



MERIS/(A)ATSR Synergy Toolbox

Software User Manual

Version 1.1

13 April 2010

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Software User Manual

Chapter 1

Introduction

1.1 Scope

This document is the software user manual (SUM) for the MERIS/(A)ATSR Synergy Toolbox.

1.2 Objectives

As outlined in [1], the aim of developing a MERIS/(A)ATSR Synergy Toolbox is to undertake research and algorithm development on MERIS/AATSR synergy, with stated objectives:

- define and prototype algorithms and processing schemes for improved cloud screening, global aerosol retrieval and land atmospheric correction using the combined multi-spectral and multi-angle information from geo-located and geo-registered MERIS and AATSR measurements
- verify the prototyped algorithms and processing schemes and demonstrate their benefit in terms of accuracy as compared to single-sensor algorithms
- implement these algorithms and processing schemes for the BEAM toolbox
- formulate recommendations for the development of future synergy algorithms and processing concepts for the Sentinel-3 OLCI and SLST instruments

This SUM specifically describes the software developed for Synergy preprocessing, cloud screening, ocean and land aerosol retrieval, and atmospheric correction.

1.3 Reader Level

This specification is mainly written for the following audiences:

- MERIS/(A)ATSR Synergy Toolbox users

This user manual specifications assumes that the reader is familiar with basic concepts in using the BEAM software and its integrated processors.

1.4 Acronyms and Nomenclature

1.4.1 Acronyms

- AATSR - Advanced Along-Track Scanning Radiometer
- AOD - Aerosol Optical Depth
- AOD - Aerosol Optical Thickness
- ATBD - Algorithm Theoretical Baseline Document
- BC - Brockmann Consult
- DEM - Digital Elevation Model
- DPM - Detailed Processing Model
- ESA - European Space Agency
- FUB - Free University of Berlin
- MERIS - Medium Resolution Imaging Spectrometer Instrument
- IODD - Input/Output Data Definition
- SDR - Surface Downwelling Reflectance
- SU - Swansea University
- SUM - Software User Manual
- VISAT - Visualization and Analysis Tool
- UV - University of Valencia

1.4.2 Nomenclature

1.5 References

- [1] ENVI-DTEX-EOPS-SW-07-0007, "MERIS/AATSR Synergy – Algorithms for cloud screening, aerosol retrieval and atmospheric correction", STATEMENT OF WORK, June 2007.
- [2] Preusker, R., and J. Fischer: Remote Sensing of Aerosol over Ocean Using a Synergy of MERIS and AATSR. SYNAO ATBD, Free University of Berlin, Version 1.0, June 2009.
- [3] North, P., Grey, W., Heckel, A., Fischer, J., Preusker, R., and C. Brockmann: MERIS/AATSR Synergy – Algorithms for cloud screening, aerosol retrieval and atmospheric correction: Land Aerosol and Surface Reflectance ATBD. Swansea University, Free University of Berlin, Brockmann Consult Geesthacht, Version 3.1, June 2009.
- [4] Gomez-Chova, L., Camps-Valls, G., Calpe, J., Munoz, J., and J. Moreno: MERIS/AATSR Synergy Algorithms for cloud screening, aerosol retrieval and atmospheric correction: Cloud Screening ATBD. University of Valencia, Version 1.0, January 2009.
- [5] MERIS/AATSR Synergy Algorithms for cloud screening, aerosol retrieval and atmospheric correction: Detailed Processing Model. Brockmann Consult, Draft Version, March 2010.
- [6] MERIS/AATSR Synergy Algorithms for cloud screening, aerosol retrieval and atmospheric correction: Input/Output Data Definition. Brockmann Consult, Draft Version, March 2010.

Chapter 2

Software Installation

2.1 The MERIS/(A)ATSR Synergy toolbox as BEAM plugin

As a BEAM plugin, the MERIS/(A)ATSR Synergy toolbox needs the following software to be installed in advance:

- BEAM, version 4.7

The BEAM software can be obtained from the BEAM download page (www.brockmann-consult.de/beam). Note that the MERIS/(A)ATSR Synergy Toolbox software has been developed in the frame of BEAM 4.7 and is not compatible with older BEAM versions. Once newer releases of BEAM are published, the MERIS/(A)ATSR Synergy Toolbox software will be updated accordingly if required.

The MERIS/(A)ATSR Synergy Toolbox software delivery consists of seven jar files: a core module, the module for AATSR recalibration, the modules for preprocessing, cloud screening, aerosol and SDR retrieval, and adjusted BRR (Bottom of Rayleigh Reflectance) and SDR (Surface Directional Reflectance) modules, which provide additional Java classes used by the toolbox:

- beam-meris-aatsr-synergy-core-1.1.jar
- beam-meris-aatsr-synergy-aerosol-retrieval-1.1.jar
- beam-meris-aatsr-synergy-preprocessing-1.1.jar
- beam-meris-aatsr-synergy-cloud-screening-1.1.jar
- beam-aatsr-recalibration-1.1.jar
- beam-meris-brr-2.1-SNAPSHOT.jar
- beam-meris-sdr-2.3-SNAPSHOT.jar

These files need to be downloaded from the BEAM plugin page:

- <http://www.brockmann-consult.de/cms/web/beam/plugin-ins>

or the Synergy Wiki page:

- <http://www.brockmann-consult.de/beam-wiki/display/SYN/Software>

The files need to be copied into the 'modules' folder of the BEAM installation (Figure 2.1). Note that existing versions of these jar files need to be replaced/overwritten. There should not be more than one jar file for each of these modules in the 'modules' folder!

