A New Atmospheric Motion Vector Intercomparison Study

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Outline

- Project Overview
- Participants
- Data
- Description and Highlights of Four Experiments
- Summary of Findings

Project Overview

The goal of this study is to:

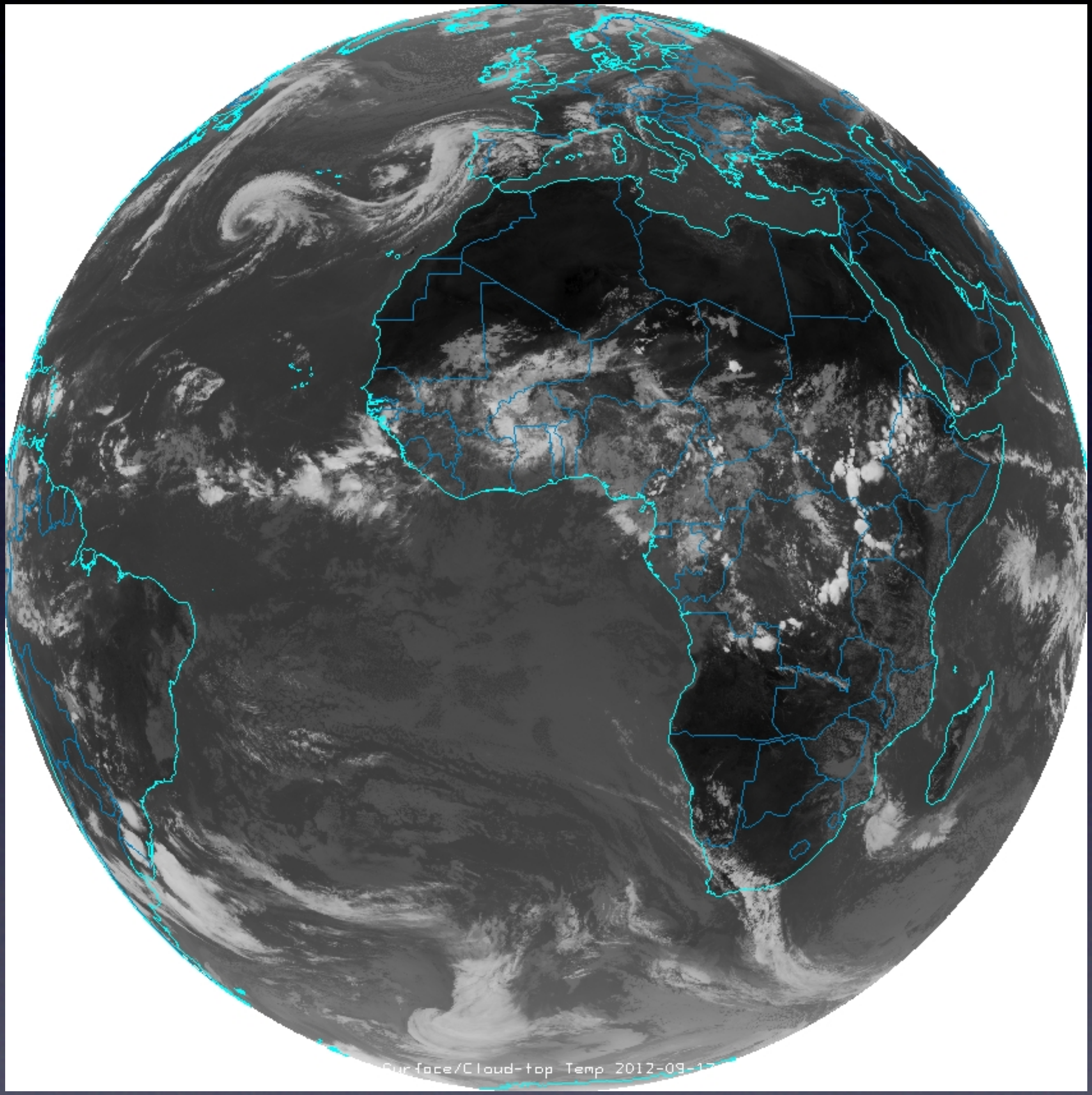
- Include the NWC SAF/HRW algorithm in the intercomparison studies
  - Quantify its performance, relative to the other AMV algorithms
- Update the results of the previous AMV intercomparison studies
  - Operational AMV algorithms may have changed since the last study
- Perform follow up studies as identified in the previous intercomparison work
  - Consider specific characteristics of the input data and AMV output

Participants

EUM: EUMETSAT
CMA: China Meteorological Administration
JMA: Japan Meteorological Agency
NOA: National Oceanic and Atmospheric Administration
KMA: Korea Meteorological Administration
NWC: Satellite Application Facility on Support to Nowcasting & Very Short Range Forecasting
BRZ: Brazilian Meteorological Center

Dataset: Input

- Triplet of infrared (10.8μ) Meteosat-9, full–disk images from 17 September 2012 at 1200, 1215, 1230 UTC
- 6.3μ, 7.2μ, 12.0μ and 13.4μ images for cloud height (Exp. 4)
- MPEF products "Scene Type and Quality" and "Cloud Analysis" (Exp. 4)
- ECMWF forecast grids: 12- and 18-hour forecast from 0000 UTC on 17 September 2012



Meteosat-9 10.8 μm from 17 September 2012 at 1215 UTC

Dataset: Output

- Text files containing these parameters: latitude, longitude, speed direction, pressure, QI without forecast, QI with forecast, horizontal and vertical pixel displacement

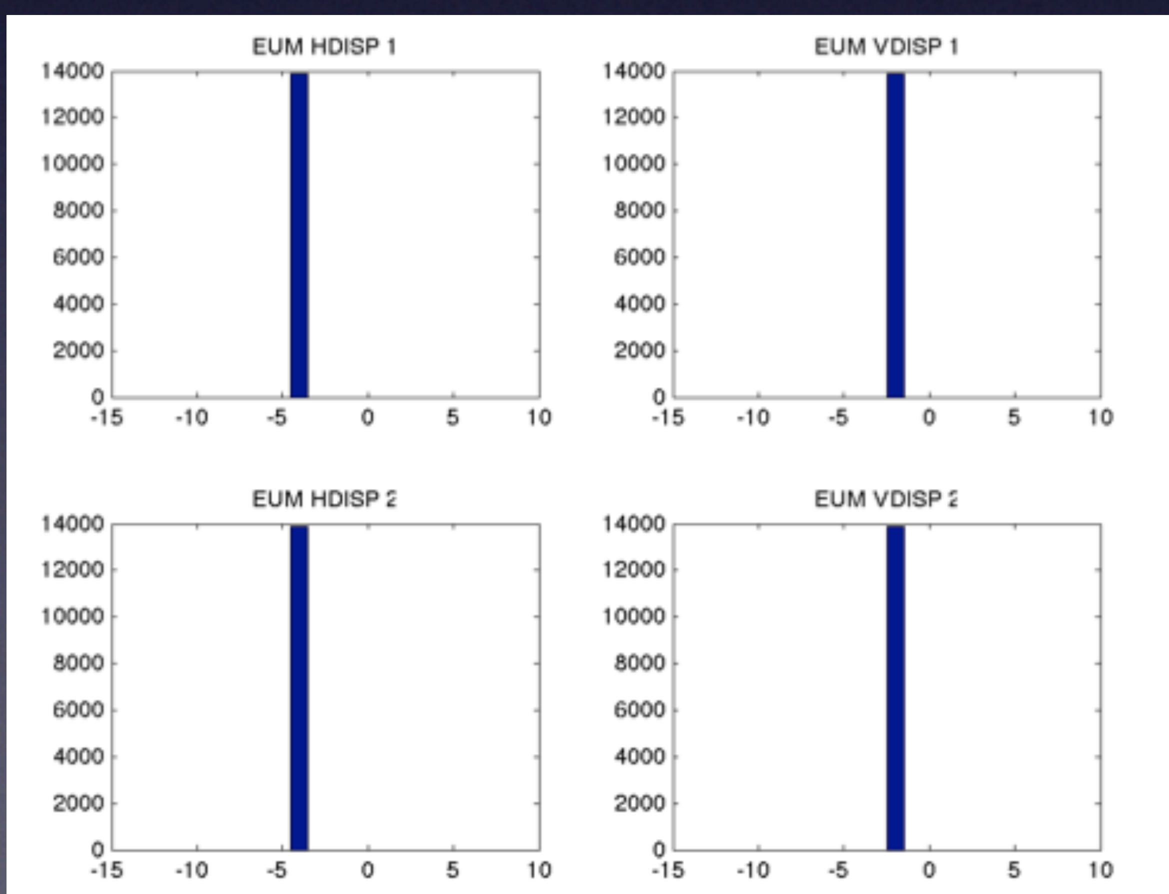
```
TargetID;Longitude;Latitude;TSize;SSize;Speed;Direction;Height;LLC;ModelSpeed;ModelDir;Albedo;MaxCorr;TM;HeightError;HAM;Q
I;QIF;Xpix1;Ypix1;Xpix2;Ypix2

1;-61.7798;14.2929;24;80;15.057;269.572;756.848;0;18.6;261.729;0;0.97202;0;101;3;52;46;4.23947;0.157385;4.51003;-0.12556
2;-62.1547;13.7968;24;80;15.37;284.809;900.139;0;16.973;263.673;0;0.958795;0;4;3;42;39;3.66613;-0.548083;4.49318;-0.552573
3;-61.94;10.922;24;80;11.8108;331.788;955.895;0;14.735;273.87;0;0.990091;0;37;3;24;29;0.839608;-1.30327;1.40387;-1.63183
4;-61.7226;9.10205;24;80;14.478;300.475;780.899;0;18.461;262.526;0;0.996648;0;101;3;43;50;4.71817;-0.2964;1.33923;-1.56868
5;-61.872;8.45049;24;80;14.2243;299.946;837.744;0;17.031;264.303;0;0.99665;0;101;3;44;50;4.66088;-0.229503;1.3282;-1.5492
6;-63.1783;6.5165;24;80;11.1117;263.069;671.976;0;16.213;272.395;0;0.976754;0;101;3;59;61;3.03942;0.392167;3.54058;-0.03336
```

Experiment 1

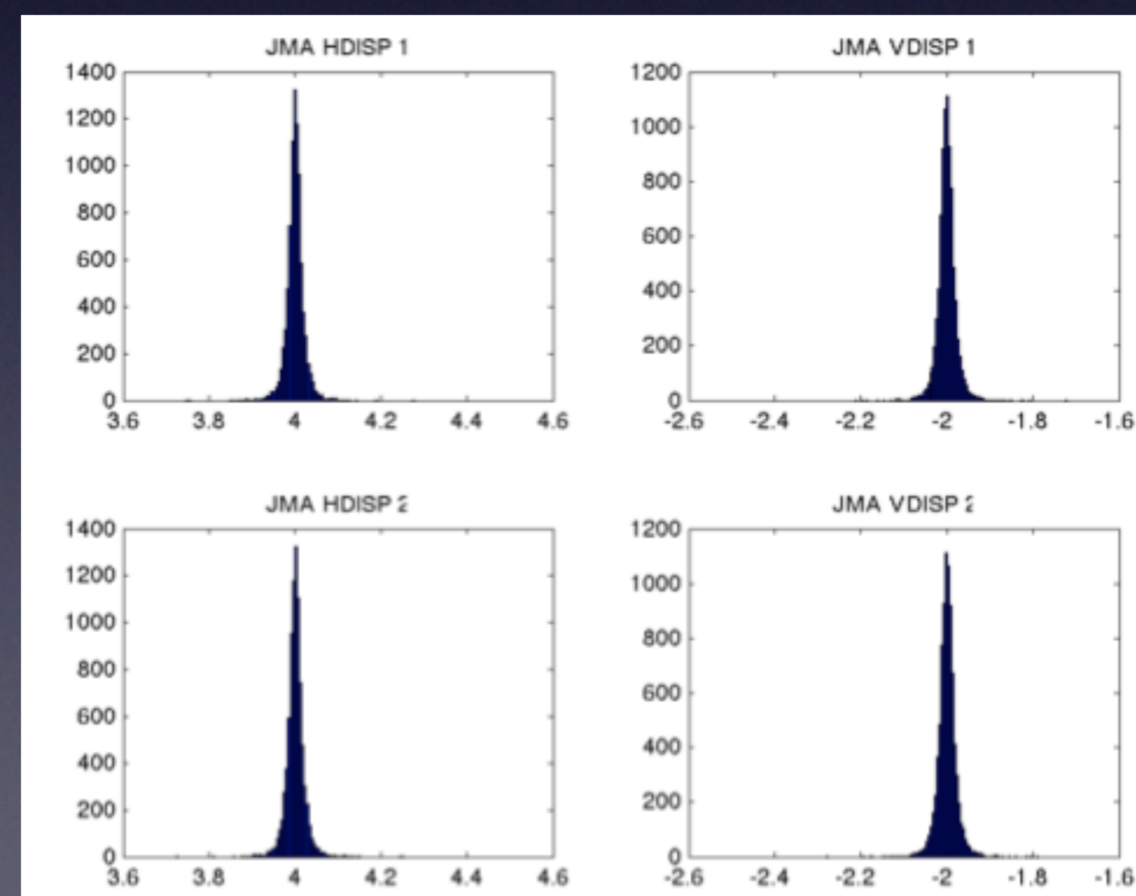
- AMV producers extract IR10.8µ channel AMVs considering a triplet of images with a known displacement:
  - Test the tracking step in all AMV algorithms
  - Test geolocation and displacement calculation
- Fixed displacement of four elements and two lines were applied to a single image
  - Create an artificial triplet

Experiment 1
Displacement

- There were two positive results:
  - All AMV algorithms detected this shift correctly
    - Generally with no more than 0.1 pixel error



EUM



JMA

Experiment 1
Displacement Differences

- There were two positive results:
  - There were 10876 colocated vectors
    - Distance threshold of 35 km
    - The differences of horizontal and vertical displacements between EUM and each of the other centres were not statistically significant

