MTG-FCI: ATBD for Atmospheric Motion Vector Product

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Document Change Record

Version	Date of Version *as on profile*	Document Change Request (DCR) Number *if applicable*	Description of changes
v1 Draft			For internal review
v1B	17 January 2011		First published version
v2	14 September 2011		Second published version, following the recommendations of the System PDR Science Panel
v2A	18 January 2013		Updated following the recommendations of scientific reviewers. - Section 3.6.1: Best-fit method description updated to follow the criteria used at UK Met Office (from IWW11 Rec.) - Section 3.7.2: Add the best fit pressure level against forecast fields, BSTFIT, in the output file of the Final AMV product.
V2B			Updated according to scientific evolution in the MSG AMV extraction algorithm. - Section 3.5.3.2.1 has been added. It describes the process to recalculate the altitude of water vapour cloudy AMVs found at low levels. - Section 3.5.3.7. which describes the HA of clear sky water vapour AMVs has been divided in 2 subsections. Section 3.5.3.7.1 describes the HA using normalised contribution RTM tables, already present in version V2A. Section 3.5.3.7.2 describes a new HA method that uses CCC method and pixel basis brightness temperature data of the corresponding water vapour channel.
V2C	March 2018		Updated according to recent scientific changes in the MTG AMV extraction strategy. - Section 3.5.3.6 Cloud Base Height Assignment removed. - Section 3.5.4.1.2 spatial consistency check updated accordingly with MSG process.

		- Section 3.5.4.2.1 – Encoding Filter has been removed. this section is specific to tuning needed for MSG and that once the MTG is commissioned the need for a corresponding tuning section will be addressed - Add section 3.5.3.6 EBBT method based on CCC pixel. - Small changes in outputs parameters to match the last version of AMV BUFR sequence adopted by WMO in November 2017

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1 INTRODUCTION

1.1 Purpose of this Document

This document describes the algorithm theoretical basis for the derivation of the Atmospheric Motion Vector (AMV) product, as it shall be derived from the Meteosat Third Generation Flexible Combined Imager (MTG-FCI).

1.2 Structure of this Document

Section 2 of this document provides a short overview over the MTG imaging instrument characteristics and the derived meteorological products, which will be referenced later in the text. This is followed by a detailed description of the underlying algorithm of the AMV product – its physical basis, the required input data, and a more detailed description of the product retrieval method.

A full list of acronyms is provided in section 1.4, a glossary of the equation symbols used in this document can be found in section 4. Literature references are listed in section 5.

1.3 Applicable and Reference Documents

The following documents have been used to establish this document:

Doc ID	*Title*	*Reference*
[AD-1]	MTG End Users Requirements Document	EUM/MTG/SPE/07/0036
[AD-2]	MTG Products in the Level-2 Processing Facility	EUM/C/70/10/DOC/08
[AD-3]	MTG-FCI: ATBD for Radiative Transfer Model	EUM/MTG/DOC/10/0382
[AD-4]	MTG FCI ATBD for Cloud Mask and Cloud Analysis Product	EUM/MTG/DOC/10/0482
[AD-5]	MTG-FCI ATBD for Optimal Cloud Analysis Product	EUM/MTG/DOC/10/0229
[AD-6]	MSG Meteorological Products Extraction Facility Algorithm Specification Document	EUM.MSG.SPE.022

[RD-1]	A Direct Link between Feature Tracking and Height Assignment of Operational Atmospheric Motion Vectors.	Borde R., and R. Oyama, 2008, Proc. Ninth Int. Winds Workshop, Annapolis, USA.
[RD-2]	Water Vapor Structure Displacements from Cloud-Free Meteosat Scenes and Their Interpretation for the Wind Field.	Büche, G. H. Karbstein, A. Kummer and H. Fischer, 2006, *J. Appl. Meteor.*, *45*, 556-575.
[RD-3]	Investigations of Cross-Correlation and Euclidian Distance Target Matching Techniques in the MPEF Environment.	Dew, G. and K. Holmlund, 2000,. *Proc. 5th International Winds Workshop*, Lorne, Australia.
[RD-4]	The Utilization of Statistical Properties of Satellite-Derived Atmospheric Motion Vectors to Derive Quality Indicators.	Holmlund, K, 1998, *Wea. Forecasting*, 13, 1093-1104.
[RD-5]	The Atmospheric Motion Vector retrieval scheme for Meteosat Second Generation.	Holmlund, K., 2000, *Proc. Fifth Int. Winds Workshop*, Lorne, Australia, EUMETSAT, EUM-P28, 201-208.
[RD-6]	Operational cloud motion winds from METEOSAT infrared images	Schmetz, J., K. Holmlund, J. Hoffman, B. Strauss, B. Mason, V. Gaertner, A. Koch and L. van de Berg, 1993, *J. Appl. Meteorol.*, 32, 1206-1225.
[RD-7]	An introduction toMeteosat Second Generation (MSG)	Schmetz, J., P. Pili, S. Tjemkes, D. Just, J. Kerkmann, S. Rota, and A. Ratier, 2002, *Bull. Am. Meteorol. Soc.*, 83, 977– 992.

1.4 Acronyms and Definitions

The following table lists definitions for all acronyms used in this document.

Acronym	*Full Name*
AMV	Atmospheric Motion Vectors
AQC	Automatic Quality Control
ASR	All Sky Radiance
CC	Cross Correlation
CCC	Cross-Correlation Contribution
CCF	Cross Correlation in Fourier domain
CRM	Clear Sky Reflectance Map
CTH	Cloud Top Height
CTTH	Cloud Top Temperature and Height
EBBT	Equivalent Blackbody Brightness Temperatures
FCI	Flexible Combined Imager
FCI-FDSS	FCI Full Disk Scanning Service
FCI-RSS	FCI Rapid Scanning Service
FDHSI	Full Disk High Spectral Resolution Imagery
GII	Global Instability Indices
HRFI	High Spatial Resolution Fast Imagery
HRV	High Resolution Visible Channel of SEVIRI
IR	Infrared
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
NWP	Numerical Weather Prediction
NTC	Normalised Total Contribution
NTCC	Normalised Total Cumulative Contribution
OCA	Cloud Product (Optimal Cloud Analysis)
QI	Quality Index
RTM	Radiative Transfer Model
RTTOV	Radiative Transfer for TOVS
SCE	Scene Identification
SAF	Satellite Application Facility
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SSD	Spatial Sampling Distance
SSDist	Sum of Squared Distances
TIROS	Television and Infrared Observation Satellite
TOVS	TIROS Operational Vertical Sounder
TOZ	Total Column Ozone
VIS	Visible (solar)

2 OVERVIEW

2.1 Relevant Instrument Characteristics

The mission of the Meteosat Third Generation (MTG) System is to provide continuous high spatial, spectral and temporal resolution observations and geophysical parameters of the Earth / Atmosphere System derived from direct measurements of its emitted and reflected radiation using satellite based sensors from the geo-stationary orbit to continue and enhance the services offered by the Second Generation of the Meteosat System (MSG) and its main instrument SEVIRI.

The meteorological products described in this document will be extracted from the data of the Flexible Combined Imager (FCI) mission. The FCI is able to scan either the full disk in 16 channels every 10 minutes with a spatial sampling distance in the range 1 – 2 km (Full Disk High Spectral Resolution Imagery (FDHSI) in support of the Full Disk Scanning Service (FCI-FDSS)) or a quarter of the earth in 4 channels every 2.5 minutes with doubled resolution (High spatial Resolution Fast Imagery (HRFI) in support of the Rapid Scanning Service (FCI-RSS)).

FDHSI and HRFI scanning can be interleaved on a single satellite (e.g. when only one imaging satellite is operational in orbit) or conducted in parallel when 2 satellites are available in orbit. Table 1 provides an overview over the FCI spectral channels and their respective spatial resolution.

The FCI acquires the spectral channels simultaneously by scanning a detector array per spectral channel in an east/west direction to form a swath. The swaths are collected moving from south to north to form an image per spectral channel covering either the full disc coverage or the local area coverage within the respective repeat cycle duration. Radiance samples are created from the detector elements at specific spatial sample locations and are then rectified to a reference grid, before dissemination to the End Users as Level 1 datasets. Spectral channels may be sampled at more than one spatial sampling distance or radiometric resolution, where the spectral channel has to fulfil FDHSI and HRFI missions or present data over an extended radiometric measurement range for fire detection applications.

Table 1: Channel specification for the Flexible Combined Imager (FCI)

Spectral Channel	*Central Wavelength, $\lambda 0$*	*Spectral Width, $\Delta\lambda 0$*	*Spatial Sampling Distance (SSD)*
VIS 0.4	0.444 µm	0.060 µm	1.0 km
VIS 0.5	0.510 µm	0.040 µm	1.0 km
VIS 0.6	0.640 µm	0.050 µm	1.0 km 0.5 km [#1]
VIS 0.8	0.865 µm	0.050 µm	1.0 km
VIS 0.9	0.914 µm	0.020 µm	1.0 km
NIR 1.3	1.380 µm	0.030 µm	1.0 km
NIR 1.6	1.610 µm	0.050 µm	1.0 km
NIR 2.2	2.250 µm	0.050 µm	1.0 km 0.5 km [#1]
IR 3.8 (TIR)	3.800 µm	0.400 µm	2.0 km 1.0 km [#1]
WV 6.3	6.300 µm	1.000 µm	2.0 km
WV 7.3	7.350 µm	0.500 µm	2.0 km
IR 8.7 (TIR)	8.700 µm	0.400 µm	2.0 km
IR 9.7 (O_3)	9.660 µm	0.300 µm	2.0 km
IR 10.5 (TIR)	10.500 µm	0.700 µm	2.0 km 1.0 km [#1]
IR 12.3 (TIR)	12.300 µm	0.500 µm	2.0 km
IR 13.3 (CO_2)	13.300 µm	0.600 µm	2.0 km

[#1]: The spectral channels VIS 0.6, NIR 2.2, IR 3.8 and IR 10.5 are delivered in both FDHSI sampling and a HRFI sampling configurations.

2.2 Generated Products

The agreed list of MTG-FCI Level 2 products is detailed in [AD-2] and is repeated here for easy reference:

1. **SCE-CLA**:
   Scene Identification (cloudy, cloud free, dust, volcanic ash, fire) and a number of cloud products (cloud top height, phase)
2. **OCA**:
   Cloud Product (cloud top height and temperature, cloud top phase, cloud top effective particle size, cloud optical depth, cloud sub-pixel fraction)
3. **ASR**:
   All Sky Radiance (mean IR radiance on an n x n pixel grid, together with other statistical information, for different scenes)
4. **CRM**:
   Clear Sky Reflectance Map (VIS reflectance for all non-absorbing channels, accumulated over time)
5. **GII**:
   Global Instability Indices (a number of atmospheric instability indices and layer precipitable water contents)
6. **TOZ**:
   Total Column Ozone
7. **AER**:
   Aerosol Product (asymmetry parameter, total column aerosol optical depth, refractive index, single scattering albedo, size distribution)
8. **AMV**:
   Atmospheric Motion Vectors (vector describing the displacement of clouds or water vapour features over three consecutive images, together with a vector height)
9. **OLR**:
   Outgoing Longwave Radiation (thermal radiation flux at the top of the atmosphere leaving the earth-atmosphere system)

The products will be derived from the spectral channel information provided by the FDHSI mission, on the resolution detailed in [AD-2].

