

OPERA data processing by BATOR

RC-LACE stay, Prague

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1. Introduction

It is a well-known fact that the quality of forecasts depends on initial fields. The information provided by meteorological radars has the potential for improving the initial conditions for a limited area model. Previous studies show that the assimilation of radar measurements (radar velocities and/or reflectivities) into the mesoscale model can improve the prediction of the convective systems (Wattrelet et al., 2014).

The aim of the stay served two purposes: first to familiarize with the HOOFF tool developed by the Slovenian colleagues and secondly to test the recent version of Bator CY43T2 with the homogenized radar data.

2. HOOFF radar data pre-processing

Radar data which are provided by OPERA (Operational Program for Exchange of Weather Radar Information), a EUMETNET program, can be represented in two ODIM formats: HDF5 (Hierarchical Data Format version 5) and BUFR (Binary Universal Form for the Representation of meteorological data). At this time, OPERA comprises information from 153 different radars from 24 countries, and their hierarchical structure differs in structure and content.

In order to be used in data assimilation process, they must contain data and metadata in the same hierarchical structure. This reorganization of HDF5 files content can be done using HOOFF (Homogenization Of Opera Files) tool. More details about how this homogenization is done can be found in the HOOFF's documentation (Smerkol, 2018). The homogenized structure of the output HDF5 data file is described in Figure 1.

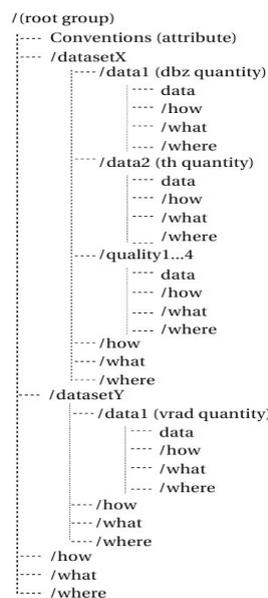


Fig.1 – Predetermined structure of the output HDF5 data file (Smerkol, 2018)

After familiarization with the files structure and content, the next step was to test the homogenization tool. For this, were chosen randomly 3 different days (20180426, 20180924 and 20181104), and have been tested using HOOF version 1.3.

Using HOOF tool we managed to process all OPERA files. The output contains information accordingly with the start time of the measurement. For our purpose, only TH (logged horizontally-polarized total (uncorrected) reflectivity factor) and DBZH (logged horizontally-polarized (corrected) reflectivity factor) quantities were used. At this moment we noticed a few issues: the first one was observed when we tested the HOOF tool from a BASH script and the log files were not in the output directory and the second one was referred to the size of the output files (which were bigger than the input). We have to mention that we identified two types of messages (errors/warnings) in log files: “warning : The DBZ group dataset1/data1 has no corresponding TH group, DBZ is taken also as TH” and the message is writing in function of how many elevation do not contain this group, (for radars who have the following IDs: bejab, bewid, chalb, chdol, chlem, chppm, chwei, iesha, isegs, iskef, mtgud, plbrz, plgda, plleg, plpas, plpoz, plram, plrze, plswi, ptfar, ptprt, robar, robob, robuc, rocra, romed, roora, rotim, rsjas, searl, sekir, sevil) and “error : No DBZ quantity in measurement (and/or startdates and elevation angles in all datasets do not exist)” (for stations/radars who have the following IDs: nohfj, nohgb, norst, noand, nohas, nosta, nohur, nober, nosmn, hunap).

Our findings were reported to the developers, which lead to some modifications in the HOOF code. Therefore, a new version of HOOF (version 1.4) can now be downloaded and used for radar data assimilation purposes.

