AATSR Performance

Dr Dave Smith

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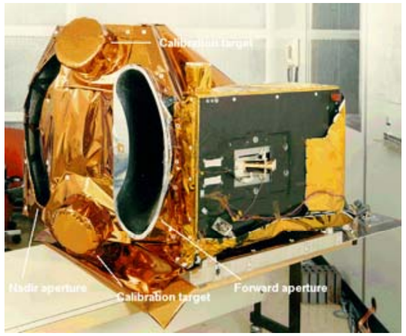
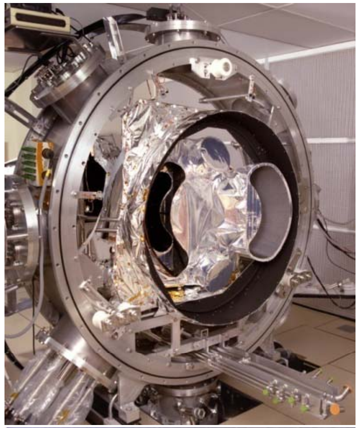
ATSR Series

1991-2000 ATSR-1



1995-2008 ATSR-2



2002-2012- AATSR

Overall Performance

- AATSR performed exceptionally well over the mission lifetime and generated the high quality data needed for accurate SST retrievals.
- All subsystems were operating within their design margins with no changes to the operating configuration.
- During routine operations only 4 AATSR-specific anomalies occurred that led to a disruption of operations
- Based on the assessment of the housekeeping and science data, AATSR would have continued to operate beyond 2014 with clear margins.
- Excluding the main commissioning phase up to 23rd July 2002, AATSR measurement data were available for >95% of the mission.

Hardware/Software Configuration Changes since Launch

- No flight hardware or software configuration changes were made to AATSR throughout the mission

AATSR Operations Summary

- For most of the time, AATSR was in MEASUREMENT mode and required no commanding from ground for specific observations. The exceptions to this operations scenario were:

- Orbit Control Manoeuvres (OCM) where AATSR was commanded to HEATER mode.

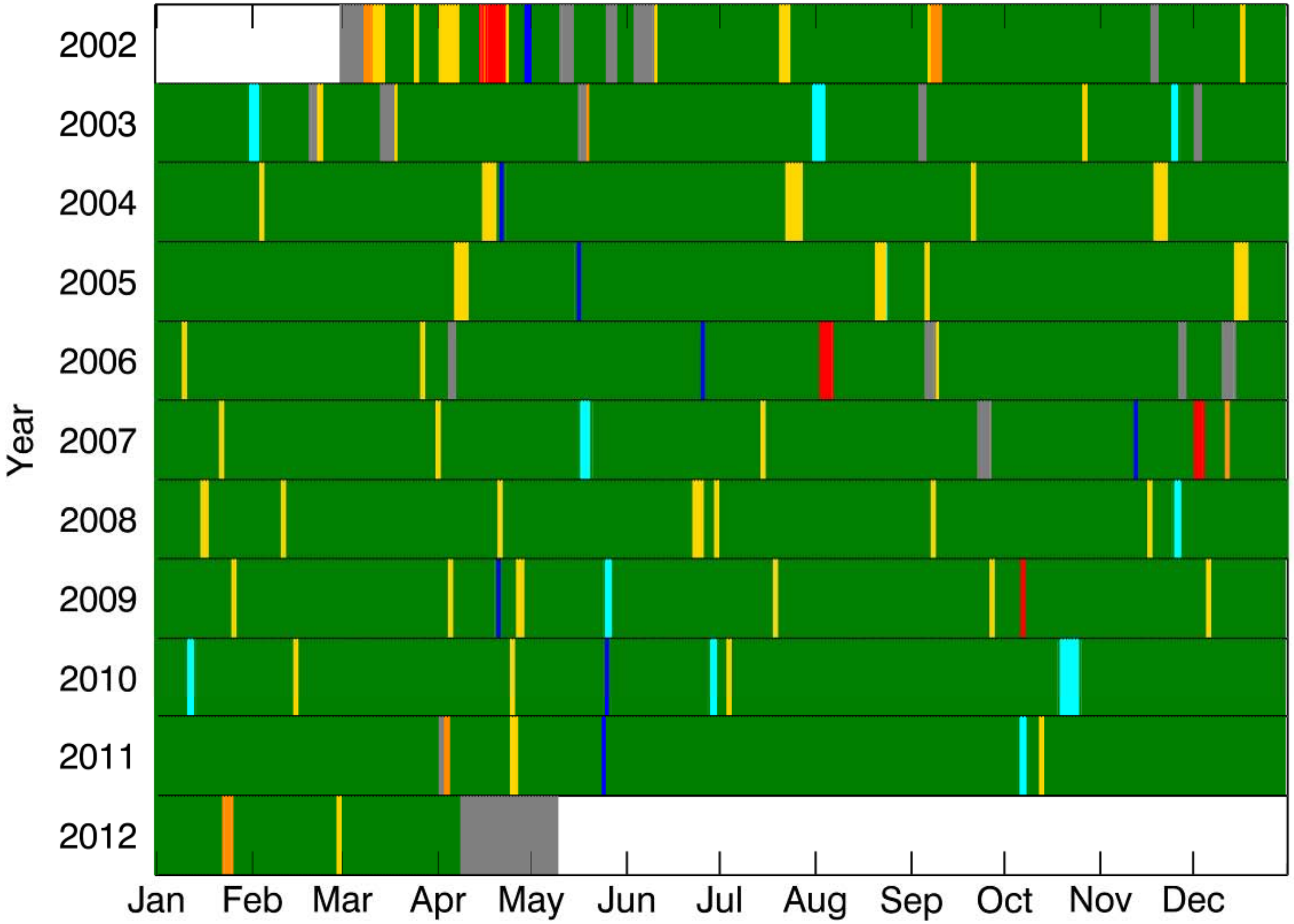
- Periodic planned OUT-GASSING activities. Here the cooler drive amplitudes were commanded to zero to allow the IR-FPA to warm up to ambient for decontamination.

- BLACKBODY CROSS-OVER tests. These were performed by switching the heated blackbodies to determine any gross calibration errors of the on-board blackbodies. AATSR remained in MEASUREMENT mode during this test to allow generation of Level-0 data for analysis.

- Commissioning phase activities where AATSR was commanded to a non-standard configuration. MEASUREMENT data may have been generated during this period but the data quality may be unsuitable for generation of L2 products.

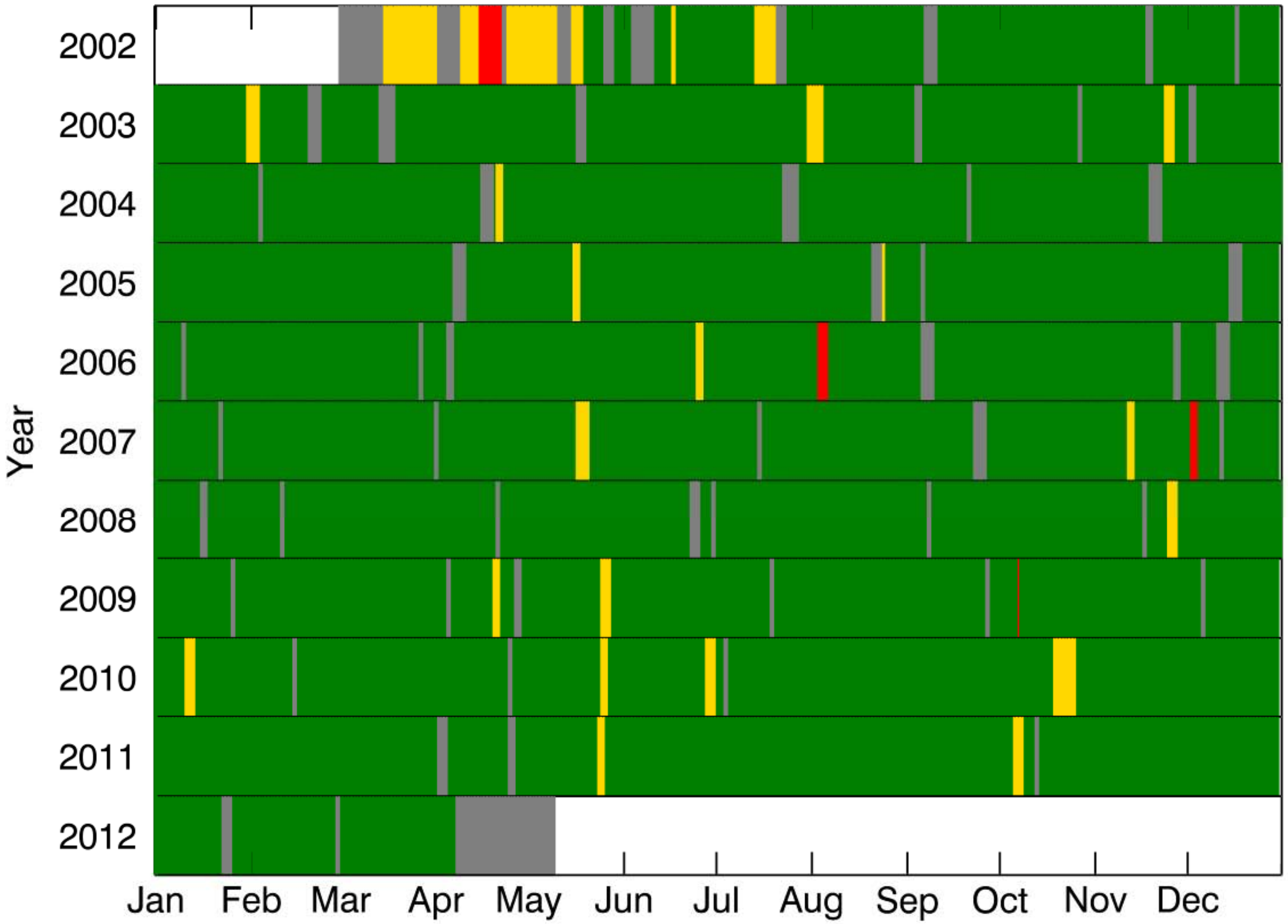
- Leonid Meteor Shower Precautions (November 2002) where all instruments were commanded OFF.

