NOAA SST Quality Monitor (SQUAM)
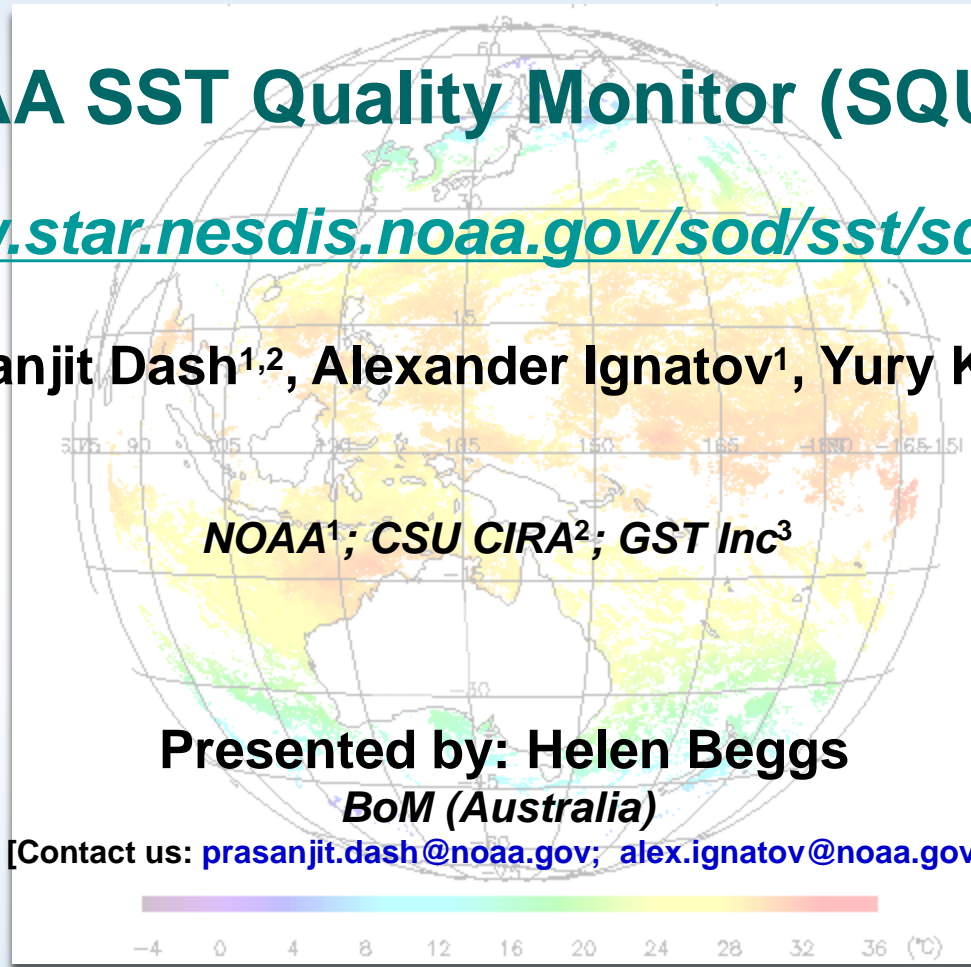
www.star.nesdis.noaa.gov/sod/sst/squam/

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NOAA[1]; CSU CIRA[2]; GST Inc[3]

Presented by: Helen Beggs

BoM (Australia)

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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*

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*

GHRSST support: Peter Minnett, Craig Donlon, Alexey Kaplan

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

Major SST data providers:

Projects and international groups

CMC

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)

SST community is data rich!
Now, how different product perform & compare?

SST Quality Monitor (SQUAM)

- **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)

