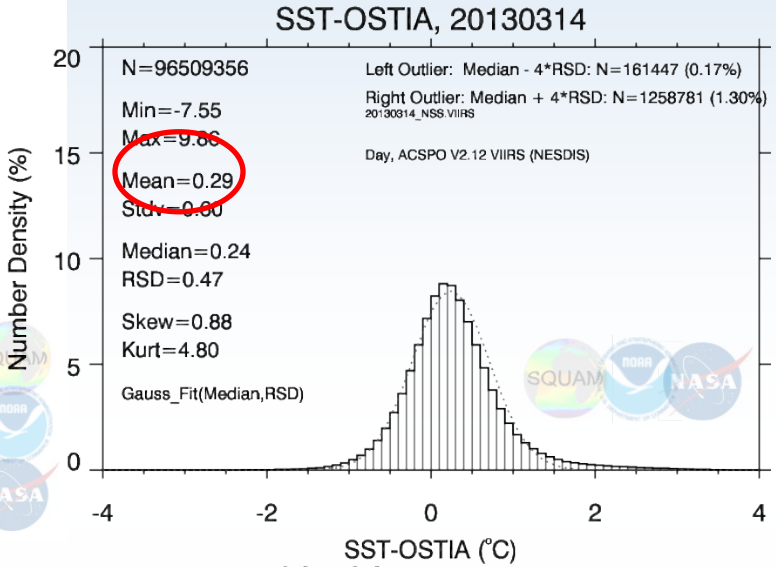
SST Std Dev from OSTIA for AVHRRs, VIIRS, MODIS

Issues: (3) VIIRS Warm-Up Cool-Down Exercises

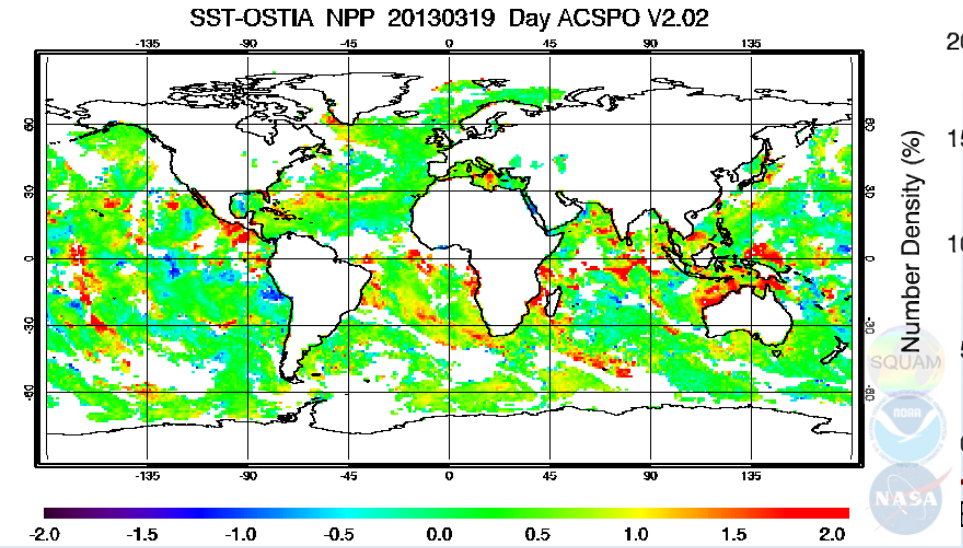
Maps | Histograms | Time-series | Dependencies | Hovmöller

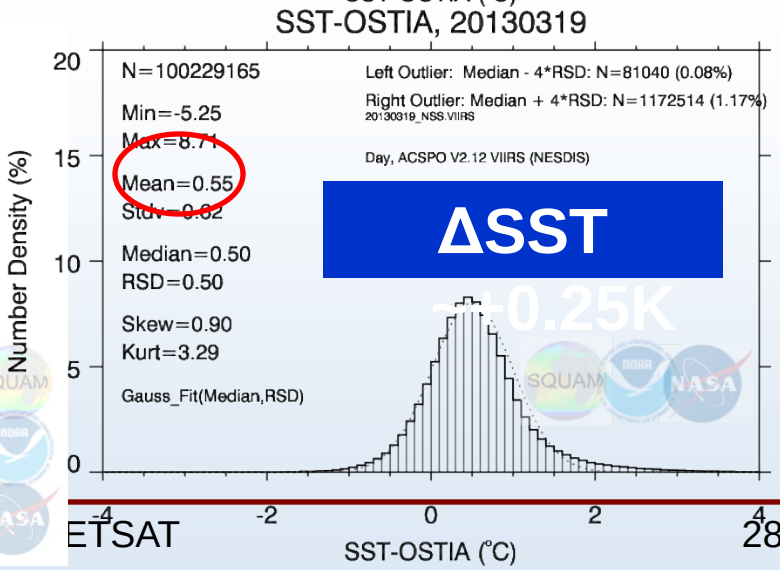
14 Mar 2013 - "Regular Day"





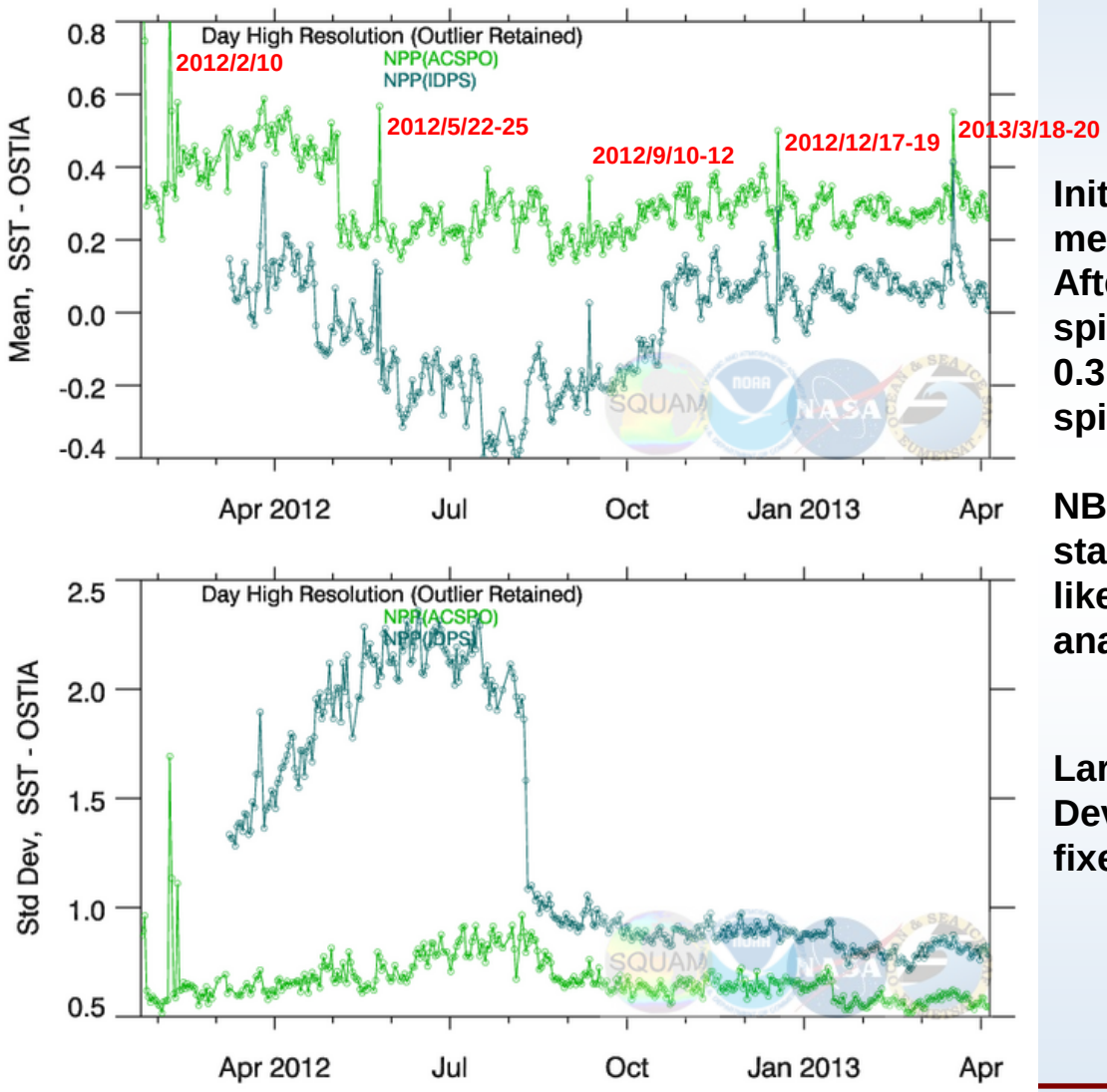
19 Mar 2013 - "WUCD Day"





Uncovering issues: (3) WuCd event, continued …

Maps | Histograms | Time-series | Dependencies | Hovmöller



Initial large spike in global mean biases in Feb 2012. After code fixes, SST spikes reduced to ~0.2-0.3K. (correlated to BT spike – not shown)

NB: These are daily global statistics. Local spikes are likely larger (no special analysis done).

