GOES-R AWG Product Validation Tool Development

Sea Surface Temperature (SST) Team

Sasha Ignatov (STAR)

SST Cal/Val Team

- **Prasanjit Dash:** SST Quality Monitor (SQUAM; http://www.star.nesdis.noaa.gov/sod/sst/squam/)
  Working with **Nikolay Shabanov** on SQUAM-SEVIRI

- **Xingming Liang, Korak Saha:** Monitoring IR Clear-sky radiances over Oceans for SST (MICROS; http://www.star.nesdis.noaa.gov/sod/sst/micros/)

- **Feng Xu:** In situ Quality Monitor (iQuam; http://www.star.nesdis.noaa.gov/sod/sst/iquam/)

OUTLINE

- SST Products
- Validation Strategies
- Routine Validation Tools and Deep-Dive examples
- Ideas for the Further Enhancement & Utility of Validation Tools
  - get ready for JPSS and GOES-R
  - Include all available SST & BT products in a consistent way
  - keep working towards making iQuam, SQUAM, MICROS community tools (half way there)
  - Interactive display (currently, graphs are mostly static)
- Summary

Validation Strategies-1: SST tools should be…

- Automated; Near-Real Time; Global; Online
- QC and monitor in situ SST
  - Quality non-uniform & suboptimal
- Heritage validation against *in situ is a must but* should be supplemented with global consistency checks using L4 fields, because in situ data are
  - Sparse and geographically biased
  - Quality often worse than satellite SST
  - Not available in NRT in sufficient numbers
- Satellite brightness temperatures should be monitored, too
- Monitor our product in context of all other community products

Validation Strategies-3: Global NRT online tools

- In situ Quality Monitor (iQuam)
  http://www.star.nesdis.noaa.gov/sod/sst/iquam/
  - QC in situ SSTs
  - Monitor "in situ minus L4 SSTs"
  - Serve Qced in situ data to outside users via aftp

- SST Quality Monitor (SQUAM)
  http://www.star.nesdis.noaa.gov/sod/sst/squam/
  - Cross-evaluate various L2/L3/L4 SST (e.g., Reynolds, OSTIA), for long-term stability, self- and cross-product consistency
  - Validate L2/L3/L4 SSTs against Qced *in situ* SST data (iQuam)

- Monitoring IR Clear-sky Radiance over Oceans for SST (MICROS)
  http://www.star.nesdis.noaa.gov/sod/sst/micros/
  - Compare satellite BTs with CRTM simulation
  - Monitor M-O biases to check BTs for stability and cross-platform consistency
    - Unscramble SST anomalies; Validate CRTM; Feedback to sensor Cal

Validation Strategies-2: Work with SST increments

- *Satellite & reference SSTs are subject to (near)Gaussian errors*

  $T_{SAT} = T_{TRUE} + \varepsilon_{SAT}$; $\varepsilon_{SAT} = N(\mu_{sat}, \sigma_{sat}^2)$

  $T_{REF} = T_{TRUE} + \varepsilon_{REF}$; $\varepsilon_{REF} = N(\mu_{ref}, \sigma_{ref}^2)$

  where μ's and σ's are global mean and standard deviations of ε's

- *The residual's distributed is near-Gaussian*

  $\Delta T = T_{SAT} - T_{REF} = \varepsilon_{SAT} - \varepsilon_{REF}$; $\varepsilon_{\Delta T} = N(\mu_{\Delta T}, \sigma_{\Delta T}^2)$

  where $\mu_{\Delta T} = \mu_{sat} - \mu_{ref}$; $\sigma_{\Delta T}^2 = \sigma_{sat}^2 + \sigma_{ref}^2$

  (if ε_{SAT} and ε_{REF} are independent)

- *If $T_{REF} = T_{in\ situ}$, then it is customary 'validation'.*

- *If $T_{REF} = T_{L4}$, and (μ_{ref}, σ_{ref}) are comparable to ($\mu_{in\ situ}$, $\sigma_{in\ situ}$), and ε_{SAT} and ε_{REF} are uncorrelated, then T_{REF} can be used as a substitute of $T_{in\ situ}$ to monitor T_{SAT} ("consistency checks")*

- *Check T_{SAT} globally, for self- and cross-consistency*

SST products: Polar

- AVHRR
  - NESDIS ACSPO (Advanced Clear-Sky Processor for Oceans, new)
  - NESDIS MUT (Main Unit Task; heritage SST system designed in 1980s)
  - NAVO SeaTemp (builds on MUT heritage)
  - O&SI SAF (Lannion, Meteo France)
- MODIS
  - ACSPO MODIS (under testing)
  - U. Miami (MOD 28)
- VIIRS
  - ACSPO VIIRS (under testing with VIIRS Proxy)
  - Contractor SST (IDPS)
- (A)ATSR (planned)
- AMSRE (planned)

**NESDIS Products*

***Partners' Products*

SST products: Geo

- ACSPO SEVIRI (prototype for GOES-R ABI; Ignatov)
  - Regression
  - Hybrid
- NESDIS Operational (Eileen Maturi) – in testing
  - GOES
  - SEVIRI
  - MTSAT
- O&SI SAF SEVIRI (Pierre LeBorgne, Meteo France) – in testing
- NAVO Operational – in testing

