



DIMITRI V4.2: USER MANUAL

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Document Signature Table

	Company		Date
Author	M. Arias / B. Alhammoud K. Barker	ARGANS Ltd (UK)	
	N. Camlong / B. Berthelot	MAGELLIUM (FR)	From 08/04/2015
Approval	M. Bouvet	ESA/ESTEC	

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1.2	08/05/2012	Updated content and code appendix	
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This is a public document, available as part of the DIMITRI_V4.2 package and for download on the ARGANS website: <https://dimitri.argans.co.uk>

For more information, email: dimitri@argans.co.uk

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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

IDL: Interactive Data Language

IVOS: Infrared and Visible Optical Sensors Subgroup of WGCV

LUT: Look-Up Table

MERIS: Medium Resolution Imaging Spectrometer

MODIS: Moderate Resolution Imaging Spectrometer

MSI: Multi Spectra Instrument

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

OLCI: Ocean and Land Colour Instrument

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QA4EO: a Quality Assurance framework for Earth Observation

RAL: Rutherford Appleton Laboratory

RD: Reference Document

Rho: Reflectance

RMS: Root Mean square

RT: Radiative Transfer

SLSTR: Sea and Land Surface Temperature Radiometer

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	Barker K., Marrable D. and Mazeran C. 2014. Automated Cloud Screening, ATBD (MO-SCI-ARG-TN-004a), Version 1.0
RD-7	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-8	Barker K., Marrable D., Hedley J. and Mazeran C. 2014. Interband Vicarious Calibration over Sun Glint, ATBD (MO-SCI-ARG-TN-004c), Version 1.0
RD-9	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
RD-10	Improved cloud screening ATBD. (OPECAL-TN-019-MAG)
RD-11	Vicarious calibration methodology ATBD Sun Glint (OPECAL-TN-022-MAG)
RD-12	Vicarious calibration methodology ATBD Rayleigh (OPECAL-TN-042-MAG)
RD-13	Vicarious calibration methodology ATBD Desert (OPECAL-TN-043-MAG)

1 INTRODUCTION

1.1 What is DIMITRI?

The DIMITRI software package contains a suite of routines for the comparison of Top Of Atmosphere (TOA) reflectance from Earth Observation sensors either between sensors or to simulations. The comparison of TOA reflectances can be done either:

- Between two sensor TOA reflectances in similar spectral bands;
- Between a sensor TOA reflectances and their simulations.

Separately from the development of the DIMITRI software, a database containing remote sensing L1 products from 2002 until the present day for various sensors is continuously being populated. Currently, it holds L1 data from ATSR2 (ESA), AATSR (ESA), MERIS (ESA), MODIS-Aqua (NASA), POLDER-3 (CNES), and VEGETATION-2 (CNES) over predetermined validation sites (see [Table 1](#)).

Site name	Site Type	North Latitude	South Latitude	East Longitude	West Longitude
AMAZON	Forest	1.33	1	-56.5	-57
DOME C	Ice	-74.9	-75.3	123.9	122.9
UYUNI	Salt	-20	-20.16	-67.45	-68.05
TUZ GOLU	Salt	38.8	38.7	33.4	33.25
BOUSSOLE	Ocean	43.45	43.25	8	7.8
SIO	Ocean	-30	-30.5	80.5	80
SPG	Ocean	-31	-31.5	-137	-137.5
LIBYA-4	Desert	29.05	28.05	23.89	22.89
SPG_OPTIMUM	Ocean	-24	-28	-118	-122
SIO_OPTIMUM	Ocean	-25	-29	80	76
NW_PACIFIC_OPTIMUM	Ocean	20	16	159	155
NE_PACIFIC_OPTIMUM	Ocean	20	16	-150	-154
NW_ATLANTIC_OPTIMUM	Ocean	25	21	-65	-69
SW_ATLANTIC_OPTIMUM	Ocean	-12	-16	-22	-26
MEDSEA_OPTIMUM	Ocean	34	33	33	32
NE_AUSTRALIA_OPTIMUM	Ocean	-18	-20	155	153
ALGERIA-3	Desert	30.82	29.82	8.16	7.16
ALGERIA-5	Desert	31.52	30.52	2.73	1.73
LIBYA-1	Desert	24.92	23.92	13.85	12.85
MAURITANIA-1	Desert	19.9	18.9	-8.8	-9.8
MAURITANIA-2	Desert	21.35	20.35	-8.28	-9.28

Table 1: Geolocation values for the predefined DIMITRI validation sites

Sensor	Data Location	Access	Date range available
AATSR	http://ats-mercids.eo.esa.int/merc/welcome.do	Requires ESA Cat-1 Registration	2002 – March 2012
ATSR2	http://ats-mercids.eo.esa.int/merc/welcome.do	Requires ESA Cat-1 Registration	2002 - Present
MERIS	http://merc-srv.eo.esa.int/merc/welcome.do http://www.odesa-info.eu/	MERCIS 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: LAADSWeb only holds VIIRS data in a 60 day rolling archive.	May & June 2013
Sentinel-2/MSI	https://scihub.copernicus.eu/s2/#/home	Requires registration	December 2015 - Present
Sentinel-3A/OLCI**	https://sentinel.esa.int/web/sentinel/sentinel-data-access	Requires registration	Unavailable at this date
Sentinel-3A/SLSTR**	https://sentinel.esa.int/web/sentinel/sentinel-data-access	Requires registration	Unavailable at this date

* 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.

**Note: Sentinel-3A sensors are supported by DIMITRI_V4.2 onwards. However, L1b data of the Sentinel-3A is not still open to the public.

Table 2: DIMITRI Sensor data location information

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1.2 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 V3.1.1 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 RD-6
4. Includes comparison of measured TOA reflectance against simulated observations over Rayleigh scattering and Sun glint (RD-7 and RD-8).
5. Includes comparison of measured TOA reflectance against simulated observations over Deserts (RD-9).
6. Has netCDF writer routine and some netCDF output files

DIMITRI V4.0 is developed by MAGELLIUM in collaboration with ARGANS Ltd and ESA/ESTEC. This version:

1. Stores the results of the ingestion and calibration processes into netCDF file format.
2. Includes comparison of measured TOA reflectance against simulated observations over Rayleigh scattering, Sun glint and Desert following methodologies developed by ARGANS Ltd (ARG suffix) and MAGELLIUM (MAG suffix).
3. Does not include anymore the 'Data download' and 'VGT simulation' functionalities which were previously available through the HMI.
4. Does not include VIIRS data reader.

DIMITRI V4.1 is developed by MAGELLIUM in collaboration with ARGANS Ltd and ESA/ESTEC. This version:

1. Include Angular matching methodology (sensor to sensor comparison);
2. Include BRDF and Spatial Scale Variability (SSV) automatic cloud screening methodologies.

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DIMITRI V4.2 is developed by ARGANS in collaboration with ESA/ESTEC. This version:

1. Includes support for Sentinel-2A/MSI.
2. Includes support for Sentinel-3A/OLCI
3. Includes support for Sentinel-3A/SLST

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2 SOFTWARE INSTALLATION

2.1 System Requirements

DIMITRI has been developed to be compatible on both Linux and Windows based systems. MAC compatibility was tested on the version 3.1.1 (MAC OS-X 10.10).

2.1.1 Interactive Data Language (IDL – Exelis) environment

The DIMITRI software is fully written in Interactive Data Language (IDL). IDL is a licensed language. However, runtime licenses are freely available which allow running the DIMITRI software on the so-called IDL virtual machine. In order to modify and recompile the code, users need to their own IDL license.

The DIMITRI_4.2 Human Machine Interface (HMI) runs through the freely available IDL Virtual Machine (VM), and allows use of the pre-compiled DIMITRI package and use of the full functionalities accessible from the HMI.

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_V3.1.1 and DIMITRI_V4.x are not compatible with IDL 8.4 yet and that may cause some running issues.

Should an IDL license not be available, one can get an IDL virtual machine in the following way:

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;

Exelis also provides the following help on the VM:

<http://www.exelisvis.com/Support/HelpArticlesDetail/TabId/219/ArtMID/900/ArticleID/4633/4633.aspx>

A full 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.

2.1.2 LinRadTran external library

DIMITRI makes use of the MYSTIC radiative transfer code to simulate TOA observation over desert sites (see below section 3.6.3.1) The Mystic model is freely available from the LibRadTran package (www.libradtran.org).

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Note: DIMITRI 3.1.1 and 4.x uses LibRadtran-1.7, which has to be installed inside the main DIMITRI directory. If this is not the case, then the User has to define the full path of the “data” required for the model input (ex: export data_files_path=/home/UserName/libRadtran-1.7/data) or one can define it in the source routine “Source/desert/write_mystic_rpv_input.pro”.

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

To avoid any installation, the Users could use the virtual machine provided by ARGANS which contains following elements:

- A Linux system;
- The LibRadTran package;
- The IDL environment.

The virtual machine is available under request. For queries, please, contact ARGANS at dimitri@argans.co.uk.

2.2 DIMITRI License and Code Modification

The DIMITRI software package is made freely available. The Intellectual Property rights are held by ESA but modification of the code is allowed for own purposes.

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

- 1) Acknowledgement to ESA, ARGANS and MAGELLIUM 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 performed under the responsibility of the User.
- 4) ESA, ARGANS and MAGELLIUM are not responsible for any damage to computer systems as a result of using the DIMITRI software package.

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.

Please feel free to share your results with the scientific community on the CalVal Portal (<http://calvalportal.ceos.org>).

2.3 How to get DIMITRI

The official version of original source code is available at <https://dimitri.argans.co.uk>.

Please note that auxiliary data and meteorological data necessary for the software proper functioning are available at ftp://us-ext-nas.eo.esa.int/DIMITRI/DIMITRI_V4/ (Login/pwd:

'dimitri_user' / 'User_Dimitr1'). Two files must be downloaded: 'AUX_DATA.zip' and 'InputMeteo.zip'.

It can also be supplied with the full database of L1 data pre-loaded, i.e., extractions from the original L1 products over the regions of interest defined in DIMITRI (see [Table 1](#)). These original Level 1b products are not distributed with the software package. They are currently stored at ARGANS and ESA-ESTEC.

2.4 Installation

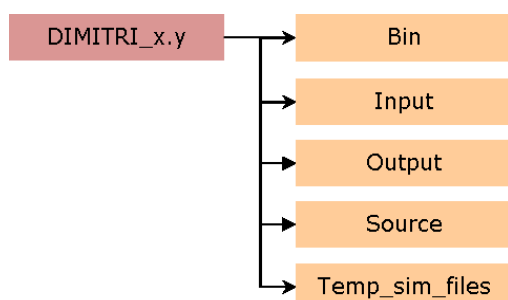
The DIMITRI software package is downloaded as a compressed file. To install DIMITRI unzip the file into the desired installation location.

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.

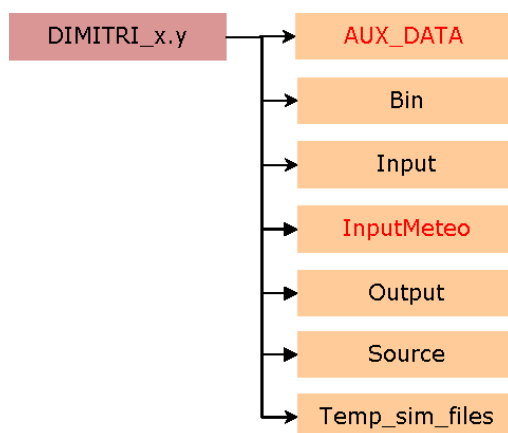
Linux users can install the DIMITRI package by typing:

tar -xvfz DIMITRI_Vx.y.tar.gz

The following tree structure appears under the installation folder:



The auxiliary data and meteorological data zip files must be uncompressed under 'DIMITRI_x.y' folder. Two new folders appear:



The installation is now completed.

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Note: DIMITRI functions commonly find the required files of the distribution by looking at the path name of DIMITRI. Because of that, the User shall ensure the parent folder of DIMITRI has the name matching the version. In other words, the parent folder shall have the same name than the DIMITRI_<x>.SAV file provided within the distribution.

2.5 Validation of the Installation

An Installation Test is being developed for DIMITRI in the frame of QA4EO – DIMITRI Evolution project, managed by ARGANS Ltd. This Installation Test will be operational from DIMITRI_V4.3 onwards. Fully details of this Installation Test will be provided in this section in future versions of this document.

3 SOFTWARE USER MANUAL

3.1 Quick start

Following extraction, DIMITRI is now ready to be utilised, this can be achieved **when in the “DIMITRI_x.y folder”** (*‘x’ or ‘x.y’ represents the version number of the DIMITRI software and must be replaced by the version number of the installed software*), by:

- **On Windows:** Double clicking the “DIMITRI_Vx.sav” file
- **On Linux:** Typing “idl -vm=DIMITRI_Vx.sav”

These commands will load the DIMITRI Human Machine Interface (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_Vx.sav'
```

You can then run DIMITRI by typing:

```
IDL>DIMITRI_Vx
```

3.2 Main DIMITRI HMI

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.

[Figure 1](#) shows the DIMITRI HMIs for V4 merged MAGELLIUM and ARGANS versions. Versions after v4.0 have the same GUI at this date. The following sections explain the functionalities (the buttons) of the HMI.

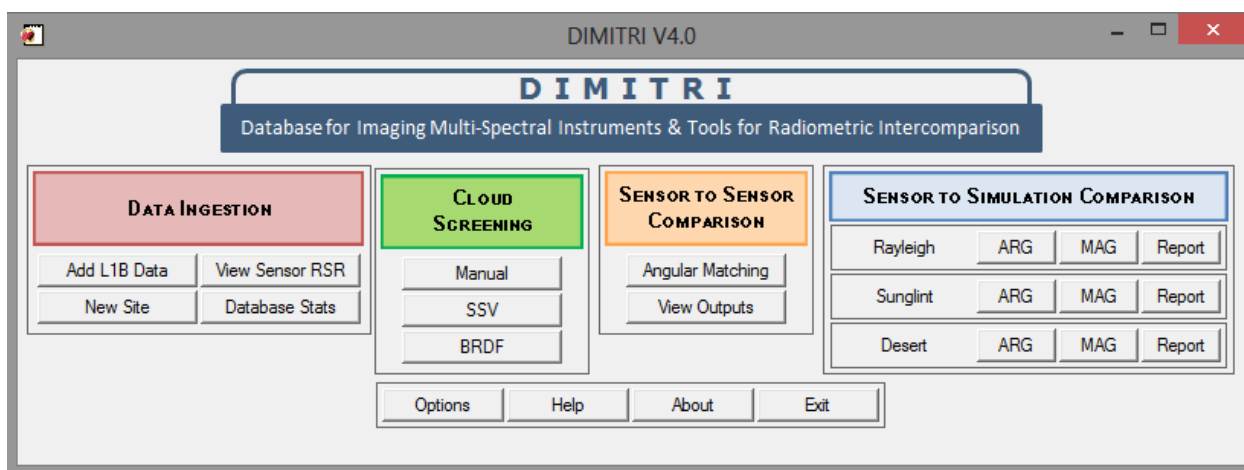


Figure 1: The DIMITRI HMI start window as seen since DIMITRI_V4.0 onwards.

3.3 Data Ingestion

3.3.1 Add L1B Data

The data are ingested if available in the 'Input' directory under the main DIMITRI directory. The data must be sorted by site name, sensor type, processing version and acquisition year.

Ingestion can be done over one of the sites listed in [Table 1](#) or over a new site defined through the 'New Site' button of the main DIMITRI HMI (Section 3.3.2).

In addition, in the specific case of L1 products that are intended for use with the sun glint calibration methodologies, users have to first add their L1 acquisitions under the /Input/Site_SUN GLINT directory. Subdirectories follow the same nomenclature as the one described for site data ingestion.



Figure 2: Input folder structure.

The Input folder tree structure observes the following rules:

— DIMITRI_x.y/Input/Site_[SITE]/[SENSOR]/Proc_[COLLECTION]/[ACQ_YEAR]

With [SITE] : Site name,
 [SENSOR] : Sensor name,
 [COLLECTION] : Collection or processing version of the L1 product,
 [ACQ_YEAR] : Acquisition year (YYYY format).

Examples:

- DIMITRI_4.2\Input\Site_Libya4\MERIS\Proc_3rd_Reprocessing\2012
- DIMITRI_4.2\Input\Site_SPG\PARASOL\Proc_Calibration_1\2011

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

- DIMITRI_x.y/Input/Site_[SITE]/VEGETATION/Proc_[COLLECTION]/[ACQ_YEAR]/Product_Folder/001/data files

For further details on ingestion process, see section 4.3.

The "Add L1B data" button starts the ingestion of L1 data products into DIMITRI. User can choose to ingest data from a given sensor, over a given site and for a given year via the HMI ([Figure 3](#)).

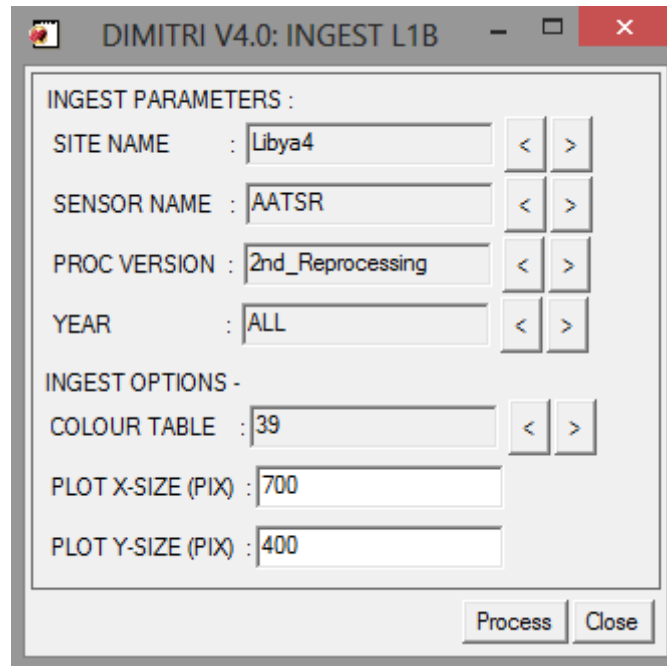


Figure 3: The 'Add L1B Data' HMI window.

All data are then automatically cloud screened according to cloud screening algorithm associated to the each sensor (Section 3.4.1). The key physical quantity extracted from all L1 files is the TOA Reflectance at any given wavelength defined as:

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

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.

Ingestion can take several minutes for each L1 product depending on system performance and which sensor (as well as if child or parent products are used).

Final comment: if storage is an issue, following the ingestion and the creation of the above mentioned files, the original L1 products can be removed from the input folder as DIMITRI will not directly access the ingested L1 products anymore.

3.3.2 New Site

The "New Site" button starts the new site creation tool. A new site is 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, L1 products should then be placed in the correct input folders before ingestion into DIMITRI.

3.3.3 View sensor RSR

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 "DIMITRI_x.y/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
```

3.3.4 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.

3.4 Cloud Screening

Cloud screening is a necessary step to discard acquisitions and/or individual pixels that are cloud contaminated and cannot be used for comparison between sensor observations or between sensor observations and their simulations.

Four methods are available in the software.

1. Automatic cloud screening
2. Manually cloud screening
3. Spatial Scale Variability (SSV) cloud screening
4. BRDF cloud screening

The first method is performed automatically during the ingestion of the data. A cloud mask is computed and provided within the ingested product. In order to allow user to check the quality of the cloud detection, a functionality has been added in the HMI allowing to visualise quicklook and to apply manually a flag which overwrites the results found with the automatic cloud screening (second method). The third and fourth methods are additional algorithms.

Note: The cloud screening methodologies indicated in points 3 and 4 of the above list could not work properly from DIMITRI v4.0 onwards, as they require auxiliary training files not available from such version.

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3.4.1 Automatic Cloud Screening

An important development in DIMITRI V2.0 was the addition of automated cloud screening during ingestion of L1 satellite data. In DIMITRI V3.0, sensor-to-simulation intercomparison methodologies were added that made use of this cloud screening: Rayleigh, Sun Glint and Desert intercomparison methodologies (See RD-7, RD-8 and RD-9). These methodologies rely on prior cloud screening of the ingested data. In DIMITRI v4.0, a new set of automated cloud screening schemes has been added to allow the exploitation of new instances of the Rayleigh, Sun Glint and Desert methodologies implemented by MAGELLIUM (See RD-11, RD-12 and RD-13). These two parallel cloud screening schemes are referred to with respectively the tags 'AUTO_CS_1' and 'AUTO_CS_2' for the ARGANS and MAGELLIUM cloud screening schemes in various files resulting from the ingestion of new data.

The following algorithms have been implemented by ARGANS since DIMITRI V2.0 for each sensor:

- **Landsat ACCA (RD-4):** ATSR2, AATSR, MODIS-Aqua, Sentinel-3/SLSTR
- **GlobCarbon-MERIS (RD-5):** MERIS, PARASOL, Sentinel-2A/MSI, Sentinel-3/OLCI
- **VGT-operational:** VEGETATION

These previous algorithms were adapted by MAGELLIUM in DIMITRI V4.0 for Ocean and Desert site types for each sensor (RD-10):

- Over sea, specific cloud detection has been implemented to identify cloud over sun glint target. Together with the addition of spatial coherence test added to flag clouds for sun glint and site data ingestion.
- Over desert, a reference built using clear data acquired over the site is used to identify clear from cloud pixels.

Note: MAGELLIUM Automatic cloud screening relies in a radiometric climatology, hosted in the auxiliary files of DIMITRI, but only available at the moment over Libya-4 site.

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 to sensor processes (Section 3.5); sensor to simulation processes (Section 3.6),

3.4.2 Manual Cloud Screening

In addition to the automated cloud screening, users can open the manual cloud screening module. This allows visualisation of product quicklook for manual determination if it is cloudy or clear, or if the product contains errors (suspect). The manual cloud screening results always overrides the automated cloud screening.

For the manual cloud screening, the flags used to define the cloudiness in the database are:

- -1 : No manual cloud screening applied (default),
- 0 : Clear,
- 1 : Cloudy,

2 : Suspect.

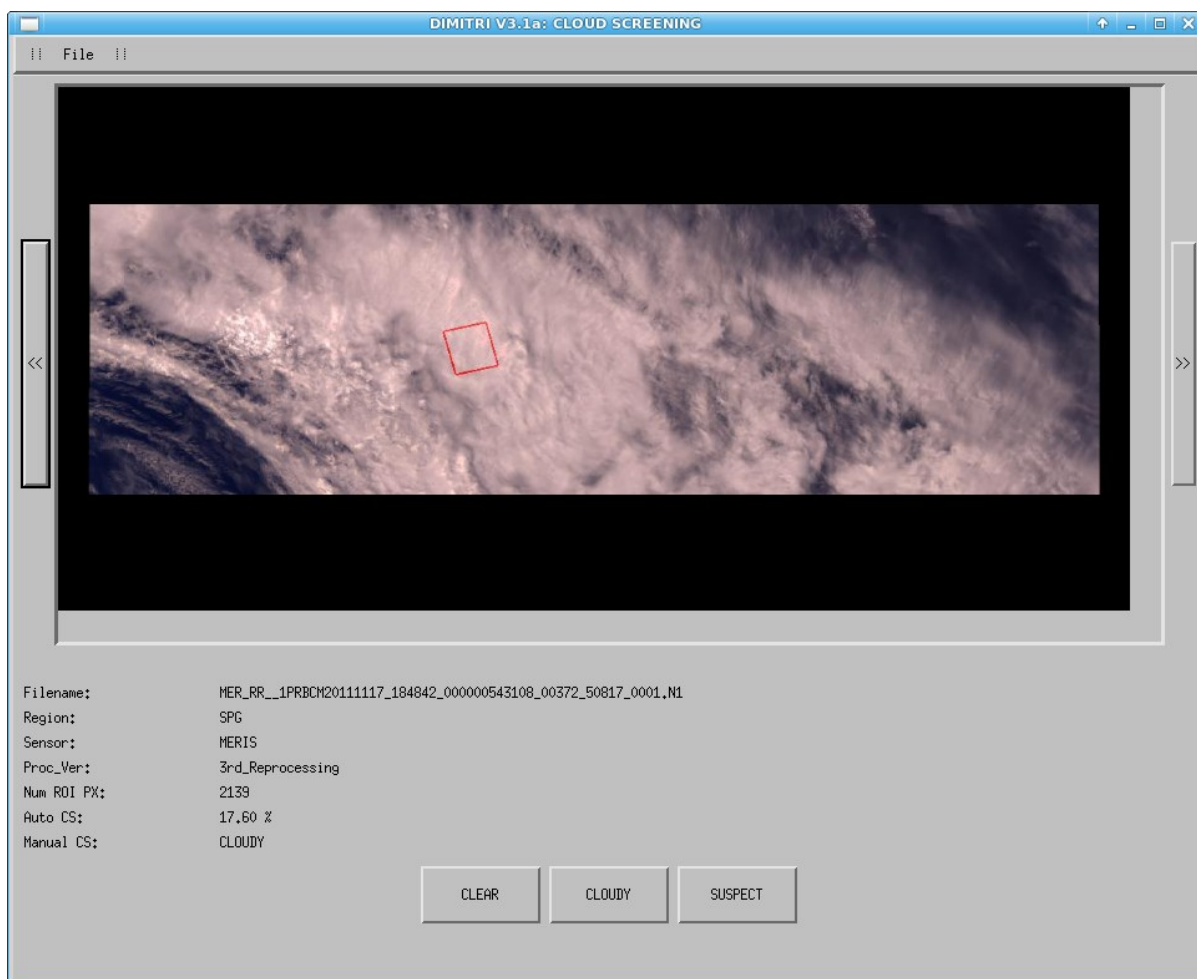


Figure 4: Manual Cloud Screening HMI

3.4.3 Spatial Scale Variability (SSV) Cloud Screening

The Spatial Scale Variability (SSV) methodology was implemented in DIMITRI V3.1.1 (RD-6). It 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.

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 ‘Output/INGESTION’ directory containing input training dataset.

The DIMITRI SSV cloud screening window is shown in [Figure 5](#). 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.

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.

- 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.

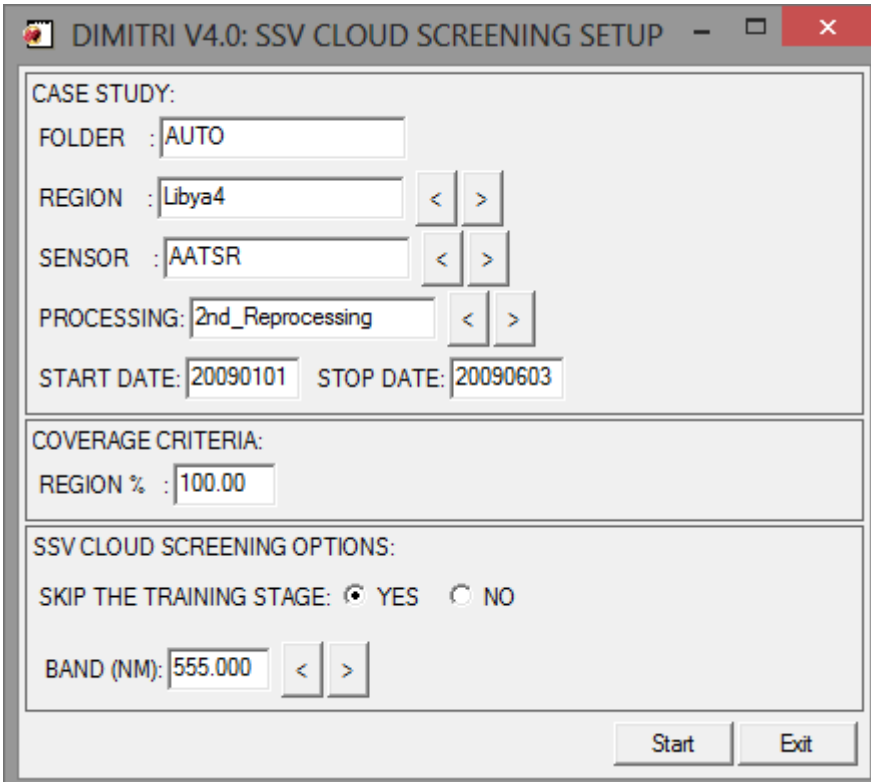


Figure 5: DIMITRI SSV cloud screening window

3.4.4 BRDF Cloud Screening

The BRDF Variability Threshold (BRDFVT) methodology was implemented in DIMITRI V3.1.1 (RD-6). It 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.

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.

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

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- **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 %).

The DIMITRI BRDF cloud screening window is shown on [Figure 6](#), 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.

DIMITRI V4.0: BRDF CLOUD SCREENING SET...

