Online Monitoring of SST and Associated IR Radiances for Cal/Val and Climate

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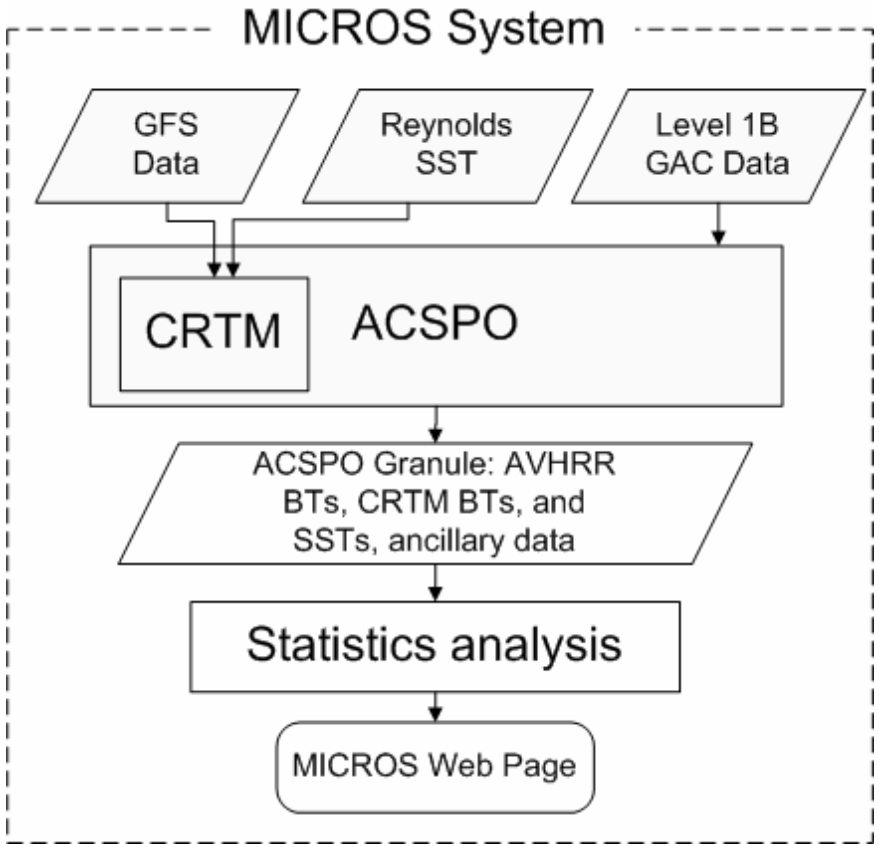
Background

- In January 2010, met with WGCV Chair Pascal Lecomte
  - Showed NESDIS online system "Monitoring of IR Clear-sky Radiances for SST" (MICROS) www.star.nesdis.noaa.gov/sod/sst/micros/
  - Pascal suggested we give an overview of MICROS principles at WGCV-31:
    - ✓ Monitoring: Online; Near-Real Time; Global
    - ✓ In addition to monitoring products (e.g., SST), also monitor associated satellite sensor radiances
    - ✓ Monitor products and radiances for
      - ✓ Stability
      - ✓ Self- Consistency
      - ✓ Cross-Platform Consistency (5 platforms)

MICROS Objectives

- Monitor Radiances using global "Model minus Observation" bias
  - Model: ***Community Radiative Transfer Model (CRTM)*** in conjunction with 1st guess upper air (NCEP forecast) 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 SST using global "Retrieved minus first-guess SST" bias
  - Retrieved SST: Regression (Linear combination of radiances)
  - First-guess SST: Reynolds daily ¼° global analysis
- In addition to monitoring Clear-Sky Radiances & SST products, MICROS proved instrumental for validation and improvements of
  - CRTM
  - AVHRR radiances

