ALADIN Project Stay report – version 0.0 (January 2019)

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(v. 2019.01.31)

Topics

1 Introduction

RADAR reflectivity and radial wind observations are essential components of a mesoscale Data Assimilation (DA) system therefore enhanced cooperation among Regional Cooperation for Limited Area Modelling in Central Europe (RC LACE) countries through a common RADAR DA working plan, has been started in 2017 [1] to optimally achieve the regional Numerical Weather Prediction (NWP) goals. Foreseen activities included:

- validation of radar volume data under the Hierarchical Data Format 5 (HDF5), available from the new European Meteorological Network (EUMETNET) Operational Programme for the Exchange of Weather Radar Information (OPERA) Internet File Server (OIFS) – OPERA Data Centre ODC, known as Odyssey;
- validation of the OPERA Data Information Model (ODIM) HDF5 reading in Bator.

This document reports the activities done during a short stay at CHMI on the two above identified topics from the 2019 RC LACE plan. Several aspects of the validation processes are described and discussed, as a sequence of the work previously done by other RC LACE colleagues (see '2018 reports' at http://www.rclace.eu/?page=11). This exploratory work with radar data is included in a series of annual stays, started in 2016 and supported by the ALADIN flat-rate, in order to maintain up to dated the know-how on the latest developments on the source code BATOR. In fact, in the last years BATOR has been up to dated in accordance to the latest WMO and OPERA data formats and directives, allowing the ingestion of recently produced SYNOP, TEMP, AMDAR and radar data by the local DA settings.

Nowadays, WMO Region VI (Europe, Middle East) has two radar exchange models available (according to [2]): OPERA (through Odyssey) and the Advanced Weather Radar Network for the Baltic Sea Region (BALTRAD). Besides, a web radar metadata database from which it is possible to track the changes in 812 weather radars [2] is maintained by the Turkish Meteorological Service (TMS) on behalf of WMO which is designated as WMO Radar Database (WRD, available from http://wrd.mgm.gov.tr/default.aspx?l=en).

Main difference between the two radar exchange models above mentioned rely on the following (see [2] for further details): Odyssey (OPERA) is a EUMETNET initiative jointly hosted by UK Met Office and Meteo-France, based on a centralized model hosted by the two (twin) centers, which receives polar ODIM data and produces directly, using the same software, pre-processed data; while, BALTRAD is based on a decentralized concept with several nodes operated by the partners in order to exchange and process data according to local requirements using a common set of data processing algorithms, shared through the same open source code.

According to [3], in a first step, OPERA has developed its own data information model, ODIM[1], and the adoption of ODIM has significantly improved the ability of members to receive, interpret and utilize each other's data. As published in [4], Odyssey generates and archives composite products from raw single site radar data using common pre-processing and composing algorithms. The initial purpose of OPERA was to deliver 2D reflectivity composites, which means data was not distributed under volume data. However, becoming aware of NWP needs, it started to work to change its original goals, providing data to a wider range of users, so that producers are now encouraged to send their volume and radial velocity data. For instance, Portugal is sending its raw volume and radial velocity data

1ODIM can have two formats: the Binary Universal Form for the Representation of meteorological data (BUFR) and HDF5, named as ODIM_BUFR. BALTRAD uses ODIM_H5 [2].

on a minute frequency under ODIM_H5 since 18 December 2018 [5].

In a second step, and still in accordance to [3], quality control algorithms as well as a beamblockage maps are applied over data, which includes: detection of land and sea clutter, nonprecipitation echoes (birds, insects, etc.) and wireless communication disturbances. A quality index (one per datum for each quality control) with values ranging on the interval 0-1, is then present in HDF5, stating the probability of disturbance in the observation.

Although the harmonization promoted by OPERA, nowadays there are still remaining differences among different radar datasets which does not allow to use these straightforward in the mesoscale DA settings; for instance, the scan strategies. Therefore a pre-processing step is still required, in order to harmonize the datasets where metadata is rearranged to be the same for all the data producers keeping the NWP code as clean as possible, so that we may use the most suitable time and space of data with as little impact as possible on the data information (thinning strategies are applied), as referred in [3]. As it is mentioned in [2], the BALTRAD data processing software is now used operationally by Odyssey to quality control all input polar data. However, as it was also mentioned in [2], BALTRAD partners (in particular, Odyssey) can tailor their use of the tools to suit their local purposes. As it was seen during this stay, besides the changes in the HDF5 structure, OIFS add one more quality check for those which already in use by BALTRAD.

At the time of writing this report two DA operational radar data flows are available for WMO Region VI: a first one based on the BALTRAD toolbox, which has been developed by HIRLAM, where raw data sent to OPERA can be accessed after being pre-processed and quality controlled by the Swedish (SHMI) server (odc.baltrad.eu, that we will keep refering as BALTRAD); and a second one which is available from OIFS, where the centralized OPERA software has been applied to pre-process and quality control the original raw data.

So far, however, none of the above mentioned exchange data models were able to provide radar datasets for NWP purposes free of inconsistencies. Therefore, RC LACE has produced a new Homogenization Of Opera Files (HOOF) tool [6] which should be used to produce a “format homogenized” set of data, suitable for the processing by NWP ALADIN tool BATOR.

Due to the sharper period of time used for this stay, main aspects of this validation will just concern radar reflectivity data under ODIM_H5 format, although the data files examination methodology may easily be extended for radial velocity. This document is organized as follows: in Section 2 a description of the main differences produced by the two Region VI exchange data centers over one single data set are described; in Section 3, the main conclusions over the validation tests performed over the RC LACE HOOF tool, are given; and finally in Section 4, the first steps onto the validation of BATOR reading of ODIM_H5 data are registered.

2 Validation of HDF5 datasets

In order to understand the differences on the two data flows available at WMO Region VI, two aspects of HDF5 radar settings where look at: structure and contents. The structure was examined for the 3 levels: /root group, /dataset groups and /data(&quality) groups; the contents were examined through their groups and /data attributes (metadata) verification and /data contents illustration (when possible).Two dates were chosen for this analysis: 20180529 (12UTC) and 20190117 (00UTC); the former for being historical and the latest to take into account the recent operational changes performed over OPERA's exchange model. Most of the work was done with focus on Portuguese radars, although whenever possible, other radar's data were simultaneously examined.

