ACSPO SST Products from GOES-16 and Himawari-8

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New Generation US GOES-R (G16) with Advanced Baseline Imager (ABI) onboard

- ✓ 19 Nov 2016: GOES-R launched from Cape Canaveral, FL
- ✓ 30 Nov 2016: GOES-R renamed GOES-16
- ✓ 15 Jan 2017: First ABI imagery sent to Earth
- ✓ 28 Feb 2017: ABI L1b declared "Beta Mature"
- ✓ 24 May 2017: ABI L2 SST declared "Beta Mature"

Users are welcome to start exploring G16 L1b and L2 SST data, with the following disclaimer **"NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing"**

- o Sep 2017: SST Provisional Maturity
- → **Nov 2017: G16 moved to GOES-East Position**
- o Dec 2017: SST Validated Maturity
- o Jan 2018: G16 SST Operational
- → **2018: Launch of GOES-S**
- o 2020s-2030s: Launches of GOES-T and GOES-U

Himawari-8 and GOES-R SST Constellation

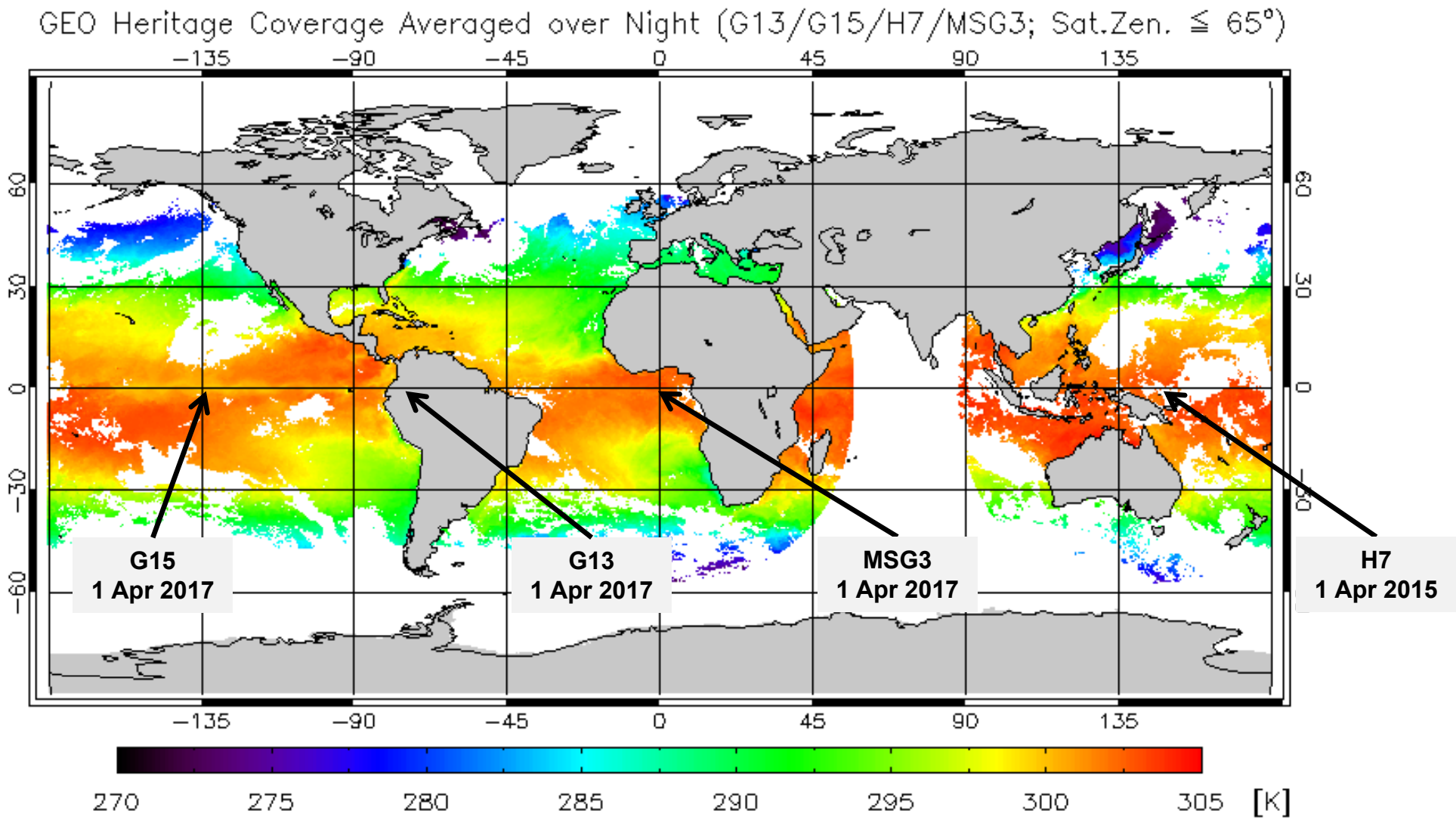
- ✓ Oct 2014: H8 launched
- ✓ Jan 2015: NOAA accesses AHI L1b via HimawariCloud
- ✓ Apr 2015: Pre-op ACSPO L2P SST generated
- ✓ Jul 2015: H8 declared operational by JMA. ASCPO L2P routinely produced & assimilated in geo-polar blend L4 SST
- ✓ H9 launched in Nov 2016 (in testing/storage mode now)

GOES-R & H-8/9 form a new-gen geo SST constellation

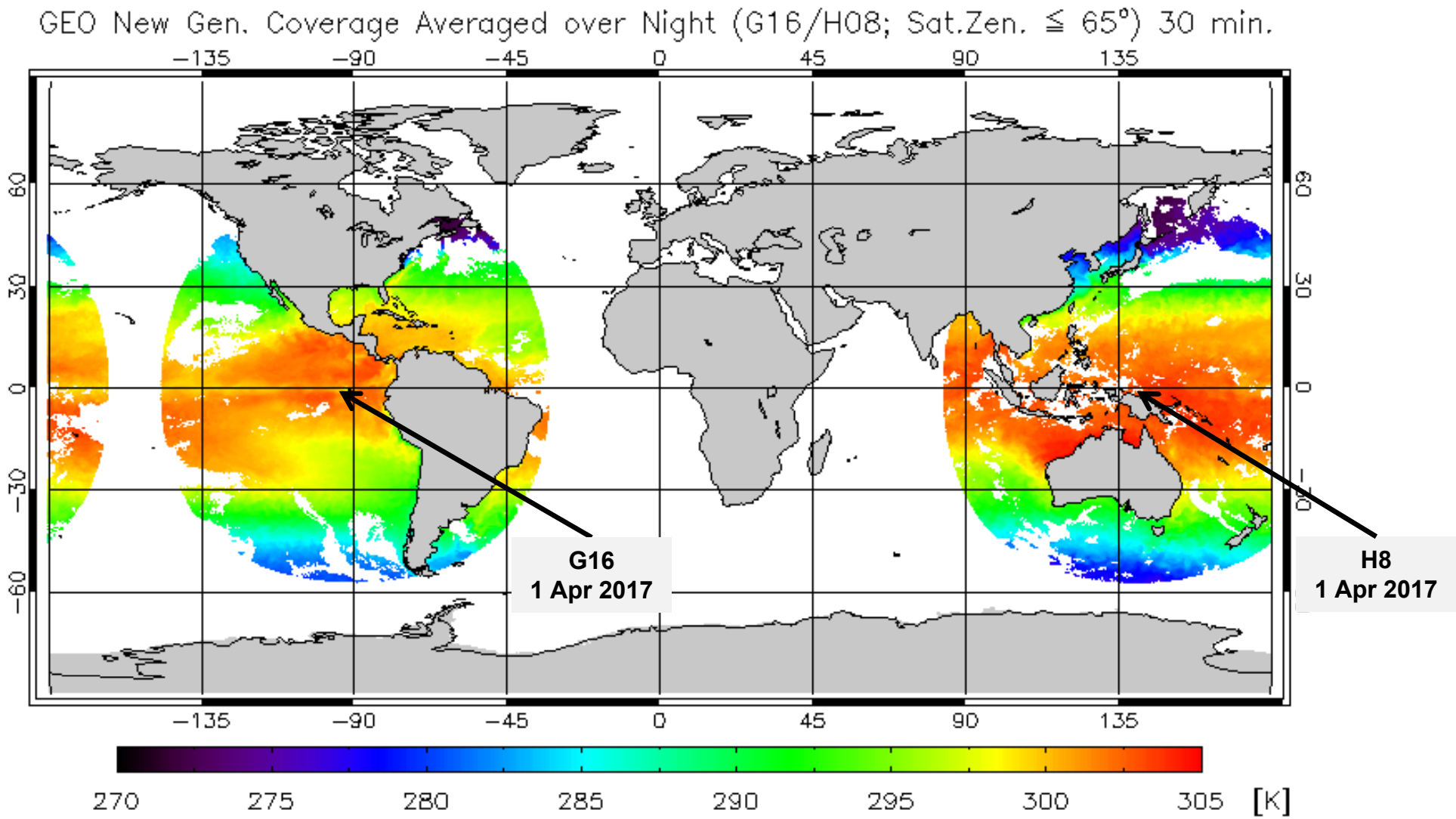
G16 & H8 carry twin sensors – Advanced Baseline Imager (ABI) & Advanced Himawari Imager (AHI)

The ABI/AHI replace the heritage imagers onboard GOES and H7/MTSAT2 and significantly improve SST capability

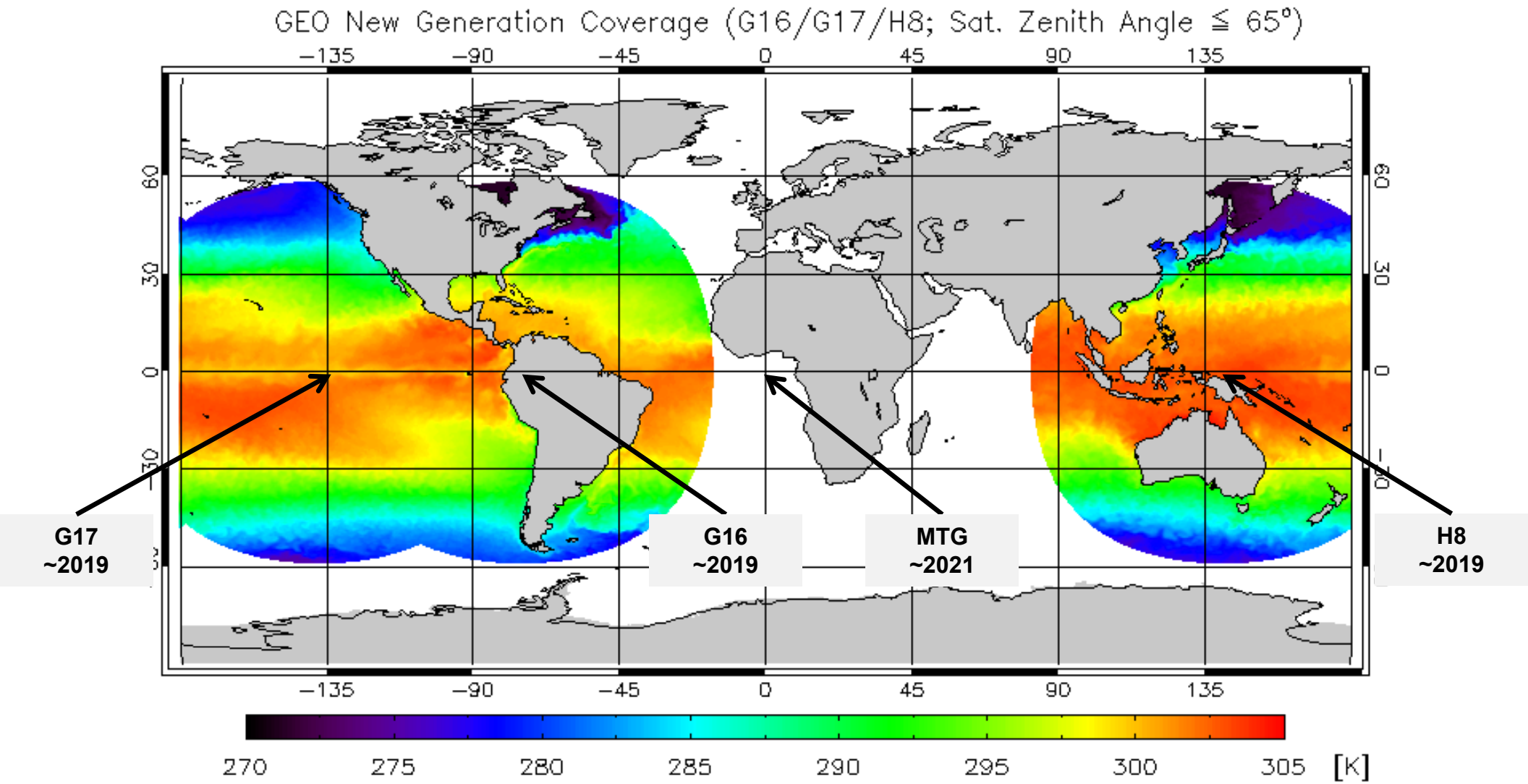
Heritage NOAA SST Products
G13 (East), G15 (West), MSG3, H7



