New developments in the High Resolution Winds Product (HRW), at the Satellite Application Facility on support to Nowcasting and Very short range forecasting (NWCSAF)

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Main characteristics of HRW v3.0

- The Satellite Application Facility on support to Nowcasting and Very short range forecasting (NWCSAF):
  - Was established between Eumetsat and Aemet (Spanish Nat. Weather Service)
  - Develops and maintains a software package calculating in near real time several meteorological products from MSG & Polar satellite data, and supports users on its handling.
- An AMV product is available among its products (High Resolution Winds, HRW):
  - Objective: to provide users locally detailed sets of AMVs, for near realtime applications.
  - Since HRW v3.0 (available to users since Spring 2010, in few weeks), the product calculates AMVs from both MSG/HRVIS and MSG/IR108 data, with the satellite working in both 'Nominal scan mode' and 'Rapid scan mode'.
  - An optimization included in HRW v3.0 has reduced algorithm running time to calculate winds in both channels (HRVIS & IR108) in ~2 min. in National areas, and ~6 min. in Continental areas.

Main characteristics of HRW v3.0

Main characteristics (explained in the previous Winds Workshops):

- Tracer calculation with two different methods:
  - Gradient (searching well defined edges).
  - Tracer characteristics (filling holes in the coverage).

- Height assignment: two different height levels dependent on NWCSAF/Cloud type:
  - Cloud top: IR108 brightness temperature of the coldest class in the tracer smoothed temperature histogram, with at least 3 pixels.
    > Used with "High semitransparent thick and meanly thick clouds".
  - Cloud base: with $T_{Base} = T_{Average} + K \cdot \sigma_{Cloud}$, with "K" different for HRVIS & IR108.
    > Used with all other valid cloud types.

- Tracer tracking / Wind calculation: Selection of up to three correlation centres with Euclidean differences or Cross correlation methods.

- Quality control: using Eumetsat Quality Indicator method.
  - Including temporal, spatial, forecast tests.

- Orographic flag test: tracers affected by land influence are rejected.

Main characteristics of HRW v3.0

Output data:

Up to two BUFR bulletins, with AMVs related to two different scales of tracers:

-"Basic winds": Tracer size: 24 pixels. -"Detailed winds": Tracer size: 12 pixels.

The decision was taken to include HRVIS & IR108 winds in the same BUFR bulletin, differentiable by parameter WCH (Wind channel).

Input: Full Resolution MSG/HRVIS & MSG/IR10.8 data, and NWP data for the region:

- **Temperature, Wind forecast.**
- **Geopotential, Surface temperature also if Orographic flag is calculated.**

The running of HRW product is as easy as a simple game:

- **Downloading and installing the sofware package in a computer/working station under Solaris/Linux/IBM AIX environment through a simple command.**
- **Running HRW product by the definition of:**
  - **Satellite and Running mode ("Nominal or Rapid scan") through the:**
    - **Model configuration file (*.cfm) - Satellite configuration file (sat_conf_file)**
  - **Region of interest (geographical centre and area size) through the:**
    - **Region configuration file (*.cfg)**

