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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

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

# NWCSAF/High Resolution Winds v2013 (v4.0)

20th November 2013

NWCSAF Event Week

EUMETRAIN

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# Use of Saba Centra Software

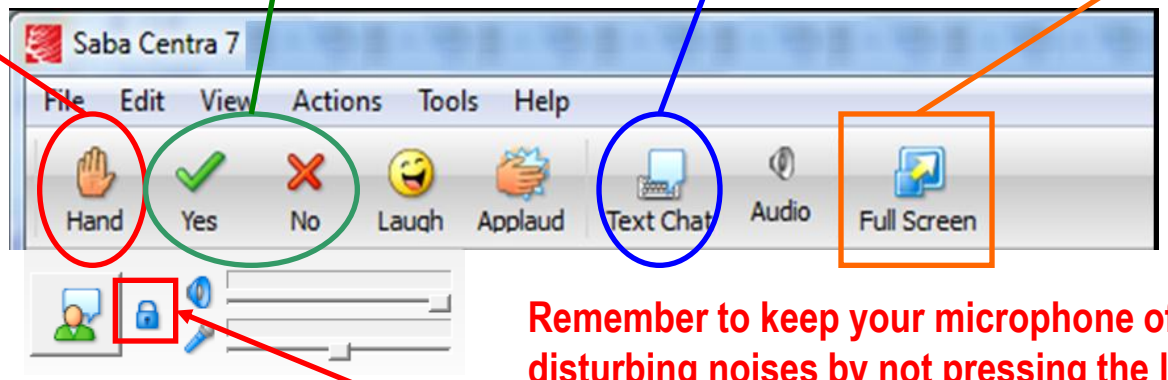
There are some interesting keys you can press throughout this NWC SAF Session for a better use of it:

Raise your hand in any moment to make a question on the contents of this Session

I will make you some simple questions which you can answer with these Yes/No keys

For any technical issue please use the Text Chat window, in which you can show your problem to our supporting ZAMG colleagues

Use full screen for a better view of the slides




Remember to keep your microphone off to avoid disturbing noises by not pressing the lock key (activating it only when receiving your turn to ask a question)

Remember to keep "sound on" to listen to the talk

For example, let's start with a question:
Have you already experience with the use of Saba Centra Software?

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V. Use of HRW AMVs in Nowcasting:

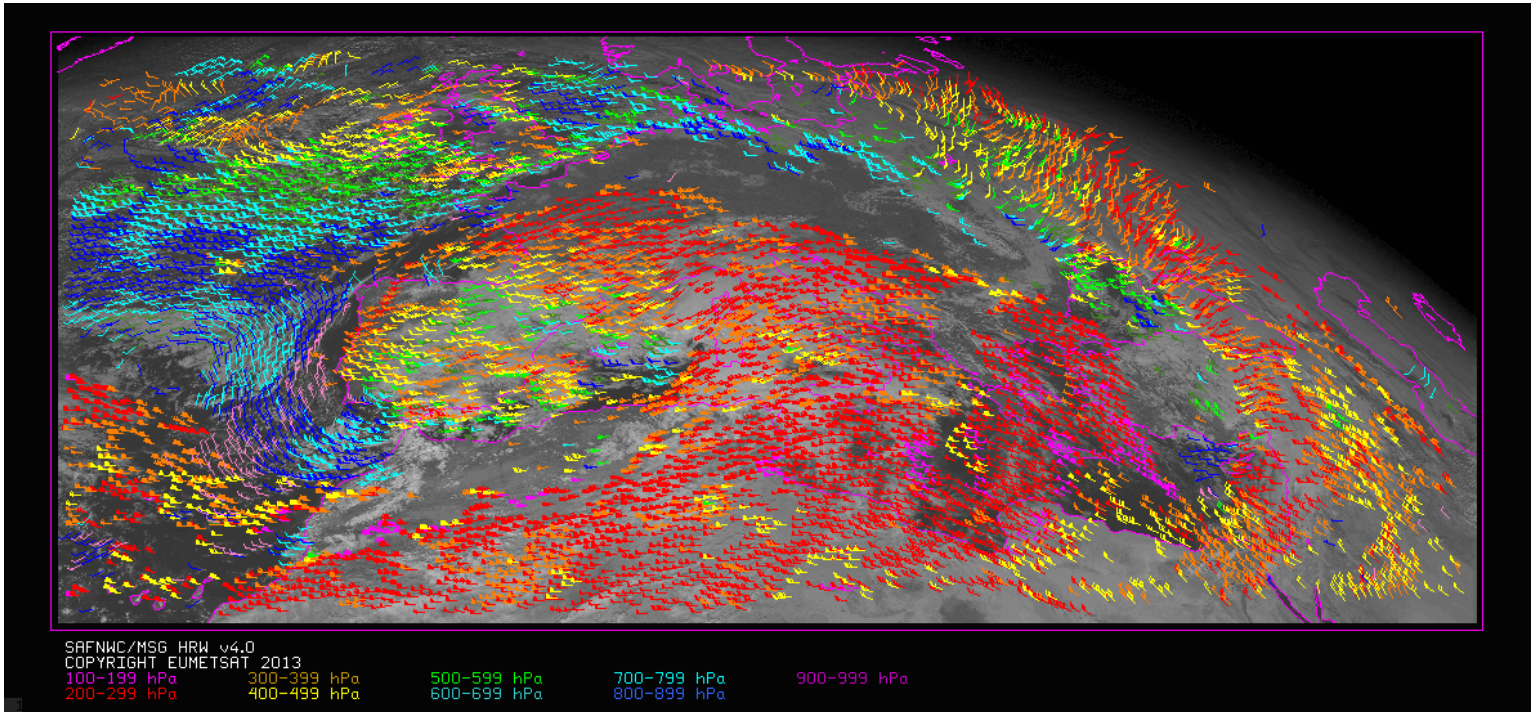
- 22-23 Dec. 2009 Rapid Cyclogenesis in Portugal
- 27-28 Feb. 2010 Rapid Cyclogenesis 'Xynthia'

# NWCSAF/High Resolution Winds

**High Resolution Winds (HRW) is the NWCSAF product with high density sets of Atmospheric Motion Vectors**

**(winds calculated with the displacement of Cloud/Water Vapour humidity tracers in consecutive satellite images)**

**from MSG images for near real time applications.**




**Example of HRW v2013 AMVs for 26 December 2009 at 1200Z**

- HRW product can be useful for:

  - Nowcasting monitoring tasks:
    * Flow displacement
    * Watch and warning of dangerous wind situations
    * Convergence and divergence (especially around cloud systems)
    * Small scale circulation
    * Wind singularities.

  - Assimilation in:
    * Analysis and Forecasting applications (including NWP models).

**Another question:**
**Have you already used HRW product for your tasks?**

# NWCSAF/High Resolution Winds

**Input data:**

- Full Resolution HRIT MSG/SEVIRI data:
  (HRVIS, VIS06, VIS08, IR108, IR120, WV062, WV073).
- NWP forecast data:
  (Temperature, Wind, Geopotential, Surface temperature).
- NWCSAF/Cloud Type & Cloud Top Temperature and Height output.

