SURVEY ON THE DIFFERENT AMV PRODUCTS

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A) AMV PRODUCT IDENTIFICATION

1. Operational status of the AMV product	
EUMETSAT GEO&LEO	Operational centre.
NWCSAF GEO	Operational product "NWCSAF/GEO-HRW High Resolution Winds".
JMA GEO	Operational at JMA/MSC: (1) AMV for global model. (2) High resolution and rapid scan AMV of Full-disk and regional observations (for internal users only).
KMA GEO	Operational centre.
NOAA GEO&LEO	NOAA/NESDIS/OSPO (operational): - List of operational AMV (on 02/Nov/2018): GOES-16, GOES-15, S-NPP, NOAA-15/18/19, Metop-A/B, Aqua/Terra - List of incoming AMV: GOES-17, NOAA-20 NOAA/NESDIS/STAR (non-operational).
CIMSS GEO&LEO	Non-operational center - Research applications.
CPTEC/INPE GEO	Operational at DSA/CPTEC/INPE.

2. Availability of the AMV product	
EUMETSAT GEO&LEO	Products disseminated via GTS, EUMETCAST.
NWCSAF GEO	Calculated locally with "NWC/GEO geostationary software package". The software package can be obtained without any cost from NWCSAF Helpdesk www.nwcsaf.org, after registration as NWCSAF user.
JMA GEO	(1) Distributed via GTS in BUFR (2) Local distribution.
KMA GEO	Distributed via GTS in BUFR.
NOAA GEO&LEO	Operational AMVs distributed by PDA at NOAA/NESDIS/OSPO and GTS
CIMSS GEO&LEO	Products calculated locally at CIMSS and available via ftp/http.
CPTEC/INPE GEO	Local use only, but could be distributed over GTS again in the future or over GEONETCast Americas service.

3. Type of AMV product	
EUMETSAT GEO&LEO	GEO: MET-8 (IODC), MET-9 (backup), MET-10 (RSS), MET-11 (FES/prime mission). LEO: Metop-A and Metop-B, Global AVHRR, Triplet Mode AVHRR.
NWCSAF GEO	Geostationary AMV product.
JMA GEO	Geostationary AMV product.
KMA GEO	Geostationary AMV products.
NOAA GEO&LEO	GEO and LEO AMV products.
CIMSS GEO&LEO	Geostationary, LEO, and LEO/GEO AMV products calculated.
CPTEC/INPE GEO	Geostationary AMV product.

4. AMV Output format	
EUMETSAT GEO&LEO	Heritage BUFR sequence. New BUFR sequence to be implemented soon.
NWCSAF GEO	Local NETCDF and BUFR formats. Heritage IWWG BUFR sequence. New IWWG BUFR sequence (modified 310077 AMV Sequence), to be implemented in Spring 2019.
JMA GEO	Heritage BUFR sequence
KMA GEO	Heritage BUFR format: COMS, GK-2A. NETCDF: GK-2A. New BUFR sequence to be implemented soon.
NOAA GEO&LEO	New BUFR sequence (310067): GOES-16, GOES-17, NOAA-20 Heritage BUFR sequence: All. NetCDF: GOES-16, GOES-17, NOAA-20, S-NPP. McIDAS MD: GOES-15, NOAA-15/18/19, Metop-A/B, Aqua/Terra
CIMSS GEO&LEO	Products available in ASCII text and McIDAS MD file formats. Some products also available in netCDF format (those that use the GOES-R AWG AMV algorithm).
CPTEC/INPE GEO	Local ASCII and BUFR. Heritage IWWG BUFR sequence.

5. Particularities in the AMV Output	
EUMETSAT GEO&LEO	MSG products include an additional AMV altitude set using the OCA product, and pressure standard deviation in hPa.
NWCSAF GEO	The satellite and satellite channels for which AMVs are calculated, the calculation of “clear air AMVs”, and the region for which AMVs are calculated are configurable by the user. The region can be as large as the full disk, or as small as the size of a country.
JMA GEO	Additional parameters are being computed but not disseminated.
KMA GEO	Output including own QI scores: COMS, GK-2A Output including common QI scores: GK-2A Output including individual QI test scores: COMS, GK-2A Output including Expected Error quality value: GK-2A
NOAA GEO&LEO	The satellite, satellite channels and region for which AMVs are obtained are configurable by the user. The obtention of “clear air AMVs” is also configurable by the user. Output includes the temperature and pressure error associated with the 1DVar cloud top height algorithm. Output includes the min/max/median values of cloud top pressure, height and temperature. Output includes the dominant phase and cloud type of target scene. Output includes individual QI test scores. Output includes the vertical temperature gradient and vertical wind shear associated with the Expected Error quality value. Output includes various parameters associated with the cluster analysis algorithm (DBSCAN) used to find the dominant motion in the target scene.
CIMSS GEO&LEO	All products include AMV satellite source, channel source, lat., lon., pressure level, speed, direction, time interval between tracking images, quality indicator. Some products also include CIMSS recursive filter quality value and expected error.
CPTEC/INPE GEO	Output comprehends the main AMV aspects with a Quality Index flag similar to the EUMETISAT QI.

