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NPP VIIRS SST Algorithm and Cal/Val Activities at NOAA/NESDIS

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NOAA/NESDIS, CIRA, NRL, NGAS

JPSS SST Team:

Doug May (NAVO), Bob Evans and Peter Minnett (U. Miami/RSMAS), Pierre LeBorgne (Meteo France)

JPSS VIIRS SST

JPSS/NPP

- ✓ JPSS: US - European Cooperation
- ✓ NPP: Link between NOAA/POES & NASA/EOS – and JPSS
- ✓ Successfully launched on 28 October 2011
- ✓ To be followed by JPSS-1 (2015) and JPSS-2 (2018)
- ✓ European contribution – Metop AVHRR

Cal/Val

- ✓ 2008: Ocean Cal/Val Team (SST/Color) formed. Lead Bob Arnone
- ✓ SST Cal/Val Team: Arnone, May, Minnett, Evans, Ignatov

IDPS Algorithm

- ✓ Developed by Northrop Grumman Aerospace Systems (NGAS)
- ✓ Run by Raytheon Interface Data Processing Segment (IDPS)
- ✓ Effective 2011, NESDIS/STAR in charge of JPSS Algorithms
  SST Algorithm Team: Ignatov (STAR), May (NAVO),
  Minnett and Evans (U. Miami), LeBorgne (EUMETSAT)

Global Polar SST Systems and Products

Raytheon: IDPS (No Radiative Transfer Model - RTM)

- ✓ Regression Non-Linear SST (NLSST)
- ✓ VIIRS Cloud Mask (VCM)

NESDIS: ACSPO (Advanced Clear-Sky Processor for Oceans) (RTM)

- ✓ Regression SST (RTM-based under testing)
- ✓ Cloud mask/QC: RTM-based
- ✓ Runs with AVHRR (GAC, FRAC), MODIS, VIIRS

Meteo France O&SI SAF: Metop/AVHHR FRAC (RTM)

- ✓ Regression SST (RTM based under testing)
- ✓ Heritage cloud mask

NAVO: SEATEMP (No RTM)

- ✓ Regression SST & Heritage cloud mask

U. Miami/RSMAS: MODIS/AVHHR Pathfinder (No RTM)

- ✓ Regression SST & Heritage cloud mask

Current Priority: Evaluate IDPS vs. other BTs/SSTs

SST Quality Monitor (SQUAM)

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

- ✓ Global validation against various L4s and *in situ* SST
- ✓ Double-Differences (Cross-Platform & Product Consistency)

In situ SST Quality Monitor (iQuam)

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

- ✓ QC *in situ* SST (drifters, moorings, ships)
- ✓ Web: Display summary statistics & Distribute QC'ed data to users

Monitoring IR Clear-sky Radiances over Oceans for SST (MICROS)

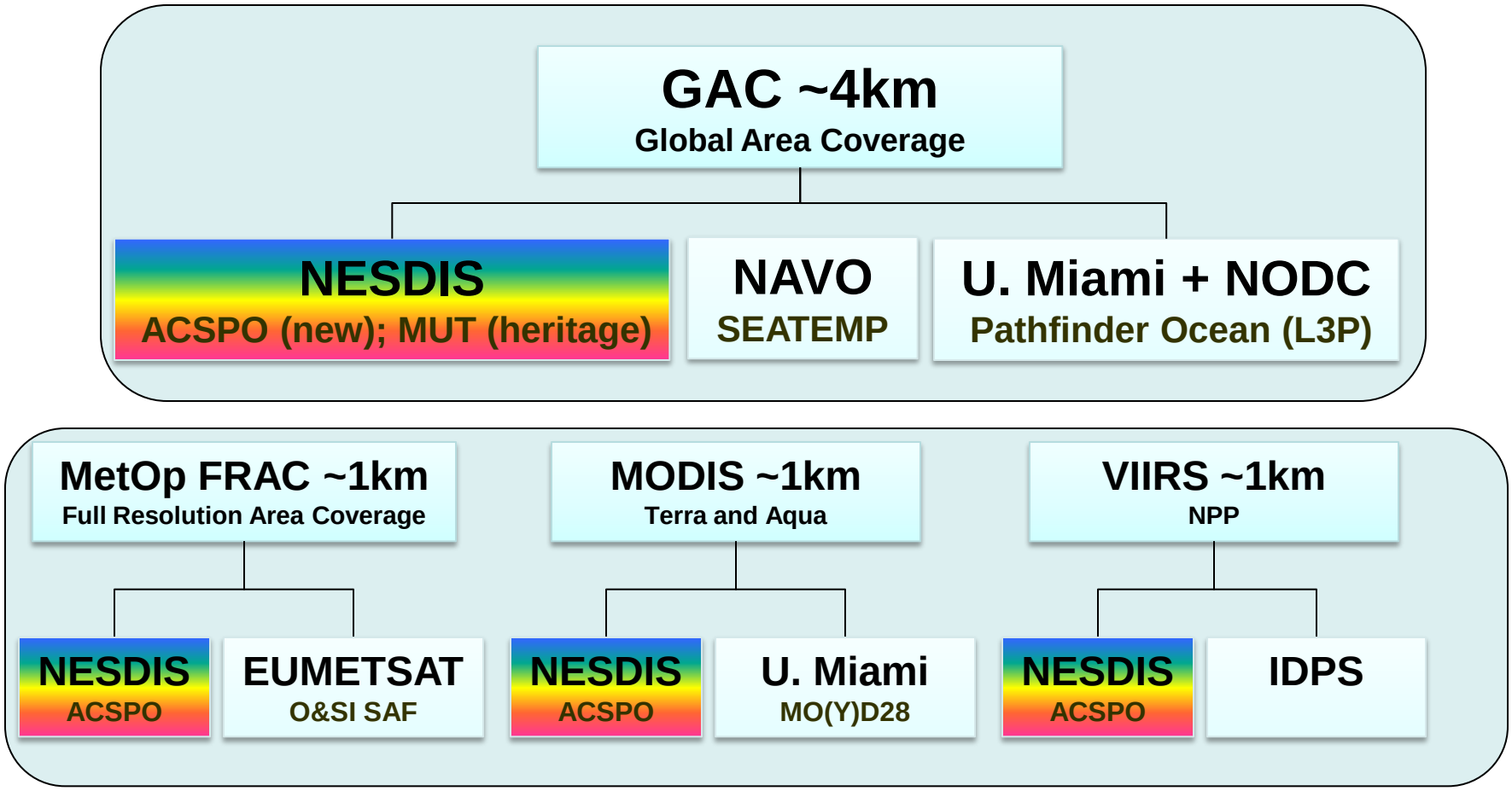
http://www.star.nesdis.noaa.gov/sod/sst/micros/

- ✓ Monitor clear-sky ocean Brightness Temperatures vs. CRTM
- ✓ Check for consistency with AVHRR/MODIS using Double-Differencing

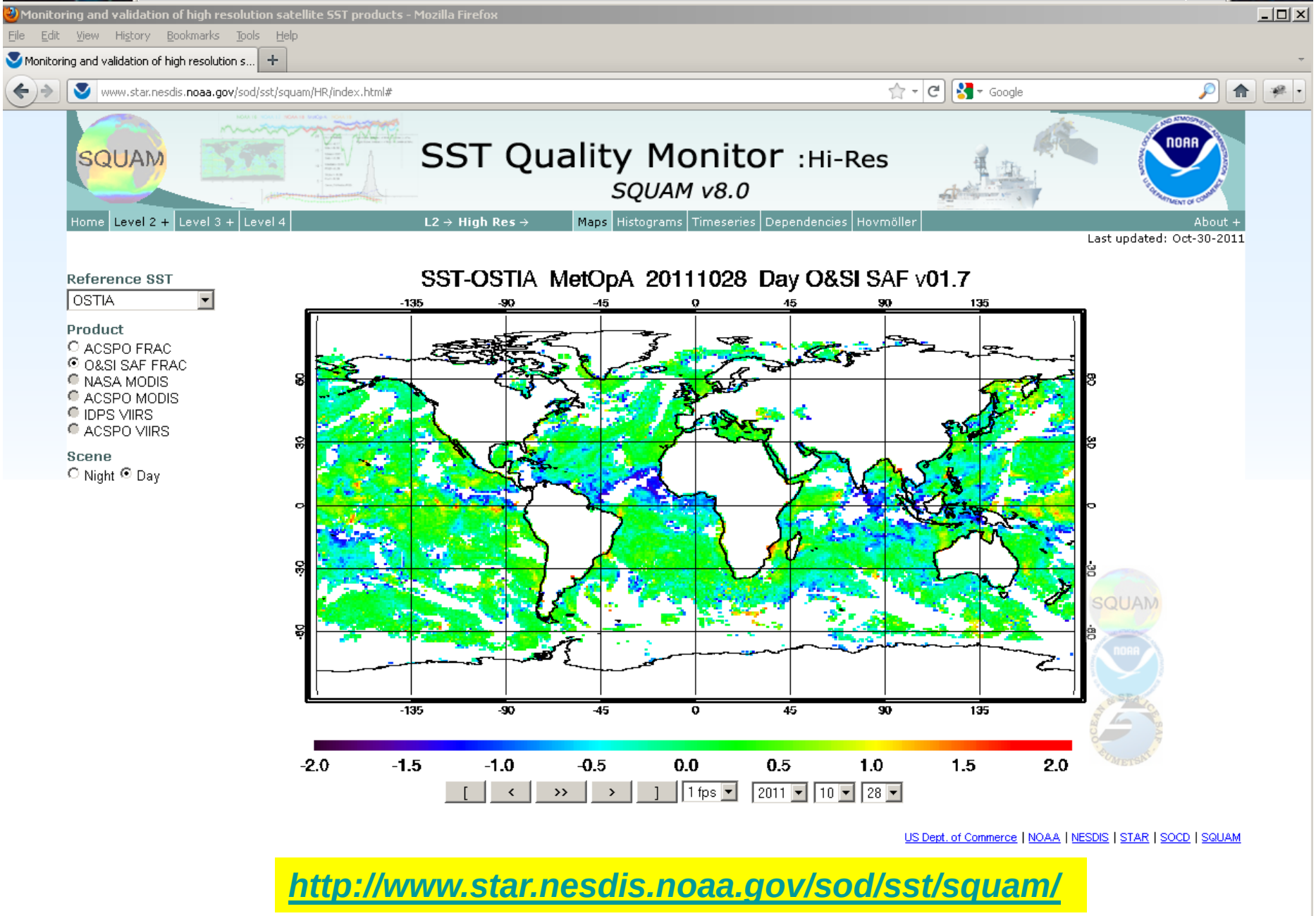
Unidirectional Variational Destriping Model (UVDM)

