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AEMet Agencia Estatal de Meteorología
EUMETSAT

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

NWCSAF/High Resolution Winds Status in 2020 and plans for CDOP4 phase (2022-2027)

11th March 2020

NWCSAF Users Workshop

Madrid, Spain

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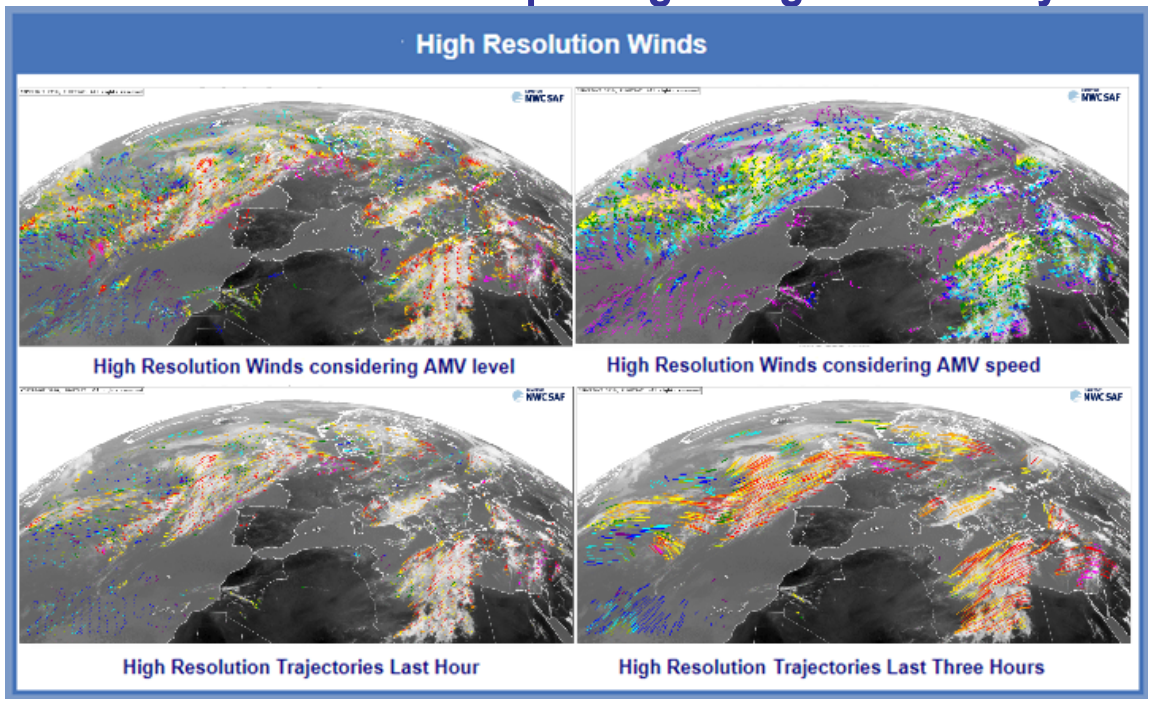
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NWC/GEO-High Resolution Winds v2018.1

- **NWC/GEO-High Resolution Winds** calculates **"Atmospheric Motion Vectors (AMVs)"** and **"Trajectories"** considering the displacement of clouds/humidity features in consecutive satellite images.

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



Example of NWCSAF/HRW different outputs at NWCSAF Helpdesk (nwc-saf.eumetsat.int) for 1 June 2019 1200Z, Meteosat 11, European & North Atlantic region

