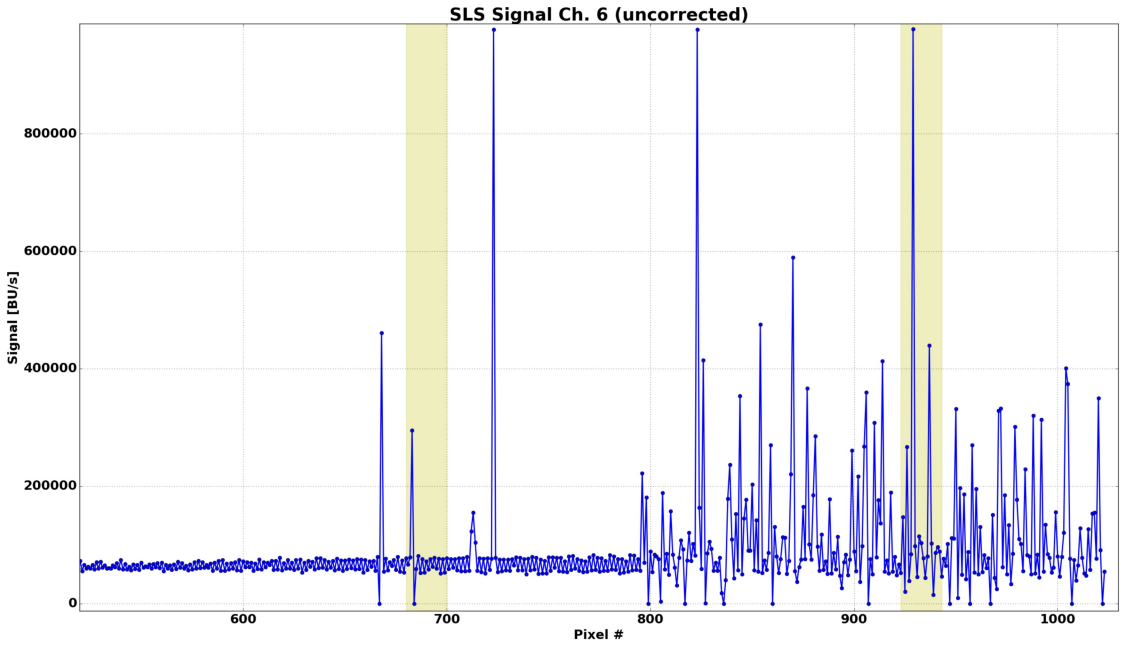
SCIAMACHY: Spectral Calibration in the SWIR Channels

G. Lichtenberg, M. Hamidouche, P. Hochstaffl, F. Schreier, M. Meringer

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Motivation

- The nominal spectral calibration of SCIAMACHY is done with an on-board PtCrNe lamp, but
  - There are not enough resolved lines in the SWIR wavelength range
  - Bad pixels hamper the determination of line positions



Method – Wavelength Fit

- As basis the method presented in *Noel et al. AMT 5/2012* is used with additional features:
  - Micro-window selection (exclude certain regions of the spectrum)
  - Two step fit: First fit in individual windows with subsequent 2nd fit using the results of micro-windows from the first fit
- Fit equation:

$$\ln(S) = P_B(\lambda) + \ln(S_{ref}(P_A(\lambda)) \text{ [+ scaled absorbers, if needed]}$$