- ✓ Check MODIS/VIIRS BTs/SSTs for stripiness; Destripe

L2 SST Products in SQUAM

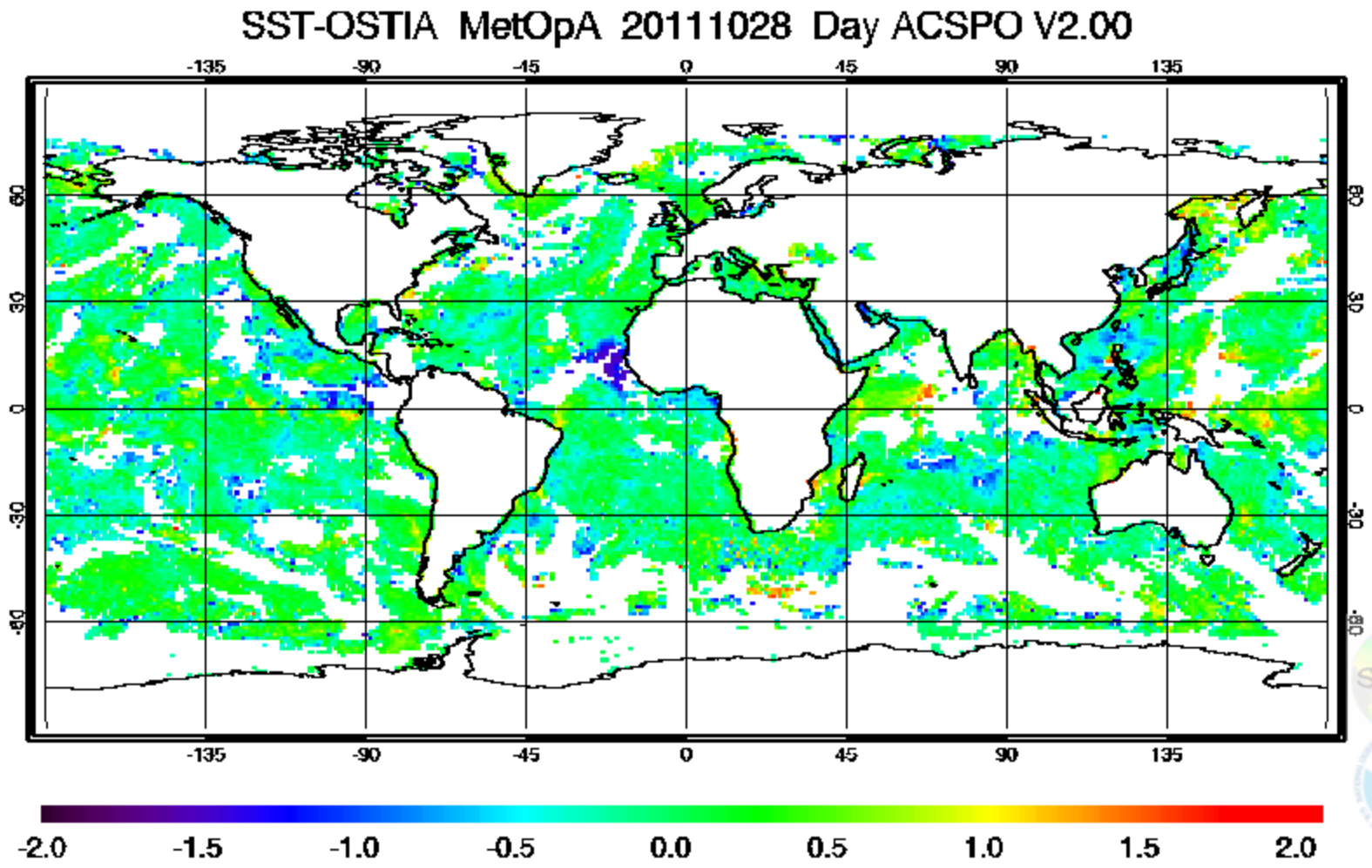


Cross-evaluate IDPS SST against ACSPO and against other available L2 AVHRR SST products



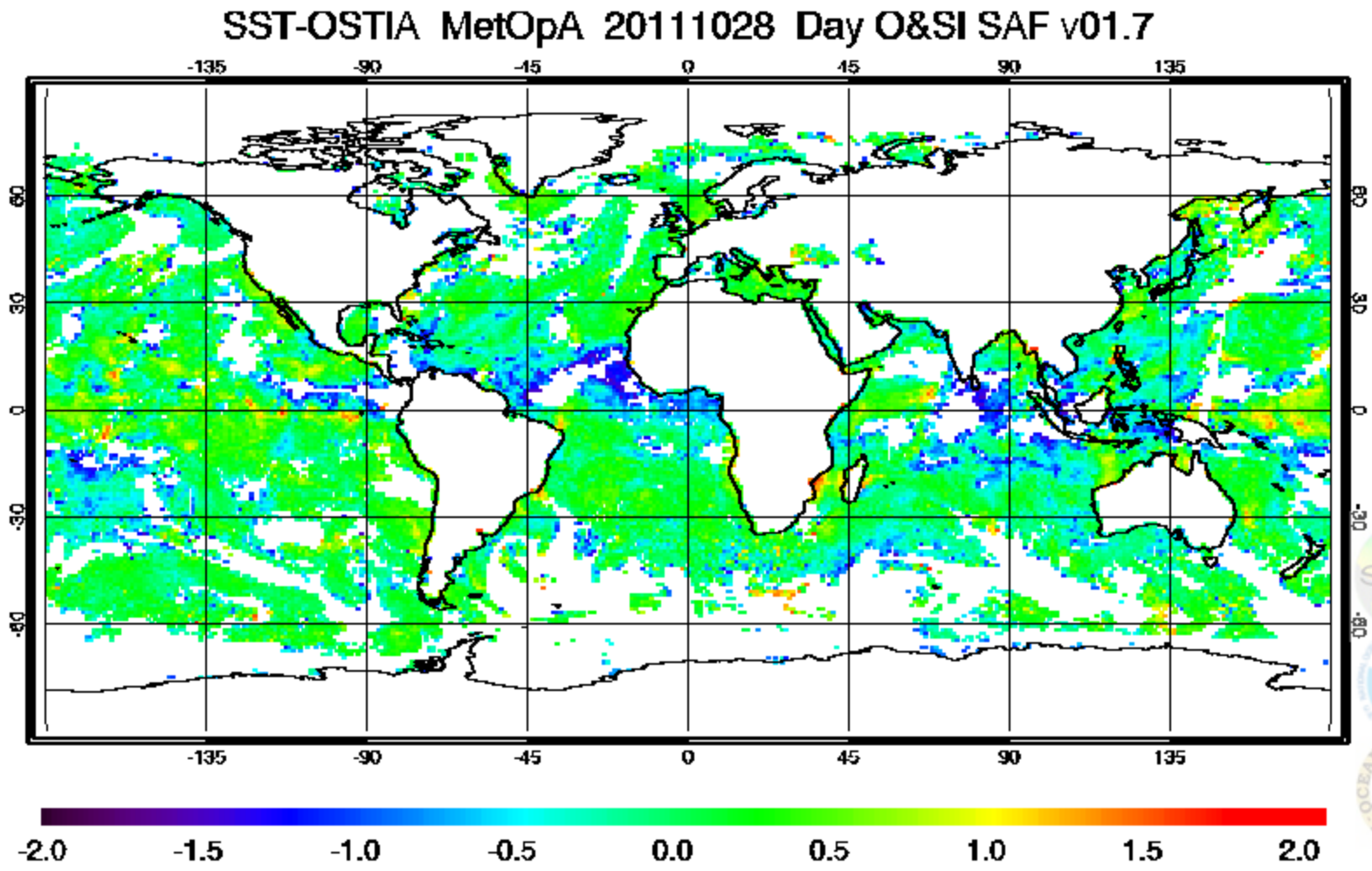
http://www.star.nesdis.noaa.gov/sod/sst/squam/