NWC/GEO-High Resolution Winds v2018.1

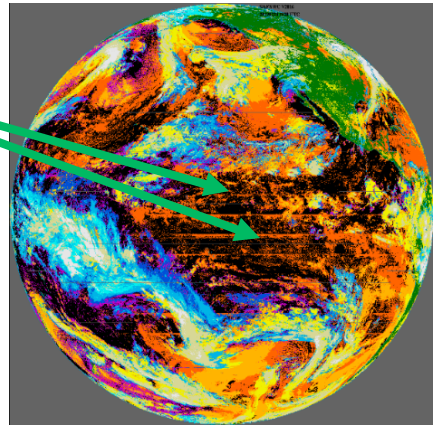
- It has been adapted and validated all throughout the world with:
  - **MSG satellites** (with images every 15 or 5 minutes)
  - **Himawari-8/9 satellites** (with images every 10 minutes)
  - **GOES-13/15 satellites** (with images every 30 or 15 minutes)
  - **GOES-16 satellite** (with images every 15 or 10 minutes) – new with v2018.1!

The extension to additional GOES-R satellites is also in the working plan.
However, with the "problems in the cooling system of ABI Imager":

➔ Significant noise occurs in GOES-17 satellite images and NWC/GEO products (e.g. Cloud products).

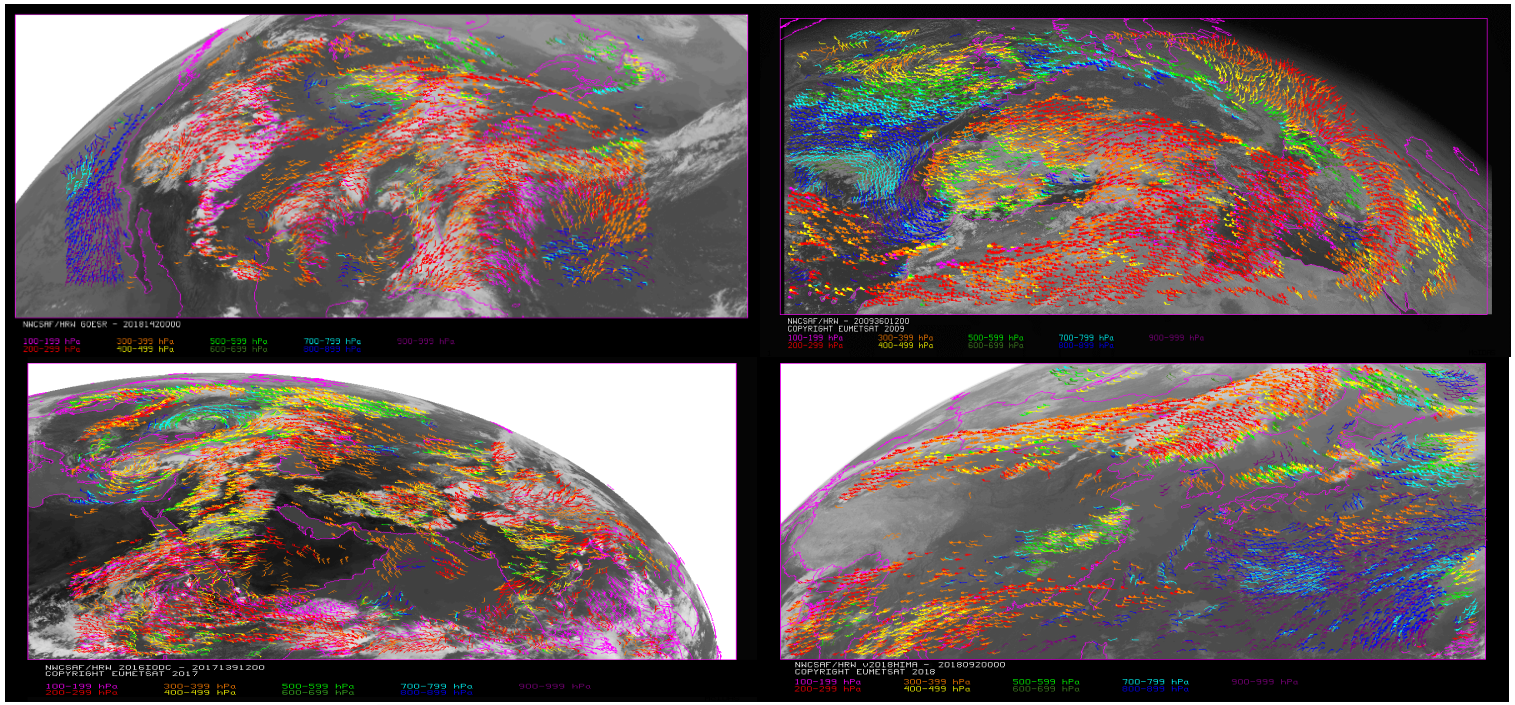
➔ Filtering of noisy data is needed using available "quality flags".

