2017 JPSS SST Progress Report

Sasha Ignatov

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NOAA Center for Satellite Applications and Research (STAR)

Summary

1. Users

- Continue supporting STAR (Coast Watch, Geo-Polar Blend, CRW), CMC, Met Office
- Significant progress with NCEP (RTG/NCODA), Australian Bureau of Meteorology, Danish Met Institute
- Working with NOS/WCOFS, NCEI, JMA

2. ACSPO Data

- Real-time L2P (May'14-pr) and L3U (May'15-pr): podaac.jpl.nasa.gov and www.nodc.noaa.gov
- Reprocessed (RAN1) L2P/L3U + rotated (2-week) buffer of real-time data: coastwatch.noaa.gov

3. ACSPO Development

- 2.41 (Aug 2016; delivered): improved mask/SST, handling H8. Implementation delayed due to NDE freeze
- v2.50 (Sep 2017; in testing): improved SST imagery/algorithms; processes GOES-R (G16); Redesigned L3U
- v2.60 (in development): pattern recognition, ocean fronts, geo "collated" (Mar 2018; Will be used in RAN2)

4. Web Monitoring Upgrades

- ACSPO Regional Monitor for SST (ARMS; www.star.nesdis.noaa.gov/sod/sst/arms/) → to v1.40
- SST Quality Monitor (SQUAM; www.star.nesdis.noaa.gov/sod/sst/squam/) → to v2
- *In situ* SST Quality Monitor (*i*Quam; www.star.nesdis.noaa.gov/sod/sst/iquam/) → to v2
- Added new data & functionality. Improved data stability, web interface, and efficiency.

5. J1 Readiness (Scheduled Launch: Oct 2017)

- ACSPO v2.50 will be ready to process J1 (code may require updates; LUTs will need to be updated)
- SQUAM and ARMS: J1 control buttons created, ready to be populated

Users

1. Continue Supporting Existing Users

- STAR Coast Watch (Paul DiGiacomo, Veronica Lance)
- STAR Geo-Polar Blended Team (Eileen Maturi, Andy Harris)
- Coral Reef Watch Team (Mark Eakin)
- CMC L4 (Dorina Surcel-Colan)
- Met Office (Simon Good, Emma Fiedler, Chongyuan Mao)

2. Significant Progress with Several New Users' Groups

- NCEP RTG Team (Bob Grumbine, Bert Katz)
- Australian Bureau of Meteorology (Helen Beggs, Chris Griffin, Pallavi Govekar)
- Danish Meteorological Institute (Jacob Høyer)

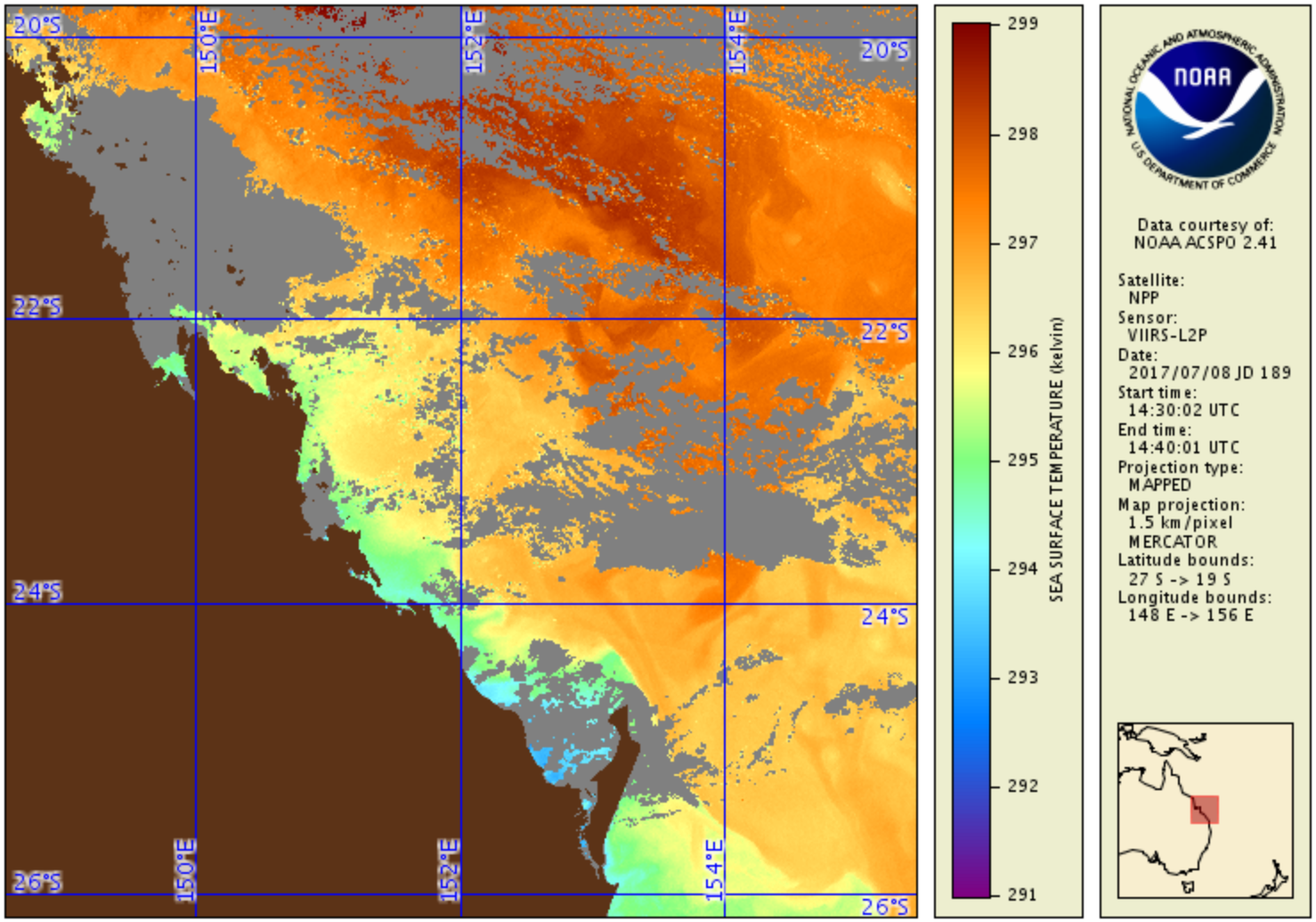
3. Emerging Users

- NOS West Coast Ocean Forecast System (Alexander Kurapov)
- NCEP NCODA Team (Ilia Rivin, Jim Cummings)
- NCEI/STAR (Tom Smith, Viva Banzon)
- JMA (Toshiyuki Sakurai)

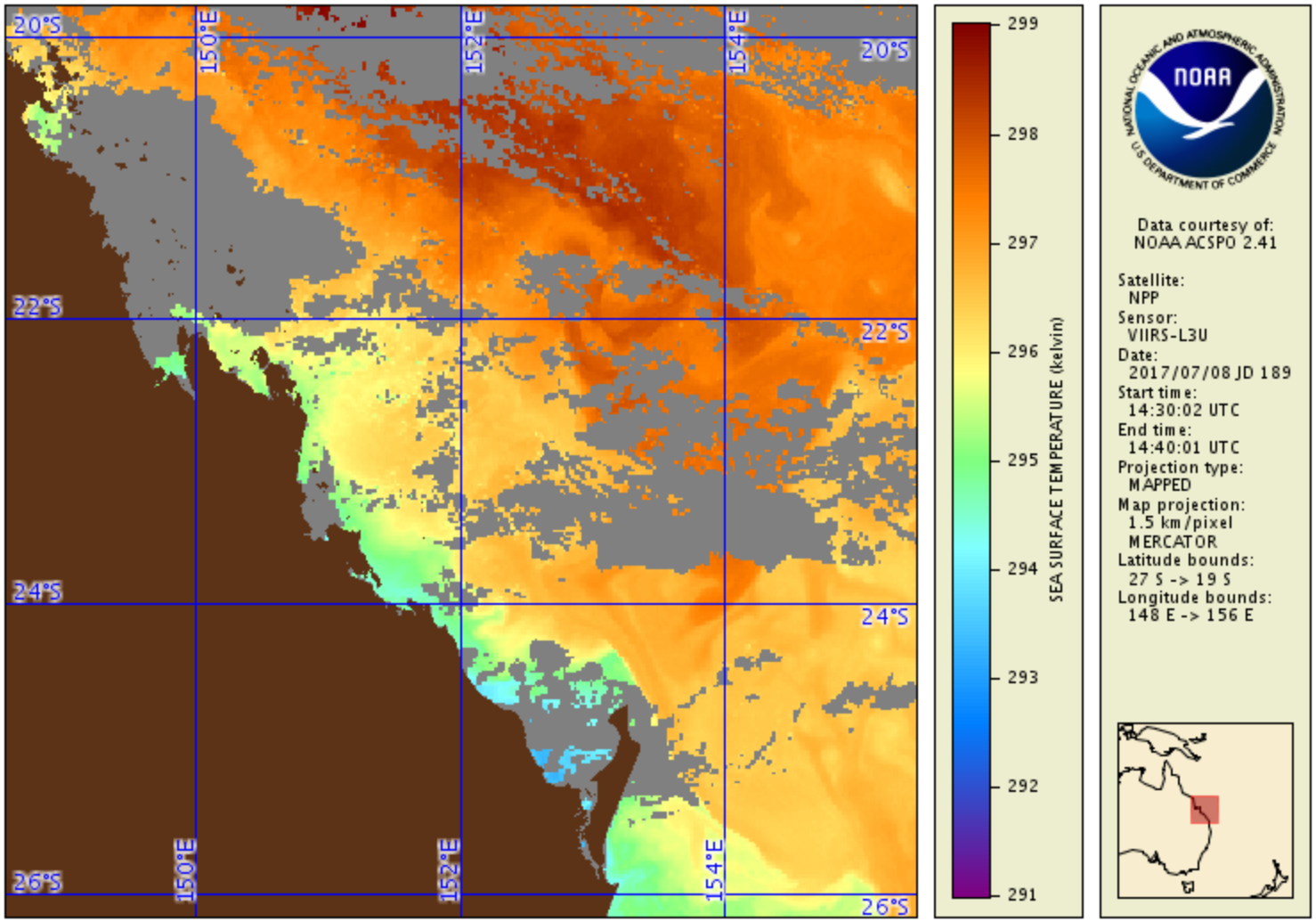
Many ACSPO Users Assimilate L3U Product

- L3U (Uncollated) = gridded L2P (~2 orders smaller size)
- ACSPO L3Us were requested by Met Office, ABoM, and JMA
- Initially in ACSPO v2.40, BoM L3U was employed (thanks to Chris Griffin and Helen Beggs for sharing BoM L3U code)
- New bilateral algorithm (weights are functions of distance and SST deviation from a typical SST) was employed in v2.41
- ACSPO v2.50 will also produce L3U for AVHRR (operationally) and MODIS (experimentally)
- L3U compares well w/L2P (preserves spatial features) & *in situ*
- L3U is a first step towards L3C ("collated" – multiple overpasses of the same satellite are collated) and L3S ("super-collated" – all overpass from all platforms collated together)