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, focus is on HR products

NPP VIIRS (ACSPO, day) – CMC L4
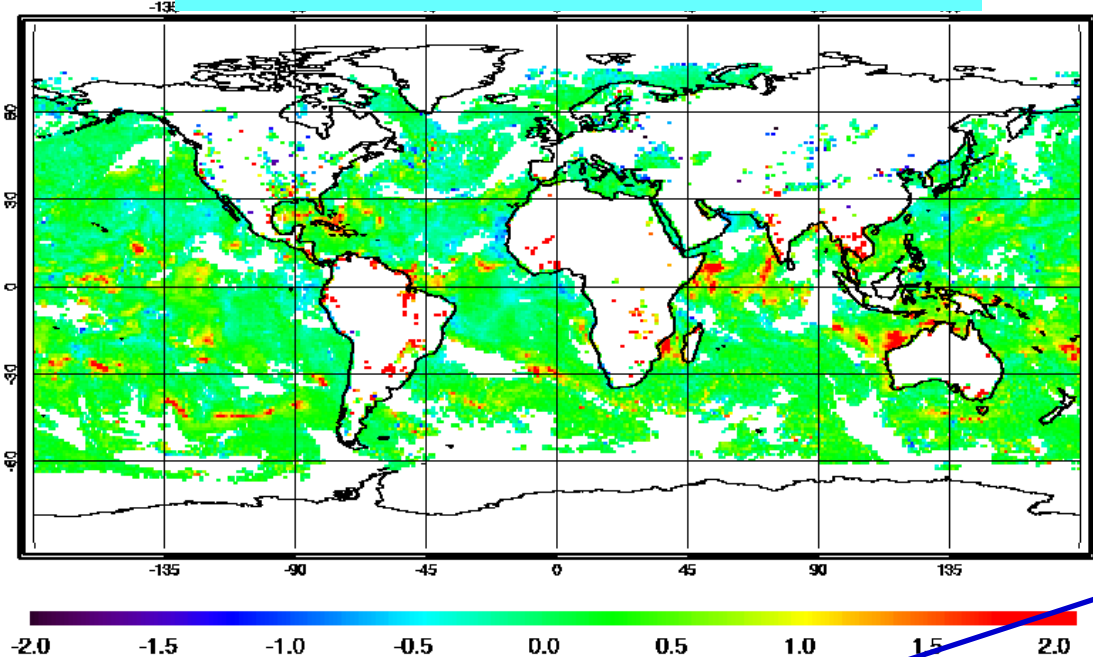
NPP VIIRS & AQUA MODIS (ACSPO)

NPP VIIRS (ACSPO) – CMC L4

SST-CMC(opr), 20151029

N=126741895

Min=-4.43
Max=8.49

Mean=0.33
Stdv=0.52

Median=0.27
RSD=0.40

Skew=1.29
Kurt=5.18

Gauss_Fit(Median,RSD)

Left Outlier: Median - 4*RSD: N=152352 (0.12%)
Right Outlier: Median + 4*RSD: N=2010213 (1.59%)
20151029_NSS.VIIRS

Day, ACSPO V2.40 VIIRS (NESDIS)
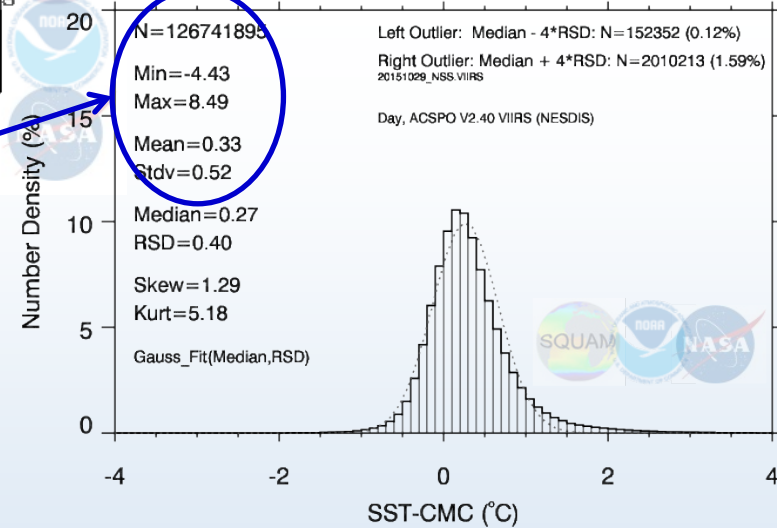
Maps used to check coverage & global product performance (cold – cloud/aerosol leakages, warm – diurnal warming)

ACSPO Aqua MODIS SST in HR-SQUAM
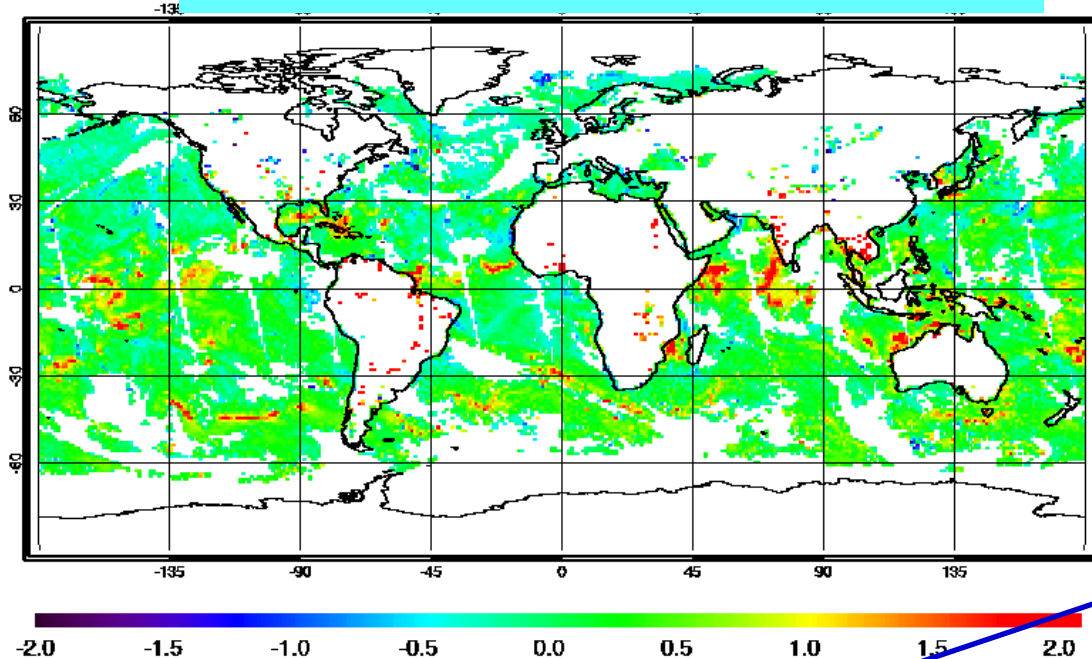
AQUA MODIS (ACSPO, day) – CMC L4