Current New-Gen Configuration (2017)
G16 (between G13/G15) and H8



Future New-Gen Configuration (~2019-2021)
G16 (current position: between G13/G15), G17 & H8



SST Bands / Used for SST And Spatial/Temporal Resolution

ABI/AHI[1]		G13/G15		H7/MTSAT2		VIIRS	
Nadir: 2km Swath edge(67º): 15km		Nadir: 4km Swath Edge(65º): 30km		Nadir: 4km Swath Edge(65º): 30km		Nadir: 0.74km Swath edge(67º) 1.5km	
FD: ABI/15 & AHI/10 min		FD: 30min		FD: 30min		Global: Twice daily	
λ, μm	*Spec NEDT, K @300K*	*λ, μm*	*Spec NEDT, K @300K*	*λ, μm*	*Spec NEDT, K @300K*	*λ, μm*	*Spec NEDT, K @300K*
3.9	≤ 0.10	3.9	0.11	3.75	0.09	3.9	0.11
8.6	≤ 0.10	–	–	–	–	8.6	0.05
10.4	≤ 0.10	10.7	0.10	10.8	0.11	10.8	0.07
11.2	≤ 0.10	–	–	12.0	0.20	12.0	0.07
12.4	≤ 0.10	13.3	0.70	–	–	–	–

- ABI/AHI Spatial/Temporal Resolution: At least ×2 better than GOES/H7
- ABI/AHI SST bands are positioned better, with improved NEDTs

ACSPO
ABI/AHI Algorithms

Current ACSPO ABI/AHI Clear-Sky Mask

- **Outcomes of all tests are binary**
  - ✓ **1 – 3: "Clear" or "Cloudy"**
  - ✓ **4 – 5: "Clear" or "Probably Cloudy"**
  - ✓ **3 & 5: Applied during Day-time only**

ACSM Test	Predictor	Outcome
1. Static SST (provides 1st guess for test 2)	$\Delta T_S = T_{SAT} - T_{CMC}$	• Mark ΔT_S colder than static threshold "cloud" • Under certain conditions, mark warm ΔT_S (caused by warm stratus clouds) as "cloud"
2. Adaptive SST	$\Delta T_S = T_{SAT} - T_{CMC}$	Refine results of Test 1 by iterative analyses of ΔT_S for "clear/cloudy" pixels in a local window
3. Reflectance	$R_{0.86}$	Mark bright $R_{0.86}$ as "cloud" (**day only**)
4. Spatial Uniformity	Spatial SD of $T_{SAT} - \mathrm{med}(T_{SAT})$	Classify pixel into clear/probably-cloudy (using variability of T_{SAT} in a local window)
5. SST/Reflectance Cross-correlation	Correlate ΔT_S vs. $R_{0.86}$	Classify pixel into clear/probably-cloudy (by analyzing correlation in a local window) (**day only**)

- **Comparison with reference SST may result in false alarms and cloud leakages, especially in dynamic & coastal areas, and in presence of diurnal warming**
- **Work is underway to improve geo mask using analysis of diurnal cycle in the vicinity of each individual pixel – discussed later in this talk**

Current ACSPO AHI/ABI SST Algorithms

Sub-skin SST:

$$T_S = a_0 + a_1 T_{11} + a_2(T_{11}-T_8) + a_3(T_{11}-T_{10}) + a_4(T_{11}-T_{12}) +$$
$$+ [a_5 + a_6 T_{11} + a_7(T_{11}-T_8) + a_8(T_{11}-T_{10}) + a_9(T_{11}-T_{12})]S_\theta +$$
$$+ [a_{10}(T_{11}-T_8) + a_{11}(T_{11}-T_{10}) + a_{12}(T_{11}-T_{12})]T_S^0$$

T_8, T_{10}, T_{11} and T_{12}	BTs observed in ABI/AHI bands centered 8.6, 10.4, 11.2, and 12.4μm
$S_\theta = 1/\cos(\vartheta) - 1$	ϑ is satellite view zenith angle
T_S^0	first guess SST in ºC (currently obtained from 0.1º L4/CMC)

- One single equation is used to minimize the possible day-night discontinuities
- Four longwave bands are used for SST
- Band centered at 3.9μm is <u>not</u> used, to minimize day/night discontinuities

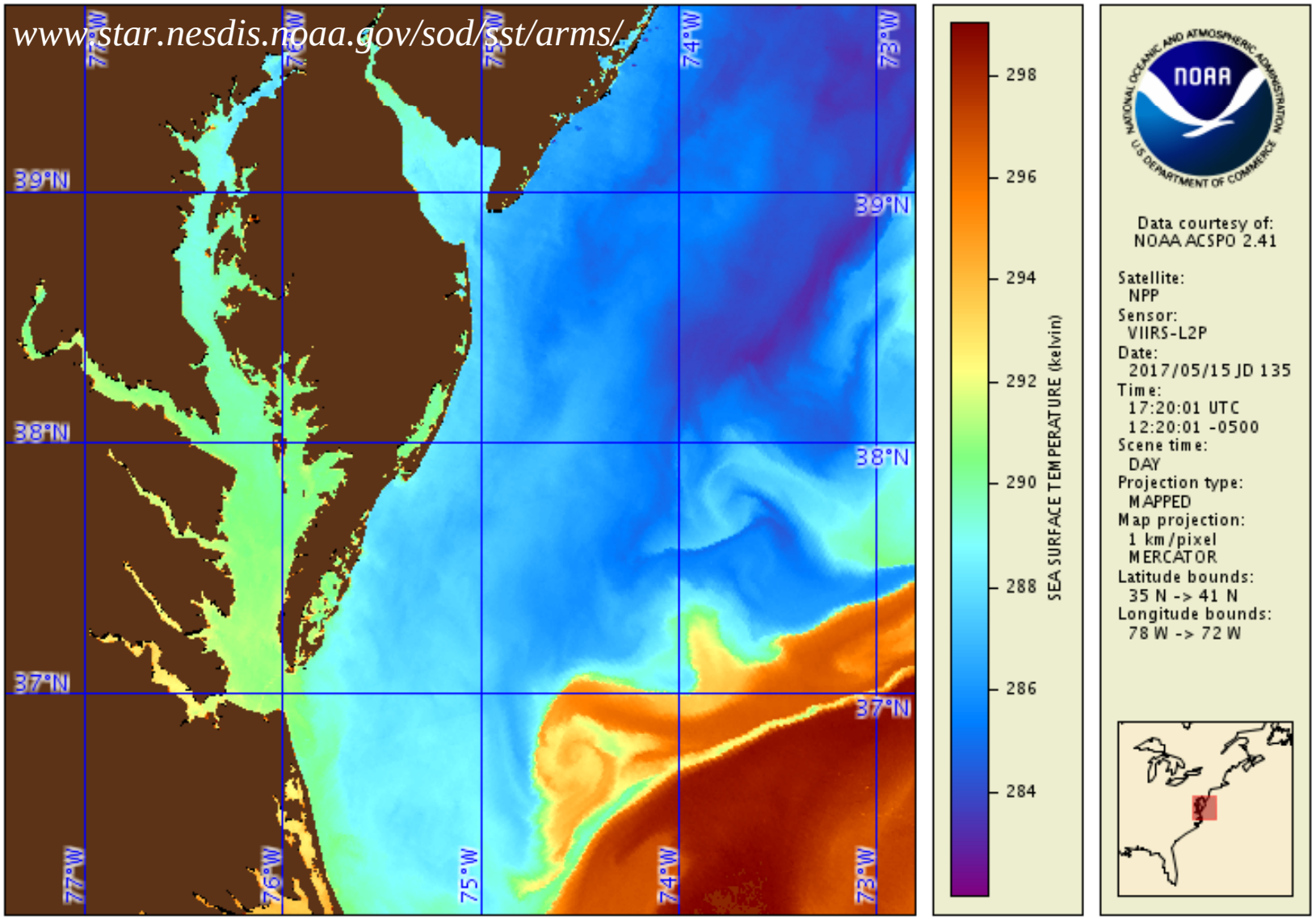
Depth SST:

Obtained by piece-wise regression vs. *in situ* SSTs as a function of the Fisher distance (calculated in space of regressors). Fits accurately *in situ* data, does not control sensitivity to "true sub-skin" SST

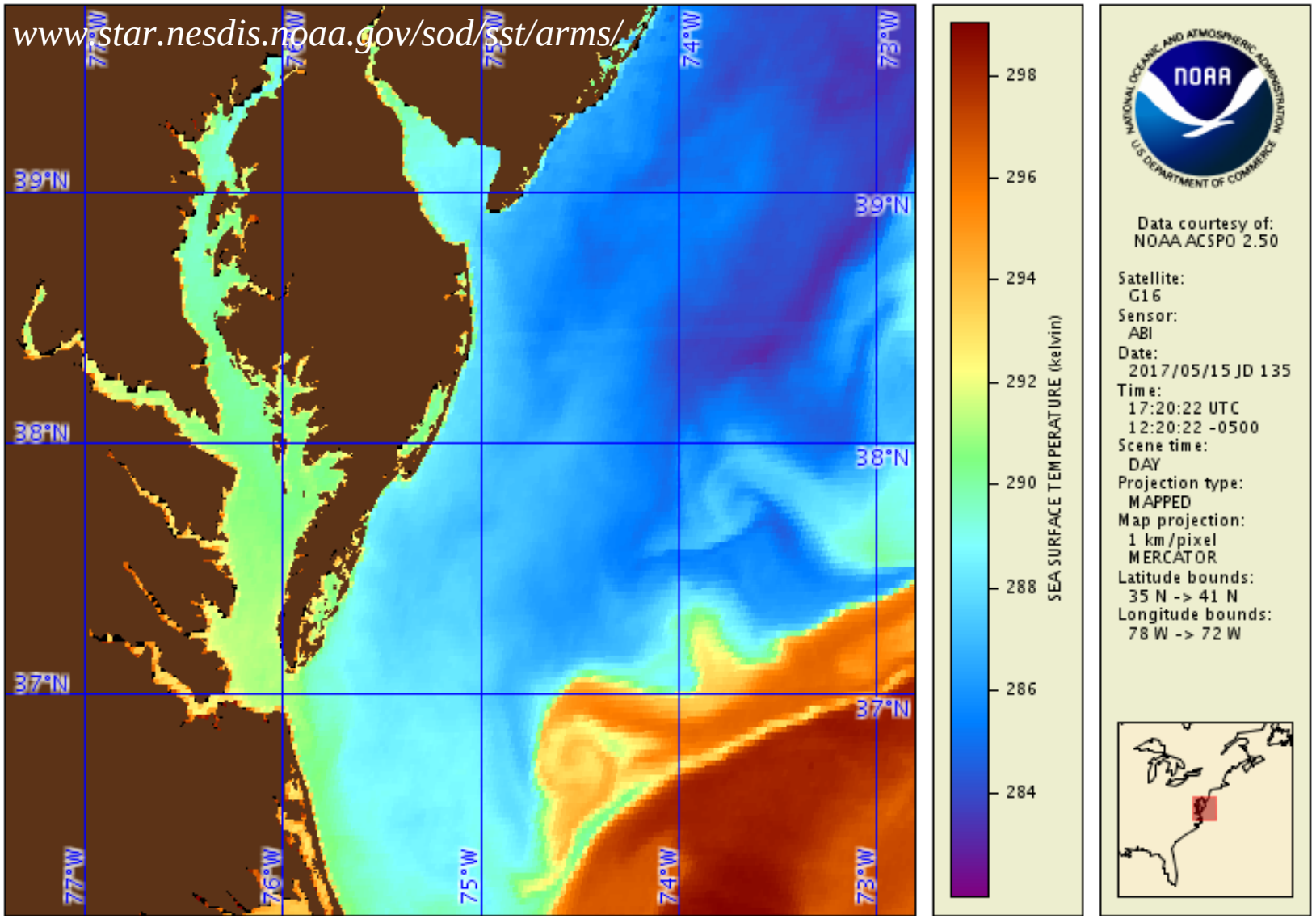
See presentation by Petrenko et al. for more info

