Status of JPSS SST Products

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NOAA; CIRA; GST Inc; CUNY

Bruce Brasnett

Canadian Met Centre

Acknowledgements

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- NOAA NDE Team – Tom Schott, Dylan Powell, Bonnie Reed
- JPSS DPA – Eric Gottshall, Janna Feeley, Bruce Gunther
- VIIRS SDR & GSICS – Changyong Cao, Frank DeLuccia, Jack Xiong, Mark Liu, Fuzhong Weng
- NOAA STAR JPSS Team – Ivan Csiszar, Lihang Zhou, Paul DiGiacomo, many others
- NOAA CRTM Team – Yong Han, Yong Chen, Mark Liu

JPSS SST Team

Name	Affiliation	% Funding	Tasks
Ignatov	STAR	NOAA	Lead, JPSS Algorithm & Cal/Val
Stroup, Kihai, Dash, Liang, Petrenko, Xu, Bouali, Zhou, Gladkova, Mikelsons	STAR/CIRA STAR/STG STAR/GST STAR/GST	JPO, NOAA ORS, GOES-R, NASA	Quality Monitoring of VIIRS SSTs (SQUAM), Radiances (MICROS), and in Situ SSTs (*i*Quam) Data support; IDPS SST code, Match up, Cloud Mask, SST retrievals; Destriping L1b & SST
May, Cayula, McKenzie, Willis	NAVO	Navy, NJO	NAVO SEATEMP SST & Cal/Val VIIRS Cloud Mask evaluation
Minnett Kilpatrick	U. Miami	JPO, U. Miami	Uncertainty & instrument analyses; RTM; VAL vs. drifters & radiometers; skin to sub-skin conversion
Arnone Fargion	USM/NRL UCSD	NJO, USM	SST Algorithm Analyses, SST improvements at slant view zenith angles/swath edge
LeBorgne Roquet	Meteo France	EUMETSAT	Processing VIIRS and Cal/Val using O&SI SAF heritage; Comparisons with AVHRR/SEVIRI

Past Year Focus Areas

Sustained NRT Monitoring/VAL of VIIRS SSTs and Radiances

- ✓ SQUAM www.star.nesdis.noaa.gov/sod/sst/squam/ - comprehensive cross-evaluation of various SST products and VAL against in situ data
- ✓ iQuam www.star.nesdis.noaa.gov/sod/sst/iquam/ - QCed in situ data
- ✓ MICROS www.star.nesdis.noaa.gov/sod/sst/micros/ - feedback to SDR

SST EDR is Provisional

- ✓ Improved & Consolidated SST Algorithm in IDPS / ACSPO – JGR special issue
- ✓ EDR Review Jan 2014 - Provisional status granted Apr 2014
- ✓ Based on users feedback & performance, JPO recommend to "discontinue IDPS and focus on NOAA ACSPO sustainment, Cal/Val and development"

→ **ACSPO Production**

- ✓ Operational at NDE Mar 2014; Archival at JPL/NODC underway
- ✓ Work with NAVO partners to cross-evaluate NAVO and ACSPO VIIRS products
- ✓ Work with users to assess ACSPO SST, provide feedback to SST Team

Destriping and ACSPO Clear-Sky Mask improvements

- ✓ Progress with operational destriping – SDR & SST breakouts – Mikelsons
- ✓ Pattern-recognition ACSPO clear-sky mask – SST break-out, Innovative science talk / I. Gladkova

VIIRS SST Products

IDPS – NOAA Interface Data Processing Segment (IDPS)

- ✓ Official NPOESS SST EDR, Now owned by NOAA JPSS PO
- ✓ Developed by NGAS; Operational at Raytheon; Archived at NOAA CLASS
- ✓ Jan 2014: JPO recommends “discontinue the IDPS EDR, concentrate on ACSPO”
- ✓ IDPS will be phased out as soon as ACSPO SST is archived at JPL/NODC
- ✓ As of this report, meets specs at night, does not meet during daytime

ACSPO – NOAA Advanced Clear-Sky Processor for Ocean (ACSPO)

- ✓ NOAA heritage SST system (AVHRR GAC and FRAC heritage)
- ✓ VIIRS operational Mar 2014, GDS2 archival at JPL/NODC underway
- ✓ Meet/exceed APU specs (both day/night), good global coverage

NAVO – SEATEMP

- ✓ Builds on NAVO AVHRR & NOAA pre-ACSPO heritage
- ✓ VIIRS operational Mar 2013; GDS2 archived at JPL/NODC May 2013
- ✓ Meet/exceed APU specs (both day/night), coverage restricted

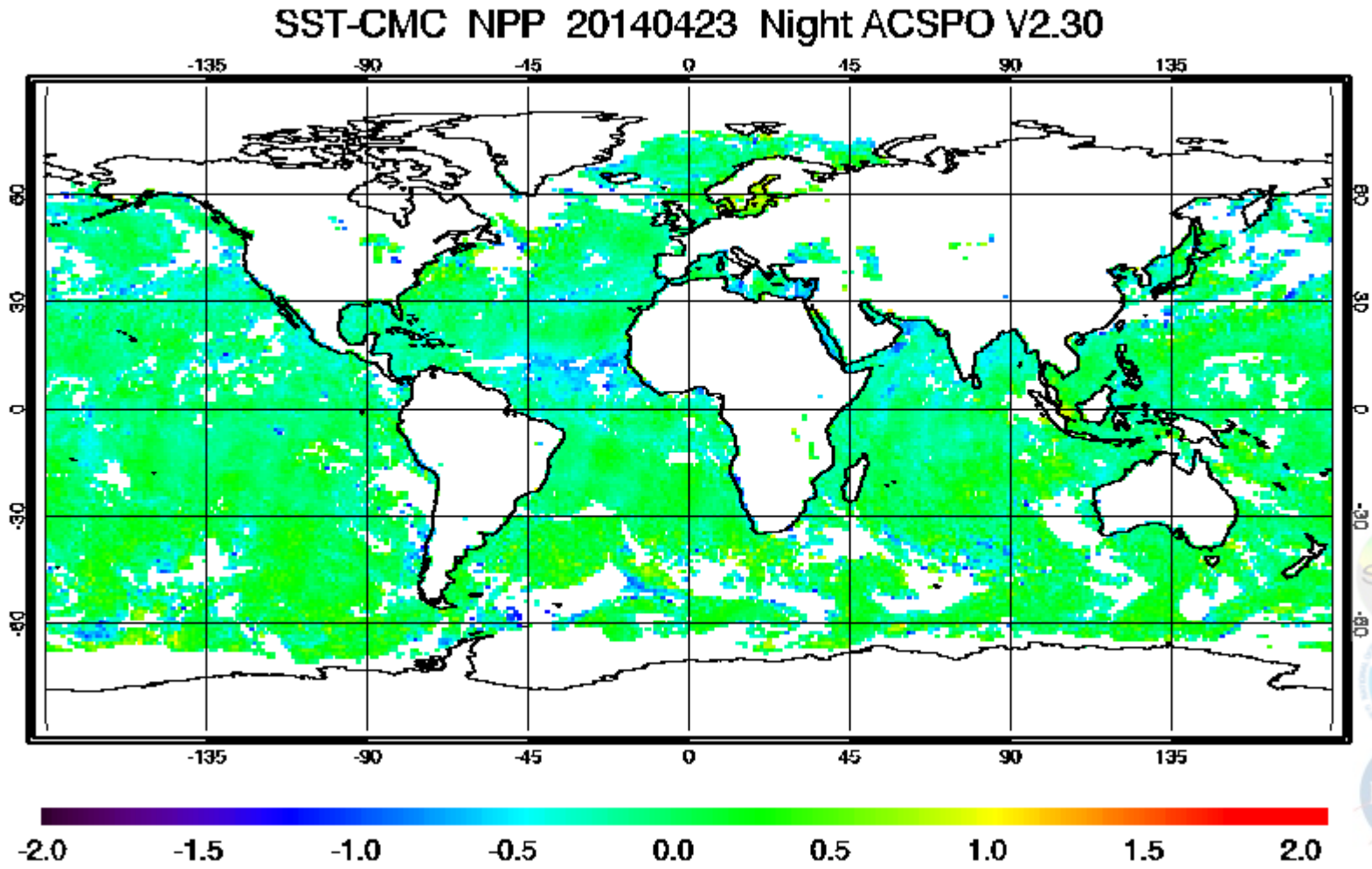
Objective & Methodology

- **Objective: Compare ACSPO and NAVO SSTs to advise users on the specifics of the two products**

- **Methodology: Compare ACSPO/NAVO SST domain & performance against two global reference SSTs**
  - **L4 SST (Canadian Met Centre CMC0.2 Analysis. Note that VIIRS data are not assimilated in CMC0.2)**
  - ***in situ* SST (QCed drifting buoys in iQuam *www.star.nesdis.noaa.gov/sod/sst/iquam/*)**

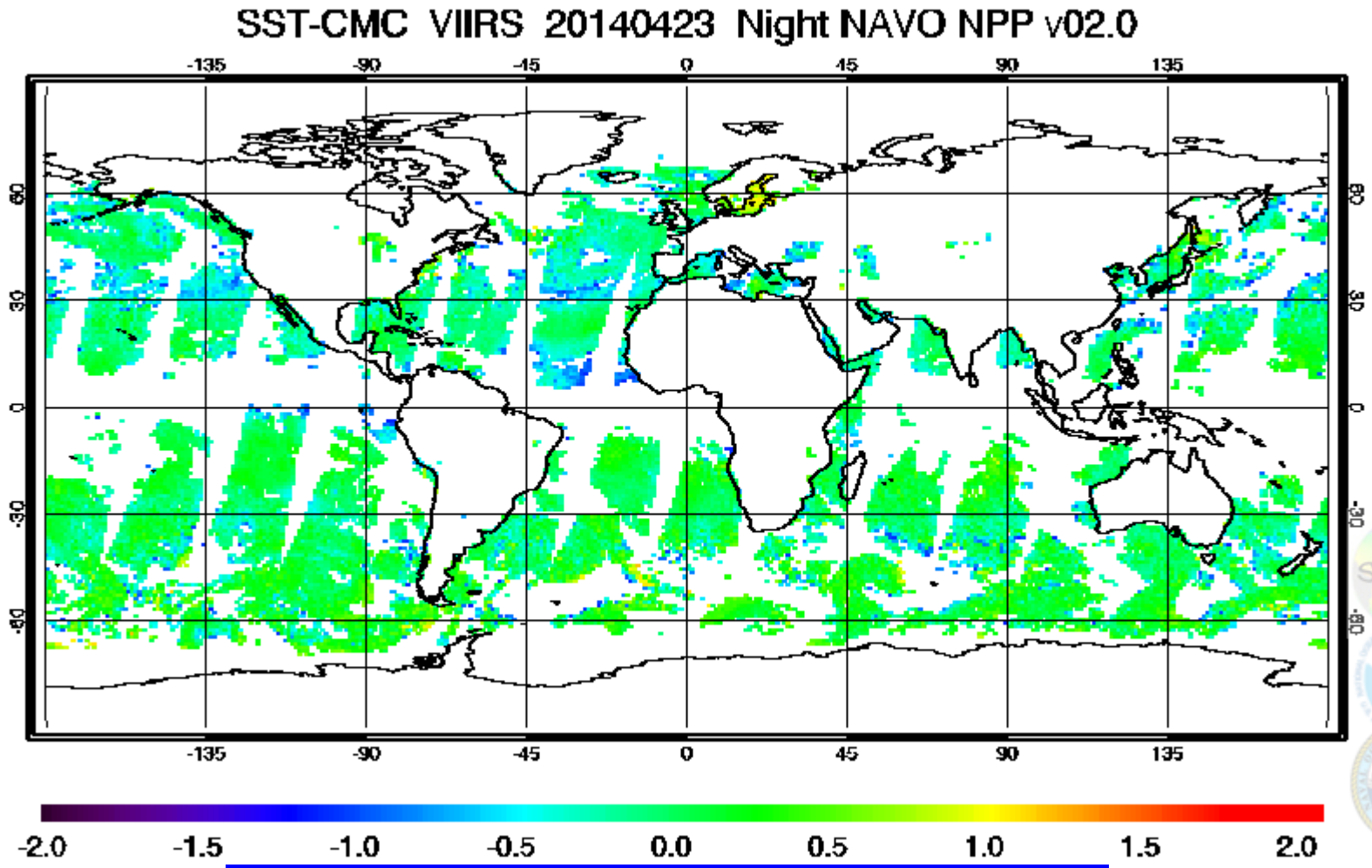
Data: one representative day of global data – 23 April 2014 – in SST Quality Monitor (SQUAM)
www.star.nesdis.noaa.gov/sod/sst/squam/

