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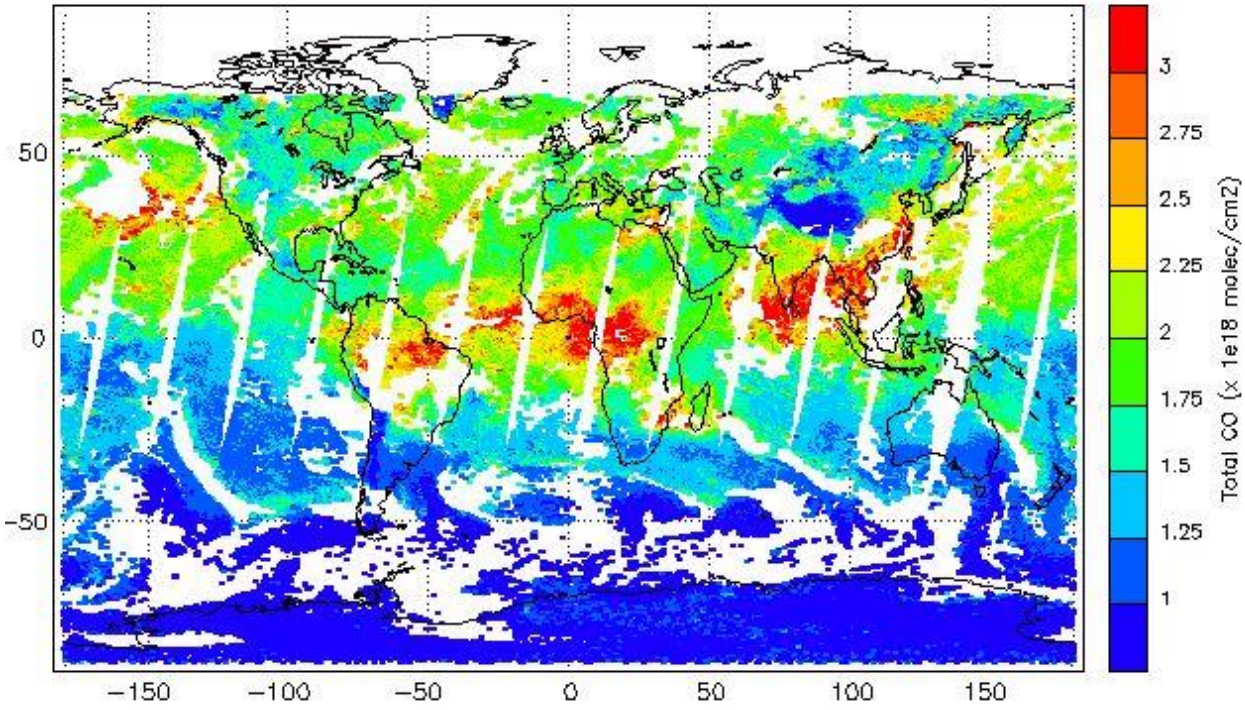
O3M SAF VALIDATION REPORT

Validated products:

Identifier	Name	Acronym
O3M-80	Near Real-Time IASI CO	MBI-N-CO



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Reporting period: 24 September 2015 – 2 November 2015

Input data versions: IASI Level 1C version 7.1, since 22.07.2014

Data processor versions: PGE version 6.1, since 24.09.2015

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1. INTRODUCTION

1.1 Purpose and scope

This Validation Report (VR) aims at assessing the CO IASI products distributed by EUMETCast in terms of:

- Compliance with the Product Requirements;

- Traceability

In this document, we will analyze the differences between the EUMETSAT products disseminated by EUMETCast in BUFR format (hereafter called COX) and the products routinely generated both at ULB (Belgium) and LATMOS (France) using the FORLI retrieval algorithm (v20140922, hereafter called FORLI-CO). Possible processing errors as well as abnormal behavior are noticed and checked.

With the Product User Manual (PUM), the Validation Report (VR) is part of the review material needed for the Operational Readiness Review (ORR).

1.2 Acronyms

O3M SAF: Ozone and Atmospheric Composition Monitoring Satellite Application Facility
EUMETSAT: European Organisation for the Exploitation of Meteorological Satellites
EUMETCast: EUMETSAT multi-service data dissemination system
IASI: Infrared Atmospheric Sounding Interferometer
FORLI: Fast Optimal Retrievals on Layers for IASI
ULB: Université Libre de Bruxelles
LATMOS: Laboratoire Atmosphères, Milieux, Observations Spatiales
ORR: Operational Readiness Review
PUM: Product User Manuel
VR: Validation Report
UID: Unique Identifier

1.3 Applicable documents

FORLI-CO Product Specification, Requirement and Assessment

SAF/O3M/ULB/FORLICO_PSRA Issue 1, 21/01/2015

2. CO MONITORING

The monitoring was performed for IASI/MetOp-A and IASI/MetOp-B.

Note that since the delivery of the code to EUMETSAT, a bug has been fixed in the emissivity integration (a double rad to degree correction was incorrectly applied). So the codes running at EUMETSAT and at LATMOS/ULB are not strictly the same, and the products slightly differ. This validation report account for this.

2.1 Compliance of the products

We looked at the CO total columns, profiles, averaging kernel matrices and BDIV field. The statistics in the following table are calculated for 20 days (20151005-20151024). Details are given in the following sections.

CO total columns	compliant	mean(relative_difference_mean) = 0.02; mean(relative_difference_std) = 3.02
CO profiles	compliant	mean(correlation_min) = 0.91
Averaging kernels	compliant	mean(distance_mean) = 2.41 x 10^{-4}, mean(distance_std) = 0.0025
CO_BDIV	not compliant	

2.2 CO_BDIV

Unfortunately the contents of the CO_BDIV field differ for FORLI-CO and COX. The latter ones are looking meaningless (mix of impossible values and/or incompatible values).

However we note that CO_BDIV = 0 in FORLI-CO corresponds to CO_BDIV = 0 in COX. And 2 COX-retrievals with the same CO_BDIV have the same CO_BDIV with FORLI-CO.

Table 1 and Table 2 hereafter illustrate this on 20 examples from W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+IASI_C_EUMC_20151002030253_46448_eps_o_cox_l2.bin for FORLI-CO and COX, respectively.

Table 1: 20 retrieval examples from W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+IASI_C_EUMC_20151002030253_46448_eps_o_cox_l2.bin (FORLI-CO values).

FORLI-CO														
#	Lon	Lat	UID	bDiv								COLUMN	bDiv (int)	bDiv Meaning
1	94,9966	-74,9836	46448537004	0000	1000	0010	0000	0000	0010	0001	0110	1,6035E+18	136315414	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 + AMP_CONTRAST + AMP_BIAS
2	94,9160	-75,2282	46448537005	0000	1000	0000	0001	0000	0010	0001	0100	1,2886E+18	134283796	AMP_L2 + AMP_FIT + AMP_LINREG_L2 +

														AMP_COVERAGE + AMP_BIAS
3	96,5471	-75,2616	46448537006	0000	1000	0000	0001	0000	0010	0001	0100	1,1775E+18	134283796	AMP_L2 + AMP_FIT + AMP_LINREG_L2 + AMP_COVERAGE + AMP_BIAS
4	96,5942	-75,0062	46448537007	0000	1000	0010	0001	0000	0010	0001	0110	1,4303E+18	136380950	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 + AMP_CONTRAST + AMP_COVERAGE + AMP_BIAS
5	91,1755	-74,8918	46448537008	0000	1000	0010	0001	0000	0010	0001	0110	1,5363E+18	136380950	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 + AMP_CONTRAST + AMP_COVERAGE + AMP_BIAS
6	91,0441	-75,1183	46448537009	0000	1000	0100	0000	0000	0010	0001	0100	1,3476E+18	138412564	AMP_L2 + AMP_FIT + AMP_LINREG_L2 + AMP_ITERATIONS + AMP_BIAS
7	92,4067	-75,1702	46448537010	0000	1000	0000	0000	0000	0000	0001	0000	9,8361E+17	134217744	AMP_FIT + AMP_BIAS
8	92,5142	-74,9343	46448537011	0000	0000	0010	0001	0000	0000	0000	0110	7,6425E+17	2162694	AMP_L1 + AMP_L2 + AMP_COVERAGE + AMP_CONTRAST
9	87,9281	-74,7629	46448537012	0000	1000	0000	0000	0000	0010	0001	0100	8,4206E+17	134218260	AMP_FIT + AMP_LINREG_L2 + AMP_BIAS
10	87,7609	-74,9742	46448537013	0000	1000	0000	0001	0000	0010	0001	0100	1,3399E+18	134283796	AMP_L2 + AMP_FIT + AMP_LINREG_L2 + AMP_COVERAGE + AMP_BIAS
11	88,9236	-75,0365	46448537014	0000	1000	0110	0001	0000	0010	0001	0110	1,4013E+18	140575254	AMP_L1 + AMP_L2 + AMP_FIT + AMP_LINREG_L2 + AMP_COVERAGE + AMP_CONTRAST + AMP_ITERATIONS + AMP_BIAS
12	89,0736	-74,8170	46448537015	0000	1000	0010	0001	0000	0010	0001	0110	1,2968E+18	136380950	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 + AMP_CONTRAST + AMP_COVERAGE + AMP_BIAS
13	85,1107	-74,6120	46448537016	0000	1000	0010	0000	0000	0010	0001	0110	1,1549E+18	136315414	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 + AMP_CONTRAST + AMP_BIAS
14	84,9176	-74,8104	46448537017	0000	1000	0000	0000	0000	0010	0001	0100	1,0304E+18	134218260	AMP_FIT + AMP_LINREG_L2 + AMP_BIAS
15	85,9277	-74,8786	46448537018	0000	1000	0010	0000	0000	0010	0001	0110	1,1132E+18	136315414	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 + AMP_CONTRAST + AMP_BIAS
16	86,1080	-74,6730	46448537019	0000	0000	0000	0000	0000	0010	0000	0100	8,1676E+17	516	AMP_L2 + AMP_LINREG_L2
17	82,6289	-74,4479	46448537020	0000	0000	0010	0000	0000	0010	0000	0110	9,3639E+17	2097670	AMP_L1 + AMP_L2 + AMP_LINREG_L2 + AMP_CONTRAST
18	82,4168	-74,6354	46448537021	0000	0000	0000	0001	0000	0010	0000	0100	9,7586E+17	66052	AMP_L2 + AMP_LINREG_L2 + AMP_COVERAGE
19	83,3081	-74,7071	46448537022	0000	0000	0000	0000	0000	0010	0000	0100	8,0851E+17	516	AMP_L2 + AMP_LINREG_L2
20	83,5108	-74,5132	46448537023	0000	1000	0010	0000	0000	0010	0001	0110	1,0152E+18	136315414	AMP_L1 + AMPL2 + AMP_FIT + AMP_LINREG_L2 +

														AMP_CONTRAST + AMP_BIAS

Table 2: 20 retrieval examples from W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+IASI_C_EUMC_20151002030253_46448_eps_o_cox_l2.bin (COX values).

COX														
#	Lon	Lat	UID	bDiv								COLUMN	bDiv (int)	bDiv Meaning
1	94,9966	-74,9836	46448537004	0100	1101	0000	0010	0000	0000	0010	0001	1,6014E+18	1291976737	AMP_ERROR + AMP_OPEN + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
2	94,9160	-75,2282	46448537005	0100	1101	0000	0000	0001	0000	0010	0001	1,2842E+18	1291849761	AMP_ERROR + AMP_OPEN + AMP_RADFILTER + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
3	96,5471	-75,2616	46448537006	0100	1101	0000	0000	0001	0000	0010	0001	1,1710E+18	1291849761	AMP_ERROR + AMP_OPEN + AMP_RADFILTER + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
4	96,5942	-75,0062	46448537007	0100	1101	0000	0010	0001	0000	0010	0001	1,4133E+18	1291980833	AMP_ERROR + AMP_OPEN + AMP_RADFILTER + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
5	91,1755	-74,8918	46448537008	0100	1101	0000	0010	0001	0000	0010	0001	1,5278E+18	1291980833	AMP_ERROR + AMP_OPEN + AMP_RADFILTER + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
6	91,0441	-75,1183	46448537009	0100	1101	0000	0100	0000	0000	0010	0001	1,3958E+18	1292107809	AMP_ERROR + AMP_OPEN + AMP_DESERT + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
7	92,4067	-75,1702	46448537010	0100	1101	0000	0000	0000	0000	0000	0001	9,8297E+17	1291845633	AMP_ERROR + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
8	92,5142	-74,9343	46448537011	0100	1010	0000	0100	0000	0000	0001	1000	7,6402E+17	1241776152	AMP_ANC + AMP_OPEN + AMP_DESERT + AMP_DIVERGED + AMP_BIAS + AMP_AVK
9	87,9281	-74,7629	46448537012	0100	1101	0000	0000	0000	0000	0010	0001	8,3852E+17	1291845665	AMP_ERROR + AMP_OPEN + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
10	87,7609	-74,9742	46448537013	0100	1101	0000	0000	0001	0000	0010	0001	1,3380E+18	1291849761	AMP_ERROR + AMP_OPEN + AMP_RADFILTER + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
11	88,9236	-75,0364	46448537014	0100	1101	0000	0110	0001	0000	0010	0001	1,3924E+18	1292242977	AMP_ERR + AMP_OPEN + AMP_RADFILTER + AMP_SEA + AMP_DESERT + AMP_CONDITION +

														AMP_GSL + AMP_BIAS + AMP_AVK
12	89,0736	-74,8170	46448537015	0100	1101	0000	0010	0001	0000	0010	0001	1,2835E+18	1291980833	AMP_ERROR + AMP_OPEN + AMP_RADFILTER + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
13	85,1107	-74,6120	46448537016	0100	1101	0000	0010	0000	0000	0010	0001	1,1549E+18	1291976737	AMP_ERROR + AMP_OPEN + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
14	84,9176	-74,8104	46448537017	0100	1101	0000	0000	0000	0000	0010	0001	1,0293E+18	1291845665	AMP_ERROR + AMP_OPEN + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
15	85,9277	-74,8786	46448537018	0100	1101	0000	0010	0000	0000	0010	0001	1,1083E+18	1291976737	AMP_ERROR + AMP_OPEN + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK
16	86,1080	-74,6730	46448537019	0100	0100	0000	0001	0000	0000	0000	0000	8,1775E+17	1140916224	AMP_COVERAGE + AMP_GSL + AMP_AVK
17	82,6289	-74,4479	46448537020	0100	1010	0000	0000	0000	1000	0001	1000	9,3586E+17	1241516056	AMP_ANC + AMP_OPEN + AMP_TSKIN + AMP_DIVERGED + AMP_BIAS + AMP_AVK
18	82,4168	-74,6354	46448537021	0100	0111	1000	0001	0000	0010	0000	0000	9,7503E+17	1199636992	AMP_LINREG_L2 + AMP_COVERAGE + AMP_NEGPC + AMP_CONDITION + AMP_DIVERGED + AMP_GSL + AMP_AVK
19	83,3081	-74,7071	46448537022	0100	0100	0000	0001	0000	0000	0000	0000	8,0789E+17	1140916224	AMP_COVERAGE + AMP_GSL + AMP_AVK
20	83,5108	-74,5132	46448537023	0100	1101	0000	0010	0000	0000	0010	0001	1,0154E+18	1291976737	AMP_ERROR + AMP_OPEN + AMP_SEA + AMP_CONDITION + AMP_GSL + AMP_BIAS + AMP_AVK

The CO_FLAG is meant to be a summary quality flag assessing the quality of the retrieved profiles following the retrieval error codes CO_BDIV. It is needed by MACC/CAMS as they filter data before assimilation. It should be calculated as described in Section 4.1 of the FORLI-CO Product Specification, Requirement and Assessment document (FORLICO_PSRA). As long as the CO_BDIV flag is not correct, it is not possible to calculate the general quality flag CO_QFLAG.

In the following as we cannot use the CO_BDIV error codes in order to filter the data, we will compare unfiltered data (i.e. even incorrect or dubious results).

2.3 Monitoring of unfiltered data

We studied 20 days of data, from 20151005 to 20151024. Table 3 presents statistics between COX data and FORLI-CO data for these 20 days. When looking at the days where we have the same number of PDU files for COX and FORLI, the differences in the number of retrieved pixels range from 2500 to 4200 (#FORLI_pixels > #COX_pixels). BUFR encoding of the COX results could be responsible for a more aggressive filtering of data.