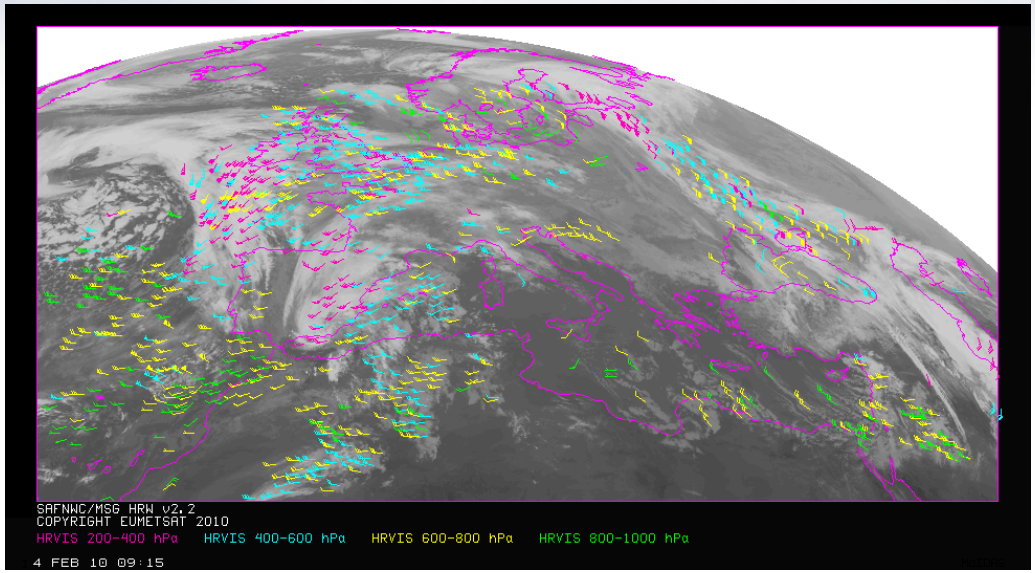
HRW algorithm examples

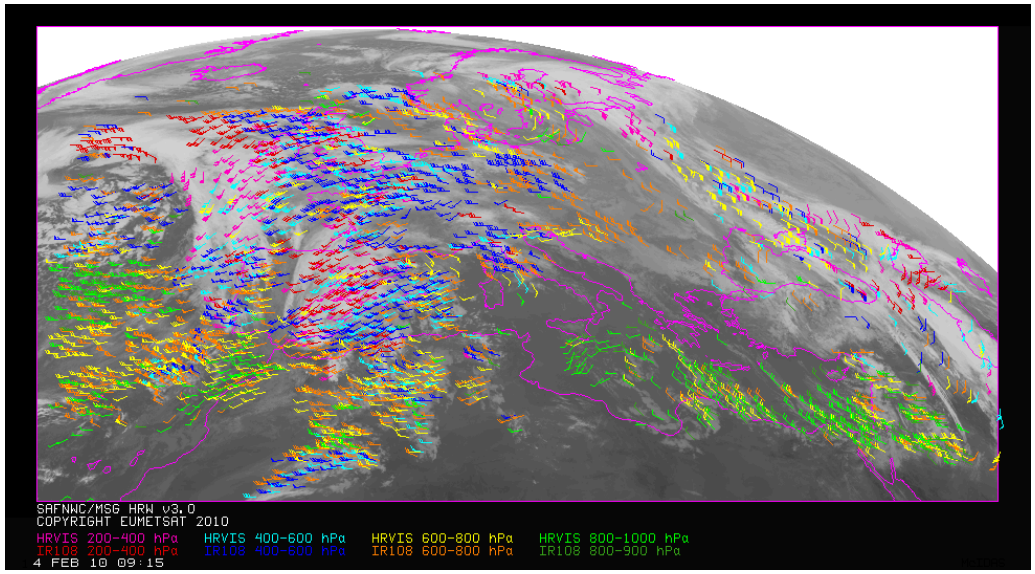
Evolution between HRW v2.2 & v3.0 (Europe & Mediterranean, Nominal scan mode)

1. The calculation in HRW v3.0 of HRVIS & IR108 AMVs, and the optimization of its algorithm expand the amount of available winds (about 2.5 times during daytime respect to HRW v2.2).

2. Discontinuities in the data during the night disappear with IR108 AMVs.

3. HRVIS & IR108 AMVs complement each other, giving information about different cloud patterns:
> Because of this, the frequency of AMV holes in cloudy areas of the images is smaller.





HRW algorithm examples

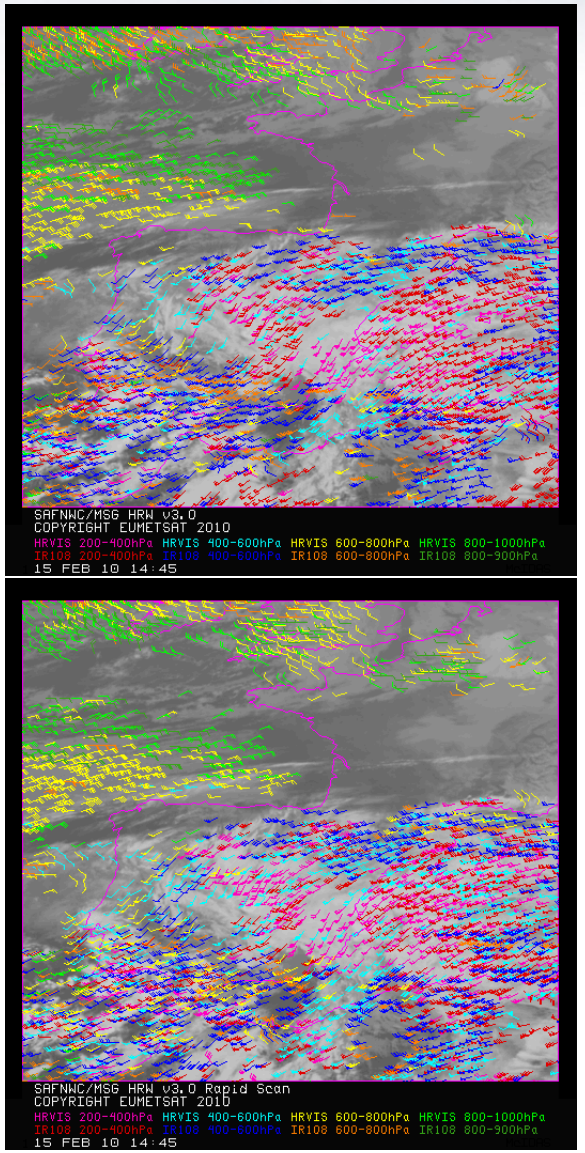
Example of HRW v3.0 outputs in “Nominal scan mode” and “Rapid scan mode” (Spanish National area)

