AMV inter-comparison between GK-2A and MTG algorithm using Himawari-8/AHI

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❖ Introduction

The GEO-KOMPSAT-2A (GK-2A) and METEOSAT Third Generation (MTG) AMVs were compared to evaluate the accuracy of algorithm. The 3rd AMV inter-comparison study cases were selected for validating wind speed, wind direction, height and quality indicator. We compared two results using exactly same input data and configuration and their own one on 12:10 UTC at 21 July 2016. The first case showed very similar results for the 4 variables. For the second case, the distribution of wind speed and wind direction show very similar because both algorithms are using same methods such as optimal target selection and Cross Correlation Coefficient in target selection and tracking, respectively. However, the height distribution and quality indicator of the vectors are not similar since methods used are different from each other. In addition, GK-2A AMV algorithm performs slightly better than COMS AMV algorithm.

❖ GK-2A and MTG AMV Algorithm

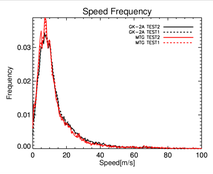
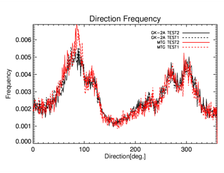
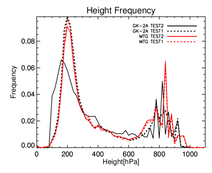
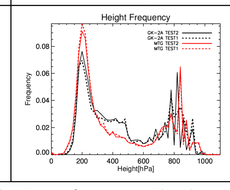
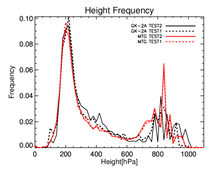
		GK-2A AMV	MTG AMV
Target selection		Optimal (Statistic)	Optimal (Statistics)
Target tracking		CC	CC
Height assignment	Cloudy target	1. CCC 2. EBBT&IR/WV rationing 3. CO2 slicing (+ Inversion layer correction)	CCC (+ Inversion layer correction)
	Clear target	NTC&NTCC	1. NTC&NTCC 2. EBBT
	coverage	100~1000 hPa	0~1050 hPa
Quality control		Quality Indicator	Quality Indicator

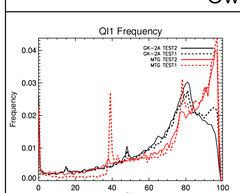
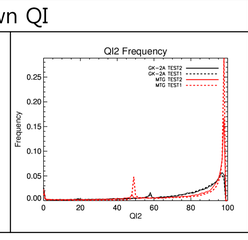
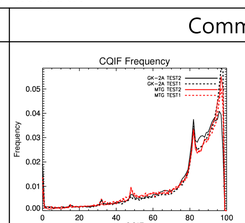
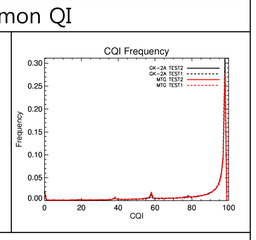
- GK-2A AMV algorithm are base on COMS and MSG/MTG AMV algorithm. The key part of each step is set to be almost the same as those of MTG. In height assignment process, we use EBBT, IR/WV rationing, CO2 slicing methods in addition to CCC method since our CTP product are still being developed.
- In this study, we consider 3 configurations as "GK-2A own configuration", "MTG own configuration", "Prescribed configuration". In prescribed configuration, GK-2A and MTG AMV algorithm use the same input.

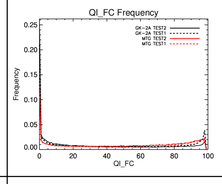
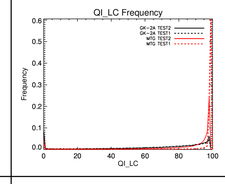
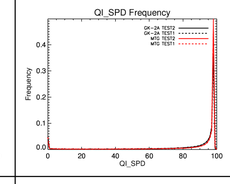
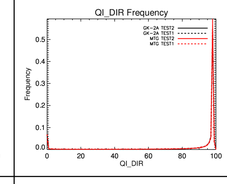
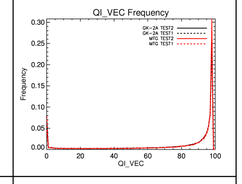
Configuration		GK-2A AMV own	MTG AMV own	Prescribed
Input L1b Images		3 images (proxy: Himawari8/AHI)	3 images (proxy: Meteosat-10/SEVIRI)	3 images (Himawari8/AHI)
Triplets		05 UTC Triplet : 201607210530, 201607210540, 201607210550 UTC 12 UTC Triplet : 201607211200, 201607211210, 201607211220 UTC		
Target box size	IR	16 by 16 pixels	24 by 24 pixels	16 by 16 pixels
Search box size	IR	54 by 54 pixels	80 by 80 pixels	54 by 54 pixels