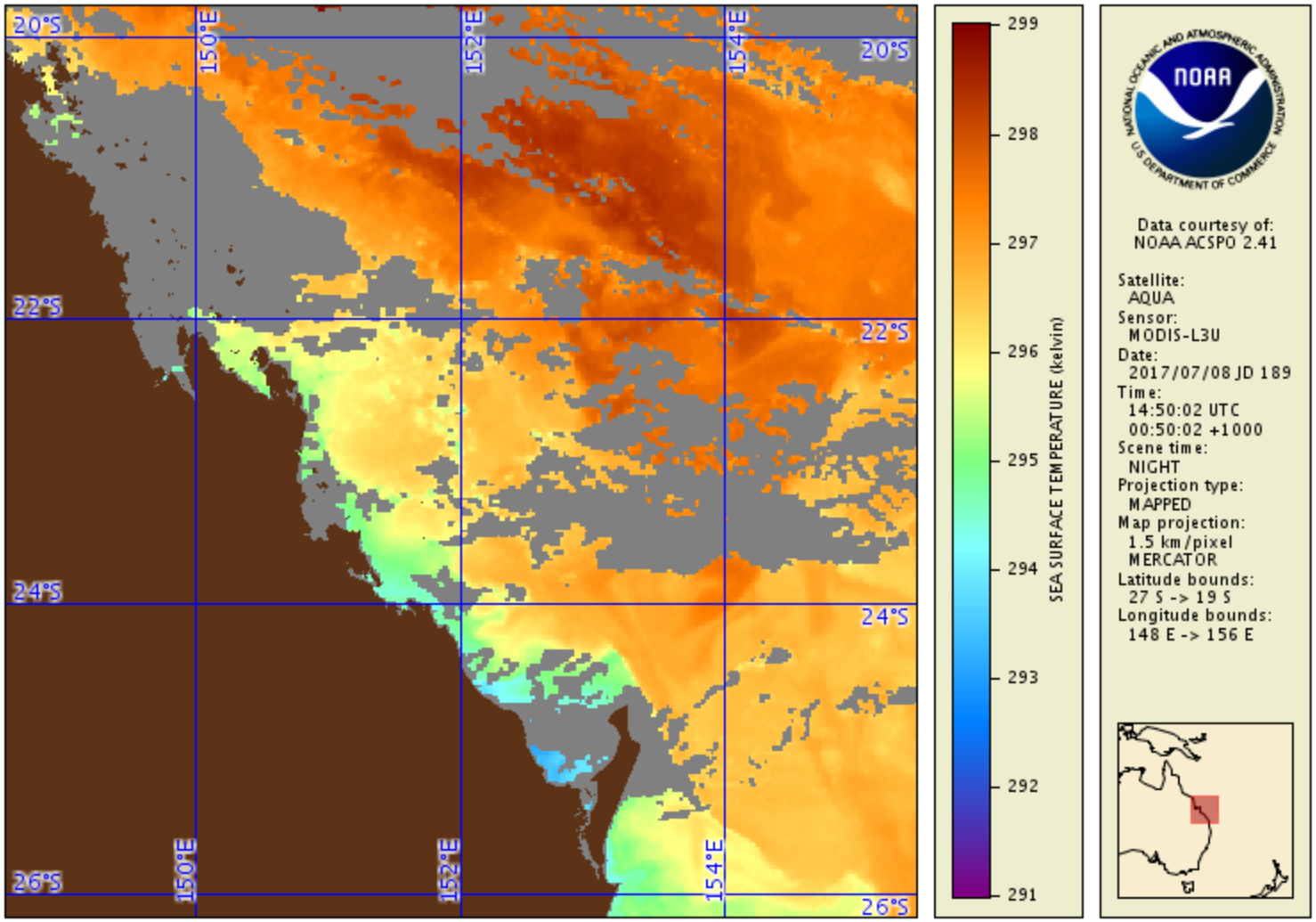
L2P: Southern Great Barrier Reef, Australia SNPP VIIRS 8 July 2017



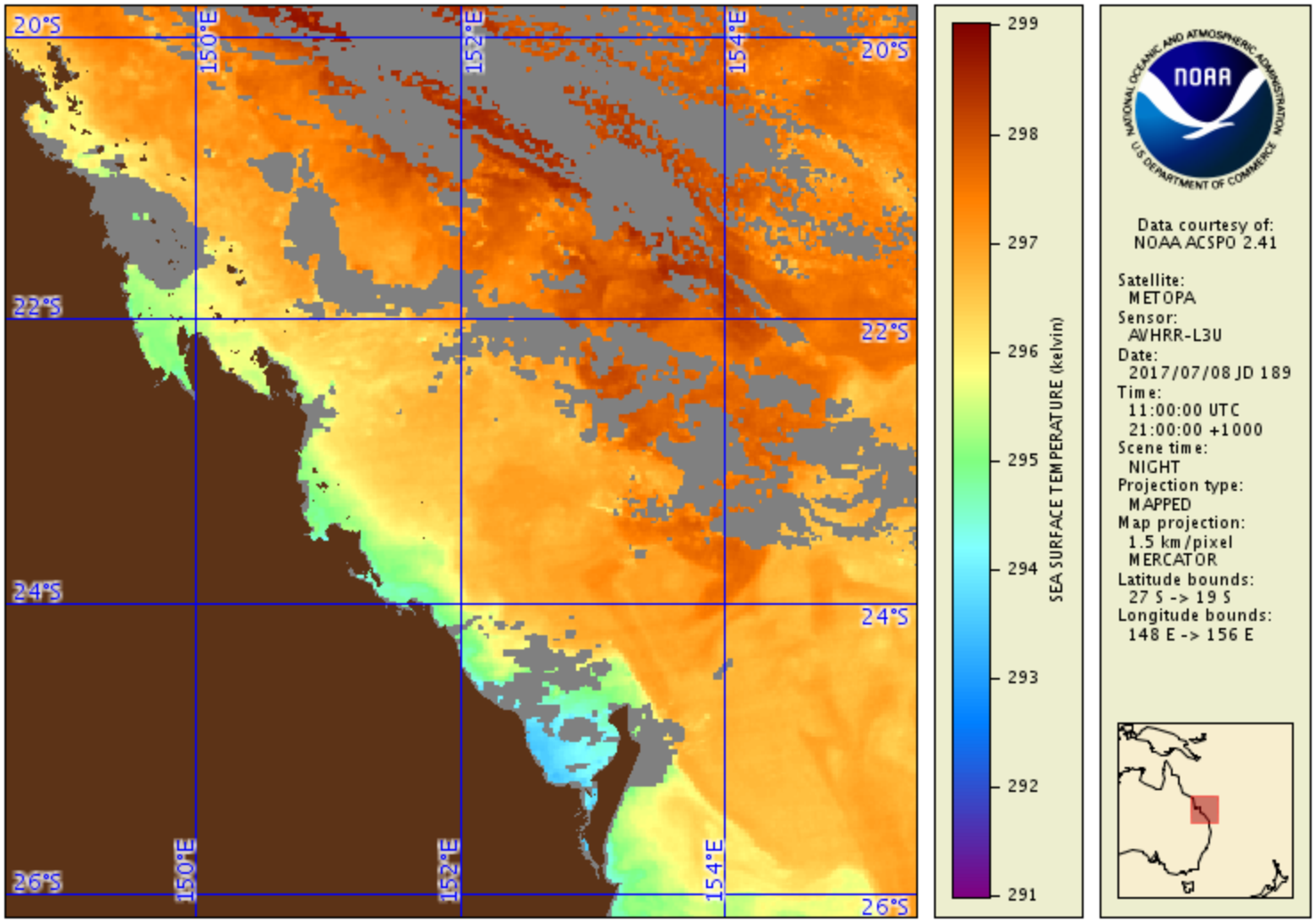
L3U: Southern Great Barrier Reef, Australia
SNPP VIIRS 8 July 2017



