Status of JPSS SST Products

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NOAA; CIRA; GST Inc; CUNY

Bruce Brasnett

Canadian Met Centre
Acknowledgements

- JPSS Program – Mitch Goldberg, Kathryn Schontz, Bill Sjoberg
- NASA SNPP Project Scientist – Jim Gleason
- NOAA NDE Team – Tom Schott, Dylan Powell, Bonnie Reed
- JPSS DPA – Eric Gottshall, Janna Feeley, Bruce Gunther
- VIIRS SDR & GSICS – Changyong Cao, Frank DeLuccia, Jack Xiong, Mark Liu, Fuzhong Weng
- NOAA STAR JPSS Team – Ivan Csiszar, Lihang Zhou, Paul DiGiacomo, many others
- NOAA CRTM Team – Yong Han, Yong Chen, Mark Liu
# JPSS SST Team

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<th>Affiliation</th>
<th>% Funding</th>
<th>Tasks</th>
</tr>
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<td><strong>Ignatov</strong></td>
<td>STAR</td>
<td>NOAA</td>
<td>Lead, JPSS Algorithm &amp; Cal/Val</td>
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<td>STAR/CIRA</td>
<td>JPO, NOAA</td>
<td>Quality Monitoring of VIIRS SSTs (SQUAM), Radiances (MICROS), and in</td>
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<tr>
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<td>STAR/STG</td>
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<td>Situ SSTs (iQuam) Data support; IDPS SST code, Match up, Cloud</td>
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<td>STAR/GST</td>
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<td>Mask, SST retrievals; Destriping L1b &amp; SST</td>
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<td>STAR/GST</td>
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<td><strong>May</strong>, Cayula,</td>
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<td>NAVO SEATEMP SST &amp; Cal/Val VIIRS Cloud Mask evaluation</td>
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<td><strong>Minnett</strong></td>
<td>U. Miami</td>
<td>JPO, U. Miami</td>
<td>Uncertainty &amp; instrument analyses; RTM; VAL vs. drifters &amp; radiometers; skin to sub-skin conversion</td>
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<td>Kilpatrick</td>
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<td><strong>Arnone</strong></td>
<td>USM/NRL</td>
<td>NJO, USM</td>
<td>SST Algorithm Analyses, SST improvements at slant view zenith angles/swath edge</td>
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<td>Fargion</td>
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<td></td>
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<td><strong>LeBorgne</strong></td>
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<td>EUMETSAT</td>
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<tr>
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</table>

13 May 2014
Past Year Focus Areas

Sustained NRT Monitoring/VAL of VIIRS SSTs and Radiances

- SQUAM [www.star.nesdis.noaa.gov/sod/sst/squam/](http://www.star.nesdis.noaa.gov/sod/sst/squam/) - comprehensive cross-evaluation of various SST products and VAL against in situ data

SST EDR is Provisional

- Improved & Consolidated SST Algorithm in IDPS / ACSPO – JGR special issue
- EDR Review Jan 2014 - Provisional status granted Apr 2014
- Based on users feedback & performance, JPO recommend to “discontinue IDPS and focus on NOAA ACSPO sustainment, Cal/Val and development”

ACSPO Production

- Operational at NDE Mar 2014; Archival at JPL/NODC underway
- Work with NAVO partners to cross-evaluate NAVO and ACSPO VIIRS products
- Work with users to assess ACSPO SST, provide feedback to SST Team

Destriping and ACSPO Clear-Sky Mask improvements

- Progress with operational destriping – SDR & SST breakouts – Mikelsons
- Pattern-recognition ACSPO clear-sky mask – SST break-out, Innovative science talk / I. Gladkova
VIIRS SST Products

**IDPS – NOAA Interface Data Processing Segment (IDPS)**
- Official NPOESS SST EDR, Now owned by NOAA JPSS PO
- Developed by NGAS; Operational at Raytheon; Archived at NOAA CLASS
- Jan 2014: JPO recommends “discontinue the IDPS EDR, concentrate on ACSPO”
- IDPS will be phased out as soon as ACSPO SST is archived at JPL/NODC
- As of this report, meets specs at night, does not meet during daytime

