NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service

NOAA MSU Intercalibration/Reanalysis System Review

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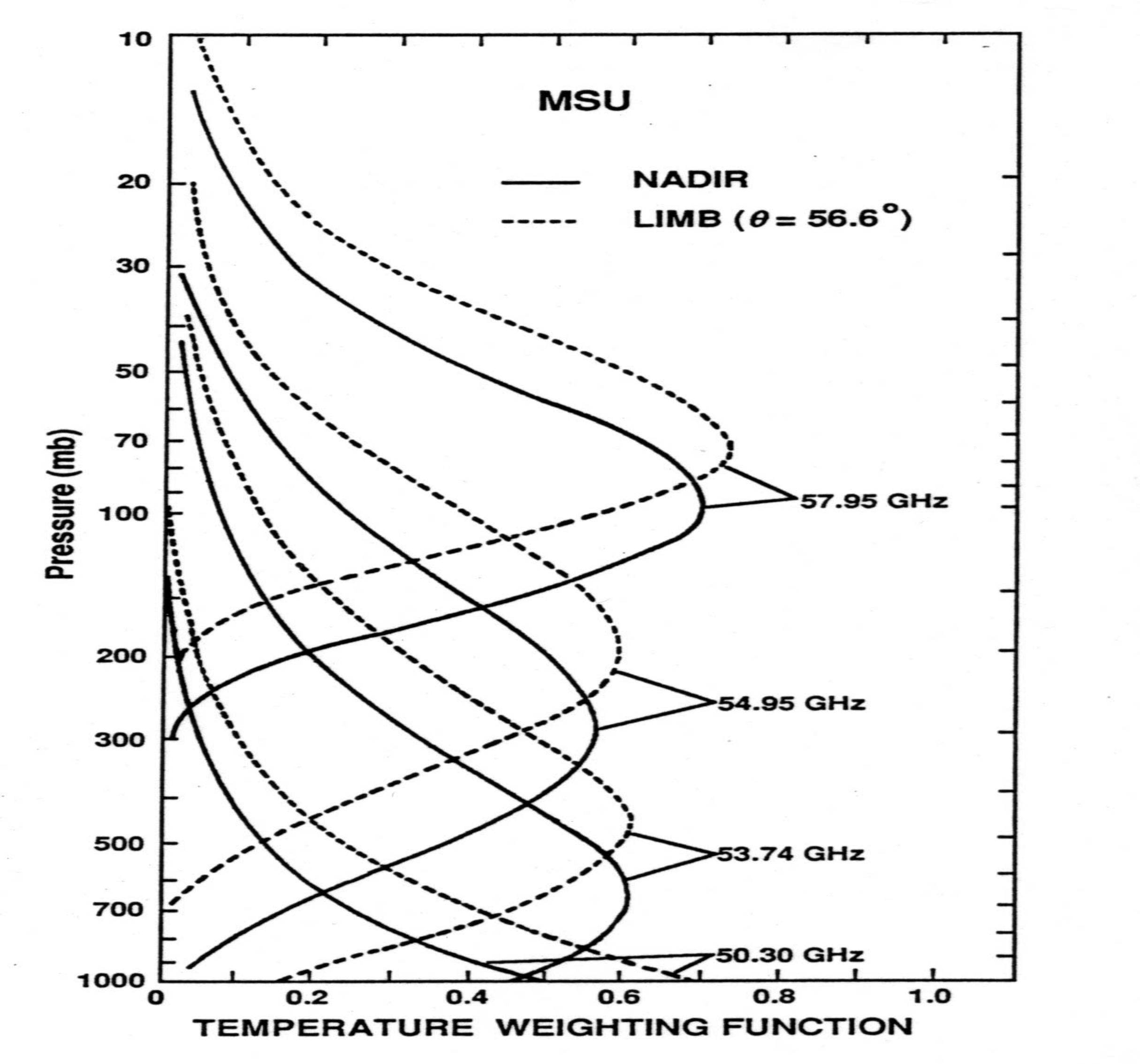
MSU Instrument



$W(p;\nu,\theta)$

MSU – channels and frequencies

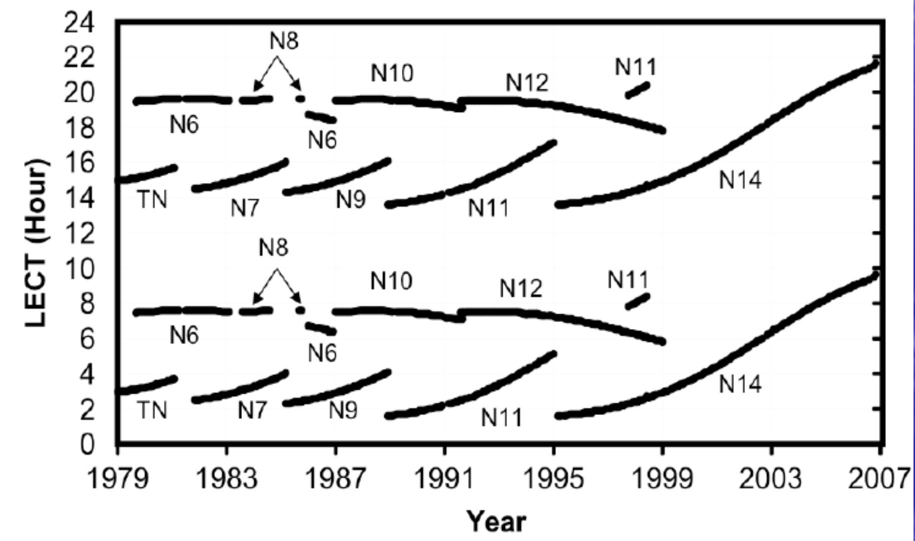
Channel #	Freq. (GHz)
4	57.95
3	54.95
2	53.74
1	50.30

