

APEX 2012 – September campaign HyMountEcos data delivery report



Document Reference: APX-VTO-HYME2012
Version: 2.2
Date: **11 April 2014**

Signatures

Editor(s)	Kristin Vreys, Marian-Daniel Iordache
Approver(s)	Koen Meuleman
Issuing authority	VITO
Dissemination	External

Change Record

Release	Date	Description of Change	Editors(s)	Reviewers(s)
1.0	25 January 2013		Sindy Sterckx, Kristin Vreys	Koen Meuleman
2.0	27 March 2013	Delivery 2: reflectance data for the Czech Republic	Sindy Sterckx, Kristin Vreys	Koen Meuleman
2.1	15 April 2013	Delivery 3: reflectance data for the Czech Republic - Poland border area	Sindy Sterckx, Kristin Vreys	Koen Meuleman
2.2	11 April 2014	Delivery 4: 4.1 Reflectance data for both Czech republic and Poland processed with updated DTM 4.2 Reflectance data for Czech Republic processed with Czech Republic DSM	Kristin Vreys, Marian-Daniel Iordache	Koen Meuleman

Contents

1. INTRODUCTION.....	6
1.1. IMAGING FLIGHT	6
1.2. DATA SET.....	8
1.2.1. <i>Delivery 1: radiance data</i>	8
1.2.2. <i>Delivery 4.1: reflectance data for the Czech Republic using Czech DSM</i>	11
1.2.3. <i>Delivery 4.2: reflectance data for the Czech Republic and Poland using DTM</i>	11
2. APEX PROCESSING.....	13
2.1. RADIOMETRIC/SPECTRAL AND GEOMETRIC CALIBRATION	13
2.2. SPECTRAL SMILE	13
2.3. GEOMETRIC CORRECTION	14
2.3.1. <i>Delivery 4.1: using Czech DSM for the Czech Republic</i>	14
2.3.2. <i>Delivery 4.2: using DTM for both Czech Republic and Poland</i>	15
2.4. ATMOSPHERIC CORRECTION	16
2.5. SMOOTHING	16
2.6. WIRES	16
2.7. KNOWN ISSUES	16
3. REFERENCES.....	17

List of figures

Figure 1: Regular flight lines.....	6
Figure 2: BRDF flight lines.....	7
Figure 3: DSM_CzechRepublic_HYME extent.....	14
Figure 4: DTM_CzechRepublic_Poland_HYME extent.....	15

1. INTRODUCTION

1.1. Imaging flight

The HyMountEcos APEX imaging flight was performed on 10/09/2012, at two different flying heights: 5750m and 6065m.

Image capture times range from 10:35 till 14:13 local time.

15 "regular" flightlines were acquired, and 4 additional "BRDF" flightlines, as shown in Figure 1 and Figure 2.



