Land Long Term Data Record Calibration

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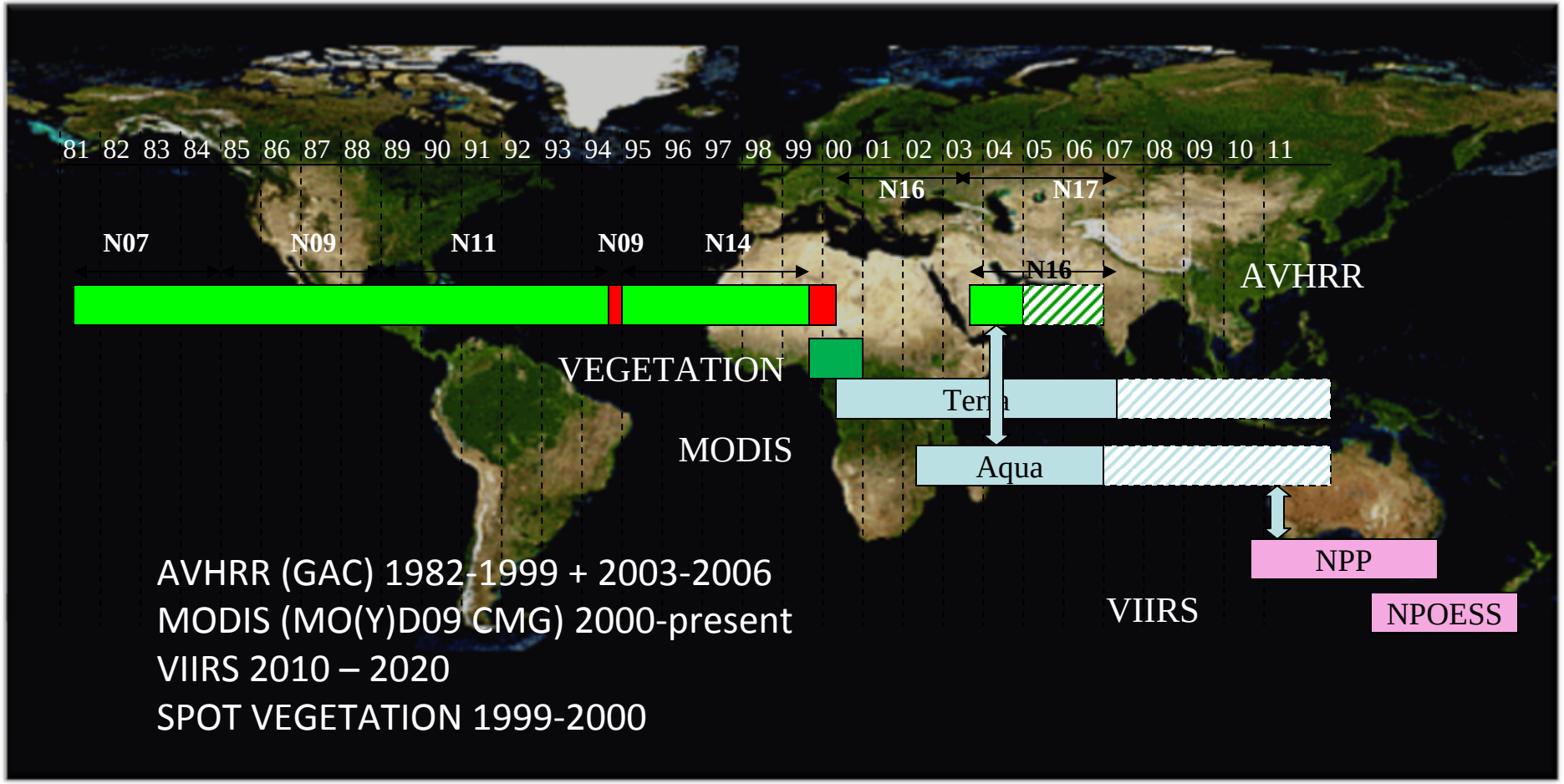
Land Systematic Observations/Climate Data Records

- Terrestrial Carbon Observations
  - Metabolism Change – quantifying productivity, length of growing season/phenology, large area disturbance (e.g. fire, insects), degradation (Moderate Spatial Resolution Satellite Data, Process Studies, Modeling)
  - Land Use Change – quantifying carbon sources / sinks, tropical land use term (High>Hyper Resolution Satellite Data, Process Studies, Modeling)

Land Climate Data Record

Multi instrument/Multi sensor Science Quality Data Records used to quantify trends and changes



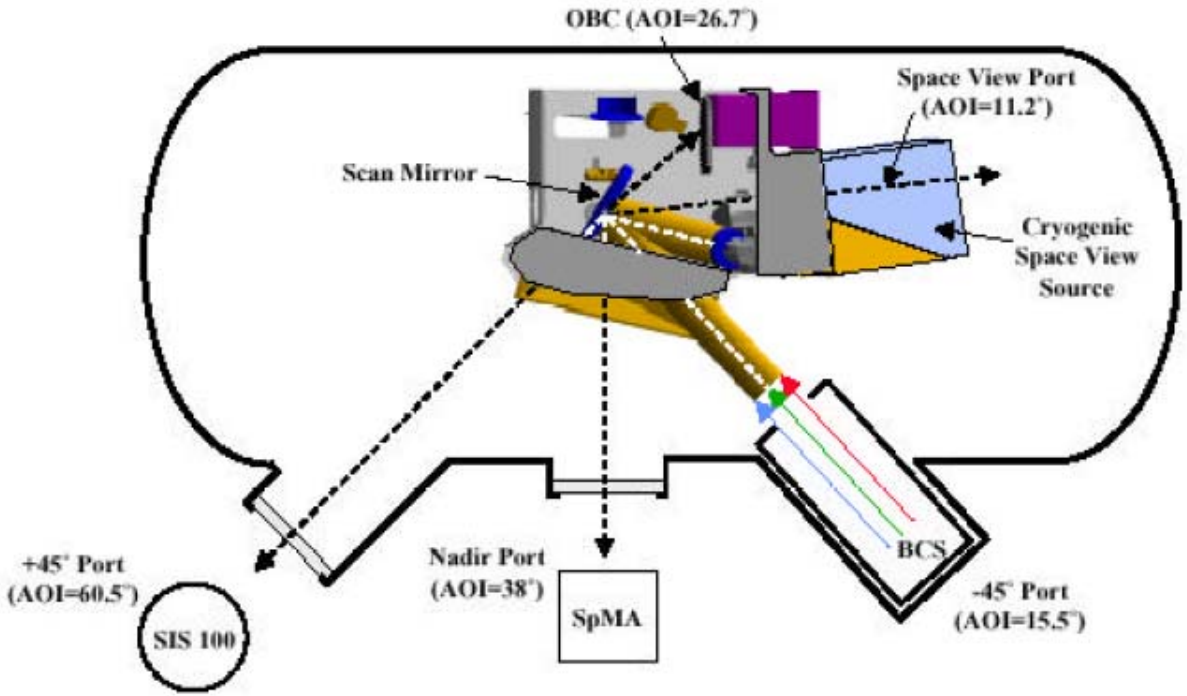
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Calibration

The accurate calibration of L1 data (top of the atmosphere) is crucial to meeting the requirement goals of higher order (downstreams) products. The on-board is designed to guarantee an accurate calibration of the visible to short wave infrared bands as the instrument optics and electronics suffer from potential degradation over time. To minimize the errors due to the uncertainty in the solar spectrum, the calibration coefficients for reflective bands should be derived in reflectance units rather than radiance units.

Preflight CALIBRATION

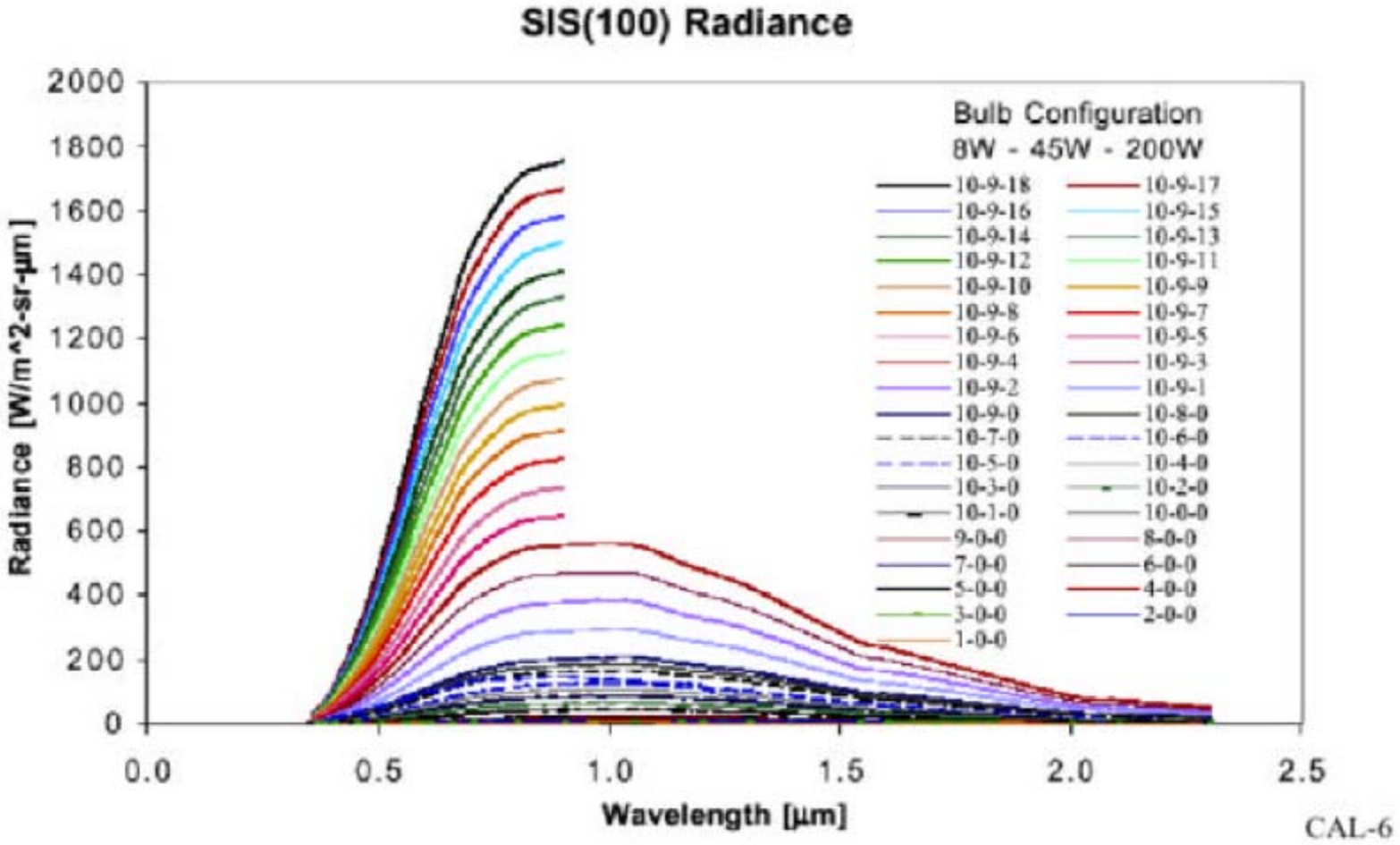
Thermal Vacuum Configuration for MODIS Pre-launch Calibration