B) INPUT DATA

6. Satellite series with which it can be used	
EUMETSAT GEO&LEO	GEO: MSG-SEVIRI. LEO: Metop-AVHRR radiance
NWCSAF GEO	MSG and GOES-N with NWC/GEO v2016 software package. MSG, GOES-N and Himawari-8/9 with NWC/GEO v2018 software package (to be released in January 2019). MSG, GOES-N, Himawari-8/9 and GOES-R in Spring 2019.
JMA GEO	Himawari-8/9
KMA GEO	COMS, GK-2A, Himawari-8 (proxy)
NOAA GEO&LEO	GEO: GOES-13/14/15 GVAR series, GOES-16/17 ABI series, Himawari-8/9 AHI series, Meteosat 8-11 SEVIRI series LEO: NPP/N20 VIIRS series, NOAA-15/18/19 AVHRR series, Metop-A/B AVHRR series, Terra/Aqua MODIS series
CIMSS GEO&LEO	CIMSS heritage WINDCO package used for GOES-N and MSG (0 degrees longitude) NESDIS GOES-R package with GOES-N, GOES-R, MSG (Indian Ocean), Himawari-8
CPTEC/INPE GEO	GOES-R or MSG.

7. Satellite channels/type of data with which it can be used	
EUMETSAT GEO&LEO	GEO : VIS0.8 and HRVIS reflectances, WV6.2, WV7.3 and IR10.8 radiances. LEO : IR10.8 radiances
NWCSAF GEO	With MSG series, HRVIS/VIS06/VIS08 reflectances and IR108/IR120/WV062/WV073 brightness temp. With GOES-N series, VIS07 reflectances and IR107/WV065 brightness temp. With Himawari-8/9 series, VIS06/VIS08 reflectances and IR112/WV062/WV070/WV073 brightness temp. With GOES-R series, VIS06/VIS08 reflectances and IR112/WV062/WV070/WV074 brightness temp. (Configurable by the user).
JMA GEO	VIS0.64um reflectance, IR(3.9, 10.4, 12.3 and 13.3um) and WV(6.2, 7.0 and 7.3um) brightness temp. (for AMV distributed via GTS, using image spatial resolution of 2km at nadir)
KMA GEO	(1) COMS AMVs: VIS(670 nm) reflectance, SWIR(3.7 um), IR-WV(6.7 um), IR-Window(10.8 nm) radiances. (2) GK-2A AMVs: VIS(645 nm) reflectance, SWIR(3.85um), IR-WV(6.25,6.95,7.35um), and IR-Window(10.45,11.2um) radiances.
NOAA GEO&LEO	GOES-13/14/15 series: VIS06 reflectance, IR039/IR107/WV065 br.temp. GOES-16/17 and Himawari- 8/9 series: VIS06 reflectance, and IR039/IR112/WV062/WV069/WV073 brightness temp. NPP/N20 series: IR112 brightness temp. NOAA-15/18/19 & Metop-A/B: Band 4 (11um) brightness temp. and radiances Terra/Aqua: Bands 27 (6.7um) and 31 (11um) brightness temp. and radiances
CIMSS GEO&LEO	MSG AMVs with VIS06 reflectances and IR039/IR108/WV062 brightness temp. Triplet breakdown: 30 min. interval for Full disk for clear sky WV062/WV073. 15 min. interval for Full Disk VIS06/IR039(dark only)/IR108/WV062(cloud top). GOES-N AMV's calculated with VIS062 reflectances, and IR039/IR107/WV065/WV074 brightness temp. GOES-15 Northern hemisphere triplet breakdown: 30 min. interval for Full NH for VIS062(2 km resolution)/IR039(dark only)/IR107/WV065. 15 min. interval for CONUS for VIS062(2 km resolution)/IR039(dark only)/IR107/WV065. The smaller GOES-15 sounder sector images are included when available with 60 minute triplet intervals for WV074. GOES-15 Southern hemisphere image triplet breakdown: 30 min. for Full southern hemisphere (SH) for VIS062(2 km resolution)/IR039(dark only)/IR107/WV065. GOES-R AMV's calculated with VIS064 reflectances, and IR039/IR112/WV062/WV069/WV073 brightness temp. Triplet breakdown: 30 min. interval for Full Disk for clear sky water vapor WV062/WV069/WV073. 15 min. interval for Full Disk for VIS064(2 km resolution)/IR039(dark only)/IR112/WV062(cloud top). 5 min. for CONUS for VIS064(2 km resolution)/IR039(dark only)/IR112/WV062(cloud top). Meso triplet breakdown: 1 min. interval for VIS064(0.5 km resolution)/IR039(dark only)/IR112/WV062(cloud top). Himawari-8 AMV's calculated with VIS064 reflectances, and IR039/IR112/WV062/WV069/WV073 brightness temp. Triplet breakdown: 30 min. interval for Full Disk for clear sky water vapor WV062/WV069/WV073. 10 min. interval for Full Disk for VIS064(2 km resolution)/IR039(dark only)/IR112/WV062(cloud top).
CPTEC/INPE GEO	High resolution Visible channels (reflectance) or IR brightness temperatures.

