ICOL+ Software User Manual

1.0

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Chapter 1

Introduction

1.1 Scope

This document is the software user manual (SUM) for the ICOL+ processor.

1.2 Objectives

In images retrieved from spectrometers such as MERIS, an increase in the radiances, especially in the near infrared bands, can often be observed over water and in the vicinity of vegetated coasts. The affected area can extend over 10km or even more. This increase is not (always) related to an increase in the aerosol optical depth but is caused by the so-called adjacency effect. This effect results when photons are reflected and scattered towards the sensor and where a substantial contrast exits between the target and its surrounding. During processing of such measurements the correction schemes need to take this effect into account, otherwise the increased radiance is erroneously associated with other physical processes, and the derived geophysical quantities have an increased error.

Observations over waters near to land surfaces, both for coastal and inland waters, are affected because of the large contrast in the red and infrared part of the spectrum, where water is almost black and vegetated areas are very bright. The effect is easier to illustrate in coastal waters because it decreases from coastline to off-shore. This effect can best be studied in MERIS Full Resolution images, but even in reduced resolution the adjacency effect can also clearly be seen.

In order to build up a reliable tool for the correction of the adjacency effect, the ICOL (= Improve Contrast over Ocean and Land) prototype processor was developed as BEAM plugin. Although this prototype (ICOL1.0) has proven to retrieve results as expected from theory, it has some well-known limitations:

- Restricted to coastal areas over water (although the AE is known to exist as well over land)
- Restriction to case 1 waters
- No proper handling of clouds and sea ice
- Restricted to application on MERIS data only
- Slow processing

To overcome these limitations and to be able to apply the AE correction within operational processing chains, an improved BEAM plugin (ICOL+) has been developed. With this processor, the AE correction is applicable anywhere over ocean as well as over land and considers case 2 waters, clouds and sea ice. An improved convolution scheme (the core mathematical part of the AE corection) has been integrated to significantly speed up the processor. Moreover, it is possible with ICOL+ to apply the AE correction on Landsat TM data. This feature mainly serves as a demonstration for the general portability of the AE correction scheme to other instruments within future projects (e.g. related to the Sentinel missions). However, the full correction scheme has been implemented as for MERIS and has shown to provide results as expected ([RD-2]).

This manual basically describes and illustrates how to use the application. For a detailed description of the underlying algorithms see [RD-1], the technical realisation of the software package is outlined in [RD-3].

1.3 Reader Level

This specification is mainly written for the following audiences:

- MERIS QWG members
- Any other scientists interested in MERIS or Landsat TM image analysis

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

1.4 Acronyms

- AE - Adjacency Effect
- AOT - Aerosol Optical Thickness
- ATBD - Algorithm Theoretical Basis Document
- BC - Brockmann Consult
- BEAM - Basic ERS & Envisat (A)ATSR and Meris Toolbox
- CTP - Cloud Top Pressure
- DEM - Digital Elevation Model
- ESA - European Space Agency
- ESTEC - European Space Technology and Research Centre
- FR - Full Resolution
- GPF - Graph Processing Framework
- GPU - Graphics Processing Unit
- ICOL - Improved Contrast over Ocean and Land
- MERIS - Medium Resolution Imaging Spectrometer
- NDSI - Normalized Difference Snow Index
- NDVI - Normalized Difference Vegetation Index
- QWG - Quality Working Group
- RR - Reduced Resolution
- SoW - Statement of Work
- SUM - Software User Manual
- TM - Thematic Mapper
- TOA - Top of Atmosphere
- TS - Technical Specification
- VVR - Verification and Validation Report

1.5 Applicable Documents

- [AD-1] Development of a multi-mission adjacency effect correction for an operational implementation. ESA Statement of Work GMES-CLVL-EOPG-SW-08-0003, Issue 1.4.
- [AD-2] MERIS Level 2 Detailed Processing Model, PO-TN-MEL-GS-0006, 15 July 2009, Issue i8r0.

1.6 Reference Documents

- [RD-1] ICOL+ ATBD. Version 1.0, ICOL+ project deliverable D4, 18 November 2010.
- [RD-2] ICOL+ VVR. Version 1.0, ICOL+ project deliverable D8, 18 November 2010.
- [RD-3] ICOL+ TS. Version 1.0, ICOL+ project deliverable D10, 18 November 2010.
- [RD-4] Khronos Group OpenCL online documentation: http://www.khronos.org/opencl/
- [RD-5] USGS Earth Explorer data archive: http://edcsns17.cr.usgs.gov/EarthExplorer/

Chapter 2

Software Installation

2.1 ICOL+ as BEAM plugin

As a BEAM plugin, the ICOL+ processor needs the following software to be installed in advance:

- BEAM, version 4.8

The BEAM software can be obtained from the BEAM download page (www.brockmann-consult.de/beam).

The ICOL+ software delivery consists of three jar files: the ICOL main module, an updated BEAM 4.8 GPF module containing ICOL relevant bug fixes, and the OpenCL modules, which provide additional Java classes which are optionally used by ICOL+ for accelerating purpose in case that a proper GPU is installed in the computer:

- beam-meris-icol-2.5.jar
- beam-gpf-4.8.1-SNAPSHOT.jar
- opencl_jars.zip

The files beam-meris-icol-2.5.jar and beam-gpf-4.8.1-SNAPSHOT.jar need to be copied into the 'modules' folder of the BEAM installation (Figure 2.1). The opencl_jars.zip files needs to be unpacked into the 'lib' folder of the BEAM installation. Note that existing versions of BEAM and ICOL jar files (e.g. ICOL1.0) need to be replaced/overwritten to avoid version conflicts of Java classes. I.e., this is true for the file beam-gpf-4.8.jar.