Calibrations performed at:

- 3 instrument temperatures (260, 270, and 280K)
- 3 cold focal plane temperatures (83, 85, and 88K)
- 21 BCS levels (170K to 340K); many SIS-100 lamp configurations

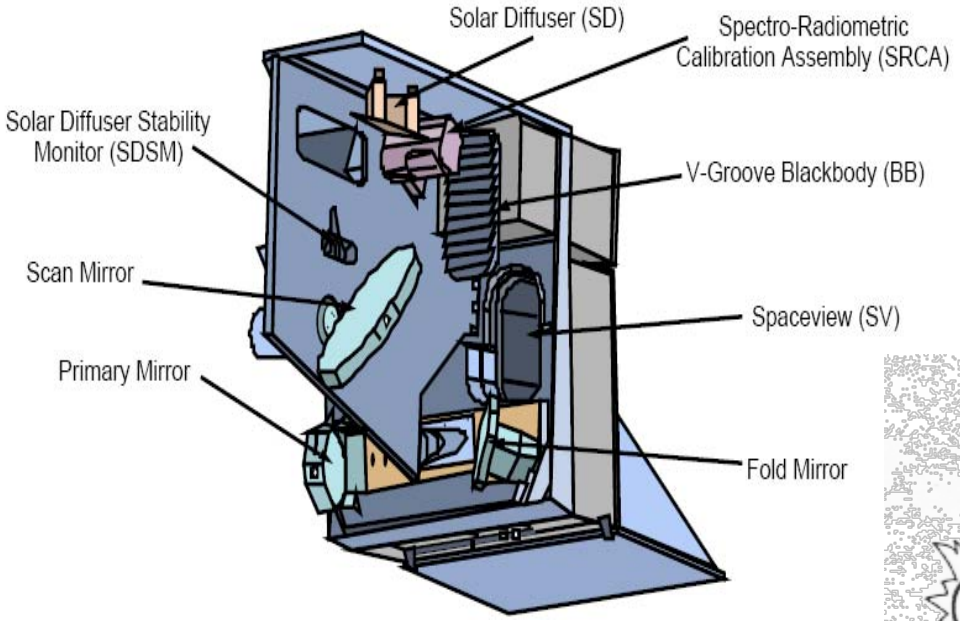
Preflight CALIBRATION

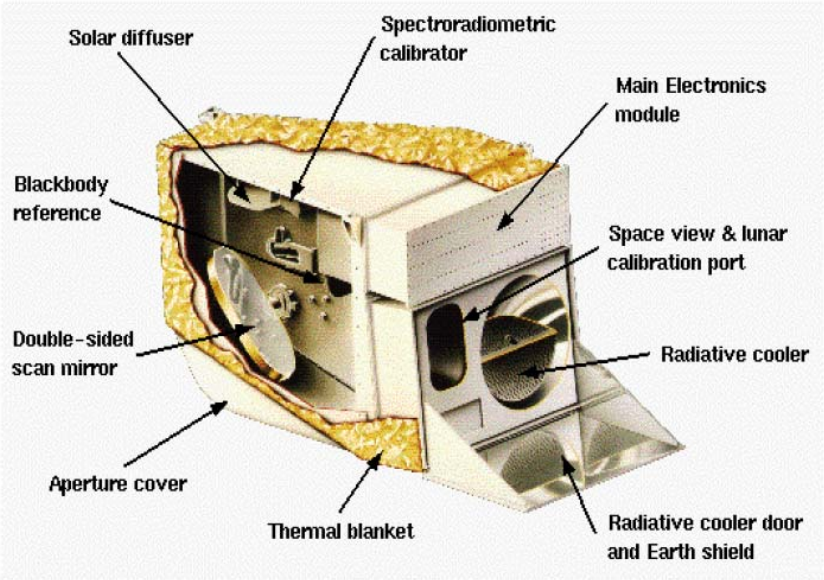


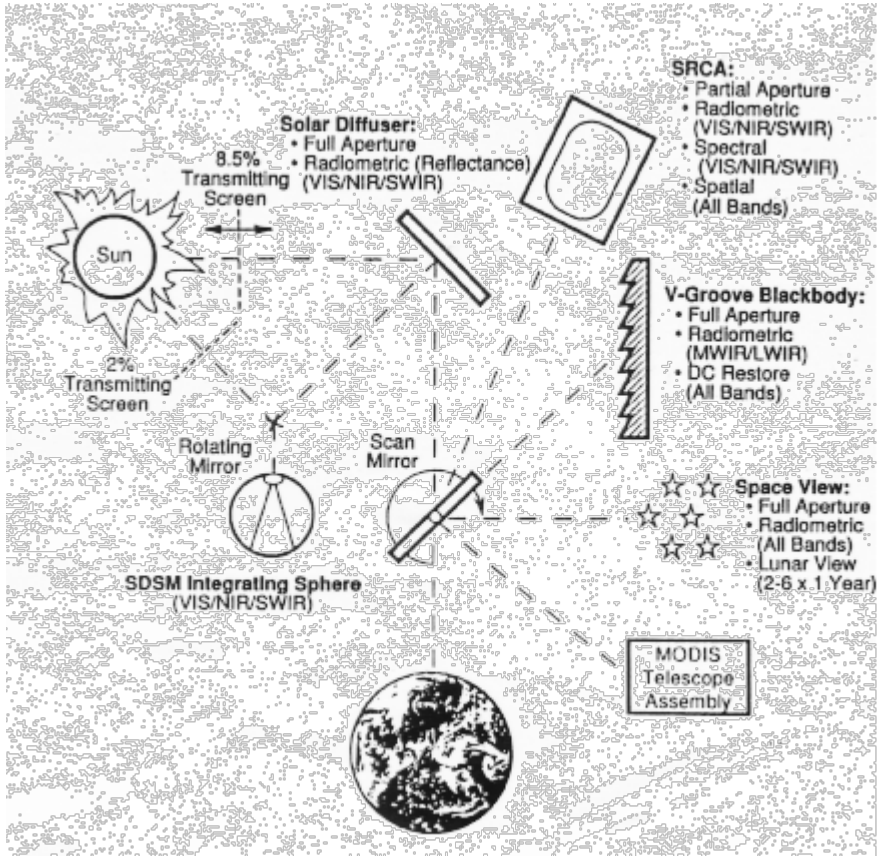
CAL-6

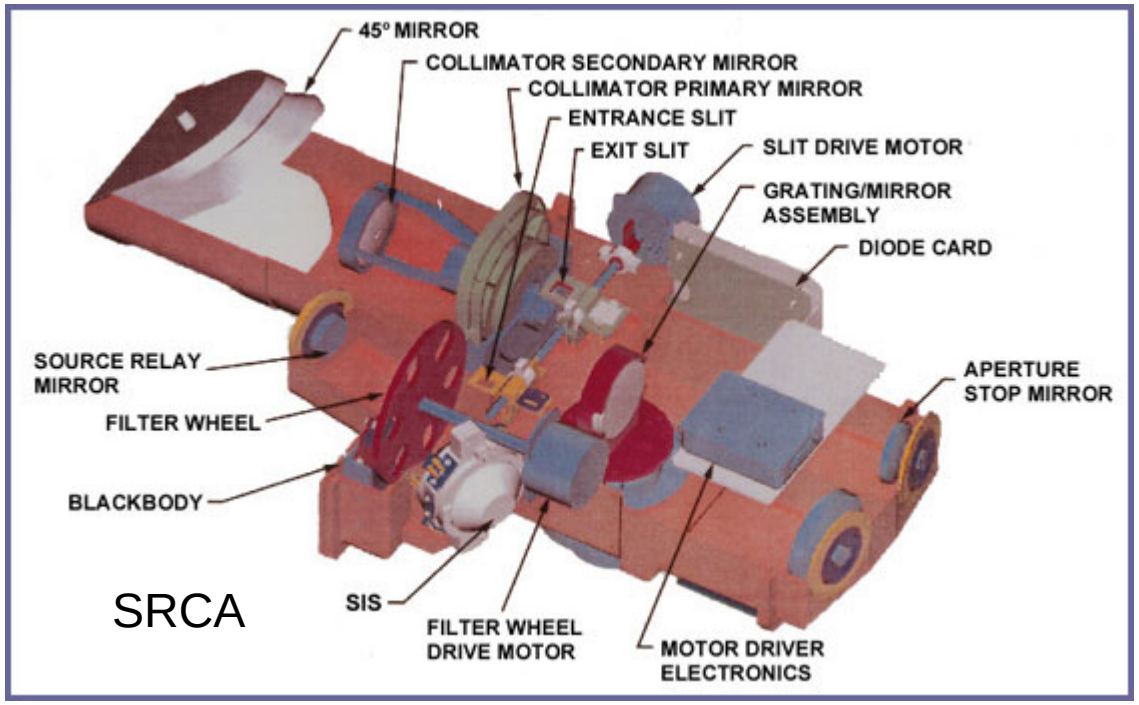
ON BOARD CALIBRATION

On-Board Calibrators in MODIS Scan Cavity





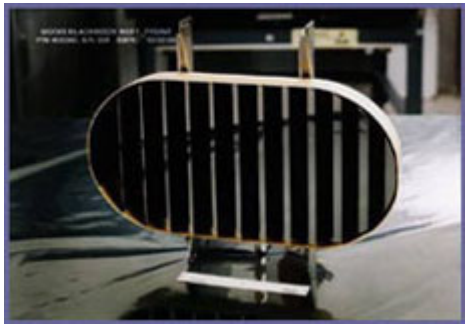




SRCA

Solar Diffuser

Solar Diffuser Stability Monitor



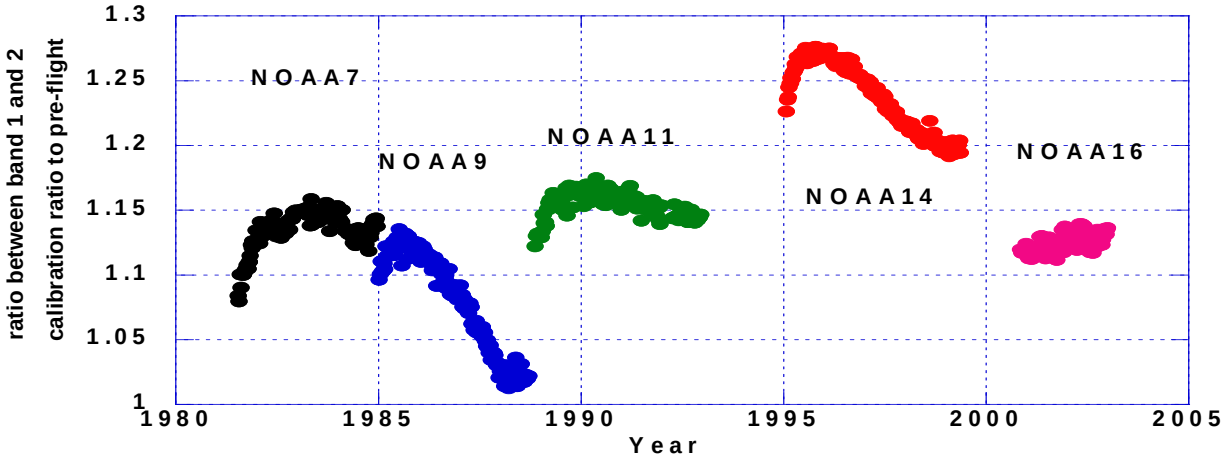
Blackbody

AVHRR does not carry any in-flight calibration system

- Many VICARIOUS CALIBRATION techniques were developed, to cite a few:
  - Vermote and Kaufman (1995), using Ocean and Clouds (Absolute Calibration)
  - Rao and Chen (1996) monitoring the relative degradation over stable desert site (Relative calibration)
  - Heidinger et al. (2002): Cross calibration with MODIS using near coincident scene (Cross Calibration)
  - Vermote and Saleous (2006), Cross calibration with MODIS over desert (Cross Calibration)

