SCIAMACHY: Spectral Calibration in the SWIR Channels
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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:

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

Inputs:

- High resolution reference spectrum
- Instrument Spectral Response Function (ISRF)
- Initial wavelength axis
- $S_{\text{ref}}$ 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

Radiance Row 15 msm [0, 1644]

Measurement #

Pixel
Method – ISRF Determination

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

\[ M = \text{ISRF} \times \text{Irradiance} + \text{Noise} \]

- ISRF parameters are varied until the model matches the reference
Channel 6 Retrieved ISRF

The corresponding fitted Slit

A best fit of Sciamachy solar measurement (< 3.32% accuracy)
# SCIAMACHY Channel 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength Range</td>
<td>971 – 1733 nm</td>
</tr>
<tr>
<td>SSI</td>
<td>0.77 nm</td>
</tr>
<tr>
<td>Resolution</td>
<td>1.48 nm</td>
</tr>
<tr>
<td>Spectral Stability</td>
<td>0.015 nm /100 minutes</td>
</tr>
</tbody>
</table>

![Graph showing SMR Ch. 6 red end (record 2000)](image)
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

Test on degB RelResid (ESA Ref.)

Date

Pixel Ch.6
600 700 800 900 1000

a3b3l3

a3b5l3

a3b7l3

a3b9l3

a3b11l3

a3b13l3

0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
First Test for Parameter Selection – $\lambda$ Difference
Pixel 730 – Difference $\lambda_{\text{diff}}$ to on-ground

Pixel Results Case a3b5l3

Shift [nm]

Date

Fit Quality

Test on degA Error Sum (ESA Ref.)

Date


0 50 100 150 200 250 300 350

a3b5l3
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

Number of Bad & Dead Pixels Channel 6+

- X-axis: Time (Oct 2008 to Oct 2011)
- Y-axis: Bad Pixel # (50 to 300)

Data points show the number of bad and dead pixels over time in Channel 6+.
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