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FEASIBILITY STUDY FOR GEO-LOCATION ASSESSMENT OF OPTICAL SENSORS GEOACCA

Software Design Document

Deliverable D02

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| <p>ABSTRACT:</p> <p>For the assessment of the geo-location accuracy of EO data, a database of Ground Control Points and Reference Data has been set up.</p> <p>The EO input data are orthorectified with the external software BEAM, and cut to appropriate data windows for each GCP. The data windows are stored in the database together with metadata information. The cloud or snow covered data windows are identified by a cloud/snow screening algorithm, and excluded from the further processing. Cloud and snow free data windows are matched against the reference data windows with template matching. The output of the matching tool is the shift of the EO data in x-, y-, along-track and across-track direction as well as a quality parameter.</p> <p>An envelope module is used for the analysis and visualisation of the geolocation accuracy of the EO input data at the GCPs.</p> | | | |
| <p>The work described in this report was done under ESA Contract. Responsibility for the contents resides in the authors or organisation that prepared it.</p> | | | |
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| 1.1 | 17/10/2014 | - | - | Comments from ESA included, updated to Software version 1.0, |
| 1.2 | 21/12/2015 | All | All | Update to Software version 1.1.0 (new sensor: PROBA-V) |
| 1.3 | 22/02/2016 | - | 5 | Information on the calculation of the orbit inclination angle included |

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1. INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the design of the processing line and the database for the assessment of the geo-location accuracy of optical EO sensors.

1.2 Outline

Section 2 describes the processing line and main modules. Sections 2.1 to 2.3 treat the particular steps of the processing software. Section 2.4 specifies the relational database for handling ground reference points and accuracy information. Section 2.5 refers to the visualisation and statistical analysis of the results.

1.3 Acronyms

| | |
|-----------|---|
| AMORGOS | Accurate MERIS Ortho-Rectified Geo-location Operational Software |
| AATSR | Advanced Along-Track Scanning Radiometer |
| BEAM | Basic ERS & Envisat (A) ATSR and Meris Toolbox |
| DEM | Digital Elevation Model |
| GCP | Ground Control Point |
| GDAL | Geospatial Abstraction Library |
| GETASSE30 | Global Earth Topography And Sea Surface Elevation at 30 arc second resolution |
| GTP | BEAM Graph Processing Tool |
| MERIS | MEdium Resolution Imaging Spectrometer |
| NDSI | Normalized Difference Snow Index |
| NDVI | Normalized Difference Vegetation Index |
| PROBA-V | Project for On-Board Autonomy - Vegetation |

2. SYSTEM DESIGN

The concept of the processing line of the geo-location assessment tool is shown in Figure 2.1. The Core Module performs the geo-location accuracy assessment, whereas an Envelope Module will be used for the evaluation of the geo-location accuracy and for the visualisation.

