Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Presenter/Affiliation: Sasha Ignatov/NESDIS

Performers: XingMing Liang, Prasanjit Dash, CIRA Research Scientists

Thrust areas: 20 - Compare w/SST RTMs; 18 - Evaluate SST Algorithms w/VIIRS Proxy Data; 28 – Demonstrate Real-Time Continuity of SST products; 13 – Automated tuning SST Algorithms; 22 – Automated Match-up w/buoys

Award date: May 2009

Total Man-Months Effort:

<table>
<thead>
<tr>
<th></th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19.2</td>
<td>19.2</td>
<td>19.2</td>
</tr>
</tbody>
</table>
## Developing the Operational Cal/Val components for NPOESS SST at NESDIS

### Project Objectives

1. Online near-real time SST Quality Monitor (**SQUAM**)  

2. Online near-real time Monitor for IR Clear-sky Radiances for SST (**MICROS**)  

3. Online near-real time Cal/Val Tool (**CALVAL**)  

Supports: Ocean Cal/Val plan elements 13, 18, 20, 22, 28

### Major FY09 Challenges/Issues

1. **Design/Demonstrate SQUAM & MICROS** (before this project, it was an idea)

2. Add **NOAA-19** data to SQUAM & MICROS (to see how quickly VIIRS can be added)

3. Add **Double-Differences** to SQUAM & MICROS (to facilitate cross-platform consistency analyses)

4. Add **high-density** AVHRR data (ACSPO) to SQUAM (data volume comparable to VIIRS)

### Milestones / Deliverables

<table>
<thead>
<tr>
<th></th>
<th>FY 09</th>
<th>FY 10</th>
<th>FY 11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td><strong>MICROS</strong>: (1) Redesign; add (2) maps, (3) N19, (4) Double-Diff, (5) FRAC; (6) Fix daytime RTM; Test with (7) AVHRR &amp; (8) VIIRS</td>
<td>2 3 4</td>
<td>2 3 4</td>
<td>3</td>
</tr>
</tbody>
</table>

1. NOAA-19 data added to SQUAM & MICROS

2. Double-Differences added to SQUAM & MICROS

3. High-density AVHRR data (ACSPO) added to SQUAM.

### Major Progress

1. **SQUAM & MICROS** Designed & Demonstrated.

2. NOAA-19 data added to **SQUAM & MICROS**

3. Double-Differences added to **SQUAM & MICROS**

4. High-density AVHRR data (ACSPO) added to **SQUAM**.
# Developing the Operational Cal/Val components for NPOESS SST at NESDIS

## Collaboration and Coordination with Inside and Outside Activities

**SQUAM Current Users:**
- NOAA/NCEP/RTG – Bob Grumbine
- UKMO/OSTIA: Matt Martin
- EUMETSAT O&SI SAF: Pierre LeBorgne
- NESDIS SST Team – John Sapper/Eileen Maturi

**MICROS Current Users**
- GSICS & NESDIS Sensor Cal Team – Changyong Cao
- NESDIS/JCSDA CRTM Team – Yong Han
- NESDIS SST Team - John Sapper/Eileen Maturi

**SQUAM and MICROS Prospect Users**
- IPO SDR – Bruce Guenther
- NGST– Sid Jackson/Justin Diehl
- NAVO – Doug May/Bruce McKenzie
- U. Miami – Bob Evans/Peter Minnett

## Transition Partners

- NOAA OSD – Jim Silva
- NOAA OSDDPD – John Sapper
- O&SI SAF – Pierre LeBorgne
- NAVO – Doug May
- NOAA Coastwatch - P. Di Giacomo

## Leveraged RDT&E Projects

- NOAA – GOES-R
- NOAA – PSDI
- NOAA – NDE
- NOAA – ORS
- NGAS
- Gravite

## International Partnerships

- O&SI SAF – Pierre LeBorgne
- UKMO/OSTIA – Matt Martin
- EUMETSAT – Marianne Konig/Tim Hewison
- GHRSST – Gary Corlett
- CEOS – Pascal Lecomte
- GSICS – Changyong Cao

