Supplement of Atmos. Chem. Phys., 15, 13195–13216, 2015
http://www.atmos-chem-phys.net/15/13195/2015/
doi:10.5194/acp-15-13195-2015-supplement

Atmospheric Chemistry and Physics Open Access EGU

Supplement of

On the ability of RegCM4 regional climate model to simulate surface solar radiation patterns over Europe: an assessment using satellite-based observations

G. Alexandri et al.

Correspondence to: G. Alexandri (alexang@auth.gr)

1. Statistical Metrics

- Normalized standard deviation (NSD) expresses the amplitude of the variance in modeled values versus the observed values:

$$NSD = \frac{\sigma_{RegCM}}{\sigma_{CMSAF}} \qquad (1)$$

where σ_{RegCM} and σ_{CMSAF} are the standard deviations of RegCM4 and CM SAF respectively.

- Modified Normalized Mean Bias (MNMB) is a normalization based on the observed (CM SAF) and the modeled (RegCM) value and is limited between -2 and +2 (-2 expresses underestimation -200% and +2 expresses overestimation +200%):

$$MNMB = \frac{2}{N}\sum_{i=1}^{N}\frac{RegCM_i - CMSAF_i}{RegCM_i + CMSAF_i} \qquad (2)$$

- RMSE expresses the standard deviation of the differences between two timeseries (RegCM and CM SAF):

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(RegCM_i - CMSAF_i)^2} \qquad (3)$$

2. Surface Solar Radiation

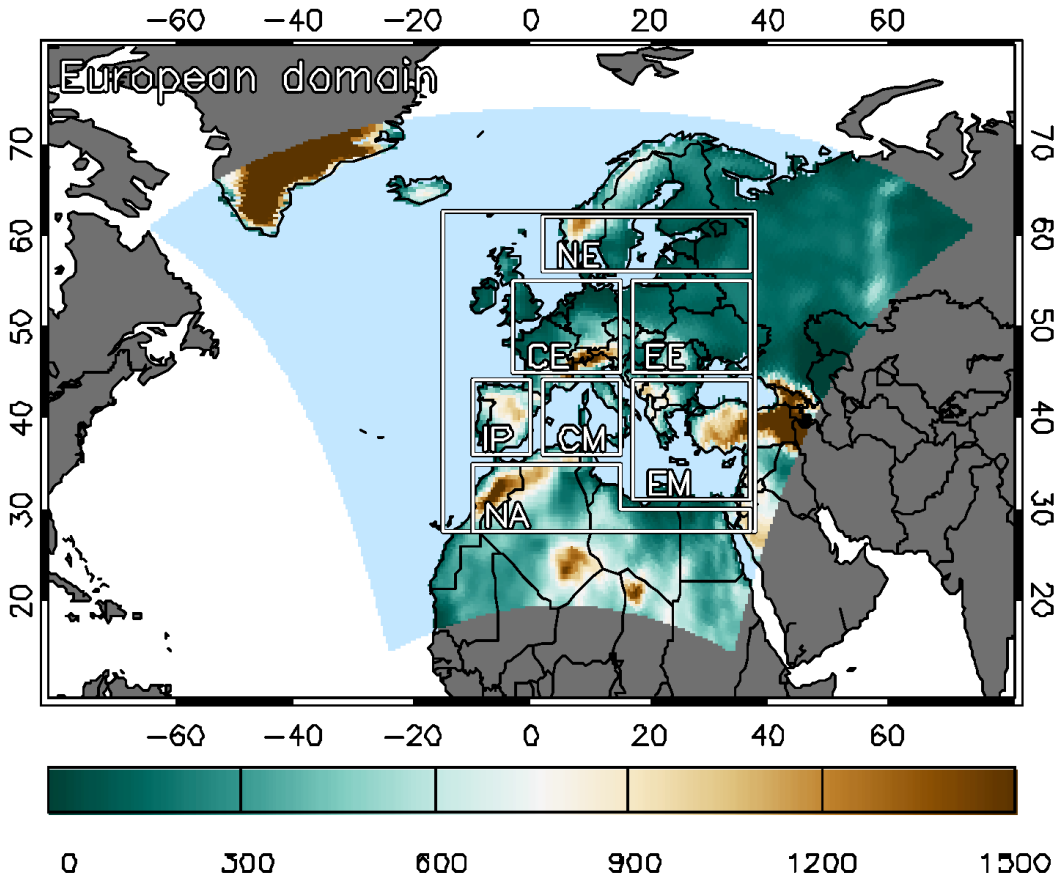
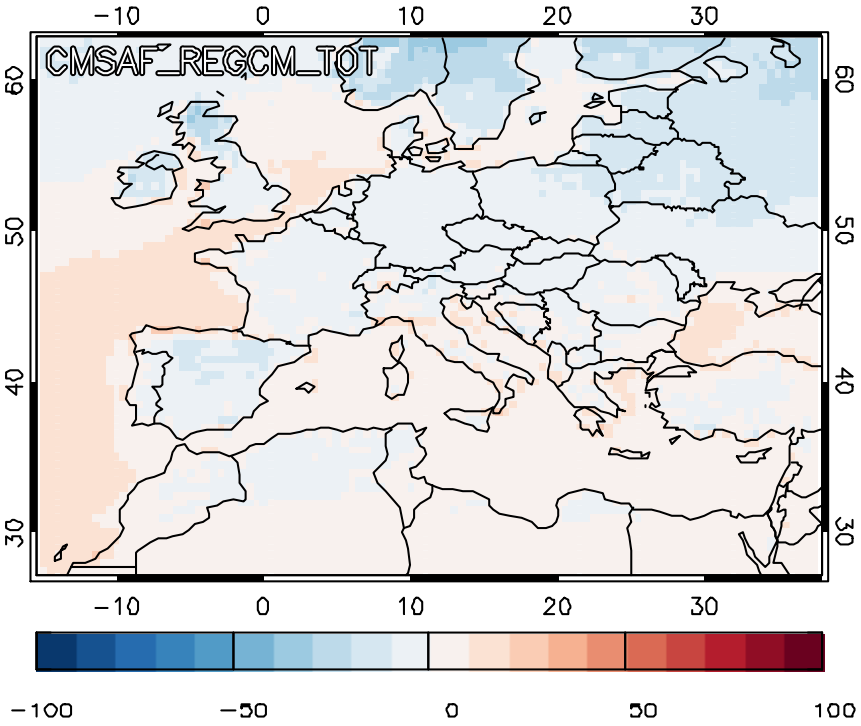


Figure S1. Topography of the RegCM4 simulation domain with the European box region and the 7 sub-regions used for the generalization of the results: Northern Europe (NE), Central Europe (CE), Eastern Europe (EE), Iberian Peninsula (IP), Central Mediterranean (CM), Eastern Mediterranean (EM) and Northern Africa (NA).

a)



b)

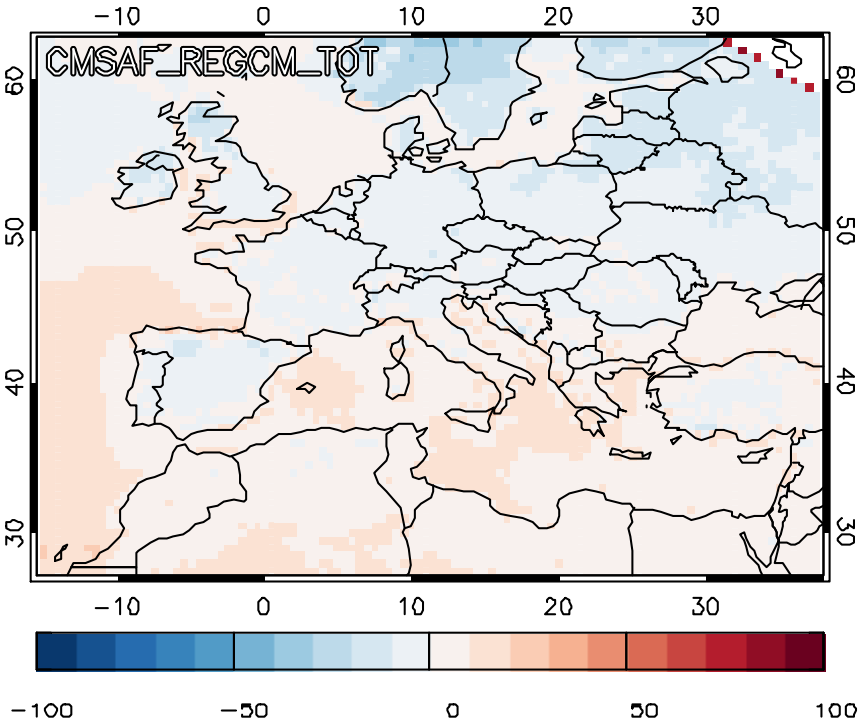


Figure S2. Normalized mean bias (NMB) patterns of RegCM4-CM SAF SSR over Europe from (a) MFG MVIRI (2000-2005) and (b) MSG SEVIRI (2006-2009) observations.

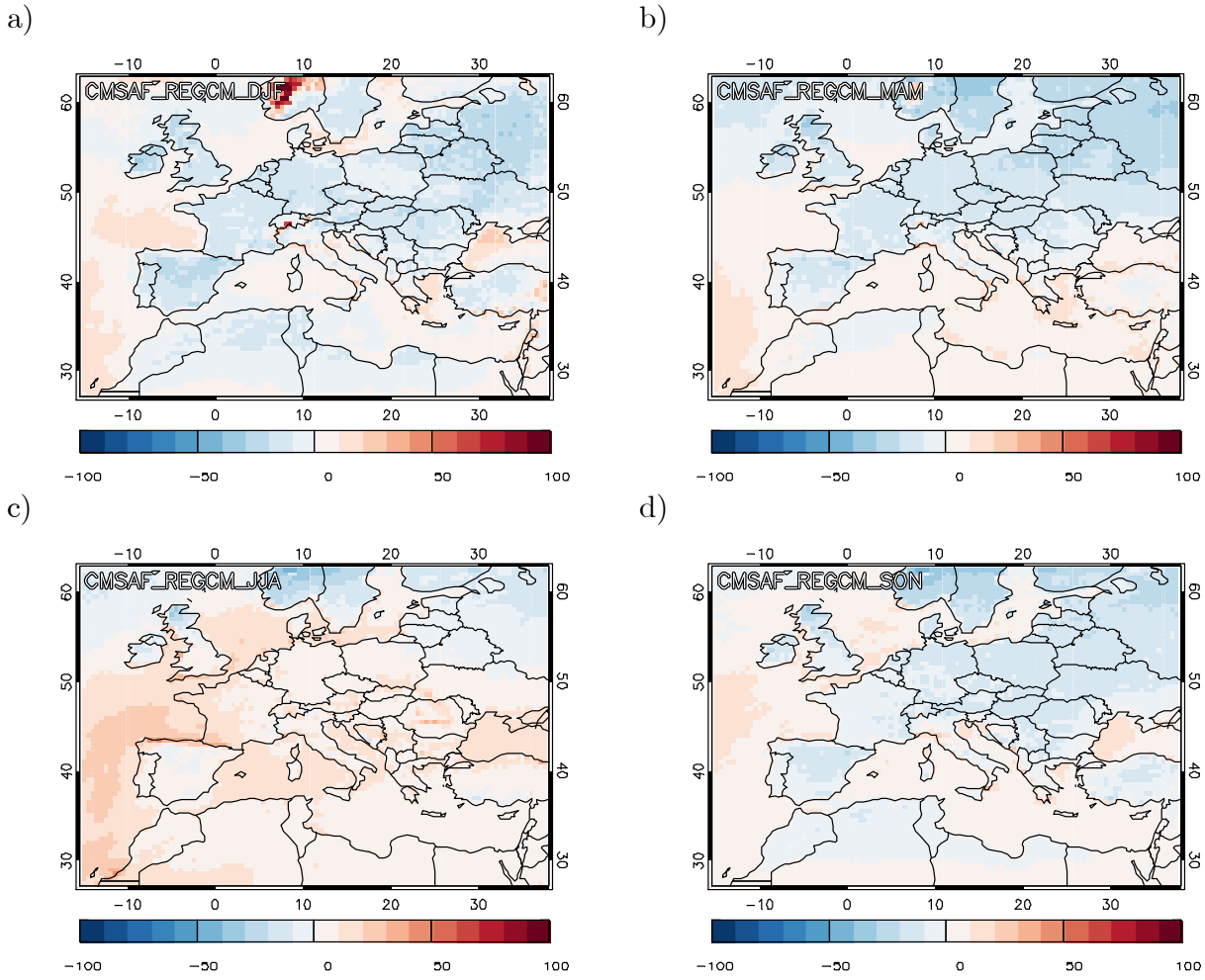


Figure S3. Seasonal Normalized mean bias (NMB) patterns of RegCM4-CM SAF SSR over Europe for (a) winter (DJF), (b) spring (MAM), (c) summer (JJA) and (d) autumn (SON) from MFG MVIRI observations.

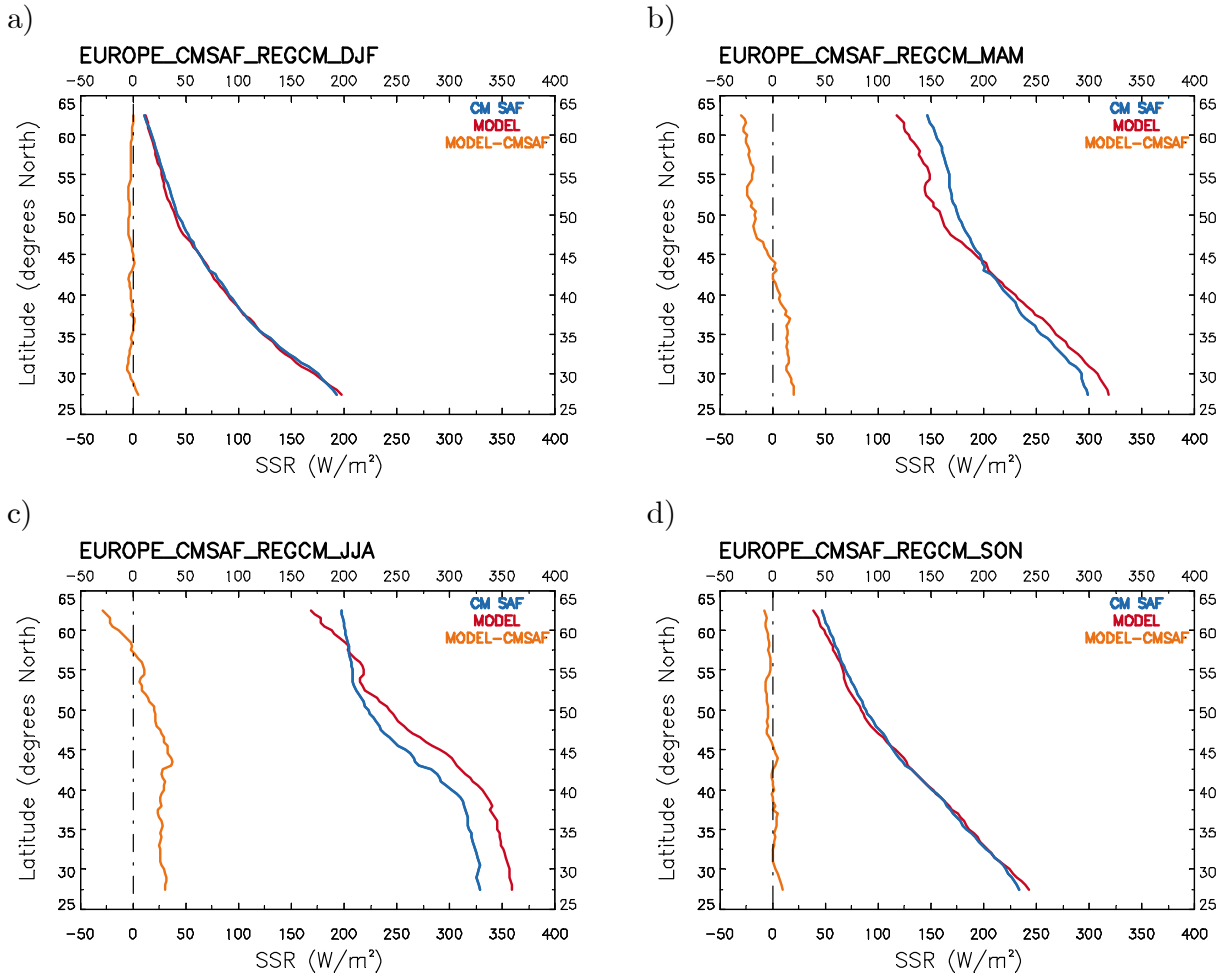


Figure S4. Latitudinal variability of RegCM4 SSR (red), CM SAF SSR (blue) and their difference (orange) over Europe for (a) winter (DJF), (b) spring (MAM), (c) summer (JJA) and (d) autumn (SON) from MFG MVIRI observations.

