The EUMETSAT Network of Satellite Application Facilities

NWC SAF

Support to Nowcasting and Very Short Range Forecasting

Studies for comparison of NWCSAF/MSG PGE13 SPhR and IASI L2 products

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1. INTRODUCTION

The Eumetsat "Satellite Application Facilities" (SAF) 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, hereafter 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 NWC SAF processing package for Meteosat satellites meteorological satellites, SAFNWC/MSG.

1.1 PURPOSE AND SCOPE OF THE DOCUMENT

The purpose of this document is to present a summary of the early activities related to the comparison of precipitable water and instability indices calculated from MSG and IASI data.

The works, studies and ideas described in this report will help to implement NWC SAF use of MTG-IRS Level 2. These studies are also valuable to anticipate the new ways that MTG-IRS Level 2 products could be used in MTG-IRS era for nowcasting.

1.2 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

AEMET	Agencia Estatal de Meteorología
BT	Brightness temperatures
CDOP	Continuous Development and Operations Phase
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FCI	Flexible Combined Imagery
IASI	Infrared Advanced Sounder Interferometer
IDL	Interactive Data Language
IRS	InfraRed Sounder
KI	K Index
LI	Lightning Imager (MTG) Lifted Index
LPW	Layer Precipitable Water
McIDAS	Man Computer Interactive Data Access System
METOP	European Polar Meteorological Satellite
MIST	Meteosat Third Generation InfraRed Sounder Team
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
NWC SAF	Satellite Application Facility for Nowcasting
NWP	Numerical Weather Prediction
PWLR	Piece Wise Linear Regression
SAF	Satellite Application Facility

SAI	PGE08 Stability Analysis Imagery (SAI) Product Generator
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SKT	SKin Temperature
SPhR	PGE13 SEVIRI Physical Retrieval (SPhR) Product Generator
TPW	Total Precipitable Water

1.3 REFERENCES

1.3.1 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.

Reference	Title	Code	Vers	Date
[AD.1]	Proposal For The Continuous Development And Operations Phase	SAF/NWC/CDOP/INM/MGT/PRO	2.2	07/08/2006
[AD. 2]	NWC SAF Project and Operations Plan for the CDOP	SAF/NWC/CDOP/INM/MGT/PL/MP	1.1	04/05/2011

Table 1: List of Applicable Documents

1.3.2 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.

Reference	Title	Code	Vers	Date
[RD.1]	Algorithm Theoretical Basis Document for "SEVIRI Physical Retrieval" (SPhR-PGE13 v2.0)	SAF/NWC/CDOP2/INM/SCI/ATBD/13	2.0	15/07/2013
[RD.2]	Product User Manual for "SEVIRI Physical Retrieval" (SPhR-PGE13 v2.0)	SAF/NWC/CDOP2/INM/SCI/PUM/13	2.0	15/07/2013
[RD.3]	Scientific Report: improvements in "PGE13 SEVIRI Physical Retrieval Product (SPhR)" using as input ECMWF GRIB files on hybrid levels	SAF/NWC/CDOP2/INM/SCI/RP/02	1.0	15/07/2013
[RD.4]	Studies for the use of MTG-IRS L1 in nowcasting based in validation and training activities of the NWCSAF clear air products	NWC/CDOP2/GEO/AEMET/SCI/RP/02	1.0	30/11/2014

Table 2: List of Referenced Documents

2. INTRODUCTION AND AIM OF THE STUDIES

In CDOP proposal [AD.1] the working package *WP 5131-3 "Comparison of PW and SAI with similar IASI products"* was foreseen as one activity to do at the end of CDOP (March 2007- March 2012). In Figure 1 it is shown the task proposed in this WP. It must be taken into account that due to the SAFs five year scheduling basis, at the moment when the proposal for CDOP was written in 2006 the first METOP was not launched yet.

WP 5131-3	**Title: Comparison of PW and SAI products with similar IASI products**			
	Comments:			
Start: March 2008	**End:** Feb 2012	**Effort (m.m):** 8.0	**Cost:** 64.912 k€	**Responsible partner:** INM
WP Content	*Objective*: Intercomparison of the parameters obtained for both sources. *Tasks*: *) Creation of IASI profile database. *) Design a method to co-locate both sets of databases (IASI and SAFNWC). *) Evaluate the validation results			
WP Input	IASI profiles and SAFNWC/MSG PGEs outputs.			
WP Output	Scientific report.			
WP Interfaces				
Interactions with other SAFS and/or Federated Activities	None			

Figure 1: Original formulation of WP 5131-3.

The WP was introduced originally in order to create an IASI L2 profile database with collocated NWCSAF SEVIRI outputs in order to make a comparison of the outputs from the old neural network based products (PGE06 TPW, PGE07 LPW and PGE08 SAI) with other truth than radiosounding or NWP. If successful, a secondary objective would be the generation of one training and validation dataset for the statistical neural network products.

Thus, when the proposal was written the purpose of this WP was to create a dataset of collocated NWC SAF outputs (precipitable water and instability indices) plus the profiles of temperature and specific humidity from IASI L2 outputs and the IASI precipitable water and instability indices. The original plan was to make first a comparison of the both IASI L2 and MSG neural network outputs and if successful the comparison of the performance with other possible truths as RAOB or NWP start the generation of datasets for training and validation purpose of the neural networks based products.

After the change in 2007, due to the a decision of EUMETSAT Secretariat, of the neural network algorithm for another one based on physical retrieval and the introduction of the PGE13 SPhR product (instead of the neural network algorithm in PGE06 TPW, PGE07 LPW and PGE08 SAI) the comparison with IASI L2 fields have less sense. Since PGE13 SPhR has as other input NWP and the deviation of the NWP after apply the PGE13 SPhR algorithm is obtained directly as other outputs then this WP had lower priority than for the older neural network products.

As result of PGE13 SPhR design, in PGE13 SPhR can be activated the writing of binary files with temperature and humidity profiles and this fact allowed make a step further and to make the triple comparison of NWP, PGE13 SPhR and IASI L2 nowcasting parameters and profiles.