**Output data:**

- BUFR bulletins, with AMVs/Trajectories related to
  up to two different scales of tracers:
  - "Basic scale": SAFNWC_HRW_*_B*.buf (Tracer size: 24 pixels).
  - "Detailed scale": SAFNWC_HRW_*_D*.buf (Tracer size: 12 pixels).
- Detailed winds calculated in areas where:
  - No basic tracers are found.
  - Basic tracers are large, with the possibility of a more meticulous search.

A new version (HRW v4.0, v2013) has been released to users in August 2013.

## Steps of HRW algorithm:

- **Preprocessing**: Initialization of SEVIRI & NWP with NWCSAF/NWCLIB library.
- **Tracer calculation** with two different methods:
  - Gradient
  - Tracer characteristics.
- **Tracer tracking / Wind calculation**: Selection of up to 3 correlation centres with:
  - Euclidean distance
  - Cross correlation method (default option).
- **Height assignment** with one of two different methods:
  - Brightness Temperature interpolation method
  - Cross Correlation Contribution (CCC) method (default option).
- **Quality control** with **Eumetsat/MPEF Quality Indicator** method.
- **Orographic flag test**: tracers affected by land influence are rejected.

## Methods for the tracer calculation:

- **Gradient / Sharp edge:** search of well defined feature edges, considering a minimum brightness value and difference.
  → *Very efficient, fast, well proven.*

- **Tracer characteristics:** fills holes in the coverage.
  → *Longer, but still reasonable computing time.*

  Each location is checked for:
  - A threshold separating "bright" versus "dark" pixels.
    *(the feature to be tracked and the background).*
  - A distribution of bright pixels showing a "well defined shape".
    *(avoiding "too linear features").*
  - A small scattering of IR-channel temperatures in Visible cases.
    *(avoiding "multilevel cloudiness" in the features).*

Given a set of tracers at the previous satellite slot:

- "Tracking candidates" of the same size are defined at the current slot, with one of two well known methods:
  - Euclidean distance.
  - Cross correlation (default method).

- The best three matching "Tracking candidates" for each tracer are kept, to perform a final selection step at Quality Control.

- NWP wind guess can be used in the definition of the search area in the second image, to reduce the algorithm running time.

## Considering "CCC method" for the Height assignment:

+ AMV pressure is defined considering
  the pressure of the pixels contributing most to the image correlation.

+ "NWC SAF Cloud products"
  (Cloud type, Cloud top temperature & height)
  are processed with HRW including their techniques to set "Cloud height":

  > Opaque cloud top pressure retrieval from IR108/IR120 BTs with:
  - RTTOV simulation of radiances.
  - Thermal inversion processing.

  > Semitransparent cloud top pressure retrieval with:
  - Radiance ratioing method (Menzel et al. 1983)
  - $H_20$/IRW intercept method (Schmetz et al. 1993).

# NWCSAF/High Resolution Winds

## Considering Cloudy AMVs:

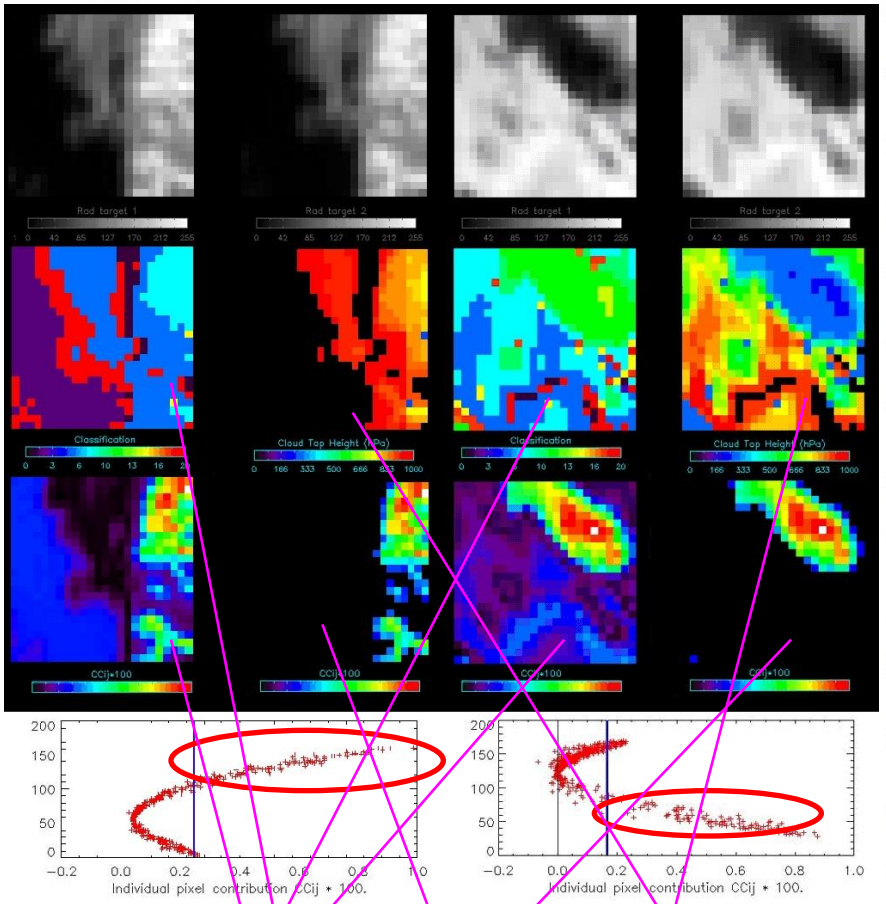
- NWC SAF/Cloud Top pressure used for calculation of "AMV pressure" and "AMV pressure error".
- Only cloudy pixels considered, as defined by NWC SAF/Cloud type.

## Considering WV Clear air AMVs:

- WV Brightness temperature used for calculation of "AMV temperature" and "AMV temperature error".
- "AMV pressure" calculated interpolating the "AMV temperature" to NWP temperature forecast profile.

**VIS08 case**
***Reflectance in 1st and 2nd image***

**IR108 case**
***Br. Temp. in 1st and 2nd image***




***NWCSAF/Cloud type*** ***NWCSAF/Cloud Top Pressure***

***CCij for all pixels and for pixels considered by the method***

# NWCSAF/High Resolution Winds

- **Eumetsat Quality Indicator method** (Holmlund 1998)
  **is adapted for HRW product for the AMV Quality Control.**

- **Several tests on consistency (partial QIs) are if possible computed:**
  - **Temporal test (vector/direction/speed consistency with AMVs in previous slot).**
  - **Spatial test (vector consistency with neighbour AMVs in current slot).**
  - **Forecast test (vector consistency with NWP wind forecast).**

  **For Detailed winds also:**
  - **Two scale test (vector consistency with simultaneous Basic winds).**

- **The sum of partial QIs gives an Overall QI,**
  **used to define the AMV final position among the 3 calculated tracking candidates.**

- An "Orographic flag" is also calculated to reject AMVs affected by land influence:

  Or.flag = 1 - 2 Important/smaller orographic influence in the current position of the tracer.