Large spike in global Std Dev Feb 2012. After code fixes, SST spikes reduced.

Outline

1. RS satellite missions and NOAA ACSPO SST products overview

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   - Example Monitoring & Validation: Maps, Histograms, Time series

3. Expanding to new modules: Geostationary (Himawari-08)

4. Uncovering issues in products: Examples

5. Expansion potential beyond the current framework:
   - **Characterization of collocation effect**
   - **Estimation of internal error by Triple Collocation Method (3-way)**

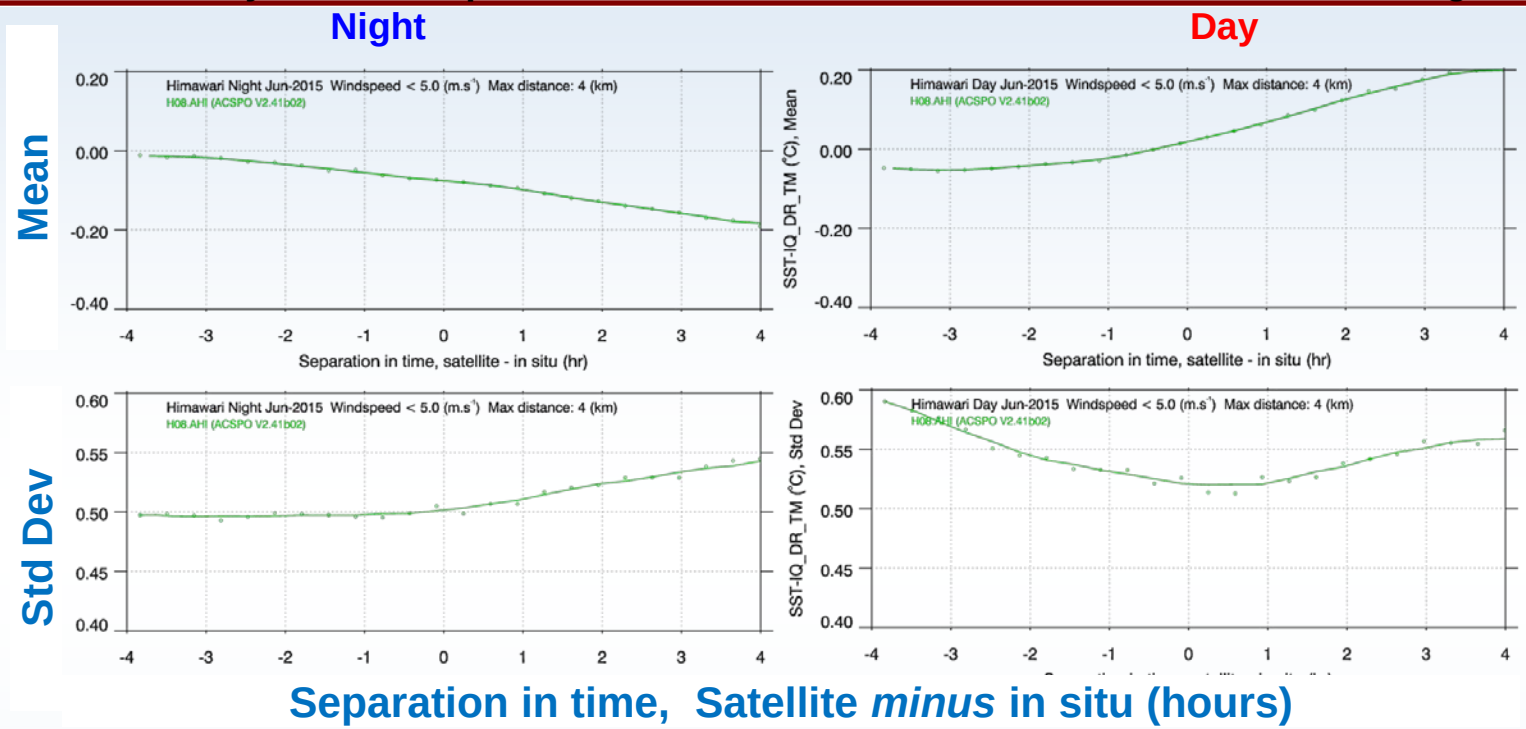
6. What we at NOAA/STAR can potentially offer for EUMETSAT SST products?
   - Examples of (A)ATSR Reprocessing for Climate (ARC) data in SQUAM
   - Examples of IASI in SQUAM (this visit; preliminary)

7. (Online demo |connectivity)

8. Summary

Beyond SQUAM: (1) collocation effect (time, space)

Sensitivity to match-up time difference; Himawari-8 vs. Drifter + Tro. Moorings



- At night, a cooling trend is observed in *bias,* due to gradual diminishing of diurnal thermocline. During the daytime, a warming trend is observed, due to forming the diurnal thermocline
- *Standard Deviation* increases with time-difference on both sides, as expected. The U-shape is more pronounced during the daytime. The nighttime asymmetry needs further investigation
- Similar investigation for space-difference (not shown; see GHRSST-15 poster)

Beyond SQUAM: (2) True random error (3-way)

Reported val error has contribution from Product & Reference: $\sigma = SQRT(\sigma_{product}^2 + \sigma_{reference}^2)$
A way to separate these errors is by 3-way analyses (O'Carroll et al., 2008).
Assumption: $\sigma_1\sigma_2 = \sigma_2\sigma_3 = \sigma_1\sigma_3 = 0$ (Zero correlated error)

~ECT	Target product	Triplets (products from the same satellite or with too different ECTs are not combined to form triplets)	Number of triplets++	Random error from TCM
Daytime				
13:30	ACSPO NPP	ACSPO NPP, ACSPO AQUA, Drifters	105,844	0.26
	IDPS NPP	IDPS NPP, ACSPO AQUA, Drifters	104,492	0.41
	NAVO NPP	NAVO NPP, ACSPO AQUA, Drifters	35,293	0.21
9:30	ACSPO Metop-A	ACSPO Metop-A, ACSPO Terra, Drifters	112,154	0.28
		ACSPO Metop-A, ACSPO Metop-B, ACSPO Terra	73,411	0.30
	OSISAF Metop-A	OSISAF Metop-A, ACSPO Terra, Drifters	102,875	0.33
		OSISAF Metop-A, ACSPO Metop-B, ACSPO Terra	69,699	0.33
9:30	ACSPO Metop-B	ACSPO Metop-B, ACSPO Terra, Drifters	119,505	0.29
		ACSPO Metop-B, ACSPO Metop-A, Drifters	143,914	0.31
		ACSPO Metop-B, ACSPO Metop-A, ACSPO Terra	73,411	0.29
		ACSPO Metop-B, OSISAF Metop-A, ACSPO Terra	69,699	0.29
10:30	ACSPO Terra	ACSPO Terra, OSISAF Metop-A, Drifters	102,875	0.33
		ACSPO Terra, ACSPO Metop-A, Drifters	112,154	0.34
		ACSPO Terra, ACSPO Metop-A, ACSPO Metop-B	73,411	0.34
		ACSPO Terra, OSISAF Metop-A, ACSPO Metop-B	69,699	0.33
13:30	ACSPO Aqua	ACSPO Aqua, ACSPO NPP, Drifters	105,844	0.30
		ACSPO Aqua, IDPS NPP, Drifters	104,492	0.28
		ACSPO Aqua, NAVO NPP, Drifters	35,293	0.31

