

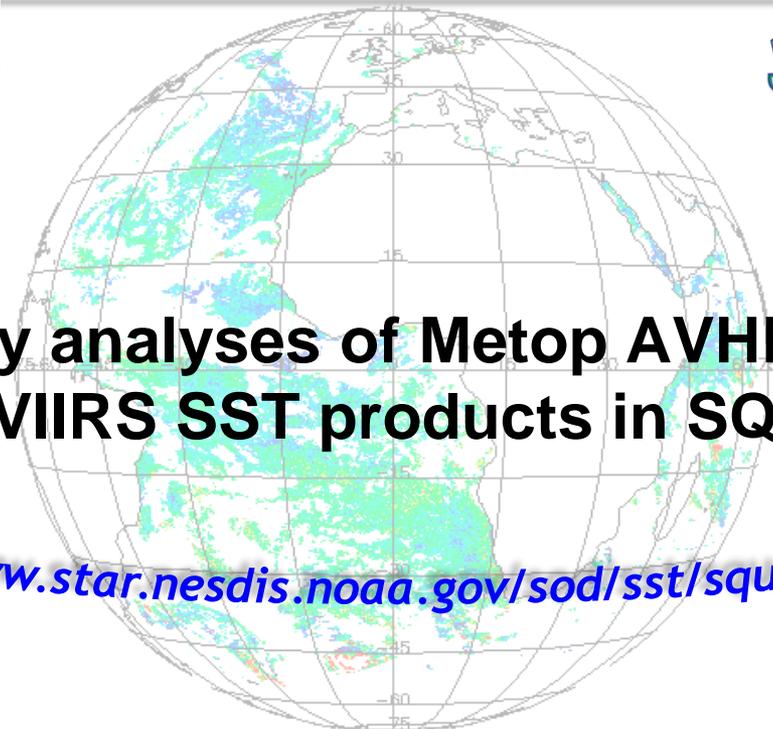


GHRSSST 2013 Annual Meeting
17–21 June, 2013, Woods Hole, MA



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

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



Prasanjit Dash^{1,2}, Alexander Ignatov¹, Yury Kihai^{1,3}, Boris Petrenko^{1,3},
John Stroup^{1,4}, John Sapper¹

¹NOAA/NESDIS, NCWCP College Park, MD

²Colorado State Univ, Cooperative Institute for Research in the Atmosphere (CIRA)

³GST, Inc, MD, USA ⁴STG, Inc, MD, USA

(Emails: FirstName.LastName@noaa.gov)

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 : ACSP0 (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, GHRSSST 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: MGDSSST;

C. Gentemann: RSS products; J. Cummings: NCODA

GHRSSST 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:



Projects and international group





SQUAM – Web interface

Locate this website: Google: "SST + SQUAM"

SQUAM v10.0

Home | Level 2 + | Level 3 + | Level 4 | About +

Last updated: Jun-05-2013

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>High Resolution</p> <p>NPOESS VIIRS NESDIS ACSP0 NGS/Raytheon IDPS</p> <p>AVHRR FRAC</p> <p>NESDIS MetOp-B (newly added) NESDIS MetOp-A ACSP0 EUMETSAT O&SI SAF</p> <p>Terra/Aqua MODIS</p> <p>NASA MOD28/MYD28 (coming) NESDIS ACSP0</p> <p>AVHRR GAC</p> <p>NESDIS ACSP0 NAVO SEATEMP NESDIS MUT (heritage)</p>	<p>AVHRR GAC</p> <p>NODC/RSMAS PathFinder v5.0</p>	<p>Bulk</p> <p>Reynolds (AVHRR) : D01_AV Reynolds (+ AMSRE-E): D01_AA RTG high resolution: RTG_HR RTG low resolution: RTG_LR NAVO K10 NESDIS POESGOES NASA JPL 1km G1SST: G1SST</p> <p>Foundation/Sub-skin</p> <p>OSTIA, UK MetOffice OSTIA Reanalysis, UK MetOffice CMC 0.2°, Environment Canada GAMSSA 28km, Australian BOM ODYSSEA, MERSEA France MUR, JPL/NASA</p> <p>Ensemble of L4 SSTs</p> <p>GHRSSST Median Ensemble</p>

- "L2/3 vs L4" complements heritage "L2/3 vs insitu" validation [++Why?](#)
- Contributes to GHRSSST STVAL [++Link](#)

- Contributes to GHRSSST IC-TAG [++Link](#)

SST data providers

Satellite missions & SST Groups

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] [PDE](#)
- 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](#)

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

L4: GHRSSST 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. –

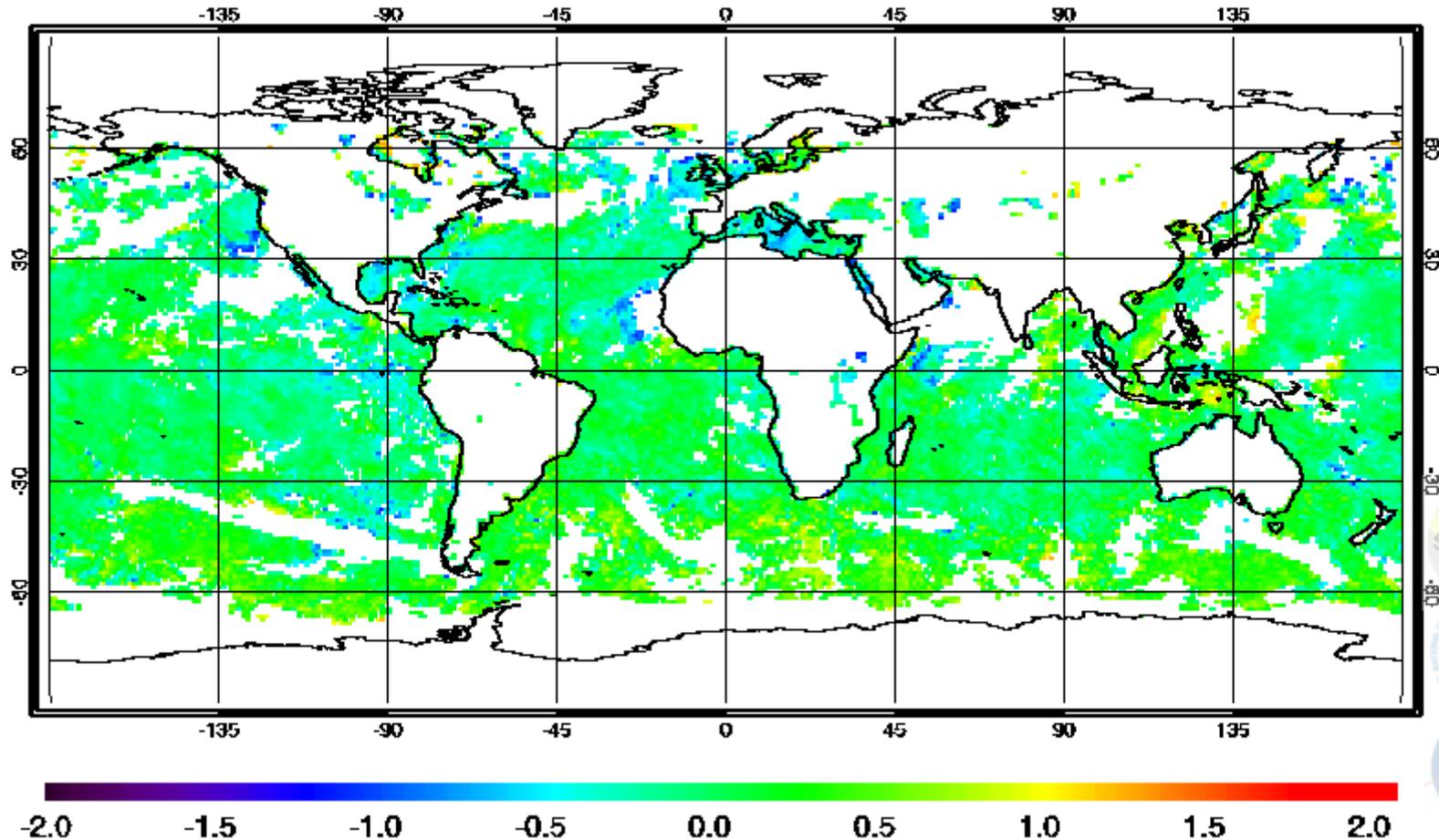
- a) Simulated study *preliminary thoughts*
- b) Real satellite (T_S) and reference (T_R) fields