Table 3: Statistics between COX data and FORLI-CO data, from 20151005 to 20151024. Profiles correlation ("Correlation") score is computed using the discreet cross correlation integral between two profiles, normalized by the square root of the product of their auto-correlation integral. Score of 1 is expected for perfectly matching profiles, 0 for unrelated ones. Absolute and relative differences are calculated for the total columns.

20151005

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	478	480	479	480
Individual Pixels	441729	445394	503891	507792
Common Pixels	441480		503634	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9125		0.9509	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0000(0.0041)		nan(nan)	
Absolute Difference Max (10^{19} mol/cm^2)	1.5025		1.1230	
Absolute Difference Min (10^{19} mol/cm^2)	-0.7113		-6.5263	
Relative Difference Mean (%)	-0.003(2.123)		nan(nan)	
Relative Difference Max (%)	798.832		666.911	
Relative Difference Min (%)	-44.379		-28.856	

20151006

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	401	401	480	480
Individual Pixels	362631	365184	497110	501074
Common Pixels	362405		496827	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8763		0.8259	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0001(0.0077)		-0.0000(0.0120)	
Absolute Difference Max (10^{19} mol/cm^2)	2.5812		6.0139	
Absolute Difference Min (10^{19} mol/cm^2)	-1.2258		-4.7437	
Relative Difference Mean (%)	-0.001(2.037)		0.001(2.233)	
Relative Difference Max (%)	705.771		1147.297	
Relative Difference Min (%)	-48.615		-66.903	

20151007

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	464	464	464	464
Individual Pixels	452560	455835	488098	492107
Common Pixels	452287		487855	
Correlation Max	1.0000		1.0000	
Correlation Min	0.6991		0.8343	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0001(0.0190)		-0.0000(0.0122)	
Absolute Difference Max (10^{19} mol/cm^2)	5.2459		3.0424	
Absolute Difference Min (10^{19} mol/cm^2)	-7.9066		-3.2980	
Relative Difference Mean (%)	-0.005(1.164)		0.000(0.876)	
Relative Difference Max (%)	473.144		235.691	
Relative Difference Min (%)	-62.977		-46.202	

20151008

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	451676	455090	500893	504795
Common Pixels	451433		500605	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8883		0.9053	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0001(0.0145)		-0.0000(0.0084)	
Absolute Difference Max (10^{19} mol/cm^2)	2.4692		1.9222	
Absolute Difference Min (10^{19} mol/cm^2)	-6.1765		-2.4402	
Relative Difference Mean (%)	-0.005(1.190)		0.005(2.384)	
Relative Difference Max (%)	471.896		1155.109	
Relative Difference Min (%)	-61.445		-53.618	

20151009

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	467135	470757	509877	513227
Common Pixels	466901		509182	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9005		0.9537	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0000(0.0101)		-0.0000(0.0048)	
Absolute Difference Max (10^{19} mol/cm^2)	2.5326		1.2186	
Absolute Difference Min (10^{19} mol/cm^2)	-4.1904		-1.0531	
Relative Difference Mean (%)	0.000(1.676)		0.000(1.565)	
Relative Difference Max (%)	808.952		803.744	
Relative Difference Min (%)	-58.477		-60.523	

20151010

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	481
Individual Pixels	460123	463569	507576	511280
Common Pixels	459689		507306	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8365		0.8469	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0119)		-0.0000(0.0104)	
Absolute Difference Max (10^{19} mol/cm^2)	2.8513		4.3987	
Absolute Difference Min (10^{19} mol/cm^2)	-2.4043		-2.6911	
Relative Difference Mean (%)	0.022(2.513)		0.005(1.044)	
Relative Difference Max (%)	684.125		321.782	
Relative Difference Min (%)	-72.844		-60.907	

20151011

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	474443	477811	508215	512272
Common Pixels	474181		507926	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8191		0.9446	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0220)		-0.0000(0.0070)	
Absolute Difference Max (10^{19} mol/cm^2)	2.8143		1.5643	
Absolute Difference Min (10^{19} mol/cm^2)	-9.8949		-1.8010	
Relative Difference Mean (%)	0.064(5.019)		0.010(1.635)	
Relative Difference Max (%)	1011.013		927.562	
Relative Difference Min (%)	-65.078		-50.974	

20151012

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	465681	469144	509731	513582
Common Pixels	465417		509481	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7691		0.8752	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0226)		-0.0000(0.0108)	
Absolute Difference Max (10^{19} mol/cm^2)	4.5461		3.4947	
Absolute Difference Min (10^{19} mol/cm^2)	-4.8026		-1.9867	
Relative Difference Mean (%)	0.068(5.288)		0.009(1.726)	
Relative Difference Max (%)	1172.610		589.751	
Relative Difference Min (%)	-67.087		-60.124	

20151013

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	457459	461185	510783	514810
Common Pixels	457208		510496	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8224		0.8543	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0271)		-0.0000(0.0165)	
Absolute Difference Max (10^{19} mol/cm^2)	5.5684		3.3331	
Absolute Difference Min (10^{19} mol/cm^2)	-4.2948		-2.7819	
Relative Difference Mean (%)	0.051(3.955)		0.019(2.189)	
Relative Difference Max (%)	888.563		625.684	
Relative Difference Min (%)	-56.073		-72.817	

20151014

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	343	343	480	480
Individual Pixels	337652	340292	514427	518269
Common Pixels	337429		514182	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7272		0.8152	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0000(0.0268)		0.0000(0.0184)	
Absolute Difference Max (10^{19} mol/cm^2)	3.6397		4.8745	
Absolute Difference Min (10^{19} mol/cm^2)	-4.1952		-3.6243	
Relative Difference Mean (%)	0.032(3.889)		0.013(1.460)	
Relative Difference Max (%)	929.994		409.107	
Relative Difference Min (%)	-69.160		-54.180	

20151015

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	421	423	410	410
Individual Pixels	403698	407203	430682	434044
Common Pixels	403500		430475	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7933		0.7385	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0001(0.0282)		-0.0000(0.0197)	
Absolute Difference Max (10^{19} mol/cm^2)	5.8612		3.9251	
Absolute Difference Min (10^{19} mol/cm^2)	-5.2664		-3.9098	
Relative Difference Mean (%)	0.048(5.216)		0.022(3.517)	
Relative Difference Max (%)	1782.746		1079.613	
Relative Difference Min (%)	-58.568		-78.185	

20151016

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	464470	468258	504942	509151
Common Pixels	464257		504696	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7823		0.8591	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0327)		-0.0000(0.0292)	
Absolute Difference Max (10^{19} mol/cm^2)	5.9630		5.1898	
Absolute Difference Min (10^{19} mol/cm^2)	-4.3108		-4.5654	
Relative Difference Mean (%)	0.024(3.700)		0.007(1.961)	
Relative Difference Max (%)	1280.132		965.564	
Relative Difference Min (%)	-95.390		-66.759	

20151017

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	478	480
Individual Pixels	446508	450586	496448	501066
Common Pixels	446312		496235	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8215		0.8927	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0000(0.0359)		-0.0001(0.0311)	
Absolute Difference Max (10^{19} mol/cm^2)	4.7222		4.5297	
Absolute Difference Min (10^{19} mol/cm^2)	-8.9889		-4.3105	
Relative Difference Mean (%)	0.049(5.120)		0.012(2.577)	
Relative Difference Max (%)	1730.382		1424.017	
Relative Difference Min (%)	-96.059		-71.618	

20151018

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	434366	438481	490335	494493
Common Pixels	434151		490118	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7941		0.8513	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0421)		0.0001(0.0370)	
Absolute Difference Max (10^{19} mol/cm^2)	7.5903		6.9646	
Absolute Difference Min (10^{19} mol/cm^2)	-19.8063		-7.3970	
Relative Difference Mean (%)	0.079(6.942)		0.044(4.672)	
Relative Difference Max (%)	1973.404		1801.874	
Relative Difference Min (%)	-81.475		-69.068	

20151019

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	436734	440343	496936	500558
Common Pixels	436105		496727	
Correlation Max	1.0000		1.0000	
Correlation Min	0.8148		0.7435	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0001(0.0356)		-0.0001(0.0368)	
Absolute Difference Max (10^{19} mol/cm^2)	10.5452		11.0583	
Absolute Difference Min (10^{19} mol/cm^2)	-5.5201		-14.9629	
Relative Difference Mean (%)	0.040(3.767)		0.028(3.549)	
Relative Difference Max (%)	972.387		1285.268	
Relative Difference Min (%)	-76.551		-82.547	

20151020

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	479	480	480	480
Individual Pixels	437828	441216	486544	490158
Common Pixels	437577		486302	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9117		0.8438	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0000(0.0266)		-0.0000(0.0287)	
Absolute Difference Max (10^{19} mol/cm^2)	4.2526		5.4373	
Absolute Difference Min (10^{19} mol/cm^2)	-6.2325		-4.2662	
Relative Difference Mean (%)	0.041(4.366)		0.022(2.819)	
Relative Difference Max (%)	1038.212		953.180	
Relative Difference Min (%)	-65.472		-76.951	

20151021

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	444230	447406	496976	500851
Common Pixels	443983		496705	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7653		0.8408	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0382)		-0.0001(0.0286)	
Absolute Difference Max (10^{19} mol/cm^2)	7.9997		5.9808	
Absolute Difference Min (10^{19} mol/cm^2)	-13.1277		-4.6946	
Relative Difference Mean (%)	0.062(6.266)		0.024(3.761)	
Relative Difference Max (%)	1827.871		1298.746	
Relative Difference Min (%)	-69.448		-68.723	

20151022

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	437835	441158	505858	509921
Common Pixels	437610		505638	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9148		0.9167	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0001(0.0405)		-0.0002(0.0318)	
Absolute Difference Max (10^{19} mol/cm^2)	7.4986		5.6231	
Absolute Difference Min (10^{19} mol/cm^2)	-17.7737		-7.3517	
Relative Difference Mean (%)	0.035(4.123)		0.013(1.960)	
Relative Difference Max (%)	1137.127		579.134	
Relative Difference Min (%)	-83.201		-69.110	

20151023

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	401	401
Individual Pixels	434575	437678	411941	414798
Common Pixels	434325		411749	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9394		0.9596	
Absolute Difference Mean (10^{19} mol/cm^2)	nan(nan)		-0.0001(0.0247)	
Absolute Difference Max (10^{19} mol/cm^2)	6.8639		5.5613	
Absolute Difference Min (10^{19} mol/cm^2)	-4.7533		-3.9628	
Relative Difference Mean (%)	nan(nan)		0.006(1.661)	
Relative Difference Max (%)	822.675		671.920	
Relative Difference Min (%)	-66.834		-76.839	

20151024

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	479	480	478	480
Individual Pixels	430346	433571	492698	495897
Common Pixels	430181		492486	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9028		0.8906	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0001(0.0238)		-0.0001(0.0303)	
Absolute Difference Max (10^{19} mol/cm^2)	6.2297		3.5104	
Absolute Difference Min (10^{19} mol/cm^2)	-7.0407		-10.1373	
Relative Difference Mean (%)	-0.001(1.429)		0.016(3.274)	
Relative Difference Max (%)	440.973		825.282	
Relative Difference Min (%)	-63.512		-77.114	

Table 4: Statistics between COX and FORLI-CO averaging kernel data, from 20151005 to 20151024. We calculated the "distance" between the averaging kernel matrix from COX and the averaging kernel matrix from FORLI-CO: distance=$\sum\sqrt{(a_{i\_COX} - a_{i\_FORLI})^2}$, for every element a_i of the averaging kernel matrix. For each day (for MetOp-A and B), the max, min, mean and standard deviation of the "distance" for every pixel has been calculated.

		Distance			
Date	**MetOp**	**Max**	**Min*10^{-5}**	**Mean*10^{-3}**	**Std**
20151005	A	0.1421	0.1602	0.2385	0.0024
	B	0.1480	0.1989	0.2392	0.0025
20151006	A	0.1510	0.0174	0.2449	0.0025
	B	0.1409	0.1923	0.2500	0.0025
20151007	A	0.1412	0.0031	0.2150	0.0022
	B	0.1541	0.0100	0.2394	0.0025
20151008	A	0.1262	0.0068	0.2238	0.0023
	B	0.1428	0.0159	0.2342	0.0024
20151009	A	0.1405	0.0123	0.2216	0.0023
	B	0.1674	0.0135	0.2512	0.0025
20151010	A	0.1413	0.0028	0.2375	0.0025
	B	0.1617	0.0143	0.2490	0.0026
20151011	A	0.1420	0.0108	0.2370	0.0025
	B	0.1455	0.0820	0.2547	0.0026
20151012	A	0.1386	0.0085	0.2330	0.0024
	B	0.1511	0.0084	0.2491	0.0025
20151013	A	0.1433	0.0018	0.2530	0.0025
	B	0.1481	0.0107	0.2687	0.0027
20151014	A	0.1487	0.0042	0.2594	0.0027
	B	0.1671	0.0067	0.2520	0.0025
20151015	A	0.1653	0.0013	0.2592	0.0026

	B	0.1770	0.0044	0.2579	0.0025
20151016	A	0.1999	0.0024	0.2378	0.0025
	B	0.2146	0.0016	0.2493	0.0025
20151017	A	0.2198	0.0033	0.2232	0.0023
	B	0.1923	0.0044	0.2411	0.0025
20151018	A	0.1738	0.0036	0.2217	0.0022
	B	0.1818	0.0024	0.2527	0.0026
20151019	A	0.1698	0.0035	0.2233	0.0023
	B	0.1728	0.0027	0.2426	0.0025
20151020	A	0.1742	0.0026	0.2346	0.0024
	B	0.1640	0.0014	0.2609	0.0026
20151021	A	0.1592	0.0035	0.2239	0.0022
	B	0.1673	0.0041	0.2581	0.0025
20151022	A	0.1693	0.0009	0.2243	0.0022
	B	0.1617	0.0011	0.2477	0.0025
20151023	A	0.1864	0.0015	0.2286	0.0024
	B	0.1729	0.0022	0.2614	0.0026
20151024	A	0.1631	0.0061	0.2159	0.0022
	B	0.1941	0.0033	0.2416	0.0025

In conclusion the CO total columns, the profiles and the averaging kernels are in good agreement when comparing 20 days. For the total columns: mean(relative_difference_mean)=0.0225; mean(relative_difference_std)=3.017. For the profiles: mean(correlation_min)=0.9125. For the averaging kernel matrices: mean(distance_mean)=2.4142 x 10^{-4}; mean(distance_std)=0.0025.

2.3.1 Total columns comparison for one day

In the following, we will focus on one day: 20151021 (randomly chosen). Relative total column differences distributions are presented in Figures 1 and 2, corresponding maps in Figure 3. Figures 4 and 5 show the absolute total column differences distributions. Linear distributions are presented in Figure 6 (by recording order) and in Figure 7 (by latitude). Finally, correlations plots are shown in Figures 8 and 9.