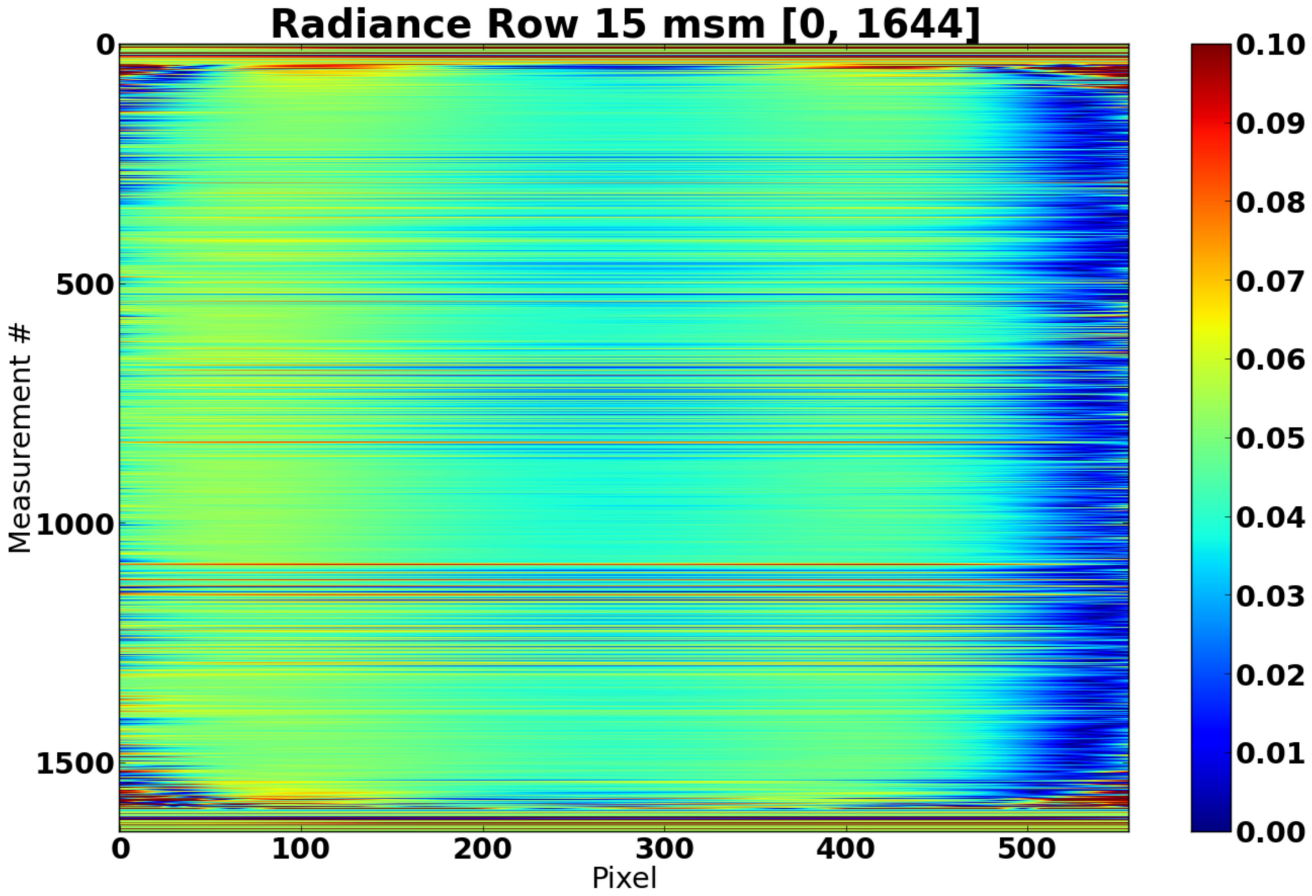
- Inputs:
  - High resolution reference spectrum
  - Instrument Spectral Response Function (ISRF)
  - Initial wavelength axis
  - S_{ref} convolved with ISRF is input to the fit

Method – Wavelength Fit

- Successful tests were done with simulated data for
  - Phase B1 Sentinel-5
  - Phase A/B for former EE 8 candidate CarbonSat
  - Sentinel-4 UVN

- The two-step fit method will be used in Level 0-1 processing for Sentinel-4 UVN (Earth radiances & Solar irradiances)
- The method was also compared to the OMI in-flight calibration which uses a similar method and to the GOME-2 in-flight calibration

Wavelength Fit – Comparison with OMI



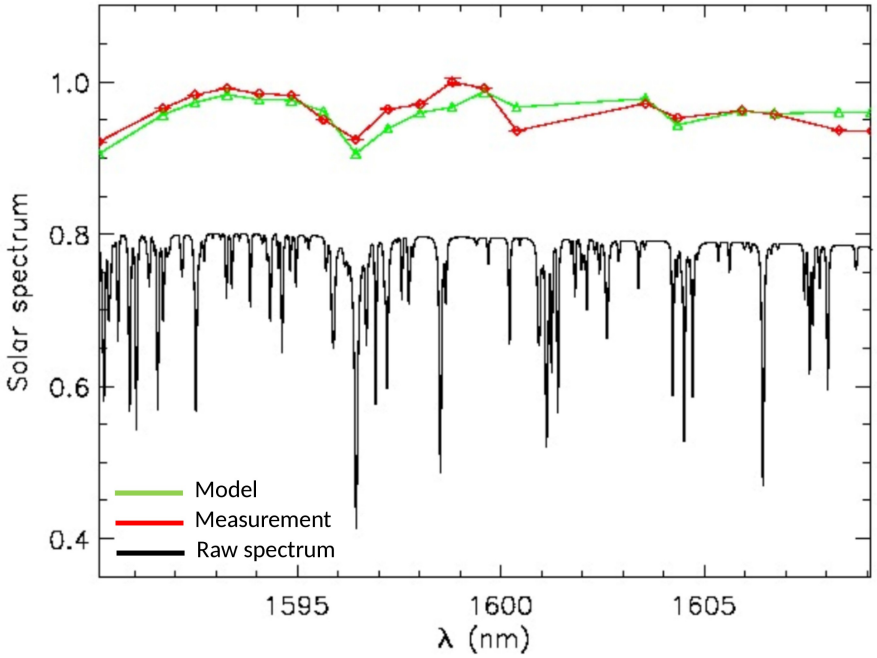
Method – ISRF Determination

- Measured solar irradiance spectra
- Solar irradiance reference
- Fit function, for channel 6: Exponential function
- Model function

