Evolution of High Resolution Winds Product (HRW), at the Satellite Application Facility on support to Nowcasting and Very short range forecasting (SAFNWC)

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Reminder of main characteristics of HRW

- The Satellite Application Facility on support to Nowcasting and Very short range forecasting (SAFNWC) was established between Eumetsat and the Spanish National Weather Service (INM, now evolved into the Agency Aemet).
- Its objective is to enhance Nowcasting and Very short range forecasting with MSG and Polar Satellite data.
- To achieve this goal, it develops and maintains a software package calculating several meteorological products, 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 meteorological applications, from MSG/HRVIS channel data.
  - Results calculated in less than 5 min. for observation cycles of 15 min, in a national or continental area.

Reminder of main characteristics of HRW

Main characteristics:

- Preprocessing: Normalisation of MSG/HRVIS reflectances.
- Tracer calculation with two different methods:
  - Gradient (searching well defined edges)
  - Tracer characteristics (filling holes in the coverage).
- Height assignment: calculation of three different height levels for each tracer:
  - Interpolation level of IR10.8 brightness temperature to NWP vertical profile.
  - Cloud top and Cloud base.
- 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.
  - Includes temporal, spatial, forecast tests; double contribution of spatial test.
- Orographic flag test: tracers affected by land influence are rejected.

Reminder of main characteristics of HRW

Input data:

- Full Resolution MSG/HRVIS & MSG/IR10.8 data.
- NWP data for the working region:
  - Temperature, Wind forecast.
  - Geopotential, Surface temperature also if Orographic flag is calculated.

  (NWP not mandatory but fairly recommended;
  if not available a rough Climatological Profile is used).

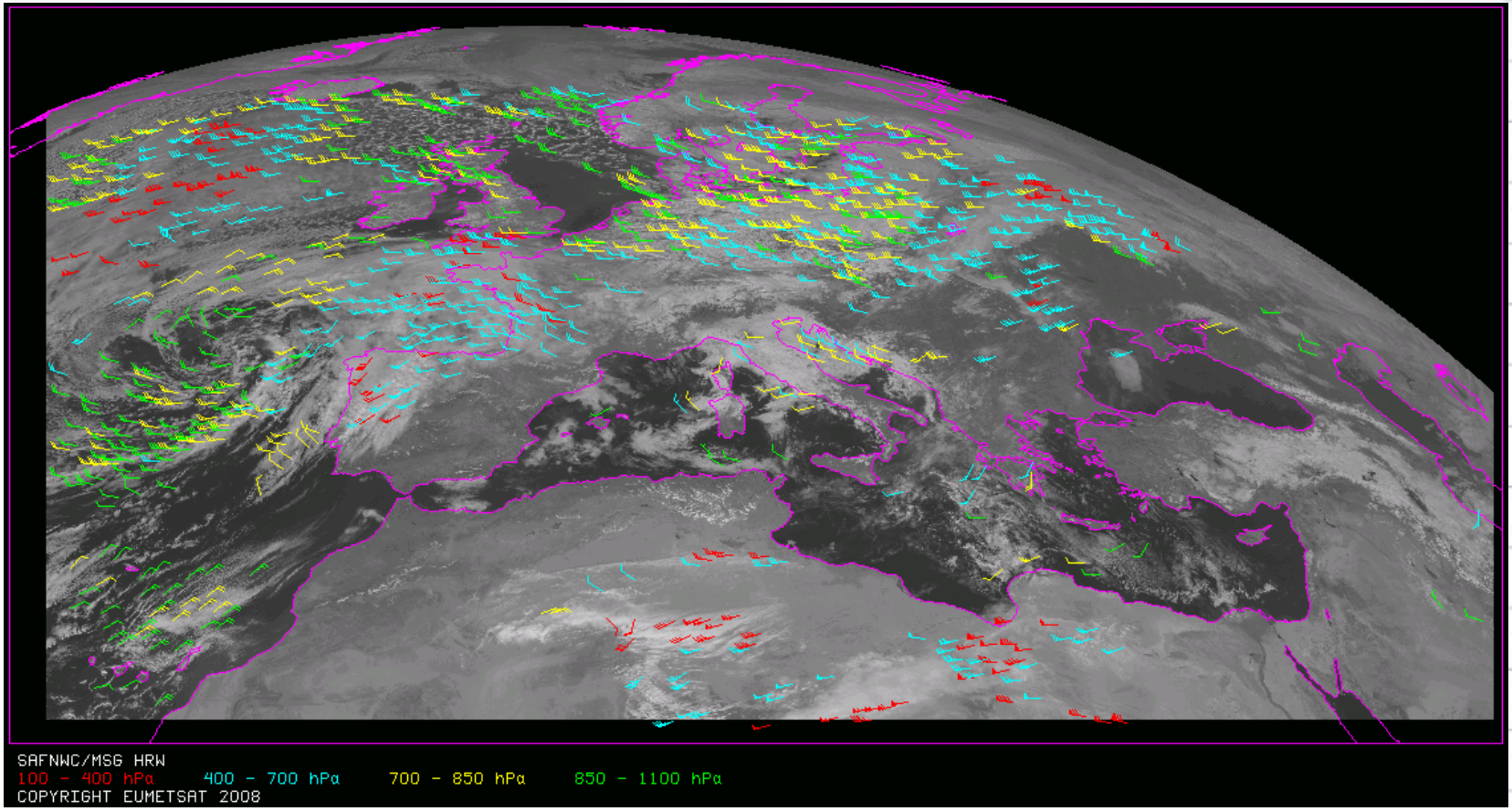
Output data:

- Two BUFR bulletins, with AMVs related to two different scales of tracers:
  - "Basic winds": SAFNWC_HRW_B.buf (Tracer size: 24 pixels).
  - "Detailed winds": SAFNWC_HRW_D.buf (Tracer size: 12 pixels).

