

# NOAA SST Quality Monitor (SQUAM)

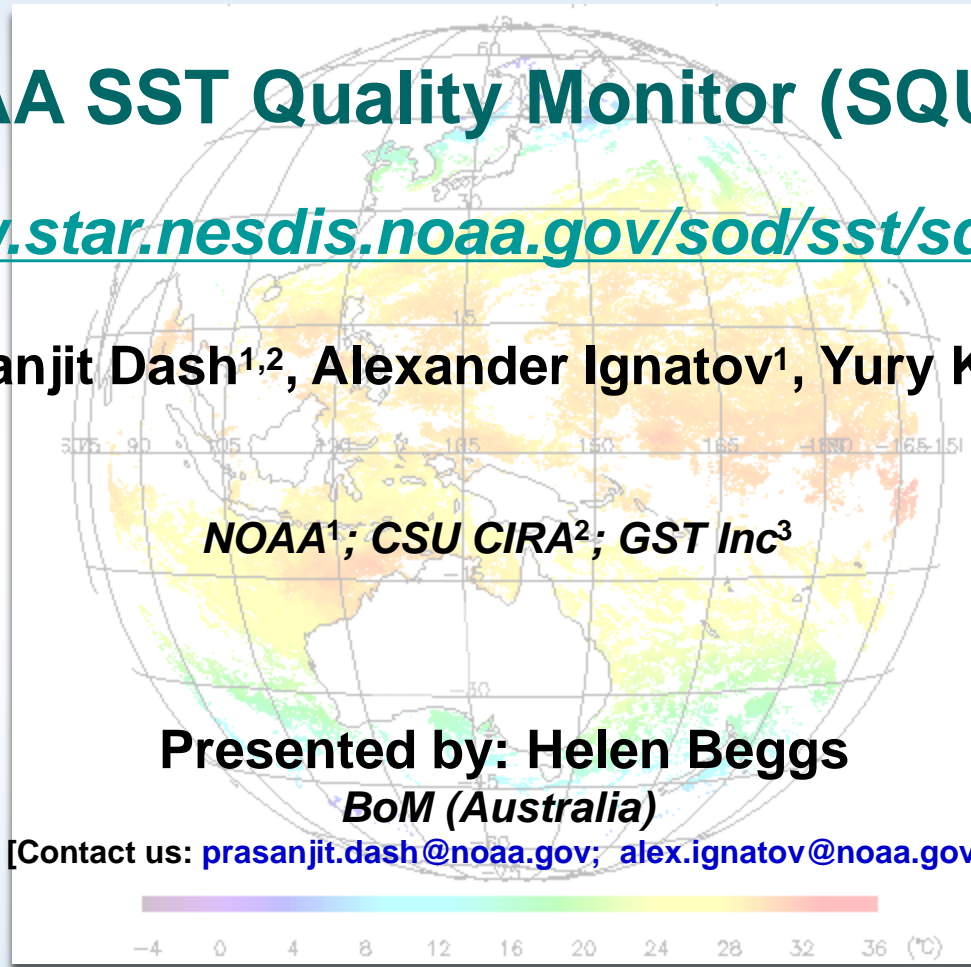
[www.star.nesdis.noaa.gov/sod/sst/squam/](http://www.star.nesdis.noaa.gov/sod/sst/squam/)

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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 AH1, JAXA

## 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

GHRSSST support: Peter Minnett, Craig Donlon, Alexey Kaplan

## Major SST data providers:

## Projects and international groups



## 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/](http://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 (GHRSSST)  
NAVO K10  
NOAA Geo-Polar Blended  
DMISST (Danish Met. Inst.)  
NCODA (NRL)  
MGDSST (JAXA, Japan)  
RSS (MW, MW+MODIS)

SST community is data rich!

Now, how different product perform & compare?

## Keywords

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

## SST products in SQUAM

- 3 SQUAM modules: Swath (L2) + Gridded (L3) + Analysis (L4)
- Initially created as a NOAA system, but now additionally monitors many community products

## Analyzed are deviations from reference SSTs, $\Delta T_S = T_S - T_{REF}$

- Gaussian? Centered at ~0? Narrow? No outliers?
- Two types of  $T_{REF}$ 
  1. *iQuam 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*



# SQUAM web-interface

(For more info, see Demo in L6 conf rooms 1+2)

File Edit View History Bookmarks Tools Help

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

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## SST Quality Monitor

SQUAM v10.0

Home Level 2 + Level 3 + Level 4 About +

Last updated: Aug-24-2015

**SQUAM objective**

- Serve as a community tool for near real-time monitoring of major global SST products

**What SQUAM does?**

- Monitors global L2 & L3 SSTs w.r.t. L4 fields & *in situ* data
- Intercompares and validates various global L4 SST products

**Methodology**

- Global QC and statistical checks for self- and cross-consistency using maps, histograms, time series, and dependencies of SST differences

**Page navigation**

- For specific data, follow the top-left menu or click inside the table
- For related info (ver., ref., ...), see "About+" at the top-right

**Contact us**

- Tell us how we can do better:

Prasanjit Dash Sasha Ignatov

Level-2	Level-3	Level-4
<p><b>High Resolution</b></p> <p><b>NPOESS VIIRS</b> NESDIS ACSP0 NGS/Raytheon DPS NAVO</p> <p><b>AVHRR FRAC</b> NESDIS MetOp-B NESDIS MetOp-A ACSP0 EUMETSAT O&amp;SI SAF</p> <p><b>Terra/Aqua MODIS</b> NASA MOD28/MYD28 (coming) NESDIS ACSP0</p> <p><b>(A)ATSR/Sentinel-3 SLSTR</b> ARC L2P (A)ATSR ESA Sentinel-3 (future)</p> <p><b>AVHRR GAC</b> NESDIS ACSP0 NAVO SEATEMP NESDIS MUT (heritage)</p>	<p><b>AVHRR GAC</b> ACSP0 L3U (currently v2.4) NODC/RSMAS Pathfinder v5.0</p>	<p><b>Bulk</b></p> <p>Reynolds (AVHRR) : DOL_AV Reynolds (+ AMSRE-E) : DOL_AA RTG high resolution: RTG_HR RTG low resolution: RTG_LR NAVO K10 NESDIS POESGOES NASA JPL 1km G1SST: G1SST</p> <p><b>Foundation/Sub-skin</b></p> <p>OSTIA, UK MetOffice OSTIA Reanalysis, UK MetOffice CMC 0.2°, Environment Canada GAMSSA 28km, Australian BOM ODYSSEA, MERSEA France MUR, JPL/NASA DMI OISST, DMI</p> <p><b>Ensemble of L4 SSTs</b> GHRSSST Median Ensemble</p>
<p>- "L2/3 vs L4" complements heritage "L2/3 vs insitu" validation <a href="#">++Why?</a> - Contributes to GHRSSST STVAL <a href="#">++Link</a></p>		<p>- Contributes to GHRSSST IC-TAG <a href="#">++Link</a></p>

**Highlights since Feb 2010**

Monthly insitu val high-res L2 SST [Jun-04-2013] [More...](#)

2012 Eumetsat presentation (VIIRS) [Aug-30-2012] [PPT](#)

VIIRS & MODIS (ACSP0) included in High Res SQUAM; HR SSTs compared against L4 & *in situ* [Mar-15-2012] [More...](#)

Insitu val of high res. SSTs included [Oct-12-2011] [More...](#)

OSTIA reanalysis SST included [May-08-2011] [More...](#)

GAMSSA SST included in L4-SQUAM [Mar-09-2011] [More...](#)

SQUAM overview presented at GHRSSST DV-WG, ST-VAL, HL-TAG combined workshop [Mar-02-2011] [PPT](#)

Insitu validation of [L4 SSTs](#) implemented [Dec-2010]

SQUAM & other NESDIS monitoring systems presented at USSST meeting [Nov-08-2010] [PPT](#)

Peer-review paper published in JAOT-Oceans [Nov-2010] [PDF](#)

JPL G1SST and CMC 0.2° SST included in L4-SQUAM [Nov-03-2010] [More...](#)

PathFinder v5.0 included in L3-SQUAM [Sep-03-2010] [More...](#)

NAVO K10, GMPE, & POES-GOES Blended SSTs included in L4-SQUAM [Aug-23-2010] [More...](#)

L4-SQUAM presented at GHRSSST-XI meeting [Jun-30-2010] [PPT](#)

MetOp-A FRAC SST (NESDIS ACSP0 and O&SI SAF) included in L2-SQUAM [May-18-2010] [More...](#)

NAVO SEATEMP products included in L2-SQUAM [Apr-07-2010] [More...](#)

SQUAM presented at 2010 MyOcean & STVAL [Feb-23-2010] [PPT](#)

**SST data providers**

**Satellite missions & SST Groups**

Notice: SQUAM L4 module is not up-to-date and updating is underway [28-May-2014].

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NOAA NESDIS SST Quality ... x +

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

squam google sst

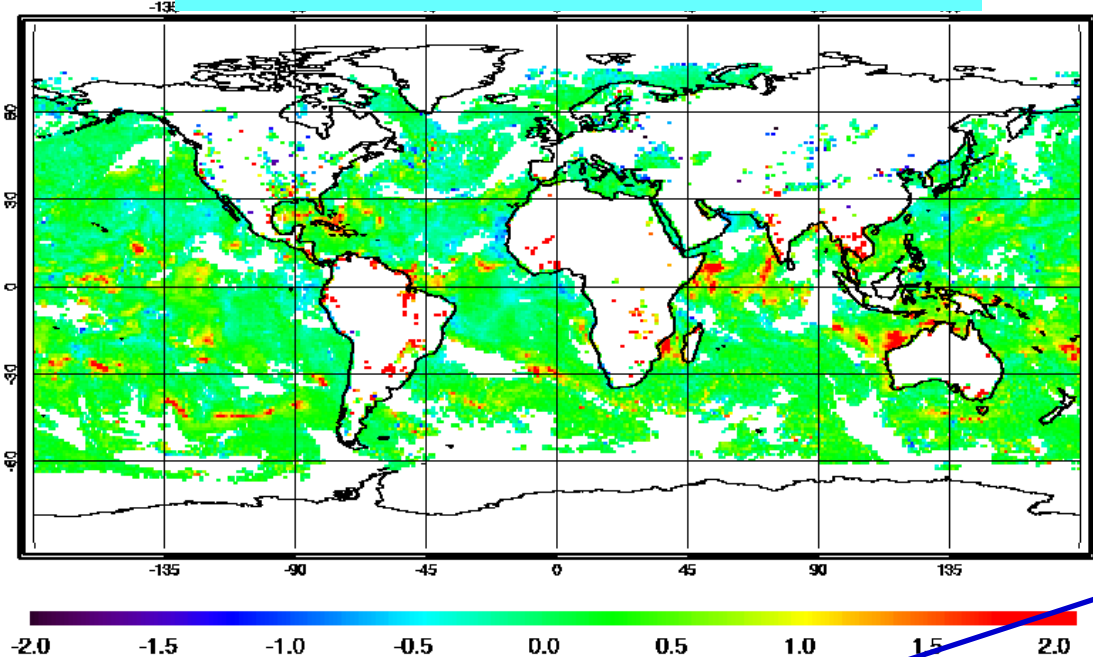
NOAA NESDIS SST Quality ... x +

# ***L2-SQUAM (HR SST)***

[www.star.nesdis.noaa.gov/sod/sst/squam/HR/](http://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, focus is on HR products