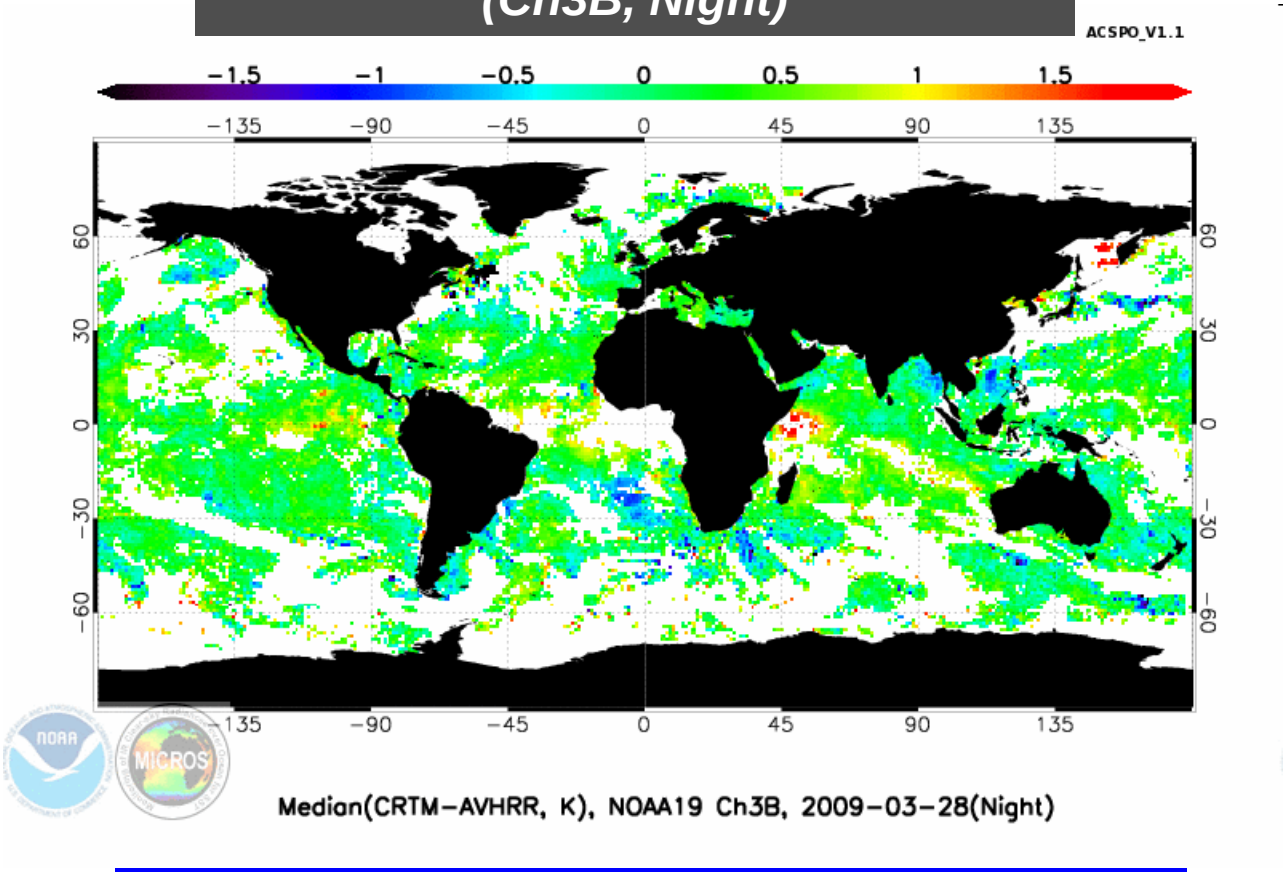
Flow Chart of MICROS



- **MICROS crons/scripts run @2am EST (lag 2 days)**
- **Process global AVHRR data from 5 platforms (3 hrs clock time) & Publish daily summaries on web**

Maps of M-O Bias

NOAA-19, 28 March 2009, 00-24 UTC
(Ch3B, Night)

