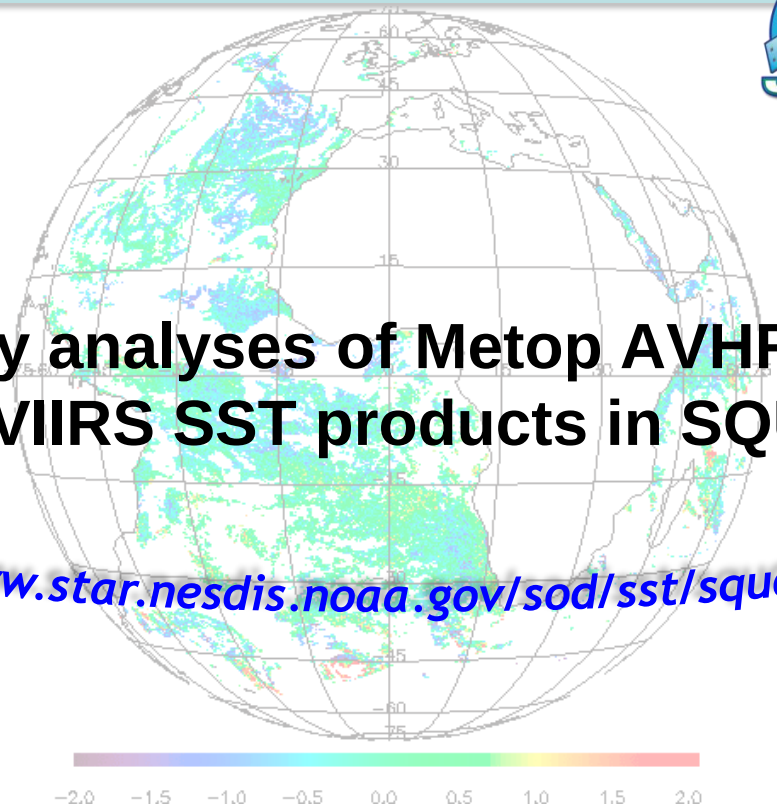
GHRSST 2013 Annual Meeting
17–21 June, 2013, Woods Hole, MA

Preliminary analyses of Metop AVHRR, MODIS and VIIRS SST products in SQUAM



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

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SQUAM objective: A global, web-based, community, quasi NRT, monitor for SST producers & users !

Contributions/Support

Level-2 SST: VIIRS/AVHRR/MODIS

- NESDIS SST Team : *ACSPO (GAC: 5 platforms, FRAC: Metop-A & B, VIIRS: NPP, MODIS: Terra/Aqua)*
- P. LeBorgne, H. Roquet : *O&SI SAF Metop-A FRAC*
- D. May, B. McKenzie : *NAVO SEATEMP*
- S. Jackson : *IDPS (NPP)*

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

- K. Casey, R. Evans, J. Vazquez, E. Armstrong: *PathFinder v5.0*
- C. Merchant: *ARC (ongoing effort – next meeting)*

Level 4 SSTs:

- R. Grumbine, B. Katz : *RTG (Low-Res & Hi-Res)*
- R. Reynolds, V. Banzon : *OISSTs (AVHRR & AVHRR+AMSRE)*
- M. Martin, J. R. Jones : *OSTIA foundation, GHRSST Median Product Ensemble, OSTIA Reanalysis*
- D. May, B. McKenzie : *NAVO K10*
- J.-F. Piollé, E. Autret : *ODYSSEA*
- E. Maturi, A. Harris, J. Mittaz : *POES-GOES blended*
- B. Brasnett : *Canadian Met. Centre, 0.2° foundation*
- Y. Chao : *JPL G1SST*
- H. Beggs : *ABOM GAMSSA*
- M. T. Chin, J. Vazquez, E. Armstrong : *JPL MUR*

L4s in SQUAM pipeline:

J. Hoyer: DMI OISST; S. Ishizaki: MGDSST;
C. Gentemann: RSS products; J. Cummings: NCODA

GHRSST support: Craig Donlon, Peter Minnett, Alexey Kaplan

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

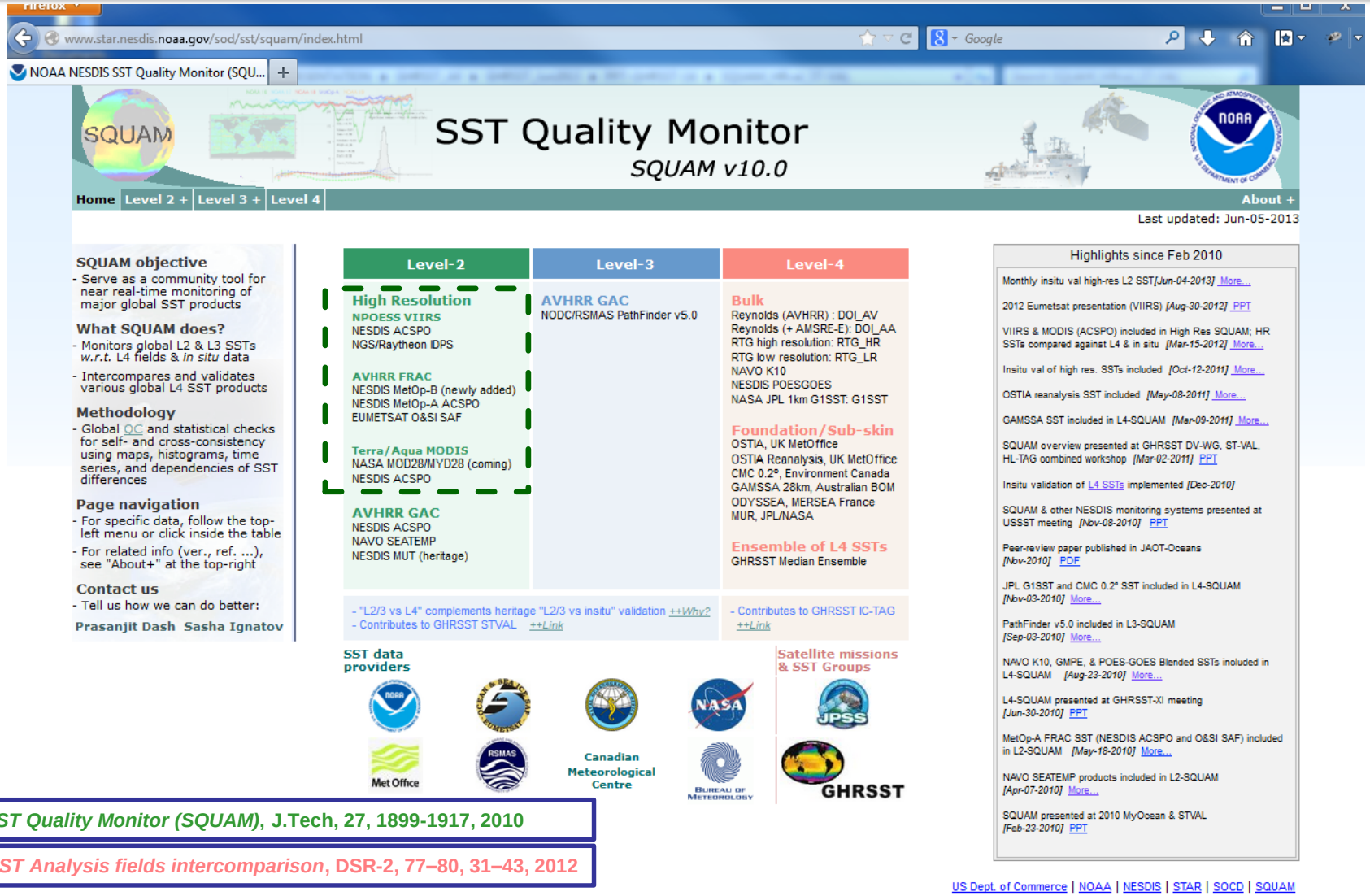
Major SST data providers:

CMC

Projects and international group

SQUAM –Web interface

Locate this website: Google: "SST + SQUAM"



L2: The SST Quality Monitor (SQUAM), J.Tech, 27, 1899-1917, 2010

L4: GHRSST Analysis fields intercomparison, DSR-2, 77–80, 31–43, 2012

Outline

1. What is available in SQUAM ? - brief intro (revisit!); newer products

a) Maps, Histograms, Stat. time-series, Dependence (daily & time-series)

b) Compare monthly stats

[available online, access anytime anywhere and explore!]

2. Case study examples:

2.1. Aggregated (long-term) maps of ΔT_S :

a) Any persistent cloud leakage/algorithm deficiency?

