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**HYPERNETS LAND AND WATER PROCESSOR**

**PRODUCT DATA FORMAT SPECIFICATION**

**Version 0.0**

**6/2/20**

**Version History**

|  |  |  |  |
| --- | --- | --- | --- |
| **Version** | **Date** | **Description** | **Author** |
| 0.0 | 6/2/20 | Draft Version | Sam Hunt |
| 0.1 | 10/02/20 | Metadata update | Clémence Goyens |
| 0.2 | 14/02/2020 | Instrument and site attributes | Matt Beck and Clémence Goyens |
| 0.3 | 05/03/2020 | Update metadata according metadata diagram (partitioning and keys) | Clémence Goyens |
| 0.4 | 06/03/2020 | Complete metadata fields | Clémence Goyens |
| 0.5 | 23/04/2020 | Add variable description (including CF standards and NERC URI), change data level | Clémence Goyens |
|  |  |  |  |

Contents

[Contents 3](#_Toc1185431911)

[List of figures 5](#_Toc720386410)

[1 Introduction 8](#_Toc1581172094)

[1.1 References 8](#_Toc781876073)

[1.2 Glossary and Acronyms 8](#_Toc2139971700)

[2 Product Definitions 9](#_Toc372773845)

[3 Product Conventions 11](#_Toc83916959)

[3.1 Product file format 11](#_Toc141850712)

[3.2 Network naming conventions 11](#_Toc989415860)

[3.3 Site name conventions 11](#_Toc2136317134)

[3.4 Filename convention 11](#_Toc230088920)

[3.5 Dimensions 12](#_Toc1952026292)

[4 Metadata 14](#_Toc346487419)

[4.1 Common Metadata 15](#_Toc1249399103)

[4.2 Instrument and system Metadata 18](#_Toc1319770388)

[4.2.1 Instrument metadata 18](#_Toc6671698)

[4.2.2 System metadata 19](#_Toc673348702)

[4.2.3 Components metadata 19](#_Toc765336334)

[4.3 Site Metadata 23](#_Toc1033074994)

[4.4 Product Metadata 23](#_Toc1899119592)

[4.4.1 Level 1a Product Metadata 23](#_Toc166636600)

[4.4.1.1 Radiance/Irradiance Product Metadata 23](#_Toc1423732038)

[4.4.2 Level 1b Product Metadata 24](#_Toc685692024)

[4.4.2.1 Land radiance and irradiance L1b product metadata 24](#_Toc431278419)

[4.4.2.2 Water Radiance, Irradiance and Water-leaving radiance L1b Product Metadata 25](#_Toc1637281100)

[4.4.3 Level 2a Product Metadata 25](#_Toc681684228)

[4.4.3.1 Land Reflectance L2a Product Metadata 25](#_Toc563623527)

[4.4.3.2 Water Reflectance and Normalized Water-leaving Radiance L2a Product Metadata 26](#_Toc474566272)

[4.4.4 Level 2b Product Metadata 26](#_Toc529115264)

[4.4.4.1 Land temporally interpolated surface reflectance L2b Product Metadata 26](#_Toc1238996812)

[5 Variables 27](#_Toc1659998183)

[5.1 Common Variables 27](#_Toc1249501674)

[5.2 Level 1a Variables 30](#_Toc1649276386)

[5.2.1.1 Land and Water L1a Radiance Variables 30](#_Toc1093686630)

[5.2.1.2 Land and Water Irradiance L1a Variables 32](#_Toc2031377748)

[5.3 Level 1b Radiance and Irradiance Variables 35](#_Toc1641764438)

[5.3.1 Land Radiance and Irradiance L1b Variables 35](#_Toc1466460475)

[5.3.2 Water Radiance and Irradiance L1b Variables 35](#_Toc2115294707)

[5.3.2.1 Upwelling radiance 35](#_Toc1783615150)

[5.3.2.2 Downwelling radiance 37](#_Toc308392687)

[5.3.2.3 Downwelling irradiance 38](#_Toc2104128193)

[5.3.2.4 Surface reflected radiance 39](#_Toc2013704071)

[5.3.2.5 Water leaving radiance 43](#_Toc112935331)

[5.4 Level 2 data 45](#_Toc303131964)

[5.4.1 Land L2a and L2b reflectance variables 45](#_Toc1115619526)

[5.4.2 Water reflectance and normalized water leaving radiance L2a Variable 47](#_Toc1432705720)

[5.5 Auxiliary data variables 50](#_Toc309803662)

List of figures

[Figure 1 . Illustration of a L1 file format and the L2a file format for the Land Network 13](#_Toc1958172962)

[Figure 2 . Illustration of a L1b and L2a file format for the water network 13](#_Toc2003073805)

[Figure 3 . Metadata diagram with keys only 14](#_Toc1074582602)

List of tables

[Table 1 – List Hypernets Processor processing levels 9](#_Toc1921560396)

[Table 2 – Hypernets products definition 9](#_Toc1880866894)

[Table 3 – Product network naming conventions 11](#_Toc238798723)

[Table 4 – Site name conventions 11](#_Toc1582838394)

[Table 5 – File naming convention data fields 12](#_Toc253366130)

[Table 6 – Common metadata 15](#_Toc10591420)

[Table 7 – Instrument metadata 18](#_Toc2119031609)

[Table 8 – System metadata 19](#_Toc1877230651)

[Table 9 – Metadata of essential components within a HYPSTAR system 20](#_Toc1591962729)

[Table 10 – Auxiliary components metadata 22](#_Toc1420179228)

[Table 11 – Site metadata 23](#_Toc795342790)

[Table 12 – Radiance/irradiance product metadata 23](#_Toc1449241702)

[Table 13 - Land: Radiance and Irradiance product metadata 24](#_Toc238991903)

[Table 14 – Water: Downwelling and upwelling radiance, downwelling irradiance, surface reflected upwelling radiance and water-leaving radiance product metadata 25](#_Toc1090965525)

[Table 15 - Land: Reflectance product metadata 25](#_Toc477359562)

[Table 16 – L2a metadata for the Water Network 26](#_Toc828790506)

[Table 17 – Common product data variables 27](#_Toc1681229087)

[Table 18 – wavelength variable definition 27](#_Toc547899743)

[Table 19 – viewing\_azimuth\_angle variable definition 27](#_Toc800714075)

[Table 20 – viewing\_zenith\_angle variable definition 28](#_Toc803357331)

[Table 21 – sun\_azimuth\_angle variable definition 29](#_Toc1513001133)

[Table 22 – sun\_zenith\_angle variable definition 29](#_Toc1692166413)

[Table 23 – acquisition\_time variable definition 29](#_Toc848060940)

[Table 24 – Radiance product variables 30](#_Toc14284251)

[Table 25 – radiance variable definition 30](#_Toc1267182842)

[Table 26 – u\_random\_radiance variable definition 31](#_Toc256865555)

[Table 27 – u\_systematic\_radiance variable definition 31](#_Toc918717107)

[Table 28 – quality\_flag variable definition 31](#_Toc760839905)

[Table 29 – Inclination variable 32](#_Toc574695292)

[Table 30 – Total number of scans variable 32](#_Toc252711636)

[Table 31 – Quality checked scans 32](#_Toc121088513)

[Table 32 – Irradiance product variables 33](#_Toc1303491164)

[Table 33 – irradiance variable definition 33](#_Toc1643675895)

[Table 34 – u\_random\_irradiance variable definition 33](#_Toc1574861762)

[Table 35 – u\_systematic\_irradiance variable definition 33](#_Toc1834645396)

[Table 36 – quality\_flag variable definition 34](#_Toc1350986528)

[Table 37 – Inclination variable 34](#_Toc1044684197)

[Table 38 – Total number of scans variable 34](#_Toc537228328)

[Table 39 – Quality checked scans 35](#_Toc170099062)

[Table 40 – L1b upwelling radiance product variables water applications 35](#_Toc37801510)

[Table 41 – L1b upwelling radiance variable definition 36](#_Toc1985976058)

[Table 42 – L1b downwelling radiance product variables for water applications 37](#_Toc1352323890)

[Table 43 – L1b downwelling radiance variable definition 37](#_Toc2000774322)

[Table 44 – L1b downwelling irradiance product variables for water applications 38](#_Toc1914918527)

[Table 45 – L1b downwelling irradiance variable definition 39](#_Toc1817485577)

[Table 46 – L1b surface reflected upwelling radiance product variables for water applications 39](#_Toc1480040820)

[Table 47 – L1b surface reflected upwelling radiance variable definition 40](#_Toc1101648657)

[Table 48 – L1b fresnel reflectance variable definition 41](#_Toc1593408042)

[Table 49 – L1b fresnel wind variable definition 41](#_Toc339955596)

[Table 50 – L1b fresnel sza variable definition 42](#_Toc894747227)

[Table 51 – L1b fresnel sza variable definition 42](#_Toc1251521602)

[Table 52 – L1b fresnel raa variable definition 43](#_Toc1227280226)

[Table 53 – L1b water leaving radiance product variables for water applications 43](#_Toc993919401)

[Table 54 – L1b water leavening radiance variable definition 43](#_Toc2041467288)

[Table 55 – L2a reflectance product variables 45](#_Toc168537485)

[Table 56 – L2b reflectance product variables 45](#_Toc453816721)

[Table 57 – Reflectance variable definition 46](#_Toc226452216)

[Table 58 – u\_random\_irradiance variable definition 46](#_Toc764239412)

[Table 59 – u\_systematic\_irradiance variable definition 47](#_Toc1771820758)

[Table 60 – quality\_flag variable definition 47](#_Toc507728857)

[Table 61 – L2a water reflectance product variables 47](#_Toc551820806)

[Table 62 – L2a water reflectance product variables without correction for NIR Similarity spectrum correction 47](#_Toc1232913130)

[Table 63 – L2a normalized water leaving reflectance product variables 48](#_Toc476334366)

[Table 64 – Reflectance variable definition 48](#_Toc103826720)

[Table 65 – u\_random\_irradiance variable definition 49](#_Toc1699623681)

[Table 66 – u\_systematic\_irradiance variable definition 49](#_Toc843407308)

[Table 67 – quality\_flag variable definition 49](#_Toc1096824055)

[Table 68 - reflectance\_nosc variable definition 49](#_Toc952383786)

[Table 70 – Normalized water leaving radiance 50](#_Toc1687712441)

[Table 71 – Auxiliary product data variables 50](#_Toc1107278272)

[Table 72 – L1b cloud cover variable definition 51](#_Toc778152576)

# Introduction

This document aims to specify definitions, conventions and formats of the various data products generated in the Hypernets land and water network processors.