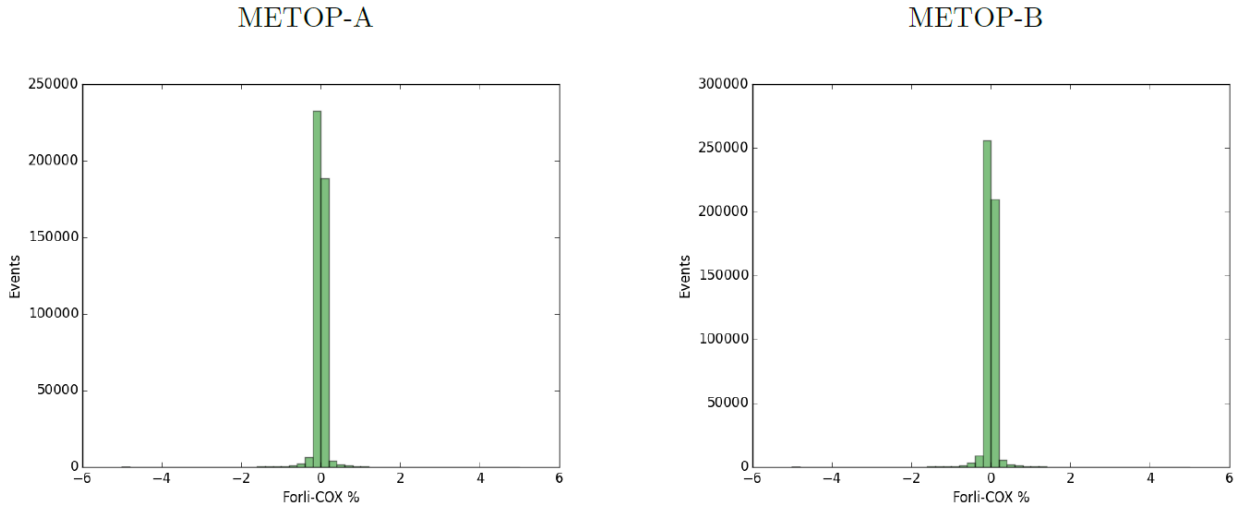


Figure 1: Linear scale total column relative differences distribution (note that the scales are different)

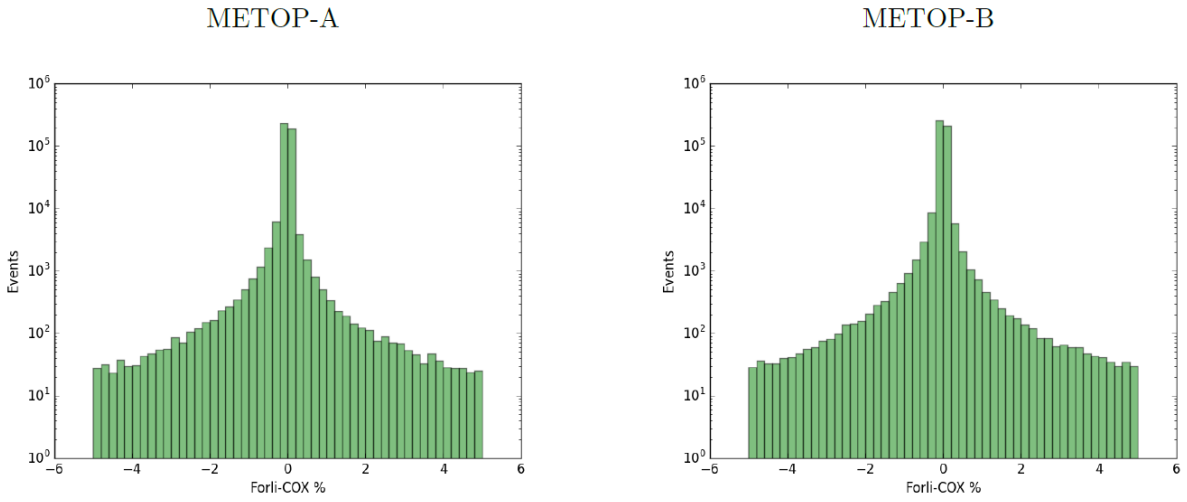


Figure 2: Logarithmic scale total column relative differences distribution

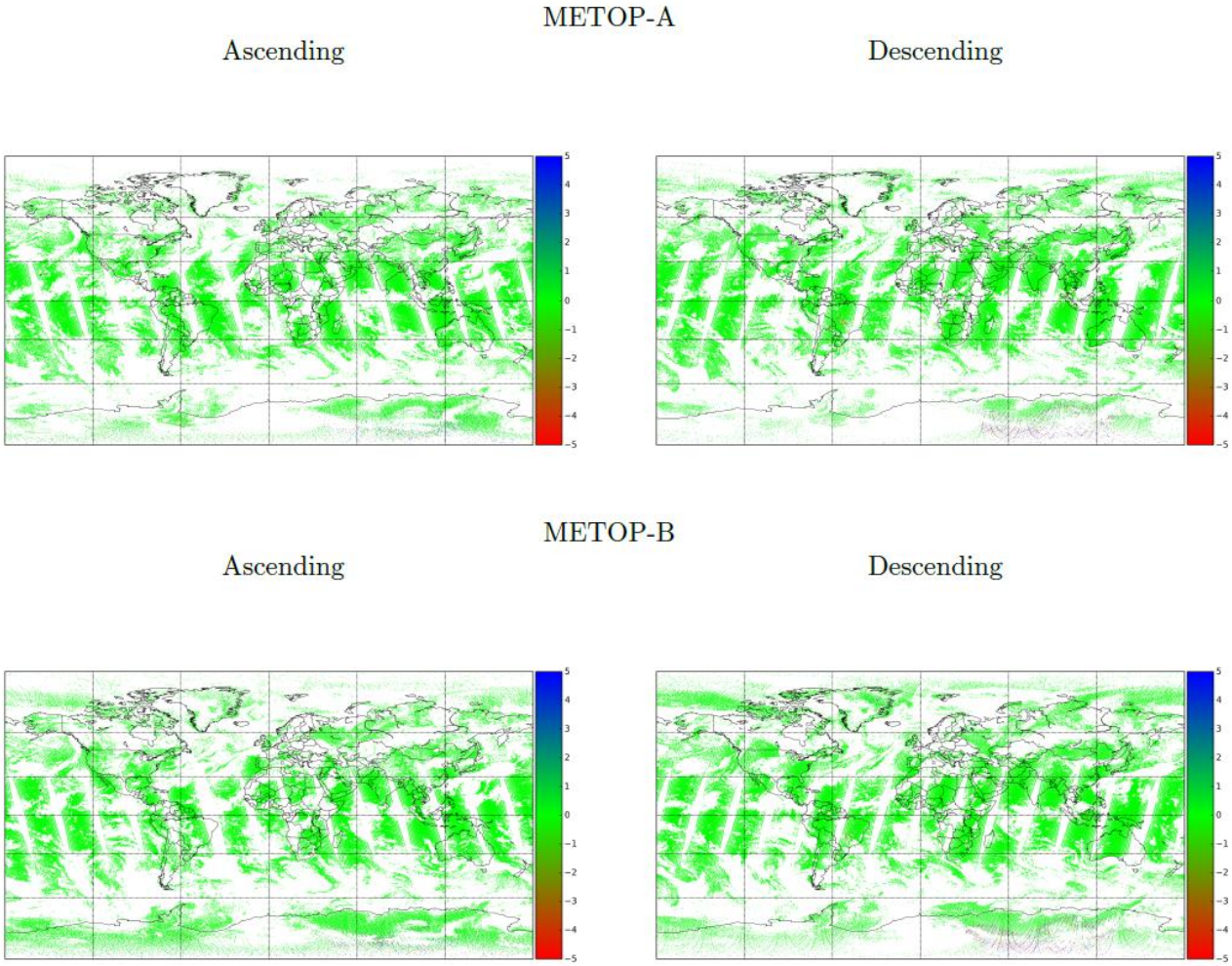


Figure 3: Total column relative differences maps

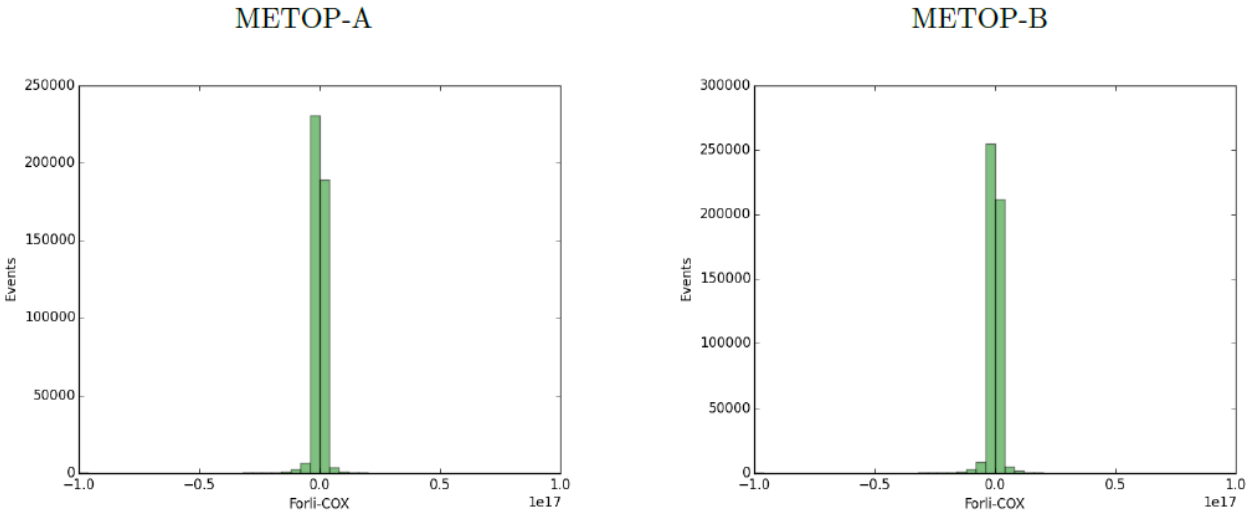


Figure 4: Linear scale total column absolute differences distribution (molecules/cm^2)

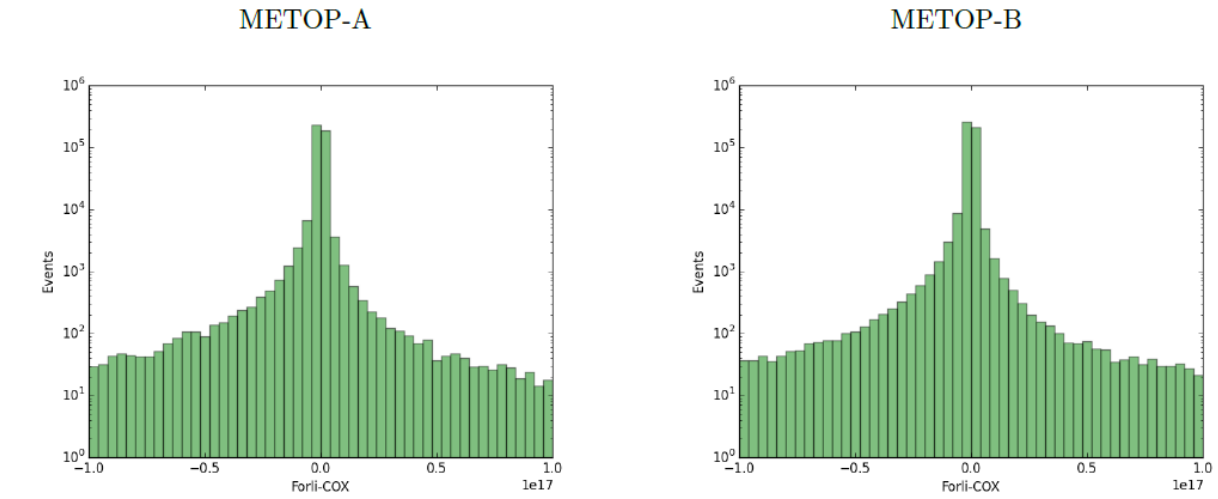


Figure 5: Logarithmic scale Total column absolute differences distribution (molecules/cm^2)

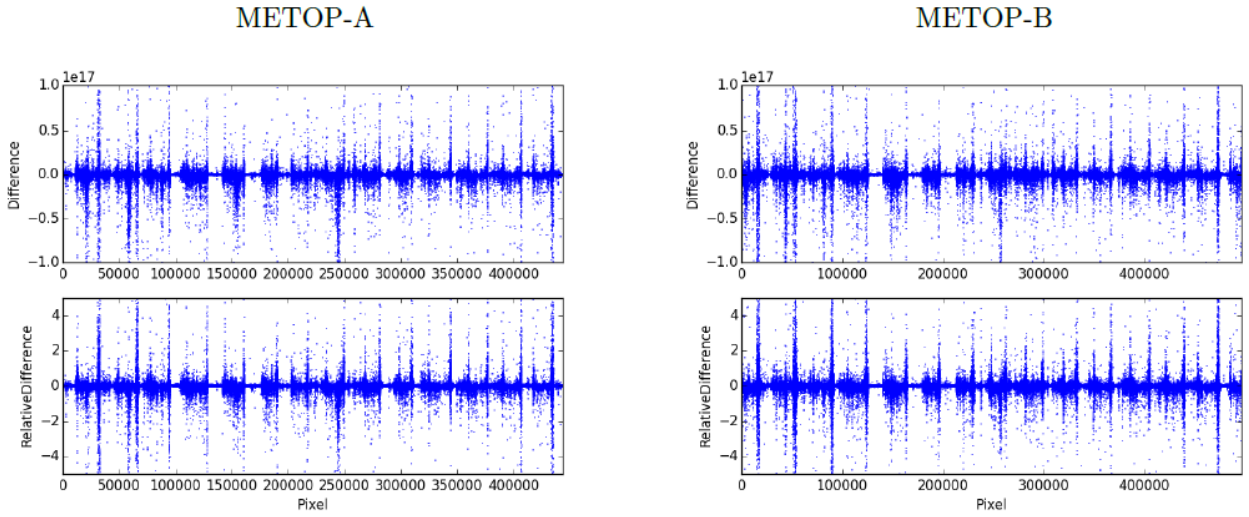


Figure 6: Absolute (molecules/cm^2) and relative (%) total column differences by pixel order

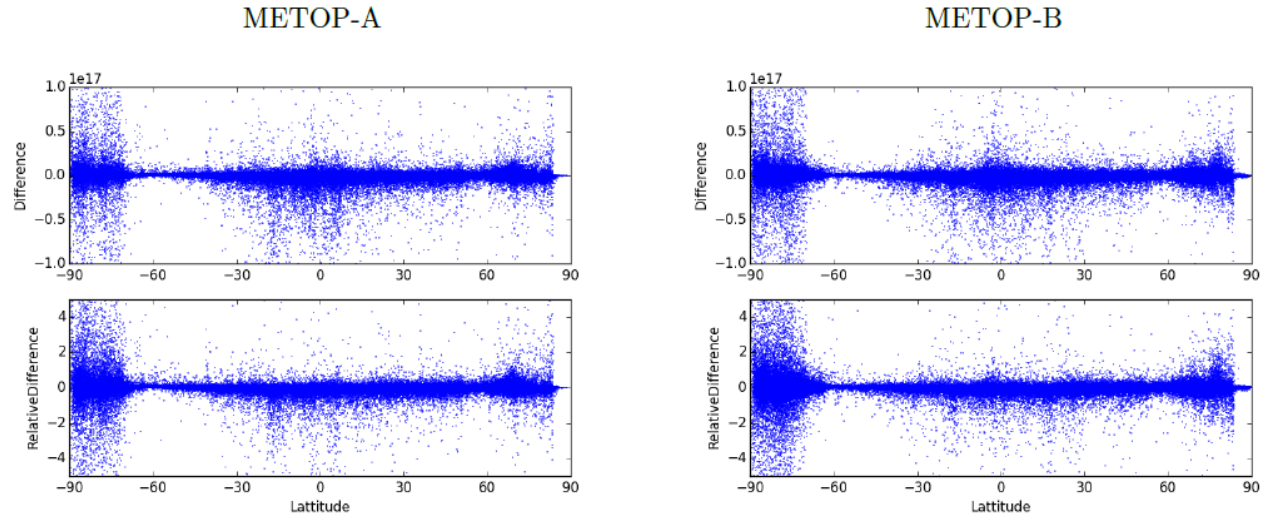


Figure 7: Absolute (molecules/cm^2) and relative (%) total column differences by latitude

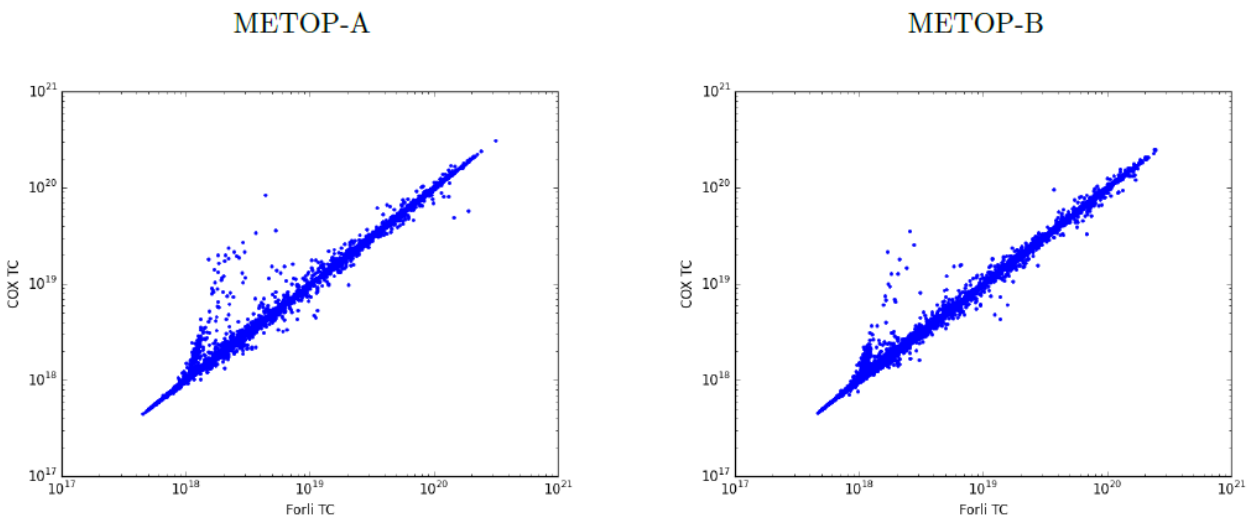


Figure 8: COX vs FORLI-CO total columns (molecules/cm^2)

