Third Atmospheric Motion Vector Intercomparison Study

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Project Overview

The main goal of this study is to:

- ✓ Update the previous AMV intercomparison studies
  (Genkova 2008/2010, Santek et al. 2014)

- ✓ Assess how the cloudy AMVs from each unique wind producer compare,
  using the new JMA's Himawari-8/AHI satellite data:
  - Verifying the advantages of calculation of AMVs with the new generation of geostationary satellites.
  - Determining the best options for calculation of AMVs.

- ✓ Compute a Common QI for all centres,
  to verify if there is a better agreement of the winds

Participants

BRZ:	Brazilian Weather Forecast and Climatic Studies Centre (CPTEC/INPE)
EUM:	EUMETSAT
JMA:	Japan Meteorological Agency
KMA:	Korea Meteorological Administration
NOA:	National Oceanic and Atmospheric Administration (NOAA)
NWC:	Satellite Application Facility on Support to Nowcasting and Very Short Range Forecasting (NWC SAF)

Participants

Note 1: CMA / China Meteorological Administration

participated in the previous intercomparison, but not in this one

Note 2: EUMETSAT sent a new AMV dataset in April

correcting errors in the calculation of the "Common Quality Index"

➔ General conclusion considering in general

the "Quality Index without forecast (QINF)",

and "Common Quality index (CQI)" used in some specific cases only

Note 3: KMA sent a new AMV dataset in April

correcting errors in the calculation of the "Height assignment"

➔ With a small check, KMA results improve a bit with the new dataset

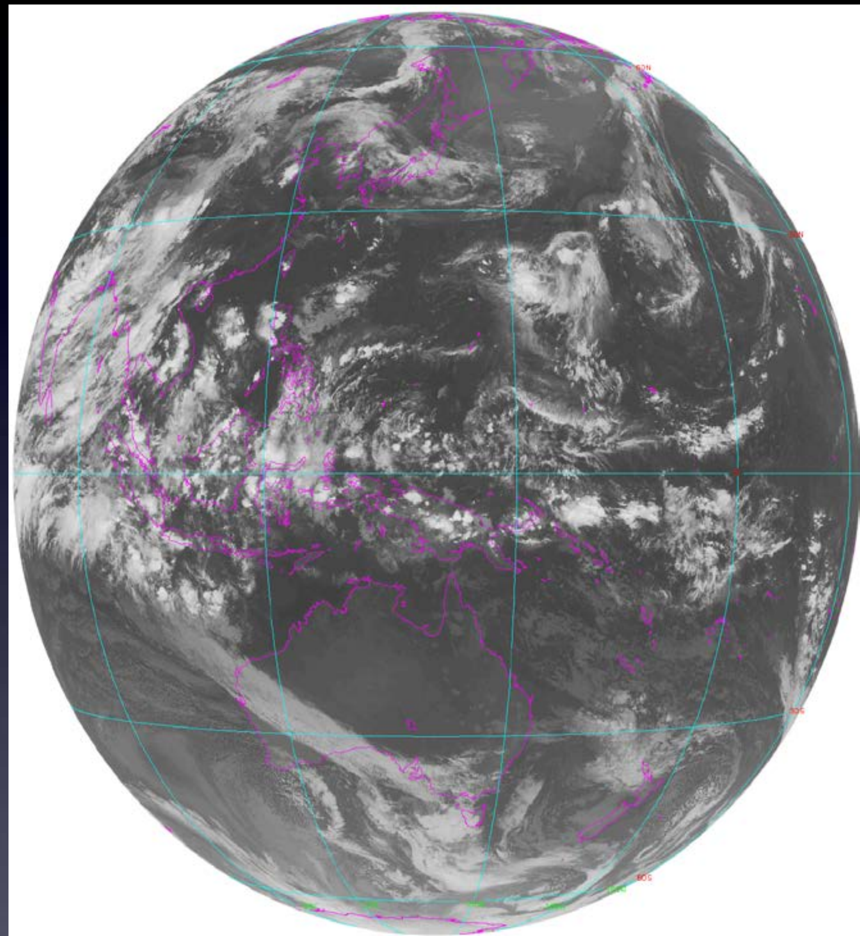
Input dataset

Three different experiments considered, using:

Two triplets of Himawari-8, full disk images (21/July/2016 at 0530-0550Z, 1200-1220Z)

ECMWF ERA-INTERIM NWP Analysis (for the given day – 37 levels – every 6 h.)

Corresponding “Cloud products” (derived by NOAA/NESDIS)



Himawari-8 10.4 µm for 21 July 2016, at 1200UTC

Output dataset

Each centre provided AMV data as Text files, easy to be analyzed, with these output parameters:

1	ID	Identification number
2	LAT[DEG]	Latitude
3	LON[DEG]	Longitude
4	TS[PIX]	Target box size
5	SS[PIX]	Search box size
6	SPD[MPS]	AMV speed
7	DIR[DEG]	AMV direction
8	PRES[hPa]	AMV pressure
9	L	Low-level correction
10	NWSSPD[MPS]	Background guess wind speed
11	NWSDIR[DEG]	Background guess wind direction
12	ALB[%]	Albedo
13	CORR[%]	Correlation
14	T	Brightness temperature
15	PRESSERR[hPa]	AMV pressure error
16	H	Height assignment method
17	QIN[%]	QI without forecast
18	QIF[%]	QI with forecast
19	QIC[%]	Common QI

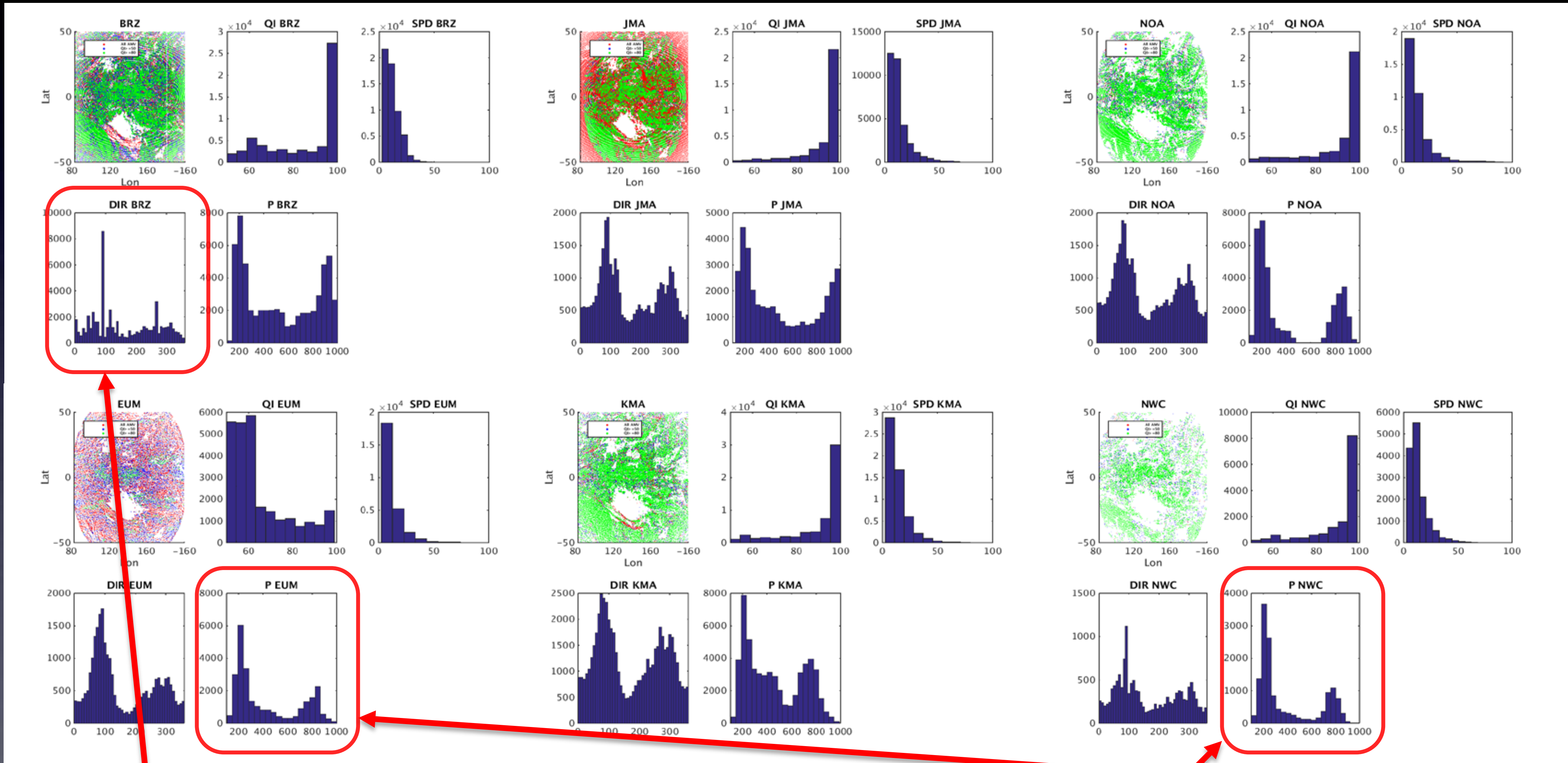
Experiment 1

- AMV producers extract IR10.4 μm cloudy AMVs,
  with the triplet 1200-1220UTC,
  using their best options for AMV calculation,
  considering a prescribed target size, target location, search scene size.