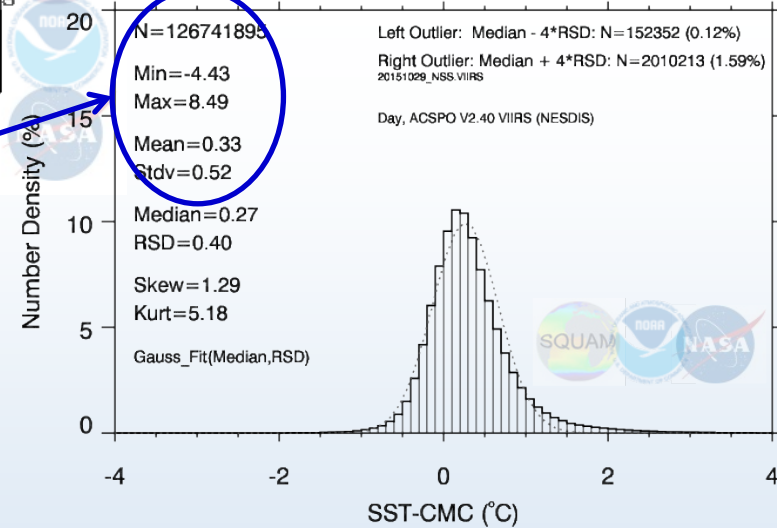
## NPP VIIRS (ACSPO, day) – CMC L4



## NPP VIIRS & AQUA MODIS (ACSPO)

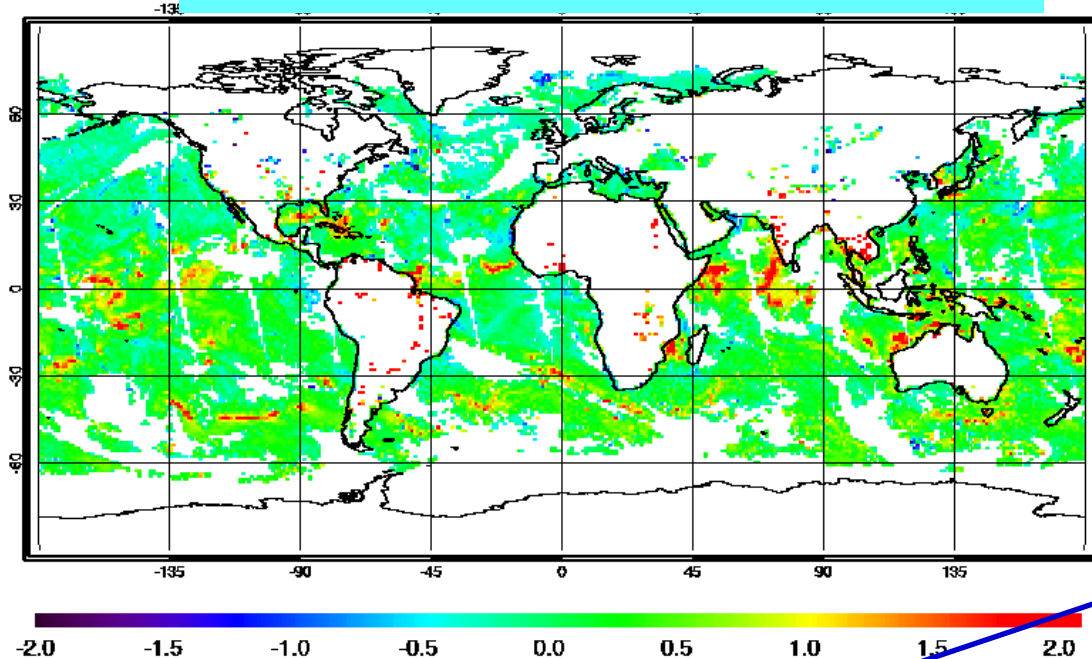
### NPP VIIRS (ACSPO) – CMC L4

SST-CMC(opr), 20151029



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

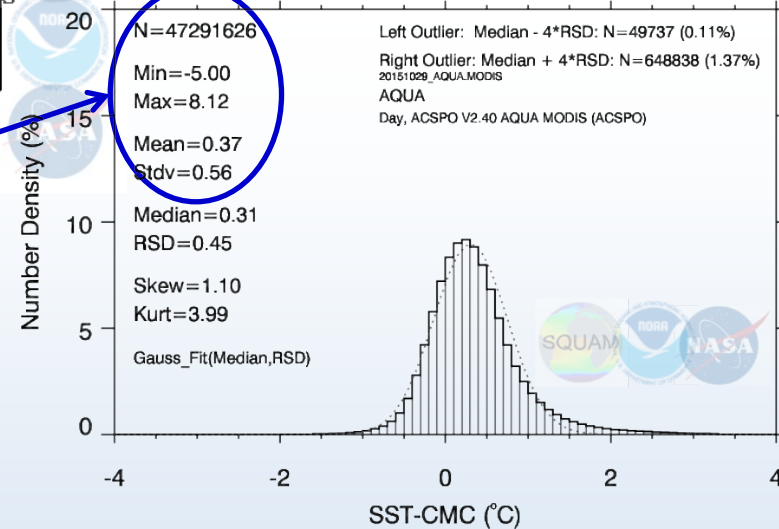
## AQUA MODIS (ACSP0, day) – CMC L4



## NPP VIIRS & AQUA MODIS (ACSP0)

### AQUA MODIS (ACSP0) – CMC L4

SST-CMC(opr), 20151029



*In ACSP0 MODIS SST product, there are a factor of 2.7 fewer valid SST pixels compared to VIIRS, and its performance is slightly degraded*