## References

|  |  |
| --- | --- |
| RD-1 | Processor ATBD |
| RD-2 | Calibration data file spec |
| RD-3 | Rugged pc data file spec |

## Glossary and Acronyms

|  |  |
| --- | --- |
| CF | Climate and Forecast |
| NetCDF | Network common data format |
|  |  |
|  |  |
|  |  |

# Product Definitions

The Hypernets land and water network processors process field radiometer data from raw instrument counts to the surface reflectance product through a series of intermediate data products, which are referred to as different processing levels. These data processing Levels are defined in Table 1. It is the scope of this document to define the products generated by the land and water network processors.

Radiometer measurements are taken in a defined set of geometries called a sequence. Each geometry in a sequence is called a series, as it is composed of a set of repeat measurements called scans that are averaged (Deliverable 2.4 “User Requirements”). For the estimation of the surface reflectance (i.e., L2 data) and because radiance and irradiance measurements are not simultaneous, data series of a sequence are combined and temporally interpolated to a coincident time-stamp. Hence, Level 1a are the quality checked radiance and irradiance data products averaged per series and generated in the same processing pipeline for both the land and water networks and so the products are of the same format [RD-X]. Level 1b products are the quality radiance and irradiance data interpolated to a coincident time-stamp, required for the retrieval of the reflectance data. For the water network this means; the upwelling and downwelling radiance data, the downwelling irradiance, the estimated fresnel reflectance coefficient (i.e., fraction of downwelling radiance reflected at the air-water interface), the auxiliary variables for the retrieval of the fresnel reflectance, and, the estimated water leaving radiance. The estimation and retrieval of these variables are further described in Deliverable 5.2: “Water Network Design”. If the retrieval of the water leaving radiance improves in the future, the L1b file format may change accordingly (in contrast to the Level 2 file format). For the Land Network, the Level 1b data will include the radiance data per series and temporally interpolated irradiance data. Land and water network Level 2 products are produced through different processing algorithms.

Table 1 – List Hypernets Processor processing levels

|  |  |
| --- | --- |
| **Level** | **Type** |
| Ancillary | Generic term covering non-measurement data used in processing chain |
| Level 0 | Raw binary files (.spe format) |
| Level 1a | Calibrated instrument data, corrected for dark samples and averaged per series |
| Level 1b | Calibrated and quality checked radiance and irradiance measurements interpolated to a common time-stamp. |
| Level 2a | Evaluated surface reflectance (and, for the water network, the normalized water leaving radiance) |
| Level 2b | Temporally interpolated surface reflectance |

Table 2 – Hypernets products definition

|  |  |  |  |
| --- | --- | --- | --- |
| **Level** | **Abbreviated Name** | **Description** | **File Scope** |
| Ancillary | CDB | Instrument calibration and characterisation data | Defined in [RD-X] |
|  | MET | Instrument, system, site and component metadata file |  |
| 0 |  | Raw instrument data from rugged PC | Defined in [RD-X] |
| 1a | RAD | Quality checked radiance data | File per sequence |
|  | IRR | Quality checked irradiance data | File per sequence |
| *Water Network* | | | |
| 1b | WLR | Downwelling quality checked radiance, upwelling quality checked radiance, water leaving radiance, downwelling irradiance, fresnel reflectance | File per sequence |
| 2a | REF | Surface reflectance data, Water reflectance not corrected for the NIR Similarity Spectrum (Ruddick et al., 2006) and normalized water leaving radiance | File per sequence |
| Land Network | | | |
| 1b | RAD | Upwelling quality checked radiance |  |
| 2a | REF | Surface reflectance data (or water leaving reflectance for the Water Network) | File per sequence |
| 2b | REFD | Temporally interpolated surface reflectance data | File per day |
| *To be confirmed - possible future update* | | | |
| *3* | *REF* | *Reflectance data from Water 2a and Land 2b over a given time period* | *File between start and end date* |
|  | *NLW* | *Normalized water leaving radiance over a given time period* | *File between start and end date* |

# Product Conventions

This section defines the various conventions that apply to the Hypernets data product, including the product file naming convention.

## Product file format

Files shall be in the NetCDF CF-convention version 1.6 format.

## Network naming conventions

Hypernets products may derive from either the Land or Water network, the abbreviations for these are contained in Table 3.

Table 3 – Product network naming conventions

|  |  |
| --- | --- |
| **Abbreviated Name** | **Product Type** |
| L | Land network |
| W | Water network |

## Site name conventions

Table 4 defines the abbreviated name convention applicable to the individual Hypernets sites.

Table 4 – Site name conventions

|  |  |
| --- | --- |
| **Abbreviated Name** | **Site Name** |
| GBNA | Gobabeb, Namibia |
| WYUK | Wytham Woods, Untied Kingdom |
| BSBE | Blankaart South, Belgium |
| TCBE | Thornton-C, Belgium |
| … |  |

## Filename convention

This section specifies the file naming convention that applies to Hypernets data files. This naming convention is intended to allow the unique identification of all product files and summarise the contents.

The file name is composed of a defined sequence of data fields, separated by an underscore in the following way:

SYTEM\_NETWORK\_SITE\_LEVEL\_TYPE\_DATETIME\_VERSION.nc

For the calibration files the file name is similar except that it includes the system\_id and the date and time of the calibration.

SYTEM\_NETWORK\_SYSTEMID\_TYPE\_CALIBRATIONDATETIME\_VERSION.nc

The files are stored in the NetCDF data format and so have the extension “.nc” (except for the RGB images taken during the measurements by the instrument). The definition of the data fields and their allowed contents is described in Table 5.

Table 5 – File naming convention data fields

|  |  |
| --- | --- |
| **Field Name** | **Description** |
| SYSTEM | “HYPSTAR” |
| NETWORK | Name of product network. Values may be abbreviated network names defined in Table 4. |
| SITE | Name of data site. Values may be abbreviated site names defined in Table 4. |
| LEVEL | Data processing Level as defined in Table 2 |
| TYPE | Name of product type. Values may be abbreviated product type names defined in Table 2. |
| DATETIME | Denotes the acquisition end date and time as UTC, formatted as “YYYYMMDDHHMM”, except for L2b products where format should be “YYYYMMDD”. |
| VERSION | Denotes data version number, formatted as “vXX.X” |

Example

For version 1 of land network radiance product, acquired in Gobabeb at 11:30 on 4/2/2020, the filename should be:

HYPSTAR\_L\_GBNA\_L1A\_RAD\_202002041130\_v01.0.nc

For version 1 of water network L1B product, acquired at Blankaart South at 11:30 on 4/2/2020, the filename should be:

HYPSTAR\_W\_BSBE\_L1B\_WLR\_202002041130\_v01.0.nc

The RGB images taken with the instrument during the radiance and irradiance measurements at Blankaart South at 11:30 on 4/2/2020, the filename should be:

HYPSTAR\_W\_BSBE\_IMG\_RAD\_202002041130.png

HYPSTAR\_W\_BSBE\_IMG\_IRR\_202002041130.png

For the calibration file for the system with id “HYPSTAR01234” and calibration date 20200204, the filename should be:

HYPSTAR\_W\_HYPSTAR01234\_CDB\_20200204.nc

HYPSTAR\_W\_HYPSTAR01234\_MET\_20200204.nc

## Dimensions

All variables (Section 5 below) are along one or more of the following dimensions:

* “wavelength” – spectral dimension of measurements
* “series” – temporal dimension of measurements within a sequence
* “sequence” - average temporal dimension of measurements for a single standard sequence

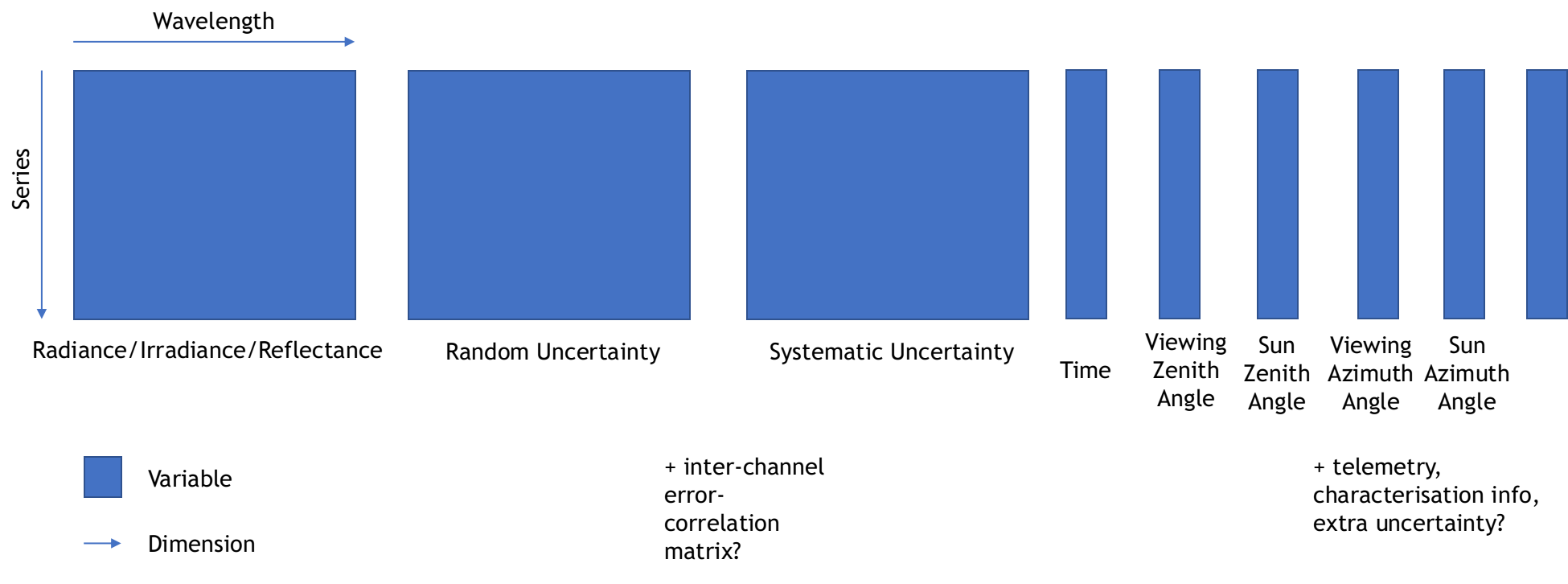


Figure 1. Illustration of a L1 file format and the L2a file format for the Land Network