For MSU channels – 2, 3, 4

$$T_b \cong \int_{-\infty}^{\ln P_S} T(p)W(p;\nu,\theta)\,d\ln p$$

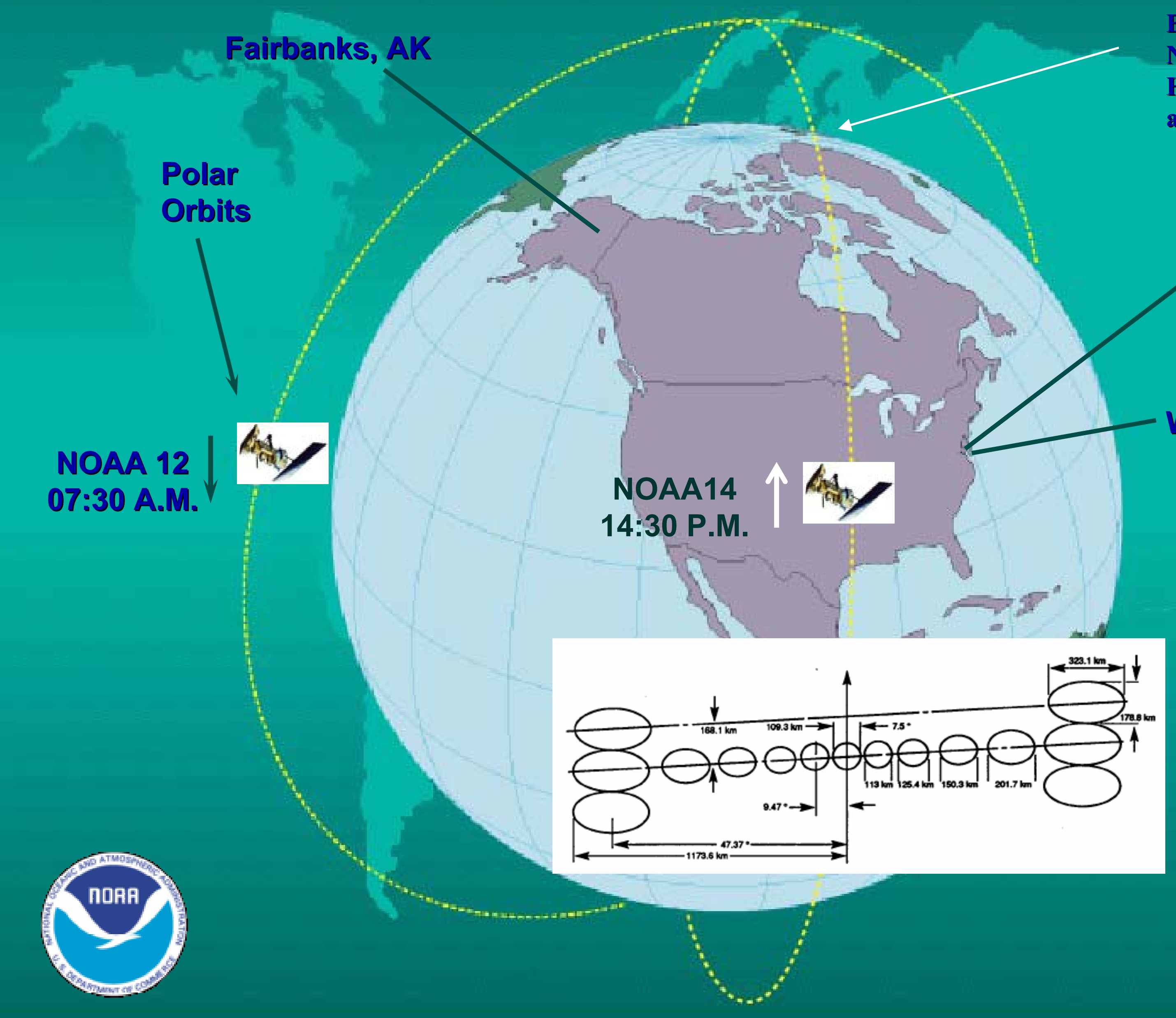
NOAA MSU Satellites

- Each satellite has
  a life cycle of a few years
- Each satellite overlaps
  With other satellites
- LECT gradually changes With time–
  orbital drift phenomenon
- Temperature observations under all weather conditions except heavy precipitation



