OSI SAF

PenWP Release Note

OSI-501-c

Version 4.0.02

August 2022

PenWP Release Note

This documentation was developed within the context of the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF).

Change record				
Version	**Date**	**Author**	**Approved**	**Remarks**
1.9.01	08-12-2014	Anton Verhoef		First version for PenWP version 1.9.01 (internal)
1.9.02	19-01-2015	Anton Verhoef		Modified for PenWP version 1.9.02 (internal)
1.9.03	19-03-2015	Anton Verhoef		Modified for PenWP version 1.9.03 (internal)
1.9.04	04-05-2015	Anton Verhoef		Modified for PenWP version 1.9.04 (preparation for NWP SAF beta release)
1.9.05	26-05-2015	Anton Verhoef		Modified for PenWP version 1.9.05 (NWP SAF beta release)
2.0.00	28-10-2015	Anton Verhoef		Version for PenWP 2.0 DRI
2.0.01	11-12-2015	Anton Verhoef		Modified according to DRI comments
2.1.00	21-02-2017	Jur Vogelzang		Version for PenWP 2.1
2.2.00	29-05-2018	Anton Verhoef		Version for PenWP 2.2
4.0.00	Mar 2022	Anton Verhoef		Version for PenWP 4.0 DRR
4.0.01	June 2022	Anton Verhoef		Modified according to DRR comments
4.0.02	Aug 2022	Anton Verhoef		Some more modifications from DRR

OSI SAF	PenWP Release Note	Doc ID : NWPSAF-KN-UD-010 Version : 4.0.02 Date : August 2022

Table of Contents

1. INTRODUCTION

The Pencil Beam Wind Processor (PenWP) is a software package written mainly in Fortran 90. The parts and libraries for handling HDF5, NetCDF, and BUFR format data have been partly written in C. The processor can handle data from the SeaWinds (on QuikSCAT or ADEOS-II), OSCAT (on Oceansat-2 and ScatSat-1), HSCAT (on HY-2A/B/C/D) and RapidScat (on the International Space Station) scatterometer instruments. PenWP is intended to be a generic wind processor for Ku-band pencil beam scatterometer data.

PenWP generates surface winds based on pencil beam radar backscatter data. It allows performing the ambiguity removal with the Two-dimensional Variational Ambiguity Removal (2DVAR) method and it supports the Multiple Solution Scheme (MSS). The output of PenWP consists of wind vectors which represent surface winds within the ground swath of the scatterometer.

Input of PenWP is Normalized Radar Cross Section (NRCS) data. The input files of PenWP are in BUFR. Conversion programs are included in the package to convert Hierarchical Data Format (HDF5) data from various instruments to BUFR. Output is written using the SeaWinds BUFR template or the KNMI BUFR template with generic wind section.

Apart from the scatterometer input data, PenWP needs Numerical Weather Prediction (NWP) model winds as a first guess for the Ambiguity Removal step. These data need to be provided in GRIB edition 1 or 2.

If you have any questions concerning PenWP, please contact the OSI SAF helpdesk on https://osi-saf.eumetsat.int/.

2. PACKAGE CONTENTS

The tar file contains everything necessary to install PenWP in a UNIX/Linux environment.

Contents of the penwp directory:
```
doc      Documentation, including this document
execs    Link to penwp executable, shell script for running PenWP
hscat    Programs to convert HSCAT HDF data to BUFR format
oscat    Programs to convert OSCAT HDF data to BUFR format
seawinds Programs to convert SeaWinds and RapidScat HDF data to BUFR format
src      Source code for PENWP program and supporting routines
test     Example HDF5 and GRIB input files for testing purposes
```

Contents of the genscat directory:
```
ambrem                    Ambiguity removal routines
ambrem/twodvar            KNMI 2DVAR ambiguity removal routines
icemodel                  Ice screening routines
inversion                 Inversion and quality control routines
support                   General purpose routines sorted in subdirectories
support/BFGS              Minimization routines needed in 2DVAR
support/Compiler_Features Compiler specific routines, mainly command line
                          handling
support/convert           Conversion between wind speed/direction and u and v
support/datetime          Date and time conversion routines
support/eccodes           BUFR and GRIB file handling routines
support/ErrorHandler      Error handling routines
support/file              File handling routines
support/hdf5              HDF5 handling routines
support/netcdf            NetCDF file handling routines
```

```
support/num              Numerical definitions and number handling routines
support/singletonfft     FFT routines needed in minimization
support/sort             Sorting routines
tools/bufr2asc           tool to convert BUFR format files to ASCII
tools/bufr2nc            tool to convert BUFR format files to NetCDF
tools/bufr_l2_reader     Support routines for conversion tools
```

