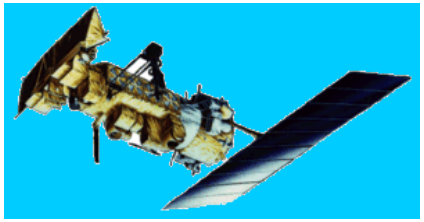
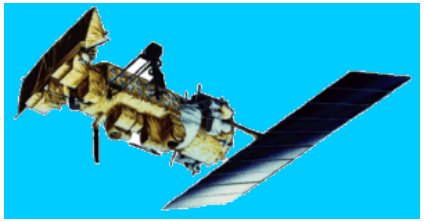


Long-term characterization of AVHRR/3 sensors onboard NOAA-KLM platforms for the NOAA/NESDIS science data stewardship program

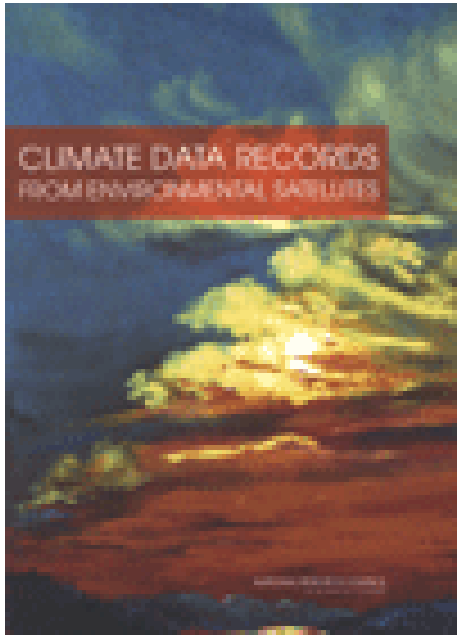
Alexander Ignatov, Changyong Cao, Jerry Sullivan, Yury Kihai, Roy Galvin, Jeff Devine, Andy Heidinger, Aleksandar Jelenak, Xiaofeng Li, Mitch Goldberg, John Bates, Eric Bayler, Dan Tarpley, Robert Levin

NOAA/NESDIS and ITT Aerospace/Communications

NRC Report
"CDR from Environmental Satellites"



NOAA Science Data Stewardship Program is being formed



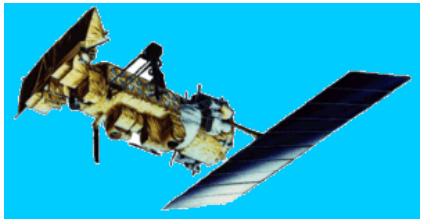
<u>Overarching recommendation</u>

NOAA should embrace *climate mandate*
(in addition to the current weather mandate)

<u>Supporting recommendations</u>

- 2 types of CDRs: Fundamental and Thematic
- FCDRs: Highest accuracy and stability
- Sensors: Thoroughly characterized/calibrated
- Scientists and engineers: Should work together

AVHRR
Advanced Very High Resolution Radiometer



Now: 4 AVHRR/3 in space

NOAA-15/K, 0730/1930, May 1998
NOAA-16/L, 0200/1400, Sep 2000
NOAA-17/M, 1000/2200, Jun 2002
NOAA-18/N, 0200/1400, May 2005

Focus: FCDR N16/17 thermal IR 2003-04

Future: 4 AVHRR/3 to fly

METOP-1, 0930/2130, Dec 2005
NOAA-19/N´, 0200/1400, Mar 2008
METOP-2, 0930/2130, Jun 2010
METOP-3, 0930/2130, Dec 2014

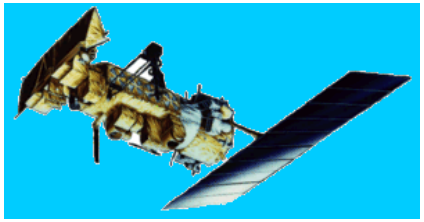
Past: Since 1978

4 AVHRR/1 (TIROS-N, N-6, 8, 10)
5 AVHRR/2 (NOAA-7, 9, 11, 12, 14)

NESDIS Science Data Stewardship:
Climate Data Records from AVHRR
(SST, Aerosol, Cloud, Vegetation)

SST: Thermal IR (Onboard calibration)
- 3B: 3.7 µm (Night only)
- 4: 11 µm
- 5: 12 µm