L3U: Southern Great Barrier Reef, Australia
Aqua MODIS 8 July 2017

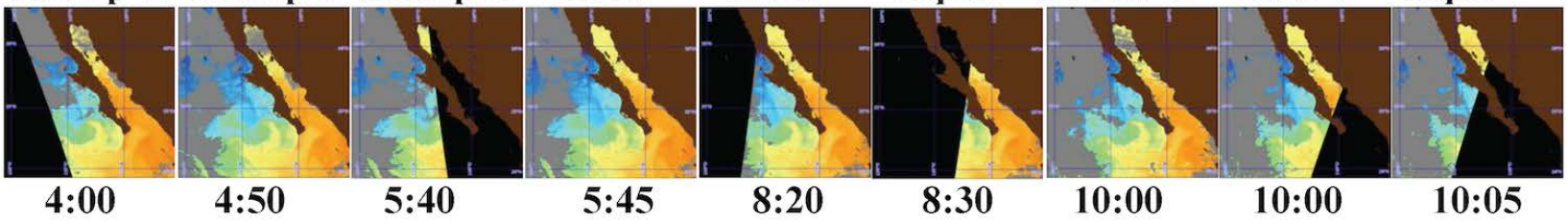


L3U: Southern Great Barrier Reef, Australia
Metop-A AVHRR 8 July 2017

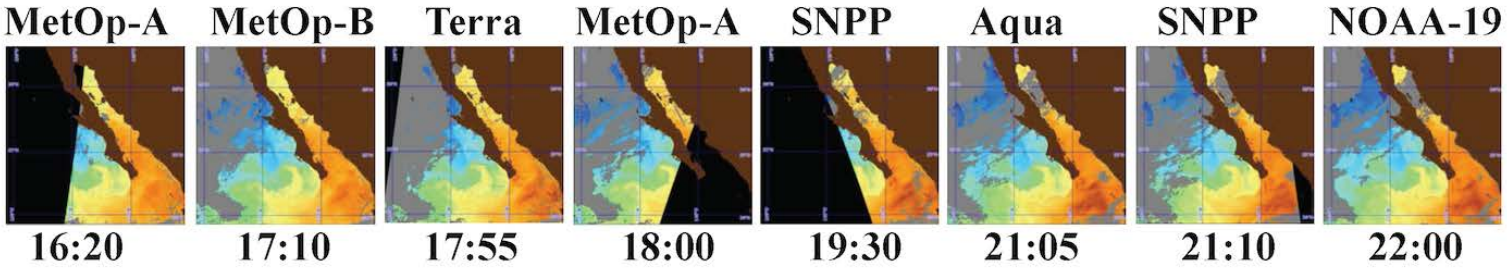


Towards L3C/L3S Products: Example over Gulf of California in Oct 2016

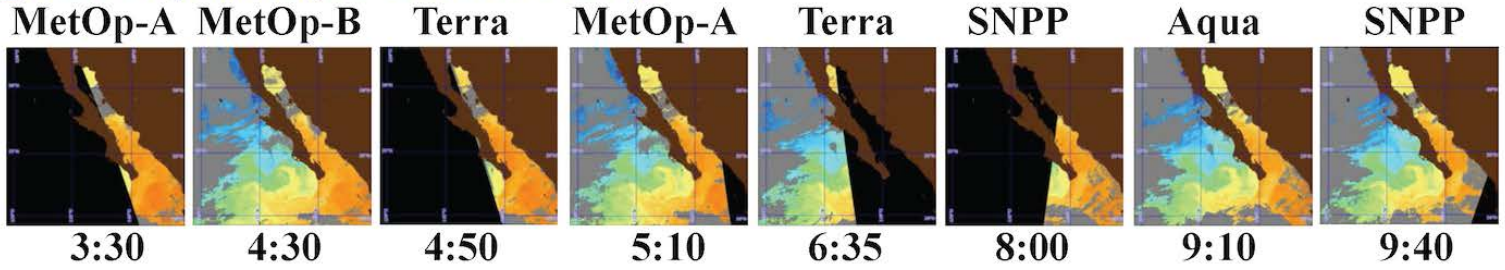
Night Overpasses (12 October 2016)



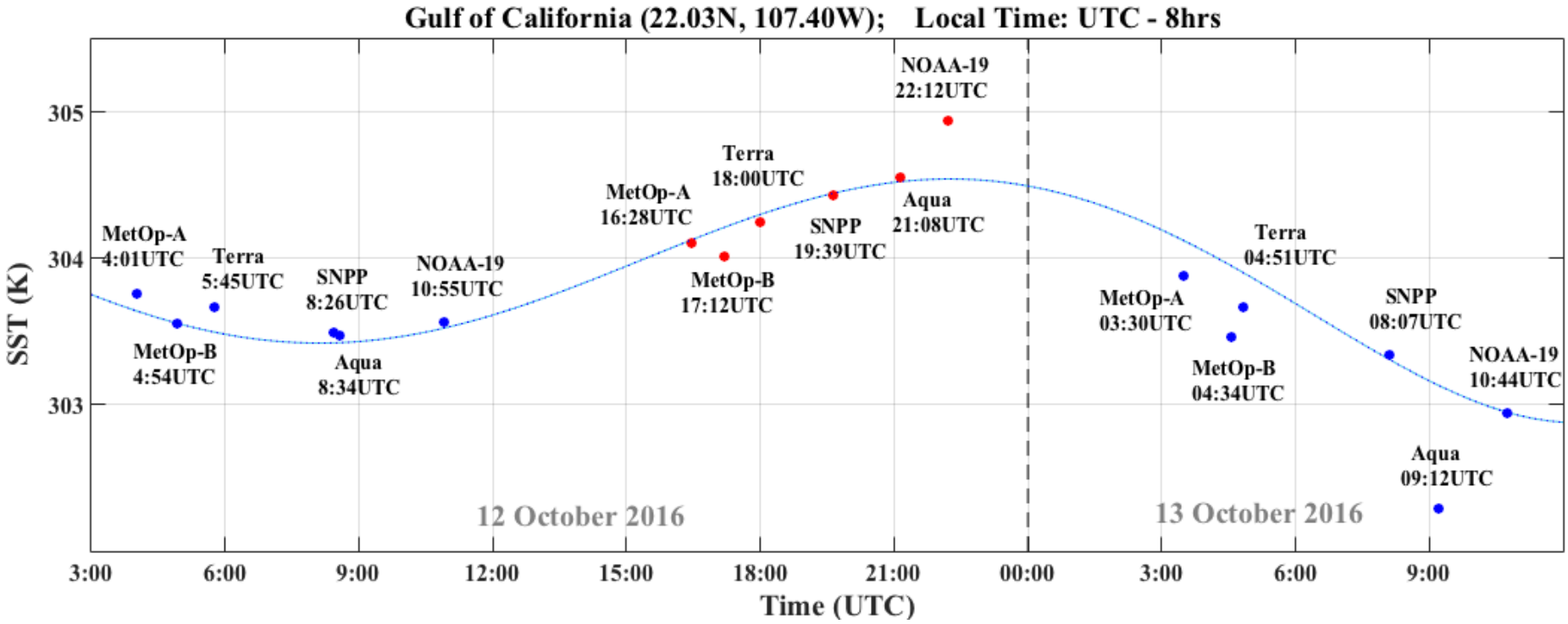
Day Overpasses (12 October 2016)



Night Overpasses (13 October 2016)



Future ACSPO L3C/L3S Products



- L3C/L3S should resolve the diurnal cycle (not simply average different L3Us together)
- Individual L3Us should be de-biased and weighed in inverse proportion to their RMSEs
- Need to understand users' needs & requirements, leverage BoM L3C/L3S experience

ACSPO Data Products & Distribution

- NDE/OSPO produce ACSPO L2P/L3U SST from VIIRS (SNPP; soon to be also J1), AVHRR GAC (N19, Metop-A/B) and FRAC (Metop-A/B) operationally
- Operational Products are distributed via OSPO “Product Distribution & Access” (PDA)
- STAR processes MODIS-A and -T experimentally, and has generated GAC and SNPP VIIRS Reanalyses-1 (“RAN1”)
- The plan is keep on Coast Watch (CW; coastwatch.noaa.gov) a rotated (~2-week) buffer of VIIRS/AVHRR and ABI/AHI operational, and MODIS experimental L3U products, and supplement them with science-quality L3U RANs. L2Ps will be only served by special request, due to data size
- The CW will work with NCEI to archive RAN products
- Things are in flux now, work underway to shape them up by Aug 2018
- Contact A. Ignatov with any questions

ACSPO L2P Products

- ACSPO files are in GHRSST Data Specification v2 (GDS2) NetCDF format
- Data organized into 10min (VIIRS, AVHRR FRAC), 1hr (AVHRR GAC), and 5min (MODIS) granules
- Daily data size: 27GB (VIIRS), 10GB (FRAC/MODIS), and 0.8GB (GAC)
- BTs in all SST bands, and “sub-skin” SST (derived by a regression algorithm) are reported in all ocean pixels (including cloud, ice, etc.) up to 10km inland
- Clear-sky mask & QLs provided in each pixel (we only recommend using QL=5)
- Single Sensor Error Statistics (SSES) Bias & SD are reported in each pixel. They were derived from match-ups with *in situ* data using Piece-Wise Regression (Petrenko et al, 2016) and represent expected SST errors wrt. *in situ* in each pixel
- Subtracting SSES bias from “regression sub-skin SST” reconciles it with *in situ* SSTs (minimizes regional biases, by minimizing residual cloud/aerosol, VZA/TPW dependent errors in regression algorithms, and diurnal effects)
- We recommend correcting for SSES biases in data assimilation/analysis applications, especially those aimed at “bulk” (foundation) SST

ACSPO L3U 0.02º Products

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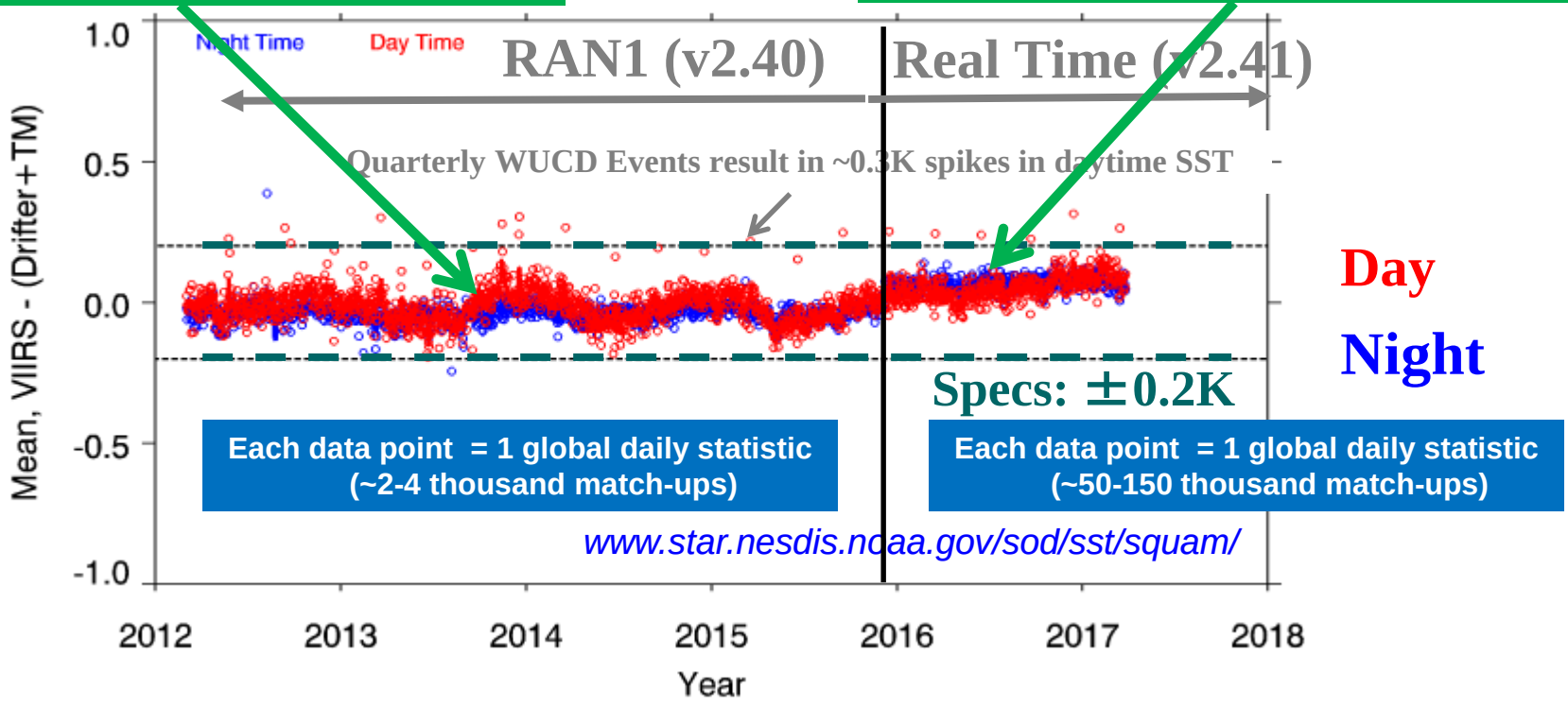
- Data organized as L2P: 10min (VIIRS, AVHRR FRAC), 1hr (AVHRR GAC), and 5min (MODIS) granules
- Daily data size: 0.7GB (VIIRS, FRAC, MODIS, GAC)
- “Sub-skin” SST are only reported in clear-sky pixels with QL=5
- BTs are not reported
- As in L2P, SSES bias and SD are reported in each pixel.
- As in L2P, we recommend correcting for SSES biases in data assimilation/analysis applications especially aiming bulk/foundation L4s

