Assessment of multiple daily precipitation statistics in ERA-Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations

Submitted to Climate Dynamics Med-CORDEX special issue

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6 - Universidad de Castilla-La Mancha, Toledo, Spain

7 - CETEMPS and University of L'Aquila, Italy

Assessment of multiple daily precipitation statistics in ERA-Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations

- Assessing the performance of an ensamble of RCMs over various EU regions against HR observations using both Med- and EURO-Cordex, with focus on extremes
- Does increased resolution (0.44 → 0.11 deg) provide real benefits compared to HR OBS?
- Do modelled precipitation climate extremes show significant Added Value?

DATASETS AND SETUP

- 9 ERA-Interim driven, double nested Med- and EURO-CORDEX Regional Climate Models
- 3 common analysis grids at 0.11, 0.44, 1.50 degrees resolution
- HR observation datasets over 9 different European regions
- Precipitation undercatch correction with UDEL dataset (Matsuura and Willmott 2010, UDEL V3.01) when applicable

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Dataset	Institution	Region	Period	~Res	Reference
EURO4M-APGD +	MeteoSwiss	Alps	1971-2008	5km	Isotta et al. (2013)
Spain02 +	Santander Meteorology Group	Spain	1971-2010	0.11 deg	Herrera et al. (2010)
SAFRAN	Meteo-France	France	1958-2013	8km	Vidal et al. (2010)
UK gridded dataset o+	UK Met Office	United Kingdom	1990-2010	0.11 deg	Perry et al. (2009)
KLIMAGRID °	METNO	Norway	1957-2013	1km	Mohr (2009)
PTHBV °	SMHI	Sweden and part of Finland	1961-2010	4km	Johansson (2002)
CARPATCLIM +	Hungarian Met Service	Carpathians	1961-2010	0.10 deg	Szalai et al. (2013)
REGNIE °+	DWD	Germany	1961-2009	1km	Rauthe et al. (2013)
CETEMPS gridded dataset +	CETEMPS, University of L'Aquila	Italy	2000-2014	0.11 deg	Not released yet