**ACSPO – NOAA Advanced Clear-Sky Processor for Ocean (ACSPO)**
- NOAA heritage SST system (AVHRR GAC and FRAC heritage)
- VIIRS operational Mar 2014, GDS2 archival at JPL/NODC underway
- Meet/exceed APU specs (both day/night), good global coverage

**NAVO – SEATEMP**
- Builds on NAVO AVHRR & NOAA pre-ACSPO heritage
- VIIRS operational Mar 2013; GDS2 archived at JPL/NODC May 2013
- Meet/exceed APU specs (both day/night), coverage restricted
Objective & Methodology

- **Objective:** Compare ACSPO and NAVO SSTs to advise users on the specifics of the two products

- **Methodology:** Compare ACSPO/NAVO SST domain & performance against two global reference SSTs
  - L4 SST (Canadian Met Centre CMC0.2 Analysis. Note that VIIRS data are not assimilated in CMC0.2)
  - *in situ* SST (QCed drifting buoys in iQuam [www.star.nesdis.noaa.gov/sod/sst/iquam/](http://www.star.nesdis.noaa.gov/sod/sst/iquam/))

**Data:** one representative day of global data
NIGHT: ACSPO L2 minus CMC L4
23 April 2014

Delta close to zero as expected
Cold spots – Residual Cloud/Aerosol leakages
NIGHT: NAVO L2 minus OSTIA L4
23 April 2014

SST-CMC VIIRS 20140423 Night NAVO NPP v02.0

• Retrievals limited to VZA<54°
NIGHT: ACSPO L2 minus CMC L4
23 April 2014

N=115860235
Min=-4.57
Max=7.60
Mean=0.02
Stdv=0.38
Median=0.02
RSD=0.30
Skew=1.46
Kurt=17.13
Gauss_Fit(Median,RSD)

Left Outlier: Median - 4*RSD: N=476956 (0.41%)
Right Outlier: Median + 4*RSD: N=819874 (0.71%)

Night, ACSPO V2.30 VIIRS (NESDIS)

• Shape close to Gaussian
NIGHT: NAVO L2 minus CMC L4
23 April 2014

Shape close to Gaussian
Domain smaller, STD slightly better
NIGHT: ACSPO L2 minus *in situ* SST
23 April 2014

SST-Drifters, 20140423, Night, ACSPO V2.30b01 VIIRS (NESDIS), $\Delta x:20.0\text{km}$ $\Delta t:4.0\text{h}$

- Much sparser data coverage
- Not fully representative of the globe
NIGHT: NAVO L2 minus *in situ* SST
23 April 2014

- Much sparser data coverage
- Not fully representative of the globe
NIGHT: ACSPO L2 minus *in situ* SST
23 April 2014

- Shape close to Gaussian – small cold tail
- Performance Stats well within specs (Bias<0.2K, STD<0.6K)
NIGHT: NAVO L2 minus *in situ* SST
23 April 2014

- Shape close to Gaussian – small cold tail
- Performance Stats well within specs (Bias<0.2K, STD<0.6K)
## NIGHT – Summary

### Vs. L4

**\( \Delta T = \text{“VIIRS minus CMC” SST} \) (expected ~0)**

<table>
<thead>
<tr>
<th>NOBS (%ACSPO)</th>
<th>Min/ Max</th>
<th>Mean/ STD</th>
<th>Med/ RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDPS 116.8M (101%)</td>
<td>-13.1/+12.6</td>
<td>-0.04/0.46</td>
<td>-0.00/0.31</td>
</tr>
<tr>
<td>ACSPO 115.9M (100%)</td>
<td>-4.6/+7.6</td>
<td>-0.02/0.38</td>
<td>-0.02/0.30</td>
</tr>
<tr>
<td>NAVO 39.5M (34%)</td>
<td>-8.9/+7.1</td>
<td>+0.04/0.37</td>
<td>+0.06/0.28</td>
</tr>
</tbody>
</table>