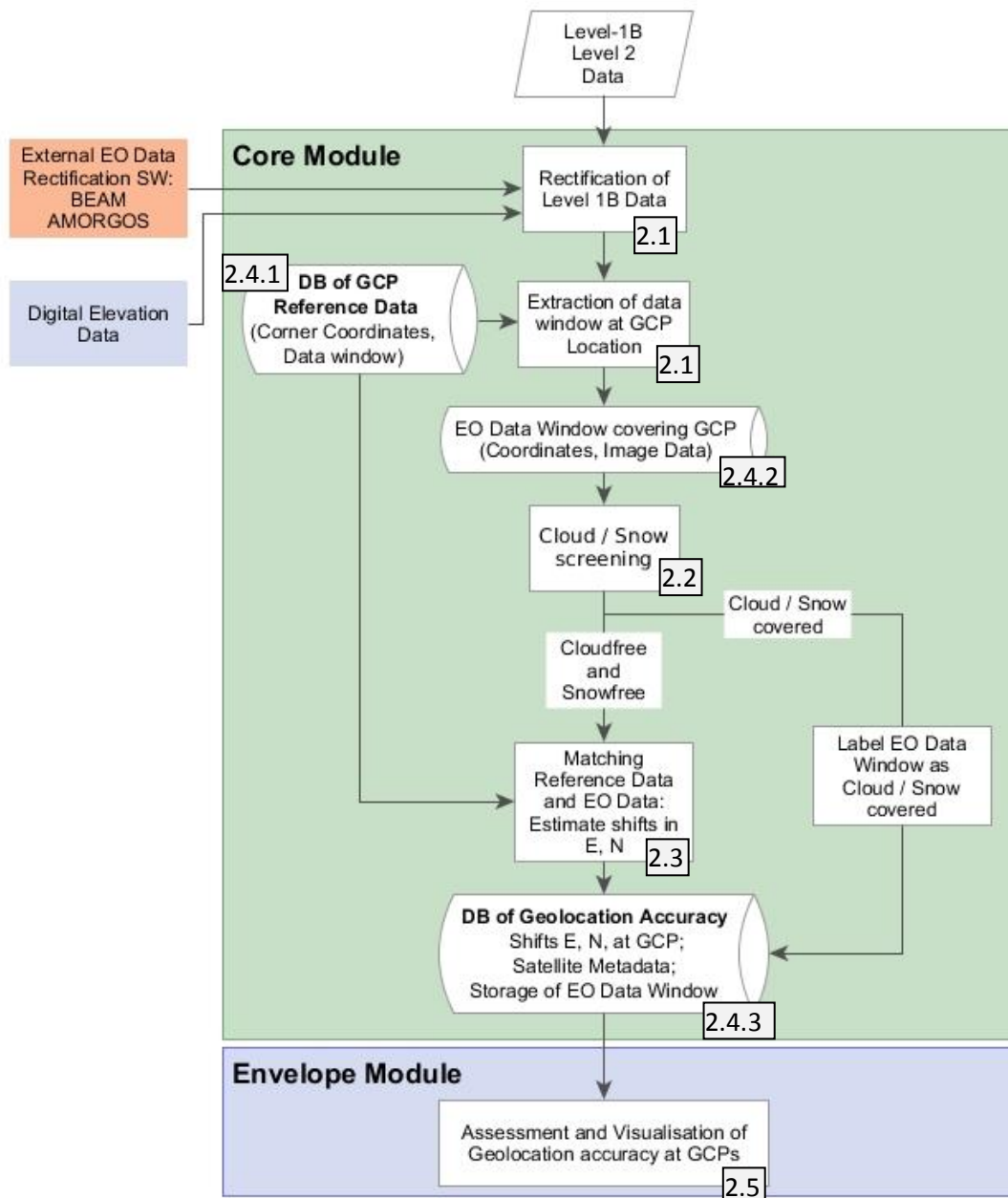


Figure 2.1: Concept of Processing Line. The numbers indicate the sections with a detailed description of the respective steps.

The Geo-location Assessment Tool has a modular design. It consists of a Core Module (performing the geo-locations accuracy assessment), an Envelope Module (for evaluation of geo-location accuracy and visualisation) and external software tools (e.g. 3rd party tools for ortho-rectification).

The orthorectification of EO data performs by external Rectification Software e.g. BEAM (public available as source code), AMORGOS (available as Executables at ESA). The modular design enables also to include software tools for upcoming sensors. Depending on the external rectification software tool a DEM is needed as input for rectification. E.g. BEAM applies the GETASSE DEM for rectifying AATSR and MERIS data.

The data base of ground control points contains reference GCPs like open water bodies. This database is generated within WP300. Each GCP is characterised by an extension given by the corner coordinates, and can be identified by a unique ID.

EO input data supported within the project are AATSR TOA, ATSR-2 TOA, MERIS TOA Level 1b (Swath data) and PROBA-V Level 3 TOA synthesis products. In a first step EO swath data are rectified using the corresponding external rectification software, producing maps of TOA in UTM coordinates. For PROBA-V, where the rectified Level 3 data are used as input, the images are directly re-projected to UTM coordinates, skipping the rectification step.

From the TOA maps, data windows are extracted covering the Ground Control points. These data windows are stored together with metadata information in a directory. Cloud and snow screening is applied to the data windows in order to identify those GCPs which cannot be used for geo-location accuracy mapping. Cloud or snow covered GCPs are labelled in the Geo-location Assessment Database.

Cloud and snow free EO data windows are used for assessment of the geo-location accuracy of the EO data windows relative to the reference data set. Matching algorithms are used to estimate the shifts in Easting and Northing. The shift vector in Easting/Northing is rotated by the orbit inclination angle in order to compute the shifts in along-track and across-track direction. For the calculation of the orbit inclination angle, Vincenty's formula for the computation of the azimuth between two geographic points on the WGS84 ellipsoid is used. The result of the matching module is stored in the Geo-location Accuracy Database for each GCP, together with matching quality parameters and metadata information on acquisition time, orbit, etc. The EO data window can be stored in a directory, and a link to the corresponding file is stored on this database.