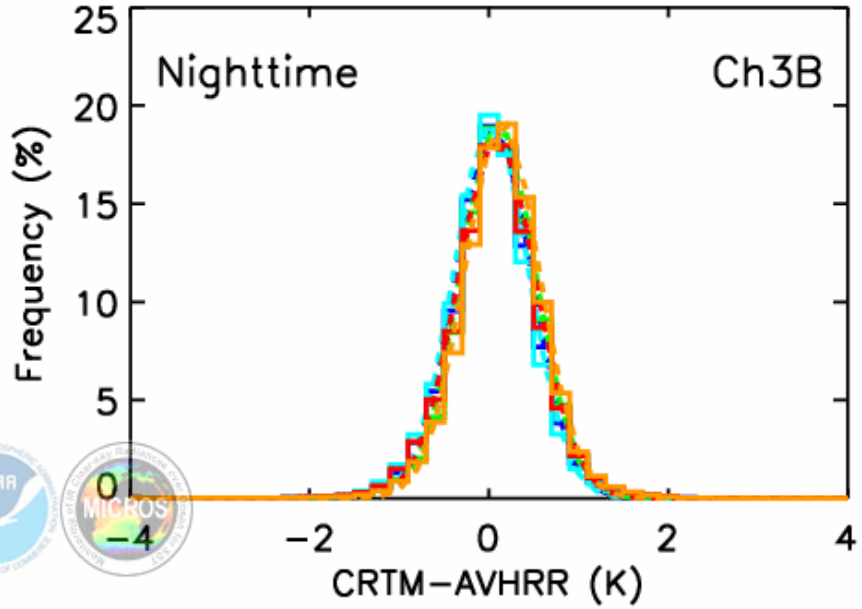


Close to zero and uniformly distributed

Histograms of M-O Bias

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

09-03-28	METOPA	NOAA16	NOAA17	NOAA18	NOAA19
Median (K)	0.054	0.102	0.027	0.090	0.145
RSD (K)	0.421	0.419	0.417	0.436	0.417
N (x1.0e+7)	0.292	0.272	0.281	0.252	0.249

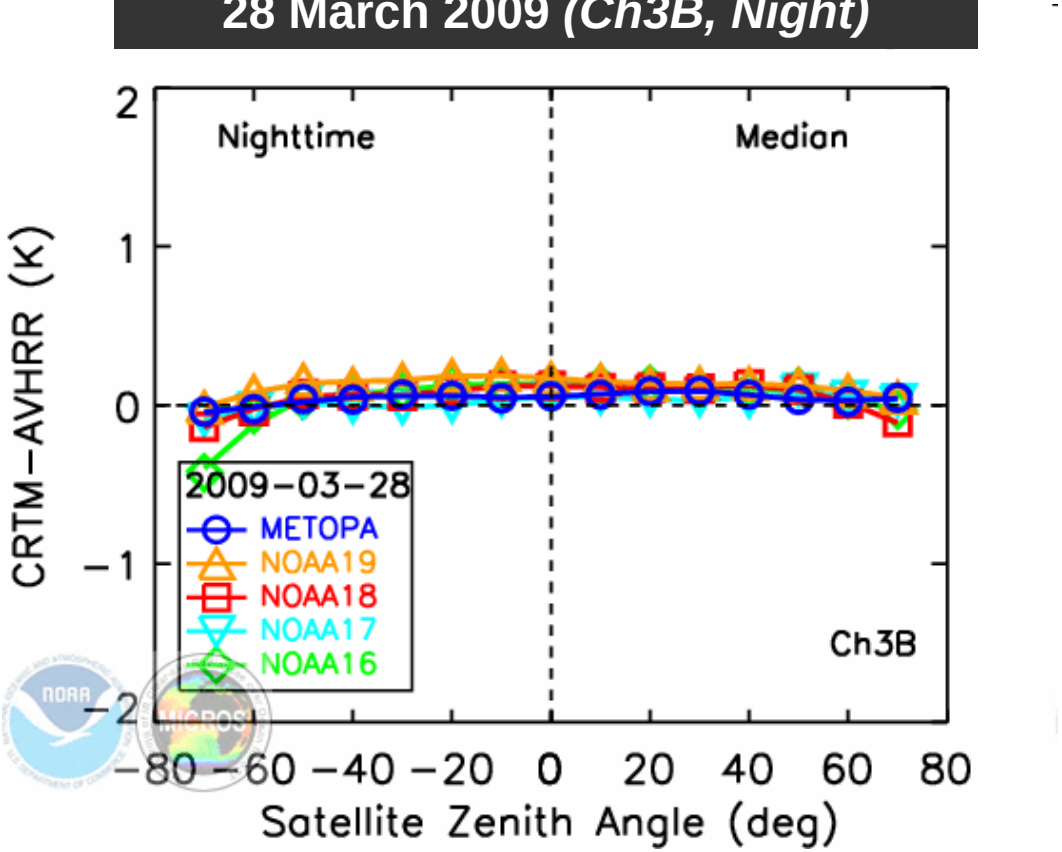


Model is warmer than Obs by ~0.1 K due to
- ✓ **using bulk SST (instead of skin)**
- ✓ **using diurnal-mean Reynolds SST at night**
- ✓ **missing aerosol in CRTM implementation**
- ✓ **possible residual cloud in AVHRR BTs**