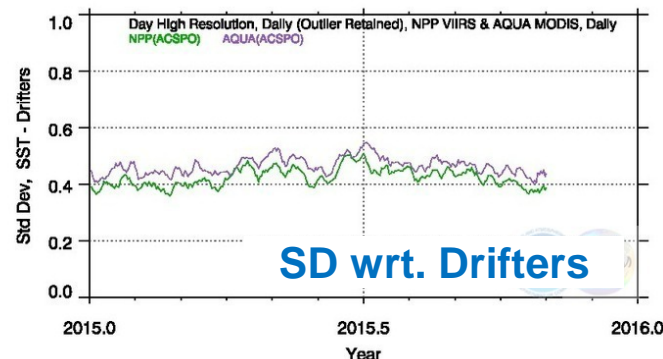
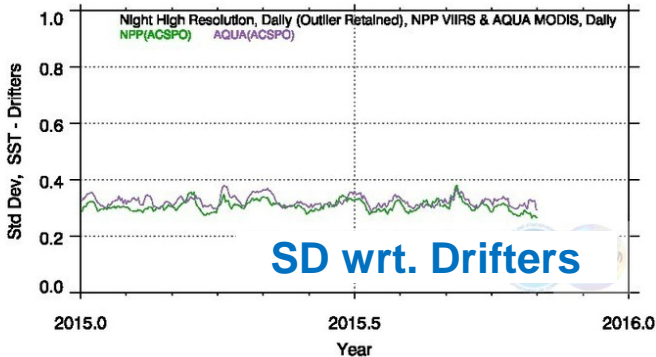
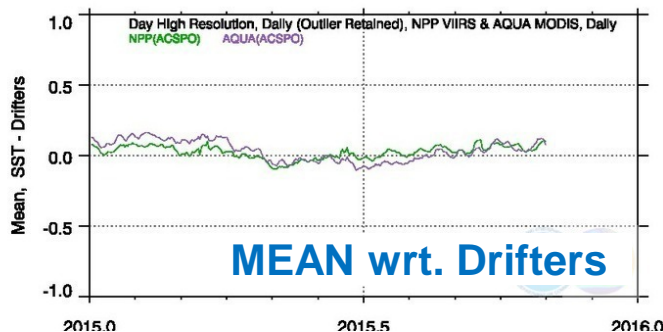
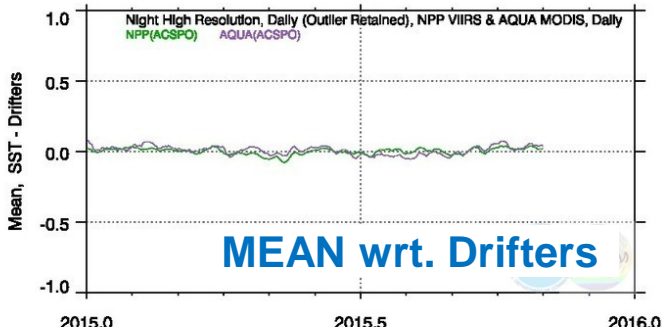
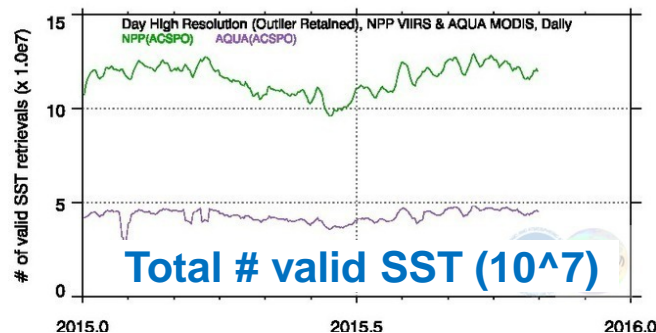
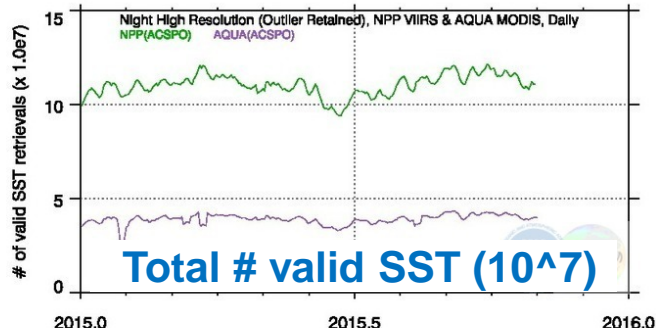
# Time series of S-NPP VIIRS & Aqua MODIS SSTs



Maps   Histograms   **Time-series**   Dependencies   Hovmöller

## NIGHT (daily)

## DAY (daily)



Comparable performances for ACSP0 VIIRS & MODIS

MODIS: less # of obs and slightly degraded SST stats

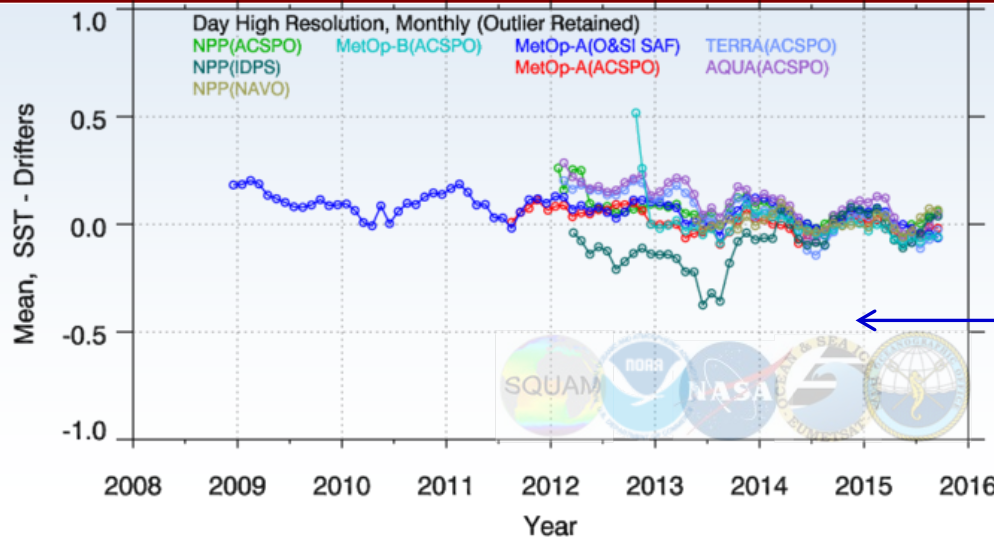
AQUA and NPP fly close orbits. NPP provides larger coverage; Aqua provides longer history. Currently, ACSP0 MODIS is experimental, but if of interest to users, we will consider making it operational in GDS2 format