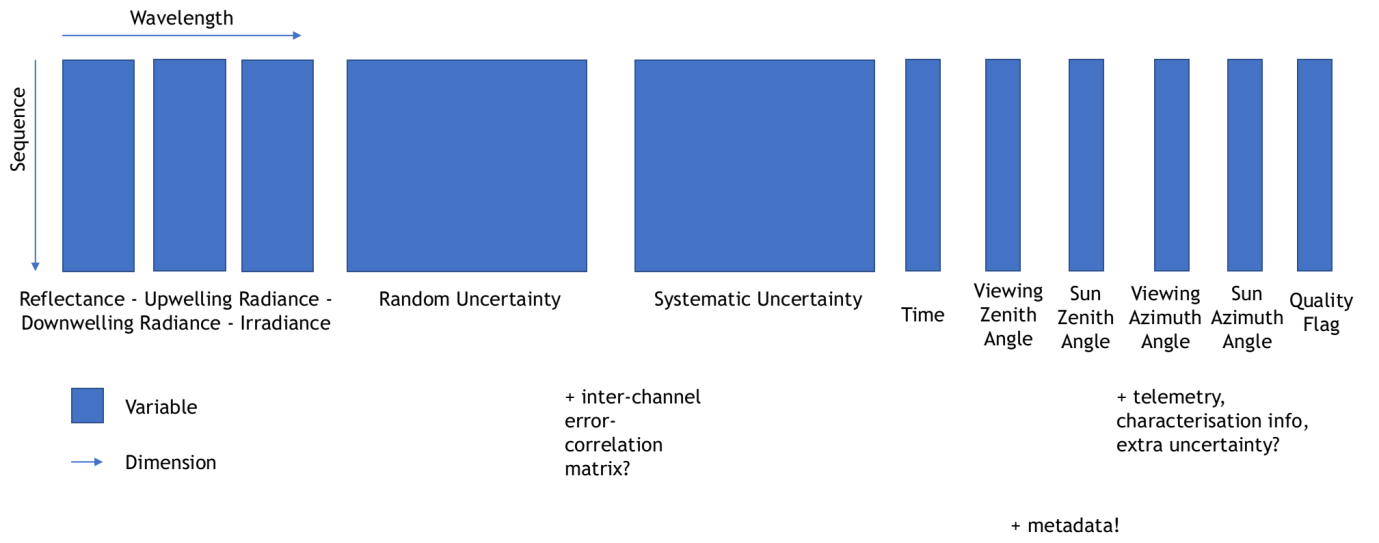


Figure 2. Illustration of a L1b and L2a file format for the water network

# Metadata

This section provides a description of the data product metadata. The first subsection describes metadata common to all product types following (when relevant) the INSPIRE directives (http://inspire.ec.europa.eu/glossary/Metadata) in accordance with the EN ISO 19115 for the metadata elements and the Dublin Core Metada Initiative (https://www.dublincore.org/specifications/dublin-core/dcmi-terms/). The second subsection describes the site, instrument, component and system metadata, respectively. This metadata partitioning allows to trace in detail the history of the system (e.g., modifications, repairs, updates in the system, components of the system, instrument, or, instrument set-up). Therefore, metadata keys are defined allowing to identify entities, fix relationships between metadata entities and accessing the records of these entities. Figure 3 shows the metadata diagram with the metadata fields used as unique identification keys. A unique identifier per system will allow to trace the history of the data at a given location and/or from a given instrument. For instance, the system ID from a system at a given place with a same instrument but for which we have replaced the radiance head, will be modified. This allows a user to select all the data provided by a single instrument while for a more advanced user it will be possible to compare the data before and after the radiance head has been replaced.

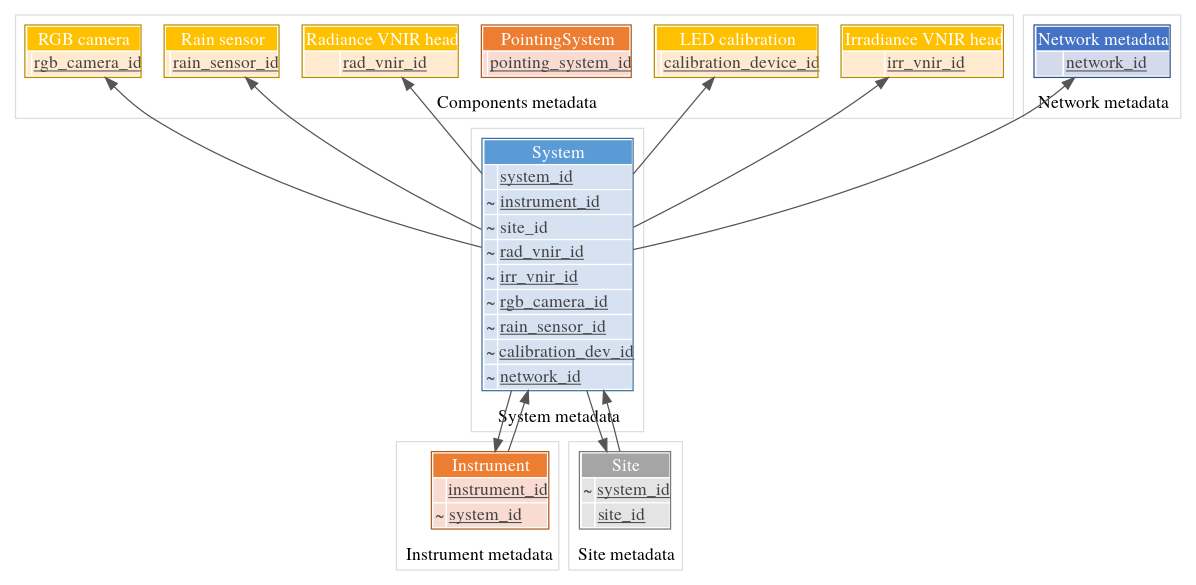


Figure 3. Metadata diagram with keys only

Table 6 to Table 14 provide for each metadata field:

* “names” : Name of the metadata as provided in the netcdf file
* “description”: Short description of the required metadata
* “value”: Example of a value that may be given to this metadata

Common metadata and product metadata will be added to any data file. These metadata include the system\_id based on which the user could also, if required, download the system metadata (including the instrument, site and component metadata).

## Common Metadata

The common metadata describe the content of the data file and ensure CF compliancy. Global attributes can be thought of as conveying five kinds of essential information. This is defined in Table 6:

* What: what are the data in this dataset;
* Where: the spatial coverage of the data;
* When: the temporal coverage of the data;
* Who: who produced the data;
* How: how were the data produced and made available.