Conditions defined for “Rapid scan mode” (later shown):

- A 10 minute time difference between the initial tracer image and the later tracking image
- The possibility to rerun HRW algorithm with every new MSG slot every five minutes in National regions

Main differences between “Nominal scan mode” and “Rapid scan mode” configurations:

- With 3 Rapid scan slots for every Nominal scan slot, the amount of HRVIS winds every 15 minutes is multiplied by 3.5, and the amount of IR108 winds is multiplied by 2.5, with a similar quality.
- Considering each image, there is a slight increment in the number of HRVIS winds and a slight decrement in the number of IR108 winds.



Validation of HRW v3.0 algorithm

- A validation procedure during the period April-December 2009 in the 'Europe & Mediterranean region' (950x1850 pixels centered in 39ºN/12ºE), has been done for a parallel comparison of:
  - HRVIS & IR108 "Nominal mode" winds.
  - HRVIS & IR108 "Rapid scan mode" winds.

- The effect of several parameters in the validation has been included in the study:
  Atmospheric Level. Orographic Flag. Cloud type.

- A special evaluation has been taken in the "Rapid scan mode", to define the best 'time difference' between the initial tracer image and the final tracking image for the calculation of AMVs.

Effect of the time difference between tracer and tracking images in 'Rapid scan'

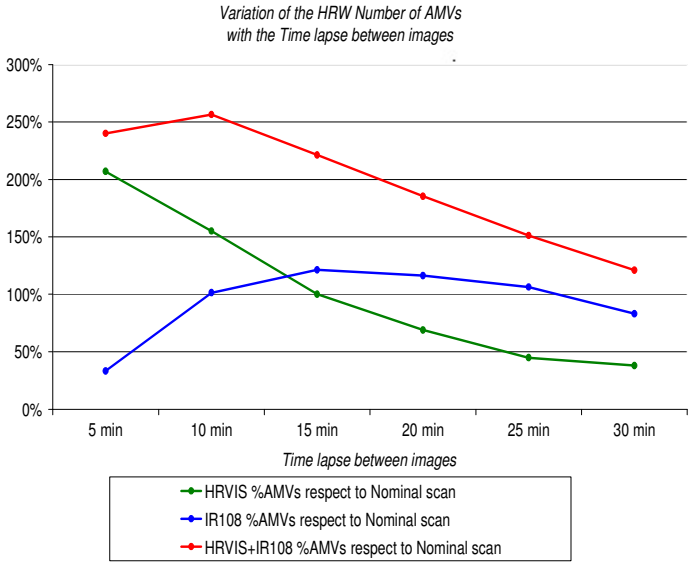
Considering the number of calculated winds:

- In the HRVIS case (green line), there is a progressive increase in the amount of winds with a smaller time difference between tracer & tracking images up to 5 min.

- In the IR108 case (blue line), the maximum amount of winds occurs with a time difference of 15 minutes, with reductions over and below this value.

  => Necessarily related to the different pixel resolution of both channels: HRVIS resolution good enough to detect the displacement of slow moving structures in 5 minutes; IR108 resolution not so much.

- Considering together both datasets (HRVIS & IR108, red line), the maximum amount of calculated winds occurs with a time difference of 10 minutes.

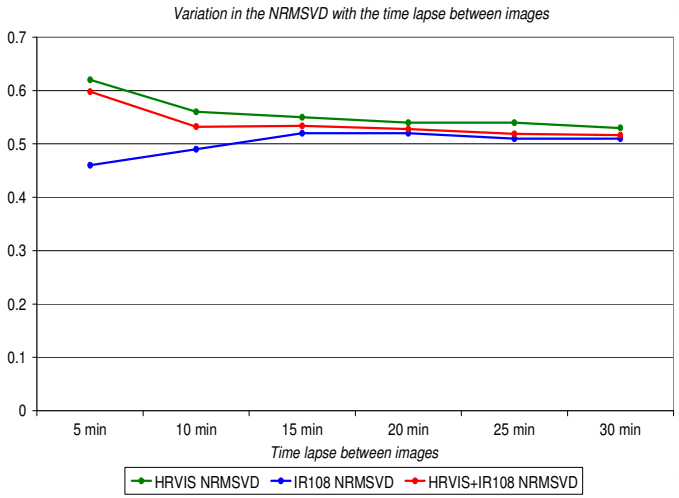


Effect of the time difference between tracer and tracking images in 'Rapid scan'

Considering the RMSVD, there are small variations with the time difference between tracer and tracking images (smaller than a 20%).

- Between 10 and 30 minutes these variations are minimal: smaller than a 4% in the composite HRVIS & IR108 dataset.