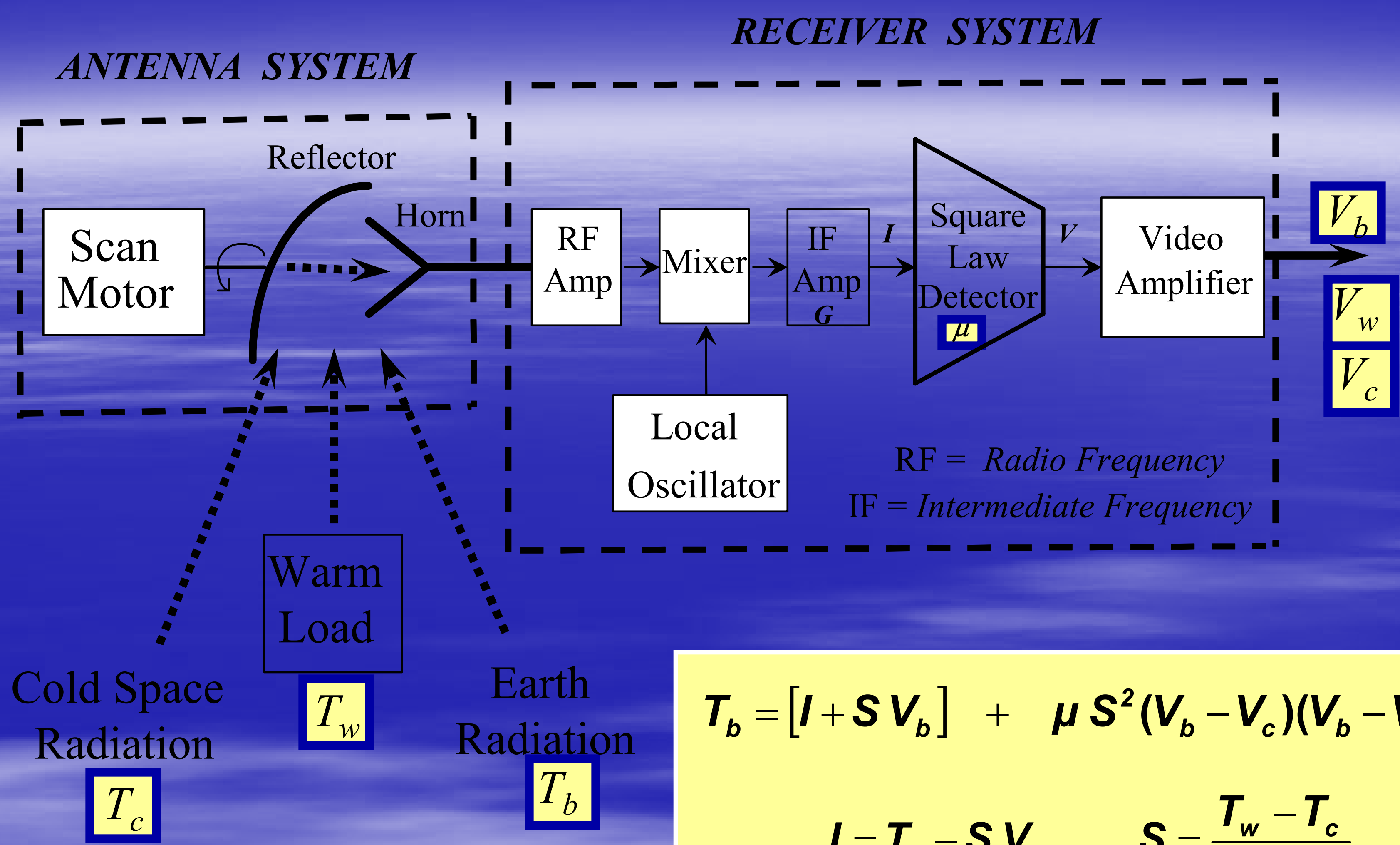
Satellite Local Equator Crossing Time (LECT)

NOAA POES Satellite System - 2006



Sun-Synchronous
Incl. 98.7/98.9
Period 101 min.
Apogee 530/518 miles

Circle Earth 14 times
per day



$$T_b = \left[I + S\,V_b \right] + \mu\, S^2 (V_b - V_c)(V_b - V_w)$$

$$I = T_c - S\,V_c \quad , \quad S = \frac{T_w - T_c}{V_w - V_c}$$

Block diagram showing the antenna and receiver systems. Errors in the earth radiation measurement, T_b, results from *errors in the cold space,* T_c*, and warm target,* T_w*, measurements and uncertainties in the nonlinear parameter,* μ .