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

Horizontal Displacement

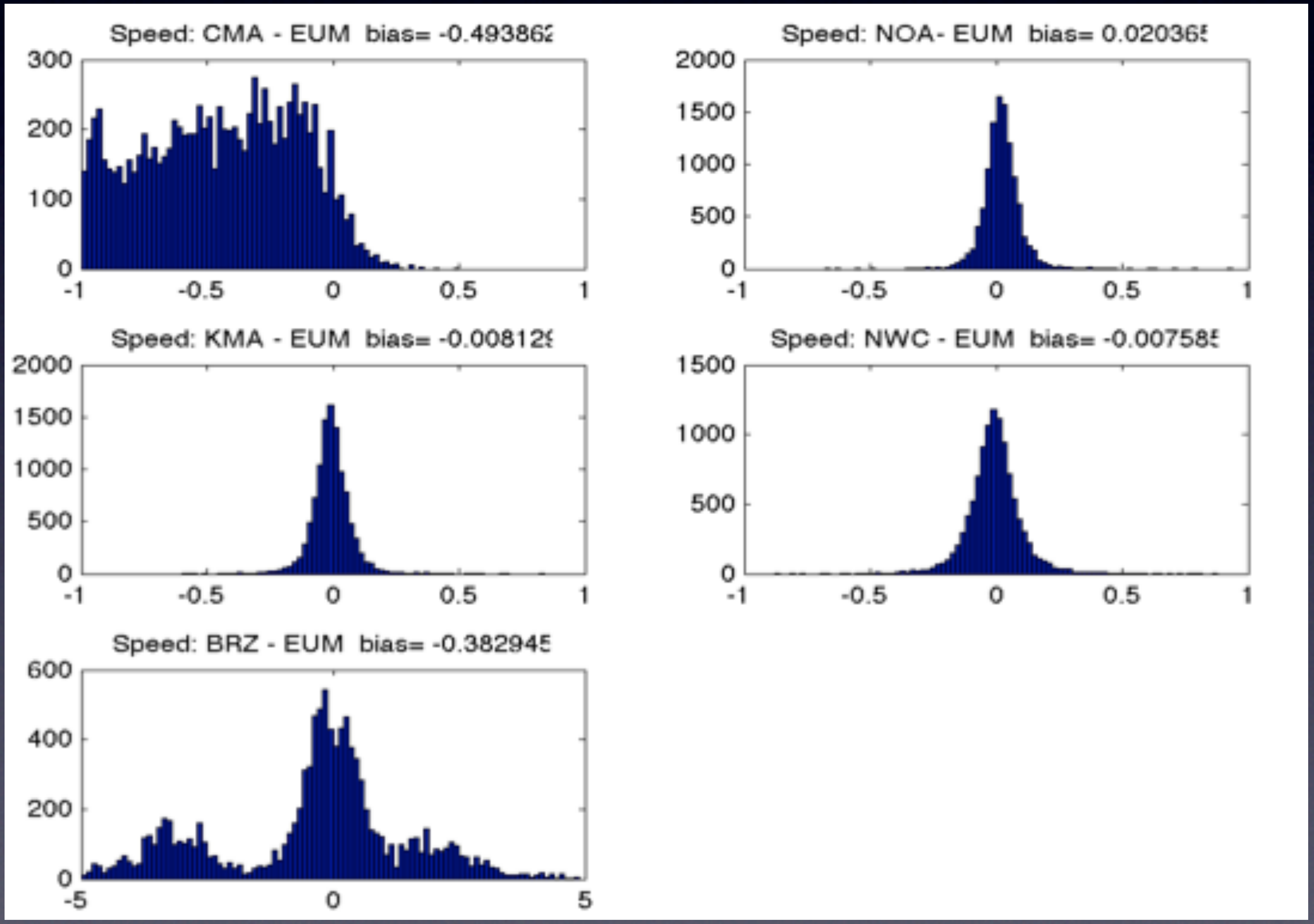
	EUM	KMA	CMA	NOA	NWC	JMA	BRZ
EUM							
KMA							
CMA							
NOA							
NWC							
JMA							
BRZ							

Vertical Displacement

Experiment 1
Speed Differences

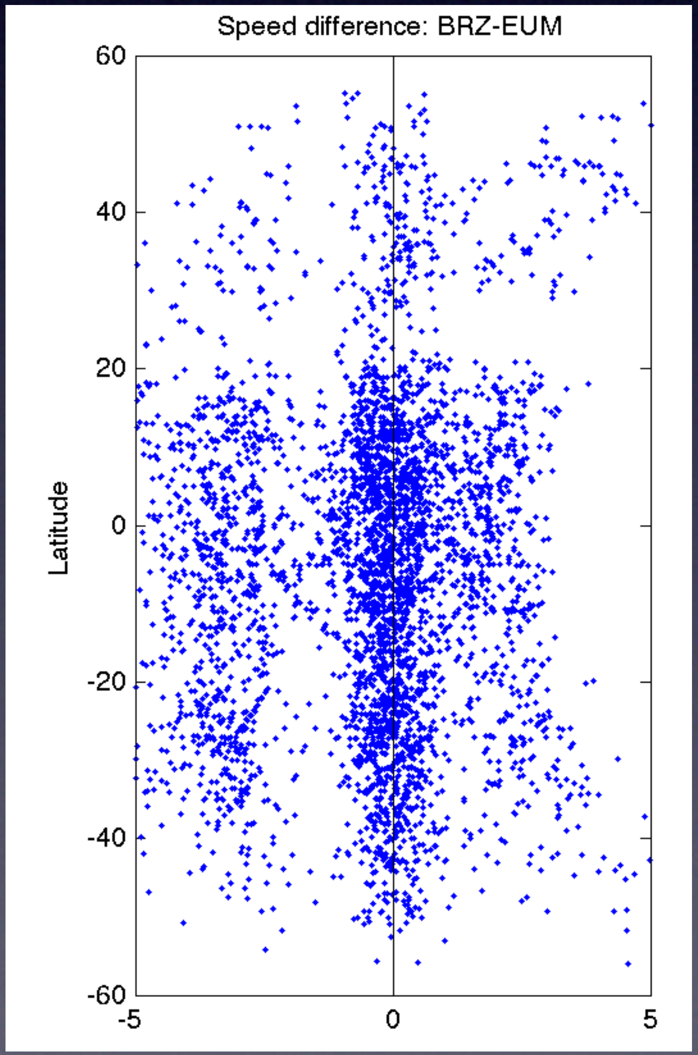
0.1 displacement in subpixel tracking results in speed difference:

- 0.3 ms^{-1} at the satellite subpoint
- 1.3 ms^{-1} at 50°N 50°W

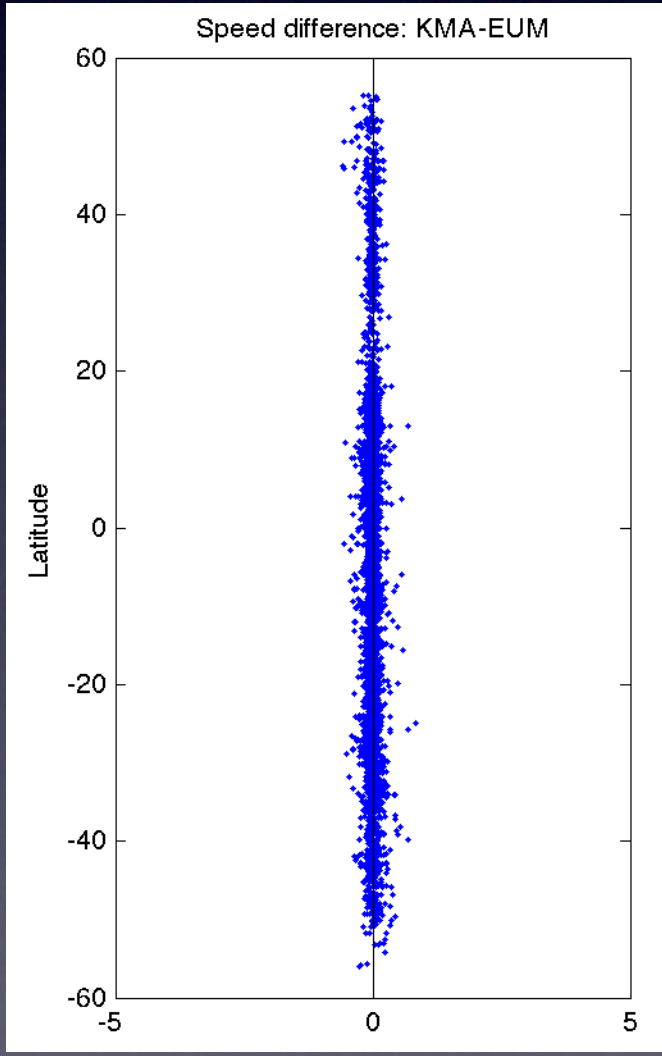


Experiment 1
Speed Differences

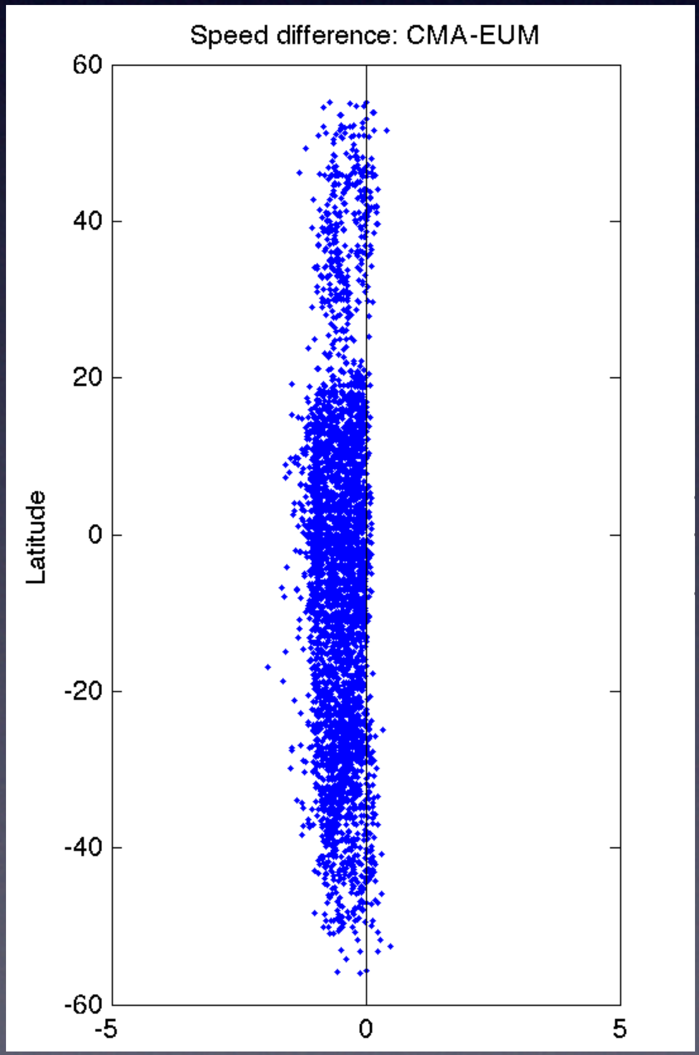
- BRZ and CMA appear to have an AMV speed dependence on distance from satellite subpoint



BRZ



KMA



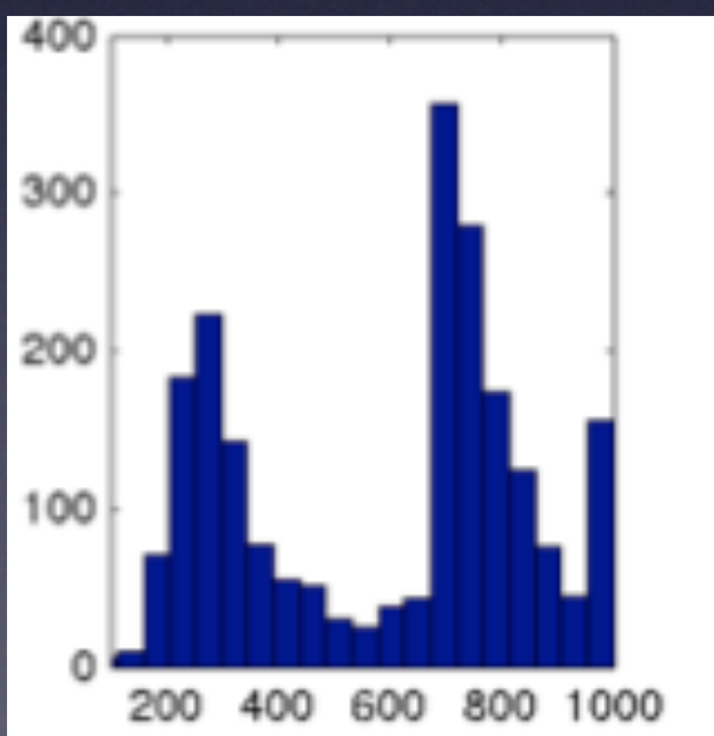
CMA

Experiment 2

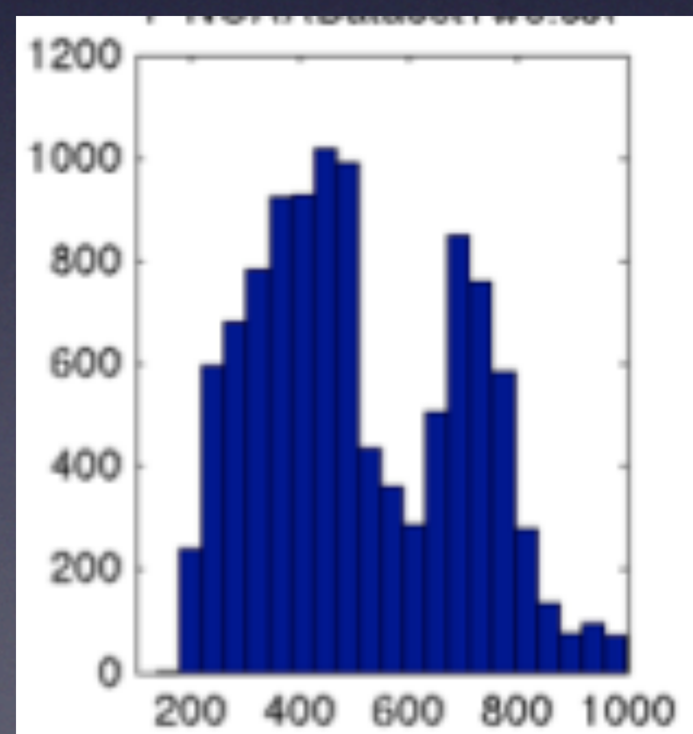
- AMV producers extract IR10.8 μ channel AMVs with their standard AMV algorithm configuration:
  - Use only the MSG/SEVIRI IR10.8 μ images and the ECMWF model data for height assignment.
  - Test the target selection, tracking, and quality control steps

