

# Long Term Monitoring of GOME/ERS-2 Calibration Parameters

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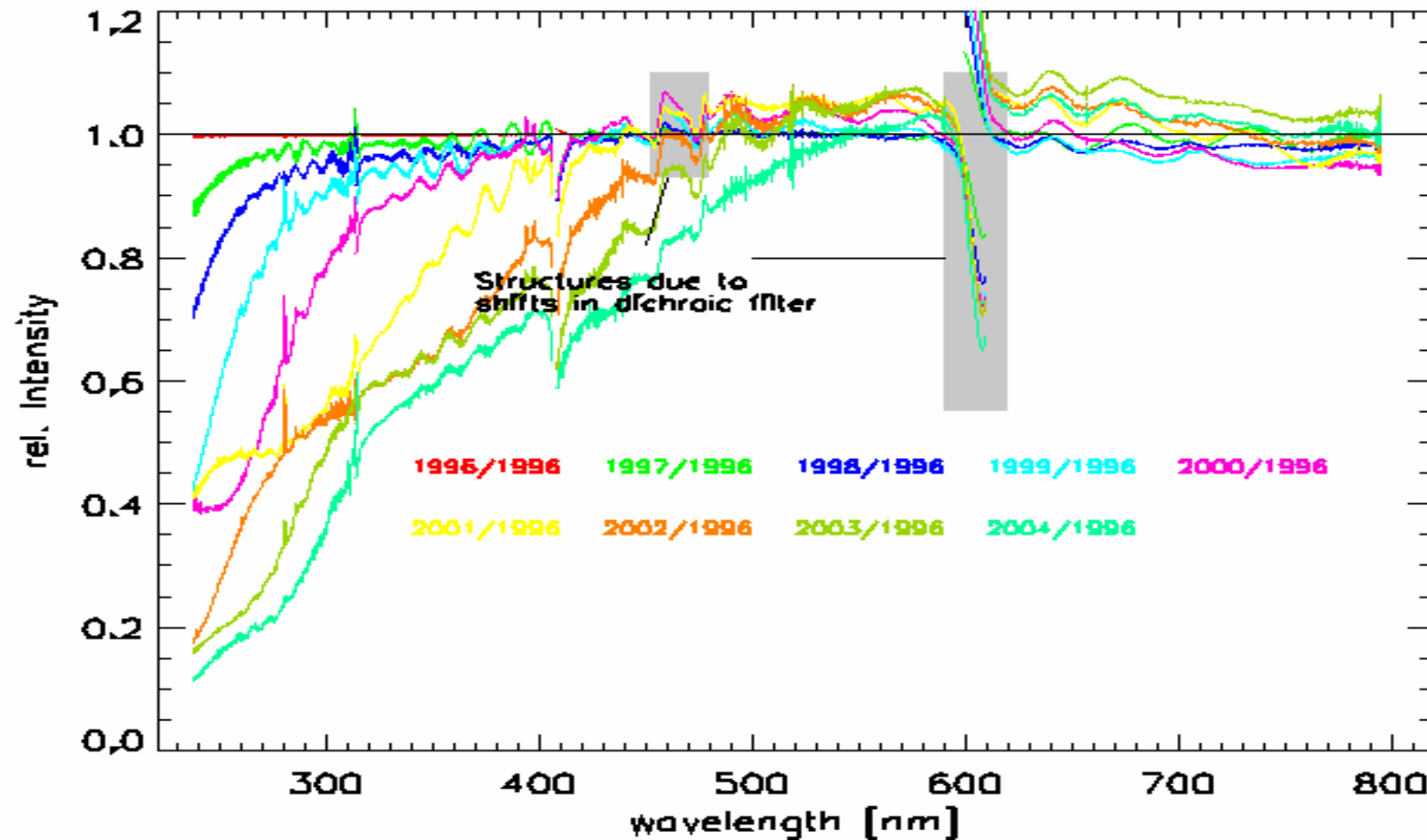
# Introduction

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- GOME Degradation
- Seasonal Dependence of Sun diffuser BSDF
- In-Flight Calibration Parameters
- Comparison of the In-Flight Calibration Parameters
- Conclusions

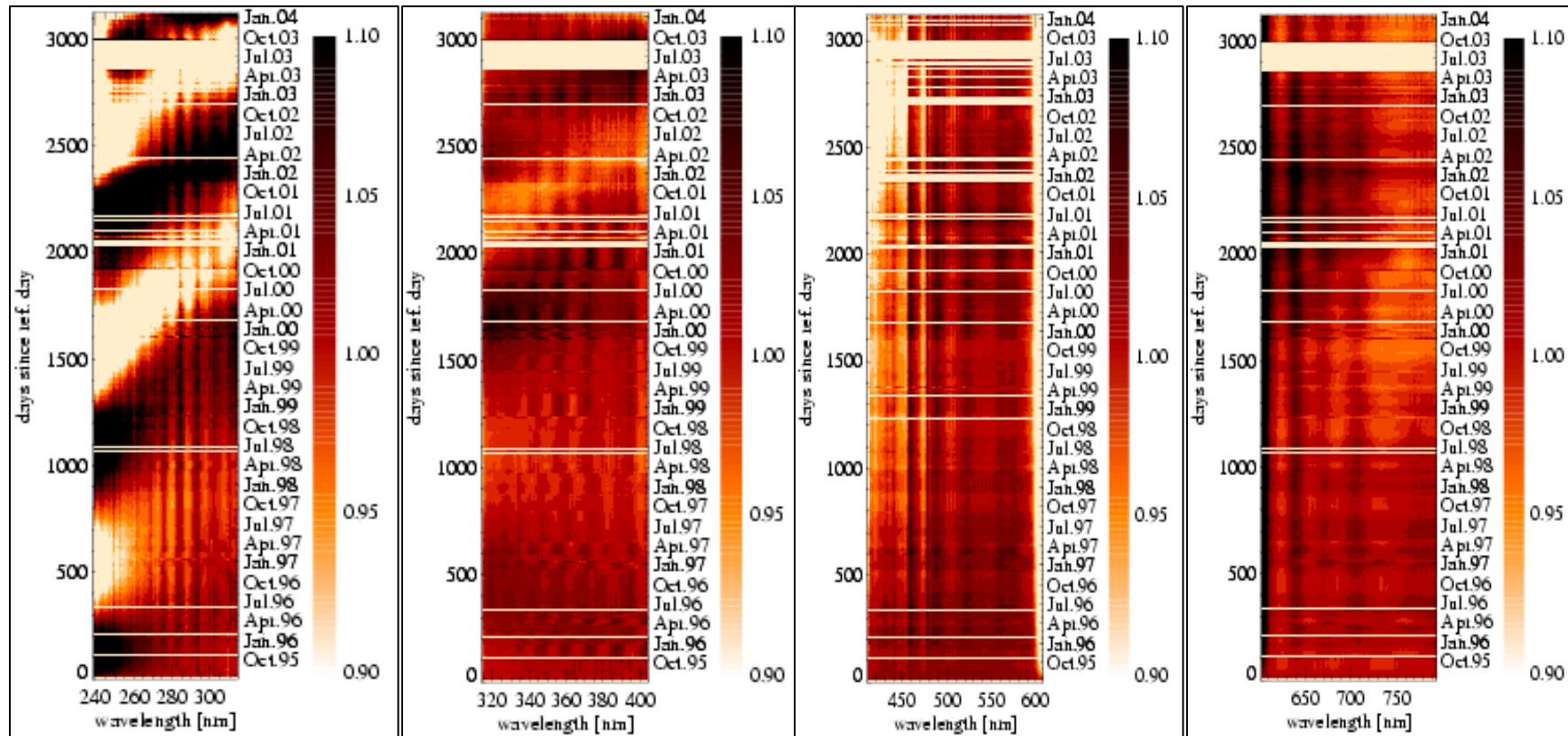
# GOME Degradation – Changes in the last 9 years

Sun Degradation relative to January 8th, 1996



# GOME Degradation - Corrections

$$\frac{I_{\text{sun}}(\lambda, t)}{I_{\text{Sun}}(\lambda, t_o = \text{July } 3, 95)} = P_{\text{Degradation}}(\lambda, t) \cdot C_{\text{SunEarthDistance}}(\lambda, t) \cdot C_{\text{BSDF}_{\text{az}}}(t) \cdot \text{Residual}_{\text{Etalon}}(\lambda, t) \cdot \text{Residual}(\lambda, t)$$