- With a value of 5 minutes, the variation is more visible, with an increase in the HRVIS RMSVD and a decrease in the IR108 RMSVD
  - > Maybe related to the increase in the number of HRVIS winds and decrease in the number of IR108 winds.
  - > Due to the higher proportion of the HRVIS winds in the composite, their effect is more important and the RMSVD is a 12% bigger in the composite population.



> Considering these two behaviours in the composite wind population: the time difference of 10 minutes between initial tracer and final tracking image is considered the best for the calculation of Atmospheric Motion Vectors in 'Rapid scan'.

Validation considering the atmospheric level

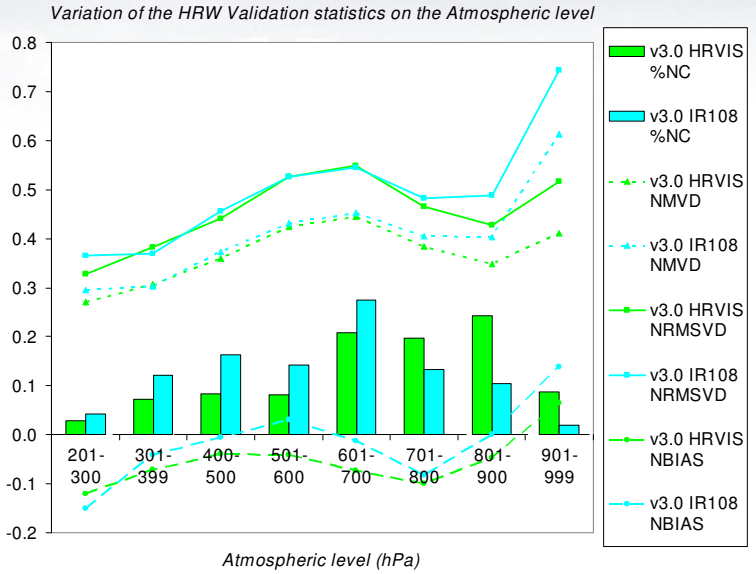
Behaviour of 'Nominal scan' and 'Rapid scan' HRVIS & IR108 winds, considering the atmospheric level:

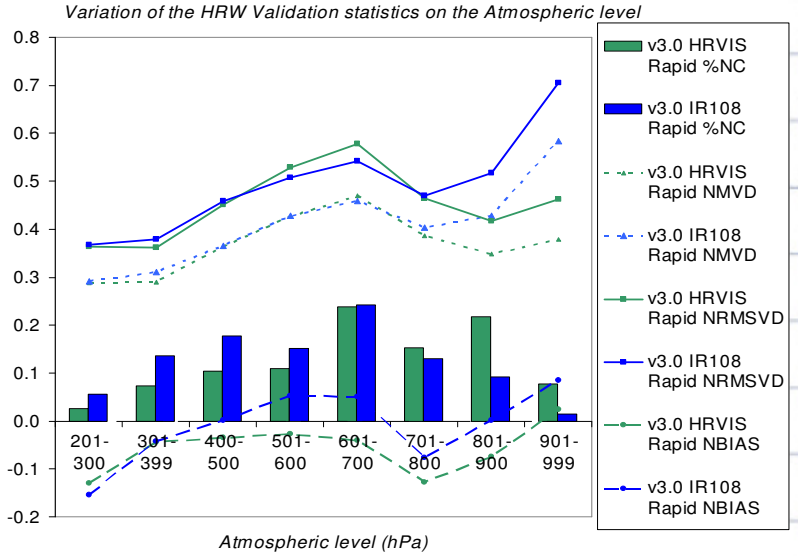
> Bigger proportion of IR108 winds in high/medium layer, and bigger proportion of HRVIS winds in low layer.
  - They tend to give information about different levels and complement each other.

> Better BIAS in general for IR108 winds (blue lines).

> Few differences in MVD/RMSVD for HRVIS & IR108 winds between 200-800 hPa, and better behaviour of HRVIS winds (green lines) in the other layers
  - IR108 winds in the lowest layer (>900 hPa) so bad and so few, that are recommended to be eliminated.

> Few differences between 'Nominal mode' and 'Rapid scan mode' winds.





Validation considering the orographic flag

Different filterings have been defined on 'HRW orographic flag' for 'Nominal scan' and 'Rapid scan' winds:

> In 'Nominal mode', all HRVIS & IR108 winds without geographical obstacles in their vicinity (Orogr.flag≠1,2) are recommended to be kept.

> In 'Rapid scan mode', only HRVIS & IR108 winds without geographical obstacles in their vicinity and trajectory (Orogr.flag≠0,1,2,3) are recommended to be kept.