The Envelope Module has the aim to enable the analysis of geo-location accuracy and uses the result stored in the Geo-location Accuracy Database. The specification of analysing the geo-location accuracy is specified together with ESA.

In the following subsections the individual modules are explained in detail.

2.1 Rectification of Level 1B Data, Extraction of data window, Oversampling

2.1.1 Level 1B input data

Module Name:

- raster.RASTERFILE.importUTMRaster

Input:

- AATSR TOA, ATSR-2 TOA or MERIS FRS TOA Level 1B. (But, due to the modular design of the software, an extension to other sensors is possible.)

Output:

- Orthorectified EO data window covering GCP, oversampled to resolution of reference image

Description:

AATSR, ATSR-2 and MERIS Level-1B input data are orthorectified with the BEAM Graph Processing Tool (GPT). This tool enables the execution of the operations within the software BEAM in batch-mode. In a first step, a subset around the GCPs is extracted in order to minimize the computing time for orthorectification. In the next step, the orthorectification, based on the DEM GETASSE30, is performed, including the extraction of the appropriate data window covering the GCP and the resampling to the same resolution as the reference data (Deliverable D04, section 2.5, 2.6). The resulting images have the coordinate reference system UTM, based on the WGS84 reference ellipsoid.

This module can be easily adapted to use other rectification software tools.

The resulting EO input data windows are stored in a directory, which is linked in the database. Additionally, metadata information is stored in the database (see Section 2.4).

2.1.2 Rectified input data

Module Name:

- raster.COMPOSITE_RASTERFILE.importUTMRaster

Input:

- PROBA-V TOA Level 3 1-day synthesis product.

Output:

- Orthorectified EO data window covering GCP, oversampled to resolution of reference image

Description:

PROBA-V Level 3 input data are imported with the HDF5 library, converted from digital numbers to physical TOA reflectance values and written to GeoTIFF images. The resulting images are re-projected to the coordinate reference system UTM, based on the WGS84 reference ellipsoid, cut to the appropriate data window size and resampled to the same resolution as the reference data with the GDAL library.

The extracted EO input data windows are stored in a directory, which is linked in the database. Additionally, metadata information is stored in the database (see Section 2.4).

2.2 Cloud and Snow screening

The cloud and snow screening algorithms are adjusted for each sensor, taking the available spectral bands into account. Due to the modular design the algorithm can be adapted and modified to meet the requirements of the sensor to be processed.

2.2.1 AATSR, ATSR-2

Module Name:

- aatsr.AATSR_RASTERFILE.chkRasterSCC, atsr2.ATSR2_RASTERFILE.chkRasterSCC

Input:

- EO AATSR or ATSR-2 data window covering GCP

Output:

- Cloud / Snow mask
- Number of cloud- or snow-covered pixels in EO data window

Description:

A cloud screening algorithm is used in order to detect cloud-covered pixels in the EO data window. Additionally, snow covered surfaces and frozen water are detected based on the Normalized Difference Snow Index (NDSI) and a threshold at 670 nm.

A mask for cloud and snow coverage is created. The number of pixels in an EO data window which are cloud- or snow-covered is stored in the data base.

Algorithm for AATSR, ATSR-2 Cloud Screening:

We take the cloud algorithm developed by SYKE in cooperation with ENVEO in the GLOBSNOW project (Metsämäki et al. 2013) as basis for the AATSR and ATSR-2 cloud algorithm. The algorithm was tested for various environments, and adapted for the requirements in the GeoAcca project.

A pixel is classified as cloud-covered if one of the following conditions is met:

$$\begin{aligned} & (band\ 7 > 17) \ \& \ (band\ 1 < 300) \\ & \text{OR} \\ & (diff < -7) \ \& \ (band\ 7 > 8) \ \& \ (band\ 1 < 294) \ \& \ (ndvi < 0.5) \ \& \ (ndsi > -0.2) \\ & \text{OR} \\ & (diff < -7) \ \& \ (band\ 1 < 275) \ \& \ (ndvi < 0.5) \ \& \ (ndsi > -0.2) \end{aligned}$$

with

$$\begin{aligned} diff &= band\ 2 - band\ 3 \\ ndvi &= \frac{(band\ 5 - band\ 6)}{(band\ 5 + band\ 6)} \\ ndsi &= \frac{(band\ 7 - band\ 4)}{(band\ 7 + band\ 4)} \end{aligned}$$