An important tool for product extraction is a radiative transfer model (RTM), as described in [AD-3]. The IR model choice for the Level 2 product extraction is RTTOV, which is developed and maintained by the Satellite Application Facility on Numerical Weather Prediction (NWP-SAF). An RTM for solar channels is likely to be product specific and yet to be fully determined.

This ATBD describes the algorithm of the AMV product. The AMV derivation makes use of the SCE/CLA or SCE/OCA product.

3 ALGORITHM DESCRIPTION

3.1 Physical Basis Overview

The derivation of Atmospheric Motion Vectors is realised by tracking clouds or water vapour features in consecutive Meteosat satellite images [RD-7]. The basic elements of wind vector production are [RD-5]:

(a) selecting a feature to track;
(b) tracking the target in a time sequence of images to obtain a relative motion;
(c) assigning a pressure (altitude) to the vector; and
(d) assessing the quality of the vector.

The final AMV product includes information on speed, direction, height, and quality.

3.2 Assumptions and Limitations

The whole AMV extraction principle is based on the following two important assumptions:

(1) The detected motion is supposed to be representative of the local wind. In other words, the cloud or water vapour feature is assumed to be travelling at the same speed and direction as the local wind.
(2) The detected motion is supposed to be the motion at the top of the tracked feature, as the altitude of the extracted motion vector is estimated using Cloud Top Height (CTH) information.

3.3 Algorithm Basis Overview

The AMV extraction scheme developed in preparation for Meteosat Third Generation (MTG) retrieves the AMVs in a generally similar fashion to the present operational extraction scheme used at EUMETSAT for Meteosat Second Generation (MSG) [RD-6]; [RD-5]. The image data preparation, target selection, tracking and AMV quality control steps remain unchanged from the MSG AMV extraction scheme. A complete and detailed description of these steps can be found in the EUM.MSG.SPE.022 document. However, several changes are documented in this ATBD which will make the algorithm more flexible and better maintainable. These differences are:

- Use of a triplet of MTG repeat cycles (currently 4 MSG repeat cycles are used for an hourly AMV product)
- No image enhancement process for IR10.5 channel
- A new height assignment scheme: CCC (RD-1)
- Use a cloud top height product to set the AMV height
- Calculation of AMV height standard deviation and possibly height error estimate
- Set the final AMV speed and direction to the speed and direction of the last intermediate component
- Set the final AMV coordinates to the position of the tracked feature

Motion vectors are extracted between each pair of consecutive repeat cycles, leading to two Intermediate AMV products for an image triplet. The final product is then derived from these two Intermediate products.
The steps performed in order to derive one single displacement vector for one channel for the Intermediate AMV product are:

(1) Target selection
(2) Derivation of target displacement
(3) Height assignment, including the pixel selection scheme
(4) Automatic quality control

This sequence of steps derives the Atmospheric Motion Vectors Intermediate product for every repeat cycle for all specified channels over the area. The primary targets are centralised around the locations of the end position of the successfully tracked targets from the previous cycle. Only targets with a quality higher than *first_cycle_min_qi* in the case that the target has been tracked only over one cycle, or *new_cycle_min_qi* in the case that the target has been tracked over two cycles, are kept for further processing. The target selection will be initialised on an equidistant grid specified by *grid_distance*.

In step (1), all possible targets are extracted for a given image. A first guess target position is at the location of the end position of the successfully tracked targets from the previous cycle. The target position is optimised within the target search area to gain maximum contrast within the target area.

Step (2) tries to find the position of the same targets in the following image.

In step (3), the extracted vector is assigned a height: Vectors successfully extracted with cloud targets are assigned a height corresponding to the temperature at which the cloud is radiating. Vectors extracted with water vapour targets are assigned a height related to a representative layer of the displacement.

Finally all vectors are subjected to an Automatic Quality Control in step (4) for both the intermediate and final products.

With this described setup the AMV product would be generated every 30 minutes – whether the final dissemination is on this temporal resolution or simply hourly is (TBC).

The AMV processing flow is shown graphically in Figure 1

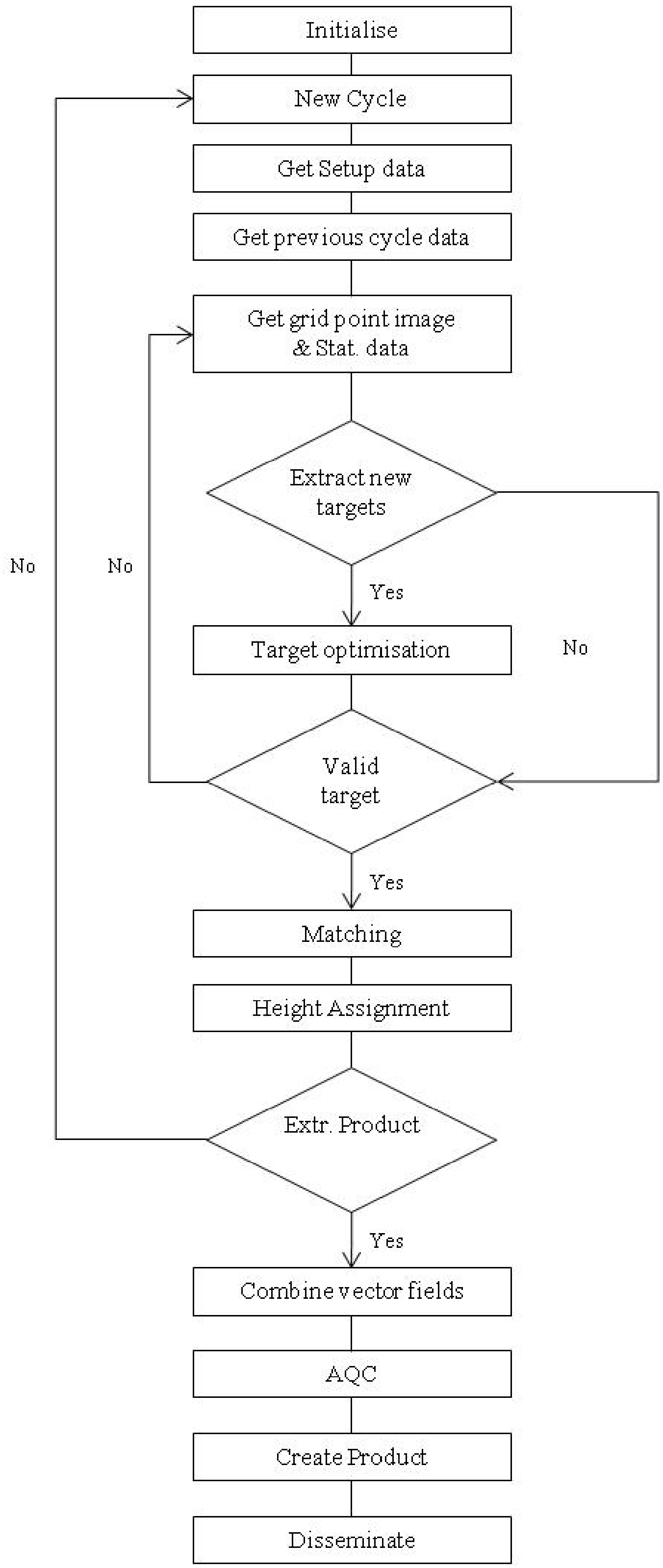

Figure 1 AMV Processing

3.4 Algorithm Input

3.4.1 Primary Sensor Data

AMVs are extracted from the VIS 0.8, IR 3.8 (night only), IR 10.5, WV 6.3 and WV 7.3 channels.

Note: It is unclear at this point in time whether the winds extracted from the IR 3.8 channel will provide additional information when compared to the IR 10.5 AMVs. The processing environment shall, however, provide the IR 3.8 AMV functionality together with a possibility to switch it off.

3.4.2 Ancillary Dynamic Data

The AMV extraction scheme uses clear sky radiances, tables relating the effect of opaque cloud at different heights to the radiances in the eight IR channels and atmospheric correction tables provided by Radiative Transfer Model (RTM as detailed in [AD-3]). This information is provided as Equivalent Blackbody Brightness Temperatures (EBBT). RTM provides the brightness temperatures for the selected IR channels. This RTM table is used in the AMV retrieval as a continuous function interpolated in time and space to the gravity centre of the target. This implies that as the table is provided only at discrete levels, the table values are also interpolated in height, when necessary.

The RTM results are used together with available cloud height information to define the suitability of the channels to provide good displacement vectors at all locations together with a height assignment for each tracer. This cloud height information could be provided by either the CTTH product from the SCE-CLA product [AD-4] or through the cloud top heights of the OCA product [AD-5]. It is not clear at this point in time which of the two cloud heights will be finally chose, i.e. the algorithm needs to provide the flexibility to select the underlying cloud top height product.

The AMV extraction scheme also uses the forecast temperature profiles for height assignment.

Table 2 lists the dynamic data needed for the AMV processing.

Table 2: Necessary dynamic data for the AMV processing

Parameter Description	Variable Name
Reflectances for the MTG-FCI channel VIS0.8 for each pixel within the processing area for the time (t-10, t and t+10)	ρ(ch)
Radiances for the MTG-FCI channels IR3.8, WV6.3, WV7.3, IR10.5 for each pixel within the processing area the time (t-10, t and t+10)	L(ch)
Brightness temperatures for the MTG-FCI channels IR10.5 and IR12.3 for each pixel within the processing area the time (t-10, t and t+10)	T_B(ch)
SCE results for each pixel the time (t-10, t and t+10)	SCE
CMa results, CT and CTTH results for each pixel the time (t-10, t and t+10)	CMa, CT, CTTH
OCA results for each pixel the time (t-10, t and t+10)	OCA
Radiances derived with RTTOV from ECMWF forecasts, for two forecast times around the image processing time. Parameters needed from RTTOV are: (1) Contribution function tables	NTC, NTCC
The forecast fields of the following parameters interpolated to pixel: • surface temperatures • surface pressure • air temperature at pressure levels as given by the NWP model • air relative humidity at pressure levels as given by the NWP model • Wind U component as given by the NWP model • Wind V component as given by the NWP model • Tropopause height • altitude of the NWP model grid	T_{sfc} P_{sfc} T(p) q(p) u(p) v(p) trop_ht $Elev_{ECMWF}$
AMV Intermediate product	AMV_prev_gen

3.4.3 Ancillary Static Data

The static application data input listed below controls the complete AMV process. These data are changed infrequently during operations but are configurable. The static inputs are specified separately for every baseline channel used for the extraction of displacement vectors.