Experiment 2
Bulk Statistics

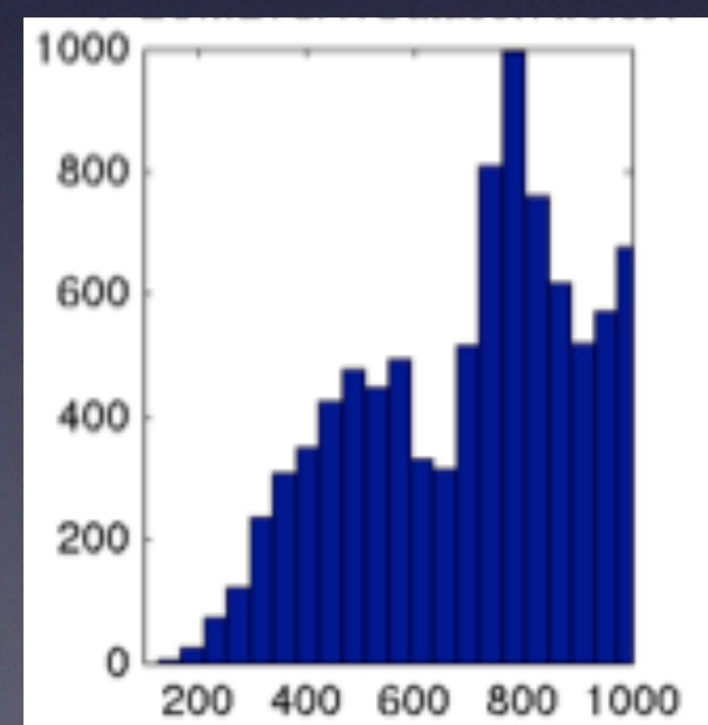
- The bulk distribution of AMV height is highly variable among the different centres
    - All are required to use only the IR T_B
    - Variability due to how representative T_B is determined



BRZ



NOA

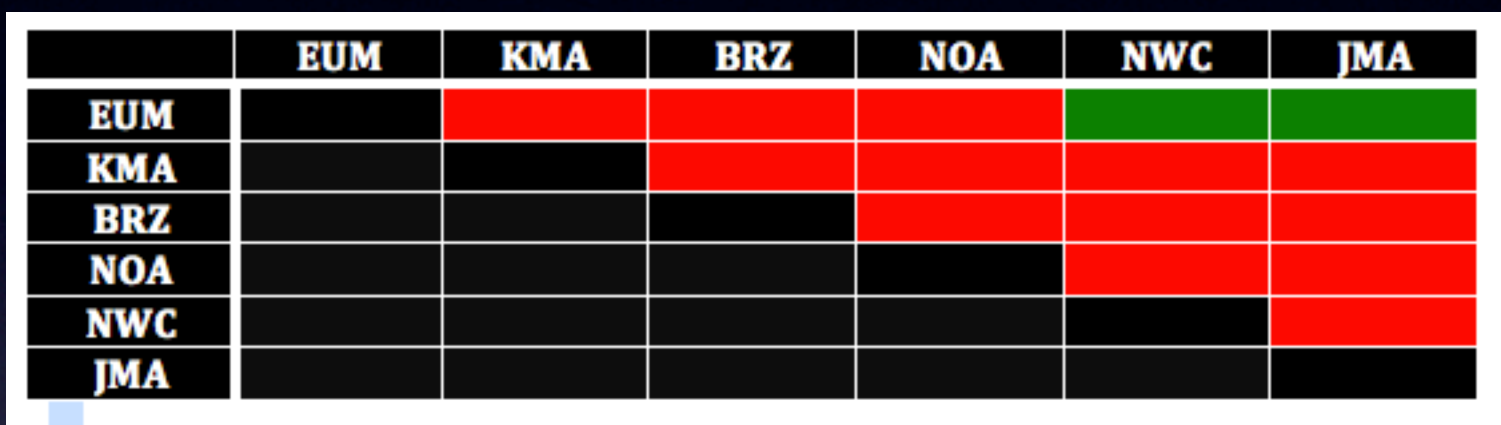


EUM

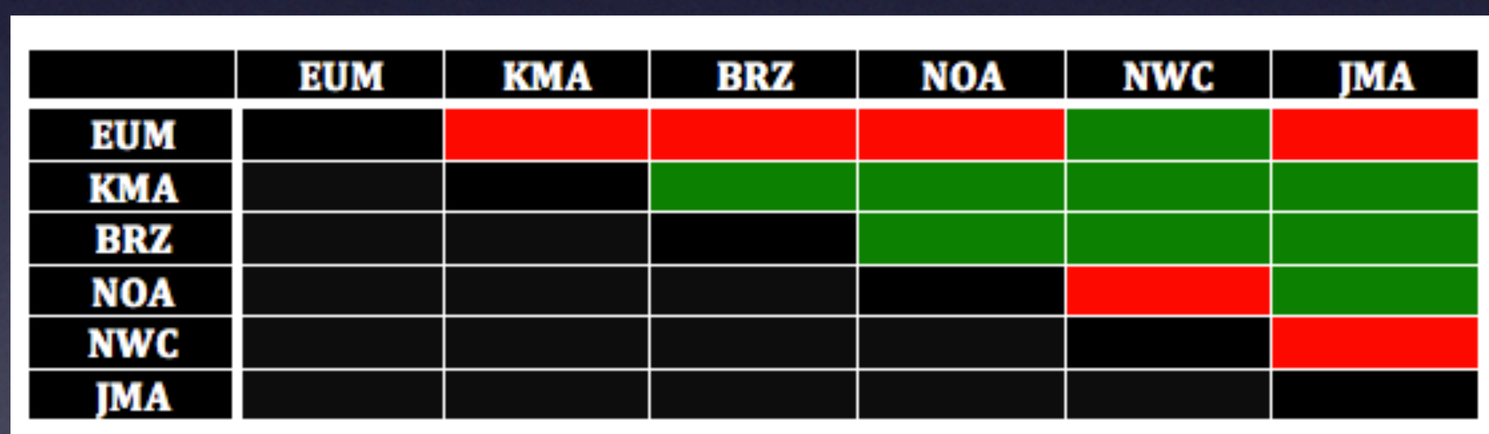
Experiment 2
Colocation Differences

- 7050 colocated AMVs (QI no forecast > 50)
  - Mean speed differences 0.3 to 1.0 ms^{-1}
  - AMV pressures are all statistically different
    - Differences ranging from 30 to 80 hPa
    - Largest differences when compared to EUM: up to 130 hPa
  - All point to IR B_T height assignment not performing well

Experiment 2
Colocation Differences

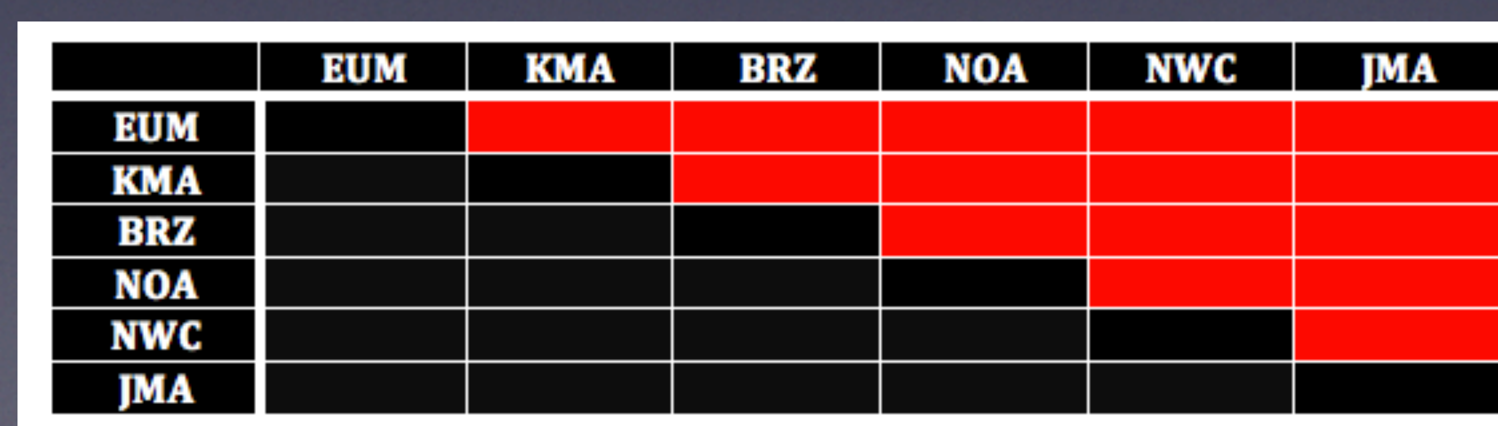


Speed



Direction

Pressure



Experiment 2 Rawinsonde Comparison

QI no forecast > 50

Site	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
BRZ	63	0.67	18.81	0.14	5.27	-11.12	9.59
EUM	268	-0.53	26.57	3.09	7.24	0.05	9.43
JMA	177	-2.20	26.26	0.36	6.04	6.07	8.04
KMA	1346	1.19	24.98	-0.02	5.94	9.04	7.91
NOA	361	-1.59	27.14	3.08	6.30	12.84	8.94
NWC	2410	-1.86	26.03	-0.78	4.75	1.53	6.14

QI with forecast > 50

Site	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
CMA	241	3.60	26.33	0.17	7.51	5.05	8.99
EUM	283	-0.71	26.15	2.74	7.07	0.57	9.46
JMA	169	-2.50	26.81	0.14	5.09	3.52	7.04
KMA	1266	1.24	24.92	0.18	5.81	8.35	7.79
NOA	342	-1.23	27.27	3.17	6.18	14.21	8.87
NWC	2410	-1.89	25.97	-0.72	4.68	1.52	6.06

Yellow: Maximum difference Cyan: Minimum difference

Experiment 2
Background Comparison

Exp	QI	N	BFN	V_O	RMSE	VAF	RAF
BRZ	QINF:80-100	745	113	7.51	8.89	7.04	8.64
CMA	QIWF:80-100	3964	755	7.07	8.22	6.44	7.81
EUM	QINF:80-100	5378	1003	6.88	9.73	6.47	9.54
JMA	QINF:80-100	3498	955	4.50	6.05	3.71	5.52
KMA	QINF:80-100	26427	5189	5.95	7.88	5.49	7.61
NOA	QINF:80-100	8180	1640	6.87	8.79	6.22	8.37
NWC	QINF:80-100	49331	11963	4.62	5.52	4.05	5.06

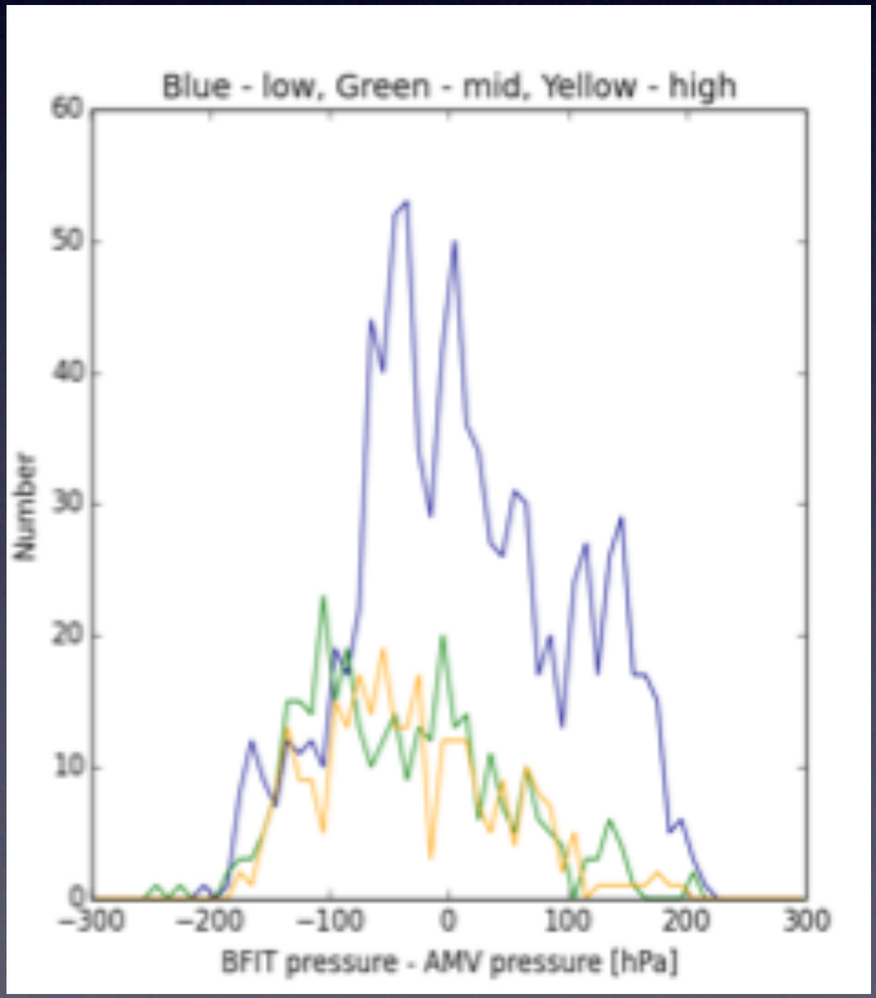
QI without forecast > 80
N = total number of AMVs
BFN = Best Fit number of AMVs
V_O = VD OMB mean
RAF = RMSE after Best Fit
VAF = Vector difference after Best Fit
RMSE = root mean square error