2.1 The structure

To get familiar with the latest structure of OIFS ODIM_H5 data files, the following set of OPERA files was examined:

T_PAZZ60_C_EUOC_20190117120000_czbrd.h5
T_PAZZ47_C_EUOC_20190117120000_frnan.h5
T_PAZZ42_C_EUOC_20190117120000_ptfar.h5

The tool hdfview_3.0 [7] was used to visualize the structure and contents of each data file as well as the tool ls_H5all.py (available from CHMI). Figure 1 shows the basic template of each of the (randomly) chosen data files. In this figure, and in accordance to [8]: DBZH, represents the horizontally-polarized (corrected) reflectivity factor; TH, represents the logged horizontally-polarized total (uncorrected) reflectivity factor; and VRAD, represents the radial velocity.

<table>
<tr><th>cz radar (brd)</th><th>fr radar (nan)</th><th>pt radar (far)</th></tr>
<tr>
<td>/(root group)
|----Conventions
|----datasetn
| |----/data1 (DBZH)
| | |----data
| | |----/what
| |----/quality1, 2, 3, 4
| | |----data
| | |----/how
| | |----/what
| |----/what
| |----/where
|----datasetm
| |----/data1
| | |----data (TH)
| | |----/what
| |----/what
| |----/where
|----datasetp
| |----/data1
| | |----data (VRAD)
| | |----/what
| |----/what
| |----/where
|----/how
|----/what
|----/where</td>
<td>/(root group)
|----Conventions
|----datasetn
| |----/data1 (DBZH)
| | |----data
| | |----/what
| |----/data2 (TH)
| | |----data
| | |----/what
| |----/data3 (VRAD)
| | |----data
| | |----/what
| |----/quality1,2 ,3, 4
| | |----data
| | |----/how
| | |----/what
| |----/what
| |----/where
|----/how
|----/what
|----/where</td>
<td>/(root group)
|----Conventions
|----/datasetn
| |----/data1 (DBZH)
| | |----data
| | |----/how
| | |----/what
| |----/data1 (TH)
| | |----data
| | |----/how
| | |----/what
| |----/how
| |----/quality1, 2, 3, 4
| | |----data
| | |----/how
| | |----/what
| |----/what
| |----/where
|----/how
|----/what
|----/where</td>
</tr>
</table>

Figure 1 – OIFS ODIM_H5 structure for radar data: cz radar (left column); fr radar (central column); pt radar (right column).

Main **conclusions** from this first examination over recent OIFS ODIM_H5 data files are:

i) in recent OIFS HDF5 files different structures can be found according to the data producer. In particular, the number of /dataset groups and the number of /data groups varies according to the radar;

ii) each /dataset corresponds to a different pair (elangle,a1gate), where "elangle' corresponds to the radar elevation angle and "a1gate" corresponds to the index of the first azimuth gate radiated in the scan (see [9] for definition; and [10] for comprehension);

iii) therefore, recent OIFS data under ODIM_H5 format may contain one or several volume scans, each volume scan being a chronologic sequence of unique pairs (elangle,a1gate) [10]). For the Portuguese radars and up to 20181218, for example, each OIFS ODIM_HD5 observation consisted on a double volume scan (see Table A.1 in Appendix, for details);

iv) in the latest OIFS ODIM_H5 data files, not all the three weather radar parameters are included. For instance, so far Portuguese radars just include TH and DBZH.

A deepest comparison was done, furthermore for a single historical radar data available from different data flows so that the main differences between them could be accessed. ODIM_H5 data from the 'ptfar' (Faro, in Portugal) radar, valid for the 12UTC on 20180529 was fetch from the following data flows: OIFS, BALTRAD and Portuguese Institute for the Sea and the Atmosphere (IPMA). In Appendix A, Tables A.1, A.2 and A.3 show the structure, as well as the contents of this data.

From the analysis of Tables A.(1 to 3) more conclusions on the structure can be added to those already listed:

v) quality control flags are only available in ODIM_H5 data files through OPERA pre-processing, either by BALTRAD or by OIFS data flow.

2.2 The contents

Table A.3 summarizes in detail the contents of the ODIM_H5 historical data files for Faro (Portugal) radar at 12UTC of 20180529; columns "OIFS" and "BALTRAD" summarize the different contents of OIFS and BALTRAD data files (for reflectivity).

In order to understand more clearly the differences on the data contents, the reflectivity values originated by the different data flows was visualized graphically and compared with raw data as well as with a 2D radar composite of reflectivity. For this examination, Portuguese data valid at 12:00:06 UTC on the 20180529 is used. To plot these illustrations, the tool plot_H5all.py (available from CHMI) was used.

Panels a) to e) of Figure 3, illustrates the effect of the application of different echoe filters (quality control) on the original raw reflectivity scan for the single elevation – 0.0, of Faro (Portuguese) radar on 12:00:06UTC on 20180529.

The main **conclusions** from the examination of this information are as follow (for Portuguese data before 20181218):

i) metadata and data contents (at least for Portuguese radar datasets) seem to be correctly handled by OPERA and BALTRAD data centers. So to say: there is no lost of relevant information and there is no erroneous and/or spurious data entering the data sets;

ii) volume scans and /dataset groups number changes according with the data flow. For instance, for Portuguese data valid on 20181218, we can see more than one volume scan (each starting, respectively, at 11:50 and 12:00) in OIFS ODIM_H5 while we could only see one volume scan in BALTRAD ODIM_H5;

iii) the number of radar weather parameters available from each ODIM_H5 data file is different according to the OPERA pre-processing center (it is missing a comparison with recent data to check if this characteristic is still maintained, but at the date of writing this report, there was a lack of information of Portuguese radars in the BALTRAD center);

iv) OIFS ODIM_H5 data files contain one more quality control flag - ‘mf.satfilter’, than BALTRAD ODIM_H5 data files;

v) for the Portuguese radar of Faro, the illustration in Figure 3 suggests that OIFS filtering results “just” from the addition of a new OPERA filtering algorithm BALTRAD DBZH data. In fact, as it is mentioned in the Introduction, the BALTRAD data processing software is now used operationally by EUMETNET OPERA’s Odyssey to quality control all input polar data. However, as it was said also in [2], BALTRAD partners (in particular, Odyssey) can tailor their use of the tools to suit their local purposes. Therefore, conclusions should be carefully taken and only on a case-by-case dataset up to more conclusive evidences will appear;

Figure 2 shows the 2D composite for the same instant as the one taken in Figure 2, for comparison. No particular conclusions were taken, thought.

