JPSS SST

Sasha Ignatov

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U. Wisconsin / CIMSS

Archive: Ken Casey, Sheekela Baker-Yeboah, Korak Saha, Ed Armstrong, Yibo Jiang
NCEI Silver Spring and PO. DAAC

L4 users of VIIRS SST: Dorina Surcel Colan, Bruce Brasnett, Andy Harris, Eileen Maturi, Emma Fiedler, Helen Beggs, Mike Chin, Masakazu Higaki, Toshiyuki Sakurai, Shiro Ishizaki
CMC; NOAA; Met Office; ABoM; JPL; JMA

Algorithm Cal/Val Team Members

Name	Organization	Tasks
Ignatov	STAR	JPSS Algorithm & Cal/Val Lead
Stroup Kihai Dash Liang Zhou, Xu Petrenko Ding	STAR – SGT STAR – GST STAR – CIRA STAR – CIRA STAR – CIRA & GST STAR – GST STAR – CIRA	Technical Liaison; ACSPO Development; ACSPO Reanalysis ACSPO code; Match ups with in situ; Destriping SST Quality Monitor (SQUAM) Monitoring IR Clear-sky Radiances Oceans for SST (MICROS) In Situ SST Quality Monitor (*i*Quam) ACSPO Clear-Sky Mask and SST Algorithm ACSPO Regional Val (high Latitudes); ACSPO L3 product
Gladkova Shahriar	STAR – CCNY, CREST & GST	Improved SST imagery; Pattern Recognition Improvements (Cloud Mask, Ocean Fronts); ACSPO Regional Monitor (ARM)
Arnone	U. Southern Mississippi	SST Cal/Val in coastal areas and from overlapping passes
May Cayula	NAVO	SST Consistency from overlapping orbits NAVO SEATEMP SST and Cal/Val
Minnett Kilpatrick	U. Miami	Improved SST retrievals in High latitudes and at swath edges
Roquet	Meteo France	VIIRS and Metop AVHRR Processing at EUMETSAT

JPSS SST Requirements

Attribute	Threshold	Objective
a. Horizontal Cell Size (Res)	1.6km[1]	0.25km
b. Mapping Uncertainty, 3σ	2km[1]	0.1km
c. Measurement Range	271 K to 313 K	271 K to 318 K
d. Measurement Accuracy[2]	0.2K	0.05K
e. Measurement Precision[2]	0.6K	0.2K (<55° VZA)
f. Refresh Rate	12 hrs	3 hrs
g. Latency	90 min	15 min
h. Geographic coverage	Global cloud and ice-free ocean; excluding lakes and rivers	Global cloud and ice-free ocean, plus large lakes and wide rivers

[1]Worst case scenario (corresponding to swath edge); both numbers are ~1km at nadir

[2]Represent global mean bias and standard deviation validation statistics against quality-controlled drifting buoys (for day and night, in full VIIRS swath, in full range of atmospheric conditions). Uncertainty is defined as square root of accuracy squared plus precision squared. Better performance is expected against ship radiometers.

S-NPP SST: Products, Progress, RAN, Users

- **Advanced Clear-Sky Processor for Oceans (ACSPO) Products**
  - Produced by NOAA ESPC/NDE; Archived w/GHRSST (PO.DAAC / NOAA NCEI)
  - L2 (swath projection; 10min granules; 27GB/day): May 2014-on
  - 0.02° L3U (Uncollated): May 2015-on (requested by ABoM, Met Office, JMA)
  - ACSPO code integrated into direct readout CSPP package at UW
- **Two ACSPO versions implemented (v.2.31/2.40) / Archived w/GHRSST**
  - Fixed warm low stratus cloud leakage
  - Produced new 0.02° L3U product (10min granules, 1 GB/day)
  - improved error characterization (facilitates data assimilation in L4 analyses)
  - Implemented destriping in the operations
- **ACSPO VIIRS SST Reanalysis (w/U. Wisconsin)**
  - Unfunded 'demo' effort w/UW L. Gumley's group – need sustainable model
- **ACSPO VIIRS SST Users (L4 producers)**
  - Included in NOAA geo-polar blended & CMC L4s; Being explored in Met Office, BoM, NCEP, JMA, MUR, NCEI L4s

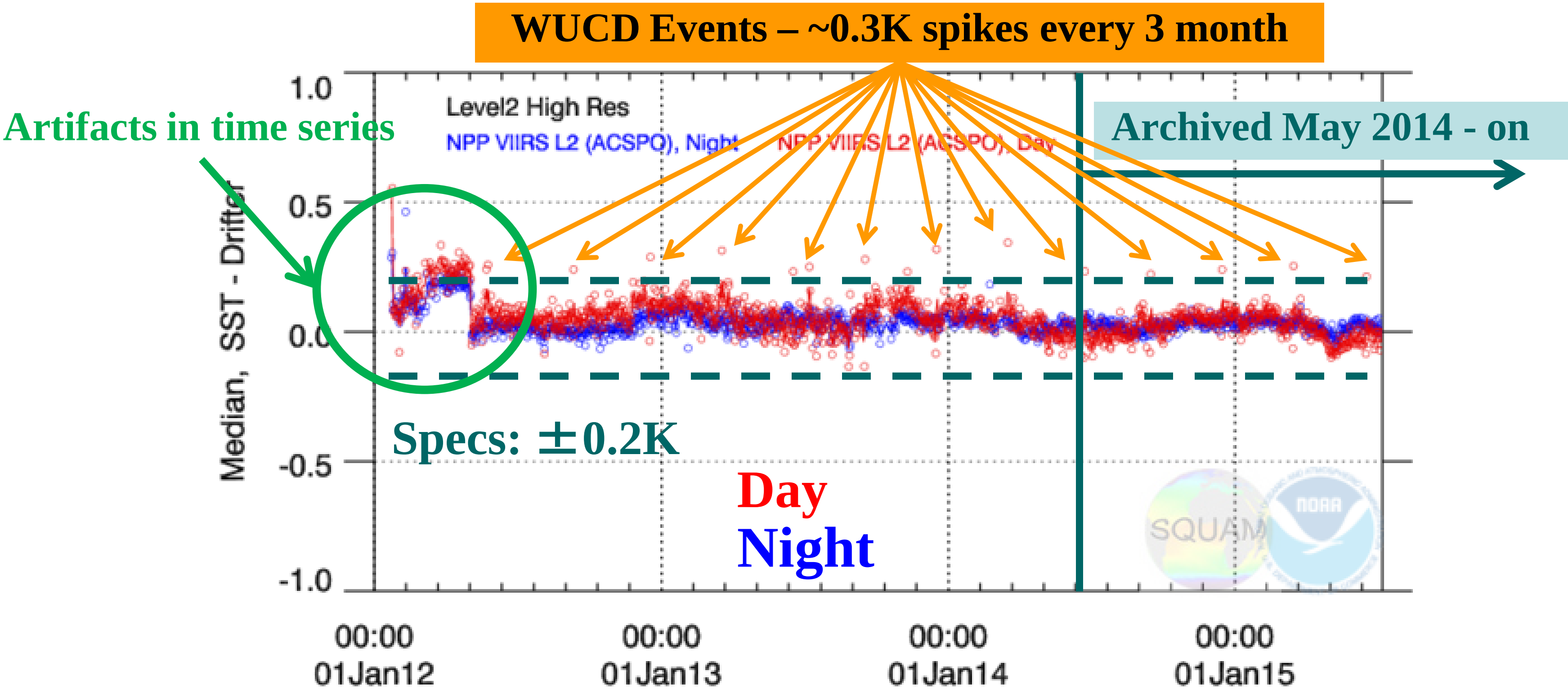
S-NPP SST: Cal/Val, Deficiencies, LTM

- **Status of ACSPO Cal/Val – Fully meet specs**
  - ACSPO L2 SST declared "Validated 3" in Sep 2014
  - ACSPO L3U SST (May 2015 – on) shows comparable performance

- **Known ACSPO Deficiencies**
  - Incomplete (May 2014 – on) & non-uniform record – RAN underway
  - Limited Regional Monitoring – ACSPO Regional Monitor for SST under development
  - Clear-Sky Mask in dynamic, coastal, hi-lat ocean has room for improvement – Future work
  - VAL time series show periodic (3-month) spikes of ~0.3 K, due to Warm-Up/Cool-Down exercises – Need SDR Team to fix the RDR-to-SDR code to minimize the effect on SST

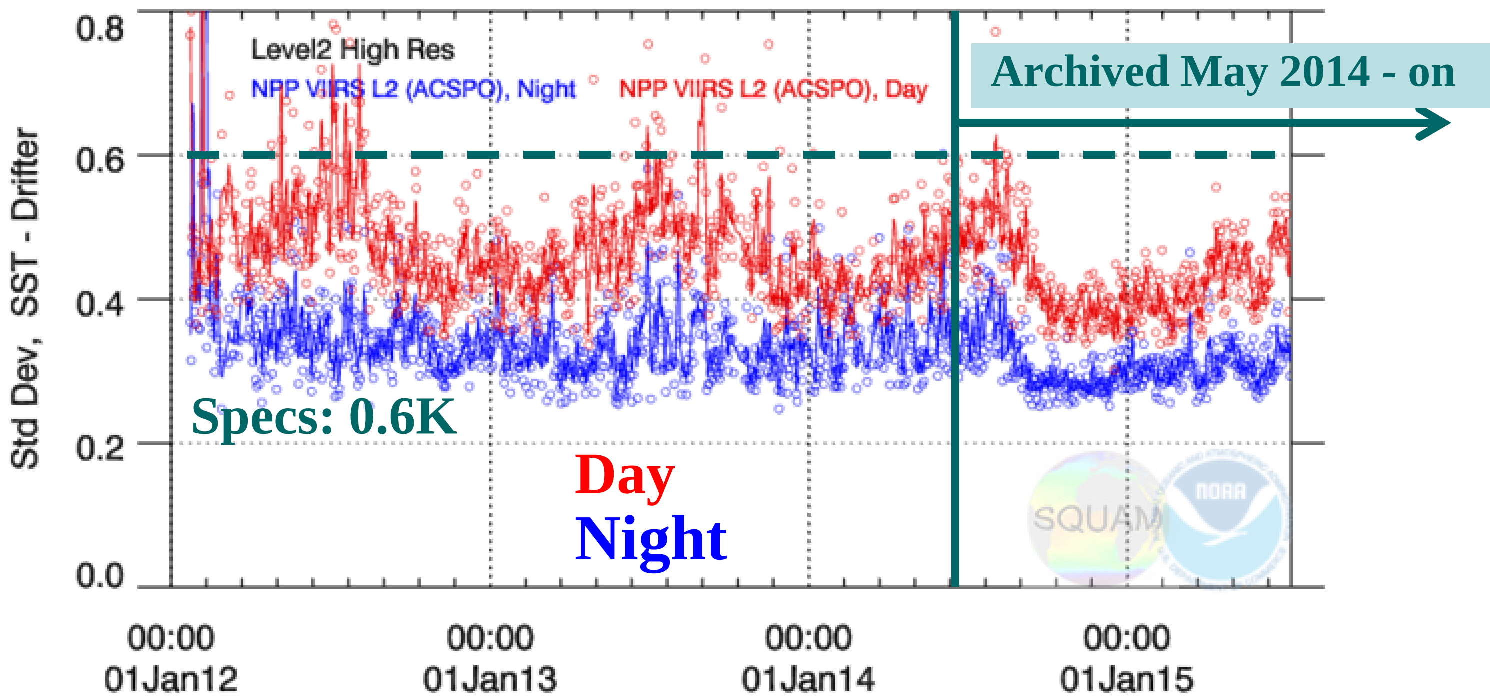
- **ACSPO Long-Term Monitoring**
  - SST Quality Monitor (SQUAM) www.star.nesdis.noaa.gov/sod/sst/squam/ - VIIRS SSTs
  - *In situ* Quality Monitor (*i*Quam) www.star.nesdis.noaa.gov/sod/sst/iquam/ - *in situ* SSTs
  - Monitoring IR Clear-Sky Radiances over Oceans for SST (MICROS) www.star.nesdis.noaa.gov/sod/sst/micros/ - VIIRS radiances associated with SST
  - ACSPO Regional Monitor for SST (ARMS) – development underway

VAL BIAS: Real Time ACSPO VIIRS L2



- ACSPO SST only archived from May 2014 – pr
- SST gradually improved due to SST algorithms improvements
- Every 3 month, “global warming” of ~0.3 K occurs, due to WUCDs
- Reprocessing with UW will produce uniform time series (except WUCD)

VAL STD: Real Time ACSPO VIIRS L2



- STD gradually improved with time as ACSPO SST algorithms matured
- Current STDs ~0.35 K (Night); ~0.45K (daytime) are well within specs
- STD smaller at night (VIIRS skin SST being closer to bulk buoy)
- Reprocessing with UW underway to produce uniform time series

ACSPO SST Users (L4 producers)

- **Active Users (assimilate in L4 analyses)**
  - Canadian Met Centre, CMC02 L4 SST (Dorina Surcel-Colan, Bruce Brasnett)
  - NOAA geo-polar blended L4 SST (Andy Harris, Eileen Maturi)
- **Advanced Users (testing)**
  - Met Office, OSTIA L4 SST (Emma Fiedler)
  - Australian Bureau of Meteorology, GAMSSA/RAMSSA L4 SSTs (Helen Beggs)
- **Users who established access to data (exploring)**
  - NCEP MMAB, RTOFS and RTG SST (Carlos Lozano, Avichal Mehra, Bob Grumbine)
  - JPL, MUR L4 SST (Mike Chin)
  - JMA, MGDSST L4 (Masakazu Higaki, Toshiyuki Sakurai, Shiro Ishizaki)
  - NCEI, Reynolds SST (Viva Banzon)
- **Tasks in 2015-2017**
  - Work with current users (to evaluate L3U product, and new error characterization)
  - Work with emerging users, to assess the impact of VIIRS SST on L4 analyses

J1 Readiness: Algorithm, Cal/Val Plans

✓ **J1 Algorithm**

- ACSPO code available by J1 launch will be implemented with J1 VIIRS

✓ **Pre-launch Cal/Val**

- Analyze proxy data: S-NPP VIIRS, AVHRR (FRAC and GAC), MODIS, AHI/ABI
- Continue ACSPO development: Release ACSPO v2.50/2.60 in 2016
- Sustain SST Cal/Val Tools: SQUAM, MICROS, *i*Quam

✓ **Post-launch Cal/Val**

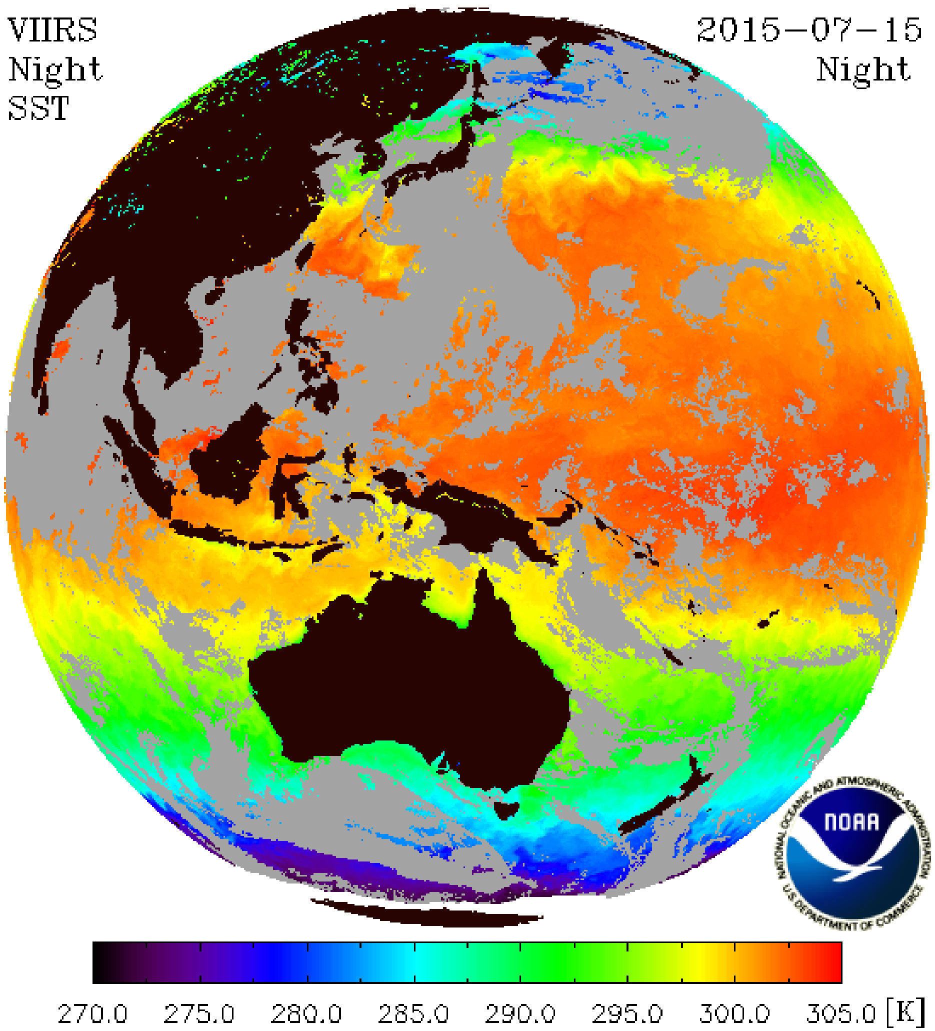
- Early Orbit Checkout (EOC): Emphasis on sensor performance / Work w/SDR to resolve
- Intensive Cal/Val Phase (ICV): Emphasis on SST performance
- Long-Term Monitoring (LTM): Create match-ups w/iQuam; Add J1 to SQUAM/MICROS
- Based on evaluation and monitoring, refine SST algorithms (recalculate coefficients, etc)

✓ **Cal/Val Timelines (cryoradiator doors open at T0)**

- Assuming that performance of J1 VIIRS is comparable to that on S-NPP:
  Beta: T0+3mo; Provisional: T0+6mo; VAL: T0+12mo

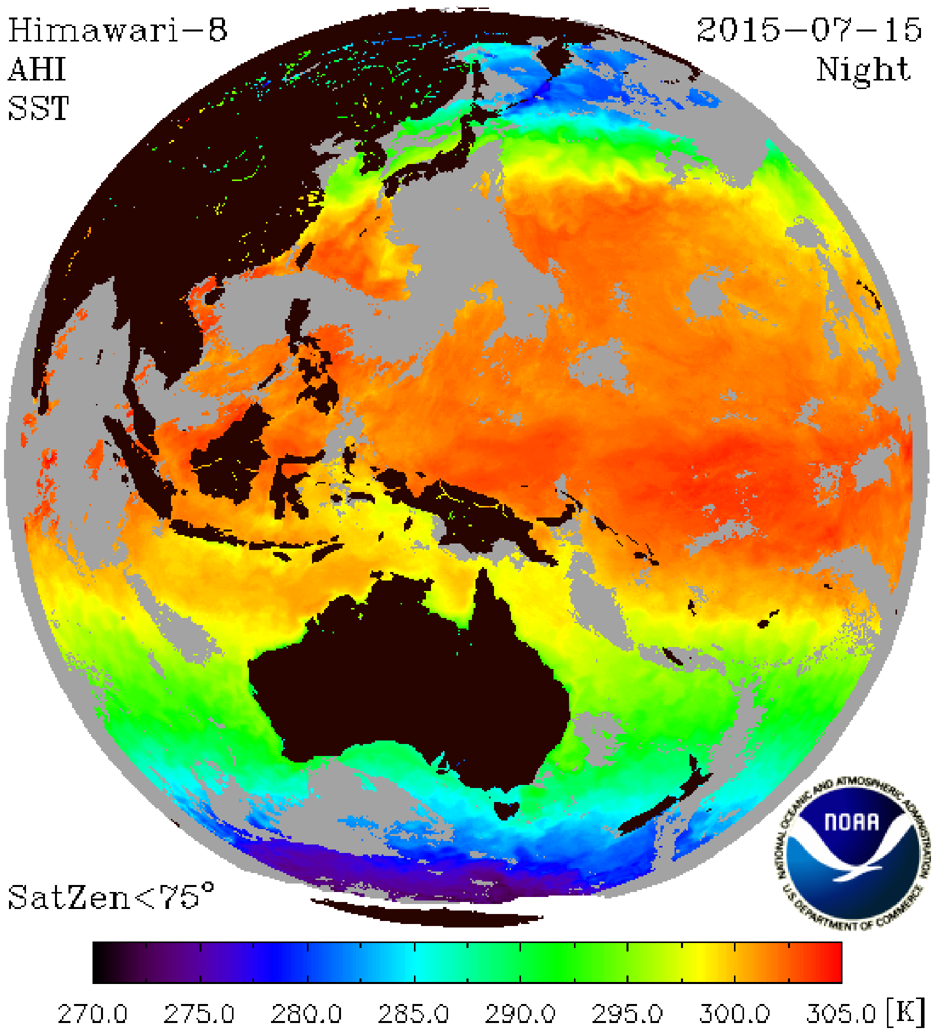
VIIRS Night SST Composite in Himawari-8 Domain

- VIIRS SST composite in H8 domain
- Large areas are cloudy during S-NPP overpass @ 1:30 am



Himawari-8 Night SST Composite

- Enterprise ACSPO algorithm applied to H8
- AHI composite covers larger domain, due to 10min refresh rate
- SST Team will be ready for J1 and GOES-R launch



ACSPO Priorities in FY16

1. (Prerequisite for tasks 2-3) Improve BT and SST Imagery: resample (“de-bowtize”) and restore pixels in bow-tie areas deleted onboard – ACSPO v2.50 (Mar 2016)

2. (Main Objective) Improve clear sky mask based on pattern recognition approach: Focus on dynamic, coastal, and high-latitude areas – ACSPO v2.60 (Dec 2016)

3. (By-product of pattern recognition) Produce Ocean Thermal Fronts – ACSPO v2.60 (Dec 2016)

Why Pattern Recognition is Important?

1. All current “in-pixel” IR clear-sky masks tend to be overly conservative. ACSPO is on a less conservative side, but still produces quite a few “false alarms” (especially in the dynamic, coastal, and high-latitude areas)

2. As a result, some areas (with variable SST, or colder than surrounding waters, or colder than expected “L4” SST) may remain unobserved for extended periods of time

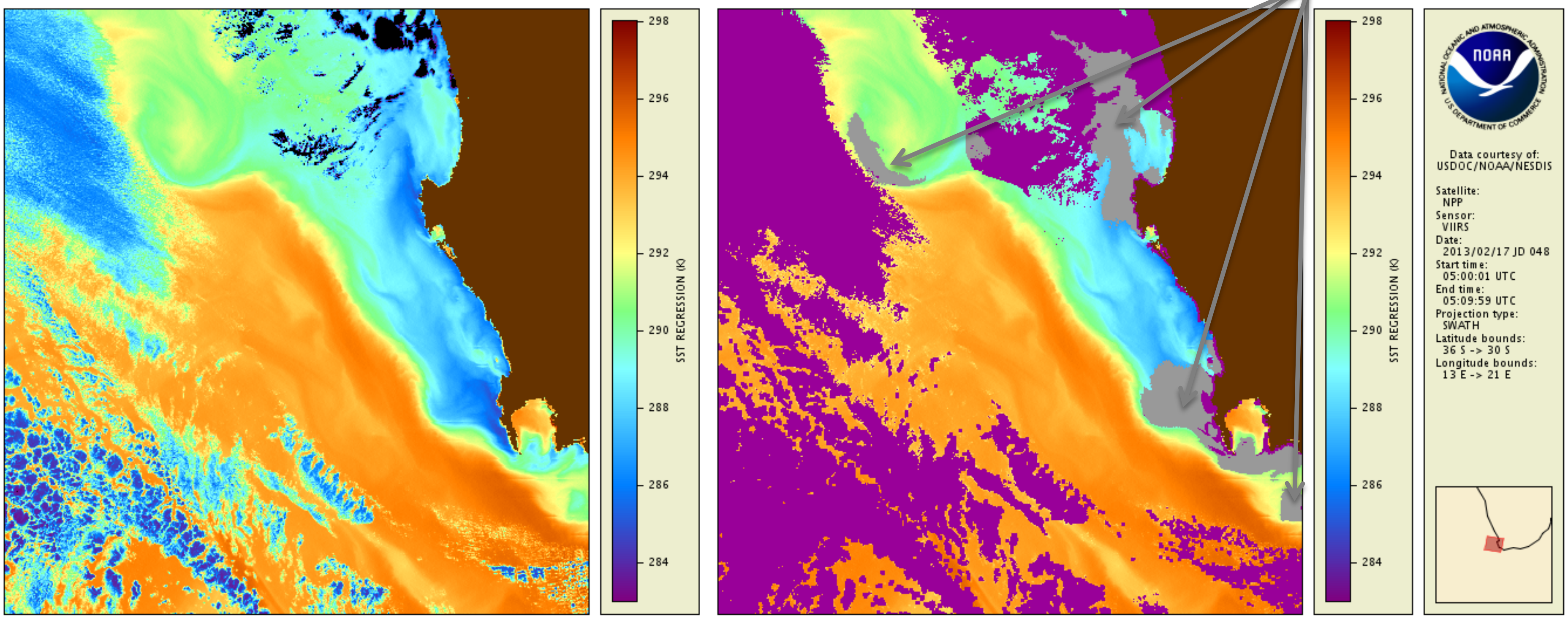
3. These areas are most interesting to users – in particular, producers of hi-res L4 analyses (which may rely on climatological SSTs here)

4. VIIRS imagery has excellent potential. We plan to fully realize it, to satisfy wide range of SST users

ACSPO v2.60: Improved Clear-Sky Mask

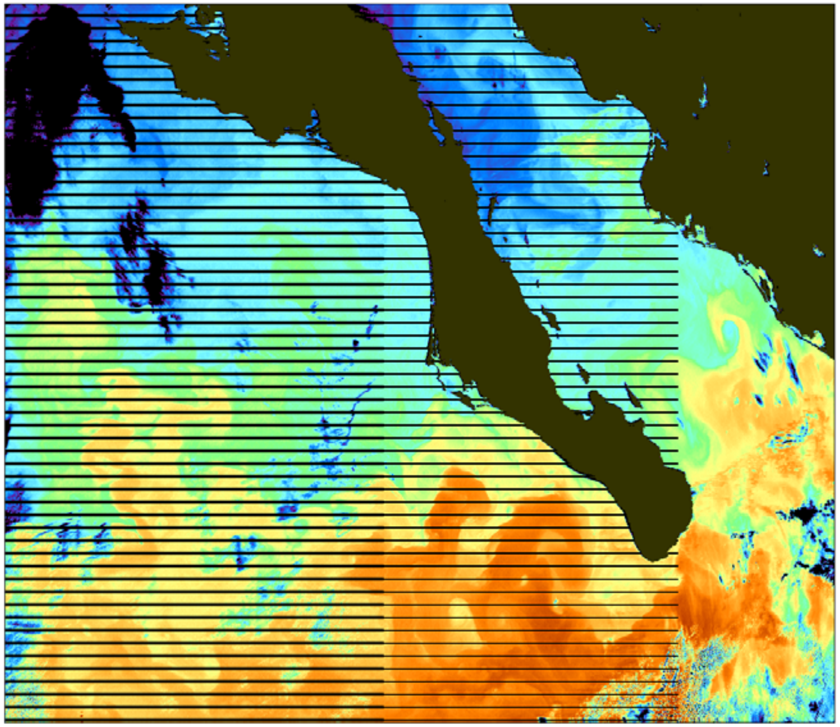
S. Africa, 02/17/2013 (day pass)

Misclassified clear sky areas

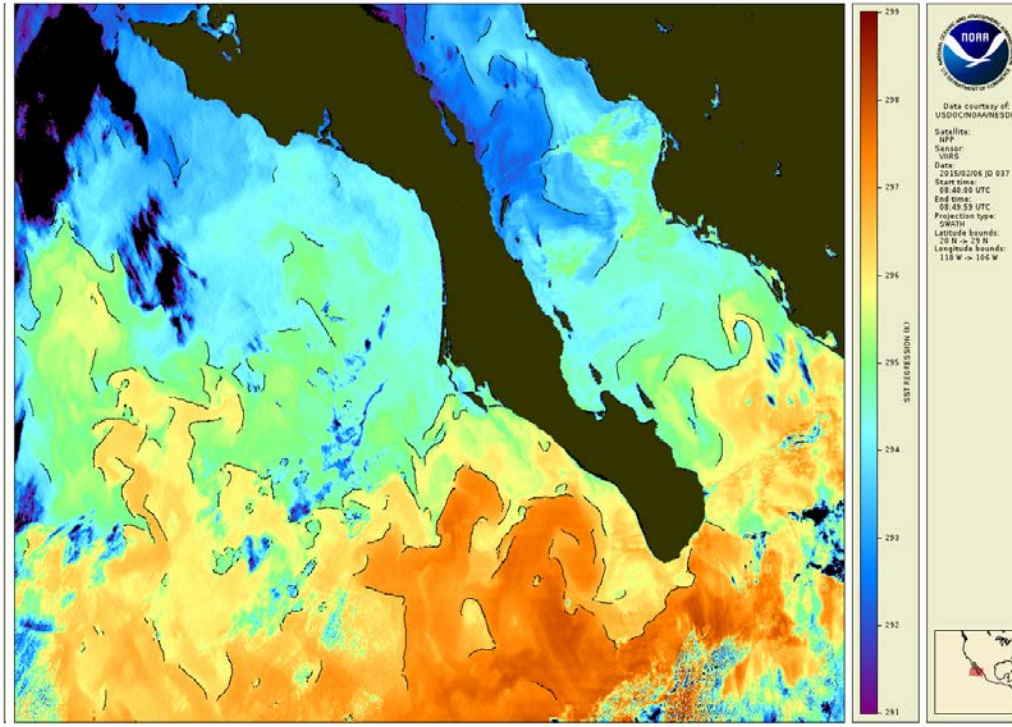


Cold upwelling and some other dynamic and coastal areas (shown in grey) are misclassified by the current ACSPO as cloud

ACSPO v2.60: Ocean Fronts



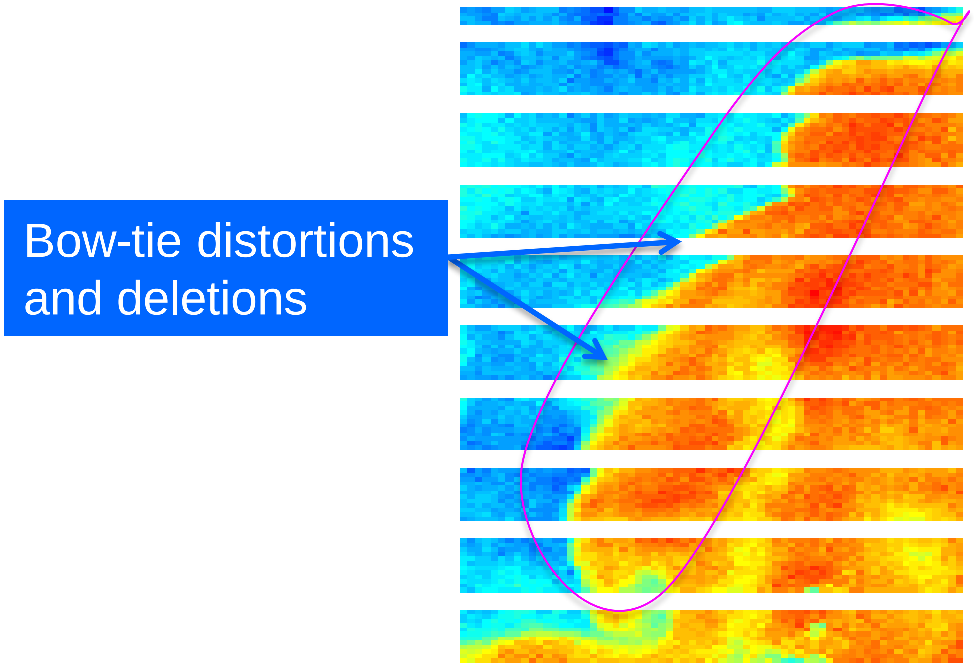
Original VIIRS SST imagery



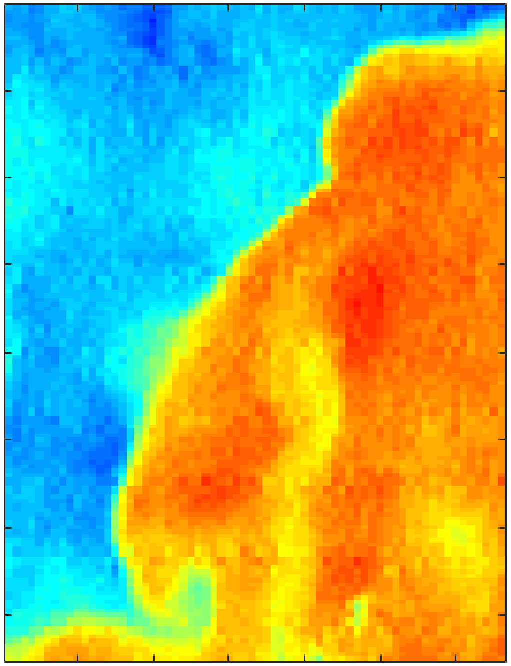
Resampled imagery with oceanic thermal fronts superimposed

ACSPO v2.50: Prerequisite to v2.60

- VIIRS swath data have bow-tie distortions, onboard deletions and aggregations
- This creates spatial discontinuities and artifacts in the gradient fields, and prevents implementation of pattern recognition algorithms
- ACSPO v2.50 will fix these artifacts as best as we can but.. **we strongly recommend against bow-tie deletions on J1 & beyond!!**

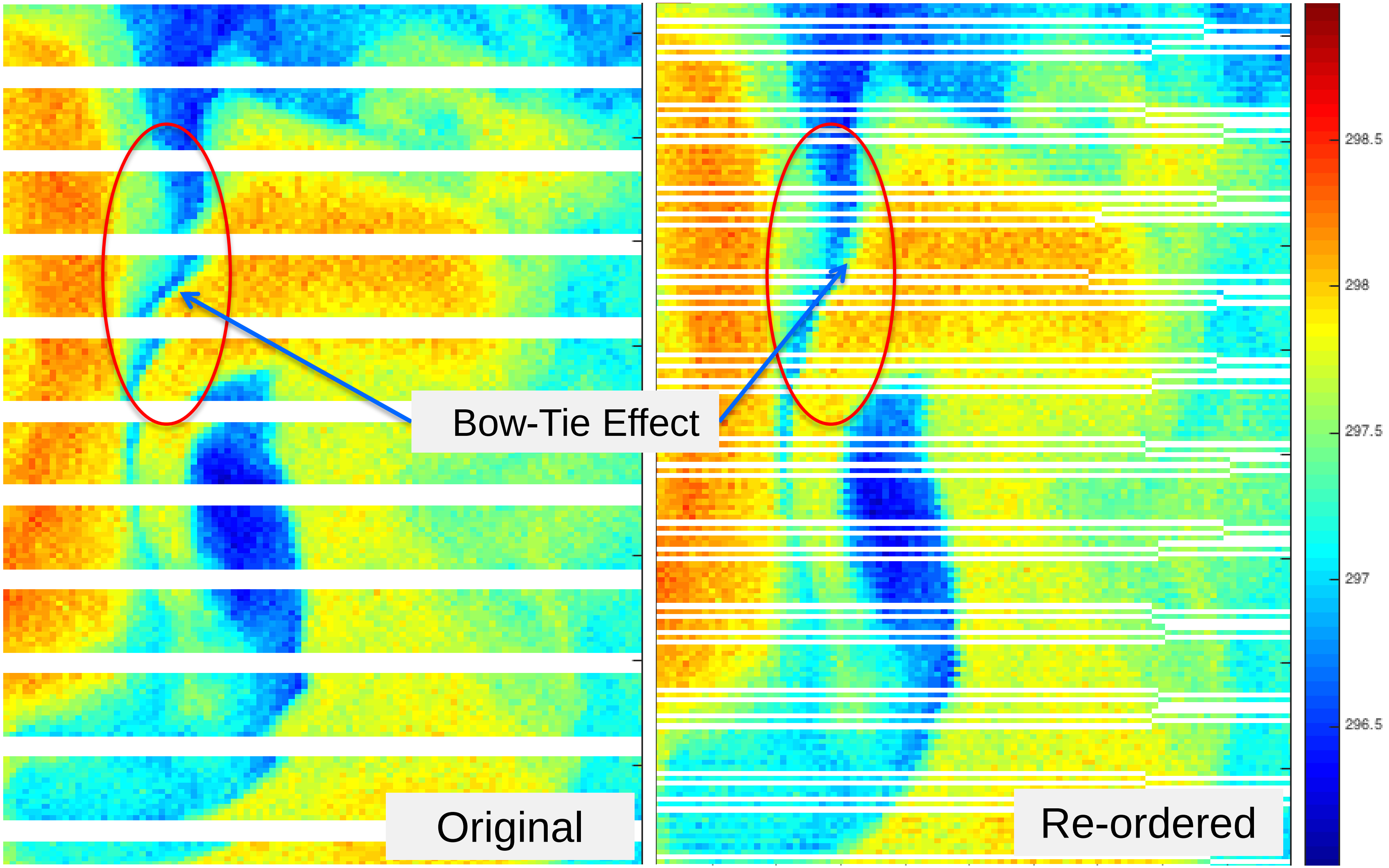


Current SST

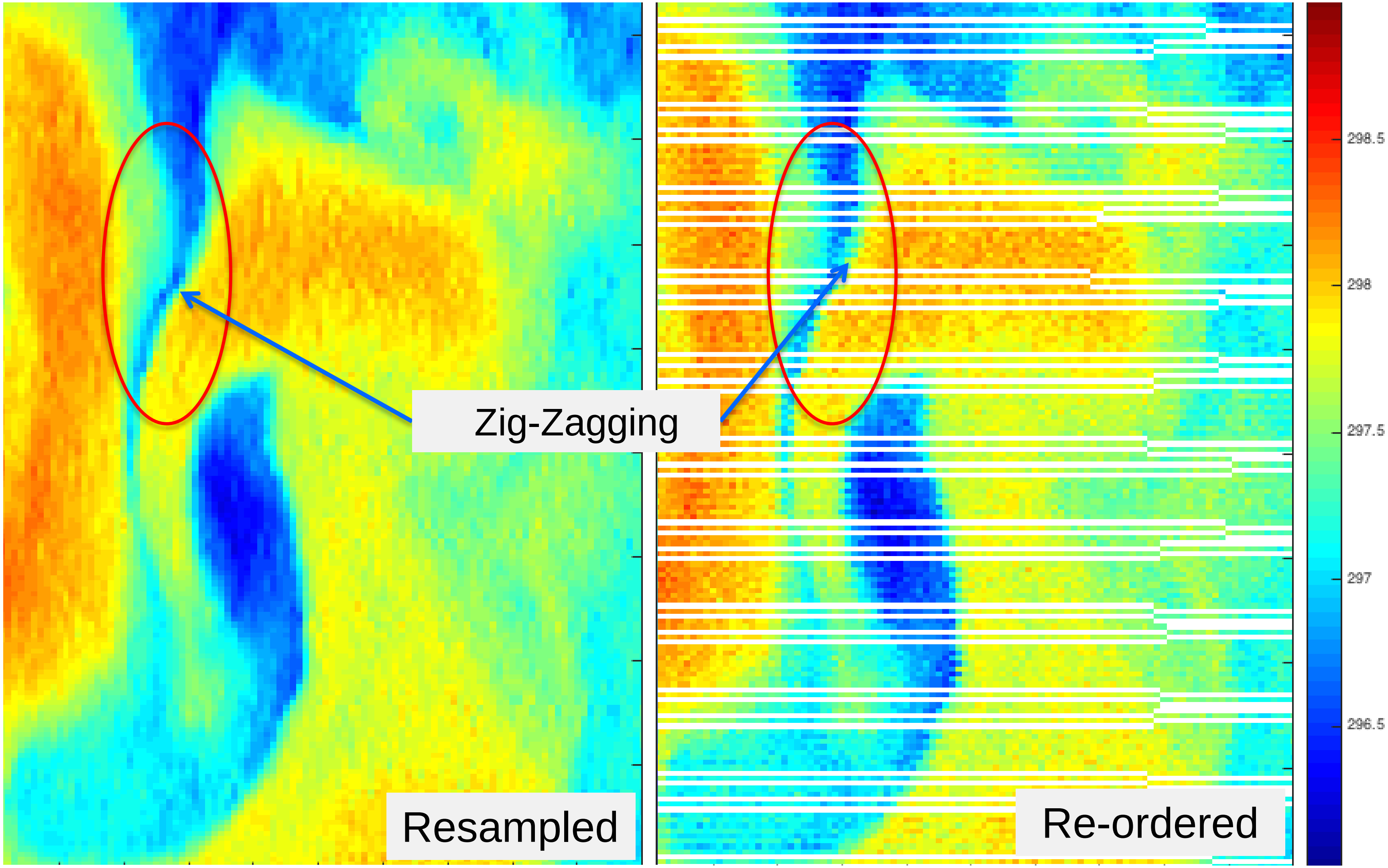


SST in ACSPO 2.50

ACSPO v2.50



ACSPO v2.50



Other SST Tasks in 2016

Complete VIIRS RAN1

- ✓ Display online in SQUAM and MICROS, QC, fix remaining issues
- ✓ Archive with NCEI Silver Spring

Sustain near-real time global VAL/Monitoring online

- ✓ Sustain match-ups with in situ SSTs (*i*Quam)
- ✓ Monitor in SQUAM and MICROS

Focus on Regional Validation

- ✓ Recommended by JPSS PO at Validated Review (Sep 2014)
- ✓ ACSPO Regional Monitor for SST (ARMS) is being developed

Work with VIIRS SST Users (L4 producers)

- ✓ Established users: Test improvements (L3U, error characterization)
- ✓ New/Emerging Users: Test improvements from assimilating VIIRS SST

Issues to Discuss at the Meeting

VIIRS Warm-Up / Cool-Down exercises affect SST

- ✓ Fix RDR to SDR code, to minimize the ~0.3K “global warming” artifacts
- ✓ Discuss with JPSS PO, STAR JPSS Management, SDR Team

ACSPO VIIRS Reanalysis (RAN)

- ✓ Unfunded “demo” RAN-1 underway with UW group (L. Gumley)
- ✓ Results look promising, need a sustained support
- ✓ Discuss with JPSS PO, UW, STAR JPSS Management

VIIRS L1.5 product? (bow-ties filled in, geo-rectification applied)

- ✓ SST will “fix” SDR in ACSPO v2.50 for pattern recognition analyses
- ✓ If you are a VIIRS data producer or user, interested in a L1.5 – please provide feedback to SST/SDR/Imagery/JSTAR Leads
- ✓ SST Team plans discuss w/JPSS PO, JSTAR, SDR, Imagery and other EDR Teams during the meeting

Status of ACSPO VIIRS SST Reanalysis

John Stroup

Sasha Ignatov, Xingming Liang, Prasanjit Dash, Yury Kihai, Irina Gladkova

NOAA ; CIRA; GST Inc; CCNY

Liam Gumley, Steve Dutcher

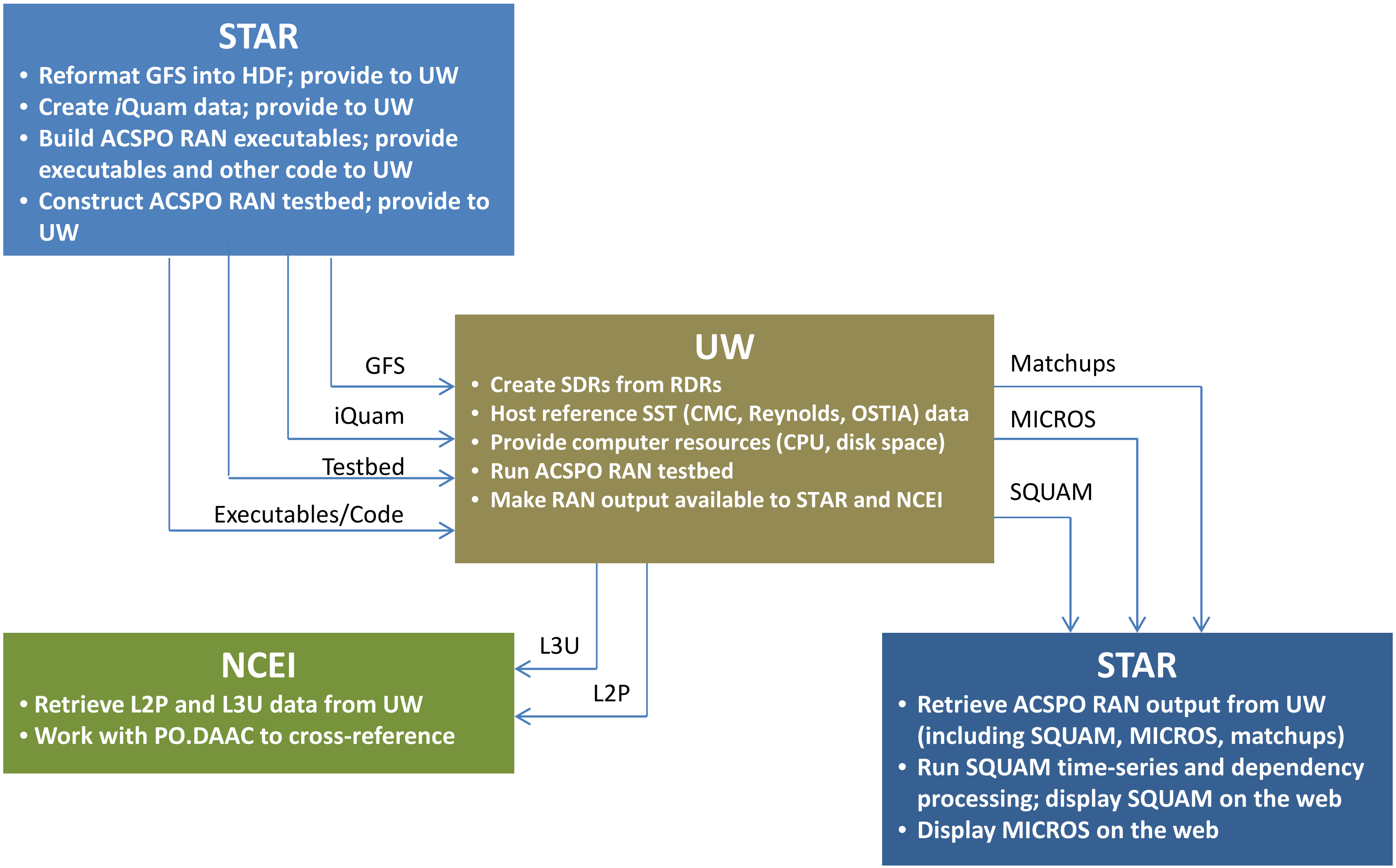
U. Wisconsin / CIMSS

ACSPO Reanalysis (RAN)

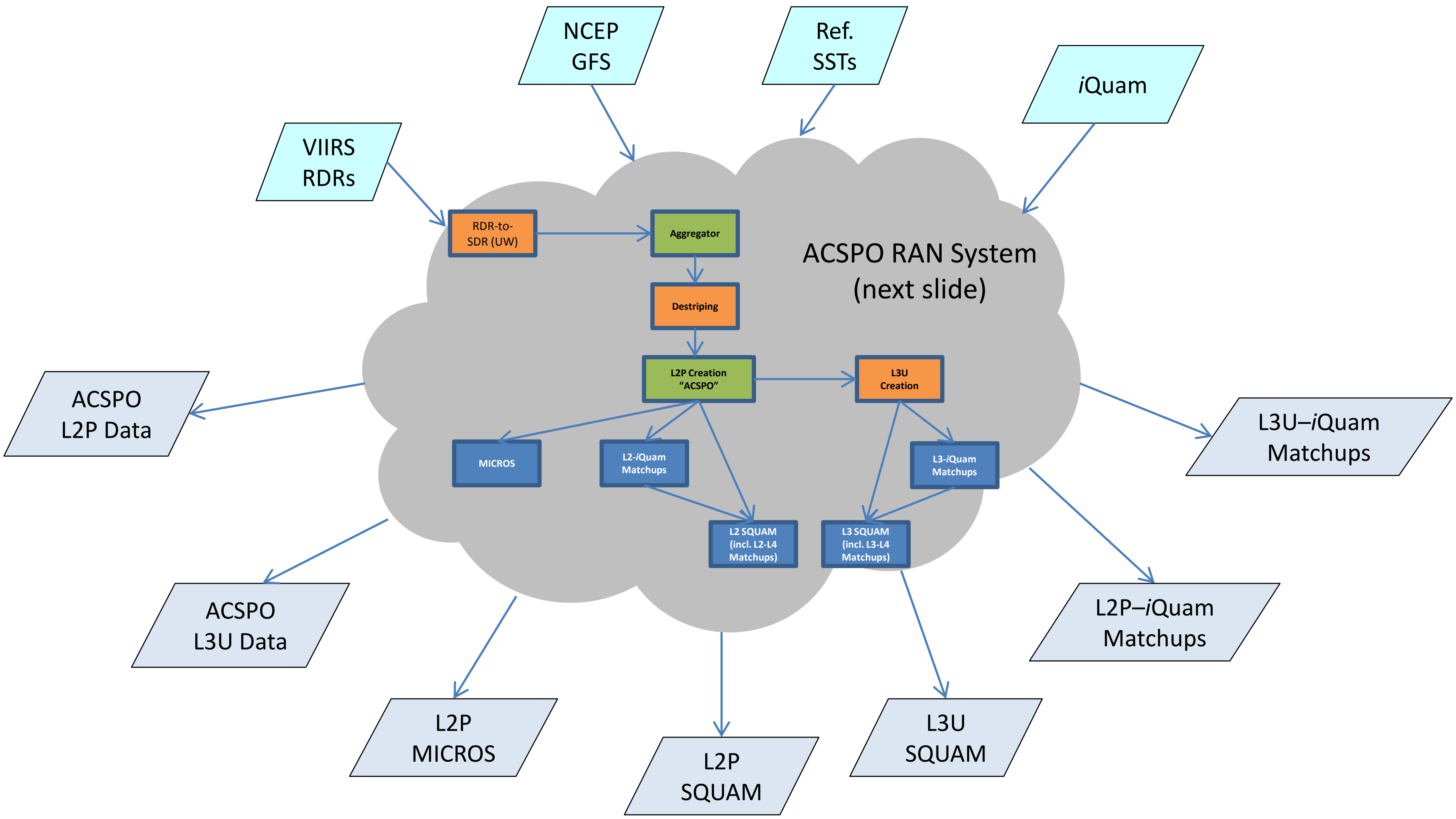
- Objective
  - Reprocess all S-NPP VIIRS data from Jan. 18, 2012 (when cryoradiator doors opened) through “present” using latest ACSPO software
  - Use UW systems for their "horsepower" and data access
    - cluster system has a large number of CPUs/nodes
    - maintain full VIIRS RDR record; host numerous ancillary data
    - UW can generate SDRs from RDRs using CSPP code (instead of using original IDPS SDRs)

- Anticipated Benefits
  - Generate full ACSPO VIIRS record (now archive from May 2014 – on)
  - Greater data availability
    - Should be less missing data (SDRs, ancillary) than seen in NRT processing
  - Better, more consistent VIIRS SDR data
    - E.g., bug that resulted in large BT differences during first WUCD event fixed
  - Better, more consistent ACSPO data
    - 4 upgrades to ACSPO code since Jan. 2012
  - Complete record of ACSPO L3U data
    - Currently data availability (in PO.DAAC and NCEI) starts May 19, 2015; SQUAM monitoring starts Jan. 1, 2015
  - Better overall statistics in MICROS and SQUAM

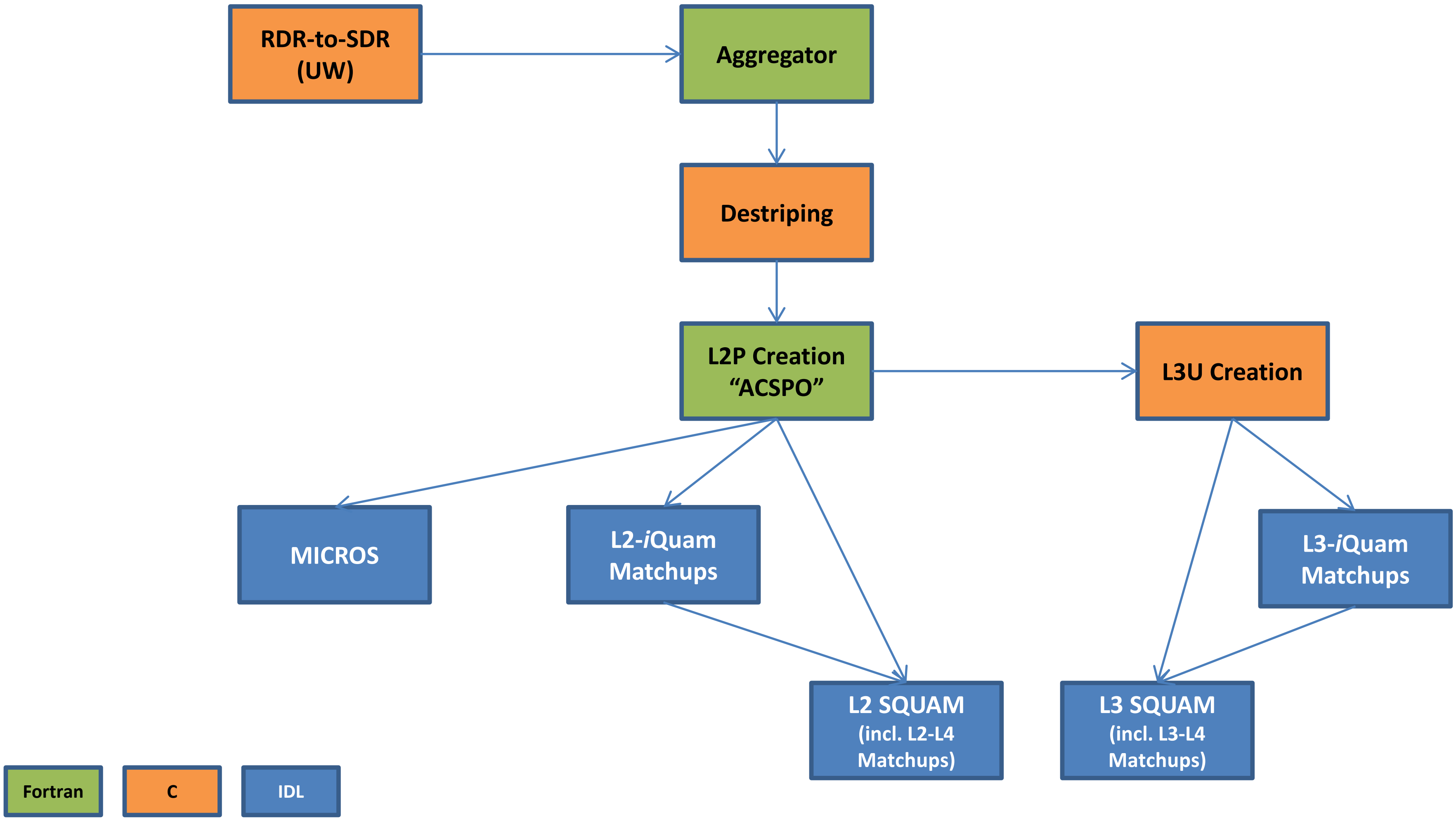
ACSPO RAN: Conceptual View



ACSPO RAN: High-Level Data Flow



ACSPO RAN: Control Flow



Testbed

- All code and data (except for external data, e.g., reference SST), plus scripts for running ACSPO RAN, are placed in a directory structure, which forms a nearly self-contained reprocessing *testbed*
- The testbed is constructed to process a single day of data assuming that each day of data would be processed on a separate CPU/node within the UW cluster
  - Note that processing of day 'n' begins with the last hour of data from day 'n-1'. This is done to "warm-up" the ACSPO histogram files before day 'n' processing begins.
- All output generated by ACSPO RAN is written to directories in the testbed
  - To provide an extra level of organization and to avoid potential write conflicts, day-specific subdirectories are created within various testbed directories during processing

Testbed Directory Structure

Directory	Description/Content
acspo	*ACSPO output files*
gds2_l2p	*GDS2 L2P SST files created by ACSPO*
gds2_l3u	*GDS2 L3U SST files created by the L2P-to-L3U tool*
legacy	*Legacy SST files created by ACSPO*
agg_sdrs	*10-minute aggregated SDR-like files created by Aggregator*
anc	*Ancillary files used by ACSPO RAN*
bin	*Executable files and supporting scripts for running ACSPO RAN*
config	*Various configuration and control files*
iQUAM	*Symlink to directory of iQuam1 data*
iQUAM2	*Symlink to directory of iQuam2 data*
log	*Log files*
matchup	*Matchup code, plus files created by the matchup processing using iQuam1 data*
L2	*L2-specific matchup code and files*
L3	*L3-specific matchup code and files*
matchup2	*Matchup code, plus files created by the matchup processing using iQuam2 data (future)*
L2	*L2-specific code and files*
L3	*L3-specific code and files*
MICROS	*MICROS working directory; MICROS code and files in their expected directory structure*
SQUAM	*SQUAM working directory; SQUAM code and files in their expected directory structure*
web_folder	*Web content (figures, images, etc.) generated by MICROS and SQUAM processing*
MICROS	*MICROS web content*
SQUAM	*SQUAM web content*

Testbed "Run" Scripts

Script	Description
run_vagg.bash	Runs the VIIRS Aggregator executable
run_destripe.bash	Runs the VIIRS destriping executable
run_acspo.bash	Runs the ACSPO executable
run_toL3U.bash	Runs the L2P-to-L3U executable
run_micros.bash	Runs MICROS
run_l2matchup.bash	Runs L2-*i*Quam matchups
run_l2squam.bash	Runs L2 SQUAM
run_l3matchup.bash	Runs L3-*i*Quam matchups
run_l3squam.bash	Runs L3 SQUAM

- All scripts require 1 command-line argument, the date of the data to process
- Most scripts have optional command-line arguments to override various default input (e.g., directories, files, parameters)

Issues Encountered

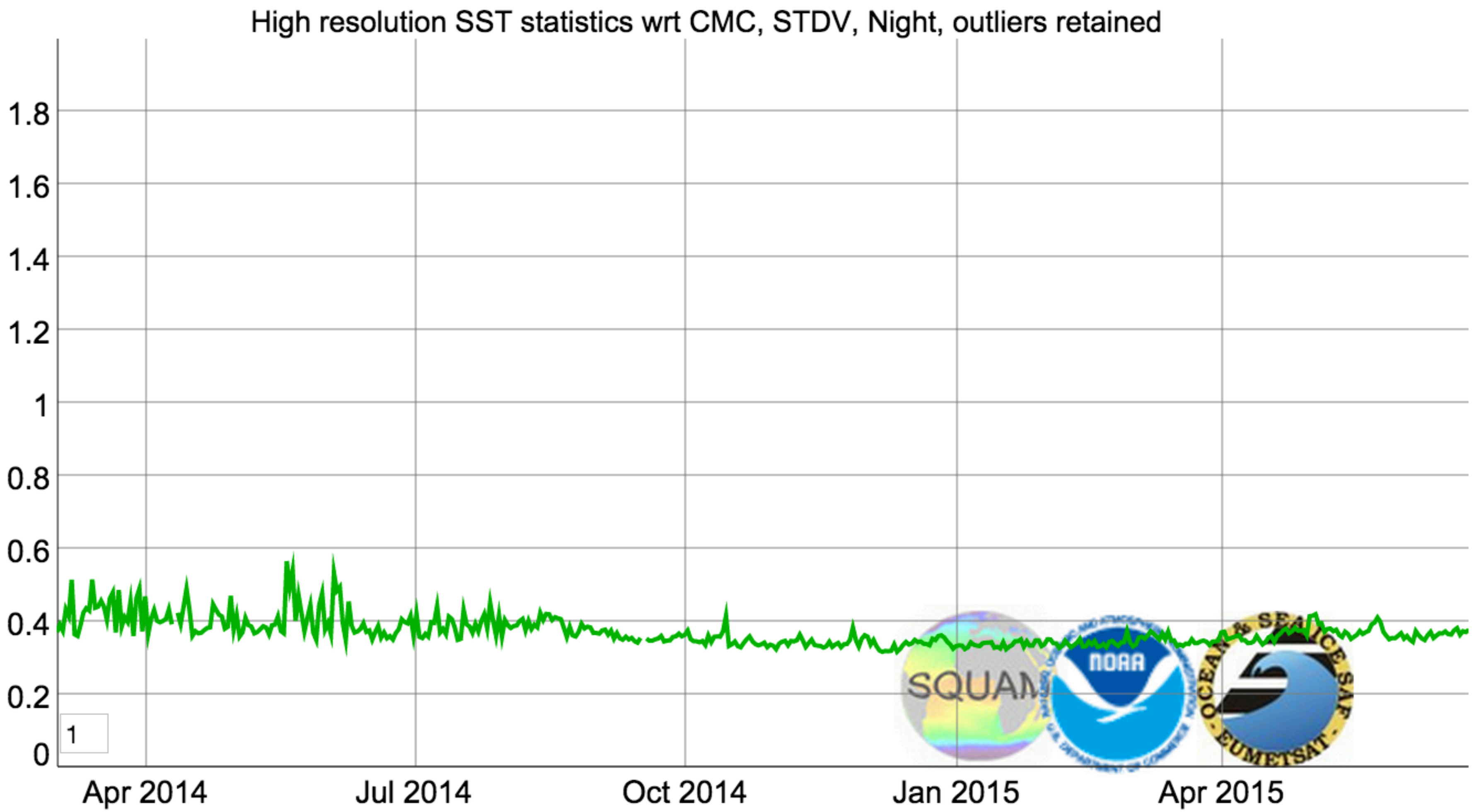
- Anomalous days seen in data/statistics (upcoming slides)
  - Need further analysis and rerun
- IDL
  - License limitation on UW cluster
    - UW worked out a 30-day trial of a 512-count run-time (RT) license
  - Executing IDL in RT mode required code and script modifications
    - UW took the lead changing all MICROS code/scripts
    - STAR modified SQUAM and matchup code/scripts
  - Discovered bug in IDL 8.2, the version on the cluster, that prevented the matchup code from running in RT mode
    - Matchup code runs pretty quick so UW ran it using their more limited number of development licenses
- Testbed
  - A script bug, which was quickly identified and fixed, prevented MICROS files from being moved to web folder
  - Several mid-stream changes made to matchup code/script for handling *i*Quam1 and *i*Quam2 data
  - Switching to RT mode turned up a minor issue with SQUAM, which UW took care of with a workaround
- Different chipset used for cluster (AMD) than development platform (Intel)

ACSPO RAN Results: Data

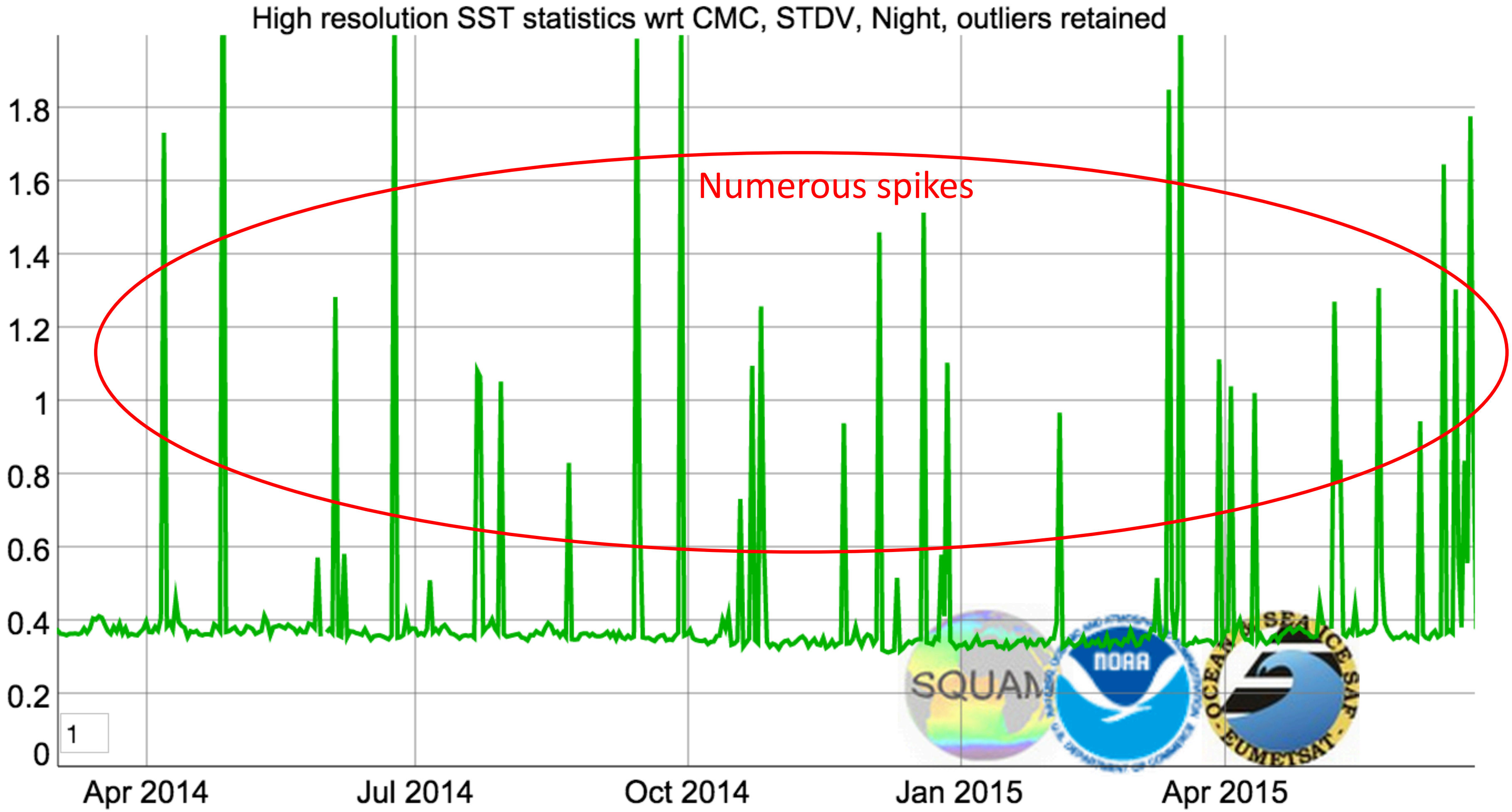
- ACSPO GDS2 L2P data
  - March 2, 2012 – June 25, 2015
- ACSPO GDS2 L3U data
  - March 2, 2012 – June 25, 2015

