SLSTR sea surface temperature: validation activities and first results

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Outline

• Sea Surface Temperature from Sentinel-3 SLSTR

• Mission Performance Framework and Sentinel-3 Validation Team (S3VT)

• Results and SLSTR validation
  • SLSTR / IASI L1b inter-comparisons
  • METIS-SST
  • Matchup databases and first results
  • CMEMS monitoring

• Importance of Fiducial Reference Measurements
  • Towards FRM drifting buoys

• Summary
Sea Surface Temperature from Sentinel-3 SLSTR

Band characteristics of the Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR). F1 and F2 are dedicated active fire monitoring bands.

<table>
<thead>
<tr>
<th>SLSTR band</th>
<th>Centre [μm]</th>
<th>Δλ [μm]</th>
<th>SNR [-]</th>
<th>Ssd [%]</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.555</td>
<td>0.02</td>
<td>20.0</td>
<td>0.5</td>
<td>Cloud screening, vegetation monitoring, aerosol</td>
</tr>
<tr>
<td>S2</td>
<td>0.659</td>
<td>0.02</td>
<td>20.0</td>
<td>0.5</td>
<td>NDVI, vegetation monitoring, aerosol</td>
</tr>
<tr>
<td>S-3</td>
<td>0.805</td>
<td>0.02</td>
<td>20.0</td>
<td>0.5</td>
<td>NDVI, cloud flagging, Pixel co-registration</td>
</tr>
<tr>
<td>S4</td>
<td>1.375</td>
<td>0.015</td>
<td>20.0</td>
<td>0.5</td>
<td>Cloud skin, ice and snow, vegetation monitoring,</td>
</tr>
<tr>
<td>S5</td>
<td>1.61</td>
<td>0.06</td>
<td>20.0</td>
<td>0.5</td>
<td>Cloud skin, ice and snow, vegetation monitoring,</td>
</tr>
<tr>
<td>S6</td>
<td>2.25</td>
<td>0.05</td>
<td>20.0</td>
<td>0.5</td>
<td>Vegetation state and cloud clearing</td>
</tr>
<tr>
<td>S7</td>
<td>3.74</td>
<td>0.38</td>
<td>80.0</td>
<td>1.0</td>
<td>SST, LST, Active fire</td>
</tr>
<tr>
<td>S8</td>
<td>10.05</td>
<td>0.9</td>
<td>50.0</td>
<td>1.0</td>
<td>SST, LST, Active fire</td>
</tr>
<tr>
<td>S9</td>
<td>12</td>
<td>1.0</td>
<td>50.0</td>
<td>1.0</td>
<td>SST, LST</td>
</tr>
<tr>
<td>F1</td>
<td>3.74</td>
<td>0.38</td>
<td>&lt;1 K</td>
<td>1.0</td>
<td>Active fire</td>
</tr>
<tr>
<td>F2</td>
<td>10.05</td>
<td>0.9</td>
<td>&lt;0.5 K</td>
<td>1.0</td>
<td>Active fire</td>
</tr>
</tbody>
</table>
Mission requirements for SLSTR SST

- To provide SST measurement capability to at least the quality of AATSR on Envisat: SST shall be accurate to $< 0.3 \text{ K @ 1 km}$ spatial resolution and with improved swath coverage.

- SST measurements shall have a long-term radiometric stability goal of $0.1 \text{ K/decade (≤0.2K/decade threshold)}$ for a $5 \times 5\text{deg latitude longitude area}$.

  -> AATSR achieved $0.1\text{K}$ uncertainties for most of the global ocean.
  -> Aiming for $0.3\text{K}$ uncertainty for L2 operational release, $0.1\text{K}$ will be the later target.
  -> Stability difficult to demonstrate out of the tropics
Mission Performance Framework and SLSTR Cal/Val

• Operational and offline marine monitoring and validation, multi-mission approach, working together with ESA and ESA-MPC. Includes:
  • Mission Performance Monitoring Facility (MPMF)
  • L1 IASI/SLSTR inter-comparisons
  • ESL (UoR, UoL)
  • METIS - SST
  • OSI-SAF SLSTR MDB – NRT/NTC validation and monitoring
  • EUMETSAT L2 Cal / Val tools and infrastructure
  • Sentinel-3 Validation Team and…
14 groups currently participating on validation using ship-board radiometers; in situ data; analysis/ model system; applications; climate / NRT users.