3. Summary and future plans

1. SQUAM – modules

Maps Histograms Time-series Dependencies Hovmöller

Night: **Suomi-NPP VIIRS (ACSP0) L2 minus OSTIA L4, 08 Jun 2013**

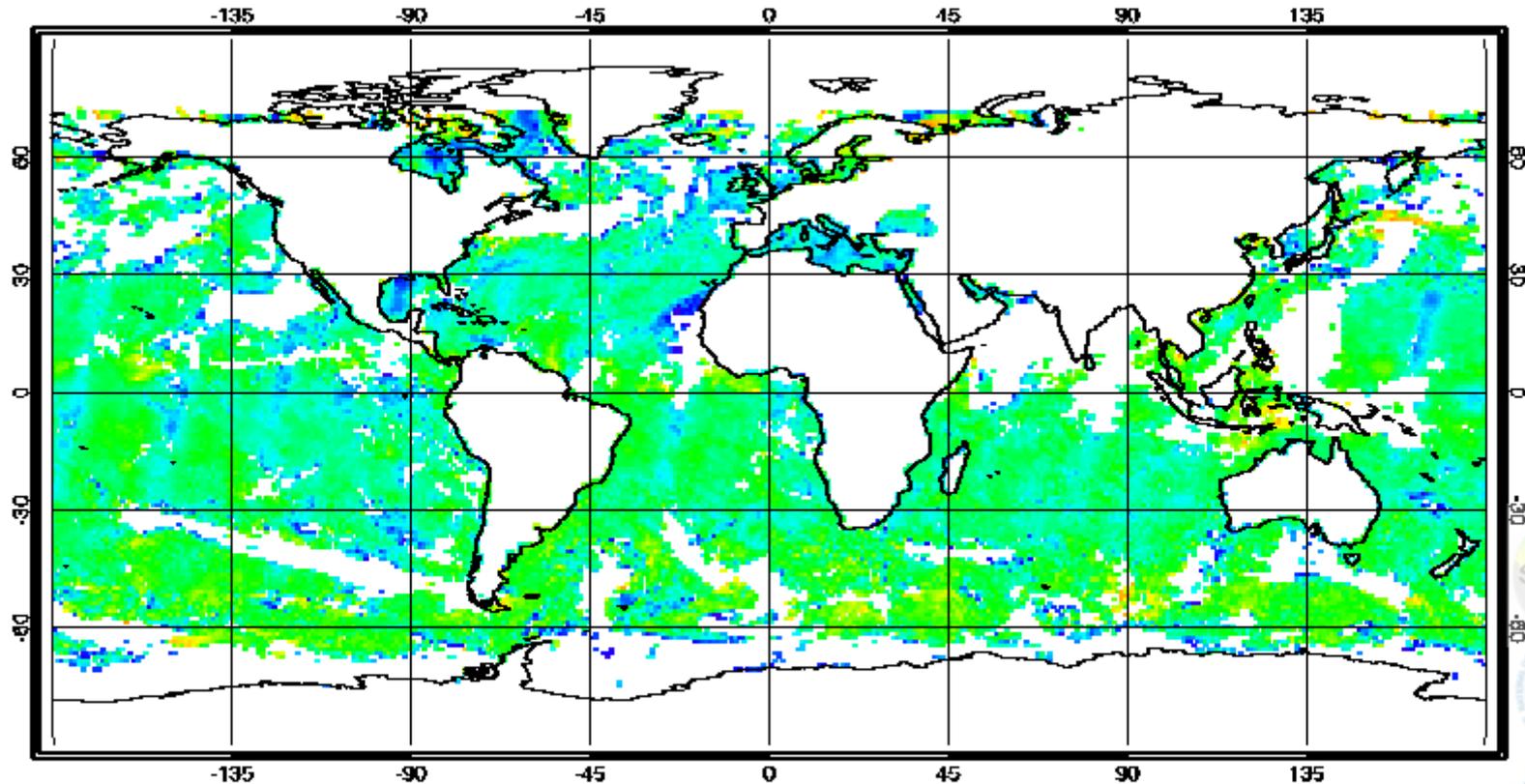


- Deviation from T_R is flat & close to 0
- Residual Cloud/Aerosol leakages seen in the Tropics, mid-latitudes

1. SQUAM – modules

Maps Histograms Time-series Dependencies Hovmöller

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



-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0

- *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

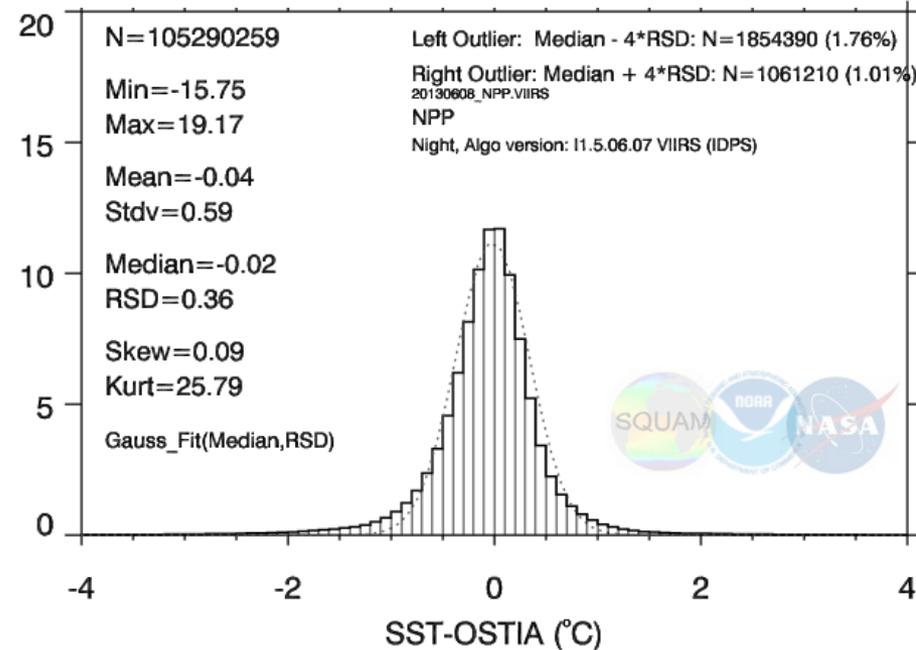
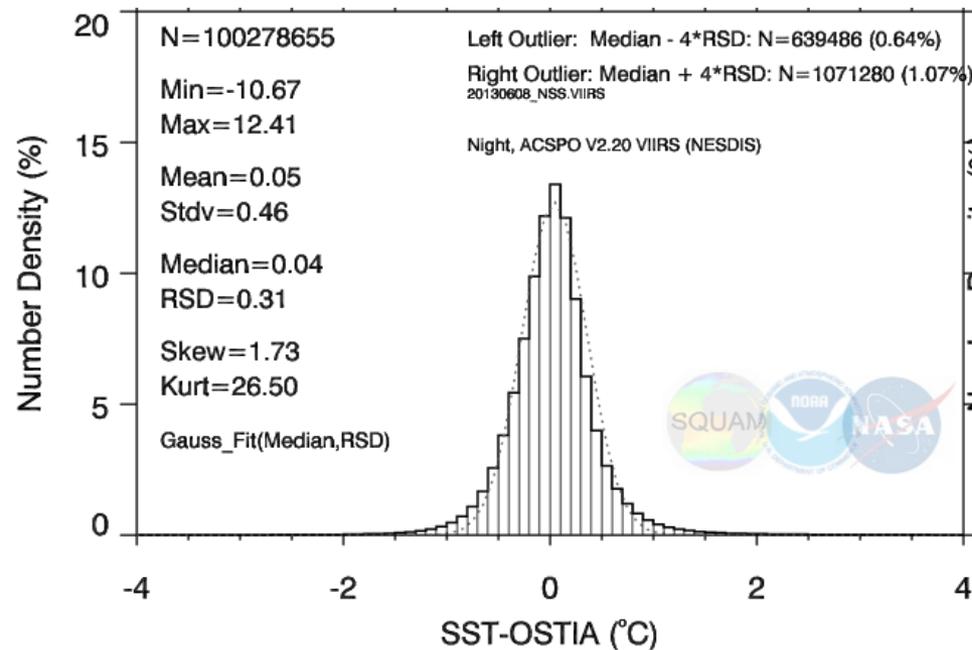


