Quantifying the effect of ambient cloud on clear-sky ocean brightness temperatures and SSTs

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Outline

1. Factors effecting Model-Observations in BTs and SSTs
2. Effect of Ambient/Residual cloud on BT and SST biases
3. Concept of Number of Clear-Sky Ocean Pixels (NCSOP) and its dependency
4. Non-linear curve fit model for NCSOP dependency
5. Quantification of ambient cloud effect on BT and SST biases
6. Testing clear-sky mask for cloud leakage
7. Summary

ACSPO

Advanced Clear-Sky Processor for Oceans (ACSPO) provides:

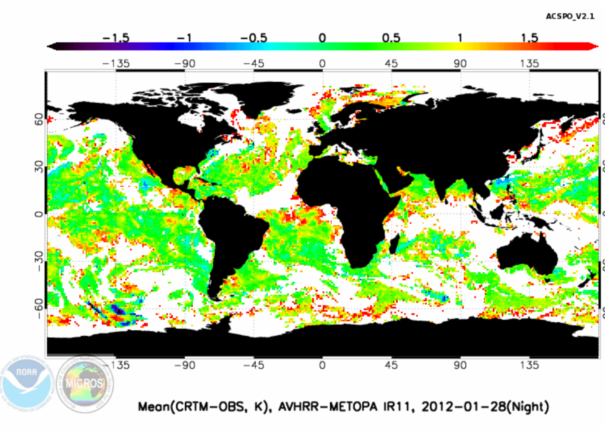
1) Clear-Sky BTs in AVHRR SST channels (3.7, 11 and 12 μm) – Observations (O)
2) BTs simulated by Community Radiative Transfer Model (CRTM) – Model (M)
3) Clear-Sky SSTs are also retrieved from the SST channels – Reg.

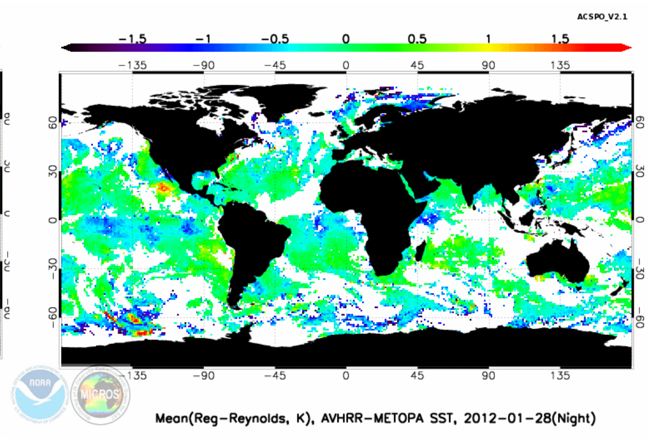
MICROS (http://www.star.nesdis.noaa.gov/sod/sst/micros)

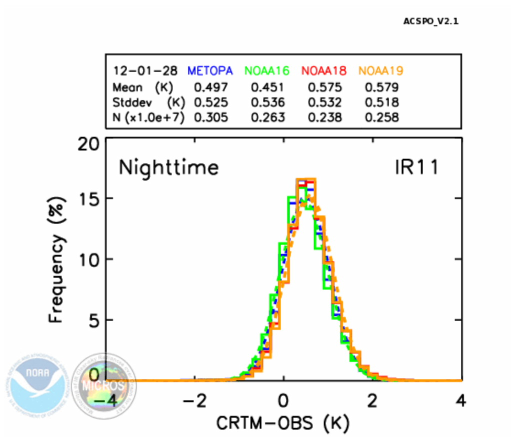
Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS) is a tool:

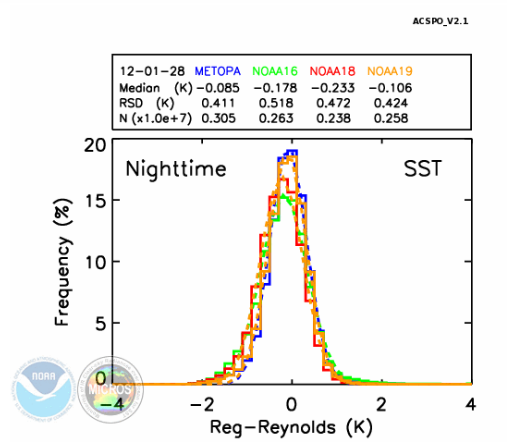
1) Compares M – O in BTs with global statistics in near-real time
2) Compares Reg. – Level-4 SSTs
3) All these comparisons are made using : (a) Global maps
   (b) Histograms
   (c) Time series-analysis
   (d) Dependencies