AATSR Operations Summary



- Grey – all units off
- Orange – AATSR in STANDBY or WAIT
- Amber – AATSR in HEATER or TRANSITION to HEATER
- GREEN – AATSR in MEASUREMENT mode
- CYAN – OUT-GASSING - AATSR in MEASUREMENT mode
- BLUE – BB CROSS OVER – AATSR in MEASUREMENT mode
- RED – AATSR in STANDBY/REFUSE or WAIT due to instrument anomaly

AATSR Outages and Anomalies



A total of 4 instrument specific anomalies occurred during normal operations

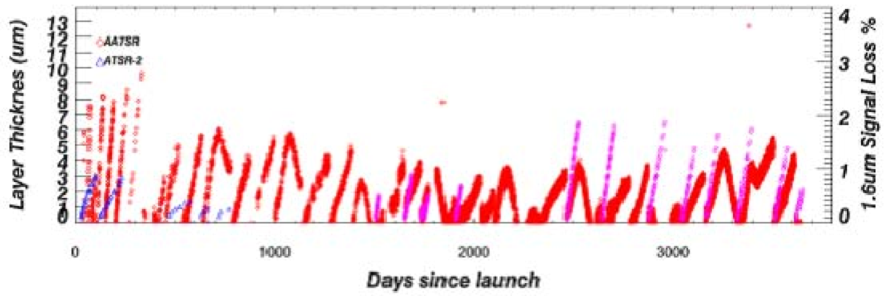
All recovered with minimum loss of data

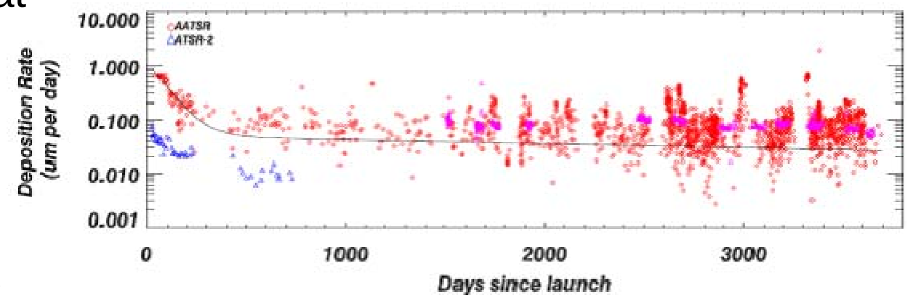
All ARBs closed

GREY – No Data generated – AATSR not in MEASUREMENT mode.
GREEN – Good quality data
Amber – Data generated but of lower quality due to out-gassing, blackbody cross-over or other instrument activity.
RED – No Data generated – AATSR anomaly.

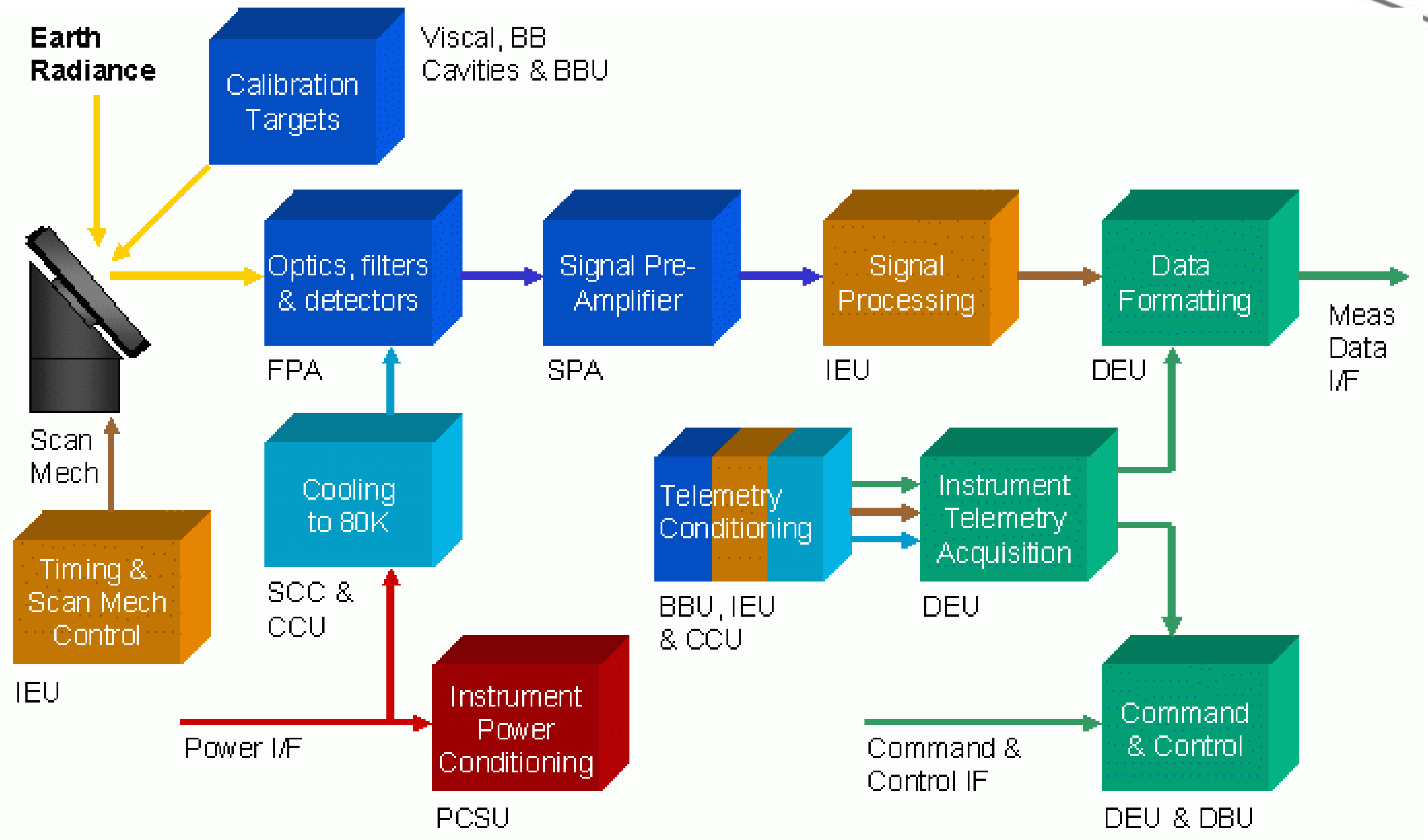
Water ICE Contamination

- Because AATSR FPA operates at 80K it was anticipated that there would be some water ice contamination on cold surfaces affecting some performance.
- Caused by out-gassing from CFRP structure
- Observed levels much higher than expected
- Cooler has to drive harder to maintain FPA at 80K
- Throughput of visible channels affected
- Regular out-gassing was still required at 5-6 monthly intervals to remove contamination to restore instrument to nominal performance
- Deposition rate remained stable at ~0.04um per day (levels at start of ERS-2 mission)





AATSR System

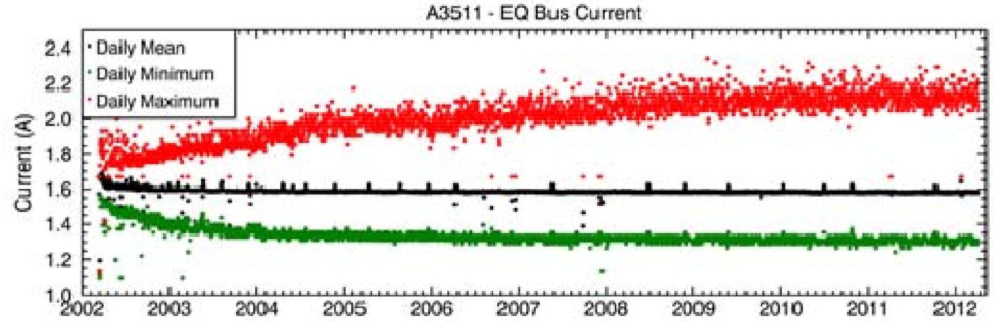


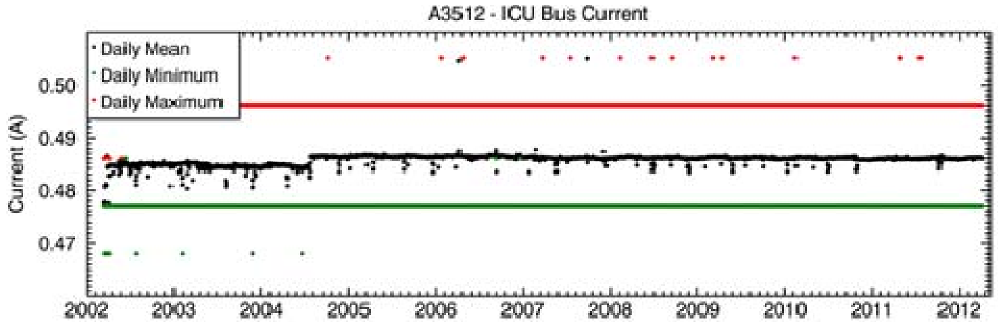
Power

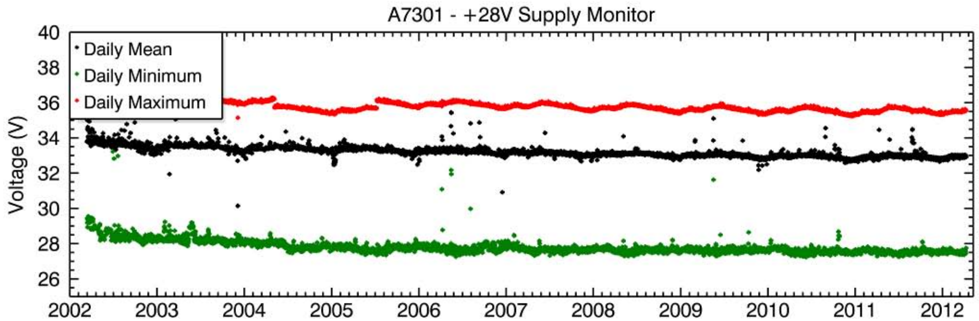
The ENVISAT platform power services utilised by AATSR are listed below

- Equipment Power 200 W – regulated supply providing power to the instrument subsystems via the PCSU.
- ICU Power (including DBU)
- Auxiliary Power – unregulated supply providing power to the cooler via the CCU.
- Heater Power for Equipment
- Heater Power for ICU

Power supplies have remained stable and within the expected limits throughout the mission