2.2. IDPS VIIRS and ice mask

2.3. WUCD event in VIIRS bands and effect on SST

2.4. Correlation in "independent" L2 SSTs: choose an L4 ref. –

a) Simulated study ***preliminary thoughts***

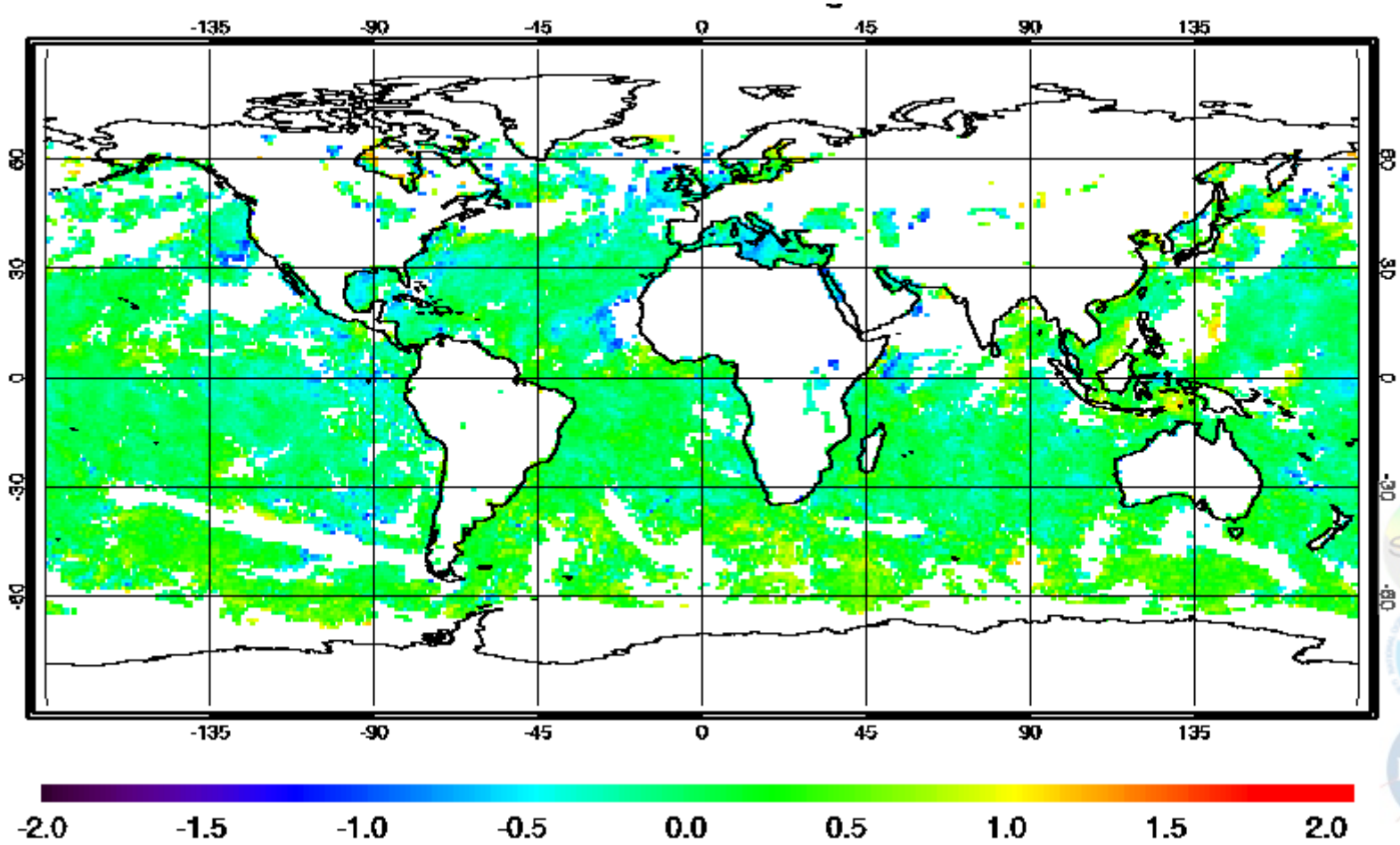
b) Real satellite (T_S) and reference (T_R) fields

3. Summary and future plans

1. SQUAM – modules

Maps | Histograms | Time-series | Dependencies | Hovmöller

Night: Suomi-NPP VIIRS (ACSPO) L2 minus OSTIA L4, 08 Jun 2013

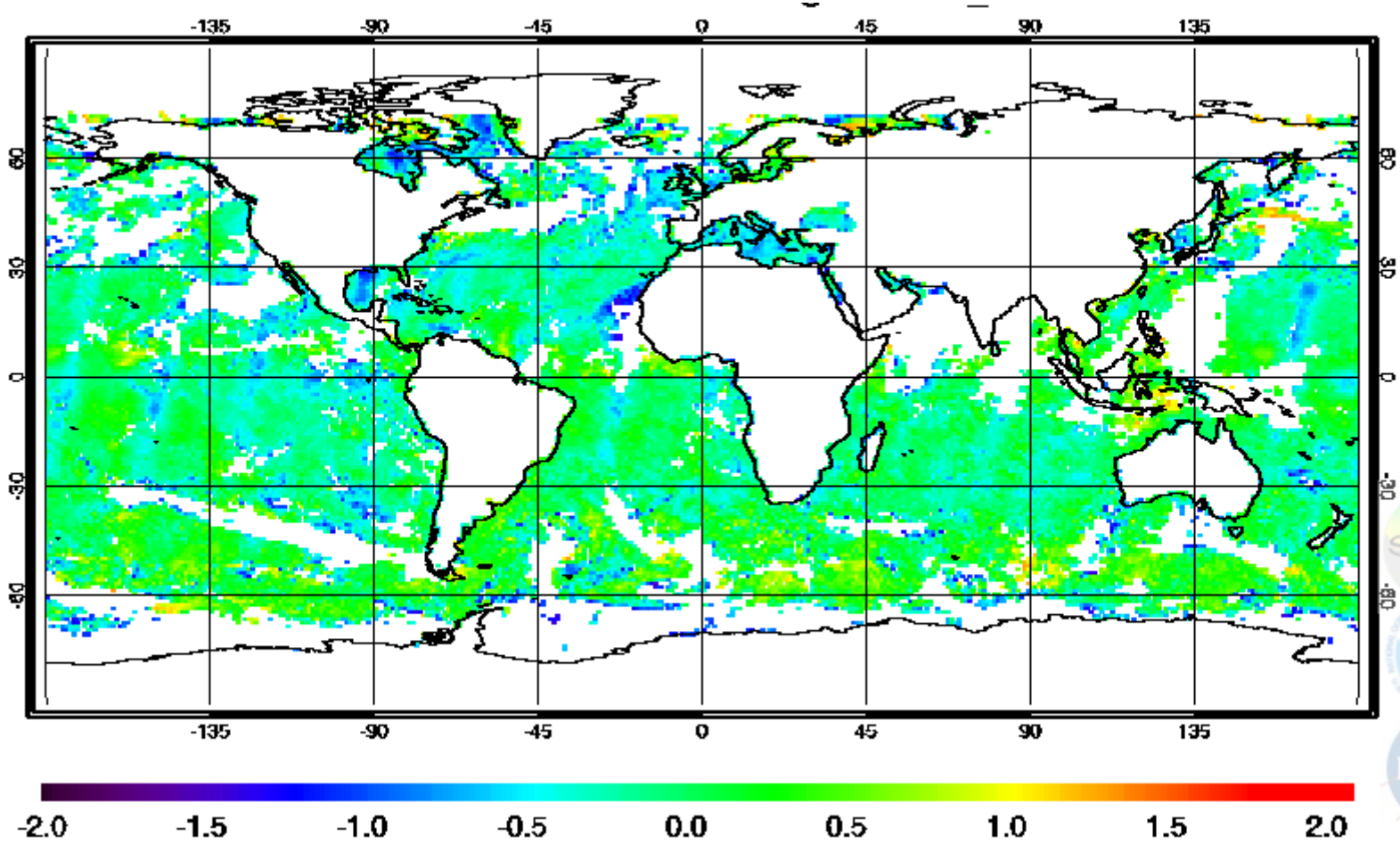


- *Deviation from T_R is flat & close to 0*
- *Residual Cloud/Aerosol leakages seen in the Tropics, mid-latitudes*

