ARGANS

DIMITRI V3.1a: USER MANUAL

Reference: DM-MAN-ARG-TN-SUM

Version: 3.1a

DATE: 30/01/2015

Document Signature Table

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Change record

Issue	Date	Description	Change pages
1.0	21/07/2011	First Version for DIMITRI V2.0	First version
1.1	25/10/2011	Text corrections	
1.2	08/05/2012	Updated content and code appendix	
1.3	04/07/2012	Updates following Final Acceptance Review	
2.0	04/07/2013	Document revisions to reflect DIMITRI data updates and IDL acquisition procedures.	Second Version
3.1	09/01/2015	Document revisions to reflect DIMITRI V3.1 data and software updates and IDL acquisition procedures.	Third Version
3.1a	30/01/2015	Document revisions to reflect DIMITRI V3.1a data and software updates and IDL acquisition procedures.	Third Version

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Acronym List

AATSR ---------------------- Advanced Along Track Scanning Radiometer
AC --------------------------- Atmospheric Correction
AD --------------------------- Applicable Document
ATBD ----------------------- Algorithm Theoretical Baseline Document
AVHRR --------------------- Advanced Very High Resolution Radiometer
BOUSSOLE ---------------- Bouée pour l'acquisition de Séries Optiques à Long Terme
BRDF--------------------- Bidirectional Radiance Distribution Function
BRDFTV--------------------- Bidirectional Radiance Distribution Function Variability Threshold
CEOS------------------------ The Committee on Earth Observation Satellites
CNES------------------------ Centre National d'Etudes Spatiales
DIMITRI -------------------- Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison
EO --------------------------- Earth Observation
ESA-------------------------- European Space Agency
GMES----------------------- Global Monitoring for Environment and Security
HMI ------------------------- Human Machine Interface
IVOS ------------------------ Infrared and Visible Optical Sensors Subgroup of WGCV
LUT-------------------------- Look-Up Table
MERIS ---------------------- Medium Resolution Imaging Spectrometer
MODIS --------------------- Moderate Resolution Imaging Spectrometer
NASA -------------------- National Aeronautics and Space Administration
N/A ------------------------- Not Applicable
netCDF --------------------- Network Common Data Format
NIR -------------------------- Near Infrared
NOAA----------------------- National Oceanic and Atmospheric Administration
NPL ------------------------- National Physical Laboratory
QA4EO --------------------- a Quality Assurance framework for Earth Observation
RAL-------------------------- Rutherford Appleton Laboratory
RD --------------------------- Reference Document
Rho ------------------------- Reflectance
RMS------------------------- Root Mean square
RT --------------------------- Radiative Transfer
SNO ------------------------- Simultaneous Nadir Overpass
SSV -------------------------- Spatial Scale Variability
TBC-------------------------- To Be Confirmed
TBD ------------------------- To Be Defined
TOA ------------------------- Top Of Atmosphere
WG-------------------------- Working Group
WGCV ---------------------- Working Group on Calibration and Validation

Reference Documents

ID	Source
RD-1	Bouvet M., Intercomparison of imaging spectrometer over the Salar de Uyuni (Bolivia), Proceedings of the 2006 MERIS AATSR Validation Team Workshop
RD-2	Bouvet M. , Ramoino F., Radiometric intercomparison of AATSR, MERIS, and Aqua MODIS over Dome Concordia (Antarctica), Can. J. Remote Sensing, Vol. 36, No. 5, pp. 464–473, 2010
RD-3	Roujean J.L., Leroy M. and Deschamps P.Y. (1992). A bidirectional reflectance model of the Earth's surface for the correction of remote sensing data. Journal of Geophysical Research, 97(DIS), 20.455-20.468.
RD-4	Irish, R.R. Landsat 7 Automatic Cloud Cover Assessment. See http://landsathandbook.gsfc.nasa.gov/pdfs/ACCA_SPIE_paper.pdf
RD-5	Plummer, S.E. 2008. The GLOBCARBON Cloud Detection System for the Along-Track Scanning Radiometer (ATSR) Sensor Series, IEEE Transactions on Geoscience and Remote Sensing, 46 (6), 1718 – 1727.
RD-6	Bouvet, M. 2011. Simulating VGT from Super Sensor observations version 3 technical note.
RD-7	Barker K., Marrable D. and Mazeran C. 2014. Automated Cloud Screening, ATBD (MO-SCI-ARG-TN-004a), Version 1.0
RD-8	Barker K., Marrable D., Hedley J. and Mazeran C. 2014. Rayleigh Scattering Methodology for Vicarious Calibration, ATBD (MO-SCI-ARG-TN-004b), Version 1.0
RD-9	Barker K., Marrable D., Hedley J. and Mazeran C. 2014. Interband Vicarious Calibration over Sunglint, ATBD (MO-SCI-ARG-TN-004c), Version 1.0
RD-10	Bouvet M., Radiometric comparison of multispectral imagers over a pseudo-invariant calibration site using a reference radiometric model, Remote Sensing of Environment, Vol. 140, pp. 141–154, 2014

1 INTRODUCTION

1.1 DIMITRI

1.1.1 DIMITRI Software Package

The DIMITRI software package contains a suite of IDL routines for the intercomparison of Top Of Atmosphere (TOA) radiance and reflectance values within the 400nm - 4µm wavelength range; this is generally known as Level 1b Earth Observation (EO) satellite data. The package includes product reader and data extraction routines, and allows comparison of satellite data based on User defined cloud screening parameters as well as temporal, spatial and geometric matching. DIMITRI is a database containing the so-called remote sensing TOA reflectance values from 2002 until the present day for ATSR2 (ESA), AATSR (ESA), MERIS (ESA), MODIS-Aqua (NASA), PARASOL POLDER-3 (CNES), and VEGETATION-2 (CNES) over eight predetermined validation sites (see Table 1).

DIMITRI is supplied with all L1b data extractions pre-loaded; the original Level 1b products are not distributed with the software package. Additional data for other validation sites, or more recent acquisitions, can be ingested into DIMITRI to allow even greater temporal and spatial analysis. The original Level 1b products are currently stored at ARGANS and ESA-ESTEC; please contact dimitri@argans.co.uk for freely available products from sensors such as MERIS, AATSR and MODIS-Aqua.

1.1.2 Purpose and principle of DIMITRI

Within DIMITRI a “reference” sensor relates to a user selected sensor for all other sensors to be intercalibrated against. A “calibration” sensor refers to a chosen sensor which will be compared against the “reference” sensor and recalibrated to its radiometric scale. A number of “calibration” sensors can be compared against one “reference sensor”.

A further function of DIMITRI allows to intercalibrate all ‘’calibration’’ sensors to the ‘’reference’’ sensor and to generate radiometrically consistent TOA reflectances from all sensors. This allows computation of a TOA Bidirectional Reflectance Distribution Function (BRDF), (See RD-3), over a selected validation site; this is then utilised to simulate VEGETATION-2 TOA reflectance using the VEGETATION-2 products viewing and solar geometries.

All stages of DIMITRI (intercalibration, BRDF modelling and TOA simulation) include an attempt to propagate uncertainties providing detailed information on the processing stages performed. The computed systematic and random uncertainties are provided in the DIMITRI outputs (See RD-6).

The standard DIMITRI TOA Reflectance at any given wavelength is defined as:

$$\rho = \pi \frac{L}{F_0 . d^2 . Cos(\theta_s)}$$

Where: ρ = reflectance, L = TOA Radiance, F_0 = Solar Irradiance Flux, Θ_s = Solar Zenith Angle, and d^2 = a correction factor for the Earth-Sun distance.

Table 1: Geolocation values for the predefined DIMITRI validation sites.

Site Name	North Lat (N)	South Lat (N)	West Lon (E)	East Lon (E)	Date range available
Uyuni Salt Lake	-20.00	-20.16	-68.05	-67.45	2002-2014
Libya 4	29.05	28.05	22.89	23.89	2002-2014
Dome C	-74.90	-75.30	122.90	123.90	2002-2014
Tuz Golu	38.80	38.70	33.25	33.40	2002-2013
BOUSSOLE	43.45	43.25	7.80	8.00	2002-2014
Amazon Forest	1.33	1.00	-57.00	-56.50	2002-2013
SPG	-31.00	-31.50	-137.5	-137.0	2002-2014
SIO	-30.00	-30.50	80.50	80.00	2002-2014
Algeria 5	31.42	30.62	1.83	2.63	2002-2014

Table 2: DIMITRI Sensor data location information

Sensor	Data Location	Access	Date range available
AATSR	http://ats-merci-ds.eo.esa.int/merci/welcome.do	Requires ESA Cat-1 Registration	2002 – March 2012
ATSR2	http://ats-merci-ds.eo.esa.int/merci/welcome.do	Requires ESA Cat-1 Registration	2002 - Present
MERIS	http://merci-srv.eo.esa.int/merci/welcome.do http://www.odesa-info.eu/	MERCI Requires ESA Cat-1 Registration No registration required for ODESA	2002 – March 2014
MODIS-Aqua	http://ladsweb.nascom.nasa.gov/	Freely available	2002 - Present
PARASOL	http://polder.cnes.fr/en/index.htm	Requires registration	2002 - Present
VEGETATION – 2*	http://www.vito-eodata.be	Requires registration	2002 – July 2012
VIIRS	http://ladsweb.nascom.nasa.gov/	Freely available Note: LADSWeb only holds VIIRS data in a 60 day rolling archive.	May & June 2013

* Note: DIMITRI is currently set up to utilise VGT-2 products distributed by VITO; these products are processed with an erroneous Earth-Sun distance coefficient. A correction, provided by CNES, is implemented within the DIMITRI VGT-2 processing.

1.1.3 DIMITRI Versions

DIMITRI V1.0 was prototyped at ESTEC by Marc Bouvet (ESA/ESTEC).

DIMITRI V2.0 was developed by ARGANS Ltd in collaboration with ESA/ESTEC. This version:

1. Includes some VIIRS data, and has a VIIRS data reader included in the package.
2. Ingests and stores the region of interest averages information only.

DIMITRI V3.1a is developed by ARGANS Ltd in collaboration with ESA/ESTEC. This version:

1. Includes some new data (see Table 2)

2. Ingests and stores the region of interest averages and pixel-by-pixel information.
3. Has two new-methods of cloud screening (SSV and BRDFTV) detailed below (See sections 3.4.1; 3.4.2; and RD-7)
4. Includes Rayleigh scattering calibration and Sun Glint correction (see sections 3.7; 3.8; RD-8 and RD-9).
5. Includes Desert calibration methodology (See section 3.9 and RD-10).
6. Has netCDF writer routine and some netCDF output files

1.1.4 How to get DIMITRI

DIMITRI can be freely downloaded, after registration at: http://www.argans.co.uk/dimitri/

Email address will only be used to provide notifications of updates to DIMITRI and to obtain User feedback; User information will only be stored at ARGANS Ltd on behalf of ESA, and will not be passed on to any other organisation.

All Users must comply with the following Service Level Agreement (SLA):

1) Acknowledgement to ESA and ARGANS is required for any presentations or publications; however written permission is not required.
2) The DIMITRI package cannot be distributed by anyone other than ESA and ARGANS.
3) Any modifications to the DIMITRI code are appropriately detailed in the code header information, and are performed under the responsibility of the User.
4) ESA and ARGANS are not responsible for any damage to computer systems as a result of using the DIMITRI software package.

Please feel free to share your results with the scientific community on the CalVal Portal (http://calvalportal.ceos.org). Please also direct feedback regarding the software package to dimitri@argans.co.uk.

1.1.5 DIMITRI License and code modification

The DIMITRI software package is made freely available by ESA and ARGANS. The Intellectual Property rights are held by ESA; however modification of code is allowed. The official version of original source code will be held at ARGANS and any modifications are done at the User's risk.

However, Users are welcome to contact the DIMITRI developers at dimitri@argans.co.uk with suggestions for improvement and if verified and approved by ESA, these may be included in later versions of DIMITRI. See Section 4 for more information on DIMTIRI routines and compilation.

1.2 System Requirements

The DIMITRI_3.1 Graphical User Interface (GUI) runs through the freely available IDL Virtual Machine, and allows use of the pre-compiled DIMITRI package and use of the full functionalities accessible from the HMI.

DIMITRI runs using the IDL Virtual Machine (VM) application which comes as part of the full IDL package.