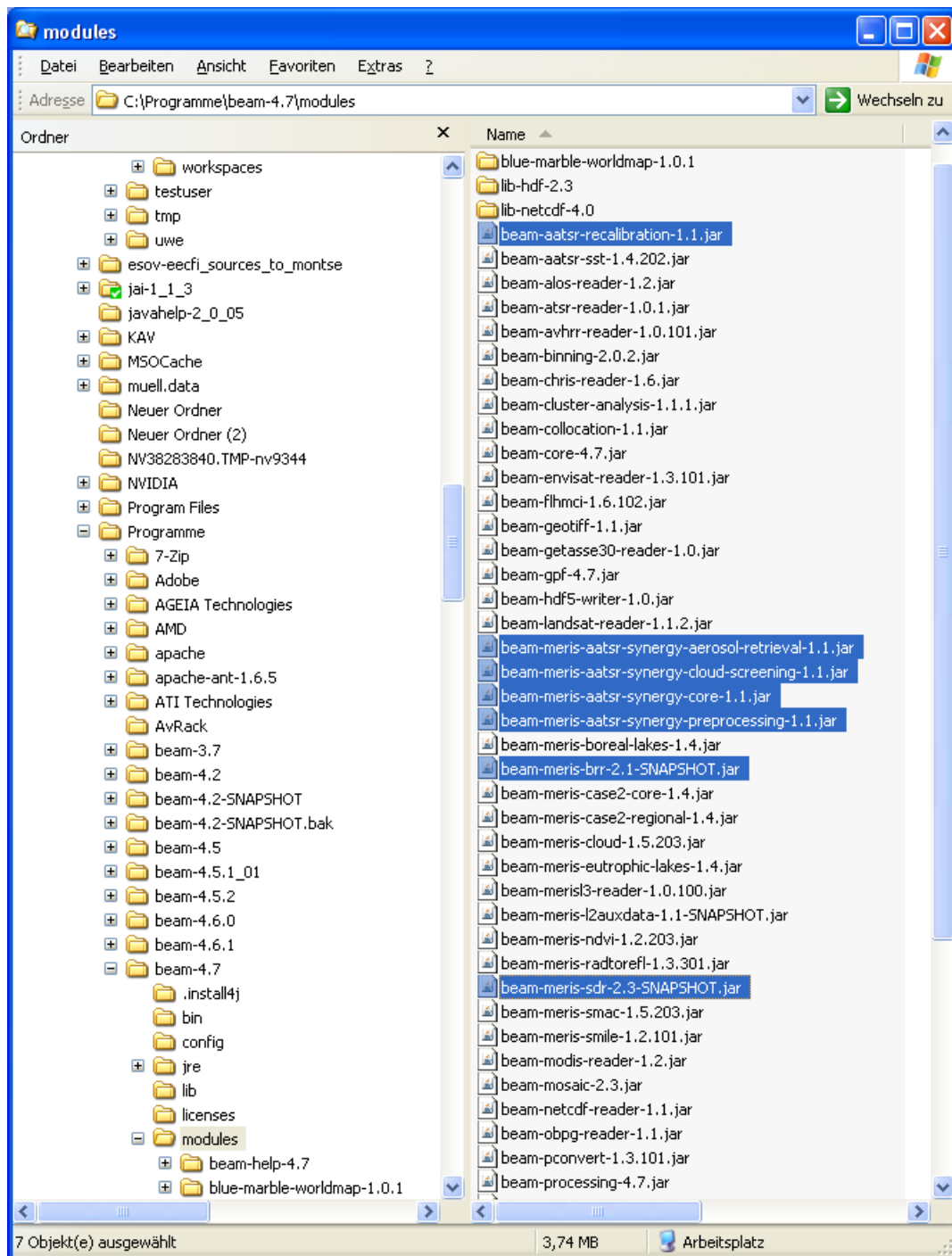


Figure 2.1: Installation of MERIS/(A)ATSR Synergy Toolbox jar files in BEAM modules folder (shown for Windows XP)

2.2 Auxiliary Data

To be able to process all options properly, the MERIS/(A)ATSR Synergy Toolbox processor needs the following auxiliary data:

- Ocean aerosol lookup tables (provided by FUB)
- Land aerosol lookup tables (provided by SU)

- Surface reflectance spectra files (provided by SU)
- Lookup tables for Glint algorithm in ocean aerosol retrieval (provided by FUB)

2.2.1 Data Format

The aerosol lookup tables come as separate files for each wavelength and each aerosol model. Overall, there are 40 aerosol models available for both land and ocean aerosol retrieval.

For the land aerosol retrieval, there are LUTs for the 13 MERIS wavelengths 412, 442, 490, 510, 560, 620, 665, 681, 708, 753, 778, 865 and 885 nm, and the 4 AATSR wavelengths 550, 665, 865 and 1610 nm. Therefore, the full set of land aerosol LUTs comprises 680 files. Although these files are in binary format, the total size is more than 6 GB. For more details on the file contents, see [3] and [6].

For the ocean aerosol retrieval, there are LUTs for the 4 AATSR wavelengths 778, 865, 885 and 1610 nm. Therefore, the full set of ocean aerosol LUTs comprises 680 files. These files are provided in NetCDF format, the total size is about 380 MB. For more details on the file contents, see [2] and [6].