1. SQUAM – modules

Maps | Histograms | Time-series | Dependencies | Hovmöller

Night: Suomi-NPP VIIRS (IDPS) L2 minus OSTIA L4, 08 Jun 2013



- *more cloud leakages*
- *limb cooling*

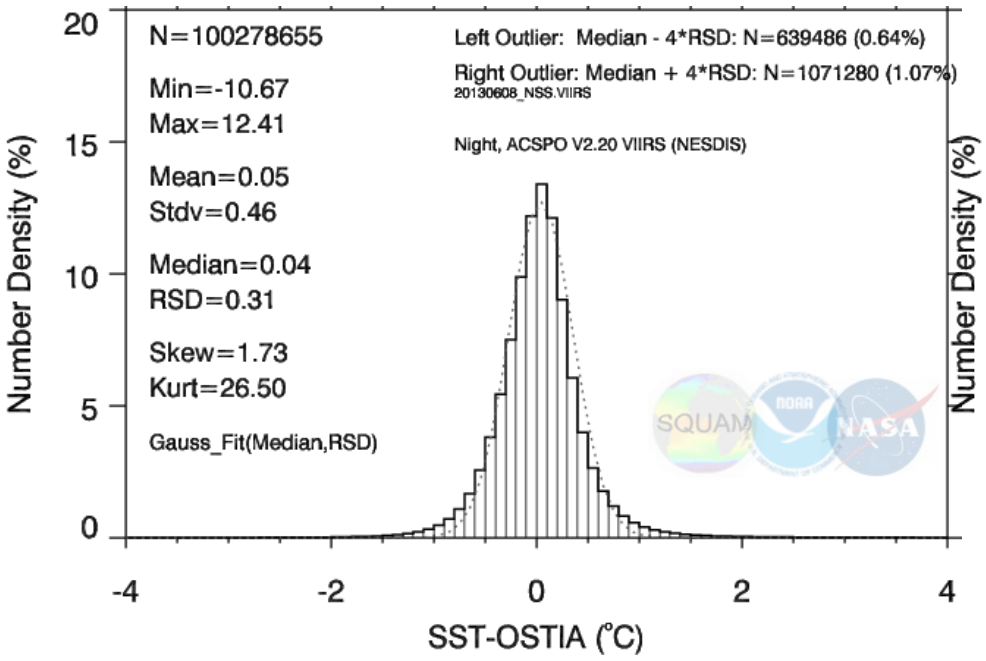
Two processors applied to the same satellite data; More HR Level-2 SST analyses at:
http://www.star.nesdis.noaa.gov/sod/sst/squam/HR/

1. SQUAM – modules

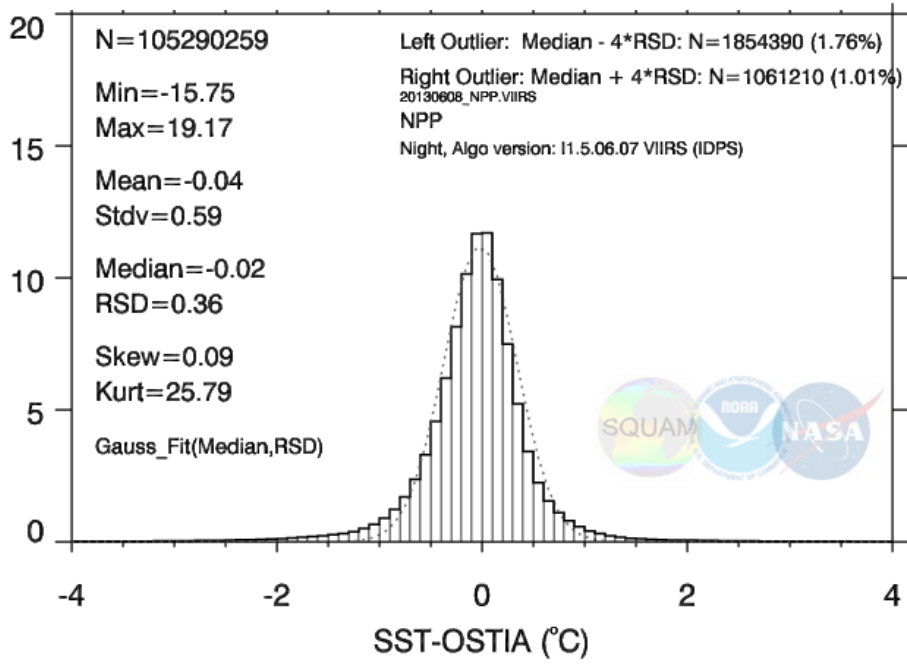
Maps | Histograms | Time-series | Dependencies | Hovmöller

Night 08 June 2013

ACSPO VIIRS minus OSTIA



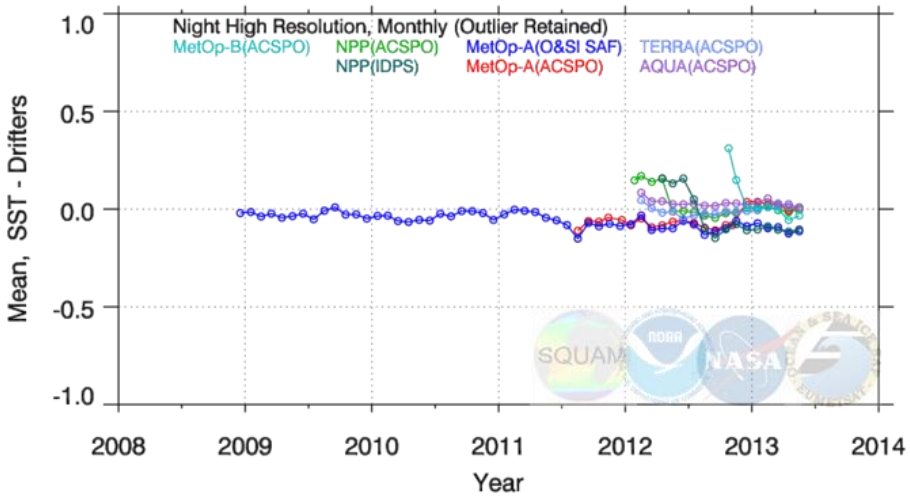
IDPS VIIRS minus OSTIA

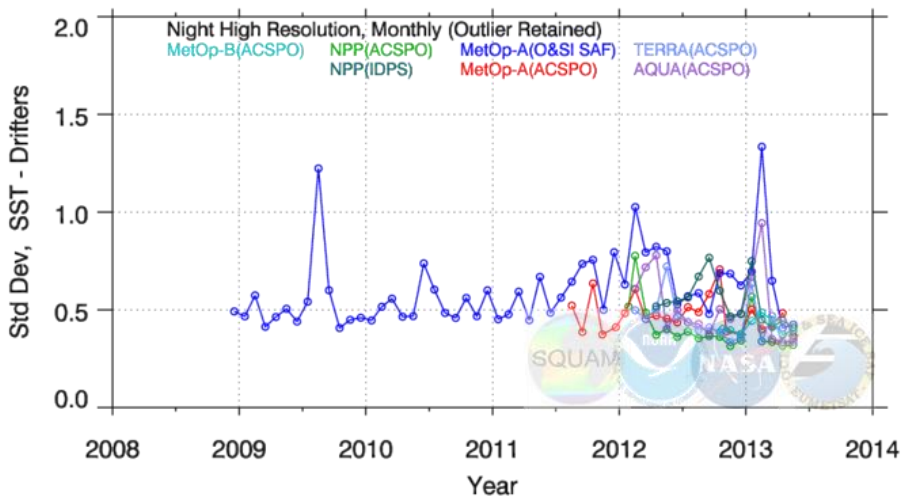


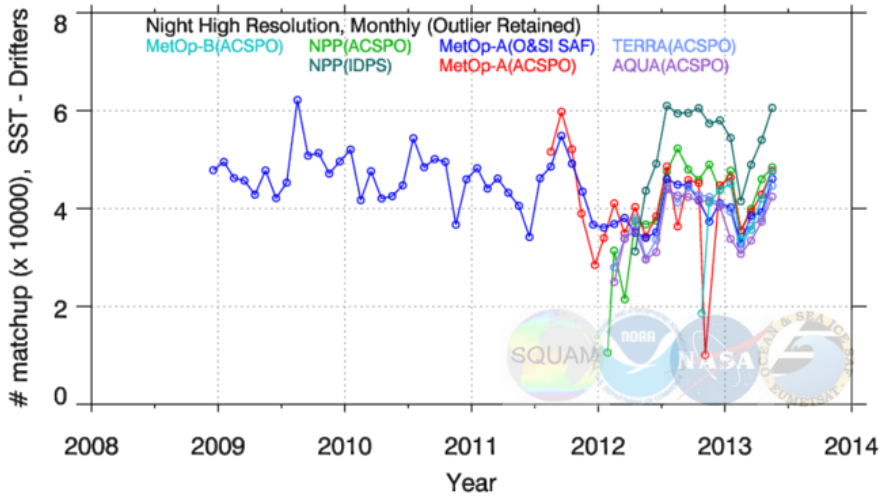
- *Shapes close to Gaussian for both processors*
- *IDPS shows somewhat higher Std Dev for comparable # of obs*
- *Also range (max – min) for IDPS is higher indicating more outliers*
- *Domain performance stat close to expected*

