EUMETSAT NWC SAF

SUPPORT TO NOWCASTING AND VERY SHORT RANGE FORECASTING

Scientific and Validation Report for the Wind product processor of the NWC/PPS

NWC/CDOP3/PPS/AEMET/SCI/VR/Wind, Issue 0, Rev.1

12 October 2021

Applicable to NWC/PPS-HRW v7.P

Applicable to SAFNWC/PPS version 2021

Applicable to the following PGEs:

Acronym	Product ID	Product name	Version number
HRW	*(demonstrational)*	High Resolution Winds	7.P (demonstrational release)

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REPORT SIGNATURE TABLE

Function	Name	Signature	Date
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DOCUMENT CHANGE RECORD

Version	Date	Pages	Changes
0.1d	*30 September 2020*	28	Version for NWC/PPS-HRW v7.P
0.1e	*1 September 2021*	28	Updates due to results of PPS v2021 RR: Change the status of HRW to ‘demonstrational’.
0.1	*12 October 2021*	28	Updates after PPS v2021 DRR: Just updated document references.

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1. INTRODUCTION

The "EUMETSAT Satellite Application Facilities (SAFs)" are dedicated centres of excellence for the processing of satellite data, and form an integral part of the distributed "EUMETSAT Application Ground Segment". This documentation is provided by the "SAF on support to Nowcasting and Very short range forecasting (NWC SAF)". The main objective of the NWC SAF is to provide, develop and maintain software packages to be used with operational meteorological satellite data for Nowcasting applications. More information about the project can be found at the NWC SAF webpage, http://www.nwcsaf.org.

This document is applicable to the NWC/PPS software package for polar satellites.

1.1 SCOPE OF THE DOCUMENT

This document is the "Scientific and Validation Report for the Wind Product Processor of the NWC/PPS" software package (NWC/PPS-HRW, High Resolution Winds), which calculates Atmospheric Motion Vectors (AMVs) and Trajectories considering images reprojected to a static region, coming from any of the following polar satellites, radiometers and channels:

- AVHRR/3 radiometer inside NOAA-15, NOAA-16, NOAA-17, NOAA-18, NOAA-19, Metop-A, Metop-B or Metop-C polar satellites, using 0.630 µm VIS06 visible channel and/or 10.800 µm IR108 infrared channel.
- VIIRS radiometer inside SNPP or NOAA-20 polar satellites, using 0.672 µm VIS06 visible channel and/or 10.763 µm IR108 infrared channel.
- MODIS radiometer inside EOS-1 (Terra) or EOS-2 (Aqua) polar satellites, using 0.645 µm VIS06 visible channel and/or 11.030 µm IR110 infrared channel.

There is a commitment so that the adaptation of NWC/PPS-HRW software to these polar satellite series. The corresponding validation results are shown in this document.

As for the all versions of NWC/GEO-HRW, the validation has been based on the comparison of the NWC/PPS-HRW v7.P AMVs with winds obtained from Radiosounding bulletins available from the GTS. The statistical indicators established in the "Report from the Working Group on Verification Statistics of the 3rd International Winds Workshop" [RD.12], with some amendments in the "Report from the Working Group on Verification & Quality Indices of the 4th International Winds Workshop" [RD.15]), are calculated to achieve this. These indicators have been thoroughly used throughout the world for the Validation of Satellite winds through the comparison with Radiosoundings.

As for the latest version of NWC/GEO-HRW, NWC/PPS-HRW v7.P is also validated using ECMWF model analysis winds as additional reference. This permits to evaluate differences in behaviour and scale of NWC/PPS-HRW AMVs with respect to both reference winds used.

A comparison with the latest version of NWC/GEO-HRW (v6.1) in NWC/GEO v2018.1 software package is also verified, to show the similarities and differences in the AMVs obtained with geostationary and polar satellites.

1.2 SOFTWARE VERSION IDENTIFICATION

This document describes the software implemented in the NWC/PPS-HRW v7.P (demonstrational release) of the NWC/PPS v2021 software package release.

1.3 IMPROVEMENTS FROM PREVIOUS VERSIONS

This is the first implementation of NWC/PPS-HRW software, for use with 12 polar satellites including AVHRR/3, VIIRS and MODIS radiometers.

The whole AMV calculation algorithm, and most of the HRW code, derive directly from NWC/GEO-HRW v6.1 software, included in NWC/GEO v2018.1 software package, which is defined for the AMV calculation with MSG, GOES-N, GOES-R and Himawari-8/9 geostationary satellite series. (91% of HRW code is common to both NWC/GEO and NWC/PPS implementations; only 5% of the code is specific to NWC/GEO, and 4% of it is specific to NWC/PPS).

This way, with the application to polar satellites defined here through NWC/PPS-HRW v7.P, the option appears for the first time to calculate AMVs throughout all the world, including polar areas, with the same algorithm (using both implementations HRW v6.1 and v7.P) This is rather uncommon in general, and can be used for example for NWP assimilation of AMVs all throughout the world calculated with the same AMV algorithm, or for climatic studies of the wind throughout all the world.

1.4 REFERENCES

1.4.1 Applicable Documents

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.X]

For versioned references, subsequent amendments to, or revisions of, any of these publications do not apply. For unversioned references, the current edition of the document referred applies.

Current documentation can be found at the NWC SAF Helpdesk web: http://www.nwcsaf.org.

Ref.	*Title*	*Code*	*Ver.*
[AD.1]	Proposal for the Third Continuous Development and Operations Phase (CDOP3)	NWC/CDOP3/SAF/AEMET/MGT/PRO	1.0
[AD.2]	Project Plan for the NWC SAF CDOP3 Phase	NWC/CDOP3/SAF/AEMET/MGT/PP	1.5
[AD.3]	Configuration Management Plan for the NWC SAF	NWC/CDOP3/SAF/AEMET/MGT/CMP	1.1
[AD.4]	NWC SAF Product Requirements Document	NWC/CDOP3/SAF/AEMET/MGT/PRD	1.4
[AD.5]	Interface Control Document for Internal and External Interfaces of the NWC/PPS	NWC/CDOP3/PPS/SMHI/SW/ICD/1	3.0
[AD.6]	User Manual for the NWC/PPS application: Software Part, 2.Operation	NWC/CDOP3/PPS/SMHI/SW/UM/OPER	3.0
[AD.7]	System and Component Requirements Document for the NWC/PPS	NWC/CDOP3/PPS/SMHI/SW/SCRD	2.3
[AD.8]	Algorithm Theoretical Basis Document for the Wind product processor of the NWC/GEO	NWC/CDOP2/GEO/AEMET/SCI/ATBD/Wind	2.2
[AD.9]	Algorithm Theoretical Basis Document for the Wind product processor of the NWC/PPS	NWC/CDOP3/PPS/AEMET/SCI/ATBD/Wind	0.1
[AD.10]	User Manual for the Wind product processor of the NWC/GEO: Software part	NWC/CDOP3/GEO/AEMET/SCI/UM/Wind	1.1
[AD.11]	User Manual for the Wind product processor of the NWC/PPS: Software part	NWC/CDOP3/PPS/AEMET/SCI/UM/Wind	0.1
[AD.12]	Scientific and Validation Report for the Wind product processor of the NWC/GEO	NWC/CDOP3/GEO/AEMET/SCI/VR/Wind	1.1

Table 1. List of Applicable Documents

1.4.2 Reference Documents

The reference documents contain useful information related to the subject of the project. These reference documents complement the applicable ones, and can be looked up to enhance the information included in this document if it is desired. They are referenced in this document in the form [RD.X]. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. For undated references, the current edition of the document referred applies.