8. Use of other input products for the AMV processing (Clouds, other observations,… and for which tasks).	
EUMETSAT GEO&LEO	GEO: SCE (scene information), CLA (cloud analysis), OCA (optimal cloud analysis), RTM (radiative transfer model), forecast fields. LEO: Metop-AVHRR: AVHRR cloud mask (CLM), and IASI cloud top pressure (IASI_SND_02 products).
NWCSAF GEO	NWC/GEO-Cloud products CMa (Cloud mask), CT (Cloud type), CTTH (Cloud top temperature and height) and CMIC (Cloud microphysics) used for the "AMV height assignment". The products are also provided inside NWC/GEO software package, and are calculated together with NWC/GEO-HRW AMV product. "Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA)" data used for NWC/GEO Cloud products calculation. These data are not strictly needed but their use is recommended for better AMVs
JMA GEO	Climatological vegetation map and land elevation data used for quality checking process.
KMA GEO	Own cloud mask products for target selection. Own cloud top pressure (height) products for target selection and height assignment processes
NOAA GEO&LEO	Cloud Mask: Used as part of the cloud amount test when selecting which target scenes to process. It is also used to screen out pixels that do not have a cloud top pressure associated with them. Cloud Top Pressure, Cloud Top Pressure quality, and Cloud Top Temperature: Used to assign a representative height to the target scene being tracked. The median cloud-top pressure from the sample of cloud-top pressures belonging to the largest cluster serves as the representative height to assign the AMV. Low-level Inversion Flag: Used to assign a representative height to the scene being tracked within a GFS model designated low-level inversion. Solar Zenith Angle: Used to determine day/night pixels. Land mask/Surface type: Used to classify each ABI pixel as being land or water. Expected Error Coefficients File: A set of regression coefficients corresponding to a number of predictors used to compute the Expected Error quality flag that is appended to each AMV that is computed.
CIMSS GEO&LEO	Cloud Mask: Used as part of the cloud amount test when selecting which target scenes to process. It is also used to screen out pixels that do not have a cloud top pressure associated with them. Cloud Top Pressure, Cloud Top Pressure quality, and Cloud Top Temperature: Used to assign a representative height to the target scene being tracked. The median cloud-top pressure from the sample of cloud-top pressures belonging to the largest cluster serves as the representative height to assign the AMV. Low-level Inversion Flag: Used to assign a representative height to the scene being tracked within a GFS model designated low-level inversion. Solar Zenith Angle: Used to determine day/night pixels. Land mask / Surface type: Used to classify each ABI pixel as being land or water. Expected Error Coefficients File: A set of regression coefficients corresponding to a number of predictors used to compute the Expected Error quality flag that is appended to each AMV that is computed.
CPTEC/INPE GEO	DSA/CPTEC/INPE cloud classification for target selection and Height Assignment.

