



GOBIERNO  
DE ESPAÑA

MINISTERIO  
DE AGRICULTURA, ALIMENTACIÓN  
Y MEDIO AMBIENTE

**AEMet**  
Agencia Estatal de Meteorología



**EUMETSAT**

Monitoring weather and climate from space  
Surveiller le temps et le climat depuis l'espace



# NWCSAF/High Resolution Winds AMV Software evolution between 2012 and 2014

16th June 2014

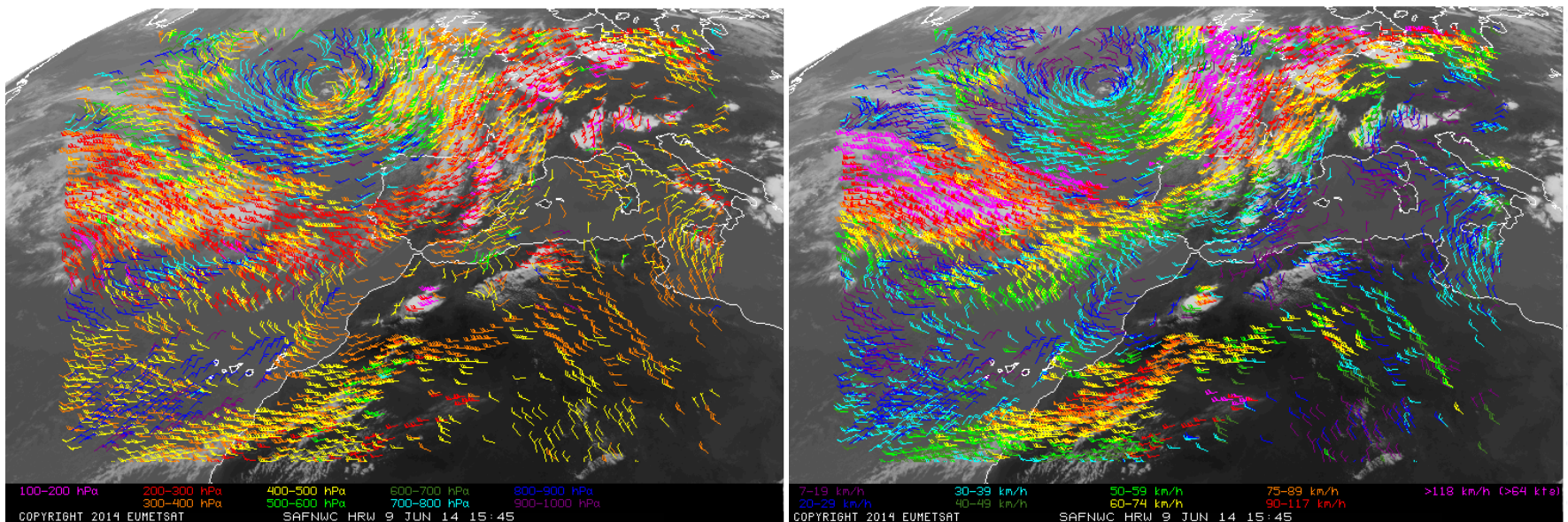
Twelfth International Winds Workshop  
Copenhagen, Denmark

Javier García-Pereda ([jgarciap@aemet.es](mailto:jgarciap@aemet.es))

- I. High Resolution Winds v2013**
  - Validation of HRW v2013.
  - Assimilation of HRW v2013.
  
- II. Improvements for High Resolution Winds v2015:**
  - Inclusion of Cloud Microphysics.
  - Processing of other satellites: GOES-N series.
  
- III. HRW as “Stand alone AMV calculation software”**
  - Seminar on High Resolution Winds in Madrid

High Resolution Winds is the AMV software developed by the NWCSAF (Satellite Application Facility on support to Nowcasting) which provides **high density sets of Atmospheric Motion Vectors** from MSG images for near real time applications.