STATIC APPLICATION DATA - SURFACE DATA			
Parameter	**Mnemonic**	**Units**	**Source**
Surface-Type-Map	Surface_type_map	-	Setup
Nearest coast distance	Nearest_coast_dist	km	Setup
Processing_area	Proc_area	pixels	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR AMV PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
AMV channel ID	AMV_chan_id	-	Setup
AMV channel selection table	AMV_chan_tab	-	Setup
AMV intermediate products to use	AMV_prev_gen	-	Setup
Minimum scene distance	min_scene_dist	K	Setup
Minimum number of pixels for a valid scene	min_sce_size	pixels	Setup
Computation grid	grid_distance	pixels	Setup
Maximum target overlap	max_tar_overlap	pixels	Setup
Minimum tracer size	min_tracer_size	pixels	Setup
Minimum standard deviation	min_sd	K	Setup
Minimum number of pixels with high standard deviation	min_num_high_sd	pixels	Setup
Cloud target size	Cl_tar_size	pixels	Setup
Clear sky target size	CS_tar_size	pixels	Setup
Cloud search area size	Cl_sar_size	pixels	Setup
Clear sky search area size	CS_sar_size	pixels	Setup
Target optimisation area	tar_opt_area	pixels	Setup
Target extraction method	tar_ex_met	-	Setup
Target extraction scheme	tar_extraction	-	Setup
Flag to define application of coastal check	lcoast_flag	Logical	Setup
matching method	mm	-	Setup
Flag indicating cloud coverage for the WV channels	wv_cloud_type	-	Setup
Apply low pass filtering	FFT_low	-	Setup
Refinement of displacement	n_fit	-	Setup
Number of cycles used to generate final	N_gen	-	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR AMV PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
product			
Minimum quality for targets after one cycle	first_cycle_min_qi	-	Setup
Minimum quality for targets after more than one cycle	new_cycle_min_qi	-	Setup
Forecast check speed scaling factor	AQC_FC_A	-	Setup
Minimum velocity for forecast check	AQC_FC_B	-	Setup
Speed offset of forecast check	AQC_FC_C	-	Setup
Distribution factor for forecast check	AQC_FC_D	-	Setup
Temporal Consistency (TC) check speed scaling factor	AQC_TC_A	-	Setup
Minimum velocity for TC check	AQC_TC_B	-	Setup
Speed offset of TC check	AQC_TC_C	-	Setup
Distribution factor for TC check	AQC_TC_D	-	Setup
Maximum pressure difference to surrounding vectors	AQC_SC_max_pp	hPa	Setup
Spatial Consistency (SC) check speed scaling factor	AQC_SC_A	-	Setup
Minimum velocity for SC check	AQC_SC_B	-	Setup
Speed offset of SC check	AQC_SC_C	-	Setup
Distribution factor for SC check	AQC_SC_D	-	Setup
Local consistency distance weight flag	lc_dist_weight	Logical	Setup
Number of best matches for local consistency	N_best_lc	-	Setup
Forecast check speed scaling factor	AQC_HC_A	-	Setup
Minimum velocity for forecast check	AQC_HC_B	-	Setup
Speed offset of forecast check	AQC_HC_C	-	Setup
Setup parameters for Temporal Speed Consistency AQC check	AQC_TSC_A	-	Setup
	AQC_TSC_B	-	Setup
	AQC_TSC_C	-	Setup
	AQC_TSC_D	-	Setup
Setup parameters for Temporal Direction Consistency AQC check	AQC_TDC_A	-	Setup
	AQC_TDC_B	-	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR AMV PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
	AQC_TDC_C	-	Setup
	AQC_TDC_D	-	Setup
	AQC_TDC_E	-	Setup
Setup parameters for Temporal Height Consistency AQC check	AQC_TPC_A	-	Setup
	AQC_TPC_B	-	Setup
	AQC_TPC_C	-	Setup
	AQC_TPC_D	-	Setup
	AQC_TDC_E	-	Setup
Setup parameters for Inter Channel Consistency AQC check	AQC_IC_A	-	Setup
	AQC_IC_B	-	Setup
	AQC_IC_C	-	Setup
	AQC_IC_D	-	Setup
	ic_low_press	hPa	Setup
	ic_min_spd	m/s	Setup
	low_ic_check_dist	km	Setup
	ic_press_diff	hPa	Setup
Setup parameters for Image Correlation AQC check	AQC_HA_A	-	Setup
	AQC_HA_B	-	Setup
	AQC_HA_C	-	Setup
	AQC_HA_pp	-	Setup
Weights of forecast consistency test in final quality mark	AMV_Q_Weights_forecast	-	Setup
Weights of image correlation in the final quality mark	AMV_Q_Weights_ha	-	Setup
Weights of inter-channel consistency in the final quality mark	AMV_Q_Weights_ic	-	Setup
Weights of spatial height test in the final quality mark	AMV_Q_Weights_shc	-	Setup
Weights of spatial vector test in the final quality mark	AMV_Q_Weights_swc	-	Setup
Weights temporal vector consistency in the	AMV_Q_Weights_tc	-	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR AMV PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
final quality mark			
Weights temporal direction consistency test in the final quality mark	AMV_Q_Weights_tdc	-	Setup
Weights temporal height consistency test in the final quality mark	AMV_Q_Weights_tpc	-	Setup
Weights temporal speed consistency test in the final quality mark	AMV_Q_Weights_tsc	-	Setup
Weight height assignment consistency test in the final quality mark	AMV_Q_Weights_hac	-	Setup
Weights of intermediate temporal vector tests in final product	N_Gen_AQC_Weights_tc	-	Setup
Weights of intermediate temporal direction tests in final product	N_Gen_AQC_Weights_tdc	-	Setup
Weights of intermediate image correlation tests in final product	N_Gen_AQC_Weights_tha	-	Setup
Weights of intermediate temporal pressure tests in final product	N_Gen_AQC_Weights_tpc	-	Setup
Weights of intermediate temporal speed tests in final quality mark	N_Gen_AQC_Weights_tsc	-	Setup
Land sea mask	LS_mask	-	Setup
Processing area	PR_area	-	Setup
Acceptable distance for collocated observations for verification 1	col_dist_1	°	Setup
Acceptable distance for collocated observations for verification 2	col_dist_2	°	Setup
Temperature Difference Threshold for STC table adjustment	Cwv_diff	K	Setup
Temperature Difference Threshold for STC table adjustment	Cir_diff	K	Setup
AMV Verification vector setup parameter	pr_vec	hPa	Setup
AMV Verification pressure setup parameter	pr_pres	hPa	Setup
AMV Verification temperature setup parameter	pr_temp	K	Setup
AMV Verification height difference setup parameter	pp_distance	hPa	Setup
Parameter to indicate whether CLA quality is to be used	AMV_use_CLA_quality	-	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR AMV PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
Width of bands for mean and SD calculation	AMV_merge_pressure	hPa	Setup
Maximum number of cloudy pixels allowed in CS target	CS_max_cloud_pix	pixels	Setup
Percantage of surface scene type which must be present in a suitable target	tar_sel_bckg_frac	%	Setup
Maximum difference allowed between repeat cycles for primary targets	max_ptarget_age	minutes	Setup
Minimum number of intermediate AMVs to be used for deriving the final AMV vector	min_derivations	-	Setup
Constants for AQC checks	A1	-	Setup
	A2	-	Setup
	B1	-	Setup
	B2	-	Setup
	A1_p	-	Setup
	A2_p	-	Setup
	B1_p	-	Setup
	B2_p	-	Setup
Pressure threshold for AQC checks	prev_gen_pp	hPa	Setup
AMV Verification vector set-up parameter	pr_vec	hPa	Setup
AMV Verification pressure set-up parameter	pr_pres	hPa	Setup
AMV Verification temperature set-up parameter	pr_temp	K	Setup
Speed Threshold for low quality winds	speed_threshold	m/s	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR HEIGHT ASSIGNMENT PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
Individual pixel contribution to cross correlation threshold definition used for CCC method.	CCij_thres_def	-	Setup
Threshold to select good quality OCA CTH product..	OCA_JM_thres	-	Setup
Threshold to apply low level height assignment	low_pres_thres	hPa	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR HEIGHT ASSIGNMENT PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
Threshold to apply clear sky height assignment to WV AMVs found at low levels	*wvll_thres*	hPa	Setup
Pressure threshold for applying the Inversion Height Assignment	inv_height_thres	hPa	Setup
Minimum pressure difference between surface and bottom of inversion layer	inv_surface_offset	hPa	Setup
Minimum pressure (highest level) for bottom of inversion layer	inv_pressure_thres	hPa	Setup
Minimum strength of temperature inversion, i.e. minimum temperature difference between top and bottom of inversion layer	inv_magnitude_thres	K	Setup
Atmospheric level to start the search for temperature inversion layers	start_pressure	hPa	Setup
Parameters in the derivation of the inversion height assignment	inv_c1	-	Setup
	inv_c2	-	Setup
	inv_c3	-	Setup
Max. pressure difference between cloud top and top of boundary layer	dp_BL	hPa	Setup
Min. pressure at top of boundary layer	p_crit_bl	hPa	Setup
Max. pressure difference between surface and cloud top	dp_SUF	hPa	Setup
Cloud base pressure threshold	Pcbpt	hPa	Setup
Pressure scaling factor	Psc_10.5	hPa	Setup
Amplitude factor of the correction (for pressure at cloud base)	K_10.5	-	Setup
Pressure scaling factor	Psc_12.3	hPa	Setup
Amplitude factor of the correction (for pressure at cloud base)	K_12.3	-	Setup
Threshold in derivation of clear-sky height standard deviation according to NTCC_N method	NTCC_threshold	-	Setup
Threshold in derivation of clear-sky heightstandard deviation according to MaxNTC method	NTC_threshold	-	Setup
Fraction of coldest pixels to be used for clear-sky EBBT height assignment	frac_cs_ebbt	%	Setup

STATIC APPLICATION DATA (PER CHANNEL USED FOR HEIGHT ASSIGNMENT PROCESSING)			
Parameter	**Mnemonic**	**Units**	**Source**
Minimum fraction of clear-sky pixels in a clearsky target	min_cs_fraction	%	Setup
Thresholds for the NTCC to derive the two single level heights in clear sky areas	NTCC_LL	-	Setup
	NTCC_N	-	Setup
	NTCC_HL	-	Setup

STATIC APPLICATION DATA FOR ENCODING FILTER (PER CHANNEL)			
Parameter	**Mnemonic**	**Units**	**Source**
Minimum average forecast consistency.	qual_forecast	%	Setup
Minimum number of AMVs with QI (exFC) > qual_qi	qual_num_good	-	Setup
Maximum number of AMVs with pressure < qual_pressure	qual_num_high	-	Setup
Pressure threshold for qual_num_high	qual_pressure	hPa	Setup
Quality threshold for qual_num_good	qual_qi	%	Setup
Minimum average vector consistency	qual_vector	%	Setup
Minimum proportion of AMVs with QI (exFC) > qual_qi related to total for channel. For HRV and VIS only low levels are considered.	qual_proportion	%	Setup

3.5 Physical Description

3.5.1 Target Extraction

The first step of the AMV processing is the target extraction based on a fixed processing grid. Around each grid location an optimum target location that is based on statistical properties of the suggested location is extracted.. Two types of targets are used to derive the products: Clouds and water vapour features. The target size is specified separately for each channel and target type by *Cl_tar_size* and *CS_tar_size*. The targets are extracted in two separate steps. The primary targets are the targets extracted from the previous extraction cycle so that the target position will be located at the best position indicated by the matching surface (in the case of cross correlation at the maximum correlation value). Primary targets are only valid if they are derived from a repeat cycle within *max_ptarget_age* of the current repeat cycle. In addition, primary targets for VIS channel are only valid for solar zenith angles (at the grid point location) less than 87 degrees.