9. Use of NWP for the AMV processing (NWP source & variables, for which tasks, including use in the other input products).	
EUMETSAT GEO&LEO	GEO: Forecast from ECMWF, used in Quality Control for QI with forecast. LEO: Forecast from ECMWF used for: wind guess used for Tracking, Quality Control for QI with forecast, estimation of EBBT pressure and low level Inversion in HA.
NWCSAF GEO	NWP grid data needed for calculation of NWC/GEO-Cloud and AMV products. NWP grid data provided from many sources (configurable by the user). The most common ones: ECMWF NWP, MétéoFrance ARPEGE, NOAA GFS models. Next NWP variables are used for the NWC/GEO-HRW AMV calculation: NWP forecast temperature, forecast geopotential, and forecast and analysis wind (for the "Quality control forecast test", the optional use of "wind guess", the "Parallax correction" calculation, and the autovalidation with NWP winds). 16 NWP forecast variables are used for the NWC/GEO-Cloud product calculation.
JMA GEO	Temperature, geopotential, humidity, pressure and wind components used for the forward calculation of the radiative transfer model. Expected clear sky radiances from ideal black body placed at each level used for height assignment and quality checking process.
KMA GEO	KMA GDAPS forecast: Vertical Temperature profiles used for Inversion layer correction. Skin (Surface) temperature used for CO2 slicing method. Vertical U/V profiles used for calculating QI component with forecast. T/q profiles, U/V profiles, 1.5m temperature/humidity, 10m U/V, and surface pressure used for the forward calculation of the radiative transfer model (RTM). RTM(RTTOV) profiles: EBBT and transmittance used for height assignment processes. CSR used for CO2 slicing method.
NOAA GEO&LEO	Short-term forecast temperature and wind data on pressure surfaces from National Centers for Environmental Prediction's (NCEP) Global Forecast System (GFS) model are used to calculate target heights and for calculating model shear and model temperature gradients used in the Expected Error algorithm. Short-term GFS forecast wind profiles are also used to center the search box on the predicted locations of targeted features being tracked in the first and last images of the loop sequence. Short-term GFS forecast wind profiles are also used to compute a vector difference between the model vector and the satellite derived wind. Winds exceeding a band-dependent threshold are discarded.
CIMSS GEO&LEO	Short-term forecast temperature and wind data on pressure surfaces from National Centers for Environmental Prediction's (NCEP) Global Forecast System (GFS) model are used to calculate target heights and for calculating model shear and model temperature gradients used in the Expected Error algorithm. Short-term GFS forecast wind profiles are also used to center the search box on the predicted locations of targeted features being tracked in the first and last images of the loop sequence. Short-term GFS forecast wind profiles are also used to compute a vector difference between the model vector and the satellite derived wind. Winds exceeding a band-dependent threshold are discarded.
CPTEC/INPE GEO	CPTEC/INPE NWP profiles used for Height Assignment and cloud classification and quality control. Variables used: Temperature, Humidity and Pressure for height assignment and wind components for quality control check.

C) FEATURE IDENTIFICATION

10. Method for the definition of features used.	
EUMETSAT GEO&LEO	GEO: Maximum contrast (nominal) or maximum entropy (alternative). LEO: Target screening based on local contrast.
NWCSAF GEO	Two methods used for definition of tracers: "Gradient method", as defined by "C.M.Hayden & R.T.Merrill, 1988: Recent NESDIS research in wind estimation from geostationary satellite images". It defines tracer locations where maximum gradients of reflectance/brightness temperature are found, while the reflectance/brightness temperature value and distribution exceeds some configurable limits in the tracer pixels. "Tracer characteristics method", based on new development. It checks that a significant contrast and a minimum value ("frontier") are found in the tracer reflectance/brightness temperature histogram. Then, it checks that pixels with reflectance/brightness temperature values over and below the frontier are properly distributed inside the tracer, so having enough variability in the different directions. "Tracer characteristics tracers" are looked for in areas where "Gradient tracers" could not be found.
JMA GEO	Targets on grid points defined in pixel-lines base are used.
KMA GEO	A pixel with the largest standard deviation of brightness temperature or albedo in target box as representative of target.
NOAA GEO&LEO	Target centered on maximum brightness temperature gradient within the scene. Targeting is done on the middle image of a 3-image loop. Coakley/Bretherton algorithm used to remove multi-layer cloud scenes. Coherence check applied to remove scenes that are too coherent.
CIMSS GEO&LEO	Target centered on maximum brightness temperature gradient within the scene. Targeting is done on the middle image of a 3-image loop. Coakley/Bretherton algorithm used to remove multi-layer cloud scenes. Coherence check applied to remove scenes that are too coherent.
CPTEC/INPE GEO	Target windows (tracers) are initially chosen using a fixed spaced grid and then a feature check is performed. If the target window is too homogeneous or has too many clear sky pixels, a new target window is searched near the original point. For Visible and NIR 3.9 µm, only low level cloud tops are selected, masking out all other cloud tops.

11. Thresholds/limits/particularities/controls in the method for definition of the features	
EUMETSAT GEO&LEO	None.
NWCSAF GEO	Limits are defined for the satellite zenith angle and the solar zenith angle (configurable by the user). "Persistent tracers" and "Trajectories" are defined considering several consecutive images (with part of the "tracers" located in the "tracking centre locations" of the previous round).
JMA GEO	Target points are selected to avoid "correlated error" (target overlapping) in tracking process.
KMA GEO	None.
NOAA GEO&LEO	BT gradient limit and Coakley/Bretherton algorithm used to filter out low contrast scenes and scenes with uniform structure. 10% cloud amount threshold used when tracking cloudy features. 0.8 threshold used in Coakley/Bretherton algorithm to filter 3x3 cloud scenes into coherent/non-coherent samples. 80% threshold limit placed on size of coherent sample. If the sample of coherent 3x3 scenes exceeds 80% the target is rejected as being too coherent
CIMSS GEO&LEO	BT gradient limit and Coakley/Bretherton algorithm used to filter out low contrast scenes and scenes with uniform structure. 10% cloud amount threshold used when tracking cloudy features. 0.8 threshold used in Coakley/Bretherton algorithm to filter 3x3 cloud scenes into coherent/non-coherent samples. 80% threshold limit placed on size of coherent sample. If the sample of coherent 3x3 scenes exceeds 80% the target is rejected as being too coherent.
CPTEC/INPE GEO	For Visible and NIR 3.9 µm, the target window needs to have at least 25% of pixels identified as low level cloud top. For IR 10.3 µm, if a target window has more than 80% pixels identified as clear sky, it is rejected and a new one is chosen.

