H - SAF

Common Radar Rainfall Rate Estimation and Quality Control Procedure for Ground-validation of the H-SAF rainfall products

H_AS15_04

Final Report

Doc. RNDr. Martin Gera, PhD,
Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava, Slovakia

Document Approval Table

	Name	**Function**	**Date**
Prepared by:	Martin Gera	Associate Scientist	1 December 2015
Reviewed by:	Ladislav Méri	SAF scientist for clouds	21 December 2015
Approved by:		SAF Project Manager	

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V1.0	1 December 2015		Initial version

ASA Summary

ASA title	***Common Radar Rainfall Rate Estimation and Quality Control Procedure for Ground-validation of the H-SAF rainfall products***		
ASA proposal ID:	H_AS15_04	***Objective category (if applicable):***	
ASA Host institute:	SHMÚ	***Related SAF products:***	All the HSAF Precipitation Product
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Contents

Acronyms

ASA	Associate Scientist Activity
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
GDEM	Global Digital Elevation Map
I/O	Input/Output
ODIM-H5	OPERA Data Information Model (implemented in hdf5 file format)
PBB	Partial Beam Blockage
QI	Quality Index
QPE	Quantitative Precipitation Estimation
R-LAN	Radio Local Area Network
SRI	Surface Rainfall Intensity
VPR	Vertical Profile of Reflectivity
WP	Working Package

1 INTRODUCTION

Organizations responsible for validation of H-SAF rainfall products by radar products are using different algorithms and methods for quantitative precipitation estimation (QPE) and different level of quality control. The main objective of the ASA was to implement a common QPE and quality control methodology and software to make easier the comparison of validation results from different organizations.
The aim of this document is to describe the ASA process and results. For more detailed description please refer to the deliverable documents of the ASA listed in the References section.

2 OBJECTIVES AND RESULTS

There were 3 main tasks depicted in the ASA Proposal H_AS15_04:

- WP1 - Consolidation of common quality control algorithms for radar volume data
- WP2 - Development and implementation of a uniform quality-constrained surface rainfall estimation from single radars
- WP3 - Development and implementation of common surface rainfall intensity, total surface rainfall compositing method from different radars and common surface quality flags for both rainfall intensity and total rainfall from radar network.

2.1 WP1 results

The implemented methodology was heavily based on the paper of Gianfranco Vulpiani, Angelo Rinollo and Silvia Puca - *Ground-validation of the H-SAF rainfall products: toward a common radar processing chain and uncertainty quantification* (as mentioned in the proposal). Only minor changes and refinements were done during the implementation phase – adding quality check and filtering of the R-LAN caused interferences, applying median filtering and VPR computation refinements. The K_{DP} retrieval algorithm was not implemented because of lack of reliable dual-pol. data, but when the user supplies a K_{DP} field inside the radar volume data, it will be processed. The retrieval algorithm can be relatively easy implemented in the future.

The resulting methodology is described in the Algorithm Theoretical Basis Document of the ASA.

Other result of this WP is the selection of used data and file formats. The basic precondition for such common radar processing software is the existence of a common data format for the radar volume data. Fortunately one of the main outputs of the OPERA EUMTENET programme is the Opera Data Information Model (ODIM) and its implementation in the hdf5 and bufr formats. This common data model allows exchanging of the radar volume measurements between the European meteorological services. It is also suitable for the needs of the implemented methodology. The hdf5 implementation (ODIM-H5) was chosen as a basic input file format for the radar volume data.

For partial beam blockage computation and VPR correction purposes, there is a need for a reliable high-resolution digital topography data. The ASTER GDEM data were chosen for these purposes. The data can be downloaded together with the software.

The freezing level height is used in the attenuation analysis and in the vertical variability quality check. In this case a textual input with a single freezing level value for given radar site was chosen as a simple input format to the software.

General problem of such common processing software is the definition of different regions and projection used by the different users. The resulting software is able to read a textual or binary list of coordinates of the intended region, or the default Mercator projection can be used when it is suitable for the user.

Three different output formats of the computed SRI and QI data were implemented: human-readable text files, binary files with fast I/O and png images. The output format of the processed radar volume data is the ODIM-H5.

All input and output data and formats are described in the Product User Manual of the ASA.

2.2 WP2 and WP3 results

The WP2 and WP3 were the core objectives of the ASA. The main activity of these tasks was to implement the methodology defined by the WP1.

One main requirement for such methodology (and the implementing software) is the portability and high performance of the resulting code. These requirements led to the choice of using the C++ programming language in the implementation process.