**NESDIS Products*

***Partners' Products*

Routine Validation Tools

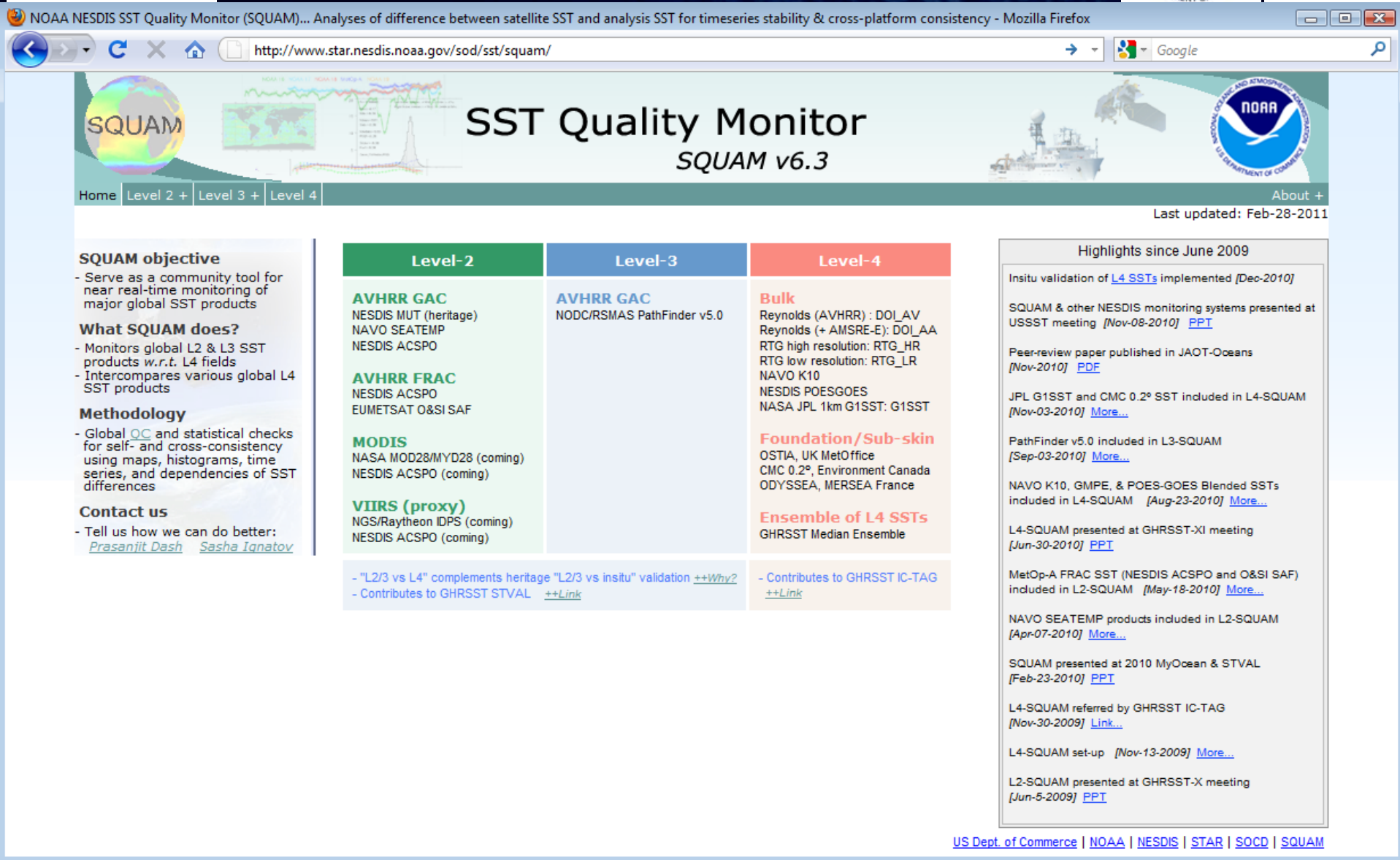
The SST Quality Monitor (SQUAM)

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

Routine Validation Tools: SQUAM Objectives

- Validate satellite L2/L3 SSTs against *in situ* data
  - Use iQuam Qced SST in situ SST as reference
- Monitor satellite L2/L3 SSTs against global L4 fields
  - for stability, self- and cross-product/platform consistency
  - on a shorter scales than heritage in situ VAL and in global domain
  - identify issues (sensor malfunction, cloud mask, SST algorithm, ..)
- Following request from L4 community, L4-SQUAM was also established, to cross-evaluate various L4 SSTs (~15) and validate against *in situ* data

Routine Validation Tools:
SQUAM Interface



Routine Validation Tools:
SQUAM : ROUTINE DIAGNOSTICS

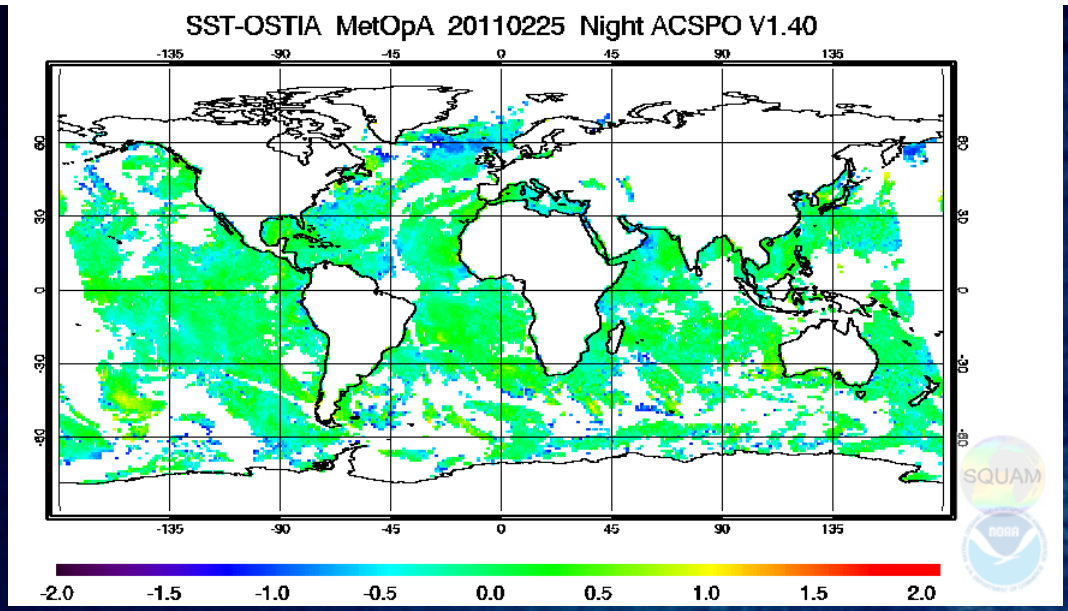
Tabs for analyzing ΔT_S ("SAT – L4" or "SAT – in situ"):

- *Maps*
- *Histograms*
- *Time series: Gaussian moments, outliers, double differences*
- *Dependencies on geophysical & observational parameters*
- *Hovmöller diagrams*

The SST Quality Monitor (SQUAM)
Journal of Atmospheric & Oceanic Technology, 27, 1899-1917, 2010

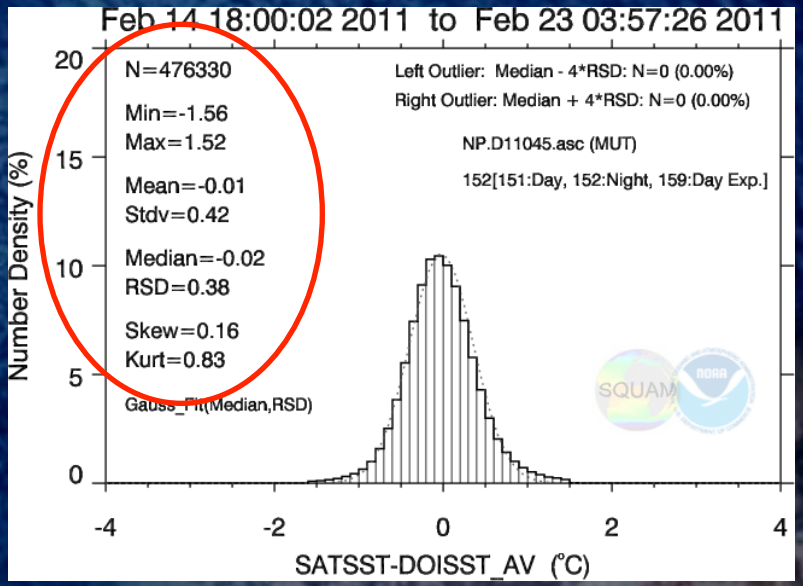
Routine Validation Tools:

SQUAM : Maps, Histograms - Polar



NESDIS Metop-A FRAC SST minus OSTIA

Maps are used to assess performance of global satellite SST "at a glance"



More FRAC analyses at:

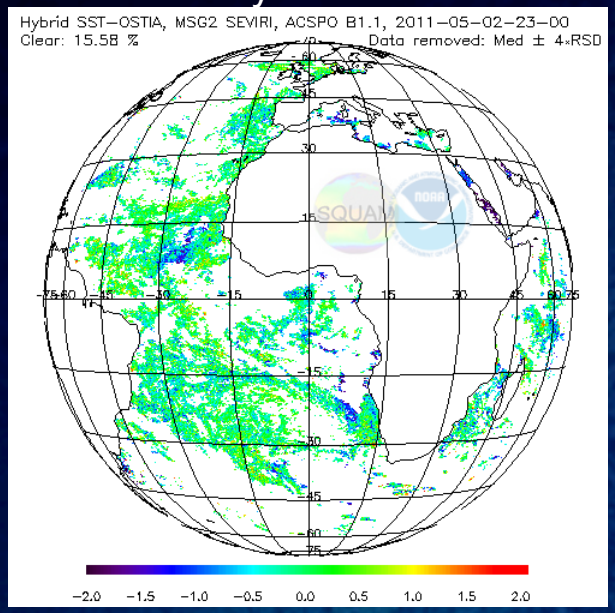
http://www.star.nesdis.noaa.gov/sod/sst/squam/FRAC

Gaussian parameters and outlier info are used in time-series plots

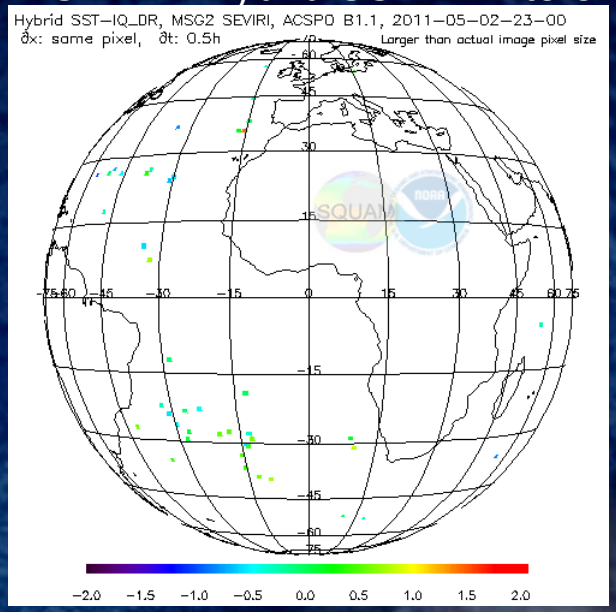
Routine Validation Tools:

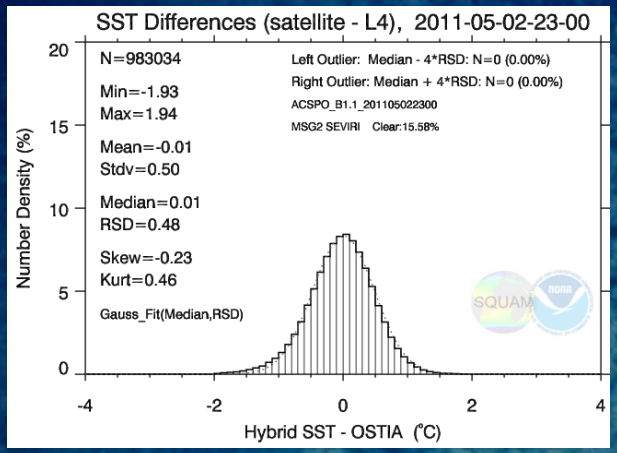
SQUAM : Maps, Histograms - SEVIRI

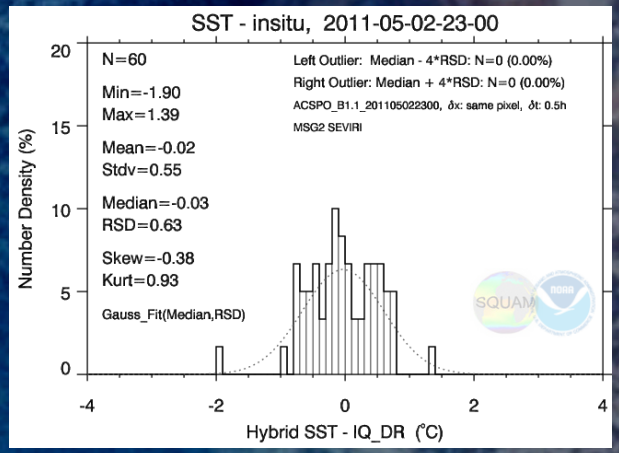
SEVIRI Hybrid SST - OSTIA



SEVIRI Hybrid SST - Drifters

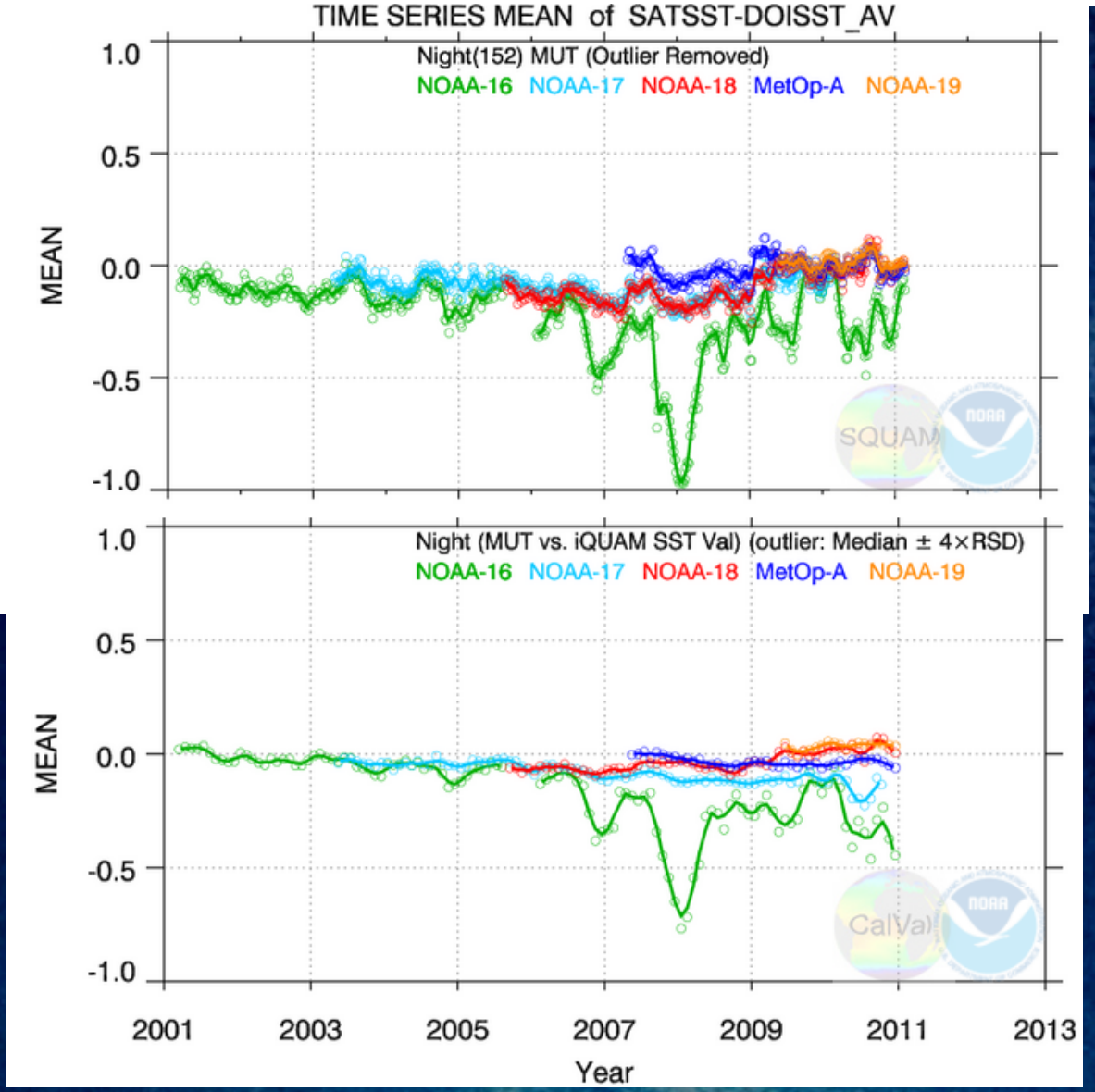






Routine Validation Tools:

SQUAM : Time Series - Polar



MUT AVHRR - Reynolds

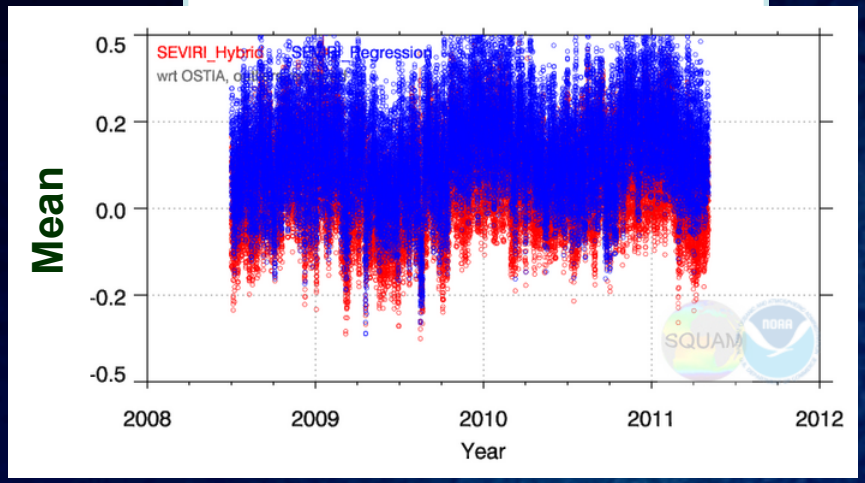
Night SST vs. Reynolds (each point ~1 week)

Night SST val. Vs. in situ (each point ~1 month)

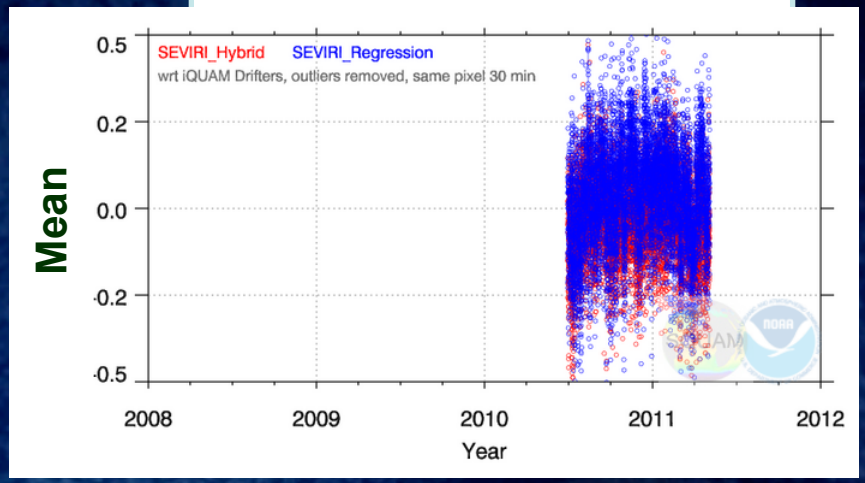
Routine Validation Tools:

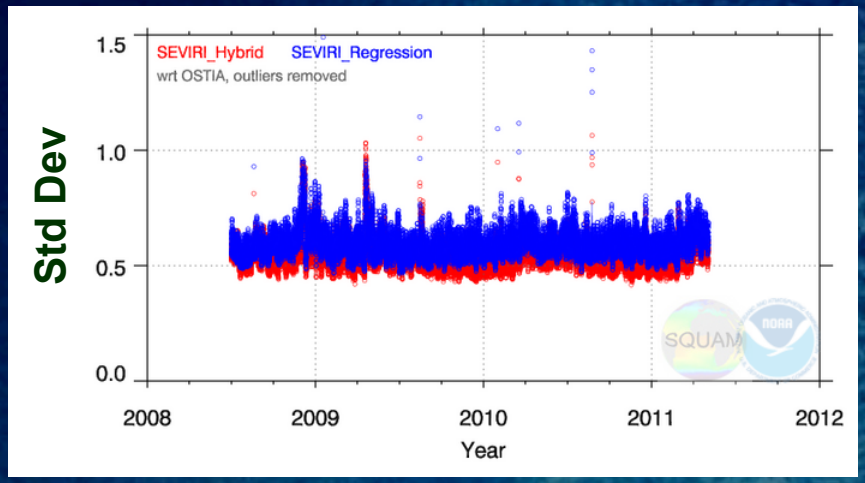
SQUAM : Time Series - SEVIRI

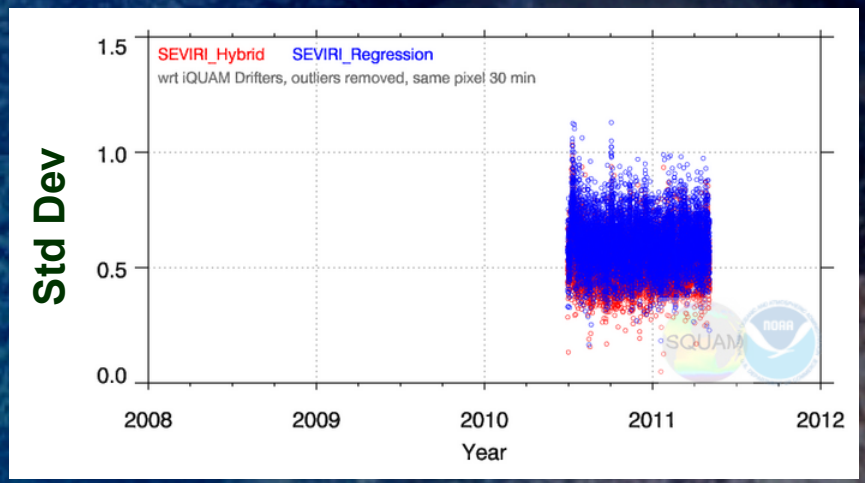
Statistics wrt. OSTIA



Statistics wrt. Drifters

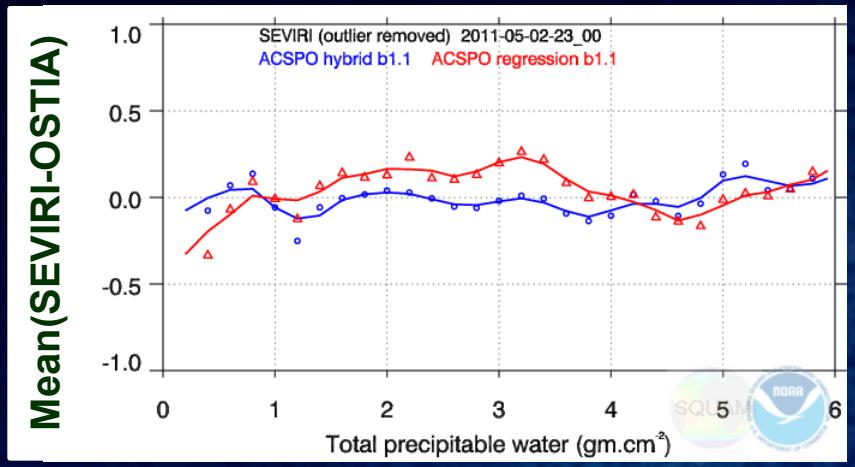


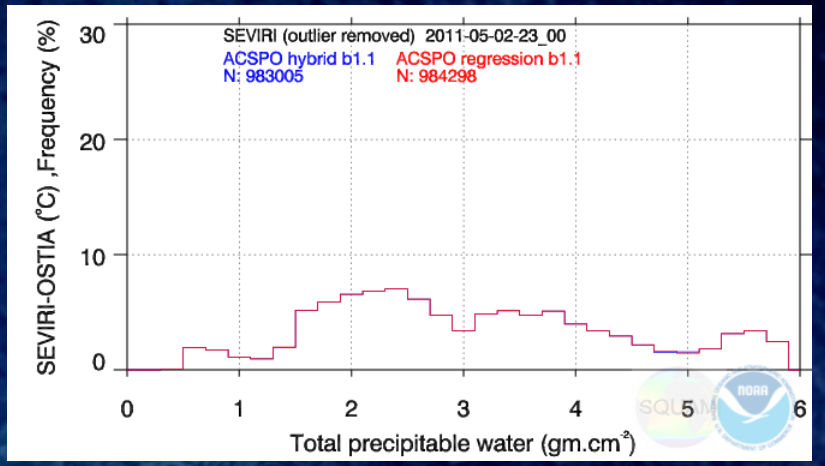


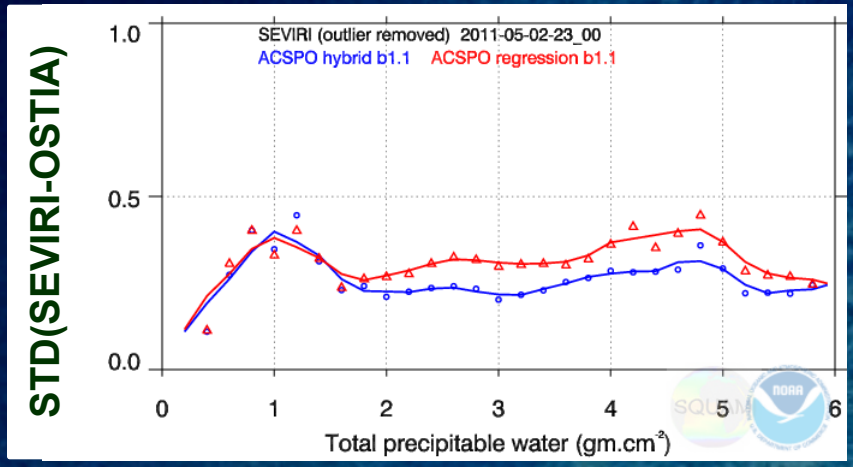


Hybrid SST — Regression SST

"Deep-Dive" Val. Tools :
SEVIRI-SQUAM (Dependency plots)