NOAA Sun-Sync Platforms



Scan motor

Scan mirror

Earth shield

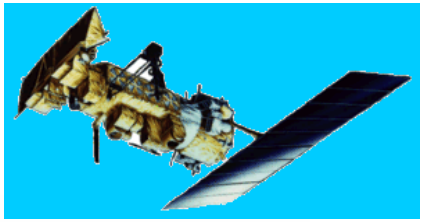
AVHRR

Solar array

Deep space on satellite right

Sun on satellite left

AVHRR Exploded View



astrium

AVHRR/3

Ref. : MO-IC-MMT-AH-0001
Issue : 5 Rev. : A
Date : December 2002
Page : 1.9

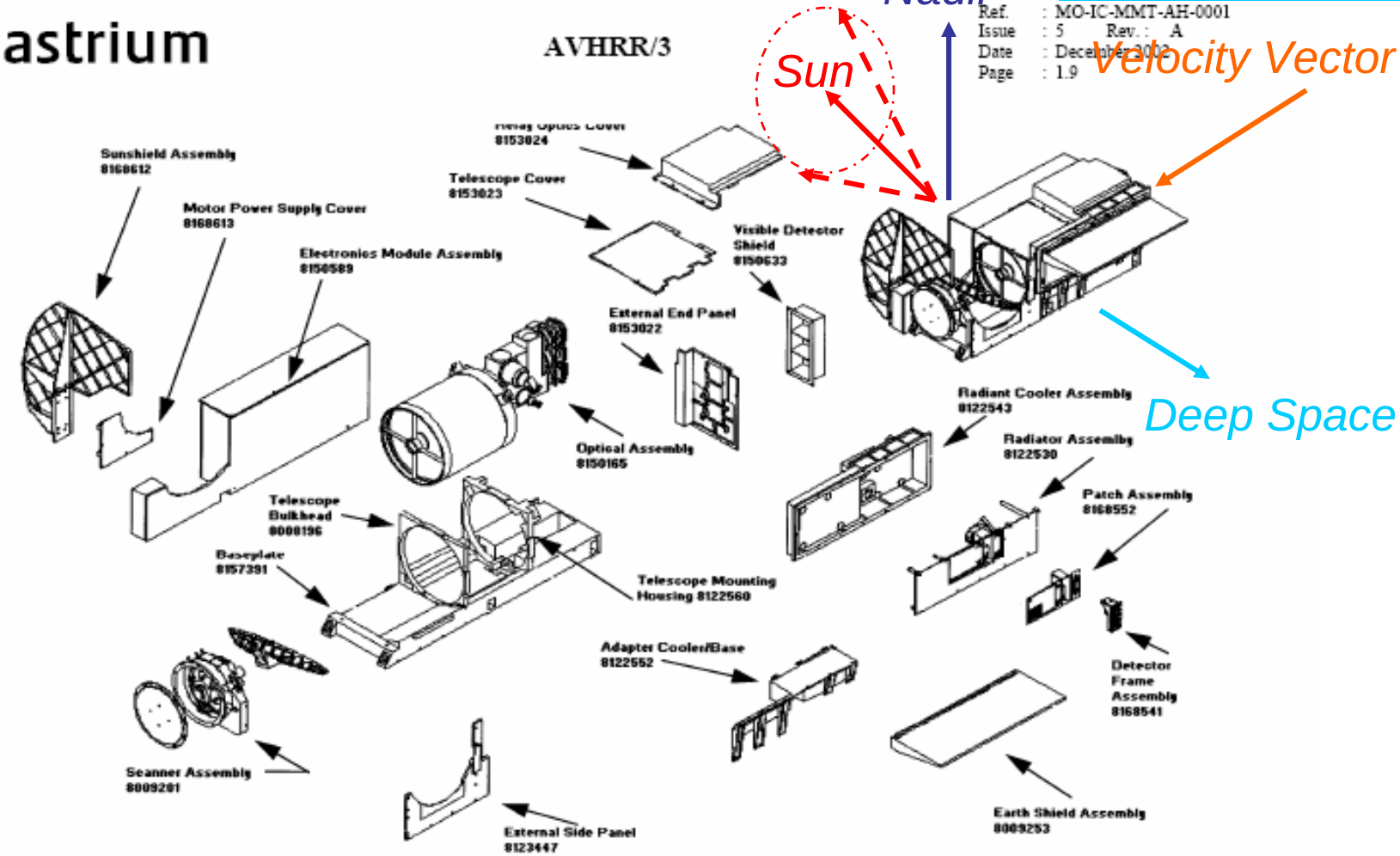
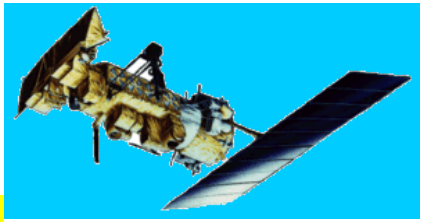


Figure 1.2.3/1 : AVHRR/3 Exploded View

[AVHIICD]