Maps **Histograms** Time-series Dependencies Hovmöller

Night 08 June 2013

ACSP0 VIIRS minus OSTIA

IDPS VIIRS minus OSTIA



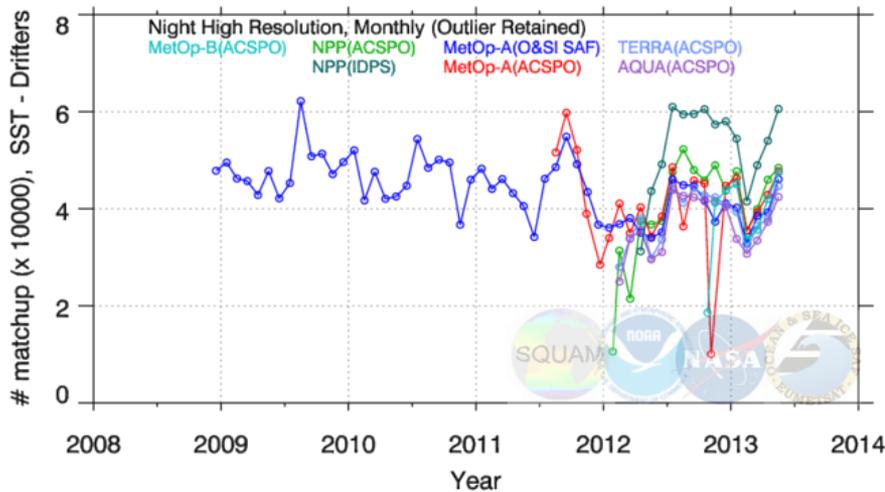
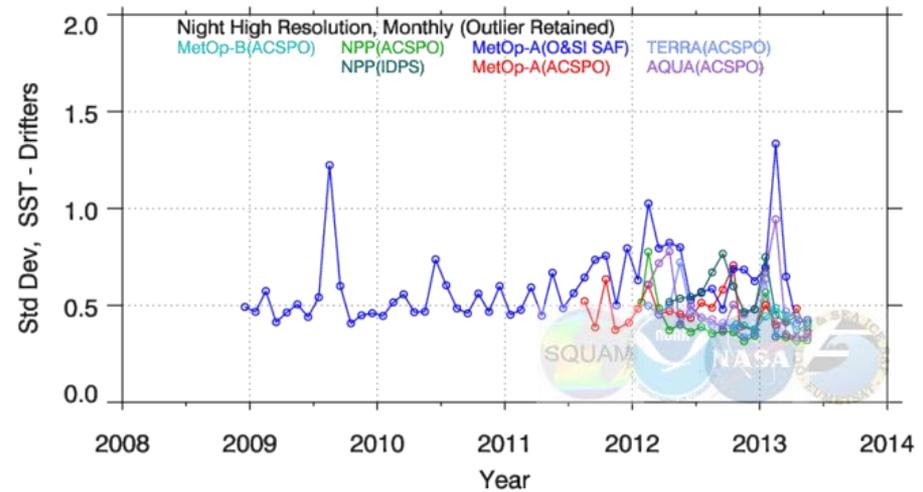
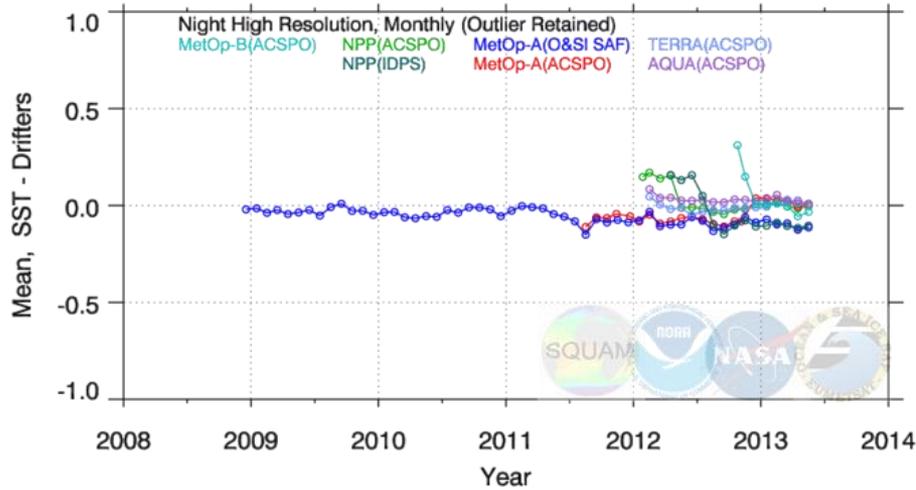
- Shapes close to Gaussian for both processors
- IDPS shows somewhat higher Std Dev for comparable # of obs
- Also range (max – min) for IDPS is higher indicating more outliers
- Domain performance stat close to expected



1. SQUAM – modules



Maps Histograms **Time-series** Dependencies Hovmöller



****Monthly validation wrt. Drifters (night)**

- a) **OSI SAF and ACSP0 Metop-A closely track each other – and ACSP0 MODIS**
- b) **ACSP0 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

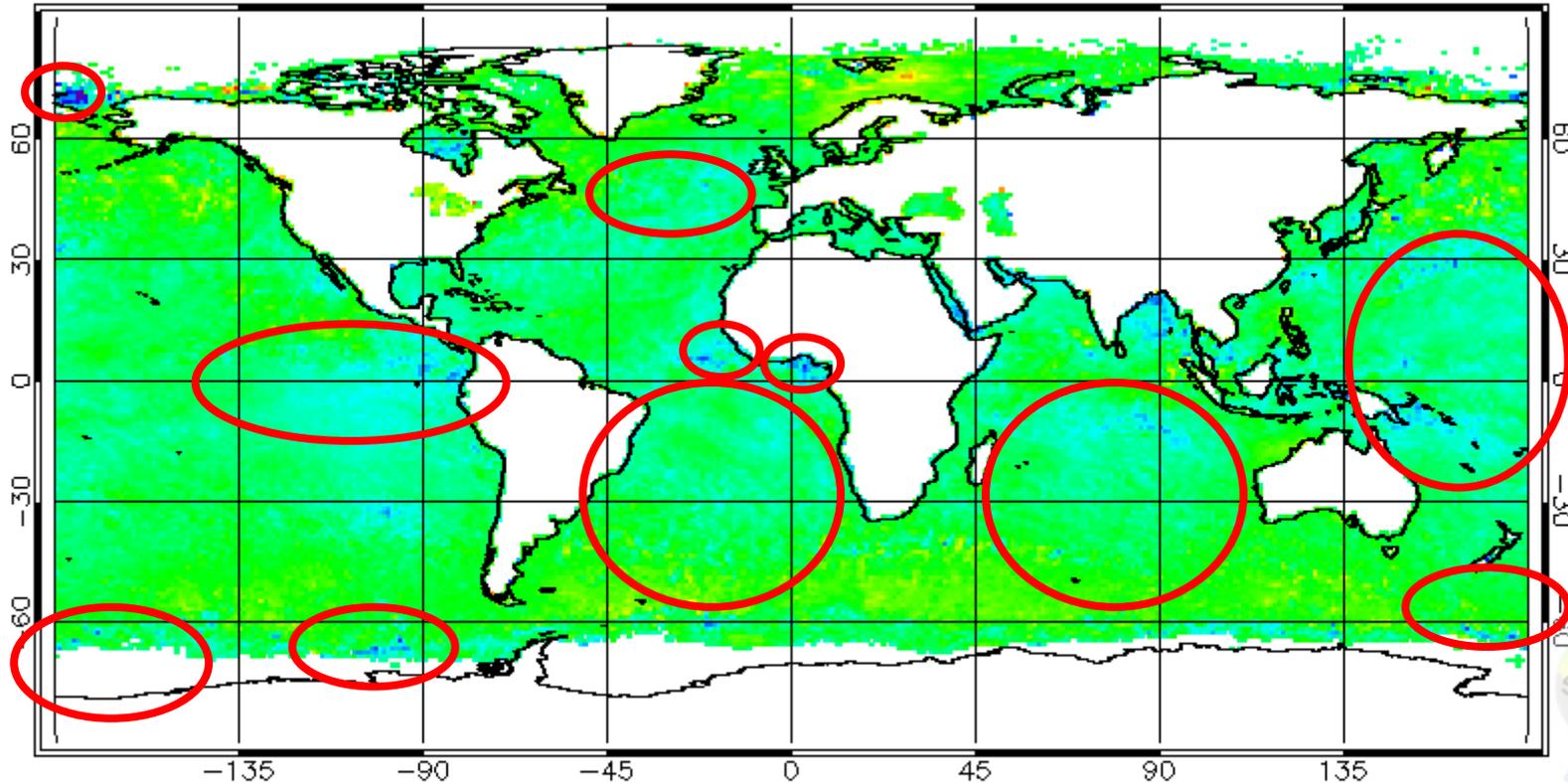
2.4. Correlation in “independent” L2 SSTs: choose an L4 ref. –