This activity began in late 2011 after downloading files from IASI UMARF L2 for the 12th August 2011 case study. As discussed in Section 3 after downloading files, the structure of the files was analyzed first. The HDF-5 structure of IASI L2 version 5 file was very complicated and difficult to use. Even with this issue still it was created an IDL program to convert from this complicated format to other more useful at the same time that the nowcasting interest fields were calculated for direct comparison with the NWC SAF one from MSG and NWP. After early subjective comparisons, it was found that the fields of IASI L2 precipitable water fields were noisy, wettest and showed disagreement in some regions with the equivalent ones with the ECMWF analysis.

Meanwhile, EUMETSAT Secretariat announced in the Science Working Group meetings that a new version called Version 6 of IASI L2 will be available end of 2012 and that strong improvements would be introduced. Thus it was desirable to wait and repeat to study when IASI L2 version 6 was available. After direct contacts with EUMETSAT Secretariat staff, Dr. Thomast August provided several early IASI L2 files for 20th June 2013 case study in format HDF-5. This EUMETSAT HDF5 format is better designed than the previous one. But, as can be seen in Section 4, still has a design failure to be used directly in operational tools. Now this activity it makes perfect sense as it allows to see and anticipate problems synergies and joint exploitation of NWP, MTG-FCI and MTG-IRS L2 outputs. In Section 4 is described this study.

Finally some conclusions and some considerations for the future and for the joint operation of NWP, MTG-FCI and MTG-IRS L2 are presented.

3. First study: Comparison with IASI L2 files version 5 on case study 11th August 2011.

In this Section it is described the first attempt to make the comparison using IASI L2 version 5 files downloaded from the UMARF for case study 12th August 2011.

The operational outputs of PGE13 SPhR are four fields related with the content of the precipitable water and three instability indexes. The precipitable water parameters are calculated from the specific humidity retrieved profiles: Total Precipitable Water (**SPhR_TPW**) and the Layer Precipitable Water (LPW) in three layers of the atmosphere (SPhR_**BL** [Pressure$_{\mathrm{Surface}}$, 850 hPa], **SPhR_ML** [850, 500 hPa] and **SPhR_HL** [500, 0.1 hPa]). The three instability indexes are calculated from the specific humidity and temperature retrieved profiles: Lifted Index (**SPhR_LI**), Showalter Index (**SPhR_SHOWALTER**) and K-Index (**SPhR_KI**). See more details in PGE13 SPhR documents ([RD.1], [RD.2] and [RD.3]) available on NWC SAF web. The main objective of this study was to make a comparison of these PGE13 SPhR parameters calculated using as inputs real SEVIRI data and ECMWF profiles with the equivalent ones calculated from IASI L2 version 5 files.

For this early comparison it was selected the case study 12th August 2011. The NWCSAF PGE13 SPhR parameters and NWP equivalent parameters for this case study can be seen in Martinez 2013. More images and slides with loops are available online in Martinez presentation at NWC SAF 2015 users' workshop (https://www.nwcsaf.org/WorkshopsTrainingSurveys/2015UsersWorkshop/2015UsersWSPresentations/SESSION_III/martinez_nwcsaf_workshop_madridfeb2015.pps)

The first task was to request on UMARF the IASI L2 version 5 files for case study 12th August 2011. As can be seen in Figure 2, between all available formats it was selected HDF-5 with the idea to use directly with tools like IDV and McIDAS-V.

Figure 2: Request of IASI L2 for case study 12th August 2011 in HDF-5 format.

But these UMARF IASI L2 files downloaded from UMARF archive in H5 format could not be used directly by users using tools like IDV or McIDAS-V. The files were open using free available *hdfview* tool to investigate the structure of them. It was discovered that it is not a problem of the data content it is only a problem of bad design of the HDF-5 structure.

Then it was needed to prepare an IDL reader of UMARF version 5 IASI L2 files. Then, a first reader was started to develop on IDL. In the developing of the IDL reader, it was discovered that the IASI L1 and IASI L2 formats from UMARF are compliant with H5 and NetCDF rules files BUT they have too complicated structures and the name and units of the variables are not CF (Climate convenion) compliant. Thus, it is possible to use IDL HDF-5 functions to just read arrays and data but the structure is too much complicated to be understood by normal user's tools. As example:

- The IASI profiles are grouped in sets with a line IASI scan. But these line scan sets are randomly organized (first set could be over Japan and second over Europe) with just the observation time as the thread to re-order ones.
- The earth location (longitude and latitude) are in same array as first and second column.
- The figure 3 have been generated with the first version IDL at 90 levels of IASI L2

Using the first IDL converter, temperature and specific humidity profiles arrays at 90 levels could be read from the HDF-5 files but this profiles are hard to manage for the forecasters and difficult to compare with PGE13 SPhR ones (As can be seen in the figure 3).

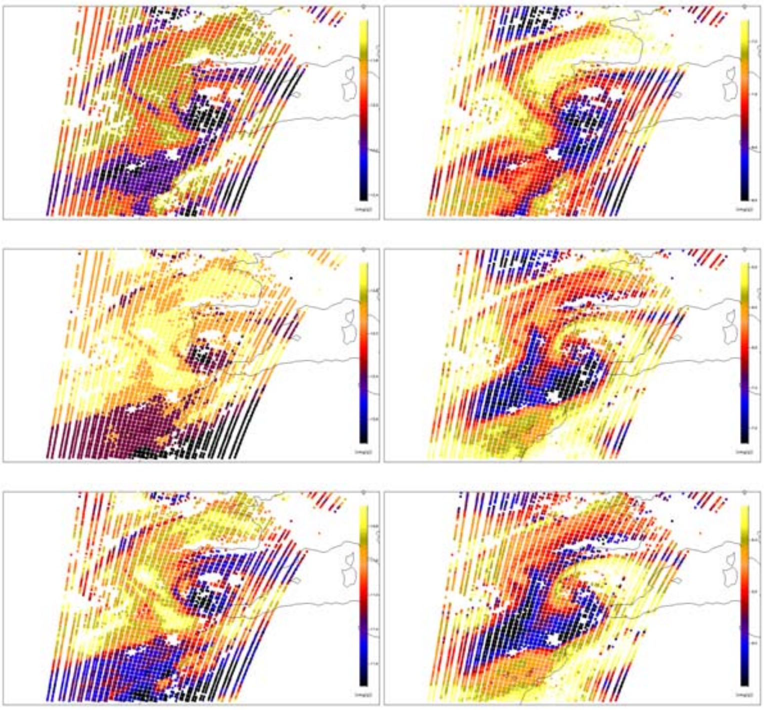

Figure 3: IASI L2 temperature and humidity at several levels for case study 12th August 2011.

