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**HYPERNETS LAND AND WATER PROCESSOR**

**PRODUCT DATA FORMAT SPECIFICATION**

**Version 0.0**

**6/2/20**

**Version History**

|  |  |  |  |
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# 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. These are the Level 1 and Level 2 products defined in Table 2.

Level 1 products are generated in the same processing pipeline for both the land and water networks and so the products are of the same format [RD-X]. Although, land and water network Level 2 products are produced through different processing algorithms, they again share the same file format and so are also specified together in the following.

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. Level 1 and Level 2a product files each correspond to one sequence of data. Level 2b temporally interpolates between sequence data to give one file per day.

Table 1 – List Hypernets Processor processing levels

|  |  |
| --- | --- |
| **Level** | **Type** |
| Ancillary | Generic term covering non-measurement data used in processing chain |
| Level 1 | Calibrated instrument data |
| Level 2a | Evaluated surface reflectance |
| 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] |
| 0 |  | Raw instrument data from rugged PC | Defined in [RD-X] |
| 1 | RAD | Radiance data | File per sequence |
|  | IRR | Irradiance data | File per sequence |
| 2a | REF | Surface reflectance data | File per sequence |
| 2b | REFD | Temporally interpolated surface reflectance data | File per day |

# 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 |
| … |  |

## 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:

*PROJECT\_NETWORK\_SITE\_TYPE\_DATETIME\_VERSION.nc*

The files are stored in the NetCDF data format and so have the extension “.nc”. 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** |
| PROJECT | “HYPERNETS” |
| 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. |
| TYPE | Name of product type. Values may be abbreviated product type names defined in Table 2. |
| DATETIME | Denotes the acquisition start 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:

HYPERNETS\_L\_GBNA\_RAD\_202002041130\_v01.0.nc

## Dimensions

All variables are along one or more of the following dimensions:

* “wavelength” – spectral dimension of measurements
* “series” – temporal dimension of measurements within a sequence
* “time” – temporal dimension of measurements for Level 2b daily file
* “latitude” - latitude of measurements in decimal degrees
* “longitude” - longitude of measurements in decimal degrees
* “viewing zenith angle” - zenith angle of the radiance and reflectance measurements in decimal degrees (0°, 90° and 180° is nadir, horizon and zenith viewing, respectively)
* “relative viewing azimuth angle” - azimuth between sun and sensor of the radiance and reflectance measurements in decimal degrees
* “absolute viewing azimuth angle” - azimuth between true north and sensor of the radiance and reflectance measurements in decimal degrees

# Metadata

This section provides a description of the data product metadata. The first subsection describes metadata common to all product types. The following subsections then define per data type metadata.

## Common Metadata

The common metadata describe the content of the data file and ensure CF compliancy. This is defined in Table 6.

Global attributes can be thought of as conveying five kinds of information:

* 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 data product metadata

Table 6.1. What

|  |  |  |
| --- | --- | --- |
| Name | Value | Description |
| ***WHAT*** | | |
| data\_type | e.g., “Waterhypernet Above-water radiometry”, “Land BRDF” | Type of data contained in the file including reference to the network |
|  |  |  |
| title | e.g., “Waterhypernet above water radiometry from HYPPSTARR” | A descriptive title for the dataset |
| conventions | CF- or SeaDataNet? | Name of the conventions followed by the dataset. |
| format\_version |  | File format version |
| netcdf\_version |  | Netcdf file format version |
| product\_name | e.g., “HYPPSTARR\_L\_GBNA\_RAD\_202002041130\_v01.0.nc” | Product name for data provider |
| creation\_date | E.g., “2020-04-01T00:02:00Z” | File creation date in UTC |
| product\_version | E.g., “0,1” | Release number of the data file |
| software\_version | E.g., “Hypernets\_processor v4” | Processing software version |
| references | E.g., ”https://hypernets-processor.readthedocs.io/en/latest/” | Web based reference that describe the data or methods used to produce it |
| history | e.g. :  “2020-04-01T00:02:00Z :  Creation\n  2008-03-23T11:56:12Z :  Merging wind data” | 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. |
| source | E.g.: “Land and water observations HYPPSTARR v0.1” | 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”) |
| comment | e.g. : “Any free-format text is  appropriate.” | Miscellaneous information about the data or methods used to produce it. Any free-  format text is appropriate. |
| ***WHERE*** | | |
| area |  |  |
| easting |  |  |
| northing |  |  |
| Southermost\_latitude |  |  |
| Northernmost\_latitude |  |  |
| Westernmost\_longitude |  |  |
| Easternmost\_longitude |  |  |
| Minimum\_altitude |  |  |
| Maximum\_altitude |  |  |
| ***WHEN*** | | |
| Time\_coverage\_start |  |  |
| Time\_coverage\_end |  |  |
| ***WHO*** | | |
| Network\_id |  |  |
| Creator\_name |  |  |
| Creator\_email |  |  |
| Responsible\_party |  |  |
| Responsible\_party\_references |  |  |
| acknowledgement |  |  |
|  |  |  |
|  |  |  |
| ***HOW*** | | |
| project\_name | E.g., “HYPERNETS | Project name and grand number if any |
| Metadata\_language | english |  |
| Topic\_category |  |  |
| Spatial\_data\_theme |  |  |
| Unique\_resource\_code\_identifier |  |  |
| Resource\_abstract |  |  |
| Operational\_status |  |  |
| Degree\_of\_conformity |  |  |
| Licence |  |  |