o = covered by EURO-CORDEX only

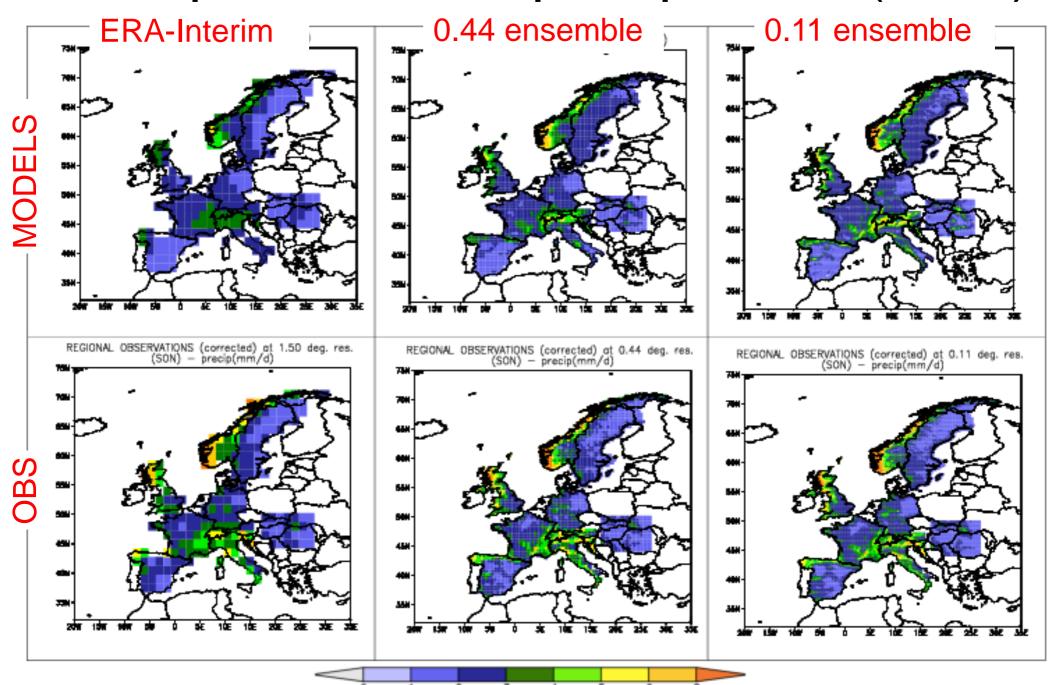
+ = undercatch-corrected with UDEL data

9 Regional Climate Models@ 0.11 and 0.44 deg resolution

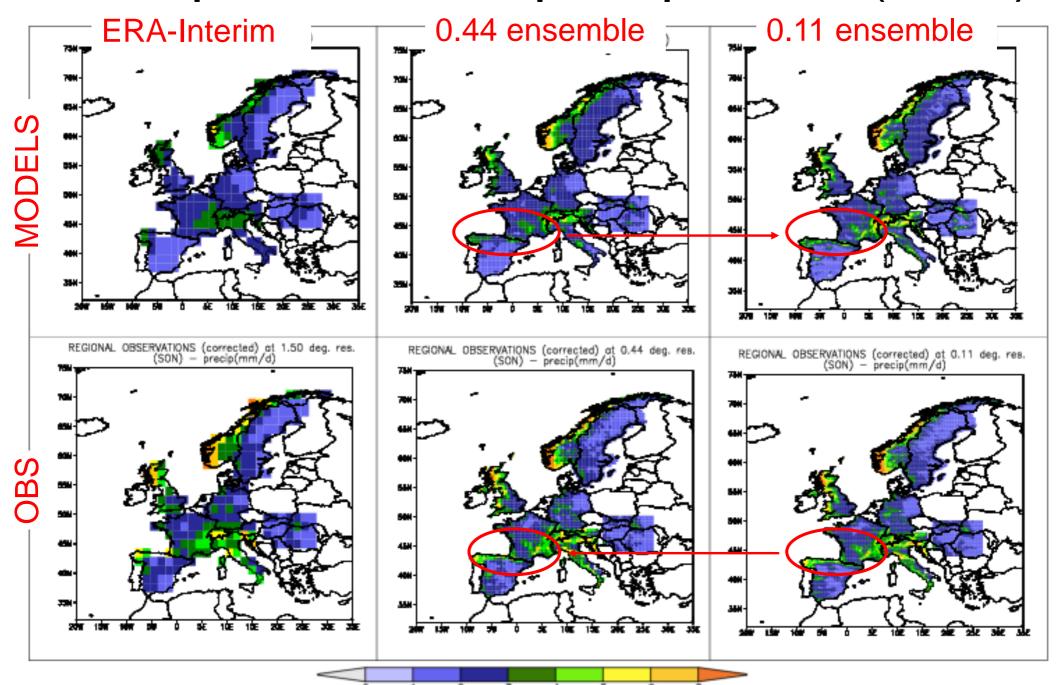
Model		Institution
CCLM4-8-17	CLMcom	
HIRHAM5	DMI	
INERIS-WRF331F	IPSL	EURO-CORDEX
RACMO22E	KNMI	
RCA4	SMHI	
ALADIN5.2	CNRM	
RegCM4.4	ICTP	> Med-CORDEX
CCLM4-8-18	GUF	WIGG-OOKDEA
PROMES	UCLM	

Analysis period: 1989-2008; 1990-2008 (UK); 2000-2010 (Italy)