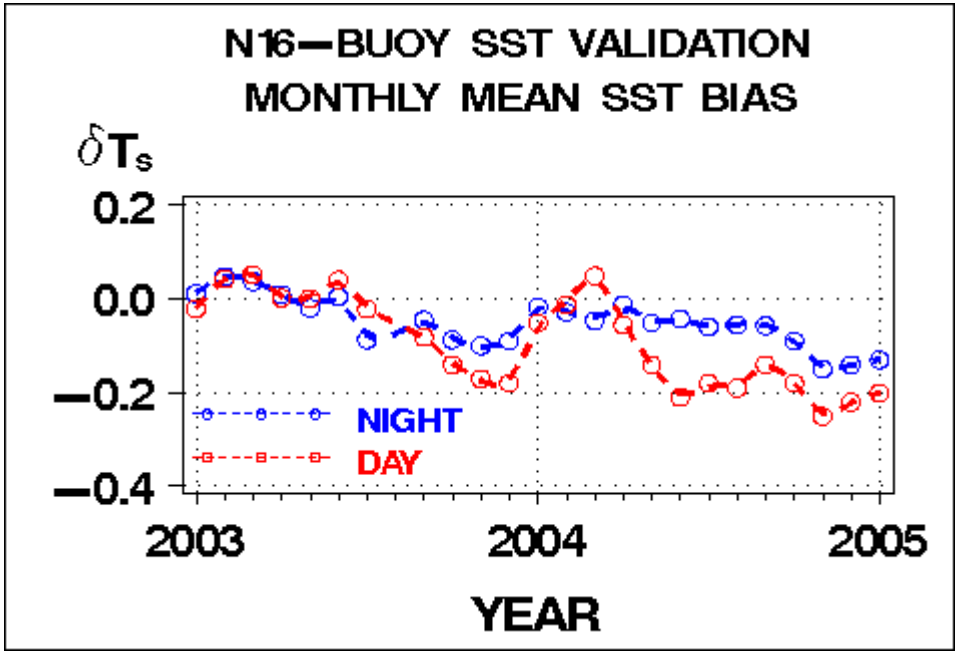
Trends in SST vs. Drifting Buoys

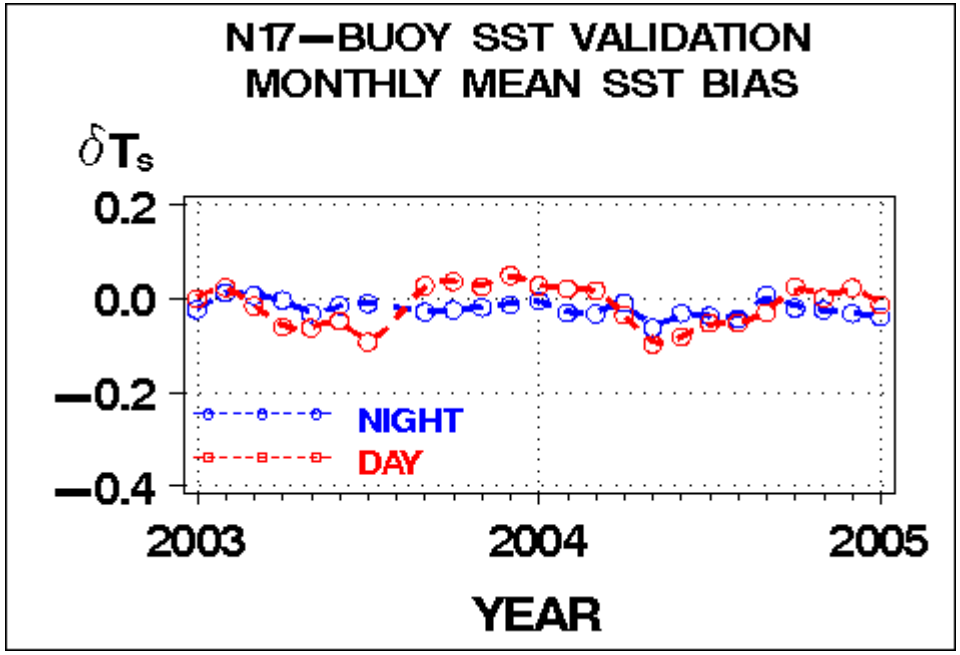


N16 SST trends are artifacts (not real climate change)

N16: negative trends in both DAY= $f(T_{11},T_{12})$ and NIGHT=$f(T_{3.7},T_{11},T_{12})$ SSTs

N17:
No trends in both DAY and NIGHT SSTs





DAY:
split-window NLSST

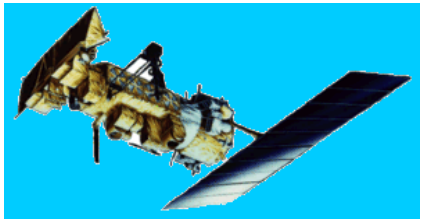
$$T_S = a_o + a_1 T_{11} + a_2 T_{SFC}(T_{11} - T_{12}) + a_3 (T_{11} - T_{12})(\sec\theta - 1)$$

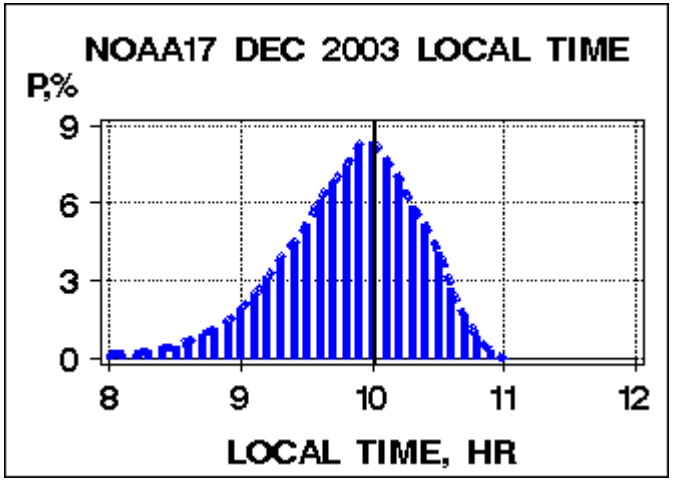
NIGHT:
triple-window MCSST

$$T_S = a_o + a_1 T_{3.7} + a_2 T_{11} + a_3 T_{12} + a_4 (T_{3.7} - T_{12})(\sec\theta - 1) + a_5 (\sec\theta - 1)$$

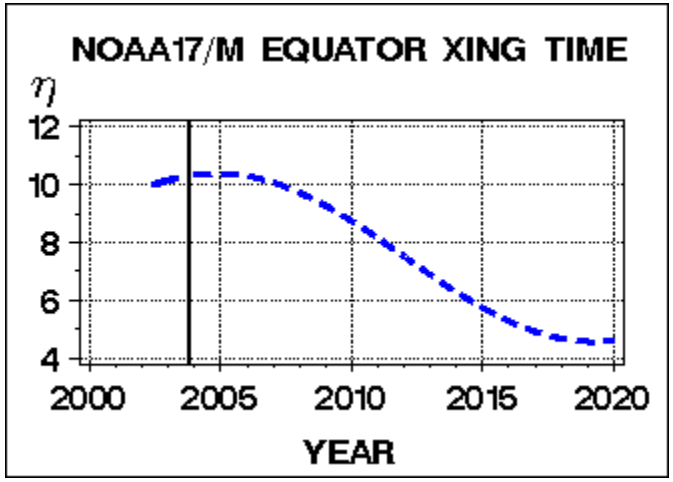
Obs time changes?