- 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/aerosol deficiency ?

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

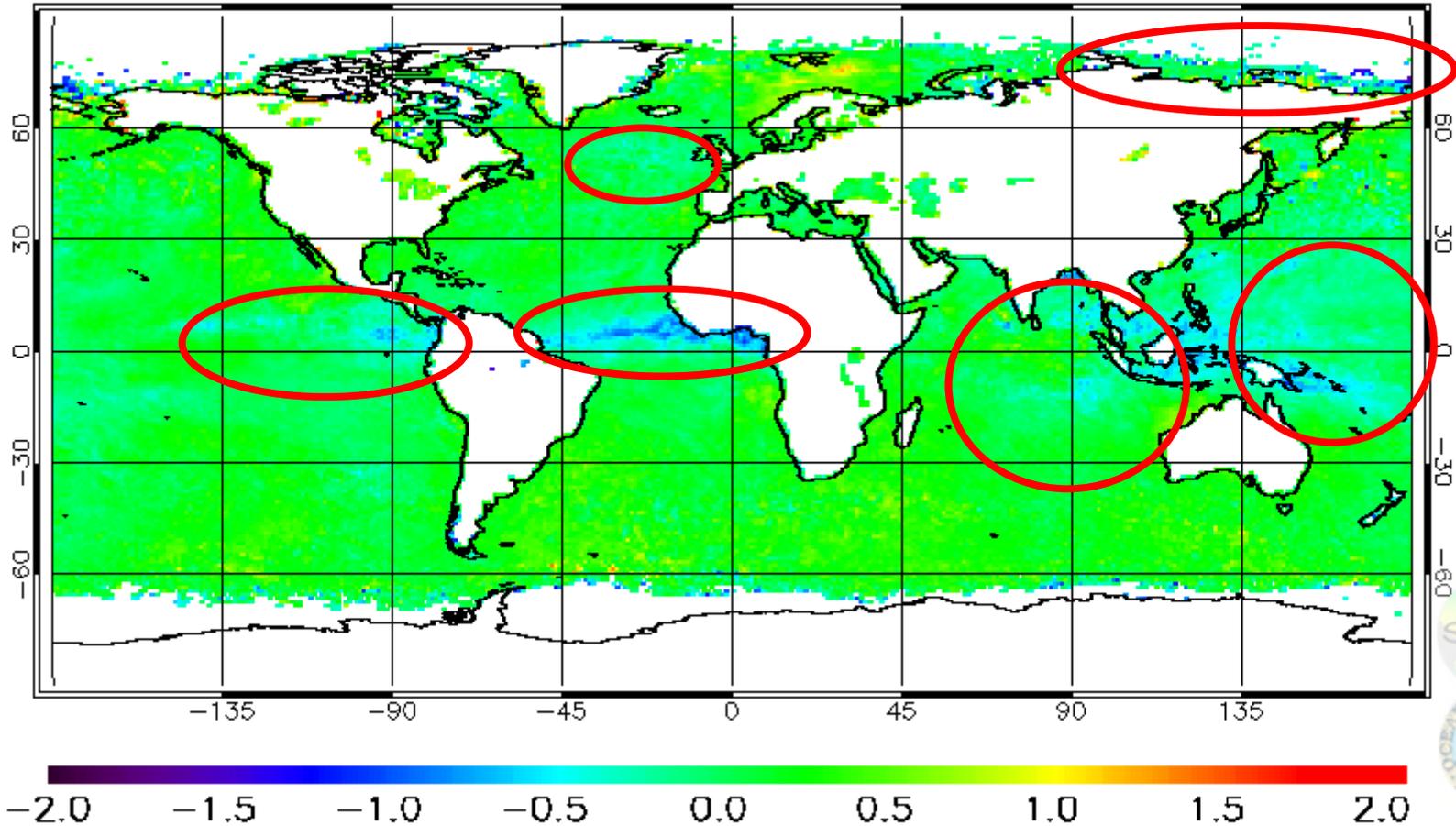


-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0

- 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 ?

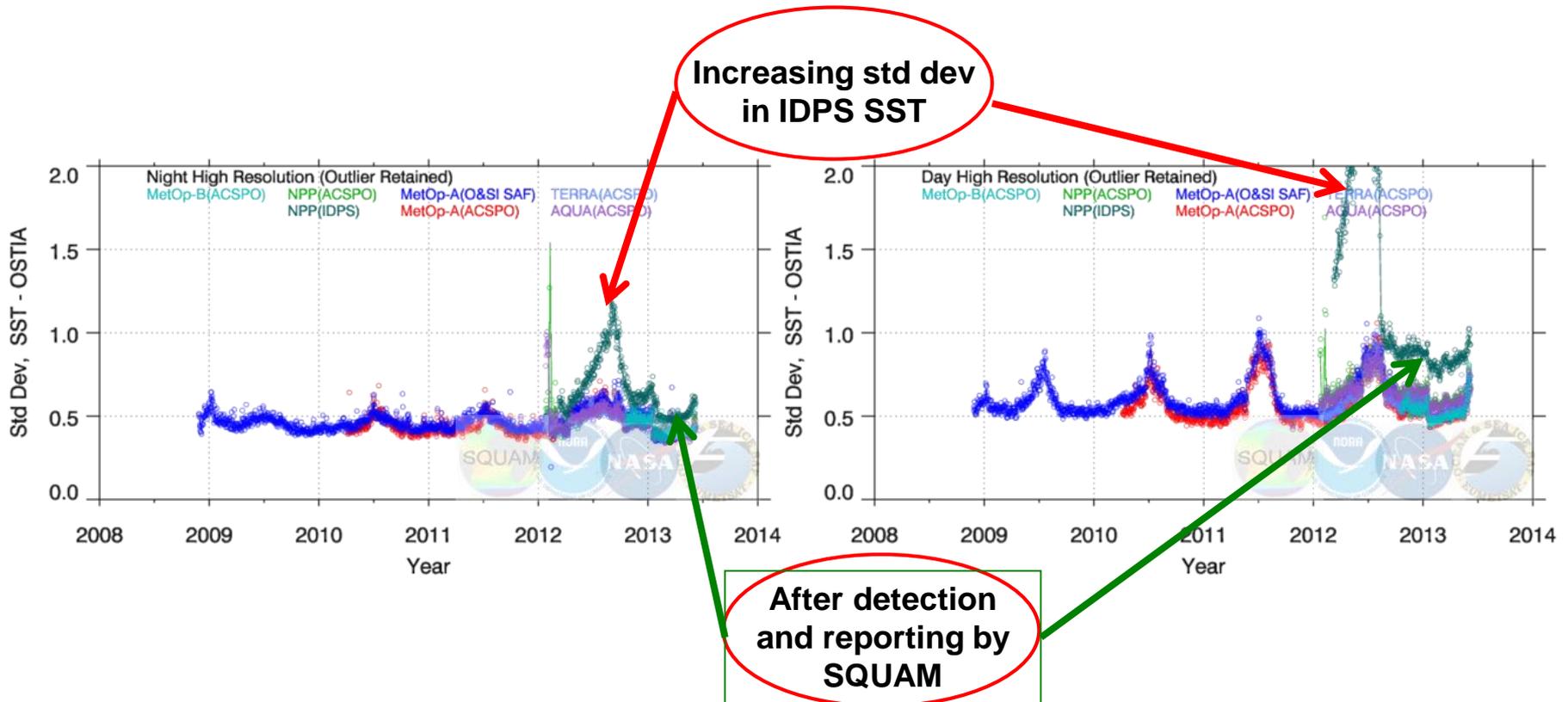
Day: **OSISAF Metop-A** L2 minus OSTIA L4, May-2013