❖ Speed, Direction, Height, Quality Indicator distribution(12 UTC 21 July 2016)

※ TEST1: Prescribed Configuration(dotted curve)
※ TEST2: Own Configuration(solid curve)

Target Tracking		Height Assignment		
speed	direction	CCC	EBBT&IR/WV	CO2
				
▪ Speed and direction are determined in target tracking step. ▪ GK-2A AMV algorithm based on MTG AMV algorithm, so distributions are very similar.		▪ In CCC method, distributions for prescribed configurations(dotted curves) are similar, but ones for both own configurations(solid curves) are different because CTP used in each algorithm is different. ▪ In EBBT&IR/WV and CO2 slicing methods, distributions are very similar to each other.		

Quality Control			
Own QI		Common QI	
			
▪ For each its own QI, QI distributions are different in shape around QI=50~100.		▪ For the prescribed common QI, QI distributions are very similar in shape to each other because the same QI modules are used.	

	Comparison between GK-2A QI and MTG QI				
	Forecast Consistency	Spatial Consistency	Speed Consistency	Direction Consistency	Vector Consistency
					
GK-2A	$1-\left(\tanh\left(\frac{Diff}{MAX(F1*Ave,\ F1')+F2}\right)\right)^{F3}$ ▪ $Diff=\sqrt{(U_{Fcst}-U)^2+(V_{Fcst}-V)^2}$ ▪ $Ave=\sqrt{(U_{Fcst}+U)^2+(V_{Fcst}+V)^2}/2.0$ ▪ $F1=0.2,\ F1'=0.01,\ F2=1.0,\ F3=3.0$ ▪ $Weight=1.0$	$\left[1-\left(\tanh\left(\frac{Diff_{Bud}}{MAX(L1*Ave_{Bud},\ L1')+L2'}\right)\right)^{L2}\right]_{All\ Bud}$ ▪ $Diff_{Bud}=\sqrt{(U_{Bud}-U)^2+(V_{Bud}-V)^2}$ ▪ $Ave_{Bud}=\sqrt{(U_{Bud}+U)^2+(V_{Bud}+V)^2}/2.0$ ▪ $L1=0.2,\ L1'=0.01,\ L2=1.0,\ L3=3.0$ ▪ $Weight=2.0$	$1-\left(\tanh\left(\frac{\lvert Diff\rvert}{MAX(S1*Vel,\ S1')+S2'}\right)\right)^{S3}$ ▪ $Diff=SPD_{Reverse}-SPD_{Forward}$ ▪ $Vel=(SPD_{Reverse}+SPD_{Forward})/2.0$ ▪ $S1=0.2,\ S1'=0.01,\ S2=1.0,\ S3=2.5$ ▪ $Weight=1.0$	$1-\left(\tanh\left(\frac{\lvert Diff\rvert}{D1*\exp(-Vel/\ D2)+D2'}\right)\right)^{D3}$ ▪ $Diff=DIR_{Reverse}-DIR_{Forward}$ ▪ $Vel=(SPD_{Reverse}+SPD_{Forward})/2.0$ ▪ $D1=20,\ D2=10,\ D2'=10,\ D3=4.0$ ▪ $Weight=1.0$	$1-\left(\tanh\left(\frac{Diff}{MAX(V1*Ave,\ V1')+V2'}\right)\right)^{V3}$ ▪ $Diff=\sqrt{(U_{Rev}-U_{For})^2+(V_{Rev}-V_{For})^2}$ ▪ $Ave=\sqrt{(U_{Rev}-U_{For})^2+(V_{Rev}-V_{For})^2}/2.0$ ▪ $V1=0.2,\ V1'=0.01,\ V2=1.0,\ V3=4.0$ ▪ $Weight=1.0$
MTG	$1-\left(\tanh\left(\frac{Diff}{MAX(F1*Ave,\ F1')+F2}\right)\right)^{F3}$ ▪ $Diff=\sqrt{(U_{Fcst}-U)^2+(V_{Fcst}-V)^2}$ ▪ $Ave=\sqrt{(U_{Fcst}+U)^2+(V_{Fcst}+V)^2}/2.0$ ▪ $F1=0.4,\ F1'=0.01,\ F2=1.0,\ F3=2.0$ ▪ $Weight=1.0$	$\left[1-\left(\tanh\left(\frac{Diff_{Bud}}{MAX(L1*Ave_{Bud},\ L1')+L2'}\right)\right)^{L2}\right]_{Best\ Bud}$ ▪ $Diff_{Bud}=\sqrt{(U_{Bud}-U)^2+(V_{Bud}-V)^2}$ ▪ $Ave_{Bud}=\sqrt{(U_{Bud}+U)^2+(V_{Bud}+V)^2}/2.0$ ▪ $L1=0.2,\ L1'=0.01,\ L2=1.0,\ L3=3.0$ ▪ $Weight=2.0$	Not Used	Not Used	$1-\left(\tanh\left(\frac{Diff}{MAX(V1*Ave,\ V1')+V2'}\right)\right)^{V3}$ ▪ $Diff=\sqrt{(U_{Rev}-U_{For})^2+(V_{Rev}-V_{For})^2}$ ▪ $Ave=\sqrt{(U_{Rev}-U_{For})^2+(V_{Rev}-V_{For})^2}/2.0$ ▪ $V1=0.2,\ V1'=0.01,\ V2=1.0,\ V3=3.0$ ▪ $Weight=1.0$
	▪ There are big differences in Spatial Vector Consistency' shape. It's because all buddies are collected to calculate final Spatial Vector Consistency in GK-2A algorithm but the only 2 best buddies were collected in MTG algorithm. That's why MTG's Spatial Vector Consistency has a sharper peak around QI=100 than GK-2A. ▪ The rest of consistencies are similar except for Forecast Consistency which is slightly different.				