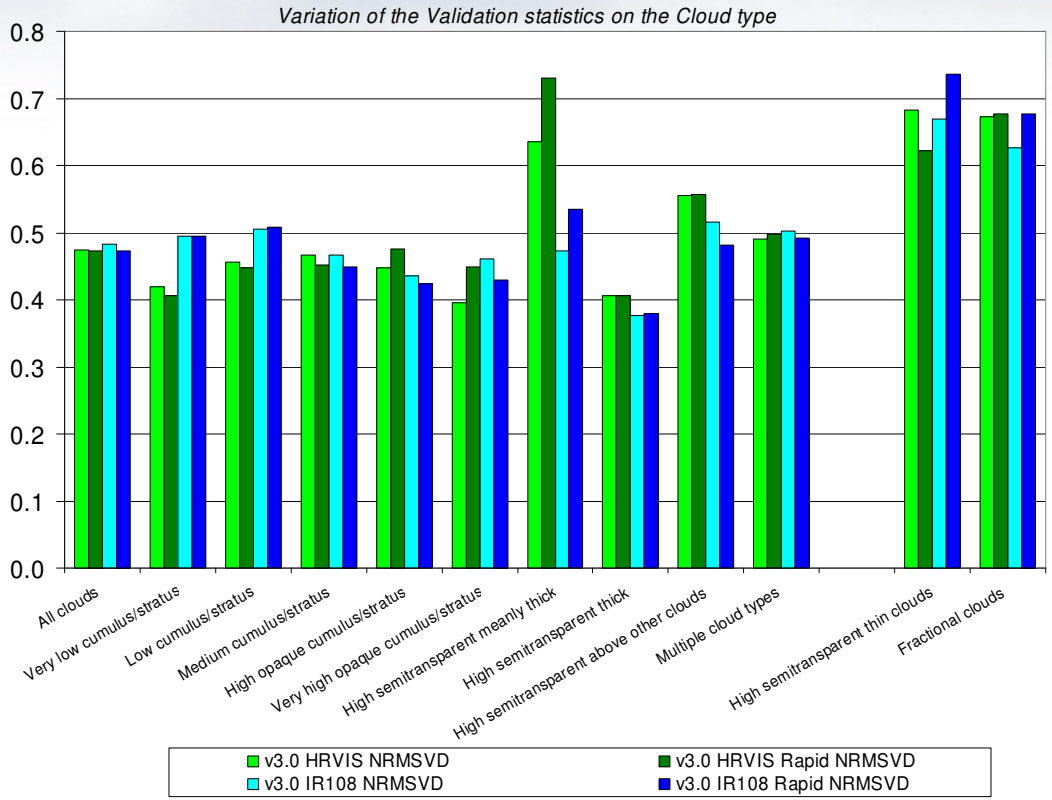
> Eliminated data conform less than a 4% of the total with much worse validation parameters (MVD and RMSVD 50%-100% higher).

> Orographic parameter keeps on being a powerful tool to eliminate wrong data in all cases.

PGE09 v3.0 (Nominal scan mode winds) Apr-Dec 2009, European & Mediterranean area	Orogr. Flag = 1,2	Orogr. Flag = 0,3,4,5
Number of collocations - HRVIS winds	1000	36858
Mean Speed - HRVIS winds	7.40	13.85
Normalized Bias - HRVIS winds	0.32	-0.07
Normalized Mean Vector Difference - HRVIS winds	0.78	0.37
Normalized Root Mean Square Vector Difference - HRVIS winds	0.95	0.47
Number of collocations - IR108 winds	381	44705
Mean Speed - IR108 winds	7.55	15.84
Normalized Bias - IR108 winds	0.13	-0.02
Normalized Mean Vector Difference - IR108 winds	0.74	0.39
Normalized Root Mean Square Vector Difference - IR108 winds	0.88	0.48

PGE09 v3.0 (Rapid scan mode winds) Apr-Dec 2009, European & Mediterranean area	Orogr. Flag = 0,1,2,3	Orogr. Flag = 4,5
Number of collocations - HRVIS winds	1631	42874
Mean Speed - HRVIS winds	8.43	14.01
Normalized Bias - HRVIS winds	0.05	-0.07
Normalized Mean Vector Difference - HRVIS winds	0.57	0.38
Normalized Root Mean Square Vector Difference - HRVIS winds	0.72	0.47
Number of collocations - IR108 winds	706	36669
Mean Speed - HRVIS winds	10.38	17.19
Normalized Bias - IR108 winds	0.14	-0.01
Normalized Mean Vector Difference - IR108 winds	0.69	0.39
Normalized Root Mean Square Vector Difference - IR108 winds	0.82	0.47