3. BATOR radar data processing

The first step in assimilating the radar reflectivity is to test if the datasets can be technically ingested by the model’s code, through Bator (version CY43T2_bf09). For this purpose, all radar datasets have been homogenized using HOOF tool. Comparing with the namelist proposed by Météo-France(Guillaume,2018), new ID stations were added. The three ID stations: bezav, deemd, defbg are not included in the radar datasets which are count in OPERA. The 153 ID station of the radar sites which deliver information to OPERA were updated in namel_bator:

```
HODIM%NodeNames(1:8)      = 'behel', 'bejab', 'bewid', 'chalb', 'chdol', 'chlem', 'chppm', 'chwei',
HODIM%NodeNames(9:16)   = 'czbrd', 'czska', 'deboo', 'dedrs', 'deeis', 'deess', 'defld', 'deflg',
HODIM%NodeNames(17:24)  = 'dehnr', 'deisn', 'demem', 'deneu', 'denhb', 'deoft', 'depro', 'deros',
HODIM%NodeNames(25:32)  = 'detur', 'deumd', 'dkbor', 'dkrom', 'dksin', 'dkste', 'dkvir', 'eehar',
HODIM%NodeNames(33:40)  = 'eesur', 'esalm', 'esbad', 'esbar', 'escor', 'eslid', 'eslpa', 'esmad',
HODIM%NodeNames(41:48)  = 'esmal', 'esmur', 'espm', 'essan', 'essev', 'esse', 'esval', 'eszar',
```

```

HODIM%NodeNames (49:56)      ='fianj','fiika','fikes','fikor','fikuo','filuo','fipet','fiuta',
HODIM%NodeNames (57:64)      ='fivan','fivim','frabb','frale','frave','frbla','frbol','frbor',
HODIM%NodeNames (65:72)      ='frbou','frcae','frche','frcol','frgre','frlep','frmom','frmtc',
HODIM%NodeNames (73:80)      ='frnan','frnim','frniz','frpla','frtou','frtra','frtre','frtro',
HODIM%NodeNames (81:88)      ='hrbil','hrosi','hrzag','hunap','hupog','husze','iesha','isegs',
HODIM%NodeNames (89:96)      ='iskef','mtgud','nldhl','nlhrw','noand','nober','nobml','nohas',
HODIM%NodeNames (97:104)     ='nohfj','nohgb','nohur','norsa','norst','nosmn','nosta','plbrz',
HODIM%NodeNames (105:112)    ='plgda','plleg','plpas','plpoz','plram','plrze','plswi','ptfar',
HODIM%NodeNames (113:120)    ='ptprt','robar','robov','robuc','rocra','romed','roora','rotim',
HODIM%NodeNames (121:128)    ='rsjas','seang','searl','sehem','sekir','selek','sella','seoer',
HODIM%NodeNames (129:136)    ='seosd','sevax','sevil','silis','sipas','skjav','skkoj','skkub',
HODIM%NodeNames (137:144)    ='sklaz','ukcas','ukche','ukcle','ukcob','ukcyg','ukdea','ukdud',
HODIM%NodeNames (145:152)    ='ukham','ukhhd','ukhmy','uking','ukjer','uklew','ukmun','ukpre',
HODIM%NodeNames (153)        ='ukthu',

```

The second step is to run Bator with the homogenized OPERA measurements. Radar datasets which have been used for the test were collected in 20181104, at 18 UTC. All radar data, except the British radar with NOD: uklew (due to a spelling mistake in the namelist) can be technically processed. Another encountered problem was the fact that the Icelandic radar, with NOD: isegs couldn't be processed by the Bator due to an error in subroutine bator_decodhdf5_mod.F90. The index of maximum value of NraysPopulation was wrongly reevaluated twice, see Figure 2.

<pre> NbConcernedData = maxval(NraysPopulation(:,2)) NraysPopulation(maxloc(NraysPopulation(:,2),DIM=1),:) = nabsi do while (any(NraysPopulation(:,1) /= nabsi) .and. SelectedNRays(2) == 0) SelectedNRays(2) = NraysPopulation(maxloc(NraysPopulation(:,2),DIM=1),1) if (mod(maxval(SelectedNRays),minval(SelectedNRays)) /= 0) then SelectedNRays(2) = 0 enddo atro bugfix for "isegs" radar imaxloc=maxloc(NraysPopulation(:,2),DIM=1) NraysPopulation(imaxloc,2) = 0 NraysPopulation(imaxloc,1) = nabsi else NbConcernedData = NbConcernedData + maxval(NraysPopulation(:,2)) endif enddo </pre>	<pre> NbConcernedData = maxval(NraysPopulation(:,2)) NraysPopulation(maxloc(NraysPopulation(:,2),DIM=1),:) = nabsi do while (any(NraysPopulation(:,1) /= nabsi) .and. SelectedNRays(2) == 0) SelectedNRays(2) = NraysPopulation(maxloc(NraysPopulation(:,2),DIM=1),1) if (mod(maxval(SelectedNRays),minval(SelectedNRays)) /= 0) then SelectedNRays(2) = 0 enddo NraysPopulation(maxloc(NraysPopulation(:,2),DIM=1),2) = 0 NraysPopulation(maxloc(NraysPopulation(:,2),DIM=1),1) = nabsi else NbConcernedData = NbConcernedData + maxval(NraysPopulation(:,2)) endif enddo </pre>
---	---

Fig.2 - BATOR bugfix for Icelandic radar with NOD: isegs

For a better understanding of how the conversion from HDF5 format to ODB is made, it is important to identify the hardcoded values. I'm a newcomer in this domain, therefore I spent some time on code analysis (especially on subroutine bator_decodhdf5_mod.F90).

Bator_decodhdf5_mod.F90 contains several subroutines, and each of them have an important impact on final results. Note a short enumeration of some subroutines and their main functionalities.