ACSPO RAN Results: Monitoring

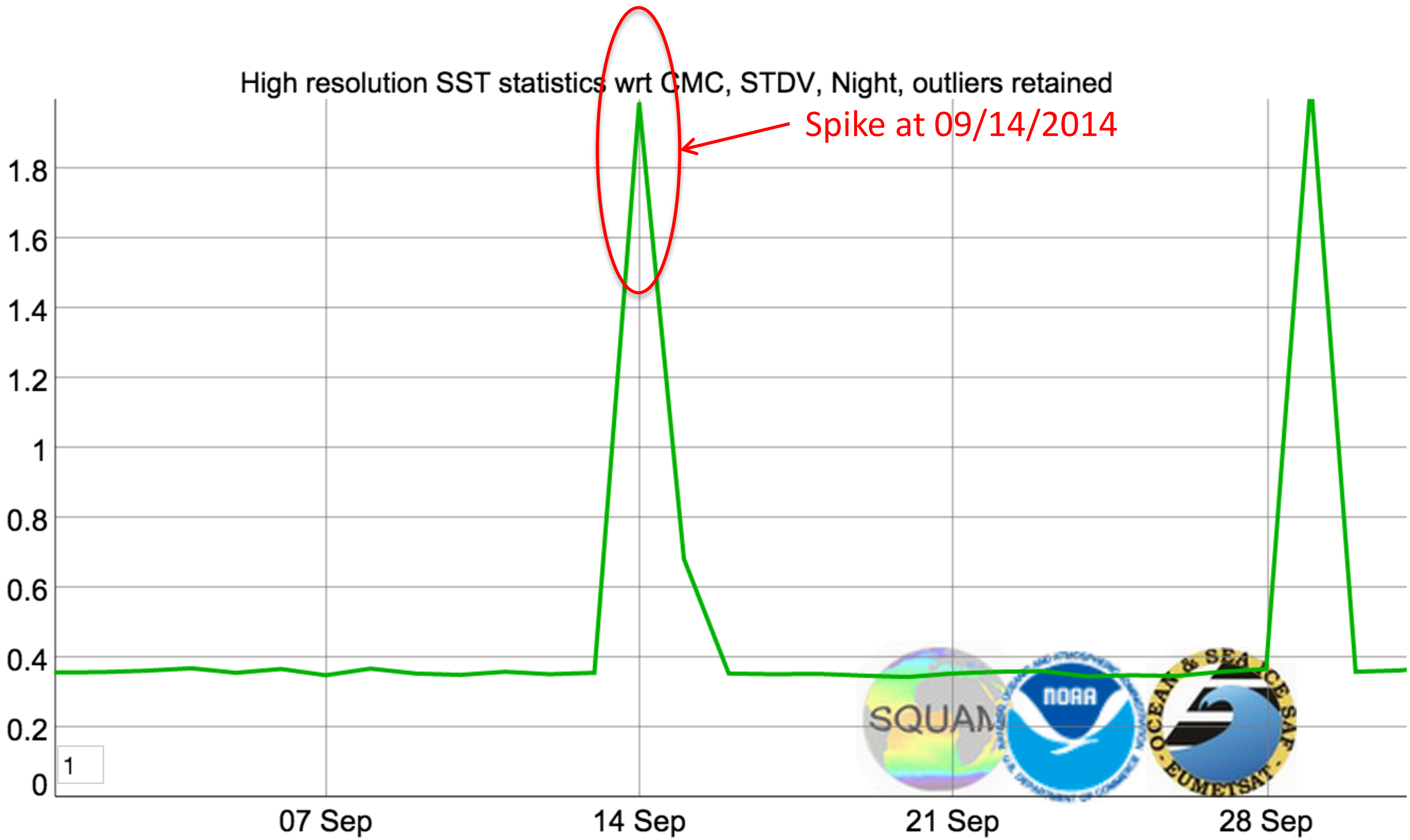
SQUAM: NRT Timeseries



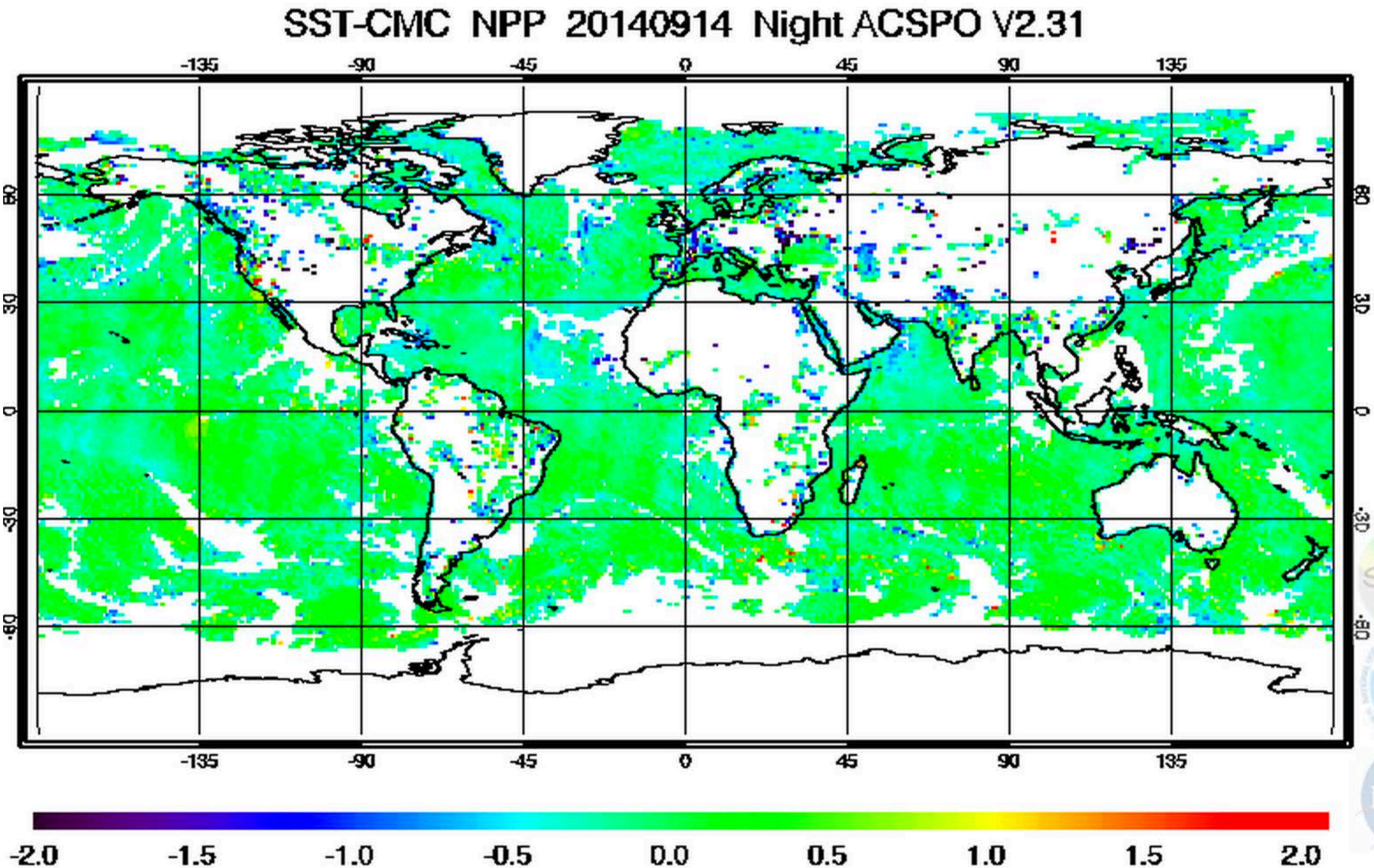
SQUAM: RAN Timeseries



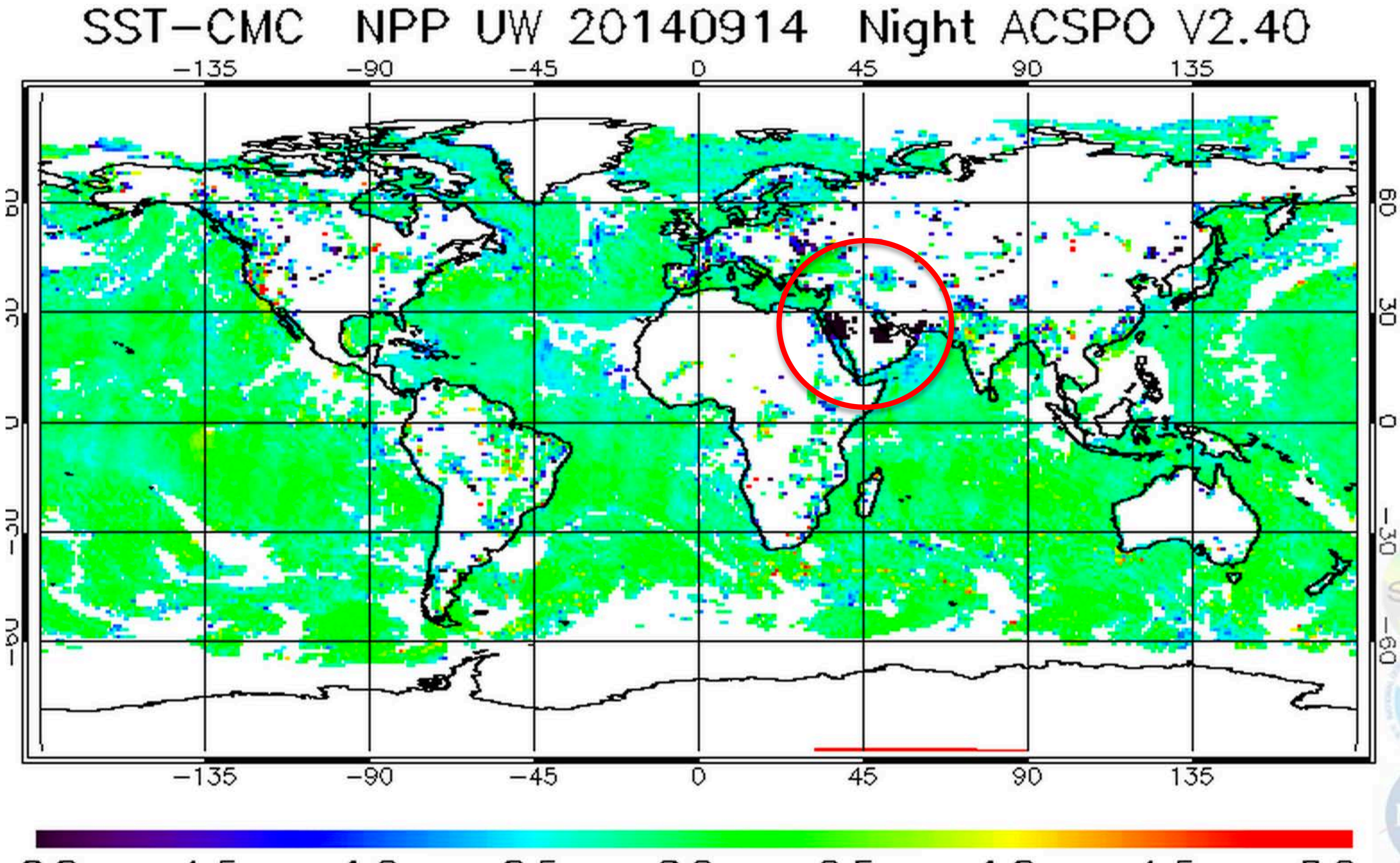
SQUAM: RAN, Timeseries



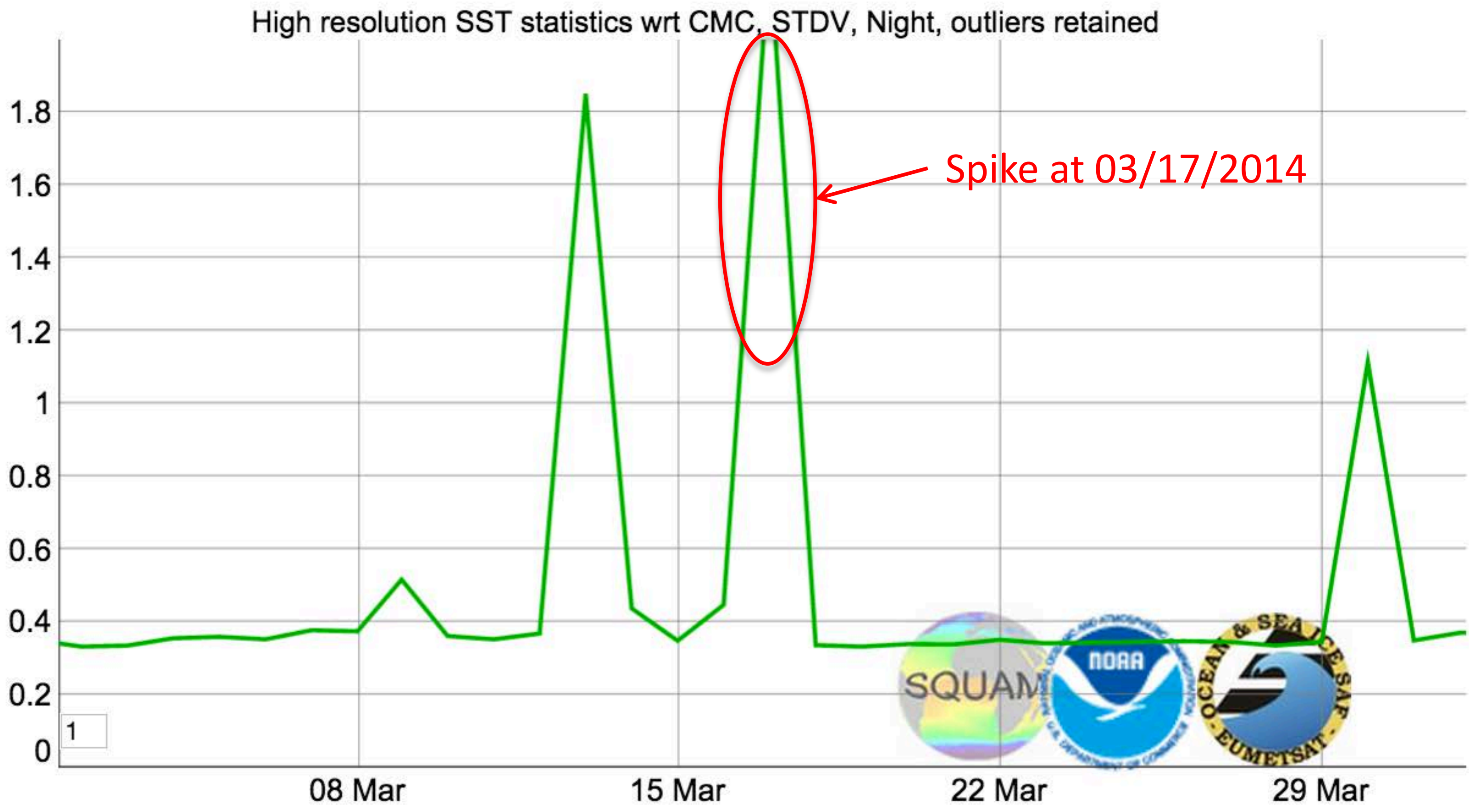
SQUAM: NRT, Map



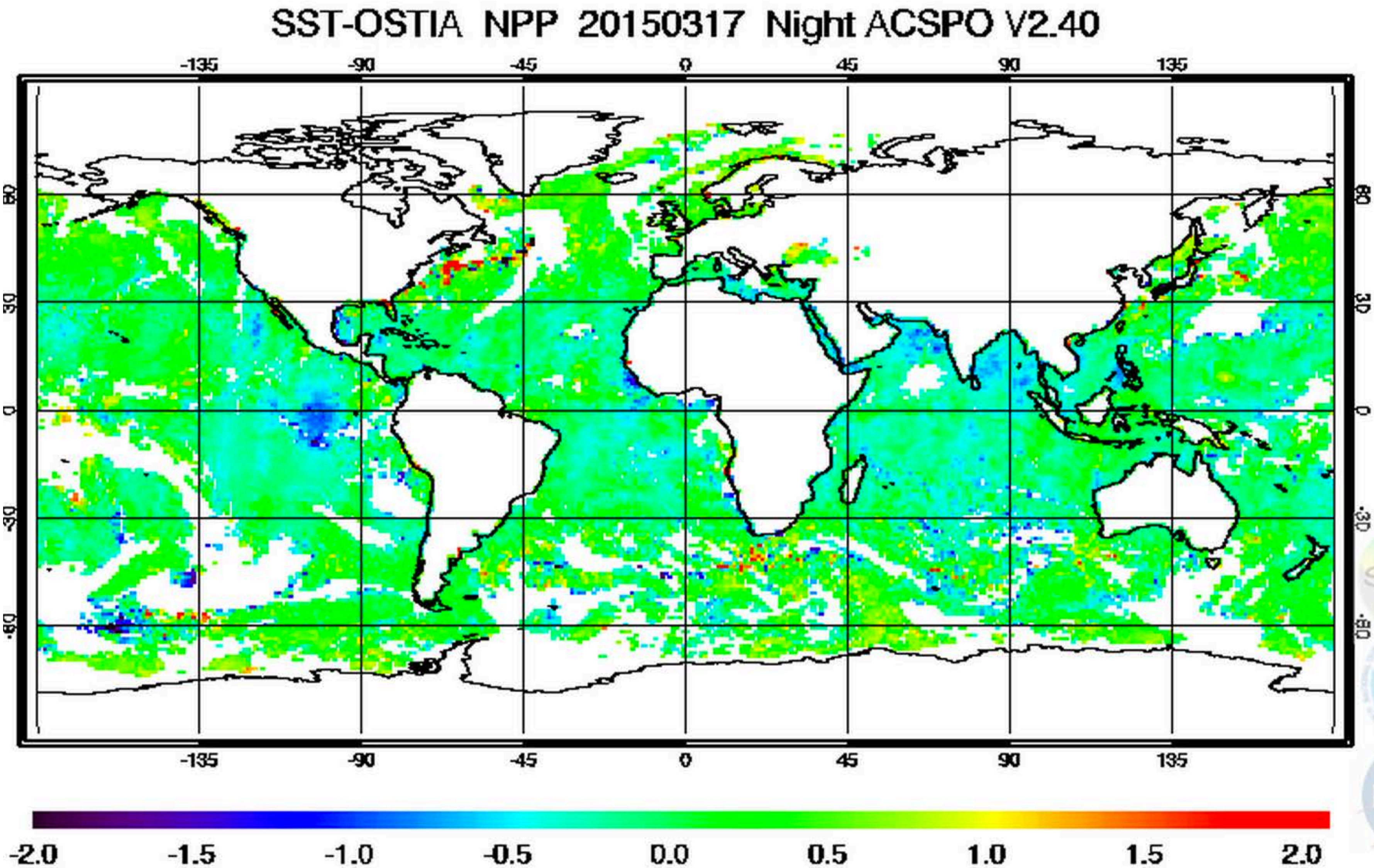
SQUAM: RAN, Map



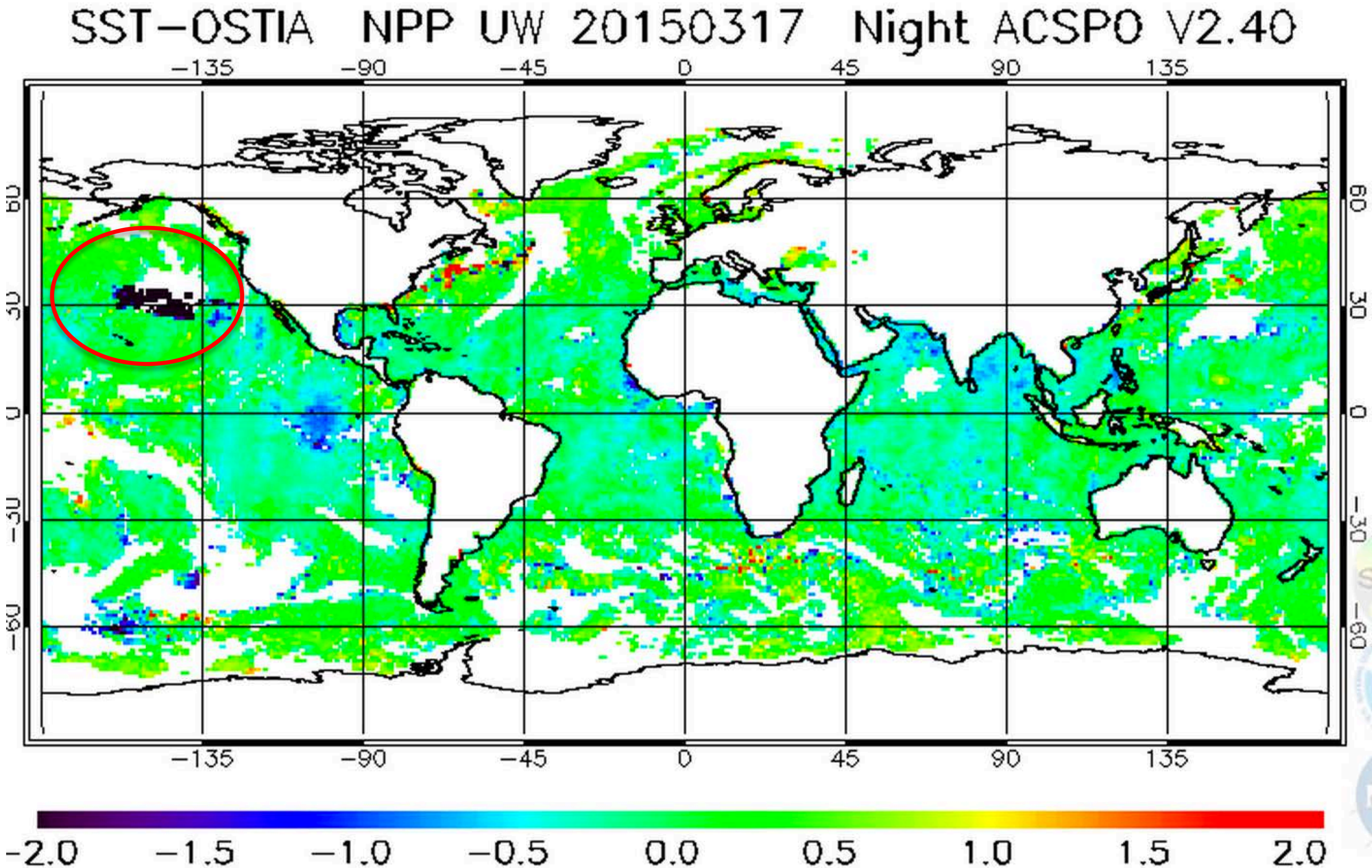
SQUAM: RAN, Timeseries



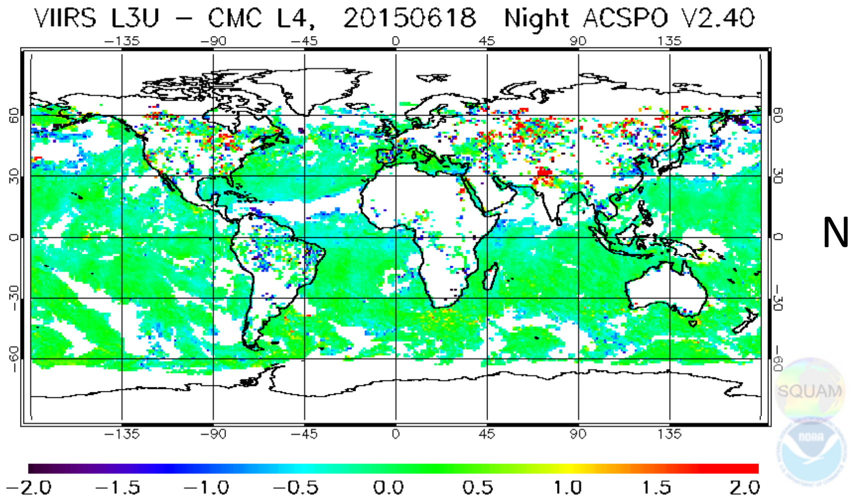
SQUAM: NRT, Map



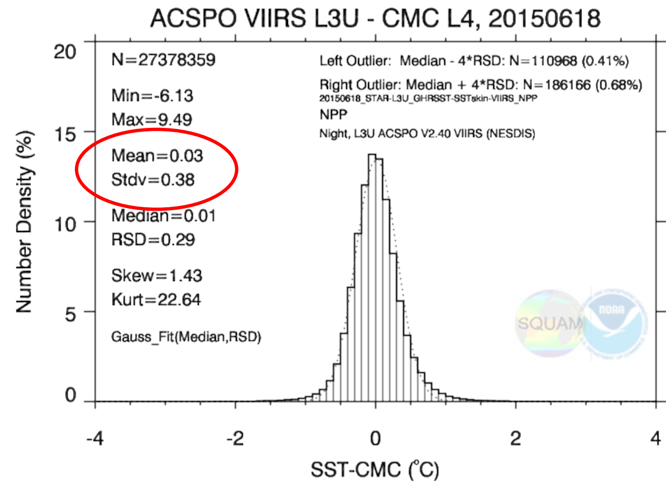
SQUAM: RAN, Map

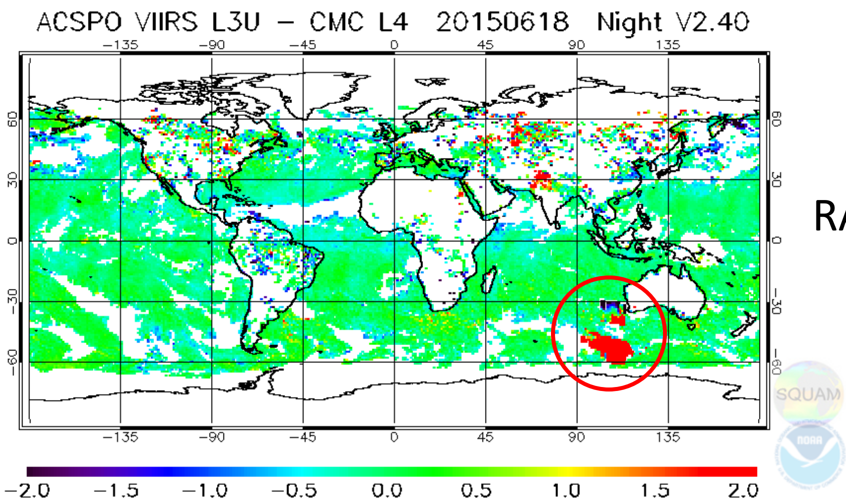


SQUAM L3: NRT vs. RAN

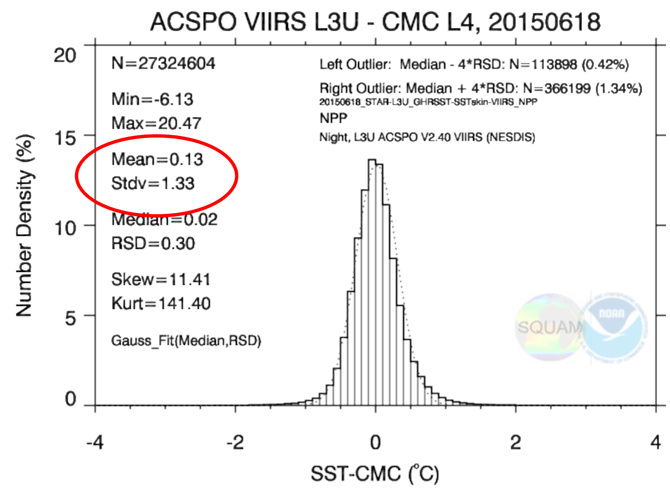


NRT

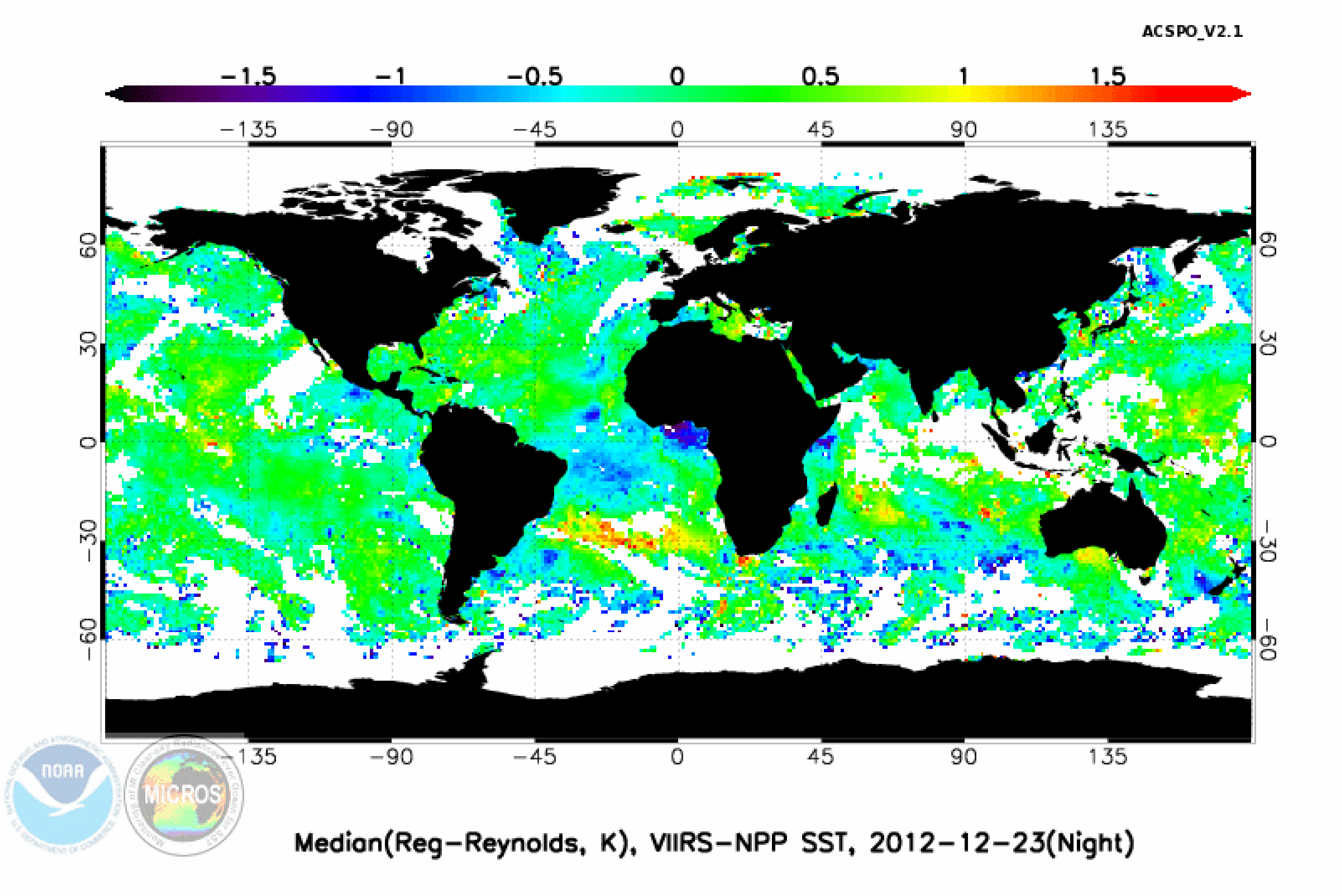




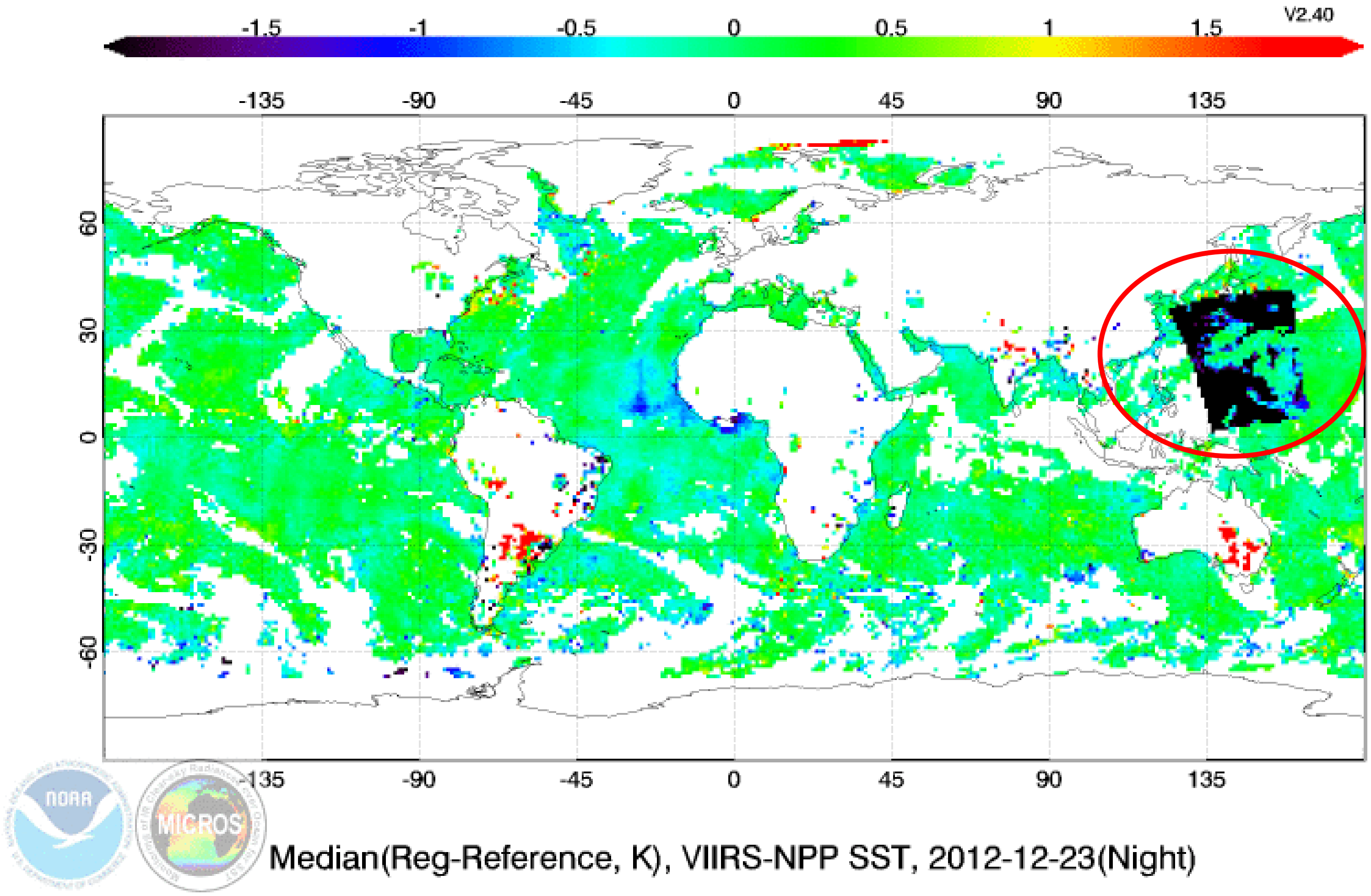
RAN



MICROS: NRT, SST, Night, 12/23/2012



MICROS: RAN, SST, Night, 12/23/2012



Things To Do

- Complete the current ACSPO reanalysis effort (RAN1):
  - **Identify problematic/outlier days, fix, and rerun**
  - Fill-in missing time periods (e.g., 1/18/2012 – 3/1/2012)
  - Generate matchups with *i*Quam2 data
- Update MICROS IDL and script to allow execution in RT mode (i.e., implement the UW changes)
- Upgrade UW system to IDL 8.4 to permit matchup code running in RT mode
- Refine STAR-UW processes for improved code delivery and data availability
- Per further NOAA-UW agreements, perform additional reprocessing runs (i.e., RAN2, RAN3,…) as ACSPO continues to improve and mature

Toward improved VIIRS SST imagery, pattern recognition based clear-sky mask and ocean fronts product in ACSPO

Irina Gladkova[1,2,3], Alexander Ignatov[1], Yury Kihai[1,3], Boris Petrenko[1,3]

[1]NOAA STAR,
[2]City College of New York, NOAA/CREST
[3]GST, Inc.

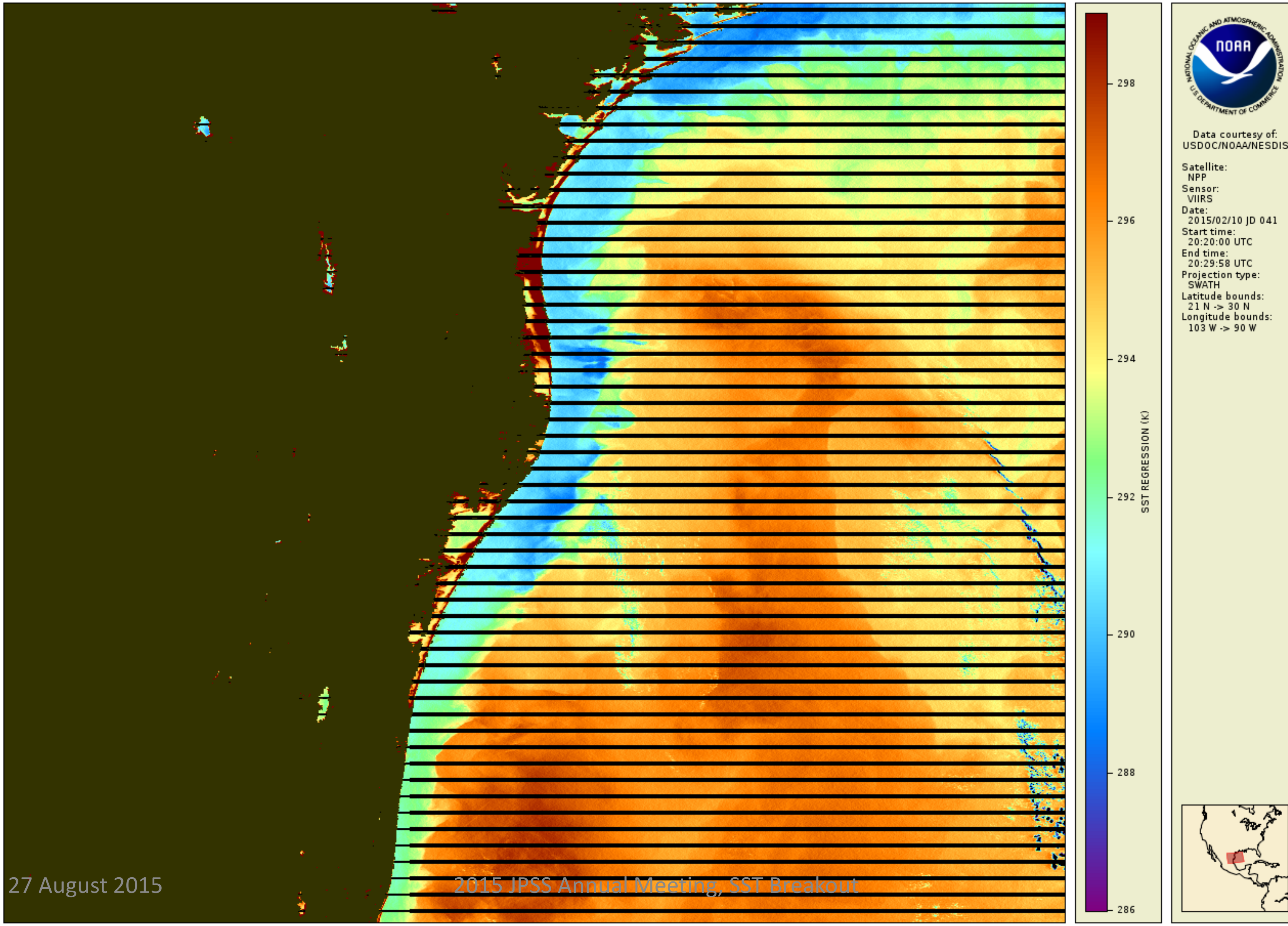
ACSPO Priorities in FY16

1. (Prerequisite for tasks 2-3) Improve BT and SST Imagery: resample ("de-bowtize") and restore pixels in bow-tie areas deleted onboard

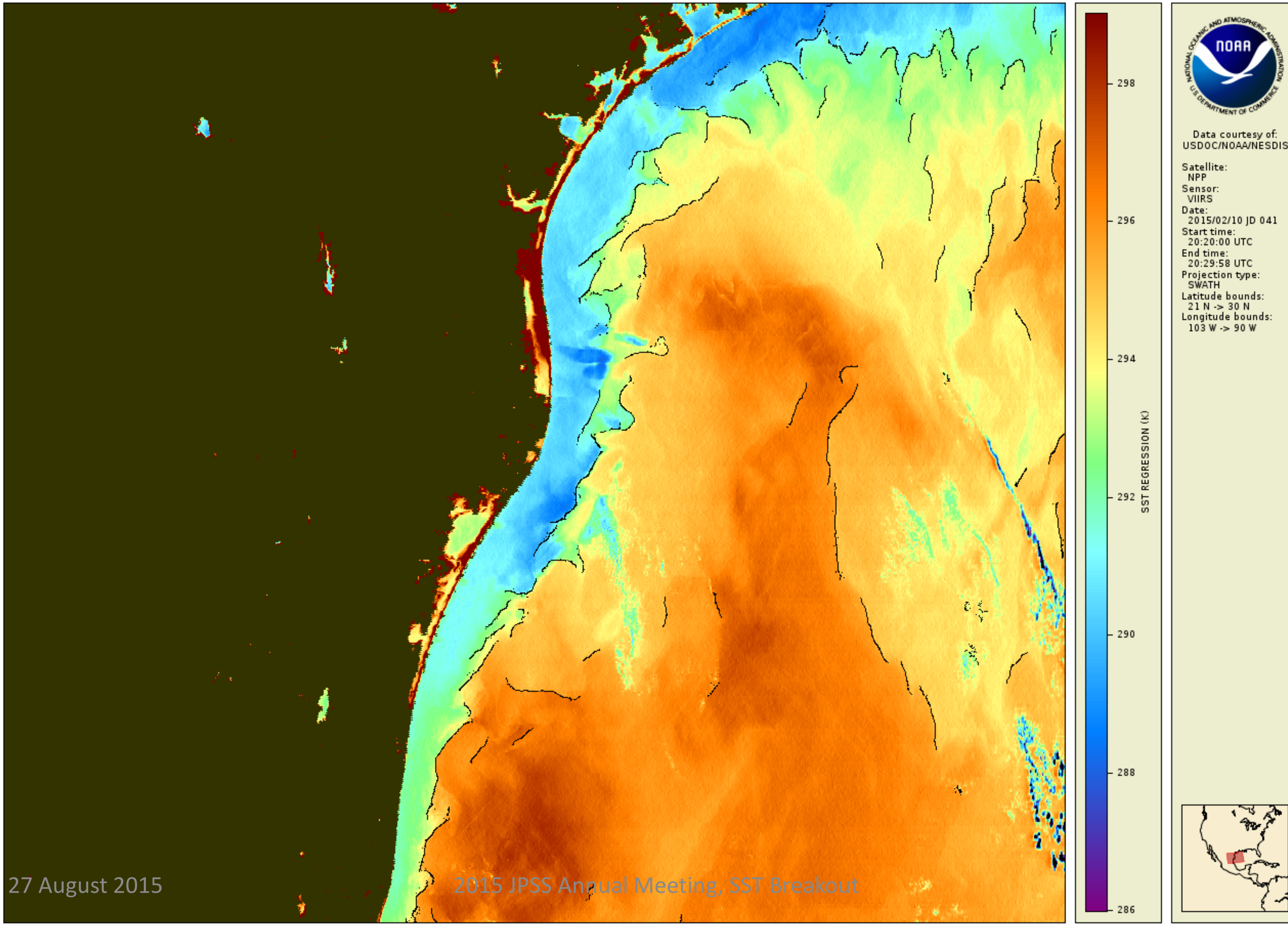
2. (Main Objective) Improve clear sky mask based on pattern recognition approach: Focus on dynamic, coastal, and high-latitude areas

3. (By-product of pattern recognition) Produce Ocean Thermal Fronts

Original VIIRS SST Imagery



Improved VIIRS SST Imagery



Task 2: Motivation

- Customarily, clear-sky mask is produced first
- Ocean dynamics (thermal fronts, currents, eddies and cold upwellings) are analyzed over clear sky pixels only
- However, clear sky mask is often overly conservative over dynamic ocean, and masks it out as cloud
- As a result, most interesting ocean areas with strong dynamics may be under-populated (or not populated at all), for long periods of time

Quality of Clear-Sky Mask

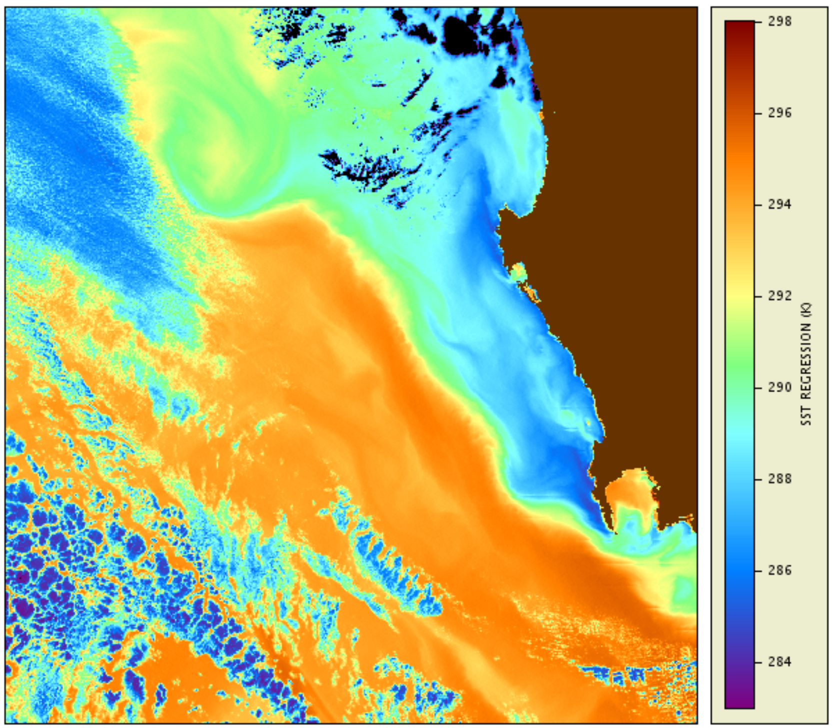
- Following majority of current masking algorithms, ACSPO uses “in-pixel thresholds”
- Liberal thresholds may result in “cloud leakages”, whereas conservative settings lead to “false alarms”
- Often, conservative SST mask is considered preferable, to minimize cloud leakages
- However, this is achieved at the expense of losing a (presumably small) fraction of clear pixels, globally

Standard Criteria of clear-sky mask performance:

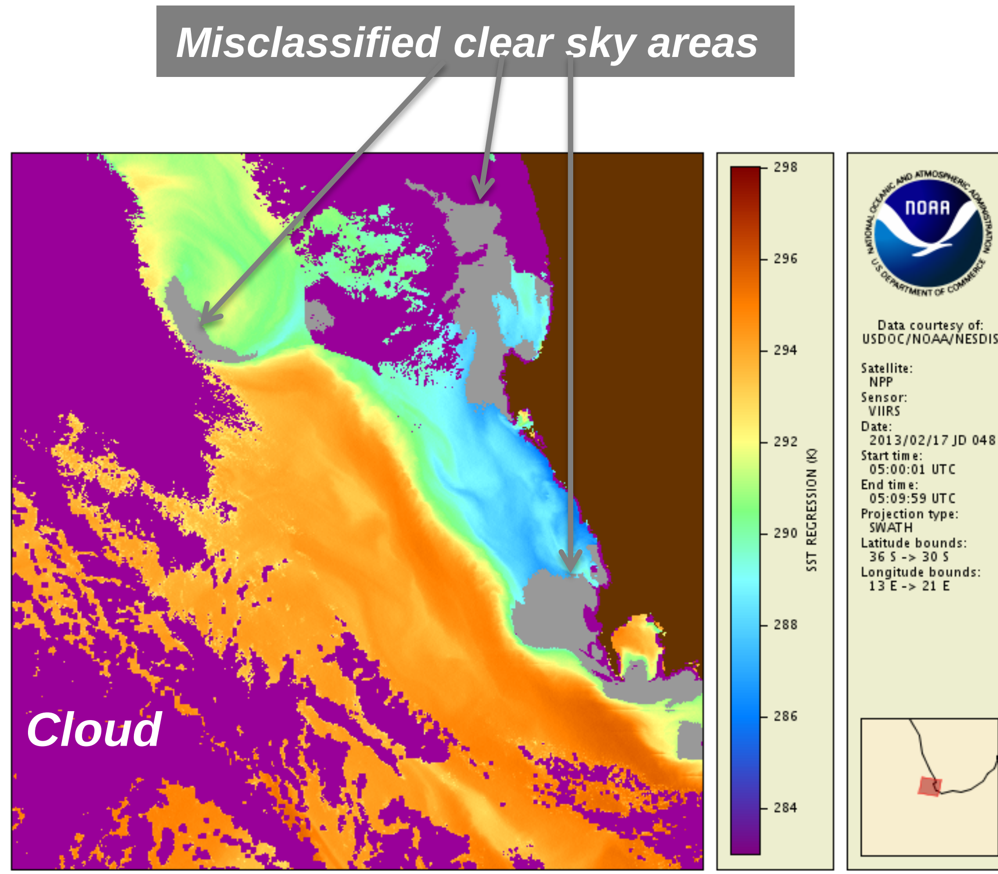
- Minimal cloud leakages,
- While still preserving good global coverage

Typical False Alarms in ACSPO

S. Africa (S-NPP day pass)



VIIRS ACSPO SST (no cloud mask)



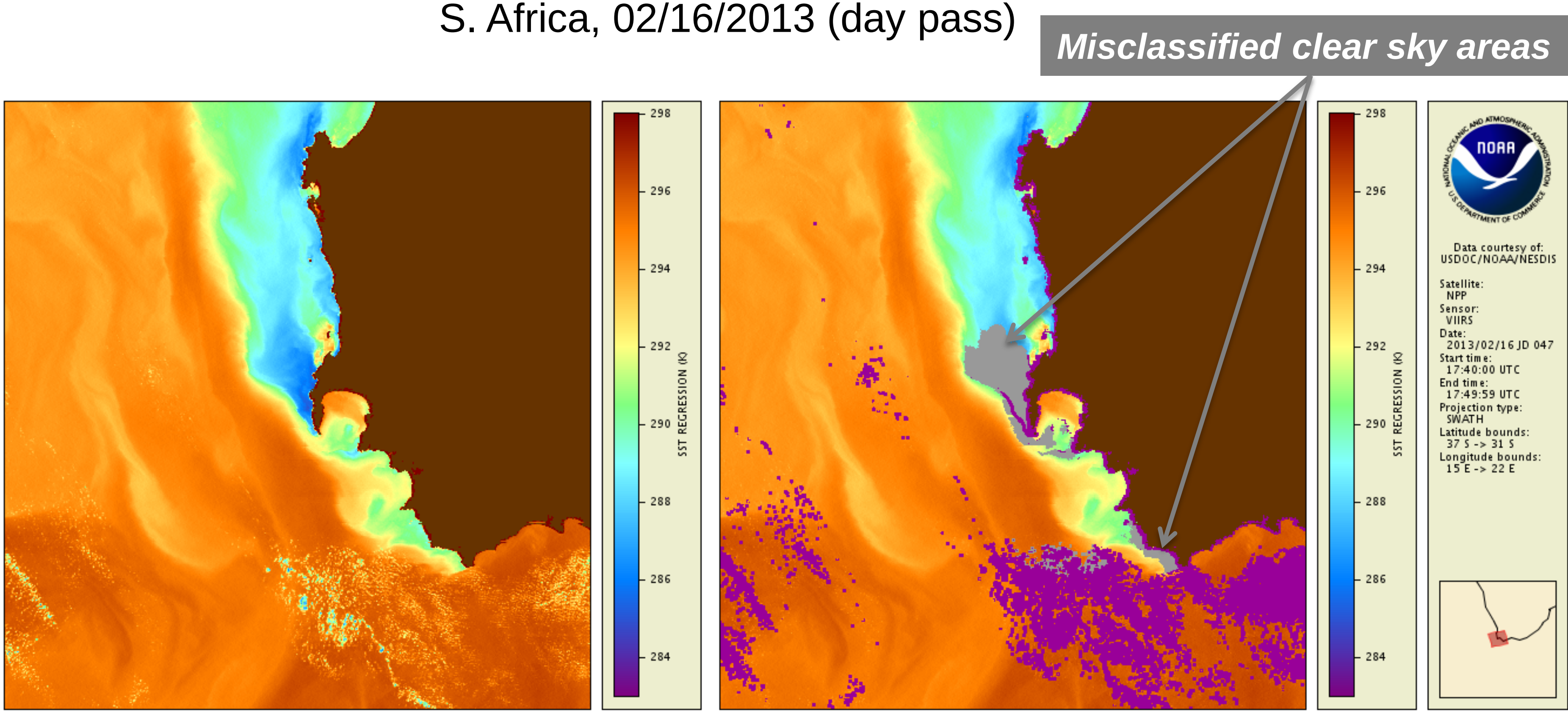
SST with ACSPO cloud mask overlaid

What is the price?

- The geographic distribution of “false alarms” is highly non-uniform, both in space and in time
- “False alarms” often persist from pass to pass
- Misclassifications most often occur in ocean areas where SST is
  - variable, and/or
  - significantly colder than surrounding waters, and/or
  - significantly colder than the first guess field

Persistent Misclassifications

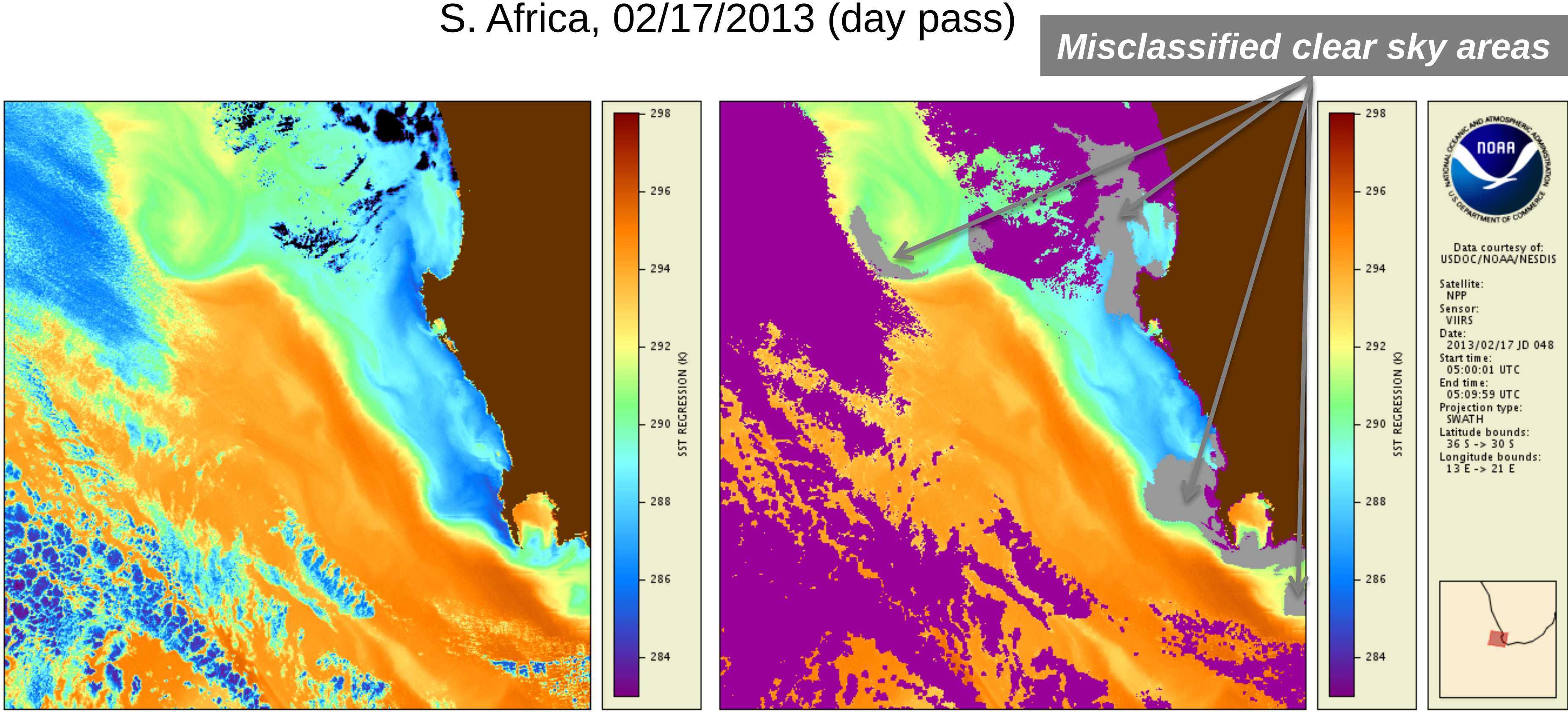
S. Africa, 02/16/2013 (day pass)



Cold upwelling (gray) is misclassified by ACSPO as cloud

Persistent Misclassifications

S. Africa, 02/17/2013 (day pass)

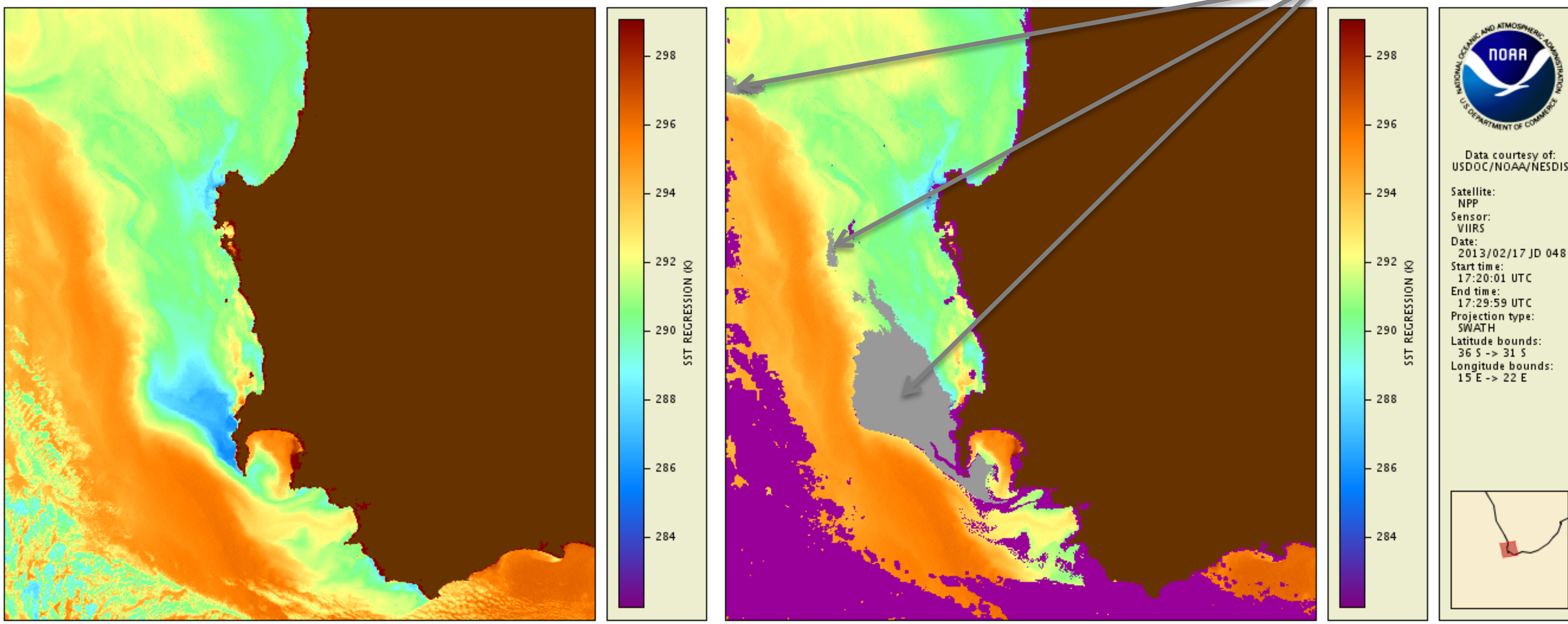


Misclassified by ACSPO as cloud on the next day as well

Persistent Misclassifications

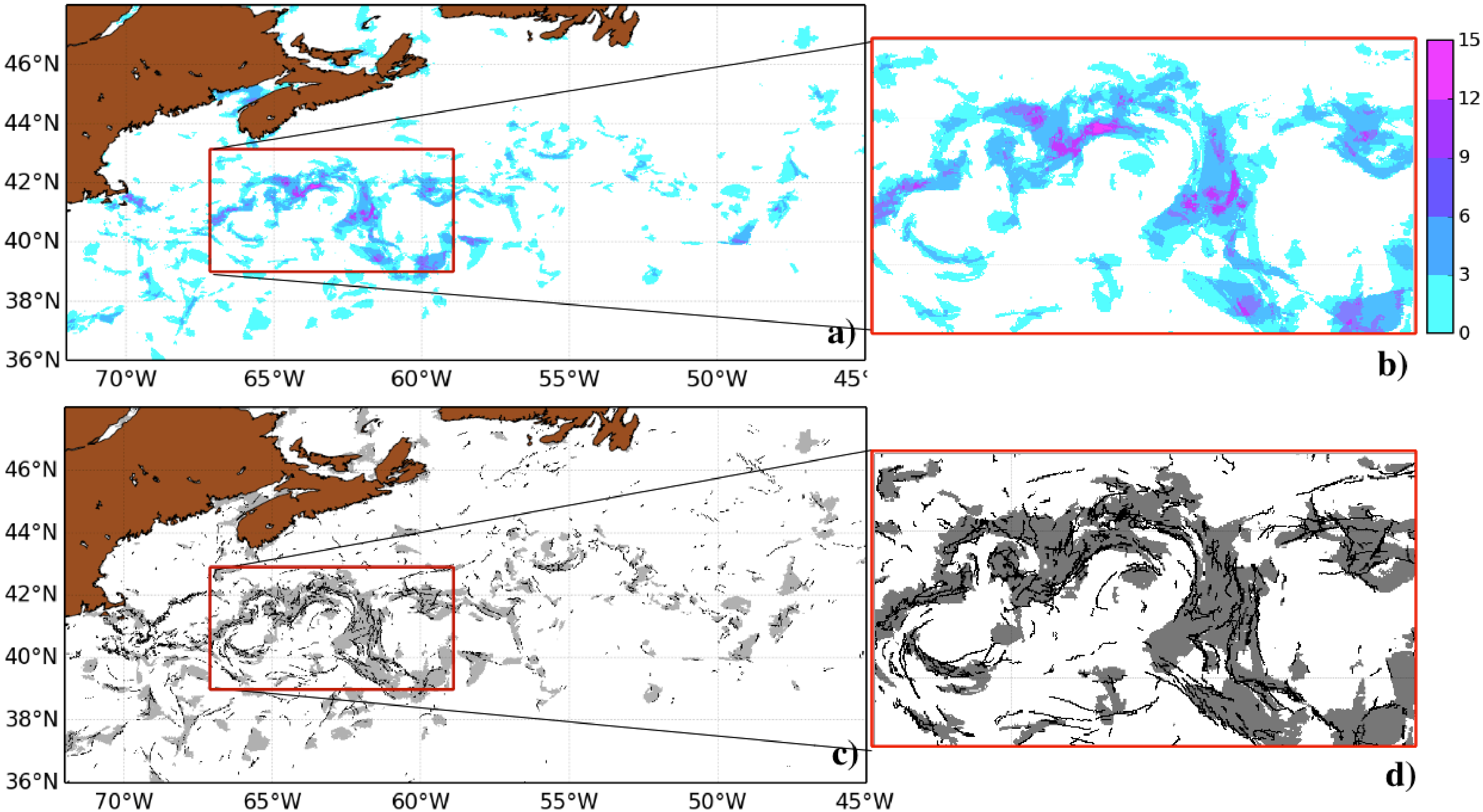
S. Africa, 02/17/2013 (night pass)

Misclassified clear sky areas



Same cold upwelling misclassified at the night pass

Misclassifications near fronts



Impact

It is dynamical, coastal and hi-latitude waters that are of most interest to SST users, for

- accurate reproduction of ocean dynamics in L4 products
- modeling of ocean dynamics
- coastal management
- fishing
- ship navigation
- generating unbiased climatologies
- marine biology studies
- .. and more

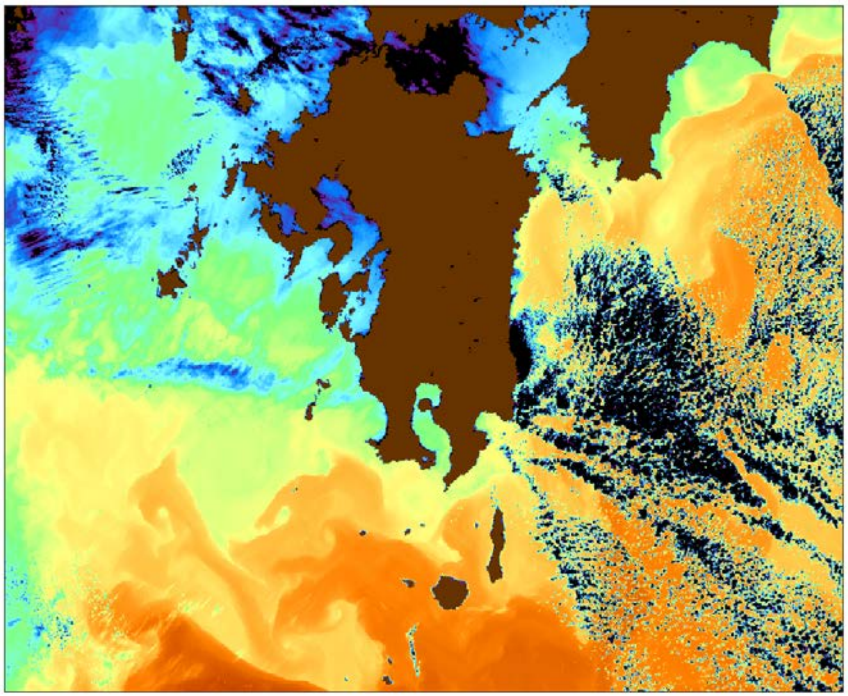
Approach

Automated SST Pattern Test

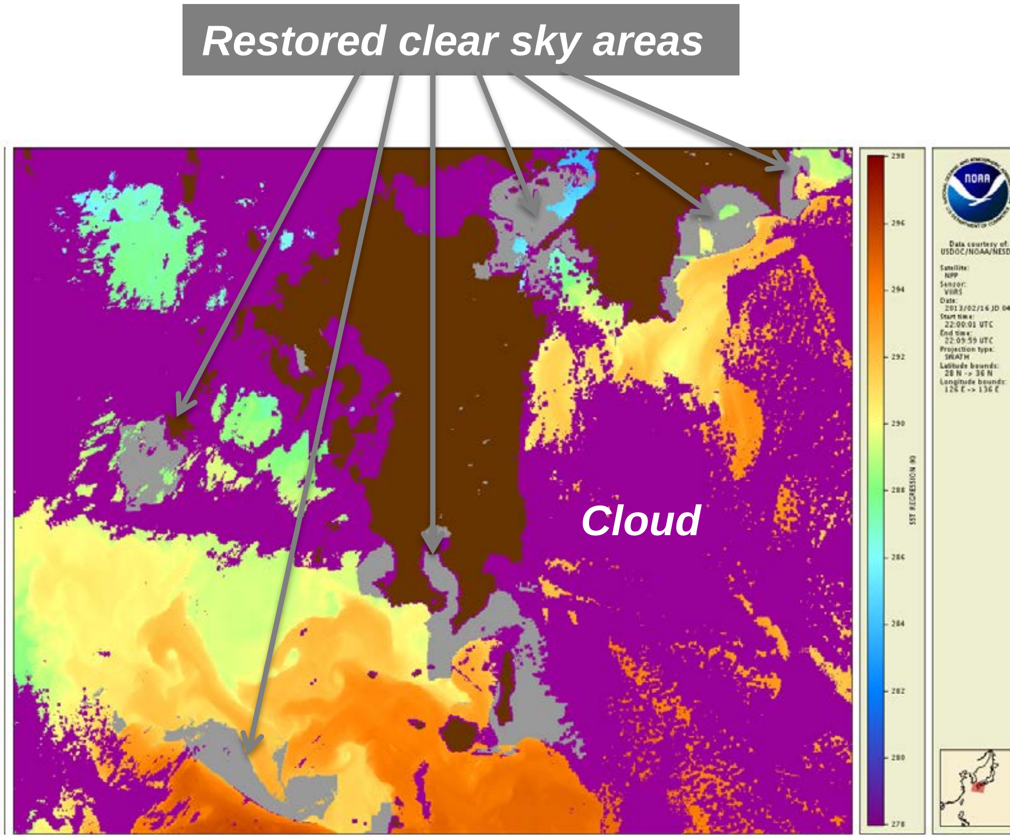
Identifies ocean thermal fronts and adjacent contiguous areas with uniform SSTs; and

Then makes ocean vs. cloud decision based on the statistics of the whole regions (vs. in-pixel)

N. Pacific Kuroshio (near Japan)

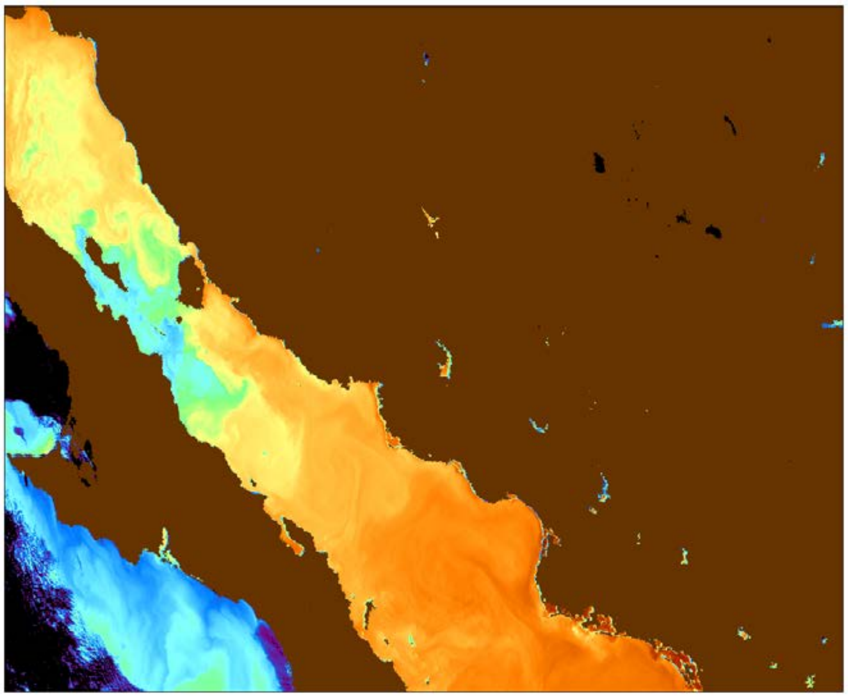


VIIRS ACSPO SST (no cloud mask)

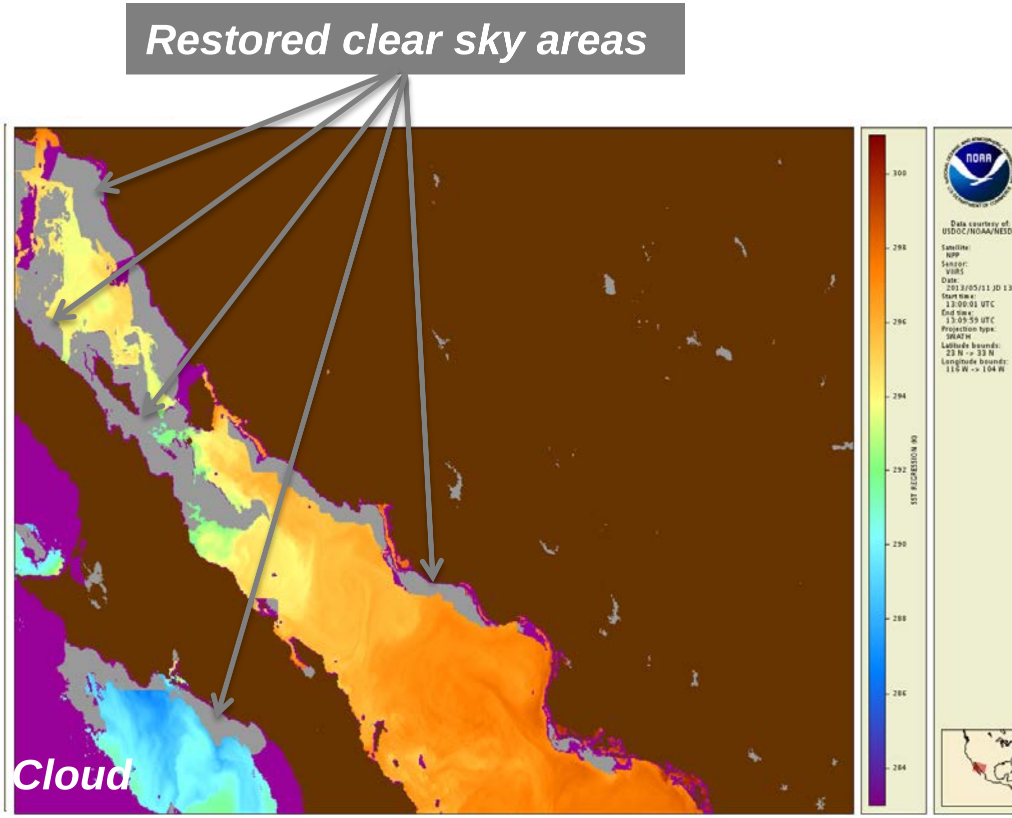


SST with ACSPO cloud mask overlaid

Bay of California

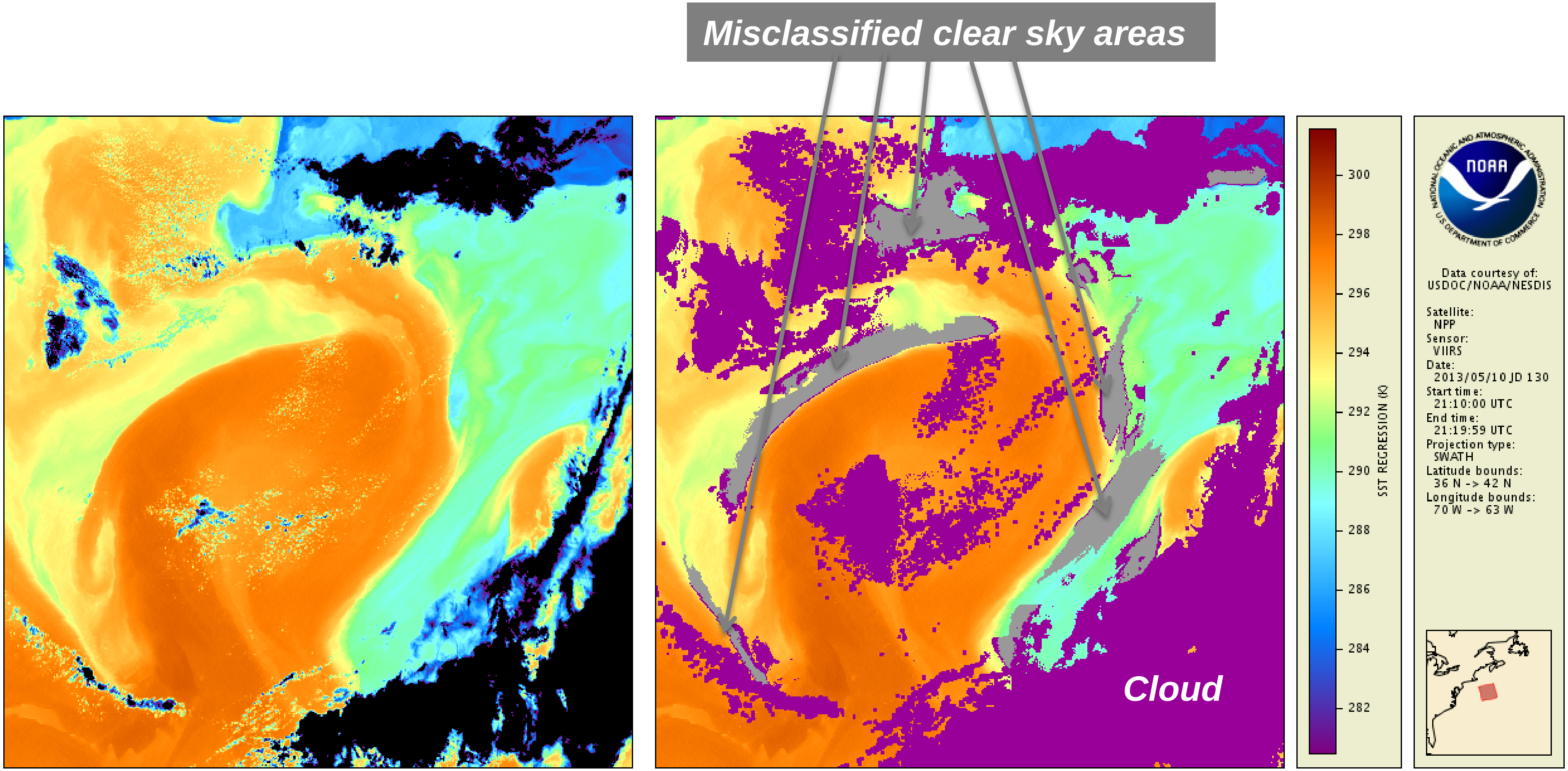


VIIRS ACSPO SST (no cloud mask)



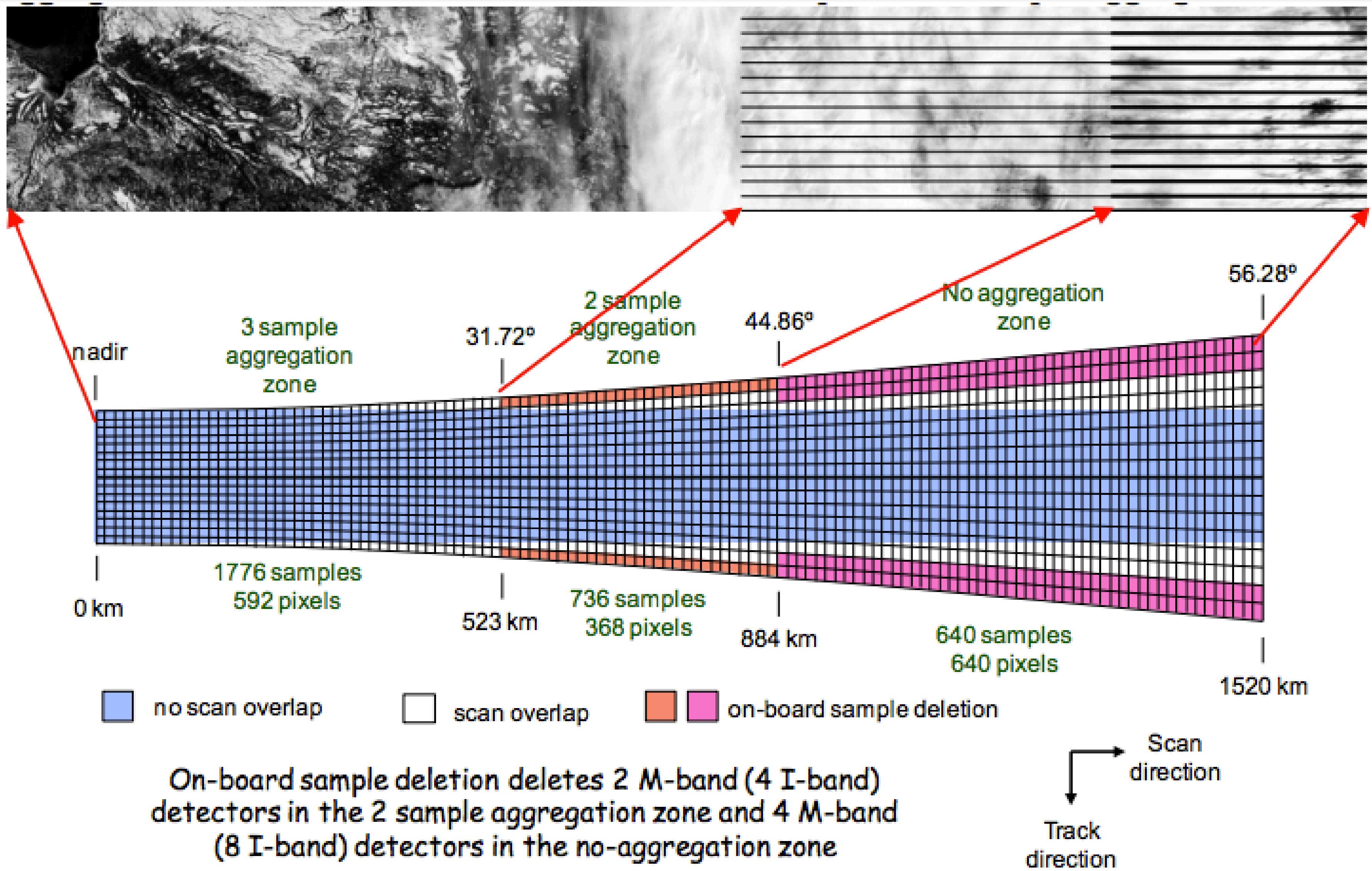
SST with ACSPO cloud mask overlaid

Gulf Stream



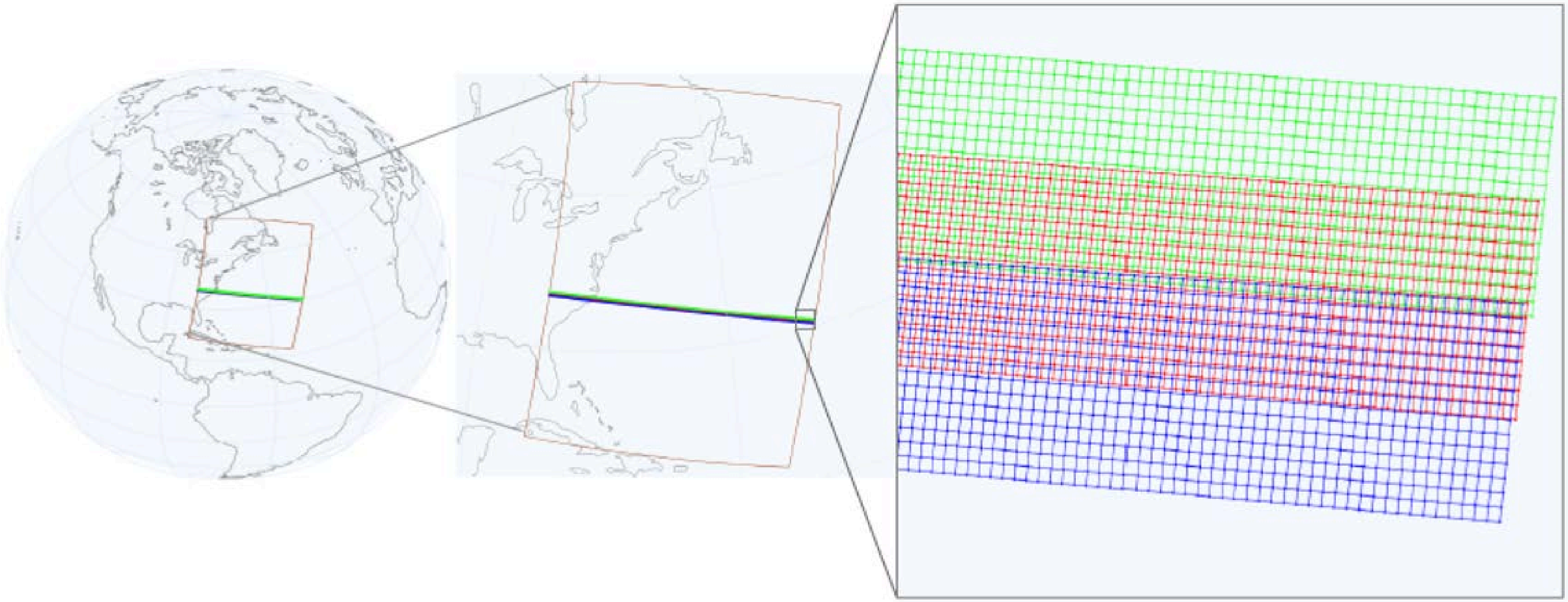
VIIRS ACSPO SST (no cloud mask) SST with ACSPO cloud mask overlaid

Task 1: Imagery Improvement

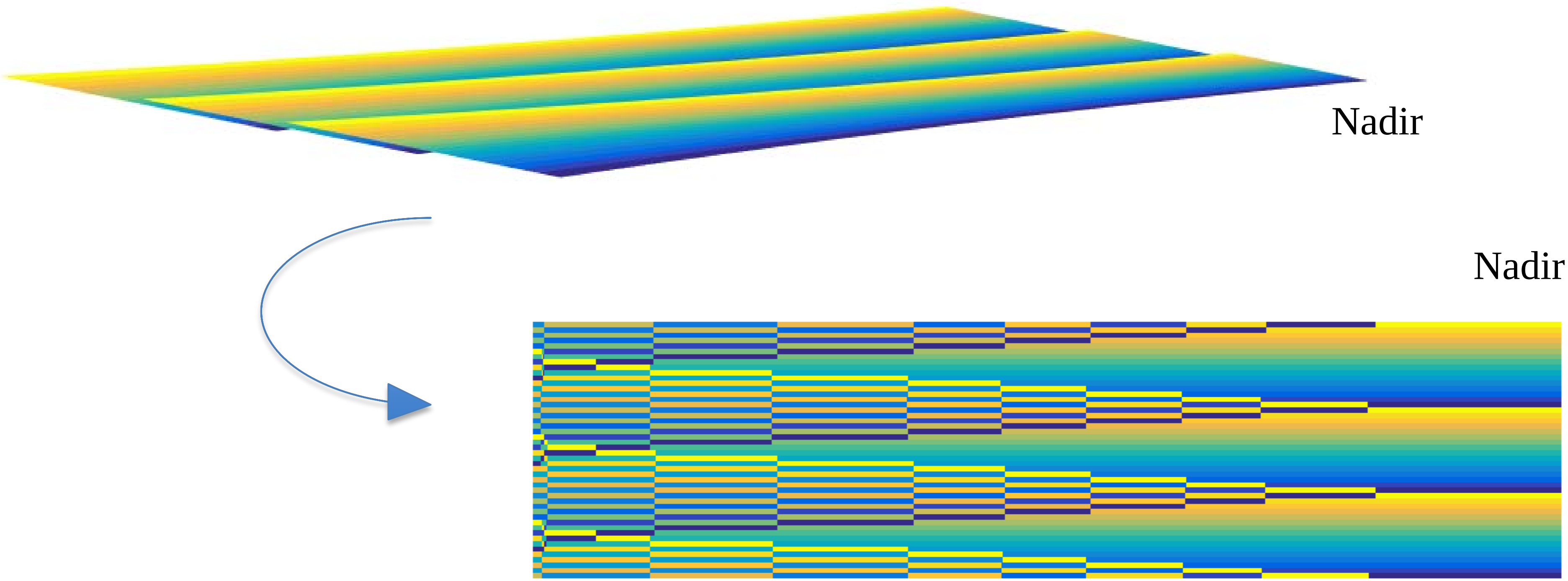


On-board sample deletion deletes 2 M-band (4 I-band) detectors in the 2 sample aggregation zone and 4 M-band (8 I-band) detectors in the no-aggregation zone

VIIRS Swath Projection

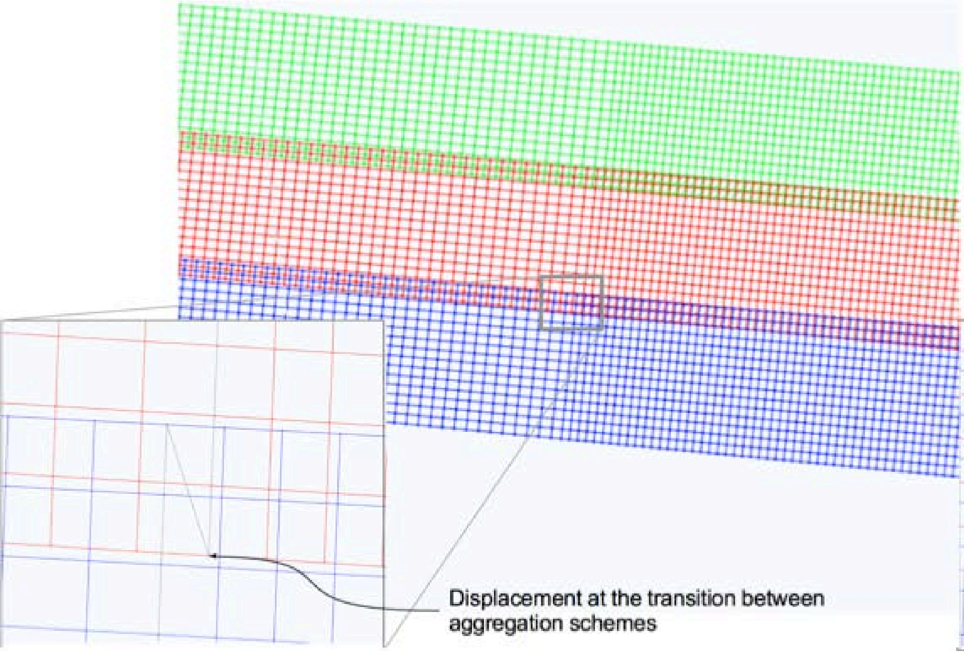


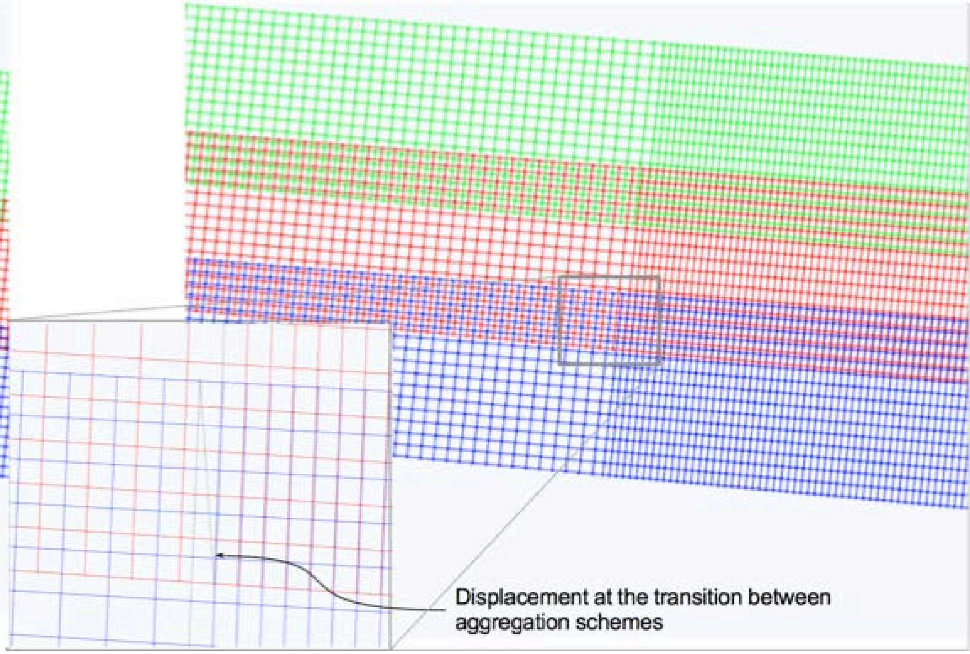
Three consecutive VIIRS scans (shown in green, red, blue), each including 16 detectors.
Overlaps create discontinuities in the VIIRS BT and SST imagery.