Validation considering the cloud type

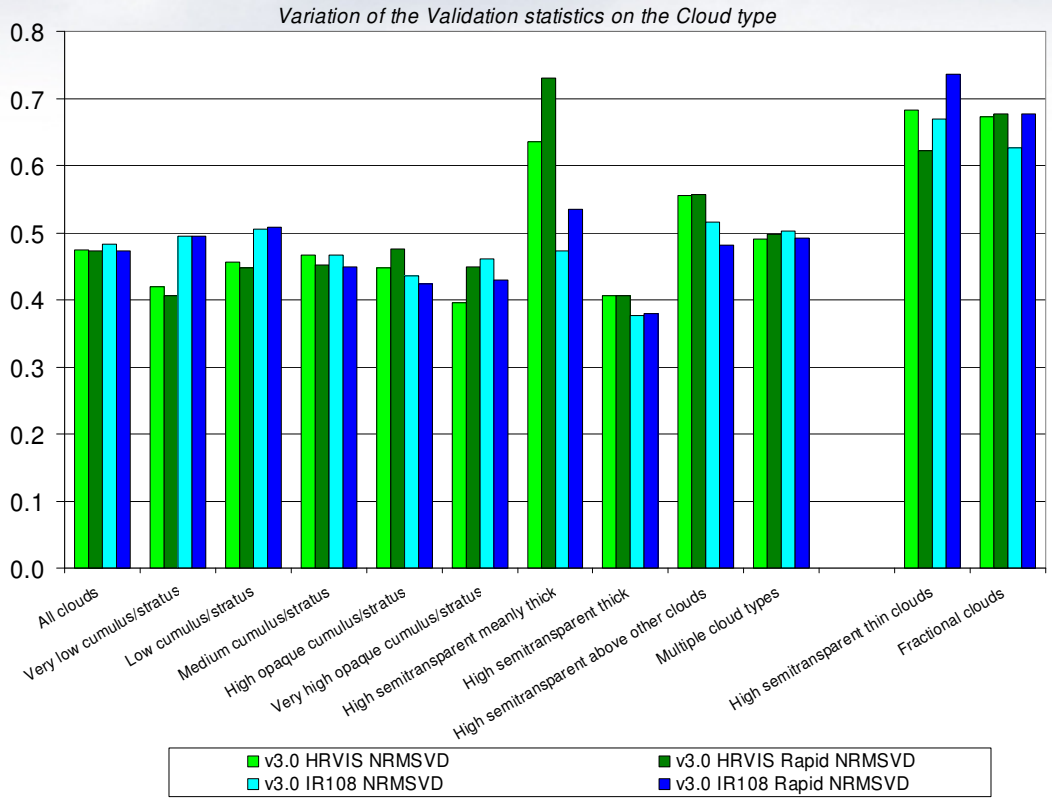


All cloud types admitted in HRW winds except:

- **"Fractional clouds"** and **"High semitransparent thin clouds"** for **HRVIS and IR108 winds**.
- **"High semitransparent meanly thick clouds"** for **HRVIS winds**.

Semitransparency corrections still not implemented (hopefully in the next HRW versions), but the algorithm is nevertheless capable of identifying and eliminating AMVs related to problematic cloud types.

Validation considering the cloud type



Comparing results between HRVIS & IR108 winds:

> **Stat.parameters better for HRVIS winds with "Very low and low cumulus/stratus", better seen in the visible.**

> **Stat.parameters better for IR108 winds with "High semitransparent thick and meanly thick clouds, and over other clouds", more clearly seen in the infrared.**

HRW v3.0 Validation results

Validation results for HRW v3.0 winds 'Nominal mode' and 'Rapid Scan mode' in the 'Europe & Mediterranean region' in the period April-December 2009.

- The algorithm adaptation and optimization included in HRW v3.0 calculates winds in HRVIS & IR108 channels in a running time similar to that for HRW v2.2 with a big increase in the number of total winds (about 2.5 times).

- As told before, IR108 winds show a much lower BIAS, similar MVD & RMSVD in high & medium layer, and slightly worse MVD & RMSVD in low layer than HRVIS winds.

- Validation statistics are nevertheless in all cases similar or better (specially the BIAS) to those shown by HRW v2.2.

PGE09 v3.0: HRVIS Nominal scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	36858	3641	13577	19640
Mean Speed (SPD)	13.85	25.70	14.57	11.16
Normalized Bias (NBIAS)	-0.07	-0.09	-0.07	-0.05
Normalized Mean Vector Difference (NMVD)	0.37	0.29	0.41	0.37
Normalized Root Mean Square Vector Difference (NRMSVD)	0.47	0.36	0.51	0.46

Validation for HRVIS Nominal scan mode winds
(QI>83; Pressure[hPa] ∈(200,1000); Orographic flag≠1,2; Cloud type≠1,2,3,4,15,16,19)

PGE09 v3.0: IR108 Nominal scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	44705	6807	24312	13586
Mean Speed (SPD)	15.84	24.55	15.75	11.63
Normalized Bias (NBIAS)	-0.02	-0.07	-0.00	-0.03
Normalized Mean Vector Difference (NMVD)	0.39	0.30	0.42	0.43
Normalized Root Mean Square Vector Difference (NRMSVD)	0.48	0.37	0.51	0.51

