The EUMETSAT Network of Satellite Application Facilities

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

User Manual of the NWCPY tool for the NWC/GEO

NWC/CDOP3/GEO/AEMET/SW/UM/NWCPY, Issue 1, Rev. 1

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for SAFNWC/GEO version 2016

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1 INTRODUCTION

1.1 PURPOSE

In the frame of the NWC SAF project, an easy-to-use tool (NWCPY) has been developed in charge of reading NWC/GEO output products in netCDF[1] format and generating a graphical representation of a certain variable in a GIF file. The tool read the required information to generate the plot from the NWC/GEO netCDF fields, as for example the colour palette, the valid range of the data, the meaning of the values, …

The present document details the functionality of the NWCPY tool, and the procedure to install and operate it.

1.2 REFERENCES

1.2.1 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 the NWC SAF Helpdesk web: http://www.nwcsaf.org

Ref	Title	Code	Vers	Date
[AD.1]	Proposal for the Third Continuous Development and Operations Phase (CDOP3) March 2017 – February 2022	NWC SAF: CDOP-3 proposal	1.0	11/04/16
[AD.2]	Data Output Format of the NWC/GEO	NWC/CDOP/GEO/AEMET/SW/DOF	1.2.1	15/06/17
[AD.3]	User Manual of the GEO-L1SD tool	NWC/CDOP3/GEO/AEMET/SW/UM/L1SD	1.0	25/05/17
[AD.4]	User Manual for the Wind product processors of the NWC/GEO: Science Part	NWC/CDOP2/GEO/AEMET/SCI/UM/Wind	1.0	15/10/16

Table 1: List of Applicable Documents

1.2.2 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].

[1] The only exception is the NWC/GEO ASII, which is generated in BUFR format and shall be read in that format. The NWC/GEO HRW product is available in netCDF format, just setting `OUTPUT_FORMAT = NET` in the HRW model configuration file.

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 the 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		

Table 2: List of Referenced Documents

2 FUNCTIONAL DESCRIPTION

The NWCPY tool implements the following high-level requirements:

Id	Description
010	The NWCPY application shall generate a graphical representation of NWC/GEO products in GIF format
020	The NWCPY application shall be developed as a tool apart from the NWC/GEO, so that a user could run it without installing the NWC SAF software
030	The application shall allow the reading of all PGE product files in native netCDF format (including EXIM products) and ASII product in BUFR format (See [AD.2])
040	The application shall also allow the reading of Satellite Data products in netCDF as generated by the NWC/GEO extra tool GEO-L1SD (See [AD.3])
050	Given a netCDF product file, the application shall read the data corresponding to a certain variable, including its attributes and colour palette. In case of HRW product file, the application shall also read trajectory data (See [AD.4])
060	Given a BUFR ASII file, the application shall read the latitude, longitude and variable name contained in each message
070	The plotting shall follow the native geostationary projection, using the gdal parameters included in the netCDF file. In case of HRW and ASII products, gdal parameters are taken from the corresponding L1SD netCDF file
080	Output image shall be provided in gif format, with the dimensions (width x height) specified by the user as an input parameter
090	No data pixels in iSHAI representation shall be filled using the data of the IR_band variable included in the iSHAI product (See [AD.2])
100	No data pixels in CI product images shall be filled with brightness temperatures data read from the GEO-L1SD IR_120_BT satellite data product for the same slot and region
110	Appropriate GEO-L1SD IR_120_BT satellite data product shall be used as background image for the representation of HRW, ASII and RDT-CW data

120	The image generated in gif format will follow the same nomenclature than the netCDF input file, only adding the parameter being displayed and changing the extension (.gif)

3 INSTALLATION OF NWCPY

3.1 ENVIRONMENT

This section describes HW/SW prerequisites needed to install and execute the NWCPY tool.

NWCPY tool has been tested in a Linux/RHEL6.4 64 bits environment. Correct execution in other environments cannot be currently guaranteed.

	Intel/Linux
O.S	RHEL release 6.4 Santiago
CPU	4x Intel(R) Core(TM) i5-4590 CPU @ 3.30GHz
Arch	x86_64
Memory(1)	8 GB
Disk	500 GB
Shell	bash; ksh
Compilers	GCC compilers 4.4.7; gcc; g++; gfortran
gzip	gzip 1.3.12
Python	2.7.10

Table 3: Minimum configuration

3.2 PREVIOUS CONDITIONS AND LICENSES

3.2.1 NWC/GEO

The NWCPY has been designed and developed to be self-dependant. Therefore, the NWC/GEO package is not required to execute this tool.

3.2.2 python

The NWCPY has been developed in python; python 2 is required to execute the NWCPY tools.