NIGHT: ACSPO L2 minus CMC L4
23 April 2014



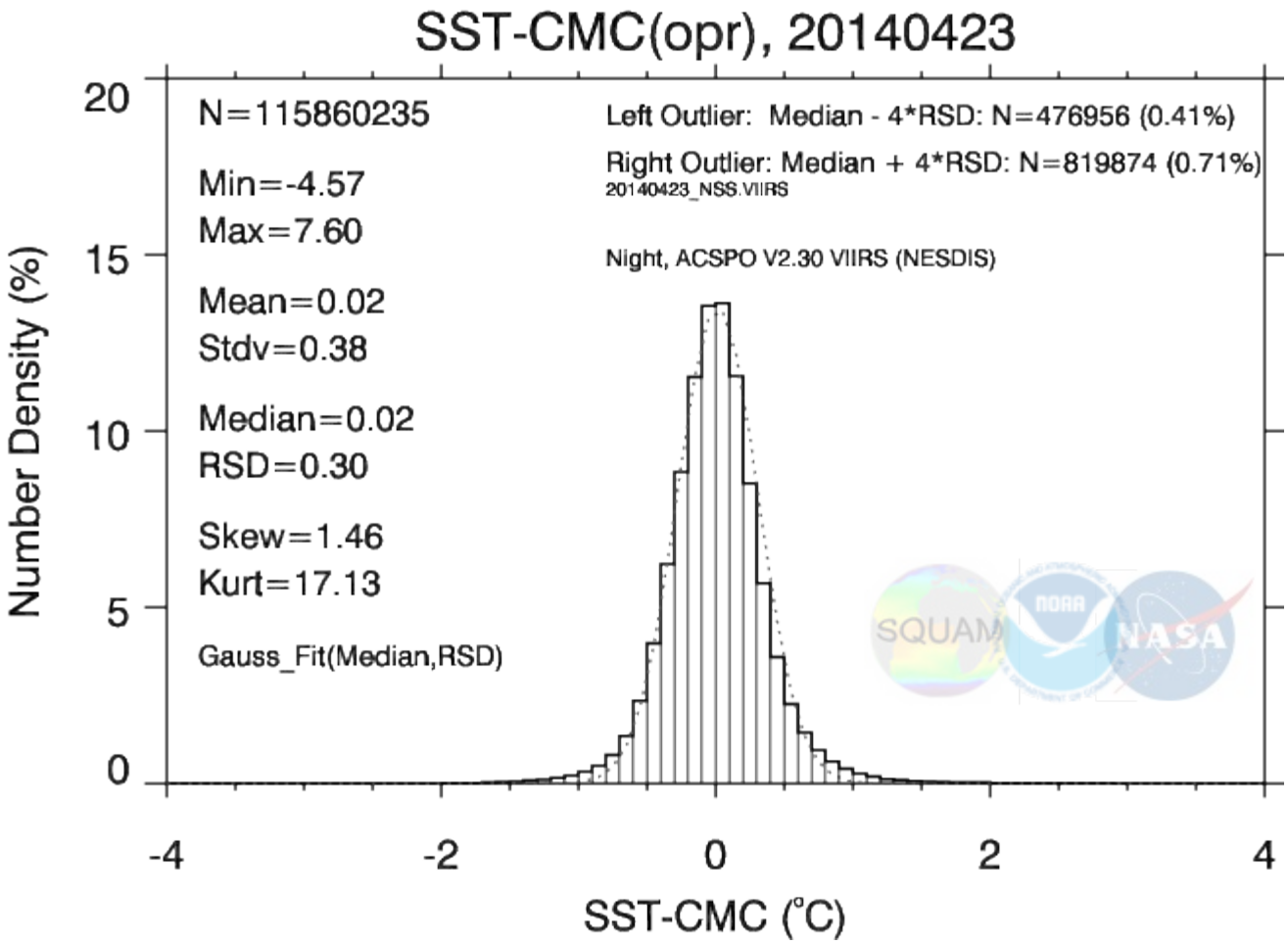
- ***Delta close to zero as expected***
- ***Cold spots – Residual Cloud/Aerosol leakages***