BT and SST biases





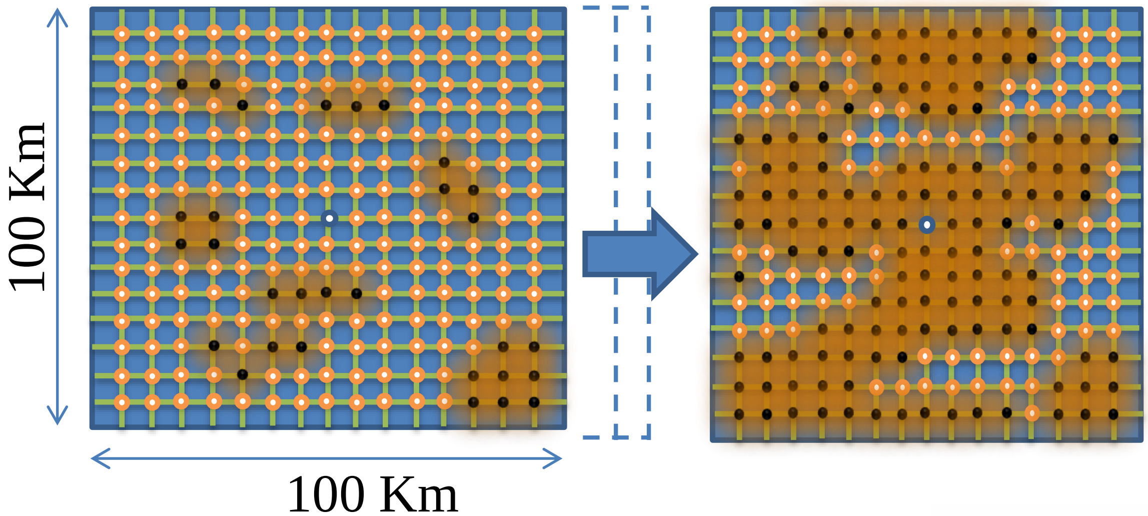


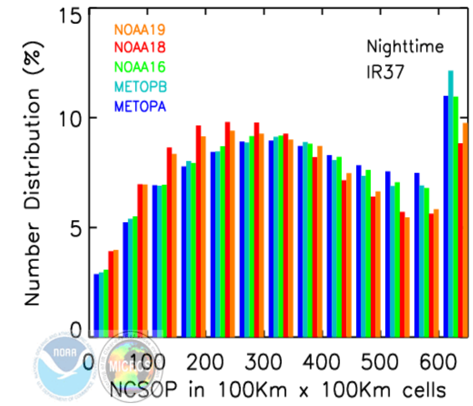


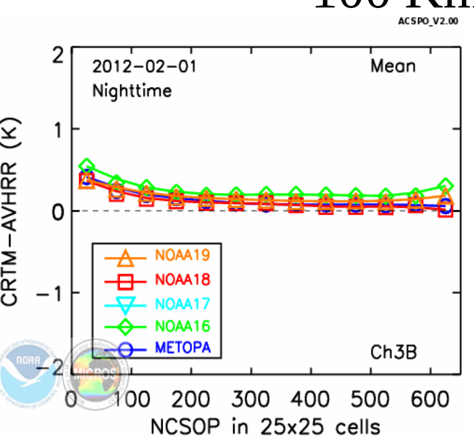
This overestimation in Modeled BT (M) and underestimation of satellite SSTs (Reg) can be attributed to:

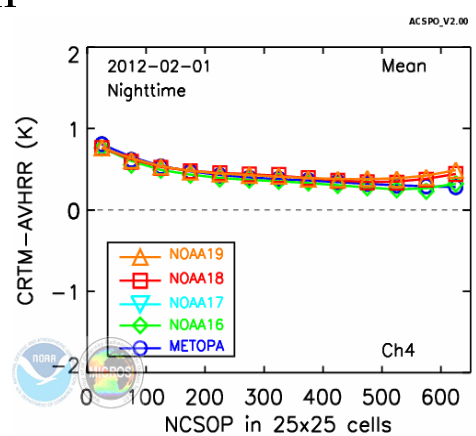
1. Errors in first-guess input fields (profiles and SST)
2. No diurnal representation in SST
3. Bulk to skin SST effect
4. Non-inclusion of aerosol effect in CRTM
5. Cloud leakage due to insufficient clear-sky masking

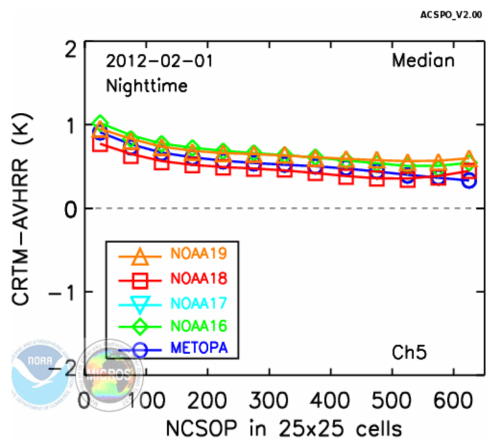
Number of clear-sky ocean pixels (NCSOP) Dependency

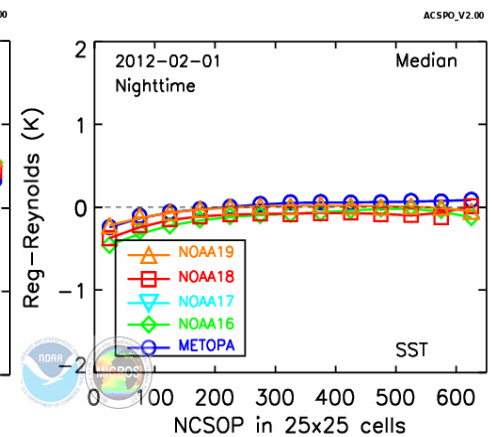












1. BTs and SSTs are most affected at NCSOP~0, and drops-off exponentially, reaching an asymptotic "confidently clear-sky" plateau at NCSOP~∞.
2. The amplitude and drop-off rate are highest at 12 μm, decrease at 11 μm and further decrease at 3.7 μm.

Non-linear curve-fit model for NCSOP dependency

Fitting function: $\Delta T \equiv f_N(NCSOP) = A_0 + A_1 \exp(-A_2 \times NCSOP)$

Here two asymptotic regimes of interest are:

(1) confident clear-sky (NCSOP $\rightarrow\infty$) – parameter A_0

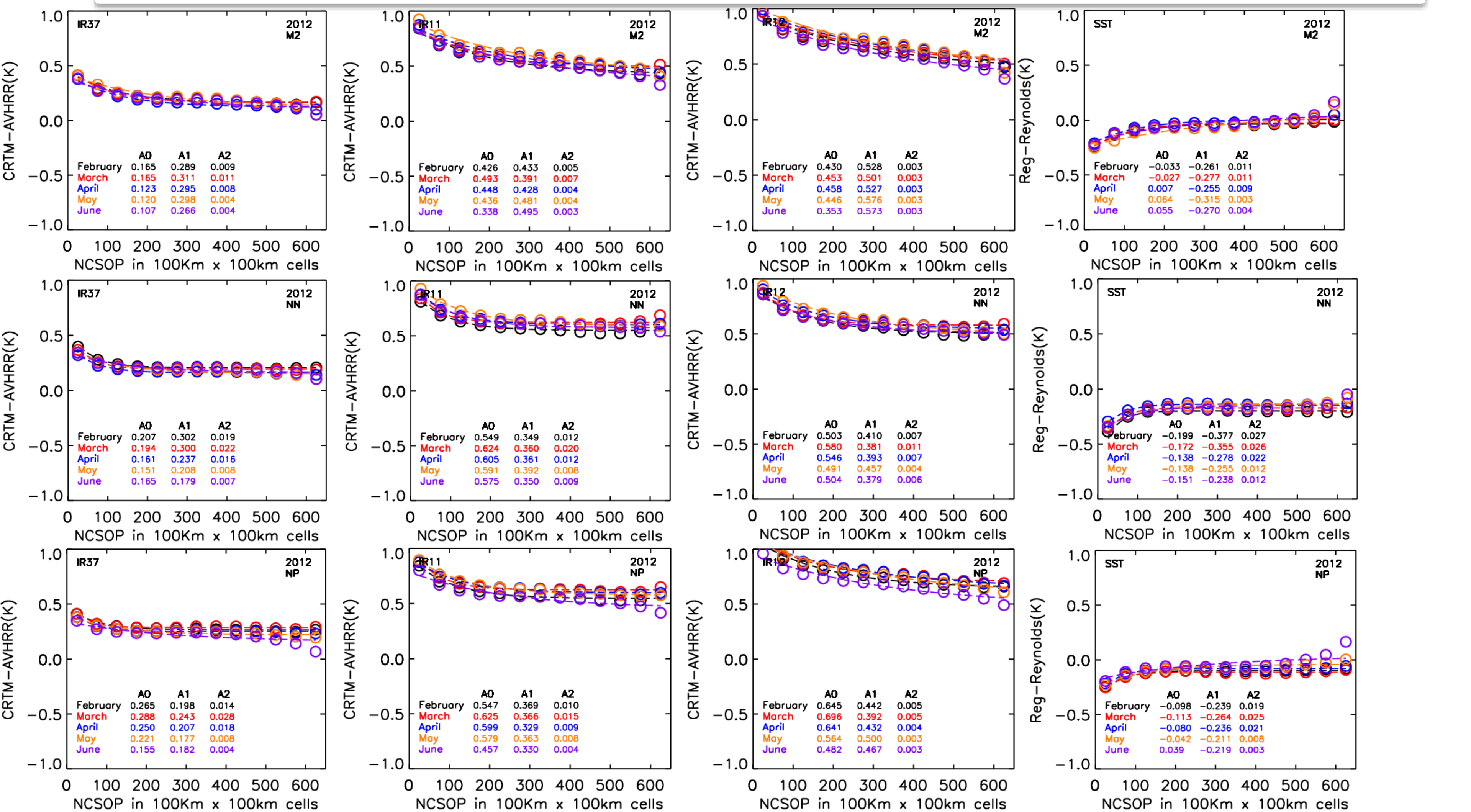
(2) confidently cloudy (NCSOP$\rightarrow$0) – the (A_0+A_1) aggregate

Parameters A_1 and A_2 represent the amplitude of the M-O bias and its drop-off rate with NCSOP, respectively.

Modified Levenberg-Marquardt least-square minimization technique, termed **MPFIT***, was adopted to estimate A_0, A_1, A_2.

***Markwardt, C. B. (2008), Non-linear Least-squares Fitting in IDL with MPFIT, *Astronomical Data Analysis Software and Systems XVIII ASP Conference Series*, Vol. 411, proceedings of the conference held 2-5 November 2008 at Hotel Loews Le Concorde, Québec City, QC, Canada. ed. D. A. Bohlender, D. Durand, and P. Dowler. San Francisco: *Astronomical Society of the Pacific*, 251 pp.**

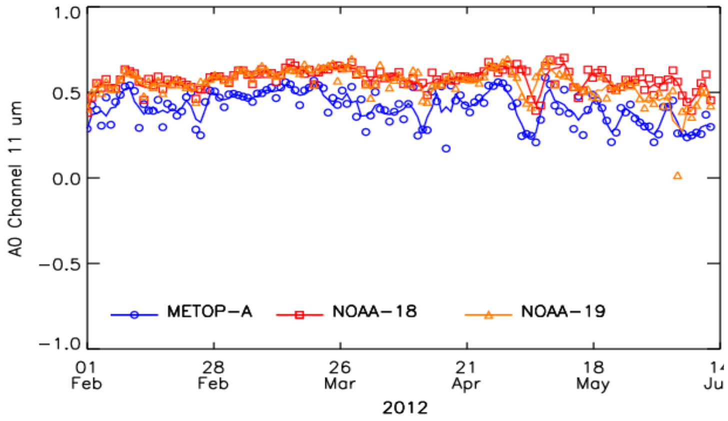
Monthly mean fitted NCSOP dependency curves

