Development of a Global QC/QA Processor for Operational NOAA 16–18 and MetOp AVHRR SST Products

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1. Introduction

National Oceanic and Atmospheric Administration (NOAA) operational sea surface temperature (SST) products are customarily calibrated and validated (Cal/Val) against *in situ* SSTs from buoy data. However, the match-ups may be sparse and of non-uniform quality in space and time. This study explores another quality control/quality assurance (QC/QA) approach, based on statistical analysis of global SST anomalies with respect to other global reference states (e.g., Ignatov et al. 2004). This work describes a global near real-time processor based on a set of statistical self- and cross-consistency checks, and results of its application to the NOAA operational SST products derived from AVHRR.

2. Motivation for global QC/QA

Customary Cal/Val relies on *in situ* SSTs. However, its results may not be fully conclusive or available in a timely manner for diagnostic purposes, as *in situ* data are:

- Scarce. As a result, longer time may be required to accumulate number of match-ups sufficient for a representative Cal/Val statistics.
- Limited in space and time. Hence, Cal/Val statistics may not be globally representative.
- Of non-uniform and often of sub-optimal quality, due to multiple origins. Therefore, Cal/Val results may not be representative of actual product performance.

A complementary QC/QA approach based on global reference SST fields is explored in this study. Global reference fields may come from SST climatology (e.g., Bauer Robinson 1985) or from global analysis or forecast systems (e.g., Reynolds-Smith 2002; RTG SST). This may alleviate some of the Cal/Val disadvantages, as large volume of match-ups is available, globally, on a more uniform and consistent basis.

The QC/QA may not provide a measure of absolute accuracy of the satellite products, but it provides a uniform measure of their spatial coherence and temporal stability.

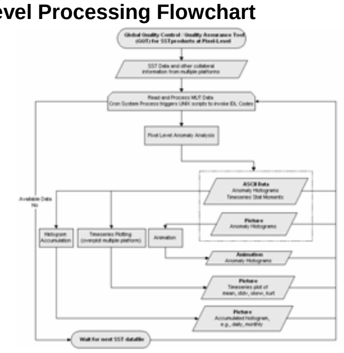
3. Methodology

- Calculate SST anomaly with respect to a global reference field; distribution is expected to be close to Gaussian.
- Analyze Gaussian parameters and perform self- & cross-consistency checks (***pixel-level***).
- Grid SST anomaly, map and plot (gridded) anomaly vs. observational parameters (***gridded level***).

4. Software Implementation

- Language: IDL 6.0 and above; OS: Linux/Unix
- Automated by configuration files/Unix scripts/Cron
- S/W distribution DVD with test data (in preparation)

5. Pixel Level Processing Flowchart



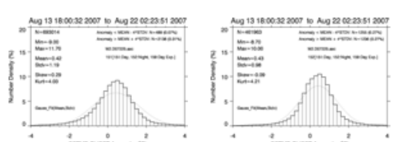
Schematic representation of pixel level processing in **Global QC/QA Tool (GQT)**. Input data used in this study are from NOAA heritage Main Unit Task (MUT) operational SST system which provides 8-day rotation SSTOBS files. Time, location, visible reflectances and brightness temperatures, and nearest Bauer-Robinson 1985 climatology are also appended to SST data.

6. Grid Level Processing Flowchart

Schematic representation of gridding and analysis of gridded data in **Global QC/QA Tool (GQT)**. Anomaly maps and trend-plots (bias vs. correlating variables, e.g. zenith angle) are major outputs of the gridded level processing.

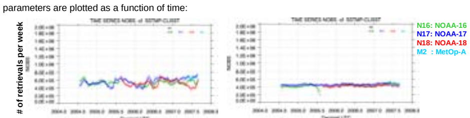
7. Pixel level anomaly statistics & time-series

Day SST anomaly example | Night SST anomaly example

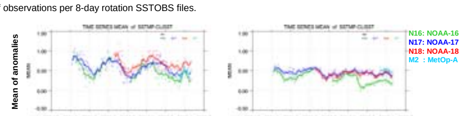


Histograms of global SST anomalies (MetOp AVHRR SST – Bauer-Robinson, 1985). Number of observations, minimum, maximum, mean, standard deviation, skewness, and kurtosis of anomalies are annotated on the histograms. Gaussian fits using sample Mean and Stdv are also over-plotted. The number of low and high outliers are shown on top-right.