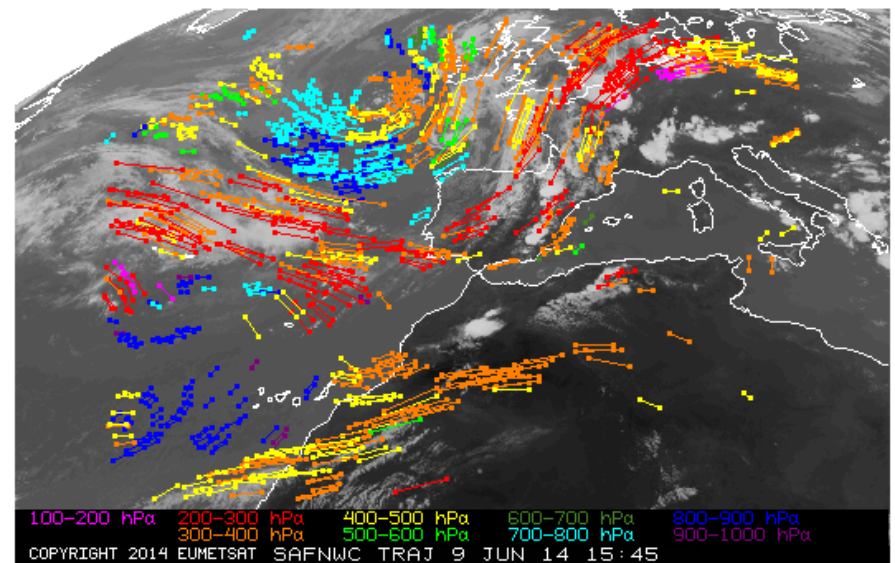
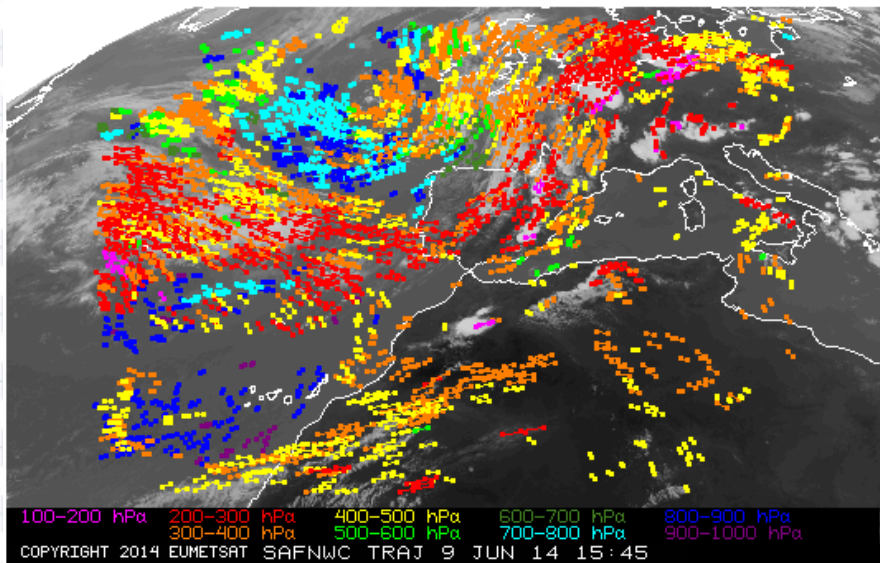
Latest HRW version (v4.0, v2013) released in **August 2013**.



**Example of HRW v2013  
AMV outputs for 9 June 2014 at 1545Z**

- Main changes introduced in HRW v2013:

1. Calculation of trajectories through  
**the continuous tracking of the same tracer in consecutive slots**  
(output provided as a different/specific Trajectory BUFR file).

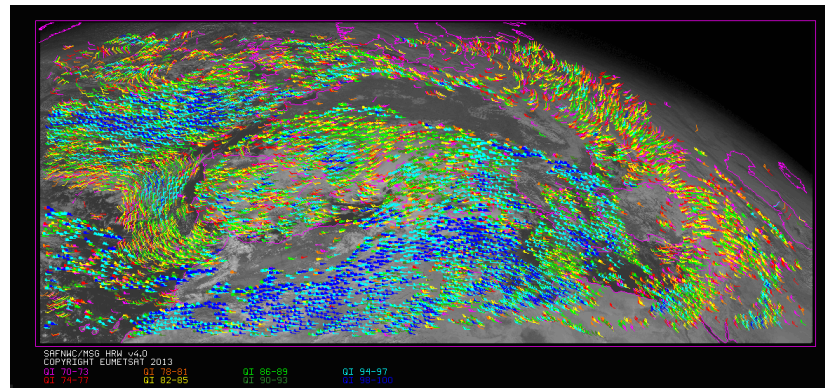


**Example of HRW v2013 One hour and Three hour  
Trajectory outputs for 09 June 2014 at 1545Z**

- Main changes introduced in HRW v2013:

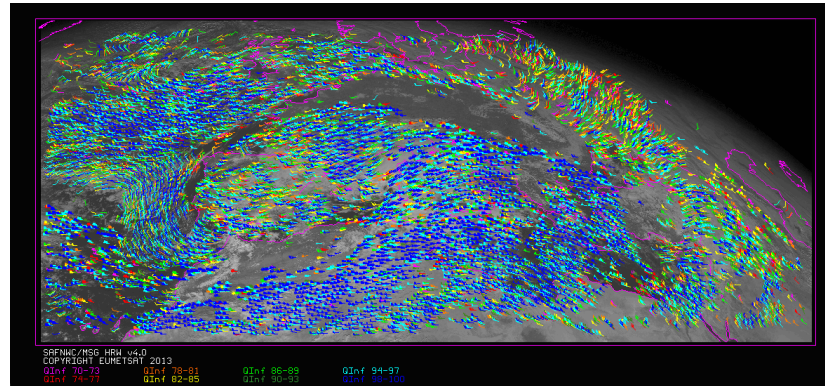
2. Update of the Quality Control process, with  
**some additional elements in the current MPEF AMV Quality Control.**  
(like a **Quality index without use of forecast contribution**).