12. Types of features used (Clouds/WV humidity,…)	
EUMETSAT GEO&LEO	GEO: Clouds are tracked using the VIS0.8, WV6.2, WV7.3, IR10.8 and HRVIS channels (cloudy AMVs). WV features are tracked using the WV6.2 and WV7.3 channels (clear-sky AMVs). LEO: Clouds.
NWCSAF GEO	Cloud features used for AMV calculation with all satellite channels (cloudy AMVs); humidity features also used for AMV calculation with water vapour channels (clear air AMVs).
JMA GEO	Clouds.
KMA GEO	Both clouds and clear-sky water vapor features.
NOAA GEO&LEO	Both clouds and clear-sky water vapor features.
CIMSS GEO&LEO	Both clouds and clear-sky water vapor features.
CPTEC/INPE GEO	Clouds for all channels and humidity features for WV channels.

13. Scale of features used (in pixels/kilometres,…)	
EUMETSAT GEO&LEO	GEO: 24x24 pixels (72x72 km2) at nadir for VIS/WV/IR cloudy AMVs. 32x32 pixels (32x32 km2) at nadir for HRVIS channel cloudy AMVs and WV clear-sky AMVs. LEO: Target box size 28x28 pixels, 28x28 km2 at nadir
NWCSAF GEO	Square tracers of 24 pixels ("Basic AMVs") used as default option. An additional set of square tracers of 12 pixels ("Detailed AMVs") can additionally be defined. The tracer size is configurable by the user, but it is similar for all channels.
JMA GEO	Both of small and large target box sizes (7x7 pixels and 31x31 pixels) are used.
KMA GEO	Target box size is 16 X 16 pixels for IR(2 km) and 48 X 48 pixels for VIS(0.5 km).
NOAA GEO&LEO	LWIR: 19x19 pixel target box All other winds: 15x15 pixel target box
CIMSS GEO&LEO	LWIR: 19x19 pixel target box All other winds: 15x15 pixel target box
CPTEC/INPE GEO	Square tracers with size varying from 16x16 up to 24x24 pixels.

14. Localization of features used (grid scale, tracer separation,…)	
EUMETSAT GEO&LEO	GEO: Regular grid with grid spacing of 24 pixels (72 km at nadir) for VIS/WV/IR. Regular grid with grid spacing of 32 pixels (32 km at nadir) for HRVIS. LEO: 28 pixels, 28 km at nadir.
NWCSAF GEO	Tracers separated with a nominal separation of 12 kilometres at subsatellite point as default option (configurable by the user; it can be different for different satellite resolutions and cloud types). The real separation of tracers changes a bit, depending on corrections in the location of the tracers, inferred by the methods used for the feature identification.
JMA GEO	Grid gap is 17 pixels (34km at nadir) for global model users.
KMA GEO	Grid scale is 16 X 16 pixels for IR(2 km) and 96 X 96 pixels for VIS(0.5 km).
NOAA GEO&LEO	Tracer separation: 15 pixels
CIMSS GEO&LEO	Tracer separation: 15 pixels
CPTEC/INPE GEO	Operationally, tracers are defined adjacent in a fixed regular grid with a maximum overlap of 25%.

D) TRACKING

15. Method for calculation of the tracking or feature displacement	
EUMETSAT GEO&LEO	GEO: Cross correlation (nominal) or Euclidean distance (alternative). LEO: Cross Correlation.
NWCSAF GEO	"Cross correlation" or "Euclidean distance" (configurable by the user). The first option is used as default one.
JMA GEO	Cross correlation (Pearson correlation coefficient) method.
KMA GEO	Cross Correlation.
NOAA GEO&LEO	Cloudy features: Sum of Squared Differences (SSD) of smaller 5x5 sub-targets combined with a cluster analysis algorithm to determine dominant motion and cloud height associated with largest motion cluster. Clear sky WV: Sum of Squared Differences (SSD) of entire 15x15 target scene. No cluster analysis to determine dominant motion.
CIMSS GEO&LEO	Cloudy features: Sum of Squared Differences (SSD) of smaller 5x5 sub-targets combined with a cluster analysis algorithm to determine dominant motion and cloud height associated with largest motion cluster. Clear sky WV: Sum of Squared Differences (SSD) of entire 15x15 target scene. No cluster analysis to determine dominant motion.
CPTEC/INPE GEO	Maximum Cross Correlation method.

