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AEMet Agencia Estatal de Meteorología
EUMETSAT

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

NWCSAF/High Resolution Winds AMV Software for Geostationary and Polar satellites Status in 2021

12-16 April 2021

Fifteenth International Winds Workshop

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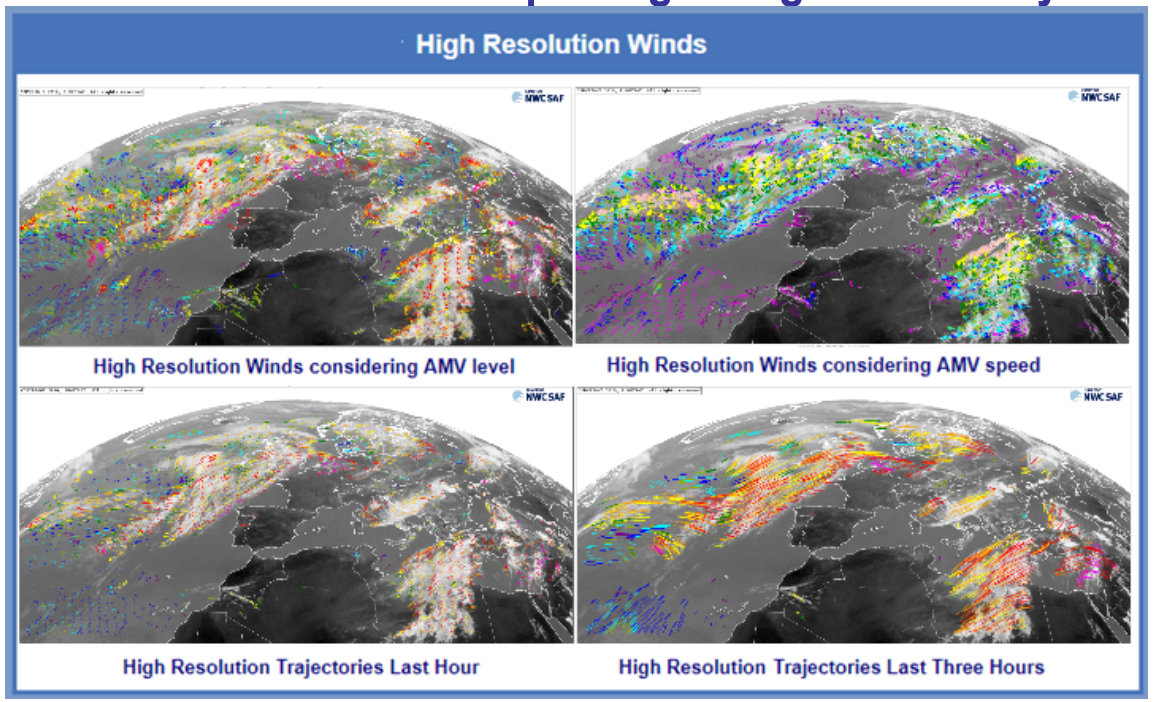
NWC/GEO-High Resolution Winds v2018.1

- **High Resolution Winds software** provides a detailed calculation of **"Atmospheric Motion Vectors (AMVs)"** and **"Trajectories"**, inside the NWCSAF Software packages for Meteorological Services and Researchers.

- **Latest version** released in **January 2020** (inside **NWC/GEO v2018.1 Software package for geostationary satellites**).



High Resolution Winds outputs from NWCSAF Helpdesk (nwc-saf.eumetsat.int)
for 1 June 2019 1200Z, Meteosat 11, European & North Atlantic region

NWC/GEO-High Resolution Winds v2018.1

Updates included in HRW v2018.1:

1. Implementation of the "New IWWG AMV BUFR" output (sequence 310077):

➔ It includes more information than the "Heritage IWWG BUFR", and allows common processing with other AMV datasets from other AMV producers.