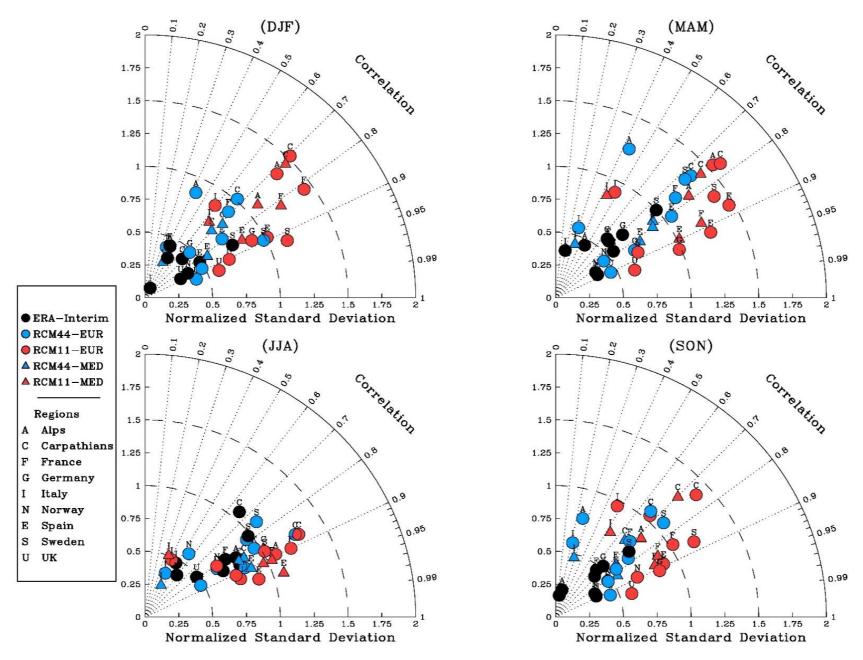
Example for mean precipitation (SON)



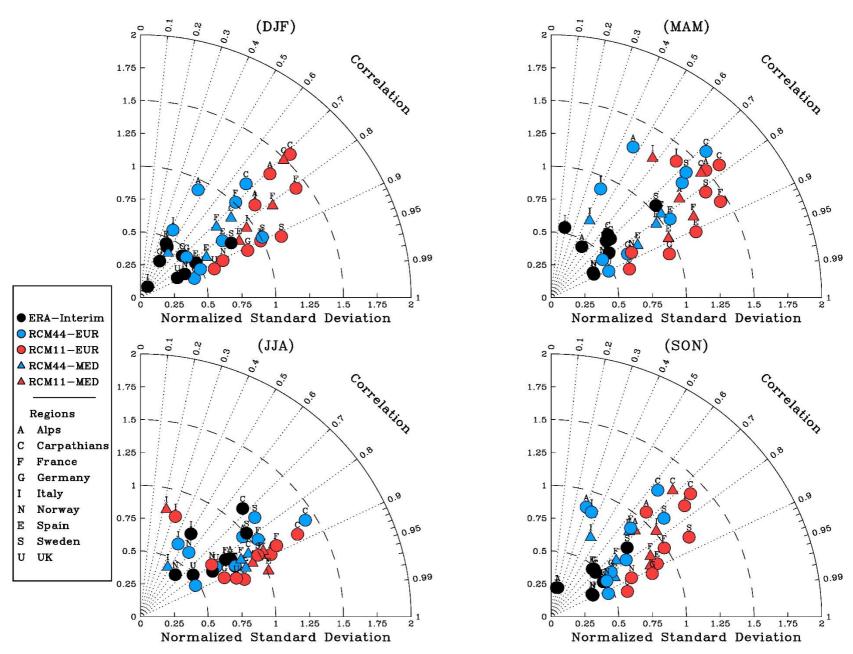
Example for mean precipitation (SON)