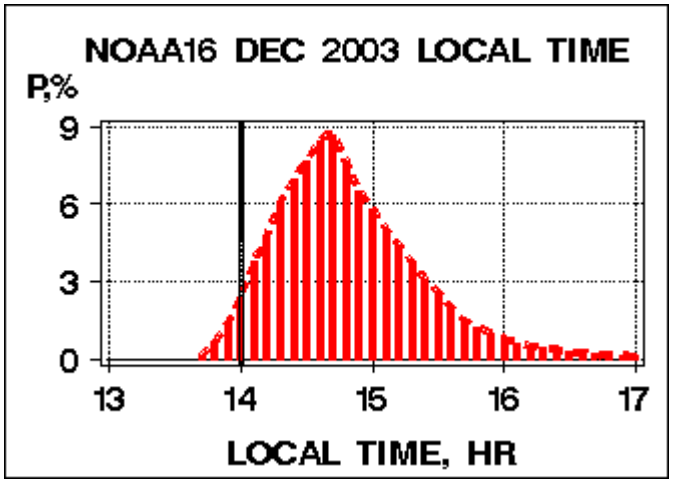
No significant change in N16/17 EXT in 2003-04



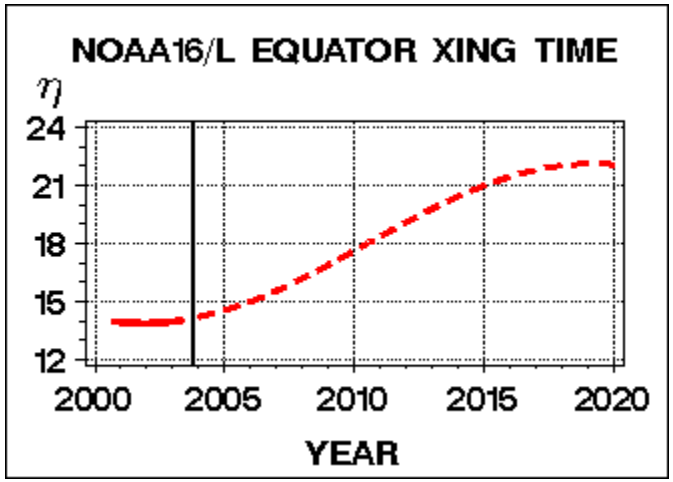


NOAA-17/L

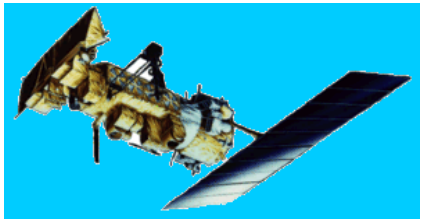




NOAA-16/M



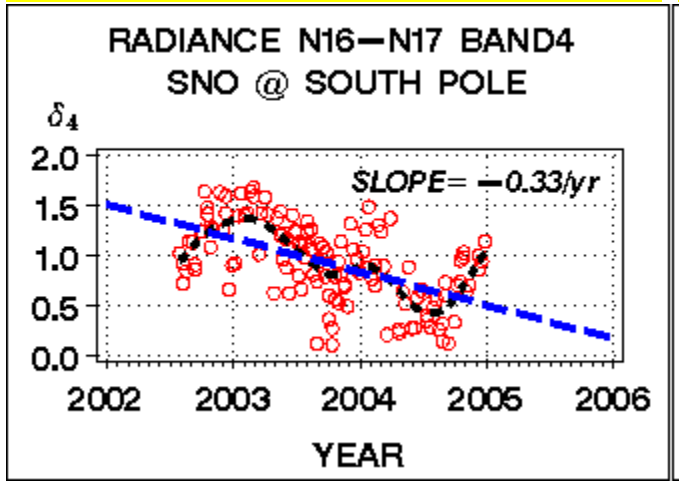
Simultaneous Nadir Observations (SNO): NOAA16 minus NOAA17