➔ HRW v2018.1 provides up to 4 output options configurable by the user:

- NWCSAF BUFR (for continuity with all previous versions of HRW).
- Heritage IWWG BUFR
- New IWWG BUFR
- NWCSAF NetCDF (available since v2016).

NWC/GEO-High Resolution Winds v2018.1

Updates included in HRW v2018.1:

2. Adaptation of HRW algorithm to GOES-16 satellite:

➔ Adaptation equivalent to the one for Himawari-8/9,
using the same procedure and the "same" satellite channels
(VIS06, VIS08, WV062, WV070, WV074, IR112).

➔ "Microphysics correction for the height assignment"
similar for GOES-16 and Himawari-8/9,
due to the small differences in the satellite channels from both satellites.

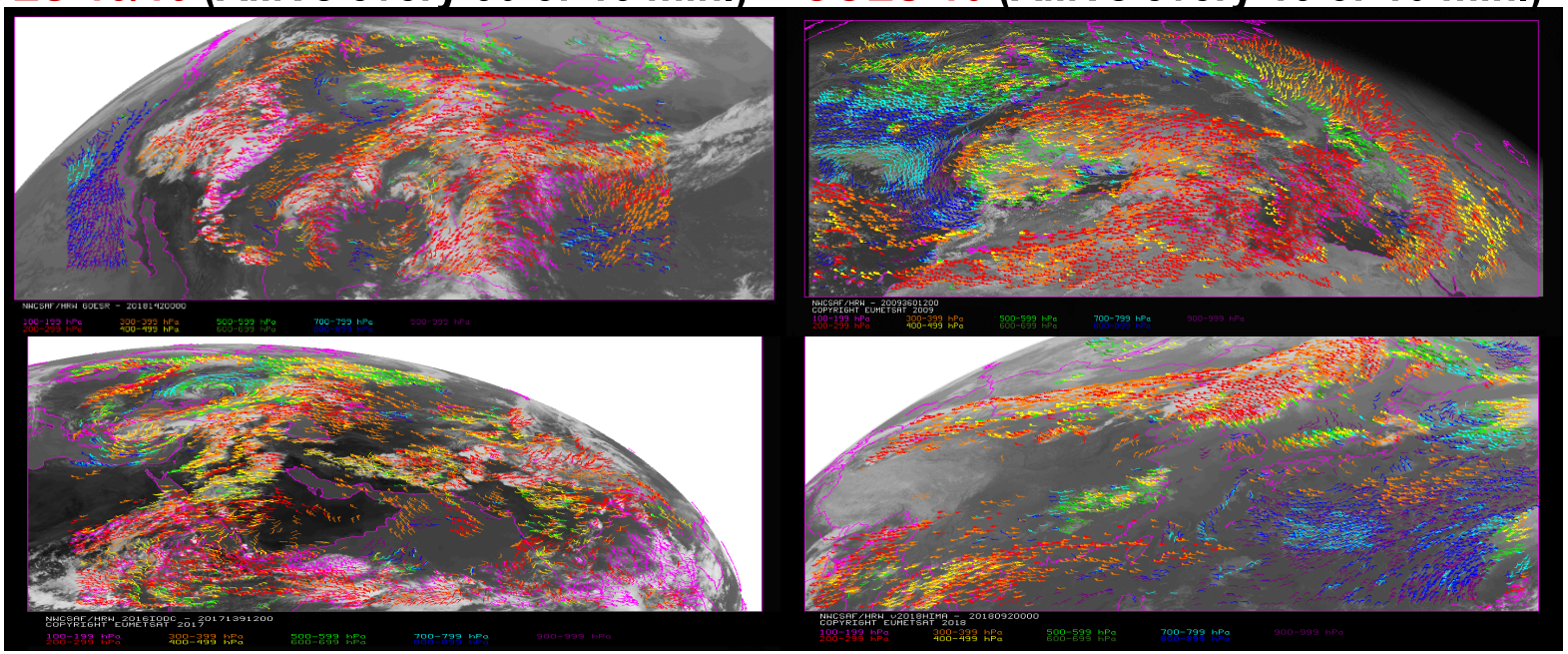
➔ Satellite input data: GOES-R NetCDF from NOAA.