Figure 1: Regular flight lines

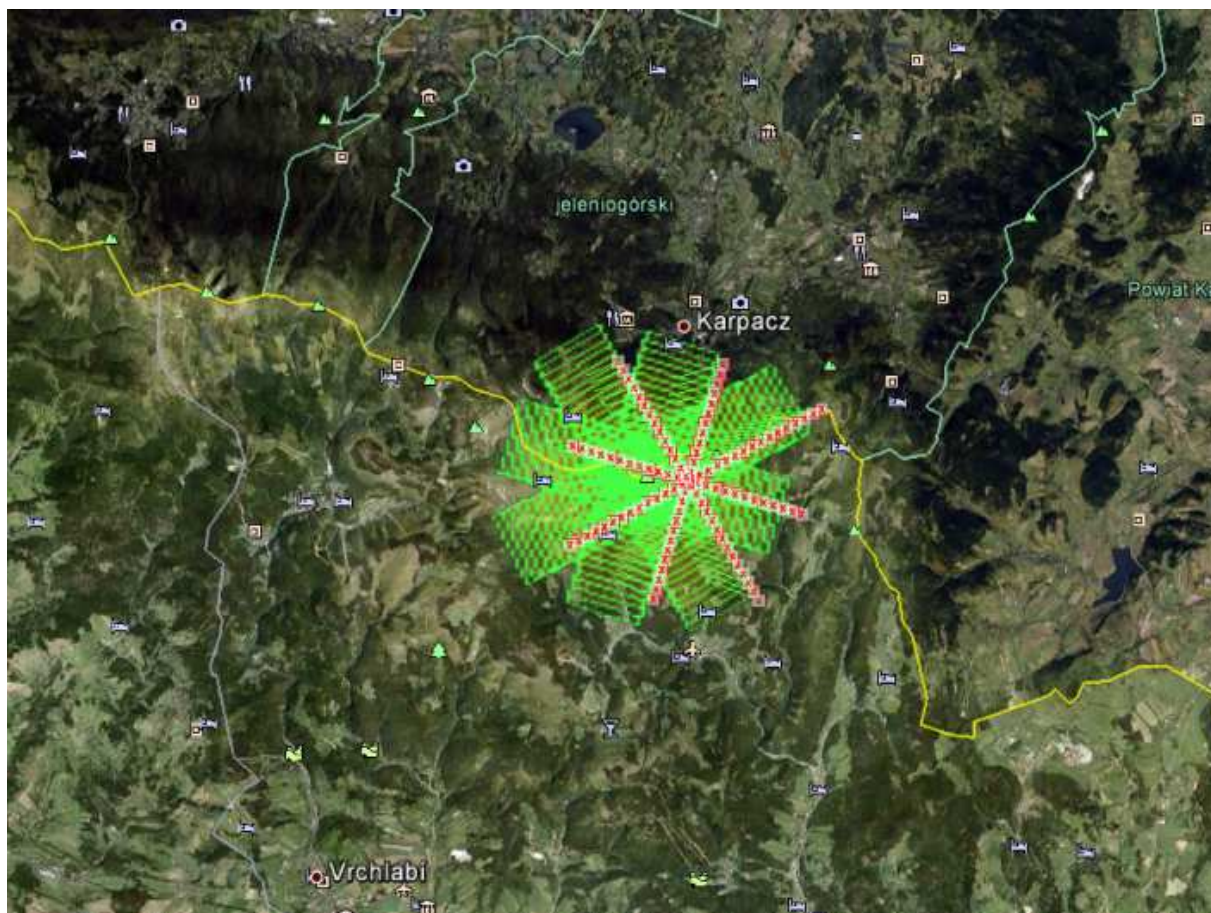


Figure 2: BRDF flight lines

1.2. Data set

The dataset will be delivered in multiple steps.

In a first delivery the radiance cubes (i.e. radiometrically calibrated data) will be provided to the user, together with their corresponding spectral properties files and georeferenced quicklooks.

In the second and following deliveries the geometrically and atmospherically corrected cubes will be provided to the user.

1.2.1. Delivery1: radiance data

In a first delivery, an external harddisk (VITO property) has been handed over to the Polish user, and the data has been copied onto an external harddisk of the Czech user.

1.2.1.1. Radiance data

The data set contains 19 flight lines in total, 15 "regular" flight lines and 4 "BRDF" lines.

To limit the size of the raw data files onboard, it was decided to split the dataset in 4 parts, further referenced as HYME1, HYME2, HYME3 and HYMEB.

HYME1 consists of 6 flight lines, numbered a01, a03, a05, a07, a09 and a11.

HYME2 consists of 6 flight lines, numbered a01, a03, a05, a07, a09 and a11.

HYME3 consists of 3 flight lines, numbered a01, a03, a05.

HYMEB consists of 4 flight lines, numbered a01, a03, a05 and a07.

Because the large amount of scanlines per flight line, it was decided to split each single flight line in parts, to ease the file handling afterwards.

There is an overlap of 200 lines between two consecutive flight line parts.

Table 1 provides the link between the flight lines as shown on Figure 1 and Figure 2, and the actual file naming of the radiance cubes.

Data is delivered in HDF5 file format.

Each HDF5 file contains both the non-georeferenced and the georeferenced (geographic coordinates, height wrt WGS84 ellipsoid, DEM=SRTM) radiance cubes, the image geometry and some additional metadata.

