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SUPPORT TO NOWCASTING AND VERY SHORT RANGE FORECASTING

NWCSAF/High Resolution Winds AMV Software for Geostationary and Polar satellites: Status in 2025

25 February 2025

NWCSAF 2025 Users' Workshop, Madrid

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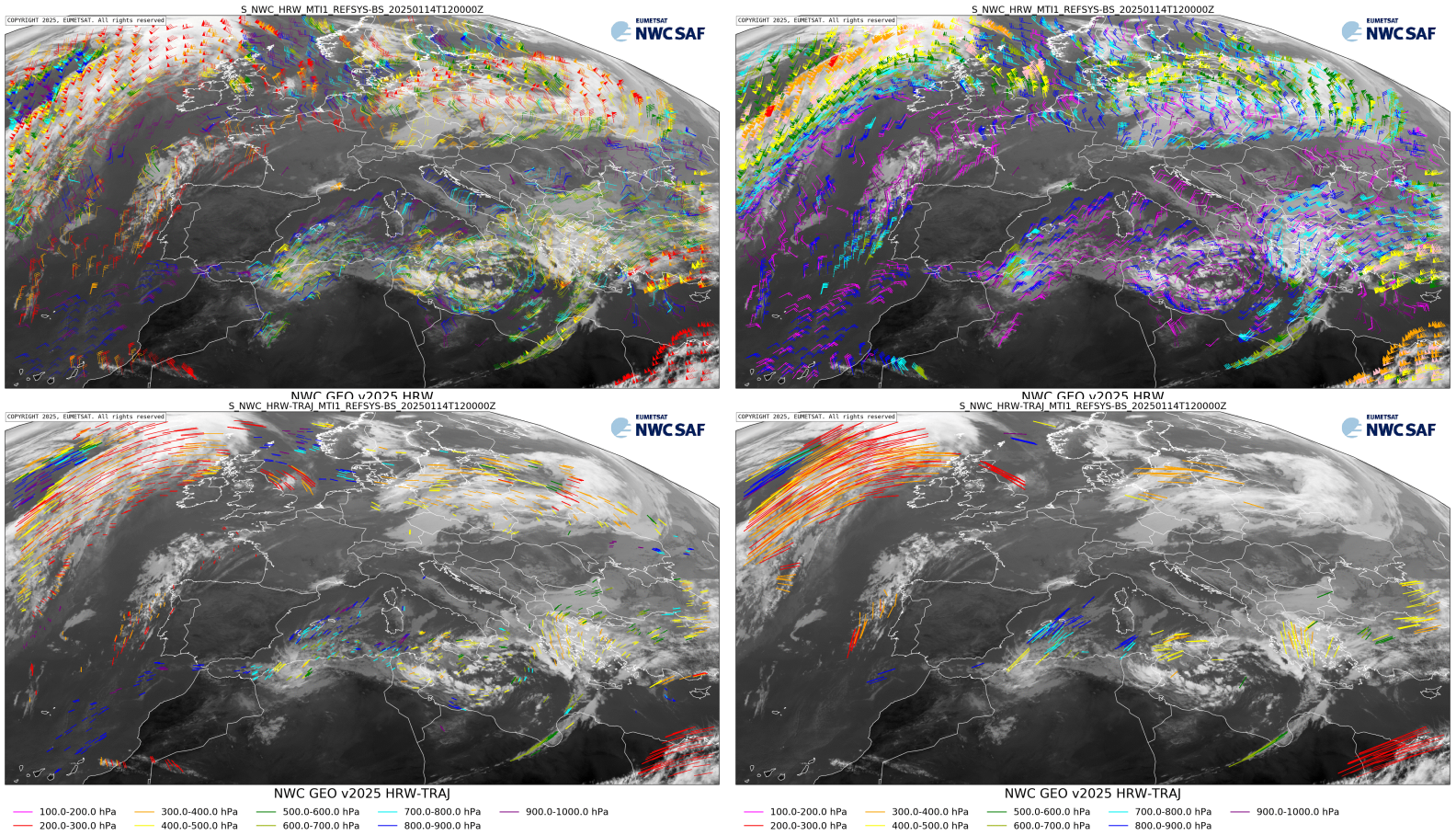
NWCSAF/High Resolution Winds for MTG-I

NWC/GEO-HRW provides "Atmospheric Motion Vectors (AMVs)" and "Trajectories" for several Geostationary satellites all around the world:

- MTG-I/MSG in Europe/Africa & Indian Ocean; Himawari-8/9; GOES-R West & East.



High Resolution Winds for MTG-I (NWC/GEO v2025, vMTG day-1), 14 January 2025 12:00Z

(AMVs considering level & speed (up); Trajectories for last 1 & 3 hours (down))

NWCSAF/High Resolution Winds for MTG-I

Updates in NWC/GEO-HRW v2025 (vMTG day-1).

Beyond the extension of the software to MTG-I satellite series we also have:

Changes in outputs:

1. Change from BUFRDC to ECCODES library
   for the Writing of BUFR output files (as recommended by ECMWF!)
2. Structure of netCDF output files now "CF compliant" and easier to process
   (as recommended by NWCSAF users!)

Changes in inputs:

3. Definition of Earth ellipsoid changing for different satellites,
   now defined as configurable parameters in different configuration files
   (previously similar for all satellites)
   ➔ Change affecting all NWC/GEO products.

NWCSAF/High Resolution Winds for MTG-I

Comparing AMV validation for MSG satellite and MTG-I satellite in the European region for the same period, using the default configuration:

NWC/GEO-HRW-v7.0 AMVs Validation in the European region against Radiosounding winds at 12:00Z (9 Oct 2024 – 8 Feb 2025)		MSG-3 satellite	MTG-I1 satellite
NC		414774	1089246
SPD [m/s]		17.24	20.09
NBIAS	(ALL LAYERS)	-0.05	-0.01
NMVD	(100-1000 hPa)	0.31	0.28
NRMSVD		0.40	0.37
NC		164645	597916
SPD [m/s]		24.65	25.42
NBIAS	(HIGH LAYER)	-0.05	-0.02
NMVD	(100-400 hPa)	0.26	0.26
NRMSVD		0.33	0.33
NC		106835	262297
SPD [m/s]		15.87	16.96
NBIAS	(MEDIUM LAYER)	-0.01	+0.02
NMVD	(400-700 hPa)	0.34	0.33
NRMSVD		0.42	0.40
NC		143294	229033
SPD [m/s]		9.73	9.80
NBIAS	(LOW LAYER)	-0.09	-0.02
NMVD	(700-1000 hPa)	0.42	0.39
NRMSVD		0.52	0.51

4 months of Validation at 12:00Z against Radiosounding winds (9 Oct 2024 – 8 Feb 2025)

* The number of AMVs with MTG-I is around 2.5 times the number for MSG (although the increment is more significant in the high & medium layer).

* This is caused by both:
  - The better resolution of MTG-I satellite.
  - The more powerful system defined for NWC/GEO vMTG day-1 processing (permitting narrower AMV densities).

Remark here to users:
Need of an important system upgrade, so that NWC/GEO software can fully exploit MTG-I satellite!