- **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)

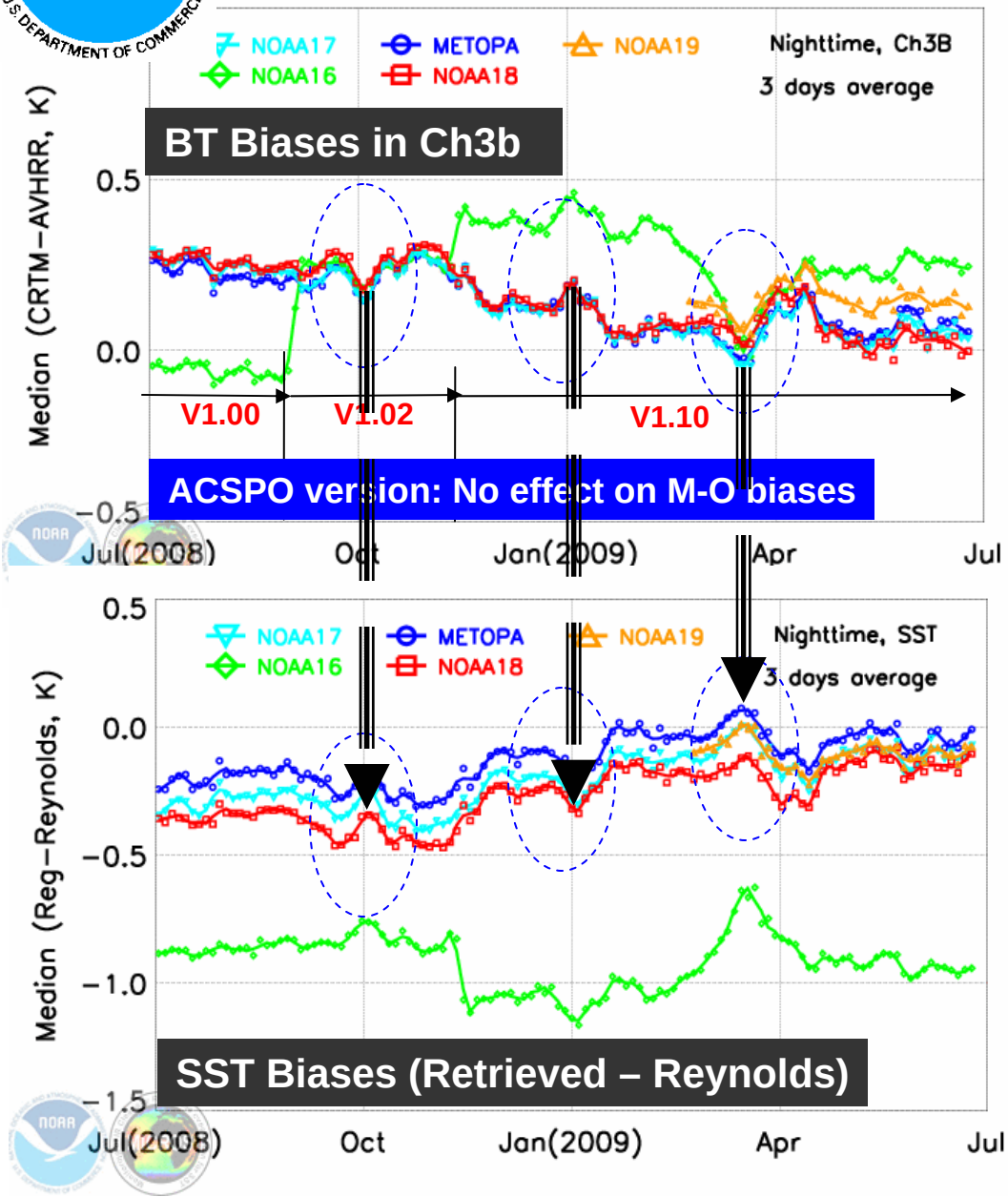
Angular Dependencies of M-O bias

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



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

Time Series of BT &SST biases



BT and SST biases change in time by several tenths of a Kelvin, in counter-phase.