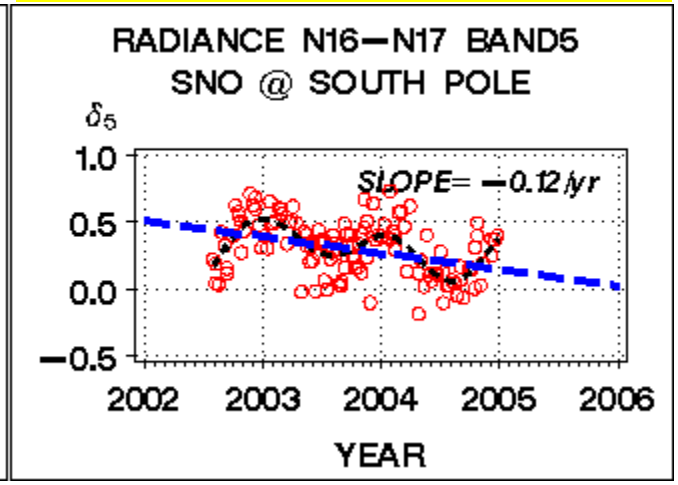


Band4 (11 µm): ~-0.25K/yr

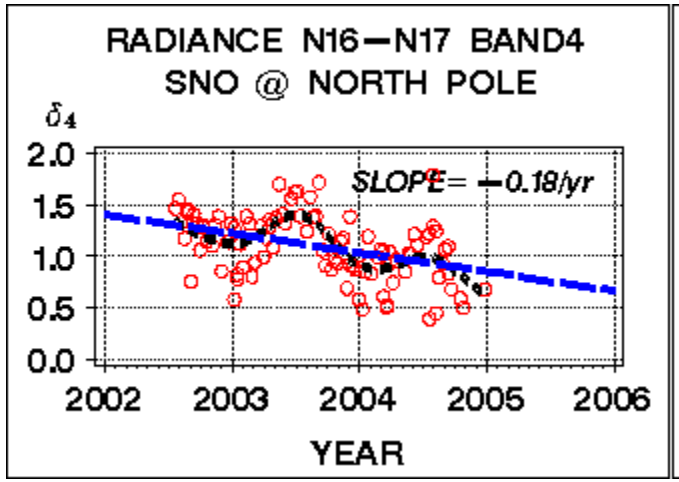
Band 5 (12 µm): ~-0.12K/yr

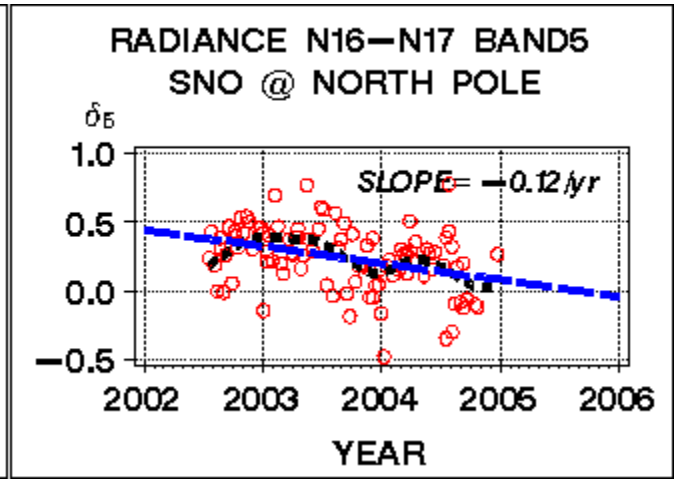
SOUTH POLE



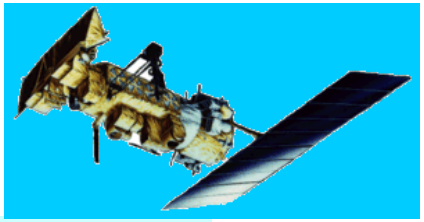


NORTH POLE





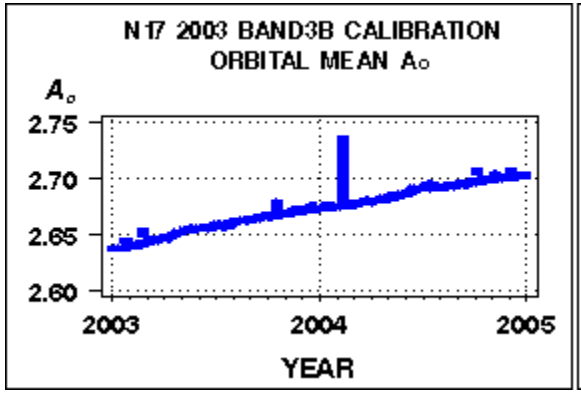
Instrument changes?

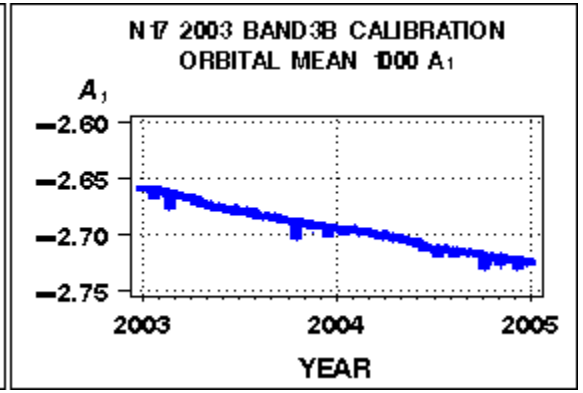


- AVHRR Thermal bands: Calibrated onboard
- Two reference points: 1) Onboard black body; 2) deep space

Ch3B (3.7 μm): detector response linear $R_{3B} = A_o + A_1 C_{3B}$

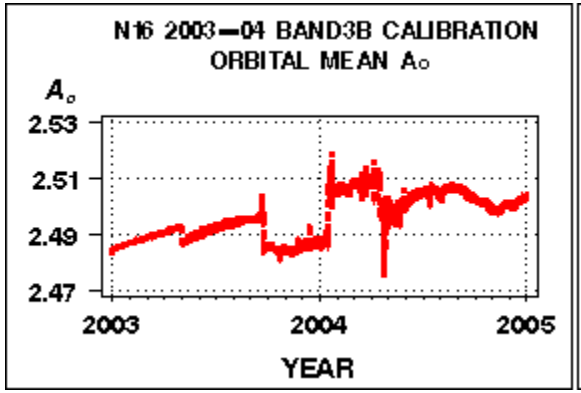
N17

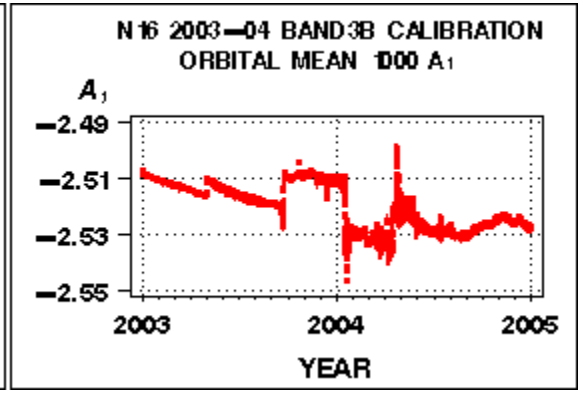




Trends "well-behaved"