Ref.	Title
[RD.1]	J.Schmetz, K.Holmlund, J.Hoffman, B.Strauss, B.Mason, V.Gärtner, A.Koch, L. van de Berg, 1993: Operational Cloud Motion Winds from Meteosat Infrared Images (Journal of Applied Meteorology, Num. 32, pp. 1206-1225).
[RD.2]	S.Nieman, J.Schmetz, W.P.Menzel, 1993: A comparison of several techniques to assign heights to cloud tracers (Journal of Applied Meteorology, Num. 32, pp. 1559-1568).
[RD.3]	C.M.Hayden & R.J.Purser, 1995: Recursive filter objective analysis of meteorological fields, and application to NESDIS operational processing (Journal of Applied Meteorology, Num. 34, pp. 3-15).
[RD.4]	K.Holmlund, 1998: The utilisation of statistical properties of satellite derived Atmospheric Motion Vectors to derive Quality Indicators (Weather and Forecasting, Num. 13, pp. 1093-1104).
[RD.5]	J.M.Fernández, 1998: A future product on HRVIS Winds from the Meteosat Second Generation for nowcasting and other applications. (Proceedings 4th International Wind Workshop, EUMETSAT Pub.24).
[RD.6]	J.M.Fernández, 2000: Developments for a High Resolution Wind product from the HRVIS channel of the Meteosat Second Generation. (Proceedings 5th International Wind Workshop, EUMETSAT Pub.28).
[RD.7]	J.M.Fernández, 2003: Enhancement of algorithms for satellite derived winds: the High Resolution and Quality Control aspects. (Proceedings 2003 Meteorological Satellite Conference, EUMETSAT Pub.39).
[RD.8]	J.García-Pereda & J.M.Fernández, 2006: Description and validation results of High Resolution Winds product from HRVIS MSG channel at the EUMETSAT Nowcasting SAF (Proceedings 8th International Wind Workshop, EUMETSAT Pub.47).
[RD.9]	J.García-Pereda, 2008: Evolution of High Resolution Winds Product (HRW), at the Satellite Application Facility on support to Nowcasting and Very short range forecasting (Proceedings 9th International Wind Workshop, EUMETSAT Pub.51).
[RD.10]	J.García-Pereda, 2010: New developments in the High Resolution Winds product (HRW), at the Satellite Application Facility on support to Nowcasting and Very short range forecasting (Proceedings 10th International Wind Workshop, EUMETSAT Pub.56).
[RD.11]	C.M.Hayden & R.T.Merrill, 1988: Recent NESDIS research in wind estimation from geostationary satellite images (ECMWF Seminar Proceedings: Data assimilation and use of satellite data, Vol. II, pp.273-293).
[RD.12]	W.P.Menzel, 1996: Report on the Working Group on verification statistics. (Proceedings 3rd International Wind Workshop, EUMETSAT Pub.18).
[RD.13]	J.Schmetz, K.Holmlund, A.Ottenbacher, 1996: Low level winds from high resolution visible imagery. (Proceedings 3rd international winds workshop, EUMETSAT Pub.18).
[RD.14]	Xu J. & Zhang Q., 1996: Calculation of Cloud motion wind with GMS-5 images in China. (Proceedings 3rd international winds workshop, EUMETSAT Pub.18).
[RD.15]	K.Holmlund & C.S.Velden, 1998: Objective determination of the reliability of satellite derived Atmospheric Motion Vectors (Proceedings 4th International Wind Workshop, EUMETSAT Pub.24).
[RD.16]	K.Holmlund, C.S.Velden & M.Rohn, 2000: Improved quality estimates of Atmospheric Motion Vectors utilising the EUMETSAT Quality Indicators and the UW/CIMSS Autoeditor (Proceedings 5th International Wind Workshop, EUMETSAT Pub.28).
[RD.17]	R.Borde & R.Oyama, 2008: A direct link between feature tracking and height assignment of operational Atmospheric Motion Vectors (Proceedings 9th International Wind Workshop, EUMETSAT Pub.51).
[RD.18]	J.García-Pereda, R.Borde & R.Randriamampianina, 2012: Latest developments in “NWC SAF High Resolution Winds” product (Proceedings 11th International Wind Workshop, EUMETSAT Pub.60).
[RD.19]	WMO Common Code Table C-1 (WMO Publication, available at https://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/WMO306_vI2_CommonTable_en.pdf)
[RD.20]	WMO Code Tables and Flag Tables associated with BUFR/CREX table B, version 31 (WMO Publication, available at www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/PrevVERSIONS/20181107/WMO306_vI2_BUFRCREX_CodeFlag_en.pdf)
[RD.21]	P.Lean, G.Kelly & S.Migliorini, 2014: Characterizing AMV height assignment errors in a simulation study (Proceedings 12th International Wind Workshop, EUMETSAT Pub.63).
[RD.22]	Á.Hernández-Carrascal & N.Bormann, 2014: Cloud top, Cloud centre, Cloud layer – Where to place AMVs? (Proceedings 12th International Wind Workshop, EUMETSAT Pub.63).
[RD.23]	K.Salonen & N.Bormann, 2014: Investigations of alternative interpretations of AMVs (Proceedings 12th International Wind Workshop, EUMETSAT Pub.63).
[RD.24]	D.Santek, J.García-Pereda, C.Velden, I.Genkova, S.Wanzong, D.Stettner & M.Mindock, 2014: 2014 AMV Intercomparison Study Report - Comparison of NWC SAF/HRW AMVs with AMVs from other producers (available at http://www.nwcsaf.org/aemetRest/downloadAttachment/225)
[RD.25]	D.Santek, R.Dworak, S.Wanzong, K.Winiecki, S.Nebuda, J.García-Pereda, R.Borde & M.Carranza, 2018: 2018 AMV Intercomparison Study Report (available at http://www.nwcsaf.org/aemetRest/downloadAttachment/5092)
[RD.26]	K.Salonen, J.Cotton, N.Bormann & M.Forsythe, 2015: Characterizing AMV height-assignment error by comparing best-fit pressure statistics from the Met Office and ECMWF data assimilation systems (Journal of Applied Meteorology and Climatology, Vol.54, Num.1).

Table 2. List of Reference Documents

2. DESCRIPTION OF THE VALIDATION PROCEDURE

2.1 VALIDATION PROCEDURE

The validation process for NWC/PPS-HRW v7.P is exactly equivalent to that of NWC/GEO-HRW v6.1. It incorporates for each AMV both reference winds used in the validation: Radiosounding winds and ECMWF model analysis winds.

For each AMV the corresponding ECMWF model analysis reference wind is defined by the autovalidation process inside NWC/PPS-HRW software, and incorporated in the HRW BUFR output with "NWC SAF specific format" (configured with OUTPUT_FORMAT = NWC). The corresponding Radiosounding reference wind for each AMV is extracted from Radiosounding wind profiles obtained from the GTS through an intermediate McIDAS process. All these validation data are then included in McIDAS MD files following a scheme called WDMR. A different WDMR MD file is generated for each day, scale ("Basic AMVs" or "Detailed AMVs") and region ("EURON1 – Scandinavia" and "EUROPA") used in the validation process.

The structure of data in this WDMR scheme is shown in the following table. The NWC/PPS-HRW validation process selects AMV data from the WDMR McIDAS MD file, considering the value of some specific parameters, and calculates the corresponding validation statistics. For validation against Radiosounding winds, elements in green in the table are used. For validation against NWP analysis winds, elements in blue in the table are used.

ROW/COLUMN ELEMENT	"NWC" BUFR DESCRIPTOR	PARAMETER MD ID.	WDMR SCHEME DESCRIPTION
Row 01	001007	SS	Satellite Identifier
Column 01	004001/002/003	DAY	Date
Column 02	004004/005	TIME	Time
Column 03	004025	INTT	Temporal interval from initial to final image
Column 04	031002	CMAX	Number of NWC/PPS-HRW AMVs per slot
Column 05	060000	TRAX	Segment size of tracer in X direction in pixels
Column 06	060001	TRAY	Segment size of tracer in Y direction in pixels
Column 07	060100	IDN	AMV sequence number in the slot
Column 08	060104	TYPE	Characterization as Basic or Detailed tracer, and Type of Detailed tracer
Column 09	002028	SIZX	Segment size of tracer in X direction in m
Column 10	002029	SIZY	Segment size of tracer in Y direction in m
Column 11	060103	TYPL	Height assignment method used
Column 12	002164	TYPT	Euclidean Distance or Cross Correlation tracking
Column 13	005001	LAT	Initial latitude
Column 14	006001	LON	Initial longitude
Column 15	005011	DLAT	Latitude increment
Column 16	006011	DLON	Longitude increment
Column 17	012001	T	AMV Temperature
Column 18	007004	P	AMV Pressure
Column 19	011001	DIR	AMV Wind Direction
Column 20	011002	SPD	AMV Wind Speed
Column 21	033007	QI	AMV Quality index with forecast
Column 22	033007	QINF	AMV Quality index without forecast
Column 23	033007	QIWG	AMV Common Quality index without forecast