MSU In-Orbit Calibration

Linear Calibration

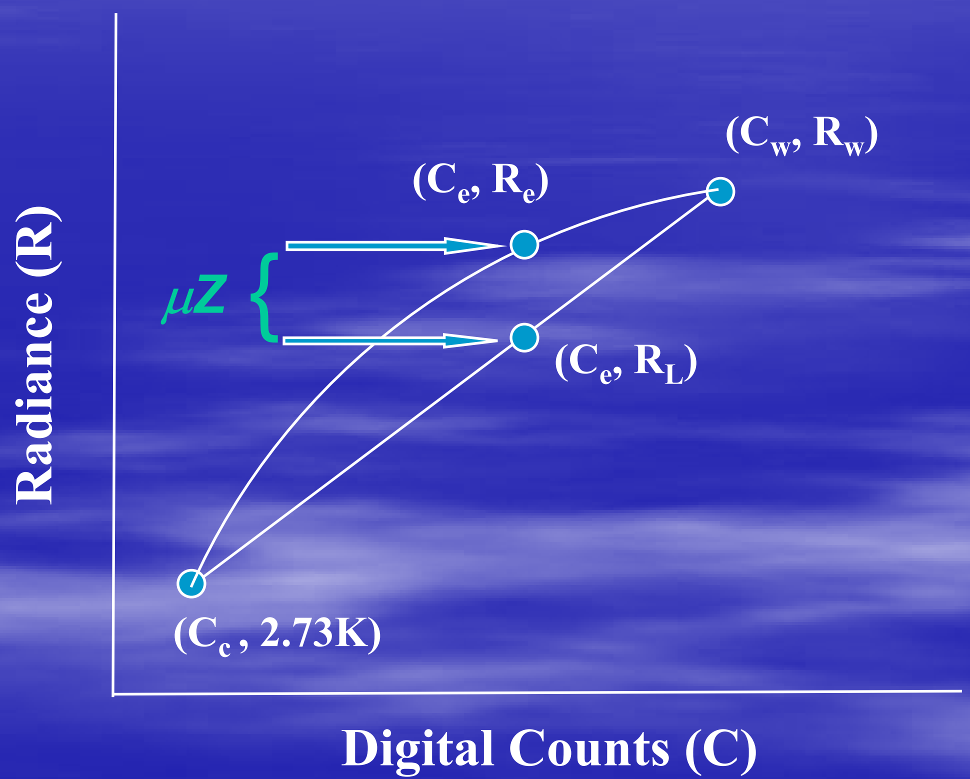
$$R_L = R_c + S(C_e - C_c)$$

S ⟶ Slope

Nonlinear Calibration

$$R = R_L - \delta R + \mu Z$$

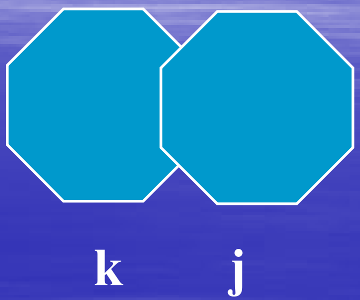
$$Z = S^2 (C_e - C_c)(C_e - C_w)$$



SNO Radiance Error Model

$$R_k = R_{L,k} - \delta R_k + \mu_k Z_k$$

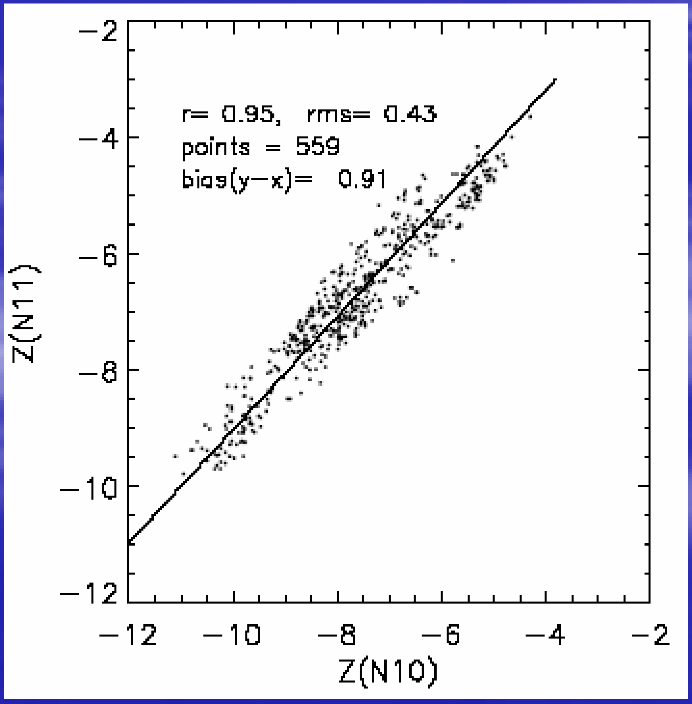
$$R_j = R_{L,j} - \delta R_j + \mu_j Z_j$$



Radiance Error Model for SNO Matchup K and J :

$$\Delta R = \Delta R_L - \Delta R_0 + \mu_k Z_k - \mu_j Z_j + E$$

$$Z_j = \beta Z_k + \alpha + \zeta$$



Sequential Calibration Procedure:

- **Assuming NOAA 10 as the reference satellite and assuming its coefficients are known. Specifically, R_0 (N10)=0**

- Compute radiance for NOAA 10

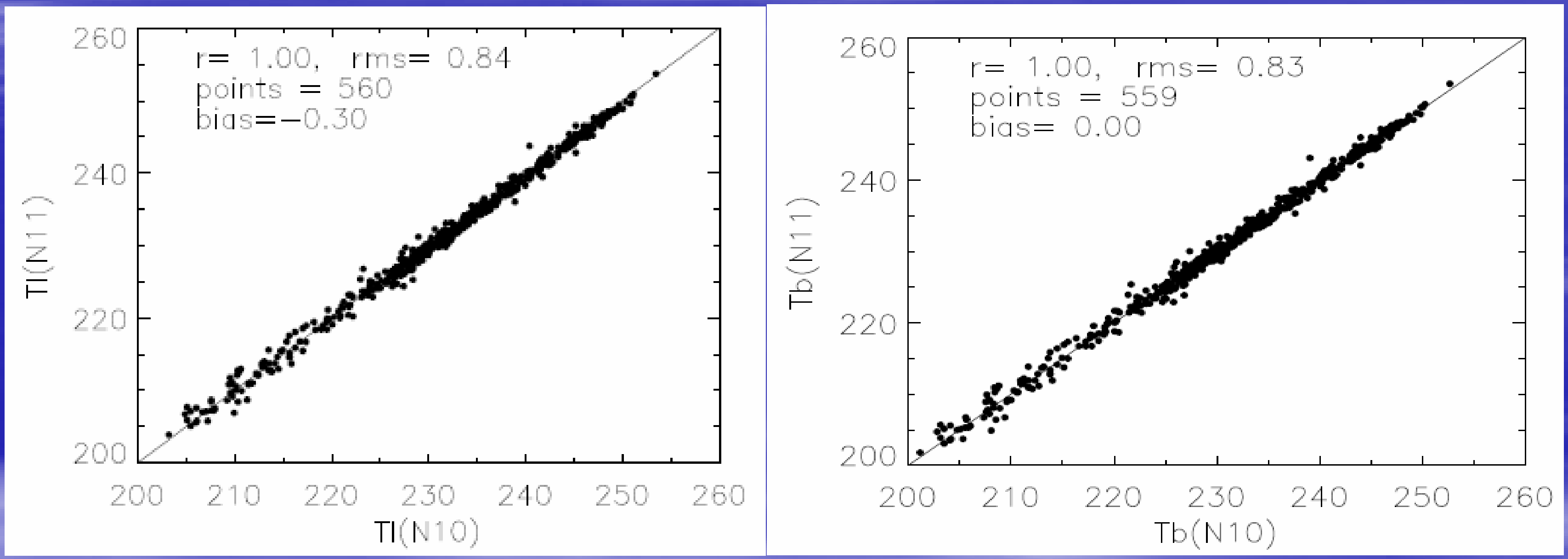
- **Obtain NOAA 11 coefficients from regressions of N11-N10 SNO**

- **Compute NOAA 11 radiance using obtained coefficients**

- **Repeat above procedure for NOAA 12 with adjusted NOAA11 as references**

……….

SNO matchups before and after SNO calibration



Scatter plots showing effects of the nonlinear calibration on the error statistics and distribution of the brightness temperature difference between NOAA 10 and NOAA 11.