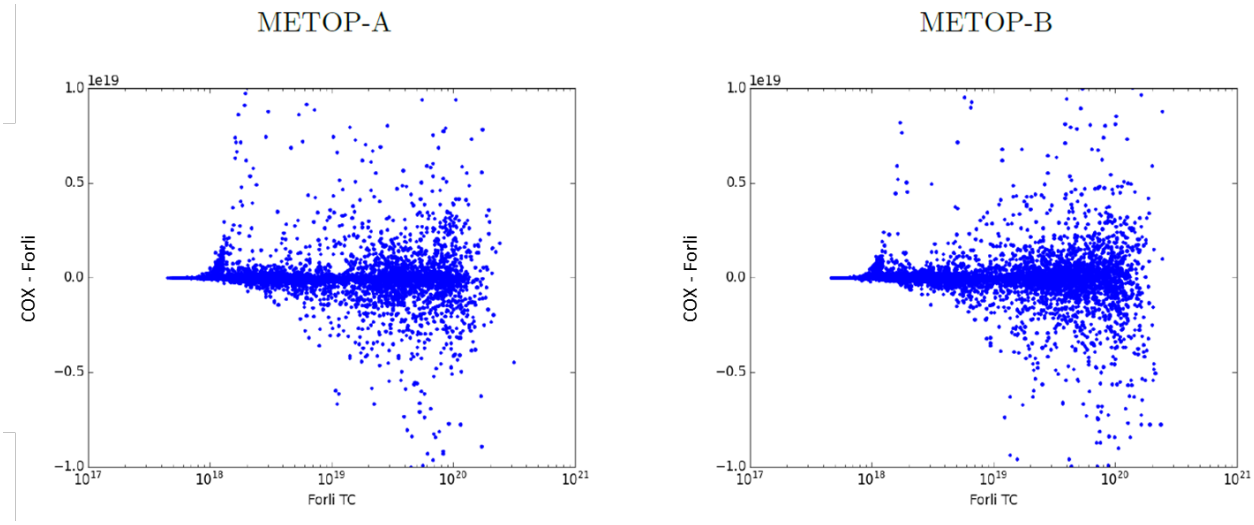


Figure 9: Total columns (molecules/cm^2) differences (COX-FORLI-CO) vs FORLI-CO total columns

2.3.2 Vertical profiles comparison for one day

For the vertical profiles comparison for 20151021, histograms showing the profiles correlation distributions are presented in Figures 10 and 11. Corresponding profiles correlation maps on the global scale are presented in Figure 12.

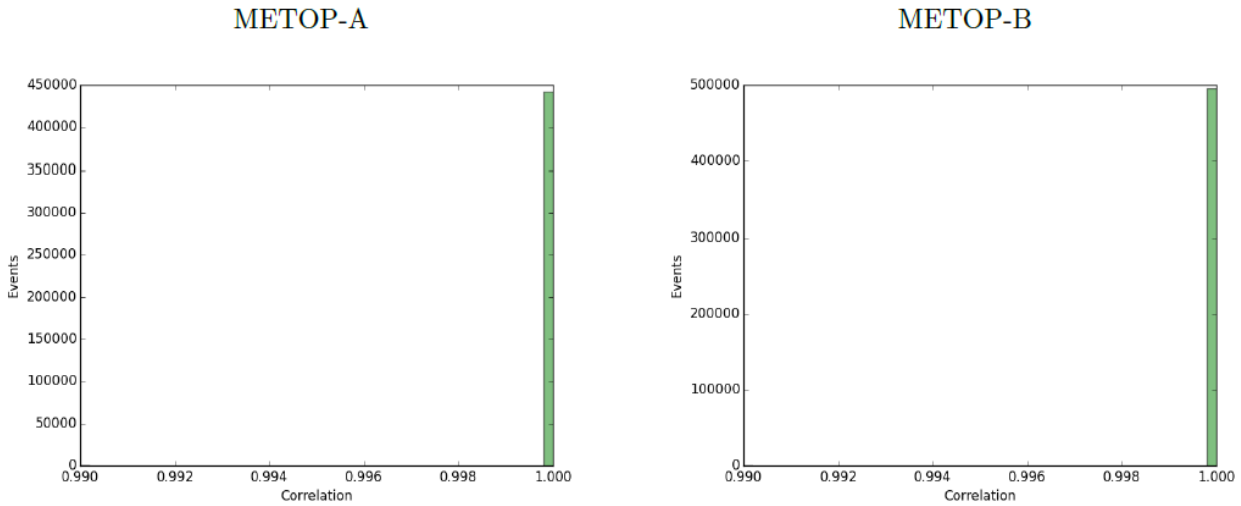


Figure 10: Linear scale profiles correlation distribution

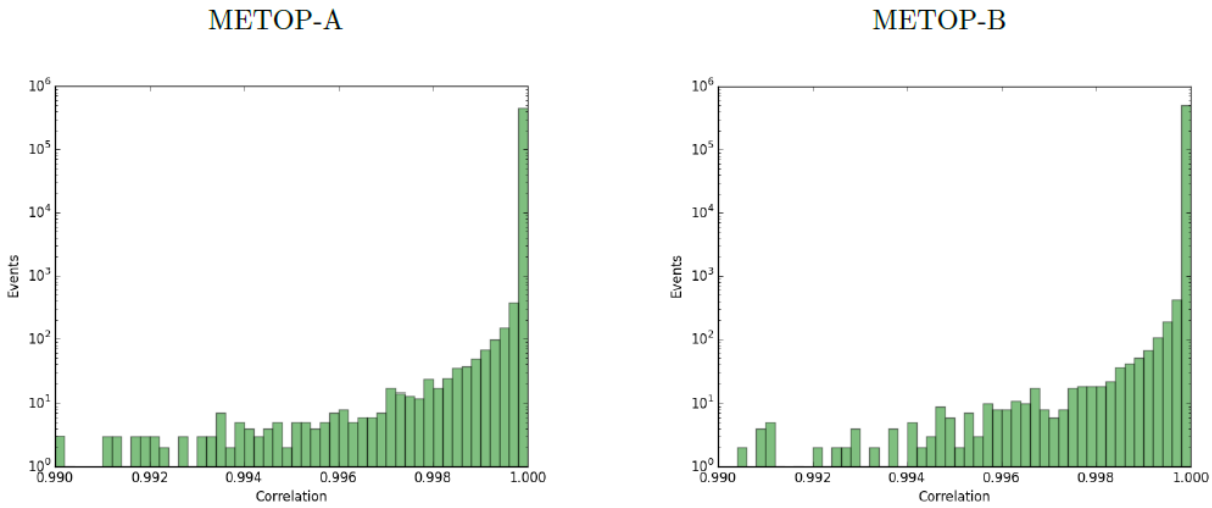


Figure 11: Logarithmic scale profiles correlation distribution

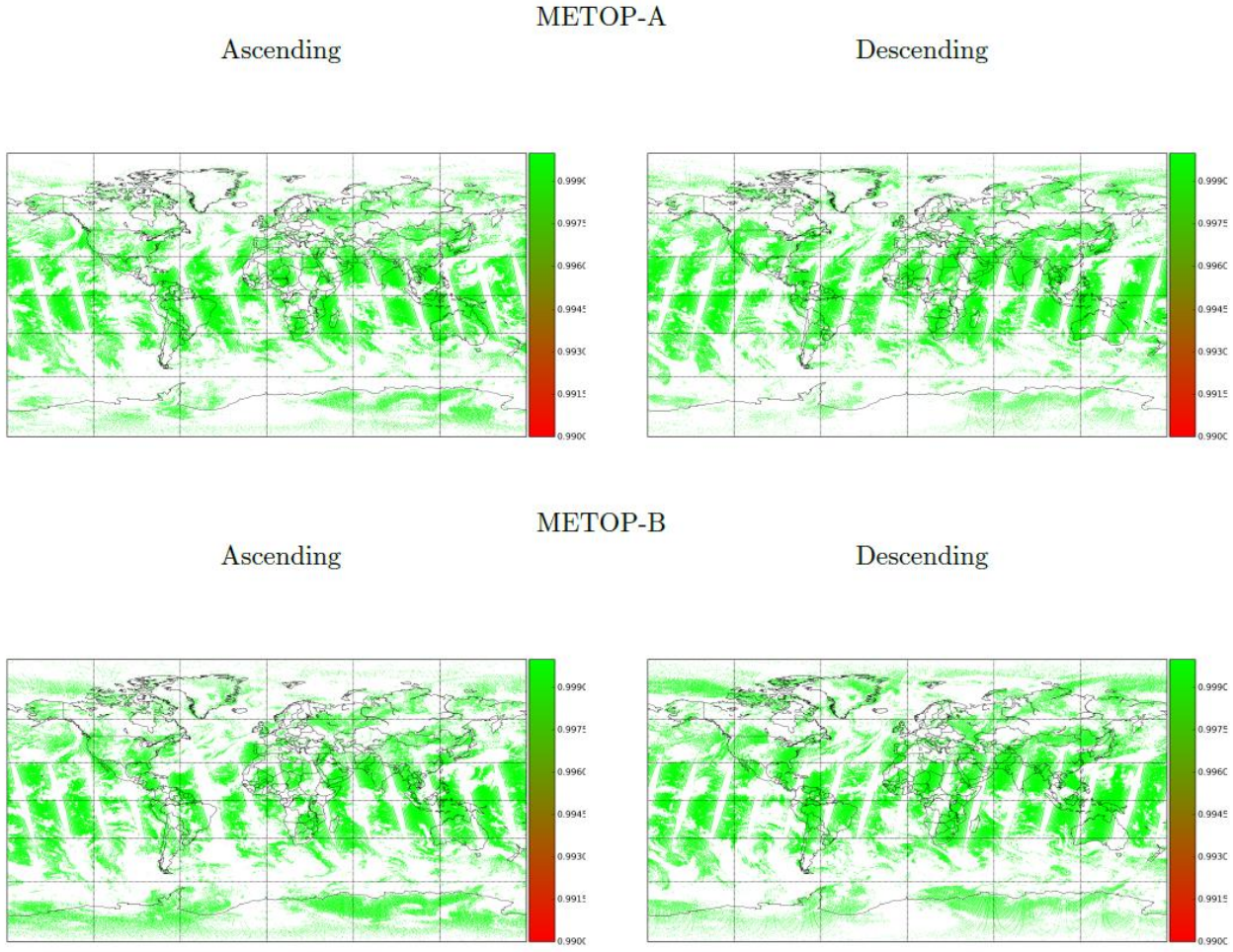


Figure 12: Maps of profiles correlation

2.3.3 Averaging kernels comparison for one day

We present here the "distance" between the averaging kernel matrix from COX and the averaging kernel from FORLI-CO for one day: 20151021. Distance=$\sum\sqrt{(a_{i\_COX} - a_{i\_FORLI})^2}$, for every element a_i of the averaging kernel matrix. Histograms showing the "distance" distributions are presented in Figures 13 and 14. Corresponding "distance" maps on the global scale are presented in Figure 15. "Distance" by pixel order and by latitude are presented in Figures 16 and 17.