Current version of SAFNWC/HRW product:

- HRW v2.1, available since spring 2008.

Reminder of main characteristics of HRW



HRW Product, Europe & Mediterranean Area

(27 Feb 2008, 1200Z; Quality Index > 83; Spatial test = 3; Orographic flag ≠ 1,2)

100 – 400 hPa 400 – 700 hPa 700 – 850 hPa 850 – 1100 hPa

Continuos Development & Operation Phase

Considering the general SAFNWC Schedule, a new Working Phase is now running:

2007 – 2012: Continuous Development and Operations Phase.

Objectives to be achieved during this phase:

1. Use of cloud information from other SAFNWC products:

   CT/Cloud type CTTH/Cloud Top Height and Temperature

   to detect the Cloud level that best represents the AMVs for each Cloud type and improve the Height assignment.
2. Adaptation of algorithm to Rapid Scanning, through two working procedures:
   - Wind calculation at every slot
   - Tracer tracking at every slot; wind calculation only every several slots.
3. Adaptation of algorithm to IR channels, to provide data during the whole day, following the requirements of the users.
4. New validation tools, not considered previously:
   - E.g., against wind profiles from Radar VAD data, for a more continuous validation of HRW throughout time and space.

Evolution of HRW between v1.2 and v2.1

- A comparison has been made between versions v1.2 (2006) and v2.1 (2008) to evaluate the evolution of HRW product.

- The effect of several parameters has also been studied:
  - Quality Index Threshold.
  - Atmospheric Level.
  - Orographic Flag.
  - Geographical distribution of errors.

Evolution of HRW between v1.2 and v2.1

- Validation of HRW v2.1 based on Comparison of 1200Z HRW Output with Radiosounding Winds in the European & Mediterranean area during the period Sep 2006 – Aug 2007.

HRW v2.1 Validation (Sep. 06 – Aug. 07, European Area)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	86144	11297	39130	35717
Mean radiosounding speed (SPD)	15.54	28.02	16.64	10.38
Normalized Bias (NBIAS)	-0.08	-0.08	-0.08	-0.05
Normalized Mean vector difference (NMVD)	0.40	0.32	0.40	0.46
Normalized Root mean square vector difference (NRMSVD)	0.53	0.41	0.51	0.59

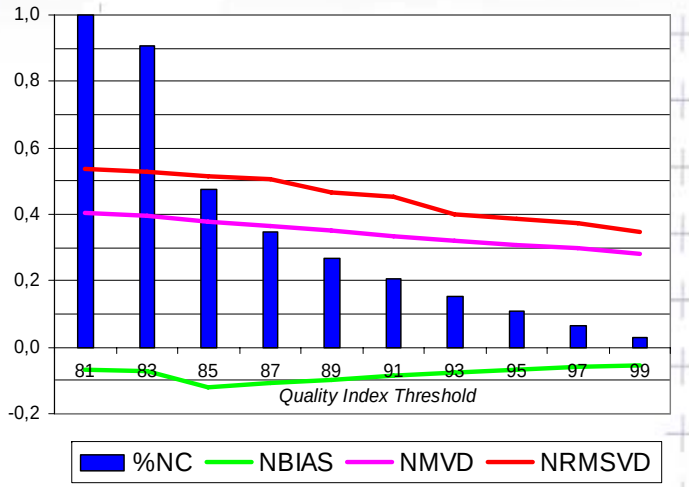
- Comparing HRW v2.1 with HRW v1.2:
  - Reduction of ~ 50% in the NBIAS.
  - Reduction of ~ 5% in the NMVD and NRMSVD.

- Improvements based basically on:
  - The optimisation of the algorithm configuration parameters.
  - The introduction of the orographic flag in the low levels.

Effect of Quality Index & Atmospheric Level

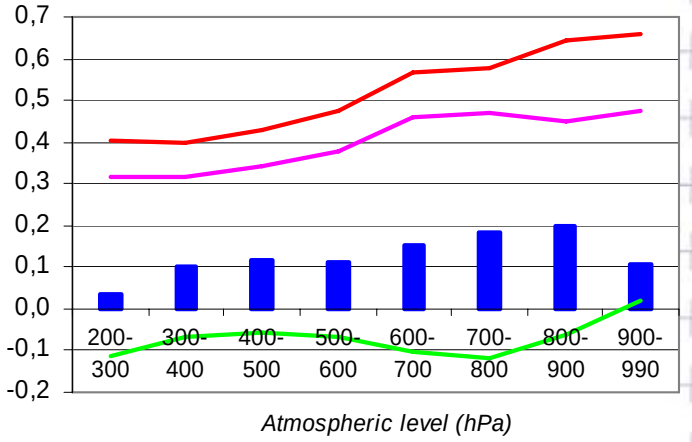
Considering the Quality Index Threshold:

- MVD and RMSVD improve clearly when the QI Threshold becomes higher.
- BIAS shows the same behaviour than for the previous versions.
- A maximum QI threshold = 83 is recommendable to keep the main part of the AMV population.