*Ocean Cal Val EDR Program Review, 2010*
# Developing the Operational Cal/Val components for NPOESS SST at NESDIS

## FY2009 Milestones

<table>
<thead>
<tr>
<th></th>
<th>Monitoring of IR Clear-Sky Radiances over Ocean for SST (MICROS)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Redesign and Demonstrate MICROS webpage</td>
<td>S,W,R</td>
</tr>
<tr>
<td>2</td>
<td>Add maps of M-O bias, other parameters, service info</td>
<td>S,W</td>
</tr>
<tr>
<td>3</td>
<td>Add double differences of M-O bias and test out</td>
<td>S,W</td>
</tr>
<tr>
<td>4</td>
<td>Add NOAA-N’ (NOAA-19) clear-sky radiances to MICROS and validate</td>
<td>S,W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>SST Quality Monitor (SQUAM)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Redesign and demonstrate SQUAM webpage</td>
<td>S,W,R</td>
</tr>
<tr>
<td>6</td>
<td>Add NOAA-N’ (NOAA-19) SSTs to SQUAM and validate</td>
<td>S,W</td>
</tr>
<tr>
<td>7</td>
<td>Add Advanced Clear–Sky Processor for Oceans (ACSPO) GAC SST to SQUAM; Test out; Adjust SQUAM</td>
<td>S,W</td>
</tr>
</tbody>
</table>

S=Software; W=Webpage; R= Report

Ocean Cal Val EDR Program Review, 2010
MICROS

- Monitor “Model minus Observation” (M-O) bias
  - Model: *Community Radiative Transfer Model (CRTM)* used in conjunction with NCEP GFS and SST fields (Reynolds)
  - Observations: *Advanced Clear-Sky Processor for Oceans (ACSPO)* Clear-Sky Radiances in AVHRR Ch3B (3.7μm), Ch4(11μm), & Ch5(12μm) onboard NOAA-16, -17, -18, -19 and MetOp-A

Monitor bias “Retrieved minus 1st guess SST” Retrieved:
- Regression (Linear combination of Radiances)
- 1st guess SST: Reynolds daily (AVHRR based)

- MICROS Objectives are to Monitor/Validate/Improve:
  - Clear-Sky ocean Radiances and SSTs
  - CRTM & 1st guess SST and GFS fields
  - Sensor radiances
    - Currently, 5 AVHRRs (NOAA-16, 17, 18, 19, Metop-A)
    - Adding Terra and Aqua MODIS is considered

*Ocean Cal Val EDR Program Review, 2010*
Flow-chart of MICROS System

- MICROS crons/scripts run daily @2am EST
- Process AVHRR data & publish results on the web
  Processing global GAC data (4km) from 5 platforms: ~3 hrs
**Milestone 1: Redesign & Demonstrate MICROS**

**Redesign**
- Vertical toolbar added (Maps, Histograms, Time Series, Dependencies)
- Menu added for platform, band, and day/night mode selection

**Demonstrate**
- AMS 2009 (Jan 2009)
- GHRSST (May 2009)
- CALCON (Aug 2009)
- JGR paper submitted (in revision)

[http://www.star.nesdis.noaa.gov/sod/sst/micros/]
Milestone 2: Add maps of ancillary data

Wind Speed, 19 March 2010

Maps of surface wind, Reynolds SST, air-sea temperature difference, integral water vapor, view zenith and glint angles, to facilitate M-O bias analyses

Ocean Cal Val EDR Program Review, 2010
Milestones 4: Add NOAA-19

NOAA-19 was added to MICROS as soon as its AVHRR thermal bands were commissioned
Milestone 3: Add Double-Differences