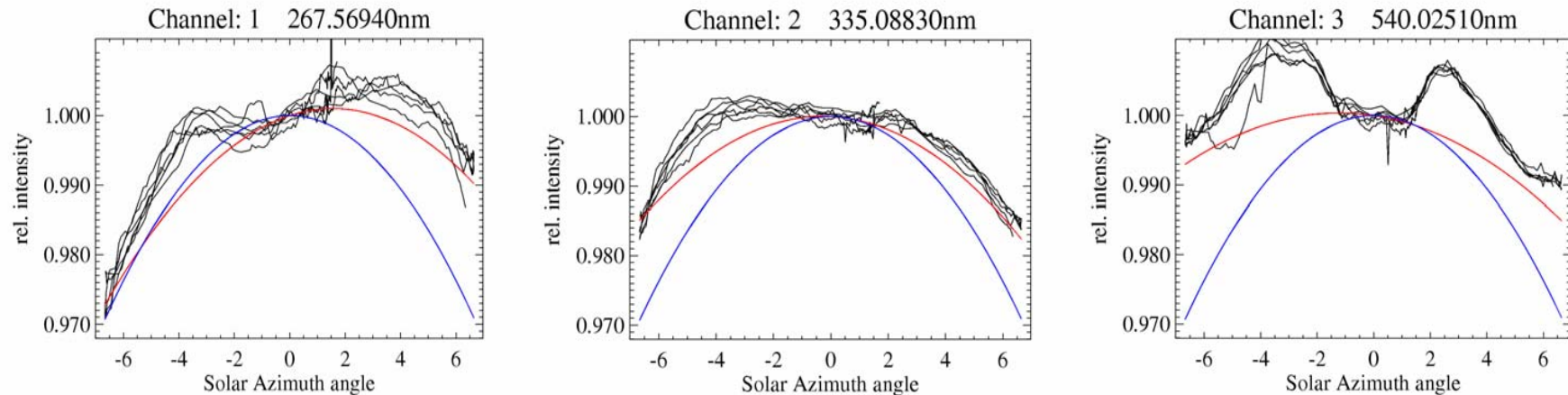


## Seasonal Dependence of Sun Diffuser BSDF (1)

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- A long time series of GOME solar measurements enables **in-orbit calibration** of the Sun-diffuser
- Absolute BSDF calibration cannot be done using GOME measurements alone (needs comparison to a radiative transfer model) but a relative determination (e.g., wrt. begin-of-life in orbit) is possible
- GOME solar measurements contain information on the combined effect of instrument degradation and diffuser BSDF
- If a time window can be found where the degradation proceeds at a steady rate, then the degradation can accurately be modeled by a polynomial function, and seasonal variation on the BSDF becomes apparent
- Low-pass filtering in wavelength removes problems with changing detector (ice) etalon ( but wipes out spectral features)
- High-pass filtering in wavelength may show spectral features on the BSDF

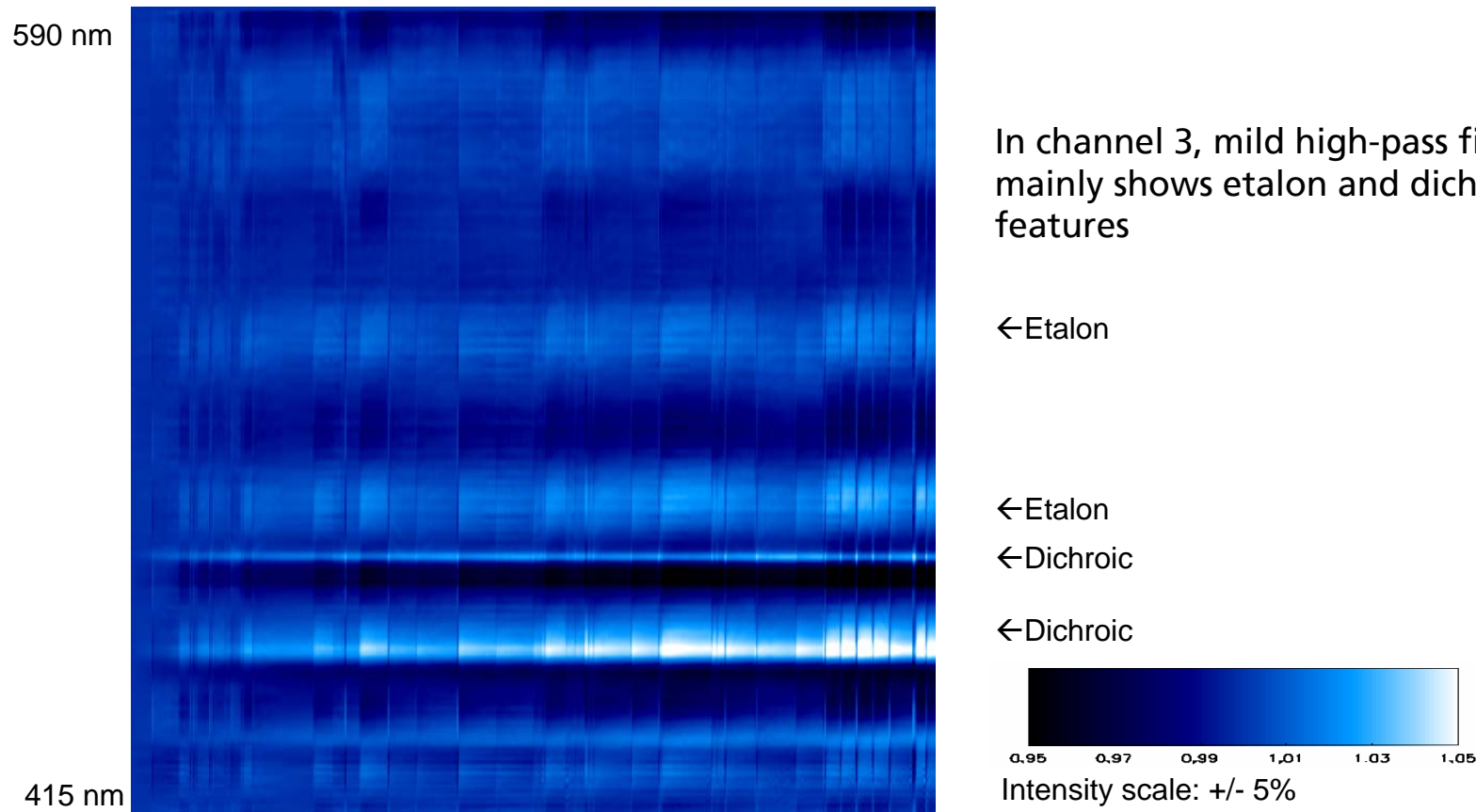
## Seasonal Dependence of Sun Diffuser BSDF (2)



- The intensity changes (black curve, normalised to azimuth 0) represent the BSDF sensitivity to solar azimuth angle  
( blue curve: on-ground calibration      red curve: GDAQI calibration )
- Note that the azimuth dependence can be reproduced within 0.2 – 0.3 % accuracy from cycle to cycle  
( reflects probably accuracy of degradation modelling, BSDF stability may be better)
- As a side remark: recent on-ground calibration of GOME-2 Aluminium diffuser showed similar behaviour