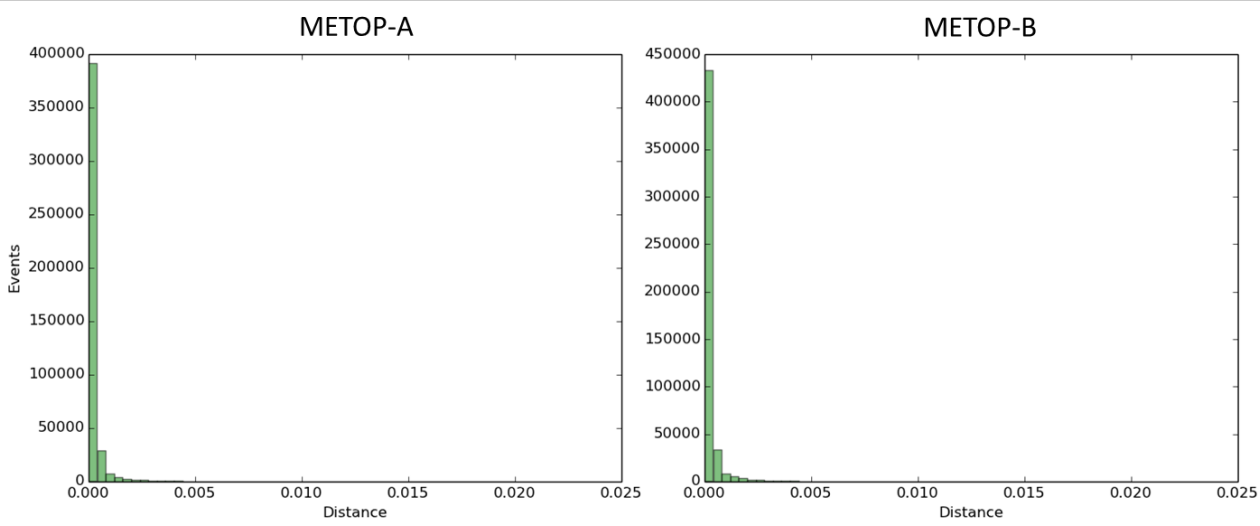


Figure 13: Linear scale distance distribution

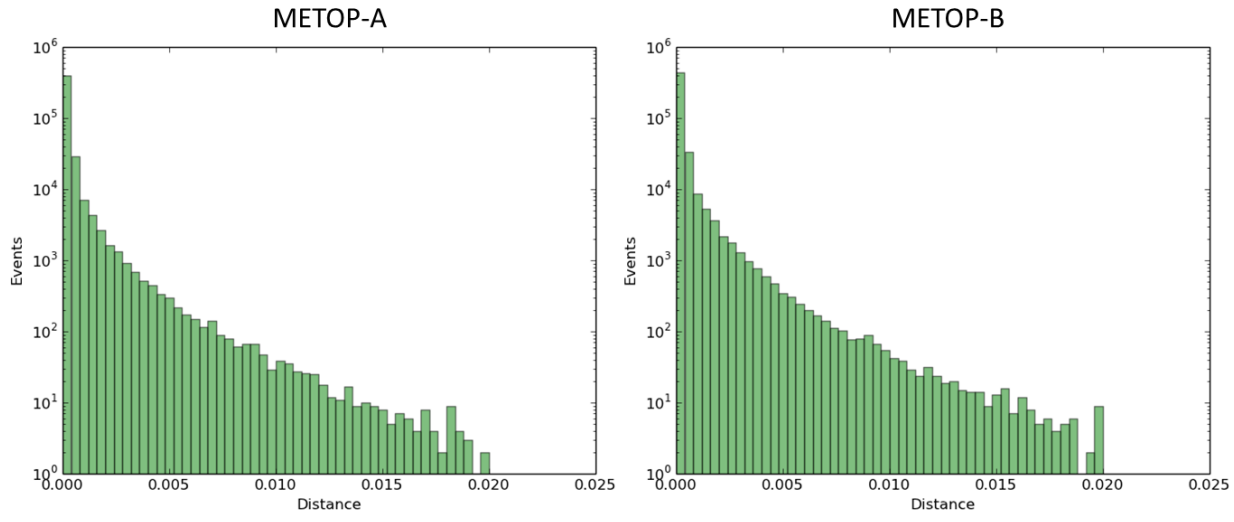


Figure 14: Logarithmic scale distance distribution

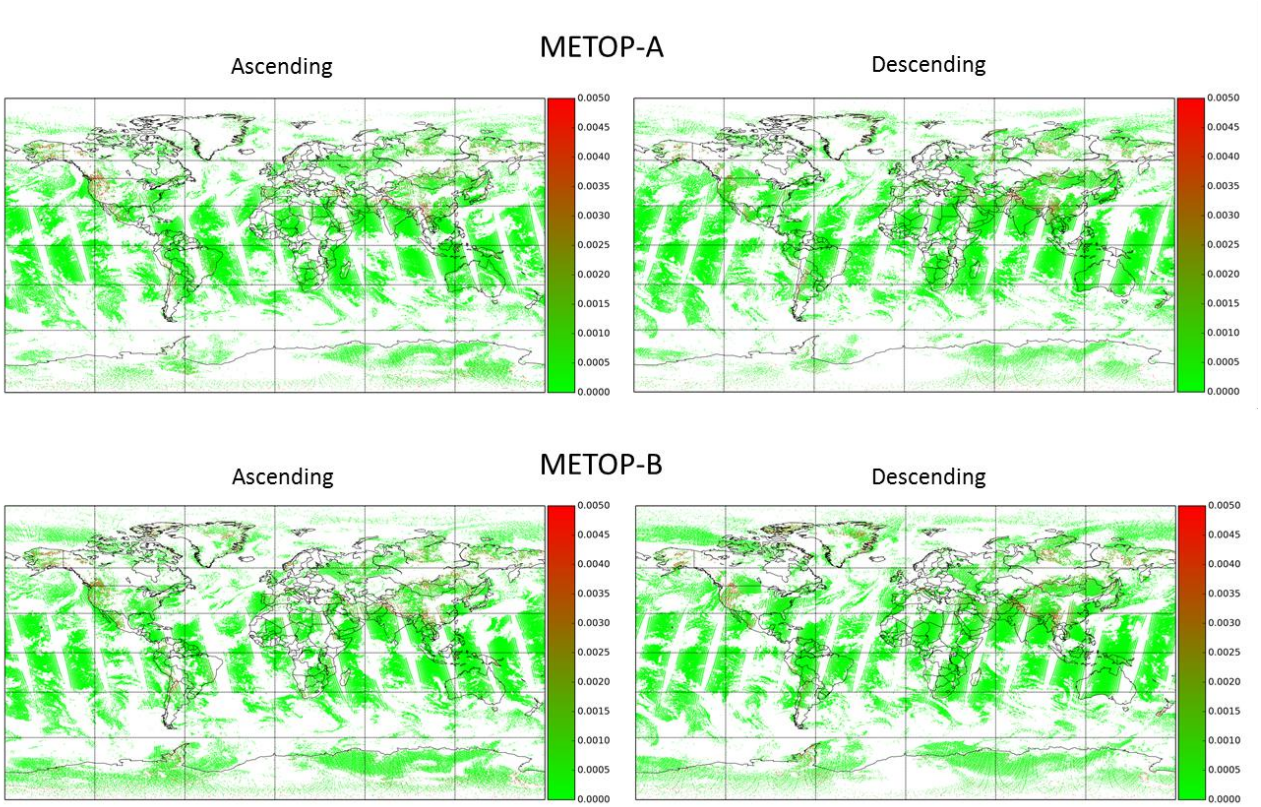


Figure 15: Distance maps

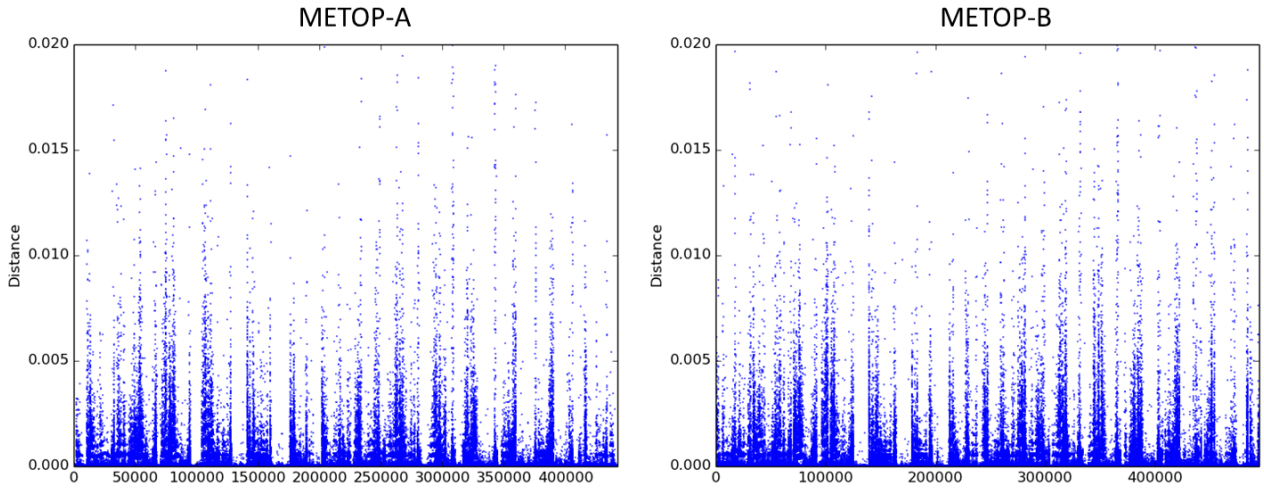


Figure 16: Distance by pixel order

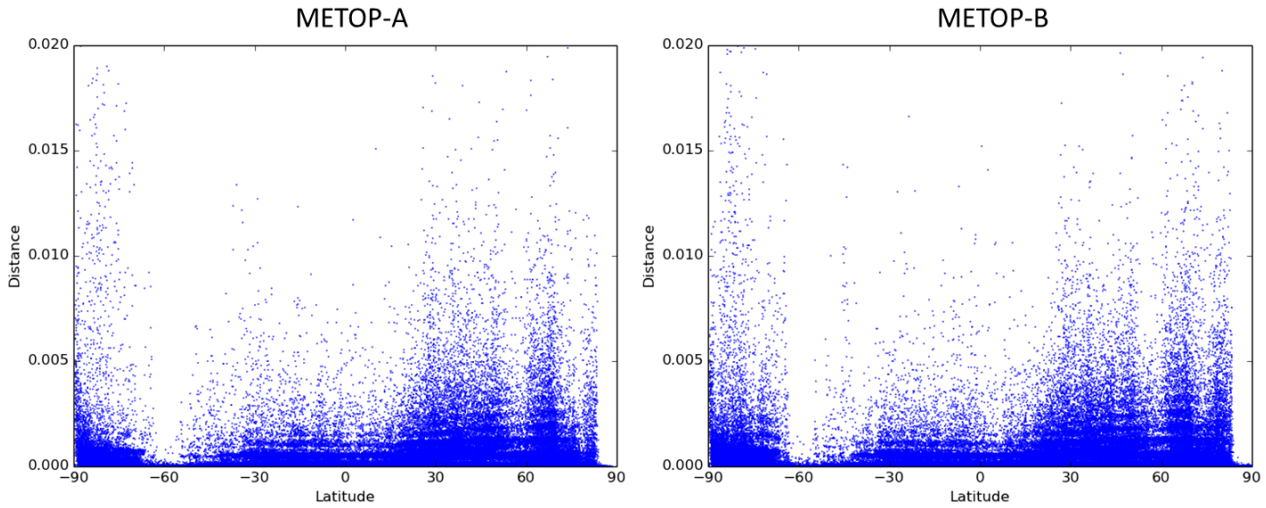


Figure 17: Distance by latitude

2.4 Monitoring of one test day of filtered data

As we cannot use the CO_BDIV error codes in order to filter the data, we did one test day (20151021) where the COX pixels have been filtered according to the pixels filtered in FORLI (by matching the pixel UID). The statistics are presented in Table 5. Figures 18 and 19 show correlation plots. As expected the correlation coefficients are larger with the filtered data compared with the unfiltered data: 0.97 vs 0.77 for MetOp-A and 0.97 vs 0.84 for MetOp-B. Regarding the absolute difference mean, the standard deviation values are smaller when the data are filtered (0.0008 vs 0.0382 for MetOp-A and 0.0015 vs 0.0286 for MetOp-B). Looking at Figures 18 and 19 (compared to Figures 8 and 9 for unfiltered data), we notice the better correlation for the total columns.

Table 5: Statistics for the 20151021, unfiltered and filtered data.

Unfiltered:

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	444230	447406	496976	500851
Common Pixels	443983		496705	
Correlation Max	1.0000		1.0000	
Correlation Min	0.7653		0.8408	
Absolute Difference Mean (10^{19} mol/cm^2)	0.0000(0.0382)		-0.0001(0.0286)	
Absolute Difference Max (10^{19} mol/cm^2)	7.9997		5.9808	
Absolute Difference Min (10^{19} mol/cm^2)	-13.1277		-4.6946	
Relative Difference Mean (%)	0.062(6.266)		0.024(3.761)	
Relative Difference Max (%)	1827.871		1298.746	
Relative Difference Min (%)	-69.448		-68.723	

Filtered:

	METOP-A		METOP-B	
	COX	FORLI	COX	FORLI
PDU's	480	480	480	480
Individual Pixels	444230	402598	496976	453482
Common Pixels	399928		450411	
Correlation Max	1.0000		1.0000	
Correlation Min	0.9732		0.9703	
Absolute Difference Mean (10^{19} mol/cm^2)	-0.0000(0.0008)		-0.0000(0.0015)	
Absolute Difference Max (10^{19} mol/cm^2)	0.0676		0.1895	
Absolute Difference Min (10^{19} mol/cm^2)	-0.1645		-0.6677	
Relative Difference Mean (%)	-0.006(0.214)		-0.005(0.213)	
Relative Difference Max (%)	33.472		24.579	
Relative Difference Min (%)	-34.324		-21.421	

METOP-A METOP-B

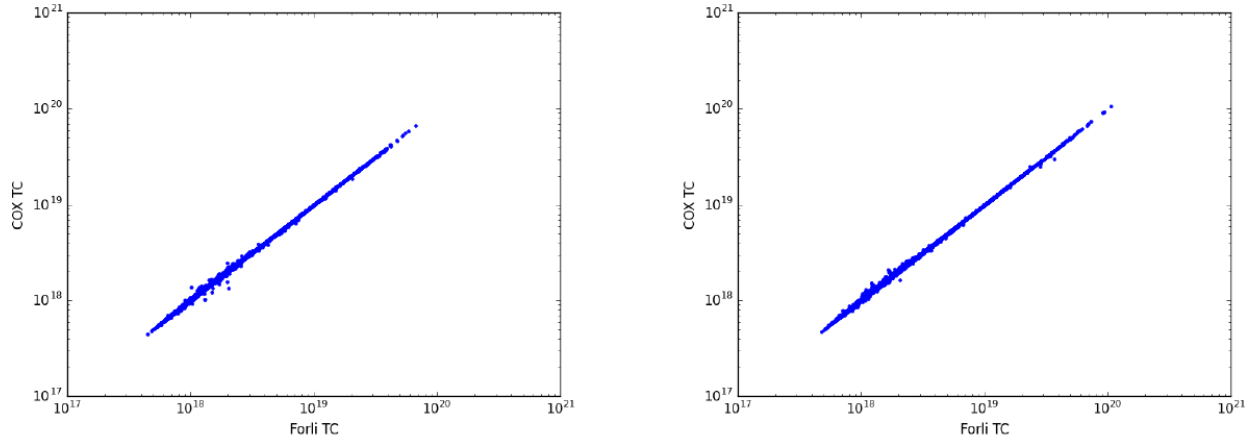


Figure 18: COX vs FORLI total columns for filtered data (20151021)

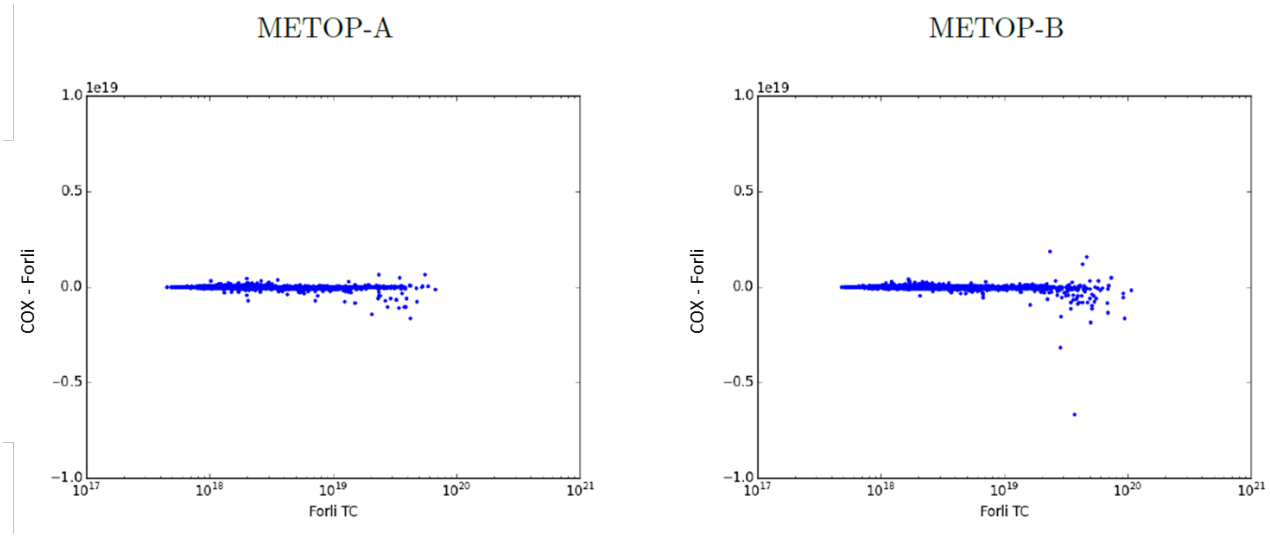


Figure 19: Total columns differences vs FORLI total columns for filtered data (20151021)

3. CONCLUSION AND RECOMMENDATIONS

3.1 Conclusions

CO total column, profiles and averaging kernels retrievals are in good agreement.

The major issue is the inconsistency of the retrieval error codes CO_BDIV. This field is mandatory for the users because it allows the filtering of the most reliable data. After this is solved, and considering the good agreement on the columns and profiles, we anticipate that the CO product can be declared operational.

The number of retrieved pixels differs between FORLI-CO and COX. When looking at 10 days where we have the same number of PDU files, the differences range from 2500 to 4200 pixels (#FORLI_pixels > #COX_pixels). BUFR encoding of the COX results could be responsible for a more aggressive filtering of data.

We noted that in the BUFR files CO_BDIV is encoded with 31 bits whereas the native width is 32 bits.

3.2 Recommendations

We would recommend updating the FORLI-CO version currently running at EUMETSAT, i.e. to switch from v20140922 to v20151001. The code was delivered to EUMETSAT on October 23rd 2015 by email.

The major changes in v20151001 are:

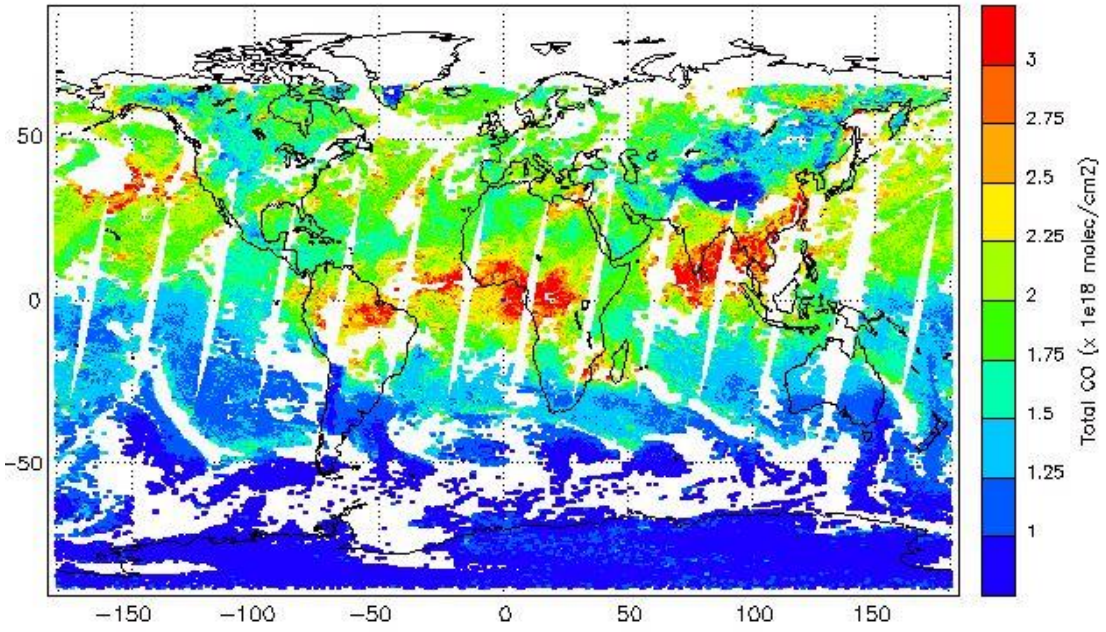
- The general quality flag (GQF) return parameter was added (Implemented for CO only)
- Correction to emissivity integration (double rad to deg correction was applied)
- Correction to some continua region
- Improved maintainability (slowly migrating to C++11 standard)
- Corrections to LUT (Bug during previous construction and/or decimation)
- Bigger LUT range for O_3 (Future improvements and features)

In this version, the general quality flag CO_QFLAG is also calculated by FORLI. This might save some time and allow delivering an operational product more rapidly.