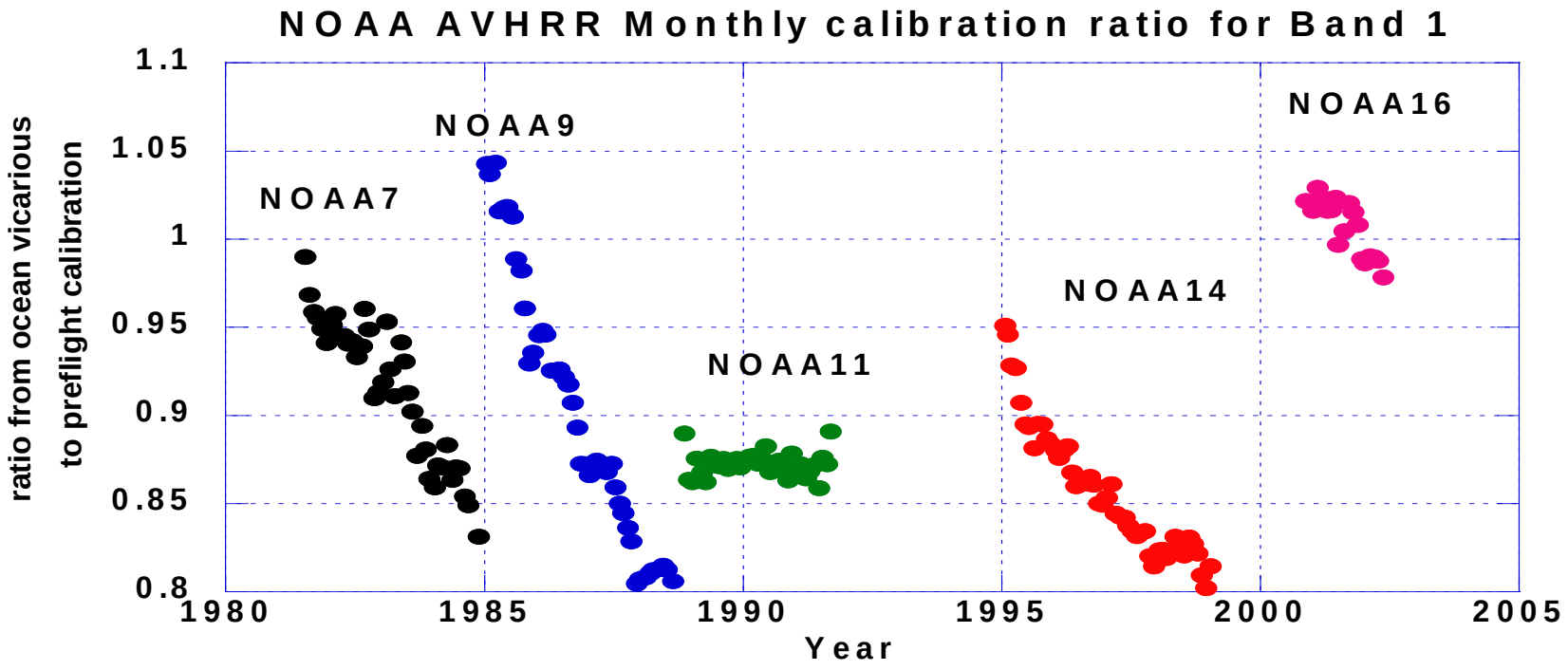
Ocean and Cloud calibration

Vicarious calibration over high altitude bright reflective clouds: , This approach is based on the flat response of high bright clouds in the region of 400 nm – 865 nm. It allows monitoring the variation of any channel in this spectral region relative to another channel within the same spectral region. Combined with the ocean approach, this method can be used to establish an absolute calibration for channels in the region 400nm to 865nm. We applied this method to the AVHRR instrument onboard NOAA-7, -9, -11, -14 and –16. The results show that this method is very accurate and stable (~1%, Vermote and Kaufman, 1997). This method can enhance the accuracy of calibration for band ratio based products such as NDVI.

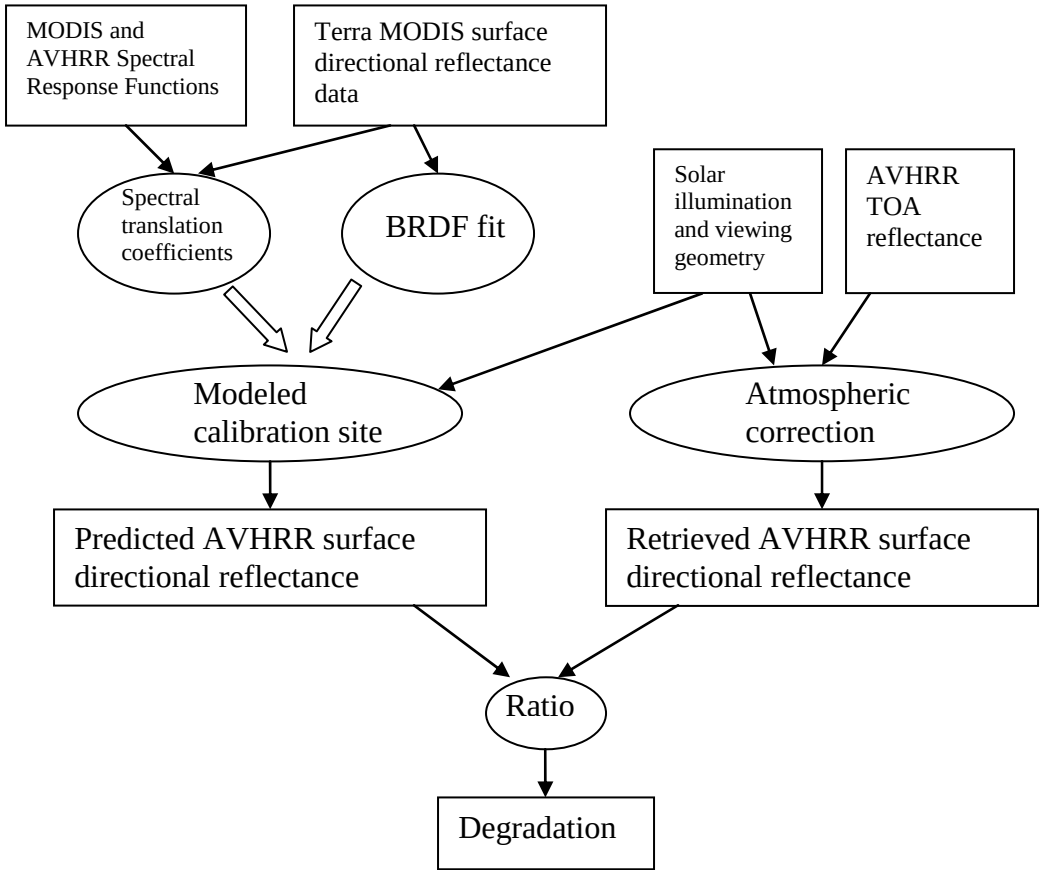


Ocean and Cloud calibration

Vicarious calibration using rayleigh scattering over ocean: The approach relies on the accurate computation of the molecular scattering over clear ocean using the 6S radiative transfer code. The rayleigh scattering component of the observed signal is compared to the simulated values to estimate the rate of degradation of the red band.

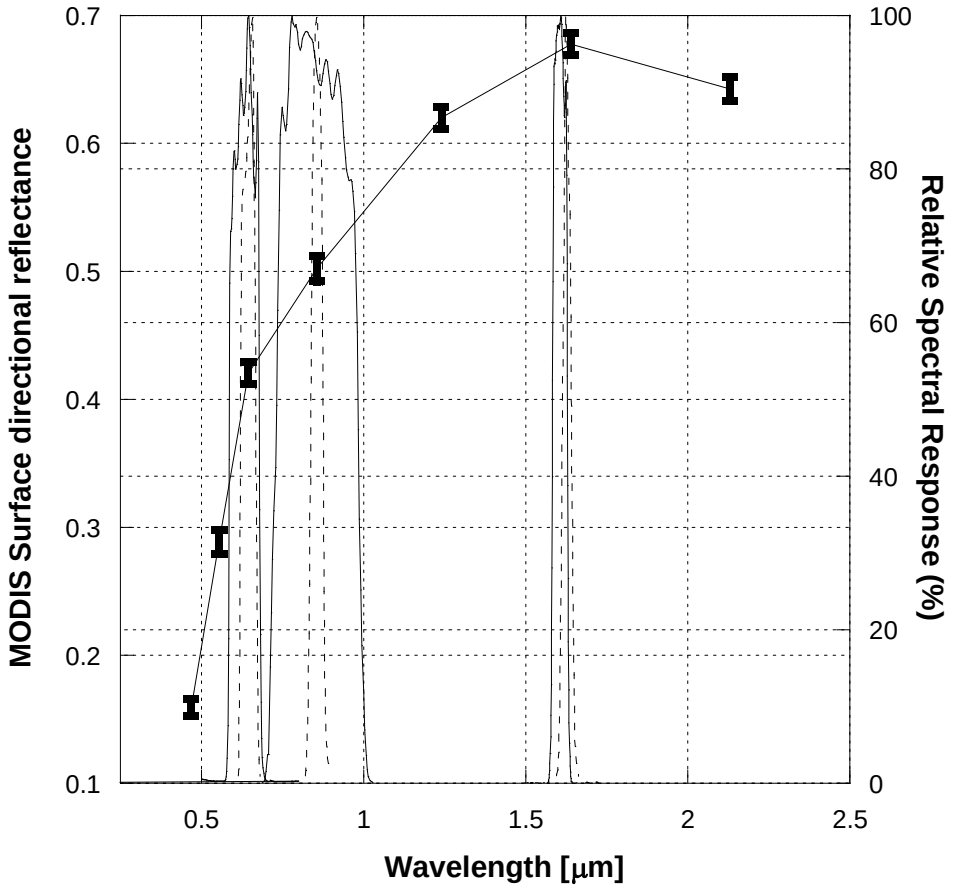


Desert Site cross-calibration (NOAA16)