N16



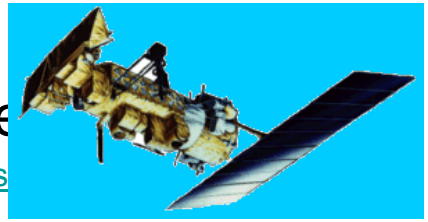


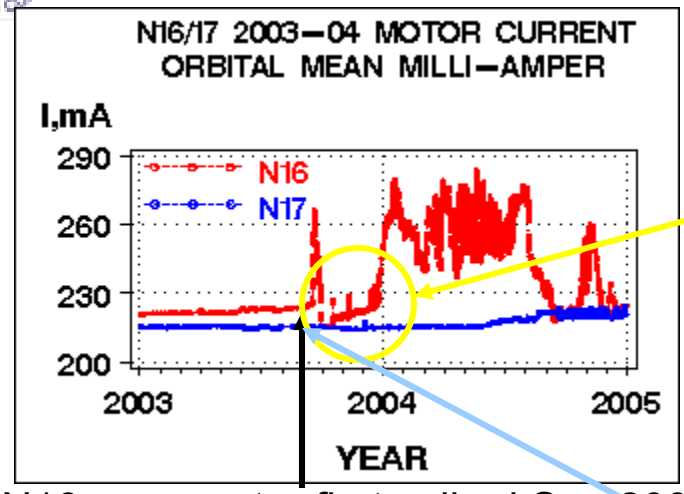
Not so well-behaved

Bands 4/5 (11/12 μm): Similar/More complex (detectors non-linear)

For complete N16/AVHRR story, see OSO Page

http://www.oso.noaa.gov/poesstatus/componentStatusSummary.asp?spacecraft=16&subsys

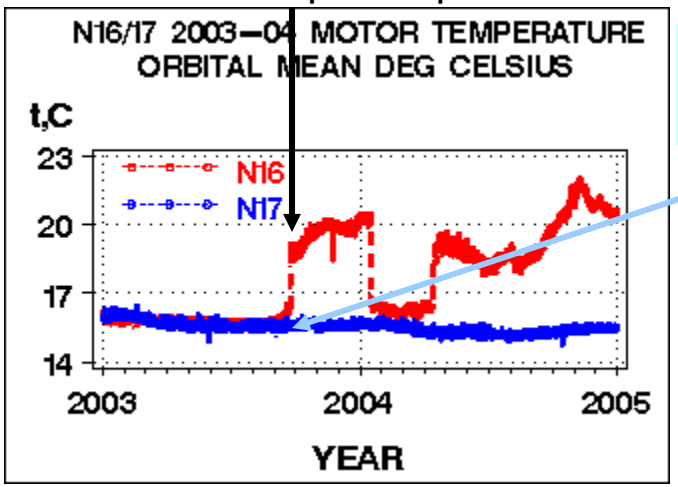




N16 AVHRR stabilized for ~3 months

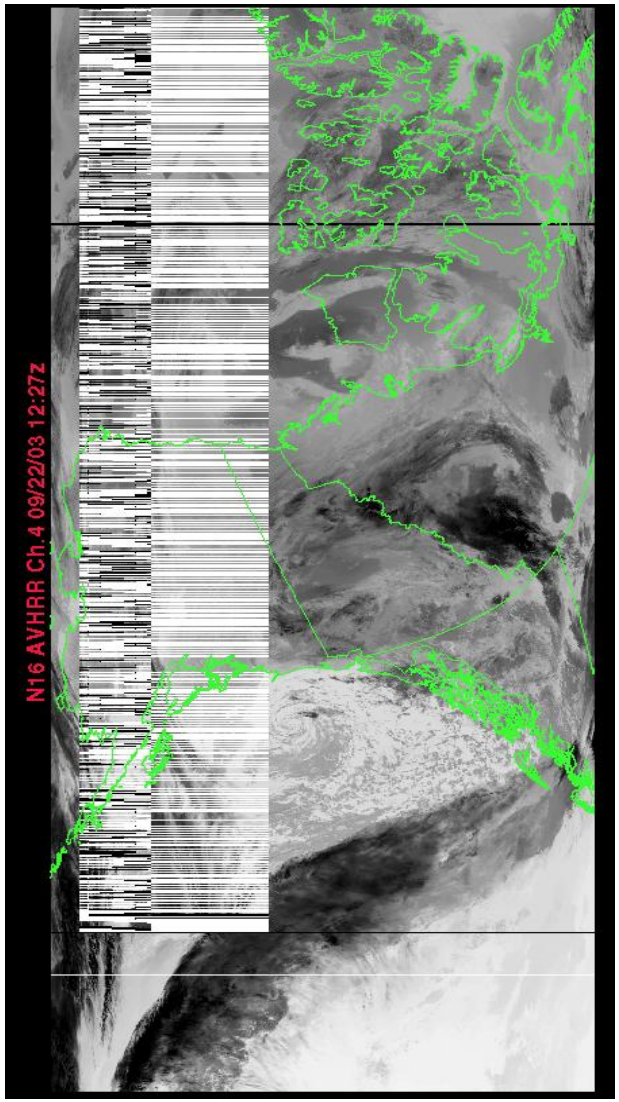
N16 scan motor first spiked Sep 2003

AVHRR warmed up to improve lubrication



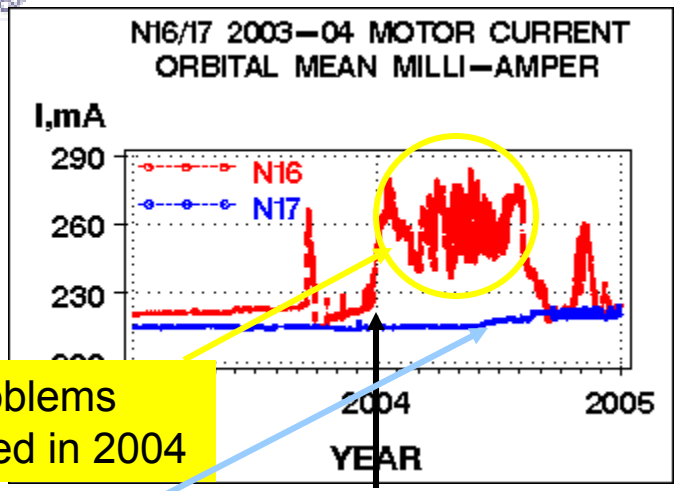
N17 AVHRR was nominal

Imagery bar-coded



For complete N16/AVHRR story, see OSO Page..

