Towards a daily Gridded Super-Collated SST Product from Low Earth Orbit Satellites (L3S-LEO-D) at NOAA

Olafur Jonasson[1,2], Irina Gladkova[1,2,3], Alexander Ignatov[1]

1. NOAA STAR, 2. Global Science and Technology, Inc., 3. City College of New York

NOAA ACSPO SST Products

- ❑ NOAA provides SST products from low earth orbit (LEO) and geostationary (GEO) satellites using its Advanced Clear Sky Processor for Ocean (ACSPO) Enterprise SST system
- ❑ ACSPO LEO L2P and L3U (0.02° gridded uncollated) products are distributed as 10-min granules, 144 files/day/sensor

With many platforms & sensors, large data volumes & number of files, some users find it challenging to acquire and utilize all available data. In response the NOAA SST team developed a suite of global super-collated SST products from LEO satellites (L3S-LEO), which comprises three products [1,2,3]:

- **PM** (afternoon satellites): 2 VIIRS instruments onboard NPP and N20 (N21 will be included when launched). Inclusion of MODIS Aqua is also considered. (2 files/24hr – Day & Night.)
- **AM** (mid-morning satellites): 3 AVHRR FRACs onboard Metop-FG (Metop-A/B/C). Inclusion of METimage onboard future Metop-SG & MODIS Terra is also planned. (Also 2 files/24hr.)
- **L3S-Daily** (under development): Combines PM/AM-Day/Night SSTs into L3S-LEO-Daily SST. (1 file/24hr.) ***First global super collated SST product from NPP/N20 (VIIRS) and Metop-A/B/C (AVHRR FRAC). Eventually, all hi-res ACSPO LEO SSTs will be included.***

Data Availability

- ❑ Complete archive of L3S-LEO-PM/AM data is available at PO.DAAC [4,5] and NOAA CoastWatch [6]. New data are added in near-real-time, with 3-6hrs latency.
- ❑ Experimental L3S-LEO-Daily product is currently available at STAR in delayed mode [7].
- ❑ L3S-LEO data are validated in NOAA SQUAM [8] and ARMS online systems [9].

ACSPO L3S-LEO AM/PM line

- ❑ Both L3S-LEO AM/PM report 2 files/24hr, 1 day & 1 night. This captures the diurnal cycle at 4 local times
- ❑ Figure 1 shows that PM-D is at ~ peak of diurnal cycle, PM-N closest to the bottom, with AM-N and AM-D falling in between
- ❑ L3S-LEO PM/AM D/N SSTs also resolve movement of ocean features (see Figure 2).

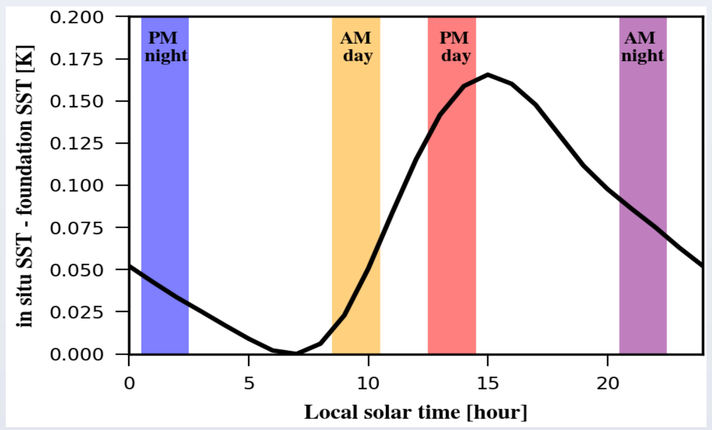

Figure 1. Black curve shows a schematic monthly mean diurnal cycle of (in situ minus CMC L4 foundation SST) as a function of local time. In situ data (drifters and tropical moorings) are from NOAA iQuam system, January 2020. Colored rectangles denote approximate temporal coverage by the four L3S-LEO-AM/PM D/N SST products.