NPP VIIRS &
AQUA MODIS
(ACSPO)

AQUA MODIS (ACSPO) – CMC L4

SST-CMC(opr), 20151029

N=47291626

Min=-5.00
Max=8.12

Mean=0.37
Stdv=0.56

Median=0.31
RSD=0.45

Skew=1.10
Kurt=3.99

Gauss_Fit(Median,RSD)

Left Outlier: Median - 4*RSD: N=49737 (0.11%)
Right Outlier: Median + 4*RSD: N=648838 (1.37%)
20151029_AQUA.MODIS
AQUA
Day, ACSPO V2.40 AQUA MODIS (ACSPO)
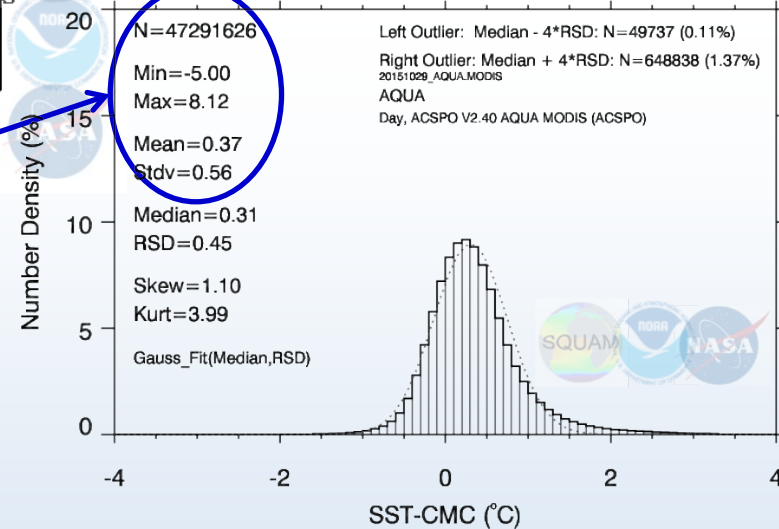
In ACSPO MODIS SST product, there are a factor of 2.7 fewer valid SST pixels compared to VIIRS, and its performance is slightly degraded

Time series of S-NPP VIIRS & Aqua MODIS SSTs

Maps   Histograms   **Time-series**   Dependencies   Hovmöller

NIGHT (daily)