Yellow: Maximum difference Cyan: Minimum difference

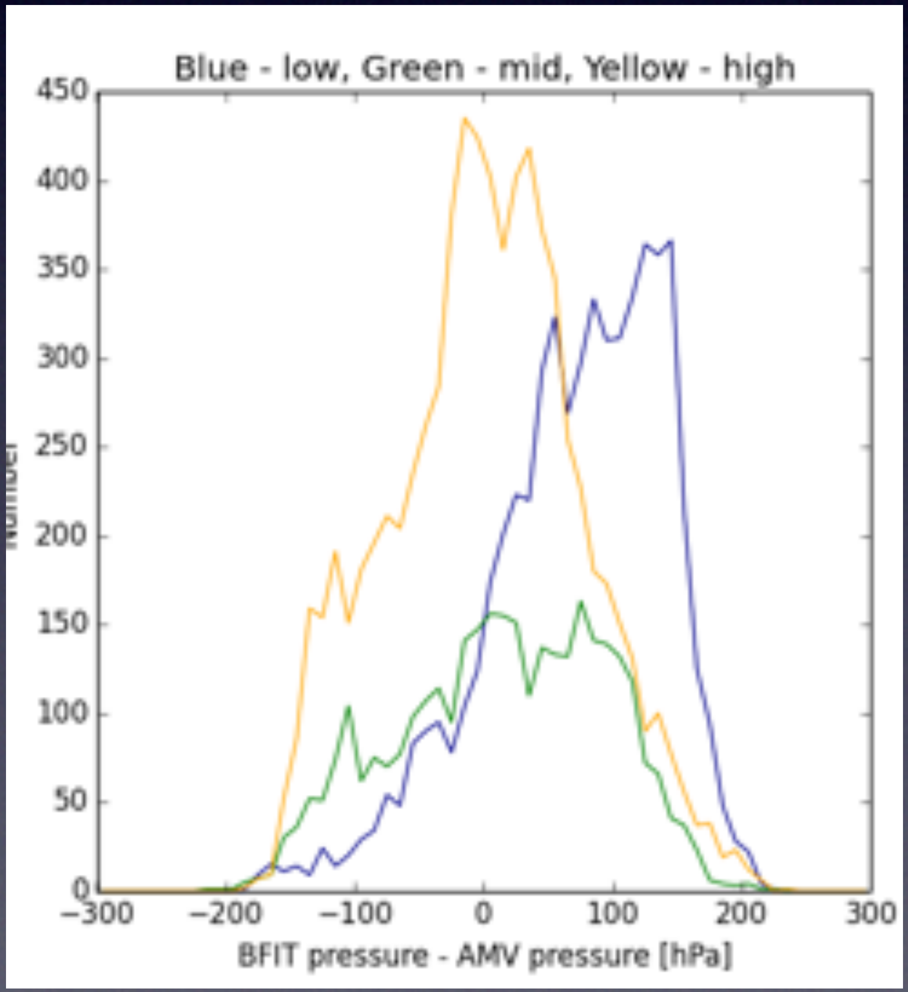
Experiment 2
Best Fit

Height assignment behaving differently for different centres

Best Fit pressure change by low, middle, high



EUM



NWC

Experiment 3

- AMV producers extract IR10.8 μ channel AMVs considering a prescribed AMV algorithm configuration
    - 24x24 target box; 80x80 search box
    - Use only the MSG/SEVIRI IR10.8 μ images and the ECMWF model data for the height assignment
    - Test tracking and quality control steps, considering similar targets

Experiment 3 Highlights

- Prescribed target and search box sizes
  - Number of winds QI > 50 range from 2300 to 9600
    - Exp. 2: 4900 to 75000
- Very few collocated vectors
  - Only 370 matches
  - Good agreement of speed and direction among centres
- Better homogeneity of data because of prescribed configuration

Experiment 3
Speed and Direction Differences

Speed (top) and direction (lower)

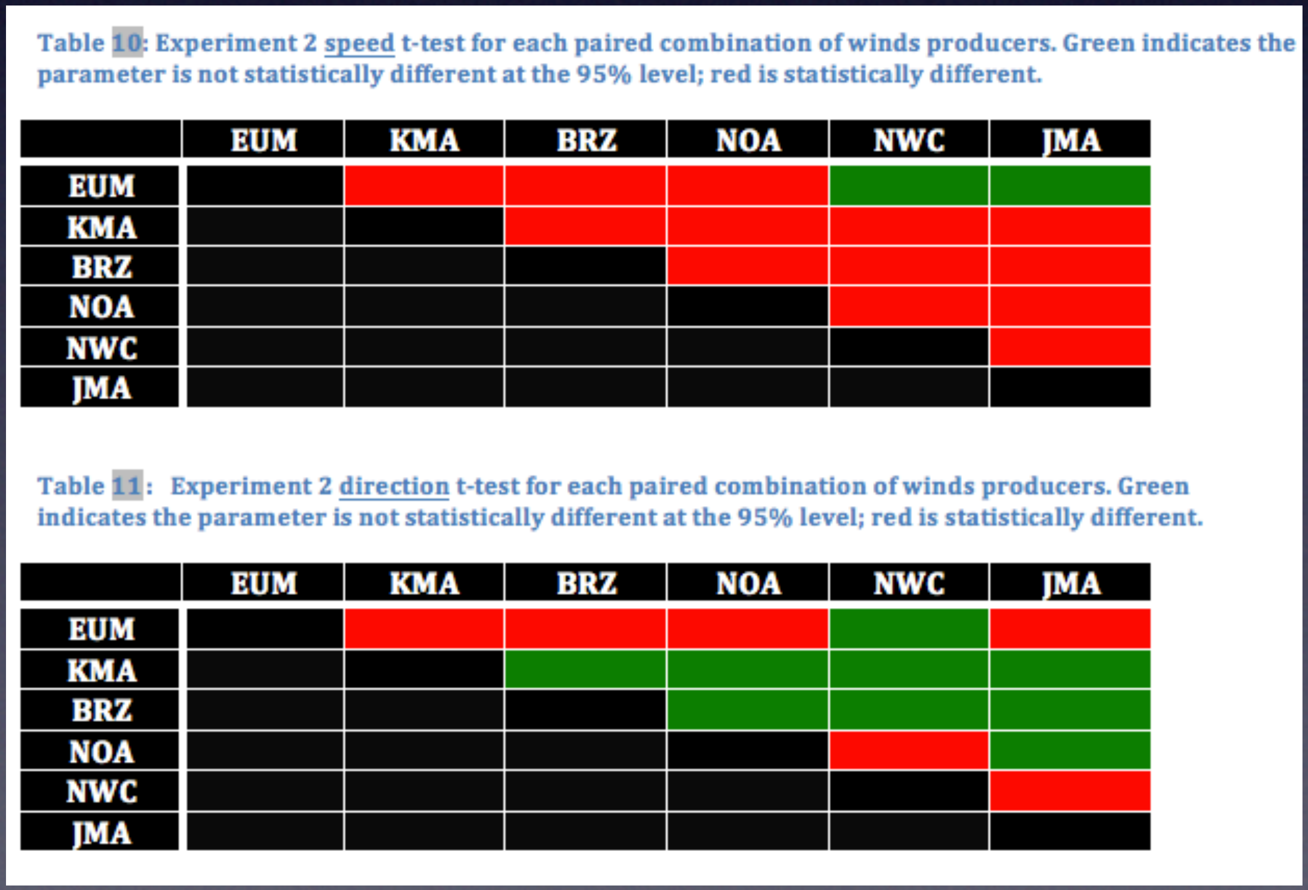


Table 10: Experiment 2 speed t-test for each paired combination of winds producers. Green indicates the parameter is not statistically different at the 95% level; red is statistically different.

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

Table 11: Experiment 2 direction 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	BRZ	NOA	NWC	JMA
EUM						
KMA						
BRZ						
NOA						
NWC						
JMA						

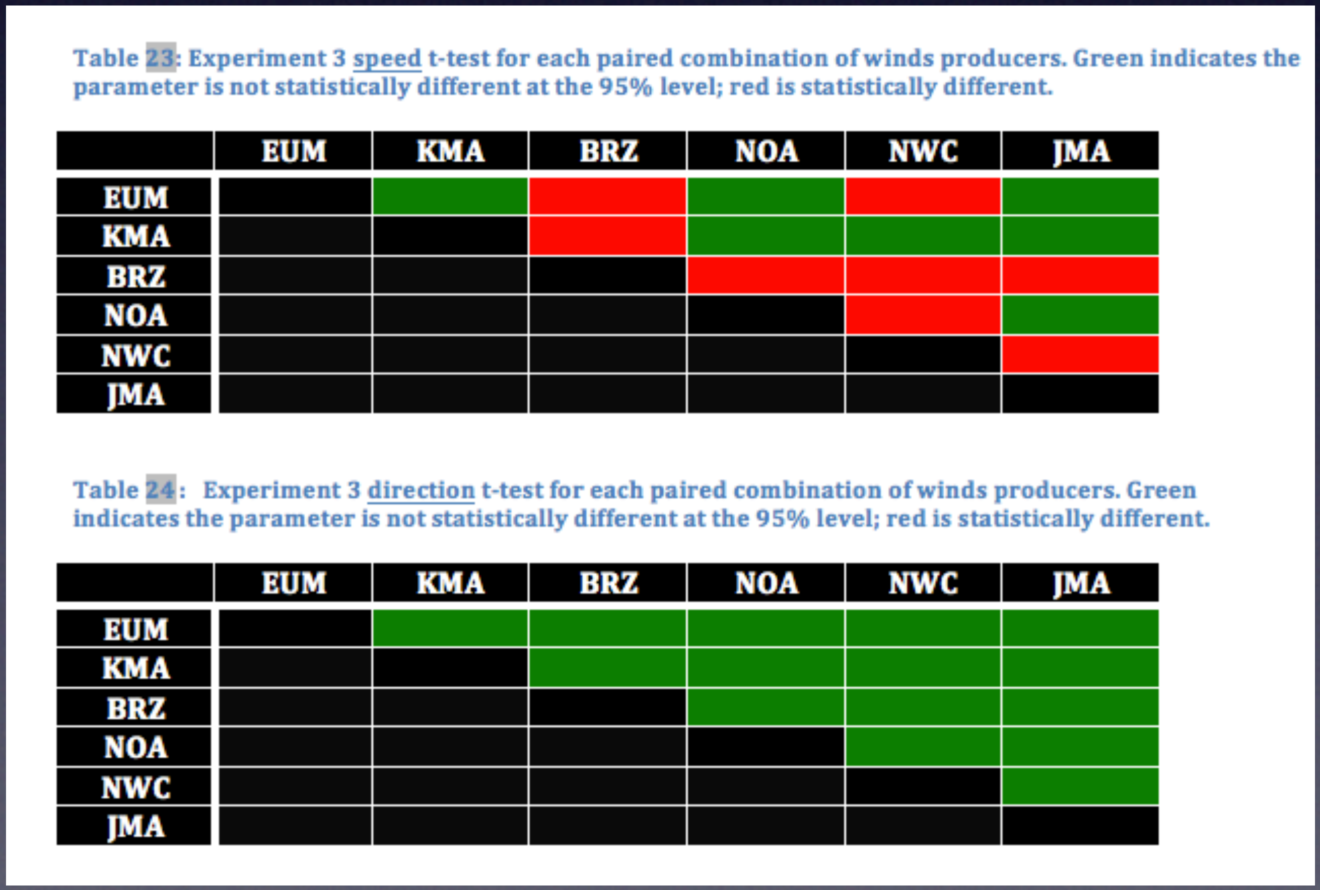


Table 23: Experiment 3 speed t-test for each paired combination of winds producers. Green indicates the parameter is not statistically different at the 95% level; red is statistically different.

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

Table 24: Experiment 3 direction 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	BRZ	NOA	NWC	JMA
EUM						
KMA						
BRZ						
NOA						
NWC						
JMA						

Experiment 2

Experiment 3

Experiment 4

- AMV producers extract IR10.8 μ channel AMVs considering a prescribed AMV algorithm configuration
  - 24x24 target box; 80x80 search box
  - Use the height assignment method of their choosing
  - Test the height assignment and quality control steps considering similar targets

Experiment 3 vs. 4

Large shift in height histograms

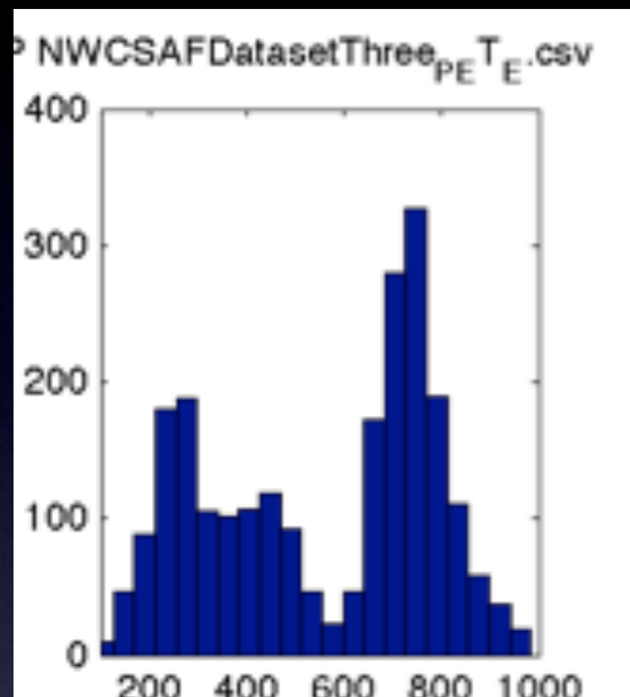
Height change between Experiments 3 and 4