In addition, the following python packages are required, and must be properly installed in the platform:

Table 4: Python packages required by NWCPY

`datetime`	Basic date and time types
`h5py`	Pythonic interface to the HDF5 binary data format
`matplotlib`	Python 2D plotting library
`mpl_toolkits`	Matplotlib Toolkits (collections of application-specific functions that extend matplotlib)
`netCDF4`	Python interface to the netCDF C library.
`numpy`	Package for scientific computing with Python
`os`	Miscellaneous operating system interfaces
`pybufrkit`	Python toolkit for WMO BUFR messages
`re`	Regular expression operations
`subprocess`	Subprocess management
`sys`	System-specific parameters and functions

3.2.3 GEO-L1SD

NWCPY requires GEO-L1SD satellite data products as background data for some products. Therefore, the user must assure the availability of GEO-L1SD products if required (CI, HRW, ASII and RDT representation).

The GEO-L1SD application is available to NWCSAF registered users in the NWCSAF Helpdesk, clicking in Software->Extra Tools. This page allows downloading both the GEO-L1SD software and the User Manual.

3.3 INSTALLATION OF THE NWCPY PACKAGE

The NWCPY package is provided in a tar.gz file:

NWC-CDOP3-GEO-AEMET-SW-CODE-NWCPY_v1.1.tgz

It is important to note that the NWCPY tool does not require NWC/GEO application to be installed in the system. It can be executed in any machine that met the requirements from Section 3.2. To install the NWCPY package:

1. Locate in the desired directory and decompress the tgz distribution:

```
% cd <target_directory>
% tar xvf <source>/NWC-CDOP3-GEO-AEMET-SW-CODE-NWCPY_v1.1.tgz
```

The following files will be created:

<target_directory>	***Decompression directory***
NWCPY	*NWCPY module*
logoNWCSAF.png	Logo of the project
nwcpy_asii.py	Source code for the NWCPY tool, ASII product
nwcpy_hrw.py	Source code for the NWCPY tool, HRW product
nwcpy_hrw_traj.py	Source code for the NWCPY tool, HRW trajectories
nwcpy.py	Source code for the NWCPY tool, image-like products
nwcpy_rdt.py	Source code for the NWCPY tool, RDT product

2. Define in the command line the environment variable `NWCPY_PATH` as the path to `logoNWCSAF.png`. Add this line to your .profile:

```
export NWCPY_PATH=<source>/NWCPY
```

No other steps are required.

4 OPERATION OF NWCPY TOOL

4.1 COMMAND LINE INTERFACE

Once the NWCPY tool is installed on the system, the command line interface is the following:

```
For image-like products (CMA, CT, CTTH, …):
    python nwcpy.py <path/file.nc> <variable1> <width> <height>

For HRW winds:
    python nwcpy_hrw.py <path/file.nc> <width> <height> <type>
[<pressure_interval>]

For HRW trajectories[4]:
    python nwcpy_hrw_traj.py <path/file.nc> <width> <height> <n_slots>
[<pressure_interval>]

For ASII product:
    python nwcpy_asii.py <path/file.bufr> <width> <height>

For RDT product:
    python nwcpy_rdt.py <path/file.nc> <width> <height>
```

where

[4] `nwcpy_hrw_traj.py` source code for trajectories generates the temporary file **`trajectories.txt`** on each execution, and removes it once the trajectory variables are properly stored. The user shall check there is no file named `trajectories.txt` in the working directory, otherwise it will be overwritten.

- `<path/file.nc>` (`<path/file.bufr>`) is the complete path to the product file in netCDF (BUFR) format.
- `<variable1>` is the name of the variable contained in the netCDF for image-like products.
- `<width> <height>` are the dimensions of the output gif image. Set to "`0 0`" to generate the output file at default size (`1100x800`).
- `<type>` is the variable to be labelled in the HRW product: "`p`" (pressure) or "`ws`" (wind speed)
- `<n_slots>` is the number of satellite slots to be used to plot trajectories (>=2)
- `[<pressure_interval>]` is an optional parameter to plot winds and trajectories only for certain pressure levels. Allowed values are 0 (only background), 1 (100-400 hPa), 2 (400-600 hPa), 3 (600-800 hPa), 4 (800-1000 hPa). If no `pressure_interval` is set, winds and trajectories are plotted for ALL pressure levels.

NWCPY commands can be executed from any directory, properly indicating the path to the netCDF/BUFR files. The output gif images are stored in the working directory.

4.2 Output Naming Criteria

The images generated by the NWCPY tool are stored in the working directory and follow the next naming criteria:

For image-like products (CMA, CT, CTTH, …):

```
<file>.<variable1>.gif
```

For HRW winds:

```
<file>.<type>_<pressure_interval_label>.gif
```

For HRW trajectories:

```
<file>.traj_<pressure_interval_label>_<n_slots>slots.gif
```

For ASII product:

```
<file>.asii.gif
```

For RDT product:

```
<file>.rdt.gif
```

where `<pressure_interval_label>` is the label associated to `<pressure_interval>`: 0-"background", 1-"100-400hPa", 2-"400-600hPa", 3-"600-800hPa", 4-"800-1000hPa" and none-"all".

IMPORTANT NOTE: HRW winds/trajectories image includes IR background (GEO-L1SD IR_120_BT) only in the following cases:

- `<pressure_interval> = 0`

- `<pressure_interval> = “”`

Otherwise GEO-L1SD satellite data product is used to read gdal projection parameters necessary to navigate wind vectors/trajectories, but these are displayed over a transparent background.