NWCSAF/High Resolution Winds for MTG-I

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4 months of Validation at 12:00Z against Radiosounding winds (9 Oct 2024 – 8 Feb 2025)

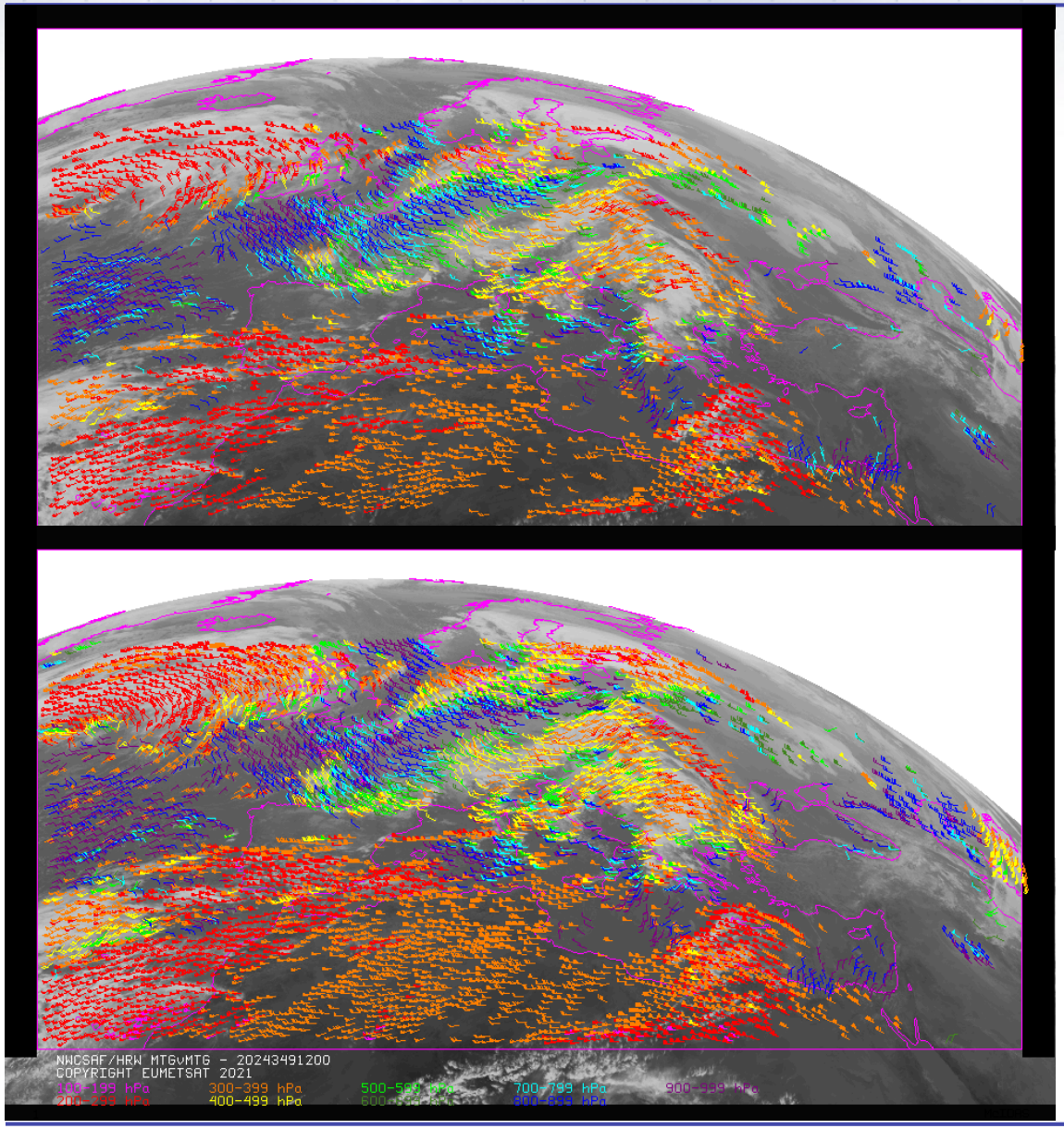
* Comparing the validation parameters for MTG-I AMVs with those for MSG:
  - NBIAS (normalized BIAS)
  - NMVD (normalized mean vector difference)
  - NRMSVD (normalized root mean square vector difference)

➔ The NBIAS is especially less negative, although this seems to have some dependence on the validation period.

➔ The NMVD and NRMSVD are similar or slightly better.

* This way, for both MSG and MTG-I satellites, the validation is for all layers inside the defined "Target accuracies".

NWCSAF/High Resolution Winds for MTG-I



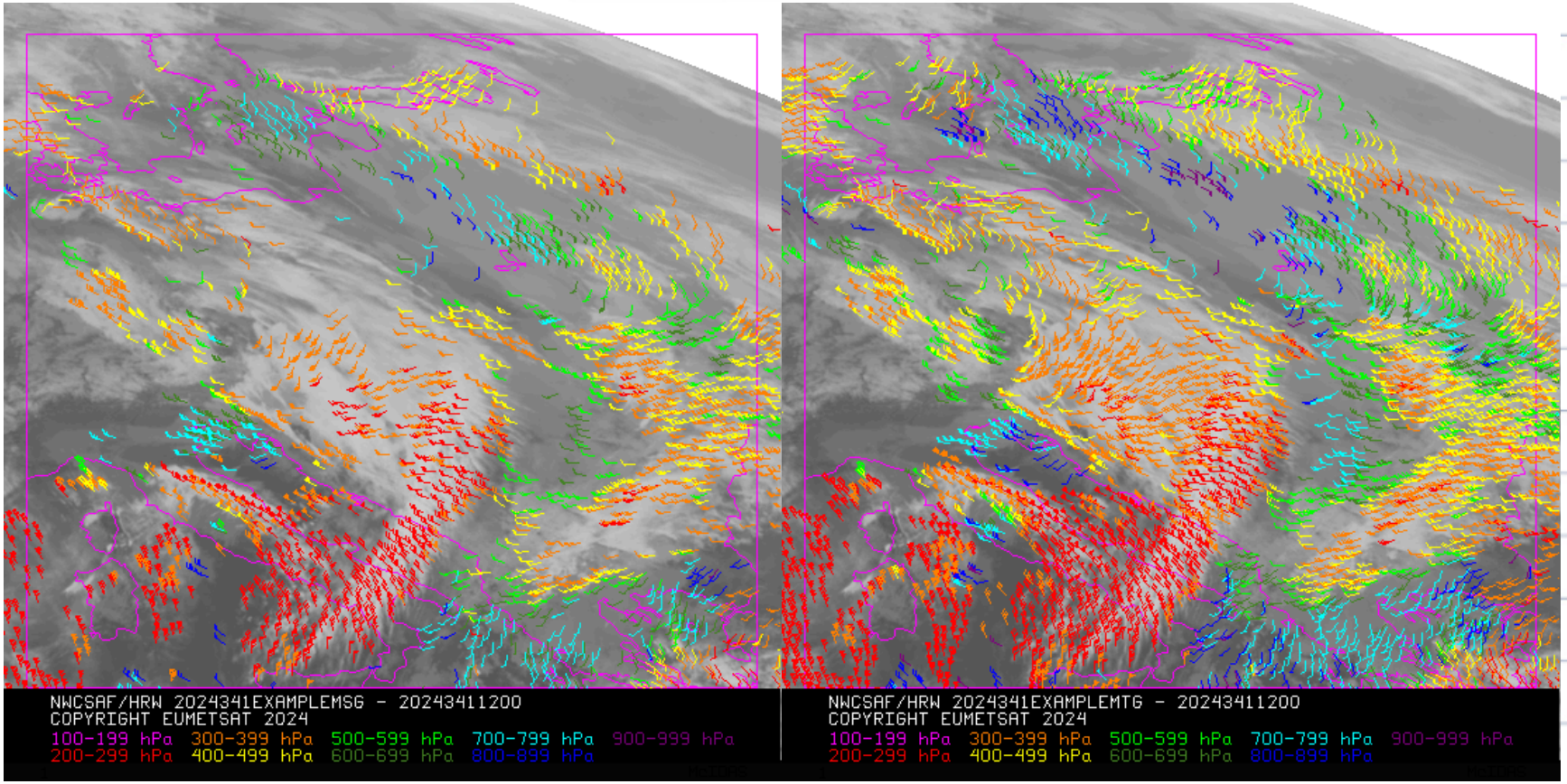
Comparing HRW outputs for MSG (up) and MTG-I (down): (AMVs at 12:00Z for 15 December 2024):

- ➔ The higher density of MTG-I AMVs can be seen visually.
- ➔ Main difference in the AMV outputs:
  - Low level MTG-I AMVs are frequently at a lower level, but this can be related to their better validation statistics.