Algorithm for AATSR, ATSR-2 Snow Screening:

A pixel is classified as snow-covered if the following condition is met:

$$(ndsi > 0.4) \ \& \ (band\ 6 > 8)$$

The AATSR, ATSR-2 bands are:

- band1: thermal band, ca. 1200 nm
- band2: thermal band, ca. 1100 nm
- band3: thermal band, ca. 370 nm
- band4: reflectance, ca. 1600 nm
- band5: reflectance, ca. 870 nm

- band6: reflectance, ca. 670 nm
- band7: reflectance, ca. 550nm

2.2.2 MERIS

Module Name:

- meris.MERIS_RASTERFILE.chkRasterSCC

Input:

- EO MERIS data window covering GCP

Output:

- Cloud / Snow mask
- Number of cloud- or snow-covered pixels in EO data window

Description:

The spectral radiance at 412.5 nm is converted to reflectance, taking into account the local sun elevation angle and the spectral irradiance. Afterwards a simple threshold at 412.5 nm is used to detect bright surfaces. Therefore, clouds, snow and frozen water are detected in one step without any differentiation.

A mask for cloud and snow coverage is created. The number of pixels in an EO data window which are cloud- or snow-covered is stored in the data base.

Algorithm for MERIS Cloud and Snow Screening:

A pixel is classified as snow- or cloud-covered if the following condition is met:

$$band\ 1 > 0.2$$

The MERIS band 1 is the reflectance at 412.5 nm.

2.2.3 PROBA-V

Module Name:

- probav.PROBAV_RASTERFILE.chkRasterSCC

Input:

- EO PROBA-V data window covering GCP

Output:

- Cloud / Snow mask
- Number of cloud- or snow-covered pixels in EO data window

Description:

A simple threshold at 463 nm is used to detect bright surfaces. Therefore, clouds, snow and frozen water are detected in one step without any differentiation.

A mask for cloud and snow coverage is created. The number of pixels in an EO data window which are cloud- or snow-covered is stored in the data base.

Algorithm for PROBA-V Cloud and Snow Screening:

A pixel is classified as snow- or cloud-covered if the following condition is met:

$$band\ 1 > 0.18$$

The PROBA-V band1 is the reflectance at 463 nm.

2.3 Matching Reference Data and EO Data

Module Name:

- matching.MATCHING.matching

Input:

- Cloud- and snow-free EO data window
- Reference data window

Output:

- Shift in x- and y-direction
- Shift in along-track and across-track direction
- Correlation coefficient

Description:

In order to calculate the shift of the EO input data in comparison to the reference data, the OpenCV function `matchTemplate` is used (Deliverable D04, section 2.1). OpenCV is an open source computer vision library, which is written in C/C++ (Bradski and Kaehler 2008). By its Python interface, the function `matchTemplate` is included in a Python program, which runs on a LINUX / UNIX system.

The function needs as input a reference image, which is taken from the reference database, and a smaller template image, which is the previously created cloud-free, orthorectified and resampled EO input data window.

The template image is shifted pixel by pixel in comparison to the reference image. At each location, a correlation coefficient between the two images is calculated, and stored in a result matrix. Hence, the location with the best match can be retrieved from the maximum correlation coefficient. The OpenCV function provides six different methods to match the two images. The normalized correlation coefficient

$$R(x, y) = \frac{\sum_{x', y'} (T'(x', y') \cdot I'(x + x', y + y'))}{\sqrt{\sum_{x', y'} T'(x', y')^2 \cdot \sum_{x', y'} I'(x + x', y + y')^2}},$$

with

$$T'(x', y') = T(x', y') - 1/(w \cdot h) \cdot \sum_{x'', y''} T(x'', y'')$$

$$I'(x + x', y + y') = I(x + x', y + y') - 1/(w \cdot h) \cdot \sum_{x'', y''} I(x + x'', y + y'')$$

is used, where I denotes the reference image, T the template and R the result. The size of the template is $w \times h$, and .

In respect to the wavelength used for the matching procedure, two possibilities are implemented in the software: One possibility is to use the near infrared band, while the other possibility is to use the relation of the red band to the near infrared band. With this ratio, the difference between land and water becomes most pronounced.