O3M SAF VALIDATION REPORT UPDATE

Validated products:

Identifier	Name	Acronym
O3M-80	Near Real-Time IASI CO	MBI-N-CO



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Reporting period: 24 September 2015 – 2 November 2015

Input data versions: IASI Level 1C version 7.1, since 22.07.2014

Data processor versions: PGE version 6.1, since 24.09.2015

Table of Contents

1. INTRODUCTION

In the CO Validation Report delivered in January 2016, we analyzed the differences between the EUMETSAT products disseminated by EUMETCast in BUFR format (COX) and the products routinely generated both at ULB (Belgium) and LATMOS (France) using the FORLI retrieval algorithm (FORLI-CO v20140922). We concluded that the CO total column, profiles and averaging kernels retrievals were in good agreement but the retrieval error codes CO_BDIV ("RETRIEVAL FLAGS") was inconsistent. This field is mandatory for the users because it allows the filtering of the most reliable data. It turned out that the issue came from BUFR encoding. In the COX BUFR files, CO_BDIV is encoded with 31 bits whereas the native width is 32 bits.

We recommended updating the FORLI-CO version running at EUMETSAT, i.e. to switch from v20140922 to v20151001. In this version, the general quality flag CO_QFLAG is calculated by FORLI (no CO_BDIV needed).

In March 2016, EUMETSAT performed the update of the FORLI-CO version. The CO_BDIV issue will be dealt at the end of 2016, after the update of the EUMETSAT computing system (OS change from AIX6 to AIX7). It is planned that CO_BDIV will be divided in 2 fields.

Systematic verification activities were jointly carried out by ULB and EUMETSAT teams prior to the release of the IASI L2 processor v6.2 including the latest FORLI v20151001, to verify its correct integration. The outputs of FORLI within the IASI L2 PPF matched perfectly with the stand-alone version quasi systematically. In very few cases (a small fraction of a percent) some small differences were observed, which were attributed to numerical precision effects in the two different environments and were considered acceptable.

In this document, we analyze the differences between the COX and the FORLI products with this new version: v20151001. The new field CO_QFLAG (calculated by FORLI) allows us to filter the data and thus improve the comparison of the products, even if some contentious pixels remain.

2. CO MONITORING

The monitoring was performed for IASI/MetOp-A and IASI/MetOp-B.

2.1 Compliance of the products

We looked at the CO total columns, profiles and CO_BDIV field (or "RETRIEVAL FLAGS" in BUFR files). The daily reports can be found here: http://cpm-pc51.ulb.ac.be/. The statistics in the following table are calculated for 20 days (20160603-20160622), for all the pixels (i.e. QFLAG=0).

For the total columns, the daily mean of the relative differences are calculated. Profiles correlation ("Correlation") score is computed using the discreet cross correlation integral between two profiles, normalized by the square root of the product of their auto-correlation integral. A score of 1 is expected for perfectly matching profiles, 0 for unrelated ones.

We present here the averages for 20 days.

CO total columns	compliant	mean(relative_difference_mean) = 0.0004%; mean(relative_difference_std) = 0.086%
CO profiles	compliant	mean(correlation_min) = 0.97
CO_BDIV	not compliant	

If QFLAG=2 the following figures are obtained:

CO total columns	compliant	mean(relative_difference_mean) = 0%; mean(relative_difference_std) = 0.023%
CO profiles	compliant	mean(correlation_min) = 0.997

QFLAG=2 means that the data are considered "reliable", i.e. when

- DOFS > 0.5376,
- CO total column < 20 x 10^{18} molecules/cm^2,
- the flag AMP_NEGPC (negative retrieval for H_2O) is null
- **1.** flags AMP_NEGZ0, AMP_TSKIN, AMP_TDIFF, AMP_DESERT, AMP_ITERATIONS, AMP_SLOPE, AMP_CONTRAST, AMP_AVK, AMP_BIAS and AMP_RMS are null

  or

  2. total cloud cover ≤12% and flags AMP_NEGZ0, AMP_TDIFF, AMP_DESERT, AMP_ITERATIONS, AMP_SLOPE, AMP_CONTRAST, AMP_AVK, AMP_BIAS and AMP_RMS are null.

  NB: The total cloud cover is the sum of the (up to) 3 cloud fractions provided in the FRACTIONAL_CLOUD_COVER field from CLP files (IASI L2 Cloud parameters product, see Section 4.3). If all the covers are NaN, total cloud cover is equal to 0.

2.2 Contentious pixels

Even if the COX and FORLI products are in good agreement, some contentious pixels remain. For instance, the 20160616 and 20160619 Metop-B data could be investigated. As shown is the Figures 1 and 6, where we can see colored "outliers pixels" for total column relative differences, i.e. pixels outside the 99.7% confidence interval, i.e. 3σ. In other words, pixels where the relative difference between COX and FORLI are larger than 3 times the standard deviation calculated for the day. The green pixels are ok but one should focus on the red and blue pixels. Figures 2, 3, 4 and 7 show zooms above these pixels for these two dates. Figures 3 and 6 show correlation plots (COX versus FORLI total columns).

Regarding these outliers pixels, two types can be distinguished: the random ones (Figures 3 and 4), that we consider ok (these pixels differ because of numerical precision effects) and the pixels from a whole PDU (Figure 2 and 7) that need to be investigated and resolved.

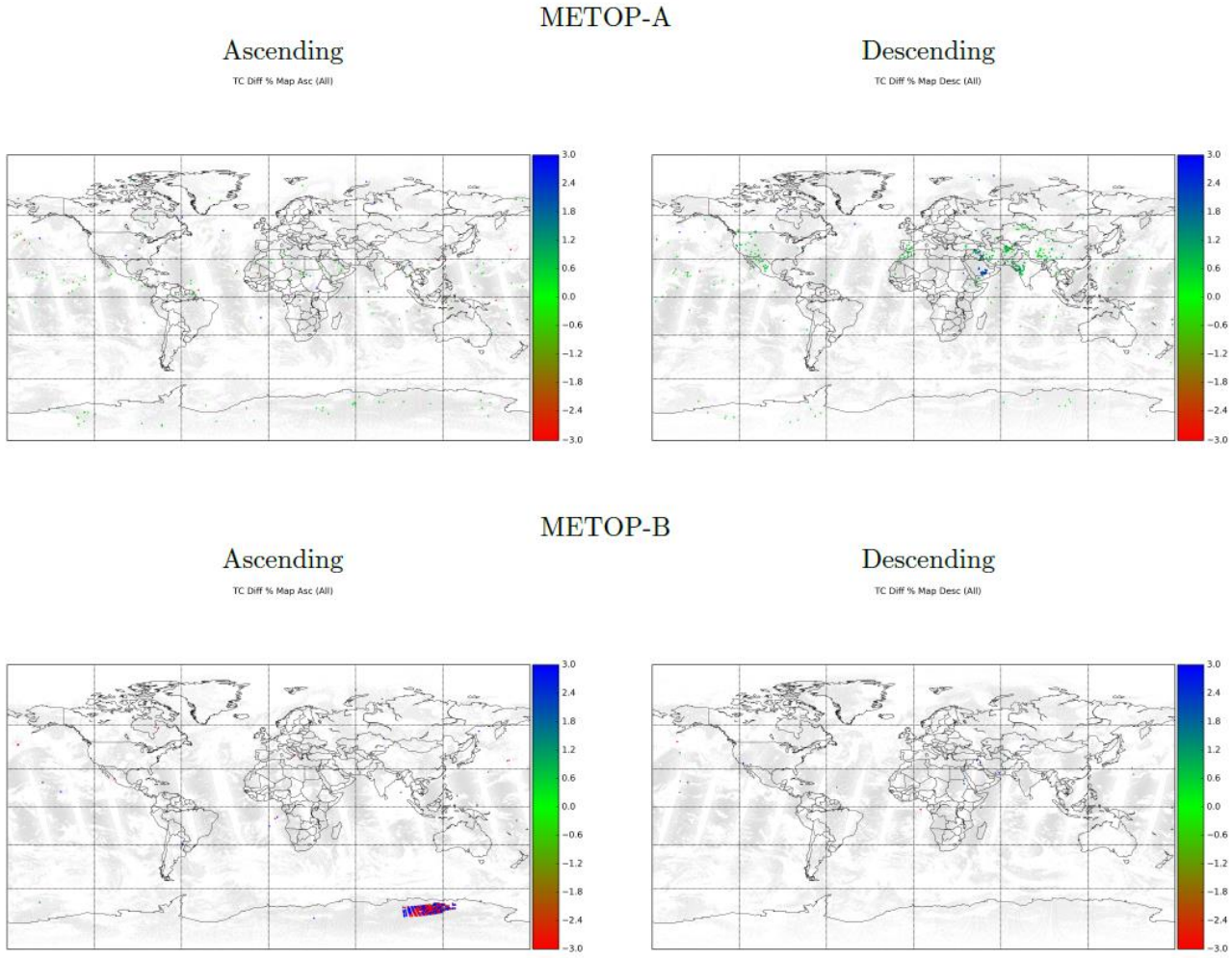


Fig. 1: "Outliers pixels" on 16 June 2016 for total column relative differences, i.e. pixels outside the 99.7% confidence interval, i.e. 3σ.

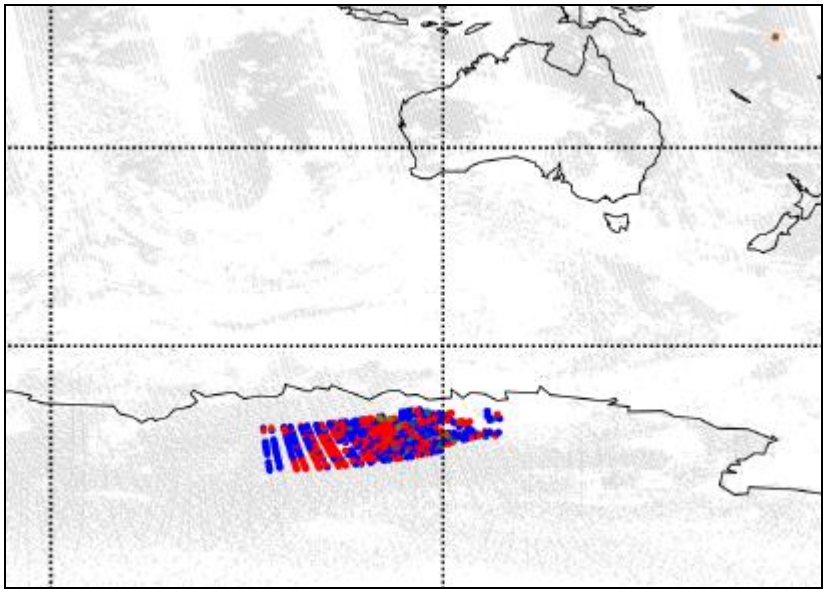


Fig. 2: Zoom over some “outliers pixels” on 16 June 2016 (METOP-B, Ascending)

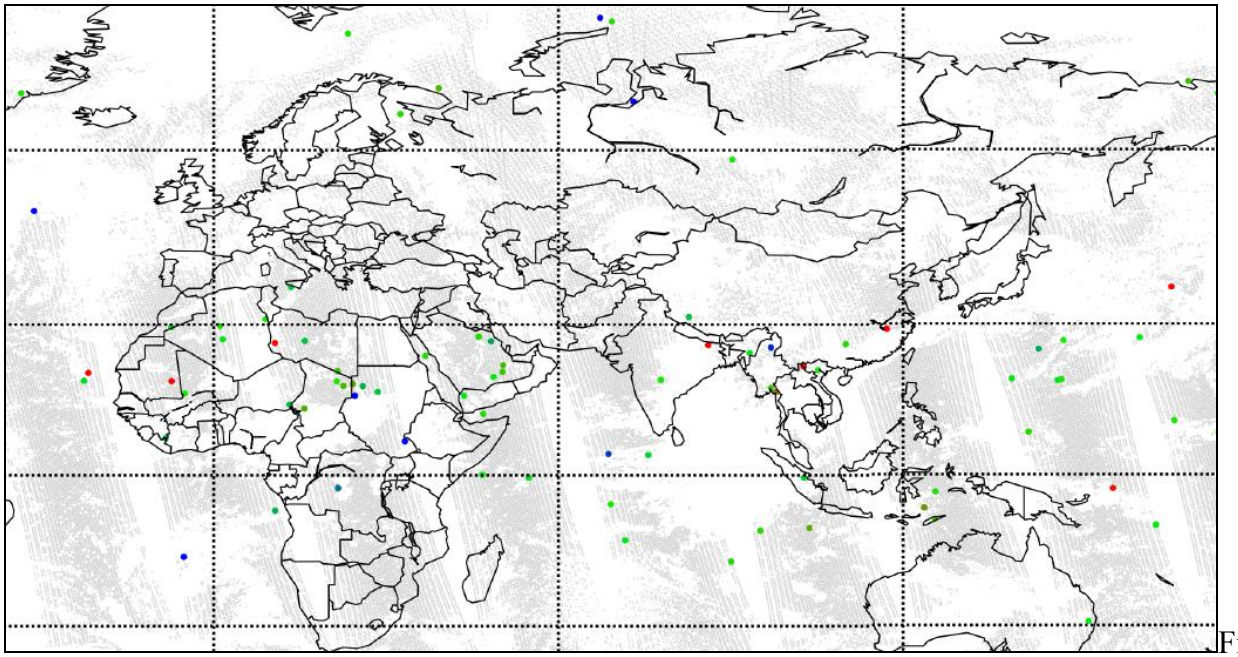


Fig. 3: Zoom over some “outliers pixels” in red and blue, on 16 June 2016 (METOP-A, Ascending)