- All AMV extraction processes can be compared this way, comparing equivalent AMV datasets:
  - ✓ Tracer selection
  - ✓ Tracer tracking
  - ✓ Height assignment
  - ✓ Quality control

Experiment 1

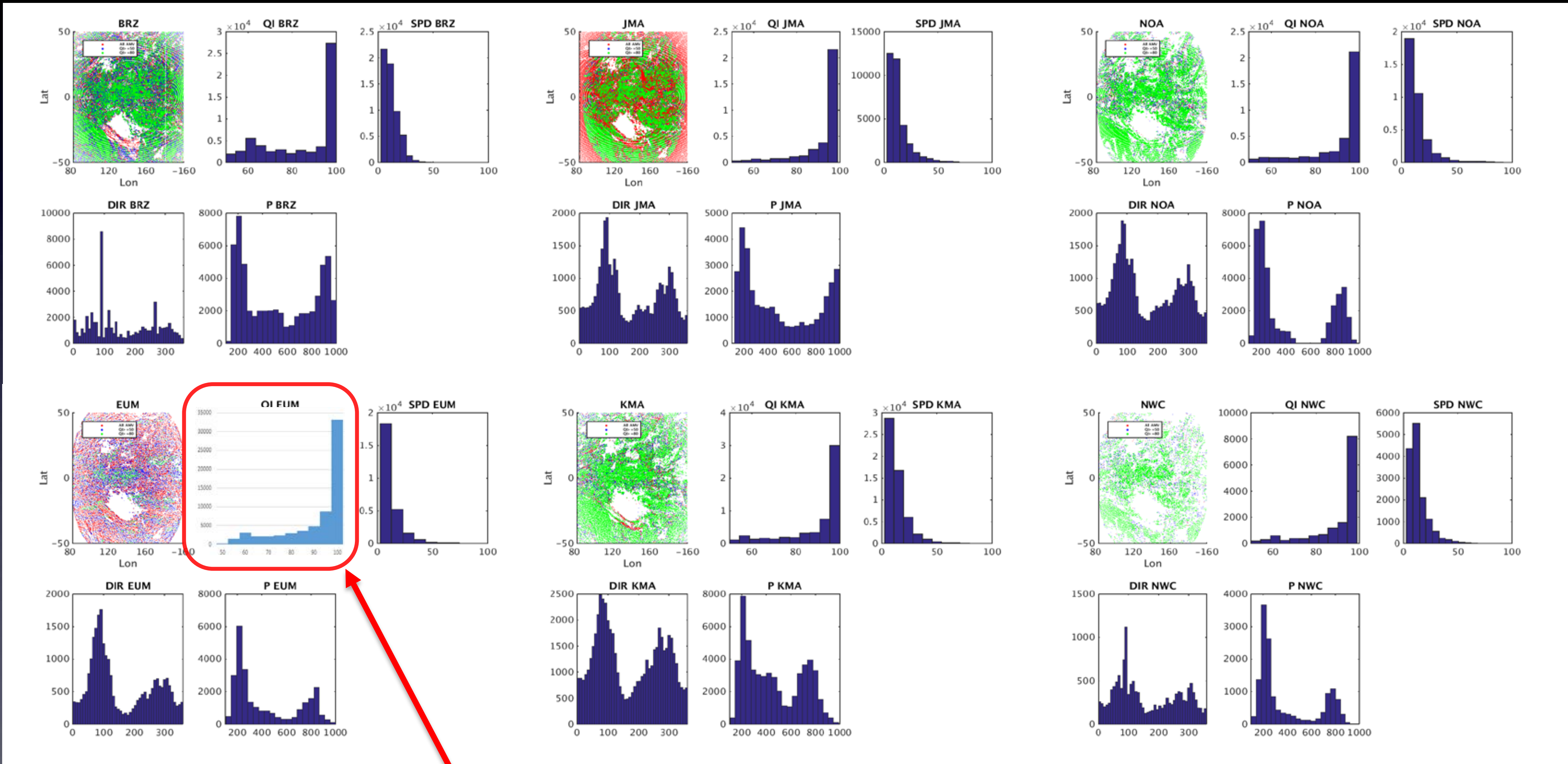
Parameter distribution (for Common QI >=50%)



Most distributions look similar, except for height assignment (with EUM & NWC the same).
Direction distribution for BRZ suspicious, with several large peaks.

Experiment 1

Parameter distribution (for Common QI >=50%)



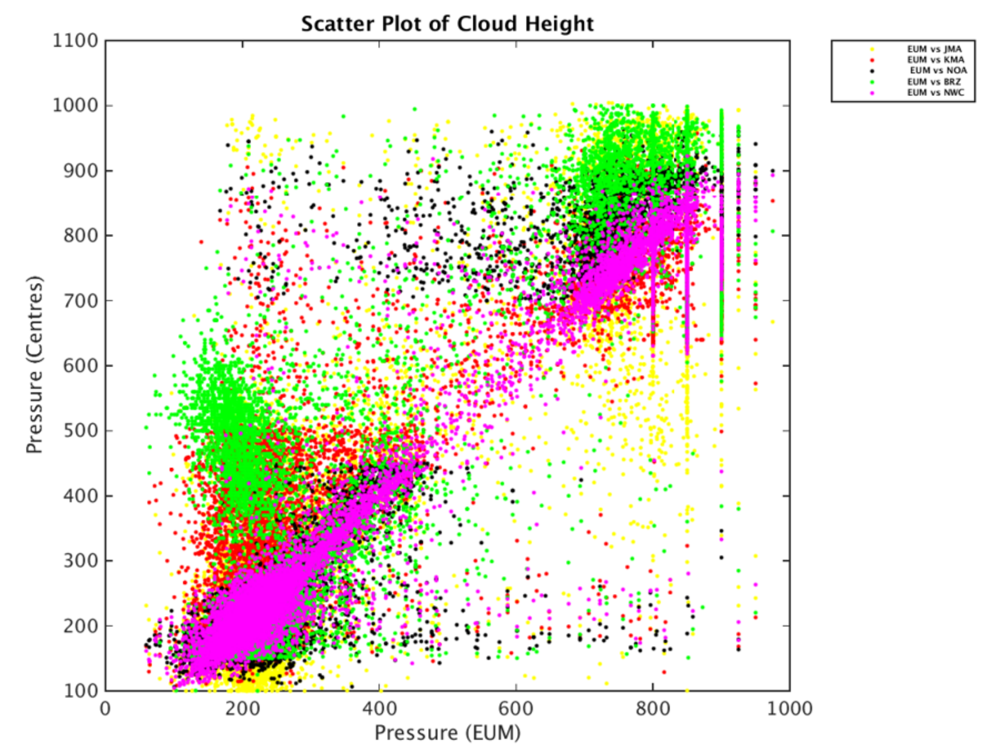
EUM after correction shows a distribution for the CQI similar to the rest of centres

Experiment 1

The bulk distribution of AMV heights is highly variable between the different centres, for collocated AMVs

- Each centre using a different Height assignment method, and

  only EUM/NWC/NOAA using “Cloud products” for this height assignment !
- Most similarities for EUM/NWC, both using “CCC method”



Scatter plot of AMV pressure for each centre vs EUM pressure (considering a QINF threshold of 50%).