NOAA MSU Calibration/Reanalysis system

Satellite raw data Input

Satellite raw observations C

Level 0 calibration:

$$R = R_L - \delta R_0 + \mu Z = F(C)$$

where C is the raw observation,
R is the calibrated pixel radiance,
δR_0 and μ are calibration coefficients

Provide δR_0 and μ

Off-line SNO sequential calibration method to determine δR_0 and μ for all satellites

Data Processing System to produce Level-3 data:

quality control; limb correction;
diurnal correction;
averaging over grid-cells

Variability Analyses

Examine global mean time series, compute STD of intersatellite difference time series to examine warm target contamination

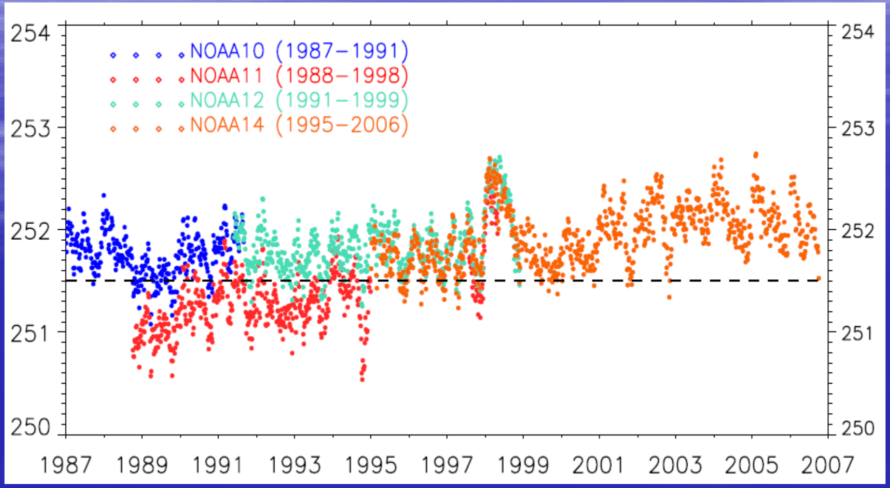
Provide feedback: select different μ for the reference satellite until STD reach smallest, which leads to a unique set of δR_0 and μ for all satellites. This set of coefficients is independent of the reference satellite. Essentially, this process is to make η to disappear. (see next slide for definition of η)

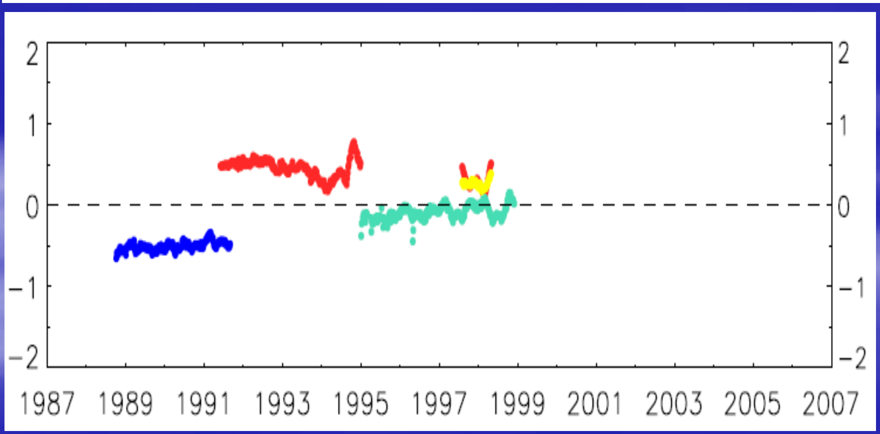
Trend analyses

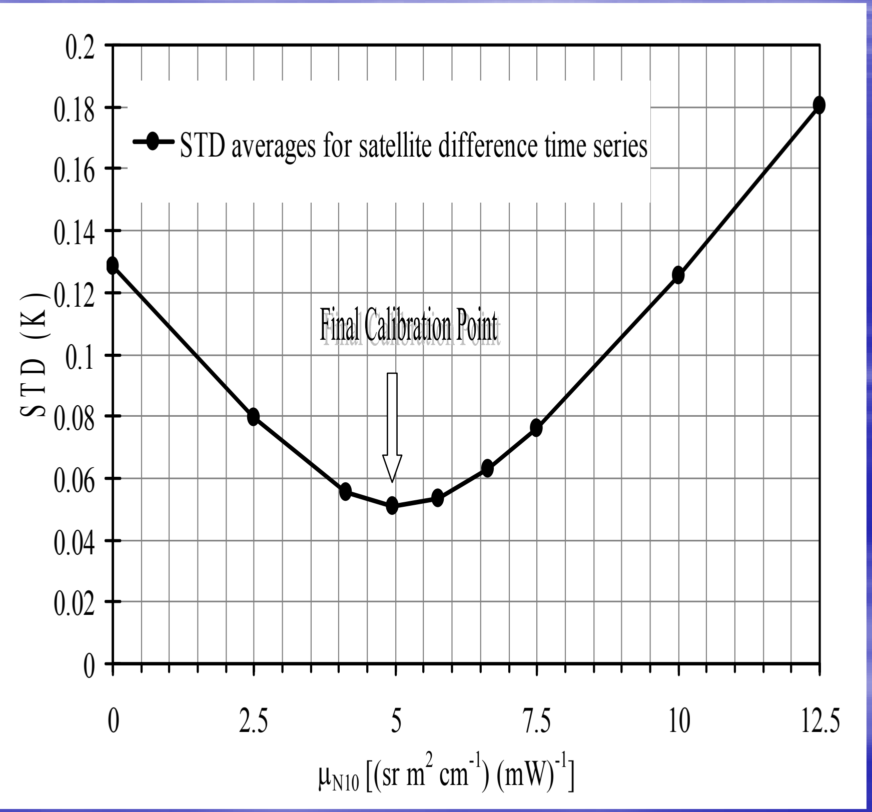
Output global mean time series for trend analyses

$$T_j = \alpha_j + \beta_j \times time + \chi_j + \varepsilon_j + \eta_j \times T_{w,j}$$