Considering the different Atmospheric levels:

- Best results in highest layers (NRMSVD ≈ 0.41).
- Worst results in lowest layers (NRMSVD ≈ 0.66).

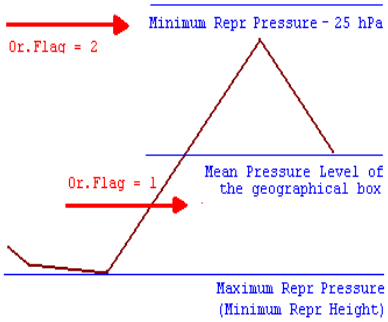


Effect of Orographic Flag

- The Algorithm calculates for Geographical Boxes of 1x1 Degree Lat/Lon:
  - Min/Max Representative Heights (3% & 97% Height Histogram Centiles).
  - Barometric conversion of Heights to Max/Min Representative Pressures.
- Orographic Flag Assignation:

  Or.flag = 1 Tracer below the Mean Pressure level of the corresponding geographical box

  Or.flag = 2 Tracer below the highest level with orogr. influence [defined as Min.Represent.Pressure - 25 hPa]



Else, if Stability is found at the Tracer location and Speed > 5 m/s, Previous positions of the Tracer are calculated with the corresponding AMV:

Or.flag = 3 Tracer below highest level with orographic influence, at any of the previous positions up to two hours (An obstacle has been found).

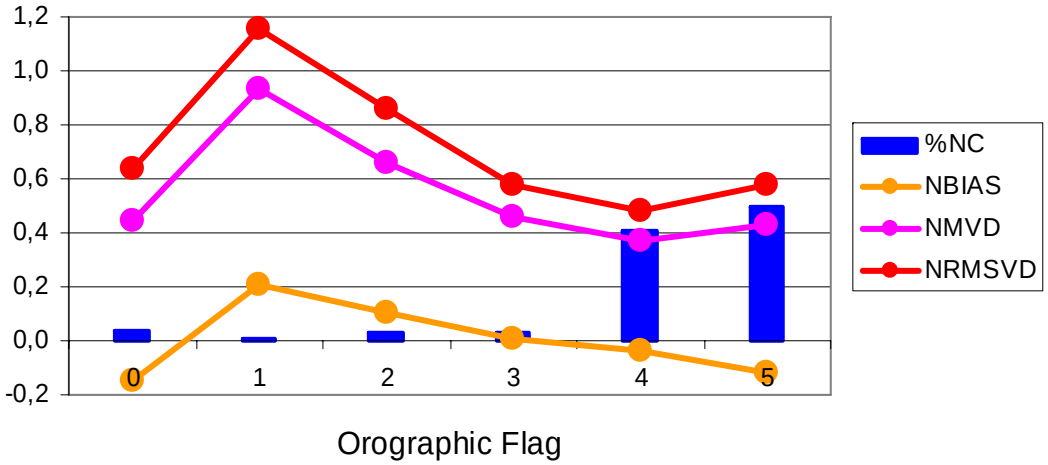
Or.flag = 4 No obstacle has been found, but Stability is still present at the previous positions (The obstacle might be at a further place).

Else, Or.flag = 5 (All other conditions: no orographic influence is found).