Experiment 1

Considering the verification statistics against radiosondes:

Table 7-7: Experiment 1: All AMVs (QI no forecast >= 50) comparison to rawinsondes within 150 km. N= number of matches; P bias = pressure bias; P RMS = pressure RMS; SpdBias = speed bias; SpdRMS= speed RMS; DirBias = wind direction bias; VecRMS = vector RMS. The extreme for each category is highlighted: Yellow = high value; cyan = low value.

Site	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
BRZ	834	0.57	14.51	-1.23	10.19	-11.72	12.60
EUM	1144	-1.57	15.85	-1.41	11.02	4.57	24.19
JMA	807	-0.36	13.53	-0.93	4.08	-0.26	5.66
KMA	917	-1.16	15.94	0.10	8.74	-3.93	11.20
NOA	511	-1.03	14.16	-0.71	5.26	0.93	7.38
NWC	132	-0.75	15.21	-0.88	5.05	-4.68	6.85

Table 7-8: Experiment 1: All AMVs (QI no forecast >= 80) comparison to rawinsondes

Site	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
BRZ	532	0.34	14.13	0.61	5.81	-13.87	8.61
EUM	772	-0.90	15.89	-2.00	7.36	6.45	8.91
JMA	433	0.75	12.89	-1.16	4.18	0.74	5.90
KMA	711	-0.66	15.22	0.95	7.89	-3.20	10.02
NOA	427	-1.49	13.96	-0.89	5.42	0.45	7.52
NWC	63	0.39	15.64	-0.10	4.05	-3.90	6.47

Cyan: Min.values
Yellow: Max.values

- ✓ Best results for JMA – then for NWC/NOAA
- ✓ EUM bad results for QINF>=50% with prescribed config.; much better for QINF >=80%
- ✓ Important differences in the number of AMVs with prescribed config.! (although in all cases larger than previously with MSG satellite)

Experiment 1

Considering the verification statistics against NWP analysis winds:

Experiment 1. All AMVs with QINF>=80%, compared to background NWP analysis
N = total number of AMVs; BFN = Best Fit number of AMVs;
VO = Vector difference mean; RMSE = Root mean square error;
VAF = Vector difference after Best Fit; RAF = RMSE after Best Fit;

EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	41304	8805	6.20	8.69	5.54	8.31
EUM	50629	15779	4.99	7.13	4.04	6.42
JMA	34160	12656	2.53	3.13	2.26	2.92
KMA	46597	13384	5.45	7.50	4.60	6.95
NOA	30377	10965	3.98	5.24	3.10	4.48
NWC	7286	2646	4.26	5.30	3.28	4.38

Experiment 1, Collocated AMVs with QINF >=80% compared to background NWP analysis

EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	5556	1341	5.87	8.41	5.23	8.09
EUM	5556	1806	3.93	4.90	3.18	4.28
JMA	5556	2006	2.47	2.95	2.22	2.75
KMA	5556	1737	4.30	5.53	3.54	4.96
NOA	5556	1957	3.43	4.29	2.75	3.72
NWC	5556	1953	3.97	4.72	3.12	3.98

Experiment 1. Collocated AMVs with CQI >=80% compared to background NWP analysis

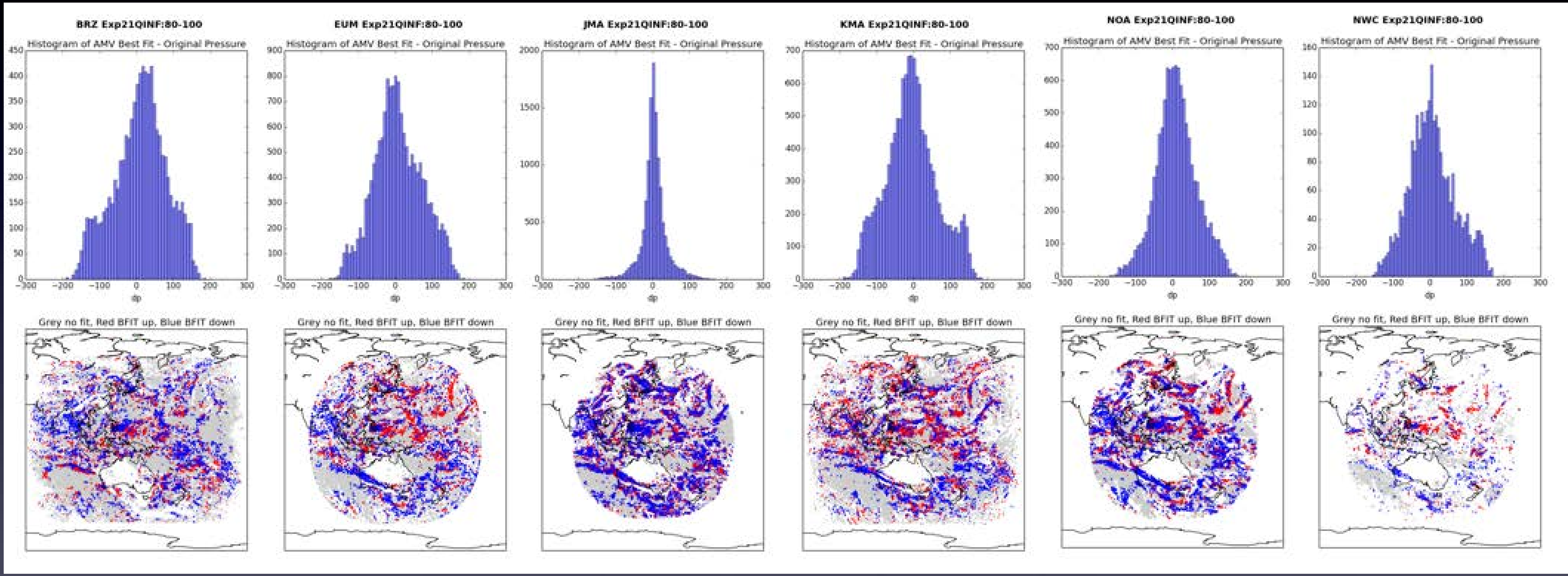
EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	2672	569	4.73	6.32	4.23	6.03
EUM	2672	674	3.76	4.61	3.11	4.03
JMA	2672	759	2.48	2.89	2.25	2.71
KMA	2672	668	4.01	4.97	3.36	4.45
NOA	2672	740	3.38	4.21	2.87	3.81
NWC	2672	752	3.75	4.40	3.05	3.79

Cyan: Min.values
Yellow: Max.values

- ✓ High QI threshold (QINF >=80%) good for the filtering of data from all centres
- ✓ Differences between centres even smaller for collocated AMVs – only BRZ over
- ✓ Differences between centres even smaller using Common QI for the filtering !

Experiment 1

Considering the AMV level against the AMV best fit level:



✓ JMA AMVs near best fit – much more than all others!