- **IDPS:** SST domain is +1% larger than ACSPO, All stats degraded
- **NAVO:** SST domain is factor of ×3 smaller than ACSPO, stats improved

### Vs. in situ

**\( \Delta T = \text{“VIIRS minus in situ” SST} \) (expected ~0)**

<table>
<thead>
<tr>
<th>NOBS (%ACSPO)</th>
<th>Min/ Max</th>
<th>Mean/ STD</th>
<th>Med/ RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDPS 2,082 (113%)</td>
<td>-2.9/+5.6</td>
<td>-0.06/0.43</td>
<td>-0.01/0.26</td>
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<tr>
<td>ACSPO 1,846 (100%)</td>
<td>-1.7/+1.3</td>
<td>-0.02/0.28</td>
<td>-0.00/0.24</td>
</tr>
<tr>
<td>NAVO 678 (37%)</td>
<td>-2.3/+1.0</td>
<td>+0.02/0.29</td>
<td>+0.07/0.24</td>
</tr>
</tbody>
</table>

- **IDPS:** SST domain is +13% larger than ACSPO, All stats degraded
- **NAVO:** SST domain is factor of ×3 smaller than ACSPO, stats comparable
## DAY – Summary

### Vs. L4

\[ \Delta T = \text{"VIIRS minus CMC" SST (expected ~0)} \]

<table>
<thead>
<tr>
<th>NOBS (%ACSPO)</th>
<th>Min/ Max</th>
<th>Mean/ STD</th>
<th>Med/ RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDPS</td>
<td>120.4M (100%)</td>
<td>-28.7/+10.4</td>
<td>+0.20/0.77</td>
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<tr>
<td>ACSPO</td>
<td>121.0M (100%)</td>
<td>-5.4/+9.2</td>
<td>+0.29/0.59</td>
</tr>
<tr>
<td>NAVO</td>
<td>41.3M (34%)</td>
<td>-8.2/+7.5</td>
<td>+0.28/0.56</td>
</tr>
</tbody>
</table>

- **IDPS**: SST domain is comparable with ACSPO, All stats degraded
- **NAVO**: SST domain is factor of \( \times 3 \) smaller than ACSPO, stats comparable

### Vs. in situ

\[ \Delta T = \text{"VIIRS minus in situ" SST (expected ~0)} \]

<table>
<thead>
<tr>
<th>NOBS (%ACSPO)</th>
<th>Min/ Max</th>
<th>Mean/ STD</th>
<th>Med/ RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDPS</td>
<td>1,758 (105%)</td>
<td>-5.3/+2.7</td>
<td>-0.06/0.77</td>
</tr>
<tr>
<td>ACSPO</td>
<td>1,680 (100%)</td>
<td>-1.4/+2.8</td>
<td>+0.07/0.42</td>
</tr>
<tr>
<td>NAVO</td>
<td>510 (30%)</td>
<td>-1.2/+2.1</td>
<td>+0.12/0.35</td>
</tr>
</tbody>
</table>

- **IDPS**: SST domain is +5% larger than ACSPO, All stats degraded
- **NAVO**: SST domain is factor of \( \times 3 \) smaller than ACSPO, stats improved
Missed lines?

Rectangular shapes?
Tri-angular shape?

Florida
Too-Regular shapes?
Users’ Feedback
Some Early Results Assimilating ACSPO VIIRS L2P Datasets

Bruce Brasnett
Canadian Meteorological Centre
May, 2014
ACSPO VIIRS L2P Datasets

- Received courtesy of colleagues at STAR
- Daily coverage is excellent with this product
- Experiments carried out assimilating VIIRS data only and VIIRS data in combination with other satellite products
- Rely on independent data from Argo floats to verify results
- Argo floats do not sample coastal regions or marginal seas
Assessing relative value of 2 VIIRS datasets: NAVO vs. ACSPO