DIMITRI requires **IDL 8.2 or above. This is important; lower versions of IDL 8.0 are not compatible and IDL 7.0 may not be supported by Exelis.**

Note that some functions of DIMITRI_V3.1a are not compatible with IDL 8.4 yet and that may cause some troubleshoot.

DIMITRI users need to:

1. Register for an account with Exelis: http://www.exelisvis.com;
2. Download IDL in full (you do not need to pay for an IDL licence to use the VM): http://www.exelisvis.com/MyAccount/Downloads.aspx (in “All Downloads” tab);
3. Install IDL;
4. Run DIMITRI as described in Section 2 (instructions are provided in the following sections for running DIMITRI in Windows and Linux). Exelis also provide the following help on the VM: http://www.exelisvis.com/Support/HelpArticlesDetail/TabId/219/ArtMID/900/ArticleID/4633/4633.aspx

DIMITRI has been developed to be compatible on both Linux and Windows based systems; however, MAC compatibility is tested on this version 3.1a and it looks like fine with MAC OS-X 10.10.

A non-free IDL license (http://www.exelisvis.com) will allow command line usage, modification of routines and recompilation of the software package with user-written code if desired.

2 SETUP

2.1 Installation

The DIMITRI software package is downloaded as a compressed file. To install DIMITRI V3.1a unzip the folder into the desired installation location.

It is recommended that either 7zip (http://www.7-zip.org/) or Filzip (http://www.filzip.com/) are used for extraction of the zip archive. Please note, it is recommended to install DIMITRI with administrator or root privileges. This is to allow the creation of all required files and folders.

Linux users can install the DIMITRI package by typing:

tar –xf DIMITRI_V3.tar.gz

The DIMITRI uses the MYSTIC radiative transfer code in the desert calibration method (see below section 3.9.)The Mystic model is freely available from the LibRadTran package (www.libradtran.org) which has to be installed.

In addition, OPAC libraries (www.libradtran.org), netCDF and libnetCDF libraries (http://www.unidata.ucar.edu/netcdf) are required.

Note: User has to define the full path of the "data" required for the model input (ex: export data_files_path=/home/bahjat/libRadtran-1.7/data) or one can define it in the source routine "Source/desert/write_mystic_rpv_input.pro".

2.2 Quickstart

Following extraction, DIMITRI is now ready to be utilised, this can be achieved **when in the "DIMITRI_3.1a folder"**, by:

- ***On Windows***: Double clicking the "**DIMITRI_V3.sav**" file
- ***On Linux***: Typing "**idl -vm=DIMITRI_V3.sav**"

These commands will load the DIMITRI Human Machine Interface (HMI). See Section 3 for details on the functionality of the HMI.

If using a full IDL license, all DIMITRI routines can be used through the command line. This requires restoration of the routines which can be performed by typing into IDL:

IDL>restore,'DIMITRI_V3.sav'

You can then run DIMITRI by typing:

IDL>DIMITRI_V3

2.3 Folder Structure

The installed DIMITRI directory has the following folder structure:

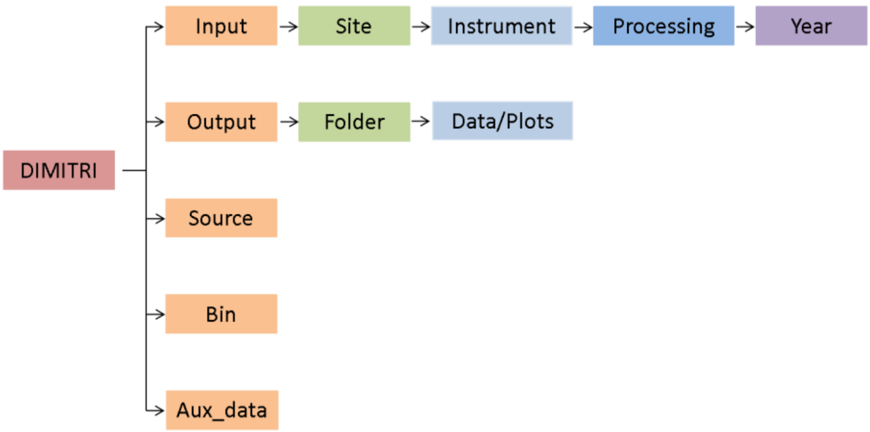

Figure 1: Schematic diagram of the DIMITRI folder structure

Important: A number of routines require the explicit syntax of certain files and folders. It is therefore critical that the folder names are NOT modified as this will result in a loss of functionality.

The **'Input'** folder will contain all of the Level 1 data for all sensors across all sites (please note, for distribution and size restrictions only the quicklooks and stored TOA reflectance data are available for download).

- All site folders will be identified through the syntax 'Site_*', (e.g. 'Site_Uyuni') and allows User-defined sites to be added to DIMITRI. It is recommended that all new sites are generated using the DIMITRI HMI "New Site" module.
- All instrument folders will be identified through the defined values such as 'MERIS', 'MODISA' and 'AATSR'.
- All processing versions will be identified through the syntax 'Proc_*', for example 'Proc_1st_Reprocessing' for the 1st reprocessing.

The **'Output'** folder will contain folder names based on the syntax "site_date_ref_sensor" (e.g. "Domc_20100922_ref_MERIS_2nd_Reprocessing"). This allows users to identify different processing options/runs performed. User defined folders will be available through the main DIMITRI HMI.

2.3.1 VEGETATION Folder Structure

Due to the structure of VEGETATION-2 products, the following filename convention must be used for **VEGETATION-2 products ONLY**:

Input→Site→VEGETATION→Proc_Version→Year→Product_Folder→0001→data files

3 HMI FUNCTIONALITY

The DIMITRI HMI has a series of primary and secondary functions, all of which have been designed for command line usage as well as through the DIMITRI HMI. A list of all the routines is included in Appendix 1; described here are the main functions of DIMITRI.

Figure 2 shows the DIMITRI HMI. The following sections explain the functionalities (the buttons) of the HMI GUI.

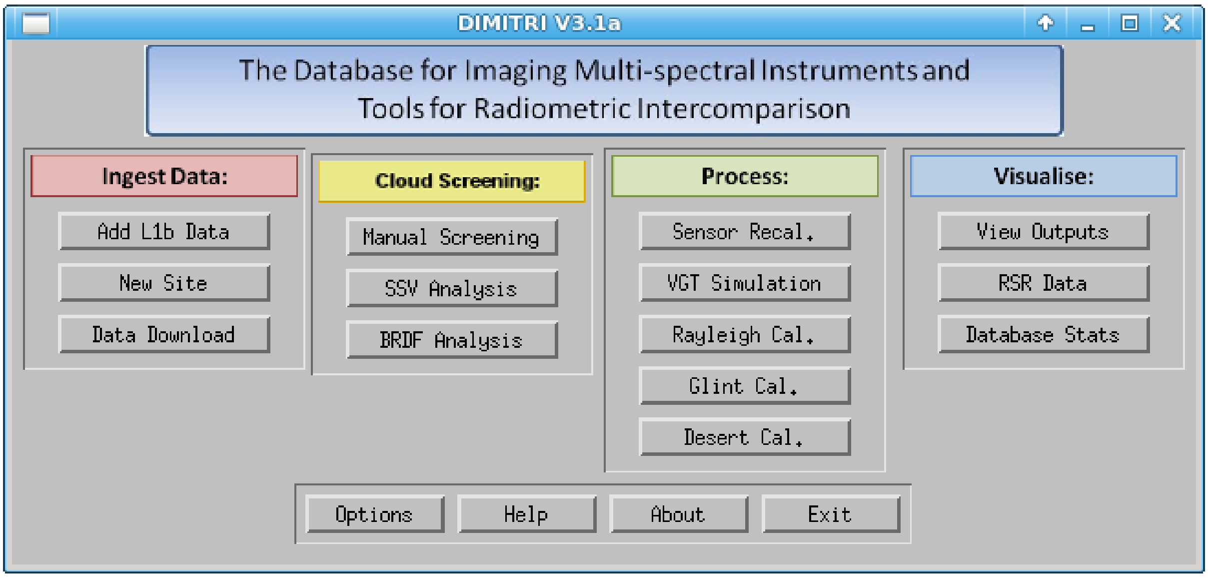

Figure 2: The DIMITRI HMI GUI start window.

3.1 Add L1b Data

The "Add L1b data" button starts the ingestion interface for adding L1b data products to the DIMITRI database. A specific site or sensor combination can be requested, or DIMITRI will automatically search for any L1b data not currently ingested into the database. All data is automatically cloud screened according to the sensors associated cloud screening algorithm (Section 3.4)

Only products located in the correct "Input" folders can be ingested into DIMITRI. If limited hard drive space is available, products can be removed from the input folder following ingestion, however the quicklook should remain for the manual cloud screening module.

Ingestion can take several minutes for each product depending on system performance and which sensor (as well as if child or parent products are used).

3.2 New Site

“New Site” starts the new site creation tool. A new site can be added to the DIMITRI database through selection of Name, Type, and basic geolocation coordinates (North, South, East and West). Once selected, the input folders for the site are automatically generated; there is no need to create any folders manually. Following creation, products can then be placed in the correct input folders for ingestion into DIMITRI.

3.3 Data Download

The “Data Download” module provides quick links to the associated sensor websites for retrieval of products. Please note that not all sensor data is freely available and some data access requires usernames and passwords.

3.4 Cloud Screening

An important development in DIMITRI V2.0 was the addition of automated cloud screening during ingestion of L1b satellite data. The following algorithms have been implemented for each sensor:

- **Landsat ACCA (RD-4):** ATSR2, AATSR, MODIS-Aqua
- **Globcarbon-MERIS (RD-5):** MERIS, PARASOL
- **VGT-operational:** VEGETATION

The computed cloudiness of each product over the validation site is stored in the DIMITRI database file and used with the selected cloudiness thresholds for Sensor Recalibration (Section 3.5) and VEGETATION Simulation (see Section 3.6).

For the manual cloud screening, the flags used to define the cloudiness in the database are: -1, 0, 1 and 2

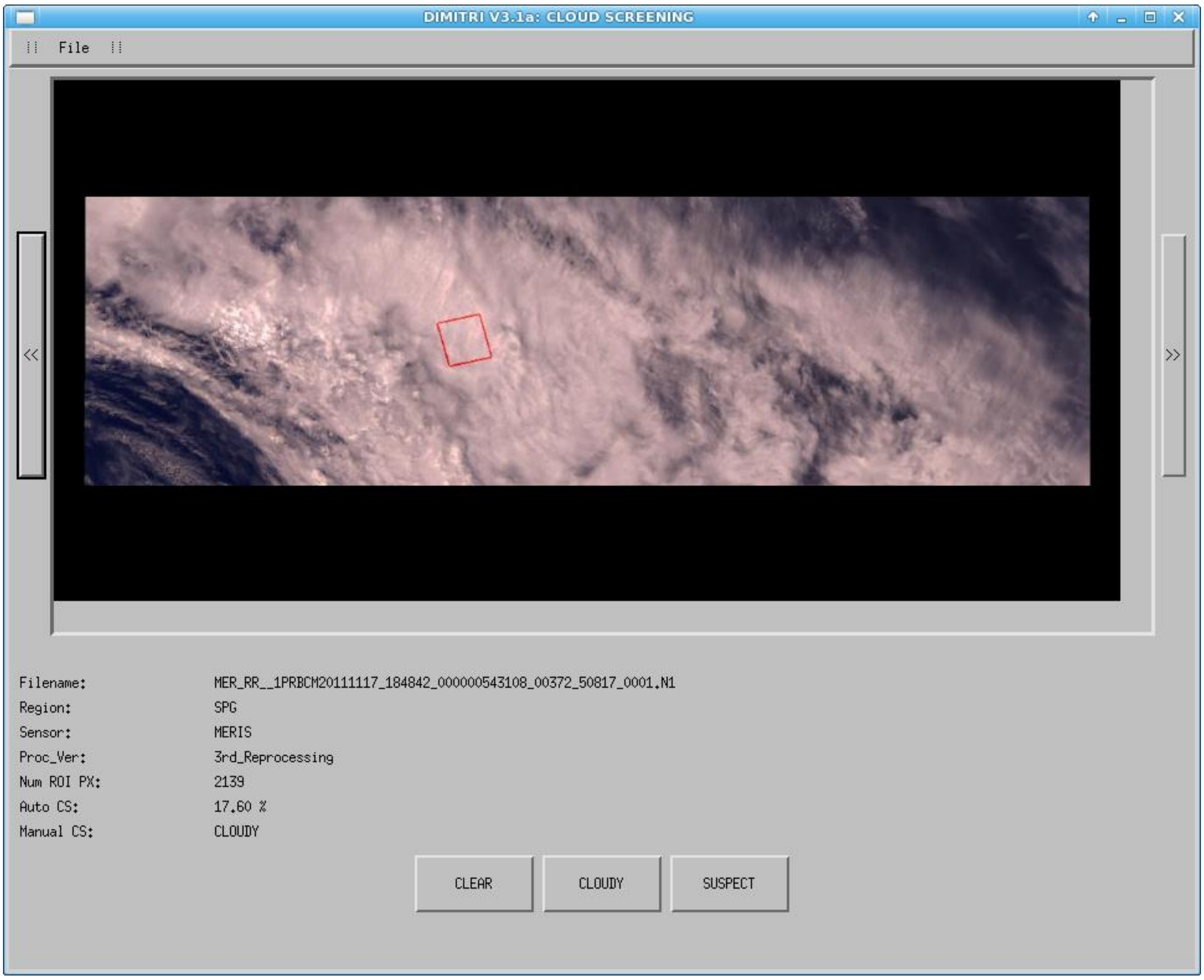

Figure 3: Manual Cloud Screening HMI

In addition to the automated cloud screening, Users can open the manual cloud screening module. This allows visualisation of a products quicklook for manual determination if it is cloudy or clear, or if the product contains errors (suspect). The manual cloud screening results always override the automated results during Sensor Recalibration and VEGETATION Simulation.