1. SQUAM – modules

Maps | Histograms | Time-series | Dependencies | Hovmöller







<u>Monthly</u> validation wrt. Drifters (night)

a) **OSI SAF and ACSPO Metop-A closely track each other – and ACSPO MODIS**

b) **ACSPO VIIRS is consistent; IDPS VIIRS shows larger variance**

****new functionality**

Outline

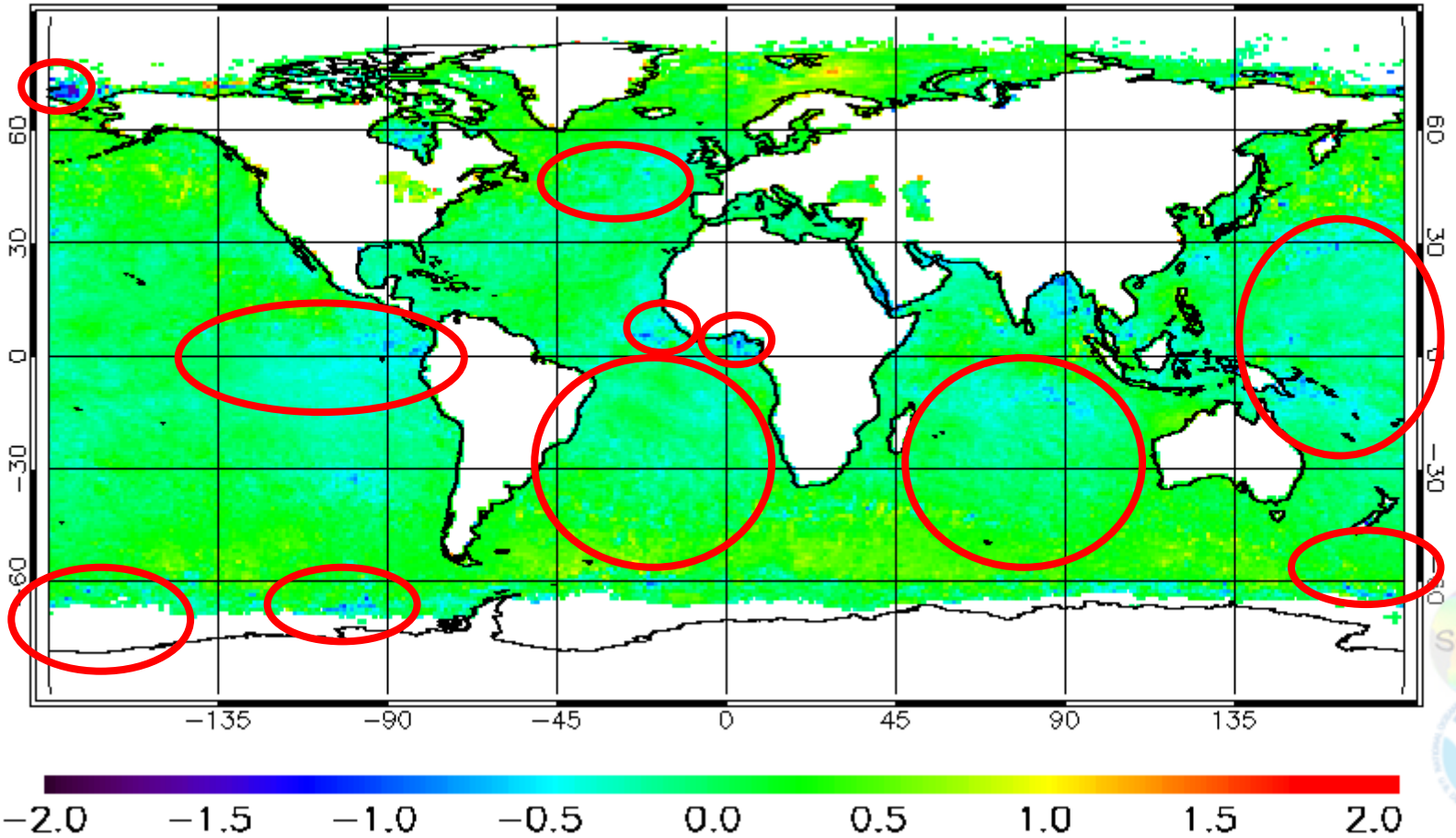
1. What is available in SQUAM ? - brief intro (revisit!); newer products
   a) Maps, Histograms, Stat. time-series, Dependence (daily & time-series)
   b) Compare monthly stats
   [available online, access anytime anywhere and explore!]

2. Case study examples:
   - 2.1. Aggregated (long-term) maps of ΔT_S :
     a) Any persistent cloud leakage/algorithm deficiency?
   - 2.2. IDPS VIIRS ice mask
   - 2.3. WuCd event in VIIRS bands and effect on SST
   - 2.4. Correlation in "independent" L2 SSTs: choose an L4 ref. –
     a) Simulated study
     b) Real satellite (T_S) and reference (T_R) fields

3. Summary and future plans

2.1. Aggregated maps of ΔT_S: Persistent cloud/algorithm deficiency ?

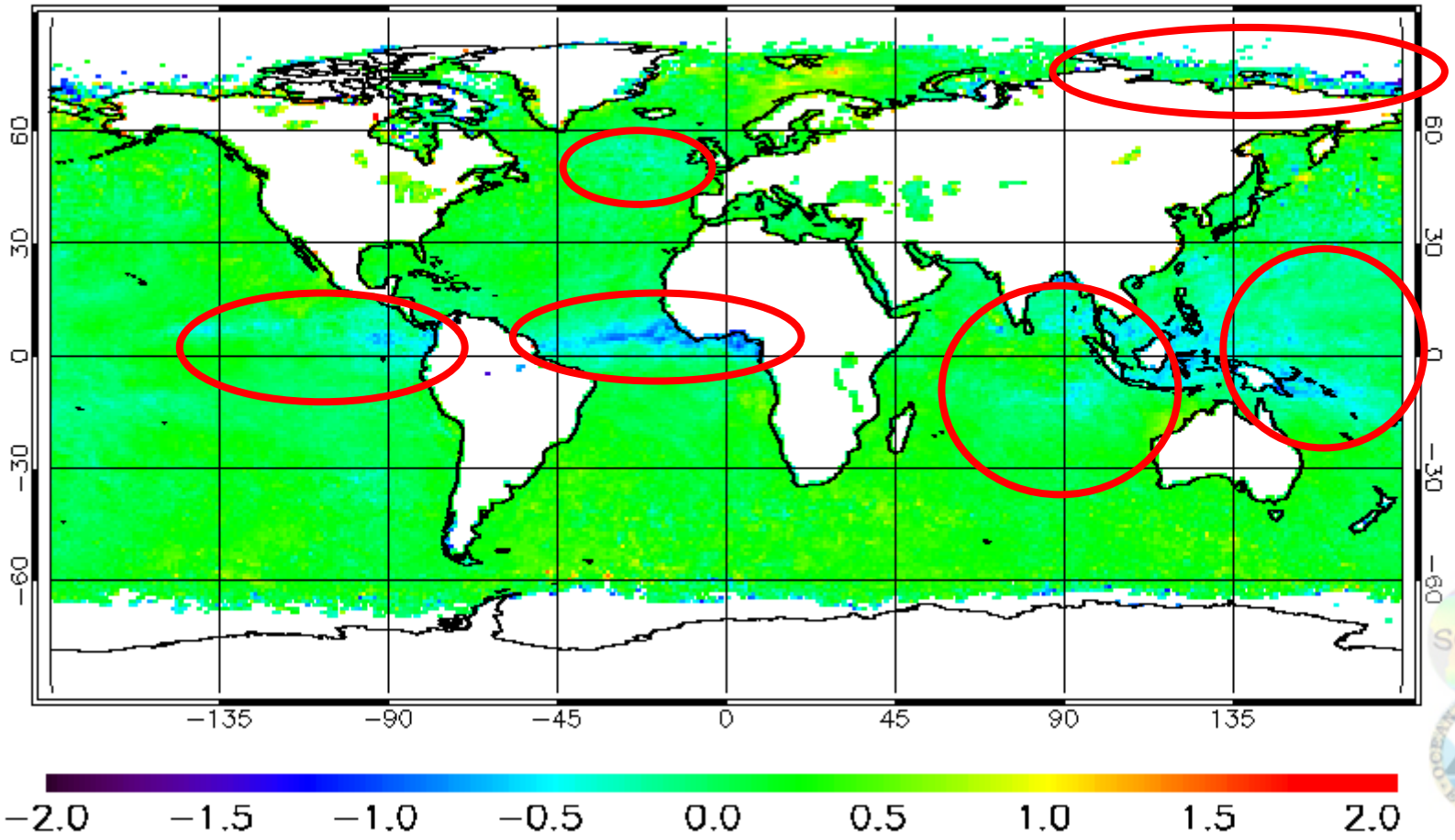
Day: **ACSPO Metop-A** L2 minus OSTIA L4, May-2013



- *Deviation from T_R is flat & close to 0 – (as shown before)*
- *Persistent residual cloud/aerosol leakages in tropics, mid-latitudes*