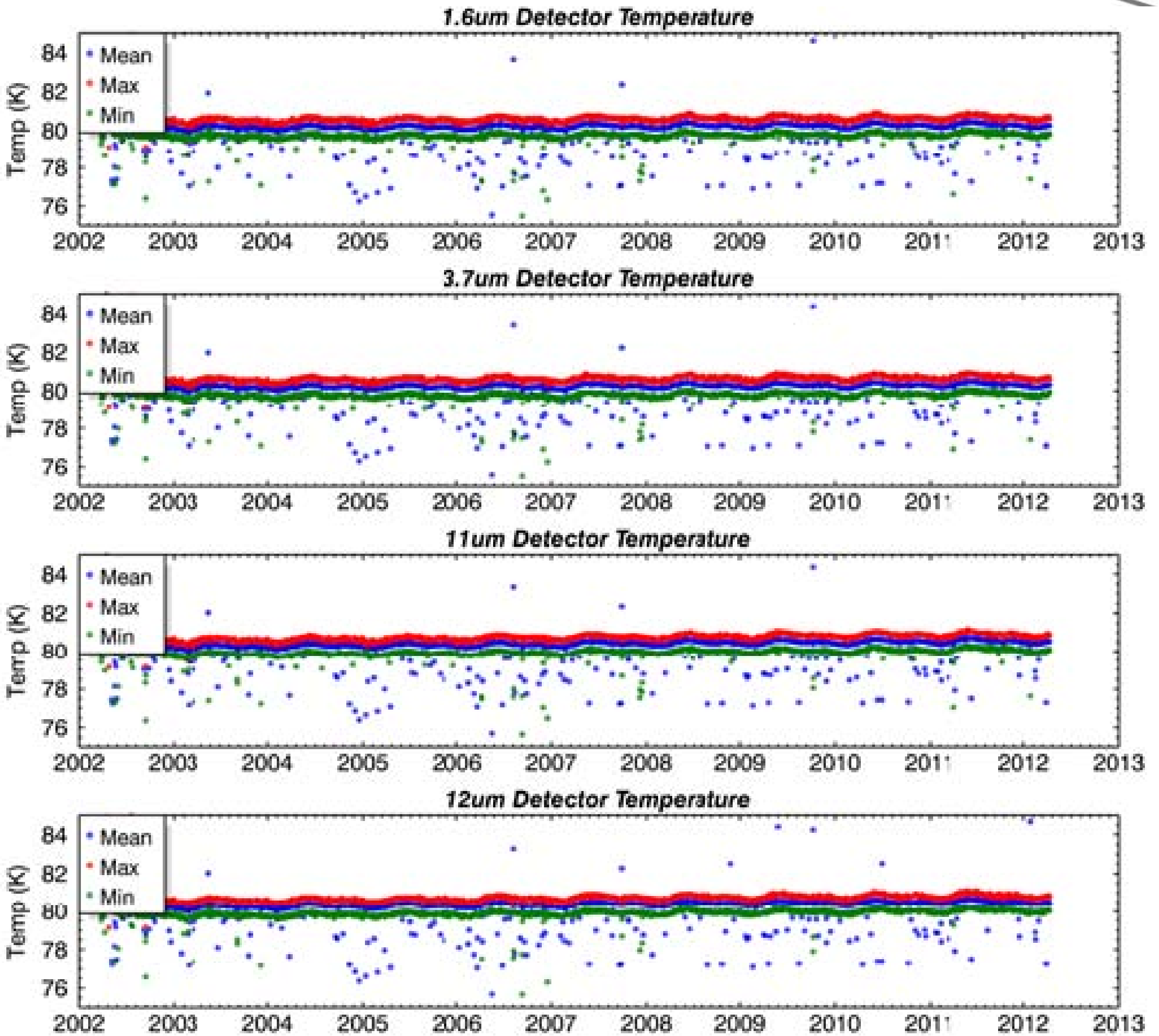




Thermal

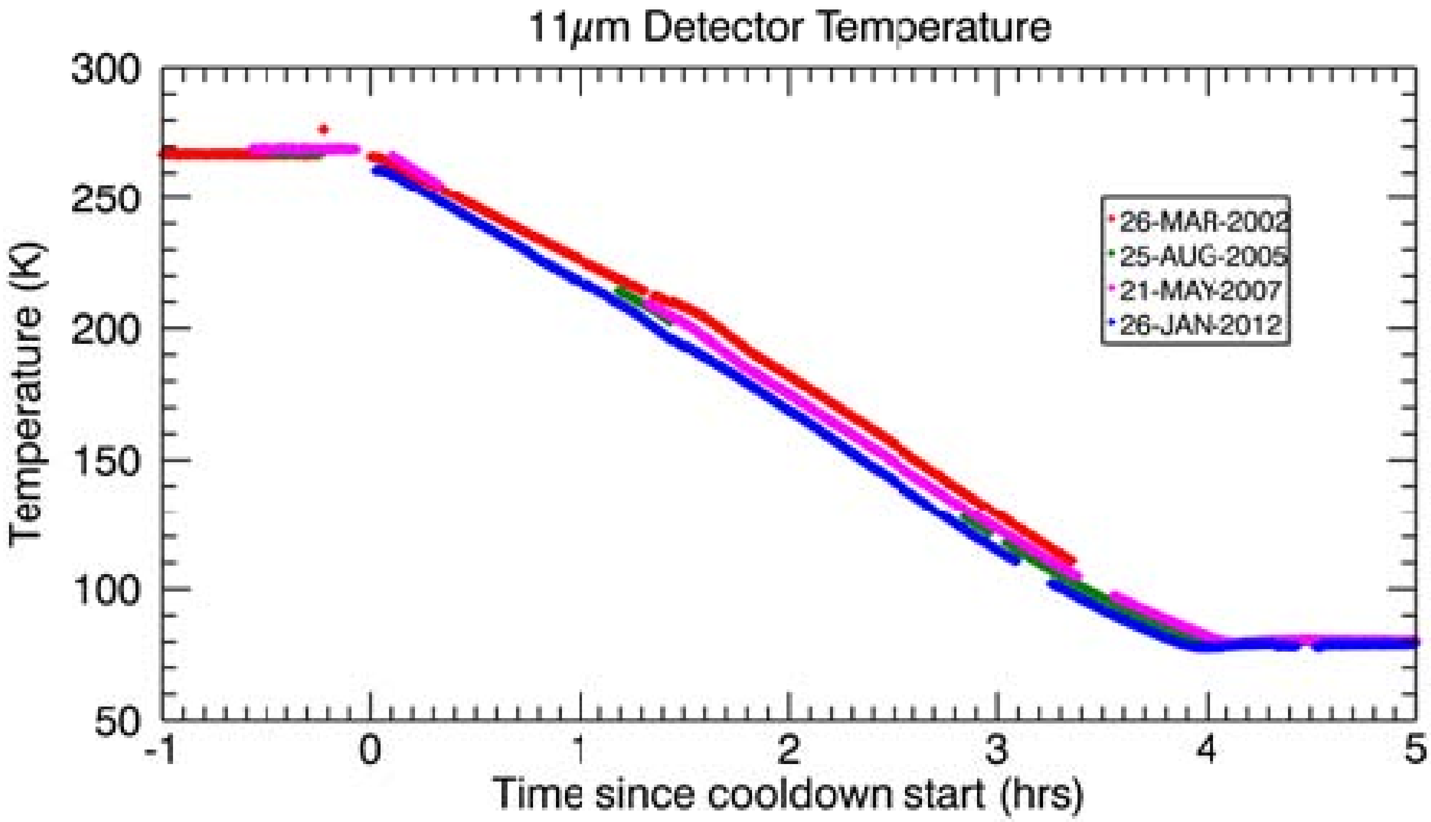
Unit	BOL Prediction ºC	EOL Prediction ºC	Unit Upper Limit ºC	In-orbit data ºC (01-2010-2003)	In-orbit data ºC (01-2003-2012)	2008 Prediction for 2012	2008 Prediction for 2014
Paraboloid Stop	-23.79	-0.11	5	-14.30	-13.70	-13.18	-12.85
IR/VFPA	-21.88	9.77	40	-9.50	-9.20	-8.07	-7.93
Viscal MA/Opal	-19.95	8.35	35	-	-	-	-
Viscal Monitor	-24.50	-1.56	35	-16.60	-16.60	-15.68	-15.55
SPA	-21.77	4.34	50	0.00	0.45	1.28	1.44
SMU	-12.14	12.23	35	3.40	3.10	4.36	4.32
Scan Mirror	-16.96	7.34	35	-			
+X Black Body	21.22	39.43	40	27.17	27.59	28.06	28.21
-X Black Body	-21.82	1.69	40	-11.93	-11.58	-10.47	-10.28
Displacer I/F	-3.05	33.49	40	7.70	7.20	8.71	8.53
Compressor I/F	-3.75	32.77	40	7.10	6.60	7.05	6.60
IEU	6.50	34.00	45	16.30	14.10	14.62	14.84
BBU	1.77	24.29	45	13.30	12.90	14.13	14.31
CCU	-8.40	25.96	45	21.58	20.60	20.54	20.21
DBU	22.19	49.69	50	-		-	-
DEU	11.87	44.24	50	25.18	26.20	27.00	27.81
PCSU	22.19	51.6	50	36.35	32.60	33.50	34.43

