RC LACE radar assimilation report
Quality control for radar assimilation in NWP

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Background

The main interest in december of 2012 was to do radar assimilation suite in AROME 36T1 (2.5km) with three hungarian radars where radar data is coded in MFBUFR 512x512. We also gathered informations about current status of radar assimilation in other ALADIN/HIRLAM countries. At the end of 2012 from RC LACE consortium only in Hungary and Croatia had some preliminary tests of radar assimilation suite. The coding of hungarian local radar data is done using by local conversion program which convert it direct to MF BUFR. Croatian (and Slovenian) data was converted with modified CONRAD (RC-CONRAD).

One of the main challenge before using radar data inside operational suite is the quality control of reflectivity and radial wind data. Another unsolved question was how to do it properly. Two possible ways can be identified.

First of all which was generally used in national meteorological services prepare quality control outside the model. Usually we use advantage that radar is in spherical projection and we use neighborhood data to compare against each other or we searching for some unrealistic patterns (RLAN). The biggest disadvantage of this approach is not using other types measurements and also not using time consistency of radar data.

 Second solution is using untapped potential of nowcasting numerical models for quality control as INCA2 which was developed on SHMU during INCA-CE project. Main difference between previous and new INCA precipitation module is the algorithm which creates the analysis. The new version is based on variational method and quality indexes which produces analyses in 3D space. Also INCA2 was built to provide a quality control tool for radar assimilation and to produce radar files with quality indexes. Input to INCA2 precipitation module is also Nowcasting SAF data which is necessary for proper radar quality control. But it is worth mentioning that Nowcasting SAF has inputs from numerical models as well. INCA2 is operationally used in Slovakia and now it is close to operational phase in Slovenia.

Third solution would be to use BALTRAD or PRORAD quality control, but nowadays we don't have any experience with it.

Within LACE we decided to investigate common RADAR data preprocessing including quality control and to identify deficiencies in raw RADAR observations from different LACE countries in order to use reliable inputs for future Data Assimilation purposes.

First stage in October

Plans & tasks

- Question 1: is it possible to have all RC LACE radar data in ODIM HDF5 format
- Question 2: is it possible and how to use outputs of INCA2 quality control in CONRAD
- To do 1: control metadata in RC LACE ODIM HDF5 radar files which includes all necessary informations to identify deficiencies
- To do 2: control content of RC LACE ODIM HDF5 radar files
- To do 3: prepare INCA2 to have QC for single radar

RC LACE radar data in ODIM HDF5 format

In october 2013 after previous discussions we already have sample data for whole RC LACE period (1st of May - 30th of June 2012) in OPERA HDF5 from:

SHMU, Slovakia (marian.jurasek@shmu.sk)
OMSZ, Hungary (steib.r@met.hu)
CHMU, Czech Republic (petr.novak@chmi.cz)
ANM, Romania (mirela.niculae@gmail.com)

we also have sample data for one particular day (5th of June 2012) from:
DHMZ, Croatia (kovacic@cirus.dhz.hr , antonio.stanesic@cirus.dhz.hr)
ARSO, Slovenia (benedikt.strajnar@gov.si)

Preparing INCA2 for QC

Appling common INCA2 Quality Control for LACE RADAR data sample was an obvious choice hence LACE people have experience with this tool. Therefore first step was to do local installation of INCA2 precipitation module for whole RC-LACE domain and to try it as quality control provided radar data in OPERA ODIM HDF5 before conversion using modified CONRAD to MFBUFR512x512. Some details about the installation and the INCA2 config file can be seen in *Appendix 1* which might be useful to understand input parameters and variables. The INCA2 config file ensures flexibility for example when different customers using only certificated data, or special data which is not measured with standard technique.

Necessary input data of INCA2

INCA2 (precipitation module as well) requires different inputs, products to generate analyses and to produce quality controlled products as well. In QC we try to use all observations which are accessible in real time.