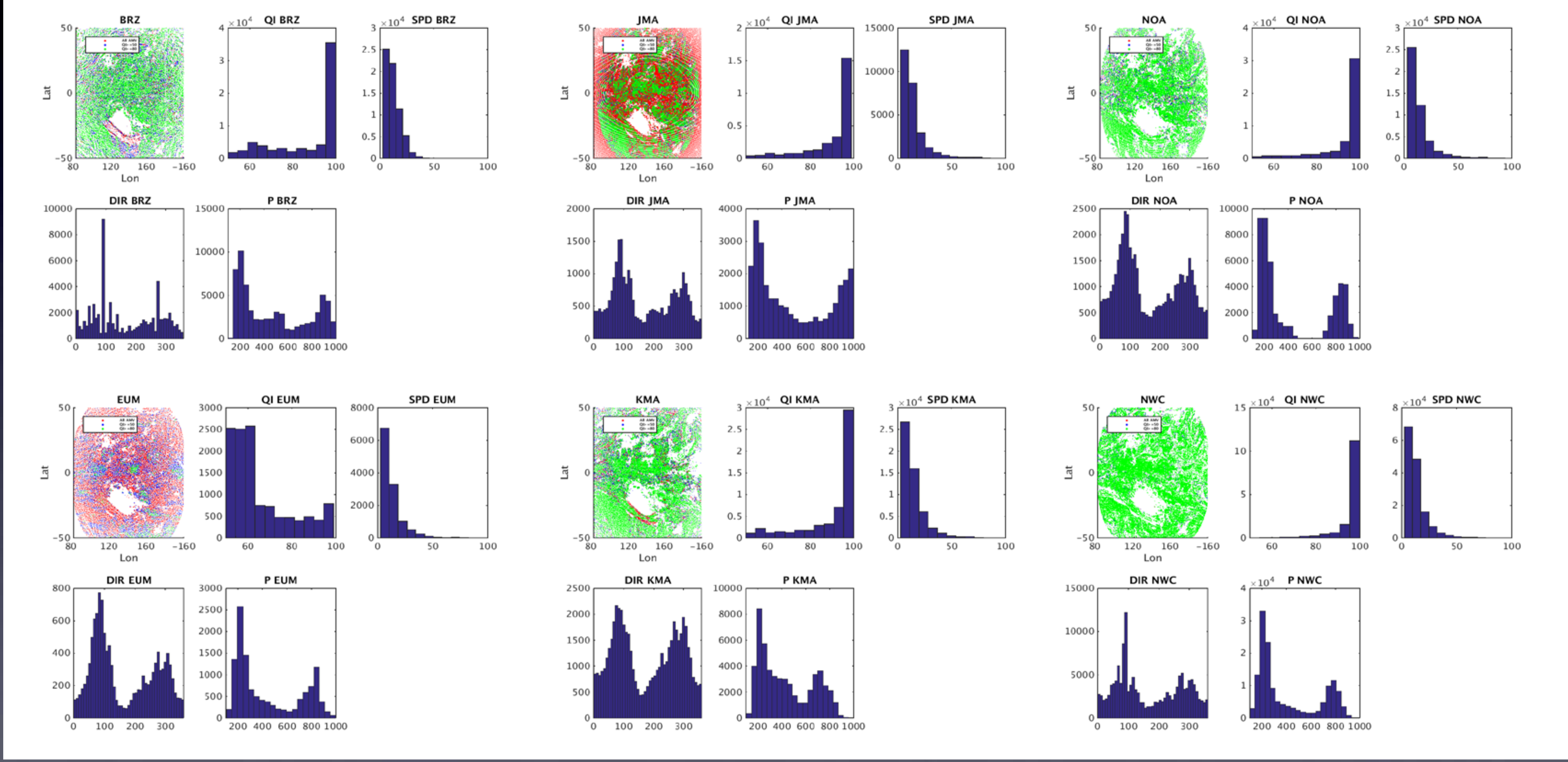
Experiment 2

- AMV producers extract IR10.4 μ cloudy AMVs, with the triplet 1200-1220UTC, using their best options for AMV calculation, considering their own configuration for target size, target location, search scene size.

- Differences in all AMV extraction processes (with respect to the previous prescribed configuration) can be compared this way.

Experiment 2

Parameter distribution (for Common QI >=50%)

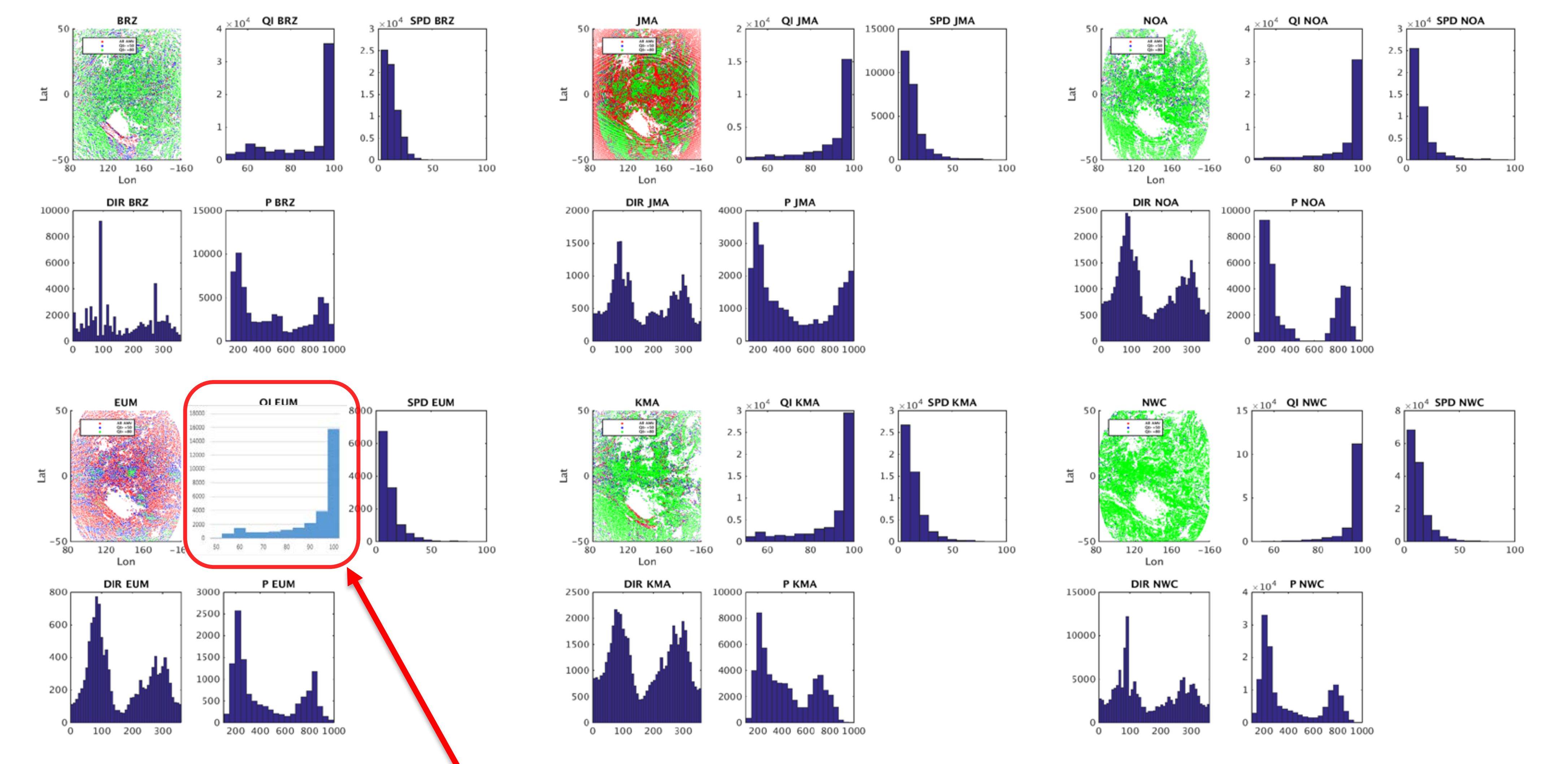


Very similar distributions to Experiment 1:

➔ Differences in "height assignment" drives the majority of differences observed.