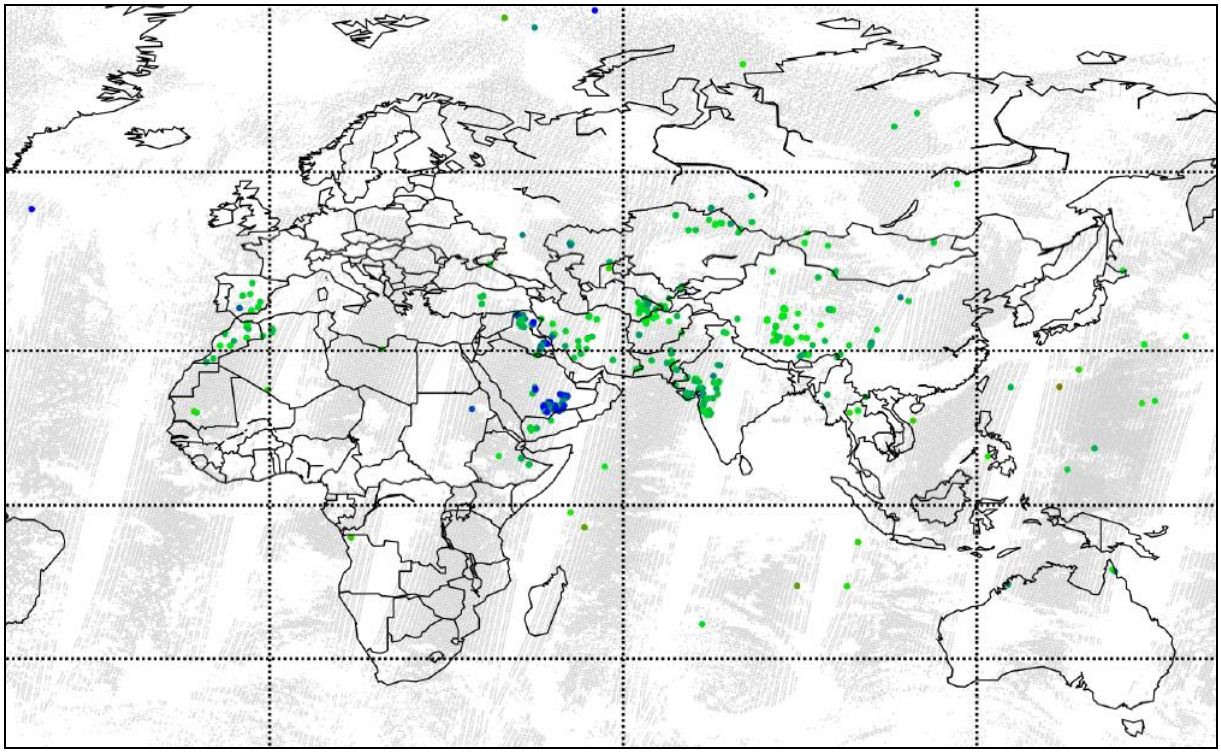


Fig. 4: Zoom over some “outliers pixels” in blue, on 16 June 2016 (METOP-A, Descending)

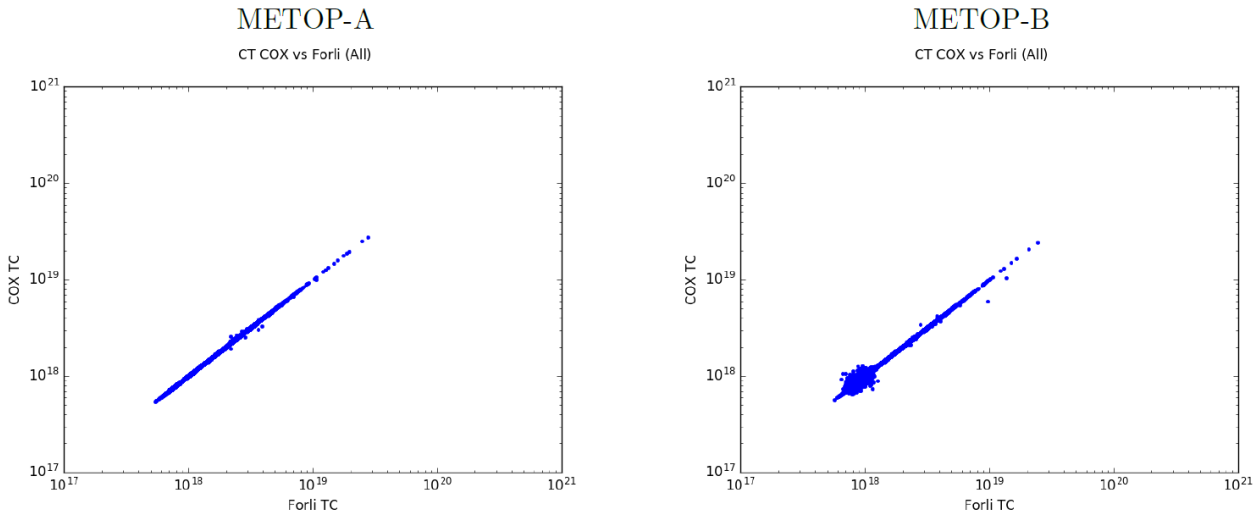


Fig. 5: Correlation plot: COX versus FORLI total columns, 16 June 2016

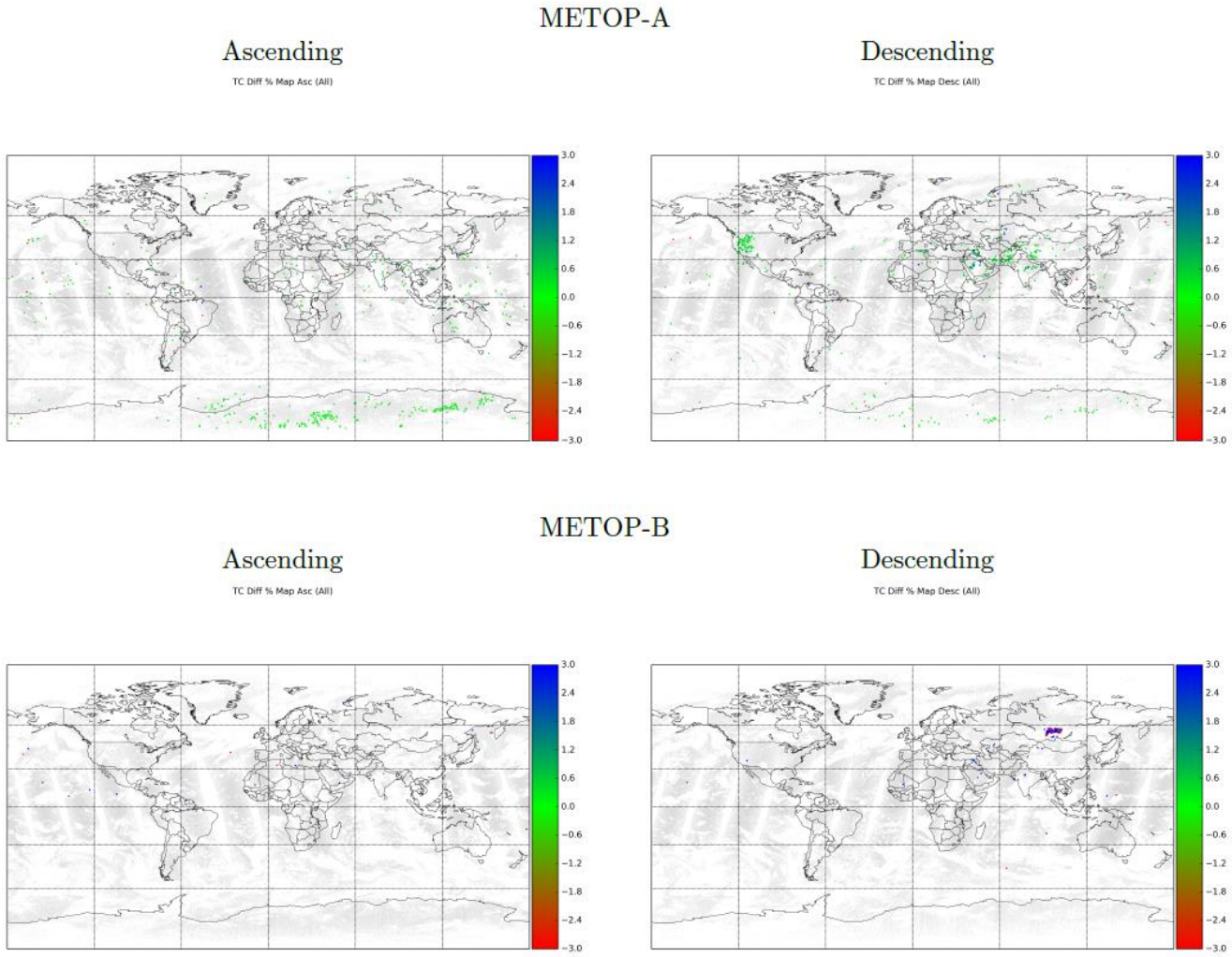


Fig. 6: “Outliers pixels” on 19 June 2016 for total column relative differences, i.e. pixels outside the 99.7% confidence interval, i.e. 3σ.

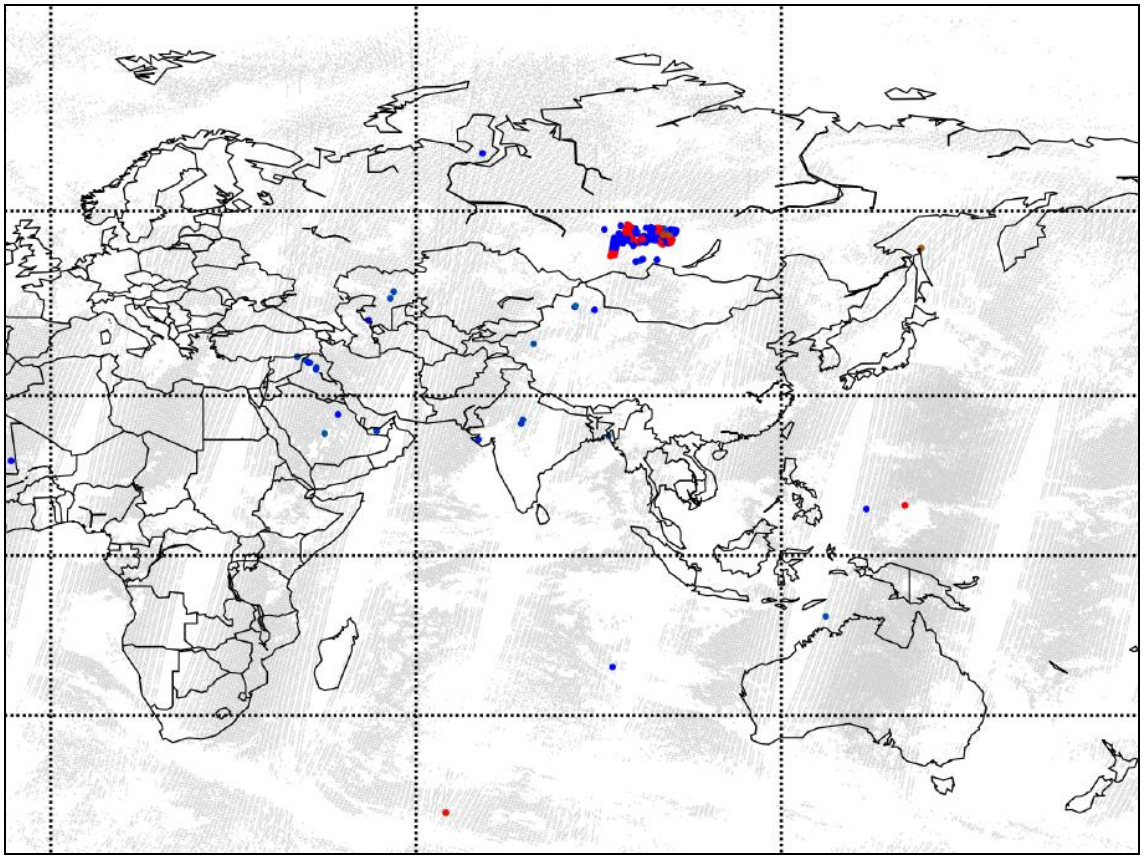


Fig. 7: Zoom over the "outliers" pixels on 19 June 2016 (METOP-B, Descending)

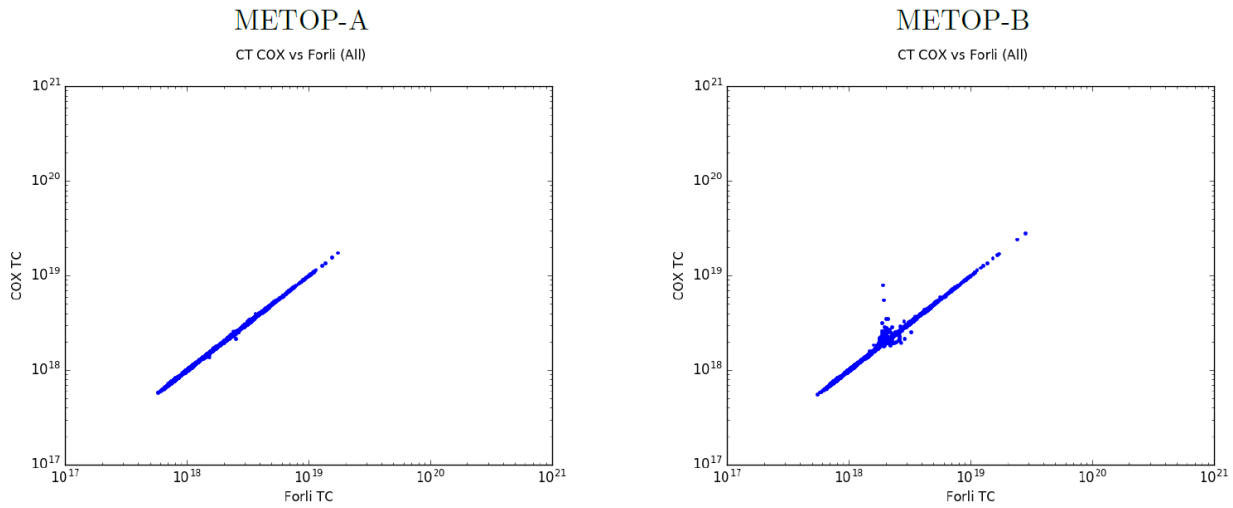


Fig. 8: Correlation plot: COX versus FORLI total columns, 19 June 2016

3. CONCLUSION

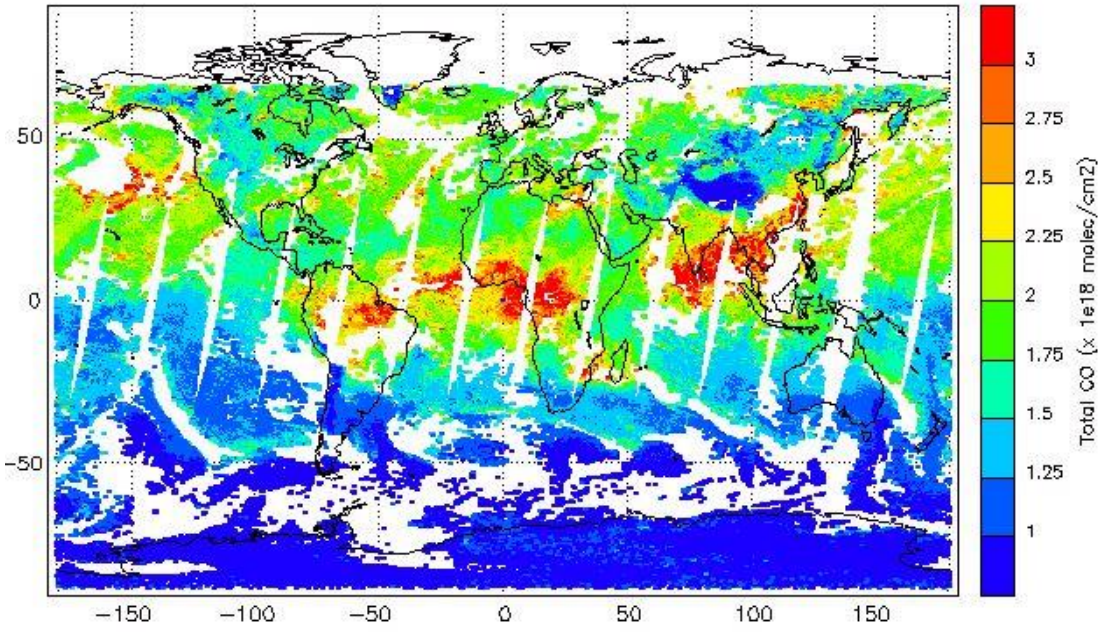
The FORLI-CO version has been updated. v20151001 is running at EUMETSAT. A QFLAG is now provided (calculated by FORLI), that allow to filter the data. The agreement between the COX and FORLI-CO total columns and profiles is good but some contentious pixels are remaining and should be investigated. One should distinguish the random outliers pixels, that we consider ok (these pixels represent about 0.008% of the retrieved pixels and differ because of numerical precision effects) and the pixels from a whole PDU, that need to be investigated and resolved. When looking at one month of data (from 20160603 to 20160703), 6 days show contentious pixels of the second type (whole PDU): we showed examples for 16 and 19 June 2016 but one can find other cases on 28 (MetOp-A, Asc.) and 30 June 2016 (MetOp-A Asc. and MetOp-B Asc. and Desc.), as well as on 2 (MetOp-A, Asc.) and 3 July 2016 (MetOp-A, Asc.).

