ACSPO VIIRS L3U version 2 SST Product

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❖ Introduction

Two NOAA Advanced Clear-Sky Processor for Ocean (ACSPO) SST products are produced from S-NPP VIIRS data: L2P (level 2; in original swath projection; 27 GB/day) and a reduced-size gridded L3U (level 3 un-collated; L2 data mapped into a 0.02º equal grid; <1GB/day). NOAA L3U version 1 code initially used a modified version of the master code kindly provided by the Australian Bureau of Meteorology (ABoM; thanks to Helen Beggs and Chris Griffin). The second version was then further optimized to better account for the specifics of the ACSPO SST product. Here, we describe the performance of the newly developed NOAA ACSPO L3U code version 2. The L3U v2 employs the bi-lateral weighted averaging approach, which is known to preserve edges and reduce noise, thus preserving high-resolution structure of swath data as much as possible.

❖ The goals of L3 code optimization

- Minimize the discrepancies between ACSPO L3U and L2 variables (including SSTs and Single Sensor Errors Statistics – SSES).
- Include into L3U the complete set of masking flags available in the L2 product (clear-sky mask, ice mask, day/night mask, glint mask, twilight zone, etc).
- Optimize and add control & flexibility to prepare for higher resolution L3U (e.g. 0.01º), development of the ACSPO L3C (collated) and L3S (super-collated) SSTs.

❖ ACSPO L3U v2 Algorithm

For each L3U grid cell, select certain number of nearest L2P pixels, and compute weighted SST L3U value using the bi-lateral weighted averaging approach:

$$SST_{i,j}^{L3U} = \Sigma_k SST_k^{L2} w_k / \Sigma_k w_k,$$

Here, w_k are weights depending on spatial proximity and local SST:

$$w_k = \exp(- d_k^2/\sigma^2 - (SST_k^{L2} - SST_{med}^{L2})^2/\sigma_i^2);$$

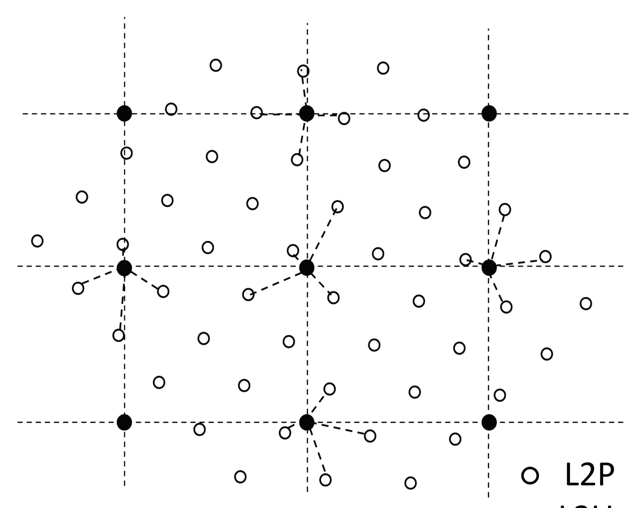

Fig. 1: sketch of searching nearest L2P points for L3U grids.

SST^{L3U} and SST^{L2} : the L3U and L2P SSTs, respectively;
d_k : geo distance between L3U cell (i,j) and selected k nearest L2 pixels;
σ and σ_i : spatial and temperature dependent parameters for Gaussian weighting;
SST^{L2}_{med} : the median SST value of k selected nearest L2 points SST_k^{L2}.

❖ Testing Parameters in L3U v2

1. Number of Nearest L2 pixels

- Increased number of nearest L2 pixels , N, reduces bias in L3U compared to L2P. However, it also increases the computation time and memory usage, and can potentially result in a loss of sharpness.
- The biases do stabilize themselves when N >= 10, (Fig. 2). We choose N = 6 as a compromise between computing performance, biases, and sharpness.

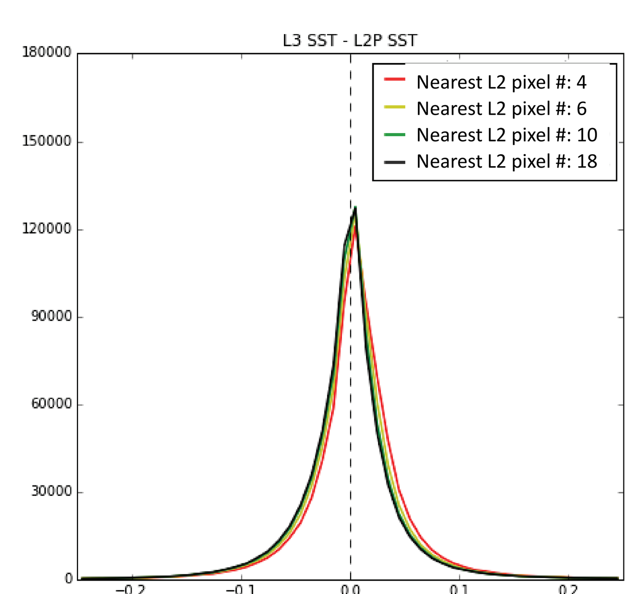

Fig. 2: Histogram of differences between L3U SST and L2P SST when different numbers of nearest points are selected. Both L3U and L2P are remapped to 0.25ºx 0.25º grids using the same mapping algorithm and then compared to each other. Plot are based on all VIIRS granules on 2016-02-18.