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

# All SST products in HR-SQUAM



Maps Histograms **Time-series** Dependencies Hovmöller

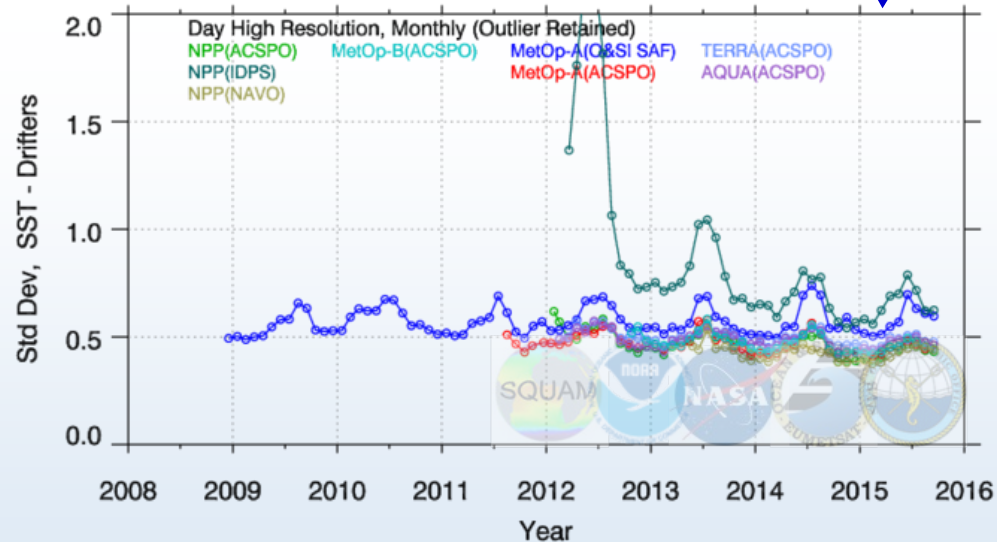


Monthly validation of 8 different hi-res SST products in HR-SQUAM (against QC'ed drifters from NOAA iQuam)

Mean (day)

Std Dev (day)

Other stat parameters and interactive plots are also available (see demo)

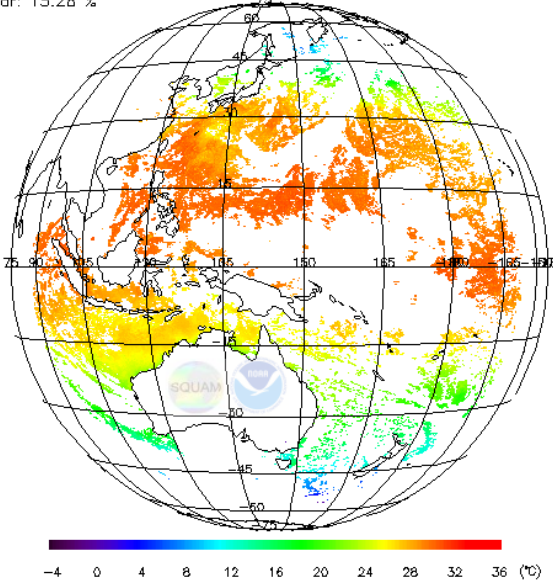


# ***L2-SQUAM (GEO) new***

[www.star.nesdis.noaa.gov/sod/sst/squam/GEO/](http://www.star.nesdis.noaa.gov/sod/sst/squam/GEO/)

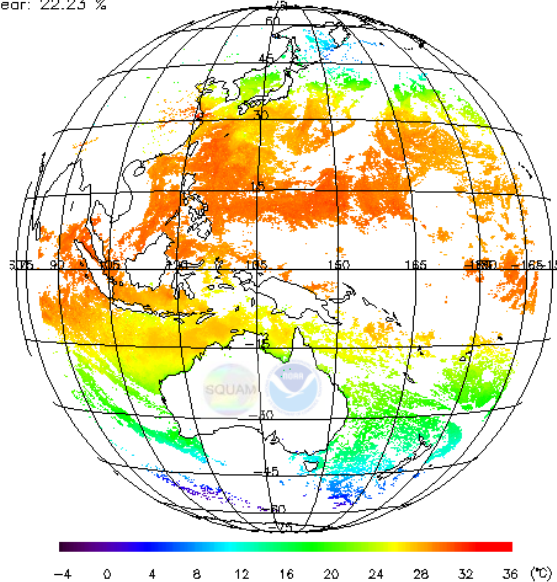
- Himawari-7 (MTSAT-2) and Himawari-8 AHI (ACSPPO and JAXA)
- Work in progress (preliminary results)

Skin SST (SSES bias applied), Himawari-7 Imager (OSPO),v02.0,2015072  
Clear: 15.28 %