Taking into account that PGE13 SPhR is executed locally and no dissemination by EUMETCast is needed, the temperature and humidity profiles interpolated at the RTTOV pressure levels at the main steps of the PGE13 SPhR Hybrid version algorithm (after NWP interpolation, FG regressions and physical retrieval) may be written as optional outputs on binary files. The users can activate the writing of the PGE13 optional binary files easily by editing a keyword in the ASCII configuration file and the PGE13 binary files are written in the *$SAFNWC/tmp* directory. This allows users to get access to the retrieved temperature and humidity profiles.

On other hand, one auxiliary, special and internal tool called PGE00Hyb has been also developed to allow the vertical, temporal and spatial interpolation from ECMWG GRIB files to binary files on SEVIRI projection for any forecast hour. Thus, it is possible to create collocated dataset of ECMWF and SEVIRI from any forecast hours; allowing the generation of training dataset, compare forecast versus analysis, etc. See for example the use on validation activities in [RD.3].

Using above process, PGE13Hyb and PGE00hyb binary files could be used to collocate IASI L2 profiles with ECMWF at any forecast hour and real SEVIRI nowcasting parameters and brightness temperature. One issue at this moment was that the IASI L2 files were in 90 pressure levels and PGE13 and ECMWF profiles were read at the 43 RTTOV-9.3 pressure levels; this make difficult the comparison and then the optimal was to calculate precipitable water on several layer.

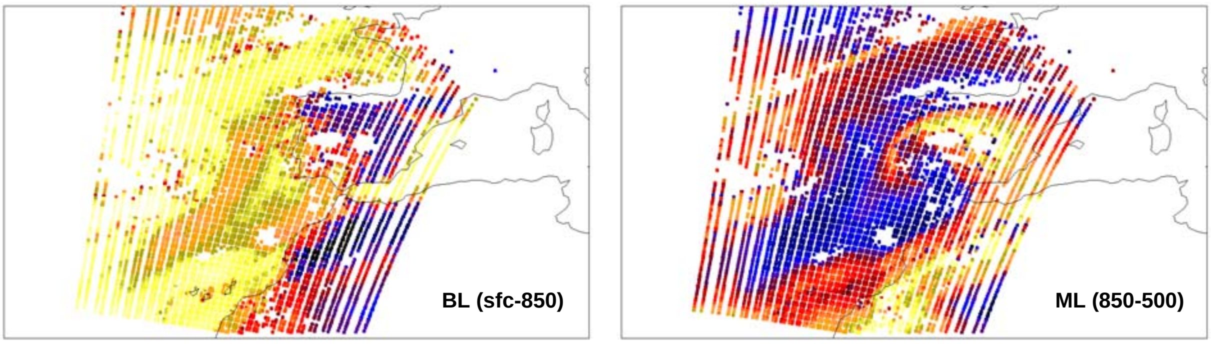

Figure 4: Precipitable water BL and ML parameter calculated from IASI L2 version for case study 12th August 2011 displayed with IDL color palette.

Using the first version of IDL basic IASI L2 reader and IDL routines for the PGE13 and PGE00hyb binary files generation of training validation dataset, it was made a second version of the IDL IASI L2 version 5 reader with the addition of the calculation of IASI L2 LPW and Instability indices. After display them on IDL, it was clear that IASI L2 version 5 precipitable water parameters were noisy; as can be seen in Figure 4.

For a better comparison it was needed to be able to display with the same color palette than in PGE13 SPhR regular representation. In the figure 5, it has been calculated the same layers than in NWC SAF PGE13 fields and displayed with same PGE13 NWCSAF palette[1]. One recommendation is of course to use optimal and same palettes for nowcasting parameter from IASI L2, PGE13 SPhR and ECMWF.

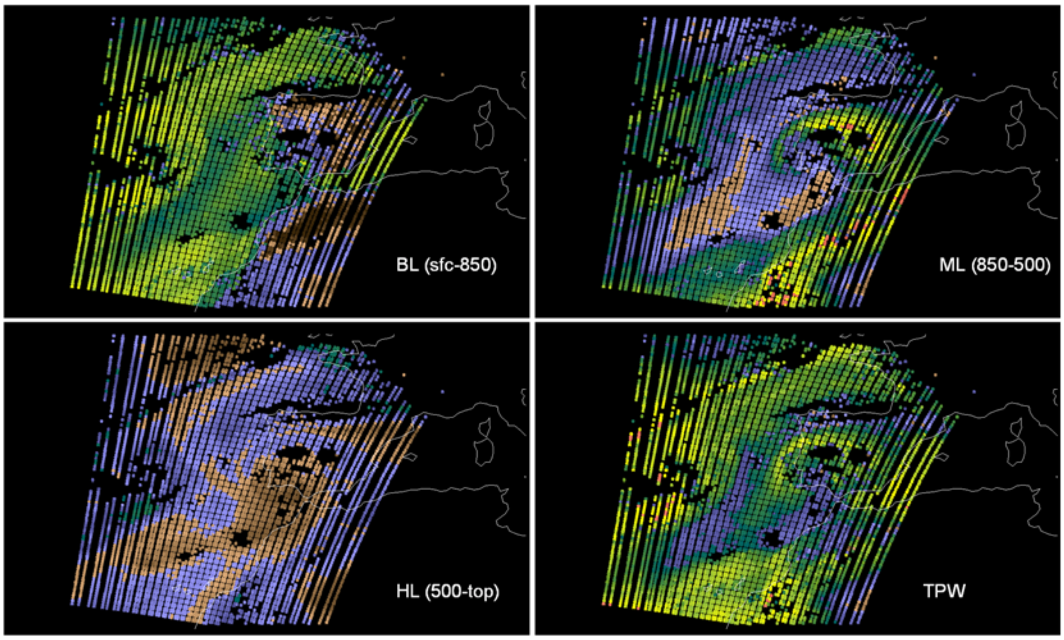

Figure 5: Precipitable water BL, ML, HL and TPW parameters calculated from IASI L2 version 5 for case study 12th August 2011 displayed with PGE13 NWCSAF color palette.