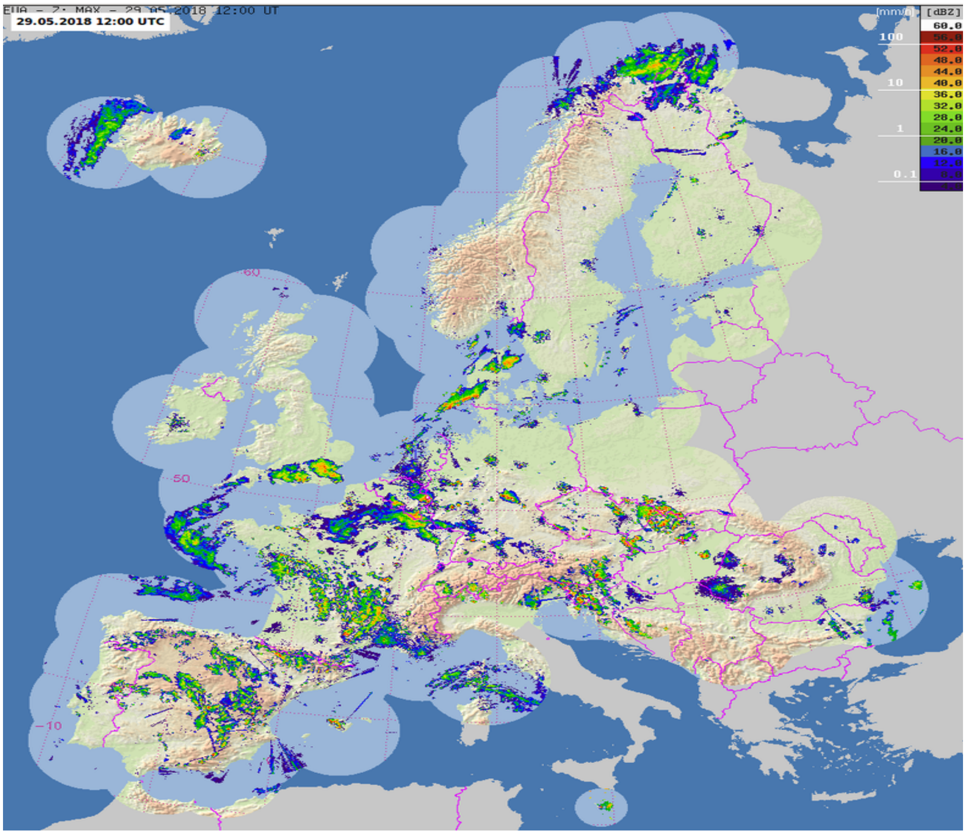

Figure 2 – Maximum reflectivity composites produced by CHMI Remote sensing department over Europe, valid at 12:00UTC on the 20180529.

