Data Output Format for the SAFNWC/PPS

NWC/CDOP2/PPS/SMHI/SW/DOF, Issue 1, Rev. 3

01 December 2015

Applicable to NWC/PPS version 2014

Applicable to the following PGE:s:

PGE	Acronym	Product ID	Product name	Version number
PGE01	CM	NWC-062	Cloud Mask	4.0
PGE02	CT	NWC-065	Cloud Type	2.0
PGE03	CTTH	NWC-068	Cloud Top Temperature and Height	4.0
PGE04	PC	NWC-073	Precipitating Clouds	1.6
PGE05	CPP	NWC-071	Cloud Physical Properties	1.1

Prepared by Swedish Meteorological and Hydrological Institute (SMHI)

REPORT SIGNATURE TABLE

Function	Name	Signature	Date
Prepared by	SMHI		01 December 2015
Reviewed by	NWC SAF Project Team EUMETSAT		 DRR 9 September 2014
Endorsed by	Steering Group		
Authorised by	Anke Thoss, SMHI *NWC SAF PPS Manager*		01 December 2015

DOCUMENT CHANGE RECORD

Version	Date	Pages	Changes
1.3	19 June 2013	58	First version for NWC/PPS v2014
1.0	29 November 2012	58	-PDCR RID OBJ6_SMHI_SW_DOF_Nicola_025: Corrections in section 4.4.3.6. -Closed TBD4, by defining keywords. -Cloud mask test flag: updated flag meanings and added a few bits. -Updated CTTH scale factors and add offsets. -Fixed some typos.
1.1d	22 January 2014	59	Closed TBC01, the definition of PGE01-03+05 status flags: -Changed CPP status flag. -Added to CMa statusflag: suspected_heavy_aerosol Added TBC02: flagged for changes to be implemented after SG03 approved requested changes in PC workpackages (CPP based rain rate available 2016, no MW based rain rate) Misc. changes: -Implemented dataset cpp_phase_extended. -Updated CPP scale factors. -Implemented flag rough terrain (previously spare bit reserved for rough terrain). -Removed flag_values, for flags where flag_masks give all necessary information. -Dimension can not have attributes in netcdf, so those attributes are removed. -Fixed some typos.
1.1d2	23 April 2014 (draft) 27 June 2014 (delivery)	60	Implemented RIDs from PCR-v2014: - Action 8 (a note on the new format) - LSc1-LSc2 (formal issues) - PW17 (clarifications on aerosol dataset for v2014) - PW23 (removing unnecessary status flags) Closed TBC02: Confirmed that CPP based rain rate will be available 2016, and no MW based rain rate will be developed. TBD01: Removed some occurrences; standard names for cpp_phase and cpp_reff are found in CF-convention standard name table v2.5. Other changes: - Added more descriptions of mappings. - Added a description of the hdf data format. - Some editorials.
1.1	15 September 2014	60	-Minor changes due to less dependence of AAPP (no orbit number for global Metop). -For precipitation likelihood, clarified that the interval bounds are in mm/h. -A little more info about the geographical data.
1.2	13 March 2015	60	Changes for v2014-patch20150327: -Added a clarification on how start/end date-time in the filenames are used. -For condition and quality flags: Added actual bit numbers. (For easier reading, no changes in the implementation.)
1.3	01 December 2015	62	Changes for PPS v2014-patch20151201: -Corrected the number of bits in cma-testlist:s. -Added time as a third dimension in the datasets.

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1 INTRODUCTION

The EUMETSAT's "Satellite Application Facilities" (SAFs) are dedicated centres of excellence for processing satellite data, and form an integral part of the distributed EUMETSAT Application Ground Segment (http://www.eumetsat.int). This documentation is provided by the SAF on Support to Nowcasting and Very Short Range Forecasting, NWC SAF. The main objective of NWC SAF is to provide, further develop and maintain software packages to be used for Nowcasting applications of operational meteorological satellite data by National Meteorological Services. More information can be found at the NWC SAF webpage, http://www.nwcsaf.org. This document is applicable to the SAFNWC processing package for polar orbiting meteorological satellites, SAFNWC/PPS, developed and maintained by SMHI (http://nwcsaf.smhi.se).

1.1 PURPOSE

This document provides a specification of the netCDF data model for the NWC/PPS, the SAF application for the timely generation of meteorological products to support nowcasting primarily using image products acquired from polar orbiting platforms.

1.2 SCOPE

As extensively discussed during the previous phase, the use of netCDF as output format for the products generated by the future PPS package of the NWC SAF (scheduled by 2014) seems to be the most suitable one for the new software package. Also the GEO package (scheduled by 2015) of NWC SAF will be using netCDF.

> On the one hand, this format has been requested as an improvement during the Users' Workshop on 26-28 April 2010 held in Madrid. The outcomes of this workshop are included in the "Consolidated Report on 2010 User Survey and Users' Workshop" document (SAF/NWC/IOP/INM/MGT/2010-US+WS).
>
> On the other hand, the use of netCDF format as standard for the products delivered by the EUMETSAT's Data Centre has been proposed and approved by the EUM Format Advisory Group (See EUM/STG-OPSWG/30/11/VWG/15 presentation)

netCDF is a set of software libraries and machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data.

netCDF files are based on the HDF5, used currently in the SAFNWC/PPS application, and their main characteristics can be summarized as follows:

- *Self-Describing*. A netCDF file includes information about the data it contains.
- *Portable*. A netCDF file can be accessed by computers with different ways of storing integers, characters, and floating-point numbers.
- *Scalable*. A small subset of a large dataset may be accessed efficiently.

- *Appendable*. Data may be appended to a properly structured netCDF file without copying the dataset or redefining its structure.
- *Sharable*. One writer and multiple readers may simultaneously access the same netCDF file.
- *Archivable*. Access to all earlier forms of netCDF data will be supported by current and future versions of the software.

The description of the following sections apply to all NWC SAF PPS products.

1.3 DEFINITIONS AND ACRONYMS

Acronym	Explanation
ACDD	Attribute Convention for Dataset Discovery
ACPG	AVHRR/AMSU Cloud Product Generation software (A major part of the SAFNWC/PPS s.w., including the PGE:s.)
AEMET	Agencia Estatal de Meteorología (Spain)
AHAMAP	AMSU-HIRS-AVHRR Mapping Library (A part of the SAFNWC/PPS s.w.)
AMSU	Advance Microwave Sounding Unit
API	Application Programming Interface
AVHRR	Advanced Very High Resolution Radiometer
CDOP	Continuous Development and Operational Phase
CDOP-2	Second Continuous Development and Operational Phase
CF	netCDF Climate and Forecast Metadata Convention
CMA	Cloud Mask (also PGE01)
CPP	Cloud Physical Products
CT	Cloud Type (also PGE02)
CTTH	Cloud Top Temperature, Height and Pressure (also PGE03)
EPS	EUMETSAT Polar System
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GEO	Geostationary satellites
hhmm	Time given as hour (2 digits), minutes (2 digits)
hhmmsst	Time given as hour (2 digits), minutes (2 digits), seconds (2 digits), tenth of a second (1 digit)
MHS	Microwave Humidity Sounding Unit
MSB	Most significant bit
netCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical weather prediction
PC	Precipitating Cloud (also PGE04)
PGE	Process Generating Element
PPS	Polar Platform System
RGB	Red Green Blue
RTTOV	Radiative Transfer for TOVS
SAF	Satellite Application Facility
SAFNWC	Satellite Application Facility for support to NoWcasting
SMHI	Swedish Meteorological and Hydrological Institute
TBC	To Be Confirmed
TBD	To Be Defined
UTC	Coordinated Universal Time

Acronym	Explanation	Acronym	Explanation
VIIRS	Visible Infrared Imaging Radiometer Suite	**YYYYMMDD**	Date given as year (4 digits), month (2 digits), day (2 digits)

See [RD.1.] for a complete list of acronyms for the NWC SAF project.

1.4 REFERENCES

1.4.1 Applicable documents

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.X].

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the current edition of the document referred applies.

Current documentation can be found at NWC SAF Helpdesk web: http://www.nwcsaf.org

Ref	Title	Code	Vers	Date
[AD.1.]	Proposal for the Second Continuous Development and Operations Phase (CDOP) March 2012 – February 2017	NWC/CDOP2/MGT/AEMET/PRO	1.0	15/03/11
[AD.2.]	NWCSAF Project Plan	NWC/CDOP2/SAF/AEMET/MGT/PP	1.5	05/06/13
[AD.3]	Configuration Management Plan for the NWC SAF	NWC/CDOP2/SAF/AEMET/MGT/CMP	1.2	29/11/13
[AD.3.]	NWCSAF Product Requirements Document	NWC/CDOP2/SAF/AEMET/MGT/PRD	1.5	05/06/14
[AD.4.]	System and Components Requirements Document for the NWC/PPS	NWC/CDOP2/PPS/SMHI/SW/SCRD	1.0	15/09/14

Table 1: List of Applicable Documents

1.4.2 Reference documents

The reference documents contain useful information related to the subject of the project. These reference documents complement the applicable ones, and can be looked up to enhance the information included in this document if it is desired. They are referenced in this document in the form [RD.X]

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the current edition of the document referred applies

Current documentation can be found at NWC SAF Helpdesk web: http://www.nwcsaf.org

Ref	Title	Code	Vers	Date
[RD.1.]	The Nowcasting SAF Glossary	NWC/CDOP2/SAF/AEMET/MGT/GLO	2.0	18/02/14
[RD.2.]	Interface Control Document for common functions of the NWC/PPS	NWC/CDOP2/PPS/SMHI/SW/ICD/2	1.1	13/03/15
[RD.3.]	Unidata: NetCDF Conventions	http://www.unidata.ucar.edu/software/netcdf/conventions.html		
[RD.4.]	netCDF Climate and Forecast (CF) Metadata Conventions	http://cf-pcmdi.llnl.gov/		
[RD.5.]	NetCDF Attribute Convention for Dataset Discovery	http://www.unidata.ucar.edu/software/netcdf-java/formats/DataDiscoveryAttConvention.html		
[RD.5b]	NetCDF Users' Guide	http://www.unidata.ucar.edu/software/netcdf/docs/netcdf.html#NetCDF-Classic-Format		
[RD.5c]	NetCDF-4 Atomic Types	http://www.unidata.ucar.edu/software/netcdf/docs/netcdf-c/NetCDF_002d4-Atomic-Types.html		
[RD.6.]	File Naming Conventions on EUMETCast	EUM/OPS/TEN/09/0264	v2	10/02/09
[RD.7.]	Writing NetCDF Files: Best Practices	http://www.unidata.ucar.edu/software/netcdf/docs/BestPractices.html		
[RD.8.]	GCMD: Keyword Community Page	http://gcmd.gsfc.nasa.gov/Resources/valids/gcmd_parameters.html		

Table 2: List of Referenced Documents

1.5 DOCUMENT OVERVIEW

This document contains the description of the Output Format for the NWC/PPS products. To cover these objectives the present document has been structured in the following sections:

- Section 1 contains the current introduction along with the list of used acronyms and applicable and reference documents.
- Section 2 provides an overview of the NWC/PPS interfaces
- Section 3 introduces the netCDF format, providing and overview of its main characteristics and capabilities.
- Section 4 presents a high-level specification of the NWC/PPS products in netCDF format, detailing common criteria, data structure, attributes, etc. applicable to all products.
- Finally, section 5 describes the specific Output Product Format for each NWC/PPS product

2 GLOBAL SYSTEM OVERVIEW

The diagram in Figure 1 shows all the interfaces of the NWC/PPS application, where the external interfaces are identified with a label beginning with “e”, for input data and “s” for output data. and “c” for control data.