CASE STUDY:
 FOLDER :
 REGION : < >
 SENSOR : < >
 PROCESSING: < >
 START DATE: STOP DATE:

COVERAGE CRITERIA:
 REGION % :

BRDF TRAINING OPTIONS:
 CLEAR SKY DATABASE :
 BRDF BIN PERIOD (DAYS) :
 BRDF OBS. THRESHOLD :
 ANGLES MIN MAX
 VZA :
 VAA :
 SZA :
 SAA :
 CLEAN TEMPORARY BRDF OUTPUTS: ☒ YES ☐ NO

BRDF CLOUD SCREENING PARAMETERS:
 BAND (NM) : < >
 TOA THRESHOLD (%):

Figure 6: DIMITRI BRDF cloud screening window

3.5 Sensor To Sensor Comparison

3.5.1 Angular Matching

The “Angular Matching” button starts the intercomparison between a “reference” sensor and a number of “calibration” sensors ([Figure 7](#)) which can be radiometrically compared to the reference sensor. This intercomparison is based on the identification of acquisitions made between the two sensors at similar time and under similar geometries. The output folder containing the results of the intercomparison can be left as “auto” to generate an automatic folder name (e.g. “DIMITRI_x.y/Output/SIO_20110426_REF_MERIS_2nd_Reprocessing”), or this can be User defined.

3.5.1.1 Sensor Selection

The “calibration” sensors and their L1 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 by selecting the configuration and pressing the << button. The temporal and angular matching between sensors over the site is done based on the information stored in the DIMITRI database file (DIMITRI_x.y/Bin/DIMITRI_DATABASE.CSV).

3.5.1.1 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:

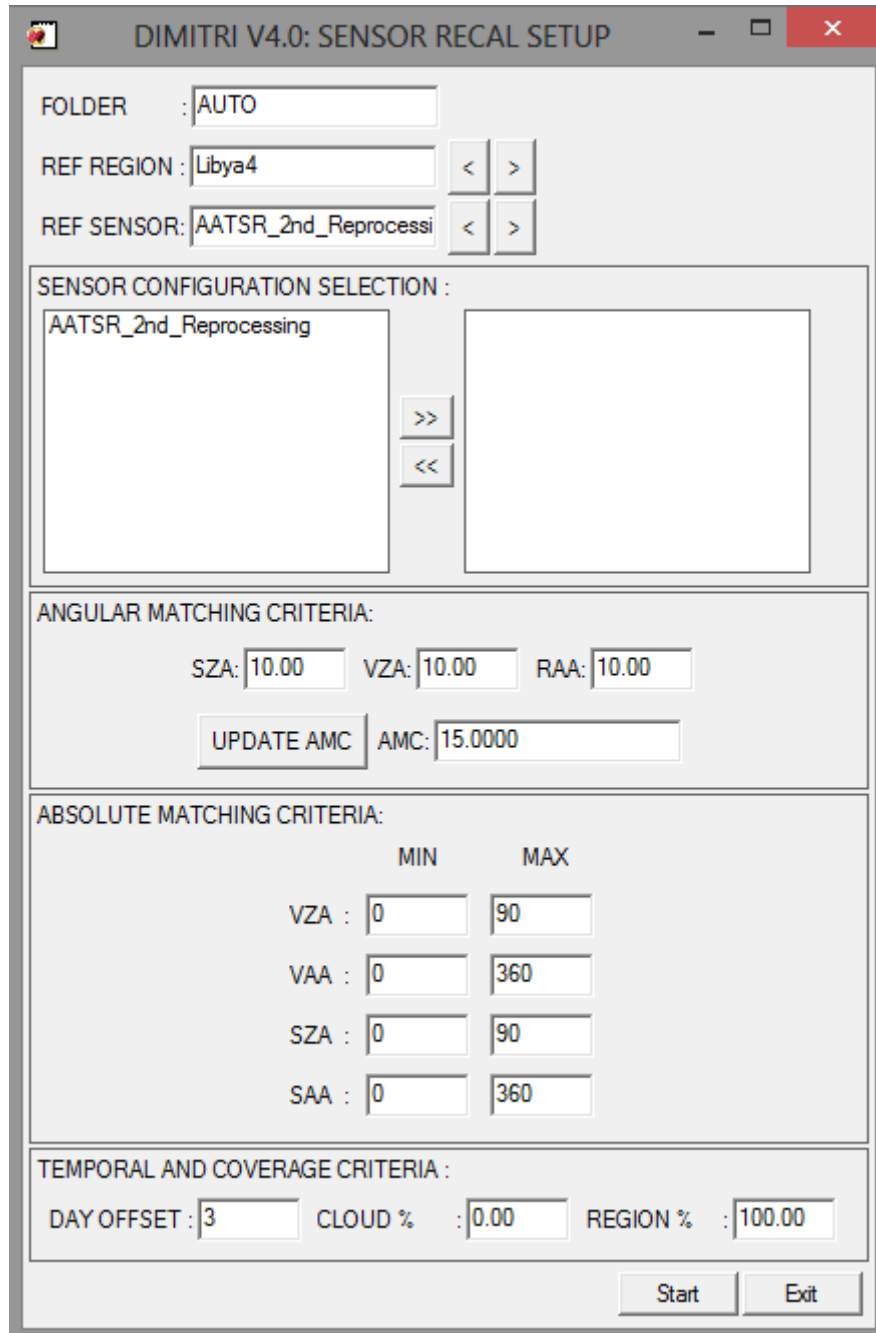
$$AMC = \sqrt{([SZA_1 - SZA_2]^2 + [VZA_1 - VZA_2]^2 + \frac{1}{4} [|RAA_1| - |RAA_2|]^2)}$$

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).

3.5.1.1 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.



DIMITRI V4.0: SENSOR RECAL SETUP

FOLDER :

REF REGION :

REF SENSOR:

SENSOR CONFIGURATION SELECTION :

ANGULAR MATCHING CRITERIA:

SZA: VZA: RAA:

AMC:

ABSOLUTE MATCHING CRITERIA:

	MIN	MAX
VZA :	<input type="text" value="0"/>	<input type="text" value="90"/>
VAA :	<input type="text" value="0"/>	<input type="text" value="360"/>
SZA :	<input type="text" value="0"/>	<input type="text" value="90"/>
SAA :	<input type="text" value="0"/>	<input type="text" value="360"/>

TEMPORAL AND COVERAGE CRITERIA :

DAY OFFSET : CLOUD % : REGION % :

Figure 7: The DIMITRI Sensor Recalibration HMI

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 value 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

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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”.

3.5.1.2 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).

3.5.1.3 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 (assumption introduced 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

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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.

3.5.2 View outputs

The visualisation module provides a quick and easy opportunity to view any output results from Sensor Recalibration. 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 (see [Figure 8](#)).

- **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

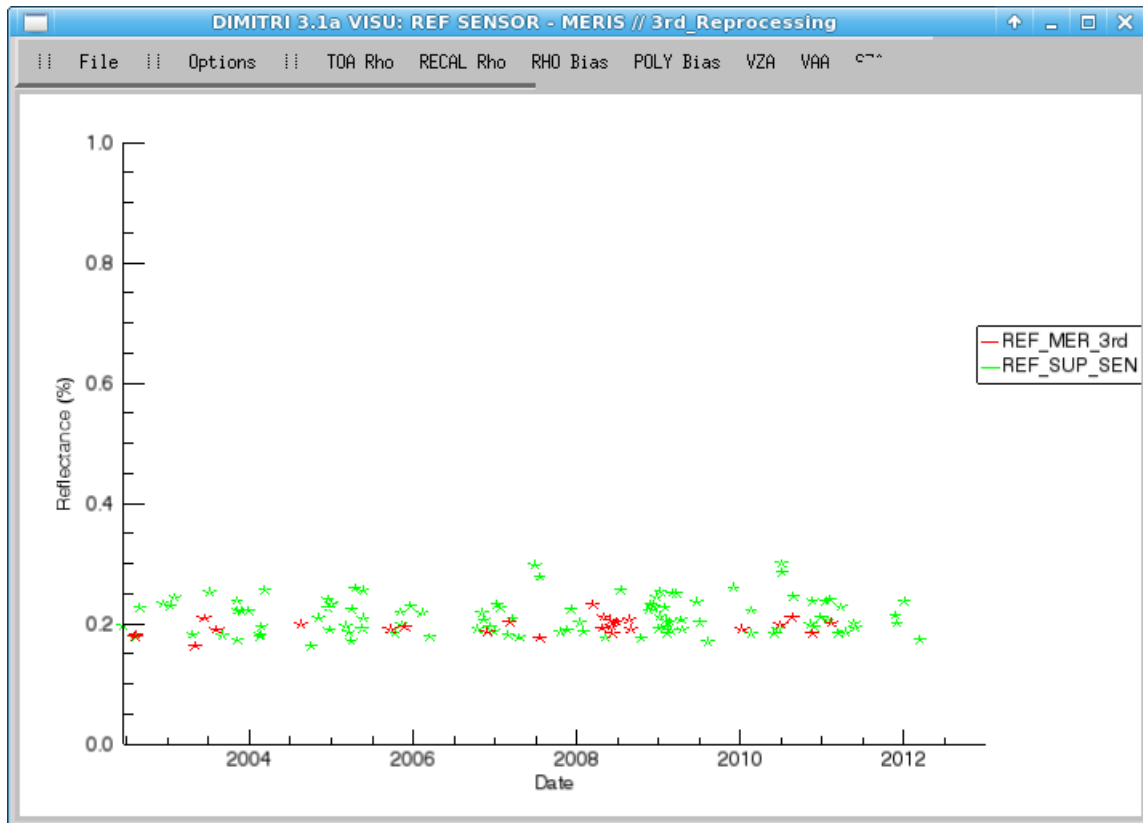


Figure 8: Example of the VISU Module

3.6 Sensor-to-Simulation Comparison

The sensor to simulation comparison methodologies are harmonized to use the same input data format and to provide the same output data format (See section 4.4.1 and 5.2.2.2 for details).

Three methodologies are available:

- Rayleigh;
- Sun Glint;
- Desert (for 6 CEOS PICS sites).

Each of them has been implemented by ARGANS and MAGELLIUM with specific algorithms.

3.6.1 Sensor-to-simulation following the Rayleigh methodology

3.6.1.1 ARGANS methodology

The 'ARG' button in the 'Rayleigh' box starts the setup module for ARGANS simulation over clear oceanic site without sun glint.

The Rayleigh methodology allows both HMI and command line activation. All processing parameters specific to the Rayleigh methodology are selectable by the user through a setup window ([Figure 9](#)):

- Case study (site, sensor, processing version and year);
- 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;
- 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.

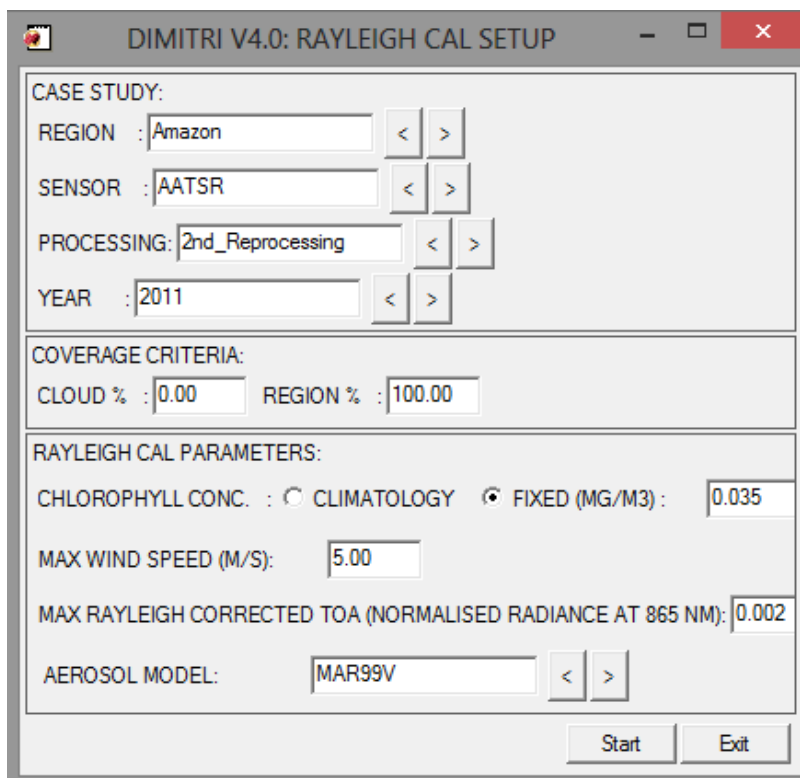


Figure 9: ARGANS Rayleigh Simulation setup module HMI

3.6.1.2 **MAGELLIUM methodology**

The 'MAG' button in the 'Rayleigh' box starts the setup module for MAGELLIUM simulation over clear oceanic site without sun glint. The Rayleigh methodology allows both HMI and command line activation.

Only the case study parameters (site, sensor, processing version and year) are selectable by the user through a new window ([Figure 10](#)).

The processing parameters are described in the ATBD document (RD-12).