For the radiance data in the HDF5 files the central wavelengths for pixel 500 as determined during on-ground calibration measurements at the CHB are given.

To allow the user to extract the information from the HDF5-files, the "HDF5Reader" tool was delivered, together with a sample batch-file. Running the tool with the "-h" option shows all possible extraction options.



ID	Name	#image lines	Recording time (local)	Flying height
6	HYME1 120910_a01r_v2_Part_[0..3]	15.320	10:35 - 10:43	6065 m
7	HYME1 120910_a03r_v2_Part_[0..4]	16.244	10:48 - 10:55	
8	HYME1 120910_a05r_v2_Part_[0..3]	15.200	11:01 - 11:08	
9	HYME1 120910_a07r_v2_Part_[0..4]	16.952	11:15 - 11:22	
10	HYME1 120910_a09r_v2_Part_[0..3]	14.960	11:29 - 11:35	
11	HYME1 120910_a11r_v2_Part_[0..4]	16.220	11:42 - 11:50	
12	HYME2 120910_a01r_v2_Part_[0..3]	15.328	11:56 - 12:03	5750 m
13	HYME2 120910_a03r_v2_Part_[0..4]	17.200	12:10 - 12:18	
5	HYME2 120910_a05r_v2_Part_[0..3]	15.460	12:22 - 12:33	
4	HYME2 120910_a07r_v2_Part_[0..4]	17.740	12:39 - 12:47	
3	HYME2 120910_a09r_v2_Part_[0..3]	15.012	12:53 - 13:00	
2	HYME2 120910_a11r_v2_Part_[0..4]	16.460	13:06 - 13:14	
1	HYME3 120910_a01r_v2_Part_[0..3]	15.000	13:19 - 13:26	5750 m
14	HYME3 120910_a03r_v2_Part_[0..1]	7.520	13:34 - 13:37	
15	HYME3 120910_a05r_v2_Part_[0..1]	6.700	13:42 - 13:45	
1	HYMEB 120910_a01r_v2	3.160	13:51 - 13:53	5750 m
2	HYMEB 120910_a03r_v2	3.260	13:57 - 13:59	
3	HYMEB 120910_a05r_v2	2.768	14:04 - 14:06	
4	HYMEB 120910_a07r_v2	3.940	14:11 - 14:13	

Table 1: Radiance dataset file naming

1.2.1.2. Spectral properties files

The names of the spectral properties files correspond to those of the HDF5 files, e.g. HYME1120910_a01r_v2_Part_0_SpectralProperties.xml.

For each band, the central wavelength and FWHM is given, together with 5 parameters to allow for spectral smile correction.

For more information on how to apply these parameter, refer to section 2.2 "Spectral smile".

1.2.1.3. Quicklooks

The delivered quicklooks are georeferenced using the SRTM DEM, output is in geographic coordinates (latitude, longitude) and height wrt WGS84 ellipsoid.

1.2.2 Delivery 4.1: Reflectance data for the Czech Republic using Czech DSM

For the fourth delivery (4.1), data has been made available to the user through the APEX FTP-server.

Account details have been provided to the user by e-mail.

The data set contains 7 flight lines, that have been atmospherically and geometrically corrected. Furthermore, the spectra have been smoothed and resampled to the wavelengths, as measured during the sensor spectral calibration on the Calibration Home Base (CHB).

The delivered flight lines are:

HYME1 a07, a09 and a11

HTME2 a01 and a03

HYME3 a03 and a05

Data is delivered in ENVI file format, i.e. 27 pairs of *.img and *.hdr files.

The naming of the delivered reflectance cubes is given in the table below:

Name
HYME1 120910_a07r_Part_[0..4]_R_smt
HYME1 120910_a09r_Part_[0..3]_R_smt
HYME1 120910_a11r_Part_[0..4]_R_smt
HYME2 120910_a01r_Part_[0..3]_R_smt
HYME2 120910_a03r_Part_[0..4]_R_smt
HYME3 120910_a03r_v2_Part_[0..1]_R_smt
HYME3 120910_a05r_v2_Part_[0..1]_R_smt

Table 2: Delivery4.1 reflectance cubes file naming

Details wrt the applied processing can be found in section 2 "APEX Processing".