Table 6 – Common metadata

|  |  |  |
| --- | --- | --- |
| Name | Description | Value |
| What |  |  |
| title | A descriptive title for the dataset | “Hyperspectral network dataset of surface reflectance”, “Hyperspectral radiance data” |
| type | Type of data contained in the file, spatial data set series (series), spatial data set (dataset) or spatial data services (services). | “dataset” |
| abstract | This is a brief narrative summary of the content of the resource. The value domain of this metadata element is free text. | “The HYPERNETS project (Horizon 2020 research and innovation, grant agreement No 775983) has the overall aim to provide high quality in situ measurements to support the (visible/SWIR) optical Copernicus products. Therefore a new multi-head hyperspectral spectroradiometer dedicated to land and water surface reflectance validation with instrument pointing capabilities and embedded calibration device has been established. The instrument has been deployed at 24 sites covering a range of water and land types and a range of climatic and logistic conditions (www.hypernets.eu)." |
| conventions | Name of the conventions followed by the dataset | “CFv72” and ”NVS2.0” |
| product\_name | Product name for data provider. | “HYPPSTARR\_L\_GBNA\_IRR\_202002041130\_v01.0.nc” |
| product\_version | Release number of the data file | “0.1” |
| netcdf\_version | Netcdf file format version (if applicable) | “1.6” |
| history | Provides an audit trail for modifications to the original data. It should contain a  separate line for each modification, with each line beginning with a timestamp,  and including modification name and optional modification arguments. | “20200401T00:02:00Z :  Creation, 20280323T11:56:12Z :  Recalibrated data” |
| processor\_name | Name of the processor for the computation of the radiance and irradiance product | “hypernets\_processor” |
| processor\_version | Version number of the processor | “v001” |
| processor\_configuration\_file | Configuration filename used for the processing of the data | “https://github.com/HYPERNETS/hypernets\_processor/tree/master/examples/config\_files/config.txt” |
| processor\_atbd | URL to the ATBD/documentation about the processing | “https://github.com/HYPERNETS/hypernets\_processor/atbd/L1” |
| date\_created | The date which specifies when the metadata record was created or update (ISO 8601: yyyy-MM-ddTHH:mm:ssZ) | “2020-04-01T00:02:00Z” |
| references | Web based reference that describe the data or methods used to produce it | ”https://hypernets-processor.readthedocs.io/en/latest/” |
| source | The method of production of the original data. If it was model-generated, source  should name the model and its version, as specifically as could be useful. If it is  observational, source should characterize it (e.g., “surface observation” or  “radiosonde”) | “surface observations” |
| topic\_category | The topic category is a high-level classification scheme to assist in the grouping and topic-based search of available spatial data resources. (in accordance with ISO191152) | “geoscientific information, environement,oceans,inlandwaters”, "land, environment, geoscientific information" |
| keyword | INSPIRE requests, if the resource is a spatial data set or spatial data set series, at least one keyword provided from the general environmental multilingual thesaurus\*. The keyword value is a commonly used word, formalised word or phrase used to describe the subject. While the topic category is too coarse for detailed queries, keywords help narrowing a full text search and they allow for structured keyword search.The value domain of this metadata element is free text.  \* GEMET - version 4.1.4, 13 Feb 2020, AGROVOC is an RDF/ SKOS-XL concept scheme, INSPIRE Spatial Data Theme | “[Environmental monitoring Facilities](https://inspire.ec.europa.eu/Themes/120/2892) (INSPIRE Spatial Data Theme), reflectance (http://aims.fao.org/aos/agrovoc/c\_28538), optical properties (http://aims.fao.org/aos/agrovoc/c\_5371), vegetation (http://www.eionet.europa.eu/gemet/concept/8922), inland waters (http://www.eionet.europa.eu/gemet/concept/4333), sea (http://www.eionet.europa.eu/gemet/concept/7495)” |
| comment | Miscellaneous information about the data or methods used to produce it. Any free-  format text is appropriate. | “Any free-format text is appropriate.” |
| locator | Link(s) to the resource and/or the link to additional information about the resource. The value domain of this metadata element is a character string, commonly expressed as uniform resource locator (URL). | “www.hypernets.eu, www.waterhypernet.org” |
| Where |  |  |
| area | Geographical coverage | “Global” |
| easting |  | “longitude” |
| northing |  | “latitude” |
| southermost\_latitude | This is the extent of the resource in the geographic space, given as a bounding box.The bounding box shall be expressed with westbound and eastbound longitudes, and southbound and northbound latitudes in decimal degrees, with a precision of at least two decimals. Value between “-90.00” and “90.00”. | “-90.00” |
| northernmost\_latitude | Value between “-90.00” and “90.00”. | “90.00” |
| westernmost\_longitude | Value between “-180.00” and “180.00”. | “-180.00” |
| easternmost\_longitude | Value between “-180.00” and “180.00”. | “180.00” |
| When |  |  |
| time\_coverage\_start | Start date of the data (ISO 8601). | “2020-04-01T00:02:00Z” |
| time\_coverage\_end | End date of the data (ISO 8601). | “2020-04-01T00:02:00Z” |
| Who |  |  |
| creator\_name | Data provider name | “Sam Hunt” |
| creator\_email | Data provider email | “sam.hunt@npl.co.uk” |
| responsible\_party | Institution in charge of the data distribution (and management) of the data file | “National Physical Laboratory, UK” |
| acknowledgement |  | “HYPERNETS project is funded by Horizon 2020 research and innovation program, Grand Agreement No 775993. Consortium of project of the Hypernets test sites, .... are greatly acknowledged.” |
| How |  |  |
| project\_name | Project name and grand number if any | “H2020 HYPERNETS GN 775993” |
| language | This is the language in which the metadata elements are expressed. | “English” |
| operational\_status | Statement like : “under development” or “operational” or “experimental” | “operational” |
| limitations | Provide information on the limitations to access and the reasons for them or, in case of no limitations on public access, indicate that fact. The value domain of this metadata element is free text, e.g., “no limitations” or “registered users only”. | “no limitations to public access” |
| licence | Creative Commons licenses providing information on the publication and re-use of the data. | “Attribution-NonCommercial-NoDerivs CC BY-NC-ND” |
| conformity | Degree of conformity: Conformant (conformant), not conformant (NotConformant) or not evaluated (notEvaluated) | “notEvaluated” |
| lineage | This is a statement on process history and/or overall quality of the spatial data set. Where appropriate it may include a statement whether the data set has been validated or quality assured, whether it is the official version (if multiple versions exist). The value domain of this metadata element is free text. | “Quality assured following [URL data processing/QC]” |

## Instrument and system Metadata

Instrument and system metadata are described in Table 7 and Table 8, respectively. As described in Figure 3, relations between these tables are ensured by “keys” metatafields. These keys also allows to link these tables with the essential components metadata table (i.e.,Table 9) and auxiliary components (i.e., Table 10) and site metadata (i.e., Table 11). Key metadata fields are given in bold.

### Instrument metadata

Table 7 – Instrument metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| **instrument\_id** | Serial number or identifier for the instrument package mounted in system\_id | “HYDER01234” |
| instrument\_manufacturer | Name of manufacturer for the instrument in instrument\_id | “Tartu University” |
| instrument\_model | Name of make or model of the instrument in instrument\_id (ex/ ‘HYPSTAR’). | “HYDER” |
| instrument\_date\_manufacture | Date of manufacture of the instrument in instrument\_id | “2020-04-01” |
| instrument\_version | Design version of the instrument in instrument\_id | “v001” |
| instrument\_firmware | Name of the firmware within the instrument | “Firmware4HYDER” |
| instrument\_firmware\_version | Firmware version for the instrument in instrument\_id | “v001” |
| instrument\_documentation\_references | Reference to documentation about the instrument | “www.hypernets/firmware4hyppstarr/” |
| instrument\_history | Free text about the instrument history and description | “2020-04-01T00:02:00Z :  Creation\n  2028-03-23T11:56:12Z :  Radiance head replaced” |
| instrument\_deployment\_date | Date of deployment of the instrument (should correspond to date of the first data send by the instrument) | “2020-04-25” |

### System metadata

Table 8 – System metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| **system\_id** | Identifier for the deployed system package (instrument + pan\_tilt + sensors) | e.g. “HYPSTAR00102” |
| system\_model | Name of make or model of the deployed system (ex/ ‘PANTHYR’ or name of HYPERNETS package) in system\_id | “HYPSTAR” |
| system\_manufacturer | Name of manufacturer for the deployed system package in system\_id | “[Laboratoire d'Océanographie de Villefranche](http://http://lov.obs-vlfr.fr/) UMR 7093 - CNRS / Sorbonne Univ” |
| system\_date\_manufacture | Date of manufacture of the system in system\_id | “2028-03-01” |
| system\_version | Design version of the system in system\_id | “v02” |
| system\_firmaware\_version | Firmware version for the system in system\_id | “v02” |
| system\_logfile | Reference to logfile of the system including details about maintenance, updates, cleaning, ect. | “www.waterhypernet/HYPSTAR01\_GBNA/logfile.txt” |
| system\_documentation\_references | Reference to documentation about the system | www.hypernets.eu/system\_documentation |
| system\_deployment\_date | Date of deployment of the system (should correspond to date of the first data send by the system). Data should be later or similar to the instrument\_deployment\_date | “2028-03-23” |
| system\_deployment\_height | Height of the system in meters just above the surface (used as reference for the radiance and irradiance measurements) | “2” |
| system\_calibration\_file | System calibration and characterisation file for the entire system used for the data processing | ”HYPSTAR\_L\_CDB\_HYPSTAR00102\_20220311.nc" |
| system\_description | If relevant free format text with short description about the system useful for the user | “damn system right below a bird nest” |

### Components metadata

The following tables describe the metadata required for each component within the system. Essential components are the radiance and irradiance visible-near infrared and shortwave infrared (referred to as vnir and swir, respectively) head, the pointing system and the calibration LED device. Auxiliary components are, for instance, rain sensor, rgb camera, relative humidity sensor, light sensor, ect., and may evolve with time (and subsequently the requested metadata).

Tartu and LOV I might need your input here for the instrument related metadata (radiance and irradiance entrance optics, visible-near infrared and swir spectrometers, LED, ...) Feel free to change it all ;)