NWCSAF/High Resolution Winds for MTG-I

Looking a few cases with more detail:

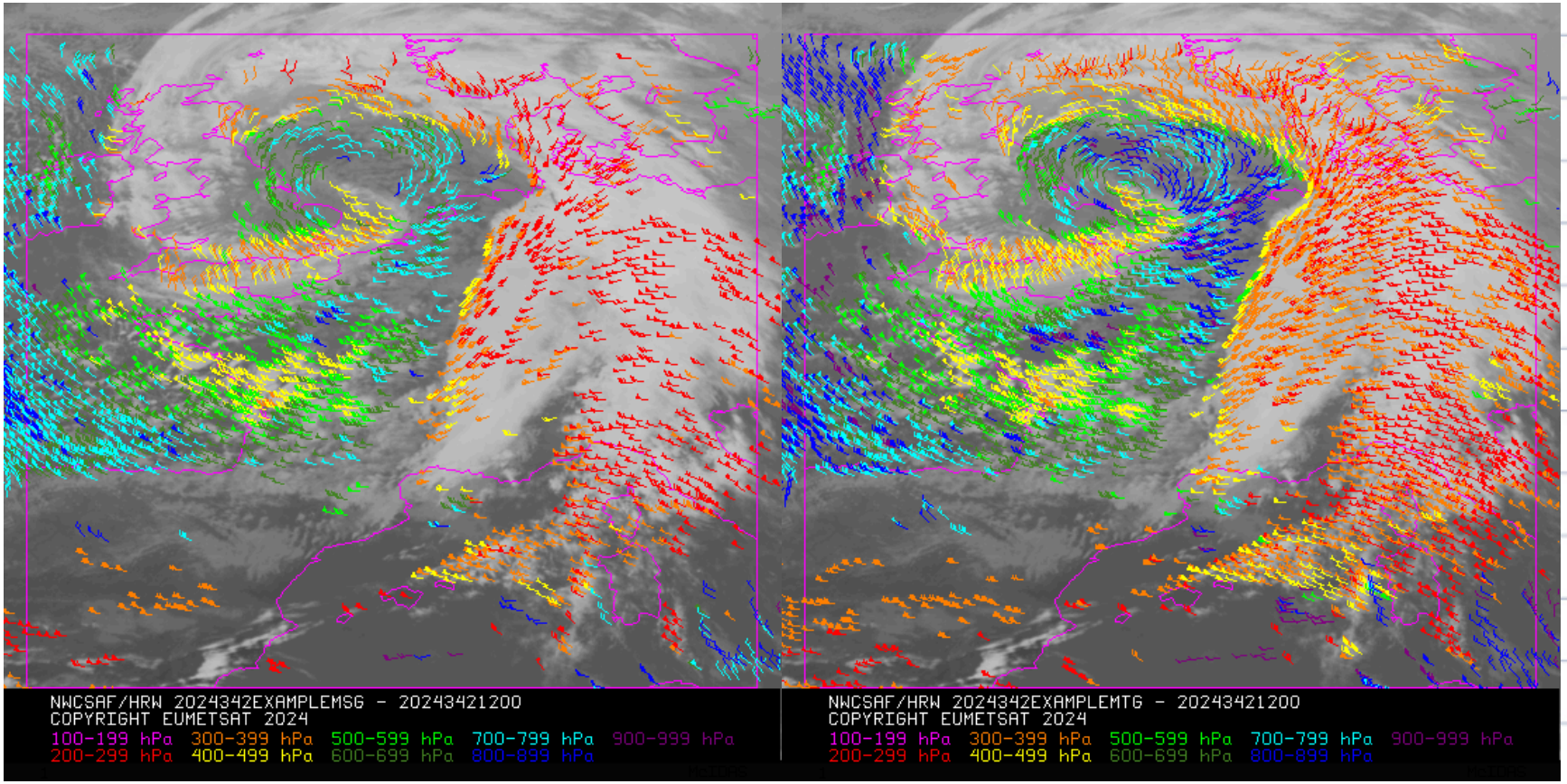
06 December 2024, 12:00Z (MSG on the left; MTG-I on the right)



➔ **The wind flow in Eastern Europe (Poland, Slovakia, Hungary) is much better covered with MTG-I, filling in general the AMV holes shown by MSG.**

NWCSAF/High Resolution Winds for MTG-I

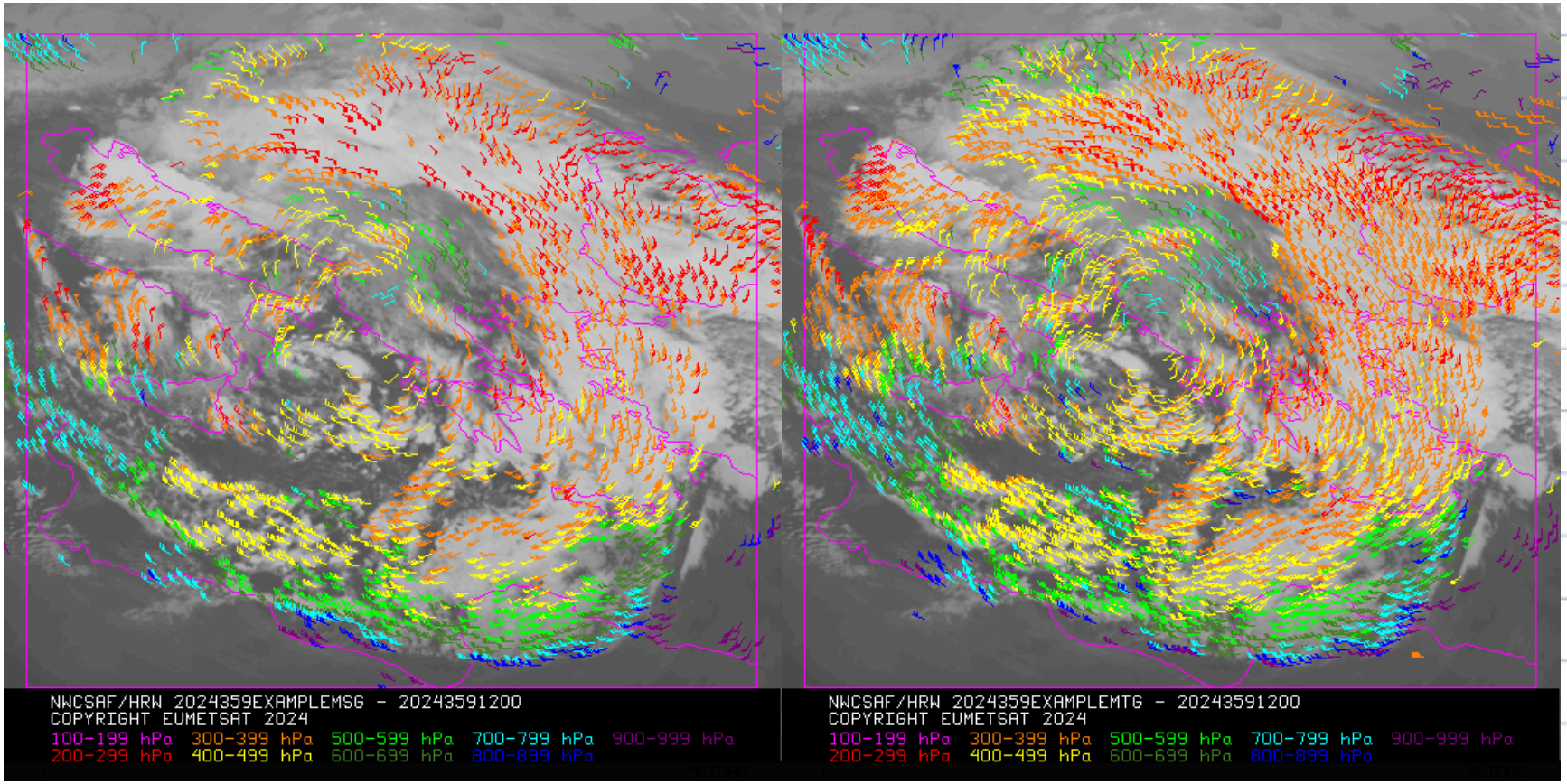
07 December 2024, 12:00Z (MSG on the left; MTG-I on the right)



➔ The AMV coverage and the wind flow around the North Sea low is much better with MTG-I, although there are still some holes (f.ex. Scotland, Wales)