DAY (daily)
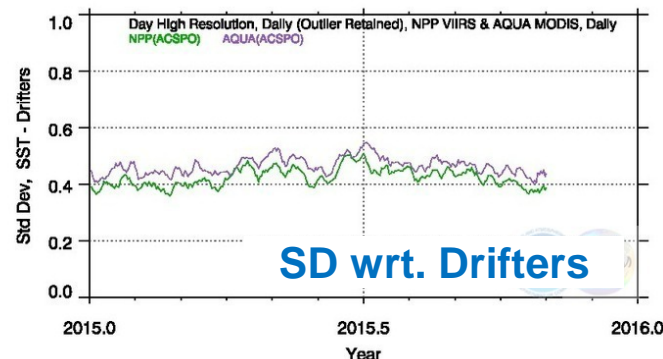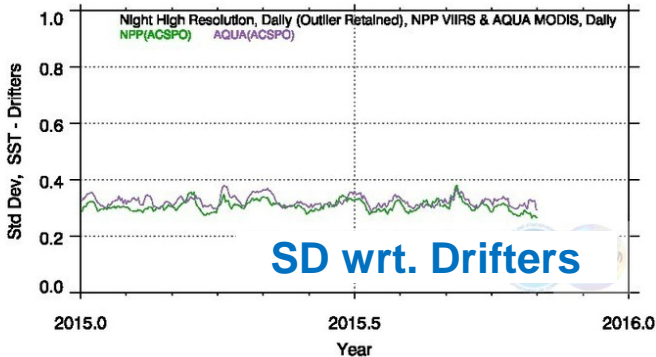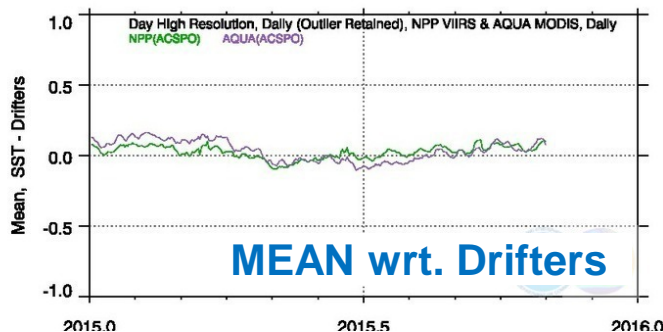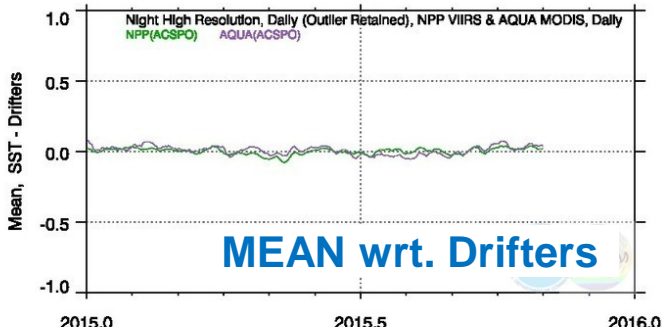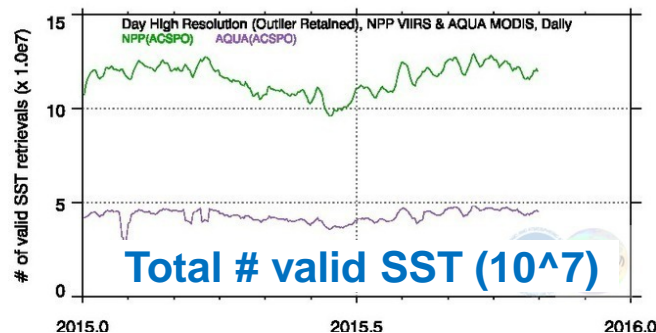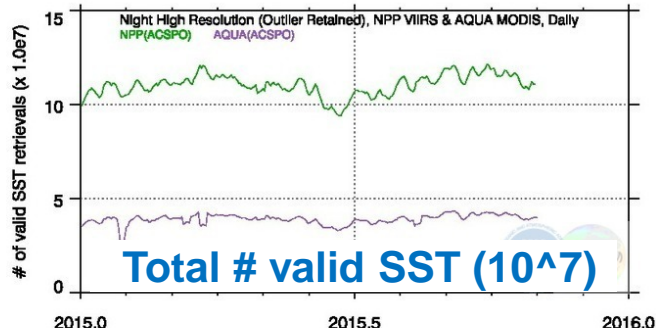
Comparable performances for ACSPO VIIRS & MODIS

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 later)

All SST products in HR-SQUAM

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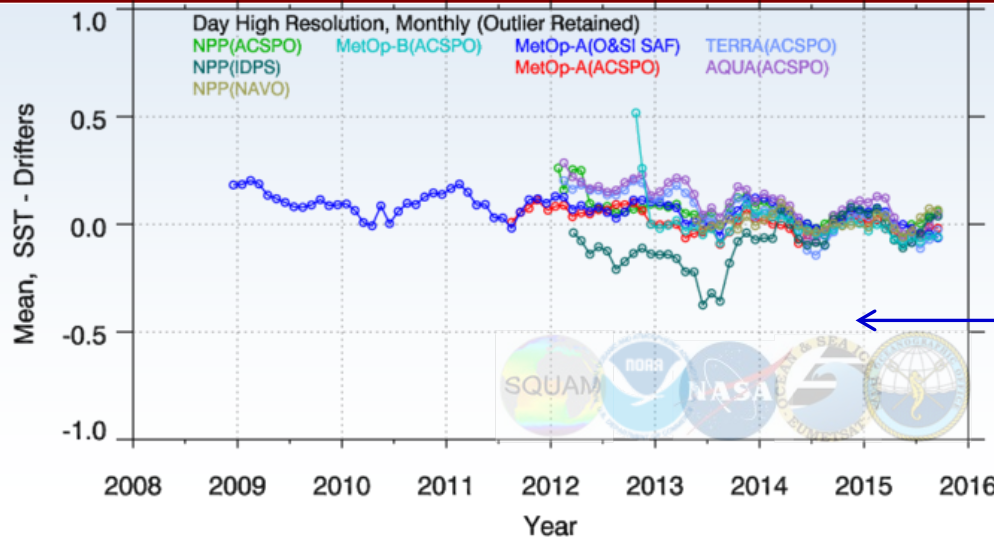
Monthly validation of 8 different hi-res SST products in HR-SQUAM (against QC'ed drifters from NOAA *i*Quam)

