The EUMETSAT Wind Vector Automatic Quality Control Scheme

The Automatic Quality Control (AQC) is an essential part of EUMETSAT's Atmospheric Motion Vector (AMV) processing. Since almost all processed AMVs are disseminated in BUFR code, the AQC provides a possibility for the user to set a minimum quality level and thereby to control the assimilation of the vector field. A Recommended Level in terms of minimum quality is included in the BUFR coded AMV products. The AQC is also basis for the choice of "best wind in segment" in the SATOB coded product.

The present AQC scheme is simple and robust. It is based on meteorological experience, and the different tests are tuned to reflect the quality in the same way as a meteorologist would experience it.

The scheme derives a Quality Indicator (QI) for each individual vector based on the properties of the vector itself and its consistency with other vectors. The scheme consists of five different tests that are normalised with a tanh-function that returns values between 0 and 1, where 0 indicates poor quality and 1 high quality. The Intermediate QI is then calculated as a linear weighted average of the returned values from these five tests.

After the calculation of the Intermediate QI above, there are some corrections applied in areas/levels where bad performance has been experienced. The corrections are:

- A reduction of the QI for too fast low level winds (IVH).
- A reduction of the QI for winds above the Tropopause.
- A reduction of the QI for low WV winds (below 400 hPa).
- A reduction of the QI for very weak winds (< 2.5 m/s).

The functionality of the corrections is described below, and the **Final QI** that is disseminated in the BUFR coded products is the product of the corrections and the Intermediate QI.

Since 5 June 2001 a **second set of Final QIs** is calculated and disseminated in all BUFR coded wind products. The only difference to the ordinary QI value is that **the forecast consistency is not included.**

For more scientific information and evaluation of the AQC scheme, please go to the list of references at the end of this document.

Test Functions

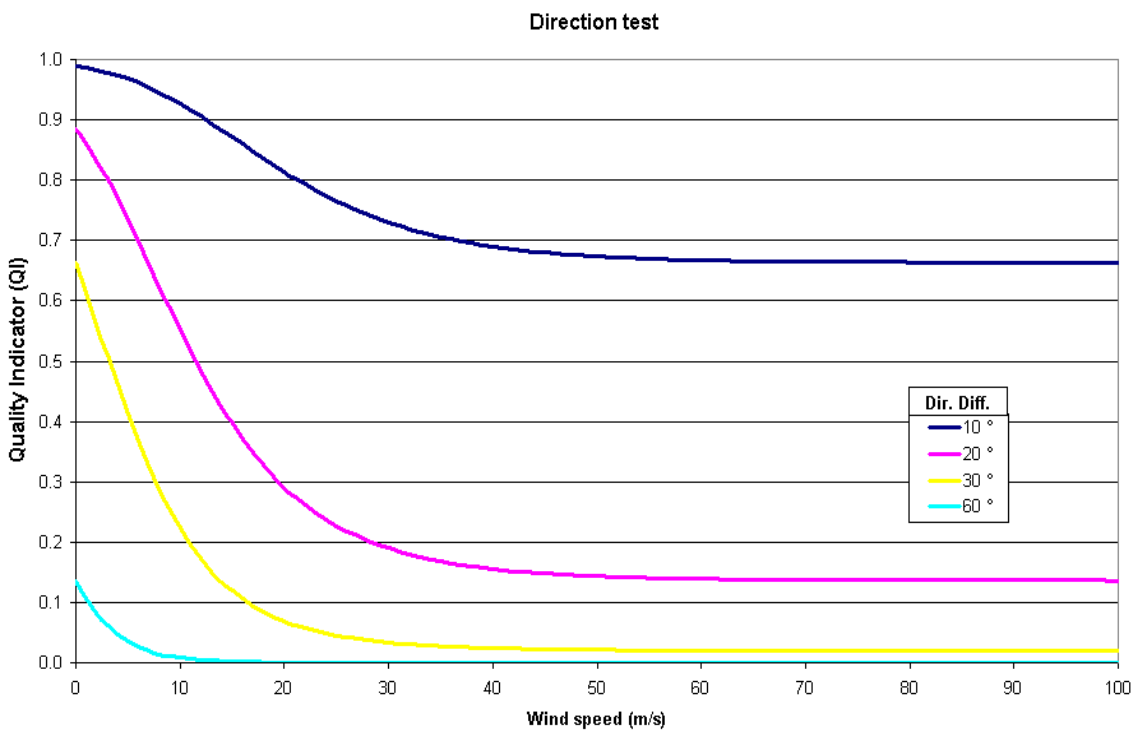
For all functions "Speed" is the speed for the wind vector concerned, calculated from the vector mean of the two components. The constants (Parameters) A - D, are used for tuning, and are defined in the Parameter Table. The diagrams reflect the behaviour of the tests in operation today.