ACSPO SST minus OSTIA (Daytime)



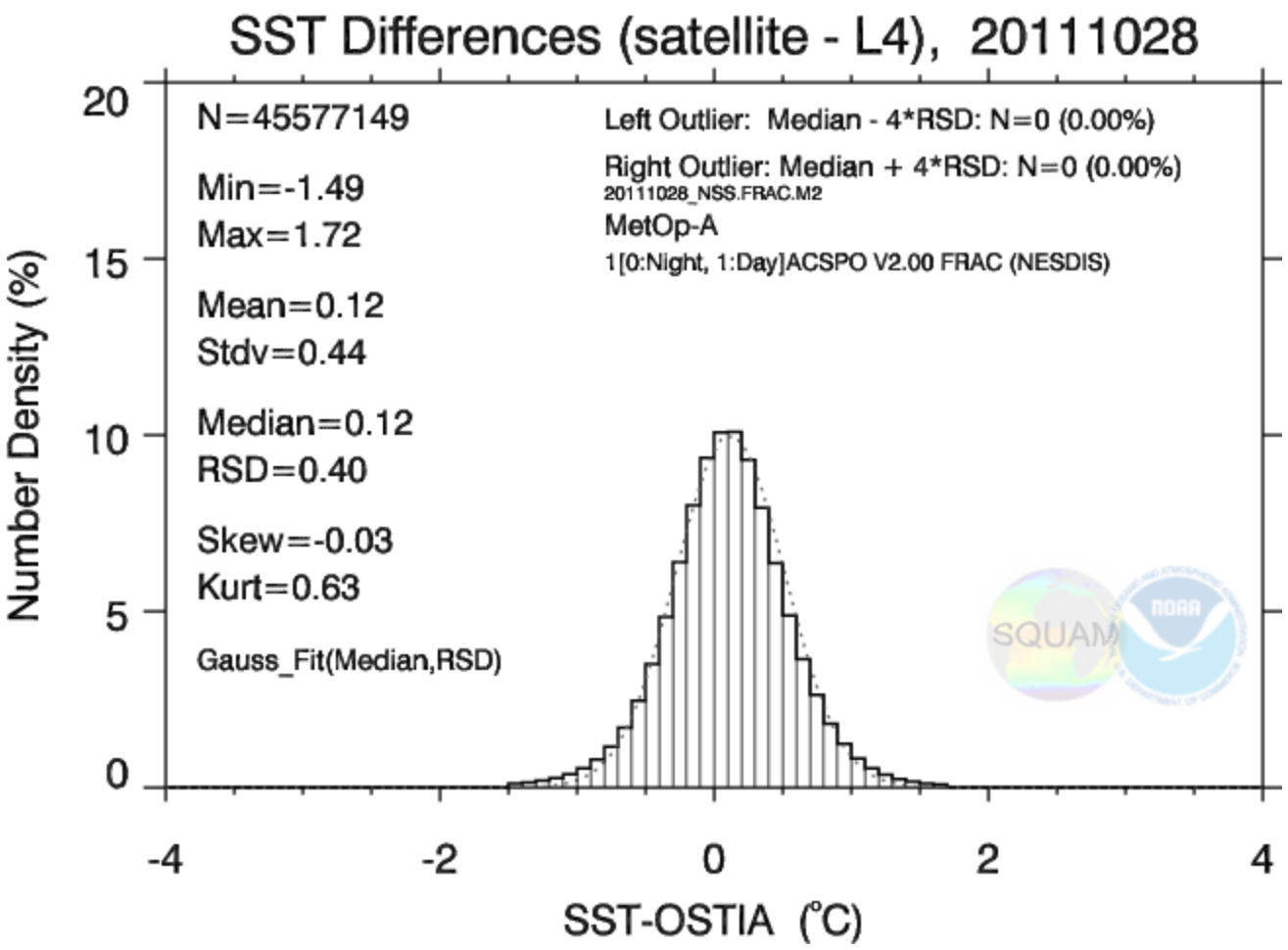
Referencing L2 to an L4 gives a quick snapshot of L2 product well-being

O&SI SAF SST minus OSTIA (Daytime)



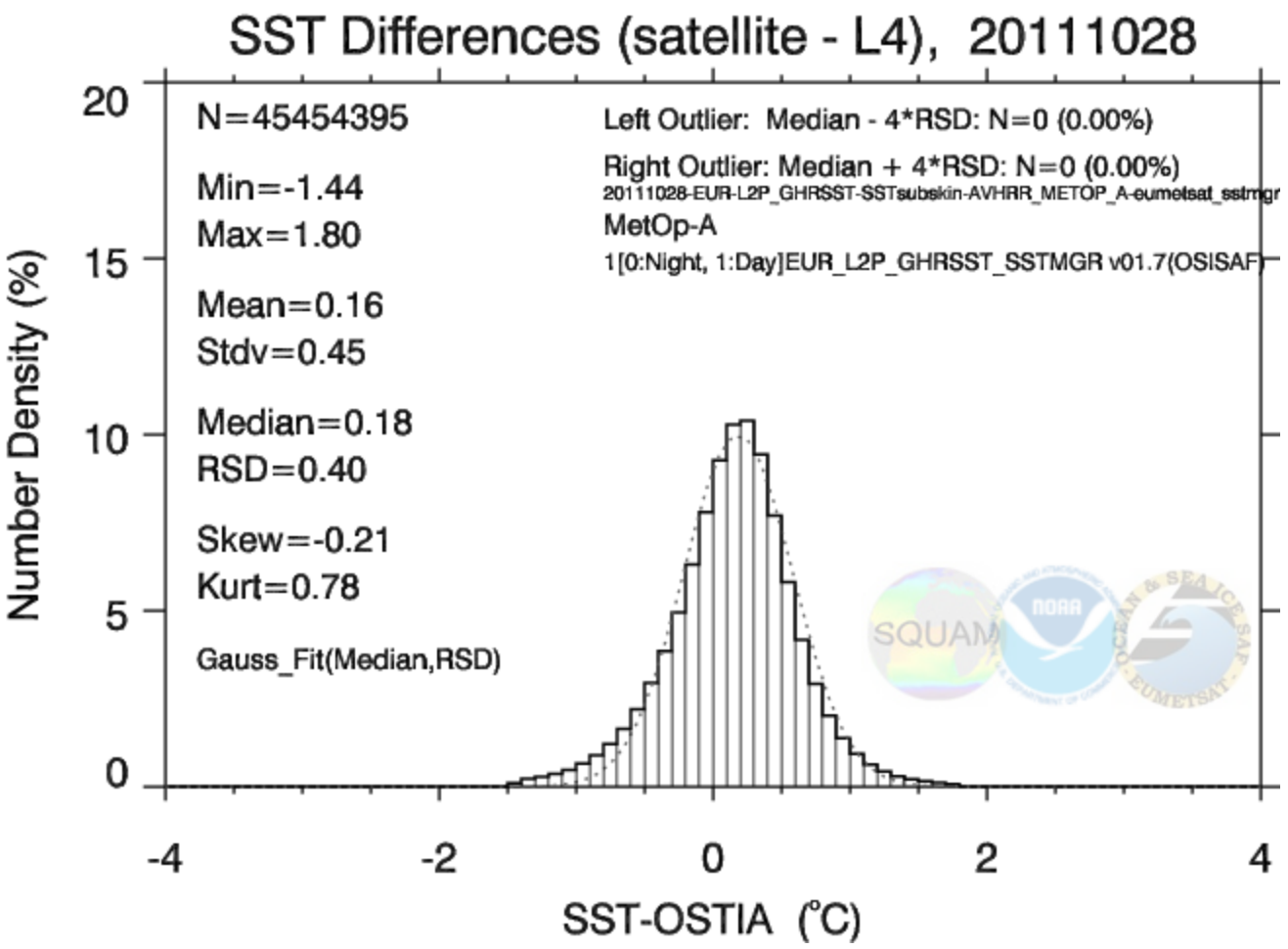
Warm Δs expected during daytime. Cold Δs may indicate residual cloud

ACSPO SST minus OSTIA (Daytime)