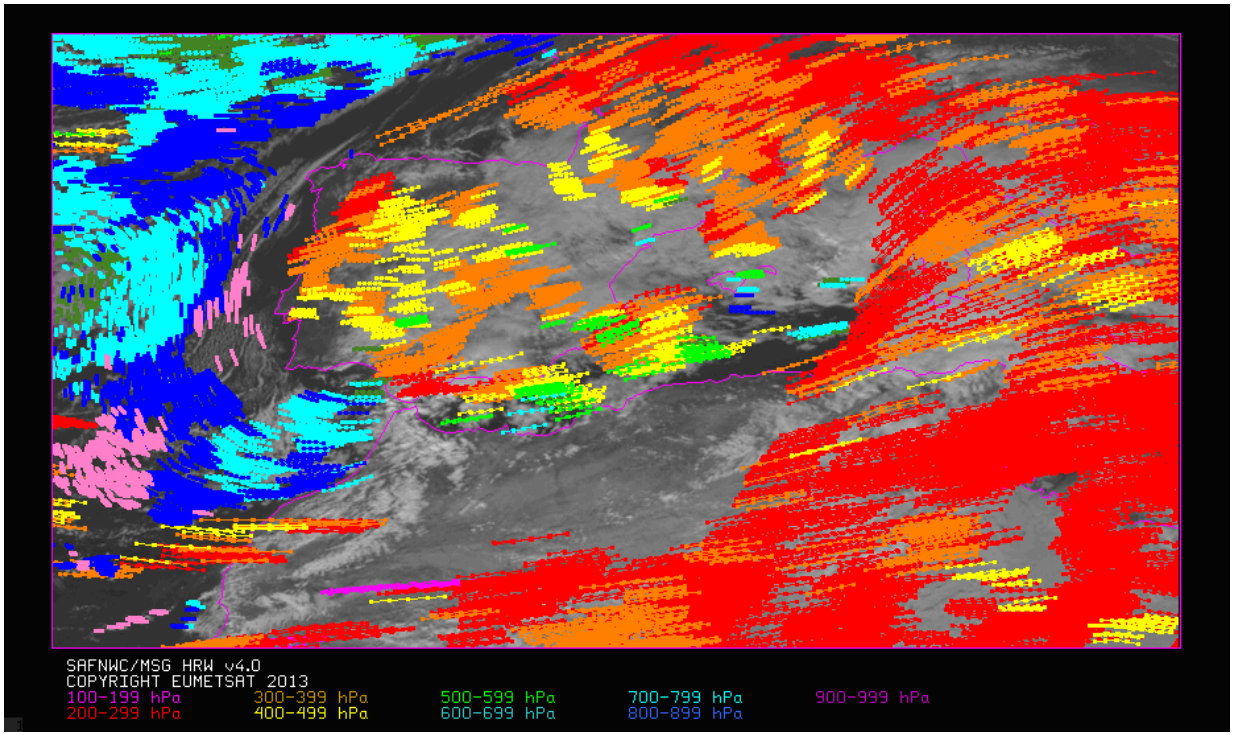
  Or.flag = 3 - 4 Important/smaller orographic influence in previous positions of the tracer.

  Or.flag = 5 - 6 No orographic influence in any current or previous position of the tracer, with stability/instability conditions.

- AMVs affected by land influence are related to:
  - Land features.
  - Tracers which are blocked or whose flow is affected by mountain ranges (for example lee wave clouds).
    > Their displacement is unrelated to the general atmospheric flow and because of this they are eliminated.

- **Main changes introduced in HRW v2013 (August 2013):**

1. Calculation of trajectories through the succesive tracking of the same tracer in consecutive slots.



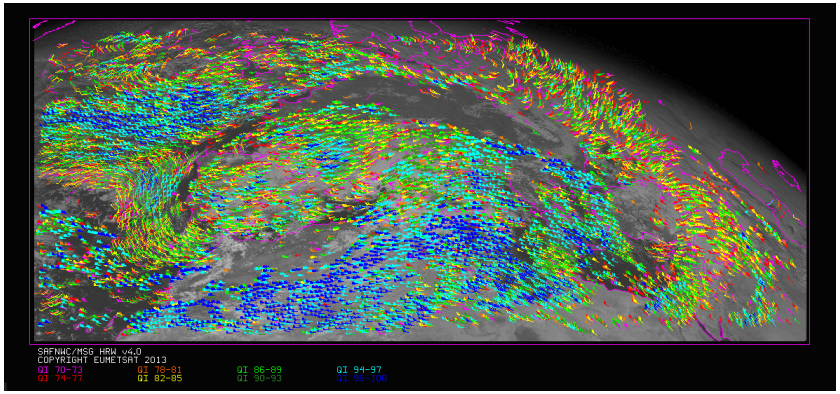

**Example of HRW v2013 Trajectory output for 26 December 2009 at 1200Z**

- **Main changes introduced in HRW v2013 (August 2013):**

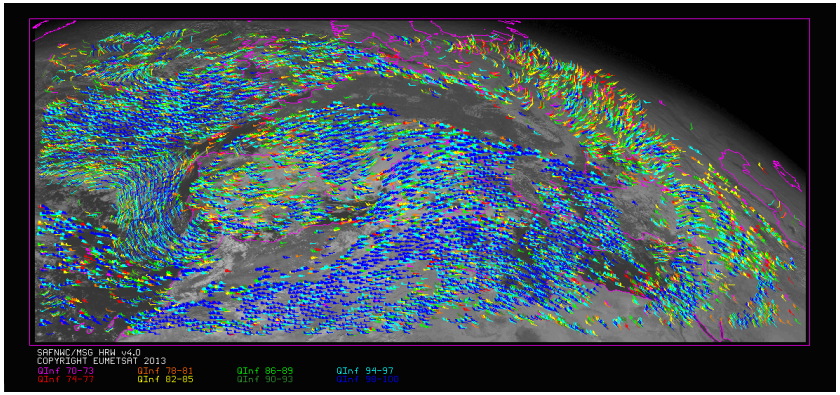
**2. Update of the Quality Control process, to include some additional elements of MPEF AMV Quality Control.**

