NOAA’s Geo-Polar Blended SST Analysis

Andy Harris¹, Jonathan Mittaz¹,⁴, Gary Wick³, Eileen Maturi², John Sapper⁵, Mark Eakin²
¹NOAA-CICS, University of Maryland
²NOAA/NESDIS/STAR
³NOAA/OAR/ESRL
⁴University of Reading, UK
⁵NOAA/NESDIS/OSPO
Maximize strengths – minimize weaknesses

POES IR has high spatial resolution
GOES IR has high temporal resolution
Microwave has all-weather capability

Combine to obtain the optimal SST analysis
Geo-SST dominates low to mid latitudes
Data Coverage – AMSR-2

- Valid SST data coverage from AMSR-2 for 2014-05-01
  - Improved coverage in both Tropics and High Latitudes
  - 3 days gives almost complete coverage away from land & ice
5-km Blended SST Analysis

- Produced daily from 24 hours of Polar- & Geo-SST
  - MetOp-B
  - GOES-E/W Imager
  - Meteosat-10 SEVIRI  [Meteosat-8 over Indian Ocean]
  - Himawari-8 Imager
  - VIIRS
  - [AMSR-2]
  - Does not use buoy data

- Multi-scale OI
  - Mimics Kalman Filter (Khellah et. al., 2005)

- 3 stationary priors
  - Short, intermediate and long correlation lengths
  - Mimic non-stationary prior while preserving rigor
  - Interpolation of resultant analyses based data density
    - Allows fine resolution where possible without introducing noise
AMSR-2 SSES Bias

- Lookup table based on incidence angle

With SSES Bias Adjustment
VIIRS data

- VIIRS incorporated into Geo-Polar Blended 5-km global SST analysis

Significant impact on accuracy cf. independent ARGO data

CPS Annual Meeting, 14 – 18 August, 2017
VIIRS coverage

- Coverage is improved w.r.t. MetOp AVHRR
NOAA Coral Reef Watch

Coral Reef Watch Satellite Monitoring

NOAA Coral Reef Watch is pleased to announce the release of its new Daily 5-km Satellite Coral Bleaching Thermal Stress Monitoring Product Suite. The 5-km products are accessible directly below, in the left navigation bar, and throughout this website. Access to our heritage suite of operational 50-km satellite monitoring products will still be possible for the next several months. We encourage all of our users to look over the new 5-km products and provide feedback to us at coralreefwatch@noaa.gov.

Click on buttons below image to change parameter; click on image to navigate to parameter’s web page.

The NOAA Coral Reef Watch program’s satellite data provide current reef environmental conditions to quickly identify areas at risk for coral bleaching, where corals lose the symbiotic algae that give them their distinctive colors. If a coral is severely bleached, disease and partial mortality become likely, and the entire colony may die.

Continuous monitoring of sea surface temperature at global scales provides researchers and stakeholders with tools to understand and better manage the complex interactions leading to coral bleaching. When bleaching conditions occur, these tools can be used to trigger bleaching response plans and support appropriate management decisions.

Announcements

October 8, 2015: NOAA announces third ever global coral bleaching event on record! Read the NOAA press release here.
Accumulated thermal stress is a predictor of bleaching risk.
CRW Products based on 5-km SST

“Coral Triangle”
CRW Products – 5-km detail

“Coral Triangle”

• New analysis enables much greater precision, e.g. small fringing reefs
• However, **climatology is not derived from same dataset**
Primary concern: water temperature at coral depth

With thanks to Scott Heron
Including diurnal warming correction in SST analysis

Algorithm Flow Diagram
Diurnal Warming Correction – Sample Model Profile of Warming with Depth

- Model simulates full vertical profile of warming
  - Enables estimation of warming at arbitrary depth
  - Model presently run to a depth of 50 m

- Time evolution of vertical temperature profile shown here for idealized forcing with a constant wind speed of 3 m/s and a peak insolation of 800 W/m²
Magnitude of warming

Example bias correction field VIIRS daytime

- Bias correction usually <2 K
- Model response damped by including *gustiness parameterization*
- Why might the *observed* diurnal excursion be damped?
Effect of diurnal adjustment on input data

- METOP adjustments are fairly modest
Effect of diurnal adjustment on input data

- VIIRS adjustments are more significant
Effect of diurnal adjustment on input data

- METOP monthly average for March 2016
Effect of diurnal adjustment on input data

- VIIRS monthly average for March 2016
Effect of diurnal adjustment on bias correction

- Unadjusted VIIRS (2016-03-21)
Effect of diurnal adjustment on bias correction

- Diurnally adjusted VIIRS (2016-03-21)
Effect of diurnal adjustment on bias correction

- Unadjusted monthly average VIIRS
Effect of diurnal adjustment on bias correction

- Diurnally adjusted monthly average VIIRS
Retrieval biases – aerosol?