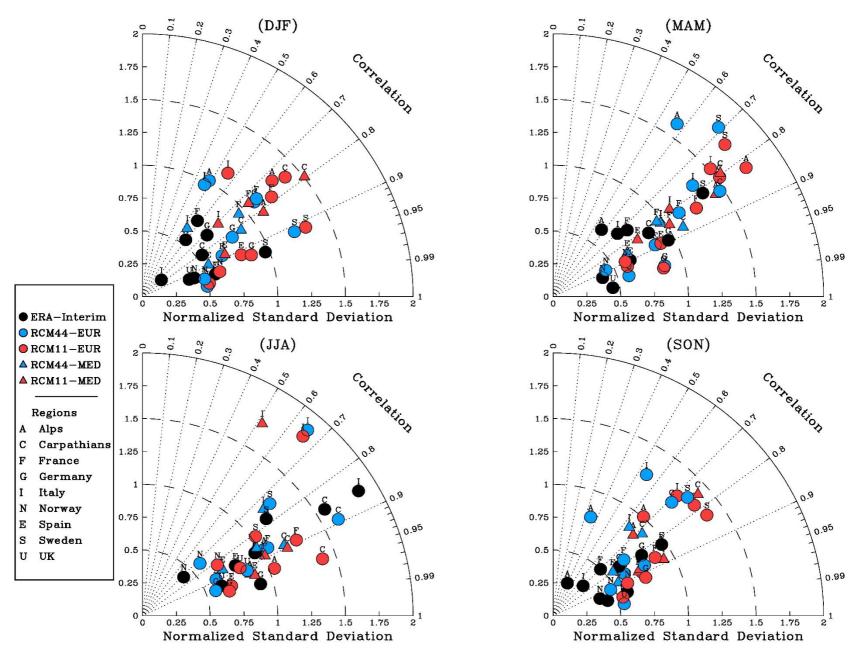
Taylor plots (0.11deg)