**> For example, a Quality index without use of forecast contribution.**

**Quality index with forecast contribution**
**26 December 2009, 1200Z**




**Quality index without forecast contribution**
**26 December 2009, 1200Z**



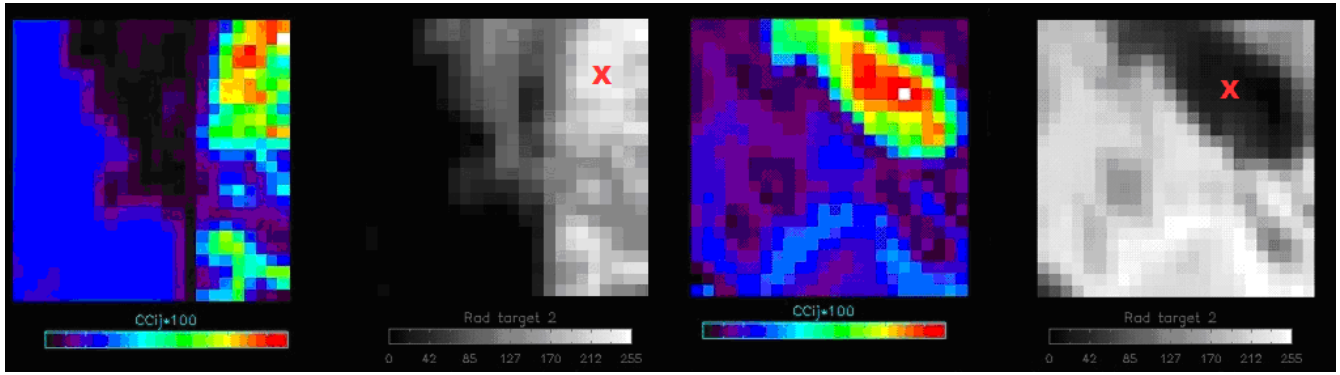

QI ≥ 70%
QI ≥ 74%
QI ≥ 78%
QI ≥ 82%
QI ≥ 86%
QI ≥ 90%
QI ≥ 94%
QI ≥ 98%

- **Main changes introduced in HRW v2013 (August 2013):**

**3. Default calculation of the AMVs without use of the wind guess** in the tracking process, through additional code optimizations, reducing the dependence from NWP data.

**4. Inclusion of the Subpixel tracking process** in the calculation of wind speeds and directions, avoiding discontinuities caused by the resolution of the pixels.

**5. Relation of the AMV to the position of maximum correlation** contribution defined by "CCC height assignment".



- Main changes introduced in HRW v2013 (August 2013):

  6. Option to provide HRW AMV BUFR output
     in a format similar than for EUMETSAT/MPEF AMVs,
     easing its use for NWP model assimilation.

  7. Formal review and recommenting of 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, Basic 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 increase in the amount of AMV data.
(Although reducing the amount of HRVIS AMVs because of the longer time they need in the processing without wind guess).

## 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 usability for the first time of all AMVs with a QI > 0%, compliant with the Target accuracy for HRW product (mean NRMSVD ≤ 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 |

# Future High Resolution Winds v2015 & v2017

- Two additional versions are planned for HRW product during CDOP-2 Phase.

- For HRW v2015:
  - > Inclusion of Microphysics from NWC SAF/Cloud products for the AMV height assignment, i.e.:
    - Cloud phase
    - Cloud optical thickness
    - Effective radius
    - Cloud water/ice path
  - > Adaptation of HRW algorithm to GOES-N satellite series.

- For HRW v2017:
  - > Adaptation of HRW algorithm to GOES-R, Himawari 8/9 satellite series (depending on availability of satellite data and GEO/Cloud product output for these satellites).
  - > Other improvements, considering user and validation needs, and through collaboration with other AMV producers.

# NWP Assimilation studies of HRW AMVs

- **HRW AMVs Assimilation studies in NWP models with neutral to positive results have been done by:**
  - **UK Met Office (Graeme Kelly) in the Met Office Unified NWP Model.**
    - **> Summary results (with HRW v2012.1):**

Met Office Unified Model South UK 1.5 km resolution
47 day HRW AMVs Assimilation trial

| Parameter | Control Data | Test Data | Test - Control |
|---|---|---|---|
| 0Z 6Z 12Z 18Z | Mean ETS | Mean ETS | Wted ETS Diff |
| Surface Visibility | 0.067 | 0.070 | 0.060 |
| 6 hr Precip Accum | 0.325 | 0.327 | 0.043 |
| Total Cloud Amount | 0.223 | 0.223 | -0.001 |
| Cloud Based Height (3/8 Cover) | 0.052 | 0.052 | 0.006 |

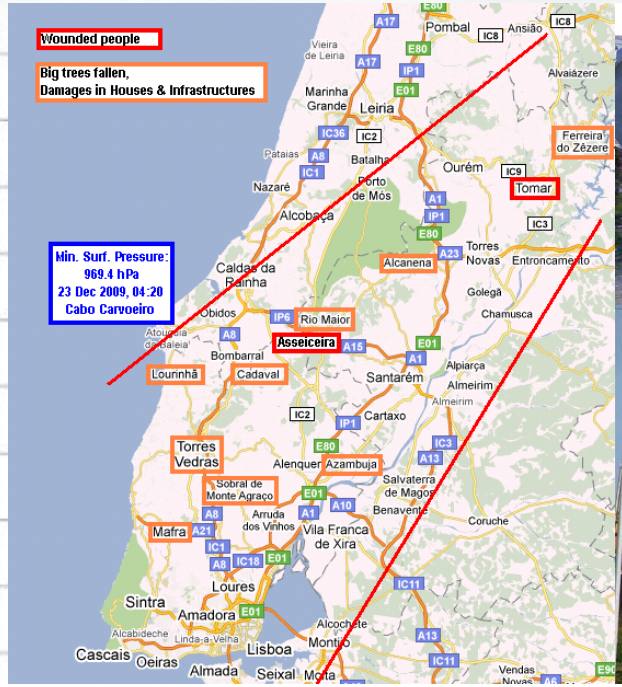
| Parameter | Control Data | Test Data | Test - Control |
|---|---|---|---|
| 0Z 6Z 12Z 18Z | Mean Skill | Mean Skill | Wted Skill Diff |
| Surface Temp | 0.647 | 0.647 | -0.007 |
| Surface Wind | 0.629 | 0.629 | -0.003 |

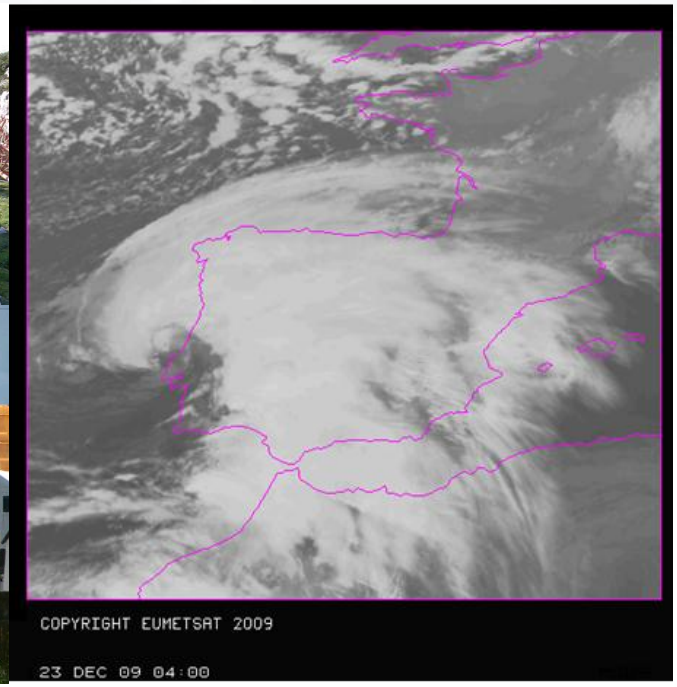
Total Weighted Score (%)
Control Case = 36.121
Test Case = 36.221
Test - Control = 0.099 ( 0.28 % change)