ROW/COLUMN ELEMENT	"NWC" BUFR DESCRIPTOR	PARAMETER MD ID.	WDMR SCHEME DESCRIPTION
Column 24		QT	Threshold: Quality index with forecast
Column 25		QTNF	Threshold: Quality index without forecast
Column 26		QTWG	Threshold: Common Quality index without forecast
Column 27	060202	TES2	Two scale quality test flag
Column 28	060202	TEST	Temporal quality test flag
Column 29	060202	TESE	Spatial quality test flag
Column 30	060202	TESG	Forecast quality test flag
Column 31	060201	TESA	Correlation test flag
Column 32	060203	AVNW	Number of NWP levels used in HRW calculation
Column 33	060204	WPRE	Number of Predecessor AMVs in the trajectory
Column 34	060200	WREP	Number of Computed AMVs for the tracer
Column 35	060101	IDN0	Number of Predecessor AMV in the previous slot
Column 36	060205	FLAI	Orographic flag
Column 37	060202	TESI	Orographic test flag
Column 38	060206	CT	AMV NWC/PPS Cloud type
Column 39	060207	WCH	AMV NWC/PPS Satellite channel
Column 40	060208	CORR	Correlation between tracer and tracking centre
Column 41	060209	PERR	AMV Pressure error
Column 42	060210	PCORR	AMV Pressure correction (not used in NWC/PPS-HRW)
Column 43	060211	DIRN	NWP Wind Direction at AMV level
Column 44	060212	SPDN	NWP Wind Speed at AMV level
Column 45	060216	DIFN	Difference with NWP wind at AMV level
Column 46	060213	DRNN	NWP Wind Direction at AMV best fit level
Column 47	060214	SPNB	NWP Wind Speed at AMV best fit level
Column 48	060217	DFNB	Difference with NWP wind at AMV best fit level
Column 49	060215	PWNB	NWP Pressure at AMV best fit level
Column 50		IDR	Radiosounding identifier
Column 51		LATR	Radiosounding latitude
Column 52		LONR	Radiosounding longitude
Column 53		DIRR	Radiosounding Wind Direction at AMV near level
Column 54		SPDR	Radiosounding Wind Speed at AMV near level
Column 55		DIFR	Difference with Radiosounding wind
Column 56		PWR	Radiosounding Pressure at AMV near level
Column 57		DRRN	Radiosounding Wind Direction at AMV best fit
Column 58		SPRB	Radiosounding Wind Speed at AMV best fit level
Column 59		DFRB	Difference with Radiosounding wind
Column 60		PWRB	Radiosounding Pressure at AMV best fit level

Table 3. Description of McIDAS WDMR Scheme
and Correspondence with NWC/PPS-HRW BUFR output with "NWC SAF" specific format

2.2 STATISTICAL PARAMETERS

The statistical parameters for the validation of NWC/PPS-HRW Atmospheric Motion Vectors (AMVs) are the ones proposed at the Third International Winds Workshop (Ascona, Switzerland, 1996), afterwards recommended by the Coordination Group for Meteorological Satellites (CGMS) for the international comparison of satellite winds.

A description of these statistical parameters is shown here:

1. N: Number of collocations between the reference wind vectors (Radiosounding winds or NWP analysis winds) [Ur,Vr] and the NWC/PPS-HRW AMV wind vectors [Ui,Vi].
2. SPD: Mean horizontal wind speed in m/s for the reference winds (Radiosounding winds or NWP analysis winds).
3. BIAS: Difference between the mean horizontal wind speed of the reference winds (Radiosounding winds or NWP analysis winds), and the collocated NWC/PPS-HRW AMVs winds:

$$BIAS = \frac{1}{N}\sum_{i=1}^{N}\left(\sqrt{U_i^2+V_i^2}-\sqrt{U_r^2+V_r^2}\right)$$

   It shows an estimation of the systematic error related to the calculation of the wind speed modulus (over- or underestimation of the mean AMV wind speed with respect to the mean reference wind speed). The index "i" here denotes each collocation and runs from 1 to the total number of collocations N.

4. MVD: Mean vector difference between the reference winds (Radiosounding winds or NWP analysis winds) and the collocated NWC/PPS-HRW AMV wind speeds:

$$MVD = \frac{1}{N}\sum_{i=1}^{N} VD_i$$

   It shows an estimation of the systematic error related to the calculation of vectors, for which:

$$VD_i = \sqrt{(U_i - U_r)^2 + (V_i - V_r)^2}$$

5. RMSVD: Root mean square vector difference:

$$RMSVD = \sqrt{(MVD)^2 + (SD)^2}$$

   It shows an estimation of the systematic and random error related to the calculation of the wind vectors. It is calculated through the Mean vector difference (MVD), and the Standard deviation (SD) of each vector difference with respect to the mean, for which:

$$SD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(VD_i - MVD)^2}$$

Due to the variable magnitude the defined statistical parameters can have in different samples, the mean horizontal wind speed for the reference winds (SPD, parameter 2) is used for normalization. So, the relative parameters related to the ones before:

3a. NBIAS = BIAS / SPD,

4a. NMVD = MVD / SPD,

5a. NRMSVD = RMSVD / SPD,

which are independent of the magnitude of the winds and can more easily be compared in different samples of data, are going to be used and presented throughout this Validation Report.

The validation process has been based on Radiosounding winds at 12:00 UTC, and ECMWF NWP model analysis winds at 12:00 UTC, during 88 days inside the period February – April 2020.

Considering the validation against Radiosounding winds, AMVs are compared to the nearest Radiosounding wind, with a maximum distance of 150 km and a maximum pressure difference of 25 hPa (standard limits defined for the comparison of AMVs with Radiosounding winds), and a maximum time difference of one hour between the Radiosounding time and the AMV time (the time of the "later image" used for the AMV calculation), This way, only AMVs for slots between 11:00 UTC and 13:00 UTC of this period complying with these characteristics have been considered valid for this validation.

Considering the validation against ECMWF NWP model analysis winds, with the same time restriction, all AMVs for slots between 11:00 UTC and 13:00 UTC can formally be validated against NWP analysis winds (considering an interpolation of the NWP wind to the AMV location and level). However, to ease the comparison of the validation of AMVs against both reference datasets (Radiosounding winds and NWP analysis winds), throughout this Validation report only AMVs which could be validated at the same time against both reference datasets are considered. Although the size of the AMV sample is this way smaller, the number of AMV data validated against both datasets is exactly the same in all cases, and differences in the validation against both datasets can be better seen because of using exactly the same AMVs in each case.

3. VALIDATION OF NWC/PPS-HRW V7.P AMVS

3.1 VALIDATION FOR BASIC AMVS WITH DEFAULT CONFIGURATION

The validation of NWC/PPS-HRW v7.P software for polar satellite series is considered here. As already said, a validation period of three months has been defined (February 2020-April 2020). All polar satellite scannings over two reprojected static regions ("EURON1 - Scandinavia", shown in *Figure 1*, and "EUROPA", shown in *Figure 2*), have been processed between 09:00 UTC and 13:00 UTC for 88 days inside this validation period, and all AMVs for all related slots between 11:00 UTC and 13:00 UTC have been validated against both Radiosounding winds and NWP analysis winds at 12:00 UTC.