3 consecutive half-scans: original and re-ordered to satisfy Latitude monotonicity

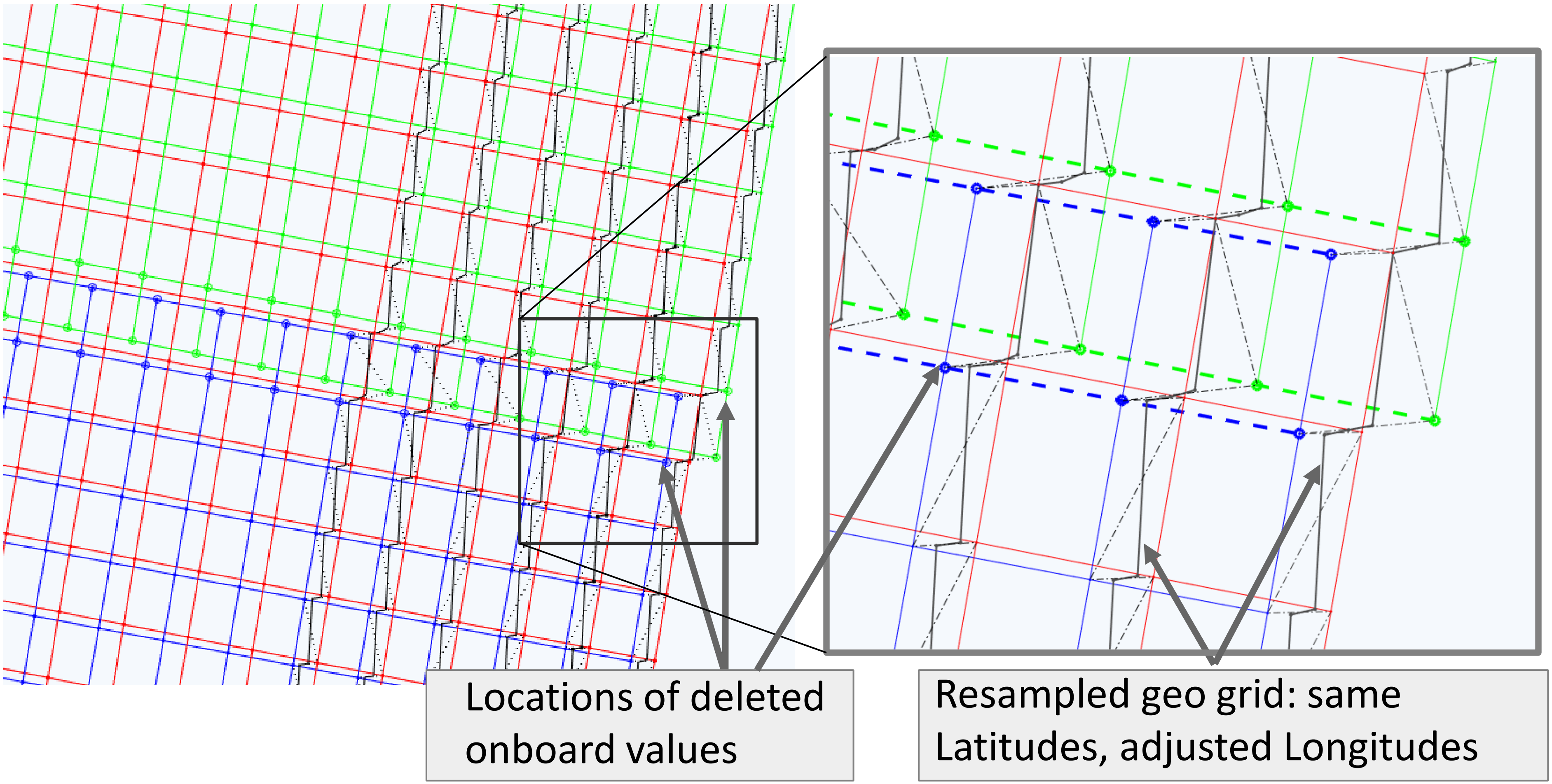
Displacements





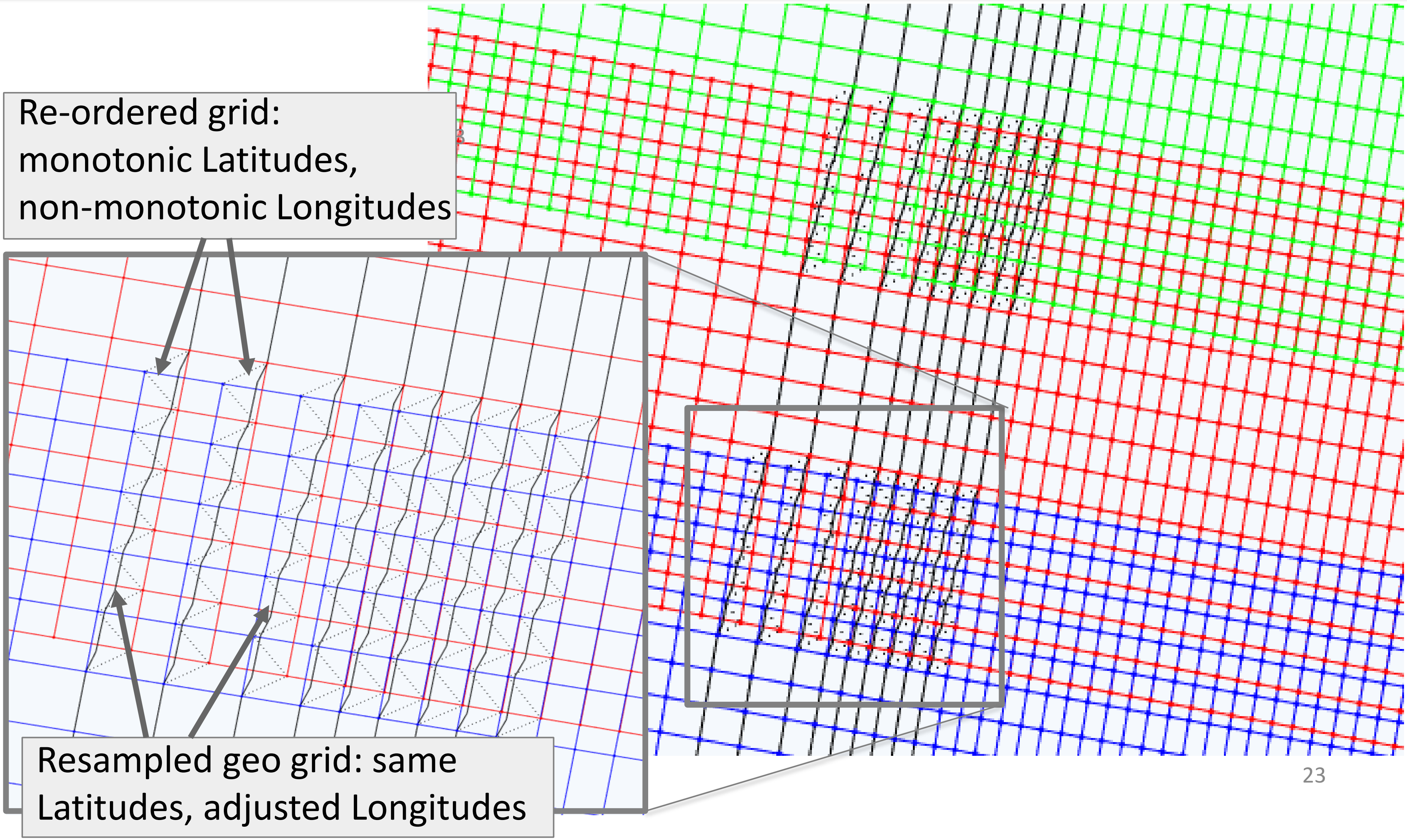
Significant shifts, especially in the areas where the aggregation scheme changes

L2 Geo resampling

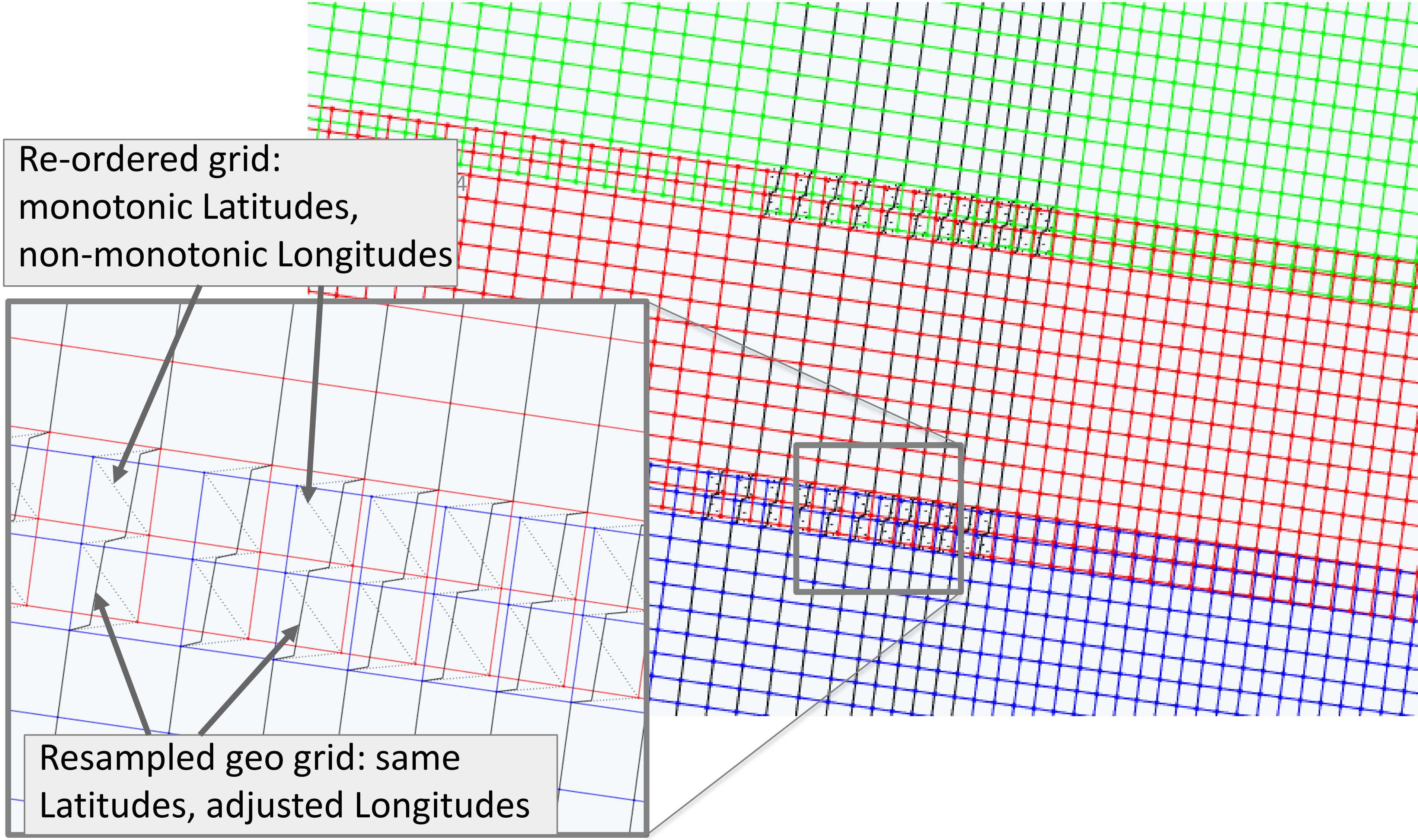


Black dash-dotted lines correspond to grid obtained by geo location re-ordering according latitude monotonicity. “Zig-zagging” at the scan overlaps are caused by satellite to Earth rotation. Solid black lines correspond to adjusted geo grid that minimize these displacements.

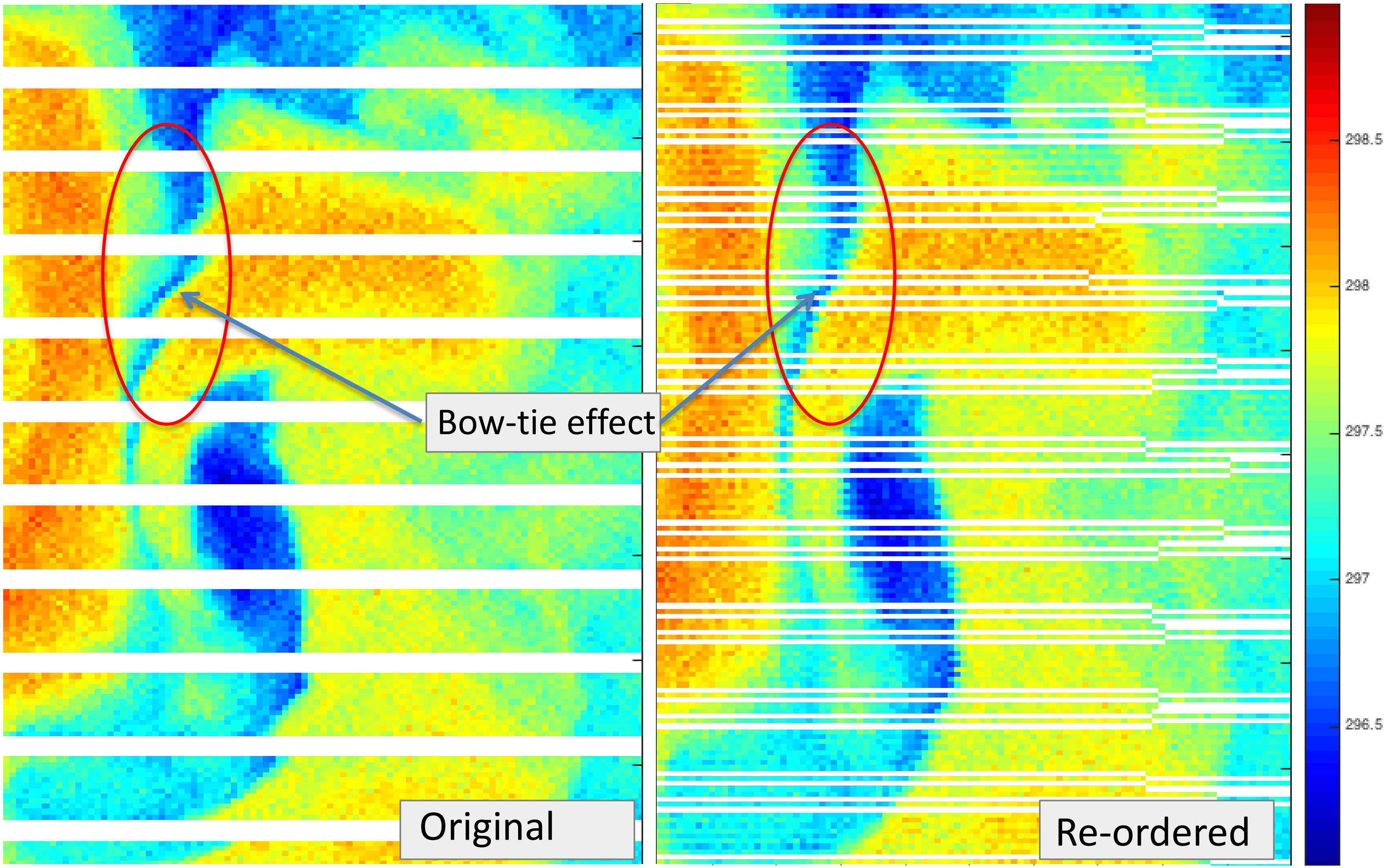
Aggregation switch 2 to 1



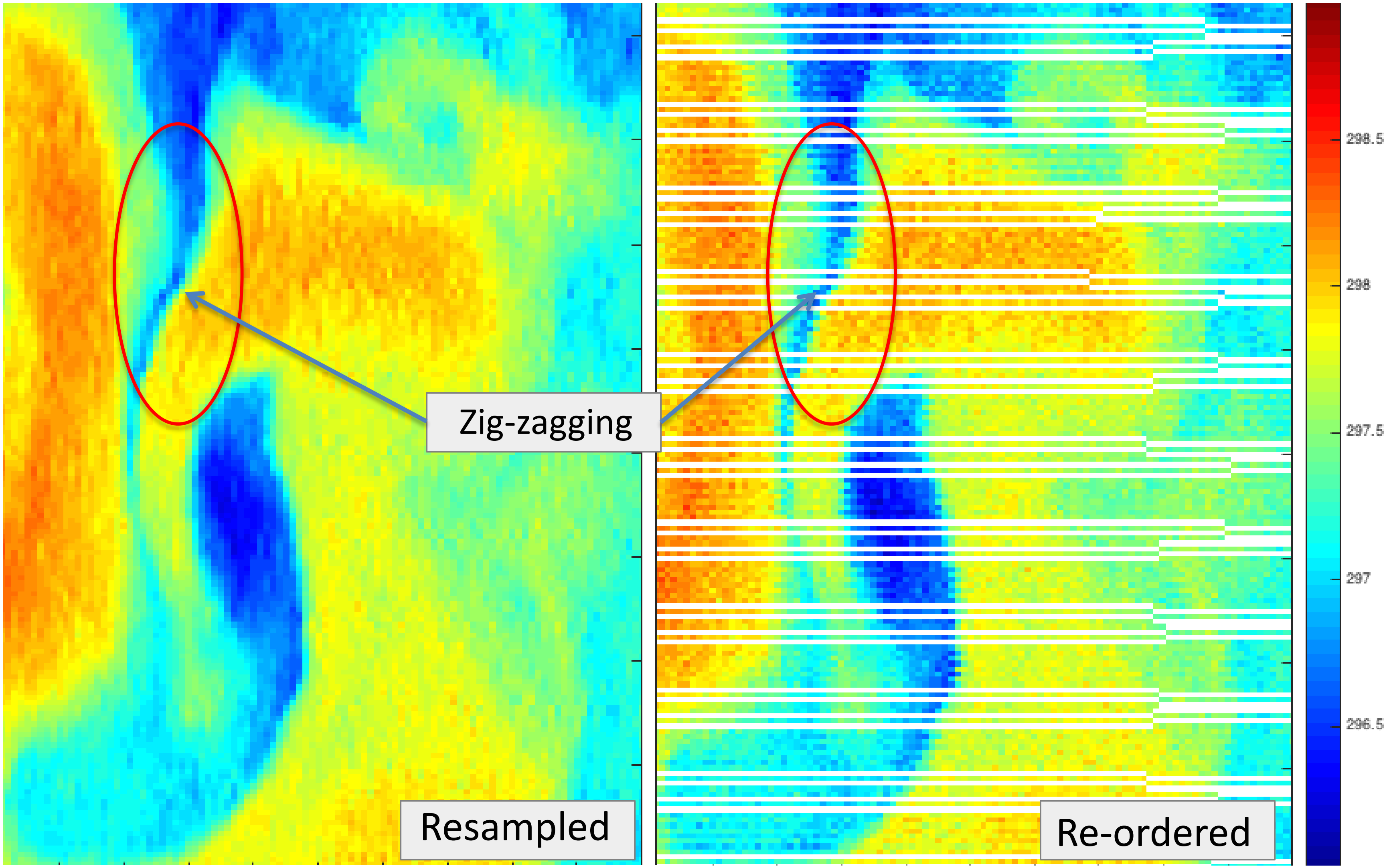
Aggregation switch 3 to 2



L2 row-wise re-ordering



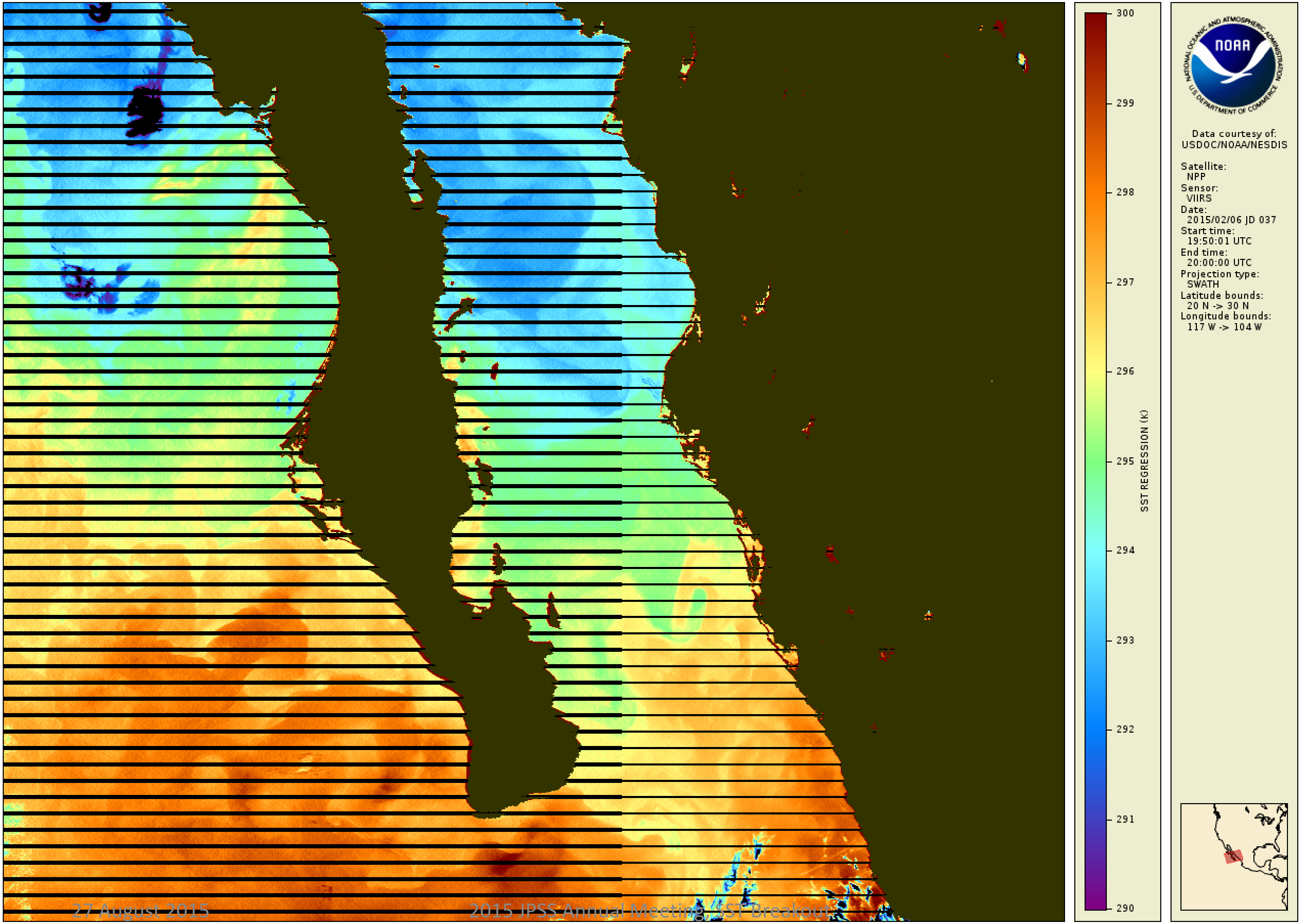
Improved SST imagery



Resampling examples

California Bay
(original swath projection):

Improved imagery
&
Oceanic Thermal Front Mask



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SST REGRESSION (K)
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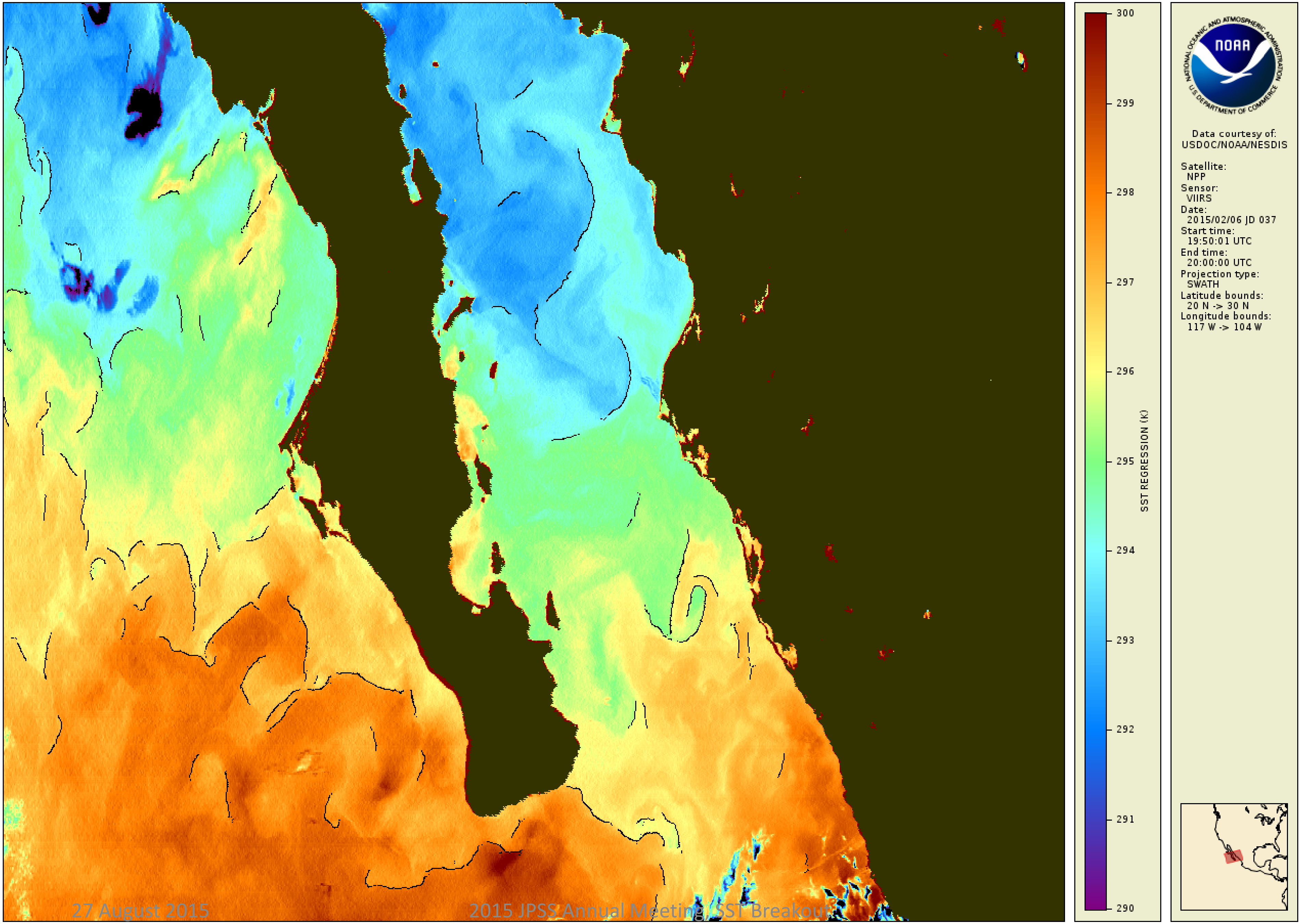
U.S. DEPARTMENT OF COMMERCE
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2015/02/06 JD 037
Start time:
19:50:01 UTC
End time:
20:00:00 UTC
Projection type:
SWATH
Latitude bounds:
20 N -> 30 N
Longitude bounds:
117 W -> 104 W



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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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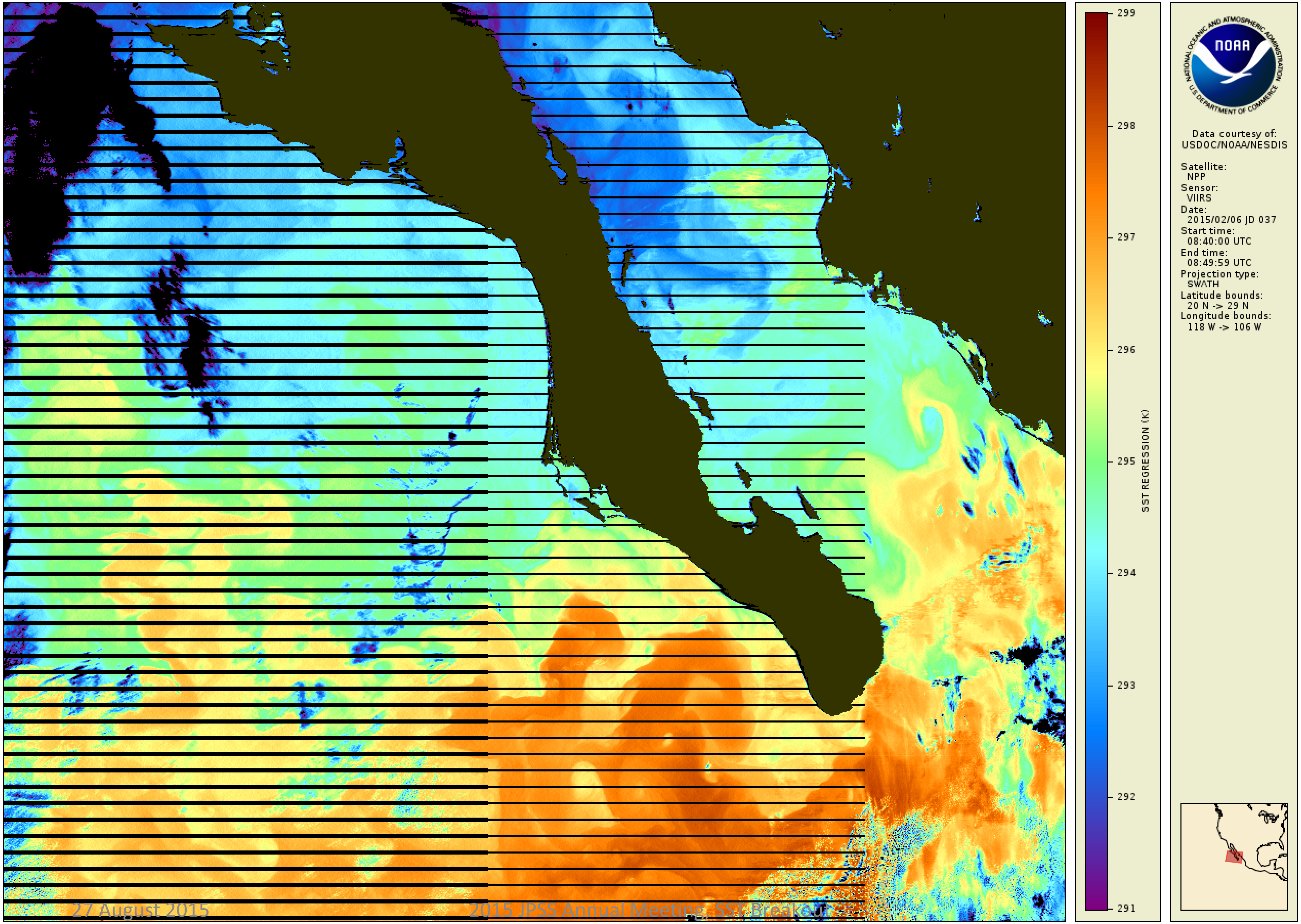
117 W -> 104 W



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Data courtesy of:
USDOC/NOAA/NESDIS
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Sensor:
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2015/02/06 JD 037
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Latitude bounds:
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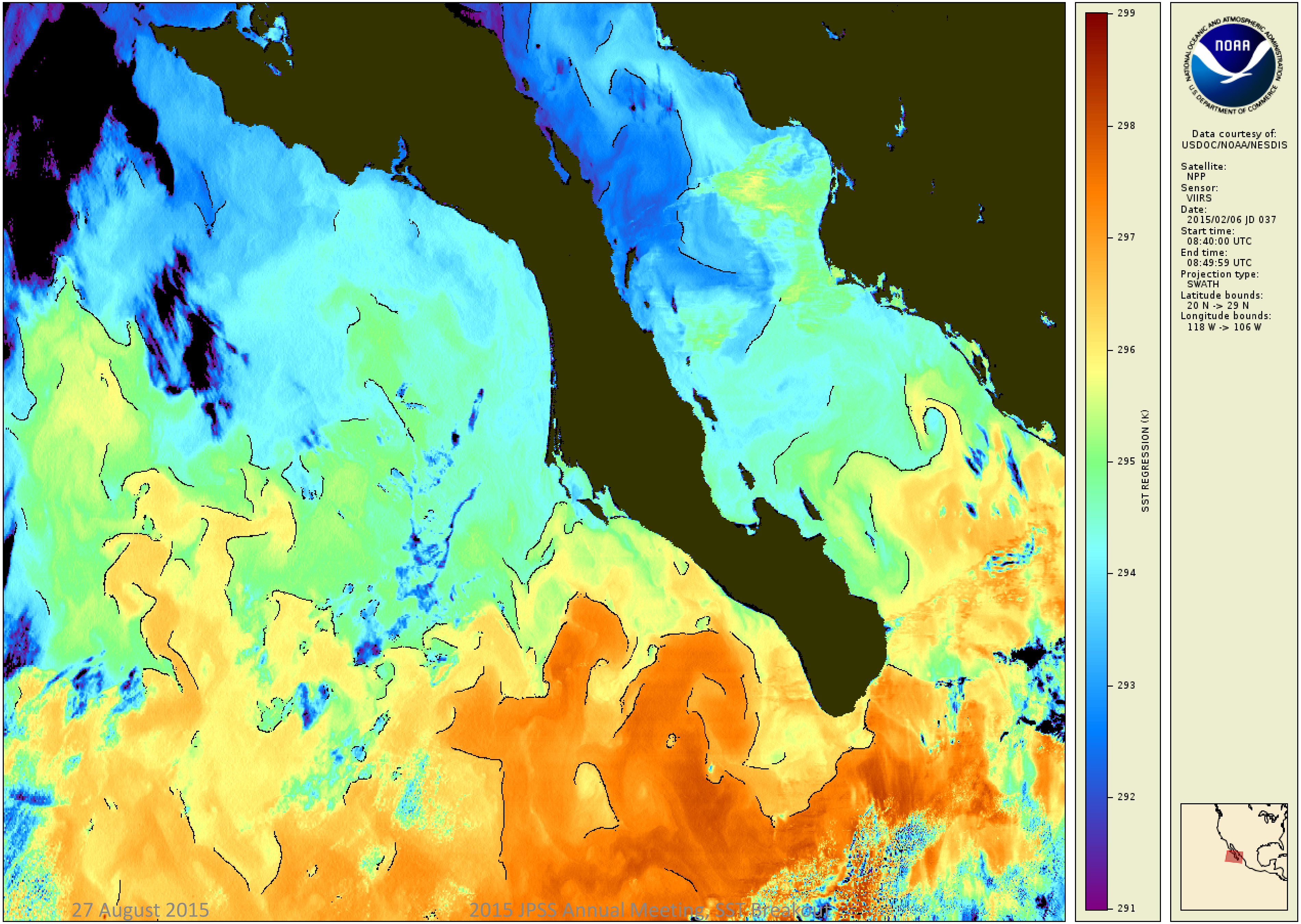
Longitude bounds:
118 W -> 106 W



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SST REGRESSION (K)
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Data courtesy of:
USDOC/NOAA/NESDIS
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VIIRS
Date:
2015/02/06 JD 037
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Projection type:
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Latitude bounds:
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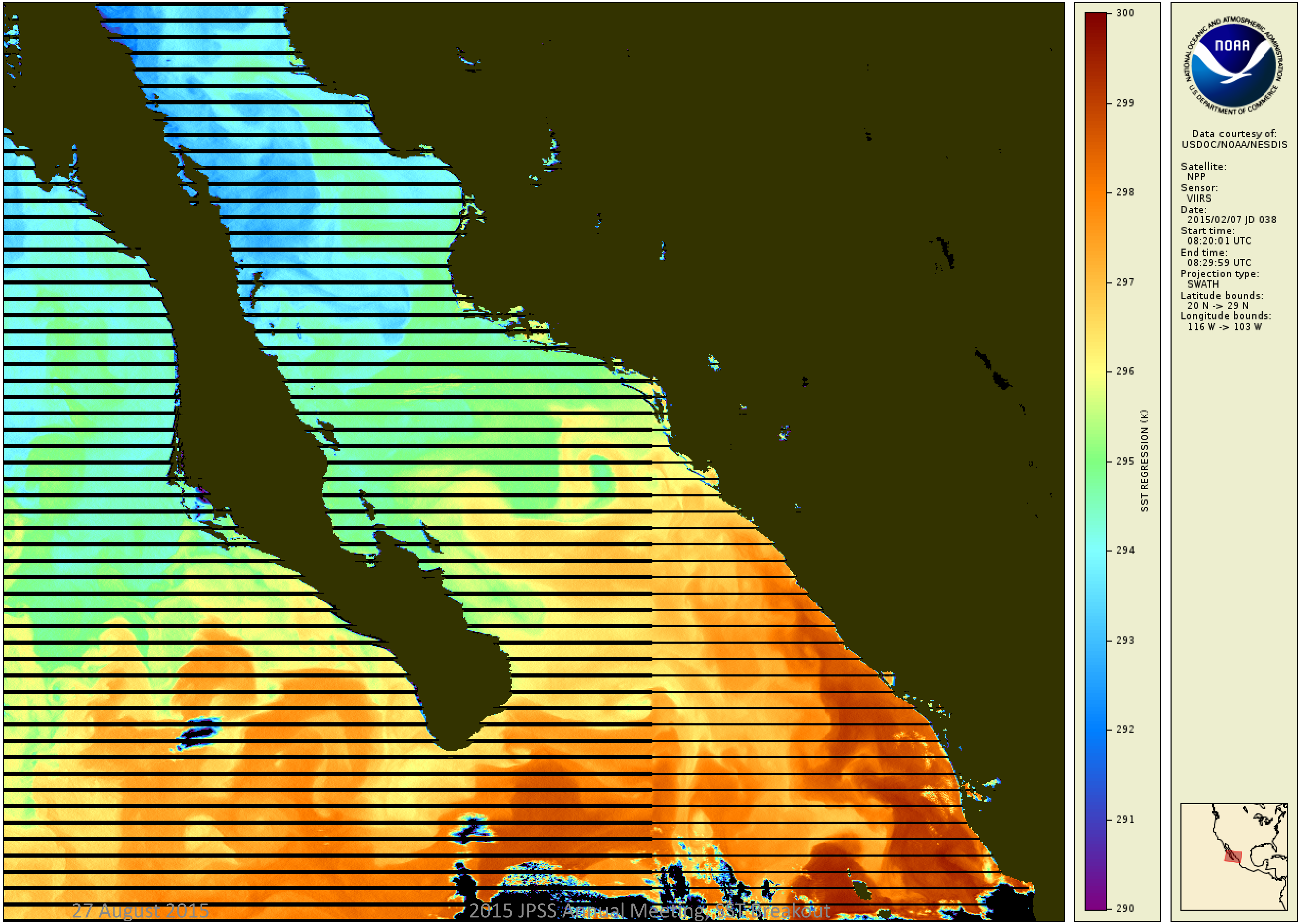
Longitude bounds:
118 W -> 106 W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SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2015/02/07 JD 038
Start time:
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End time:
08:29:59 UTC
Projection type:
SWATH
Latitude bounds:
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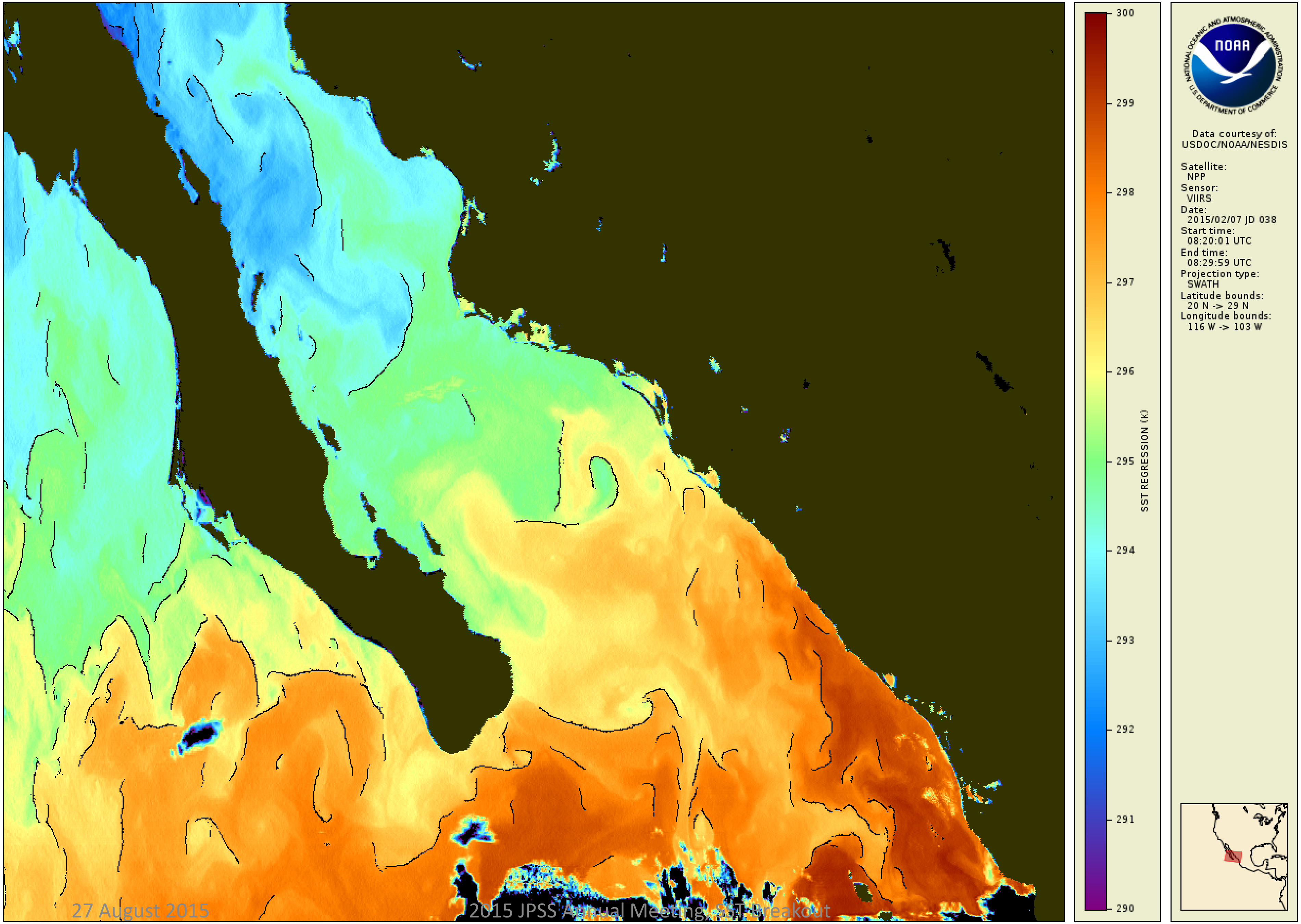
Longitude bounds:
116 W -> 103 W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SST REGRESSION (K)
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
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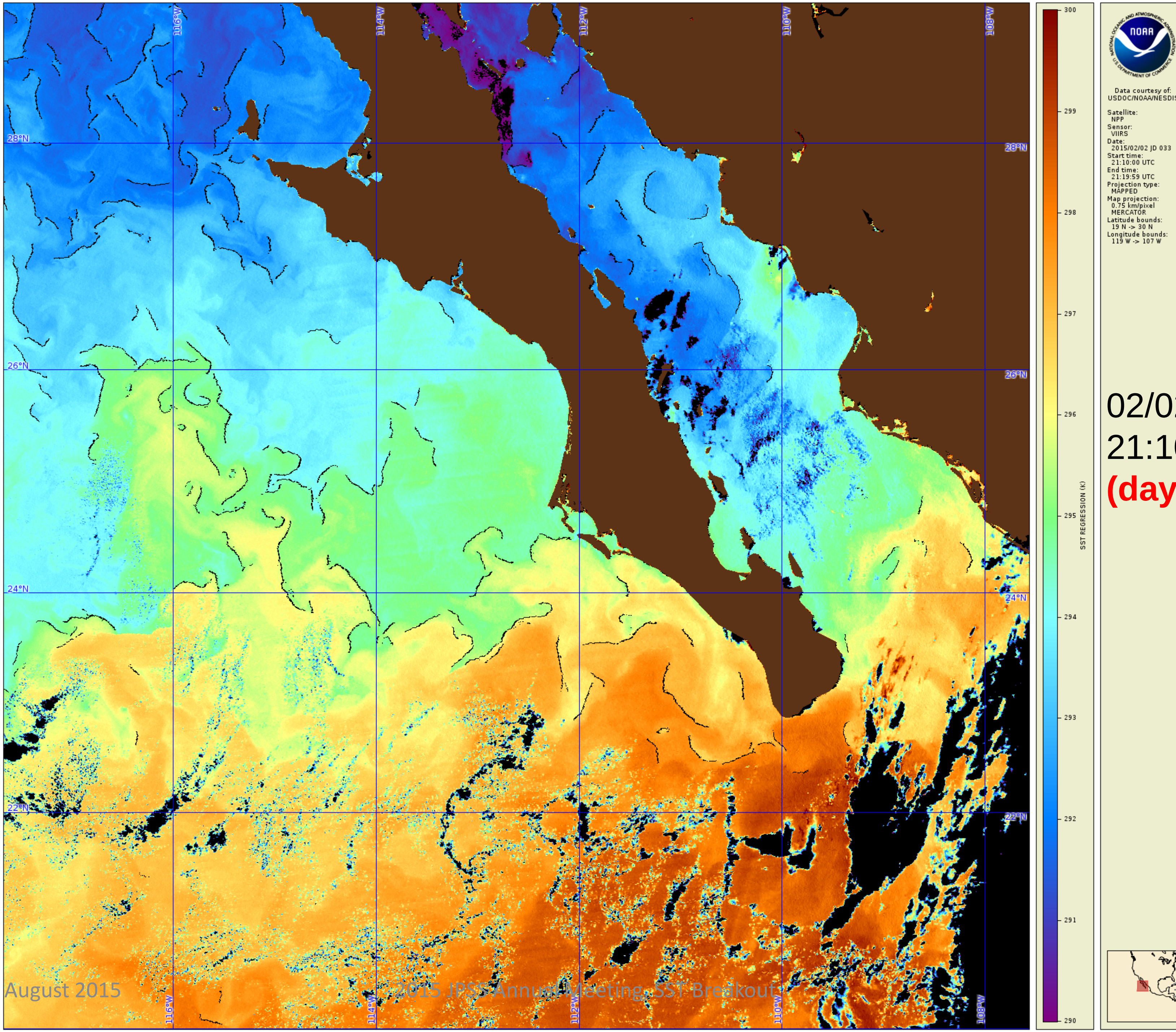
Sensor:
VIIRS
Date:
2015/02/07 JD 038
Start time:
08:20:01 UTC
End time:
08:29:59 UTC
Projection type:
SWATH
Latitude bounds:
20 N -> 29 N
Longitude bounds:
116 W -> 103 W

Remapped Fronts

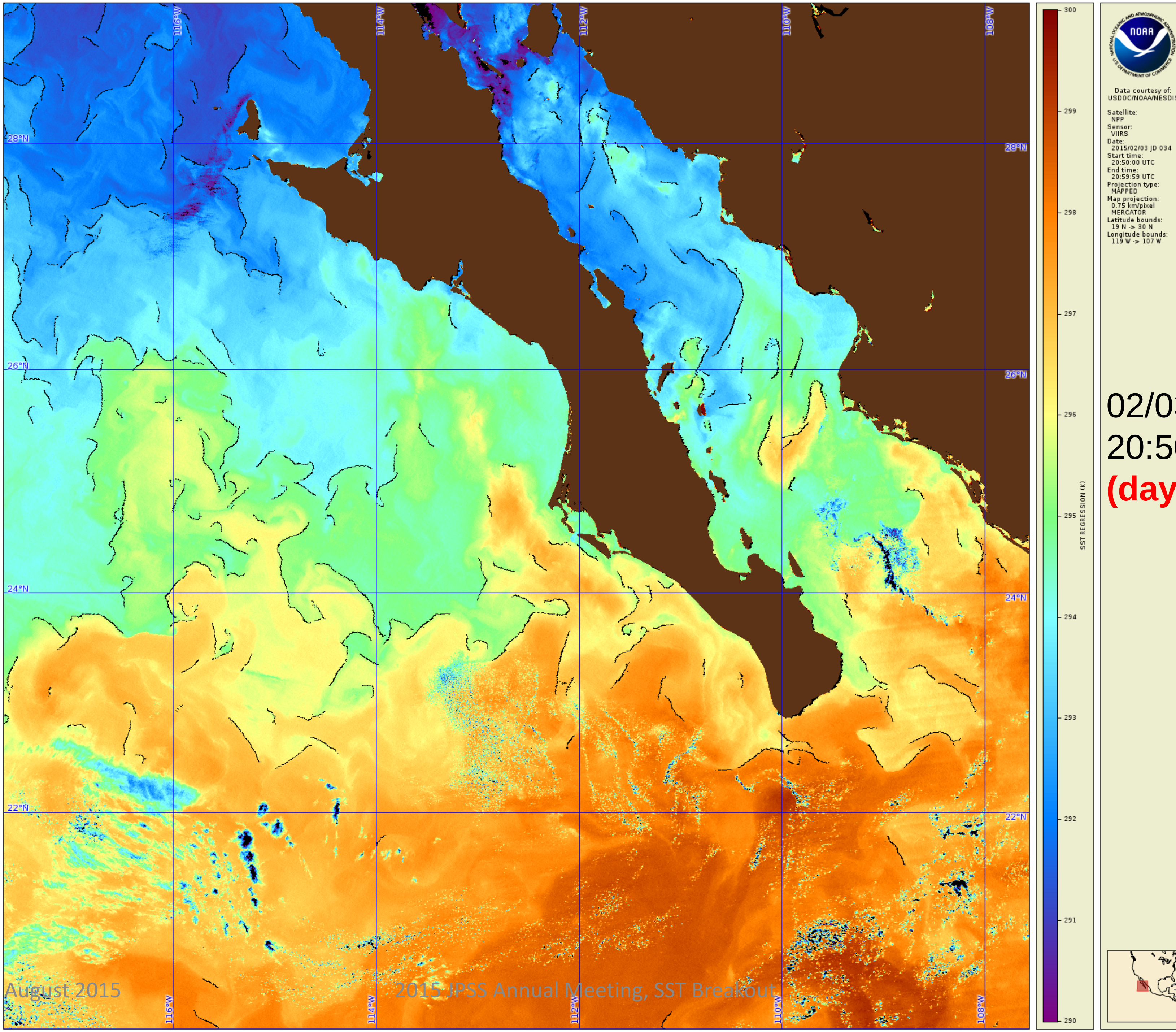
California Bay (remapped)

02/02/2015 – 02/10/2015

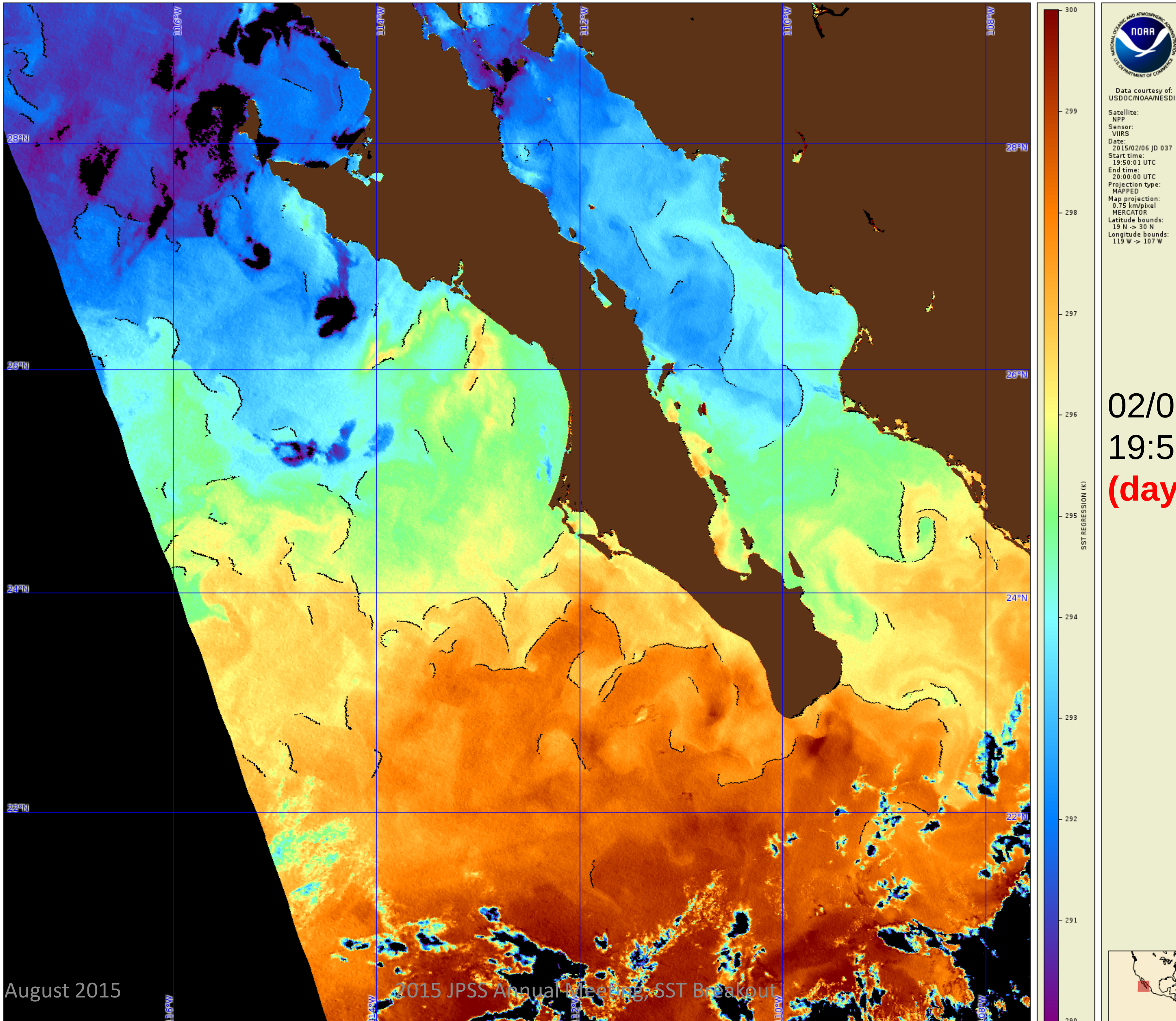
Improved imagery
&
Oceanic Thermal Front Mask



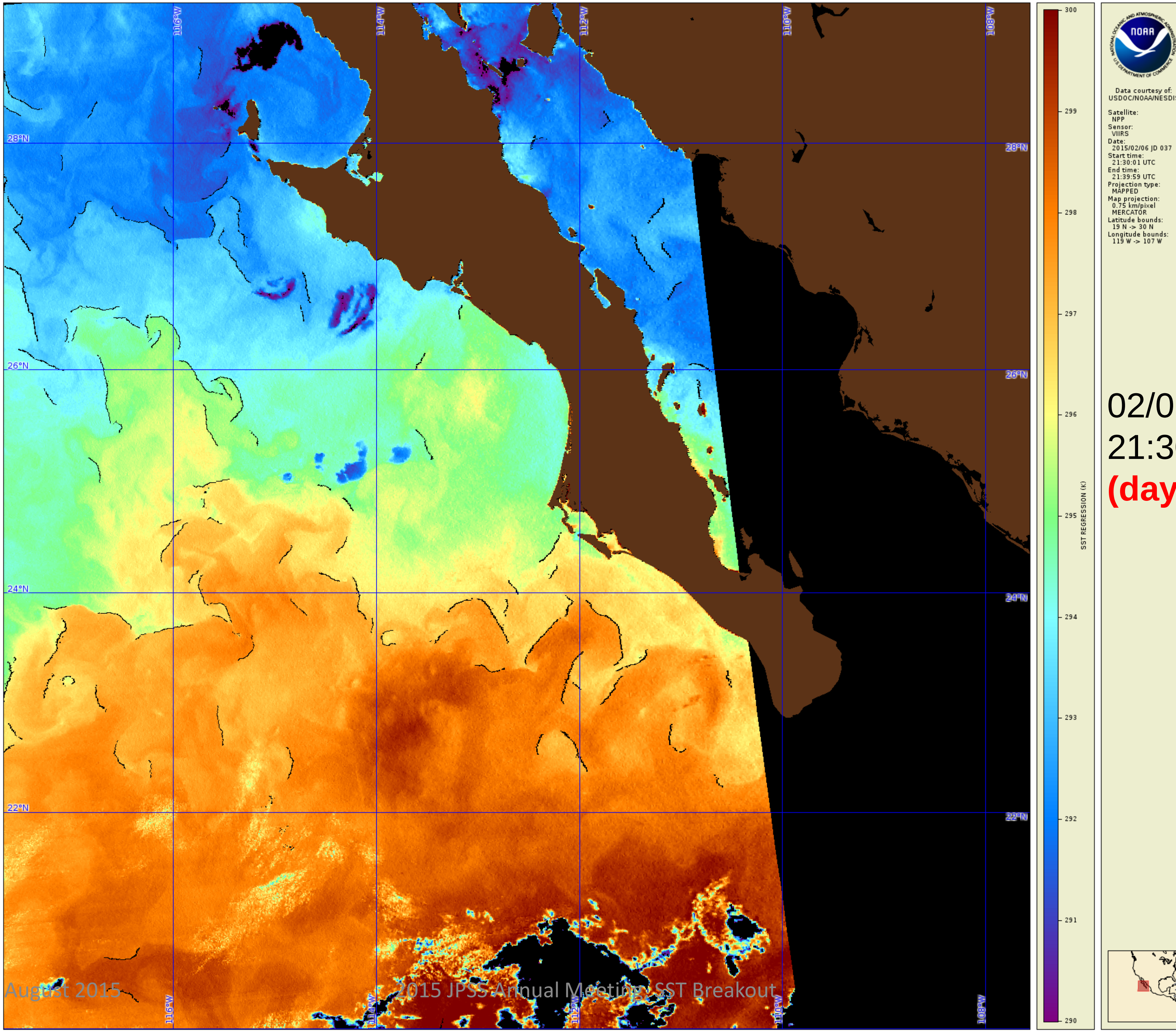
02/02/2015
21:10 UTC
(day)



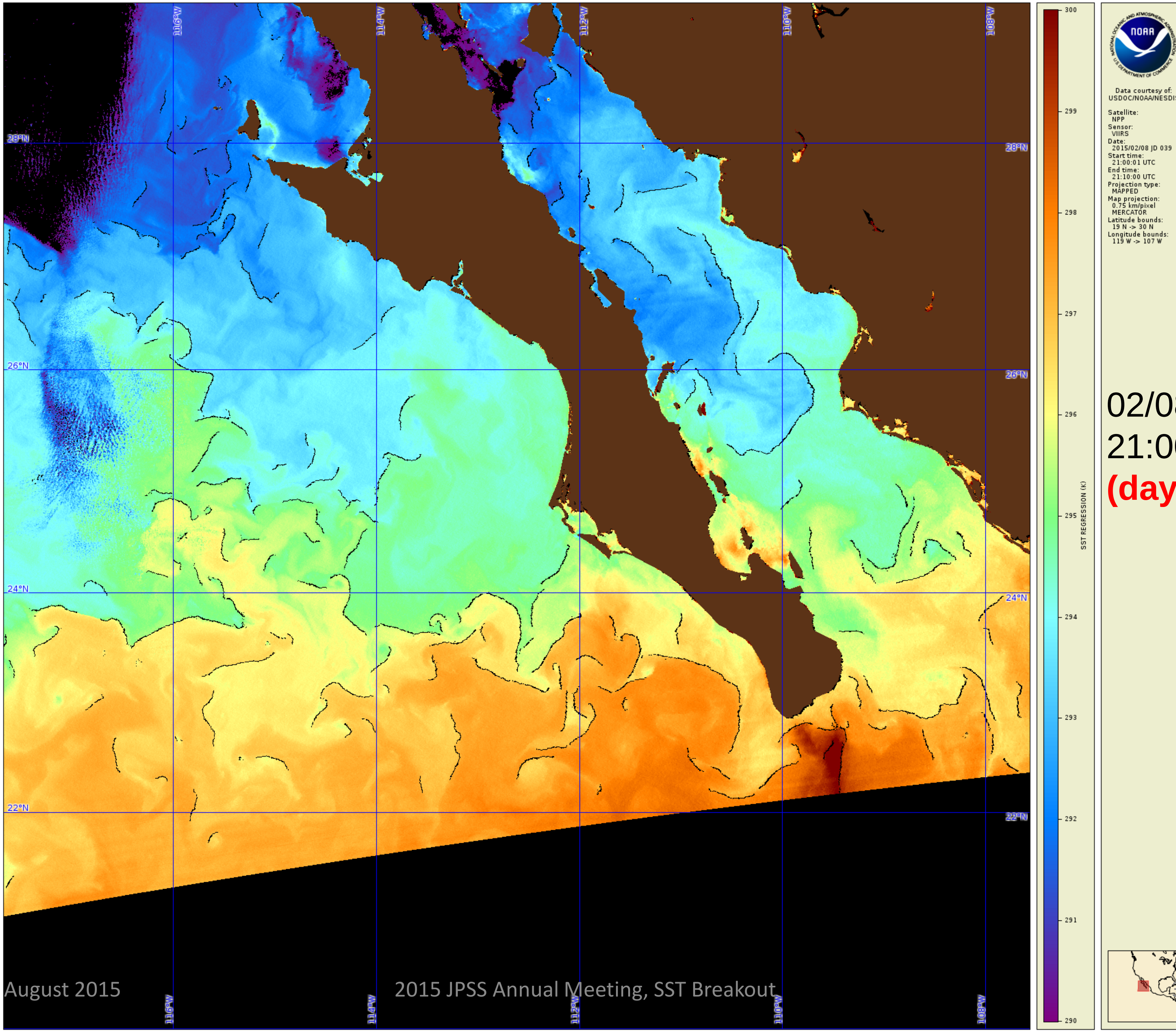
02/03/2015
20:50 UTC
(day)



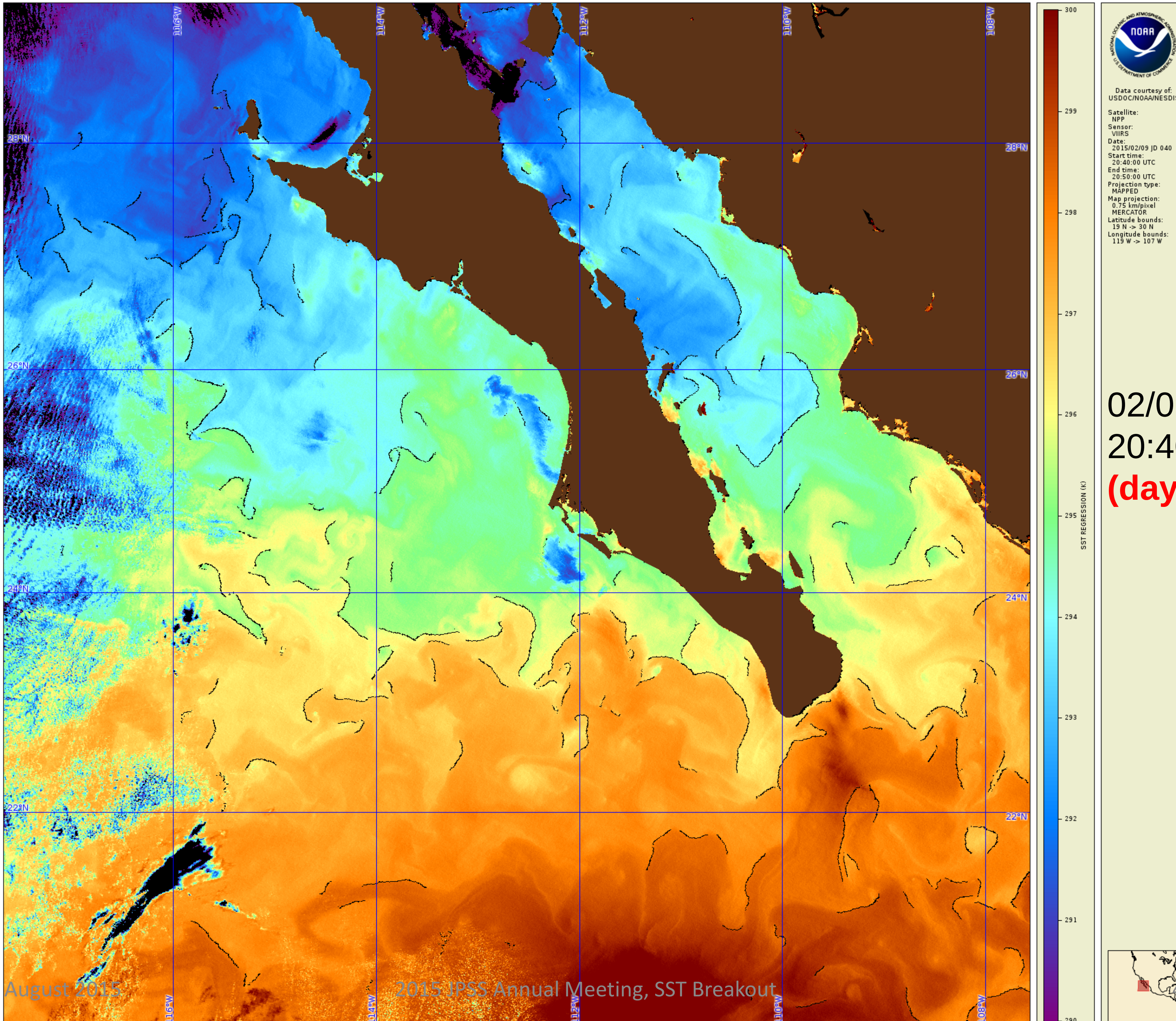
02/06/2015
19:50 UTC
(day)



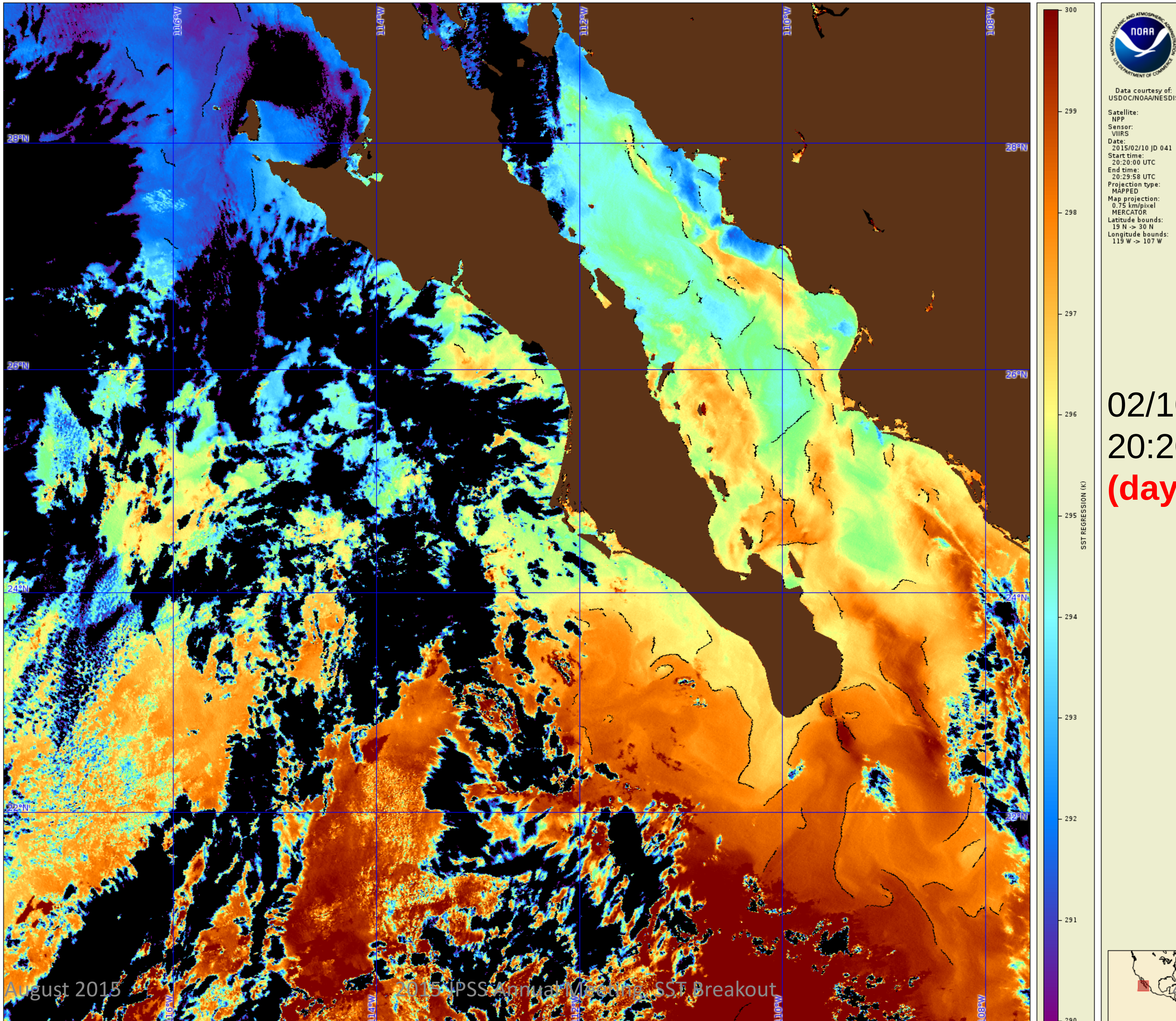
02/06/2015
21:30 UTC
(day)



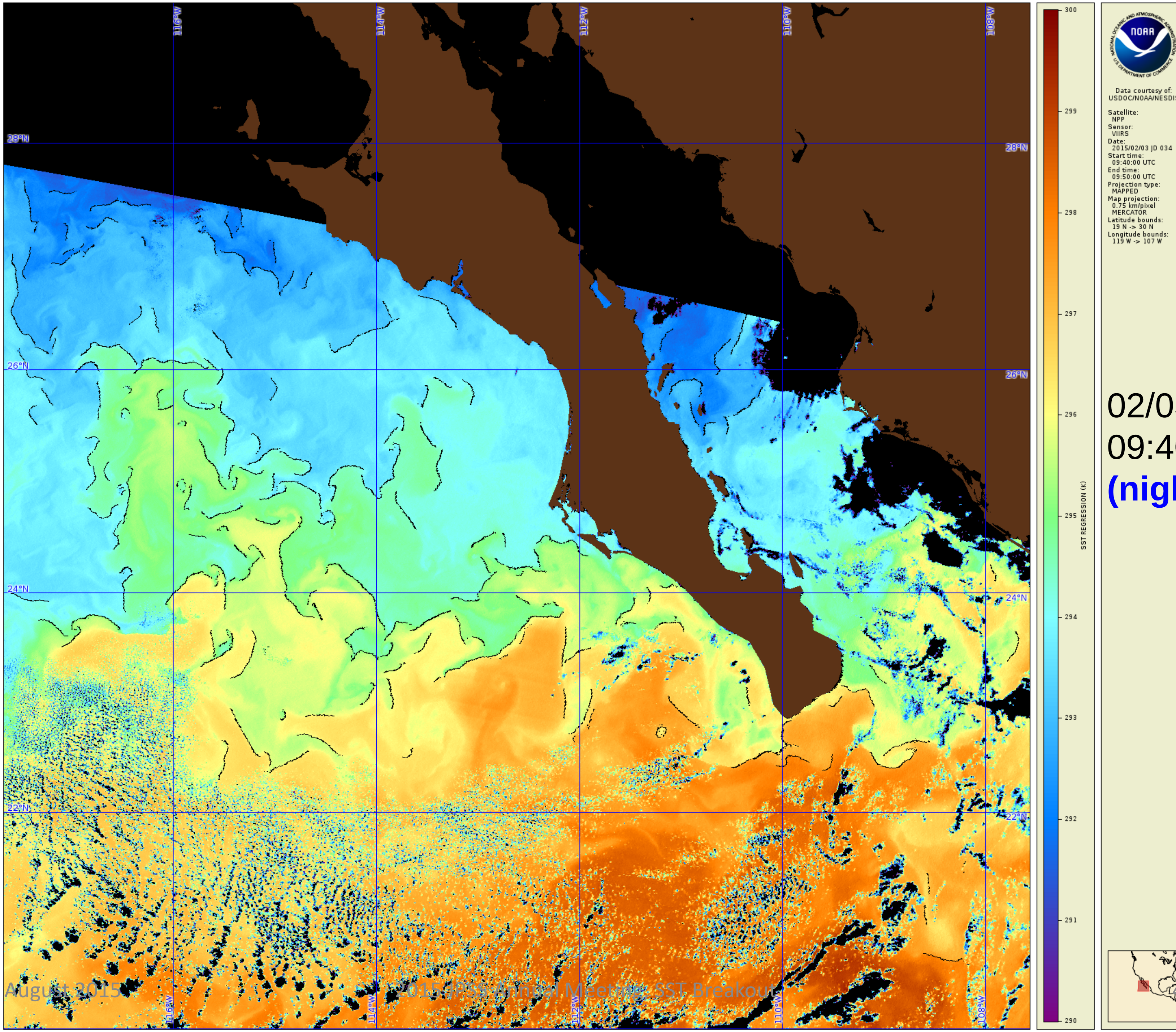
02/08/2015
21:00 UTC
(day)



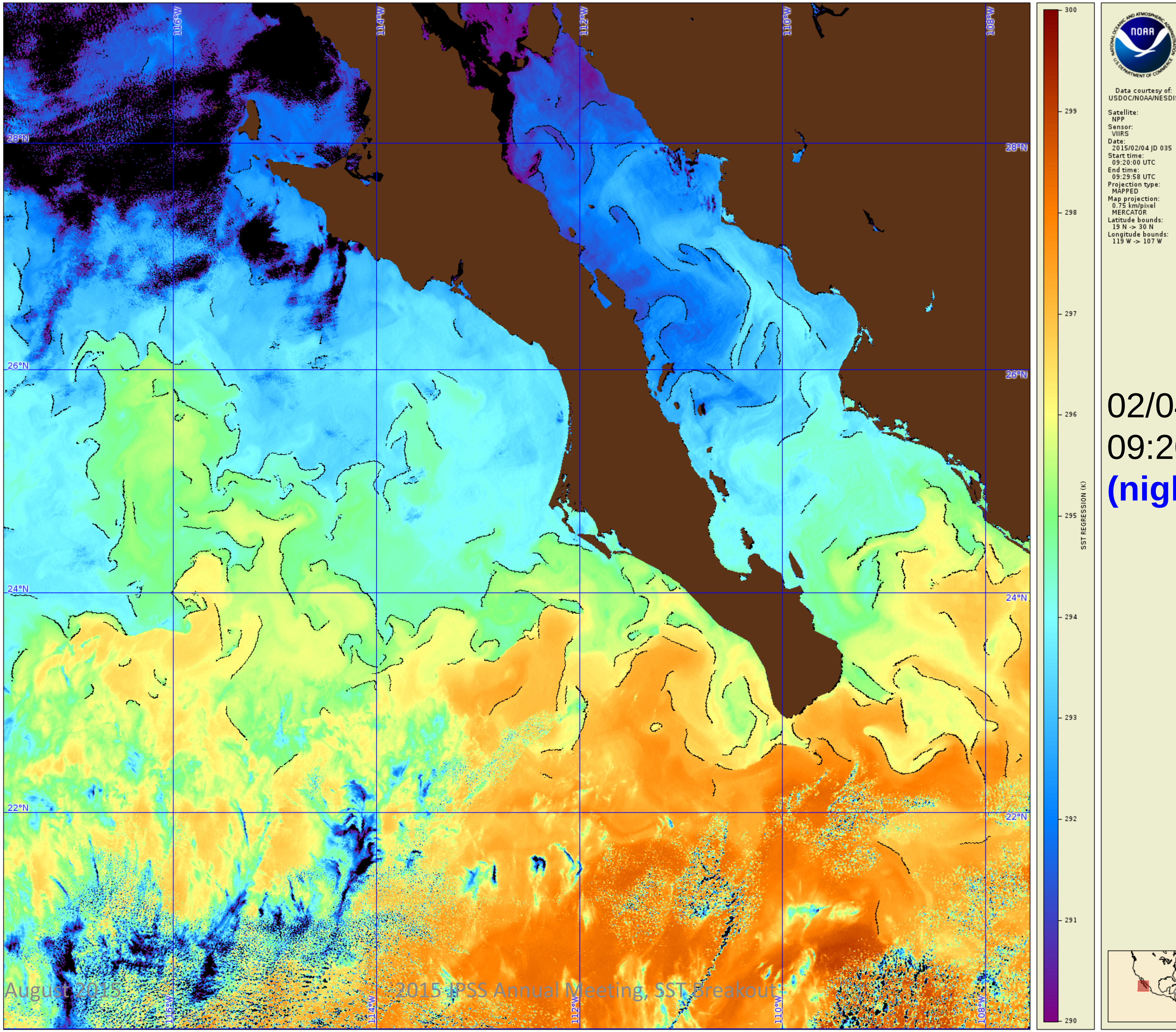
02/09/2015
20:40 UTC
(day)



02/10/2015
20:20 UTC
(day)



02/03/2015
09:40 UTC
(night)



02/04/2015
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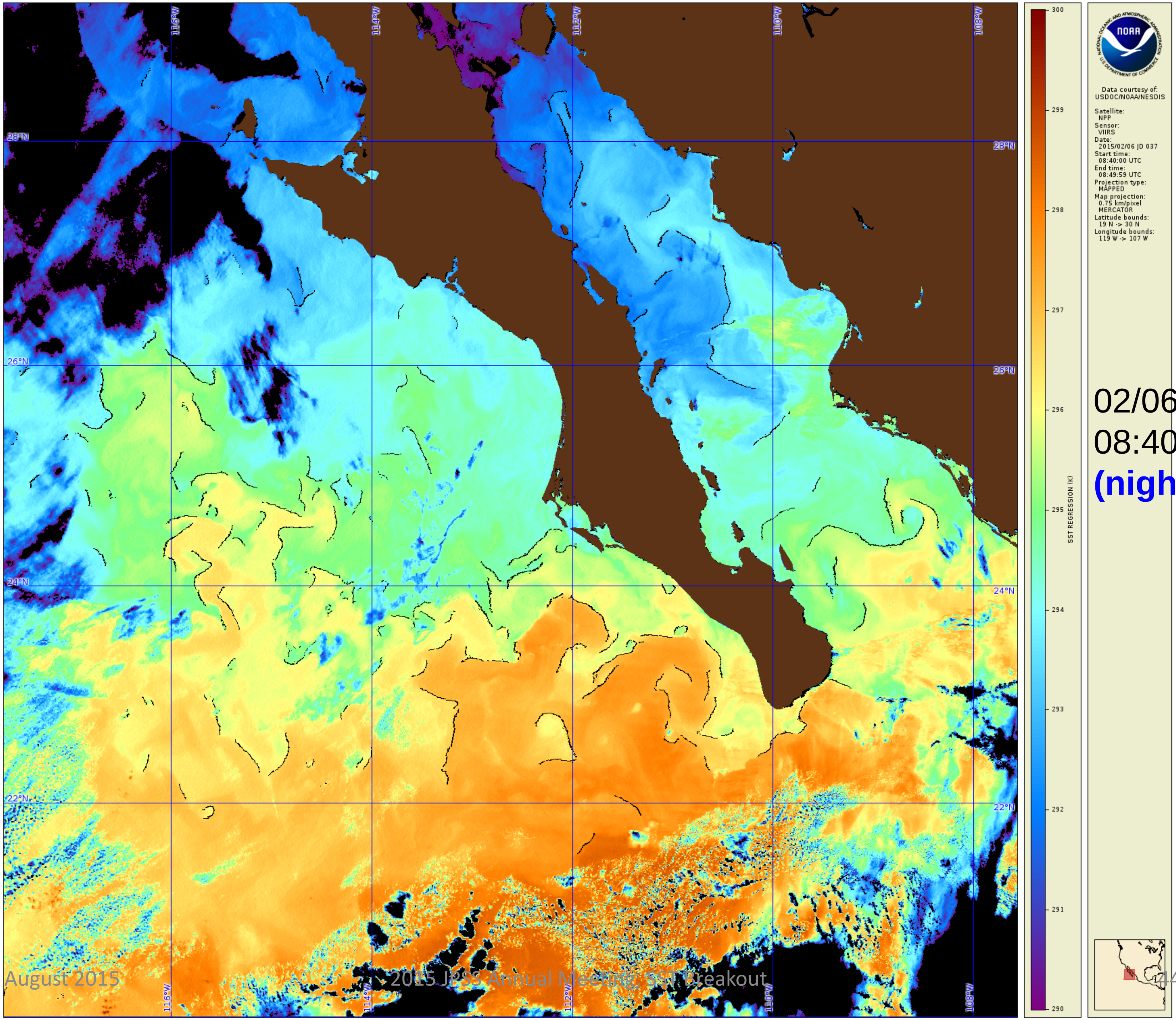
(night)



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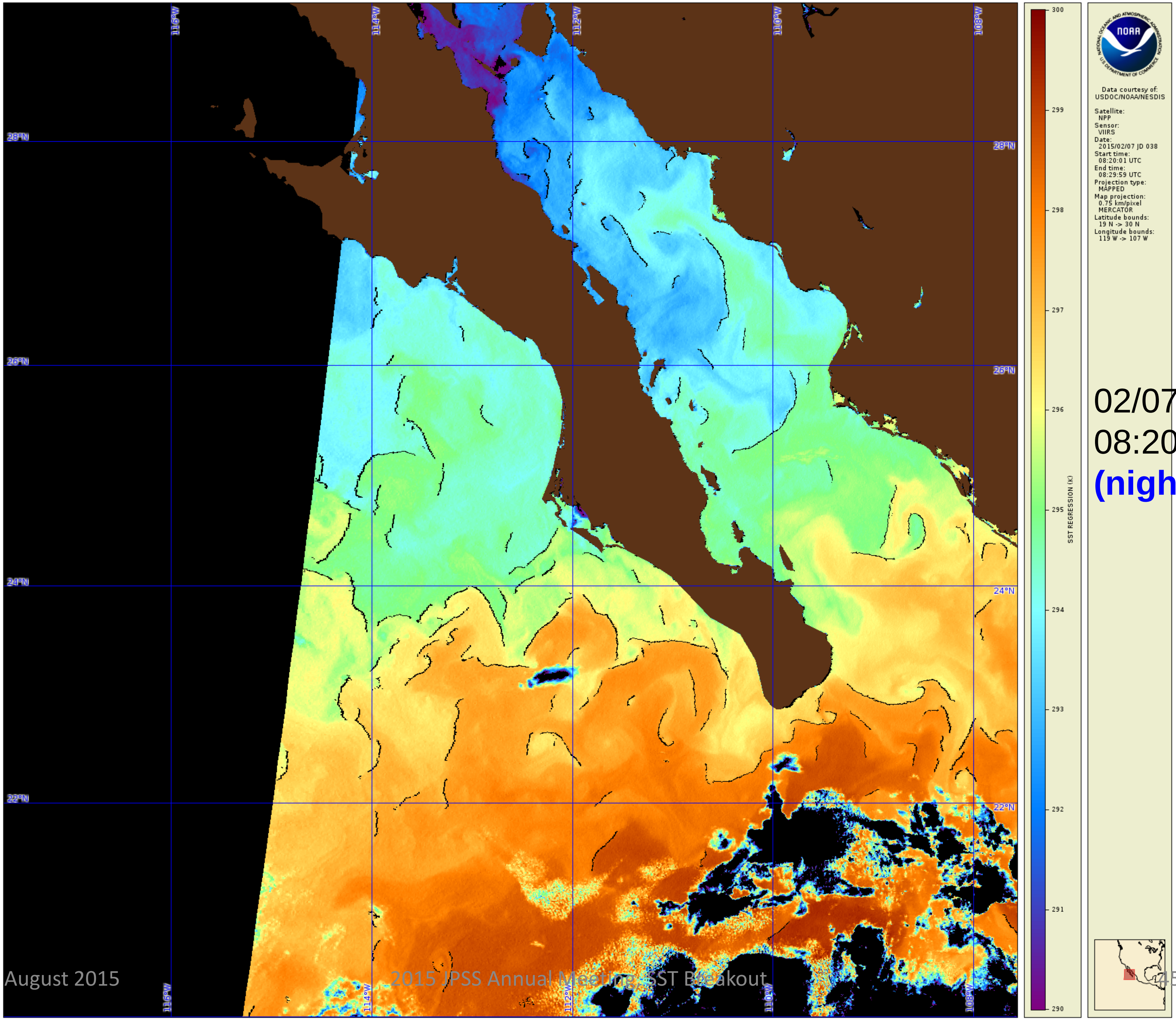

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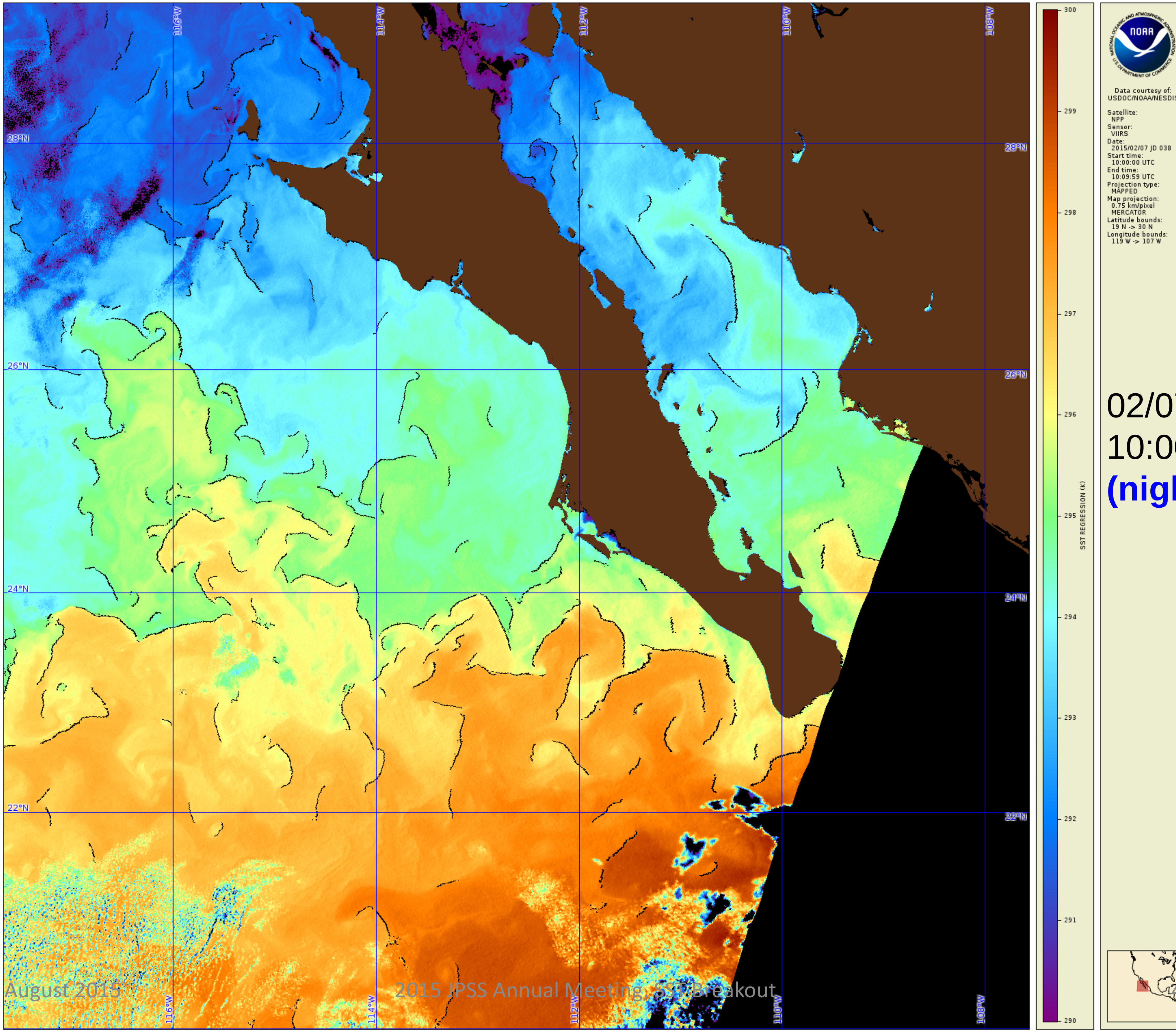

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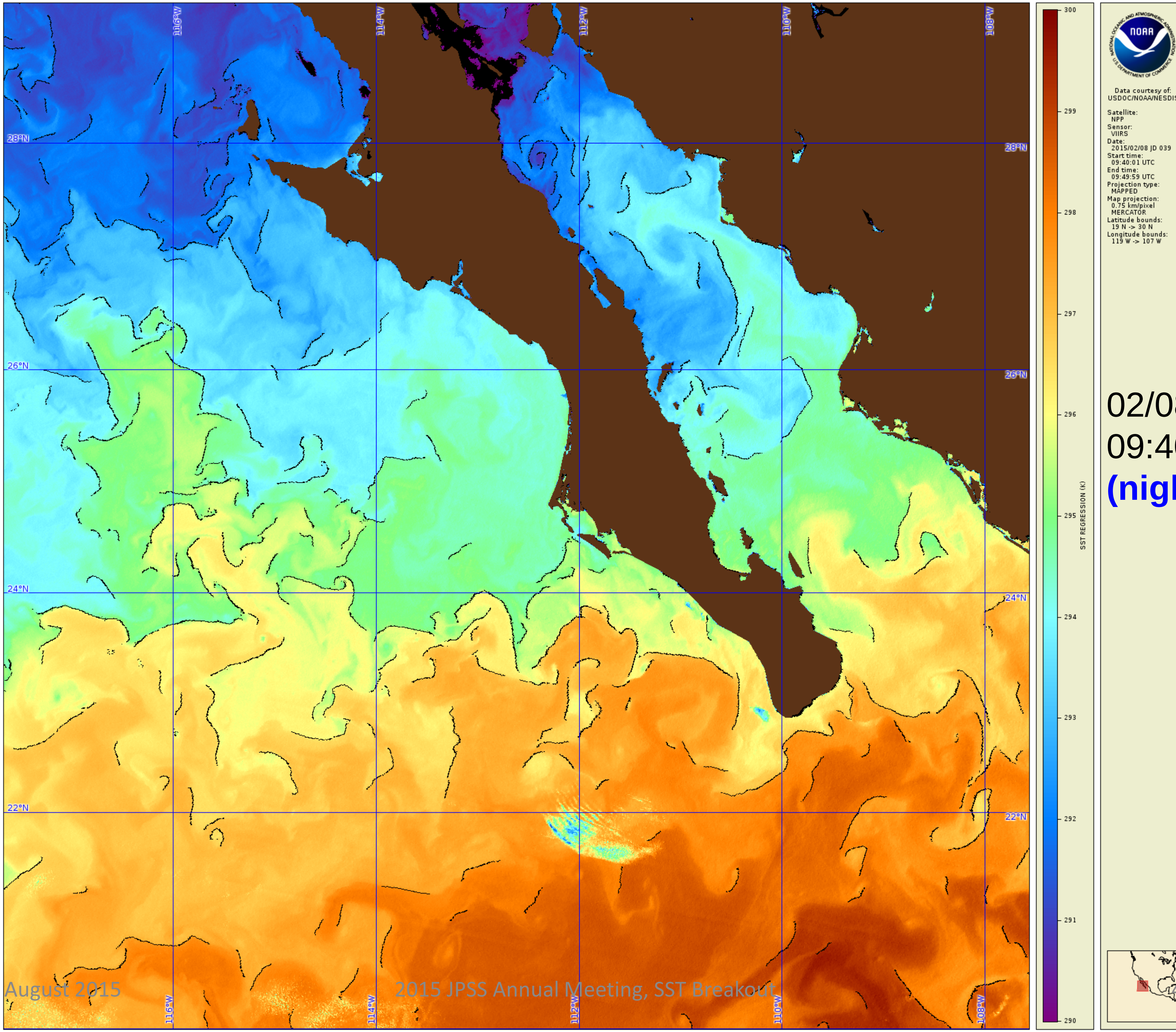

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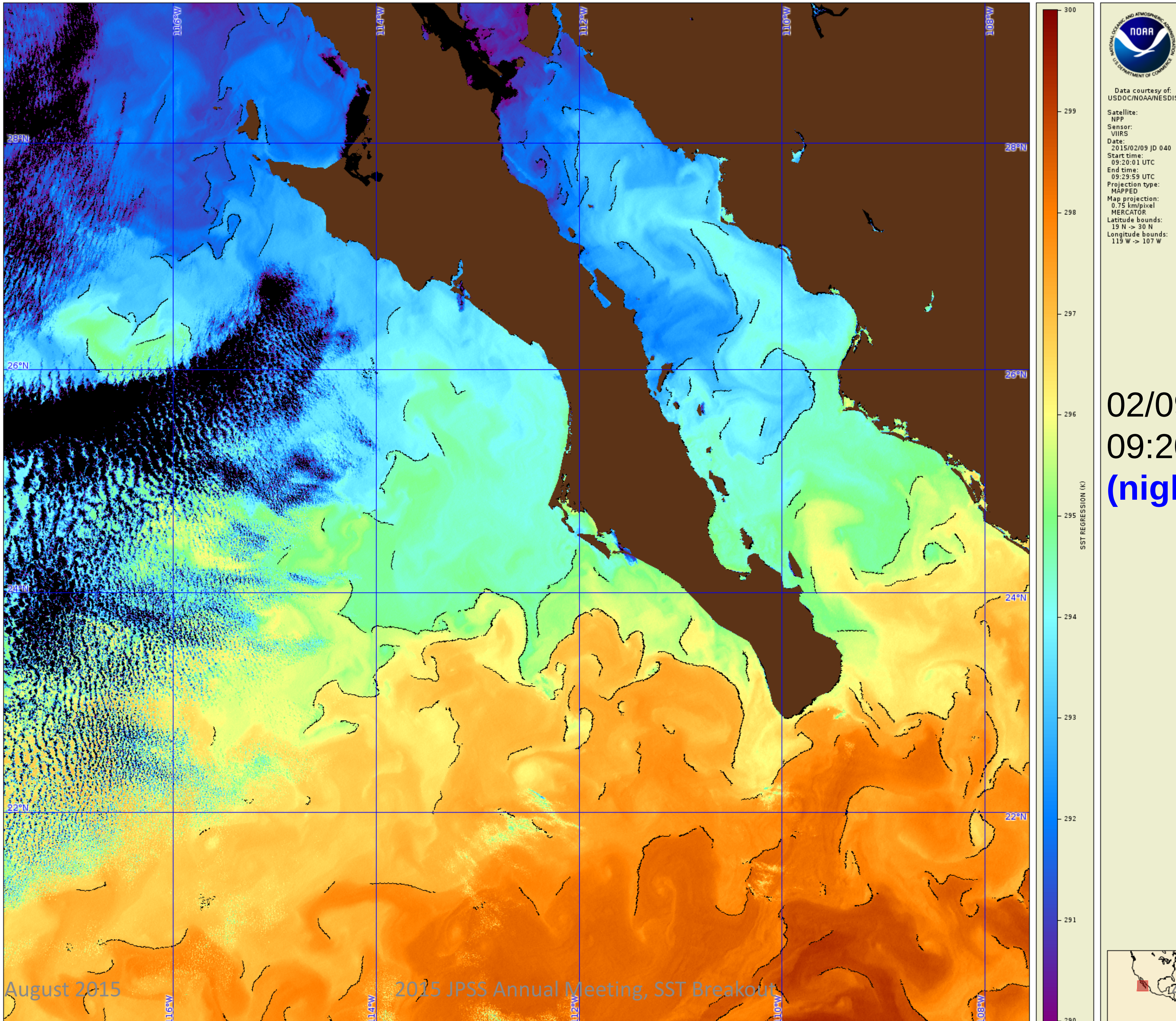


02/09/2015
09:20 UTC
(night)

ACSPO Planned Milestones

Main objective: Improve clear sky mask (with focus on dynamic, coastal, and high-latitude areas)

ACSPO 2.50 (Mar 2016): Improve BT and SST Imagery: Resample (de-bowtize) & Restore pixels in bow-tie areas deleted onboard

ACSPO 2.60 (Dec 2016): Version 1 of (1) Pattern recognition improvements to ACSPO clear-sky mask; and (2) Oceanic Thermal Front Product (can save bit mask; reaching out to user community for additional requirements).