Note: the termination "_smt" in the file names is added automatically during the smoothing process. It is kept in order to help the user to easily discriminate between the current version and previously delivered versions.

1.2.2. Delivery 4.2: reflectance data for the Czech Republic and Poland using DTM

For the fourth delivery (4.2), data has been made available to the user through the APEX FTP-server.

Account details have been provided to the user by e-mail.

The data set contains **all** flight lines listed in Table 1 from Section 1.2.1, that have been atmospherically and geometrically corrected.

Furthermore, the spectra have been smoothed and resampled to the wavelengths, as measured during the sensor spectral calibration on the Calibration Home Base (CHB).



Data is delivered in ENVI file format, i.e. 66 pairs of *.img and *.hdr files. The naming of the delivered reflectance cubes is given in the table below:

Name
HYME1 120910_a01r_v2_Part_[0..3]_smt
HYME1 120910_a03r_v2_Part_[0..4]_smt
HYME1 120910_a05r_v2_Part_[0..3]_smt
HYME1 120910_a07r_v2_Part_[0..4]_smt
HYME1 120910_a09r_v2_Part_[0..3]_smt
HYME1 120910_a11r_v2_Part_[0..4]_smt
HYME2 120910_a01r_v2_Part_[0..3]_smt
HYME2 120910_a03r_v2_Part_[0..4]_smt
HYME2 120910_a05r_v2_Part_[0..3]_smt
HYME2 120910_a07r_v2_Part_[0..4]_smt
HYME2 120910_a09r_v2_Part_[0..3]_smt
HYME2 120910_a11r_v2_Part_[0..4]_smt
HYME3 120910_a01r_v2_Part_[0..3]_smt
HYME3 120910_a03r_v2_Part_[0..1]_smt
HYME3 120910_a05r_v2_Part_[0..1]_smt
HYMEB 120910_a01r_v2_smt
HYMEB 120910_a03r_v2_smt
HYMEB 120910_a05r_v2_smt
HYMEB 120910_a07r_v2_smt

Table 3: Delivery4.2 reflectance cubes file naming

Details wrt the applied processing can be found in section 2 "APEX Processing".

Note: the termination "_smt" in the file names is added automatically during the smoothing process. It is kept in order to help the user to easily discriminate between the current version and previously delivered versions.

2. APEX PROCESSING

This section describes shortly the several calibration and processing steps performed on the acquired APEX image cube.

2.1. Radiometric/spectral and geometric Calibration

The APEX radiometric, spectral, and geometric calibration is performed by means of calibration cubes generated from data measured and collected on the APEX Calibration Home Base (CHB) hosted at DLR Oberpfaffenhofen, Germany (Gege *et al.*, 2009). This calibration is performed before and after each flight season and generates the level 1 APEX data.

However, some radiometric miscalibrations are known to exist in the first blue bands, in the SWIR spectral band region around 1020 nm and at the end of the SWIR detector.

Currently, the artifacts in the SWIR are corrected for by vicariously retrieved gain coefficients based on the metadata (ground reflectance spectra) provided by the user. A vicarious adjustment is also performed for blue bands.

Furthermore, the first 2 blue and the last 5 SWIR bands should be treated with care by the user.

2.2. Spectral smile

APEX is known to have some smile effects, i.e. the central wavelength depends slightly on the column pixel location. Furthermore, due to spectral instabilities of APEX caused by pressure and/or temperature variations, an in-flight spectral wavelength shift analysis is performed on the basis of atmospheric absorption features to reassign new central wavelengths to each pixel.

This method is used to generate the *SpectralProperties.xml files delivered to the user.

On the basis of this file the user can calculate the central wavelength for each pixel (or column of detector array), as follows :

For pixel i with i between 1 and 1000

$$\begin{aligned} wvl(i) = & (ns1:CentralWavelengths_Micrometer) + \\ & (ns1:CentralWaveLength_Parameter1) + \\ & (ns1:CentralWaveLength_Parameter2) * i + \\ & (ns1:CentralWaveLength_Parameter3) * i^2 + \\ & (ns1:CentralWaveLength_Parameter4) * i^3 + \\ & (ns1:CentralWaveLength_Parameter5) * i^4 \end{aligned}$$

Note that for the delivered **reflectance** cubes, the ENVI header-file contains the wavelength of pixel 500, spectral resampling to this wavelength was performed!