Experiment 2

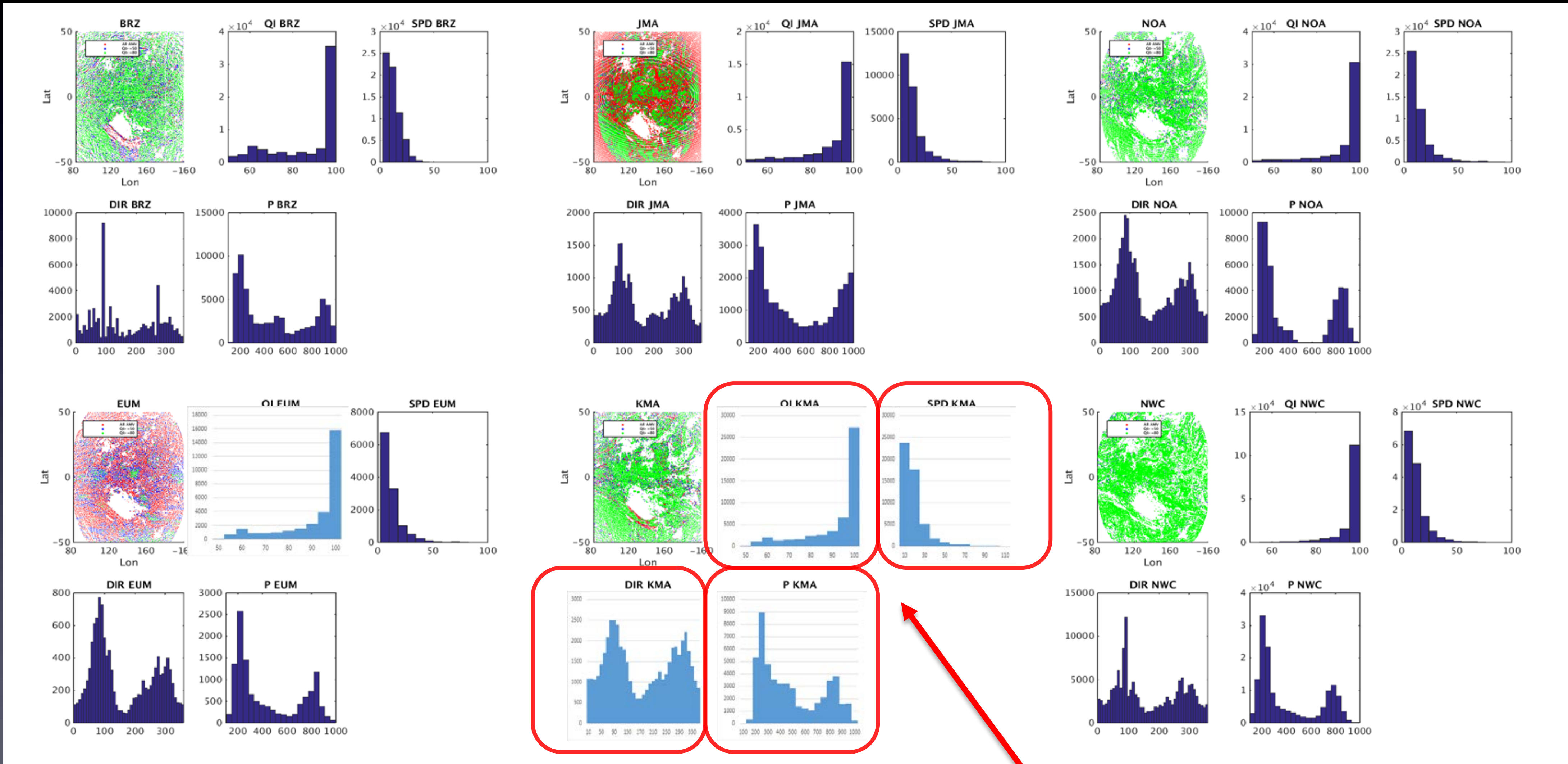
Parameter distribution (for Common QI >=50%)



Again, EUM after correction shows a distribution for the CQI similar to the rest of centres

Experiment 2

Parameter distribution (for Common QI >=50%)



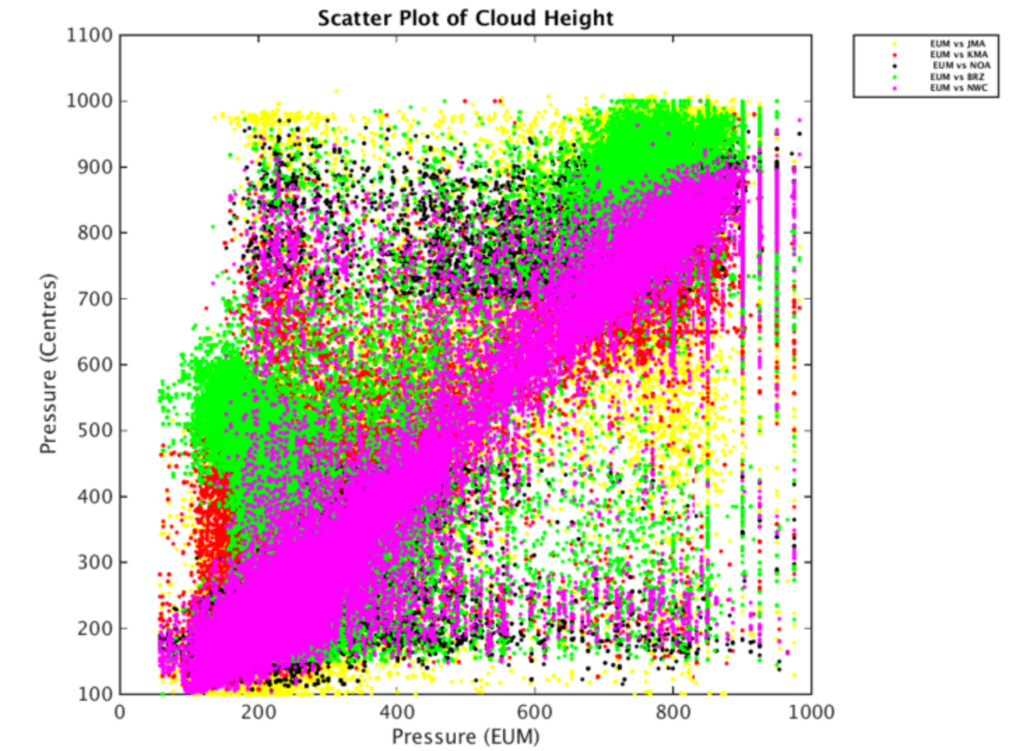
Difference for KMA histograms with the new AMV dataset not very significant
Considering height assignment: mean pressure difference = +12 hPa

Experiment 2

The bulk distribution of AMV heights
similar to the one seen before (methods being the same!)

- Main change related to different number of AMVs for each centre

  ➔ NWC 15 times more AMVs // EUM less than half



Scatter plot of AMV pressure for each centre vs EUM pressure (considering a QINF threshold of 50%).

Experiment 2

Considering the verification statistics against rawinsondes:

Table 8-7: Experiment 2: All AMVs (QI no forecast >= 50) comparison to rawinsondes within 150 km. N= number of matches; P bias = pressure bias; P RMS = pressure RMS; SpdBias = speed bias; SpdRMS= speed RMS; DirBias = wind direction bias; VecRMS = vector RMS. The extreme for each category is highlighted: Yellow = high value; cyan = low value.

Site	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
BRZ	971	1.40	14.43	-2.58	11.60	-11.31	13.47
EUM	460	-0.58	15.71	-2.47	7.05	8.87	8.71
JMA	701	-0.53	14.38	-1.08	4.43	-0.28	6.20
KMA	886	-1.23	14.91	-1.25	7.84	-5.43	10.53
NOA	691	-1.58	13.93	-0.90	5.44	1.89	7.62
NWC	1954	-1.17	16.16	-1.96	5.85	-0.75	7.82

Table 8-8: Experiment 2: All AMVs (QI no forecast >= 80) comparison to rawinsondes within 150 km

Site	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
BRZ	676	0.72	13.34	-0.09	6.82	-12.06	9.36
EUM	334	-0.83	15.09	-2.37	6.28	7.80	7.88
JMA	355	0.21	13.94	-1.71	4.64	2.38	6.42
KMA	689	-1.02	14.51	-0.78	7.50	-5.36	9.76
NOA	599	-1.69	13.98	-0.88	5.25	0.39	7.48
NWC	1450	-1.04	16.06	-2.03	6.01	-0.88	8.07

Cyan: Min.values
Yellow: Max.values

- ✓ Best results again for JMA
- ✓ EUM results much better with their own config.

Experiment 2

Considering the verification statistics against NWP analysis winds:

Experiment 2. All AMVs with QINF >=80% compared to background NWP analysis.
N = total number of AMVs; BFN = Best Fit number of AMVs;
VO = Vector difference mean; RMSE = root mean square error;
VAF = Vector difference after Best Fit; RAF = RMSE after Best Fit.

EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	48916	10675	6.86	9.66	6.12	9.27
EUM	21083	6761	4.67	6.41	3.68	5.56
JMA	26492	10009	2.51	3.11	2.24	2.90
KMA	44762	13505	5.54	7.54	4.66	6.96
NOA	40472	14180	4.00	5.17	3.12	4.38
NWC	104722	35948	4.24	5.21	3.30	4.37

Experiment 2. Collocated AMVs with QINF >=80% compared to background NWP analysis.

EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	70114	17242	5.90	8.24	5.22	7.87
EUM	70089	23823	3.94	4.90	3.11	4.17
JMA	70200	25587	2.50	2.99	2.24	2.78
KMA	70265	22163	4.42	5.63	3.66	5.06
NOA	70213	24435	3.50	4.28	2.81	3.66
NWC	70620	24503	3.97	4.72	3.12	3.99

Experiment 2. Collocated AMVs with CQI >=80% compared to background NWP analysis.

EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	14329	2944	5.34	7.00	4.66	6.51
EUM	14145	3618	3.74	4.74	3.12	4.20
JMA	14339	4226	2.49	2.93	2.27	2.75
KMA	14394	3795	4.20	5.24	3.54	4.73
NOA	14369	3885	3.52	4.34	2.93	3.80
NWC	14585	4075	3.83	4.65	3.14	4.02

Cyan: Min.values
Yellow: Max.values

- ✓ Results similar to the ones obtained with Experiment 1.
- ✓ Again, differences between centres smaller for collocated AMVs - only BRZ over
- ✓ Again, differences between centres even smaller using Common QI for the filtering !

Experiment 2

Considering the verification statistics against NWP analysis winds:

Experiment 2. All AMVs with QINF >=80% compared to background NWP analysis.
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KMA	44762	13505	5.54	7.54	4.66	6.96
NOA	40472	14180	4.00	5.17	3.12	4.38
NWC	104722	35948	4.24	5.21	3.30	4.37

New KMA dataset of April

32674 10640 4.73 6.65 3.88 6.05

Experiment 2. Collocated AMVs with QINF >=80% compared to background NWP analysis.

EXP	N	BFN	VO	RMSE	VAF	RAF
BRZ	70114	17242	5.90	8.24	5.22	7.87
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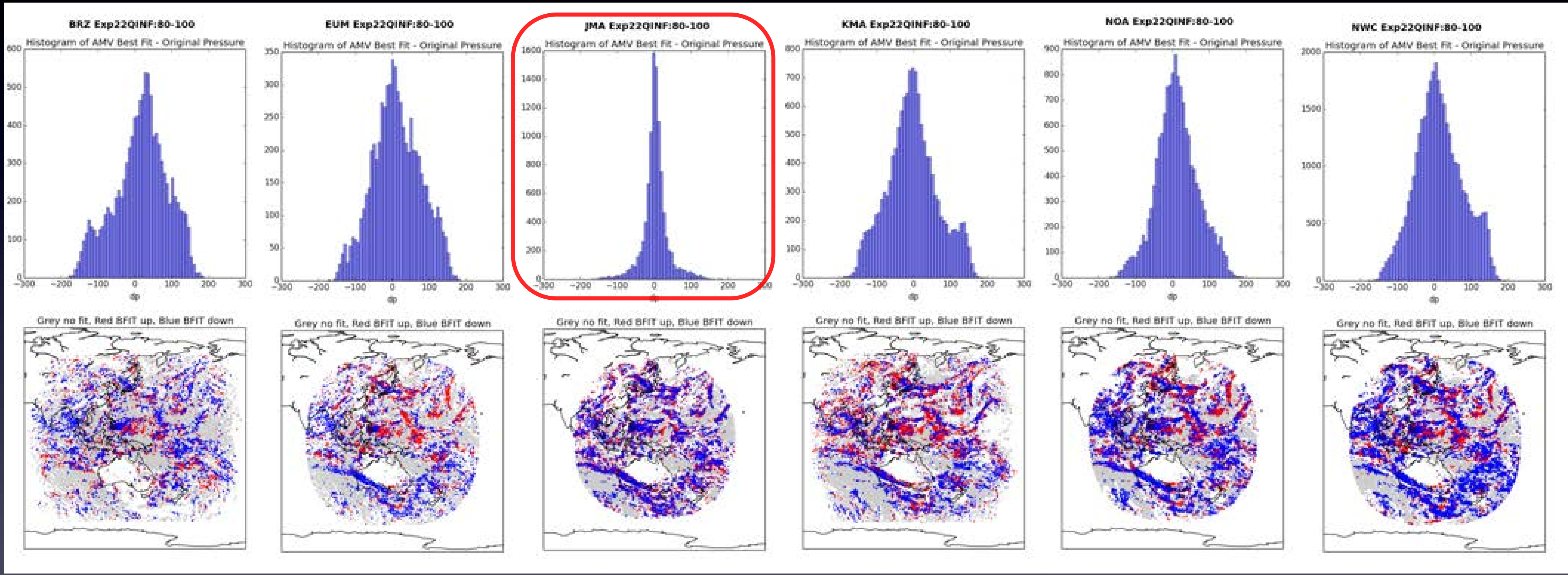
KMA	14394	3795	4.20	5.24	3.54	4.73
NOA	14369	3885	3.52	4.34	2.93	3.80
NWC	14585	4075	3.83	4.65	3.14	4.02

- ✓ With the new KMA dataset of April, numbers improve a bit, keeping more or less the same position

Experiment 2

Considering the AMV level against the AMV best fit level:



✓ Results similar to those in Experiment 1,

again with JMA AMVs near best fit – much more than all others!

✓ Best fit displacements up and down,

tend to be in similar locations for all centres for collocated AMVs

Similarities in AMV datasets

One of the goals of the study is to determine
the similarity in the AMVs from the different centres.

➔ A "paired t-test" is so used with all combinations
of producers and parameters to determine
if differences of speed/direction/pressure/quality values
are statistically significant for collocated pairs of AMVs.

➔ Statistics computed with the "Matlab t-test" function and
the difference in a parameter for each pair of AMV producers
(with the hypothesis that the data have a distribution
with mean zero)

Similarities in AMV datasets

Tables show for Exp.1 (prescribed conf.) / Exp.2 (own conf.) the pairs of combinations with "differences not statistically significant".

➔ 15 combs. per parameter; 60 combs. in total.

➔ QINF>=80% and CQI>=80% used to reduce differences.

PRESCRIBED CONFIG.	Speed	Direction	Pressure	Quality	ALL
QINF>=80%	4	4	0	1	9
CQI>=80%	5	10	1	1	17

OWN CONFIG.	Speed	Direction	Pressure	Quality	ALL
QINF>=80%	0	3	1	0	4
CQI>=80%	2	2	0	0	4

More similarities using the same prescribed configuration !

More similarities using the Common QI !

➔ Common QI useful for AMV processing !

Similarities in AMV datasets

Largest similarity f.ex. in the Direction,
with the Prescribed configuration and CQI>=80%,
<u>in which there are no statistical differences</u>
<u>in any of the centres except Brazil</u>

Experiment 1 CQI 80 <u>direction</u> t-test for each paired combination of winds producers.
Green indicates the parameter is not statistically different at the 95% level; red is statistically different.

	EUM	KMA	NOA	NWC	JMA	BRZ
EUM						
KMA						
NOA						
NWC						
JMA						
BRZ						

Similarities reduce progressively for
<u>Direction, Speed, Quality, Pressure</u> parameters.

Experiment 3

- AMV producers extract IR10.4 μ cloudy AMVs, with the triplet 0530-0550UTC, using their best options for AMV calculation, considering their own configuration for target size, target location, search scene size.

- This dataset is used for validation against NASA's CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation), which provides an independent measurement of cloud top heights.

Experiment 3

- CALIPSO is a line-of-site measurement, so there are few collocations with AMVs (10's matches only).

- Therefore, this evaluation is qualitative as illustrated in the following figures.