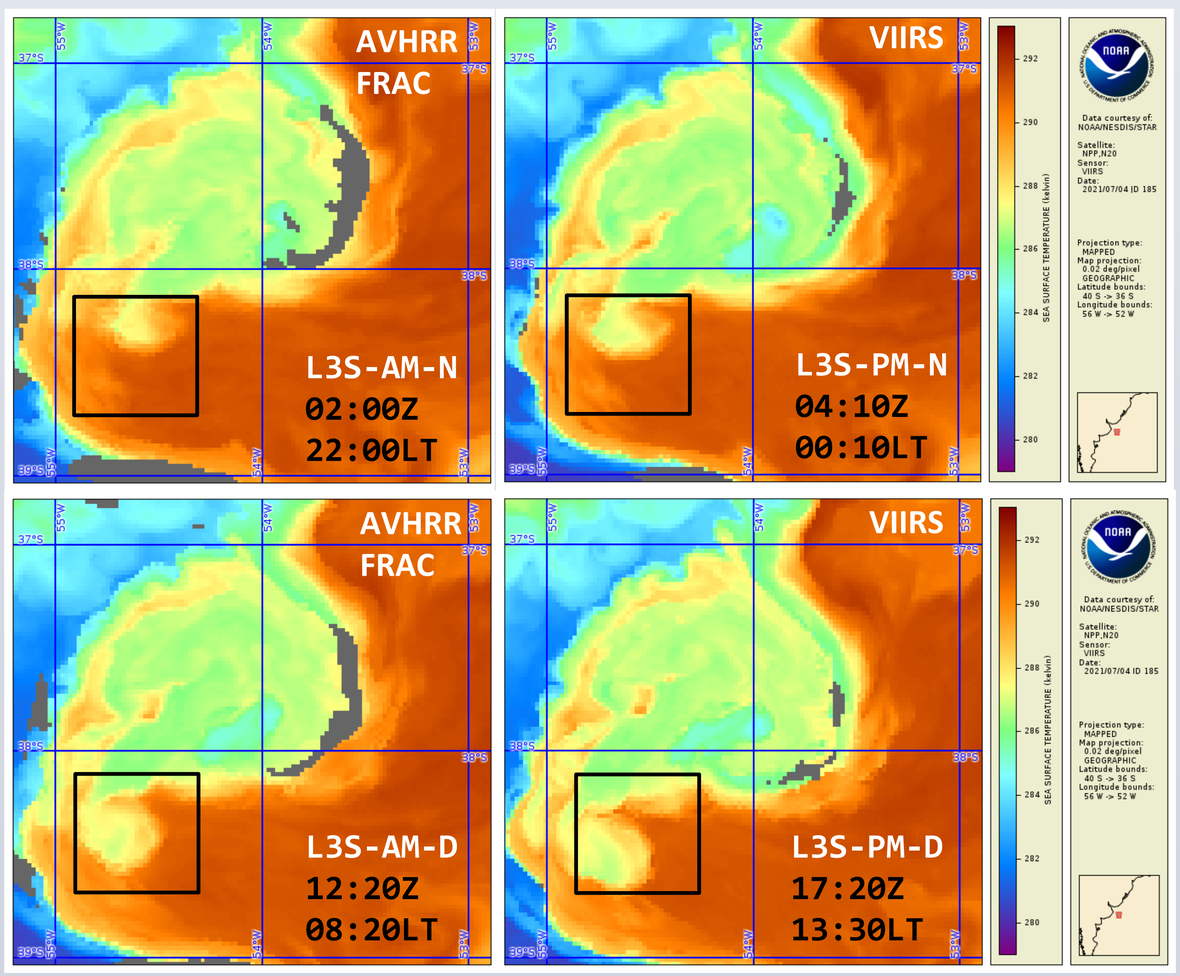

Figure 2. ACSPO L3S-LEO-AM/PM D/N subskin SST imagery from the Brazil Current on 4 July 2021. UTC (Z) and local time of the highest weighted satellite overpass are shown. Black rectangle denotes rapidly evolving features. Gray overlay represents cloudy pixels.