ABI SST Imagery Vs. SNPP VIIRS

SNPP VIIRS L2P SST (Mapped to 1km Mercator)
Chesapeake Bay 15 May 2017 17:20UTC – All Sky

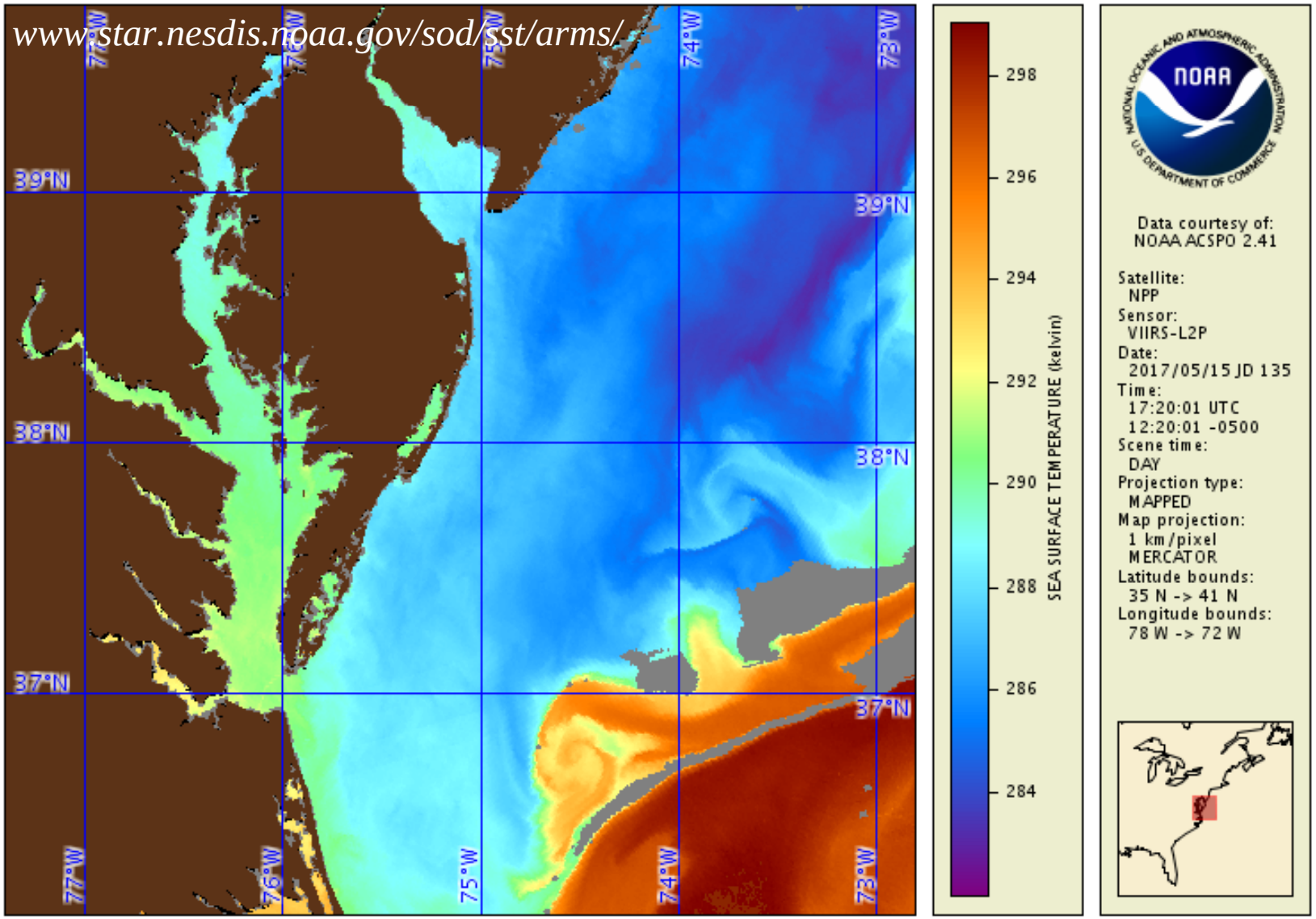


G16 ABI L2P SST (Mapped to 1km Mercator) Chesapeake Bay 15 May 2017 17:20UTC – All Sky

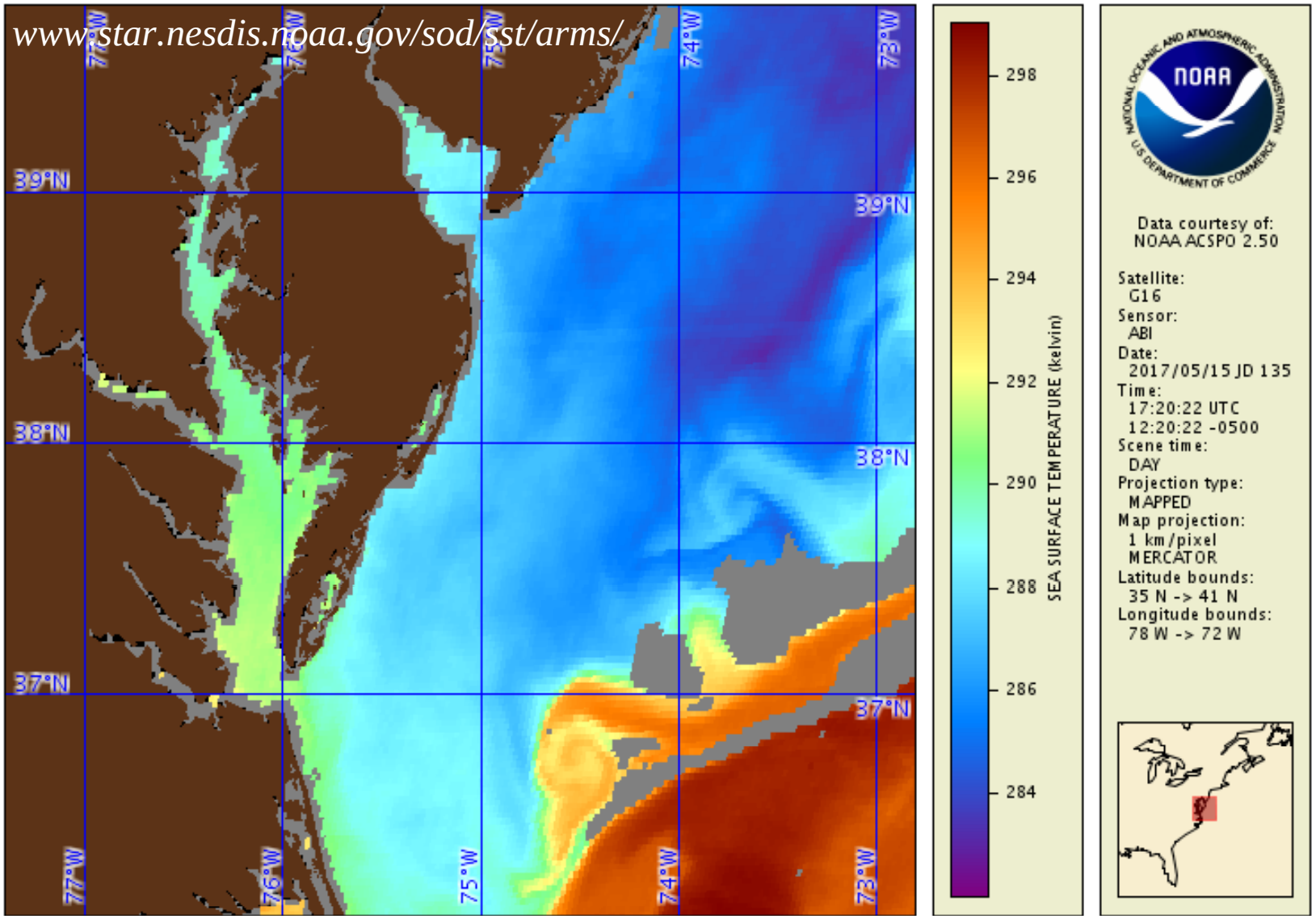


NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing

SNPP VIIRS L2P SST (Mapped to 1km Mercator)
Chesapeake Bay 15 May 2017 17:20UTC – Clear Sky



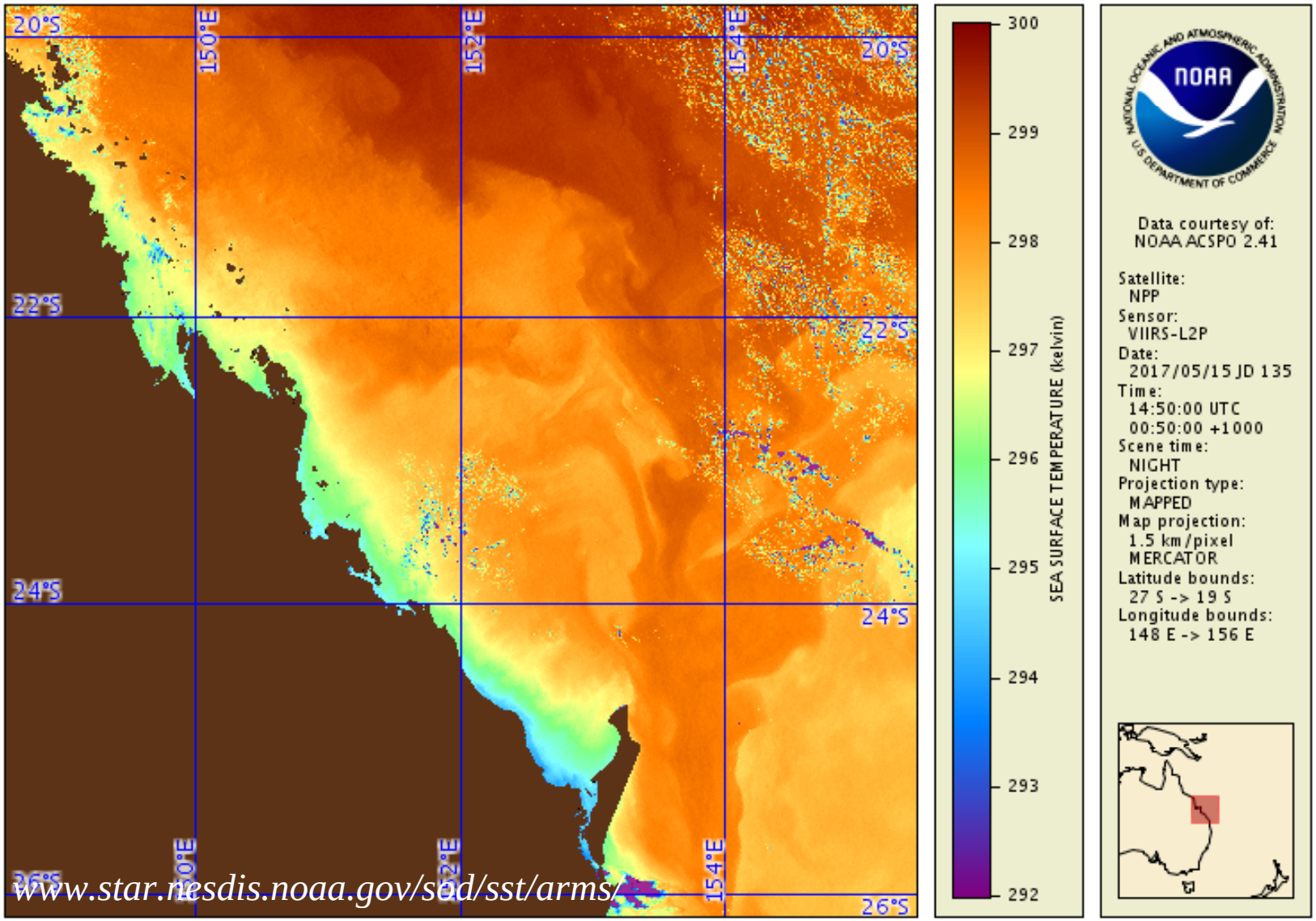
G16 ABI L2P SST (Mapped to 1km Mercator)
Chesapeake Bay 15 May 2017 17:20UTC – Clear Sky