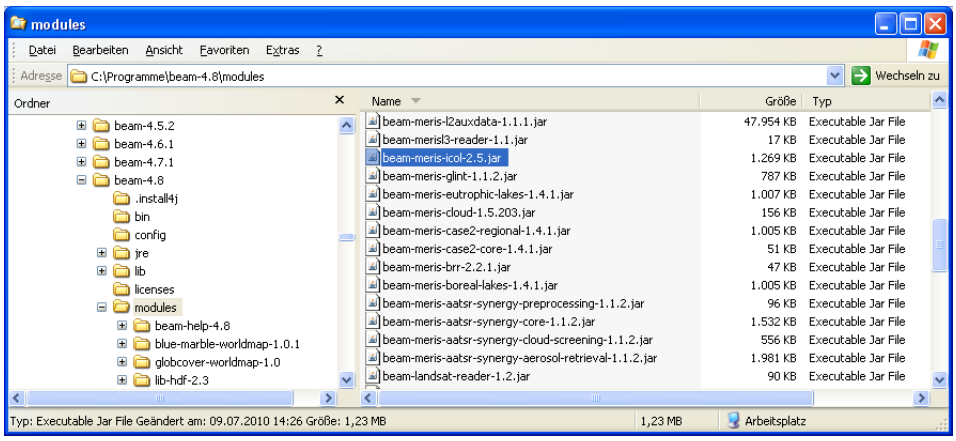

Figure 2.1: Installation of ICOL+ jar files in BEAM modules and lib folder (shown for Windows XP)

2.2 Additional Requirements

To be able to process all options properly, the ICOL+ processor needs the following add-ons to be installed in BEAM (if not already done):

- MERIS L2 Auxdata module
- GETASSE30 DEM (required for LANDSAT TM processing)
- GETASSE30 DEM reader (required for LANDSAT TM processing)

The MERIS L2 Auxdata and the GETASSE30 DEM reader 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). The GETASSE30 DEM can be downloaded from the BEAM download page. See also BEAM help documentation (http://www.brockmann-consult.de/beam/doc/help/visat/GETASSE30ElevationModel.html).

Chapter 3

ICOL+ Products

3.1 Input Products

The input products which can be processed with the ICOL+ processor are:

- MERIS L1b radiance files (.N1 format or BEAM DIMAP format)
- MERIS L1b radiance files (BEAM DIMAP format, i.e. subsets of original .N1 files)
- MERIS L2 cloud product (BEAM DIMAP format): An optional input product which must contain a suitable cloud classification flag band which can then be used to define an alternative cloud mask expression for the AE correction algorithm.
- LANDSAT TM L1b radiance files (GEOTIFF format)
- LANDSAT TM L1g radiance files (original GEOTIFF file downscaled to AE correction grid with ICOL+ and saved as BEAM DIMAP file)

3.2 Output Products

3.2.1 MERIS

The MERIS L1c output products which can be derived using the ICOL+ processor are:

- MERIS L1c radiances: The MERIS radiances for bands 1-15 corrected for the adjacency effect. This product can be retrieved in either original .N1 format or BEAM DIMAP format (user option).
- MERIS L1c TOA reflectances: AE corrected radiances for bands 1-15 converted to TOA reflectances. This product is provided in BEAM DIMAP format. Within this product, the following quantities are optionally provided (user option):
  - TOA reflectances (bands 1-15) corrected for AE (Rayleigh part of correction only)
  - TOA reflectances (bands 1-15) corrected for AE (Rayleigh and aerosol parts of correction)
  - AE Rayleigh correction term (bands 1-15)
  - AE aerosol correction term (bands 1-15)
  - Angstrom coefficient and aerosol optical thickness at 865nm.

3.2.2 LANDSAT

The LANDSAT TM output products which can be derived using the ICOL+ processor are:

- LANDSAT TM L1c radiances: The LANDSAT TM radiances for bands 1-5 and 7 corrected for the adjacency effect. This product is provided in BEAM DIMAP format. It contains the same bands as the GEOTIFF input product.
- LANDSAT TM L1g radiances: The LANDSAT TM radiances for bands 1-7 downscaled to the AE correction grid. This product is provided in BEAM DIMAP format. Processing time can be saved if this product is computed once and then re-used as input for different AE correction processes with varying user options.
- LANDSAT TM L1g flag bands: The LANDSAT TM cloud and land classification flags as used for the AE correction (i.e. downscaled to the AE correction grid). This product is provided in BEAM DIMAP format.