NWCSAF/High Resolution Winds for MTG-I

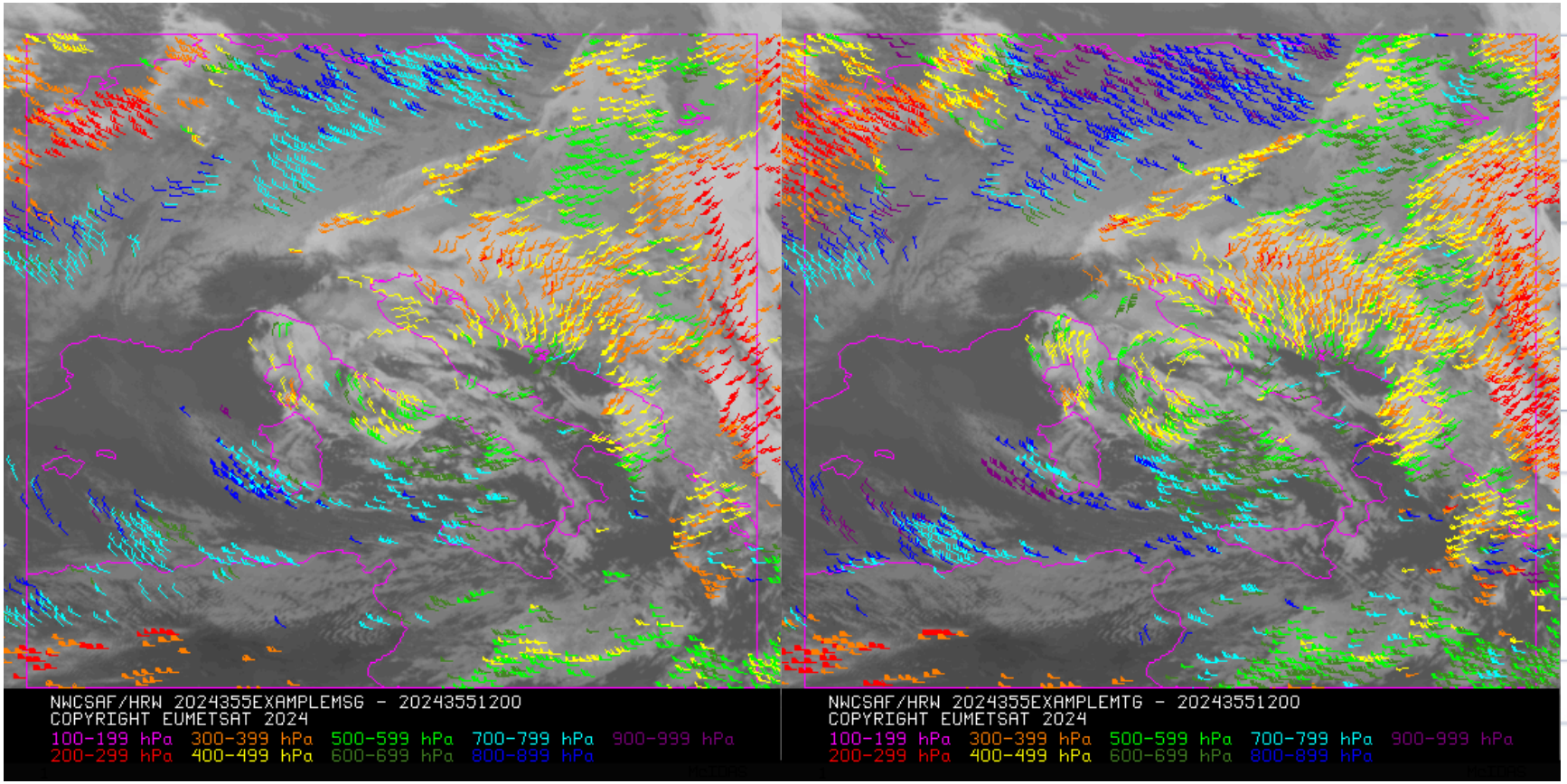
24 December 2024, 12:00Z (MSG on the left; MTG-I on the right)



➔ A very good example of a low over Greece where MTG-I defines very well the flow from all directions with very good AMV densities, and fills very well all MSG AMV holes

NWCSAF/High Resolution Winds for MTG-I

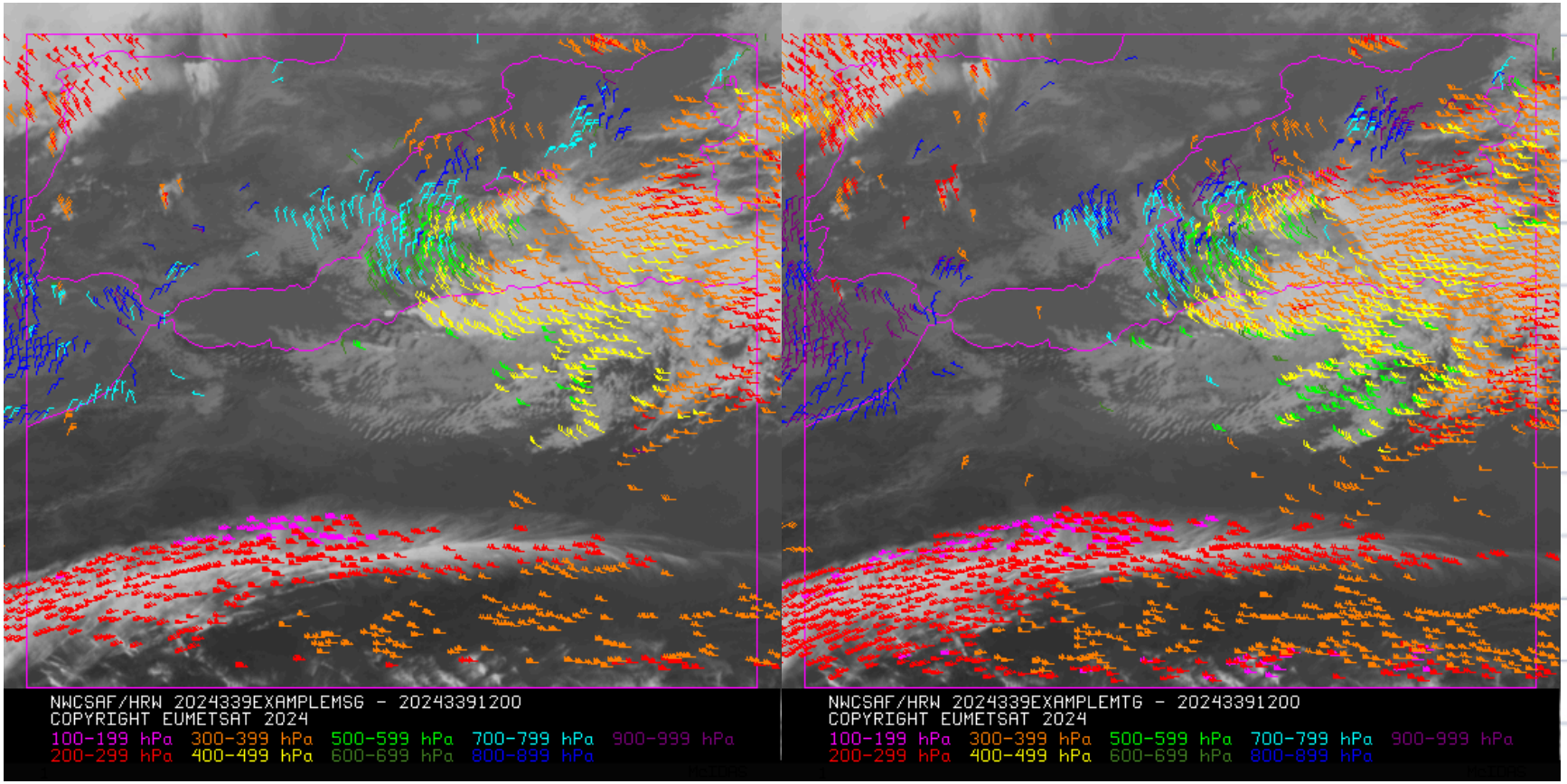
20 December 2024, 12:00Z (MSG on the left; MTG-I on the right)



➔ **The AMV coverage and the wind flow around this low over Italy is also better with MTG-I, although here the difference between both images is smaller and more holes are noticeable**