$$M = ISRF \times Irradiance + Noise$$

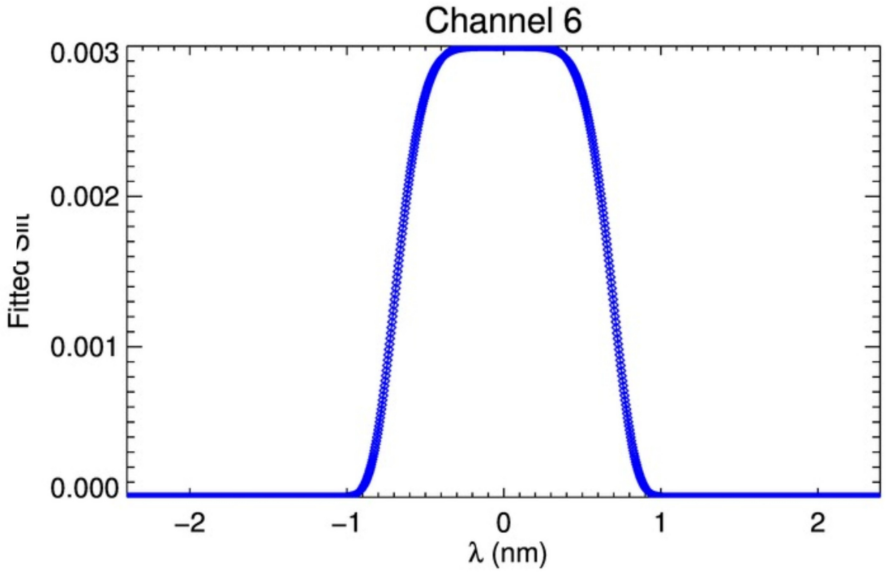
- ISRF parameters are varied until the model matches the reference

Channel 6 Retrieved ISRF



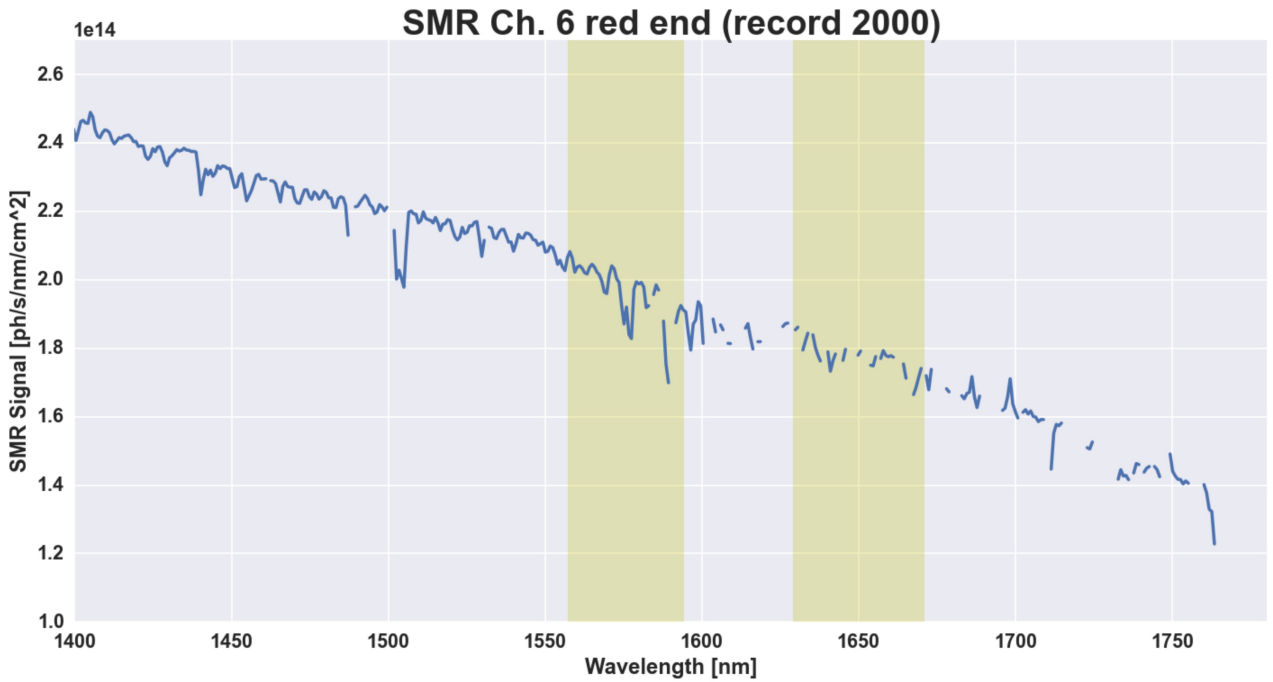
A best fit of Sciamachy solar measurement (< 3.32% accuracy)