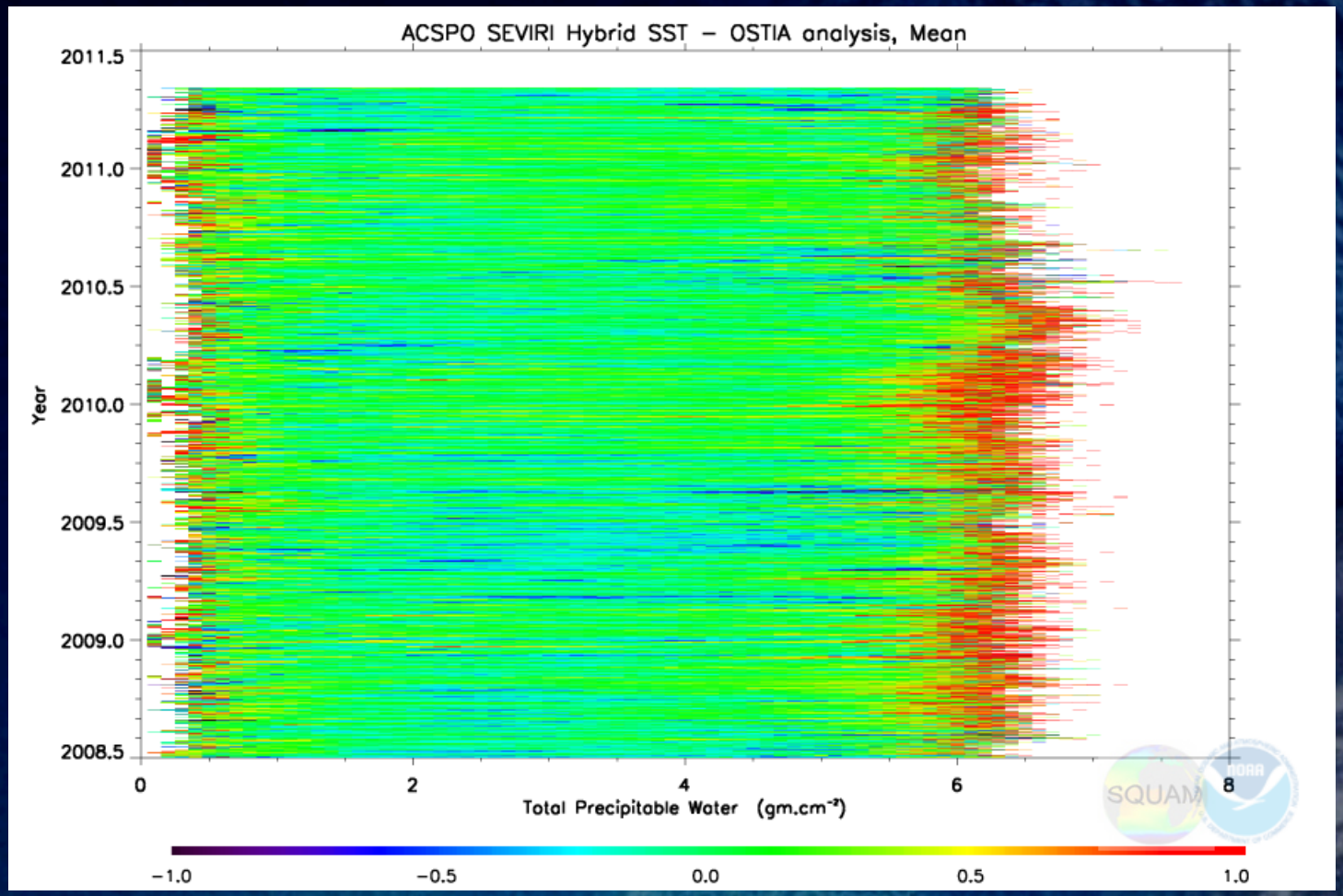






Objective: Maximally uniform sample & performance across retrieval space

”Deep-Dive” Val. Tools :
SEVIRI-SQUAM Hovmoller



Dependency of Hybrid SST vs. TPW.

More at SEVIRI SQUAM web:

http://www.star.nesdis.noaa.gov/sod/sst/squam/SEV/

More on SQUAM

- Demo follows
- Publications

- Dash, P., A. Ignatov, Y. Kihai, and J. Sapper, 2010: *The SST Quality Monitor (SQUAM)*. *JTech*, 27, doi: 10.1175/2010JTECHO756.1, 1899-1917.
- Martin, M., P. Dash, A. Ignatov, C. Donlon, A. Kaplan, R. Grumbine, B. Brasnett, B. McKenzie, J.-F. Cayula, Y. Chao, H. Beggs, E. Maturi, C. Gentemann, J. Cummings, V. Banzon, S. Ishizaki, E. Autret, D. Poulter. 2011: *Group for High Resolution SST (GHRSST) Analysis Fields Inter-Comparisons: Part 1. A Multi-Product Ensemble of SST Analyses (prep)*
- P. Dash, A. Ignatov, M. Martin, C. Donlon, R. Grumbine, B. Brasnett, D. May, B. McKenzie, J.-F. Cayula, Y. Chao, H. Beggs, E. Maturi, A. Harris, J. Sapper, T. Chin, J. Vazquez, E. Armstrong, 2011: Group for High Resolution SST (GHRSST) Analysis Fields Inter-Comparisons: Part2. Near real time web-based L4 SST Quality Monitor (L4-SQUAM) (prep)