2.1. Aggregated maps of ΔT_S: Persistent cloud/algorithm deficiency ?

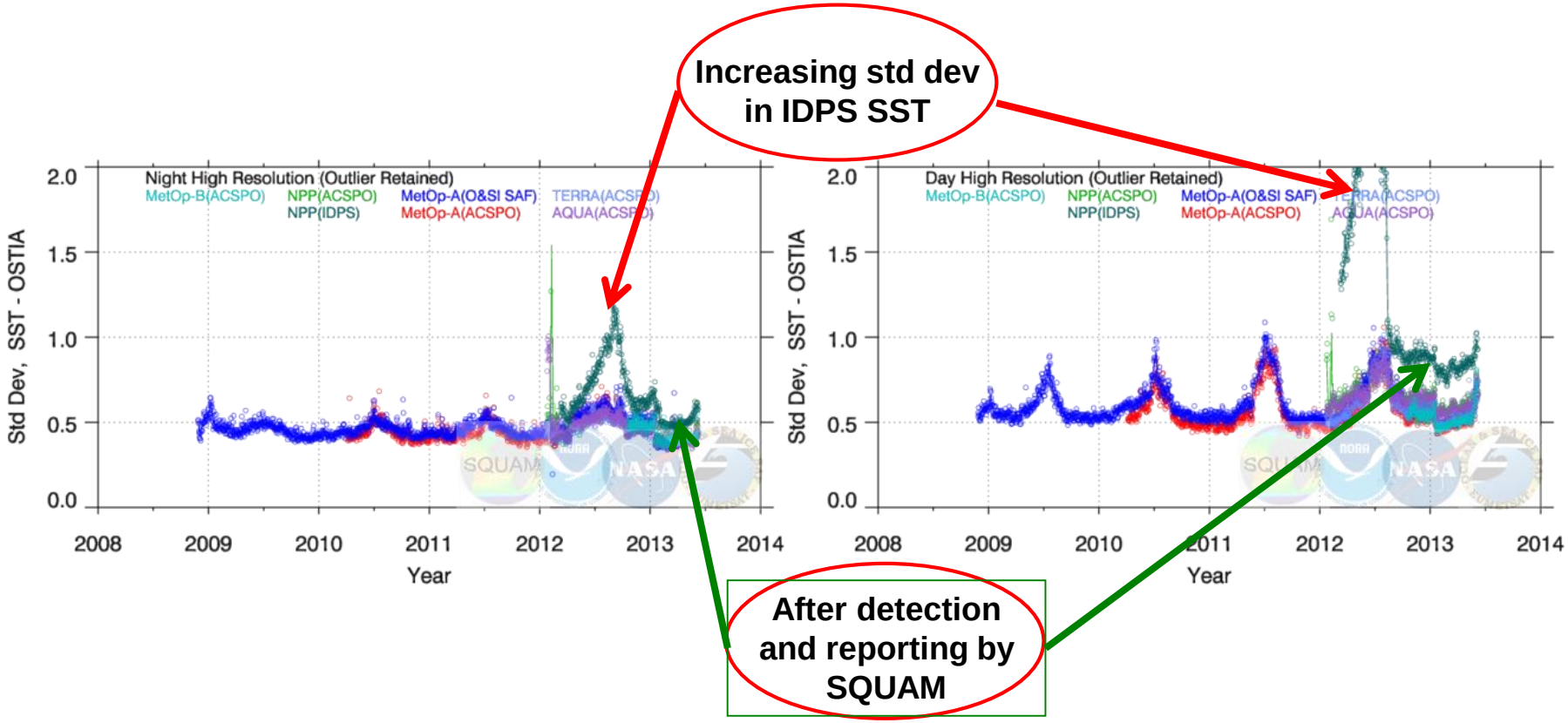
Day: **OSISAF Metop-A** L2 minus OSTIA L4, May-2013



- *more cloud leakages in the tropics, less in mid-latitudes*

2.2. IDPS VIIRS ice mask issue

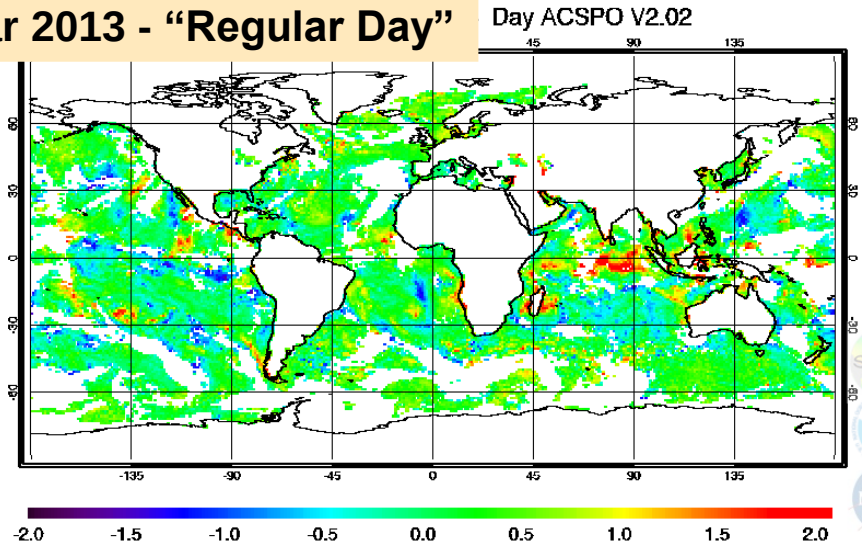
Standard deviation of IDPS VIIRS SST increased in early 2012, when compared against several reference SST fields (due to sub-optimal ice mask)

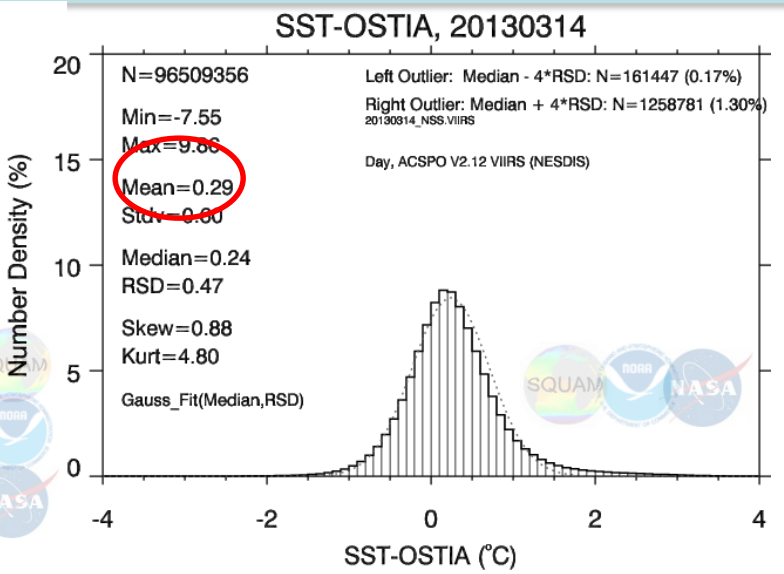


2.3. Warm-up Cool-down event in VIIRS bands

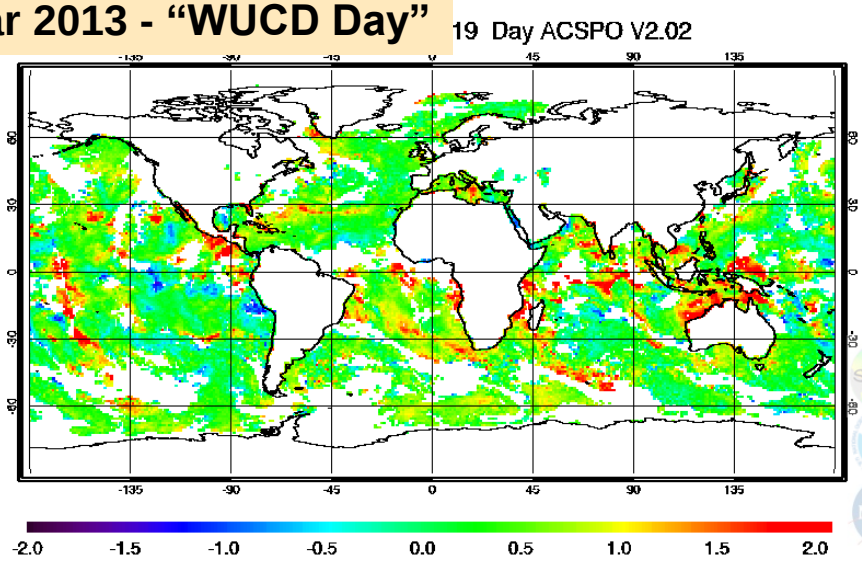
Maps | Histograms | Time-series | Dependencies | Hovmöller