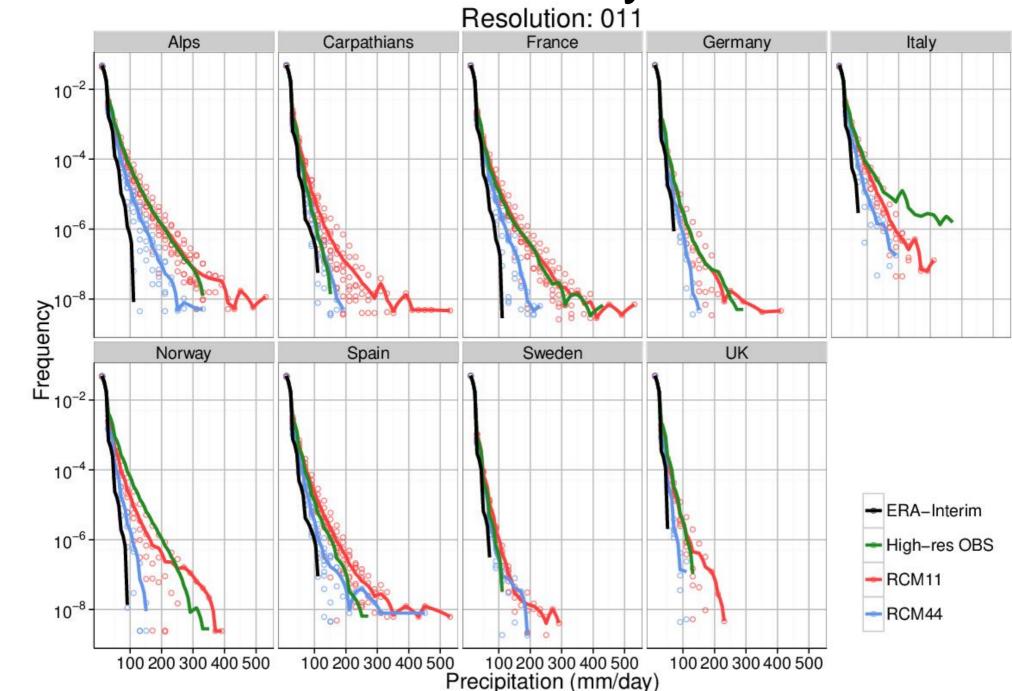


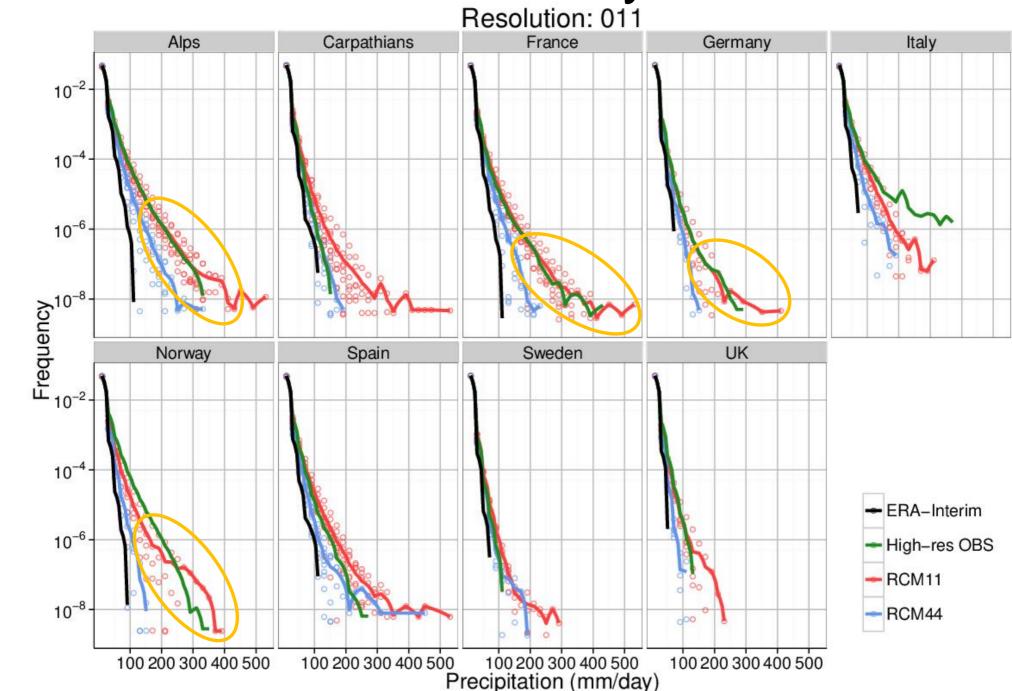
Taylor plots (0.44deg)



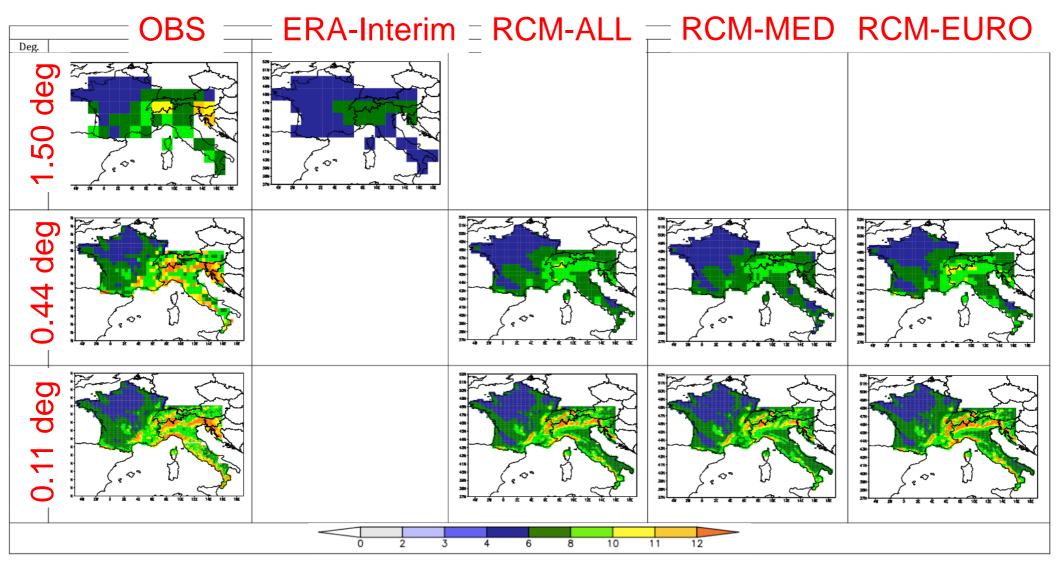
Taylor plots (1.50deg)