## Seasonal Dependence of Sun Diffuser BSDF (3)

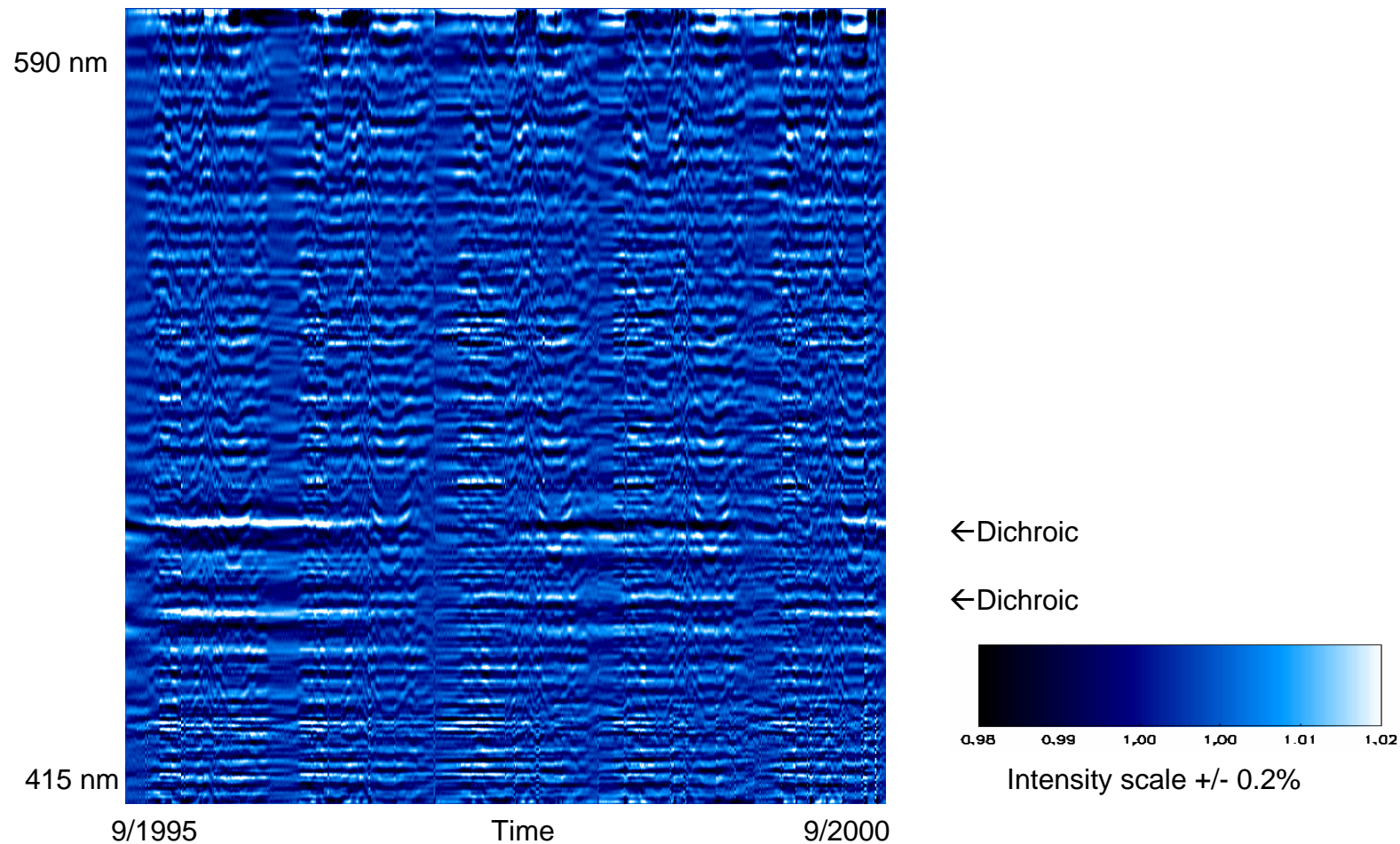
- High-pass filtering yields spectra corrected for long-term transmission degradation, hence longer time series can be analysed (shown here are 5 years of data up to Sept. 2000)
- In channels 1 and 2 no clear high-frequency features are visible, but channels 3 and 4 show ripples which change with azimuth angle





## Seasonal Dependence of Sun Diffuser BSDF (4)

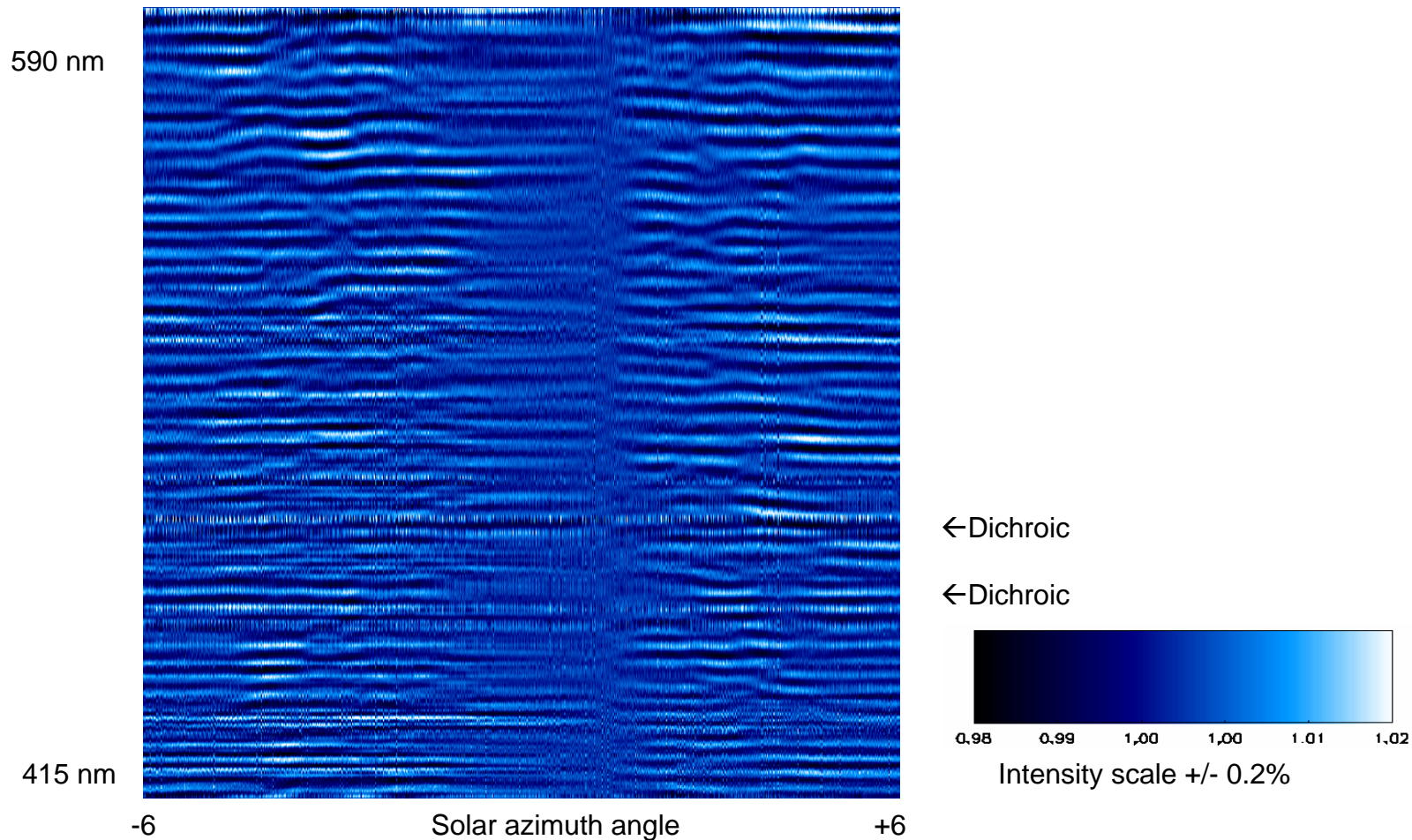
- In channel 3, aggressive high-pass filtering clearly shows high-frequency ripples with a pattern that repeats in time



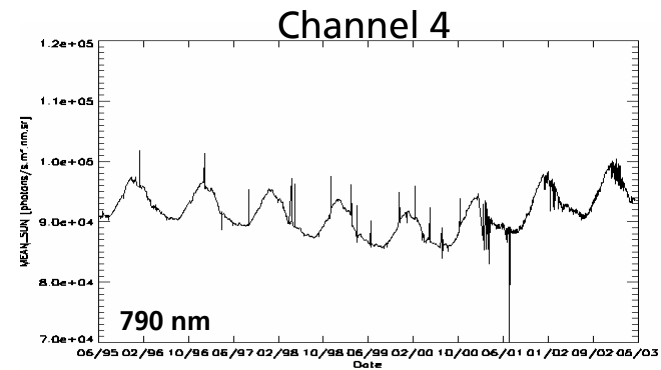
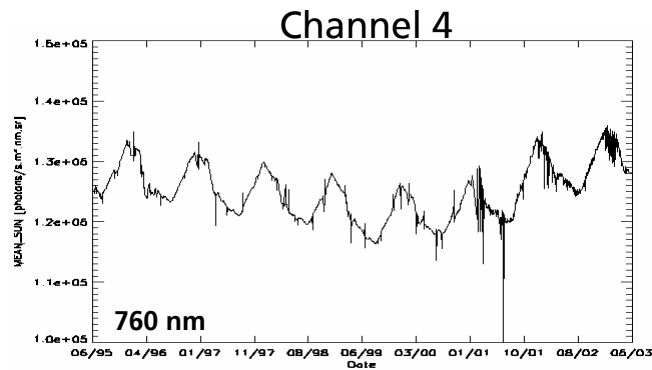
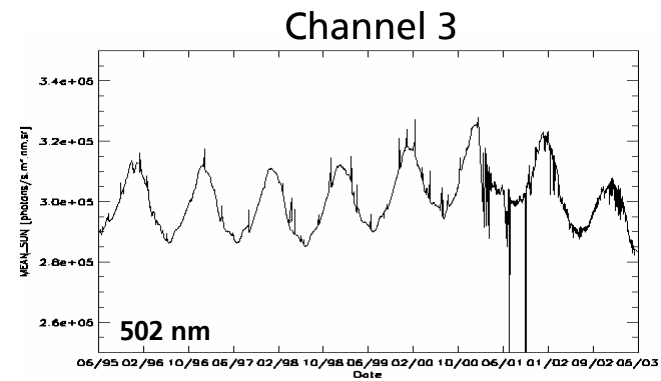
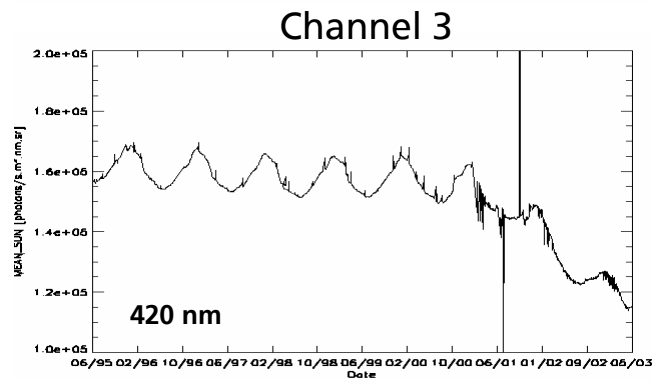
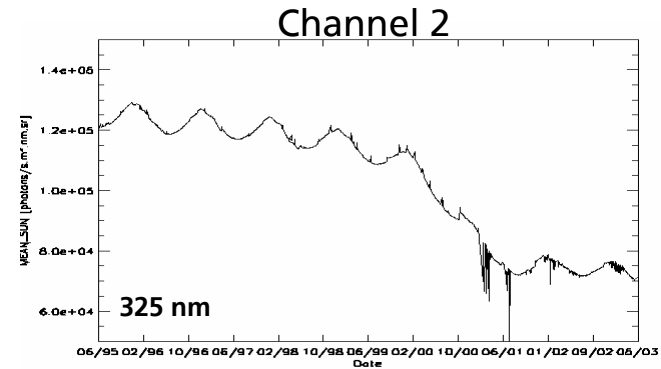
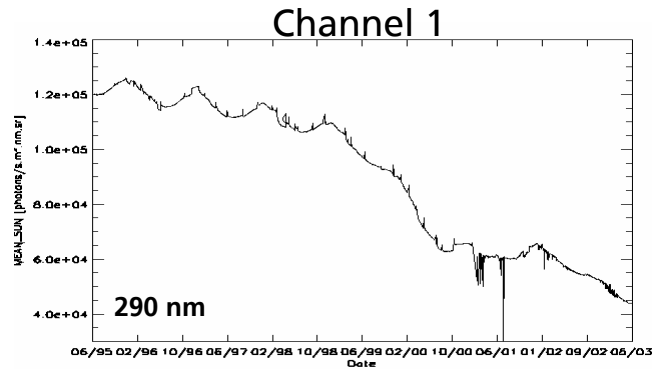