Stirling Cycle Cooler



FPA temperatures maintained at 80K

Stirling Cycle Cooler

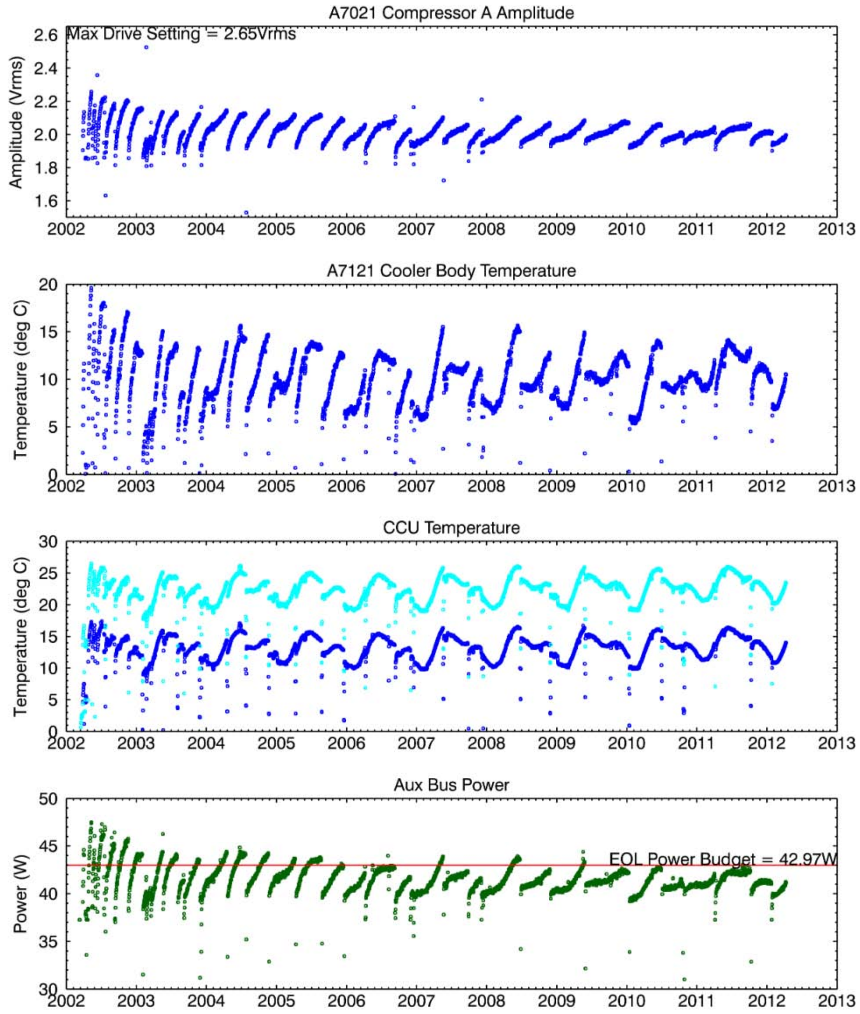


Cooldown < 4 hours for all mission

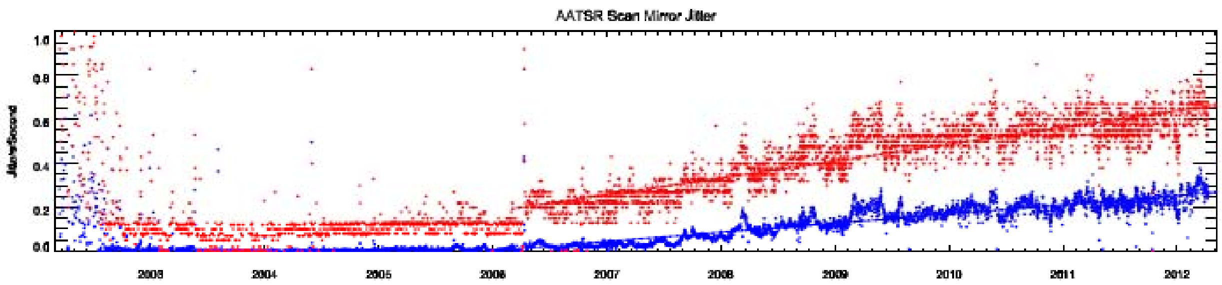
Stirling Cycle Cooler

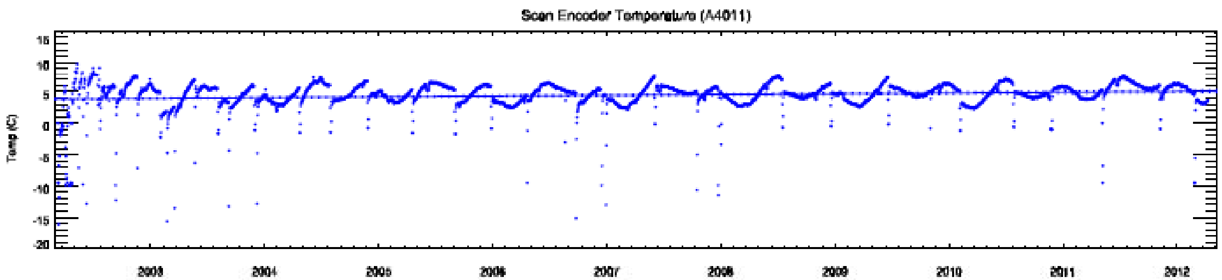
Operations well within margins

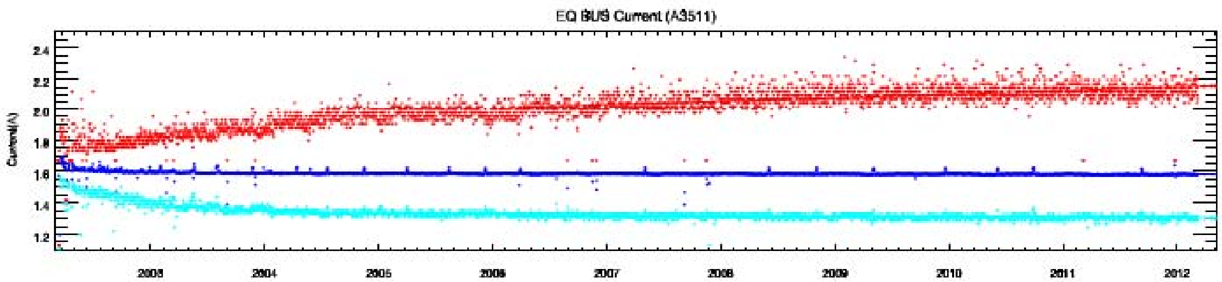
No adjustment needed for operating parameters



Scan Mirror Unit

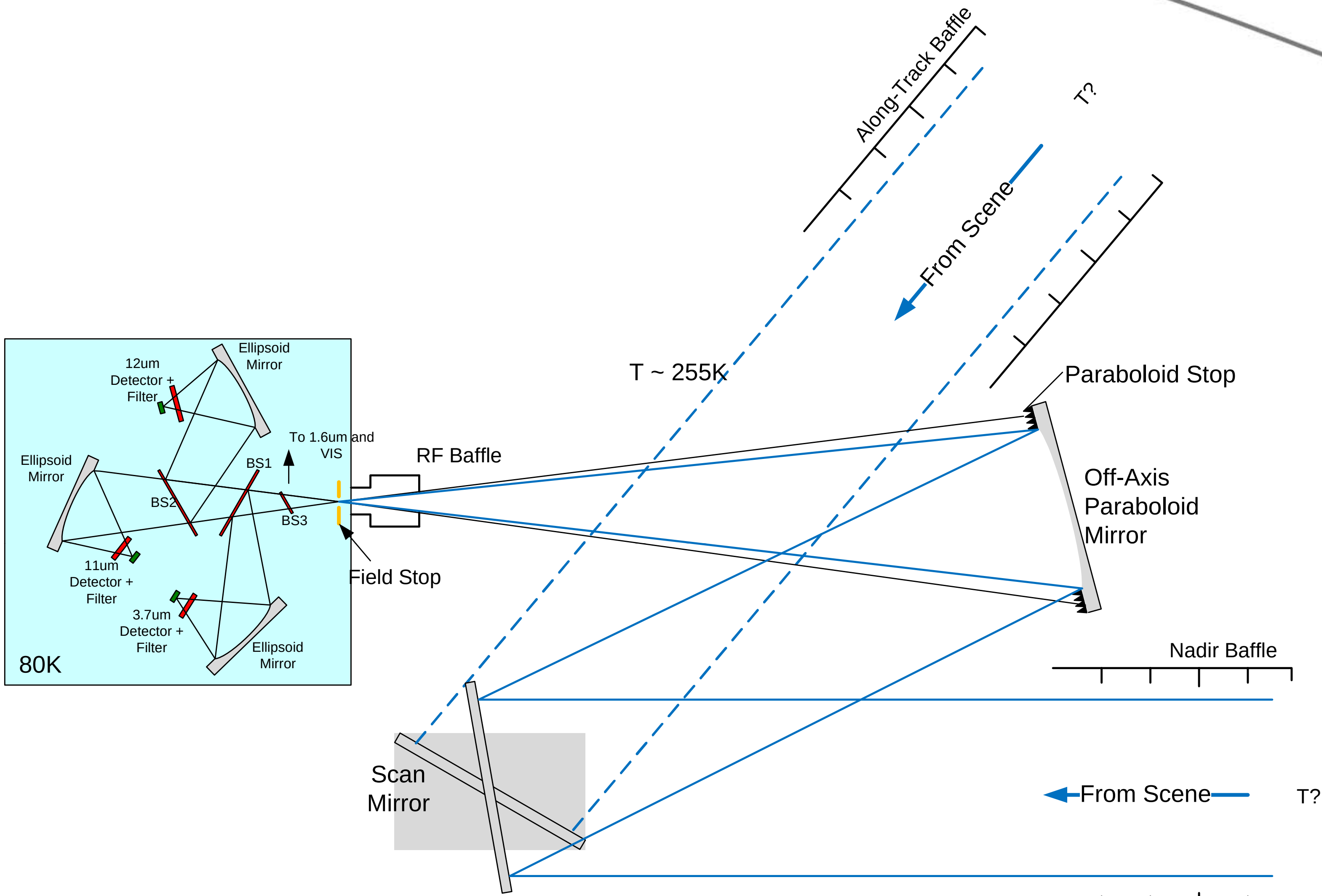






Since the first switch-on, the scan mirror has completed in excess of 2.1 billion revolutions with the scan period being maintained at 150ms.

TIR Channels

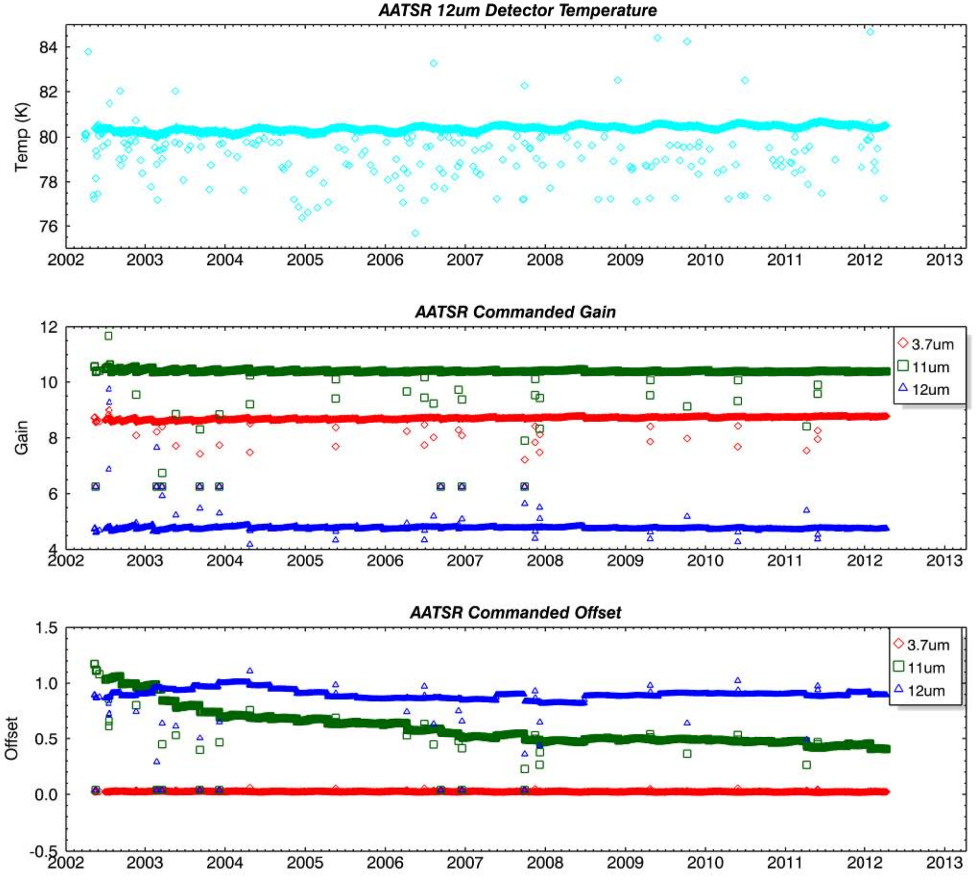


TIR Channels Performance

Gains of the channels remained stable over the mission and were predicted to remain at roughly the same level up to 2014.

This indicates that there has been no significant degradation of the radiometric performance of the detectors since launch.

The trends for the offsets show a slight drift over time, but this is not significant and the predicted offsets for 2014 are well above the minimum values

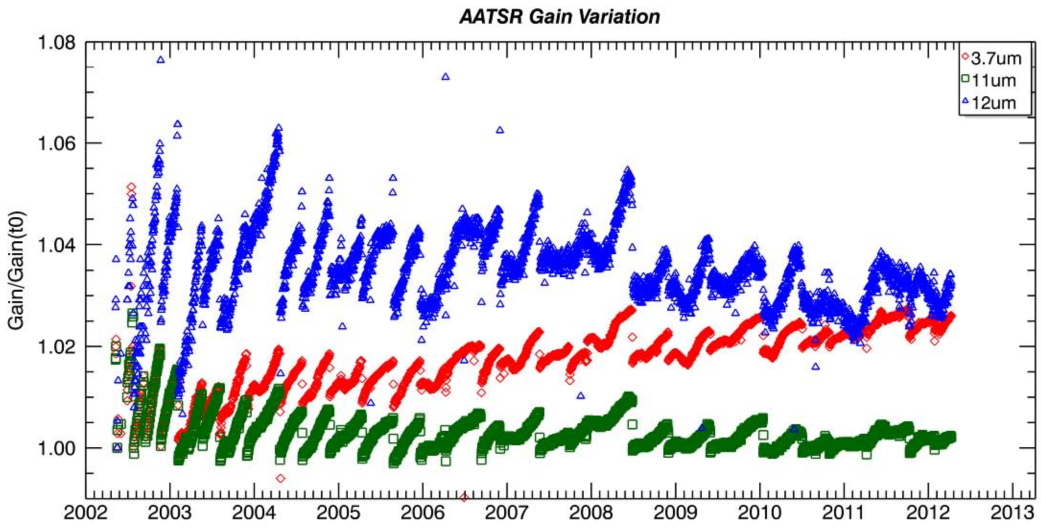


TIR Channels Performance

Closer inspection of the gain variation over the mission reveals behaviour very similar to the cooler trends.