The Direction Consistency test

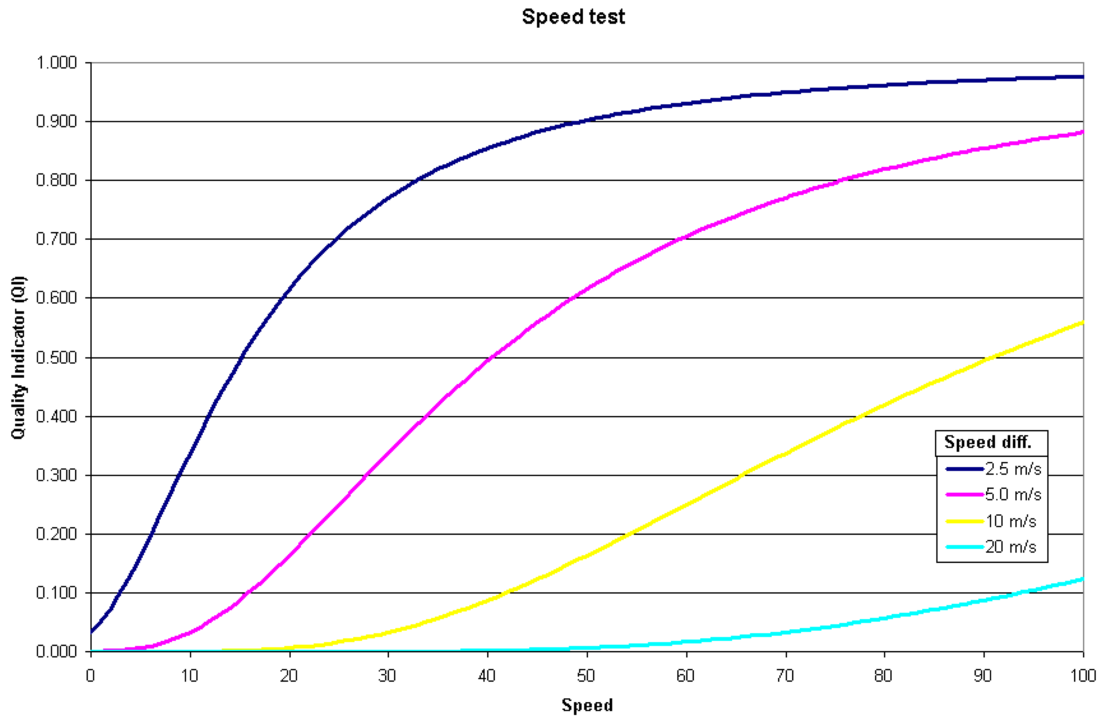
Function:

$QI = 1 - [\tanh["Difference" / (A*EXP(-Speed/B)+C)]]^D$,

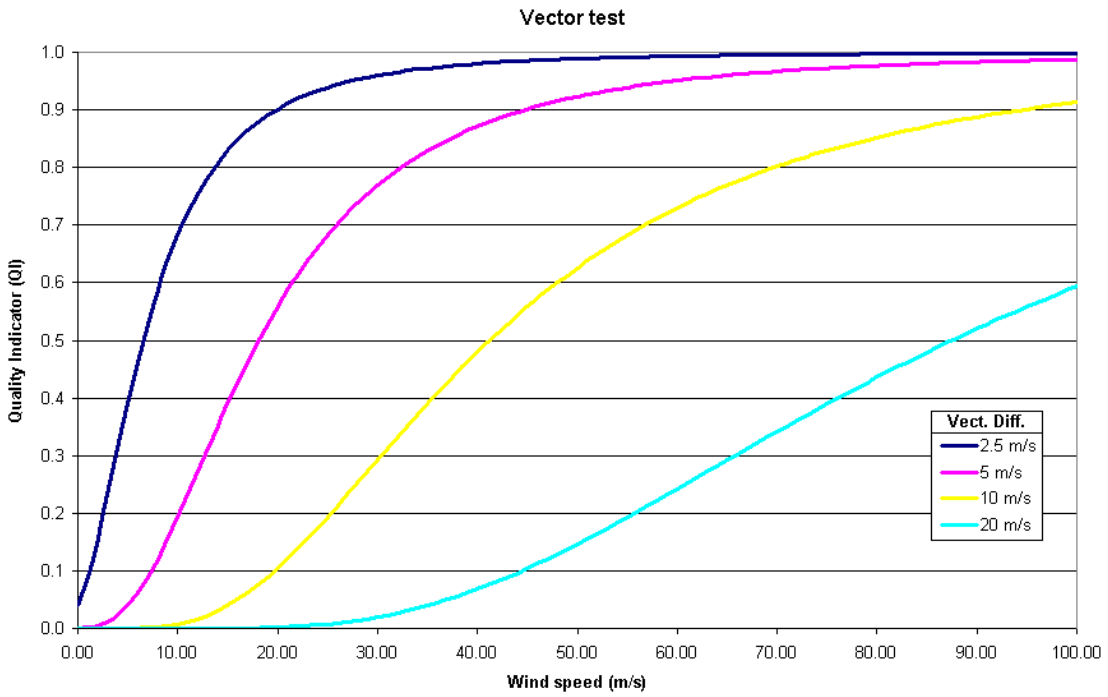
where Difference = direction difference between 1st and 2nd satellite wind component (degrees).



The Speed Consistency test
Function: QI = 1 - [tanh["Difference" / (MAX(A*speed,B)+C]]^D,
where Difference = speed difference between 1st and 2nd satellite wind component.



The Vector Consistency test
Function: QI = 1 - [tanh["Difference" / (MAX(A*speed,B)+C]]^D,
where Difference = length of the difference vector between 1st and 2nd satellite wind component.