The default surface reflectance spectra are provided in two small ASCII files. The user can specify own reflectance spectra files as processing parameter. For more details on the file contents, see [3] and [6].

The lookup tables for Glint algorithm in ocean aerosol retrieval are provided as two small netCDF files. For more details on the contents of these files, see [2] and [6].

2.2.2 Download and Installation

Since the full auxiliary dataset is rather large due to the LUTs for land aerosol retrieval, the auxiliary data are provided as a 'standard' and a 'full' bundle. The standard bundle only contains the three land aerosol models required for the retrieval in default mode (see Section 4.3), which reduces the size of the zip archive to below 1 GB. This is sufficient for most use cases. To specify an own list of land aerosol models to be used by the algorithm, advanced users need to download and install the full bundle.

The auxdata can be downloaded from the BC ftp site:

- ftp.brockmann-consult.de
- username: synergy
- password: MER_ATS_SYN
- cd to meris-aatsr-synergy/auxdata
- download either 'beam-meris-aatsr-synergy-auxdata-standrard.zip' or 'beam-meris-aatsr-synergy-auxdata-full.zip'
- extract the archive into your \$(user.home)/.beam folder

2.3 Additional Requirements

To be able to process all options properly, the MERIS/(A)ATSR Synergy Toolbox processor needs the following add-ons to be installed in BEAM (if not already done):

- MERIS L2 Auxdata module

The MERIS L2 Auxdata can be installed with the BEAM module manager. See BEAM help documentation for details (<http://www.brockmann-consult.de/beam/doc/help/visat/ModuleManager.html>). Alternatively, you can directly download and install from the BC ftp site as described above:

- again, cd to meris-aatsr-synergy/auxdata

- download 'beam-meris-l2auxdata.zip' and 'beam-meris-l2auxdata-1.1-SNAPSHOT.jar'
- extract the archive 'beam-meris-l2auxdata.zip' into your \$(user.home)/.beam folder
- copy the file 'beam-meris-l2auxdata-1.1-SNAPSHOT.jar' into the 'modules' folder of your BEAM installation

Chapter 3

Products

The input and output products of the MERIS/(A)ATSR Synergy Toolbox are described in detail in the IODD document (see [6]).

Chapter 4

Processors

The MERIS/(A)ATSR Synergy toolbox can be invoked from the BEAM 'Tools' menu as shown below.