Quality index  
with forecast contribution  
26 December 2009, 1200Z

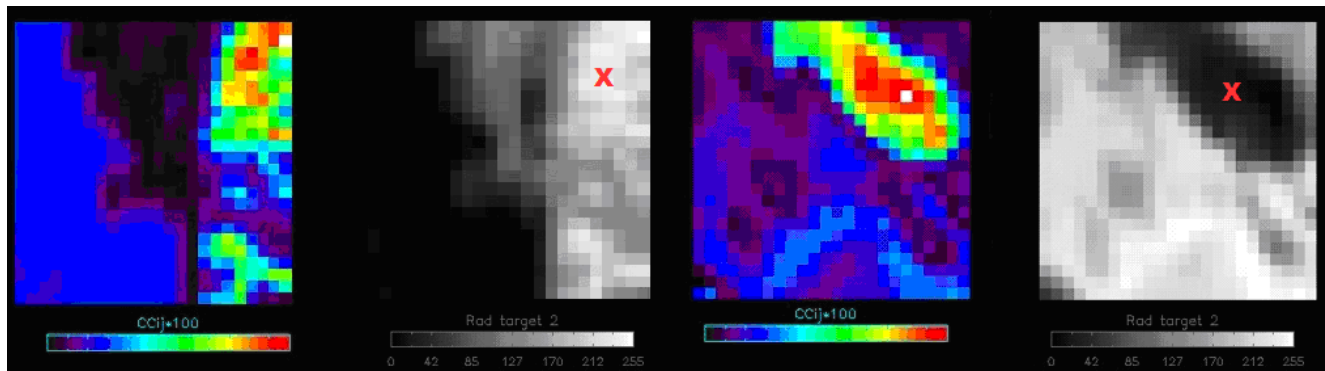


QI ≥ 70%  
QI ≥ 74%  
QI ≥ 78%  
QI ≥ 82%  
QI ≥ 86%  
QI ≥ 90%  
QI ≥ 94%  
QI ≥ 98%

Quality index  
without forecast contribution  
26 December 2009, 1200Z



- Main changes introduced in HRW v2013:
  3. Default calculation of the AMVs without use of the wind guess in the tracking process, through additional code optimizations, **so reducing the dependence from NWP data.**
  4. Inclusion of the Subpixel tracking process in the calculation of wind speeds and directions.
  5. Relation of the AMV to the position of maximum correlation contribution defined by “CCC height assignment method”.



- **Main changes introduced in HRW v2013:**
  - 6. Option to provide HRW AMV BUFR output in a format exactly similar to the one for EUMETSAT/MPEF AMVs, easing its use for **NWP model assimilation**.**
  - 7. Formal review and recommenting of all HRW code for its clearer understanding by anyone who wants to read and use the code.**

- Comparing Validation statistics against Radiosoundings for the default configurations of HRW v2012 and v2013 (Jul 2009-Jun 2010, Europe & Mediterranean region, Cross correlation tracking, CCC height assignment, “Basic scale AMVs”):**

HRW v3.2 AMV Validation (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	138633	71213	64022	133011	176648	112833	115171	48178	859709
SPD [m/s]	18.03	11.75	11.71	23.63	21.96	19.68	19.89	16.32	19.08
NBIAS	-0.11	-0.16	-0.16	-0.06	-0.08	-0.11	-0.10	-0.04	-0.09
NMVD	0.32	0.44	0.44	0.29	0.31	0.32	0.32	0.35	0.33
NRMSVD	0.40	0.52	0.52	0.36	0.39	0.41	0.40	0.43	0.41

HRW v4.0 AMV Validation (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	47280	100836	91677	189804	262992	251524	252375	43004	1239492
SPD [m/s]	16.14	11.04	11.04	23.51	21.28	19.58	19.74	16.52	19.01
NBIAS	-0.10	-0.18	-0.18	-0.06	-0.08	-0.12	-0.11	-0.00	-0.10
NMVD	0.31	0.42	0.42	0.26	0.28	0.30	0.29	0.33	0.31
NRMSVD	0.38	0.50	0.50	0.32	0.35	0.37	0.36	0.40	0.38

- > There are reductions in the mean NMVD/NRMSVD (~7%) with an important increase in the amount of AMV data. (Amount of HRVIS AMVs reduced because of the longer time they need in the processing without wind guess).**



The Validation for HRW v2013 has also verified:

- The **good validation of the “Detailed scale AMVs”**,  
with a **smaller tracer size of 12x12 pixels**  
and **even better validation statistics (smaller NMVD, NRMSVD)**:

HRW v4.0 AMV Validation (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	23453	106066	100123	157088	220841	258347	255583	11623	1133124
SPD [m/s]	15.32	11.22	10.89	24.56	22.72	20.22	20.47	16.89	19.56
NBIAS	-0.09	-0.16	-0.16	-0.05	-0.06	-0.09	-0.08	+0.06	-0.09
NMVD	0.32	0.41	0.42	0.25	0.26	0.28	0.27	0.33	0.29
NRMSVD	0.40	0.49	0.50	0.30	0.32	0.34	0.34	0.41	0.36

- The **possibility to use all AMVs with  $QI \geq 1\%$** ,  
with mean NRMSVD  $\leq 0.50$ :

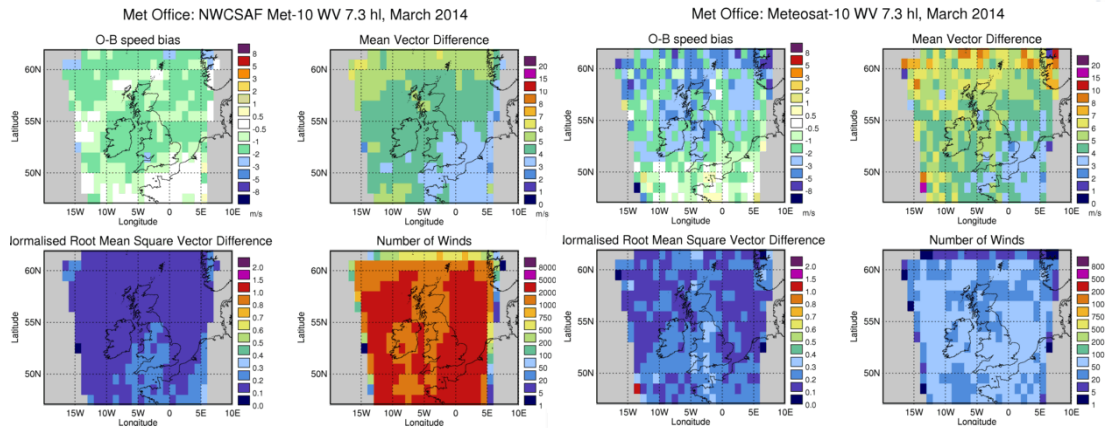
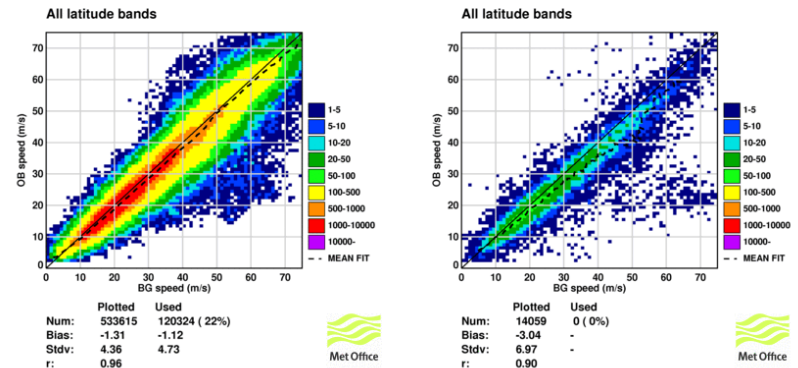
HRW v4.0 AMV Validation (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	116737	293256	279776	290907	427707	488159	486724	136309	2519575
SPD [m/s]	14.28	9.76	9.62	21.32	18.86	16.46	16.59	14.72	15.72
NBIAS	-0.18	-0.32	-0.35	-0.09	-0.11	-0.18	-0.17	-0.11	-0.19
NMVD	0.41	0.55	0.56	0.30	0.34	0.38	0.37	0.44	0.41
NRMSVD	0.51	0.66	0.67	0.37	0.42	0.47	0.46	0.55	0.50

The MetOffice includes since last year the HRW AMVs in the AMV Monitoring pages of NWP SAF at:  
[http://nwpsaf.eu/monitoring/amv/14\\_03/density\\_ukv.html](http://nwpsaf.eu/monitoring/amv/14_03/density_ukv.html)  
[http://nwpsaf.eu/monitoring/amv/14\\_03/map\\_ukv.html](http://nwpsaf.eu/monitoring/amv/14_03/map_ukv.html)

It is a **monthly updated Verification of HRW AMVs** around the British Isles, in comparison with Eumetsat/MPEF AMVs, including:

- Speed scatterplots
- Spatial distribution of validation parameters

NWCSAF Met-10 IR 10.8, March 2014, Above 400 hPa      Meteosat-10 IR 10.8, March 2014, Above 400 hPa



The comparison with Eumetsat/MPEF AMVs shows:

- The very high density of HRW data (1-2 orders of magnitude larger!).
- Similar, often better, validation parameters.  
(specially since Mar.2014 and HRW v2013.1\*, with +40 hPa at High levels)

\*more info: “Characterizing AMV height assignment errors in a simulation study”  
by P.Lean, S.Migliorini, G.Kelly on Thursday