An important development in DIMITRI V3.1a is the addition of two automated cloud screening methodologies (RD-7). The first method, Spatial Scale Variability (SSV), measures the statistical variance of the per-pixel values from the mean top of atmosphere value over the area of interest. If the variance is above an empirically derived threshold then the scene is considered cloudy. The second method, BRDF Variability Threshold (BRDFVT), measures how closely the BRDF of a satellite measurement over a site complies with an empirically derived model of the BRDF for that site. If the BRDF deviates beyond a certain threshold from the modelled BRDF the scene is considered cloudy. Both methods have been implemented for each sensor.

3.4.1 Spatial Scale Variability (SSV)

Firstly a training set of images have to be selected such that images can be classified into three classes and defined as: clear, part-cloudy or cloudy sky. This training set of images are automatically stored and updated in the input directory corresponding to the run in three files (databases) "e.g. **DIMITRI_DATABASE_CLOUD_TRAINING_CLASS1_CLEAR.CSV**", which are needed for the training stage, when not skipped (see below), in the SSV and BRDFVT methods. It is more convenient to run the SSV after a manual cloud screening.

The "SSV" button starts the setup module the cloud screening. The output folder can be left as "auto" to generate an automatic folder named SITE_DATE_SSV_CS_SENSOR_PROC where DATE is the date of run (e.g. "SPG_201401016_SSV_CS_MERIS_3nd_Reprocessing"), or this can be User defined.

Two types of files are systematically generated for each SSV cloud screening run: **SSV_CS_LOG.txt (**log file summarising all parameters of the run) and **SCENE_SSV.JPG (**plots of the standard-deviation as function of the subsampling window size, for both the processed scene and the training classes)

Furthermore, when the SSV is run for the first time, the fitting coefficients of the training stage are stored in an IDL SAV file placed in the Input directory containing input training dataset.

The DIMITRI SSV cloud screening window is shown in Figure 4. Options are:

- Case study (region, sensor, processing version, time range)

  Selections are then made for the validation site to be used. The sensors and processing versions can then be selected by pressing the ">" button. The available selections are determined from the DIMITRI database file.

  Then DIMITRI suggests the whole period covered in the DIMITRI-DATABASE, or it can be user defined.

  <u>NOTE: THERE ARE AS MANY SCENE_SSV.JPG OUTPUTS AS SCENES CORRESPONDING TO THE CHOSEN TIME RANGE. HENCE IT IS WORTH LIMITING EACH SSV CLOUD SCREENING RUN TO FEW DAYS OR FEW MONTHS.</u>

- Coverage criteria. This applies both for the training stage (if activated) and the screening stage. User can define then the percentage of the ROI covered (default value is 100%).

- Cloud screening option: skip the training stage or not and select the band used for standard-deviation computation. Skipping the training stage can be of interest when the fitting coefficients already exists from a previous run because computation may take a relatively long time, depending on number of classes and number of scenes per classes. Selections are made then on the bands (predefined in DIMITRI) for each sensor.

- Final step: Once all parameters have been selected, press the START button to begin processing. Images of the cloud detection are generated for each scene by band and are stored in the output directory.

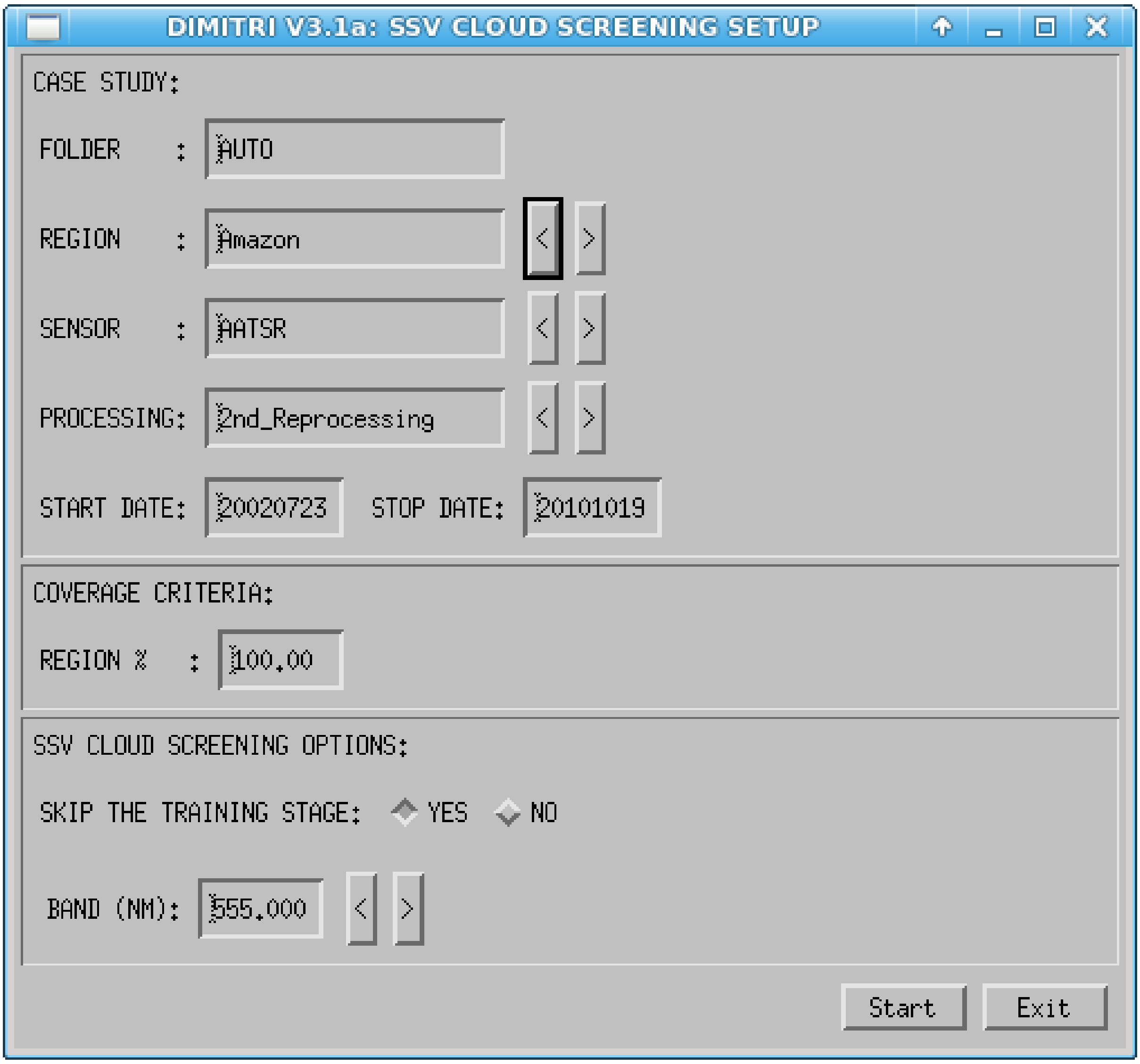

Figure 4: DIMITRI SSV cloud screening window

3.4.2 BRDF Variability Threshold (BRDFVT)

The BRDF method is implemented in the single cloudscreening/brdf_cloud_screening.pro routine and makes use of already existing BRDF modules. Similarly to VEGETATION TOA simulations, the TOA signal is first corrected for gaseous absorption (with exact integration on the sensor RSR) but not corrected for Rayleigh and aerosol scattering. The module mainly consists in two stages: the training stage and screening stage.

NOTE: BECAUSE THIS MODULE CALLS BRDF ROUTINES COMPILED AFTER THE CLOUD MODULES, A COMPILATION ERROR APPEAR WHEN COMPILING ONCE. HENCE DIMITRI MUST BE COMPILED TWICE, BY TYPING TWICE @COMPILE_DIMITRI

The output folder can be left as "auto" to generate an automatic folder named SITE_DATE_BRDF_CS_SENSOR_PROC where DATE is the date of run (e.g. "SPG_201401016_BRDF_CS_MERIS_3nd_Reprocessing"), or this can be User defined. Six types of files are systematically generated for each BRDF cloud-screening run: **BRDF_CS_LOG.txt (**log file summarising all parameters of the run);

- **BRDF_CS_ANALYSIS_SITE_SENSOR_PROC.JPG**: plot of the simulated over observed TOA signal ratio as function of time, for all observations providing a manual classification as either cloud or clear
- **AUTO_CS_PERF_SITE_SENSOR_PROC.JPG**: histogram plot performance of the nominal DIMITRI cloud screening (AUTO_CS field in DB), for clear and cloudy conditions as referred by the manual classification (result of the nominal screening is considered as cloudy if AUTO_CS>0)
- **BRDF_CS_PERF_SITE_SENSOR_PROC.JPG**: histogram plot performance of the BRDF cloud screening, for clear and cloudy conditions as referred by the manual classification
- **BRDF_CS_PERF_SITE_SENSOR_PROC.CSV**: text file containing the performance number used in the histogram plots (in %).
- **DIMITRI_DATABASE_BRDF_CS.CSV**: subset of the DIMITRI database file corresponding to user options (site, sensor, etc.) with BRDF cloud screening output instead of AUTO_CS field.

The DIMITRI BRDF cloud screening window is shown on Figure 5, the options are:

- Case study (region, sensor, processing version, time range)
- Coverage criteria. This applies both for the BRDF computation stage and the screening stage
- BRDF training parameters, including:
    - Clear sky database for BRDF computation (has to be present in the input directory)
    - Size of bins in days (default value is 5 days)
    - Minimal number of observation per bin (default value is 3)
    - Viewing and solar angles range: the Viewing Zenith Angle (VZA), Viewing Azimuth Angle (VAA), Solar Zenith Angle (SZA), and Solar Azimuth Angles (SAA).
    - Option to clean the output directory for all temporary BRDF outputs (default value is "YES")
- BRDF cloud screening parameters, i.e. band of the TOA ratio and threshold to detect clouds

The clear sky database is exactly similar to training datasets of the SSV cloud screening and must correspond to good condition for BRDF computation (typically user can select the clear sky class of the SSV cloud screening).

Note: when the clear sky database is scarce, the bin period must be large (e.g. 100 days or more), otherwise the Roujean BRDF cannot find enough observations inside the bins.

