CLOUD MASK AND QUALITY CONTROL FOR SST WITHIN THE ADVANCED CLEAR SKY PROCESSOR FOR OCEANS (ACSPO)

B. Petrenko[1,2], A. Ignatov[1], N.Shabanov[1,2], X. Liang[3], Y. Kihai[1,4], A. Heidinger[1]

[1]NOAA/NESDIS/STAR, [2]IM Systems Group, Inc., [3]CIRA, [4]Perot/QSS Group, Inc.

1. Introduction

ACSPO product has been operational at NESDIS since May 2008. It generates clear-sky ocean products at a pixel resolution, including clear sky brightness temperatures (BT) and Sea Surface Temperature (SST, T_S). Current ACSPO includes a single cloud screening module called the ACSPO Clear-Sky Mask (Petrenko et al., 2009).

Future ACSPO versions will have two separate cloud masking modules:

- **The ACSPO Cloud Mask (ACM)** will generate a robust cloud mask, independent of real-time ancillary data.
- **The ACSPO Quality Control (AQC)** will perform more accurate cloud filtering using radiative transfer simulations with real-time SST and upper air fields as input.

2. The flow chart of ACM and AQC

"Telescopic" Approach

- ✓ ACM initially classifies all pixels over ocean into "clear", "probably clear" and "cloudy"
- ✓ AQC analyzes only ACM "clear" and "probably clear" pixels and reclassifies some of them into "cloudy"
- ✓ AQC does not analyze pixels classified by ACM as "cloudy"

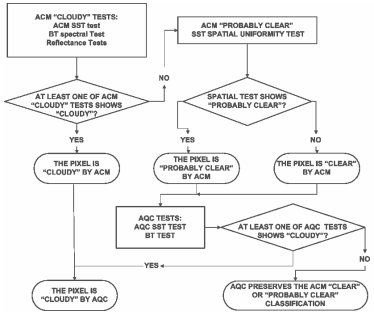


Fig. 1. The joint flow chart of ACM and AQC

3. ACM and AQC Tests

ACM Tests

✓**SST test**, using Climate SST (Xue a et al., 2003) as a reference field

- Initial classification cuts off unrealistic T_S anomalies using a static gross threshold
- Classification refined using clusterization of T_S anomalies within a sliding window

✓**BT Spectral Test** checks for the BT differences

- between Ch3b and Ch5 at night; and
- between Ch4 and Ch5 in the daytime.

✓**Reflectance tests** are used during daytime (CLAVRx, Heidinger, 2004)

- Reflectance Gross Contrast Test;
- Reflectance Ration Contrast Test; and
- Ch3A Albedo Test.

✓**SST Uniformity Test** checks the T_S field for elevated spatial variability

- special precautions are taken to minimize false cloud detections in the areas with high SST contrasts such as upwellings, currents, coastal lines (Petrenko, 2008).

AQC Tests

✓**SST test** uses daily 0.25° blended SST (Reynolds et al., 2007) as a reference field

- Initial classification cuts off unrealistic T_S anomalies using a location- and time-dependent gross threshold
- Classification refined using clusterization of T_S anomalies within a sliding window

✓**BT test** checks for accuracy of approximating observed BTs with Model BTs, simulated with T_S and NCEP/GFS upper air fields as input.

4. Accounting for biases in Observed (AVHRR) minus Model (CRTM) BT

- ✓ The AQC BT test checks for accuracy of approximation of observed BT with CRTM (Liang et al., 2009), using T_S and NCEP atmospheric data as input (Petrenko, 2008).
- ✓ Global biases of "Observed – Simulated" BTs in AVHRR Ch3B, 4 and 5 are estimated from histograms, accumulated over all ocean pixels.

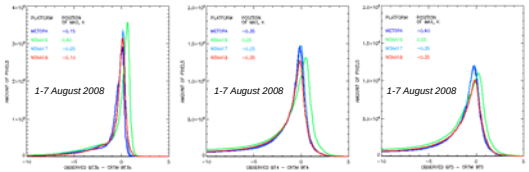


Fig. 2. Nighttime histograms of "Observed – Simulated" BT in AVHRR Ch3B, 4 and 5.

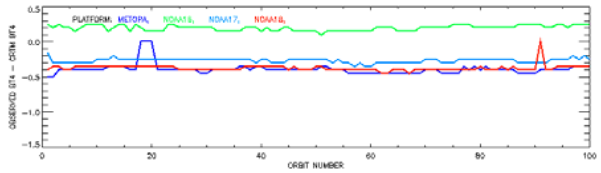


Fig. 3. Nighttime biases in "Observed – Simulated" BTs in the AVHRR Ch4.

- Time series of the modes are stable in time, except for a few unexplained spikes.
- NOAA-16 biases are "out-of-family", in all bands (cf. Liang et al., 2009).

5. Accounting for biases in "Retrieved minus Reference" SST

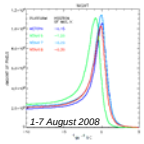


Fig. 4. ACM uses Retrieved – Climate SST.

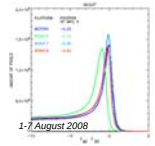


Fig. 5. AQC uses Retrieved – Daily SST.

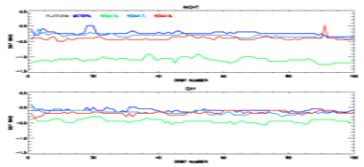


Fig. 6. Time series of "Retrieved – Daily Reynolds" SST

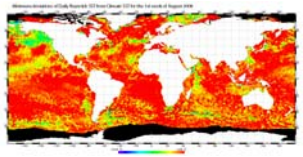
- Time series of the modes are stable in time (except for a few unexplained spikes).
- NOAA-16 bias is "out-of-family", due to near-terminator orbit and sensor problems.