- Use Double-differences (DD) to rectify cross-platform biases from “noise” in M-O bias

\[ SAT - REF = SAT[-(M - O)] - REF[-(M - O)] \]

- NOAA-17 = Reference satellite
- CRTM used as a ‘transfer standard’
- DD minimizes artifacts in M-O biases arising from e.g.
  - Errors in Reynolds SST and GFS upper air data
  - Missing aerosol in current CRTM implementation
  - Possible systematic biases in CRTM
  - Changing versions of ACSPO algorithm
- DDs take into account differences in spectral responses between different sensors
Milestones 3-4: Add DDs and NOAA-19

Ch3b biases relative to N17
- MetOp-A: -0.002 K
- NOAA-18: -0.014 K
- NOAA-19: -0.095 K
- NOAA-16: Unstable

Cross-platform inconsistencies are due to
- Cross-Sensor calibration biases
- Spectral response function deviate from used in CRTM
- Local time differences (affect SST/BTs through diurnal cycle)

Work underway to understand biases & reconcile platforms
**Milestone 3-4: DDs in Ch4 and Ch5**

**Double Differences in Ch4**

Nighttime, Ch4
REF: NOAA17
3 days average

- **METOPA:** $\mu = -0.039$, $\sigma = 0.017$
- **NOAA-18:** $\mu = -0.111$, $\sigma = 0.026$
- **NOAA-19:** $\mu = -0.151$, $\sigma = 0.014$

**Mean Ch4 biases relative to N17**
- **MetOp-A:** -0.039 K
- **NOAA-18:** -0.111 K
- **NOAA-19:** -0.151 K
- **NOAA-16:** Unstable

**Double Differences in Ch5**

Nighttime, Ch5
REF: NOAA17
3 days average

- **METOPA:** $\mu = 0.036$, $\sigma = 0.014$
- **NOAA-18:** $\mu = -0.061$, $\sigma = 0.020$
- **NOAA-19:** $\mu = 0.050$, $\sigma = 0.030$

**Mean Ch5 biases relative to N17**
- **MetOp-A:** -0.036 K
- **NOAA-18:** +0.050 K
- **NOAA-19:** -0.061 K
- **NOAA-16:** Unstable

Work underway to understand & reconcile cross-platform biases
Milestone 3-4: DDs in Ch4 and Ch5

- **Cal/Val against *in-situ* SST has limitations:**
  - Coverage sparse and non-uniform in space
  - May not be globally representative
  - Quality of *in-situ* SST suboptimal and non-uniform
  - Up to 1 month to accumulate enough match-ups
  - Val statistics available in a delayed mode

- **Global monitoring against L4 needed to complement heritage Cal/Val against *in situ* SST**
  - Global statistical checks of SST anomalies with respect to global reference SSTs (Reynolds, RTG, OSTIA, ..)
  - Continuously monitor SST products online, in NRT
  - Quickly identify & resolve anomalies
  - Check products for stability cross-platform consistency
Milestone 5: Redesign & Demonstrate SQUAM

Redesign
- Toolbars implemented: Maps, Histograms, Time Series, Dependencies
- CSS/JS/Text Editor (vs. MS Frontpage/Expression Web2).
- Smooth navigation, data access

Demonstrate
- AMS 2009 (Jan 2009)
- GHRSST (May 2009)
- JTech paper submitted (in revision)

http://www.star.nesdis.noaa.gov/sod/sst/squam/
**Milestones 6: Add NOAA-19**

SST from NOAA-19 was added to SQUAM as soon as its AVHRR thermal bands were commissioned. **NOAA-19 SST is consistent with NOAA-18 SST (the two platforms have closest overpass time).**
Milestones 7: Add higher-resolution Advanced Clear-Sky Processor for Oceans (ACSPO) data

sst_regression-Reynolds_SST_NOAA19_2010-03-12_Day ACSPO

Daily composite

ACSPO minus Reynolds SST for 12 March 2010 (NOAA-19)
Milestones 7: Add higher-resolution Advanced Clear-Sky Processor for Oceans (ACSPO) data