- *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)





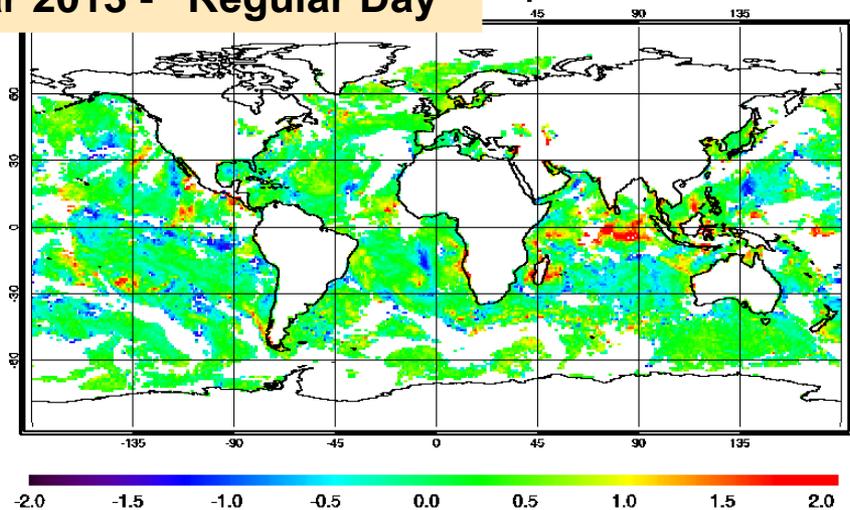
2.3. Warm-up Cool-down event in VIIRS bands



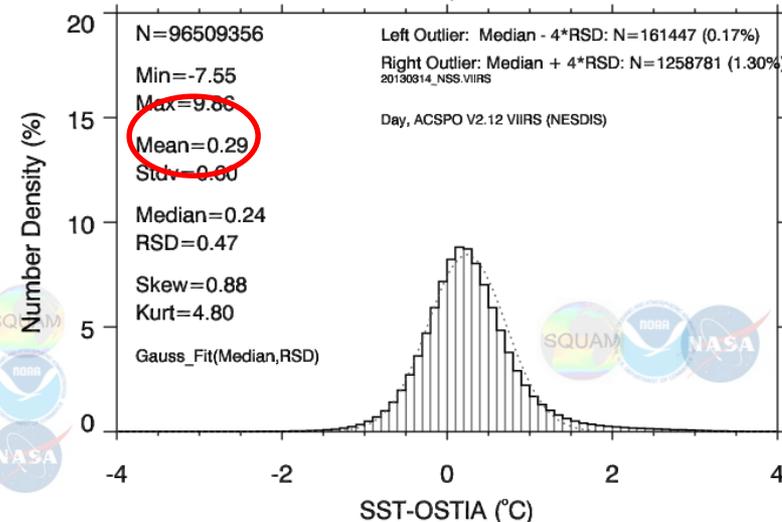
Maps Histograms Time-series Dependencies Hovmöller