	2013 DEC	2014 JAN	2014 FEB	2014 MAR	2014 APR	2014 MAY
NWCSAF AMV BIAS	-3.38	-2.99	-2.68	-1.31	-1.31	-0.42
EUMETSAT AMV BIAS	-3.93	-3.61	-3.23	-3.04	-2.00	-2.33
NWCSAF AMV STD	5.34	5.39	5.10	4.36	4.37	4.08
EUMETSAT AMV STD	6.86	6.59	6.13	6.97	4.70	4.98
NWCSAF AMV NUM	807017	644560	553310	533615	728237	574661
EUMETSAT AMV NUM	19323	12030	12546	14059	15502	14932

In the AMV intercomparison study \*\*:

> NWCSAF/HRW has often the best validation statistics  
(Pressure rms, Speed rms, Vector rms)

\*\* more info: “AMV Intercomparison project” by D.Santek on Tuesday

Verification of AMV algorithms against Radiosondes + NWP 12h forecast,  
in Exp.4 (17 Sep 2012 1215Z, prescribed config., height assignment method of their choosing).

Site	Number	P Bias	P Rms	Spd Bias	Spd Rms	Dir Bias	Vec Rms
BRZ	153	0.63	19.77	0.55	5.61	-3.07	10.05
JMA	154	-3.00	21.50	-2.26	7.64	8.89	9.60
CMA	237	-1.11	18.58	-1.30	6.40	5.28	7.74
NOA	131	0.35	22.75	1.48	5.79	9.01	7.70
KMA	326	-0.63	21.91	-0.73	4.72	2.68	6.38
EUM	307	0.22	22.87	-0.61	4.73	1.99	6.07
NWC (Prescribed conf. EUM Clouds)	73	-0.76	17.53	-0.60	3.48	-3.74	4.67
NWC (Operational conf. EUM Clouds)	2375	-1.06	22.79	-0.39	3.90	0.46	5.12
NWC (Operational conf. NWC Clouds)	2797	-0.65	21.64	-1.23	4.49	-1.55	5.67

Site	Number	Vec Diff.	Vec Rms
BRZ	1590	8.01	9.43
JMA	3514	4.91	5.88
CMA	4743	6.38	7.02
NOA	2274	5.90	6.83
KMA	4574	5.16	6.52
EUM	6583	3.91	4.84
NWC (Prescribed conf. EUM Clouds)	1419	3.05	3.40
NWC (Operational conf. EUM Clouds)	53010	3.23	3.65
NWC (Operational conf. NWC Clouds)	52464	3.77	4.04

The key might be the **extensive but exigent search of tracers by HRW algorithm:**

- > **Under similar conditions than other AMV algorithms,**  
smaller amount of AMVs but with very good statistics.
- > **Under operational configuration,**  
large amount of AMVs also with good statistics.

**Verification of AMV algorithms against Radiosondes + NWP 12h forecast, in Exp.4 (17 Sep 2012 1215Z, prescribed config., height assignment method of their choosing).**

Site	Number	P Bias	P Rms	Spd Bias	Spd Rms	Dir Bias	Vec Rms
BRZ	153	0.63	19.77	0.55	5.61	-3.07	10.05
JMA	154	-3.00	21.50	-2.26	7.64	8.89	9.60
CMA	237	-1.11	18.58	-1.30	6.40	5.28	7.74
NOA	131	0.35	22.75	1.48	5.79	9.01	7.70
KMA	326	-0.63	21.91	-0.73	4.72	2.68	6.38
EUM	307	0.22	22.87	-0.61	4.73	1.99	6.07
NWC (Prescribed conf. EUM Clouds)	73	-0.76	17.53	-0.60	3.48	-3.74	4.67
NWC (Operational conf. EUM Clouds)	2375	-1.06	22.79	-0.39	3.90	0.46	5.12
NWC (Operational conf. NWC Clouds)	2797	-0.65	21.64	-1.23	4.49	-1.55	5.67

Site	Number	Vec Diff.	Vec Rms
BRZ	1590	8.01	9.43
JMA	3514	4.91	5.88
CMA	4743	6.38	7.02
NOA	2274	5.90	6.83
KMA	4574	5.16	6.52
EUM	6583	3.91	4.84
NWC (Prescribed conf. EUM Clouds)	1419	3.05	3.40
NWC (Operational conf. EUM Clouds)	53010	3.23	3.65
NWC (Operational conf. NWC Clouds)	52464	3.77	4.04

The MetOffice has also started to include HRW AMVs in its Operational UKV region NWP data assimilation (British Isles; 1.5 km resolution).

- > Since January 2014: 100-400 hPa HRW AMVs.
- > Since a very near future: also 400-900 hPa HRW AMVs over sea (confirmed).