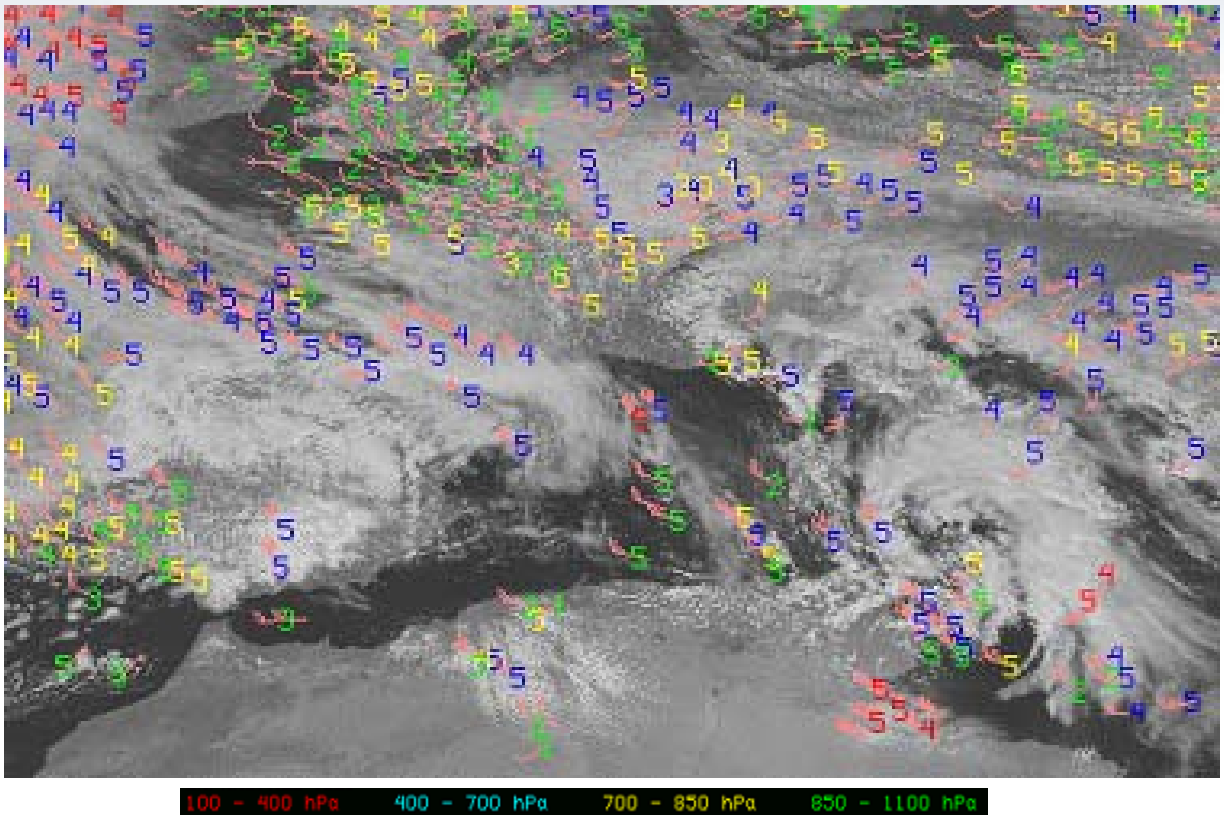
Effect of Orographic Flag

- Normalized MVD & RMSVD are about a 70% worse when Orographic Flag = 1,2.
- The Orographic Flag is a good parameter to filter out an 8% of low level winds with worse quality.

HRW v2.1 (Sep.06 – Aug.07, European Area)	Orog.Flag=1,2	Orog.Flag=0,3,4,5
Number of collocations (NC)	3177	86144
Mean radiosounding speed (SPD)	7.28	15.54
Normalized Bias (NBIAS)	0.12	-0.08
Normalized Mean vector difference (NMVD)	0.69	0.40
Normalized Root mean square vector difference (NRMSVD)	0.90	0.53



Effect of Orographic Flag



Example of HRW with Orographic flag for each tracer (27 Mar 2008, 1200Z):

- Orographic flags = 1,2 restricted to low levels:
  tracers near the ground; although sometimes also tracers in sea areas near land masses.
- The general flux is better represented in mountainous areas without Orographic flags = 1,2:
  in this case for example in Algeria.

Geographical distribution of errors

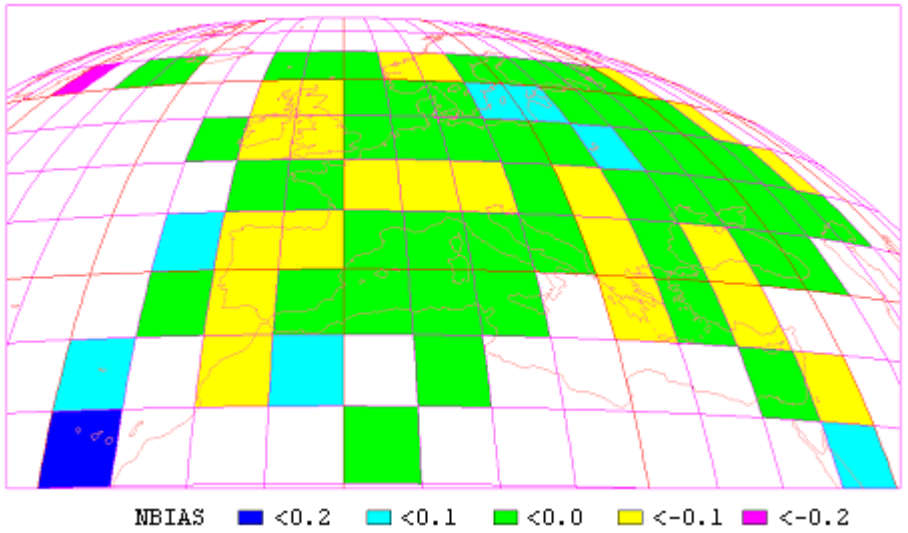
To define the areas in which the atmospheric flux is best and worst represented:

- The geographical dispersion of the normalized validation parameters (NBIAS, NMVD and RMSVD) is calculated for the European area.
- The values are calculated for 5x5 degree boxes with at least 40 collocations.

Main result: Small variation of statistical parameters with geographical coordinates.

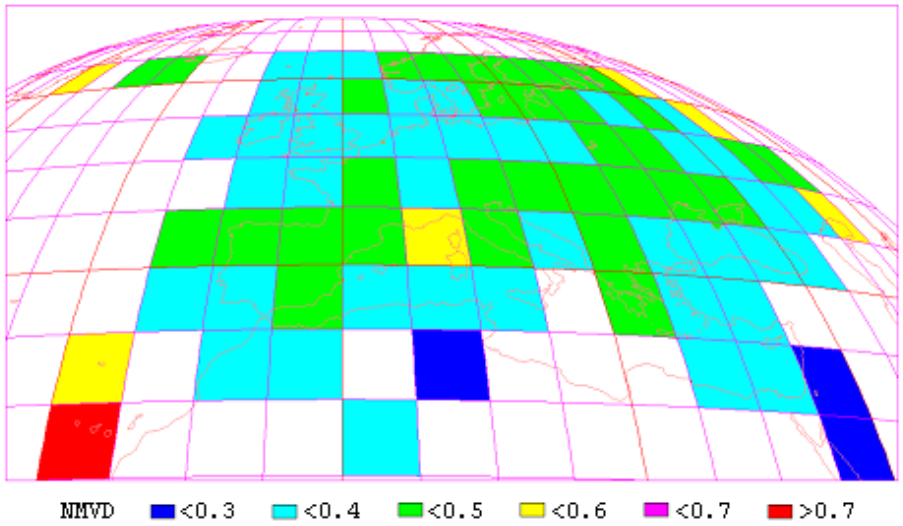
- Similar results in Northern Europe and the Mediterranean Sea.