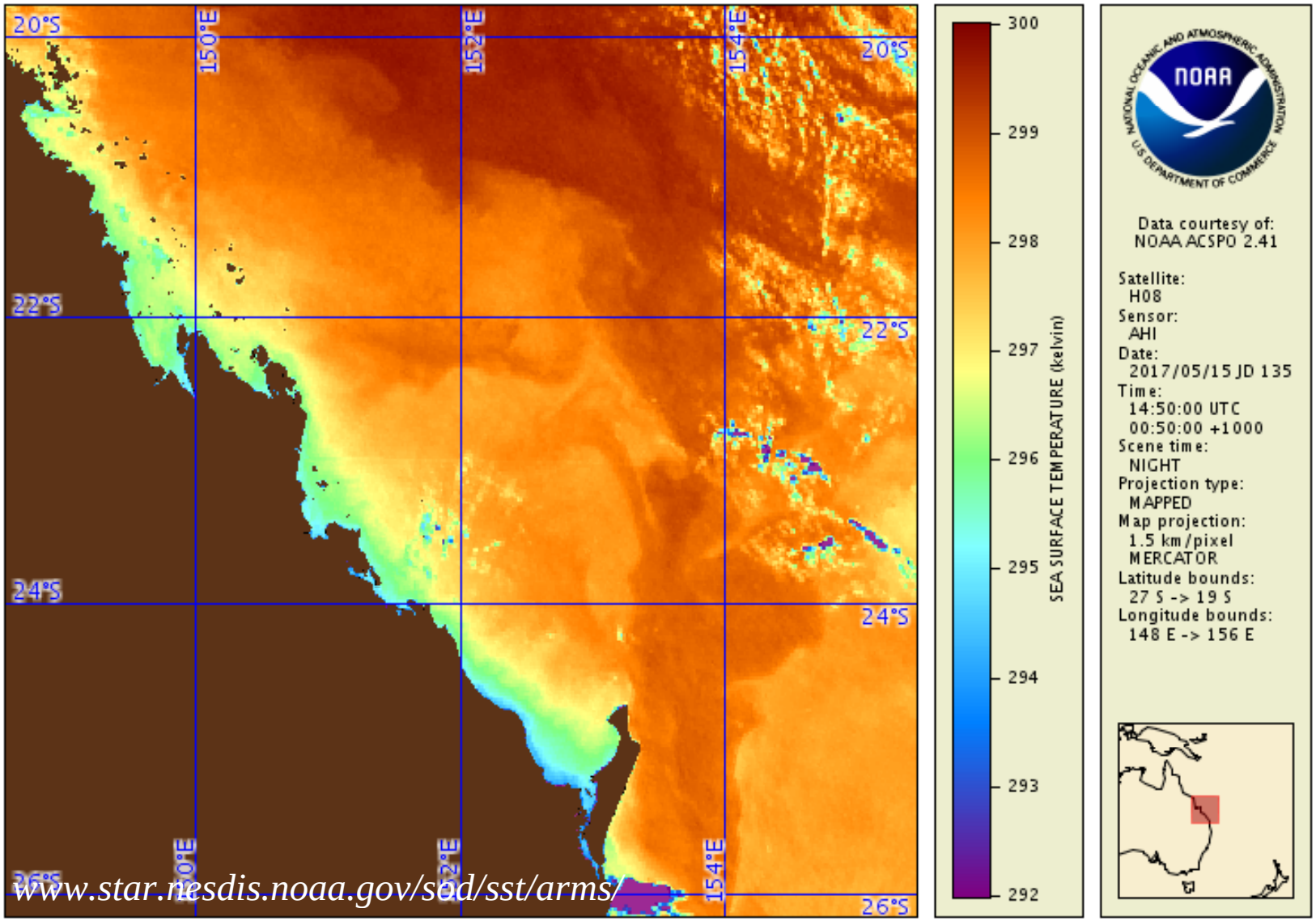
NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing

AHI SST Imagery Vs. SNPP VIIRS

SNPP VIIRS L2P SST (Mapped to 1.5km Mercator) Australia GBR, 15 May 2017 14:50UTC – All Sky

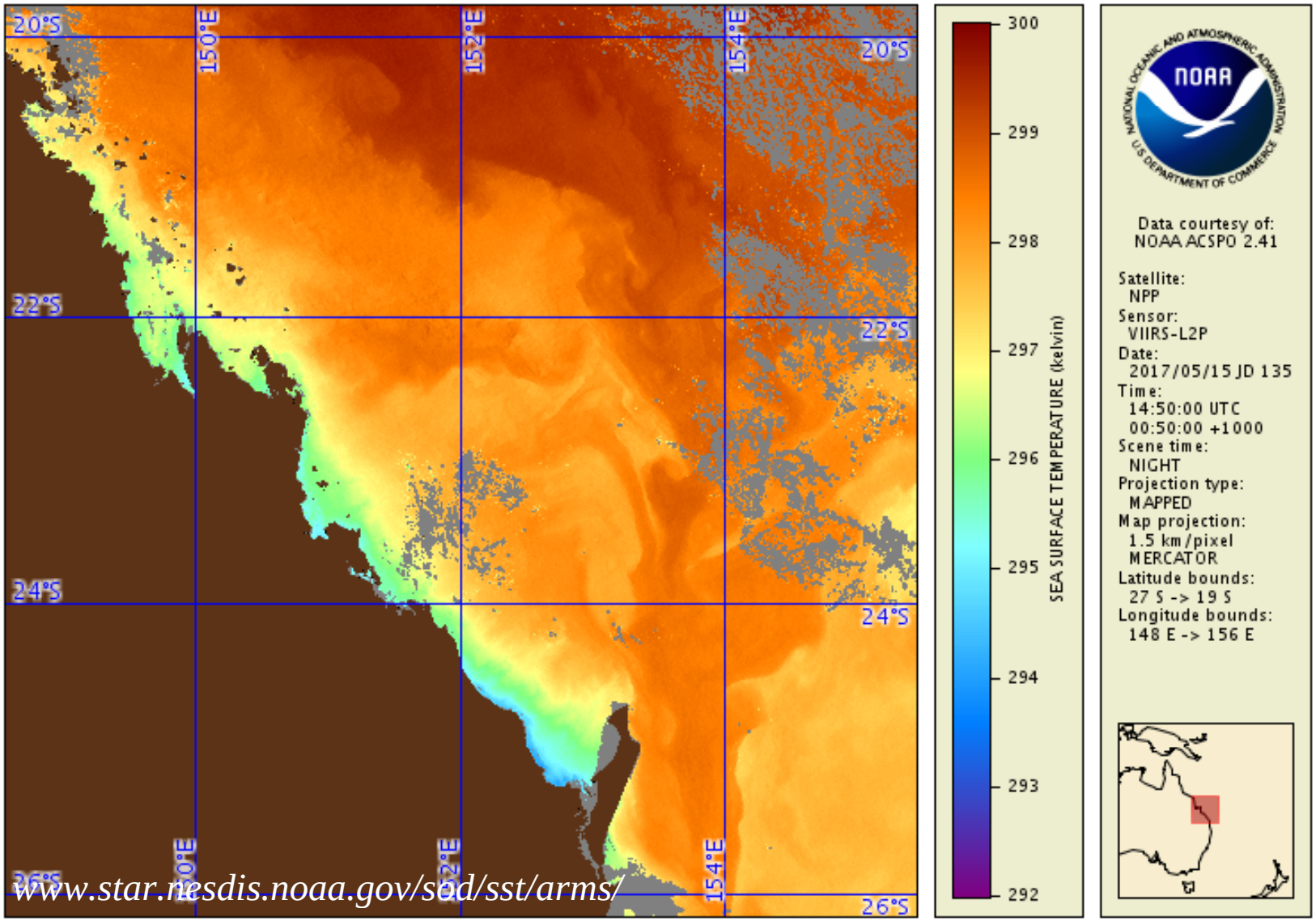


H8 AHI L2P SST (Mapped to 1.5km Mercator) Australia GBR, 15 May 2017 14:50UTC – All Sky

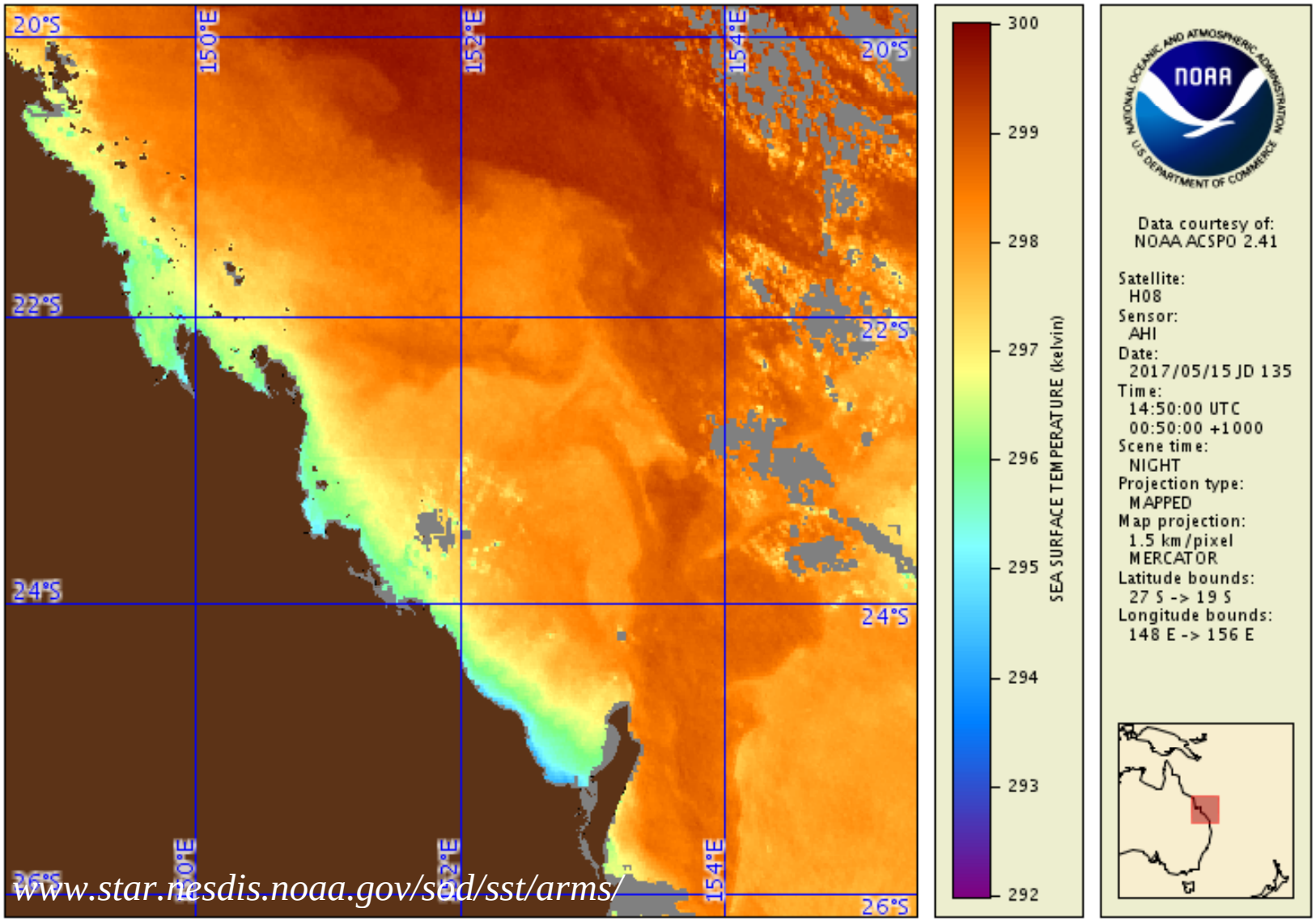


www.star.nesdis.noaa.gov/sod/sst/arms/

SNPP VIIRS L2P SST (Mapped to 1.5km Mercator)
Australia GBR, 15 May 2017 14:50UTC – Clear Sky