NWC/GEO-High Resolution Winds v2018.1

Updates included in HRW v2018.1:

3. Validation all throughout the world with all satellites:

- **MSG** (AMVs every 15 or 5 min.)
- **Himawari-8/9** (AMVs every 10 min.)
- **GOES-13/15** (AMVs every 30 or 15 min.)
- **GOES-16** (AMVs every 15 or 10 min.)



Similar validation for all satellites;
a bit better for Himawari & GOES-16

NWC/GEO-HRW v2018.1 AMVs	MSG-2 Jul'09-Jun'10 Europe	GOES-13 Jul'10-Jun'11 CONUS	Himawari-8 Mar'18-Aug'18 China-Korea-Japan	GOES-16 May'19-Jul'19 CONUS (Mode 6)
NC	1097907	608690	1197466	1283683
SPD [m/s]	17.23	22.43	21.46	20.49
NBIAS (ALL LAYERS)	-0.07	-0.05	+0.05	+0.05
NMVD (100-1000 hPa)	0.32	0.28	0.28	0.28
NRMSVD	0.39	0.36	0.35	0.34

NWC/GEO-High Resolution Winds v2018.1

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Additional validation of NWC/GEO-HRW AMVs is in the "NWPSAF AMV Monitoring":

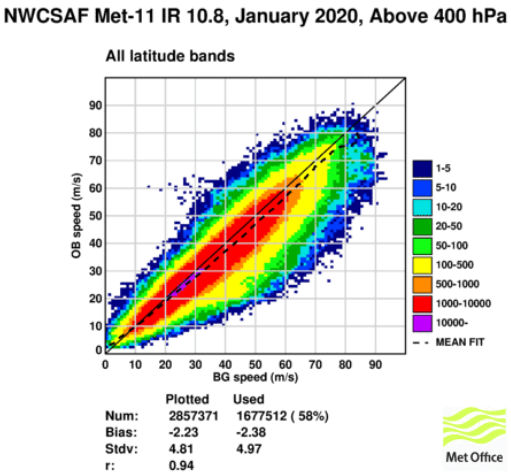
http://nwpsaf.eu/monitoring/amv/20_01/density_ukv.html

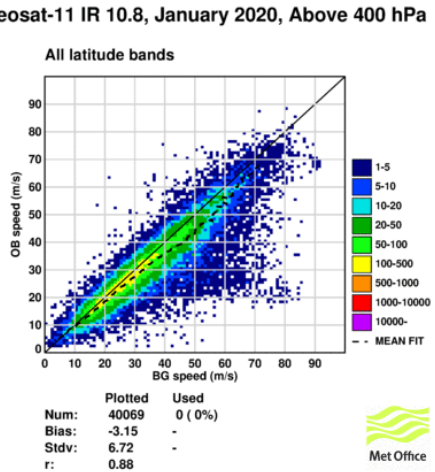
http://nwpsaf.eu/monitoring/amv/20_01/map_ukv.html

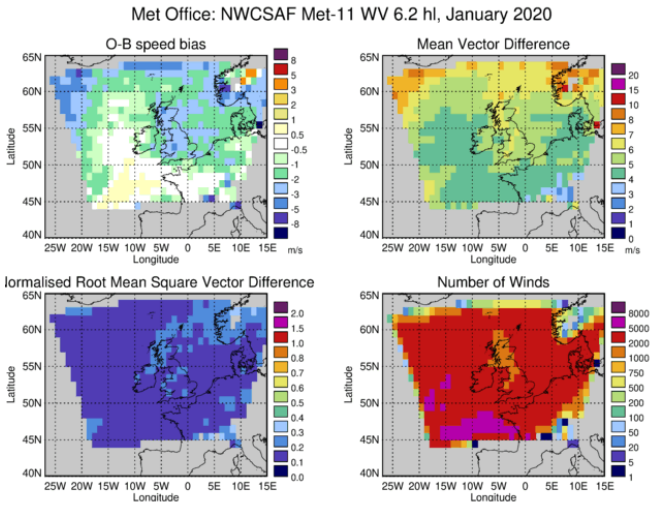
Monthly verification
around the British Isles,
of NWCSAF/HRW AMVs (left)
in comparison with
Eumetsat/MPEF AMVs (right)