The subroutine InitHdf5 is used to initialize and check fortran interface for HDF5 library (if the version >=1.8.8). If the files don't match the criteria, they are omitted. The computing of number of observations (NbOBS and NbWag) is done in subroutine PrefetchHdf5, which calls different subroutines (Hdf5Type, GetAttribute, ReadAttributeStr1, ReadAttributeReal1, ReadAttributeInt1,

ValidOdim) to extract the following information:

```
*** INFO - BATOR : File HDF5.site130  prefetched - NbOBS=    93600 NbWag=    3369600
```

With the help of the subroutine ExpandHdf5File, each HDF5 file is decoded (decoding subroutines as: Odim, HdfType, GetAttribute, ReadAttributeStr1, ReadAttributeReal1) to extract the following string and real attributes from datasets:

```
*** INFO - BATOR : Type produit      : PVOL
*** INFO - BATOR : Source NOD        : czbrd
*** INFO - BATOR : Date optimale     : 2018-11-04
*** INFO - BATOR : heure optimale    : 18:00:00
*** INFO - BATOR : Hauteur           : 916.00
*** INFO - BATOR : lat               : 49.658300
*** INFO - BATOR : lon               : 13.817800
*** INFO - BATOR : BeamWidth         : 1.00
*** INFO - BATOR : 12Dataset groups found.
```

4. Conclusions

During the stay, I've got familiar with the radars content and structure and I tested the homogenization of OPERA radars data sets using the HOOF tool, version 1.3. The new homogenized files in whose structure are found TH and DBZH quantities were further used in assimilation process through Bator.

A first drawn conclusion was that Bator can process all homogenized OPERA radar measurements. For the Icelandic radar (NOD: isegs), some modifications in subroutine bator_decodhdf5_mod.F90 were done.

In order to study the impact of the final results DBZH quantities (which are copied and take into account as TH quantities) and to test if input data which contain only DBZH quantities can be processed by Bator more experiments should be made. Another aspect that we have to consider refers to the radars with small number of elevations (less than 4 elevations), if we assimilate them or not.

We should continue to investigate the Bator source code for a better understanding of data structures, quality information, data reduction and to investigate the possibilities to add a data super-obbing.

Acknowledgments

I would like to thank to Alena Trojáková and Antonín Bučánek for their constant help, advice and support during my stay and also to Benedikt Strajnar and Peter Smerkol from ARSO for the development of the HOOF tool. Many thanks to all NWP colleagues in Prague for their hospitality.

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APPENDIX A

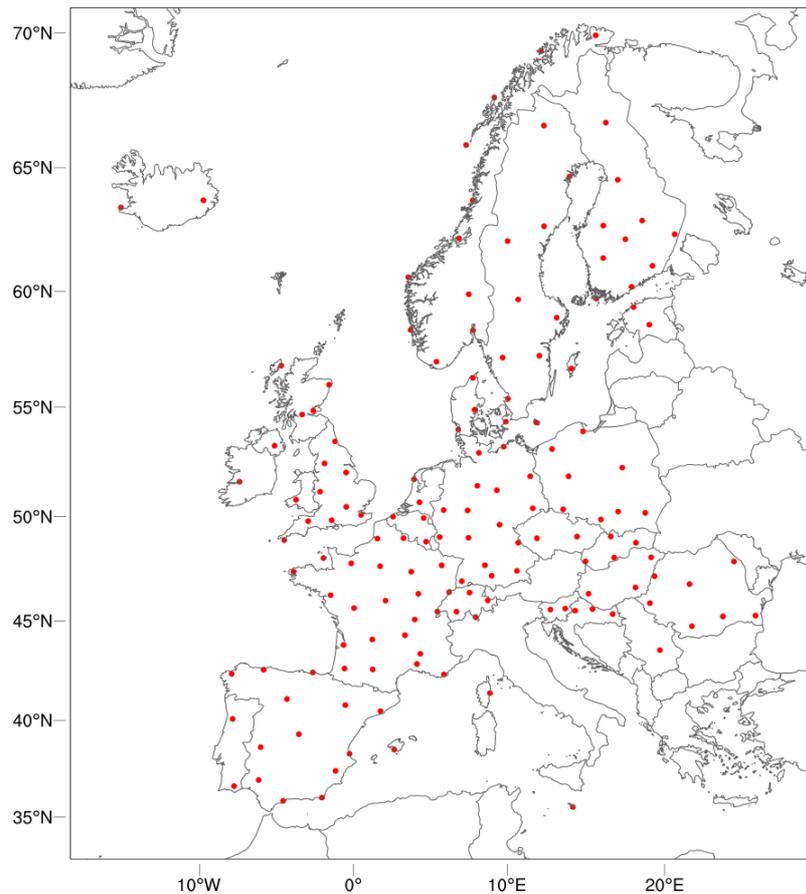


Fig. 3 – OPERA radars locations

All the files and results can be found in my user on CHMI server kazi2:

```
# directories where radar datasets used for tests can be found
```

```
/home/mma248/20180426  
/home/mma248/20180924  
/home/mma248/20181104
```

```
#scripts directory
```

```
/home/mma248/scr
```

```
# namelist directory
```

```
/home/mma248/scr/namelist43/bator
```

```
# source code
```

```
/work/mma248/build_bator_op2_hdf5
```

```
# rundir directory where results after processing with Bator can  
be found
```

```
/home/mma248/rundir
```