Normalised BIAS



Geographical distribution of errors

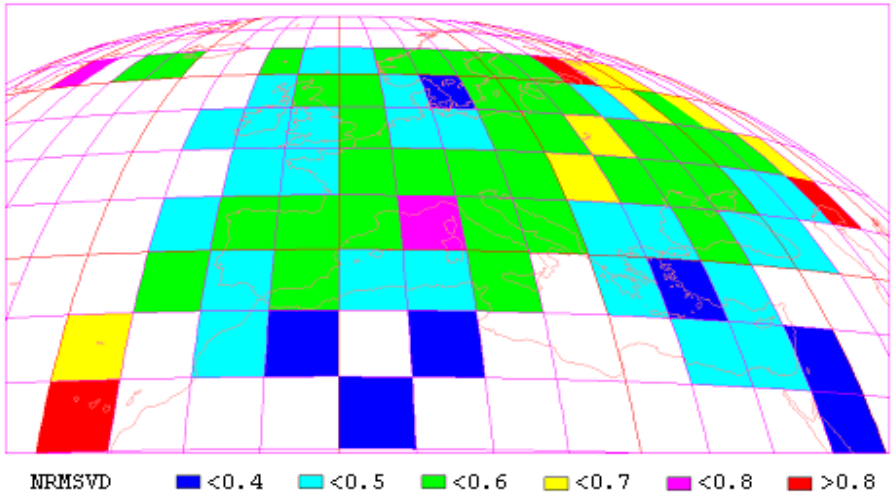
Normalised MVD



Worse results for NMVD/NRMSVD:

- Edge of working region: far NW/NE
  - > A reduction of Satellite zenith angle threshold from 80º to 75º is enough to improve results.

- Some maritime boxes (Canaries, Madeira, Corsica, Sardinia)
  - > Maritime AMVs are compared to land radiosoundings.
  - > Local effects reduce correlation between land and sea winds.



Normalised RMSVD

Inclusion of SAFNWC/Cloud Type product

- HRW can run in parallel to SAFNWC/Cloud Type product, and take advantage of it.
- This product classifies all pixels considering information from MSG/SEVIRI channels: VIS0.6, VIS0.8, IR1.6, IR3.9, IR8.7, IR10.8, IR12.0

- Next Cloud types categories are now available:

1 Cloud free land	12 High opaque cumulus/stratus
2 Cloud free sea	14 Very high opaque cumulus/stratus
3 Land with snow/ice	15 High semitransparent thin cloud
4 Sea with ice	16 High semitransparent meanly thick cloud
6 Very low cumulus/stratus	17 High semitransparent thick cloud
8 Low cumulus/stratus	18 High semitransparent above other clouds
10 Medium cumulus/stratus	19 Fractional cloud

(Separation of cumulus & stratus still not available; product still not fully developed).

Inclusion of SAFNWC/Cloud Type product

- A preliminary study (still not included in the official HRW version) has been run to define which of the different height levels defined for each tracer:
  - IR10.8 brightness temperature interpolation level to NWP.
  - Cloud top: coldest non isolated class in the smoothed temperature histogram.
  - Cloud base: calculated through formula $T_{Cloud\ Base} = T_{Mean} + \sqrt{2}\ \sigma_{Temp}$