Validation of VIIRS L2P SST Vs. Drifters + Trop. Moor. Global Bias (No SSES Bias Correction)

One-to-One Matchups (10km,30min)

One-to-Many Matchups (10km,30min)



- Overall, product meets specs & users' requirements – except the WUCD events
- Quarterly spikes are due to Warm-Up Cool-Down exercises – working with SDR to resolve
- Biases are more consistent during RAN1 (Mar'12 – Dec'15). In NRT, a warming trend is seen
- **Working w/SDR to fix WUCD and set up infrastructure in STAR for RAN2 (in FY18)**

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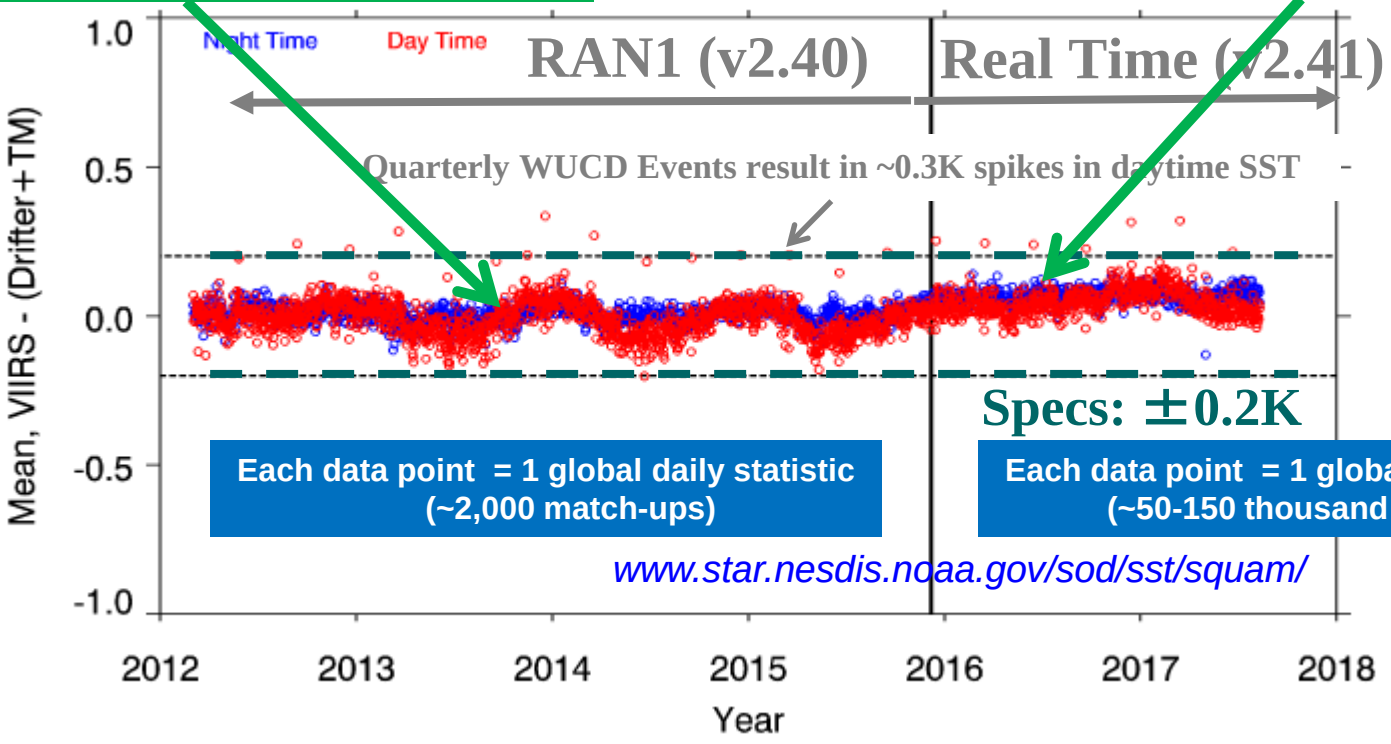

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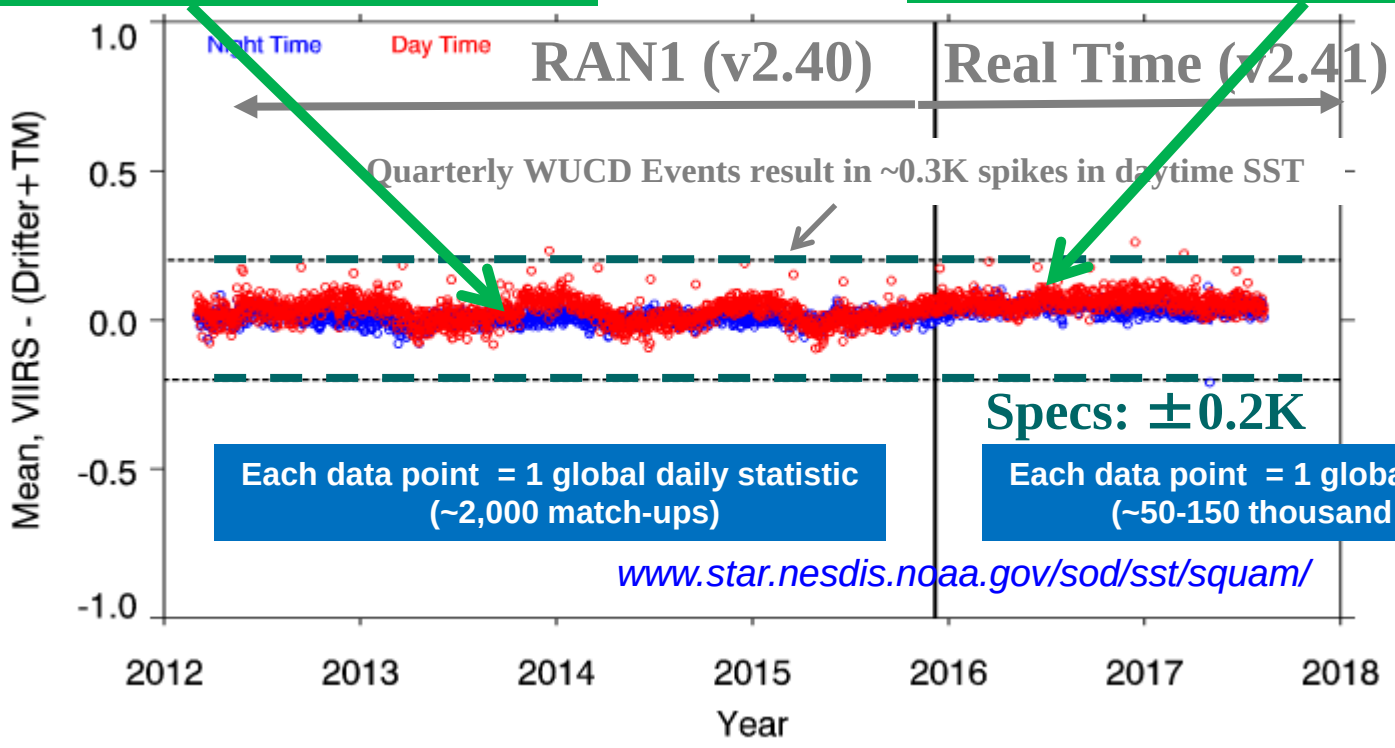