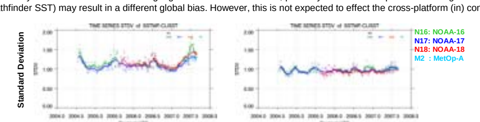
The annotated parameters are plotted as a function of time:



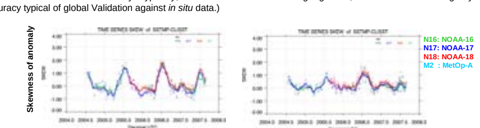
Total number of observations per 8-day rotation SSTOBS files.



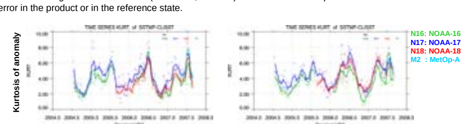
Global mean of SST anomaly (satellite SST – Bauer-Robinson SST). Each point represents statistical mean for 8 days of global data. Note excellent consistency between N17 and N18 during nighttime. N16 is biased low, probably due to sensor problems. Using a different reference state (e.g., Pathfinder SST) may result in a different global bias. However, this is not expected to effect the cross-platform (in) consistencies.



Global standard deviation of SST anomaly. Typically, STDV is from 0.9-1.1K during nighttime, and from 1-1.5K during daytime. (cf. with 0.5K RMSD accuracy typical of global Validation against *in situ* data.)



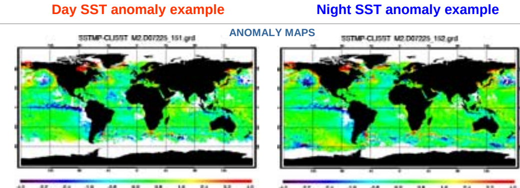
Time series of skewness. Higher order moments (skewness, kurtosis) should be zero for perfect Gaussian distributions. Any deviation may indicate either error in the product or in the reference state.



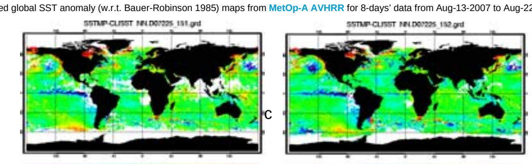
Time series of kurtosis. In the newer AVHRR Clear-Sky Processor for Oceans (ACSPO) currently being developed at NESDIS, analysis will be done with respect to multiple reference states.

8. Grid level anomaly analysis

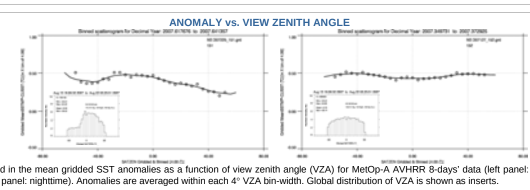
Day SST anomaly example | Night SST anomaly example



Gridded global SST anomaly (w.r.t. Bauer-Robinson 1985) maps from MetOp-A AVHRR for 8-days' data from Aug-13-2007 to Aug-22-2007.



Gridded global SST anomaly (with respect to Bauer-Robinson 1985) maps from NOAA-18 AVHRR for 8-days' data from Aug-13-2007 to Aug-22-2007 (left panel: daytime; right panel: nighttime).



Trend in the mean gridded SST anomalies as a function of view zenith angle (VZA) for MetOp-A AVHRR 8-days' data (left panel: daytime; right panel: nighttime). Anomalies are averaged within each 4° VZA bin-width. Global distribution of VZA is shown as inserts.

Note that similar "trend-plots" are also generated for other observational parameters (solar zenith angle, glint angle, # of points in a grid etc.) and geophysical parameters (water vapor, if available) and are animated. All of these facilitate detection of algorithm/sensor malfunctioning and performance of the processors throughout their lifetimes.

9. Summary

- The Global QC/QA Tool (GQT) facilitates routine monitoring of SST products and detecting algorithm/sensor anomalies in a timely manner.
- The anomaly histograms from different platforms are typically consistent, with a mean bias of *ca.* 0.4 K and an RMSD of *ca.* 1.0 K with respect to Bauer-Robinson 1985 climatology.
- Upon successful testing with the new MetOp SST processor (being developed), the GQT will also be implemented to operationally monitor the quality of other platforms in future, e.g., NPOESS/VIIRS and GOES-R/ABI SST products.
- The same tool may also be used for statistical analysis of other products, e.g., aerosols, land surface temperature (LST) and radiative transfer model (RTM) validation etc.

Literature

- Walton, 1988, Nonlinear algo for SST, JAM.
- Ignatov *et al.*, 2004, 13th AMS conf, Sep 2004.
- Reynolds et al., 2002 Improved in situ, JOC
- Donlon et al., 2002, Towards imp. Val, JOC
- Bauer-Ron., 1985, Desc. of BR Num. Atlas

Acknowledgment

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