The corresponding fitted Slit



SCIAMACHY Channel 6

Wavelength Range	971 – 1733 nm
SSI	0.77 nm
Resolution	1.48 nm
Spectral Stability	0.015 nm /100 minutes

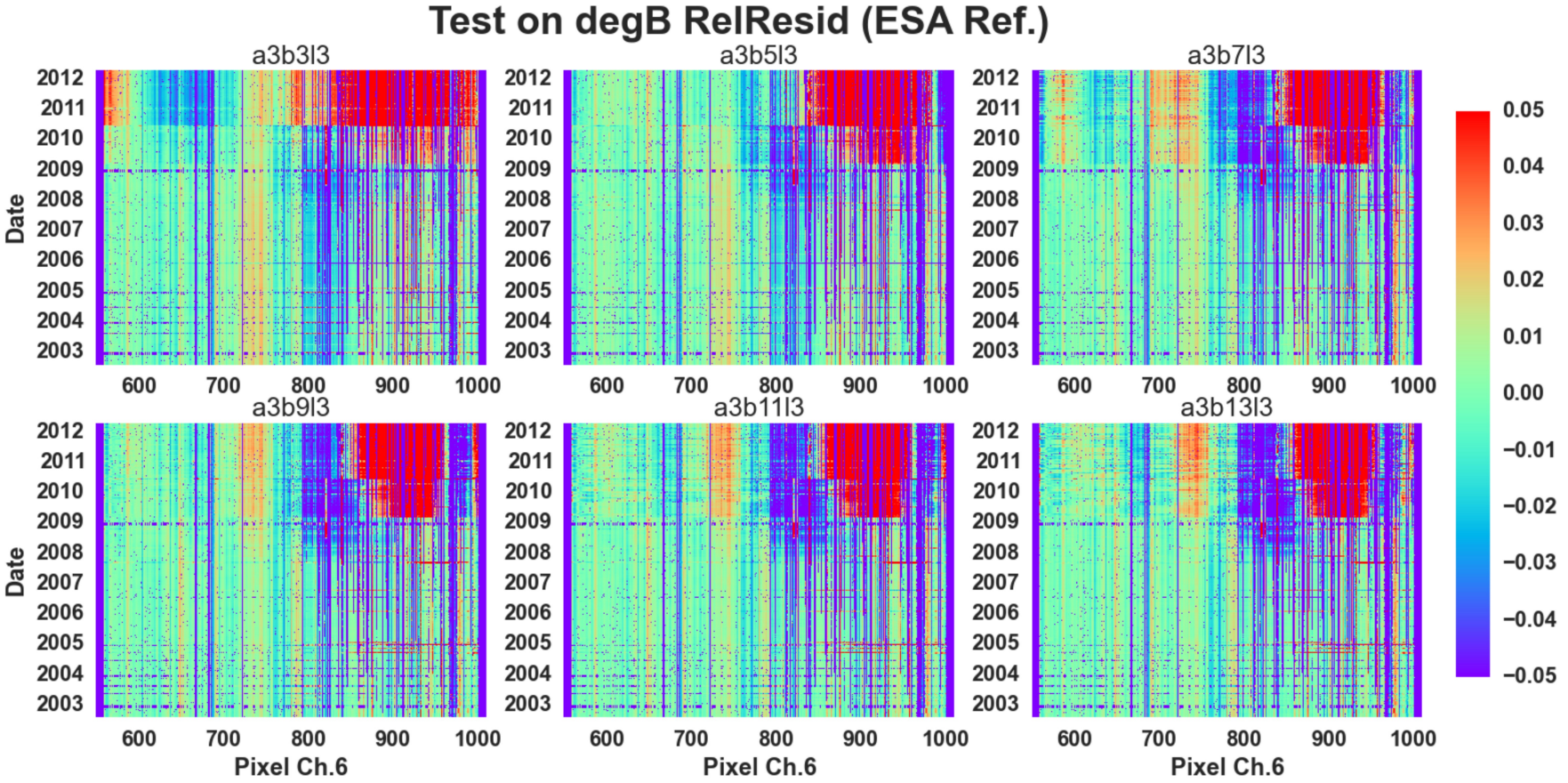


Wavelength Fit Parameters for Channel 6 Red End