Routine Validation Tools

MICROS

Monitoring of IR Clear-sky Radiances over Oceans for SST

http://www.star.nesdis.noaa.gov/sod/sst/micros

Routine Validation Tools: MICROS Objectives

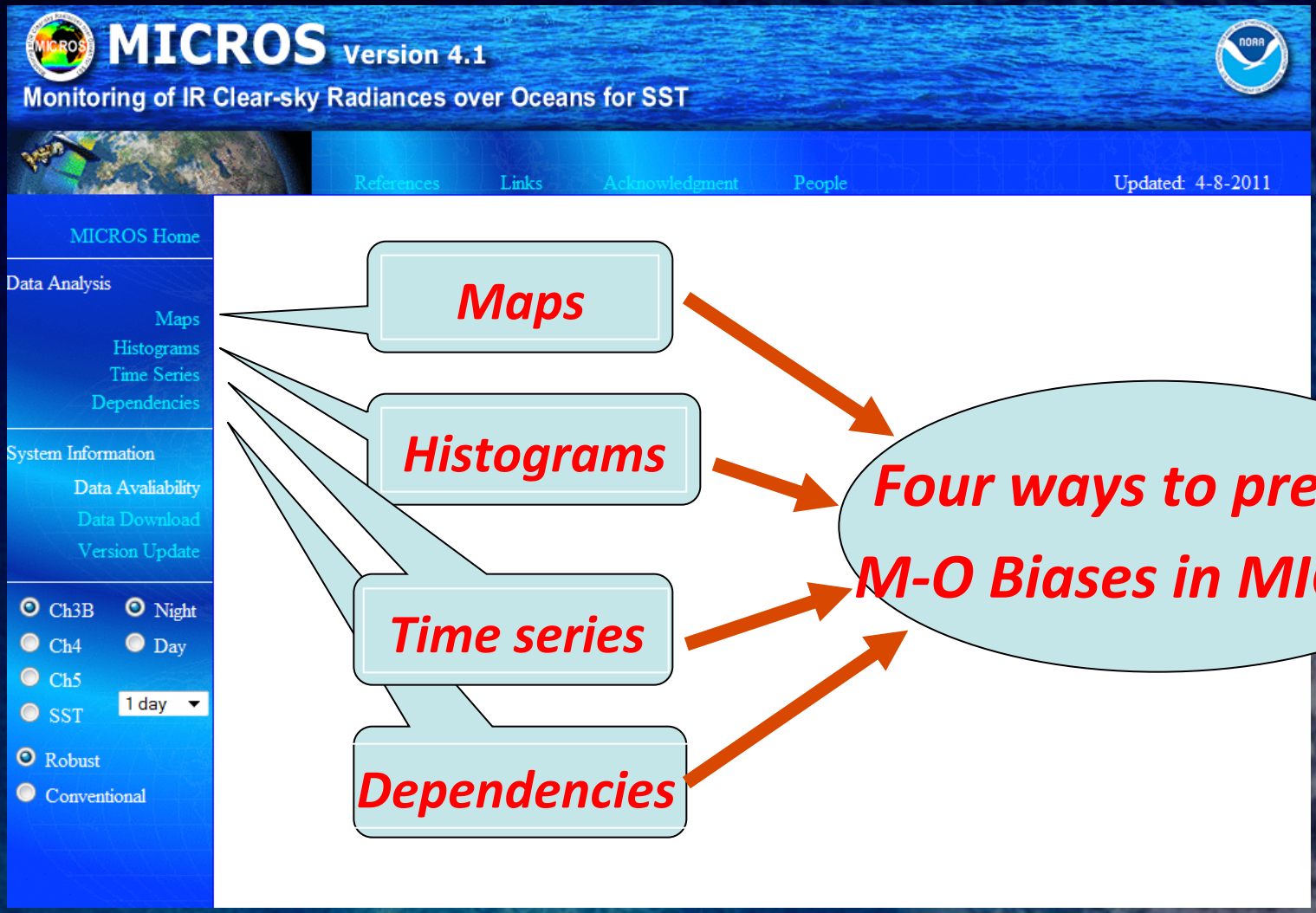
- Monitor in NRT clear-sky sensor radiances (BTs) over global ocean ("OBS") for stability and cross-platform consistency, against CRTM with first-guess input fields ("Model")

- Fully understand & minimize M-O biases in BT & SST (minimize need for empirical 'bias correction')
  - Diagnose SST products
  - Validate CRTM performance
  - Evaluate sensor BTs for Stability and Cross-platform consistency

Platforms/Sensors monitored in MICROS

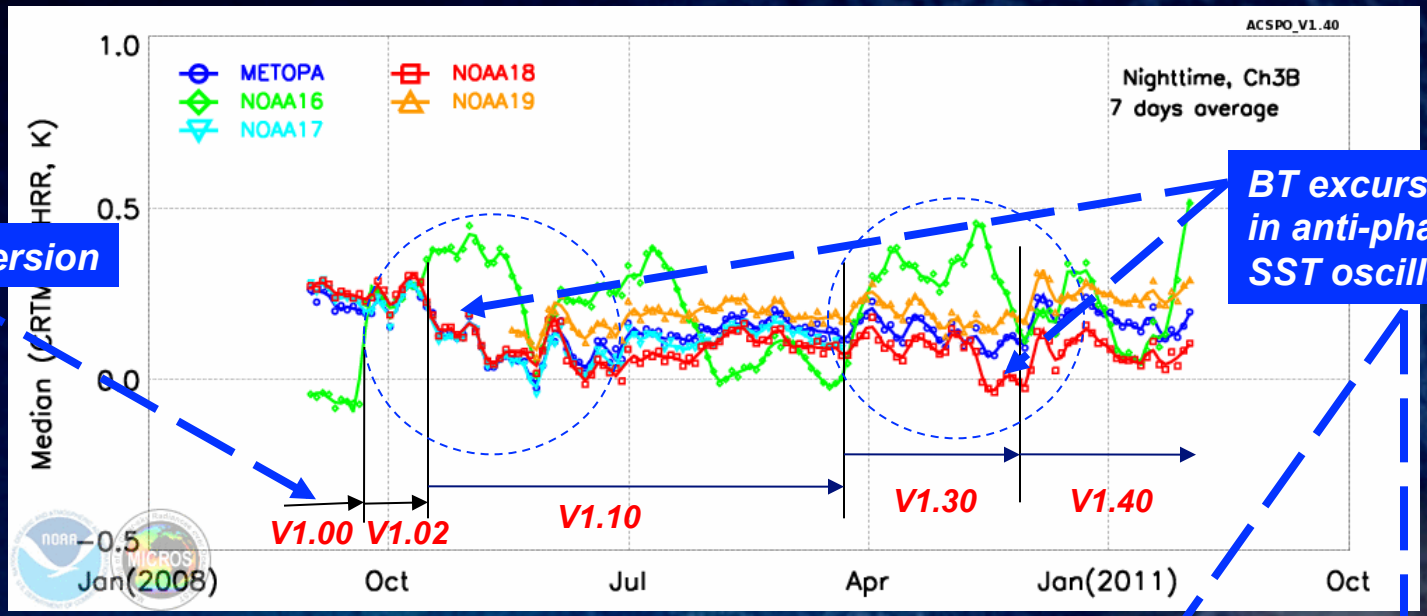
- Routinely processing AVHRR Jul' 2008-on
  - Metop-A (GAC and FRAC - Good)
  - NOAA19 (Good)
  - NOAA18 (Good)
  - NOAA17 (stopped processing 2/10; sensor issues)
  - NOAA16 (out of family)
- Under testing / In pipeline
  - VIIRS Proxy
  - MODIS (Terra & Aqua)
  - MSG/SEVIRI