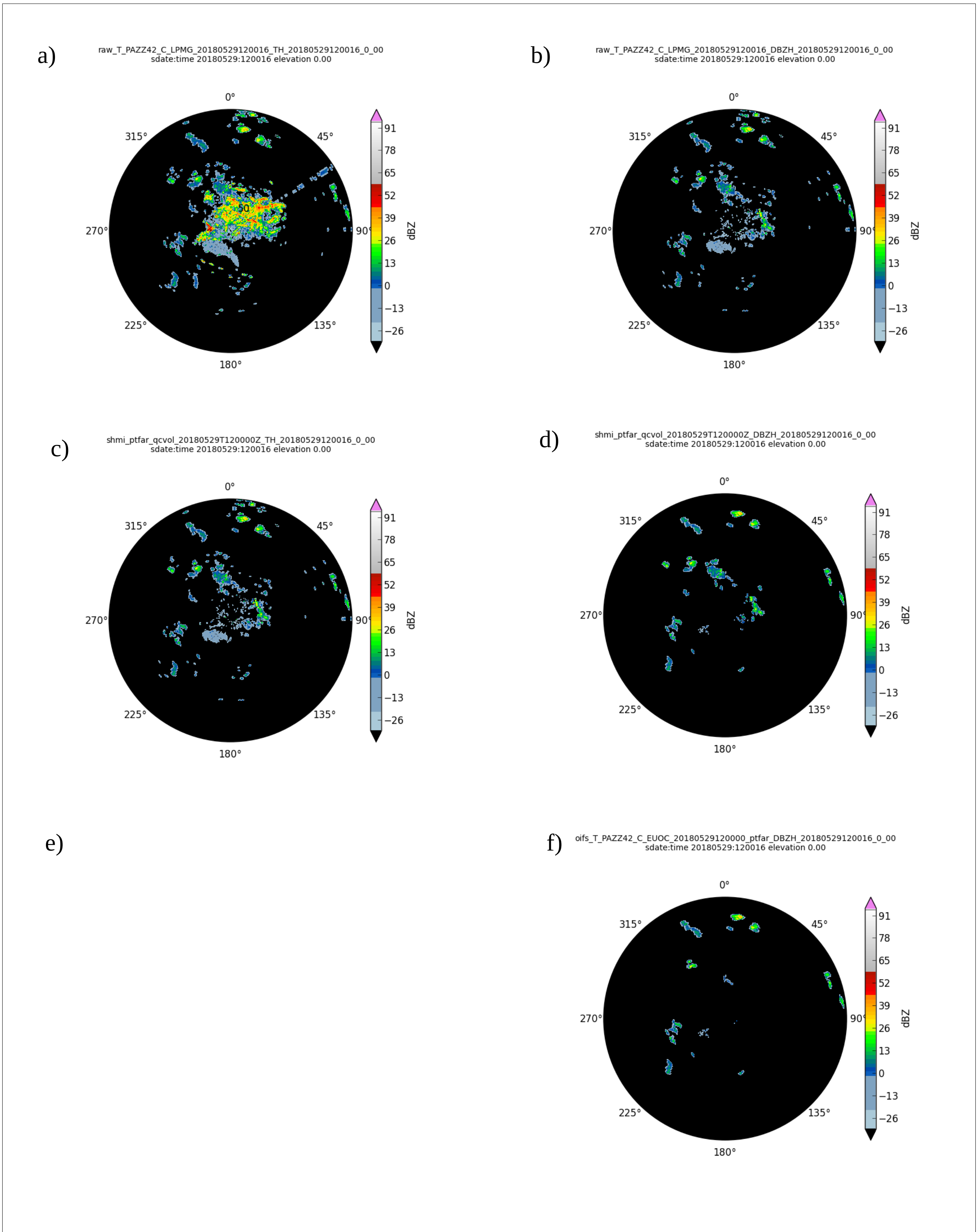

Figure 3 – Radar reflectivity for the 0.0 elevation of Faro Portuguese radar, at 12:00:06UTC on the 20180529, left column concerns TH data while right column concerns DBZH data: a) IPMA raw signal; b) IPMA raw signal after being pre-processed by the observing system; c) BALTRAD raw (input) data; d) BALTRAD (output) data after being pre-processed by BALTRAD system; and f) OIFS (output) data after being pre-processed by the OIFS system. Panel e) is missing because of lack of information.

3 Pre-processing: Homogenization of Opera Files (HOOF) tool

Although the joint harmonization efforts done by OPERA and the Numerical Weather Prediction (NWP) community at the level of the pre-processing and quality control, the adequate ingestion of neighborhood radar data by the local mesoscale Data Assimilation systems still requires a special attention, specially because the tunning of the observation signal has to be done in accordance to the characteristics of the assimilation system (through thinning and/or super-obbing processes, in particular).

HOOF is an homogenization tool recently created by the RC LACE community [6] so that OIFS ODIM_H5 may be easily manipulated (read and changed, essentially) before being ingested by the assimilation procedures. Although a different tool already existed within the HIRLAM community, the preopera_nv.py, the idea behind HOOF's creation is to minimize hard-coding and to use more modular approach with namelist kind of flexibility. It should be applicable to any radar dataset and easier to maintain. In order to support the validation of this tool, versions 4.0 and 5.0 of HOOF were tested as it is explained below.

3.1 HOOF_v4.0

HOOF_v4.0 was tested over a complete set of OPERA OIFS ODIM_H5 data, valid for the 12UTC of 20180529. This experiment has shown HOOF still needed some development to make it robust at least in the two following situations [11]:

- when datasets have startdate set to 0000-00-00 (present in 'dkvir' radar from Denmark);
- when the group name for the output file is not set (as in ODIM_H5 data from radars 'dedrs', 'deflg' and 'denhb' from Germany).

In this way, a new version of HOOF was created and the validation test proceeded with HOOF_V5.0.

3.2 HOOF_v5.0

In order to test the HOOF_v5.0, and as a sequence of the work already done, OIFS ODIM_H5 data for the Portuguese radar 'ptfar', valid at 12UTC on the 20180529 was practiced. The HOOF manipulation follows the algorithm which fulfills a set of pre-defined homogenization rules as explained in [6]. Table A.3 summarizes the detailed information on the transformed files; HOOF performance was examined through the comparison of columns 2 and 5 of this table.

The main **conclusions** are as follows (note that we have used OIFS, but the conclusions are valid over any HDF5 data file):

i) each original ODIM_H5 is split by HOOF into different files, one per volume scan, according to the volume scans contained in the original data file;

ii) the new data files are renamed according to the initial hour of the scan;

iii) the attributes 'how' disappear from most of the /dataset groups;

iv) the attributes CLASS and IMAGE_VERSION disappear from /data group;

v) some attributes disappear. For instance, 'a1gate' disappears from /dataset/where attributes;

vi) when it is not present, the quantity TH is duplicated from DBZH;

vii) storage attributes from ‘dataspace and datatype’ are now different; they change from CHUNKET: 360x300 to CHUNKET: 90x75.

What concerns the points iii) to v), it was possible to verify later that some attributes can be easily introduced in the ODIM_H5 datasets through the inclusion of the appropriate parameters on the HOOF namelist. It was just a question to add in the HOOF namelist of the lines (for instance):

/dataset/how/HVratio = None
/dataset/data/how/CSR = None

Note that, according to [9], the ‘how’ attributes are not mandatory. It was later confirmed by [11] that the original HOOF namelist was chosen to strictly fulfill BATOR metadata requirements. However, what concerns the inclusion of attributes CLASS and IMAGE_VERSION, this approach does not work. In fact, adding the line below:

/dataset/data/CLASS = None

gives an error. So it means the technical solution for this problem is not trivial, though this is a mandatory attributes set, as explained by [7, page 25], requiring further development on the tool.

3.3 Recent updates on OIFS data exchange

One added difficulty when using different observation types in DA is that one should keep track of the data historical changes which are usually differently publicized according to the type (because different communities with different methodologies are involved). In this section, we examine the recent changes introduced in OIFS exchange model. For that, the OIFS ODIM_H5 datasets recently produced are examined in comparison with the historical ones. Porto radar data valid at 00UTC on 20190117 and 20180529, are then examined together. The changes in data structure can been seen before (Figures 4) and after Figure 5) HOOF manipulation.

<table>
<tr><th>OIFS ODIM_H5 Porto historical data</th><th>OIFS ODIM_H5 Porto actual data</th></tr>
<tr><td>/(root group)
|----Conventions
|----dataset1...10 (one per elangle; two data volumes with the same number of angles per data volume)
| |----/data1 (DBZH)
| | |----data
| | |----/what
| |----/how
| |----/quality1
| | |----data
| | |----/how
| | |----/what
| |----/quality2
| |----/quality3
| |----/quality4
| |----/what
| |----/where
|----/how
|----/what
|----/where</td><td>/(root group)
|----Conventions
|----/dataset1...21 (one per elangle; three volume scans with different number of angles)
| |----/data1 (DBZH)
| | |----data
| | |----/how
| | |----/what
| |----/data2 (TH)
| |----/how
| |----/quality1
| | |----data
| | |----/how
| | |----/what
| |----/quality2
| |----/quality3
| |----/quality4
| |----/what
| |----/where
|----/how
|----/what
|----/where</td></tr>
</table>

Figure 4 – OIFS ODIM_H5 data structure for Porto radar, valid at 00UTC: 20180529 historical data (left column); and 20170117 actual data (right column).

