NPP VIIRS SST Algorithm and Cal/Val Activities at NOAA/NESDIS

Sasha Ignatov


NOAA/NESDIS, CIRA, NRL, NGAS

JPSS SST Team:
Doug May (NAVO), Bob Evans and Peter Minnett (U. Miami/RSMAS), Pierre LeBorgne (Meteo France)

24 January 2012
JPSS VIIRS SST

**JPSS/NPP**
- JPSS: US - European Cooperation
- NPP: Link between NOAA/POES & NASA/EOS – and JPSS
- Successfully launched on 28 October 2011
- To be followed by JPSS-1 (2015) and JPSS-2 (2018)
- European contribution – Metop AVHRR

**Cal/Val**
- 2008: Ocean Cal/Val Team (SST/Color) formed. Lead Bob Arnone
- SST Cal/Val Team: Arnone, May, Minnett, Evans, Ignatov

**IDPS Algorithm**
- Developed by Northrop Grumman Aerospace Systems (NGAS)
- Run by Raytheon Interface Data Processing Segment (IDPS)
- Effective 2011, NESDIS/STAR in charge of JPSS Algorithms
  SST Algorithm Team: Ignatov (STAR), May (NAVO), Minnett and Evans (U. Miami), LeBorgne (EUMETSAT)
Global Polar SST Systems and Products

**Raytheon: IDPS (No Radiative Transfer Model - RTM)**
- ✓ Regression Non-Linear SST (NLSST)
- ✓ VIIRS Cloud Mask (VCM)

**NESDIS: ACSPO (Advanced Clear-Sky Processor for Oceans) (RTM)**
- ✓ Regression SST (RTM-based under testing)
- ✓ Cloud mask/QC: RTM-based
- ✓ Runs with AVHRR (GAC, FRAC), MODIS, VIIRS

**Meteo France O&SI SAF: Metop/AVHHR FRAC (RTM)**
- ✓ Regression SST (RTM based under testing)
- ✓ Heritage cloud mask

**NAVO: SEATEMP (No RTM)**
- ✓ Regression SST & Heritage cloud mask

**U. Miami/RSMAS: MODIS/AVHHR Pathfinder (No RTM)**
- ✓ Regression SST & Heritage cloud mask
Current Priority: Evaluate IDPS vs. other BTs/SSTs

**SST Quality Monitor (SQUAM)**
[www.star.nesdis.noaa.gov/sod/sst/squam/](http://www.star.nesdis.noaa.gov/sod/sst/squam/)
- Global validation against various L4s and *in situ* SST
- Double-Differences (Cross-Platform & Product Consistency)

**In situ SST Quality Monitor (iQuam)**
[www.star.nesdis.noaa.gov/sod/sst/iquam/](http://www.star.nesdis.noaa.gov/sod/sst/iquam/)
- QC *in situ* SST (drifters, moorings, ships)
- Web: Display summary statistics & Distribute QC’ed data to users

**Monitoring IR Clear-sky Radiances over Oceans for SST (MICROS)**
- Monitor clear-sky ocean Brightness Temperatures vs. CRTM
- Check for consistency with AVHRR/MODIS using Double-Differencing

**Unidirectional Variational Destriping Model (UVDM)**
- Check MODIS/VIIRS BTs/SSTs for stripiness; Destripe

24 January 2012
L2 SST Products in SQUAM

GAC ~4km
Global Area Coverage

- NESDIS
  - ACSPO (new); MUT (heritage)
- NAVO
  - SEATEMP
- U. Miami + NODC
  - Pathfinder Ocean (L3P)

MetOp FRAC ~1km
Full Resolution Area Coverage

- NESDIS
  - ACSPO
- EUMETSAT
  - O&SI SAF

MODIS ~1km
Terra and Aqua

- NESDIS
  - ACSPO
- U. Miami
  - MO(Y)D28

VIIRS ~1km
NPP

- NESDIS
  - ACSPO
- IDPS

Cross-evaluate IDPS SST against ACSPO and against other available L2 AVHRR SST products

24 January 2012
Referencing L2 to an L4 gives a quick snapshot of L2 product well-being

24 January 2012
Warm $\Delta$s expected during daytime. Cold $\Delta$s may indicate residual cloud.
ACSPSO SST minus OSTIA (Daytime)

Histograms of $\Delta$s are near-Gaussian and centered at zero
Moments of histograms are used to cross-evaluate different products
STD “AVHRR minus OSTIA” (Daytime)

L2-L4 statistics are automatically trended in near-real time
STD “AVHRR minus Drifters” (Daytime)

Similar analyses are performed in L2 minus in situ space

24 January 2012
Mean “ACSPO minus OSTIA” (Daytime)

Hovmoller diagrams updated in near-real time
Mean “O&SI SAF minus OSTIA” (Daytime)

Hovmoller diagrams updated in near-real time
Different platform types are shown in different colors, with outliers (erroneous observations) shown in gray. Each symbol stands for one observation.