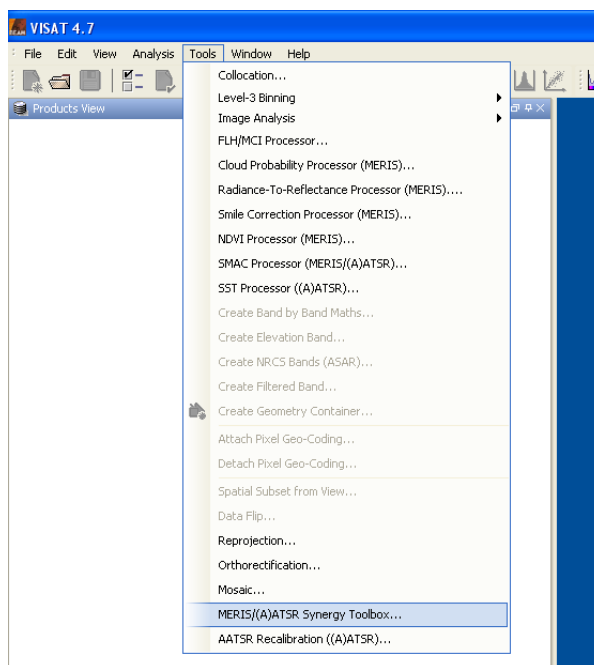


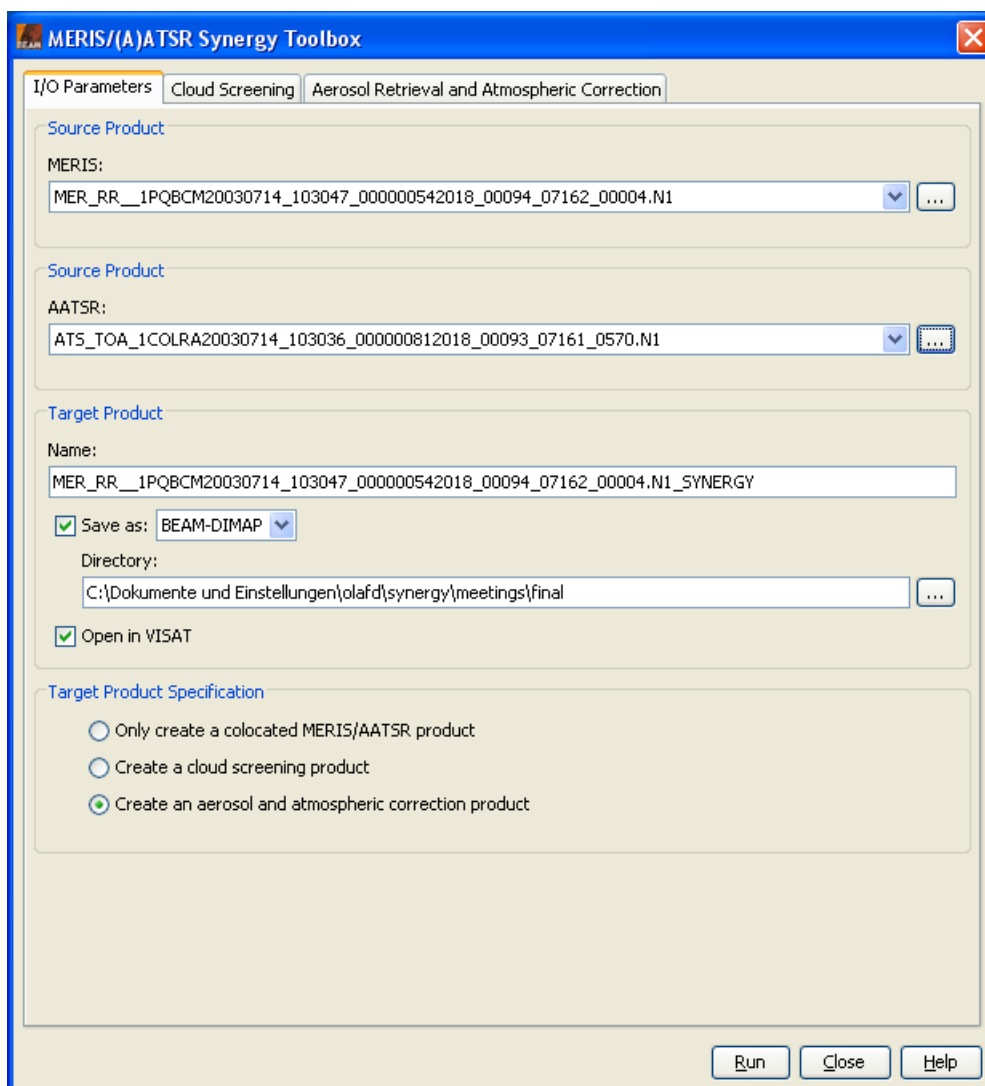
Figure 4.1: The MERIS/(A)ATSR Synergy toolbox in BEAM Visat

4.1 I/O Parameters and Preprocessing

The Synergy Preprocessor is the first of three main modules within the MERIS/(A)ATSR Synergy toolbox. Its purpose is to create a colocated MERIS/(A)ATSR L1b product containing radiances/reflectances of all channels of both MERIS and AATSR. This colocated product shall be used as input for the cloud screening module.

There is no separate user interface for the Synergy Preprocessor, also, there are no processing parameters. The preprocessor is invoked automatically when a MERIS/AATSR colocated product is generated either as final product or as intermediate product required for cloud screening or aerosol retrieval. These options are provided through radio buttons on the Synergy Toolbox I/O Parameters Tab Pane (see below).

4.1.1 I/O Parameters Tab Pane



The screenshot shows the 'I/O Parameters' tab pane of the 'MERIS/(A)ATSR Synergy Toolbox' window. The window has three tabs: 'I/O Parameters' (selected), 'Cloud Screening', and 'Aerosol Retrieval and Atmospheric Correction'. The 'I/O Parameters' tab contains several sections:

- Source Product:** A section with a label 'MERIS:' and a text box containing the path 'MER_RR__1PQBCM20030714_103047_000000542018_00094_07162_00004.N1'. There is a dropdown arrow and a file selection button (three dots) to the right.
- Source Product:** A section with a label 'AATSR:' and a text box containing the path 'ATS_TOA_1COLRA20030714_103036_000000812018_00093_07161_0570.N1'. There is a dropdown arrow and a file selection button (three dots) to the right.
- Target Product:** A section with a label 'Name:' and a text box containing the path 'MER_RR__1PQBCM20030714_103047_000000542018_00094_07162_00004.N1_SYNERGY'. Below this is a checkbox labeled 'Save as:' which is checked, followed by a dropdown menu showing 'BEAM-DIMAP'. Below that is a label 'Directory:' and a text box containing the path 'C:\Dokumente und Einstellungen\olafd\synergy\meetings\final', with a file selection button (three dots) to the right. At the bottom of this section is a checkbox labeled 'Open in VISAT' which is checked.
- Target Product Specification:** A section with three radio buttons:
 - ☐ Only create a colocated MERIS/AATSR product
 - ☐ Create a cloud screening product
 - ☒ Create an aerosol and atmospheric correction product

At the bottom right of the window are three buttons: 'Run', 'Close', and 'Help'.

Figure 4.2: Synergy Toolbox: I/O Parameters Tab Pane

This tab pane consists of the following components:

- MERIS source product file: Select the source product file by either typing the product path into the text filed or by pressing the file selection button to invoke a standard file dialog. This source product must be a standard MERIS L1b product.
- AATSR source product file: Select the source product file by either typing the product path into the text filed or by pressing the file selection button to invoke a standard file dialog. This source product must be a standard AATSR L1b product.
- Target product file: Select the target product file by either typing the product path into the text filed or by pressing the file selection button to invoke a standard file dialog.
- Target product format and target directory:
 - 'Save as': If this checkbox is selected, the output product will be saved to disk.
 - Target product format: Select one of the available output product formats.
 - Select the target product directory by either typing the product path into the text filed or by pressing the file selection button to invoke a standard file dialog.