The secondary targets are extracted at an equidistant grid specified *grid_distance*. The search for the optimum secondary target in the vicinity of each grid point is limited to an optimisation area and it also takes into account the positions of the already identified targets. This is controlled by *tar_opt_area*, which defines the optimisation area size and *max_tar_overlap,* which defines the acceptable target overlap in total pixels. Secondary targets for VIS channel are only valid for solar zenith angles (at the grid point location) less than 87 degrees.

The concept of target and search areas is shown in Figure 2.

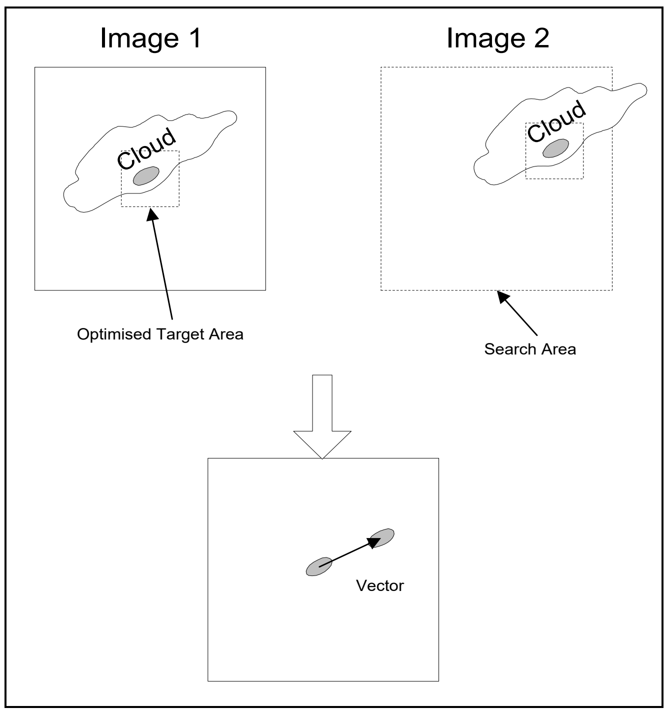

Figure 2: Target and Search Areas

The optimisation of the target position extracts the location within the optimisation area at which the contrast within the target area and/or entropy is maximised.

Entropy E is defined from the probability P_i that a pixel has a value *i,* as:

$$E = \sum_{i=1}^{N} P_i \cdot 2 \cdot \log(P_i) \qquad \textbf{(1)}$$

where N is the total number of pixels

The following steps is performed in order to find a suitable target:

1. Use *Cl_tar_size*

2. Retrieve local means and local standard deviations (computed over 3x3 pixels) for each location in the target search area.

3. For all possible locations within the target search area: the primary target locations are defined by the vector of the previous extraction having a quality greater than *new_cycle_min_qi* (nominally 0.0).

4. Control that the current location is valid, i.e. the overlap with previously identified targets is less than *max_tar_overlap*. For each valid location continue with steps 4 to 12. If the location is invalid skip to the next location.

5. (a) In the case of *Cl_tar_size*, check the number of cloudy pixels for all locations. For the water vapour channels the definition of which cloud layers contribute to the final number of cloudy pixels should be defined by *wv_cloud_type* (nominally 2 for WV6.3 and WV7.3). The possible values of *wv_cloud_type* are = 0, 1, 2 and correspond to all cloud layers (0), High cloud only (1), High and Medium cloud only (2). For all other channels all cloud layers contribute to the definition of the number of cloudy pixels. (If a pixel does not contribute to a cloudy target it will automatically be considered to contribute to a clear sky target.) If the number of cloudy pixels in the location is less than *min_tracer_size*, skip to next location.
   (b) In the case of *CS_tar_size*, the location is skipped if it contains more than *CS_max_cloud_pix* cloud pixels. The parameters are set to ensure that nominally clear sky targets can only be generated for the water vapour channels.

6. Derive maximum local mean, minimum local mean, maximum local standard deviation, and number of pixels with a local standard deviation greater than *min_sd* for each of these possible target locations.

7. Check that more than *min_num_high_sd* number of pixels have a standard deviation larger than *min_sd*.

8. Extract the contrast as the local standard deviation at the target centre.

9. Extract the entropy.

10. Find position of maximum contrast/entropy within the target optimisation area.

11. Check that the background location is valid. This is carried out using the *Surface_type_map.* A set-up flag *lcoast_flag* is used to determine which location is valid. It can take the following values:

    0 = Any background is valid: land, sea or coast.
    1 = Land or sea but no coastline, where e.g.

$$\frac{(100 * MAX(number\_of\_seapixels, number\_of\_landpixels))}{(number\_of\_seapixels + number\_of\_landpixels)} \geq tar\_sel\_bckg\_frac$$

(*tar_sel_bckg_frac* nominally has a value of 100%).
2 = Land only (set *tar_sel_bckg_frac* to a value of 100%) or land/coastline (set *tar_sel_bckg_frac* to a value of 0%).
3 = Sea only (set *tar_sel_bckg_frac* to a value of 100%) or sea/coastline (set *tar_sel_bckg_frac* to a value of 0%).
4 = Coast only (set *tar_sel_bckg_frac* to a value of 100%). *Number_of_seapixels* and *number_of_landpixels* are determined from the static land/sea-mask, where any pixel location containing sea or water is assigned to *number_of_seapixels*. The nominal values for *lcoast_flag* and *tar_sel_bckg_frac* are 1 and 100% respectively.

Note: for cases 0 and 1 the dominant background type should be noted (as it is required to be written to the output products).

12. Determine the centre position of the target.

13. Compute the mean and standard deviation of all scenes for all channels within the target area, using only the pixels within the target area.

14. If a successful optimum location was found then return. Use *Cl_tar_size* and *Cl_sar_size* for matching.

15. If no location contains enough cloudy pixels then if *CS_tar_size* is greater than zero recompute steps 2 to 13, using *CS_tar_size* (and step 5b rather than 5a).

16. Compute the number of cloudy pixels for the final location. If the total number is greater than *min_tracer_size* skip return and identify the location with no valid target and proceed to next grid point.

17. If the number of cloudy pixels is less than *min_tracer_size* then return. Use *CS_tar_size* and *CS_sar_size* for matching. The following four alternative target extraction schemes shall be implemented:
    1 The primary targets are always used and are always complemented by the secondary targets.
    2 The primary targets are always used and the secondary targets are extracted only from the first image of a new generation cycle.
    3 As 1) except no primary targets are extracted from the first image of a new generation cycle.
    4 As 3) except secondary targets are extracted only from the first image of a new generation cycle.

It shall be possible to select the extraction scheme with the appropriate setting of *tar_extraction* .

The target optimisation will provide the position of the optimised target location for the follow-on processes together with a flag stating the validity of the location. The target area and search area of the matching shall be centred at the location-optimised location.

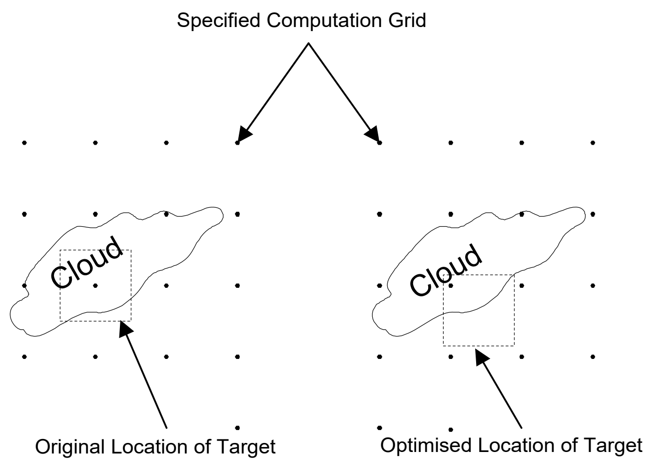

Figure 3: Target Optimisation

The target area and search area are centred at the optimised location. The latitude/longitude assigned to the intermediate AMV are then the centre of the optimised target area.

NB. The processing environment shall provide the possibility to switch off the target optimisation process.

3.5.2 Tracking

The goal of this step is to find within the search area a matching surface, i.e. a surface which is the same or as close as possible to the target area. Matching surfaces are calculated at full resolution.

The derivation of the target displacement uses the image data at locations centralised around the locations provided by the target selection scheme. It is based on the derivation of a matching surface derived by matching the selected target within the defined search area in the next image.

Three basic matching methods exist: Cross Correlation (CC) in time domain, Sum of Squared Distances (SSDist) and Cross Correlation in the Fourier domain (CCF). Only the CCF method is used operationally, except for water vapour Clear sky targets for which the SSD method is used. [RD-3] gives the detailed description of the implementation of these methods for MSG. A complete mathematical description of each of these methods can be found in the EUM.MSG.SPE.022 document.

The matching surface is considered valid and is computed only for relative positions of target and search areas, such that the target area is always completely included in the search area.

The extracted matching surface is used to derive a sub grid location of the best fit position. This is done with a polynomial fit in the vicinity of the best fit location within the matching surface. Based on the extracted maximum correlation value (or minimum distance) at a sub grid accuracy, the measured displacement as a function of pixels is converted to longitude and latitude positions as defined by the central location of the target in the image pair.

In the second step the distance between the two longitude/latitude locations is derived and an "instantaneous" wind speed,direction, wind u component and wind v componentare computed from these locations.

3.5.3 Height Assignment

3.5.3.1 CCC Method for Pixel Selection

The degree of matching between pixel counts a and b between the two images A and B is classically given by the following two-dimensional cross-correlation coefficient:

$$CC(m,n) = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} \frac{a_{i+m,j+n} - \bar{a}(m,n)}{\sigma_a(m,n)} \frac{b_{ij} - \bar{b}}{\sigma_b} \quad \textbf{(2)}$$

where m, n is the (lines, elements) displacement of the target box in image B from the initial position in the first image A. The correlation coefficient CC(m, n) is normalized to values between -1 (mirror structures) and +1 (identical structures). The symbols $\bar{a}$ and σ_a represent the average and the standard deviation of the count value a in image A, respectively (correspondingly for b in image B). Values M and N correspond to the box size, MxN=24x24. According to [RD-2], the correlation coefficient can also be written following equation (3), where the symbol CC_{ij} expresses how much the individual pair of pixels (i, j) and (i+m, j+n) contributes to the total correlation coefficient of the pair b and a(m, n) within target boxes in the two images.

$$CC(m,n) = \sum_{i,j}^{M,N} CC_{ij}(m,n) \quad \textbf{(3)}$$

Figure 4 illustrates how the individual pairs of pixels taken from the 24x24 pixels target boxes between two consecutive Meteosat-8 images (1 December 2006, 0200 and 0215 UTC), contribute to the maximisation of CC(m,n). Green dots correspond to clear sky pixels, red dots to cloudy pixels within the target area. The corresponding scene and cloud top height information are plotted on the right side. High levels, mid levels and low levels clouds correspond respectively to clear blue, violet and grey colours. The correlation matching has been done using count values, but radiance can be used indifferently. Usually, coldest and warmest pixels in the target box contribute the most to CC(m,n). In the case of a clear distinction between cold and warm scenes within the target box, the relative individual pixel contributions, CC_{ij}, present a clear 'C-shaped' distribution, as shown in Figure 4. The distance between the two branches corresponds to the contrast of the structures within the target area. Several pixels have a negative CC_{ij}, which generally correspond to pixels that have very different radiative properties but the same position within the two target boxes in the image 1 and image 2. Appearance and/or decay of clouds between image 1 and 2 generally induce such negative CC_{ij}. Pixels that contribute the most to CC(m,n) are defined as those that have CC_{ij} greater than the average CC_{ij}, $<CC_{ij}>$, figured by the dashed blue line on Figure 4.