NIGHT: NAVO L2 minus OSTIA L4
23 April 2014



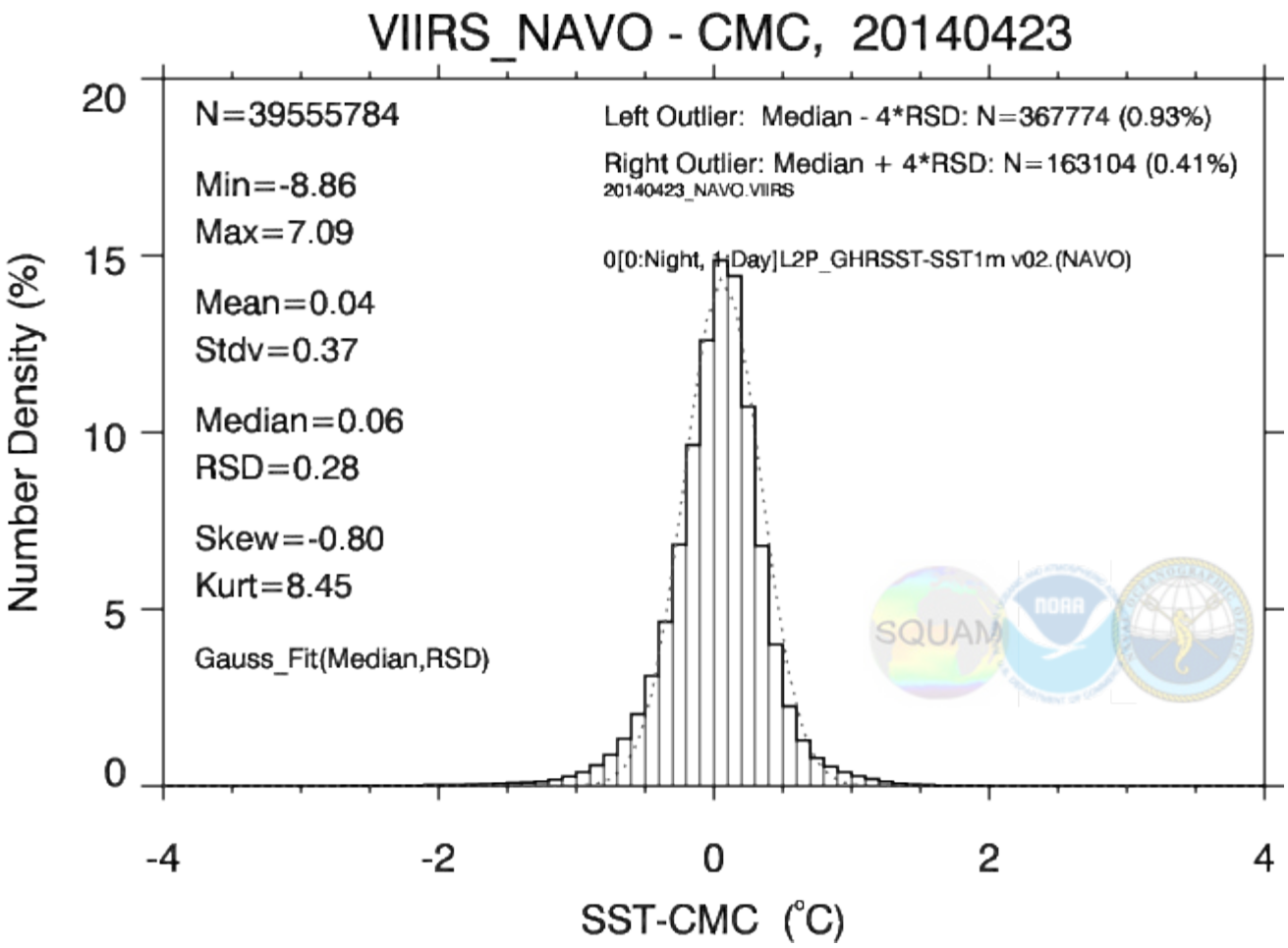
- ***Retrievals limited to VZA<54°***

NIGHT: ACSPO L2 minus CMC L4
23 April 2014



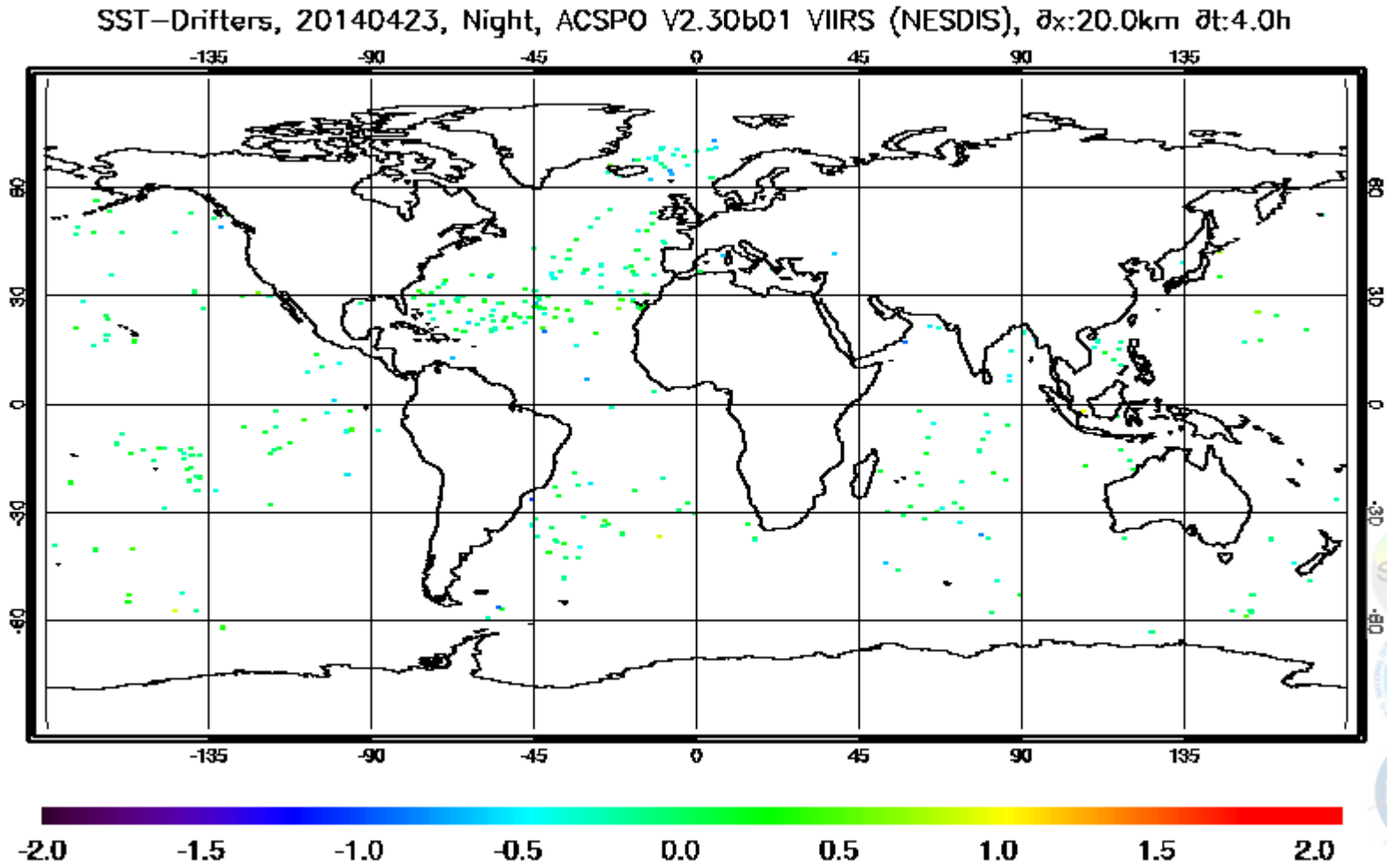
- ***Shape close to Gaussian***

NIGHT: NAVO L2 minus CMC L4
23 April 2014



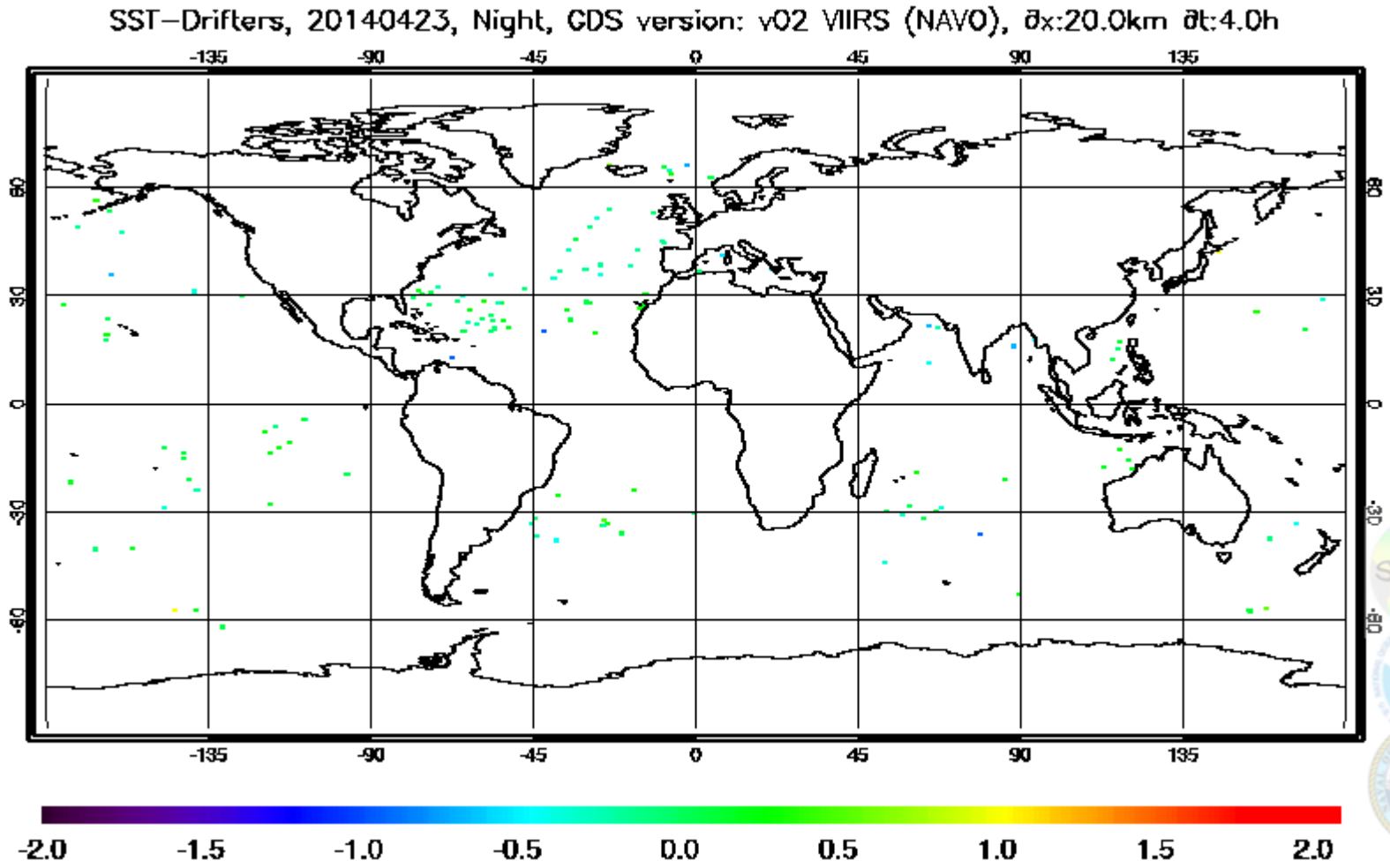
- ***Shape close to Gaussian***
- ***Domain smaller, STD slightly better***

NIGHT: ACSPO L2 minus *in situ* SST
23 April 2014



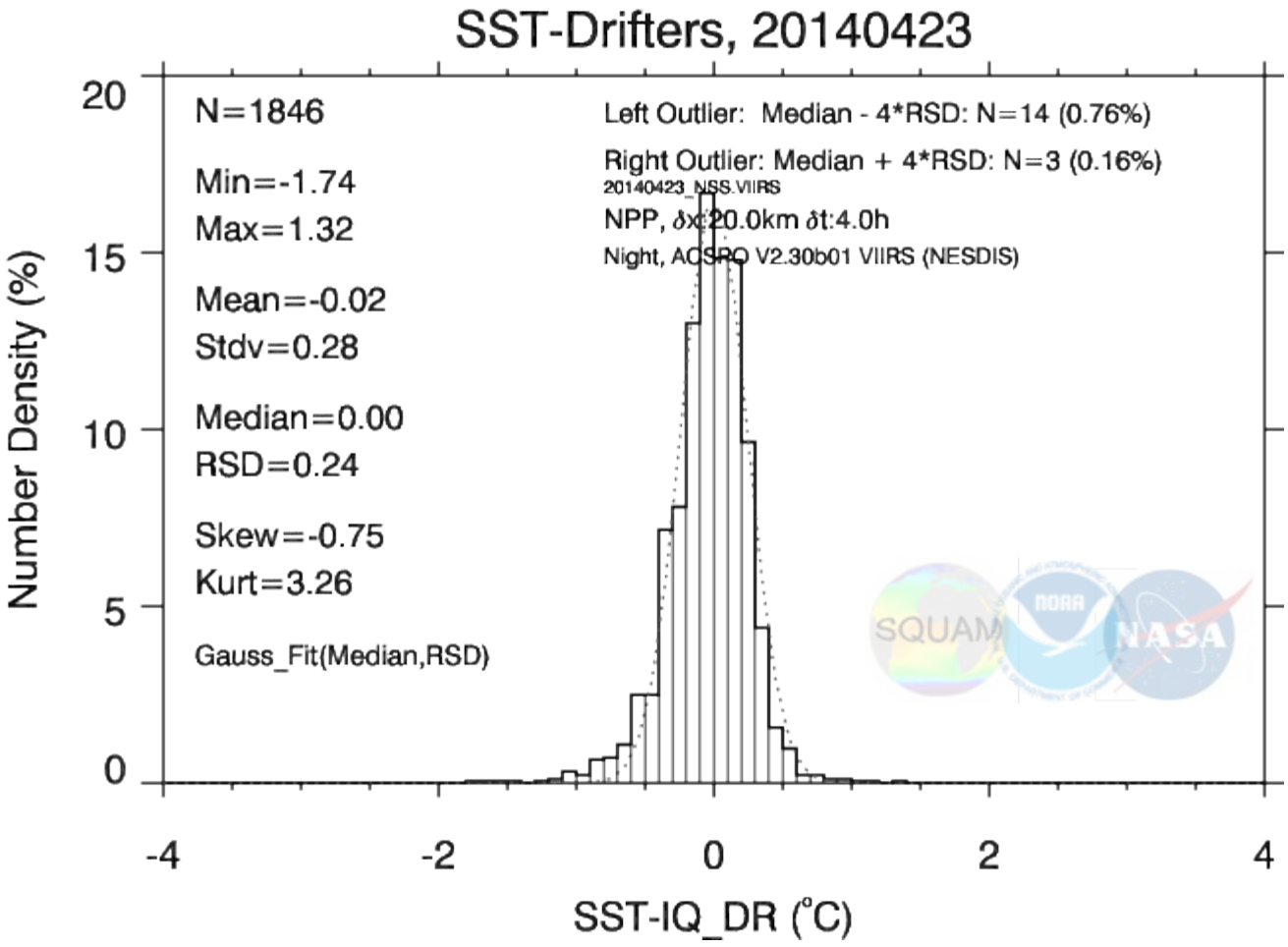
- ***Much sparser data coverage***
- ***Not fully representative of the globe***

NIGHT: NAVO L2 minus *in situ* SST
23 April 2014



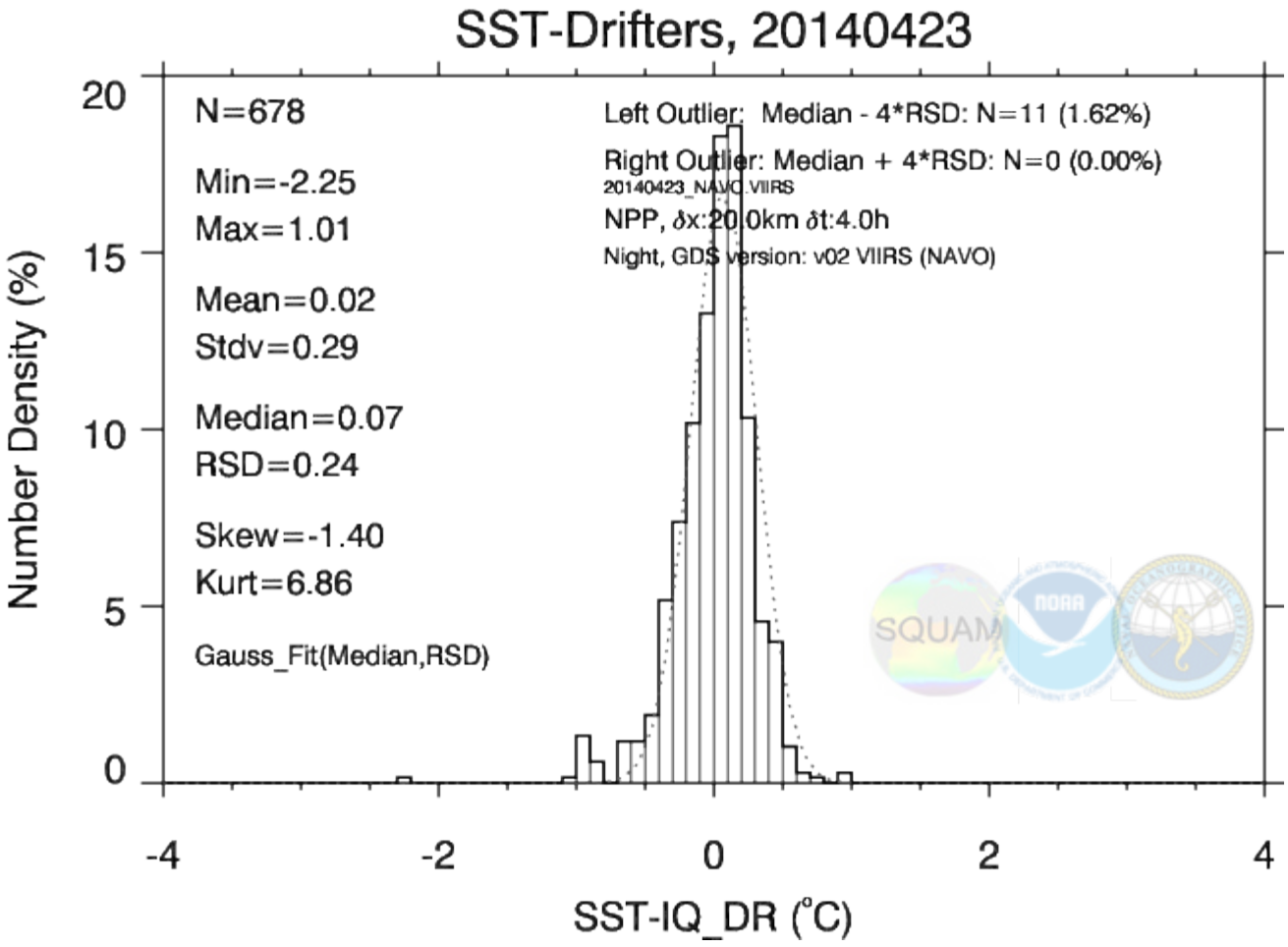
- ***Much sparser data coverage***
- ***Not fully representative of the globe***

NIGHT: ACSPO L2 minus *in situ* SST
23 April 2014



- ***Shape close to Gaussian – small cold tail***
- ***Performance Stats well within specs (Bias<0.2K, STD<0.6K)***

NIGHT: NAVO L2 minus *in situ* SST
23 April 2014



- ***Shape close to Gaussian – small cold tail***
- ***Performance Stats well within specs (Bias<0.2K, STD<0.6K)***

NIGHT – Summary

Vs. L4

ΔT = "VIIRS minus CMC" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	116.8M (101%)	-13.1/+12.6	-0.04/0.46	-0.00/0.31
ACSPO	115.9M (100%)	- 4.6/+7.6	-0.02/0.38	-0.02/0.30
NAVO	39.5M (34%)	- 8.9/+7.1	+0.04/0.37	+0.06/0.28

- *IDPS: SST domain is +1% larger than ACSPO, All stats degraded*
- *NAVO: SST domain is factor of ×3 smaller than ACSPO, stats improved*

Vs. in situ

ΔT = "VIIRS minus in situ" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	2,082 (113%)	-2.9/+5.6	-0.06/0.43	-0.01/0.26
ACSPO	1,846 (100%)	-1.7/+1.3	-0.02/0.28	-0.00/0.24
NAVO	678 (37%)	-2.3/+1.0	+0.02/0.29	+0.07/0.24

- *IDPS: SST domain is +13% larger than ACSPO, All stats degraded*
- *NAVO: SST domain is factor of ×3 smaller than ACSPO, stats comparable*

DAY – Summary

Vs. L4

ΔT = "VIIRS minus CMC" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	120.4M (100%)	- 28.7/+10.4	+0.20/0.77	+0.24/0.45
ACSPO	121.0M (100%)	- 5.4/+ 9.2	+0.29/0.59	+0.21/0.41
NAVO	41.3M (34%)	- 8.2/+ 7.5	+0.28/0.56	+0.22/0.40

- *IDPS: SST domain is comparable with ACSPO, All stats degraded*
- *NAVO: SST domain is factor of ×3 smaller than ACSPO, stats comparable*