++match-up criteria: ±8km ±96min; Jun-2013 to May-2014

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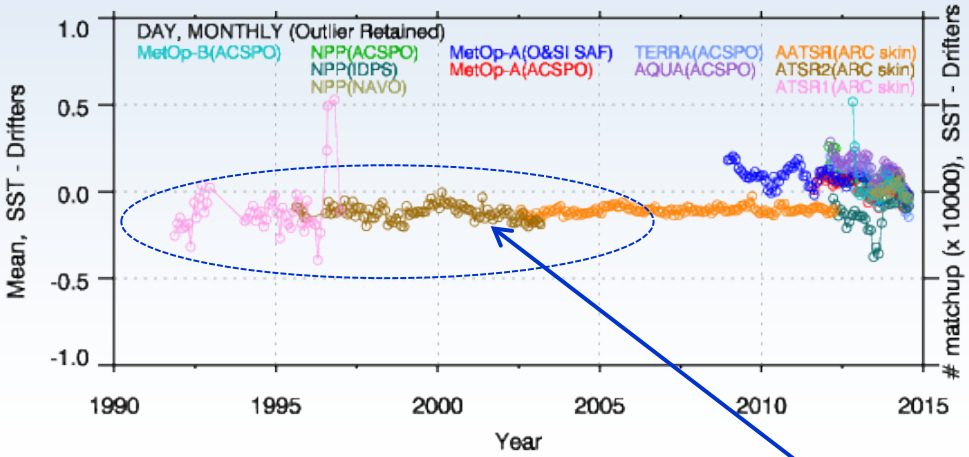
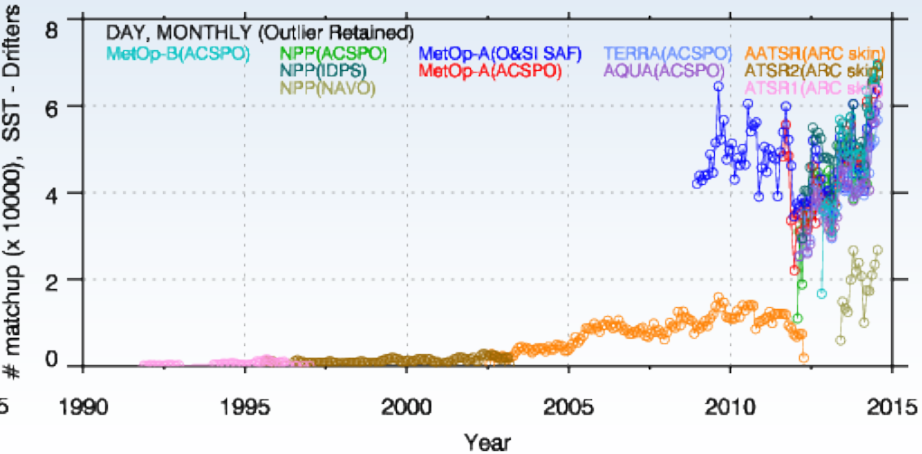
   - **Examples of IASI in SQUAM (this visit; preliminary)**

7. (Online demo |connectivity)

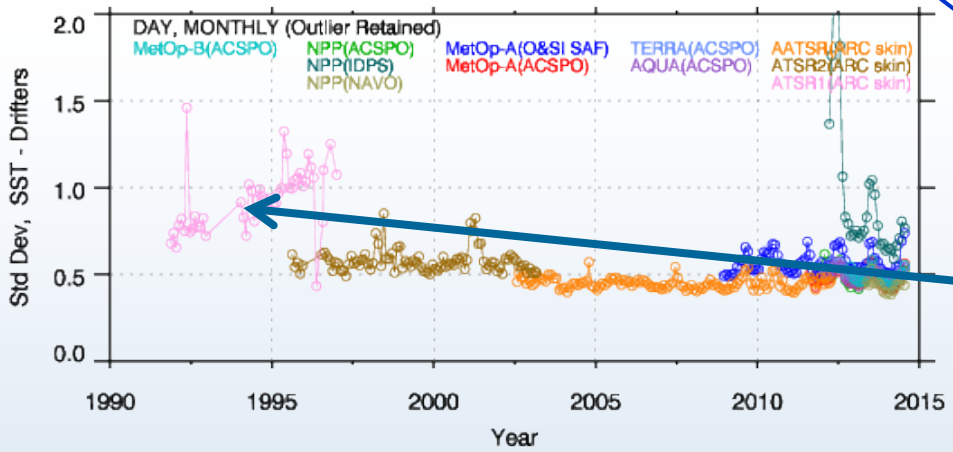
8. Summary

Potential NOAA/EUMETSAT SST Collaboration
1. Sentinel-3 (The ARC experience)





ARC (A)ATSR 'cool' skin SST products



ARC ATSR1: Sensor issues

- *Eleven products (different colors)*

Potential NOAA/EUMETSAT SST Collaboration

2. Metop-A IASI SST (sensitivity of QF & SSES bias)

- General diagnostics of Metop-A IASI SST
- IASI data /GDS2.0 format: Quality Flag for each retrieval. Performance statistics is stratified in 3 cat: QL ge 3, QL ge 4, QL eq 5
- Estimated SSES bias and error for each retrieval point is provided. The effect of applying SSES bias is also characterized.
- Total **6 combo**: 3 for QF + 3 for SSES bias (applied and not applied)

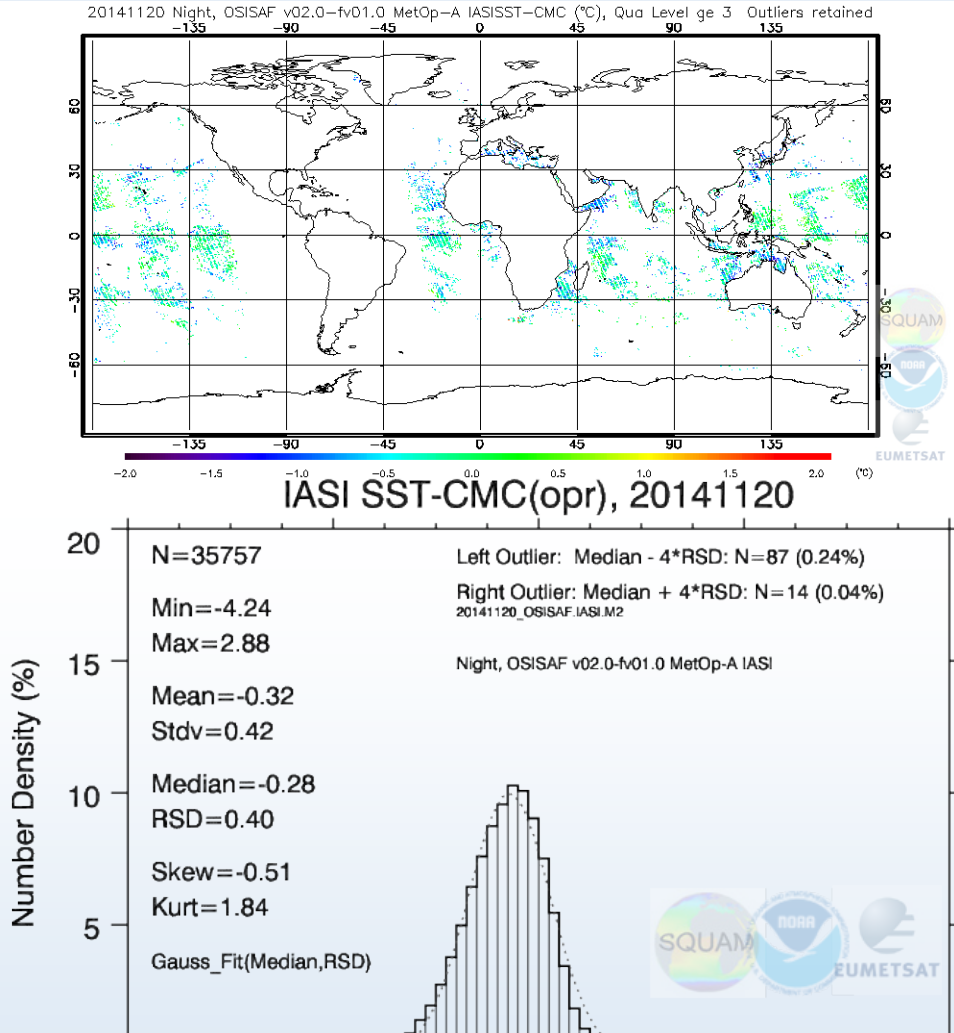
- Performances are stratified by “DAY” and “NIGHT” for any given date.
- 20-Nov-2014 is used as a test date