Using ACSPO instead of NAVO improves assimilation
Coverage for 2014/02/01

ACSPO VIIRS

NAVO AVHRR19
Coverage for 2013/09/01

ACSPO VIIRS

NAV0 AVHRR18 & 19
and Metop-A combined

13 May 2014
JPSS SST EDR
CMC Summary

• ACSPO VIIRS L2P is an excellent product

• Based on the Jan – Mar 2014 sample, VIIRS contains more information than either the OSI-SAF MetOP-A or the RSS AMSR2 datasets

• L2P ancillary information: quality level flags and wind speeds are useful but experiment with SSES bias estimates was inconclusive

• Current plan at CMC is to assimilate ACSPO VIIRS L2P dataset when it becomes available
Conclusion to ACSPO/NAVO comparison

ACSPO and NAVO are two viable VIIRS SST choices for users

- Both are available in GDS2 (ACSPO shortly will be) via JPL/NODC

- ACSPO retrieval domain is larger than NAVO, by a factor of ~3, due to narrow NAVO swath VZA<54°, and conservative cloud mask

- NAVO STDs are smaller than ACSPO by a narrow margin

- Initial ACSPO assimilation in CMC L4 analysis suggests that ACSPO adds information to the currently used L2 SSTs (AMSR2, OSI SAF and NAVO AVHRR, NAVO VIIRS), mainly due to its superior coverage

- ACSPO areas for improvement: Warm bias in the high latitudes, SSES bias is calculated but was found not informative to improve assimilation
Coming Year Work

✓ Continue Monitor, Validate and cross-evaluate various SST products in SQUAM, iQuam, MICROS
✓ Go validated with ACSPO SST product (already meet specs)
✓ Archive ACSPO GDS2 format at JPL/NODC, discontinue IDPS
✓ Explore improved quality flags / Levels in ACSPO
✓ Establish reprocessing and back-fill ACSPO VIIRS to Jan’2012
✓ Received multiple user requests for ACSPO VIIRS Level 3 product – will need to generate
✓ Implement destriping operationally (SDR feedback/Tue PM – Ignatov; SST breakout/Wed – K. Mikelsons)
✓ Implement version 1 pattern recognition ACSPO clear-sky mask enhancements (SST breakout/Wed and innovative science talk/Fri – I. Gladkova)
U. Miami Input
(presented at SST breakout)
VIIRS Atmospheric Correction Algorithms

Miami V6:
• \( \text{SST2b} = a_0 + a_1 T_{11} + a_2 (T_{11} - T_{12}) \ T_{\text{sfc}} + a_3 (T_{11} - T_{12}) \ S_{\theta} \)
• \( \text{SST3b} = a_0 + a_1 T_{11} + a_2 (T_{3.7} - T_{12}) \ T_{\text{sfc}} + a_3 \ S_{\theta} \)

Miami V7:
• \( \text{SST2b} = a_0 + a_1 T_{11} + a_2 (T_{11} - T_{12}) \ T_{\text{sfc}} + a_3 (T_{11} - T_{12}) \ S_{\theta} + a_4 \ S_{\theta} + a_5 \ S_{\theta}^\chi \), where \( \chi = \text{fn(lat)} \)
• \( \text{SST3b} = a_0 + a_1 T_{11} + a_2 (T_{3.7} - T_{12}) \ T_{\text{sfc}} + a_3 \ S_{\theta} + a_4 \ S_{\theta}^\chi \), where \( \chi = 0.1 \) for \( |\text{lat}| \leq 40^\circ \); \( 2.0 \) for \( |\text{lat}| > 40^\circ \)