References

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[4] NOAA/STAR, *GHRSST ACSPO v2.80 0.02° L3S Dataset from Afternoon LEO Satellites*, https://doi.org/10.5067/GHLPM-3SS28
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New ACSPO Product: L3S-LEO-Daily

- ❑ Requested by users interested in most complete spatial coverage, not interested in diurnal cycle, and lack resources to ingest/reconcile data from multiple individual platforms/sensors
- ❑ Combines 4 L3S-LEO PM/AM D/N files into one file per 24 hours

The two main challenges in creating a hi-res daily SST:

- L3S-LEO PM/AM D/N sample different phases of the diurnal cycle. Systematic biases due to diurnal warming must be mitigated.
- Ocean features move during the 24hr collation period. L3S-LEO-D should preserve feature resolution present in individual L3S-LEO files without creating artificial features.

Both challenges are addressed in L3S-LEO Daily Algorithm, which comprises 3 iterated steps:

1. Create a low-resolution L3S reference
- Use data from all 4 ACSPO L3S-LEO files (PM/AM-D/N)
- Diurnally debias/harmonize PM-D, AM-D and AM-N to PM-N viewing conditions using a statistical empirical model of diurnal warming informed by MERRA/GFS shortwave insolation & wind speed

2. Debias input L3S-LEO PM/AM-D/N SSTs to L3S reference
- Regional biases are present due to variable atmospheric conditions and view angles at different acquisition times
- Debiasing mitigates large-scale regional biases between overpasses while preserving feature resolution and hi-res spatial scale features

3. Compute Daily SST from debiased PM/AM-D/N SSTs
- Use hi-res scale features from PM-N (if available)
- Otherwise, use hi-res scale features from AM-N, AM-D and PM-D (in order listed)

Steps 2-3 are iterated until converging on the final Daily SST
- Iterations mitigate residual non-systematic regional biases
- In step 2, Daily SST from previous iteration is used as the new L3S reference
- Debiasing to L3S reference becomes more aggressive in subsequent iterations