16. Thresholds/limits/particularities used in the tracking or feature displacement	
EUMETSAT GEO&LEO	None.
NWCSAF GEO	The use of “wind guess” for the definition of the tracking area (not implemented as default option), and the “subpixel tracking process” (implemented as default option) are available for the tracking process. The size of the “tracking area” is also configurable by the user (with a default value considering displacements for the tracer of at least 272 km/h). A gradual approach in the tracking process, considering four iterations, and based on the idea that “Euclidean distance”/”Cross correlation” change slowly (such as shown by “Xu J. & Zhang Q., 1996: Calculation of Cloud motion wind with GMS-5 images in China”), is used for the calculation of+ the “Euclidean distance minima”/”Cross correlation maxima”. Up to three tracking centres (with the best “Euclidean distance”/”Cross correlation” values) are calculated for each tracer, so defining up to three possible AMVs. Later, in the AMV output filtering, only one of them is retained. The “initial image” related to the “tracer” calculation and the “later image” related to the “tracking centre” calculation are not necessarily consecutive; the interval between images can be configured by the user. A “correlation threshold” is defined for valid AMVs using “Cross correlation” (80% as default option; configurable by the user).
JMA GEO	Four cross-correlation surfaces are calculated with small and large target boxes using 3 sequential images. The four cross-correlation surfaces are averaged and the averaged cross-correlation surface is used for tracking. Cross correlation threshold is 75%.
KMA GEO	None.
NOAA GEO&LEO	Cloudy features: 80% correlation threshold applied to individual 5x5 sub-targets Clear sky WV features: 60% correlation threshold applied to 15x15 target
CIMSS GEO&LEO	Cloudy features: 80% correlation threshold applied to individual 5x5 sub-targets Clear sky WV features: 60% correlation threshold applied to 15x15 target
CPTEC/INPE GEO	Tracers with MCC lower than 70% correlation are rejected.

17. Thresholds/limits/particularities used in the calculation of the wind	
EUMETSAT GEO&LEO	GEO: The final AMV is the average of three AMV intermediate components. LEO: None.
NWCSAF GEO	The displacement between the “tracer” and the “tracking centre” is calculated considering the corresponding “great circle”, as defined by “haversine formula”. If “CCC method” is used for the height assignment, the location in the “tracer”/”tracking centre” with largest contribution to the correlation is used to define the displacement of the AMV. The real time the “tracer”/”tracking centre” was scanned in the initial and final images, and not the nominal time of both images, is used for the calculation of the wind. Since NWC/GEO v2018, a “parallax correction” of the latitude/longitude of the “tracer”/”tracking centre” location is used, to correct the horizontal deviation in the apparent position of the “tracer”/”tracking centre” due to its height over the Earth surface. Its use is configurable. Since NWC/GEO v2018, a “mixed calculation method” is available for processing, considering at the same time short and long time intervals (not used as default option). Through this, tracers are tracked considering smaller time intervals, but AMVs are calculated considering 2 to 4 displacements of the same tracer in longer time intervals.
JMA GEO	Defined in the quality check process.
KMA GEO	The final AMV is the average of two intermediate winds between three images.
NOAA GEO&LEO	Acceleration check of two intermediate winds, band dependent Cloudy winds: DBSCAN cluster analysis algorithm used to determine number of motion clusters and to identify largest one.
CIMSS GEO&LEO	Acceleration check of two intermediate winds, band dependent Cloudy winds: DBSCAN cluster analysis algorithm used to determine number of motion clusters and to identify largest one.
CPTEC/INPE GEO	The final wind direction/speed corresponds to the tracer displacement between the second and third images. The displacement calculated using the first and second images are used only for quality control check. The real scanning time for the central target pixel in each image are used to calculate the wind speed.