## Seasonal Dependence of Sun Diffuser BSDF (5)

- When data are plotted in order of ascending azimuth angle (from -6 to +6) the stability of the features over the analysis period is apparent (note: no smoothing applied ! Data are really that reproducible)

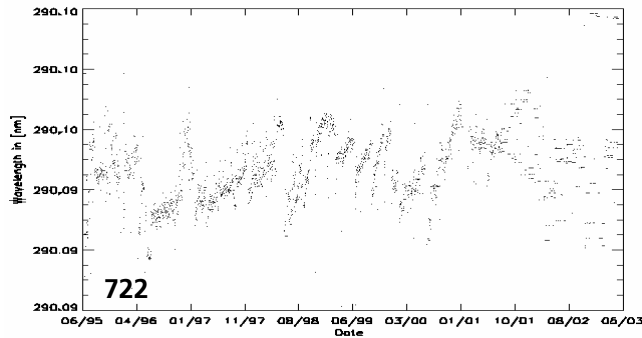


# Calibration Parameters – Sun Mean Reference

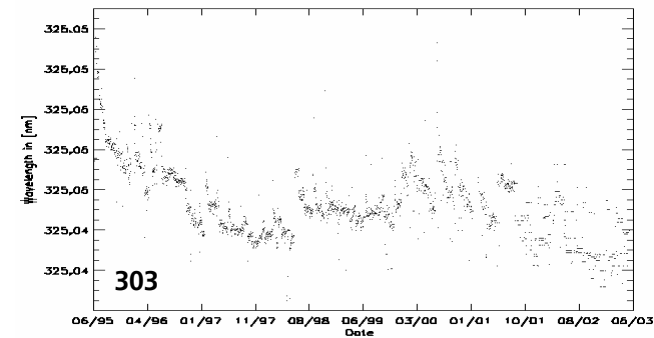


# Calibration Parameters – Wavelength Calibration

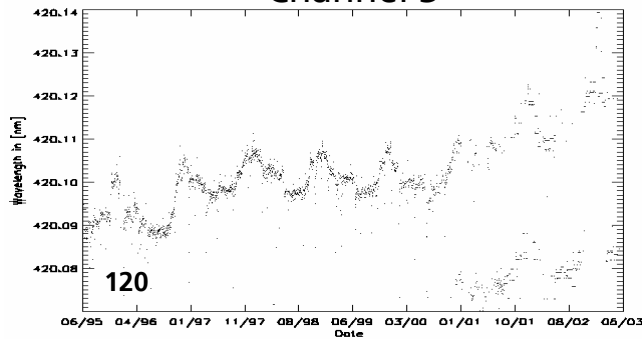
Channel 1