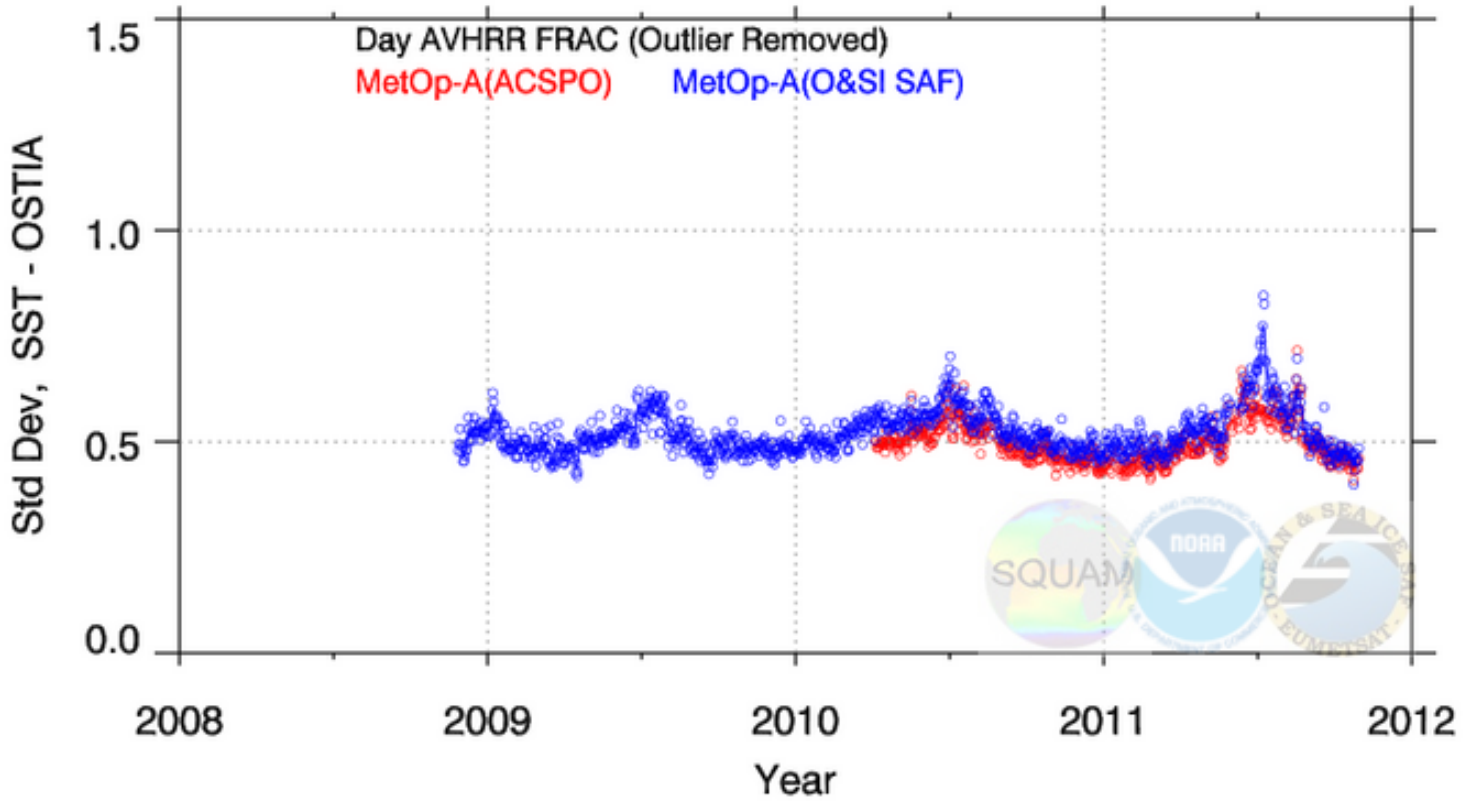
Histograms of Δs are near-Gaussian and centered at zero

O&SI SAF SST minus OSTIA (Daytime)



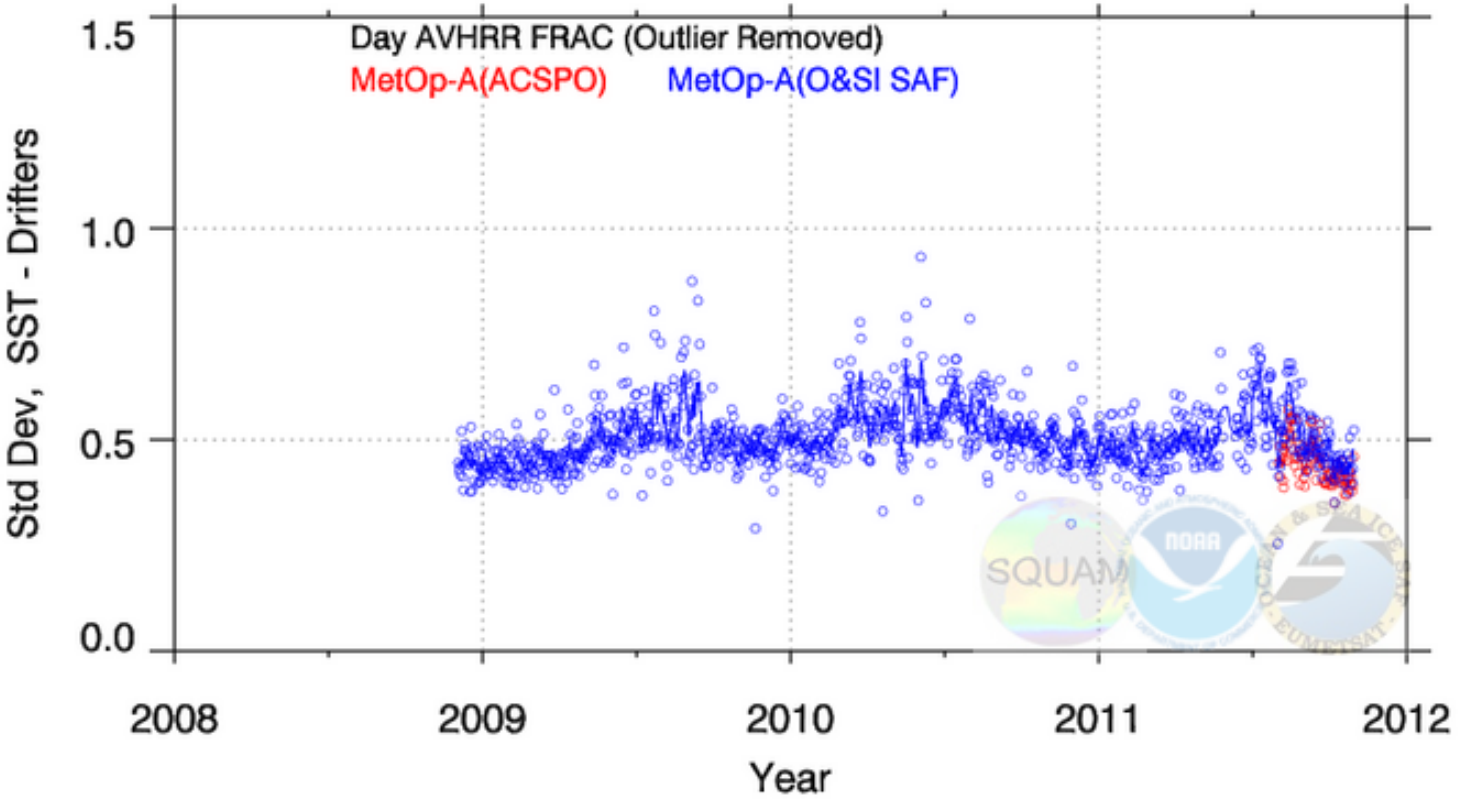
Moments of histograms are used to cross-evaluate different products

STD “AVHRR minus OSTIA” (Daytime)



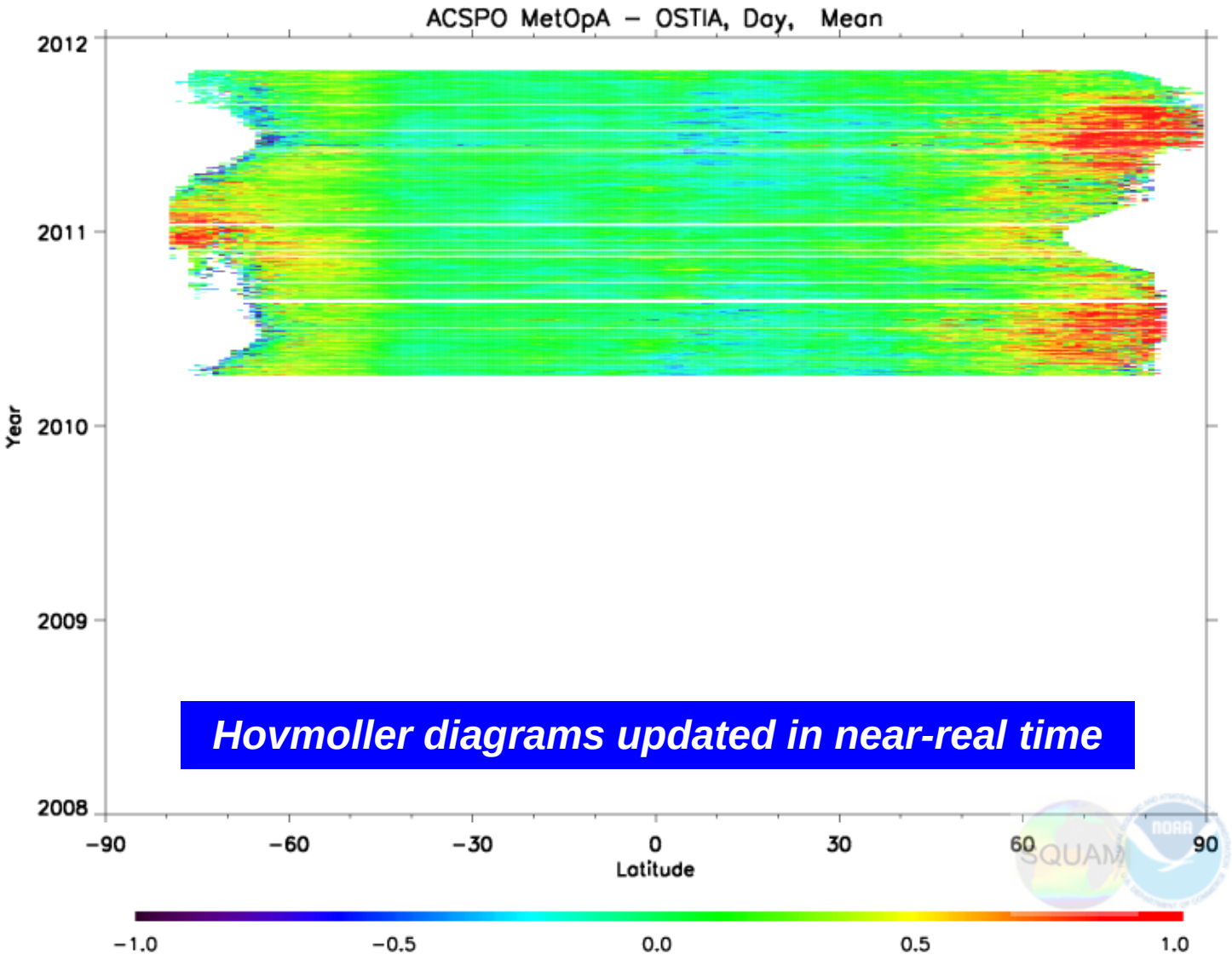
L2-L4 statistics are automatically trended in near-real time