  The coding of the cloud classification flag is listed in the following table:

Name	Value	Description
F_CLOUD	0	Pixel was finally specified as cloudy (if all flags below are set)
F_BRIGHT	1	Brightness flag (set if TM3 < BT)
F_NDVI	2	NDVI flag (set if NDVI < NDVIT_CLOUD, with NDVI = (TM4 - TM3)/(TM4 + TM3))
F_NDSI	4	NDSI flag (set if NDSI < NDSIT, with NDSI = (TM2 - TM5)/(TM2 + TM5))
F_TEMP	8	Temperature flag (set if TM6 < TM6T_CLOUD)

Table 3.1: Cloud classification flags

The coding of the land classification flag is listed in the following table:

Name	Value	Description
F_LANDCONS	0	Pixel was classified as land
F_LOINLD	1	Pixel was classified as inland waters (currently no algorithm implemented and set to false)
F_NDVI	2	NDVI flag (set if NDVI < NDVIT_LAND, with NDVI = (TM4 - TM3)/(TM4 + TM3))
F_TEMP	8	Temperature flag (set if TM6 > TM6T_LAND (summer), TM6 < TM6T_LAND (winter))
F_ICE	16	Pixel was classified as ice (currently no algorithm implemented and set to false)

Table 3.2: Land classification flags

Chapter 4

ICOL+ User Interface

The ICOL+ processor graphical user interface is represented by one main dialog, which consists of the following components:

- 'I/O Parameters' Tab Pane
- 'General Settings' Tab Pane
- 'MERIS' Tab Pane
- 'LANDSAT TM' Tab Pane
- 'Run', 'Close' and 'Help' control buttons

4.1 I/O Parameters Tab Pane

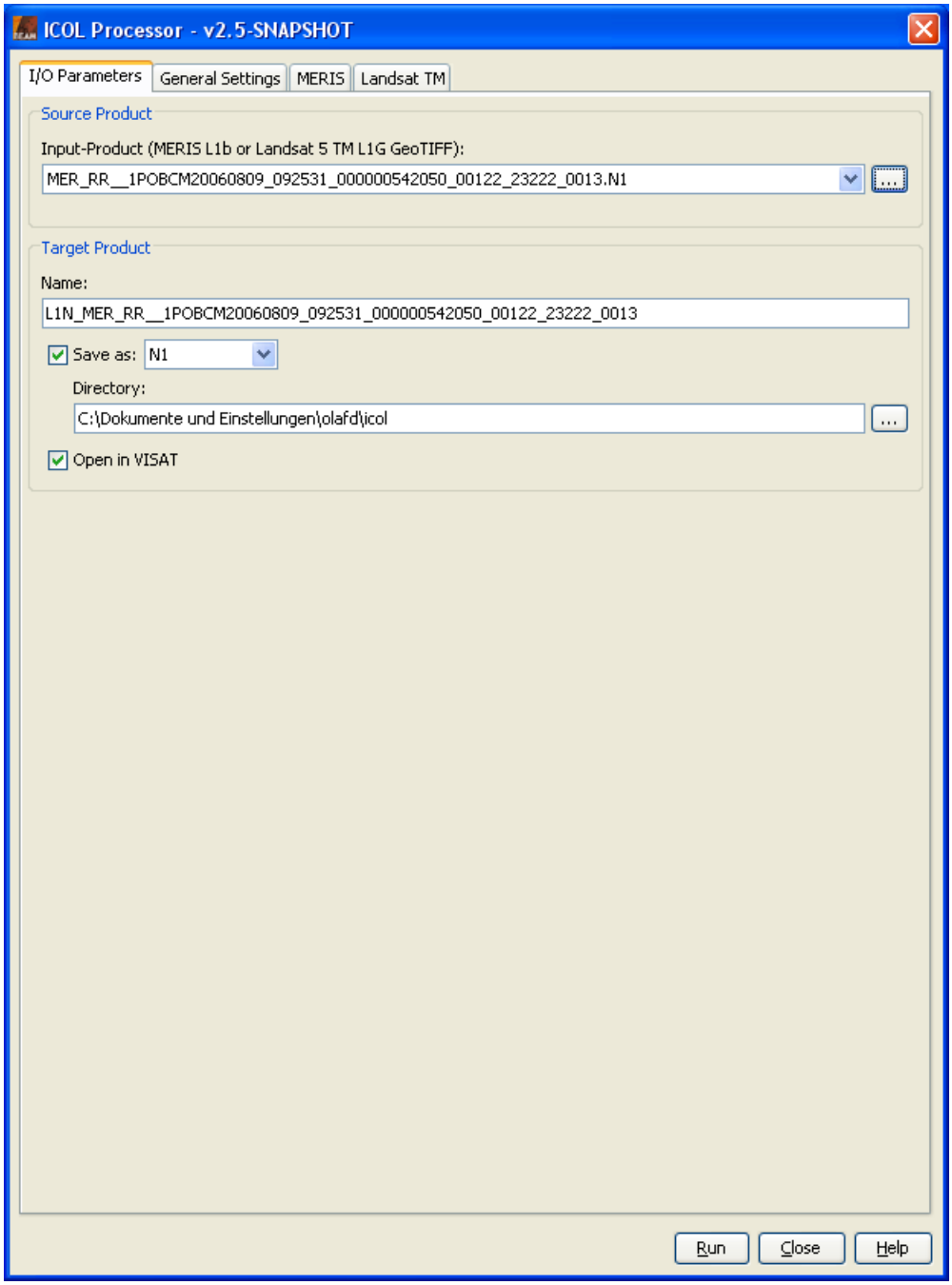

Figure 4.1: I/O Parameters Tab Pane

This tab pane (Figure 4.1) consists of the following components:

- Input product file: Select the input product file by pressing the file selection button to invoke a standard file dialog.
  - MERIS: Select a L1 product given in .N1 or BEAM-DIMAP format
  - LANDSAT TM: Select a L1 product given in GEOTIFF (original product) or BEAM-DIMAP format ('Geometry' product, see Section 3.1). A large number of Landsat TM products in GEOTIFF format can be found at the USGS Earth Explorer site ([RD-5]). To process TM GEOTIFF data in ICOL, do the following steps:

    * The data from [RD-5]usually come in gzipped format named like 'LT5...tar.gz'. If so, unpack this archive.
    * The unpacked product should consist of seven single .tif files and two metafiles with suffixes '_MTL.txt' and '_GCP.txt'.
    * Select the file '..._MTL.txt' as input file.