4.3 EXAMPLES

4.3.1 NWC/GEO Image-like product (CT)

Execution of the NWCPY tool for `ct` variable contained in the CT image-like product, generated for MSG-N region, with the default dimensions:

```
python nwcpy.py /home/CT/S_NWC_CT_MSG3_MSG-N-VISIR_20151013T150000Z.nc ct 0 0
```

The tool generates the image *S_NWC_CT_MSG3_MSG-N-VISIR_20151013T150000Z.ct.gif* shown in Figure 1

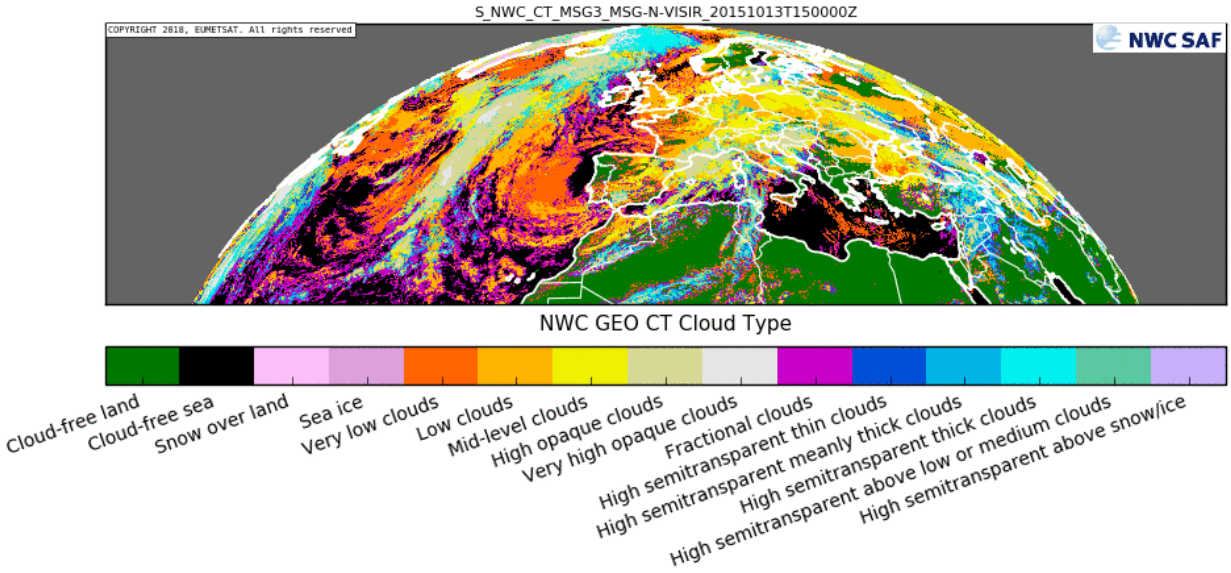

Figure 1: Graphical representation of a NWC/GEO CT product

4.3.2 GEO-L1SD Satellite Data

Execution of the NWCPY tool for `data` variable contained in the L1SD IR120-BT image-like product, generated for Spain region, with dimensions 600x600:

```
python nwcpy.py /home/L1SD/S_NWC_IR120-BT_MSG3_Spain-VISIR_20151013T150000Z.nc
        data 600 600
```