STD “AVHRR minus Drifters” (Daytime)



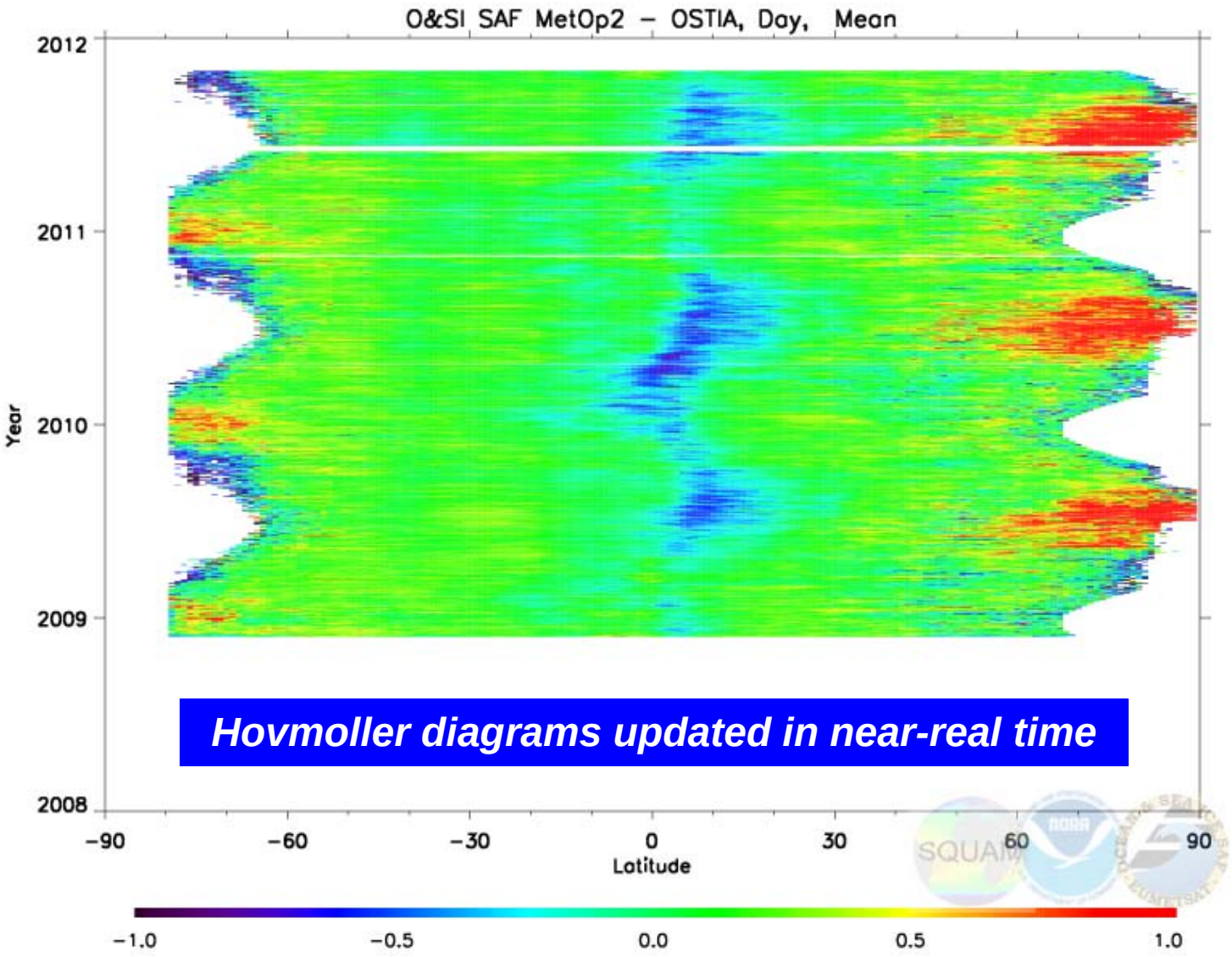
Similar analyses are performed in L2 minus in situ space

Mean “ACSPO minus OSTIA” (Daytime)



Hovmoller diagrams updated in near-real time

Mean “O&SI SAF minus OSTIA” (Daytime)



Hovmoller diagrams updated in near-real time

iQuam - in situ SST quality monitoring - Mozilla Firefox

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iQuam - in situ SST quality monitoring

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

NOAA NESDIS STAR

iQUAM *in situ* SST quality monitor

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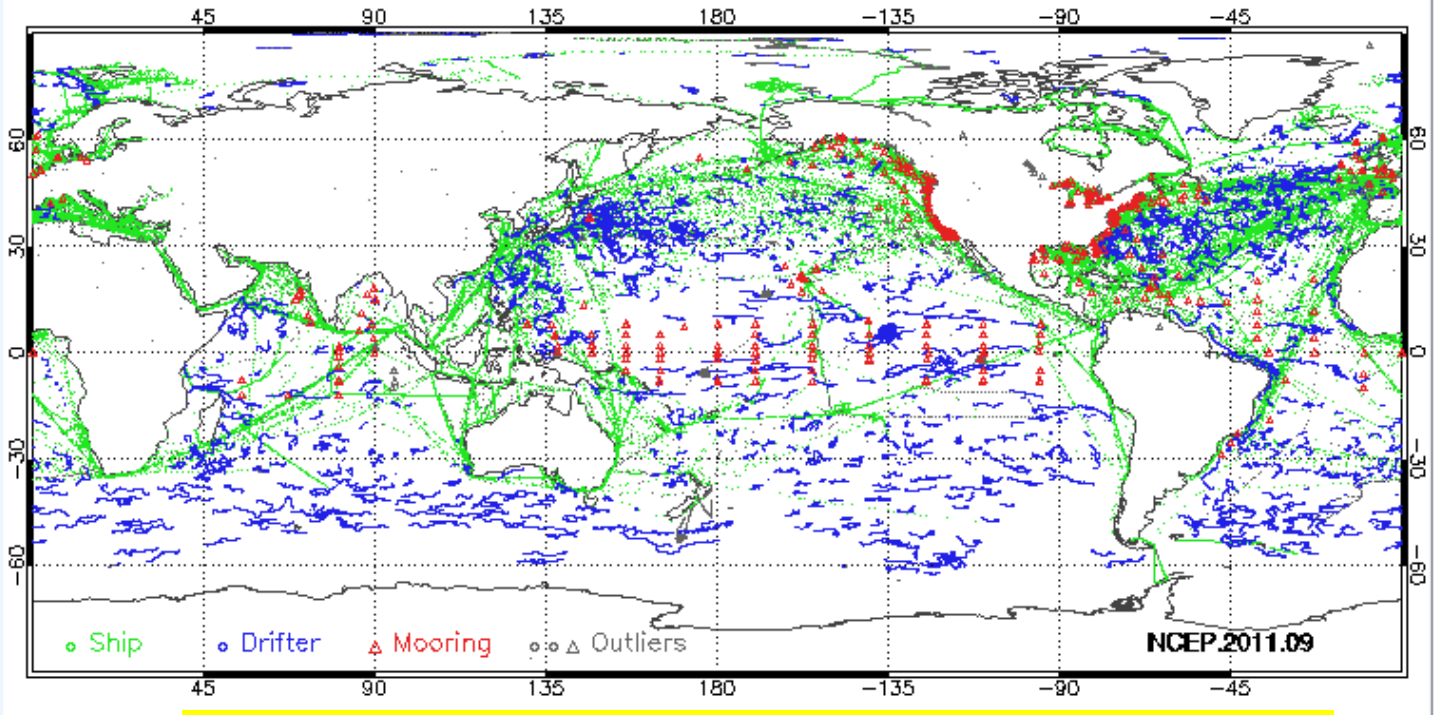
Maps
Statistics
Time-series
Platforms

< 09 2011 >

Different platform types are shown in different colors, with outliers (erroneous observations) shown in gray. Each symbol stands for one observation.