- 'Open in Visat': If this checkbox is selected, the output product is opened in Visat after successful processing.
- Target product specification: This user option is represented by radio buttons and specifies the computation type and results written to the target product:
 - 'Only create a colocated MERIS/AATSR product': If this radio button is selected, just a colocated MERIS/AATSR product will be generated. No cloud screening or aerosol retrieval is performed.
 - 'Create a cloud screening product': If this radio button is selected, a cloud screening product will be generated. A colocated MERIS/AATSR product is created as intermediate product. No aerosol retrieval is performed.
 - 'Create an aerosol and atmospheric correction product': If this radio button is selected, an aerosol and atmospheric correction product will be generated. Atmospheric correction over land can be added by aerosol retrieval user option (see [Section 4.3](#)) The aerosol retrieval processor automatically creates a colocated MERIS/AATSR product and performs cloud screening as foregoing steps.

4.1.2 Control Buttons

From the 'I/O Parameters' tab pane, the following control buttons can be accessed:

- 'Run': If this button is clicked, the processor will start the computations.
- 'Close': If this button is clicked, the 'MERIS/(A)ATSR Synergy Toolbox' dialog is closed.
- 'Help': If this button is clicked, this manual is displayed as online help.

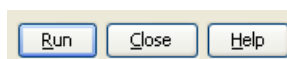


Figure 4.3: Synergy Toolbox: control buttons

4.2 Cloudscreening

The Cloud Screening Processor is the second of three main modules within the MERIS/(A)ATSR Synergy toolbox. Its purpose is to add various bands (i.e cloud flags) to the colocated MERIS/(A)ATSR L1b product obtained from the preprocessor. The output product from the cloud screening shall be used as input for the third module (aerosol retrieval and atmospheric correction).

The user interface for the Cloud Screening Processor can be accessed by clicking the 'Cloud Screening' tab in the 'MERIS/(A)ATSR Synergy Toolbox' dialog. (Figure [4.4](#)):

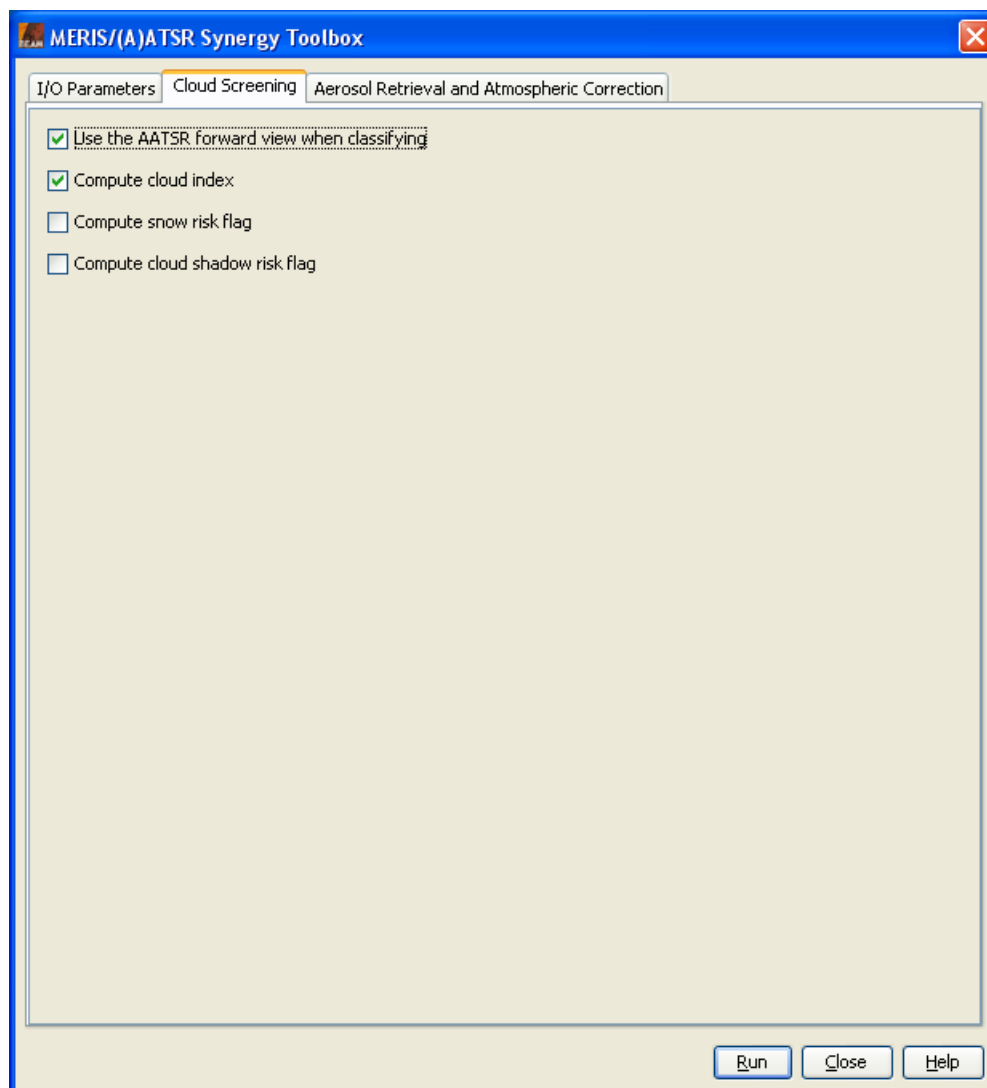


Figure 4.4: Synergy Toolbox: Cloud Screening Tab Pane

The Cloud Screening tab pane consists of the following components:

- 'Use the AATSR forward view when classifying': If this checkbox is selected, the AATSR forward view is considered in the cloud classification algorithm (otherwise nadir view only).
- 'Compute cloud index': If this checkbox is selected, a cloud index is computed and written as single band 'cloud_index_synergy' to the target product.
- 'Compute snow risk flag': If this checkbox is selected, a snow risk flag is computed and added to a flag band 'cloud_flags_synergy', which is written to the target product.
- 'Compute cloud shadow risk flag': If this checkbox is selected, a cloud shadow risk flag is computed and added to a flag band 'cloud_flags_synergy', which is written to the target product.