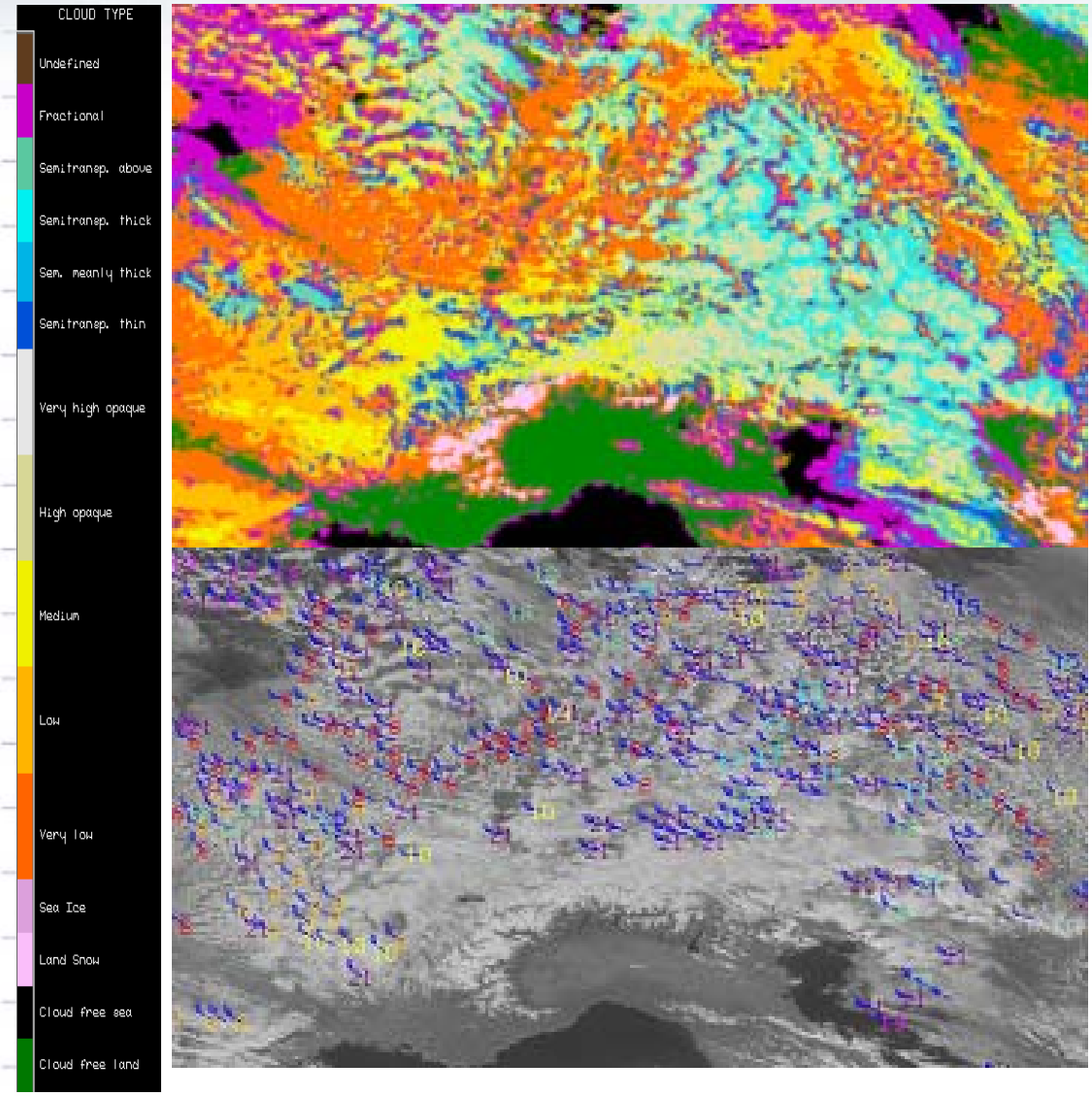
  is best for the Height assignment, for the different types of cloud.

- Several procedures were tried to define the "tracer cloud type".

  The clearest information was obtained with:

  - The most common cloud must be at least 1.5 times the second most common.
  - If this is not clear: "undefined cloud type".

Inclusion of SAFNWC/Cloud Type product



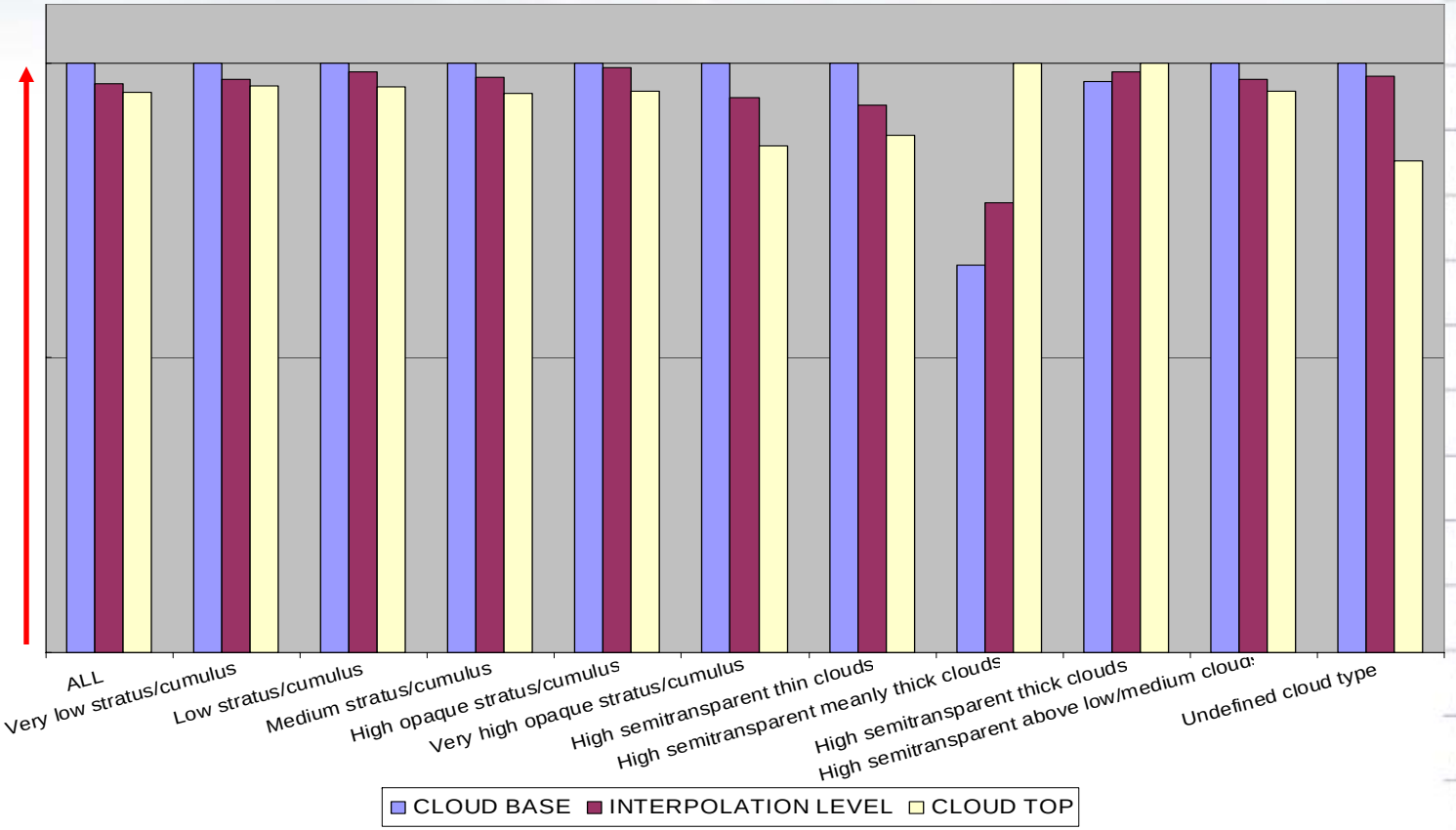
Examples of:

- SAFNWC/CT Product
- SAFNWC/HRW with the Cloud type related to each tracer

(25 Mar 2008, 1200Z)

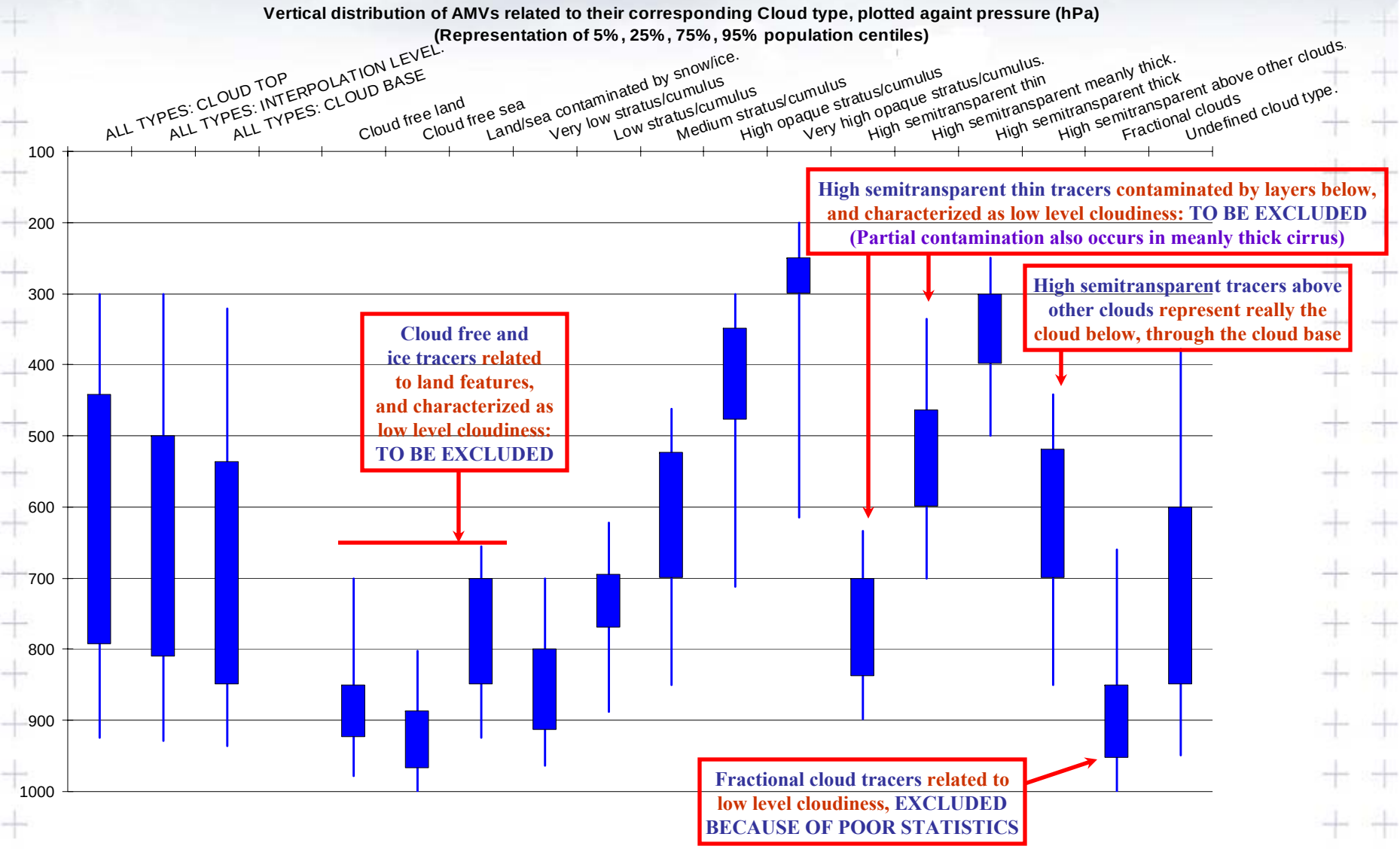
Inclusion of SAFNWC/Cloud Type product

Statistical parameters best fit



- The best fit is reached with:
  - The cloud top for High semitransparent thick and meanly thick clouds.
  - The cloud base for all other cloud types.