Aim: To find a suitable combination of Quality Flag and SSES bias usage, and recommend it to be included in the SQUAM stream for multi-sensor comparisons

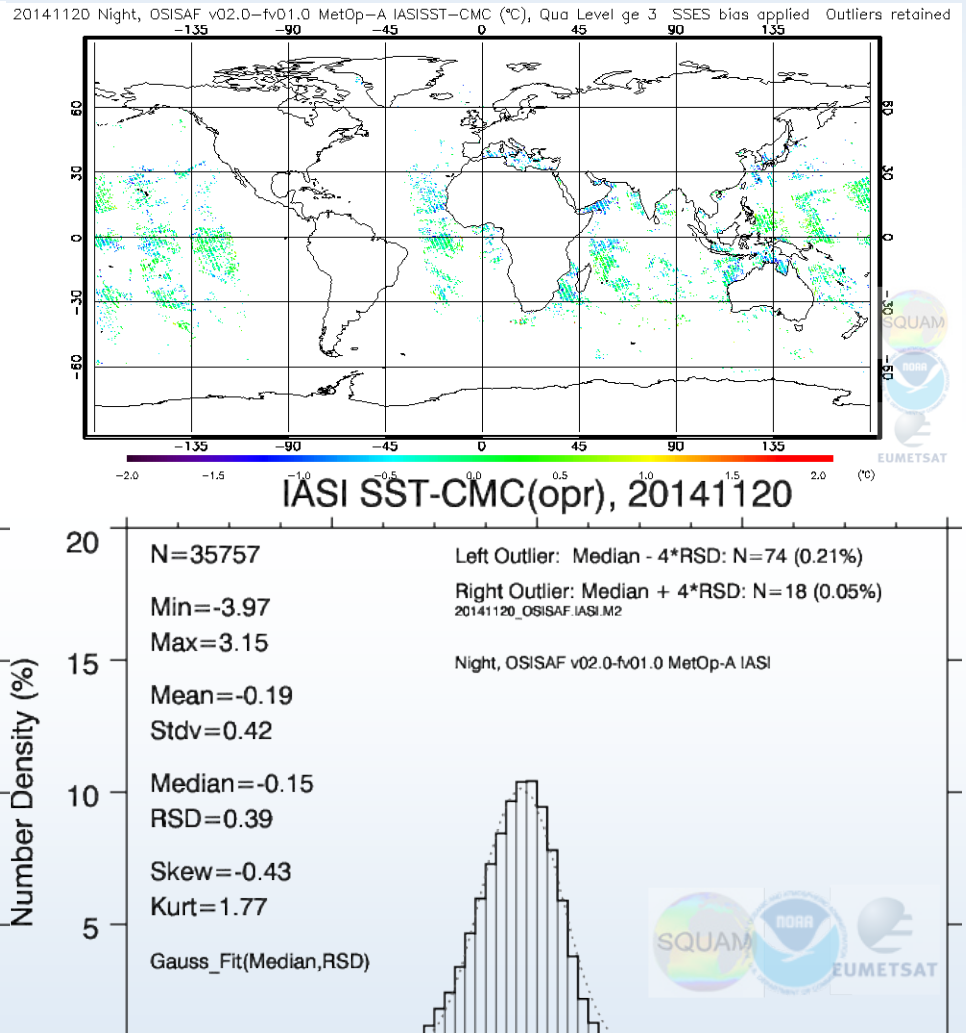
Potential NOAA/EUMETSAT SST Collaboration

2. Metop-A IASI SST (sensitivity of QF & SSES bias); *continued…*

SSES bias not applied (QL GE 3)



SSES bias applied (QL GE 3)



Potential NOAA/EUMETSAT SST Collaboration

2. Metop-A IASI SST (sensitivity of QF & SSES bias)

Quality level		SSES bias not applied			SSES bias applied		
		# of obs	Mean (°C)	Std Dev (°C)	# of obs	Mean	Std Dev
≥ 3	Night	35,757	-0.32	0.42	35,757	-0.19	0.42
	Day	44,161	-0.23	0.40	44,161	-0.11	0.40
≥ 4	Night	32,554	-0.31	0.41	32,554	-0.19	0.41
	Day	40,575	-0.22	0.40	40,575	-0.11	0.40

Data loss (compared to QL ge 3): 9% 8%

= 5	Night	20,803	-0.26	0.37	20,803	-0.17	0.37
	Day	31,889	-0.20	0.38	31,889	-0.11	0.38

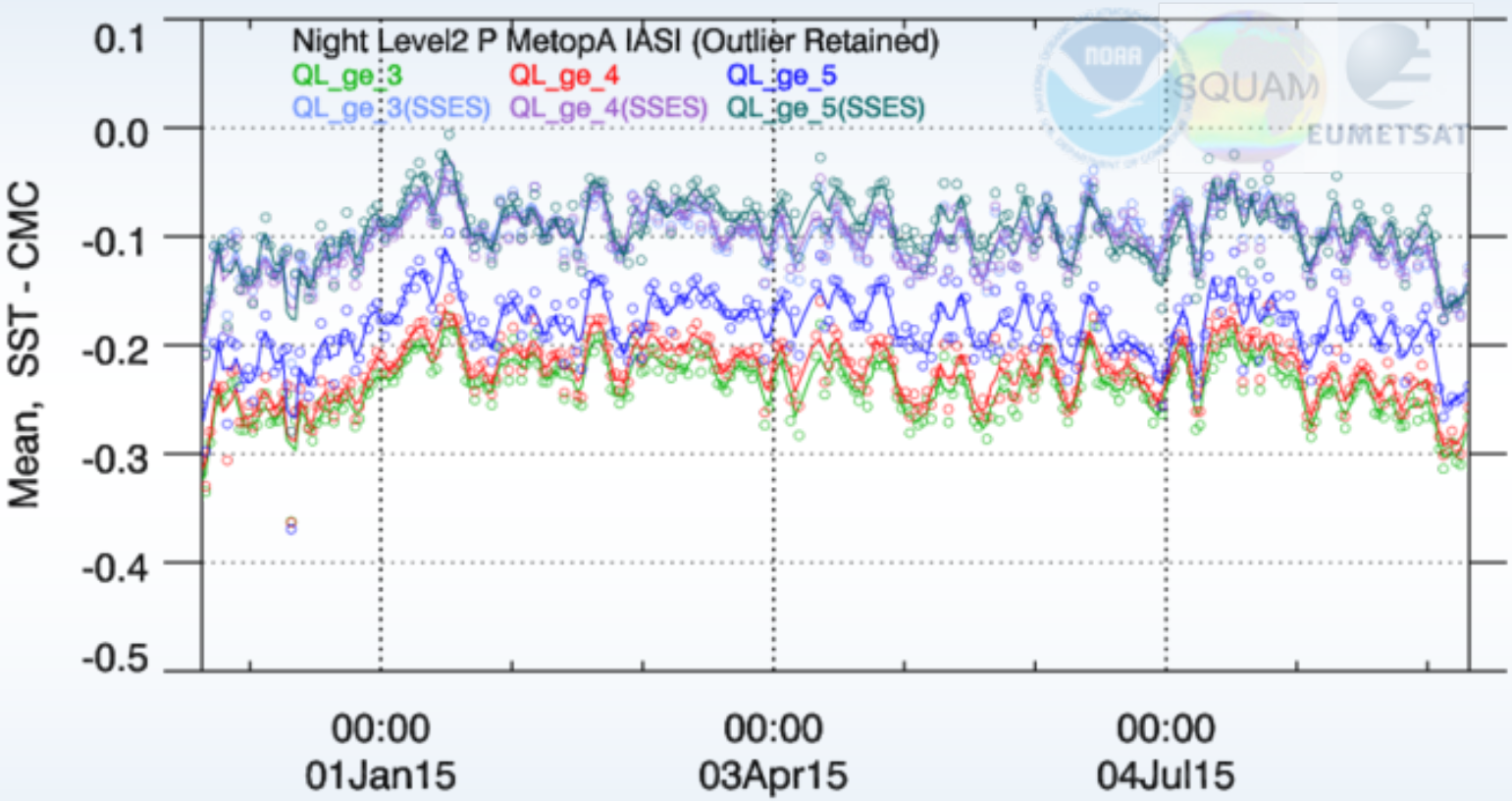
Data loss (compared to QL ge 3): 42% 28%