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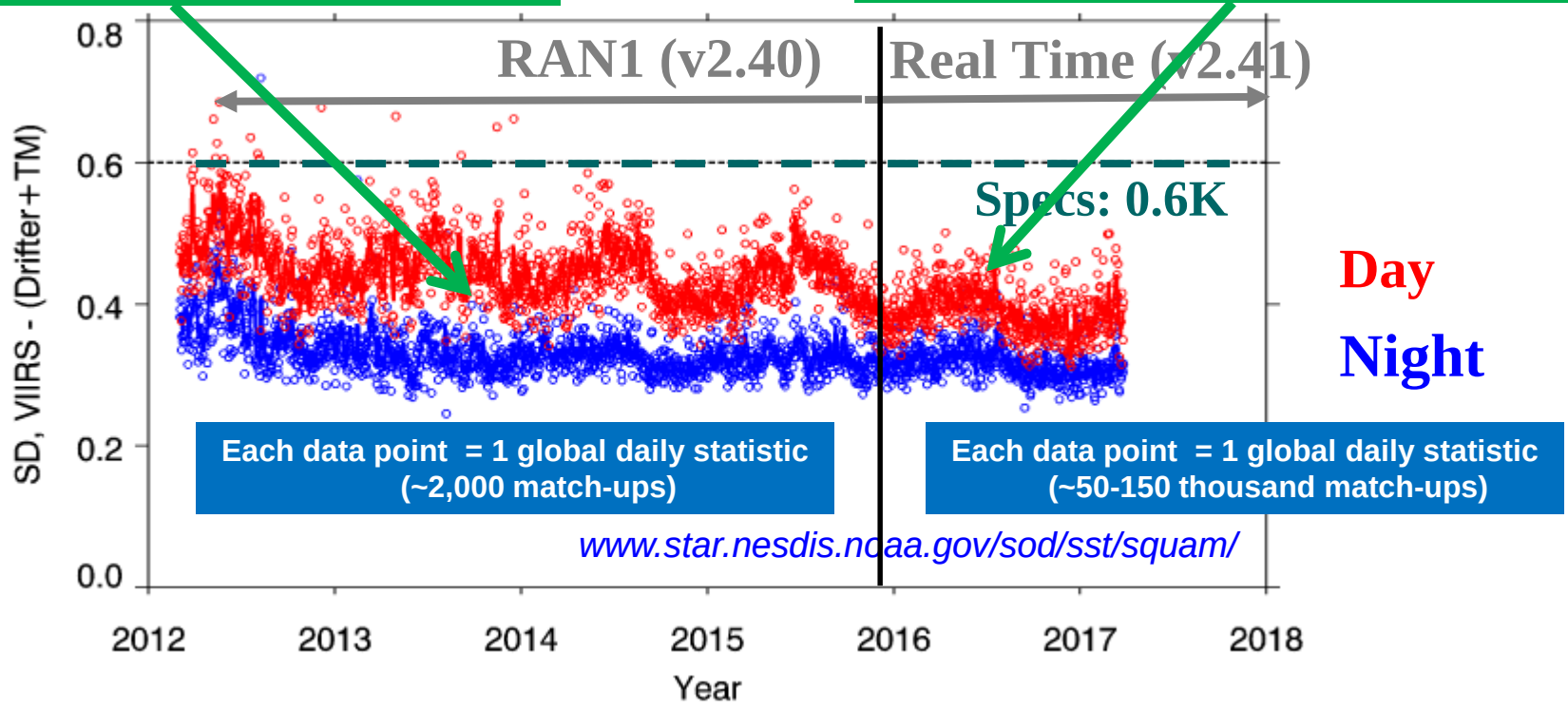

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- SDs smaller @night (skin VIIRS SST is closer to buoy bulk SST) and larger during daytime
- ACSPO v2.41 appears less noisy, compared to previous version 2.40 used in RAN1
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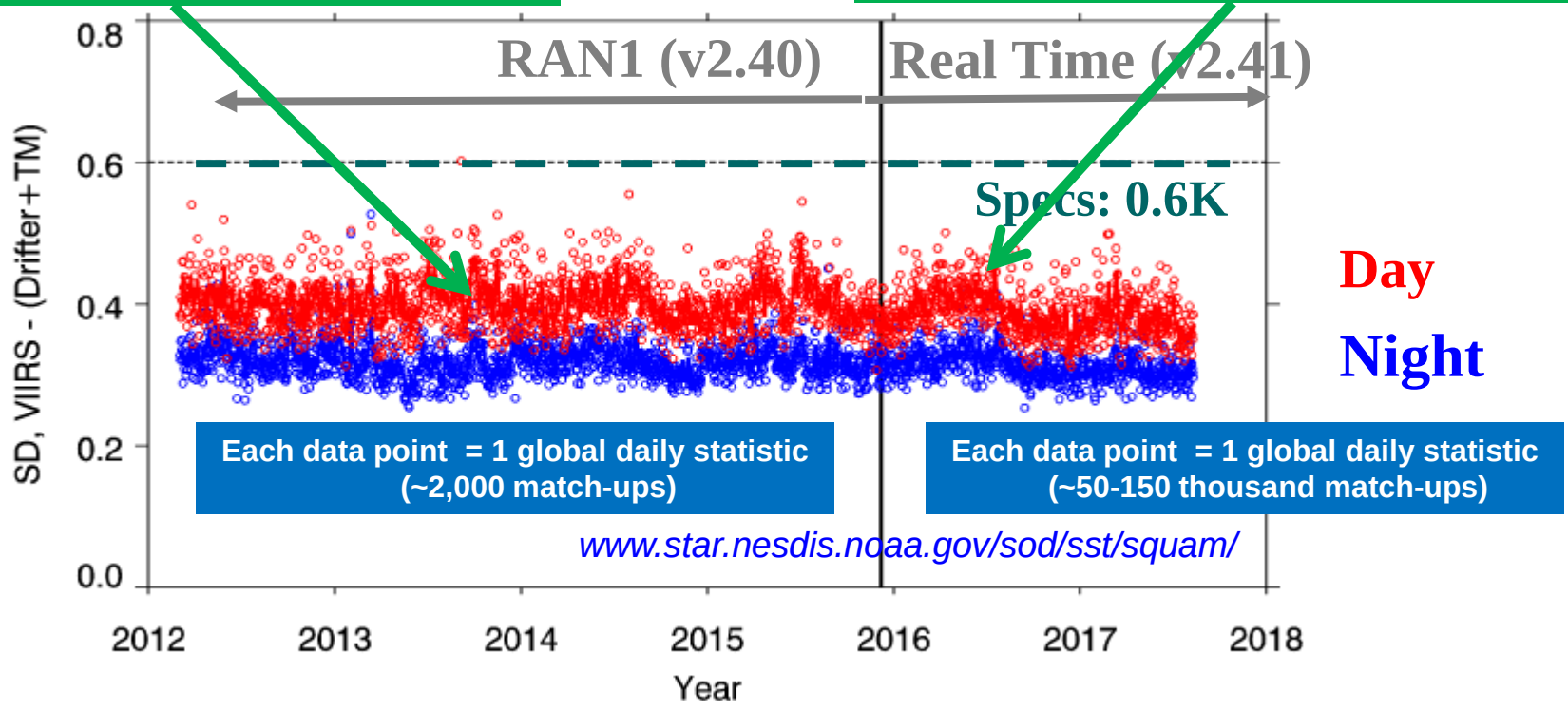

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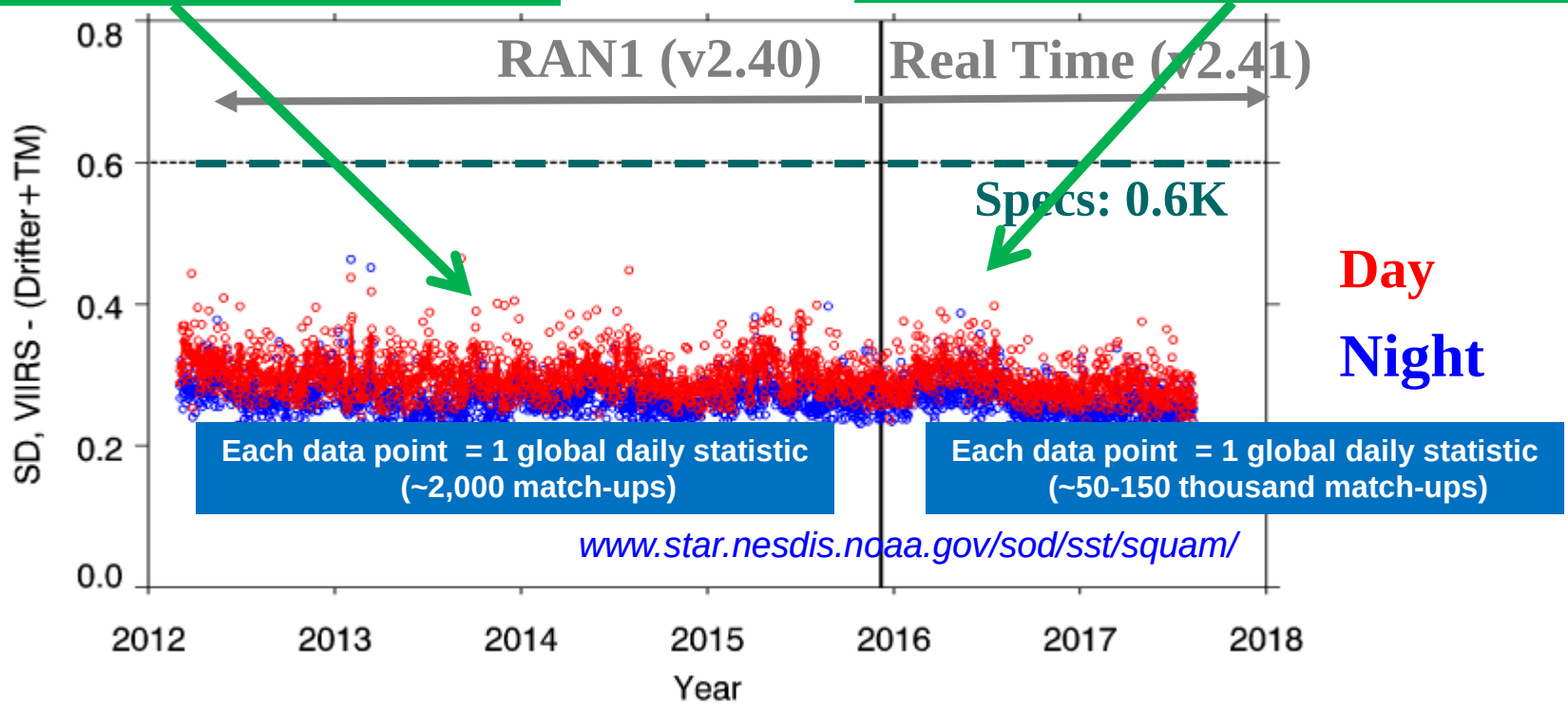