NWCSAF/High Resolution Winds for MTG-I

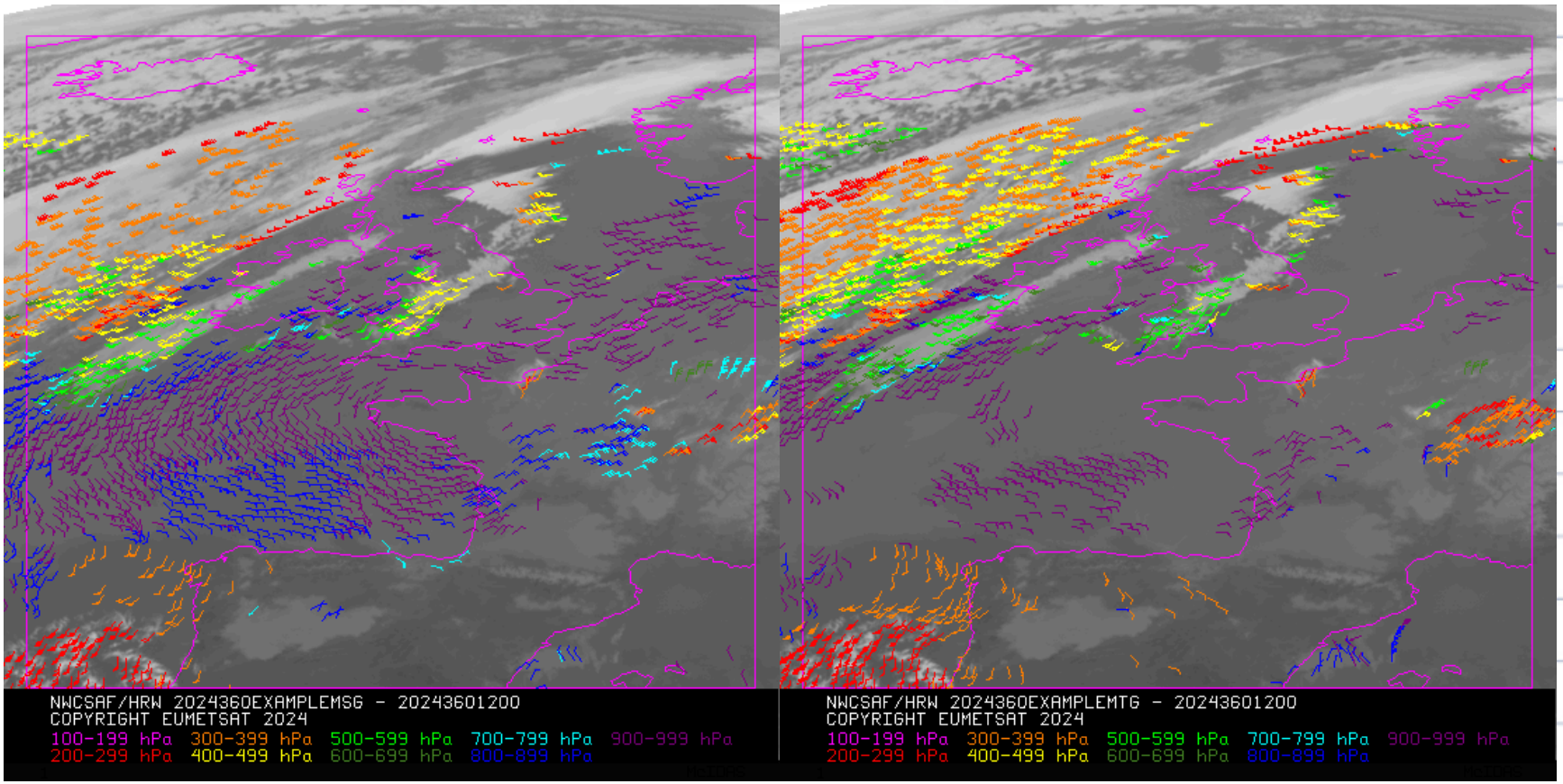
4 December 2024, 12:00Z (MSG on the left; MTG-I on the right)



➔ Better definition of the subtropical jet over the Sahara Desert

NWCSAF/High Resolution Winds for MTG-I

25 December 2024, 12:00Z (MSG on the left; MTG-I on the right)



But there are also a few cases for which MSG output is better (generally related to low level flow)

➔ **Flow around the western side of the anticyclone, over the Bay of Biscay.**

With all this, the validation process
for NWC/GEO-HRW v2025 (vMTG day-1) is positive for all GEO satellite series,
and it is expected that it passes successfully the final ORR2 review
(review meeting on 6th May in Darmstadt)

Summary of Validation statistics for NWC/GEO- HRW v7.0, related to the Operative thresholds defined in the HRW Product Requirement Table (against Radiosounding winds)	High Layer NRMSVD	Medium Layer NRMSVD	Low Layer NRMSVD
NWC/GEO-HRW v7.0, Default configuration, MSG	0.33	0.42	0.52
NWC/GEO-HRW v7.0, Default configuration, MTG-I	0.33	0.40	0.51
NWC/GEO-HRW v7.0, Default configuration, Himawari-8/9	0.31	0.44	0.54
NWC/GEO-HRW v7.0, Default configuration, GOES-16	0.33	0.43	0.49
NWC/GEO-HRW Product Requirement Table Optimal Accuracy	0.30	0.40	0.45
NWC/GEO-HRW Product Requirement Table Target Accuracy	0.36	0.48	0.54
NWC/GEO-HRW Product Requirement Table Threshold Accuracy	0.42	0.56	0.63

NWCSAF/High Resolution Winds for polar satellites

NWCSAF already delivered to users
two versions of its NWC/PPS-HRW software for polar AMVs:

- ➔ NWC/PPS-HRW v7.P (inside NWC/PPS v2021 software in November 2021).
- ➔ NWC/PPS-HRW v7.Q (inside NWC/PPS v2021.3 software in March 2023).

AMVs calculated considering
polar images projected into static regions of different sizes and resolutions,
in a similar way to what is done by NWC/GEO-HRW for geostationary satellites.

- ➔ 90% of the code is exactly equivalent for both implementations.
- ➔ HRW outputs equivalent for both geostationary and polar AMVs.

Someone using NWC/GEO-HRW can use NWC/PPS-HRW very quickly!

NWCSAF/High Resolution Winds for polar satellites

Updates in latest version NWC/PPS-HRW v7.Q:

➔ Processing of AMVs extended to 16 polar satellites
with AVHRR-3, VIIRS, MODIS, MERSI-2 (new!) and SLSTR (new!) radiometers.
(AMVs with any combination of images from all these satellites!).

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.

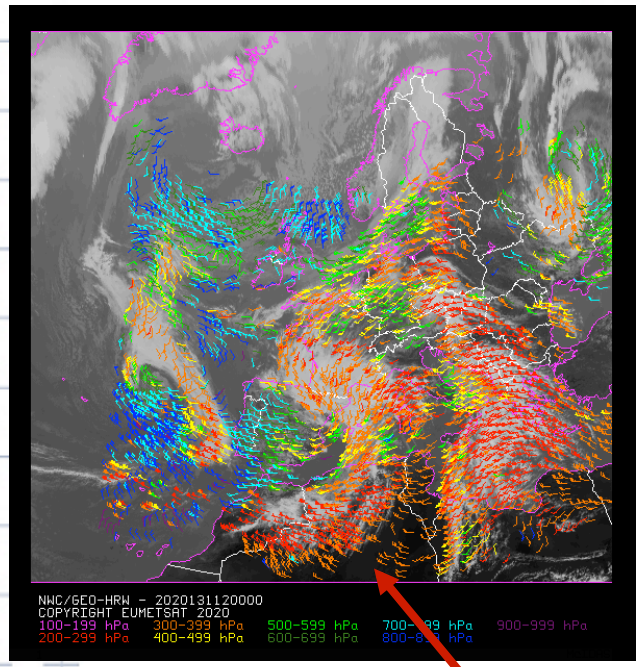
➔ AMV calculation: VIS and IR channel cloudy AMVs.
MODIS/WV067 cloudy and clear air AMVs (new!),
MERSI-2 & MODIS/WV073 cloudy and clear air AMVs (new!).