Tropical moorings include TAO/TRITON, PIRATA, RAMA etc. Coastal moorings are all other moorings.

Global map of measurements



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

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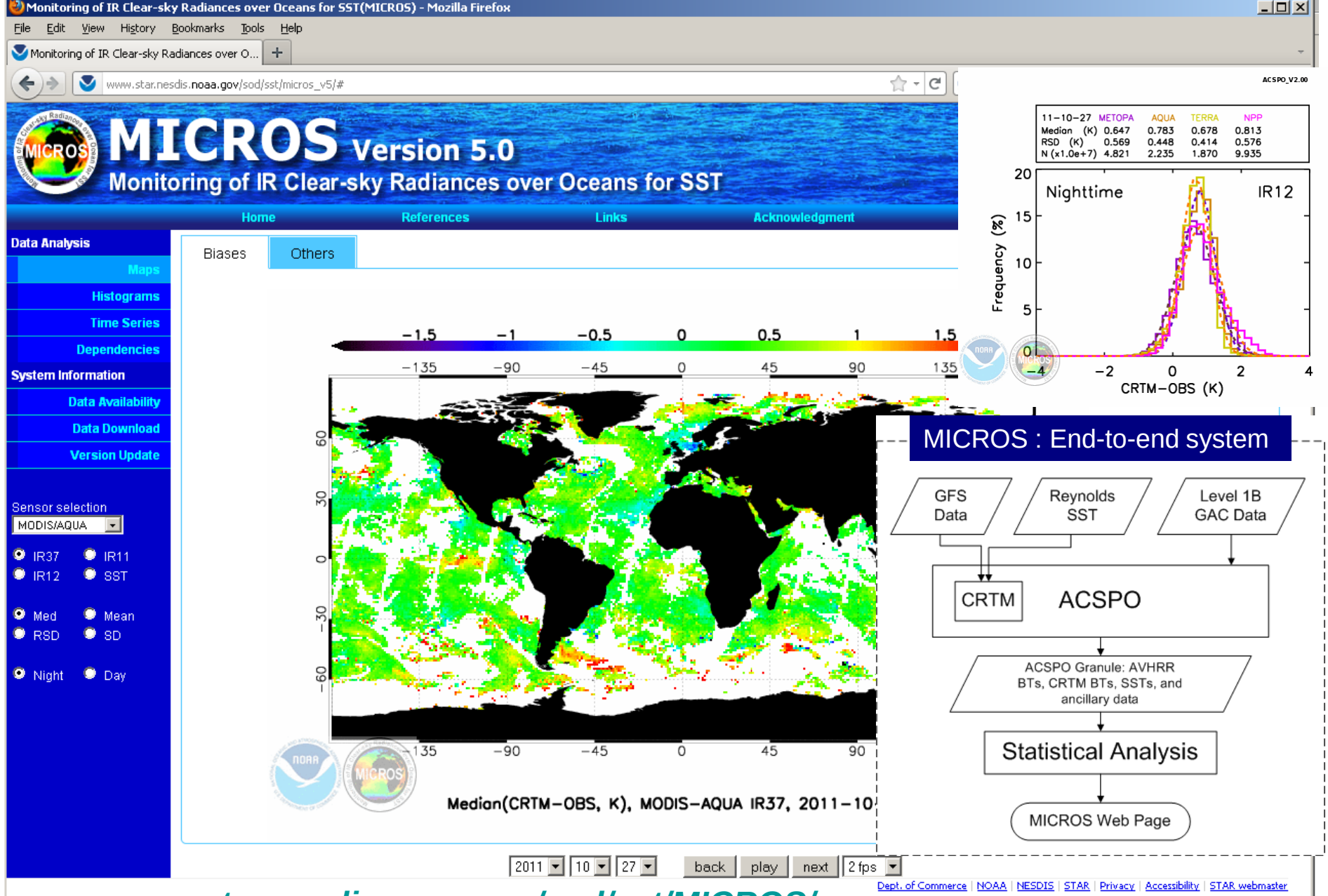
*i*Quam QC is Consistent with UK Met Office

Category	Check	Type of error handled	Physical basis
Preprocessing	Duplicate Removal	Duplicates arise from multiple transmission or data set merging	Identical space/time/ID
Plausibility	Plausibility checks	Unreasonable field values	Range of single fields & Relationships among them
Internal consistency	Tracking	Points falling out of track	Travel speed exceeds limit
	Spike check	Discontinuities in SST time series along track	SST gradient exceeds limit
External consistency	Reference Check	Measurements deviating far away from reference	Bayesian approach (*) (Ref. SST: Daily OI SST v2)
Mutual consistency	Cross-platform Check	Mutual verification with nearby measurements (“buddies check”)	Bayesian approach (*) based on space/time correlation of SST field (Correlation model: 2-scale SOAR, Martin et al., 2002)

(*) Lorenc and Hammon, 1988; Ingleby and Haddleston, 2007



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

M-O Biases and Double Differences

Model minus Observation ("M-O") Biases

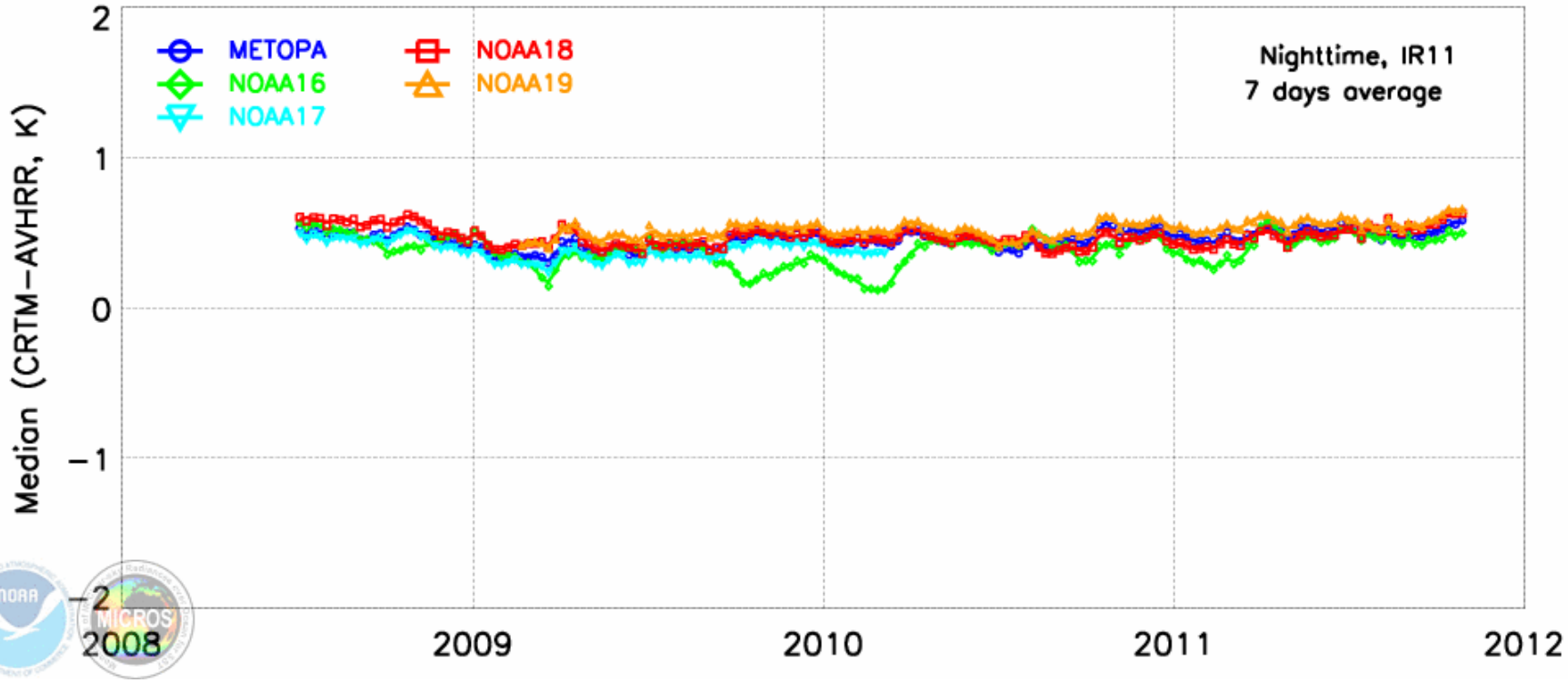
- **M (Model)** = Community Radiative Transfer Model (CRTM) simulated TOA Brightness Temperatures (w/ Reynolds SST, GFS profiles as input)
- **O (Observation)** = Clear-Sky sensor (AVHRR, MODIS, VIIRS) BTs