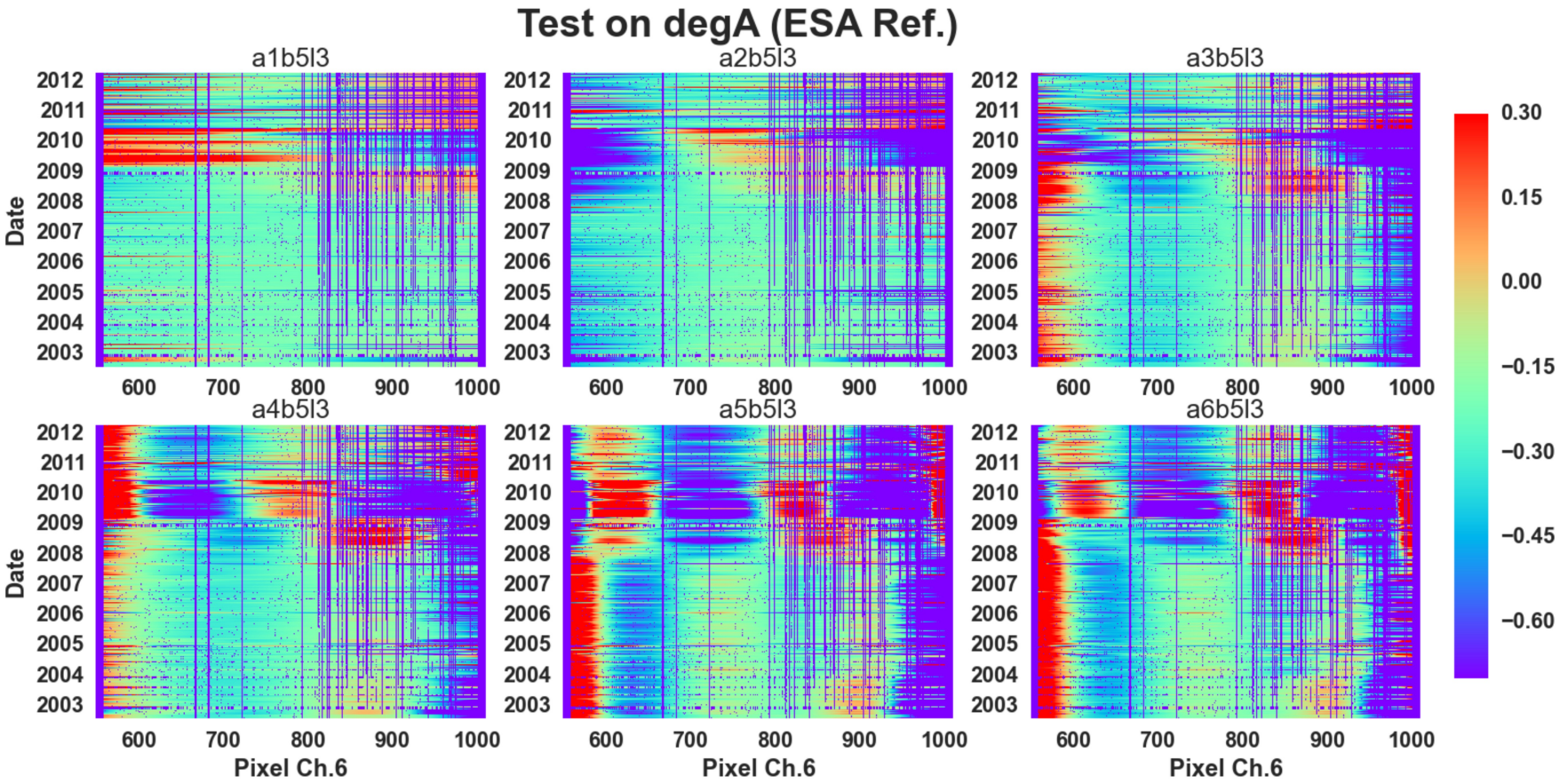
- Input data used:
  - Sun reference from ESA study Sentinel-5
  - Fitted ISRF
  - L0-1 Processor V.8 (V.9 not yet finished)
  - Sun Mean Reference Spectra SCIAMACHY “D0”, whole mission
  - Orbital Bad&Dead Pixel Mask