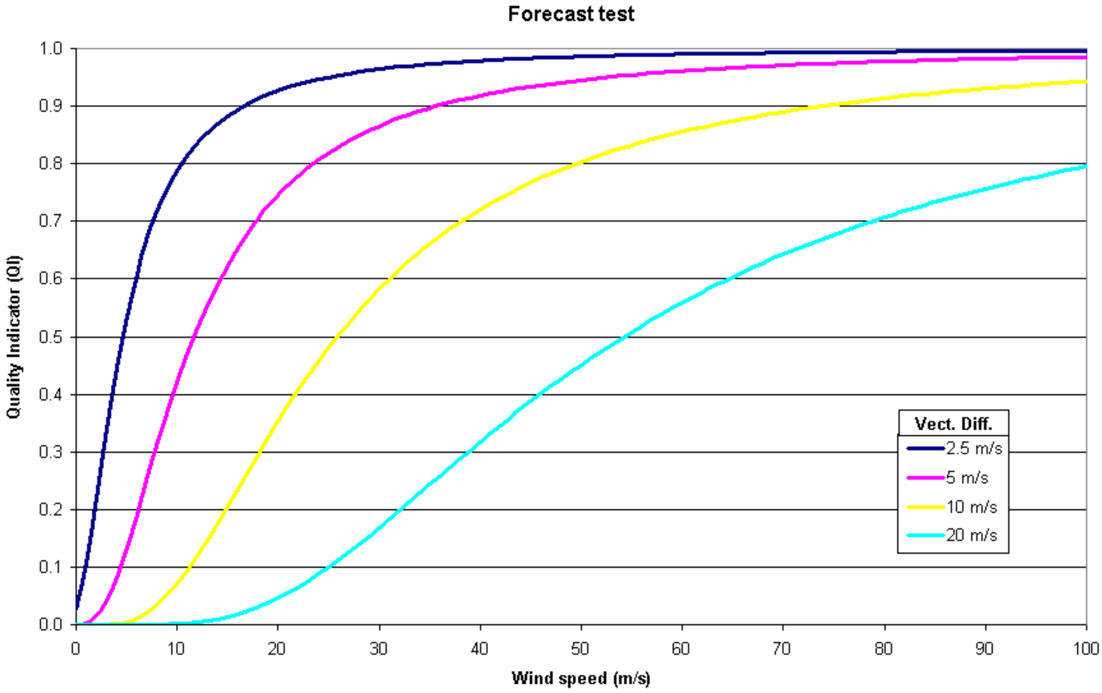


The Forecast Consistency test

Function:

QI = 1 - [tanh["Difference" / (MAX(A*speed,B)+C]]^{D},

where Difference = length of the difference vector between satellite wind and forecast wind.

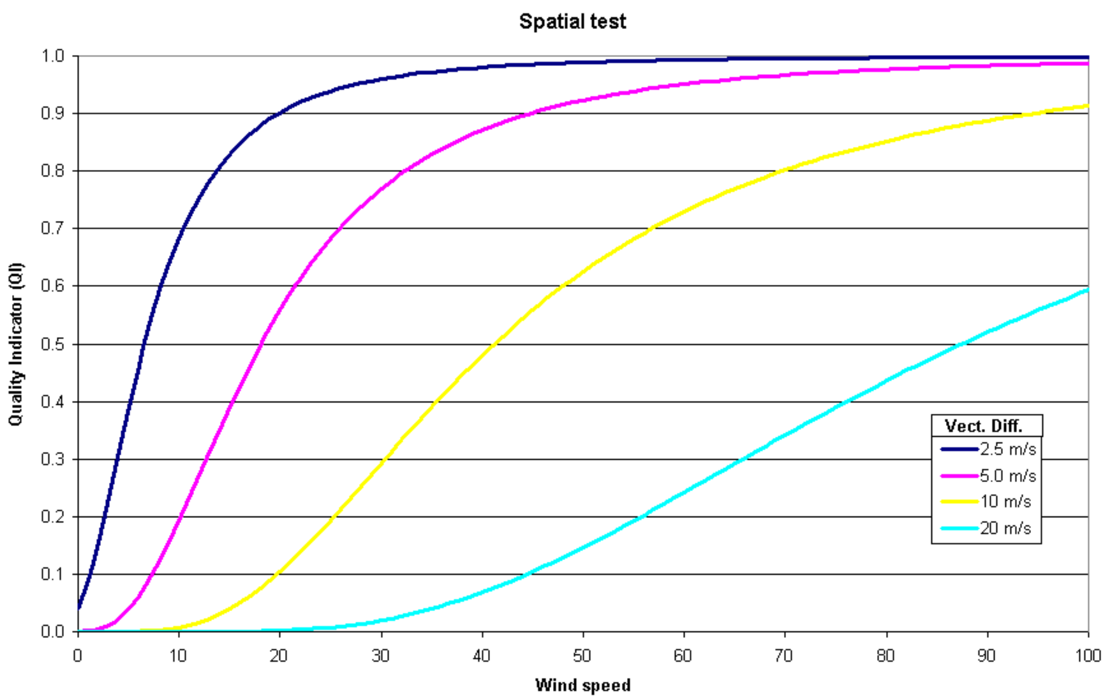


The Spatial Consistency test

Function:

QI = 1 - [tanh["Difference" / (MAX(A*"Speed",B)+C]]^{D},

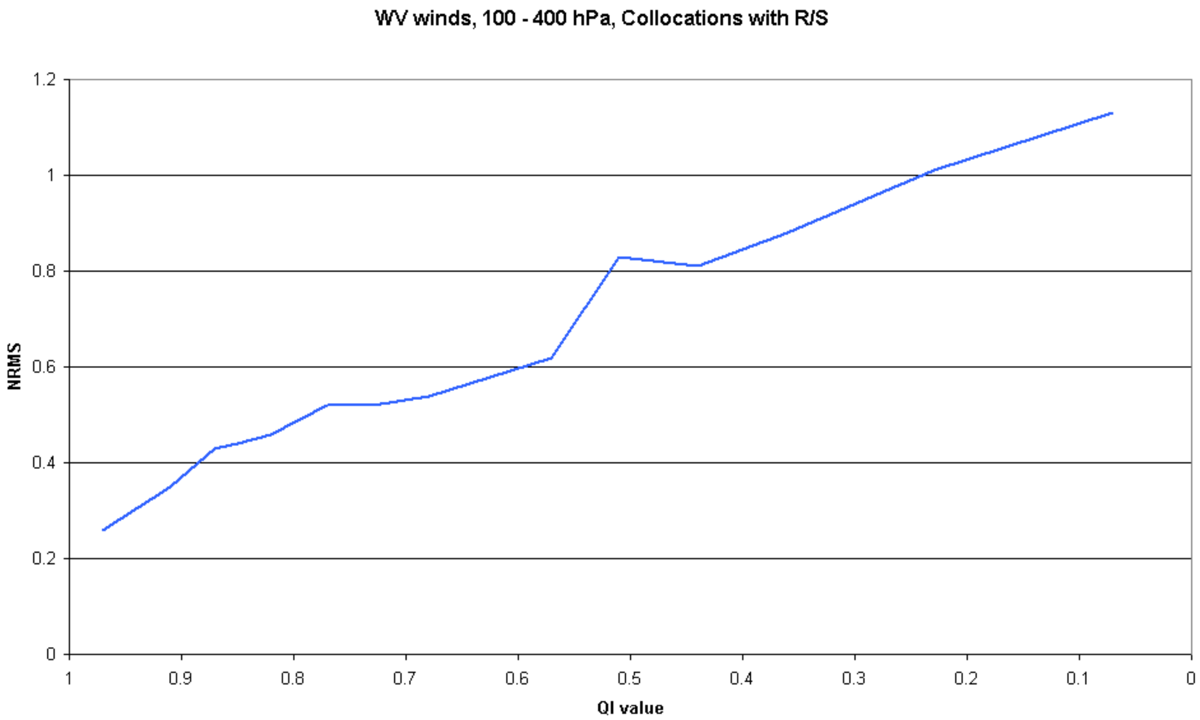
where Difference = length of the difference vector between the satellite wind concerned and its best neighbour (any channel). The best neighbour is determined by the smallest vector difference.



The **Intermediate Quality Indicator** (QI) is then calculated as follows:

QI =[[A*Dir.Cons + B*Spd.Cons + C*Vect.Cons + D*Fcst.Cons + E*Spat.Cons] / [Sum(A-E)]]

The weights A-E are specified in the Parameter Table. The diagram shows the behaviour of the final QI value against RMS error normalised with the radiosonde wind speed.



QI Corrections

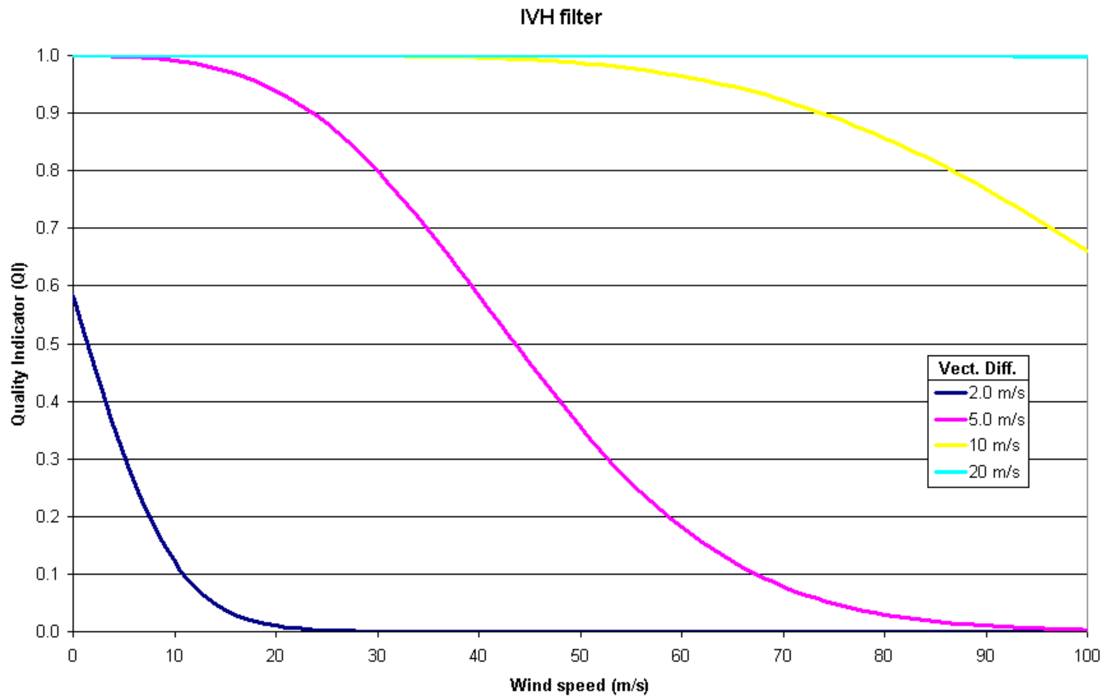
Inter-channel Vertical Heterogeneity filter (IVH)