➔ A decision has been taken by NWCSAF Project Team to implement the official extension to GOES-17 satellite inside NWC/GEO v2018.2 during 2021.



NWC/GEO-High Resolution Winds v2018.1

- **Examples of NWCSAF/HRW with all possible regions:**
  - **Americas with GOES-16.**
  - **Europe and Africa with MSG.**
  - **West Asia with MSG/IODC.**
  - **East Asia, West Pacific with Himawari-8.**



Cases here for different moments, showing the maximum densities of AMVs

NWC/GEO-High Resolution Winds v2018.1

Considering the updates included in HRW v2018.1:

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

- This "New IWWG AMV BUFR"
  was defined by the "International Winds Working Group (IWWG)"
  as common output for all AMV datasets around the world.
- It includes more information than the "Heritage IWWG BUFR",
  and allows the common processing with
  other AMV datasets from other AMV producers.

HRW v2018.1 so provides up to four output options (configurable by the user):

- NWCSAF BUFR "NWC" (for continuity with all previous versions of HRW).
- Heritage IWWG BUFR "EUM"
- New IWWG BUFR "IWWG"
- NWCSAF NETCDF "NET" (available since v2016).

NWC/GEO-High Resolution Winds v2018.1

Considering the 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" not retuned for GOES-16,
  due to the small differences in the satellite channels with Himawari.
- Satellite input data: GOES-R NETCDF from NOAA.

Comparing the operability for all satellites (MSG, Himawari, GOES-13/16):

- Similar validation for all satellites:
  - Inside "Optimal accuracy" for High layer AMVs (100-400 hPa).
  - Inside "Target accuracy" for Medium and Low layer AMVs (400-1000 hPa).

NWC/GEO-High Resolution Winds validation

NWC/GEO-HRW AMVs is included in the "NWPSAF AMV Monitoring":