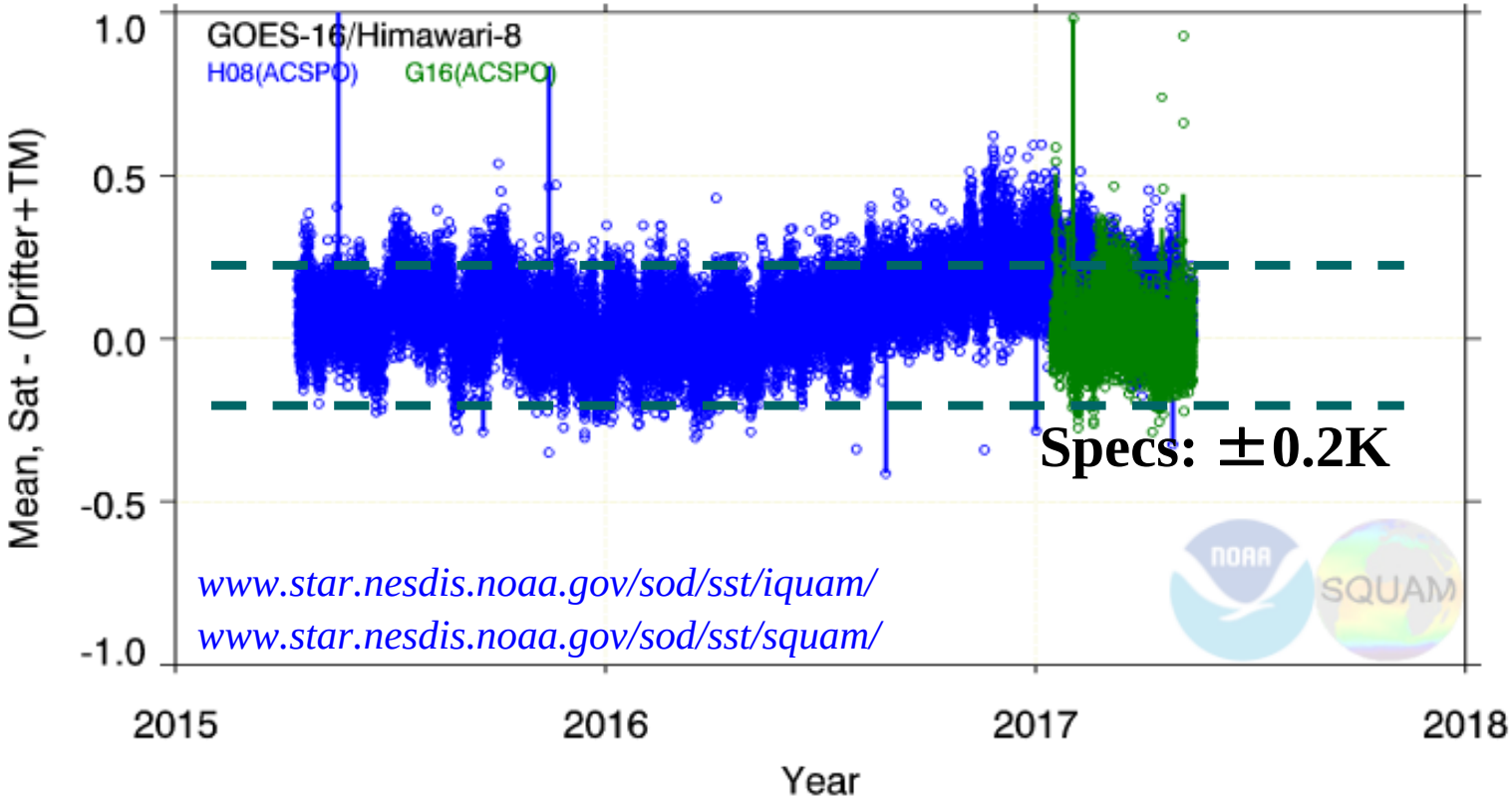


H8 AHI L2P SST (Mapped to 1.5km Mercator)
Australia GBR, 15 May 2017 14:50UTC – Clear Sky



G16/ABI and H8/AHI SSTs vs. *i*Quam *in situ* SSTs

G16 and H8 Global Bias vs. Drifters + Trop. Moor.
Sub-Skin SST (No SSES Bias Correction)

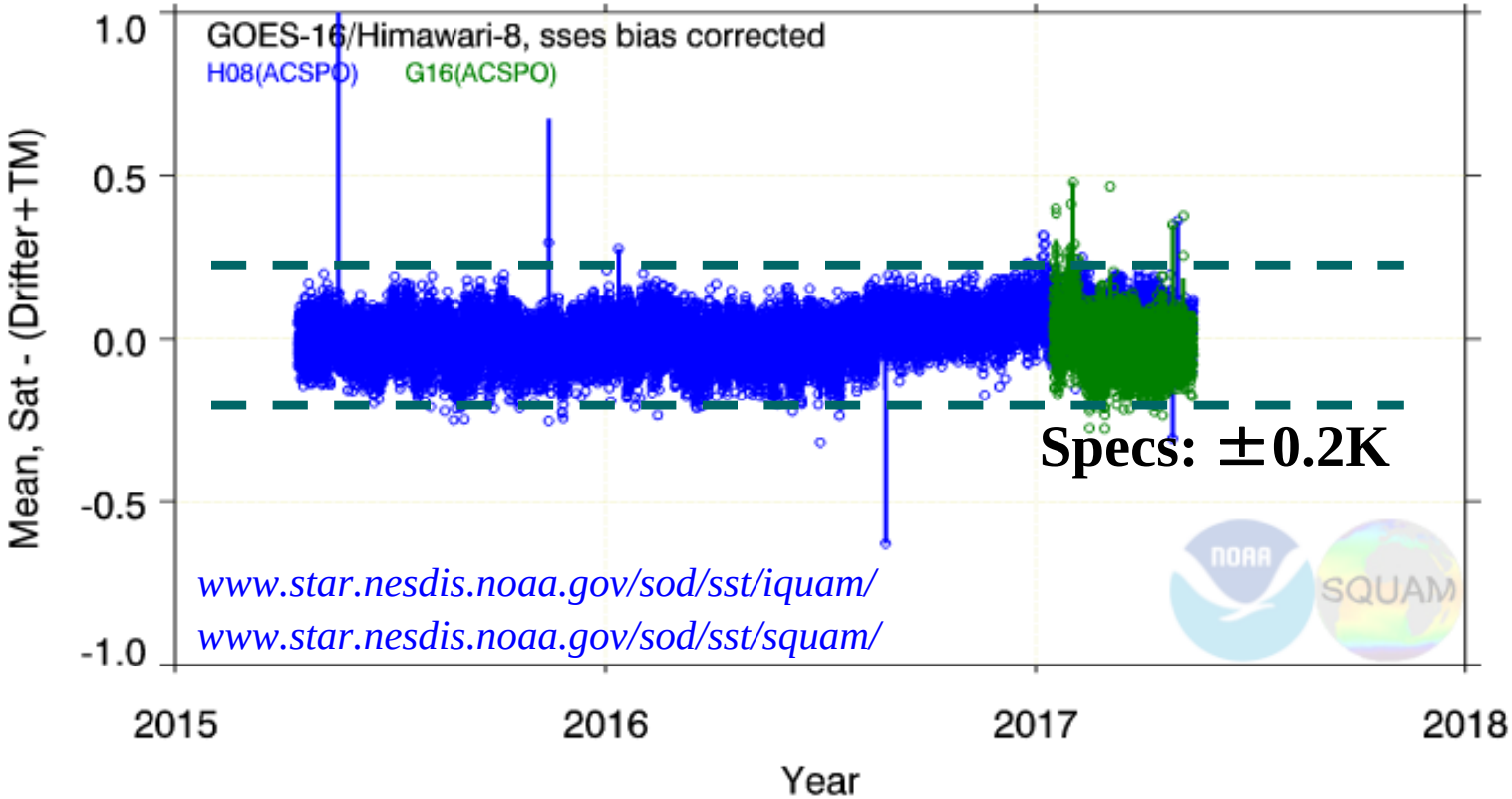


- ACSPO H8 SST produced from 15 Apr 2015 – on
- ACSPO G16 SST produced from 15 Jan 2017 – on
- Both products are close to meeting NOAA accuracy specs ±0.2K

NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing

Zhou et al, iQuam2, Poster #22
He et al, SQUAM2, Poster #8

G16/ABI & H8/AHI Global Bias vs. Drifters + Trop. Moor. Depth SST (with SSES Bias Correction)

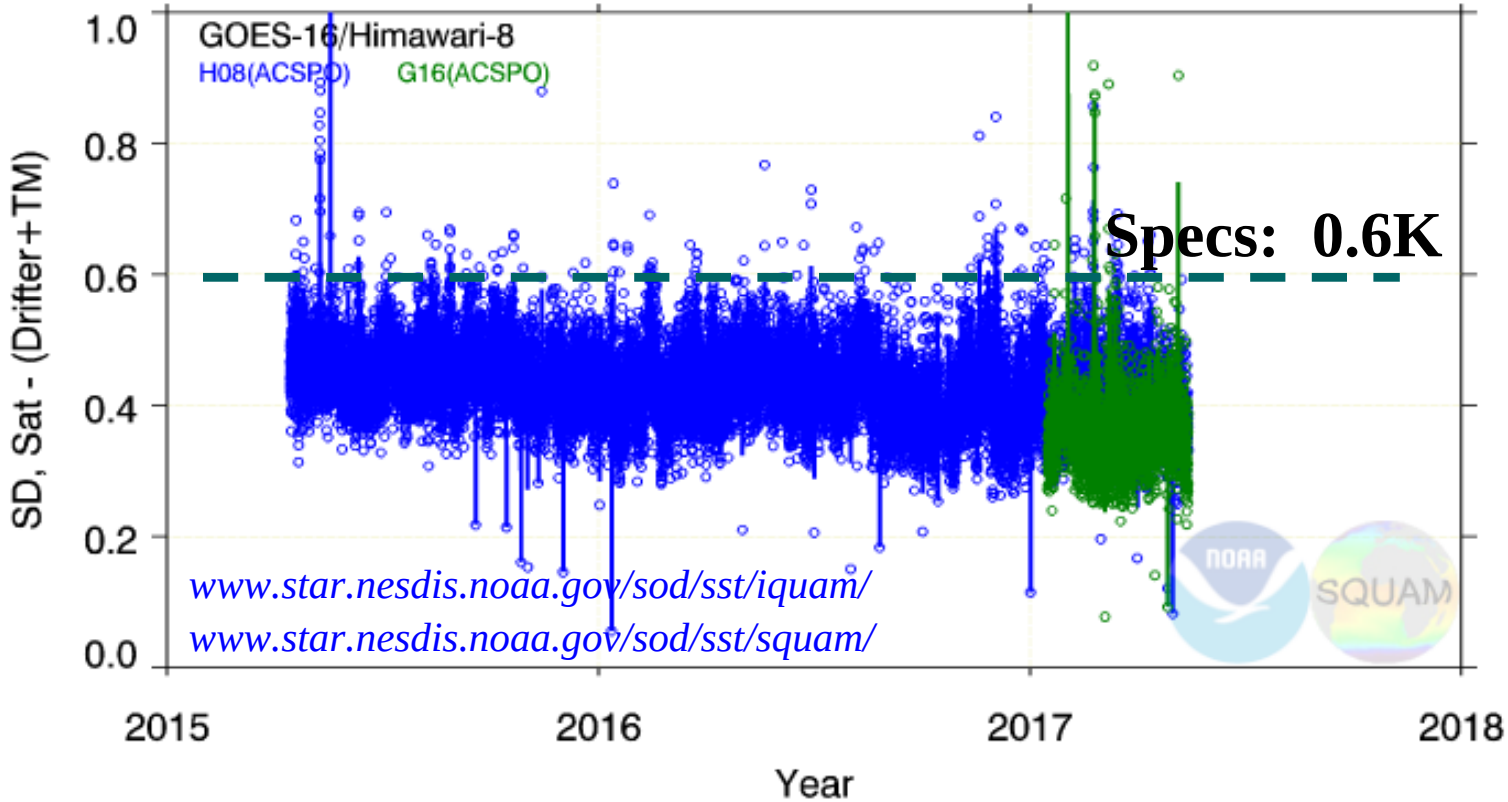


- ACSPO "depth SST" (obtained by subtracting SSES bias from the "global regression" sub-skin SST) is more tight & stable in time wrt. *in situ* SST
- Both products meet NOAA accuracy specs of ±0.2K

NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing

Zhou et al, iQuam2, Poster #22
He et al, SQUAM2, Poster #8

G16/ABI & H8/AHI Global Std. Dev vs. Drifters + Trop. Moor.
Sub-Skin SST (No SSES Bias Correction)