Weekly composite

NESDIS heritage minus Reynolds SST for 2-12 March 2010 (NOAA-19)
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Status and Issues:

• **M1:** Redesign and Demonstrate MICROS
  1. January 2010
  2. Development status: 100% at time of this review
  3. Major technical issues and their impacts: None

• **M2:** Add Maps of other parameters and service information
  1. June 2009
  2. Development status: 100% at time of this review
  3. Major technical issues and their impact: None
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Status and Issues:

• **M3:** Add double-differences and test out
  
  1. March 2010
  2. Development status: 100% at time of this review
  3. Major technical issues and their impacts: NOAA-17 selected as reference platform - AVHRR shows motor spike problems recently

• **M4:** Add NOAA-19 to MICROS and Validate
  
  1. March 2009
  2. Development status: 80% at time of this review
  3. Major technical issues and their impact: NOAA-19 brightness temperatures are off by ~0.1K in all bands. Work is underway to verify the spectral response functions used as input to CRTM.
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Status and Issues:

• **M5:** Redesign and Demonstrate SQUAM webpage
  1. November 2009
  2. Development status: 100% at time of this review
  3. Major technical issues and their impacts: None

• **M6:** Add NOAA-19 to SQUAM and Validate
  1. April 2009
  2. Development status: 100% at time of this review
  3. Major technical issues and their impact: None.
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Status and Issues:

- **M7**: Add high-resolution new ACSPO SST product to SQUAM
  
  1. March 2010
  2. Development status: 70% at time of this review
  3. Major technical issues and their impacts:
    - Processing on local STAR Linux box remains unstable. Work is underway to improve stability
    - ACSPO SST formulation was adopted from NESDIS heritage system. Remains suboptimal at large view zenith angles. Work is underway to improve ACSPO SST.
# Developing the Operational Cal/Val components for NPOESS SST at NESDIS

## FY2010 Milestones

<table>
<thead>
<tr>
<th>Monitoring of IR Clear-Sky Radiances over Ocean for SST (MICROS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 1 Add 1km global data (AVHRR FRAC or MODIS) to MICROS</td>
</tr>
<tr>
<td>• 2 Explore improved cross-platform consistency (diurnal cycle, sensor)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SST Quality Monitor (SQUAM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 3 Add 1km global data (AVHRR FRAC or MODIS) to SQUAM</td>
</tr>
<tr>
<td>• 4 Explore improved cross-platforms consistency (diurnal cycle, sensor)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SST Calibration and Validation (CALVAL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 5 Design and Demonstrate Cal/Val online near-real time tool</td>
</tr>
</tbody>
</table>

*S=*Software; *W=*Webpage; *R=* Report
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Schedule with Major Deliverables

Red background indicates delays and green indicates on or ahead of schedule (as compared to FY09 DD1498)

<table>
<thead>
<tr>
<th>Title</th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milestones</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
<td>Q1</td>
</tr>
<tr>
<td>MICROS (Radiances against RTM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SQUAM (SST against Level 4 fields)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CALVAL (SST against in situ data)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Timeliness of deliverables science and transition (i.e., documents/demo/software, etc). Indicate changes from FY09 1498 by highlighting original planned time in red. You can use this table legend:
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

Summary: Impact of Deliverables on Program:

Role of the milestones on IPO efforts (SDR/EDR)

- MICROS, SQUAM CALVAL help IPO, NGST, data users independently evaluate VIIRS SST & associated BTs in context of AVHRR/MODIS
- This info is provided online in near-real time facilitates monitoring VIIRS SSTs and BTs for accuracy, stability, self- and cross-consistency