E) HEIGHT ASSIGNMENT

18. Height assignment method	
EUMETSAT GEO&LEO	GEO: CCC method used nominally for cloudy AMVs, with Cloud Top Pressure estimated on a pixel basis. AMVs extracted at low level are set to the temperature inversion level whenever a temperature inversion exists and certain criteria are met. EBBT height used whenever the AMV pressure calculated using CCC is found below the temperature inversion level. NTC/NTCC methods used nominally for clear-sky AMVs. LEO: CCC method applied with EBBT estimated on pixel basis. AMS extracted at low level are set to temperature inversion level when temperature inversion exists. IASI L2 Cloud Top Pressure used when IASI footprint collocated with feature tracked.
NWCSAF GEO	"CCC method" or "Brightness temperature interpolation method" used for the AMV height assignment (configurable by the user). The first option is used as default one.
JMA GEO	AMV height assignment is based on the optimal estimation method using the derived motion vectors, the observed IR radiances, the wind vertical profile of NWP and the estimated brightness temperatures using the radiative transfer model.
KMA GEO	CCC, EBBT&IR/WV rationing, CO2 slicing for cloudy AMVs NTC, NTCC for clear-sky AMVs.
NOAA GEO&LEO	Cloudy winds: median cloud top pressure (CTP) of largest motion cluster. Clear sky winds: median BT of coldest 20% of target scene used as lookup with forecast model temperature profile.
CIMSS GEO&LEO	Cloudy winds: median cloud top pressure (CTP) of largest motion cluster. Clear sky winds: median BT of coldest 20% of target scene used as lookup with forecast model temperature profile.
CPTEC/INPE GEO	Effective Black-body Brightness Temperature (EBBT), WV/IR rationing and CO2 intercept

19. Thresholds/limits/particularities used in the Height assignment process	
EUMETSAT GEO&LEO	None.
NWCSAF GEO	"CCC method" applies to both cloudy and clear air AMVs. "CCC method" includes the calculation of an "AMV pressure error", for which only values up to 150 hPa are valid (this is configurable by the user). For cloudy AMVs, "CCC method" includes a "Microphysics correction" of the "AMV pressure", related to the cloud thickness and calculated through NWC/GEO-Cloud Microphysics product. This correction is applied to all satellite series except GOES-N, for which NWC/GEO-Cloud Microphysics product is not available. For clear air AMVs, the "AMV temperature" is calculated through the brightness temperature of the pixels considered by the method, and then this "AMV temperature" is converted to "AMV pressure" through interpolation to the NWP temperature forecast. "Brightness temperature interpolation method" is used when NWC/GEO-Cloud products are not available. Two pressure values are calculated by the method: "AMV top pressure" and "AMV base pressure", from which the "AMV pressure" is defined depending on the "AMV cloud type".
JMA GEO	If the geometric mean of radiance likelihood term is less than 0.5 or if the optimal radiance and the observed radiance are significantly different, the target is rejected. (QC process)
KMA GEO	None.
NOAA GEO&LEO	10% cloud amount threshold used when tracking cloudy features 100% clear sky threshold for clear sky WV winds. 100 hPa threshold applied to difference between intermediate cloud top pressure assignment of largest motion cluster. Visible and SWIR winds are limited to 700-1000 hPa layer. Cloud top WV winds limited to 100 - 350 hPa layer. LWIR winds limited to 100 -1000 hPa layer.
CIMSS GEO&LEO	10% cloud amount threshold used when tracking cloudy features 100% clear sky threshold for clear sky WV winds. 100 hPa threshold applied to difference between intermediate cloud top pressure assignment of largest motion cluster. Visible and SWIR winds are limited to 700-1000 hPa layer. Cloud top WV winds limited to 100 - 350 hPa layer. LWIR winds limited to 100 -1000 hPa layer.
CPTEC/INPE GEO	EBBT is used for all opaque tracers. Semi-transparent tracers are identified using the local cloud classification product and its brightness temperature are corrected by WV/IR and CO2 slicing methods.

20. NWP/products specifically used in the Height assignment process	
EUMETSAT GEO&LEO	NWP fields are used in AMV software only when EBBT method or inversion methods are applied
NWCSAF GEO	With “CCC method” and Cloudy AMVs, NWC/GEO-CT (Cloud type), CTTH (Cloud top temperature and height) and CMIC (Cloud microphysics) are used. With “CCC method” and Clear air AMVs, the brightness temperature of the pixels and the NWP temperature forecast are used. With “Brightness temperature interpolation method”, the brightness temperature of the pixels, the NWP temperature forecast and NWC/GEO-CT (cloud type) are used.
JMA GEO	Brightness temperature for all bands, at each vertical layer, calculated using NWP vertical profile with RTTOV. First guess wind vertical profile. Vegetation data for BIAS correction
KMA GEO	NWP Temperature profiles are used for Inversion layer correction for cloudy AMVs if there is inversion layer.
NOAA GEO&LEO	The upstream 1DVar cloud height and cloud phase algorithms use several NWP profile parameters. The AMV algorithm uses the NWP wind profiles for gross error (vector difference) checks and temperature profile for clear sky WV height assignment.
CIMSS GEO&LEO	The upstream 1DVar cloud height and cloud phase algorithms use several NWP profile parameters. The AMV algorithm uses the NWP wind profiles for gross error (vector difference) checks and temperature profile for clear sky WV height assignment.
CPTEC/INPE GEO	Temperature, pressure, humidity and wind profiles.