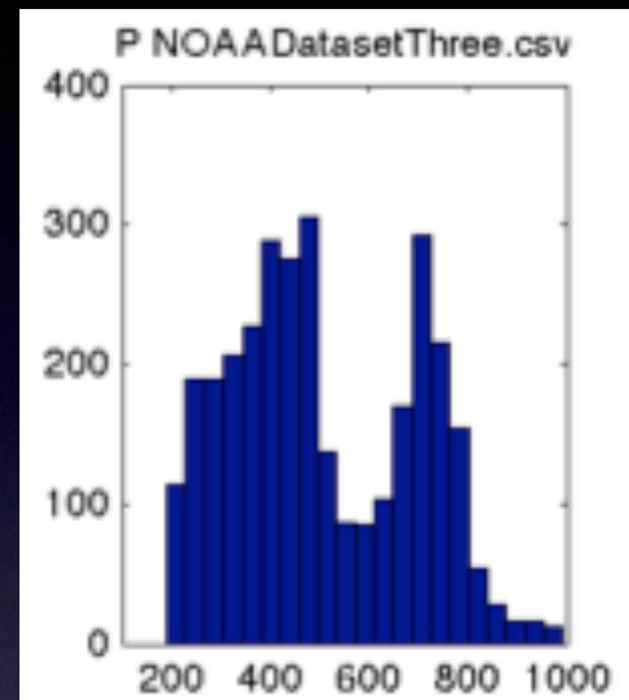
NWC

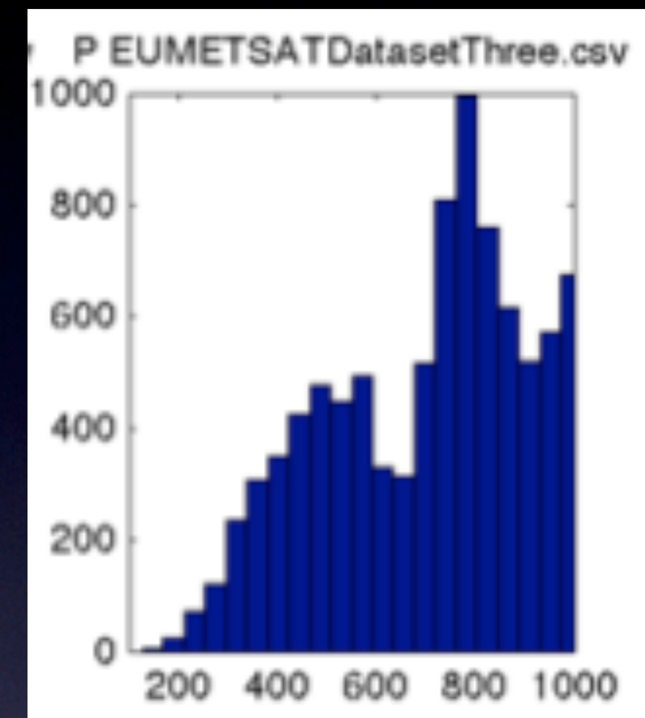
NOA

EUM

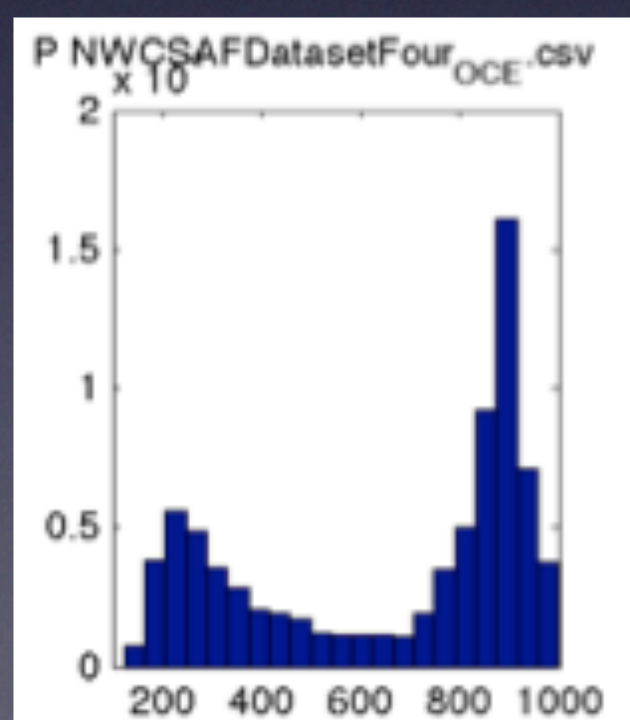
Exp. 3

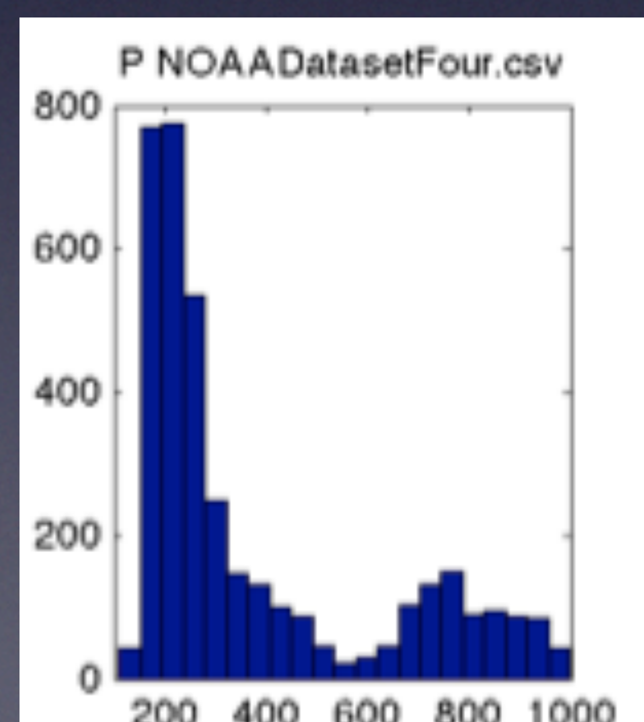


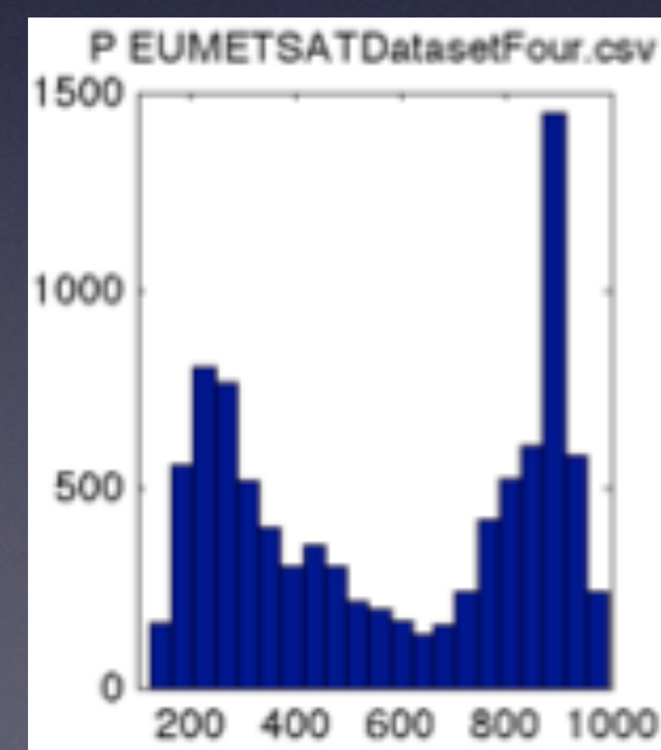




Exp. 4







Experiment 3 vs. 4

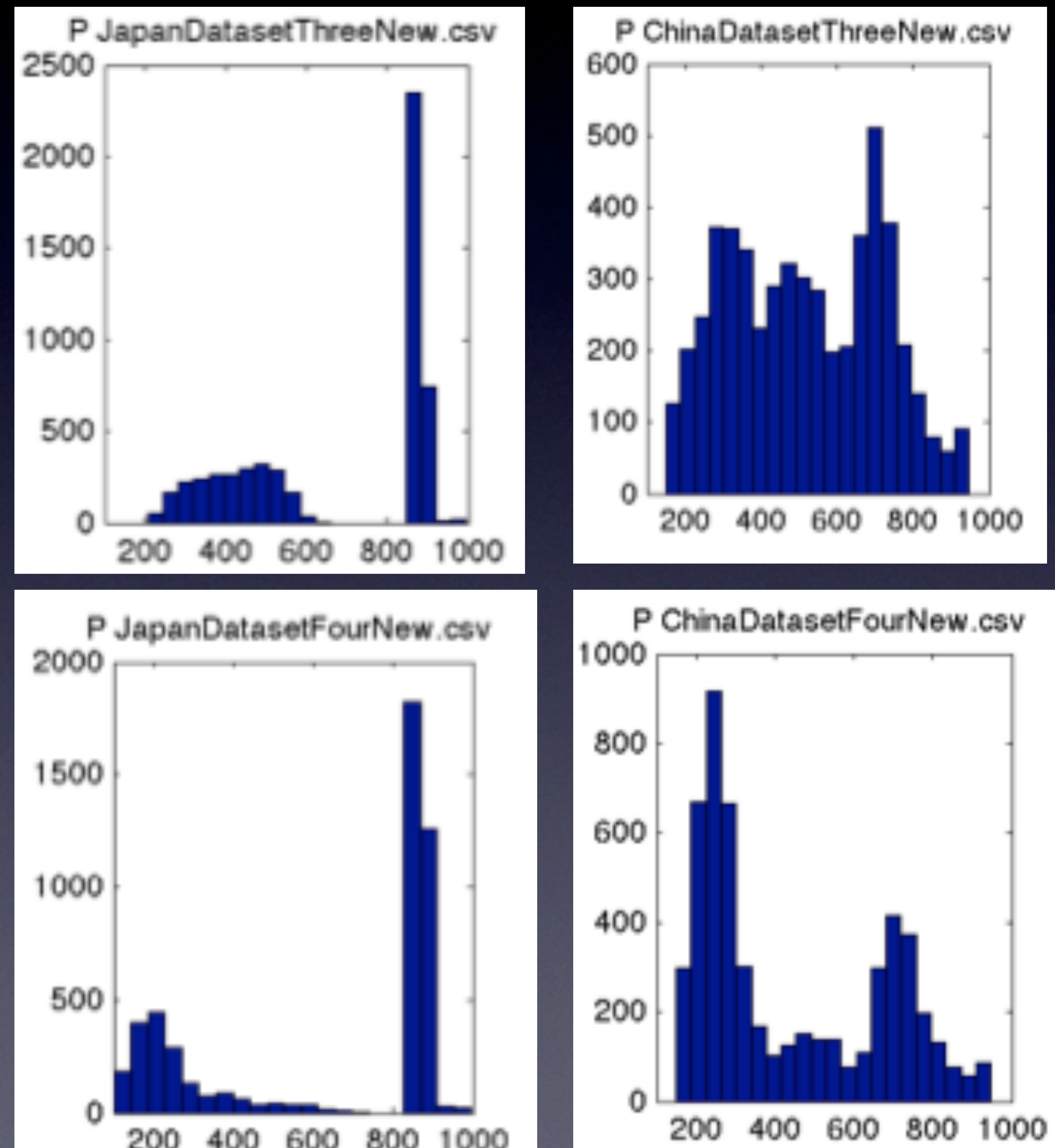
Height change between Experiments 3 and 4

JMA

CMA

Exp. 3

Exp. 4



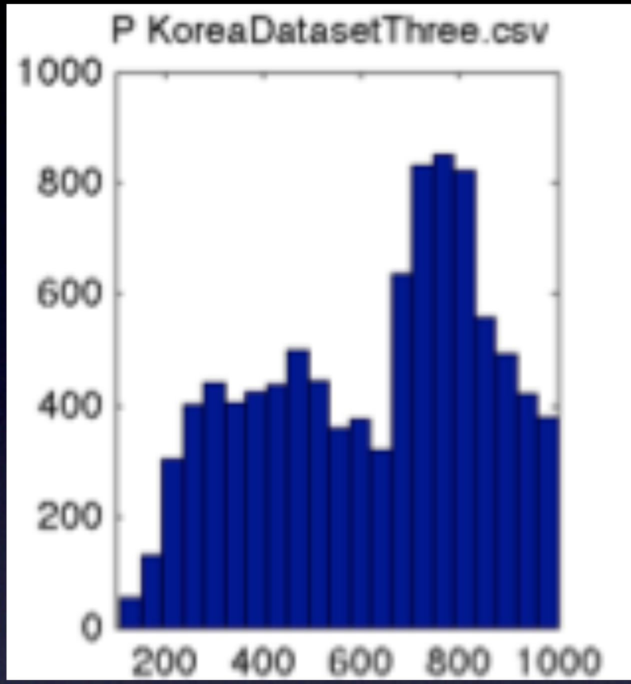
Experiment 3 vs. 4

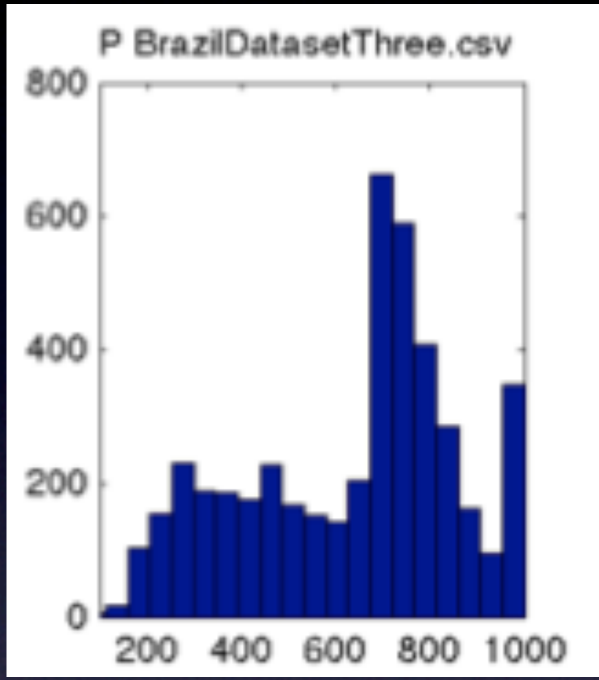
Height change between Experiments 3 and 4