  - **Hungarian Met.Service (Roger Randriamampianina, Máté Mile) in the ALADIN Limited area NWP model.**
    - **> Results to be presented by Máté Mile's presentation coming up.**

**Is anybody of you interested in using HRW winds in NWP assimilation?**
**Máté's presentatation will be very useful for this!!**

# Use of HRW AMVs in Nowcasting: 22-23 Dec. 2009 Rapid Cyclogenesis in Portugal



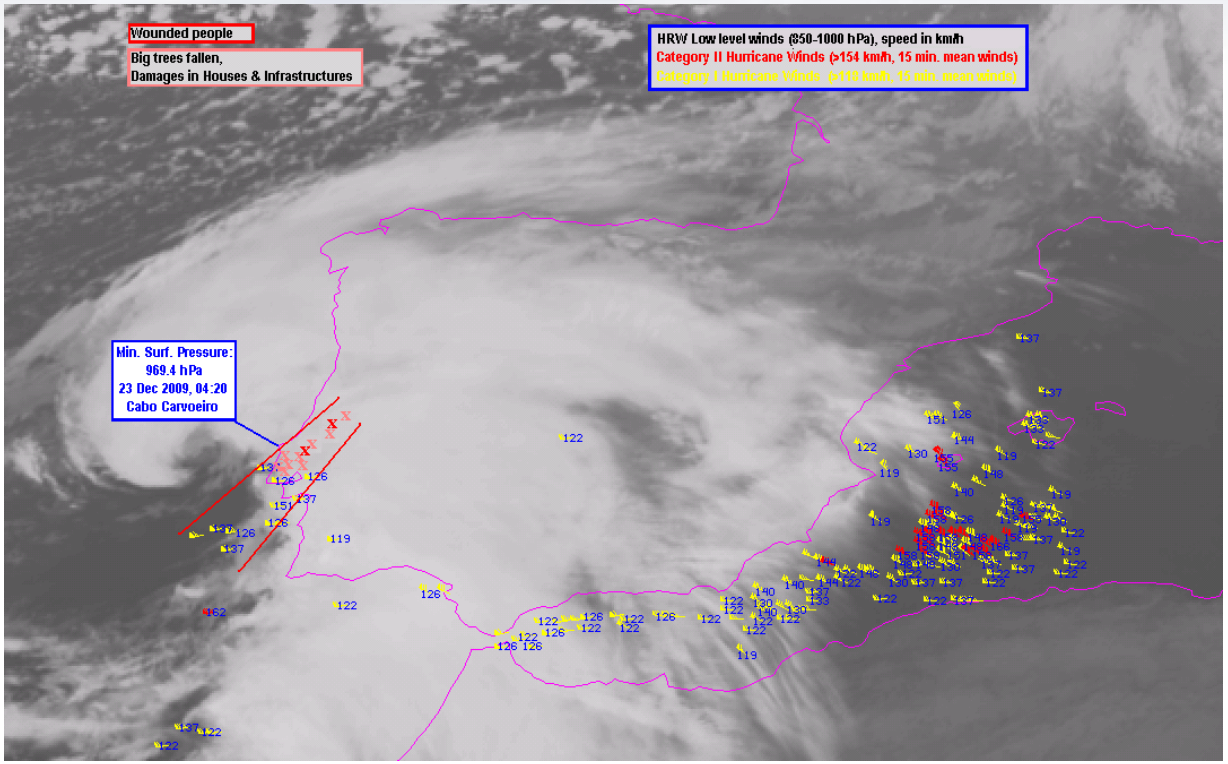

**An Atlantic cyclogenesis entering Portugal during the night 22-23 December 2009**

**(deepening stronger than 20 hPa/24 h; low of 969.4 hPa at Cabo Carvoeiro),**

**caused important damages (people wounded, damages in houses/infrastructures)**

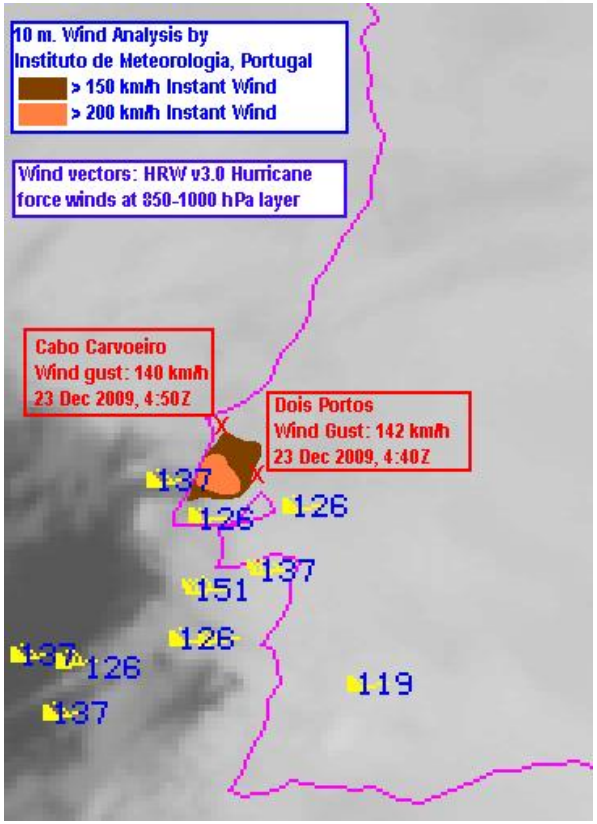
**along a strip moving northeast from the Tagus mouth into the inner country.**

# Use of HRW AMVs in Nowcasting: 22-23 Dec. 2009 Rapid Cyclogenesis in Portugal




**HRW product identifies a narrow area of Hurricane force low level winds coming from the ocean in the area where the main damages occurred (15 min. mean winds between 125-150 km/h in the layer 850-1000 hPa)**