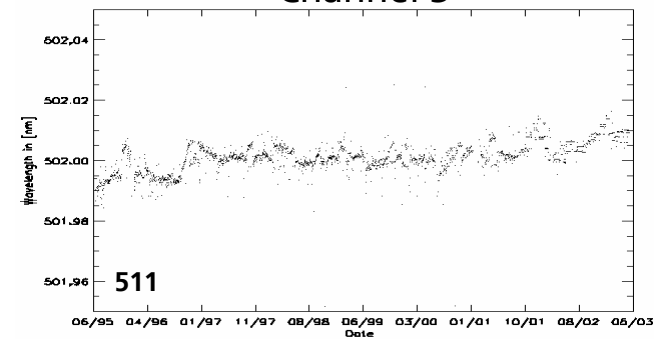
Channel 2



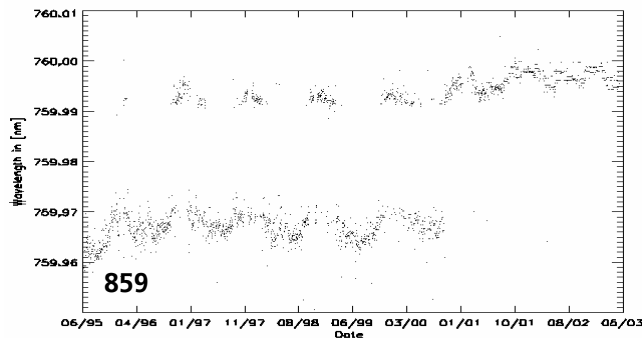
Channel 3



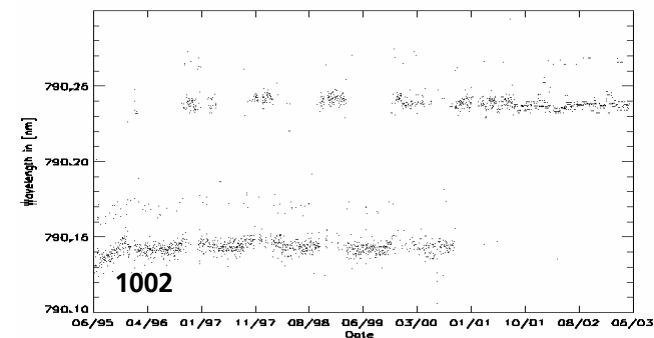
Channel 3



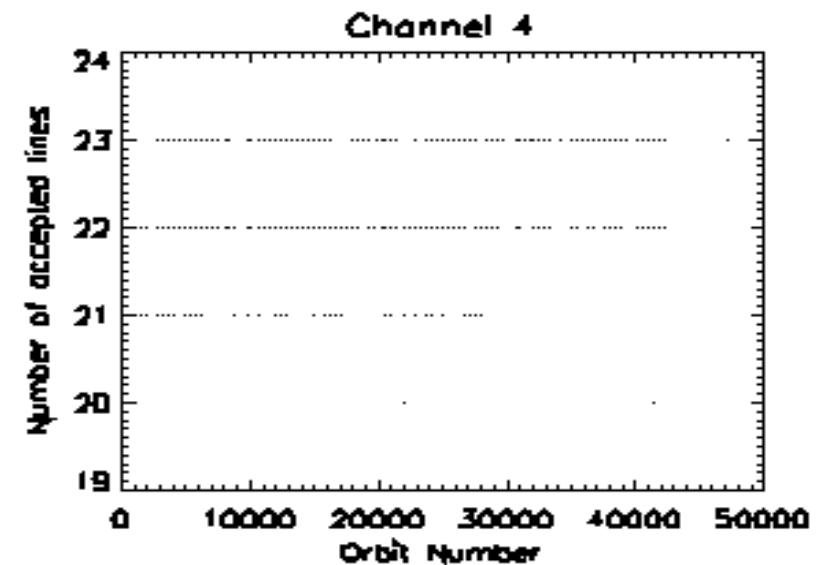
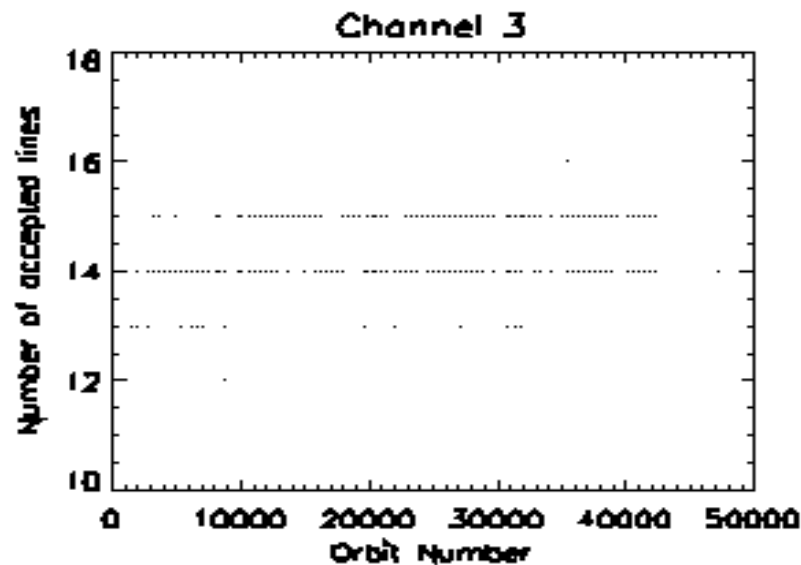
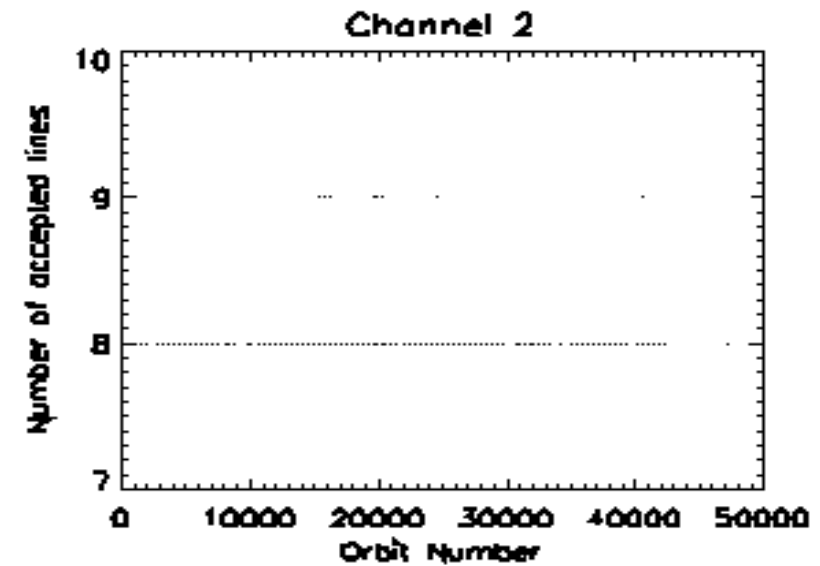
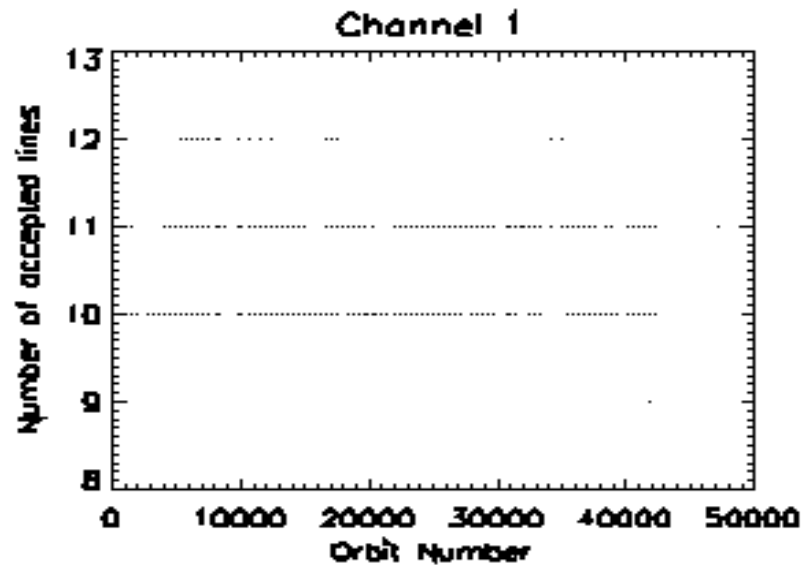
Channel 4



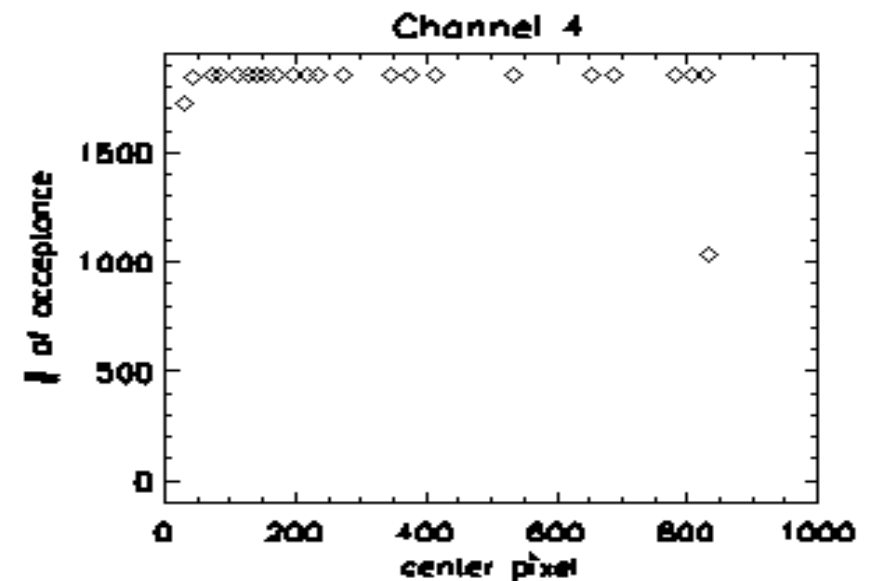
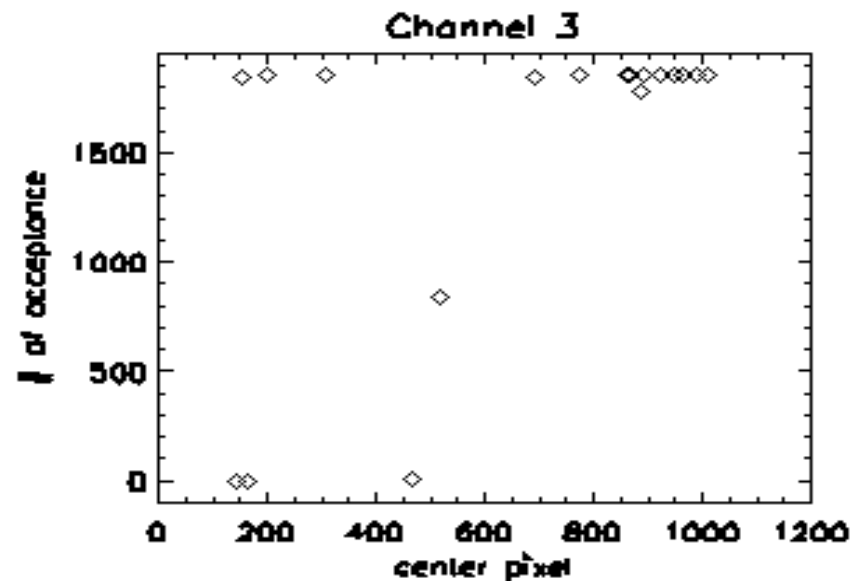
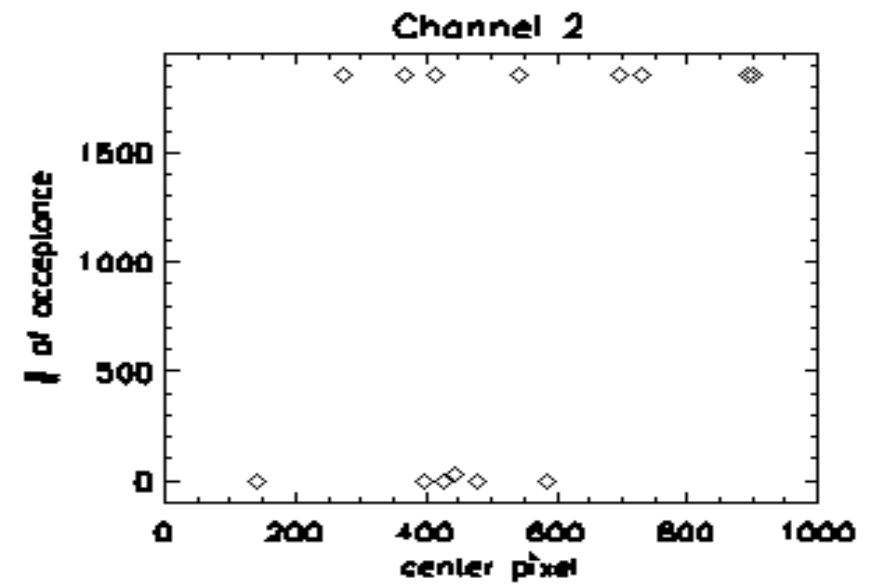
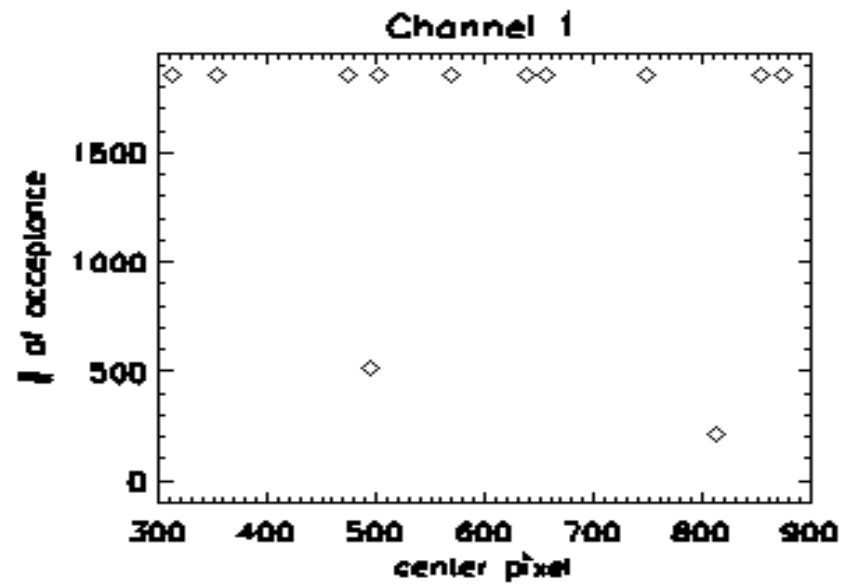
Channel 4