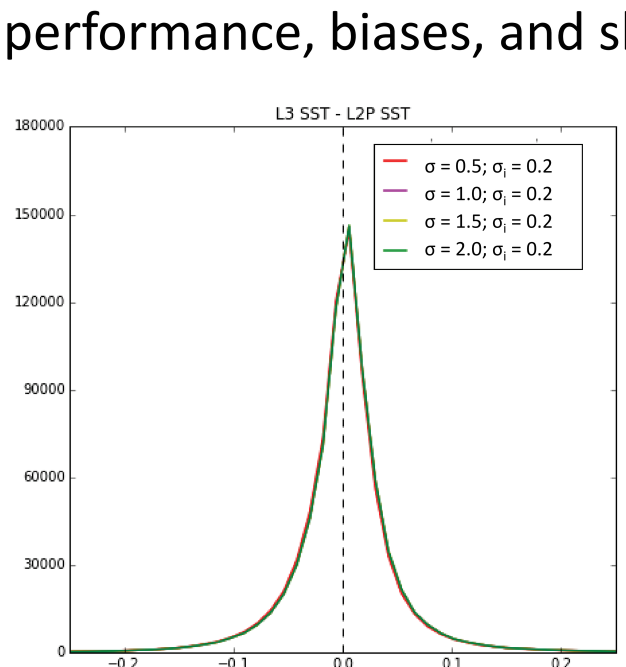

Fig. 3: Same as Fig. 2 except for selecting different σ. σ_i is fixed to 0.2 K and N is 6.

2. σ: geo-distance weighting parameter

- We tested σ from 0.5 to 2 km (VIIRS L2P resolution: 0.75 km at nadir). The bias compared to L2P does not show much sensitivity (Fig. 3). We set σ to 2 km, which is closest to the L3U resolution, 0.02º.

3. σ_i: weighting term to preserve edge

- We tested σ_i from 0.1 to 0.5 K. Values between 0.2 and 0.3 K give the smallest bias compared with L2P (Fig. 4). Larger σ_i gives negative bias. It might be a result of including cold pixels, which are missed by the ACSPO clear-sky mask. We set σ_i to 0.2 K, to keep the smallest bias compared to L2.

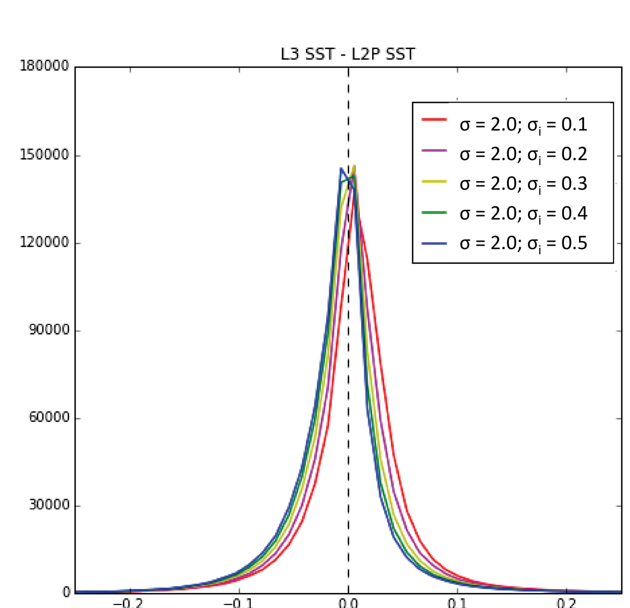

Fig. 4: Same as **Fig. 2** except for selecting different σ_i. σ is fixed to 2 Km and N is 6.

❖ L3U Code Performance Evaluation

The L3U v2 saves half of running time of v1 with ~1/3 increase in memory. Meanwhile, it keeps more image details and coverage than in v1.

	L3U v1	L3U v2
Running time	~25s	~11s
Memory Usage	~3G	~4G
Sharpness	smoother	sharper (nearest L2 # is 6)
Coverage	similar	similar

Table 1: Comparison of computer performance, sharpness and coverage.