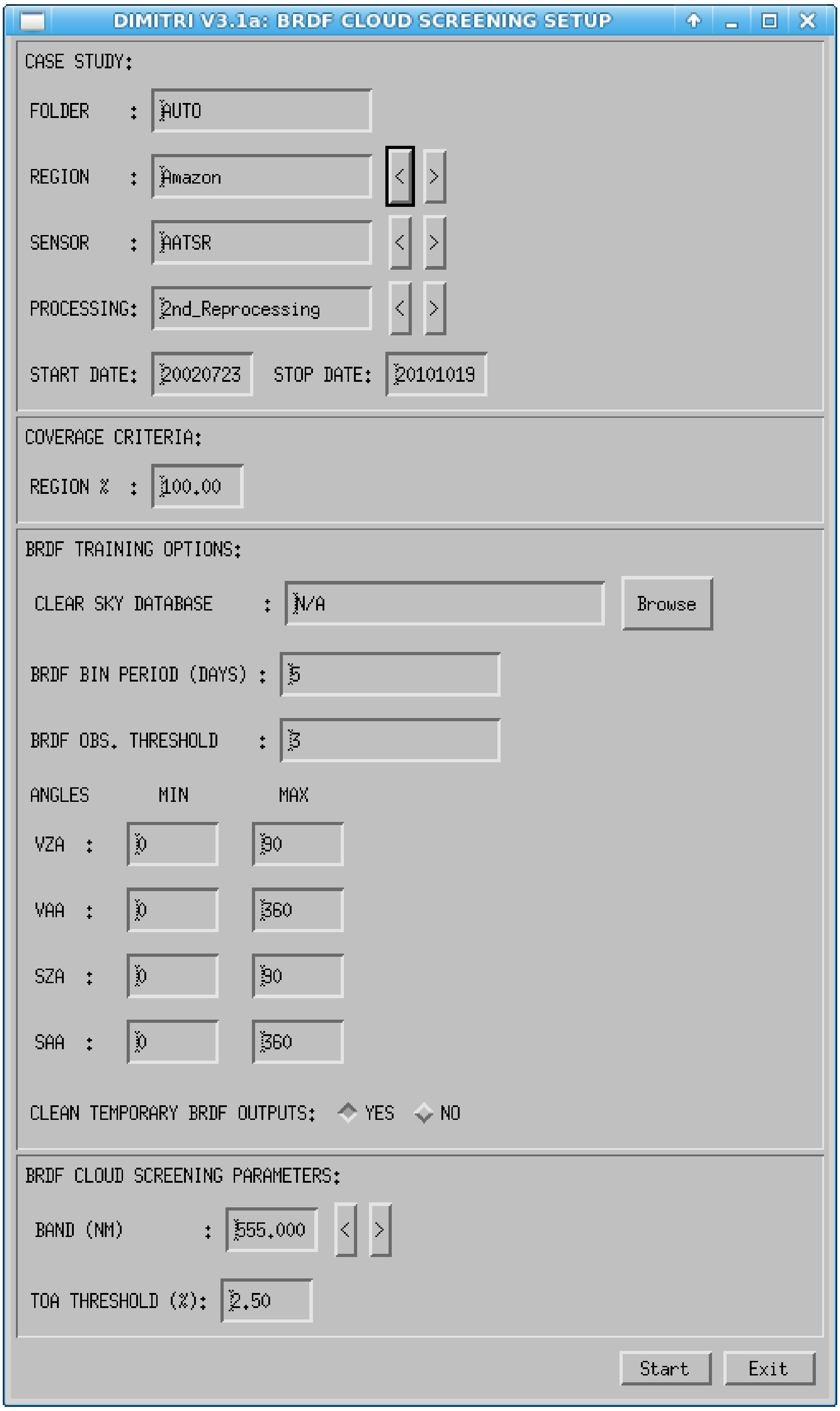

Figure 5: DIMITRI BRDF cloud screening window

3.5 Sensor Recalibration

“Sensor Recalibration” starts the setup module for intercomparison between a “reference” sensor and a number of “calibration” sensors (Figure 6). This intercomparison is based on the identification of acquisitions made between the two sensors at similar time and under similar geometries. The output folder can be left as “auto” to generate an automatic folder name (e.g. “SIO_20110426_REF_MERIS_2nd_Reprocessing”), or this can be User defined.

3.5.1 Sensor Selection

Selections are then made for the validation site to be used, the reference sensor and its processing version. The available selections are determined from the DIMITRI database file.

The “calibration” sensors and processing versions can then be selected by moving the required sensor configuration into the right hand list (highlighting the configuration and pressing “>>”). Unwanted configurations can also be removed from the list be selecting the configuration and pressing the << button.

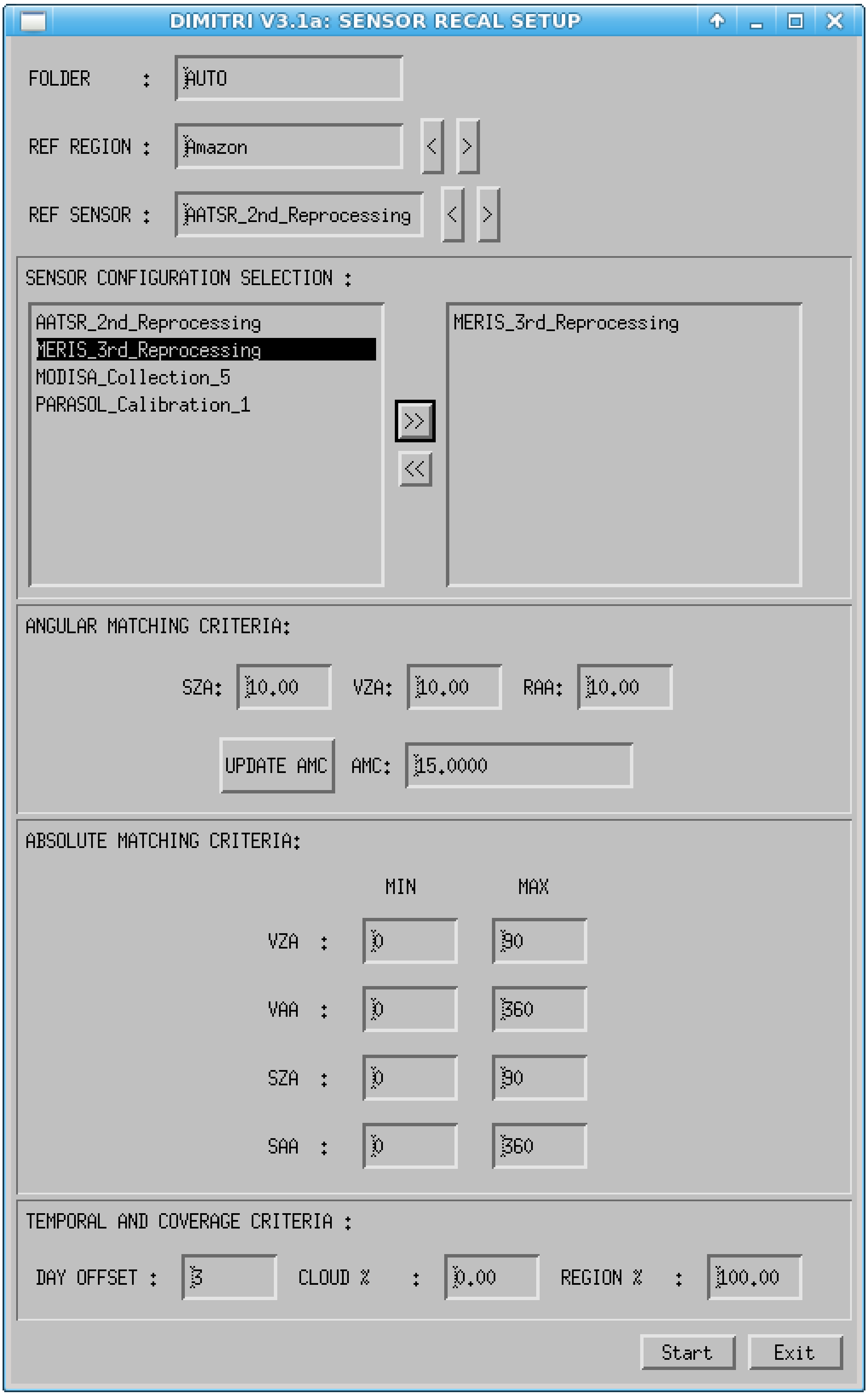

Figure 6: The DIMITRI Sensor Recalibration HMI

3.5.2 Angular Matching Criteria

The parameter AMC is used for geometrically matching satellite data from two different sensors. The SZA, VZA and RAA can be selected and used to update the AMC threshold to be utilised. Any corresponding satellite observations with an AMC value less than the threshold are selected and stored. The AMC parameter is defined as:

$$AMC = \sqrt{([SZA_1 - SZA_2]^2 + [VZA_1 - VZA_2]^2 + \frac{1}{4}[|RAA_1| - |RAA_2|]^2)}$$

The User also has the option of selecting absolute angle criteria for the Viewing Zenith Angle (VZA), Viewing Azimuth Angle (VAA), Solar Zenith Angle (SZA), and Solar Azimuth Angles (SAA).

3.5.3 Temporal, Spatial and Cloud Criteria

The final parameter selections require the User to define the maximum allowed acquisition time difference (in days) between two satellite observations, as well as the automated cloud percentage threshold and percentage of the ROI covered.

Any manual cloud screening results (performed by the User) override the corresponding automated cloud screening threshold checks. For example, if a product has been manually identified as clear (non-cloudy) it will always be considered for matching with other satellite observations. If no manual identification has been performed, the product will only be used if its automated cloud screening percentage is below the cloud threshold set by the User.

If the input ROI percentage coverage is less than 100%, the expected number of pixels for the selected sensor is compared against the actual number for each observation. If however the values is set as 100%, a different test is used; only products in which the four corners of the defined ROI are covered, are kept (this utilises the “ROI_COVER” flag within the DIMITRI database). This check has been implemented due to the varying pixel resolution of MODIS-Aqua data across the swath; at higher viewing zenith angles fewer pixels are required to cover the entire ROI – this however is recorded as not fully covered due to the expected constant pixel resolution. It is therefore recommended to always set the ROI percentage cover as 100%.

Any satellite observations from two separate sensors (or configurations) which are within the defined temporal and spatial matching criteria (including cloud coverage) are known as “doublets”.

3.5.4 Final Steps

Once all parameters have been selected, press the START button to begin processing. “Sensor Recalibration” comprises of doublet matching between the “reference” sensor and all “calibration” sensors, generation of a polynomial to fit the temporal variations of the radiometric difference between these sensors, and recalibration of all “calibration” sensor data to the radiometric scale of the “reference” sensor. These steps are known as doublet extraction, intercalibration and recalibration, and output a so called "super sensor" time series of sensor observations over the same location with different viewing and solar geometries.

During intercalibration a polynomial fit is applied to the temporal differences between the calibration and reference sensor for a given band. The following model is used for the polynomial fit:

$$y = Ax^2 + Bx + C$$

The coefficients A, B and C are computed using a least squares regression fit and are output in the "ICAL" CSV files. No weighting is applied to the polynomial model computation. In addition to the polynomial coefficients, the covariance matrix is also output in the "ICAL" CSV file. The matrix is a 3x3 element array with columns A, B and C, and rows 1, 2 and 3; the output values can therefore be replaced into a matrix given the values header information. For example CVAR_A1 refers to the covariance value matrix [1,1] (starting from 1).

3.5.5 Super Sensor observation uncertainty

The final output of the process previously described is the time series of super sensor observations. All sensors observations have been rescaled to the reference sensor radiometric scale. This does not mean that the super sensor observations have the same systematic uncertainty than the reference sensor because the methodology has introduced additional uncertainties, both random and systematic. To evaluate these uncertainties, it is assumed in DIMITRI V2.0, that all standard satellite TOA reflectance values have both systematic and random uncertainties of respectively 3% and 3% (3σ) – see RD-6. In addition, the doublet matching process has then been estimated to introduce a 3% systematic uncertainty (with respect to the reference sensor) and a 3% (3σ) random uncertainty (see references in RD-1 and RD-2).

The super sensor observation radiometric systematic uncertainty is thus 3% with respect to the reference sensor radiometric scale.

The combined random uncertainty associated to the super sensor observations is the quadratic sum of the random uncertainties of the calibration sensor + reference sensor + methodology uncertainty. This amounts to 5.2% (3σ). The consistency of this figure is checked against the value of the RMSE of the polynomial fit to the radiometric differences between the calibration and reference sensor doublets. If the polynomial's RMSE fit is greater than the combined random uncertainty then this value becomes the random uncertainty for the calibration sensor time series; the super sensor observations can therefore have different uncertainties for each day and wavelength depending on which 'calibration' sensor data has been used.

The propagated uncertainties are output in both internal IDL save files and semi-colon delimited CSV files. Please note, updated uncertainty propagation is foreseen for future releases of DIMITRI.