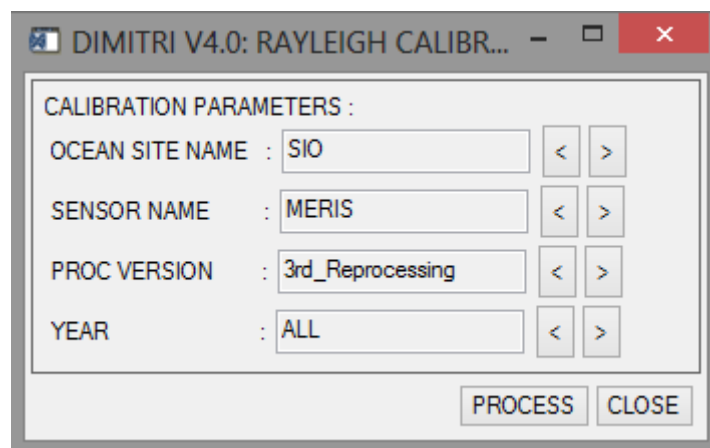


Figure 10: MAGELLIUM Rayleigh Calibration setup module HMI

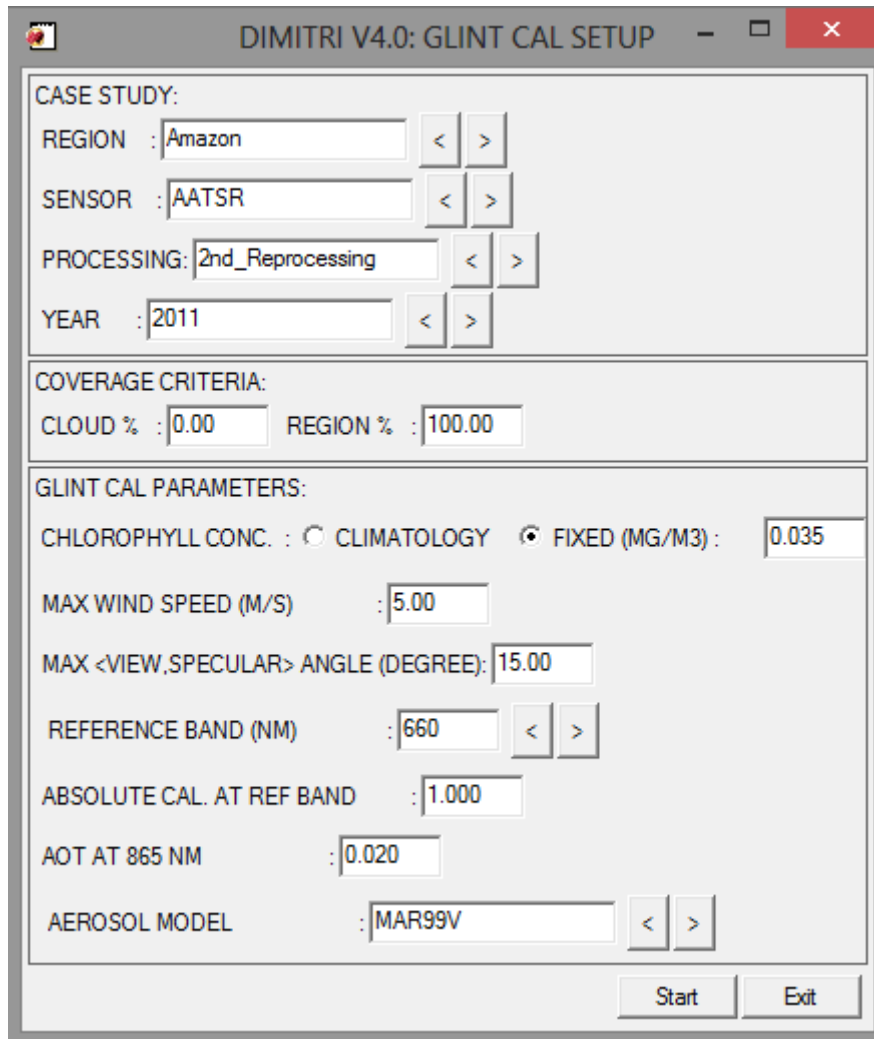
3.6.2 Sensor-to-simulation following the Sun glint methodology

3.6.2.1 ARGANS methodology

The 'ARG' button in the 'Sun glint' box starts the setup module for simulation over sun glint following ARGANS approach (RD-8). This methodology allows both HMI and command line activation.

All processing parameters specific to the glint calibration are selectable by the user through a new window ([Figure 11](#)):

- Case study (site, sensor, processing version and year);
- 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;
- 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.



DIMITRI V4.0: GLINT CAL SETUP

CASE STUDY:

REGION : Amazon < >

SENSOR : AATSR < >

PROCESSING: 2nd_Reprocessing < >

YEAR : 2011 < >

COVERAGE CRITERIA:

CLOUD % : 0.00 REGION % : 100.00

GLINT CAL PARAMETERS:

CHLOROPHYLL CONC. : ☐ CLIMATOLOGY ☒ FIXED (MG/M3) : 0.035

MAX WIND SPEED (M/S) : 5.00

MAX <VIEW, SPECULAR> ANGLE (DEGREE): 15.00

REFERENCE BAND (NM) : 660 < >

ABSOLUTE CAL. AT REF BAND : 1.000

AOT AT 865 NM : 0.020

AEROSOL MODEL : MAR99V < >

Start Exit

Figure 11: ARGANS Sun Glint simulations setup module HMI

3.6.2.2 *MAGELLIUM methodology*

The 'MAG' button in the 'Sun glint' box starts the setup module for simulation over Sun glint following MAGELLIUM's approach. The glint calibration methodology allows both HMI and command line activation.

Only the case study parameters (site, sensor, processing version and year) are selectable by the user through a new window ([Figure 12](#)).

The processing parameters are described in the ATBD document (RD-11)

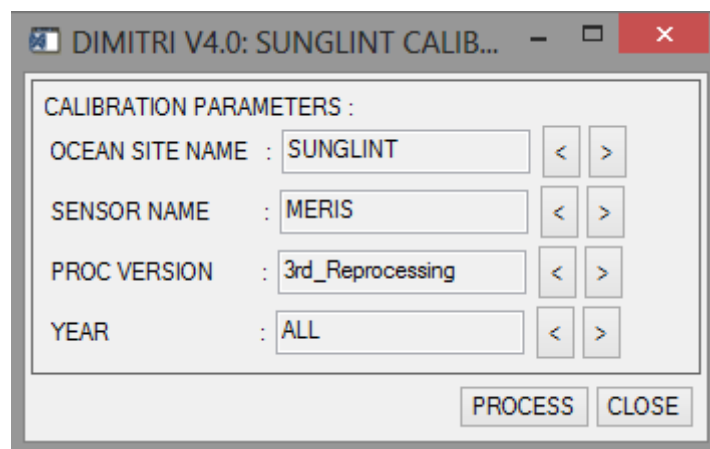


Figure 12: MAGELLIUM Sun glint Calibration setup module HMI

3.6.3 Sensor-to-simulation following over the 6 CEOS PICS sites

3.6.3.1 ARGANS methodology

The 'ARG' button in the 'Desert' box starts the ARGANS setup module to simulate TOA observations in the visible to NIR spectral range over the six CEOS Pseudo-Invariant calibration sites (http://calval.cr.usgs.gov/rst-resources/sites_catalog/ceos-reference-sites/). 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-9). The model was calibrated to mimic MERIS spectral observations in the period 2006 to 2009 over each desert site. The model allows mimicking observations from sensors with spectral bands in the spectral range 390 nm – 960 nm.

This methodology allows both HMI and command line activation.

All processing parameters specific to the Desert calibration are selectable by the user through a new window (Figure 13):

- Case study (site, sensor, processing version and year);
- Desert calibration parameters: Number of Jobs and 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 choose jobs-number in the range of [1, max-CPU]. The default Number of photons is set to 1500.

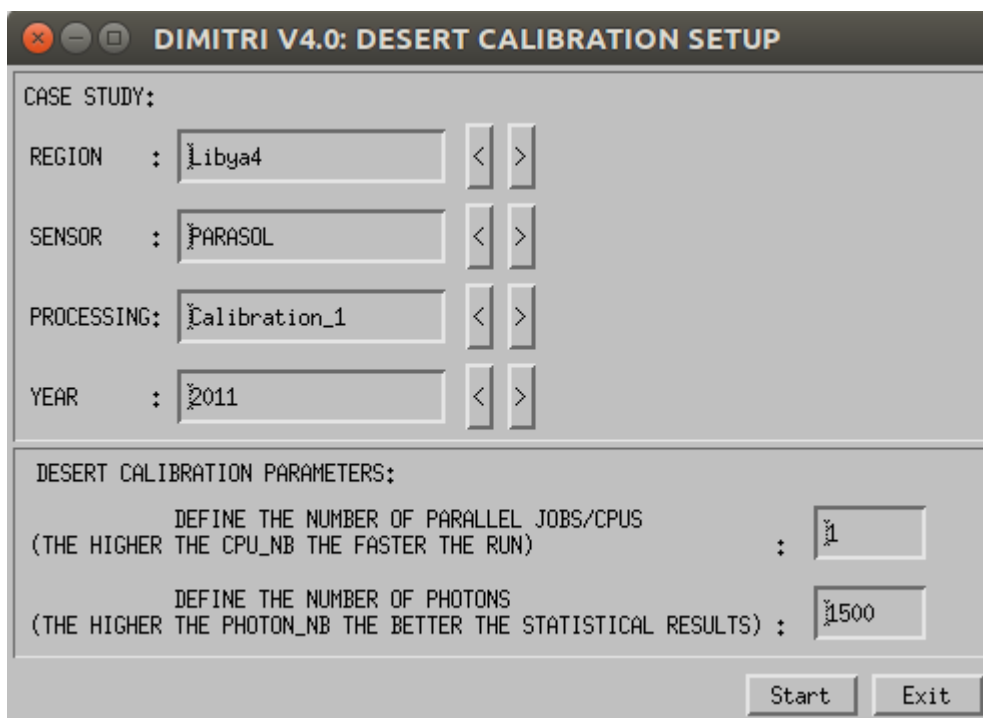


Figure 13: ARGANS Desert Calibration setup module HMI

3.6.3.2 *MAGELLIUM methodology*

The 'MAG' button in the 'Desert' box starts the setup module for MAGELLIUM calibration over the Libya-4 Pseudo-Invariant calibration site (and only). The desert calibration methodology allows both HMI and command line activation.

Only the case study parameters (site, sensor, processing version and year) are selectable by the user through a new window ([Figure 14](#)).

The processing parameters are described in the ATBD document (RD-13)

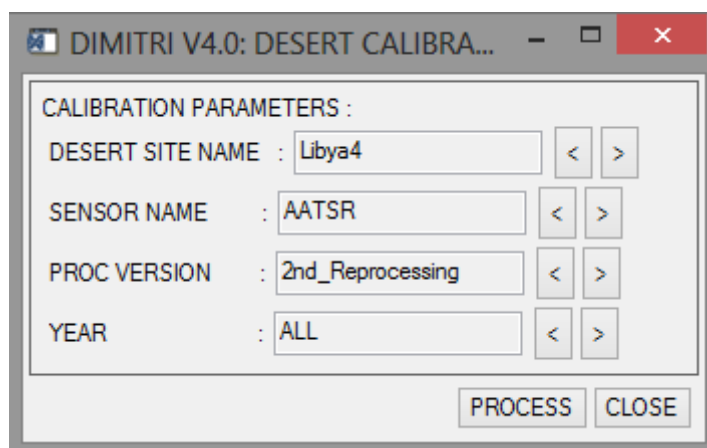


Figure 14: MAGELLIUM Desert Calibration setup module HMI

3.6.4 Report

The time series calibration reporting process provides two types of output files (for details see section 4.4.4):

- The CSV statistical report database common to all products.
- The figure files (JPG format): one file created for each triplet [product, viewing direction, band], (Band number x Viewing direction number) figure files per product. The figure contains the temporal variability of the ratio RTOA measured / RTOA simulated graph.

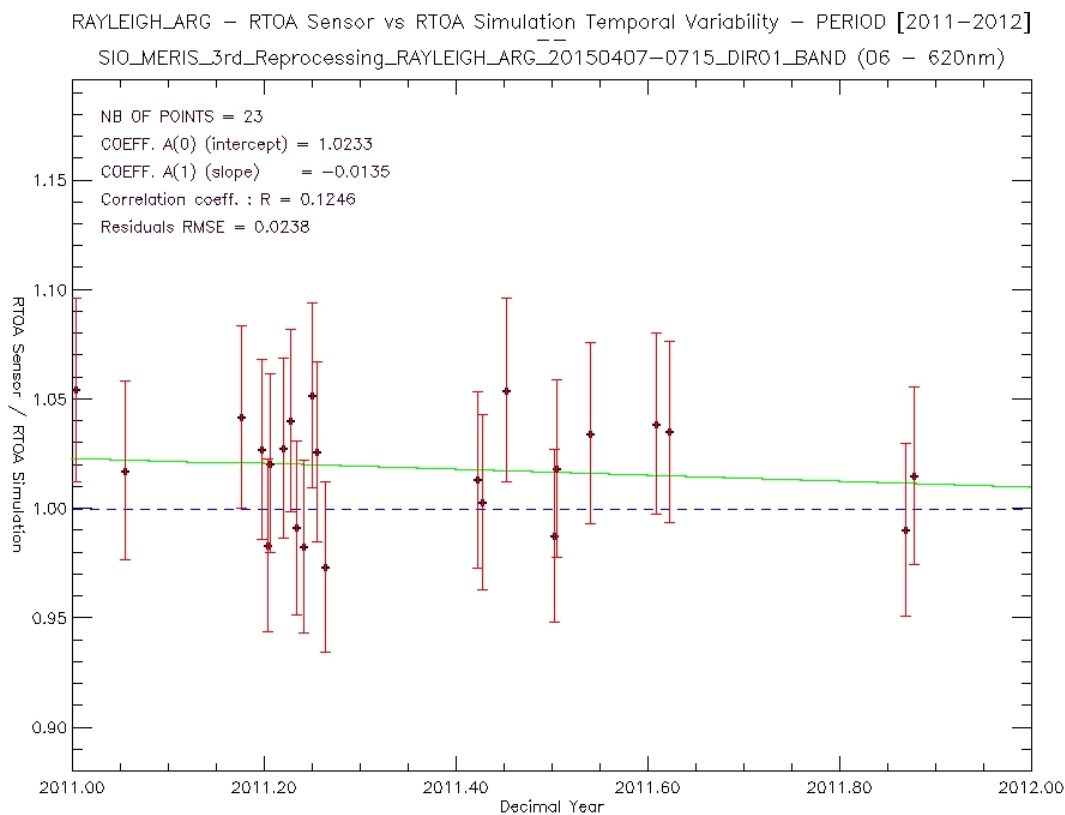


Figure 15: Time series rho_TOA_sensor / rho_simulated reporting graphs example

3.7 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 modules as default values.

3.8 Help

Opens this user manual.

	<p><i>DIMITRI V4.2</i></p> <p><i>Software User Manual</i></p>	<p>Ref: ARG_DIM_QA4EO_DIMITRI_V4.2_SUM</p> <p>Date: 26/04/2016</p> <p>Issue: 4.2</p> <p>Page: 39</p>
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3.9 About

Displays information regarding the version of DIMITRI.

4 ADVANCE SOFTWARE USER MANUAL

4.1 Recompilation

DIMITRI 4.2 has been developed in IDL8.4 and is open to users with full IDL licenses to modify the code and develop it further (note, ESA, MAGELLIUM 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 without IDL license.

4.2 Folder Structure

The installed DIMITRI directory has the following folder structure:

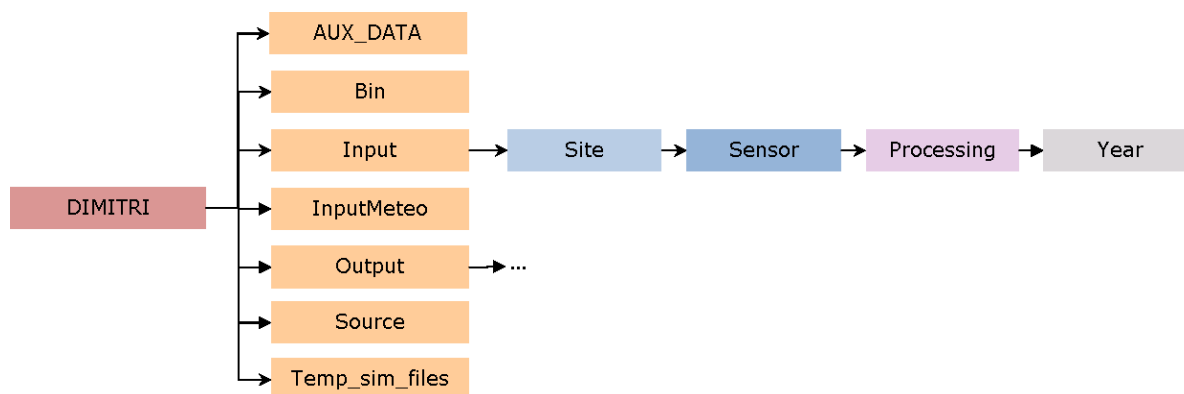


Figure 16: Schematic diagram of the DIMITRI folder structure

The output directory has the structure indicated in [Figure 17](#).