http://www.oso.noaa.gov/poesstatus/componentStatusSummary.asp?spacecraft=16&subsystem=4

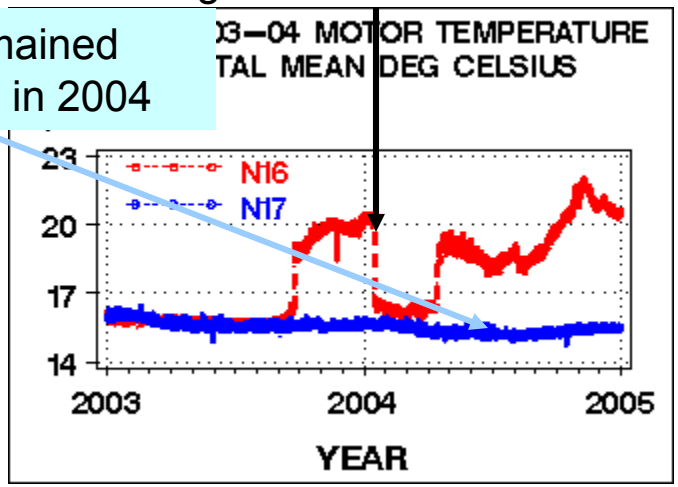


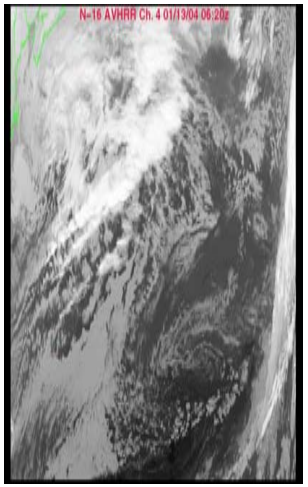
N16 problems continued in 2004

N16 scan motor spiked again Dec03/Jan04

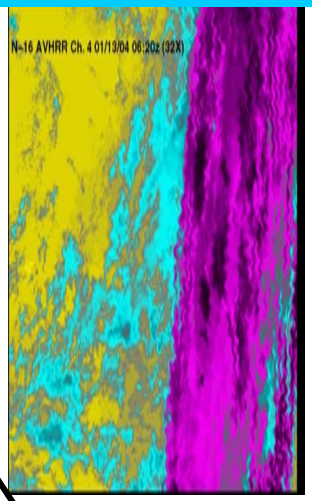
Further heating. Earth: commanded to cool

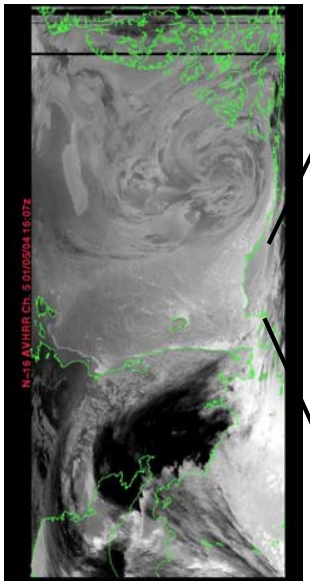
N17 remained nominal in 2004



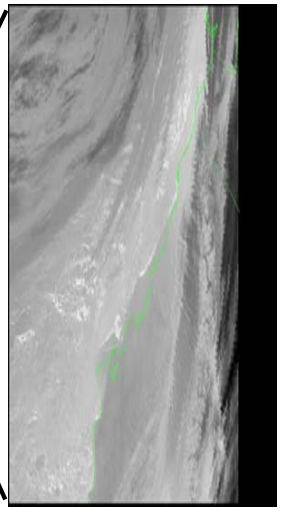


Imagery reveals wavy patterns





SOCC Normal (1x) zoom)

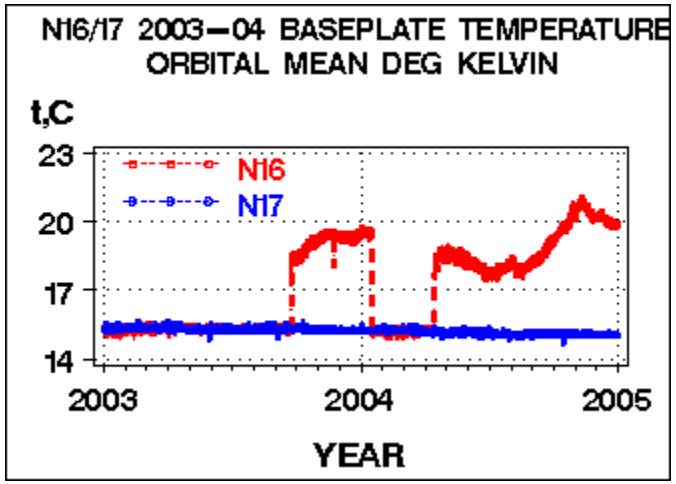


SOCC Zoom in 32x

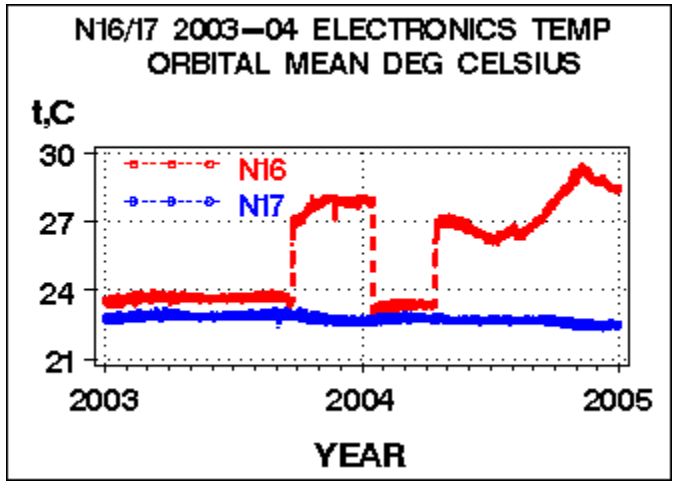
User image 32x

How motor story affects calibration? Through AVHRR changing/non-equilibrium thermal regime