An example of the output of the matching procedure is shown in Figure 2.2. The calculated shifts of EO input data in x- and y-direction, along-track and across-track direction (in meters), as well as the value of the maximum correlation coefficient, are stored in the database. For PROBA-V, where a

composite of multiple images is used as input, the retrieval of the orbit inclination angle is not possible, hence the shifts are not converted to along-track and across-track direction.

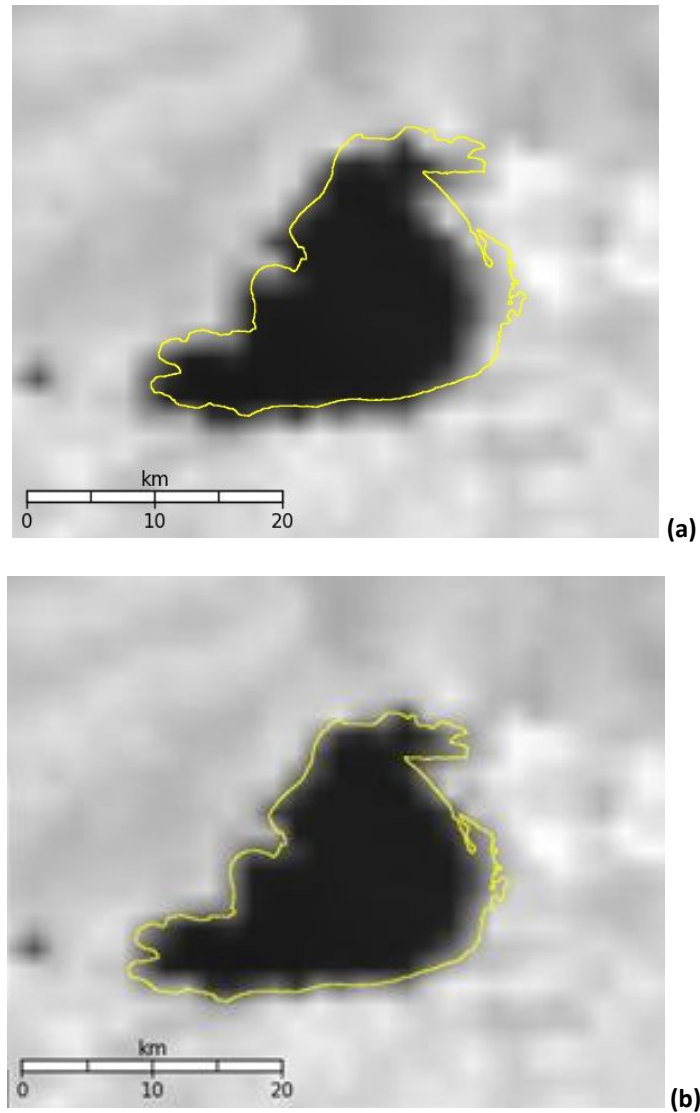


Figure 2.2: Example of GCP lake Dali Nuoyer (China). (a): SWBD water outlines laid over the AATSR data window. (b): SWBD water outlines laid over the shifted AATSR data window. Shift in x-direction is 1130 meters, shift in y-direction is 970 meters, the correlation coefficient is 0.855.

2.4 Geo-location Assessment Database

In support of efficient data management and handling a PostgreSQL database has been set up, with the spatial database extender PostGIS, adding support for geographic objects. An overview of the PostgreSQL/PostGIS database is given in Figure 2.3. Table 2.1 to Table 2.11 list detailed descriptions of the SQL database tables.