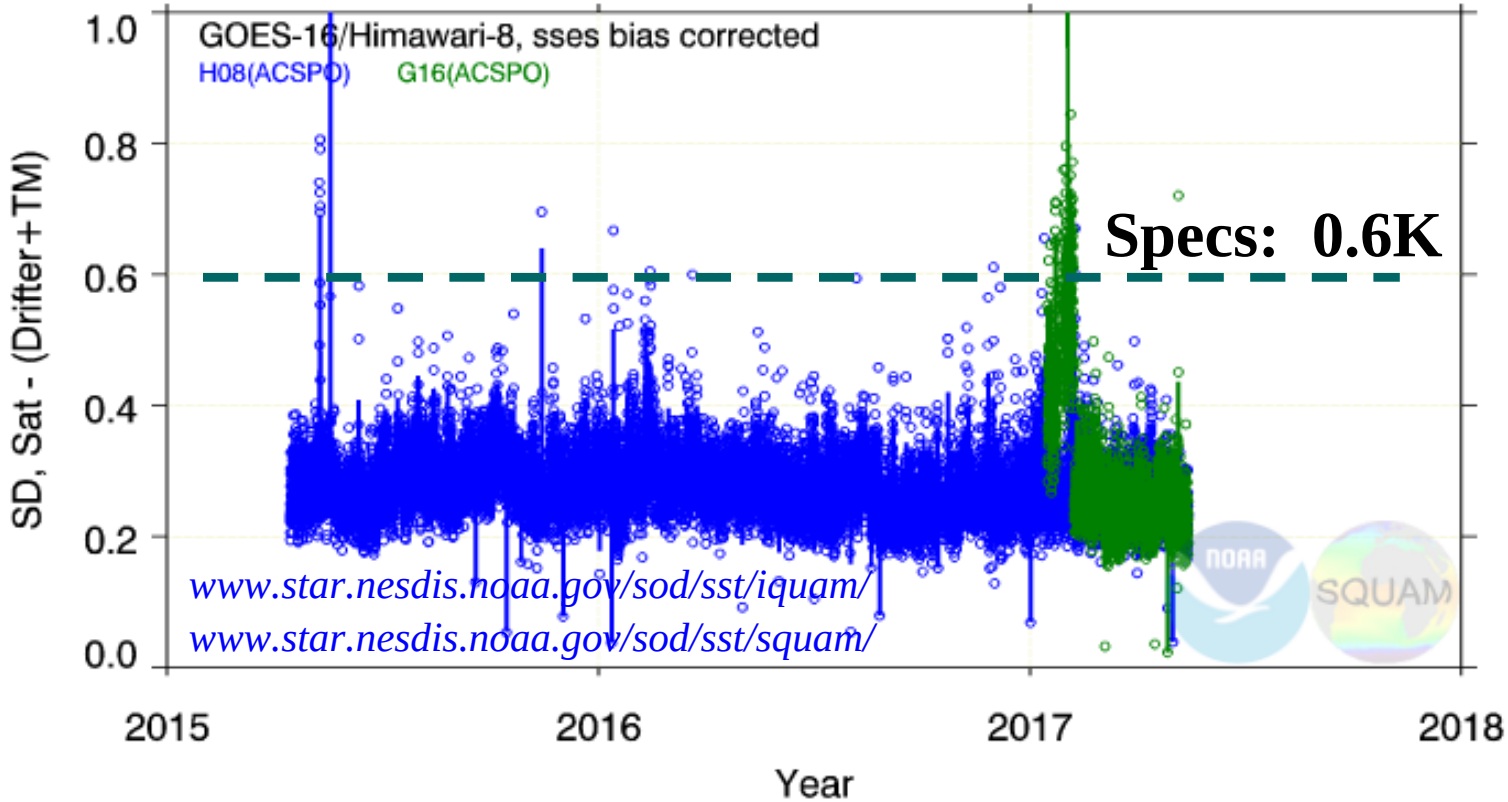


- **Both G16 and H8 SSTs are close to meeting NOAA precision specs 0.6K**

NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing

Zhou et al, iQuam2, Poster #22
He et al, SQUAM2, Poster #8

G16/ABI & H8/AHI Global Std. Dev vs. Drifters + Trop. Moor. Depth SST (with SSES Bias Correction)



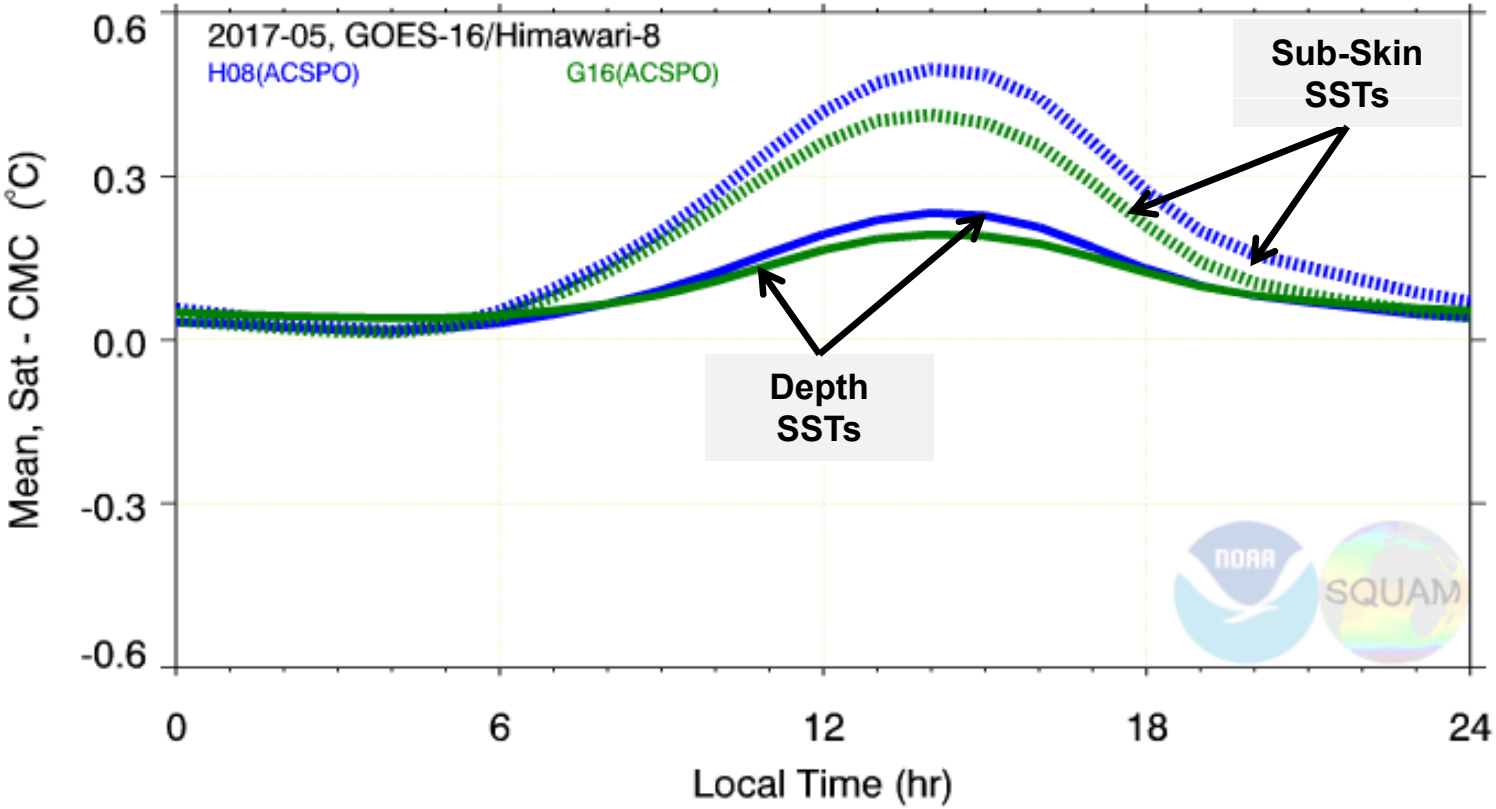
- "Depth SST" ("Sub-skin" minus SSES bias) is more tight & stable in time
- Both G16 and H8 products are close to meeting NOAA precision specs ~0.6K (except for the 1st month of G16, when initial LUTs/Coefficients were used)
- Work is underway to reprocess G16 and H8 SSTs & make available to users

NOAA's G16 satellite has not been declared operational and its data are preliminary and undergoing testing

Zhou et al, iQuam2, Poster #22
He et al, SQUAM2, Poster #8

Diurnal Cycle in ABI/AHI SSTs Vs. Heritage Geo Products

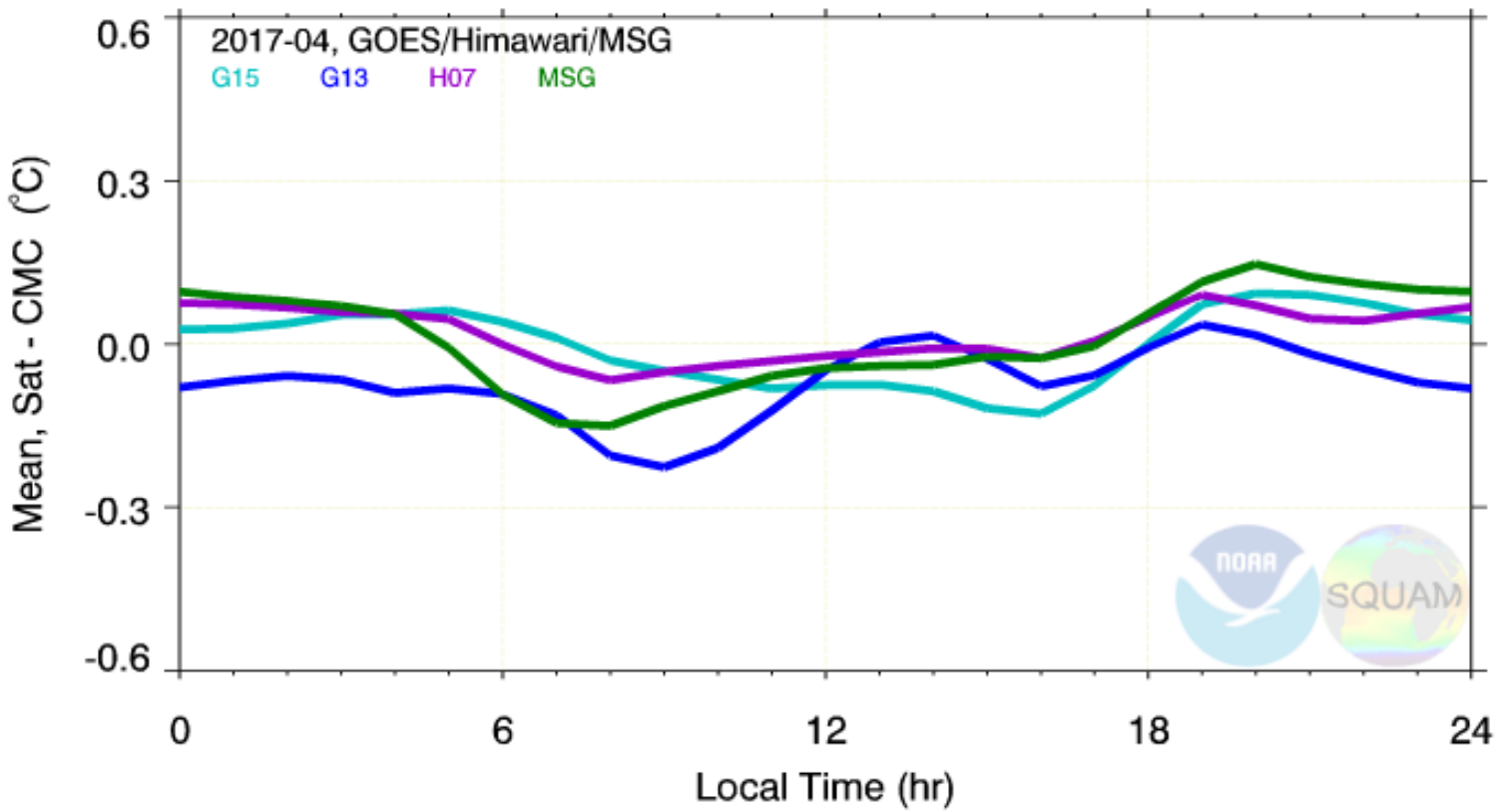
G16/H8 SSTs May 2017
Monthly Mean (T_{sat} – $T_{CMC\ L4}$)



- G16/H8 DCs are close to CMC at night. During the day, show diurnal warming
- Sub-Skin SST: Min occurs at ~4-5am, Max ~2pm LT; Amplitude ~0.5 K (sensitivity to true SST not controlled to be ~1; see Petrenko's presentation)
- Depth SST: Min/Max lag later in the day by 1-2hrs; Smaller amplitude ~0.2K