The cause is instability in Reynolds SST (input to CRTM).

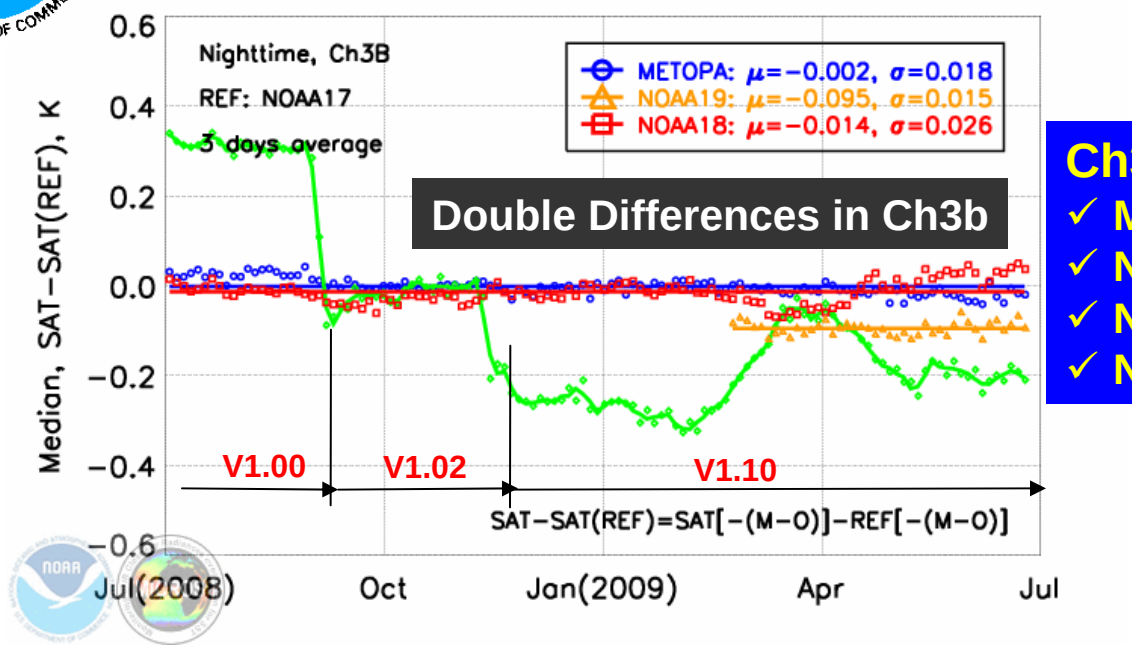
Double-Differences

- Double-differencing (DD) technique helps rectify cross-platform biases from "noise" in M-O bias

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

  - NOAA-17 = Stable reference satellite
  - CRTM used as a 'transfer standard'
  - DDs minimize artifacts in M-O biases arising from e.g.
    - Errors in Reynolds SST and GFS upper air data
    - Missing aerosol in current implementation
    - Possible systematic biases in CRTM
    - Changing versions of ACSPO algorithm
  - DDs do take into account differences in spectral responses between different sensors (*for instance, the SNO is not accounting for spectral differences*)

Double Differences (DD): Cancel out most errors in BT/SST biases



Ch3b biases relative to N17

- ✓ MetOp-A: -0.002 K
- ✓ NOAA-18: -0.014 K
- ✓ NOAA-19: -0.095 K
- ✓ NOAA-16: Unstable