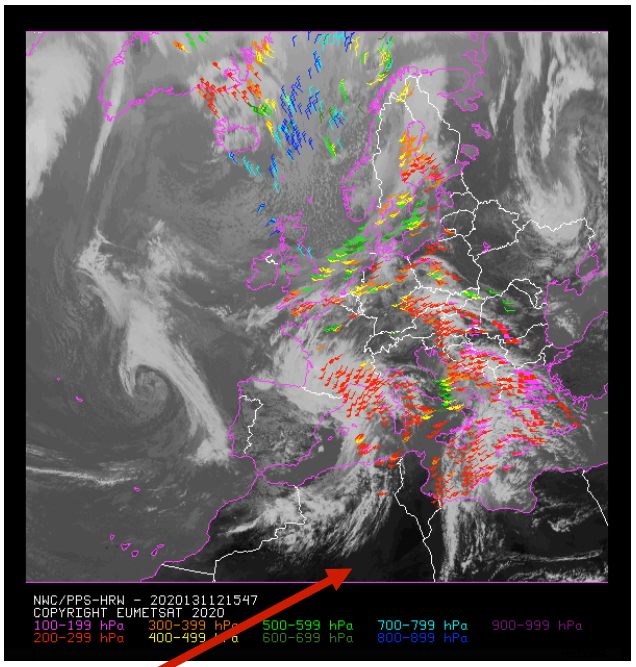
➔ Many running parameters of NWC/PPS-HRW retuned:
better AMV densities (4 times more AMVs!) and fewer holes in the coverage.

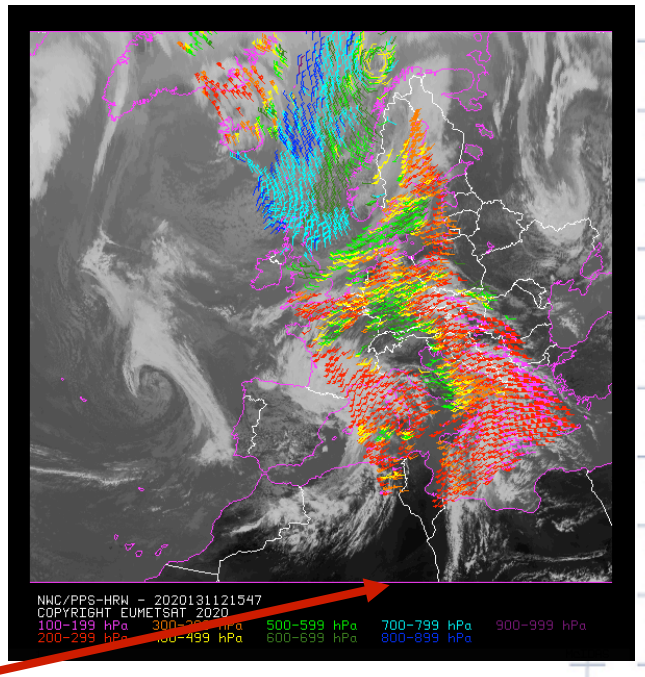
NWCSAF/High Resolution Winds for polar satellites

Comparing (for 10 May 2020, 1200UTC):

NWC/GEO-HRW | **NWC/PPS-HRW 1st version** | **NWC/PPS-HRW 2nd version**







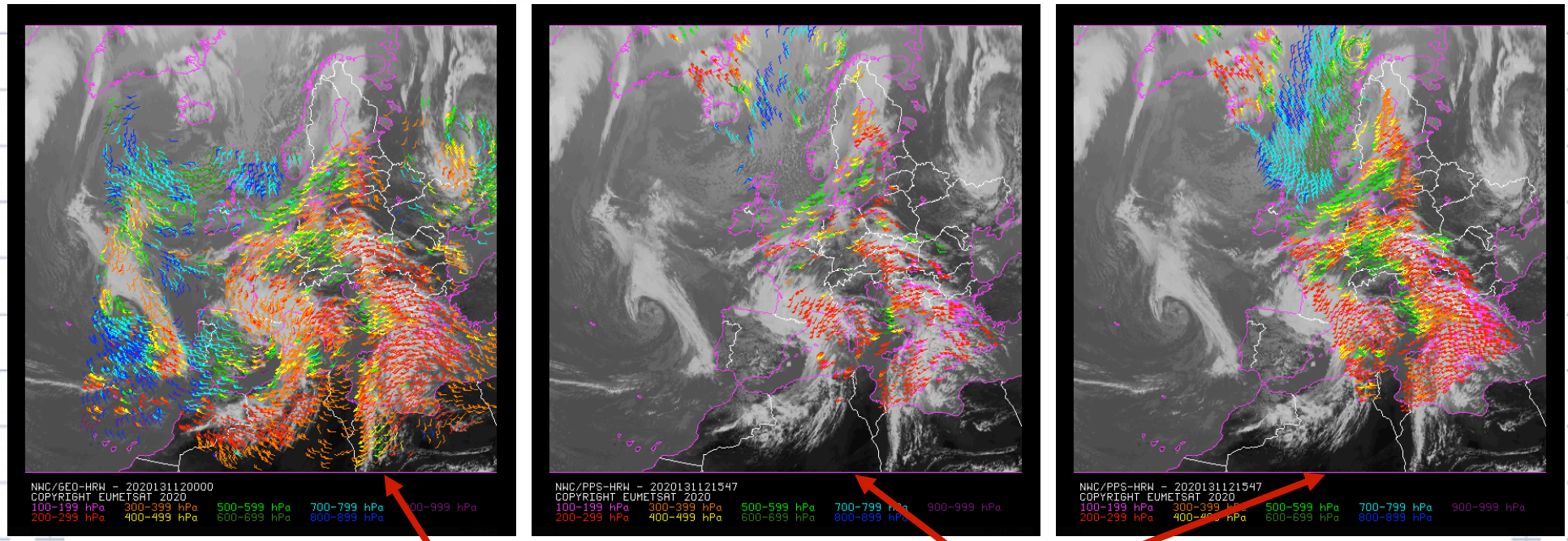
➔ For NWC/GEO-HRW, the "satellite zenith angle" defines a geographical limit (around ≈ 65º latitude) for the AMV calculation.

➔ For NWC/PPS-HRW, there are no geographical limits for the AMV calculation, but AMVs can only be obtained in areas for which both initial image & final image provide satellite & NWC/PPS-Cloud (CT/CTTH/CMIC) data.

NWCSAF/High Resolution Winds for polar satellites

Comparing (for 10 May 2020, 1200UTC):

NWC/GEO-HRW | **NWC/PPS-HRW 1st version** | **NWC/PPS-HRW 2nd version**



➔ **The AMV spatial density in the first polar HRW version was smaller, but it is very similar comparing the second polar HRW version and the geostationary HRW version due to the mentioned retuning of its running parameters.**

Comparing AMV validation between Geostationary and Polar HRW versions in Europe:

Validation in the European region against Radiosounding winds	NWC/GEO-HRW v2021 (v6.2) Jul'09-Jun'10, 12:00Z	NWC/PPS-HRW v2021 (v7.P) Apr'20-Jun'20, 11:00Z-13:00Z	NWC/PPS-HRW v2021.3 (v7.Q) Apr'20-Jun'20, 11:00Z-13:00Z
NC	1164357	109905	413478
SPD [m/s]	15.54	19.08	17.64
NBIAS (ALL LAYERS)	-0.07	-0.05	-0.02
NMVD (100-1000 hPa)	0.33	0.36	0.34
NRMSVD	0.40	0.44	0.41
NC	407408	66059	191243
SPD [m/s]	22.28	24.29	23.28
NBIAS (HIGH LAYER)	-0.04	-0.06	-0.03
NMVD (100-400 hPa)	0.26	0.34	0.33
NRMSVD	0.32	0.40	0.38
NC	377043	25985	124906
SPD [m/s]	13.99	12.90	13.94
NBIAS (MEDIUM LAYER)	-0.07	-0.03	-0.02
NMVD (400-700 hPa)	0.36	0.40	0.36
NRMSVD	0.44	0.48	0.43
NC	379906	17861	97329
SPD [m/s]	9.86	8.79	11.33
NBIAS (LOW LAYER)	-0.10	-0.02	-0.02
NMVD (700-1000 hPa)	0.42	0.48	0.34
NRMSVD	0.49	0.55	0.40

➔ The improvement between the first and the second polar HRW version is clear:
4 x AMVs with better validation parameters.

➔ NWC/PPS-HRW AMV validation inside the defined "Target accuracy" in all layers.

➔ Comparing the Geostationary version and the second Polar version:

- Statistics for the whole dataset of AMVs are comparable (with GEO AMVs better at the high layer; Polar AMVs better at the low layer).
- Polar AMVs are more frequent in the high layer.