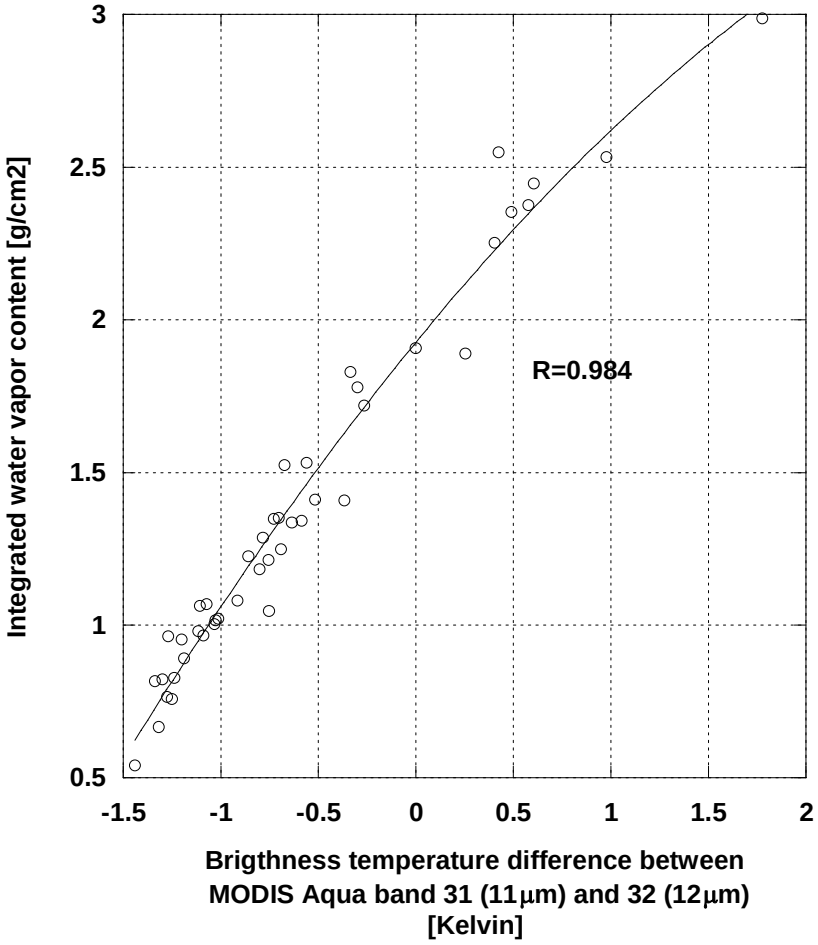
Adjustement for spectral responses

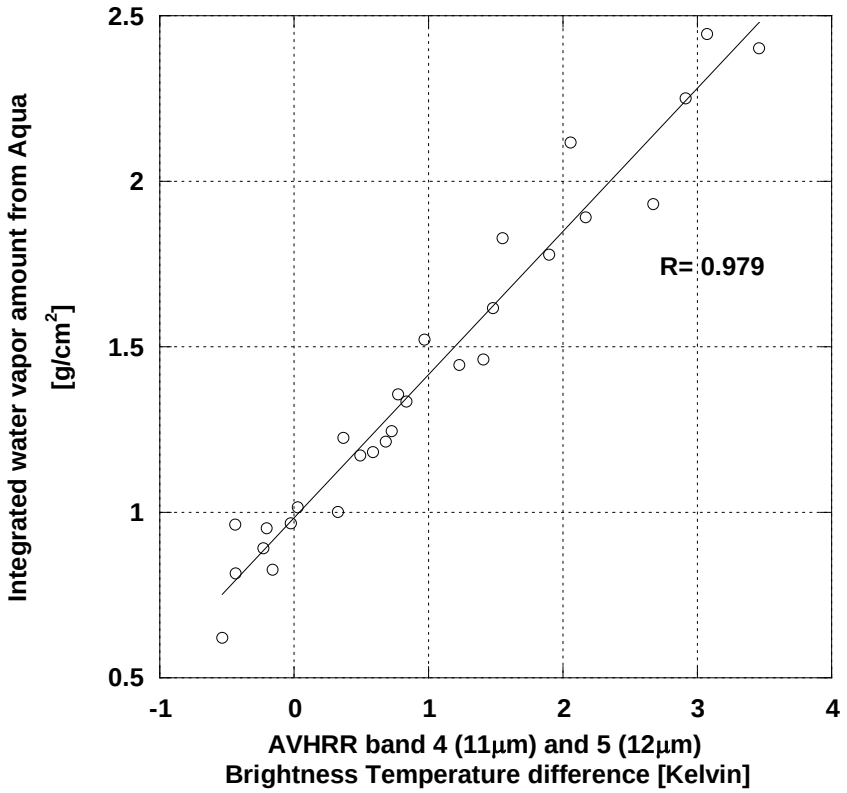
$\rho_{avhrr,i} = a_i \rho_{modis,j}$



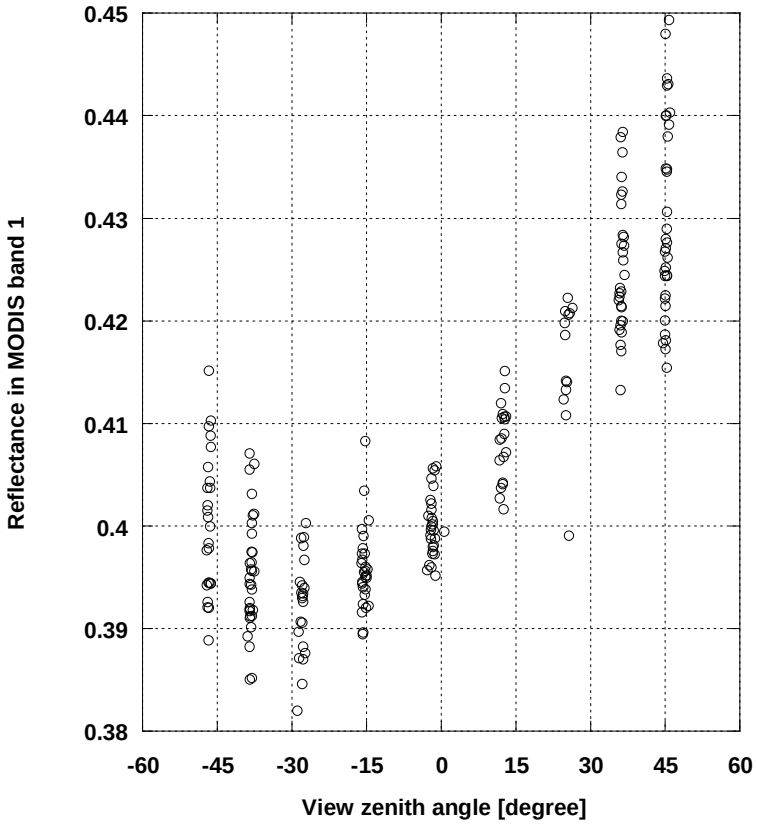
Spectral Translation coefficients			
	AVHRR 1 (0.645 μm)	AVHRR 2 (0.865 μm)	AVHRR 3 (1.6 μm)
a_i	0.952	0.988	0.994

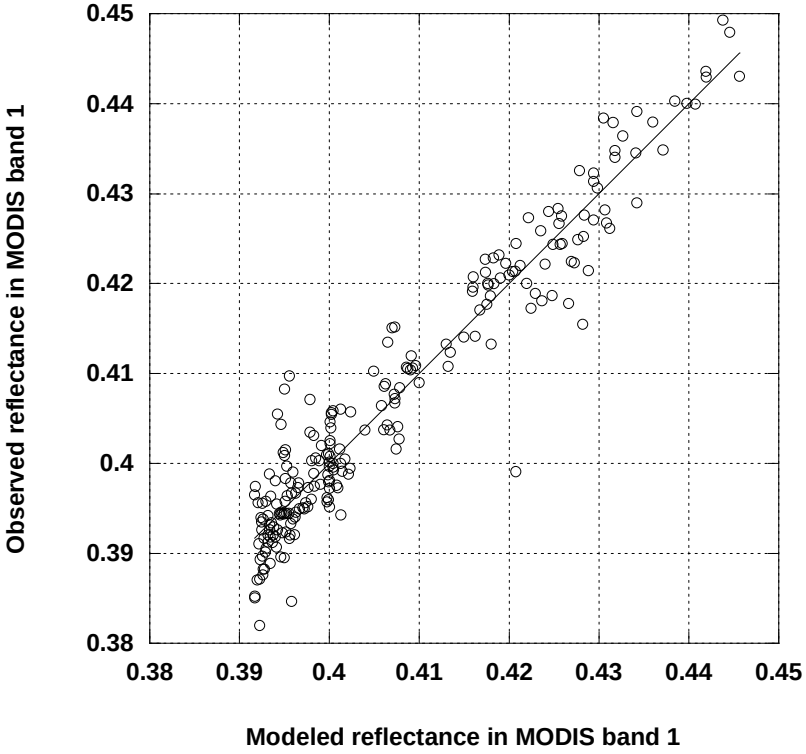
Atmospheric effect (water vapor)