## Instrument and system Metadata

### Instrument metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| Instrument\_id |  |  |
| Instrument\_manufacturer |  |  |
| Instrument\_model |  |  |
| Instrument\_date\_manufacture |  |  |
| Instrument\_version |  |  |
| Instrument\_firmware\_version |  |  |
| Instrument\_documentation\_references |  |  |
| Instrument\_description |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

### System metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| System\_id |  |  |
| system\_model |  |  |
| System\_manufacturer |  |  |
| System\_date\_manufacture |  |  |
| System\_version |  |  |
| System\_firmaware\_version |  |  |
| System\_logfile |  |  |
| System\_documentation\_references |  |  |
|  |  |  |
|  |  |  |

### Components metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| ***[RGB camera][rain\_sensor][light\_sensor]*** | | |
| **Rgb\_camera\_id** |  |  |
| **Rgb\_camera\_manufacturer** |  |  |
| **Rgb\_camera\_date\_manufacture** |  |  |
| [Radiance][irradiance]\_[VNIR][SWIR]\_head | | |
| **Rad\_vnir** |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

## Site Metadata

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Value** |
| **Site\_id** |  |  |
| **Site\_description** |  |  |
| **Site\_latitude** |  |  |
| **Site\_longitude** |  |  |
| **Site\_owner** |  |  |
| **Site\_operator** |  |  |
| **Site\_manager** |  |  |
| **Site\_contact\_details** |  |  |
|  |  |  |

## Radiance/Irradiance Product Metadata

Table 7 provides additional radiance/irradiance product metadata.

Table 7 – Radiance/irradiance product metadata

|  |  |  |
| --- | --- | --- |
| **Key** | **Description** | **Scope** |
|  |  |  |

## Reflectance Product Metadata

Table 8 provides additional radiance/irradiance product metadata.

Table 8 – Reflectance product metadata

|  |  |  |
| --- | --- | --- |
| **Key** | **Description** | **Scope** |
|  |  |  |

# 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 9. The remaining tables in this subsection define each of the common data variables.

Table 9 - Common product data variables

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

Table 10 - 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 |  |  |

Table 11 - viewing\_azimuth\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **viewing\_azimuth\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | viewing\_azimuth\_angle |  |
| long\_name | Viewing azimuth angle |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

Table 12 - viewing\_zenith\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **viewing\_zenith\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | viewing\_zenith\_angle |  |
| long\_name | Viewing zenith angle |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

Table 13 - sun\_azimuth\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **sun\_azimuth\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | sun\_azimuth\_angle |  |
| long\_name | Sun azimuth angle |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

Table 14 - sun\_zenith\_angle variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **sun\_zenith\_angle** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | sun\_zenith\_angle |  |
| long\_name | Sun zenith angle |  |
| units | degrees |  |
| scale\_factor | 0.01 |  |
| add\_offset | 0.0 |  |
| ancillary\_variables |  |  |

Table 15 - 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 |  |  |

## Radiance Variables

Data variables specific to radiance products are defined in Table 16. The remaining tables in this subsection define each of the listed data variables.

Table 16 - 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 |

Table 17 - radiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **radiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | radiance |  |
| long\_name | Radiance |  |
| units | mW m^-2 sr^-1 nm^-1 |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |

Table 18 - 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 19 - 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 | - |  |

Table 20 - 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 |  |

## Irradiance Variables

Data variables specific to irradiance products are defined in Table 21. The remaining tables in this subsection define each of the listed data variables.

Table 21 - 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 |

Table 22 - irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **irradiance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | irradiance |  |
| long\_name | Irradiance |  |
| units | mW m^-2 nm^-1 |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |

Table 23 - 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 24 - 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 25 - 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 |  |

## Reflectance Variables

Data variables specific to Level 2a and Level 2b reflectance products are defined in Table 26 and Table 27 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 26 – 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 27 – 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 28 - irradiance variable definition

|  |  |  |  |
| --- | --- | --- | --- |
| **reflectance** | **Attribute** | **Value** | **Comment** |
| \_FillValue | -999999 |  |
| standard\_name | reflectance |  |
| long\_name | Reflectance |  |
| units | mW m^-2 nm^-1 |  |
| scale\_factor |  |  |
| add\_offset | 0.0 |  |
| ancillary\_variables | quality\_flag |  |

Table 29 - 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 30 - 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 31 - 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 |  |