- The **AUX_DATA** folder contains the auxiliary data used for the processing (LUTs, SMAC coefficients, spectral response, 6S solar irradiances...).
- The **'Bin'** folder contains the DIMITRI configuration and database files and Site, Sensor and Bands information files.
- 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. In the case of the L1 product meant to be used with the sun glint methodologies, a site called 'Site_SUN GLINT' must be created.

- All sensor 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 '**InputMeteo**' folder contains the meteorological auxiliary data files needed by the calibration processes (Water vapour, Ozone, Wind speed, Pressure, Chlorophyll) sorted by years.
- The '**Output**' folder contains output files produced from ingestion and calibration processes. The ingestion output files are sorted by site, sensor, collection and year folders. The calibration output files are sorted at first by calibration process type and date, and in second step by site, sensor, collection and year folders

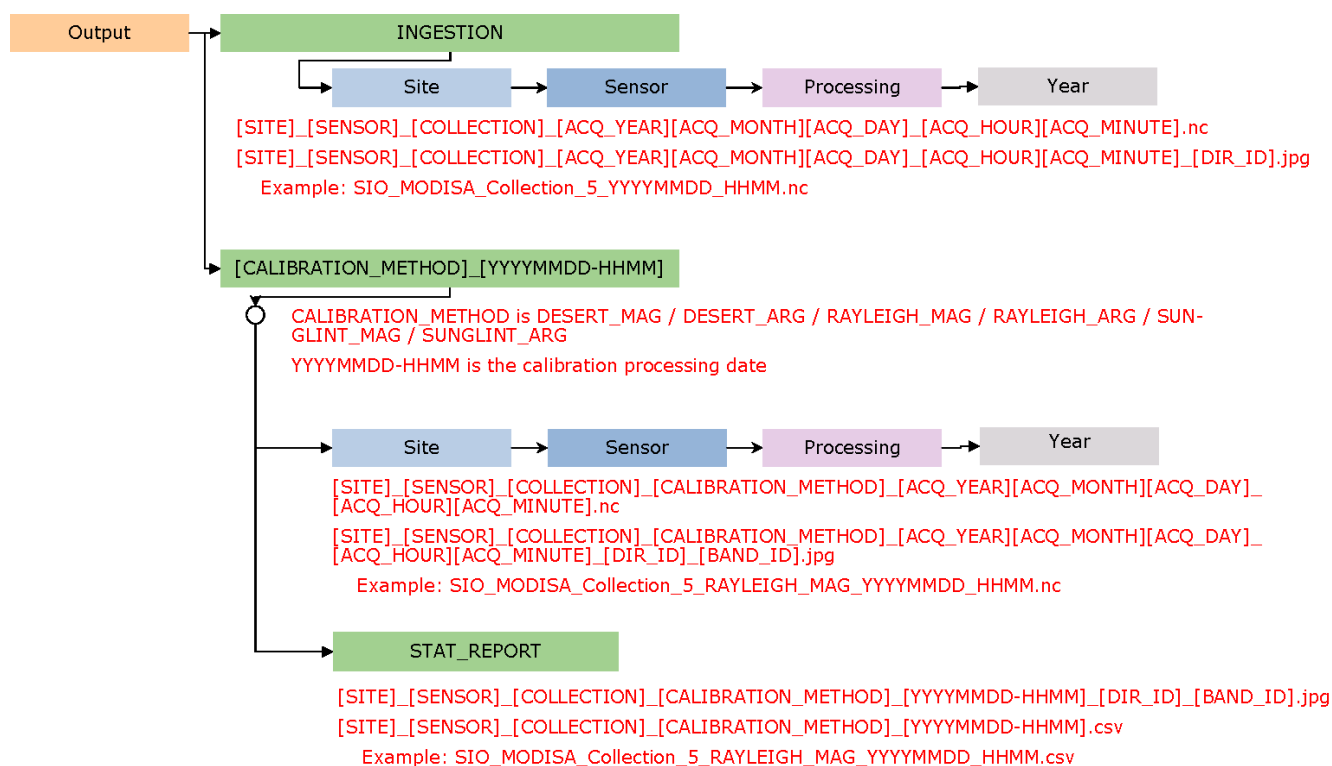


Figure 17: Schematic diagram of the DIMITRI output folder structure

- The '**Source**' folder contains all the DIMITRI routines developed by ESA, MAGELLIUM and ARGANS. Each file contain a code header providing information on what the routine does, how it is called, what are the outputs, and the modification history.
- The '**Temp_sim_files**' folder contains the LibRadTran temporary input files. It is necessary for the desert calibration function described in section 3.6.3.1 and 4.4.3.3.

Important: A number of routines requires 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.

4.3 Ingestion Process

Figure 18 shows the summary diagram of the ingestion process with the input data needed (auxiliary data and product data) and the output data created during the process.

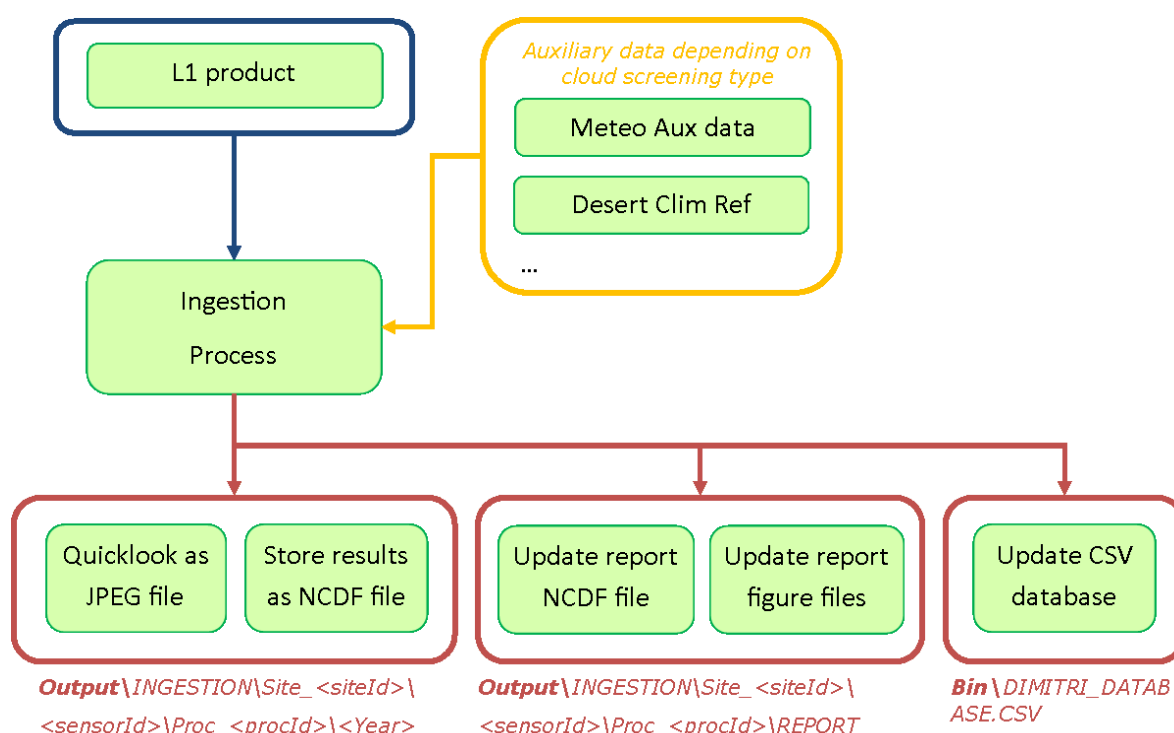


Figure 18: L1 product ingestion summary diagram.

As a result of the ingestion of new L1 products, a number of files are produced at different level:

- 1) At product level: for each L1 product ingested, a netCDF product gathering all information relevant to DIMITRI will be generated.
- 2) For a given sensor, site and processing version of this sensor L1 products: the full time series of acquisitions is stored in a single netCDF file and plots of this data are generated (TOA reflectance and geometry of observations)
- 3) At the level of the DIMITRI tool: a database (.csv format) is updated.

There are two types of files produced for each L1 ingested:

- A netCDF file: one file created for each product (description on section 5.2.2.1).
- A set of quicklook files (JPG format): one file created per product and viewing direction. The ROI is highlighted with red colour.

These files are stored under 'Output/INGESTION' folder and sorted by site, sensor, collection and year in sub-folders. Their names observe the following rules:

- [SITE]_[SENSOR]_[COLLECTION]_[ACQ_YEAR][ACQ_MONTH][ACQ_DAY]_[ACQ_HOUR][ACQ_MINUTE].nc
- [SITE]_[SENSOR]_[COLLECTION]_[ACQ_YEAR][ACQ_MONTH][ACQ_DAY]_[ACQ_HOUR][ACQ_MINUTE]_[DIR_ID].jpg

With [SITE] : Site name
 [SENSOR] : Sensor name
 [COLLECTION] : Collection or processing version of the L1 product
 [ACQ_YEAR][ACQ_MONTH][ACQ_DAY] : Acquisition date (YYYYMMDD format)
 [ACQ_HOUR][ACQ_MINUTE] : Acquisition time (HHmm format)
 [DIR_ID] : Viewing direction identifier



Figure 19: Quicklook example (MODISA product over Libya4 site)

There are two types of output files produced for each sensor, on each site and for each L1 processing version:

- A netCDF file: one file created for all products from a given sensor over a given site with the same L1 processing version.
- A number of figure files (JPG format) corresponding to plots of the of the following parameters against the decimal year:

- ❖ The mean sensor zenith angle over the ROI,
- ❖ The mean solar zenith angle over the ROI,
- ❖ The mean of the Top Of Atmosphere Reflectance over the ROI in each spectral band,

These files are updated after each new ingestion of the associated sensor and processing version and located under the corresponding 'REPORT' folder. Their names follow the following rules:

— [SITE]_[SENSOR]_[COLLECTION].nc

— [SITE]_[SENSOR]_[COLLECTION]_[GRAPH_TYPE].jpg

With [SITE] : Site name
[SENSOR] : Sensor name
[COLLECTION] : Collection or processing version of the L1 product
[GRAPH_TYPE] : One of the three graph types: 'SENSOR_ZENITH_ANGLE', 'SOLAR_ZENITH_ANGLE', 'TOA_REFLECTANCE'.

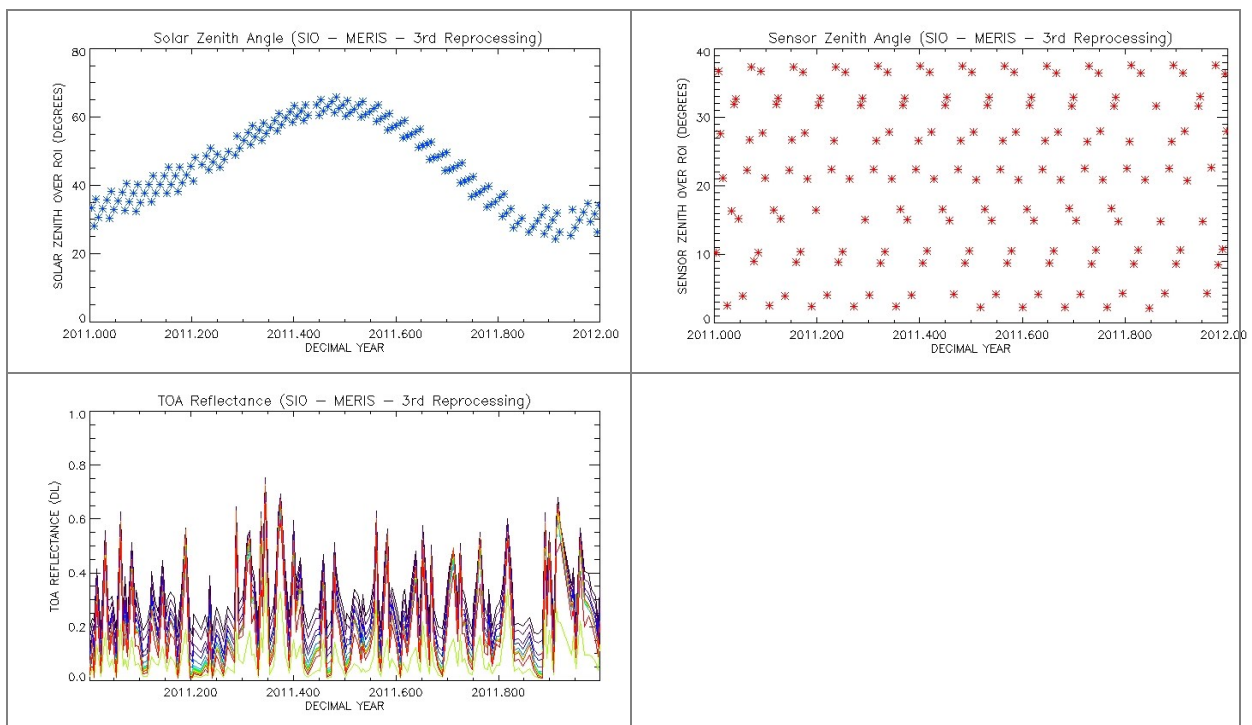


Figure 20: Ingestion process graphs example

There is one file updated after ingestion at the DIMITRI tool level:

- The DIMITRI database which provides reference to all products ingested and their main characteristics (description on Section 5.2.1). This database is stored under 'DIMITRI_x.y/Bin' folder and is named 'DIMITRI_DATABASE.CSV'.

4.4 Sensor to Simulation Comparison Process

4.4.1 Overview

Figure 21 shows the summary diagram of the sensor to simulation comparison process with the input data needed (auxiliary data and product data) and the output data created during the process.