6. Accounting for accuracy of Reference SST Field

Both ACM and AQC check if the bias-corrected Retrieved SST is within a realsitic range of Reference SST. The "gross" thresholds are specified taking into account the accuracy of the corresponding reference SST field.

The ACM "gross" SST threshold of -6K has been chosen from the analysis of the difference between Climate and Daily SST fields.

Fig. 7. A composite map of minimum difference Daily-Climate SST for August 1-7, 2008. The difference is less than -6K for no more than 10-6 of the total amount of ocean pixels.



The AQC "gross" SST threshold is set to min(-2K,-5σ), where σ is location- and time-specific STD available from the daily Reynolds SST dataset. Typically, 0.1K < σ <0.7K.

The initial classification by "gross" thresholds is iteratively refined using local statistics of "clear" and "cloudy" pixels within a sliding window surrounding the pixel.

7. Evaluation of resulting Retrieved SST after ACM and AQC

Preliminary evaluation of retrieved SST was done against daily 0.25° Reynolds SST

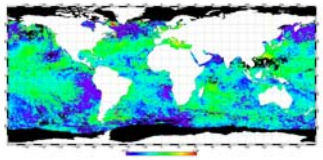


Fig. 8. A composite map of T_S – Daily SST for "clear" pixels as defined by ACM. Nighttime MetOp-A, August 1-7, 2008.

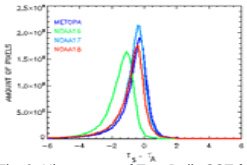


Fig. 9. Histograms of T_S – Daily SST for ACM "clear" pixels. Nighttime data for 4 AVHRR sensors from 1-7 August 2008.

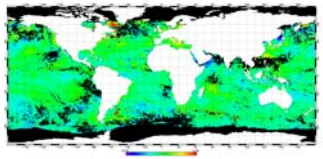


Fig. 10. A composite map of T_S – Daily SST for "clear" pixels as defined by AQC. Nighttime MetOp-A, August 1-7, 2008.

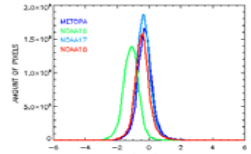


Fig. 11. Histograms of T_S – Daily SST for AQC "clear" pixels. Nighttime data for 4 AVHRR sensors from 1-7 August 2008.

Table 1. Summary statistics of T_S –Daily SST anomalies for "clear" pixels by ACM and AQC.

Module	Percentage of "clear" pixels to the total amount of ocean pixels	Mean SST anomaly $-B_D$, K (B_D for 4 platforms is shown on Fig. 3)	STD,K
ACM (night)	17.8% to 22.3%	-0.27K to -0.37K	0.92K to 1.04K
ACM (day)	21.3% to 23%	-0.06K to -0.12K	0.86K to 0.99K
AQC (night)	11.2% to 14.8%	0.06K to 0.11K	0.50K to 0.52K
AQC (day)	13.7% to 15.0%	0.03K to 0.28K	0.58K to 0.67K

8. Conclusions and future work

- Two modules, ACM and AQC, will provide different combinations of stability and accuracy of cloud masking within ACSPO. ACM will produce relatively liberal cloud mask, independent of real-time ancillary data. AQC will generate more conservative cloud mask using real-time ancillary data and radiative transfer simulations.
- Accounting for real accuracy of T_S and reference SST fields will minimize false cloud detections and make statistics of clear-sky T_S anomalies for different platforms comparable. The sources of residual variations in clear-sky statistics between the platforms are currently analyzed.
- Further optimization of the ACM and AQC thresholds will be explored.
- Future work will be aimed also at enhancement of the satellite SST product, reducing algorithm-induced biases, improving consistency between the RTM simulated and observed BTs.
- Work is underway to explore the day-time continuity of cloud mask and clear-sky products over ocean, and to improve the quality of clear-sky products in the twilight zone.

9. References

Heidinger A.,2004: CLAVR cloud mask ATBD, NOAA/NESDIS/STAR

Liang, X., A. Ignatov, and Y. Kihai, 2009: *JGR, in press*

McClain, P., W. Pichel, and C. Walton, 1985: *JGR*, **90.**

Petrenko, B., A. Ignatov, Y. Kihai, and A. Heidinger, 2008: http://www.star.nesdis.noaa.gov/sod/osb/sst/ignatov/conf/2008-AGU-OSM-PetrenkoEtAl_ACSPO_CSM_Poster.pdf

Reynolds, R., T. Smith, C. Liu, D. Chelton, K. Casey, and M. Schlax, 2007: *J.Climate*, **20.**

Xue, Y., T.M. Smith, and R.W. Reynolds, 2003: *Int. J. Climate*, **16.**

10. Acknowledgement

This work is done under the Algorithm Working Group funded by the GOES-R Program Office. Tanks to J. Sapper (ODPD), P. Dash (STAR/CIRA), F. Xu (STAR/CIRA), and D. Frey (OSDPD) for helpful discussions. The views, opinions and findings contained in this report are those of the authors and should not be construed as an official NOAA or US Government position, policy or decision.

16th Conference on Satellite Meteorology and Oceanography, 11-15 January 2009, Phoenix, AZ, JP1.12

Contact information: Boris Petrenko, 5200 Auth Rd., 601-4, Camp Springs, MD, 20746, USA, boris.petrenko@noaa.gov