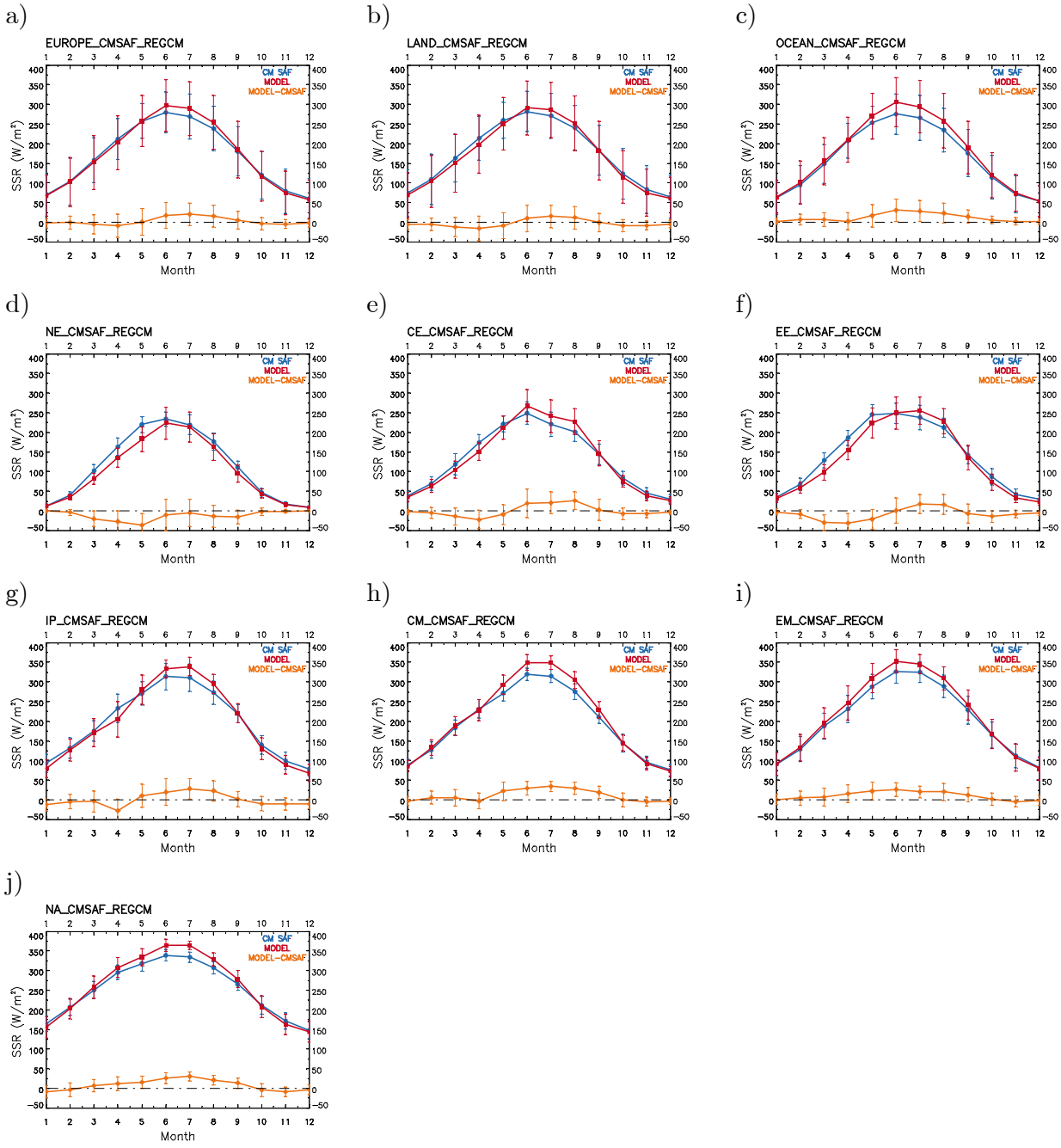


Figure S5. Seasonal variability of RegCM4 SSR (red), CM SAF SSR (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA from MFG MVIRI observations.

Table S1. Average RegCM4 SSR, CM SAF SSR (MFG MVIRI), their difference, the corresponding Normalized Mean Bias (NMB) and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test per season[1] and region. The NSD, MNMB and RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CMSAF+b). The region are listed in alphabetic order.

Season	Region	REG	CMS	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
DJF	CE	41.57	45.48	-3.91	-8.60	1	0.90	13986	3.48	0.84	0.93	-8.70	10.53
JJA	CE	245.32	223.63	21.69	9.70	1	0.72	13986	47.85	0.88	1.23	8.89	36.65
MAM	CE	155.88	171.25	-15.37	-8.97	1	0.88	13986	-4.02	0.93	1.06	-10.43	28.55
SON	CE	86.45	90.76	-4.31	-4.75	1	0.93	13986	-6.13	1.02	1.10	-8.82	19.43
TOT	CE	132.31	132.78	-0.48	-0.36	0	0.96	55944	-8.82	1.06	1.11	-4.76	25.72
DJF	CM	96.69	96.75	-0.06	-0.06	0	0.90	8262	0.57	0.99	1.10	-0.90	13.38
JJA	CM	334.50	303.32	31.18	10.28	1	0.84	8262	60.38	0.90	1.07	9.79	34.82
MAM	CM	236.73	228.59	8.14	3.56	1	0.88	8262	-3.93	1.05	1.20	2.95	25.17
SON	CM	154.90	150.33	4.57	3.04	1	0.96	8262	-15.63	1.13	1.18	1.15	18.51
TOT	CM	205.70	194.75	10.96	5.63	1	0.98	33048	-13.65	1.13	1.15	3.25	24.33
DJF	EE	37.97	43.54	-5.57	-12.80	1	0.90	15498	1.95	0.83	0.91	-15.38	10.51
JJA	EE	244.18	233.06	11.12	4.77	1	0.68	15498	50.57	0.83	1.22	4.37	30.33
MAM	EE	158.72	186.67	-27.95	-14.97	1	0.91	15498	-32.53	1.02	1.12	-18.94	36.93
SON	EE	80.46	90.20	-9.74	-10.80	1	0.93	15498	-7.34	0.97	1.05	-15.74	20.03
TOT	EE	130.33	138.37	-8.03	-5.81	1	0.96	61992	-10.31	1.02	1.06	-11.42	26.43
DJF	EM	101.43	100.43	1.00	0.99	1	0.92	19926	4.25	0.97	1.05	0.64	14.84
JJA	EM	335.73	313.39	22.34	7.13	1	0.85	19926	64.10	0.87	1.02	6.92	28.96
MAM	EM	250.43	235.66	14.78	6.27	1	0.93	19926	-5.74	1.09	1.17	5.43	27.72
SON	EM	171.91	168.63	3.28	1.95	1	0.97	19926	-12.50	1.09	1.13	0.05	17.78
TOT	EM	214.87	204.53	10.35	5.06	1	0.98	79704	-8.19	1.09	1.11	3.26	23.15
DJF	EU	76.23	78.11	-1.87	-2.40	1	0.98	135468	-0.97	0.99	1.01	-3.69	12.64
JJA	EU	280.00	262.24	17.76	6.77	1	0.91	135468	-12.28	1.11	1.23	5.42	35.08
MAM	EU	204.26	208.78	-4.53	-2.17	1	0.94	135468	-33.21	1.14	1.22	-5.20	30.05
SON	EU	125.37	126.35	-0.98	-0.78	1	0.98	135468	-7.76	1.05	1.08	-4.17	17.33
TOT	EU	171.47	168.87	2.59	1.54	1	0.97	541872	-10.81	1.08	1.11	-1.91	25.46
DJF	IP	91.95	101.17	-9.22	-9.11	1	0.89	6426	-5.72	0.97	1.09	-11.54	18.46
JJA	IP	322.84	299.11	23.73	7.94	1	0.65	6426	163.21	0.53	0.82	7.99	37.40
MAM	IP	218.76	225.96	-7.21	-3.19	1	0.84	6426	-9.72	1.01	1.20	-4.45	33.36
SON	IP	146.42	152.64	-6.21	-4.07	1	0.95	6426	-13.92	1.05	1.10	-6.36	19.59
TOT	IP	194.99	194.72	0.27	0.14	0	0.96	25704	-18.12	1.09	1.14	-3.59	28.45
DJF	LA	77.83	82.68	-4.85	-5.86	1	0.98	85518	-2.91	0.98	1.00	-8.59	14.17
JJA	LA	276.53	264.43	12.10	4.58	1	0.91	85518	-21.39	1.13	1.24	3.18	32.68
MAM	LA	199.88	212.10	-12.22	-5.76	1	0.94	85518	-44.55	1.15	1.23	-9.66	32.35
SON	LA	123.93	129.85	-5.92	-4.56	1	0.98	85518	-12.76	1.05	1.08	-9.85	18.42
TOT	LA	169.55	172.30	-2.75	-1.59	1	0.97	342072	-14.98	1.07	1.10	-6.26	25.67
DJF	NA	167.82	173.18	-5.37	-3.10	1	0.91	19440	-14.23	1.05	1.15	-3.88	16.08
JJA	NA	352.74	326.82	25.92	7.93	1	0.82	19440	53.24	0.92	1.12	7.61	28.98
MAM	NA	299.97	288.23	11.74	4.07	1	0.91	19440	-5.50	1.06	1.17	3.77	20.59
SON	NA	216.44	216.16	0.28	0.13	0	0.96	19440	-45.33	1.21	1.26	-1.09	17.13
TOT	NA	259.24	251.10	8.14	3.24	1	0.98	77760	-35.56	1.17	1.20	1.61	21.31
DJF	NE	18.63	20.14	-1.52	-7.53	1	0.94	16614	2.12	0.82	0.87	-3.67	5.40
JJA	NE	199.86	209.66	-9.80	-4.67	1	0.67	16614	-0.78	0.96	1.43	-6.33	35.83
MAM	NE	133.38	161.50	-28.13	-17.42	1	0.86	16614	5.84	0.79	0.92	-19.97	39.08
SON	NE	51.53	57.89	-6.36	-10.98	1	0.95	16614	3.51	0.83	0.87	-9.81	14.73
TOT	NE	100.85	112.30	-11.45	-10.20	1	0.96	66456	-0.65	0.90	0.95	-9.95	27.64
DJF	OC	73.45	70.07	3.38	4.83	1	0.98	49950	0.14	1.05	1.07	4.88	11.00
JJA	OC	285.95	258.49	27.46	10.62	1	0.92	49950	-1.45	1.11	1.20	9.24	38.84
MAM	OC	211.75	203.10	8.65	4.26	1	0.95	49950	-19.73	1.14	1.19	2.45	25.63
SON	OC	127.83	120.36	7.47	6.21	1	0.99	49950	-1.32	1.07	1.09	5.56	15.28
TOT	OC	174.74	163.00	11.74	7.20	1	0.98	199800	-5.31	1.10	1.12	5.53	25.10

[1]TOT stands for the whole dataset, DJF for December-January-February, MAM for March-April-May, JJA for June-July-August and SON for September-October-November. Regions are listed in alphabetical order.

Table S2. Average RegCM4 SSR, CM SAF SSR (MSG SEVIRI), their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test per season and region. The NSD, MNMB and RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CMSAF+b). The region are listed in alphabetic order.

Season	Region	REG	CMS	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
DJF	CE	42.30	42.75	-0.45	-1.05	0	0.86	8547	11.08	0.73	0.85	11.11	12.57
JJA	CE	245.57	228.91	16.66	7.28	1	0.79	9324	17.85	0.99	1.25	6.42	33.59
MAM	CE	158.12	174.03	-15.91	-9.14	1	0.84	9324	-0.14	0.91	1.08	-11.09	34.51
SON	CE	84.38	90.92	-6.54	-7.19	1	0.94	9324	1.15	0.92	0.97	-8.15	17.49
TOT	CE	134.52	136.10	-1.58	-1.16	1	0.96	36519	-5.04	1.03	1.07	-0.67	26.59
DJF	CM	97.29	96.68	0.61	0.63	0	0.92	5049	2.30	0.98	1.07	0.28	11.62
JJA	CM	331.26	299.93	31.34	10.45	1	0.82	5508	62.57	0.90	1.09	9.93	35.08
MAM	CM	243.68	225.86	17.82	7.89	1	0.91	5508	-20.14	1.17	1.28	6.53	31.07
SON	CM	157.71	149.80	7.90	5.28	1	0.95	5508	-9.18	1.11	1.18	3.68	19.89
TOT	CM	209.83	195.12	14.71	7.54	1	0.98	21573	-12.36	1.14	1.16	5.21	26.33
DJF	EE	37.53	38.84	-1.31	-3.38	1	0.90	9471	10.00	0.71	0.79	10.90	10.14
JJA	EE	248.43	242.79	5.63	2.32	1	0.79	10332	11.72	0.97	1.23	1.75	27.91
MAM	EE	155.22	179.35	-24.13	-13.45	1	0.89	10332	-13.70	0.94	1.06	-16.36	37.11
SON	EE	80.07	88.77	-8.70	-9.80	1	0.96	10332	-0.59	0.91	0.94	-11.31	15.62
TOT	EE	132.29	139.54	-7.25	-5.20	1	0.96	40467	-5.52	0.99	1.02	-4.07	25.24
DJF	EM	105.08	101.76	3.31	3.25	1	0.92	12177	2.68	1.01	1.09	2.75	14.67
JJA	EM	339.32	312.76	26.56	8.49	1	0.84	13284	68.89	0.86	1.03	8.18	31.21
MAM	EM	251.44	235.60	15.85	6.73	1	0.94	13284	-27.95	1.19	1.26	5.05	30.27
SON	EM	171.81	163.66	8.16	4.98	1	0.96	13284	-5.70	1.08	1.13	3.38	19.57
TOT	EM	219.29	205.61	13.68	6.66	1	0.98	52029	-8.06	1.11	1.13	4.89	25.12
DJF	EU	77.08	74.17	2.91	3.93	1	0.98	82238	4.79	0.97	1.00	29.58	12.54
JJA	EU	281.62	265.18	16.44	6.20	1	0.90	89760	-25.13	1.16	1.28	4.73	35.38
MAM	EU	206.76	206.67	0.09	0.04	0	0.93	89760	-32.42	1.16	1.24	-3.02	31.42
SON	EU	126.27	123.31	2.96	2.40	1	0.97	89736	-4.17	1.06	1.09	5.74	18.21
TOT	EU	174.99	169.33	5.66	3.34	1	0.97	351494	-6.32	1.07	1.10	8.82	26.33
DJF	IP	91.71	98.58	-6.87	-6.97	1	0.87	3927	7.46	0.85	0.98	-7.44	15.42
JJA	IP	317.51	296.28	21.23	7.17	1	0.68	4284	136.21	0.61	0.90	7.11	32.57
MAM	IP	224.84	223.98	0.87	0.39	0	0.87	4284	-13.79	1.07	1.22	-0.91	27.62
SON	IP	148.61	151.77	-3.17	-2.09	1	0.94	4284	-4.02	1.01	1.07	-3.40	18.65
TOT	IP	197.88	194.66	3.22	1.66	1	0.97	16779	-14.73	1.09	1.13	-1.03	24.70
DJF	LA	78.12	78.01	0.11	0.14	0	0.98	51735	1.66	0.98	1.00	21.91	12.76
JJA	LA	278.63	266.99	11.64	4.36	1	0.90	56484	-34.83	1.17	1.30	2.77	34.69
MAM	LA	202.65	208.71	-6.06	-2.90	1	0.93	56484	-40.87	1.17	1.25	-6.72	33.35
SON	LA	124.87	126.07	-1.20	-0.95	1	0.98	56460	-8.61	1.06	1.09	0.20	18.05
TOT	LA	173.07	171.92	1.15	0.67	1	0.97	221163	-10.40	1.07	1.10	4.17	26.70
DJF	NA	164.74	161.80	2.94	1.81	1	0.93	11880	-1.61	1.03	1.10	1.44	13.19
JJA	NA	353.48	320.52	32.96	10.28	1	0.77	12960	118.57	0.73	0.95	9.83	35.89
MAM	NA	303.81	280.20	23.61	8.43	1	0.90	12960	-5.06	1.10	1.22	7.83	29.87
SON	NA	217.20	205.79	11.41	5.54	1	0.95	12960	-25.80	1.18	1.25	4.52	20.89
TOT	NA	261.83	243.79	18.04	7.40	1	0.98	50760	-21.07	1.16	1.18	6.00	26.63
DJF	NE	19.31	12.67	6.64	52.45	1	0.91	9810	11.08	0.65	0.72	118.94	10.19
JJA	NE	198.68	219.39	-20.71	-9.44	1	0.72	10740	32.98	0.76	1.05	-10.51	39.29
MAM	NE	137.62	160.43	-22.81	-14.22	1	0.91	10740	8.89	0.80	0.88	-15.28	33.68
SON	NE	52.88	53.42	-0.53	-1.00	0	0.94	10720	9.69	0.81	0.86	26.59	15.74
TOT	NE	103.98	113.69	-9.71	-8.54	1	0.97	42010	8.60	0.84	0.87	27.97	27.79
DJF	OC	75.32	67.66	7.66	11.32	1	0.98	30503	9.00	0.98	1.00	42.58	12.16
JJA	OC	286.69	262.11	24.57	9.37	1	0.93	33276	-12.49	1.14	1.23	8.05	36.52
MAM	OC	213.75	203.22	10.53	5.18	1	0.95	33276	-20.68	1.15	1.21	3.26	27.83
SON	OC	128.65	118.63	10.02	8.45	1	0.98	33276	1.98	1.07	1.09	15.13	18.49
TOT	OC	178.24	164.93	13.31	8.07	1	0.98	130331	-0.40	1.08	1.10	16.72	25.69

3. Cloud Fractional Cover

Table S3. Average RegCM4 SSR and CM SAF CFC (MSG SEVIRI) with their standard deviations ($\pm 1\sigma$) and the corresponding NMB per season and region. When the difference between RegCM4 and CM SAF CFC is statistically significant at the 95% confidence level due to a two independent sample t-test, the NMB values are marked with bold letters while in the opposite case they are marked with an asterisk. Positive NMBs are marked with red color while negative NMBs with blue. ANN corresponds to annual, DJF to winter, MAM to spring, JJA to summer and SON to autumn results while the regions are listed in alphabetical order.

	ANN			DJF			MAM			JJA			SON		
	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias
CE	0.55±0.11	0.69±0.12	**-19.73**	0.62±0.06	0.74±0.12	**-16.00**	0.58±0.07	0.67±0.112	**-13.95**	0.42±0.11	0.65±0.123	**-34.80**	0.58±0.08	0.68±0.13	**-14.96**
CM	0.35±0.16	0.51±0.17	**-31.19**	0.47±0.08	0.64±0.112	**-25.92**	0.41±0.1	0.57±0.105	**-28.05**	0.14±0.11	0.30±0.125	**-54.86**	0.39±0.11	0.54±0.12	**-27.26**
EE	0.56±0.14	0.67±0.15	**-15.99**	0.67±0.05	0.8±0.085	**-16.84**	0.59±0.09	0.65±0.117	**-9.20**	0.4±0.12	0.55±0.129	**-27.46**	0.58±0.1	0.67±0.14	**-12.21**
EM	0.32±0.2	0.44±0.24	**-28.83**	0.49±0.13	0.66±0.147	**-25.67**	0.36±0.16	0.51±0.156	**-28.60**	0.1±0.11	0.18±0.147	**-45.93**	0.33±0.17	0.44±0.20	**-26.57**
EU	0.44±0.2	0.58±0.25	**-24.34**	0.53±0.15	0.68±0.229	**-21.81**	0.47±0.17	0.59±0.209	**-20.53**	0.3±0.21	0.47±0.281	**-36.57**	0.47±0.18	0.59±0.24	**-21.14**
IP	0.41±0.16	0.48±0.17	**-13.65**	0.5±0.10	0.54±0.143	**-7.68**	0.48±0.11	0.56±0.134	**-14.37**	0.23±0.13	0.33±0.169	**-30.11**	0.45±0.12	0.49±0.15	**-7.95**
LA	0.45±0.2	0.53±0.24	**-13.74**	0.54±0.17	0.61±0.24	**-11.53**	0.48±0.17	0.54±0.205	**-9.82**	0.31±0.20	0.43±0.257	**-26.92**	0.48±0.18	0.53±0.24	**-9.44**
NA	0.23±0.14	0.23±0.14	0.36*	0.3±0.11	0.27±0.137	**8.12**	0.26±0.11	0.26±0.122	**-2.27**	0.11±0.10	0.15±0.128	**-29.22**	0.28±0.14	0.25±0.14	**13.14**
NE	0.59±0.09	0.75±0.12	**-20.34**	0.65±0.05	0.83±0.092	**-21.20**	0.59±0.07	0.68±0.106	**-12.79**	0.52±0.09	0.7±0.107	**-25.63**	0.62±0.07	0.78±0.11	**-21.39**
OC	0.42±0.19	0.68±0.23	**-38.41**	0.52±0.12	0.8±0.142	**-35.23**	0.44±0.15	0.68±0.184	**-34.98**	0.27±0.21	0.54±0.306	**-49.63**	0.44±0.17	0.7±0.27	**-36.50**

Table S4. Average RegCM4 CFC, CM SAF CFC (MSG SEVIRI), their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test per season and region. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CMSAF+b). The region are listed in alphabetic order.