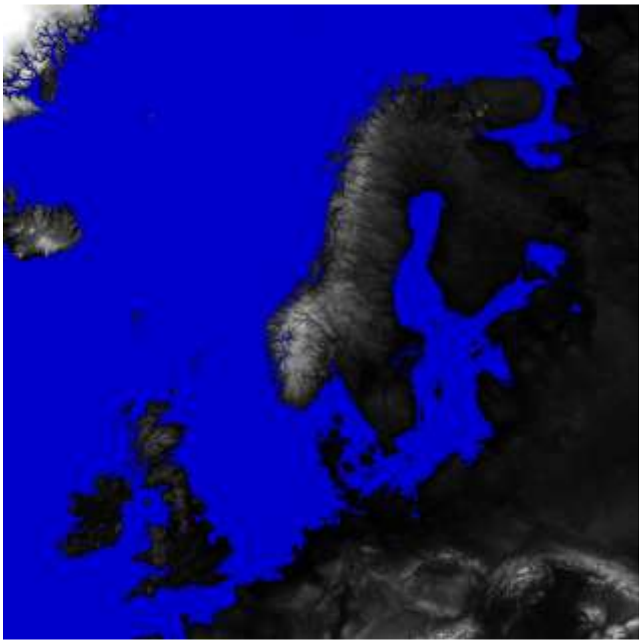

Figure 1: "EURON1 – Scandinavia" static region used for the validation of NWC/PPS-HRW v7.P

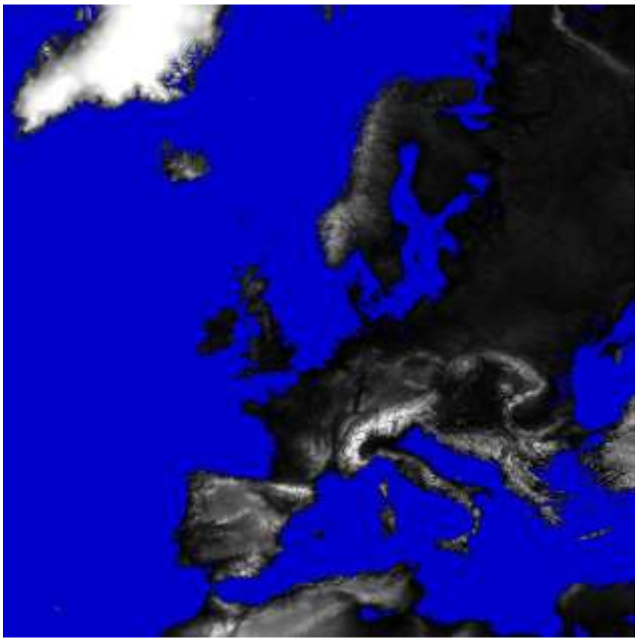

Figure 2: "EUROPA" static region used for the validation of NWC/PPS-HRW v7.P

The configuration considers the conditions defined in the default "model configuration file" `$SM_CONFIG_DIR/safnwc_HRW_POLAR.cfm`. For this process, NWC/PPS-CMA/CT/CTTH in both reprojected validation regions have to be produced before the running of NWC/PPS-HRW. Examples of AMVs calculated with NWC/PPS-HRW software for these two static regions are shown in *Figure 3* and *Figure 4*.

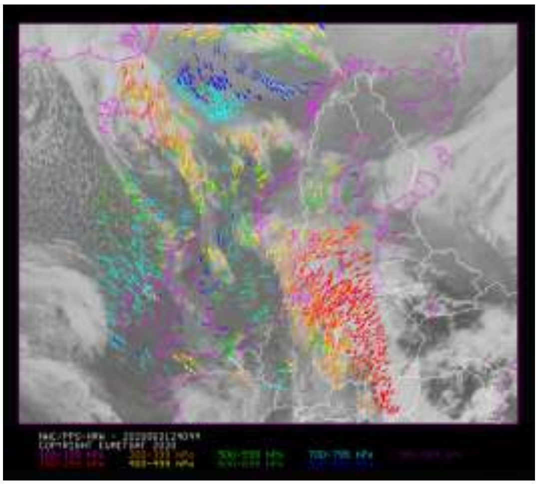

Figure 3: NWC/PPS-High Resolution Winds "Basic AMV" output example in the region "EURON1 - Scandinavia" (3 March 2020 12:40:44 UTC for SNPP satellite, with tracers calculated at 12:20:09 UTC for EOS-2 satellite), considering conditions defined in $SM_CONFIG_DIR/safnwc_HRW_POLAR.cfm model configuration file. Colour coding based on the AMV pressure level

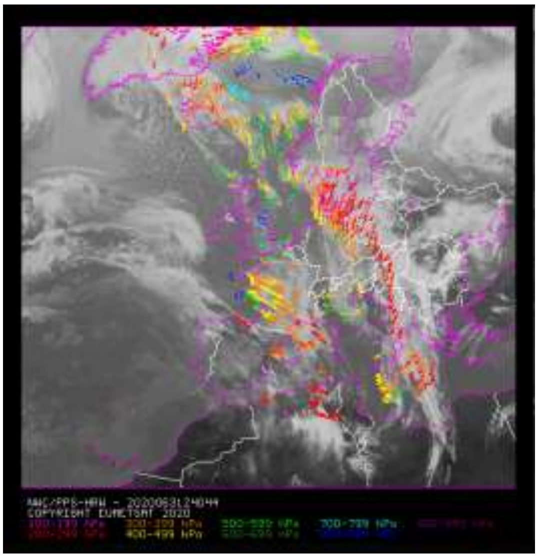

Figure 4: NWC/PPS-High Resolution Winds "Basic AMV" output example in the region "EUROPA" (3 March 2020 12:40:44 UTC for SNPP satellite, with tracers calculated at 12:20:09 UTC for EOS-2 satellite), considering conditions defined in $SM_CONFIG_DIR/safnwc_HRW_POLAR.cfm model configuration file. Colour coding based on the AMV pressure level

Comparing the statistics for NWC/PPS-HRW against Radiosounding winds and ECMWF NWP analysis winds in *Table 4* (considering all layers together) and in *Table 5* (considering three layers separately), it can be seen that the NMVD and NRMSVD parameters are significantly smaller (around a 30% smaller) against NWP analysis winds. A conclusion can be taken here, that the general scale and behaviour of AMV winds is more similar to that of NWP analysis winds than to that of Radiosounding winds.

Considering differences in NWC/PPS-HRW for VIS06 and IR108 channel, statistics for IR108 AMVs are slightly better (with NMVD and NRMSVD values up to a 10% better for IR108 channel in region "EURON1"). This could in general be explained by the generally low solar elevation in these Northern regions throughout the used validation period (around the Spring Equinox), which limits the illumination conditions in the visible channels. However, it is also to be remarked that the differences in the AMV statistics for both VIS06 and IR108 channels are not so significant in spite of this.

Considering the differences in the AMVs for regions "EURON1 - Scandinavia" and "EUROPA", using respectively pixels of 5 km size and 1 km size, in general AMVs for region "EURON1" have smaller NBIAS values, which can be related to the fact of using smaller tracers due to smaller pixel sizes. Instead, NMVD and NRMSVD values are slightly higher for region "EURON1". Both results are general results for all AMV calculation processes when using smaller tracers.

Comparing the distribution of AMVs in the different layers, NWC/PPS-HRW shows a value of 69%/20%/11% for the High/Medium/Low layer in the region "EUROPA" and a value of 52%/25%/23% in the region "EURON1". Some improvement could be needed in future NWC/PPS-HRW versions to increase a bit the distribution of low level AMVs in the region "EUROPA", to better characterize the behaviour of the wind in the different levels of the troposphere.

Considering the different layers, the validation parameters are progressively higher for the high layer, medium layer and low layer. Nevertheless, the NWCSAF/HRW Product Requirement Table "Target accuracy" is reached for both validation regions for all layers (with values of 0.44, 0.50 and 0.56 against Radiosounding winds). And the Product Requirement Table "Optimal accuracy" is even reached in the Low layer for region "EURON1" (with a value of 0.45 against Radiosounding winds).

NWC/PPS-HRWv7.P AMVs (Feb 2020-Apr 2020)	"EURON1-Scandinavia" region VIS06	IR108/ IR110	All AMVs		"EUROPA" region VIS06	IR108/ IR110	All AMVs
NC	199190	294099	493289		136348	508408	644756
SPD [m/s]	21.75	25.00	23.69		20.25	23.76	23.02
NBIAS (ALL LAYERS)	+0.00	+0.02	+0.01		-0.08	-0.06	-0.06
NMVD (100-1000 hPa)	0.34	0.32	0.33		0.31	0.32	0.32
NRMSVD	0.44	0.40	0.42		0.39	0.39	0.39
NC	199190	294099	493289		136348	508408	644756
SPD [m/s]	21.70	25.08	23.71		19.88	23.77	22.95
NBIAS (ALL LAYERS)	+0.00	+0.02	+0.01		-0.06	-0.06	-0.06
NMVD (100-1000 hPa)	0.26	0.25	0.25		0.24	0.23	0.23
NRMSVD	0.35	0.31	0.33		0.31	0.29	0.30

Table 4: Validation parameters for NWC/PPS-HRW v7.P AMVs, considering all layers together, against Radiosounding winds in light green and against ECMWF NWP analysis winds in dark green. (Basic AMVs in nominal configuration; Feb 2020-Apr 2020 between 11:00 and 13:00 UTC; Polar satellites with AVHRR/3, VIIRS and MODIS radiometers). Statistics for region "EURON1 - Scandinavia" on the left side; region "EUROPA" on the right side.