Since the PGE13 and PGE00 binary files are not easy to manage, one IDL prototype to convert the PGE13 binary files to netCDF format was written in 2010. These netCDF files have been designed in order can be managed by several meteorological tools like McIDAS-V[2] and IDV to produce 3D&2D displays interactively. This IDL prototype is not part of NWCSAF software package and it is supported as best effort basis. Currently on request to ***mmartinezr@aemet.es***

Then, it was decided to make a third version of the IDL IASI L2 version 5 program to add the conversion to NetCDF format with one design similar to netCDF PGE13 SPhR structure. It was develop an IDL program to read the IASI L2 data, reorder them, crop the orbit to one desired region, calculate the nowcasting parameters equivalent to the PGE13 SPhR one and write on file with NetCDF format with the same structure successfully used with PGE13 SPhR optional binary files. Since official PGE13 SPhR parameters files could be converted to McIDAS AREA format it was possible to compare with same projection, color palette and tool. It can be seen in Figure 6 the ML fields (Precipitable Water in Middle Layer 850 to 500 hPa) from IASI L2 version 5 and PGE13 SPhR hybrid version 2013 displayed with MCIDAS-V on same projection and color palette.

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[1] *Note: The NWCSAF color palette is same that used at Wisconsin CIMSS for GOES sounder products*

[2] *Note: McIDAS-V and IDV are freely available on their respective web pages:*

MCIDAS-V *http://www.ssec.wisc.edu/mcidas/software/v/*

IDV *http://www.unidata.ucar.edu/software/idv/*

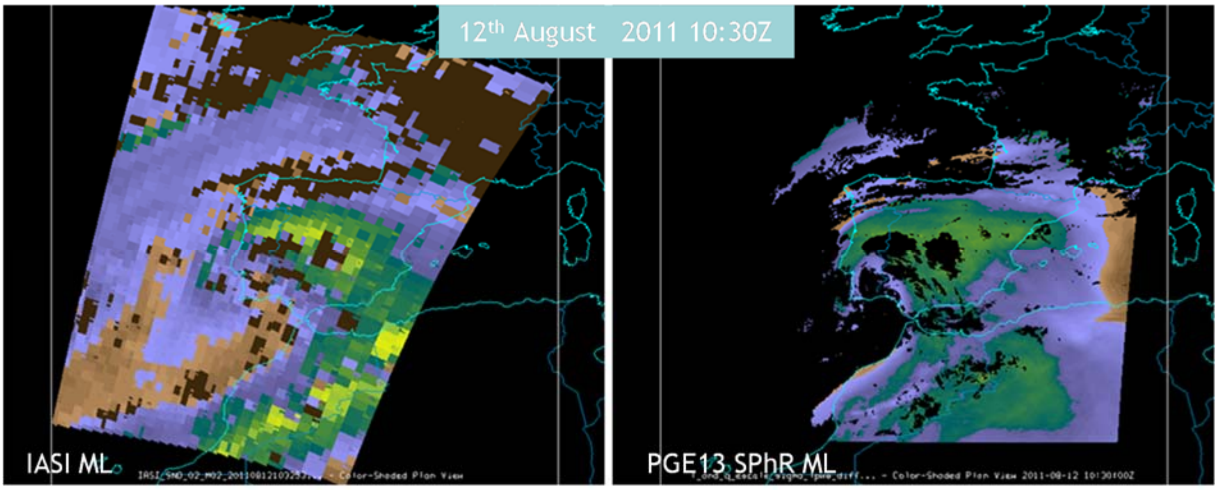

Figure 6: Precipitable water ML parameter calculated from IASI L2 version 5 (right) and from NWCSAF/MSG PGE13 SPhR hybrid version for case study 12th August 2011 displayed with PGE13 NWCSAF color palette using McIDAS-V tool in the same projection.

Thus, IASI L2 converted to NetCDF files can be used directly by user's tools like IDV or McIDAS-V and to make a full comparison of IASI L2, NWP and PGE13 SPhR nowcasting parameters with the same tool and in the same conditions (color palette and projections).

In the case study 12th August 2011, the south high humidity on medium levels is the "fuel" for the convection inside of the Iberian Peninsula. At large scale it is well represented on the IASI L2 but there are disagreements in some region and the IASI ML field is noisy.

After these early subjective comparisons, it was found that the fields of IASI L2 version 5 precipitable water fields had not enough quality to build a wider period dataset and since EUMETSAT Secretariat announced that a Version 6 of IASI L2 would be available end of 2012 with strong improvements, it was decided to wait and repeat to study when IASI L2 version 6 was available; see (August, 2014) and (Hultberg, 2014).

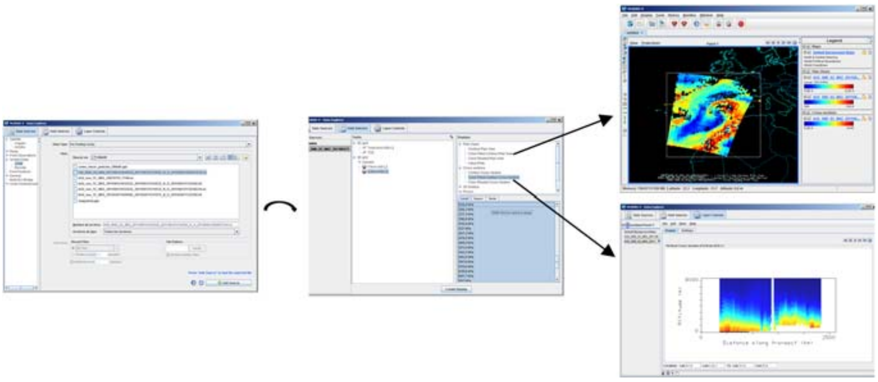

Figure 7: Very early examples of 2D and 3D interactive capabilities after with McIDAS-V after conversion to netCDF with adequate structure of IASI L2 data for case study 12th August 2011.

In the meantime, since PGE13 SPhR netCDF structure has been used to write the IASI L2 and since this netCDF structure it is a heritage of WRF netCDF files, it allows the generation of great variety of 3D&2D graphics on McIDAS-V. Early examples interactive use with McIDAS-V are shown in Figure 7. Advance use of the 3D capabilities are shown in Section 4.