14 Mar 2013 - "Regular Day"

Day ACSP0 V2.02

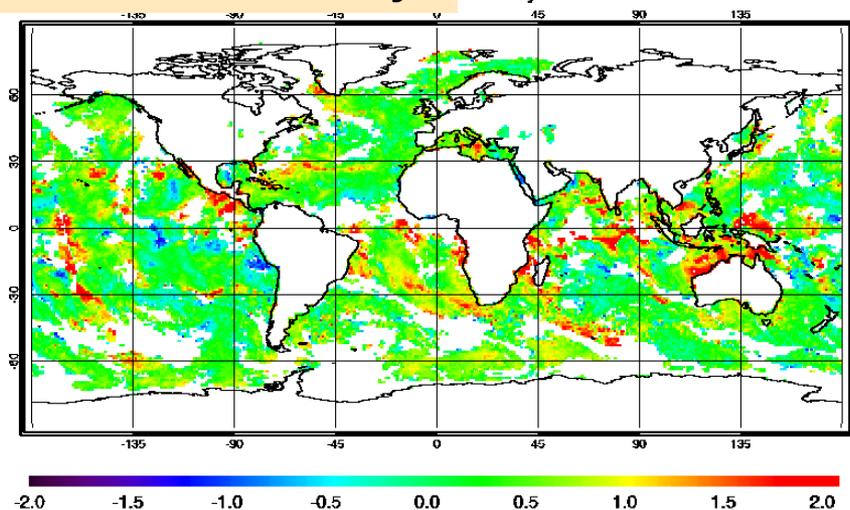


SST-OSTIA, 20130314

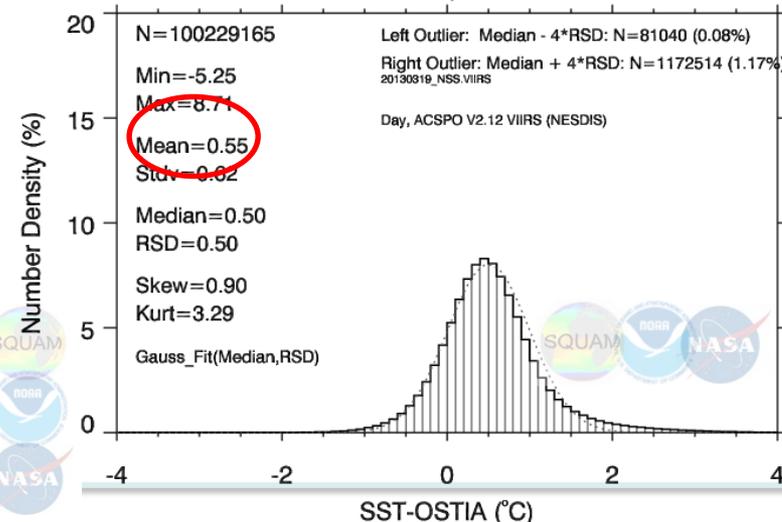


19 Mar 2013 - "WUCD Day"

19 Day ACSP0 V2.02



SST-OSTIA, 20130319

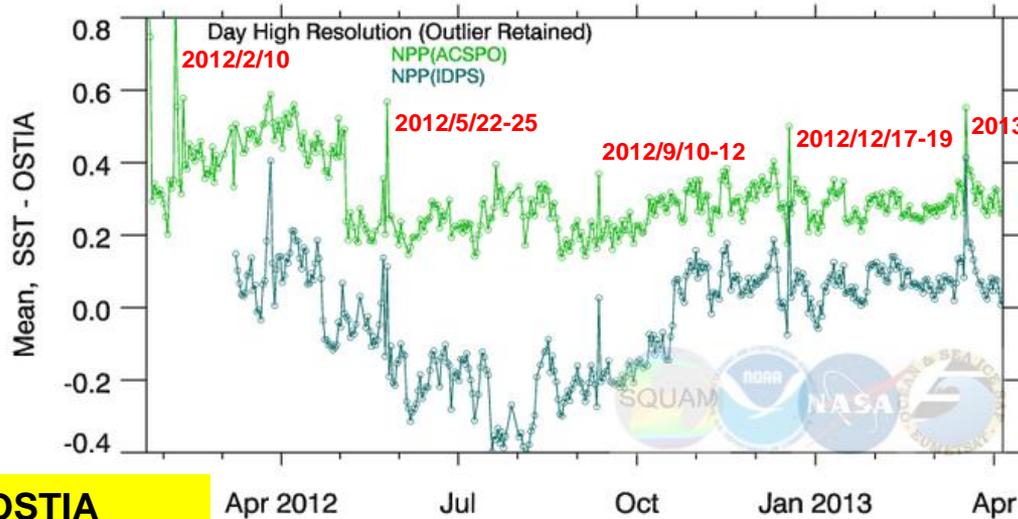




2.3. Warm-up Cool-down event in VIIRS bands



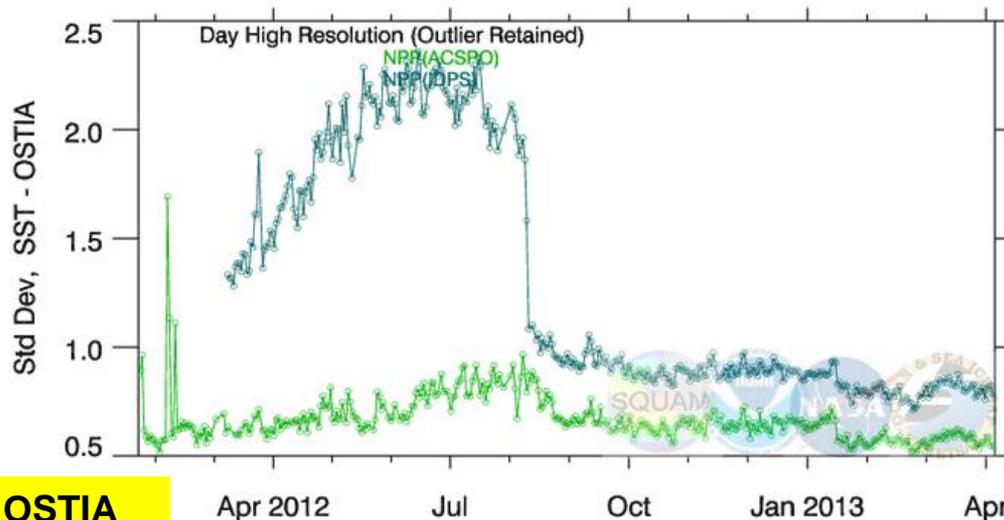
Maps Histograms **Time-series** Dependencies Hovmöller



del SST 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

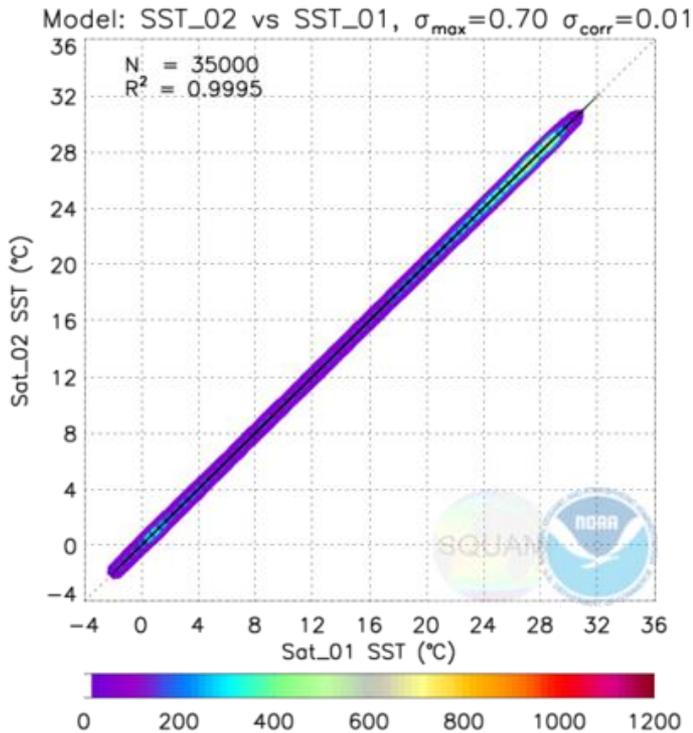


SST Std Dev wrt. OSTIA

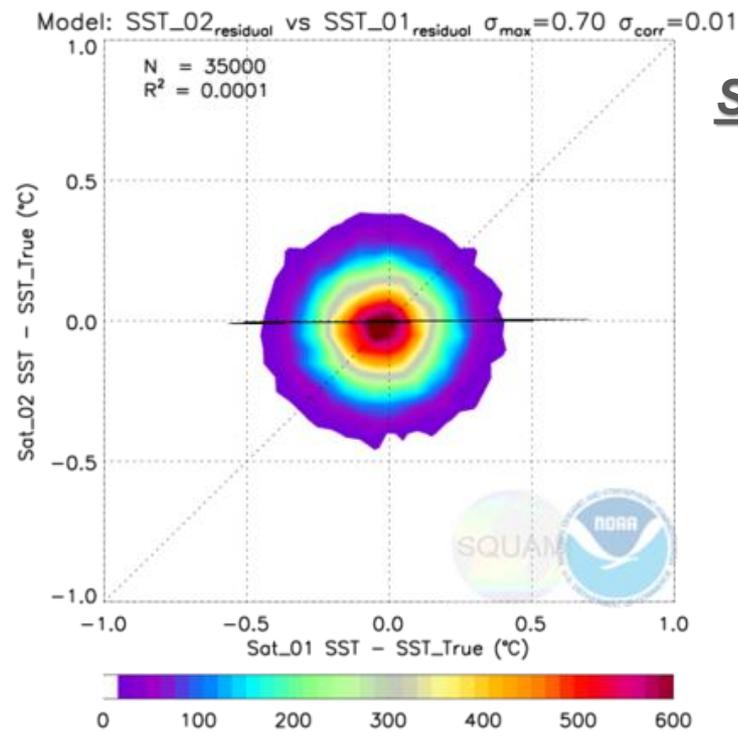
Large spike in global Std Dev Feb 2012. After code fixes, SST spikes not seen.

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

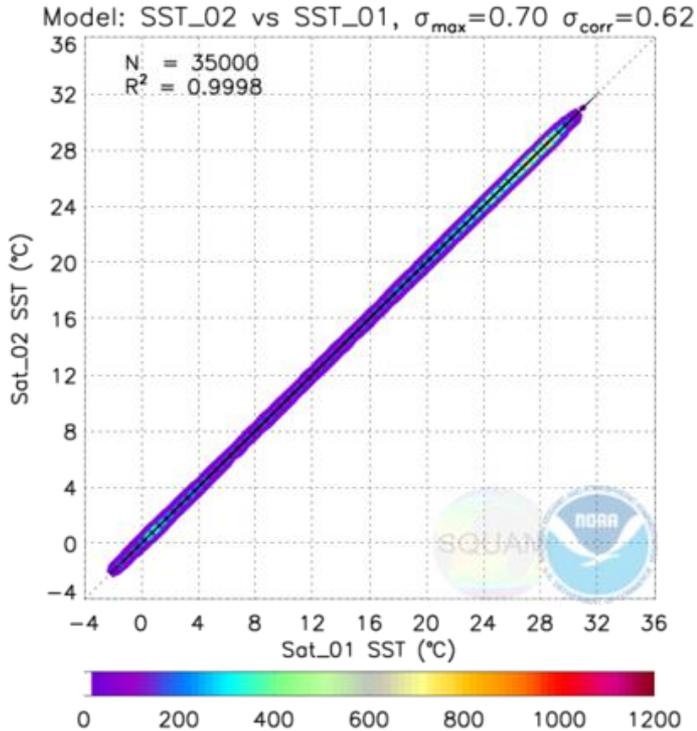
σ_1, σ_2 uncorrelated; $\sigma_{corr} \sim 0.0$