2.3. Geometric correction

The geometric correction is performed by VITO's own developed C++ module and is based on direct georeferencing. Input data from the sensor's GPS/IMU, boresight correction data and a user-specified DTM/DSM are further used during the geometric correction process. Finally the data are projected to UTM (WGS84, zone 33N). Note that the output resolution was not forced to a particular value, thereby causing slight differences in the observed pixel size of the images.

2.3.1. Delivery4.1: using Czech DSM for the Czech Republic

VITO received from the Czech user 631 DSM-tiles (ASCII), converted and merged these into the so-called "DSM_CzechRepublic_HYME_LatLon_WGS84" DSM.

This DSM has been used in the geometric correction of the dataset for delivery4.1.

Fig. 3 shows the merged DSM for Czech Republic.

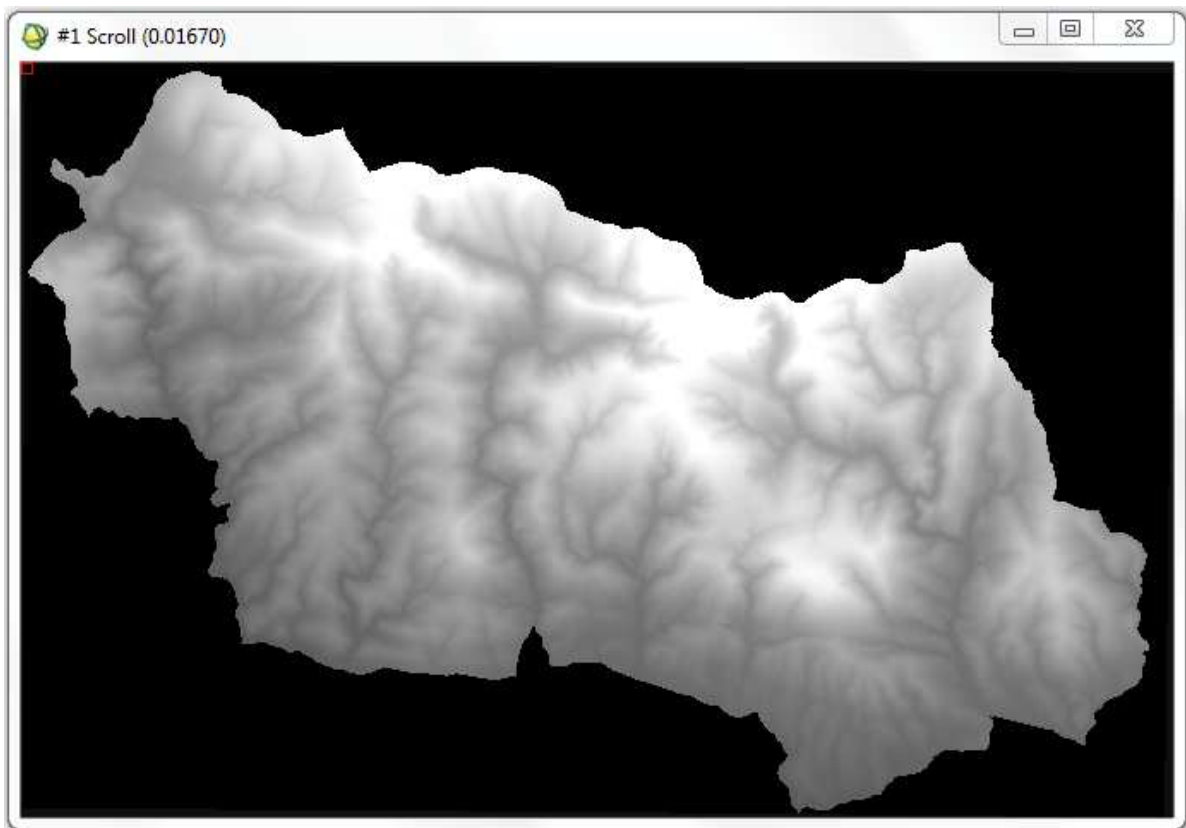


Figure 3: DSM_CzechRepublic_HYME extent

2.3.2. Delivery4.2: using DTM for both Czech Republic and Poland

VITO received from the Czech and Polish users 918 DTM-tiles (ASCII), converted and merged these into the so-called "DTM_CzechRepublicPoland_HYME_LatLon_WGS84" DTM.