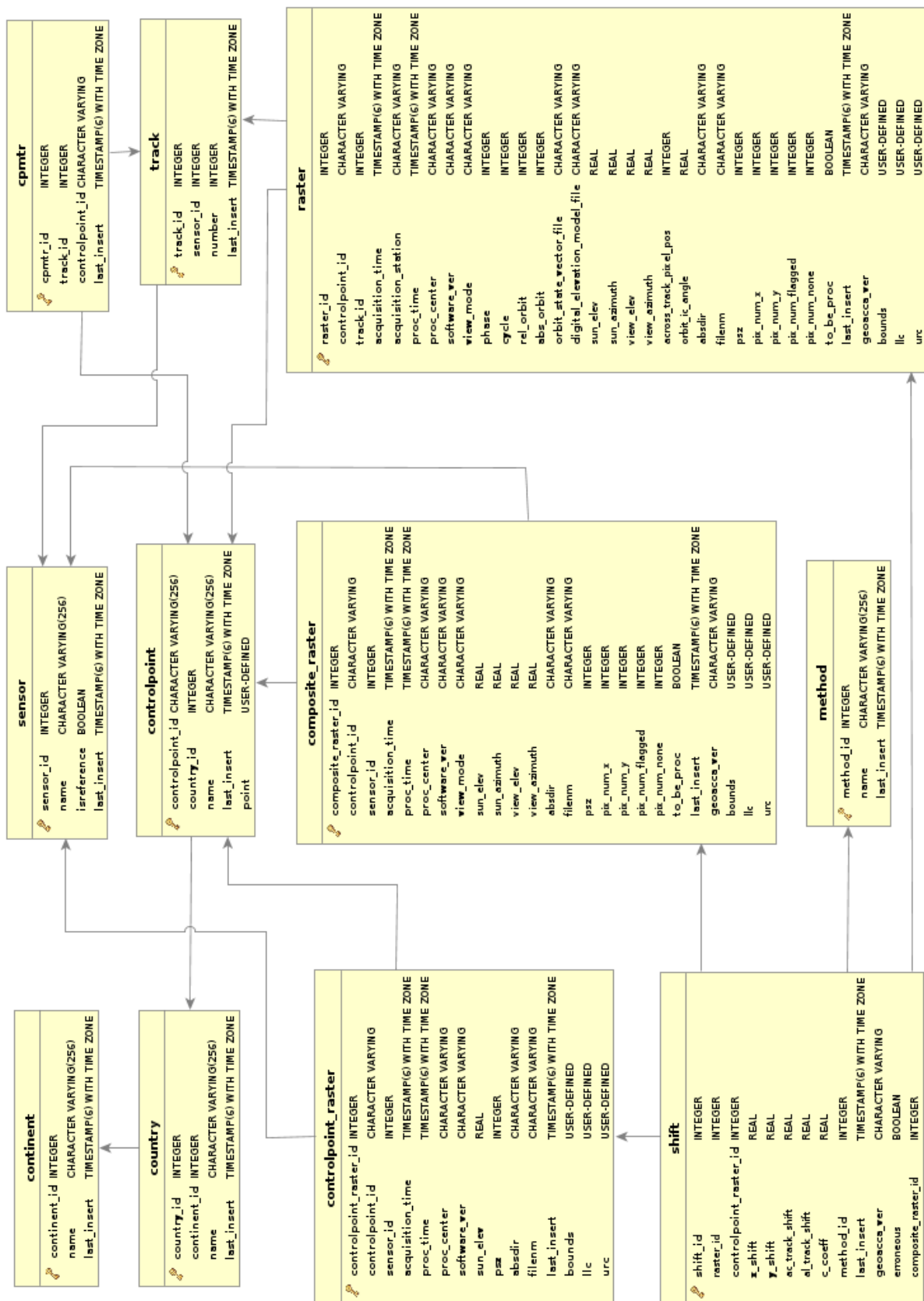


Figure 2.3: Data model of the Geolocation Assessment Database.

Table 2.1:
Database table “continent” (see Figure 2.3), containing the continents where the GCPs are located

| Column | Data type | Description |
|--------------|--|----------------------------|
| continent_id | INTEGER | unique key |
| name | VARCHAR | name of continent |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |

Table 2.2
Database table “country” (see Figure 2.3), containing the countries where the GCPs are located. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|--------------|--|--------------------------------|
| country_id | INTEGER | unique key |
| continent_id | INTEGER | reference to table “continent” |
| name | VARCHAR | name of country |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |

Table 2.3:
Database table “controlpoint” (see Figure 2.3), describing the GCPs. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|-----------------|--|--------------------------------------|
| controlpoint_id | VARCHAR | unique key |
| country_id | INTEGER | reference to table “country” |
| name | VARCHAR | name of GCP feature (lake or island) |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |

| | | |
|-------|----------|--|
| point | geometry | mean coordinates (lat/lon) of GCP feature (lake or island) |
|-------|----------|--|