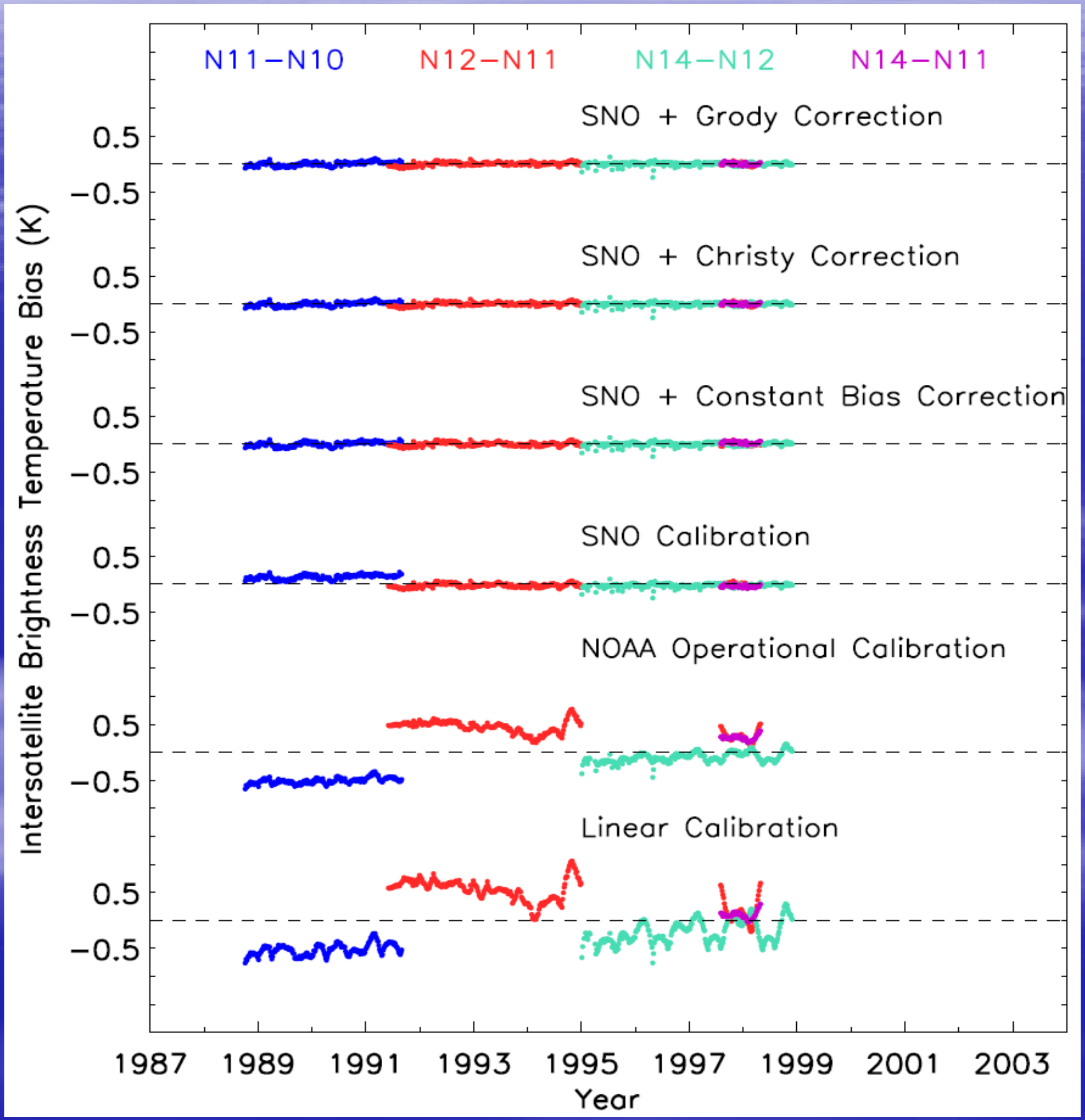
Global Ocean Mean Time Series







Ch2 global mean difference time series



STD=0.04K

STD=0.04K

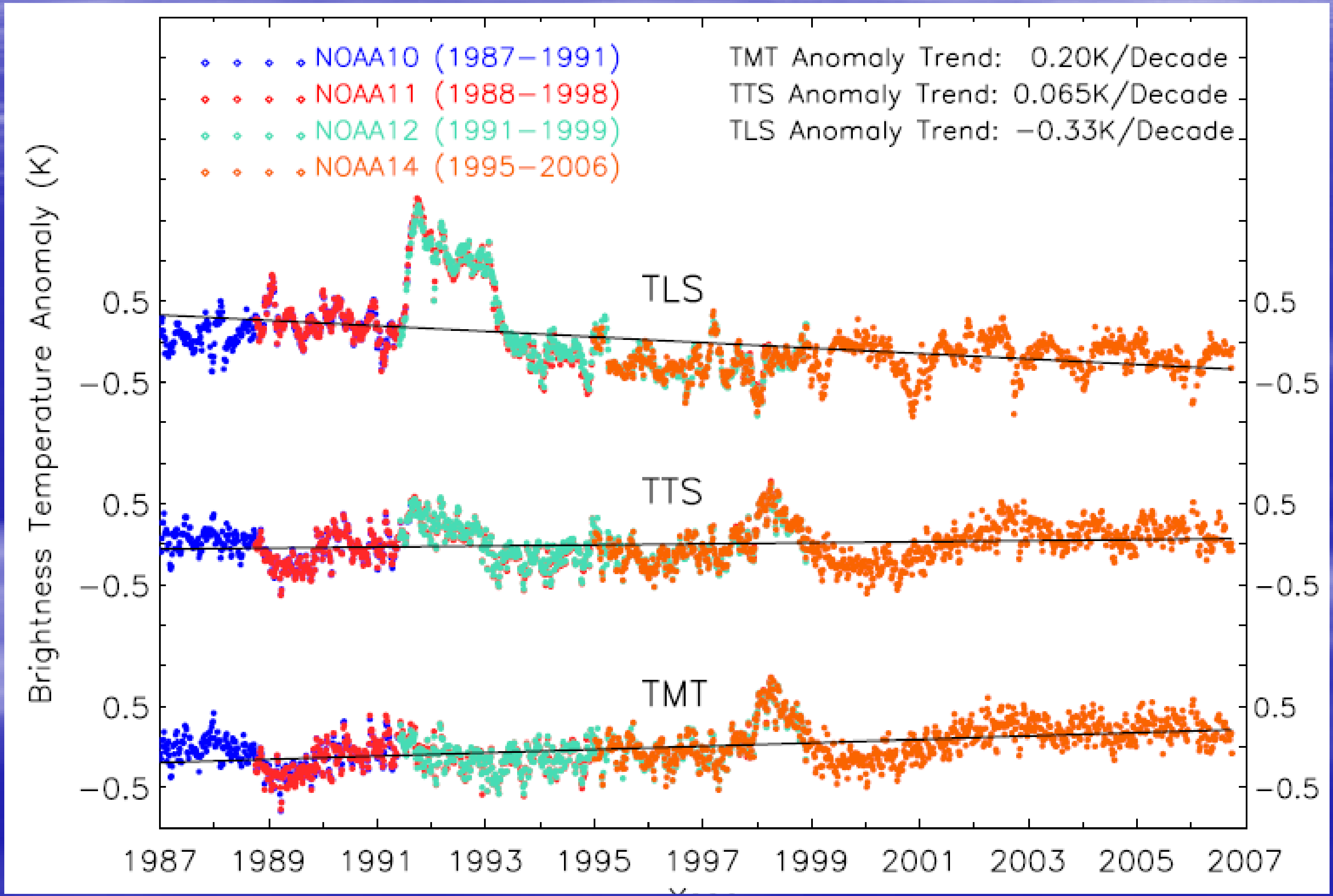
STD=0.04K

STD=0.04K

STD=0.10K

STD=0.20K

SNO calibrated anomaly time series and trend



Service—Data archive and exchange

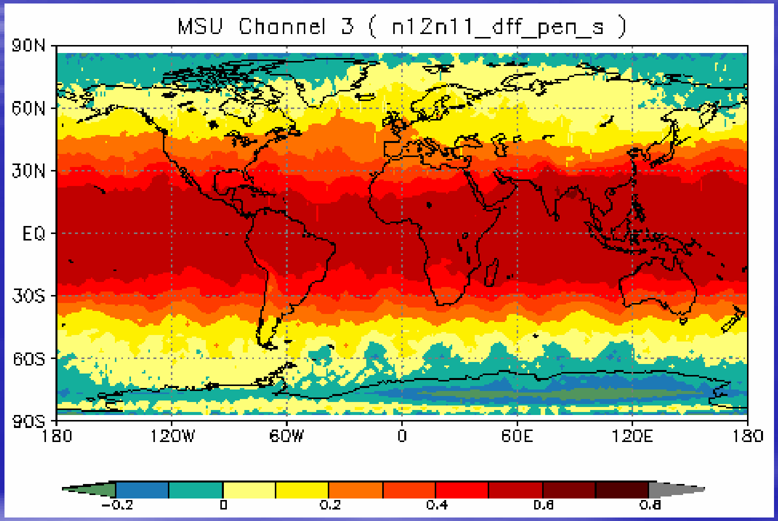
Website address:
http://www.orbit.nesdis.noaa.gov/smcd/emb/mscat/mscatmain.htm

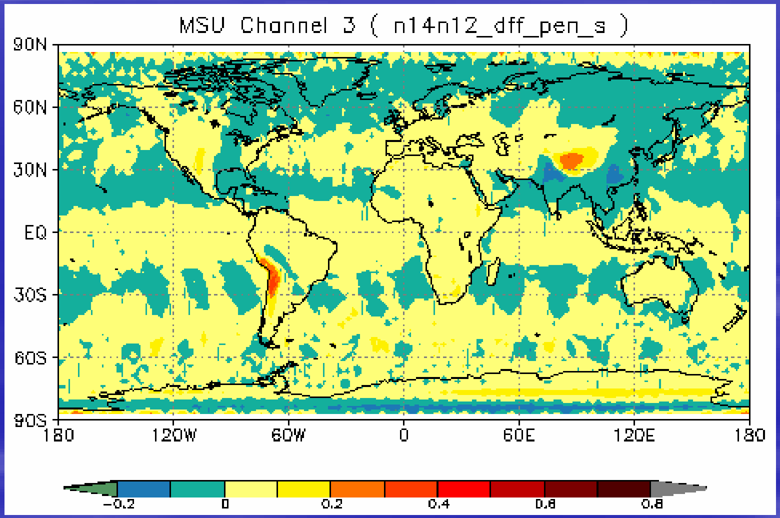
Datasets for public access:

- Level 1b calibration coefficients: Counts to radiance
- Level 2 radiance:
  - pre-launch (operationally) calibrated
  - SNO calibrated
- Level 3 gridded products: $2.5^0 \times 2.5^0$
  - pentad T_2, T_3, and T_4 of merged and individual satellite
  - pentad anomaly T_2, T_3, and T_4, 1987-present
  - merged monthly T_2, T_3, and T_4, 1987-present
  - monthly anomaly T_2, T_3, and T_4, 1987-present
- Continue to add more when available

issues

- Biases depend on geographic locations: ch3(N12-N11), ch2 (N11-N10)