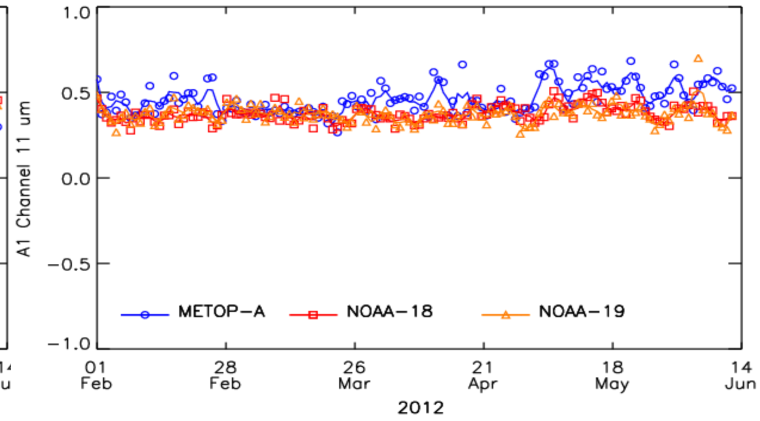


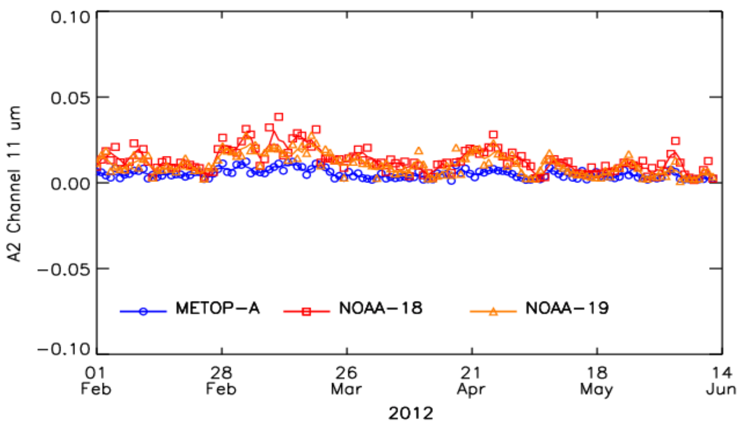
1. A good consistency is observed between all platforms
2. The values of Ao, A_1 and A_2 for each months does not vary much and is more or less constant
3. Fixing the apriori values for Ao, A_1 and A_2 can provide best fit results for any given day

Time series of day-to-day fit parameters (11 μm channel)

The stability of the fitting is investigated by trending the day-to-day fit parameters in time (Approximately 5 months of data (Feb-Jun 2012))