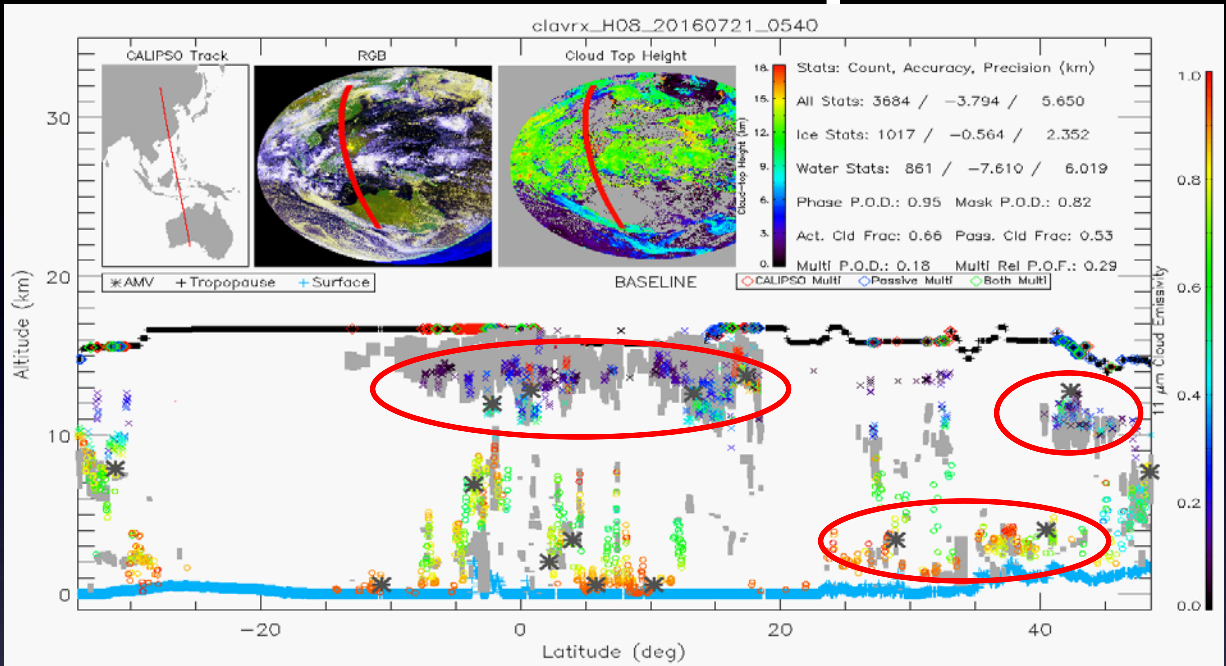
- AMVs generally:

  Near the cloud base for high-level, thin cirrus clouds.

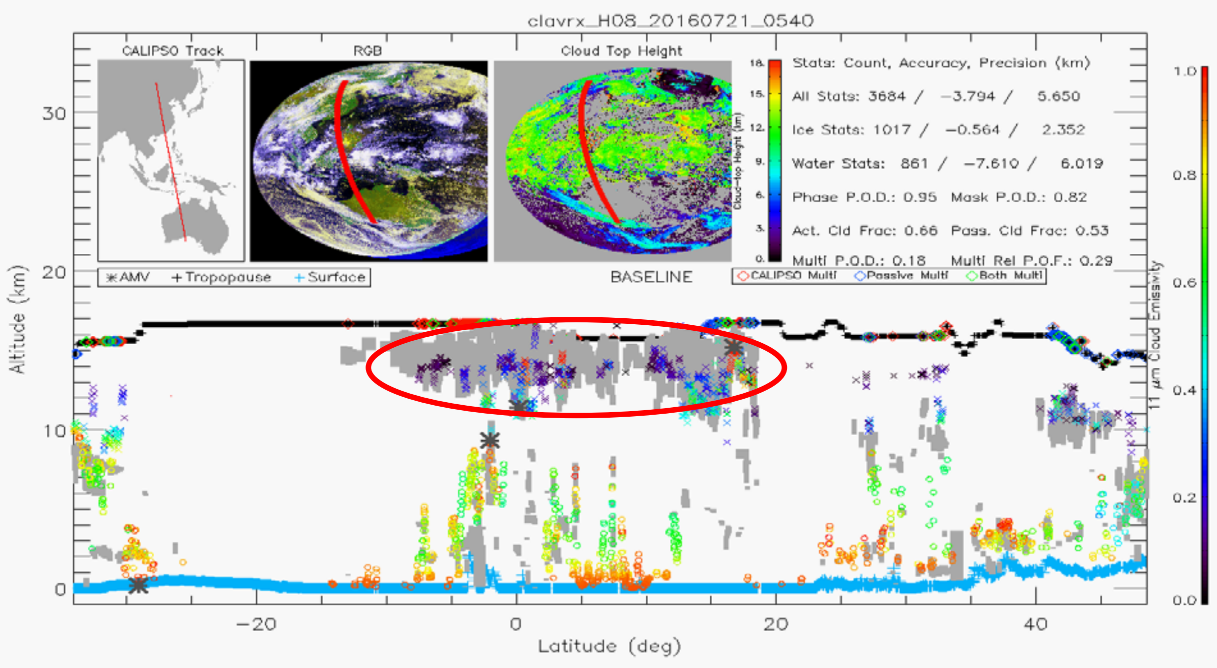
  Near the cloud top for low- and mid-level clouds.

- AMV heights for the different centres in good agreement in this specific example, in apparent disagreement with previous pressure scatter plots.