Plan

- **Implement resampling/reordering algorithms with ACSPO VIIRS and MODIS (ACSPO v2.50)**
- **The L2 VIIRS and MODIS swath product will contain**
  a) **Resampled BT and SST values**
  b) **bow-tie pixels filled in (but flagged as "filled", in case users don't want to use estimated values)**
- **Implement pattern recognition algorithms in ACSPO v2.60 Generate Ocean Fronts Product, improve Clear-Sky Mask**
- **Comprehensively test/evaluate the improved ACSPO clear-sky mask**
- **Work with L4 users to evaluate the effect on their analyses**

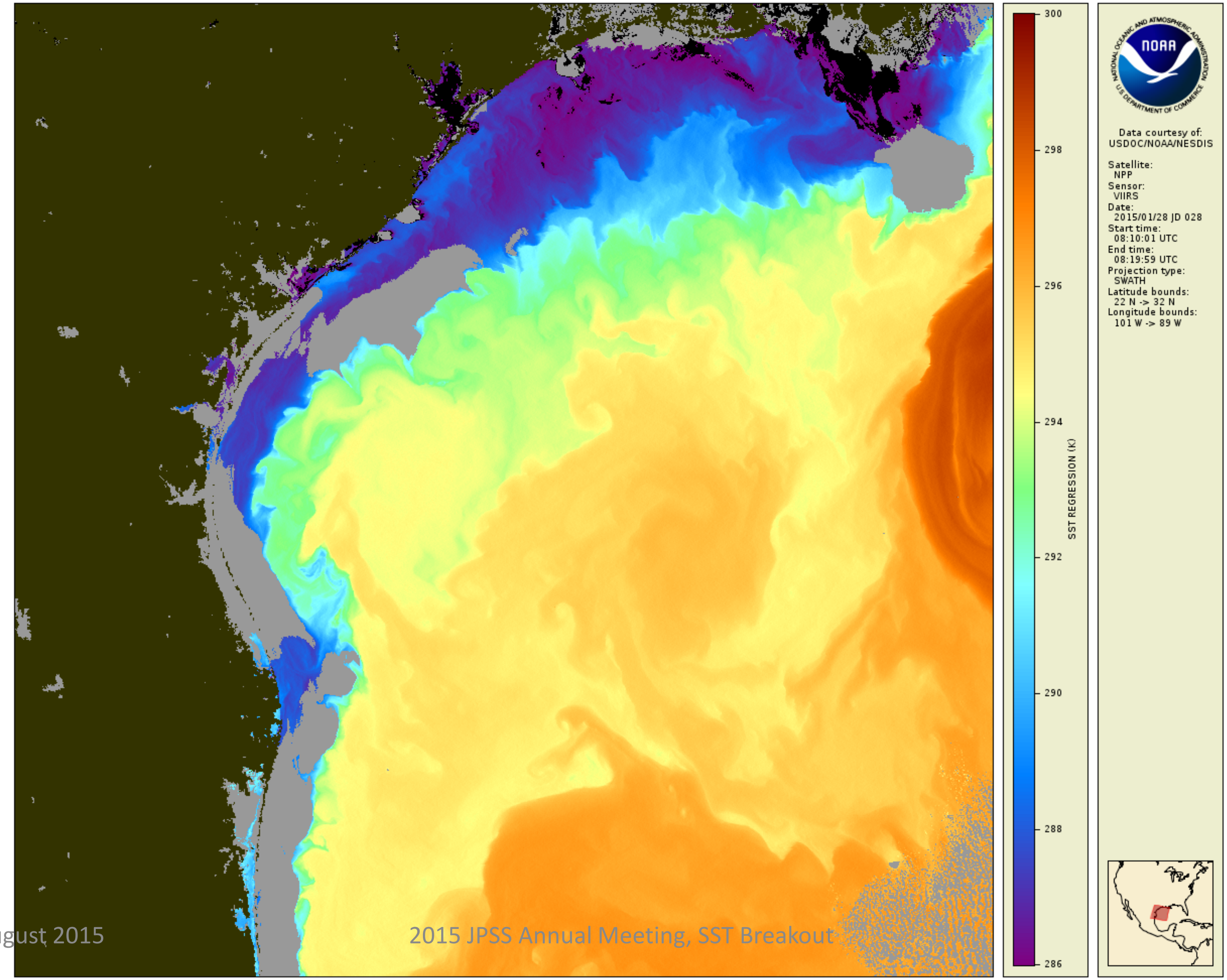
Backup Slides

Practical Considerations

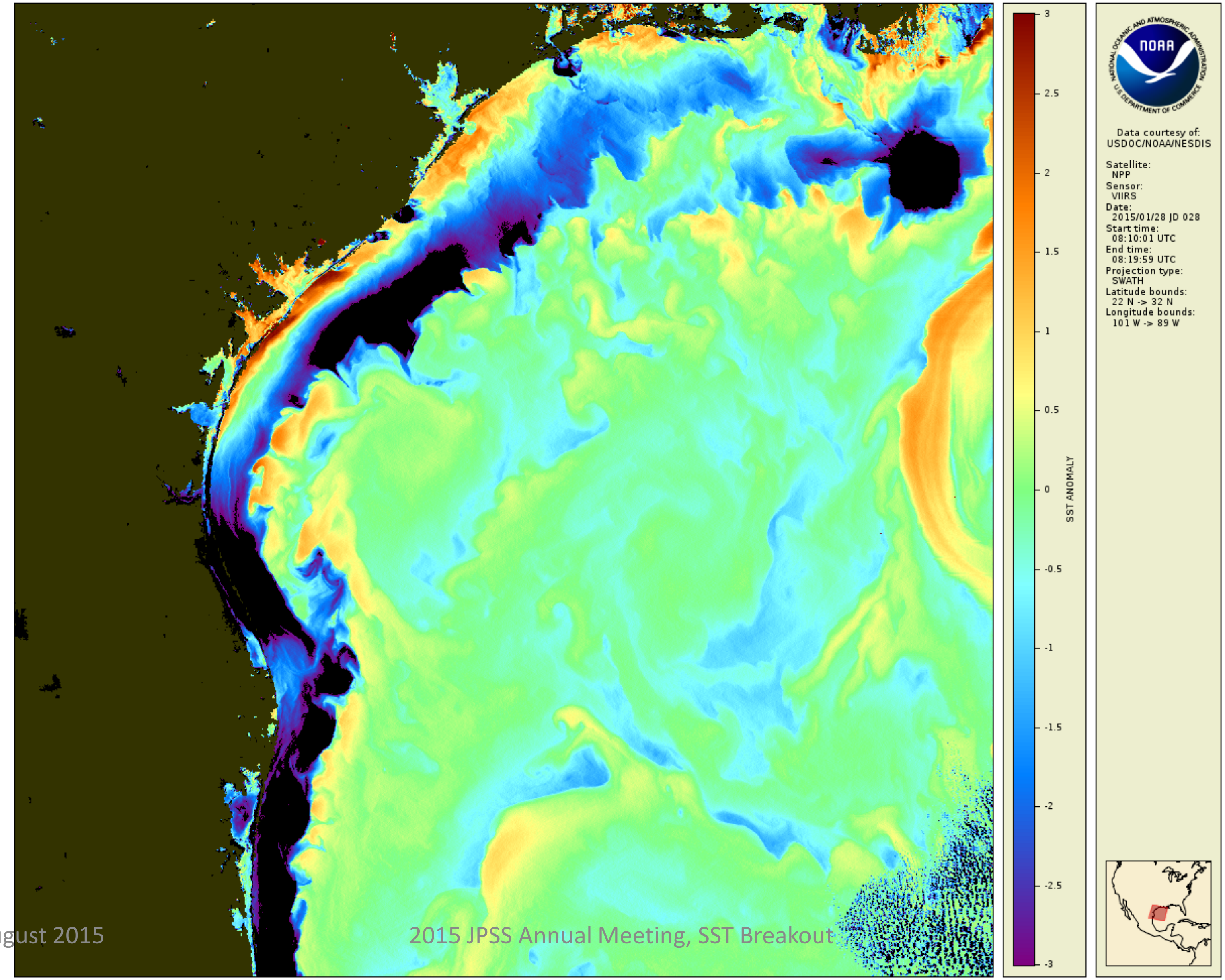
Algorithm is meant for real time processing at the Level 2 products. We use the following standard functions from optimized openCV library:

- **gradient filter**
- **range filter**
- **median filter**
- **standard deviation filter**
- **Gaussian filter**
- **Laplacian of Gaussian (LoG) filter**
- **bilateral filter**
- **zero crossing filter**
- **erosion/dilation morphological function**
- **connected components**

Current clear-sky mask



Delta SST


3
2.5
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-0.5
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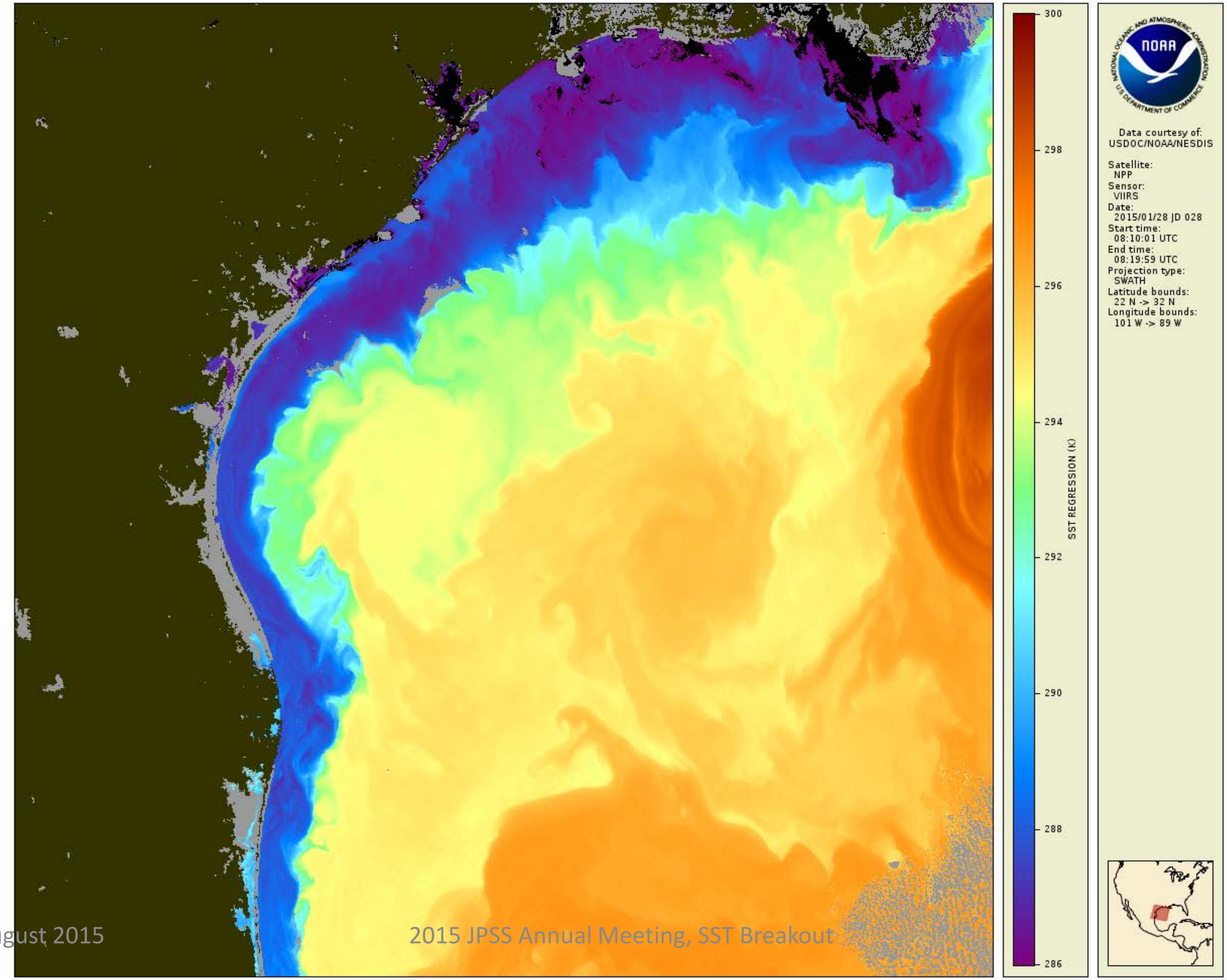
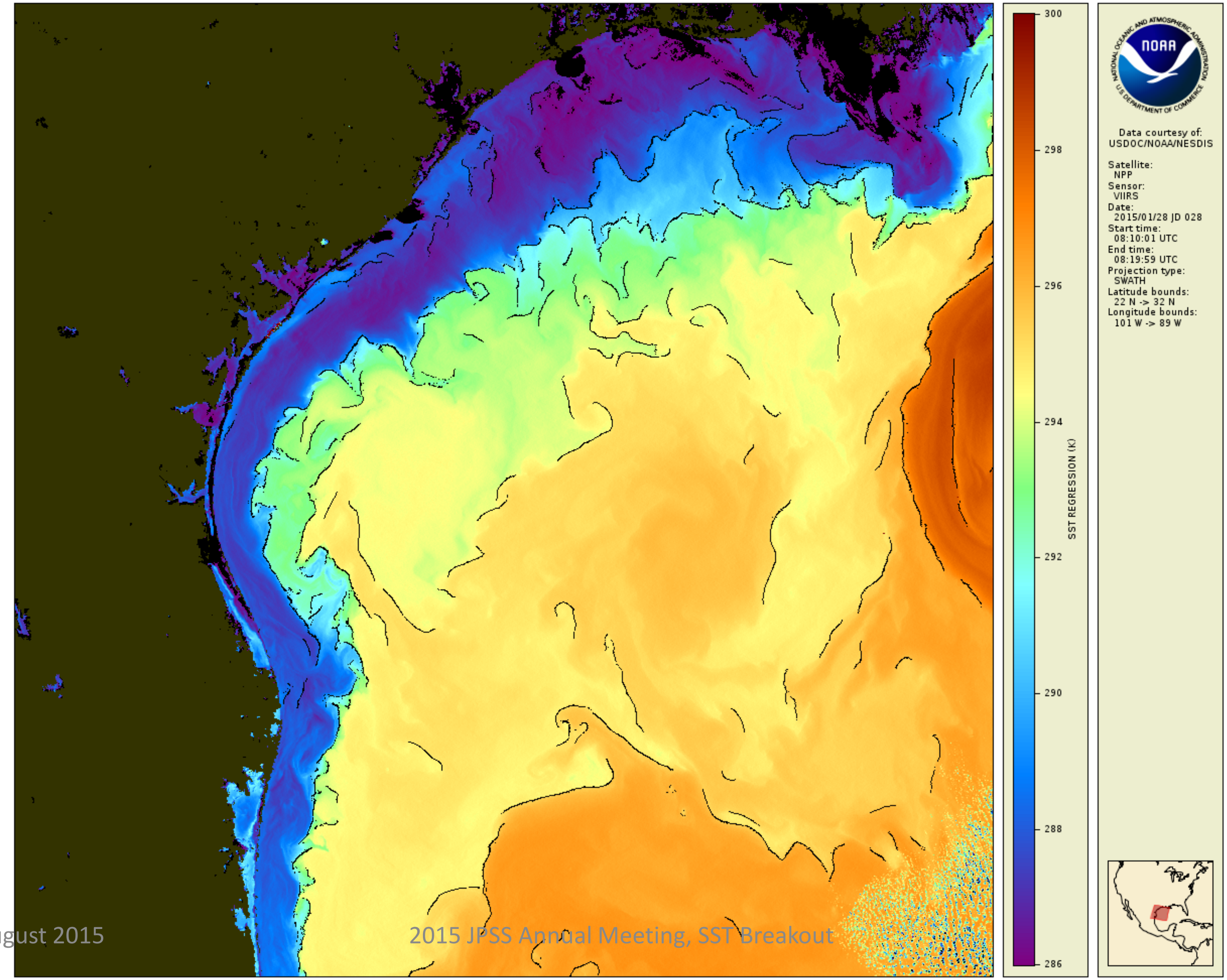
SST ANOMALY
Data courtesy of:
USDOC/NOAA/NESDIS
Satellite:
NPP
Sensor:
VIIRS
Date:
2015/01/28 JD 028
Start time:
08:10:01 UTC
End time:
08:19:59 UTC
Projection type:
SWATH
Latitude bounds:
22 N -> 32 N
Longitude bounds:
101 W -> 89 W

Improved clear-sky mask



Thermal Fronts



VIIRS Sea-Surface Temperatures: pathways for improvements

Kay Kilpatrick, Peter J Minnett, Elizabeth Williams,

Sue Walsh

Rosenstiel School of Marine & Atmospheric Science
University of Miami

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NOAA JPSS annual VIIRS SST Science Team Meeting
27 August 2015

Focus of studies

- Cloud screening algorithms
  - machine learning ensemble algorithms and boosting
- Improving and evaluating algorithm performance a higher viewing angles
  - Response versus scan angle corrections
- Sensor and algorithm performance evaluations
  - Analysis of global fields and matchups with in situ data from IQUAM.

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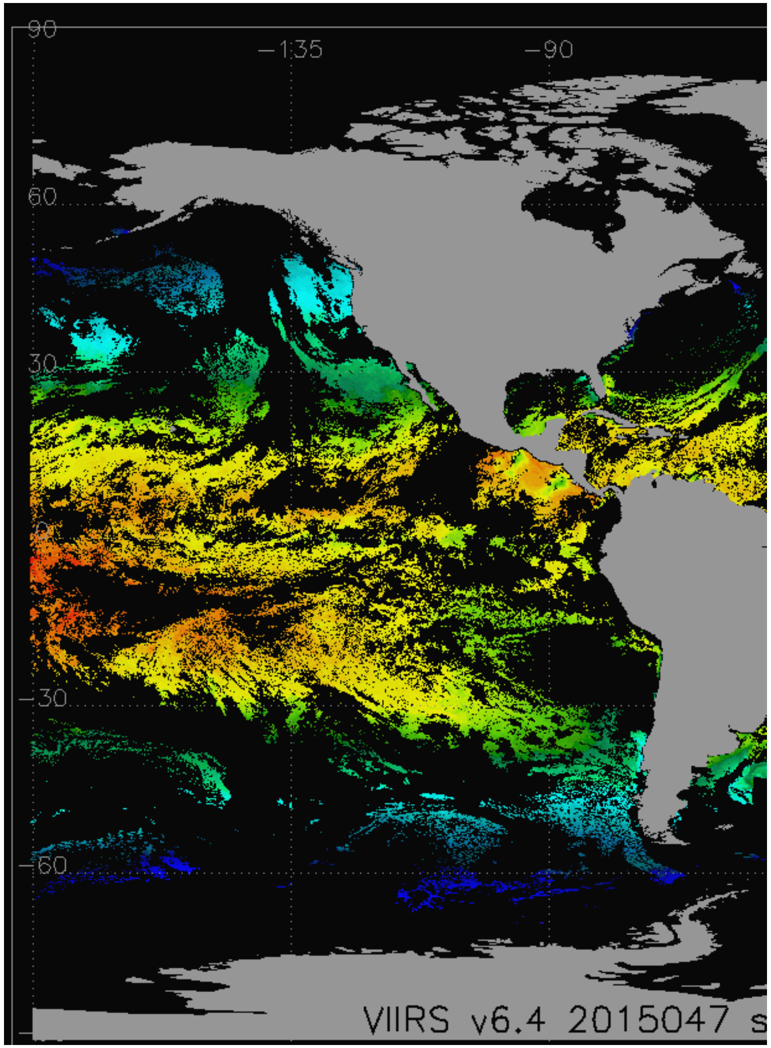
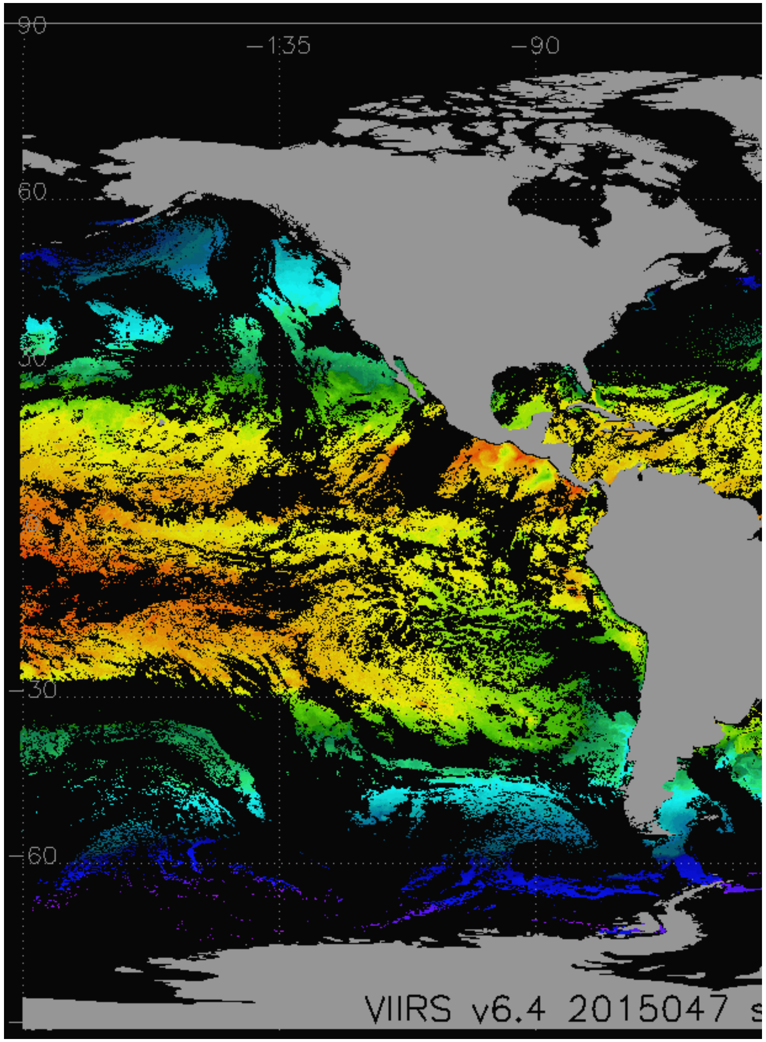
Cloud mask

- IR algorithms are only accurate in cloud free and atmospherically "clean" pixels
- Decision Tree misclassification errors.
  - Sensitivity versus specificity
  - Good classified as bad and bad classified as good.
- Differences in ability to detect clouds between day and night can impact sampling/binning of higher level products.
  - Differences in gap free fraction
- Ensemble classification methods to improve misclassification errors using boosting and alternating decision trees (ADTree)

Cloud free night versus day classifiers



night



day

Ensemble machine learning for pixel cloud classification

- Alternating decision trees combine the simplicity of single decision trees and the power of boosting
  - Highly accurate
  - Relatively small size easy to interpret and code
  - Provides a measure of prediction confidence
- Boosting turns weak learners collectively into strong classifiers
  - repeat reweighing of training examples to focus on problematic/misclassified pixels

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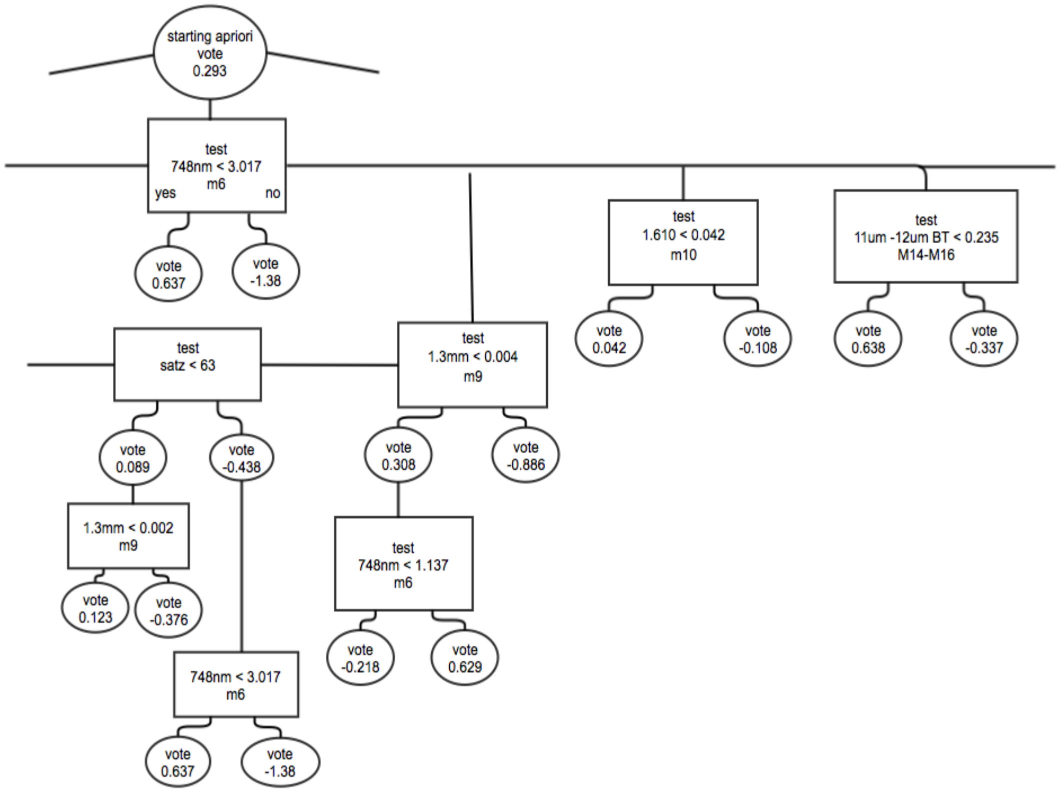
Branch of SST ADTree cloud classifier

(crowd sourcing classification with the help of experts)



Classification is based on sum of community vote across all tree stumps and branches.

A positive sum is classified as good/clear and a negative is bad/cloud. The absolute magnitude of the sum provides an estimate of the confidence in the classification.

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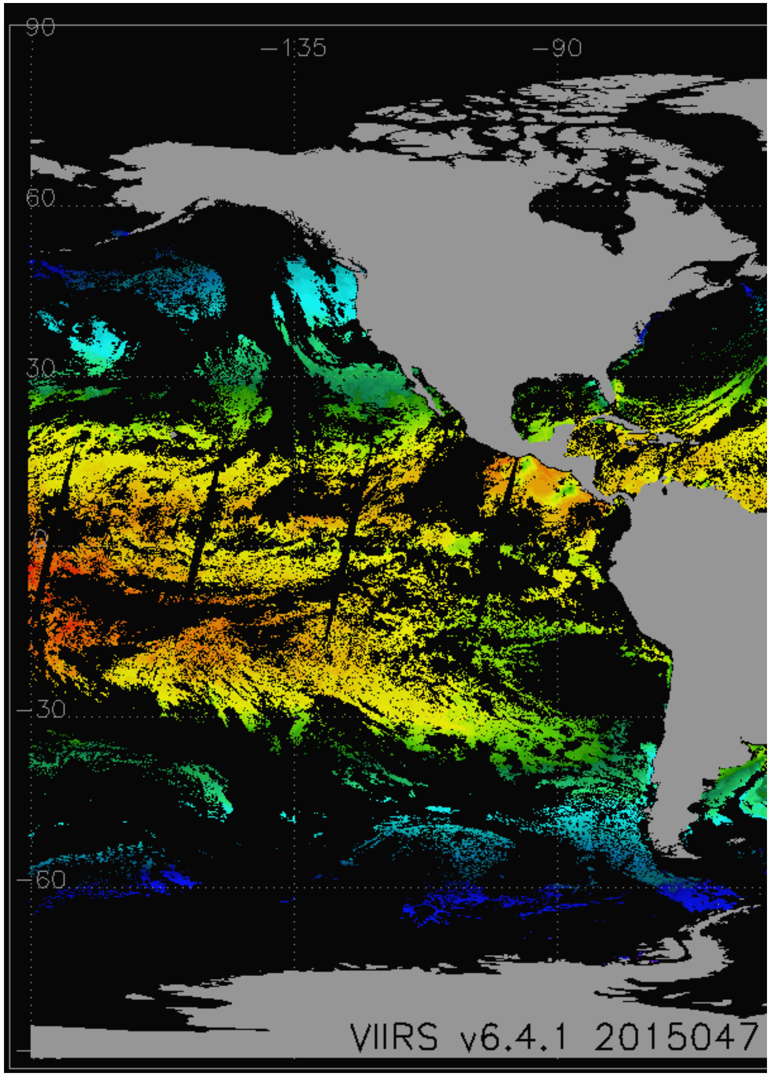
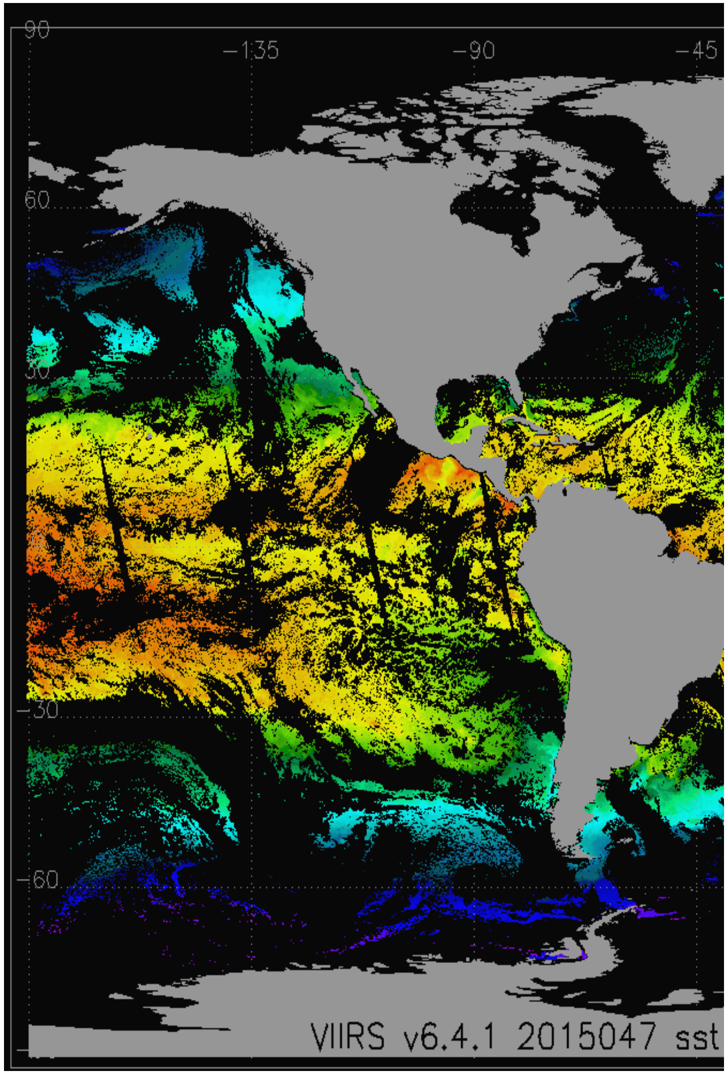
Night ADTree lower misclassification

Night Decision Tree:
misclassified
0.20
sensitivity
0 .69
Specificity
0.81

Night ADTree:
misclassified
0.099
sensitivity
0 .80
Specificity
0.90

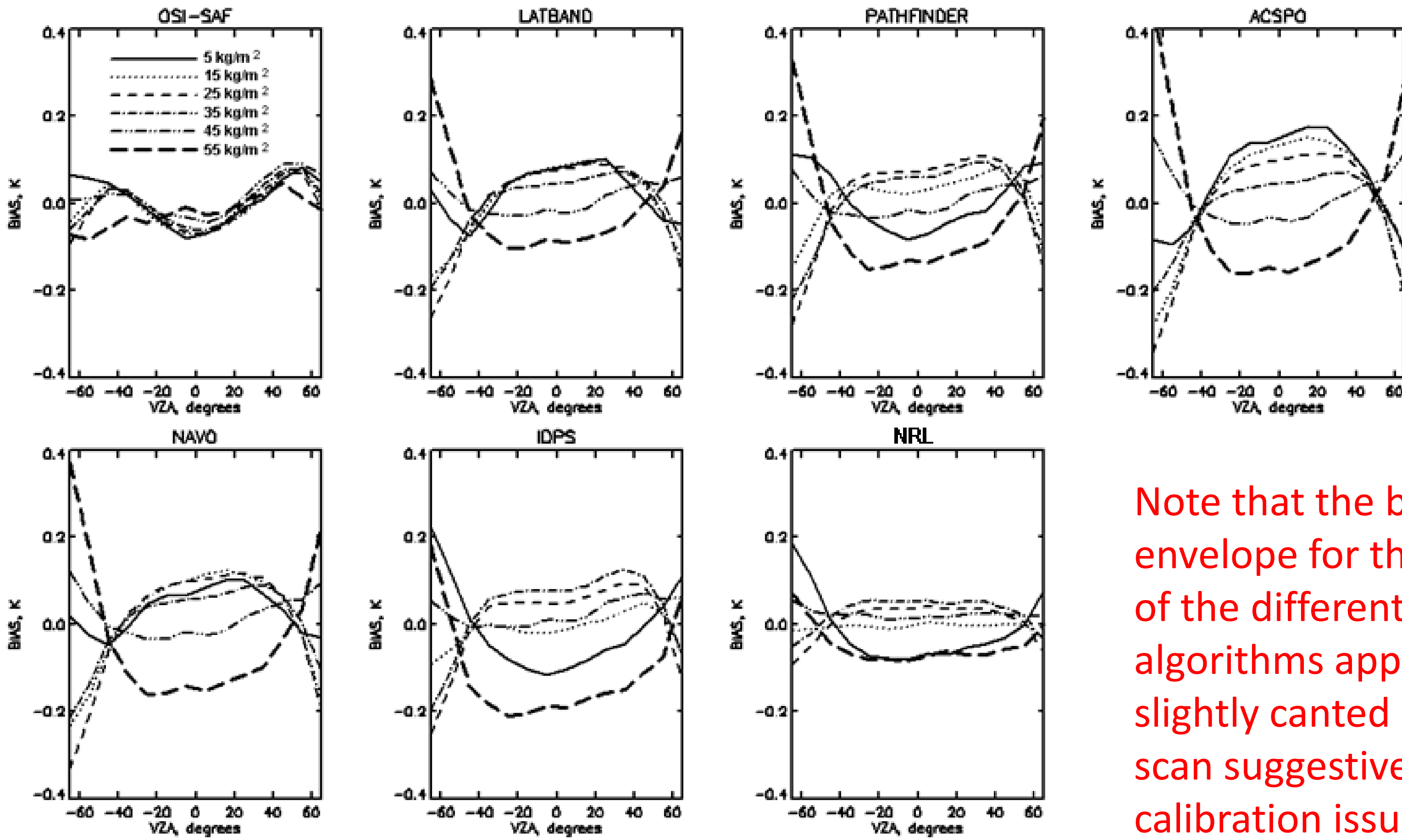


night



day

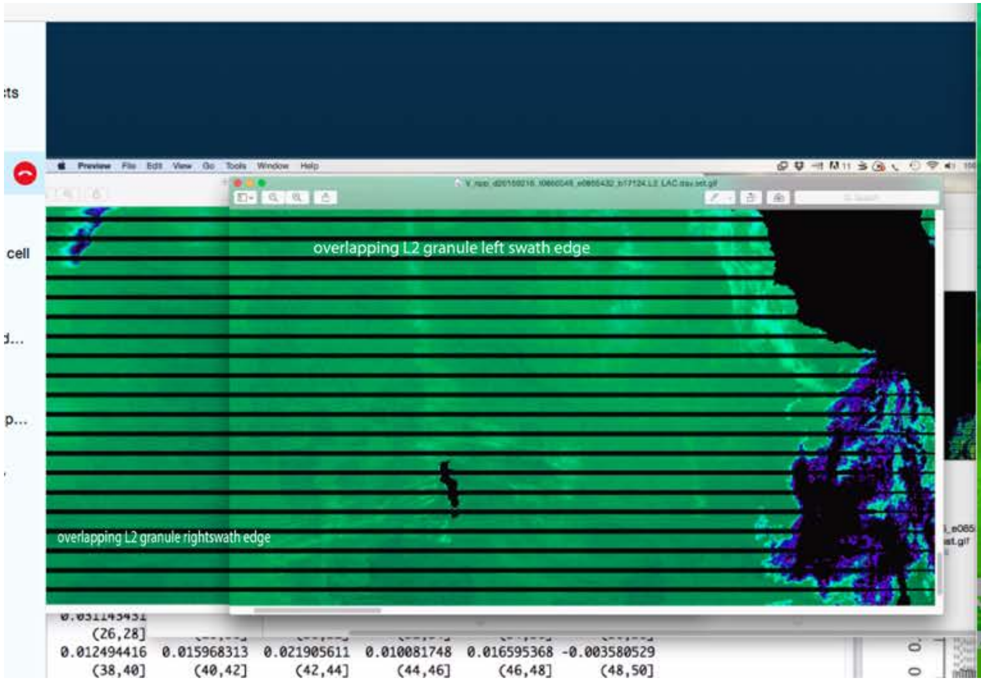
Algorithms for Improving accuracy at high scan angles

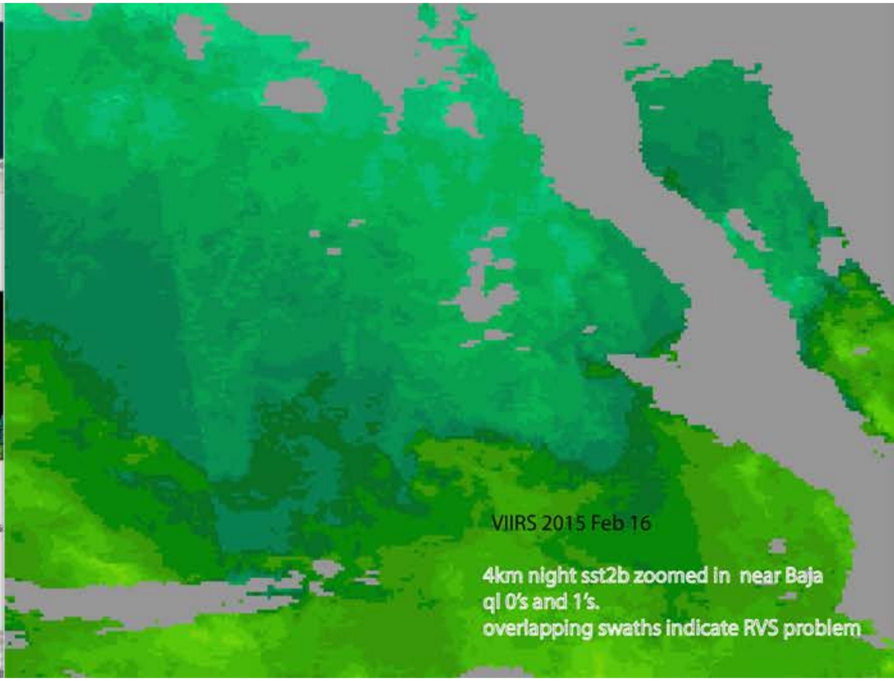


Note that the bias envelope for the majority of the different algorithms appear slightly canted across the scan suggestive of an RVS calibration issue

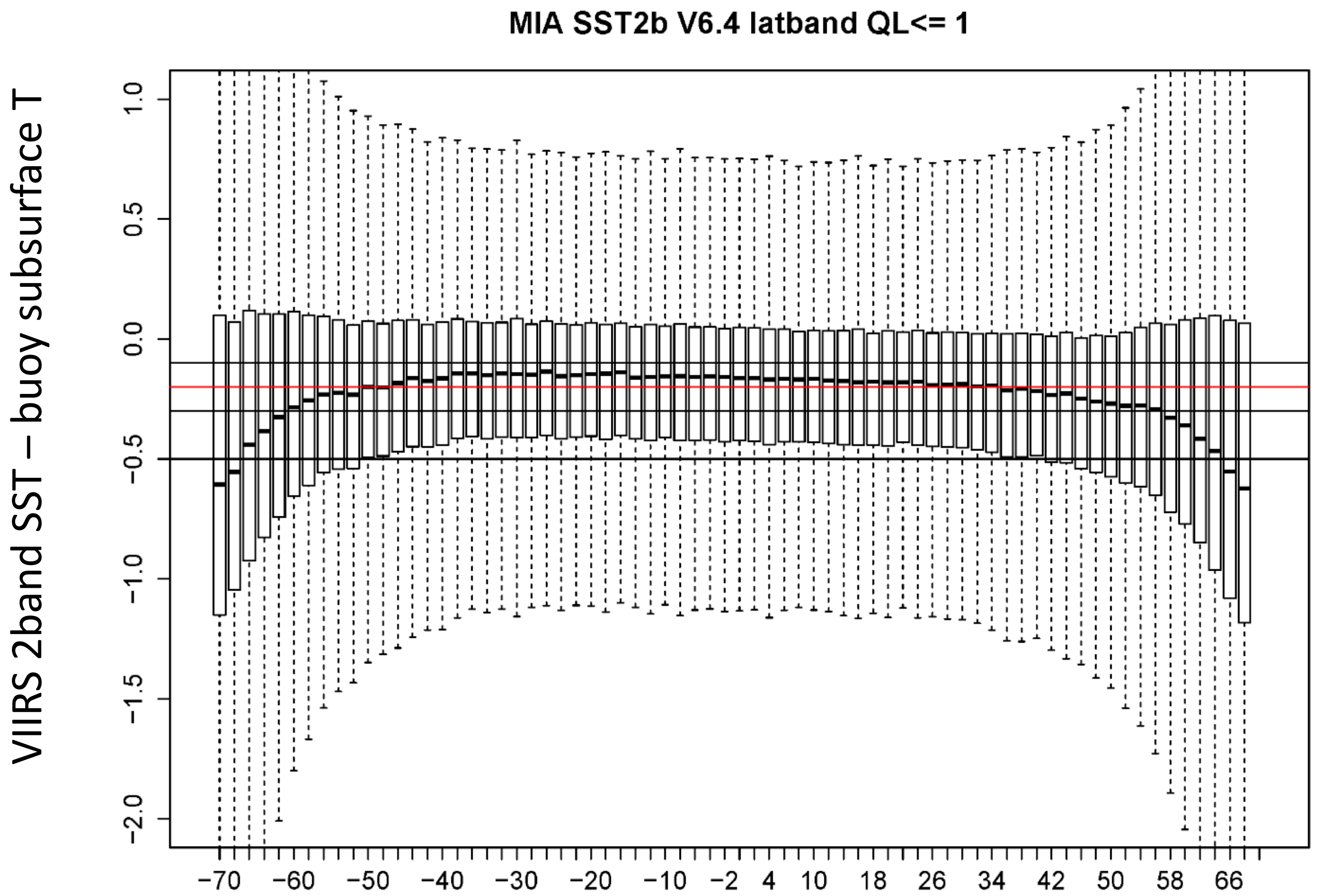
Figure from: Petrenko et al. 2014 JGR JPSS SST Algorithms for VIIRS

VIIRS wide swath algorithms RVS issue at 10-12μm?





SST uncertainties as f(satellite zenith angle). QL=0,1



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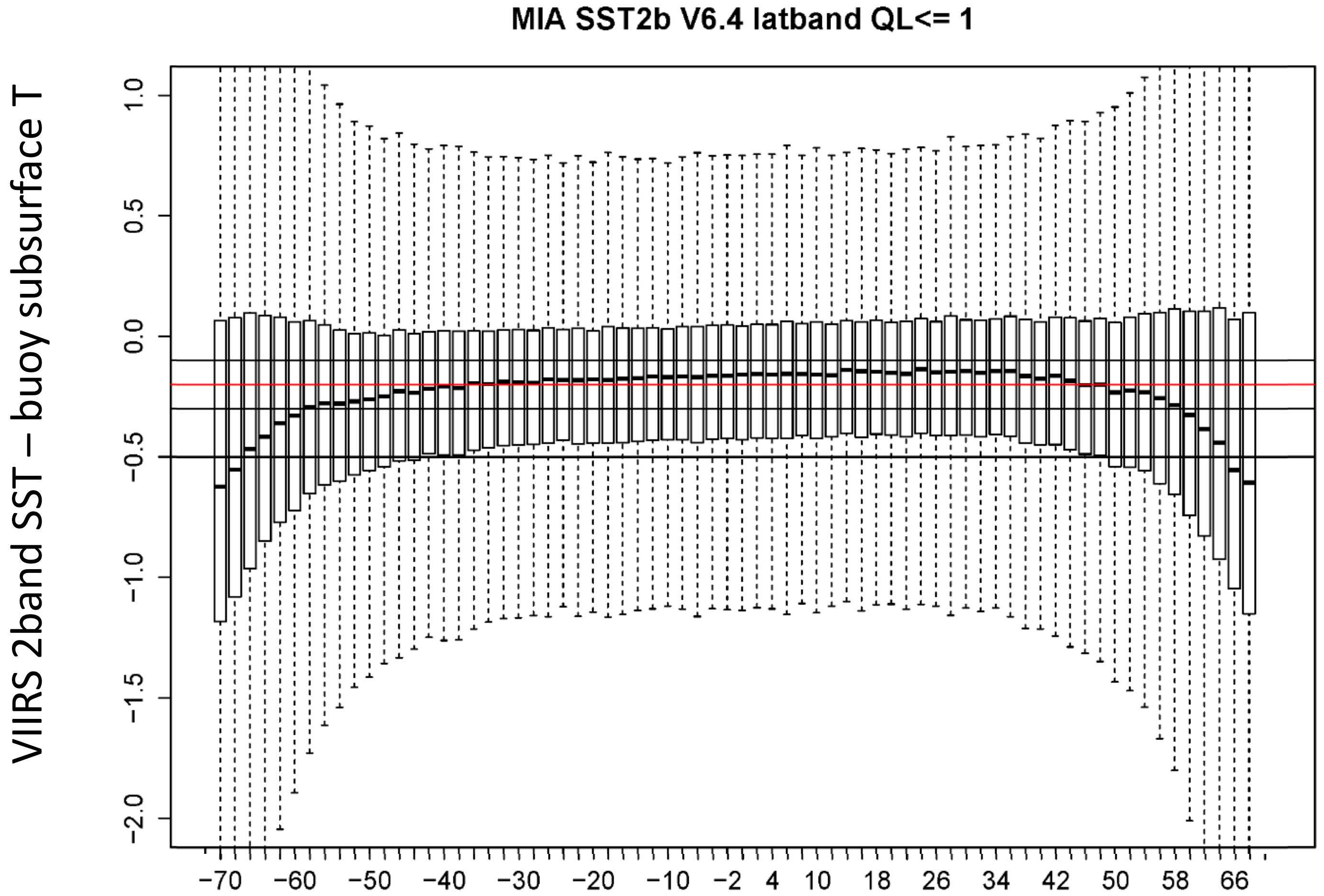
SST uncertainties as f(satellite zenith angle). QL=0,1



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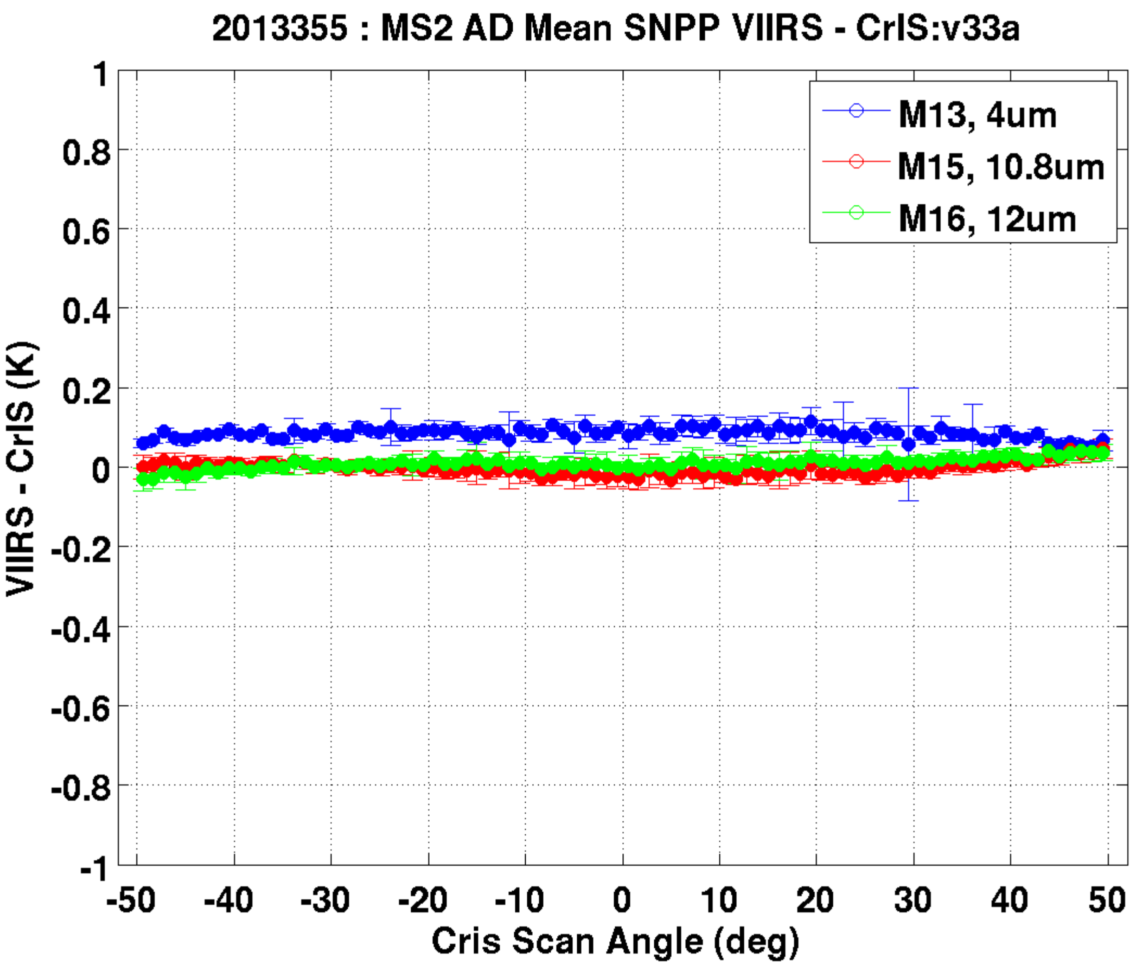
VIIRS *vs* CrIS



Provided by Chris Moeller

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Algorithm innovations

Objective to extend retrievals towards edge of VIIRS swaths and corrected for any RVS artifacts

$$
\begin{aligned}
SST_{sat} = {} & a_0 + \\
& a_1 T_{11} + \\
& a_2 (T_{11} - T_{12}) T_{sfc} + \\
& a_3 (\sec(\theta) - 1)(T_{11\mu m} - T_{12\mu m}) + \\
& a_5 (\theta) + \\
& a_6 (\theta^2)
\end{aligned}
$$

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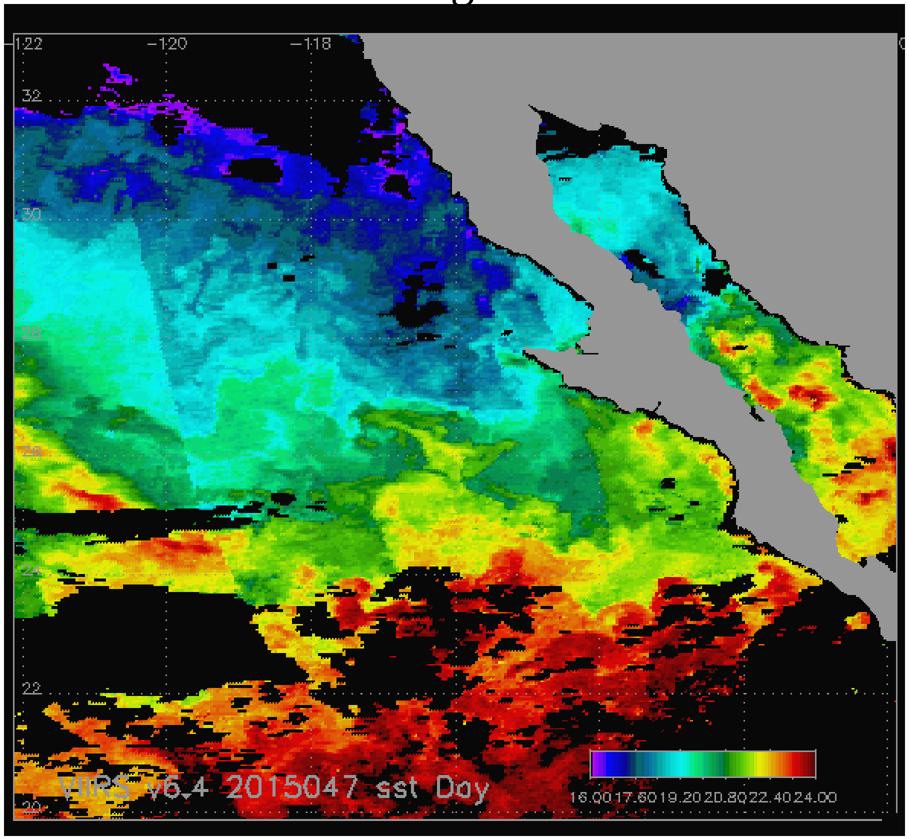
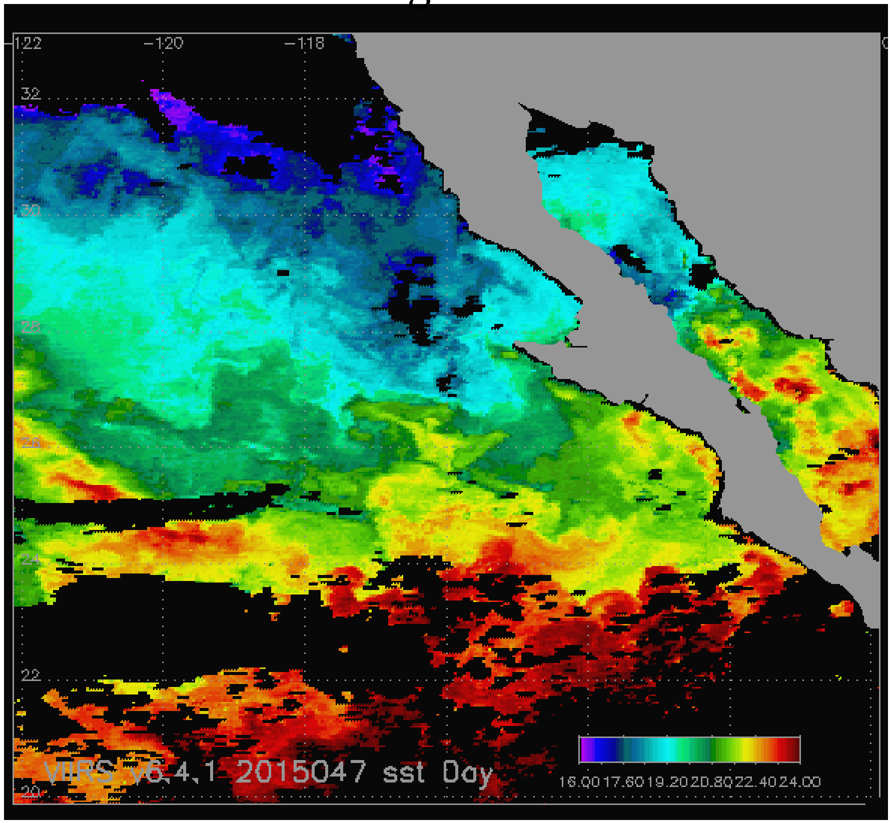
VIIRS Day SST Feb 16 2015

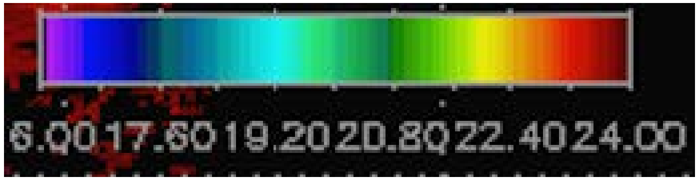
4km map image

Before scan angle correction



After scan angle correction





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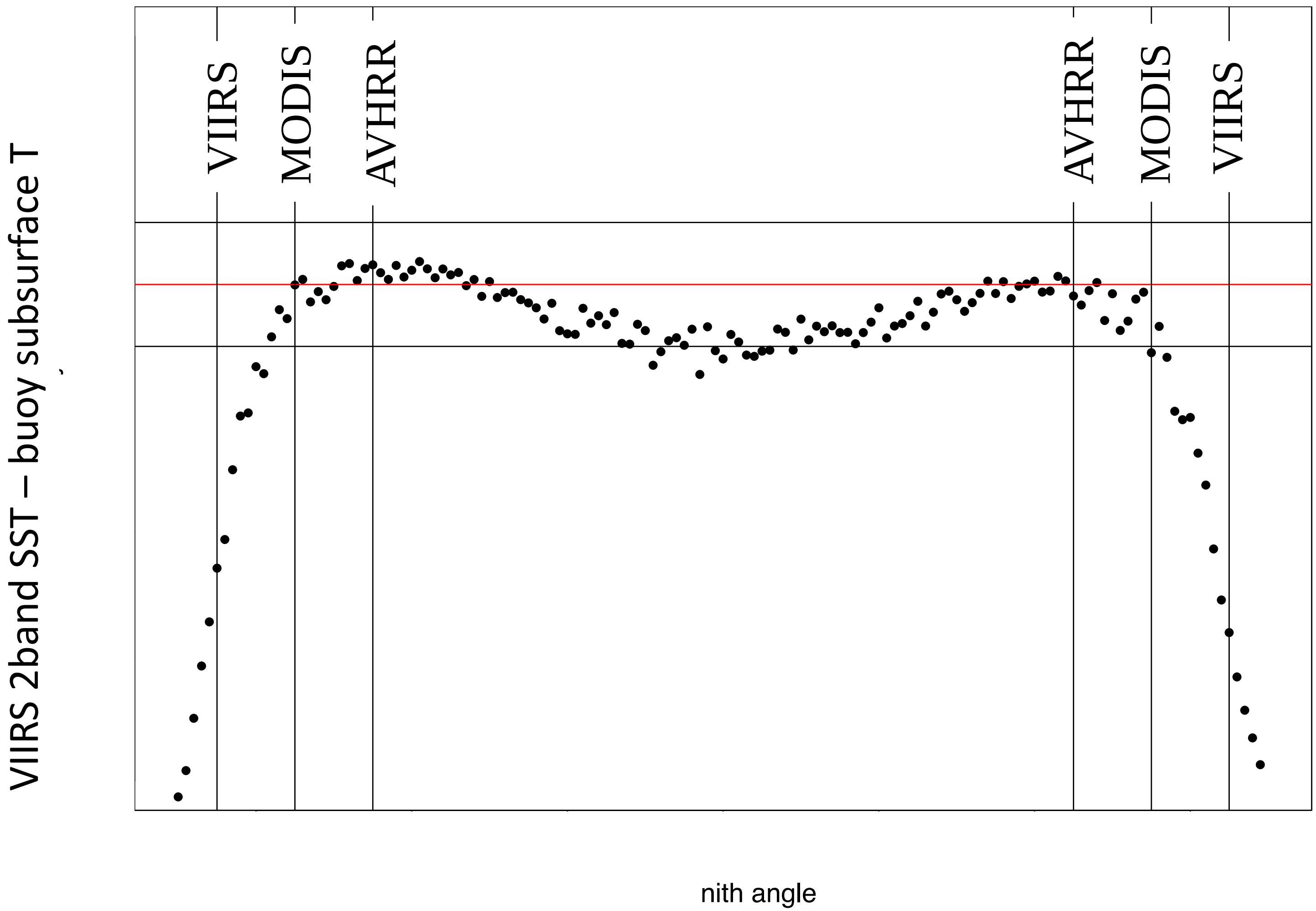
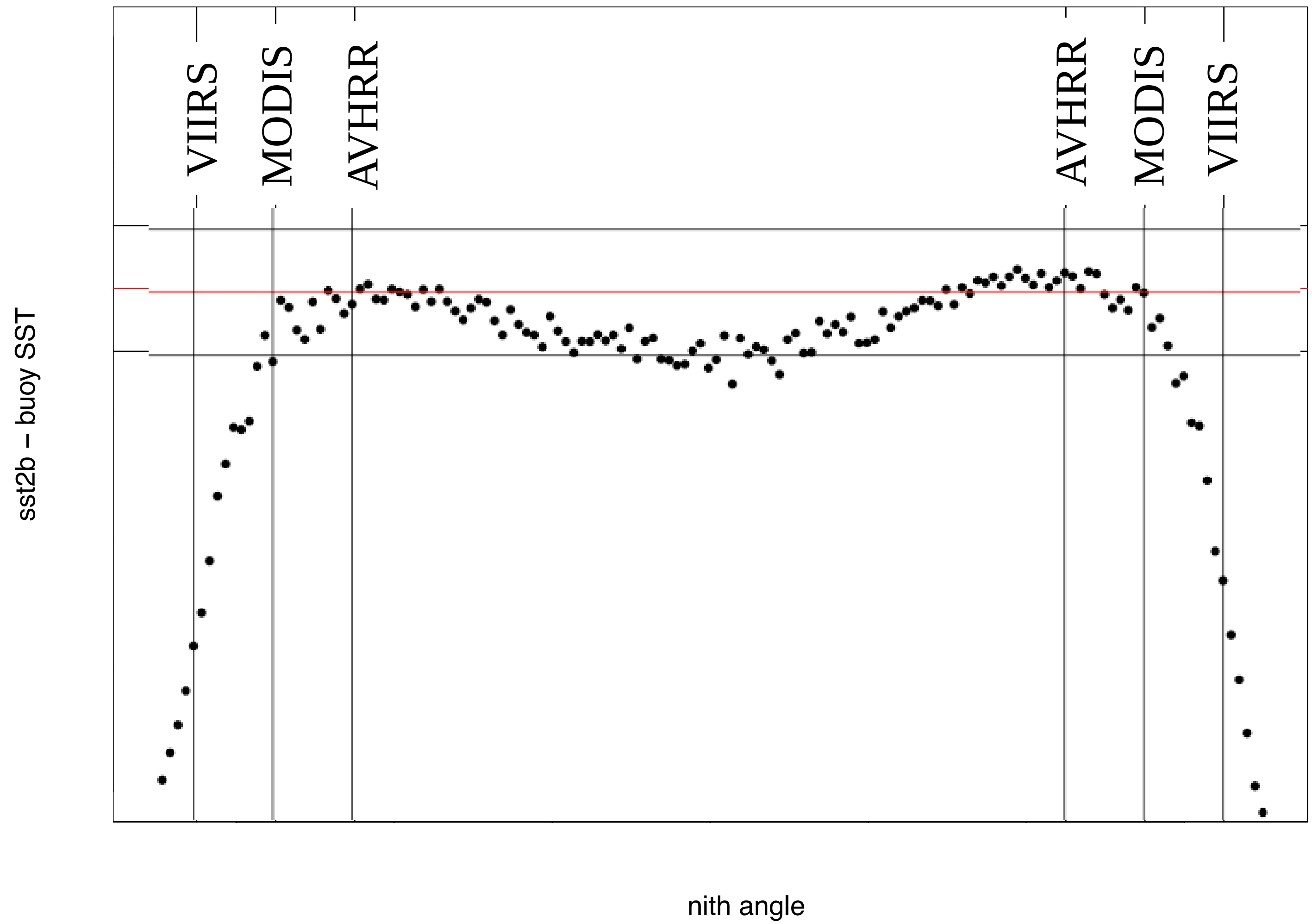
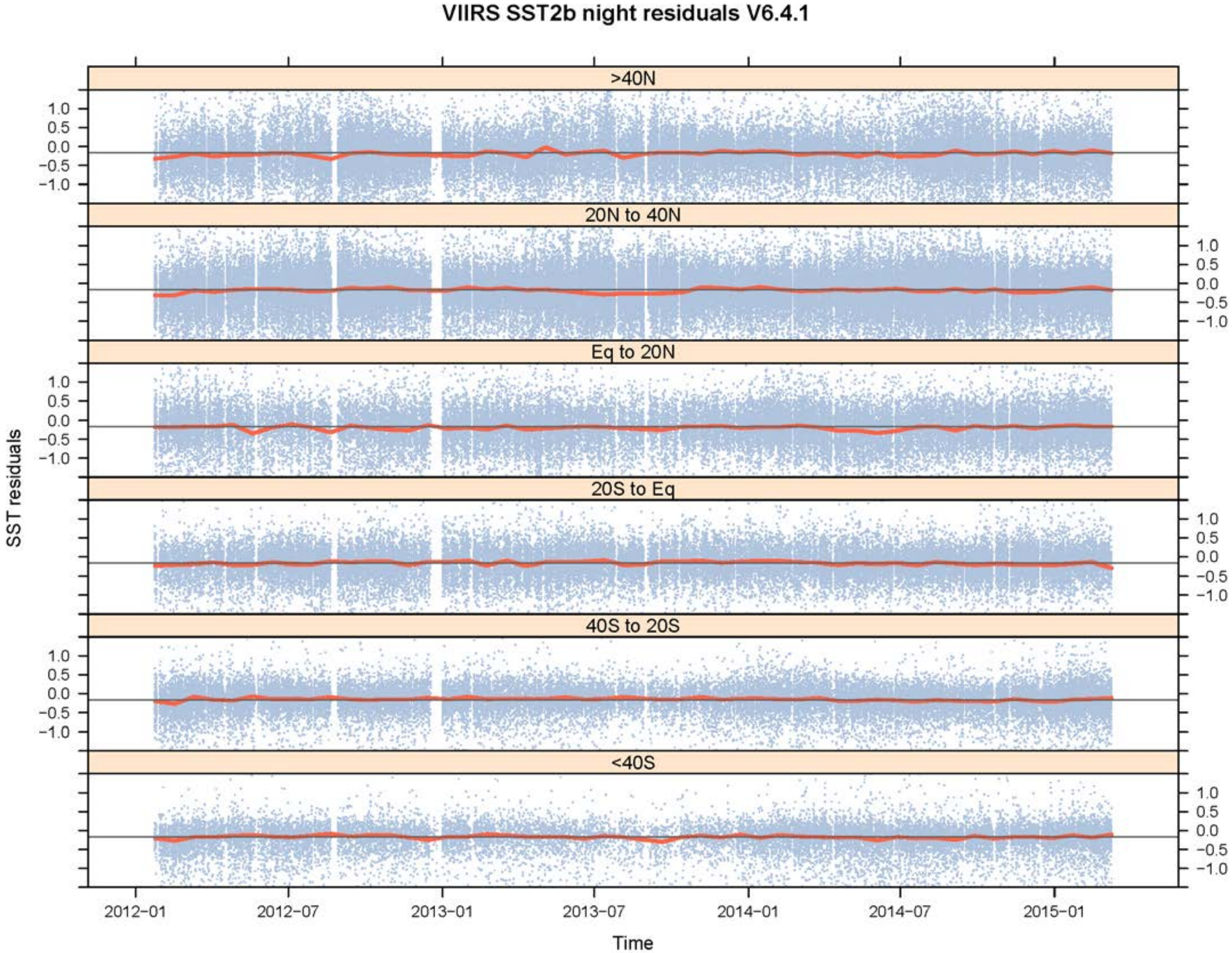

VIIRS
MODIS
AVHRR
AVHRR
MODIS
VIIRS
VIIRS 2band SST – buoy subsurface T
nith angle


VIIRS
MODIS
AVHRR
AVHRR
MODIS
VIIRS
sst2b – buoy SST
nith angle

VIIRS SST matchups with Miami improvements



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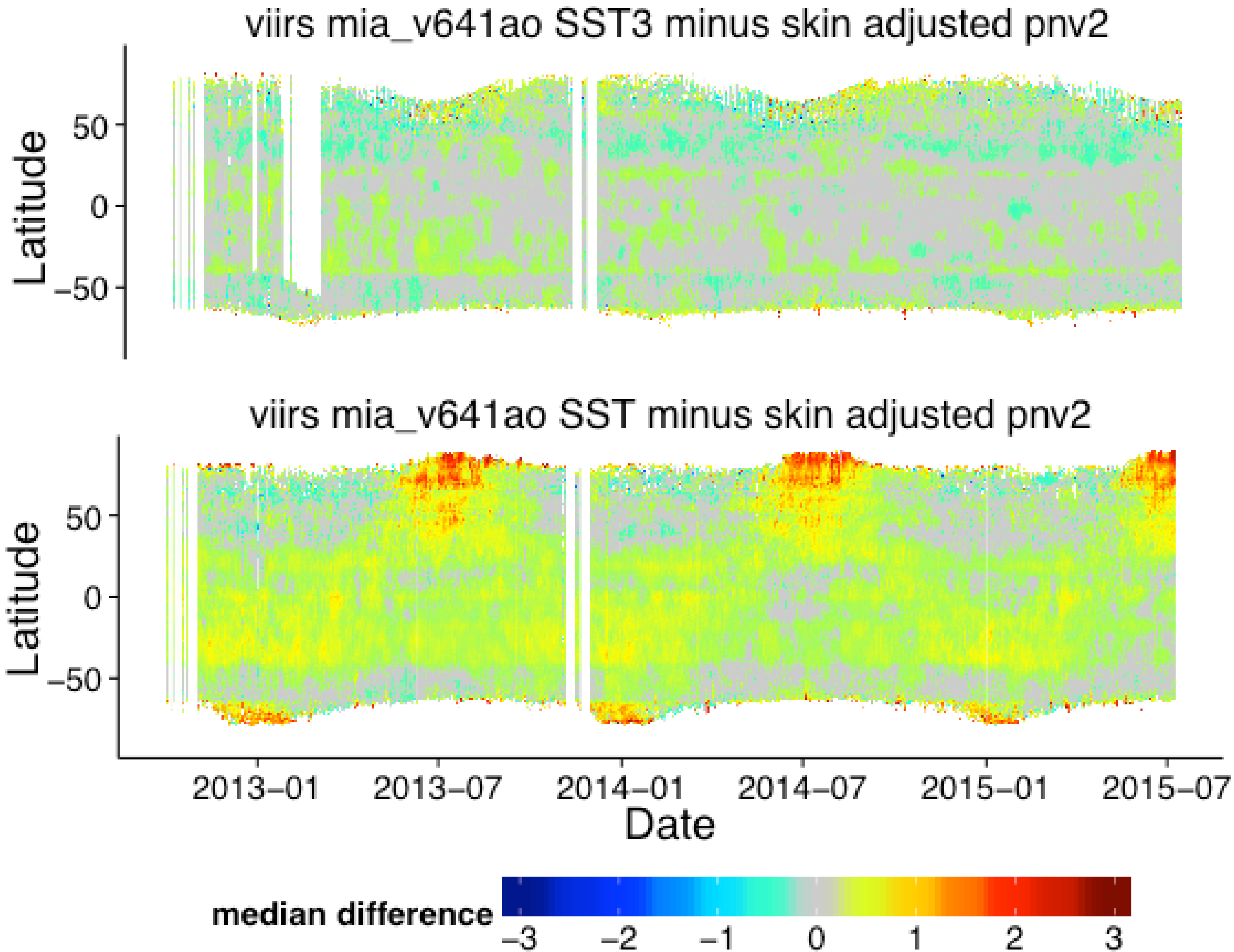
Difference relative to daily Reynolds SST 0.25º

Night

day



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Summary

- Cloud screening and quality of SST can be improved by the use of ensemble machine learning classification methods and provide classification confidence estimates
- The VIIRS sensor has a small scan angle artifact in both the 11 and 12um channels which is magnified by the channel difference terms in the SST algorithms
- Analysis of global fields and matchups with in situ data indicate that VIIRS SST performance and stability is very good but there are paths for operational SST product improvement.