The tool generates the image

S_NWC_IR120-BT_MSG3_Spain-VISIR_20151013T150000Z.data.gif shown in Figure 2

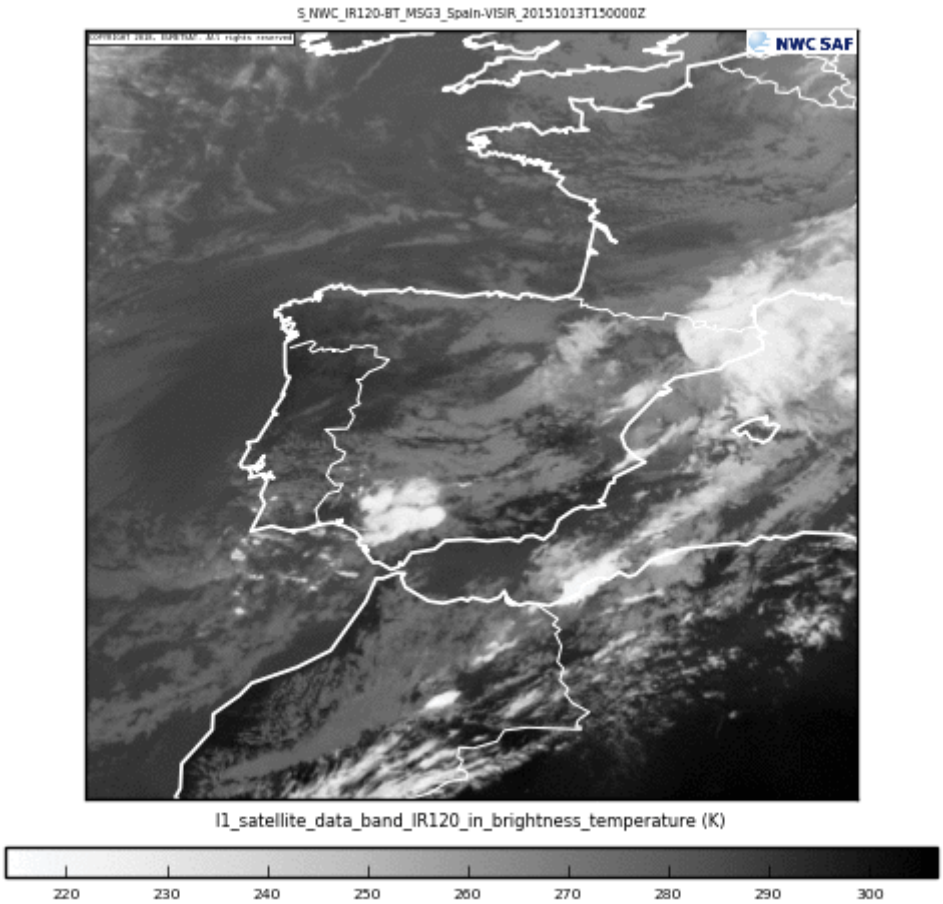

Figure 2: Graphical representation of a NWC/GEO-L1-SD product

4.3.3 NWC/GEO Image-like product (iSHAI)

Execution of the NWCPY tool `ishai_ki` variable contained in the iSHAI image-like product, generated for Spain region, with dimensions 1000x1000:

```
python nwcpy.py /home/iSHAI/S_NWC_iSHAI_MSG3_Spain-VISIR_20151013T150000Z.nc
        ishai_ki 1000 1000
```

The tool generates the image *S_NWC_iSHAI_MSG3_Spain-VISIR_20151013T150000Z.ishai_ki.gif* shown in Figure 3