The main inputs which are nowadays used in INCA2:

- *NWP model forecast*
- *3D volume radar OPERA ODIM HDF5 files*
- *NWCSAF products* - EUMETSAT produce software packages that support Nowcasting and Very Short Range Forecasting. This software is installed at the user's site and processes data from operational meteorological satellites flying in geostationary orbits (e.g. Meteosat Second Generation (MSG)) or polar orbits (e.g. Metop or NOAA)
- *automatic stations measurements*

First tests of INCA2 precipitation module on RC LACE domain

       To preserve the continuity with INCA-CE project and our current local domain on SHMU which outputs for temperature, wind and wind gust going to common nowcasting webportal http://inca-ce.eu/CE-Portal/index.html with one hour frequency we decide working with same domain (this can be seen on the picture below). Size of domain is Nx = 1671 and Ny = 1766 points with 1km resolution (numberOfDataPoints = 2950986). Next advantage for future of this domain is also ability to be good start to spatial verification of model outputs in high resolution. However Romania is partly out from this domain, but the received RADAR samples are luckily from western Romania.

.
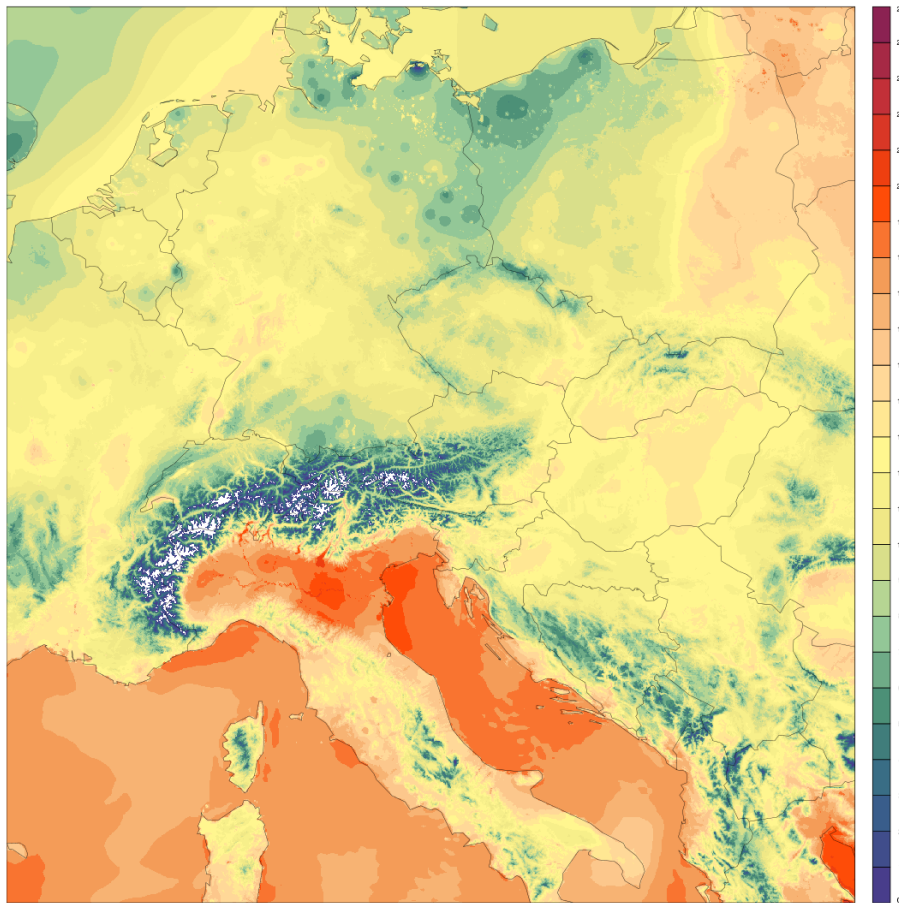
LACE Radar data content

After first run with our test suite of INCA2 on RC LACE domain we observed that the content of OPERA ODIM HDF5 files differs country by country. After quick look on each national file we find that so many radars sites don't include requested informations and data. That leads to new task to control or filter content of each radar data site where deficiencies or missing settings were observed.