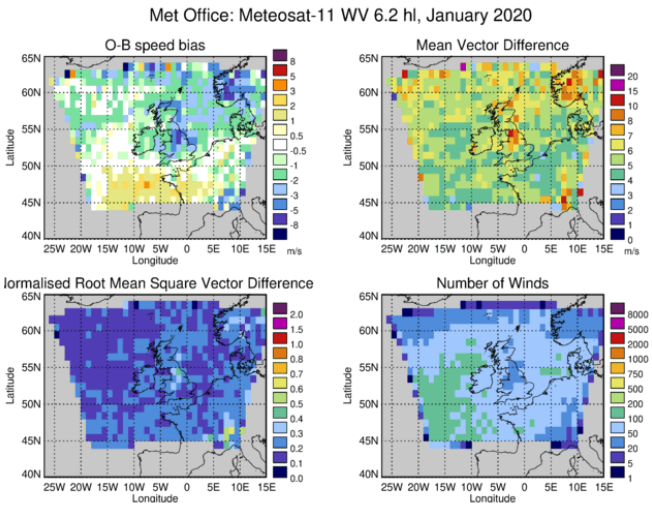
NWCSAF/HRW AMVs
show in general:

- **Higher density of AMVs (1-2 orders of magnitude larger).**
- **Better MVD, RMSVD values.**







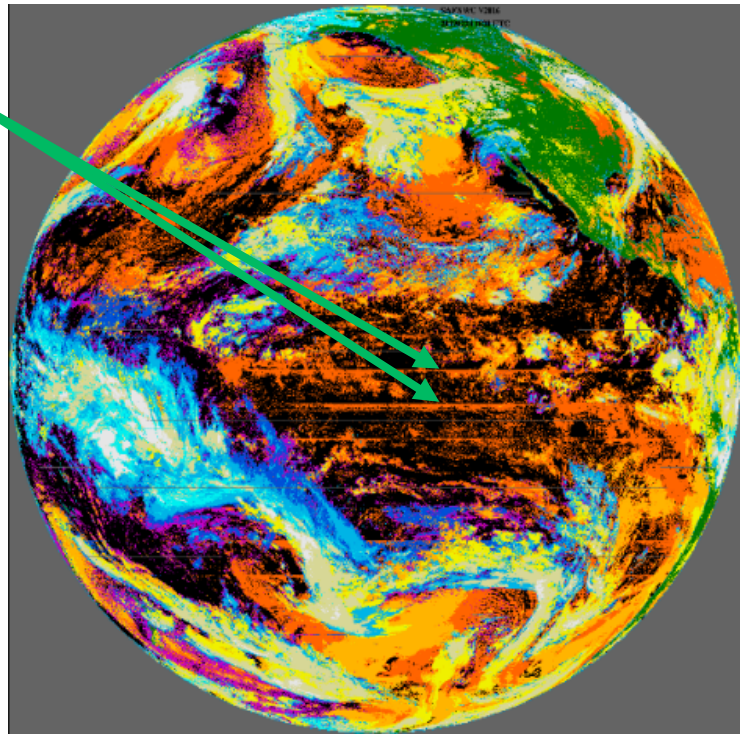


NWC/GEO-High Resolution Winds v2018.1

The extension to additional GOES-R satellites is also in the working plan.