This early comparison of PGE13 SPhR, ECMWF and IASI L2 nowcasting fields served as an early example of issues to be solved for the future operation of the MTG-IRS. The images shown in Section 3 were shown in presentations at 2012 and 2013 scientific advisory MTG-IRS group (MIST Group) Workshops as pioneering activities on the use on nowcasting of future MTG-IRS L2 profiles. Some conclusion as the need to be prepare for issues illustrated here as the need to add nowcasting parameters on future MTG-IRS L2 files, the need that MTG-IRS L2 file format structure and design should be compatible with user tools directly, etc. were extracted.

Also, were presented on the first MTG-IRS Nowcasting Workshop that took place in EUMETSAT Headquarter in July 2013. The Workshop was chaired by Paul Menzel (U. Wisconsin-Madison) and Herve Roquet (Meteo-France).

4. Second study: Collocation of IASI l2 version 6 with ECMWF and PGE13 SPhR on case study 20th June 2013.

After downloading the version 6 (Piece Wise Linear Regression) PWLR IASI L2 HDF-5 files kindly provided by T. August (EUMETSAT) it was proceeded to make first an analysis of the HDF-5 internal structure using *hdfview* in the same way that for IASI L2 version 5.

Although the PWLR IASI L2 files contain all the needed data and the design of PWLR IASI L2 was better than the IASI L2 version 5 files design unfortunately they could not be used directly with McIDAS-V (and likely by many applications). This is due to a slight design structure error. The array of pressure levels has been written as a global attribute instead to define the array of pressure levels as other dimension and to declare temperature and specific humidity profiles as arrays with dimension longitude, latitude and pressure. In the figure 8 it can be seen the differences in the definition of the 3D temperature array between files PWLR IASI L2 (left) and PGE13 files (right).

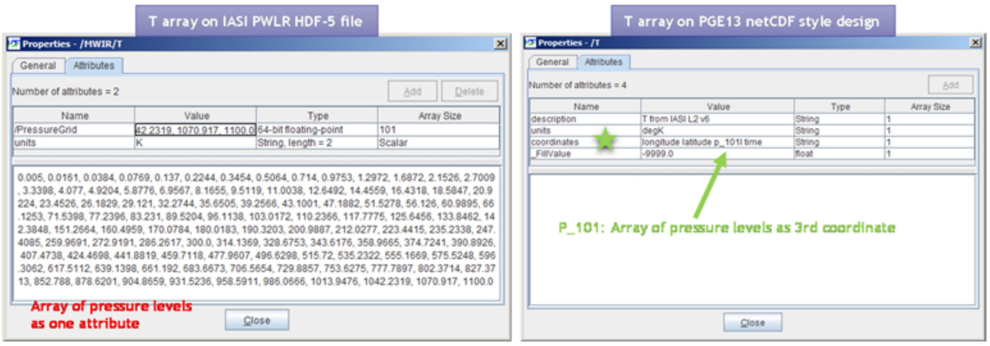

Figure 8: Difference in the definition of the 3D temperature array between PWLR IASI L2 HDF-5 files (left) and netDF style PGE13 files (right).

PWLR IASI L2 HDF-5 files contain several hours with several orbits for the global coverage and in order to facilitate the "collocation" process the intermediate files for just a predefined region and only one orbit should be created. To specify the region just a range of longitude and latitude that cover one area similar to the region used to process the PGE13 SPhR and PGE00Hyb (to get ECWMF profiles) could be used.

This facts and due to they do not provides the nowcasting interest parameters (TPW, LPW and instability indices) forced to develop an IDL converter program. Based on the experience gained in the activities described in Section 3, the planned process to compare the PWLR IASI L2 with PGE13 SPhR fields was:

1. Download the PWLR IASI L2 files for the date of one PGE13 SPhR case study. It was selected the 20th June 2013[3].
2. Develop an IDL program to: read PWLR IASI L2 profiles, calculate the precipitable water fields and instability indices and write on netCDF files using the same structure as used for PGE13 SPhR on independent files for every orbit over a predefined region.
3. Use McIDAS-V to make a comparison of PGE13 SPhR files and vertical cross sections of temperature and specific humidity over a predefined region.
4. After read above files search for PGE13 SPhR and ECMWF for next date and region. For every IASI L2 profile search the nearest PGE13 SPhR and ECMWF pixels (or n x n window) and write collocated dataset of IASI L2, ECMWF and PGE13 SPhR parameters.

Since PWLR IASI L2 HDF-5 files contain several hours with several orbits for the global coverage and in order to facilitate the "collocation" process the program creates IASI L2 netCDF and binary

[3] *See slides 19th to 21st and 64th to 69th in Martinez presentation at NWC SAF 2015 users' workshop*

https://www.nwcsaf.org/WorkshopsTrainingSurveys/2015UsersWorkshop/2015UsersWSPresentations/SESSION_III/martinez_nwcsaf_workshop_madridfeb2015.pps dataset files for just a predefined region and only one orbit. Thus, the IDL program write separated files for each orbit and are only created when at least a PWLR IASI L2 profile is inside a predefined region. To specify the region in the IDL program is just used a range of longitude and latitude that cover one area similar to the region used to process the PGE13 SPhR and PGE00Hyb (to get ECWMF profiles).

By all above reasons above, the first task performed over the version 6 IASI L2 files was to create an IDL program for:

- reading the data version 6 IASI L2 files
- crop to an orbit and region
- calculation of equivalent to those calculated in the clear air NWCSAF parameters with PGE13 SPHR (ie BL, ML, HL, TPW, LI, SHW and KI)
- calculation of q, sigma_q, sigma_T, etc
- Correctly write netCDF file using the concepts of manageable size etc McIDAS-V format. At the same time write binary files with the IASI L2 structures.

Once created the IDL IASI conversion format from HDF-5 L2 to PGE13. Early objective comparison can be seen in Section 4.1. In Section 4.2 one example of advance use for subjective comparison can be seen.

4.1 QUANTITATIVE COMPARISON OF COLLOCATED IASI L2 VERSION 6 FIELDS WITH ECMWF AND PGE13 SPHR FIELDS. CASE STUDY 20TH JUNE 2013.

Using by one hand the binary files with the IASI L2 structures for every orbit on a predefined region and by other hand the set of all slots for days 19th to 21st June 2013 of PGE13 SPhR and PGE00 Hyb for ECMWF profiles on the region of Figure 11, it was develop an IDL program to make the collocation process.