KMA

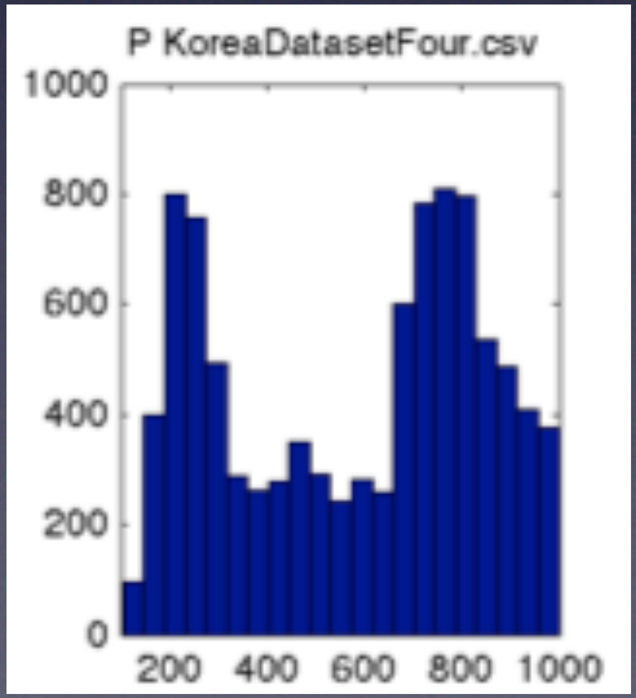
BRZ

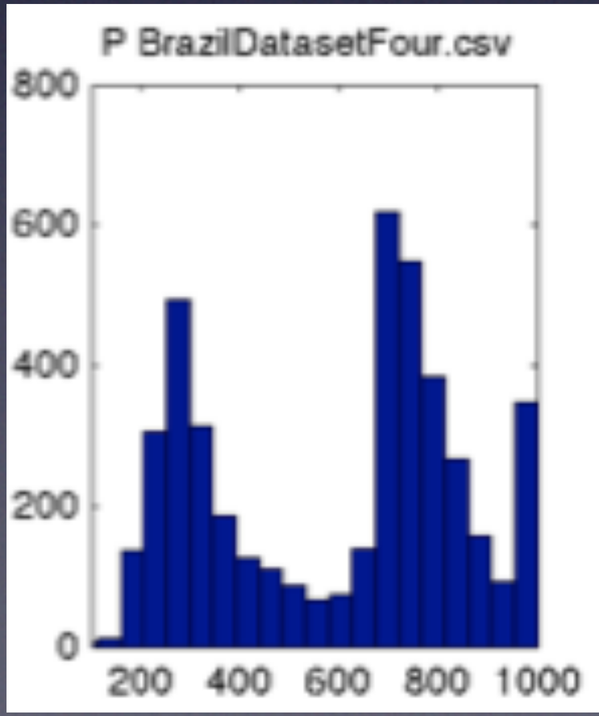
Exp. 3





Exp. 4





Experiment 4
Rawinsonde Comparison

QI with forecast > 50

SIte	N	P bias	P RMS	SpdBias	SpdRMS	DirBias	VecRMS
CMA	237	-1.11	18.58	-1.30	6.40	5.28	7.74
EUM	320	-0.05	22.85	-0.80	4.90	3.29	6.26
JMA	149	-3.40	21.98	-2.62	7.04	4.76	8.96
KMA	304	-0.59	21.67	-0.67	4.27	4.19	5.83
NOA	125	0.57	23.53	1.29	5.47	8.30	7.36
NWC (Operational conf., EUM Clouds)	2378	-0.74	22.76	-0.36	3.86	0.45	5.09
NWC (Operational conf., NWC Clouds)	2789	-0.53	21.65	-1.20	4.44	-1.64	5.61
NWC (Prescribed conf., EUM Clouds)	73	-0.00	17.42	-0.60	3.47	-2.27	4.56

Substantial improvement in the vector RMS with rawinsonde comparisons between Experiments 3 and 4 for

EUM: from 9.46 to 6.26 ms^{-1}

NOA: from 9.30 to 7.36 ms^{-1}

Experiment 4
Background Comparison

Exp	QI	N	BFN	V_O	RMSE	VAF	RAF
BRZ	QINF:80-100	1590	220	8.01	9.67	7.54	9.43
CMA	QIWF:80-100	4743	1090	6.38	7.44	5.77	7.02
EUM	QIWF:80-100	6583	2301	3.91	5.36	3.29	4.84
JMA	QINF:80-100	3514	1056	4.91	6.59	3.94	5.88
KMA	QINF:80-100	4574	1221	5.16	6.83	4.66	6.52
NOA	QINF:80-100	2274	807	5.90	7.54	4.84	6.83
NWC (Oper.conf, EUM Clouds)	QINF:80-100	53010	18115	3.23	4.15	2.71	3.65
NWC (Oper.conf, NWC Clouds)	QINF:80-100	52464	18732	3.77	4.65	3.05	4.04
NWC (Pres.conf, EUM Clouds)	QINF:80-100	1419	605	3.05	4.01	2.45	3.40

QI without forecast > 80

N = total number of AMVs

BFN = Best Fit number of AMVs

V_O = VD OMB mean

RAF = RMSE after Best Fit

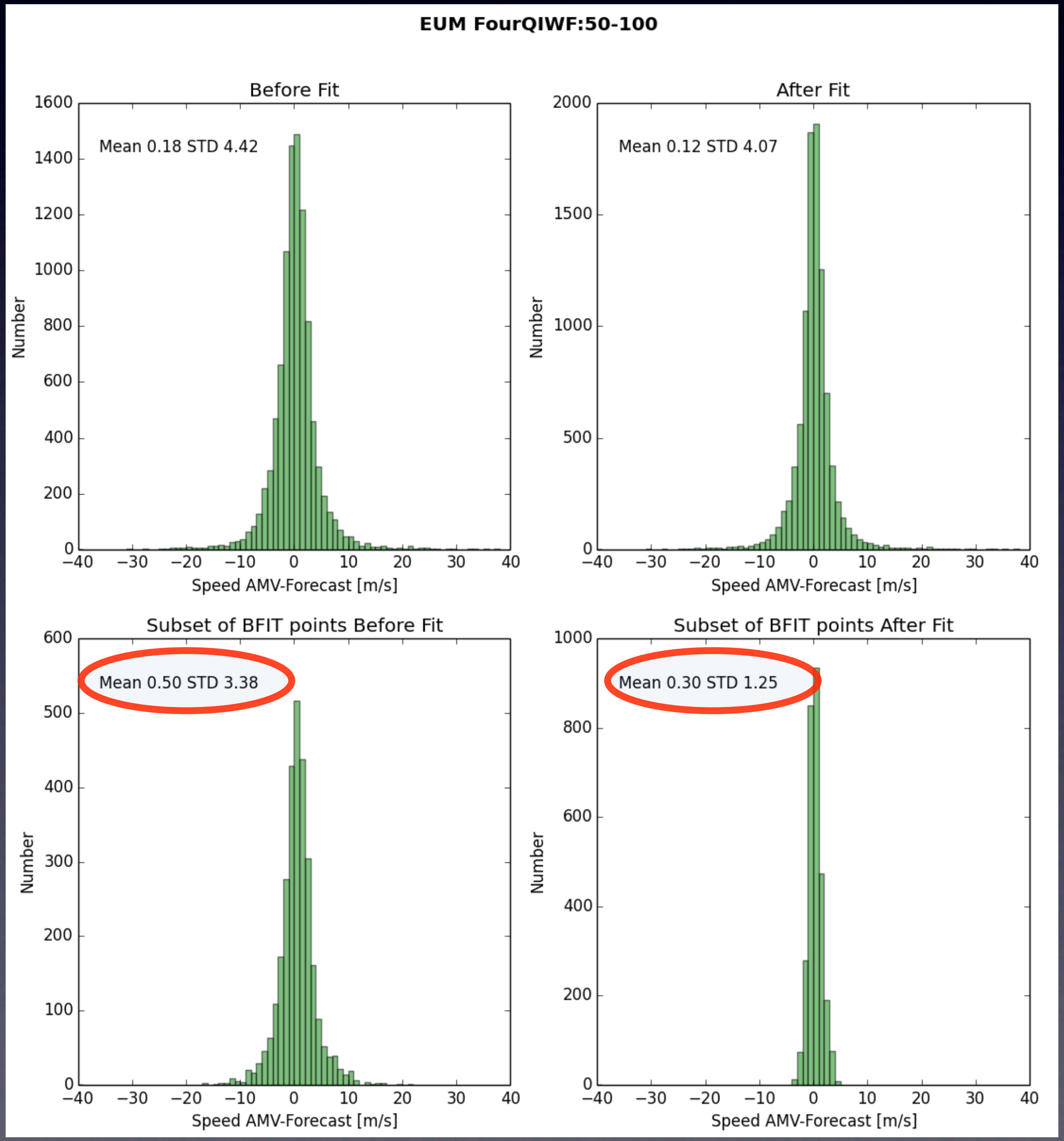
VAF = Vector difference after Best Fit

RMSE = root mean square error

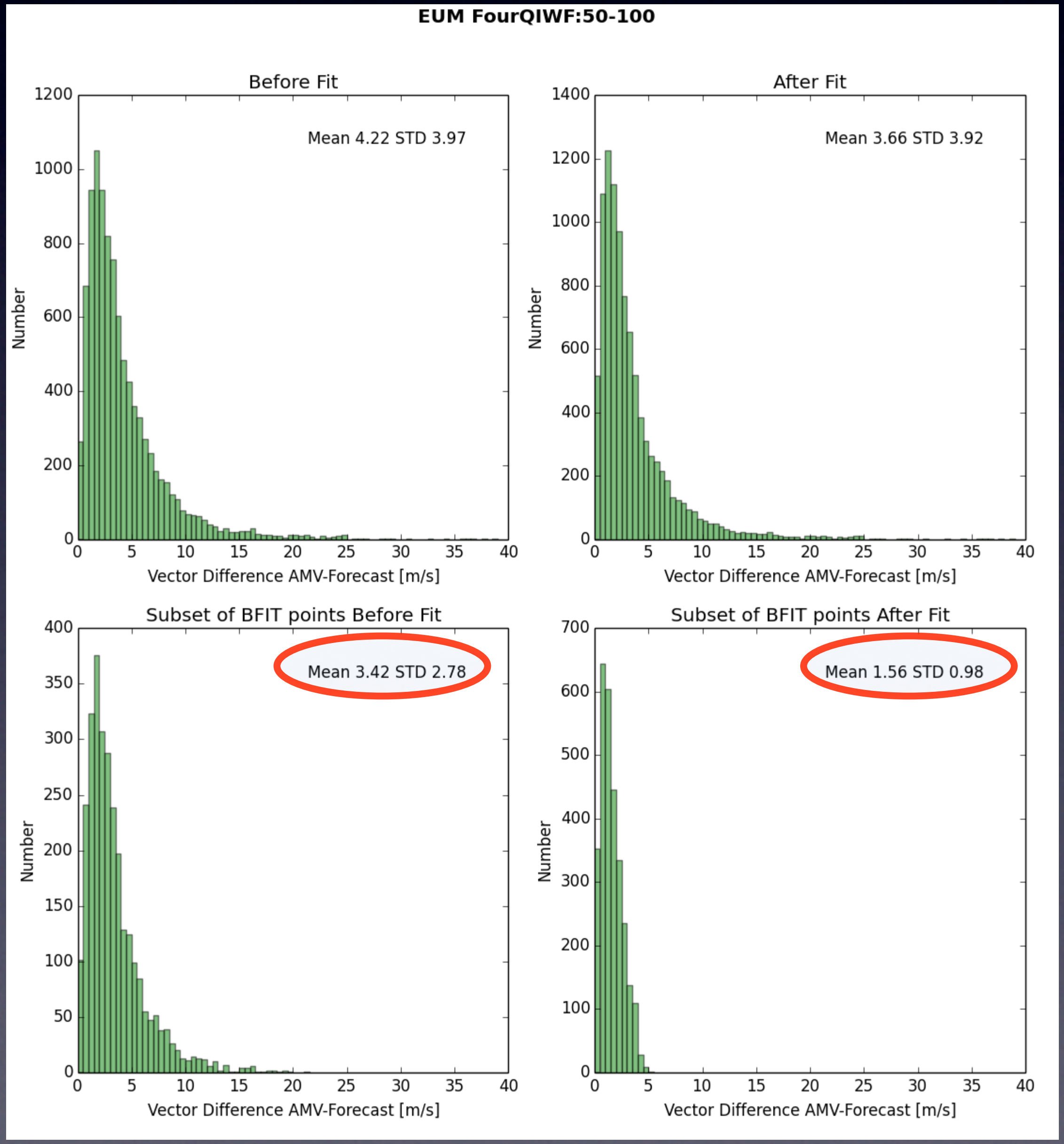
Yellow: Maximum difference   Cyan: Minimum difference