Forecast impact \*\*\*  
of both types of HRW AMVs

Parameter	Control Data	Test Data	Test - Control
0Z 6Z 12Z 18Z	Mean ETS	Mean ETS	Wted ETS Diff
Surface Visibility	0.029	0.043	0.277
6 hr Precip Accum	0.246	0.248	0.021
Total Cloud Amount	0.173	0.174	0.010
Cloud Based Height (3/8 Cover)	0.166	0.168	0.020

Parameter	Control Data	Test Data	Test - Control
0Z 6Z 12Z 18Z	Mean Skill	Mean Skill	Wted Skill Diff
Surface Temp	0.617	0.617	-0.008
Surface Wind	0.560	0.560	0.004

Total Weighted Score (%)  
 Control Case = 32.441  
 Test Case = 32.765  
 Test - Control = 0.323 ( 1.00 % change)

\*\*\* more info: “Operational use of NWCSAF/AMV package in the MetOffice Mesoscale Forecasting system” by G.Kelly on Wednesday

Next version (HRW v2015) expected to have next improvements:

> **Inclusion of Microphysical information from NWCSAF/Cloud products for the AMV height assignment, i.e.:**

- Cloud phase
- Cloud optical thickness
- Effective radius
- Cloud liquid/ice water path

> **Adaptation of HRW algorithm to GOES-N satellite series**

- > **Extracting AMVs from:** 0.6 $\mu$ m High resolution visible channel,  
10.7 $\mu$ m Infrared channel,  
6.5 $\mu$ m Water vapour channel.

(Initial step for adaptation to other Geostationary satellites in later HRW versions).

An option is studied to modify CCC Method with NWCSAF/Cloud Microphysics:

1. **Calculation of the AMV Cloud phase:**

Cloud phase of the pixels with largest correlation contribution.

2. For AMVs with larger “liquid phase contribution”:

- Calculation of the “Pixel liquid water path” with

$$LWP_{ij} = (2 * \tau_{ij} * reff_{ij} * \rho_w) / 3 \quad (\text{Stephens et al. 1978}).$$

For AMVs with larger “ice phase contribution”:

- Calculation of the “Pixel ice water path” with

$$IWP_{ij} = (\tau_{ij} / 0.065)^{(1/0.84)} \quad (\text{Heymsfield et al. 2003}).$$

[being  $\tau_{ij}$  and  $reff_{ij}$  the Optical thickness and Effective Radius].

3. “AMV Liquid/Ice water path” then calculated as

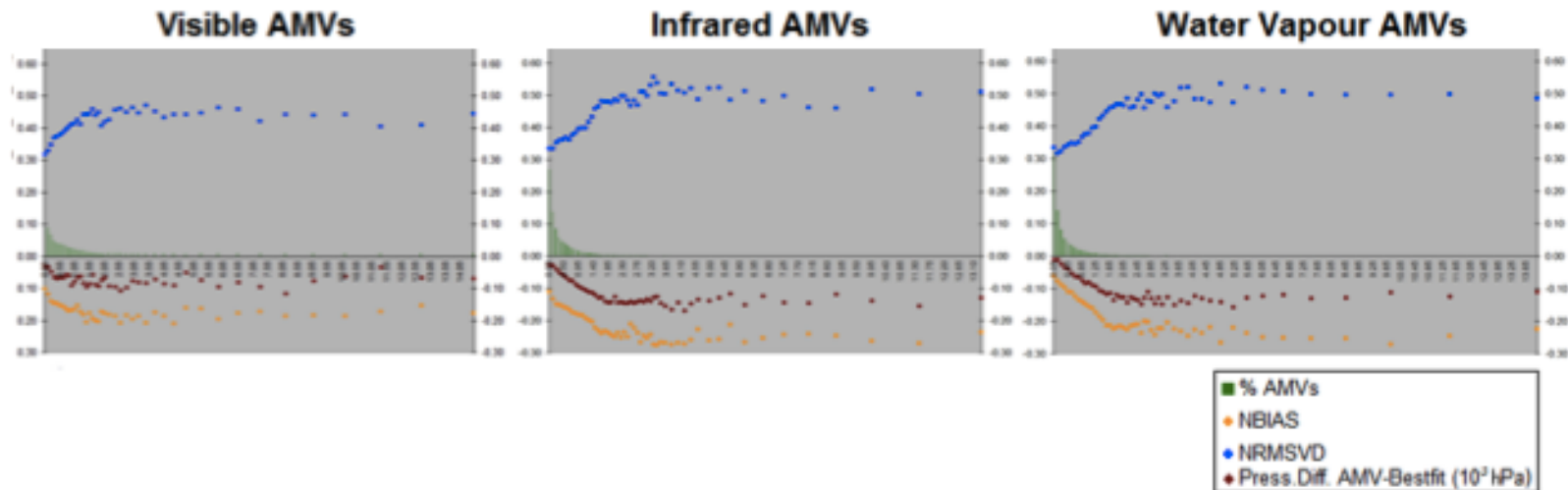
the correlation contribution weighted sum of pixels over the threshold (similarly to other CCC method parameters).