- Fit variant used:
  - Full spectrum, no micro-windows
  - Different polynomial degrees of P_A
  - Different polynomial degrees of P_B

First Test for Parameter Selection – Radiance Residual

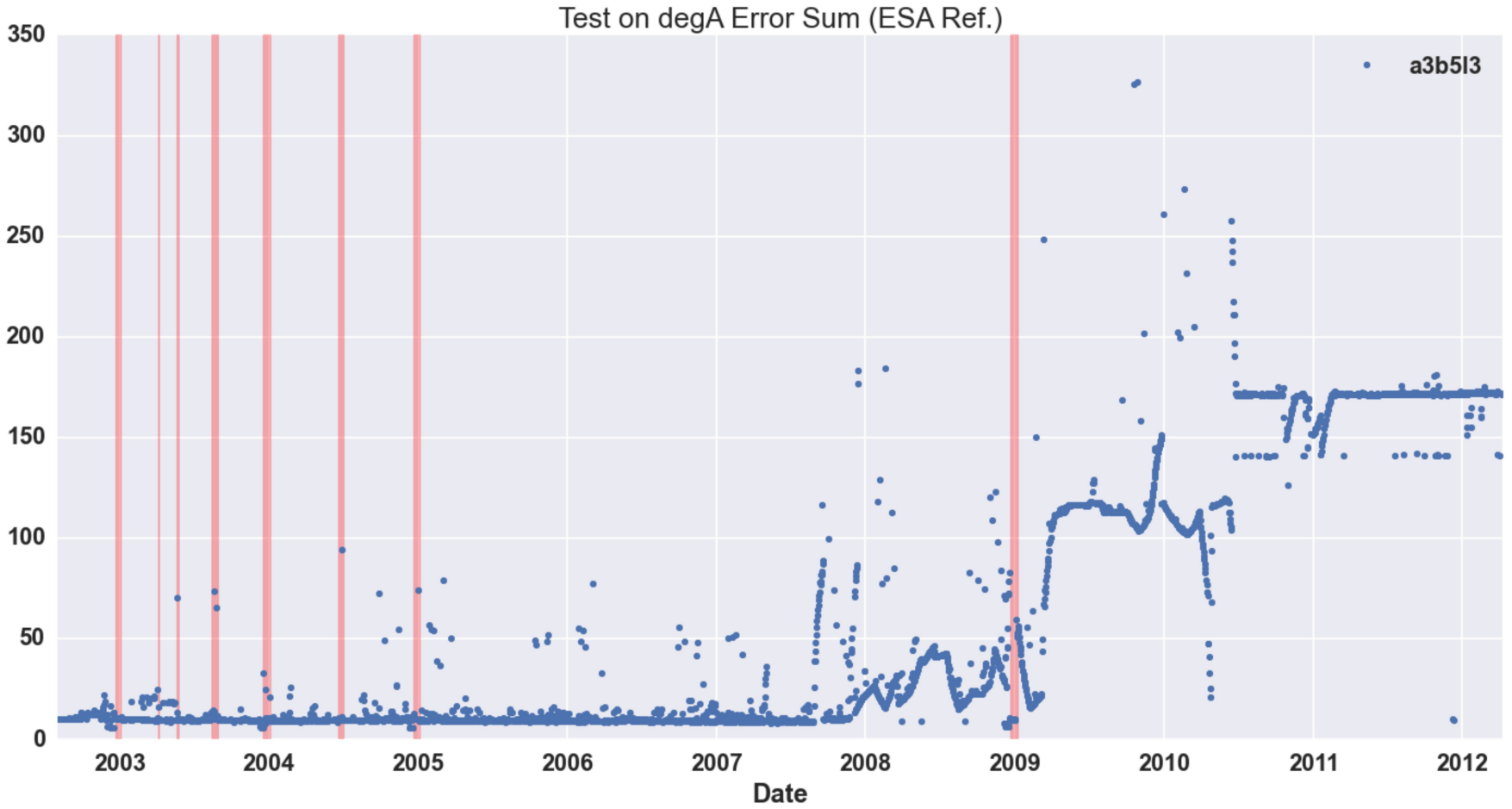


First Test for Parameter Selection – λ Difference



Pixel 730 – Difference λ_{diff} to on-ground

Fit Quality


Test on degA Error Sum (ESA Ref.)
a3b5l3
350
300
250
200
150
100
50
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Date