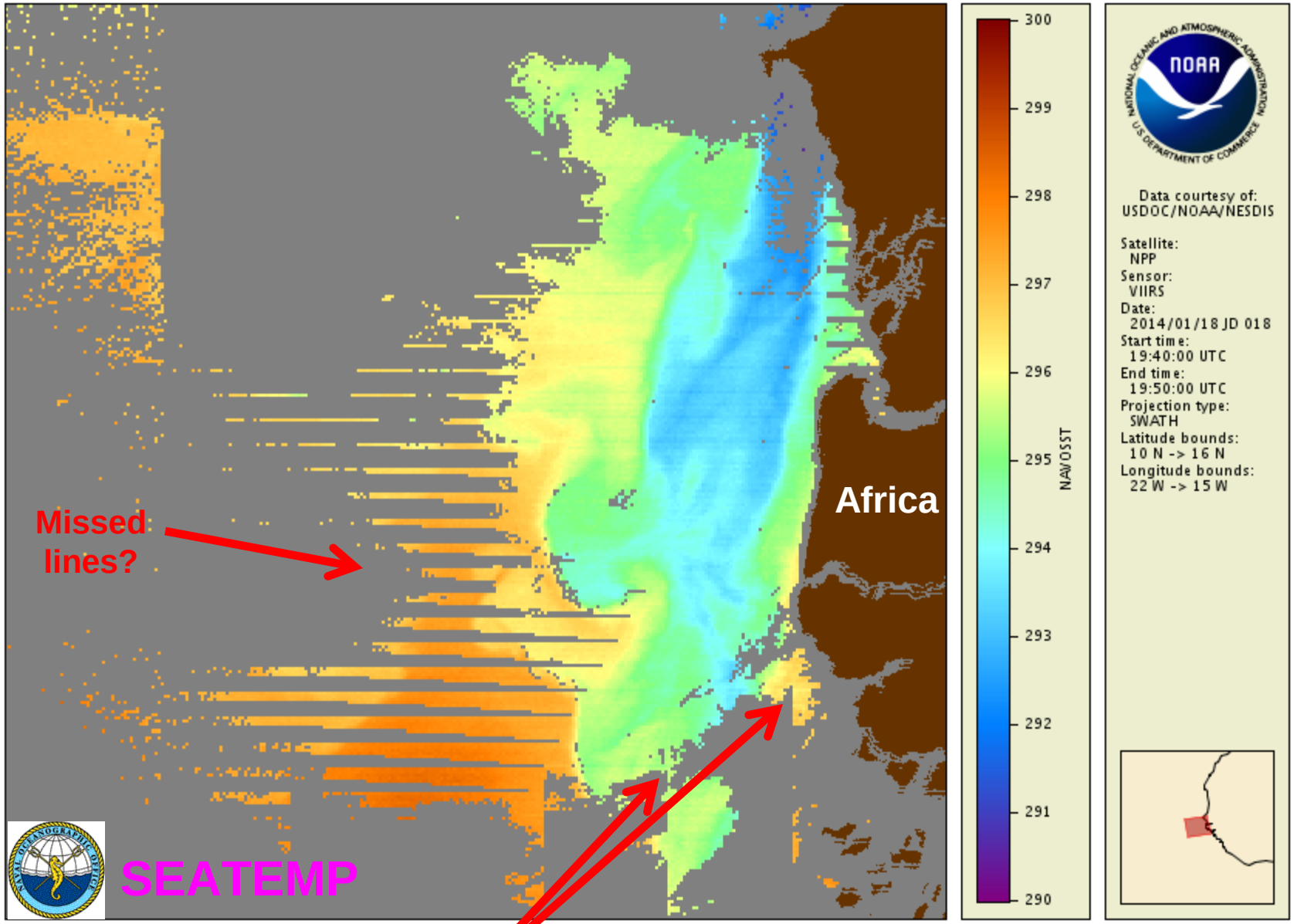
Vs. in situ

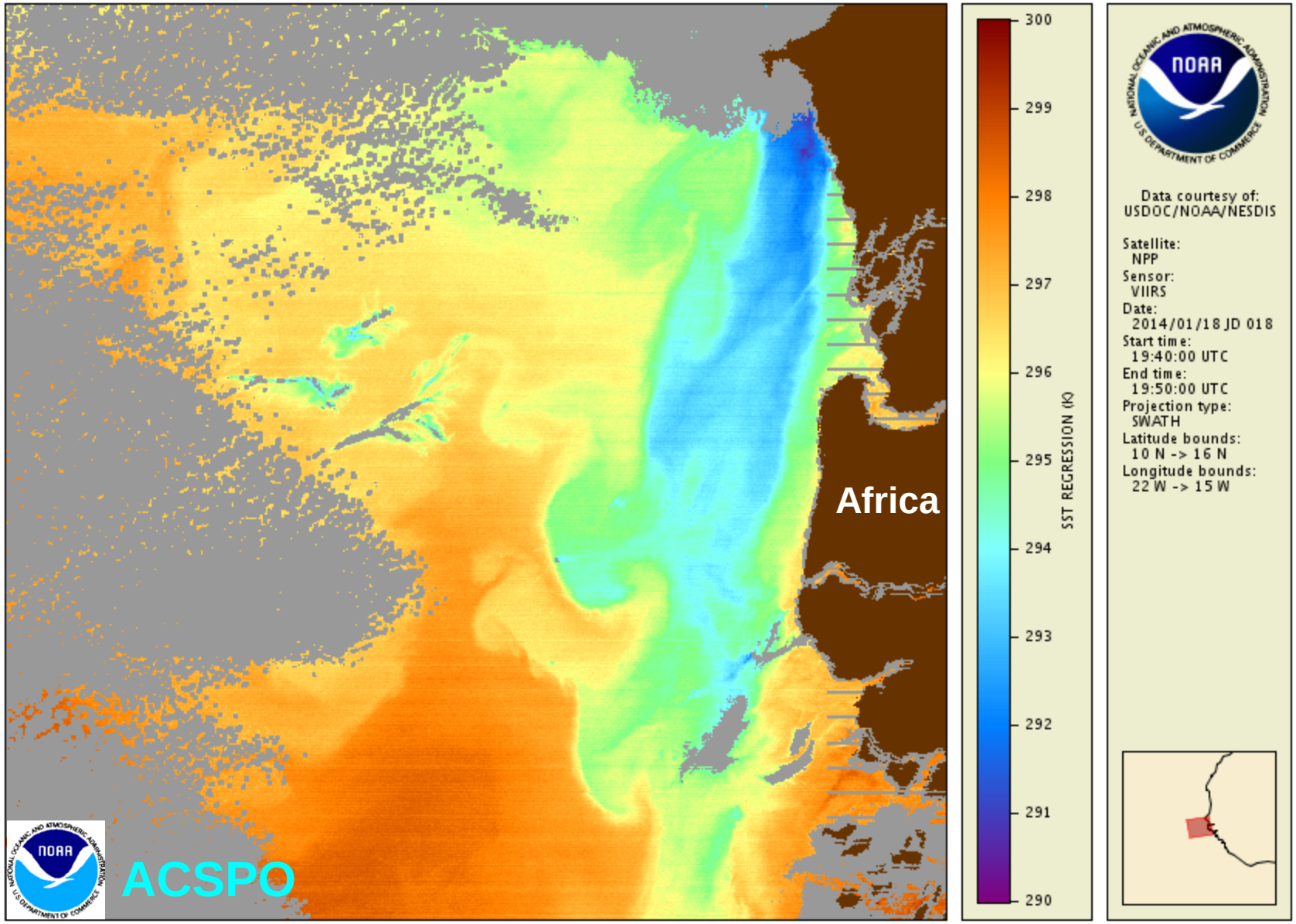
ΔT = "VIIRS minus in situ" SST (expected ~0)

	NOBS (%ACSPO)	Min/ Max	Mean/ STD	Med/ RSD
IDPS	1,758 (105%)	-5.3/+2.7	-0.06/0.77	+0.10/0.48
ACSPO	1,680 (100%)	-1.4/+2.8	+0.07/0.42	+0.06/0.37
NAVO	510 (30%)	-1.2/+2.1	+0.12/0.35	+0.07/0.35

- *IDPS: SST domain is +5% larger than ACSPO, All stats degraded*
- *NAVO: SST domain is factor of ×3 smaller than ACSPO, stats improved*

ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_1440-1450_20140314.174252_NAVO