Main objective for NWCSAF/PPS-High Resolution Winds up to 2027:

To be declared operational also for polar satellites

➔ **Currently, NWC/PPS-HRW status is only demonstrational.**

➔ **A replanning has been done for NWCSAF CDOP4 phase, so that NWC/PPS-HRW can be declared operational:**

- **Corresponding Requirements Review (RR) has just taken place.**
- **Product Consolidation Review (PCR)/Delivery Readiness Review (DRR) after release of NWC/PPS vEPS-SG-A day-1 (planned for Q3 2026).**

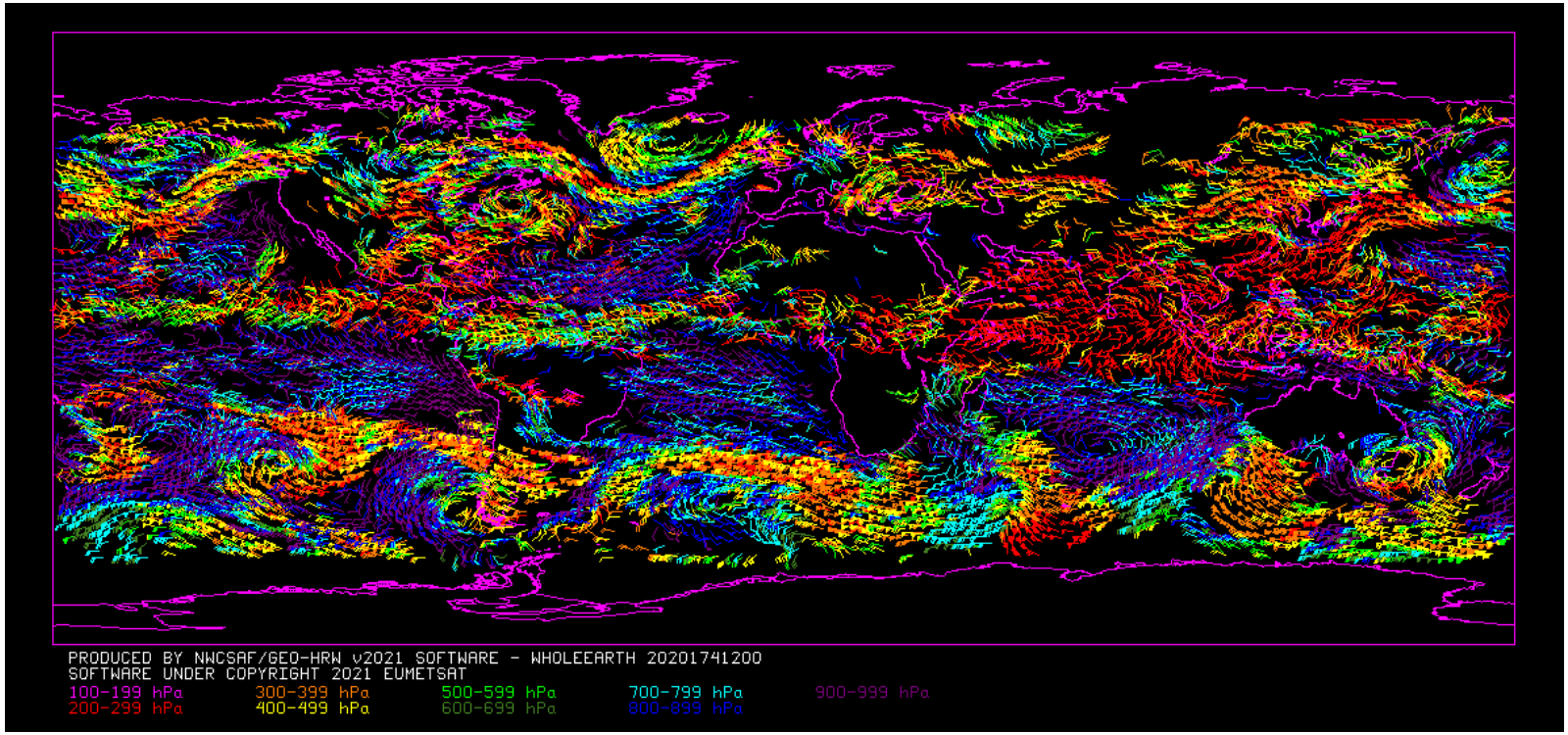
NWCSAF/High Resolution Winds climatic data

With both options (NWC/GEO-HRW and NWC/PPS-HRW)

the user is able to obtain with a high update frequency

AMVs with the same algorithm in all corners of the world:

- ➔ **4-6 times per hour throughout the geostationary ring (GOES-R W+E, MTG-I/MSG in Europe/Africa & Indian Ocean, Himawari-8/9).**
- ➔ **Up to several times per hour (depending on latitude) with polar satellites**



(Example of NWC/GEO-HRW calculating AMVs in all regions of the world with 5 geostationary satellites)

NWCSAF/High Resolution Winds climatic data

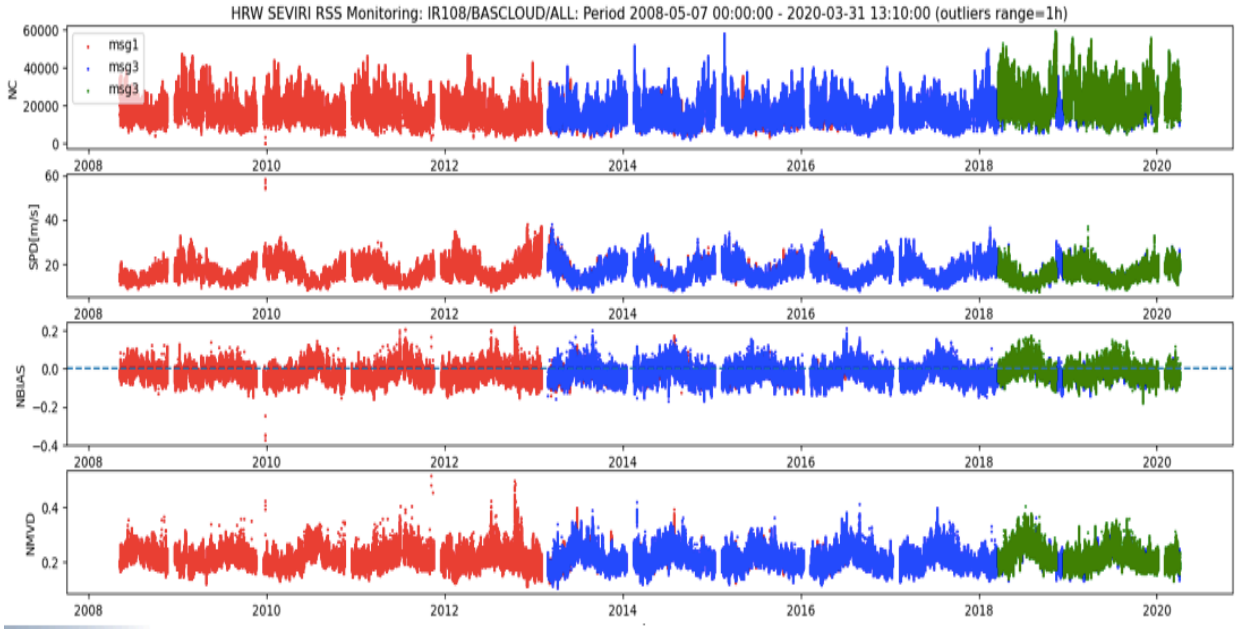
Global AMVs coming from the same source (software) can be important for:

➔ **NWP assimilation in global models (including reanalysis).**

➔ **Climatic studies.**

Alessio Lattanzio (alessio.lattanzio@eumetsat.int)

has created f.ex. a "Climate Data Record (CDR)" for NWC/GEO-HRW with MSG/Rapid Scan data (2008-2020):