However, with the problems in the cooling system of GOES-17/ABI Imager:

- ➔ **Significant noise can occur in the satellite images and NWCSAF products.**
- ➔ **Filtering of noisy data is needed using available "quality flags".**
- ➔ **With this, the extension to GOES-17 is going to be implemented in the following update during 2021.**



(Example of noisy NWCSAF/Cloud type for GOES-17 satellite)

NWC/PPS-HRW (Adaptation to polar satellites)

A requirement from NWCSAF users has been raised to extend NWCSAF/High Resolution Winds to polar satellites:

➔ **European Nordic weather services**
(f.ex. related to the regional MetCoOp HARMONIE model)
wish more wind data for NWP assimilation at high latitudes,
with a stringent timeliness requirement of 15 minutes!

➔ **No other dataset of winds**
from polar orbiting satellites
can satisfy this timeliness requirement.

NWC/PPS-HRW (Adaptation to polar satellites)

Considering this:

➔ **HRW is being included inside NWC/PPS software package,**
calculating winds and trajectories from
reprojected polar images in static regions of different sizes,
in a similar way to what is being done for geostationary satellites
inside NWC/GEO software package.

➔ **Several polar satellites/instruments are considered for this:**

- NOAA & Metop/AVHRR-3
- S-NPP & JPSS/VIIRS
- EOS/MODIS

In later versions also:

- FY-3/Mersi-2
- EPS-SG-A/MetImage

➔ **Currently 9-10 satellites are providing images for the AMV calculation.**
The optimal pair of images for each calculation is considered through:

- The time separation between images.
- The percentage of common scanning in the static processing region.

This way the quantity and quality of AMVs is maximized.

NWC/PPS-HRW (Adaptation to polar satellites)

The plan for this work is:

➔ **Delivery of a "beta version of NWC/PPS-HRW"**
for evaluation, testing and applicability
- Release to users throughout 2021.
- Prepared since Summer 2019 by
Javier García-Pereda (AEMET, Spain) &
Nina Håkansson (SMHI, Sweden).

➔ **Delivery of the "first official version of NWC/PPS-HRW"**
inside NWCSAF/CDOP4 phase (> 2022).

NWC/PPS-HRW (Adaptation to polar satellites)

NWC/PPS-HRW is based on an adaptation of NWC/GEO-HRW v2018.1 code (latest operational version for NWC/GEO-HRW).

HRW code kept as an only software element valid for both software packages (NWC/GEO and NWC/PPS), but installed with two different "makefiles".

- ➔ **Two different "executables" are so produced with the same code.**
- ➔ **However, 90% of the code (34000 code lines out of 38000 total code lines) is exactly equivalent for both implementations!**

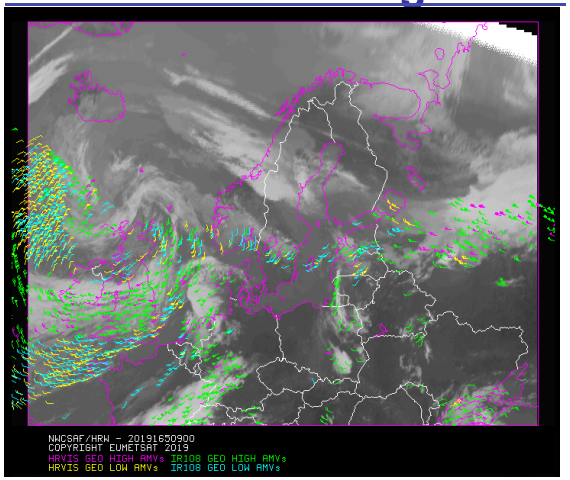
This way, results for NWC/PPS-HRW in perfect consonance with those for NWC/GEO-HRW!