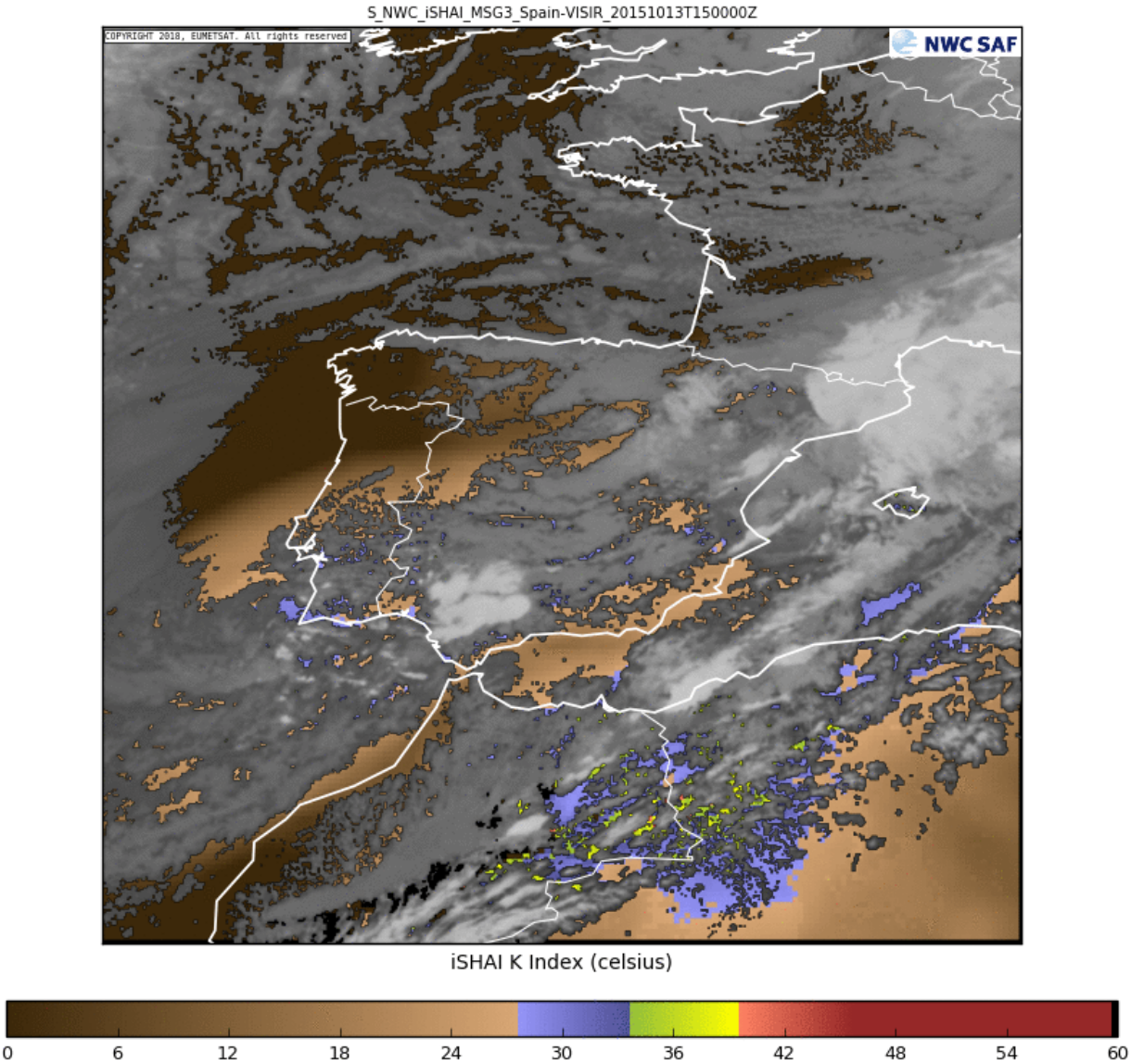

Figure 3: Graphical representation of a NWC/GEO-iSHAI product (K-index parameter)

4.3.4 NWC/GEO HRW product (winds)

4.3.4.1 Considering pressure level

Execution of the NWCPY tool for the HRW product for all pressure levels compared to the background image, with the label corresponding to the pressure interval. The image is generated for Spain region with dimensions 700x700:

```
python nwcpy_hrw.py /home/HRW/S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.nc 700
        700 p
python nwcpy_hrw.py /home/HRW/S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.nc 700
        700 p 0
```

The tool generates the images *S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.p_all.gif* and *S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.p_background.gif*, respectively shown in Figure 4.

Note that the generation of the HRW graphical product requires de availability of both

The HRW product: S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.nc
The GEO-L1SD product: S_NWC_IR120-BT_MSG3_Spain-VISIR_20151013T150000Z.nc

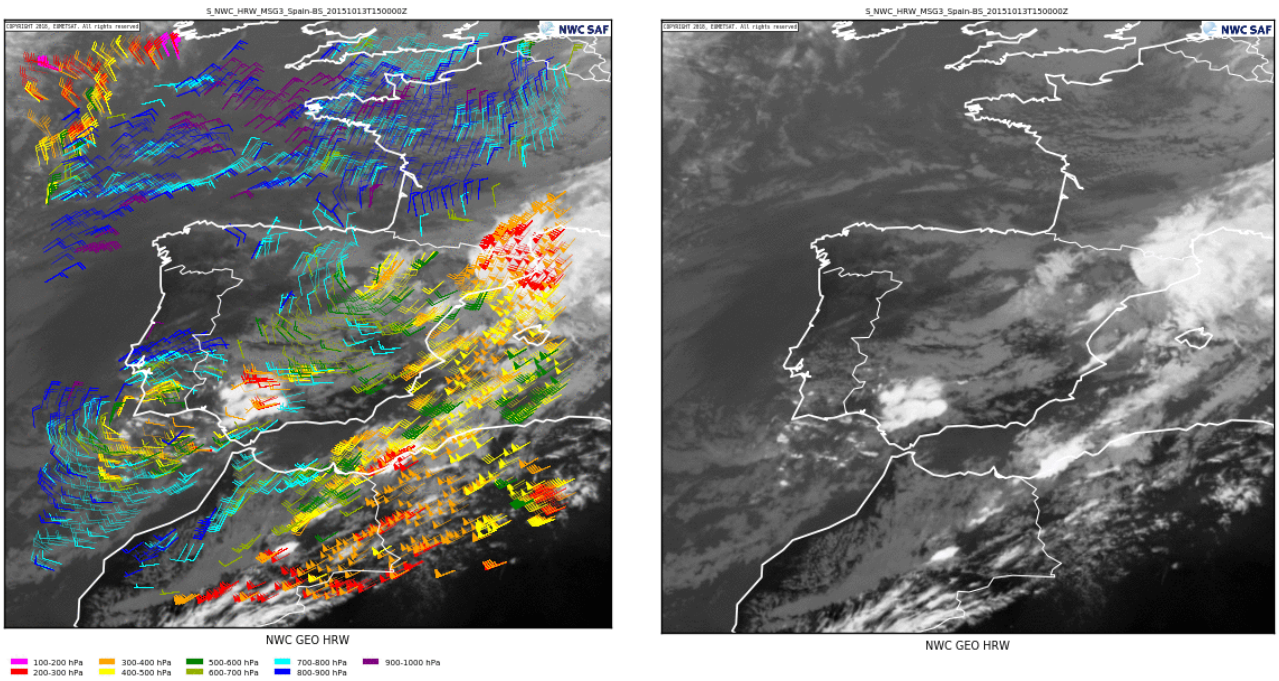

Figure 4: Graphical representation of a NWC/GEO-HRW product in terms of pressure level

4.3.4.2 Considering wind speed

Execution of the NWCPY tool for the HRW product for 100-400 hPa pressure interval compared to the background image, with the label corresponding to the wind speed. The image is generated for Spain region with dimensions 700x700:

```
python nwcpy_hrw.py /home/HRW/S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.nc 700
        700 ws 1
python nwcpy_hrw.py /home/HRW/S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.nc 700
        700 ws 0
```

The tool generates the images *S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.ws_100-400hPa.gif* and *S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.ws_background.gif*, respectively shown in Figure 5.