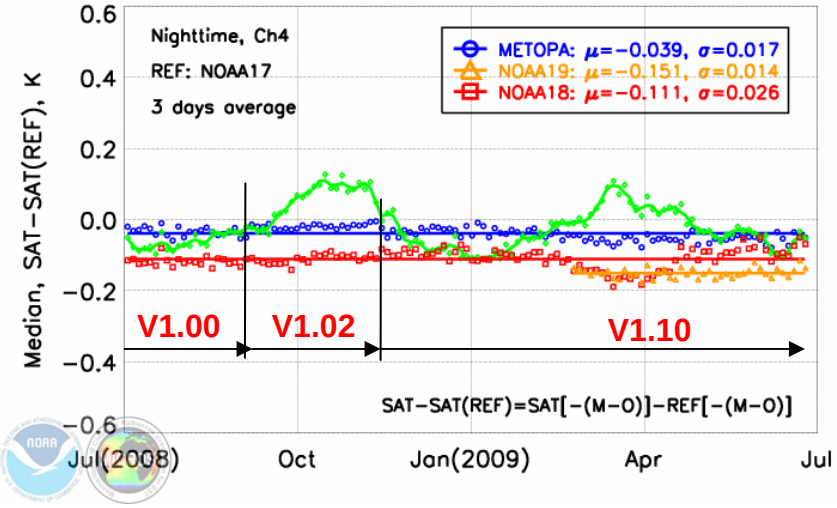
Cross-platform inconsistencies are due to

- ✓ Sensor calibration biases
- ✓ Spectral response function (deviate from used in CRTM)
- ✓ Local time differences (affect SST/BTs through diurnal cycle)

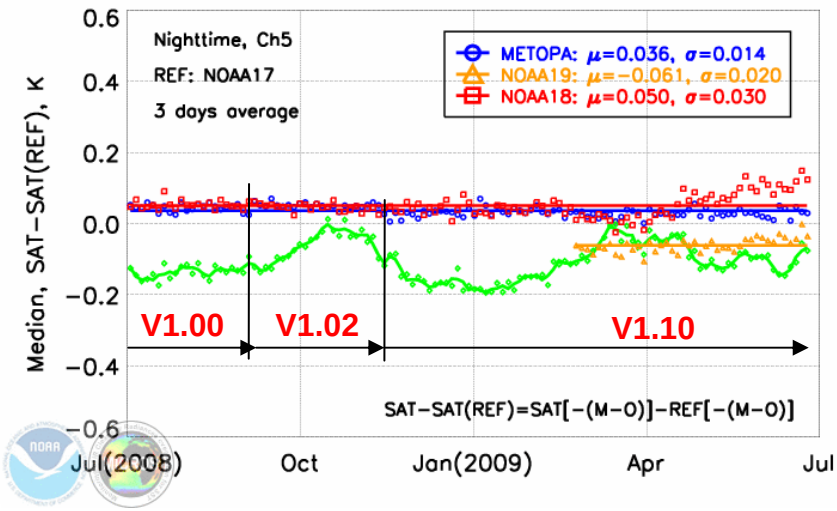
Work underway to attribute causes & reconcile platforms

Double-Differences in Ch4 and Ch5

Double Differences in Ch4



Double Differences in Ch5



Mean Ch4 biases relative to N17

- MetOp-A: -0.039 K
- NOAA-18: -0.111 K
- NOAA-19: -0.151 K
- NOAA-16: Unstable

Mean Ch5 biases relative to N17

- MetOp-A: -0.036 K
- NOAA-18: +0.050 K
- NOAA-19: -0.061 K
- NOAA-16: Unstable

Conclusion

- Online near-real time tool, Monitoring of IR Clear-sky Radiances for SST (MICROS) developed at NESDIS www.star.nesdis.noaa.gov/sod/sst/micros/

- MICROS methodology complements the Simultaneous Nadir Overpasses (SNO) technique (Changyong Cao)

- Currently, data from N-16, -17, -18, -19, and MetOp-A are monitored for stability, self- and cross-platform consistency using global ocean as a "calibration site"

- Double-Differences employed to measure cross-platform biases. Work underway to link DD biases to errors in sensor calibration & response functions

Ongoing Work

- Reduce uncertainty in DD-derived cross-platform biases
  - ✓ Establish “SST sites”, in addition to global (C. Cao)
  - ✓ Sensitivity studies to assumptions and input fields (ECMWF vs. NCEP; OSTIA vs. Reynolds)
  - ✓ Explore diurnal corrections to Reynolds SST (Chelle Gentemann, RSS)
  - ✓ Check for consistency with the Simultaneous Nadir Overpasses (SNO) (C. Cao)
  - ✓ Improve CRTM performance (Yong Han, NESDIS)

- Understand / Minimize DD-derived cross-platform biases resulting from errors in AVHRR calibration & spectral response functions (C. Cao & CAL experts, NESDIS)