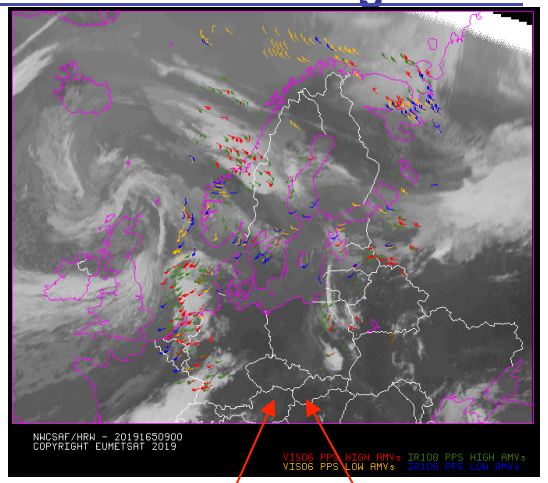
HRW outputs will be exactly equivalent for both GEO and PPS options.

- ➔ **Someone already using GEO-HRW can use PPS-HRW very quickly, simply adding the polar outputs to the ones already used.**

NWC/PPS-HRW (Adaptation to polar satellites)

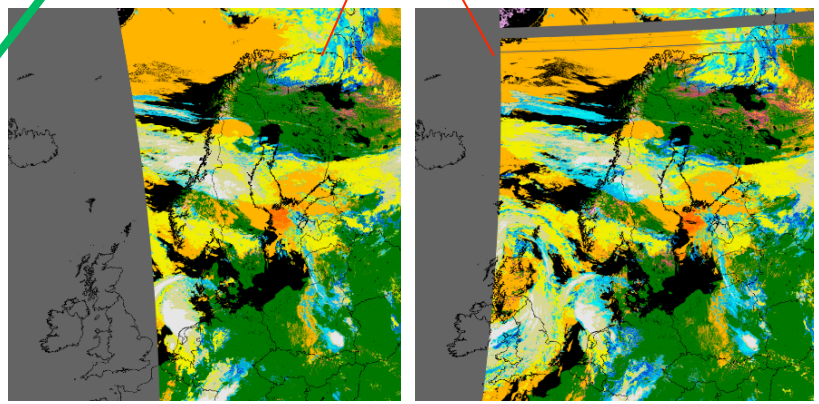
Example for 14/June/2019 09:00Z, comparing AMVs obtained by NWC/GEO-HRW algorithm and NWC/PPS-HRW algorithm:





For NWC/GEO-HRW,
the "satellite zenith angle"
defines a geographical limit
for the AMV calculation.

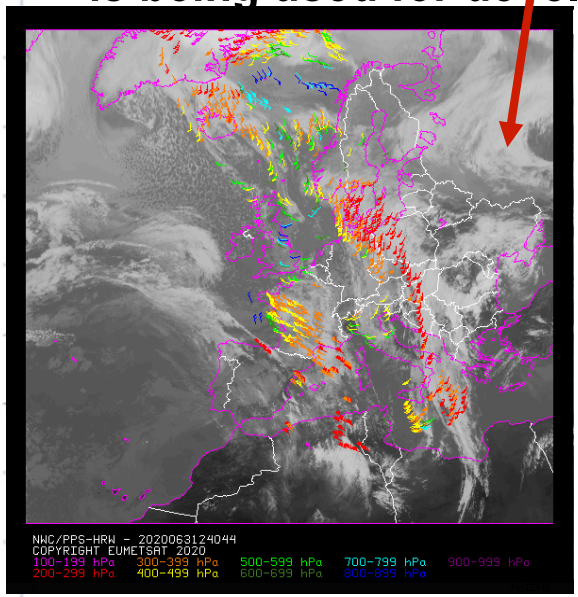
For NWC/PPS-HRW, there are
no geographical limits for the AMV calculation,
but the AMV temporal/spatial density is smaller
(calculating AMVs
only with VIS06/IR108 channels).