<table>
<tr><th>HOOF transformed OIFS ODIM_H5 Porto historical data</th><th>HOOF transformed OIFS ODIM_H5 Porto actual data</th></tr>
<tr><td>/(root group)
|----Conventions
|----dataset1...5 (one per elangle; one volume scan)
| |----/data1 (DBZH)
| | |----data
| | |----/what
| |----/data2 (TH)
| |----/quality1
| | |----data
| | |----/what
| |----/quality2
| |----/quality3
| |----/quality4
| |----/what
| |----/where
|----/how
|----/what
|----/where</td><td>/(root group)
|----Conventions
|----/dataset1...11 (one per elangle; one volume scan)
| |----/data1 (DBZH)
| | |----data
| | |----/what
| |----/data2 (TH)
| |----/quality1
| | |----data
| | |----/what
| |----/quality2
| |----/quality3
| |----/quality4
| |----/what
| |----/where
|----/how
|----/what
|----/where</td></tr>
</table>

Figure 5 – HOOF transformed OIFS ODIM_H5 data structure for Porto radar, valid at 00UTC: 20180529 historical data (left column); and 20170117 actual data (right column).

Main **conclusions** are as follow:

i) HOOF is able to handle properly historical as well as recent OFIS ODIM_H5 datasets;

ii) for Portuguese radars, OIFS ODIM_H5 files are still available on a hourly basis as it used to be the case with historical data (note however that this may not be truth for all radars); however,

iii) recently exchanged data can contain more datasets than historical data in each OIFS ODIM_H5 file. In the first place we see that recent files can contain more volume scans (for the chosen recent date/00UTC we see one volume scan at approximately each 5 minutes: 20190116235005, 20190116235505, 20190117000007, while for the historical data/00UTC, we were able to see only two volume scans, at approximately at each 10 min: 20180528235006, 20190117000007);

iv) HOOF is equally able to transform historical and recent OIFS ODIM_H5 files, creating one new HDF5 file per volume scan and uses explicitly the starting moment of the scan on the new filename;

v) for each dataset, the new OIFS data contains not only DBZH data (filtered reflectivity) as TH data (raw input reflectivity). For this reason, HOOF does not creates a log file with recent date since it does need to add TH information on recent hourly HDF5 file as requested on the namelist (which is not exactly truth for 30 min data).

In order to validate the reading of ODIM_H5 files in BATOR, a set of experiments was done at CHMI computing platforms (kazi1)[2] starting from a locally tested script/executable. Tests were done either for one single or multi radar observations, before and after pre-processed with HOOF tool.

In order to get the most up to date conclusions, the latest export version cycle of the BATOR code source was used[3], CY43T2, and the recent OIFS ODIM_H5 observations. Information on BATOR code source version 43 was available from [12,13 and 14].

4.1 HOOF pre-processed OIFS ODIM_H5: single file

As the first test case and in order to assess BATOR's performance under the recent OIFS data exchange conditions, the following data file was chosen:

T_PAZZ43_C_EUOC_20190117000007_ptprt.h5

This file had previously been manipulated by HOOF using as input the OIFS ODIM_H5 file T_PAZZ43_C_EUOC_20190117000000_ptprt.h5, therefore, as seen in Section 3, so it contained only one single volume scan. The examination of BATOR pre-processing was done under different ways: by examining its direct log file and by examining the contents of the created ECMA (ODB) data base.

Ideally, one should be able to plot the 2D data values (one per 'elangle') in order to get a rough comparison of the input data with the one which is created by BATOR under ODB database. However, due to the lack of time it was not possible to invest on building such a tool. A basic validation was then accessed using the ODBSQL tool and noting the parameters correspondence for the queries present in Table B.1 (see Apendix B). With this methodology and some not specific plotting tools it was possible for instance, to confirm that the location of 2D data is being properly done. Figure 6 shows, for instance,

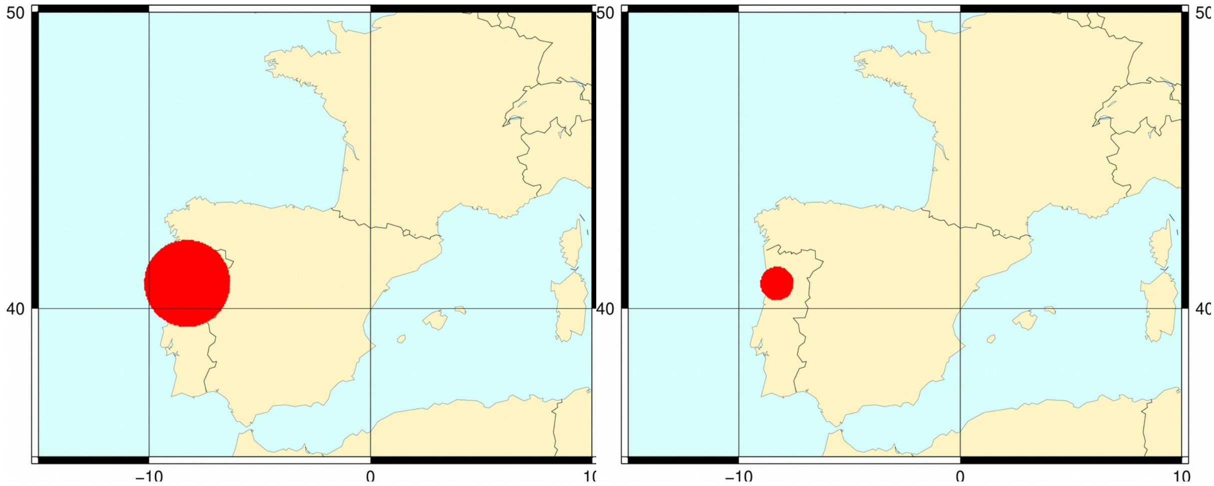

Figure 6 – Porto radar data points 2D location after being ingested by BATOR (CY43T2), at 00UTC on 20190117, for elevations: 0.0 (left); and 10.2 (right).