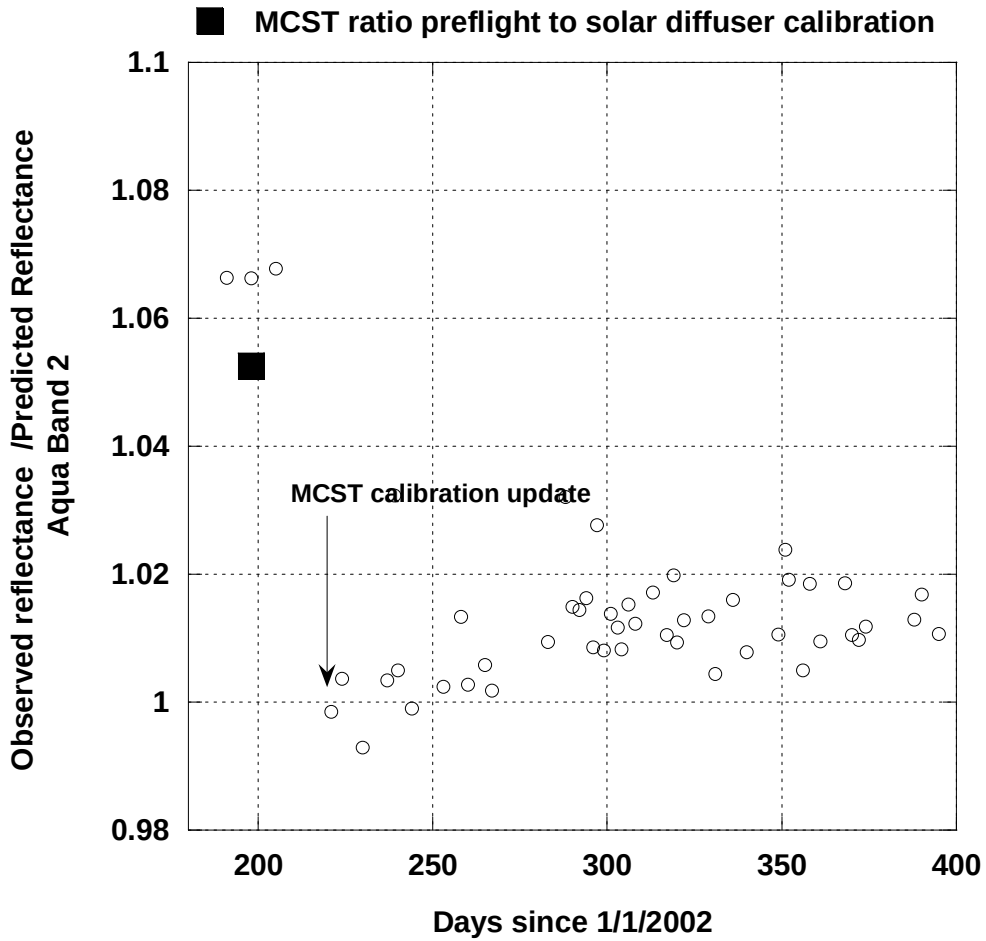


BDRF effect inversion (MODIS linear kernel approach)

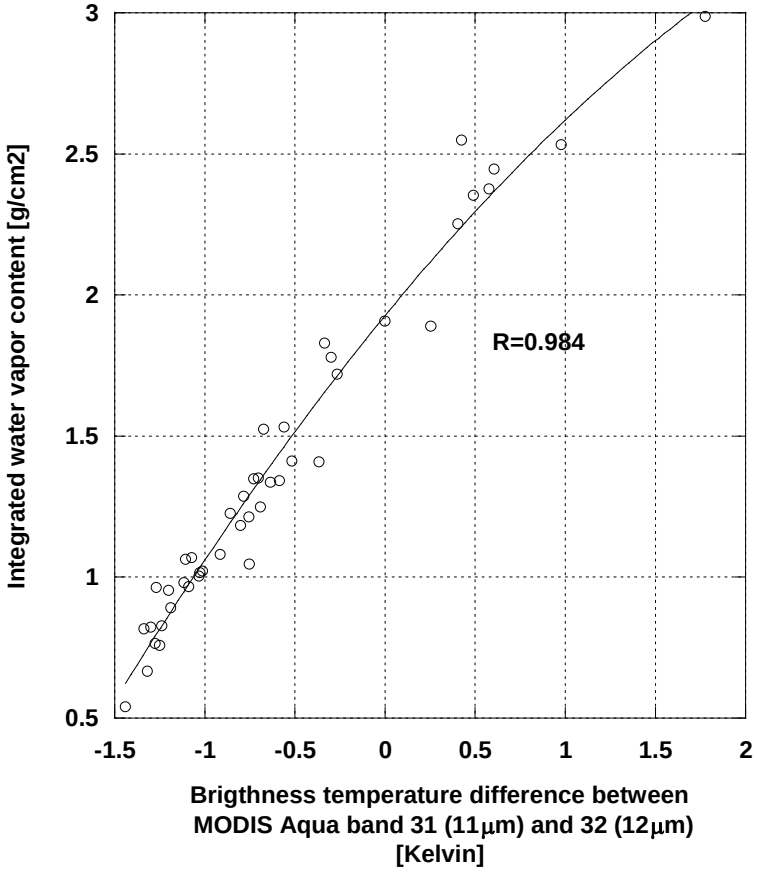




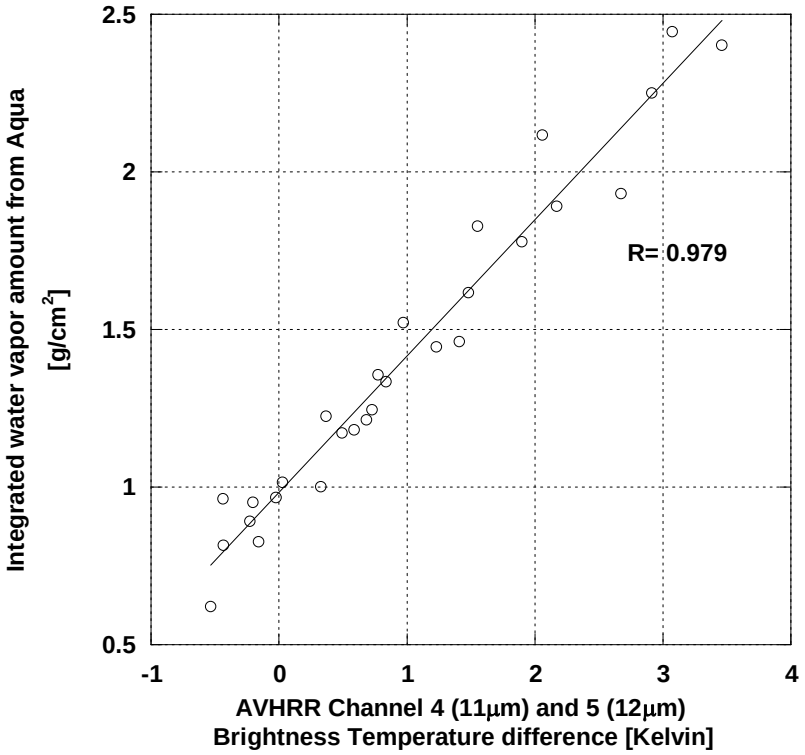
Test of the approach using Terra (MODIS morning) /Aqua (MODIS afternoon)