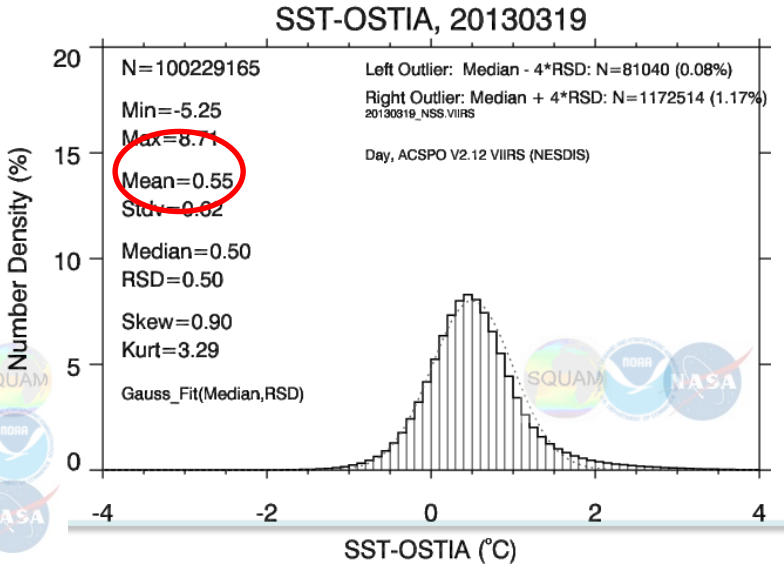
14 Mar 2013 - "Regular Day"



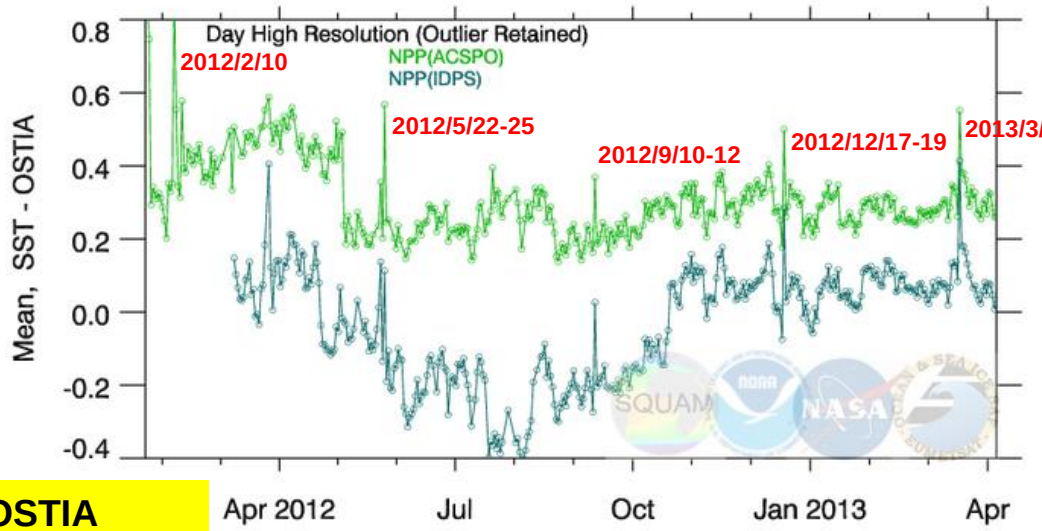


19 Mar 2013 - "WUCD Day"

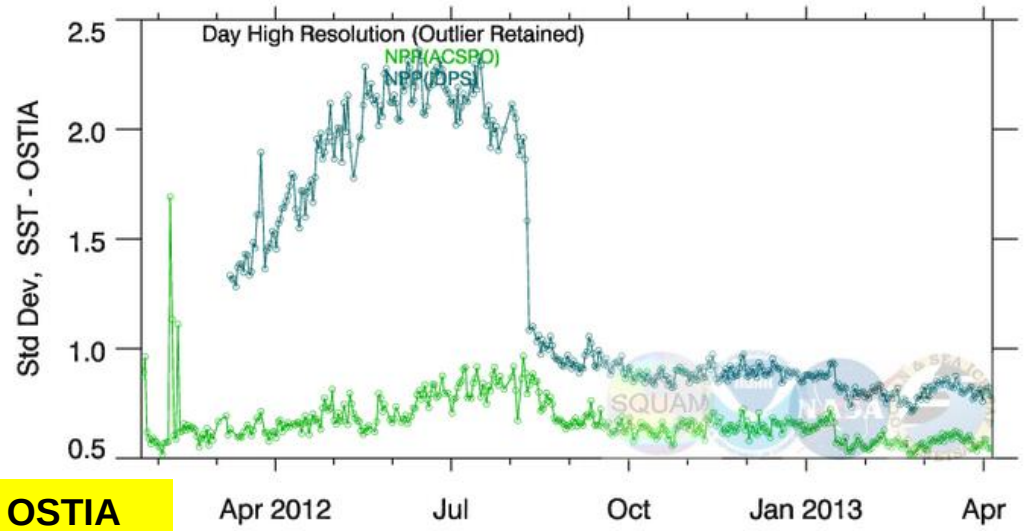




2.3. Warm-up Cool-down event in VIIRS bands



del SST wrt. OSTIA



SST Std Dev wrt. OSTIA

Initial large spike in global mean biases in Feb 2012. After code fixes, SST spikes reduced to ~0.2-0.3K.

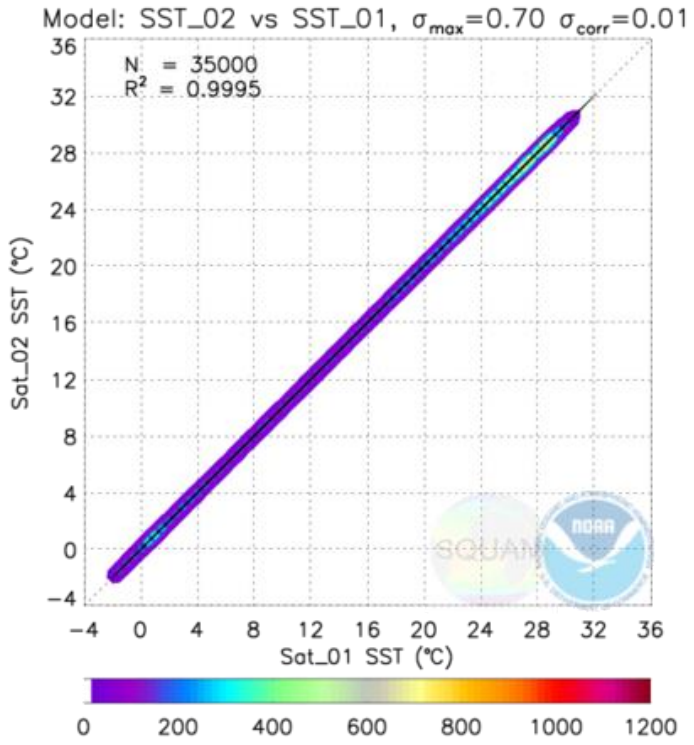
NB: *these are daily global stat of VIIRS SST –OSTIA; local spikes are likely larger*

Large spike in global Std Dev Feb 2012. After code fixes, SST spikes not seen.

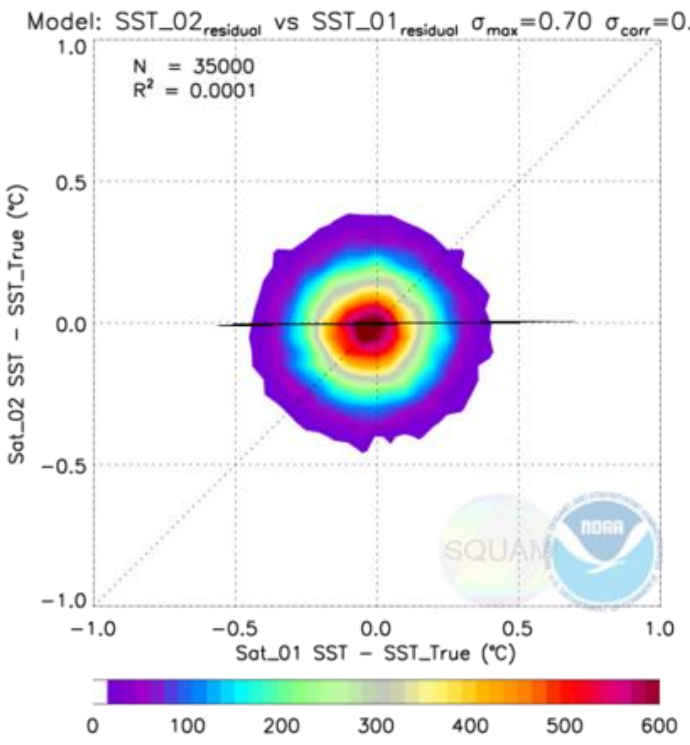
3. Choose an L4 as ref. based on min. corr. error