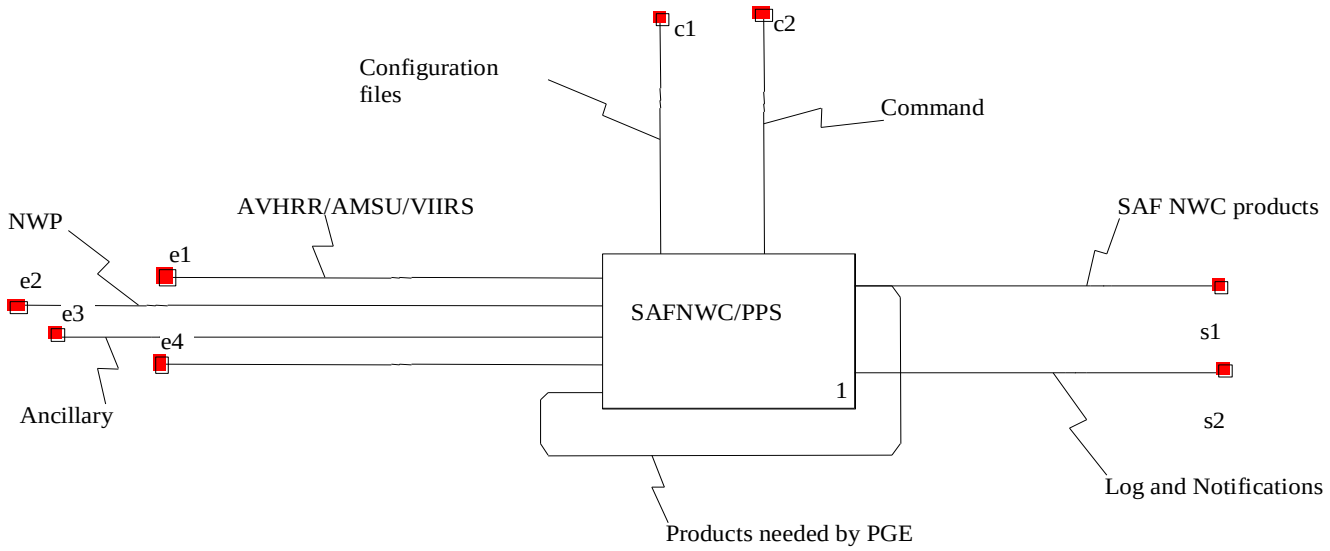

Figure 1: NWC/PPS Interfaces

This document defines the NWC/PPS output products format (*s1*). All other interfaces represented in the figure are described in specific Interface Control Documents or in the Software User Manual.

3 THE NETCDF FILE FORMAT

The netCDF (network Common Data Form) is more than just a File Format, also involving i) a Data Model, ii) an Application Programming Interface (API) and iii) a Library implementing this API. In that way, netCDF (as a whole) allows the creation, access, and sharing of scientific data.

Main benefits in using netCDF format for data sharing and storage with respect to other formats are:

- Uses portable files as unit of self-describing data
- Emphasizes efficient direct access to data within files
- Provides a multidimensional array abstraction for scientific applications
- Avoids dependencies on external tables and registries
- Emphasizes simplicity over power
- Has built-in client support for network access to structured data from servers
- Has a large enough community of users to foster development of:
    - support in many third-party applications
    - third-party APIs for other programming and scripting languages
    - community conventions, such as Climate and Forecast (CF) metadata conventions
- A large number of software packages, both freeware and licensed software, is available to manipulate or display netCDF data. As an example, IDV or McIDAS-V are widely used by the meteorological community.
  Please refer to http://www.unidata.ucar.edu/software/netcdf/software.html for an extensive list of existing software.

netCDF supports two different data models: the classic model and the enhanced model. The classic model is associated with all versions of netCDF prior netCDF-4. The enhanced model is a superset of the classic model, and closely mirrors the HDF5 data model. As suggested by Unidata, except in the case of very complex data, the use of the classic model is suggested to assure maximum portability of data.

NWC/PPS products will be coded in netCDF format using the netCDF-4 software (HDF5-based) and the Classic Data Model.*

* Even if following the Classic Data Model, netCDF-4 files will be created without the NC_CLASSIC_MODEL flag in order to allow using unsigned data types.

netCDF files are containers for i) Dimensions, ii) Variables and iii) Attributes iv) Coordinate Variables:

- *Dimensions* are used to specify variable shapes, common grids, and coordinate systems.

- *Variables* have name, type, shape and attributes, and hold data values. Allowed data types for variables are char, byte, short, integer, float and double. Use of unsigned data types is allowed in netCDF-4 data model.
- *Attributes* hold metadata containing information about properties of a variable or dataset
- *Coordinate Variables* If a variable has the same name as a dimension it is a coordinate variable. It describes in more detail the dimension.

Therefore, the classic netCDF data model uses dimensions, variables and attributes to package array-oriented scientific data. Using UML notation, the classic netCDF data model is presented in Figure 2. This figure shows that:

- A file has named variables, dimensions and attributes
- Variables have attributes
- Variables may share dimensions

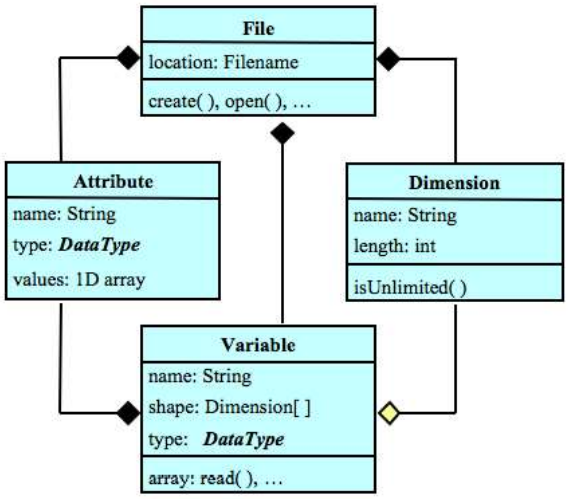

Figure 2: UML diagram of the Classic netCDF Data Model

Even if netCDF is designed to write data in a well-defined and structured manner, it does not require the creation of self-describing datasets. In order to provide a standard implementation of netCDF, conventions are supported by netCDF ([RD.3.]) in order to avoid lack or misinterpretation of data and to ensure the generation of self-documented data in the sense that each variable in the file has an associated description of what it represents. One of the most widely used and recommended by Unidata is the *netCDF Climate and Forecast (CF) Metadata Conventions* ([RD.4.]). CF standard is intended to use with *climate and forecast* data, for atmosphere, surface and ocean.

Besides, the CF conventions have been adopted by EUMETSAT to be used as a standard for Data Centre delivery of all data retrievable from the EUMETSAT Data Centre (former UMARF) following the WMO suggestions.

A netCDF group at Unidata recommends the use of netCDF Attribute Convention for Dataset Discovery (ACDD) ([RD.5.]). This convention describes attributes recommended for describing a

netCDF dataset to discovery systems. At least “highly recommended” and “recommended” attributes should be used.

netCDF Climate and Forecast (CF) Metadata Conventions and netCDF Attribute Convention for Dataset Discovery (ACDD) will be applicable to the generation of NWC/PPS products in netCDF format

4 NWC/PPS PRODUCTS GLOBAL FORMAT DEFINITION

All products generated by the NWC PPS package will be coded in netCDF/CF/ACDD format.

Please observe that the output format differs substantially from NWC/PPS v2012 to NWC/PPS v2014, both in term of filenames, names of datasets, class definitions (CMa, CT, CPP-phase), quality flags and attributes. Though the products are generally the same in v2012 and v2014.

4.1 PRODUCT NAMES

EUMETSAT does not provide a File Naming Criteria to name Products. In fact, a large variety of naming conventions are in use, for example, in the dissemination of products by means of the EUMETCast System (See [RD.6.])

After review of different file naming conventions used by different SAFs, it is not evident to define a common File Naming Convention. In any case, some commonalties have been identified and a new naming convention for NWC/PPS products is proposed based on the found commonalities.

Following Naming Convention is proposed for NWC/PPS Products (As an interpretation of [RD.6.], fitting our needs.)

Size	**1**		**3**		**any**		**any**		**5**		**17**		**17**		**any**
Field	S	_	SAFX	_	ProdName	_	SatID	_	Orbit	_	Date/ Time start	_	Date/ Time end	.	Ext

If the products are remapped, the region ID will be added to the filename. Like this:

Size	**1**		**3**		**any**		**any**		**5**		**17**		**17**		**any**		**any**
Field	S	_	SAFX	_	ProdName	_	SatID	_	Orbit	_	Date/ Time start	_	Date/ Time end	_	RegionID	.	Ext

For PPS v2014 HDF5 files will be produced and converted to netCDF4 files, by a converter program. We recommend the usage of netCDF files as this format will be the only supported format from PPS v2016 and onwards! Both HDF5 and netCDF files will follow this naming convention.

For PPS v2016 all output, including intermediate product outputs, will be in netCDF format.

Field	Meaning	Content	Coment
S	System	S	Fixed, meaning SAF
SAFX	SAF	NWC	Fixed, meaning Nowasting
ProdName	product type	CMA CT CTTH PC CPP	Identification of the Product.
SatID	Satellite name	metopb noaa19 npp …	Satellite identifier (source of data) Preferably, name after commission to be used.
orbit	Orbit number	01234	Unique identifier of each orbit on a certain satellite. For global Metop and GAC data, the orbit number is not available. For global Metop 00000 is used. For GAC 99999 is used.
Date/Time start	Datation	YYYYMMDD**T**hhmmss**Z**	The nominal date and time of the product in ISO8601 basic format representation. 't' means tenth of a second. 'Z' means UTC. Time for the first line in the scan.
Date/Time end	Datation	YYYYMMDD**T**hhmmss**Z**	The nominal date and time of the product in ISO8601 basic format representation. 't' meand tenth of a second. 'Z' means UTC. Time for the last line in the scan.
RegionID	Region Identification	Configurable. Examples: sswe germ	For remapped products, an identification of that region. Name and region definition are configurable by the user. *The original products are processed in satellite projection. This is the default, and in that case **no** RegionID is given.*
Ext	File extension	nc h5	The file format. Normally netCDF but in case other format is used, other format suffixes are used

If you chose to process a part of a scene (giving start line and end line as parameters in the call), the value of start/end date-time will be adapted to the lines you process. If you do remapping to a region, the value of start/end date-time will not change; it will stay as for the scene in satellite project, even if the region is smaller.

A single output file is generated per product. Information previously provided in different files for a single PGE (though never used for PPS) is proposed to be stored in a single netCDF file.

According to this File Naming Convention, NWC/PPS output products in netCDF will be named as:

PGE Id	Filename
PPS-CMA	S_NWC_CMA_<sat_id>_<orbit>_YYYYMMDDThhmmsstZ_YYYYMMDDThhmmsstZ.nc
PPS-CT	S_NWC_CT_<sat_id>_<orbit>_YYYYMMDDThhmmsstZ_YYYYMMDDThhmmsstZ.nc
PPS-CTTH	S_NWC_CTTH_<sat_id>_<orbit>_YYYYMMDDThhmmsstZ_YYYYMMDDThhmmsstZ.nc
PPS-CPP	S_NWC_CPP_<sat_id>_<orbit>_YYYYMMDDThhmmsstZ_YYYYMMDDThhmmsstZ.nc
PPS-PC	S_NWC_PC_<sat_id>_<orbit>_YYYYMMDDThhmmsstZ_YYYYMMDDThhmmsstZ.nc

Note:

<sat_id> is the identifier of the satellite data used to generate the product
<orbit> is the orbit number
the first YYYYMMDDThhmmsstZ represent the start time, while the second represents the end time

Table 3: Filenames for the NWC/PPS products in netCDF format

For a product remapped to a region, the region id will we added in the end of the name, but before the extension. Eg:
S_NWC_CMA_<sat_id>_<orbit>_YYYYMMDDThhmmsstZ_YYYYMMDDThhmmsstZ_<region_id>.nc

4.2 NETCDF DATA MODEL FOR NWC/PPS PRODUCTS

CF conventions have been applied as far as possible.