Table 9 – Metadata of essential components within a HYPSTAR system

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| ***radiance\_[vnir][swir]\_head*** | | |
| **radiance\_[wwww]\_head\_id** | Serial number of the radiance/irradiance head. For HYPSTAR this sensor is inside of the instrument in instrument\_id. | “IBSENUVNIR001” |
| radiance\_[wwww]\_head\_manufacturer | Name of manufacturer | “Ibsen” |
| radiance\_[wwww]\_head\_model | Name of make or model | “Freedom FSA-101” |
| Radiance\_[wwww]\_head\_manufacture | Date of manufacture of the radiance head | “20201202” |
| radiance\_[wwww]\_head\_version | Design version | “101” |
| radiance\_[wwww]\_head\_firmware\_version | Firmware version for the sensor | “v001” |
| radiance\_[wwww]\_head\_ documentation\_reference | URL to the documentation of the radiance head (e.g., manufacturer documentation, publications) | “https://hypernets.to.ee/documentation” |
| radiance\_[wwww]\_head\_description | If relevant, free-format text about specific description of the component | “custom 25 μm slit width for the VNIR spectral region” |
| radiance\_[wwww]\_head\_radiometric\_resolution | Radiometric resolution (bits) | “16” |
| radiance\_[wwww]\_head\_spectral\_range | Spectral range of the radiance head | “190-1100” |
| radiance\_[wwww]\_head\_spectral\_sampling | Spectral sampling for a single channel/pixel | “1.5” |
| radiance\_[wwww]\_head\_spectral\_resolution | Spectral resolution expressed in Full-Width-Half\_Maximum (FWHM) in nm | “3” |
| radiance\_[wwww]\_head\_spectral\_accuracy | Spectral accuracy in nm | “0.3” |
| radiance\_[wwww]\_head\_spectral\_fov | Field of view of the radiance sensor in decimal degrees | “5” |
| radiance\_[wwww]\_head\_cosine\_documentation\_reference | URL to the files containing the angular response functions of the radiance head | “www.waterhypernet.org/calibration/IBSENUVNIR001/cosine/” |
| radiance\_[wwww]\_head\_calibration\_documentation\_reference | URL to the files containing the calibration coefficients of the radiance head | “www.waterhypernet.org/calibration/IBSENUVNIR001/calcoeff/” |
| radiance\_[wwww]\_head\_linearity\_documentation\_reference | URL to the files containing the radiometric linearity data | “www.waterhypernet.org/calibration/IBSENUVNIR001/lin/” |
| Radiance\_[wwww]\_head\_spectral\_response\_documentation\_reference |  | “www.waterhypernet.org/calibration/IBSENUVNIR001/spectralResp” |
| ***irradiance\_[vnir][swir]\_head*** | | |
| **irradiance\_[wwww]\_head\_id** | Serial number of the irradiance head | “SJ1002SMA001234” |
| irradiance\_[wwww]\_head\_manufacturer | Name of manufacturer of the sensor head | “CMS Schreder” |
| Irradiance\_head\_manufacture | Date of manufacture | “20190120” |
| irradiance\_[wwww]\_head\_model | Name of make or model | “J1002-SMA” |
| irradiance\_[wwww]\_head\_version |  | “v001” |
| irradiance\_[wwww]\_head\_ documentation\_reference | URL to documentation of the irradiance head including characterisation/calibration files | “www.waterhypernet.org/calibration/SJ1002SMA001234/” |
| irradiance\_[wwww]\_head\_description | Any free-format text if required with additional information/specifications | “or will we have an in-house designed irradiance entrance optics” |
|  |  |  |
| ***[Pointing system]*** | | |
| **pointing\_system\_id** | Unique identification for the component | “MAD01234” |
| pointing\_system\_manufacturer | Name of the manufacturer of the pointing system | “Will Burt” |
| pointing\_system\_model | Date of manufacture | “Bowler-RX” |
| pointing\_system\_date\_manufacture | Name of make or model | “20180101” |
| pointing\_system\_version | Design version | “RX001” |
| pointing\_accuracy | Accuracy of the pointing device in degrees | “1” |
| pointing\_range\_azimuth | Azimuth range of the pointing device in degrees | “0-359” |
| pointing\_range\_zenith | Zenith range of the pointing device in degrees | “2-180” |
| pointing\_system\_documentation\_directory | URL to the documentation of the pointing system | “https://www.willburt.com/mad/pan-and-tilt-heads/light-duty” |
| pointing\_system\_description | Any free-format text if required with additional information/specifications | “pan and tilt with custom azimuth to 359°” |
| ***[Calibration device]*** | | |
| **calibration\_device\_id** | Identifier for the calibration device | “CALspars01234” |
| calibration\_device\_manufacturer | Name of manufacturer for the the calibration device | “Tartu University” |
| calibration\_device\_model | Name of make or model of the deployed the calibration device | e.g. : “Calspars01” |
| calibration\_device\_date\_manufacture | Date of manufacture of the the calibration device | e.g. “20200101” |
| calibration\_device\_version | Design version of the the calibration device | “v01” |
| Calibration\_device\_LED\_ID | Identifier for the LED source within the calibration device | “LOLTW01234” |
| Calibration\_device\_LED\_model | Description of LED source used within the calibration device | “LTW-2S3D7” |
| Calibration\_device\_LED\_manufacturer | Manufacturer of the LED source within the calibration device | “Lite-On” |
| calibration\_device\_documentation\_directory | URL to the documentation of the calibration device including files or reference to the calibration files of the LED source | “https://www.hypernets/eu/Calspars\_CalibrationDevice” |
| calibration\_device\_description | Any free-format text if required with additional information/specifications | “I found the CALspars a nice name for the LED device but HyLight maybe better” |
| calibration\_device\_id | Identifier for the calibration device | “CALspars01234” |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

Table 10 – Auxiliary components metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| ***[rgb\_camera][rain\_sensor][light\_sensor]*** | | |
| **[name]\_id** | Unique identification for the component | “cameraID01234”, “rainsensorID01234” |
| [name]\_manufacturer | Manufacturer of the component | “ABUS”, “KemoElectronic” |
| [name]\_date\_manufacture | Data of manufacture | “20191102” |
|  |  |  |
|  |  |  |
|  |  |  |

## Site Metadata

Table 11 – Site metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| **site\_id** | Unique site identification | “BSBE” |
| site\_description | Short site description with some details about the target surface/water type | ”De Blankaart, Belgium Viewing direction, southern side of the reservoir” |
| site\_latitude | Latitude in decimal degrees with 6 decimals | "50.836404” |
| site\_longitude | Longitude in decimal degrees with 6 decimals | “4.375634” |
| site\_owner | Owner of the site (public or private institute) | “De Watergoep” |
| site\_operator | Operator at the site (e.g., during the project this should be a member of the consortium) | “RBINS” |
| site\_manager | Site manager (not necessarily a member of the consortium) | “De Watergroep” |
| site\_contact\_details | At least name and email of the contact person at the site | “Clémence Goyens, [cgoyens@naturalsciences.be](mailto:cgoyens@naturalsciences.be)” |
| Site\_documentation reference | URL to the documentation of the site (including documentation about spatial and temporal variability, guidelines in terms of measurement and validation protocols and other possible publications) | “www.waterhypernet.org/sites/deBlankaart/South/” |

## Product Metadata

### Level 1a Product Metadata

#### Radiance/Irradiance Product Metadata

Table 12 provides additional radiance/irradiance product metadata for the L1a data (both for radiance and irradiance data and for the Land and Water Network.

Table 12 – Radiance/irradiance product metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| sequence\_id | Unique identifier of the sequence including references to site, date and time (see Sequence Scheduler) | “SEQ20200312T135926” |
| **system\_id** | Unique identifier of the system used for the measurements (key metadata, see Table 8) | “HYPSTAR001234” |
| instrument\_config\_file | Filename of the instrument configuration file | “https://github.com/HYPERNETS/hypernets\_processor/blob/metareader/hypernets\_processor/data\_io/tests/reader/SEQ20200312T135926/config.txt” |
| sequence\_file | Filename of the sequence scheduler | “https://github.com/HYPERNETS/hypernets\_processor/blob/metareader/hypernets\_processor/data\_io/tests/reader/SEQ20200312T135926/test\_STD.csv” |
| inputfile | Filename of the raw data file | “https://github.com/HYPERNETS/hypernets\_processor/blob/metareader/hypernets\_processor/data\_io/tests/reader/SEQ20200312T135926/RADIOMETER/01\_002\_-030\_2\_057\_8\_01\_0000.spe” |
| vza\_average | Average viewing zenith angle during the series (decimal degrees with 3 decimals) | 57.000 |
| saa\_average | Average solar azimuth angle during the series (decimal degrees with 3 decimals) | 190.000 |
| raa\_average | Average relative azimuth angle from sun to sensor during the series (decimal degrees with 3 decimals) | 326.000 |
| sza\_average | Average solar zenith zenith angle during the series (decimal degrees with 3 decimals, 0°is at nadir and 90° is at horizon) | 50.000 |
| vza\_min | Average viewing zenith angle during the series (decimal degrees with 3 decimals) | 57.000 |
| saa\_min | Minimum solar azimuth angle during the series (decimal degrees with 3 decimals) | 190.000 |
| raa\_min | Minimum relative azimuth angle from sun to sensor during the series (decimal degrees with 3 decimals) | 326.000 |
| sza\_min | Minimum solar zenith angles during the series (decimal degrees with 3 decimals, 0°is at nadir and 90° is at horizon) | 50.000 |
| vza\_max | Average viewing zenith angle during the series (decimal degrees with 3 decimals) | 57.000 |
| saa\_max | Maximum solar azimuth angle during the series (decimal degrees with 3 decimals) | 190.000 |
| raa\_max | Maximum relative azimuth angle from sun to sensor during the series (decimal degrees with 3 decimals) | 326.000 |
| sza\_max | Maximum solar zenith angles during the series (decimal degrees with 3 decimals, 0°is at nadir and 90° is at horizon) | 50.000 |
| spectral\_range | Spectral range of the dataset in nm | “400-1700” |
| spectral\_resolution | Spectral sampling of the dataset in nm | “3” |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

### Level 1b Product Metadata

#### Land radiance and irradiance L1b product metadata

Table 13 - Land: Radiance and Irradiance product metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

#### Water Radiance, Irradiance and Water-leaving radiance L1b Product Metadata

Table 14 provides additional (in addition to Table 12) products metadata required for the Level 1b data.

Table 14 – Water: Downwelling and upwelling radiance, downwelling irradiance, surface reflected upwelling radiance and water-leaving radiance product metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| Fresnel\_type | Reference to the fresnel correction applied to the data for the computation of the water leaving radiance (e.g., “Mobley1999” and “Mobley2015” for Mobley’s (1999) and (2015) look up tables, respectively) | “Mobley1999” |
|  |  |  |
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|  |  |  |
|  |  |  |

### Level 2a Product Metadata

#### Land Reflectance L2a Product Metadata

Table 15 - Land: Reflectance product metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

#### Water Reflectance and Normalized Water-leaving Radiance L2a Product Metadata

For the Water Network, the product metadata for the Level 2a products should include, in addition to the metadata provided in Table 12 and Table 14, also the metadata fields described in Table 16.

Table 16 – L2a metadata for the Water Network

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| Wavelen1 | First wavelength used for the NIR-similarity spectrum correction in nm used for the computation of the water reflectance “REF” (see Ruddick et al., 2006) | “720” |
| Wavelen2 | Second wavelength used for the NIR-similarity spectrum correction in nm used for the computation of the water reflectance “REF” | “780” |
| epsave | Average reflectance ratio at wavelen1 and wavelen2 for the NIR similarity correction (Ruddick et al., 2006) | “0.662967” |
| epmin | Min reflectance ratio at wavelen1 and wavelen2 for the NIR similarity correction (Ruddick et al., 2006) | “0.603160” |
| epmax | Max reflectance ratio at wavelen1 and wavelen2 for the NIR similarity correction (Ruddick et al., 2006) | “0.762356” |
| epstd | Standard deviation reflectance ratio at wavelen1 and wavelen2 for the NIR similarity correction (Ruddick et al., 2006) | “0.057877” |
|  |  |  |

### Level 2b Product Metadata

#### Land temporally interpolated surface reflectance L2b Product Metadata

# Variables

This section provides a description of the data product variables. The first subsection describes variables common to all product types (as defined in Table 2). The following subsections then define per data type variables.