# Use of HRW AMVs in Nowcasting: 22-23 Dec. 2009 Rapid Cyclogenesis in Portugal

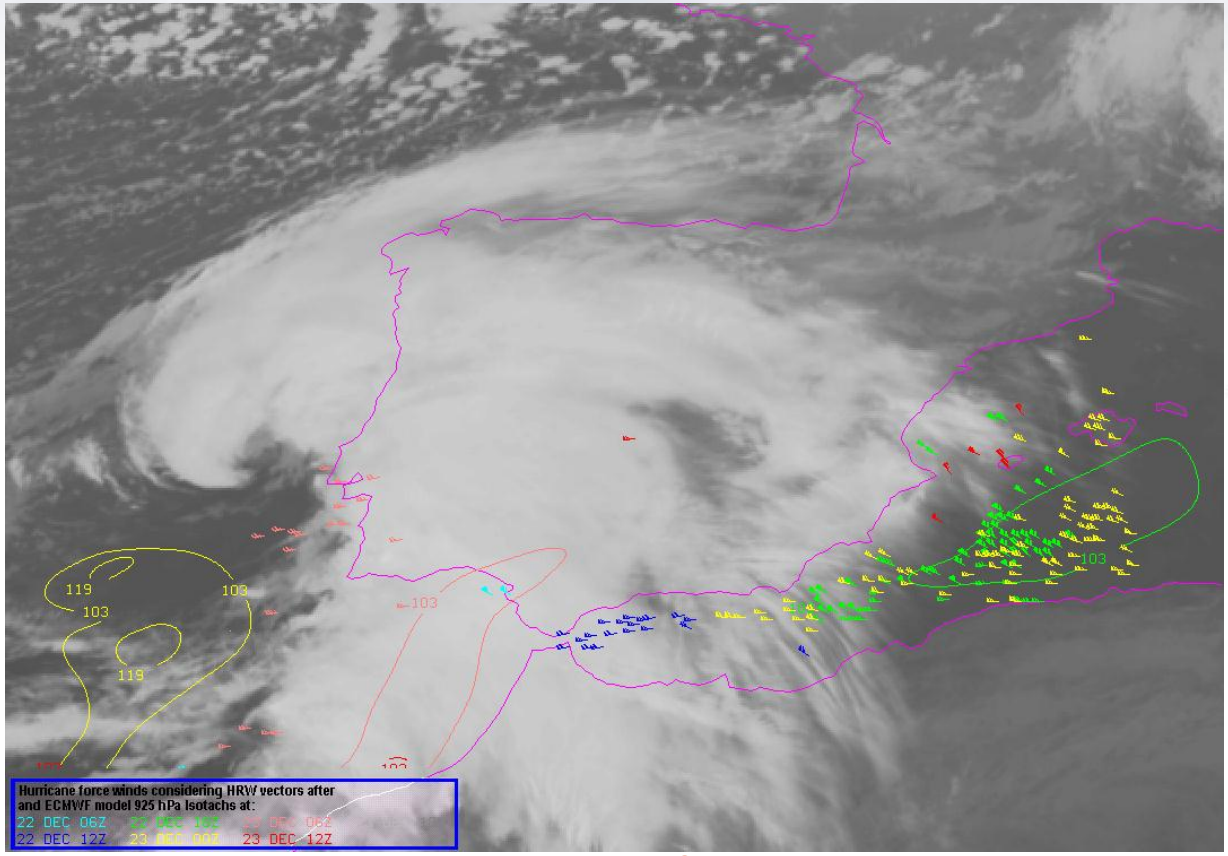



Only **two Surface wind observations were available** in the affected area, with **Wind gusts ~140 km/h**:

- Cabo Carvoeiro
- Dois Portos

A later **Analysis of Surface winds considering extrapolation of Doppler Radar Winds** by the Portuguese Instituto de Meteorologia shows **Areas with 10 m. Maximum winds >150 km/h and >200 km/h** in the affected regions around 23 Dec 2009, 04:30Z.

# Use of HRW AMVs in Nowcasting: 22-23 Dec. 2009 Rapid Cyclogenesis in Portugal




The areas in Portugal and all the Spanish Mediterranean,

where HRW product defines its 850-1000 hPa Hurricane force winds

were not identified by the ECMWF model forecast

HRW output can be helpful for Watch & Warning tasks,

beyond the possibilities given by the NWP model used for its calculation

# Use of HRW AMVs in Nowcasting: 27-28 Feb. 2010 Rapid Cyclogenesis 'Xynthia'

AEMet Agencia Estatal de Meteorología

NWC SAF Support to Nowcasting and Very Short Range Forecasting

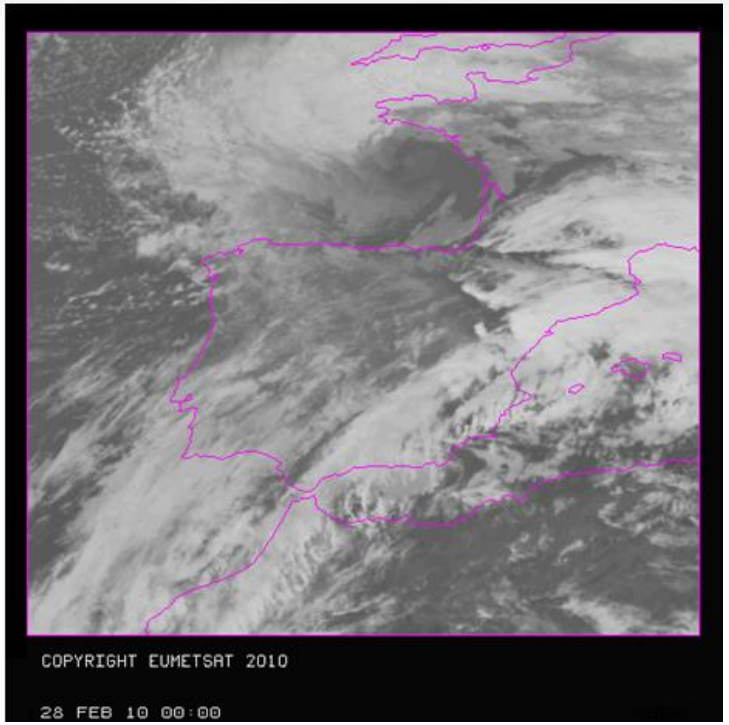
During 27-28 February 2010, Rapid Cyclogenesis 'Xynthia' (Deepening ~ 20 hPa/24 h, Min. Surf. Pressure ~ 968 hPa) crosses NW Iberian Peninsula & Bay of Biscay into France.

Although not as strong as other Cyclogenesis, it was very damaging:

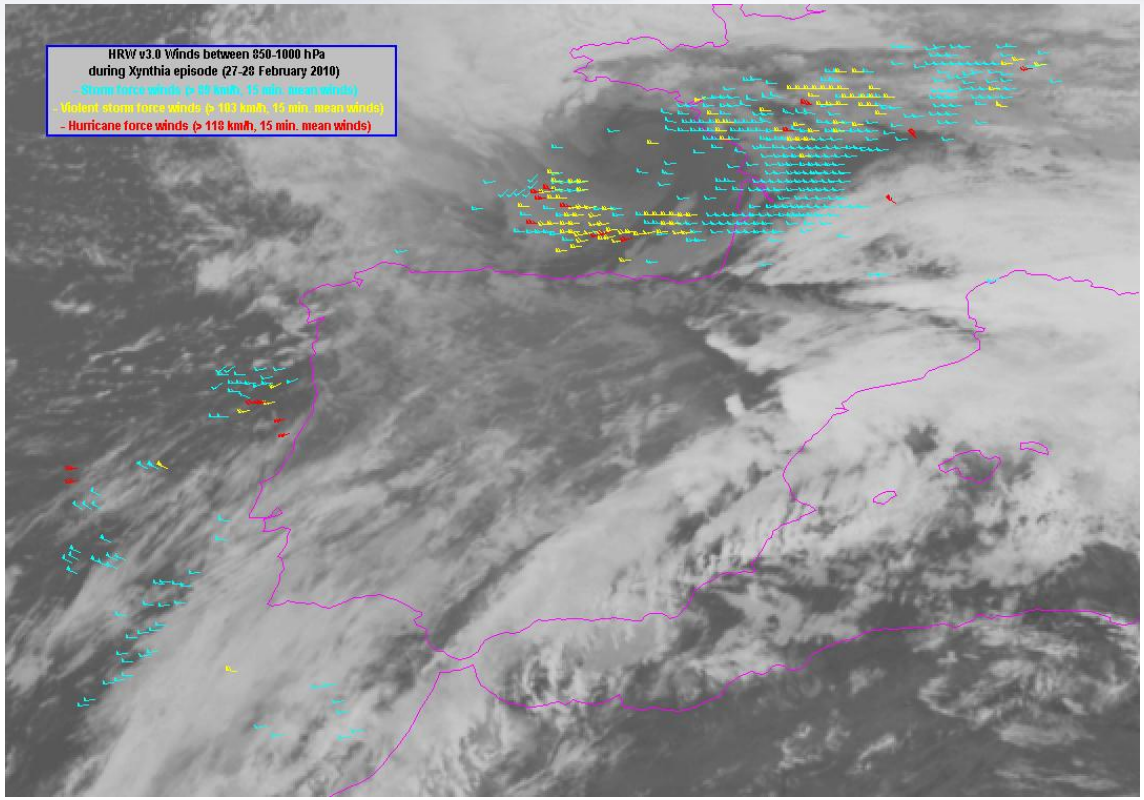
> 65 deaths in several European countries
(Specially in France, through floodings caused by the spring tide and a 1.5 m storm surge).

> Property losses higher than 1000 million euros.

> Around one million homes without electricity in Western and Central France.



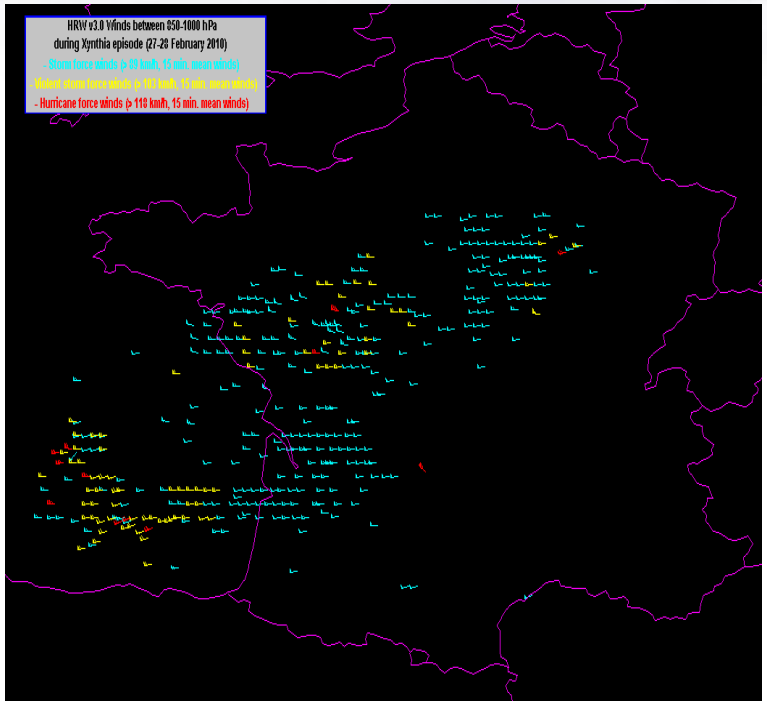

# Use of HRW AMVs in Nowcasting: 27-28 Feb. 2010 Rapid Cyclogenesis 'Xynthia'

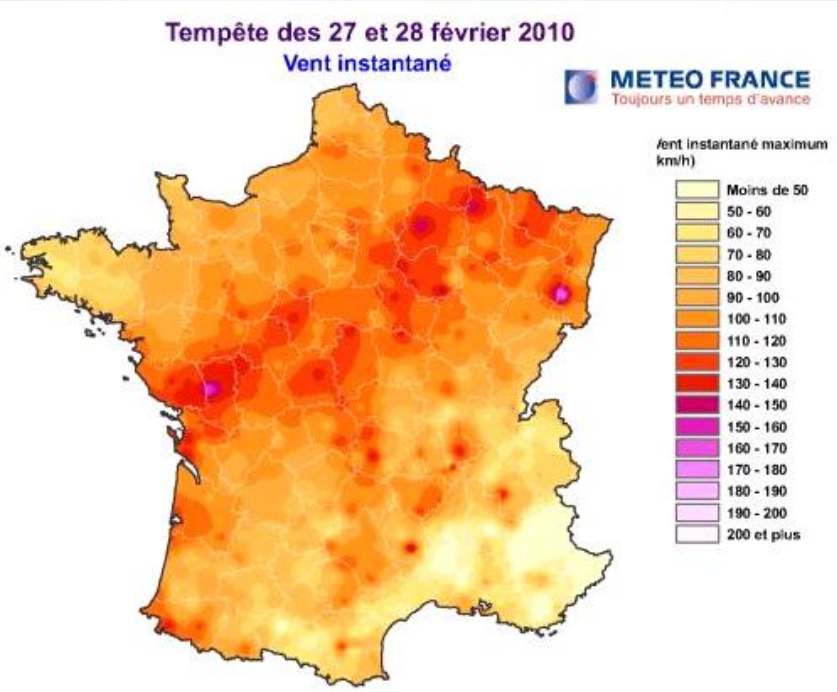



**HRW product defines very clearly the areas with strongest winds:**

- **Wind force over France more important than over the Iberian Peninsula.**
- **Storm force winds in France moving from southwestern Coastal areas into the inner country.**