- **QL=5 results in substantial data loss with marginal improvement in stats (rather disappointing!)**
- **SSES bias must be applied for this data (does not change noise but gets closer to skin expectation)**

Recommendation for inclusion in SQUAM: QL ge 3, SSES bias applied

Potential NOAA/EUMETSAT SST Collaboration

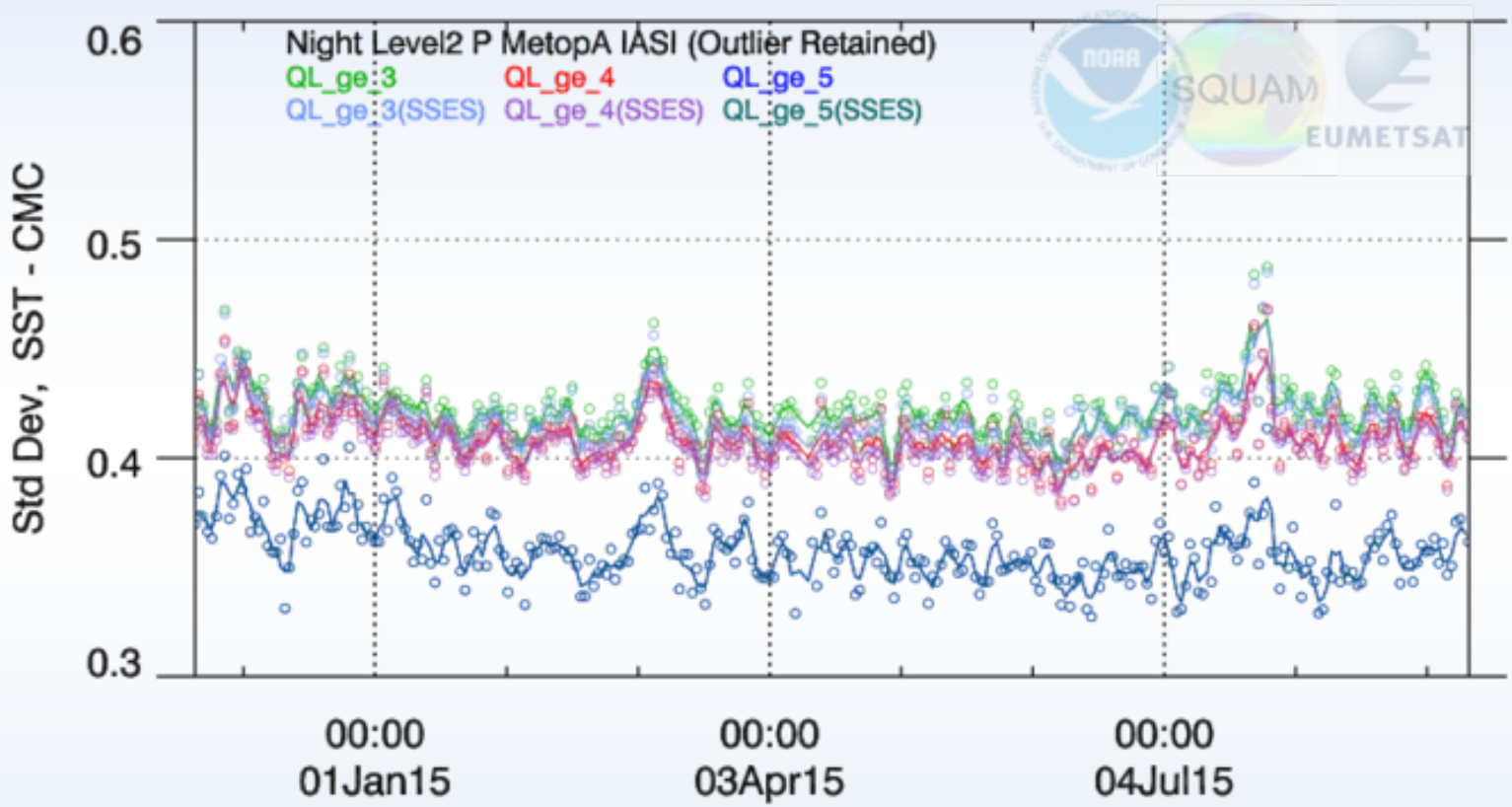
2. Metop-A IASI SST (sensitivity of QF & SSES bias)



Night time, Mean (IASI – CMC) for 6 combo

Potential NOAA/EUMETSAT SST Collaboration

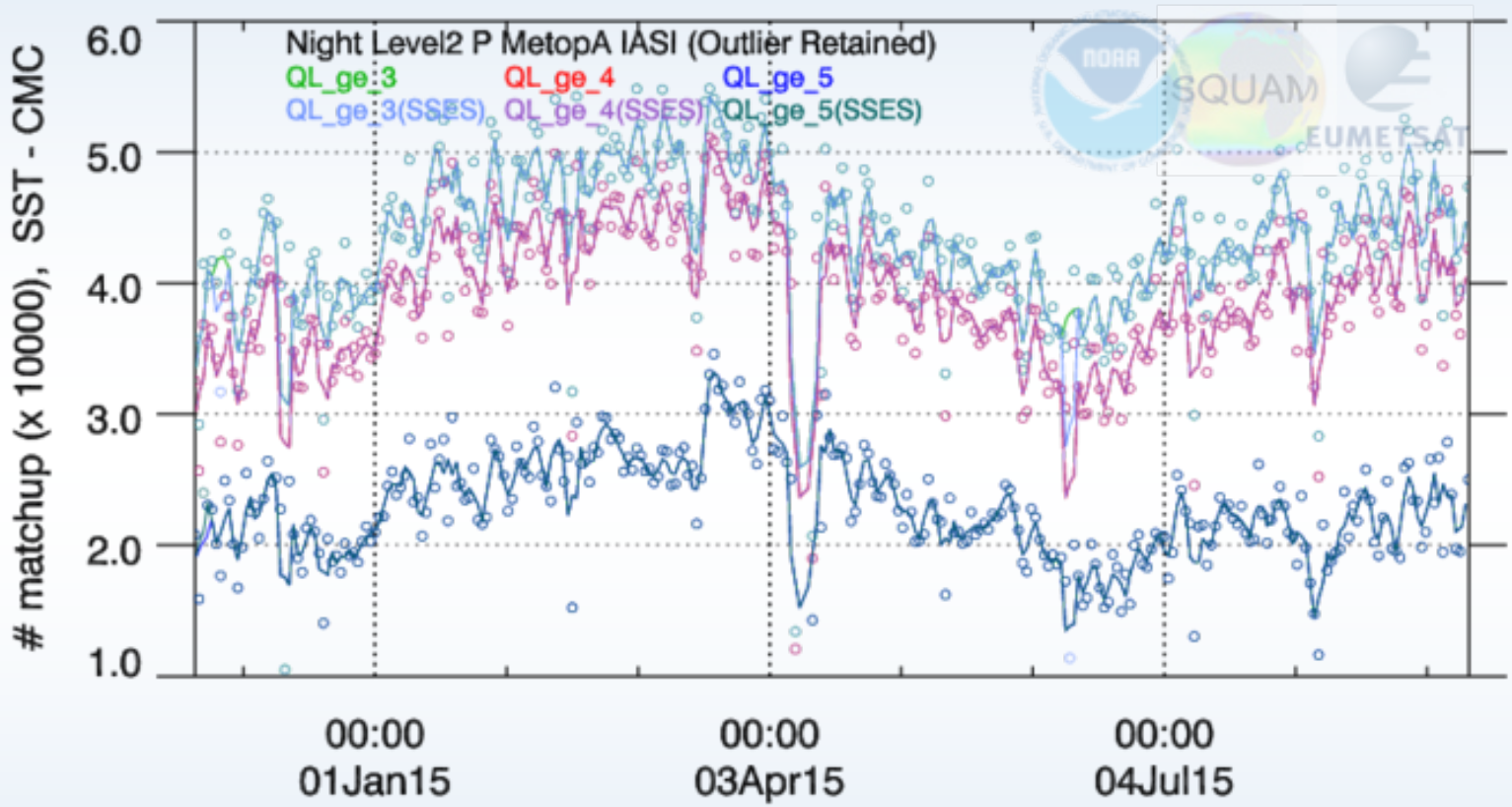
2. Metop-A IASI SST (sensitivity of QF & SSES bias)