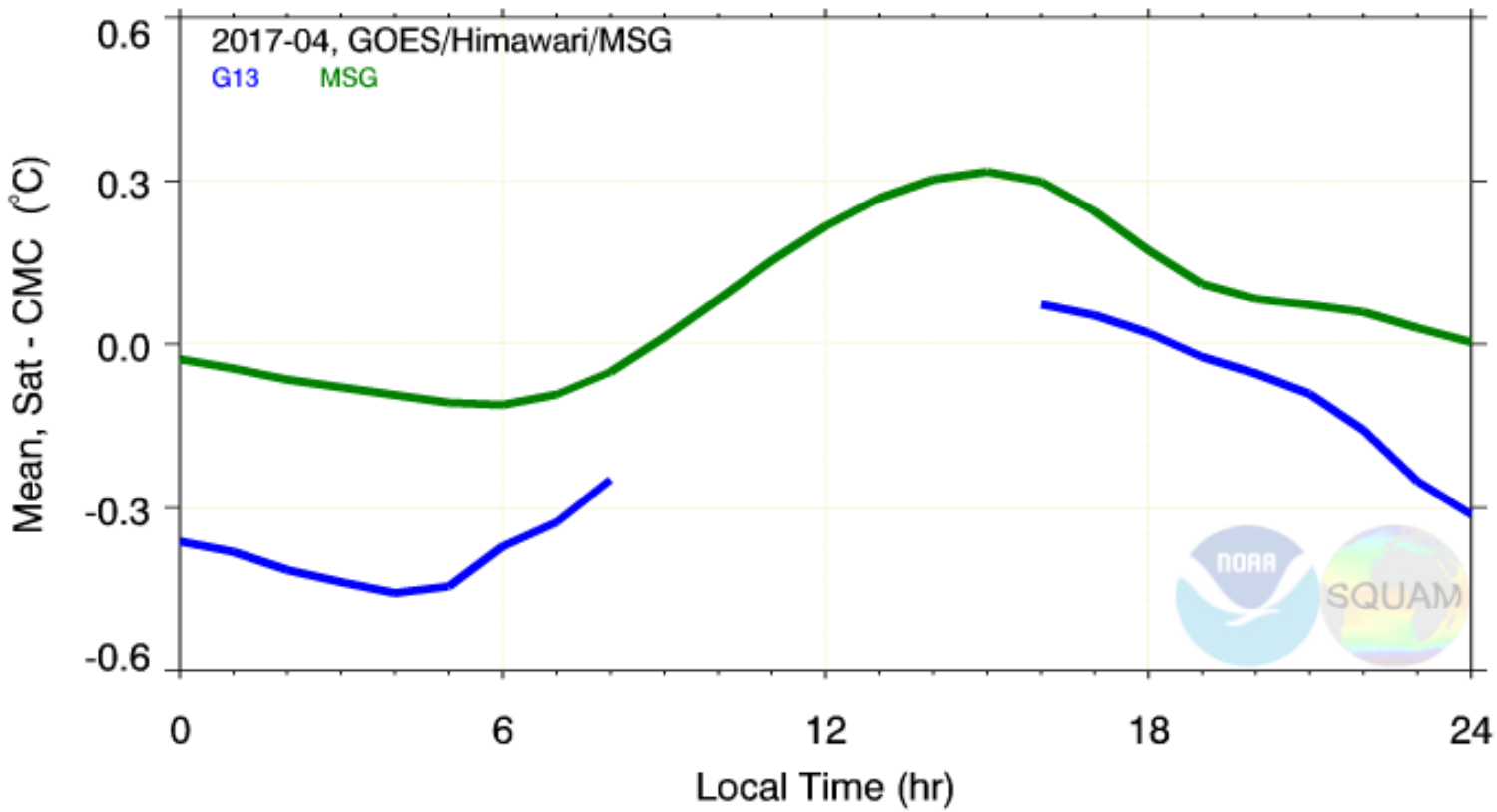
NOAA Heritage SST G13/G15/MSG3 Apr 2017 (H7: Apr 2015)

Monthly Mean (T_{sat} – $T_{CMC\ L4}$)



- **NOAA heritage SSTs are generated from G13, G15 and MSG3. H7 (MTSAT2) SST was also generated until Dec 2015**
- **DC more noisy compared to G16/H8, and less consistent across satellites**

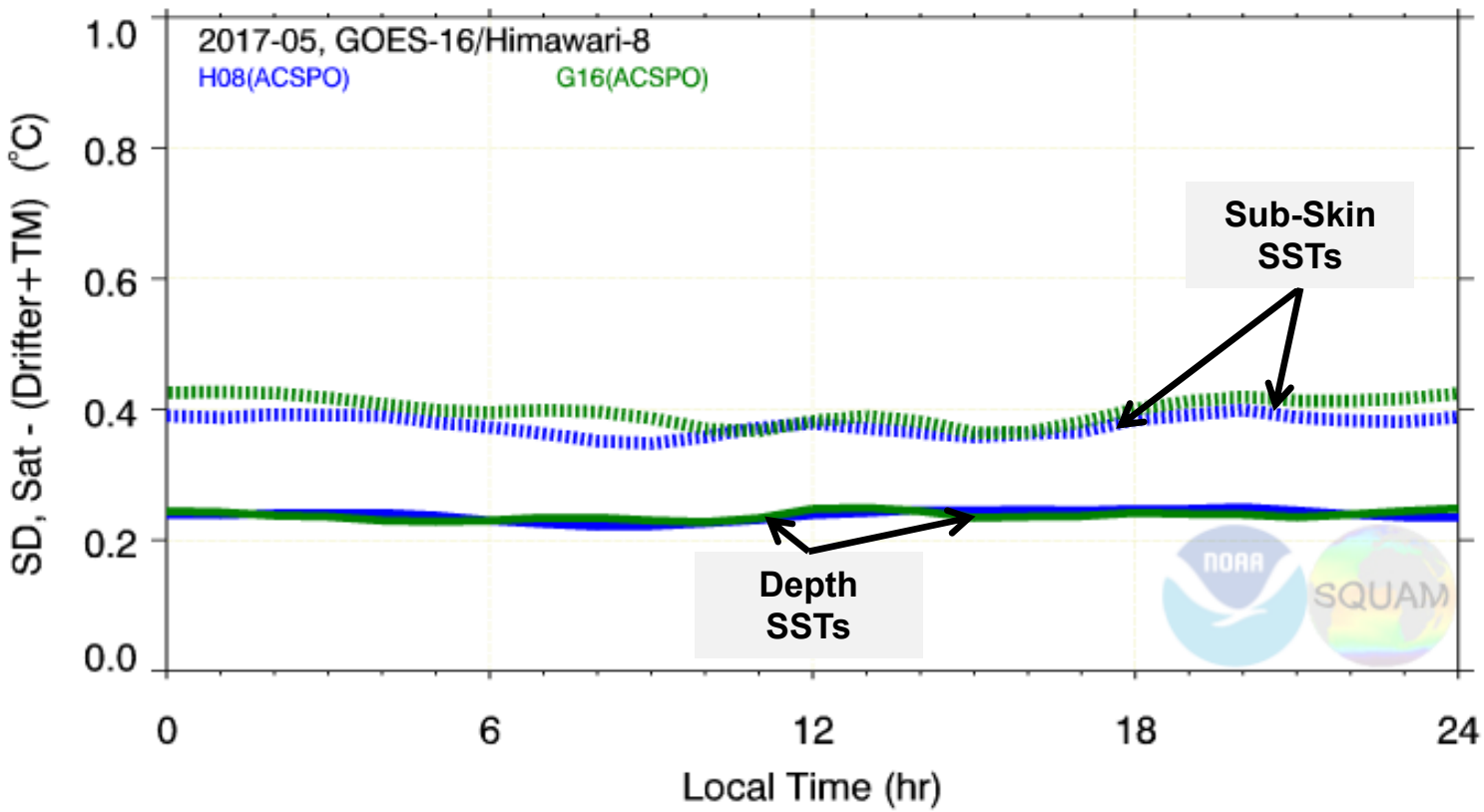
OSI SAF SSTs G13/MSG3 Apr 2017
Monthly Mean (*Tsat – TCMC L4*)



- **OSI SAF SSTs from MSG3 has been widely used for DC analyses. Min ~6am, Max~3pm, Amplitude ~0.5K**
- **OSI SAF G13 SST only produced at low sun (when 3.7 µm can be used). Generally, it follows the MSG DC, by biased low by ~-0.3K**

G16 and H8 SSTs Monthly Mean DC May 2017

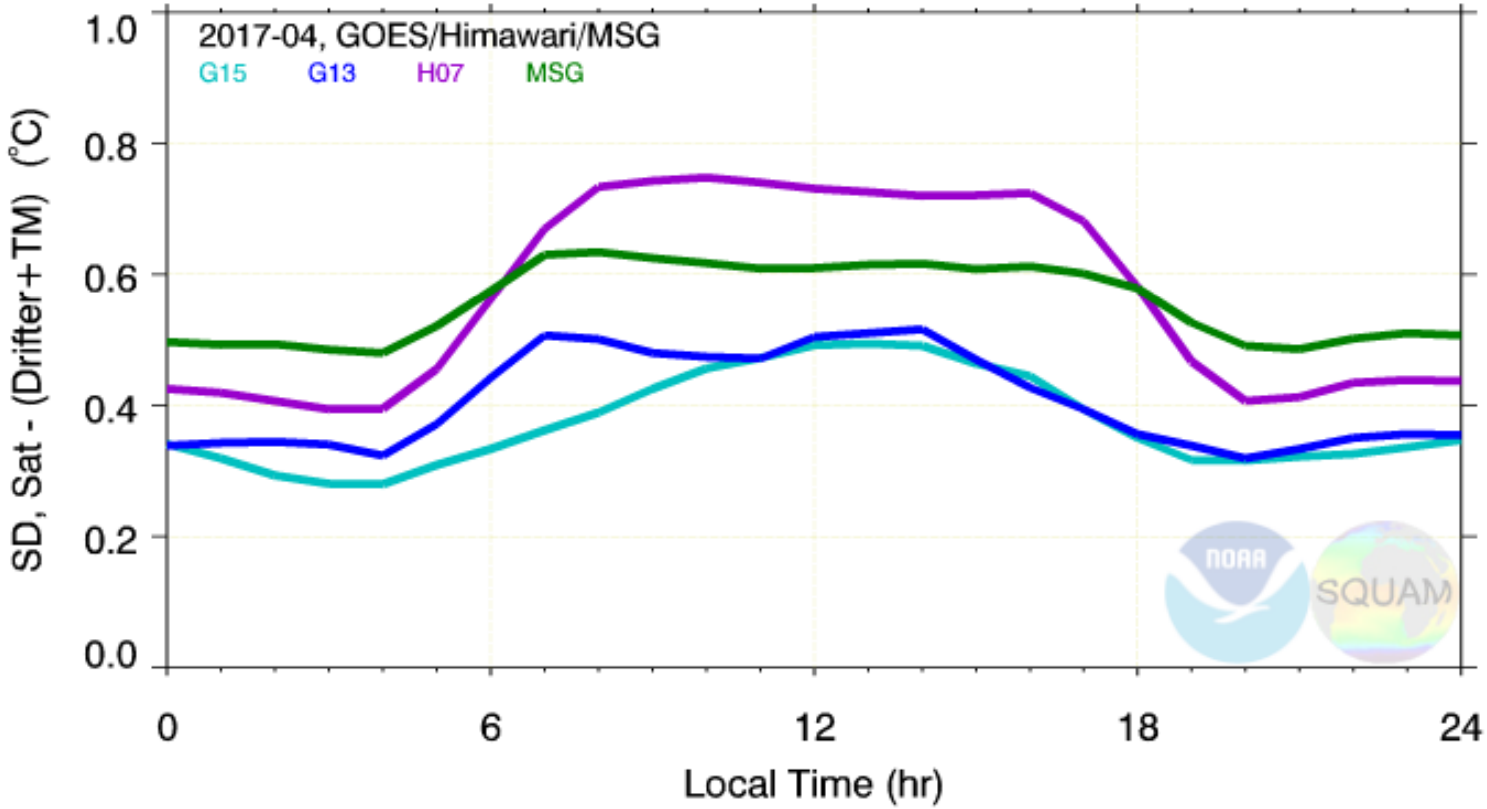
Std. Dev (*Tsat* – *Tinsitu*)



- **G16 and H8 SSTs validate against *in situ* SST nearly uniformly across the DC**
- **Typical Std. Dev. is~0.4K for the "sub-skin" and ~0.25K for the "depth SST"**