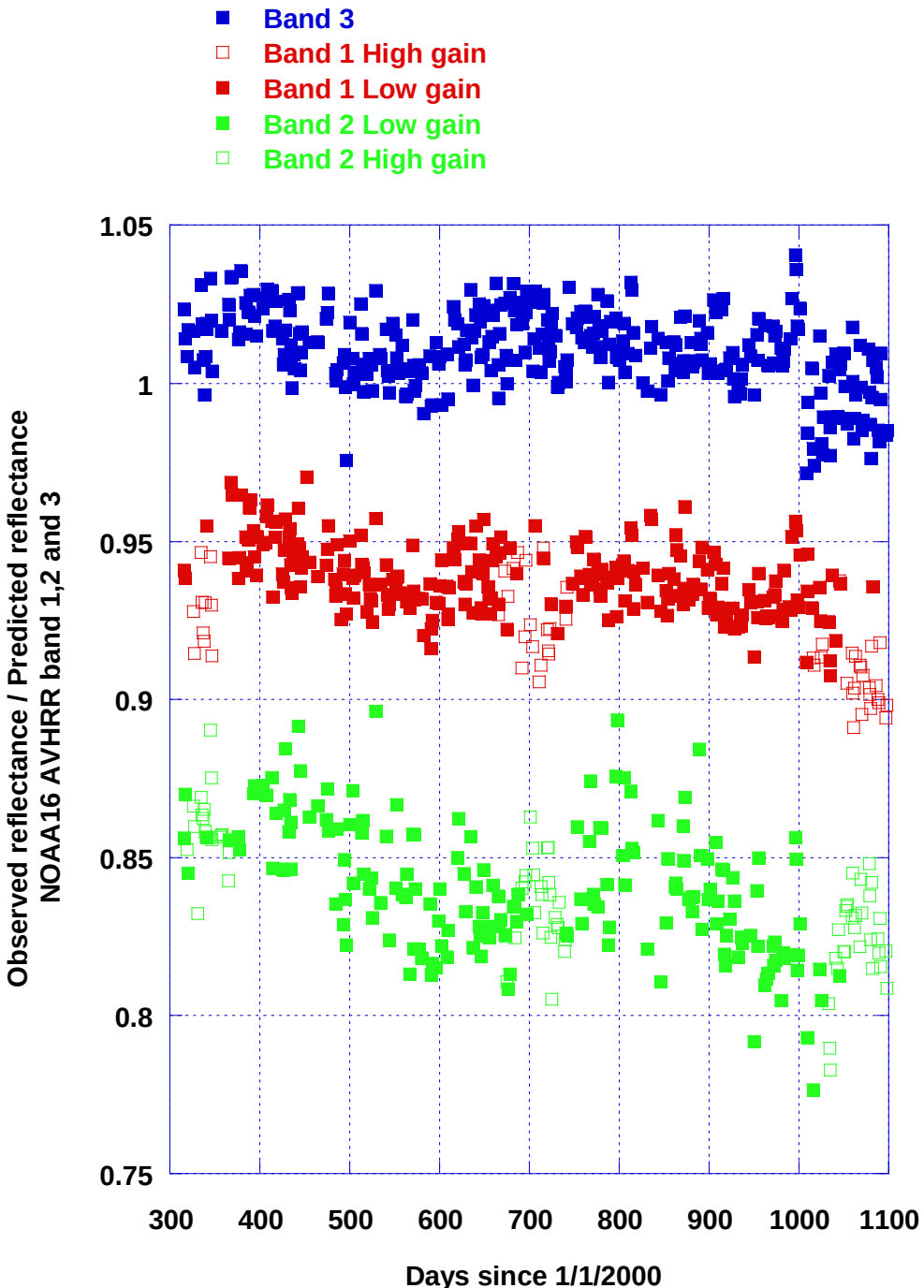


Retrieval of Water vapor from AVHRR



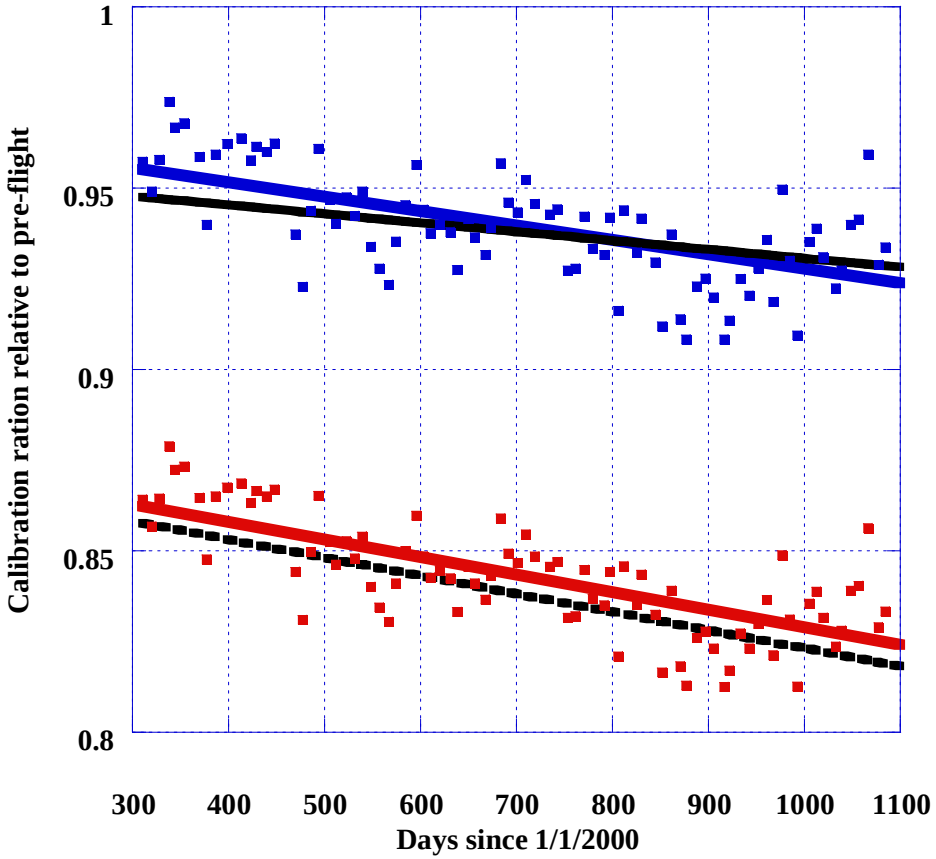
uwv [g/cm2] = 0.418 ΔT [K] + 1





Results for NOAA16

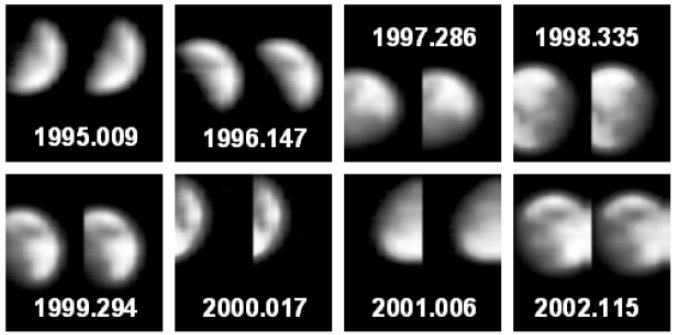
Comparison with independent Ocean and Clouds results



Comparison of the desert calibration trends for band 1 (black solid line) and band 2 (black interrupted line), with the trends obtained using the Ocean and Clouds method for band 1 (blue line and square) and band 2 (red line and square).

The coefficients were consistent within less than 1%

Comparison with lunar calibration



Cao, C., E. Vermote, and X. Xiong, Using AVHRR Lunar Observations for NDVI Long-term Climate Change Detection, *J. Geophys. Res.*, doi:10.1029/2009JD012179), 2009

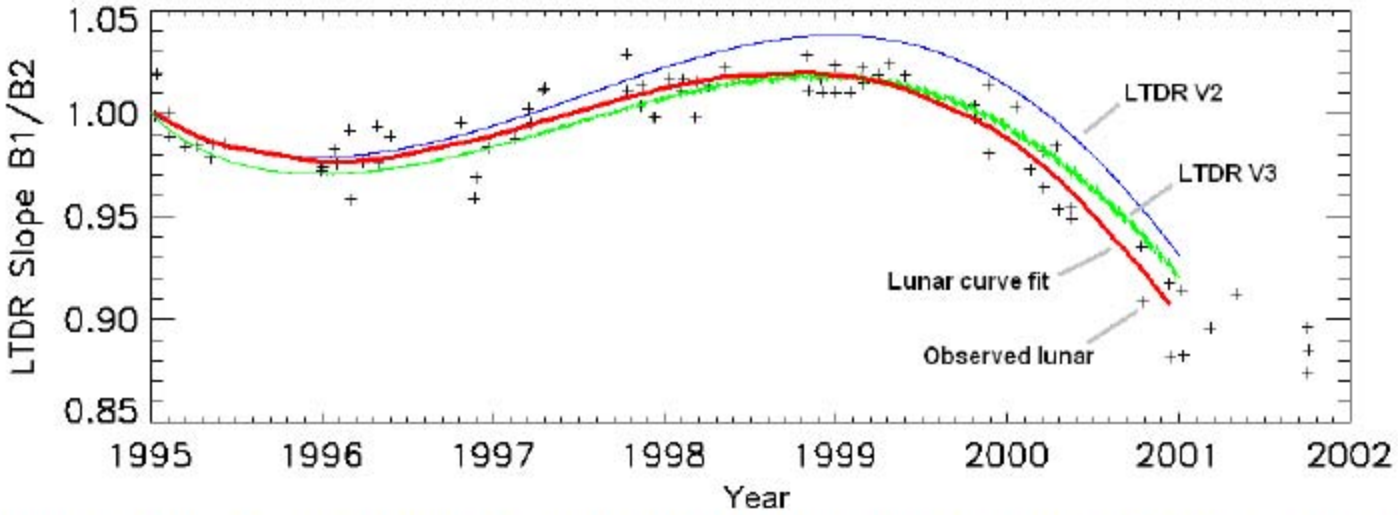
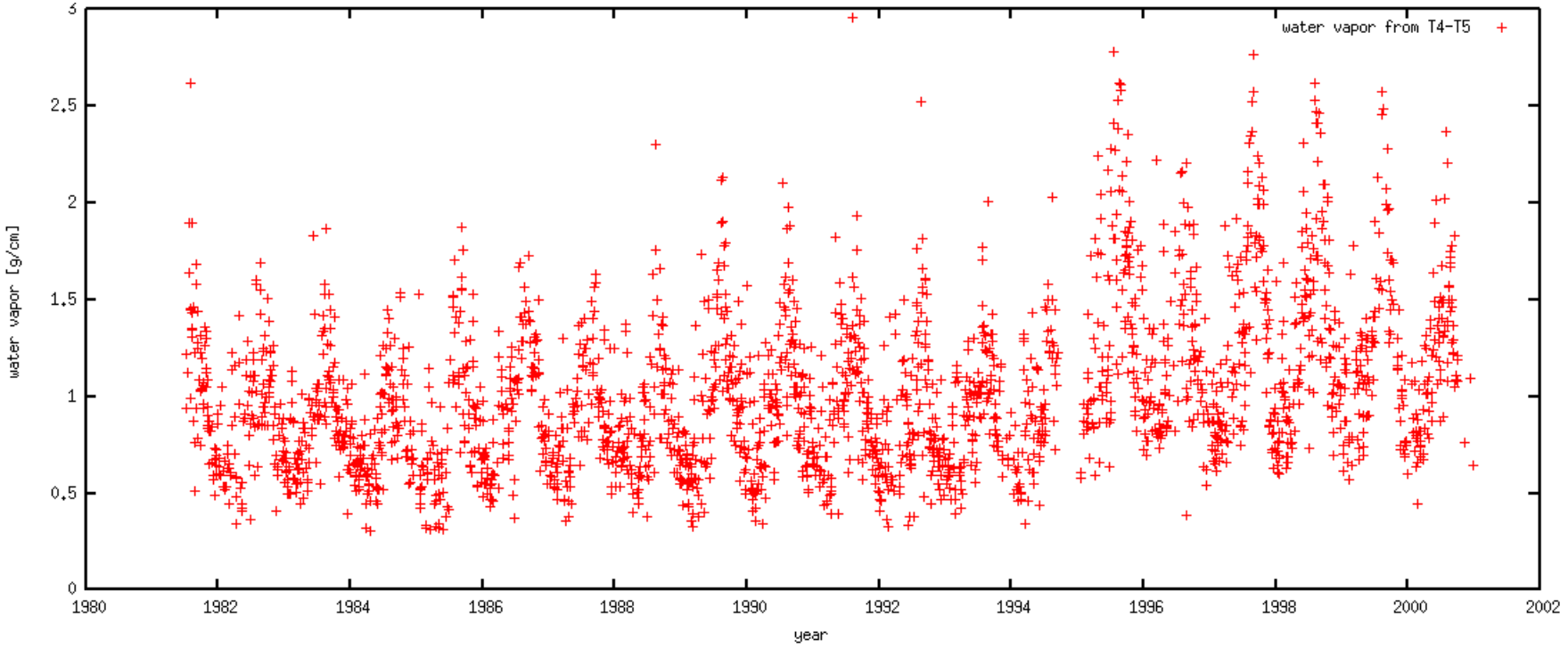


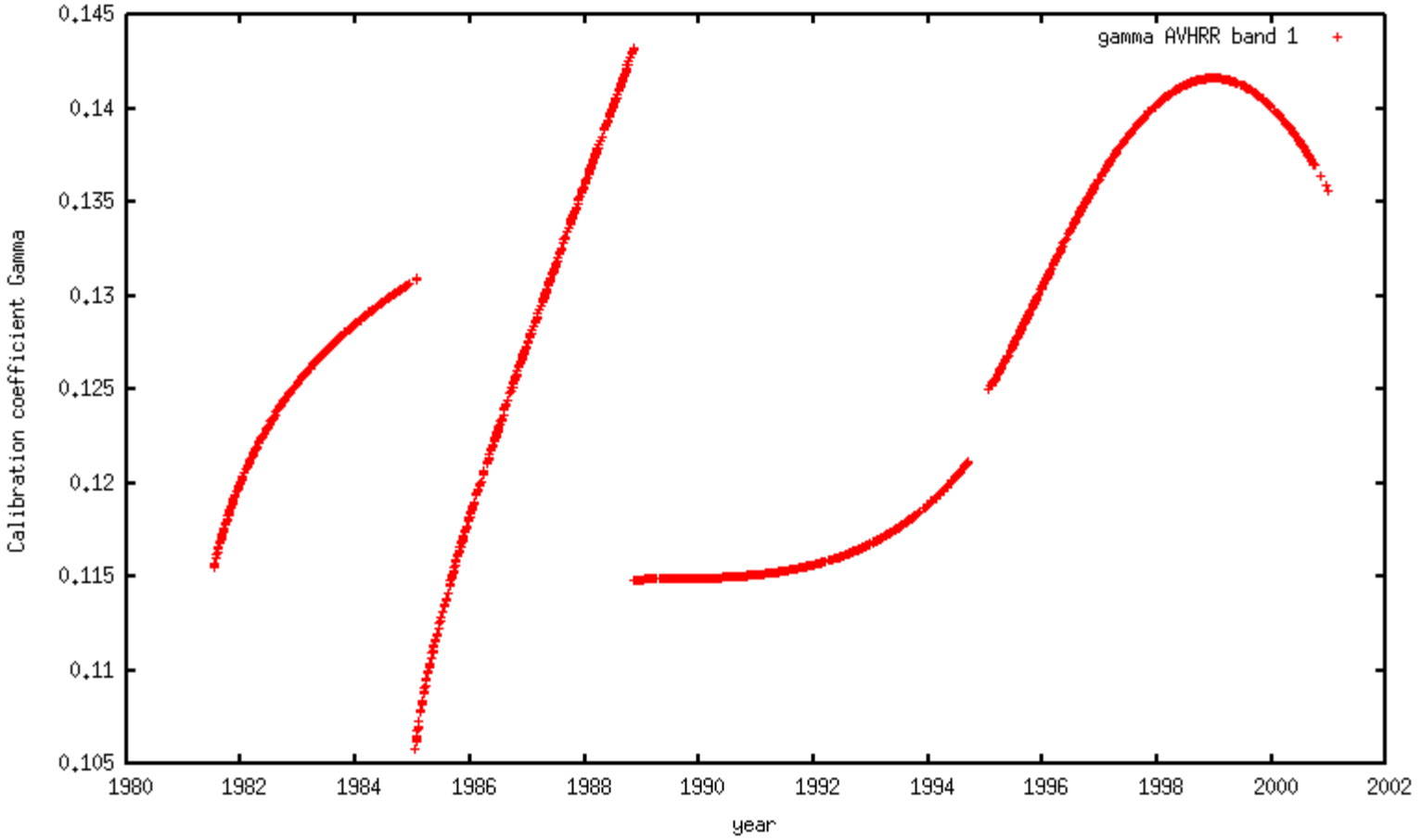
Figure 3. Comparison of the long-term trend of band 1 to band 2 ratio for NOAA-14 between lunar and LTDR (red=lunar curve fit; + = lunar observation; green = LTDR version 3; and blue = LTDR version 2).