R² = ~0
No linear relation between σ_1 and σ_2

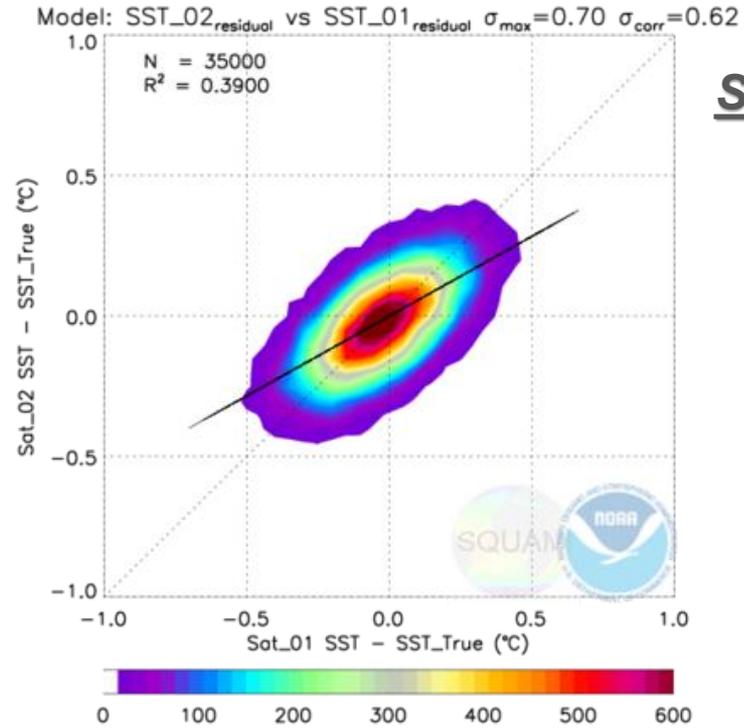
Ideal case for "independent" products

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

State space: bivariate ρ



Residual space: bivariate ρ



Simulated

$$x: \text{Sat_01} = \text{SST_True} + \sigma_1$$

$$y: \text{Sat_02} = \text{SST_True} + \sigma_2$$

σ_1, σ_2 uncorrelated; $\sigma_{\text{corr}} \sim 0.62$

$R^2 \sim 0.39$

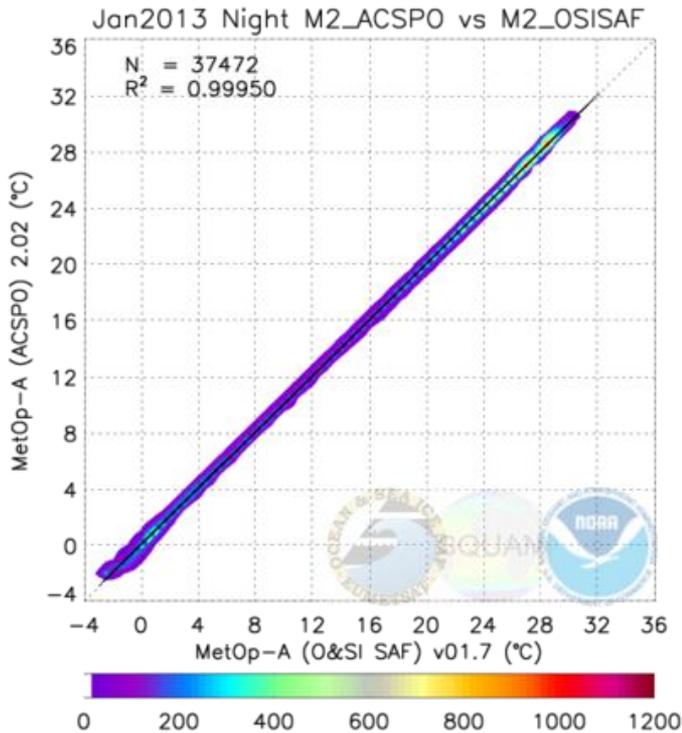
Moderate linear relation between σ_1 and σ_2

f : correlated errors \rightarrow residual R^2 (increasing)