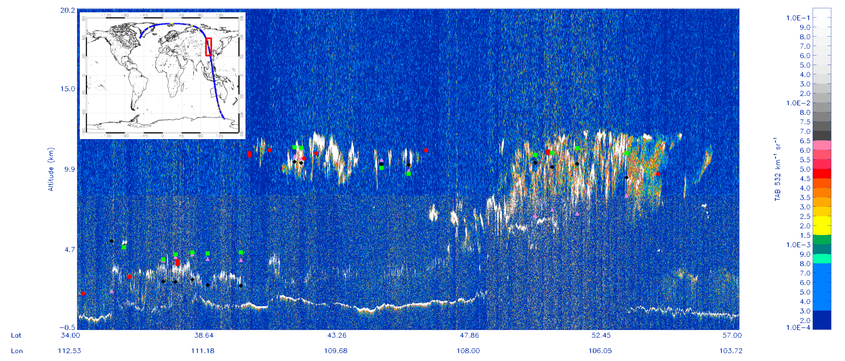
❖ Validation

1. With NWP and Sonde(12 UTC 21 July 2016)

Ch13	GK-2A								MTG			
	Prescribed CCC		Own CCC		Own EBBT&IR/WV		Own CO2		Prescribed CCC		Own CCC	
	ECMWF	Sonde	UM N768	Sonde	UM N768	Sonde	UM N768	Sonde	ECMWF	Sonde	ECMWF	Sonde
	All levels(1000-100 hPa)								All levels(1000-100 hPa)			
Number	33706	862	38190	836	26825	492	28517	584	36659	787	17340	362
NMVD	0.233	0.311	0.405	0.414	0.278	0.304	0.277	0.297	0.314	0.342	0.321	0.337
NRMSVD	0.313	0.368	0.540	0.500	0.361	0.358	0.362	0.352	-0.033	-0.058	-0.043	-0.063
Nbias	-0.045	-0.080	-0.071	-0.051	-0.012	-0.031	-0.032	-0.008	-0.033	-0.058	-0.043	-0.063
NRMSE	0.243	0.278	0.405	0.398	0.267	0.282	0.271	0.266	0.243	0.259	0.240	0.255
Mean_SPD	16.29	19.75	15.29	18.66	15.99	19.29	16.65	19.78	15.7	19.22	15.93	19.19
	High levels(400-100 hPa)								High levels(400-100 hPa)			
Number	21053	786	23505	714	14429	425	17361	548	20976	688	9720	314
NMVD	0.235	0.305	0.395	0.402	0.281	0.289	0.282	0.291	0.231	0.277	0.251	0.272
NRMSVD	0.307	0.359	0.503	0.480	0.343	0.339	0.345	0.345	0.302	0.327	0.306	0.322
Nbias	-0.049	-0.074	-0.103	-0.064	-0.021	-0.037	-0.028	-0.004	-0.036	-0.051	-0.045	-0.053
NRMSE	0.237	0.272	0.379	0.381	0.253	0.263	0.255	0.263	0.233	0.247	0.226	0.246
Mean_SPD	18.39	20.39	17.45	20.21	17.94	20.54	17.67	20.33	18.56	20.34	19.36	20.4
	Middle levels(700 hPa-400 hPa)								Middle levels(700 hPa-400 hPa)			
Number	3979	65	5876	90	4415	51	4301	27	4572	66	2092	33
NMVD	0.252	0.412	0.445	0.448	0.290	0.475	0.291	0.431	0.256	0.427	0.256	0.434
NRMSVD	0.320	0.484	0.605	0.566	0.391	0.586	0.391	0.502	0.325	0.502	0.344	0.505
Nbias	-0.097	-0.186	-0.062	0.092	-0.044	0.152	-0.087	-0.132	-0.089	-0.142	-0.111	-0.170
NRMSE	0.256	0.373	0.472	0.453	0.299	0.525	0.307	0.342	0.261	0.387	0.270	0.345
Mean_SPD	19.03	14.02	16.29	10.64	20	11.47	22.25	12.91	18.41	12.94	18.33	12.85
	Low levels(1000-700 hPa)								Low levels(1000-700 hPa)			
Number	8674	11	8809	32	7981	16	6855	9	11111	33	5528	15