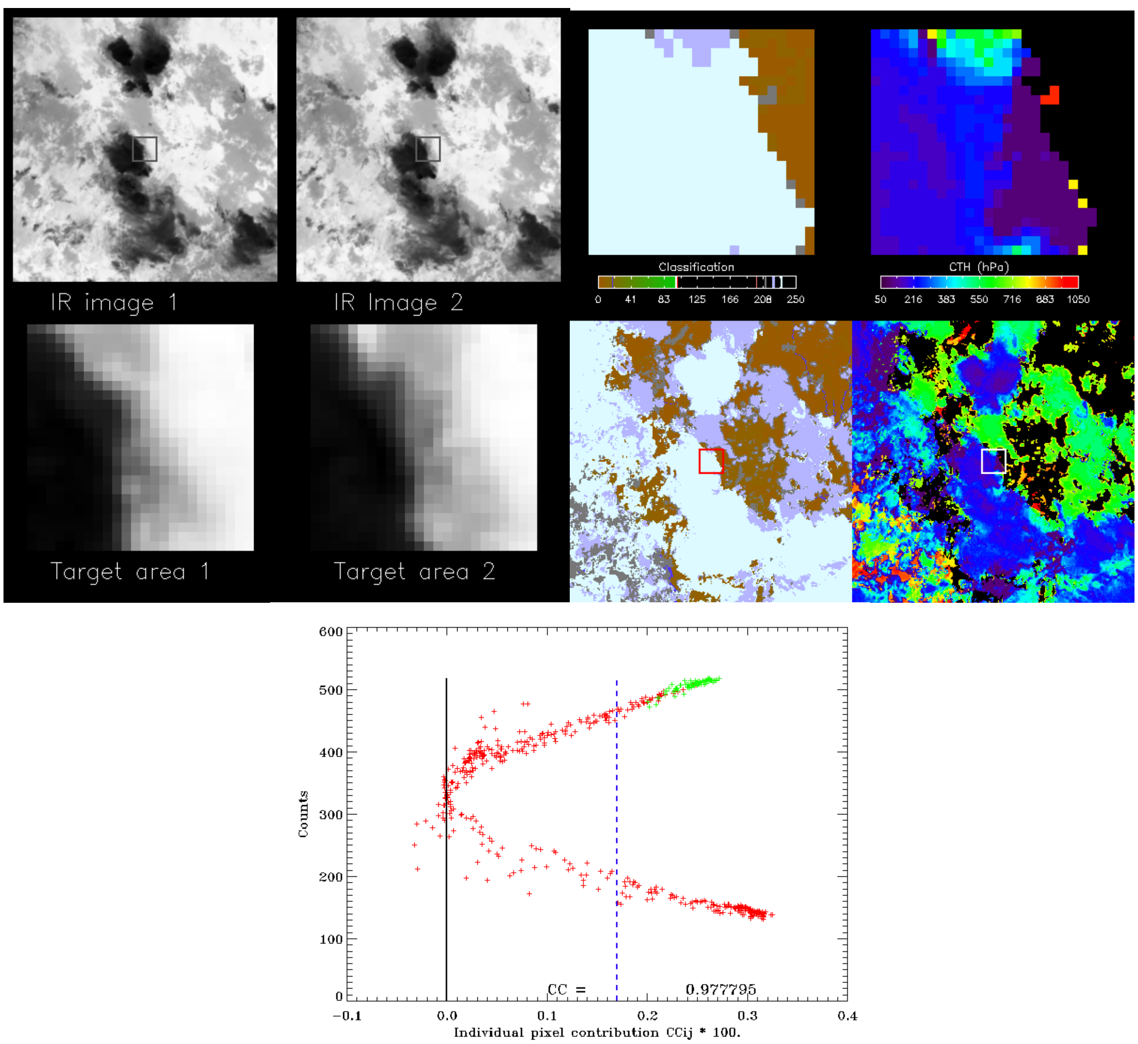

Figure 4: Infrared counts within the target area are plotted against their individual pixels contribution (left) for the corresponding target area (right). AMV has been extracted using IR10.8 channel of SEVIRI (1st December 2006, 2:00 and 2:15 UTC images)

3.5.3.2 IR Channels (IR 10.5 and IR 3.8) and Cloudy Targets in WV Channels (WV6.3 and WV7.3)

The height assignment of the AMVs shall be estimated using a cloud height product, which gives an estimation of the cloud top height for all the cloudy pixels.

This cloud height information could be provided by the SCE-CLA product [AD-4] or by the OCA product [AD-5]. It is planned to use the OCA product in the first place, but the AMV algorithm shall be flexible and allow a final selection of the underlying height assignment product, and the use of associated cloud product quality flag if available. This allows using latest and best validated scientific improvements in cloud height assignment.

In the following description of the AMV pressure estimation, the generic CTH acronym refers to the cloud top height product, irrespectively whether this is provided by SCE-CLA or OCA.

The AMV pressure P is calculated as the average CTP (cloud-top pressure) of the selected pixels, weighted by their individual contribution to correlation coefficient CC_{ij}.:

$$P = \frac{\sum_{\substack{cold\_branch \\ CC_{i,j} > CCij\_thresh}} CC_{i,j} CTP_{i,j}}{\sum_{\substack{cold\_branch \\ CC_{i,j} > CCij\_thresh}} CC_{i,j}} \qquad \textbf{(4)}$$

For AMVs derived using infrared channels only the pixels that get a successful CTP value AND that are on the cold branch of the plot of the figure 1 (count value smaller than the average count value within the target area) AND that have CC_{ij} greater than *CCij_thres* threshold are selected to calculate the pressure. The dynamic calculation of *CCij_thres* is driven by the *CCij_thres_def* setup parameter. If *CCij_thres_def* is set to 0, *CCij_thres* is also set to 0. If *CCij_thres_def* is set to 1, *CCij_thres* is set dynamically to the average CC_{ij}, $<CC_{ij}>$ calculated using the pixels present within the target area. This *CCij_thres_def* parameter can be different for IR and WV channels.

It is recommended to set *CCij_thres_def* to 1 for IR10.5 AMVs. However, when the target areas contain very large and homogeneous cloudy layer it can happen that no coldest pixels have CC_{ij} greater than the average CC_{ij}, $<CC_{ij}>$. In such case all the pixels of the cold branch that have CC_{ij} greater than 0 are used to calculate the pressure.

A weighted pressure standard deviation is calculated accordingly, and associated to the pressure P, using the same set of pixels. This standard deviation gives information on the variability which is present within the target box. It is expressed in hPa.

An AMV temperature T is calculated using the same equation, but for CTT temperatures, and similarly an associated weighted temperature standard deviation.

Also, an AMV geometric height H is calculated using the same equation (13-5), but for CTH heights, and similarly an associated weighted height standard deviation.

3.5.3.2.1 AMVs extracted at low levels from water vapour channels.

It may happen that a pressure P is found at low levels associated to AMVs extracted from water vapour channels WV6.3 or WV7.3. Such cases are not realistic because only the high and mid levels of the troposphere can be seen using water vapour channels WV6.3 and WV7.3. These cases correspond to targets that have been identified as cloudy because low level clouds are present in the target boxes, but the AMVs correspond to the motion of water vapour features located at higher levels in the troposphere, above the low clouds.
So, if an AMV is extracted from a water vapour channel and its pressure P is larger than a given threshold, *wvll_thres*, then the AMV pressure shall be recalculated considering height assignment methods used in clear sky areas. The *wvll_thres* threshold is dependent on the water vapour channel used for the AMV extraction. The target shall be re-set to a clearsky target.

3.5.3.3 AMVs Extracted from Visible Channel (VIS 0.8)

Like for infrared channel, the cross correlation process uses the contrast of the pixels present within the target box, and same kind of graph as Figure 4 can be plotted considering VIS radiance as function of the individual pixel contribution to correlation process.

In the visible part of the spectra the scattering of the photons on cloud particles dominates the radiative transfer processes. Therefore the cloud tops which correspond to pixels having the smaller radiance in the IR channel now correspond to the pixels which have the larger reflectance in Visible channels.

For AMVs derived using VIS 0.8 channel only the pixels that get a successful CTH value AND that are on the 'warm branch' of the plot of Figure 4 (count value larger than the average count value within the target area) AND that have CC_{ij} greater than *CCij_thres* are selected to calculate the pressure.

The rest of the pressure and pressure standard deviation calculation processes remains identical to the one described in section 3.5.3.2 for the IR channel.

3.5.3.4 Use of OCA Product

The AMV pressure shall be calculated using OCA cloud top height information instead of the CLA CTH product in the equation 4.

The OCA product includes information about the reliability of the retrieval which can be used advantageously in the calculation of the AMV pressure. This information is stored in the OCA product through the JM factor.

Only the pixels that have a JM factor less than a predefined threshold *OCA_JM_thres* AND that satisfy the criteria defined in section 3.5.3.2 are used to calculate the AMV pressure. If no pixels satisfy these conditions, all the pixels that satisfy the conditions defined in section 3.5.3.2 are used to calculate the AMV pressure, disregarding the JM factor.

Weighted standard deviation associated to pressure is calculated accordingly, using the same set of pixels.

3.5.3.5 Inversion Height Assignment

Whenever there is a temperature inversion present, for VIS and IR channel winds there needs to be a check to see if a low-level correction is to be made to the cloud height. Inversion height assignment shall not be applied to WV channel targets.

For all targets with a final pressure, *fin_pres*, bigger than *inv_height_thres* (600 hPa) the inversion height assignment is performed. The inversion height assignment must:

1. Find the temperature *T-bottom* (and corresponding pressure *P-bottom*) at the bottom of the inversion layer. The bottom of the inversion layer is defined as the lowest level (index j) at which $T(j) < T(j+1)$. The search for *T-bottom* will fail if *P-bottom* is not between *inv_height_thres* and the surface pressure + *inv_surface_offset* (40 hPa). In that case quit the inversion height assignment, without changing *fin_pres*.

2. Find the temperature *T-top* (and corresponding pressure *P-top*) at the top of the inversion layer. The top of the inversion layer is defined as the lowest level (index j) above the bottom of the inversion layer at which $T(j) > T(j+1)$. The search for *T-top* will fail if *P-top* is smaller than *inv_height_thres*. In that case quit the inversion height assignment, without changing *fin_pres*.

3. If (*T-top* - *T-bottom*) > *inv_magnitude_thres* (nominally 0 K) then *inv_pres* = (*inv_c1* * *P-bottom* + *inv_c2* * *P-top*) / (*inv_c1* + *inv_c2*) + *inv_c3*
where nominally *inv_c1* = 1, *inv_c2* = 0 and *inv_c3* = 0.
Otherwise, quit the inversion height assignment, without changing *fin_pres*.