Double Differences ("DD") for Cross-Platform Consistency

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

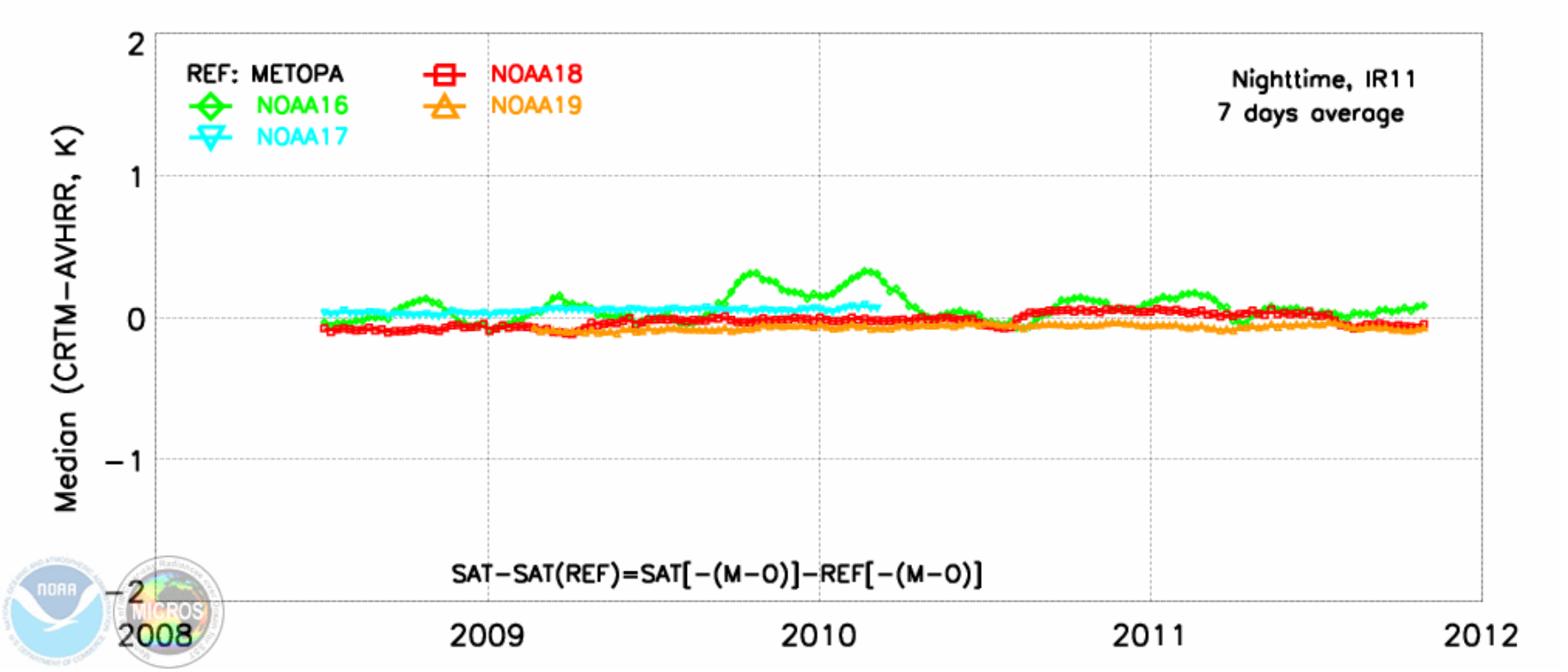
- "M" used as a "Transfer Standard"
- DDs cancel out/minimize effect of systematic errors & instabilities in BTs arising from e.g.
  - Errors/Instabilities in Reynolds SST & GFS
  - Missing aerosol
  - Possible systemic biases in CRTM
  - Updates to ACSPO algorithm

AVHRR M-O Biases @11 μm



M-O Biases change in time but are largely consistent between platforms

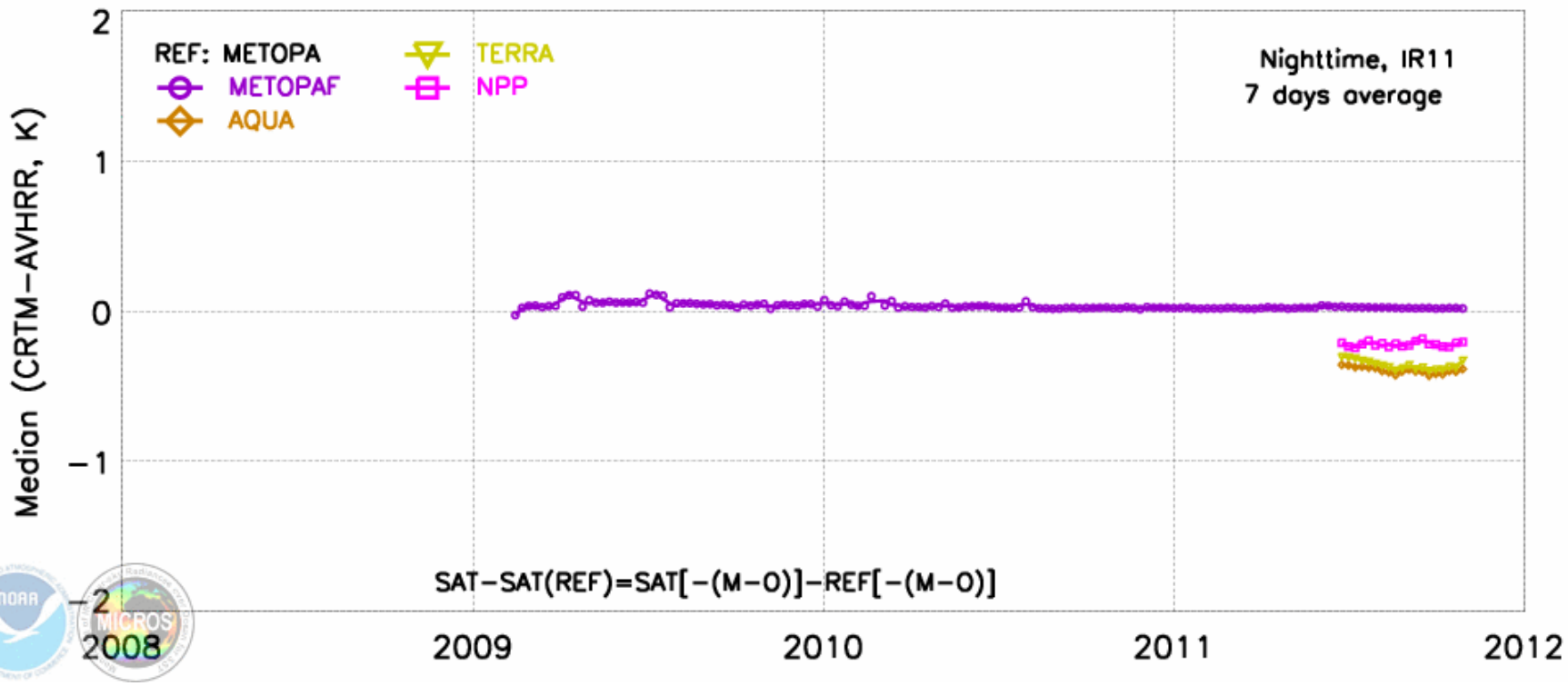
AVHRR Double Differences @11 μm (Ref=Metop-A)



Double Differences emphasize cross-platform BT (in)consistencies

NOAA-16 shows anomalous behavior. Other platforms show cross-platform systematic biases of several hundredths-to-tenths of a Kelvin

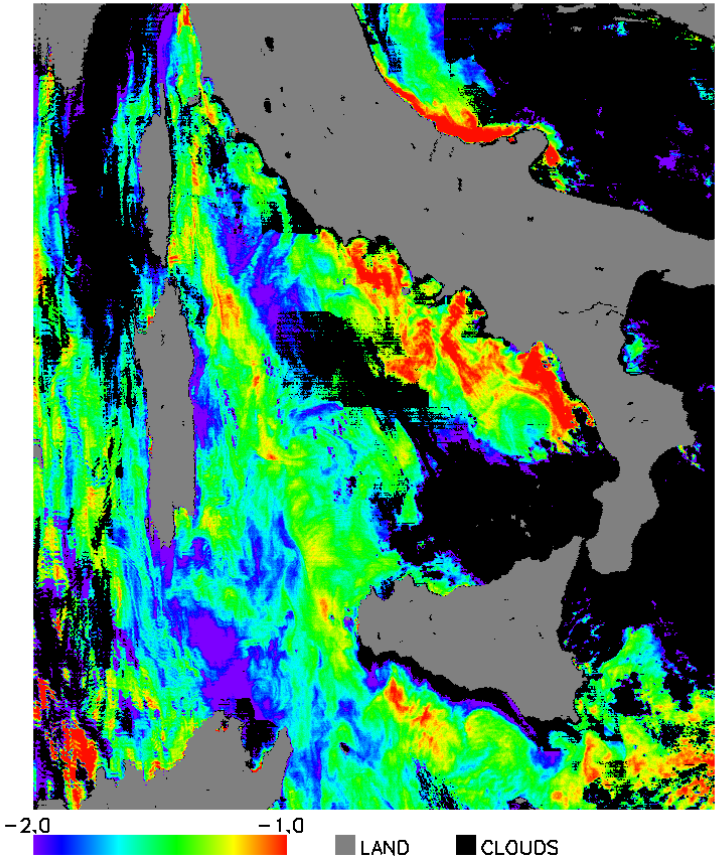
MODIS & Proxy VIIRS DD's @11 μm (Ref=Metop-A)