Season	Region	REG	CMS	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
DJF	CE	0.62	0.74	-0.12	-16.01	1	0.13	13209	0.57	0.07	0.52	-16.33	0.17
JJA	CE	0.42	0.65	-0.23	-34.80	1	0.53	13986	0.11	0.48	0.90	-43.29	0.25
MAM	CE	0.58	0.67	-0.09	-13.96	1	0.23	13986	0.48	0.15	0.66	-14.14	0.15
SON	CE	0.58	0.68	-0.10	-14.96	1	0.41	13986	0.40	0.26	0.63	-15.20	0.16
TOT	CE	0.55	0.69	-0.14	-19.73	1	0.40	55167	0.30	0.36	0.90	-22.33	0.19
DJF	CM	0.47	0.64	-0.17	-25.92	1	0.29	7803	0.34	0.20	0.69	-29.29	0.20
JJA	CM	0.14	0.30	-0.16	-54.86	1	0.68	8262	-0.04	0.60	0.87	-91.85	0.19
MAM	CM	0.41	0.57	-0.16	-28.05	1	0.38	8262	0.20	0.37	0.96	-33.47	0.20
SON	CM	0.39	0.54	-0.15	-27.26	1	0.44	8262	0.18	0.39	0.89	-32.43	0.19
TOT	CM	0.35	0.51	-0.16	-31.19	1	0.78	32589	-0.02	0.73	0.95	-47.00	0.19
DJF	EE	0.67	0.80	-0.14	-16.84	1	0.31	14637	0.53	0.17	0.54	-17.99	0.16
JJA	EE	0.40	0.55	-0.15	-27.46	1	0.74	15498	0.02	0.69	0.93	-34.04	0.18
MAM	EE	0.59	0.65	-0.06	-9.20	1	0.34	15498	0.43	0.25	0.74	-9.03	0.13
SON	EE	0.58	0.67	-0.08	-12.21	1	0.76	15498	0.21	0.56	0.74	-12.39	0.12
TOT	EE	0.56	0.67	-0.11	-16.00	1	0.74	61131	0.11	0.67	0.91	-18.37	0.15
DJF	EM	0.49	0.66	-0.17	-25.67	1	0.47	18819	0.22	0.40	0.86	-29.59	0.22
JJA	EM	0.10	0.18	-0.08	-45.93	1	0.76	19926	-0.01	0.57	0.75	-82.30	0.13
MAM	EM	0.36	0.51	-0.14	-28.60	1	0.73	19926	-0.02	0.75	1.02	-38.06	0.19
SON	EM	0.33	0.44	-0.12	-26.57	1	0.73	19926	0.05	0.62	0.85	-33.17	0.18
TOT	EM	0.32	0.44	-0.13	-28.83	1	0.84	78597	0.00	0.71	0.85	-46.01	0.18
DJF	EU	0.53	0.68	-0.15	-21.81	1	0.75	127942	0.19	0.50	0.67	-20.99	0.21
JJA	EU	0.30	0.47	-0.17	-36.57	1	0.87	135468	0.00	0.63	0.73	-50.47	0.23
MAM	EU	0.47	0.59	-0.12	-20.53	1	0.74	135468	0.12	0.59	0.80	-22.29	0.19
SON	EU	0.47	0.59	-0.13	-21.14	1	0.80	135468	0.13	0.57	0.72	-19.80	0.19
TOT	EU	0.44	0.58	-0.14	-24.34	1	0.81	534346	0.07	0.63	0.78	-28.49	0.21
DJF	IP	0.50	0.54	-0.04	-7.68	1	0.32	6069	0.38	0.22	0.69	-6.24	0.15
JJA	IP	0.23	0.33	-0.10	-30.11	1	0.52	6426	0.10	0.39	0.75	-37.14	0.18
MAM	IP	0.48	0.56	-0.08	-14.37	1	0.39	6426	0.30	0.32	0.81	-15.05	0.16
SON	IP	0.45	0.49	-0.04	-7.95	1	0.52	6426	0.25	0.41	0.79	-7.08	0.14
TOT	IP	0.41	0.48	-0.07	-13.65	1	0.63	25347	0.14	0.56	0.90	-16.52	0.16
DJF	LA	0.54	0.61	-0.07	-11.53	1	0.88	80767	0.16	0.62	0.71	-7.73	0.14
JJA	LA	0.31	0.43	-0.12	-26.92	1	0.91	85518	0.01	0.70	0.78	-29.04	0.16
MAM	LA	0.48	0.54	-0.05	-9.82	1	0.84	85518	0.10	0.71	0.85	-9.07	0.12
SON	LA	0.48	0.53	-0.05	-9.44	1	0.88	85518	0.13	0.66	0.75	-3.57	0.13
TOT	LA	0.45	0.53	-0.07	-13.74	1	0.88	337321	0.08	0.72	0.82	-12.42	0.14
DJF	NA	0.30	0.27	0.02	8.12	1	0.53	18360	0.18	0.42	0.78	11.55	0.12
JJA	NA	0.11	0.15	-0.04	-29.22	1	0.71	19440	0.02	0.57	0.80	-16.70	0.10
MAM	NA	0.26	0.26	-0.01	-2.27	1	0.63	19440	0.10	0.58	0.91	-1.23	0.10
SON	NA	0.28	0.25	0.03	13.14	1	0.73	19440	0.10	0.71	0.98	20.29	0.11
TOT	NA	0.23	0.23	0.00	0.37	0	0.70	76680	0.07	0.68	0.98	3.36	0.11
DJF	NE	0.65	0.83	-0.18	-21.20	1	0.00	15691	0.65	0.00	0.54	-23.25	0.20
JJA	NE	0.52	0.70	-0.18	-25.63	1	0.33	16614	0.33	0.27	0.82	-29.39	0.21
MAM	NE	0.59	0.68	-0.09	-12.79	1	0.29	16614	0.46	0.20	0.69	-13.12	0.14
SON	NE	0.62	0.78	-0.17	-21.33	1	0.44	16614	0.40	0.28	0.65	-23.40	0.20
TOT	NE	0.59	0.75	-0.15	-20.34	1	0.43	65533	0.36	0.31	0.72	-22.28	0.19
DJF	OC	0.52	0.80	-0.28	-35.23	1	0.76	47175	0.00	0.64	0.85	-43.70	0.30
JJA	OC	0.27	0.54	-0.27	-49.63	1	0.91	49950	-0.07	0.63	0.69	-87.16	0.31
MAM	OC	0.44	0.68	-0.24	-34.98	1	0.82	49950	-0.02	0.68	0.82	-44.91	0.26
SON	OC	0.44	0.70	-0.25	-36.48	1	0.89	49950	-0.03	0.68	0.77	-47.60	0.27
TOT	OC	0.42	0.68	-0.26	-38.42	1	0.88	197025	-0.05	0.70	0.79	-56.01	0.28

4. Cloud Optical Thickness

Table S5. The same as Table S3 but for RegCM4 and CM SAF COT.

	ANN			DJF			MAM			JJA			SON		
	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias
CE	14.63±5.76	11.79±3.80	**24.09**	16.75±5.9	13.45±4.87	**24.56**	16.1±4.72	10.41±2.97	**54.58**	10.35±4.35	10.87±2.65	**-4.82**	15.79±5.62	12.79±3.76	**23.46**
CM	6.4±3.71	9.24±3.83	**-30.74**	8.02±3.7	11.29±3.96	**-28.92**	7.55±3.6	9.3±3.16	**-18.83**	3.44±1.91	6.69±3.22	**-48.67**	6.58±3.45	9.71±3.462	**-32.26**
EE	15.64±6.02	11.95±4.01	**30.85**	18.1±4.32	14.23±4.89	**27.17**	16.72±4.97	10.01±2.70	**67.02**	9.9±3.98	10.61±2.69	**-6.67**	18.36±6.00	13.44±3.972	**36.60**
EM	7.15±4.93	9.17±4.701	**-21.96**	9.64±5.19	11.51±4.82	**-16.25**	7.65±4.57	8.23±3.41	**-7.03**	3.81±2.7	7.02±4.47	**-45.75**	7.04±4.89	9.64±4.812	**-27.02**
EU	10.05±6.4	9.63±4.22	**4.29**	10.78±6.05	11.04±4.89	**-2.31**	10.74±6.1	8.67±3.38	**23.83**	7.85±5.76	8.72±3.48	**-9.98**	10.87±7.05	10.38±4.581	**4.68**
IP	8.29±4.98	9.63±3.59	**-13.85**	11.01±5.25	11.13±3.90	-1.08*	9.03±4.4	9.4±2.94	**-3.88**	4.51±2.32	8.01±3.09	**-43.71**	8.77±5.00	10.06±3.634	**-12.78**
LA	11.45±6.96	10.67±4.40	**7.29**	12.63±6.49	12.01±5.28	**5.22**	12.21±6.64	9.62±3.58	**27.02**	8.34±6.01	9.81±3.42	**-14.94**	12.69±7.60	11.49±4.725	**10.41**
NA	4.77±2.93	7.93±3.43	**-39.81**	6.22±3.2	8.25±3.36	**-24.68**	4.81±2.48	7.65±3.14	**-37.11**	2.88±1.8	7.97±3.65	**-63.83**	4.92±2.98	7.88±3.581	**-37.57**
NE	15.24±5.6	9.88±5.22	**54.33**	12.81±3.78	11.34±7.36	**12.97**	15.11±4.87	8.64±4.95	**74.84**	14.57±5.68	9.16±2.87	**59.04**	17.34±6.30	11.83±6.081	**46.63**
OC	7.71±4.43	7.9±3.23	**-2.46**	7.55±3.23	9.35±3.54	**-19.22**	8.33±4.06	7.13±2.32	**16.83**	7.04±5.24	6.93±2.78	**1.46**	7.84±4.66	8.54±3.646	**-8.17**

Table S6. Average RegCM4 COT, CM SAF COT (MSG SEVIRI), their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test per season and region. The NSD, MNMB and RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CMSAF+b). The region are listed in alphabetic order.

Season	Region	REG	CMS	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
DJF	CE	16.75	13.45	3.30	24.56	1	0.18	10956	13.83	0.22	1.21	20.51	7.69
JJA	CE	10.35	10.87	-0.52	-4.82	1	0.37	13986	3.78	0.60	1.64	-10.97	4.21
MAM	CE	16.10	10.41	5.68	54.58	1	0.26	13986	11.80	0.41	1.59	41.43	7.49
SON	CE	15.79	12.79	3.00	23.46	1	0.30	13986	10.00	0.45	1.50	17.56	6.48
TOT	CE	14.63	11.79	2.84	24.09	1	0.29	52914	9.40	0.44	1.52	16.94	6.54
DJF	CM	8.02	11.29	-3.26	-28.92	1	0.43	7803	3.46	0.40	0.93	-35.88	5.23
JJA	CM	3.44	6.69	-3.26	-48.67	1	0.31	7948	2.22	0.18	0.59	-62.84	4.57
MAM	CM	7.55	9.30	-1.75	-18.83	1	0.49	8262	2.39	0.55	1.14	-24.17	3.86
SON	CM	6.58	9.71	-3.13	-32.26	1	0.32	8262	3.46	0.32	1.00	-41.64	5.10
TOT	CM	6.40	9.24	-2.84	-30.74	1	0.50	32275	1.92	0.49	0.97	-41.00	4.72
DJF	EE	18.10	14.23	3.87	27.17	1	0.15	12139	16.18	0.13	0.88	25.69	7.14
JJA	EE	9.90	10.61	-0.71	-6.67	1	0.22	15475	6.46	0.32	1.48	-11.41	4.34
MAM	EE	16.72	10.01	6.71	67.02	1	0.33	15470	10.70	0.60	1.84	47.56	8.26
SON	EE	18.36	13.44	4.92	36.60	1	0.36	15477	11.04	0.54	1.51	28.42	7.67
TOT	EE	15.64	11.95	3.69	30.85	1	0.35	58561	9.38	0.52	1.50	22.39	7.01
DJF	EM	9.64	11.51	-1.87	-16.25	1	0.48	18819	3.74	0.51	1.08	-22.96	5.46
JJA	EM	3.81	7.02	-3.21	-45.75	1	0.52	16268	1.62	0.31	0.60	-53.52	5.01
MAM	EM	7.65	8.23	-0.58	-7.03	1	0.60	19926	1.08	0.80	1.34	-14.00	3.78
SON	EM	7.04	9.64	-2.61	-27.03	1	0.61	19842	1.11	0.61	1.02	-37.93	5.04
TOT	EM	7.15	9.17	-2.01	-21.96	1	0.58	74855	1.56	0.61	1.05	-31.19	4.85
DJF	EU	10.78	11.04	-0.26	-2.31	1	0.47	101916	4.31	0.59	1.24	-9.40	5.70
JJA	EU	7.85	8.72	-0.87	-9.98	1	0.40	121638	2.13	0.66	1.65	-27.80	5.49
MAM	EU	10.74	8.67	2.07	23.83	1	0.39	130152	4.64	0.70	1.80	9.07	6.07
SON	EU	10.87	10.38	0.49	4.68	1	0.54	123815	2.28	0.83	1.54	-9.27	6.02
TOT	EU	10.05	9.63	0.41	4.29	1	0.46	477521	3.32	0.70	1.52	-9.02	5.84
DJF	IP	11.01	11.13	-0.12	-1.08	0	0.41	6069	4.82	0.56	1.35	-5.86	5.09
JJA	IP	4.51	8.01	-3.50	-43.71	1	0.44	6419	1.87	0.33	0.75	-57.96	4.57
MAM	IP	9.03	9.40	-0.36	-3.88	1	0.39	6426	3.57	0.58	1.50	-9.86	4.26
SON	IP	8.77	10.06	-1.29	-12.79	1	0.54	6426	1.37	0.74	1.37	-22.29	4.51
TOT	IP	8.29	9.63	-1.33	-13.85	1	0.51	25340	1.48	0.71	1.39	-24.24	4.61
DJF	LA	12.63	12.01	0.63	5.22	1	0.45	64836	6.01	0.55	1.23	-1.69	6.30
JJA	LA	8.34	9.81	-1.47	-14.94	1	0.33	75424	2.75	0.57	1.76	-33.69	6.05
MAM	LA	12.21	9.62	2.60	27.02	1	0.35	80657	5.97	0.65	1.86	10.77	6.86
SON	LA	12.69	11.49	1.20	10.40	1	0.51	77414	3.29	0.82	1.61	-4.01	6.71
TOT	LA	11.45	10.67	0.78	7.29	1	0.43	298331	4.23	0.68	1.58	-7.01	6.50
DJF	NA	6.22	8.25	-2.04	-24.68	1	0.40	18240	3.07	0.38	0.95	-31.11	4.13
JJA	NA	2.88	7.97	-5.09	-63.83	1	0.32	15742	1.63	0.16	0.49	-93.43	6.19
MAM	NA	4.81	7.65	-2.84	-37.11	1	0.37	19429	2.57	0.29	0.79	-46.61	4.28
SON	NA	4.92	7.88	-2.96	-37.57	1	0.42	18637	2.16	0.35	0.83	-49.00	4.63
TOT	NA	4.77	7.93	-3.16	-39.82	1	0.36	72048	2.37	0.30	0.85	-53.53	4.81
DJF	NE	12.81	11.34	1.47	12.97	1	0.25	4014	11.34	0.13	0.51	21.54	7.52
JJA	NE	14.57	9.16	5.41	59.04	1	0.32	12484	8.77	0.63	1.98	41.88	7.70
MAM	NE	15.11	8.64	6.47	74.84	1	0.23	12453	13.18	0.22	0.98	56.75	8.89
SON	NE	17.34	11.83	5.52	46.63	1	0.31	9471	13.58	0.32	1.04	40.13	9.14
TOT	NE	15.24	9.88	5.37	54.34	1	0.27	38422	12.36	0.29	1.07	44.14	8.45
DJF	OC	7.55	9.35	-1.80	-19.22	1	0.27	37080	5.25	0.25	0.91	-22.89	4.47
JJA	OC	7.04	6.93	0.10	1.47	1	0.53	46214	0.10	1.00	1.89	-18.19	4.44
MAM	OC	8.33	7.13	1.20	16.83	1	0.17	49495	6.19	0.30	1.75	6.30	4.48
SON	OC	7.84	8.54	-0.70	-8.17	1	0.41	46401	3.42	0.52	1.28	-18.06	4.66
TOT	OC	7.71	7.90	-0.19	-2.46	1	0.34	179190	4.03	0.47	1.37	-12.36	4.52