This DTM has been used in the geometric correction of the dataset for delivery4.2.

Fig. 4 shows the extent of the DTM for the regions covered by flightlines in the two countries.

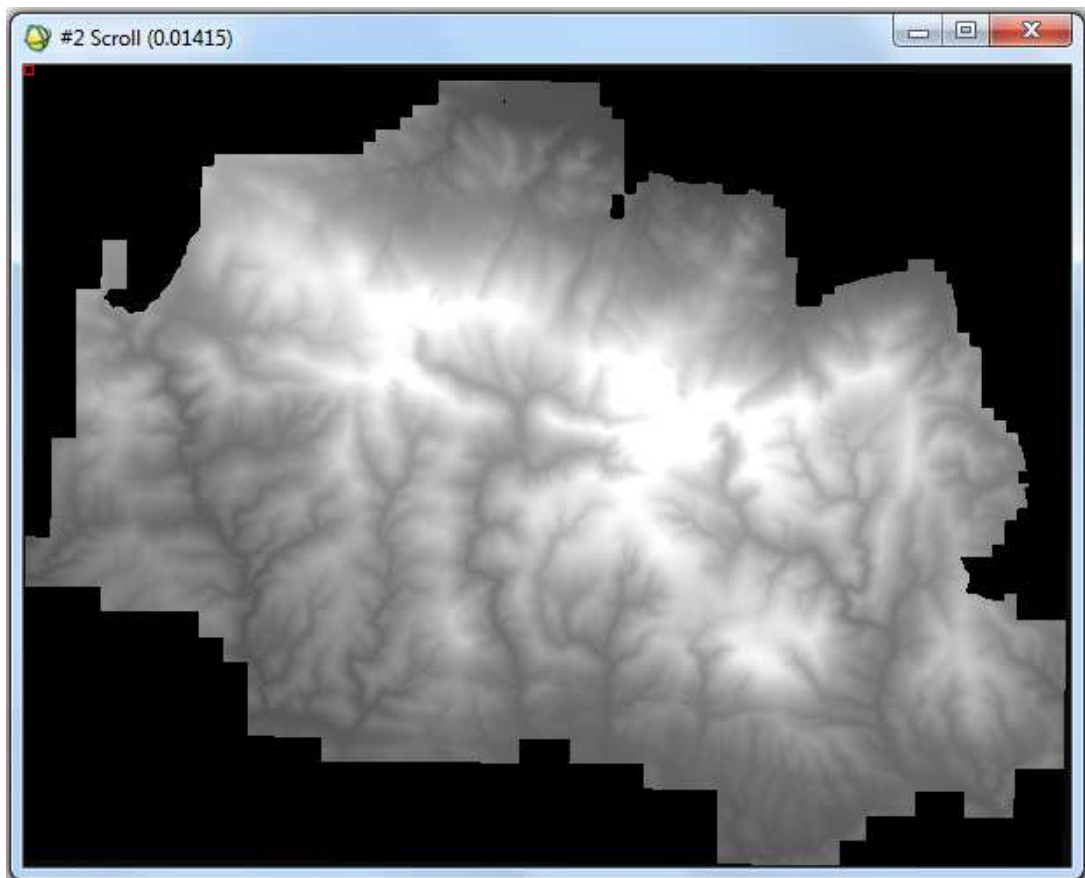


Fig. 4 DTM_CzechRepublic_Poland_HYME extent

When using DTM, the reflectance images were delivered for **all** the flightlines listed in Table 1. The delivered images are listed in Table 3 "Delivery4.2 reflectance cubes file naming".