This IDL program mades for each IASI L2 by orbit:

- read IASI L2 profiles for one orbit inside a region
- search the nearest date in the set of PGE13 SPhR and PGE00 ECMWF files
- open and read the nearest temporal PGE13 SPhR and PGE00 ECMWF files
    - for every IASI L2 profile search the nearest PGE13 and PGE00 (ECMWF) pixels
    - creates one structure with IASI+PGE13+PGE00(ECMWF) profiles for each IASI profile
    - writes all the records on a binary file.

Then, an early quantitative comparison was done during for the collocated data for this case study.

In Figures 9 and 10, the BL, ML, HL and TPW two dimensional histograms for cases IASI L2 vs ECMWF and PGE13 SPhR hybrid mode versu ECMWF are shown.

What is of interest now is just to show the ECMWF, IASI L2 and PGE13 SPhR fields have similar values and no pathological behaviour can be detected in the scatter plots. The correlation is high and the rmse is relatively low in both cases.

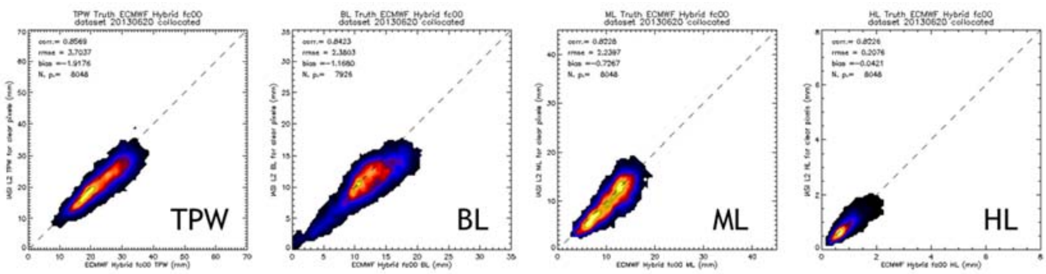

Figure 9: Comparison precipitable parameters from IASI L2 v6 versus ECMWF precipitable water parameters.

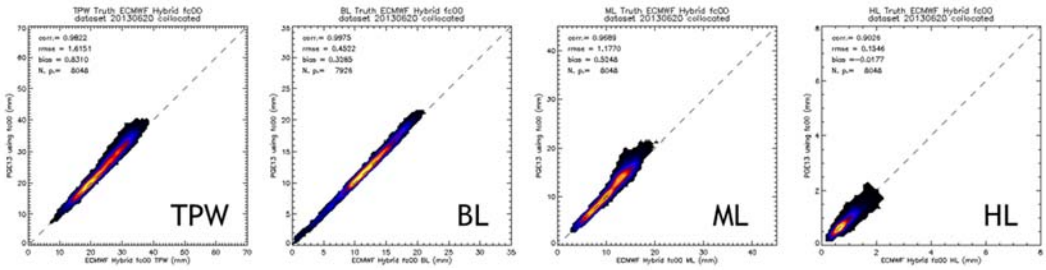

Figure 10. Comparison precipitable parameters from PGE13 SPhR versus ECMWF precipitable water parameters.

But always the correlation is higher and the rmse is lower in case PGE13hyb vs ECMWF since PGE13Hyb uses as first guess ECMWF. The fact that rmse is higher in case IASI vs ECMWF than in case PGE13 vs ECMWF together with the subjective comparison analysis of next section, has warned us to postpone the generation collocated IASI L2-ECMWF and PGE13 for a wider period till more studies will be made in CDOP-2.

4.2 QUALITATIVE COMPARISON. CASE STUDY 20TH JUNE 2013.

In this subsection the purpose is to show the potential of subjective comparison of the ECMWF, IASI L2 and PGE13 SPhR fields and profiles when the set of adequate tools and adequate to the tool files are available.

In this section several examples of advanced 2D and 3D subjective and interactive comparison are shown. They are shown in order to demonstrate the huge potential of generation of products from different sources with adequate formats and structures synchronised and ready to use with common users tools. If this harmonization of products and tools is reach it will allow full access and comparison of the different products. In this study has been used the McIDAS-V tool as a proxy of near future 2D and 3D user interactive tools.

In the Figure 11 the process to create a vertical cross section comparison is shown. In Figure 11.a the BL parameter from ECMWF has been displayed over a 3D display of orography. In Figure 11.b, the pink line represent the line used to make the vertical cross sections of figures 11 and 12. It has been chosen to follow the humidity maximum flow west of Sardinia and Corsica and continues through the Rhône valley. In the animations of dates from 19th to 21st of June is possible to see how the water vapour in low levels is moving to South of Germany using the Rhone valley door[4]. The Figure 11.a is on regular perspective and the Figures 11.b to 11.d are after interactive rotation to get that the vertical cross sections are horizontal.

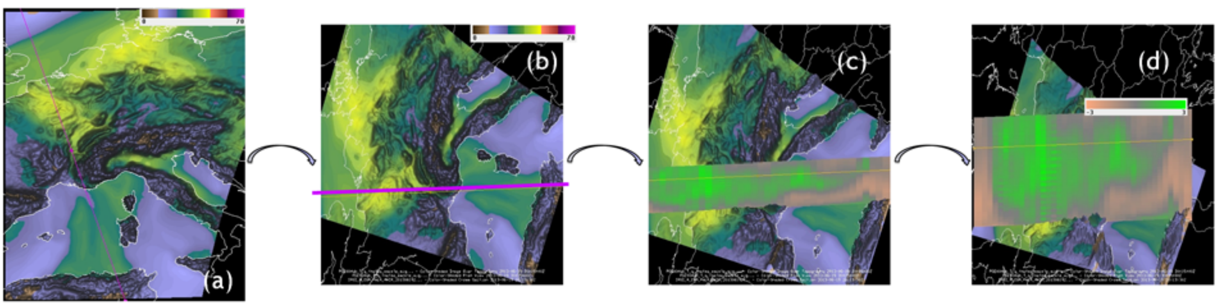

Figure 11. Steps in the process to create the vertical cross sections and change in the perspective of normalized water content for case study 20th June 2013 of PWLR IASI L2 profiles.