## Common Variables

The common data variables are defined in Table 15. The remaining tables in this subsection define each of the common data variables. Standard names and long names follow, when possible, the CF standard names V72 (http://cfconventions.org/Data/cf-standard-names/72/build/cf-standard-name-table.html). When relevant the “Uniform Resource Identifier (URI)” following the NERC Vocabulary Server is provided together with the variable “Identifier”, “Prefered label” and “Alternative label”.

Table 17 – Common product data variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| wavelength | wavelength | int32 | wavelength |
| viewing\_azimuth\_angle | sensor\_azimuth\_angle | int32 | series |
| viewing\_zenith\_angle | sensor\_zenith\_angle | int32 | series |
| solar\_azimuth\_angle | solar\_azimuth\_angle | int32 | series |
| solar\_zenith\_angle | solar\_zenith\_angle | int32 | series |
| acquisition\_time | time | int32 | series |

Table 18 – wavelength variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **wavelength** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | wavelength |  |
| long\_name | Wavelength |  |
| units | nm |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |
|  | preferred\_symbol | wv |  |

Table 19 – viewing\_azimuth\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **viewing\_azimuth\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | sensor\_azimuth\_angle |  |
| long\_name | sensor\_azimuth\_angle is the horizontal angle between the line of sight from the observation point to the sensor and a reference direction at the observation point, which is often due north. The angle is measured clockwise positive, starting from the reference direction. A comment attribute should be added to a data variable with this standard name to specify the reference direction. |  |
| reference | True North |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |
|  | preferred\_symbol | vaa |  |

Table 20 – viewing\_zenith\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **viewing\_zenith\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | sensor\_zenith\_angle |  |
| long\_name | sensor\_zenith\_angle is the angle between the line of sight to the sensor and the local zenith at the observation target. This angle is measured starting from directly overhead and its range is from zero (directly overhead the observation target) to 180 degrees (directly below the observation target). Local zenith is a line perpendicular to the Earth's surface at a given location. "Observation target" means a location on the Earth defined by the sensor performing the observations. |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |
|  | preferred\_symbol | vza |  |

Table 21 – sun\_azimuth\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **Solar\_azimuth\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | solar\_azimuth\_angle |  |
| long\_name | Solar azimuth angle is the horizontal angle between the line of sight to the sun and a reference direction which is often due north. The angle is measured clockwise. |  |
| reference | True North |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |
|  | preferred\_symbol | saa |  |

Table 22 – sun\_zenith\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **Solar\_zenith\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | solar\_zenith\_angle |  |
| long\_name | Solar zenith angle is the the angle between the line of sight to the sun and the local vertical. |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |
|  | preferred\_symbol | sza |  |

Table 23 – acquisition\_time variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **acquisition\_time** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | time |  |
| long\_name | Acquisition time in seconds since 1970-01-01 00:00:00 |  |
| units | s |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

## Level 1a Variables

#### Land and Water L1a Radiance Variables

Data variables specific to radiance products are defined in Table 22. The remaining tables in this subsection define each of the listed data variables.

Table 24 – Radiance product variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| radiance | radiance | int32 | wavelength, series |
| u\_random\_radiance | u\_random\_radiance | int16 | wavelength, series |
| u\_systematic\_radiance | u\_systematic\_radiance | int16 | wavelength, series |
| quality\_flag | quality\_flag | int16 | series |
| inclination | sensor\_inclination | int16 | series |
| scans\_total | total\_number\_scans | int16 | series |
| scans\_qc | total\_qualitychecked\_scans | int16 | series |
|  |  |  |  |

Table 25 – radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **radiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | radiance\_per\_unit\_wavelength\_in\_air |  |
| long\_name | Radiance is the radiative flux in a particular direction, per unit of solid angle. The direction from which it is coming must be specified, for instance with a coordinate of zenith\_angle. |  |
| units | mW m^-2 sr^-1 nm^-1 | CF standards suggest Wm^-2m^-1sr^-1 however “nm” and “mW” is preferred |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag, inclination, scans\_total, scans\_qc, vza, sza, saa, raa |  |

Table 26 – u\_random\_radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_random\_radiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_random\_radiance |  |
| long\_name | Random radiance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 27 – u\_systematic\_radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_systematic\_radiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_systematic\_radiance |  |
| long\_name | Systematic radiance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Partners, please provide feedback about possible flags you would like to consider

Table 28 – quality\_flag variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **quality\_flag** | **Attribute** | **Value** | **Comment** |
| standard\_name | quality\_flag |  |
| long\_name | A variable with the standard name of quality\_flag contains an indication of assessed quality information of another data variable. The linkage between the data variable and the variable or variables with the standard\_name of quality\_flag is achieved using the ancillary\_variables attribute. |  |
| flag\_masks | 1,2,4,8,16,32,64,128 |  |
| flag\_meanings | Blah  Blah  Blah |  |

TARTU could you provide some input here about the what kind of information is given currently by the instrument?

Table 29 – Inclination variable

|  |  |  |  |
| --- | --- | --- | --- |
| **inclination** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | sensor\_inclination | In the CF standards:  pitch  roll |
| long\_name | sensor\_inclination |  |
| units | degrees |  |
|  |  |  |  |

Table 30 – Total number of scans variable

|  |  |  |  |
| --- | --- | --- | --- |
| **scans\_total** | **Attribute** | **Value** | **Comment** |
| standard\_name | total\_number\_scans |  |
| long\_name | Total number of scans within a series |  |
| \_FillValue | -999999 |  |
|  |  |  |

Table 31 – Quality checked scans

|  |  |  |  |
| --- | --- | --- | --- |
| **scans\_qc** | **Attribute** | **Value** | **Comment** |
| standard\_name | total\_qualitychecked\_scans |  |
| long\_name | Total number of scans that passed the quality check within a single series (need to be > than Nx, see Water Network Design) |  |
| \_FillValue | -999999 |  |
|  |  |  |

#### Land and Water Irradiance L1a Variables

Data variables specific to irradiance products are defined in Table 30. The remaining tables in this subsection define each of the listed data variables.

Table 32 – Irradiance product variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| irradiance | irradiance | int32 | wavelength, series |
| u\_random\_irradiance | u\_random\_irradiance | int16 | wavelength, series |
| u\_systematic\_irradiance | u\_systematic\_irradiance | int16 | wavelength, series |
| quality\_flag | quality\_flag | int32 | series |
| inclination | sensor\_inclination | int16 | series |
| scans\_total | total\_number\_scans | int16 | series |
| scans\_qc | total\_qualitychecked\_scans | int16 | series |

Table 33 – irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **irradiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | Spherical\_irradiance\_per\_unit\_wavelength\_in\_air |  |
| long\_name | Spherical irradiance is the radiation incident on unit area of a hemispherical (or "2-pi") collector. |  |
| units | mW m^-2 nm^-1 | CF standards suggest Wm^-2m^-1sr^-1 however “nm” and “mW” is preferred |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag, inclination, scans\_total, scans\_qc, saa, sza |  |

Table 34 – u\_random\_irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_random\_irradiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_random\_irradiance |  |
| long\_name | Random irradiance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 35 – u\_systematic\_irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_systematic\_irradiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_systematic\_irradiance |  |
| long\_name | Systematic irradiance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 36 – quality\_flag variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **quality\_flag** | **Attribute** | **Value** | **Comment** |
| standard\_name | quality\_flag |  |
| long\_name | A variable with the standard name of quality\_flag contains an indication of assessed quality information of another data variable. The linkage between the data variable and the variable or variables with the standard\_name of quality\_flag is achieved using the ancillary\_variables attribute. |  |
| flag\_masks | 1,2,4,8,16,32,64,128 |  |
| flag\_meanings | Blah  Blah  Blah |  |

Table 37 – Inclination variable

|  |  |  |  |
| --- | --- | --- | --- |
| **inclination** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | Sensor\_inclination | In the CF standards I found platform\_pitch  platform\_roll |
| long\_name | Sensor\_inclination |  |
| units | degrees |  |
|  |  |  |  |

Table 38 – Total number of scans variable

|  |  |  |  |
| --- | --- | --- | --- |
| **scans\_total** | **Attribute** | **Value** | **Comment** |
| standard\_name | Total\_number\_scans |  |
| long\_name | Total number of scans within a series |  |
| \_FillValue | -999999 |  |
|  |  |  |

Table 39 – Quality checked scans

|  |  |  |  |
| --- | --- | --- | --- |
| **scans\_qc** | **Attribute** | **Value** | **Comment** |
| standard\_name | Total\_qualitychecked\_scans |  |
| long\_name | Total number of scans that passed the quality check within a single series (need to be > than Nx, see Water Network Design) |  |
| \_FillValue | -999999 |  |
|  |  |  |

## Level 1b Radiance and Irradiance Variables

### Land Radiance and Irradiance L1b Variables

### Water Radiance and Irradiance L1b Variables

Processed and quality checked irradiance and radiance variables provided in the Level 1b product data (required for the retrieval of the water reflectance and normalized water leaving radiance data, Level 2a) are defined and each of the listed data variables.