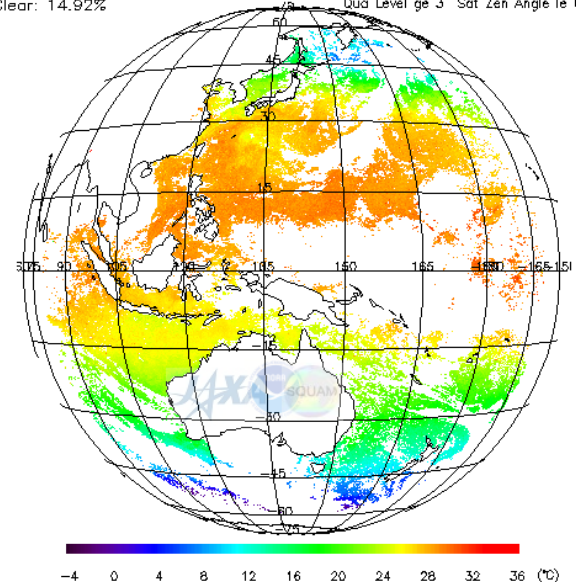
**Himawari-7/MTSAT2 (NOAA OSPO)**  
Clear sky coverage = 15.3%  
(Probabilistic cloud determination - Bayesian)

Regression SST, Himawari-8 AHI (ACSP0),v2.41b02,201507281530  
Clear: 22.23 %



**Himawari 8 (NOAA ACSP0)**  
Clear sky coverage = 22.2%  
(ACSP0 Clear-Sky Mask, Petrenko et al., JTech, 2010)

Skin SST, Himawari-8 AHI (JAXA),v1.0-v02.0-fv01.0,201507281530  
Clear: 14.92%  
Dua Level ge 3 Sat Zen Angle le 67



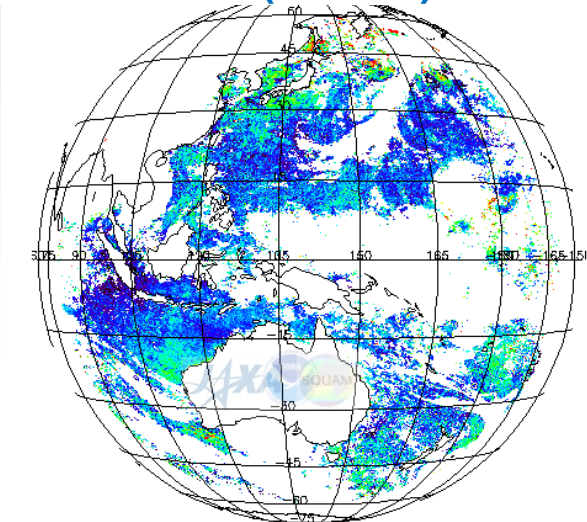
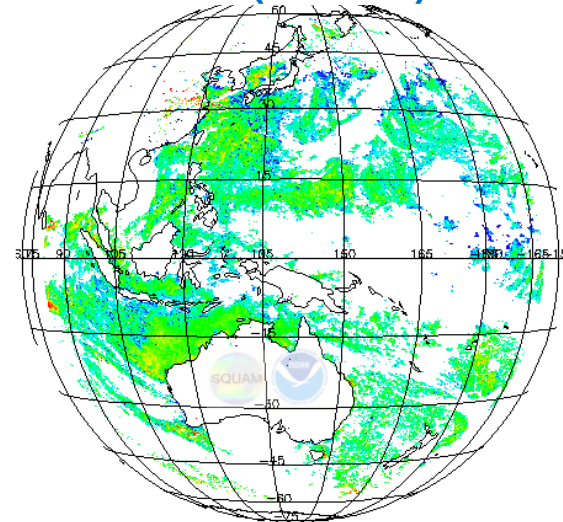
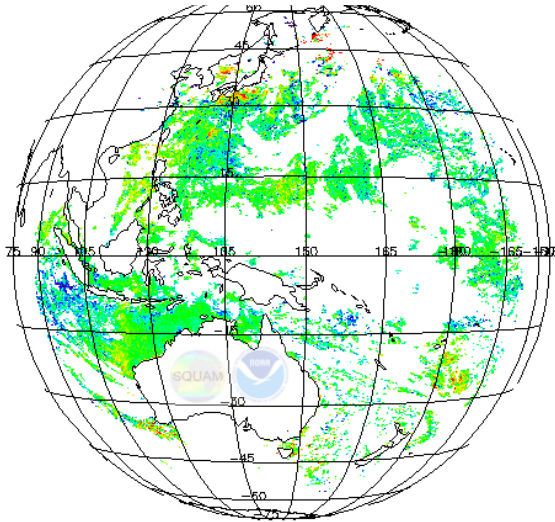
**Himawari 8 (JAXA)**  
Clear sky coverage = 14.9%  
(Bayesian cloud mask; see Yukio's talk for more info)

**SST maps are useful to check for coverage and large image quality issues.  
For product performance, SQUAM checks the residuals wrt. L4s**