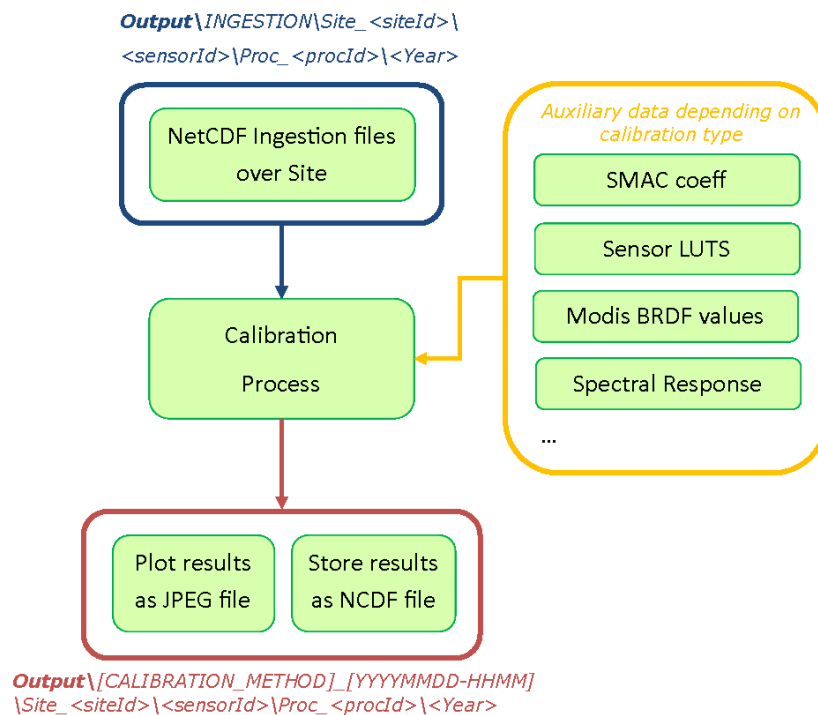


Figure 21: Summary diagram of sensor to simulation comparison process

There are two types of output files:

- The netCDF file: one file created for each product (description on Section 5.2.2.2).
- The figure files (JPG format): one file created for each triplet [product, viewing direction, band], (Band number x Viewing direction number) figure files per product. Two graphs are provided within Figure 22.
 - The scatterplot RTOA sensor versus RTOA simulation,
 - The histogram of the ratio RTOA sensor / RTOA simulation.
 -

The output files are stored under the 'Output/[CALIBRATION_METHOD]_[YYYYMMDD-HHMM]' folder and sorted by site, sensor, collection and year in sub-folders.

- The CALIBRATION_METHOD value is one of the following keywords: DESERT_MAG, DESERT_ARG, RAYLEIGH_MAG, RAYLEIGH_ARG, SUN GLINT_MAG or SUN GLINT_ARG.
- The YYYYMMDD-HHMM date is the calibration processing date.

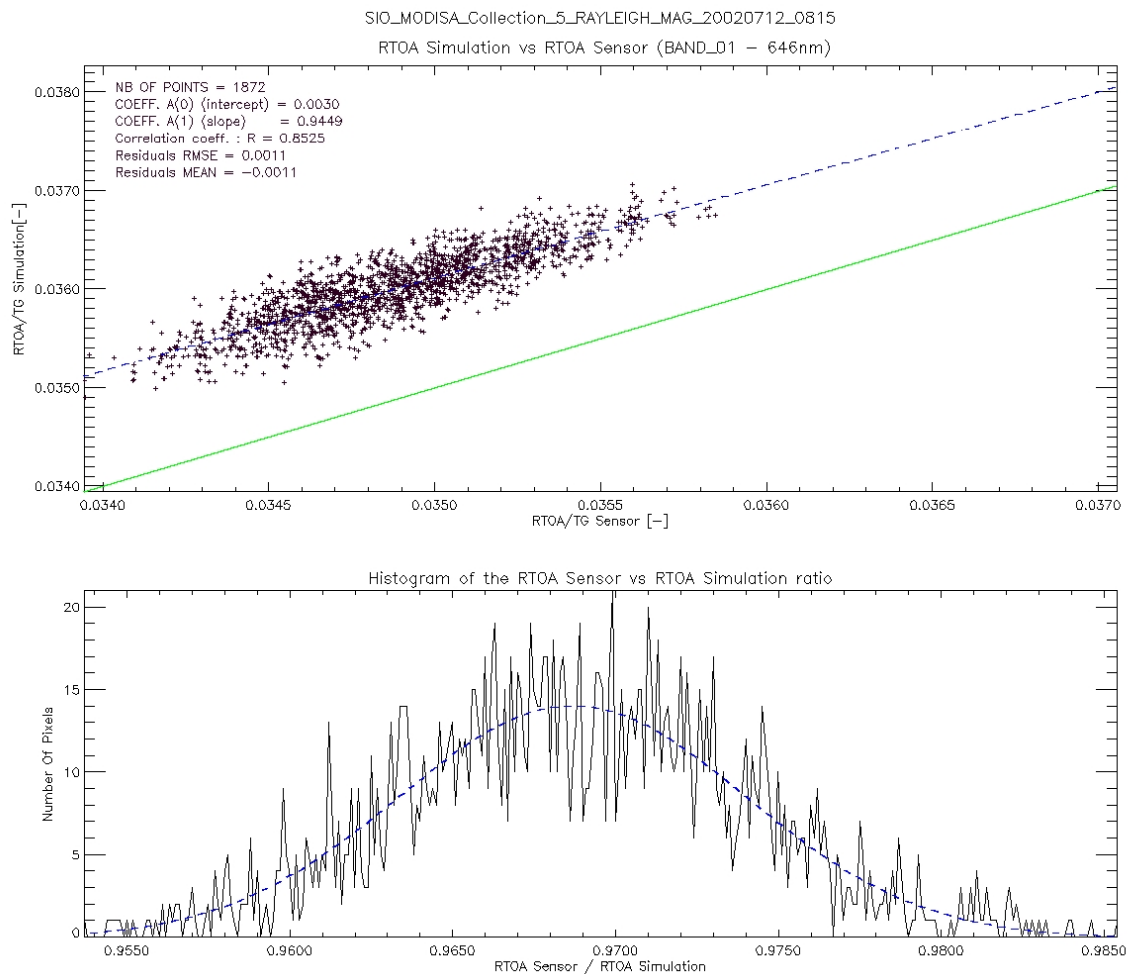


Figure 22: Calibration process graphs example

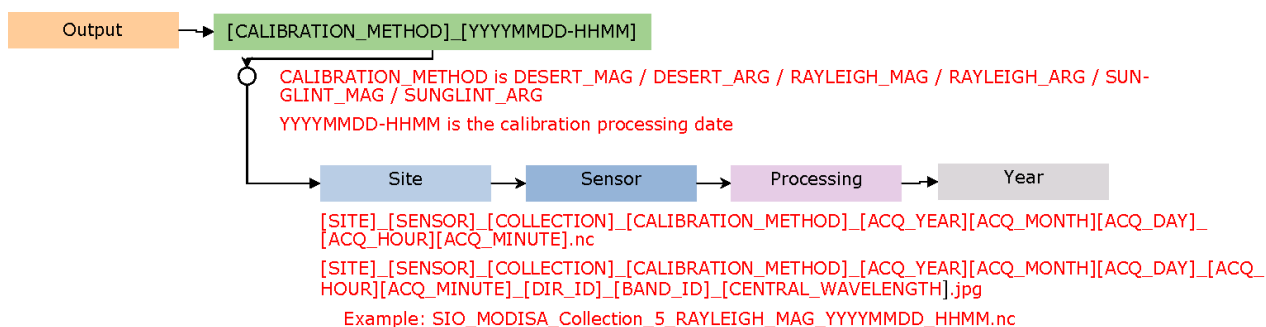


Figure 23: Schematic diagram of the calibration output folder structure and content

The name of the netCDF file and figure files (JPG format) observes the following rules:

- [SITE]_[SENSOR]_[COLLECTION]_[CALIBRATION_METHOD]_[ACQ_YEAR][ACQ_MONTH][ACQ_DAY]_[ACQ_HOUR][ACQ_MINUTE].nc
- [SITE]_[SENSOR]_[COLLECTION]_[CALIBRATION_METHOD]_[ACQ_YEAR][ACQ_MONTH][ACQ_DAY]_[ACQ_HOUR][ACQ_MINUTE]_[DIR_ID]_[BAND_ID]_[CENTRAL_WAVELENGTH].jpg

With [SITE]: Site name
[SENSOR]: Sensor name
[COLLECTION]: Collection or processing version of the L1 product
[CALIBRATION_METHOD]: Calibration method name (DESERT_MAG, DESERT_ARG, RAYLEIGH_MAG, RAYLEIGH_ARG, SUN GLINT_MAG or SUN GLINT_ARG)
[ACQ_YEAR][ACQ_MONTH][ACQ_DAY]: acquisition date (YYYYMMDD format)
[ACQ_HOUR][ACQ_MINUTE]: Acquisition time (HHmm format)
[DIR_ID]: Viewing direction identifier
[BAND_ID]: Band identifier (order number of the band in the L1 product)
[CENTRAL_WAVELENGTH]: Central wavelength of band

4.4.2 Processing by command line

The sensor to simulation comparison processes could be activated by command line.

4.4.2.1 Desert / Rayleigh / Sun Glint ARG process

Command lines:

Method	Command line
Desert ARG	STATUS = DIMITRI_INTERFACE_DESERT_ARG (SITE_NAME, SENSOR, PROC_VERSION, YEAR, PHOTON_NB, CPU_NB, VERBOSE=VERBOSE)
Rayleigh ARG	STATUS = DIMITRI_INTERFACE_RAYLEIGH_ARG (SITE_NAME, SENSOR, PROC_VERSION, YEAR, CLOUD_PERCENTAGE, ROI_PERCENTAGE, WS_MAX, CHL, THRESH_RHRC 865, AER, CLIM=CLIM, VERBOSE=VERBOSE)
Sun Glint ARG	STATUS = DIMITRI_INTERFACE_SUN_GLINT_ARG (SITE_NAME, SENSOR, PROC_VERSION, YEAR, CLOUD_PERCENTAGE, ROI_PERCENTAGE, WS_MAX, CONE_MAX, BREF, ABS_CALREF, CHL, TAUA_865_CLIM, CLIM=CLIM, AER, VERBOSE=VERBOSE)

Parameters description:

Parameter	Description
SITE_NAME	ROI folder User placed product ('Uyuni')
SENSOR	Product Sensor ('ATSR2')
PROC_VERSION	User defined processing version of product ('2nd_Reprocessing')

Parameter	Description
YEAR	Year of product acquisition (2002)
PHOTON_NB	Number of photons
CPU_NB	Number of Jobs/CPUS
CLOUD_PERCENTAGE	Cloud coverage percentage; note that scenes having a manual cloud screening set to 0 will be selected whatever the automated cloud screening value
ROI_PERCENTAGE	ROI coverage percentage
WS_MAX	Maximum wind speed
CHL	Chlorophyll concentration (fixed values)
AER	Aerosol model, among an automated list built on all models existing in DIMITRI auxiliary folder, sensor per sensor
CLIM	If keyword set, the chlorophyll concentration is estimated by monthly climatology put in the DIMITRI auxiliary folder
THRESH_RHRC_865	Maximum Rayleigh corrected normalised radiance at 865 nm
CONE_MAX	Maximum angle between viewing and specular directions for Sun Glint condition
BREF	Reference band for the Sun Glint methodology
ABS_CALREF	Absolute calibration coefficient for the reference band in the frame of the Sun Glint methodology; this coefficient must be understood as in the Rayleigh methodology
TAUA_865_CLIM	Aerosol optical thickness at 865 nm
VERBOSE	If keyword set, verbose mode activated

4.4.2.2 Desert / Rayleigh / Sun Glint MAG process

Command lines:

Method	Command line
Desert MAG	STATUS = DIMITRI_INTERFACE_DESERT_MAG (SITE_NAME, SENSOR, PROC_VERSION, ALL=ALL, YEAR=YEAR, VERBOSE=VERBOSE)
Rayleigh MAG	STATUS = DIMITRI_INTERFACE_RAYLEIGH_MAG (SITE_NAME, SENSOR, PROC_VERSION, ALL=ALL, YEAR=YEAR, VERBOSE=VERBOSE)
Sun Glint MAG	STATUS = DIMITRI_INTERFACE_SUN_GLINT_MAG (SITE_NAME, SENSOR, PROC_VERSION, ALL=ALL, YEAR=YEAR, VERBOSE=VERBOSE)

Parameters description:

Parameter	Description
SITE_NAME	ROI folder User placed product ('Uyuni')
SENSOR	Product Sensor ('ATSR2')
PROC_VERSION	User defined processing version of product ('2nd_Reprocessing')
YEAR	Year of product acquisition (2002)
ALL	If keyword set, all products are processed whatever their acquisition year
VERBOSE	If keyword set, verbose mode activated

4.4.3 Details on ARGANS methodologies

4.4.3.1 Sensor-to-simulation following the Rayleigh methodology

Schematically, the main Rayleigh calibration module:

- Interfaces with the DIMITRI database to identify the L1 extractions corresponding to the user selected site, sensor, processing version and year;
- Screens data for which the ROI cloudiness, region of interest coverage and cloud masking corresponding to the user selection;
- Finds all pixels in line with the user defined parameters specific to the calibration method;
- Reads all RTM LUT;
- Performs the simulation of the TOA signal following the Rayleigh methodology per product, direction and band;
- Stores the results in netCDF file and creates figure.

Besides the common outputs, the process generates a log file, summarising all options of the run (parameters), updated for each run of the Rayleigh methodology and located under 'Output' folder (RAYLEIGH_CAL_LOG.txt).

4.4.3.2 Sensor-to-simulation following the Sun Glint methodology

Besides the common outputs, the process generates a log file, summarising all options of the run (parameters), updated for each Rayleigh calibration run and located under 'Output' folder (GLINT_CAL_LOG.txt).

4.4.3.3 Sensor-to-simulation following over the 6 CEOS PICS sites

Schematically, the module:

- Reads the sensor data and consolidates the meteo data (from ECMWF-ERA-Interim climatology) if needed;
- Performs the selection of the valid data (by several criteria) in order to simulate the remote sensing observation;
- Runs the MYSTIC model over the valid data;
- Stores the results in the netCDF files and creates the figures.

Besides the common outputs, the process generates input files (**mc_simulation_cpu_0.input**) summarising all inputs of the MYSTIC run (parameters and auxiliary data) stored in the folder 'Temp_sim_files'. These files are not meant to be used by the user and are simply intermediate files generated by the methodology.

4.4.4 Report

The [Figure 24](#) shows the summary diagram of the time series calibration reporting process with the input data needed and the output data created during the process.