3.6 VEGETATION-2 Simulation

"VGT Simulation" starts the setup modules for BRDF model generation and simulation of VEGETATION-2 TOA reflectance (Figure 7). This process will only work with outputs from 'Sensor Recalibration' where both MERIS and AATSR have been separately used as "reference" sensors.

3.6.1 Super Sensor Selection

The output folders containing the "Sensor Recalibration" results can be found using the < and > buttons. If the required data is found in the folder, the processing configurations become available for selection in the corresponding selection boxes. If no data is available the value "n/a" is presented.

The routine then determines if any VEGETATION-2 data is available corresponding to the site provided in the selected MERIS folder. All outputs are placed in this MERIS output folder.

3.6.2 BRDF and VEGETATION-2 Criteria

You are then able to select if automatic BRDF plots should be generated (note, for large time series this can take a long time), the BRDF binning period (how many days should cover one bin period), the acquisition limit (how many super sensor observations are required to make the BRDF model valid for each bin), and the cloud and ROI thresholds for the VEGETATION-2 sensor data (recommended to be the same as the doublet extraction values).

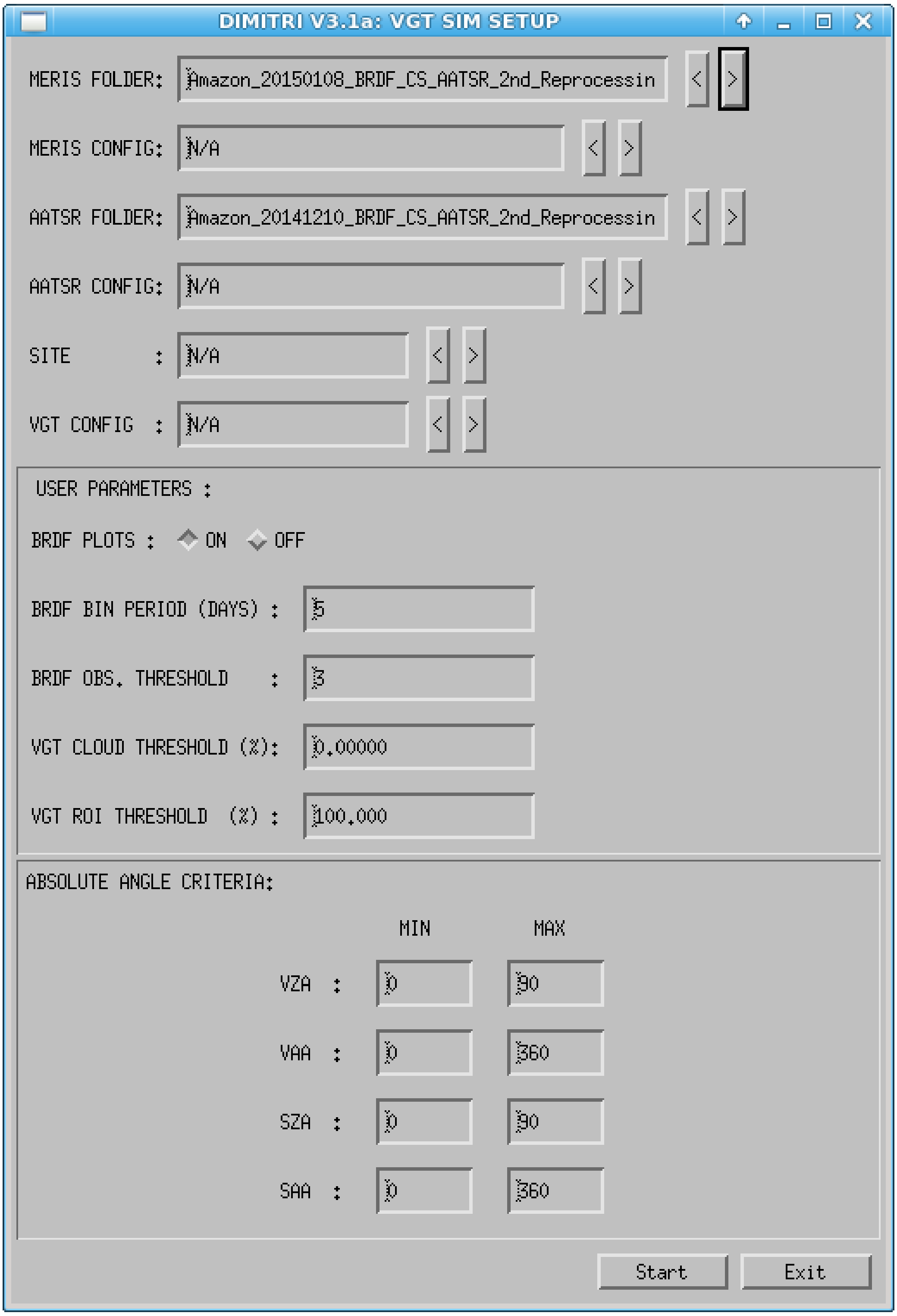

Figure 7 : VEGETATION-2 setup module HMI

3.6.3 Final Steps

When all parameters are selected, press the “START” button to begin processing. DIMITRI then utilises the “super sensor” time series to generate the ROUJEAN BRDF model (RD-3) for each band and each binning period. Once complete, the BRDF models are concatenated and used to simulate the VEGETATION TOA reflectances. This involves:

- Extraction of VEGETATION observations corresponding to each BRDF bin,
- The checking of BRDF models at each MERIS band plus the AATSR 1.6 micron band (any missing MERIS bands are computed from the closest nominal BRDF model),
- The generation of TOA reflectance using VEGETATION geometries and the BRDF models,
- Correction for water vapour, ozone and gaseous transmission,
- Interpolation to hyperspectral wavelengths,
- Re-addition of atmospheric transmission,
- Convolution to the VEGETATION bands.

Please note, the VGT-2 simulation methodology can be performed using only MERIS BRDF models; in this instance the 1.6 micron band is extrapolated from the MERIS 900nm band and should therefore be disregarded.

3.6.4 Simulated VEGETATION TOA reflectance uncertainty

The final uncertainties output are the random and systematic uncertainties associated with the VEGETATION simulated observations.

Starting from the uncertainties associated to the super sensor observations, we need to add the methodology uncertainties. These are described in details in RD-6.

The final uncertainties associated with the simulated VEGETATION observations are respective a systematic uncertainty of at least 8% and a random uncertainty of at least 11% (3σ). The systematic and random uncertainties output can be higher (RD-6).

3.7 Rayleigh Calibration (Rayleigh Cal.)

“Rayleigh Cal.” starts the setup module for Rayleigh calibration. The Rayleigh calibration methodology is implemented as an individual IDL module called by a new GUI module (or directly in command line); it then calls several separated routines for specific jobs (e.g. computation of Rayleigh reflectance, of marine models, etc.). All routines related to the Rayleigh vicarious calibration are stored in the Source/vicarious directory. Except for the GUI, there is no interaction with previous DIMITRI_v2.0 modules. The Rayleigh is applicable to all sensors AATSR, ATSR2, MERIS, MODIS-A, PARASOL and VGT-2 (but only for BOUSSOLE; other marine targets are not available in DIMITRI) (RD-8).

Schematically, the main Rayleigh calibration module:

- Interfaces with the DIMITRI database to identify appropriate L1b extractions with respect to chosen region, sensor, processing version and year;
- Screens data for ROI cloud and region coverage; in the pixel-by-pixel mode, pixels are further screened by the cloud mask;
- Finds all pixels within other user defined parameters specific to the calibration method;
- Reads all RTM LUT;
- Performs the Rayleigh Calibration band per band;
- Post-processed the coefficients (averaged, statistics);
- Outputs the individual and averaged calibration coefficients for each band in several text and image file (see below).

The output folder can be left as “auto” to generate an automatic folder name (e.g. “SPG_20141026_RAYLEIGH_MERIS_3nd_Reprocessing”), or this can be User defined.

Six types of files are systematically generated for each Rayleigh vicarious calibration run:

- **RAYLEIGH_CAL_LOG.txt:** log file summarising all options of the run (parameters).
- **RAYLEIGH_CAL_SITE_SENSOR_PROC_AVG.dat:** IDL SAV file storing array VIC_COEF_AVG of averaged vicarious coefficients per observation (when pixel by pixel mode) or directly coefficients starting from the averaged TOA signal.
- **RAYLEIGH_CAL_SITE_SENSOR_PROC_AVG.csv:** same as previous but in csv format for direct reading.
- **RAYLEIGH_CAL_SITE_SENSOR_PROC_STAT.csv:** csv file containing statistics on the final unique set of coefficients per wavelength (median, mean, standard-deviation, number of points, mean uncertainty).
- **RAYLEIGH_CAL_SITE_SENSOR_PROC_MEAN.JPG:** plot of the mean coefficients as a function of wavelength.
- **RAYLEIGH_CAL_SITE_SENSOR_PROC_WAV.JPG:** plots for each wavelength, of the time-series of averaged coefficients.

When the pixel-per-pixel mode is activated, another output is:

- **RAYLEIGH_CAL_SITE_SENSOR_PROC_PIX.dat:** IDL SAV file identical to the _AVG.dat one’s but providing information for all individual pixels, consistently with input SENSOR_TOA_REF_PIX.dat file.

The Rayleigh calibration methodology allows both GUI and command line activation. All processing parameters specific to the Rayleigh calibration are selectable by the user through a setup window (Figure 8):

- Case study (region, sensor, processing version, year, output directory);
- Cloud and region coverage percentage; note that scenes having a manual cloud screening set to 0 will be selected whatever the automated cloud screening value;
- Pixel-by-pixel mode;
- Chlorophyll concentration, either by monthly climatology put in the DIMITRI auxiliary folder or by a fixed values;
- Maximum wind speed;
- Maximum Rayleigh corrected normalised radiance at 865 nm;
- Aerosol model, among an automated list built on all models existing in DIMITRI auxiliary folder, sensor per sensor.

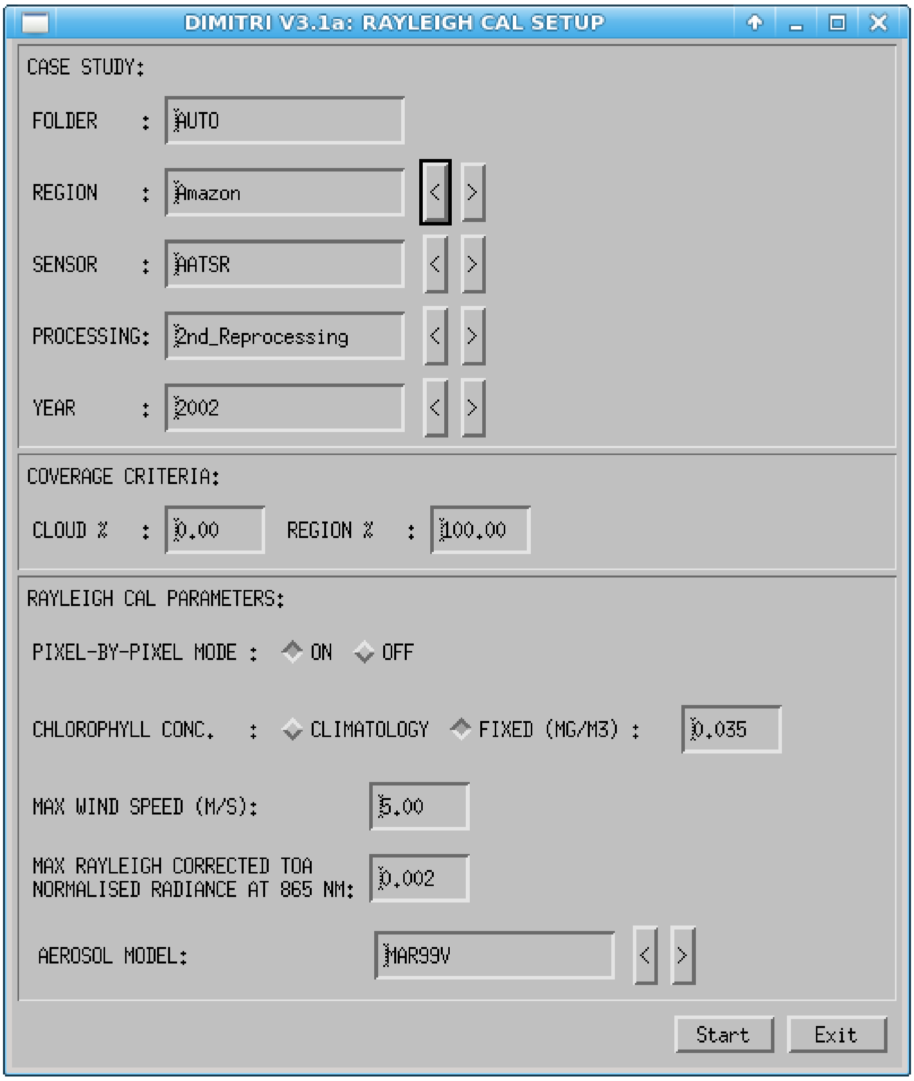

Figure 8: Rayleigh Calibration setup module HMI

3.8 Sunglint Calibration (Glint Cal.)

"Glint Cal." starts the setup module for Vicarious Calibration over Sunglint (RD-9). The glint calibration methodology allows both GUI and command line activation.