NWC/PPS-HRWv7.P AMVs (Feb 2020-Apr 2020)	"EURON1-Scandinavia" region VIS06	IR108/ IR110	All AMVs	"EUROPA" region VIS06	IR108/ IR110	All AMVs
NC	82514	172397	254911	71182	373464	444646
SPD [m/s]	32.80	30.29	31.10	28.10	27.22	27.36
NBIAS (HIGH LAYER)	+0.00	+0.02	+0.01	-0.09	-0.06	-0.07
NMVD (100-400 hPa)	0.31	0.31	0.31	0.28	0.30	0.30
NRMSVD	0.38	0.37	0.38	0.34	0.36	0.36
NC	43130	82440	125570	29585	96716	126301
SPD [m/s]	19.44	19.39	19.41	14.90	15.96	15.71
NBIAS (MEDIUM LAYER)	-0.00	+0.02	+0.01	-0.06	-0.03	-0.04
NMVD (400-700 hPa)	0.38	0.38	0.38	0.37	0.42	0.41
NRMSVD	0.49	0.46	0.47	0.46	0.51	0.50
NC	73546	39262	112808	35581	38228	73809
SPD [m/s]	10.72	13.55	11.70	8.99	9.73	9.37
NBIAS (LOW LAYER)	+0.00	-0.01	-0.00	-0.02	+0.02	-0.00
NMVD (700-1000 hPa)	0.38	0.33	0.36	0.43	0.44	0.44
NRMSVD	0.45	0.39	0.43	0.50	0.51	0.51
NC	82514	172397	254911	71182	373464	444646
SPD [m/s]	32.51	30.28	31.00	27.28	27.11	27.13
NBIAS (HIGH LAYER)	+0.01	+0.02	+0.02	-0.07	-0.06	-0.06
NMVD (100-400 hPa)	0.25	0.24	0.24	0.23	0.23	0.23
NRMSVD	0.31	0.29	0.30	0.28	0.28	0.28
NC	43130	82440	125570	29585	96716	126301
SPD [m/s]	19.64	19.73	19.70	14.75	16.12	15.80
NBIAS (MEDIUM LAYER)	-0.01	+0.01	+0.00	-0.05	-0.04	-0.05
NMVD (400-700 hPa)	0.28	0.28	0.28	0.27	0.27	0.27
NRMSVD	0.36	0.35	0.35	0.33	0.33	0.33
NC	73546	39262	112808	35581	38228	73809
SPD [m/s]	10.78	13.45	11.71	9.35	10.48	9.93
NBIAS (LOW LAYER)	+0.00	-0.00	-0.00	-0.06	-0.05	-0.05
NMVD (700-1000 hPa)	0.25	0.23	0.25	0.28	0.25	0.27
NRMSVD	0.31	0.28	0.30	0.33	0.29	0.31

Table 5: Validation parameters for NWC/PPS-HRW v7.P AMVs,
considering respectively the high, medium and low layer,
against Radiosounding winds in light green and against ECMWF NWP analysis winds in dark green.
(Basic AMVs in nominal configuration; Feb 2020-Apr 2020 between 11:00 and 13:00 UTC;
Polar satellites with AVHRR/3, VIIRS and MODIS radiometers).
Statistics for region "EURON1 - Scandinavia" on the left side; region "EUROPA" on the right side.

3.2 COMPARISON WITH NWC/GEO-HRW V6.1 DEFAULT CONFIGURATION

The comparison of the statistics for NWC/PPS-HRW v7.P default configuration, with those for NWC/GEO-HRW v6.1 (latest version of NWC/GEO-HRW software for geostationary satellites, released in 2020), is considered here.

Statistics for NWC/GEO-HRW are shown for MSG satellites, in *Table 6* considering all layers together, and in *Table 7* considering three layers separately (high, medium and low). Statistics are shown for MSG/IR108 channel, for MSG/HRVIS channel (only visible channel for which statistics are calculated for all layers), and for all channels together.

NWC/PPS-HRW shows cases in which the values of NMVD and NRMSVD parameters can be up to a 20% higher than those for NWC/GEO-HRW. In spite of this, while for NWC/GEO-HRW software the Product Requirement Table “Optimal accuracy” is reached in the High layer (with a value of 0.35 against Radiosounding winds), and the Product Requirement Table “Target accuracy” is reached in the Medium and Low layer (with values respectively of 0.50 and 0.56 against Radiosounding winds), for NWC/PPS-HRW the Product Requirement Table “Target accuracy” is still reached for both validation regions for all layers.

Considering the different layers, for both implementations NWC/PPS-HRW and NWC/GEO-HRW, the validation parameters are progressively higher for the high layer, medium layer and low layer. It can also be seen that for both, that NMVD and NRMSVD parameters are significantly smaller (around a 30% smaller) against NWP analysis winds.

Comparing the distribution of AMVs in the different layers, NWC/GEO-HRW shows a value of 52%/25%/23% in the “European and Mediterranean” region, considering all AMVs for all possible channels, while for NWC/PPS-HRW in the “EURON1 – Scandinavia” static region the distribution is exactly also 52%/25%/23%.

Taking into account all these elements, it can be concluded that the behaviour of both NWC/GEO-HRW AMVs and NWC/PPS-HRW AMVs is very similar, and so NWC/PPS-HRW outputs can perfectly be used by NWC SAF users the same way they are using NWC/GEO-HRW outputs, in spite of having defined this NWC/PPS-HRW version only as a “demonstrational version”.

	European/Mediterranean region		
NWC/GEO-HRW v6.1 AMVs (Jul 2010-Jun 2020, MSG sat.)	HRVIS	IR108	All AMVs
NC	67288	226314	1097907
SPD [m/s]	12.87	17.50	17.23
NBIAS (ALL LAYERS)	-0.03	-0.08	-0.07
NMVD (100-1000 hPa)	0.35	0.30	0.32
NRMSVD	0.42	0.37	0.39
NC	67288	226314	1097907
SPD [m/s]	12.72	17.19	16.91
NBIAS (ALL LAYERS)	-0.02	-0.07	-0.05
NMVD (100-1000 hPa)	0.22	0.20	0.22
NRMSVD	0.28	0.25	0.27

Table 6: Validation parameters for NWC/GEO-HRW v6.1 AMVs (latest NWC/GEO-HRW version), considering all layers together, against Radiosounding winds in light blue and against ECMWF NWP analysis winds in dark blue.
(Basic AMVs in nominal configuration; Jul 2009-Jun 2010 at 12:00 UTC; MSG-2 satellite; “European and Mediterranean” region).

NWC/GEO-HRW v6.1 AMVs (Jul 2010-Jun 2020, MSG sat.)	European/Mediterranean region HRVIS	IR108	All AMVs
NC	15919	119091	566718
SPD [m/s]	21.13	21.85	22.19
NBIAS (HIGH LAYER)	-0.03	-0.07	-0.05
NMVD (100-400 hPa)	0.25	0.26	0.26
NRMSVD	0.30	0.32	0.32
NC	15447	65544	276959
SPD [m/s]	12.88	14.29	13.91
NBIAS (MEDIUM LAYER)	-0.05	-0.09	-0.08
NMVD (400-700 hPa)	0.35	0.35	0.36
NRMSVD	0.42	0.43	0.44
NC	35922	41679	254230
SPD [m/s]	9.21	10.11	9.79
NBIAS (LOW LAYER)	-0.02	-0.11	-0.09
NMVD (700-1000 hPa)	0.45	0.40	0.42
NRMSVD	0.53	0.48	0.50
NC	15919	119091	566718
SPD [m/s]	20.87	21.54	21.83
NBIAS (HIGH LAYER)	-0.01	-0.06	-0.04
NMVD (100-400 hPa)	0.16	0.17	0.17
NRMSVD	0.19	0.22	0.21
NC	15447	65544	276959
SPD [m/s]	12.58	13.95	13.56
NBIAS (MEDIUM LAYER)	-0.03	-0.07	-0.05
NMVD (400-700 hPa)	0.25	0.25	0.26
NRMSVD	0.31	0.31	0.33
NC	35922	41679	254230
SPD [m/s]	9.17	9.86	9.58
NBIAS (LOW LAYER)	-0.01	-0.09	-0.07
NMVD (700-1000 hPa)	0.28	0.27	0.28
NRMSVD	0.34	0.33	0.34

Table 7: Validation parameters for NWC/GEO-HRW v6.1 AMVs (latest NWC/GEO-HRW version), considering respectively the high, medium and low layer, against Radiosounding winds in light blue and against ECMWF NWP analysis winds in dark blue. (Basic AMVs in nominal configuration; Jul 2009-Jun 2010 at 12:00 UTC; MSG-2 satellite; "European and Mediterranean" region).

