MERIS & AATSR Calibration

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Enhancement of diffuser BSDF accuracy
Contents

- Context of the study
- SF recall
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Context of the ESA study

- ESA contract 18432/04/NL/AR, **Enhancement of diffusers BSDF Accuracy.**

- **Study conducted to investigate properties of diffusers regarding:**
  - Spectral Features
  - Air/vacuum effect on the BSDF
Space instruments and BSDF [1/2]

- Diffusers used for in-orbit radiometric calibration

Instrument on-board diffuser to measure solar irradiance

Solar irradiance

Earth radiance
Space instruments and BSDF [2/2]

> Knowledge of the on-board diffuser BSDF is mandatory.

> Small noise like structures on spectra from diffusers, so-called *Spectral Features*.

> In-orbit differences are found in absolute values that may come from "air/vacuum" effect.
  
  ◆ On-ground measurements in air
  ◆ In-orbit measurements in vacuum
## Diffusers

<table>
<thead>
<tr>
<th>Diffuser type</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>TNO</td>
</tr>
<tr>
<td>Material = Aluminium</td>
<td></td>
</tr>
<tr>
<td>Space qualified = Yes (SCIAMACHY, GOME, OMI, …)</td>
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<tr>
<td>QVD</td>
<td>TNO</td>
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<tr>
<td>Material = Quartz</td>
<td></td>
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<tr>
<td>Space qualified = Yes (GOME2, OMI, …)</td>
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<tr>
<td>SPECTRALON</td>
<td>Labsphere</td>
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<tr>
<td>Material = PTFE</td>
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</tr>
<tr>
<td>Space qualified = Yes (MERIS, …)</td>
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</tr>
<tr>
<td>FLUORION</td>
<td>Altran technology</td>
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<tr>
<td>Material = PTFE</td>
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<tr>
<td>Space qualified = No</td>
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<tr>
<td>White tile</td>
<td>NPL</td>
</tr>
<tr>
<td>Material = Depolished white ceramic</td>
<td></td>
</tr>
<tr>
<td>Space qualified = No</td>
<td></td>
</tr>
</tbody>
</table>
Measured Spectral Features: SCIAMACHY

Orbit 5806: Residuals of 2nd order polynomial fit to solar-elevation dependency
Measured Spectral Features: GOME-2

Sun angle dependence (AZ=0, EL=-2.05 from normal)
Measured Spectral Features: MERIS

- Speckle effect Band 4 (510nm)
  - 3068 vs 3175
  - 3068 vs 2444

- Speckle effect Band 15 (900nm)
  - 3068 vs 3175
  - 3068 vs 2444
Spectral Features

- Caused by speckles in entrance slit of the spectrometer.
- Small bandwidth per detector pixel gives large enough coherence length to observe speckles.

Amplitude of *Spectral Features* depends on:
- Number of speckles per detector pixel
- Inner pixel averaging
- Coherence effects
- Opening angle of the illumination
Measurement overview

- 3 measurement campaigns
  - Winter 2004 (in UV/VIS)
  - Spring 2005 (in NIR)
  - Summer 2005 (in UV/VIS)

- 3 type of measurements
  - Spectral Features Amplitude (SFA)
  - Spectral Features dynamics
  - Polarisation measurements
Light measurements ratio over the spectrum for Aluminum diffuser

Wavelength [nm]

Light 1 / Light 0

band1
band2
band3
band4
band5

SFA on ALUMINIUM all bands

SFA (over 20 & 40 nm bands)

Wavelength
Inner pixel averaging reduces with wavelength. Coherence effects reduce with wavelength and end at about 1100nm for a 3mm thick Spectralon diffuser.
Measurement & simulation: Aluminum

Aluminium - comparison measurements model

- SFA (%)
- Wavelength (nm)

Legend:
- VIS data msm
- Simulation data
- NIR data msm

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Measurement & simulation: Spectralon

Spectralon - comparison measurements model

![Graph showing Spectralon data comparison](image)

- **Wavelength (nm)**: 0 to 2500
- **SFA (%)**: 0.0% to 3.5%

- **VIS data msm**
- **Simulation data**
- **NIR data msm**
Measurement & simulation: QVD

QVD - comparison measurements model

- VIS data msm
- Simulation data
- NIR data msm

Wavelength (nm) vs. SFA (%) graph showing data points for different wavelengths.
Spectral Features modelling for MERIS

- The optical arrangement as modeled is the MERIS layout:
  - Free propagation over 359.4 mm
  - Followed by a Fourier mode: focal length for the lens system equal to 67 mm.
- A Spectralon diffuser was taken in reflection where the penetration depth of the light into the diffuser was modeled to be 5 mm.
- The bandwidth per spectral band is taken in agreement with the MERIS specifications.
- The following averaging effects were taken into account:
  - Inner-pixels
  - Coherence effect
  - Beam divergence
SFA modelling for MERIS

Peak-Peak amplitude of Spectral Features is $x6$

$\Delta\lambda = 7.5 \text{ nm}$  
$\Delta\lambda = 15 \text{ nm}$  
$\Delta\lambda = 3.75 \text{ nm}$
Air/vacuum effect

- In-orbit differences are found in absolute values that may come from “air/vacuum” effect.
  - On-ground measurements in air
  - In-orbit measurements in vacuum

- TNO BRDF set-up has been implemented (vacuum chamber, dedicated rotation stage)

- Error budget
  - Absolute accuracy: 0.9 % ($1\sigma$, worst case)
  - Relative (to environment) accuracy: 0.35 % ($1\sigma$, worst case),

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Set-up overview
BSDF ratio relative to the environment

Relative air/vacuum effect on the BRDF versus pressure at 280 nm

Relative air/vacuum effect on the BRDF versus pressure at 1000 nm

TNO March 2005.
BRDF of Spectralon diffuser in air and vacuum.
Conclusions


**Spectral Features:**
- The *Spectral Features Amplitude SFA* is a good qualification method to enable comparison between diffusers.
- The SFA increases “almost” linearly with wavelength.
- Deviation from linear behaviour of SFA vs wavelength can be explained with model.
- The SFA is highest for the Aluminium diffuser. The diffusers with the best performances are:
  - UV/VIS: QVD
  - NIR (1000 nm): QVD and white tile
  - NIR (1400 nm): Spectralon, Fluorion
- The SF model has been validated: *useful tool for optical design of future instruments*.

**Air/vacuum effect on the BSDF**

Trends in BSDF ratios can be observed with respect to:
- *Wavelength*: deviation from 1 of ratio decreases with wavelength.
- *Pressure*: increase of the BSDF is happening when the pressure drops below $10^{-5}$ mbar.
Eye On Australia
An outreach program for earth observation

- Shows Australia from space and on the ground
- Goals:
  - To promote Australia
  - To promote Earth Observation
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- Exhibition in the Netherlands in Q4 2006
- Exhibition in Australia in Q4 2006
- Exhibitions in other locations + book in 2007 TBC
- Support from NASA, CSIRO, others TBC
- More information + Google Earth preview:
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