- Output product file: Select the output product file by typing the product filename into the text field.
- Output product format and target directory:
  - 'Save as': If this checkbox is selected, the output product will be saved to disk.
  - Output product format: Select one of the available output product formats. For MERIS, these are:
    * BEAM-DIMAP
    * NETCDF
    * N1 (in case the input product is a .N1 file and the output product has been selected as 'Radiance Product' (see below). In this case, the output product contains the same bands as the input N1 product. This allows the AE corrected product to be re-used as input for many other BEAM processors (such as Case 2 Regional) within a processing chain.

    For LANDSAT TM, these are:
    * BEAM-DIMAP
    * NETCDF
    * GeoTIFF
  - Select the output 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.

4.2 'General Settings' Tab Pane

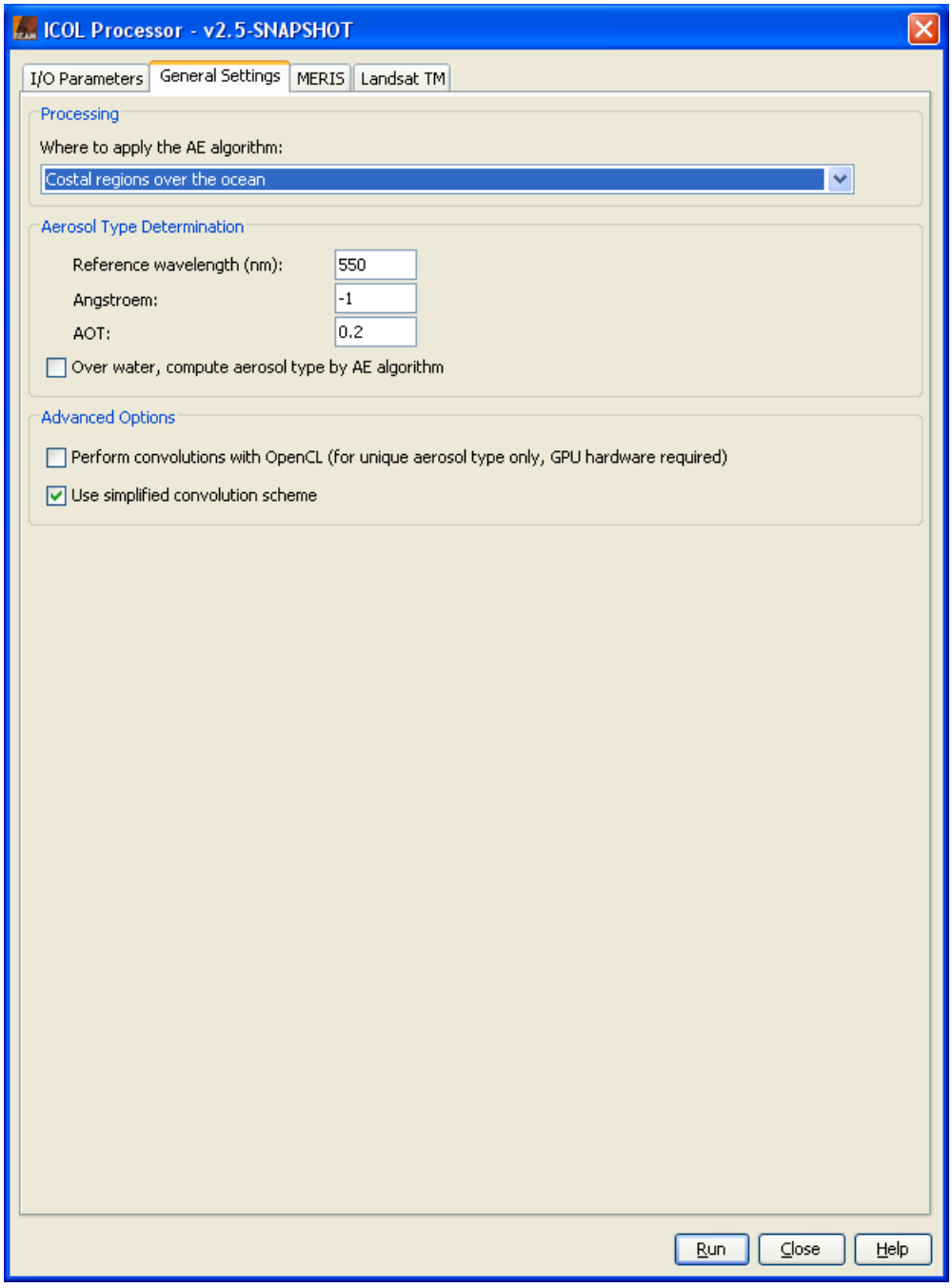

Figure 4.2: 'General Settings' Tab Pane

This tab pane (Figure 4.2) consists of three subpanels.