2 These experiments can be found in /home/mma236/scr/radar directory.
3 Up to CY43T2, BATOR was not prepared to read HDF5 datasets unless back-phased.

Basic **conclusions** are:

i) BATOR runs without any problems pre-processed HOOF data, creating the respective ODB structures;

ii) BATOR identifies correctly the different datasets, one per ‘elangle’;

iii) for each ‘elangle’, BATOR seems to pick up correctly the location of the data points.

4.2 Original OIFS ODIM_H5: single file

In order to test BATOR performance over a not HOOF pre-processed OIFS ODIM_H5 file, the original OIFS ODIM_H5 the following data file was used:

T_PAZZ43_C_EUOC_20190117000000_ptprt.h5

This file corresponds to data used in Section 4.1, but one should re-call here that this observation file contained originally 3 volume scans, on the time intervals (UTC): [23:50:05,23:50:20]; [23:55:53,23:56:08]; [00:02:54-00:03:06].

The examination of ECMA data base has shown the contents of ODB created by BATOR is exactly equal to the one obtained with one single volume scan, which means that for the data file used without transformation, only the volume scan which is the closest to the analysis hour is picked up as explained in rule 3.e) decided to BATOR as explained in document. This observation allows us to add one more line to the conclusions:

iv) when more than one radar volume scan is available for the same location, BATOR chooses the one which is closest to the analysis time.

4.3 Original and HOOF manipulated OIFS ODIM_H5 file: multiple files

As a final step, BATOR was tested for a multiple set of data files. Basic conclusion is:

i) BATOR is able to handle properly a multiple set of OIFS ODIM_H5 files.

5 Ongoing work and conclusions

Odyssey (OIFS) and BALTRAD ODIM_H5 radar data files have different structure and contents although the correspondent data flow seems to be coherent with original raw data files. In particular, OIFS ODIM_H5 contains one more quality control index, the 'mf.satfilter', produced by Météo-France.

OIFS ODIM_H5 files structure and contents are not stabilized for assimilation purposes and a special attention has to be payed when pre-processing neighborhood datasets. For instance, during this stay it was seen that ODIM_H5 files are heterogeneous in structure and content; moreover, at the date of writing this report, it was possible to see that OIFS has recently promoted changes in their data exchange model, with impact on this data structure and content.

An homogenization pre-processing tool created by RC LACE, the HOOF tool, has been tested to manipulate OIFS ODIM_H5 files. Although a wider variety of tests should still be performed to confim its robustness, the tool is already able to coherently manipulate and transform ODIM_H5 data files.

BATOR (CY43T2) seems to be able to properly ingest OIFS ODIM_H5 files, thought a deeper analysis over ECMA data base should still be performed, eventually by creating a plotting tool for the data values.

Acknowledgments

Acknowledgments are due to Peter Smerkol, Paulo Pinto and Sérgio Barbosa. The first one, for the exchange of information on the HOOF tool and for providing its Version 5.0 in due time; the second for providing IPMA raw radar data for the tests here performed and the third for providing useful information on the recent changes of Odyssey. Finally, I would like to thank all the CHMI NWP colleagues for the friendship environment and concerns during my stay in Prague, in particular to Alena Trojakova for her personal commitment to the success of Data Assimilation in ALADIN community.

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Appendix A: Structure and contents of (historical) ODIM HDF5 data

Table A.1 – ODIM_H5 data files (first level) structure.

Data/structure	OIFS	BALTRAD	IPMA	HOOF o OIFS
Filename	T_PAZZ42_C_EUOC_20180529120000_ptfar.h5	ptfar_qcvol_20180529T120000Z.h5	T_PAZZ42_C_LPMG_20180529120016.h5	T_PAZZ42_C_EUOC_20180529120016_ptfar.h5
Structure	dataset1	dataset1	dataset1	dataset1
	dataset2	dataset2	dataset2	dataset2
	dataset3	dataset3	dataset3	dataset3
	dataset4	dataset4	dataset4	sataset4
	dataset5	how	how	how
	dataset6	what	what	what
	dataset7	where	where	where
	dataset8			
	how			
	what			
	where			

Table A.2 – ODIM_H5 data files basic contents.

Data/contens	OIFS	BALTRAD	IPMA	HOOF o OIFS
Filename	T_PAZZ42_C_EUOC_20180529120000_ptfar.h5	ptfar_qcvol_20180529T120000Z.h5	T_PAZZ42_C_LPMG_20180529120016.h5	T_PAZZ42_C_EUOC_20180529120016_ptfar.h5
Number of volume scans	2 (10 min interval)	1	1	1
Number angles per volume scan	4 (0.0, 0.9, 1.9, 2.9)	4 (0.0, 0.9, 1.9, 2.9)	4 (0.0, 0.9, 1.9, 2.9)	4 (0.0, 0.9, 1.9, 2.9)
Number of exchanged parameters	1 (DBZH)	2 (TH, DBZH)	2 (TH, DBZH)	2 (TH, DBZH)
Number of data per dataset	1	2	2	2
Number of quality control indexes per dataset	4	3	0	4

Table A.3 – ODIM_H5 data files detailed contents ("--" means the element is not in use).