Africa
ACSPO
300
299
298
297
296
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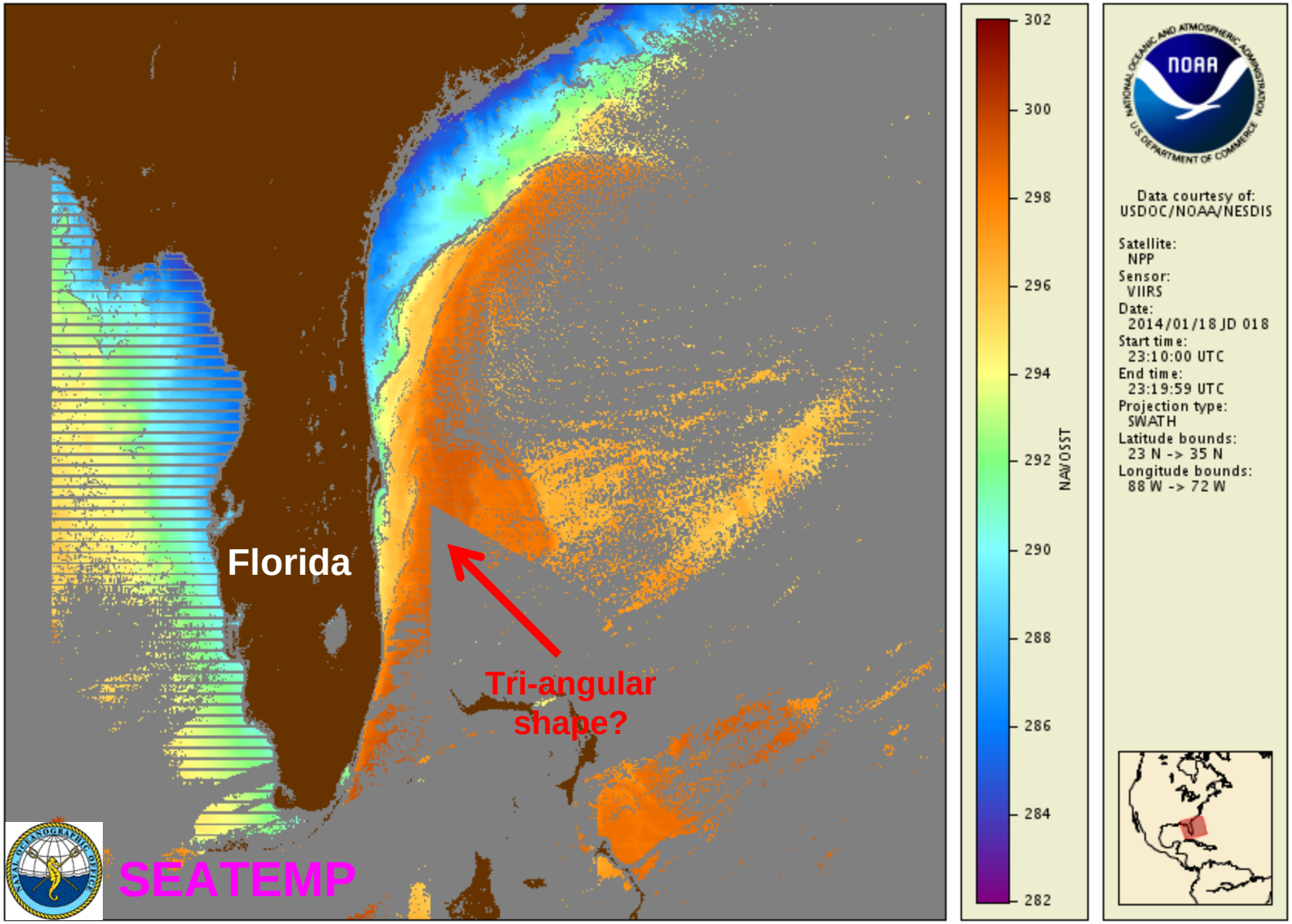
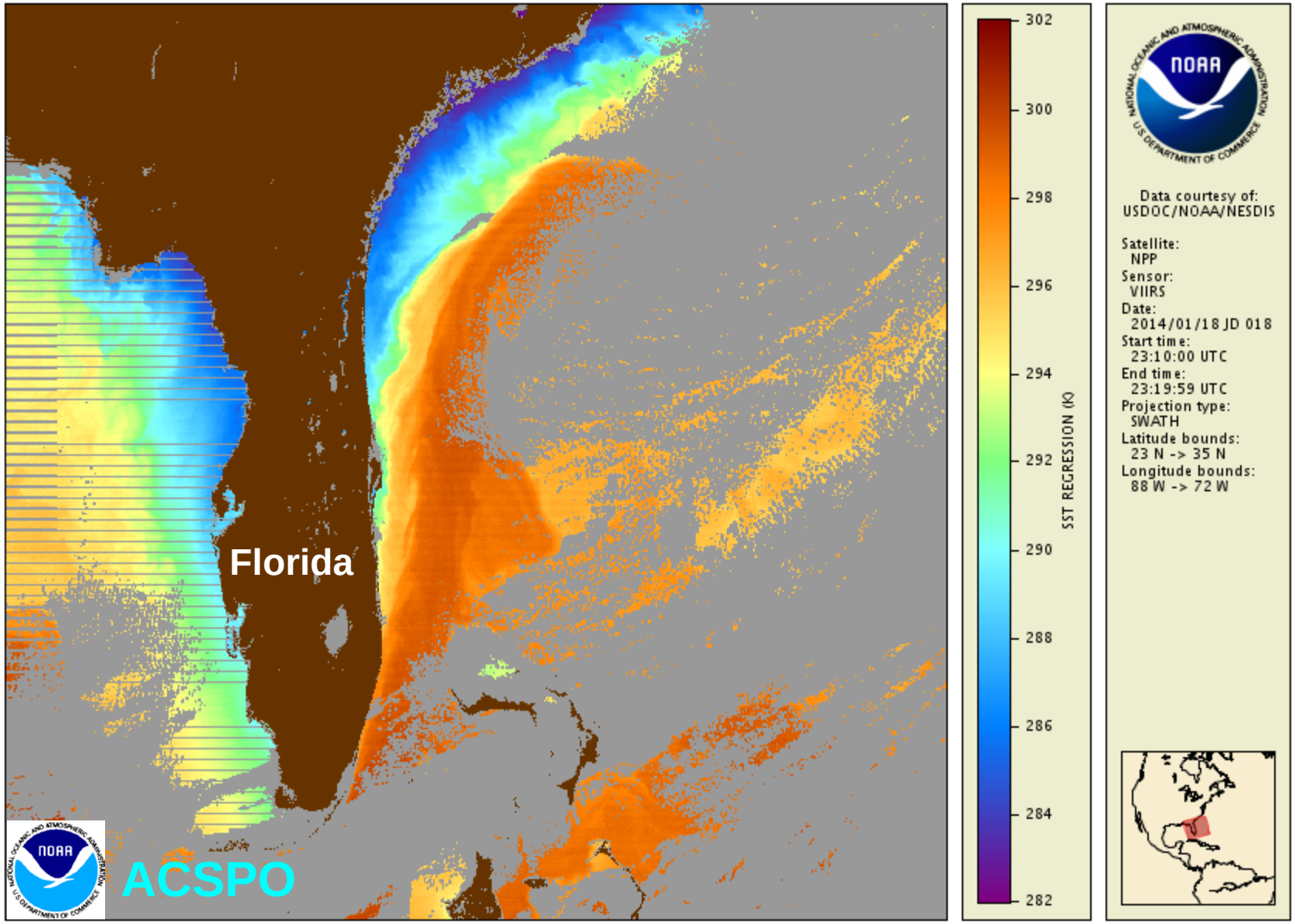
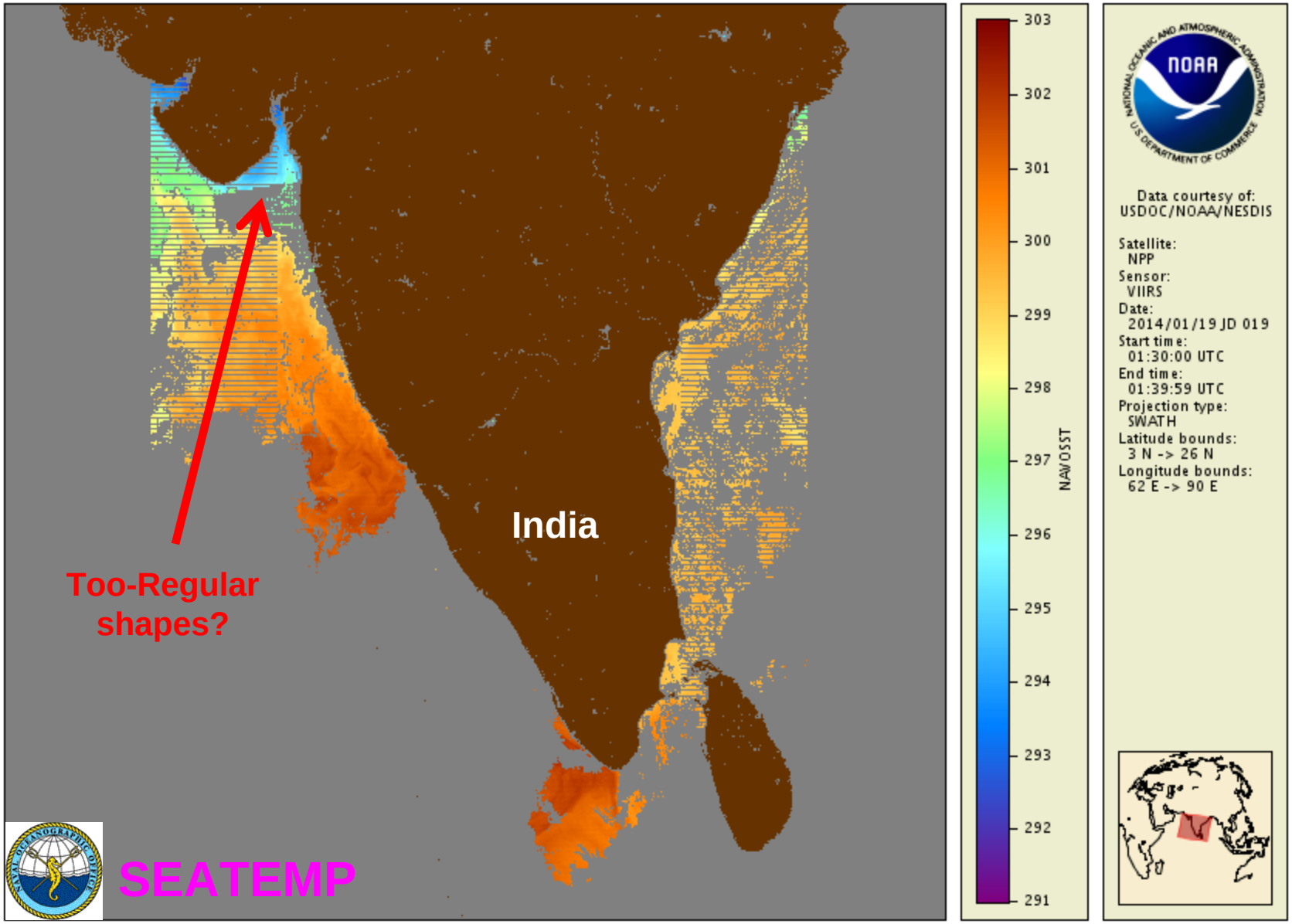
294
293
292
291
290
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/18 JD 018
Start time:
19:40:00 UTC
End time:
19:50:00 UTC
Projection type:
SWATH
Latitude bounds:
10 N -> 16 N
Longitude bounds:
22 W -> 15 W

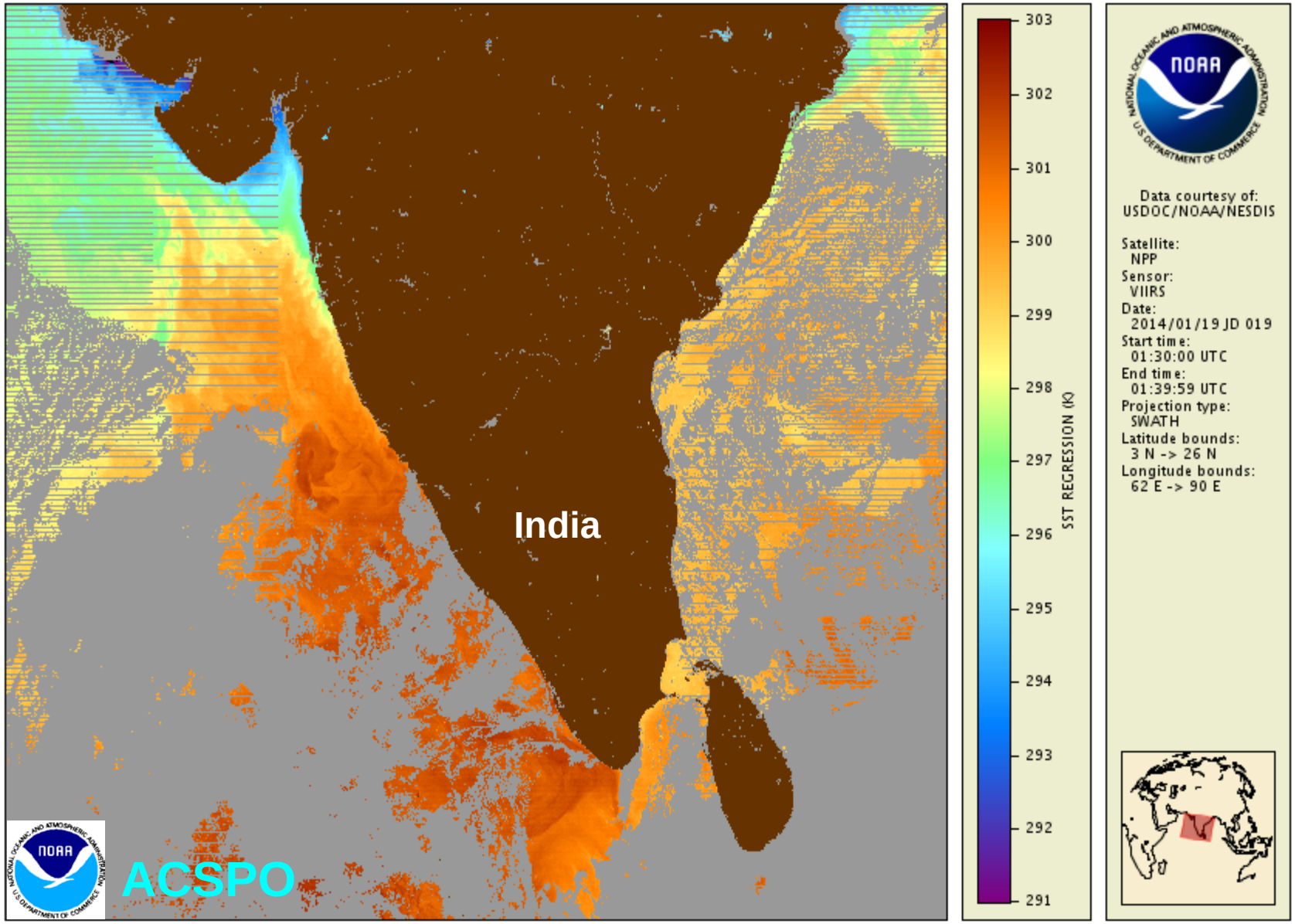
ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_1810-1819_20140314.184153_NAVO




Florida
ACSPO
302
300
298
296
294
292
290
288
286
284
282
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/18 JD 018
Start time:
23:10:00 UTC
End time:
23:19:59 UTC
Projection type:
SWATH
Latitude bounds:
23 N -> 35 N
Longitude bounds:
88 W -> 72 W

ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_2030-2039_20140314.192134_NAVO