The structure of the NWC/PPS products in netCDF format is as follows:

- *Dimensions*.
- *Product Attributes*: Contains general information of the product. All NWC/GEO products will include a set of common attributes.
- Several *Product-specific Variables*, each containing different parameters of the product. These containers also hold a set of attributes to include specific information about the variable.

Variables containers can provide the following information:

- A **quantitative geophysical retrieval**. Store specific geophysical retrieval, as for example, the cloud top temperature in Kelvin.
- A **categorized value**, selecting a value between a set of choices For instance, the cloud mask: cloud free, cloud filled…
- A **set of bits** or **Flags** indicating whether some condition is present or not. For instance, the processing flag and threshold test flags are specified in this way.
- A **palette** for the graphical representation of a meteorological field as an image. The palette will be provided as a table (2-dimensional array, and provides the R(ed), G(reen) and B(lue) indices ([0-255]) associated to each image value.

- **Georeference information**, storing parameters and data allowing to retrieve geographic coordinates (latitude, longitude) for each product element (pixel (i,j)..
    - **latitude** and **longitude** fields*:* 2 dimensional matrices storing the latitude and longitude of the centre of the pixels of the image (See section 4.4.3.1)
    - **Georeference coordinates nx, ny**, Two 1-dimensional vectors containing the values of the centre of the pixels of the image in X (easting) and Y (northing) dimensions (See section 4.4.3.1)

Main variables containers will be constituted by 2-dimensional arrays storing, at pixel level, the value (quantitative, category, flag, ...) in each pixel of the processed region.

Some conventions (compliant with CF) to be applied to variable containers are:

- Supported data types in netCDF-4 are presented in the table below

netCDF type	C-type	Bits
NC_BYTE NC_CHAR	char	8
NC_UBYTE	unsigned char	8
NC_SHORT	short	16
NC_USHORT	unsigned short	16
NC_INT	int	32
NC_UINT	unsigned int	32
NC_UINT64	long long	64
NC_UNIT64	unsigned long long	64
NC_FLOAT	float	32
NC_DOUBLE	double	64

Note that unsigned and INT64 types are not supported in netCDF classic or 64-bit offset format files or in netCDF-4 files if they are created with the NC_CLASSIC_MODEL flags

- *_FillValue* attribute will be used to specify missing value (as suggested by CF when only one missing value is needed) The missing values of a variable with scale_factor and/or add_offset are interpreted relative to the values stored in the netCDF file, not the values that result after the scale and offset are applied.

- Whenever possible, missing data will be set to:(n is the number of bits of the data type)
    - Signed integer types: -2^{n-1} (eg. unsigned byte: n=8; _FillValue=-128)
    - Unsigned integer types: $2^{n}-1$ (eg. signed byte: n=8; _FillValue=255)
    - Float type: -9999.0 (NODATA value)
    - About fill values, see also [RD.5b] and [RD.5c]

- All quantitative meteorological measures will be stored as “packed data”, making use of *scale_factor* and *add_offset* attributes to retrieve the quantitative measure.

- *units* attribute must be filled for all variables that represent dimensional quantities by a string recognized by UNIDATA’s Udunits package (See

http://www.unidata.ucar.edu/software/udunits) and compliant with CF convention. This attribute will be omitted for dimensionless variables.

- *standard_name* attribute will be filled, when ever possible, by a string according the list of permissible standard names list provided in http://cf-pcmdi.llnl.gov/documents/cf-standard-names/standard-name-table/current/cf-standard-name-table.html/

- *ancillary_variables* attribute is used to express a relationship with values of another data variable. The content of the variable is a blank separated list of variable names. Variables included in the *ancillary_variables* attribute often have the standard name of the variable which points to them including a modifier to identify the relationship.

- Status Flags containers will be used to store data values indicating the quality or other status of the data values. In that case

    - The Status Flag container will be named as the name of the Variable container containing the data values followed by the modifier "_status_flag"

    - The Variable container will include the *ancillary_variables* attribute whose value will be the name of the previous referred Status Flag container

- Image-like products will be stored as 2-dimensional arrays, either in satellite projection, or – when remapped to regions- in a user defined projection. The *coordinates* attributes will be used to define the coordinate variables lat, lon.

- The use of reserved raw counts or intervals to store specific information must be avoided, as for example:
    - Storage of Stability Index (for cloud free pixels) and IR (for cloudy pixels) in a single variable container
    - Use of reserved raw counts for
        - Pixel zenith angle > threshold
        - Pixel height > threshold
        - Other

  The use of specific flags to identify all these conditions is proposed instead

4.3 COMMON ATTRIBUTES

Attributes provide general information about the product in order to make it self-explaining. Most attributes will be common to all NWC/PPS products, and some other will be product specific.

Common attributes for all NWC/PPS products are presented in Table 4.

Conv	Name	Content
CF	Conventions	CF-1.6
CF ACDD	title	A short description of the dataset. (See Table 6)
CF ACDD	history	*<date>* Product Created by NWC/PPS v*YYYY* *<date>* Translation from *XXX.h5* to *XXX.nc*
CF ACDD	institution	Institution producing this file (e.g. SMHI, AEMET, DMI). To be obtained from configuration

CF	source	NWC/PPS version *YYYY* Substitutes version from earlier NWC/PPS products.
CF ACDD	comment	Copyright *YYYY*, EUMETSAT, All Rights Reserved
CF	references	http://www.nwcsaf.org
CF	contact	NWC/PPS contact: safnwchd@aemet.es
ACDD	summary	A paragraph describing the dataset. (See Table 7) Substitutes description from earlier NWC/PPS products.
ACDD	keywords	A comma separated list of key words and phrases (See Table 8)
ACDD	keywords_vocabulary	For example, "GCMD Science Keywords" http://gcmd.gsfc.nasa.gov/Resources/valids/gcmd_parameters.html
ACDD	id	= <filename>
ACDD	naming_authority	EUMETSAT or SMHI
ACDD	cdm_data_type	The data type appropriate for the dataset: for image-like products: Image
ACDD	date_created	The date on which the data was created. YYYY-MM-DDThh:mm:ss
ACDD	project	SAFNWC/PPS released by SMHI
ACDD	processing_level	Level 2
ACDD	geospatial_lat_max	
ACDD	geospatial_lat_min	
ACDD	geospatial_lon_max	
ACDD	geospatial_lon_min	
ACDD	time_coverage_start	Time stamps for the first line of the processing region.
ACDD	time_coverage_end	Time stamps for the last line of the processing region.
ACDD	license	EUMETSAT user policy
-	product_name	Product name Id
-	product_algorithm_version	Version of the algorithm used to produce the present product
-	platform	<platform_ID> (See Table 5) Substitutes satellite_id from earlier NWC/PPS products.
-	orbit_number	Orbit number.
-	region_id	'satproj' is used for satellite projection, as the products are processed. After remapping is given the id of the region remapped to; eg. europe.
-	region_name	A longer text description of the region

Table 4: Common Attributes for NWC/PPS products

<Satellite_ID>
MetopA
MetopB
NOAA18
NOAA19
Suomi-NPP

Table 5: A sample of Satellite_IDs, using names after commissioning.

4.4 NETCDF DATA MODEL FOR NWC/PPS IMAGE-LIKE PRODUCTS

This section presents the basic information for the detailed specification of the image-like products of the NWC/PPS package in netCDF. All NWC/PPS products are image-like, thus this is valid for all the NWC/PPS products.

4.4.1 Dimensions

Dimensions container will include the following information

	Content
Dimensions	
time	The time dimension has got extent 1. Thus it is a dimension, but it does not add any more data having 3d (time, ny, nx) than having 2d (ny, nx).
ny	For satellite projection: number of scanlines For region: Number of Lines of the Region
nx	For satellite projection: number of pixels per scanline. For region: Number of Columns of the Region
pal_colors	Number of colours in the palette (will be the number of lines of the 2-D array containing the palette). *n* (01,02, …) will be used for different palettes
pal_rgb	3 Number of columns of the 2-D array containing the palette. It will be set to 3 (R, G, B)
nv	2 Number of boundaries.

The time dimension will get the following attributes:

Conv	Name	Content
CF	long name	"time"
CF	units	"seconds since <middle time> +00:00", eg. "seconds since 2014-08-27 07:52:52.350000 +00:00" Always as UTC.
CF	bounds	"time bnds"

The attribute "bounds" refer to the dataset "time_bnds", which contains start and end time. The unit for "time_bnds" is the same unit as defined in "time".

	Content
Variables	
float time bnds(time,nv)	//Time boundaries
Dimensions	
time	
nv	

Thus the times are read this way: Dimension "time" always has the value 0. The attribute "units" tells, in string format, the middle time of the scene. The dataset "time_bnds" contains start time and end time given in seconds related to the middle time. Eg. if a scene is 1000.4 seconds long, the start time will be -500.2 and the end time will be 500.2.

The time of the scene is also given as the common attributes "time_coverage_start" and "time_coverage_end", see 4.3.

4.4.2 Attributes

See section 4.3 for common attributes to all NWC/PPS products.

In addition to common attributes presented in previous section 4.3, image-like products will include the following product specific attributes:

None specified so far

4.4.3 Variables

4.4.3.1 lat and lon Containers

The NWC/PPS products in satellite projection will include two variable containers storing the latitude and longitude of the centre of each pixel in the scene (region). Both arrays are dimensioned to the size of the region (ny,nx).

	Content
Variables	
float lat(ny,nx)	//Latitudes
Dimensions	
ny	
nx	
Attributes	
CoordinateAxisType	"Lat"
standard_name	"latitude"
long_name	"Latitude at the centre of each pixel"
units	"degrees_north"
valid_range	-90.0, 90.0
FillValue	-999.0
float lon(ny,nx)	//Longitudes
Dimensions	
ny	
nx	
Attributes	
CoordinateAxisType	"Lon"
standard_name	"longitude"
long_name	"Longitude at the center of each pixel"
units	"degrees east"
valid_range	-180.0, 180.0
FillValue	-999.0
float nx(nx)	**//X pixel number**
Dimensions:	
nx	
float ny(ny)	**//Y scan line number**
Dimensions:	
ny	

When the products are remapped to an area, the nx and ny variables are used in a different ways dependent on the projection method, but generally describing the coordinates of the pixels along the two dimensions the region.

	Content
Variables	
float nx(nx)	**//X Coordinates for the centre of the pixel**
Dimensions:	
nx	
float ny(ny)	**//Y Coordinates for the centre of the pixel**
Dimensions:	
ny	

4.4.3.2 Mapping Container

The mapping container is *only* used for remapped products. The format of the mapping container depends of the projection used for the region. Here is given the format when using polar stereographic. The container is referenced by the main variables attribute: grid_mapping.

For more info on grid_mappings, see CF-convention v1.6 section 5.6.