- Early access to SLSTR SST data (including internal products) in NRT through EUMETSAT ODA and EUMETCast, plus archive services.
- First and early SST validation contributing to prioritising improvements e.g. cloud screening
- Progress towards ship-board radiometer network
- Pre-deployment calibration of drifting buoys (HRSST2)
- FRM and validation of uncertainties
- SLSTR Product Format Specifications
- SLSTR different characteristics from AATSR

More teams always welcome, please contact: Anne.Ocarroll@eumetsat.int or Craig.Donlon@esa.int for more information on how to participate

Last meeting:
http://www.eumetsat.int/website/home/News/ConferencesandEvents/DA T_2326254.html
Current status of Sentinel-3 SLSTR SST

**Product Releases:**
- Initial Marine Level-2 products released to **S3VT 21st June 2016**
- Reprocessed data released to S3VT **25th January 2017** (covering 15th June to 15th November 2016)
- Operational Marine L2 NRT/NTC data release planned in **June / July 2017**

**Product Validation Status (for operational release):**
- Validated against in situ measurements (felyx - SLSTR MDB):
  - Using experimental SLSTR L1/L2 matchup dataset collocated with in situ data (drifters, buoys, radiometer) for reprocessed period and NRT
  - Used to adjust the inter-algorithm biases
  - Derivation of Sensor Specific Error Statistics (SSES) to complete the SST product
- Evaluated against L4 analysis (METIS)

**Product improvements for operational release**
- Updates to oblique geolocation and co-registration to the nadir view (L1) **5 May 2017**
- Further cloud screening updates (L1) **June / July 2017**
- Sensor Specific Error Statistics and quality level (L2) **June / July 2017**
- Check that SST analysis is within 5K (residual cloud) **June / July 2017**

**Future improvements**
- Bayesian cloud-screening, SST algorithm implementation improvements
L1 status and SLSTR / IASI L1b inter-comparisons

**Status**

- Regular monitoring of VIS and IR calibration
- Improvement of oblique view geo-location (within 0.5 pix), nadir view geo-location calibration performance at the limit (-0.5 pix across-track)
- TIR radiometric performance nominal, good agreement with IASI
- Improvement in cloud flagging
- L1B Product service is operational (NRT/NTC)

**Issues**

- Geometric calibration: nadir at the limit
- VIS/SWIR (S4 to S6) radiometric calibration still not nominal: Up to 10% too low
- Cloud flagging limitations (mainly daytime)
- Channel co-registration
  - S7 vs. S8/S9 – sub-pixel miss-alignment
  - Fire channel: S7 vs. F1


I. Tomazic, EUM Copernicus Cal/ Val expert
Monitoring and Evaluation of Thematic Information from Space (METIS-SST) – routine monitoring

http://metis.eumetsat.int

See talk by Prasanjit Dash
METIS-SST: monitoring of PB2.16 for L2 release
METIS-SST: monitoring of PB2.16 for L2 release
Sea Surface Temperature Difference: Sentinel-3 SLSTR – UK MetOffice OSTIA L4 Night May 2017

Global Oceans, N_Grid(0.25x0.25)=520894, N_Obs=1035080512, Min=-3.74, Max=5.06, Avg=-0.13 (°C), outliers retained
METIS-SST: stdev global maps vs OSTIA for May 2017

SST Standard Deviation in grid-cell: Sentinel-3 SLSTR – UK MetOffice OSTIA L4 Night May 2017

Global Oceans, N_Grid(0.25x0.25)=520894, N_Obs=1035080512, Min=0.00, Max=2.45, Avg=0.35 (°C), outliers retained.
SLSTR SST matchup database

- Routine collocation of in situ and satellite data.
- Drifters, Moored buoys, Argo, Ship Borne radiometers.
- Use of Coriolis.
- Use of FRM
- Coordination with international teams.