4.2.1 'Processing' Subpanel

- 'Where to apply the AE algorithm': This drop-down menu provides the following options where the AE algorithm shall be applied (see alsoFigure 4.3):

- Coastal regions over the ocean
- Everywhere over the ocean
- Coastal regions over ocean and land
- Everywhere

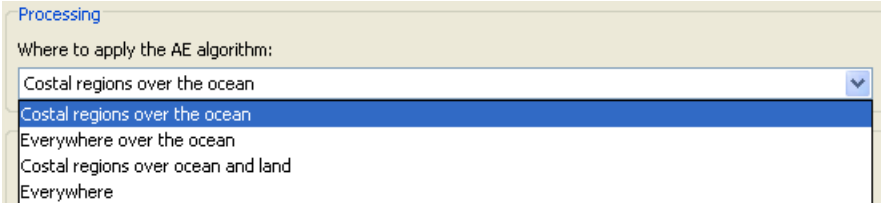

Figure 4.3: Drop-down menu for the selection of the area to apply the AE correction

4.2.2 'Aerosol Type Determination' Subpanel

- 'Reference wavelength (nm)': A text field to enter the reference wavelength for Angstrom and AOT values below. The default is 550nm..
- 'Angstrom': A text field to enter the Angstrom coefficient. The default is -1, the valid interval is [-2.1, -0.4].
- 'AOT': A text field to enter the aerosol optical thickness. The default is 0.2, the valid interval is [0.0, 1.5].
- 'Over water, compute aerosol type by AE algorithm': If this checkbox is selected, the aerosol type over water used for the AE correction will be determined by the algorithm itself. Otherwise, it will be taken from the Angstrom/AOT combination as set by the user above (same as over land).

4.2.3 'Advanced Options' Subpanel

- 'Perform convolution with OpenCL (for unique aerosol type only, GPU hardware required)': If this checkbox is selected, the convolution (the core mathemaical part of the AE correction) is performed using OpenCL libraries. Under suitable conditions, this results in a significant speed-up of the processor. However, this option is based on a rather new technology, and the implementation in ICOL+ is still somewhat experimental. There are the following limitations:
  - Suitable GPU hardware must be integrated in the computer and properly be installed. In general, this procedure is machine- and platform-dependent and is completely separate from the ICOL+ installation.
  - The current implementation is applicable only for an aerosol type which is unique (constant) over the computed scene.
  - The efficiency of the procedure depends on the dimensions of the particular scene and is parameter-dependent. Currently, a set of constant, hard-coded parameters is being used which is very likely not perfect for many cases.

  A more detailed description of the OpenCL issue is beyond the scope of this manual. A good literature starting point is e.g. [RD-4].