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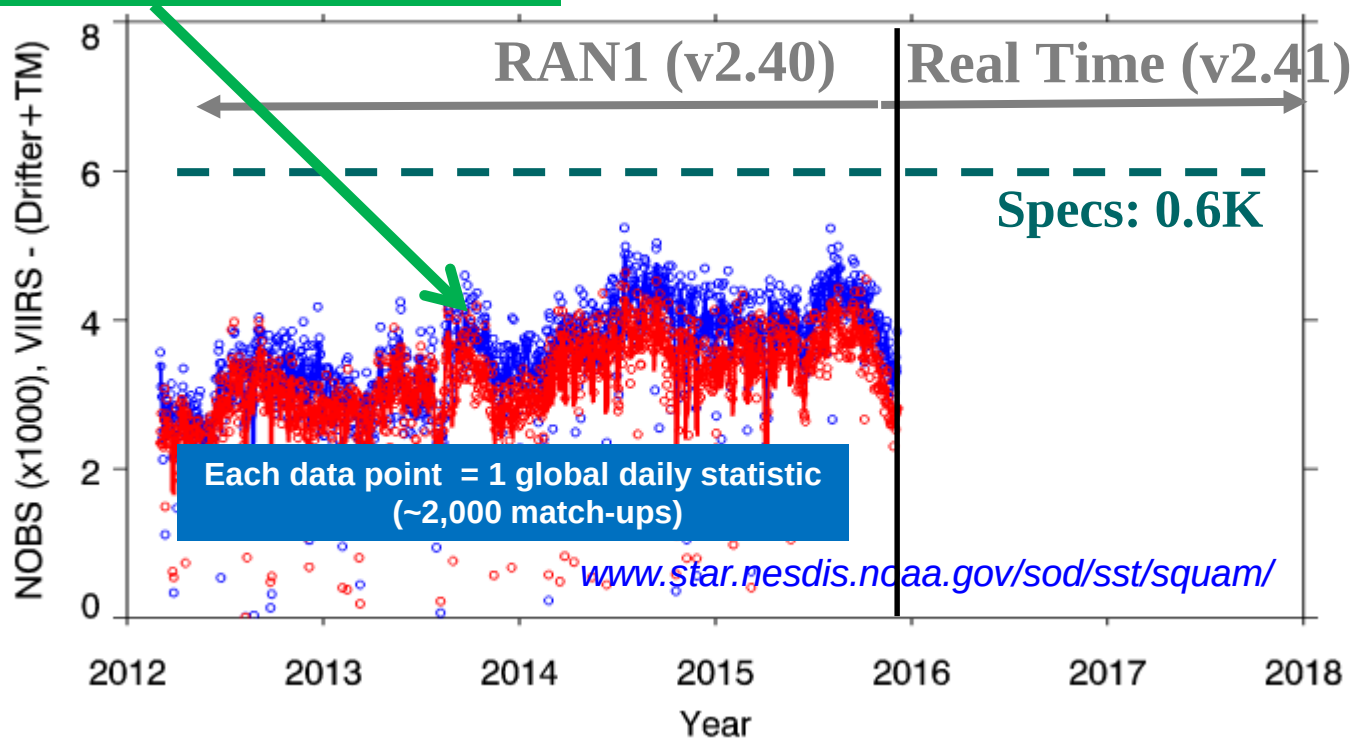

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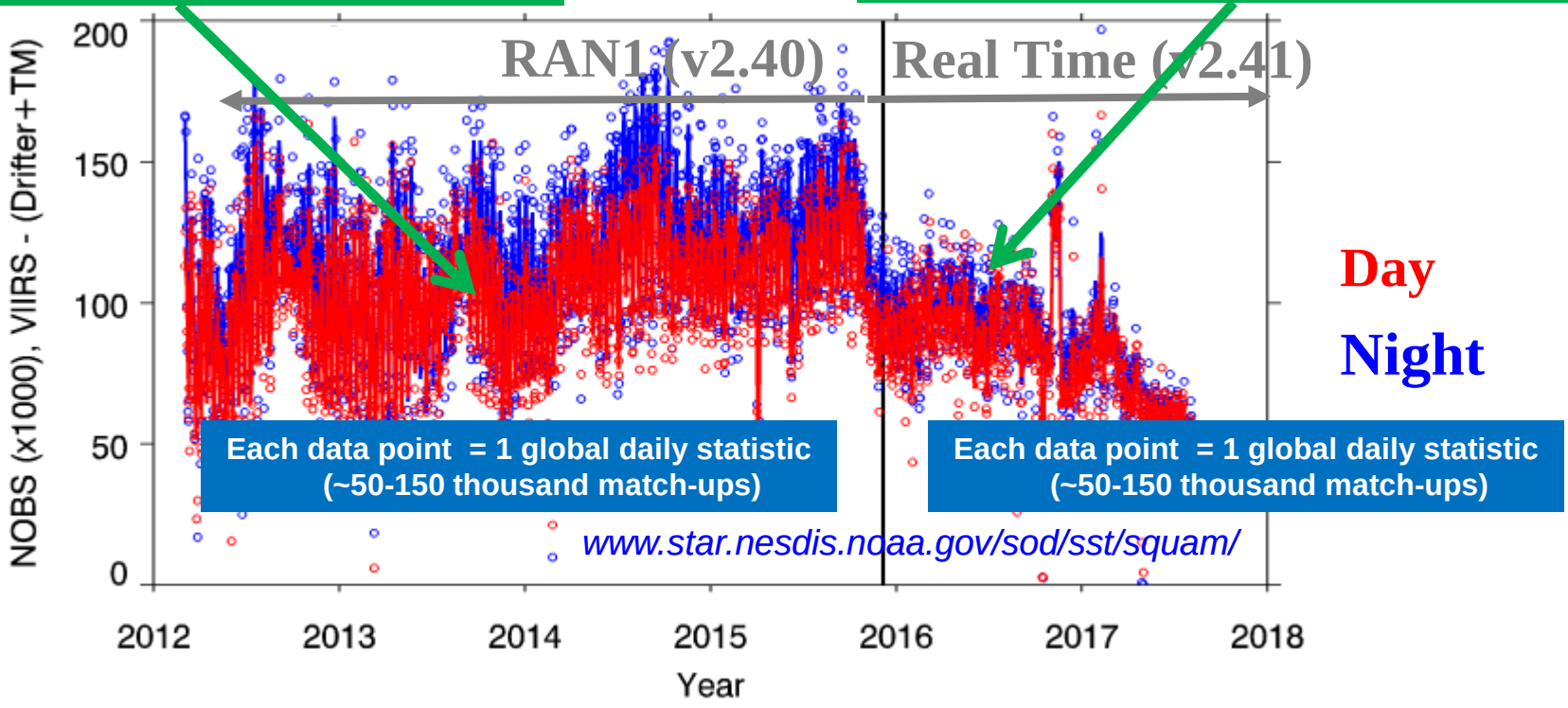

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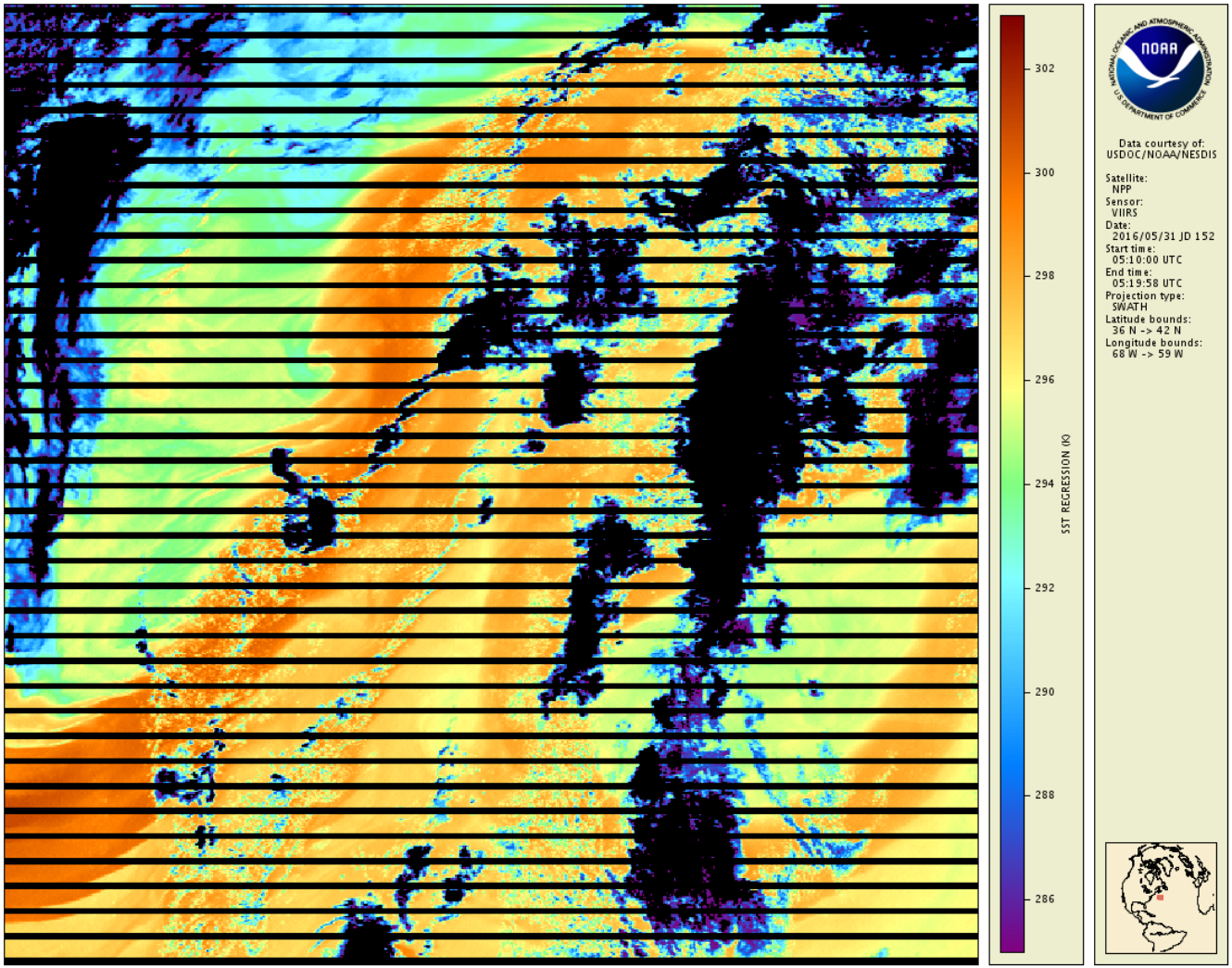
ACSPO Versions 2.50 and 2.60

1. ACSPO 2.50 (Sep 2017) will improve brightness temperature (BT) and SST imagery in the full VIIRS swath, using special **resampling** algorithms to (a) minimize geometrical distortions; and (b) fill in the bow-tie deleted pixels.