## MTSAT 2 - CMC

## Himawari-8 (ACSP0) - CMC

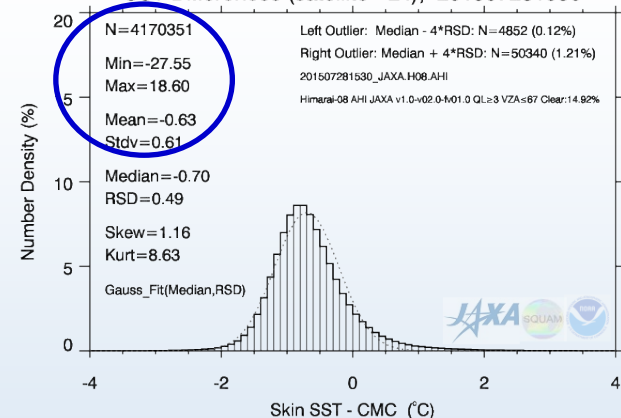
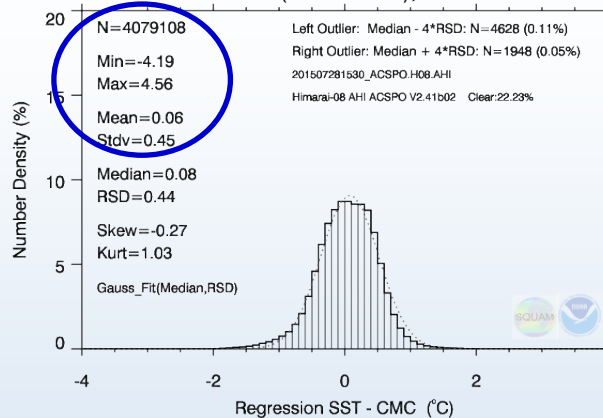
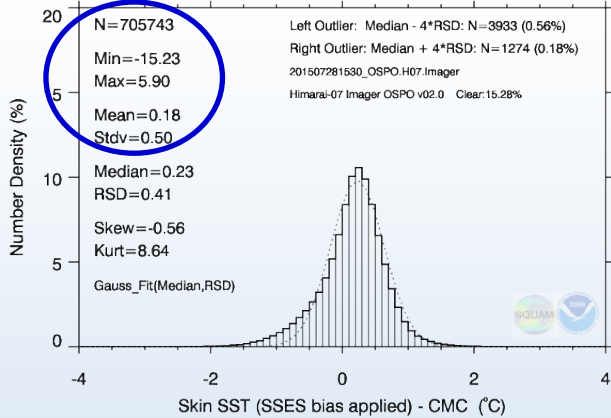
## Himawari-8 (JAXA\*\*) - CMC



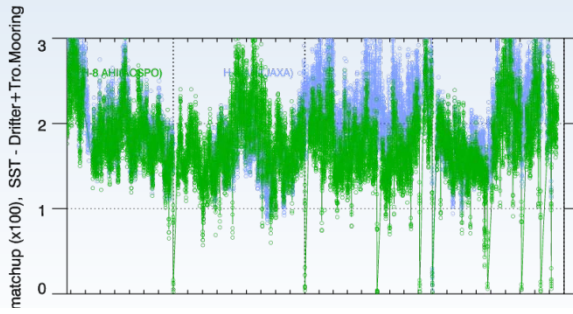
SST Differences (satellite - L4), 201507281532

SST Differences (satellite - L4), 201507281530

SST Differences (satellite - L4), 201507281530

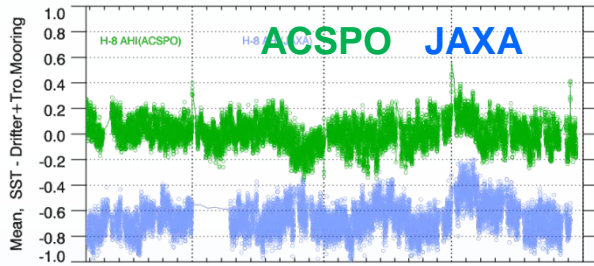


Total # matches



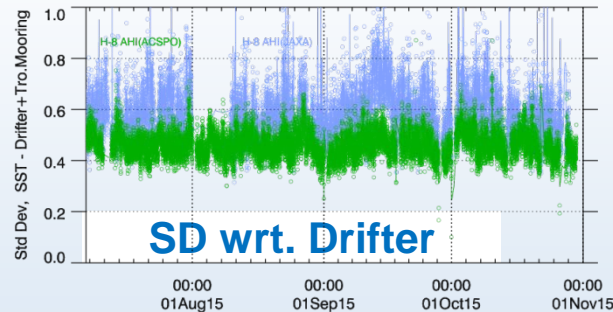
Validation of GEO SSTs wrt Drifters + Tropical moorings (from *i*Quam)

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 ACSP0 AHI SST but somewhat noisier.

# L4-SQUAM

[www.star.nesdis.noaa.gov/sod/sst/squam/L4/](http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/)

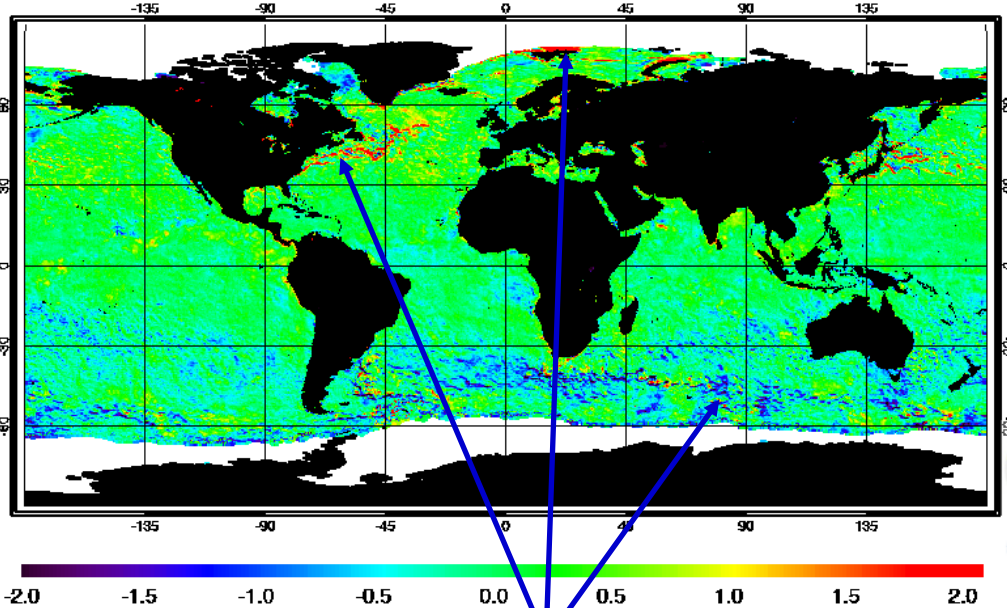
- Inter-compare ~15 L4 SSTs (Maps, Histograms, time series ...)
- Validate consistently against QCed *in situ* data