Variables	
byte grid_mapping_info	// Mapping container
Attributes	
grid_mapping_name	polar_stereographic
straight_vertical_longitude_from_pole	
latitude_of_projection_origin	// Either +90. Or -90
standard_parallel	
false_easting	// default 0.0
false_northing	// default 0.0
ellipsoid	//if available; eg. bessel or WGS84
scale_factor_at_projection_origin	//if available

Here is given the format for some other types of projection:

Variables	
byte grid_mapping_info	// Mapping container
Attributes	
grid_mapping_name	lambert_azimuthal_equal_area
latitude_of_projection_origin	
longitude_of_projection_origin	
false_easting	// default 0.0
false_northing	// default 0.0
semi_major_axis	
inverse_flattening	// if available

Variables	
byte grid_mapping_info	// Mapping container
Attributes	
grid_mapping_name	rotated_latitude_longitude
grid_north_pole_latitude	
grid_north_pole_longitude	
north_pole_grid_longitude	//This parameter is optional (default is 0).

Variables	
byte grid_mapping_info	// Mapping container
Attributes	
grid_mapping_name	lambert_cylindrical_equal_area
latitude_of_central_meidian	
standard_parallel	
false_easting	// default 0.0
false_northing	// default 0.0
ellipsoid	//if available; eg. bessel or WGS84
k_0	//if available

Variables	
byte grid_mapping_info	// Mapping container
Attributes	
grid_mapping_name	albers_conical_equal_area
latitude_of_projection_origin	
longitude_of_central_meridian	
standard_parallel	// 2-d array; one or two values
false_easting	// default 0.0
false_northing	// default 0.0
ellipsoid	//if available; eg. bessel

4.4.3.3 Palette Containers

Image-like NWC/PPS products can store several Palette containers providing the "proposed" palette to be used in the graphical representation the meteorological parameters as a coloured image. Palettes provide the (R,G,B) indices ([0,255]) associated to each image raw count. Palette is provided as a 2-dimensional array where:

- Number of lines (*pal*_colors) is the number of colours, and
- Number of columns (pal_rgb) is fixed to 3, storing
  - R index
  - G index
  - B index
- Variable containers will refer applicable palette in their *ancillary_variables* attribute.
- Palette containers must be named as the name of the variable which points to them including the modifier *"_pal"*

  In case a single palette is used by (is applicable to) different variable containers, it is proposed to name palette containers as
  <PGE id>[nn]_pal
  where
  <PGE_id> is the PGE identifier, and
  nn is a sequential number to define, if required, different palettes

	Content
Variables	
unsigned byte <dataset>_pal(pal_colors,pal_rgb)	//Palette
Dimensions	
pal_colors	
pal_rgb	3
Attributes	
long_name	"RGB Palette for <container> [<container> …]
valid_range	0, 255
colormodel	"RGB"
Comment	"Palette applicable to field[s] <container> [<container> …]

4.4.3.4 Quantitative Geophysical Retrieval Containers

These containers store specific and quantifiable geophysical parameters at pixel level. For instance, cloud top temperature in Kelvin. They will be stored as 2-dimensional arrays dimensioned to the size of the region (ny,nx). Following rules will be used in the generation of Quantitative Meteorological Measure containers:

- Information will be coded as a 16 bit ***unsigned short*** (pixelCount)

- Special value ***65535*** (2^{16}-1) will be used to identify missing data.
  - ***_FillValue*** attribute will be set to ***65535*** (2^{16}-1)
- ***scale_factor*** and ***add_offset*** attributes will be used to retrieve the physical magnitude from the raw counts
- All Quantitative Geophysical Retrieval containers will include the ***units*** attribute. The value of the units attribute will be a string recognized by the UNIDATA's Udunits package (See http://www.unidata.ucar.edu/software/udunits/).
- ***valid_range*** attributes will provide the maximum and minimum permitted values (in pixelCounts representation)
- Quantitative Geophysical Retrieval containers will reference the applicable Palette container in the ***ancillary_variables*** attribute

Please refer to netcdf best practices for additional information about how to compute the scale_factor and add_offset attributes (See [RD.7.])

	Content
Variables	
unsigned short <dataset>(time, ny,nx)	// Quantitative Meteorological Measure
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	According http://cf-pcmdi.llnl.gov/documents/cf-standard-names/standard-name-table/current/cf-standard-name-table.html/
long name	
description	//when needed
scale_factor	
add_offset	
units	According http://www.unidata.ucar.edu/software/udunits To be omitted for dimensionless variables
valid_range	
FillValue	-32768
ancillary_variables	"<dataset>_status_flag <dataset>_CONDITIONS <dataset> QUALITY <dataset> pal"
grid_mapping	"region"
coordinates	"lon lat"

4.4.3.5 Categorized Value Containers

These containers store qualitative meteorological information at pixel level in form of classes, as for example, the Cloud Mask (free, filled) or the Cloud Type (very low clouds, low clouds, mid-level clouds, high opaque, ...). They will be stored as 2-dimensional arrays dimensioned to the size of the region (ny,nx). Following rules will be used in the generation of Parameterized Value containers:

- Information will be coded as 8 bit ***unsigned byte*** (class) (it is not expected to have more than 255 ([0,254]) different classes
- Special value 255(2^8-1) will be used to identify missing data.
  _FillValue attribute will be set to 255

- ***valid_range*** attributes will provide the maximum and minimum permitted values (class representation)
- The meaning of the different classes will be described by flag_values and flag_meanings.
- CategorizedValue container will reference the applicable Palette container in the ***ancillary_variables*** attribute

	Content
Variables	
unsigned byte <dataset>(time, ny,nx)	// Parameterized Value Containers
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	
long_name	
valid_range	0, 254
_FillValue	255
ancillary_variables	"<dataset>_statusflag <dataset>_CONDITIONS <dataset> QUALITY <dataset> pal"
coordinates	"lon lat"
flag_values	1b, 2b, 3b, 4b
flag_meanings	"cloudfree cloud contaminated cloudfill snow ice"

4.4.3.6 Flags Containers

Flag containers are intended to include status codes and Boolean conditions information consisting in mutually exclusive coded values

- Flag containers will be stored as ***unsigned short*** (16 bits)
- ***flag_values*** attribute will be used to describe status flag, consisting of a set of mutually exclusive coded values. For example, in the <pge-id>_CONDITIONS flag containing the values day, night and twilight.
- ***flag_masks*** attribute is used to describe a number of independent Boolean conditions. For example, in the PPS-CMA_status_flag, where 'Low level_thermal_inversion_in_NWP_field' is either true or false.
- ***flag_meanings*** attribute is used to provide descriptive information for each case.

If a container only includes Boolean conditions:

- Store, at maximum, 15 bits. MSB bit will be used to specify missing value ***_FillValue*** = 32767 (=2^{15}-1)

If a container includes a set of status codes, or status codes and Boolean conditions

- Status codes shall be coded as 1,2, ..., avoiding the "0", in order to allow the individual matching using the ***flag_masks*** attribute (See details in the netCDF CF metadata Conventions v1.5, section 3.5 and example 3.4)

- ***_FillValue*** = 0 (Because if data, all status codes will have some value [1,*]

	Content
Variables	
unsigned short FLAG(time, ny,nx)	Flags container
Dimensions	
time	
ny	
nx	
Attributes	
standard name	
long name	
valid range	
FillValue	0 or 32767
flag masks	See example hereafter
flag values	
flag meanings	
coordinates	"lon lat"

For example, the specification for the PPS-CMA_CONDITIONS field of the NWC/PPSCMA product (identical for all NWC/PPS image-like products)

13	12	11	10	9	8	7	6	5	4	3	2	1	0
aux_input data		NWP_input data		satellite input data		rough terrain	high terrain	land/ sea		sun-glint	illumi-nation		outside swath

should be

	Content
Variables	
unsigned short PPS-CMA_CONDITIONS (time, ny,nx)	
Dimensions	
time	
ny	
nx	
Attributes	
Standard name	"PPS-CMA status flag"
long name	""Common geophysical and processing conditions flag"
valid range	1, 32767
FillValue	0
flag_masks	1b, 6b, 6b, 6b 8b 48b, 48b, 48b 64b 128b 768b, 768b, 768b 3072b, 3072b, 3072b 12288b, 12288b, 12288b 49152b, 49152b, 49152b,
flag_values	1b, 2b, 4b, 6b, 8b, 16b, 32b, 48b, 64b, 128b, 256b, 512b, 768b, 1024b, 2048b, 3072b, 4096b, 8192b,12288b, 16384b, 32768b, 49152b

flag_meanings	"outside_swath night day twilight sunglint land sea coast high_terrain spare bit all_satellite_channels_available usefull_satellite_channels_missing mandatory_satellite_channels_missing all_NWP_fields_available usefull_NWP_fields_missing mandatory_NWP_fields_missing all_product_data_available usefull_product_data_missing mandatory_product_data_missing all_auxiliary_data_available usefull_auxiliary_data_missing mandatory_auxiliary_data_missing"

4.4.4 Common Quality containers

All image-like products will contain Quality Containers storing information about

Geophysical Conditions

Field	Type	Bit Number	Description
Outside swath	Flag	0	Set to 1 for pixels outside swath or space pixels. (for GEO: space pixel)
Illumination	Parameter	1-2	Defines the illumination condition 0: N/A 1: Night 2: Day 3: Twilight
Sunglint	Flag	3	Set to 1 if Sunglint
Land_Sea	Parameter	4-5	Defines whether it is land, sea or coast 0: N/A 1: Land 2: Sea 3: Coast
High Terrain	Flag	6	Set to 1 if it is high terrain
Rough Terrain	Flag	7	Set to 1 if it is rough terrain

Size: 8 bits

Processing Conditions

Field	Type	Bit Number	Description
Satellite_input_data	Parameter	8-9	Describes the Satellite input data status 0: N/A 1: All satellite data are available 2: At least one useful satellite channel is missing 3: At least one mandatory satellite channel is missing
NWP_input_data	Parameter	10-11	Describes the NWP input data status 0: N/A (not classified pixel or NWP data not used) 1: All NWP data are available 2: At least one useful NWP field is missing 3: At least one mandatory NWP field is missing
Product_input_data	Parameter	12-13	Describes the Product input data status 0: N/A (not classified pixel or Auxiliary data not used) 1: All input Product data are available 2: At least one useful input Product is missing 3: At least one mandatory input Product is missing
Auxiliary_input_data	Parameter	14-15	Describes the Auxiliary input data status (includes products used as input to PGE) 0: N/A (not classified pixel or Auxiliary data not used) 1: All Auxiliary data are available 2: At least one useful Auxiliary field is missing 3: At least one mandatory Auxiliary field is missing

Size: 8 bits

Quality

Field	Type	Bit Number	Description
Nodata	Flag	0	Set to 1 if pixel is NODATA
Internal_consistency	Flag	1	This bit is not used in PPS. It is left over to keep the same bit numbers as GEO .
Temporal_consistency	Flag	2	This bit is not used in PPS. It is left over to keep the same bit numbers as GEO.
Quality	Parameter	3-5	Retrieval Quality 0: N/A (no data) 1: Good 2: Questionable 3: Bad 4: Interpolated/Reclassified Each PGE must describe the criteria used to classify each pixel in different classes

Size: 6 bits

Two common Containers will be included in all image-like products

- **<PGE_ID>_conditions**: Stores common geophysical and processing conditions

- **<PGE_ID>_quality**: Stores common quality indicators

Additional and product-specific information on processing conditions, quality checks, … shall be included in separate containers in each PGE