India
ACSPO
303
302
301
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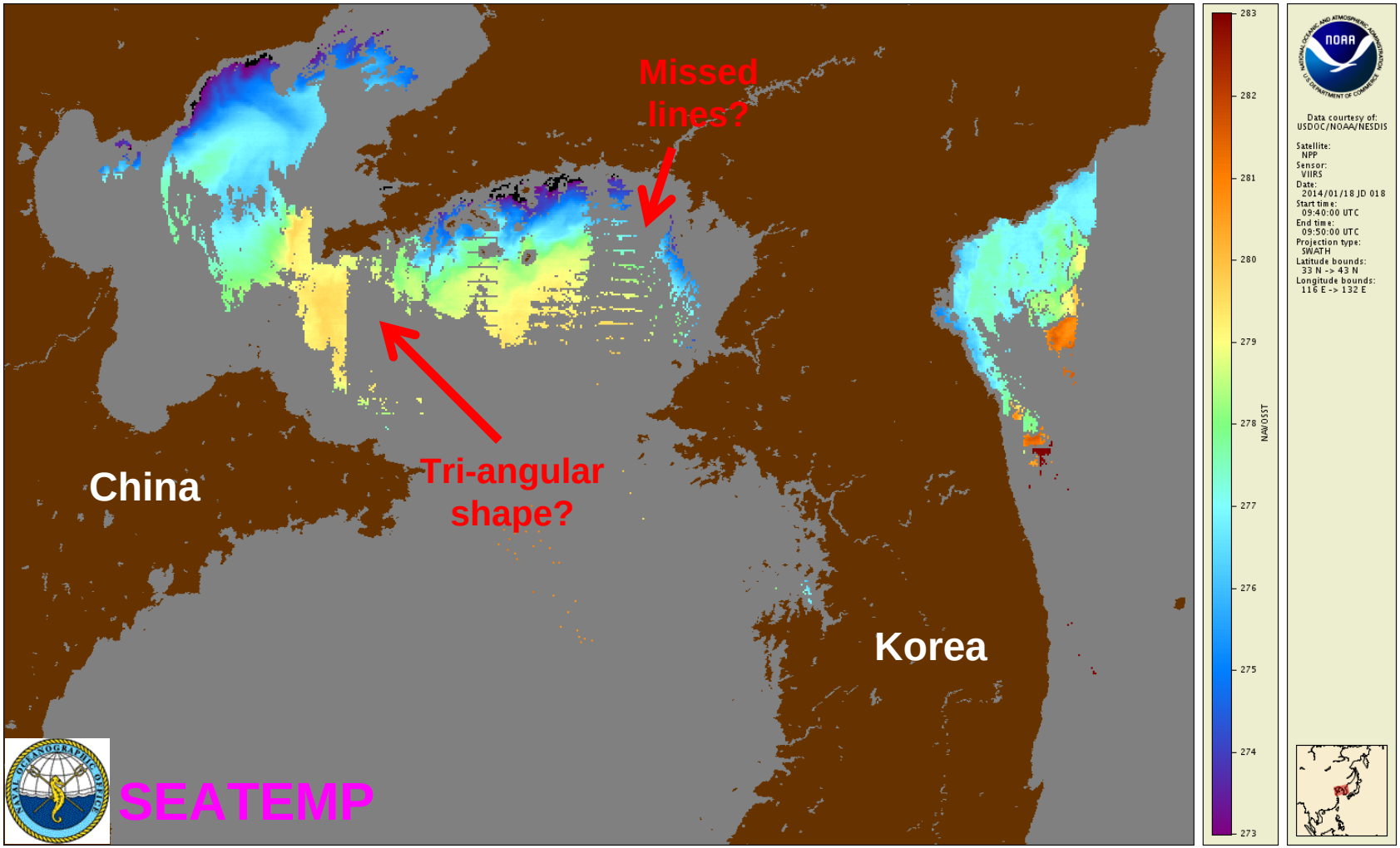
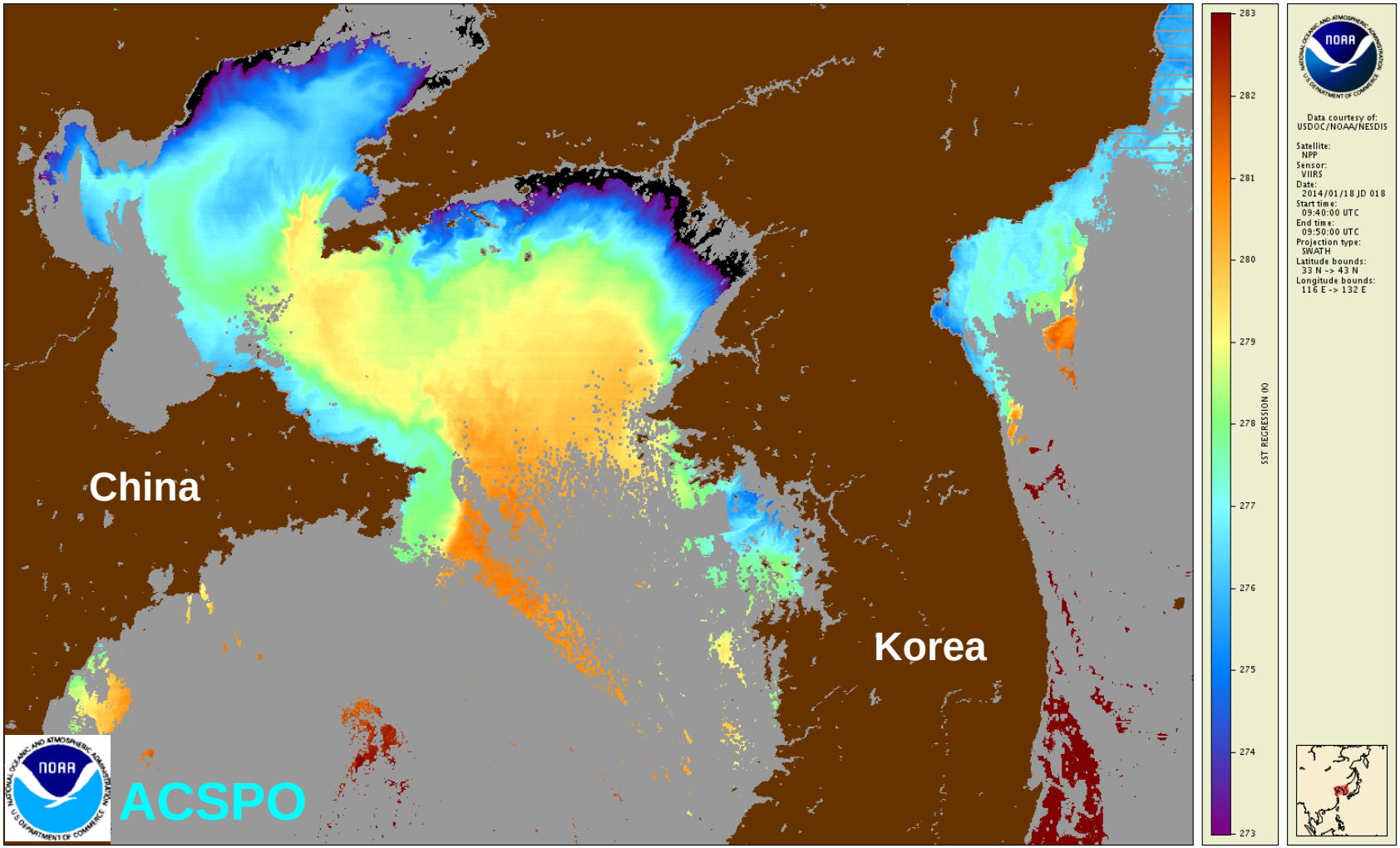
291
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/19 JD 019
Start time:
01:30:00 UTC
End time:
01:39:59 UTC
Projection type:
SWATH
Latitude bounds:
3 N -> 26 N
Longitude bounds:
62 E -> 90 E

ACSPO_V2.30b01_NPP_VIIRS_2014-01-18_0440-0450_20140314.145310_NAVO




China
Korea
ACSPO
283
282
281
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277
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275
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273
SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2014/01/18 JD 018
Start time:
09:40:00 UTC
End time:
09:50:00 UTC
Projection type:
SWATH
Latitude bounds:
33 N -> 43 N
Longitude bounds:
116 E -> 132 E

Users' Feedback

Environment Canada Environnement Canada

Canada

Some Early Results Assimilating ACSPO VIIRS L2P Datasets

Bruce Brasnett

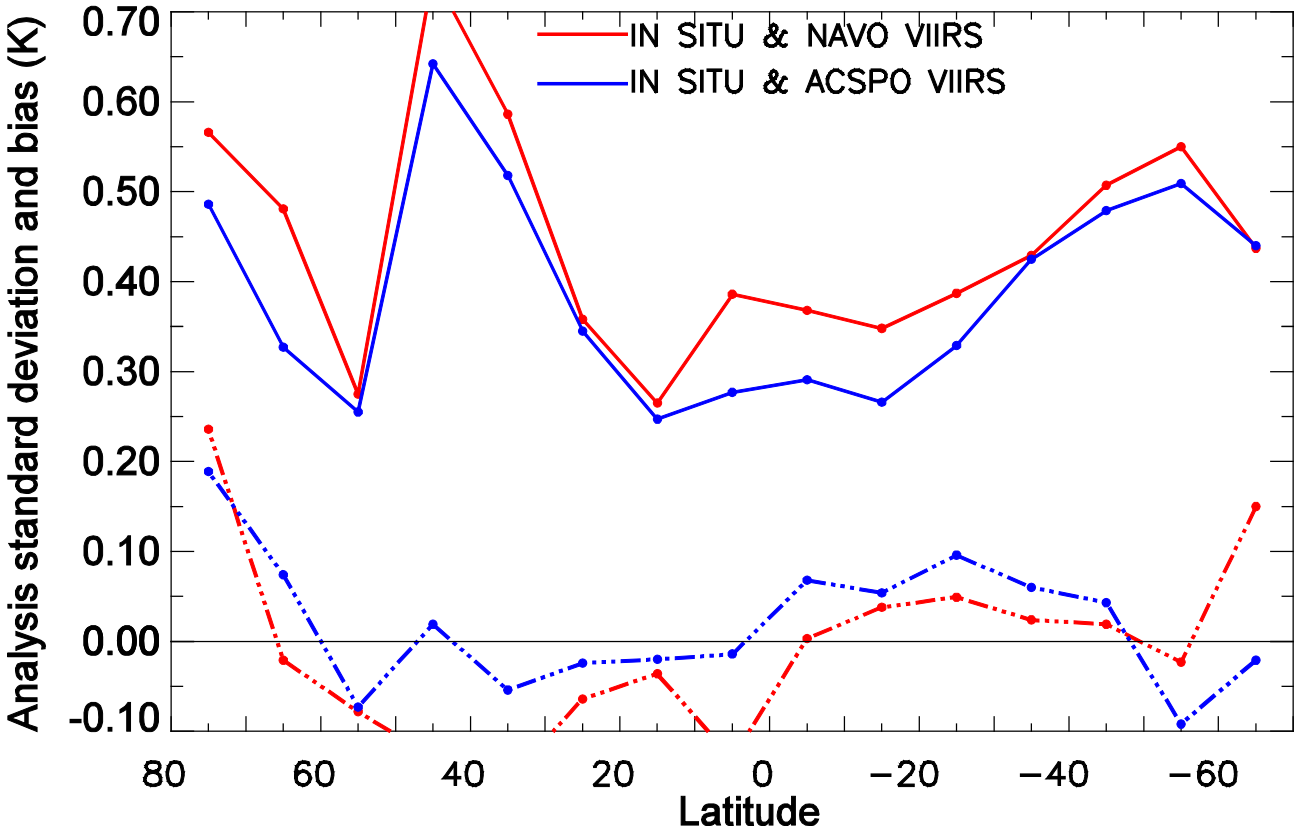
Canadian Meteorological Centre

May, 2014

ACSPO VIIRS L2P Datasets

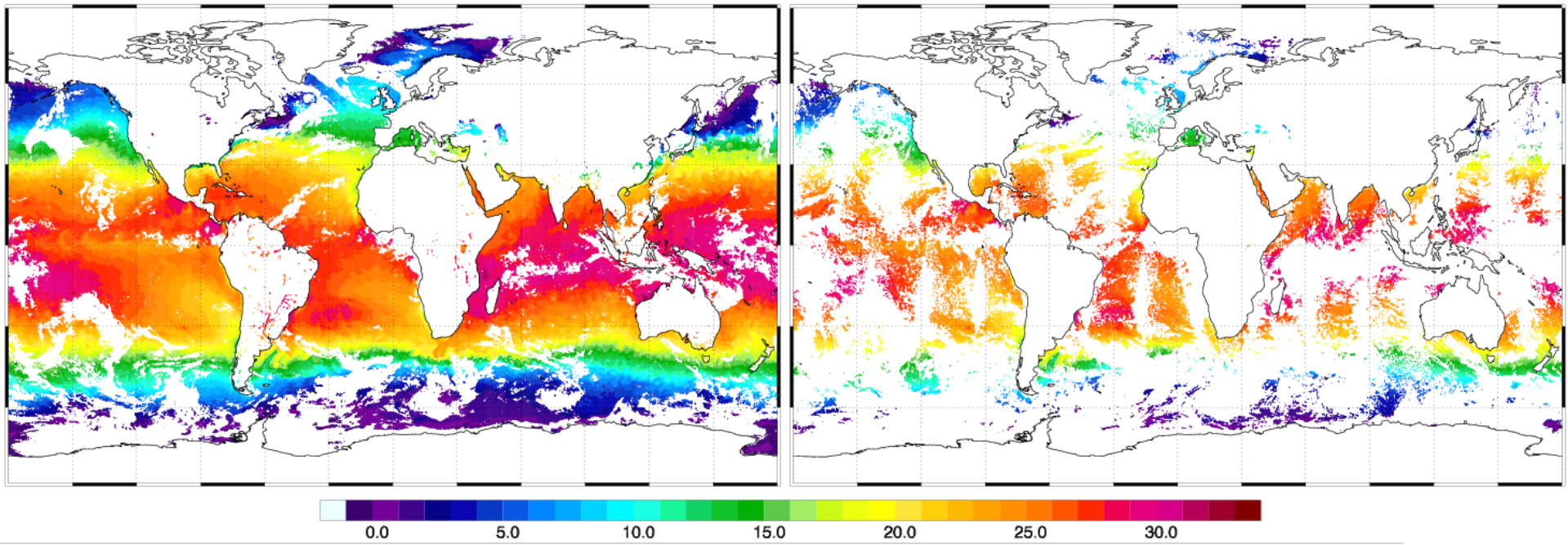
- Received courtesy of colleagues at STAR
- Two periods: 1 Jan – 31 Mar 2014 & 15 Aug – 9 Sep 2013
- Daily coverage is excellent with this product
- Experiments carried out assimilating VIIRS data only and VIIRS data in combination with other satellite products
- Rely on independent data from Argo floats to verify results
- Argo floats do not sample coastal regions or marginal seas