3. APPLICABLE DOCUMENTS

In directory penwp/doc:
- PenWP Release Note (NWPSAF-KN-UD-010_PenWP_Release_Note.pdf), this document.
- PenWP User Manual and Reference Guide (NWPSAF-KN-UD-009_PenWP_User_Guide.pdf), a document that includes information on how to install and run the package.
- PenWP Product Specification (NWPSAF-KN-DS-002_PenWP_Prod_Spec.pdf), a document that contains information on the functionality of PenWP and on the input and output specifications.

Delivered separately / to be obtained from the NWP SAF web site (https://nwp-saf.eumetsat.int/):
- PenWP Top Level Design (NWPSAF-KN-DS-001), a document containing information on the design of PenWP and its module design.
- PenWP Test Plan and Test Report (NWPSAF-KN-TV-008), a document that contains all undertaken tests and their results.

4. MAIN CHANGES

As compared to previous release 2.2, PenWP version 4.0 can process data from the Haiyang-2B/C/D satellites. The new NSCAT-4DS Geophysical Model Function is included for improved consistency between Ku-band wind retrievals and C-band wind retrievals and buoy winds. Sea Surface Temperature dependent adjustments to the backscatter can be applied to reduce wind speed biases. Improved and New Quality Control flags have been introduced. The backscatter calibrations have been tuned for the generation of climate data records from QuikSCAT, RapidScat and Oceansat-2. See the list of changes in section 8 for more details. The previously released version of PenWP was 2.2.00, the changes from version 2.2.02 onwards in section 8 are implemented in the current release.

5. INSTALLATION

The system requirements for compiling and running PenWP are described in section 2.4 of the Product Specification. In short, PenWP should run on most Unix/Linux based platforms with e.g. the Portland or Gfortran compilers. CMake version 3.6 or higher (https://cmake.org/) is required in order to compile the ecCodes library. Also, some of the scripts in the PenWP package are written in ksh (Korn shell scripting) and bash (Bash shell scripting), hence ksh and bash need to be installed as well. Detailed instructions for installation can also be found in the User Manual and Reference Guide, section 2 (see Applicable documents in section 3 of this document). A shortened version is given here.

To install PenWP, the following steps must be taken:
1. Copy the PenWP package (file PenWP<version>.tar.gz) to the directory from which PenWP will be applied, and unzip and untar it. This will create subdirectories penwp and genscat that contain all code needed, and a script called compile_penwp for easy compilation.
2. Unlike in older PenWP versions, it is not necessary anymore to download BUFR and GRIB libraries separately from the ECMWF website. The ecCodes library now falls under the Apache License, Version 2.0 and can be redistributed in combination with PenWP. You may obtain a copy of the License at http://www.apache.org/licenses/LICENSE-2.0.

3. Run the script ./compile_penwp which is in the top directory where the PenWP package (tar file) was copied to and follow its directions.
4. PenWP is now ready for use, provided that the environment variables have the proper settings. PenWP can be invoked by the script penwp/execs/penwp_run_4ds, which sets all necessary environment variables and passes the command line options provided with the script to PenWP. If no command line options are given, PenWP will display a help text and exits with an error message stating that no processing was done.
5. The penwp/tests directory contains some sample OSCAT and NWP files that can be used to test the software. See the readme.txt in this directory for more details.

6. LICENSE

Before using this software, users need to register for PenWP with the NWP SAF (https://nwp-saf.eumetsat.int), and to agree with the terms of the license agreement.

7. KNOWN PROBLEMS

During compilation, the gcc and Gfortran compilers issue warning messages. Some of the warnings are unavoidable, e.g. since they occur in the compilation of the external (ecCodes, HDF5) libraries. Other warnings that occur in the genscat and PenWP modules are fixed as much as possible but in some cases it appears that the compilers are not able to fully assess the dependencies in the software. This leads in some cases e.g. to a warning that a variable may be used without initialisation although in practice this will not happen. We also sometimes see that warnings appear in some versions of the Gfortran compilers and then disappear again in later versions. The remaining warnings have been checked to have no impact on the proper functioning of the software and they can be safely neglected.

Some users have reported problems at runtime with older versions of the Gfortran compiler. When you have a version older than 4.6.3, it may be advisable to upgrade.