#### Upwelling radiance

Table 40 – L1b upwelling radiance product variables water applications

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| lu | upwelling\_radiance\_per\_unit\_wavelength\_in\_air  alias: upwelling\_spectral\_radiance\_in\_air | int32 | wavelength, sequence |
| u\_random\_lu\* | u\_random\_upwelling\_radiance | int16 | wavelength, sequence |
| u\_systematic\_lu\* | u\_systematic\_upwelling\_irradiance | int16 | wavelength, sequence |
| quality\_flag\_lu\* | quality\_flag\_lu | int32 | sequence |
| scans\_total\_lu\* | total\_number\_scans\_lu | int16 | sequence |
| scans\_qc\_lu\* | total\_qualitychecked\_scans\_lu | int16 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 41 – L1b upwelling radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **lu** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | upwelling\_radiance\_per\_unit\_wavelength\_in\_air  *alias:* upwelling\_spectral\_radiance\_in\_air |  |
| long\_name | Upwelling radiation is radiation from below. It does not mean "net upward". The sign convention is that "upwelling" is positive upwards and "downwelling" is positive downwards. Radiance is the radiative flux in a particular direction, per unit of solid angle. The direction towards which it is going must be specified, for instance with a coordinate of zenith\_angle. |  |
| reference | See system\_height\_deployment |  |
| units | mW m^-2 nm^-1 sr^-1 | W m-2 m-1 sr-1 |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag\_lu,scans\_total\_lu, scans\_qc\_lu, sza, saa, vza, vaa |  |
|  | NERC URI | [http://vocab.nerc.ac.uk/collection/P01/current/TTWTIR01/](http://vocab.nerc.ac.uk/collection/P01/current/TTWTIR01/" \t "/home/cgoyens/Documents\\x/_blank) |  |
|  | NERC Identifier () | SDN:P01::TTWTIR01 |  |
|  | NERC Preferred label (en) | Total water radiance of electromagnetic radiation (unspecified single wavelength) from the water body by radiometer |  |
|  | NERC Alternative label (en) | Lsfc\_lambda |  |

#### Downwelling radiance

Table 42 – L1b downwelling radiance product variables for water applications

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| ld | downwelling\_radiance\_per\_unit\_wavelength\_in\_air  alias: downwelling\_spectral\_radiance\_in\_air | int32 | wavelength, sequence |
| u\_random\_ld\* | u\_random\_downwelling\_radiance | int16 | wavelength, sequence |
| u\_systematic\_ld\* | u\_systematic\_downwelling\_irradiance | int16 | wavelength, sequence |
| quality\_flag\_ld\* | quality\_flag\_ld | int32 | sequence |
| scans\_total\_ld\* | total\_number\_scans\_ld | int16 | sequence |
| scans\_qc\_ld\* | total\_qualitychecked\_scans\_ld | int16 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 43 – L1b downwelling radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **ld** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | downwelling\_radiance\_per\_unit\_wavelength\_in\_air  *alias:* downwelling\_spectral\_radiance\_in\_air |  |
| long\_name | Downwelling radiation is radiation from above. It does not mean "net downward". The sign convention is that "upwelling" is positive upwards and "downwelling" is positive downwards. A coordinate variable for radiation wavelength should be given the standard name radiation\_wavelength. Radiance is the radiative flux in a particular direction, per unit of solid angle. The direction from which it is coming must be specified, for instance with a coordinate of zenith\_angle. |  |
| Reference | See system\_deployment\_height |  |
| units | mW m^-2 nm^-1 sr^-1 | CF suggest: W m-2 m-1 sr-1 |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag\_ld,scans\_total\_ld, scans\_qc\_ld, sza, saa, vza, vaa |  |
|  | NERC URI | [http://vocab.nerc.ac.uk/collection/P01/current/SKYIRR01/](http://vocab.nerc.ac.uk/collection/P01/current/SKYIRR01/" \t "/home/cgoyens/Documents\\x/_blank) |  |
|  | NERC Identifier () | SDN:P01::SKYIRR01 |  |
|  | NERC Preferred label (en) | Sky radiance as energy of electromagnetic radiation (unspecified single wavelength) in the atmosphere by cosine-collector radiometer |  |
|  | NERC Alternative label (en) | Lsky\_lambda |  |
|  |  |  |  |

#### Downwelling irradiance

Table 44 – L1b downwelling irradiance product variables for water applications

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| ed | downwelling\_irradiance\_per\_unit\_wavelength\_in\_air  alias: downwelling\_spectral\_irradiance\_in\_air | int32 | wavelength, sequence |
| u\_random\_ed\* | u\_random\_downwelling\_irradiance | int16 | wavelength, sequence |
| u\_systematic\_ed\* | u\_systematic\_downwelling\_irradiance | int16 | wavelength, sequence |
| quality\_flag\_ed\* | quality\_flag\_ed | int32 | sequence |
| scans\_total\_ed\* | total\_number\_scans\_ed | int16 | sequence |
| scans\_qc\_ed\* | total\_qualitychecked\_scans\_ed | int16 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 45 – L1b downwelling irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **ed** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | downwelling\_irradiance\_per\_unit\_wavelength\_in\_air  *alias:* downwelling\_spectral\_irradiance\_in\_air |  |
| long\_name |  | This variable is missing in the CF metadata table |
| Reference | See system\_deployment\_height |  |
| units | mW m^-2 nm^-1 |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag\_ed,scans\_total\_ed, scans\_qc\_ed, sza, saa |  |
|  | NERC URI | [http://vocab.nerc.ac.uk/collection/P01/current/CSLRCCR1/](http://vocab.nerc.ac.uk/collection/P01/current/CSLRCCR1/" \t "/home/cgoyens/Documents\\x/_blank) |  |
|  | NERC Identifier () | SDN:P01::CSLRCCR1 |  |
|  | NERC Preferred label (en) | Downwelling vector irradiance as energy of electromagnetic radiation (unspecified single wavelength) in the atmosphere by cosine-collector radiometer |  |
|  | NERC Alternative label (en) | Es\_lambda |  |
|  |  |  |  |

#### Surface reflected radiance

Table 46 – L1b surface reflected upwelling radiance product variables for water applications

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| ls | surface\_upwelling\_radiance\_per\_unit\_wavelength\_in\_air\_reflected\_by\_water | int32 | wavelength, sequence |
| u\_random\_ls\* | u\_random\_surface\_upwelling\_radiance | int16 | wavelength, sequence |
| u\_systematic\_ls\* | u\_systematic\_surface\_upwelling\_radiance | int16 | wavelength, sequence |
| quality\_flag\_ls\* | quality\_flag\_surface\_upwelling\_radiance | int32 | sequence |
| rhof | fresnel\_reflectance | int32 | wavelength, sequence |
| u\_random\_rhof\* | u\_random\_fresnel\_reflectance | int16 | wavelength, sequence |
| u\_systematic\_rhof\* | u\_systematic\_fresnel\_reflectance | int16 | wavelength, sequence |
| quality\_flag\_rhof\* | quality\_flag\_rhof | int32 | sequence |
| fresnel\_wind | fresnel\_wind | uint16 | sequence |
| fresnel\_sza | fresnel\_sza | uint16 | sequence |
| fresnel\_vza | fresnel\_vza | uint16 | sequence |
| fresnel\_raa | fresnel\_raa | uint16 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 47 – L1b surface reflected upwelling radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| ls | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | surface\_upwelling\_radiance\_per\_unit\_wavelength\_in\_air\_reflected\_by\_(sea\_)water  alias: surface\_upwelling\_spectral\_radiance\_in\_air\_reflected\_by\_(sea\_)water | We should remove the “sea” to account for all water bodies |
| long\_name | The surface called "surface" means the lower boundary of the atmosphere. Upwelling radiation is radiation from below. It does not mean "net upward". The sign convention is that "upwelling" is positive upwards and "downwelling" is positive downwards. Radiance is the radiative flux in a particular direction, per unit of solid angle. The direction towards which it is going must be specified, for instance with a coordinate of zenith\_angle. | We should remove the “sea” to account for all water bodies |
| units | - |  |
| scale\_factor |  |  |
| add\_offset |  |  |
| ancillary\_variables | quality\_flag\_ls, u\_random\_ls, u\_systematic\_ls, quality\_flags\_ls, rhof, fresnel\_wind, fresnel\_sza, fresnel\_vza, fresnel\_raa |  |

Table 48 – L1b fresnel reflectance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| rhof | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | fresnel\_reflectance |  |
| long\_name | Fraction of downwelling sky radiance reflected at the air-water interface |  |
| units | - |  |
| scale\_factor |  |  |
| add\_offset |  |  |
| ancillary\_variables | quality\_flag\_lw, u\_random\_lw, u\_systematic\_lw, quality\_flags\_lw, rhof, fresnel\_wind, fresnel\_sza, fresnel\_vza, fresnel\_raa |  |

Table 49 – L1b fresnel wind variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| fresnel\_wind | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | fresnel\_wind |  |
| long\_name | Surface wind speed used for the retrieval of the fraction of downwelling sky radiance reflected at the air-water interface | Estimated or measured |
| units | ms^-1 |  |
| scale\_factor |  |  |
| add\_offset |  |  |
| ancillary\_variables |  |  |

Table 50 – L1b fresnel sza variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| fresnel\_sza | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | fresnel\_solar\_zenith\_angle |  |
| long\_name | Solar zenith angle used for the retrieval of the fraction of downwelling sky radiance reflected at the air-water interface |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

Table 51 – L1b fresnel sza variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| fresnel\_vza | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | fresnel\_sensor\_zenith\_angle |  |
| long\_name | Sensor zenith angle used for the retrieval of the fraction of downwelling sky radiance reflected at the air-water interface |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

Table 52 – L1b fresnel raa variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| fresnel\_raa | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | fresnel\_sensor\_zenith\_angle |  |
| long\_name | Relative azimuth angle from sun to sensor (0° when sun and sensor are aligned 180° when the sensor is looking into the sunglint) used for the retrieval of the fraction of downwelling sky radiance reflected at the air-water interface |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