Experiment 3

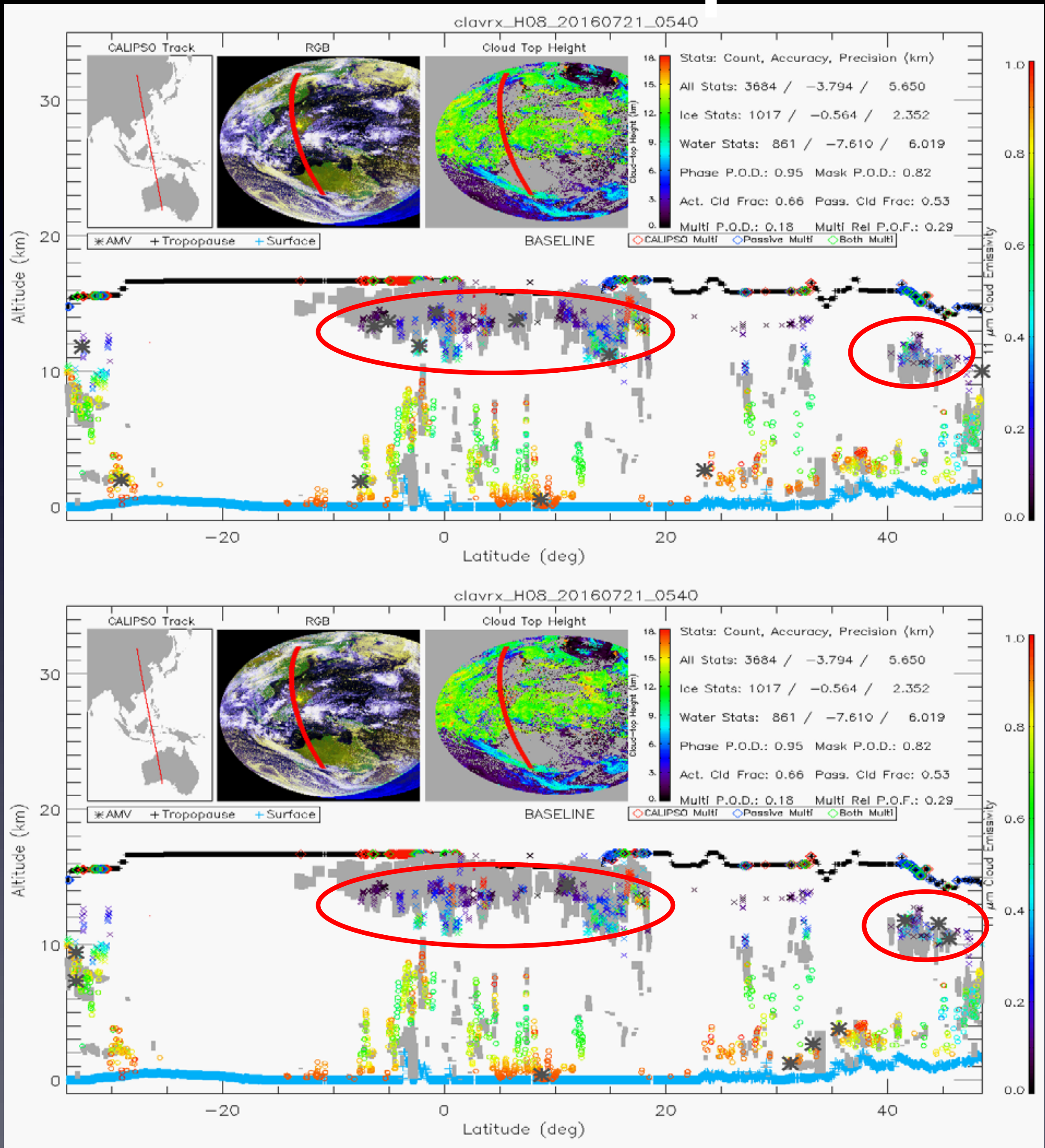


- BRZ



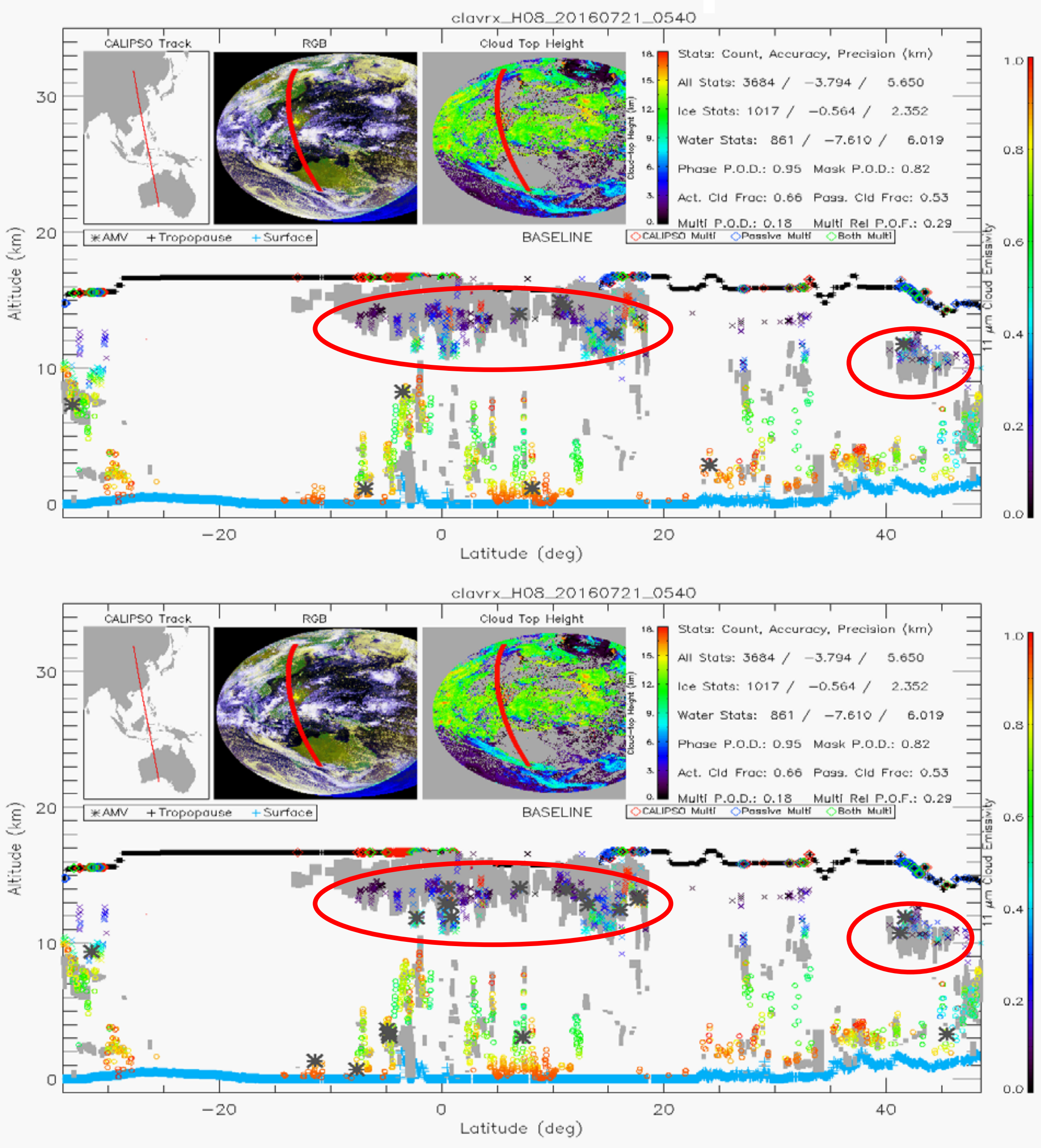
- EUM

Experiment 3



- JMA
- KMA

Experiment 3



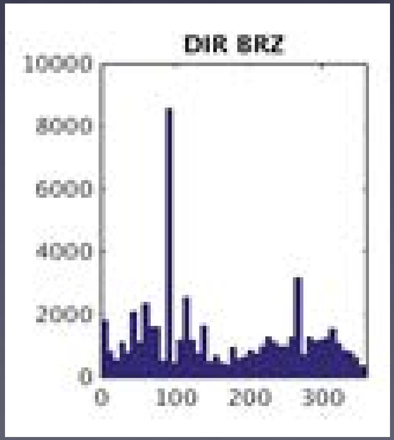
- NOA

- NWC

Conclusions
Brazil

Performance of BRZ algorithm improved with respect to the previous AMV intercomparison, with better agreement with other centres (especially, for a high QI threshold and collocated AMV data).

There still exists room for improvement:
- Large differences in height assignment
- Need to verify direction histograms, with some directions much more frequent than others.



Conclusions KMA

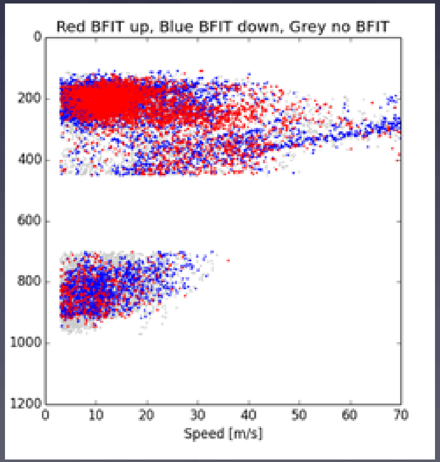
- AMV histograms do not show significant differences with respect to other centres.
- A small check showed statistics with the new April AMV dataset improved a bit.
- KMA algorithm is reasonably good, but it needs to define its final stable version.

Conclusions
NOAA

- NOAA agreement compared to other centers improved over previous study.

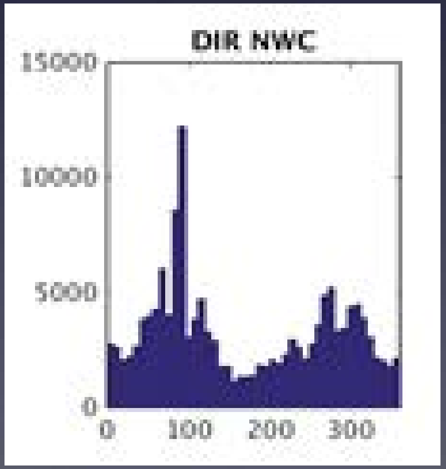
- NOAA algorithm has now 2nd best statistics (along with NWCSAF).

- Elements for analysis:
  vertical distribution of AMVs,
  with no AMVs present
  between 450-700 hPa
  (in contrast to other algorithms).



Conclusions
NWCSAF

- NWCSAF algorithm has 2nd best statistics (with NOAA).
- Algorithm basically similar to the one in previous study (Due to this stability, performance similar to found then).
- Elements for analysis:
  some directions with Himawari
  more frequent than others
  in the vicinity of 90º



Conclusions
EUMETSAT

- Behavior of EUM algorithm much better when QI thresholds high (80%) and specific configuration used (with performance then similar to NOAA/NWC centres).

- Similarity in the height assignment of EUM/NWC, both using “CCC method”.

- After the correction of the EUM “Common QI”, distribution of CQI values very similar for all centres.

Conclusions
JMA

- JMA algorithm has the best overall performance considering all validation and checking elements.

- This is the most important change in all AMV algorithms since latest Intercomparison !!

- Most likely due to updated cloud height assignment: "optimal estimation method using observed radiance and NWP vertical profile"

- However, to be studied if the small difference between AMVs and background NWP has a good impact in later applications, like NWP assimilation.

Conclusions
In general

- Differences between Experiment 1 and 2
basically related to the number of AMVs.

- Differences between centres
much more related to the Height assignment
than to the use of a prescribed or a specific configuration.

- The use of the Common QI has a real skill
in filtering collocated AMVs
for an improved statistical agreement.

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    - our colleagues from CIMSS/UW
      for the big work done (a 230+ page Report!)
      with a very tight schedule (work started in December).

    - our colleagues in the AMV production centres
      for the effort to provide the AMV datasets
      for the AMV Intercomparison.

- Report for the AMV Intercomparison available in the following weeks at www.nwcsaf.org webpage.
  ➔ A notification will be done through the IWWG email list.
  ➔ A preliminary version can be requested to me if desired.