8. DETAILED LIST OF CHANGES

Changes in PenWP v4.0.00 1 March 2021
- Removed -allswath option from hscat_hdf2bufr, it is always used now.
- Several improvements and bug fixes for processing of HY-2A data.
- Downloaded new version of ecCodes library, software version is 2.24.2. Made compilation of eccodes module more robust.

Changes in PenWP v2.2.08 14 October 2021
- Removed -wo command line option.
- Downloaded new land sea mask from ECMWF with some improvements in the coastlines.
- Improvements of Oceansat-2 and QuikSCAT level 1b processing, calibrations and MLE normalisations.

Changes in PenWP v2.2.05 6 September 2021
- Several fixes for use of gcc and gfortran version 10 compilers. Updated HDF5 and NetCDF libraries to latest versions (HDF 1.12.0 and NetCDF 4.7.4).
- Correct Oceansat-2 sloping wind speed bias from left to right with antenna azimuth dependent sigma0 correction.
- Implemented new mixed Quality Control based both on MLE and Joss.
- Made some changes in preparation of RapidScat and QuikSCAT reprocessing.
- Implemented HY-2D processing.

Changes in PenWP v2.2.04 11 February 2021
- Added program oscat_l1b_bufr to convert OSCAT level 1b HDF files directly to BUFR.
- Changed the HSCAT level 1b conversion program (hscat_l1b_bufr) to give it the same set-up as the corresponding programs for SeaWinds and OSCAT, kept the old program with extension '_old'.
- Several bug fixes.

Changes in PenWP v2.2.03 12 November 2020
- Initial implementation of HY-2B processing.
- Separated inner and outer swath corrections for SeaWinds, RapidScat, ScatSat-1, HY-2A and HY-2B. This results in flatter wind speed biases across the swath and in a reduction of the 'S' shape in the wind direction biases.
- Implemented SST dependent backscatter adjustments including incidence angle dependence.
- Implemented new NSCAT4DS GMF obtained by adapting NSCAT4 using ScatSat-1 and ASCAT-A collocations.
- In MSS case, write also the MLE of the selected wind solution to the BUFR output on top of the speed and direction. It used to be the MLE of the local minimum solution.
- Updated ScatSat-1 calibrations after the switch to redundant hardware in June 2019.
- Replaced the old NetCDF-3 library in genscat by the latest NetCDF-4 library. Default format for writing is still NetCDF-3, but NetCDF-4 files can now be read as well.
- New calibrations for ScatSat-1 v1.1.4, shift of 0.35 dB w.r.t. 1.1.3
- Moved from GRIB API to ecCodes, software version is 2.17.0.
- Implemented HY-2C processing.
- Use ecCodes instead of BUFRDC for reading and writing of BUFR files.
- Added program seawinds_l1b_bufr to convert SeaWinds level 1b HDF files directly to BUFR.
- Several bug fixes.

Changes in PenWP v2.2.02 1 October 2018
- Implemented SST adjustments on simulated sigma0 for Ku-band. Note that these adjustments are valid only for ScatSat-1 incidence angles, not for other instruments.
- Several improvements for processing near-real time ScatSat-1 data.
- Use integer parameters for powers to enhance computing speed in routine JoScat_old in 2DVAR.
- Implemented HY-2A level 1b converter (hscat_l1b_bufr) from Wenming Lin.
- Determined separate ice line parameters for different instruments and implemented these in ice screening module.

Changes in PenWP v2.2.00 21 March 2018
- Several fixes and improvements implemented for Oceansat-2 reprocessing in OSI SAF.
- Several changes to properly handle ScatSat-1 data.
- Fixed a small bug in GRIB collocation module leading to a model data displacement of up to one grid point in East-West direction. This was only an issue for reduced Gaussian grids, not for regular grids.
- Refined ice probability thresholds, use 0.50 for OSCAT and 0.55 for other Ku-band instruments.
- Apply non-linear s0 corrections for ScatSat-1.
- Changed interface and handling of 2DVAR Ambiguity Removal to streamline and simplify the processing.
- Enlarged number of grib files to be handled to 35, to enable handling of hourly NWP forecasts.
- Reject observations that are too far out of the swath edge in the L1B to L2A processing.

- Implemented an improved method to determine if a real has missing value, to reduce the number of compiler warnings with gfortran.
- In oscat_l1b_l2a, the number of slices per footprint is dynamically determined.