5. Effective Radius (liquid clouds)

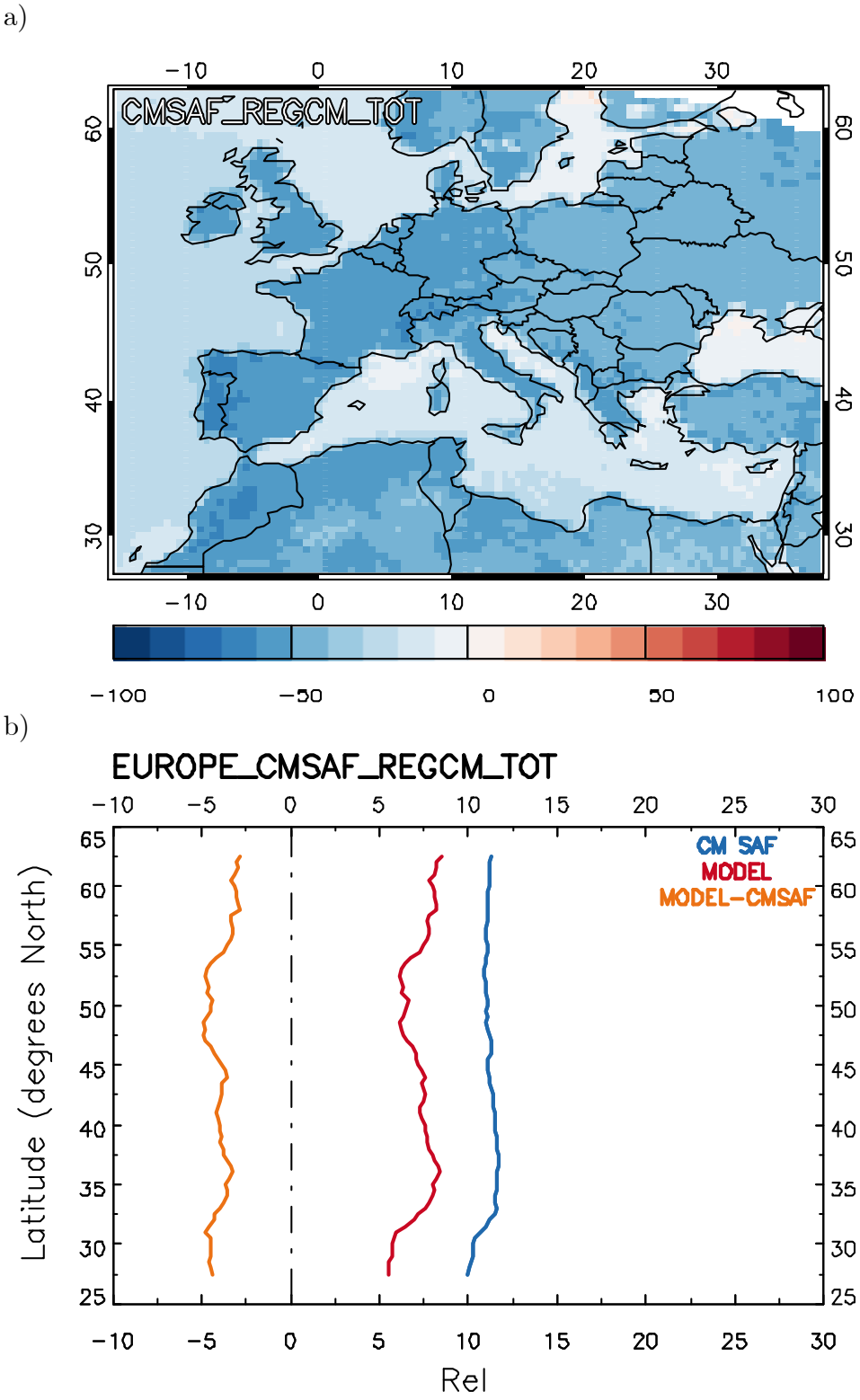


Figure S6. (a) NMB patterns of RegCM4-CM SAF Rel and (b) Latitudinal variability of RegCM4 Rel (red), CM SAF Rel (blue) and their difference (orange) over Europe from MSG SEVIRI observations.

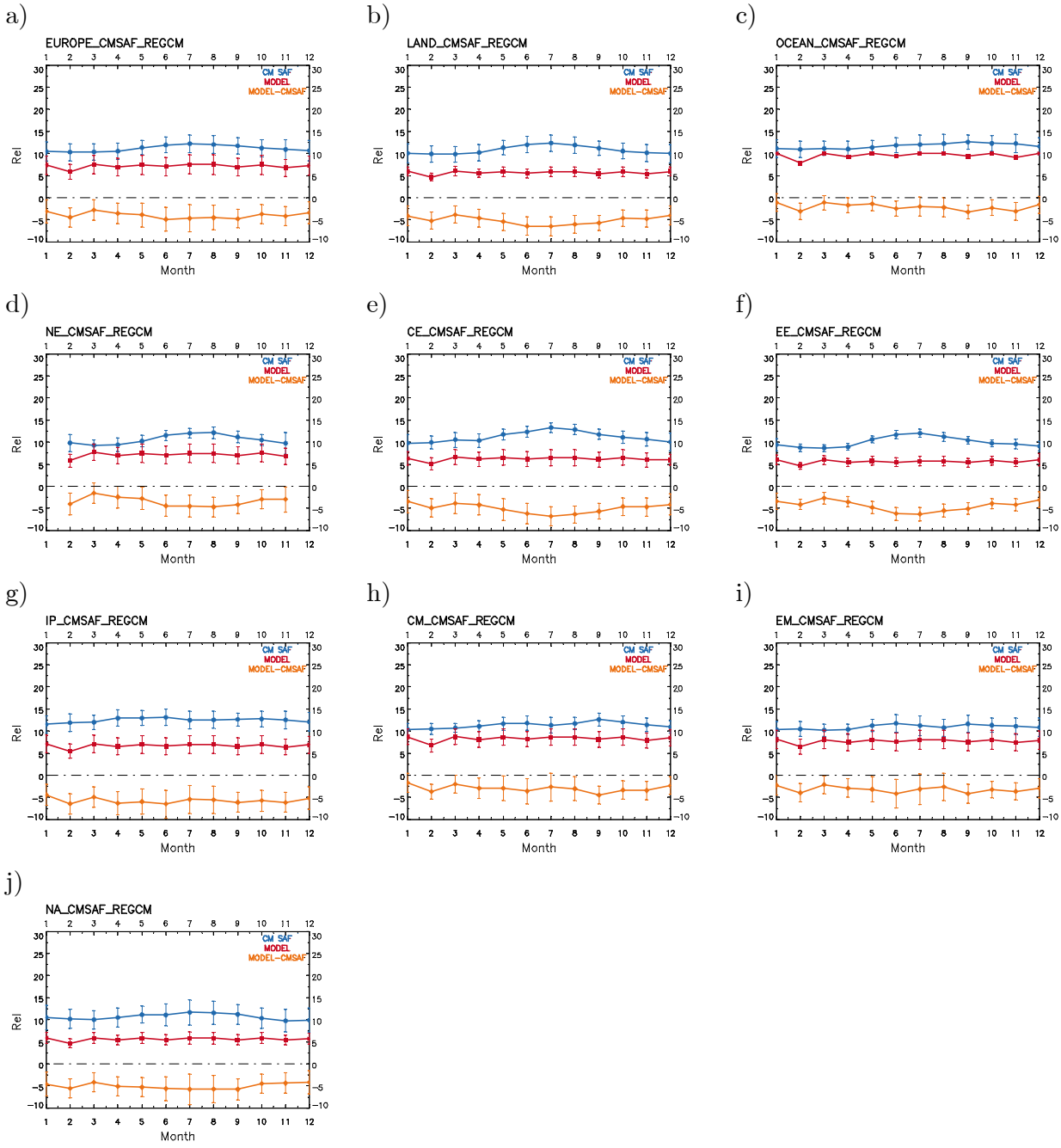


Figure S7. Seasonal variability of RegCM4 Rel (red), CM SAF Rel (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA from MSG SEVIRI observations.

Table S7. Average RegCM4 Rel, CM SAF Rel (MSG SEVIRI), their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test for each region of interest. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CMSAF+b). The region are listed in alphabetic order.

Season	Region	REG	CMS	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
TOT	CE	6.19	11.27	-5.08	-45.05	1	0.07	35197	5.45	0.07	0.93	-58.89	5.62
TOT	CM	8.31	11.34	-3.03	-26.71	1	-0.03	22030	8.68	-0.03	1.18	-32.03	3.91
TOT	EE	5.58	10.06	-4.48	-44.55	1	0.01	38829	5.54	0.00	0.74	-57.15	4.83
TOT	EM	7.73	10.93	-3.20	-29.25	1	0.15	51998	5.91	0.17	1.13	-35.82	4.10
TOT	EU	7.13	11.15	-4.02	-36.06	1	0.24	321501	4.34	0.25	1.03	-45.45	4.77
TOT	IP	6.70	12.43	-5.73	-46.10	1	0.05	17136	6.09	0.05	1.04	-61.25	6.33
TOT	LA	5.65	10.82	-5.16	-47.73	1	0.13	196563	4.95	0.07	0.52	-61.61	5.60
TOT	NA	5.58	10.59	-5.01	-47.31	1	0.18	48288	4.65	0.09	0.49	-59.90	5.63
TOT	NE	7.17	10.66	-3.49	-32.76	1	0.06	25573	6.47	0.07	1.15	-40.71	4.35
TOT	OC	9.56	11.71	-2.15	-18.33	1	0.10	120242	9.17	0.03	0.34	-18.93	2.92

6. Effective Radius (ice clouds)

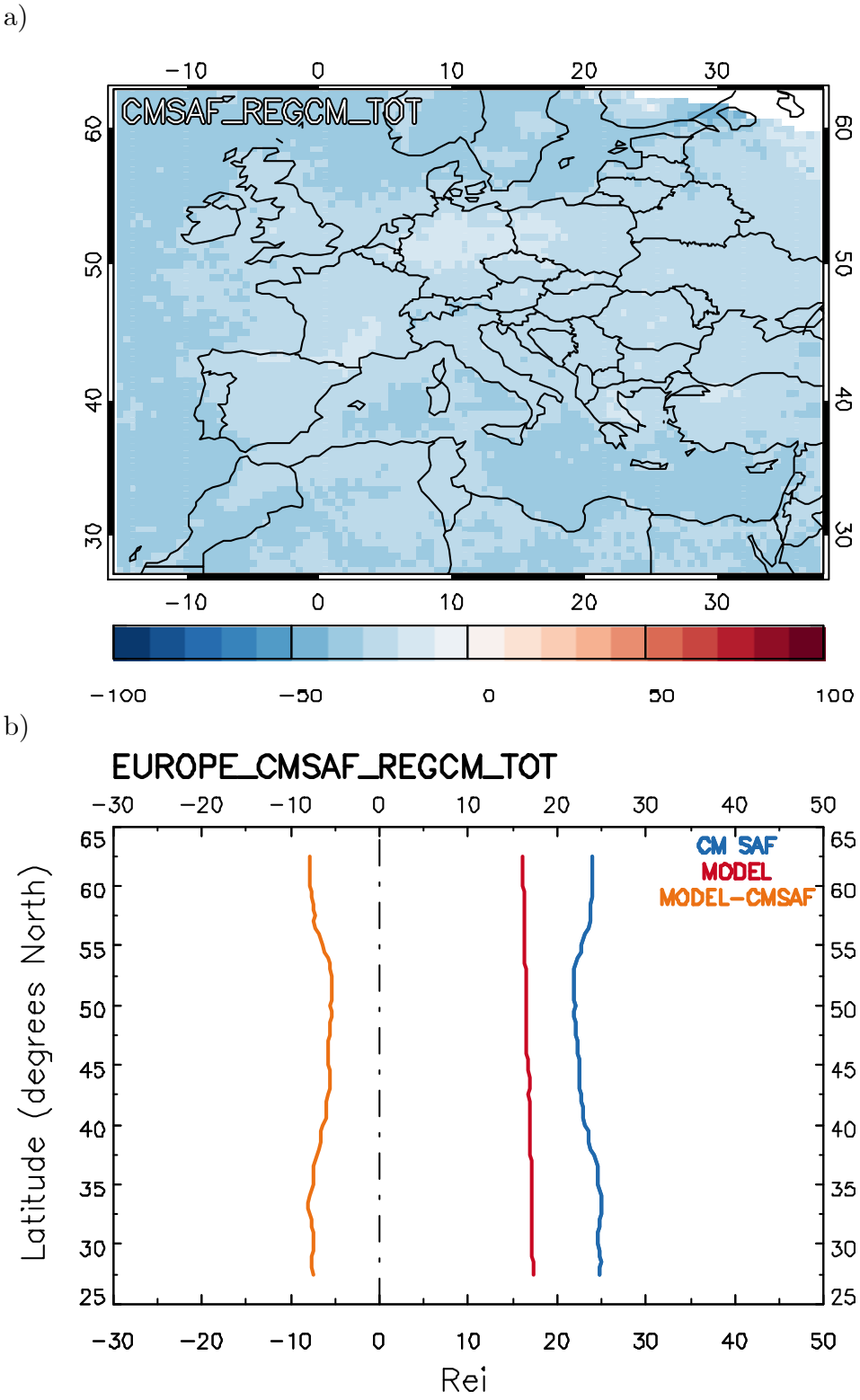


Figure S8. (a) NMB patterns of RegCM4-CM SAF Rei and (b) Latitudinal variability of RegCM4 Rei (red), CM SAF Rei (blue) and their difference (orange) over Europe from MSG SEVIRI observations.

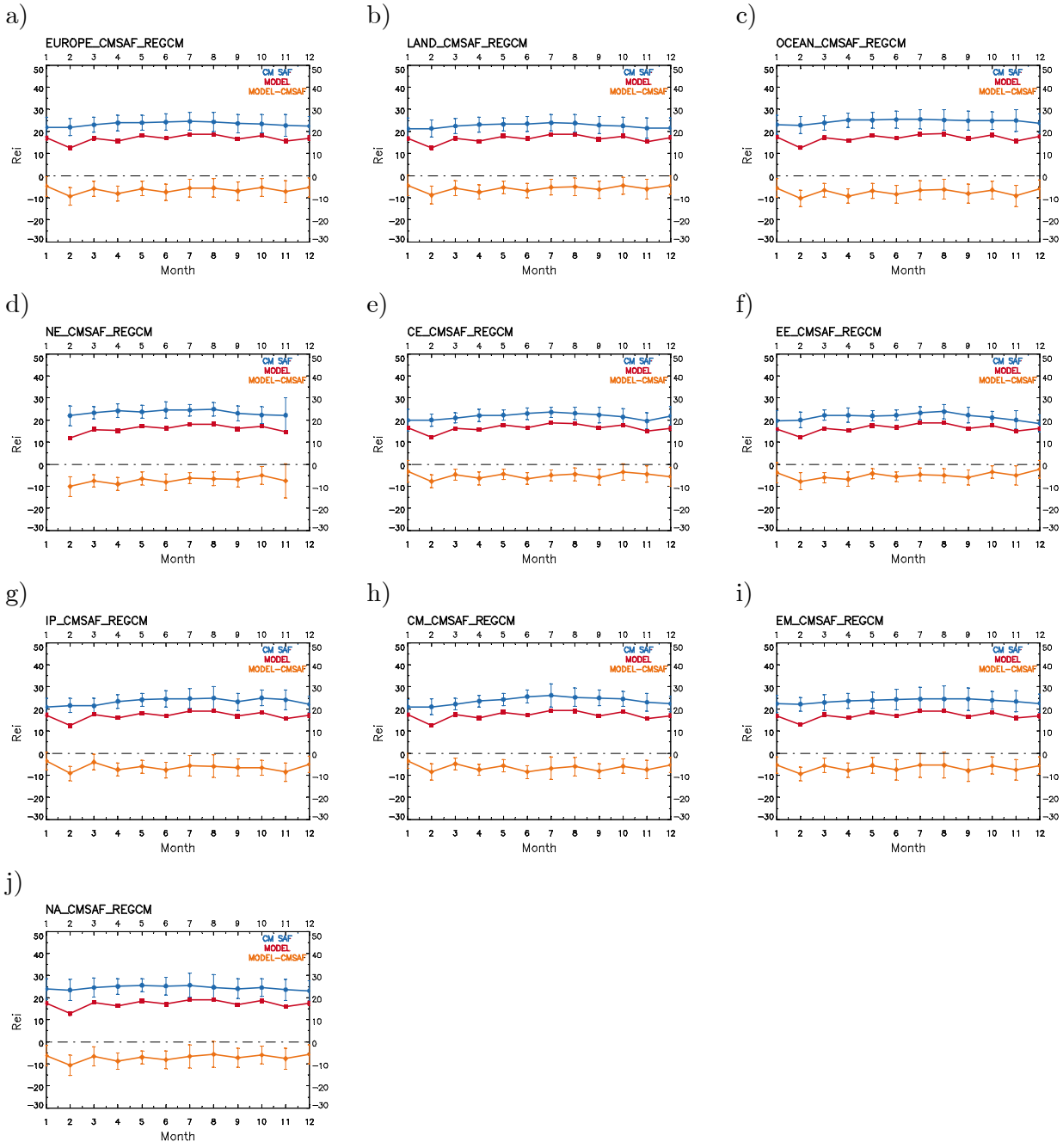


Figure S9. Seasonal variability of RegCM4 Rei (red), CM SAF Rei (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA from MSG SEVIRI observations.

Table S8. Average RegCM4 Rei, CM SAF Rei (MSG SEVIRI), their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test for each region of interest. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CMSAF+b). The region are listed in alphabetic order.