The result of this investigation is attached in *Appendix 5*. which was sent to DA and RADAR people.

Quality flag based on Nowcasting SAF products

For specific day 20120605 we use NWCSAF inputs from SHMU archive which is necessary to get INCA2 quality index number 4. The details about NWCSAF input files can be seen in *Appendix 2*.

!

Future problem is that archive start from 2012-05-28 and that means that for first part of the RC LACE radar test period we don't have NWCSAF date, which is important for running INCA2 precipitation module. But obviously we already know two possible solution for this problem. First is easier that means compute NWC SAF data for period 2012-05-01 to 2012-05-28 with actual operational model ALARO-0 9km. Second is solution with benefit compute period 2012-05-01 to 2012-07-01 with NWP data from AROME 2.5km and use overlapping period to compare results and find impact of NWP for different resolutions.

Automatic stations observations

For preliminary test 2012-06-05 00:00 I already use observations from SK, CZ, PL, AT, HU. But this requirements also leads to additional data request and that is high resolution precipitation data from automatic precipitation stations.

Second stage in December

Plans & tasks

- Question 1: is it possible and how to use outputs of INCA2 quality control in CONRAD
- To do 1: control metadata in RC LACE ODIM HDF5 radar files and send feedbacks to LACE DA & RADAR people
- To do 2: fix the content of RC LACE ODIM HDF5 radar files during common pre-processing (in CONRAD)

Till December raw RADAR data was received for whole RC LACE period in OPERA HDF5 from:

ZAMG, Austria (christoph.wittmann@zamg.ac.at)

Thanks to Austrian RADAR data sample now we received samples from every LACE countries which is a good basis to investigate RADAR data preprocessing.

Quality Controlled OPERA ODIM HDF5 as input of CONRAD

As we wrote previously after first test runs with INCA2 on RC LACE domain we found major format differences between OPERA ODIM HDF5 files received from LACE members. The summary of these differences can be seen in *Appendix 3*.

We think there are more possible ways to solve these deficiencies like:
- make pressure on manufacturer which create software
- ask radar people to fix it
- make radar consistency check in INCA side
- make radar consistency check in CONRAD side
- replace missing radar info in BATOR (bator_decodebufr_mod.F90)

Temporally we solved problems with missing radar description variables inside the CONRAD which changes are based on latitude, longitude and it is not the final solution. It is important to note that crucial parameters are latitude, longitude, height, wavelength and beamwidth which have to be set correctly during or before quality control (e.g. value 0.0 leads to rejection in Screening of all Doppler winds with message "no first guess value"). About technical side of this task some important notes are added in Appendix 3. which might be useful for different RADAR data providers.

Connection of INCA2 quality indexes (QI) with CONRAD flags

The biggest challenge is the connection of INCA2 QI, CONRAD flags and Meteo France flags. CONRAD flags and MF classification is possible to find in CONRAD routine called "mod/conrad_types.F90". More details about flags can be seen in *Appendix 4*.

Because the final phase of INCA-CE project was finish, we must discuss as a next step how to consolidate INCA2 precipitation module quality indexes with CONRAD flags and also with Meteo France classification. But in BATOR currently only two quality flags are used (no rain = 0 and rain = 8).

Conclusion

During the work in October and in December several issues were tackled, but several new ones were also appeared. We decided to make common quality control to all RADAR observations received from LACE members and then we collected raw OPERA ODIM HDF5 files from Austria, Czech Republic, Slovakia, Hungary, Romania, Croatia and Slovenia. This RADAR data collection can provide good basis for future RADAR assimilation purposes and for learning RADAR data preprocessing in a proper way. On the other hand some major problems and deficiencies were also noticed that the content of RADAR samples differ country by country. In order to improve future data exchange feedbacks were sent to LACE DA and RADAR data providers in ordet to improve data quality in the future. In conclusion more works are needed to fix new problems and continue current work in 2014.