Extension of Ocean and Clouds calibration evaluation to NOAA 7,9,11 and 14

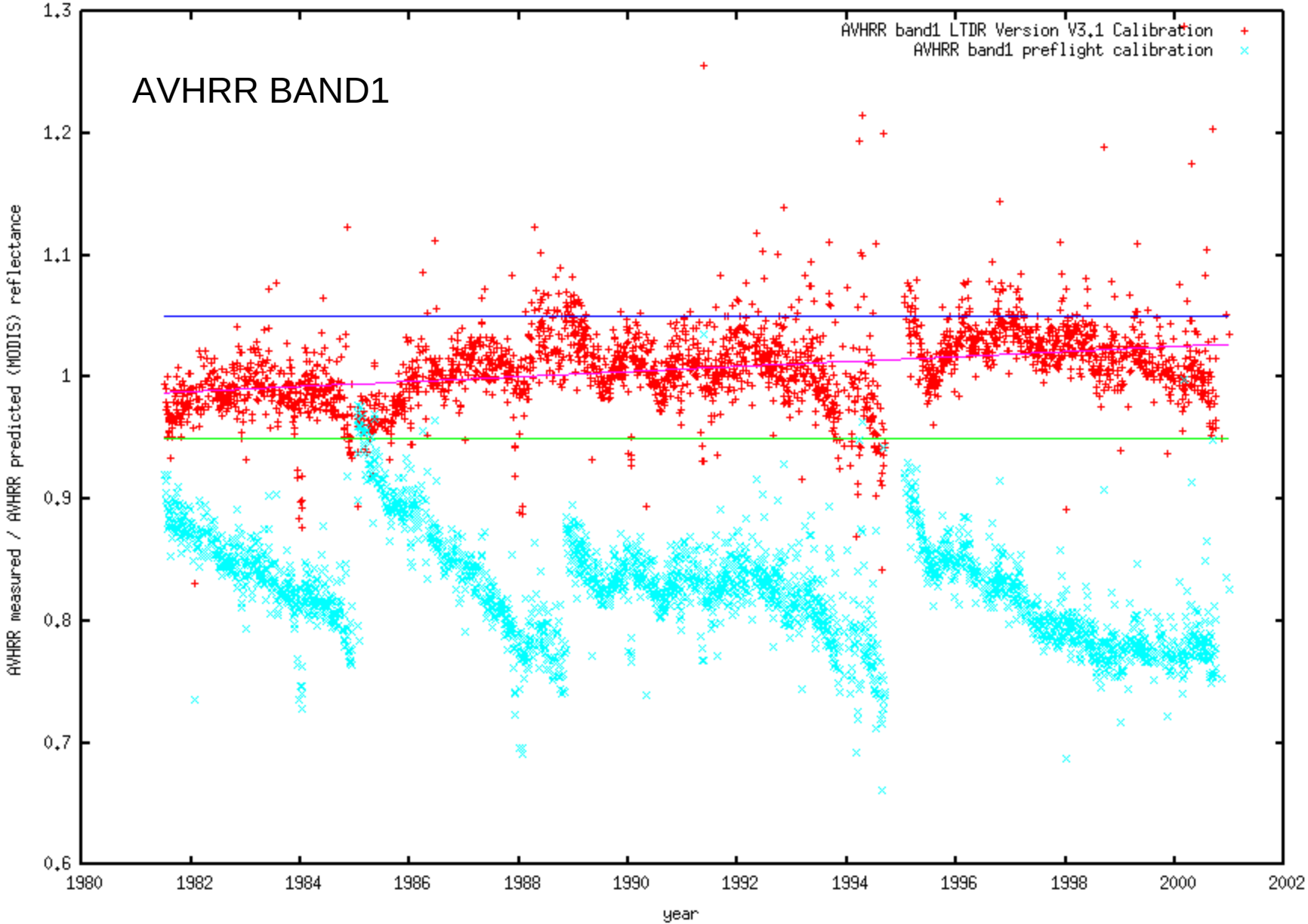
Water vapor retrieval from T4-T5



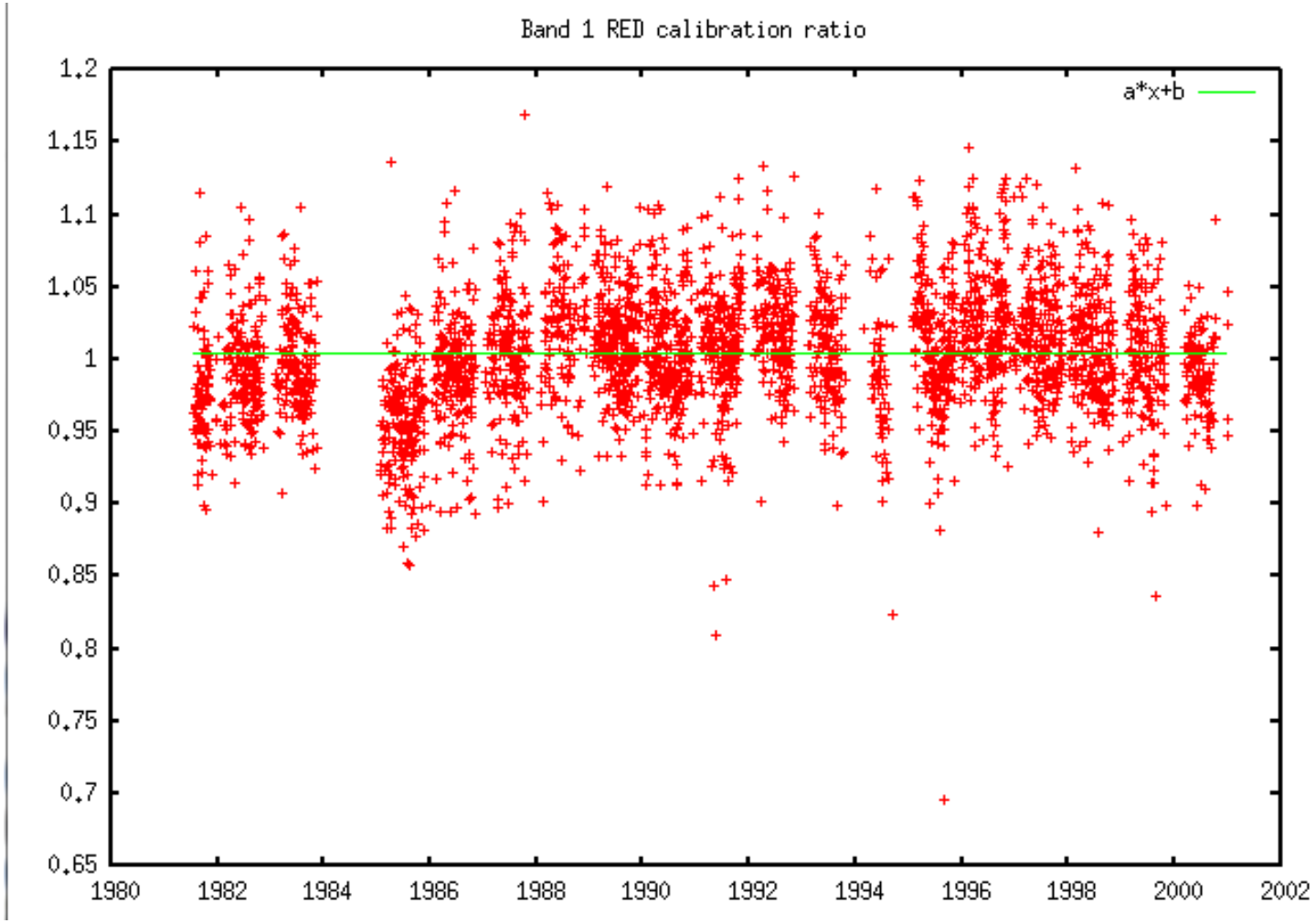
AVHRR band 1 calibration (Ocean-Clouds)