4.3 'MERIS' Tab Pane

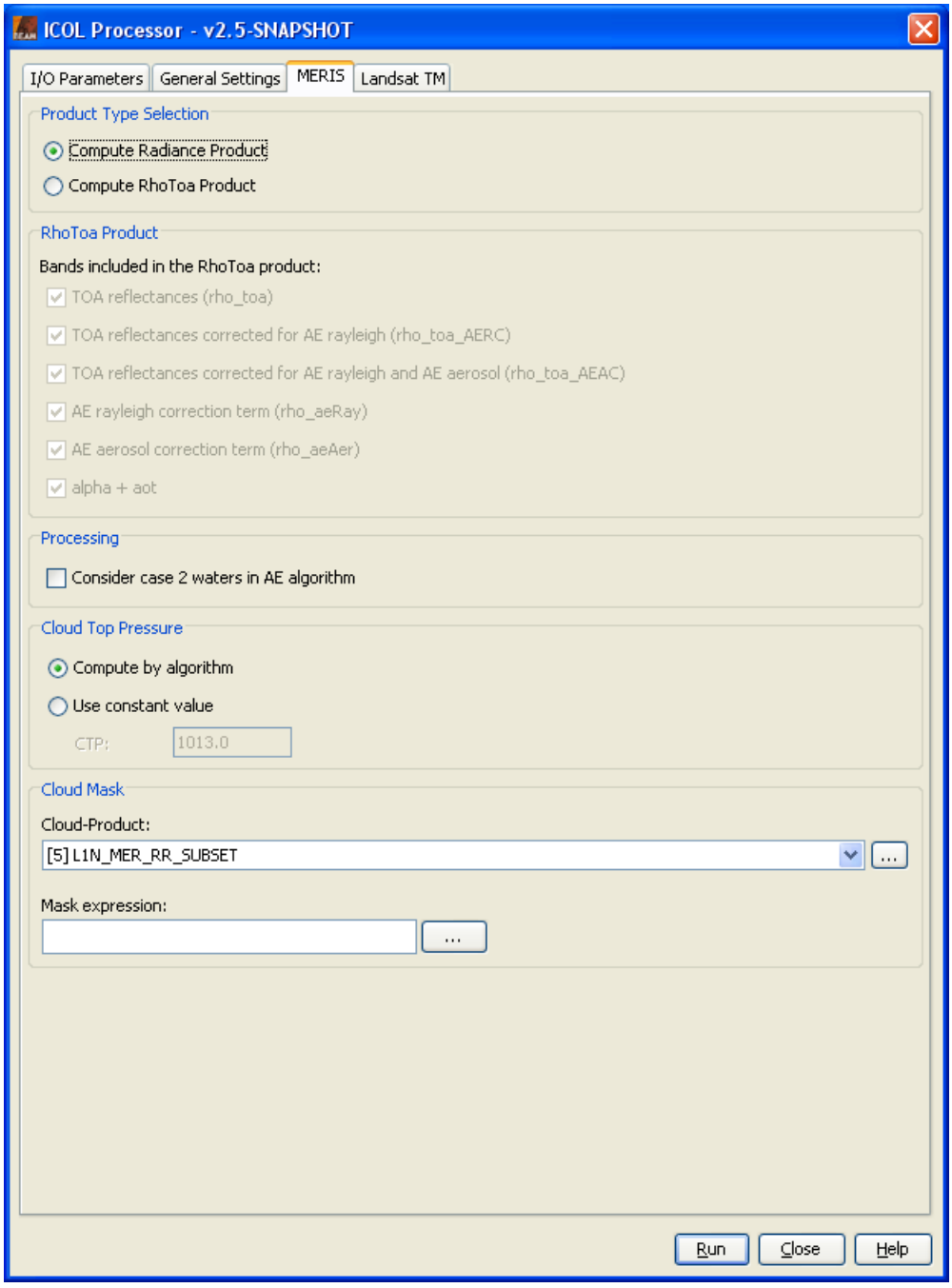

Figure 4.4: 'MERIS' Tab Pane

This tab pane (Figure 4.4) consists of five subpanels.

4.3.1 'Product Type Selection' Subpanel

- 'Compute radiance product', 'Compute rhoToa product': With this radio button group (toggle button), the user can determine whether he wants to write AE corrected radiances or TOA reflectances to the output product.

4.3.2 'RhoToa Product' Subpanel

- Bands included in the rhoToa product: With the checkboxes in this subpanel, the user can select additional quantities (as listed inSection 3.2.1) to be written to the output product. Note that the checkboxes are enabled only if 'Compute rhoToa product' was selected above.

4.3.3 'Processing' Subpanel

- 'Consider case 2 waters in AE algorithm': With this checkbox the user can select that case 2 waters are considered in the AE correction algorithm.

4.3.4 'Cloud Top Pressure' Subpanel

- 'Compute by algorithm', 'Use constant value': With this radio button group (toggle button), the user can determine whether he wants to use a cloud top pressure computed by the algorithm or to use a constant value.
- 'CTP': A text field to enter the constant cloud top pressure value. The default is 1013 hPa, the valid interval is [0.0, 1013.0]. Note that this textfield is enabled only if 'Use constant value' was selected above.

4.3.5 'Cloud Mask' Subpanel

- Cloud product file: Select the cloud product file by pressing the file selection button to invoke a standard file dialog.
- Mask expression: Define a cloud mask expression by either typing in the text field or by pressing selection button to invoke a standard BEAM expression editor (Figure 4.5). A detailed description how to use this component can be found in the BEAM help (search keyword 'Band Maths Expression Editor'). An expression validity check is performed before the ICOL processing is being started. E.g., if 'xxx' is typed into the text field, an error message as shown in Figure 4.6 will be displayed.

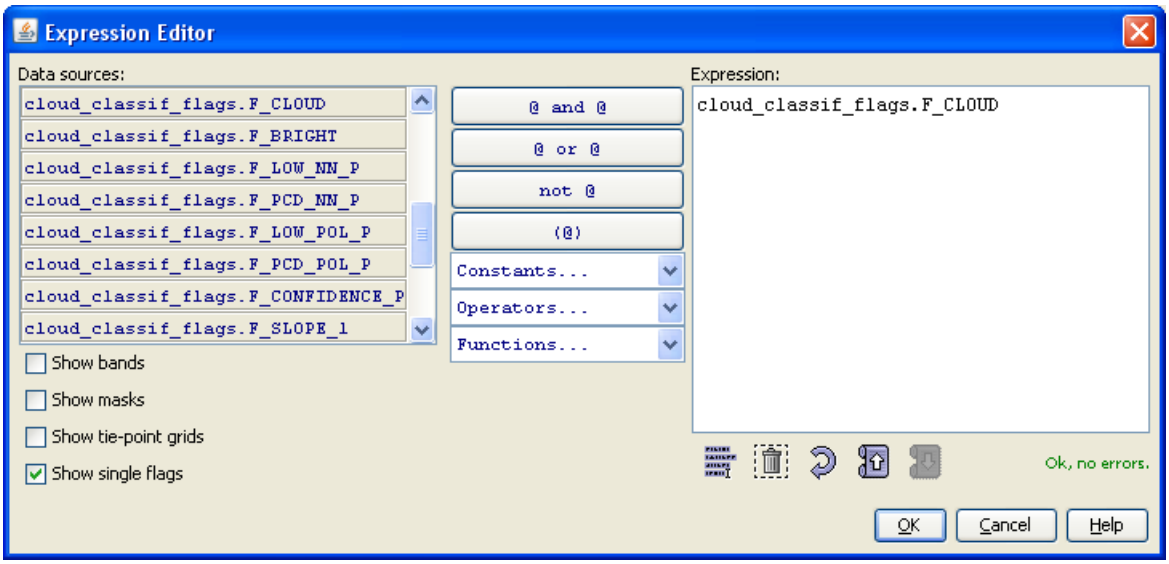

Figure 4.5: BEAM Band Maths Expression Editor

Figure 4.6: Cloud mask expression validation: expression invalid.