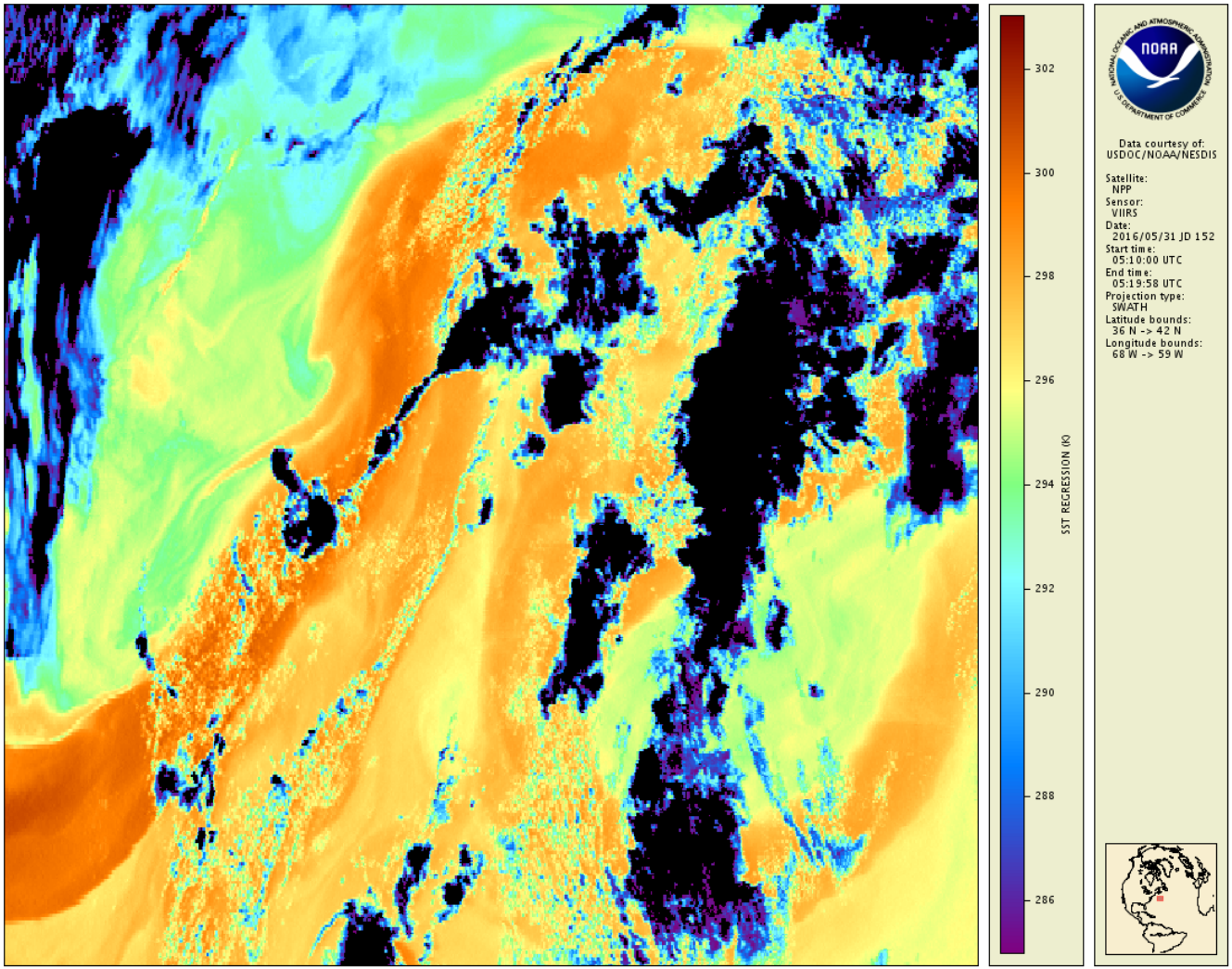
2. ACSPO 2.60 (Mar 2018) will (a) derive **ocean fronts**; and (b) improve **clear sky identification** in dynamic, coastal, and high-latitude areas of the ocean.

For SST Improvements in v2.50, see presentation by Petrenko et al (this breakout)

VIIRS SST Imagery in ACSPO v2.41



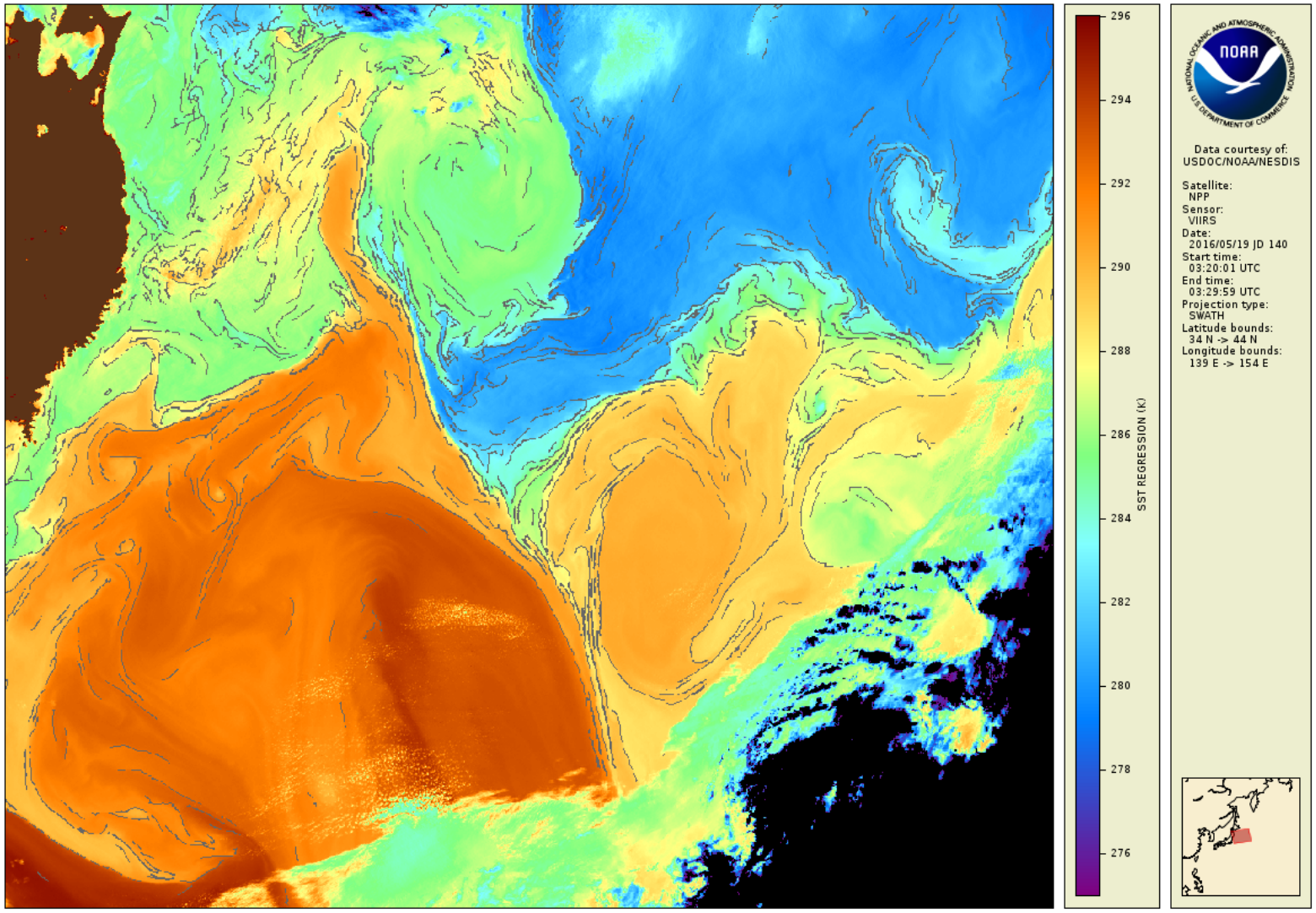
VIIRS SST Imagery in ACSPO v2.50 – on



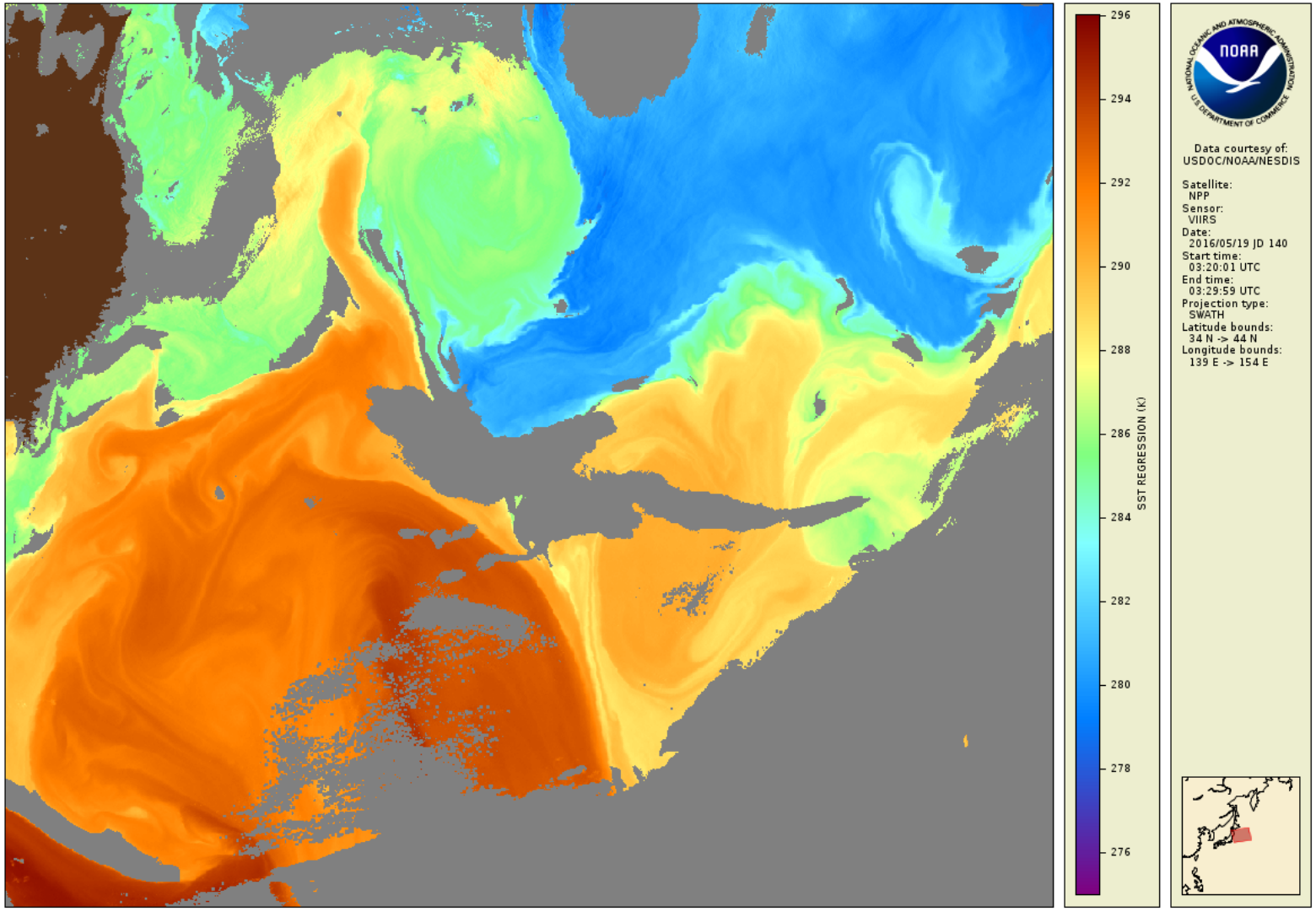
Clear-Sky Identification for SST: Current Practices and Limitations