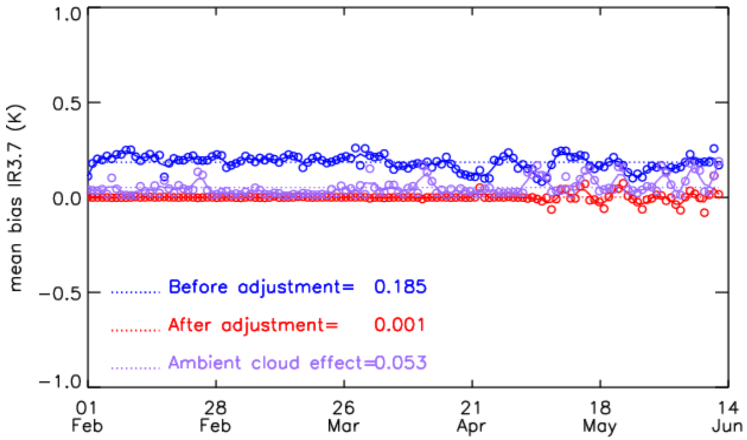


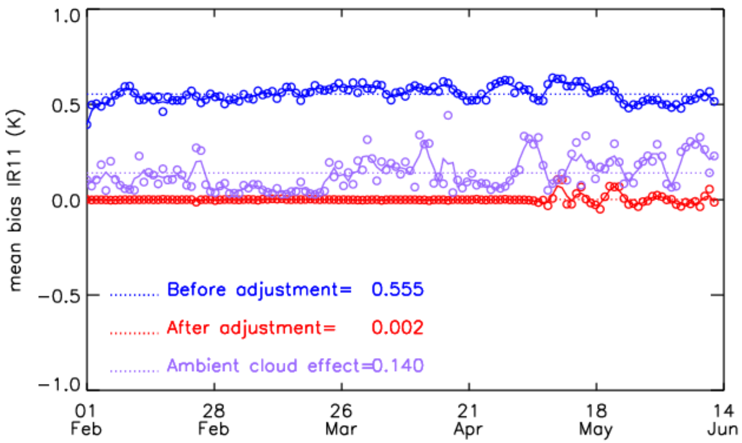


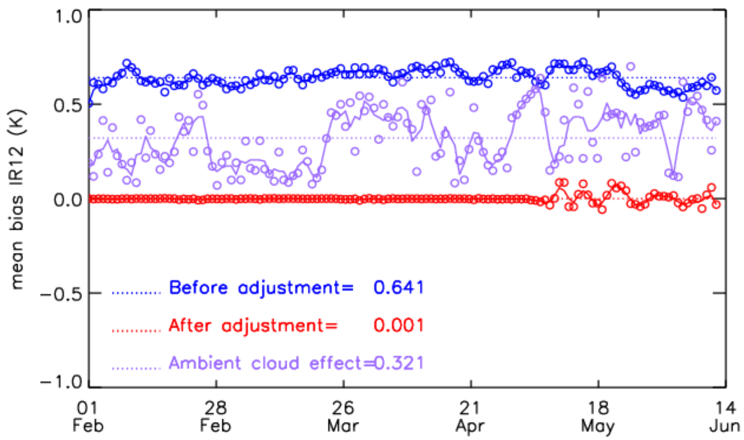


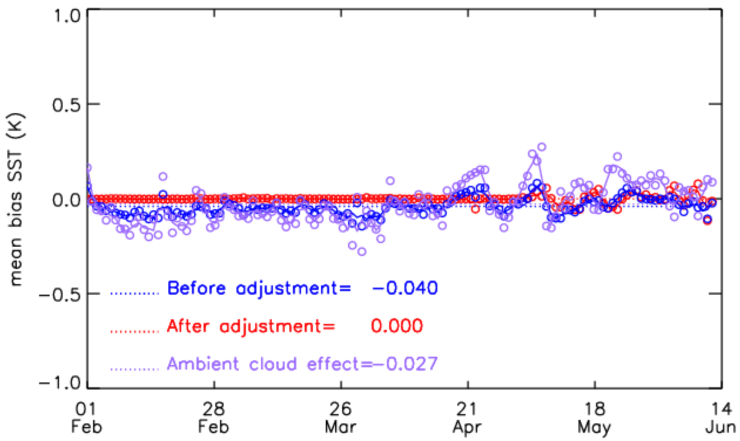
1. A_o for Channels 3.7, 11 and 12 μm shows the model simulation is biased high with respect to the observed BTs by 0.1-0.3 K, 0.4-0.6 K and 0.3-0.7 K, respectively. Where as for SST bias it is 0 to -0.2 K
2. A_1 ranges from 0.2 – 0.3 K, 0.3 - 0.4 K and 0.4 – 0.7 K for Channels 3.7, 11 and 12 μm, respectively. For SST it is ~0.3 K
3. A_2 appears to be more stable for the BT differences than the SST bias fields for all the sensors