Note that the generation of the HRW graphical product requires de availability of both

The HRW product: S_NWC_HRW_MSG3_Spain-BS_20151013T150000Z.nc
The GEO-L1SD product: S_NWC_IR120-BT_MSG3_Spain-VISIR_20151013T150000Z.nc

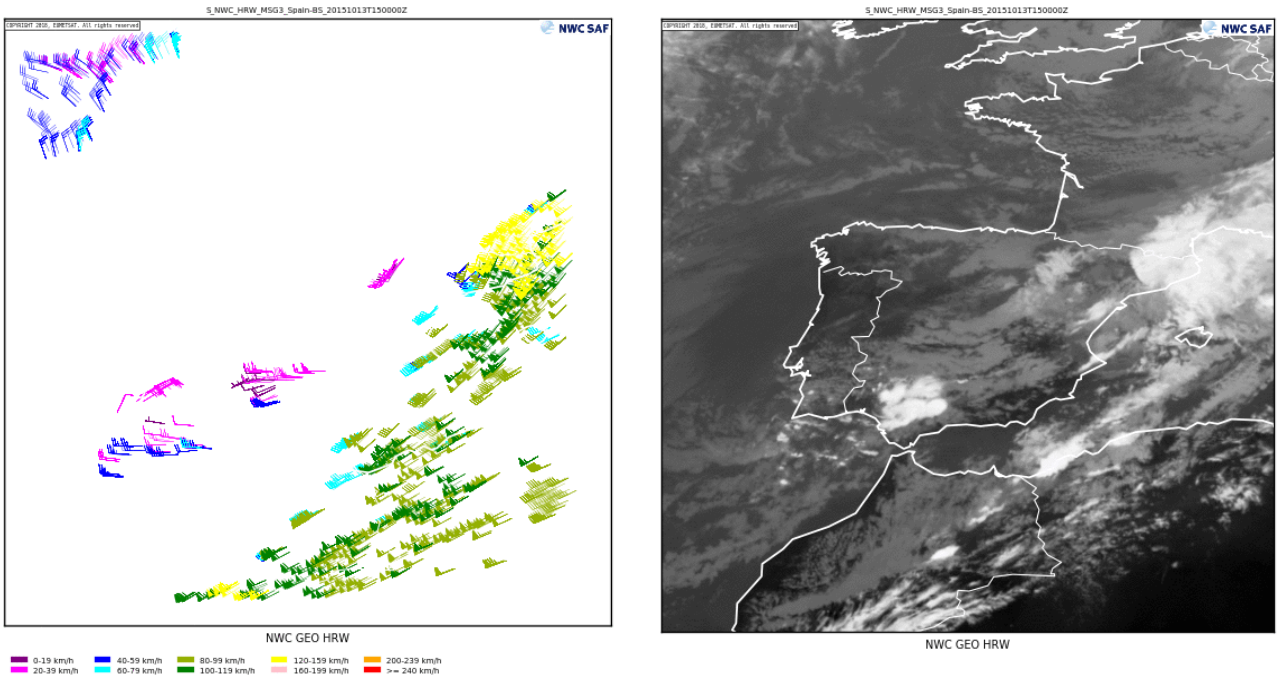

Figure 5: Graphical representation of a NWC/GEO-HRW product in terms of wind speed

4.3.5 NWC/GEO HRW product (trajectories)

Execution of the NWCPY tool for HRW trajectories for 600-800 hPa pressure interval compared to trajectories for all pressure intervals, considering 4 MSG slots (1 hour). The image is generated for Spain region with dimensions 700x700:

```
python nwcpy_hrw_traj.py /home/HRW/S_NWC_HRW_MSG3_Spain-BS_20151013T154500Z.nc
        700 700 4 3
python nwcpy_hrw_traj.py /home/HRW/S_NWC_HRW_MSG3_Spain-BS_20151013T154500Z.nc
        700 700 4
```

The tool generates the images *S_NWC_HRW_MSG3_Spain-BS_20151013T154500Z.traj_600-800hPa_4slots.gif* and *S_NWC_HRW_MSG3_Spain-BS_20151013T154500Z.traj_all_4slots.gif*, respectively shown in Figure 6.