Appendix 1.

Preparing INCA2 Quality Control:

Develop version of INCA2 was installed on HPC in SHMU
shmu:hpcdev01: /users/nwp202/wrk/inca2_rr_exp

This local installation directory structure:
bin   - include binary for run
config   - include config file for inca2, which determine used observations, radars, … (more detailed description will be later in text)
import   - this directory include the input meteorological and geographical data and also domain template for grib

       grib_template
       radar   - single radar ODIM OPERA HDF5 files
       safnwc - NWCSAF input data
       station   - ascii with automatic weather stations observations
export   - outputs from nowcasting model
       yyyymmdd   - results of INCA2 analyse
       rad_vol   - single radar volume files in ODIM OPERA HDF5 which include new quality indexes
src   - source code

Config file of INCA2:

 # EXPORT settings #
INCA_EXPORT_DIR - output directory
INCA_GRIB_TEMPLATE_FILE - template for gribapi

 # background data #
INCA_RR_BACKGROUND_TYPE - this parameter determine which background field it is use on beginning (
CAPPI_2 / LAST / FORECAST)

 # INPUT data for the analysis #
INCA_RR_INPUT_NUM = 4
INCA_RR_INPUT_NAME_1 = STA_PREC
INCA_RR_INPUT_NAME_2 = OPERA_RADAR
INCA_RR_INPUT_NAME_3 = SAFNWC
INCA_RR_INPUT_NAME_4 = SRTM

 # prec. station parameters #
PREC_STATION_DATA_DIR   = /users/nwp202/wrk/inca2_rr_exp/import/station
PREC_STATION_DATA_REPEAT_FREQ_MIN = 5
PREC_STATION_DEF_QI   = 1.0
PREC_STATION_DEF_STDDEV_MMH = 2.0
PREC_STATION_QI_TEST_NUM = 1
PREC_STATION_QI_TEST_NAME_1 = SAFNWC_PC_QI
PREC_STATION_QI_TEST_NAME_2 = RADAR_QI
PREC_STATION_SAFNWC_PC_QI_CORR_COEF = 2.0

 # radar parameters #
OPERA_RADAR_DATA_DIR = /users/nwp202/wrk/inca2_rr_exp/import/radar
OPERA_RADAR_SITE_NUM - number of radars sites

OPERA_RADAR_SITE_CODE_1 = T_PAGZ41_C_LZIB (radar file name)
OPERA_RADAR_SITE_REPEAT_FREQ_MIN_1 = 5 (measurement frequency of radar site)
OPERA_RADAR_SITE_DEF_QI_1 = 1.0 (default QI set to 1)
OPERA_RADAR_SITE_DEF_STDDEV_DBZ_1 = 4.0
OPERA_RADAR_SITE_CLIM_QI_FILE_1 =
/users/nwp202/wrk/inca2_rr_exp/import/radar_clim/T_PAGZ41_C_LZIB_CLIM_QI.hdf
OPERA_RADAR_SAVE_CORRECTED_1 = 1
OPERA_RADAR_SAVE_CORRECTED_DIR_1 = /users/nwp202/wrk/inca2_rr_exp/export/rad_vol

OPERA_RADAR_QI_TEST_NUM = 6
OPERA_RADAR_QI_TEST_NAME_1 = LAPLACE
OPERA_RADAR_QI_TEST_NAME_2 = RLAN
OPERA_RADAR_QI_TEST_NAME_3 = ATTEN
OPERA_RADAR_QI_TEST_NAME_4 = SAFNWC_CT_CTTH
OPERA_RADAR_QI_TEST_NAME_5 = BEAM_BLOCK
OPERA_RADAR_QI_TEST_NAME_6 = CLIM