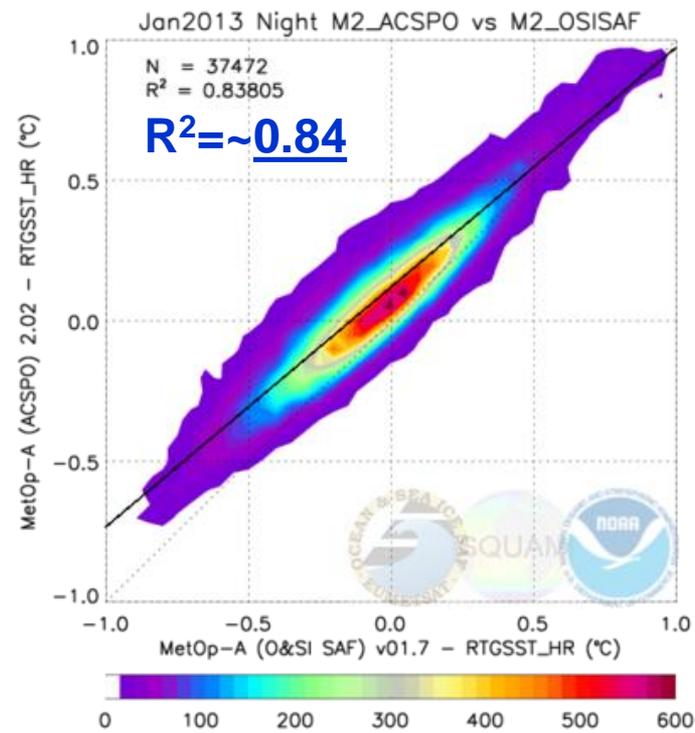


3. Correlation of “independent” L2 SSTs (preliminary) ACSP0 (y-axis) vs. OSI SAF(x-axis) for Metop-A, Night

State space: bivariate ρ



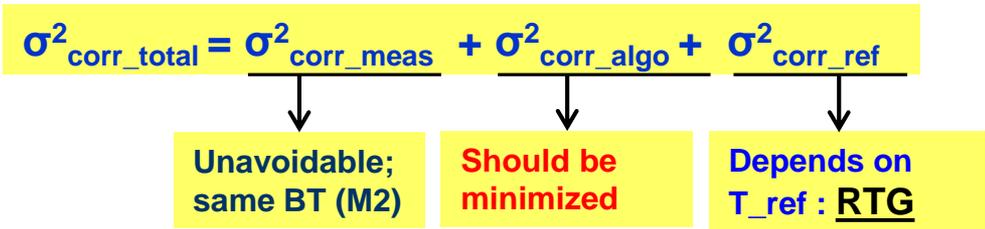
Residual space: bivariate ρ



Ref: RTG

x: OSI SAF = SST_True + σ_{OSISAF}
y: ACSP0 = SST_True + σ_{ACSP0}

$\sigma_{OSISAF}, \sigma_{ACSP0}$ uncorrelated

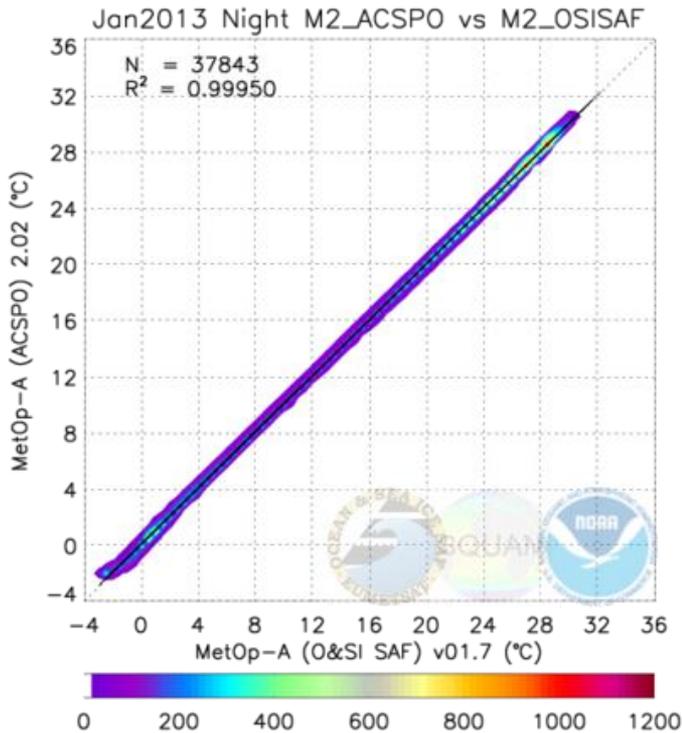




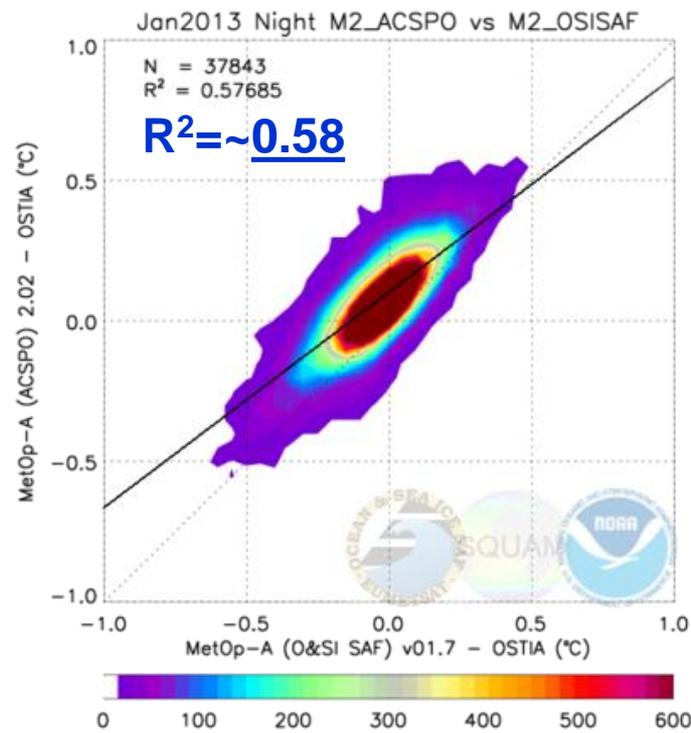
3. Correlation of “independent” L2 SSTs (preliminary)

ACSP0 (y-axis) vs. OSI SAF(x-axis) for Metop-A, Night

State space: bivariate ρ



Residual space: bivariate ρ

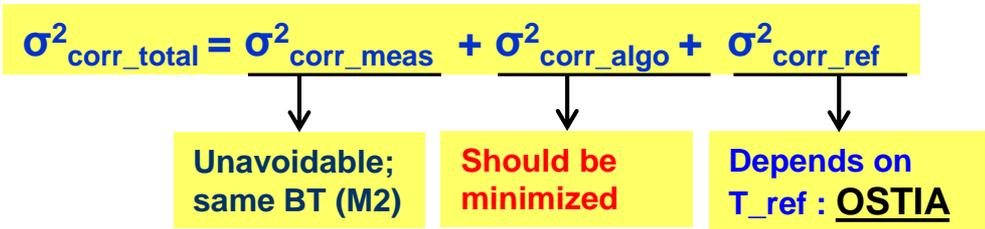


Ref: OSTIA

$$x: \text{OSI SAF} = \text{SST_True} + \sigma_{\text{OSISAF}}$$

$$y: \text{ACSP0} = \text{SST_True} + \sigma_{\text{ACSP0}}$$

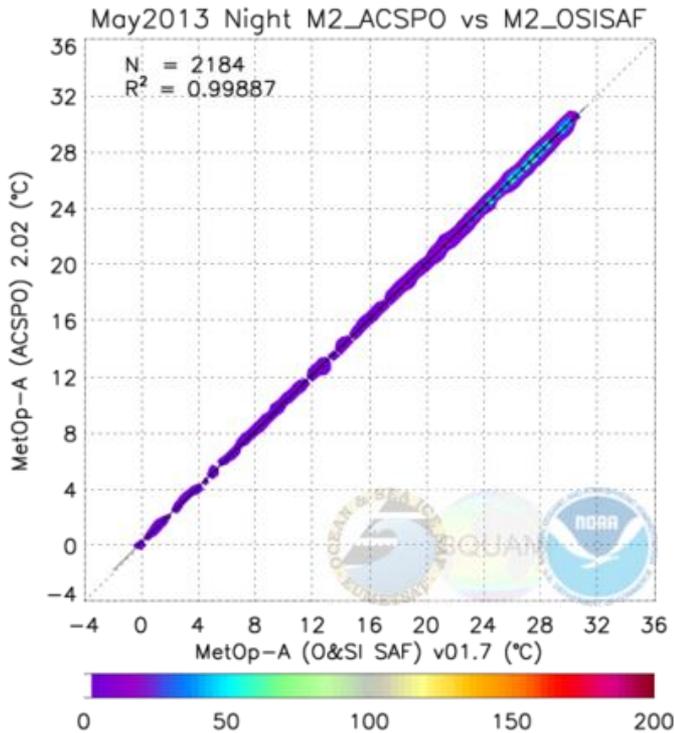
$\sigma_{\text{OSISAF}}, \sigma_{\text{ACSP0}}$ uncorrelated



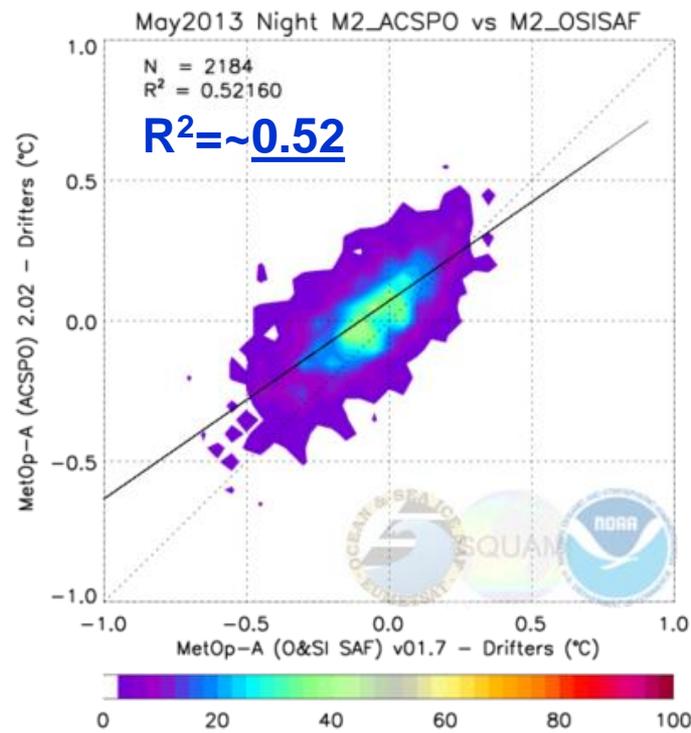


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State space: bivariate ρ



Residual space: bivariate ρ

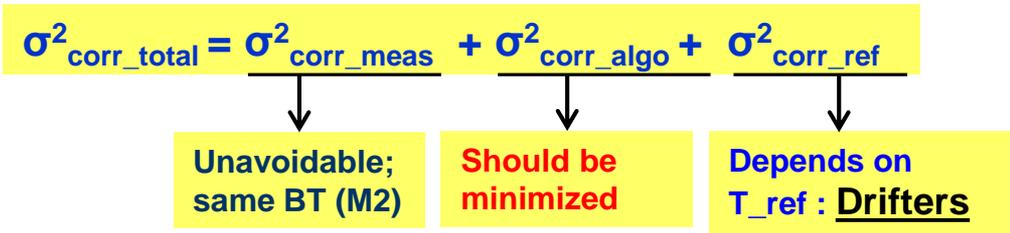


Ref: Drifters

$$x: \text{OSI SAF} = \text{SST_True} + \sigma_{\text{OSISAF}}$$

$$y: \text{ACSP0} = \text{SST_True} + \sigma_{\text{ACSP0}}$$

$\sigma_{\text{OSISAF}}, \sigma_{\text{ACSP0}}$ uncorrelated





3. Correlation of “independent” L2 SSTs (preliminary)

Implications: $\sigma^2_{\text{corr_total}} = \sigma^2_{\text{corr_meas}} + \sigma^2_{\text{corr_algo}} + \sigma^2_{\text{corr_ref}}$

- Sheds light on choice of T_{ref} (minimize $\sigma^2_{\text{corr_ref}}$), e.g., for night, **OSTIA and Drifters** show comparable corr. errors (for this particular L2-combination); ensures that it is 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): $\sigma^2_{\text{corr_algo}}$ should be low
 - For **different Sat** (e.g., M1, M2), **same proc**(e.g., ACSPO/OSISAF): $\sigma^2_{\text{corr_meas}} = 0$. 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!