Night time, StdDev (IASI – CMC) for 6 combo

Potential NOAA/EUMETSAT SST Collaboration

2. Metop-A IASI SST (sensitivity of QF & SSES bias)



Night time, #of valid Obs (IASI) for 6 combo

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   - Examples of IASI in SQUAM (this visit; preliminary)

7. (Online demo |connectivity) – check connectivity/ web browser

8. Summary

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8. Summary

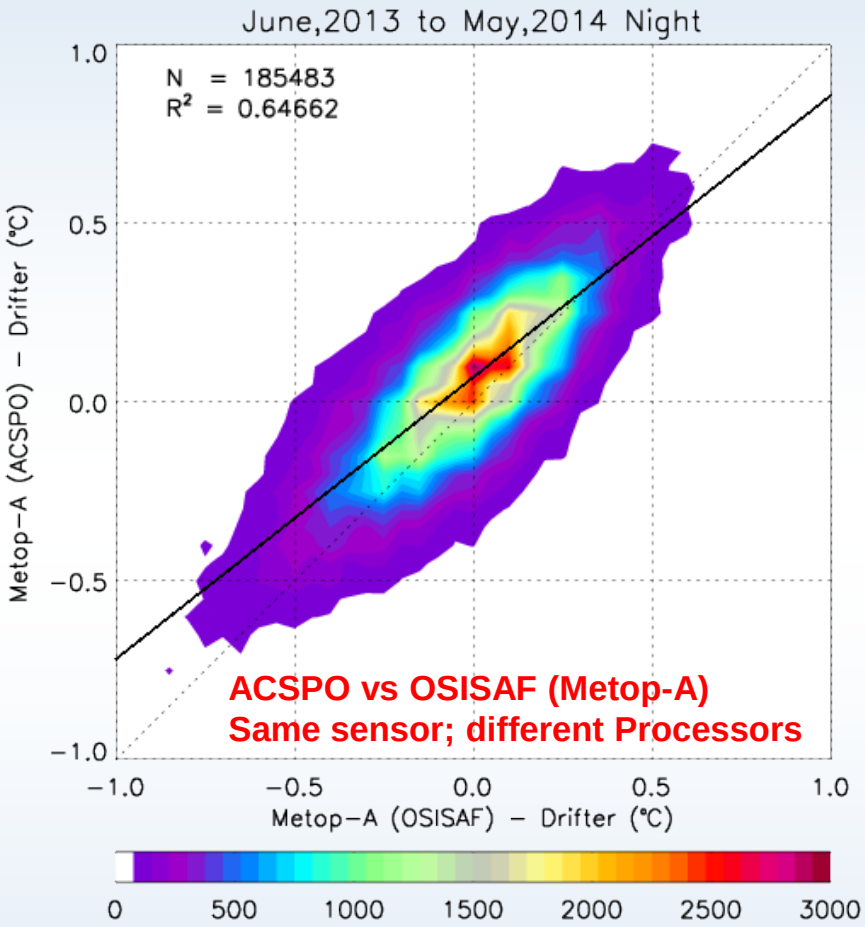
SUMMARY

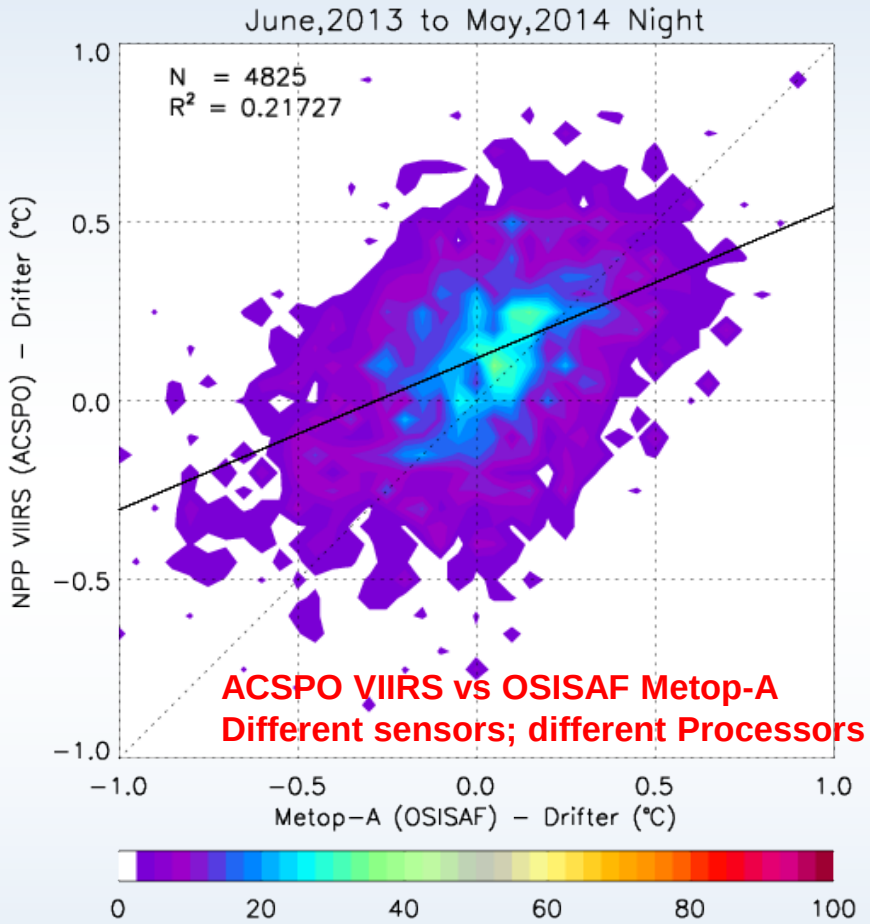
- SQUAM currently monitors major global polar L2/3 SST products from VIIRS, MODIS, and AVHRR, and >14 L4 SST products
- ACSPO VIIRS products have been generated since Jan 2012 and monitored in SQUAM. Data are available in GDS2.0 format from NCEI and PO.DAAC
- Recently, a GEO SQUAM module was developed. Himawari-7 (aka MTSAT-2; NOAA heritage product), Himawari-8 (new NOAA ACSPO product), and Himawari-8 (JAXA product) are included. The results are preliminary but show SQUAM potential in sustained monitoring of these products
- NOAA/EUMETSAT collaboration potential with SQUAM (VS work covered some aspects)
  - IASI (onboard Metop-A and B)
  - Sentinel-3 SLSTR

Thanks for your attention and for having me here!