The output folder can be left as "auto" to generate an automatic folder name (e.g. "SPG_20141026_GLINT_MERIS_3nd_Reprocessing"), or this can be User defined.

Six types of files are systematically generated for each glint vicarious calibration run:

1. **GLINT_CAL_LOG.txt:** log file summarising all options of the run (parameters).
2. **GLINT_CAL_SITE_SENSOR_PROC_AVG.dat:** IDL SAV file storing array VIC_COEF_AVG of averaged vicarious coefficients per observation (when pixel by pixel mode) or directly coefficients starting from the averaged TOA signal (if not) and associated uncertainties. Consistently with the standard SENSOR_TOA_REF.dat DIMITRI files, parameters of VIC_COEF_AVG array are:

decimal_time, VZA, VAA, SZA, SAA, Ozone (avg+stddev), Pressure (avg+stddev), Humidity (avg+stddev), Zonal_wind (avg+stddev), Meridional_wind (avg+stddev), Water_vapour (avg+stddev), DAk_band_0, …, DAk_band_n, DAk_unc_band_0,…DAk_unc_band_n

3. **GLINT_CAL_SITE_SENSOR_PROC_AVG.csv:** same as previous but in csv format for direct reading.
4. **GLINT_CAL_SITE_SENSOR_PROC_STAT.csv:** csv file containing statistics on the final unique set of coefficients per wavelength (median, mean, standard-deviation, number of points, mean uncertainty).
5. **GLINT_CAL_SITE_SENSOR_PROC_MEAN.JPG**: plot of the mean coefficients as a function of wavelength.
6. **GLINT_CAL_SITE_SENSOR_PROC_WAV.JPG:** plots for each wavelength: of the time-series of averaged coefficients.

When the pixel-per-pixel mode is activated, another output is:

GLINT_CAL_SITE_SENSOR_PROC_PIX.dat: IDL SAV file identical to the _AVG.dat one's but providing information for all individual pixels, consistently with input SENSOR_TOA_REF_PIX.dat file.

All processing parameters specific to the glint calibration are selectable by the user through a new window (Figure 9):

- Case study (region, sensor, processing version, year, output directory);

- Cloud and region coverage percentage; note that scenes having a manual cloud screening set to 0 will be selected whatever the automated cloud screening value;
- Pixel-by-pixel mode;
- Chlorophyll concentration, either by monthly climatology put in the DIMITRI auxiliary folder or by a fixed values;
- Maximum wind speed;
- Maximum angle between viewing and specular directions;
- Reference band for the calibration;
- Absolute calibration coefficient for the reference band; this coefficient must be understood as in the Rayleigh absolute calibration
- Aerosol optical thickness at 865 nm;
- Aerosol model, among an automated list built on all models existing in DIMITRI auxiliary folder, sensor per sensor.

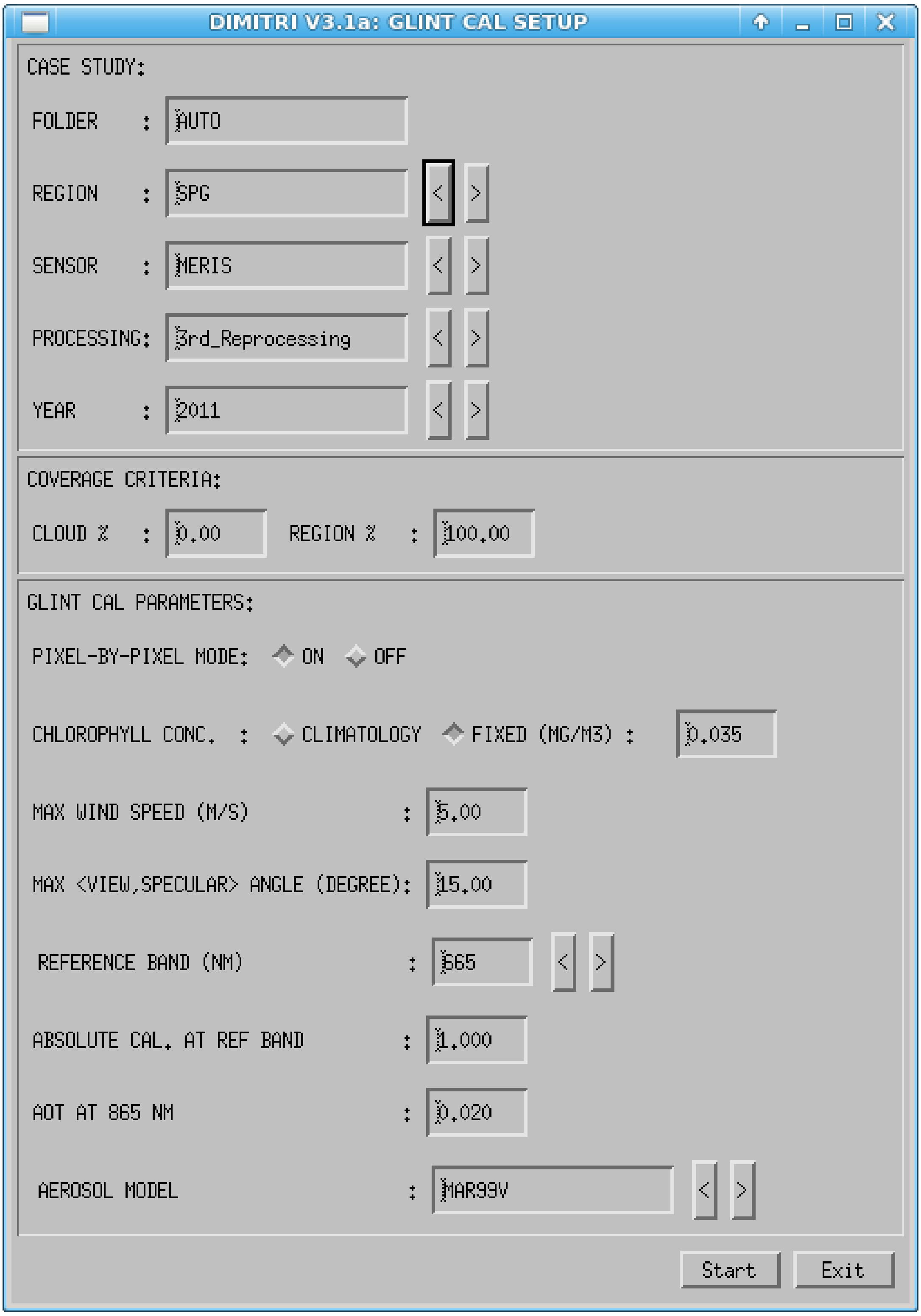

Figure 9: Glint Calibration setup module HMI

3.9 Desert Calibration (Desert Cal.)

“Desert Cal.” starts the setup module to simulate TOA observations in the visible to NIR spectral range over desert sites (e.g. Libya4). This methodology is based on a physical radiative transfer model simulating the coupling between a realistic atmosphere and a spectral surface BRDF model (See RD-10). First the model is calibrated to MERIS spectral bands, and then the outputs are spectrally interpolated to be used as input to the radiative transfer model (MYSTIC) to simulate the observations of other sensors.

The desert calibration methodology allows both GUI and command line activation.

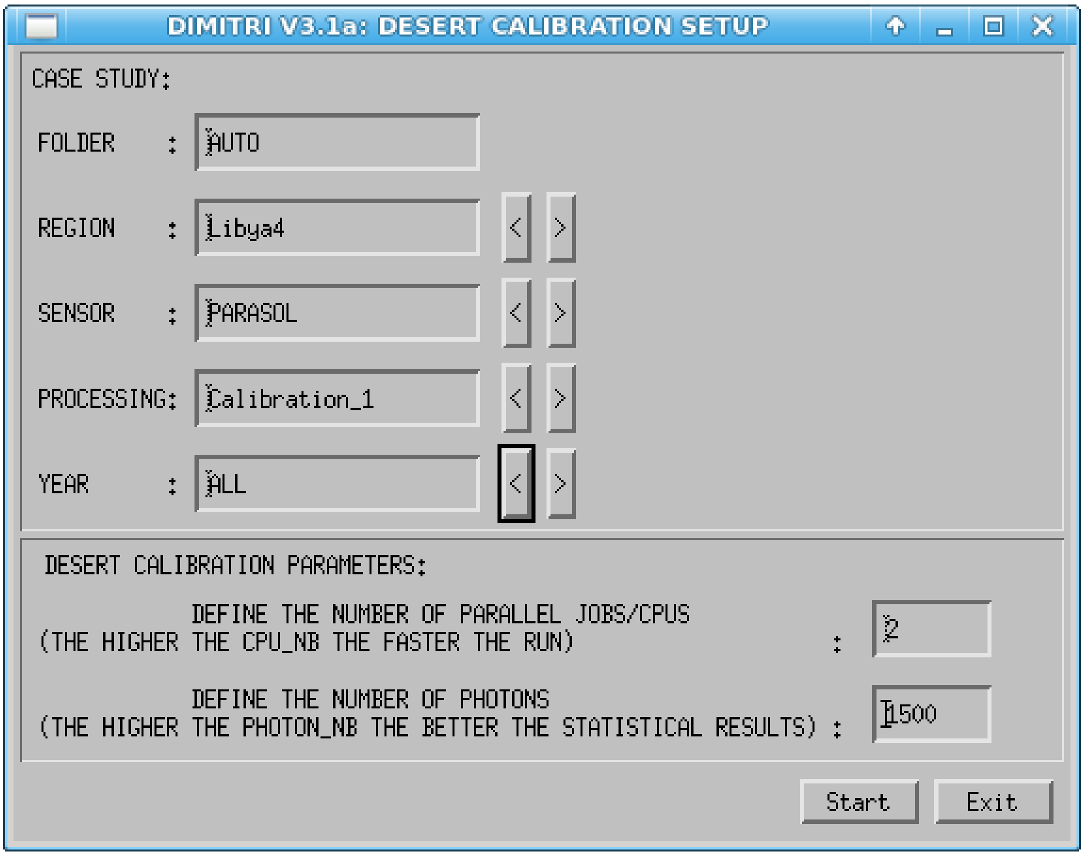

Figure 10: Desert Calibration setup module HMI

The output folder can be left as “auto” to generate an automatic folder name (e.g. “Libya4_20150120_DESERT_PARASOL_Calibration_1”), or this can be User defined.

Several files are systematically generated for each desert calibration run:

1. **mc_simulation_cpu_0.input :** Input file summarising all options of the MYSTIC run (parameters and auxiliary data) stored in the folder temp_sim_files

2. **Plot_sim_vs_true_SENSOR_Proc_VER_SITE_band_1_statistics.sav and Plot_sim_vs_true_SENSOR_Proc_VER_SITE_band_1.sav:** IDL SAV files storing the outputs of the calibration run (they are in the output folder).

All processing parameters specific to the Desert calibration are selectable by the user through a new window (Figure 10):

- Case study (output directory, region, sensor, processing version, year);
- Desert calibration parameters: (Number of Jobs/CPUS, Number of photons)

  For the default value of the number of CPUs is set to 1, while DIMITRI retrieves the maximum CPUs of the platform and allows the user to chose jobs-number in the range of [1, max-CPUs]. The default Number of photons is set to 1500.

When all parameters are selected, press the “START” button to begin processing and following the progress of your jobs on the screen.