Season	Region	REG	CMS	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
TOT	CE	16.48	21.68	-5.20	-23.97	1	0.25	35118	13.73	0.13	0.51	-26.34	6.24
TOT	CM	17.11	23.63	-6.51	-27.57	1	0.29	21923	13.94	0.13	0.46	-30.99	7.55
TOT	EE	16.36	21.57	-5.22	-24.18	1	0.23	38976	13.86	0.12	0.49	-26.49	6.33
TOT	EM	16.77	23.42	-6.65	-28.40	1	0.21	46496	14.83	0.08	0.40	-31.73	7.89
TOT	EU	16.73	23.31	-6.59	-28.25	1	0.20	311416	14.68	0.09	0.44	-31.64	7.78
TOT	IP	16.95	23.31	-6.36	-27.29	1	0.22	16968	14.71	0.10	0.44	-30.40	7.58
TOT	LA	16.63	22.59	-5.96	-26.38	1	0.21	191686	14.53	0.09	0.45	-29.19	7.18
TOT	NA	17.08	24.39	-7.31	-29.97	1	0.12	45444	15.92	0.05	0.39	-33.72	8.63
TOT	NE	16.21	23.58	-7.37	-31.26	1	0.17	25607	14.22	0.08	0.51	-36.27	8.28
TOT	OC	16.93	24.55	-7.62	-31.05	1	0.16	115049	15.21	0.07	0.45	-35.68	8.70

7. Aerosol Optical Depth

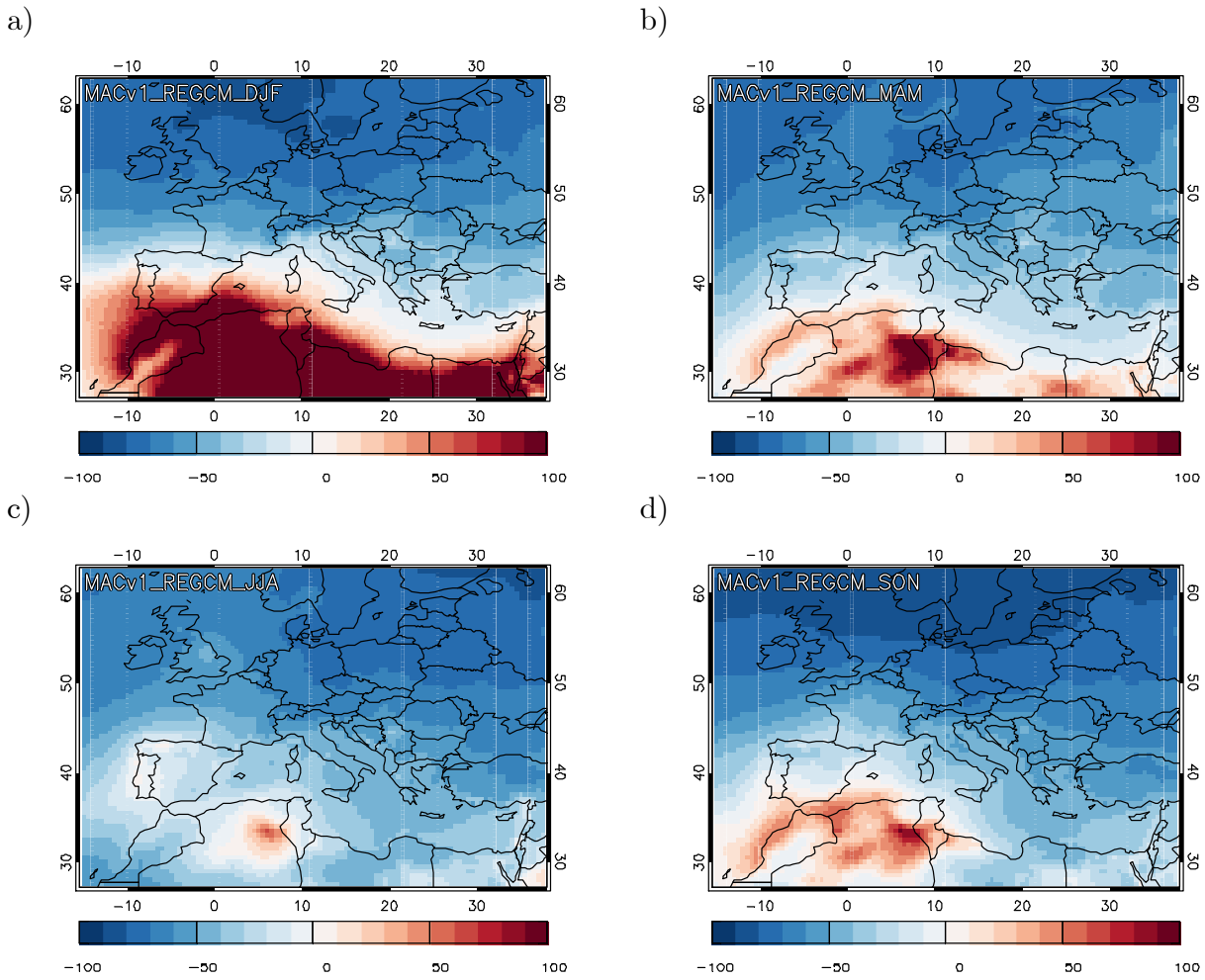


Figure S10. Seasonal Normalized mean bias (NMB) patterns of RegCM4-MACv1 AOD_{550} over Europe for (a) winter (DJF), (b) spring (MAM), (c) summer (JJA) and (d) autumn (SON).

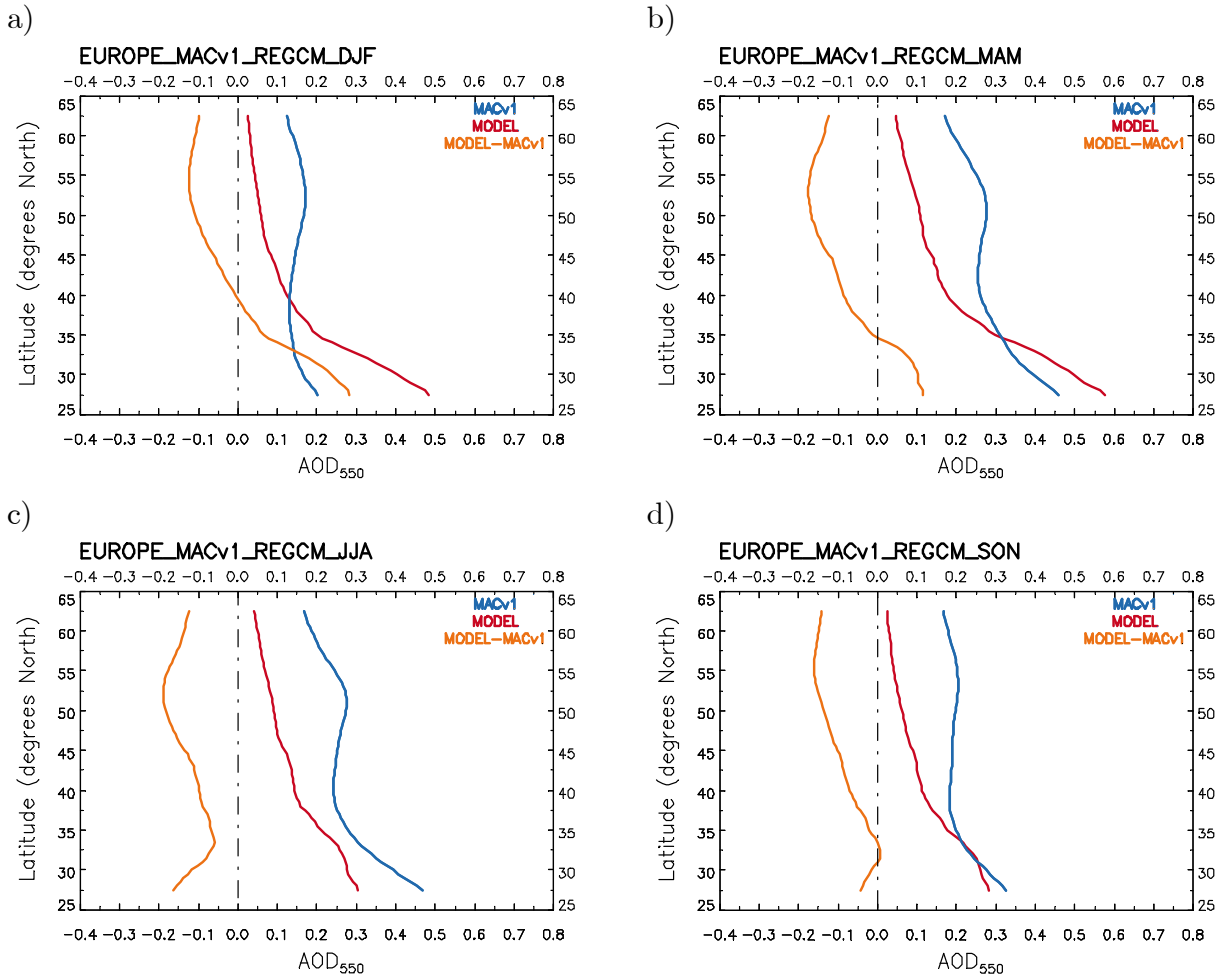


Figure S11. (a) NMB patterns of RegCM4-MACv1 AOD_{550} and (b) Latitudinal variability of RegCM4 AOD_{550} (red), MACv1 AOD_{550} (blue) and their difference (orange) over Europe.

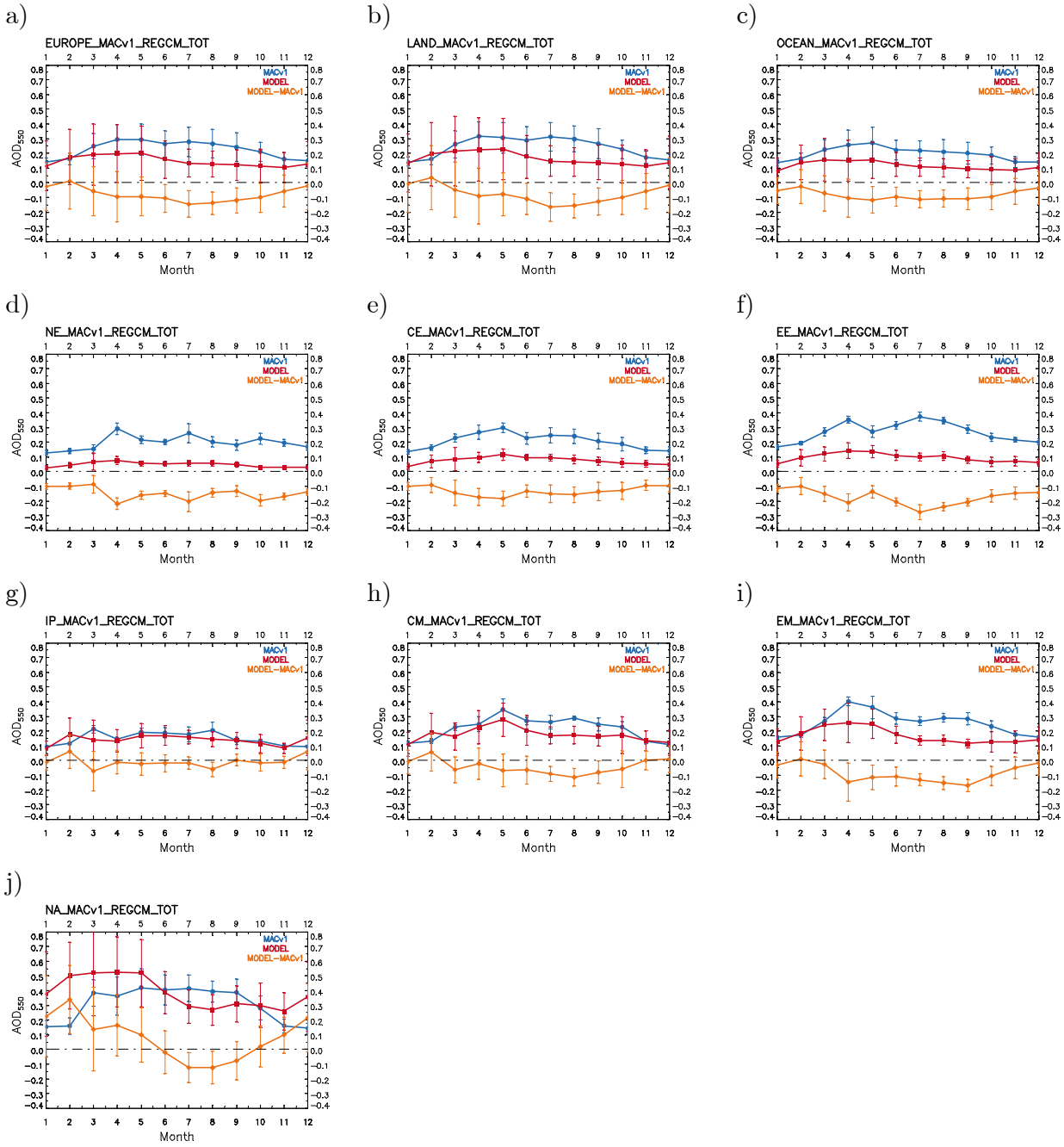


Figure S12. Seasonal variability of RegCM4 AOD_{550} (red), CM SAF AOD_{550} (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA.

Table S9. The same as Table S3 but for RegCM4 and MACv1 AOD_{550}.

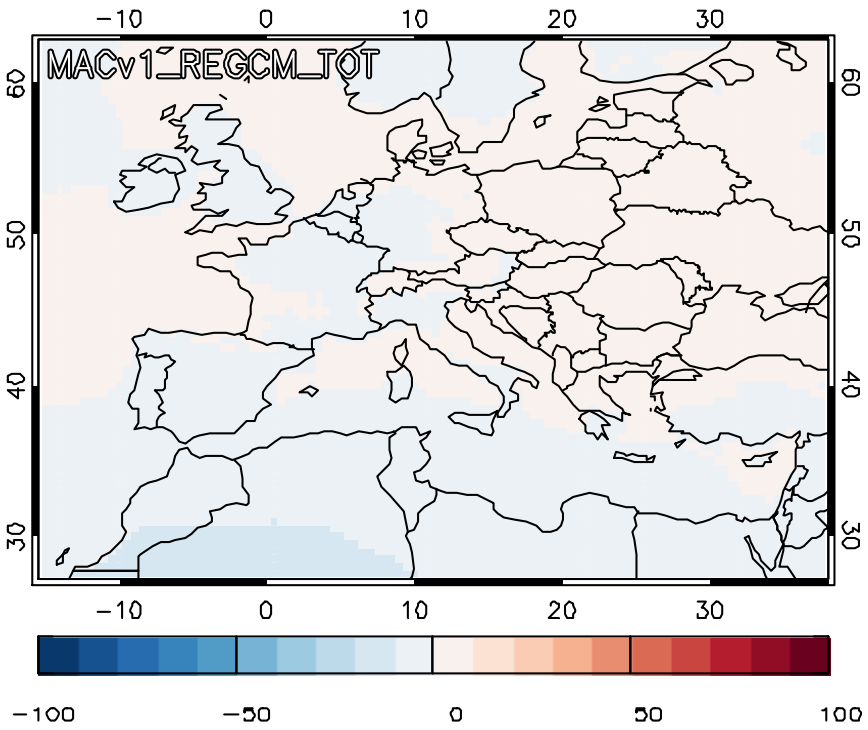
	ANN			DJF			MAM			JJA			SON		
	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias	MOD	SAT	bias
CE	0.08±0.04	0.21±0.06	**-63.59**	0.05±0.04	0.15±0.02	**-64.92**	0.1±0.06	0.27±0.05	**-62.94**	0.09±0.03	0.24±0.05	**-61.58**	0.06±0.03	0.18±0.05	**-66.18**
CM	0.18±0.1	0.22±0.08	**-19.33**	0.14±0.11	0.12±0.02	**16.18**	0.22±0.12	0.27±0.07	**-18.45**	0.18±0.08	0.27±0.03	**-32.93**	0.16±0.09	0.2±0.06	**-22.36**
EE	0.1±0.05	0.27±0.07	**-64.58**	0.07±0.04	0.19±0.02	**-62.44**	0.13±0.05	0.3±0.05	**-55.47**	0.1±0.03	0.34±0.04	**-69.58**	0.07±0.03	0.25±0.04	**-70.17**
EM	0.17±0.1	0.26±0.08	**-34.19**	0.15±0.1	0.16±0.02	**-7.73**	0.25±0.11	0.34±0.07	**-27.7**	0.15±0.05	0.28±0.03	**-46.68**	0.12±0.06	0.23±0.06	**-46.39**
EU	0.15±0.15	0.23±0.1	**-35.27**	0.14±0.17	0.15±0.04	**-7.91**	0.20±0.20	0.28±0.1	**-29.36**	0.14±0.11	0.27±0.1	**-48.38**	0.11±0.11	0.2±0.08	**-45.12**
IP	0.14±0.09	0.15±0.05	**-7.43**	0.14±0.11	0.1±0.01	**33.79**	0.15±0.1	0.18±0.04	**-19.27**	0.16±0.06	0.19±0.05	**-17.09**	0.11±0.06	0.12±0.02	**-7.11**
LA	0.17±0.17	0.24±0.1	**-32.09**	0.16±0.2	0.15±0.04	**2.66**	0.22±0.22	0.29±0.1	**-24.56**	0.15±0.12	0.3±0.1	**-48.22**	0.13±0.12	0.22±0.08	**-42.97**
NA	0.39±0.22	0.31±0.14	**25.01**	0.41±0.26	0.15±0.05	**171.38**	0.52±0.26	0.39±0.12	**34.17**	0.32±0.13	0.4±0.09	**-22.08**	0.29±0.14	0.28±0.12	**4.62**
NE	0.05±0.03	0.2±0.06	**-75.92**	0.03±0.02	0.15±0.02	**-76.94**	0.07±0.04	0.22±0.07	**-70.23**	0.06±0.02	0.22±0.05	**-74.61**	0.03±0.02	0.2±0.04	**-82.95**
OC	0.12±0.1	0.2±0.08	**-41.95**	0.11±0.11	0.15±0.03	**-26.75**	0.15±0.14	0.25±0.09	**-39**	0.11±0.07	0.22±0.07	**-48.76**	0.09±0.08	0.18±0.06	**-49.72**

Table S10. Average RegCM4 AOD_{550}, MACv1 AOD_{550}, their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test per season and region. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·MACv1+b). The region are listed in alphabetic order.