3.3 VALIDATION FOR DETAILED AMVS WITH DEFAULT CONFIGURATION

The validation of "Detailed AMVs" (with a default "tracer size" of 12x12 pixels instead of the 24x24 pixels considered by the "Basic AMVs") with NWC/PPS-HRW software is considered now. The calculation of "Detailed AMVs" is activated with configurable parameter CDET = 1 in the NWC/PPS-HRW "model configuration file". They are provided as an additional dataset of AMVs, provided together with the "Basic AMVs" which are always calculated. The conditions for the validation are exactly equivalent to those in chapter 3.1 for the "Basic AMVs". Examples of "Detailed AMVs" calculated for the same two static regions "EURON1 – Scandinavia" and "EUROPA" are shown in *Figure 5* and *Figure 6*. Corresponding validation statistics are presented in *Table 8* (considering all layers together), and *Table 9 (*considering the three layers separately).

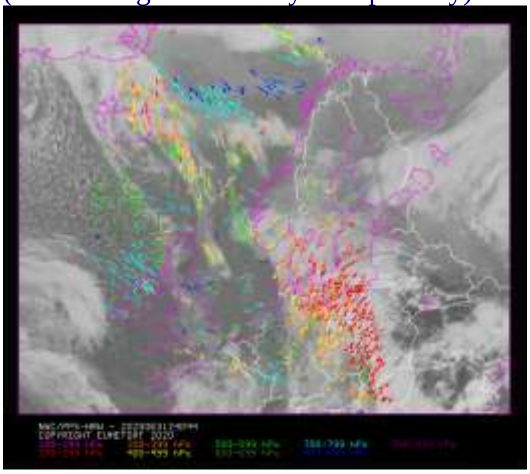

Figure 5: NWC/PPS-High Resolution Winds "Detailed AMV" output example in the region "EURON1 - Scandinavia" (3 March 2020 12:40:44 UTC for SNPP satellite, with tracers calculated at 12:20:09 UTC for EOS-2 satellite), considering conditions defined in $SM_CONFIG_DIR/safnwc_HRW_POLAR.cfm model configuration file and configurable parameter CDET=1. Colour coding based on the AMV pressure level

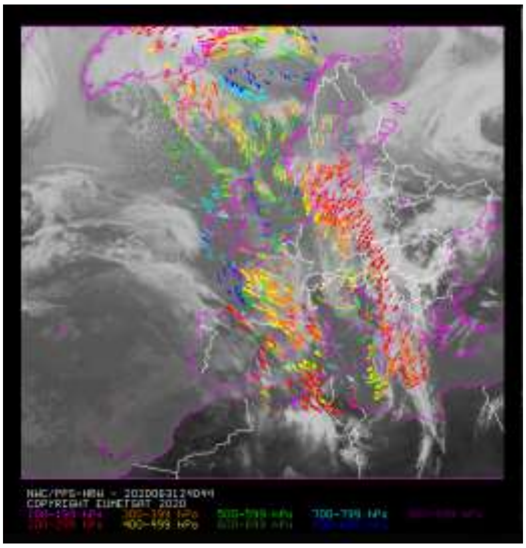

Figure 6: NWC/PPS-High Resolution Winds "Detailed AMV" output example in the region "EUROPA" (3 March 2020 12:40:44 UTC for SNPP satellite, with tracers calculated at 12:20:09 UTC for EOS-2 satellite), considering conditions defined in $SM_CONFIG_DIR/safnwc_HRW_POLAR.cfm model configuration file and configurable parameter CDET=1. Colour coding based on the AMV pressure level

Comparing with the "Basic AMVs", an increase in the number of AMVs of about a 25% is seen for the "Detailed AMVs" in the "EUROPA" region, while a decrease in the number of AMVs of about a 40% is seen in the "Detailed AMVs in the "EURON1 – Scandinavia" region. The different scale of the pixels in both regions (5 km and 1 km respectively) explains this different behaviour. In "EUROPA" region, "Basic AMVs" are related to tracer sizes around 120 km while "Detailed AMVs" are related to tracer sizes around 60 km. In "EURON1" region, "Basic AMVs" are related to tracer sizes around 24 km while "Detailed AMVs" are related to tracer sizes around 12 km. The smaller size of the tracer in pixels is favourable in "EUROPA" region for the calculation of more AMVs, while in "EURON1" region it is less convenient. Nevertheless, in both cases the "Detailed AMVs" define an additional dataset of valid AMVs.

Considering the validation parameters, the NBIAS becomes more positive for "Detailed AMVs" in both regions. Meanwhile, the NMVD and NRMSVD parameters are similar to those for "Basic AMVs" in "EUROPA" region, while they are up to a 15% larger in "EURON1" region. Considering these small differences, "Detailed AMVs" are inside the Product Requirement Table "Target accuracy" for both regions in the three validation layers (high, medium and low), and the low layer in "EUROPA" region is even inside the Product Requirement Table "Optimal accuracy".

Comparing the statistics against Radiosounding winds and ECMWF NWP analysis winds, NMVD and NRMSVD parameters are again for "Detailed AMVs" significantly smaller (up to a 30% smaller) against NWP analysis winds, showing the similar behaviour than with "Basic AMVs".

Considering the distribution of AMVs in the different layers, the "Detailed AMVs" show a value of 70%/21%/9% for the High/Medium/Low layer in the region "EUROPA" and a value of 54%/26%/20% in the region "EURON1". This distribution is basically equivalent to that for "Basic AMVs", so helping to characterize the behaviour of the wind in the different levels of the troposphere.

In short, the behaviour of "Detailed AMVs" is very similar to that of "Basic AMVs" (with small differences in the validation statistics), and so both datasets can be used together for the characterization of the wind in the different layers of the troposphere.

	"EURON1-Scandinavia" region			"EUROPA" region		
NWC/PPS-HRWv7.P AMVs (Feb 2020-Apr 2020)	**VIS06**	**IR108/ IR110**	**All AMVs**	**VIS06**	**IR108/ IR110**	**All AMVs**
NC	152454	129829	282283	178621	628388	807009
SPD [m/s]	27.16	27.61	27.37	22.76	25.53	24,92
NBIAS (ALL LAYERS)	+0.05	+0.06	+0.05	-0.04	-0.03	-0.03
NMVD (100-1000 hPa)	0.36	0.35	0.35	0.32	0.31	0.31
NRMSVD	0.45	0.43	0.44	0.41	0.38	0.39
NC	152454	129829	282283	178621	628388	807009
SPD [m/s]	27.05	27.68	27.34	22.78	25.42	24.83
NBIAS (ALL LAYERS)	+0.06	+0.05	+0.05	-0.04	-0.03	-0.03
NMVD (100-1000 hPa)	0.29	0.28	0.29	0.24	0.23	0.23
NRMSVD	0.38	0.35	0.37	0.33	0.29	0.30

Table 8: Validation parameters for NWC/PPS-HRW v7.P AMVs, considering all layers together, against Radiosounding winds in light green and against ECMWF NWP analysis winds in dark green. (Detailed AMVs in nominal configuration; Feb 2020-Apr 2020 between 11:00 and 13:00 UTC; Polar satellites with AVHRR/3, VIIRS and MODIS radiometers). Statistics for region "EURON1 - Scandinavia" on the left side; region "EUROPA" on the right side.