Although the long-term mission trend has remained stable (<3% drift), the short-term variation suggests that the IR-FPA throughput was also affected by water ice contamination.

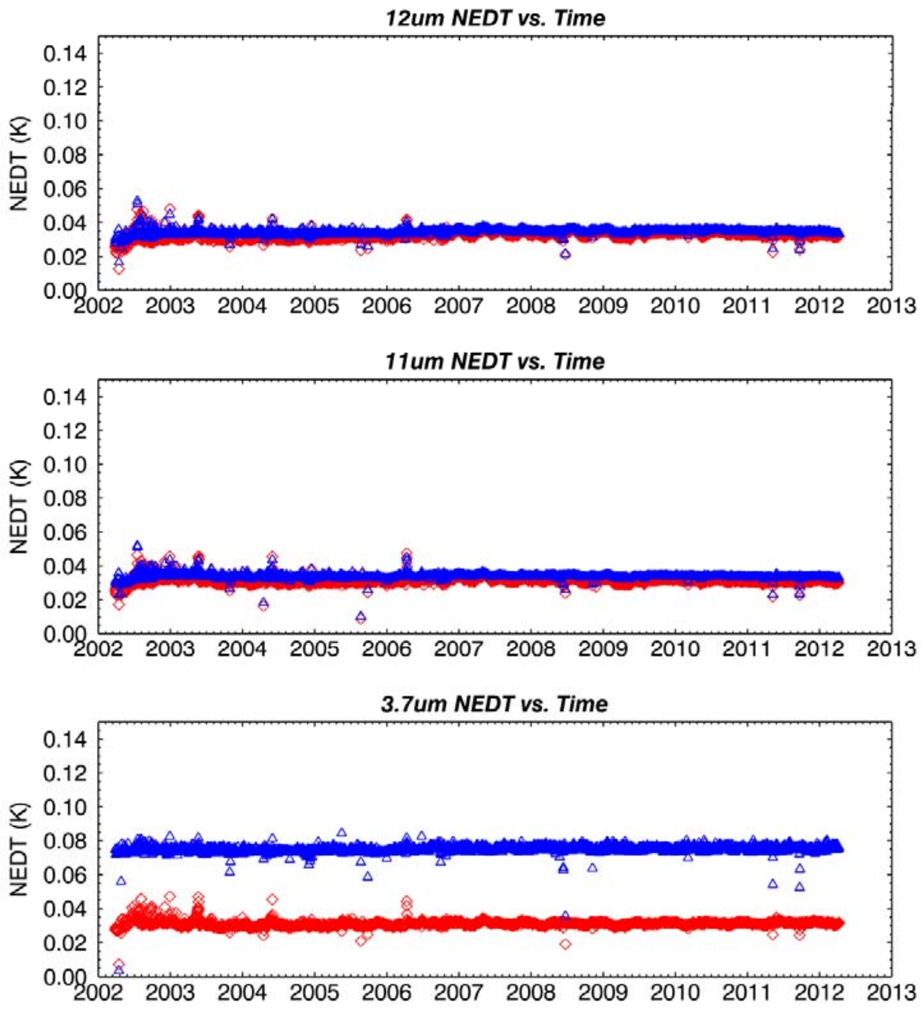
This is consistent with the build-up of molecular contamination either around the field stop or deposition on BS3



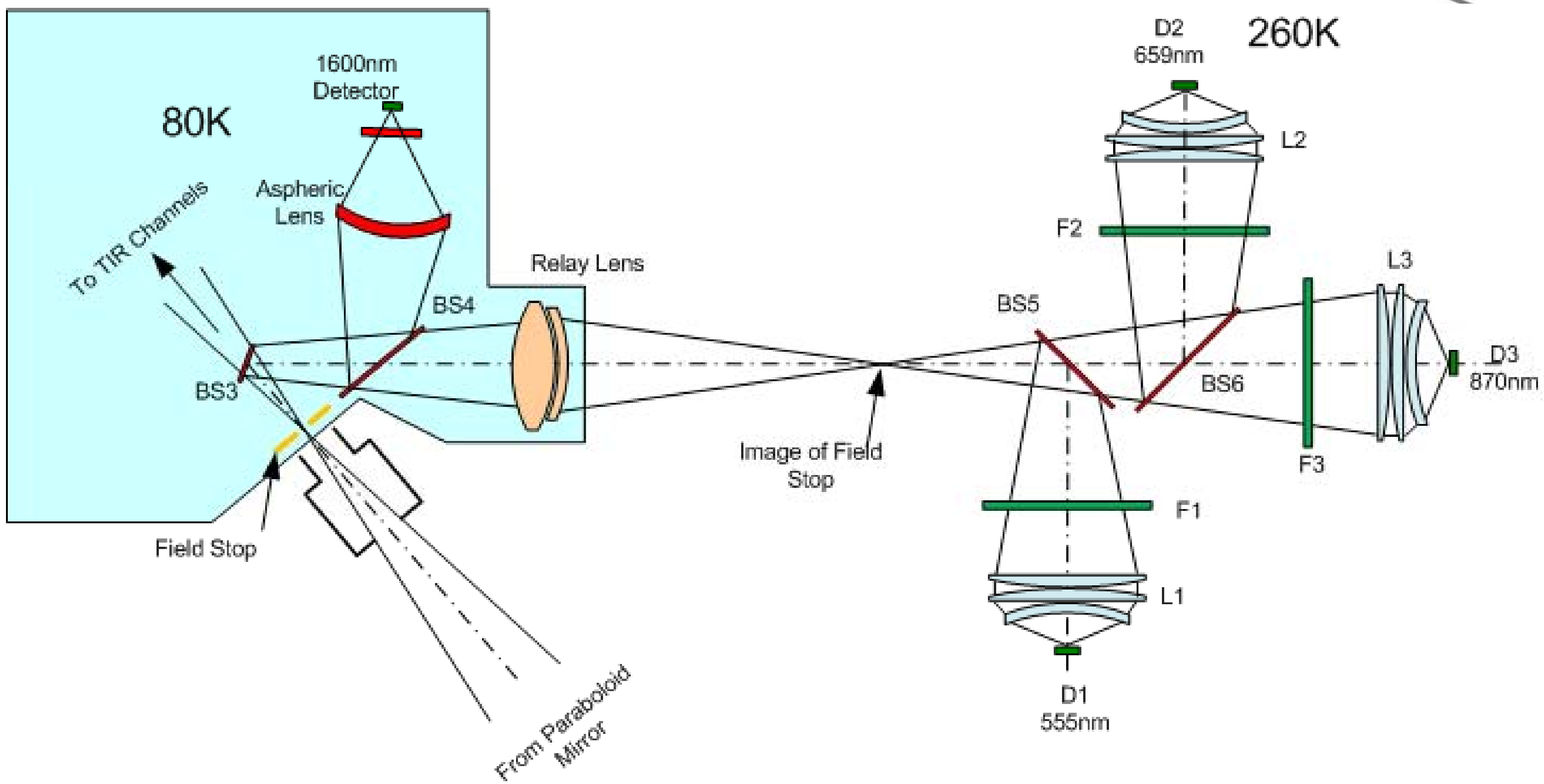
TIR Channels Noise

NEΔTs for the thermal infrared channels have remained stable for the duration of the mission.

The mean values over this time are within the requirements and are comparable with the pre-launch calibration measurements



VIS-SWIR Channels



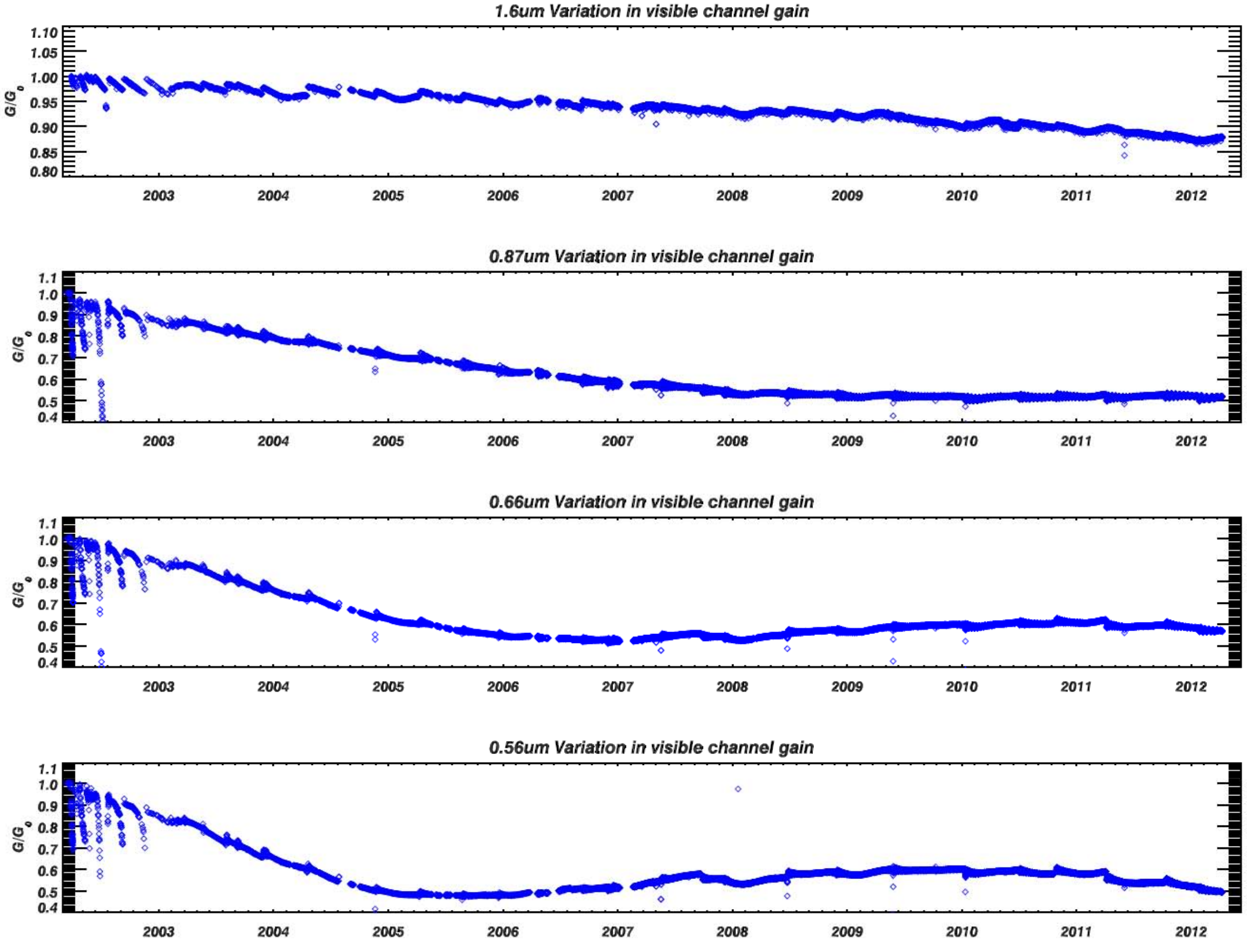
VIS-SWIR Channels Performance

The optical throughput of the 1600nm, 860nm, 660nm and 560nm channels is monitored using the VISCAL system.