Mean (day)

Std Dev (day)

Other stat parameters and interactive plots are also available (see demo)
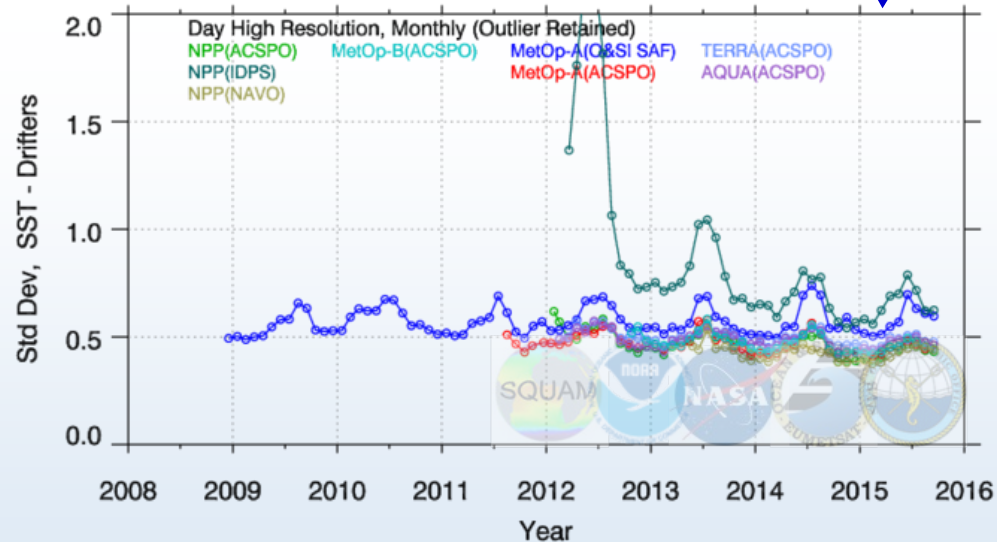
L2-SQUAM (GEO) new

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

- Himawari-7 (MTSAT-2) and Himawari-8 AHI (ACSPO and JAXA)

- Work in progress (preliminary results)

GEO-SQUAM
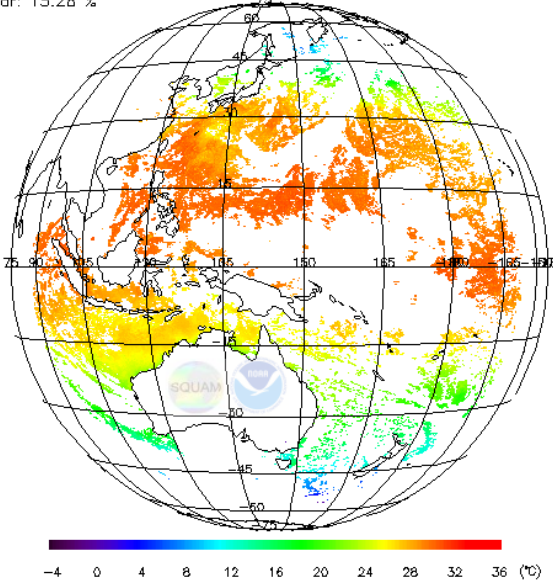
Himawari-7/MTSAT2 (NOAA OSPO)

Clear sky coverage = 15.3%

(Probabilistic cloud determination - Bayesian)
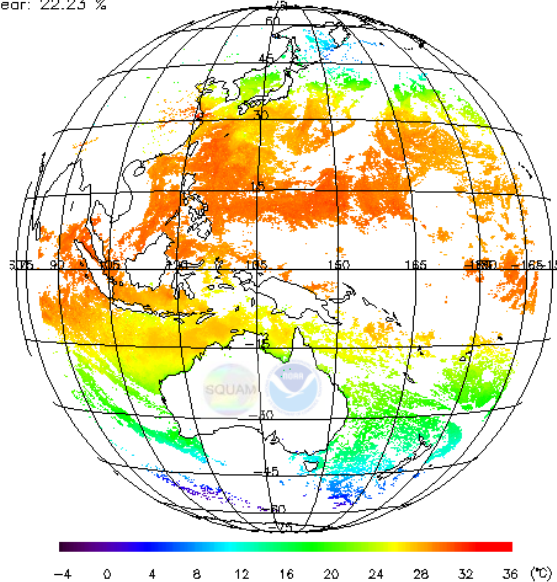
Himawari 8 (NOAA ACSPO)