Season	Region	REG	MACv1	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
DJF	CE	0.05	0.15	-0.09	-64.92	1	0.07	13209	0.04	0.10	1.55	-102.94	0.10
JJA	CE	0.09	0.24	-0.15	-61.58	1	0.00	13986	0.09	0.00	0.54	-88.55	0.16
MAM	CE	0.10	0.27	-0.17	-62.94	1	0.11	13986	0.06	0.13	1.21	-97.02	0.18
SON	CE	0.06	0.18	-0.12	-66.18	1	0.05	13986	0.06	0.03	0.57	-99.14	0.13
TOT	CE	0.08	0.21	-0.13	-63.59	1	0.37	55167	0.02	0.25	0.68	-96.83	0.15
DJF	CM	0.14	0.12	0.02	16.18	1	0.12	7803	0.05	0.73	6.02	-10.77	0.11
JJA	CM	0.18	0.27	-0.09	-32.93	1	0.34	8262	-0.04	0.82	2.41	-44.66	0.12
MAM	CM	0.22	0.27	-0.05	-18.45	1	0.47	8262	0.02	0.75	1.59	-29.27	0.12
SON	CM	0.16	0.20	-0.05	-22.36	1	0.22	8262	0.09	0.33	1.52	-31.87	0.11
TOT	CM	0.18	0.22	-0.04	-19.33	1	0.38	32589	0.07	0.50	1.30	-29.40	0.11
DJF	EE	0.07	0.19	-0.12	-62.44	1	0.10	14637	0.03	0.21	1.97	-96.30	0.12
JJA	EE	0.10	0.34	-0.24	-69.58	1	0.00	15498	0.11	0.00	0.87	-107.59	0.24
MAM	EE	0.13	0.30	-0.17	-55.47	1	0.25	15498	0.06	0.26	1.01	-79.22	0.18
SON	EE	0.07	0.25	-0.17	-70.17	1	0.16	15498	0.04	0.12	0.74	-109.66	0.18
TOT	EE	0.10	0.27	-0.17	-64.58	1	0.41	61131	0.02	0.27	0.67	-98.22	0.19
DJF	EM	0.15	0.16	-0.01	-7.73	1	0.19	18819	-0.04	1.17	6.14	-25.40	0.10
JJA	EM	0.15	0.28	-0.13	-46.68	1	0.19	19926	0.08	0.27	1.40	-63.17	0.14
MAM	EM	0.25	0.34	-0.10	-27.70	1	0.31	19926	0.09	0.47	1.53	-37.28	0.15
SON	EM	0.12	0.23	-0.11	-46.39	1	0.07	19926	0.10	0.08	1.12	-64.82	0.13
TOT	EM	0.17	0.26	-0.09	-34.19	1	0.40	78597	0.05	0.47	1.18	-47.98	0.13
DJF	EU	0.14	0.15	-0.01	-7.91	1	0.11	127942	0.06	0.52	4.92	-50.42	0.17
JJA	EU	0.14	0.27	-0.13	-48.38	1	0.62	135468	-0.04	0.68	1.10	-74.45	0.16
MAM	EU	0.20	0.28	-0.08	-29.36	1	0.60	135468	-0.13	1.18	1.95	-60.14	0.18
SON	EU	0.11	0.20	-0.09	-45.12	1	0.42	135468	-0.01	0.57	1.37	-75.24	0.14
TOT	EU	0.15	0.23	-0.08	-35.27	1	0.44	534346	-0.01	0.70	1.59	-65.27	0.16
DJF	IP	0.14	0.10	0.03	33.79	1	0.12	6069	0.04	0.97	8.30	2.17	0.11
JJA	IP	0.16	0.19	-0.03	-17.09	1	0.49	6426	0.05	0.57	1.16	-21.32	0.06
MAM	IP	0.15	0.18	-0.04	-19.27	1	0.17	6426	0.06	0.47	2.84	-36.02	0.11
SON	IP	0.11	0.12	-0.01	-7.11	1	0.56	6426	-0.04	1.28	2.28	-15.87	0.05
TOT	IP	0.14	0.15	-0.01	-7.43	1	0.29	25347	0.07	0.48	1.67	-18.04	0.09
DJF	LA	0.16	0.15	0.00	2.66	1	0.09	80767	0.09	0.47	5.42	-45.15	0.20
JJA	LA	0.15	0.30	-0.14	-48.22	1	0.59	85518	-0.07	0.74	1.25	-75.21	0.17
MAM	LA	0.22	0.29	-0.07	-24.56	1	0.62	85518	-0.18	1.36	2.19	-54.69	0.19
SON	LA	0.13	0.22	-0.10	-42.97	1	0.43	85518	-0.01	0.63	1.47	-72.91	0.15
TOT	LA	0.17	0.24	-0.08	-32.09	1	0.42	337321	-0.01	0.71	1.71	-62.23	0.18
DJF	NA	0.41	0.15	0.26	171.38	1	0.18	18360	0.26	1.02	5.62	74.32	0.37
JJA	NA	0.32	0.40	-0.09	-22.08	1	0.35	19440	0.10	0.52	1.48	-29.75	0.16
MAM	NA	0.52	0.39	0.13	34.17	1	0.43	19440	0.17	0.90	2.12	21.60	0.27
SON	NA	0.29	0.28	0.01	4.62	1	0.32	19440	0.19	0.37	1.13	4.05	0.15
TOT	NA	0.39	0.31	0.08	25.01	1	0.22	76680	0.28	0.35	1.59	16.76	0.25
DJF	NE	0.03	0.15	-0.11	-76.94	1	0.17	15691	0.02	0.12	0.68	-126.86	0.11
JJA	NE	0.06	0.22	-0.17	-74.61	1	0.16	16614	0.04	0.05	0.33	-118.24	0.17
MAM	NE	0.07	0.22	-0.16	-70.23	1	0.16	16614	0.04	0.10	0.60	-110.20	0.17
SON	NE	0.03	0.20	-0.17	-82.95	1	-0.09	16614	0.04	-0.04	0.48	-141.96	0.17
TOT	NE	0.05	0.20	-0.15	-75.92	1	0.29	65533	0.02	0.15	0.50	-124.28	0.16
DJF	OC	0.11	0.15	-0.04	-26.75	1	0.14	47175	0.04	0.46	3.33	-59.45	0.11
JJA	OC	0.11	0.22	-0.11	-48.76	1	0.65	49950	-0.02	0.62	0.96	-73.14	0.12
MAM	OC	0.15	0.25	-0.10	-39.00	1	0.54	49950	-0.04	0.77	1.44	-69.48	0.15
SON	OC	0.09	0.18	-0.09	-49.72	1	0.27	49950	0.03	0.32	1.20	-79.25	0.12
TOT	OC	0.12	0.20	-0.08	-41.95	1	0.45	197025	0.00	0.58	1.29	-70.48	0.13

8. Aerosol Asymmetry Factor

a)



b)

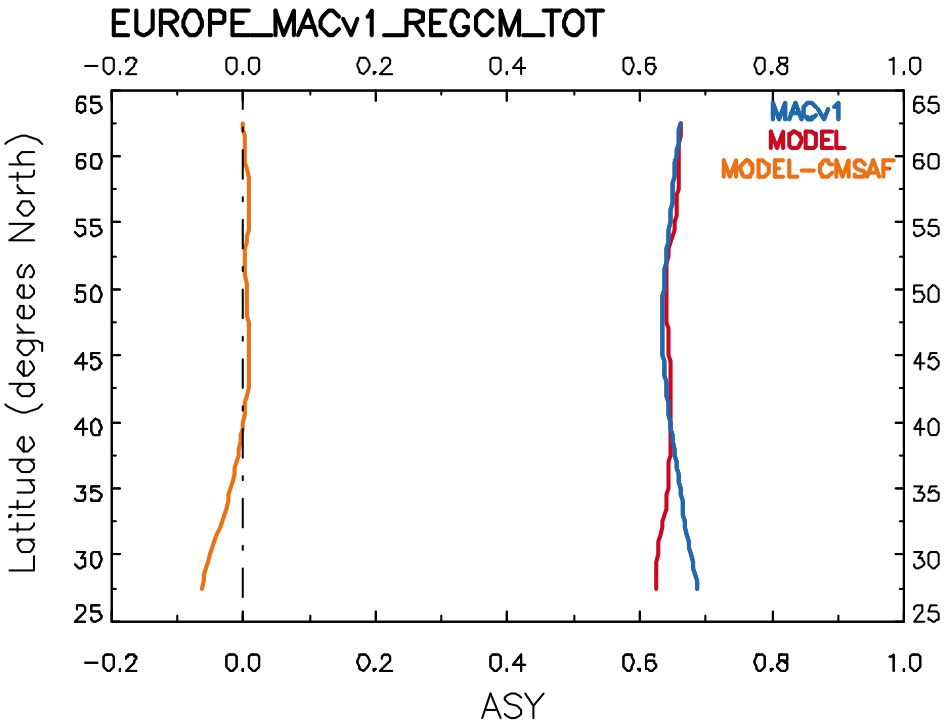


Figure S13. (a) NMB patterns of RegCM4-MACv1 ASY and (b) Latitudinal variability of RegCM4 ASY (red), MACv1 ASY (blue) and their difference (orange) over Europe.

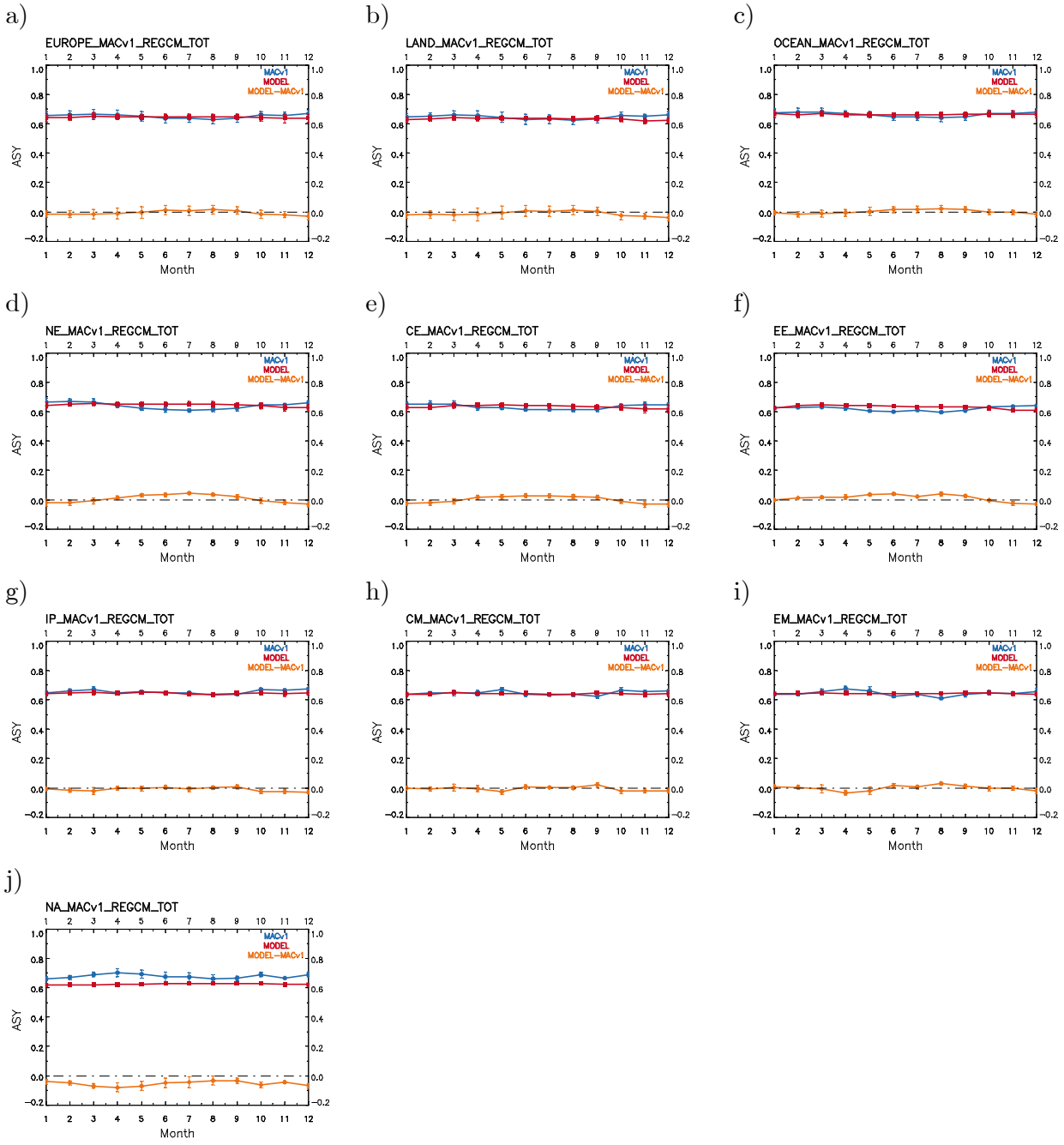


Figure S14. Seasonal variability of RegCM4 ASY (red), MACv1 ASY (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA.

Table S11. Average RegCM4 ASY, MACv1 ASY, their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test for each region of interest. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·MACv1+b). The region are listed in alphabetic order.

Season	Region	REG	MACv1	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
TOT	CE	0.63	0.63	0.00	0.03	0	0.23	36519	0.50	0.22	0.96	0.04	0.03
TOT	CM	0.64	0.65	0.00	-0.74	1	0.11	21573	0.59	0.07	0.66	-0.72	0.02
TOT	EE	0.63	0.62	0.01	2.08	1	-0.23	40467	0.76	-0.21	0.92	2.06	0.03
TOT	EM	0.64	0.64	0.00	-0.04	1	0.07	52029	0.62	0.03	0.41	0.01	0.02
TOT	EU	0.64	0.65	-0.01	-1.07	1	0.30	353722	0.50	0.22	0.74	-1.02	0.03
TOT	IP	0.64	0.65	-0.01	-1.52	1	0.30	16779	0.48	0.25	0.83	-1.52	0.02
TOT	NA	0.62	0.68	-0.05	-7.87	1	-0.16	50760	0.66	-0.06	0.36	-8.13	0.06
TOT	LA	0.63	0.64	-0.01	-1.79	1	-0.09	223297	0.66	-0.05	0.52	-1.72	0.04
TOT	NE	0.65	0.64	0.01	1.03	1	0.21	43381	0.55	0.15	0.71	1.07	0.03
TOT	OC	0.66	0.66	0.00	0.13	1	0.53	130425	0.42	0.36	0.69	0.17	0.02

9. Aerosol Single Scattering Albedo

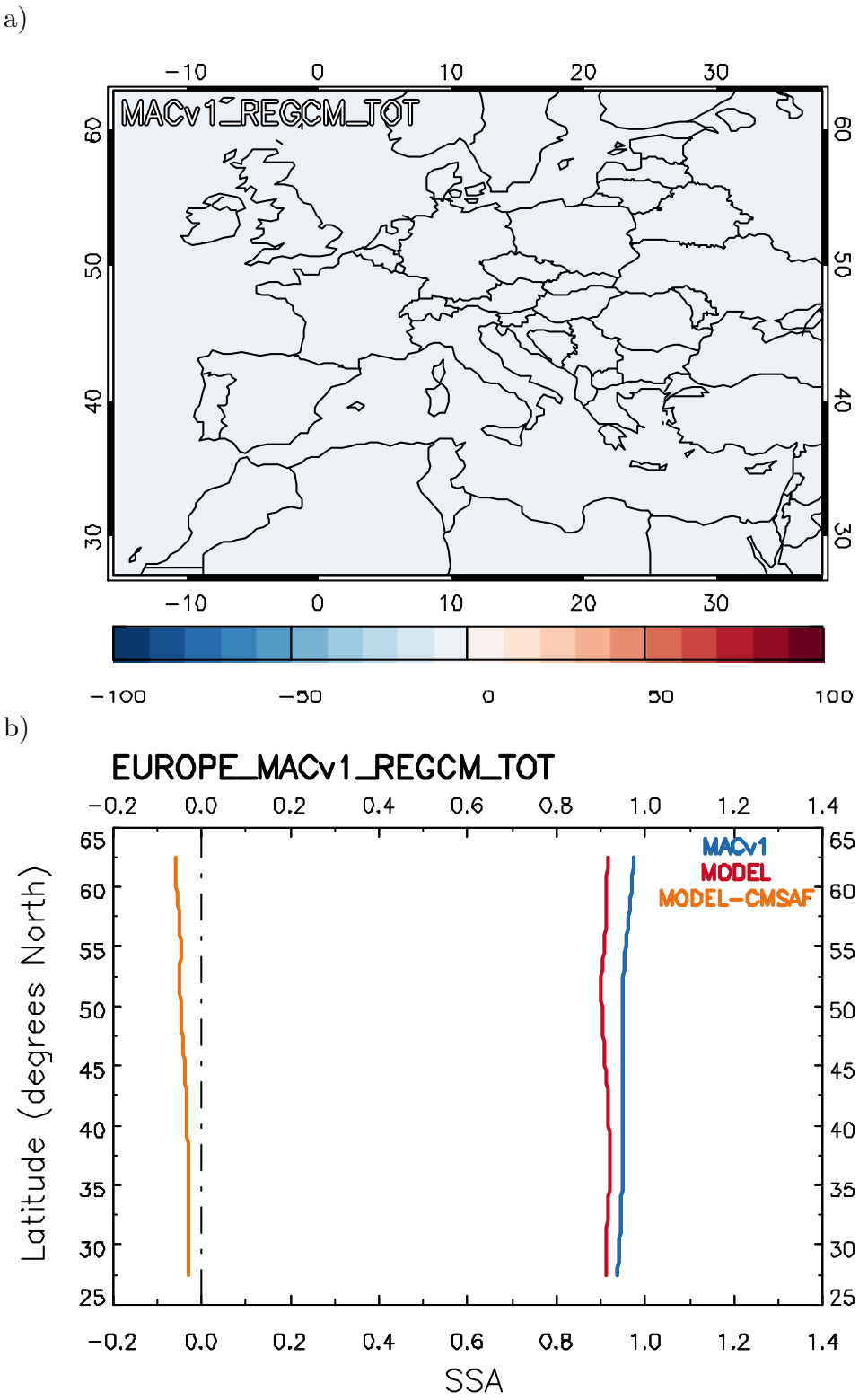


Figure S15. (a) NMB patterns of RegCM4-MACv1 SSA and (b) Latitudinal variability of RegCM4 SSA (red), MACv1 SSA (blue) and their difference (orange) over Europe.