4. If *inv_pres* > *fin_pres* then define *inv_pres* as height of AMV.

3.5.3.6 EBBT method based on CCC pixels

An EBBT pressure for each AMV shall be calculated based only on those pixels used by the Cross-Correlation Contribution (CCC) method. The EBBT is calculated using equation 4, but applied to pixel EBBT (T_B) values instead of pixel pressure values.

For IR3.8 winds the T_B38 pixel EBBTs are used. For the other channels the T_B105 pixel EBBTs are used, noting that for the VIS winds the spatial resolution of the EBBTs used is increased to 1 km. The single value EBBT is converted to EBBT pressure, P_{ebbt}, using the forecast temperature profile.

If, for a given channel, there is a low level thermal inversion and the EBBT pressure is larger than the calculated AMV pressure obtained, then the AMV pressure shall be re-set to the EBBT pressure. This prevents pixels whose height was inversion-corrected upwards in the atmosphere during the CTTH process contributing to the low-level AMV – which would otherwise have an artificially too high altitude. Thus, winds associated to clouds below the inversion layer effectively remain below the inversion layer.

If no EBBT data is available then the AMV pressure remains unchanged.

If the EBBT pressure, P_{ebbt}, is selected as the AMV pressure then the associated weighted temperature standard deviation, $EBBT_{sd}$, is calculated. The weighted pressure standard deviation is calculated by:

$$\mathrm{P}_{sd} = \sqrt{\left(P_{ebbt} - P_{\sigma-}\right)^2 + \left(P_{ebbt} - P_{\sigma+}\right)^2}$$

where $P_{\sigma-}$ and $P_{\sigma+}$ are the forecast pressure associated with ($EBBT + EBBT_{sd}$) and ($EBBT - EBBT_{sd}$) respectively. These are the standard deviation values assigned to the wind.

3.5.3.7 Height assignment in clear sky areas

3.5.3.7.1 Use of normalised contribution RTM tables

The height assignment in clear sky areas is carried out only for WV channels (WV6.3 and WV7.3). It is based on the normalised total contribution (NTC) and the normalised total cumulative contribution tables (NTCC) provided by the RTM tables [AD-3] for these channels. Three single level heights are estimated.

The first height, P_{MaxNTC}, is defined as the level at which NTC reaches a maximum (i.e. equals 1). The second height, P_{NTCC_N}, is defined as the level at which NTCC exceeds the value NTCC_N (50%). The difference $\Delta P = (P_{NTCC\_N} - P_{MaxNTCC})$ defines the reliability of the single level height and shall be provided as an output.

The representative layer thickness, P_{LT} defined by $P_{LT} = P_{NTCC\_LL} - P_{NTCC\_HL}$, is also calculated. Pressures P_{NTCC_LL} and P_{NTCC_HL} are defined as the levels where the NTCC assumes the values NTCC_LL=10% and NTCC_HL=90%.

The entire process is illustrated graphically in Figure 5.

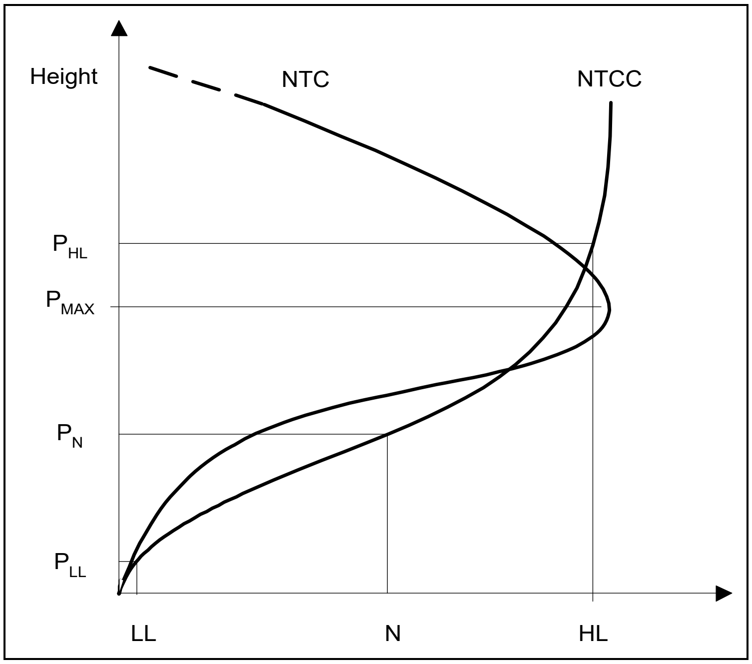

Figure 5: NTC and NTCC methods

A third height, $P_{wv,EBBT}$, is derived from the average EBBT of the coldest water vapour pixels in the clear sky cluster. The number of pixels from which the average EBBT is derived is determined by the fraction *frac_cs_ebbt* (30% of the total cluster size).

All derived heights, i.e. P_{maxNTC}, P_{NTCC_N}, P_{LT}, P_{NTCC_LL} and P_{NTCC_HL} as well as $P_{wv,EBBT}$, shall be saved for further processing.

The final height associated with the target shall be computed in one of two ways. If *iflag_sequence_ha*= 0, a weighted mean of the three single level heights shall be computed, using set-up parameter values for *iflag_ClearSky_MaxNTC, iflag_ClearSky_NTCC_N* and *iflag_ClearSky_EBBT*. If *iflag_sequence_ha* = 1, the final height shall be set to P_{NTCC_N}.

3.5.3.7.2 Use of CCC method and WV channel T_{BS}

This method is mainly based on the CCC method described in section 3.5.3.2. An average AMV brightness temperature $\overline{T}_B$ is calculated as the average T_B of the selected pixels, weighted by their individual contribution to correlation coefficient CC_{ij}. The pixel basis $T_B(chan)_{i,j}$ values are used in Equation 4 instead of the $CTH_{i,j}$ values:

$$\overline{T}_B = \frac{\sum\limits_{\substack{cold\_branch \\ CC_{i,j} > CCij\_thr}} CC_{i,j} \, T_B(chan)_{i,j}}{\sum\limits_{\substack{cold\_branch \\ CC_{i,j} > CCij\_thr}} CC_{i,j}}$$

The corresponding pressure of the AMV shall be estimated by interpolation of this average brightness temperature value $\overline{T}_B$ in the corresponding FC fields.

An estimate of the AMV pressure error shall also be provided. This shall be computed as a function of the standard deviation of the temperature of the pixels in the target area.

3.5.3.8 Derivation of the Final Vector

The speed and direction of the final AMV correspond to the speed and direction of the second intermediate component (second pair of images). There is not any averaging process to derive the final AMV information. The central image of the triplet is considered as the reference image for the time, for the estimation of the position and for the HA calculation.
Then the final location of the AMV is set to the location of the feature tracked in the second image. A weighted CCij location is calculated for latitude and longitude in a similar way than for the pressure in the equation 4. This final location shall be used for comparison against radiosonde observations, aircraft measurements or forecast fields.

The height and temperature associated to the final AMV are estimated from the weighted CCij pressure and temperature using the second image of the triplet.

3.5.4 Automatic Quality Control (AQC)

The Automatic Quality Control (AQC) is based on the same principles used for Meteosat first and second generations [RD-4]. The baseline automatic quality control tests are based on several consistency checks that evaluate the consistency of the vector components and compare the final vector to its surrounding and background field. Each test provides a normalised output value such that they can be linearly combined to obtain a final quality estimate of each of the vectors. The final quality index is computed at the end of each AMV derivation cycle and is a weighted mean of the individual tests. It is disseminated together with the vectors.

3.5.4.1 AQC for Intermediate AMV product

3.5.4.1.1 Comparison to Forecast

This process generates a quality mark from 0 and 1, which is a measure of the consistency with the forecasted AMV. The quality mark is close to 1 when the AMV is in good agreement with the forecasted wind vector interpolated at the same pressure level and location. The vector difference of the AMV values and the forecast vector interpolated to the same location and pressure level is computed for all the raw AMV vectors according to the following equation:

$$M_{forecast}\ (i) = 1 - \left(\tanh\left(\frac{|S(x,y)-F(x,y)|}{\max(AQC\_FC\_A \cdot |S(x,y)+F(x,y)|/2, AQC\_FC\_B) + AQC\_FC\_C}\right)\right)^{AQC\_FC\_D}$$

$$AQC\_FC\_A = 0.2,\ AQC\_FC\_B = 0.01,\ AQC\_FC\_C = 1,\ AQC\_FC\_D = 2, i = 1, N$$

where N = number of cycles to be used for the final vector.

All interpolated forecast wind directions are derived by interpolating the u and v components then calculating the resultant direction.

3.5.4.1.2 Spatial Consistency Test

This process generates 2 spatial quality marks, M_{SWC} and M_{SHC}, which are respectively spatial vector and spatial height consistency tests.

To assess the spatial vector consistency of the AMV, M_{SWC}, this process generates a quality mark between 0 and 1. To do this, the AMV values are compared with the AMVs computed at the neighbouring grid points. The better the agreement is between the AMV and the AMVs extracted at the neighbouring points (for those at a similar pressure level), the larger the quality mark. The goal of this test is to give a poor quality index to the AMVs that are very different to the neighbouring AMVs detected at the same pressure level.

The quality mark is computed against all neighbouring vectors within the height threshold, *AQC_SC_max_pp*, for which ELL_DIST < 1, where

$$ELL\_DIST = (X/A)^2 + (Y/B)^2$$

where

$$A = A1 + WindSpeed \cdot A2;$$
$$B = B1 + WindSpeed \cdot B2;$$
$$X = WindDist \cdot \cos(WindAngle);$$
$$Y = WindDist \cdot \sin(WindAngle);$$

and *WindSpeed* is the reference wind speed. In order to compute the distance between the reference wind and the test wind locations, and the angle of the line containing both locations with respect to the reference wind direction (*WindDist* and *WindAngle*, respectively), the following vectors shall be defined first (see Figure 2):

$$VectorC(1) = \cos(WindLat) \cdot \cos(WindLon);$$
$$VectorC(2) = \cos(WindLat) \cdot \sin(WindLon);$$
$$VectorC(3) = \sin(WindLat);$$
$$VectorE(1) = \cos(TestLat) \cdot \cos(TestLon);$$
$$VectorE(2) = \cos(TestLat) \cdot \sin(TestLon);$$
$$VectorE(3) = \sin(TestLat);$$
$$VectorV(1) = -\sin(WindLon);$$
$$VectorV(2) = \cos(WindLon);$$
$$VectorV(3) = 0.0;$$

where: *WindLon* and *WindLat* are the longitude and latitude, respectively, of the reference wind, and *TestLon* and *TestLat* are the longitude and latitude, respectively, of the test wind.