## Displaying for “Ice phase AMVs”

the relationship between the  $IWP_{AMV}$  and

NBIAS / NRMSVD / Pressure difference with the Radiosounding best fit level:

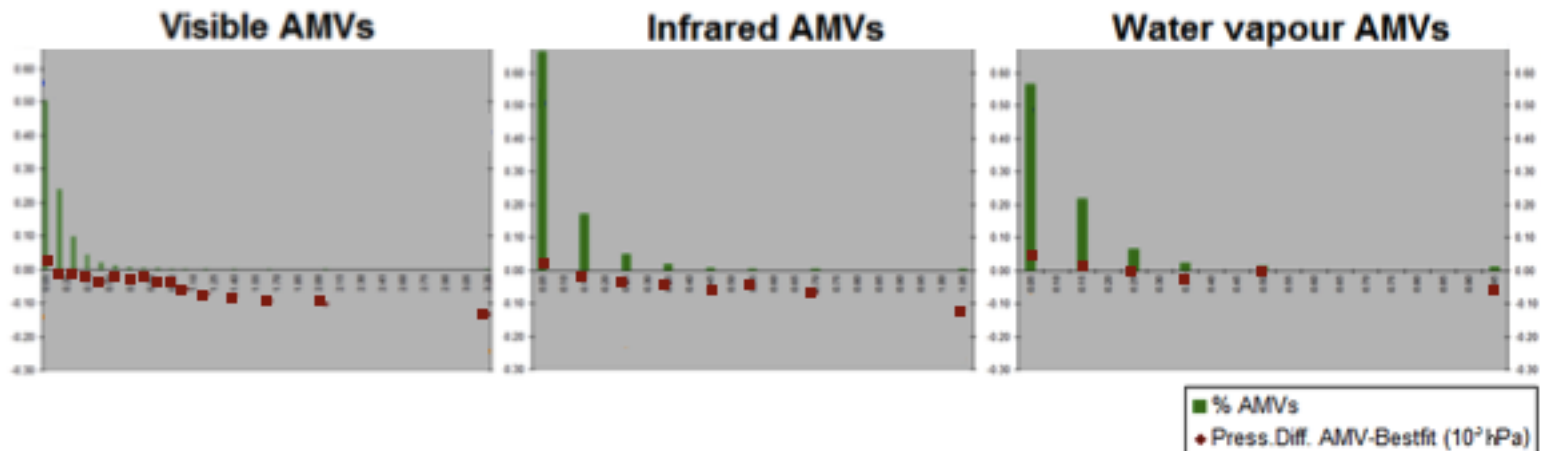


- > Radiosounding best fit level lower than AMV level (Negative values of P.Diff.)
- > Linear increase with the  $IWP_{AMV}$  ( $Corr_{IR/WV} \sim 0.98!$ ) of NBIAS, NRMSVD and Pressure difference with the best fit level, up to a maximum  $IWP_{AMV}$ , over which values become constant.

Displaying for “Liquid phase AMVs”

the relationship between the  $LWP_{AMV}$  and

NBIAS / NRMSVD / Pressure difference with the Radiosounding best fit level:



- > Radiosounding best fit level lower than AMV level (Negative values of P.Diff.) except for  $LWP_{AMV} \sim 0$ .
- > Less defined linear increase with the  $LWP_{AMV}$  (although  $Corr > 0.79$ ) of the Pressure difference with the best fit level.

## Defining a correction of the AMV height with:

- The calculated  $IWP_{AMV}/LWP_{AMV}$
- The relationships of Pressure difference with the best fit( $IWP_{AMV}/LWP_{AMV}$ )

Before:

Without microphysics corr. (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	47280	100836	91677	189804	262992	251524	252375	43004	1239492
SPD [m/s]	16.14	11.04	11.04	23.51	21.28	19.58	19.74	16.52	19.01
NBIAS	-0.10	-0.18	-0.18	-0.06	-0.08	-0.12	-0.11	-0.00	-0.10
NMVD	0.31	0.42	0.42	0.26	0.28	0.30	0.29	0.33	0.31
NRMSVD	0.38	0.50	0.50	0.32	0.35	0.37	0.36	0.40	0.38

After:

With microphysics corr. (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	46137	102303	92322	225974	308506	296381	300244	43943	1415810
SPD [m/s]	14.78	10.77	10.79	22.55	20.48	18.29	18.48	16.59	18.35
NBIAS	-0.05	-0.16	-0.17	-0.02	-0.06	-0.08	-0.07	-0.00	-0.07
NMVD	0.31	0.42	0.42	0.26	0.28	0.29	0.29	0.32	0.30
NRMSVD	0.38	0.50	0.50	0.32	0.34	0.35	0.35	0.40	0.36

- > Increase in the amount of AMVs (~15%).
  - > Smaller NBIAS, specially for IR/WV channels.
  - > Slight impact in the NRMSVD, although positive.
- ➔ The method might imply a refining for different channels/cloud types.