[4] *See slide 19th in Martinez presentation at NWC SAF 2015 users' workshop*

https://www.nwcsaf.org/WorkshopsTrainingSurveys/2015UsersWorkshop/2015UsersWSPresentations/SESSION_III/martinez_nwcsaf_workshop_madridfeb2015.pps

In the images of Figures 11.b, 11.d, 12 and 14 it has been displayed the vertical cross section of the normalized water vapour content using a colour palette that show wetter than normal on green colours and drier than normal on beige colours. Normalization is made subtracting the mean on the level of one reference slot (example the 12Z 20th June 2013 analysis) and dividing by the standard deviation at every level. In one improvement of the IDL program is was added the writing of normalized T, q and θ_e 3D arrays in order to get an equal representation at all levels for easy comparison.

The images shown in this subsection has been generated in the interactive way; thus user can interactively move the line for the vertical cross section making a scanning (as example looking for maxima or minima or just) and tilt the display allowing change also the perspective interactively.

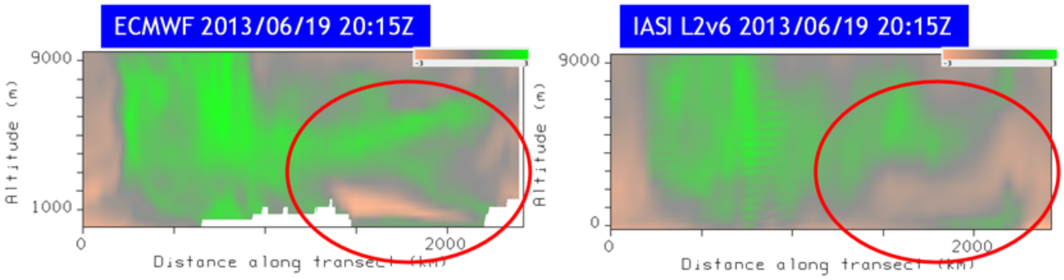

Figure 12. Normalized water content vertical cross sections at the pink line of Figure 11 from ECMWF (left) and PWLR IASI L2 v6 (right) for 19th June 2013 at 20:15UTC.

It can be seen in the Figure 12 that the humidity flow is more intense in the ECMWF (left image) and the great differences on low level in the Mediterranean and desert part of the vertical cross section (red circles).

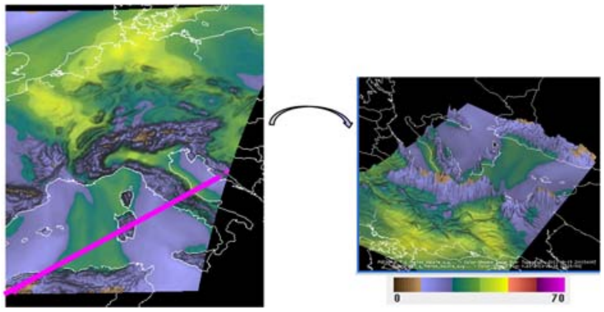

Figure 13. Steps in the search of line where made a simultaneous comparison of the three sources of data vertical cross sections and change in the perspective of normalized water content for case study 19th June 2013 of PWLR IASI L2 profiles.

It has not been shown in Figure 12 the PGE13 SPhR humidity vertical cross section because a high percent of pixels in the line were cloudy. In order to allow a simultaneous comparison of the three sources of data it was searched a line for vertical cross section with a high percent of clear pixels and with interest for the comparison. After interactive scanning was selected the pink line on figure 13.

In the Figure 13 it has been shown the vertical cross section of the normalized water vapour content with same colour palette from the PWLR IASI, ECMWF and PGE13Hyb profiles (denoted as sigma q) at pink line of figure 12. These vertical cross sections cross vertically the maximum flow of the subtropical jet that flow west of Sardinia and Corsica perpendicular to the Alps (see red arrows). It can be seen as the ECMWF and PGE13Hyb shown stronger flows (greener signal)

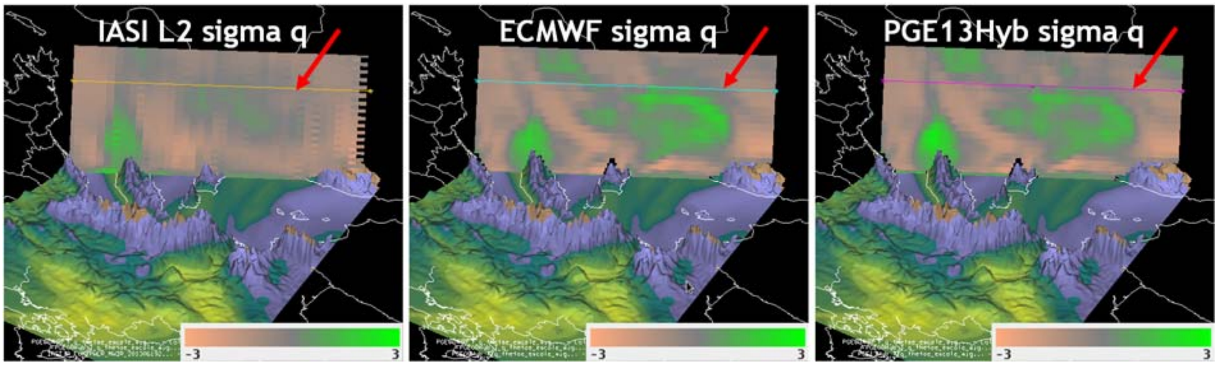

Figure 14. Normalized water content vertical cross sections at the pink line of Figure 13 from PWLR IASI L2 v6 (left) ECMWF (center) and PGE13 SPhR hybrid (right) for 19th June 2013 at 20:15UTC.

Together with the parameters calculated directly from the retrieved profile, the differences between the parameters calculated from the retrieved profiles and the ones calculated from background NWP are also available as other outputs. The differences have been calculated directly inside the McIDAS-V. In the Figure 15 are represented the differences between IASI q and ECMWF q (left) and between PGE13 q and ECMWF q (right).