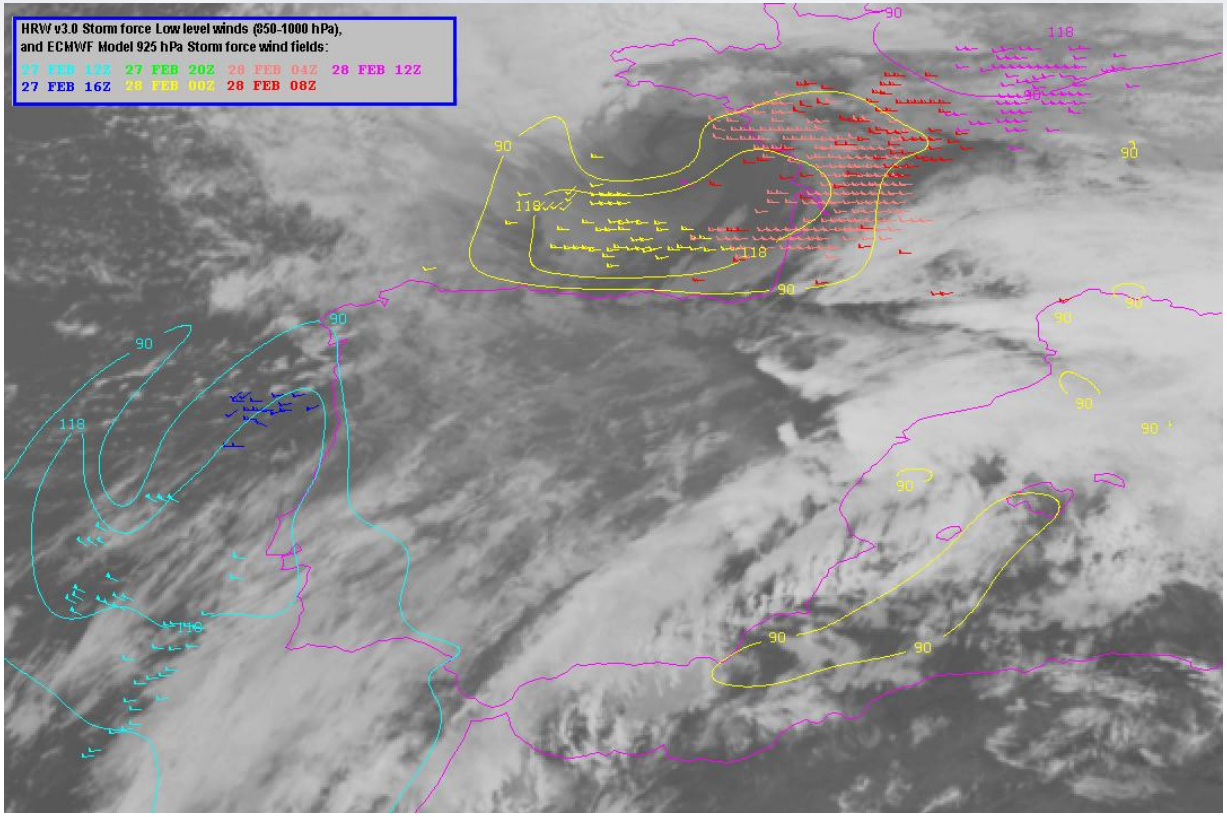
# Use of HRW AMVs in Nowcasting: 27-28 Feb. 2010 Rapid Cyclogenesis 'Xynthia'



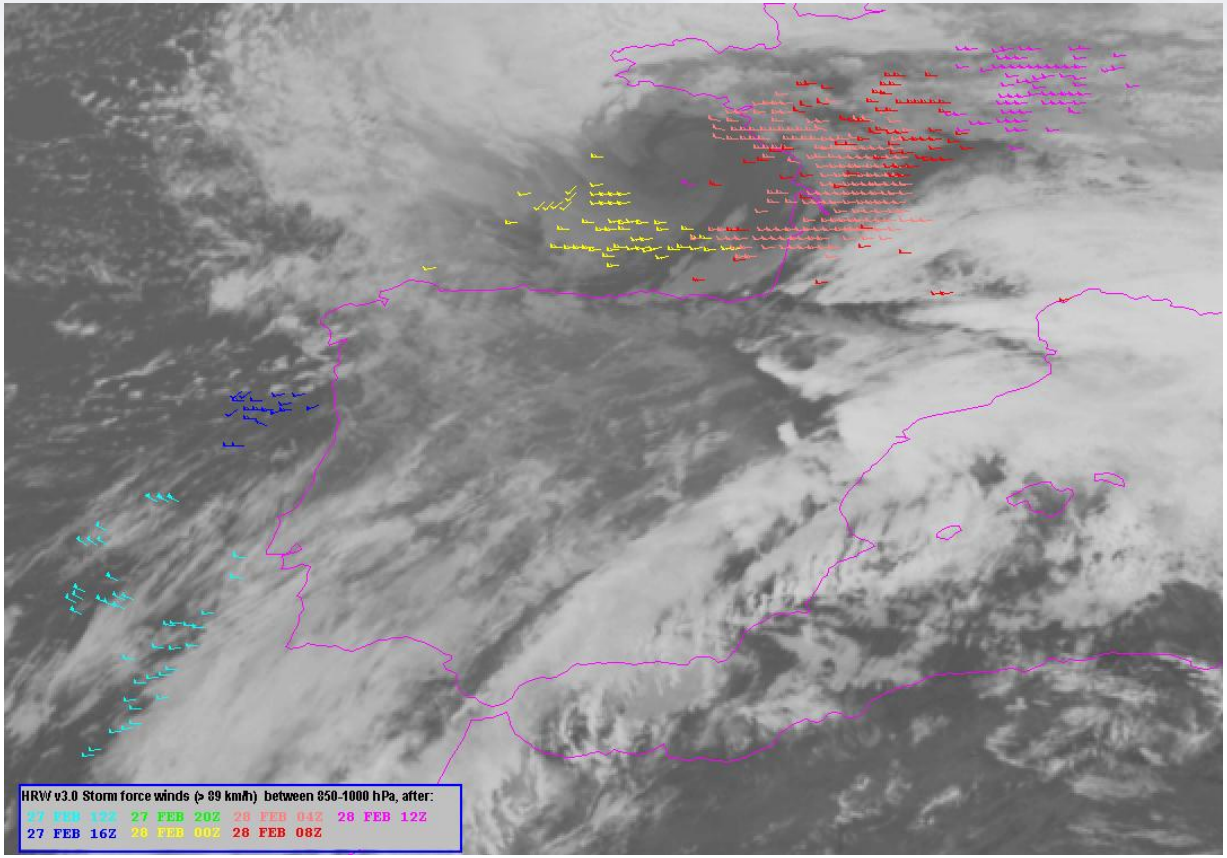

**Comparing HRW output in France (Storm force low level winds) with Surface Wind observations, the path followed by the strongest winds is clearly identified.**

# Use of HRW AMVs in Nowcasting: 27-28 Feb. 2010 Rapid Cyclogenesis 'Xynthia'




**Comparing against ECMWF Model wind fields, HRW confirms the NWP model forecast (trajectory of Xynthia and the areas suffering the strongest winds), although in general winds are weaker than expected.**

# Use of HRW AMVs in Nowcasting: 27-28 Feb. 2010 Rapid Cyclogenesis 'Xynthia'




The temporal evolution of HRW winds permits also to identify when the hardest winds are striking.

The capabilities of HRW product for operative nowcasting are shown by its dense wind fields:
- Spatial and temporal identification of winds
- Verification of the NWP model wind forecast

# Further information

**Thank you for your interest!**

**Further information on "High Resolution Winds" product can be obtained through the NWC SAF/Helpdesk (http://www.nwcsaf.org)**

**(specially at http://www.nwcsaf.org/indexScientificDocumentation.html, where the HRW ATBD / Validation Report are located)**

**or through my email address:**
**jgarciap@aemet.es**

**Any questions/doubts now from the audience?**