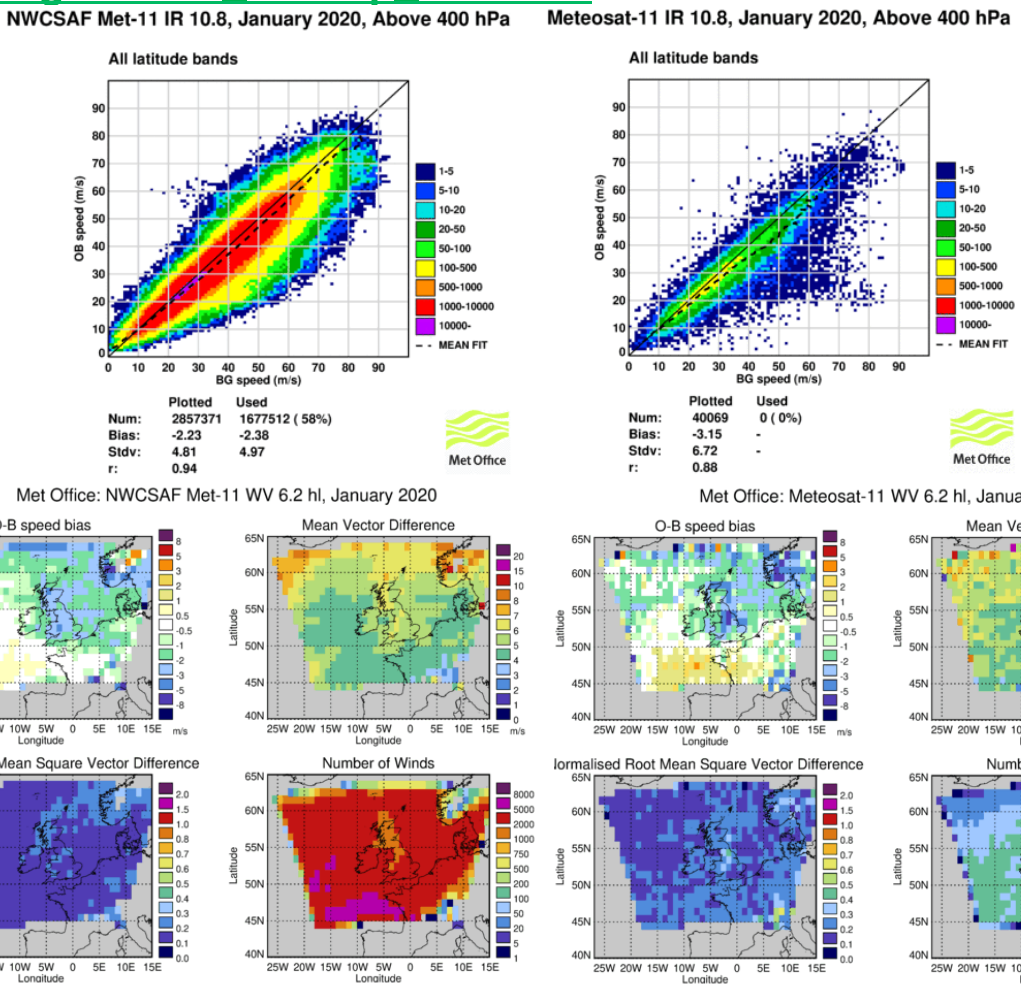
http://nwpsaf.eu/monitoring/amv/20_01/density_ukv.html

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

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

NWCSAF/HRW AMVs show in general:

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

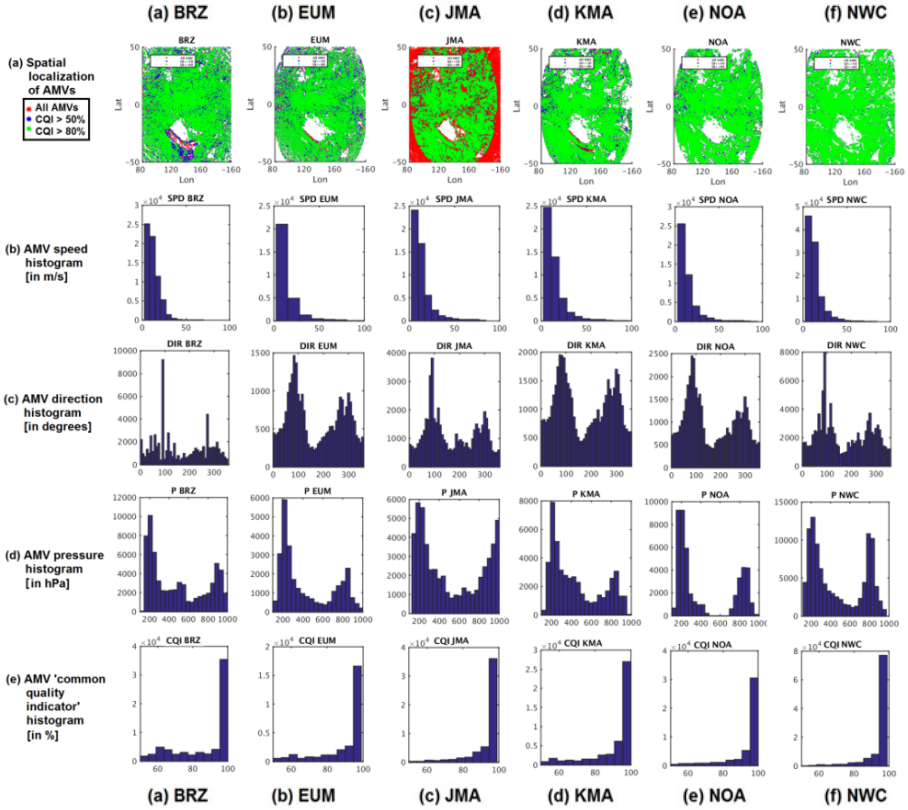


NWC/GEO-High Resolution Winds validation

NWC/GEO-HRW AMVs have also been included in the new "2018 AMV intercomparison study" by CIMSS/University of Wisconsin.

Operational AMVs were compared for triplets of images from Himawari-8 satellite for 21 July 2016, from next institutions:

- **BRZ:** Brazil Weather Forecast and Climatic Studies Center (CPTEC/INPE)
- **EUM:** EUMETSAT
- **JMA:** Japan Meteorological Agency (JMA)
- **KMA:** Korea Meteorological Administration (KMA)
- **NOA:** NOAA
- **NWC:** NWCSAF



NWC/GEO-High Resolution Winds validation

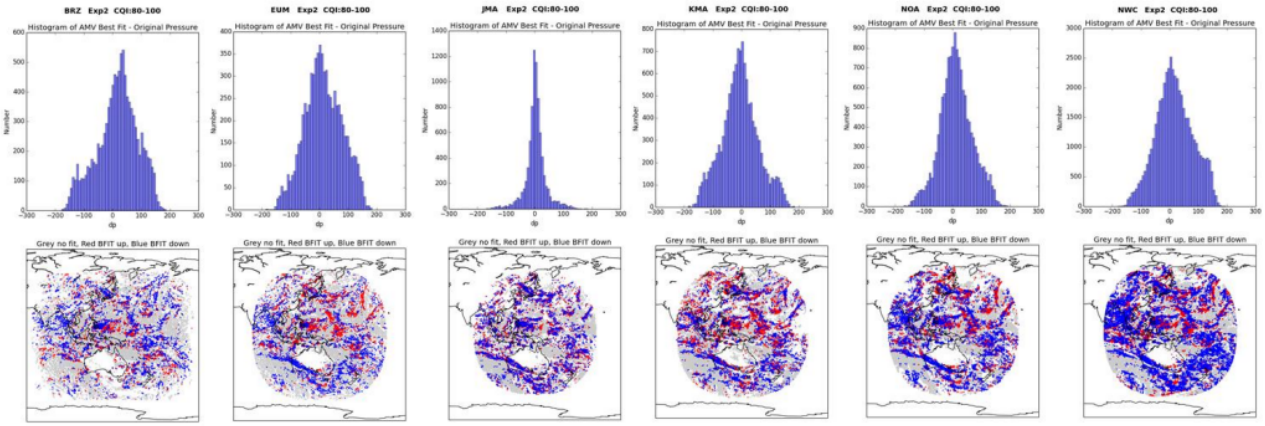
NWC/GEO-HRW AMVs are in 2nd position in the validation, after JMA AMVs

Validation of the AMV algorithms against Radiosonde winds (left) and NWP analysis winds (right) (21 July 2016, 1200-1220Z, Common Quality Index (CQI) > 80%)

	N	Pre Bias	Pre RMS	Spd Bias	Spd RMS	Dir Bias	Vec RMS
BRZ	619	1.16	13.44	−0.40	7.36	−14.65	9.80
EUM	366	−0.66	14.74	−2.20	6.15	8.43	8.56
JMA	270	−3.43	18.67	−1.40	4.64	−0.83	5.93
KMA	628	−0.84	14.30	−1.21	7.39	−2.66	8.97
NOA	599	−1.69	13.98	−0.88	5.25	0.39	7.52
NWC	2063	−1.19	16.19	−2.11	5.99	0.79	6.94