*(preliminary**; also presented in Lannion meeting)*

State space: bivariate ρ



Residual space: bivariate ρ



Simulated

x: Sat_01 = *SST_True* + σ_1
y: Sat_02 = *SST_True* + σ_2

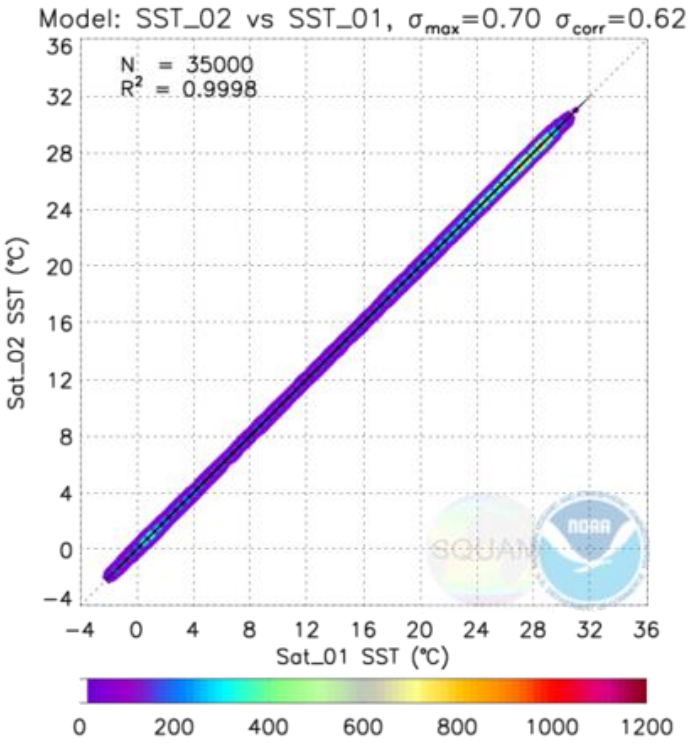
σ_1,σ_2 uncorrelated; **σ_{corr}=~0.0**

→ **R^2 = ~0**
No linear relation between σ_1 and σ_2

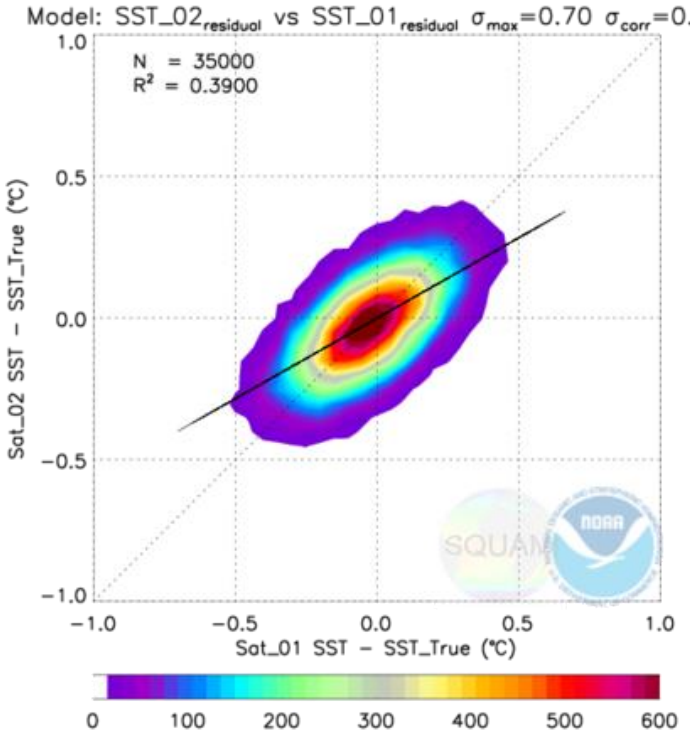
Ideal case for "independent" products

3. Correlation of "independent" L2 SSTs *(preliminary)*
Simulated study

State space: bivariate ρ



Residual space: bivariate ρ



Simulated

x: Sat_01 = *SST_True* + σ_1
y: Sat_02 = *SST_True* + σ_2

σ_1,σ_2 ~~un~~correlated; σ_{corr}=~0.62

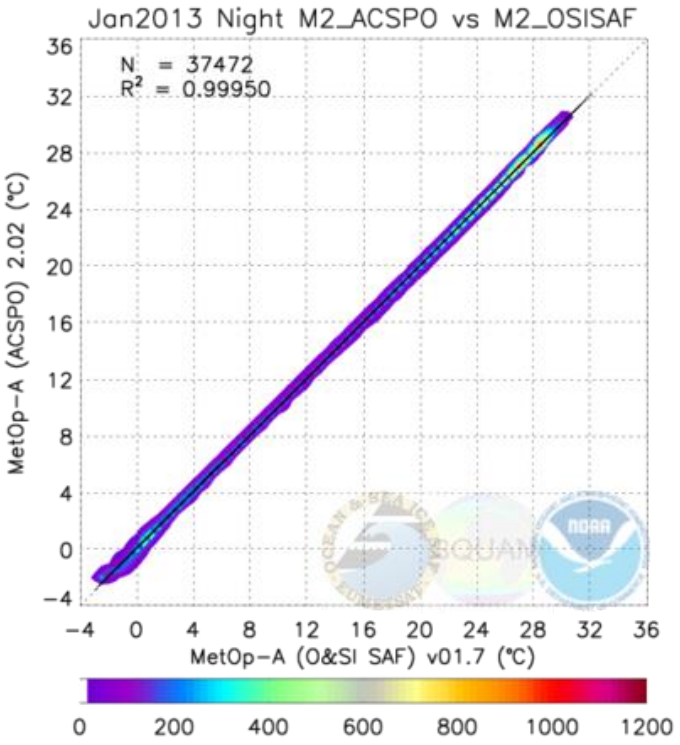
→ **R^2 = ~0.39**
Moderate linear relation between σ_1 and σ_2

f : correlated errors → residual R^2 (increasing)

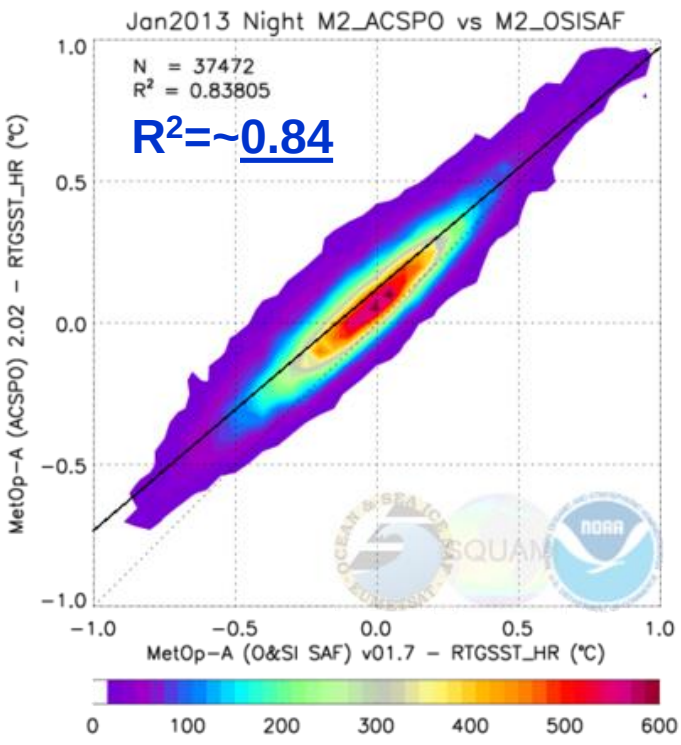
3. Correlation of "independent" L2 SSTs *(preliminary)*

ACSPO (y-axis) vs. OSI SAF(x-axis) for Metop-A, Night

State space: bivariate ρ



Residual space: bivariate ρ



Ref: RTG

x: OSI SAF = *SST_True* + σ_{OSISAF}
y: ACSPO = *SST_True* + σ_{ACSPO}

σ_{OSISAF},σ_{ACSPO} ~~un~~correlated;

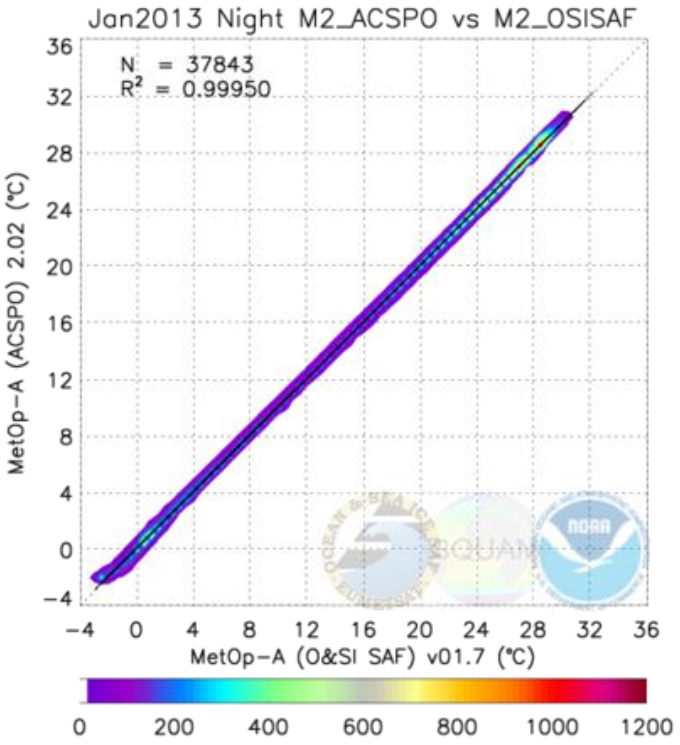
$$\sigma^2_{corr\_total} = \sigma^2_{corr\_meas} + \sigma^2_{corr\_algo} + \sigma^2_{corr\_ref}$$