Ways to present M-O Bias



Routine Validation 1: Time series

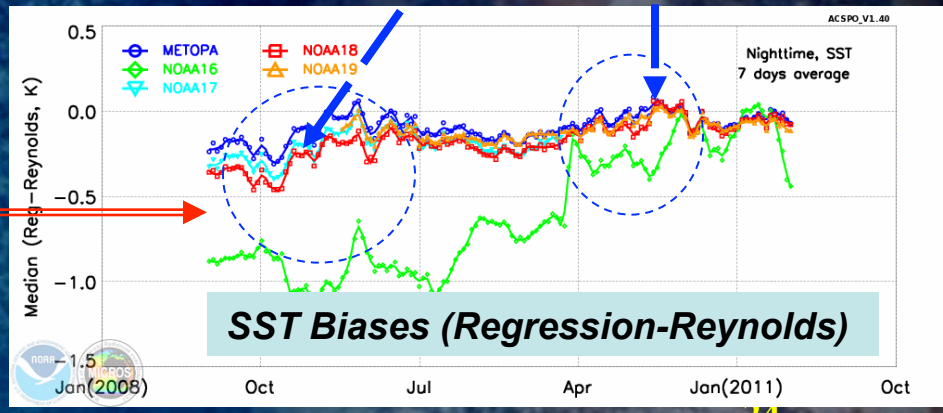
M-O bias in Ch3B



ACSPO version

BT excursions occur in anti-phase with SST oscillations

- *Warm M-O biases: Combined effect of: Missing aerosols; Using bulk SST (instead of skin); Using daily mean Reynolds SST (to represent nighttime SST); Residual cloud.*
- *Unstable M-O biases: Due to unstable Reynolds SST input to CRTM.*
- *N16: Out of family/Unstable (CAL problems).*
- *N17: Scan motor spiked in Feb'2010.*



SST Biases (Regression-Reynolds)

Routine Validation 2: Double Differences

Cross-platform consistency

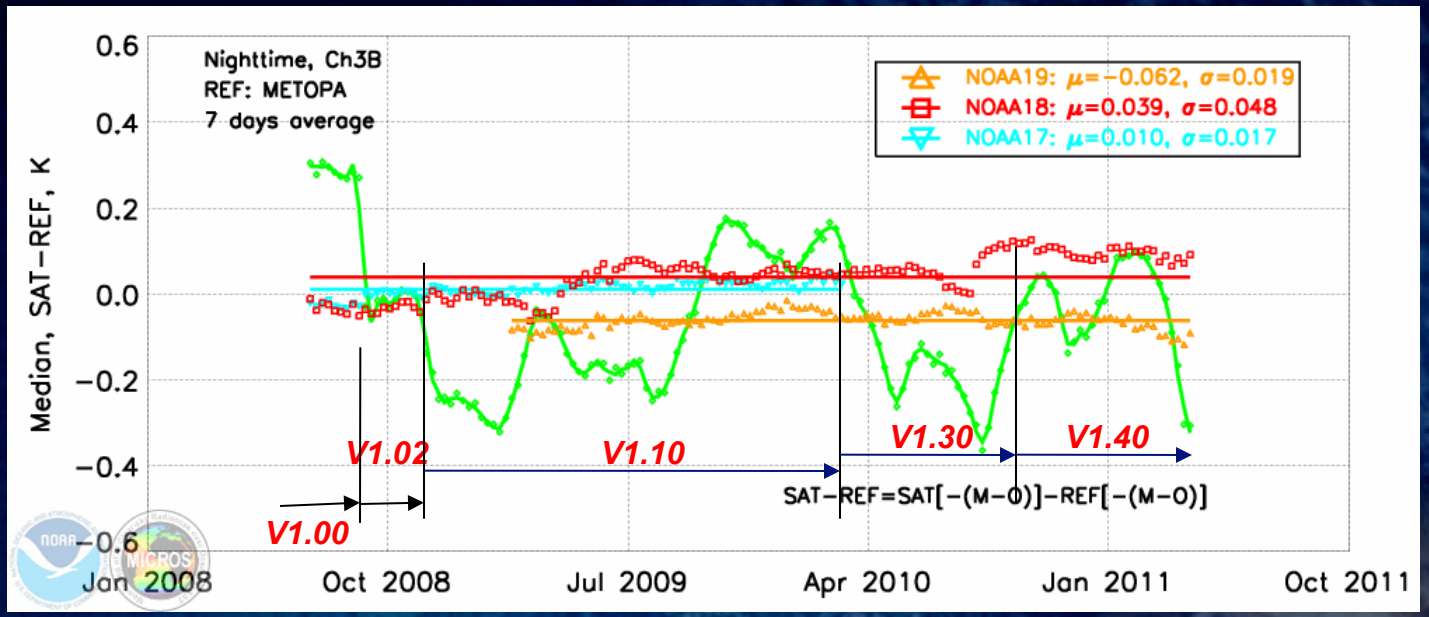
- *Double-differencing (DD) technique employed to rectify the "cross-platform bias" signal from "noise"*

$$SAT - REF = SAT[-(M - O)] - REF[-(M - O)]$$

- *Metop-A used as a Reference Satellite (Stable)*
- *CRTM is used as a 'Transfer Standard'.*
- *DDs cancel out/minimize effect of systematic errors & instabilities in BTs arising from e.g.:*
  - *Errors/Instabilities in reference SST & GFS*
  - *Missing aerosol*
  - *Possible systemic biases in CRTM*
  - *Updates to ACSPO algorithm*

Routine Validation 3: Double Differences

Cross-platform consistency in Ch3B



- *Metop-A used as a Reference Satellite (Stable)*
- *CRTM is used as a 'Transfer Standard'.*
- *DDs cancel out most errors/noise in M-O biases*
- *Relative to Metop-A , biases are*
  - *N17: +0.01 ± 0.02 K (stopped working Feb'10)*
  - *N18: +0.04 ± 0.05 K*
  - *N19: -0.06 ± 0.02 K*
  - *N16: unstable*

More on MICROS

- Demo follows
- Publications

- **Liang, X., and A. Ignatov, 2011: Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS). JTech, in press.**
- **Liang, X., A. Ignatov, and Y. Kihai, 2009: Implementation of the Community Radiative Transfer Model (CRTM) in Advanced Clear-Sky Processor for Oceans (ACSPO) and validation against nighttime AVHRR radiances. JGR,114, D06112, doi:10.1029/2008JD010960.**

Summary

- Three near-real time online monitoring tools developed by SST team
  - In situ Quality Monitor (iQuam)
  - SST Quality Monitor (SQUAM)
  - Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS)
- iQuam performs the following functions (ppt available upon request)
  - QC in situ SST data
  - Monitor Qced data on the web in NRT
  - Serve Qced data to outside users
- SQUAM performs the following functions
  - Monitors available L2/L3/L4 SST products for self- and cross-consistency
  - Validates them against in situ SST (iQuam)
- MICROS performs the following functions
  - Validates satellite BTs associated with SST against CRTM simulations
  - Monitors global "M-O" biases for self- and cross-consistency
    - "SST": Facilitate SST anomalies diagnostics
    - "CRTM": Validate CRTM
    - "Sensor": Validate satellite radiances for stability & cross-platform consistency