Performance of the visible channels was strongly affected by the build-up of contamination on the IR-FPA.

Prior to November 2002, the throughput of short wavelength channels fell off sharply after running the IR-FPA at 80K for a few weeks.

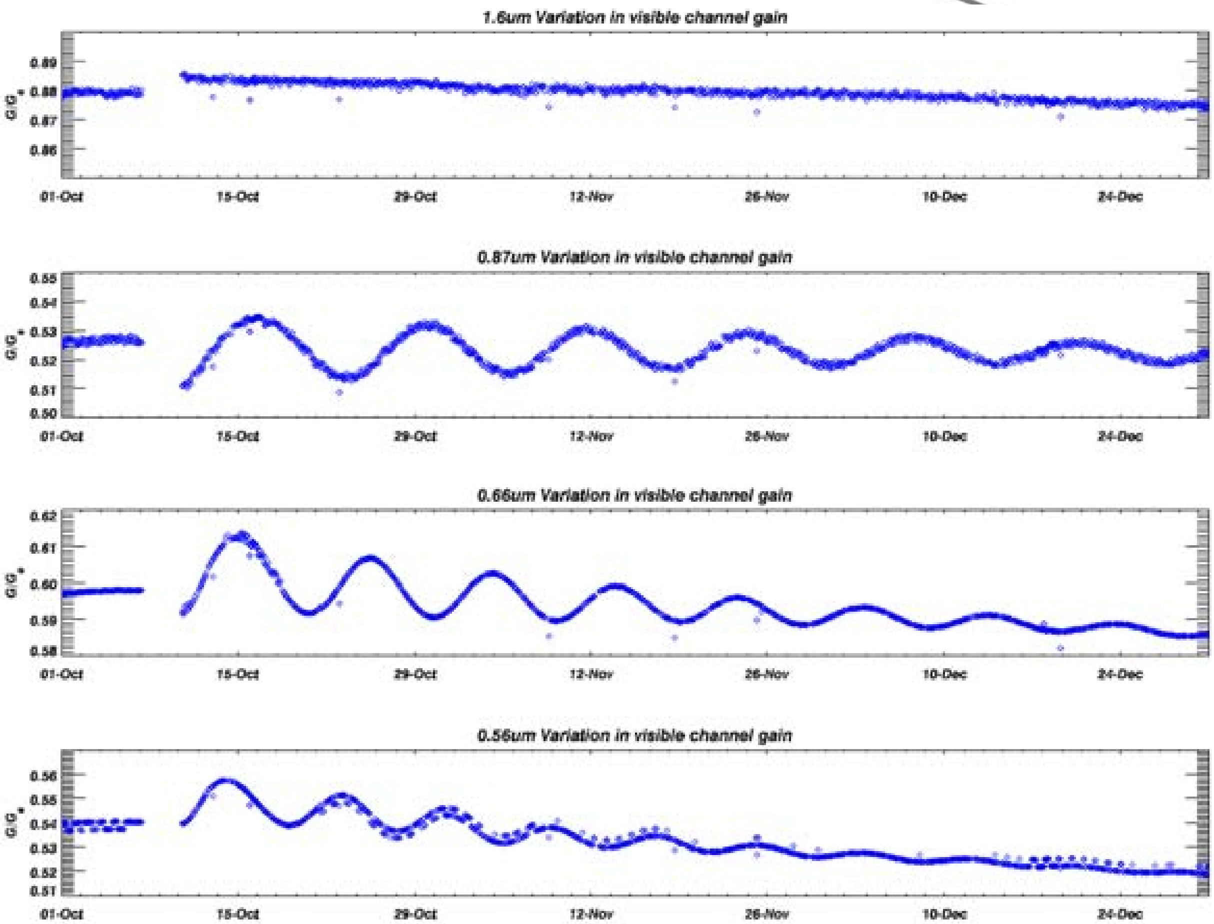
After November 2002, the fall off in signal was much less as the condensation rate had reduced to rates approaching that seen at the start of the ATSR-2 mission.



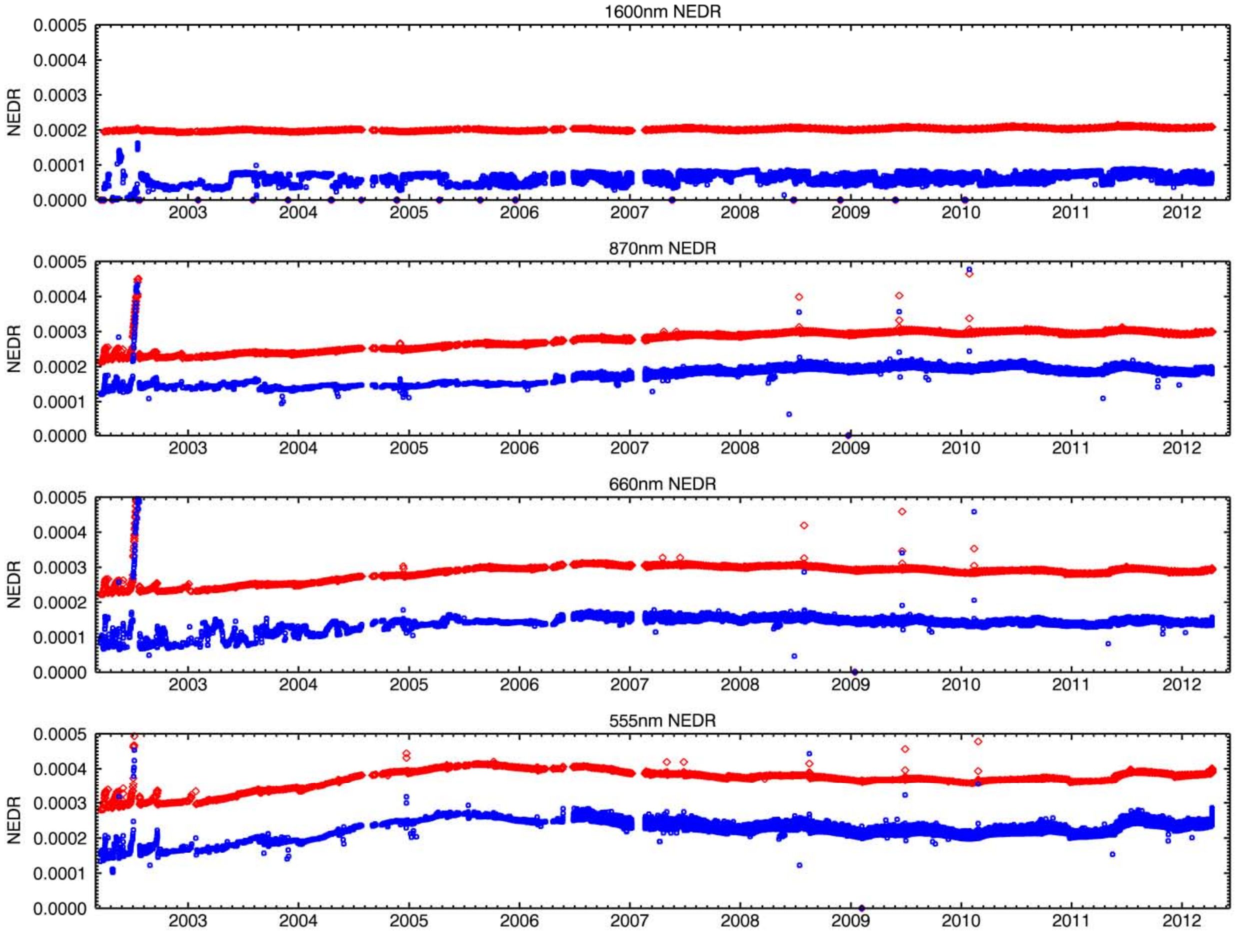
VIS-SWIR Channels Performance

Detail for the period from 01-Oct-2011 to 31-Dec-2011 showing the 1600nm, 860nm, 660nm and 560nm visible channel calibration levels, G, relative to the level at the start of the mission, G_0.

The oscillations in the signal are due to the build-up of a thin condensation layer causing a thin film interference effect.



VIS-SWIR Noise performance

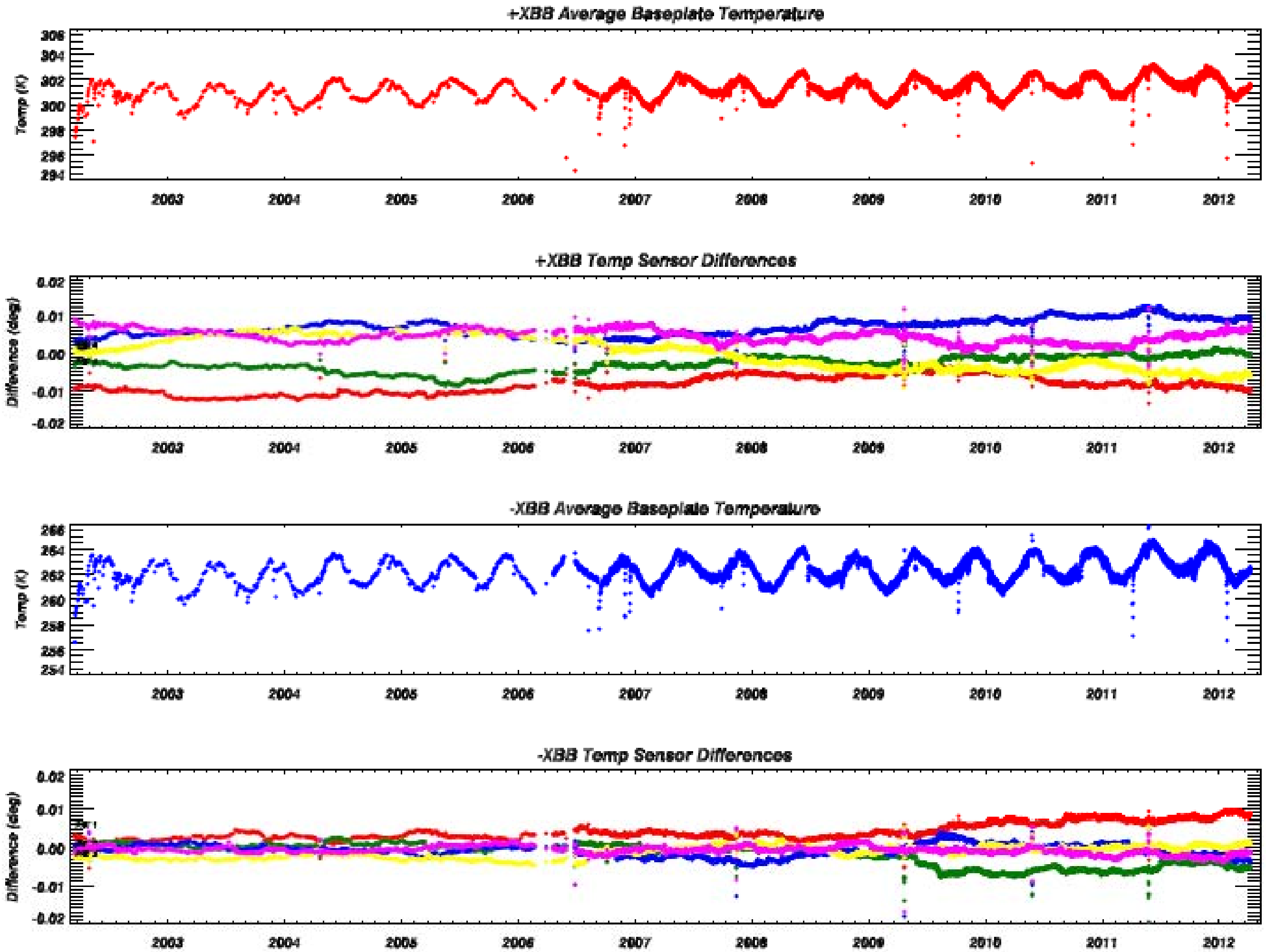


	R_{viscal}	SNR - Cal	SNR at BOL	SNR at EOL
1600nm	0.192	1086	1052	917
870nm	0.154	482	674	432
660nm	0.163	714	686	552
560nm	0.165	607	501	398