- $\sigma^2_{corr\_meas}$: Unavoidable; same BT (M2)
- $\sigma^2_{corr\_algo}$: Should be minimized
- $\sigma^2_{corr\_ref}$: Depends on T_ref : RTG

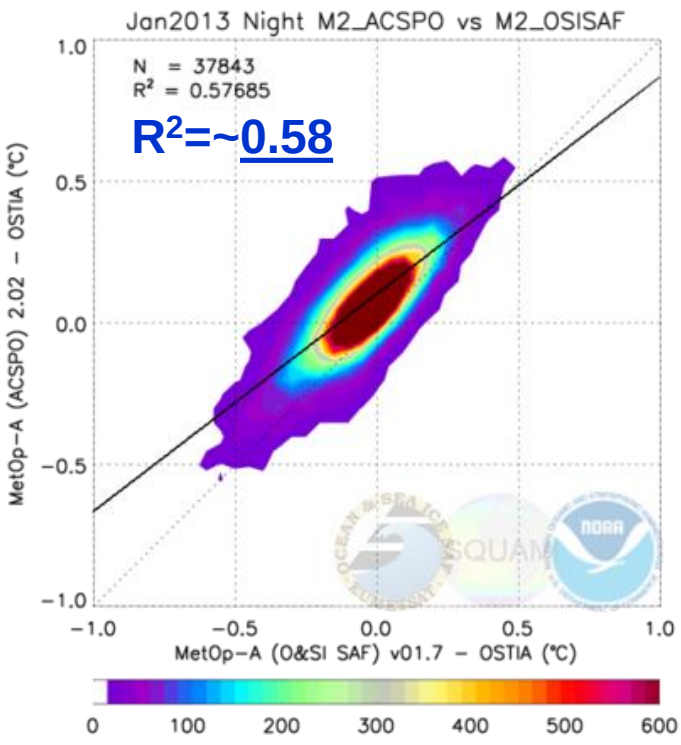
3. Correlation of "independent" L2 SSTs *(preliminary)*

ACSPO (y-axis) vs. OSI SAF(x-axis) for Metop-A, Night

State space: bivariate ρ



Residual space: bivariate ρ



Ref: OSTIA

x: OSI SAF = *SST_True* + σ_{OSISAF}
y: ACSPO = *SST_True* + σ_{ACSPO}

σ_{OSISAF},σ_{ACSPO} ~~un~~correlated;

$$\sigma^2_{corr\_total} = \sigma^2_{corr\_meas} + \sigma^2_{corr\_algo} + \sigma^2_{corr\_ref}$$

- $\sigma^2_{corr\_meas}$: Unavoidable; same BT (M2)
- $\sigma^2_{corr\_algo}$: Should be minimized
- $\sigma^2_{corr\_ref}$: Depends on T_ref : **OSTIA**

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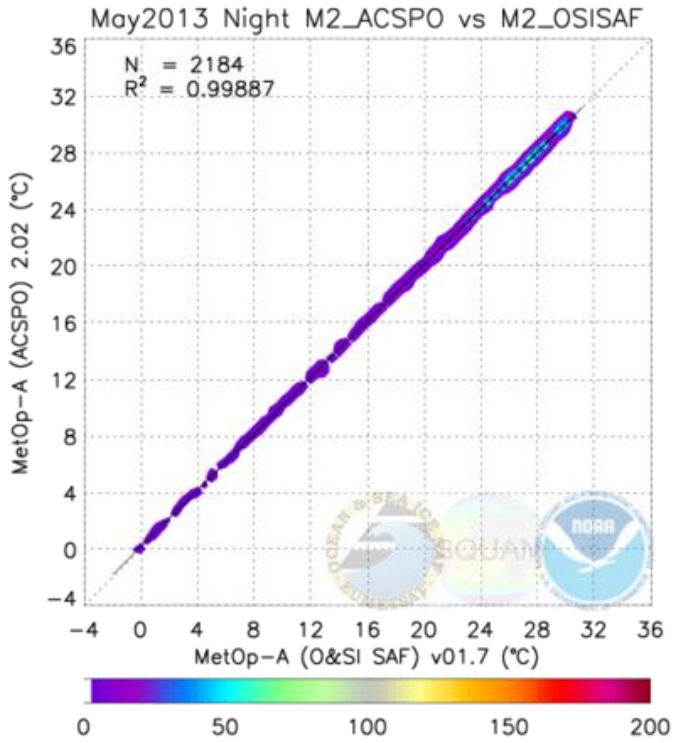
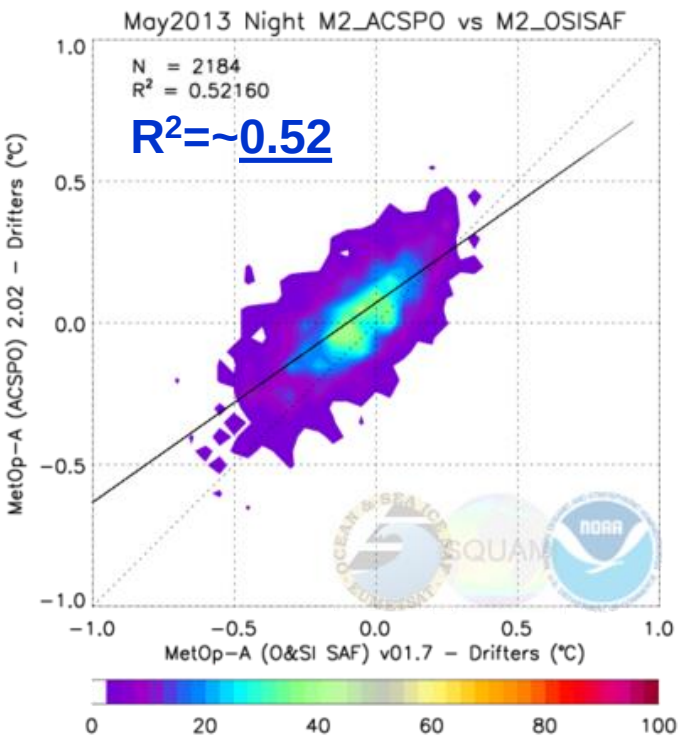
ACSPO (y-axis) vs. OSI SAF(x-axis) for Metop-A, Night

State space: bivariate ρ



Residual space: bivariate ρ



Ref: Drifters

x: OSI SAF = *SST_True* + σ_{OSISAF}
y: ACSPO = *SST_True* + σ_{ACSPO}

σ_{OSISAF},σ_{ACSPO} ~~un~~correlated

$$\sigma^2_{corr\_total} = \sigma^2_{corr\_meas} + \sigma^2_{corr\_algo} + \sigma^2_{corr\_ref}$$

- $\sigma^2_{corr\_meas}$: Unavoidable; same BT (M2)
- $\sigma^2_{corr\_algo}$: Should be minimized
- $\sigma^2_{corr\_ref}$: Depends on T_ref : **Drifters**

3. Correlation of "independent" L2 SSTs *(preliminary)*

Implications: $\sigma^2_{corr\_total} = \sigma^2_{corr\_meas} + \sigma^2_{corr\_algo} + \sigma^2_{corr\_ref}$

- Sheds light on choice of T_{ref} (minimize $\sigma^2_{corr\_ref}$), e.g., for night, ***OSTIA and Drifters*** *show comparable corr. errors* (for this particular L2-combination); *ensures that is it okay to use OSTIA as a reference in SQUAM*.

- Can the individual contributions be separated ? - **don't know!** – some simplifications:
  - For **same Sat**, **different proc** (ACSPO, OSISAF): $\sigma^2_{corr\_algo}$ should be *low*
  - For **different Sat** (e.g., M1, M2), **same proc**(e.g., ACSPO/OSI SAF): $\sigma^2_{corr\_meas} = 0$. If not, then algorithm should be revisited.

- **May be** used to check if the assumption of zero correlated error is violated in related studies (e.g., Triple-C-M): $\sigma_1\sigma_2 = \sigma_2\sigma_3 = \sigma_1\sigma_3 = \cancel{0}$. ?

Summary and Future Work

- SQUAM currently monitors major global polar L2/3 SST products from VIIRS, MODIS, and AVHRR, and >14 L4 SST products
- Two VIIRS SST products were added in Jan 2012: ACSPO and IDPS
- Metop-B is generated by ACSPO and was included (OSI SAF plans?)
- All SSTs are 'more or less' consistent

- Future data additions in SQUAM
  - Polar: MODIS MOD29/MYD28, (A)ATSR, OSI SAF Metop-B
  - Geostationary: MSG, MTSAT, GOES – Preparation for GOES-R
  - Remaining L4 SSTs
  - More residual analyses (towards correlation issues, cloud leakages: EUMETSAT2013)

THANK YOU!