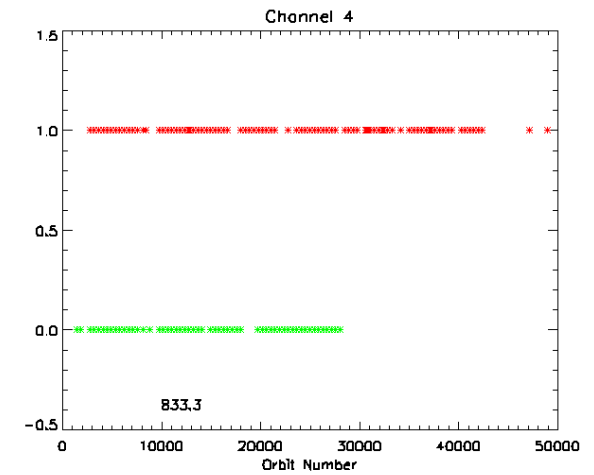
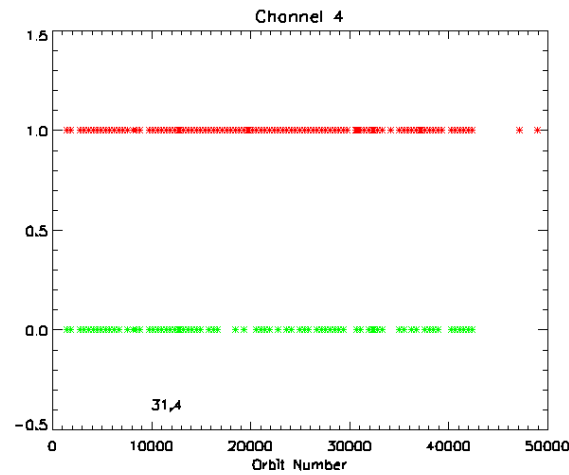
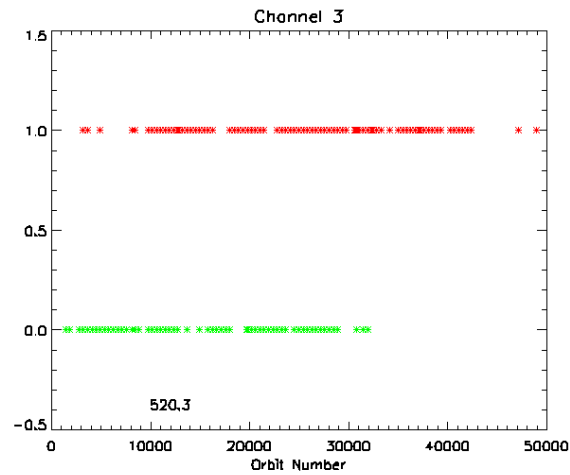
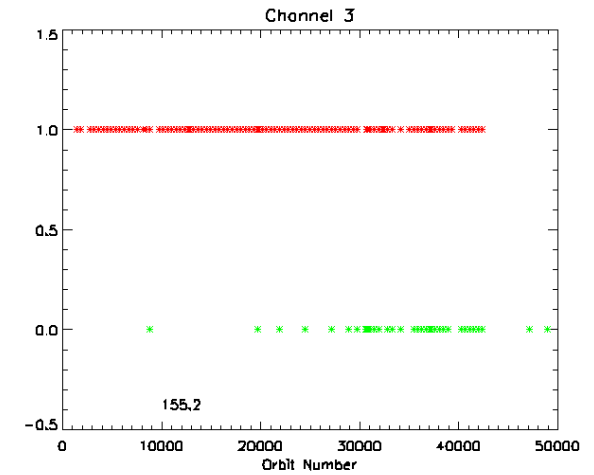
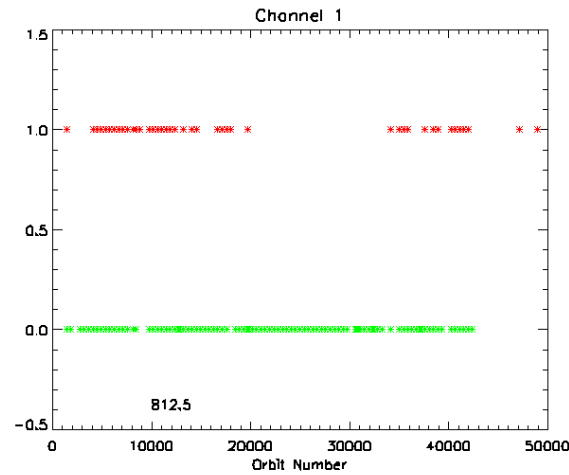
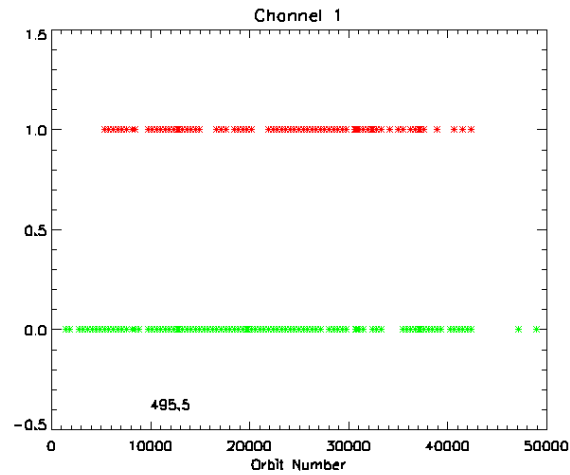
# Calibration Parameters – Wavelength Calibration



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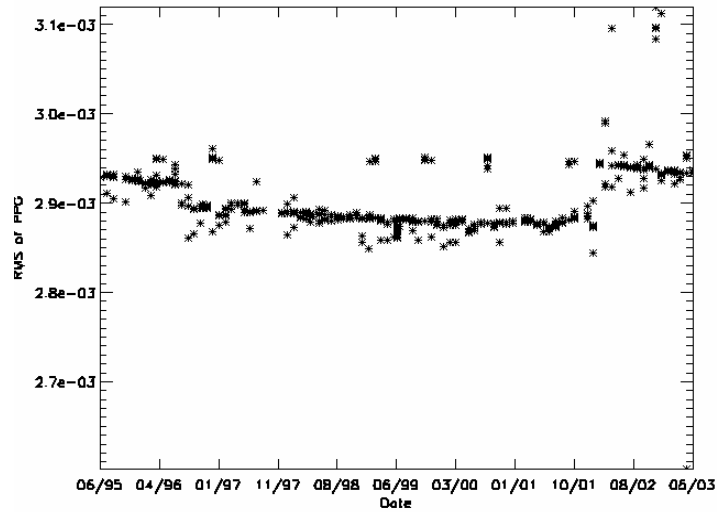