NWC/PPS-HRWv7.P AMVs (Feb 2020-Apr 2020)	"EURON1-Scandinavia" region VIS06	IR108/ IR110	All AMVs	"EUROPA" region VIS06	IR108/ IR110	All AMVs
NC	73351	78338	151689	102340	463065	565405
SPD [m/s]	38.47	32.45	35.36	29.84	28.24	28.53
NBIAS (HIGH LAYER)	+0.04	+0.05	+0.04	-0.04	-0.03	-0.03
NMVD (100-400 hPa)	0.33	0.33	0.33	0.30	0.30	0.30
NRMSVD	0.39	0.40	0.39	0.37	0.36	0.36
NC	36845	37912	74757	37378	134251	171629
SPD [m/s]	21,99	22.42	22.21	16.38	19.22	18.60
NBIAS (MEDIUM LAYER)	+0.09	+0.09	+0.09	-0.05	-0.05	-0.05
NMVD (400-700 hPa)	0.42	0.39	0.41	0.38	0.38	0.38
NRMSVD	0.52	0.48	0.50	0.47	0.47	0.47
NC	42258	13579	55837	38903	31072	69975
SPD [m/s]	12.04	14.14	12.55	10.25	12.36	11.19
NBIAS (LOW LAYER)	+0.07	+0.06	+0.07	+0.01	-0.01	-0.00
NMVD (700-1000 hPa)	0.39	0.37	0.39	0.39	0.36	0.38
NRMSVD	0.48	0.45	0.48	0.46	0.43	0.45
NC	73351	78338	151689	102340	463065	565405
SPD [m/s]	38.09	32.46	35.18	29.64	28.07	28.36
NBIAS (HIGH LAYER)	+0.05	+0.05	+0.05	-0.04	-0.02	-0.03
NMVD (100-400 hPa)	0.28	0.27	0.28	0.24	0.22	0.23
NRMSVD	0.33	0.33	0.33	0.30	0.28	0.28
NC	36845	37912	74757	37378	134251	171629
SPD [m/s]	22.02	22.54	22.28	16.66	19.24	18.68
NBIAS (MEDIUM LAYER)	+0.09	+0.08	+0.08	-0.07	-0.05	-0.05
NMVD (400-700 hPa)	0.34	0.31	0.32	0.27	0.26	0.26
NRMSVD	0.42	0.38	0.40	0.34	0.33	0.33
NC	42258	13579	55837	38903	31072	69975
SPD [m/s]	12.28	14.44	12.80	10.63	12.48	11.45
NBIAS (LOW LAYER)	+0.05	+0.04	+0.05	+0.02	-0.02	-0.02
NMVD (700-1000 hPa)	0.28	0.27	0.28	0.26	0.25	0.25
NRMSVD	0.37	0.35	0.36	0.31	0.29	0.30

Table 9: Validation parameters for NWC/PPS-HRW v7.P AMVs,
considering respectively the high, medium and low layer,
against Radiosounding winds in light green and against ECMWF NWP analysis winds in dark green.
(Detailed AMVs in nominal configuration; Feb 2020-Apr 2020 between 11:00 and 13:00 UTC;
Polar satellites with AVHRR/3, VIIRS and MODIS radiometers).
Statistics for region "EURON1 - Scandinavia" on the left side; region "EUROPA" on the right side.

3.4 VALIDATION FOR BASIC AMVS WITHOUT CLOUD PRODUCTS

The validation for the situation in which NWC/PPS-Cloud outputs are not available for the running of NWC/PPS-HRW software, and so the "Brightness temperature interpolation" height assignment without Cloud products is used, is presented here in *Table 10* (considering all layers together) and *Table 11* (considering the three layers separately) for the same validation period. So users are able to know what they can expect from NWC/PPS-HRW v7.P software when it is run independently.

An example of this configuration is shown in *Figures 7 and 8* for the same examples shown previously in *Figures 3 and 4* using NWC/PPS-Cloud outputs and "CCC method" height assignment (default conditions for NWC/PPS-HRW running).

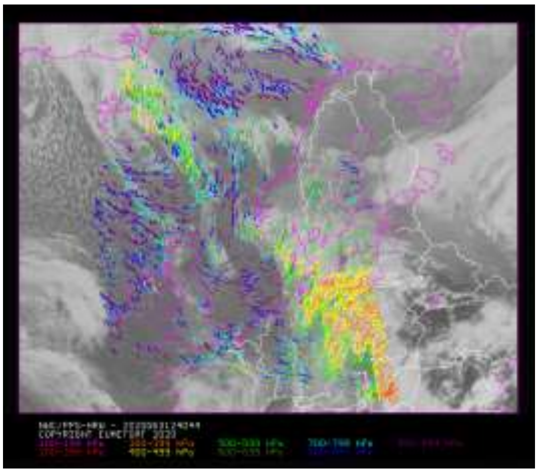

Figure 7: NWC/PPS-High Resolution Winds "Basic AMV" output example in the region "EURON1 - Scandinavia" (3 March 2020 12:40:44 UTC for SNPP satellite, with tracers calculated at 12:20:09 UTC for EOS-2 satellite), using "Brightness temperature interpolation" height assignment without Cloud products. Colour coding based on the AMV pressure level

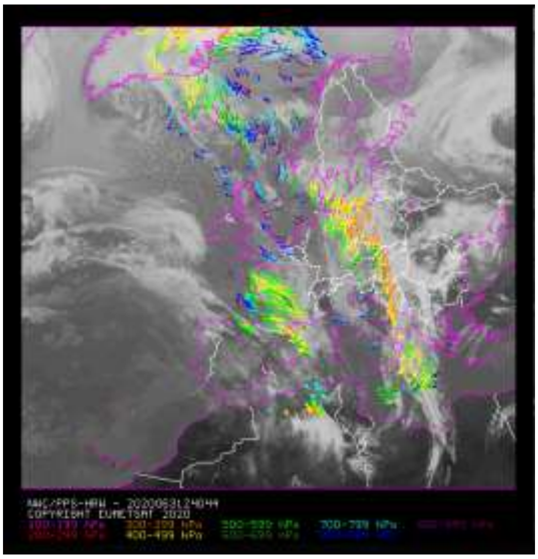

Figure 8: NWC/PPS-High Resolution Winds "Basic AMV" output example in the region "EUROPA" (3 March 2020 12:40:44 UTC for SNPP satellite, with tracers calculated at 12:20:09 UTC for EOS-2 satellite), using "Brightness temperature interpolation" height assignment without Cloud products. Colour coding based on the AMV pressure level

Comparing *Tables 10 and 11* with *Tables 4 and 5* (using "CCC method" height assignment), the main difference between both results is the reduction in the number of high level AMVs (between 100 and 400 hPa), and the increase in the number of medium and low level AMVs (between 400 and 1000 hPa), with a distribution of validated AMVs for the High/Medium/Low layer of 20%/49%/31% for "EURON1 – Scandinavia" region and 14%/56%/30% for "EUROPA" region, which seems to be in less agreement with reality.

Considering the validation parameters for all layers together, NMVD and NRMSVD parameters are higher in general (up to a 15%) using "Brightness temperature interpolation" height assignment without Cloud products. And the NBIAS also shows in this case higher positive values.

With these results, the recommendation is to use NWC/PPS-HRW together with NWC/PPS-Cloud outputs, and to try to avoid the independent use of NWC/PPS-HRW without NWC/PPS-Cloud outputs.

In spite of the differences, considering the accuracies defined in the NWCSAF/HRW Product Requirement Table, the situation is still similar when NWC/PPS-HRW is run independently: all layers in both validation regions comply with the "Target accuracy" (0.44/0.50/0.56 respectively for the High/Medium/Low layer), and the high layer AMVs in "EUROPA" region even complies with the "Optimal accuracy" (0.35).

Finally, comparing the statistics against Radiosounding winds and ECMWF NWP analysis winds, the NMVD and NRMSVD parameters are as in previous cases up to a 25% smaller using NWP analysis winds as reference.