Additional slides

Correlation between residuals (SST-drifters)
±8km ±96min; Jun-2013 to May-2014





General observation: SSTs from same sensors, despite different processors, are highly correlated (in residuals) → table follows

8 products: Correlation between residuals (SST-drifters)

±8km ±96min; Jun-2013 to May-2014

Residuals (SST – Drifters)	~ECT	ACSPO NPP	IDPS NPP	NAVO NPP	ACSPO Metop-A	OSISAF Metop-A	ACSPO Metop-B	ACSPO Terra	ACSPO Aqua
ACSPO NPP	13:30	1.00 (Night) 1.00 (Day)	0.79 0.83	0.63 0.64	0.31 0.25	0.22 0.25	0.35 0.28	0.39 0.24	0.47 0.36
IDPS NPP			1.00 1.00	0.57 0.54	0.19 0.16	0.19 0.16	0.20 0.20	0.22 0.17	0.31 0.27
NAVO NPP				1.00 1.00	0.27 0.36	0.25 0.32	0.23 0.32	0.33 0.28	0.47 0.33
ACSPO Metop-A	9:30				1.00 1.00	0.65 0.59	0.42 0.31	0.42 0.29	0.38 0.27
OSISAF Metop-A						1.00 1.00	0.27 0.29	0.28 0.27	0.32 0.28
ACSPO Metop-B	9:30						1.00 1.00	0.41 0.31	0.37 0.27
ACSPO Terra	10:30							1.00 1.00	0.47 0.31
ACSPO Aqua	13:30								1.00 1.00

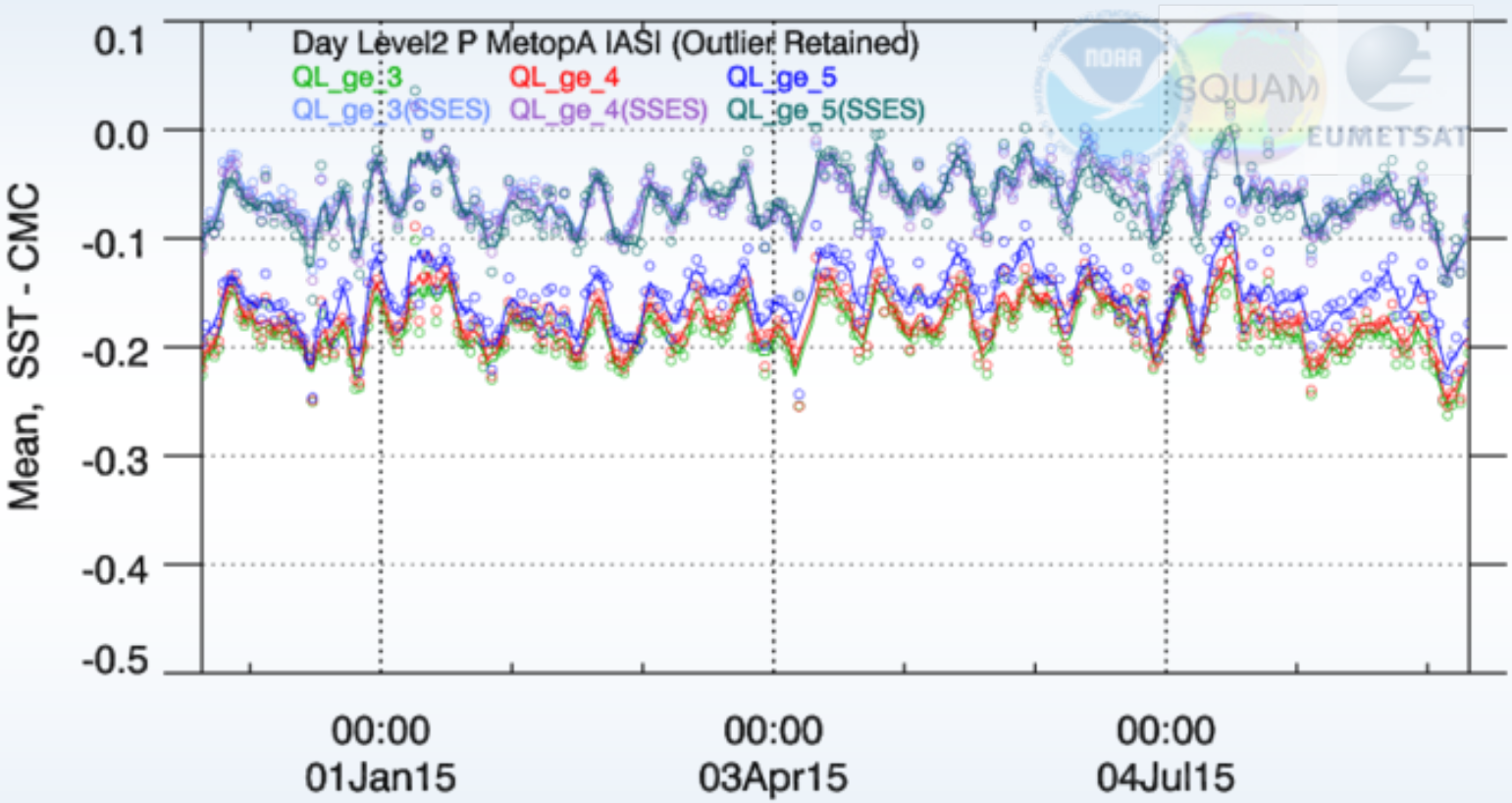
Correlation higher for different products from the same sensor

Correlation lower for the same product from different sensors

- This info is used to create triplets for error characterization using three-way error analyses (shown)
- May be useful for L4 producers to reduce redundancy while choose input L2 SSTs

Potential NOAA/EUMETSAT SST Collaboration

2. Metop-A IASI SST (sensitivity of QF & SSES bias)



Day time, Mean (IASI – CMC) for 6 combo

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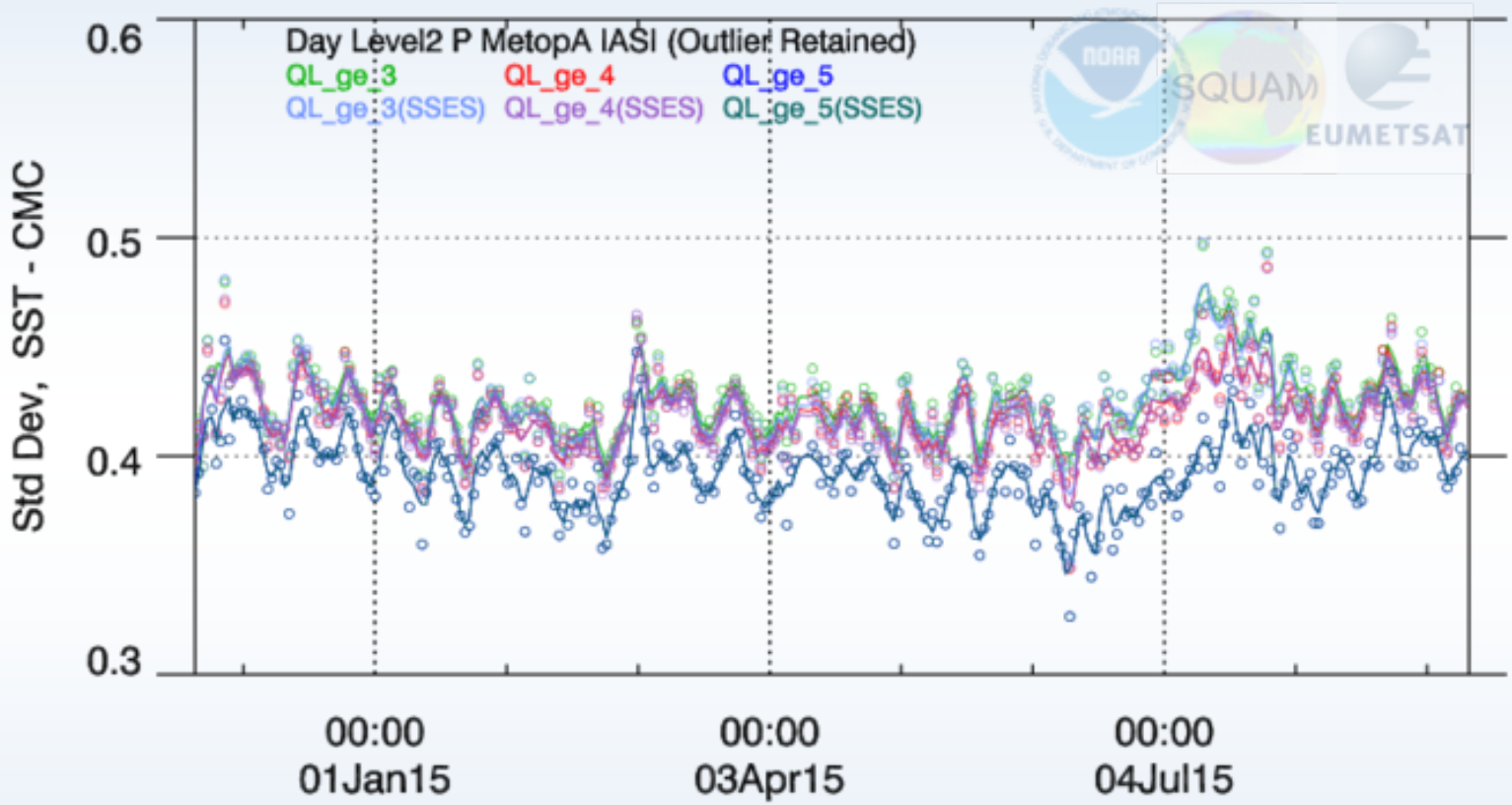