As already mentioned in Section 3 of the Validation Report (27 January 2016), the contents of the CO_BDIV field (code 0-40-243 in BUFR files, "RETRIEVAL FLAGS") differ for FORLI-CO and COX. At the end of 2016, the EUMETSAT BUFR team should divide this flag in 2 fields, in order to solve the 31/32 bits encoding issue.

O3M SAF VALIDATION REPORT UPDATE #2

Validated products:

Identifier	Name	Acronym
O3M-80	Near Real-Time IASI CO	MBI-N-CO



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Cathy Clerbaux	LATMOS, France
Pierre Coheur	ULB, Belgium
Rosa Astoreca	ULB, Belgium

Reporting period: 7 September 2016 – 30 November 2016

Input data versions: IASI Level 1C version 7.1, since 22.07.2014

Data processor versions: PGE version 6.1, since 24.09.2015

Table of Contents

1. INTRODUCTION

This update follows the update from 6 September 2016.

In this former update, we analyzed the differences between the EUMETSAT products disseminated by EUMETCast in BUFR format (COX) and the products routinely generated both at ULB (Belgium) and LATMOS (France) using the FORLI retrieval algorithm (FORLI-CO v20151001). In this version, the general quality flag CO_QFLAG is calculated by FORLI. The agreement between the COX and FORLI-CO total columns and profiles was found within expected numerical precision for a vast majority of the pixels. Larger deviations between the operational and the research productions, exceeding acceptance thresholds, were observed in some contentious pixels. They consist of random outliers pixels (0.008% occurrence rate) associated to numerical precision effects, considered acceptable, and of outliers pixels clusters within isolated PDUs. The latter required investigations and resolutions before declaring the product operational.

Daniel Hurtmans visited EUMETSAT (hosted by Thomas August and Marc Crapeau, 17-21 October 2016) in that perspective. An issue in the line numbering in some BUFR products (not specific to COX, but affecting more generally EPS products) was identified. The corrupted line numbering yielded misalignements between the COX and stand-alone FORLI-CO products compared, and caused the outlier pixels clusters found in a first place. The visit confirmed that in these cases, the mismatch reported previously between the two FORLI-CO products was in fact an artifact. The monitoring is now configured to detect this line numbering anomaly and computes comparison statistics between well collocated IASI pixels, showing excellent agreement between the CO products from the operational and research production line (see Section 2.2).

In the present update, we analyze and report the differences and consistencies after this bug has been by-passed and conclude that the FORLI-CO product is ready for operational mode.

2. CO MONITORING

The monitoring was performed for IASI/Metop-A and IASI/Metop-B.

2.1 Compliance of the products

We looked at the CO total columns and profiles. The daily reports can be found here: http://cpm-pc51.ulb.ac.be/. The statistics in the following tables are calculated for 20 days (20161106-20161125), for all the pixels (*i.e.* QFLAG=0) and for the "reliable" pixels (*i.e.* QFLAG=2).

For the total columns, the daily mean of the relative differences are calculated. Profiles correlation ("Correlation" in the "Data statistics" section of the daily reports) score is computed using the discreet cross correlation integral between two profiles, normalized by the square root of the product of their auto-correlation integral. Score of 1 is expected for perfectly matching profiles, 0 for unrelated ones.

If QFLAG=0, *i.e.* for all the retrieved pixels:

CO total columns	compliant	mean(relative_difference_mean) = 0.0005%; mean(relative_difference_std) = 0.145%
CO profiles	compliant	mean(correlation_min) = 0.97

If QFLAG=2, *i.e.* for the "reliable" pixels, the following figures are obtained:

CO total columns	compliant	mean(relative_difference_mean) = -0.0002%; mean(relative_difference_std) = 0.1%
CO profiles	compliant	mean(correlation_min) = 0.99

QFLAG=2 means that the data are considered "reliable", *i.e.* when

- DOFS > 0.5376,
- CO total column < 20 x 10^{18} molecules/cm^2,
- the flag AMP_NEGPC (negative retrieval for H_2O) is null
- **1.** flags AMP_NEGZ0, AMP_TSKIN, AMP_TDIFF, AMP_DESERT, AMP_ITERATIONS, AMP_SLOPE, AMP_CONTRAST, AMP_AVK, AMP_BIAS and AMP_RMS are null

  or

  2. total cloud cover ≤12% and flags AMP_NEGZ0, AMP_TDIFF, AMP_DESERT, AMP_ITERATIONS, AMP_SLOPE, AMP_CONTRAST, AMP_AVK, AMP_BIAS and AMP_RMS are null.

We did not look at the CO_BDIV field (or "RETRIEVAL FLAGS" in BUFR files) in this update. The EUMETSAT BUFR team has split this flag in 2 fields, in order to solve the 31/32 bits encoding issue (see Validation Report from 27 January 2016). This new fields will be available in the next version of the IASI L2 data (v6.3) in December 2016.

2.2 Bug by-passing for the contentious pixels

As seen in the previous update, we consider acceptable the random outliers pixels probably due to numerical precision effects: these pixels represent about 0.008% of the retrieved pixels.

Some outliers pixels were found having a regular pattern, forming clusters, within isolated PDUs, as shown in Figure 1 and 2 (20161011). In these 2 plots, the "outliers pixels" for total column relative differences are plotted in colors, *i.e*. when the pixels are outside the 99.7% confidence interval (*i.e*. 3σ). In other words, pixels where the relative difference between COX and FORLI are larger than 3 times the standard deviation calculated for the day. The green pixels are within acceptable range but the red and blue pixels reveal deviations that matter.

During Daniel Hurtmans'visit at EUMETSAT in October 2016, a bug in the BUFR line numbering (not specific to IASI COX, generally affecting EPS products) has been found and a workaround was deployed in the monitoring system to compute comparison statistics on well collocated pixels. This resulted in the suppression of these outliers as seen in Figures 3 and 4, which were artifacts from comparing non-collocated pixels.

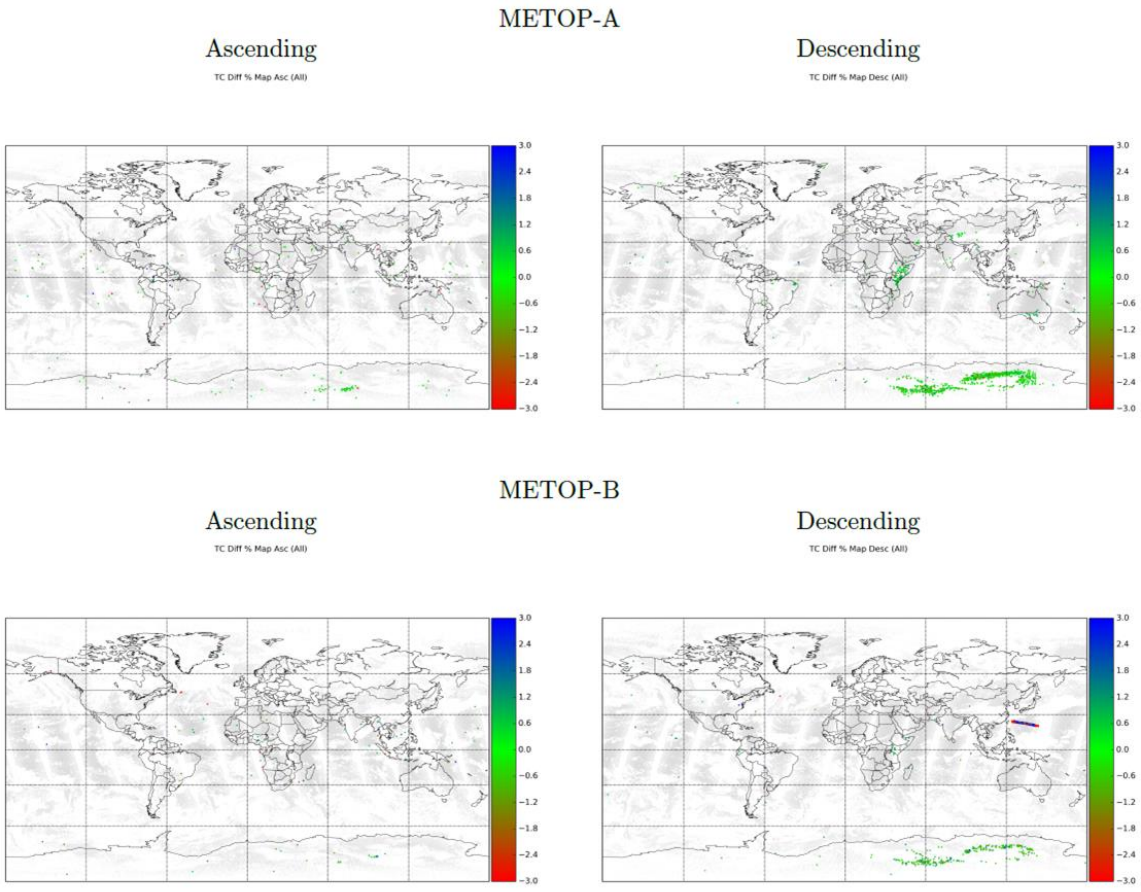

Fig. 1: "Outliers pixels" on 11 October 2016 for total column relative differences, *i.e*. pixels outside the 99.7% confidence interval, *i.e*. 3σ.

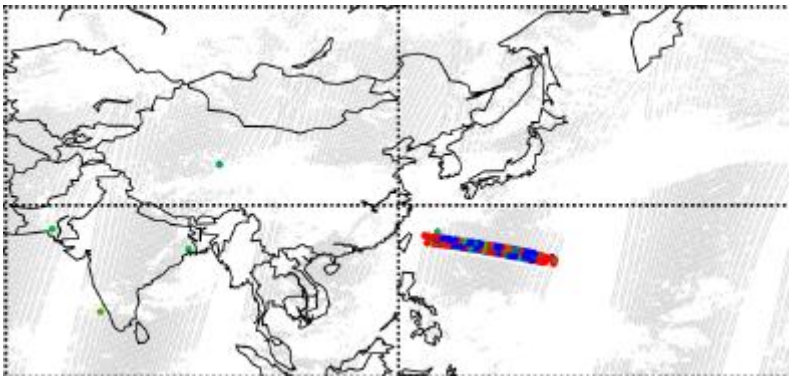

Fig. 2: Zoom over some “outliers pixels” on Fig. 1 (METOP-B, Descending).

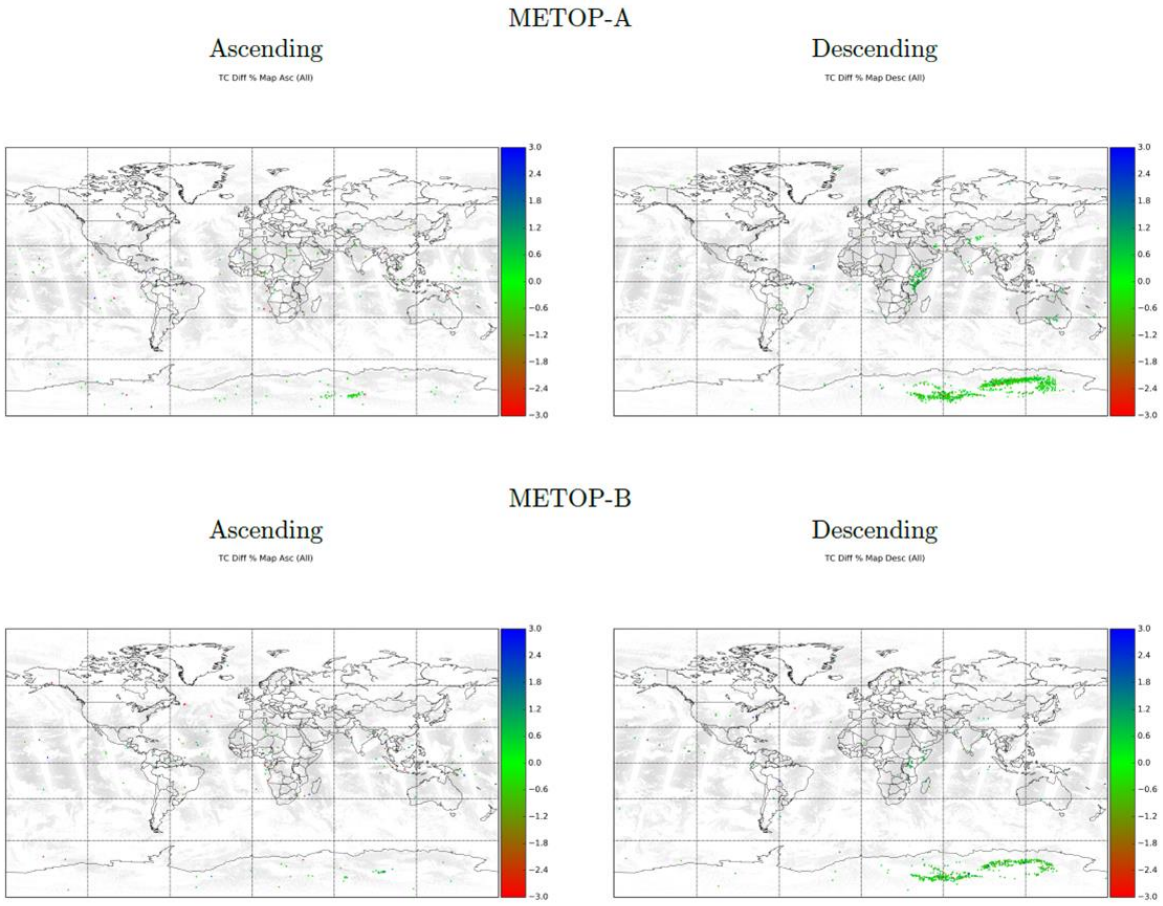

Fig. 3: Same as Fig. 1 but after by-passing the line numbering bug.

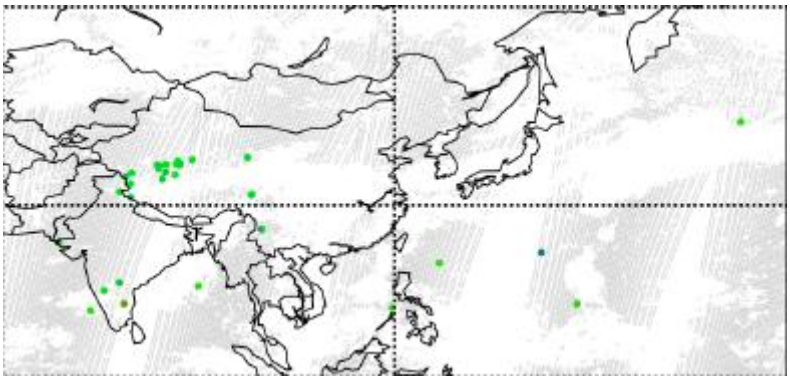

Fig. 4: Same as Fig. 2 but after by-passing the line numbering bug.

3. CONCLUSION

This second update aims at declaring the FORLI-CO product ready for operational production.

The EUMETSAT products disseminated by EUMETCast in BUFR format (COX) and the products routinely generated both at ULB (Belgium) and LATMOS (France) using the FORLI retrieval algorithm (FORLI-CO v20151001) are in good agreement: For 20 days, the mean of the relative difference means for the total columns is 0.0005%. The mean of the minimum correlations for the profiles is 0.97. When filtering the data with QFLAG=2 to get the "reliable" pixels, the figures are -0.0002% and 99% respectively.

Random outliers (0.008% of the retrieved pixels) are considered acceptable. Some contentious outliers identified in the previous update can be explained by the line numbering bug within the BUFR files. As shown in this report, updating the monitoring tool to retain well-collocated pixels for comparisons solved the outlying clusters observed previously, which were actually monitoring artifacts (Fig. 2 and 4 for 20161011).

In order to keep looking after the good similarity of the products, the daily reports are available here: http://cpm-pc51.ulb.ac.be/. The last version of these reports gives a table with the outliers occurrence and filenames in order to investigate potential future severe major outliers.

In December 2016, version 6.3 of the IASI L2 data should be released. The CO_BDIV field (or "RETRIEVAL FLAGS" in BUFR files) will be split in 2 fields, in order to solve the 31/32 bits encoding issue (see Validation Report from 27 January 2016).

Finally, note that the present Validation Report, as well as the 2 updates (this one included) refer to both Metop-A and Metop-B. The scope of the original CDOP-2 proposal did include Metop-B only, but retrieval algorithm and configuration were actually supplied, integrated, verified and validated for both Metop-A and –B platforms in the CDOP-2 work packages.