# Level-4(L4) SQUAM



Maps Histograms Time-series Hovmöller

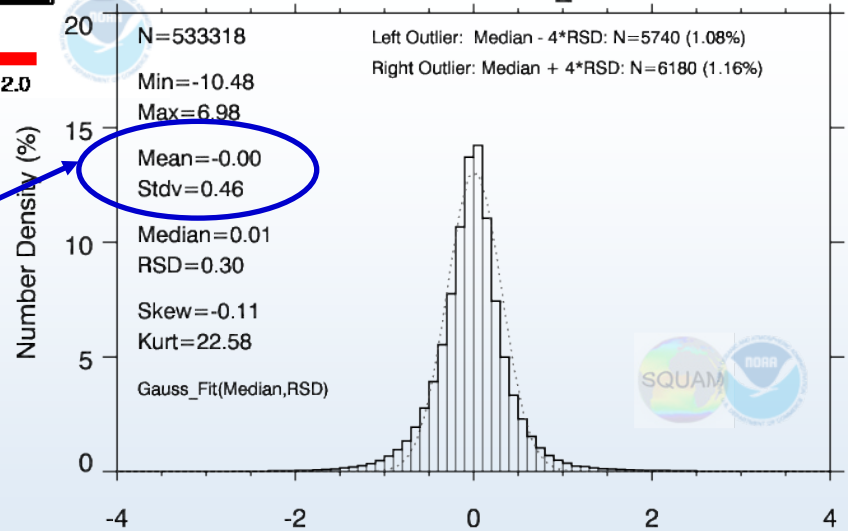
CMC 0.2° GDS2.0 - GAMSSA\_28km, 20151031



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*

CMC 0.2° GDS2.0 - GAMSSA\_28km, 20151031

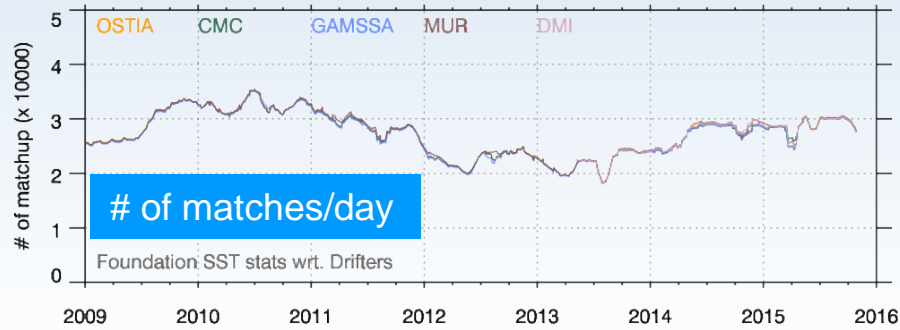




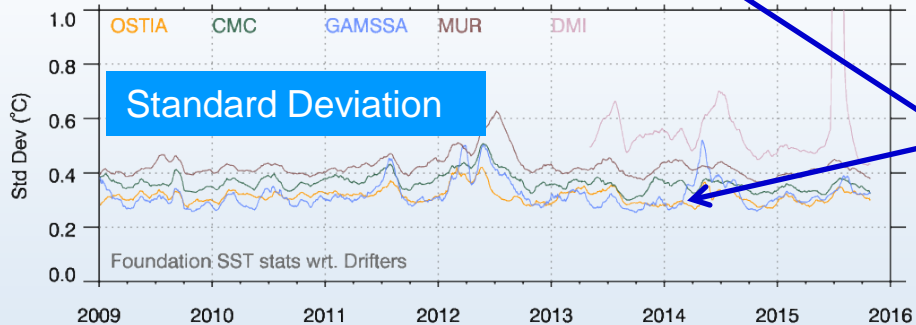
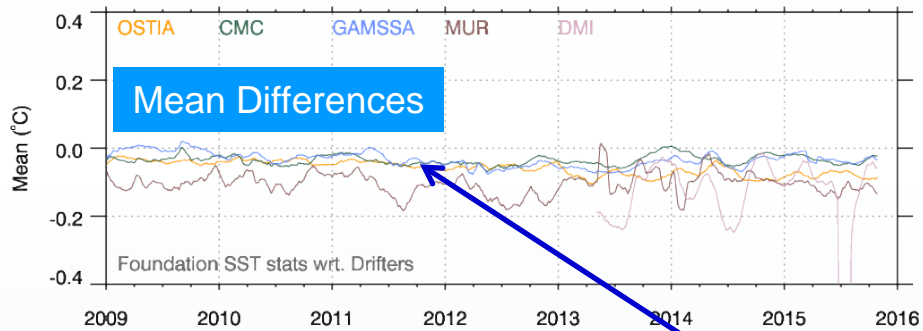
# Level-4(L4) SQUAM



Maps Histograms **Time-series** Hovmöller



**Validation of L4 Foundation SSTs wrt. iQuam drifters**



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

- ❑ SQUAM currently monitors major global polar L2/3 SST products from VIIRS, MODIS, and AVHRR, and >14 L4 SST products
- ❑ ACSP0 VIIRS products have been generated since Jan 2012 and monitored in SQUAM. Data are available in GDS2.0 format from NCEI and PO.DAAC
- ❑ Aqua overpass time is close to that of S-NPP. MODIS SST is slightly inferior to that of VIIRS, but time series goes back to 2002. Users interested in ACSP0 MODIS SST, please contact [Alex.Ignatov@noaa.gov](mailto:Alex.Ignatov@noaa.gov)
- ❑ Recently, a GEO SQUAM module was developed. Himawari-7 (aka MTSAT-2; NOAA heritage product), Himawari-8 (new NOAA ACSP0 product), and Himawari-8 (JAXA product) are included. The results are preliminary but show SQUAM potential in sustained monitoring of these products
- ❑ Potential future data additions in SQUAM
  - ABoM Himawari-8 AHI
  - IASI (onboard Metop-A and B)
  - Sentinel-3 SLSTR

## Thank You!