Thank you.

VIIRS Data Products at the Naval Oceanographic Office

Keith Willis, Daniel Olszewski, Valinda Kirkland,
Paul Lyon, and Pam Posey (NRL)

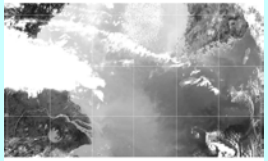
STAR JPSS Science Team Meeting
College Park, Maryland
August 27, 2015

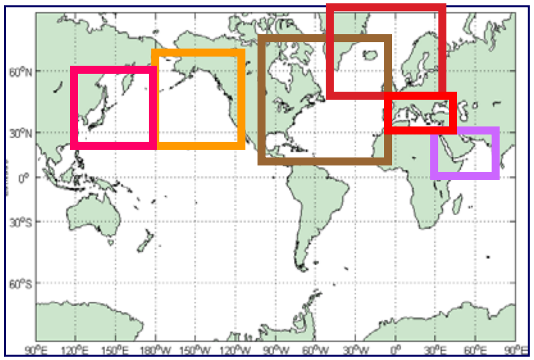
Ocean Feature Analysis

Supports ASW and Maritime Operations
WPAC, EPAC, NLANT, WIND, GIUK, MED

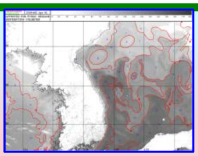
N-19
Metop-A
Metop-B
NPP

→ ***Satellite Digital Imagery Analysis*** →





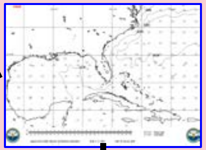
Annotated Imagery



Overlay2 Message

OVLY/NPCOMP FRONT/031200Z6/MAR/1OF1/OCEAN FEATURE ANALYSIS
TEXT/10/0/A/5000N5/13000E4/FRONTAL ANALYSIS 03MAR14
TEXT/10/0/A/3945N1/13503E2/MARITIME PROVINCE COLD
LINE/90/0/G/4143N2/12952E9/4143N2/12952E9/4144N3/12959E6
/4143N2/13002E6/4140N9/13004E8/4138N6/13007E1/4133N1/13010E5
/4128N5/13014E9/4127N4/13017E2/4126N3/13020E6/4126N3/13021...

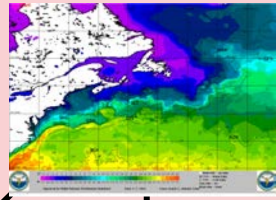
Shapefile



JOTS Message

AMPN/JOTS ENVIRONMENTAL OVERLAY BCST SCHEDULE//
RMKS/1. GULF STREAM NORTH WALL DATA FOR 03 MAR 14:
25.0N79.9W 25.1N79.9W 25.1N79.9W 25.2N79.9W 25.3N79.9W 25.3N80.0W
25.4N80.0W 25.5N80.0W 25.6N80.0W 25.6N80.0W 25.8N80.0W 25.9N80.0W
26.0N80.0W 26.1N80.0W 26.1N80.0W 26.2N80.0W 26.3N80.0W 26.3N80.0W

Ocean Feature Analysis



Canadian Hydrographic Office
Digital Charts
Analyses

NOAA/NWS/NCEP/EMC
Ocean Model Validation

NOAA/NWS/NCEP/OPC
24hr Wind/Wave Forecast Chart
Ocean Model Validation

NOAA/NWS Forecast Offices
Coastal Marine Forecasts
Offshore Forecasts

NRL-Stennis,NAVO, Academia
Historical Studies

NRL-Stennis
Model validation

NOAA/NWS/NCEP/NHC
Tropical Storm Prediction

UK Hydrographic Office
Digital Charts
Analyses

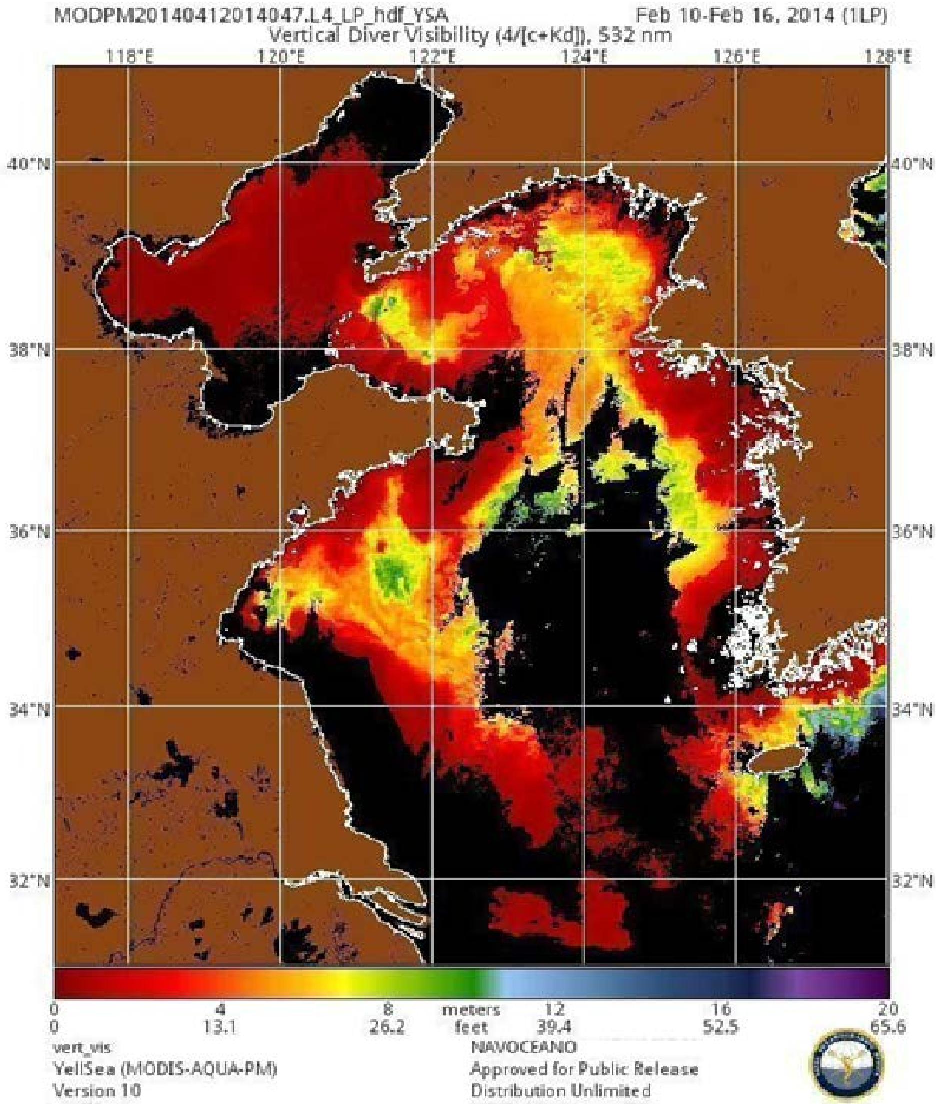
UK Royal Navy
Decision Aids
Staff Briefing Material
Environmental Assessments
•OPS Planning
•Area Familiarization

NAVY FLEET
ASW Decision Aids
Staff Briefing Material
Environmental Assessments
•OPS Planning
•Area Familiarization

COAST GUARD ICE PATROL
Atlantic Iceberg Extent
Sea Ice Conditions

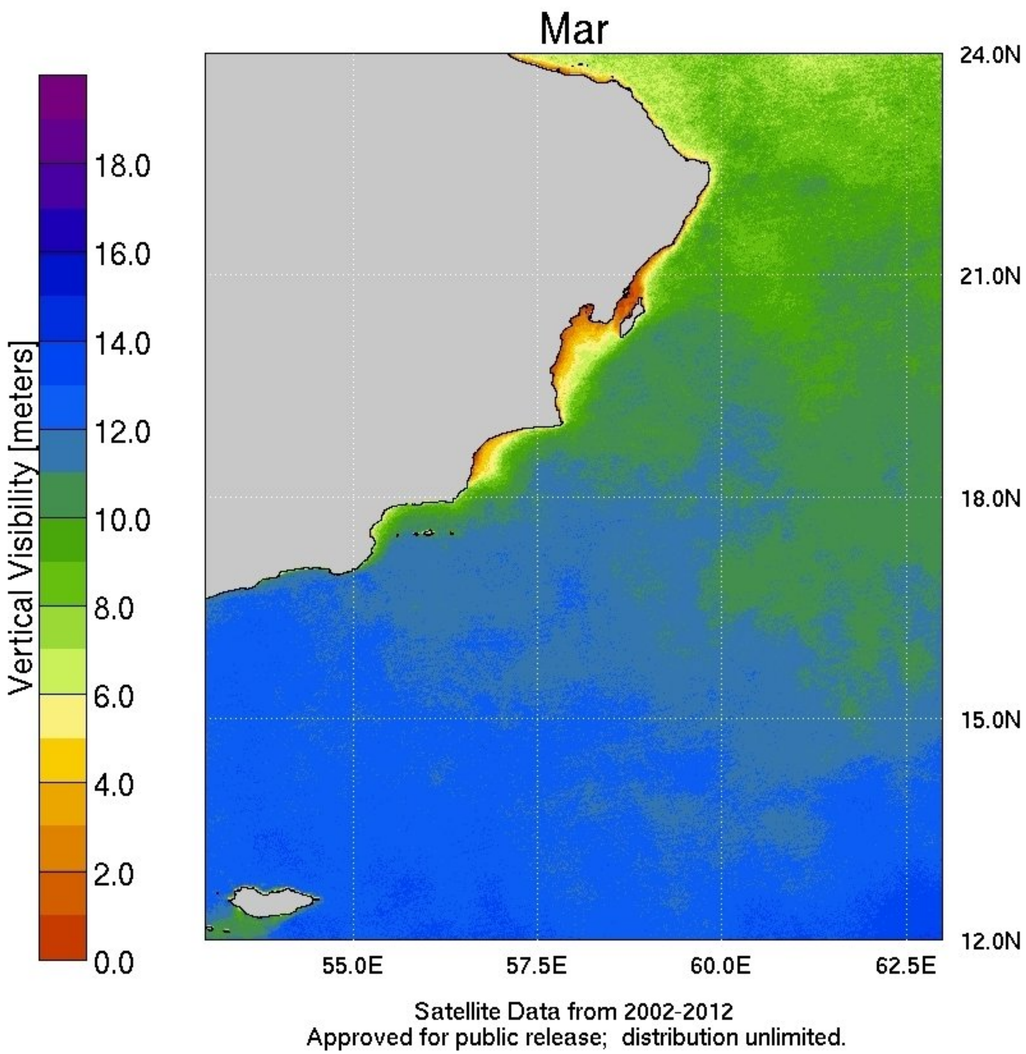
BOND

Ocean Optics



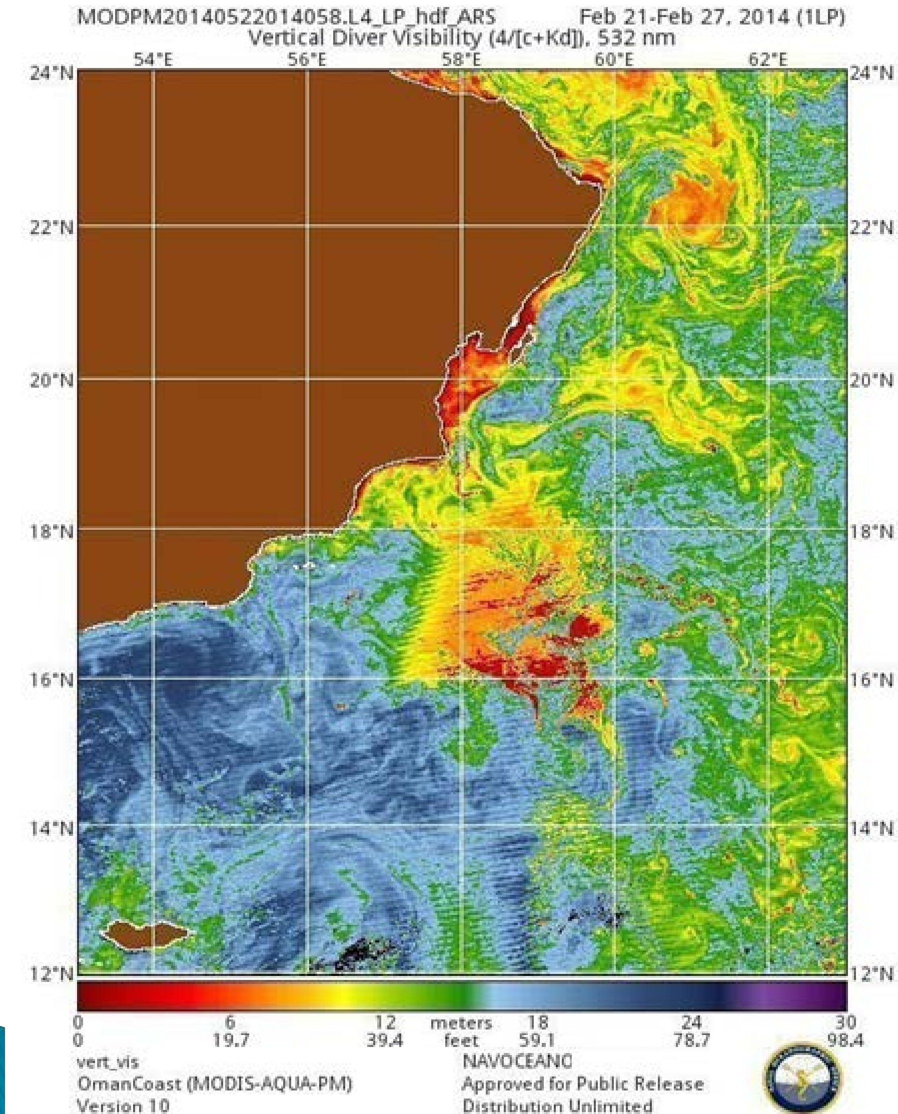
- Product is designed to predict optical visibility from above the water.
- 7 Day Composites can remain substantially cloud filled.

Ocean Optics



- Climatology products can be used for planning.
- Monthly climatology products are cloud free for most of the globe with some exceptions; Indian Ocean during Monsoon season.
- Monthly climatology products average out all but seasonally persistent features.

Ocean Optics

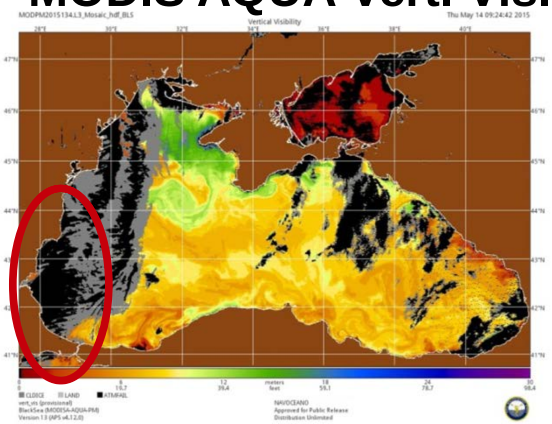


- 7 Day Composites can resolve finer detail of eddies and fronts.

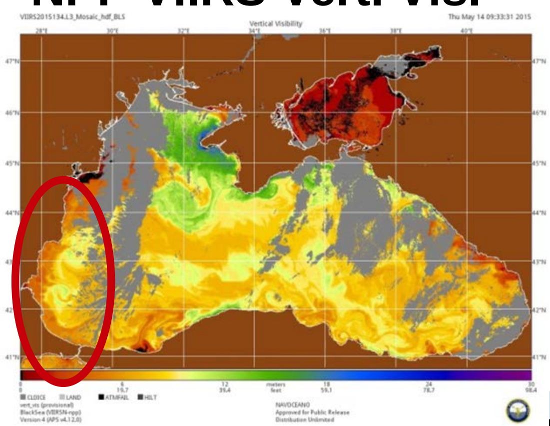
Ocean Optics

*Implementation of Linear Matrix Inversion (LMI) in AOPS allows NAVO to merge Navy products from MODIS AQUA and NPP VIIRS. Multiple satellites will be used to provide **ONE** merged set of Navy products to the war fighter.*

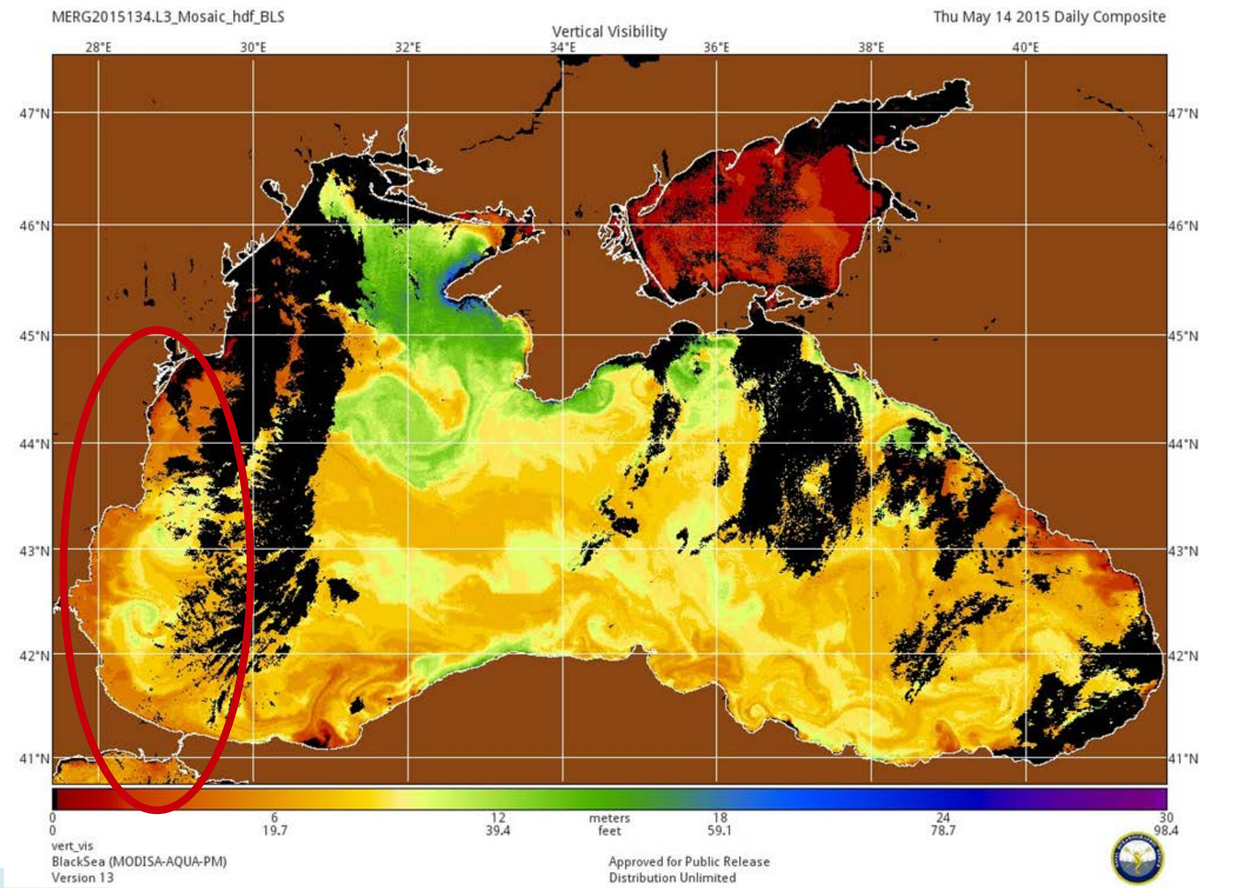
MODIS AQUA Vert. Vis.



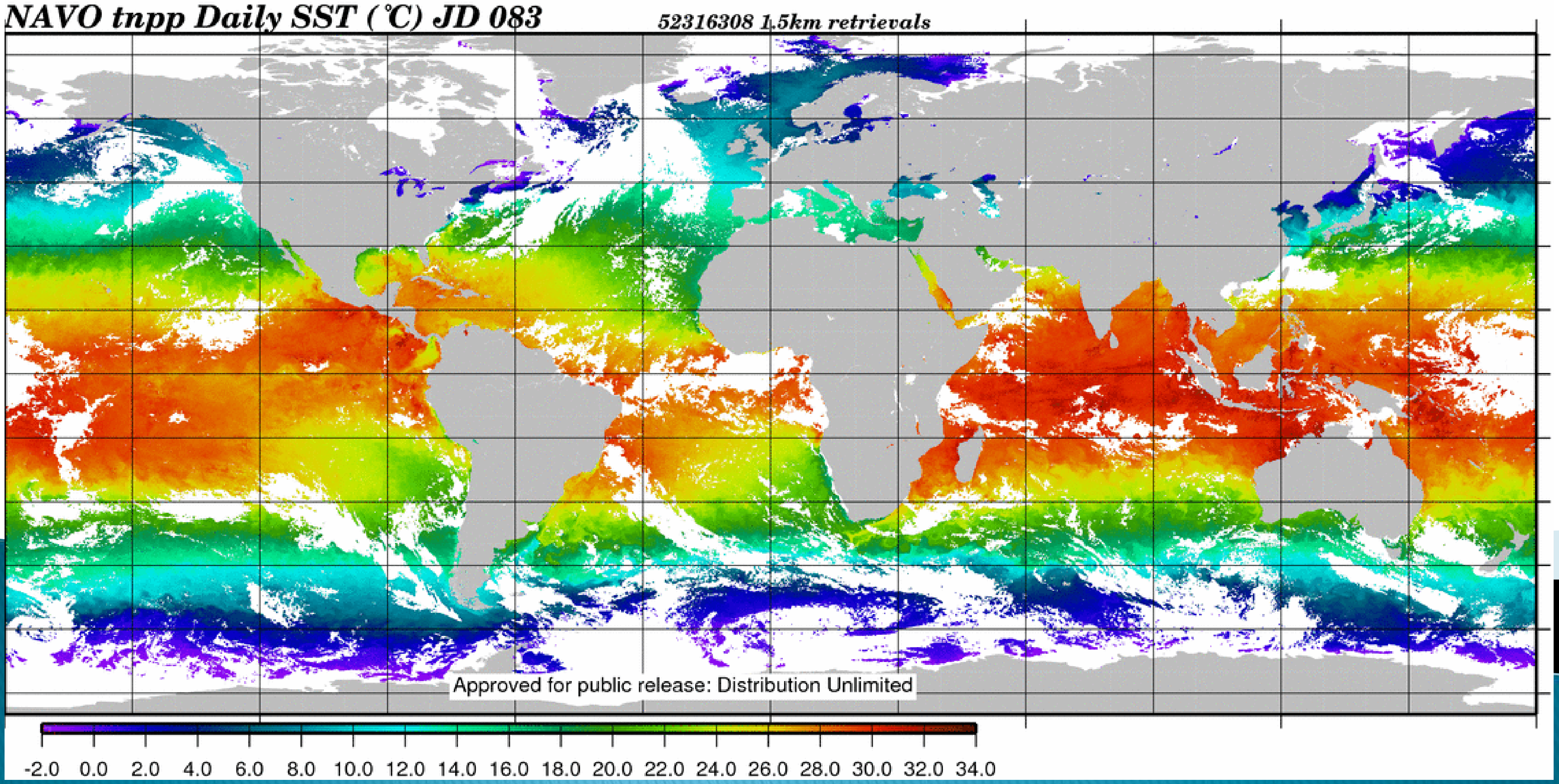
NPP VIIRS Vert. Vis.



MERGED Vertical Visibility

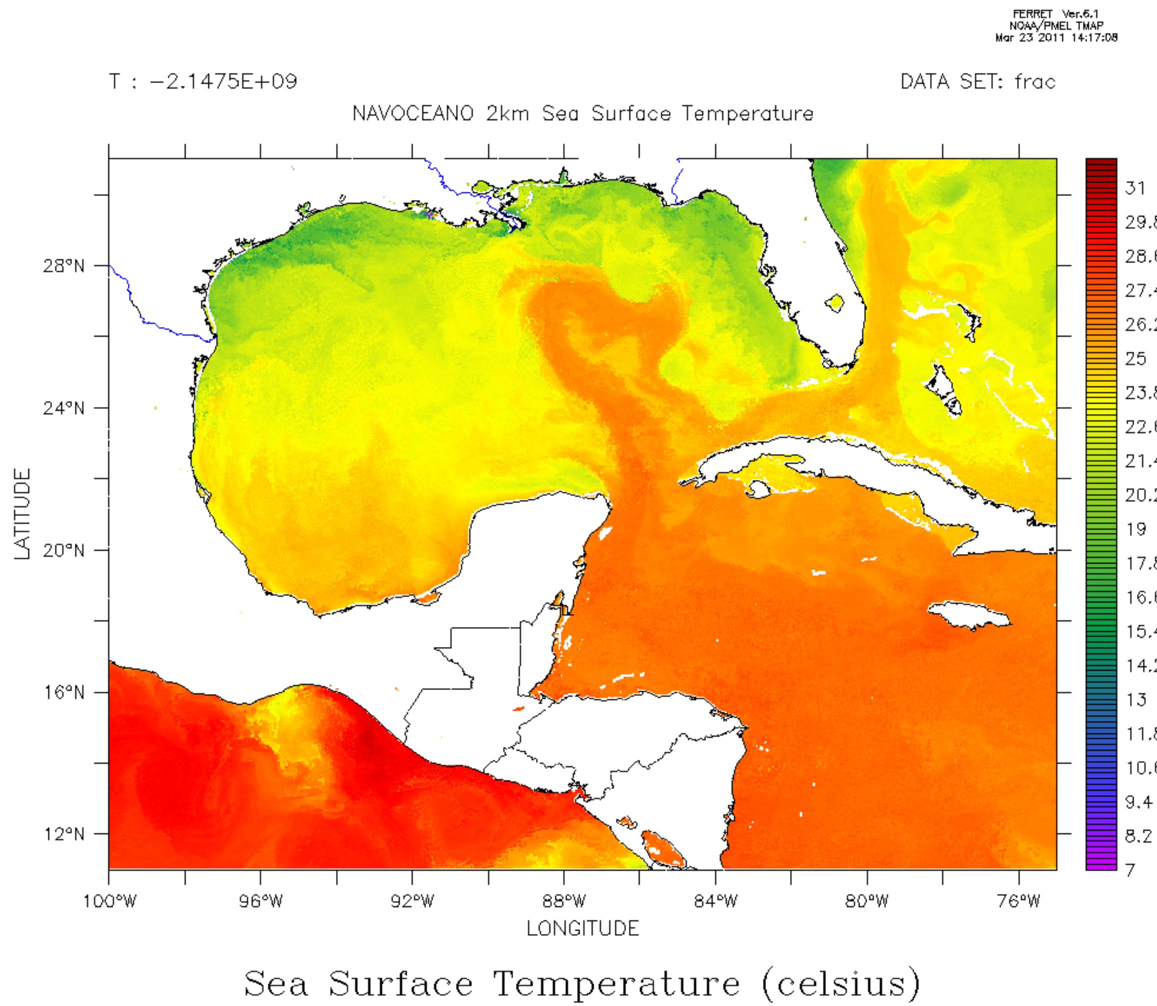


Multi-Channel Sea Surface Temperature



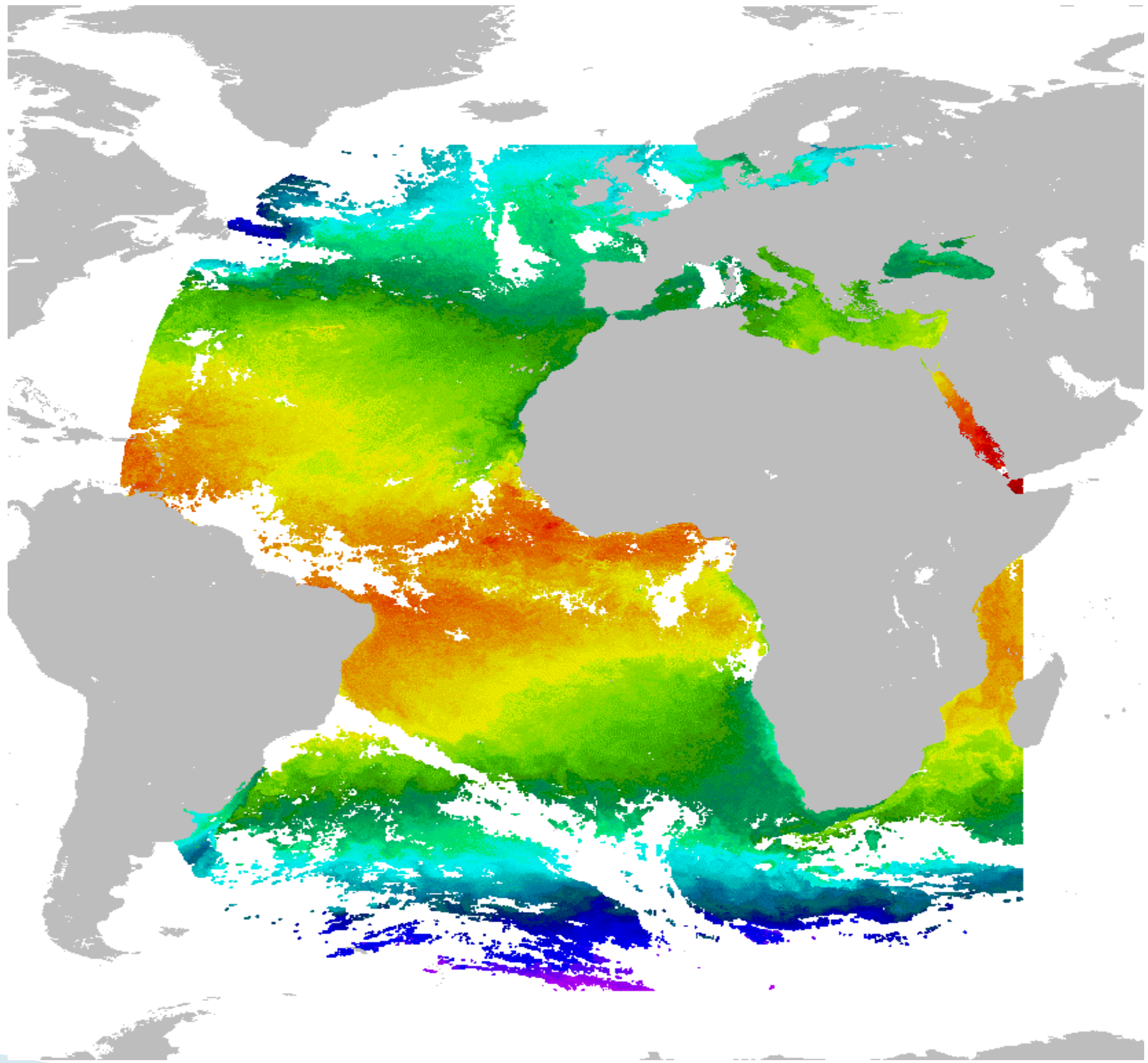
Satellite Sources – NAVO SSTs

- **Polar**
  - NOAA-18 GAC
  - NOAA-19 GAC, LAC
  - METOP-A GAC, FRAC
  - METOP-B GAC, FRAC
  - SNPP
- **Geostationary**
  - GOES-15 (WEST)
  - GOES-13 (EAST)



Other SST Data Sources

- MTSAT (NOAA)
- MSG-3 (IFREMER)
- WindSAT (REMSS)

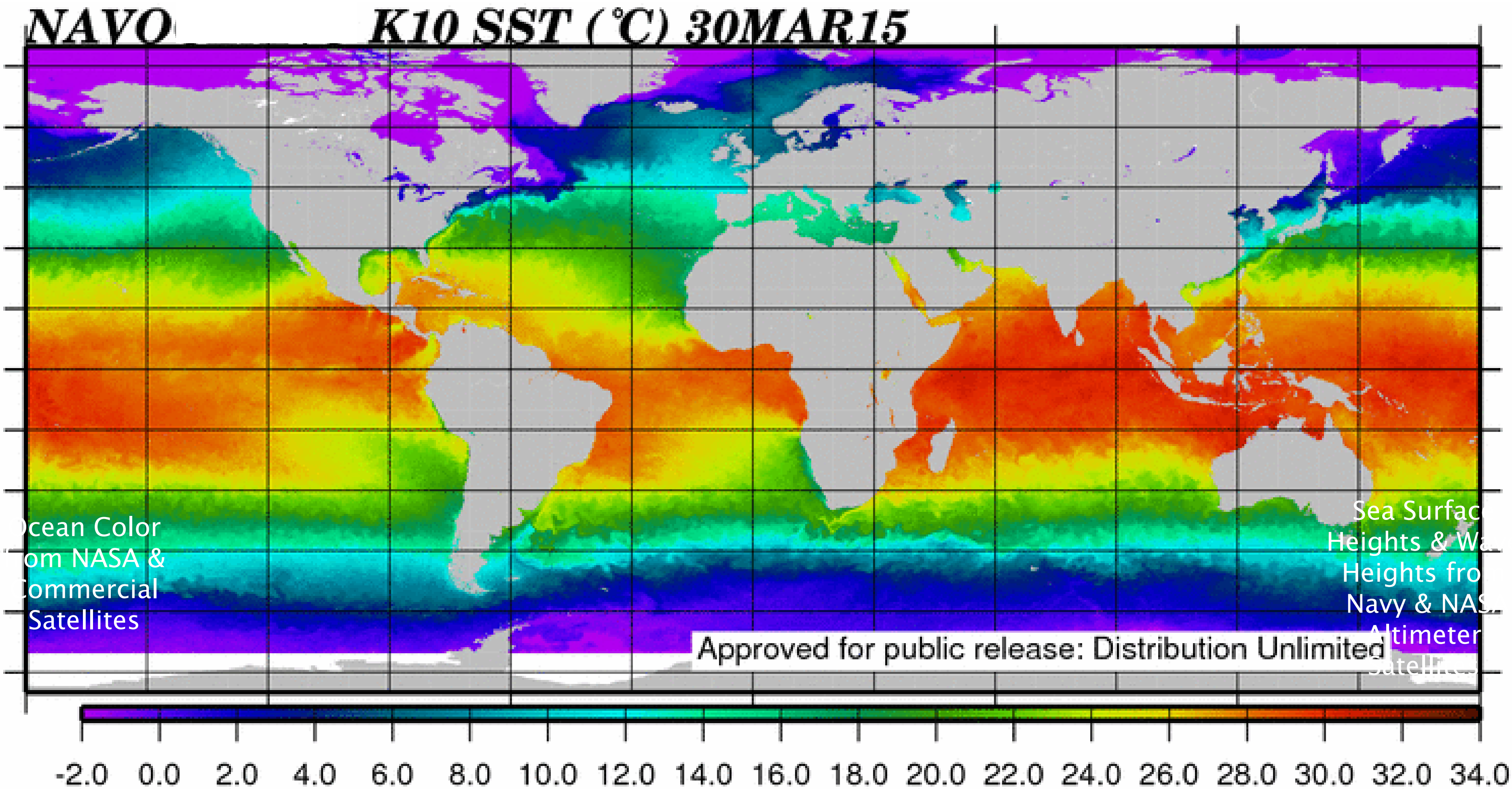


Future SST Data Sources

- Polar
  - AMSR-2
  - JPSS
  - Sentinel-3

- Geostationary
  - Himawari-8
  - GOES-R/S
  - MSG-4

NAVO 10km Gridded SST Field

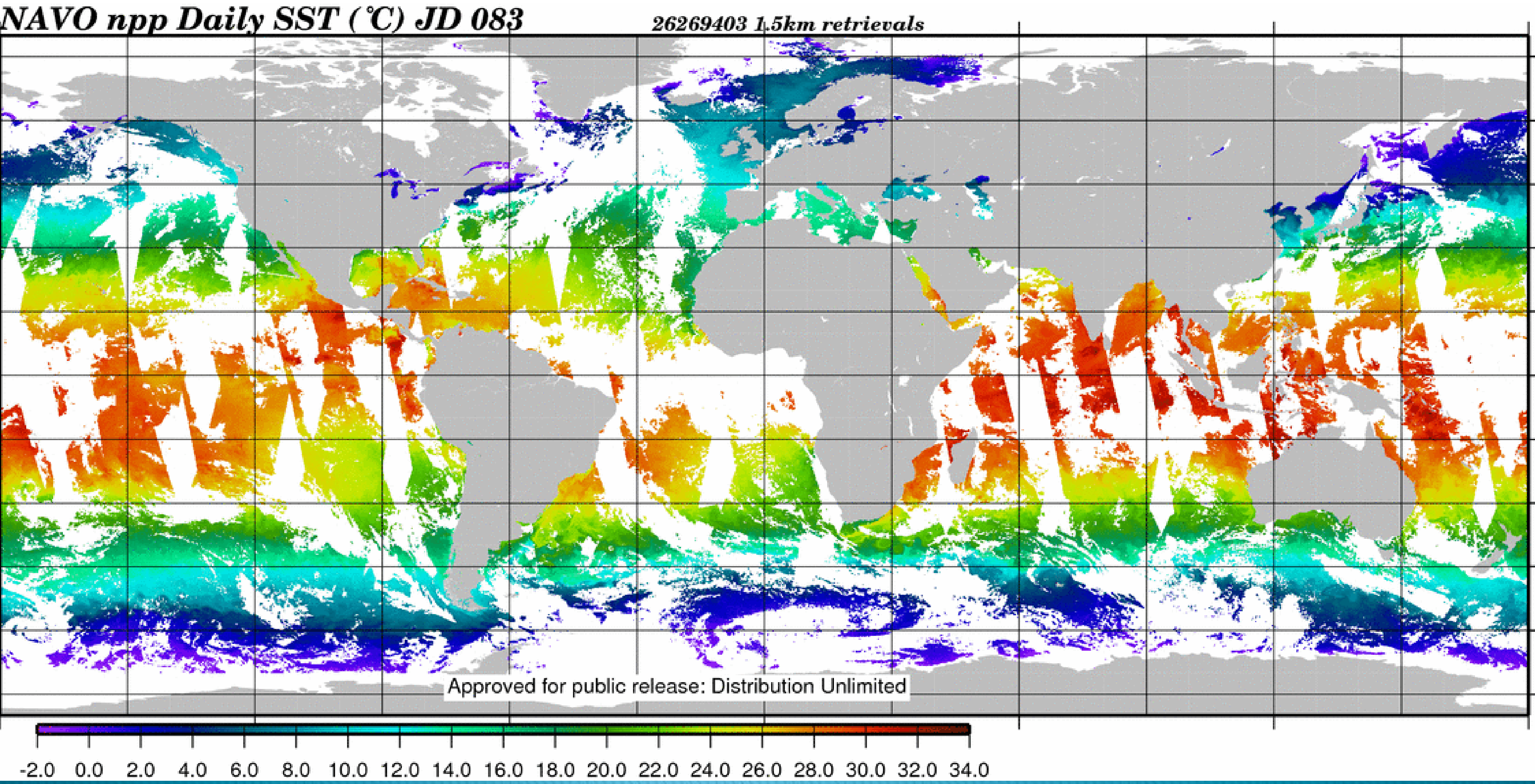


Approved for public release . Distribution is unlimited

VIIRS SST Enhancements

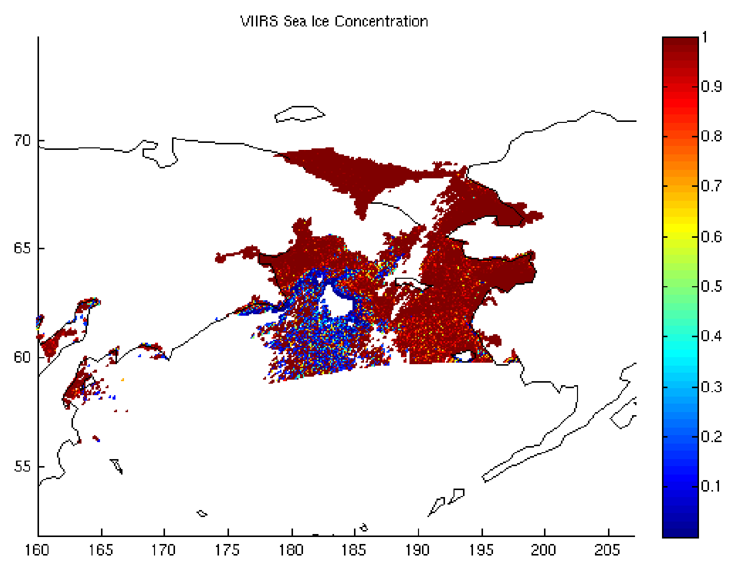
- NPP/VIIRS SST Process Improvements
  - Full swath processing
  - Extended bounds
  - Improved contamination screening techniques
  - New Algorithms
  - High Quality

VIIRS SST Daily Coverage Before and After



VIIRS Ice Concentration

- **NRL tasks for FY16:**
  - **Determine VIIRS ice concentration EDR errors**
  - **Update the current data assimilation module (NCODA) to include VIIRS ice concentration EDR's**
  - **Test the assimilation of VIIRS ice concentration into the existing ice forecast systems**



VIIRS Ice Surface Temperature

- **Future NRL task:**
  - Investigate using VIIRS ice surface temperatures as a possible new data source for assimilation into Naval ice forecast systems.

2015 STAR JPSS Annual Science Team Meeting,
College Park, Maryland
August 24-28, 2015

VIIRS SST - ACSPO Evaluation
Annual Summary

Robert Arnone, Ryan Vandermeulen,

[1] **Dept. of Marine Science, University of Southern Mississippi, 39529**

"Seasonal trends of ACSPO VIIRS SST product characterized by the differences in orbital overlaps for various waters types" - Arnone, Vandermeulen, Ignatov, Caylua

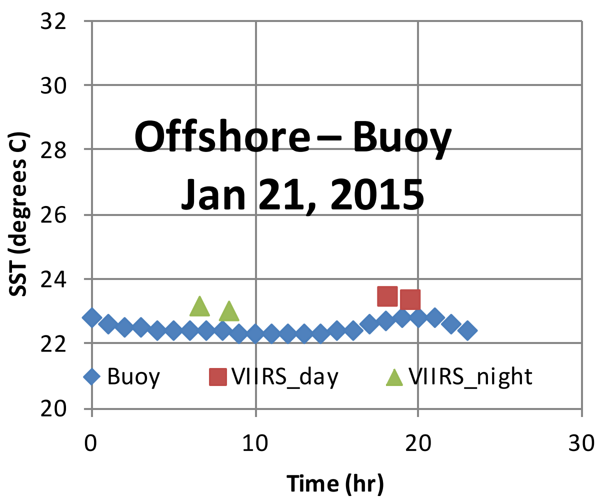
1. **Evaluation of the SST using overlaps in coastal areas**
2. **Diurnal changes in SST**
3. **Ocean model SST validation**

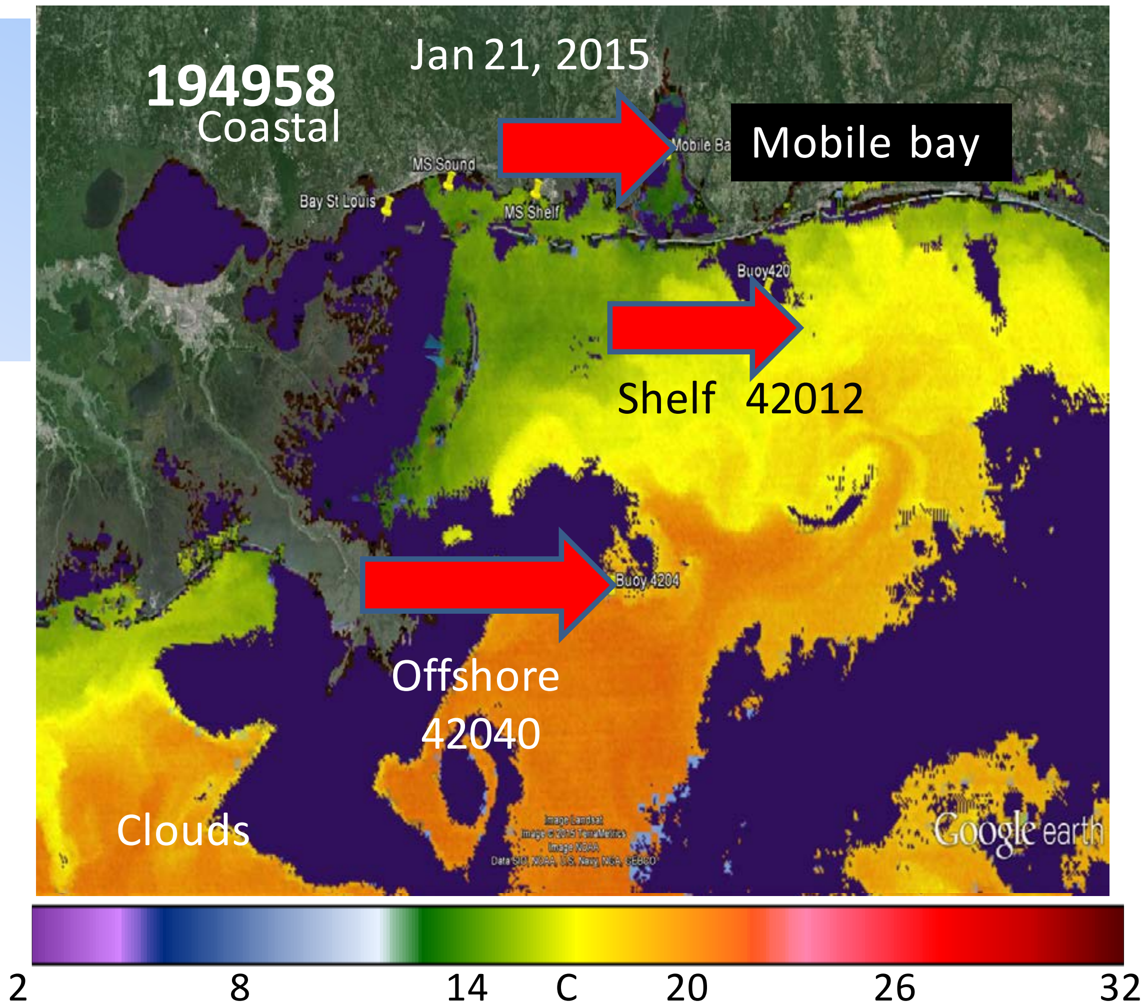
ACSPO Orbital VIIRS Overlaps

100 minute Day and Night 4 per day !

Diurnal Changes - Advection and surface heating

Water masses –
Coastal to Offshore
Buoy data for SST Locations off the Mississippi Delta for the Matchup

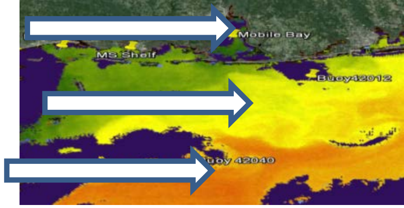


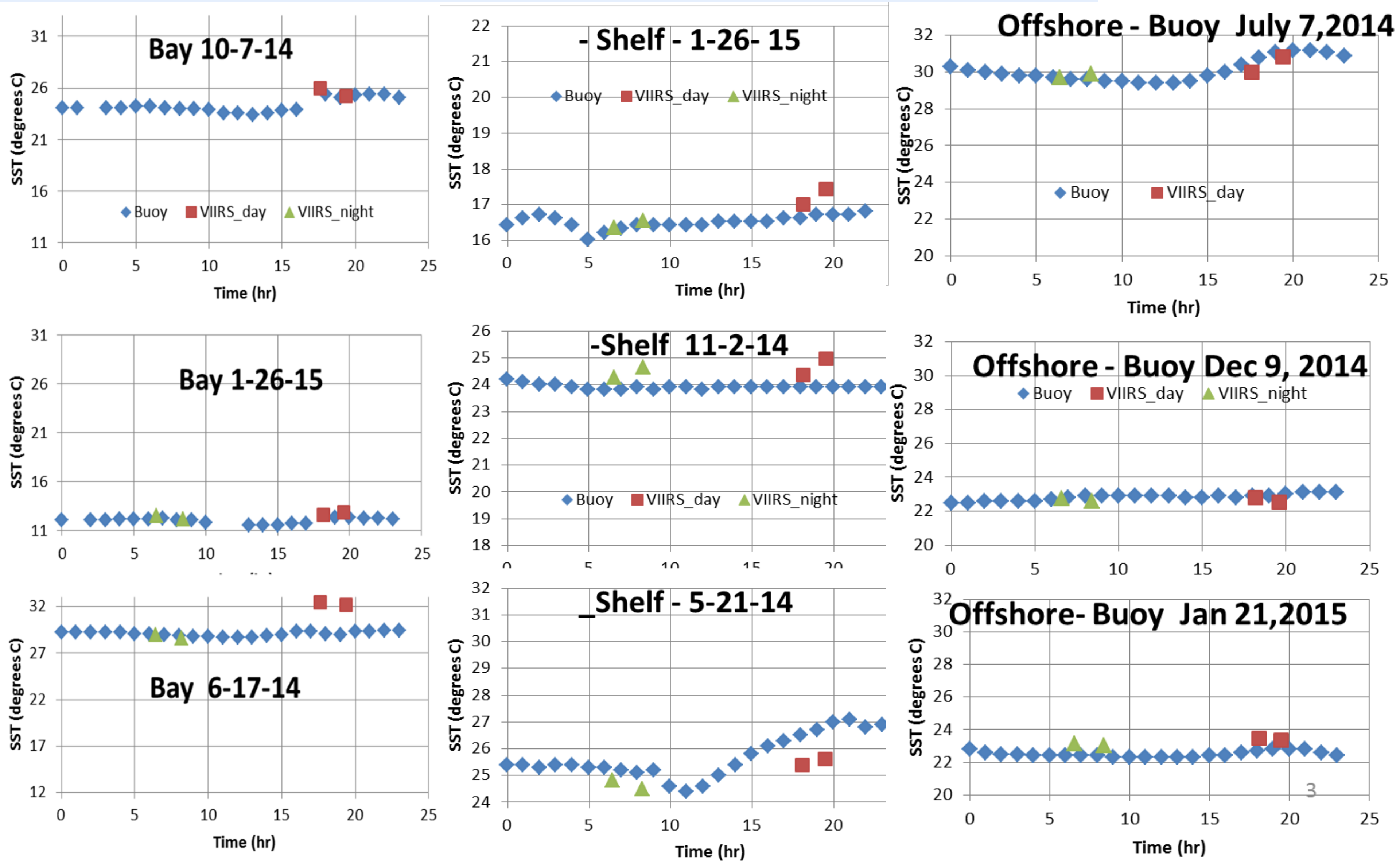


January 21 2015

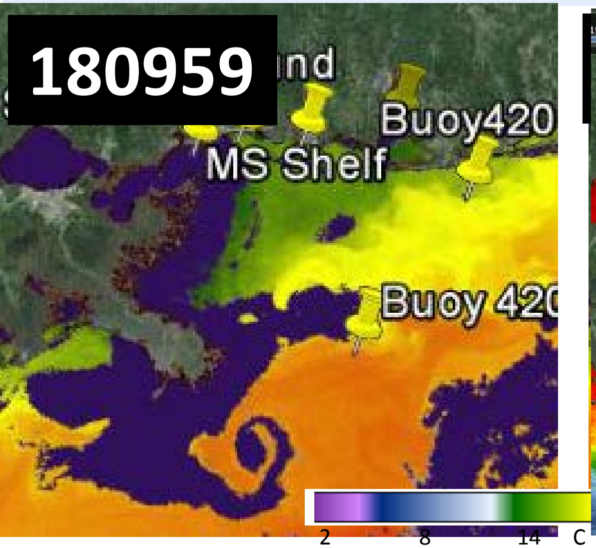
VIIRS ACSPO

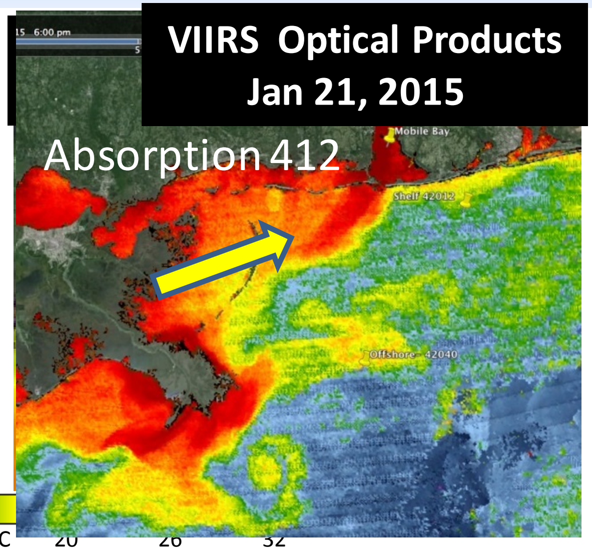
1. Captured the Diurnal Variability with overlaps !!
2. What can cause the temperature change?

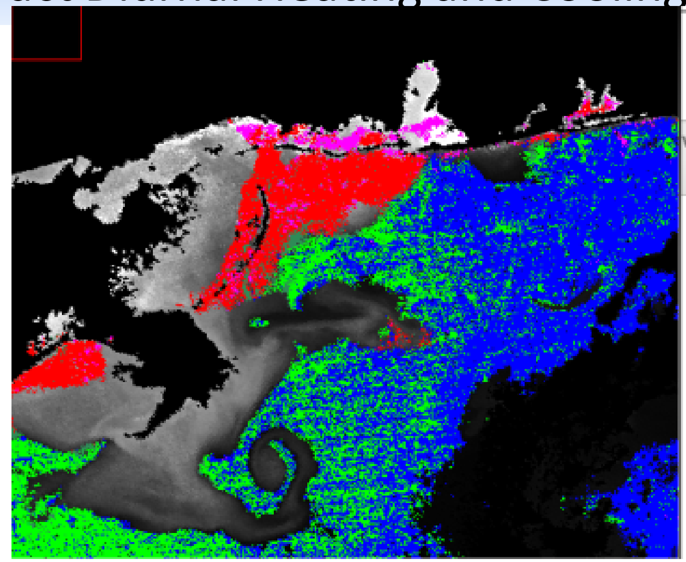




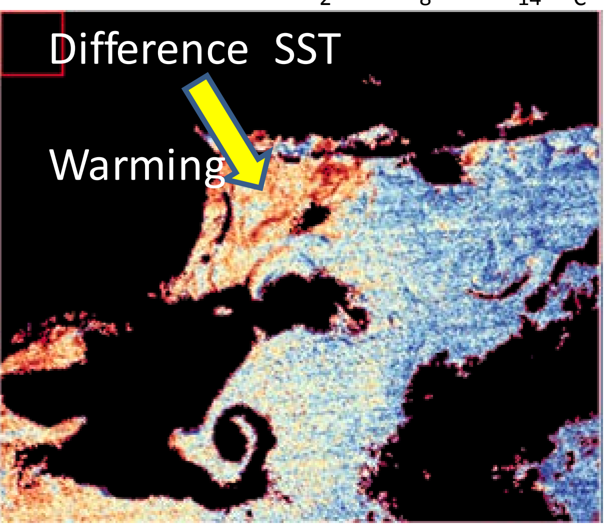
Does the Water Optics (Turbidity or absorption) Impact Diurnal Heating and Cooling?



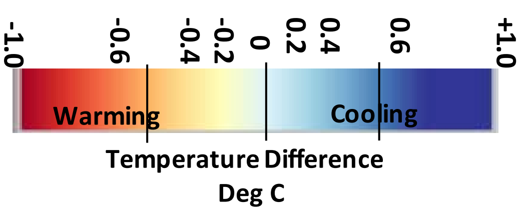


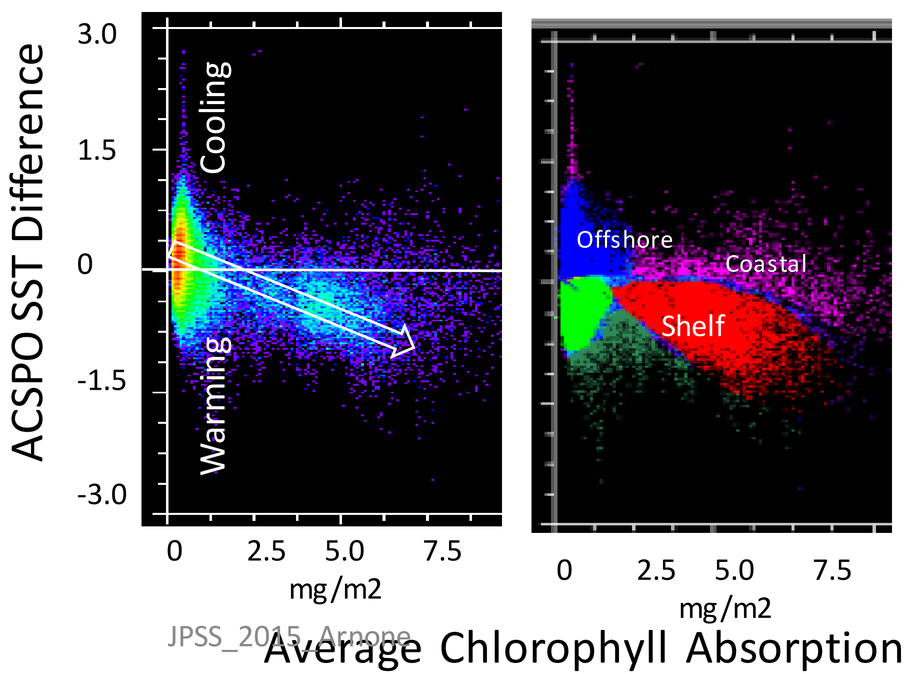


Water Mass Classification



Orbit 1 minus 2



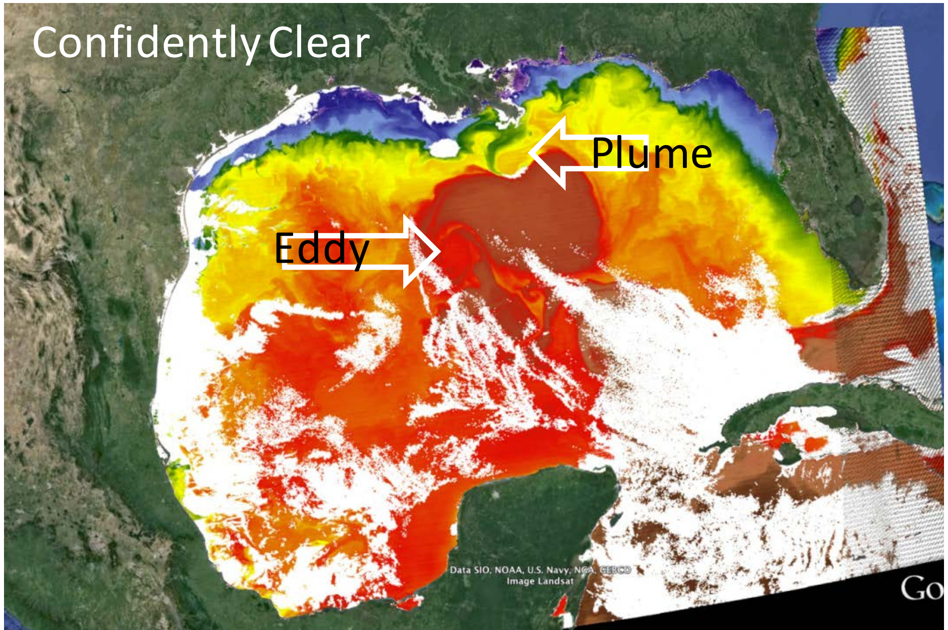


Cooling occurs from First to Second orbit in Clear waters.

Warming occurs in high Absorption waters.

Jan 28, 2015 ACSPO _Confidently Clear

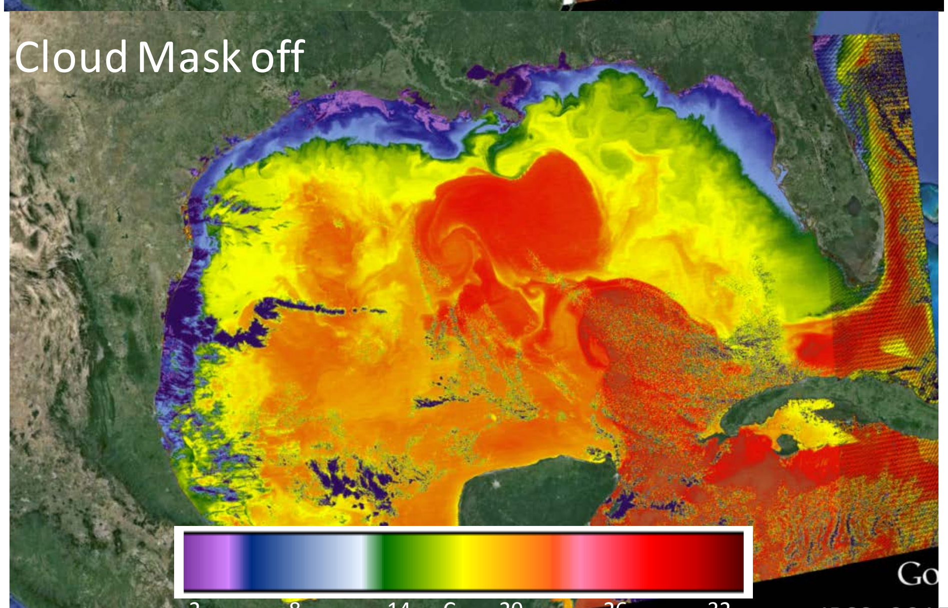
Example of ACSPO

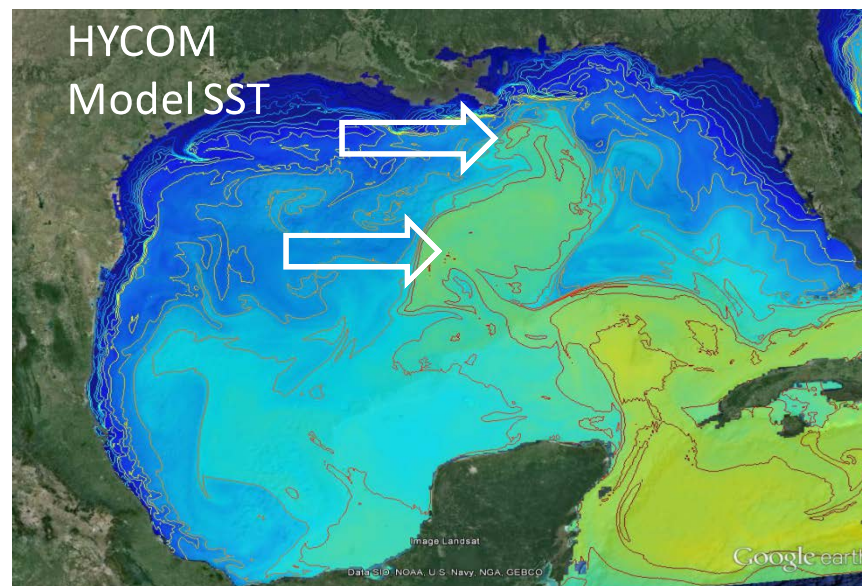


Cloud Cover – some cases is aggressive.

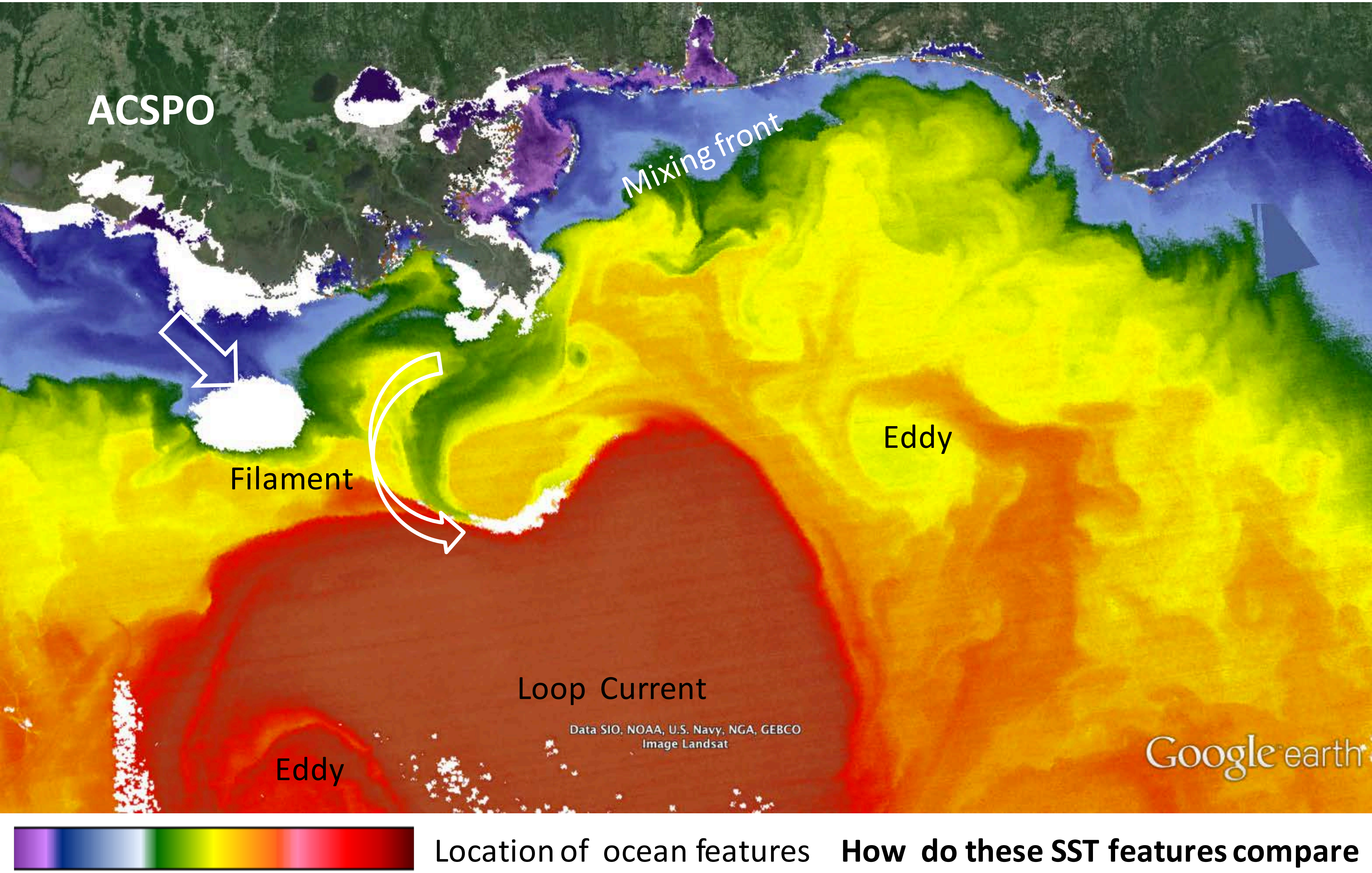
SST ACSPO and Model showing different features (scales are different) .

HYCOM model – VIIRS SST data Assimilated
VIIRS SST can validate model feature "Coastal Plumes"





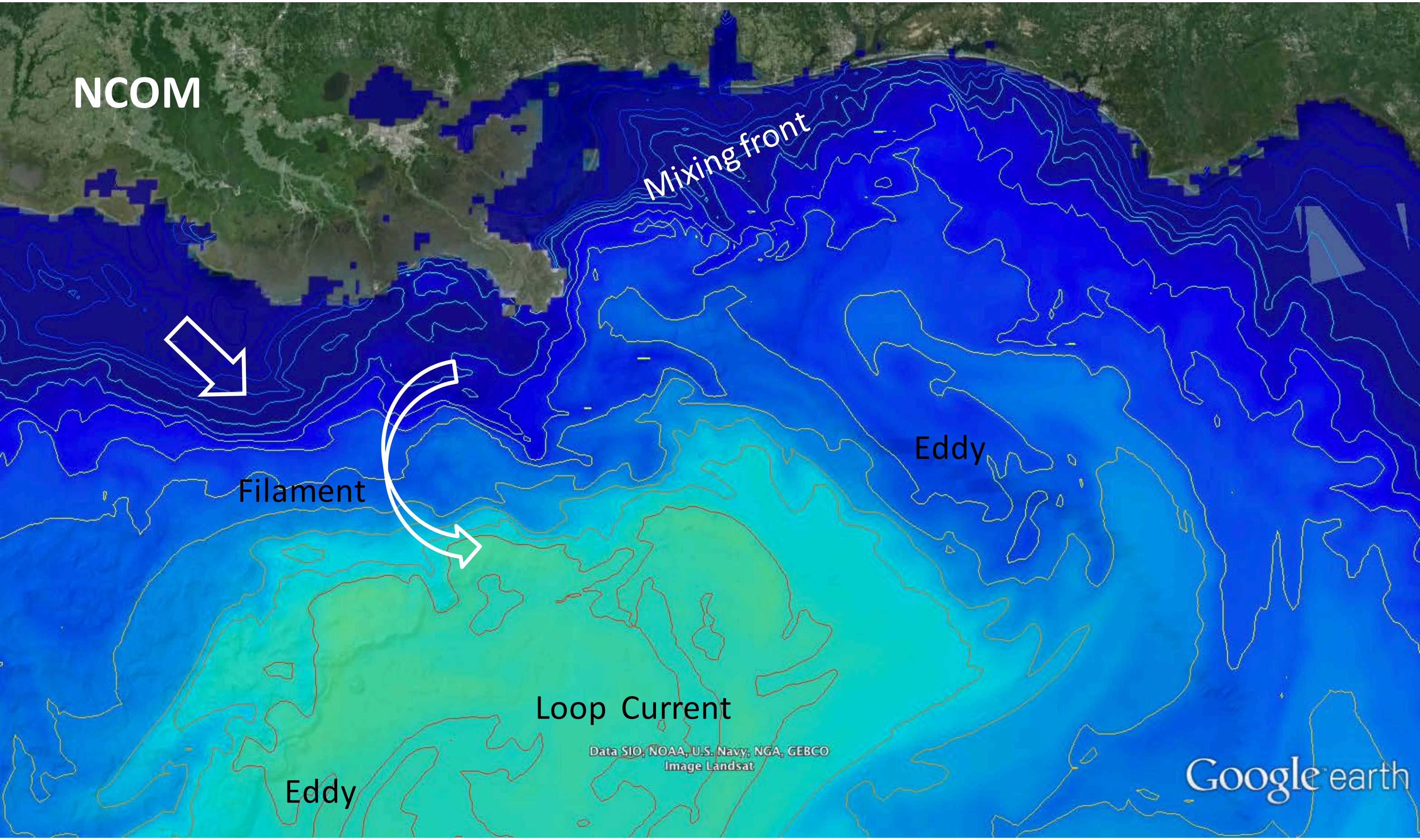
VIIRS SST can be used for Identifying Coastal Circulation Features



Location of ocean features
Coastal flagging of Clouds

How do these SST features compare Model (HYCOM / NCOM)?

VIIRS ACSPO SST can be used for Validation of Circulation Models



Missing the Coastal Filament. Other areas are Validated

Difference in NCOM and HYCOM Model, No Plume was identified in the SST

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Summary:

See Poster !

1. **VIIRS 100 minute Orbital overlap used to evaluate the ACSPO SST in coastal waters**
2. **ACSPO SST matchup with buoys in coastal , shelf and offshore waters was excellent!**
3. **Minimal trends of the overlaps SST difference suggests the stability of the product.**
4. **The diurnal signal in SST was validated in ACSPO SST !!**
   - **Products accuracy must account for short temporal changes.**
   - **Influence of water optics on surface heating and heat flux !**

5. **ACSPO cloud mask may be aggressive with some coastal features**
6. **VIIRS SST used for Validation of Circulation Models.**
   Integrated into Ocean Weather Lab. .

7. **Plans**
   - **SST for defining the Gulf Stream front in upcoming cruises.**
   - **Evaluate ACSPO SST and coastal dynamics and river plumes.**
   - **Validation of circulation model's SST**

Publications

Arnone, R., Vandermeulen, R. , Ignatov, A. Cayula , J.-F. (2015) "Seasonal trends of ACSPO VIIRS SST product characterized by the differences in orbital overlaps for various waters types", 2015 SPIE *Proc. SPIE* Ocean Sensing and Monitoring VII, 9459 (June2015), Baltimore Ocean Sensing and Monitoring VII Proc of SPIE Vol 9495)OT-1 – OT-7 edited by W. Hou and R. Arnone editors.

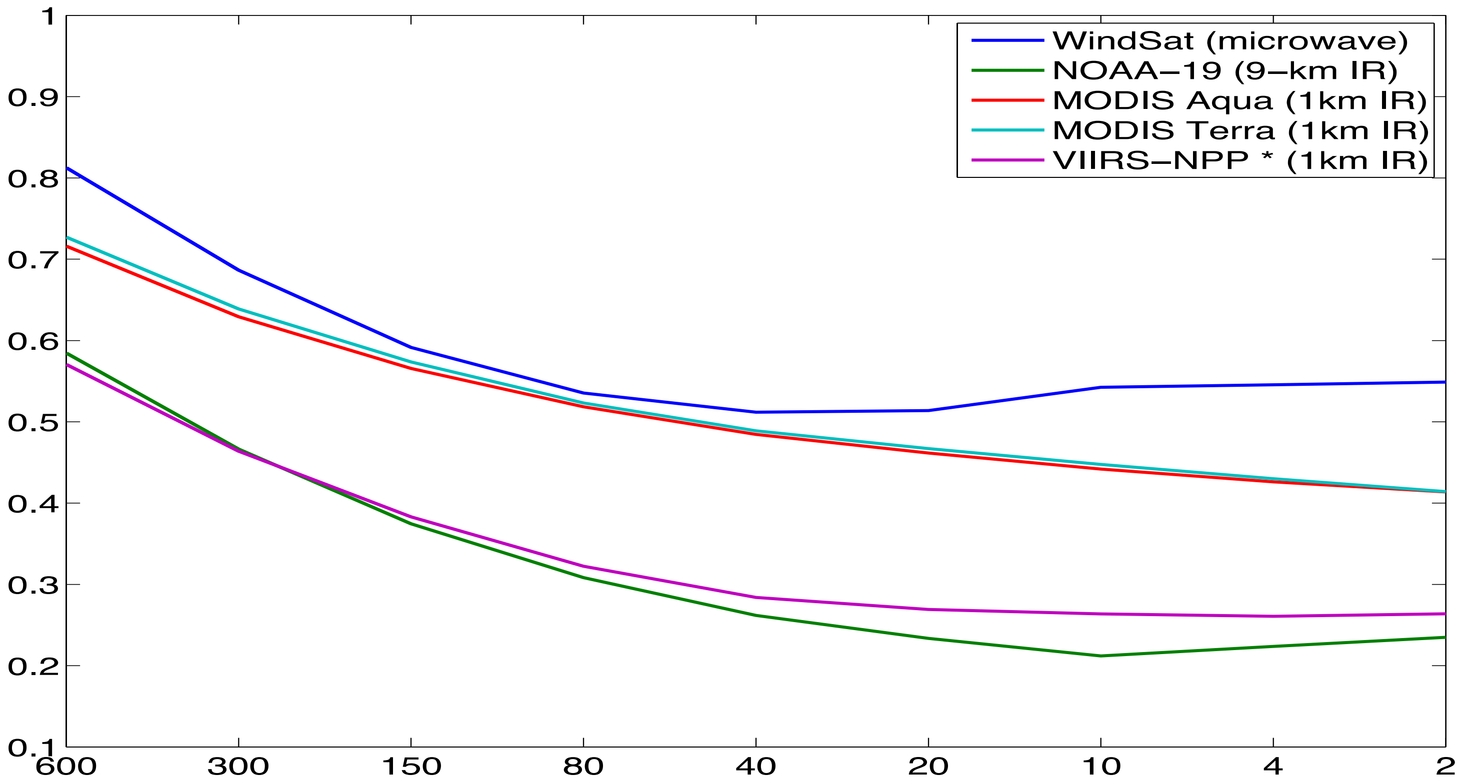
Cayula ,J,F, Arnone, R. Vandermeulen ,R. "(2015) Comparison of VIIRS SST fields obtained from differing SST equations applied to a region covering the northern Gulf of Mexico and western North Atlantic", 2015 SPIE *Proc. SPIE* Ocean Sensing and Monitoring VII, 9459 (June2015), Baltimore Ocean Sensing and Monitoring VII Proc of SPIE Vol 9495OS-1 – OS-11 edited by W. Hou and R. Arnone editors doi:10.1117/12.2053435

Towards assimilation of ACSPO VIIRS SST in JPL Multi-scale Ultra-high Resolution (MUR) L4 analysis

Mike Chin, JPL

"MUR" Gridded SST Analysis

- *Multi-scale Ultra-high Resolution (MUR)* SST analysis uses a **1-km grid**.
- MODIS is the source of high-resolution SST retrievals; no VIIRS ingested at present.
- VIIRS is the **best option** for independent data to *validate* the **<u>spatial patterns at fine scales</u>**.
- MUR plans to ingest VIIRS in the future.



- Horizontal axis is the feature scale (resolution) of the MUR analysis.
- MODIS's RMS (red + light blue) decrease with the MUR resolution.
- VIIRS is the only data set *not* ingested by MUR in the plot.
- VIIRS's RMS (purple) also **decreases monotonically** with the MUR resolution, **cross-validating the fine scale features**.