Clear sky coverage = 22.2%

(ACSPO Clear-Sky Mask, Petrenko et al., JTech, 2010)
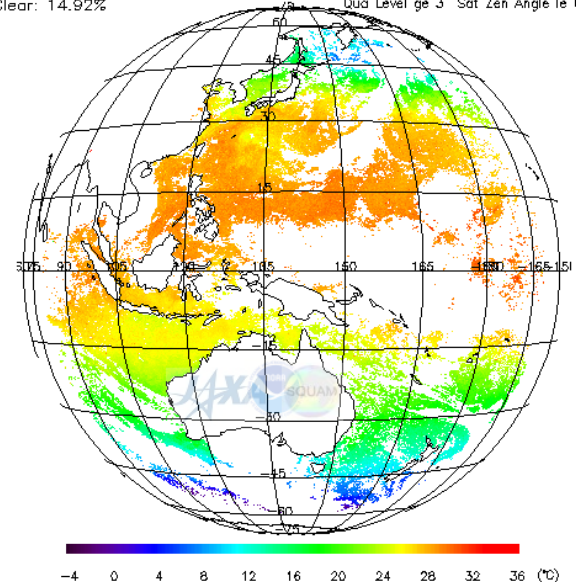
Himawari 8 (JAXA)

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

GEO-SQUAM

MTSAT 2 - CMC   **Himawari-8 (ACSPO) - CMC**   **Himawari-8 (JAXA**) - CMC**
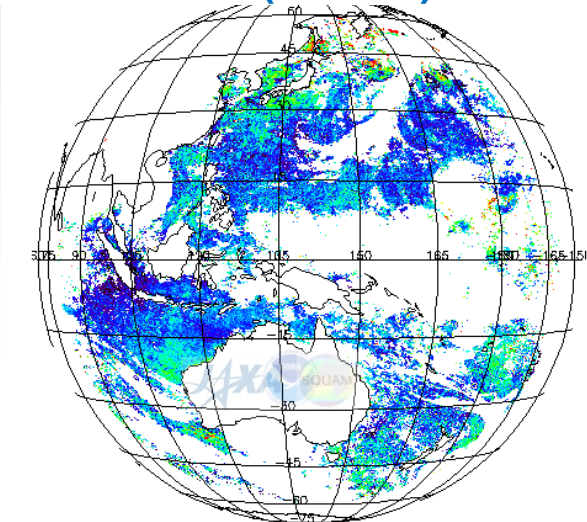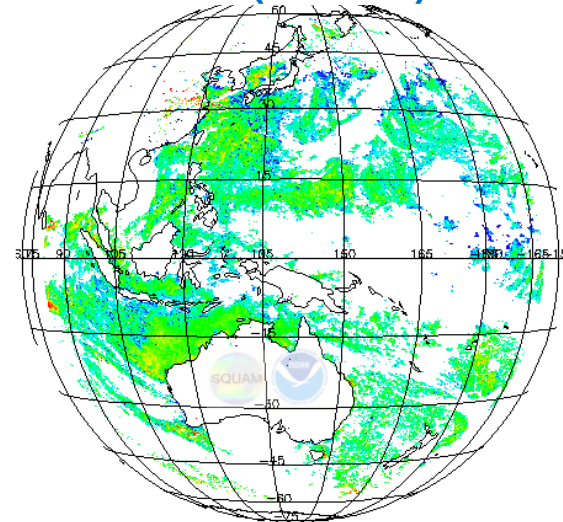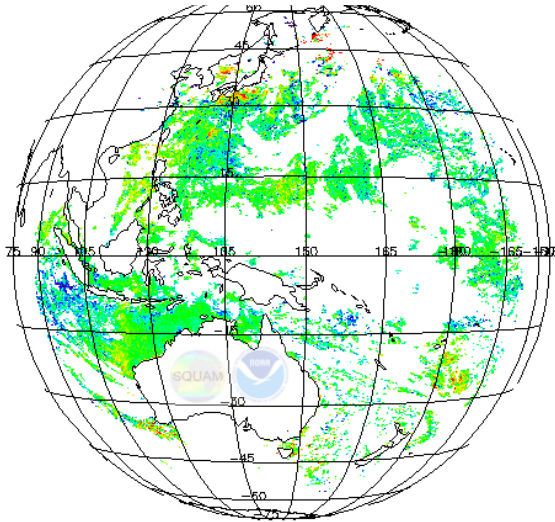
**Please note that JAXA results are preliminary, work is underway with Yukio to resolve
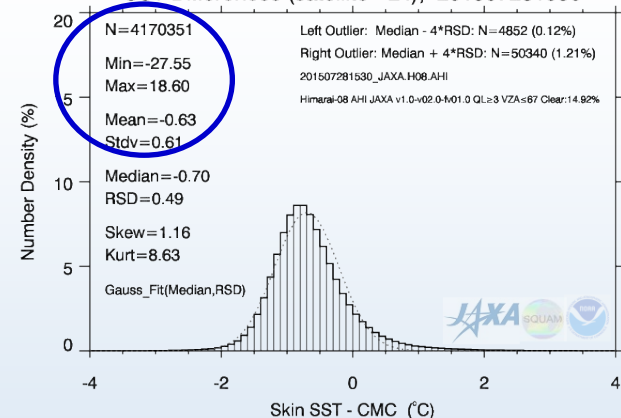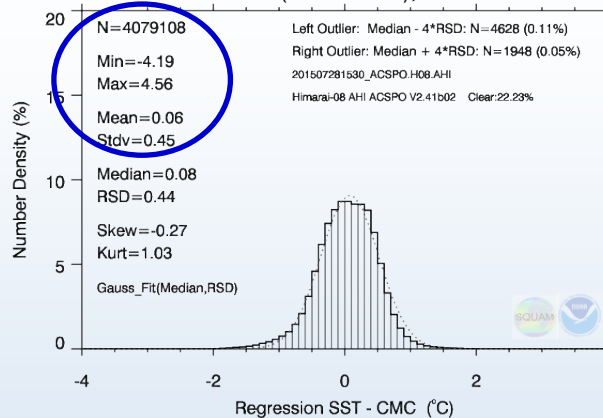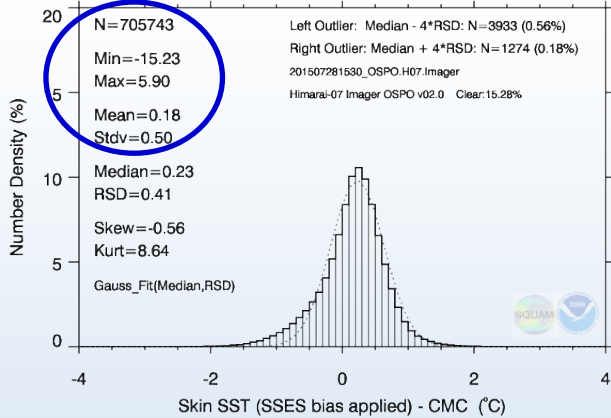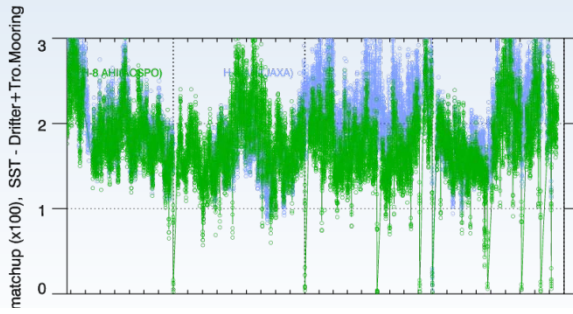
Validation of GEO SSTs wrt Drifters + Tropical moorings (from *i*Quam)