See talk by J-F Piolle
SLSTR MDB activities

- Coordination of the OSI SAF / EUMETSAT MDB for use by all Sentinel-3 Validation Team (temp sub-group)
  - Also needed for inter-algorithm adjustments, SSES and uncertainty, cloud-screening assessments

http://www.ifremer.fr/cerweb/sentinel-3/mdb-slstr/

- FRM radiometer activities from PIs:
  - U of Miami, U of Southampton, RAL, DMI, Bureau of Meteorology
  - Data coordinated by EUMETSAT / S3VT for inclusion in OSI SAF MDB
  - Collocated data available to S3VT and later open

See talk by J-F Piolle
Global buoy SST differences

Includes 5K dt_analysis filter

G. Corlett, SLSTR validation scientist
Buoy matchup results (d = red, n2 = blue, n3 = green) (dual = solid, nadir = dashed)

With cut off wind speed > 6 ms-1 and SatZA < 55 deg

Retrieval: Number mean (St. Dev) Median (RSD) in K

EXP matchups:

N2: 7387  -0.480 (1.410)  -0.209 (0.429)
N3: 4956  -0.349 (0.976)  -0.178 (0.249)
D2: 5712  -0.326 (1.279)  -0.136 (0.309)
D3: 3163  -0.114 (0.675)  -0.121 (0.263)

All matchups:

N2: 19373 -0.420 (1.397)  -0.185 (0.367)
N3: 13697 -0.294 (0.859)  -0.152 (0.208)
D2: 10556 -0.327 (1.328)  -0.134 (0.306)
D3: 6498  -0.115 (0.642)  -0.123 (0.266)

Includes filter where dt_analysis > 5K, wind speed < 6 m/s, SZA > 55 deg

G. Corlett, SLSTR validation scientist
SLSTR SST validation summary

- Large difference in number of daytime and night time match-ups
- DT analysis cut-off at 5 K reduces influence of cloud
  - Largest influence on nadir only cases
- Residual algorithm bias in N2 retrievals outside of oblique view
  - Can reduce with SSES (in the mean)
- D2 uncertainty stratification needs optimizing
  - Most uncertainties are overestimated for cases > 0.3 K
- N2 uncertainties okay to about 0.8 K
  - Then significant variation in bias seen
  - Overestimated slightly for cases > 0.4 K
- Little correlation between uncertainty and difference to drifter for current QL model
  - Advise users to ignore data with satellite zenith angle > 55.0

G. Corlett, SLSTR validation scientist
CMEMS monitoring (pre-operational and L3 EUR SST)

Validation analyses and results by CMEMS, S3VT, and all other contributors essential for continuing improvement of products
Fiducial Reference Measurements - drifters

- New project to provide measurements from a significant number of drifting buoys equipped with digital SST probes in order to achieve a better calibrated capability.

“Assess and establish the benefit of improved calibrated capability of drifting buoys for satellite SST validation”

“Well calibrated, towards traceable drifting buoys, HRSST-FRM”

- Include assessment through Sentinel-3 SST Cal/Val activities, and together with GHRSSST.

- Endorsed by S3VT meeting, February 2017
HRSST-2 / FRM project details

- Improved calibration capability, provision of measurements over a 2+2 year period.
- Provide a service via ftp and GTS, possible inclusion of high frequency data.
- Additional digital SST probe to standard SVP-B -> two sensors for use and evaluation.
- Near surface water pressure sensor -> understand depth of drifter and loss of drogue.
- All relevant technical documentation, metadata, manufacturing information.
- Preparations for S3B SLSTR SST.
Summary

• SLSTR SST validation continue, with priority use of MDB and METIS-SST

• SLSTR SST meet mission requirements (<0.3K), advisory to use only dual-view part of swath for reference purposes

• Sentinel-3 Validation team and other contributing projects / activities important for feeding back into product improvements

• SLSTR SST general data release planned for June / July 2017