# Calibration Parameters – Wavelength Calibration

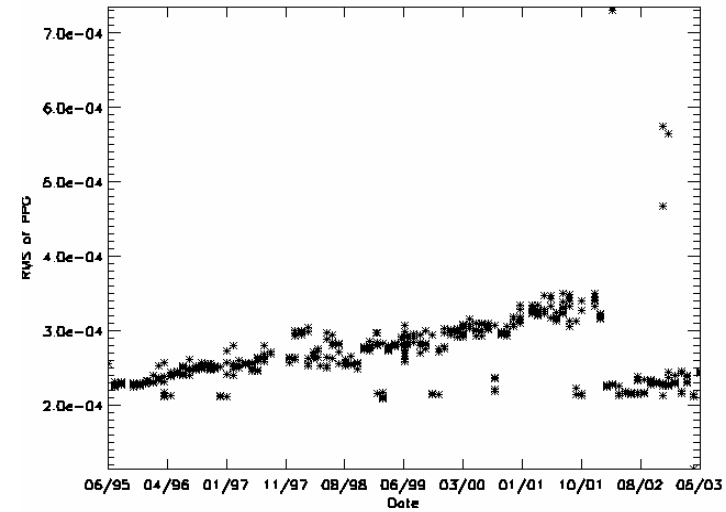


# Calibration Parameters – Pixel-to-Pixel Gain

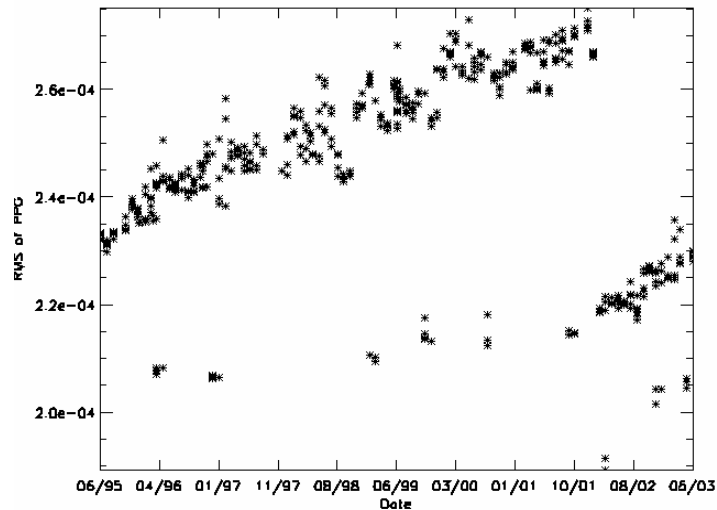
Channel 1



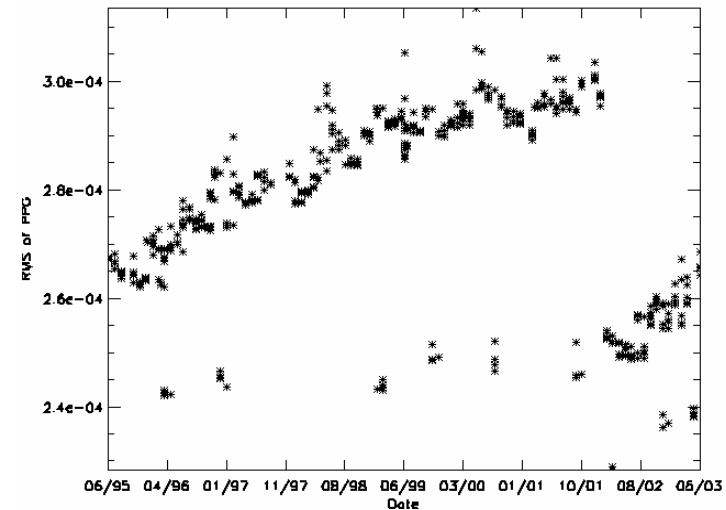
Channel 2



Channel 3



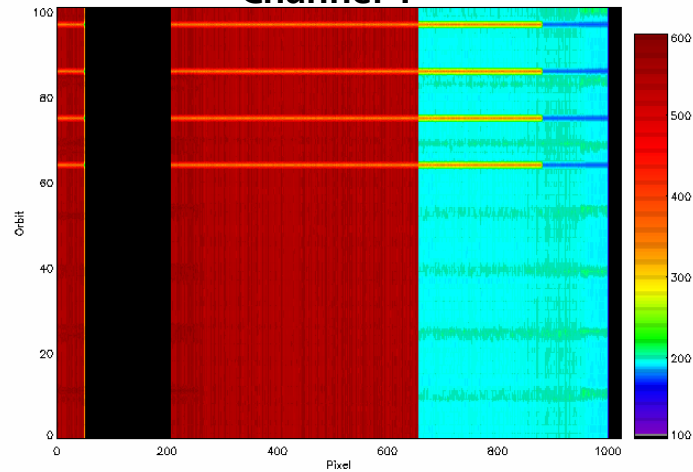
Channel 4



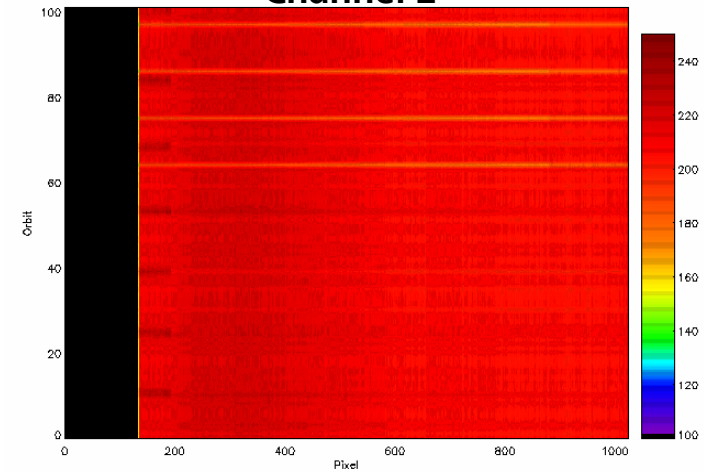


# Calibration Parameters – Leakage Current

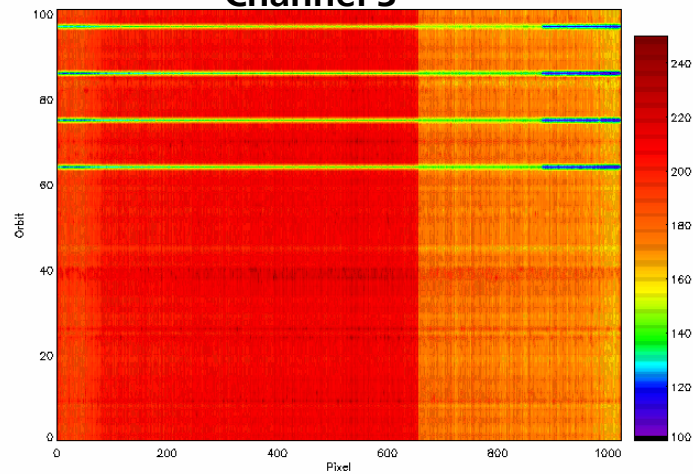
Channel 1



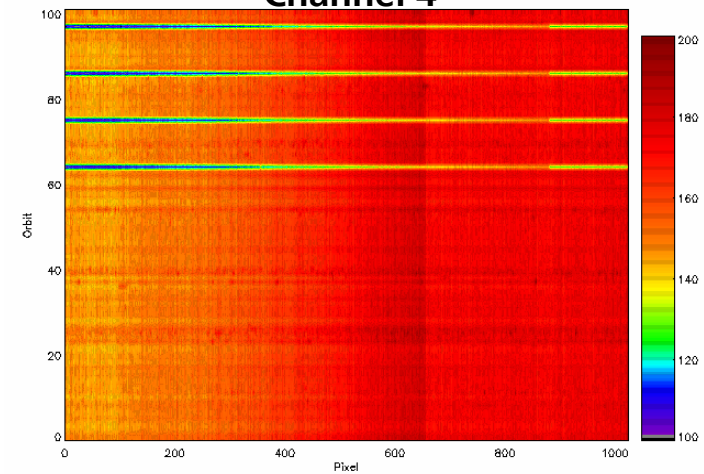
Channel 2



Channel 3

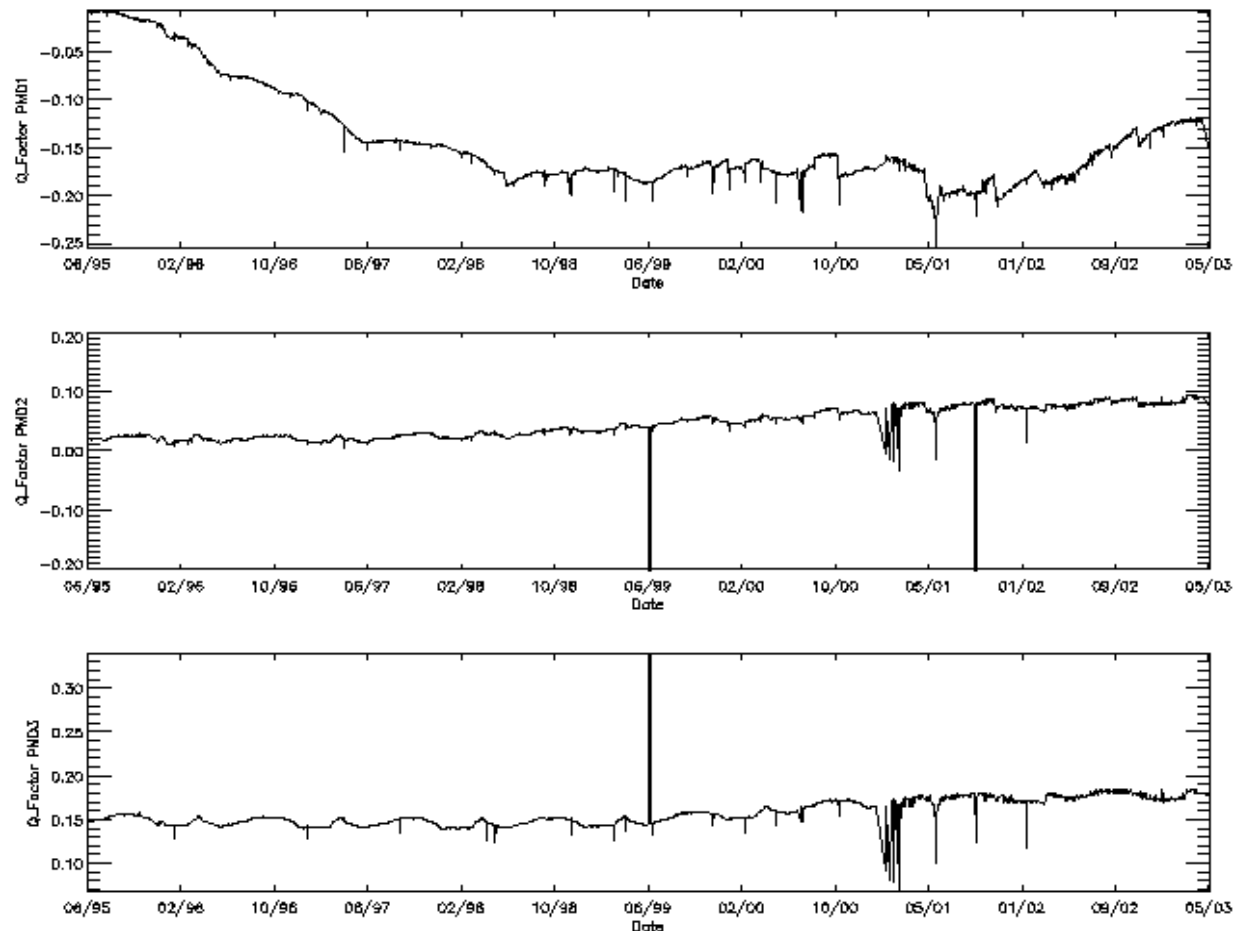


Channel 4



# Calibration Parameters – Q-factors

**Q-factors:** ratio of the measured PMD signal and the expected signal calculated from the channel array intensity

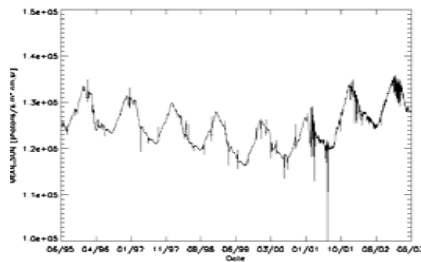


- decrease of the signal of PMD 1 corresponds to the degradation of channel 1

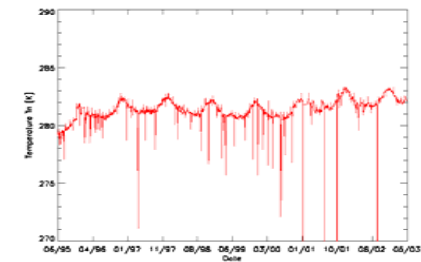
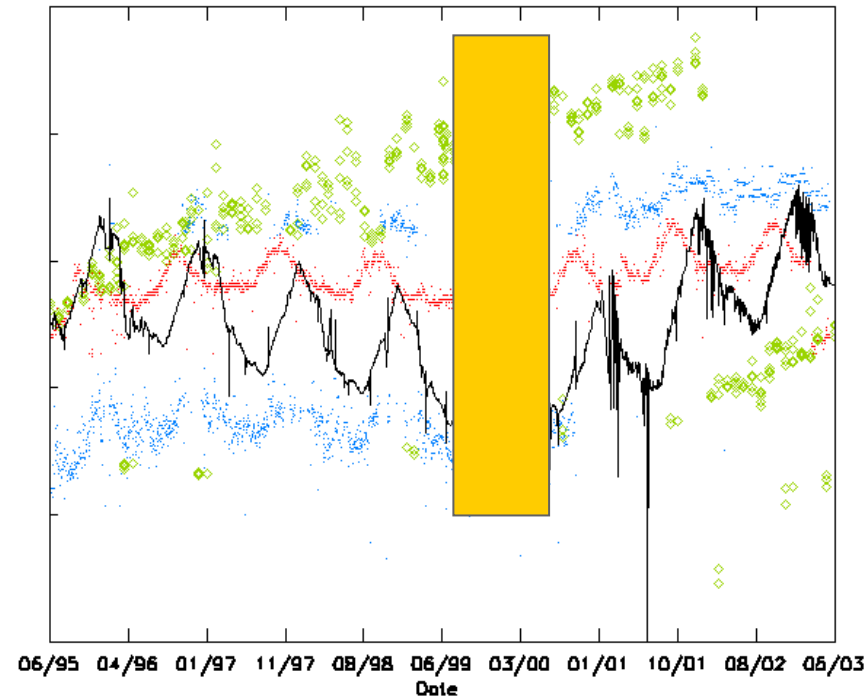
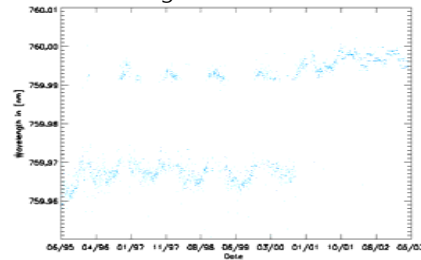
- large peaks of PMD 2 and PMD 3 are due to measurement anomalies

# Calibration Parameters - Comparisons

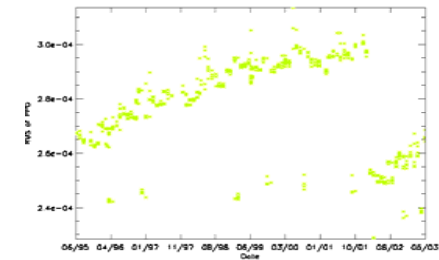
Sun Mean Reference at 760 nm



Wavelength at Pixel Point 859



RMS of PPG for channel 4



- peaks of the sun mean reference correlate with the peaks of the wavelength calibration
- the peaks of the temperature correlates with the peaks of the wavelength calibration phase-shifted
- the similar behavior of the RMS of the PPG has no correlation to the other parameters

## Conclusions and Outlook (1)

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- instrument degradation must be continuously monitored and analysed in order to assure a homogeneously high quality data set
- the degradation correction parameters are publicly available on the web at the GOME web page [http://wdc.dlr.de/sensors/gome/degradation\\_files/degradation.html](http://wdc.dlr.de/sensors/gome/degradation_files/degradation.html)
- Using modelling of degradation in the period 1995-1998, the (smoothed) BSDF could be derived, as function of Solar azimuth angle.  
The reproducibility lies by approximately 0.2% (accuracy of degradation modelling)
- High-frequency spectral features on the BSDF can be detected in channels 3 and 4, with peak-to-peak amplitude of 0.4%  
The features are reproducible over (at least) 5 years with an accuracy of  $\sim 0.05\%$

**GOME delivers consistent spectra over several years with high accuracy**

## Conclusions and Outlook (2)

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- all analysed calibration parameters show a good stability over the entire mission time of GOME
- the study is a first overview on the most important parameters
- further analysis of more calibration parameters will be interesting, e.g. leakage current through the SAA
- this analysis need a reprocessing of the Level 1 data