Total # matches

Mean

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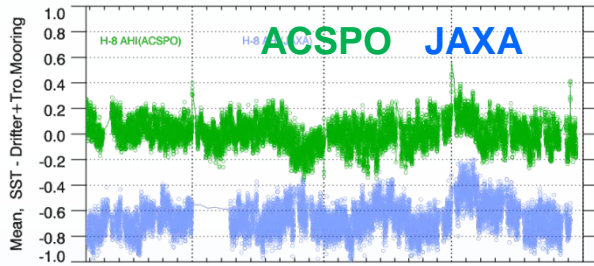
Persistent cold bias observed in JAXA AHI SST against *in situ* data (same as against CMC).

Std Dev

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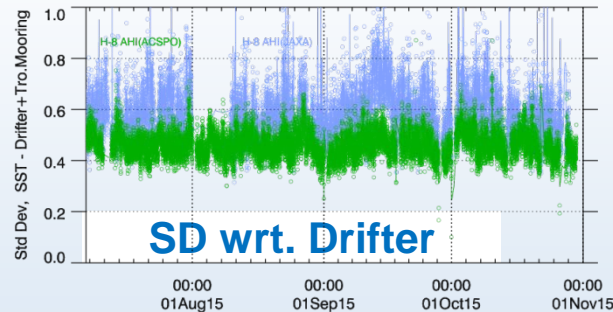
Standard deviation of JAXA SST is comparable to that of ACSPO AHI SST but somewhat noisier.

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

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

N=533318

Left Outlier: Median - 4*RSD: N=5740 (1.08%)
Right Outlier: Median + 4*RSD: N=6180 (1.16%)

Min=-10.48
Max=6.98

Mean=-0.00
Stdv=0.46

Median=0.01
RSD=0.30

Skew=-0.11
Kurt=22.58

Gauss_Fit(Median,RSD)