Assessing relative value of 2 VIIRS datasets: NAVO vs. ACSPO



Using ACSPO instead of NAVO improves assimilation

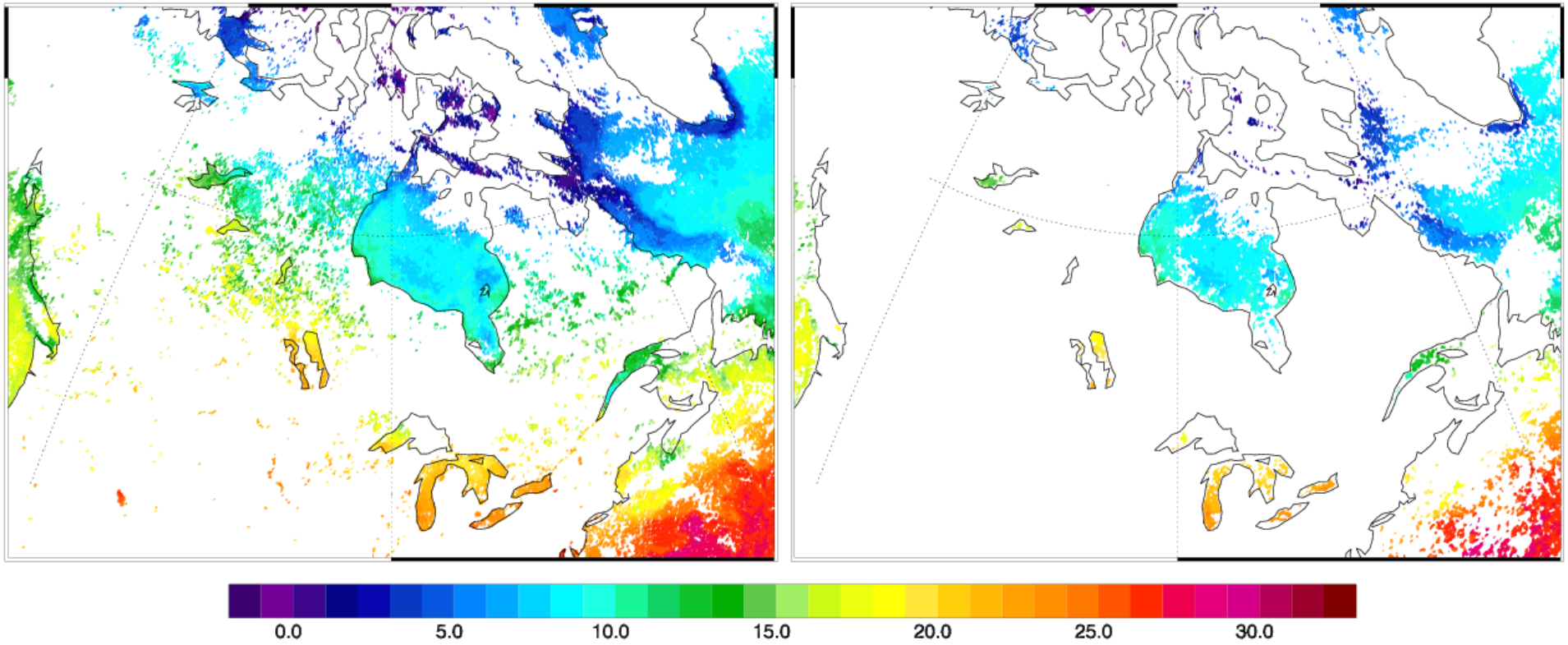
Coverage for 2014/02/01



ACSPO VIIRS

NAVO AVHRR19

Coverage for 2013/09/01



ACSPO VIIRS

NAVO AVHRR18 & 19
and Metop-A combined

CMC Summary

- ACSPO VIIRS L2P is an excellent product
- Based on the Jan – Mar 2014 sample, VIIRS contains more information than either the OSI-SAF MetOP-A or the RSS AMSR2 datasets
- L2P ancillary information: quality level flags and wind speeds are useful but experiment with SSES bias estimates was inconclusive
- Current plan at CMC is to assimilate ACSPO VIIRS L2P dataset when it becomes available

Conclusion to ACSPO/NAVO comparison

ACSPO and NAVO are two viable VIIRS SST choices for users

- ✓ Both are available in GDS2 (ACSPO shortly will be) via JPL/NODC
- ✓ ACSPO retrieval domain is larger than NAVO, by a factor of ~3, due to narrow NAVO swath VZA<54°, and conservative cloud mask
- ✓ NAVO STDs are smaller than ACSPO by a narrow margin
- ✓ Initial ACSPO assimilation in CMC L4 analysis suggests that ACSPO adds information to the currently used L2 SSTs (AMSR2, OSI SAF and NAVO AVHRR, NAVO VIIRS), mainly due to its superior coverage
- ✓ ACSPO areas for improvement: Warm bias in the high latitudes, SSES bias is calculated but was found not informative to improve assimilation

Coming Year Work

- ✓ Continue Monitor, Validate and cross-evaluate various SST products in SQUAM, iQuam, MICROS
- ✓ Go validated with ACSPO SST product (already meet specs)
- ✓ Archive ACSPO GDS2 format at JPL/NODC, discontinue IDPS
- ✓ Explore improved quality flags / Levels in ACSPO
- ✓ Establish reprocessing and back-fill ACSPO VIIRS to Jan'2012
- ✓ Received multiple user requests for ACSPO VIIRS Level 3 product – will need to generate
- ✓ Implement destriping operationally (SDR feedback/Tue PM – Ignatov; SST breakout/Wed – K. Mikelsons)
- ✓ Implement version 1 pattern recognition ACSPO clear-sky mask enhancements (SST breakout/Wed and innovative science talk/Fri – I. Gladkova)

U. Miami Input
(presented at SST breakout)

VIIRS Atmospheric Correction Algorithms

Miami V6:

- $SST2b = a_0 + a_1 T_{11} + a_2(T_{11} - T_{12})\, T_{sfc} + a_3(T_{11}-T_{12})\, S_\theta$
- $SST3b = a_0 + a_1 T_{11} + a_2(T_{3.7} - T_{12})\, T_{sfc} + a_3\, S_\theta$

Miami V7:

- $SST2b = a_0 + a_1 T_{11} + a_2(T_{11} - T_{12})\, T_{sfc} + a_3(T_{11}-T_{12})\, S_\theta + a_4\, S_\theta + a_5\, S_\theta^{\chi}$

$\chi = fn(lat)$

- $SST3b = a_0 + a_1 T_{11} + a_2(T_{3.7} - T_{12})\, T_{sfc} + a_3\, S_\theta + a_4\, S_\theta^{\chi}$