#### Water leaving radiance

Table 53 – L1b water leaving radiance product variables for water applications

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| lw | water\_leaving\_radiance | int32 | wavelength, sequence |
| u\_random\_lw\* | u\_random\_water\_leaving\_radiance | int16 | wavelength, sequence |
| u\_systematic\_lw\* | u\_systematic\_water\_leaving\_radiance | int16 | wavelength, sequence |
| quality\_flag\_lw\* | quality\_flag\_lw | int32 | sequence |
| scans\_total\_lw\* | total\_number\_scans\_lw | int16 | sequence |
| scans\_qc\_lw\* | total\_qualitychecked\_scans\_lw | int16 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 54 – L1b water leavening radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **lw** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | water\_leaving\_radiance | CF standards suggest: surface\_upwelling\_radiance\_per\_unit\_wavelength\_in\_air\_emerging\_from\_sea\_water  *alias:* surface\_upwelling\_spectral\_radiance\_in\_air\_emerging\_from\_sea\_water |
| long\_name | The surface called "surface" means the lower boundary of the atmosphere. Upwelling radiation is radiation from below. It does not mean "net upward". The sign convention is that "upwelling" is positive upwards and "downwelling" is positive downwards. Radiance is the radiative flux in a particular direction, per unit of solid angle. The direction towards which it is going must be specified, for instance with a coordinate of zenith\_angle. If the radiation does not depend on direction, a standard name of isotropic radiance should be chosen instead. A coordinate variable for radiation wavelength should be given the standard name radiation\_wavelength. |  |
| units | mW m^-2 sr^-1 nm^-1 |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag\_lw, u\_random\_lw, u\_systematic\_lw, quality\_flags\_lw, rhof, fresnel\_wind, fresnel\_sza, fresnel\_vza, fresnel\_raa |  |
|  | NERC URI | [http://vocab.nerc.ac.uk/collection/P01/current/RWLRCCR1/](http://vocab.nerc.ac.uk/collection/P01/current/RWLRCCR1/" \t "/home/cgoyens/Documents\\x/_blank) |  |
|  | NERC Identifier () | SDN:P01::RWLRCCR1 |  |
|  | NERC Preferred label (en) | Water-leaving radiance of electromagnetic radiation (unspecified single wavelength) from the water body by cosine-collector radiometer |  |
|  | NERC Alternative label (en) | Lw\_2D |  |
|  | NERC Definition (en) | The radiance leaving the water as determined once the total water radiance, the sky radiance and the downwelling irradiance are known |  |

## Level 2 data

### Land L2a and L2b reflectance variables

Data variables specific to Level 2a and Level 2b reflectance products are defined in Table 55 and Table 56 respectively. These variables only differ by dimensions and so the remaining tables in this subsection define each of the listed data variables for both products together.

Table 55 – L2a reflectance product variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| reflectance | reflectance | int16 | wavelength, series |
| u\_random\_reflectance | u\_random\_reflectance | int16 | wavelength, series |
| u\_systematic\_reflectance | u\_systematic\_reflectance | int16 | wavelength, series |
| quality\_flag | quality\_flag | int32 | series |

Table 56 – L2b reflectance product variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| reflectance | reflectance | int16 | wavelength, time |
| u\_random\_reflectance | u\_random\_reflectance | int16 | wavelength, time |
| u\_systematic\_reflectance | u\_systematic\_reflectance | int16 | wavelength, time |
| quality\_flag | quality\_flag | int32 | time |

Table 57 – Reflectance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | reflectance | CF Standards suggest: surface\_bidirectional\_reflectance  Or should we use surface\_hemispherical\_conical\_reflectance |
| long\_name | Reflectance | The surface called "surface" means the lower boundary of the atmosphere. "Bidirectional\_reflectance" depends on the angles of incident and measured radiation. Reflectance is the ratio of the energy of the reflected to the incident radiation. A coordinate variable of radiation\_wavelength or radiation\_frequency can be used to specify the wavelength or frequency, respectively, of the radiation. |
| units | - |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |

Table 58 – u\_random\_irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_random\_reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_random\_reflectance |  |
| long\_name | Random reflectance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 59 – u\_systematic\_irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_systematic\_reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_systematic\_reflectance |  |
| long\_name | Systematic reflectance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 60 – quality\_flag variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **quality\_flag** | **Attribute** | **Value** | **Comment** |
| standard\_name | quality\_flags |  |
| long\_name | Quality indicator per acquisition |  |
| flag\_masks | 1,2,4,8,16,32,64,128 |  |
| flag\_meanings | Blah  Blah  Blah |  |

### Water reflectance and normalized water leaving radiance L2a Variable

Data variables specific for the L2a water network data are the reflectance (same as for land network also referred to as the remote sensing reflectance, REF= pi\*(Lu – rhof\* Ld) / Ed), the reflectance without NIR-similarity spectrum correction (REF\_NOSC, see Ruddick et al., 2006), and, the normalized water leaving radiance (calculated as REF\*F0/pi, where F0 is the top of atmosphere incident radiation adjusted for the Earth-Sun distance on the day sampled). Variables REF and REF\_NOSC are defined in and respectively.

Table 61 – L2a water reflectance product variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| reflectance | reflectance | int16 | wavelength, sequence |
| u\_random\_reflectance | u\_random\_reflectance | int16 | wavelength, sequence |
| u\_systematic\_reflectance | u\_systematic\_reflectance | int16 | wavelength, sequence |
| quality\_flag | quality\_flag | int32 | sequence |

Table 62 – L2a water reflectance product variables without correction for NIR Similarity spectrum correction

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| Reflectance\_nosc | Reflectance\_nosc | int16 | wavelength, sequence |
| u\_random\_reflectance\_nosc\* | u\_random\_reflectance\_nosc | int16 | wavelength, sequence |
| u\_systematic\_reflectance\_nosc\* | u\_systematic\_reflectance\_nosc | int16 | wavelength, sequence |
| quality\_flag\_nosc\* | quality\_flag\_nosc | int32 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 63 – L2a normalized water leaving reflectance product variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| nlw | normalized\_water\_leaving\_radiance | int16 | wavelength, sequence |
| u\_random\_nlw\* | u\_random\_normalized\_water\_leaving\_radiance | int16 | wavelength, sequence |
| u\_systematic\_nlw\* | u\_systematic\_normalized\_water\_leaving\_radiance | int16 | wavelength, sequence |
| quality\_flag\_nlw\* | quality\_flag\_normalized\_water\_leaving\_radiance | int32 | sequence |

*\*These variables are not further defined below. They are similar to the variables described in Section 5.2 except that they refer to the variable referred in their name.*

Table 64 – Reflectance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | reflectance | CF Standards suggest: surface\_bidirectional\_reflectance  Or should we use surface\_hemispherical\_directional\_reflectance |
| long\_name | Reflectance of the water column at the surface corrected for the NIR Similarity spectrum (Ruddick et al., 2006) | The surface called "surface" means the lower boundary of the atmosphere. "Bidirectional\_reflectance" depends on the angles of incident and measured radiation. Reflectance is the ratio of the energy of the reflected to the incident radiation. A coordinate variable of radiation\_wavelength or radiation\_frequency can be used to specify the wavelength or frequency, respectively, of the radiation. |
| units | - |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |
|  | Alternative symbol | rho\_w |  |

Table 65 – u\_random\_irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_random\_reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_random\_reflectance |  |
| long\_name | Random reflectance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 66 – u\_systematic\_irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **u\_systematic\_reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | u\_systematic\_reflectance |  |
| long\_name | Systematic reflectance uncertainty |  |
| units | % |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | - |  |

Table 67 – quality\_flag variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **quality\_flag** | **Attribute** | **Value** | **Comment** |
| standard\_name | quality\_flags |  |
| long\_name | Quality indicator per acquisition |  |
| flag\_masks | 1,2,4,8,16,32,64,128 |  |
| flag\_meanings | Blah  Blah  Blah |  |

Table 68 - reflectance\_nosc variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **reflectance\_nosc** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | Reflectance\_nosc |  |
| long\_name | Water reflectance without correction for the NIR similarity spectrum (see Ruddick et al., 2006) |  |
| units | - |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |
|  | Alternative symbol | rhow\_nosc |  |

Table 70 – Normalized water leaving radiance

|  |  |  |  |
| --- | --- | --- | --- |
| **lwn** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | normalized\_water\_leaving\_radiance |  |
| long\_name | normalized\_water\_leaving\_radiance |  |
| units | mW m^-2 nm^-1 |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |
|  | NERC URI | http://vocab.nerc.ac.uk/collection/P01/current/NRWLRCR1/ |  |
|  | NERC Identifier () | SDN:P01::NRWLRCR1 |  |
|  | NERC Preferred label (en) | Normalised water-leaving radiance of electromagnetic radiation (unspecified single wavelength) from the water body by cosine-collector radiometer |  |
|  | NERC Alternative label (en) | Nlw\_2D |  |
|  | Alternative symbol | nlw |  |

## Auxiliary data variables

Table 71 – Auxiliary product data variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable Name** | **Standard Name** | **Data Type** | **Dimension** |
| cloud\_area\_fraction | cloud\_area\_fraction | uint16 | sequence |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Table 72 – L1b cloud cover variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| Cloud\_area\_fraction | Attribute | Value | Comment |
| \_FillValue | -999999 |  |
| standard\_name | cloud\_area\_fraction |  |
| long\_name | "Area fraction" is the fraction of a grid cell's horizontal area that has some characteristic of interest. It is evaluated as the area of interest divided by the grid cell area. It may be expressed as a fraction, a percentage, or any other dimensionless representation of a fraction. The cloud area fraction is for the whole atmosphere column, as seen from the surface or the top of the atmosphere. Cloud area fraction is also called "cloud amount" and "cloud cover". |  |
| units | - |  |
| Reference | Directory with images for each sequence |  |
| scale\_factor |  |  |
| add\_offset |  |  |
| ancillary\_variables |  |  |
|  | NERC URI | http://vocab.nerc.ac.uk/collection/P01/current/WMOCCCAC/ |  |
|  | NERC Identifier () | SDN:P01::WMOCCCAC |  |
|  | NERC Preferred label (en) | Cloud cover (all clouds) in the atmosphere by visual estimation and conversion to WMO code |  |
|  | NERC Alternative label (en) | WMOCloudCovAll |  |

# Conclusion

The scope of this document to define the products generated by the land and water network processors from raw instrument counts to surface reflectance product including all the intermediate data products. When possible, land and water network products are kept similar. However, at some levels products for both networks are processed differently and subsequently result in distinct data format and metadata fields.

This document is expected to evolve with the Hypernets processor development and based on the feedback of the data users.