Specific implementation of these containers is detailed hereafter

	Content
Variables	
unsigned short <PGE_ID>_conditions(time, ny,nx)	// Common geophysical and processing conditions
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	<PGE ID> status_flag
long_name	"Common geophysical and processing conditions flag"
valid_range	1b, 65535b
_FillValue	0
flag_masks	1b, 6b, 6b, 6b 8b 48b, 48b, 48b 64b 128b 768b, 768b, 768b 3072b, 3072b, 3072b 12288b, 12288b, 12288b 49152b, 49152b, 49152b,
flag_values	1b, 2b, 4b, 6b, 8b, 16b, 32b, 48b, 64b, 128b, 256b, 512b, 768b, 1024b, 2048b, 3072b, 4096b, 8192b,12288b, 16384b, 32768b, 49152b
flag_meanings	"outside_swath night day twilight sunglint land sea coast high_terrain rough_terrain all_satellite_channels_available usefull_satellite_channels_missing mandatory_satellite_channels_missing all_NWP_fields_available usefull_NWP_fields_missing mandatory_NWP_fields_missing all_product_data_available usefull_product_data_missing mandatory_product_data_missing all_auxiliary_data_available usefull_auxiliary_data_missing mandatory_auxiliary_data_missing" Comment: bit 7 is a spare bit, reserved for rough terrain, if/when implemented.
coordinates	"lon lat"
comment	"Common geophysical and processing conditions"
unsigned short <PGE_ID>_quality(time, ny,nx)	// Common Quality Indicators
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"<PGE_ID> status_flag"
long_name	"Common Quality Indicators flag"
valid_range	1b, 64b
_FillValue	0
flag_masks	

	1b 2b 4b 32b, 32b, 32b, 32b
flag_values	1b, 2b, 4b, 8b, 16b, 24b, 32b
flag_meanings	"no_data spare_bit spare_bit good questionable bad interpolated_reclassified" Comment: bit 1 and 2 are spare bits. GEO use them for internal consistency and temporal consistency.
coordinates	"lon lat"
comment	"Common Quality Indicators"

4.5 HDF5 DATA MODEL FOR NWC/PPS V2014

For PPS v2014 HDF5 files will be produced and afterwards converted to netCDF, by a converter program. For PPS v2016 only netCDF files will be produced. We therefore recommend using netCDF files already from v2014.

The rest of this document (except from this section) describes the netCDF data format. The data format for HDF5 is mainly the same as for netCDF, and thus rather different from the HDF5 format of previous versions of PPS!

Similarities between HDF5 and netCDF formats:

- The datasets are the same, including their names and data types, excluding the dimensions (see differences, below)
- Dataset attributes
- Common attributes
- Filenames (except from the suffix .h5 or .nc)

Differences between HDF5 and netCDF formats:

- Dimensions are described separately only in netCDF
- In netCDF dataset has dimensions (time, ny, nx) while in HDF5 the dimensions are (ny, nx). Though the extent in the dimension time is 1, thus the amount of data is the same in both cases.
- lat/lon data are only provided in netCDF. For HDF5: you find them in the intermediate output file (name starting with "S_NWC_sunsatangles") holding the sun-satellite viewing geometry – just as has been the case with previous versions of PPS.
- Region information is differently described in HDF5 and netCDF.

For region description in netCDF, see 4.4. In HDF5 a compound data type, `RegionType`, is used. The region of the specific data is properly specified in the data set `region`, of the type previously defined.

For products on satellite projection[1] the horizontal resolution and the pixel size is defined by the satellite resolution and pixel sizes. Also here the data type `RegionType` and the data set `region`, are used. But for satellite projection some of the data in the data set `region` are set to no-value; only the attributes `xsize` and `ysize` are actually used.

[1] Since version 2010 PPS output products are always in satellite projection. However, since PPS was originally developed for processing on a geographic map projected region/area from start to end, and since the original HDF5 file format has not been changed since then, there are a few remnants that are not fully applicable anymore. The Region definitions is such a remnant. It is kept and being used to the extent that it applies.

5 NWC/PPS PRODUCT-SPECIFIC FORMAT DEFINITION

5.1 PPS CLOUD MASK (PPS-CMA) PRODUCT

The Cloud Mask Product provides, on a pixel basis, information on the presence of clouds and aerosols.

5.1.1 PPS-CMA High-level specification

The high level structure of the PPS-CMA product is shown below

	Content
Dimensions	nx, ny
Attributes	
Variables	
float lat(ny, nx)	// Latitudes
float lon(ny,nx)	// Longitudes
byte grid_mapping_info	// Container for mapping description (*Only when region-projection*)
float nx(nx)	// pixel number
float ny(ny)	// scanline number
unsigned byte cma(time, ny,nx)	// PPS-CMA Cloud Mask
unsigned byte cma_extended(time, ny,nx)	// PPS-CMA Cloud Mask Extended
unsigned byte cma_aerosol(time, ny,nx)	// PPS-CMA Aerosol Detection *
unsigned short cma_testlist1(time, ny,nx)	// PPS-CMA First List of Tests (optional by configuration)
unsigned short cma_testlist2(time, ny,nx)	// PPS-CMA Second List of Tests (optional by configuration)
unsigned short cma status flag(time, ny,nx)	// PPS-CMA Specific Processing Conditions flag
unsigned short cma_conditions(time, ny,nx)	// Common Geophysical and Processing Conditions flag
unsigned short cma_quality(time, ny,nx)	// Common Quality Indicators flag
unsigned short cma_pal(pal01 colors,pal rgb)	// Palette for PPS-CMA
unsigned short cma_extended_pal(pal02 colors,pal rgb)	// Palette for PPS-CMA_EXTENDED
unsigned short cma_aerosol_pal(pal03_colors,pal_rgb)	// Palette for PPS-CMA_AEROSOL *

*Aerosol detection is planned for NWC/PPS version 2016. An older aerosol dataset is available for v2014.

In addition to common georeference information (lat, lon) and condition indicators (cma_conditions) and quality data (cma_quality), following information is provided at pixel level

<table>
<tr><th>Container</th><th>Content</th></tr>
<tr><td>cma</td><td>SAFNWC PPS CMA Cloud Mask

<table><tr><th>Class</th><th>Cloud Mask category</th></tr><tr><td>0</td><td>Cloud-free</td></tr><tr><td>1</td><td>Cloudy</td></tr><tr><td>_FillValue</td><td>No_data/Undefined (separability problem)</td></tr></table></td></tr>
<tr><td>cma_extended</td><td>SAFNWC PPS CMA Cloud Mask Extended

<table><tr><th>Class</th><th>Cloud Mask category</th></tr><tr><td>0</td><td>Cloud-free</td></tr><tr><td>1</td><td>Cloudy</td></tr><tr><td>2</td><td>Cloud Contaminated</td></tr><tr><td>3</td><td>Snow/Ice</td></tr><tr><td>_FillValue</td><td>No_data/Undefined (separability problem)</td></tr></table></td></tr>
<tr><td>cma_aerosol</td><td>SAFNWC PPS CMA Aerosol Detection

<table><tr><th>Class</th><th>Dust Detection category</th></tr><tr><td>0</td><td>No aerosol</td></tr><tr><td>1</td><td>Aerosol</td></tr><tr><td>_FillValue</td><td>No_data/Undefined (separability problem)</td></tr></table>Aerosol detection is planned for NWC/PPS version 2016. An older aerosol dataset (with other classes) is available for v2014, but not recommended.</td></tr>
<tr><td>cma_testlist1</td><td>Optional by configuration
16 bits indicating (if set to 1)

bit 0: TEST_T11TSUR
bit 1: TEST_T11T37
bit 2: TEST_T37T12
bit 3: TEST_T11T12
bit 4: TEST_QR37R06
bit 5: TEST_R37
bit 6: TEST_VISNIR
bit 7: TEST_TEXT_T11
bit 8: TEST_TEXT_T37T12
bit 9: TEST_TEXT_R06
bit 10: TEST_T11
bit 11: TEST_TSUR
bit 12: TEST_TSURT950
bit 13: TEST_PSUNGLINT
bit 14: TEST_VIS_STATIC
bit 15: TEST_QR16R06</td></tr>
<tr><td>cma_testlist2</td><td>Optional by configuration
5 bits indicating (if set to 1)

bit 0: TEST_T85T11i
bit 1: TEST_T85T11
bit 2: TEST_QR09R06
bit 3: TEST_SPATIAL_SEA
bit 4: TEST_SPATIAL_LAND</td></tr>
</table>

cma_status_flag	5 bits indicating (if set to 1; or parameters as described below) Bit 0: Low level thermal inversion in NWP field Bit 1: NWP data suspected low quality Bit 2: Sea ice map is available Bit 3: Sea ice, according to external map Bit 4: No method for aerosols Bit 5: Suspected heavy aerosol

Note: Bit flag 'No method for aerosols' is set either if the dataset aerosols is not created, or if the dataset is created: the bit is set if no aerosol retrieval could be done in the pixel. While bit flag 'Suspected heavy aerosol' is set independently of the dataset aerosols; this bit is set if the aerosols are suspected to be so heavy that they disturb the cloud mask retrieval.

5.1.2 PPS-CMA Specific specification

5.1.2.1 Dimensions

See section 4.4.1 for common dimensions data for image-like products. Product-specific parameters are:

	Content
Dimensions	
pal01 colors	3 (number of classes in cma Container)
pal02 colors	5 (number of classes in cma extended Container)
pal03 colors	3 (number of classes in cma aerosol Container)

5.1.2.2 Attributes

See section 4.3 for common NWC/PPS attributes, and section 0 for common attributes of the image-like products.

5.1.2.3 Variables

See following sections for a detailed description of common variable containers to all image-like products:

- section 4.4.3.1: lat and lon Containers
- section 4.4.3.2: Mapping Container
- section 4.4.3.3: Palette Containers
- section 4.4.4: Common Quality containers

Implementation of PPS-CMA-specific Variables Containers are hereafter presented

	Content
Variables	
unsigned byte cma(time, ny,nx)	**// PPS-CMA Cloud Mask**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"cloud_binary_mask" TBD01
long_name	"SAFNWC PPS CMA Cloud Mask"
valid_range	0, 1
_FillValue	255
ancillary_variables	"cma_status_flag cma_conditions cma_quality cma_testlist1 cma_testlist2 cma_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*
flag_values	0b, 1b
flag_meanings	"cloudfree cloudy"

*grid_mapping="grid_mapping_info" is only used for products in region projection.

	Content
Variables	
unsigned byte cma_extended(time, ny,nx)	**// PPS-CMA Cloud Mask Extended**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS CMA Cloud Mask Extended"
valid_range	0, 3
FillValue	255
ancillary_variables	"cma_status_flag cma_conditions cma_quality cma_testlist1 cma_testlist2 cma_extended_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*
flag_values	0b, 1b, 2b, 3b
flag_meanings	"cloudfree cloudy cloud_contaminated snow_ice"

*grid_mapping="grid_mapping_info" is only used for products in region projection.

	Content
Variables	
unsigned byte cma_aerosol(time, ny,nx)	**// PPS-CMA Aerosol Detection**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"aerosol_binary_mask" TBD01
long_name	"SAFNWC PPS CMA Aerosol Detection"
valid_range	0, 1
FillValue	255
ancillary_variables	"cma_status_flag cma_conditions cma_quality cma_aerosol_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*
flag_values	0b, 1b
flag_meaning	"no_aerosol aerosol"

*grid_mapping=”grid_mapping_info” is only used for products in region projection

Aerosol detection is planned for NWC/PPS version 2016. An older aerosol dataset is available for v2014.