See [4] for more details on the computation and physical meaning of the quantities listed above.

4.3 Aerosol Retrieval and Atmospheric Correction

The Processor for Aerosol Retrieval and Atmospheric Correction is the third of three main modules within the MERIS/(A)ATSR Synergy toolbox. Its purpose is to derive aerosol optical depths over land and/or ocean and (optionally) provide an atmospheric correction by using the derived AODs. The processor also makes use of quantities derived from the cloud screening module. Therefore, the input for the aerosol retrieval must be an output product from the cloud screening.

The user interface for the Aerosol Retrieval and Atmospheric Correction can be accessed by clicking the 'Aerosol Retrieval and Atmospheric Correction' tab in the 'MERIS/(A)ATSR Synergy Toolbox' dialog. (Figure 4.5):

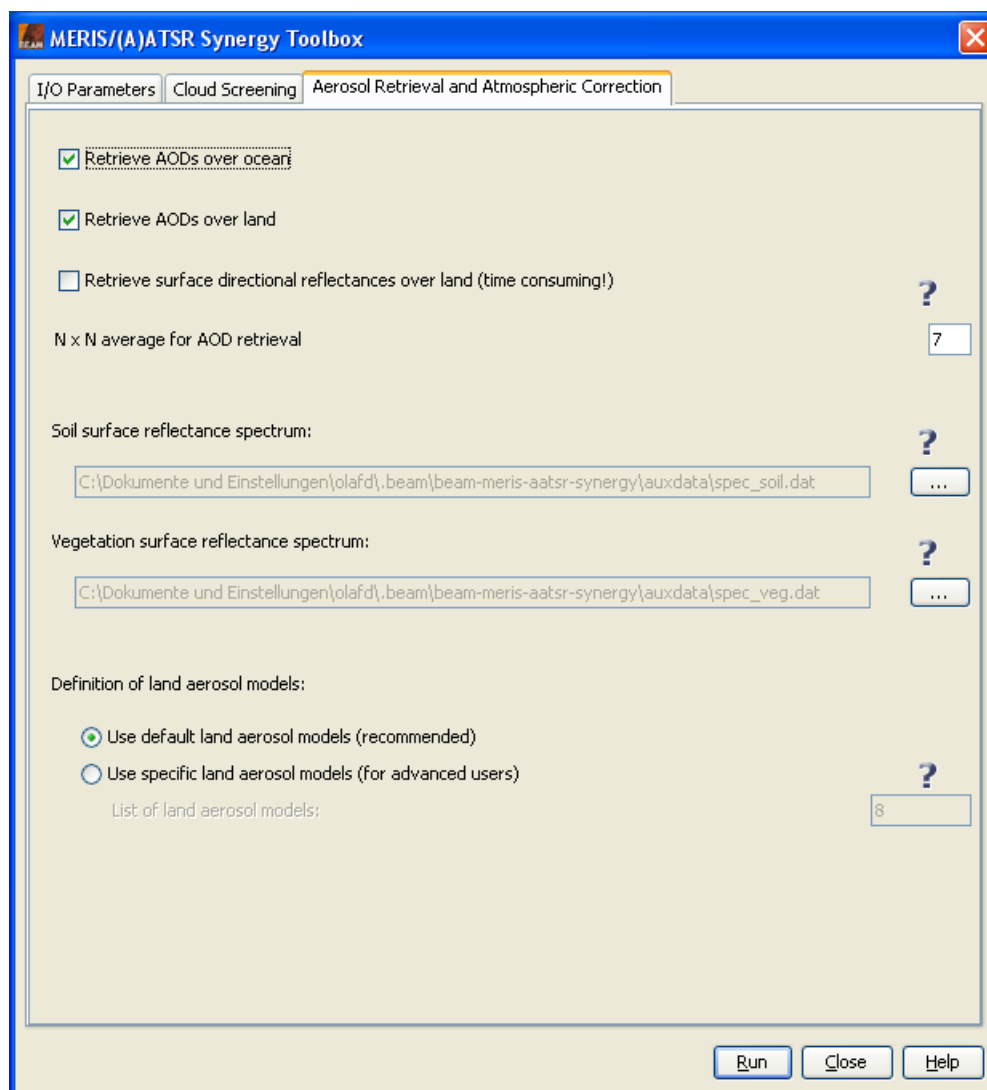


Figure 4.5: Synergy Toolbox: Aerosol Retrieval and Atmospheric Correction Tab Pane

The Aerosol Retrieval and Atmospheric Correction tab pane consists of the following components:

- 'Retrieve AODs over ocean': If this checkbox is selected, aerosol optical depths will be retrieved over ocean. The default is 'true'.
- 'Retrieve AODs over land': If this checkbox is selected, aerosol optical depths will be retrieved over land. The default is 'true'.
- 'Retrieve surface directional reflectances over land (time consuming!)': If this checkbox is selected, SDRs will be retrieved from rescaled AODs. This computation is performed over land only.