❖ Results

1. Comparison with L2P

- The biases relative to L2P are significantly reduced in L3U v2, especially for ΔSST and SSES standard deviation (SD), with a reduction by 0.02K and 0.07K, respectively. For SST and SSES biases, the reduction in bias is smaller, but the data are better clustered around 0, indicating less bias compared to L2P. The spatial non-uniformity of biases is also reduced in v2.

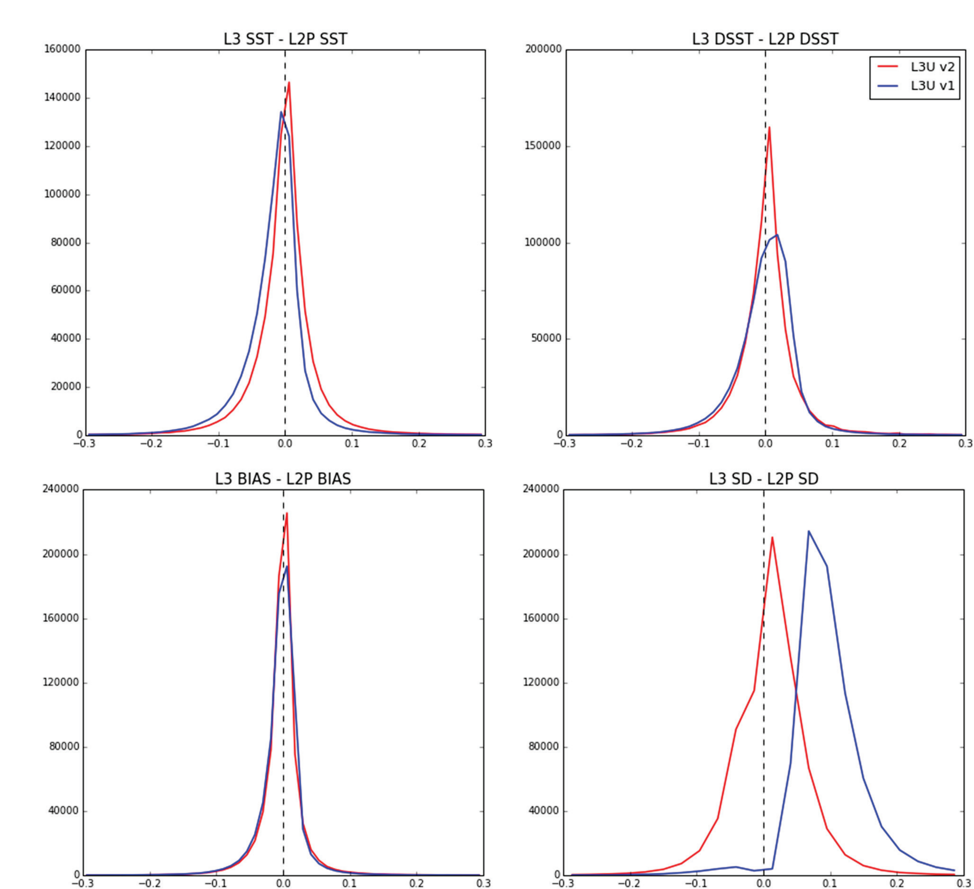

Fig. 5: Histogram of differences between L3U and L2P SST, ΔSST (ACSPO minus reference SST) and Single-Scanner Error Statistics (SSES) bias and standard deviation.

2. Comparison with CMC L4

- When comparing nighttime L3U to CMC L4, the data are better clustered around 0 in L3U v2, with smaller SD and much smaller skewness.