Validation for IR108 Nominal scan mode winds
(QI>83; Pressure[hPa] ∈(200,900]; Orographic flag≠1,2; Cloud type≠1,2,3,4,15,19)

PGE09 v3.0: HRVIS Rapid scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	42874	4713	18812	19349
Mean Speed (SPD)	14.01	25.91	14.34	10.80
Normalized Bias (NBIAS)	-0.07	-0.08	-0.05	-0.08
Normalized Mean Vector Difference (NMVD)	0.38	0.30	0.42	0.36
Normalized Root Mean Square Vector Difference (NRMSVD)	0.47	0.37	0.52	0.44

Validation for HRVIS Rapid scan winds
(QI(High,Medium)>83; QI(Low)>84; Pressure[hPa] ∈(200,1000); Orographic flag≠0,1,2,3; Cloud type≠1,2,3,4,15,16,19; Speed(High)>10 m/s; Image time lapse=10 min)

PGE09 v3.0: IR108 Rapid Scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	36669	6809	19836	10024
Mean Speed (SPD)	17.19	25.57	16.67	12.53
Normalized Bias (NBIAS)	-0.01	-0.08	0.04	-0.02
Normalized Mean Vector Difference (NMVD)	0.39	0.30	0.42	0.43
Normalized Root Mean Square Vector Difference (NRMSVD)	0.47	0.38	0.50	0.50

Validation for IR108 Rapid scan winds
(QI>83; Pressure[hPa] ∈(200,900]; Orographic flag≠0,1,2,3; Cloud type≠1,2,3,4,15,19; Image time lapse=10min)

HRW v3.0 Validation results

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Validation results for HRW v3.0 winds

- The validation of 'Rapid scan winds' is similar with the filterings defined by HRW operative thresholds (difference in MVD/RMSVD always smaller than a 5%).

- The main difference is the number of winds per slot, with the behaviour described before: In 'Rapid scan' with the filterings defined, the number of HRVIS winds increases a 20%; the number of IR108 winds decreases a 15% per slot (related to the better spatial resolution of HRVIS channel).

- Considering a 15 minute period the main advantage of 'Rapid scan mode' is seen: With 3 'Rapid scan slots' for every Nominal scan slot, the amount of HRVIS winds every 15 minutes is multiplied by 3.5, and the amount of IR108 winds is multiplied by 2.5, with a similar quality.

PGE09 v3.0: HRVIS Nominal scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
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Mean Speed (SPD)	13.85	25.70	14.57	11.16
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Normalized Mean Vector Difference (NMVD)	0.37	0.29	0.41	0.37
Normalized Root Mean Square Vector Difference (NRMSVD)	0.47	0.36	0.51	0.46

Validation for HRVIS Nominal scan mode winds
(QI>83; Pressure[hPa] ∈(200,1000); Orographic flag≠1,2; Cloud type≠1,2,3,4,15,16,19)

PGE09 v3.0: IR108 Nominal scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	44705	6807	24312	13586
Mean Speed (SPD)	15.84	24.55	15.75	11.63
Normalized Bias (NBIAS)	-0.02	-0.07	-0.00	-0.03
Normalized Mean Vector Difference (NMVD)	0.39	0.30	0.42	0.43
Normalized Root Mean Square Vector Difference (NRMSVD)	0.48	0.37	0.51	0.51

Validation for IR108 Nominal scan mode winds
(QI>83; Pressure[hPa] ∈(200,900]; Orographic flag≠1,2; Cloud type≠1,2,3,4,15,19)

PGE09 v3.0: HRVIS Rapid scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	42874	4713	18812	19349
Mean Speed (SPD)	14.01	25.91	14.34	10.80
Normalized Bias (NBIAS)	-0.07	-0.08	-0.05	-0.08
Normalized Mean Vector Difference (NMVD)	0.38	0.30	0.42	0.36
Normalized Root Mean Square Vector Difference (NRMSVD)	0.47	0.37	0.52	0.44

Validation for HRVIS Rapid scan winds
(QI(High,Medium)>83; QI(Low)>84; Pressure[hPa] ∈(200,1000); Orographic flag≠0,1,2,3; Cloud type≠1,2,3,4,15,16,19; Speed(High)>10 m/s; Image time lapse=10 min)

PGE09 v3.0: IR108 Rapid Scan mode winds (April – December 2009)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	36669	6809	19836	10024
Mean Speed (SPD)	17.19	25.57	16.67	12.53
Normalized Bias (NBIAS)	-0.01	-0.08	0.04	-0.02
Normalized Mean Vector Difference (NMVD)	0.39	0.30	0.42	0.43
Normalized Root Mean Square Vector Difference (NRMSVD)	0.47	0.38	0.50	0.50

Validation for IR108 Rapid scan winds
(QI>83; Pressure[hPa] ∈(200,900]; Orographic flag≠0,1,2,3; Cloud type≠1,2,3,4,15,19; Image time lapse=10min)

Future developments in HRW product

Developments during the Continuous Development and Operations Phase (until 2012)

> Configuration of HRW product to calculate AMVs with other MSG channels.
  - Based on suggestions from users at the next "NWCSAF Users Workshop".
  - For the moment, the calculation of Water Vapour AMVs is expected.