Due to the nature of the algorithm, the retrieval of surface directional reflectances requires much more computation time than the pure aerosol retrieval. If you are interested in aerosol quantities only, it is recommended to keep this option unselected. For the computation of surface directional reflectances on larger datasets, it is further recommended to create in advance subsets of the input data which just cover the regions of interest.

- 'N x N average for AOD retrieval': Text field to set the number of pixels to average over in the aerosol retrieval. The default number is '7', which corresponds to a square with 3 pixels to each side of a center pixel.
- 'Soil surface reflectance spectrum': Text field to set the filename containing the soil surface reflectance spectrum. The default is 'spec_soil.dat', this file is included in the auxiliary data (see Section 2.2) If the user wants to use a different file, it must be selected via the file chooser button right to the text field. Note that any user selected file must exactly follow the format of the default file.
- 'Vegetation surface reflectance spectrum': Text field to set the filename containing the vegetation surface reflectance spectrum. The default is 'veg_soil.dat', this file is included in the auxiliary data (seeSection 2.2) If the user wants to use a different file, it must be selected via the file chooser button right to the text field. Note that any user selected file must exactly follow the format of the default file.
- 'Use default land aerosol models (recommended)': If this radio button is selected, the default land aerosol models are used for aerosol retrieval. This set of models is included in the 'standard' auxiliary data set (seeSection 2.2). No further user action is required. This option is recommended not only for simplicity, but also because only a small number of models is used. For most purposes, this option will be sufficient. A large number of models (which can be specified with the option below) significantly increases computation time for the aerosol retrieval.

For more details on these aerosol models and underlying lookup tables see [3] and [6].

- 'Use specific land aerosol models (for advanced users)': If this radio button is selected, specific land aerosol models must be entered by a comma-separated list of model indices in the text field below. To use this option for aerosol retrieval, the 'full' auxiliary data set (seeSection 2.2) must be downloaded and installed.

For more details on these aerosol models and underlying lookup tables see [3] and [6].

- 'List of land aerosol models': Text field to set a comma separated list of the indices of the aerosol models to be used for the land aerosol retrieval (Figure 4.6). This text field is enabled only if the 'Use specific land aerosol models (for advanced users)' radio button is selected. The valid range of indices is [1,40]. In principle, up to all 40 models could be entered. However, to keep computation time in an acceptable frame, it is recommended to use as few models as possible.

For more details on these aerosol models and underlying lookup tables see [3] and [6].

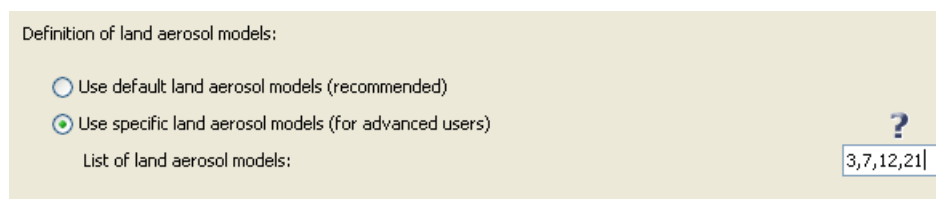


Figure 4.6: Synergy Toolbox: Selection of aerosol models for land aerosol retrieval

4.4 Processing from command line

Since the MERIS/(A)ATSR Synergy toolbox makes use of the BEAM graph processing framework, it can be used also as a command line tool outside BEAM-VISAT. The graph processing is invoked by the command

- `${BEAM-INSTALL-DIR}/bin/gpt`

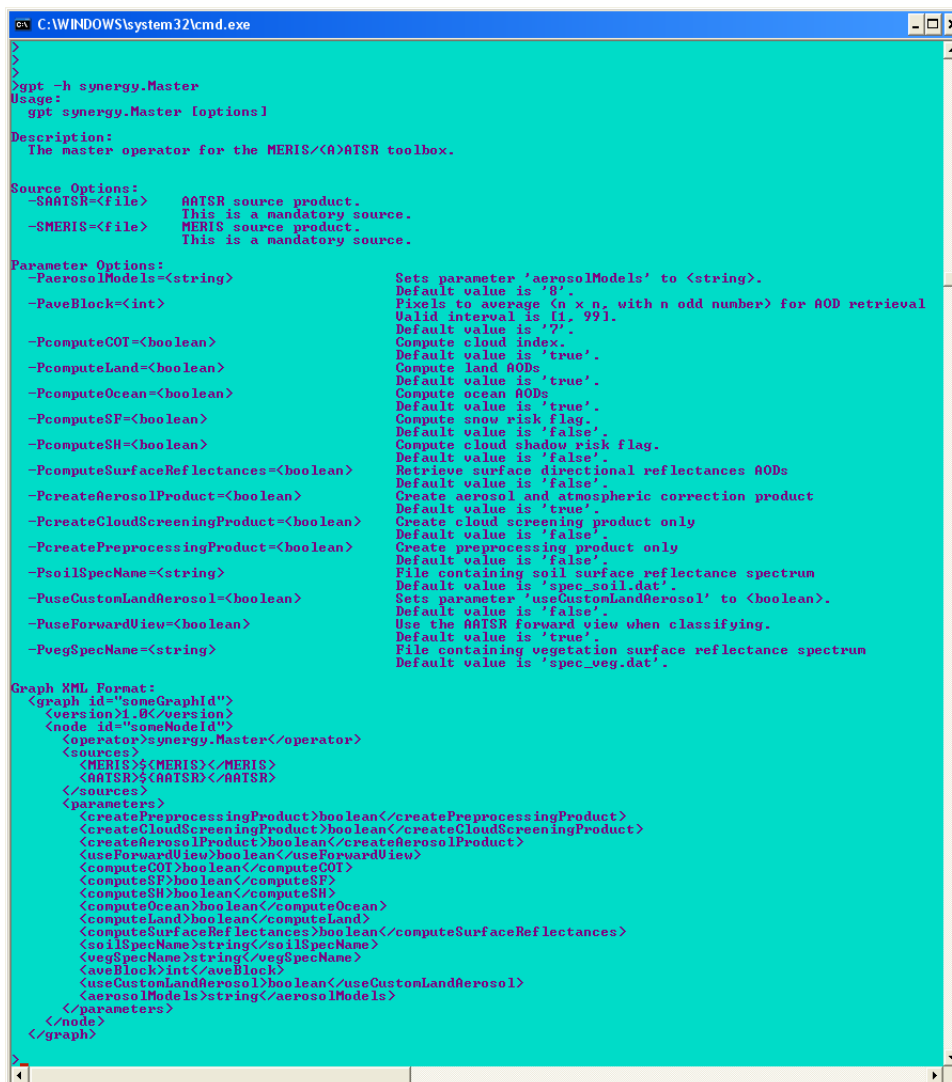
To obtain general help on the graph processing, use the command