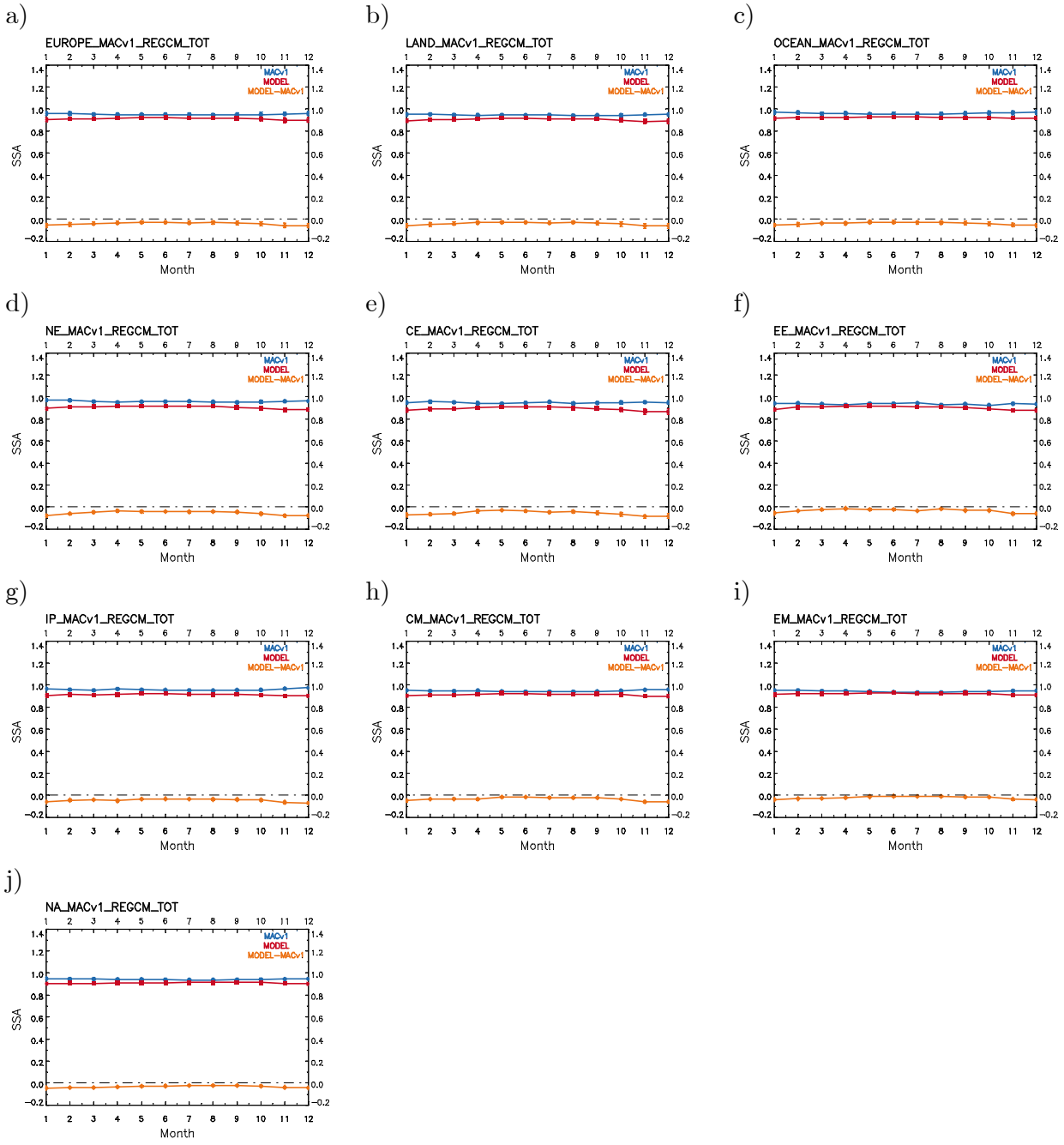


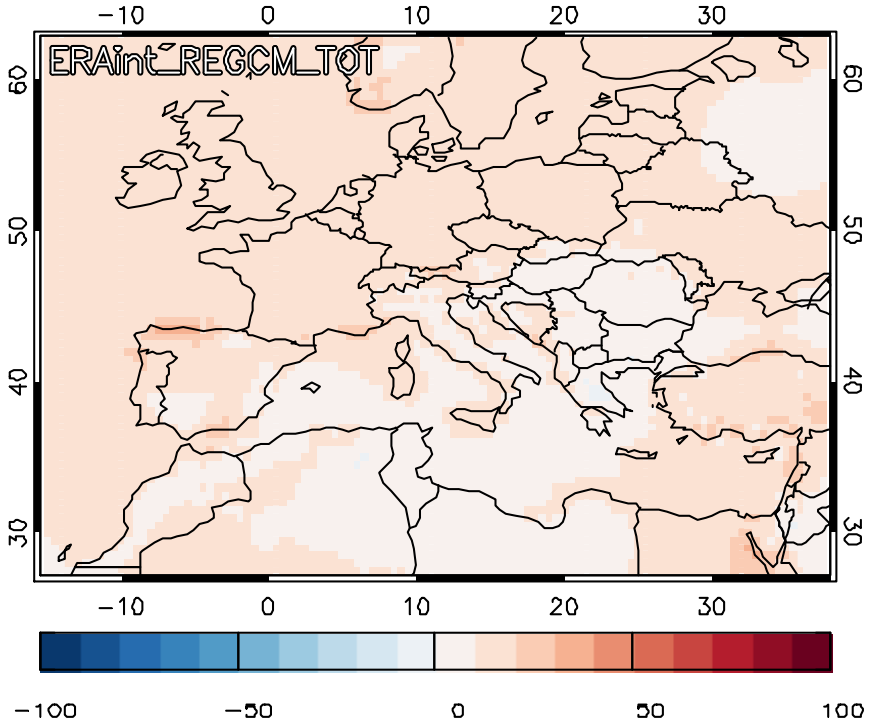
Figure S16. Seasonal variability of RegCM4 SSA (red), MACv1 SSA (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA.

Table S12. Average RegCM4 SSA, MACv1 SSA, their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test for each region of interest. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·MACv1+b). The region are listed in alphabetic order.

Season	Region	REG	MACv1	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
TOT	CE	0.89	0.95	-0.06	-5.88	1	0.26	36519	0.54	0.37	1.46	-6.07	0.06
TOT	CM	0.91	0.95	-0.03	-3.53	1	-0.30	21573	1.37	-0.49	1.61	-3.60	0.04
TOT	EE	0.90	0.94	-0.03	-3.54	1	0.10	40467	0.72	0.20	2.03	-3.62	0.04
TOT	EM	0.92	0.94	-0.02	-2.32	1	-0.19	52029	1.11	-0.20	1.06	-2.34	0.03
TOT	EU	0.91	0.95	-0.04	-4.23	1	0.29	353722	0.65	0.28	0.97	-4.33	0.04
TOT	IP	0.91	0.96	-0.05	-4.75	1	-0.14	16779	1.05	-0.14	1.05	-4.87	0.05
TOT	NA	0.91	0.94	-0.03	-3.46	1	-0.23	50760	1.11	-0.22	0.96	-3.52	0.03
TOT	NE	0.91	0.96	-0.05	-5.57	1	0.13	43381	0.75	0.16	1.25	-5.73	0.06
TOT	LA	0.90	0.95	-0.04	-4.33	1	0.03	223297	0.87	0.04	1.22	-4.43	0.05
TOT	OC	0.92	0.96	-0.04	-4.07	1	0.22	130425	0.81	0.12	0.53	-4.14	0.04

10. Water Vapor

a)



b)

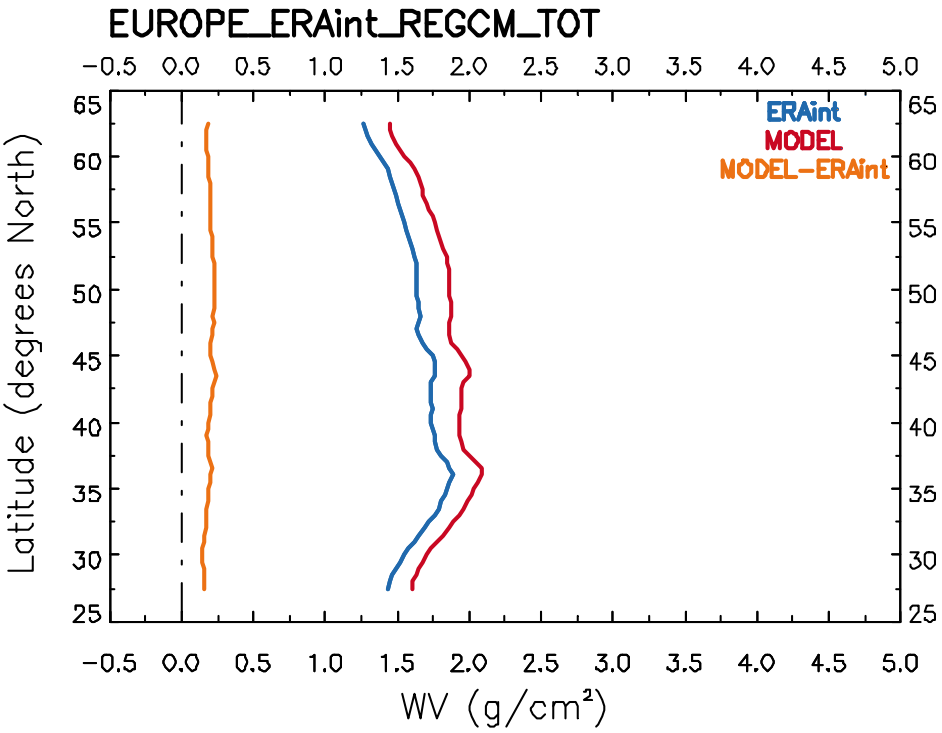


Figure S17. (a) NMB patterns of RegCM4-ERA-Interim WV and (b) Latitudinal variability of RegCM4 WV (red), ERA-Interim WV (blue) and their difference (orange) over Europe.

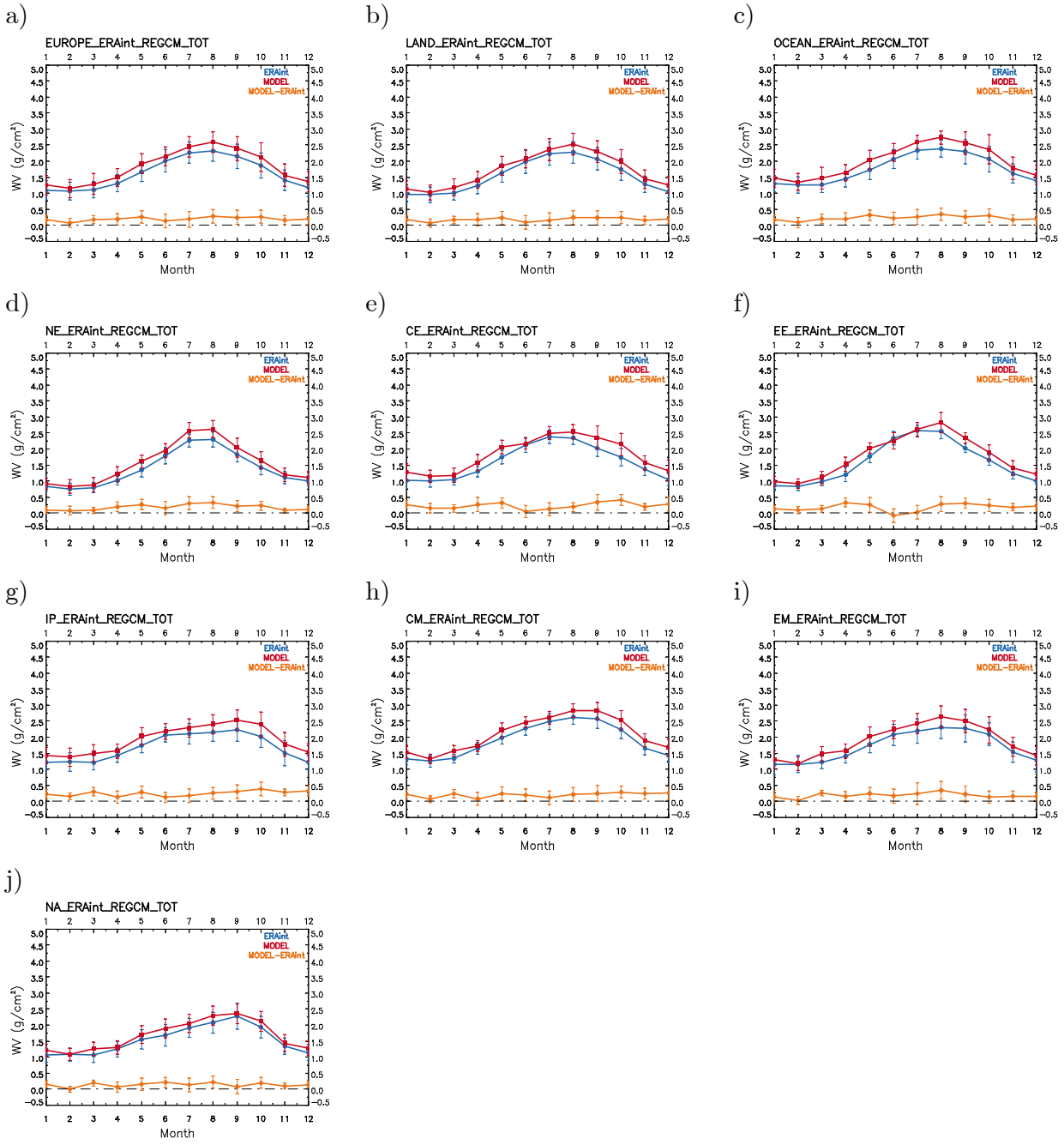


Figure S18. Seasonal variability of RegCM4 WV (red), ERA-Interim WV (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA.

Table S13. Average RegCM4 WV, ERA-Interim WV, their difference, the NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test for each region of interest. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·ERAint+b). The region are listed in alphabetic order.

Season	Region	REG	ERAint	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
TOT	CE	1.83	1.60	0.23	14.02	1	0.94	36519	0.29	0.96	1.02	14.18	0.30
TOT	CM	2.11	1.91	0.20	10.42	1	0.94	21573	0.28	0.96	1.03	10.42	0.28
TOT	EE	1.77	1.60	0.17	10.82	1	0.95	40467	0.23	0.96	1.01	11.50	0.27
TOT	EM	1.90	1.72	0.19	10.85	1	0.92	52029	0.23	0.97	1.05	10.87	0.29
TOT	EU	1.82	1.63	0.19	11.98	1	0.95	353722	0.18	1.01	1.07	11.71	0.28
TOT	IP	1.93	1.68	0.24	14.43	1	0.93	16779	0.31	0.96	1.03	14.27	0.31
TOT	LA	1.72	1.54	0.18	11.42	1	0.95	223297	0.20	0.98	1.04	11.56	0.26
TOT	NA	1.67	1.54	0.13	8.66	1	0.94	50760	0.21	0.95	1.01	8.98	0.22
TOT	NE	1.56	1.38	0.18	13.05	1	0.97	43381	0.03	1.11	1.14	11.80	0.25
TOT	OC	1.99	1.77	0.23	12.81	1	0.94	130425	0.16	1.04	1.11	11.97	0.30

11. Surface Albedo

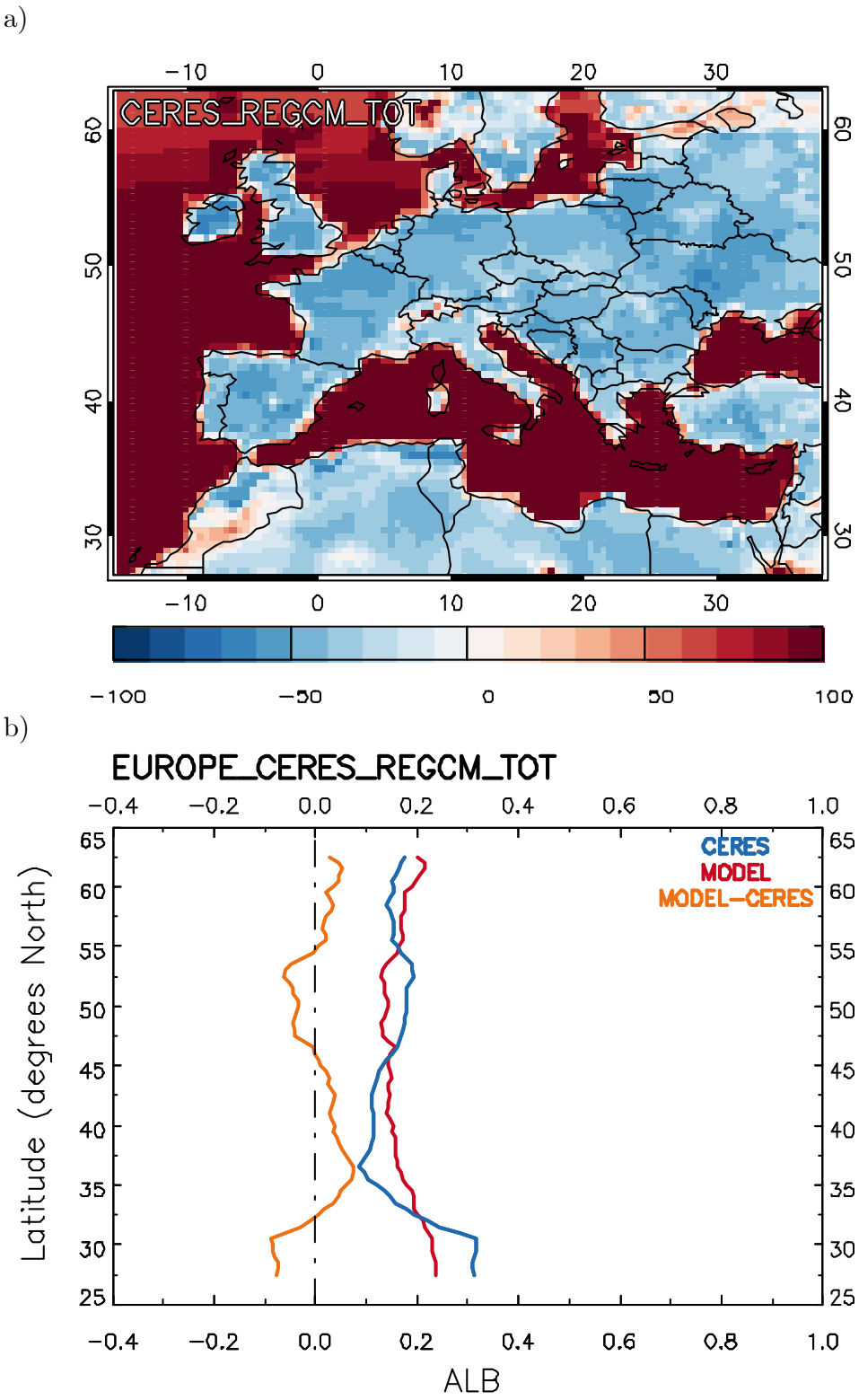


Figure S19. (a) NMB patterns of RegCM4-CERES ALB and (b) Latitudinal variability of RegCM4 ALB (red), CERES ALB (blue) and their difference (orange) over Europe.