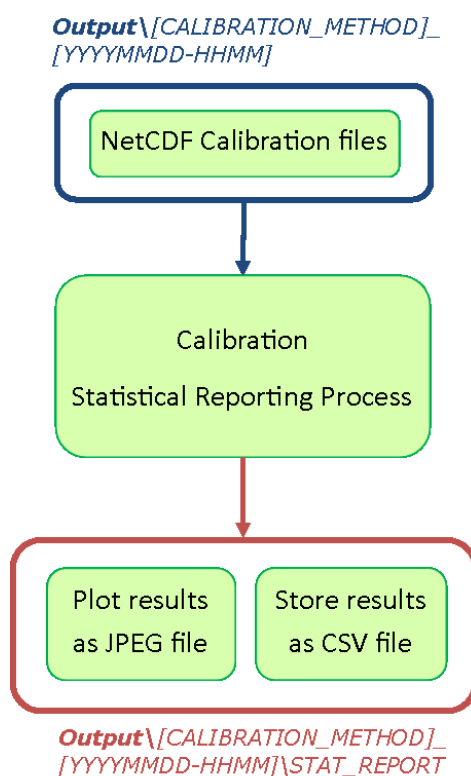


Figure 24: Time series report summary diagram

There are two types of output files:

- The CSV statistical report database common to all products.

- The figures files (JPG format): one file created for each triplet [product, viewing direction, band], (Band number x Viewing direction number) figure files per product. The figure contains the temporal variability of the ratio RTOA measured / RTOA simulated graph.

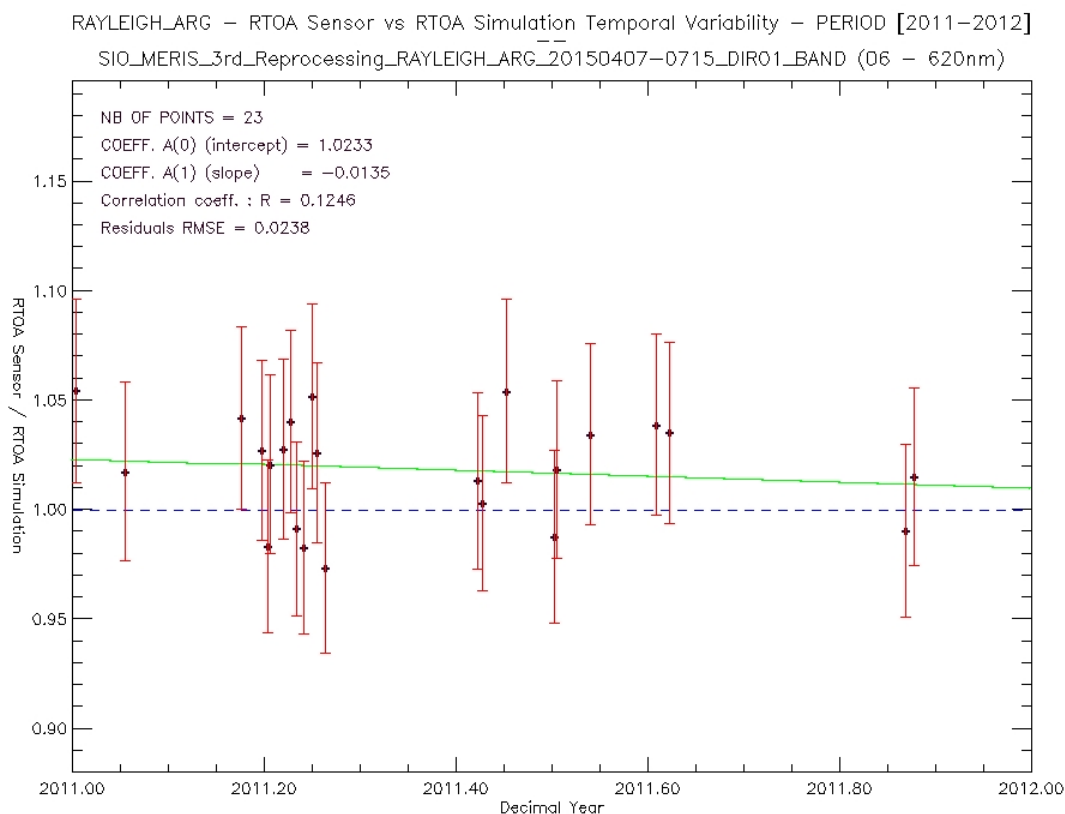


Figure 25: Time series rho_TOA_sensor / rho_simulated reporting graphs example

The output files are stored under the 'Output/[CALIBRATION_METHOD]_[YYYYMMDD-HHMM]\STAT_REPORT' folder.

- The CALIBRATION_METHOD value is one of the following keywords: DESERT_MAG, DESERT_ARG, RAYLEIGH_MAG, RAYLEIGH_ARG, SUN GLINT_MAG or SUN GLINT_ARG.
- The YYYYMMDD-HHMM date is the calibration processing date.

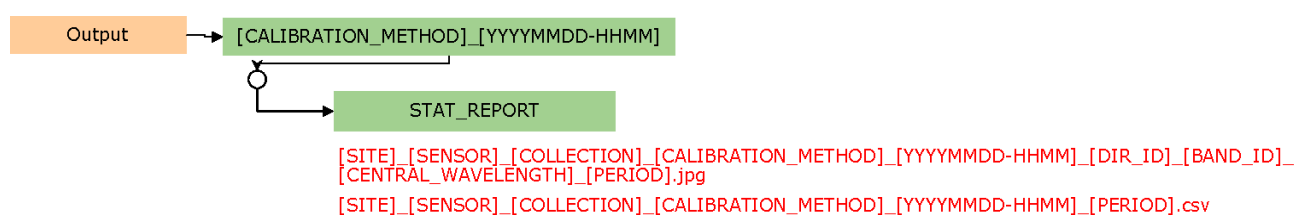


Figure 26: Schematic diagram of the calibration output folder structure and content

	<p align="center">DIMITRI V4.2</p> <p align="center">Software User Manual</p>	<p>Ref: ARG_DIM_QA4EO_DIMITRI_V4.2_SUM</p> <p>Date: 26/04/2016</p> <p>Issue: 4.2</p> <p>Page: 52</p>
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The name of the CSV file and figure file (JPG format) observes the following rules:

- [SITE]_[SENSOR]_[COLLECTION]_[CALIBRATION_METHOD]_[YYYYMMDD-HHMM]_[PERIOD].csv
- [SITE]_[SENSOR]_[COLLECTION]_[CALIBRATION_METHOD]_[YYYYMMDD-HHMM]_[DIR_ID]_[BAND_ID]_[CENTRAL_WAVELENGTH]_[PERIOD].jpg

With [SITE]: Site name
[SENSOR]: Sensor name
[COLLECTION]: Collection or processing version of the L1 product
[CALIBRATION_METHOD]: Calibration method name (DESERT_MAG, DESERT_ARG, RAYLEIGH_MAG, RAYLEIGH_ARG, SUN GLINT_MAG or SUN GLINT_ARG)
[YYYYMMDD-HHMM]: Calibration date (from calibration folder name)
[DIR_ID]: Viewing direction identifier
[BAND_ID]: Band identifier (order number of the band in the L1 product)
[CENTRAL_WAVELENGTH]: Central wavelength of band
[PERIOD]: Time period selected for statistical report process

4.5 External Routines

The DIMITRI software package has been developed by ESA, ARGANS and MAGELLIUM 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://cimss.ssec.wisc.edu/~gumley>).
- **ninterpolate.pro**
↳ Created by J.D. Smith (2003)

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5 DIMITRI DATA FILES

The DIMITRI software package utilises number of different data files. These can be found in the “AUX_DATA”, “Bin” and “Output” folders, and include database files, netCDF output files, internal IDL binary files and auxiliary data files, each outlined below.

5.1 DIMITRI Input Data Files

5.1.1 Auxiliary data files



A number of auxiliary data files are used by the DIMITRI software package. The main auxiliary files are available under ‘DIMITRI_x.y/Bin’ folder.

1. **Sensor info** (‘DIMITRI_SENSOR_DATA.txt’): this file contains information on the available satellite sensors within the DIMITRI software package.
2. **Band info** (‘DIMITRI_Band_Names.txt’): this file contains information on the available sensor bands with wavelength values.
3. **Site info** (‘DIMITRI_SITE_DATA.txt’): this file contains information on each of the DIMITRI validation sites, as well as any user defined sites.
4. **Configuration file** (‘DIMITRI_CONFIGURATION.txt’): this file contains the user’s DIMITRI configuration settings (e.g. plot sizes and RGB quicklooks), and is updated by the configuration HMI module.
5. **Band centre index** (‘DIMITRI_Band_Centre_Index.txt’): 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 that 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.
6. **DIMITRI_Band_Configuration** (‘DIMITRI_Band_Configuration.csv’): this file contains relative indexes for each sensor band against the defined DIMITRI wavelengths, the band standard label (NIR, SWIR, BLUE...), the reference label (BAND_01, BAND_02, BAND_03...) as ordered in the native product format, the SMAC file names, the Rayleigh LUT file names and the Desert LUT file names. These file names are used by MAGELLIUM processes.

5.2 DIMITRI Output Data Files

5.2.1 DIMITRI database file

The semi-colon delimited database file contains information regarding all ingested L1 data products. It is used by a number of DIMITRI functions. 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:

Fields	Description
DIMITRI_DATE	The calendar date the product was ingested into DIMITRI, DD- MMM-YY (14-Dec-10)
SITE_NAME	ROI folder User placed product ('Uyuni')
SITE_TYPE	Site type (Ocean, Desert, Forest...)
SITE_COORDINATES	Site coordinates (LAT_MAX, LAT_MIN, LON_MAX, LON_MIN)
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)
L1_FILENAME	L1 product filename (without path reference)
L1_INGESTED_FILENAME	L1 ingested product filename (without path reference)
ROI_STATUS	Integer, raised if the ROI is covered by the product or if a Sun Glint area is detected in case of specific SUN GLINT site: <div>  -1 = not covered/no Sun Glint,  1 = covered/Sun Glint </div>
ROI_PIX_NUM	Number of pixels within the associated ROI (1068)
THETA_N_MEAN	Mean value of the wave angle; this angle is defined as the wave slope that enables having an exact specular reflection given the sun and viewing directions (computed for all products over SUN GLINT or OCEAN sites)
THETA_R_MEAN	Mean value of the sun reflected angle (computed for all products over SUN GLINT or OCEAN sites)
AUTO_CS_1_NAME	Automated ROI Cloud Screening method name (ARGANS)
AUTO_CS_1_MEAN	Automated ROI Cloud Screening result in percent: -1 not done, [0 (clear)...100% (cloudy)]
ROI_CS_1_CLEAR_PIX_NUM	Number of clear pixels detected on the ROI
AUTO_CS_2_NAME	Automated ROI Cloud Screening method name (MAGELLIUM)
AUTO_CS_2_MEAN	Automated ROI Cloud Screening result in percent: -1 not done, [0 (clear)...100% (cloudy)]
ROI_CS_2_CLEAR_PIX_NUM	Number of clear pixels detected on the ROI

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Fields	Description
BRDF_CS_MEAN	BRDF automated ROI Cloud Screening method status: -1 not done, 0 clear, 1 partially cloudy
SSV_CS_MEAN	SSV automated ROI Cloud Screening method status: -1 not done, 0 clear, 1 partially cloudy
MANUAL_CS	Manual ROI Cloud Screening status indicating -1: not performed, 0: clear, 1: cloudy, 2: suspect (ie: error product)
ERA_WIND_SPEED_MEAN	Mean value of the meteorological auxiliary data on the ROI from table provided by ESA or ERA.
ERA_WIND_DIR_MEAN	
ERA_OZONE_MEAN	
ERA_PRESSURE_MEAN	
ERA_WATERSVAPOUR_MEAN	
ESA_CHLOROPHYLL_MEAN	
AUX_DATA_1_NAME	A string of auxiliary data used to process the L1 product
AUX_DATA_2_NAME	
AUX_DATA_3_NAME	
AUX_DATA_4_NAME	
AUX_DATA_5_NAME	
AUX_DATA_6_NAME	
AUX_DATA_7_NAME	
AUX_DATA_8_NAME	
AUX_DATA_9_NAME	
AUX_DATA_10_NAME	

5.2.2 DIMITRI netCDF files

A netCDF files is split in three parts as follow:

- Global attributes part,
- Dimensions part,
- Variables part.

5.2.2.1 Ingestion output file

The global attributes and the dimensions are described in [Table 3](#) and the variables are described in [Table 4](#).

The example on [Figure 27](#) presents the netCDF file structure of an ingested product with 2 available viewing directions (as AATSR and ATSR2).

Some variables are expanded to show their dedicated attributes.

For information, the attributes are the same inside each of the following groups:

- Sun and viewing angles (SAA, SZA, VAA, VZA),
- Reflectance value of each spectral band (REFL_BAND_01, REFL_BAND_02, REFL_BAND_xx),
- Meteorological Auxiliary Data (ERA_WIND_SPEED, ERA_WIND_DIR, ERA_OZONE...).