SAFNWC_DATA_DIR = /users/nwp202/wrk/inca2_rr_exp/import/safnwc
SAFNWC_SATELLITE = MSG2
SAFNWC_REPEAT_FREQ_MIN = 15
SAFNWC_REGION_NAME = slovakia___p
SAFNWC_PRODUCT_NUM = 3
SAFNWC_PRODUCT_NAME_1 = CT
SAFNWC_PRODUCT_NAME_2 = CTTH_HEIGHT
SAFNWC_PRODUCT_NAME_3 = PC

 # SRTM parameters #
SRTM_DATA_DIR = /data/users/nwp202/inca_rr/srtm
SRTM_LON_MIN = 12.0
SRTM_LON_MAX = 24.9
SRTM_LAT_MIN = 46.0
SRTM_LAT_MAX = 51.9

Appendix 2.

dsmc retr -asnode=hpc /data/odm/safnwc/archive/safnwc_20120605.tar import/safnwc/safnwc_20120605.tar

Cloud Mask
SAFNWC_MSG2_CMa__201206050000_slovakia____.h5 - original product
SAFNWC_MSG2_CMa__201206050000_slovakia___f.h5 - forecasted product from previous term
SAFNWC_MSG2_CMa__201206050000_slovakia___p.h5 - original product with paralax correction
SAFNWC_MSG2_CMa__201206050000_slovakia__fp.h5 - forecasted product with paralax correction from previous term

SAFNWC_PRODUCT_NAME_1 = CLOUD TYPE
SAFNWC_PRODUCT_NAME_2 = CTTH_HEIGHT
SAFNWC_PRODUCT_NAME_3 = PC

Appendix 3.

In mod/conrad_conv.F90 there are two important parts for different countries with adaptive scanning strategy (for example in higher elevation there are less numbers of rays)

makeSameNumberOfRangeBins() - this routine to extend the product (if necessary), to have the same number of bins for all elevations. Added pixels are initialized with missing value and flag "is_nodata".

makeSameNumberOfRays(), a routine to reduce the number of rays (ie. angles, directions) so that all slices have the same number.

All routines for print content of conrad variables we can find in conrad_print.F90

Appendix 4.

 type conrad_flags

```
sequence
!> Flag used for pixel values outside the range of the radar
integer(kind=KindOfByteInt)::is_nodata          = CUNSET
!> blocked data
integer(kind=KindOfByteInt)::is_blocked         = CUNSET
!> sea clutter
integer(kind=KindOfByteInt)::is_seaclutter      = CUNSET
!> ground clutter
integer(kind=KindOfByteInt)::is_groundclutter   = CUNSET
!> other clutter
integer(kind=KindOfByteInt)::is_otherclutter    = CUNSET
!> block percent
integer(kind=kindOfInt)   ::block_percent        = imiss !<[0..100]
!> clutter probability
integer(kind=kindOfInt)   ::clutter_probability  = imiss !<[0..100]

! Classification (as in Meteo-France BUFR)

integer(kind=KindOfByteInt)::is_drizzle   = CUNSET !< drizzle
integer(kind=KindOfByteInt)::is_rain      = CUNSET !< rain
integer(kind=KindOfByteInt)::is_largedrops = CUNSET !< largedrops
integer(kind=KindOfByteInt)::is_rainhail  = CUNSET !< rainhail
integer(kind=KindOfByteInt)::is_sleet     = CUNSET !< sleet
integer(kind=KindOfByteInt)::is_hail      = CUNSET !< hail
integer(kind=KindOfByteInt)::is_drysnow   = CUNSET !< drysnow
integer(kind=KindOfByteInt)::is_slush     = CUNSET !< slush
integer(kind=KindOfByteInt)::is_crystals  = CUNSET !< crystals
end type conrad_flags
```

For printing flags inside our programs we may use subroutine conrad_print.F90:*printConradFlag(conradFlag)*.

Appendix 5.

online accessible
https://docs.google.com/spreadsheet/ccc?key=0Ah_L9TfPFbktdHlTMV9QNjBVeEdQanFNb2hYQU5uenc&usp=drive_web#gid=1