- MODIS-A mean aerosol, Mar 2016
- Other atmospheric factors, e.g. water vapour loading
Effect of diurnal adjustment on bias correction

- Diurnally adjusted VIIRS + SSES Bias (2016-03-21)
Effect of diurnal adjustment on bias correction

- Diurnally adjusted VIIRS (2016-03-21)
Effect of diurnal adjustment on bias correction

- Diurnally adjusted monthly average VIIRS + SSES Bias
Effect of diurnal adjustment on bias correction

- Diurnally adjusted monthly average VIIRS
Improve Diurnal Adjustment

- Difficult to model the observed distribution of warming
  - Especially in tropics

- New parameterization + wind gustiness
  - Substantially improved distribution of modeled warming
Validation vs ARGO

- March 2016
- iQuam QC
- 3 – 7 m depth

Global: $\pm 0.28 \pm 0.40 (0.37)$
$30^\circ N$: $-0.40 \pm 0.46 (0.36)$
$<30^\circ$: $-0.18 \pm 0.36 (0.30)$
$30^\circ S$: $-0.40 \pm 0.41 (0.37)$

*N.B. Virtually identical statistics to uncorrected analysis!*
Locations of currently active ARGO floats

3750 Floats
12-Dec-2014
Effect of diurnal adjustment on input data

- VIIRS monthly average for March 2016
VIIRS data

- **N.B. VIIRS now used as bias correction reference for OSTIA**

Significant impact on accuracy *cf. independent* ARGO data
Summary

• NOAA produces all the L2 data that go into the analysis
  – Polar data – ACSPO regression SST
  – Geostationary – Bayesian cloud + MTLS Physical retrieval
  – *N.B.* Convergence on ACSPO means Himawari-8 is ACSPO
  – AMSR-2 SST is processed with NOAA GAASP algorithm
    ➢ Initial SSES scheme *based on incidence angle*

• L4 SST analysis continues to be improved
  – Bias correction against OSTIA
    ➢ OSTIA has improved *cf.* independent ARGO
    ➢ Therefore Geo-Polar Blended 5-km Analysis has also improved
  – Analysis bias correction scheme due for overhaul
    ➢ ACSPO VIIRS [+Sentinel-3 SLSTR]
Summary cont’d

• Diurnal correction with turbulence model & Stokes’ Drift
  — Beneficial for applications that depend on SST at depth (e.g. CRW)
  — Daytime SST retrieval may not see full scope of DW, especially in tropics
  — Gustiness parameter damps warming (too much?)
    ➢ Partly a work-around for above issue
  — New parameterization **substantially improves warming distributions**
    ➢ Should be incorporated in next update to model
  — Other regional algorithm biases
    ➢ On balance, using SSES bias + diurnal adjustment is better
Summary cont’d

- Reprocessing 2002 – 2016
  - Improved baseline for CRW
    - ACSPO GAC AVHRR + Geo-SST (Physical+Bayesian) \([N.B. \text{ no VIIRS}]\)
    - OSTIA RAN + OSTIA Operational

Reprocessed GOES-W
• Reprocess again using ACSPO nighttime 3-chan + SSES as reference?
Backup slides
MODIS: Addition of aerosol

• **Put aerosol information in the CRTM**
  – NGAC profiles, multiple species (dust, salt, sulfate, soot)
  – Improve match of RTM to observation
  – Does this improve retrieval?

• **Put aerosol in the retrieval vector**
  – Allow Total Column Aerosol to vary
  – \( x = [\text{SST}, \text{WV}, \text{TCA}]^T \)
  – Jacobian now includes \( \partial T / \partial \text{TCA} \) for each channel
  – Does this improve retrieval?

• **MTLS developed for 2-parameter retrieval**
  – Try different regularization operator since problem is now more ill-conditioned: **Truncated Total Least Squares (TTLS)**

\[
|\Delta y| \leq 1: \quad \lambda = (\sigma_{\text{end-1}})^2 \quad |\Delta y| > 1: \quad \lambda = (\sigma_{\text{end-1}} / \log(|\Delta y|))^2
\]
Inclusion of aerosol

- Accuracy with TTLS & joint [SST, WV, TCA] ~0.2 K
- Algorithm sensitivity is also improved cf. MTLS