Optional by configuration:

	Content
Variables	
unsigned short cma_testlist1(time, ny,nx)	**// PPS-CMA First List of Tests**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	“SAFNWC PPS CMA First List of Tests”
standard_name	“cloud binary mask status flag”
valid_range	1b, 65535b
_FillValue	0
flag_masks	1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b, 256b, 512b, 1024b, 2048b, 4096b, 8192b, 16384b, 32768b
flag_meanings	“T11-Tsur T11-T37 T37-T12 T11-T12 R37/R06 R37 R06_or_R09 T11_texture T37-T12_texture R06_texture T11 Tsurface Tsurface-T950hPa Sunglint_probability Static_visible R16/R06”
coordinates	“lon lat”

Optional by configuration:

	Content
Variables	
unsigned short cma_testlist(time, ny,nx)	**// PPS-CMA Second List of Tests**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	“SAFNWC PPS CMA Second List of Tests”
standard_name	“cloud_binary_mask status_flag”
valid_range	1b, 65535b
_FillValue	0
flag_masks	1b, 2b, 4b, 8b, 16b
flag_meanings	“T85-T11inverse T85-T11 R09/R06 Spatial_homogeneity_land Spatial_homogeneity_sea”
coordinates	“lon lat”

	Content
Variables	
unsigned short cma_status_flag(time, ny,nx)	**// PPS-CMA Specific Processing Conditions**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"Information on specific SAFNWC PPS CMA processing"
standard_name	"cloud binary mask status flag"
valid_range	0, 64b
FillValue	65535b
flag_masks	1b, 2b, 4b, 8b, 16b, 32b
flag_meanings	"Low_level_thermal_inversion_in_NWP_field NWP_low_quality Sea_ice_map_available Sea_ice_according_to_external_map No_method_for_aerosol Suspected_heavy_aerosol"
coordinates	"lon lat"

5.2 PPS CLOUD TYPE (PPS-CT) PRODUCT

The Cloud Type Product provides, on a pixel basis, information on the major cloud types and on snow/sea ice occurrence.

5.2.1 PPS-CT High-level specification

The high level structure of the PPS-CT product is shown below

	Content
Dimensions	
time	
ny	
nx	
Attributes	
Variables	
float lat(ny, nx)	// Latitudes
float lon(ny,nx)	// Longitudes
byte grid_mapping_info	// Container for mapping information (*Only when region-projection*)
float nx(nx)	// pixel number
float ny(ny)	// scanline number
unsigned byte ct(time,ny,nx)	// PPS-CT Cloud Type
unsigned byte ct_multilayer(time,ny,nx)	// PPS-CT Multilayer Cloud Detection
unsigned short ct_status_flag(time,ny,nx)	// PPS-CT Specific Processing Conditions flag
unsigned short ct_conditions(time,ny,nx)	// Common Geophysical and Processing Conditions flag
unsigned short ct_quality(ny,nx)	// Common Quality Indicators flag
unsigned short ct_pal (pal01 colors,pal rgb)	// Palette for PPS-CT
unsigned short ct_multilayer_pal (pal02 colors,pal rgb)	// Palette for PPS-CT_MULTILAYER

In addition to common georeference information (lat, lon) and condition indicators (ct_conditions) and quality data (ct_quality), following information is provided at pixel level

<table>
<tr><th>Container</th><th>Content</th></tr>
<tr><td>ct</td><td>SAFNWC PPS CT Cloud Type
<table>
<tr><th>Class</th><th>Cloud Type category</th></tr>
<tr><td>1</td><td>Cloud-free land</td></tr>
<tr><td>2</td><td>Cloud-free sea</td></tr>
<tr><td>3</td><td>Snow over land</td></tr>
<tr><td>4</td><td>Sea ice</td></tr>
<tr><td>5</td><td>Very low clouds</td></tr>
<tr><td>6</td><td>Low clouds</td></tr>
<tr><td>7</td><td>Mid-level clouds</td></tr>
<tr><td>8</td><td>High opaque clouds</td></tr>
<tr><td>9</td><td>Very high opaque clouds</td></tr>
<tr><td>10</td><td>Fractional</td></tr>
<tr><td>11</td><td>High semitransparent very thin clouds</td></tr>
<tr><td>12</td><td>High semitransparent thin clouds</td></tr>
<tr><td>13</td><td>High semitransparent thick clouds</td></tr>
<tr><td>14</td><td>High semitransparent above low clouds</td></tr>
<tr><td>15</td><td>not used for PPS (For GEO: High semitransparent above snow/ice)</td></tr>
<tr><td>_FillValue</td><td>No data or corrupted data</td></tr>
</table></td></tr>
<tr><td></td><td></td></tr>
<tr><td>ct_multilayer</td><td>SAFNWC PPS CT Multilayer Cloud Detection
<table>
<tr><th>Class</th><th>Multilayer Cloud category</th></tr>
<tr><td>0</td><td>No multilayer detected</td></tr>
<tr><td>1</td><td>Multilayer detected</td></tr>
<tr><td>_FillValue</td><td>nodata/no cloud/Undefined (separability problem)</td></tr>
</table></td></tr>
<tr><td>ct_status_flag</td><td>4 bits indicating (if set to 1)

Bit 0: Low level thermal inversion in NWP field
Bit 1: NWP data suspected low quality
Bit 2: Sea ice map is available
Bit 3: Sea ice, according to external map</td></tr>
</table>

5.2.2 PPS-CT Specific specification

5.2.2.1 Dimensions

See section 4.4.1 for common dimensions data for image-like products. Product-specific parameters are:

	Content
Dimensions	
pal01_colors	15 (number of classes in ct Container)
pal02_colors	3 (number of classes in ct_multilayer Container)

5.2.2.2 Attributes

See section 4.3 for common NWC/PPS attributes, and section 4.4.3 for common image-like products attributes.

5.2.2.3 Variables

See following sections for a detailed description of common variable containers to all image-like products:

- section 4.4.3.1: lat and lon Containers
- section 4.4.3.2: Mapping Container
- section 4.4.3.3: Palette Containers
- section 4.4.4: Common Quality containers

Implementation of PPS-CT-specific Variables Containers are hereafter presented

	Content
Variables	
unsigned byte ct(time, ny,nx)	**// PPS-CT Cloud Type**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS CT Cloud Type"
valid_range	1, 14
FillValue	255
ancillary_variables	"ct status_flag ct_conditions ct_quality ct_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *
flag_meanings	"Cloud-free_land Cloud-free_sea Snow_over_land Sea_ice Very_low_clouds Low_clouds Mid-level_clouds High_opaque_clouds Very_high_opaque_clouds Fractional_clouds High_semitransparent_very_thin_clouds High_semitransparent_thin_clouds High_semitransparent_thick_clouds High_semitransparent_above_low_or_medium_clouds "
flag_values	1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b, 10b, 11b, 12b, 13b, 14b

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned byte ct_multilayer(time, ny,nx)	**// PPS-CT Multilayer Cloud Detection**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS CT Multilayer Cloud Detection"
valid_range	0, 1
FillValue	255
ancillary_variables	"ct_status_flag ct_conditions ct_quality ct_multilayer_pal"
coordinates	"lon lat"
grid_maping	"region"
flag_values	0b, 1b
flag_meanings	"no_multilayer_detected multilayer_detected "

	Content
Variables	
unsigned short ct_status_flag(time,ny,nx)	**// PPS-CT Specific Processing Conditions**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"Information on specific SAFNWC PPS CT processing"
valid_range	0b, 16b
FillValue	65535
flag_masks	1b, 2b, 4b, 8b
flag_meanings	" Low_level_thermal_inversion_in_NWP_field NWP_low_quality Sea_ice_map_available Sea_ice_according_to_external_map "
coordinates	"lon lat"

5.3 PPS CLOUD TOP TEMPERATURE AND HEIGHT (PPS-CTTH) PRODUCT

The Cloud Top Temperature and Height Product provides, on a pixel basis, information on cloud top height and on cloud top temperature.

5.3.1 PPS-CTTH High-level specification

The high level structure of the PPS-CTTH product is shown below

	Content
Dimensions	
time	
ny	
nx	
Attributes	
Variables	
float lat(ny, nx)	// Latitudes
float lon(ny,nx)	// Longitudes
byte grid_mapping_info	// Mapping information container (*Only when region-projection)*
float nx(nx)	// pixel number
float ny(ny)	// scanline number
unsigned short ctth_pres(time, ny,nx)	// PPS-CTTH Cloud Top Pressure
unsigned short ctth_alti (time, ny,nx)	// PPS-CTTH Cloud Top Altitude
unsigned short ctth_tempe(time, ny,nx)	// PPS-CTTH Cloud Top Temperature
unsigned short ctth status flag(time, ny,nx)	// PPS-CTTH Specific Processing Conditions flag
unsigned short ctth_conditions(time, ny,nx)	// Common Geophysical and Processing Conditions flag
unsigned short ctth_quality(time, ny,nx)	)// Common Quality Indicators flag
unsigned short ctth_pres_pal (pal01 colors,pal rgb)	// Palette for ctth_pres
unsigned short ctth_alti_pal (pal02 colors,pal reg)	// Palette for ctth_alti
unsigned short ctth_tempe_pal (pal03_colors,pal_rgb)	// Palette for ctth_tempe

In addition to common georeference information (lat, lon), condition indicators (PPS-CTTH_CONDITIONS) and quality data (PPS-CTTH_QUALITY), following information is provided at pixel level

Container	Content
ctth_pres	SAFNWC PPS CTTH Cloud Top Pressure PPS-CTTH_PRES(Pa) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *10.0* *add_offset* = //Could be eg. *0.0*
ctth_alti	SAFNWC PPS CTTH Cloud Top Altitude PPS-CTTH_ALTI(m) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *1.0* *add_offset* =//Could be eg. *0.0*
ctth_tempe	SAFNWC PPS CTTH Cloud Top Temperature PPS-CTTH_TEMPE(K) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *0.01* *add_offset* = //Could be eg. *0.0*

Container	Content
ctth_status_flag	8 bits indicating (if set to 1) Bit 0: Cloud-free Bit 1: No reliable method (nodata due to failed calculations) Bit 2: Opaque clouds Bit 3: Multilayer suspected Bit 4: Low level thermal inversion in NWP field Bit 5: NWP data suspected low quality Bit 6: Using RTTOV Bit 7: Using windowing technique

5.3.2 PPS-CTTH Specific specification

5.3.2.1 Dimensions

See section 4.4.1 for common dimensions data for image-like products. Product-specific parameters are:

	Content
Dimensions	
pal01_colors	20 (number of colours used for ctth_pres)
pal02_colors	20 (number of colours used for ctth_alti)
pal03_colors	20 (number of colours used for ctth_tempe)

5.3.2.2 Attributes

See section 4.3 for common NWC/PPS attributes, and section 4.4.3 for common image-like products attributes.