In addition to the AQC, the IVH filter is applied. It filters out wind vectors processed from extremely thin cirrus clouds that have remained unidentified in the image analysis, and therefore are erroneously assigned to a low level. This IVH filter is applied on both IR and VIS winds below 600 hPa with speeds above 15 m/s. It affects the QI for a small number of winds only, and is based on the theory that if a low level wind and a high level wind in the same segment are almost identical, then the low level wind is wrong and will be rejected. This function is "inverted" compared to the other tests, i.e. if the difference is small, it will return a small value, indicating a low quality. It is tuned to be "binary" i.e. it returns 0 or 1, rarely something in-between.

Function:

Correction Factor = [tanh["Difference" / (MAX (A*Speed,B) + C]]^D,

where Difference = length of the difference vector between the satellite wind concerned and the WV wind vector in the same segment.



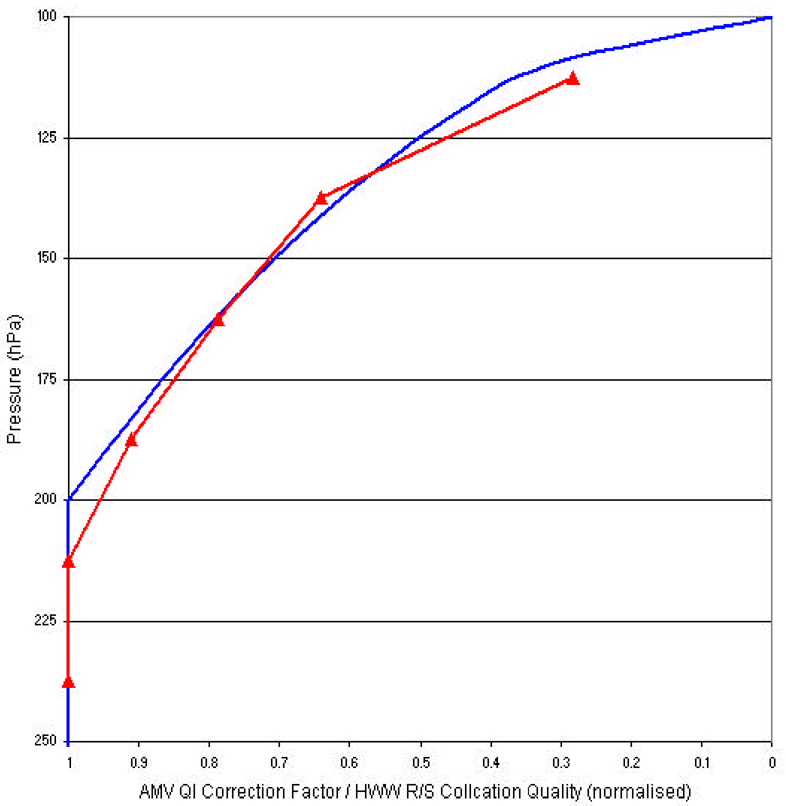
Reduction of the QI for winds above the Tropopause

The height correction of semitransparent clouds (Semitransparency Correction) is sometimes overreacting. Therefore a reduction of the QI for all winds **above 200 hPa and outside the tropics** is applied, by multiplying the intermediate QI with a Correction Factor according to the function below. **All winds on exactly 100 hPa (upper processing limit), also in the Tropics, are assigned QI = 0.**

Function:

Correction Factor = [(Pressure-100)/100]^2,

where Pressure = pressure in hPa of the AMV concerned.