VIS-SWIR channels remain fully operational with good noise performance

Main impact remains water ice contamination affecting signal stability

Blackbodies



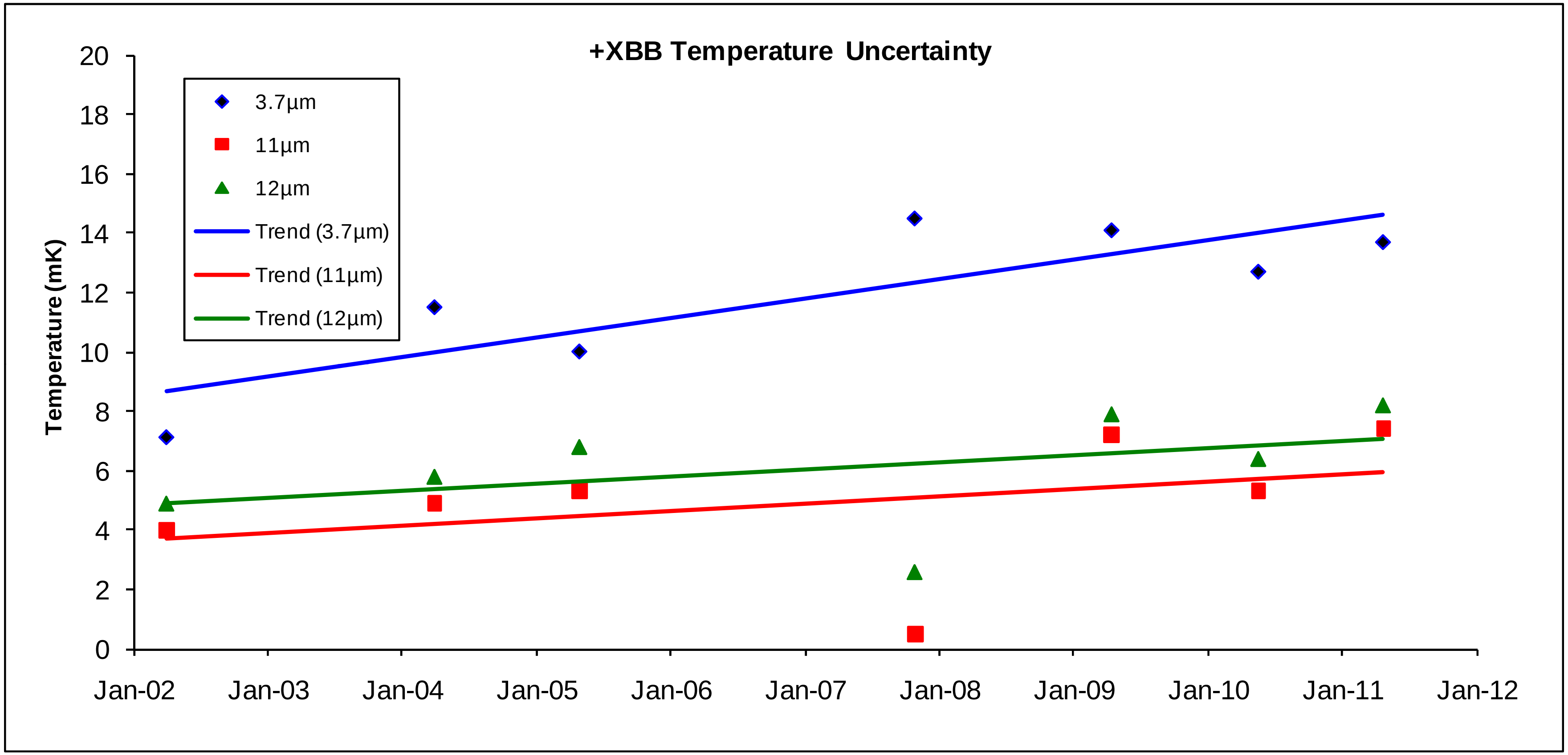
The blackbodies functioned exceptionally well throughout the mission. The heated blackbody (+XBB) is being maintained by the heaters approximately 40^{o} C above the cool blackbody (-XBB).

The results from the blackbody cross-over tests performed over the mission lifetime indicate that, relative to each other, the brightness temperature errors from the blackbodies are less than 10mK.

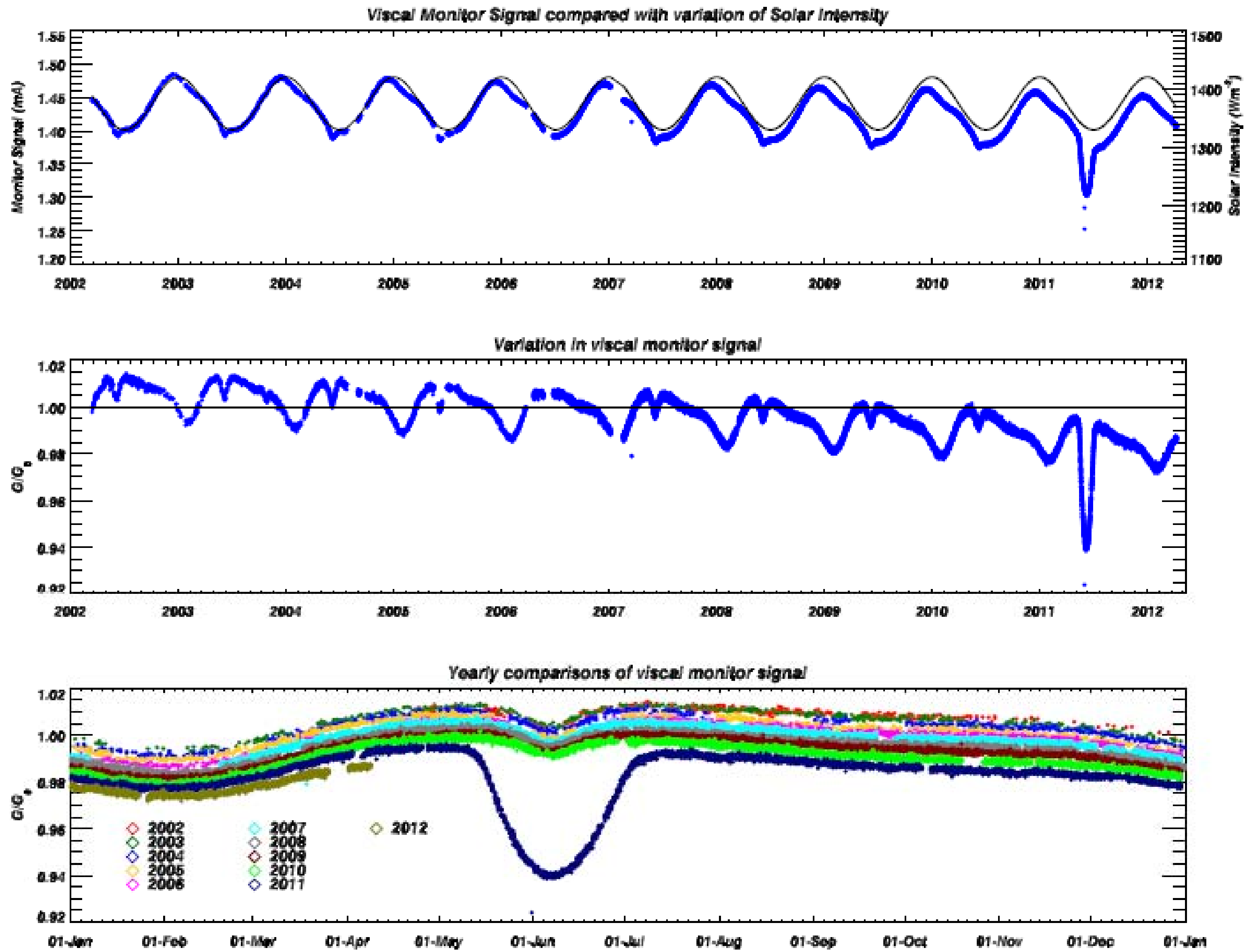
Blackbodies Crossover Tests

The basic idea is to compare the radiometric signals in the thermal channels when the two blackbodies are at identical temperatures.

Any significant difference would imply a drift in the blackbody thermometer calibration or change in target emissivity caused by a deterioration of the black surface finish



VISCAL


Viscal Monitor Signal compared with variation of Solar Intensity
Monitor Signal (mA)
Solar Intensity (W/m^{-2})
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1500
1400
1300
1200
1100
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Variation in viscal monitor signal
G/G$_0$
1.02
1.00
0.98
0.96
0.94
0.92
Yearly comparisons of viscal monitor signal
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
01-Jan