5.3.2.3 Variables

See following sections for a detailed description of common variable containers to all image-like products:

- section 4.4.3.1: lat and lon Containers
- section 4.4.3.2: Mapping Container
- section 4.4.3.3: Palette Containers
- section 4.4.4: Common Quality containers

Implementation of PPS-CTTH-specific Variables Containers are hereafter presented

	Content
Variables	
unsigned short ctth_pres(time, ny,nx)	**// PPS-CTTH Cloud Top Pressure**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"air_pressure_at_cloud_top"
long_name	"SAFNWC PPS CTTH Cloud Top Pressure"
scale_factor	//Could be eg. 10.0
add_offset	//Could be eg. 0.0
units	"Pa"
valid_range	0, 11000
FillValue	65535
ancillary_variables	"ctth_status_flag ctth_conditions ctth_quality ctth_pres_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short ctth_alti(time, ny,nx)	**// PPS-CTTH Cloud Top Altitude**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"cloud_top_altitude"
long_name	"SAFNWC PPS CTTH Cloud Top Altitude"
scale_factor	//Could be eg. 1.0
add_offset	//Could be eg. -2000.0
units	"m"
valid_range	0, 27000
FillValue	65535
ancillary_variables	"ctth_status_flag ctth_conditions ctth_quality ctth_alti_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short ctth_tempe(time, ny,nx)	**// PPS-CTTH Cloud Top Temperature**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"air_temperature_at_cloud_top"
long_name	"SAFNWC PPS CTTH Cloud Top Temperature"
scale_factor	//Could be eg. 0.01
add_offset	//Could be eg. 130.0
units	"K"
valid_range	0, 22000
_FillValue	65535
ancillary_variables	"ctth_status_flag ctth_conditions ctth_quality ctth_tempe_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short ctth_status_flag(time, ny,nx)	**// PPS-CTTH Specific Processing Conditions**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"air_temperature_at_cloud_top_status_flag"
long_name	"Information on specific SAFNWC PPS CTTH processing"
valid_range	0b, 256b
FillValue	65535b
flag_masks	1b, 2b, 4b, 8b, 16b, 32b, 64b, 128b
flag_meanings	" Cloud-free No_reliable_method Opaque_cloud Multilayer_cloud_suspected Low_level_thermal_inversion_in_NWP_field NWP_low_quality Using_RTTOV Using_windowing_technique "
coordinates	"lon lat"

5.4 PPS CLOUD PHYSICAL PROPERTIES (PPS-CPP) PRODUCT

The Cloud Physical Properties Product provides, on a pixel basis, information on cloud microphysics, as cloud thermodynamical phase and liquid water path. Additional parameters are drop effective radius, cloud optical depth and ice water path.

5.4.1 PPS-CPP High-level specification

The high level structure of the PPS-CPP product is shown below

	Content
Dimensions	
time	
ny	
nx	
Attributes	
Variables	
float lat(ny, nx)	// Latitudes
float lon(ny,nx)	// Longitudes
byte grid_mapping_info	// Container for mapping info (*Only when region-projection*)
float nx(nx)	// pixel number
float ny(ny)	// scanline number
unsigned byte cpp_phase(time,ny,nx)	// PPS-CPP Cloud Top Phase
unsigned byte cpp_phase_extended(time,ny,nx)	// PPS-CPP Cloud Top Phase Extended
unsigned short cpp_reff (time,ny,nx)	// PPS-CPP Cloud Particle Effective Radius
unsigned short cpp_cot(time,ny,nx)	// PPS-CPP Cloud Optical Thickness
unsigned short cpp_lwp(time,ny,nx)	// PPS-CPP Liquid Water Path
unsigned short cpp_iwp(time,ny,nx)	// PPS-CPP Ice Water Path
unsigned short cpp_cwp(time,ny,nx)	// PPS-CPP Cloud Water Path
unsigned short cpp_dreff (time,ny,nx)	// PPS-CPP Error in Cloud Particle Effective Radius
unsigned short cpp_dcot(time,ny,nx)	// PPS-CPP Error in Cloud Optical Thickness
unsigned short cpp_dcwp(time,ny,nx)	// PPS-CPP Error in Cloud Water Path
unsigned short cpp_status_flag(time,ny,nx)	// PPS-CPP Specific Processing Conditions flag
unsigned short cpp_conditions(time,ny,nx)	// Common Geophysical and Processing Conditions flag
unsigned short cpp_quality(time,ny,nx)	// Common Quality Indicators flag
unsigned short cpp_phase_pal (pal01_colors,pal_rgb)	// Palette for PPS-CPP_PHASE
unsigned short cpp_reff_pal (pal02_colors,pal_rgb)	// Palette for PPS-CPP_REFF
unsigned short cpp_cot_pal (pal03_colors,pal_rgb)	// Palette for PPS-CPP_COT
unsigned short cpp_lwp_pal (pal04_colors,pal_rgb)	// Palette for PPS-CPP_LWP/IWP/CWP

Of the main variables, cpp_lwp and cpp_phase are official products, and cpp_iwp, cpp_cwp, cpp_cot, cpp_reff and cpp_phase_extended are additional products.

In addition to common georeference information (lat, lon), condition indicators (cpp_conditions) and quality data (cpp_quality), following information is provided at pixel level

<table>
<tr><th>Container</th><th>Content</th></tr>
<tr><td>cpp_phase</td><td>SAFNWC PPS CPP Cloud Top Phase

<table><tr><th>Class</th><th>Cloud Top Phase category</th></tr><tr><td>1</td><td>liquid</td></tr><tr><td>2</td><td>ice</td></tr><tr><td>_FillValue</td><td>No data/Cloud free/Corrupted data</td></tr></table></td></tr>
<tr><td>cpp_phase_extended</td><td>SAFNWC PPS CPP Cloud Top Phase Extended

<table><tr><th>Class</th><th>Cloud Top Phase category</th></tr><tr><td>0</td><td>clear</td></tr><tr><td>2</td><td>fog</td></tr><tr><td>3</td><td>water</td></tr><tr><td>4</td><td>super-cooled</td></tr><tr><td>5</td><td>mixed</td></tr><tr><td>6</td><td>opaque</td></tr><tr><td>7</td><td>cirrus</td></tr><tr><td>8</td><td>overlap</td></tr><tr><td>_FillValue</td><td>No data/Corrupted data</td></tr></table></td></tr>
</table>

Container	Content
cpp_reff	SAFNWC PPS CPP Cloud Particle Effective Radius PPS-CPP_REFF(m) = scale_factor * Counts + add_offset where: *scale_factor* =//Could be eg. 10^{-8} *add_offset* = //Could be eg. *0.0*
cpp_cot	SAFNWC PPS CPP Cloud Optical Thickness PPS-CPP_COT = scale_factor * Counts + add_offset where: *scale_factor* =//Could be eg. *0.01* *add_offset* = //Could be eg. *0.0*
cpp_lwp	SAFNWC PPS CPP Liquid Water Path PPS-CPP_LWP($kg.m^{-2}$) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *0.0001* *add_offset* = //Could be eg. *0.0*
cpp_iwp	SAFNWC PPS-CPP Ice Water Path PPS-CPP_IWP($kg.m^{-2}$) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *0.0001* *add_offset* = //Could be eg. *0.0*
cpp_cwp	SAFNWC PPS CPP Cloud Water Path PPS-CPP_CWP($kg.m^{-2}$) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *0.0001* *add_offset* = //Could be eg. *0.0*
cpp_dreff	Optional by configuration: SAFNWC PPS-CPP Error in Cloud Particle Effective Radius PPS-CPP_DREFF(m) = scale_factor * Counts + add_offset where: *scale_factor* =//Could be eg. 10^{-8} *add_offset* = //Could be eg. *0.0*
cpp_dcot	Optional by configuration: SAFNWC PPS-CPP Error in Cloud Optical Thickness PPS-CPP_DCOT = scale_factor * Counts + add_offset where: *scale_factor* =//Could be eg. *0.01* *add_offset* = //Could be eg. *0.0*

Container	Content
cpp_dcwp	Optional by configuration: SAFNWC PPS-CPP Error in Cloud Water Path PPS-CPP_DCWP(kg.m^{-2}) = scale_factor * Counts + add_offset where: *scale_factor* = //Could be eg. *0.0001* *add_offset* = //Could be eg. *0.0*
cpp_status_flag	5 bits indicating (if set to 1) Bit 0: Cloud-free Bit 1: bad_optical_conditions Bit 2: snow_ice Bit 3: 1.6µm used Bit 4: 3.8µm used

5.4.2 PPS-CPP Specific specification

5.4.2.1 Dimensions

See section 4.4.1 for common dimensions data for image-like products. Product-specific parameters are:

	Content
Dimensions	
pal01_colors	3 (number of classes in cpp_phase Container)
pal02_colors	256 (number of colours used for cpp_reff)
pal03_colors	256 (number of colours used for cpp_cot)
pal04_colors	256 (number of colours used for cpp_lwp/iwp/cwp)

5.4.2.2 Attributes

See section 4.3 for common NWC/PPS attributes, and section 4.4.3 for common image-like products attributes.

5.4.2.3 Variables

See following sections for a detailed description of common variable containers to all image-like products:

- section 4.4.3.1: lat and lon Containers
- section 4.4.3.2: Mapping Container
- section 4.4.3.3: Palette Containers
- section 4.4.4: Common Quality containers

Implementation of PPS-CPP-specific Variables Containers are hereafter presented

	Content
Variables	
unsigned byte cpp_phase(time, ny,nx)	**// PPS-CPP Cloud Top Phase**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"thermodynamic_phase_of_cloud_water_particles_at_cloud_top"
long_name	"SAFNWC PPS CPP Cloud Top Phase"
valid_range	1, 2
_FillValue	255
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality cpp_phase_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *
flag_values	1b, 2b
flag_meanings	"liquid ice"

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short cpp_lwp(time, ny,nx)	**// PPS-CPP Cloud Liquid Water Path**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"atmosphere_cloud_liquid_water_content"
long_name	"SAFNWC PPS CPP Cloud Liquid Water Path"
scale_factor	//Could be eg. 0.0001
add_offset	//Could be eg. 0.0
units	"kg m-2" //Means kg/m^2
valid_range	0, 32000
_FillValue	65535
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality cpp_dcwp cpp_lwp_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *

*grid_mapping="grid_mapping_info" is only used for products in region projection

The following four variable containers are PPS-CPP-specific, but only as additional parameters:

	Content
Variables	
unsigned short cpp_reff(time, ny,nx)	**// PPS-CPP Cloud Drop Effective Radius**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"effective_radius_of_cloud_condensed_water_particles_at_cloud_top"
long_name	"SAFNWC PPS CPP Cloud Particle Effective Radius"
scale_factor	//Could be eg. 10^{-8}
add_offset	//Could be eg. 0.0
units	"m"
valid_range	0, 32000
_FillValue	65535
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality cpp_dreff cpp_reff_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short cpp_cot(time, ny,nx)	**// PPS-CPP Cloud Optical Thickness**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"atmosphere_optical_thickness_due_to_cloud"
long_name	"SAFNWC PPS CPP Cloud Optical Thickness"
scale_factor	//Could be eg. 0.01
add_offset	//Could be eg. 0.0
units	"1"
valid_range	0, 32000
_FillValue	65535
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality cpp_dcot cpp_cot_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short cpp_iwp(time,ny,nx)	**// PPS-CPP Cloud Ice Water Path**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"atmosphere_cloud_ice_content"
long_name	"SAFNWC PPS CPP cloud ice water path"
scale_factor	//Could be eg. 0.0001
add_offset	//Could be eg. 0.0
units	"kg m-2" //Means kg/m^2
valid_range	0, 32000
FillValue	65535
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality cpp_dcwp cpp_lwp_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short cpp_cwp(time,ny,nx)	**// PPS-CPP Cloud Water Path**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"atmosphere_cloud_condensed_water_content"
long_name	"SAFNWC PPS CPP Cloud Water Path"
scale_factor	//Could be eg. 0.0001
add_offset	//Could be eg. 0.0
units	"kg m-2" //Means kg/m^2
valid_range	0,32000
FillValue	65535
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality cpp_dcwp cpp_lwp_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned byte cpp_phase_extended(time,ny,nx)	**// PPS-CPP Cloud Top Phase Extended**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS CPP Cloud Top Phase Extended"
valid_range	0, 8
_FillValue	255
ancillary_variables	"cpp_status_flag cpp_conditions cpp_quality"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *
flag_values	0b 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b
flag_meanings	"clear spare_value fog water supercooled mixed opaque cirrus overlap"