Inclusion of SAFNWC/Cloud Type product



Inclusion of SAFNWC/Cloud Type product

- AMV statistical parameters for the different cloud types (Jun 2007 – Jan 2008):

NUMBER OF TRACERS	CLOUD TYPE	SPEED	NBIAS	NMVD	NRMSVD	CHOSEN LEVEL	
597	Cloud free sea	7,91	0,10	0,74	0,95	Eliminated	X
734	Cloud free land	8,72	-0,03	0,59	0,77	Eliminated	X
14	Land/sea with snow/ice	10,64	-0,08	0,57	0,67	Eliminated	X
1722	Fractional clouds	9,90	0,05	0,51	0,66	Eliminated	X
8681	Low stratus/cumulus	11,74	-0,11	0,48	0,60	Cloud base	√
489	High semitransparent thin	10,57	-0,08	0,48	0,59	Eliminated	X
567	High semitransparent meanly thick	15,27	0,16	0,48	0,58	Cloud top	√
2396	High semitransparent above clouds	14,75	-0,04	0,47	0,57	Cloud base	√
7619	Very low stratus/cumulus	10,51	-0,11	0,44	0,54	Cloud base	√
5096	Medium stratus/cumulus	14,48	-0,03	0,42	0,53	Cloud base	√
8153	Undefined cloud type	13,71	-0,03	0,41	0,52	Cloud base	√
2327	High semitransparent thick	26,31	-0,00	0,35	0,45	Cloud top	√
5650	High opaque stratus/cumulus	23,54	-0,01	0,33	0,42	Cloud base	√
615	Very high opaque stratus/cumulus	31,52	-0,03	0,30	0,37	Cloud base	√

- Best statistics for High stratus/cumulus and High semitransparent thick clouds.
- Worst statistics for Low stratus/cumulus and Other high semitransparent types.

Inclusion of SAFNWC/Cloud Type product

- With these results, some kinds of cloud types can be eliminated:

  - Wrong tracers:
    (Cloud free, Ice contaminated tracers: 3% of the total)

  - Cloud types with poor verification statistics:
    (Fractional clouds: 4% of the total).

  - Cloud types incorrectly identified in the height assignment:
    (High semitransparent thin clouds: 1% of the total).

Inclusion of SAFNWC/Cloud Type product

- The inclusion of SAFNWC/CT product is positive in the height assignment, taking advantage of the cloud identification process considered in its algorithm:
  - With it there are additional reductions in the NRMSVD:

~ 10% in the low levels ~ 5% in the high levels
No impact in the medium levels

- The change is significant in the low levels, where the statistical parameters become better than the medium level ones.

HRW without SAFNWC/CT in the Height assignment (Jan. 08 – Mar.08, European Area)	All levels	High levels	Med. levels	Low levels
Number of collocations (NC)	14687	2323	6304	6060
Mean radiosounding speed (SPD)	18.20	35.60	18.01	11.74
Normalized Bias (NBIAS)	-0.09	-0.09	-0.11	-0.06
Normalized Mean vector difference (NMVD)	0.37	0.31	0.39	0.40
Normalized Root mean square vector difference (NRMSVD)	0.49	0.40	0.50	0.51

HRW with SAFNWC/CT in the Height assignment (Jan.08 – Mar.08, European Area)	All levels	High levels	Med. Levels	Low levels
Number of collocations (NC)	12221	1400	5761	5060
Mean radiosounding speed (SPD)	17.45	35.04	17.81	12.18
Normalized Bias (NBIAS)	-0.10	-0.10	-0.11	-0.08
Normalized Mean vector difference (NMVD)	0.37	0.30	0.39	0.38
Normalized Root mean square vector difference (NRMSVD)	0.48	0.38	0.50	0.47

Conclusions

- The validation is homogeneous and good enough throughout all the European and Mediterranean area.
  - > Product perfectly usable up to a satellite zenith angle of about 75º.
  - > Quality similar in Scandinavia and in Southern Europe.
- The orographic flag is valuable in the filtering of data to get a better validation.
  - > Orographic flag values = 1,2 detect a small proportion of low level AMVs (about an 8%) with a much lesser quality.
- Positive evolution since HRW v1.2 (2006):
  - > Reduction of ~ 50% in the NBIAS.
  - > Reduction of ~ 5% in the NMVD and NRMSVD.
- Effects of SAFNWC/Cloud type product in the Height assignment:
  - > AMVs represent better the cloud base displacement for all cloud types, except for High semitransparent thick/meanly thick clouds (related to cloud top).
  - > Some cloud types can be eliminated to improve statistics:

    Cloud free, Ice contaminated, Fractional, High semitransparent thin clouds.
  - > Its inclusion causes additional reductions in the NRMSVD:

    ~10% in the low levels and ~ 5% in the high levels.

SAFNWC 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 SAFNWC Software.

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

Luis Fernando López Cotín
SAFNWC CDOP Manager
l.cotin@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 SAFNWC Help Desk Restricted Area are provided, where the SAFNWC software can be downloaded:

http://nwcsaf.inm.es