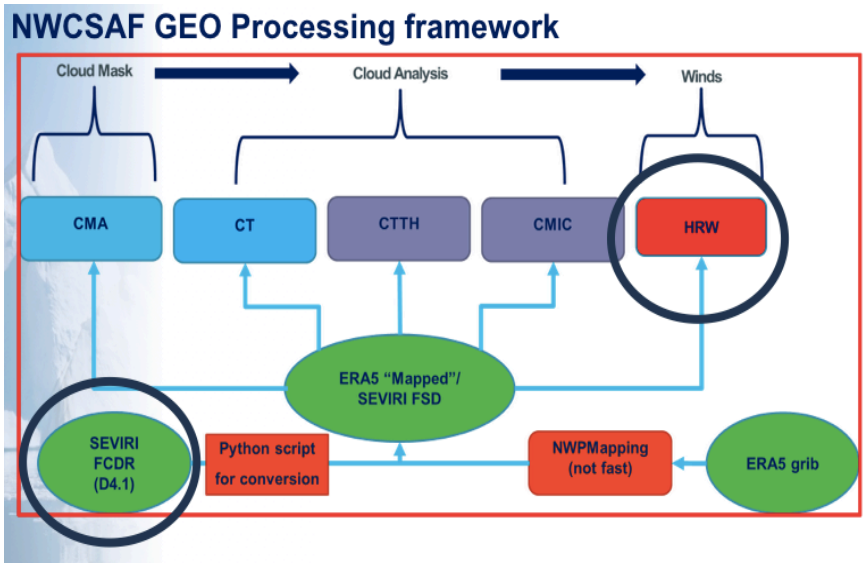


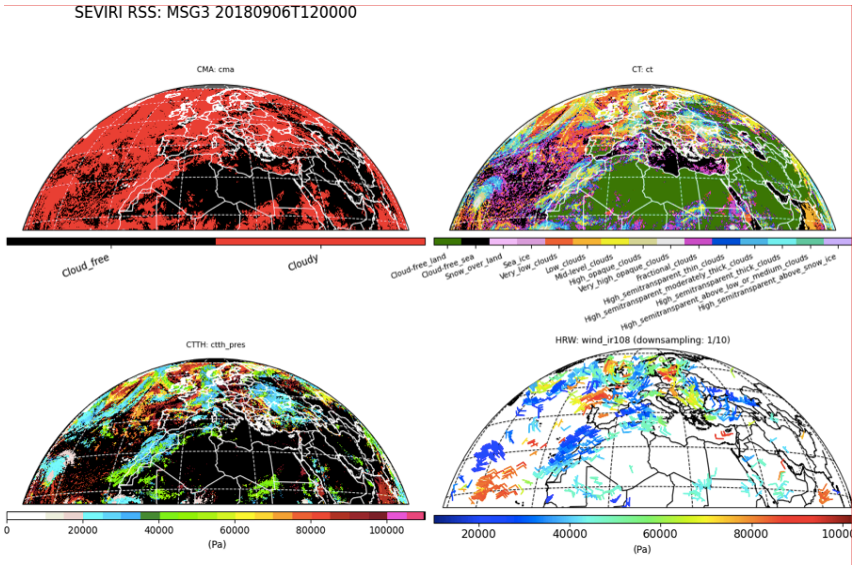
Interruptions due to RSS service schedule (stopping 2 days every 28 and 1 month every 12) and unprogrammed interruptions (≈ once every year)

Statistics for "NWC/GEO-HRW AMV Climate Data Record" considering: MSG1 MSG2 MSG3

NWCSAF/High Resolution Winds climatic data

The process implied the running of NWC/GEO v2021.3 Clouds + HRW inside the "EUMETSAT Reprocessing Framework"
(100 CPUs, 1TB of RAM for a total processing of 25 days)





SSP 9.5E - DOI: TBD (Q2/2025)					
Contains geolocation speed, direction, quality index, zonal and meridional speed, ancillary information					
Satellite	**Start date**	**End date**	**products**	**NC (TB)**	**BUFR (TB)**
Meteosat-8 (MSG1)	2008-05-06	2016-06-30	387768	7.8	3.7
Meteosat-9 (MSG2)	2013-02-27	2020-04-02	443682	8.9	4.2
Meteosat-10 (MSG3)	2018-03-20	2020-04-03	158728	4	1.9

Inputs: - SEVIRI RSS recalibrated CDR (D4.1)
(converted with Python for NWC/GEO use)
- ERA5 ECMWF NWP Reanalysis

HRW Climate Dataset Record (CDR)
available to users in Q2 2025.

Other activities in CDOP4 phase (up to 2027)

1. A Visiting Scientist Activity (VSA) takes place in 2025

with University of Maryland for:

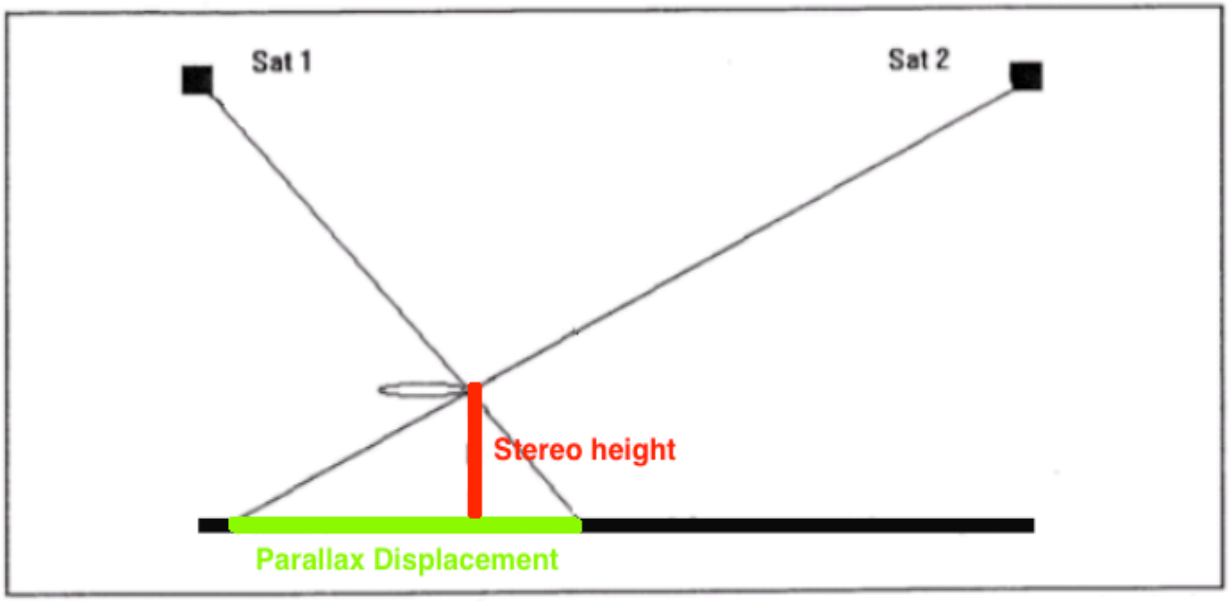
➔ Calculation of the "AMV stereo height assignment" with MTG-I & GOES-East

(considering the "parallax displacement of an AMV"

observed by two GEO satellites in two different locations):

- Purely geometric method, with limited and known errors,

but not applicable everywhere.



Other activities in CDOP4 phase (up to 2027)

2. Another version of NWC/GEO software expected during current CDOP4 phase.

Main objectives for NWC/GEO-HRW product:

➔ **Improvements due to updates in NWC/GEO-Cloud products:**

- Stratiform/cumuliform cloud separation.
- Better assessment of multilayer clouds/semitransparent clouds.
- Possible CTTH for fractional clouds, possible CMIC for night conditions.
- Possible calculation of Cloud base.

➔ **Calculation of the "error in the AMV displacement"**

➔ **Additional optimizations in:**

- Distribution of AMVs in the different layers.
- Time processing of the software.

Plans for CDOP5 phase (2027-2032)

Some comments/recommendations have already been received for "NWCSAF winds products" for CDOP5 phase (2027-2032) from:

➔ 2024 NWCSAF Users Survey (with 64 answers)

NWC/GEO-HRW product well considered:

➔ Used by 48% answers.

> Similar to Precipitation and Convection products (Cloud products being used by >85% answers)

With a 7.9/10 rate.

For all possible tasks:

> Research/Forecasting/Warning/Assimilation in NWP models.

With all possible satellites:

> MSG, Himawari, GOES-R

5 cases for NWC/GEO-HRW

1 additional case for NWC/PPS-HRW

➔ Requested for continuation by 50% answers.

➔ Other requests: Winds/Wind profiles from MTG-S/IRS (62% answers)

Adaptation to other sensors: FY-4B, GEO-KOMPSAT-2 (1 user each)

Conclusions

Please help us to define your needs from "NWCSAF winds products" at this "NWCSAF Users Workshop" through:

- ➔ the Working Groups on Wednesday
- ➔ the "Google docs" links for Requirements for following phase (provided by email).

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

<jgarciap@aemet.es>