	VD	RMS
BRZ	5.73	8.35
EUM	4.00	5.17
JMA	2.27	2.80
KMA	3.92	5.25
NOA	3.53	4.42
NWC	3.55	4.24

The better results of the JMA AMVs are related to its "height assignment" (Optimal estimation method) with a better fit to the "best-fit pressure level":



(a) BRZ (b) EUM (c) JMA (d) KMA (e) NOA (f) NWC

HRW adaptation to polar satellites

A requirement from NWCSAF users has been shown in CDOP3 phase, so that NWCSAF/High Resolution Winds could be extended 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 readily available dataset of winds from polar orbiting satellites can satisfy this timeliness requirement.**

HRW adaptation to polar satellites

Considering this:

➔ **HRW will work also inside NWC/PPS software package**
calculating winds and trajectories from
reprojected polar images in a static region,
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
- NOAA-20 & S-NPP & JPSS/VIIRS
- EOS/MODIS

In later versions, also:
- FY-3/Mersi-2
- EPS-SG-A/MetImage

HRW adaptation to polar satellites

The plan for this work is:

➔ **Delivery of a "beta version of NWC/PPS-HRW"**
for evaluation and testing of the algorithm and its applicability
- First release to users throughout 2021.
- Prepared since Summer 2019
by Javier García-Pereda/AEMET & Nina Håkansson/SMHI.

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

HRW adaptation to polar satellites

NWC/PPS-HRW is based on:

- ➔ A reduced NWC/GEO library.
- ➔ 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!

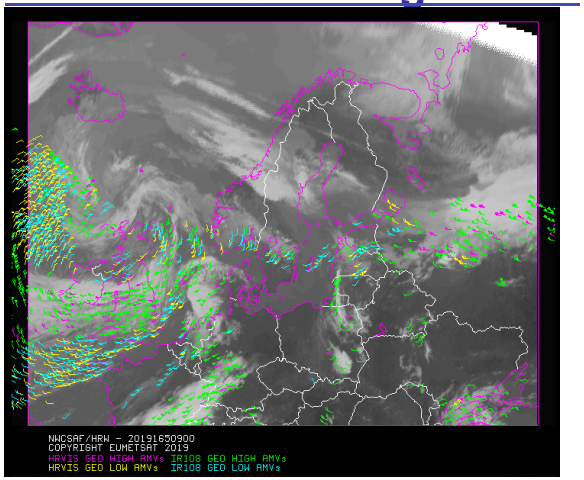
This way, results for NWC/PPS-HRW in much consonance with those for NWC/GEO-HRW!

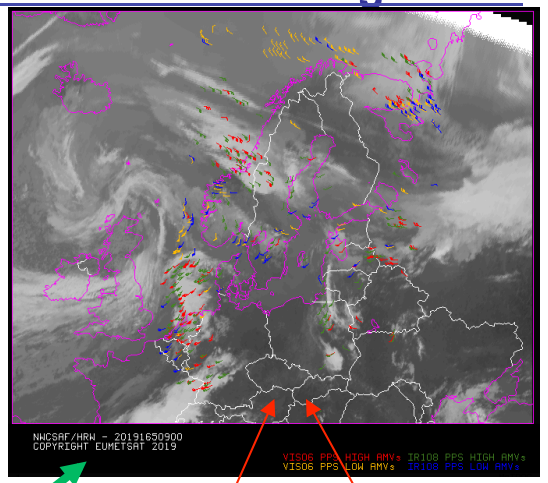
HRW outputs will be exactly equivalent for both GEO and PPS options.