	"EURON1-Scandinavia" region			"EUROPA" region		
NWC/PPS-HRWv7.P AMVs (Feb 2020-Apr 2020)	VIS06	IR108/ IR110	All AMVs	VIS06	IR108/ IR110	All AMVs
NC	346157	635999	982156	109847	402515	512362
SPD [m/s]	22.16	22.00	22.05	16.46	19.22	18.63
NBIAS (ALL LAYERS)	+0.12	+0.14	+0.13	+0.06	+0.11	+0.10
NMVD (100-1000 hPa)	0.37	0.36	0.36	0.36	0.34	0.35
NRMSVD	0.48	0.45	0.46	0.44	0.42	0.43
NC	346157	635999	982156	109847	402515	512362
SPD [m/s]	22.48	22.28	22.35	16.78	19.61	19.00
NBIAS (ALL LAYERS)	+0.10	+0.13	+0.12	+0.04	+0.09	+0.08
NMVD (100-1000 hPa)	0.31	0.29	0.29	0.27	0.26	0.26
NRMSVD	0.40	0.37	0.38	0.34	0.32	0.32

Table 10: Validation parameters for NWC/PPS-HRW v7.P AMVs, considering all layers together, against Radiosounding winds in light green and against ECMWF NWP analysis winds in dark green. (Basic AMVs using Brightness temperature interpolation height assignment without Cloud products; Feb 2020-Apr 2020 between 11:00 and 13:00 UTC; Polar satellites with AVHRR/3, VIIRS and MODIS radiometers). Statistics for region "EURON1 - Scandinavia" on the left side; region "EUROPA" on the right side.

NWC/PPS-HRWv7.P AMVs (Feb 2020-Apr 2020)	"EURON1-Scandinavia" region VIS06	IR108/ IR110	All AMVs	"EUROPA" region VIS06	IR108/ IR110	All AMVs
NC	73695	126936	200631	15415	57298	72713
SPD [m/s]	38.07	37.55	37.74	30.81	36.95	35.65
NBIAS (HIGH LAYER)	+0.10	+0.10	+0.10	-0.00	+0.05	+0.04
NMVD (100-400 hPa)	0.33	0.30	0.31	0.26	0.27	0.26
NRMSVD	0.39	0.36	0.37	0.32	0.31	0.31
NC	170668	309891	480559	50590	237403	287993
SPD [m/s]	20.68	20.72	20.78	17.59	18.41	18.27
NBIAS (MEDIUM LAYER)	+0.14	+0.17	+0.16	+0.08	+0.13	+0.12
NMVD (400-700 hPa)	0.40	0.39	0.40	0.36	0.36	0.36
NRMSVD	0.49	0.48	0.48	0.43	0.43	0.43
NC	101794	199172	300966	43842	107814	151656
SPD [m/s]	13.14	14.10	13.77	10.10	11.58	11.15
NBIAS (LOW LAYER)	+0.10	+0.14	+0.13	+0.08	+0.12	+0.11
NMVD (700-1000 hPa)	0.41	0.37	0.38	0.46	0.42	0.43
NRMSVD	0.51	0.47	0.49	0.57	0.51	0.52
NC	73695	126936	200631	15415	57298	72713
SPD [m/s]	37.99	37.19	37.49	29.70	37.16	35.58
NBIAS (HIGH LAYER)	+0.10	+0.11	+0.10	+0.03	+0.04	+0.04
NMVD (100-400 hPa)	0.28	0.26	0.27	0.22	0.19	0.20
NRMSVD	0.34	0.31	0.32	0.26	0.23	0.24
NC	170668	309891	480559	50590	237403	287993
SPD [m/s]	21.08	21.13	21.11	18.06	18.77	18.64
NBIAS (MEDIUM LAYER)	+0.11	+0.15	+0.14	+0.05	+0.11	+0.10
NMVD (400-700 hPa)	0.33	0.32	0.33	0.27	0.28	0.28
NRMSVD	0.42	0.40	0.41	0.33	0.34	0.34
NC	101794	199172	300966	43842	107814	151656
SPD [m/s]	13.60	14.58	14.25	10.75	12.15	11.74
NBIAS (LOW LAYER)	+0.06	+0.10	+0.09	+0.01	+0.07	+0.05
NMVD (700-1000 hPa)	0.29	0.26	0.27	0.30	0.28	0.29
NRMSVD	0.37	0.34	0.35	0.37	0.35	0.36

*Table 11: Validation parameters for NWC/PPS-HRW v7.P AMVs,
considering respectively the high, medium and low layer,
against Radiosounding winds in light green and against ECMWF NWP analysis winds in dark green.
(Basic AMVs using Brightness temperature interpolation height assignment without Cloud products;
Feb 2020-Apr 2020 between 11:00 and 13:00 UTC;
Polar satellites with AVHRR/3, VIIRS and MODIS radiometers).
Statistics for region "EURON1 - Scandinavia" on the left side; region "EUROPA" on the right side.*

4. CONCLUSIONS

Some conclusions can be extracted from this "Validation report" for NWC/PPS-HRW v7.P:

NWC/PPS-HRW software has been validated against both Radiosounding winds and NWP model analysis winds. In general, it has been seen that the NBIAS, NMVD and NRMSVD validation parameters are significantly smaller (up to a 30% smaller) against NWP analysis winds, and the general scale and behaviour of AMV winds is more similar to that of NWP analysis winds than to that of Radiosounding winds.

Considering NWC/PPS-HRW AMVs for VIS06 and IR108 channels, validation parameters are up to a 10% better for IR108 AMVs. This could in general be explained by the generally low solar elevation in these Northern regions, which limits the illumination conditions in the visible channels.

Considering the differences in the AMVs for regions "EURON1 - Scandinavia" and "EUROPA", (using respectively pixels of 5 km size and 1 km size), AMVs for region "EURON1" have smaller NBIAS values and slightly higher NMVD and NRMSVD values. Both results are general results for all AMV calculation processes when using smaller tracers.

The behaviour for NWC/PPS-HRW is generally similar to that of NWC/GEO-HRW:

- Considering the default configuration, NMVD and NRMSVD validation parameters are progressively higher for the high layer, medium layer and low layer. And the distribution of AMVs in the different layers shows a value of 52%/25%/23% in the region "EURON1 - Scandinavia". Both results are equivalent to those shown by NWC/GEO-HRW v6.1 software.
- Comparing the validation for NWC/PPS-HRW v7.P with the one for NWC/GEO-HRW v6.1 (summarized in *Table 12*), NMVD and NRMSVD validation parameters can be up to a 20% higher. In spite of this, while for NWC/GEO-HRW software the Product Requirement Table "Optimal accuracy" is reached in the High layer and the "Target accuracy" is reached in the Medium and Low layer, for NWC/PPS-HRW software the Product Requirement Table "Target accuracy" is still reached for both validation regions in all layers, and the "Optimal accuracy" is even reached in the Low layer for region "EURON1".

Considering all this, NWC/PPS-HRW outputs can be perfectly used by NWC SAF users the same way they are using NWC/GEO-HRW outputs, in spite of being defined only as a "demonstrational version". There is however still room for improvement trying to reduce the errors in all layers, and trying to homogenize the density of NWC/PPS-HRW AMVs for different slots (now the density of calculated AMVs can be very variable for different slots).

Evolution of the Validation statistics between HRW versions, related to the Operative thresholds defined in the NWCSAF/HRW Product Requirement Table (against Radiosounding winds)	High Layer NRMSVD	Medium Layer NRMSVD	Low Layer NRMSVD
NWC/PPS-HRW v7.P, Default configuration, "EURON1 region"	**0.38**	**0.47**	**0.43**
NWC/PPS-HRW v7.P, Default configuration, "EUROPA region"	**0.36**	**0.50**	**0.51**
NWC/GEO-HRW v6.1, Default configuration, MSG satellites	**0.32**	**0.44**	**0.50**
NWCSAF/HRW Product Requirement Table Optimal Accuracy	**0.35**	**0.40**	**0.45**
NWCSAF/HRW Product Requirement Table Target Accuracy	**0.44**	**0.50**	**0.56**
NWCSAF/HRW Product Requirement Table Threshold Accuracy	**0.53**	**0.60**	**0.67**

Table 12: Validation statistics for NWC/PPS-HRW v7.P and NWC/GEO-HRW v6.1, related to the Operative thresholds defined in the NWCSAF/HRW Product Requirement Table