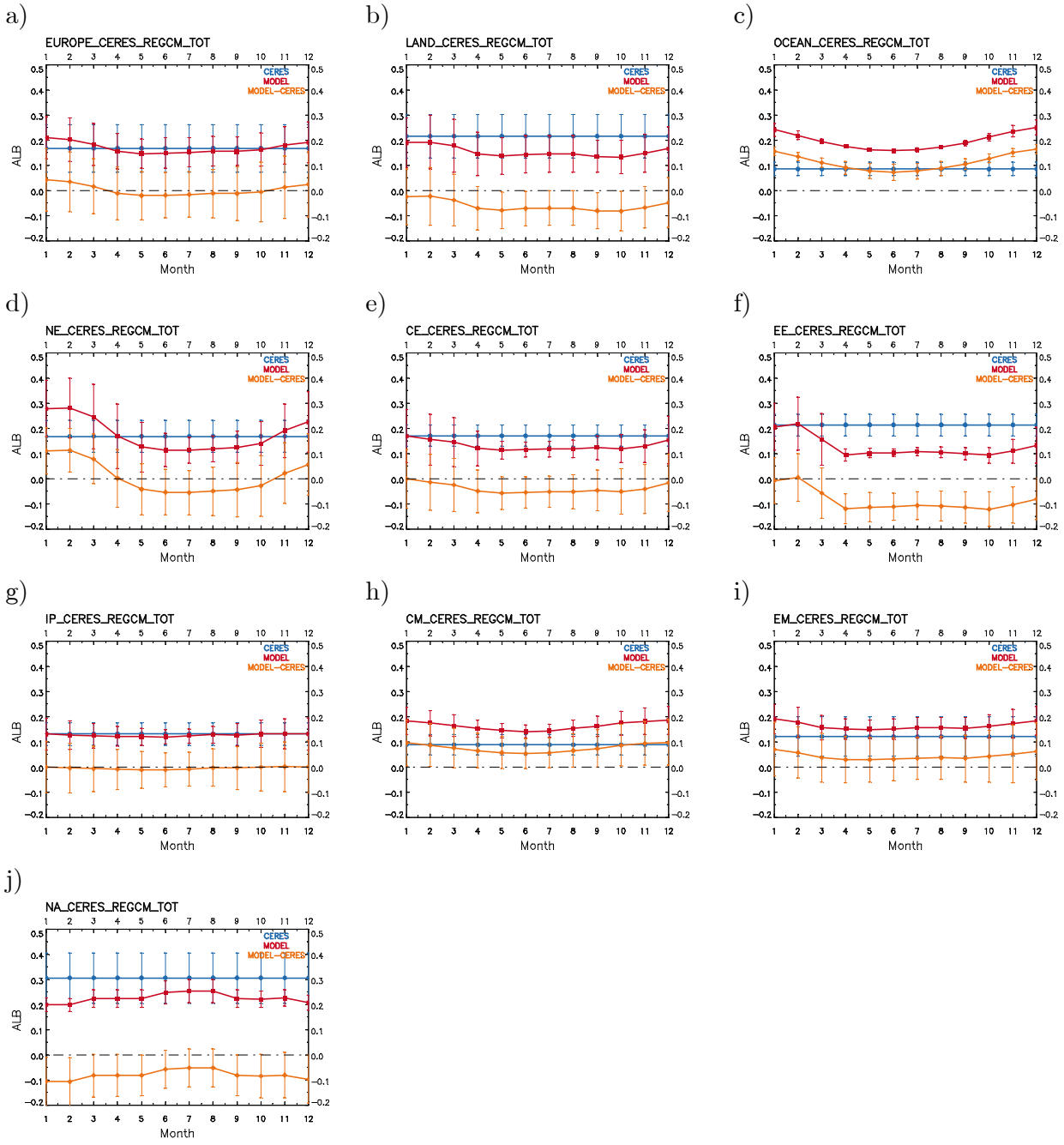
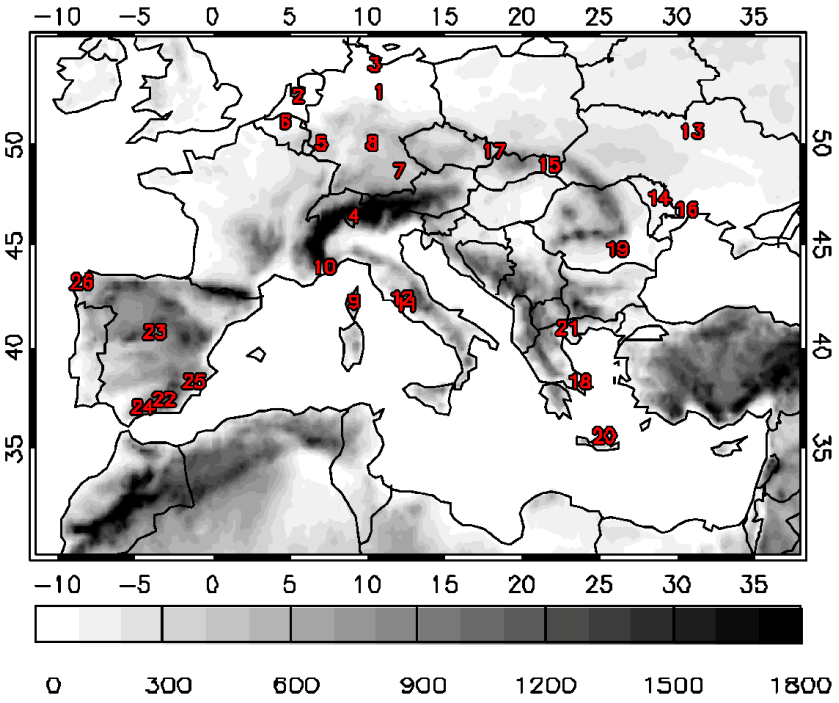


Figure S20. Seasonal variability of RegCM4 ALB (red), CERES ALB (blue) and their difference (orange) over (a) the whole Europe, (b) Land, (c) Ocean, (d) NE, (e) CE, (f) EE, (g) IP, (h) CM, (i) EM, (j) NA.

Table S14. Average RegCM4 ALB, CERES ALB, their difference, the corresponding NMB and the statistical significance of the results at the 95% confidence level due to a two independent sample t-test for each region of interest. The NSD, MNMB and the RMSE are also given along with Pearson's correlation coefficient (R), the number of observations used and the coefficients a and b of the regression line (RegCM4=a·CERES+b). The region are listed in alphabetic order.

Season	Region	REG	CER	Diff.	NMB	Signif.	R	Obs.	b	a	NSD	MNMB	RMSE
TOT	CE	0.13	0.17	-0.04	-22.71	1	-0.26	37296	0.21	-0.45	1.74	-30.05	0.10
TOT	CM	0.16	0.09	0.08	85.92	1	-0.66	22032	0.23	-0.73	1.11	59.75	0.11
TOT	EE	0.13	0.21	-0.09	-40.68	1	-0.02	41328	0.13	-0.03	1.67	-56.04	0.12
TOT	EM	0.16	0.12	0.04	35.43	1	-0.17	53136	0.18	-0.11	0.64	38.34	0.11
TOT	EU	0.17	0.17	0.00	1.58	1	0.13	361248	0.15	0.10	0.79	7.11	0.11
TOT	IP	0.13	0.13	0.00	-3.76	1	-0.78	17136	0.24	-0.84	1.08	-4.75	0.09
TOT	LA	0.15	0.22	-0.06	-28.27	1	0.46	223297	0.06	0.46	1.00	-35.62	0.11
TOT	NA	0.23	0.31	-0.08	-26.38	1	0.49	51840	0.16	0.20	0.40	-24.21	0.12
TOT	NE	0.18	0.17	0.01	5.24	1	0.20	44304	0.12	0.36	1.82	-4.34	0.12
TOT	OC	0.20	0.08	0.11	131.07	1	0.21	130425	0.17	0.27	1.30	80.29	0.12



	Region_Station	lat	lon
1	CE_Braunschweig	52.30	10.45
2	CE_DeBilt	52.10	5.18
3	CE_Hamburg	53.65	10.12
4	CE_Locarno_Modi	46.17	8.78
5	CE_Trier	49.75	6.67
6	CE_Uccle	50.80	4.35
7	CE_Weihenstephan	48.40	11.70
8	CE_Wuerzburg	49.77	9.97
9	CM_Ajaccio	41.92	8.80
10	CM_Nice	43.65	7.20
11	CM_Roma	41.80	12.58
12	CM_Vigna_di_Valle	42.08	12.22
13	EE_Kiev	50.33	30.96
14	EE_Kishinev	47.00	28.82
15	EE_Milhostov	48.66	21.72
16	EE_Odessa	46.48	30.63
17	EE_Ostrava_Poruda	49.32	18.15
18	EM_Athens	37.97	23.72
19	EM_Bucharest	44.50	26.13
20	EM_Herakleion	35.33	25.28
21	EM_Thessaloniki	40.63	22.96
22	IP_Granada	37.13	-3.13
23	IP_Madrid	40.45	-3.73
24	IP_Malaga	36.72	-4.48
25	IP_Murcia	38.00	-1.17
26	IP_Santiago	42.90	-8.42

Figure S21. Elevation map (in meters) with the position of the 23 WRDC and 3 independent ground stations which are used for the evaluation of the CM SAF SSR data. The number and the name of each station along with the region where they belong and the exact geolocation are also given.

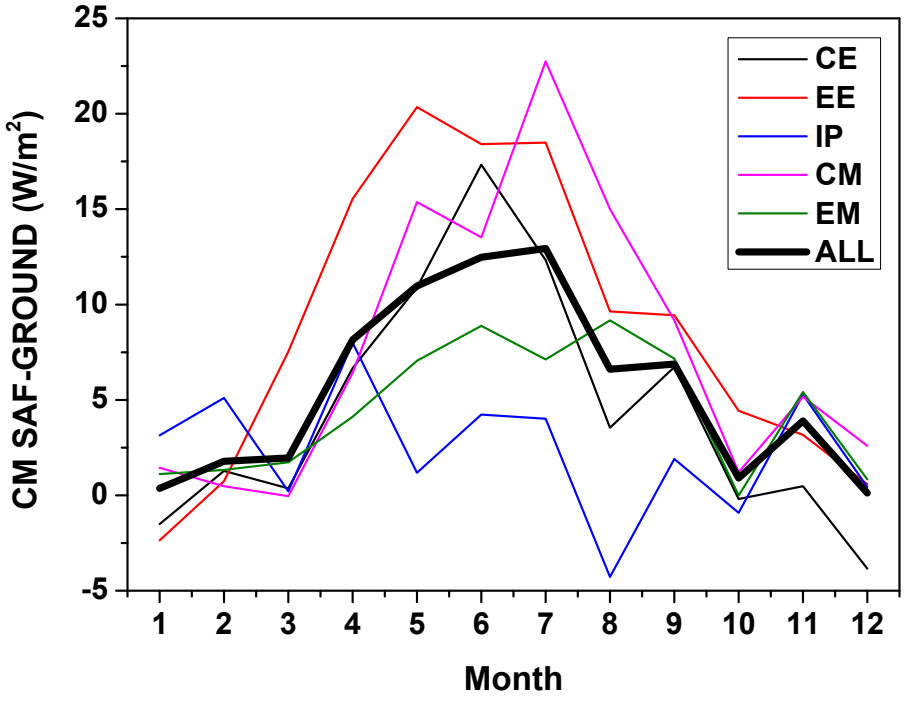


Figure S22. Mean bias between the CM SAF SSR data from MSG and ground-based observations for the period 2006-2009 for the five sub-regions appearing in Fig. 10.

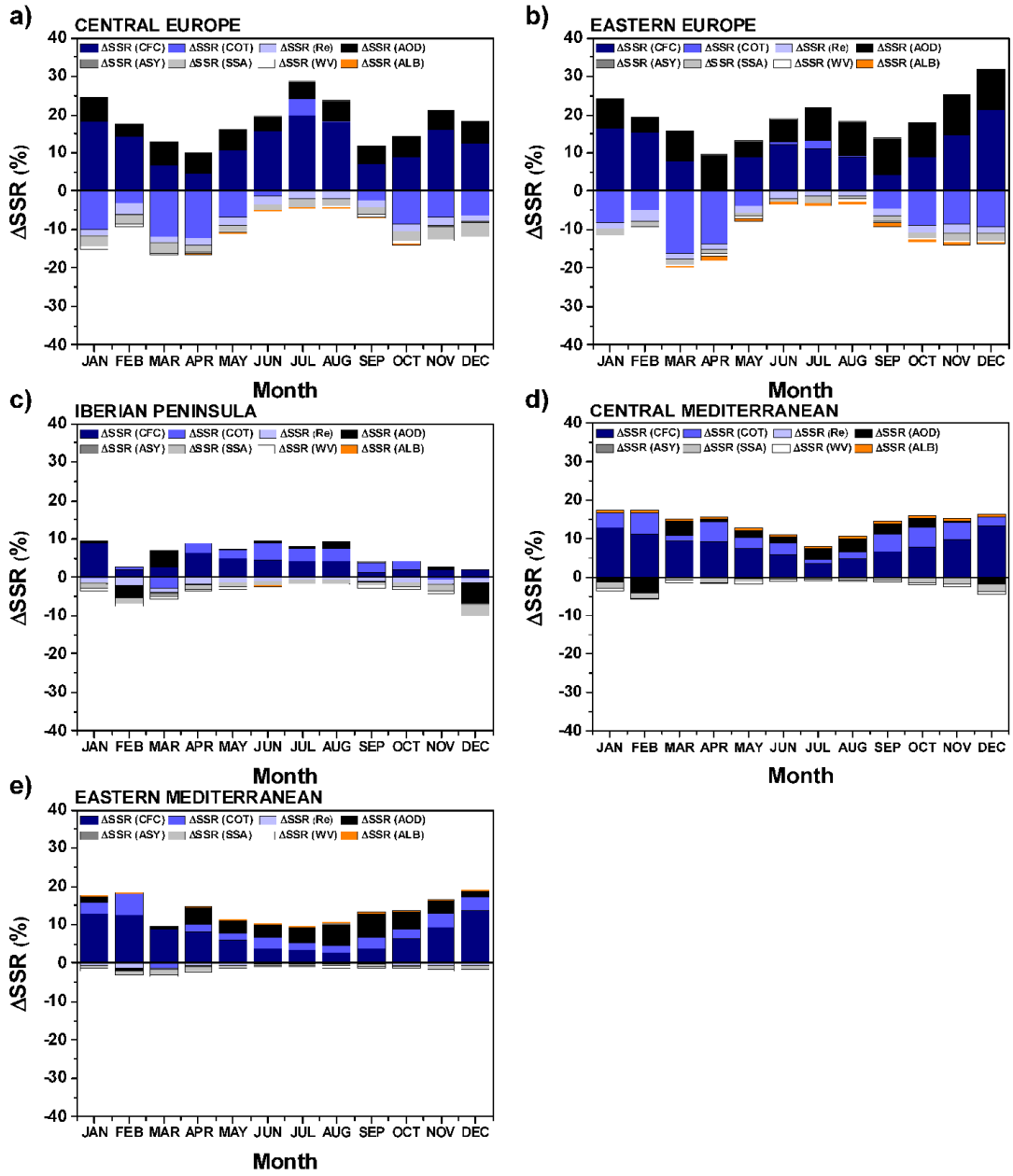


Figure S23. SSR (%) caused by CFC, COT, Re, AOD, ASY, SSA, WV and ALB for (a) CE, (b) EE, (c) IP, (d) CM and (e) EM. These results were produced assuming the simulated SSR fields with all the CM SAF, MACv1 and ERA-Interim input data as the control run and replacing each time the corresponding parameter with data from RegCM4 (inverse procedure from the one followed for the production of Fig. 10).

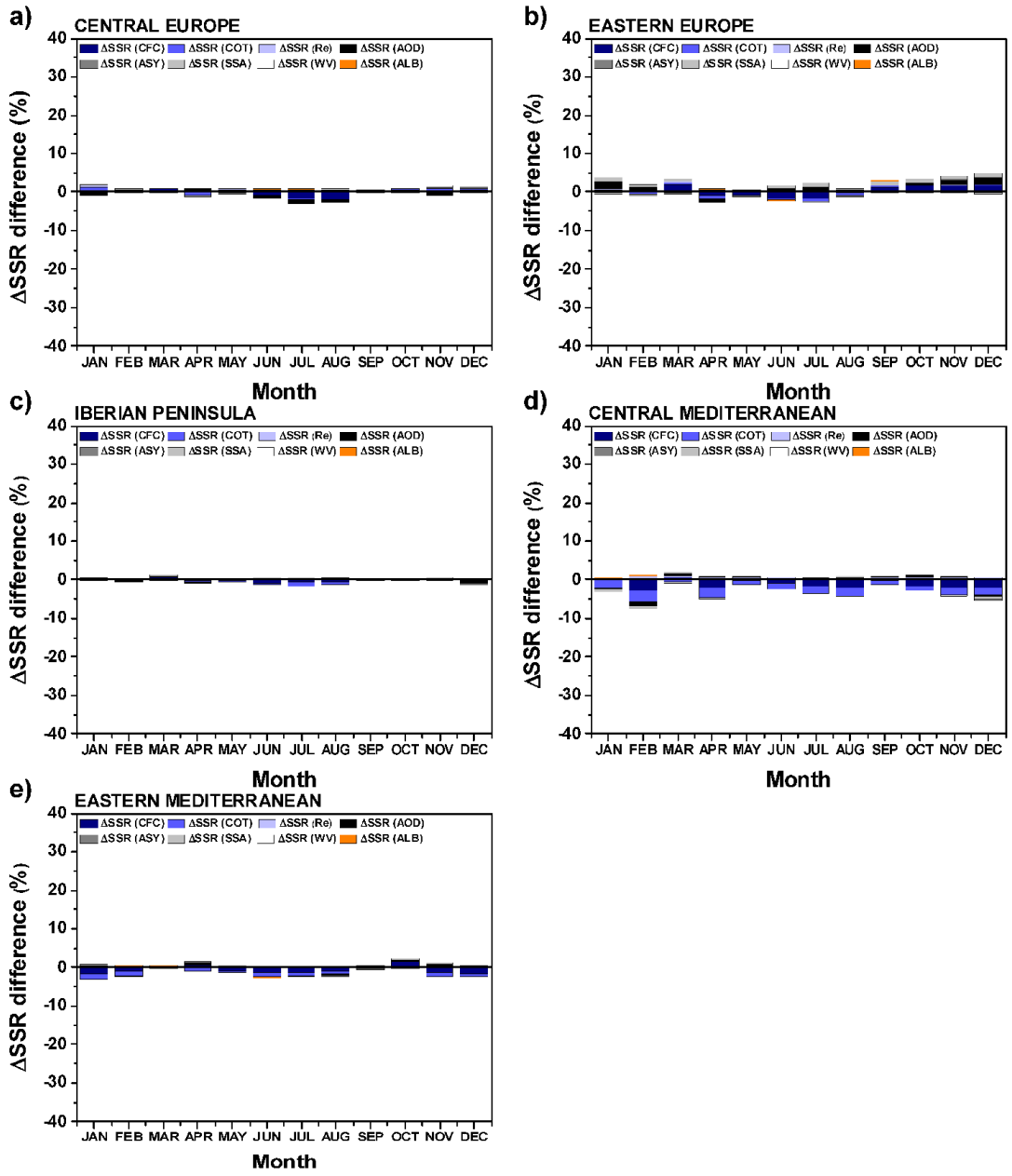


Figure S24. Difference between the results presented in Fig. 10 and Fig. S21.