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

HRW adaptation to polar satellites

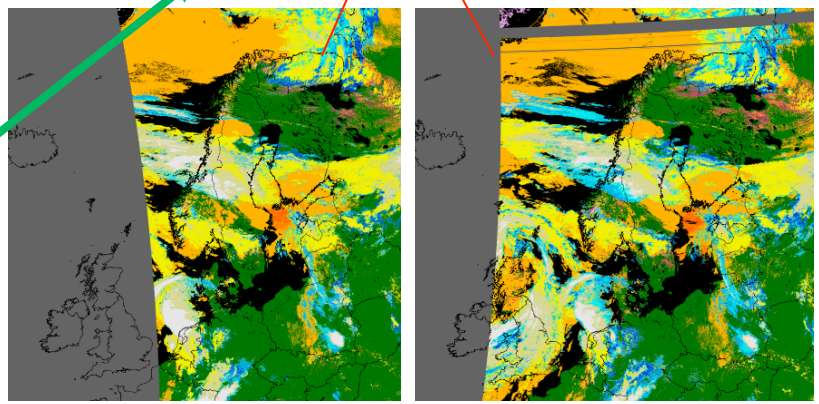
An example is shown for 14/June/2019 09:00Z comparing AMVs obtained by NWC/GEO-HRW algorithm and NWC/PPS-HRW algorithm:





For NWC/GEO-HRW with MSG,
the "North limit" is a configurable parameter
which can be extended a bit northwards
(although not too much).

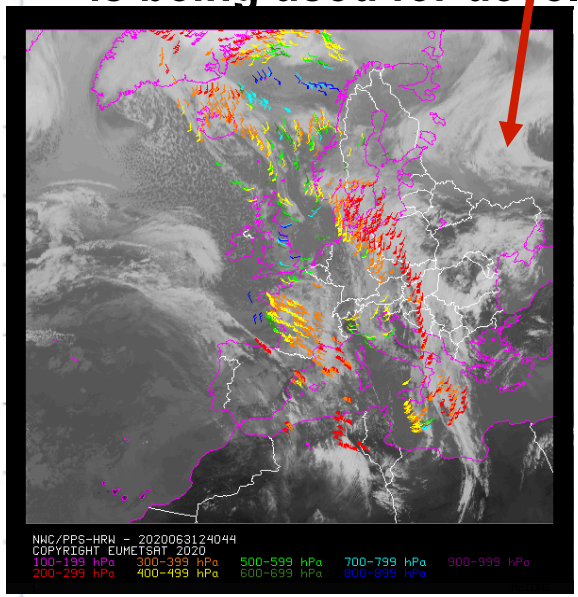
For NWC/PPS-HRW,
there is no "North limit" for AMV calculation,
although the AMV density is smaller
but still significant (calculating AMVs
only with VIS06/IR108 channels).

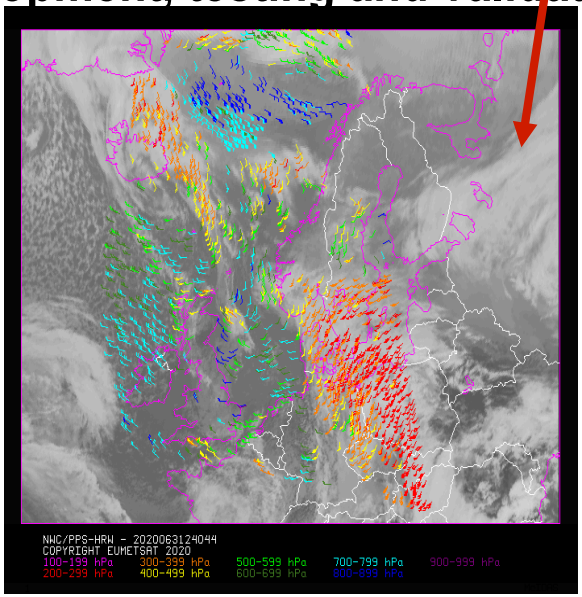


NWC/PPS-HRW AMVs can be obtained
in areas for which both "initial image" and "final image"
provide satellite & cloud (CT/CTTH) data.

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: Scandinavia region	NWC/PPS-HRW v7.P AMVs Feb'20-Apr'20, 11:00 - 13:00 UTC: Europe region	NWC/GEO-HRW v6.1 AMVs Jul'09-Jul'10, 12:00Z: 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 are in both cases better for high levels and worse for low levels.