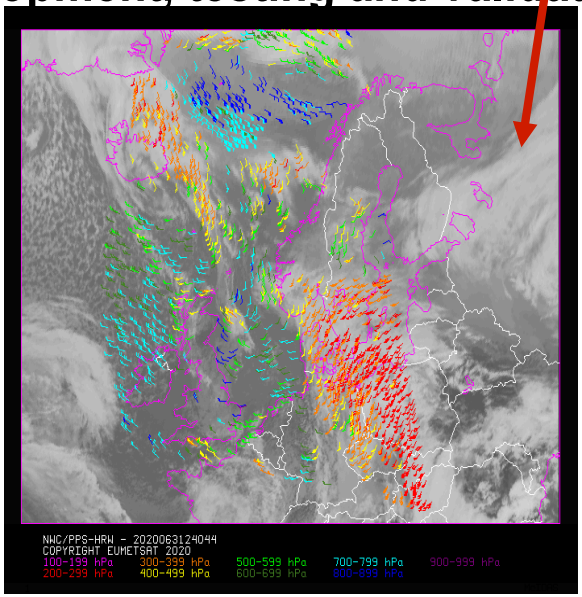


NWC/PPS-HRW AMVs can be obtained
in areas for which both "initial image" and "final image"
provide satellite & NWC/PPS-Cloud (CT/CTTH) data.

NWC/PPS-HRW (Adaptation to polar satellites)

A 3 month period in two regions with two different pixel resolutions (5 km per pixel "Europe" and 1 km per pixel "Scandinavia") is being used for development, testing and validation





Basic VIS06 & IR108 AMVs	NWC/PPS-HRW v7.P AMVs Feb'20-Apr'20, 11:00 - 13:00 UTC		NWC/GEO-HRW v6.1 AMVs Jul'09-Jul'10, 12:00Z
	Scandinavia region	Europe region	Europe and Mediterranean region
NC	254911	444646	566718
SPD [m/s]	31.10	27.36	22.19
NBIAS (HIGH LAYER)	+0.01	-0.07	-0.05
NMVD (100-400 hPa)	0.31	0.30	0.26
NRMSVD	0.38	0.36	0.32
NC	125570	126301	276959
SPD [m/s]	19.41	15.71	13.91
NBIAS (MEDIUM LAYER)	+0.01	-0.04	-0.08
NMVD (400-700 hPa)	0.38	0.41	0.36
NRMSVD	0.47	0.50	0.44
NC	112808	73809	254230
SPD [m/s]	11.70	9.37	9.79
NBIAS (LOW LAYER)	-0.00	-0.00	-0.09
NMVD (700-1000 hPa)	0.36	0.44	0.42
NRMSVD	0.43	0.51	0.50
NC	493289	644756	1097907
SPD [m/s]	23.69	23.02	17.23
NBIAS (ALL LAYERS)	+0.01	-0.06	-0.07
NMVD (100-1000 hPa)	0.33	0.32	0.32
NRMSVD	0.42	0.39	0.39

➔ NWC/PPS-HRW AMV validation is inside the "Target accuracy" for all layers and both validation regions.

➔ Comparing with NWC/GEO-HRW AMVs:

- NMVD/NRMSVD values are similar or slightly higher (up to 15%)
- Vertical distribution of AMVs and AMV validation behave similarly (better for high levels and worse for low levels).

NWC/PPS-HRW (Adaptation to polar satellites)

With both options (NWC/GEO-HRW and NWC/PPS-HRW)
the user is going to be able to obtain AMVs
in all corners of the world with a high update frequency:

- ➔ **4-6 times per hour throughout all the geostationary ring,**
- ➔ **Up to several times per hour (depending on latitude) with polar satellites.**

This is better than what other AMV products can do,
due to the larger number of processable satellites,
and can be important for example for:

- ➔ **Global NWP assimilation.**
- ➔ **Climatic studies.**

Other developments with HRW up to 2022

(Up to the end of current NWCSAF/CDOP3 phase)

1. NWC/GEO-HRW for MTG-Imager.

➔ The experience of HRW algorithm
with Himawari-8/9 and GOES-R satellite series
is very helpful for this adaptation.

➔ Currently, main difficulties related to:

- The optimal use for the AMV extraction of
High resolution visible channels VIS06 and VIS08
(good AMV densities, optimization of time processing,…)
- Better distribution of AMVs
at medium and low levels.