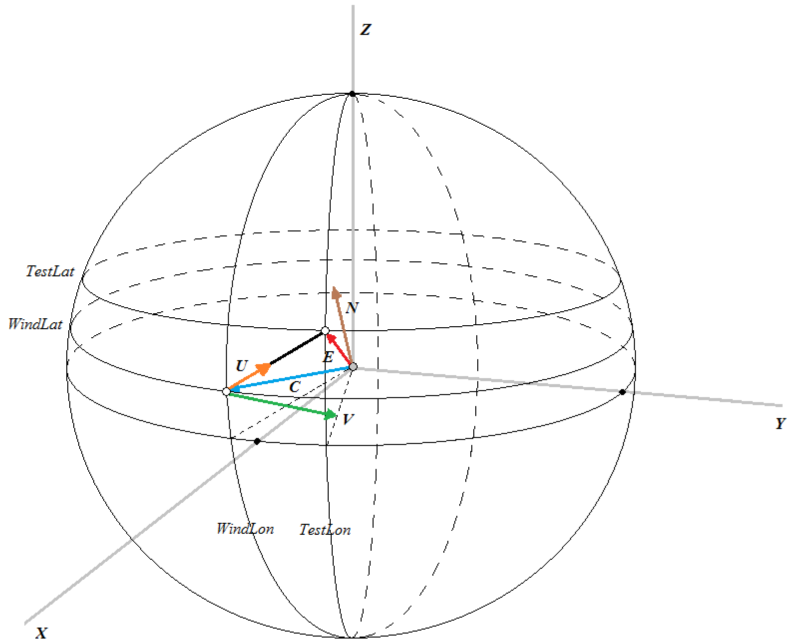

Figure 2: Reference wind and test wind locations with auxiliary vectors (assuming Earth Radius = 1, for clarity).

If the difference in latitude for the reference and test winds is smaller than a given threshold (10^{-6} rad), then the vector from the reference wind location to the test wind location shall be:

$$VectorU = \begin{cases} VectorV, & \text{if } TestLon \geq WindLon; \\ -VectorV, & \text{if } TestLon < WindLon. \end{cases}$$

Otherwise:

$$VectorU = \frac{VectorN \times VectorC}{|VectorN \times VectorC|};$$

where the auxiliary vector *VectorN* is:

$VectorN = VectorC \times VectorE.$

Then, the angle formed by *VectorU* with respect to the reference wind direction shall be computed as:

$WindAngle = PsiAngle - WindDir,$

where *WindDir* is the reference wind direction and *PsiAngle* = acos(*VectorU* · *VectorV*) is the angle between *VectorU* and the local parallel.

The distance between the reference wind and the test wind locations shall finally be computed as the great-circle distance between the two wind locations:
WindDist = *EarthRadius* · acos(*VectorC* · *VectorE*).

A1, A2, B1 and B2 are set-up parameters included in the AMV Static Application Data.
The individual quality marks are calculated according to the following equation:

$$M_{SWC_{i,j}} = 1 - \left(\tanh \left(\frac{|S(x,y) - S(x-i, y-j)|}{\max(AQC\_SC\_A \cdot |S(x,y) + S(x-i,y-i)| / 2, AQC\_SC\_B) + AQC\_SC\_C} \right) \right)^{AQC\_SC\_D}$$

AQC_SC_A to AQC_SC_D are set-up parameters included in the AMV Static Application Data file. *S(x,y)* and *S(x-i,y-j)* represent respectively the AMV and neighbouring AMVs.

If *lc_dist_weight* is false (default value) the final quality mark is a linear average of the *N_best_lc* (nominally 2) matches.

If *lc_dist_weight* is true the final quality mark is the distance weighted average of the *N_best_lc* individual marks:

$$M_{SWC} = \frac{1}{1 / \sum ELL\_DIST} \left(\sum \frac{1}{ELL\_DIST} M_{SWC_{i,j}} \right)$$

If no suitable neighbouring wind vectors are found the quality mark M_{SWC} is set to zero.

To assess the spatial height consistency of the AMV, M_{SHC}, the height difference is calculated for all neighbouring AMV vectors within the height threshold, *AQC_SC_max_pp*. The minimum height difference is used to compute the quality mark, according to the following equation:

$$M_{SHC} = 1 - \left(\tanh \left(\frac{abs\,(P(x,y) - P(x-i, y-j))_{MIN}}{AQC\_HC\_A \cdot P(x,y) + AQC\_HC\_B} \right) \right)^{AQC\_HC\_C}$$

AQC_HC_A to AQC_HC_C are set-up parameters included in the AMV Static Application Data file. *P(x,y)* and *P(x-i,y-j)* represent respectively the AMV and neighbouring AMV pressures.

3.5.4.1.3 Temporal Vector Consistency Test

This process generates a quality mark in 0 to 1, which is a measure of the temporal consistency of the AMV. To do this, the AMV values are compared with the instantaneous AMVs computed

for the same target during each repeat cycle. This test gives a poor quality mark to the AMVs for which their intermediate vectors are very different from each other.
For the first AMV in a new generation cycle, the quality mark are computed against the mean AMV of the previous generation cycle, if the target of the previous generation cycle is used as a starting point for the new channel. For new targets the quality mark are derived to the target within *prev_gen_pp* and within the smallest *prev_gen_ell*, with

prev_gen_ell = $(X/(A\_p))^2 + (Y/(B\_p))^2$

where:

A_p = A1_p + spd*(A2_p)

B_p = B1_p + spd*(B2_p)

X, Y as in 3.5.4.1.2, except that d_lat and d_lon are based on the backward propagation of the target into the previous cycle.

This process generates the quality mark M_{TC} which is a measure of the temporal consistency of the AMV.

To do this, the AMV values is compared with the instantaneous AMVs computed for the same target during each repeat cycle.

$$M_{TC}(i) = 1 - \left(\tanh\left(\frac{|S(x,y) - S_N(x,y)|}{\max(AQC\_TC\_A \cdot |S(x,y) + S_N(x,y)|/2, AQC\_TC\_B) + AQC\_TC\_C}\right)\right)^{AQC\_TC\_D}$$

$$AQC\_TC\_A = 0.2,\ AQC\_TC\_B = 0.01,\ AQC\_TC\_C = 1,\ AQC\_TC\_D = 2, i = 1, N$$

N = number of repeat cycles to be used for the final vector

3.5.4.1.4 Temporal Speed Consistency Test

This process generates a quality mark from 0 to 1, which is a measure of the speed consistency of the AMV. This test gives a poor quality mark to the AMVs for which the speeds of their intermediate vectors are very different from each other.

For the first AMV in a new generation cycle, the quality mark is computed against the mean AMV of the previous generation cycle, if the target of the previous generation cycle is used as a starting point for the new channel. For new targets the quality mark are derived to the target within *prev_gen_pp* (nominally 50 hPa) and within the smallest *prev_gen_ell*, with

prev_gen_ell = $(X/(A\_p))^2 + (Y/(B\_p))^2$

where:

A_p = A1_p + spd*(A2_p)

B_p = B1_p + spd*(B2_p)

X, Y as in 3.5.4.1.2, except that d_lat and d_lon are based on the backward propagation of the target into the previous cycle.

This process generates the quality mark M_{TSC} which is a measure of the speed consistency of the AMV.

The current AMV value is compared with the value of the instantaneous AMVs for the same target derived N cycles earlier:

$$M_{TSC} = 1 - \left(\tanh\left(\frac{\left\| S(x,y) \right| - \left| S_N(x,y) \right\|}{\max(AQC\_TSC\_A \cdot \left(\left| S(x,y) \right| + \left| S_N(x,y) \right| \right) / 2, AQC\_TSC\_B) + AQC\_TSC\_C} \right) \right)^{AQC\_TSC\_D}$$

where AQC_TSC_A, AQC_TSC_B, AQC_TSC_C, and AQC_TSC_D are setup parameters and where N is the number of repeat cycles to be used for the final vector.

3.5.4.1.5 Temporal Direction Consistency Test

This process generates a quality mark from 0 to 1, which is a measure of the direction consistency of the AMV. This test gives a poor quality mark to the AMVs for which the directions of their intermediate vectors are very different from each other.

For the first AMV in a new generation cycle, the quality mark is computed against the mean AMV of the previous generation cycle, if the target of the previous generation cycle is used as a starting point for the new channel it is computed against the instantaneous AMVs computed for the same target during previous N cycles. For new targets the quality mark is derived to the target within *prev_gen_pp* (nominally 50 hPa) and within the smallest *prev_gen_ell*, with

prev_gen_ell = $(X/(A\_p))^2 + (Y/(B\_p))^2$

where:

A_p = A1_p + spd*(A2_p)

B_p = B1_p + spd*(B2_p)

X, Y as in 3.5.4.1.2, except that d_lat and d_lon are based on the backward propagation of the target into the previous cycle.
This process generates the quality mark M_{TDC} which is a measure of the direction consistency of the AMV. It is computed against the instantaneous AMVs computed for the same target during previous N cycles.

$$M_{TDC} = 1 - \left(\tanh\left(\frac{\left| DIR(x,y) - DIR_N(x,y) \right|}{(AQC\_TDC\_A \cdot e^{-vel/AQC\_TDC\_B}) + AQC\_TDC\_C \cdot vel + AQC\_TDC\_D} \right) \right)^{AQC\_TDC\_E}$$

where

AQC_TDC_A, AQC_TCD_B, AQC_TCD_C, AQC_TDC_D and AQC_TDC_E are setup parameters

$$vel = \frac{|S(x,y)| + |S_N(x,y)|}{2}$$

3.5.4.1.6 Temporal Pressure Consistency Test

This process generates the quality mark M_{TPC} which is a measure of the temporal height consistency of the AMV. This test gives a poor quality mark to the AMVs for which the altitudes of their intermediate vectors are very different from each other.
To do this, the AMV is compared with the AMV from the preceding Intermediate AMV Product in the same way as the Temporal Vector Test above:

$$M_{TPC} = 1 - \left(\tanh\left(\frac{\left\| P(x,y) \right| - \left| P_{-1}(x,y) \right\|}{\max(AQC\_TPC\_A \cdot (|P(x,y)|), AQC\_TPC\_B) + AQC\_TPC\_C} \right) \right)^{AQC\_TPC\_D}$$

where AQC_TPC_A to AQC_TPC_D are set-up parameters included in the static data file.

3.5.4.1.7 Image correlation Test

This process generates the quality mark M_{HAC} which is a measure of the correlation cc(ir,wv) between the IR10.5 and WV6.3 channels. The quality mark shall be computed as follows:

$$M_{HAC} = \left(\tanh\left(\frac{MAX(AQC\_HA\_A, cc(ir,wv))}{AQC\_HA\_B} \right) \right)^{AQC\_HA\_C}$$

where AQC_HA_A to AQC_HA_C are set-up parameters included in the static data file.

The test is applied to mid-low level cloud winds. If the pressure of the corresponding AMV > AQC_HA_PP, then

$M_{HAC} = 1 - M_{HAC}$
else
$M_{HAC} = 1$
The above test is also applied to clear sky winds using the above main formula for M_{HAC} and setting
$M_{HAC} = M_{HAC} - 1$

3.5.4.1.8 Inter Channel Consistency Test

All winds with pressure > *ic_low_press* (default 600hPa) and a minimum speed of *ic_min_spd* (default 20m/s) are compared to all winds within *low_ic_check_dist* (nominally 100 km). Against these vectors if the pressure difference is > *ic_pres_diff* (nominally 100 hPa) the following test is performed:

$$M_{IC} = \left(\tanh\left(\frac{\left|S(x,y) - S_N(x,y)\right|}{\max\left(AQC\_IC\_A \cdot \left(\left|S(x,y) + S_N(x,y)\right|/2\right), AQC\_IC\_B\right) + AQC\_IC\_C} \right) \right)^{AQC\_IC\_D}$$

where AQC_IC_A, AQC_IC_B, AQC_IC_C, and AQC_IC_D are setup parameters.