Tropical moorings include TAO/TRITON, PIRATA, RAIMA etc. Coastal moorings are all other moorings.

http://www.star.nesdis.noaa.gov/sod/sst/i quam/
## iQuam QC is Consistent with UK Met Office

<table>
<thead>
<tr>
<th>Category</th>
<th>Check</th>
<th>Type of error handled</th>
<th>Physical basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preprocessing</td>
<td>Duplicate Removal</td>
<td>Duplicates arise from multiple transmission or data set merging</td>
<td>Identical space/time/ID</td>
</tr>
<tr>
<td>Plausibility</td>
<td>Plausibility checks</td>
<td>Unreasonable field values</td>
<td>Range of single fields &amp; Relationships among them</td>
</tr>
<tr>
<td>Internal consistency</td>
<td>Tracking</td>
<td>Points falling out of track</td>
<td>Travel speed exceeds limit</td>
</tr>
<tr>
<td></td>
<td>Spike check</td>
<td>Discontinuities in SST time series along track</td>
<td>SST gradient exceeds limit</td>
</tr>
<tr>
<td>External consistency</td>
<td>Reference Check</td>
<td>Measurements deviating far away from reference</td>
<td>Bayesian approach (*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Ref. SST: Daily OI SST v2)</td>
</tr>
<tr>
<td>Mutual consistency</td>
<td>Cross-platform Check</td>
<td>Mutual verification with nearby measurements (“buddies check”)</td>
<td>Bayesian approach (*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>based on space/time correlation of SST field</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Correlation model: 2-scale SOAR, Martin et al., 2002)</td>
</tr>
</tbody>
</table>

(*) Lorenc and Hammon, 1988; Ingleby and Haddleton, 2007
**M-O Biases and Double Differences**

**Model minus Observation (“M-O”) Biases**
- **M (Model)** = Community Radiative Transfer Model (CRTM) simulated TOA Brightness Temperatures (w/ Reynolds SST, GFS profiles as input)
- **O (Observation)** = Clear-Sky sensor (AVHRR, MODIS, VIIRS) BTs

**Double Differences (“DD”) for Cross-Platform Consistency**
\[
SAT - REF = SAT[-(M - O)] - REF[-(M - O)]
\]
- “M” used as a “Transfer Standard”
- DDs cancel out/minimize effect of systematic errors & instabilities in BTs arising from e.g.
  - Errors/Instabilities in Reynolds SST & GFS
  - Missing aerosol
  - Possible systemic biases in CRTM
  - Updates to ACSPO algorithm
AVHRR M-O Biases @11 µm

M-O Biases change in time but are largely consistent between platforms

24 January 2012
AVHRR Double Differences @11 µm (Ref=Metop-A)

Double Differences emphasize cross-platform BT (in)consistencies

NOAA-16 shows anomalous behavior. Other platforms show cross-platform systematic biases of several hundredths-to-tenths of a Kelvin

24 January 2012
In Band 31, Terra/Aqua are consistent but 0.3-0.4K off AVHRR cluster.
In Band 32, MODIS and AVHRR agree closely.
In Band 20, Terra and Aqua are 0.3 K apart and bracket AVHRR.
Proxy VIIRS included to test ACSPO/MICROS processor end-to-end
Stripeing in MODIS

MODIS-AQUA, CH31, BT – CRTM BT

MODIS-AQUA, CH32, BT – CRTM BT

Stripeing smaller for Aqua and in long wave bands 31 (11) and 32 (12 µm)

24 January 2012
Striping in MODIS

MODIS-AQUA, CH20, BT – CRTM BT

MODIS-AQUA, SST - REYNOLDS

Striping more pronounced in band 20 (3.7 µm) used for nighttime SST

24 January 2012
Summary

- International JPSS SST Team formed - well positioned to generate top-notch SST product from VIIRS

- STAR (1) supports IDPS Algorithm; and (2) runs ACSPO on VIIRS

- Cal/Val
  - MICROS fully functional with AVHRR, MODIS & proxy VIIRS
  - iQuam fully functional
  - SQUAM fully functional w/AVHRR (OSI SAF, ACSPO, Seatemp, Pathfinder). Adding MODIS (MO(Y)D28, ACSPO), VIIRS (IDPS, ACSPO) underway

- Stripiness
  - Performing analyses with MODIS
  - Initiated analyses for VIIRS

24 January 2012
Ongoing JPSS SST Work at STAR

- Algorithms
  - Work with NGAS to enable IDPS SST
  - Enable ACSPO Cloud Mask and SST
  - Work with VIIRS SDR and Cloud Mask Teams to improve

- Cal/Val
  - Evaluate IDPS L2 SST in SQUAM against ACSPO & other SSTs
  - Evaluate VIIRS Clear-Sky Ocean Radiances in MICROS

- Stripiness
  - Monitor & fix striping in VIIRS SDRs and MODIS

- Metop-B (launch 23 May 2012)
  - Enable ACSPO Cloud Mask and SST
  - Enable monitoring ACSPO and OSI SAF SSTs in SQUAM

24 January 2012
Acknowledgments

- **JPSS**
  - iQuam - [http://www.star.nesdis.noaa.gov/sod/sst/iquam/](http://www.star.nesdis.noaa.gov/sod/sst/iquam/)

- **GOES-R**
  - SQUAM, MICROS, iQuam

- **NOAA Product System Development & Implementation (PSDI)**
  - Advanced Clear-Sky Processor for Oceans (ACSPO)
    (NOAA operational SST system for AVHRR)

- **NOAA NPP Data Exploitation (NDE)**
  - SQUAM, MICROS, iQuam
  - ACSPO extension to process MODIS and VIIRS