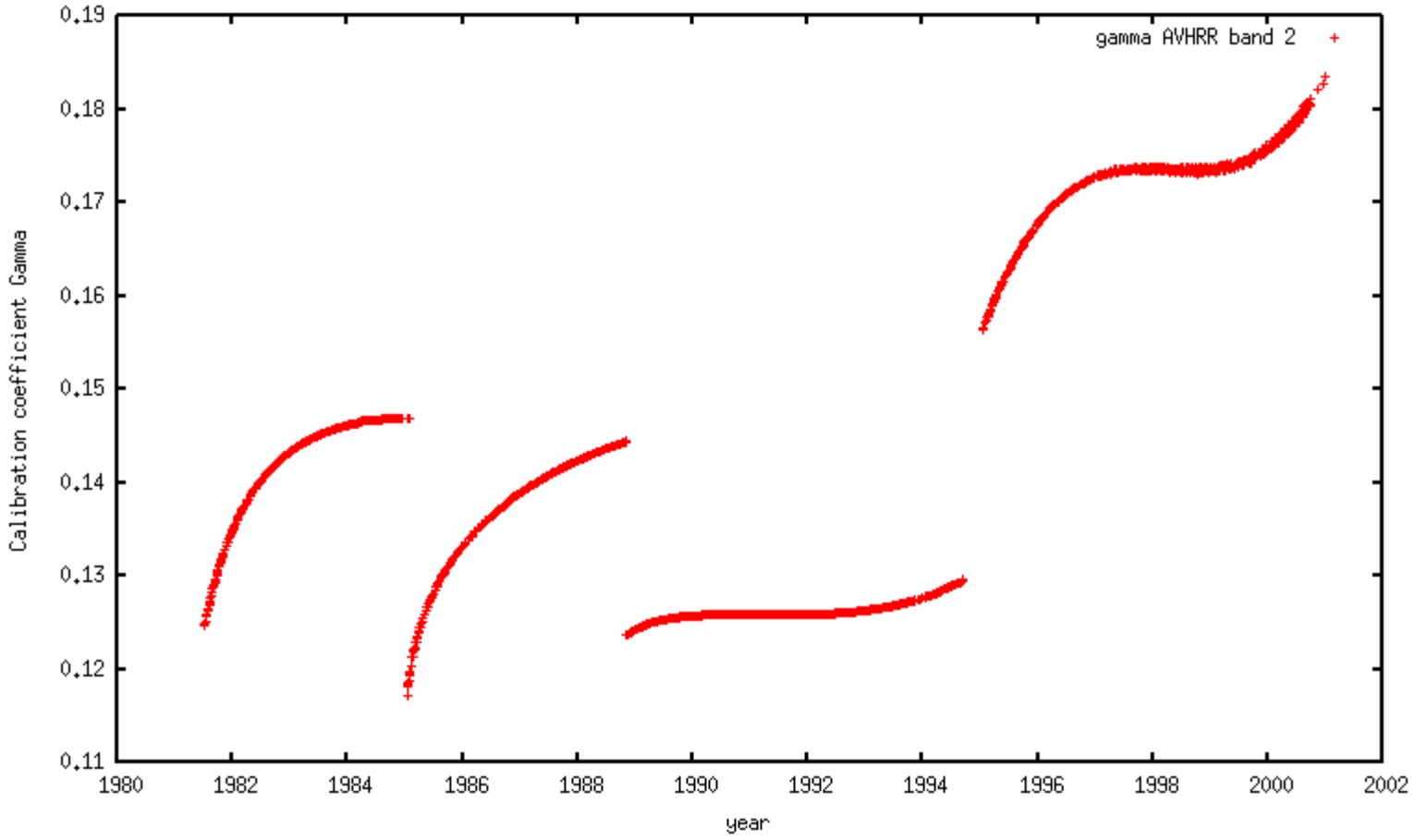
Extension of Ocean and Clouds calibration evaluation to NOAA 7,9,11 and 14



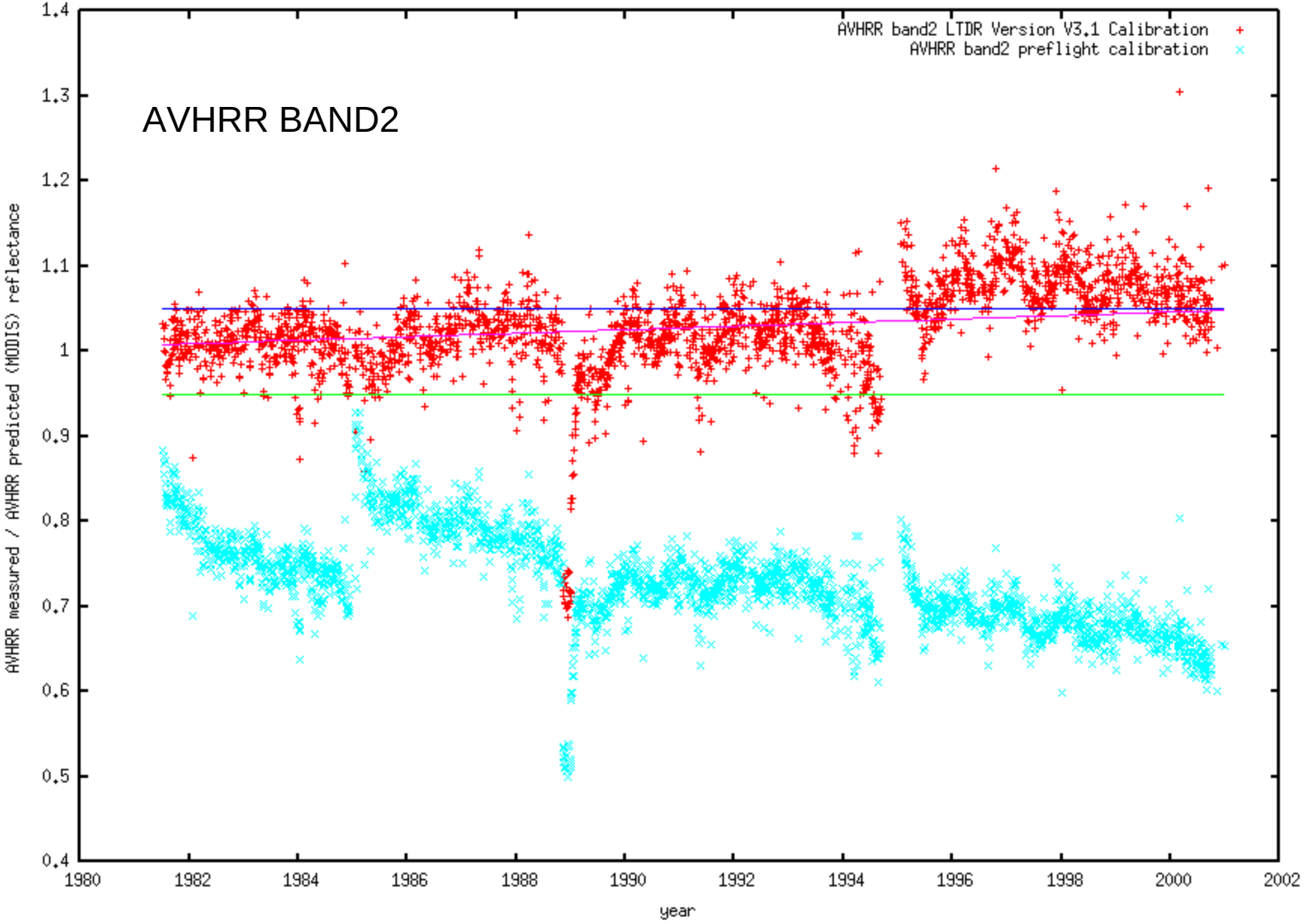
Band 1 results for NOAA7,9,11,14



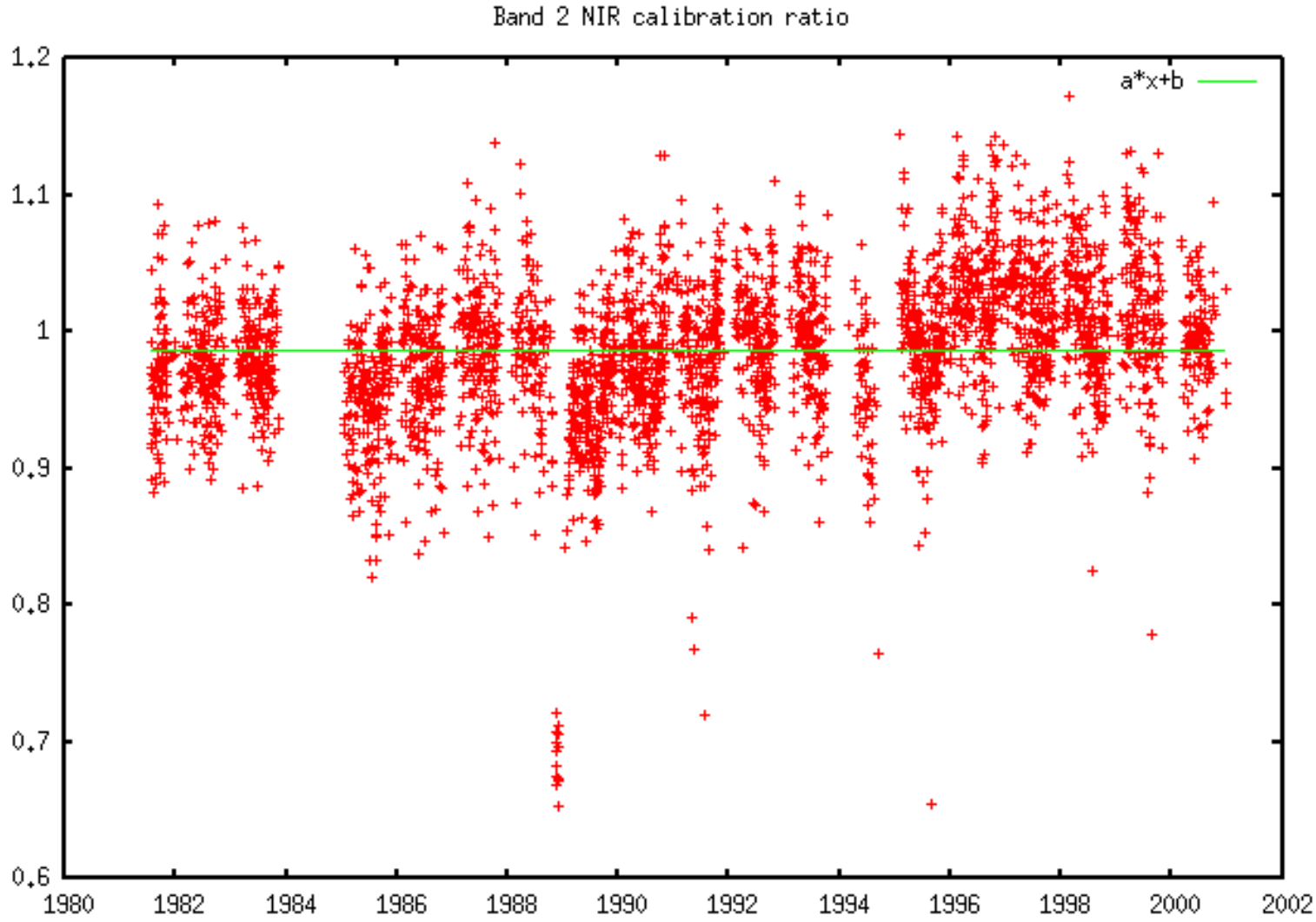
AVHRR band 2 calibration (Ocean-Clouds)



Extension of Ocean and Clouds calibration evaluation to NOAA 7,9,11 and 14



Band 2 for NOAA 7,9,11,14



Conclusions

- AVHHR long term time series is invaluable for climate studies but suffers from lack of onboard calibration.
- Methods for vicarious calibration could now be evaluated using new generation of sensors (MODIS,VIIRS).
- Convergence of results from different approaches accounting for specific sources of uncertainties (e.g orbital drift) will enable to recommend a set AVHRR absolute calibration coefficients and associated uncertainties.