VIIRS SSES usage potentials in MUR

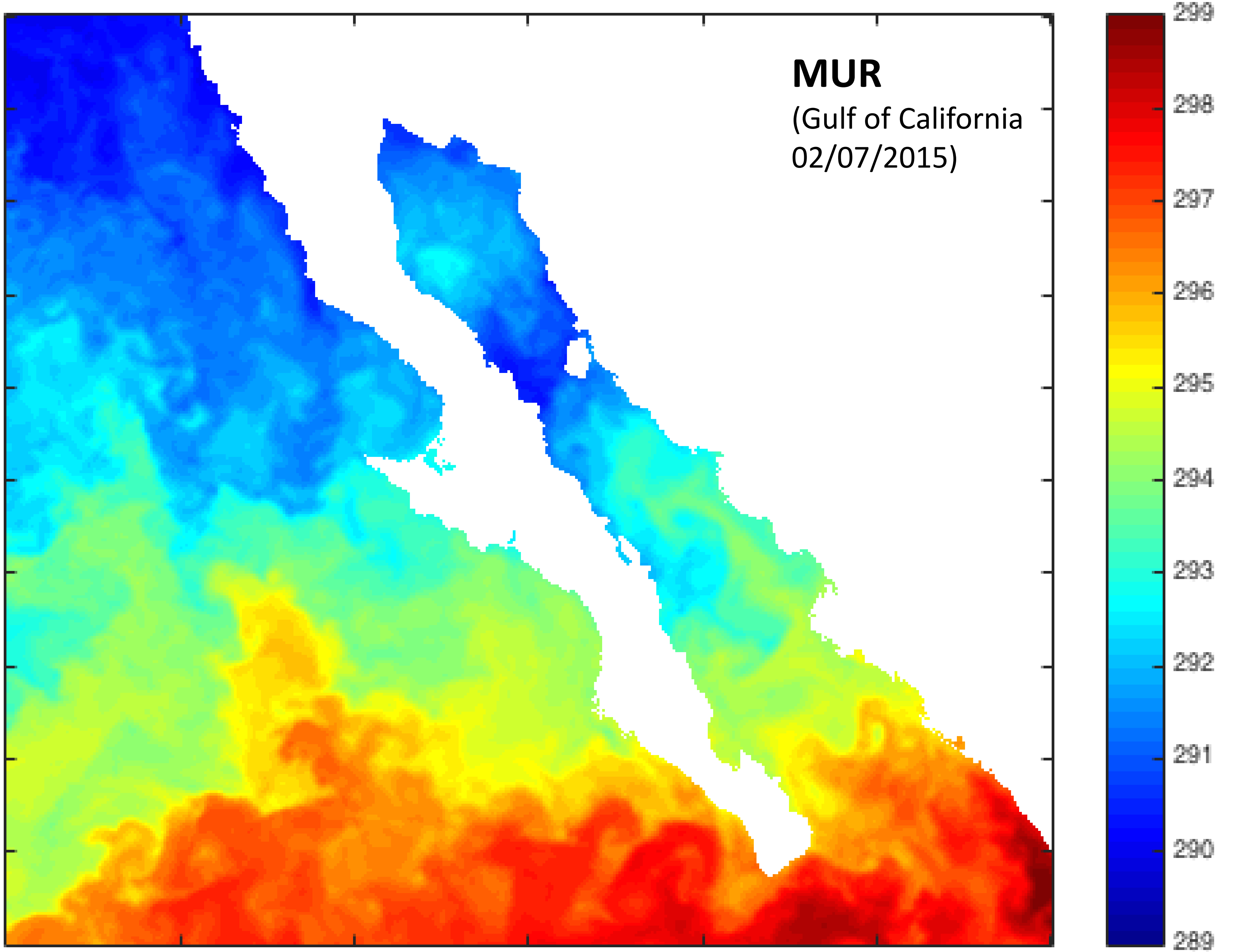
- Use of *VIIRS v2.4 SSES Bias* improves agreement between MUR and VIIRS slightly (by 0.01^{o}C, globally averaged).
- If the *foundation/bulk temperature* can be estimated accurately (via SSES Bias), VIIRS data can be used as the reference for all other retrieval data sets in data-fusion/analysis operations like MUR.

MUR/VIIRS comparison

02/07/2015

Gulf of California

- We have conducted a very limited comparison at this point
- Compared is MUR with ACSPO VIIRS SST, which is not assimilated by L4 MUR
- To facilitate the comparison, ACSPO VIIRS SST was reprojected to same grid as MUR
- Thermal fronts were calculated from MUR SST using gradient field, and superimposed with VIIRS SST imagery
- MUR product seems to capture high resolution ocean features very well!
- Standard global statistics on Delta SST (retrieved – reference SST) may not capture the quality of high resolution spatial features and perhaps a different metric is needed to highlight superior high resolution performance of MUR with respect to other L4 products


MUR
(Gulf of California
02/07/2015)
299
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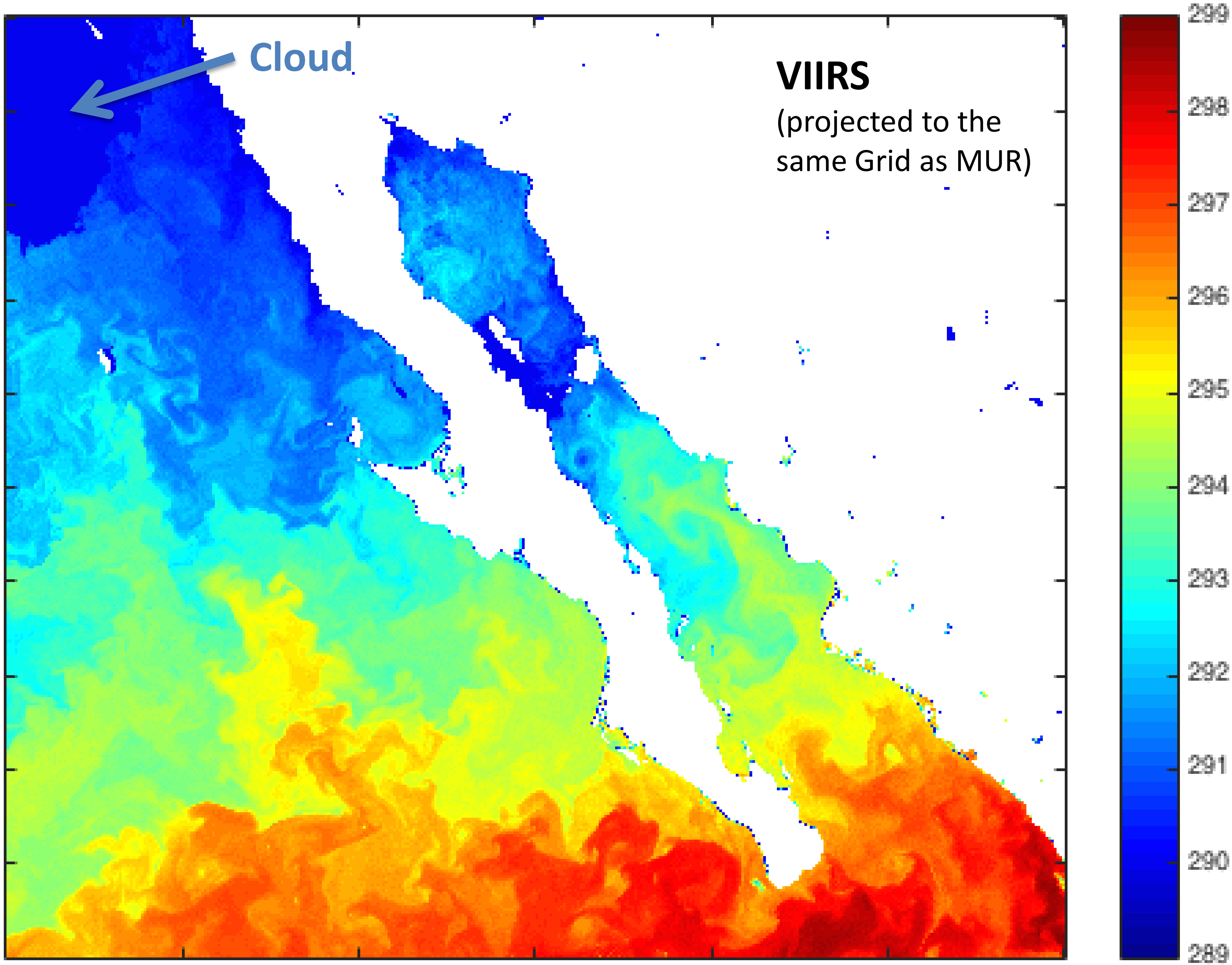
289


Cloud
VIIRS
(projected to the same Grid as MUR)
299
298
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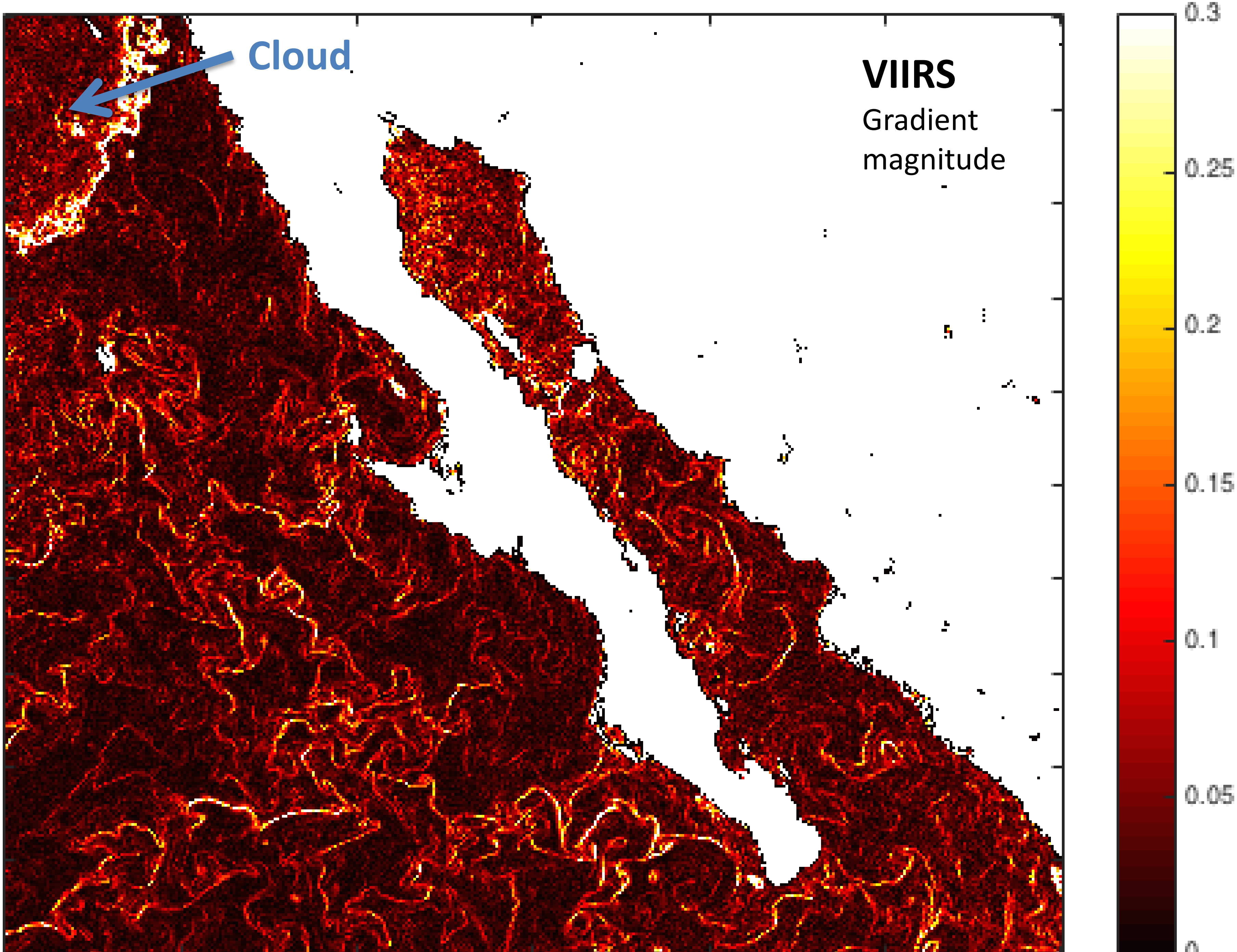
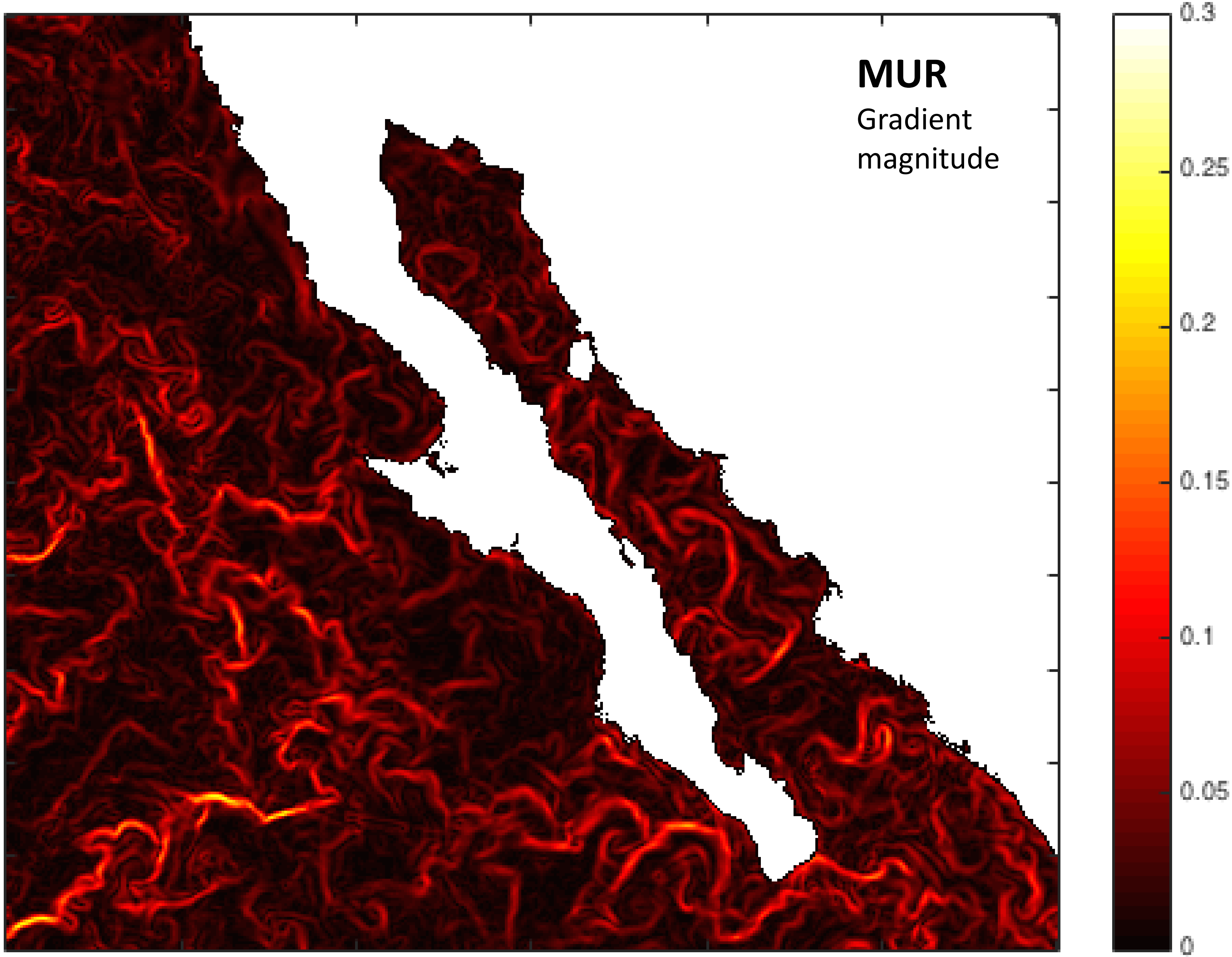
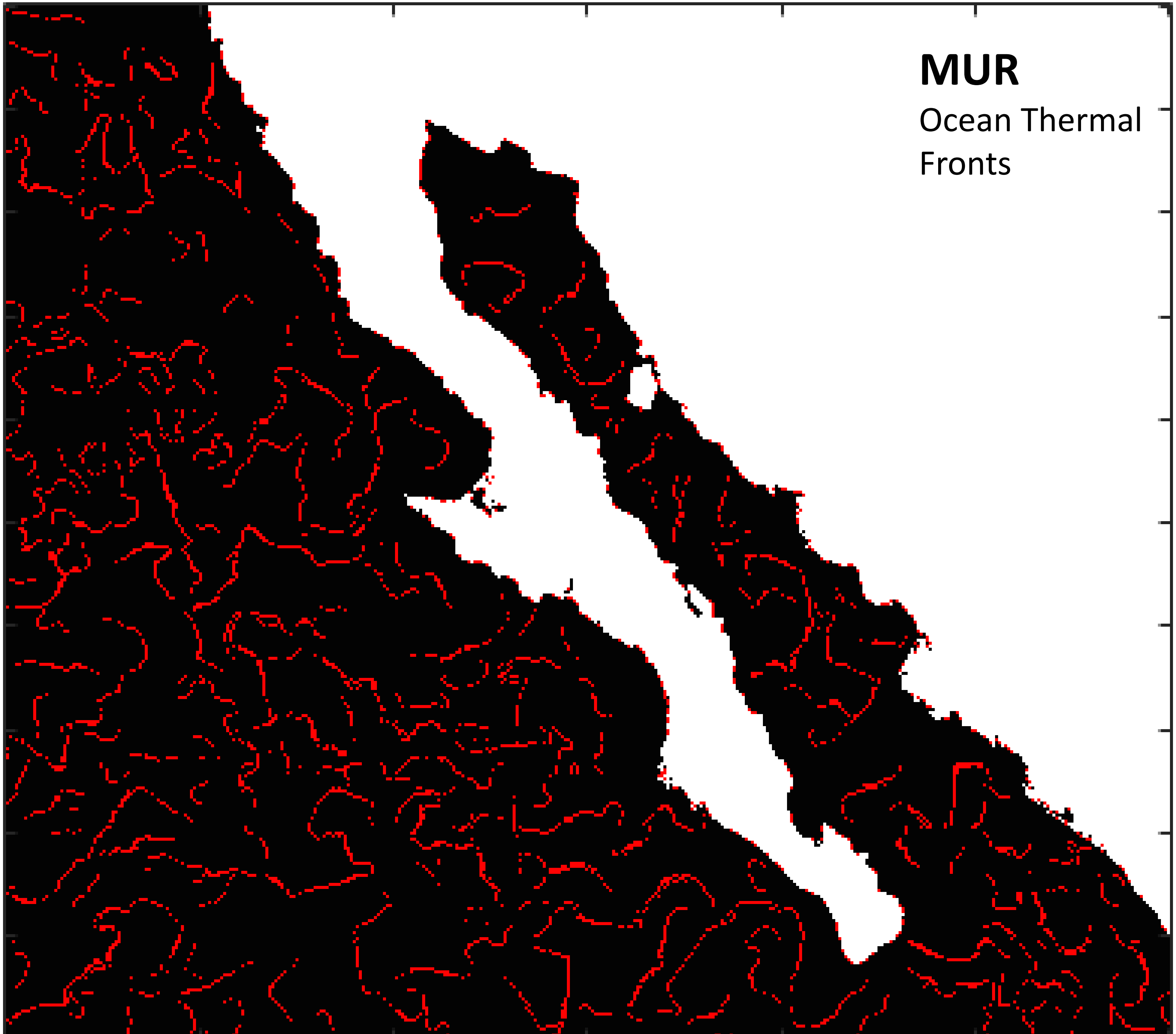
289

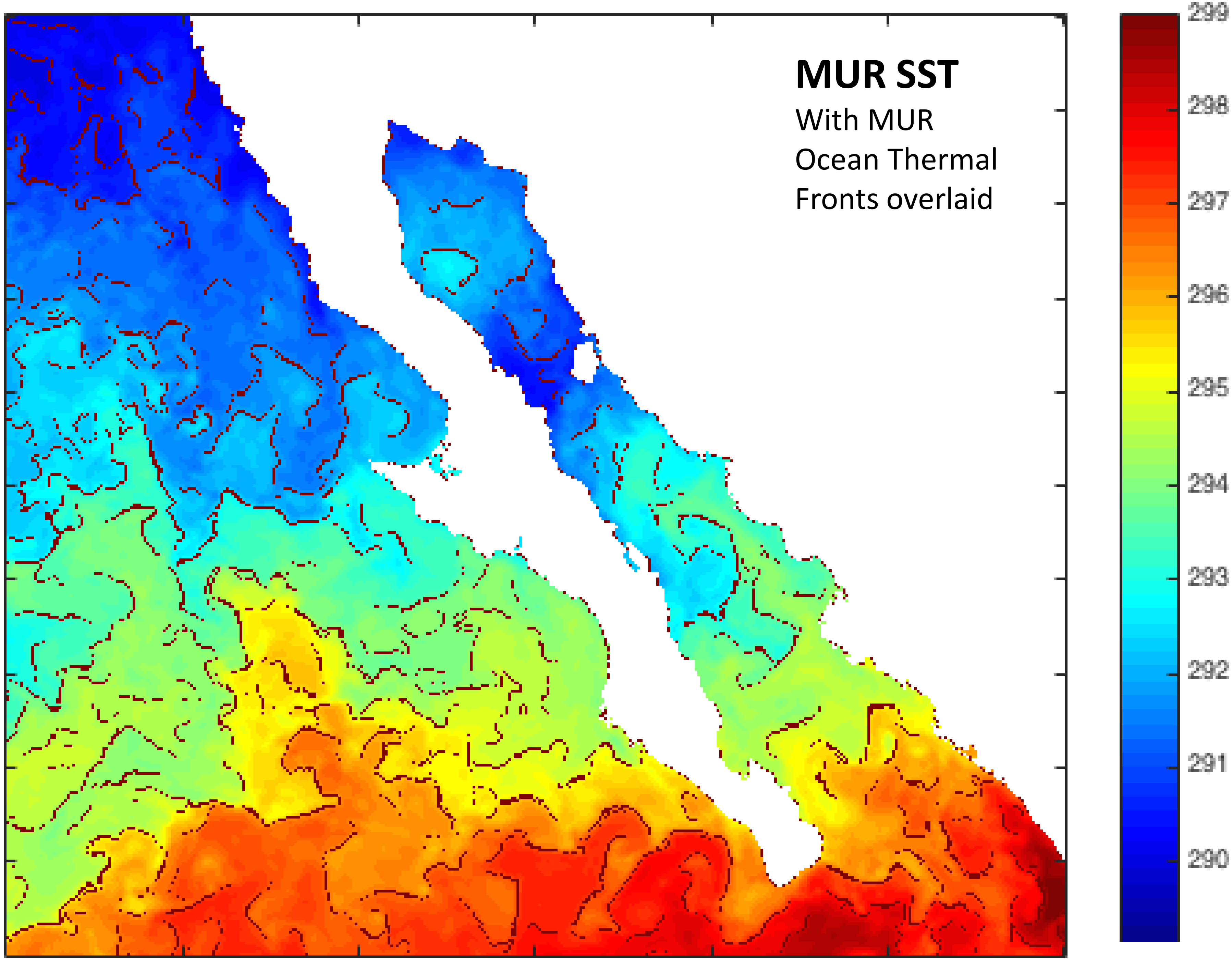


Cloud
VIIRS
Gradient
magnitude
0.3
0.25
0.2
0.15
0.1
0.05
0


MUR
Gradient
magnitude
0.3
0.25
0.2
0.15
0.1
0.05
0



MUR
Ocean Thermal
Fronts


MUR SST
With MUR
Ocean Thermal
Fronts overlaid
299
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293
292
291
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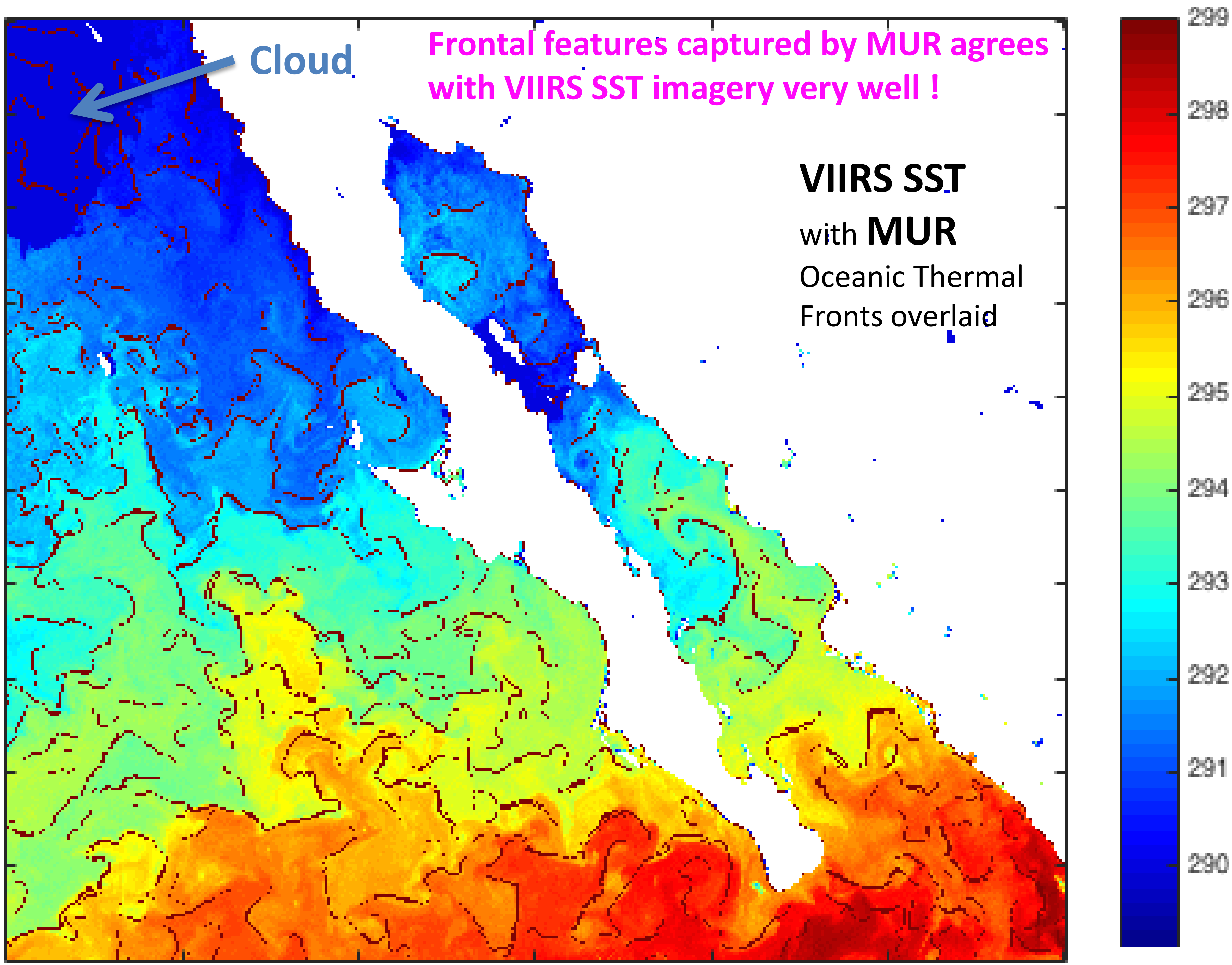

Cloud
Frontal features captured by MUR agrees
with VIIRS SST imagery very well !
VIIRS SST
with MUR
Oceanic Thermal
Fronts overlaid
299
298
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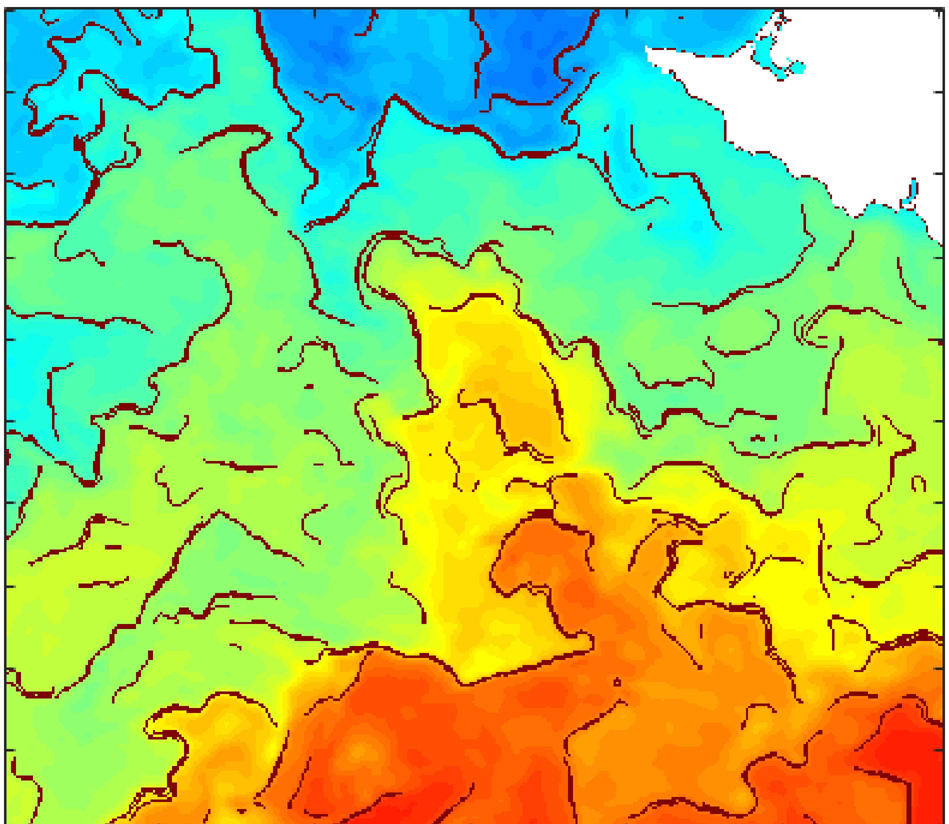
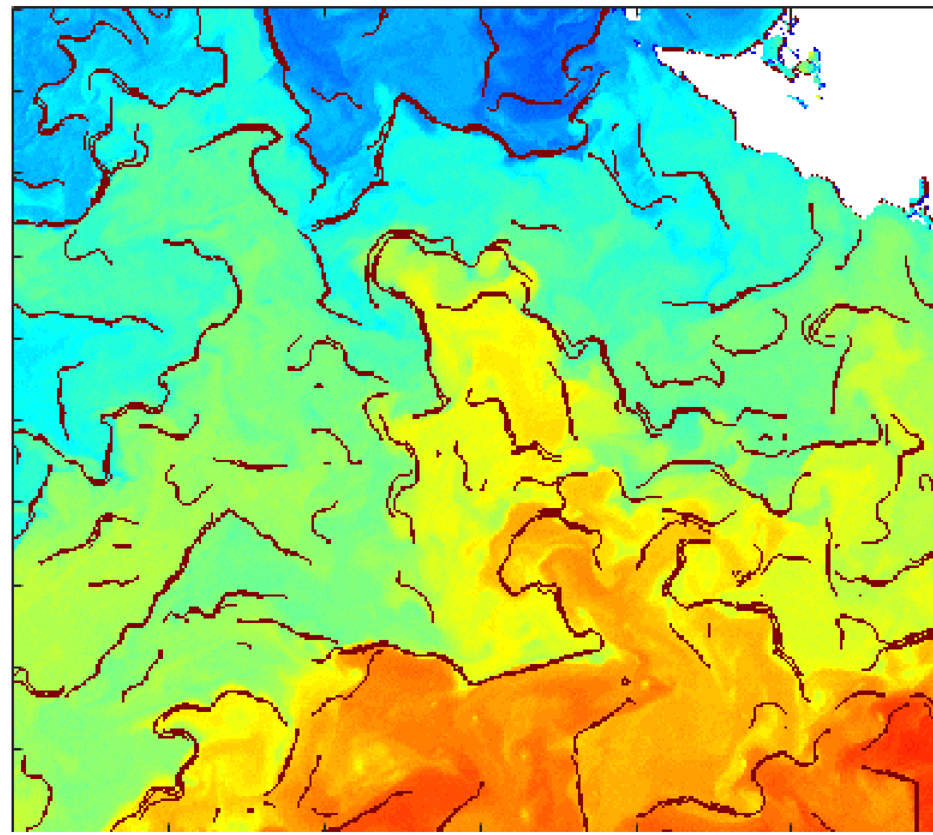
Zoomed

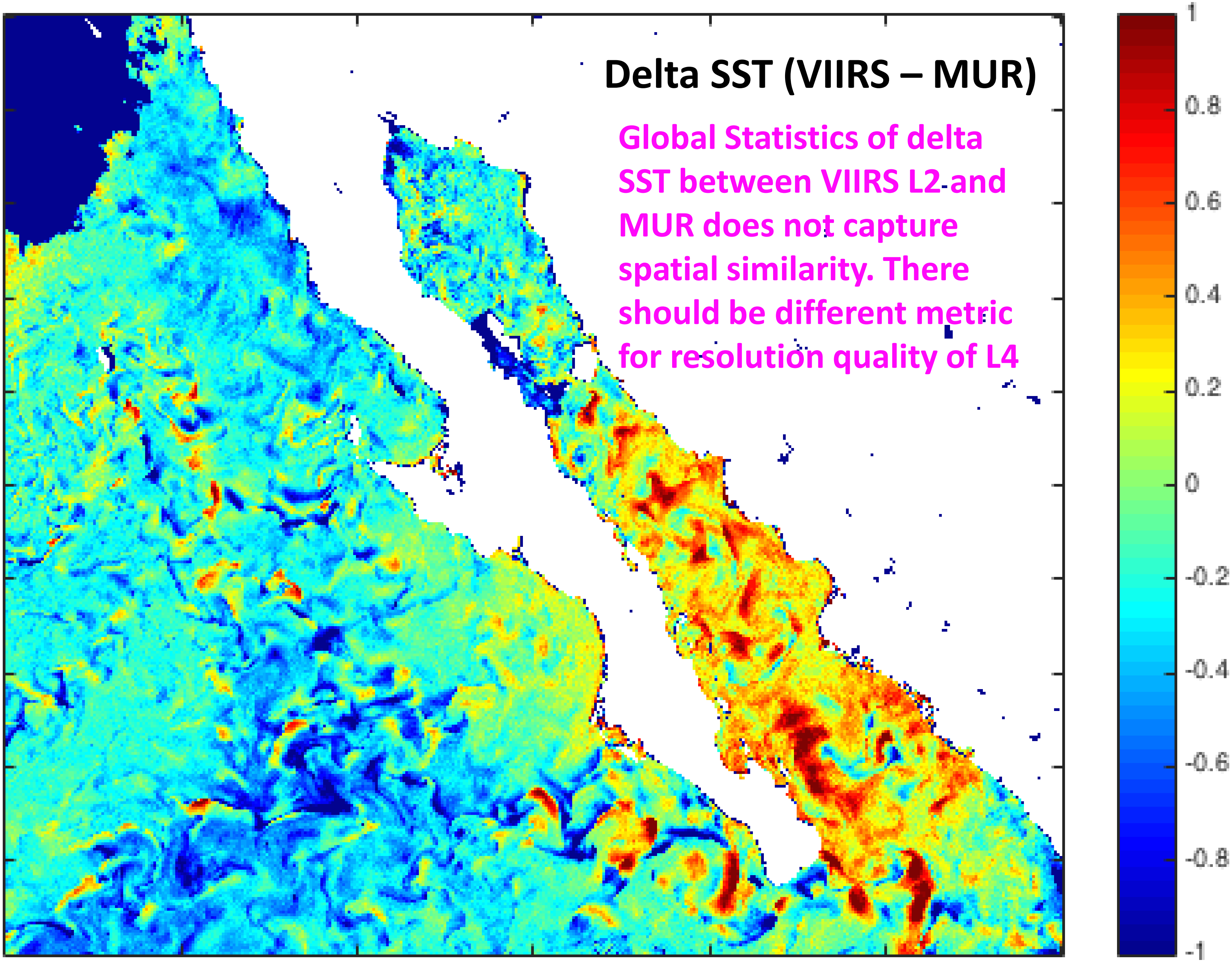
Closer look at the frontal features captured by MUR revels a great deal of agreement between re-projected ACSPO VIIRS SST imagery and L4 MUR product. MUR is currently the only L4 product that captures small features so well.

MUR SST
With Ocean Thermal Fronts overlaid



VIIRS SST with **MUR**
Ocean Thermal Fronts overlaid





Delta SST (VIIRS – MUR)
Global Statistics of delta SST between VIIRS L2 and MUR does not capture spatial similarity. There should be different metric for resolution quality of L4
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

Environment Canada Environnement Canada

Canada

Assessment of contributions from ACSPO VIIRS retrievals of SST in the new high resolution CMC SST analysis

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National Prediction Development Division, Meteorological Service of Canada, Environment Canada, Canada

JPSS Annual Meeting

24-28 August 2015, College Park, MD, USA

Introduction

- CMC runs 3 SST analysis:
  - 0.2° with AVHRR
  - 0.2° with AVHRR, ACSPO VIIRS and RSS AMSR2
  - 0.1° with AVHRR, ACSPO VIIRS and RSS AMSR2
- All analyses assimilate in situ observations (ships, drifting buoys and moored buoys) and ice data
- SST analysis refers to a depth temperature (foundation SST) without diurnal variability
- First analysis is running in operations, the last two only in experimental mode

VIIRS SST Product

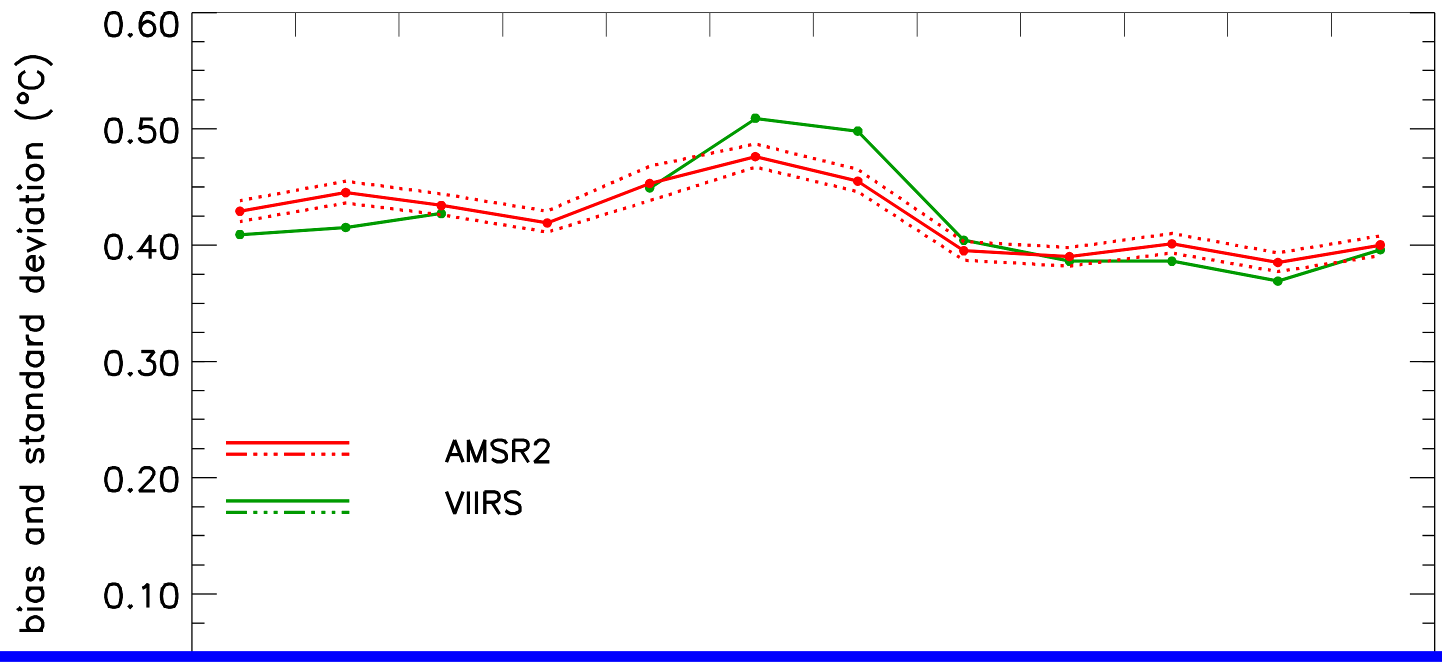
- VIIRS data is produced by NOAA using Advanced Clear-Sky Processor for Oceans - ACSPO (Petrenko et al. 2014)
- ACSPO VIIRS retrievals publicly available since May 2014, include quality flags and surface wind speeds
- CMC started using VIIRS retrievals and AMSR2 retrievals at the end of May 2014
- Some improvements in CMC SST 0.1°:
  - Improved spatial resolution (from 0.2° to 0.1°)
  - Background error correlations length scale reduced for high latitudes
  - Observations spacing reduced compared to 0.2° SST analysis (33 km compared to 44 km for infrared data at high latitudes)
  - Increased resolution of proxy data from CMC 3DVar ice analysis

Evaluation of VIIRS in CMC SST

- Because AMSR2 and VIIRS retrievals have been used in the same time, two analysis were produced with the same methodology on a grid with 0.2° resolution assimilating only AMSR2 retrievals or only VIIRS retrievals

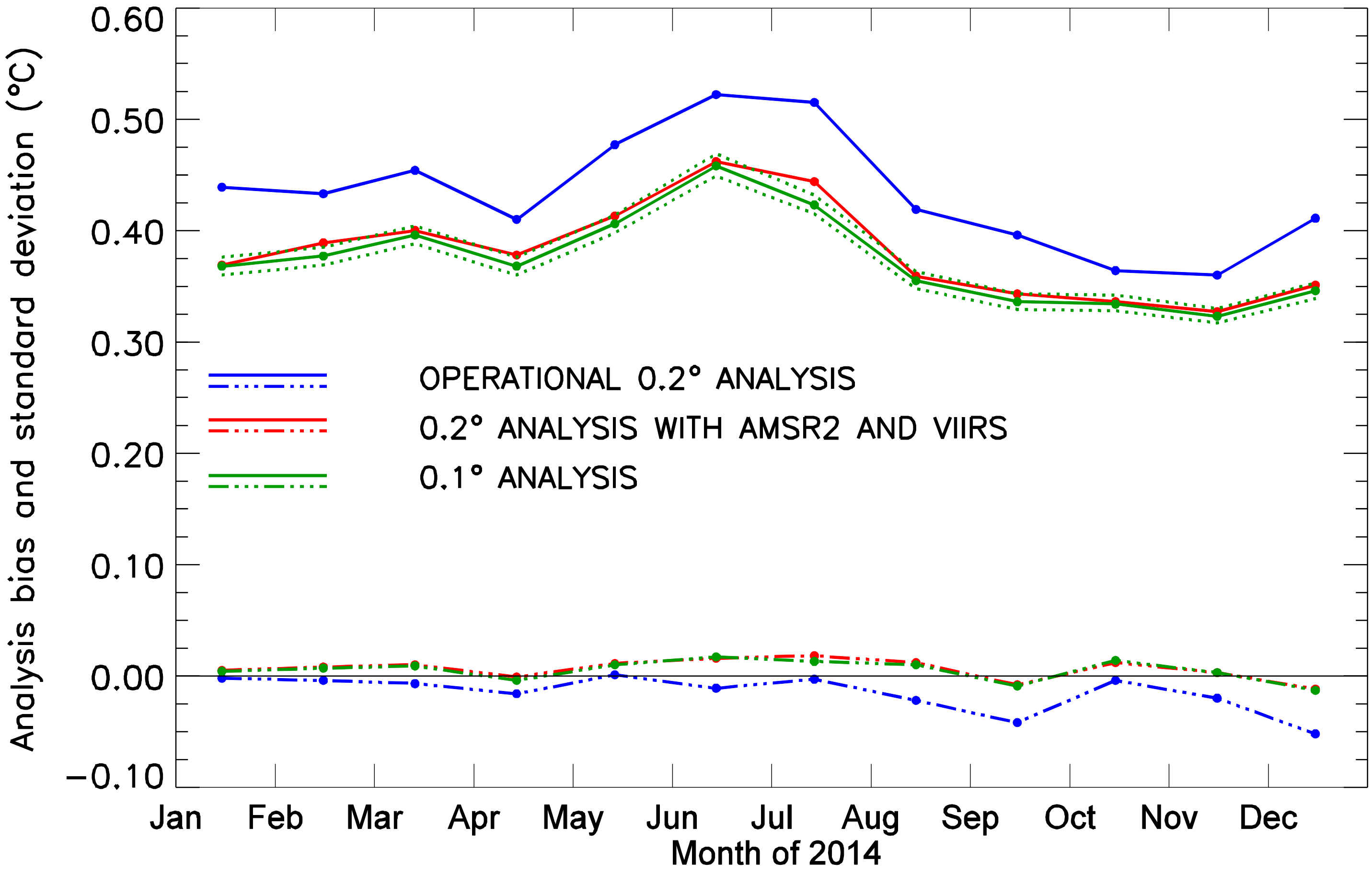
- All verifications are done against independent measurements from Argo floats
- Observations are used only if they are between 3 m and 5 m and within four standard deviations of the climatology

AMSR2 vs VIIRS



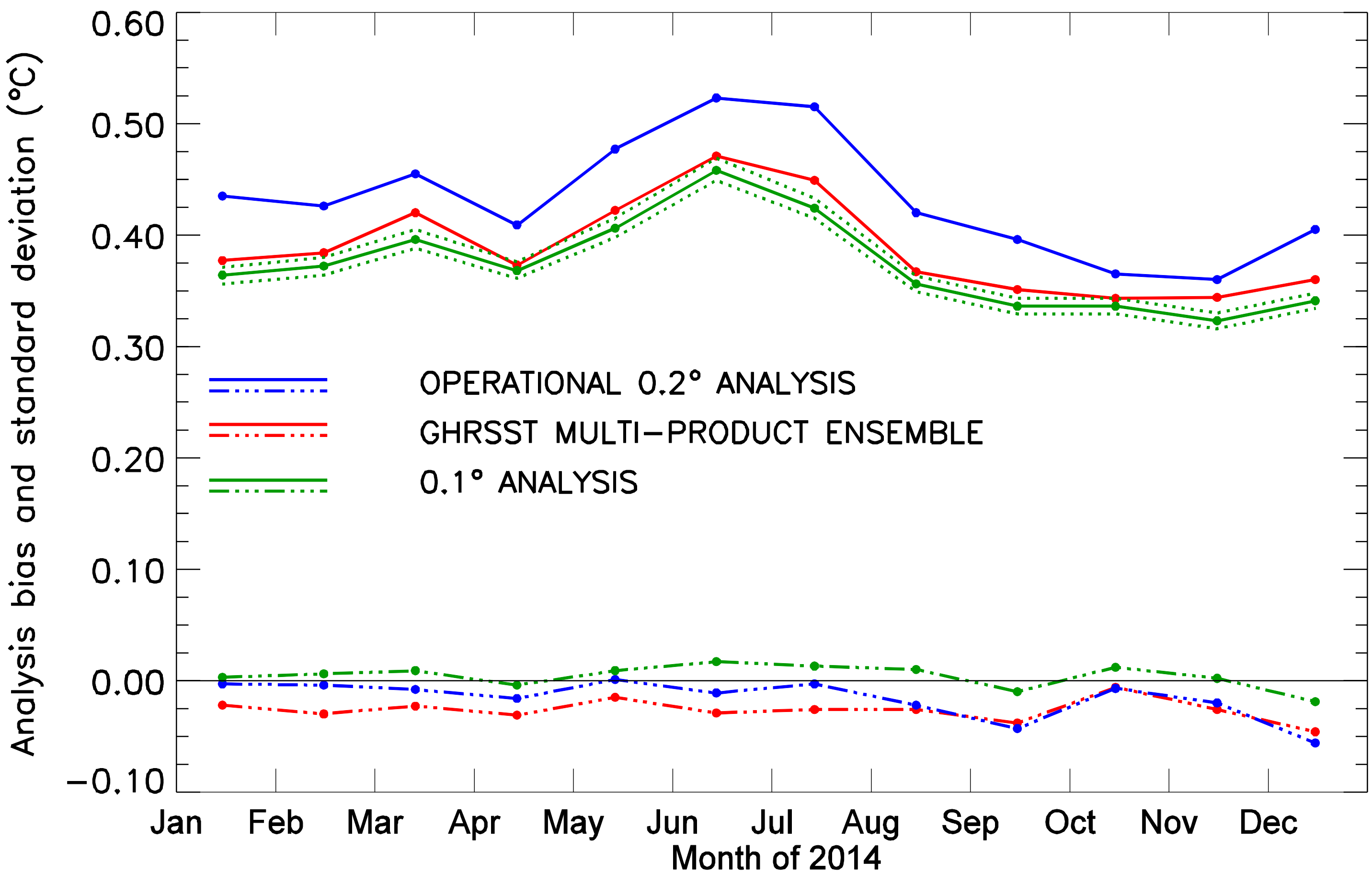
- ***VIIRS experiment significantly better than the AMSR2 experiment during January, February, October and November***
- ***AMSR2 experiment significantly better than VIIRS during June, July and August (months when data was available 60% of the time compared to 30% of the time for VIIRS over some regions of the globe)***
- ***No data were available for VIIRS from April 1st to May 19th 2014***

0.1° vs 0.2°



Most of the reduction in analysis standard deviation results from the addition of AMSR2 and VIIRS data

CMC SST vs GMPE



The 0.1° analysis outperforms (1) the operational 0.2° analysis and (2) the GMPE product even in April (when no VIIRS data were available)

VIIRS 2.30 vs VIIRS 2.40

- NOAA provided VIIRS 2.40 for January to March 2015 in L2P and L3U format
- Improvements in VIIRS 2.40

  - improved cloud screening

  - redesigned SSES

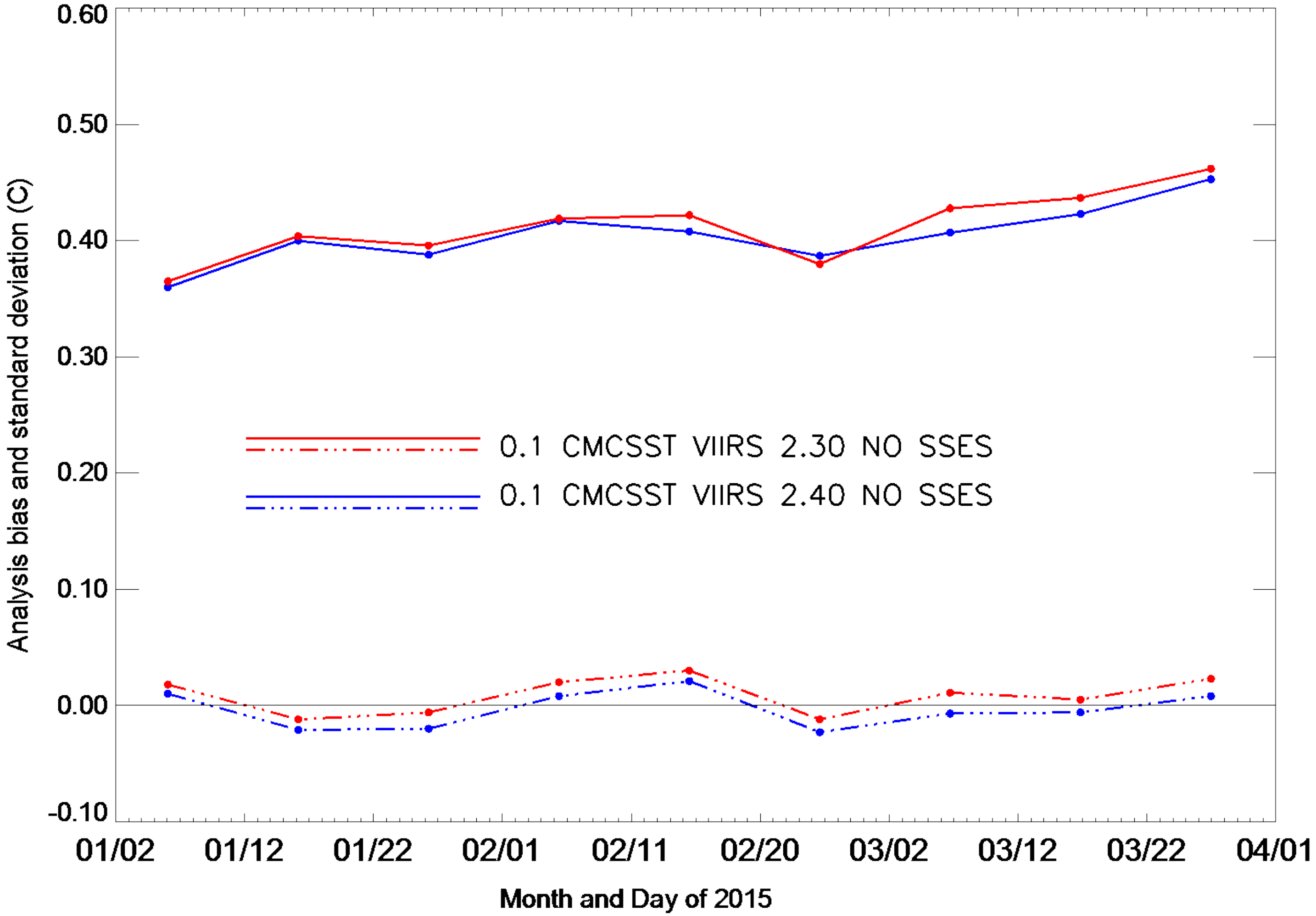
  - destriping

NOTE:

- CMC SST applies its own internal bias correction (BC) to satellite retrievals before they are assimilated in analysis (Brasnett, 2008)
- In 2014 the use of SSES biases in ACSPO VIIRS v2.30 was inconclusive. No SSES biases are used in operational analysis
- 0.2° CMC SST is used as reference for ACSPO VIIRS retrievals

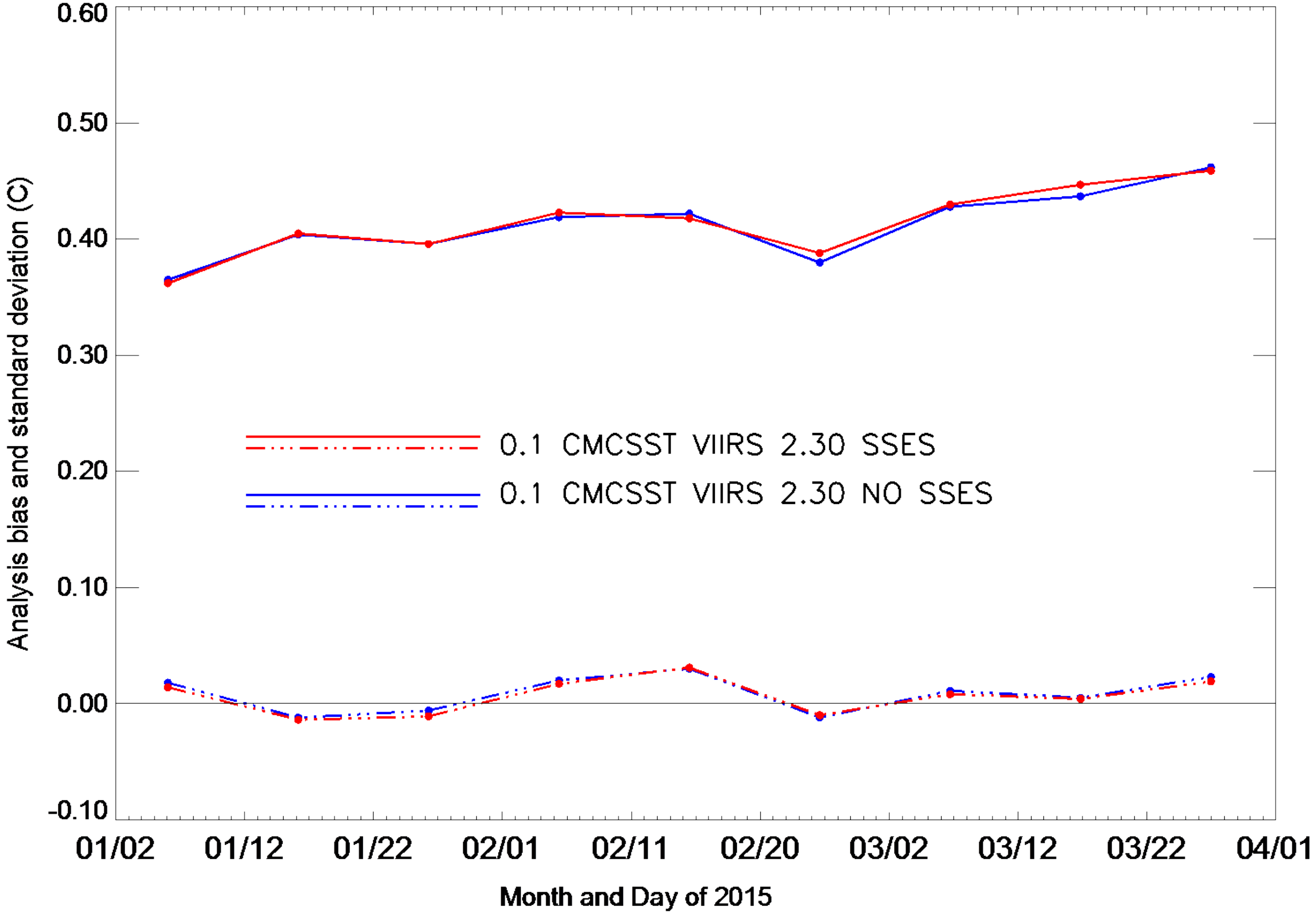
What is the influence of new VIIRS SSES biases in CMC SST analysis?

VIIRS 2.30 vs VIIRS 2.40 (no SSES)



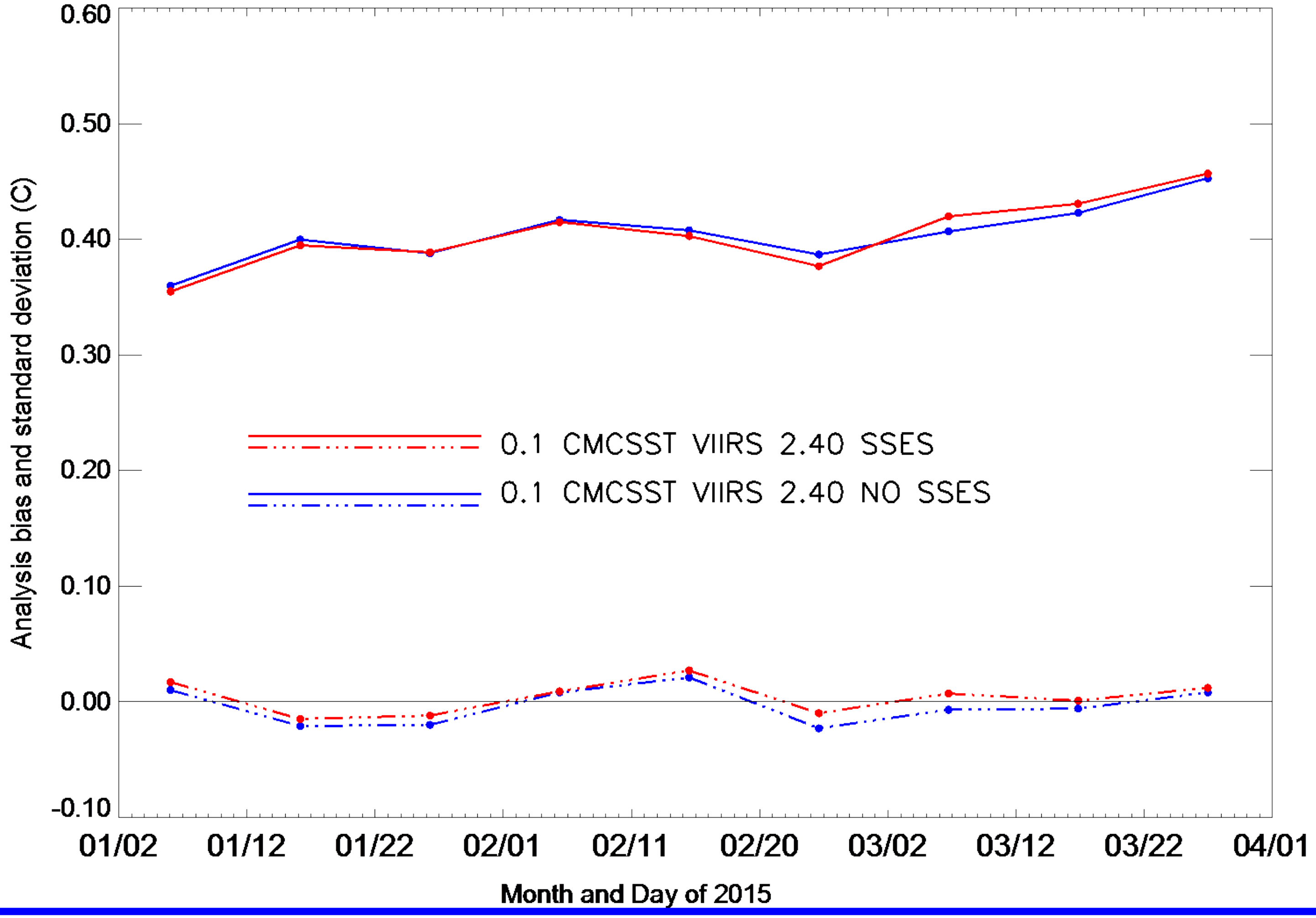
VIIRS 2.40 performs generally better than VIIRS 2.30

VIIRS 2.30 SSES vs VIIRS 2.30 no SSES



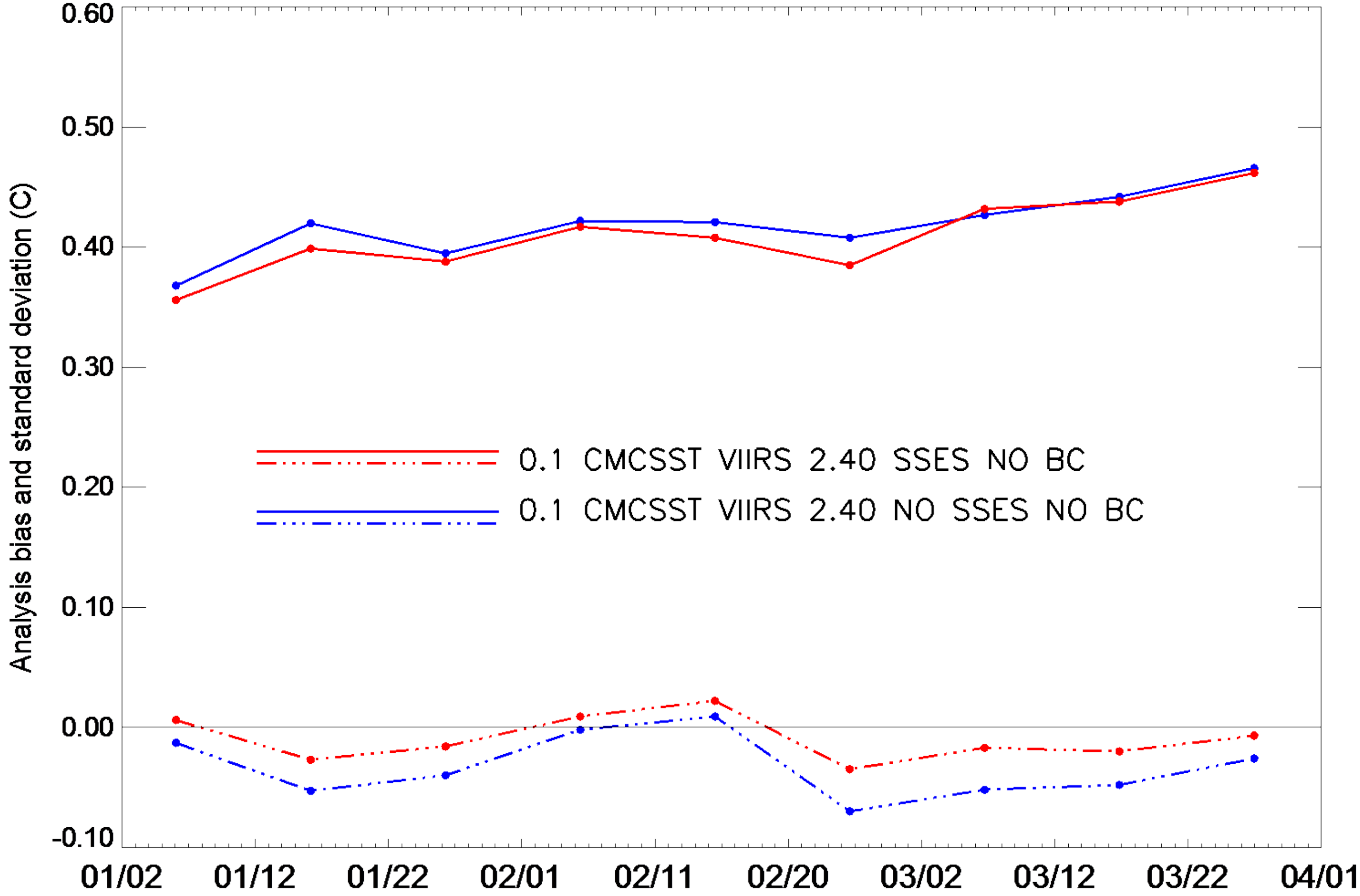
January to March 2015 – use of VIIRS 2.30 SSES inconclusive

VIIRS 2.40 SSES vs VIIRS 2.40 no SSES



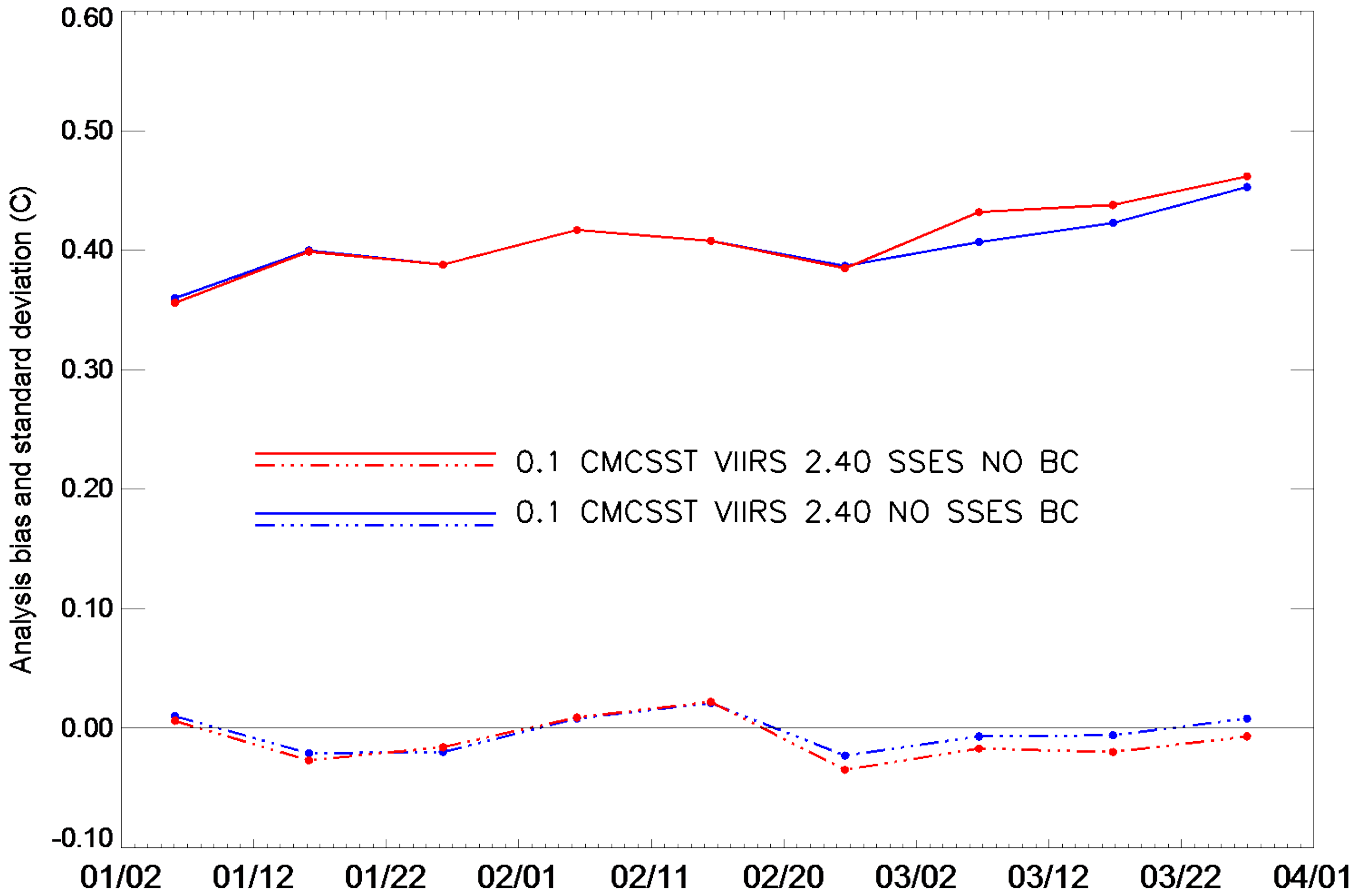
When SSES biases are used: Slight improvement in January and February, some degradation in March

VIIRS 2.40 SSES (no bias correction)



Using SSES biases reduces the standard deviation in the absence of CMC internal bias correction procedure

Bias correction or SSES biases?



In January and February: SSES biases produce similar results to CMC internal BC. In March: the CMC BC does better

Conclusions

- The reduction of "CMC minus ARGO floats" standard deviation by 0.05 – 0.08° C is obtained by adding two new satellite datasets – AMSR2 and VIIRS. VIIRS contributes more in some months, and AMSR2 in some others
- Use of SSES biases and/or CMC BC method produces smaller reductions in SST standard deviation, due to the methodology used to produce the analysis
- In the next weeks CMC will test VIIRS 2.40 in L3U format
- Tests will continue for the SSES bias; if the improvements will be consistent and/or the use of SSES standard deviation could improve the analysis then we plan to add these in CMC SST 0.1°

Assimilation of VIIRS SSTs and Radiances into Level 4 Analyses

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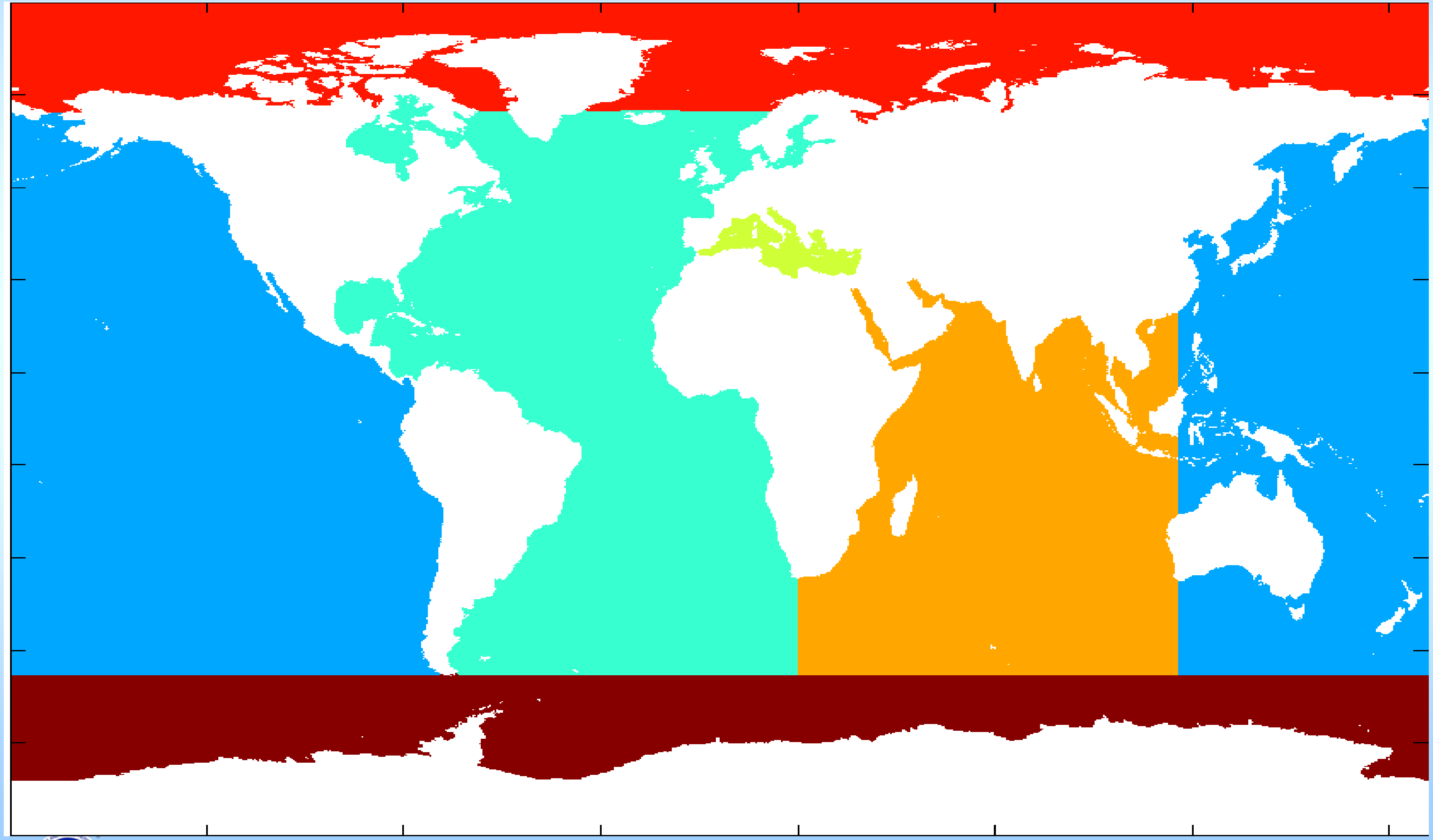
Jon Mittaz (U Reading)
Robert Grumbine (NCEP/EMC/MMAB)
Mark Eakin (NOAA CRW)
Eileen Maturi (NESDIS/STAR)

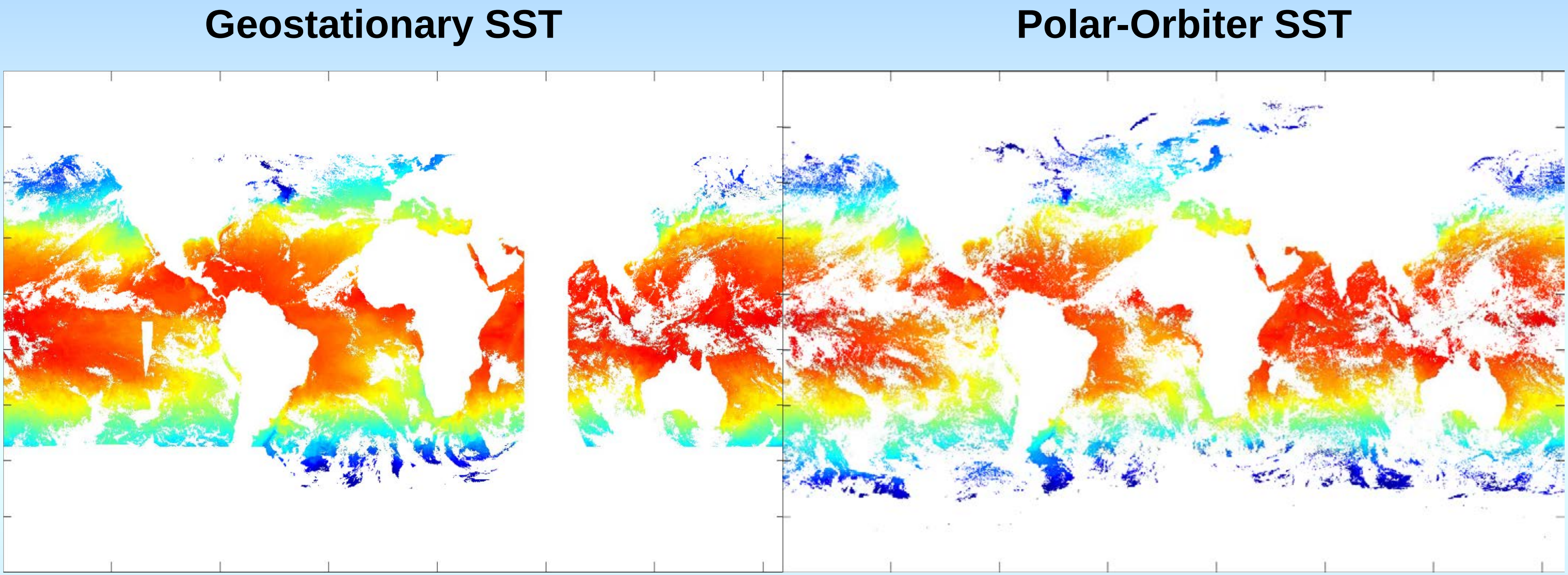
5-km Blended SST Analysis

- **Produced daily from 24 hours of AVHRR & Geo-SST**
  - MetOp-B
  - GOES-E/W Imager
  - MTSAT-2 Imager
  - Meteosat-10 SEVIRI
  - VIIRS
  - [AMSR-2]
  - **Does not use buoy data**
- Multi-scale OI
  - Mimics Kalman Filter **(***Khellah et. al., 2005***)**
- **3 stationary priors**
  - Short, intermediate and long correlation lengths
  - Mimic non-stationary prior while preserving rigor
  - Interpolation of resultant analyses based data density
    - **Allows fine resolution where possible without introducing noise**

Separate Ocean Basins

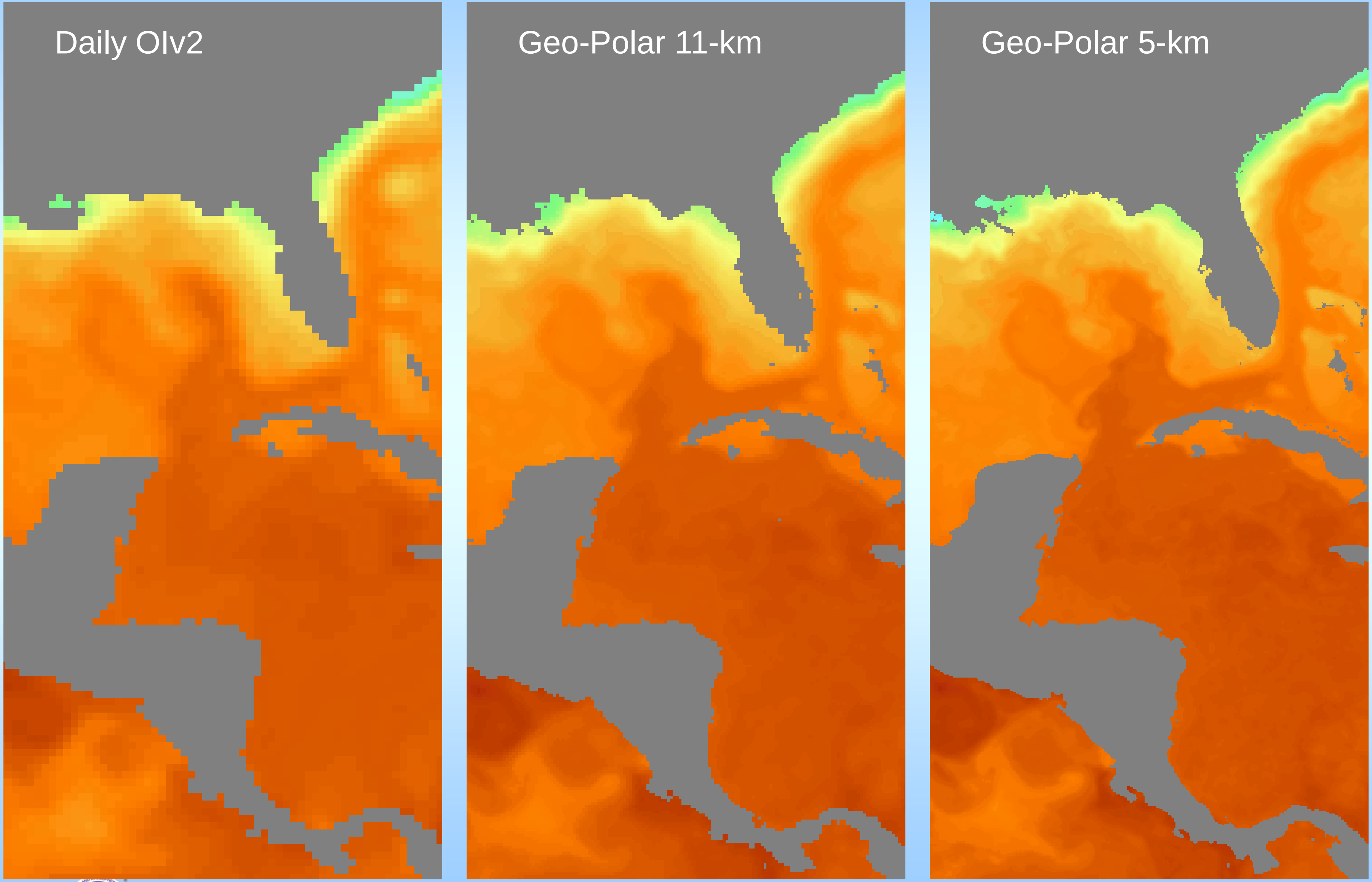


Data Coverage



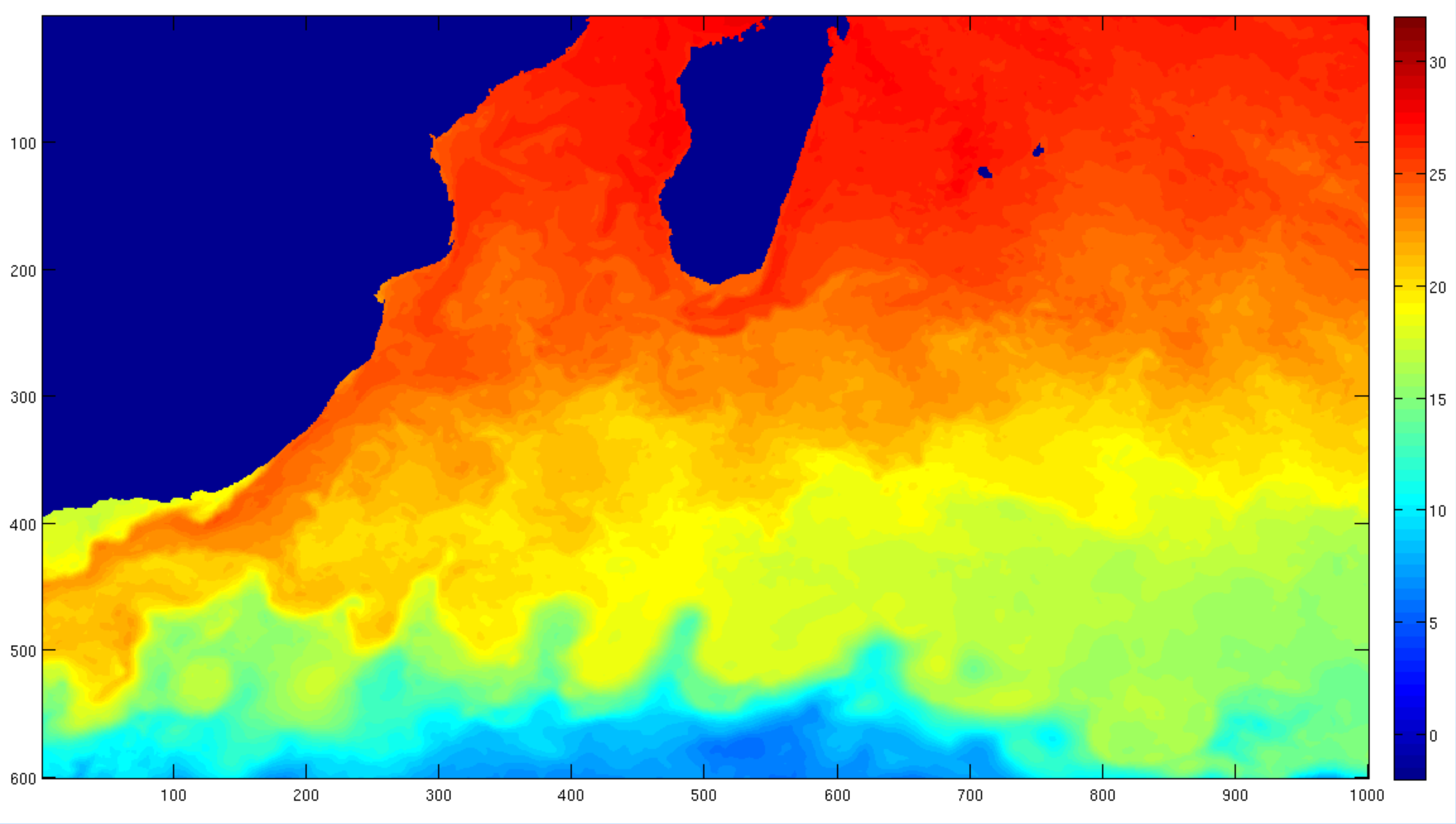
- **Geostationary data in particular provide lots of observations**
  - N.B. gap in coverage in Indian Ocean
- **Data-driven analysis**
  - Need to treat the input data “carefully”