NMVD	0.210	0.382	0.402	1.058	0.256	0.474	0.238	0.600	0.211	0.545	0.246	0.693
NRMSVD	0.258	0.469	0.560	1.249	0.304	0.532	0.287	0.721	0.260	0.668	0.297	0.833
Nbias	0.019	-0.020	0.090	0.149	0.051	-0.291	0.027	0.034	0.021	-0.151	0.016	-0.185
NRMSE	0.195	0.283	0.366	1.091	0.207	0.421	0.188	0.385	0.196	0.404	0.194	0.444
Mean_SPD	9.92	7.98	8.88	6.72	10.23	11.11	10.53	7.43	9.18	8.5	9	7.9

- In prescribed configurations, GK-2A statistics is similar to MTG statistics.
- In its own configurations,
  → GK-2A statistics for CCC is worse than any other case.
  → GK-2A statistics for EBBT&IR/WV rationing and CO2 slicing are also similar to MTG statistics.

2. With CALIPSO CALIOP data



- This figure shows collocation plot of MTG AMV height(CCC: red circle), GK-2A AMV height(CCC: green square, EBBT&IRWV: violet triangle, CO2 slicing: black diamond) and CALIPSO 532 nm back scatter for 05 UTC 21 July 2016.
- Heights of AMVs are consistent with CALIPSO.

❖ Comparison with COMS, Himawari-8 AMVs

	GK-2A		COMS		Himawari-8	
	UM N768	Sonde	UM N768	Sonde	UM N768	Sonde
Number	592415	59384	392130	25835	570451	52153
MVD	4.21	4.92	4.34	5.62	4.12	4.78
RMSVD	5.18	6.08	5.17	6.82	5.01	6.01
Bias	-0.03	-0.47	-0.45	-0.76	-0.10	-0.27
RMSE	3.78	4.54	4.20	5.35	3.70	4.40
Mean_SPD	13.32	16.26	13.56	15.88	13.52	16.05

- This table show validation score of GK-2A, COMS and Himawari-8 AMVs on July 2016.
- GK-2A statistics is better than COMS.
- GK-2A statistics is similar to Himawari-8.

❖ Summary and Further Study

- GK-2A AMV algorithm is based on COMS and MSG/MTG AMV algorithm.
- For Ch13 cloudy AMVs, our speed, direction, height, and common QI distribution is very similar to each other, and validation results are also similar.
- GK-2A AMV performs slightly better than COMS AMV algorithm.
- In further study, we'll compare our GK-2A AMVs with MTG AMVs for other channels such as CH03, 07, 08, 09, 10. Not only clear AMVs but also cloudy AMVs will be a very important issue.