Note that the generation of the HRW graphical product requires de availability of both

The HRW product: S_NWC_HRW_MSG3_Spain-BS_20151013T154500Z.nc
The GEO-L1SD product: S_NWC_IR120-BT_MSG3_Spain-VISIR_20151013T154500Z.nc

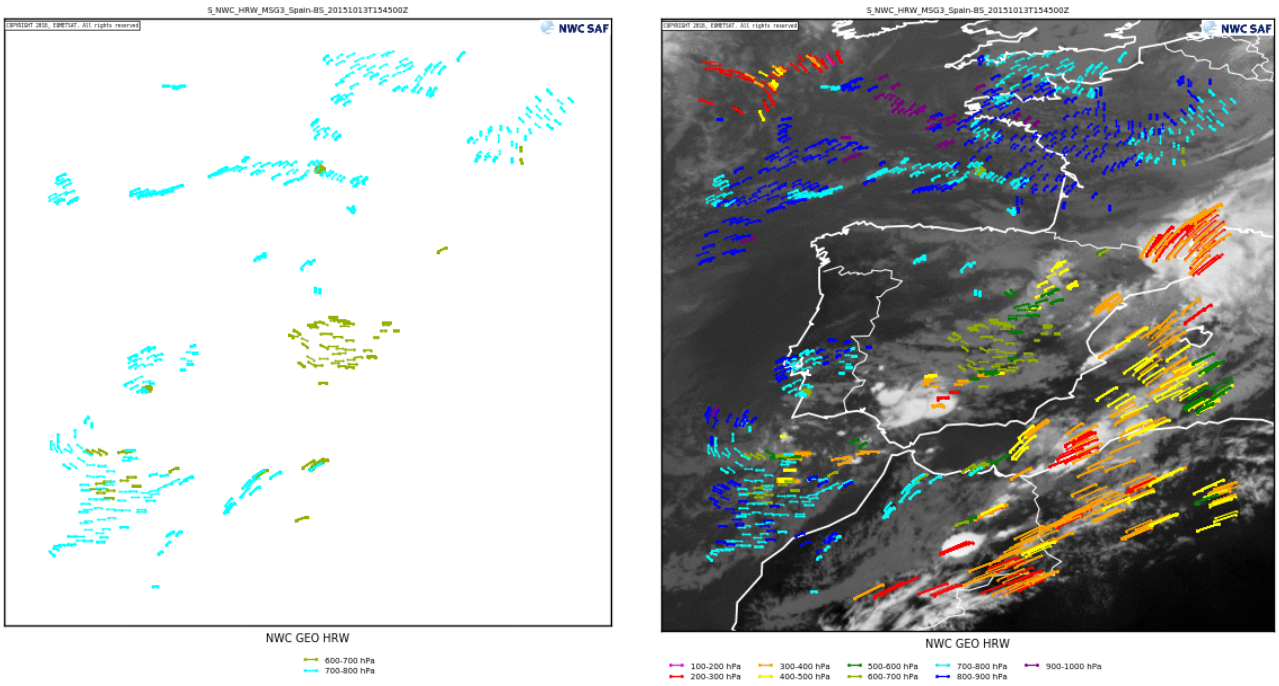

Figure 6: Graphical representation of NWC/GEO-HRW trajectories considering 4 MSG slots

4.3.6 NWC/GEO ASII product

Execution of the NWCPY tool for the ASII product, generated for Europe region, with dimensions 1000x1000:

```
python nwcpy_asii.py /home/ASII/S_NWC_ASII-SAT_MSG3_Europe-
        VISIR_20151013T154500Z.bufr 1000 1000
```

The tool generates the image *S_NWC_ASII-SAT_MSG3_Europe-VISIR_20151013T154500Z.asii.gif* shown in Figure 7.

Note that the generation of the ASII graphical product requires de availability of both

The ASII product:	S_NWC_ASII-SAT_MSG3_Europe-VISIR_20151013T154500Z.bufr
The GEO-L1SD product:	S_NWC_IR120-RAD_MSG3_Europe-VISIR_20151013T154500Z.nc