Data/dataset (not necessarily by the order they appear in the full structure)	OIFS	BALTRAD	IPMA	HOOF o OIFS
Filename	T_PAZZ42_C_EUOC_20180529120000_ptfar.h5	ptfar_qcvol_20180529T120000Z.h5	T_PAZZ42_C_LPMG_20180529120016.h5	T_PAZZ42_C_EUOC_20180529120016_ptfar.h5
Number of attributes	1	1	1	1
Number of elements	11	7	7	7
Attributes:				
conventions	ODIM_H5/V2.2	ODIM_H5/V2.2	ODIM_H5/V2.1	ODIM_H5/V2.2
/root/how				
Number of attributes	1	13	13	1
Number of elements	0	0	0	0
Attributes:				
beamwidth	0.95...		0.95...	0.95...
RAC	--	0.016	0.016	--
antgain	--	45.6	45.6	--

azmethod	--	AVERAGE	AVERAGE	--
beamwodth	--	0.95..	0.95..	--
binmethod	--	AVERAGE	AVERAGE	--
comment	--			--
freeze	--	1.767...	1.767...	--
nomTXpower	--	256.459	256.459	--
simulated	--	False	False	--
software	--	IRIS	IRIS	--
sw_version	--	8.13	8.13	--
system	--	GEMAMETEOR360/IRIS	GEMAMETEOR360/IRIS	--
wavelength	--	5.33	5.33	--
/root/what				
Number of attributes	5	5	5	4
Number of elements	0	0	0	0
Attributes:				
date	20180529	20180529	20180529	20180529
object	PVOL	PVOL	PVOL	PVOL
source	WMO:08553,RAD:PO42,PLC:Faor,NOD:ptfar	WMO:08553,RAD:PO42,PLC:Faor,NOD:ptfar	WMO:08553,RAD:PO42,PLC:Faor,NOD:ptfar	WMO:08553,RAD:PO42,PLC:Faor,NOD:ptfar
time	120000	120000	120000	120000
version	H5rad2.2	H5rad2.2	H5rad2.1	--
/root/where				
Number of attributes	3	4	4	3
Number of elements	0	0	0	0
Attributes:				
height	616.0	616.0	616.0	616.0
lat	37.30533...	37.30533...	37.30533...	37.30533...
lon	-7.95173...	-7.95173...	-7.95173...	-7.95173...
overweight	--	29	29	--
/dataset1	**dataset5**			
Number of attributes	0	0	0	0
Number of elements	8	5	5	8
Attributes:				
/dataset1/how	**dataset5/where**			
Number of attributes	32	32	32	0
Number of elements	0	0	0	0
Attributes:				
Dclutter	3	3	3	--
NEZ	-50.8125	-50.8125	-50.8125	--
NI	5.99625	5.99625	5.99625	--
ProcMode	FFT	FFT	FFT	--
Vsamples	16	16	16	--
XMTphase	Random	Random	Random	--
averaged_bins	4	4	4	--
avg_power	230.8131...	230.8131...	230.8131...	--
f_3alg_PP02	false	false	false	--

f_Z_atten_Zc	True	True	True	--
f_beamblock_Zc	False	False	False	--
f_beginpulse	False	False	False	--
f_dp_atten_Z+ZDR	False	False	False	--
d+dp+atten+ZDRc	False	False	False	--
f_endpuse	False	False	False	--
f_fallsp_Vc	false	false	false	--
f_rangenorm	true	true	true	--
f_shipVcorr	false	false	false	--
f_speckle_V	true	true	true	--
f_speckle_Z	true	true	true	--
f_stormrel_Vc	false	false	false	--
f_targdetect_Zc	false	false	false	--
f_unfold_Vc	false	false	false	--
f_varpulses_dPRF	false	false	false	--
highprf	450.0	450.0	450.0	--
lowprf	450.0	450.0	450.0	--
polarization	H	H	H	--
pulsewidth	2.0	2.0	2.0	--
radconstH	61.88	61.88	61.88	--
radhoriz	299.79998	299.79998	299.79998	--
rpm	4.66644...	4.66644...	4.66644...	--
Task	REFLECTVOL_A	REFLECTVOL_A	REFLECTVOL_A	--
/dataset1/what	**dataset5/where**			
Number of attributes	5	5	5	4
Number of elements	0	0	0	0
Attributes:				
enddate	20180529	20180529	20180529	20180529
endtime	120029	120029	120029	120029
product	SCAN	SCAN	SCAN	--
startdate	20180529	20180529	20180529	20180529
starttime	120016	120016	120016	120016
/dataset1/where	**dataset5/where**			
Number of attributes	6	6	6	
Number of elements	0	0	0	
Attributes:				
a1gate	146	146	146	
elangle	0.0	0.0	0.0	
nbins	300	300	300	
nrays	360	360	360	
rscale	1000.0	1000.0	1000.0	
rstart	0.0	0.0	0.0	
/dataset1/data1	**dataset5/data1**		**dataset1/data2**	
Number of attributes	0	0	0	0
Number of elements	3	3	3	2
Attributes:				
/dataset1/data1/data	**dataset5/data1/data**		**dataset1/data2/data**	

Number of attributes	2	2	2	1
Number of elements	0	0	0	0
Dataspace and datatype				
Storage layout	CHUNKET: 360x300	CHUNKET: 360x300	CHUNKET: 360x300	CHUNKET: 90x75
Compression	Level = 5	Level = 6	Level = 6	Level= 5
(...)				
Attributes:				
CLASS	IMAGE	IMAGE	IMAGE	--
IMAGE_VERSION	1.2	1.2	1.2	--
/dataset1/data1/how	**dataset5/data1/how**		**dataset1/data2/how**	
Number of attributes	2	2	1	0
Number of elements	0	0	0	0
Attributes:				
CSR	12.0	12.0	--	--
LOG	2.625	2.625	2.625	--
/dataset1/data1/what	**dataset5/data1/how**		**dataset1/data2/what**	
Number of attributes	5	5	5	5
Number of elements	0	0	0	0
Attributes:				
gain	0.5	0.5	0.5	0.5
nodata	255.0	255.0	255.0	255.0
offset	-32.0	-32.0	-32.0	-32.0
quantity	DBZH	DBZH	DBZH	DBZH
undetected	0.0	0.0	0.0	0.0
/dataset1/data2	--			
(analogue)	--	(analogue)	(analogue)	(analogue)
/dataset1/data2/data	--			
(analogue)	--	(analogue)	(analogue)	(analogue)
/dataset1/data2/how	--			
(analogue)	--	(analogue)	(analogue)	(analogue)
/dataset1/data2/what	--		**/dataset1/data1/what**	**/dataset1/data2/what**
Number of attributes	--	5	5	5
Number of elements	--	0	0	0
Attributes:	--			
gain	--	0.5	0.5	0.5
nodata	--	255.0	255.0	255.0
offset	--	-32.0	-32.0	-32.0
quantity	--	TH	TH	TH
undetected	--	0.0	0.0	0.0
dataset*n*				
(analogue)				
/dataset1/quality1	**/dataset5/quality1**			
Number of attributes	0	0	--	0
Number of elements	3	3	--	
Attributes:				
/dataset1/quality1/how				
Number of attributes	2	2	--	1