	Fields	Description
GLOBAL Attributes	TOOL	Tool name
	CREATION_TIME	Creation time
	MODIFICATION_TIME	Modification time
	SITE_NAME	ROI folder User placed product
	SITE_TYPE	Site type
	SITE_COORDINATES	Site coordinates (LAT_MAX, LAT_MIN, LON_MAX, LON_MIN)
	SENSOR	Product Sensor
	PROCESSING_VERSION	User defined processing version of product
	ACQUISITION_DATE	Product acquisition date (YYYY-MM-DD HH:MM)
	L1_FILENAME	L1 product filename (without path reference)
	ROI_PIX_NUM	Number of pixels within the associated ROI
	AUTO_CS_1_NAME	Automated ROI Cloud Screening method name (ARGANS)
	AUTO_CS_1_MEAN	Automated ROI Cloud Screening result in percent: -1 not done, [0 (clear)...100% (cloudy)]
	ROI_CS_1_CLEAR_PIX_NUM	Number of clear pixels detected on the ROI
	AUTO_CS_2_NAME	Automated ROI Cloud Screening method name (MAGELLUM)
	AUTO_CS_2_MEAN	Automated ROI Cloud Screening result in percent: -1 not done, [0 (clear)...100% (cloudy)]
	ROI_CS_2_CLEAR_PIX_NUM	Number of clear pixels detected on the ROI
	BRDF_CS_MEAN	BRDF automated ROI Cloud Screening method status : -1 not done, 0 clear, 1 partially cloudy
	SSV_CS_MEAN	SSV automated ROI Cloud Screening method status: -1 not done, 0 clear, 1 partially cloudy
	MANUAL_CS	Manual ROI Cloud Screening status indicating -1: not performed, 0: clear, 1: cloudy
DIMENSIONS	ROI_PIXEL_NUMBER	Pixel number of the ROI [ROI_PIX]
	VIEWDIR_NUMBER	Sensor viewing direction number [VIEW_DIR]

Table 3: netCDF Ingestion output file description (Global attributes and dimensions)

	Fields	Size	Description
VARIABLES	ROI_STATUS	[VIEW_DIR]	ROI status for each viewing direction ↳ with attribute 'THETA_R_mean' / 'THETA_N_mean' for SUN GLINT and OCEAN sites
	ROI_PIXEL_NUMBER		Number of pixels of the ROI for each viewing direction
	LAT	[ROI_PIX, VIEW_DIR]	Latitude of each pixel of the ROI
	LON		Longitude of each pixel of the ROI
	SZA		Sun Zenith Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	SAA		Sun Azimuth Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	VZA		View Zenith Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	VAA		View Azimuth Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	REFL_BAND_[xx]		Values of the band number 'xx' on the ROI ↳ with attributes 'wavelength_mean', 'viewDir[xx]_mean' and 'viewDir[xx]_stdev' (two last repeated for each direction) All bands of the L1 product
	PIXEL_COLUMN_INDICE		Column index in the product of each point of the ROI
	PIXEL_ROW_INDICE		Line index in the product of each point of the ROI
	AUTO_CS_1_VALID_INDEX		Index in the ROI of each <u>valid</u> point of the ROI for cloud screening process
	AUTO_CS_2_VALID_INDEX		
	AUTO_CS_1_MASK		Cloud screening mask values on the ROI
	AUTO_CS_2_MASK		
	ERA_WIND_SPEED		Meteo auxiliary data ↳ with attribute 'viewDir[xx]_mean' and 'viewDir[xx]_mean_L1_aux_data' for each of them (repeated for each direction)
	ERA_WIND_DIR		
	ERA_OZONE		
	ERA_PRESSURE		
	ERA_WATERSVAPOUR		
	ESA_CHLOROPHYLL		

Table 4: netCDF Ingestion output file description (variables)

'Global Attributes' part of the file

Global Attributes

- AB TOOL
- AB CREATION_TIME
- AB MODIFICATION_TIME
- AB SITE_NAME
- AB SITE_TYPE
- AB SITE_COORDINATES
- AB SENSOR
- AB PROCESSING_VERSION
- AB ACQUISITION_DATE
- AB L1_FILENAME
- AB ROI_PIX_NUM
- AB AUTO_CS_1_NAME
- AB AUTO_CS_1_MEAN
- AB ROI_CS_1_CLEAR_PIX_NUM
- AB AUTO_CS_2_NAME
- AB AUTO_CS_2_MEAN
- AB ROI_CS_2_CLEAR_PIX_NUM
- AB BRDF_CS_MEAN
- AB SSV_CS_MEAN
- AB MANUAL_CS

'Dimensions' part of the file

Dimensions

- ROI_PIXEL_NUMBER
- VIEWDIR_NUMBER

'Variables' part of the file

Variables

- ROI_STATUS
- ROI_PIXEL_NUMBER
- LAT
- LON
- SZA
 - AB long_name
 - AB units
 - AB missing_value
 - AB viewDir01_mean
 - AB viewDir02_mean
- SAA
- VZA
- VAA
- REFL_BAND_01
 - AB long_name
 - AB wavelength_mean
 - AB missing_value
 - AB viewDir01_mean
 - AB viewDir01_stdev
 - AB viewDir02_mean
 - AB viewDir02_stdev
- REFL_BAND_02
- REFL_BAND_03
- REFL_BAND_04
- PIXEL_COLUMN_INDICE
- PIXEL_ROW_INDICE
- AUTO_CS_1_VALID_INDEX
- AUTO_CS_2_VALID_INDEX
- AUTO_CS_1_MASK
- AUTO_CS_2_MASK
- ERA_WIND_SPEED
 - AB long_name
 - AB units
 - AB missing_value
 - AB viewDir01_mean
 - AB viewDir01_mean_L1_aux_data
 - AB viewDir02_mean
 - AB viewDir02_mean_L1_aux_data
- ERA_WIND_DIR
- ERA_OZONE
- ERA_PRESSURE
- ERA_WATERSVAPOUR
- ESA_CHLOROPHYLL

Figure 27: netCDF ingestion output file example

5.2.2.2 Sensor to simulation comparison output file

The global attributes and the dimensions are described in [Table 5](#) and the variables are described in [Table 6](#).

The example on [Figure 28](#) presents the netCDF file structure after sensor to simulation comparison process. In this example, 2 viewing directions are available (as AATSR and ATSR2).

Some variables are expanded to show their dedicated attributes.

For information, the attributes are the same inside each of the following groups:

- Sun and viewing angles (SAA, SZA, VAA, VZA),
- Reflectance value of each spectral band (REFL_BAND_01, REFL_BAND_02, REFL_BAND_[xx]),
- Meteo Auxiliary Data (ERA_WIND_SPEED, ERA_WIND_DIR, ERA_OZONE...),
- Sensor to simulation ratio (BAND_[xx]_REF_TO_SIM_RATIO).

	Fields	Description
GLOBAL Attributes	TOOL	Tool name
	CREATION_TIME	Creation time
	MODIFICATION_TIME	Modification time
	CALIBRATION_METHOD	Calibration method name
	SITE_NAME	ROI folder User placed product
	SITE_TYPE	Site type
	SITE_COORDINATES	Site coordinates (LAT_MAX, LAT_MIN, LON_MAX, LON_MIN)
	SENSOR	Product Sensor
	PROCESSING_VERSION	User defined processing version of product
	ACQUISITION_DATE	Product acquisition date (YYYY-MM-DD HH:MM)
	L1_FILENAME	L1 product filename (without path reference)
	ROI_PIX_NUM	Number of pixels within the associated ROI
	AUTO_CS_1_NAME	Automated ROI Cloud Screening method name (ARGANS)
	AUTO_CS_1_MEAN	Automated ROI Cloud Screening result in percent: -1 not done, [0 (clear)...100% (cloudy)]
	ROI_CS_1_CLEAR_PIX_NUM	Number of clear pixels detected on the ROI
	AUTO_CS_2_NAME	Automated ROI Cloud Screening method name (MAGELLIUM)
	AUTO_CS_2_MEAN	Automated ROI Cloud Screening result in percent: -1 not done, [0 (clear)...100% (cloudy)]
	ROI_CS_2_CLEAR_PIX_NUM	Number of clear pixels detected on the ROI
	BRDF_CS_MEAN	BRDF automated ROI Cloud Screening method status : -1 not done, 0 clear, 1 partially cloudy
	SSV_CS_MEAN	SSV automated ROI Cloud Screening method status: -1 not done, 0 clear, 1 partially cloudy

	Fields	Description
	MANUAL_CS	Manual ROI Cloud Screening status indicating -1: not performed, 0: clear, 1: cloudy
DIMENSIONS	ROI_PIXEL_NUMBER	Number of pixel of the ROI [ROI_PIX]
	CALIB_PIXEL_NUMBER	Number of pixel selected for the sensor to simulation comparison process [CALIB_PIX]
	VIEWDIR_NUMBER	Number of sensor viewing direction [VIEW_DIR]

Table 5: netCDF sensor to simulation comparison output file description (Global attributes and dimensions)

	Fields	Size	Description
VARIABLES	ROI_STATUS	[VIEW_DIR]	ROI status for each viewing direction ↳ with attribute 'THETA_R_mean' / 'THETA_N_mean' for SUN GLINT and OCEAN sites
	ROI_PIXEL_NUMBER		Number of pixel of the ROI (for each viewing direction)
	CALIB_PIXEL_NUMBER		Number of pixel of the ROI selected for the sensor to simulation comparison process (for each viewing direction)
	LAT	[ROI_PIX, VIEW_DIR]	Latitude of each pixel of the ROI
	LON		Longitude of each pixel of the ROI
	SZA		Sun Zenith Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	SAA		Sun Azimuth Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	VZA		View Zenith Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	VAA		View Azimuth Angle of each pixel of the ROI ↳ with attribute 'viewDir[xx]_mean' (repeated for each direction)
	REFL_BAND_[xx]		Values of the band number 'xx' on the ROI ↳ with attributes 'wavelength_mean', 'viewDir[xx]_mean' and 'viewDir[xx]_stdev' (two last repeated for each direction) Only selected bands for calibration
	PIXEL_COLUMN_INDICE		Column index in the product of each point of the ROI
	PIXEL_ROW_INDICE		Line index in the product of each point of the

Fields	Size	Description
		ROI
AUTO_CS_1_VALID_INDEX		Index in the ROI of each selected point of the ROI (check on the reflectance for 'classical' site and on the angles for Sun Glint)
AUTO_CS_2_VALID_INDEX		
AUTO_CS_1_MASK		Cloud screening mask values on the ROI
AUTO_CS_2_MASK		
ERA_WIND_SPEED	[ROI_PIX, VIEW_DIR]	Meteo auxiliary data ↳ with attribute 'viewDir[xx]_mean' for each of them (repeated for each direction)
ERA_WIND_DIR		
ERA_OZONE		
ERA_PRESSURE		
ERA_WATERSVAPOUR		
ESA_CHLOROPHYLL		
CALIB_VALID_INDEX	[CALIB_PIX, VIEW_DIR]	Index in the ROI of each selected points used for sensor to simulation comparison process (pixel selection depends on the method and filtering parameters applied) Common for all bands
WIND_SPEED_ESTIM		Wind speed estimation (available for Sun Glint calibration methods)
AEROSOL_OT_ESTIM		Aerosol optical thickness estimation (available for Rayleigh calibration methods)
BAND_[xx]_GAZ_TRANS		Gaseous transmission coefficient for band number 'xx'
BAND_[xx]_RHO_SIM		Simulated TOA reflectance for band number 'xx'
BAND_[xx]_RHO_SIM_UNCERT		Uncertainty on the simulated TOA reflectance for band number 'xx'
BAND_[xx]_REF_TO_SIM_RATIO		TOA reflectance observed to simulated TOA reflectance ratio band number 'xx' ↳ with attributes 'viewDir[xx]_mean' / 'viewDir[xx]_stdev' / 'viewDir[xx]_median' (repeated for each direction)
BAND_[xx]_VALID_INDEX		Valid indexes for band number 'xx' of the sensor to simulation process results (additional filtering on the validity of the TOA values for the band number 'xx') To apply on the sensor to simulation associated fields to select only valid pixels.

Table 6: netCDF sensor to simulation comparison output file description (variables)

'Global Attributes' part of the file

Global Attributes

- AB TOOL
- AB CREATION_TIME
- AB MODIFICATION_TIME
- AB CALIBRATION_METHOD
- AB SITE_NAME
- AB SITE_TYPE
- AB SITE_COORDINATES
- AB SENSOR
- AB PROCESSING_VERSION
- AB ACQUISITION_DATE
- AB L1_FILENAME
- AB ROI_PIX_NUM
- AB AUTO_CS_1_NAME
- AB AUTO_CS_1_MEAN
- AB ROI_CS_1_CLEAR_PIX_NUM
- AB AUTO_CS_2_NAME
- AB AUTO_CS_2_MEAN
- AB ROI_CS_2_CLEAR_PIX_NUM
- AB BRDF_CS_MEAN
- AB SSV_CS_MEAN
- AB MANUAL_CS

'Dimensions' part of the file

Dimensions

- ROI_PIXEL_NUMBER
- CALIB_PIXEL_NUMBER
- VIEWDIR_NUMBER

'Variables' part of the file

Variables

- ROI_STATUS
- ROI_PIXEL_NUMBER
- CALIB_PIXEL_NUMBER
- LAT
- LON
- SZA
- SAA
- VZA
- VAA
- REFL_BAND_01
- REFL_BAND_02
- REFL_BAND_03
- REFL_BAND_04
- PIXEL_COLUMN_INDICE
- PIXEL_ROW_INDICE
- AUTO_CS_1_VALID_INDEX
- AUTO_CS_2_VALID_INDEX
- AUTO_CS_1_MASK
- AUTO_CS_2_MASK
- ERA_WIND_SPEED
- ERA_WIND_DIR
- ERA_OZONE
- ERA_PRESSURE
- ERA_WATERSVAPOUR
- ESA_CHLOROPHYLL
- CALIB_VALID_INDEX
- BAND_01_GAZ_TRANS
- BAND_01_RHO_SIM
- BAND_01_RHO_SIM_UNCERT
- BAND_01_REF_TO_SIM_RATIO
- long_name
- missing_value
- viewDir01_mean
- viewDir01_stdev
- viewDir01_median
- viewDir02_mean
- viewDir02_stdev
- viewDir02_median
- BAND_01_VALID_INDEX
- BAND_02_GAZ_TRANS
- BAND_02_RHO_SIM
- BAND_02_RHO_SIM_UNCERT
- BAND_02_REF_TO_SIM_RATIO
- BAND_02_VALID_INDEX
- BAND_03_GAZ_TRANS
- BAND_03_RHO_SIM
- BAND_03_RHO_SIM_UNCERT
- BAND_03_REF_TO_SIM_RATIO
- BAND_03_VALID_INDEX
- BAND_04_GAZ_TRANS
- BAND_04_RHO_SIM
- BAND_04_RHO_SIM_UNCERT
- BAND_04_REF_TO_SIM_RATIO
- BAND_04_VALID_INDEX

Figure 28: netCDF sensor to simulation comparison output file example

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5.2.3 DIMITRI internal binary files

A number of intermediate results are stored as IDL save files which are restored by DIMITRI when required. These files can also be restored by users with full IDL licenses if required by typing:

IDL> restore, sav_filename [, /verbose]

5.2.3.1 Files from sensor-to-sensor comparison

5.2.3.1.1 Extracted doublets

The extracted doublet internal binaries are of the syntax "ED_SITE_SENSOR1_PROCOVER1_SENSOR2_PROCOVER2.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:

**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, Number of pixels, automated_cloud_screening,
manual_cloud_screening, matching_type, AMC**

** Indicates mean value and standard deviation*

Note: 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.

The number of observations is dependent on the matching criteria selected.

5.2.3.1.2 Intercalibration

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

- **"ICDIF_SITE_SENSOR_PROCOVER_REF_SENSOR_PROCOVER_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_PROCOVER_REF_SENSOR_PROCOVER_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_PROCOVER_REF_SENSOR_PROCOVER_BAND.dat"**

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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.

5.2.3.1.3 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:

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, Number of pixels, automated_cloud_screening, manual_cloud_screening, matching_type, AMC

** Indicates mean value and standard deviation*

The observations are the recalibrated and reference sensor reflectances.

- **“SEEN_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.

5.2.3.1.4 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.

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“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.

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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 L1 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 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 site spectra?

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

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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 been designed in 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, DIMITRI_Band_Centre_Index.txt and DIMITRI_Band_Configuration.csv)
- 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
- Potential modification of the sensor-to-sensor and sensor-to-simulation intercomparison routines

[End of Document]