CMC - GAMSSA (°C)
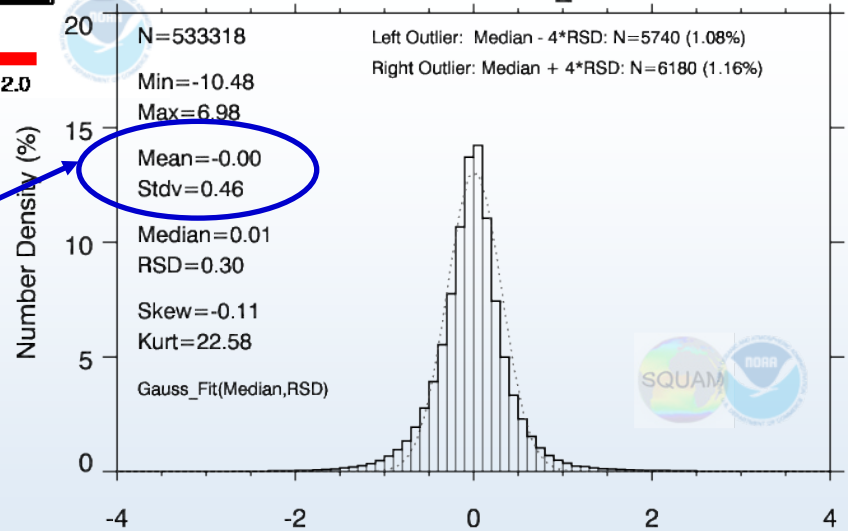
Level-4(L4) SQUAM

Maps   Histograms   **Time-series**   Hovmöller

# of matches/day

Mean Differences

Standard Deviation
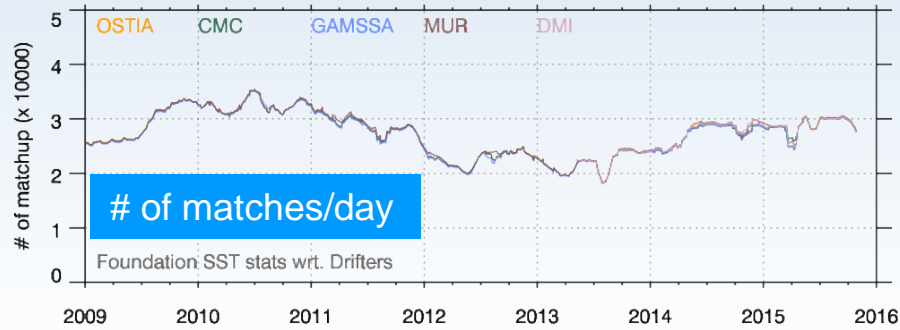
Validation of L4 Foundation SSTs wrt. *i*Quam drifters
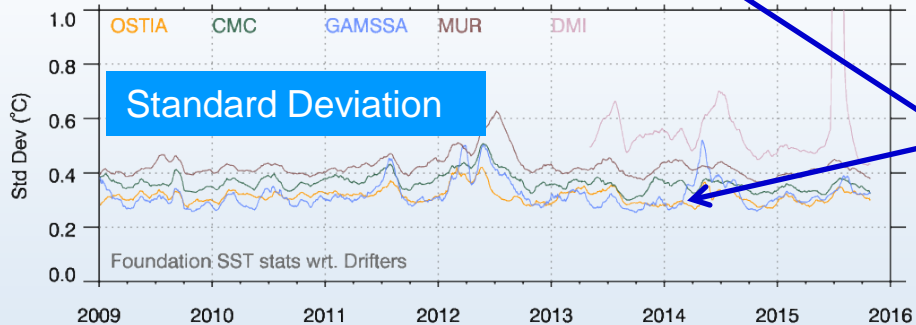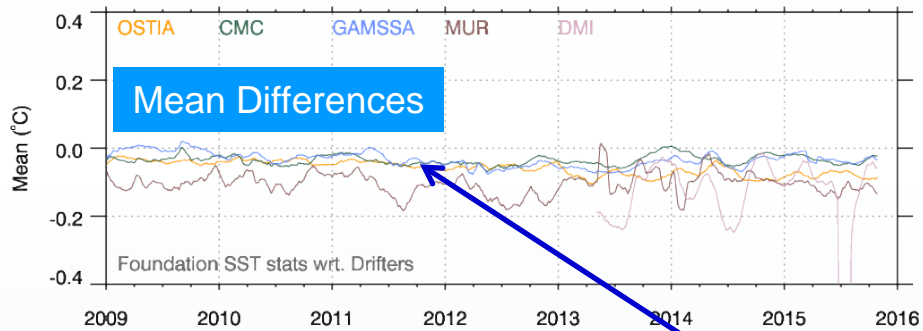
Globally, GAMSSA and OSTIA closely track each other in terms of Mean Differences and Standard Deviation (note that drifters are assimilated in both)

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

- [ ] 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 ACSPO MODIS SST, please contact Alex.Ignatov@noaa.gov

- [ ] 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

- [ ] Potential future data additions in SQUAM
  - ABoM Himawari-8 AHI
  - IASI (onboard Metop-A and B)
  - Sentinel-3 SLSTR

Thank You!