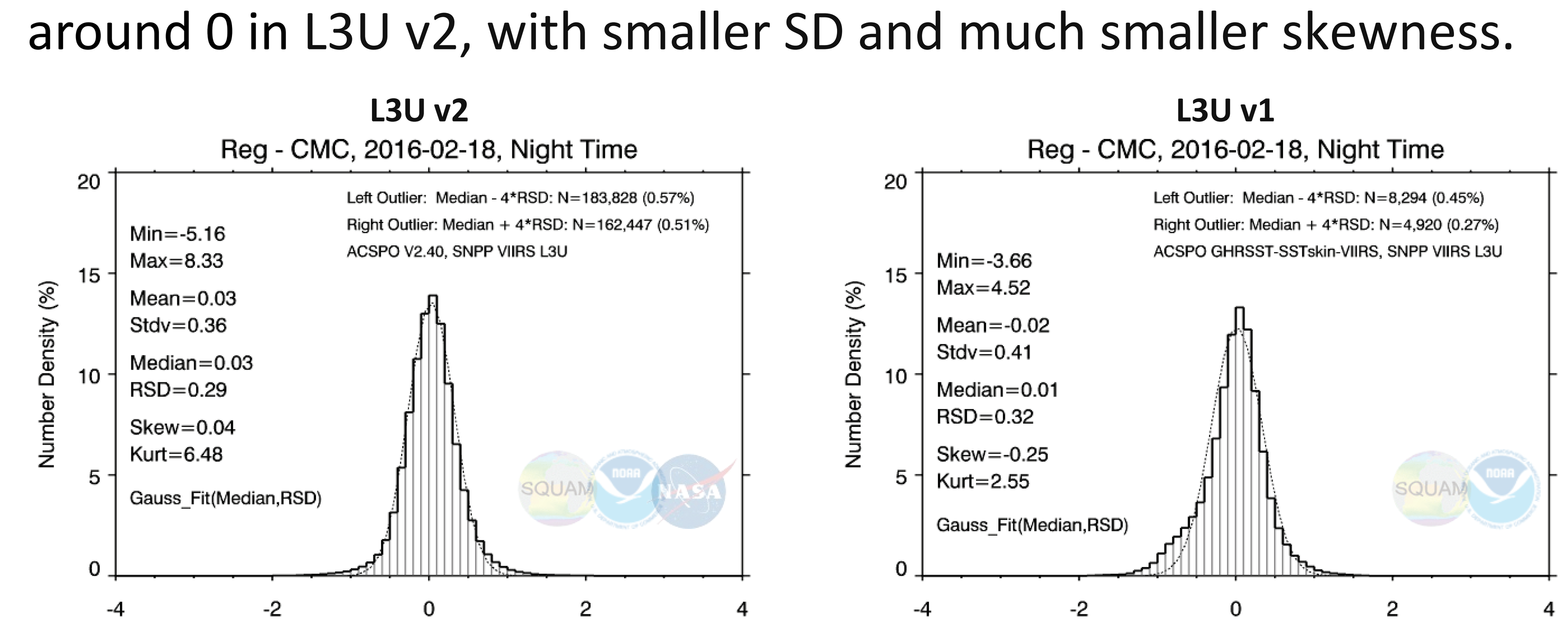

Fig.6: Differences between nighttime L3U and L4 (CMC) for 2016-02-18.

3. Masking flags

- ACSPO L3U v2 provides all masking flags available in L2P (clear-sky mask, ice mask, day/night mask, glint mask, twilight zone, etc.)
- Pixels with quality level equal to 5 are treated as clear-sky; all other pixels set to cloudy.

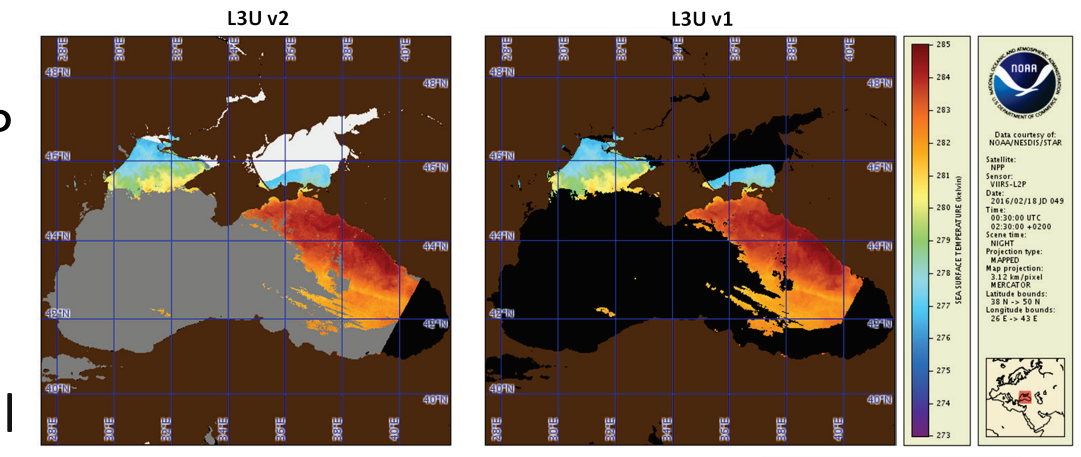

Fig.7: An example showing the masking flag difference between the (left) current L3U v1 product and (right) the new L3U v2 product.

❖ Summary

- A new ACSPO L3U v2 was designed using the bi-lateral weighted averaging approach. The new version runs faster, and better preserves the spatial gradients.
- L3U v2 reduces the biases compared to L2P (especially for ΔSST and SSES SD), and skewness and SD in (L3U – L4) SST.
- It includes a complete set of L2P flags available in the ACSPO L2P SST product. The code will be used to produce higher-resolution L3, including L3C and L3S.