Changes in PenWP v2.1.00 21 February 2017
- Implemented new HDF5 library, source code is compiled now rather than using binary library files.
- Changes to support MacOSX Darwin platform.
- Added functionality to read either slices (default) or eggs from L1b file in oscat_l1b_l2a.
- Conversion tools Bufr2Asc and Bufr2Nc are now included in the PenWP package.
- Correction of 0.2 m/s in monitoring for real NWP winds is skipped when neutral NWP winds are read from GRIB.
- Corrected small bug in the averaging of L1B azimuth angles to L2A azimuth angles in oscat_l1b_l2a.
- Added -wo option to use or write data from only one orbit in the input file. Used to split OSCAT files at the south pole.
- Do not stop processing when ice map cannot be read successfully but continue with empty ice map.
- Added functionality for ScatSat-1.
- Apply extra constant correction of -0.47 dB HH and -0.56 dB VV for Oceansat-2 data before 20 Aug 2010.
- Corrected bug in computation of Oceansat-2 orbit numbers, orbit numbers have to be computed before sorting and merging of rows.
- Assign row numbers to Oceansat-2 data even when the file starts after the descending equator crossing.
- Empirical background error correlations in 2DVAR invoked by the -nbec command line option. This leads to a better analysis and, hence, to better ambiguity removal in 2DVAR.

Changes in PenWP v2.0.00 28 October 2015
- Introduced WVC dependent backscatter corrections for Oceansat-2/OSCAT.
- Lowered the QC rejection rate between 6 and 18 m/s by looking at RapidScat - ASCAT collocations. Created new QC threshold tables for RapidScat, QuikSCAT, OSCAT and HSCAT.
- In seawinds_hdf2bufr, allow negative sigma0s until -29 dB rather than -33 dB to get some more low winds after the RapidScat noise increase due to the anomaly in Aug. 2015. Moreover, improved setting of s0_quality flags.
- Implemented version 000405 of the BUFR software and version 1.14.0 of the GRIB API software.

Changes in PenWP v1.9.05 26 May 2015
- For RapidScat, skip inner swath when redistributing the eggs of beam 1 over beam 1 and 3 in seawinds_hdf2bufr.F90.
- For RapidScat, allow extra margin for KNMI flag in nadir swath when setting monitoring bit.
- Make changes in file names, variables etc. to consistently use HSCAT rather than HYSCAT for the scatterometer on HY-2A.
- Changed the GRIB module such that it can handle reduced Gaussian grids as well as regular grids.
- Set qual_sigma0 flag in WVC quality always when one of the beam data is incomplete (bug fix).

Changes in PenWP v1.9.04 4 May 2015
- Removed the compiler directives for NCEP in the GRIB module. Code will now automatically detect if model data is from ECMWF or other models, and handle this appropriately.

- InstrumentShortName of RapidScat HDF input data files was changed from SeaWinds into RapidScat, allow this name as well when converting to BUFR.

Changes in PenWP v1.9.03 19 March 2015
- Implemented monitoring bit setting for ISS/RapidScat.
- Changed common code tables C-5 and C-8 entries for HY-2A/scat and ISS/RapidScat into proposed values:
- C-5: HY-2A: 502 (was 990), ISS: 801 (was 991)
- C-8: HY-2A/scat: 686 (was 990), RapidScat 314 (was 991)
- Changed the backscatter calibration coefficients for QuikSCAT to the values used in SDP for reprocessing. Re-computed MLE normalisation and QC threshold tables.

Changes in PenWP v1.9.02 19 January 2015
- Recomputed MLE normalisation tables and QC threshold tables. Removed very high values in the right part of the swath which are associated with missing or corrupted data.
- For ISS, redistribute beam 1 data (HH) over beam 1 and 3 in case of missing beam 3 (seawinds_hdf2bufr.F90). This should help to reduce the number of missing winds in the right part of the swath where data is sometimes missing due to blockage by solar panels.
- Bug fix in seawinds_hdf2bufr to ensure that all output files are always written with -wpo option.
- For ISS, reduced the backscatter calibration coefficients from 0.75 dB to 0.45 dB for 25km and from 0.70 dB to 0.38 dB for 50 km. Re-computed MLE normalisation and QC threshold tables.
- In the monitoring, changed computation of number of WVCs containing sufficient backscatter info. Exclude WVCs with four_beam flag set from this number.

Changes in PenWP v1.9.01 8 December 2014
- First internal version for near-real time processing of ISS/RapidScat.