- `${BEAM-INSTALL-DIR}/bin/gpt -h`

Specific help on the MERIS/(A)ATSR Synergy toolbox can be obtained with

- `${BEAM-INSTALL-DIR}/bin/gpt -h synergy.Master`

In this case, information on the usage and a list of all available parameters are given (see Figure 4.7).



```

C:\WINDOWS\system32\cmd.exe
>
>gpt -h synergy.Master
Usage:
  gpt synergy.Master [options]

Description:
  The master operator for the MERIS/(A)ATSR toolbox.

Source Options:
  -SAATSR=<file>      AATSR source product.
                     This is a mandatory source.
  -SMERIS=<file>      MERIS source product.
                     This is a mandatory source.

Parameter Options:
  -PaerosolModels=<string>      Sets parameter 'aerosolModels' to <string>.
                               Default value is '0'.
  -PaveBlock=<int>              Pixels to average (n x n, with n odd number) for AOD retrieval.
                               Valid interval is [1, 991].
                               Default value is '7'.
  -PcomputeCOT=<boolean>        Compute cloud index.
                               Default value is 'true'.
  -PcomputeLand=<boolean>       Compute land AODs.
                               Default value is 'true'.
  -PcomputeOcean=<boolean>      Compute ocean AODs.
                               Default value is 'true'.
  -PcomputeSF=<boolean>         Compute snow risk flag.
                               Default value is 'false'.
  -PcomputeSH=<boolean>         Compute cloud shadow risk flag.
                               Default value is 'false'.
  -PcomputeSurfaceReflectances=<boolean> Retrieve surface directional reflectances AODs.
                               Default value is 'false'.
  -PcreateAerosolProduct=<boolean> Create aerosol and atmospheric correction product.
                               Default value is 'true'.
  -PcreateCloudScreeningProduct=<boolean> Create cloud screening product only.
                               Default value is 'false'.
  -PcreatePreprocessingProduct=<boolean> Create preprocessing product only.
                               Default value is 'false'.
  -PsoilSpecName=<string>        File containing soil surface reflectance spectrum.
                               Default value is 'spec_soil.dat'.
  -PuseCustomLandAerosol=<boolean> Sets parameter 'useCustomLandAerosol' to <boolean>.
                               Default value is 'false'.
  -PuseForwardView=<boolean>     Use the AATSR forward view when classifying.
                               Default value is 'true'.
  -PvegSpecName=<string>        File containing vegetation surface reflectance spectrum.
                               Default value is 'spec_veg.dat'.

Graph XML Format:
<graph id="someGraphId">
  <version>1.0</version>
  <node id="someNodeId">
    <operator>synergy.Master</operator>
    <sources>
      <MERIS>$(MERIS)</MERIS>
      <AATSR>$(AATSR)</AATSR>
    </sources>
    <parameters>
      <createPreprocessingProduct>boolean</createPreprocessingProduct>
      <createCloudScreeningProduct>boolean</createCloudScreeningProduct>
      <createAerosolProduct>boolean</createAerosolProduct>
      <useForwardView>boolean</useForwardView>
      <computeCOT>boolean</computeCOT>
      <computeSF>boolean</computeSF>
      <computeSH>boolean</computeSH>
      <computeOcean>boolean</computeOcean>
      <computeLand>boolean</computeLand>
      <computeSurfaceReflectances>boolean</computeSurfaceReflectances>
      <soilSpecName>string</soilSpecName>
      <vegSpecName>string</vegSpecName>
      <aveBlock>int</aveBlock>
      <useCustomLandAerosol>boolean</useCustomLandAerosol>
      <aerosolModels>string</aerosolModels>
    </parameters>
  </node>
</graph>

```

Figure 4.7: 'Synergy Toolbox: command line processing