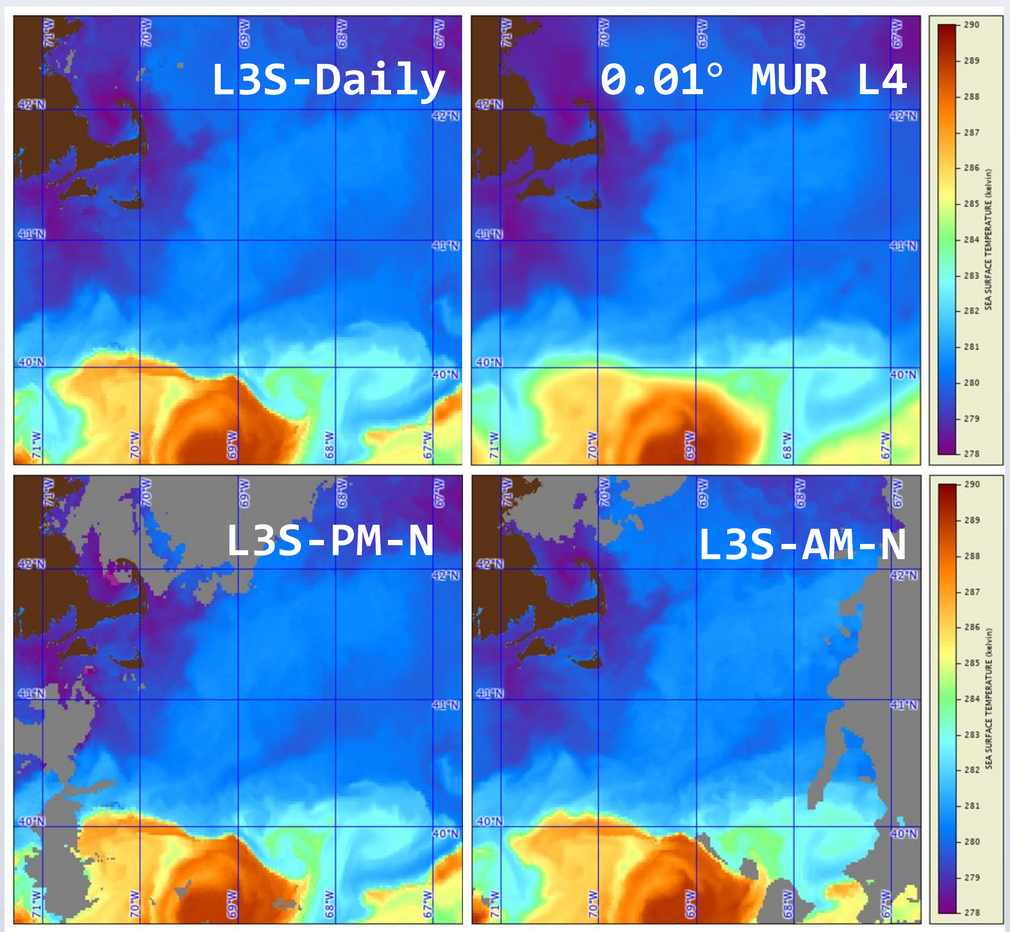

Figure 3. L3S-LEO and MUR L4 SST imagery over the Georges Bank on 26 March 2022.

- ❑ L3S-LEO-Daily algorithm is described in more detail in [3]
- ❑ Figure 3 shows example L3S-LEO-Daily imagery (upper left). The two main L3S-Daily contributors, PM-N (lower left) and AM-N (lower right), are also shown. PM-D/AM-D (not shown) had minor contribution, in this particular scene.
- ❑ Figure 3 shows that the L3S-LEO-Daily preserves PM-N features (where available), with gaps filled from AM-N, AM-D, and PM-D, without visible stitching artifacts.
- ❑ Where data is available L3S-Daily has higher resolution than L4 SST products, including the 0.01° MUR, also shown in Figure 3 (upper right).

Global Validation Statistics Against *In Situ* SSTs

L3S-LEO SSTs were validated against *in situ* SST data (drifters + tropical moorings) from *i*Quam using data within 10km × 30min space/time windows

	Mean [K]	Median [K]	SD [K]	RSD [K]	NOBS
Daily	-0.01	-0.01	0.30	0.22	24.4 M
PM-N	-0.01	0.00	0.28	0.21	13.5 M
AM-N	0.00	0.00	0.30	0.25	14.0 M
AM-D	-0.03	-0.03	0.35	0.30	14.3 M
PM-D	-0.05	-0.05	0.34	0.27	12.0 M

- Table shows aggregated 2019 validation statistics for L3S-LEO subskin SST vs *in situ* SST
- Daily validation statistics (SD and RSD) fall in between the two best-performing L3S-LEO SSTs (PM-N and AM-N)
- Substantial increase (up to ×2) in NOBS (number of observations) for Daily compared to PM/AM SSTs

Future Plans for L3S-LEO-Daily

- ❑ Establish a near-real-time dataflow with data served via NOAA CoastWatch
- ❑ Add L3S-LEO Daily Monitoring to ARMS online system [9]
- ❑ Reprocess L3S-LEO-Daily back to first available PM data (currently 2012; can be extended back to 2002 with Aqua) and archive with PO.DAAC/CoastWatch
- ❑ Make adjustment/improvements to L3S-LEO-Daily algorithm based on results of long-term evaluation in SQUAM and ARMS [8,9]

olafur.jonasson@noaa.gov