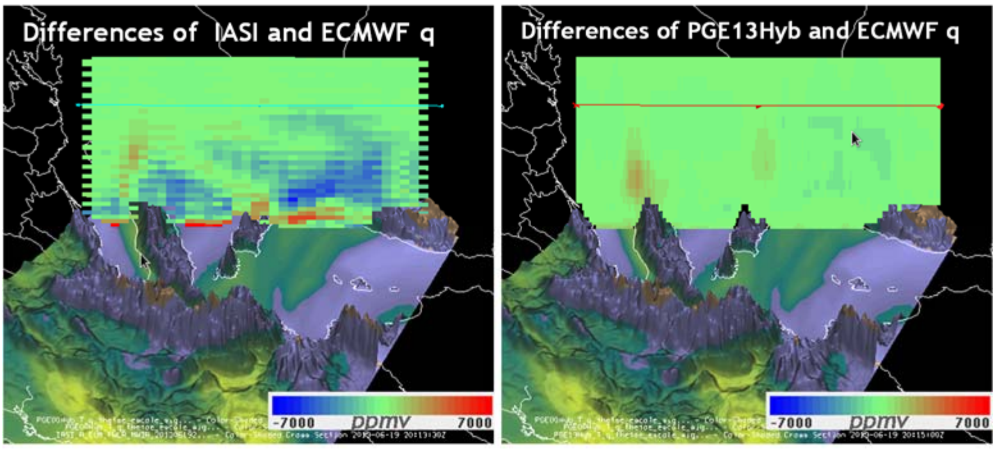

Figure 15. (left) Differences between IASI q and ECMWF q (right) Differences between PGE13 SPhR q and ECMWF q vertical cross sections at the pink line of Figure 13 for 19th June 2013 at 20:15UTC.

These images in Figure 15 show one of the greatest added value of these utilities. The difference has been displayed with same colour palette using red colours for pixels where PGE13 or IASI L2 are greater than ECMWF respectively (blue colours for pixel where are lower than ECMWF). These differences q vertical cross sections show the problem to interpret the differences between IASI L2 and ECMWF; ***what part is due to the satellite algorithm and deficiencies and what part is due to NWP deficiencies.***

In the case of the differences between PGE13Hyb and ECMWF the interpretation is direct since PGE13Hyb has used as first guess ECMWF and the differences are all due to the satellite data; i. e. due the difference of SEVIRI and RTTOV BTs. After watching of Figure 15 the greater spread on the scatter plots of Figure 9 than in Figure 10 could be understood.

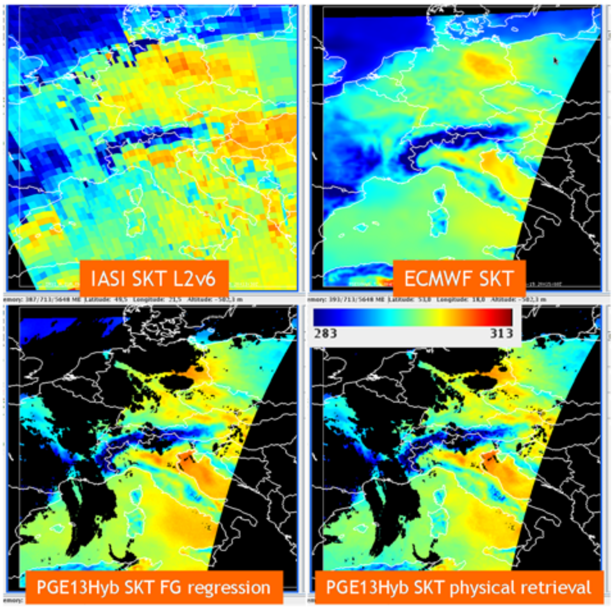

Figure 16. SKT comparison of PWLR IASI L2v6, ECMWF and PGE13Hyb 2013/06/19 20:15Z

As other example of monitoring and debugging of several steps for future algorithm developing are shown in Figure 16 the comparison of the SKT fields from PWLR IASI L2, ECMWF and PGE13Hyb after First-Guess non-linear regression and after physical retrieval steps.

5. CONCLUSIONS

No quantitative extended validation has been done during this studies because only two case studies has been analysed, but the tools to create later a database with a wider period has been developed. It will developed in CDOP-2 and CDOP-3 a wider period database in which together IASI L2 profiles it will be added IASI L1 plus ECMWF profiles (from several forecast time) plus the result to apply a statistical retrieval to IASI L1 and SEVIRI BTs.

Satellite information can be very valuable to compute products useful for nowcasting tasks due to can provide near real time L2 products over wide areas. Real IASI L2 have been used and compared to NWCSAF/MSG L2 ones and ECMWF; it has been shown the advantages and limitations. But the main fact is the possibility of the generalization of L2 management using interactive tools.

The NWCSAF/MSG L2 and IASI L2 generated from low earth orbit hyperspectral instruments like AIRS, IASI and CrIS could be used now operationally and synergistically in nowcasting. IASI and MSG L2 have the disadvantage of having different spatial and temporal resolutions; IASI ones are less suitable to be used for nowcasting purposes than MSG ones but could be used to assess the possibilities for MTG era when MTG-IRS and MTG-I were available. Then, this studies could also be considered as early experiments for future exploitation on nowcasting of future MTG-IRS L2 products.

All the problems found to get nowcasting parameters from IASI L2 files could be similar to the ones that local users will found with future MTG-IRS L2 delivered files if not careful design is made and a local software package is not provided to the users.

If the structure and format of the files is adequate and users have an adequate tool then they could make a complete 2D and 3D exploitation of the data allowing to use the satellite data as detector of deviation of NWP and monitoring tool. Thus, EUMETSAT (Secretariat and SAFs) should work taking into account that the final format of their products should be open and managed by the most widely users tools.

One important activity for CDOP-3 and CDOP-4 should be the development of a local software package that uses local NWP as first guess and IRS L1 data locally received by the users as main input. Taking into account the huge CPU consume of optimal estimation algorithm one statistical algorithm similar of the PGE13 SPhR non-linear regression could be used. This will allow to investigate the added value of the faster update repeat cycle of future MTG-FCI with poor number of channels and high spatial resolution and the added value of the lower update repeat cycle of future MTG-IRS with higher number of channels and lower spatial resolution. These facts could be used by forecasters to modify their forecasts (based mainly on NWP) with the modifications introduced by the satellite and NWP differences.

5.1 FUTURE WORKS

These activities has not been closed and will be retaken during CDOP-2 and CDOP-3.

6. ACKNOWLEDGEMENTS

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