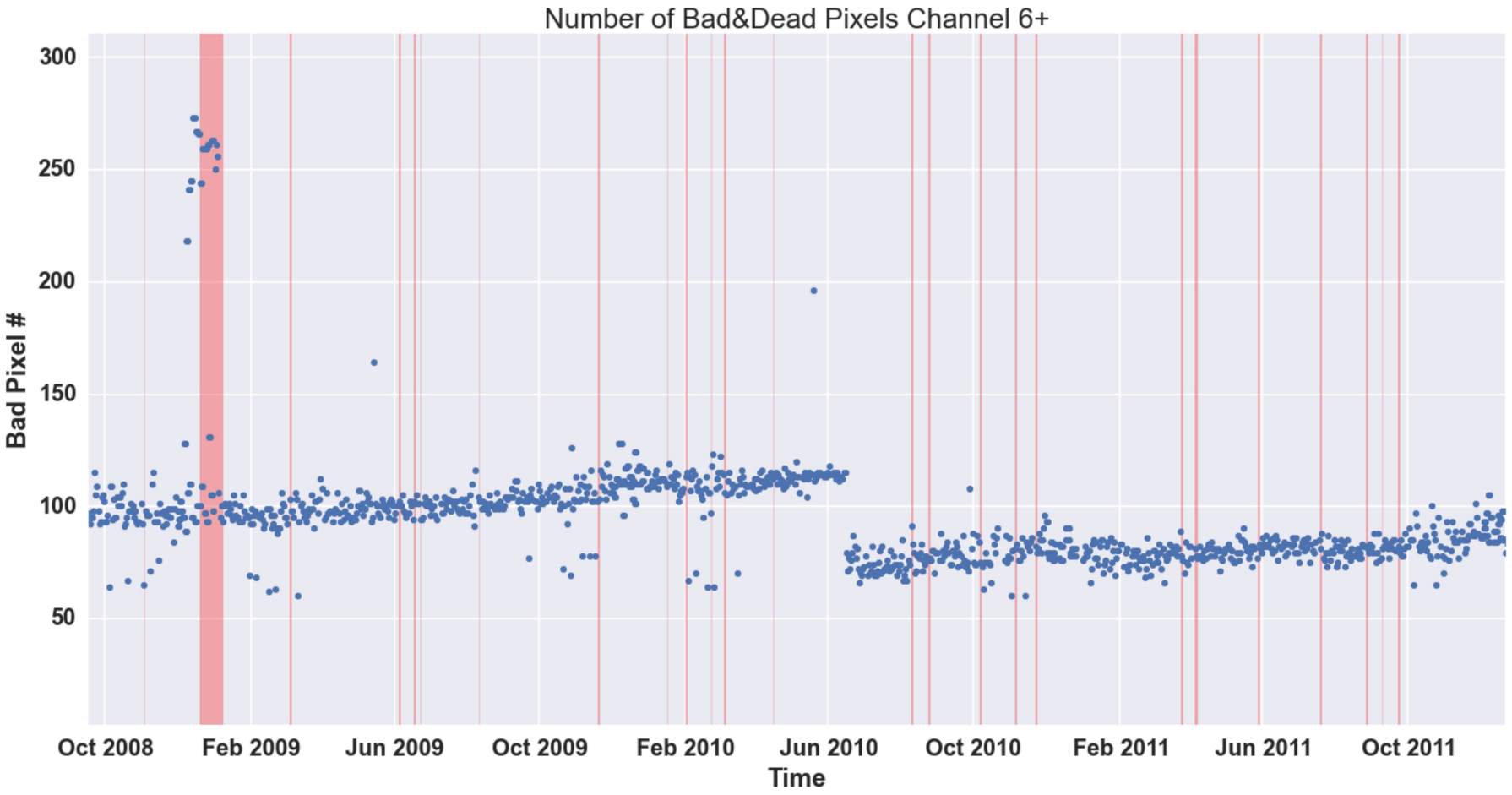
First Test Results

- Degree of P_A > 4 leads to unrealistic high shift at fit window edge
  - Change in spectral axis seems to be relative constant in time, at least until march 2009 → on-ground to in-flight effect?
- Exclusion/inclusion of bad pixels have a significant influence on result