NOTE: the border region between Czech Republic and Poland is covered in these images. The corresponding flightlines are listed in Table 4. These flightlines were not processed and delivered using DSM, as there were missing DSM data from the Polish part, which led to clearly visible artifacts in the quicklooks. As soon as the Polish DSM is available, the aforementioned flightlines will also be processed using DSM.

Name
HYME1 120910_a01r_Part_[0..3]_R_smt
HYME1 120910_a03r_Part_[0..4]_R_smt
HYME1 120910_a11r_Part_[0..3]_R_smt
HYME2 120910_a01r_Part_0_R_smt
HYME2 120910_a03r_Part_3_R_smt
HYMEB 120910_a01r_v2_smt
HYMEB 120910_a03r_v2_smt
HYMEB 120910_a05r_v2_smt
HYMEB 120910_a07r_v2_smt

Table 4: Delivery4.2 reflectance cubes file naming for the flightlines covering the border region between Czech Republic and Poland

2.4. Atmospheric correction

The atmospheric correction of the acquired APEX data is performed by the CDPC (Biesemans *et al.*) with the MODTRAN4 radiative transfer code following the algorithms given in de Haan *et al.* (1991) and de Haan and Kokke (1996) and taking into account the in-flight determined central wavelengths for each pixel (column) (i.e. smile aware atmospheric correction).

2.5. Smoothing

Wavelength dependent spectral smoothing of the data is performed to remove noise and spikes remaining after atmospheric correction.

2.6. Wires

Wires were placed on the entry slit to observe spatial shifts. In the delivered dataset wires are interpolated during the processing. Depending on the geometric shifts apparent on the flight level of this data cube, some remaining wire residuals may exist. Some linear artefacts due to interpolation may exist. The across track wire positions are: 336-337 and 676-677, the interpolated region currently encompasses a buffer of 1 pixel around the wire positions. Pixels in the interpolated wire region should be treated with caution.

2.7. Known issues

- Residual along track striping

APEX is a pushbroom instrument and hence technologically prone to striping artefacts. Most of the striping is removed during radiometric calibration and destriping before atmospheric correction. However, some residual striping, occasionally at lower spatial frequency may appear.

- **Residual across track striping**

Some minimal across track striping may be observed in a limited number of bands.

- **Image crispness**

Spatial misregistration correction can lead to loss of information and according visual fuzziness due to spatial resampling.

- **Radiometric artefacts**

Some radiometric miscalibrations are known to exist in the spectral band region 1020nm \pm 2 bands and spatial sample positions 319-324 as well as in the 1030nm region for all across-track positions. Pixels contained within the above mentioned spatial-spectral regions have been corrected for these artefacts but should be treated with care in this processing version.

- **Directional effects**

The data are known to exhibit spectro-directional effects which have not yet been corrected for. These natural effects are known to affect information extraction routines in shaded and sloped areas of the imaged scene.

3. REFERENCES

De Haan J.F., Hovenier J.W, Kokke J.M.M, Van Stokkom H.T.C. (1991) Removal of atmospheric influences on satellite-borne imagery: a radiative transfer approach. *Remote Sensing of Environment*, 37,1–21

De Haan, J. F., Kokke, J.M.M. (1996). Remote sensing algorithm development toolkit I Operationalization of atmospheric correction methods for tidal and inland waters (Netherlands Remote Sensing Board (BCRS) publication. Rijkswaterstaat Survey Dept. Technical Report) 91p.

Gege, P., J. Fries, J., Haschberger, P., Schötz, P., Schwarzer, H., Strobl, P., Suhr, B., Ulbrich, G., Vreeling, W.J (2009). Calibration facility for airborne imaging spectrometers, *ISPRS Journal of Photogrammetry & Remote Sensing*, 64, 387-397.

Biesemans, J., S. Sterckx, E. Knaeps, K. Vreys, S. Adriaensen, J. Hooyberghs, K. Meuleman, P. Kempeneers, B. Deronde, J. Everaerts, D. Schläpfer & J. Nieke., "Image processing workflows for airborne remote sensing". In: Proc. 5th EARSeL Workshop on Imaging Spectroscopy, EARSeL, Bruges, Belgium, pp. 8 (2007).