- All existing clear-sky masks are subject to 2 types of misclassifications: “false alarms” and “cloud leakages”
- False alarms often occur in dynamic areas (currents, eddies, upwellings), costal zones, and sea-ice transitions
- Misclassifications are often persistent from one overpass to another
- Result in loss of data in interesting areas and day/night inconsistency
- Cloud leakages can lead to false front detection
- Traditional front detection algorithms assume availability of external clear-sky mask

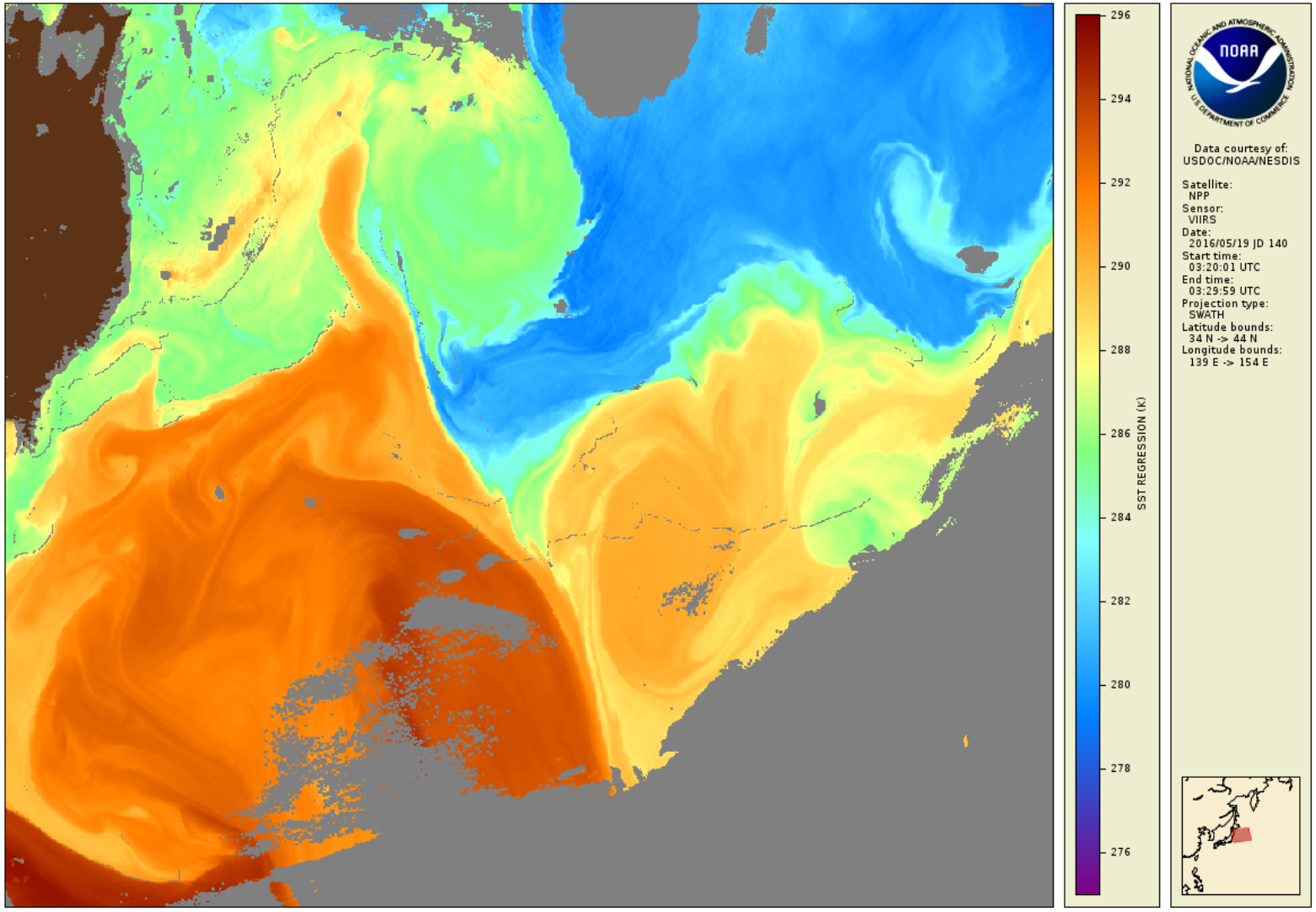
All-Sky SST with Thermal Fronts Overlaid: Kuroshio Current 19 May 2016



Example of False Alarms: Kuroshio Current 19 May 2016



SST with Corrected Clear-Sky Mask: Kuroshio Current 19 May 2016



Motivation for SQUAM Redesign

- Challenging data volumes and demand for computing resources
  - New gen polar: VIIRS onboard SNPP and future J1 – J4; AVHRR FRAC onboard Metops; MODIS onboard Terra and Aqua
  - New gen geo: ABI onboard G16 and future GOES-S/T/U, AHI onboard Himawari-8/9
  - Reanalyses (RAN): AVHRR GAC and VIIRS, future FRAC, MODIS, etc.
- Need for new functionalities
  - SSES bias correction
  - Variable regression coefficients (for ACSPO RAN SSTs)
  - SQUAM processing improvements: time aggregation, match-up, etc
- Need for updating the web interface
  - Room for improvement with new web tech (graphic, interactivity, speed, etc.)
- Development of SQUAM2 started in 2016

He et al, SQUAM2 (this breakout)

Enhancements in *i*Quam2

As *i*Quam user community grows, it requested several enhancements

- Extend time series to full satellite era (Sep 1981 – on)
- Improve QC, by adding
  - the 2nd reference SST (CMC)
  - performance history check (*i*Quam check similar to the UKMO/CMS “black lists”)
  - CMS black list; and individual QFs from data producers (ICOADS, ARGO, IMOS)
- Improve web interface
  - Redesign web engine (from flash player to High Charts)
  - Add daily (hourly) statistics
  - Enhance graphics (interactive display, and print/save functions)
- Add new *in situ* data
  - ARGO Floats (in NRT and post-processing modes)
  - High-Resolution Drifters
  - IMOS Ships
  - Coral Reef Watch buoys
- Change output data files to NetCDF4. (Maximally reconcile with GHRSST GDS2 satellite L2/L3 format).

Zhou et al, SQUAM2 (this breakout)

What is ARMS?

1. **A part of the NOAA SST Monitoring system, focusing on challenging areas, most interesting to data users & producers**
   - Coastal/Internal waters
   - Dynamic areas
   - High latitudes
   - Cloudy regions
2. **Monitors regional performance of ACSPO SST & clear-sky mask**
3. **Checks for image quality & consistency**
4. **Compares polar vs. geo ACSPO SSTs**
   - Himawari-8 AHI
   - GOES-16 ABI
5. **Compares ACSPO L2/L3 SSTs with several hi-res L4 SSTs**
   - 0.01° JPL MUR
   - 0.05° Met Office OSTIA
   - 0.05° NOAA Geo Polar Blended
   - 0.10° Canadian Met Centre CMC

Ding et al, SQUAM2 (this breakout)

Main Take-Home Messages

- Users are key NOAA priorities. We are committed to product services and improvements to meet users' needs and expectations
- VIIRS L3U product finds a good traction with VIIRS SST users. We encourage whose users who still use L2P data, to consider L3U
- ACSPO L3U line of products is being extended to include other polar (AVHRR FRAC/GAC, MODIS) and geo (ABI/AHI) sensors
- This will provide a uniform line of high quality / small size ACSPO products to users, from all US polar sensors
- Also, it will set the stage for collated/super-collated ACSPO products
- NOAA Coast Watch will serve ACSPO RAN products, supplemented by rotated buffers of near-real time data (to complement NOAA PDA and JPL PO.DAAC), and transition to NCEI for archival
- NOAA Monitoring and Validation systems are being continuously upgraded to best serve needs of ACSPO users & producers

Future Work

- Support J1 launch
  - NOAA ACSPO system and Monitoring tools are ready
- Two coming ACSPO deliveries to operations
  - V2.50 (Sep 2017): Improved SST imagery & SST algorithms
  - V2.60 (Mar 2018): Improved cloud mask and thermal fronts
- Perform SNPP RAN2 (v2.60), archive w/Coast Watch (2018)
- Release new versions of monitoring systems and document (2018)
  - SQUAM v2
  - *i*Quam v2
  - ARMS v1.40
- Work with STAR/JPSS/GOES-R Management to define path to L3 collated (L3C) and super-collated (L3S) ACSPO products (TBD)


Thank You!