Resolution difference



Key Results/Accomplishments

- VIIRS successfully incorporated into Geo-Polar Blended 5-km global SST analysis

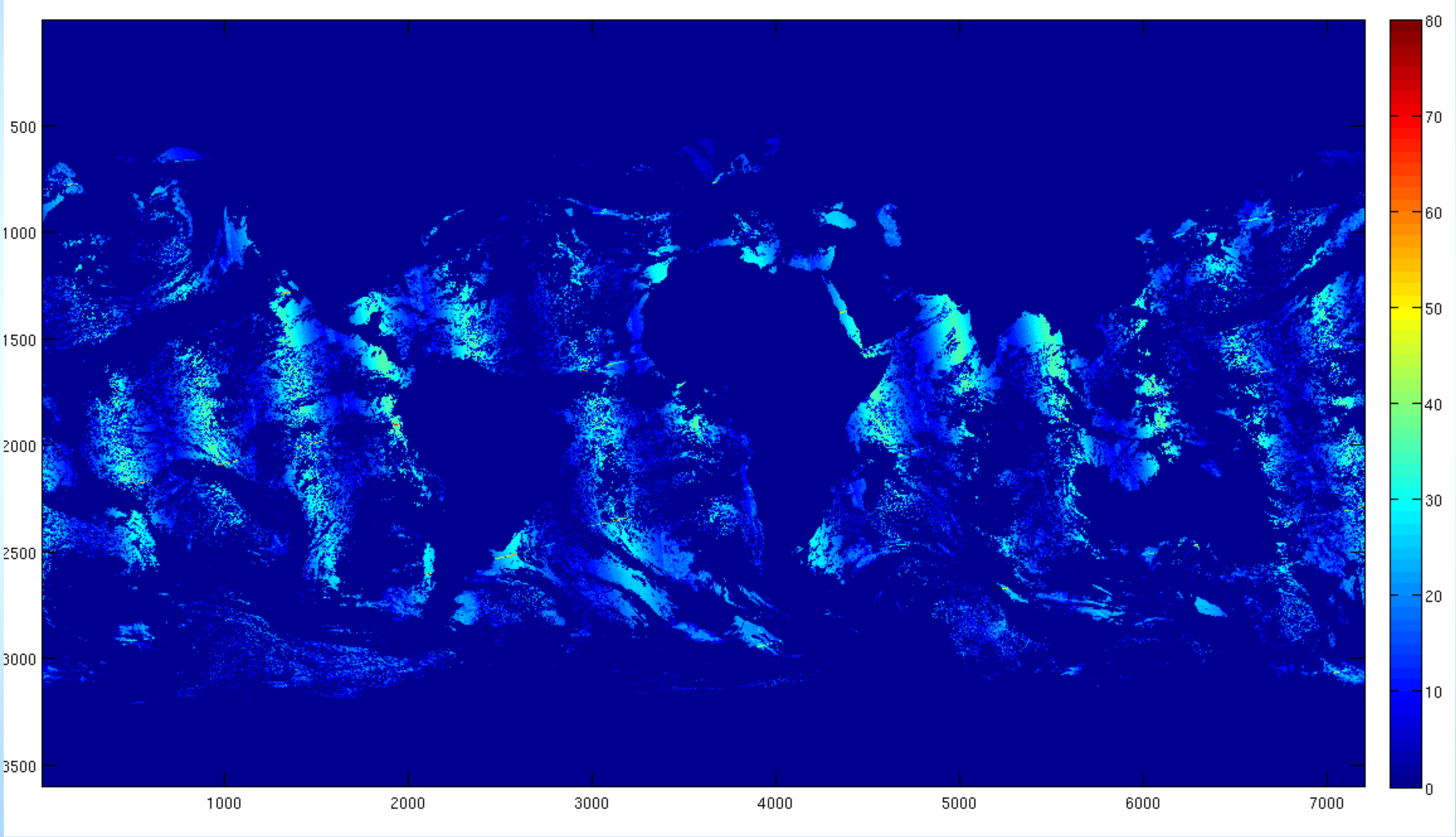


Super-Ob'd VIIRS SST data

Final SST analysis

Key Results/Accomplishments

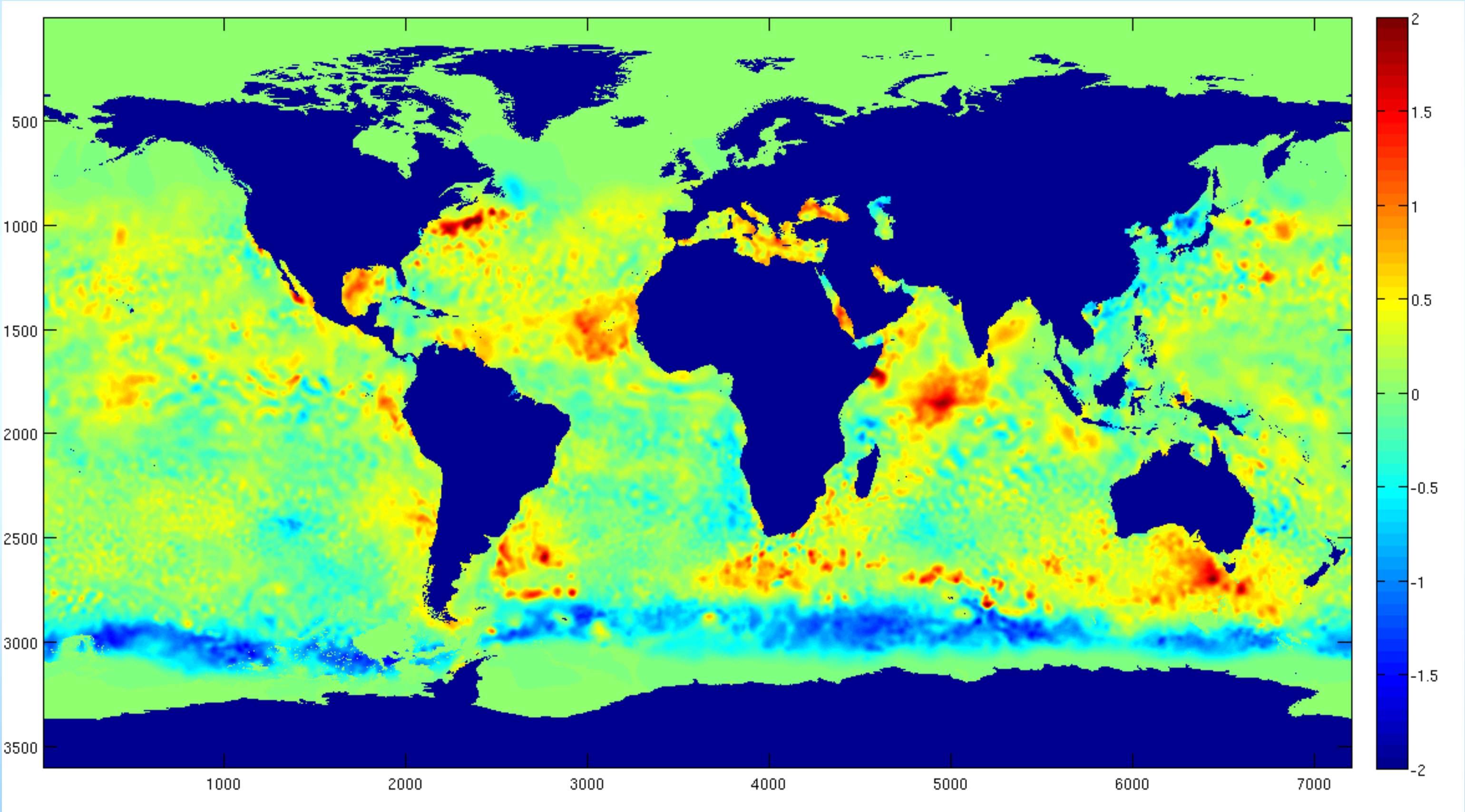
- Coverage is improved w.r.t. MetOp AVHRR



ACSPO AVHRR coverage
ACSPO VIIRS coverage

Key Results/Accomplishments

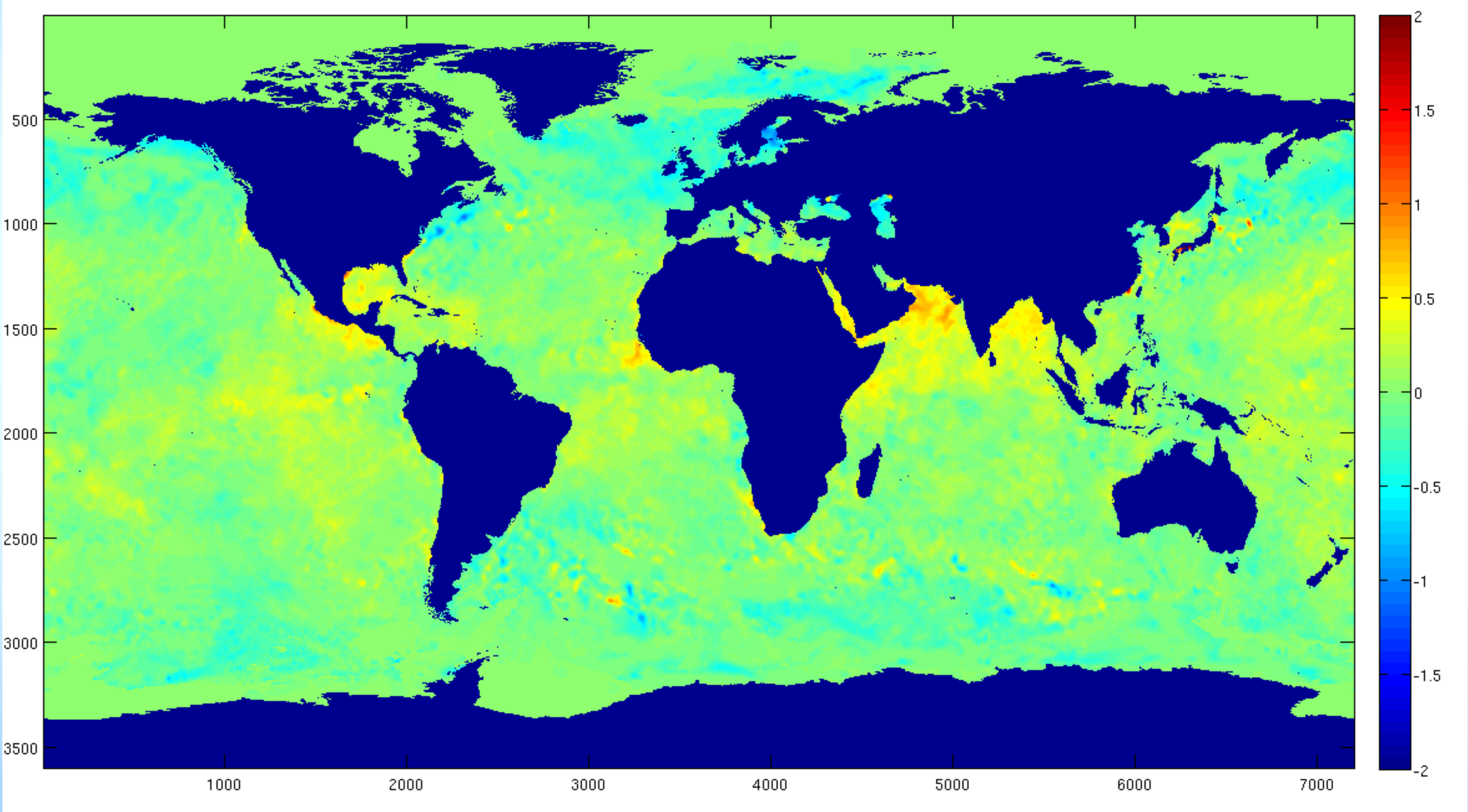
- Biases w.r.t. NCEP RTG_HR_SST indicate problem with the latter



ACSPO VIIRS SST bias correction field

Key Results/Accomplishments

- Biases seems to be somewhat reduced w.r.t. RTG recently, but less *cf.* OSTIA SST analysis



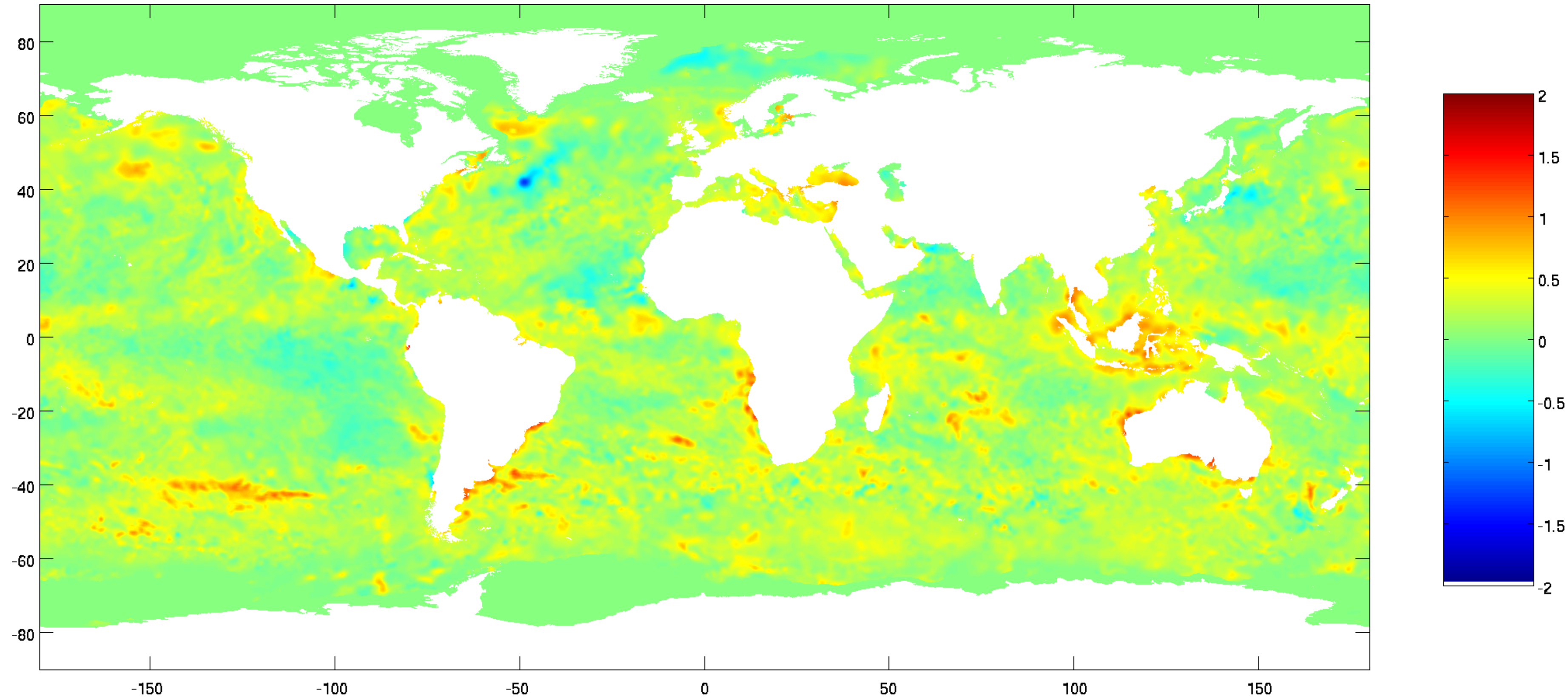
ACSPO VIIRS SST bias correction field w.r.t. OSTIA

Use of GHRSST ancillary info

- Switching to GHRSST L2P format
  - More compact & contains useful ancillary data
  - *N.B.* QL supplied in ACSPO GHRSST not particularly useful at present – likely to change
  - Sensor-Specific Error Statistics
    - Estimated bias & uncertainty (Std. Dev.)
  - Using these should improve product accuracy
    - Reduced biases
    - Reduced random error
  - Analysis performs statistical bias correction against a reference (currently OSTIA ➔ Sentinel-3 SLSTR)
    - Does use of SSES information reduce magnitude of bias correction?

Key Results/Accomplishments

- Compare use of Bias & S.D., Bias-only, and no SSES

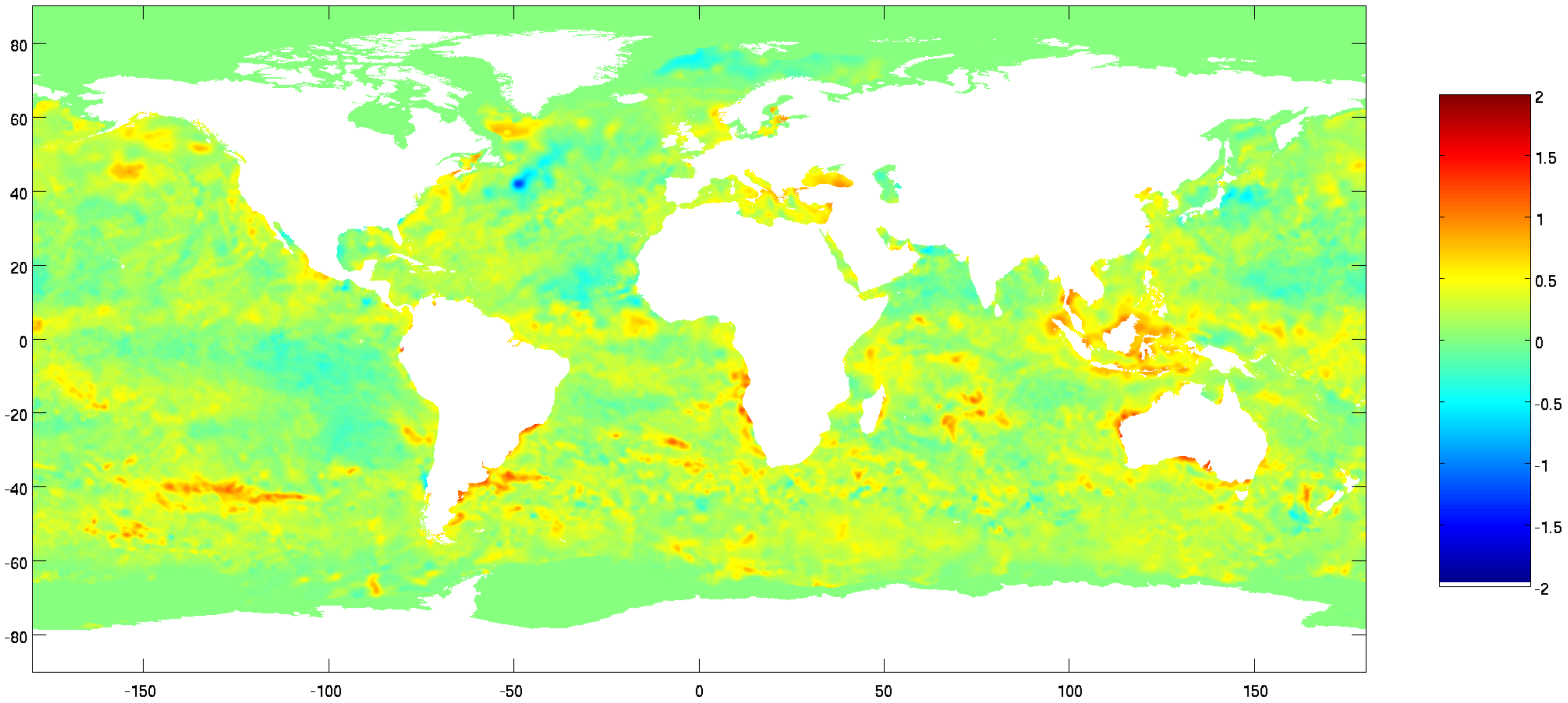


Bias for ACSPO VIIRS Day SSES Bias+SD

N.B. reversed sign *cf.* previous bias correction plots

Key Results/Accomplishments

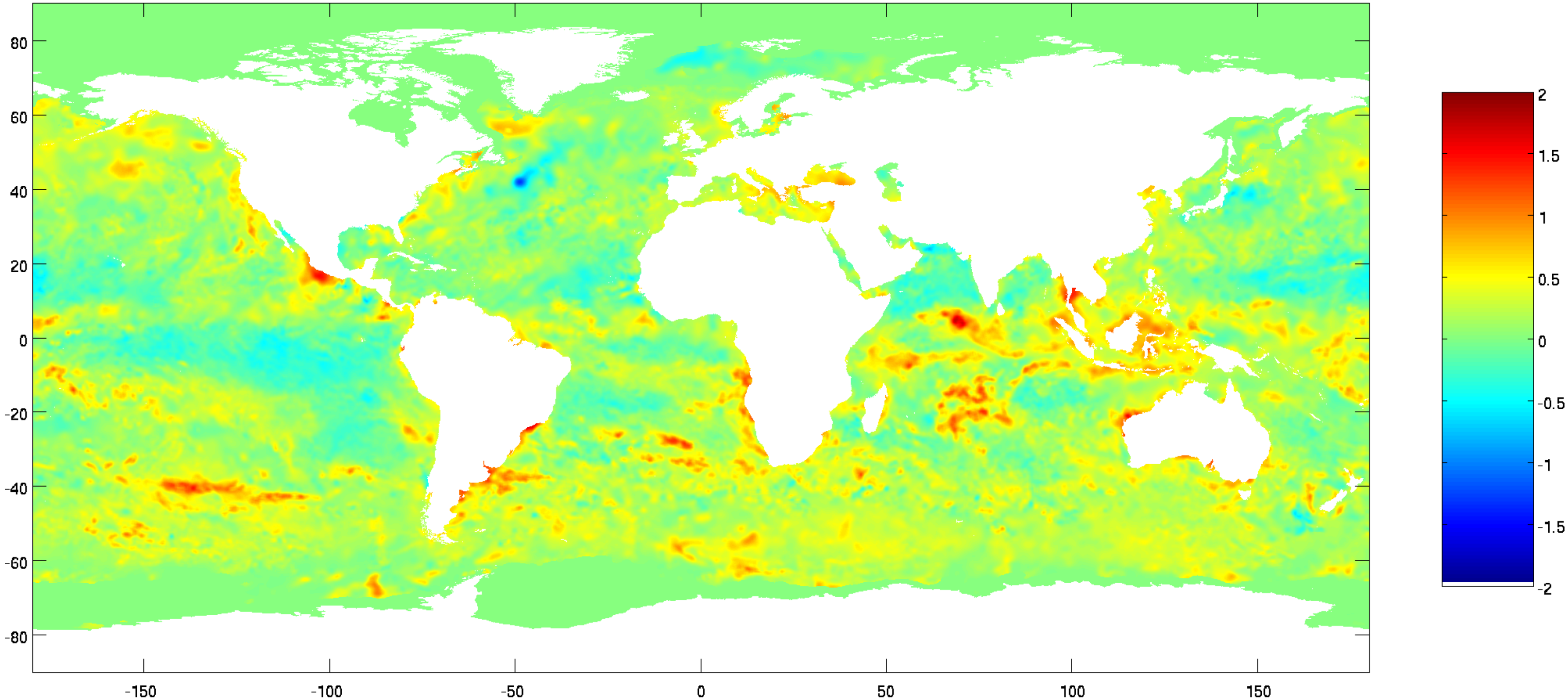
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO VIIRS Day SSES Bias

Key Results/Accomplishments

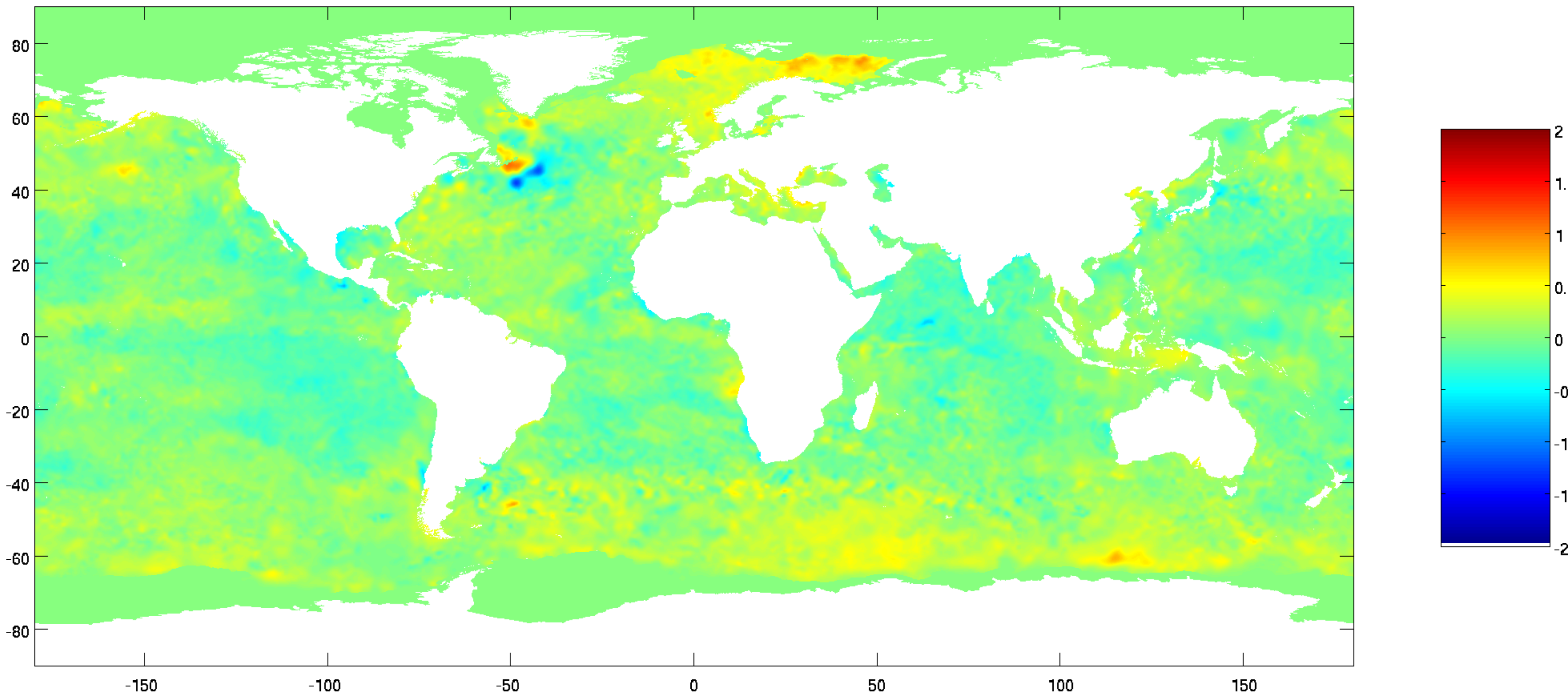
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO VIIRS Day No SSES

Key Results/Accomplishments

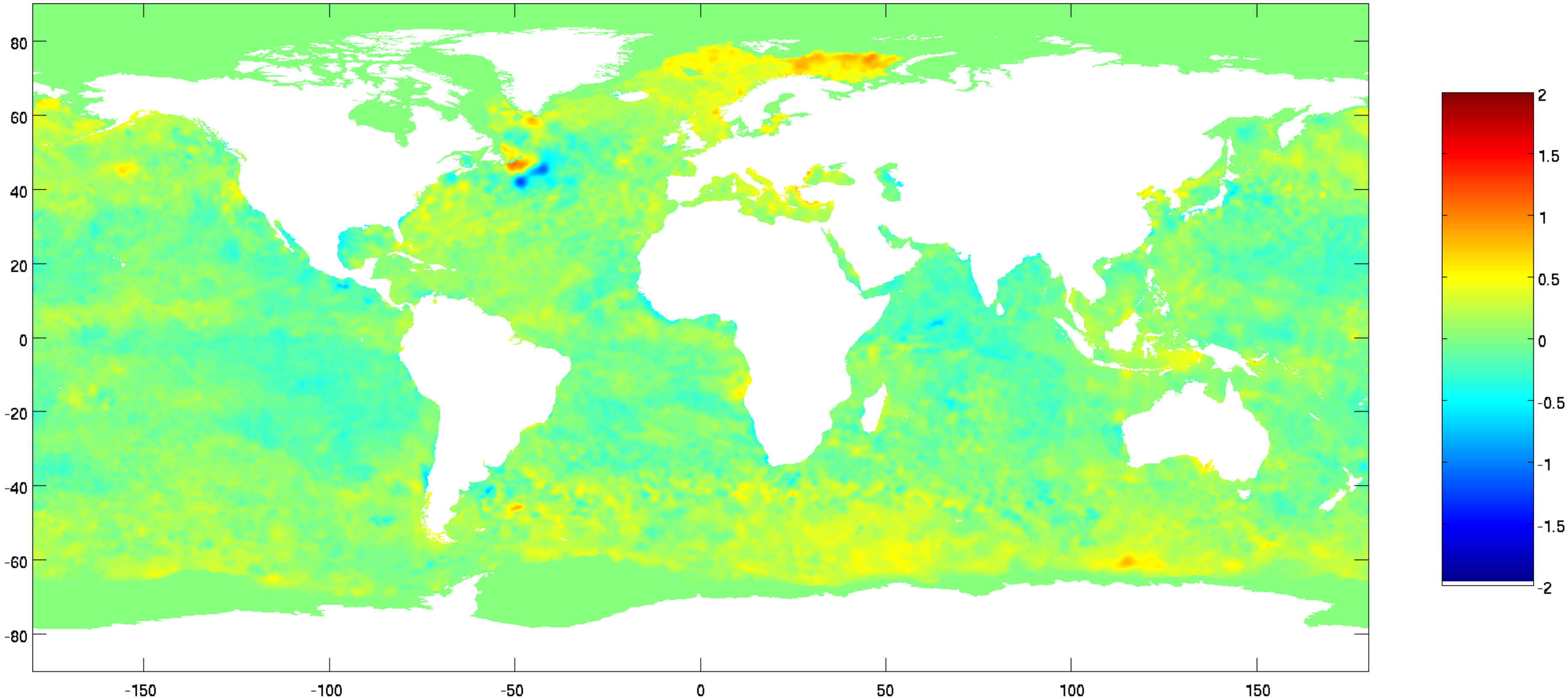
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO VIIRS Night SSES Bias+SD

Key Results/Accomplishments

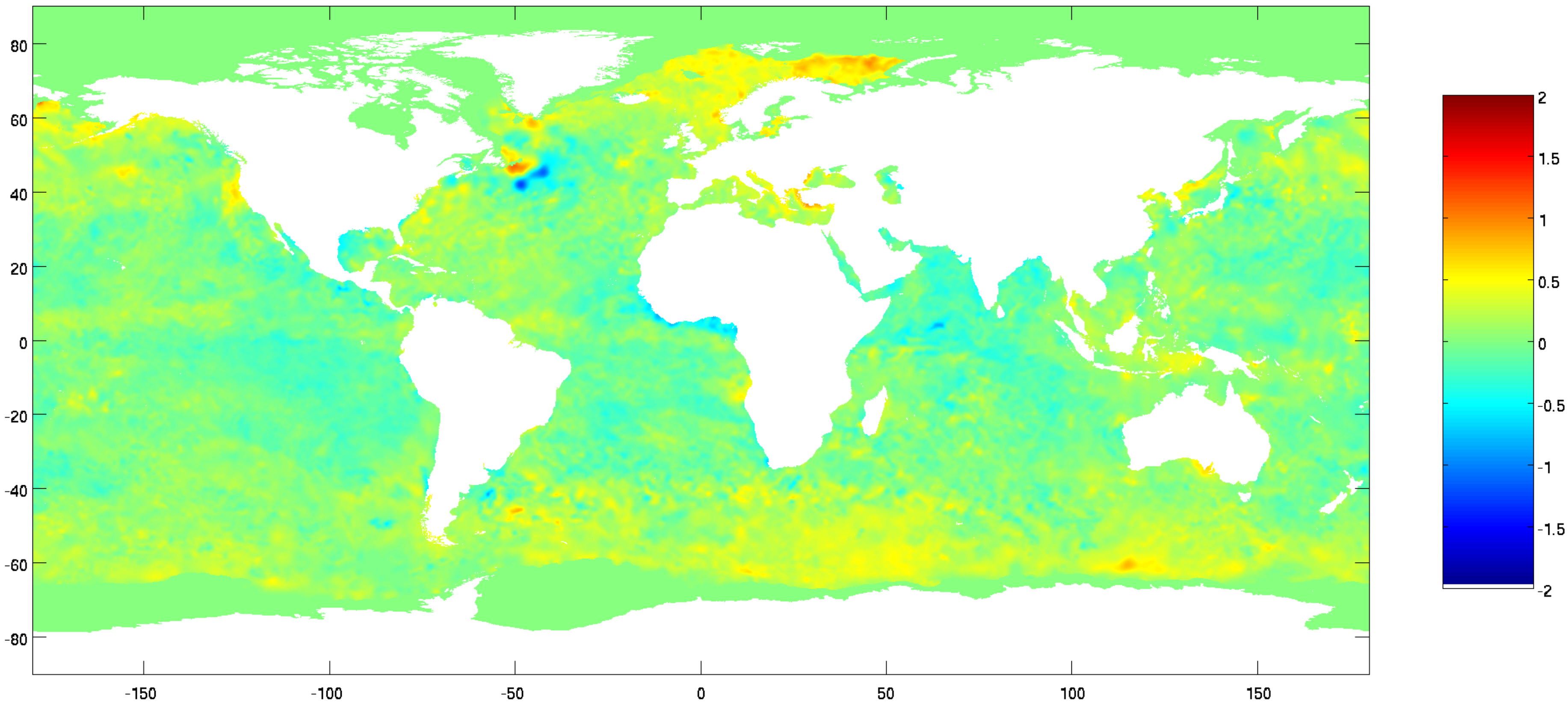
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO VIIRS Night SSES Bias

Key Results/Accomplishments

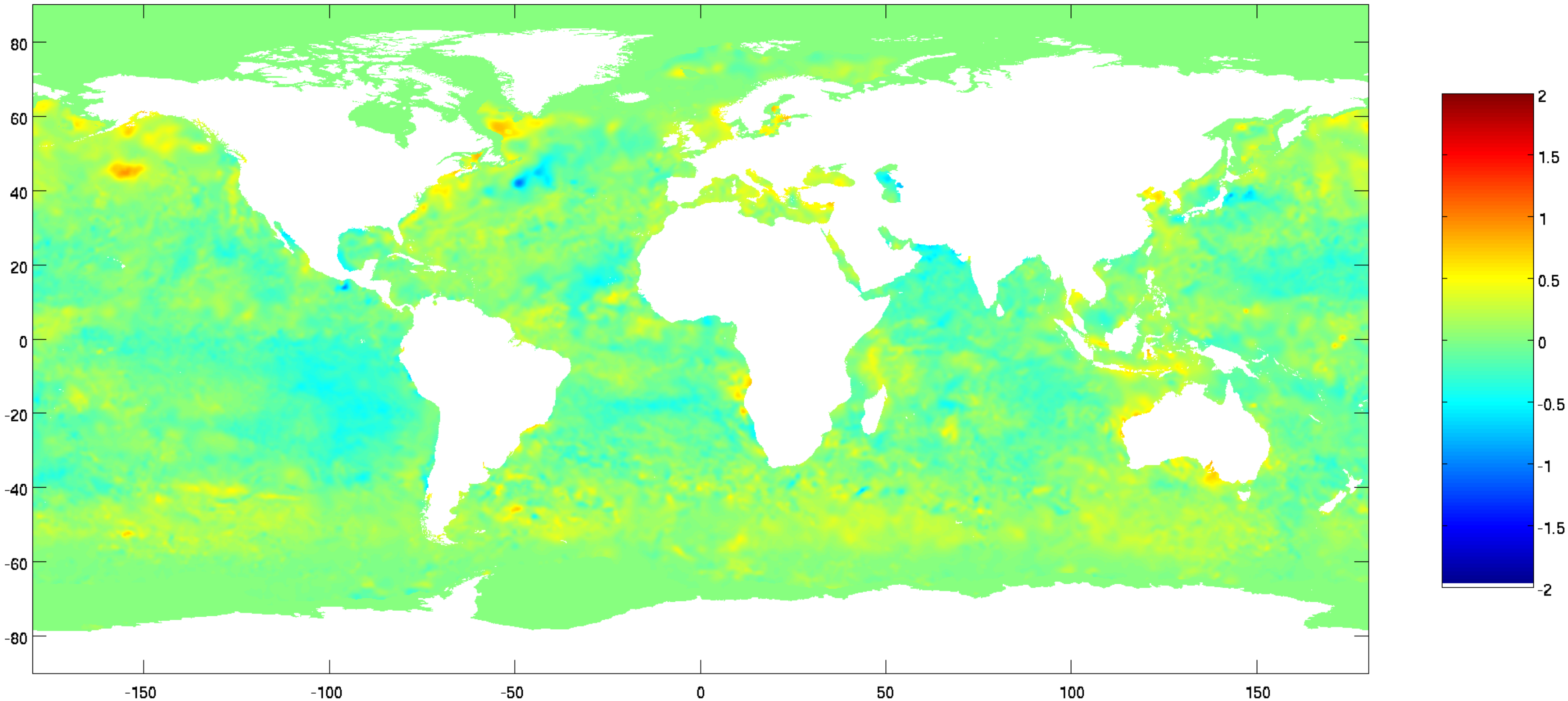
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO VIIRS Night No SSES

Key Results/Accomplishments

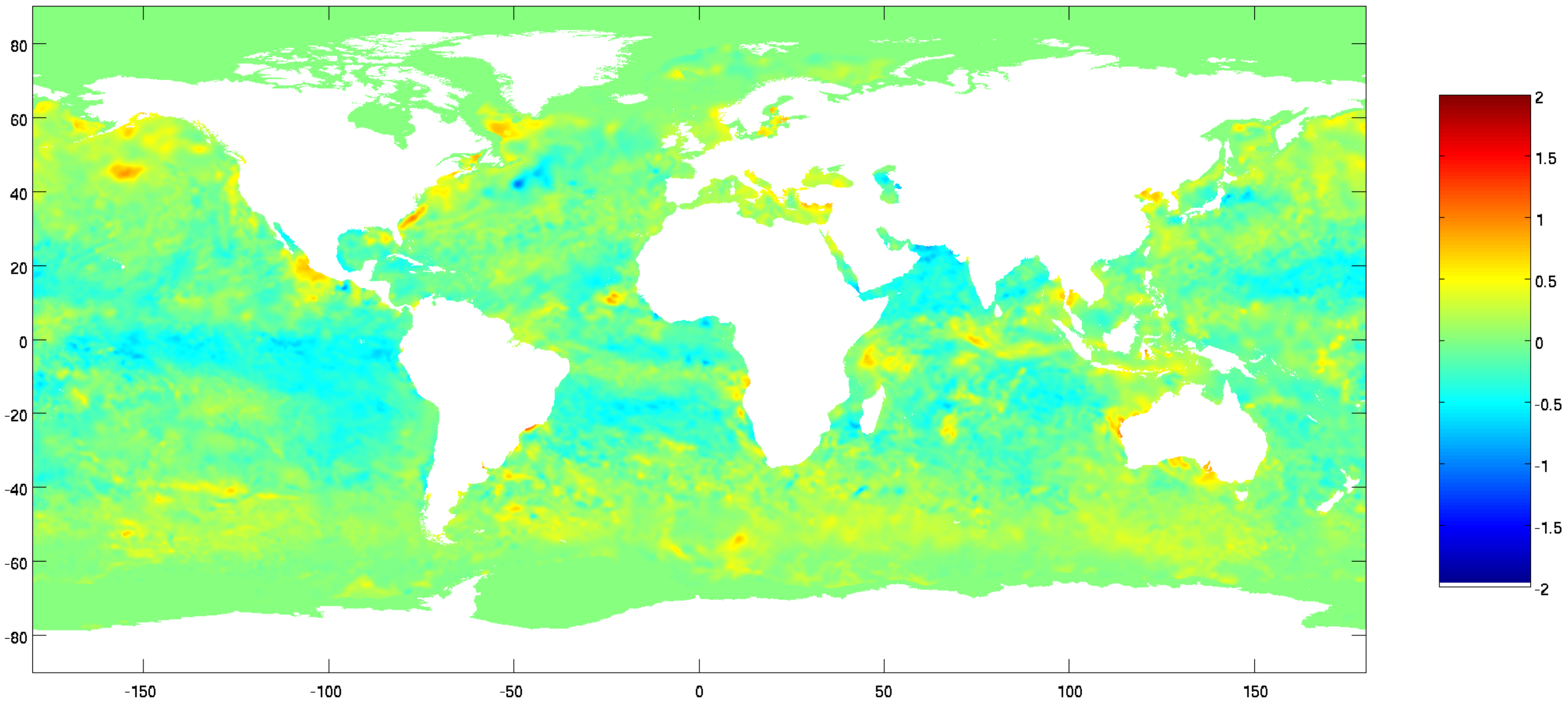
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO METOP-B Day SSES Bias

Key Results/Accomplishments

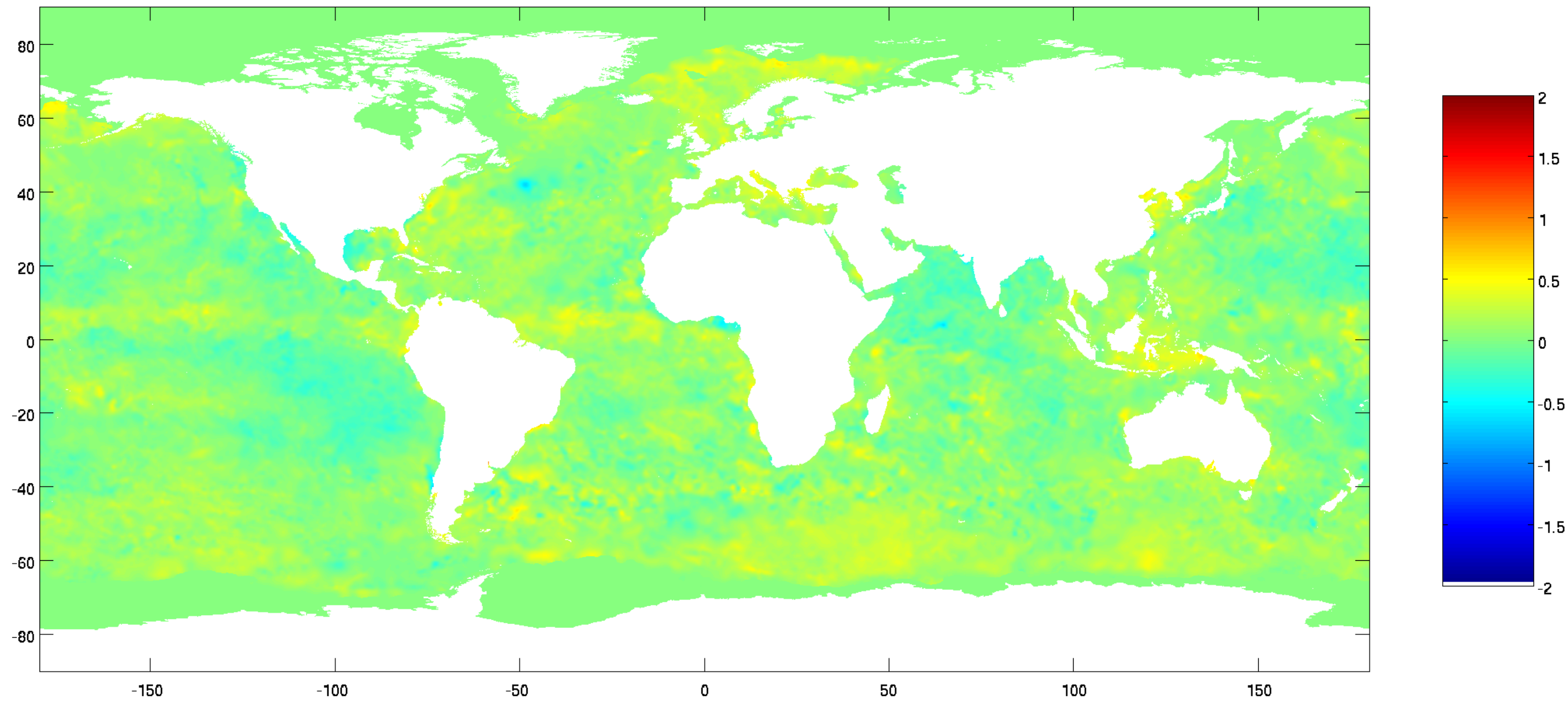
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO METOP-B Day No SSES

Key Results/Accomplishments

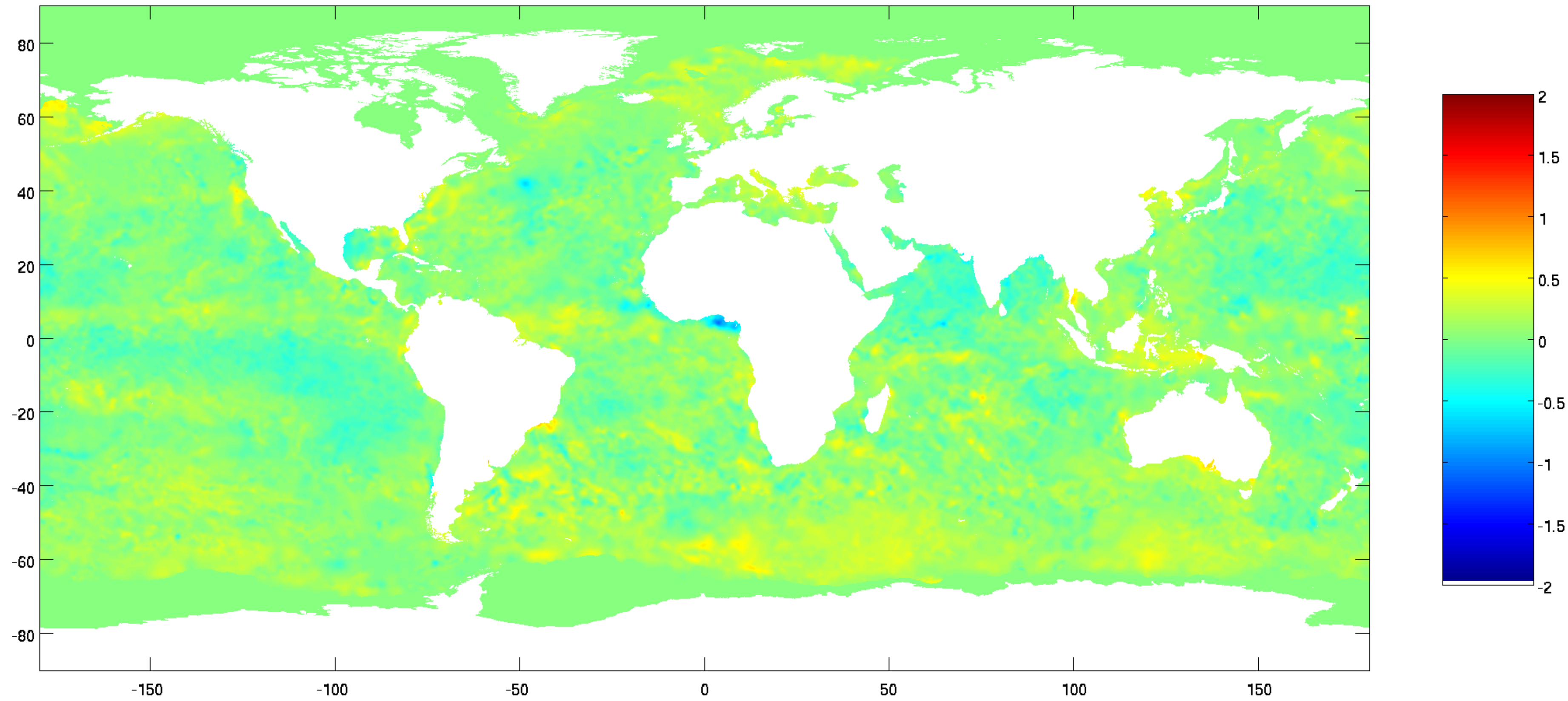
- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO METOP-B Night SSES Bias

Key Results/Accomplishments

- Compare use of Bias & S.D., Bias-only, and no SSES



Bias for ACSPO METOP-B Night SSES Bias

Points to note

- Using S.D. makes very little difference to bias
  - Not too surprising
- Biases w.r.t. reference (OSTIA) may not reduce
  - OSTIA uses OSI-SAF METOP-A nighttime GHRSST QL5 restricted swath data and *in situ* as its bias-correction reference
  - Explain reduced biases for METOP-B night *cf.* VIIRS?
- ACSPO SSES bias is adjustment to PWR SST
  - Appears to suppresses diurnal warming
  - Makes correction for residual DW difficult
  - Since PWR does not make use of wind speed, implies there are signals (at least distinct statistical groupings) in BTs due to DW
    - Interesting physics
  - Investigate nighttime VIIRS PWR SST as reference?
  - Question – is SSES S.D. effectively that for PWR SST?

Use of ACSPO VIIRS SST in OSTIA

Emma Fiedler, Simon Good

Introduction

OSTIA is the Met Office Operational SST and Ice Analysis

- L4 (gap-free analysis), global, daily
- Foundation SST (uses all nighttime observations and daytime observations only when wind speed >6 m s^{-1})
- 1/20º grid resolution
- Optimal Interpolation type assimilation scheme
- Validates well against other analyses (compared to independent near-surface Argo observations)

Introduction

Data types currently assimilated in OSTIA:

- NOAA-18 and 19 AVHRR
- MetOp-A AVHRR
- SEVIRI
- GOES-E
- In situ (ships, drifters, moored buoys)

OSTIA performs a bias-correction of satellite data to a reference dataset of all in situ data and a high-quality subset of MetOp-A AVHRR.

We are actively testing new data types for inclusion in OSTIA, including ACSPO VIIRS L3U.

Met Office

www.metoffice.gov.uk

VIIRS in OSTIA

Owing to data storage and processing limitations, it is not possible for us to use VIIRS L2P, so L3 product is very useful.

A control OSTIA run, and a run including VIIRS L3U were conducted, for a test month of March 2015.

The VIIRS data were subsampled to around 1,000,000 observations per day, giving a similar number of observations to the other data types to avoid swamping the analysis.

Other data is also subsampled as at the moment we have no need for data at a higher spatial resolution than our grid size ($1/20^o$).

Met Office

VIIRS in OSTIA

Similar to the other satellite data types, the observation error variance for ACSPO VIIRS used in the analysis is taken from the SSES standard deviation estimate.

The SSES bias estimate was removed from the observation before the analysis bias correction using the reference dataset was applied.

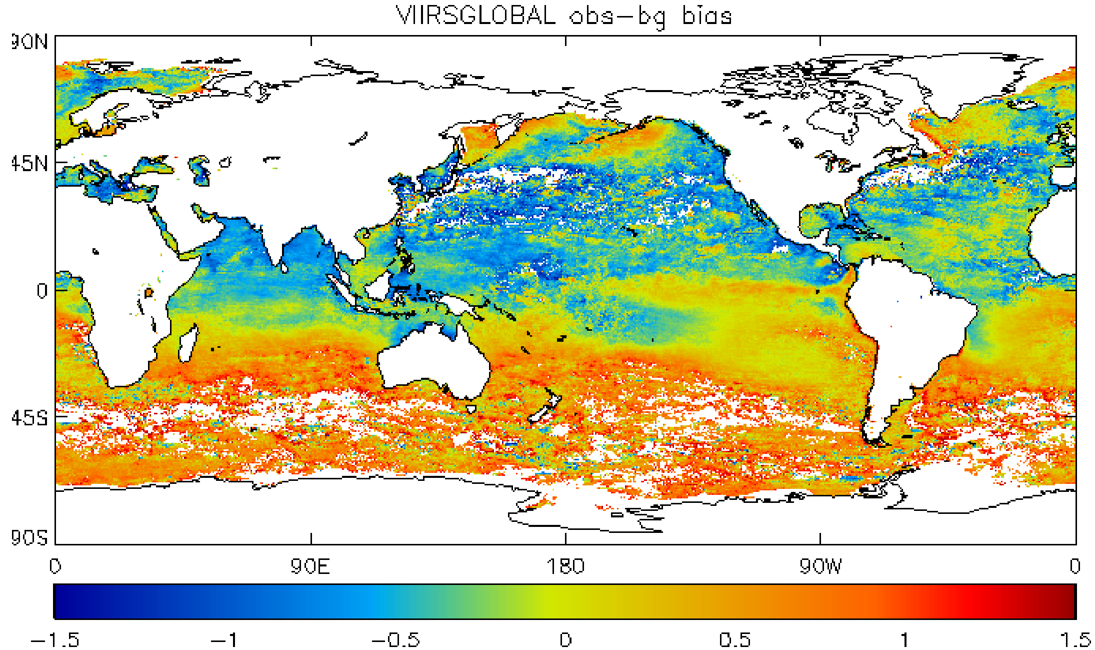
Results

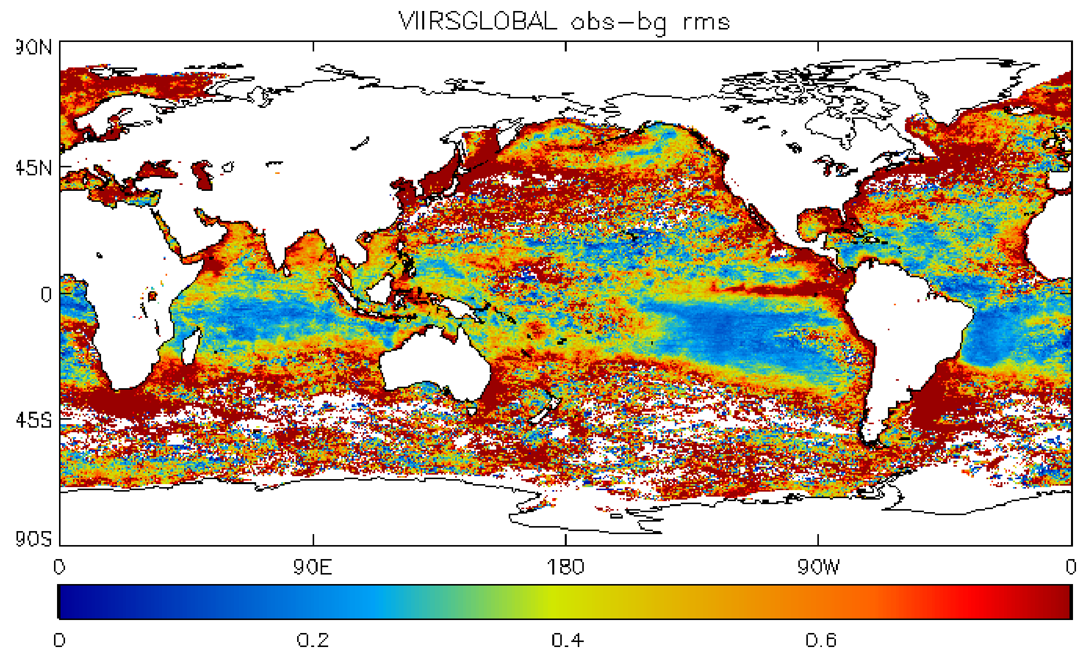
Hmm...

Observations look like latitudes have been switched around, with lots of observations rejected in mid-latitudes.

~75% of observations fail the background check, and the dataset does not improve the analysis (obviously...)

Means for March 2015, for ¼ degree grid boxes





Met Office

Next steps

• The latitude problem is being investigated – looks like this is due to a stack overflow error.

• A run investigating the effect of not using the VIIRS SSES bias will also be conducted, and daily plots of the analysis bias correction for VIIRS will be produced for both runs. It is hoped that these results will demonstrate that the application of the SSES bias will result in less work being done by the analysis bias correction.

• We would plan to include VIIRS in OSTIA at the next operational change (early 2016), pending successful testing.

Met Office

Questions?

emma.fiedler@metoffice.gov.uk

NCEP Update (RTOFS, RTG)

MMAB/EMC/NCEP
JPSS meeting 08/27/2015

Carlos Lozano, Avichal Mehra, Robert Grumbine

OUTLINE

- Overview ocean modelling (RTOFS)
- Global
- Regional (Atlantic, HYCOM-HWRF, ET-WPAC)
- NCODA, RTOFS-NEMS
- Analysis: SST RTG, Ice Cover
- Recent developments: NN mapping, BGC Modeling

Five major efforts:

- *Eddy resolving ocean modeling*
- *Eddy resolving ocean initialization*

  Operational 2005 — RTOFS Atlantic

  Operational 2011 — RTOFS Global

- *Coupled modeling for hurricanes.*

  Live testing (started 2014) — RTOFS-HWRF

- *Coupled modeling for weather – Global V1.1, CFS/NEMS*

  Under development — RTOFS-NEMS, NCODA

- *Episodic tracers*

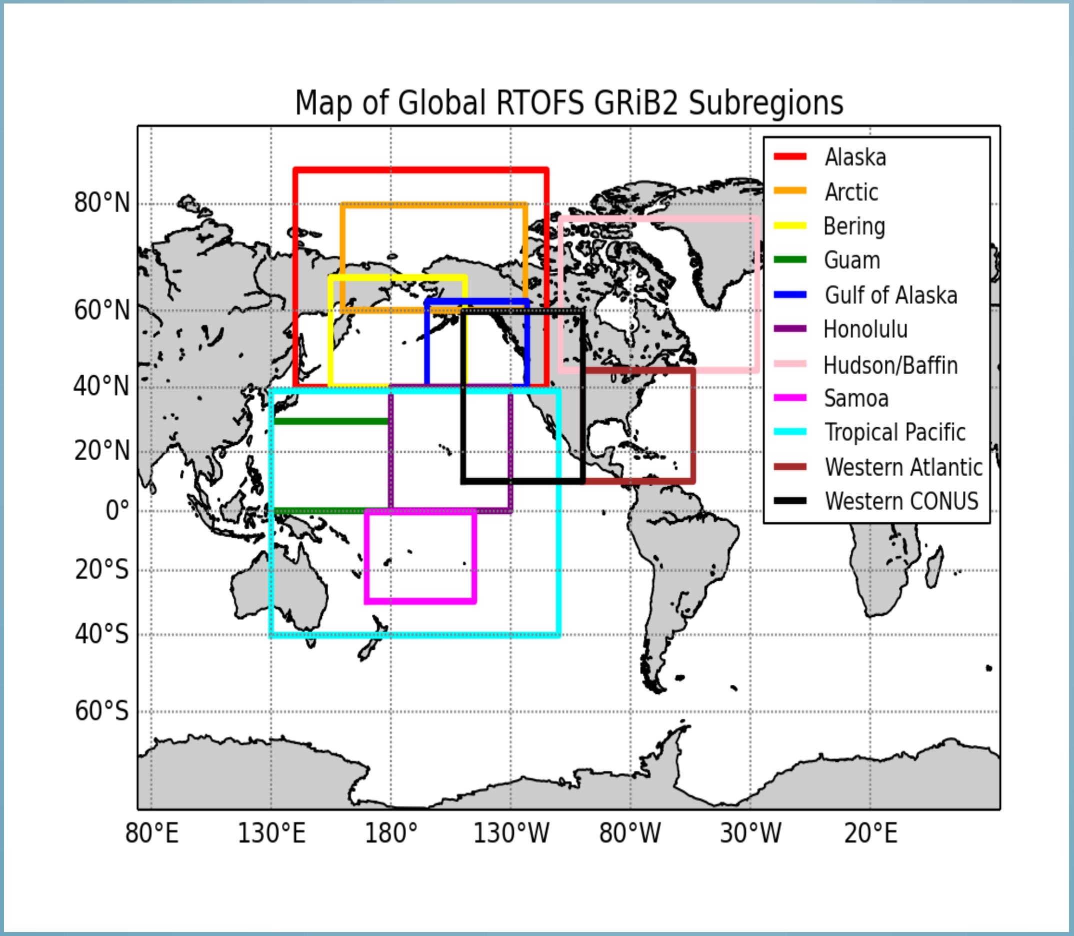
  Operational 2012, Decommissioned 2014

- *Real time ocean forecast system (RTOFS) represent line of products*
  - *HYCOM is underlying numerical ocean model*

RTOFS Global Current Status

- NCEP implemented RTOFS-Global v1.0 in operations on 10/25/11 in close collaboration with Navy (GOFS 3.0)
- NAVOCEANO delivers initialization data daily (NCODA-3DVar)
- MMAB/EMC employs GFS/GDAS derived atmospheric fluxes.
- Multiple data distribution channels have been developed:
  - NOMADS (operational)
  - FTP (operational)
  - AWIPS (operational)

1/12 Degree Global Domain



Primary Users:

NWS:
EMC,OPC,NHC, coastal WFO's, NWPS

NOS:
CO-OPS, IOOS RA's, WCOFS

OAR:
OWAQ, AOML/HRD

DHS:
US Coast Guard

Primary research partners: NRL, ESRL, AOML, NESDIS, JCSDA, JAEA (Japan), UMD, FSU, MSU, RSMAS, INCOIS (India)

RTOFS Global v1.1.0/GOFS 3.1

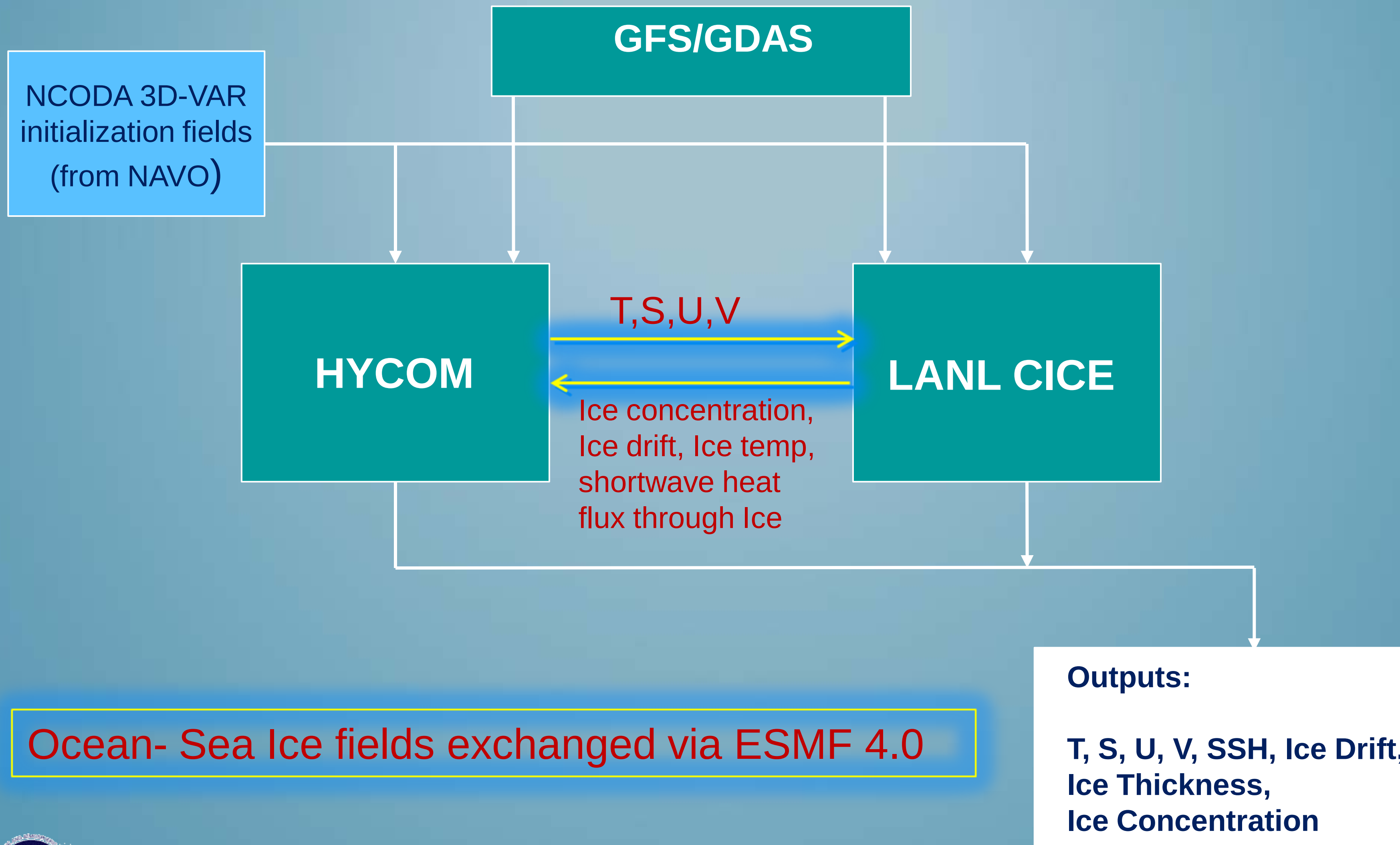
Primary upgrades:

- 41 hybrid layers (increased from 32 layers)
  - Air-Sea boundary flux improvements for coupled applications (including Hurricanes)
  - Finer resolution for mixed layer (9 additional near surface layers)
  - Improved vertical coastal resolution for downstream applications

- Two-way coupled HYCOM with Los Alamos CICE (Community ICE code) (which replaces Energy-Loan Sea-Ice model)
  - 1 hour coupling frequency
  - Using ESMF v4.0 (non-NUOPC)
  - Additional forecasts (ice thickness, ice concentration, ice drift and speed)

- Improved climatology/bathymetry

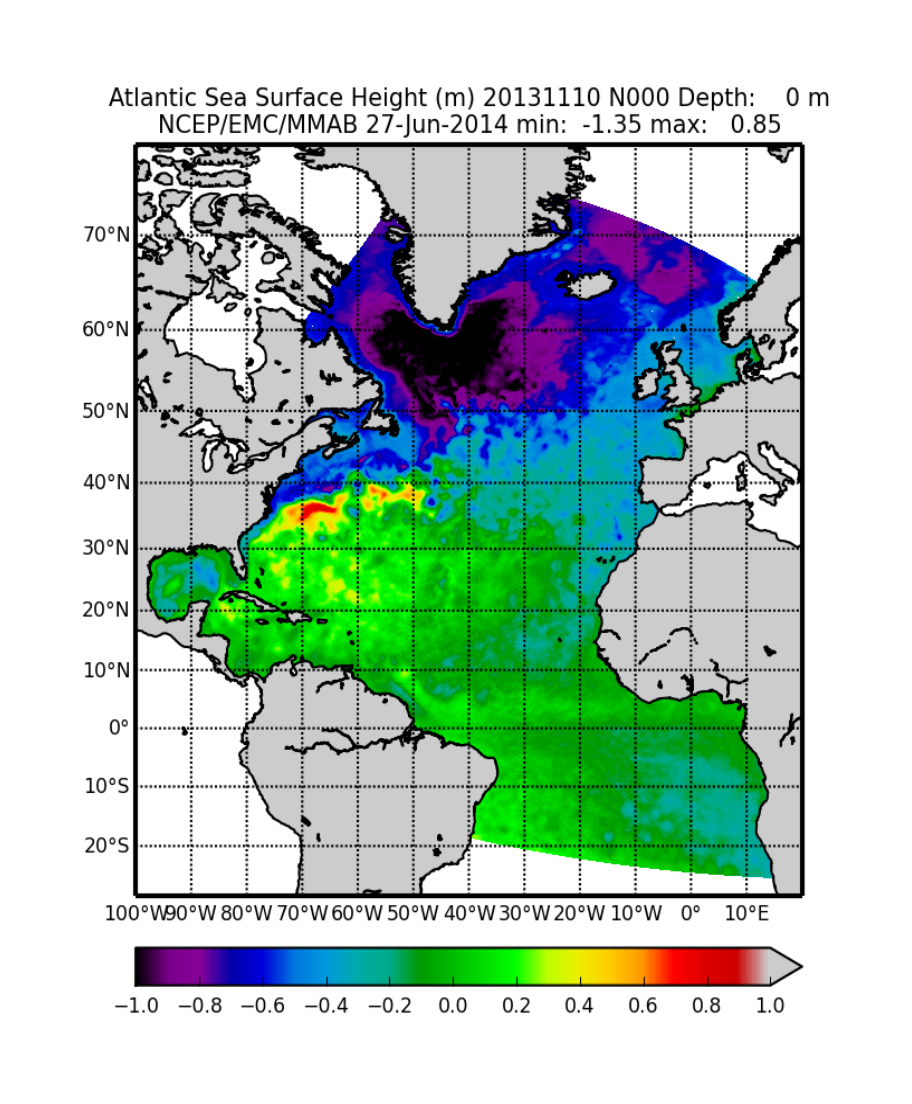
HYCOM CICE coupling



Ocean- Sea Ice fields exchanged via ESMF 4.0

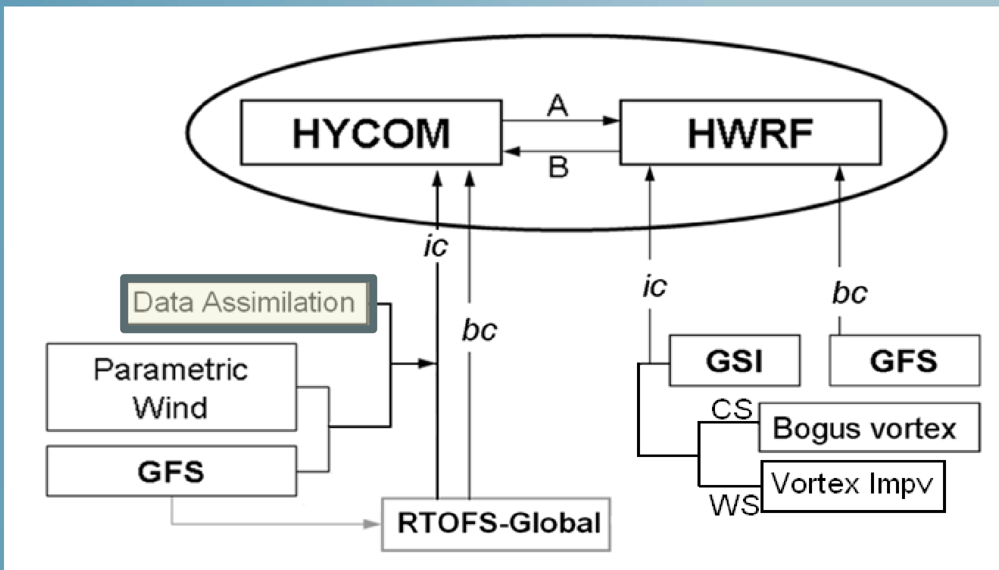
RTOFS ATLANTIC V3.0.0

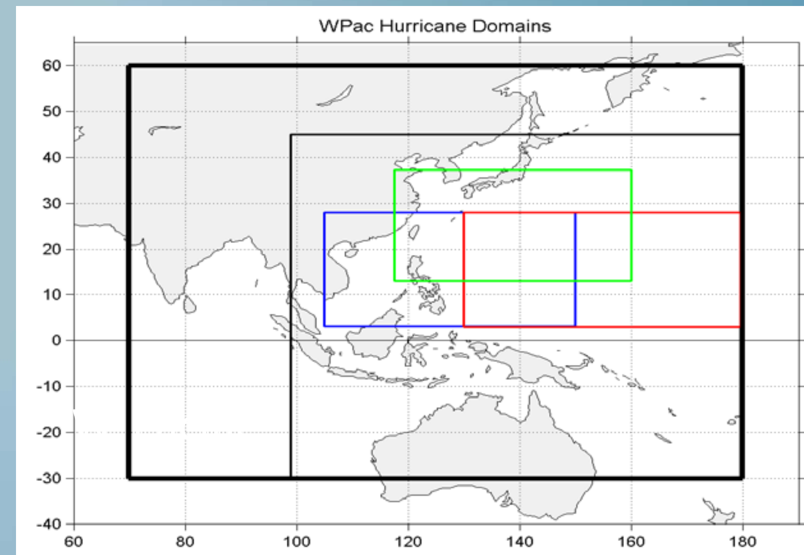
- Update codes to unify with RTOFS Global.
- Improve representation of basin geometry.
- Updates to data assimilation algorithm with new data sets for surface (SST, SSH, SSS).
- Updates to open boundary conditions to prevent drift.
- Ready to receive boundary data from RTOFS-Global.

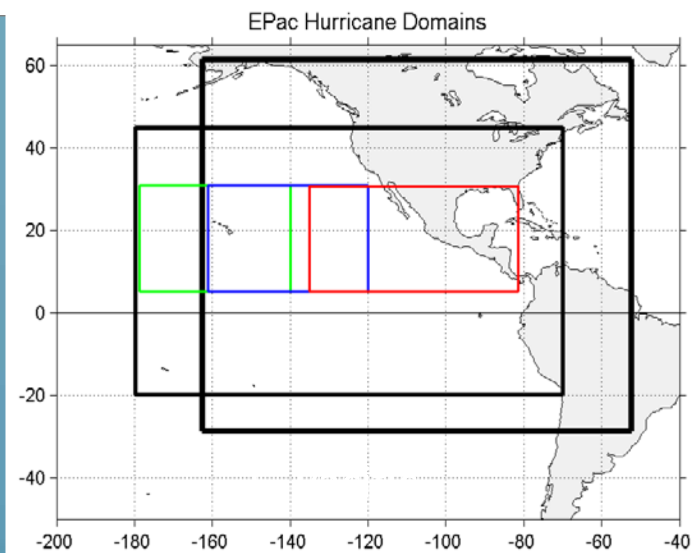


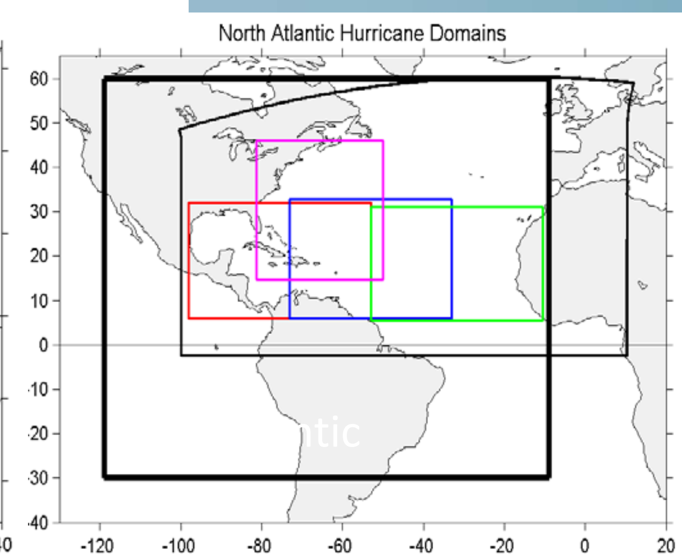
Coupled HWRF-HYCOM System

Coupled hurricane modeling with regional ocean components









Current:

Future - basin

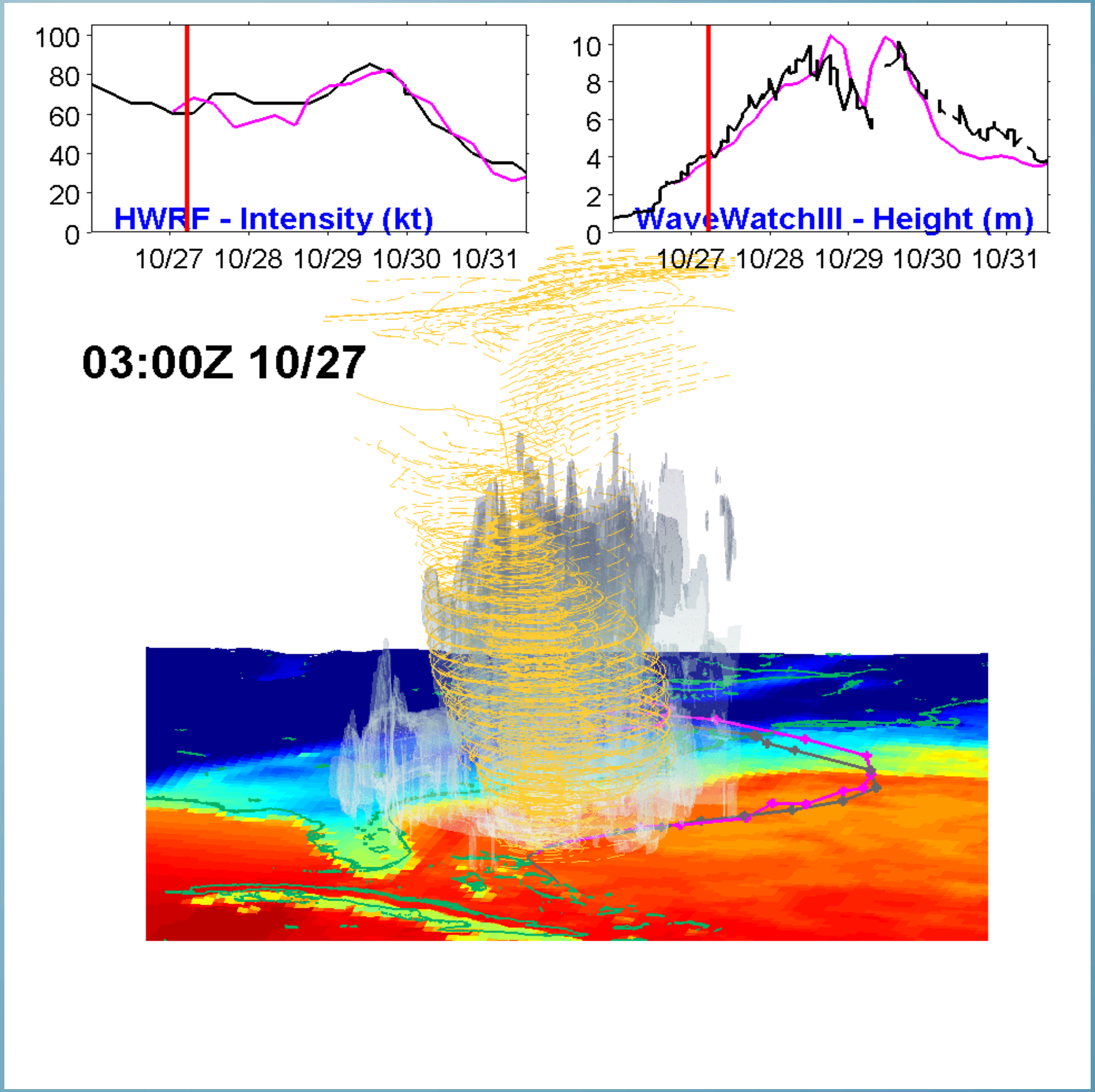
HWRF parent

North Atlantic Hurricane Forecasts

RTOFS-HWRF

Example of coupled simulation for Sandy 2012

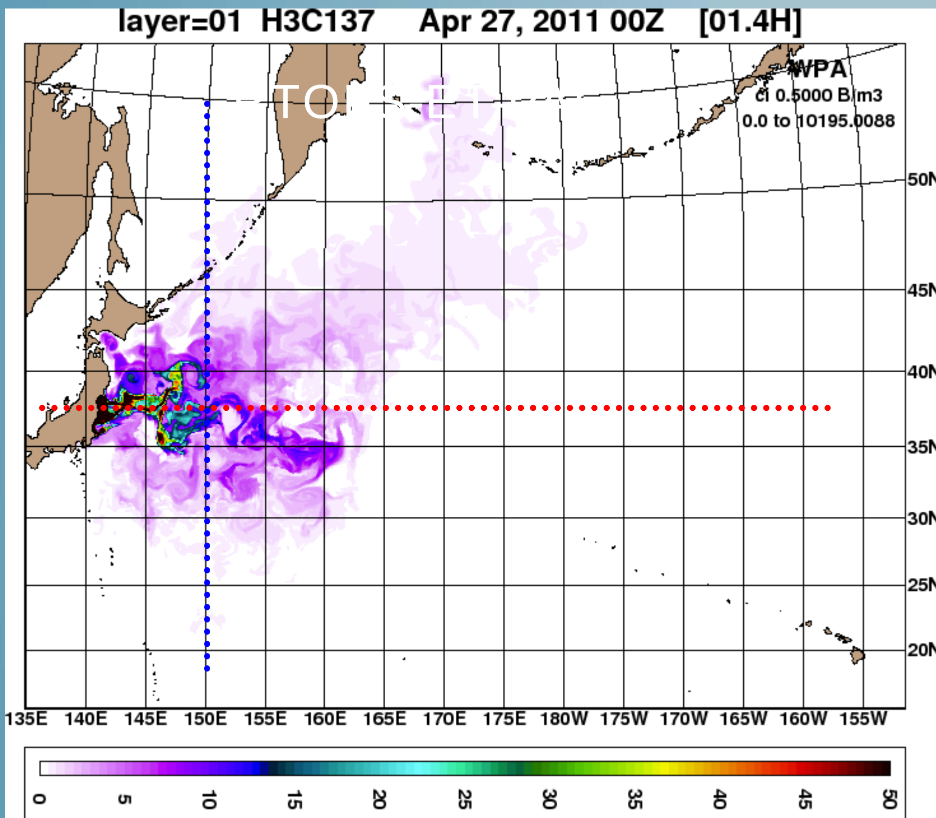
- Top left – Intensity (kt) comparison between coupled HWRF-HYCOM simulation (pink) with best track (black)
- Top right – Hs (m) comparison between WWIII (pink) and NDBC buoy observations (black).
- Bottom - HWRF-HYCOM simulation (IC=2012/10/27 00Z) , T. of the ocean and land (color); water content (black-gray shade); vertical velocity (yellow lines); forecast tracks (pink) and best track (dark gray).