- **NWCSAF/HRW software was proposed in 2012 as an option for “Stand alone AMV calculation software”, available to all AMV researchers and users.**
  - \*\*\*\* More info about its use:  
“NWC SAF High Resolution Winds (HRW) as Stand alone AMV calculation software” presentation at 11th IWW.
- **The good validation results for NWCSAF/HRW software by independent studies (MetOffice, AMV intercomparison study) should solve any doubts about the usefulness of the algorithm.**

# HRW as “Stand alone AMV calculation software”

- In case of interest on using NWCSAF/HRW software:
  - + All National Meteorological Services within Eumetsat Member/Cooperating States are automatically **considered potential users**.
  - + All other Organisations may also apply to become user of NWC SAF Software.

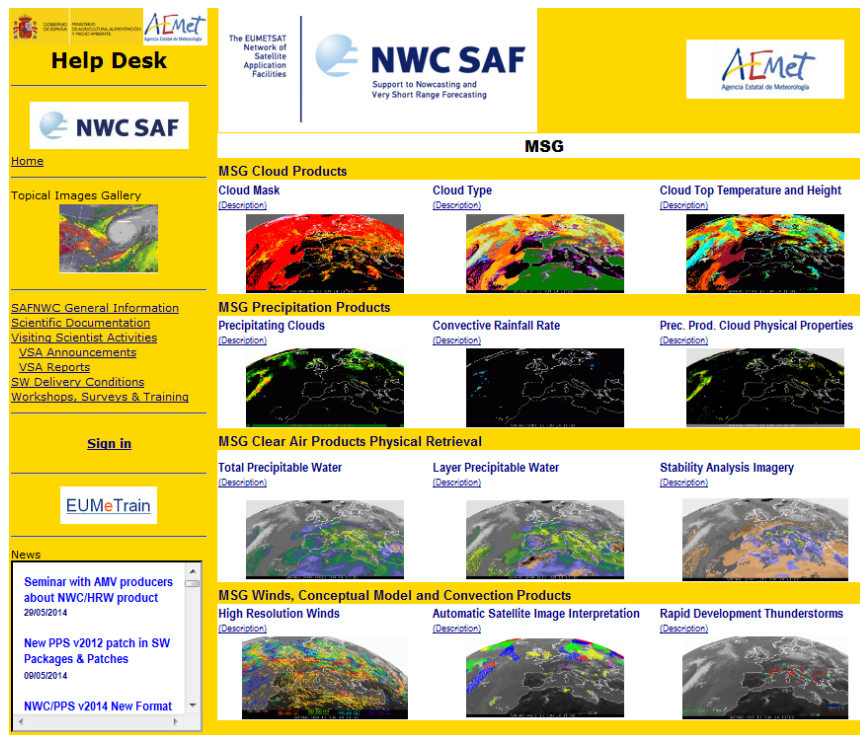
- Please contact:

**Pilar Rípodas or Ana Sánchez**  
([pripodasa@aemet.es](mailto:pripodasa@aemet.es) // [asanchezp@aemet.es](mailto:asanchezp@aemet.es))

- All applicants became users of NWCSAF software up to now without restrictions:
  - **> 100** Institutions from all around the world (Europe, Africa, Americas, Asia,...)
  - All types of institutions:
    - National Meteorological Services
    - Research institutions
    - Public and private companies
    - Universities
    - Public service providers

# HRW as “Stand alone AMV calculation software”

- Software Delivery is authorized to users **through their Licence Agreement**, to be signed by **EUMETSAT** (represented by AEMET) **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 and run locally!**



<http://www.nwcsaf.org>

In relationship with the use of  
HRW software as “Portable stand alone AMV calculation software”

The NWCSAF is going to celebrate a:

“Seminar with AMV producers about NWCSAF/HRW product”  
(Madrid, Aemet HQ, 3 – 7 November 2014)

**Objective:**

- > To give a detailed description of HRW v2013 algorithm;
- > a complete study of HRW code and functions;
- > how it can be best configured for the user interests.

Any AMV producer interested in HRW software is welcome to this Seminar!

In 5 days all needed info would be provided to be an expert in HRW software!

In relationship with the use of  
HRW software as “Portable stand alone AMV calculation software”

The NWCSAF is going to celebrate a:

“Seminar with AMV producers about NWCSAF/HRW product”  
(Madrid, Aemet HQ, 3 – 7 November 2014)

For any more info:

[www.nwcsaf.org](http://www.nwcsaf.org)  
[www.nwcsaf.org/WorkshopsTrainingSurveys/TRAINING/AnnouncementHRWSeminar.pdf](http://www.nwcsaf.org/WorkshopsTrainingSurveys/TRAINING/AnnouncementHRWSeminar.pdf)

Writing an email to me:

**Javier García-Pereda**  
([jgarciap@aemet.es](mailto:jgarciap@aemet.es))

Or contacting me at any moment during this Winds Workshop.