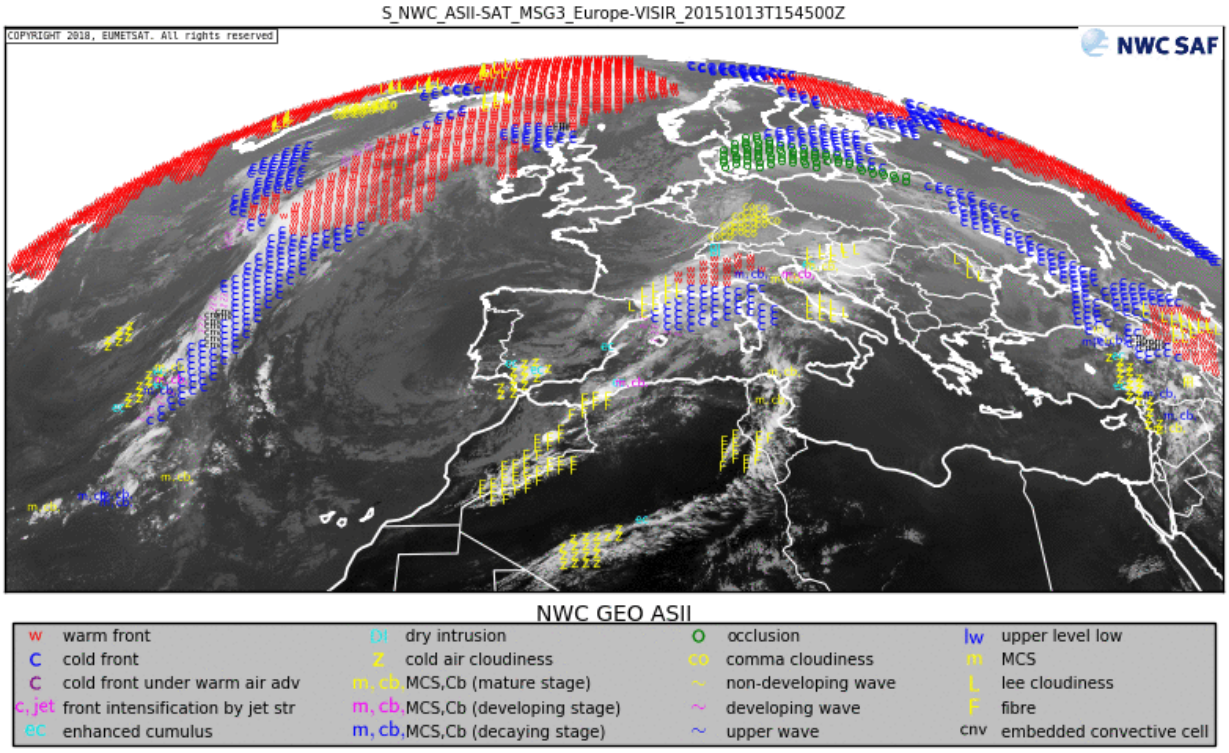

Figure 7: Graphical representation of a NWC/GEO-ASII product

4.3.7 NWC/GEO RDT-CW product

Execution of the NWCPY tool for the RDT-CW product, generated for Europe region, with dimensions 1200x1000:

```
python nwcpy_rdt.py /home/RDT/S_NWC_RDT-CW_MSG3_Europe-
        VISIR_20151013T150000Z.nc 1200 1000
```

The tool generates the image *S_NWC_RDT-CW_MSG3_Europe-VISIR_20151013T150000Z.rdt.gif* shown in Figure 8.

Note that the generation of the RDT-CW graphical product requires de availability of both

The RDT-CW product: S_NWC_RDT-CW_MSG3_Europe-VISIR_20151013T150000Z.nc
The GEO-L1SD product: S_NWC_IR120-RAD_MSG3_Europe-VISIR_20151013T150000Z.nc

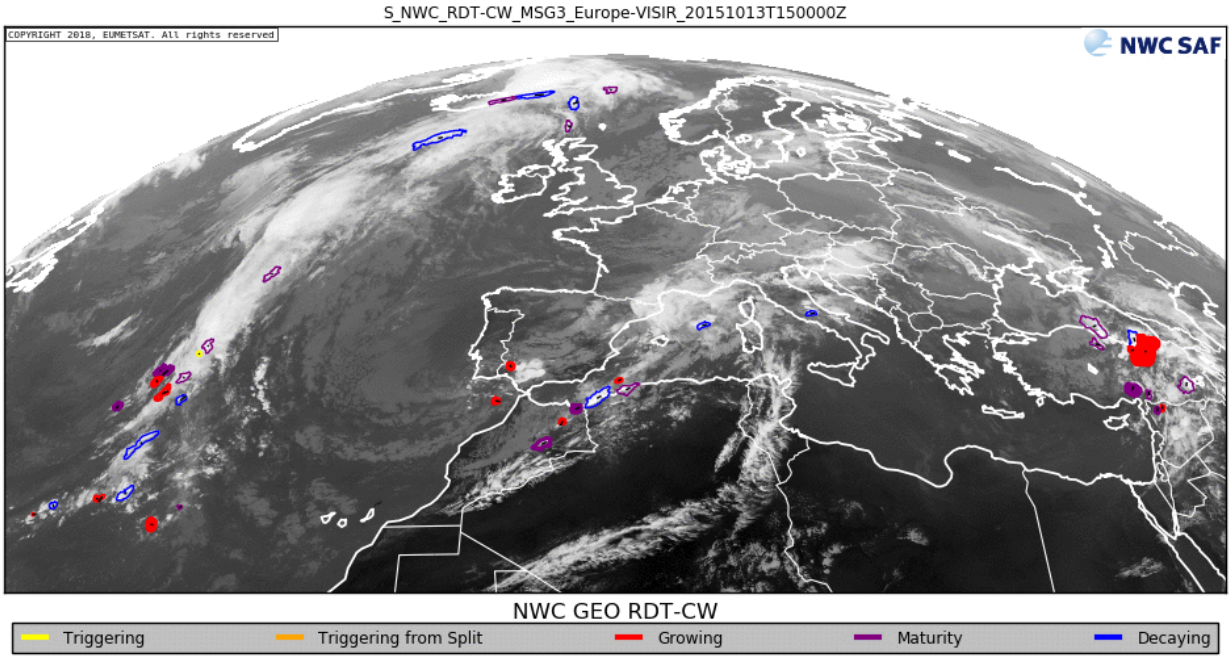

Figure 8: Graphical representation of a NWC/GEO-RDT-CW product