- DIMITRI then reads the sensor data and consolidates the meteo data (from ECMWF-ERA-Interim climatology) if needed.
- Selection of the valid data (by several criteria) is performed in order to simulate the remote sensing observation.
- MYSTIC model is run over the valid data.
- Plots of the simulation time series and statistics on the calibration methodology for each wavelength band are done and stored into the output folder. (Figure 11)

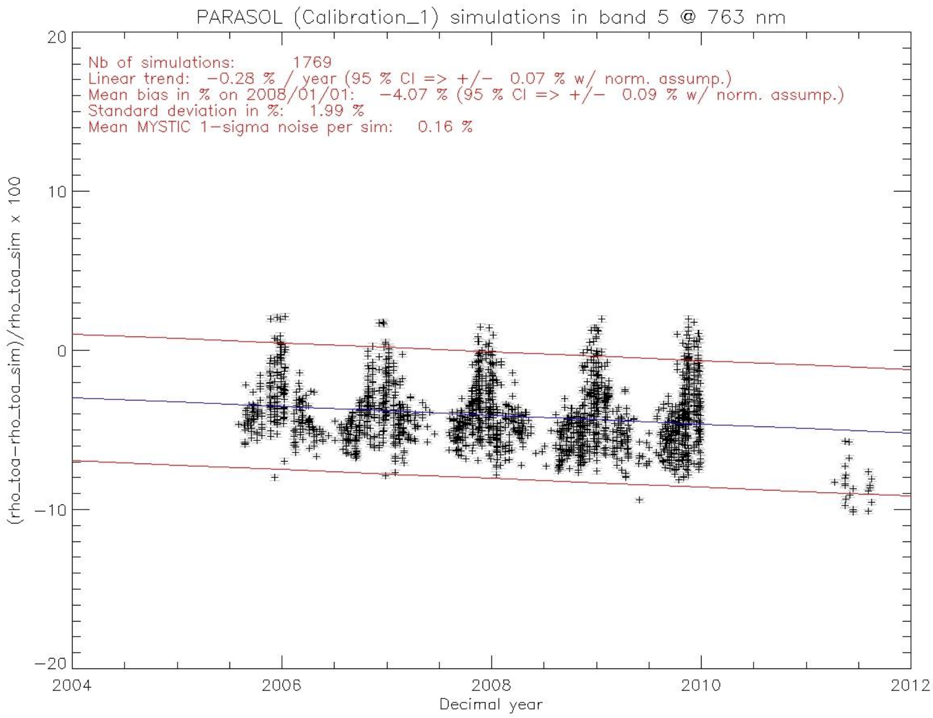

Figure 11: Example of the desert calibration time series from PARASOL-Band 5

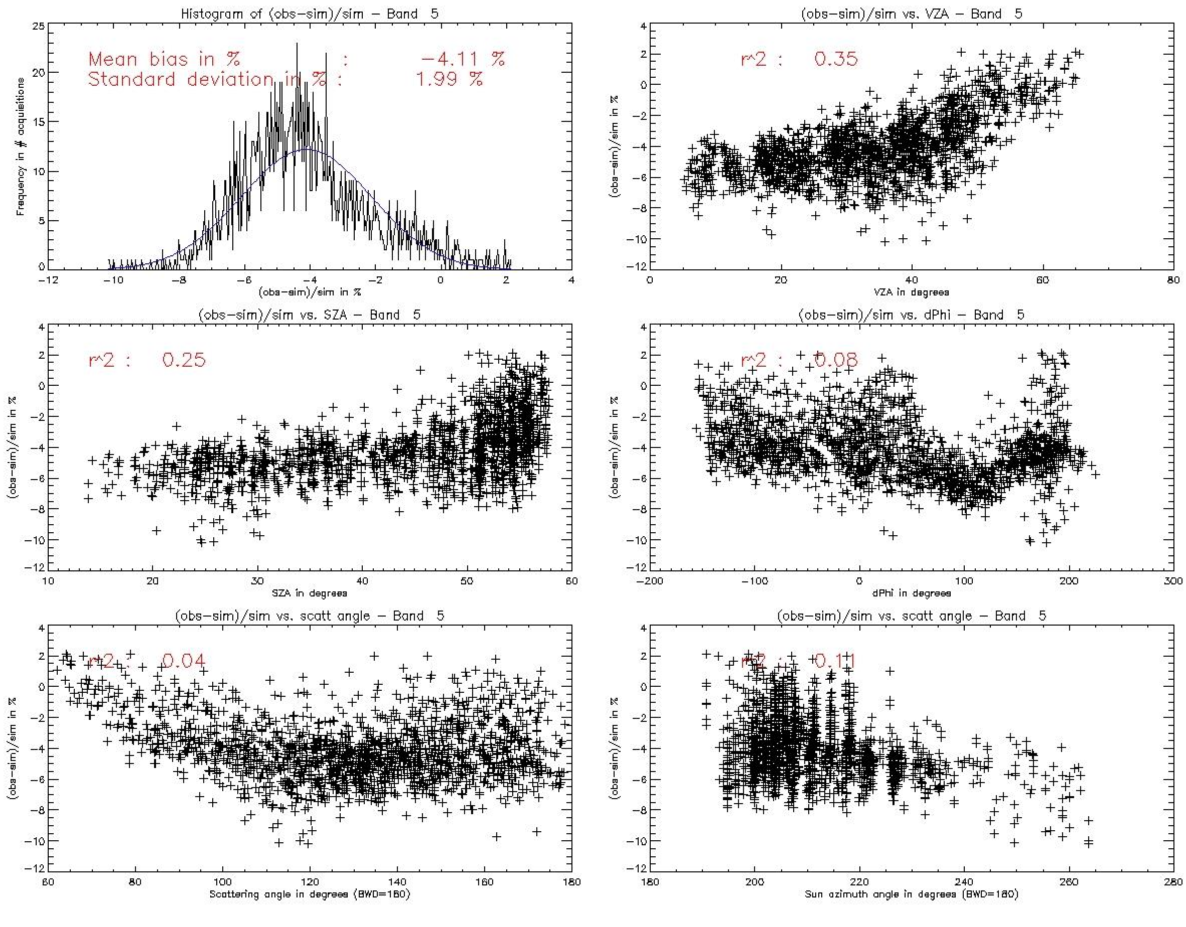

Figure 12: Example of the desert calibration statistics on the band 5 from PARASOL sensor

3.10 Visualisation

The visualisation module provides a quick and easy opportunity to view any output results from either Sensor Recalibration or VEGETATION Simulation. Each menu is dynamically created depending on which data is available in the output folder selected.

Plots can be generated and saved as JPG's or PNG's, or as a semi-colon delimited (CSV) file. Statistics on plotted data can also be viewed through the visualisation module and saved as a CSV file (Figure 13).

- **TOA RHO:** Plots Sensor doublet observations, Super Sensor and simulated VEGETATION time series.
- **RECAL RHO:** Plots the recalibrated time series data for each "calibration sensor" used.
- **RHO Bias:** Plots the reflectance bias (difference to "reference" sensor) for each "calibration" sensor
- **POLY Bias:** Plots the polynomial bias (difference to "reference" sensor) for each "calibration" sensor
- **VZA/VAA/SZA/SAA:** Plots the doublet angular information
- **AMC:** Plots the computed AMC values between observations

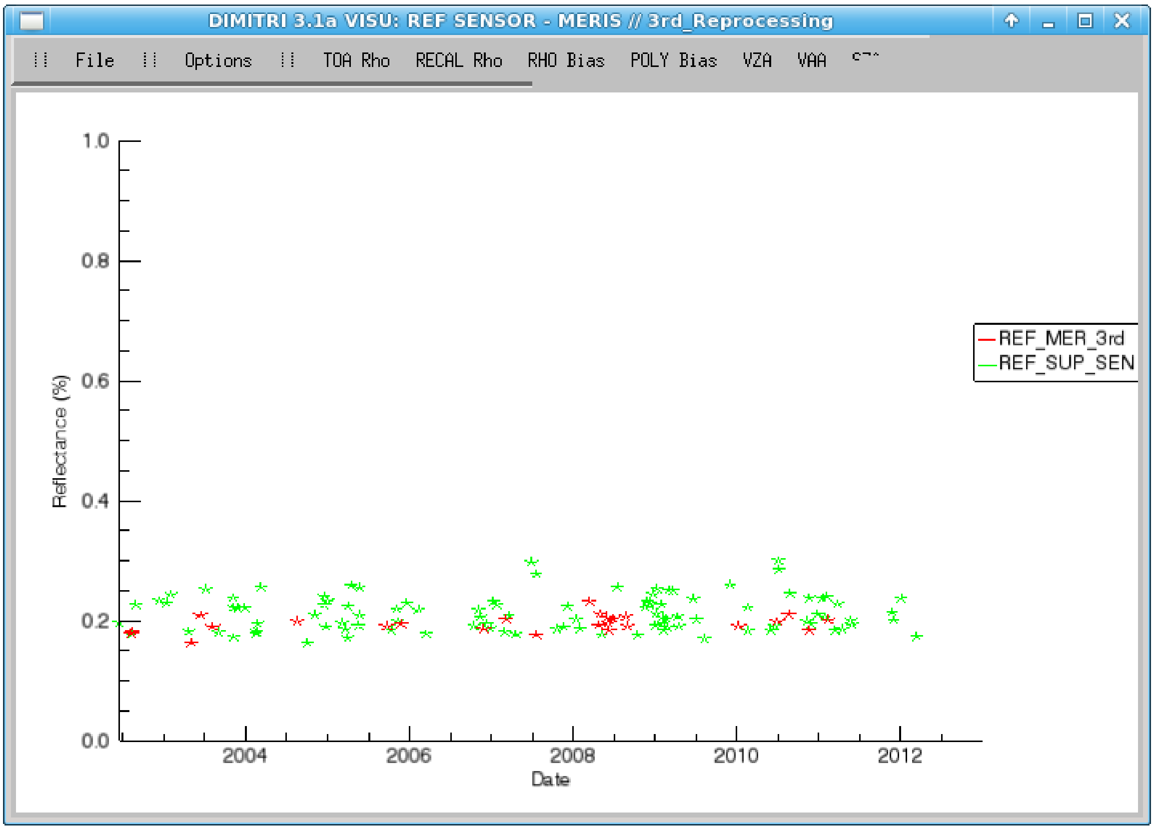

Figure 13: Example of the VISU Module

3.11 Database statistics

The “Database Stats” button starts the database statistics module which provides up to date statistics on the current DIMITRI database file. Further to this, plots can also be viewed highlighting the number of products ingested for each product over each site. Plots can be saved in the JPG, PNG and CSV formats.

3.12 Relative Spectral Response viewer

The Relative Spectral Response (RSR) viewer allows generation and visualisation of plots of sensor RSR functions with User specified wavelength ranges. Users can also view the associated reflectance for each sensor as the spectra is convoluted to the sensor RSR, and add new site spectra to the ”AUX_DATA/spectral_response/USER_Sites” folder. These files must be semi-colon separated and contain two columns containing the wavelength in nm, and the RSR function (between 0 and 1). For example, a User generated spectra file would be of the form:

354.000;2.304685712e-01
355.000;2.281964719e-01
356.000;2.259108275e-01
357.000;2.233817428e-01

3.13 Options

The “Options” module allows the definition of the DIMITRI configuration parameters including plot size, colour table, and RGB (red / green / blue) overlays. These values are then loaded into the Sensor Recalibration and VEGETATION Simulation modules as default values.

3.14 Help

Opens this user manual.

3.15 About

Displays information regarding the version of DIMITRI.

3.16 DIMITRI Output

DIMITRI outputs a number of jpg plots and semi-colon delimited CSV files. A number of intermediate results are stored as IDL save files which are restored by DIMITRI when required (see Section 5.3). These files can also be restored by users with full IDL licenses if required by typing:

IDL> restore, sav_filename

4 DIMITRI ROUTINES

4.1 Routine location

All DIMITRI routines can be found in the source folder. All routines developed by ESA and ARGANS contain a code header providing information on what the routine does, how it is called, what are the outputs, and the modification history. If users update any routines, please ensure the code header is updated accordingly.

4.2 Recompilation

DIMITRI 3.1 has been developed in IDL8.2 and is open to users with full IDL licenses to modify the code and develop it further (note, ESA and ARGANS are not responsible for any damage this may cause to your computer). All routines can be found within the Source folder, including a shell script called "compile_dimitri" which recompiles all routines. A compiled SAV file can then be generated by typing twice:

IDL> @compile_dimitri

The created save file can then be used by the IDL runtime version which does not require an IDL license.