Experiment 4
Additional Graphs

Before and after Best Fit speed and vector difference



Speed difference

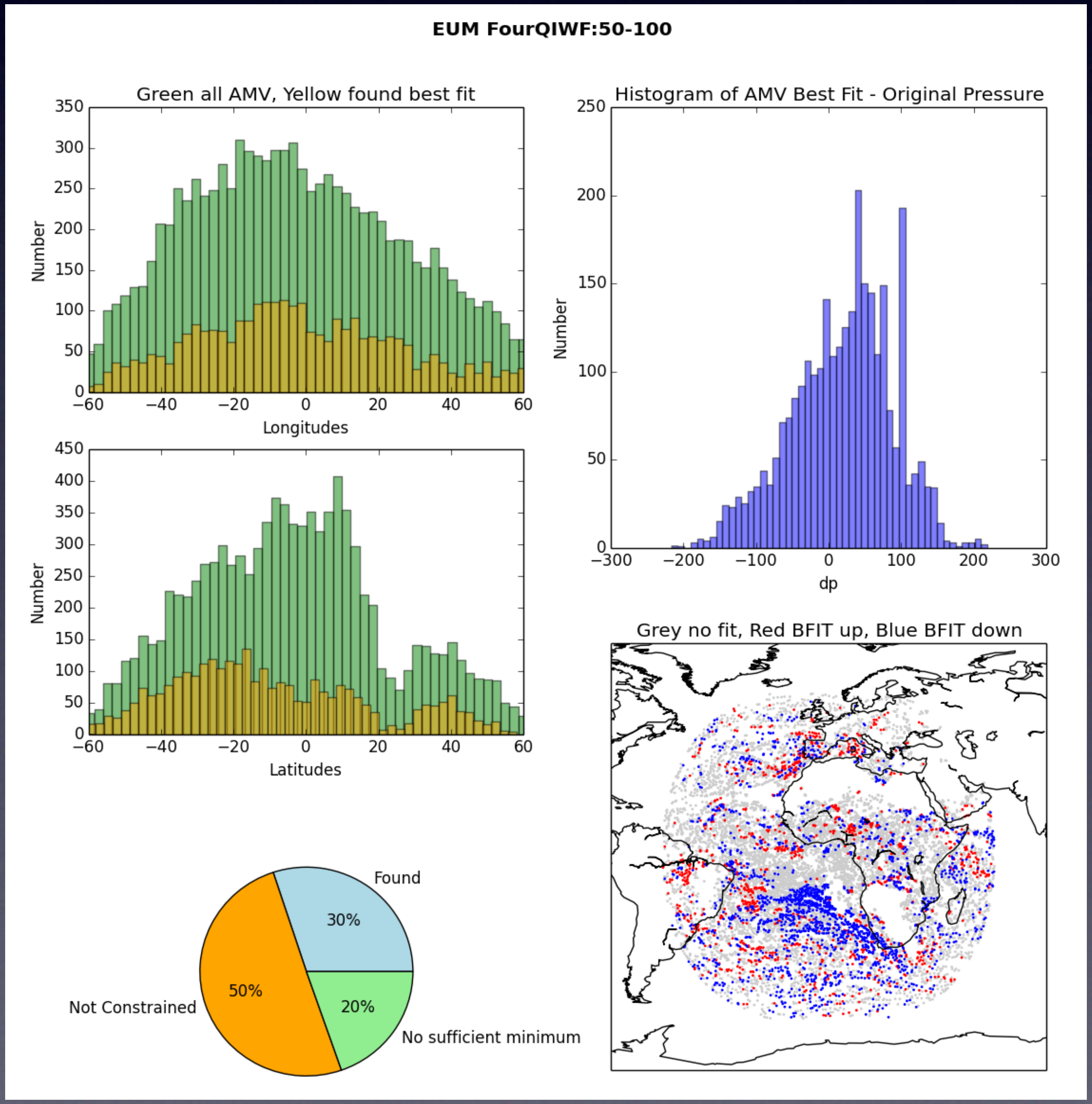


Vector difference

Experiment 4 Additional graphs

Best Fit distribution

latitude, longitude, height, pressure change



Conclusions EUMETSAT

- The strengths of the algorithm were especially noted in Experiment 4. The statistical comparison of the EUM AMVs to rawinsondes and the background forecast wind field, was second only to NWCSAF.

- However, the use of only the IR B_T for cloud height (Experiment 3) resulted in AMVs being placed several hundred hPa different than when other techniques could be used (Experiment 4).

Conclusions
CMA

- AMV comparison to rawinsondes and the background wind field exhibited larger errors than other centres. May be due to very extensive use of IR-only B_T in determining AMV heights.

- However, the Best Fit analysis indicates that there are good AMVs in this dataset as Best Fit height adjustment and corresponding improvement in statistics (compared to the background) are very similar to other centres.

Conclusions JMA

- The results from Experiment 4 show that the JMA algorithm is in the middle (statistically) when measuring performance based on comparisons to rawinsondes and the background wind field.

Conclusions NOAA

- The strength of the NOAA algorithm is its cloud height determination as evidenced in Experiment 4: A substantial number of heights were adjusted (as compared to IR-only B_T) resulting in a improvement in a statistical comparison to rawinsondes and the background forecast wind field.

- Unfortunately, they were not able to use a high vertical resolution background grid, to better detect temperature inversions and the height of low-level clouds.

Conclusions
KMA

- The results from Experiment 4 show that the KMA algorithm is in the middle (statistically) when measuring performance based on comparisons to rawinsondes and the background wind field.

Conclusions
Brazil

- The performance of the BRZ AMV algorithm could not be evaluated because the results of Experiment 1 indicates an error in determining wind speed up to 10 ms^{-1} depending on the distance from the satellite subpoint.

- However, the Best Fit analysis indicates that there are good AMVs in this dataset as the Best Fit height adjustment and corresponding improvement in statistics (compared to the background) are very similar to other centres.

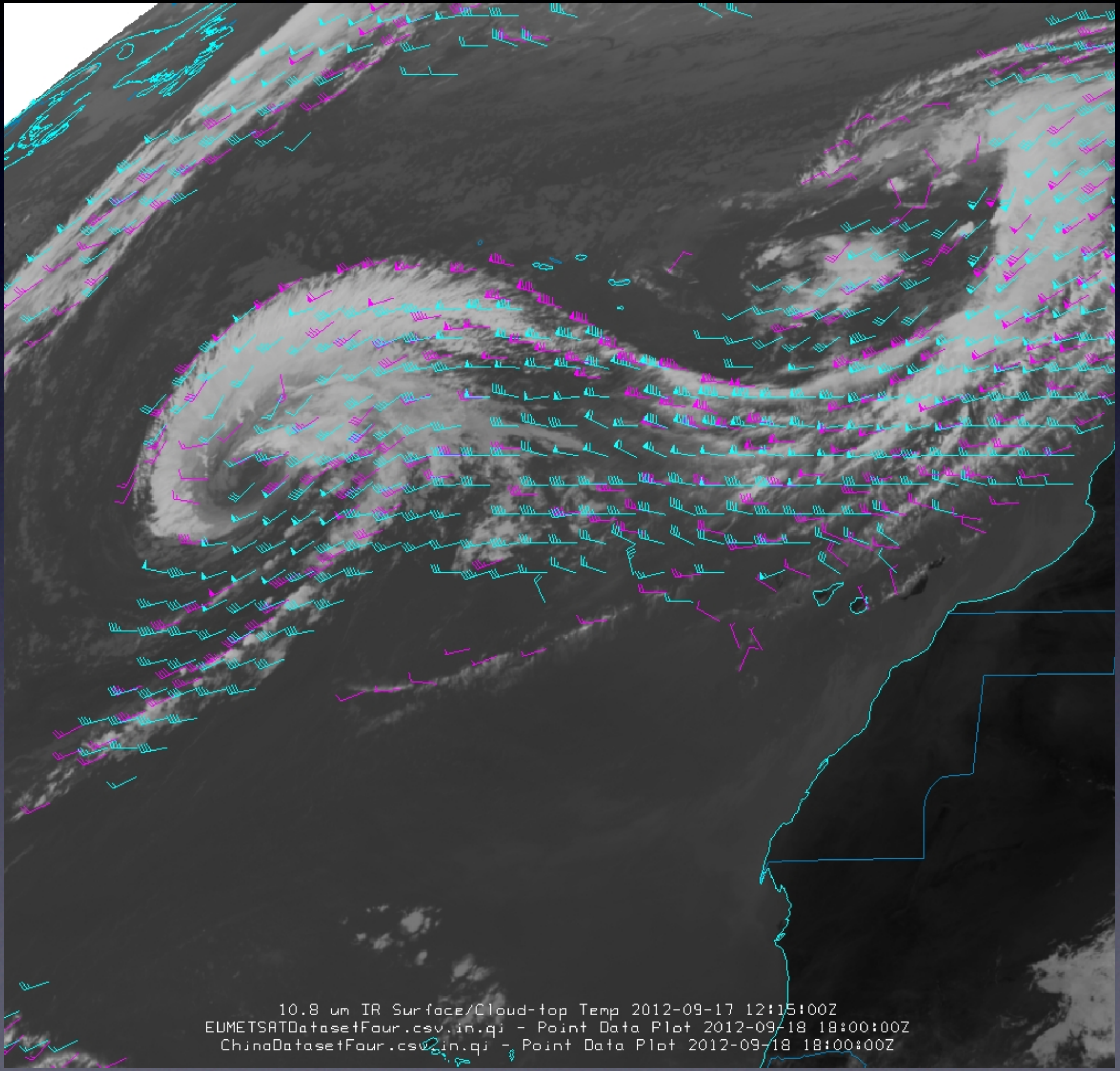
Conclusions NWC/SAF

- Among all the centres in this study, the NWCSAF/HRW algorithm had the best statistics as compared to rawinsondes and the background forecast wind field. This was the case for both Experiment 3 (IR B_T only cloud height) and Experiment 4 (any cloud height technique).

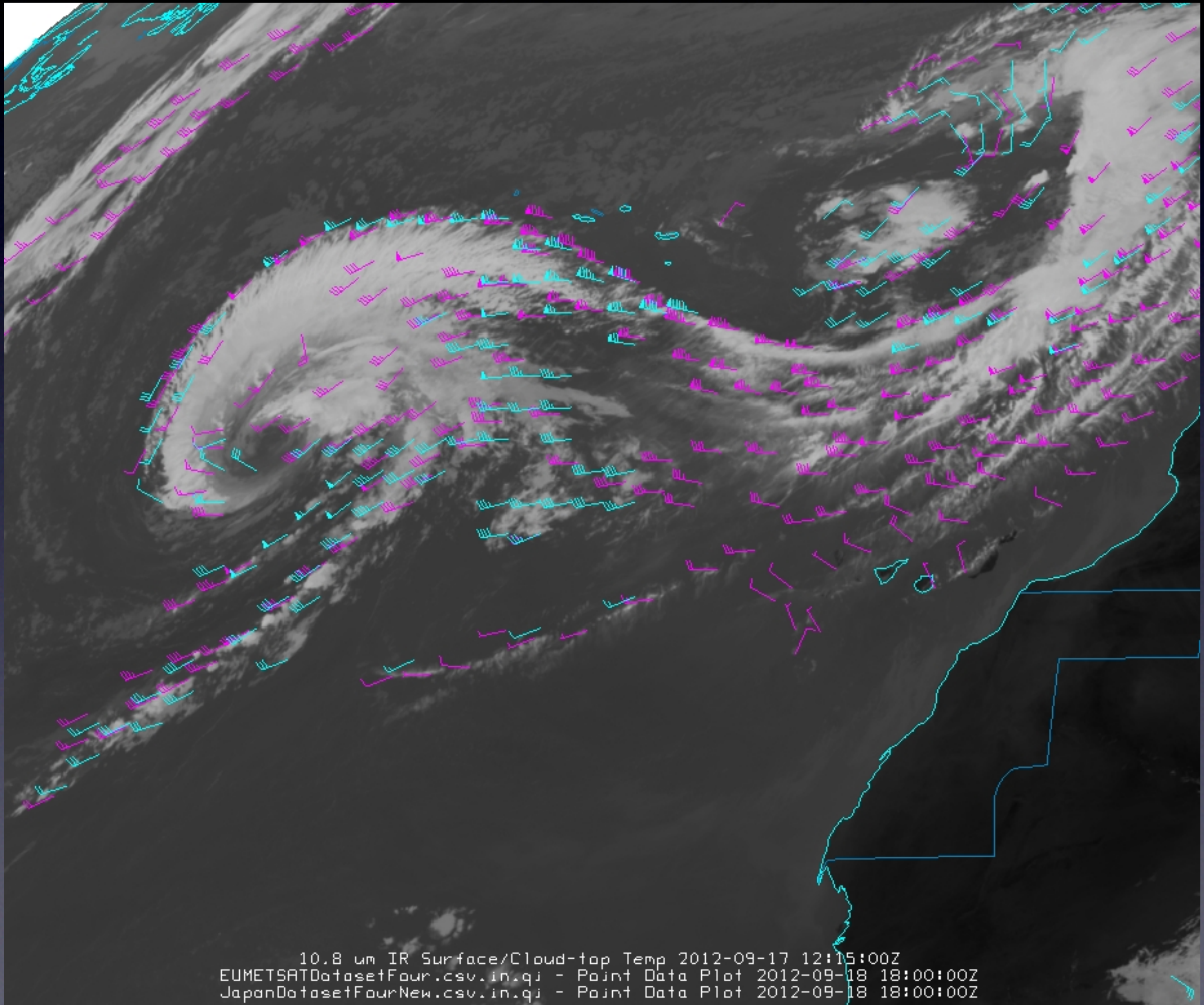
- Moreover, NWC AMVs with IR-only cloud height performed better than several other centres using other cloud height techniques.

Thank You!