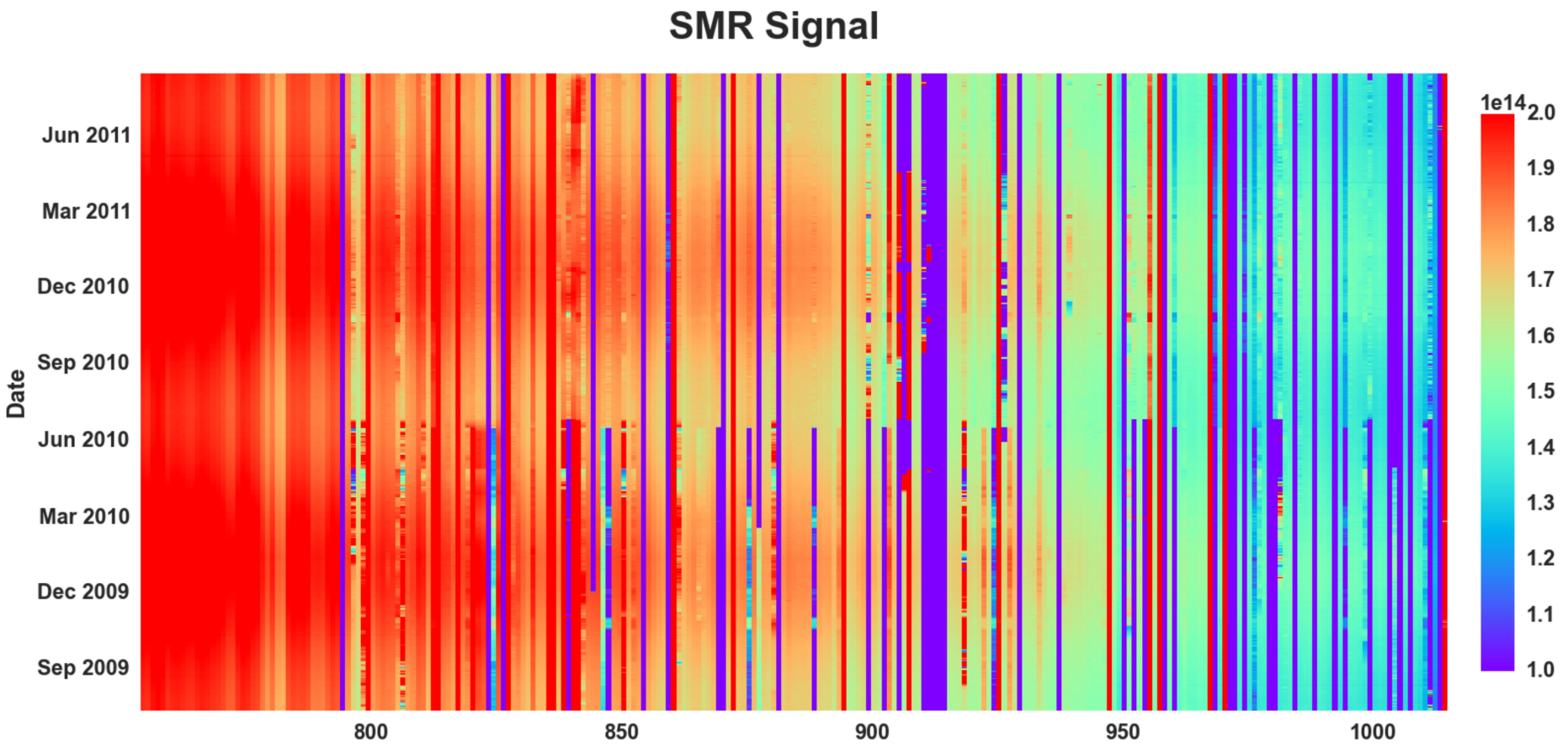
- In March 2009 and June 2010 the fit gets suddenly worse, possible reasons
  - Important pixel gets bad
  - Optical path degradation
  - Change of spectral features of the diffuser (unlikely for channel 6)

- Besides a few occasional deviations, overall the results do not show temporal variations in ISRF shape over the mission

Bad Pixel Mask Over Time



SMR Signal Channel 6 (no mask applied)



Summary

- Results are preliminary
  - Only V.8 data were used, there are considerable improvements in V.9
  - Tested parameters only cover small part of parameter space
- Results:
  - Wavelength axis seems mainly a one time change on-ground to in-flight
  - Typical shifts are few tenth of the SSI
  - The polynomial degrees of $P_A > 4$ lead to strong, unrealistic oscillations
- Bad Pixels Contradictory Information for June 2010 change
  - Drop in number seem to be justified by first look on SMR signals
  - Fit worsens, which may indicate that more bad pixels were included (because they were no longer excluded by the mask)
  - Other reason for drop in fit quality could be optical path degradation

Further Steps & Outlook

- Wait for V.9 and repeat the tests
- Bad & Dead Pixels
  - Investigate bad pixel detection in more detail
  - Develop pixel replacement method for sun spectra to be used for fit method

- Extend the ISRF analysis
- Use additional solar references that span the whole channel
- Test two-step fit variant for channel 6
- Extend analysis to channel 8 (ISRF and spectral calibration)

- In the L1b product we will provide two spectral calibrations
  - The current one (on-ground)
  - The new one, based on SMR fitting