The final quality of the low level vectors is multiplied with this test value. If no suitable collocated clear sky winds are available, the test returns a value equal to 1.

3.5.4.1.9 Final Quality Mark

The Final Quality Value (QI) for AMVs in the Intermediate AMV product is calculated as a weighted mean of the forecast, temporal and spatial consistency tests described above, multiplied by the image correlation test. The weights are defined by the set-up parameters *AMV_Q_Weights_**. This normalised value shall be the final quality indicator which is attached to the AMV. The final quality indicator is always in the range 0 to 1, because of the way in which the individual quality marks have been defined.

3.5.4.2 AQC for the final AMV product

Similar consistency tests are used for the AMV Final Product.

For the forecast consistency test, the vector difference between the AMV final vector and the forecast vector interpolated to the same location and pressure level be computed, using the same set-up parameters as for the Intermediate Product AQC.

The quality values for the spatial consistency tests are calculated using the surrounding AMVs in the Final AMV Product itself, using the same set-up parameters as for the Intermediate Product AQC.

For the individual temporal consistency tests on speed, direction, vector and height, the quality values for the AMVs in the Final AMV Product shall be based on the corresponding quality values for the AMVs in the Intermediate AMV Products used to form the Final AMV. The Final value shall be calculated as a weighted mean of the contributing Intermediate values. The weights shall be defined by the corresponding set-up parameters N_Gen_AQC_Q_Weights_*(1-2), where (1-2) indicates the intermediate AMV product. Values for the first intermediate AMV product are never used in the averaging for the temporal tests.

For the image correlation test, the quality shall be calculated in the same way as for the temporal tests above, but the first intermediate AMV product value is now included in the averaging.

The Final Quality Value (QI) for AMVs in the Final AMV product is calculated in the same way as described for AMVs in the Intermediate AMV Product above. An additional Final Quality Value which excludes the forecast consistency shall also be calculated. This is provided for users requesting a product as independent as possible from the input forecast.

An additional Common Quality Index shall be calculated, however this is currently undefined and shall be set to ‘missing_value’.

A so-far-undefined fourth quality indicator shall be provided as a placeholder, and shall be set to ‘missing_value’.

Both quality values shall also be modified to reduce the quality of slow winds. If AMV wind speed, wind_spd < *speed_threshold* (2.5 m/s), then the Final Quality Value is multiplied by the factor, wind_spd/speed_threshold.

3.6 Monitoring of the Product Quality

The quality of the final product shall be continuously monitored. The monitoring shall be based on the Final Quality Mark. The data shall be sorted into classes according to the Final Quality Mark, and for each group statistics against collocated radiosondes as well as NWP vector fields shall be computed.

For this purpose certain selected variables shall be written into a database located in the facility itself. The selection of these variables is a continuous activity which has to be based on experience when gained.

3.6.1 AMV Verification

The satellite-derived AMVs shall be compared to independent measurements such as observations by radiosondes and forecast wind profiles. The information collected by the verification shall be stored in a database located in the facility itself. This shall include all the information described below for the successful collocations and the corresponding AMV vector and quality information.
To support the verification, the following information shall be calculated:

- For the AMV pressure the forecast wind u and v components are extracted from the forecast profile using logarithmic interpolation in pressure for both components independently
- For the best-fit pressure the forecast wind u and v components are extracted from the forecast profile using logarithmic interpolation in pressure for both components independently

The comparison shall take into account all observations or forecast profiles within the MTG processing area. For each AMV only those observations will be considered that are within a distance of 250 km (in horizontal sense) and 50 hPa (in vertical sense) of the AMV position. The final location of the AMV is considered for the comparison. It corresponds to the location of the feature tracked in the second image

For radiosonde and forecast profiles the best fit height level shall be derived. The best fit level shall be specified as the level at which the magnitude of the vector difference between the AMV vector $S(x,y)$ and the collocated vector at height p, $F(x,y,p)$, reaches its minimum.

For forecast data the magnitude of the vector difference shall be calculated at all forecast levels from the surface to the tropopause. Once the minimum of these values is found, a parabolic interpolation is applied to find the best fit pressure *BSTFIT*.

For radiosonde data the *BSTFIT* value shall be calculated only at the observation profile heights.

Additional following constraints are considered to validate the best fit value BSTFIT:

- The minimum magnitude of the vector difference $VDmin = (S(x,y) - F(x,y,BSTFIT))$ shall be smaller than 4 m/s.
- At pressure values, p outside the band (best-fit pressure +/- 100 hPa), the vector difference $VD = (S(x,y) - F(x,y,p))$ shall not be smaller than ($VDmin$ + 2 m/s).

The following information shall be stored for every AMV in the verification database:

- Spacecraft number, date and time for collocation.
- The AMV vector information: band, type, latitude, longitude, speed, direction, height, temperature and layer thickness.
- The collocated forecast information: forecast latitude, forecast longitude, forecast information at first level below AMV and at first level above AMV comprising: forecast speed, forecast direction, forecast pressure and forecast temperature.
- The AMV quality information: final quality mark, forecast quality mark, temporal vector quality mark, temporal speed quality mark, temporal direction quality mark, temporal height quality mark, spatial vector quality mark, spatial height quality mark, inter-channel quality mark, image correlation quality mark.
- The collocated observation information: observation type, observation quality, observation time, station identifier, latitude, longitude, pressure, temperature, speed, direction.
- The derived Best Fit information for the collocated radiosonde and forecast observations, comprising for both: best fit speed, best fit direction, best fit height, and best fit temperature.
- Additional information such as wind method; target type; horizontal, vertical and time separations between AMV and radiosonde; and a flag labelling the nearest observation to every AMV.

3.7 Output Description

3.7.1 Intermediate AMV Product

Parameter	Mnemonic	Units	To
Channel identifier	chan_id		AMV Intermediate Header

Processing Segment Columns	Proc_width	pixels	
Processing Segment Rows	Proc_height	Pixels	
Cloud Target Area Columns	Cloud_t_width	Pixels	
Cloud Target Area Rows	Cloud_t_height	Pixels	
Clear sky Target Area Columns	Clear_t_width	Pixels	
Clear sky Target Area Rows	Clear_t_height	pixels	
Cloud Search Area Columns	Cloud_s_width	Pixels	
Cloud Search Area Rows	Cloud_s_height	Pixels	
Clear sky Search Area Columns	Clear_s_width	Pixels	
Clear sky Search Area Rows	Clear_s_height	pixels	
No. Vectors in Product	N_vec		
For each AMV:			AMV Intermediate Body
Target ID	Tgt_Id		
Latitude	lat	°	
Longitude	lon	°	
Vector speed	spd	ms-1	
Direction	dir	°	
Temperature Uncorrected	Temp_uncor	K	
Height Uncorrected	Pres_uncor	hPa	
Correction Method	Corr_method		
Temperature	Temp	K	
Temperature STD	Temp_std	K	
Pressure	Pres	hPa	
Pressure STD	Pres_std	hPa	
Value of best matching	Match_val		
Best Match Row Offset	Row_Offset	pixels	
Best Match Column Offset	Col_Offset	pixels	
Overall reliability	OR	-	
Estimated height error	pp_err	hPa	
Cloud target	cloud_target		
No. pixels used for HA	tar_pix	pixels	
Fraction of land pixels in target area	land_frac	%	
Results from each quality test	qc_res	-	
Height Assignment Method	HA_mthd		
Confidence of estimate (forecast consistency)	height_rel		

Parameter	Mnemonic	Units	To
Channel identifier	chan_id		AMV Intermediate Header
Processing Segment Columns	Proc_width	pixels	
Processing Segment Rows	Proc_height	Pixels	
Cloud Target Area Columns	Cloud_t_width	Pixels	
Cloud Target Area Rows	Cloud_t_height	Pixels	
Clear sky Target Area Columns	Clear_t_width	Pixels	
Clear sky Target Area Rows	Clear_t_height	pixels	
Cloud Search Area Columns	Cloud_s_width	Pixels	
Cloud Search Area Rows	Cloud_s_height	Pixels	
Clear sky Search Area Columns	Clear_s_width	Pixels	
Clear sky Search Area Rows	Clear_s_height	pixels	
No. Vectors in Product	N_vec		
For each AMV:			AMV Intermediate Body
Target ID	Tgt_Id		
Fraction of pixels used	height_pix	%	

3.7.2 Final AMV Product

Parameter	Mnemonic	Units	To
Channel identifier	chan_id		AMV Final Header
Centre Frequency	Frequency	Hz	
Bandwidth	Frequency	Hz	
Processing Segment Columns	Proc_width	pixels	
Processing Segment Rows	Proc_height	Pixels	
Segment Size Columns	Seg_width	m	
Segment Size Rows	Seg_height	m	
Correlation Method	Corr_method		
No. Vectors in Product	N_vec		
No. Vectors passing AQC threshold	N_aqc		
No. cycles	N_cyc		
For each cycle:	Cyc_time	secs	
Product Time	Prod_time	Yr, Day, Mth,Hr	
Start Time	Start_time	Hr,Min, Sec	
End Time	End_time	Hr,Min, Sec	
For each AMV:			AMV Final Body
Latitude	lat	°	
Longitude	lon	°	
Vector speed	spd	ms-1	
Direction	dir	°	
Speed u component	u	ms-1	
Speed v component	v	ms-1	
Temperature	temp	K	
Temperature STD	Temp_std	K	
Pressure	pres	hPa	
Pressure STD	Pres_std	hPa	
AMV height	height	m	
AMV height STD	height-std	m	
Estimated height error	pp_err	hPa	
Results from each quality test	qc_res		
Channel Identifier	Chan_id		
Satellite Zenith	Sat_zen	°	

Cloud target	Cloud_target	logical	
Height consistency	H_cons		
Best fit pressure	BSTFIT	hPa	
Wind method	Wind_mthd		
Fraction of land pixels in target area	land_frac	%	
Land-sea flag	land_sea_flag		
For each wind intermediate component:			
Direction	dir	°	
Speed	spd	m/s	
Pressure	pres	hPa	
Pressure SD	pres_sd	hPa	
Temperature	temp	K	
Temperature SD	temp_sd	K	
For each Height Assignment method written to BUFR:			
BUFR Code	BUFR_code		
Pressure	pres	hPa	
Temperature	Temp	K	

4 FUTURE DEVELOPMENTS

The following future enhancements shall be foreseen in the design of the algorithm:

- The use of the other channels, e.g. NIR1.3, IR3.8, IR8.7 and IR9.7. These channels will be used in a similar fashion to the IR10.8 channel.
- AQC checks: Additional AQC checks or improved error estimates may be introduced in the future. Possibility to put them in intermediate or final output files shall exist.
- There are some plans to use inter-channel consistencies to improve the AMV quality. The ground segment must be configured appropriately in the way to allow such analysis/test easily in the future.