2. Optimization of HRW code.

Plans for NWCSAF/CDOP4 phase (2022-2027)

Plans for the following years have been agreed

with Eumetsat inside "NWCSAF/CDOP4 phase (2022-2027) Proposal"

from Comments/Recommendations defined at:

- ➔ 2016 and 2018 International Winds Workshops
- ➔ 2019 NWCSAF Users Survey
- ➔ 2020 NWCSAF Users Workshop

From the 2019 NWCSAF Users Survey:

- ➔ HRW well considered among NWCSAF products:
  - Used by 55% of answers (second only to NWC/GEO-Cloud products).
  - With a 7.8/10 rate (after only NWC/GEO-Cloud and Convective products).

Plans for NWCSAF/CDOP4 phase (2022-2027)

I. Improvements due to updates in NWCSAF/Cloud products:

- ➔ Stratiform and cumuliform cloud separation
- ➔ Improvements in CTTH and CMIC products
  (including extension of CMIC to night conditions).
- ➔ Better assessment of multilayer clouds and semitransparent clouds.

II. Improvements suggested by NWCSAF users:

- ➔ Inclusion of "Error in the AMV displacement"
  as defined by Graeme Kelly/MetOffice.
- ➔ Inclusion of "Aeronautical units (flight level)"
  in the AMVs for use by aviation.

Plans for NWCSAF/CDOP4 phase (2022-2027)

III. Extension to additional GOES-T and GOES-U satellites by the NWCSAF Team.

Considering the extension to other GEO satellites (GEO-KOMPSAT2, FY-4,…):

- **The whole world is covered with five geostationary satellites from MSG/MTG, Himawari-8/9, GOES-R satellite series.**
- **No specific plans have been defined for adaptation to additional GEO satellites by the NWCSAF Team.**
- **The work could be done through integration of improvements suggested/developed by NWCSAF users.**

"NWCSAF Visiting Scientist Activities" give the chance to finance and integrate AMV procedures in HRW algorithm, in parallel to those developed by the NWCSAF team.

Plans for NWCSAF/CDOP4 phase (2022-2027)

IV. Implementation of the NOAA/NESDIS "nested tracking"

➔ Considering several tracers of smaller size inside a large tracer.

V. Possible implementation of "stereo height assignment"

➔ Considering the parallax displacement of an AMV observed by two geostationary satellites in two different locations.

We keep the interest of having the collaboration of experts in this task for the implementation through a "NWCSAF Visiting Scientist Activity" (f.ex. James Carr, Dong Wu,…)

Plans for NWCSAF/CDOP4 phase (2022-2027)

VI. Redefinition of HRW NetCDF output

➔ For a better use by external applications
(envisaging as a guidance the “CF conventions”).

VII. Possible distribution of HRW outputs through Eumetcast

➔ Due to the big configurability of HRW product
it is difficult to define a HRW option valid for everybody.

➔ However, if different users define what they need,
and this is relatively similar, it can be considered.

Plans for NWCSAF/CDOP4 phase (2022-2027)

VIII. Further studies related to winds from hyperspectral retrievals (winds and wind profiles from MTG-Sounder radiances or T/q profiles)

➔ From the several working groups in this area it seems clear that the <u>"optical flow" perspective is winning the deal</u>.

➔ A feasibility study has also been recommended to the NWCSAF to check how worthwhile it still is to calculate AMVs with MTG-Sounder data.

NWCSAF/HRW as "Stand-alone AMV software"

Due to its characteristics and its ease to be obtained/understood/run locally,

NWCSAF/HRW was proposed at previous "International Winds Workshops"

as "Stand-alone AMV calculation software"

available for all AMV researchers and users.

Its good validation results by independent studies

➔ 2014/2018 AMV intercomparisons with MSG and Himawari

and its usability with many satellites in all areas of the world

should be enough to convince any researchers about the use of NWCSAF/HRW.

For any further need or help, do not hesitate to contact me.

Thank you very much for listening!

Javier García-Pereda

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