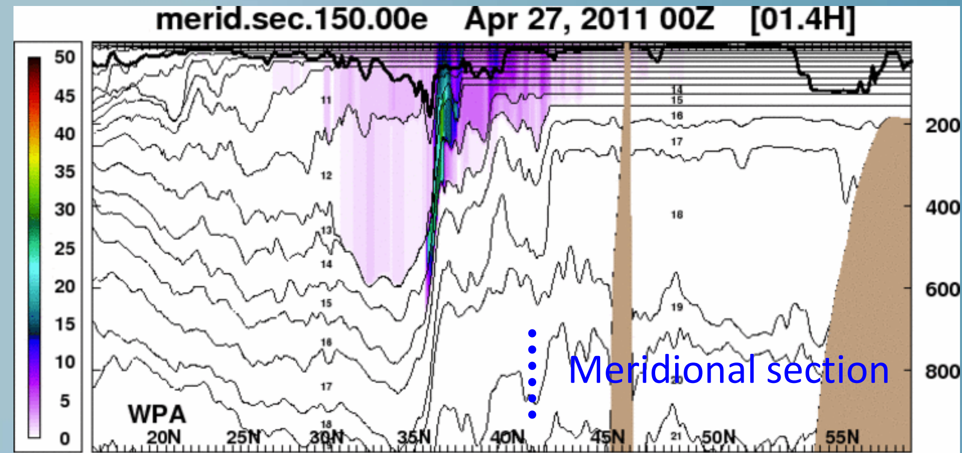


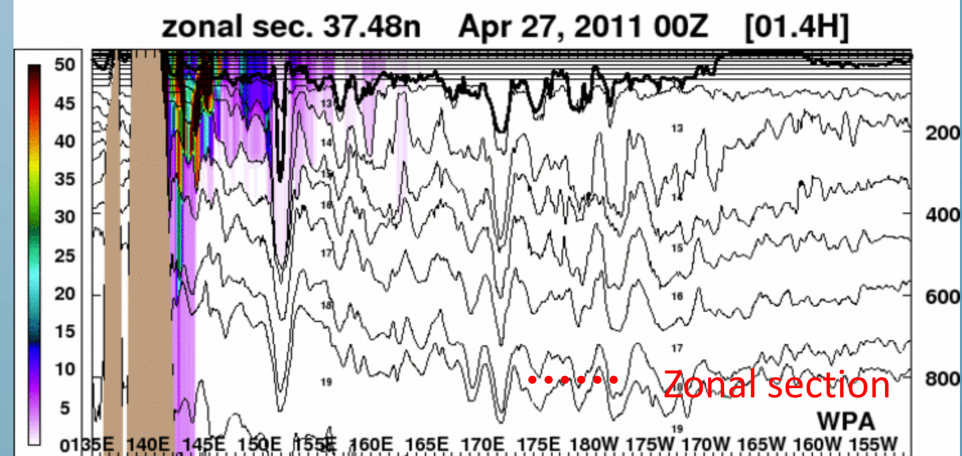
	MCL (Bq/l)	1 mrem dose (Bq/l)
^{137}Cs	7.4	33

RTOFS-ET-WPAC

http://polar.ncep.noaa.gov/global/tracers







^{137}Cs surface concentration

(scale max: 0.05 Bq/m^3 or 50 Bq/m^3)

Simulated results after atmospheric (HYSPLIT) and coastal (ROMS) sources were combined (April 27, 2011 ~ December 31, 2011) (Garraffo et al. WAF 2014)

Decommissioned on 1st April, 2014

- EMC became US government lead on ocean plume modeling for Fukushima Dai'ichi ocean issues.
  - CONOPS to rapidly generate actionable information for decision makers.
  - Prototype for emergency response and ecosystems modeling
    - Active ongoing research collaboration with JAEA
    - Repeat experiments with improved sources of radiation

NCODA

- As part of the Navy-NCEP collaboration Navy's NCODA (3Dvar) will be used for NCEP ocean forecast systems
  - Initially for RTOFS Global
  - 3DVAR, seven overlapping regions
  - Configure to use NCEP data tanks and data streams.
  - Tentative implementation FY 2016.
  - Add new observations in the future (e.g. SSS, HF Radar)
  - Next step: NAVY-NCEP joint DA development work.

- Progress on RTOFS-NEMS
  - HYCOM coupled to GSM/GFS using ESMF NUOPC layer (with ESRL, GFDL and Navy)
  - Initial testing of the coupler ongoing for ¼ º global model
  - Mediators/connectors also being built for Sea Ice, Waves and Land
  - Feasibility of RTOFS-NEMS in GFS or CFS context for future operational applications.
    - Working with global branch.
    - Weather time scales will benefit from proper seasonal characteristics too.
      - Control model drift in coupled model.
      - Coupling with WW III® , CICE, KISS
      - Explore medium-term events (MJO)
      - Proposal pending for India's Monsoon project

Assimilation of Near Real Time Satellite Sea-surface Salinity Fields: upper ocean impact

Temperature:

Employing satellite SSS tends to create general heating throughout

Salinity:

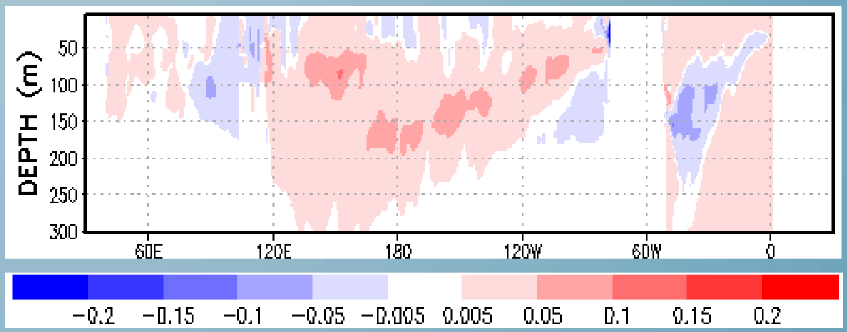
Employing satellite SSS generally freshens the Atlantic and Indian Oceans while increasing the salinity in the Pacific

Collaborators:

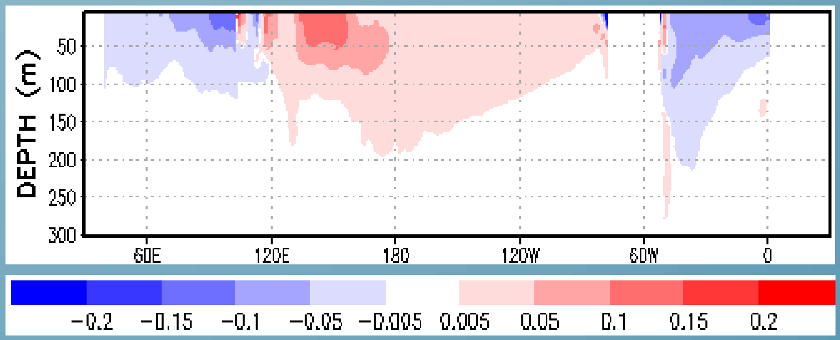
STAR-NESDIS, JCSDA, NASA

Impacts of using Aquarius V3.0 data on upper ocean (0-300m) equatorial region (5°S – 5°N)

Temperature Difference (C°)



Salinity Difference (pss)

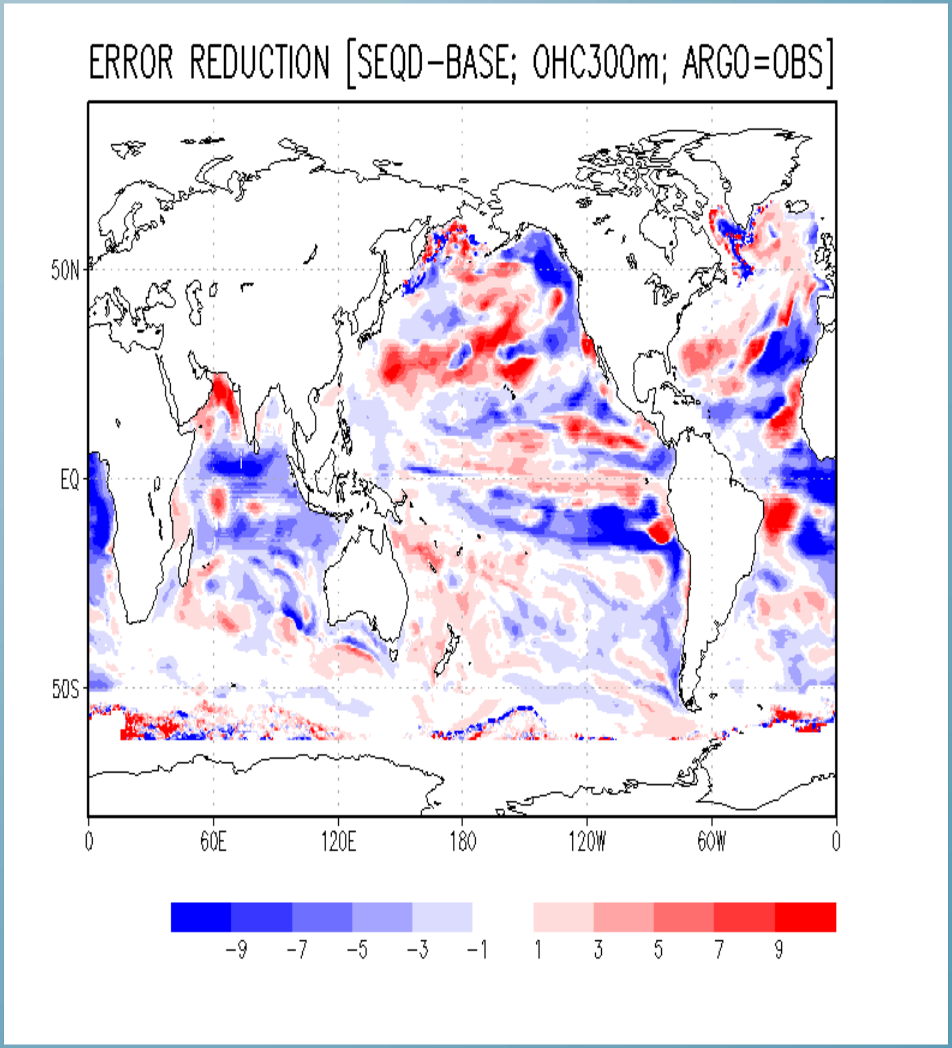


Use of near real time Ocean Color data for improved air-sea fluxes

Using composited daily SeaWiFS/VIIRS ocean color fields instead of the existing operational framework (monthly climatology from 1997-2001) reduces ocean heat content (0-300m) errors.

Collaborators:

STAR-NESDIS, JCSDA, NASA



- Global: stays at 1/12°, coupled via ESMF in NEMS
  - Resources for resolution versus resources for ensemble.
  - High-resolution for NCEP justifiable on US coasts only.
  - New data types for NCODA.
  - Better MLD, OHC, coupling with WW III® for Langmuir and Stokes mixing in ocean.
- HYCOM-HWRF
  - Continue real-time testing in 2015 season for all basins.
  - Upgrade HYCOM source code, vertical levels, expanded domains.
  - Development of data assimilation algorithms.
  - Explore coupling with WW III®.

- Basin scale models:
  - RTOFS-Arctic: New model, coupled to NMMB, Sea Ice, Waves.
  - RTOFS-Atlantic: New finer grid.
  - RTOFS-Pacific: New model for East Pacific.
- Future of basin scale models:
  - 1/24° or 1/36° resolution.
  - Nested in Global.
  - Coupled:
    - Waves for upper ocean mixing (and surface fluxes if coupled to atmosphere)
    - Ice and atmosphere for Arctic.
  - Ensemble, particular for Arctic.

SEA-ICE

- Ice Concentration
- Ice Drift
- Ice Modeling

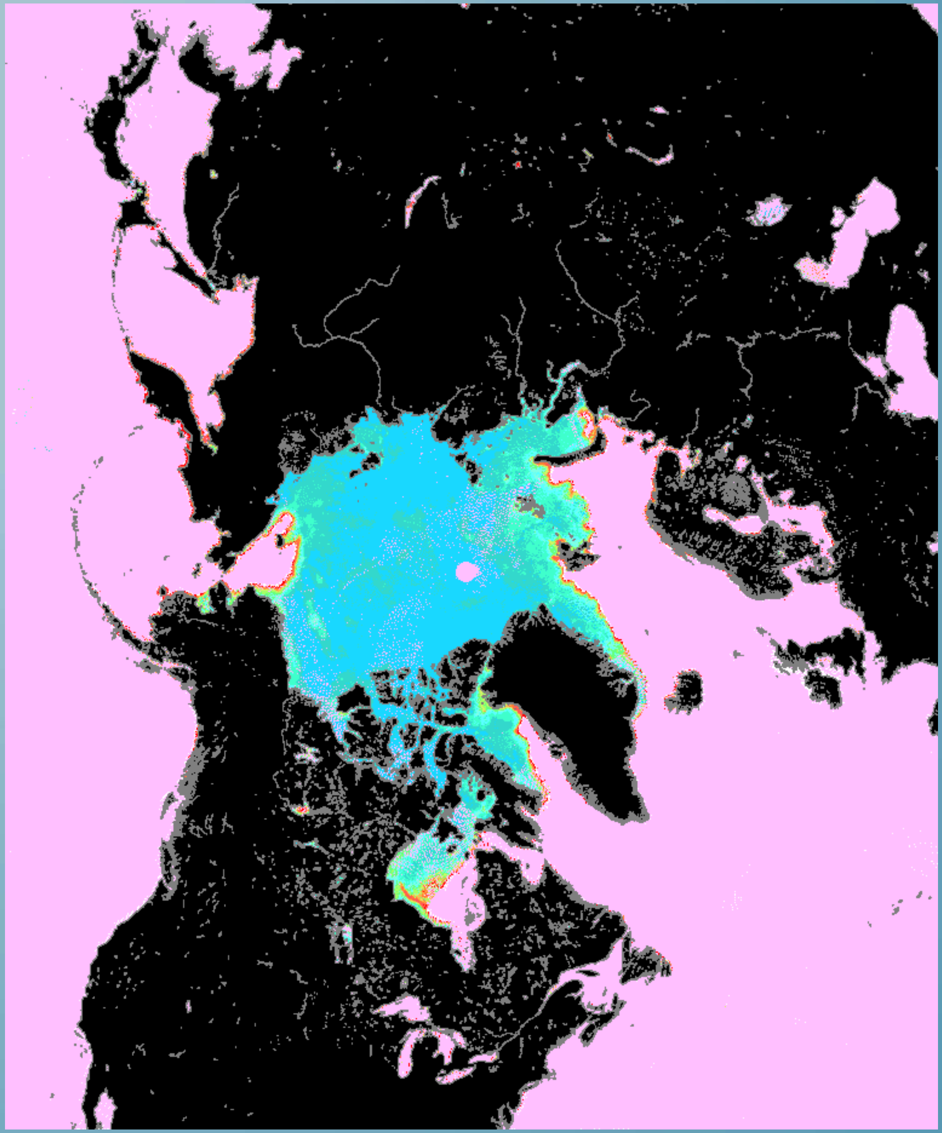
ICE CONCENTRATION ANALYSIS

Added in FY 14:

- Climatology Reference
- Use NIC IMS if overage data

Coming in FY 15:

- Adding Instruments:
  AMSR2
  SSMI/S from F-16, F-18
- Updated weather filter



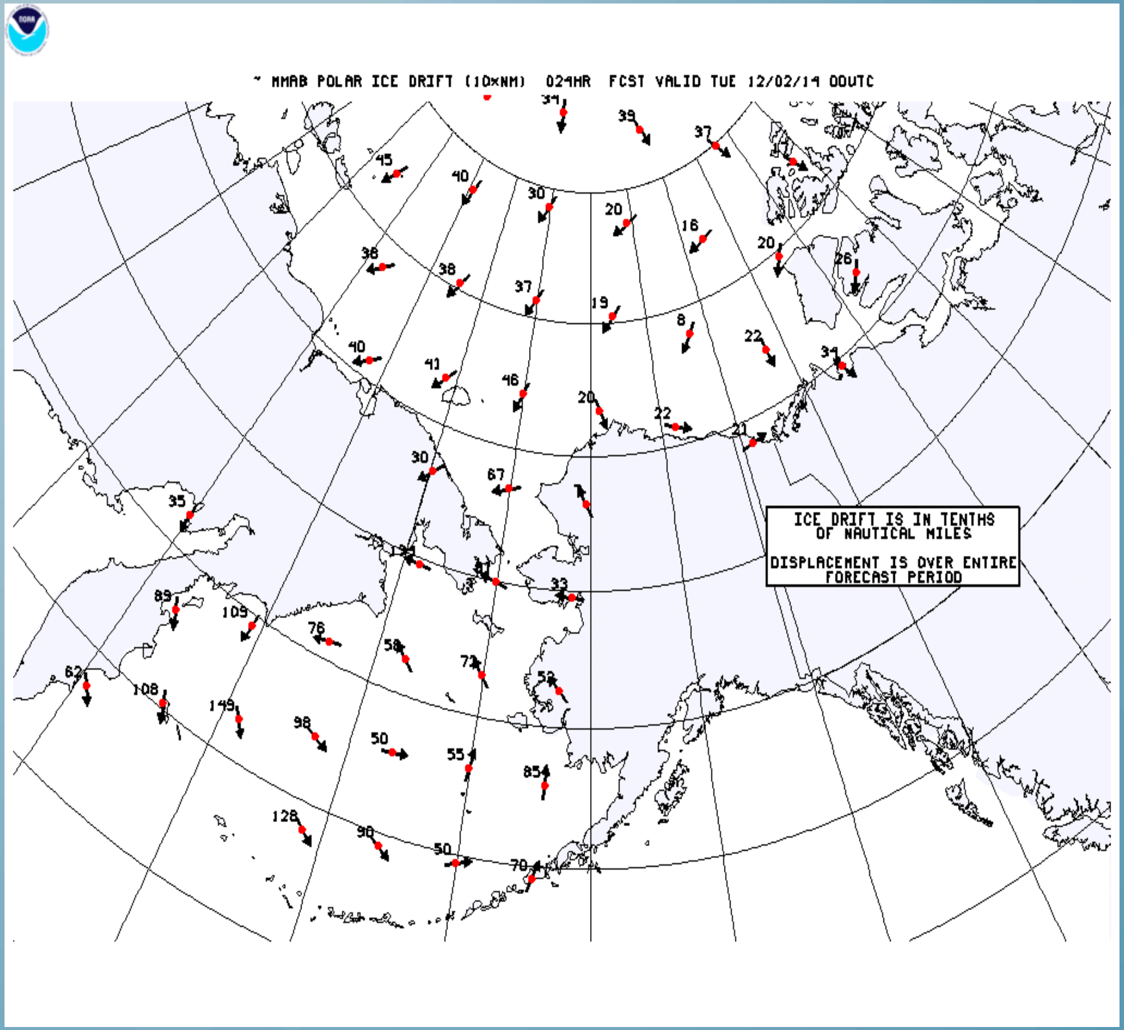
ICE DRIFT MODEL

Change in 2014:

- Now runs on GEFS
- Operational .kml output
- AR favorable evaluation

Changes for FY 15:

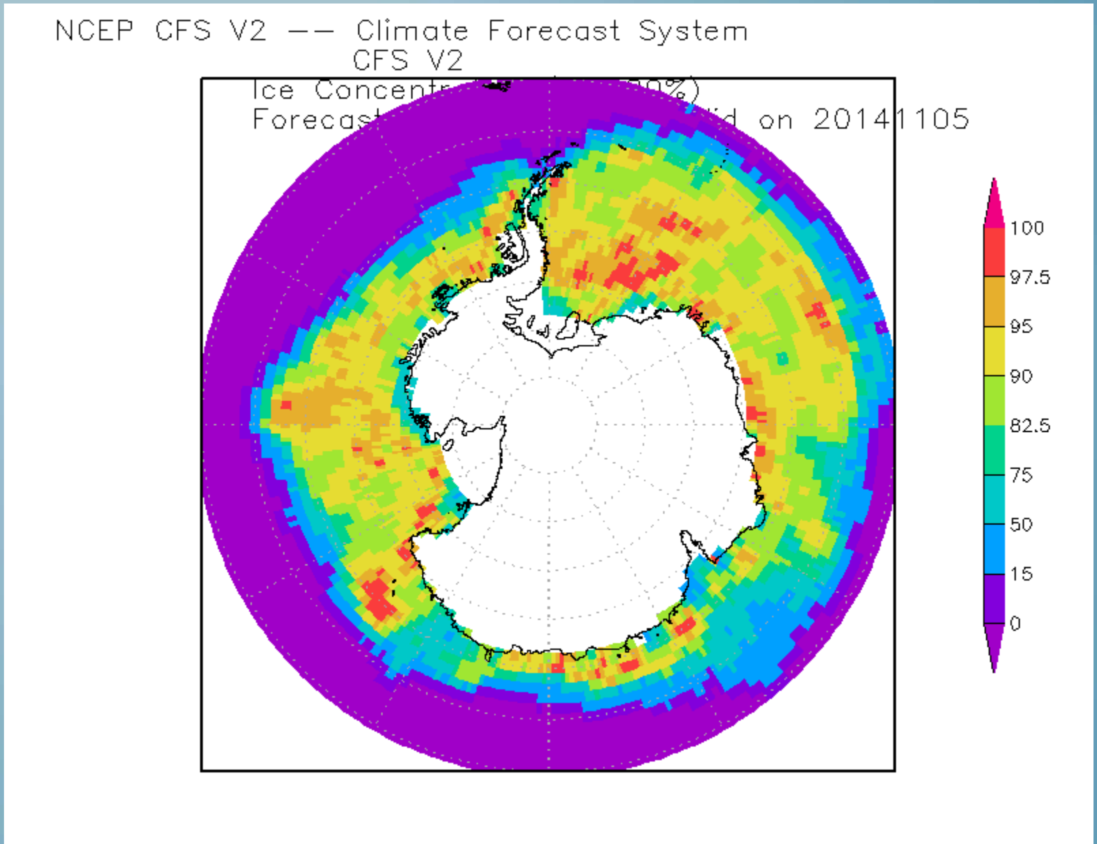
Update for new GEFS



KISS ICE MODEL

Coming for FY15:

- Thermodynamics
- Velocity plots
- NUOPC framing
- Coupled modeling tests
- Additional skill measures

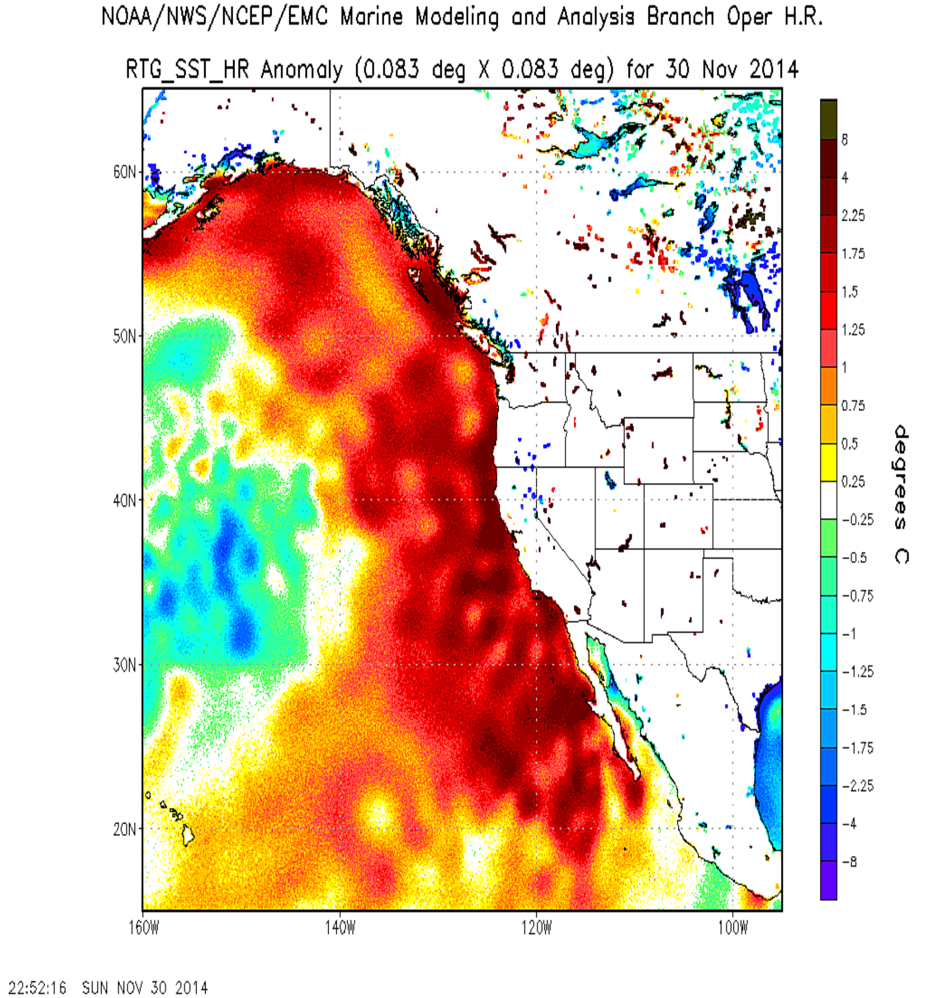


http://polar.ncep.noaa.gov/develop/icemodel
User: icemodel
Password: nansen

REAL TIME GLOBAL (RTG) SST

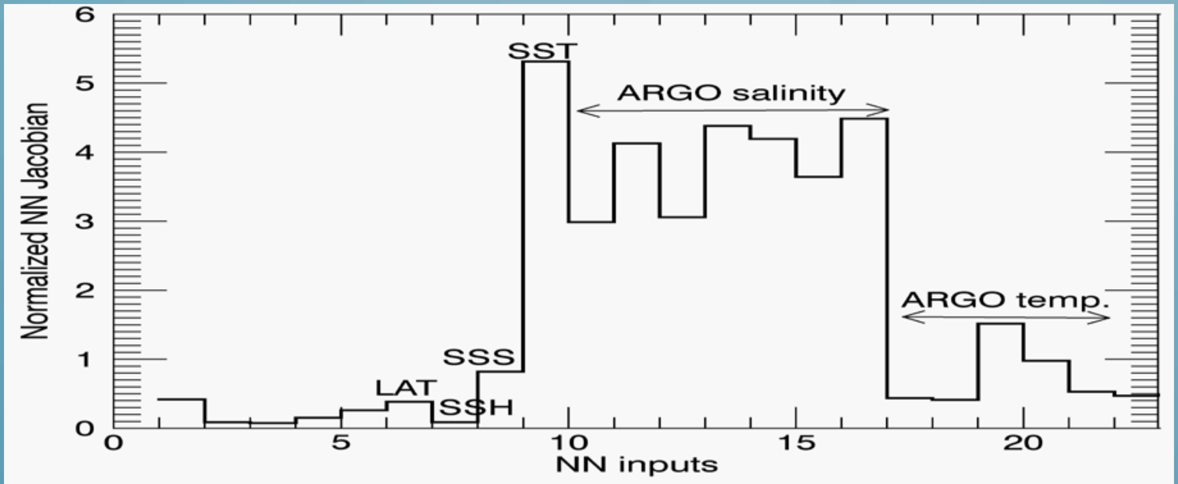
Additions for FY15:

- Updated Climatology Reference
- New Instruments:
  GOES (hourly scans)
  VIIRS (high res)
  METOP-B
  AMSR2 (Microwave)
- Updated land treatment
  (update from Weaver)

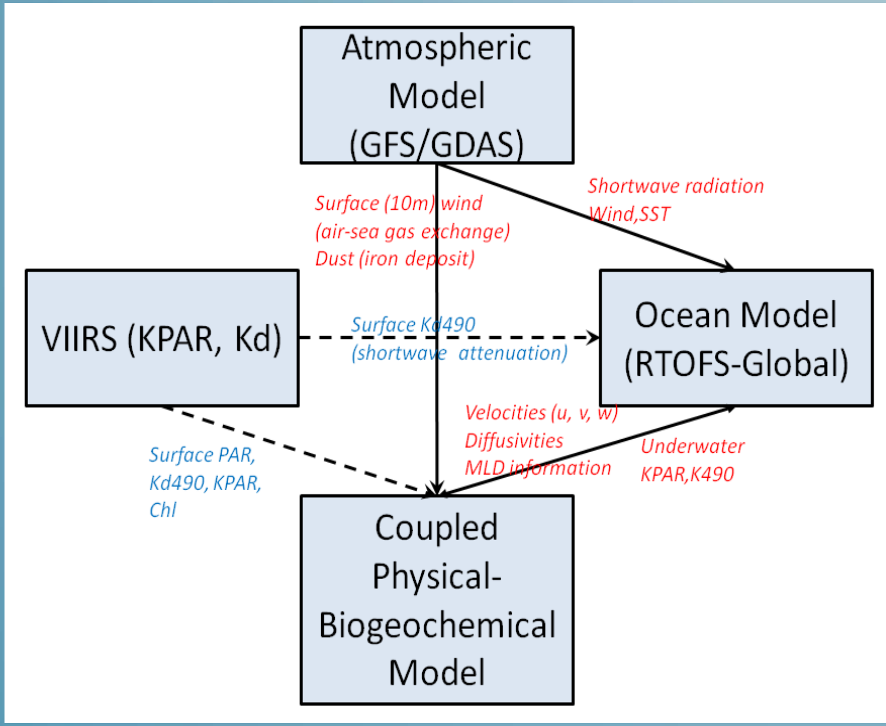


NEURAL NETWORK MAPPING OCEAN PHYSICAL FIELDS TO CHLA

- *Chla=Nnmap(SST,SSS,T&S profiles, SSH, Location, Time)*
- *Provides an accurate, computationally cheap method for filling gaps in satellite ocean color fields.*
- *Accurately estimates the seasonal cycle and large-scale spatial patterns in the VIIRS chl-a fields.*
- *Best reproduces VIIRS chl-a variability in the major ocean gyres at t mid-latitudes.*
- *The largest errors are found where the spatial scales of variability are small and the variability is large, e.g., continental shelves, coastal regions, marginal seas, etc.*



BIOGEOCHEMISTRY COUPLED TO PHYSICS (RTOFS-PHYSICS-BGC-GLOBAL)



- *A modified NASA Ocean Biogeochemical Model (NOBM) will be embedded into RTOFS-Global;*
- *NOBM has 12 ecosystem components (nutrients, phytoplankton, detritus) with 2 carbon components (DOC, DIC) for air-sea CO2 dynamics;*
- *Dissolved oxygen submodule will support Ecological Forecasting Roadmap strategy*
- *VIIRS products will be assimilated.*

See Hae-Cheol Kim Session 5 JPSS 2015 (August 25)

RTOFS-RTG

USER NEEDS & WISH LIST

- *SST high space-time coverage is needed to support data assimilation, verification, monitoring and process studies to improve operational products derived from all ocean models and analyses .*
- *Resolve coastal and inland water bodies. To support high resolution weather prediction.*

- *Physical based retrievals*
- *After a major data processing update, a revised edition of previously released data is provided.*
- *Timeliness for products supporting real time forecasting.*
- *Operational grain distribution*

Use of ACSPO VIIRS L3U SST in the Australian Bureau of Meteorology

Helen Beggs and Chris Griffin

Bureau of Meteorology, Melbourne, Australia

JPSS Annual Meeting, College Park, MD, USA, 24-28 August 2015 2015

Australian Government
Bureau of Meteorology

Background

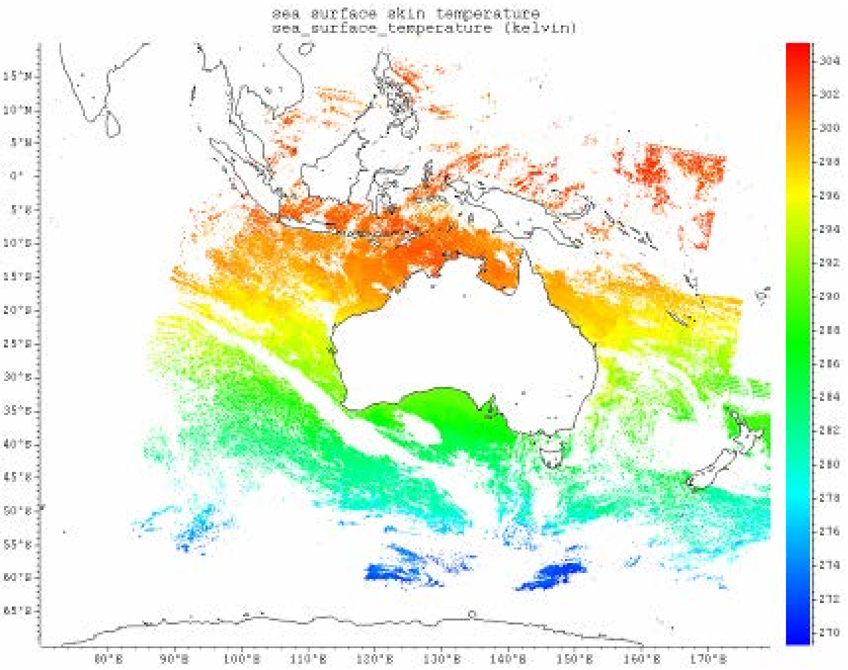
- ABoM currently uses NAVOCEANO's 9 km x 4 km global AVHRR SST data from NOAA-18/19 and METOP-A/B in operational global SST analyses and ocean models
- Need VIIRS SSTs as a follow-on to NOAA-19 AVHRR
- Unable to access VIIRS L2P SST via FTP in real-time due to high volumes so requested 0.02º gridded ACSPO VIIRS L3U files
- NOAA/NESDIS/STAR used ABoM IMOS AVHRR L2P_to_L3U code to produce ACSPO VIIRS 0.02º L3U product with grid aligned with IMOS 0.02º L3U product
- Since July 2015 ABoM has routinely downloaded ACSPO VIIRS L3U files in near real-time for testing for use in operational SST analyses and ocean models

IMOS HRPT AVHRR SST GHRSST products

http://imos.org.au/sstproducts.html

- ABoM and CSIRO have raw 1 km HRPT AVHRR data from NOAA-11 to NOAA-19 from groundstations in Australia and Antarctica
- As part of IMOS, ABoM has produced GHRSST products (L2P and 0.02º gridded L3U, L3C, L3S) over two domains (Australia and Southern Ocean) from 1992 to present
- Useful for comparison with ACSPO VIIRS 0.02º L3U SST

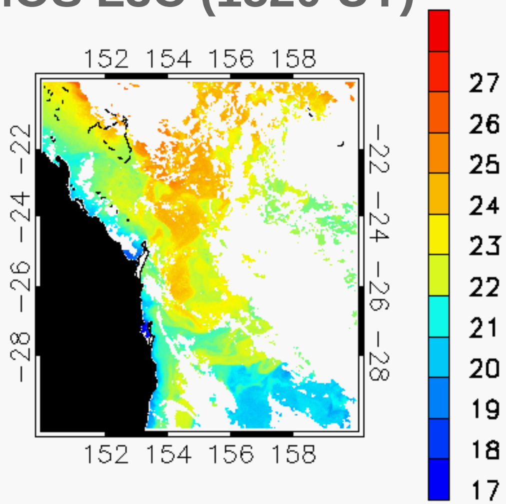
IMOS 1-night L3S



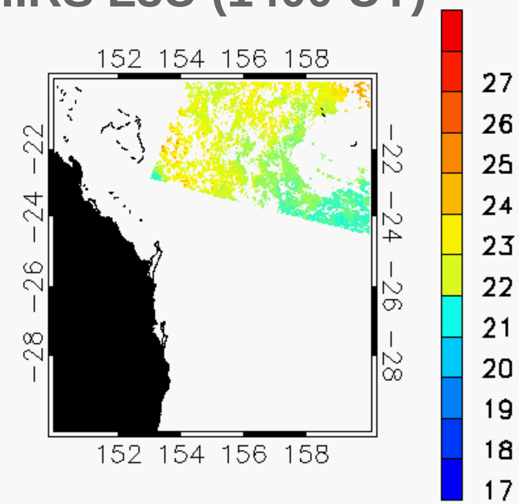
IMOS NOAA-19 fv01 L3C SSTskin vs not bias-corrected VIIRS L3U SSTskin Queensland Coast: 17 Aug 2015 Night

Australian Government
Bureau of Meteorology

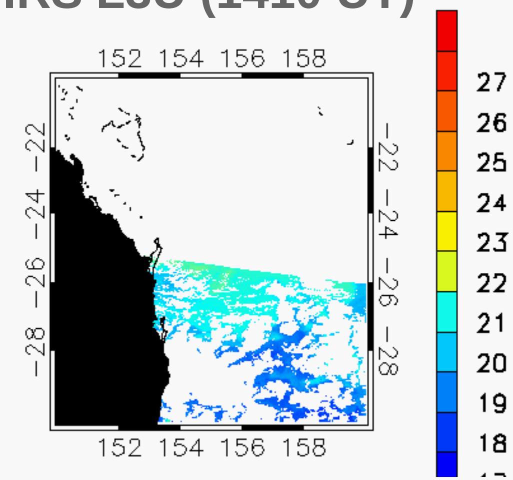
IMOS L3C (1520 UT)



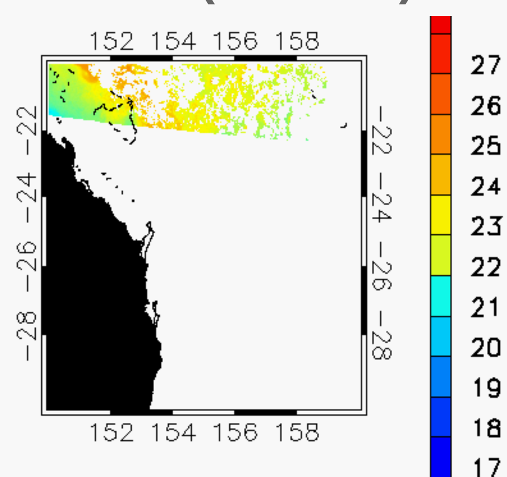
VIIRS L3U (1400 UT)



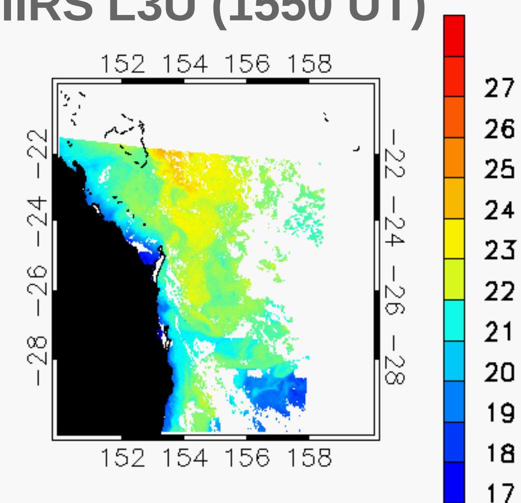
VIIRS L3U (1410 UT)



VIIRS L3U (1540 UT)

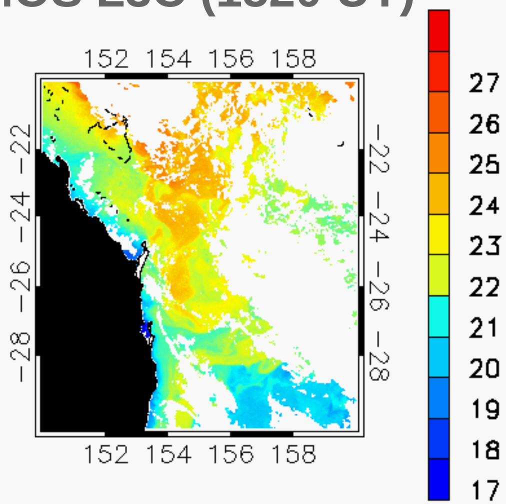


VIIRS L3U (1550 UT)

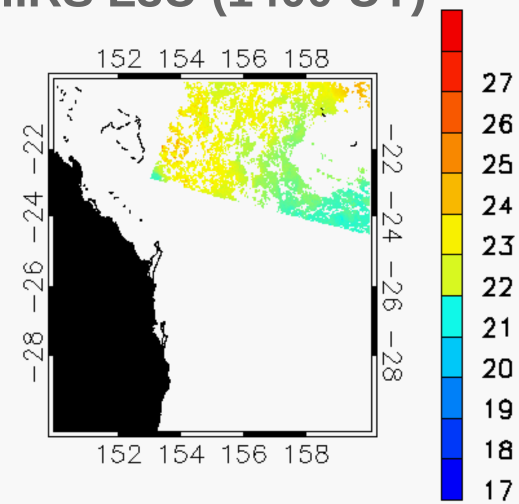


IMOS NOAA-19 fv01 L3C SSTskin vs bias-corrected VIIRS L3U SSTsubskin Queensland Coast: 17 Aug 2015 Night

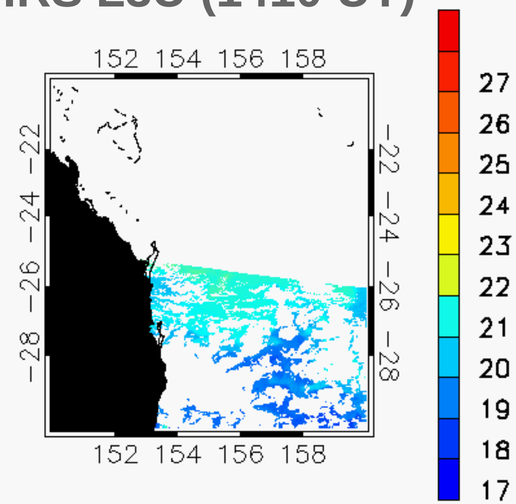
IMOS L3C (1520 UT)



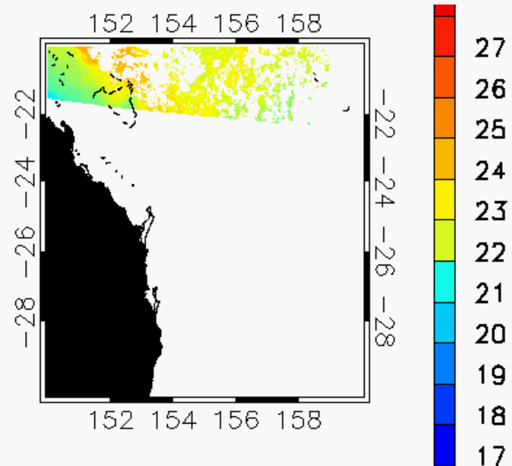
VIIRS L3U (1400 UT)



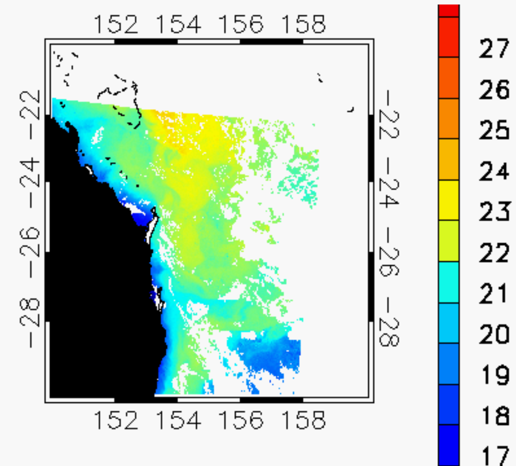
VIIRS L3U (1410 UT)



VIIRS L3U (1540 UT)



VIIRS L3U (1550 UT)

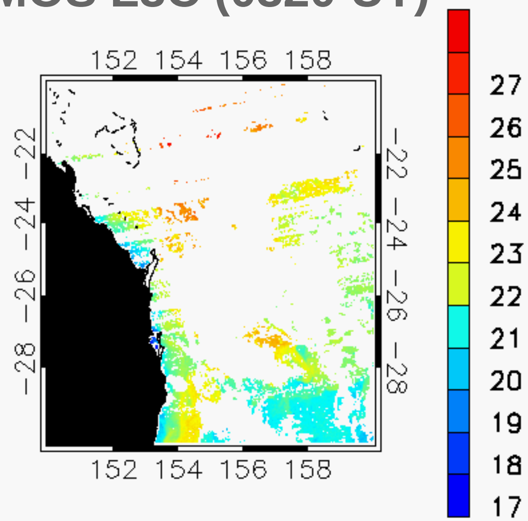


Australian Government
Bureau of Meteorology

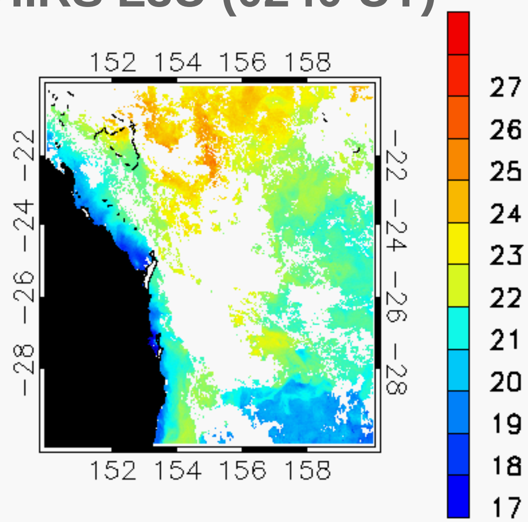
IMOS NOAA-19 fv01 L3C SSTskin vs not bias-corrected VIIRS L3U SSTskin Queensland Coast: 17 Aug 2015 Day

Australian Government
Bureau of Meteorology

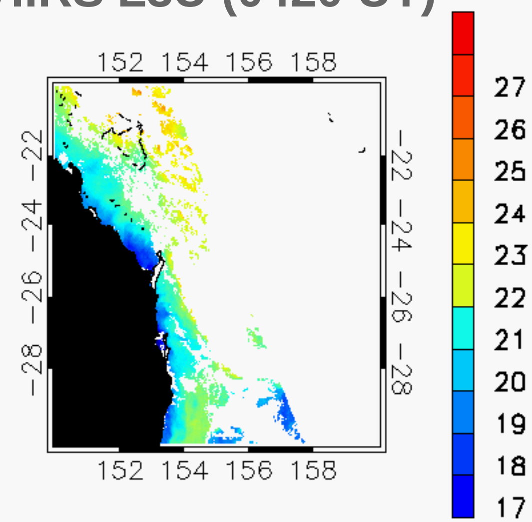
IMOS L3C (0320 UT)



VIIRS L3U (0240 UT)



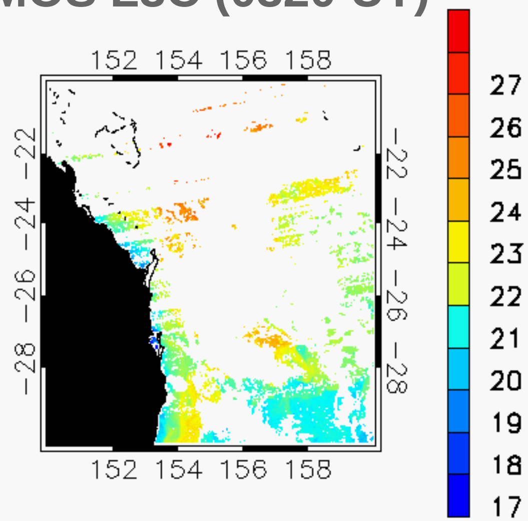
VIIRS L3U (0420 UT)



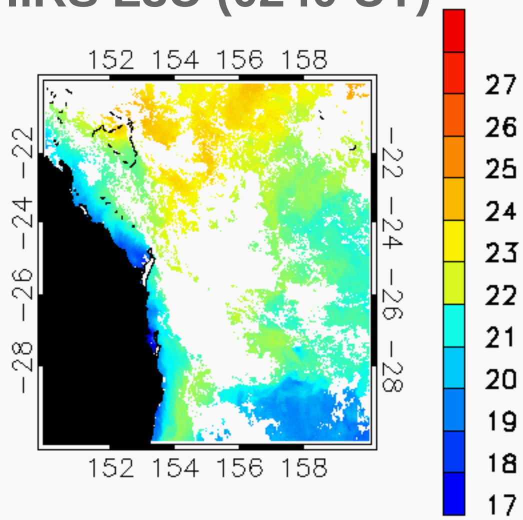
IMOS NOAA-19 fv01 L3C SSTskin vs bias-corrected VIIRS L3U SSTsubskin Queensland Coast: 17 Aug 2015 Day

Australian Government
Bureau of Meteorology

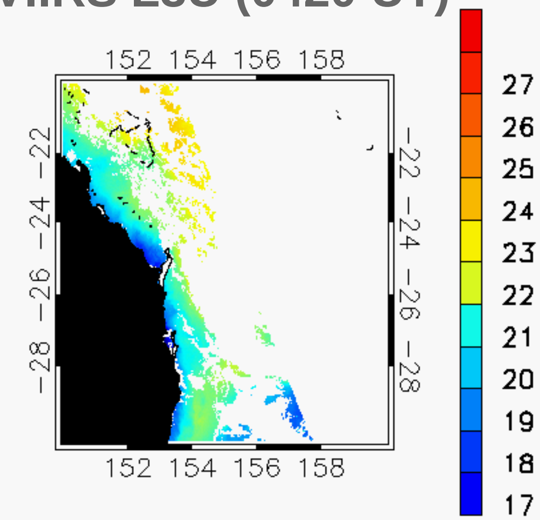
IMOS L3C (0320 UT)



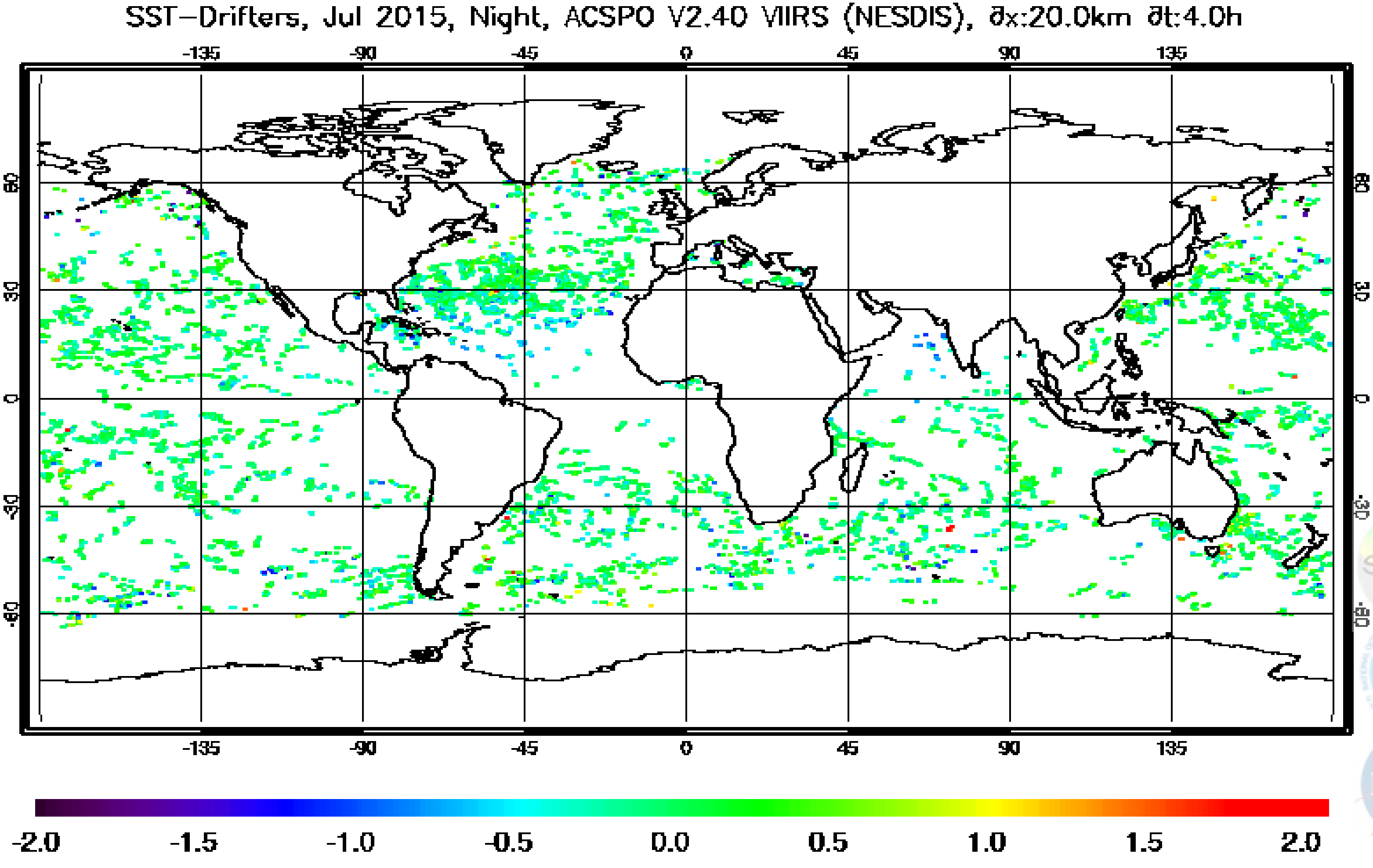
VIIRS L3U (0240 UT)



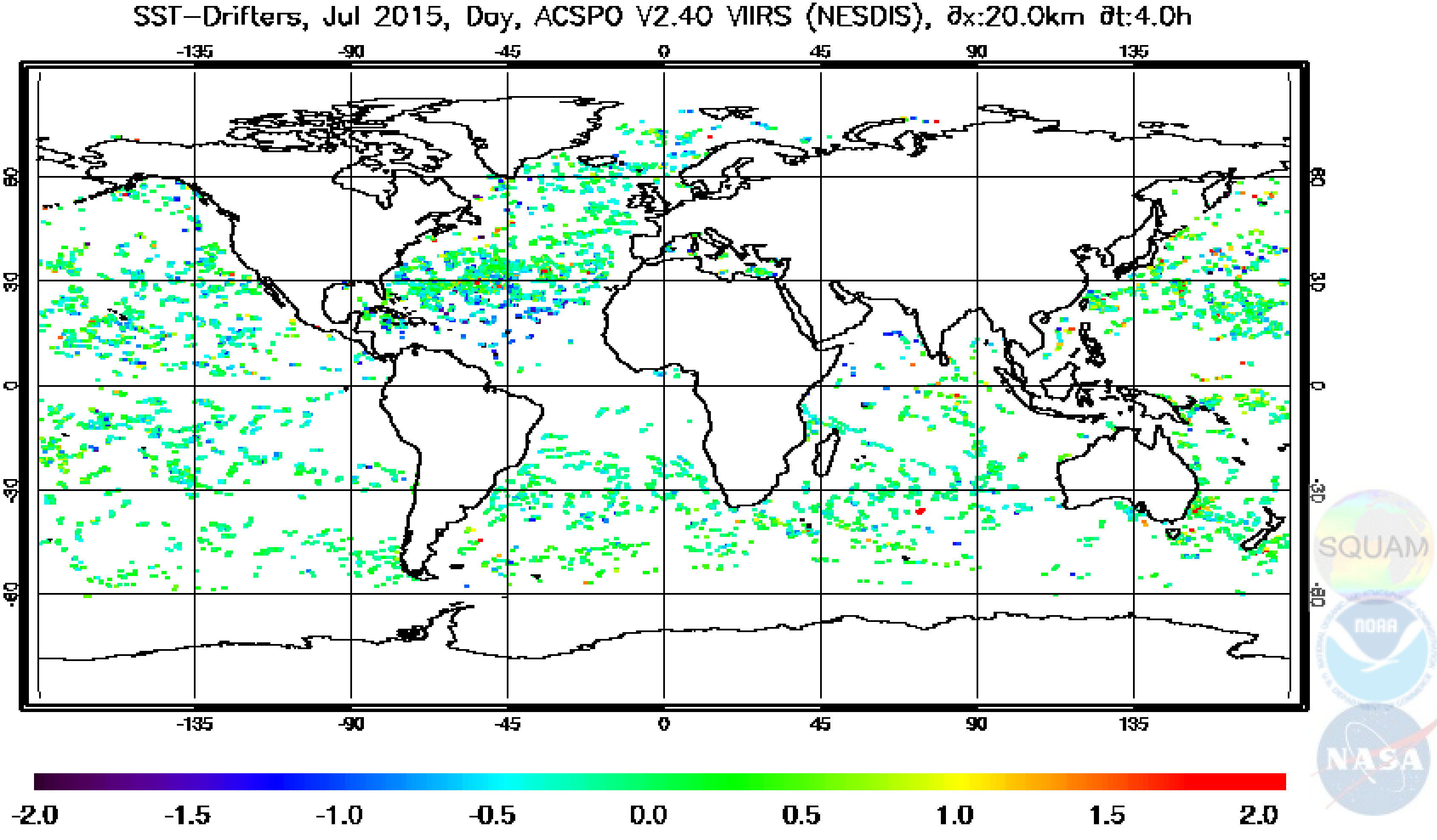
VIIRS L3U (0420 UT)



ACSPO VIIRS L2P SST – Drifter SST
1-31 July 2015 Night



ACSPO VIIRS L2P SST – Drifter SST
1-31 July 2015 Day



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Initial Findings

- Night-time bias-corrected VIIRS L3U SST as much as 1ºC colder than IMOS NOAA-19 fv01 L3C SSTskin but generally within +/- 0.5ºC of drifting buoy SSTs off Queensland coast
- Daytime bias-corrected VIIRS L3U SST as much as 2ºC colder than IMOS NOAA-19 fv01 L3C SSTskin but generally within +/- 1ºC of drifting buoy SSTs off Queensland coast
- VIIRS L3U SSTs (filtered for QL = 5) have greater spatial coverage than IMOS fv01 NOAA-19 L3C SSTs (filtered for QL ≥ 4) - particularly close to Queensland coast
- Daytime VIIRS L3U SSTs have greater spatial coverage than IMOS fv01 NOAA-19 L3C SSTs, possibly due to ACSPO VIIRS system having better daytime cloud identification

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Future use of VIIRS L3U SSTs

Over coming 12 months VIIRS SST is highest priority satellite SST data stream to add to data ingested into:

- RAMSSA/GAMSSA L4 analyses
- OceanMAPS3 Global 0.1º Ocean Model
- eReefs Great Barrier Reef ~ 4 km Ocean Model
- Trial IMOS 0.02º VIIRS+AVHRR L3S
    - currently near real-time IMOS 0.02º AVHRR L3S products ingest only NOAA-18 and NOAA-19 SSTs

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Questions

1. What is the correlation radius of the VIIRS 0.02º L3U? (Very important for DA into ABoM ocean models)
2. How reliable are the sses_bias and sses_standard_deviation values in the VIIRS L3U files? Both will be needed for assimilation into the ABoM's ocean models.
3. What are the spatial biases with respect to in situ SST in the VIIRS SST products – particularly within a few kilometres of coasts?
4. How accurate/reliable are the wind speed values in the VIIRS L3U files? (Note: We know that other GHRSST L2P files contain 10 m wind speeds interpolated to the SST observation location from relatively coarse global NWP models.)

EXTRA SLIDES FOR DISCUSSION

Regional Australian Multi-Sensor SST Analysis

Australian Government
Bureau of Meteorology

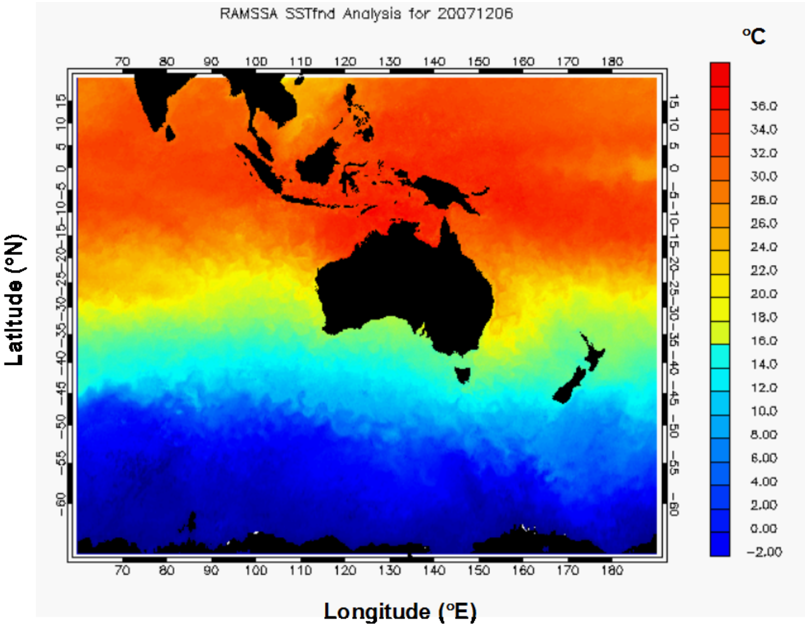
Depth: Foundation (pre-dawn SST)

Resolution: Daily, 1/12°

Domain: 60ºE - 170ºW , 20ºN - 70ºS

Data Inputs:

- 1 km IMOS HRPT AVHRR (NOAA-18,-19) **L2P**
- 9 km NAVOCEANO GAC AVHRR (NOAA-18, NOAA-19, METOP-A, METOP-B) **L2P**
- 25 km JAXA AMSR-2 (Aqua) **L2P**
- Buoy, ship, Argo, CTD, XBT obs (GTS)
- 1/12° NCEP ice concentration analyses
- BGF: Combination of previous day's RAMSSA SST and Reynolds climatology



Uses: Boundary condition for ABoM operational regional NWP models

Global Australian Multi-Sensor SST Analysis

Australian Government

Bureau of Meteorology

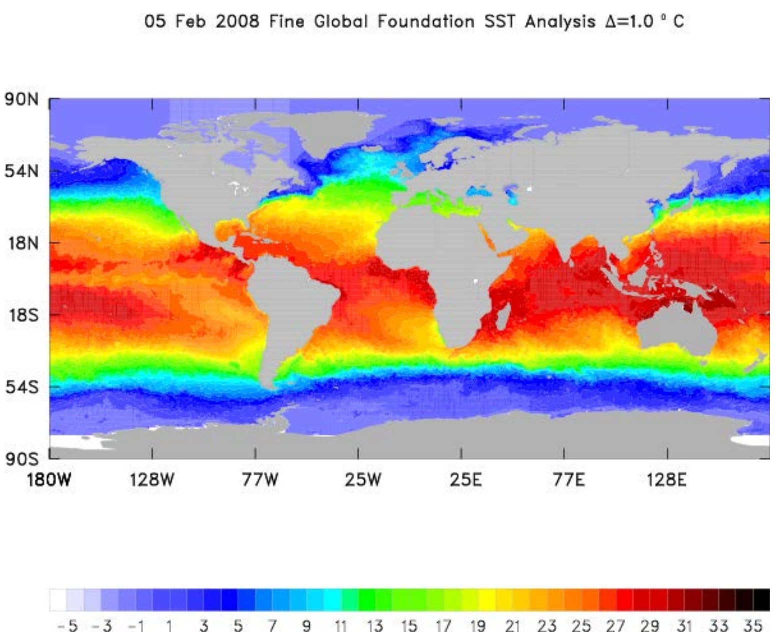
Depth: Foundation (pre-dawn SST)

Resolution: Daily, 1/4°

Domain: Global

Data Inputs:

- 1 km IMOS HRPT AVHRR (NOAA-18,-19) **L2P**
- 9 km NAVOCEANO GAC AVHRR (NOAA-18, NOAA-19, METOP-A, METOP-B) **L2P**
- 25 km JAXA AMSR-2 (Aqua) **L2P**
- Buoy, ship, CTD, XBT obs (GTS)
- 1/12° NCEP ice concentration analyses
- BGF: Combination of previous day's GAMSSA SST and Reynolds climatology



Uses: Boundary condition for ABoM operational global NWP models; Initialises ABoM seasonal prediction model; Contributes to GMPE.

Japan, Japan Meteorological Agency: 1/2
Toshiyuki Sakurai

- Are the SNPP/JPSS product continuity for products that you get now from POES, METOP, DMSP, EOS? – **Yes: VIIRS data are expected to be continuity for AVHRR data used in the JMA's operational SST analysis system (MGDSST).**
- When do you plan to use them? **– We will initiate tests for ingestion into MGDSST soon, since the registration for the access from JMA has recently been done.**
- What improvements do you expect from SNPP/JPSS? – **We expect to see improved accuracy and feature resolution of MGDSST due to ACSPO VIIRS L3U.**
- Are the current products well utilized? – **We do not yet use VIIRS SST products.**
- Is the SNPP/JPSS product part of a blended product? – **In future it will be part of MGDSST.**
- Will the SNPP/JPSS product be well utilized? -**Yes**
  - Is there a plan? Is it funded? – **JMA will continue to sustain the operational SST analysis system under regular budget.**
  - What is the priority? – **VIIRS products are second priority to ingest into SST analysis after MTSAT and Himawari product.**
- If not well utilized, what enhancements are needed for SNPP? – N/A

Japan, Japan Meteorological Agency: 2/2
Toshiyuki Sakurai

- Accessibility (data flow, latency, format) **– Required latency is 3 hours, including download time, for ingestion into real-time SST analysis systems.**
- Product performance (accuracy, precision) **– VIIRS SSTs are expected to be at least equivalent in accuracy and precision to currently available NOAA-19/AVHHR products.**
- User applications (modifications to modeling , decision tools, visualization to use the new products) **– No modification may not be needed, since ACSPO VIIRS L3U is provided in GDS2.0 format.**

Scientific Stewardship of VIIRS Ocean Satellite Data

Sheekela Baker-Yeboah[1,2], Korak Saha[1,2], Yongsheng Zhang[1,2], Kenneth S. Casey[1], Yuanjie Li[1,3]

[1]NCEI, [2]University of Maryland CICS, [3]Science and Technology Corporation

NOAA NESDIS National Centers for Environmental Information (NCEI)

- **Previously known NODC is NCEI-MD**
- Provides scientific stewardship of remotely sensed oceanographic data.
- Develops satellite data products and provides authoritative records.

NCEI Data Stewardship Tiers

Data Stewardship Tiers (T1-T6) are continuous from bottom to top.

1: Long Term preservation and Basic Access

- Preserve original data with metadata for discovery and access
- Serve as expert advisors on standards for data providers
- Archive only necessary data using appropriate retention schedules
- Safeguard data over its entire life-cycle
- Coordinate support agreements for sustainable data archiving
- Provide data citation services by mining DOIs

NCEI Data Stewardship of VIIRS Ocean Satellite Data

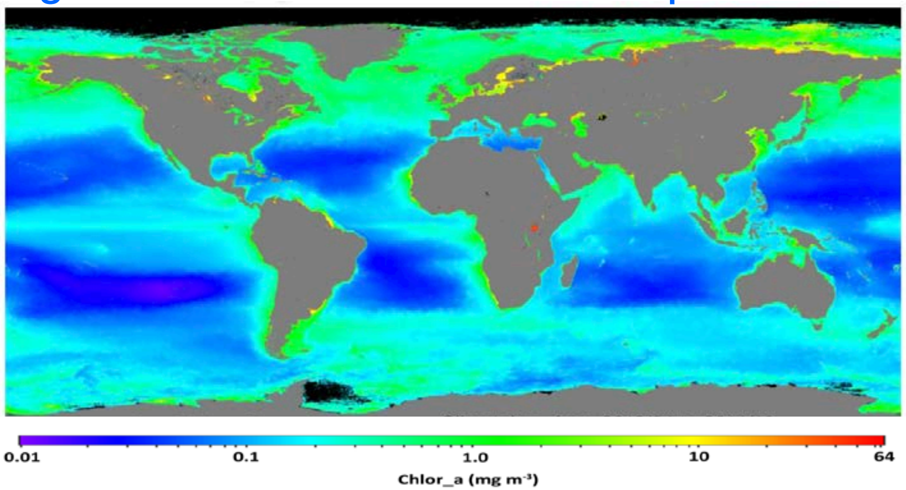
T1 Archive for

- VIIRS Ocean Color Reprocessed and
- VIIRS Sea Surface Temperature (derived using NOAA heritage Advanced Clear-Sky Processor for Oceans)

products from STAR and ASPO.

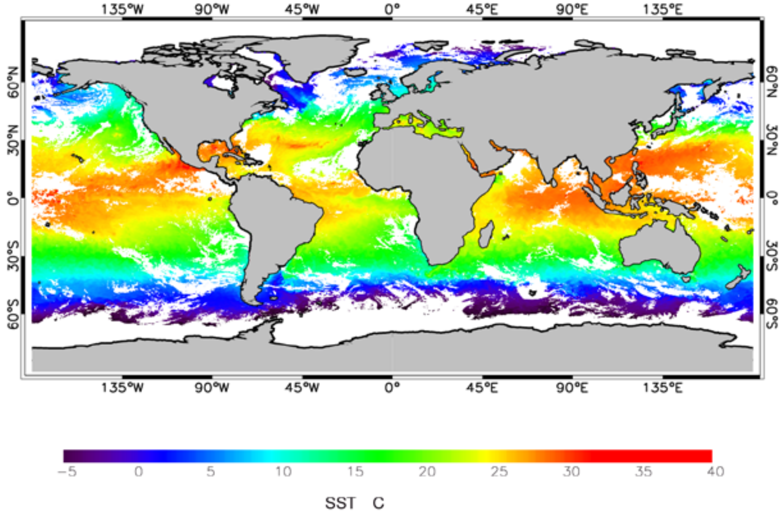
In Progress

Figure 1. VIIRS Ocean Color Reprocessed



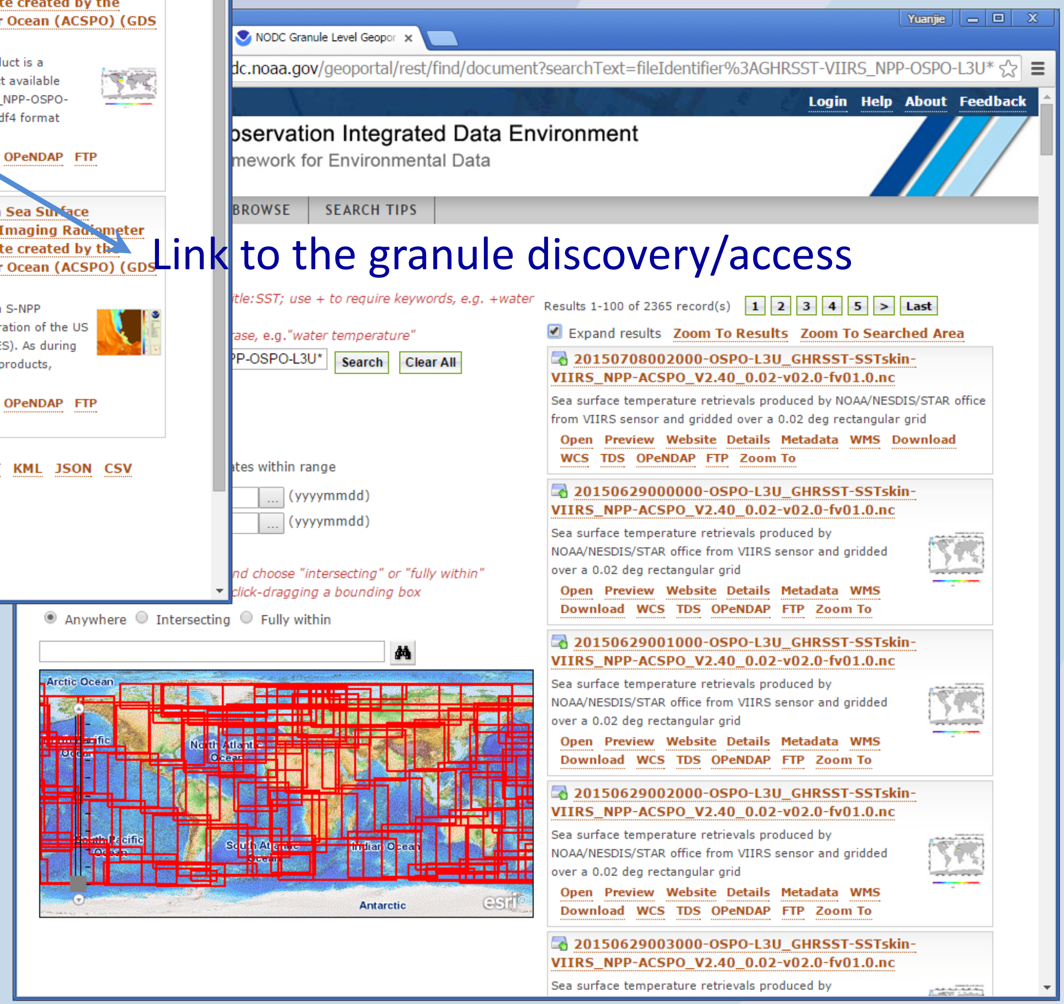
In Archive

Figure 2. VIIRS ACSPO SST



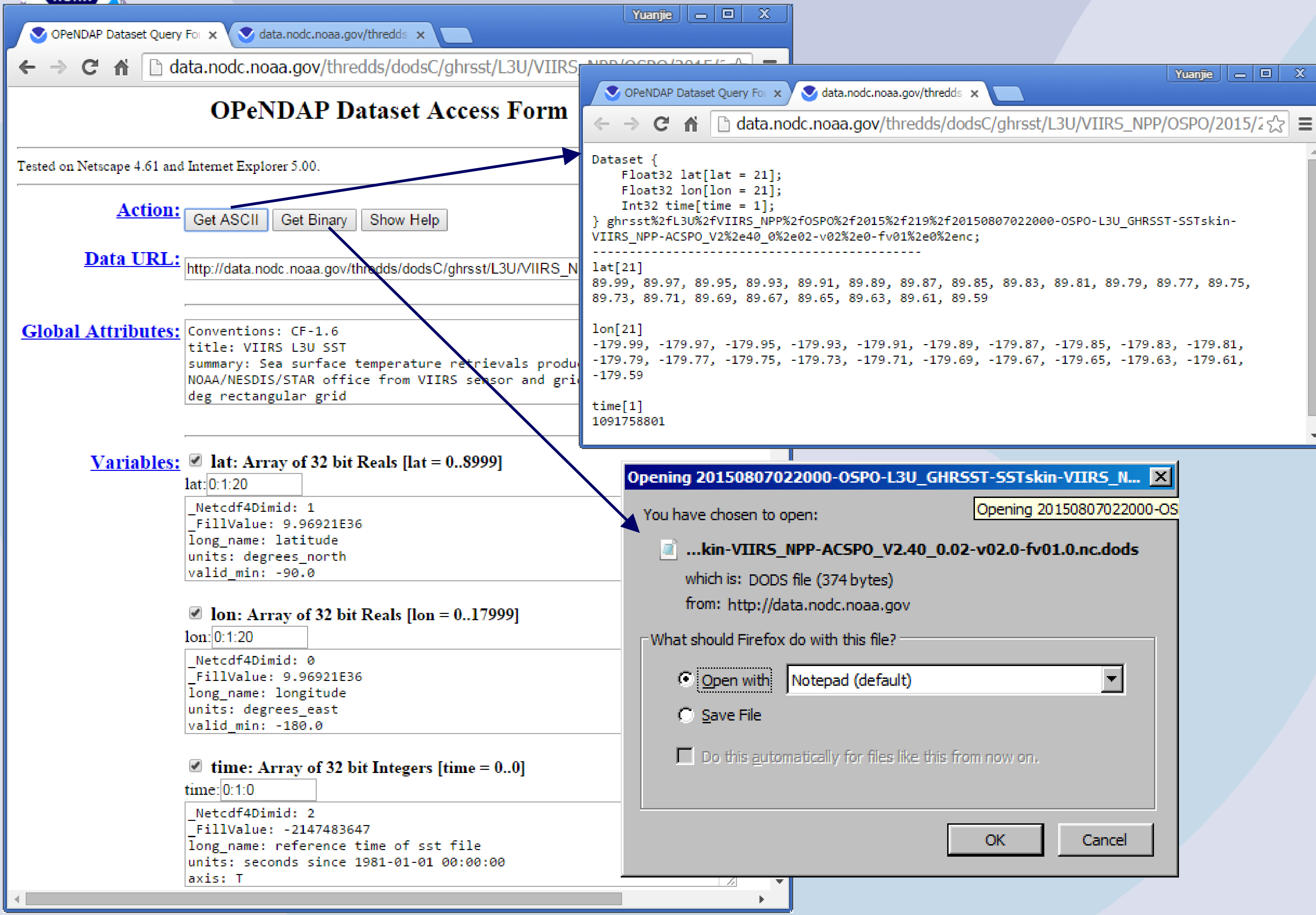
Data Access & Discovery

At both collection level and granule level via HTTP, FTP, Live Access Server, THREDDS server, OPeNDAP server, and OGC services.



Link to the granule discovery/access

Example: Using OPeNDAP to extract a subset of data



ACSPO Data in the NCEI Archive

ACSPO Version 2.3

http://data.nodc.noaa.gov/geoportal/rest/find/document?searchText=title%3AGHRSST%20AND%20ACSPO&start=1&max=25&f=searchPage&expandResults=True

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- L2P: 2014/7/24 to 2015/5/19 archived
- Ongoing work
- backfilling of some of the dataset still missing.

ACSPO Version 2.4

- http://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:GHRSST-VIIRS_NPP-OSPO-L3U-v2.4
- L3U : 2015/06/29 to 2015/08/17 archived
- Ongoing work
  - downloaded from the GHRSST GDAC (JPL PoDAAC),
  - granules are accessible http://www.nodc.noaa.gov/geoportal/rest/find/document?searchText=fileIdentifier%3AGHRSST-VIIRS_NPP-OSPO-L3U*%20OR%20fileIdentifier%3AVIIRS_NPP-OSPO-L3U*&start=1&max=1

Summary

The satellite oceanography team provides a stewarded archive of remotely sensed oceanographic data.

- **Scientific data stewardship**
  - Consists of the application of an integrated suite of functions designed to preserve and exploit the full scientific value of
  - environmental data and information over the long-term (decades).
  - Acquire, archive, provide access, and add value!

FTP Link

ftp://ftp.nodc.noaa.gov/pub/data.nodc/ghrsst/L2P/VIIRS_NPP/OSPO

DOI URL

http://dx.doi.org/10.7289/V5PR7SX5