Baseplate



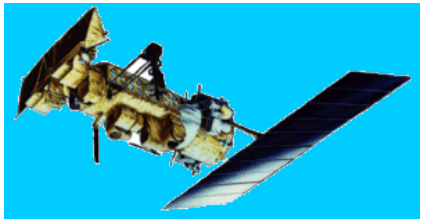
Electronics



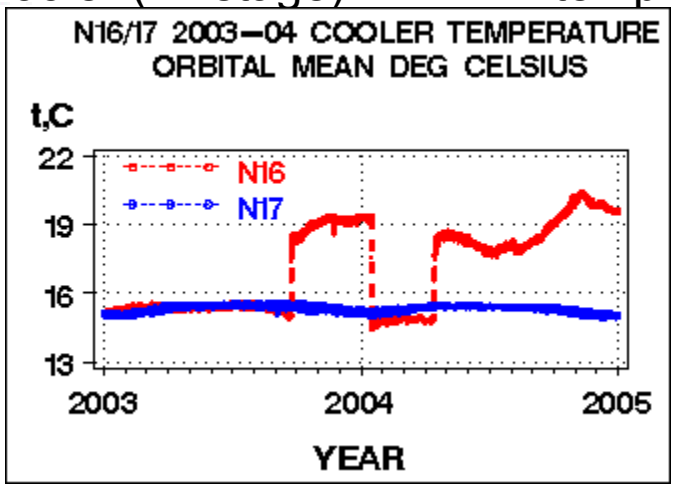
AVHRR is a compact instrument.
Temperature of all instrument interior changes coherently.

Temperature of IR detectors is very important for calibration. Luckily, thermal impact on detectors was negated by two-stage passive radiant cooler (next slide..)

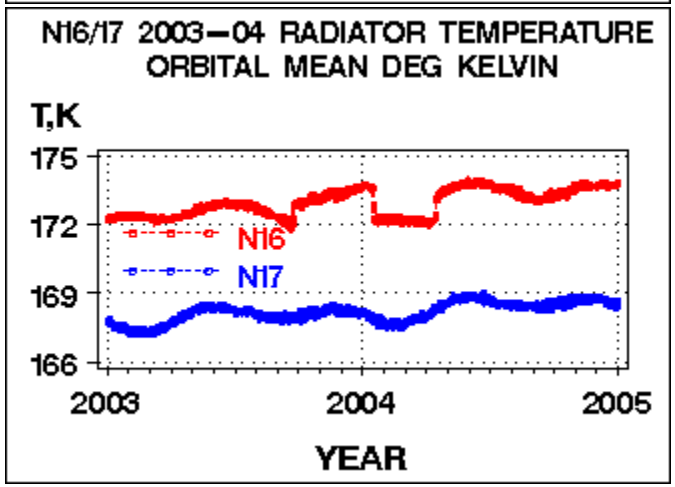
Detector temperature not affected

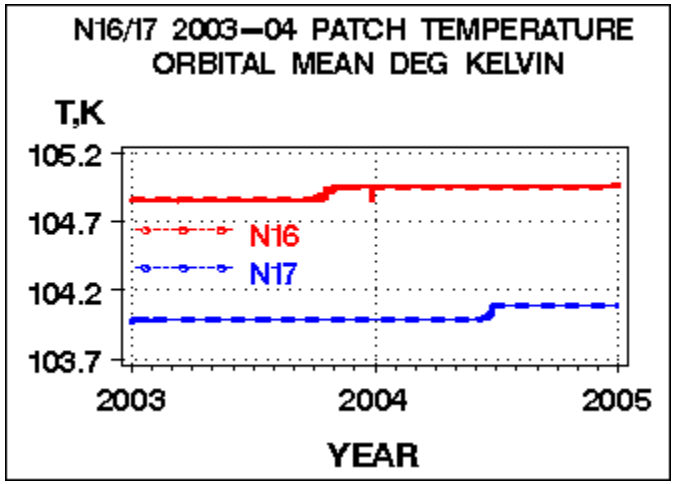


Cooler (1st stage): AVHRR temp



- Temperature of IR detectors: Unlikely cause of cal changes
- Subtle analyses needed to understand mechanisms of cal/temp relationship (check GOES experience!)

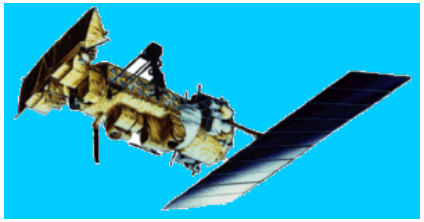




Radiator (2nd stage): Largely reduced

IR detectors: Not impacted

Summary



For climate analyses

- In 2003-04 AVHRR/3: AVHRR on N17 well-behaved; on N16 variable
- Cal errors seen in Brightness Temperatures and SSTs
- Need understand long-term instrument changes/Calibration
- Engineers monitor instrument (SOCC); Scientists do product analyses
- For climate: Scientists should pay more attention to instrument
- Much instrument info is available from L1b data

Before generation/analyses of SST CDRs from AVHRR

- Analyze/Understand instrument info (available on L1b)
- Improve cal → generate L1b´ (New cal appended/Bad data flagged out)

Implications for AVHRR EDRs (MetOp/NOAA-N') in NPOESS era

- AVHRR is a well tested, robust, dependable instrument
- With improved cal, can successfully supplement VIIRS/ABI/..