Table 2.4:
Database table “controlpoint_raster” (see Figure 2.3), describing reference raster data window. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|------------------------|--|---|
| controlpoint_raster_id | INTEGER | unique key |
| controlpoint_id | VARCHAR | reference to table “controlpoint” |
| sensor_id | INTEGER | reference to table “sensor” |
| acquisition_time | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | acquisition time |
| proc_time | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | processing time |
| proc_center | VARCHAR | processing center |
| software_ver | VARCHAR | software version of processing software |
| sun_elev | REAL | sun elevation |
| psz | INTEGER | pixel size |
| absdir | VARCHAR | absolute path to the directory where raster is stored |
| filenm | VARCHAR | file name of raster |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |
| bounds | geometry | bounding box (lat/lon) of raster |
| llc | geometry | lower left corner (lat/lon) of raster |
| urc | geometry | upper right corner (lat/lon) of raster |

Table 2.5:
Database table “cpmtr” (see Figure 2.3), listing the GCPs covered by a given track. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|-----------------|--|-----------------------------------|
| cpmtr_id | INTEGER | unique key |
| track_id | VARCHAR | reference to table “track” |
| controlpoint_id | INTEGER | reference to table “controlpoint” |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |

Table 2.6:
Database table “track” (see Figure 2.3), containing the tracks of a given sensor. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|---------------|--|-----------------------------|
| track_id | VARCHAR | unique key |
| sensor_id | INTEGER | reference to table “sensor” |
| number | INTEGER | track number |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |

Table 2.7:
Database table “sensor” (see Figure 2.3), containing the sensors which recorded the reference and input raster data. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|---------------|------------------|-------------------------------------|
| sensor_id | INTEGER | unique key |
| name | VARCHAR | sensor name |
| isreference | BOOLEAN | flag if sensor is used as reference |

| | | |
|-------------|--|----------------------------|
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |
|-------------|--|----------------------------|

Table 2.8:
Database table "raster" (see Figure 2.3), describing EO input raster data window. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|------------------------------|---|--|
| raster_id | INTEGER | unique key |
| controlpoint_id | VARCHAR | reference to table "controlpoint" |
| track_id | INTEGER | reference to table "track" |
| aquisition_time | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss.ss UTC) | acquisition time of center point |
| acquisition_station | VARCHAR | acquisition station |
| proc_time | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss.ss UTC) | processing time (product generation time) |
| proc_center | VARCHAR | processing center |
| software_ver | VARCHAR | software version number of processing software |
| view_mode | VARCHAR | direction of sensor view (nadir or forward) |
| phase | INTEGER | phase |
| cycle | INTEGER | cycle number |
| rel_orbit | INTEGER | relative orbit number |
| abs_orbit | INTEGER | absolute orbit number |
| orbit_state_vector_file | VARCHAR | auxiliary information on orbit state vector |
| digital_elevation_model_file | VARCHAR | auxiliary information on DEM |
| sun_elev | REAL | sun elevation angle at center point |

| <i>Column</i> | <i>Data type</i> | <i>Description</i> |
|-----------------------------|--|---|
| sun_azimuth | REAL | sun azimuth angle at center point |
| view_elev | REAL | sensor view elevation angle at center point |
| view_azimuth | REAL | sensor view azimuth angle at center point |
| across_track_pixel_position | INTEGER | pixel position of center point |
| orbit_ic_angle | REAL | orbit inclination angle |
| absdir | VARCHAR | absolute path to the directory where raster is stored |
| filenm | VARCHAR | file name of raster |
| psz | INTEGER | pixel size |
| pix_num_x | INTEGER | number of pixels in x-direction |
| pix_num_y | INTEGER | number of pixels in y-direction |
| pix_num_flagged | INTEGER | number of pixels classified as cloud- or snow-covered |
| pix_num_none | INTEGER | number of NaN pixels in NIR band |
| to_be_proc | BOOLEAN | flag on further processing |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |
| geoacca_ver | VARCHAR | geoacca software version |
| bounds | geometry | bounding box (lat/lon) of raster |
| llc | geometry | lower left corner (lat/lon) of raster |
| urc | geometry | upper right corner (lat/lon) of raster |