> Change in the Quality Control, letting small local variations in the QI threshold.
  - To avoid the total elimination of all AMVs with the Quality filterings in some areas, as sometimes occurs with the current configuration.

> Changes in the height assignment.
  - To consider only the pixels related to the Cloud type identified in the tracer, and the corresponding NWCSAF/Cloud Top Height value.
  - To implement possibly semitransparency corrections.

Future developments in HRW product

Possible developments to be started after CDOP Phase (after 2012)

- Calculation of divergence and vorticity fields, with AMV data.

- Application to calculate extrapolated images through the displacement of image elements with AMV data.
  (Possible customers like the solar photovoltaic platforms growing quickly in Spain, have shown interest on this, to know exactly when it is going to get cloudy in a certain location).

Conclusions

- **Optimized HRW v3.0 algorithm permits to calculate HRVIS & IR108 winds:**
  => In a running time similar to the time used by previous versions to calculate only HRVIS winds.
  => With a big increase in the number of available winds (~2.5 times if winds from both channels are considered together).

- **Operationally, the main consequences of the new HRW algorithm are:**
  => The possibility to use HRW product 24 hours a day, with a monitoring of winds and fluxes without intermittencies.
  => The possibility of a quicker update of the wind data fields, with the 'Rapid scan mode' configuration.
  *** Time limitations allow only to use operationally this configuration in national areas, but this can be useful in regional studies.**
  *** The calculation of new wind data every 5 minutes causes also an important increase in the number of available winds (multiplied by a factor of about 3).**

Conclusions

- The small variations in the validation statistics for all HRW algorithm outputs ('Nominal scan mode' and 'Rapid scan mode' HRVIS & IR108 winds), permit to consider them as similar quality wind datasets.
  => They can then be used jointly as an only dataset for later applications (as calculation of divergence/vorticity fields or regular wind grids).

- Anyhow, HRVIS & IR108 data complement each other up to a certain point, and tend to give information about different levels of the troposphere:
  => HRVIS winds are more common in the Low layer
  => IR108 winds are more common in the High and Medium layers (The spectrum of information gets broader).

Conclusions

- With these improvements, the utility of "High Resolution Winds product" has increased significantly and is now more in accordance with the needs of NWCSAF users.

  => It is expected an important increase in the use of HRW product with the new version of the algorithm.

- The users collaboration is expected (including you!) to evaluate the impact of HRW winds in NWP assimilation in mesoscale or regional models.

  => Mary Forsythe? Alexander Cress? Any other users?

  This work could be even economically awarded after the ellaboration of a Report on the impact of HRW data in NWP assimilation, through an NWCSAF Visiting Scientist Activity.

NWCSAF Software delivery procedure

- In case of interest on using the HRW product, all National Meteorological Services within Eumetsat Member/Cooperating States are automatically considered potential users of NWCSAF Software.

- Any other Organisation may apply to become user of NWCSAF Software through the Leading Entity:

Pilar Fernández
NWCSAF CDOP Manager
pif@inm.es

- Software Delivery will be authorized to users according to their Licence Agreement, signed by Eumetsat (represented by the Leading Entity) and the applicant User.

- Once the Licence Agreement is signed, Access Credentials to the NWCSAF Help Desk Restricted Area are provided, where the NWCSAF software can be downloaded:

http://www.nwcsaf.org

NWCSAF Users Workshop

- The "NWCSAF Users Workshop" is going to be celebrated in Madrid (Spain), during the days 26-28 April 2010.
  The registration is open up to 15 March 2010 through webpage:

  http://www.nwcsaf.org/2010UsersWS/Announcement.html

- The Workshop is free to NWCSAF Users, and all Scientists interested in its products developed for Nowcasting and Very short range forecasting:
  - Cloud products (Cloud mask; Cloud type; Cloud top height, temperat. & pressure).
  - Atmospheric humidity & stability products (through statistical & physical retrieval).
  - Precipitation products (Probability of precipitation; Convective clouds & rainfall).
  - Atmospheric analysis (through Air mass analysis & Conceptual models).
  - Atmospheric motion vectors (HRW product).

- The attendance to the Workshop from users trying to adapt NWCSAF products to other geostationary satellites is even expected
  ➔ National Meteorological Satellite Center at Korea Meteorological Administration, for COMS satellite.

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- The Users Workshop is not so frequent (the prior one was in 2005), so the attendance is very recommended to all people interested in our products.

Travelling funding can be even offered from NWCSAF to some few people, through the responsability on some special tasks during and after the Workshop.

For more information on this and any other question, you can contact me through:

jgpereda@inm.es