A short description of the developed libraries is listed below. For further details please refer to the delivered source code of the software.

- *lib_mynavi* - This library is used to perform the geodesic computations in the software. It is used mainly to convert the position of the radar measurement points defined in polar coordinates to geographical coordinates. The standard atmospheric refraction conditions are taken in the account when computing the ray propagation in the atmosphere.
- *lib_mymaps* - The basic Mercator projection and other map-manipulation procedures are implemented in this library. It is used also when working with user supplied region definition.
- *lib_myradar* - This library is responsible for all the radar volume data manipulation and I/O.
- *lib_myradartools* – The quality checking and filtering procedures and the VPR processing algorithms are implemented in this library.
- *lib_myhdf5* – a wrapper library for simplify the core hdf5 library calls.
- *lib_myimage* – The png image generation is implemented in this library.
- *lib_inihpp* – Library for configuration file processing.

The 3rd party hdf5 library source code is also attached to the software to generate a thread-safe version of the hdf5 library for parallel I/O (the default installation of the hdf5 library is not thread-safe).

The main results of these working packages are the tools implementing the methodology. The list of developed tools is listed below:

- *hsafradproc* - This is the main tool to process the radar volume data to generate the surface rainfall intensity (SRI) and quality index (QI) output. It gets a list of radar volume files, runs all the necessary quality checks and generates an SRI and QI maps.
- *hsafclutter* – This tool is computing the static clutter map used in the clutter analysis procedure. It gets a list of radar volume files (preferably for a clear-sky event) to compute the average clutter reflectivity.
- *hsafpbb* – This tool generates the partial beam blockage volume file. It gets a radar volume file and according to its scan elevation values computes the partial beam blockage for the given radar.
- *hsafvpr* – It is used to generate a starting VPR profile for VPR correction purposes.

There is no distinction between the processing of single radar product and the processing of a composite product in the final implementation. The *hsafradproc* tool can be used for generating single radar product and also for generating composite products by setting the number of input radar sites in the configuration file.

The surface rainfall accumulation step was not implemented, as the surface rainfall intensity was defined as the main input for the validation procedures. However this step can be easily implemented, when necessary.

Further details and the usage of the tools are described in the Product User Manual of the ASA.

3 DELIVERABLES

The main outputs of the ASA are the software implementing the common radar processing methodology and the documentation:

- Algorithm Theoretical Basis Document – serves as a theoretical background of the implemented software
- Product User Manual – the detailed software user manual including the installation instructions
- Quick Start Guide – the tutorial for testing and learning the software usage with example input data
- Final Report

There are also delivered some example input files and the ASTER GDEM data to test and learn the usage of the software.

4 SOFTWARE TESTING RESULTS

The software was tested on several environments, with a number of different compilers in serial and parallel processing modes. The building of the executables went without an error and without a major warning message (besides the 3rd party hdf5 library with some negligible warning messages). The test runs with proper configuration file settings went without an error message on all the tested system.

The execution time of the main *hsafradproc* tool with a 2-radar composite on a 1135x780 sized region warried between 36(Intel Core Dou – 2GHz, serial run) and 16 seconds (IBM Power 775 – 8 threads). The memory usage with the mentioned inputs and region size was at around 280 Mb. The disk space usage of the installed software without the input data is around 220 Mb.

4.1 Table of tested environments and compilers

ENVIRONMENT	COMPILER
Cygwin (CYGWIN_NT-6.1 version 2.0.2 on Windows 7, 32bit)	clang, clang++ (version 3.5.2)
	gcc, g++ (version 4.9.2)
AIX (version 6.1)	xlc, xlc++ (IBM XL C/C++ for AIX, V11.1)
Gentoo Linux (version 2.6.30.5)	gcc, g++ (Gentoo Hardened 4.7.3-r1)
Debian Linux (version 2.6.26-2-686-bigmem)	gcc, g++ (Debian 4.3.2-1.1)

5 REFERENCES

[1] Martin Gera, 2015: Common Radar Rainfall Rate Estimation and Quality Control Procedure for Ground-validation of the H-SAF rainfall products - Algorithm Theoretical Basis Document, H-SAF H_AS15_04 ASA document

[2] Martin Gera, 2015: Common Radar Rainfall Rate Estimation and Quality Control Procedure for Ground-validation of the H-SAF rainfall products - Product User Manual, H-SAF H_AS15_04 ASA document

[3] Martin Gera, 2015: Common Radar Rainfall Rate Estimation and Quality Control Procedure for Ground-validation of the H-SAF rainfall products - Quick Start Guide, H-SAF H_AS15_04 ASA document