4.4 'LANDSAT TM' Tab Pane

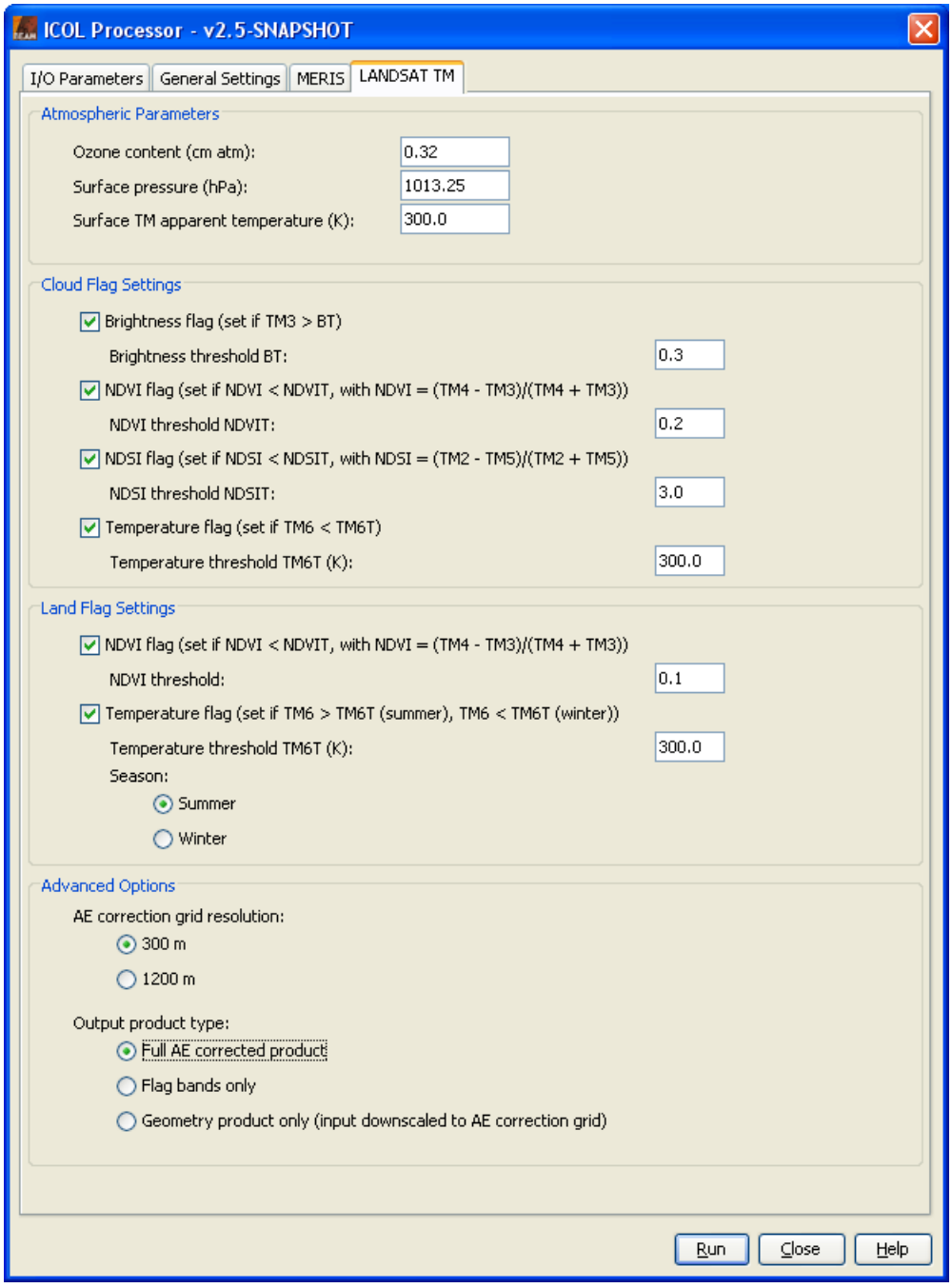

Figure 4.7: 'LANDSAT TM' Tab Pane

This tab pane (Figure 4.7) consists of four subpanels.

4.4.1 'Atmospheric Parameters' Subpanel

- 'Ozone content (cm atm):' : A text field to enter the ozone content value to be used by the AE correction algorithm. The default is 0.32 cm atm, the valid interval is [0.01, 1.0].

- 'Surface pressure (hPa):' : A text field to enter the surface pressure value to be used by the AE correction algorithm. The default is 1013.0 hPa, the valid interval is [300.0, 1060.0].
- 'Surface TM apparent temperature (K):' : A text field to enter the ozone content value to be used by the AE correction algorithm. The default is 300 K, the valid interval is [200.0, 320.0].

4.4.2 'Cloud Flag Settings' Subpanel

- With the checkboxes in this subpanel, the user can select subsequent tests (see alsoSection 3.2.2) to finally define a cloud flag:
  - Brightness test ('passed' if TM3 < BT)
  - NDVI test ('passed' if NDVI < NDVIT_CLOUD, with NDVI = (TM4 - TM3)/(TM4 + TM3))
  - NDSI test ('passed' if NDSI < NDSIT, with NDSI = (TM2 - TM5)/(TM2 + TM5))
  - Temperature test ('passed' if TM6 < TM6T_CLOUD)

  If all selected tests are passed, the given pixel is considered and flagged as 'cloudy'.
- With the textfields in this subpanel, the user can specify distinct thresholds for the tests above:
  - Brightness threshold BT: The default is 0.3, the valid interval is [0.0, 1.0]
  - NDVI threshold NDVIT_CLOUD: The default is 0.2, the valid interval is [0.0, 1.0]
  - NDSI threshold NDSIT: The default is 3.0, the valid interval is [0.0, 10.0]
  - Temperature threshold TM6T_CLOUD: The default is 300.0, the valid interval is [200.0, 320.0]

4.4.3 'Land Flag Settings' Subpanel

- With the checkboxes in this subpanel, the user can select subsequent tests (see alsoSection 3.2.2) to finally define a land flag:
  - NDVI test ('passed' if NDVI < NDVIT_LAND, with NDVI = (TM4 - TM3)/(TM4 + TM3))
  - Temperature test ('passed' if TM6 > TM6T (summer), TM6 < TM6T (winter))

  If all selected tests are passed, the given pixel is considered and flagged as 'land'.
- With the textfields in this subpanel, the user can specify distinct thresholds for the tests above:
  - NDVI threshold NDVIT_LAND: The default is 0.2, the valid interval is [0.0, 1.0]
  - Temperature threshold TM6T_LAND: The default is 300.0, the valid interval is [200.0, 320.0]
- 'Season': With this radio button group (toggle button), the user can specify if he wants to apply the 'winter' or the 'summer' criterion in the temperature test above.