The red curve illustrates the average quality related to height. Only winds with Intermedite QI > 0.6 are included.

In spite of this quite high Intermediate QI, it is clear that the quality is deteriorating rapidly with height.

The blue curve is the correction factor applied.

Reduction of the QI for medium level WV winds

For the WV channel the theoretical lower limit for wind processing is around 400 hPa. Nevertheless there are some winds processed at levels below that, and rather than excluding them (as in the SATOB product) they are disseminated in BUFR code, but with a reduced QI. The same function as above for too high wind is used inverted, and applied from 400 hPa down to 500 hPa. All WV winds below 500 hPa are assigned QI = 0.

Reduction of the QI for very weak winds

The EUMETSAT wind processing does not have any fixed minimum speed, allowing for observations also in weak wind areas. These winds are, however, statistically of a low quality. Also, cold surface is sometimes classified wrongly as cloud (typically desert during night), causing very weak winds from "rectification movement" in the image. The QI for winds weaker than 2,5 m/s is therefore multiplied with a factor that is 1 for 2,5 m/s, and linearly decreasing to 0 for zero speed.

Parameter Table

	PARAMETER	Until 12/12/1997 1000 UTC	From 12/12/1997 1000 UTC
Direction consistency	A	40	20
	B	15	10
	C	15	10
	D	3	4
Speed consistency	A	0.5	0.1
	B	0.01	0.01
	C	2	1
	D	0.7	2.5
Vector consistency	A	0.1	0.2
	B	0.01	0.01
	C	1	1
	D	3	3
Forecast consistency	A	0.4	0.4
	B	0.01	0.01
	C	1	1
	D	2	2
Spatial consistency	A	0.1	0.2
	B	0.01	0.01
	C	1	1
	D	3	3
IVH-filter	A	not applied	0.03
	B		0.01
	C		0.8
	D		40

AQC weights	**Until 5/6/2001 1130 UTC**	**From 5/6/2001 1130 UTC**	
	with FC-cons	**FC**	**no FC**
A Direction consistency	1.0	1.0	1.0
B Speed consistency	1.0	1.0	1.0
C Vector consistency	1.0	1.0	1.0
D Forecast consistency	1.0	1.0	0.0
E Spatial consistency	2.0	2.0	2.0

Future Development

As mentioned above, the present tests are tuned to reflect quality in the same way, as a meteorologist would experience it. This has had the effect that the tests are somewhat unbalanced, the tests returns much higher frequency of high scores than low scores. For instance the direction test returns quality one (1) for more than 50% of the wind vectors since most vectors have a good tracking. This causes some statistical problems, and there is an ongoing project to achieve a more even distribution of the QIs.
Studies have indicated that the present AQC scheme works better on high levels than on low levels. The possibility of having differently tuned tests and/or different weights for low levels is therefore evaluated.

The IVH filter is not solving the problem with "very fast low level winds" to 100 %, and has at the same time the deficiency of rejecting some good winds in the polar regions. Other solutions to the problem are studied.

References

Holmlund, K.1998: The Utilisation of Statistical Properties of Satellite-Derived Atmospheric Motion Vectors to Derive Quality Indicators. Weather and Forecasting, Vol. 13, pp. 1093-1104.

Holmlund, K. Velden, C. and Rohn, Michael. 1999: Enhanced Automated Quality Control Applied to High-Density GOES Winds Derived during the North Pacific Experiment. Reference: NORPEX-98

Elliott, S. and Gustafsson, J. 1998: The design and implementation of an Inter-Channel Vertical Heterogeneity (IVH) filter for use in the quality control of low level cloud motion winds. EUMETSAT reference: EUM/MTP/TEN/0141