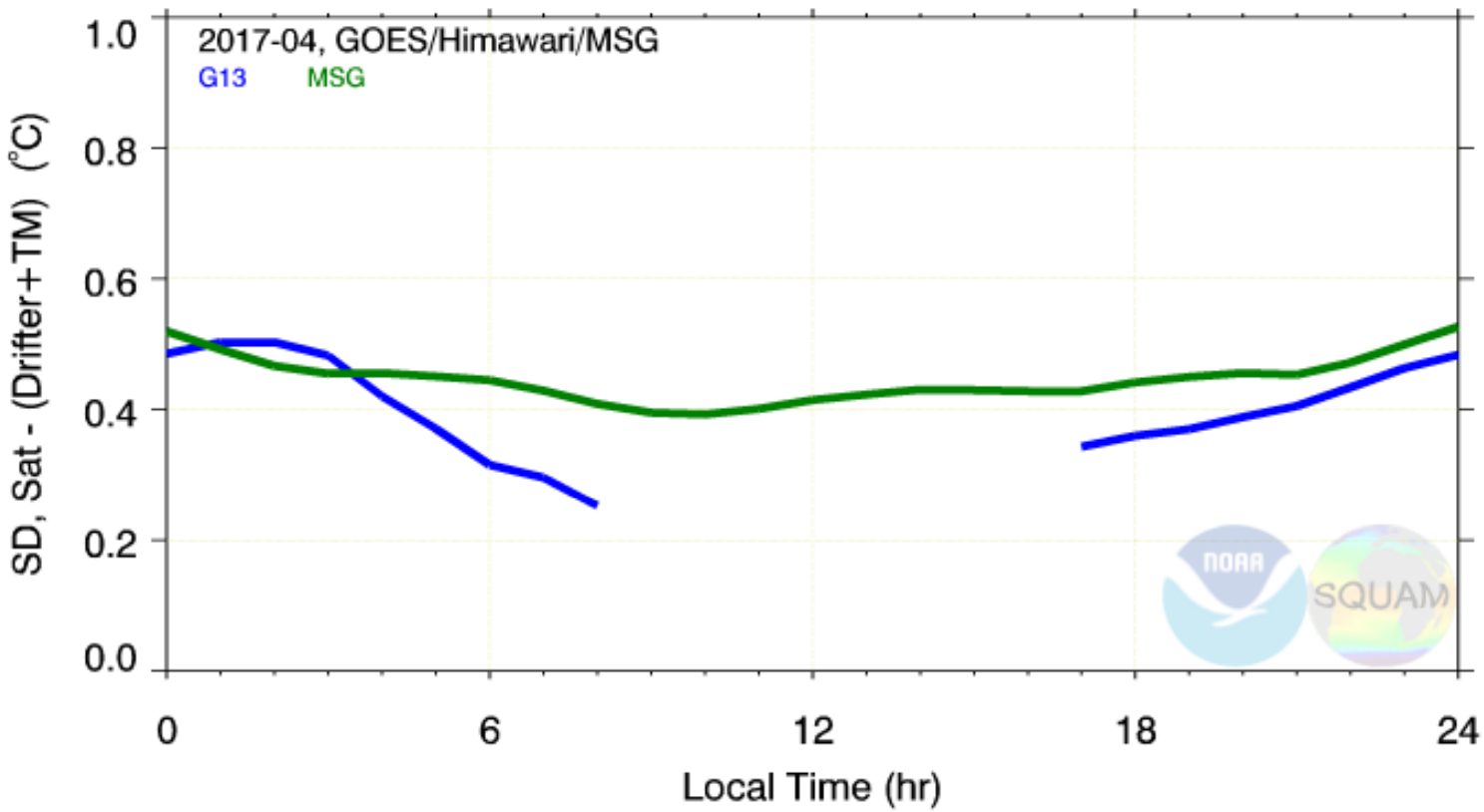
NOAA Heritage G13/G15/MSG3 SST Apr 2017 (H7: Apr 2015)

Std. Dev (*Tsat – Tinsitu*)



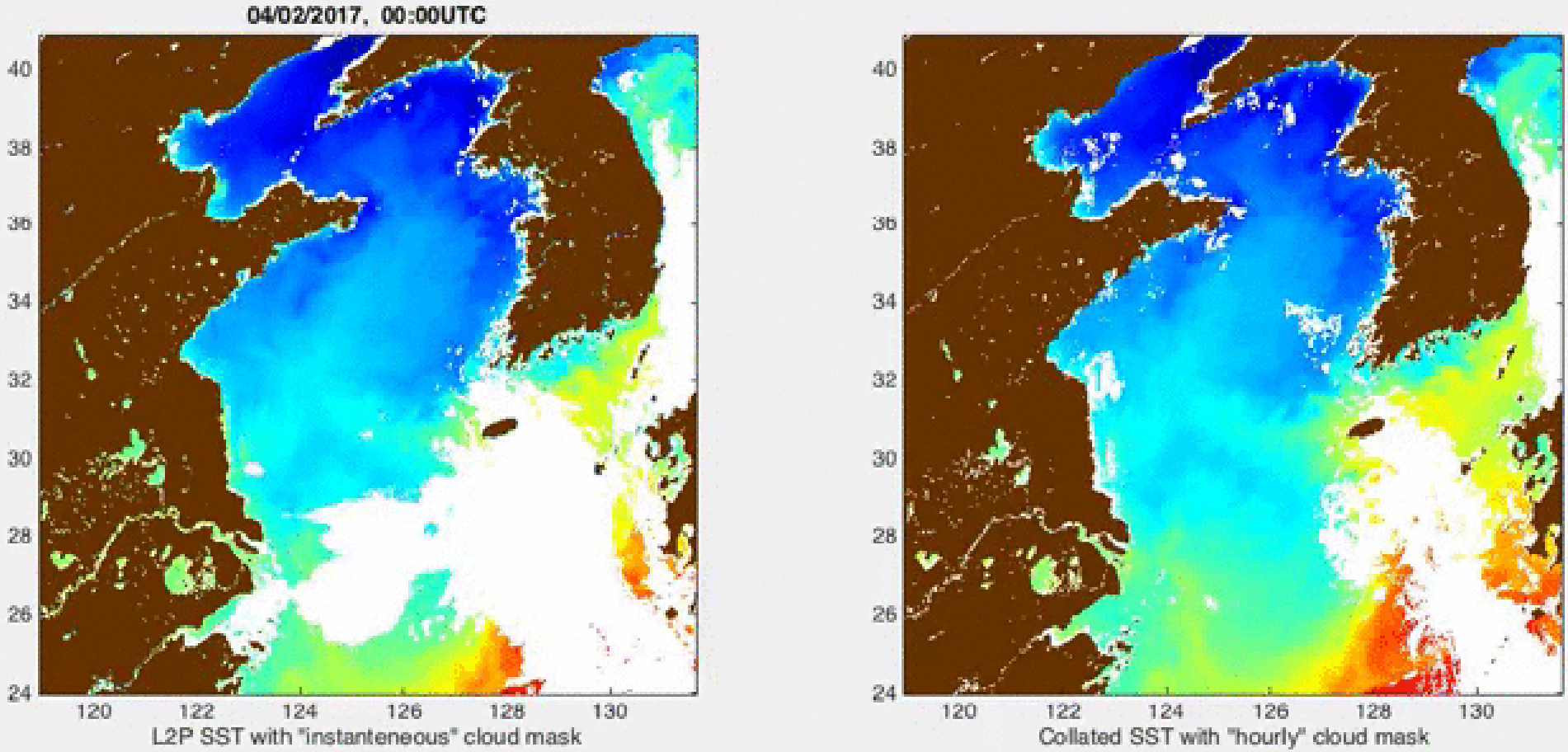
- **G13G15 SSTs validate against *in situ* SST ~0.35K/night and ~0.45 K/daytime**
- **(In 2015) H7 validated at ~0.45K at night and ~0.7K during the daytime**
- **MSG SDs range from 0.5-0.6 K**

OSI SAF SST G13/MSG3 Apr 2017
Std. Dev (*Tsat* – *Tinsitu*)



- **MSG SST validates against *in situ* SST with ~0.5K across the full DC**
- **The G13 is comparable at night but shows smaller SD towards daytime**

Work is underway to generate the ACSPO “collated” 1hr product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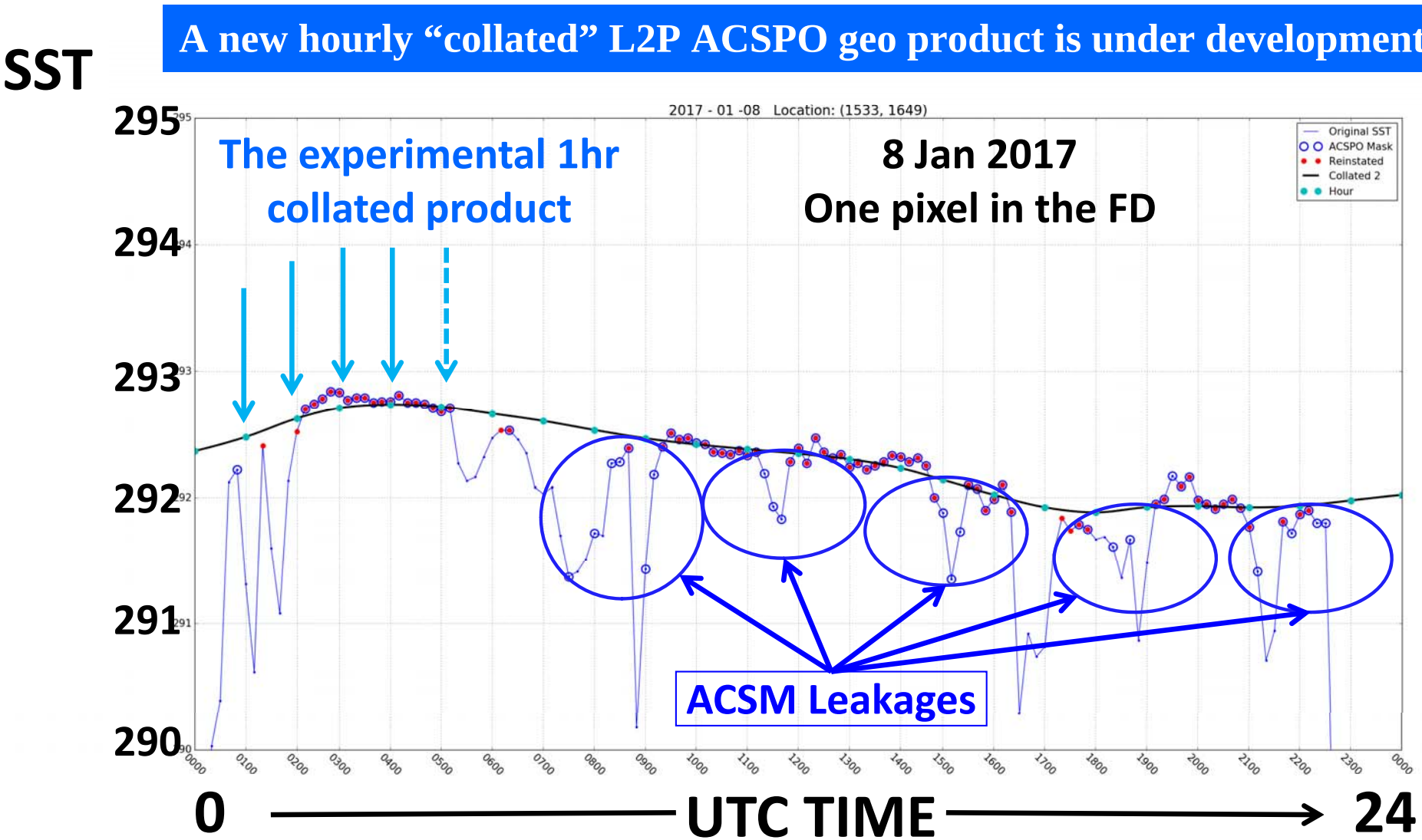
L2P SST with "instanteneous" cloud mask
Collated SST with "hourly" cloud mask

ACSM is also subject to cloud leakages

A new hourly "collated" L2P ACSPO geo product is under development



Conclusion and Ongoing Work

- **H8 & G16 1hr L2P will be available to users by Aug'17 on CW**
  - H8: Apr'15 – pr (8GB/day; ~3TB/yr)
  - G16: Mar'17 – pr (8GB/day; ~3TB/yr)
  - Please drop a line to alex.ignatov@noaa.gov for data access
- **Imagery, VAL vs. *in situ* & diurnal cycle look as expected**
  - H8 is more mature due to longer time in orbit
  - **G16 is not operational ("NOAA disclaimer") – Feedback welcome**
- **Ongoing improvements**
  - SST sub-skin/depth SST and SSES Algorithms – Boris's presentation
  - Explore temporal information: Generate 1hr collated with improved coverage, reduced cloud leakages, and reduced SST noise

NOAA will work with users to meet their expectations & needs

Thank You!