Time series of mean M-O biases before and after adjustment



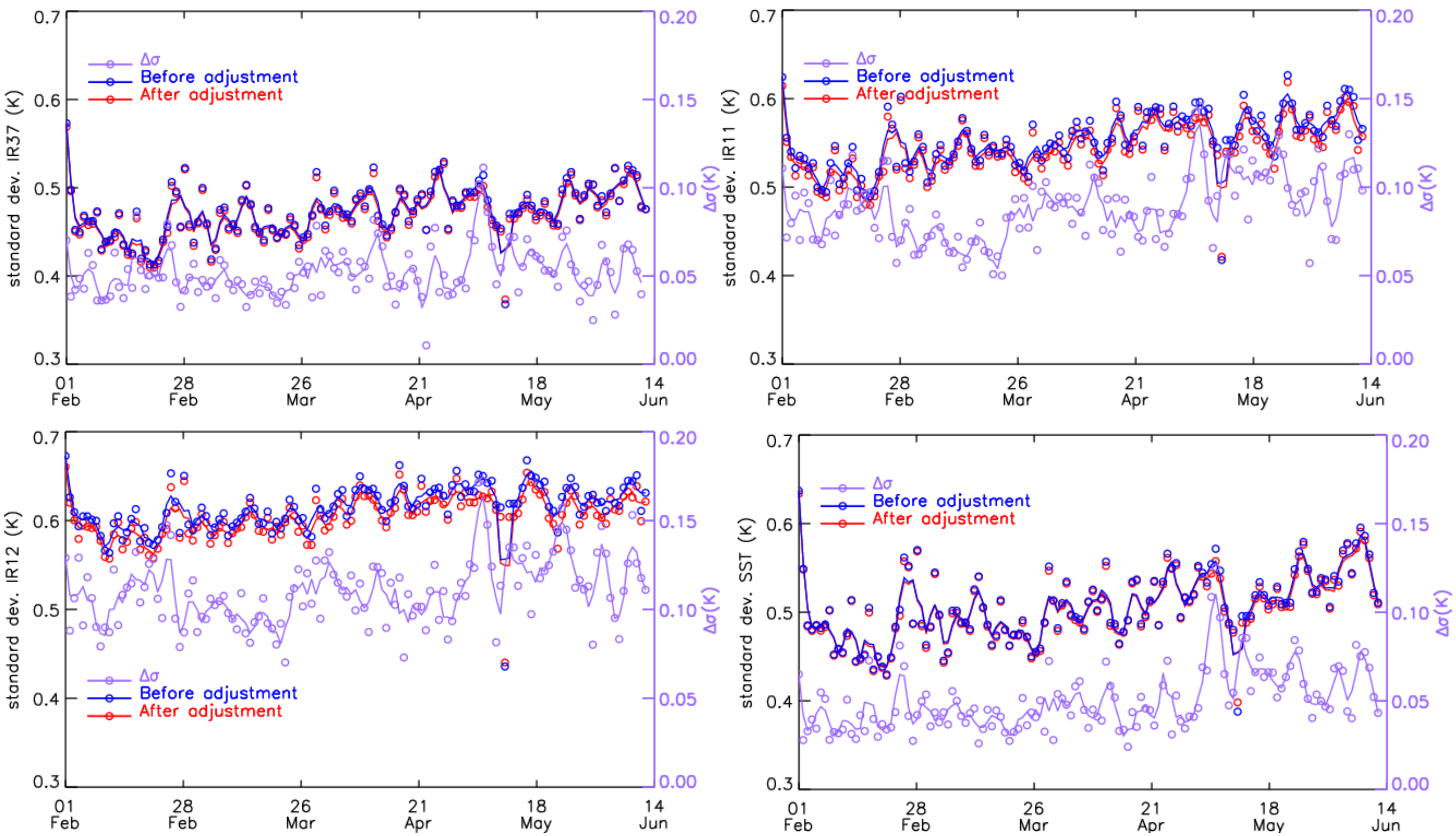






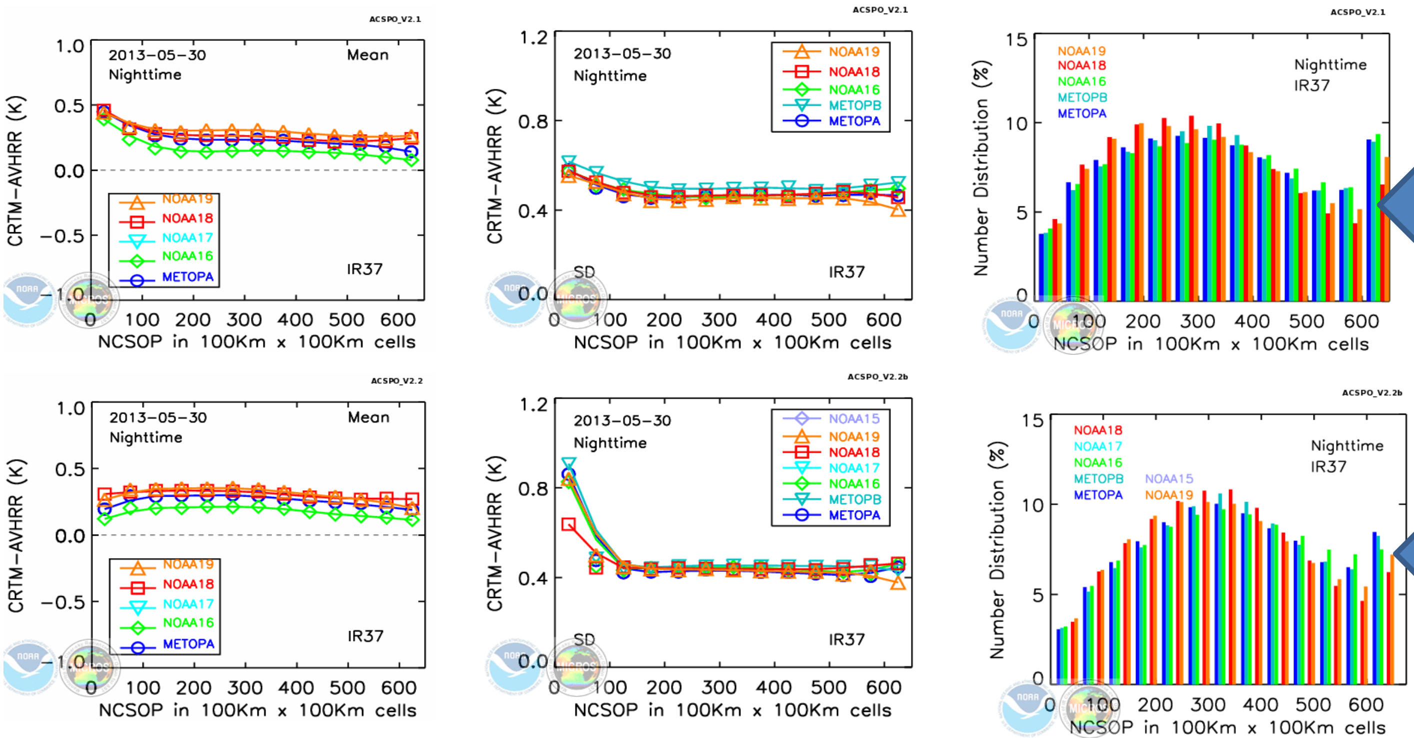
1. The global mean bias is centered close to zero after the bias adjustment
2. Ambient cloud error corresponds to ~30% of total M-O bias for Channels 3.7 and 11 μm
3. This error is >50% for 12 μm and SST biases

Stdv. in BT and SST biases before and after adjustment



1. Clear improvement in Stdv. (σ) with $\Delta\sigma$ obtained from: $\Delta\sigma^2 = \sigma^2_{before} - \sigma^2_{after}$
2. $\Delta\sigma$ is ~0.05 K for Channel 3.7 μm and SST
3. $\Delta\sigma$ is ~0.1 K for Channels 11 and 12 μm

Testing clear-sky mask for cloud leakages



ACSM for ACSPO 2.1

ACSM for ACSPO 2.2

1. Number density distribution slightly shifted: with some of cloudy pixels represented as clear-sky ones
2. Mean bias decreases and SD increases considerably in the highly cloudy areas

Summary

1. SST and BT biases decreases exponentially with NCSOP (which is a proxy for residual cloud)
2. These NCSOP dependencies are routinely calculated and published in near-real time web-based MICROS: http://www.star.nesdis.noaa.gov/sod/sst/micros/
3. This dependency is modeled using a modified Lavenberg-Marquardt least-square minimization technique termed as: MPFIT
4. Stability of the fitting is estimated by time trending 5 months of the fitting parameters
5. Quantitative contribution of ambient cloud to the mean BT and SST biases are reported; varies from 30% to 50% of the total bias
6. The root mean square reduction in standard deviation is ~0.1 K after a bias adjustment is implemented at pixel level
7. The results of this study can be used for testing cloud leakages in the new clear-sky mask

THANK YOU

Questions?