Table 2.9:
Database table “composite_raster” (see Figure 2.3), describing EO input composite raster data window. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|---------------------|---|---|
| composite_raster_id | INTEGER | unique key |
| controlpoint_id | VARCHAR | reference to table “controlpoint” |
| sensor_id | INTEGER | reference to table “sensor” |
| aquisition_time | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss.ss UTC) | acquisition time of center point |
| proc_time | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss.ss UTC) | processing time (product generation time) |
| proc_center | VARCHAR | processing center |
| software_ver | VARCHAR | software version number of processing software |
| view_mode | VARCHAR | direction of sensor view (nadir or forward) |
| sun_elev | REAL | sun elevation angle at center point |
| sun_azimuth | REAL | sun azimuth angle at center point |
| view_elev | REAL | sensor view elevation angle at center point |
| view_azimuth | REAL | sensor view azimuth angle at center point |
| absdir | VARCHAR | absolute path to the directory where raster is stored |
| filenm | VARCHAR | file name of raster |
| psz | INTEGER | pixel size |
| pix_num_x | INTEGER | number of pixels in x-direction |
| pix_num_y | INTEGER | number of pixels in y-direction |
| pix_num_flagged | INTEGER | number of pixels classified as cloud- or snow-covered |

| Column | Data type | Description |
|---------------|--|--|
| pix_num_none | INTEGER | number of NaN pixels in NIR band |
| to_be_proc | BOOLEAN | flag on further processing |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |
| geoacca_ver | VARCHAR | geoacca software version |
| bounds | geometry | bounding box (lat/lon) of raster |
| llc | geometry | lower left corner (lat/lon) of raster |
| urc | geometry | upper right corner (lat/lon) of raster |

Table 2.10:

Database table “shift” (see Figure 2.3), containing the calculated shifts of EO input data window in comparison to reference data window. Keys in blue colour are referencing another database table.

| Column | Data type | Description |
|------------------------|------------------|---|
| shift_id | INTEGER | unique key |
| raster_id | INTEGER | reference to table “raster” |
| composite_raster_id | INTEGER | reference to table “composite_raster” |
| controlpoint_raster_id | INTEGER | reference to table “controlpoint_raster” |
| x_shift | REAL | calculated x-shift of EO input raster compared to reference raster [meters] |
| y_shift | REAL | calculated y-shift of EO input raster compared to reference raster [meters] |
| ac_track_shift | REAL | calculated shift in across-track direction of EO input raster compared to reference raster [meters] |
| al_track_shift | REAL | calculated shift in along-track direction of EO input |

| | | |
|-------------|--|--|
| | | raster compared to reference raster [meters] |
| c_coeff | REAL | correlation coefficient between EO input raster and reference raster |
| method_id | INTEGER | reference to table "method" |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |
| geoacca_ver | VARCHAR | geoacca software version |
| erroneous | BOOLEAN | flag for erroneous shift calculation |

Table 2.11:
Database table "method" (see Figure 2.3), containing the method used for the template matching between EO input data window and reference data window.

| Column | Data type | Description |
|-------------|--|---|
| method_id | INTEGER | unique key |
| name | VARCHAR | name of method used for template matching |
| last_insert | TIMESTAMP with TIMEZONE (DD.MM.YYYY hh:mm:ss UTC) | time of insert to database |

The GCPs objects are stored within the *controlpoint* table holding a defined unique key, composed of its centre coordinates, as well as its name and its geographic location. Each GCP relates to its country and the corresponding continent. Furthermore, it is linked to at least one optical high resolution cloud-free satellite image chip, covering its bounds. These reference images are stored within the *controlpoint_raster* table. In order to obtain sensor information of a given scene, it references the *sensor* table.

The selection of EO data to be processed is sensor dependant. For AATSR an intermediate table *cpmtr* containing all value pairs of matching tracks and GCPs is used. For MERIS and PROBA-V, the scene bounds are read from the metadata file and intersected with the GCP raster bounds to identify covered GCPs.

In case an EO scene is selected for processing the GCP specific subset will be stored and its file name and directory is written to the *raster* table for the sensors AATSR, ATSR-2 and MERIS, which additionally contains metadata information on the EO input data. Respectively, for the composite input raster files from the sensor PROBA-V, the raster information is written to the *composite_raster* table.

The results of the matching process (x/y shifts, across-track/along-track shifts) are written to the *shift* table, referencing both the reference and the EO input scene.

As database standard geographical data are represented in geographical coordinates based on WGS84 reference system.

2.5 Visualisation of Geolocation accuracy at GCPs

The Envelope Module enables the analysis of geo-location accuracy. It uses the results stored in the database, where the required information can be retrieved efficiently. Possible scenarios are

- (i) statistical evaluation of the geo-location accuracy of GCPs of one swath, and
- (ii) geo-location accuracy of a time series of swaths for a selected GCP (or a group of GCPs).

As all information on geo-location accuracy is stored in a database management system, SQL statements enable efficient access to the required information.

3. REFERENCES

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