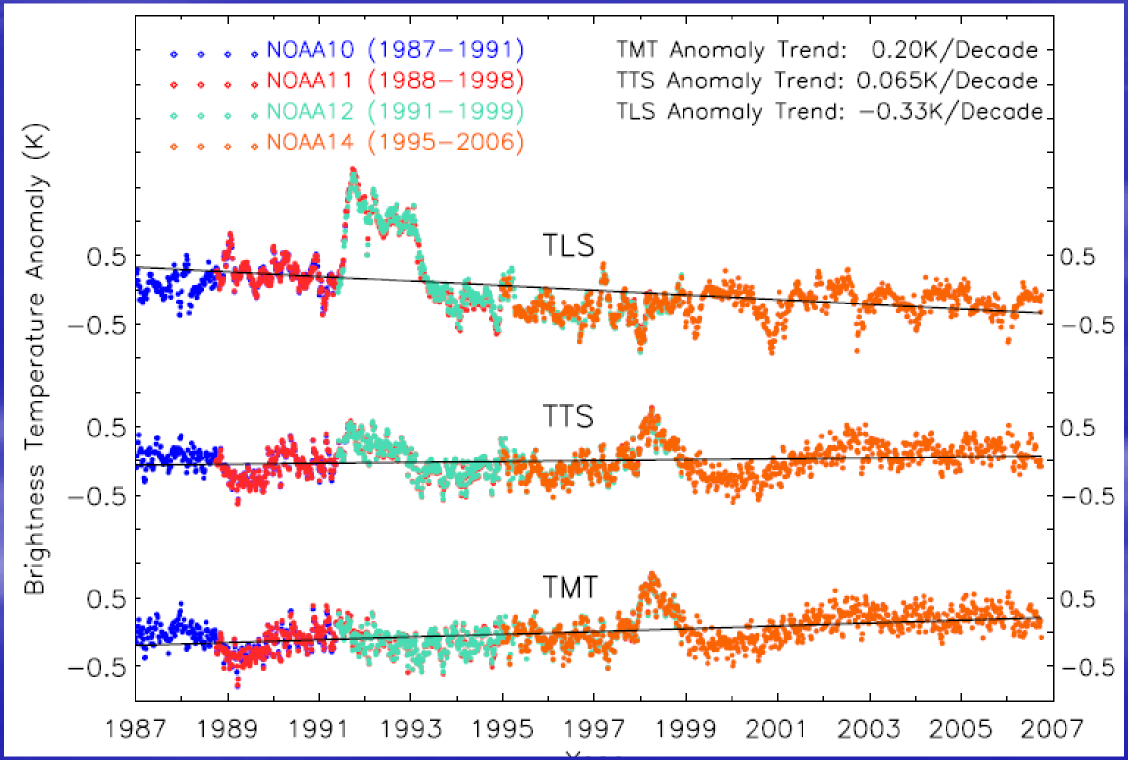




- Do we need to add higher order terms in the calibration equation?
- How the local oscillator affect this bias non-uniformity?
- Can radiometric calibration of the warm target help to remove this?

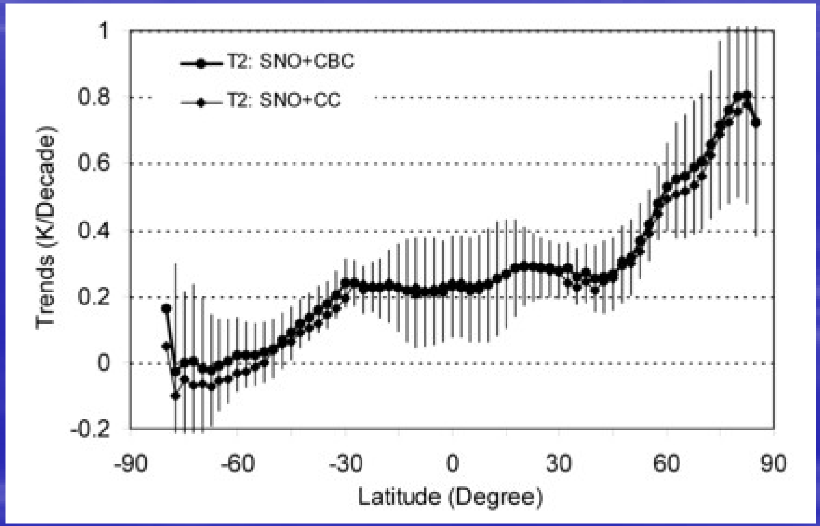
Issues

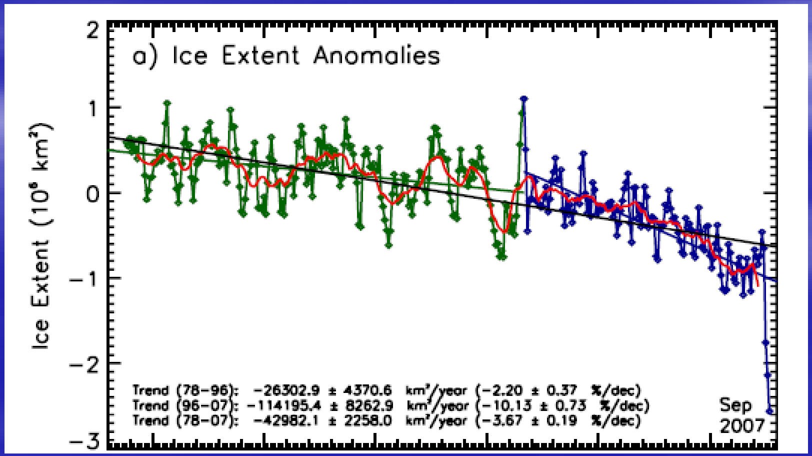
- The nonlinear coefficient maybe changing with time. How to determine it in this case?



Comparisons with Sea Ice Trends

[1] Satellite data reveal unusually low Arctic sea ice coverage during the summer of 2007, caused in part by anomalously high temperatures and southerly winds. The extent and area of the ice cover reached minima on 14 September 2007 at 4.1×10^6 km^2 and 3.6×10^6 km^2, respectively. These are 24% and 27% lower than the previous record lows, both reached on 21 September 2005, and 37% and 38% less than the climatological averages. Acceleration in the decline is evident as the extent and area trends of the entire ice cover (seasonal and perennial ice) have shifted from about −2.2 and −3.0% per decade in 1979–1996 to about −10.1 and −10.7% per decade in the last 10 years. The latter trends are now comparable to the high negative trends of −10.2 and −11.4% per decade for the perennial ice extent and area, 1979–2007. **Citation:** Comiso, J. C., C. L. Parkinson, R. Gersten, and L. Stock (2008), Accelerated decline in the Arctic sea ice cover, *Geophys. Res. Lett.*, *35*, L01703, doi:10.1029/2007GL031972.





Thank you!