Other developments with HRW up to 2022

(Up to the end of current CDOP3 phase)

1. NWC/GEO-HRW for MTG-Imager "version day 1":

➔ 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 with
  High resolution visible channels VIS06 and VIS08
  (good AMV densities, optimization of time processing,…)
- Additional improvement of AMV statistics at medium and low levels.

2. Work in the optimization/parallellization of HRW code.

Plans for CDOP4

Some comments/recommendations have already been received for HRW algorithm for CDOP4 (2022-2027) from:

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

From the 2019 NWCSAF Users Survey:

➔ **HRW well considered:**

- **Used by 55% of answers (second only to Cloud products)**
- **With a 7.8/10 rate (after only Cloud and Convective Rainfall products).**

Plans for CDOP4

Recommendations from the 2019 NWCSAF Users Survey:

1. AMVs/Trajectories very scarce at low levels

➔ The matter has been improved for MSG satellites in HRW v2018

- AMV proportions of 45% - 23% - 32% for MSG for High/Medium/Low levels.

➔ But this is still an issue for the new generation of satellites (with better pixel resolutions).

- AMV proportions for High/Medium/Low levels:

78% - 14% - 8% for Himawari 80% - 11% - 9% for GOES-R

Specific work has been defined for this inside NWC/GEO-HRW version for MTG-Imager.

Plans for CDOP4

Recommendations from the 2019 NWCSAF Users Survey:

2. HRW BUFR/NETCDF outputs should be rearranged (1 user)

➔ Considering HRW BUFR outputs, no modifications should be implemented:

- NWCSAF BUFR "NWC" to keep as it is
  for continuity with all HRW versions.
- New IWWG BUFR "IWWG"
  defined by the International Winds Working Group
  for common processing with other AMV producers.

➔ Considering HRW NETCDF output, much more flexibility is possible.

Plans for CDOP4

Recommendations from the 2019 NWCSAF Users Survey:

3. Distribution of HRW through Eumetcast (2 users).

➔ The big adaptability/configurability of HRW product to the user needs make us think it is difficult to define a HRW option valid for everybody.

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

Plans for CDOP4

Recommendations from the 2019 NWCSAF Users Survey:

4. Extension to additional Geostationary satellites beyond MTG

Ex.: GEO-KOMPSAT2 (1 user), FY-4 (1 user).

- 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 the moment) 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 CDOP4

Recommendations from the 2016/2018 International Winds Workshops:

1. Collaboration/share of software code with other AMV producers encouraged

   to compare AMV algorithms and produce consistent high quality products.

> A continuous contact is kept for this
> with the "International Winds Working Group (IWWG).

2. Investigation of:

   - "Error in the AMV displacement" through
     the size of the correlation surface used for the tracking in the later image.
   - "Nested tracking" technique.
   - "Stereo height assignment" technique (with "Visiting Scientist Activities").

> Inside the plans for CDOP4 phase.

Plans for CDOP4

Recommendations from the 2016/2018 International Winds Workshops:

3. Further studies to assess the value of winds from hyperspectral retrievals (winds and wind profiles from MTG-Sounder radiances or T/q profiles)

➔ From the several working groups in “winds from sounder satellites” it seems clear that the “optical flow” perspective is winning the deal. Considering this, it still needs to be checked if precision of sounder data is enough to calculate correct "optical flows".

➔ A feasibility study will also be considered to check how worthwhile it still is to calculate AMVs with MTG-Sounder data.

4. NWP community (MetOffice, MetNorway, DWD) and HRW software developers to define the optimal configuration for use in global/regional NWP models.

The work is starting now.

Conclusions

Options have been defined for HRW algorithm in next CDOP4 phase,

and many more are expected during this "NWCSAF Users Workshop".

Please help us to define what you might need,

and what might be most important for your use of HRW algorithm!

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

- ➔ **through email**
- ➔ **or at any moment during this Workshop.**

Thank you very much for listening!

Javier García-Pereda

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