Day time, StdDev (IASI – CMC) for 6 combo

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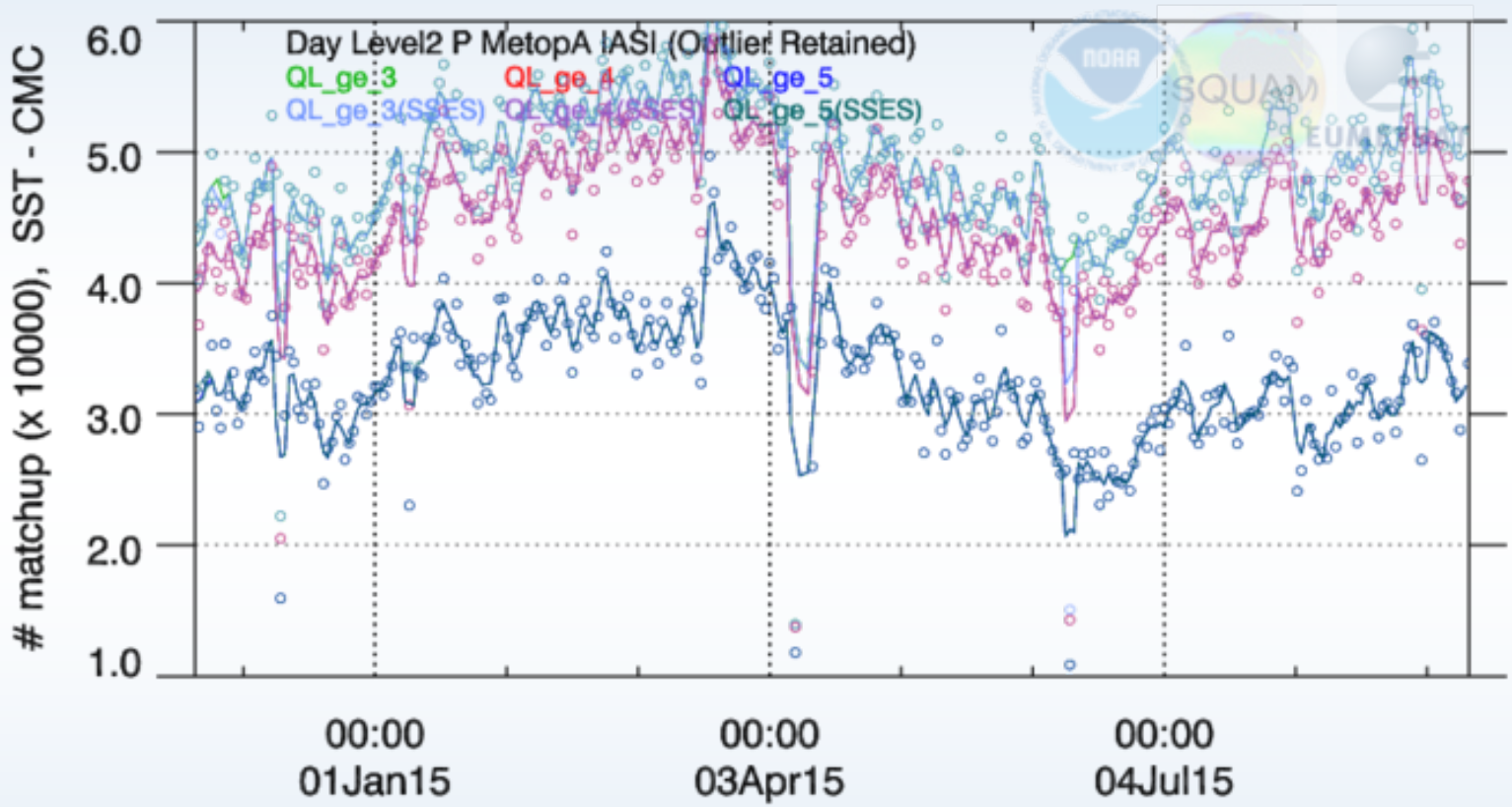

Day time, #of valid Obs (IASI) for 6 combo

ARC in SQUAM – preliminary analysis

Summary stat wrt. OSTIA for 30-Mar-2012	Avg. num. of retrievals / day	Avg. median Difference, K	Avg. robust Std Dev, K
ARC AATSR L2P	14.4 mi (day) 11.8 mi (night)	-0.02 (+0.17) -0.10 (+0.17)	0.38 0.27
OSISAF Metop-A FRAC	44.9 42.9	0.19 0.03	0.40 0.29
ACSPO Metop-A FRAC	46.1 46.3	0.14 0.00	0.42 0.28
ACSPO VIIRS	93.9 89.6	0.44 0.16	0.48 0.31

Triple-collocation (Night)

Nighttime				
~ECT	Target product	Triplets (products from the same satellite or with too different ECTs are not combined to form triplets)	Number of triplets	Random error from TCM
1:30	ACSPO NPP	ACSPO NPP, ACSPO AQUA, Drifters	107,023	0.19**
	IDPS NPP	IDPS NPP, ACSPO AQUA, Drifters	109,103	0.23**
	NAVO NPP	NAVO NPP, ACSPO AQUA, Drifters	43,661	0.13**
21:30	ACSPO Metop-A	ACSPO Metop-A, ACSPO Terra, Drifters	112,833	0.26
		ACSPO Metop-A, ACSPO Metop-B, ACSPO Terra	74,886	0.25
	OSISAF Metop-A	OSISAF Metop-A, ACSPO Terra, Drifters	83,856	0.26
		OSISAF Metop-A, ACSPO Metop-B, ACSPO Terra	58,352	0.24
21:30	ACSPO Metop-B	ACSPO Metop-B, ACSPO Terra, Drifters	114,434	0.26
		ACSPO Metop-B, ACSPO Metop-A, Drifters	156,456	0.25
		ACSPO Metop-B, ACSPO Metop-A, ACSPO Terra	74,886	0.25
		ACSPO Metop-B, OSISAF Metop-A, ACSPO Terra	58,352	0.23
22:30	ACSPO Terra	ACSPO Terra, OSISAF Metop-A, Drifters	83,856	0.22
		ACSPO Terra, ACSPO Metop-A, Drifters	112,833	0.23
		ACSPO Terra, ACSPO Metop-A, ACSPO Metop-B	74,886	0.25
		ACSPO Terra, OSISAF Metop-A, ACSPO Metop-B	58,352	0.23
1:30	ACSPO Aqua	ACSPO Aqua, ACSPO NPP, Drifters	107,023	0.22
		ACSPO Aqua, IDPS NPP, Drifters	109,103	0.21
		ACSPO Aqua, NAVO NPP, Drifters	43,661	0.21