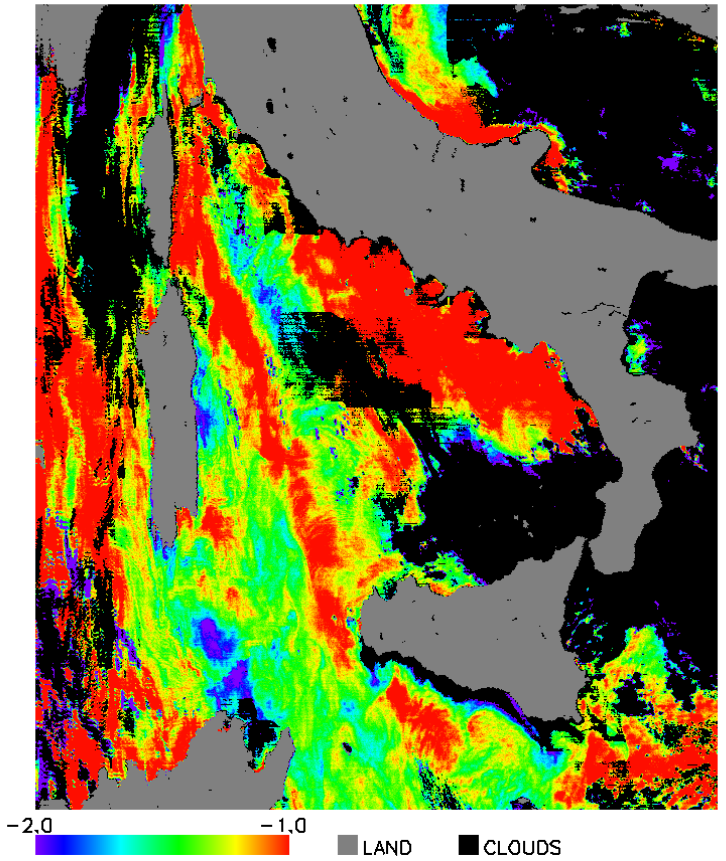
In Band 31, Terra/Aqua are consistent but 0.3-0.4K off AVHHR cluster.
In Band 32, MODIS and AVHRR agree closely.
In Band 20, Terra and Aqua are 0.3 K apart and bracket AVHRR.
Proxy VIIRS included to test ACSPO/MICROS processor end-to-end

Striping in MODIS

MODIS-AQUA, CH31, BT – CRTM BT



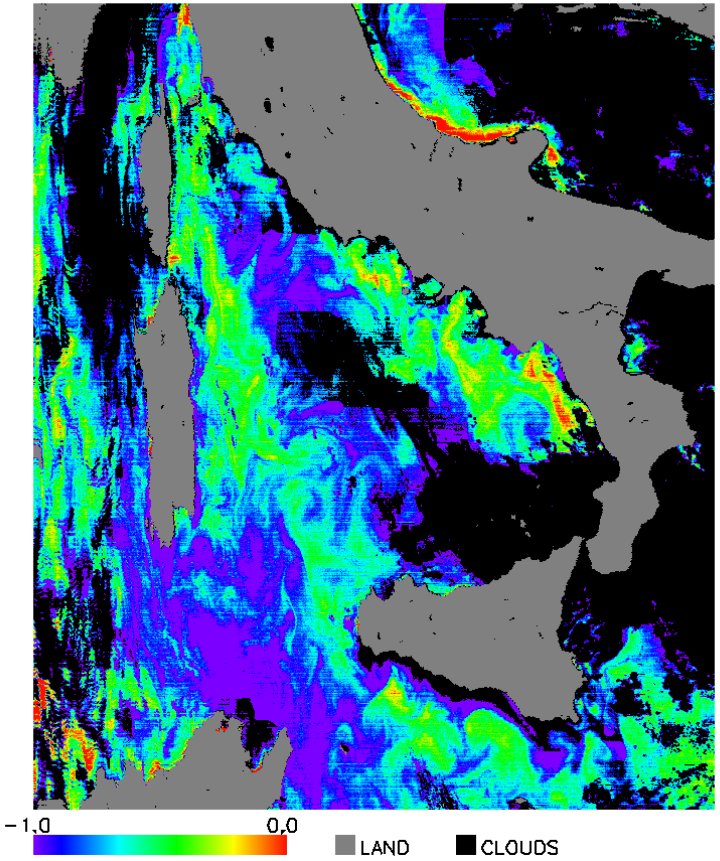
MODIS-AQUA, CH32, BT – CRTM BT



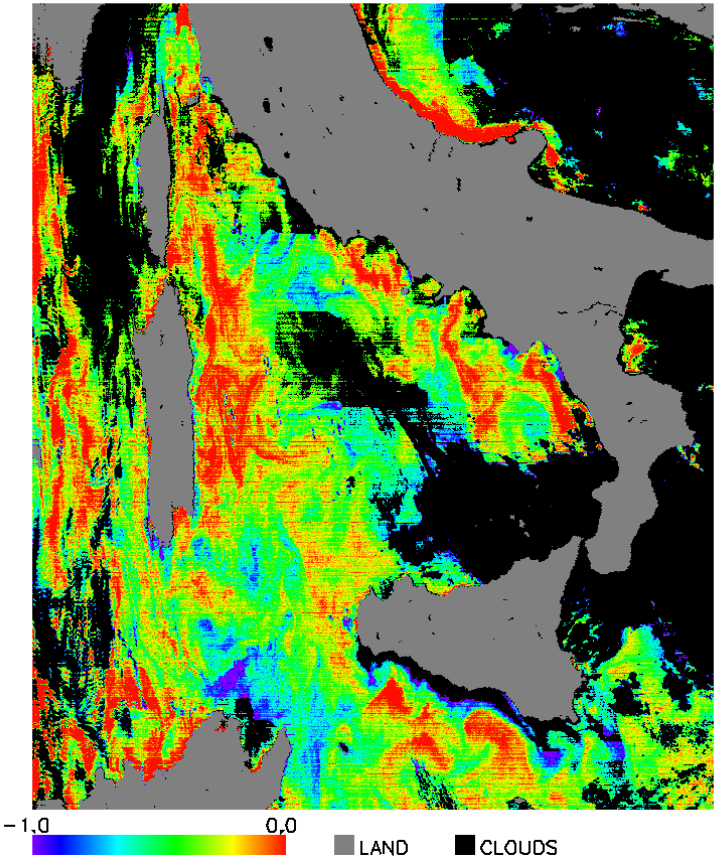
Striping smaller for Aqua and in long wave bands 31 (11) and 32 (12 μm)

Striping in MODIS

MODIS-AQUA, CH20, BT – CRTM BT



MODIS-AQUA, SST - REYNOLDS



Striping more pronounced in band 20 (3.7 µm) used for nighttime SST

Summary

- International JPSS SST Team formed - well positioned to generate top-notch SST product from VIIRS
- STAR (1) supports IDPS Algorithm; and (2) runs ACSPO on VIIRS
- Cal/Val
  - MICROS fully functional with AVHRR, MODIS & proxy VIIRS
  - *i*Quam fully functional
  - SQUAM fully functional w/AVHRR (OSI SAF, ACSPO, Seatemp, Pathfinder). Adding MODIS (MO(Y)D28, ACSPO), VIIRS (IDPS, ACSPO) underway
- Stripiness
  - Performing analyses with MODIS
  - Initiated analyses for VIIRS

Ongoing JPSS SST Work at STAR

- Algorithms
  - Work with NGAS to enable IDPS SST
  - Enable ACSPO Cloud Mask and SST
  - Work with VIIRS SDR and Cloud Mask Teams to improve
- Cal/Val
  - Evaluate IDPS L2 SST in SQUAM against ACSPO & other SSTs
  - Evaluate VIIRS Clear-Sky Ocean Radiances in MICROS
- Stripiness
  - Monitor & fix striping in VIIRS SDRs and MODIS
- Metop-B (launch 23 May 2012)
  - Enable ACSPO Cloud Mask and SST
  - Enable monitoring ACSPO and OSI SAF SSTs in SQUAM

Acknowledgments

- ***JPSS***
  - SQUAM - http://www.star.nesdis.noaa.gov/sod/sst/squam/
  - MICROS - http://www.star.nesdis.noaa.gov/sod/sst/micros/
  - *i*Quam - http://www.star.nesdis.noaa.gov/sod/sst/iquam/

- ***GOES-R***
  - SQUAM, MICROS, *i*Quam

- ***NOAA Product System Development & Implementation (PSDI)***
  - Advanced Clear-Sky Processor for Oceans (ACSPO) (NOAA operational SST system for AVHRR)

- ***NOAA NPP Data Exploitation (NDE)***
  - SQUAM, MICROS, *i*Quam
  - ACSPO extension to process MODIS and VIIRS