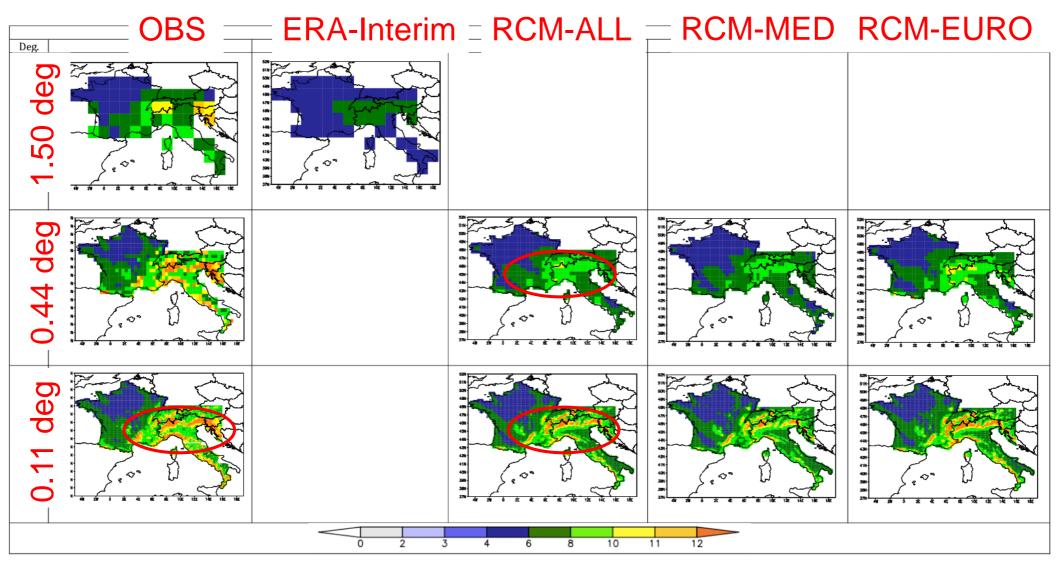




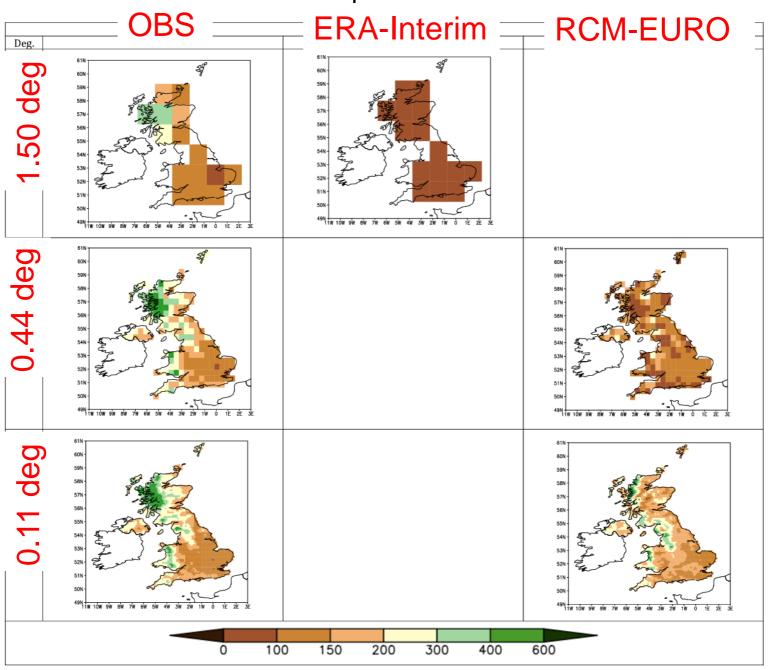
Selected maps: SDII