EUM and CMA


10.8 um IR Surface/Cloud-top Temp 2012-09-17 12:15:00Z
EUMETSATDatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z
ChinaDatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z

EUM and JMA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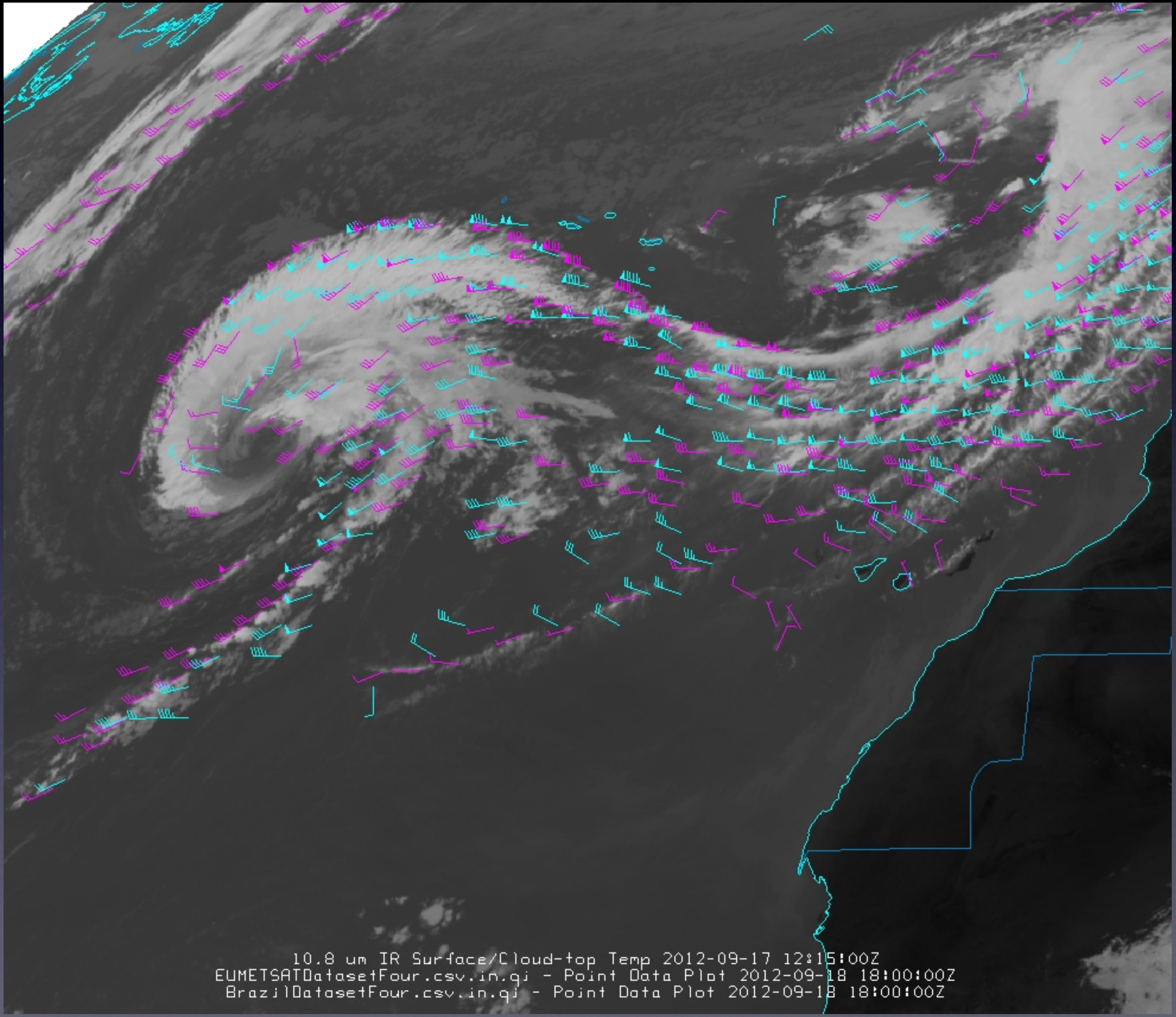
JapanDatasetFourNew.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z

EUM and BRZ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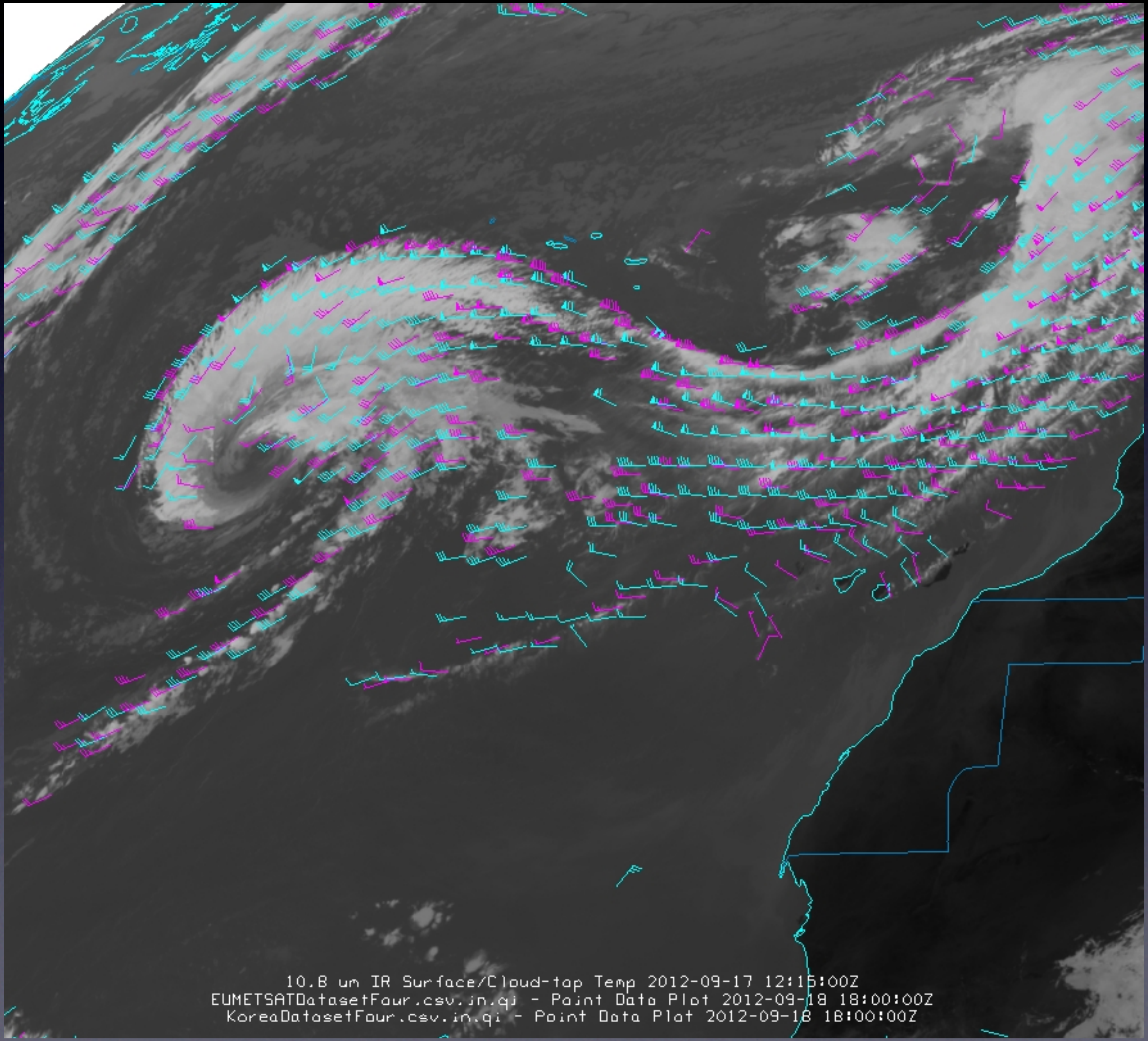
EUM and KMA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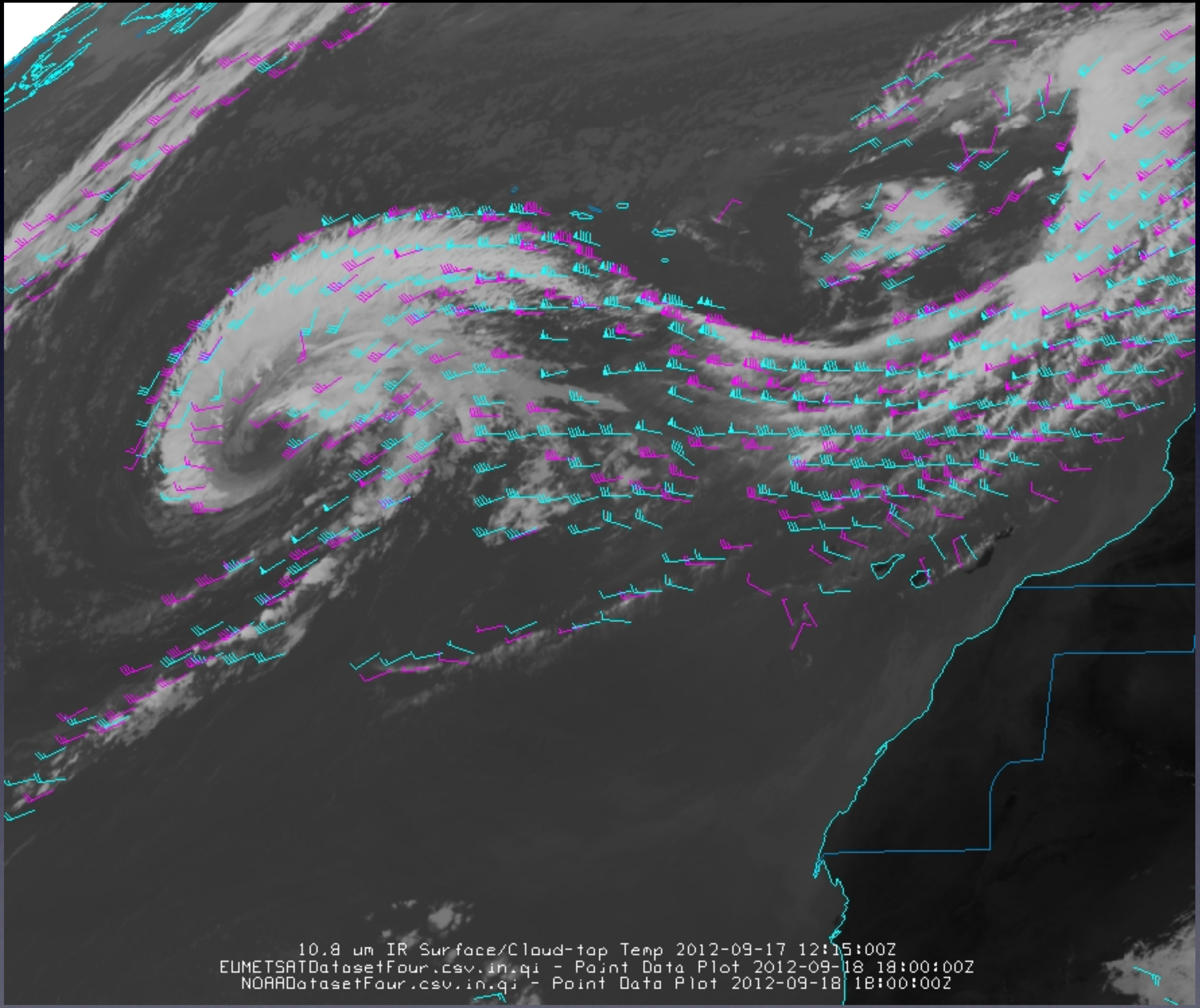
EUMETSATDatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z
KoreaDatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z

EUM and NOA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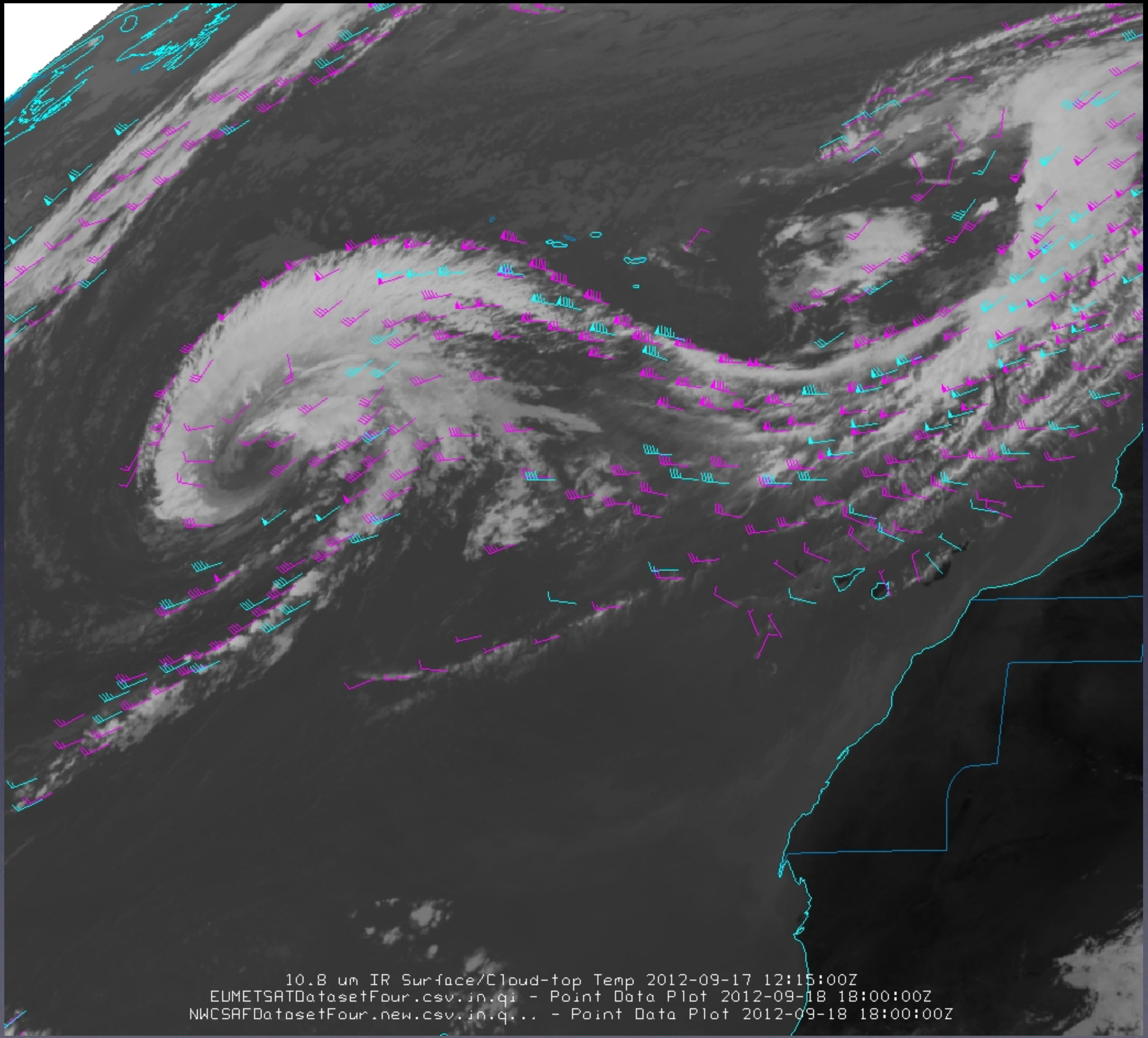
EUMETSATDatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z
NOAADatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z

EUM and NWC



10.8 um IR Surface/Cloud-top Temp 2012-09-17 12:15:00Z
EUMETSATDatasetFour.csv.in.qi - Point Data Plot 2012-09-18 18:00:00Z
NWCSAFDatasetFour.new.csv.in.q... - Point Data Plot 2012-09-18 18:00:00Z