Role of efforts on other partners

- NCEP RTG Team uses SQUAM to monitor RTG SST and AVHRR SST (input to RTG). Interested in CALVAL page, too.
- GSICS and NESDIS Cal Team use SST feedback to monitor and improve sensor performance.
- JCSDA CRTM team uses MICROS to improve CRTM
- Hopefully IPO SDR, NGST and Cal/Val partners find this info useful

Role of milestones at launch scenario

- MICROS and SQUAM show available SST and BT resources and help weigh risks of NPP/NPOESS launch slip
NESDIS SST GRAVITE Access
GRAVITE Linux Machine (proc8)

- IPO VPN and Linux accounts set up and accessible
- Intel compilers
  - Version 9.1, 32-bit installed (ACSPO requires 11+ and 64-bit)
  - Version 11.1 (32- & 64-bit) available (evaluation copy), but license expired
- IDL
  - Version 7.0.1 available (we have 6.4 and 7.1)
  - No license -- demo mode only
- HDF, netCDF, and Eclipse available
- Basic ACSPO requirements provided to Steve Thomas
  - Steve indicated that running ACSPO on GRAVITE was “very doable”
GRAVITE Data Portal (GDP)

- GDP accessible via the GRAVITE Transfer Protocol (GTP) software
- Script created on our side to run under cron to download latest proxy VIIRS files from GDP using GTP, but…
- No new proxy VIIRS data since Feb. 4, 2010
  - 2 emails sent to Steve in Feb’10. Responses were that the data would be back within a few days
- Proxy VIIRS data analysis
  - File names don’t exactly match what’s defined in the IDPS Common Data Format Control Books (CDFCB)
  - Format of data does not quite match what’s defined in the CDFCB and the test data we’ve received from IDPS
    - Differences are primarily with the attributes data
  - Noted differences sent to Steve who forwarded them to the person responsible for tracking such issues
- No MODIS L1B data.
Questions, Issues, and Concerns

• Lack of notification concerning the status of the proxy data.
  – When will the proxy data generation be back?
• If ACSPO is run on GRAVITE, a process needs to be worked out to ensure that ACSPO has access to the latest NCEP GFS data and Reynolds data
• With Steve’s departure, who is the point of contact for technical issues (status/questions/problems with GRAVITE and GDP, anomalies in proxy data, running our software on GRAVITE, etc.)?
• What’s the status of the Intel Version 11.1 64-bit compilers?
• What’s the status of IDL? When will licenses be purchased?
• What’s the status of upgrades to the proxy VIIRS data to make it match the CDFCB?
• Is it possible to make MODIS L1B data available on the GDP?
Developing the Operational Cal/Val components for NPOESS SST at NESDIS

1) Define a VIIRS Proxy Data Stream
2) Define the required in situ data stream for Cal/Val
3) Tuning of algorithms and LUTS (Vicarious calibration and SDR feedback)
4) Ocean Algorithm, stability evaluation and uncertainty
5) Product validation and product long-term stability
6) Satellite inter-comparisons, robustness, seasonal and product stability

Questions?
Histograms of M-O Bias in MICROS

NOAA-16, -17, 18, 19, and MetOp-A 28 March 2009 (Ch3B, Nighttime)

Model is warmer than Obs by ~0.1 K due to:
- using bulk SST (instead of skin)
- using diurnal-mean Reynolds SST at night
- missing aerosol in CRTM implementation
- possible residual cloud in AVHRR BTs

- Stat: 2.5-3 million clear-sky pixels per day
- Shape of histograms: Close to Gaussian
- Cross-platform consistency: within ~0.1 K
(NB: Overpass time is from 9:30pm-5am)
Dependencies of M-O Bias in MICROS

NOAA-16, -17, 18, 19, and MetOp-A 28 March 2009

- Angular dependencies: within <0.2 K
- Cross-platform consistency: within < 0.1 K

Ocean Cal Val EDR Program Review, 2010
M-O BT and SST Biases in MICROS

NOAA-19 was added to MICROS as soon as its AVHRR thermal bands were commissioned.