4.4.4 'Advanced Options' Subpanel

- 'AE correction grid resolution': With this radio button group (toggle button), the user can specify if the LANDSAT TM AE correction shall be performed with a 300m (MERIS FR) or a 1200m (MERIS RR) resolution.
- 'Output product type': With this radio button group (toggle button), the user can specify what kind of output he wants to write into the target product:
  - 'Full AE corrected product': The AE corrected product with all radiance bands.
  - 'Flag bands only': Only the flag bands are comoputed and written to the output product. This option has the advantage that the user can adjust the cloud/land test thresholds in several runs towards 'optimal' cloud/land masks without computing the AE correction. This may save computation time significantly since the AE correction needs to be performed only once in a final run with the 'full' product being written.

– 'Geometry product only (input downscaled to AE correction grid)': The output product will be the same as the input product, but downscaled from the original TM resolution (30m) to the AE correction grid resolution as selected above. This option has the advantage that processing time can be saved for the 'Flag bands only' step described before, since this product (a 'Geometry' product following the ATBD notation) needs to be computed only once and can then re-used as input for different AE correction runs with varying user options (such as test thresholds as outlined above). In principle it is possible to perform a 'full' AE correction run from a Geometry product as well, but in this case, of course, the AE corrected product cannot be upscaled to the TM resolution since the information from the original product is missing.

4.5 Control Buttons

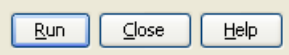

Figure 4.8: ICOL+ control buttons

From all ICOL+ tab panes, 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 ICOL+ dialog is closed.
- 'Help': If this button is clicked, this manual is displayed as BEAM help.

4.6 Processing from command line

Since the ICOL+ processor 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 ICOL+ processor (MERIS or LANDSAT TM), can be obtained with

- ${BEAM-INSTALL-DIR}/bin/gpt -h icol.Meris
- ${BEAM-INSTALL-DIR}/bin/gpt -h icol.ThematicMapper

In this case, information on the usage and a list of all available parameters are given. (see Figure 4.9).

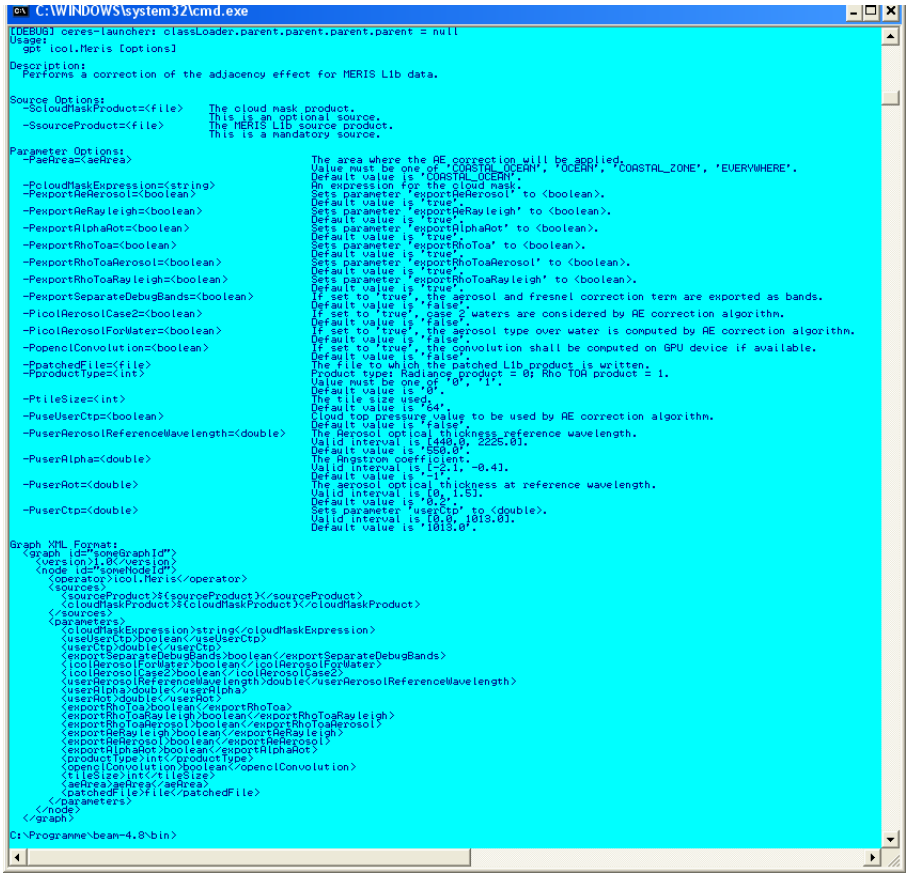

Figure 4.9: ICOL+ command line processing