$\chi = 0.1$ for $|lat| \leq 40°$; 2.0 for $|lat| > 40°$

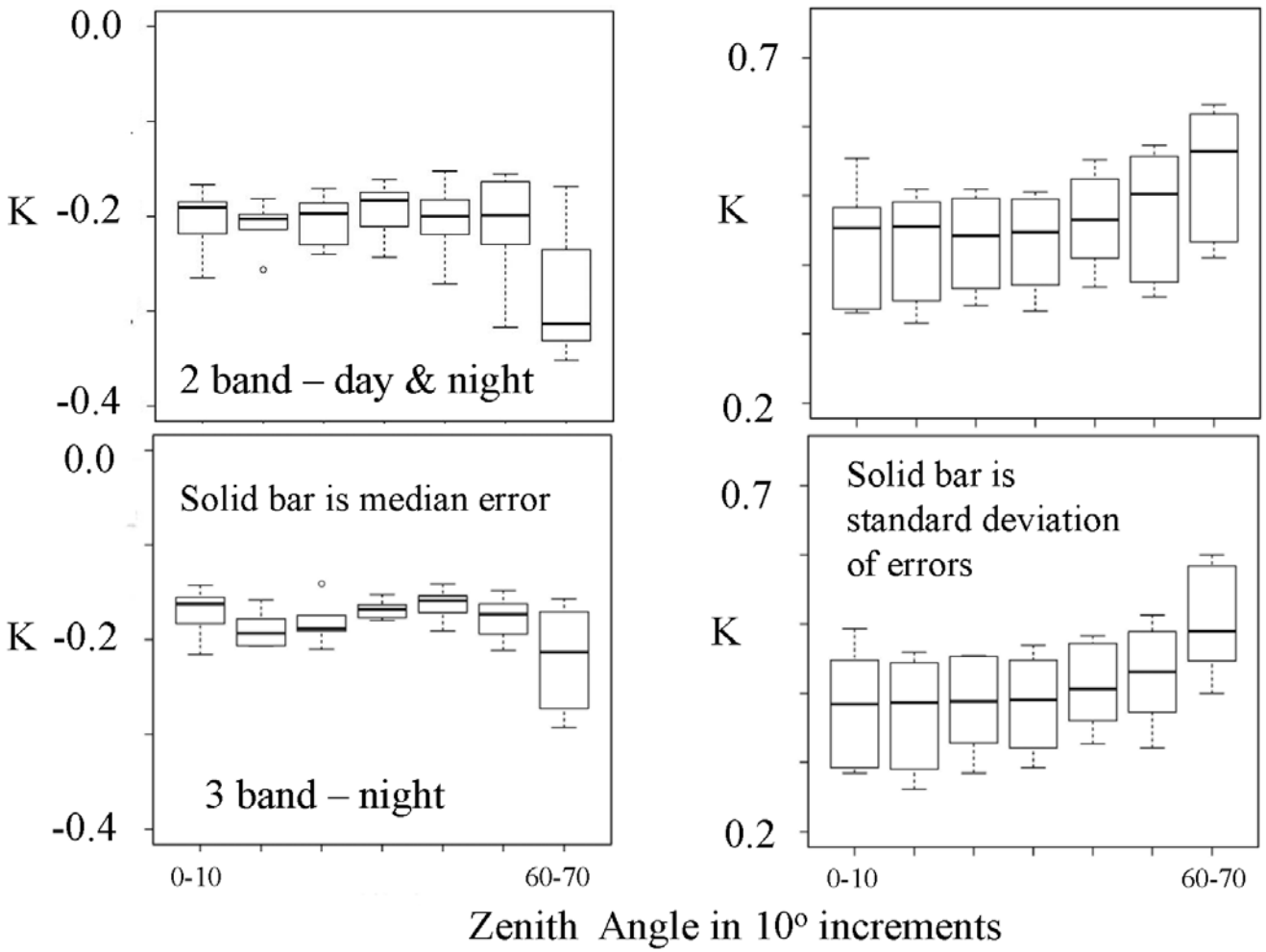
$$S_\theta = \sec(\theta)-1$$

Simple Global Statistics

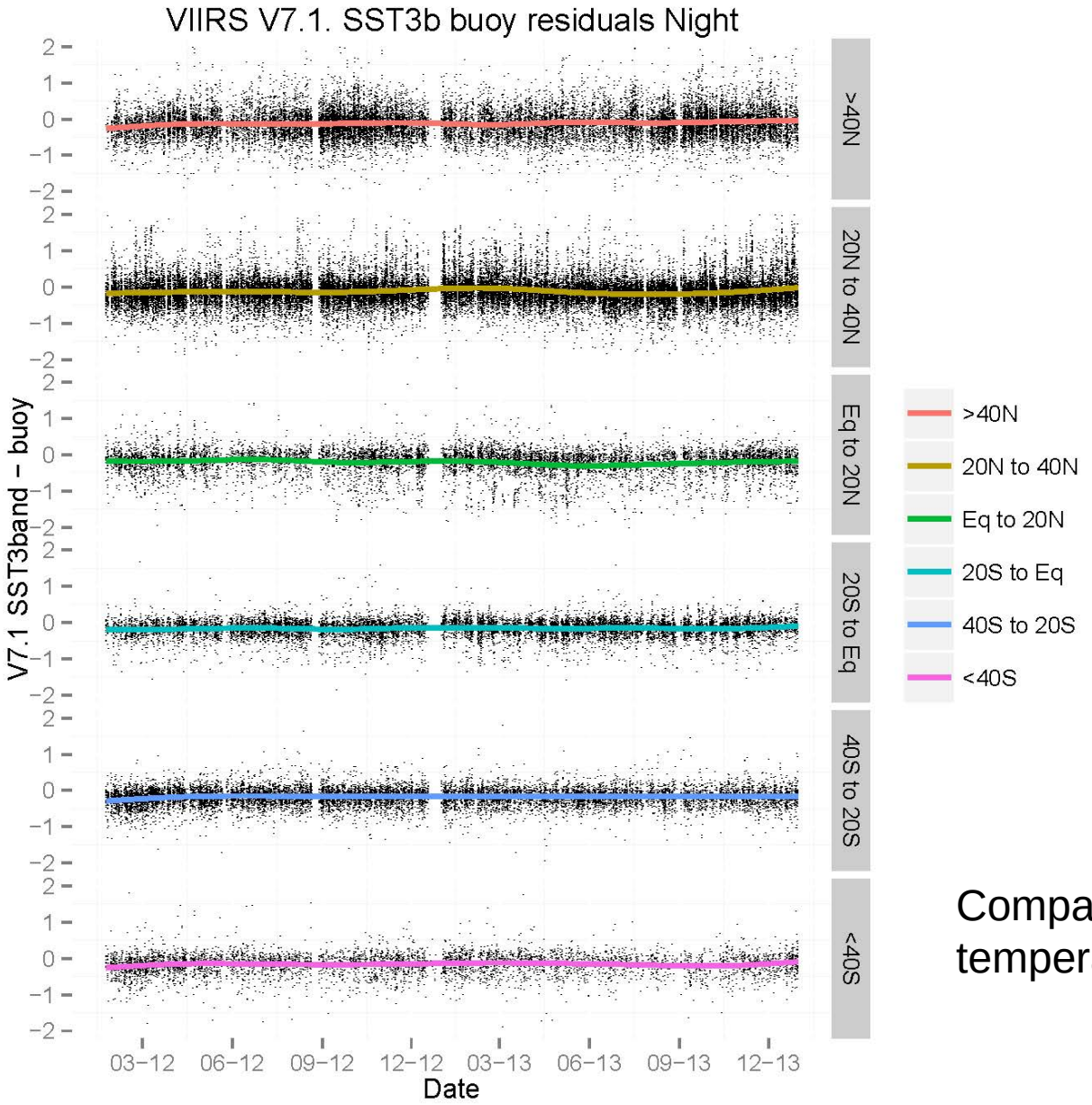
Algorithm	N	Mean	Std Dev	Median	Median Abs Diff
Satellite zenith <55^o					
SST - day	92061	-0.089	0.510	-0.085	0.337
SST - night	126174	-0.160	0.436	-0.153	0.331
SST_3 - night	81155	-0.172	0.395	-0.152	0.230
Satellite zenith >55^o					
SST - day	34693	-0.105	0.647	-0.149	0.536
SST - night	29922	-0.193	0.519	-0.206	0.485
SST_3 - night	35982	-0.131	0.489	-0.161	0.355

Statistics of the differences between the VIIRS skin SST retrievals and the subsurface temperatures measured from drifting buoys.

Zenith angle dependence



Time dependences – in latitude bands



Comparisons to buoy temperatures

NAVO Input
(presented at SST breakout)

Effect of VIIRS Cloud Mask on accuracy of SST

J-F Cayula and Doug May

NAVOCEANO

VCM effect on SST accuracy

- Evaluation of the VIIRS Cloud Mask (VCM) on the accuracy of "cloud-free" SST retrievals
- NAVOCEANO Cloud Mask (NCM) used as comparison standard because it produces very clean SST for input into oceanographic models.
- VCM requires additional tests as SST cloud detection usually handles all contaminants:
  - ➔ Daytime: reflectance test contingent on field test
  - ➔ Nighttime: NCM aerosol test + adjacency test/field test

"Cloud-free": classified as "confidently clear" and determination is "High quality"

VCM effect on SST accuracy

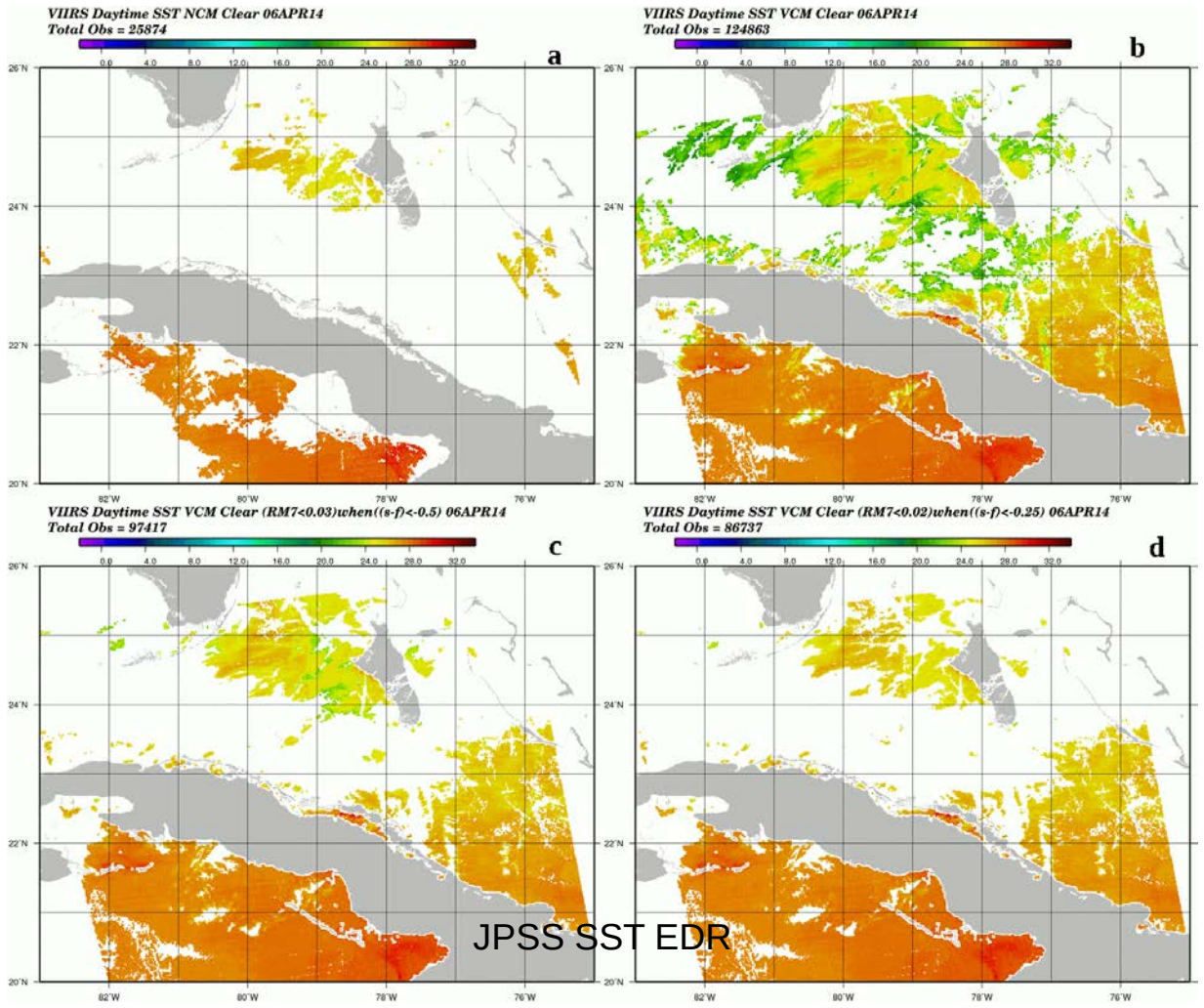
Daytime / February	Buoy matches	RMS error
NCM / NCM + test	4967 / 4901	0.51 / 050
VCM / VCM + test	16844 / 14863	0.70 / 0.51

Nighttime / February	Buoy matches	RMS error
NCM	6785	0.36
VCM / VCM + tests	21052 / 17171	0.56 / 0.34

- VCM with additional tests performs as well as NCM, with better coverage
- However closer inspection shows that most of the VCM improvements come from the additional tests flagging retrievals adjacent to detected clouds. This indicates significant cloud leakage with the original VCM.

VCM effect on SST accuracy

Example: Daytime SST fields on April 6, 2014 a) for NCM clear, b) for VCM clear, c) for VCM clear with additional test, d) with a tightened additional test to remove remaining cloud leakage



NAVO Input
(presented at SST breakout)

Sea Surface Temperature (University of Southern Miss)

Arnone, Vandermeulen, Fargion,

Objectives: VIIRS Cal Val – SST EDR products

Evaluate SST product performance for operational use and science applications

Evaluate Regional Coast SST products

Updates for IDPS processing and algorithms

Project Accomplishments: Past year

1. **Assembled SST products from IDPS , and OSI_SAF and Miami algorithms in Gulf of Mexico .**
2. **Compared SST products in Coastal Fronts and coastal regions.**
3. **Demonstrated use of the VIIRS orbital overlap for sensor validation. - Poster**
4. **Began SST validation in Coastal areas (Mississippi Sound, Mobile Bay)**
5. **Evaluated the SST assimilation into Ocean Models (NCOM, HYCOM)**

Future Plans –

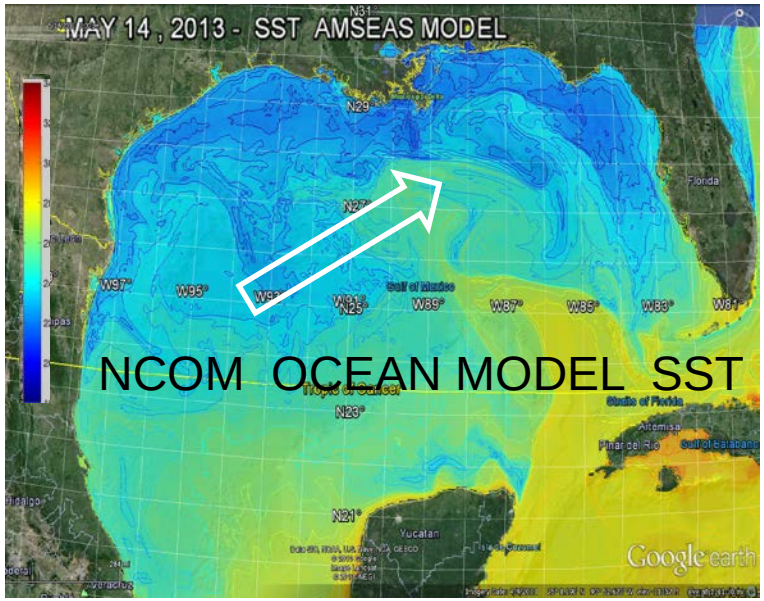
Paper on SST Cal Val Over lap orbits with J.Cayula and S. Ignatov

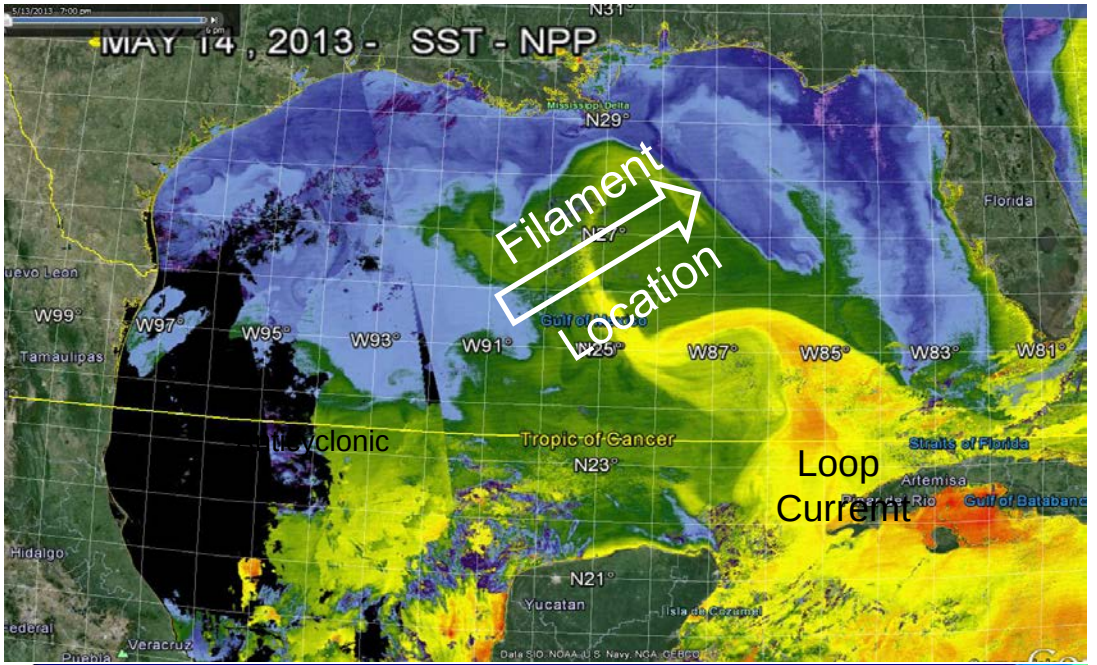
Validation SST products in Coastal and estuary areas –

Examine the Detector response on SST retrievals

Sea Surface Temperature (University of Southern Miss)

Regional Studies - Filament Location





Over compensation in Cloud Mask can impact the Ocean Model SST

Difference in Filament location of Model and SNPP SST - associated with Assimilation and Cloud MASK