Number of elements	0	0	--	0
Attributes:				
task	fi.fmi.ropo.detector.classification	i.fmi.ropo.detector.classification	--	fi.fmi.ropo.detector.classification
task_args	SPEC:-30,12;SPECKNORMOLD:-20,24,8;SOFTCUT:5,170,180;SHIP:20,8,EMITTER:-10,3,3	SPEC:-30,12;SPECKNORMOLD:-20,24,8;SOFTCUT:5,170,180;SHIP:20,8,EMITTER:-10,3,3	--	--
/dataset1/quality1/what				
Number of attributes	2	2	--	2
Number of elements	0	0	--	0
Attributes:				
gain	-0.00392...	-0.00392...	--	-0.00392...
offset	1.0	1.0	--	1.0
/dataset1/quality1/data				
Number of attributes	2	2	--	1
Number of elements	0	0	--	0
Dataspace and datatype				
Storage layout	CHUNKET: 360x300	CHUNKET: 360x300	--	CHUNKET: 90x75
Compression	Level = 5	Level = 6	--	Level= 5
(...)				
Attributes:				
CLASS	IMAGE	IMAGE	--	--
IMAGE_VERSION	1.2	1.2	--	--
/dataset1/quality2		--		
(analogue)	(analogue)	--	--	(analogue)
/dataset1/quality2/how				
Number of attributes	1	--	--	1
Number of elements	0	--	--	0
Attributes:		--	--	
task	mf.satfilter	--	--	mf.satfilter
/dataset1/quality2/what				
(analogue, except for offset)		--	--	(analogue, except for offset)
/dataset1/quality3		**/dataset1/quality2**		
(analogue)		(analogue)	--	(analogue)
/dataset1/quality3/how				
Number of attributes	1	1	--	1
Number of elements	0	0	--	0
Attributes:				
task	se.shmi.detector.beamblockage	se.shmi.detector.beamblockage	--	se.shmi.detector.beamblockage
/dataset1/quality3/what		**/dataset1/quality2/what**		
(analogue, except for offset)		(analogue, except for offset)	--	(analogue, except for offset)
/dataset1/quality4		**/dataset1/quality3**		
(analogue)		(analogue)	--	(analogue)
/dataset1/quality4/how		**/dataset1/quality3/how**		

Number of attributes	2	Number of attributes	--	1
Number of elements	0	Number of elements	--	0
Attributes:		Attributes:		
task	pl.imgw.quality.qi_total	task	--	pl.imgw.quality.qi_total
task_args	method:minimum	task_args	--	--
/dataset1/quality4/what		**/dataset1/quality3/what**		
(analogue, except for offset)		(analogue, except for offset)		(analogue, except for offset)

(...) not registered.

Appendix B: ODB parameters for radar metadata and data values (CY43T2)

Table B.1 – Correspondence between ODB and ODIM_H5 metadata and data values

ODB name	ODB table	from yomdb_vars.h	Values obtained for HOOF transformed single observation data file	<> h5	Values
antenht	radar_station	antenht@radar_station	0 (group value)		
beamwidth	radar_station	beamwidth@radar_station	0.95...(group value)	how beamwidth	
frequency	radar_station		0 (group value)		
ident	radar_station		21578384 (group value)		
lat	radar_station	lat@radar_station	40.84...(group value)	where lat	
lon	radar_station	lon@radar_station	-8.27...(group value)	where lon	
type	radar_station	type@radar_station	Ptprt (group value)	what source	
stalt	radar_station	stalt@radar_station	1097 (group value)	where height	
Anaprop	radar_body	anaprop@radar_body	0 (45471 values)		
distance	radar_body	distance@radar_body	33500?-158500 (45471 values)		
elevation	radar_body	elevation@radar_body	0-19.5 (45471 values)	/dataset*n*/elevation	0-19.5 (11 values)
flgdyn	radar_body	flgdyn@radar_body	0,1,NULL (45471 values)		
polarisation	radar_body	polarisation@radar_body	0 (45471 values)		
azimuth	radar_body	azimuth@radar_body	0.5, 1.5, 2.5, …, 358.5 (45471 values)		
Press	radar_body	press@radar_body	0 (45471 values)		
Q1		Not available			
Q2		Not available			
q_1dv	radar_body	q_1dv@radar_body	0 (45471 values)		
reflcost	radar_body	reflcost@radar_body	0 (45471 values)		
Temp1	radar_body	Nor available			
temp2	radar_body	Not available			
temp_1dv	radar_body	temp_1dv@radar_body	0 (45471 values)		
time	tradar_body	time@radar_body	NULL (45471 values)		
Qmod	radar	Not available			
Zsimp	Radar	Not available			
lat	hdr	lat@hdr	… (3218 values)		
lon	hdr	lon@hdr	… (3218 values)		
Date	hdr	date@hdr	20170117 (3218 values)	what date:	
time	hdr	time@hdr	000000 (3218 values)	what time:	
Statid	Hdr	statid@hdr	Ptprt (3218 values)		
report_blacklist	hdr	report_blacklist@hdr	0 (3218 values)		
obsvalue	body	obsvalue@body	… (45471 values)		
datum_blacklist	body	datum_blacklist@body	0 (45471 values)		
varno	body	varno@body	29, 192 (45471 values)	/dataset*n*/data1,/dataset*n*/data2	reflectiviry=192 RH upper-air = 29 radar Doppler wind=195
datum_status	body	datum_status@body	0 (45471 values)		

Rabish or not ????

Data/country	Number of files	Number of radars	Typical number of subsets	OIFS o HOOF	Typical number of subsets found
20190117_pt	70		20,21,36	279	4,5,14
20190117_es	449				
20190117_fr	574				
20190117_cz	48				