4.3 External Routines

The DIMITRI software package has been developed by ESA and ARGANS using IDL. However, some functions have been included which were developed by other people. These include:

- **FSC_field.pro:** Created by David Fanning, http://www.idlcoyote.com/ – a must see website containing many pages of useful IDL hints and tips.
- **Mpfit.pro and mpcurvefit.pro:** Created by Craig B. Markwardt (http://www.physics.wisc.edu/~craigm/idl/fitting.html)
- **AATSR/ATSR2 product reader routines:** Created by Dave Smith, RAL (http://www.aatsrops.rl.ac.uk/)
- **FILEINFO.pro:** Created by Liam Gumley (http://www.gumley.com).

5 DATA FILES

The DIMITRI software package utilises a number of different data files. These can be found in the "AUX_data", "Bin" and "Output" folders, and include Database files, internal IDL binary files and Auxiliary data files, each outlined below.

5.1 DIMITRI Database file

The semi-colon delimited Database file contains information regarding all ingested L1b data products. It is used by a number of DIMITRI functions such as doublet extraction and VEGETATION simulation. The database file can be opened in a number of text editors including Microsoft excel to allow further analysis of the ingested product data. A breakdown of the column headers is provided below:

- **DIMITRI_DATE:** The calendar date the product was ingested into DIMITRI, DD-MMM-YY (14-Dec-10)
- **REGION:** ROI folder User placed product ('Uyuni')
- **SENSOR:** Product Sensor ('ATSR2')
- **PROCESSING_VERSION:** User defined processing version of product ('2nd_Reprocessing')
- **YEAR:** Year of product acquisition (2002)
- **MONTH:** Month of product acquisition (3)
- **DAY:** Day within month of acquisition (30)
- **DOY:** Day-Of-Year relating to YEAR,MONTH and DAY values (89)
- **DECIMAL_YEAR:** Decimal year of data acquisition (2002.244)
- **FILENAME:** Product filename (without path reference)
- **ROI_COVER:** Integer, raised if all corners of the corresponding ROI are covered by the product
- **NUM_ROI_PX:** Number of pixels within the associated ROI (1068)
- **AUTO_CS:** Automated ROI Cloud Screening result in percent (50.0)
- **MANUAL_CS:** Integer flag indicating, -1: not performed, 0: clear, 1: cloudy
- **AUX_DATA(1:10):** A string of auxiliary data used to process the L1b product

5.2 Auxiliary data files

A number of auxiliary data files are used by the DIMITRI software package. The main aux files are:

1. **Sensor info:** This file contains information on the available satellite sensors within the DIMITRI software package.
2. **Site info:** this file contains information on each of the DIMITRI validation sites, as well as any user defined sites.
3. **Configuration file:** this file contains the user's DIMITRI configuration settings (e.g. plot sizes and RGB quicklooks), and is updated by the configuration HMI module.
4. **Band centre index:** This file contains the relative indexes for each sensor band against the defined DIMITRI wavelengths. It is used throughout a number of DIMITRI functions and should not be modified. There are 30 defined "DIMITRI" bands covering the wavelength range 400-12000nm; for each sensor, the band index is linked with the corresponding DIMITRI band to allow comparison against other sensors which also have bands matching that DIMITRI band. This comparison is performed internally, and allows specification of comparing different bands; for example, MODISA has two band setting, land and ocean, which are defined in the Band_centre_index auxiliary file.

5.3 Internal SAV binaries

5.3.1 Extracted TOA Reflectances

For each sensor, over each site, an internal SAV stores the extracted time series data; the syntax for these files are SENSOR_TOA_REF.dat, and have dimensions

[num_of_parameters, num_of_observations*num_directions]

Where the parameters are:

decimal_time, VZA, VAA, SZA, SAA, Ozone*, Pressure*, Humidity*, Zonal_WIND*, Meridional_WIND*, Water_Vapour*, Mean_RHO_Band_0...Band_n, STDEV_RHO_Band_0...Band_n

** Indicates mean value and standard deviation, num_directions are the number of different views from the sensor (e.g. 1 for MERIS, 2 for AATSR). Where more than one viewing direction is available the observations are ordered as [obs_1_dir_1...obs_1_dir_n, obs_2_dir_1...]*

NB, for MODIS Aqua the reflectance bands are stored with indexes 0:14 as the 1Km bands, 15:19 as the 500m bands, and 20:21 as the 250m bands.

5.3.2 Extracted doublets

The extracted doublet internal binaries are of the syntax "ED_SITE_SENSOR1_PROCVER1_SENSOR2_PROCVER2.dat", and contain the extracted doublets for

SENSOR1 when it has been extracted against SENSOR2, given the User selected matching parameters. These files are of the form:

[num_of_parameters, num_of_observations]

Where the parameters are the same as those listed in section 5.3.1, but with the added parameter s of [‘Number of pixels’, ‘automated_cloud_screening’, ‘manual_cloud_screening’, ‘matching_type’, ‘AMC’]. The number of observations is dependent on the matching criteria selected.

5.3.3 Intercalibration

A number of internal binaries are created during the intercalibration of sensor doublet information. These include:

- **“ICDIF_SITE_SENSOR_PROCVER_REF_SENSOR_PROCVER_BAND.dat” ,**
  This has the dimensions: [num_observations, num_params], where the parameters are decimal_time, reflectance bias to reference sensor, and the polynomial bias to the reference sensor.

- **“ICERR_ SITE_SENSOR_PROCVER_REF_SENSOR_PROCVER_BAND.dat”**
  This has the dimensions: [num_observations, num_params], where the parameters are the decimal_time and the error between the actual radiometric differences and the polynomial approximation of the differences.

- **“ICOEF_ SITE_SENSOR_PROCVER_REF_SENSOR_PROCVER_BAND.dat”**
  This binary contains the 3 polynomial coefficients for the specified calibration sensor, reference sensor and band.

- **“IUCRT_SENSOR_PROCVER_REF_SENSOR_PROCVER_BAND.dat”**
  This binary contains the uncertainty values associated to the polynomial coefficients and contains the systematic error, the random error, and a flag indicating that the random error has been taken from the polynomial fit rather than the original sensor time series.

5.3.4 Recalibration

A number of internal binaries are output during the recalibration and super sensor time series generation. These include:

- **“RECAL_ SITE_SENSOR_PROCVER_REF_SENSOR_PROCVER.dat”**
  “RECAL_REF_SITE_SENSOR_PROCVER.dat”
  These SAV files are of the form: [num_parameters, num_observations], where the parameters are as those described in Section 5.3.1, and the observations are the recalibrated and reference sensor reflectances.
- **“SSEN_ SITE_SENSOR_PROCVER _BAND.DAT”**

These files contain the Super Sensor observations generated for the specific band, using the SENSOR value as the reference sensor. These files have the form: [num_parameters, num_observations], where the parameters are:

decimal_time, VZA, VAA, SZA, SAA, Ozone*, Pressure*, Humidity*, Zonal_WIND*, Meridional_WIND*, Water_Vapour*, Mean_RHO_Band, Systematic_uncertainty, Random_uncertainty, Poly_err_flag, and a flag indicating which sensor configuration the observation originates.

5.3.5 ROUJEAN BRDF

The following internal SAV files are generated during the BRDF computation:

- **“ROUJEAN_ER_SITE_REF_SENSOR_PROCVER.dat”**
- **“ROUJEAN_K1_SITE_REF_SENSOR_PROCVER.dat”**
- **“ROUJEAN_K2_SITE_REF_SENSOR_PROCVER.dat”**
- **“ROUJEAN_K3_SITE_REF_SENSOR_PROCVER.dat”**

These files are all of the form: [num_params, number_bins], where the parameters are: decimal_time, the number of sensor observation within the bin, and the corresponding ROUJEAN coefficient for all bands. The number of bins will depend on the bin size selected for processing.

- **“ROUJEAN_UC_SITE_REF_SENSOR_PROCVER.dat”**

This file is of the form: [num_params, number_bins], where the parameters are: time, num_sensor observations, VZA min, VZA max, SZA min, SZA max, RAA min, RAA max, poly_err_flag, the systematic uncertainty for each band, and the random uncertainty for each band.

5.3.6 VGT-2 Simulation

The VEGETATION simulation module outputs the following IDL SAV binaries:

- **“Amazon_VEGETATION_Calibration_1.DAT”**

  This file has the same format as the extracted sensor L1b file in Section 5.3.1.

- **“Amazon_VEGETATION_Calibration_1_SIM.DAT”**

  This file is of the form: [num_observations, num_parameters], where the parameters are decimal time, and the VEGETATION reflectance bands.

- **“Amazon_VEGETATION_Calibration_1_UCT.DAT”**

  This file is also of the form [num_observations, num_parameters], however contains the parameters: decimal time, systematic uncertainty at each VEGETATION band, and the random uncertainty and each VEGETATION band.

6 TROUBLESHOOTING/FAQ

Q: Why doesn't DIMITRI run when I double click on the sav file?

A: Please ensure you have correctly unzipped the DIMITRI zip archive and that you are choosing to open the save file with IDL.

Q: The automated cloud screening values seem incorrect when viewing the product quicklooks, why is this?

A: Automated cloud screening of L1b data is very difficult. The results are likely to vary depending on which validation site you are interested in; clouds over ocean are easy to detect however over snow, ice and salt lakes this is very difficult. The performance of the algorithms is also linked to the available wavebands for each sensor; ideally wavebands in the thermal wavelengths are needed for accurate cloud detection.

Further updates are planned for DIMITRI to also include statistical screening, using the knowledge that validation sites by definition should be generally radiometrically homogeneous.

Q: My computer crashed whilst ingesting new products, is there a backup of the DIMITRI database file?

A: Yes, the latest copy of the DIMITRI database can be found in the folder 'Bin/DB_backup'

Q: Why can't I access the uncertainty data through the visualisation module?

A: The visualisation module is designed to allow quick visual inspection of the general DIMITRI outputs. For uncertainty analysis please use the output CSV files.

Q: Why are some MODIS bands showing a strong cosine dependence?

A: A number of the ocean bands available for MODIS-Aqua can saturate over land; DIMITRI extracts all data no matter which validation site is used, however only intercalibrates/recalibrates the Land bands for Land validation sites

Q: What is the best tool for reading/utilising the output CSV files?

A: The semi-colon delimited output CSV files can be opened in most text editing software; the data can also be read into Microsoft Excel for further analysis (e.g. plots and statistics).

Q: How do I add extra RSR site spectra?

A: User generated site RSR spectra will be automatically read by DIMITRI if placed in the 'AUX_DATA/spectral_response/USER_Sites' folder. These files must be semi-colon separated and contain 2 columns containing the wavelength in nm, and the RSR function. Please see the other site and sensor RSR files for examples.

Q: Why do no new IDL windows open when DIMITRI generates plots/ I stopped DIMITRI during processing, why can't I generate any new IDL plots?

A: DIMITRI utilises IDL's Z-buffer for generating plots; this buffer does not have a viewable window but is stored in the machines memory. Plots can therefore be saved without displaying multiple IDL windows. If you stop DIMITRI during processing it will still be working in the Z-buffer; to return to your normal IDL graphics display type:

WINDOWS: IDL> set_plot, 'win'

LINUX: IDL> set_plot, 'x' under

Q. Why is the super sensor time series so variable?

A. The super sensor time series includes radiometrically corrected data from a number of different sensors. These sensors all have different viewing and solar geometries over the same location (dependant on your chi value chosen). The greater the range of geometries the better the BRDF fit!

Q: How do I find the details of created sites?

A: The DIMITRI file 'DIMITRI_SITE_DATA.txt' is a semi colon delimited file containing the site information including coordinates and type.

Q: How do I add a new sensor to DIMITRI?

A: DIMITRI has be designed in a modules to allow modification by users however adding a new sensor is not a simple task, this requires:-

- New IDL product readers located in a new folder under "Source", named after the sensor;
- Updates to the DIMITRI auxiliary data files located in the 'AUX_DATA' and 'Bin' folders (e.g. DIMITRI_SENSOR_DATA.txt, DIMITRI_Band_Names.txt and DIMITRI_Band_Centre_Index.txt)
- Addition of the sensor and the processing routine to ingest the data to the routine "Source/ingest/DIMITRI_INTERFACE_INGEST.pro"
- Addition of text to compile all the routines to the "Source/compile_dimitri" script file

It is recommended that the DIMITRI auxiliary data files and database are fully backed up before adding any new sensor code.

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