F) QUALITY AND AMV FILTERING

21. Quality methods used for the AMV filtering	
EUMETSAT GEO&LEO	Weighted average of consistency checks based on Holmlund 1998
NWCSAF GEO	Four methods are used one after the other for the AMV filtering: 1. "Quality Indicator" method. The method uses exactly the same procedure and configuration that EUMETSAT is using, but with a triple weight for the spatial and temporal vector consistency tests. 2. "Common Quality Index without forecast" self-contained Fortran method, distributed to the IWWG in May 2017. This option is available since NWC/GEO v2018 software package. 3. A "Final control check". The function calculates velocity and direction histograms for all valid AMVs in square boxes of 5x5 degrees of latitude and longitude. When any of the histogram columns has only one element, that AMV is excluded. 4. "Orographic flag" method, which combining topographic information and NWP data, detects and rejects AMVs affected by land influence.
JMA GEO	Wind speed range, satellite zenith angle, maximum cross-correlation coefficient, radiance likelihood checking and stripe noise check. Imagery navigation error check with "QI not using forecast".
KMA GEO	Own QI: Weighted average of each QI tests scores based on Holmlund 1998 Common Quality index(QI) Expected Error(EE)
NOAA GEO&LEO	Acceleration thresholds used on the intermediate wind vectors. Band dependent. A vector difference threshold is applied using the forecast wind. Band dependent.
CIMSS GEO&LEO	Acceleration thresholds used on the intermediate wind vectors. Band dependent. A vector difference threshold is applied using the forecast wind. Band dependent.
CPTEC/INPE GEO	Local Quality Index based on the one used by EUMETSAT.

22. Specific Quality indices provided in the AMV output	
EUMETSAT GEO&LEO	GEO: QI with forecast, QI without forecast, QI without forecast based on OCA (rather than CLA), Common QI. LEO: QI with FC, QI without FC
NWCSAF GEO	"Quality Index with forecast". "Quality Index without forecast". "Common Quality Index without forecast" (since NWC/GEO v2018 software package). "Orographic flag".
JMA GEO	The Quality Index with forecast The Quality Index without forecast
KMA GEO	Own QI and common QI with forecast Own QI and common QI without forecast
NOAA GEO&LEO	EUMETSAT Quality Indicator (QI) without forecast term. Expected Error computed but not used.
CIMSS GEO&LEO	QI without forecast and CIMSS recursive filter flag in text and MD files, same as NESDIS for netCDF files
CPTEC/INPE GEO	Own Quality Index flag with NWP forecast. Own Quality Index flag without NWP forecast. A common QI could be added in the future.

23. Thresholds/limits/particularities used in the AMV output filtering	
EUMETSAT GEO&LEO	GEO: None. LEO: Only a pair of images are used to extract Global AVHRR and single mode AVHRR AMV products. So, a reverse tracking is done to calculate the temporal consistency check.
NWCSAF GEO	"Quality Index with forecast" ≥ 70% is defined for valid AMVs. However, the threshold and the fact of using for the filtering the "Quality Index with/without forecast" is configurable by the user. All AMVs affected by land influence are rejected. However, this is configurable by the user. AMVs related to some specific pressure values, some cloud types, and some "spatial quality flags" are rejected, depending on the satellite channel. However, this is configurable by the user. Considering the up to three AMVs calculated for each tracer, only the one with best values for most quality tests plus correlation (when calculated) is retained.
JMA GEO	Only AMVs that have passed quality control process and quality index thresholds are retained. "QI with forecast" has to be larger than 75% (85% for WV AMV).
KMA GEO	AMVs with pressure between 1000 and 100 hPa.
NOAA GEO&LEO	Vector difference thresholds: Visible (low levels): 6 m/s SWIR (low levels): 7 m/s Cloud-top WV: 10 m/s Clear-sky WV: 12 m/s LWIR: 10 m/s QI thresholds: Visible winds: QI >= 50%; All winds except visible: QI >= 60%
CIMSS GEO&LEO	Text/MD files are available both with/without AMV's over land. Vector difference thresholds: Visible (low levels): 6 m/s SWIR (low levels): 7 m/s Cloud-top WV: 10 m/s Clear-sky WV: 12 m/s LWIR: 10 m/s Synoptic scale QI thresholds: GOES-N QI>=50% for all channels GOES-R QI>=50% for all channels Meteosat-8 VIS006 QI>=70%, other channels QI>50% Meteosat-11 VIS006 QI>=70%, other channels QI>50% Himawari-8 QI>=60% for all channels GOES-16 mesoscale products: VIS064 QI>=90%, pressure level >= 700 hPa or pressure level <= 300 hPa and cloud top temperature <= 220 K IR039(dark only)/IR112/WV062(cloud top) QI>=60%.
CPTEC/INPE GEO	Recommendation to use only AMV with QI over 70%. Except AMVs rejected during the MCC calculation, all AMVs evaluated by the final QI remain in the final output. AMVs with speed out of a predefined range receive a QI=0.