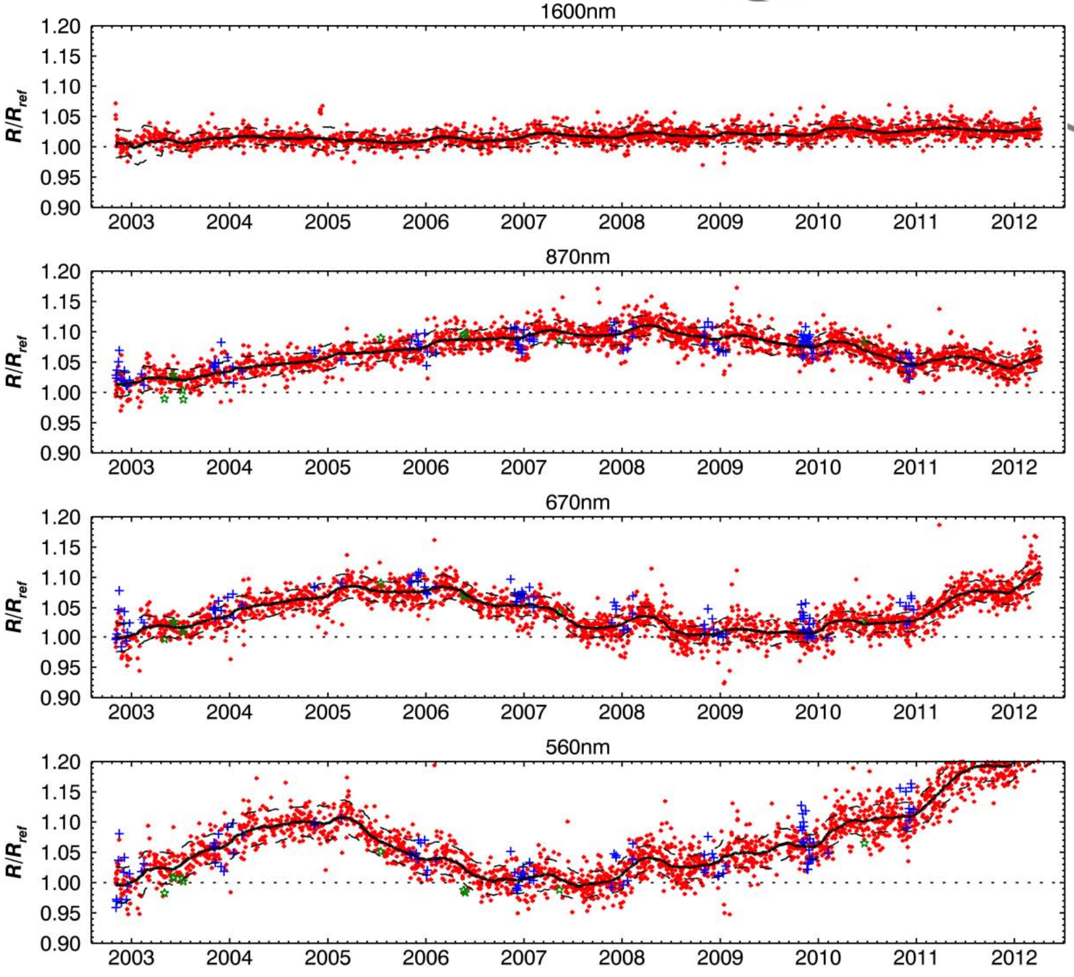
AATSR Reflectance Channel Drift Analysis

To obtain drift we compare measured BRF against reference BRF for all sites

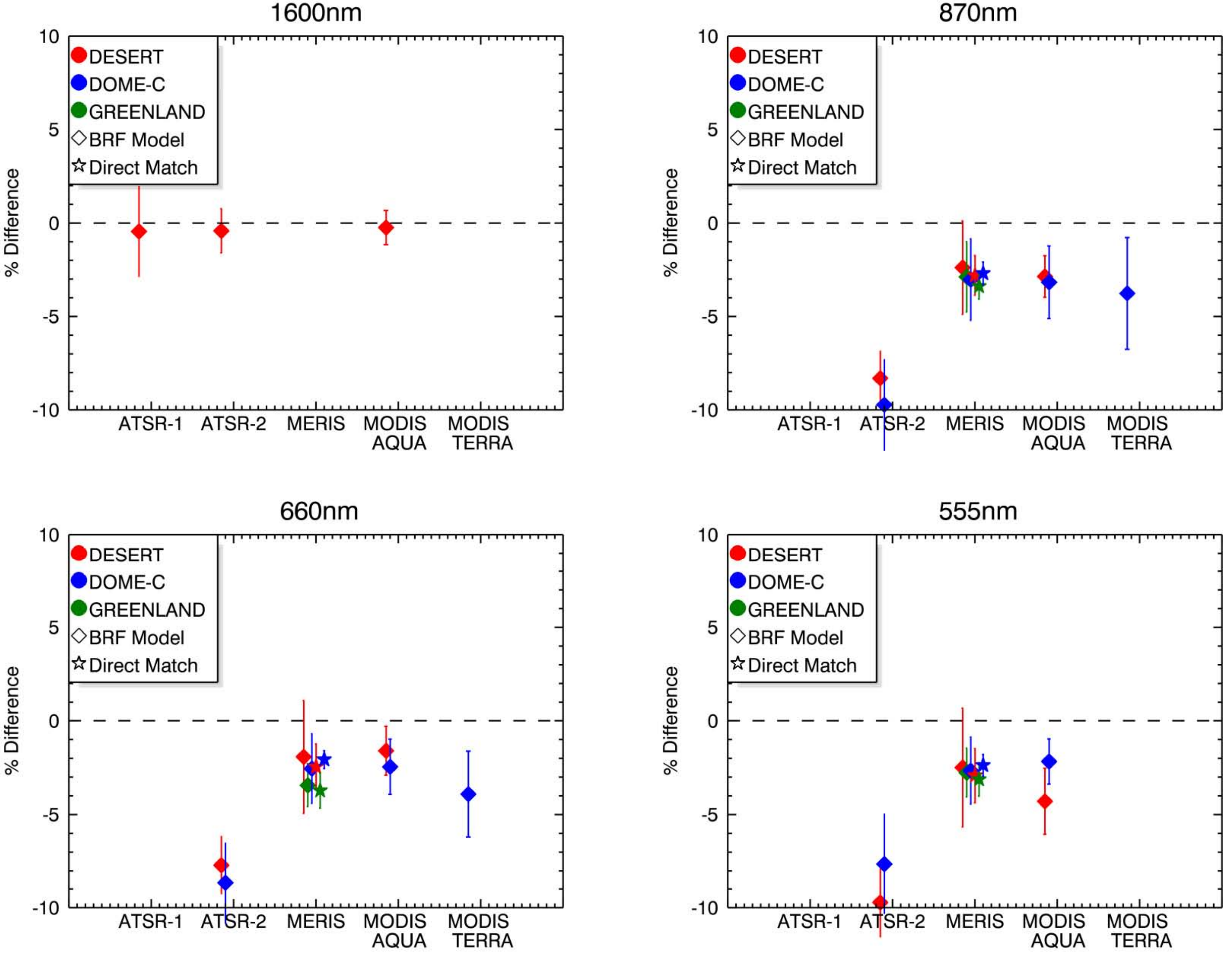
Trend is obtained by averaging drift for all sites of 90day window filtering for values <2sigma from mean.

AATSR drift does not follow linear trend as originally expected – suggests a more complex model for drift

Results provide input to drift correction look-up-table



Intercomparison summary of reflectance channels
Adjusted for estimated spectral errors



Electronics

- The DEU, IEU and CCU performed well throughout the mission.
- Apart from the two suspected SEUs there were no anomalies encountered.
- AATSR does not contain Error Detection and Correction (EDAC) so there are no statistics for these

Anomaly Investigations

- A total of 37 AATSR specific anomalies have occurred during the mission.
- All have been closed.
- The majority of these occurred during phase E1 and were mainly due to database, procedure or documentation errors.
- Only four AATSR specific anomalies have occurred throughout the mission that led to a disruption of operations.
- In each case the instrument was fully recovered and operations continued as normal.
- No flight HW failures have occurred

Lessons Learned

- The key lessons learned for AATSR are presented in the "ENVISAT AATSR Instrument Performance - End of Mission Report" PO-RP-RAL-AT-0621

- These are provided by the AATSR QWG and FOS team and covers
  - Technical Design, AIV, Early Validation and Verification, Operations, Anomaly Treatment, Documentation, and Organisation.

Lessons Learned – Key Points (1)

- The efficient running and timely data analysis of the AATSR commissioning phase and operations monitoring activities was made possible with the Engineering Data System (EDS) that was developed by RAL Space (http://www.aatsrops.rl.ac.uk/).

- The system acquired 'Real Time' telemetry from the ESOC FOCC, and NRT Level-0 data from Kiruna via DDS to provide orbital, daily and long term trends of key parameters, in particular BB temperatures, signal channel counts, radiometric noise, scan mirror jitter and VISCAL performance.

- This system was web based and allowed engineers and scientists to access key information remotely. A similar approach should be considered for future missions, e.g. Sentinel-3 SLSTR"

Lessons Learned – Key Points (2)

- There needs to be a clearer communication of key information on the status and calibration of the sensor performance (including references to anomaly investigations), both engineering and scientific. The present approach has information scattered across several web-pages and sites and it is very difficult for users to find relevant information.

- For example, details of the pre-launch calibration are provided in the product handbook, but this only contains a fraction of the information needed by data users. There is then no direct link to any of the post-launch cal/val or instrument performance reports.

- A future web based system needs to link more closely data product access, quality assurance, engineering performance, calibration and validation datasets and results.

Conclusions

- AATSR performed exceptionally well and was producing high quality data right up to loss of ENVISAT communications

- All data and documentation connected with instrument operations must be archived and made available on-line for future use.

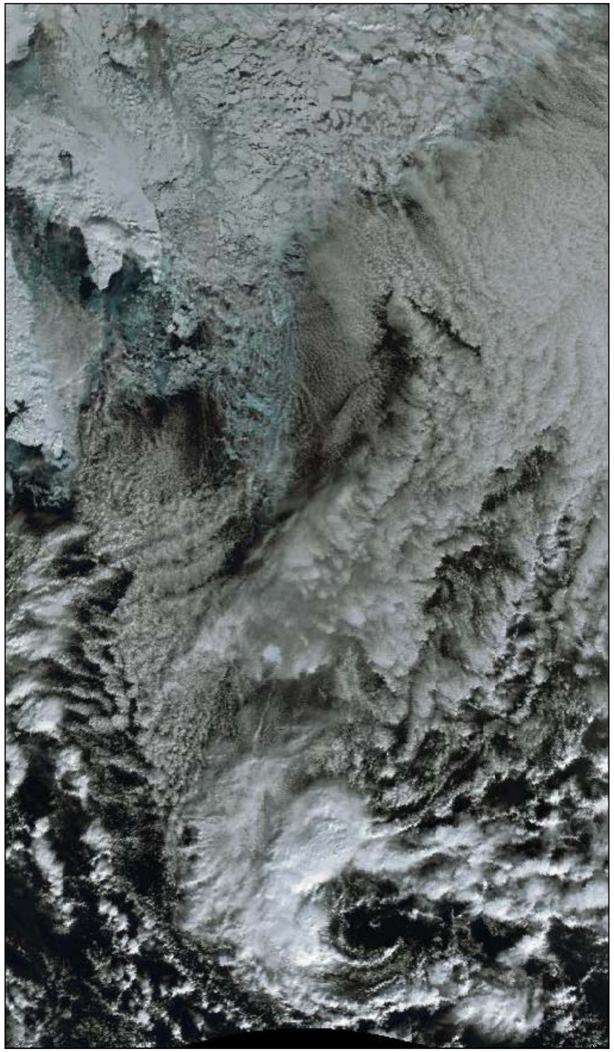
- Although the mission is no longer gathering data, there is plenty of work to do to improve the calibration and quality of the L1 data products.

Thanks to -

- AATSR was funded by the UK Department for Energy and Climate Change (DECC).

- All those who contributed to the instrument design, build, calibration, operations and data exploitation over the years from RAL Space, Astrium UK, Leicester University, Space ConneXions, Vega, ESA etc…

Final tape dump, final scene



April 8th 2012
Starts in orbit #52866, ends in orbit #52867
Last science data timed at 10:55:58.6 UTC