\( S_{\theta} = \text{sec(}\theta\text{)}-1 \)
### Simple Global Statistics

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Median</th>
<th>Median Abs Diff</th>
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<tbody>
<tr>
<td>Satellite zenith &lt;55°</td>
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<td></td>
<td></td>
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<tr>
<td>SST - day</td>
<td>92061</td>
<td>-0.089</td>
<td>0.510</td>
<td>-0.085</td>
<td>0.337</td>
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<tr>
<td>SST - night</td>
<td>126174</td>
<td>-0.160</td>
<td>0.436</td>
<td>-0.153</td>
<td>0.331</td>
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<tr>
<td>SST₃ - night</td>
<td>81155</td>
<td>-0.172</td>
<td>0.395</td>
<td>-0.152</td>
<td>0.230</td>
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<tr>
<td>Satellite zenith &gt;55°</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SST - day</td>
<td>34693</td>
<td>-0.105</td>
<td>0.647</td>
<td>-0.149</td>
<td>0.536</td>
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<tr>
<td>SST - night</td>
<td>29922</td>
<td>-0.193</td>
<td>0.519</td>
<td>-0.206</td>
<td>0.485</td>
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<tr>
<td>SST₃ - night</td>
<td>35982</td>
<td>-0.131</td>
<td>0.489</td>
<td>-0.161</td>
<td>0.355</td>
</tr>
</tbody>
</table>

Statistics of the differences between the VIIRS skin SST retrievals and the subsurface temperatures measured from drifting buoys.
Zenith angle dependence

2 band – day & night

Solid bar is median error

3 band – night

Solid bar is standard deviation of errors

Zenith Angle in 10° increments
Time dependences – in latitude bands

Comparisons to buoy temperatures

13 May 2014
NAVO Input
(presented at SST breakout)
Effect of VIIRS Cloud Mask on accuracy of SST

J-F Cayula and Doug May

NAVOCEANO
VCM effect on SST accuracy

- Evaluation of the VIIRS Cloud Mask (VCM) on the accuracy of “cloud-free” SST retrievals
- NAVOCEANO Cloud Mask (NCM) used as comparison standard because it produces very clean SST for input into oceanographic models.
- VCM requires additional tests as SST cloud detection usually handles all contaminants:
  - Daytime: reflectance test contingent on field test
  - Nighttime: NCM aerosol test + adjacency test/field test

“Cloud-free”: classified as “confidently clear” and determination is “High quality”
VCM effect on SST accuracy

<table>
<thead>
<tr>
<th>Daytime / February</th>
<th>Buoy matches</th>
<th>RMS error</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCM / NCM + test</td>
<td>4967 / 4901</td>
<td>0.51 / 050</td>
</tr>
<tr>
<td>VCM / VCM + test</td>
<td>16844 / 14863</td>
<td>0.70 / 0.51</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nighttime / February</th>
<th>Buoy matches</th>
<th>RMS error</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCM</td>
<td>6785</td>
<td>0.36</td>
</tr>
<tr>
<td>VCM / VCM + tests</td>
<td>21052 / 17171</td>
<td>0.56 / 0.34</td>
</tr>
</tbody>
</table>

- VCM with additional tests performs as well as NCM, with better coverage
- However closer inspection shows that most of the VCM improvements come from the additional tests flagging retrievals adjacent to detected clouds. This indicates significant cloud leakage with the original VCM.
VCM effect on SST accuracy

Example: Daytime SST fields on April 6, 2014 a) for NCM clear, b) for VCM clear, c) for VCM clear with additional test, d) with a tightened additional test to remove remaining cloud leakage
NAVO Input
(presented at SST breakout)
Objectives: VIIRS Cal Val – SST EDR products

- Evaluate SST product performance for operational use and science applications
- Evaluate Regional Coast SST products
- Updates for IDPS processing and algorithms

Project Accomplishments: Past year

1. Assembled SST products from IDPS, and OSI_SAF and Miami algorithms in Gulf of Mexico.
2. Compared SST products in Coastal Fronts and coastal regions.
3. Demonstrated use of the VIIRS orbital overlap for sensor validation. - Poster
4. Began SST validation in Coastal areas (Mississippi Sound, Mobile Bay)
5. Evaluated the SST assimilation into Ocean Models (NCOM, HYCOM)

Future Plans –

- Paper on SST Cal Val Over lap orbits with J.Cayula and S. Ignatov
- Validation SST products in Coastal and estuary areas –
- Examine the Detector response on SST retrievals

Sea Surface Temperature (University of Southern Miss)

Arnone, Vandermeulen, Fargion,
Over compensation in Cloud Mask can impact the Ocean Model SST

Difference in Filament location of Model and SNPP SST - associated with Assimilation and Cloud MASK