*grid_mapping="grid_mapping_info" is only used for products in region projection

The following three variable containers are error estimations, and they are optional by configuration:

	Content
Variables	
unsigned short cpp_dreff(time, ny,nx)	**// PPS-CPP Error in Cloud Drop Effective Radius**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"effective_radius_of_cloud_condensed_water_particles_at_cloud_top standard_error"
long_name	"SAFNWC PPS CPP Error in Cloud Particle Effective Radius"
scale_factor	//Could be eg. 10^{-8}
add_offset	//Could be eg. 0.0
units	"m"
valid_range	0, 32000
_FillValue	65535
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short cpp_dcot(time, ny,nx)	**// PPS-CPP Error in Cloud Optical Thickness**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"atmosphere_optical_thickness_due_to_cloud standard_error"
long_name	"SAFNWC PPS CPP Error in Cloud Optical Thickness"
scale_factor	//Could be eg. 0.01
add_offset	//Could be eg. 0.0
units	"1"
valid_range	0, 32000
_FillValue	65535
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short cpp_dcwp(time, ny,nx)	**// PPS-CPP Error in Cloud Water Path**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"atmosphere_cloud_condensed_water_content standard_error"
long_name	"SAFNWC PPS CPP Error in Cloud Water Path"
scale_factor	//Could be eg. 0.0001
add_offset	//Could be eg. 0.0
units	"kg m-2" //Means kg/m^2
valid_range	0,32000
FillValue	65535
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*

*grid_mapping="grid_mapping_info" is only used for products in region projection

The following variable is a status flag:

	Content
Variables	
unsigned short cpp_status_flag(time,ny,nx)	**// PPS-CPP Specific Processing Conditions**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	""thermodynamic particle phase at cloud top status_flag"
long_name	"Information on specific SAFNWC PPS CPP processing"
valid_range	0b, 32b
FillValue	65535b
flag_masks	1b, 2b, 4b, 8b, 16b
flag_meanings	" cloud-free bad_optical_conditions snow_ice 16_micron_used 38_micron_used "
coordinates	"lon lat"
comment	

5.5 PPS PRECIPITATING CLOUDS (PPS-PC) PRODUCT

The Precipitating Clouds Product provides, on a pixel basis, precipitation rate and the probability of precipitation in pre-defined intensity intervals.

5.5.1 PPS-PC High-level specification

The high level structure of the PPS-PC product is shown below

	Content
Dimensions	
time	
ny	
nx	
Attributes	
Variables	
float lat(ny, nx)	// Latitudes
float lon(ny,nx)	// Longitudes
byte grid_mapping_info	// Container for mapping info(*Only when region-projection*)
float nx(nx)	// pixel_number
float ny(ny)	// scanline_number
unsigned byte pc_precip_light(time,ny,nx)	// PPS-PC Likelihood for precipitation of light intensity
unsigned byte pc_precip_moderate(time,ny,nx)	// PPS-PC Likelihood for precipitation of moderate intensity
unsigned byte pc_precip_intense(time,ny,nx)	// PPS-PC Likelihood for precipitation of high intensity.
unsigned short pc_precip_rate_cpp(time,ny,nx)	// PPS-PC precipitation rate, from CPP*
unsigned short pc_status_flag(time,ny,nx)	// PPS-PC Specific Processing Conditions flag
unsigned short pc_conditions(time,ny,nx)	// Common Geophysical and Processing Conditions flag
unsigned short pc_quality(time,ny,nx)	// Common Quality Indicators flag
unsigned short pc_precip_rate_pal(pal01_colors,pal_rgb)	// Palette for PPS-PC precipitation_rate

*Precipitation rate from CPP is planned for NWC/PPS version 2016.

In addition to common georeference information (lat, lon) and condition indicators (pc_conditions) and quality data (pc_quality), following information is provided at pixel level

Container	Content
pc_precip_light	SAFNWC PPS PC Likelihood for light precipitation PPS-PC_PRECIP_LIGHT (%) = scale_factor * Counts + add_offset where: *scale_factor = 1.0* *add_offset = 0.0*
pc_precip_moderate	SAFNWC PPS PC Likelihood for moderate precipitation PPS-PC_PRECIP_MODERATE (%) = scale_factor * Counts + add_offset where: *scale_factor = 1.0* *add_offset = 0.0*
pc_precip_intense	SAFNWC PPS PC Likelihood for intense precipitation PPS-PC_PRECIP_INTENSE (%) = scale_factor * Counts + add_offset where: *scale_factor = 1.0* *add_offset = 0.0*
pc_precip_rate_cpp	SAFNWC PPS PC precipitation rate; derived from cloud physical properties. PPS-PC_PRECIP_RATE (mm/h) = scale_factor * Counts + add_offset where: *scale_factor = TBD02* *add_offset = TBD02*
pc_status_flag	TBD03 bits indicating (if set to 1) (list TBD03) Bit 0: NWP data suspected low quality Bit 1: precip_rate: no reliable method Bit 2: likelihood: AMSU used Bit 3: likelihood: AVHRR used Bit 4: likelihood: solar channels used

5.5.2 PPS-PC Specific specification

5.5.2.1 Dimensions

See section 4.4.1 for common dimensions data for image-like products. Product-specific parameters are:

	Content
Dimensions	
pal01_colors	TBD02 (number of colours used for pc_precip_rate)

5.5.2.2 Attributes

See section 4.3 for common NWC/PPS attributes, and section 4.4.3 for common image-like products attributes.

5.5.2.3 Variables

See following sections for a detailed description of common variable containers to all image-like products:

- section 4.4.3.1: lat and lon Containers
- section 4.4.3.2: Mapping Container
- section 4.4.3.3: Palette Containers
- section 4.4.4: Common Quality containers

Implementation of PPS-PC-specific Variables Containers are hereafter presented

	Content
Variables	
unsigned byte pc_precip_light(time,ny,nx)	**// PPS-PC Likelihood of precipitation, of light intensity**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS PC likelihood of light precipitation"
units	"percent"
valid_range	0, 100
FillValue	255
ancillary_variables	"pc status_flag pc conditions pc quality"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *
description	"Intensity interval (mm/h): 0.1, 0.5"

* grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned byte pc_precip_moderate(time,ny,nx)	**// PPS-PC Likelihood of precipitation, of moderate intensity**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS PC likelihood of moderate precipitation"
units	"percent"
valid_range	0, 100
FillValue	255
ancillary_variables	"pc_status_flag pc_conditions pc_quality"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*
description	"Intensity interval (mm/h): 0.5, 5.0"

* grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned byte pc_precip_intense(time,ny,nx)	**// PPS-PC Likelihood of precipitation, of high intensity**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"SAFNWC PPS PC likelihood of intense precipitation"
units	"percent"
valid_range	0, 100
FillValue	255
ancillary_variables	"pc_status_flag pc_conditions pc_quality"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info"*
description	"Intensity interval (mm/h): 5.0, 1000.0"

* grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short pc_precip_rate_cpp(time,ny,nx)	**// PPS-PC Precipitation Rate, from cloud physical properties**
Dimensions	
time	
ny	
nx	
Attributes	
standard_name	"lwe_precipitation_rate"
long_name	"SAFNWC PPS PC precipitation rate"
units	"mm/h"
valid_range	0, TBD02
FillValue	65535
ancillary_variables	"pc_status_flag pc_conditions pc_quality pc_precip_rate_pal"
coordinates	"lon lat"
grid_mapping	"grid_mapping_info" *

* grid_mapping="grid_mapping_info" is only used for products in region projection

	Content
Variables	
unsigned short pc_status_flag(time,ny,nx)	**// PPS-PC Specific Processing Conditions**
Dimensions	
time	
ny	
nx	
Attributes	
long_name	"Information on specific SAFNWC PPS PC processing"
valid_range	0b, 32768b
FillValue	65535b
flag_masks	1b, 2b, 4b, 8b, 16b
flag_meanings	Flag content TBD03 " NWP_low_quality preciprate_No_reliable_method amsu_used avhrr_used solar_channels_used "
coordinates	"lon lat"

ANNEX A. Product-specific data

A.1 Attributes.title

"title" common attribute stores the following information for each NWC/PPS product:

PGE Id	title
PPS-CMA	NWC PPS Cloud Mask Product
PPS-CT	NWC PPS Cloud Type Product
PPS-CTTH	NWC PPS Cloud Top Temperature and Height Product
PPS-CPP	NWC PPS Cloud Physical Properties Product
PPS-PC	NWC PPS Precipitating Clouds Product

Table 6: title attribute for NWC/PPS products

A.2 Attributes.description

"summary" common attribute stores the following information for each NWC/PPS product:

PGE Id	summary
PPS-CMA	Cloud Mask Product of the NWC/PPS. Information on the presence of clouds and aerosols
PPS-CT	Cloud Type Product of the NWC/PPS. Information on the major cloud types and on snow/sea ice occurrence, and on occurrence of multi-level.
PPS-CTTH	Clout Top Temperature and Height Product of the NWC/PPS. Information on cloud top height, cloud top pressure and on cloud top temperature.
PPS-CPP	Cloud Physical Properties of the NWC/PPS. Information on cloud microphysics, as cloud thermodynamical phase and liquid water path. Additional parameters are: drop effective radius, cloud optical thickness and ice water path
PPS-PC	Precipitating Clouds Product of the NWC/PPS. Precipitation rate and also information on probability of precipitation in pre-defined intensity intervals.

Table 7: summary attribute for NWC/PPS products

A.3 Attributes.keywords

"keywords" common attribute stores the information presented in next table for each NWC/PPS product. Note that, according to `keywords_vocabulary` value, these keywords must be compliant with the GCMD Science Keywords. Please visit link in [RD.8.] for a detailed list of available keywords.

The following reference applies to the GCMD keywords: *Olsen, L.M., G. Major, K. Shein, J. Scialdone, S. Ritz, T. Stevens, M. Morahan, A. Aleman, R. Vogel, S. Leicester, H. Weir, M. Meaux, S. Grebas, C.Solomon, M. Holland, T. Northcutt, R. A. Restrepo, R. Bilodeau, 2013. NASA/Global Change Master Directory (GCMD) Earth Science Keywords. Version 8.0.0.0.0*

PGE Id	keywords
PPS-CMA	Clouds, Aerosols
PPS-CT	Cloud Types
PPS-CTTH	Cloud Top Height, Cloud Top Pressure, Cloud Top Temperature
PPS-CPP	Cloud Liquid Water, Cloud Ice, Cloud Droplet Size, Cloud Optical Thickness
PPS-PC	Precipitation, Precipitation Rate

Table 8: keywords attribute for NWC/PPS products

ANNEX B. List of TBC, TBD, Open Points and Comments

TBD/TBC	Section	Resp.	Comment
TBD01	5.1	SMHI	For a number of datasets, their standard_name:s have been up for discussion on the CF-mailing-list, but are not yet in the standard name table.
TBD02	5.5	SMHI	Some details in the implementation of precipitation rate, in PC has to be defined. Eg. valid range and palette. To be done for v2016.
TBD03	5.5	SMHI	The status flag of PC might be expanded while precipitation rate is being developed. To be done for v2016.

END OF DOCUMENT