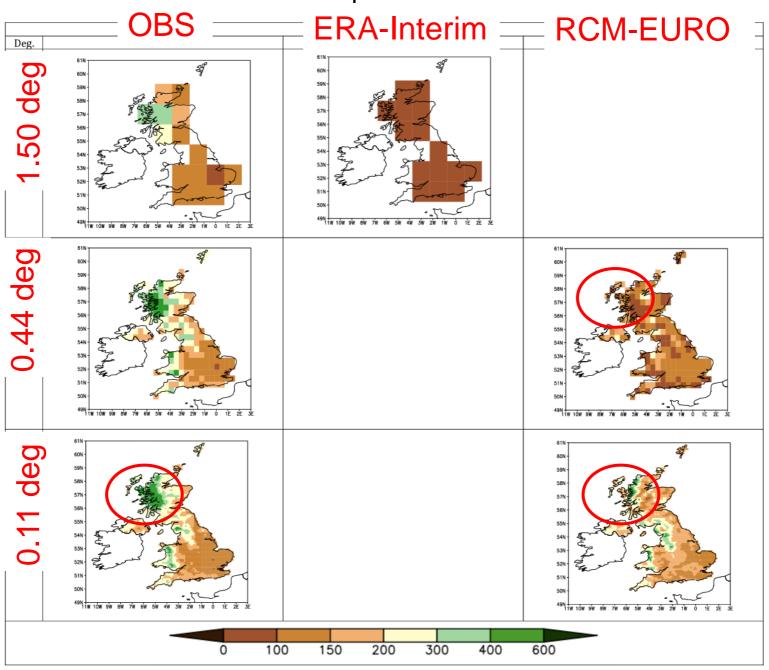
Selected maps: SDII



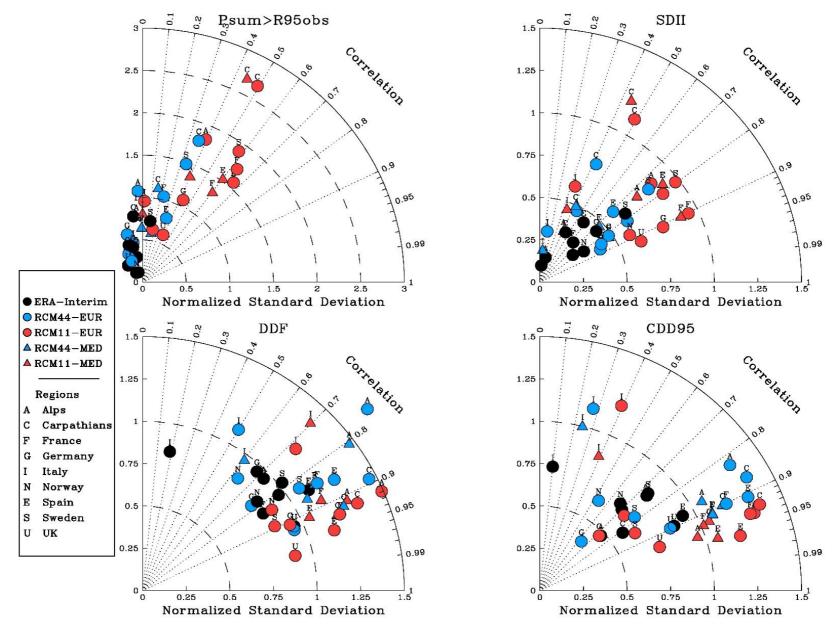
Selected maps: Psum>R95obs

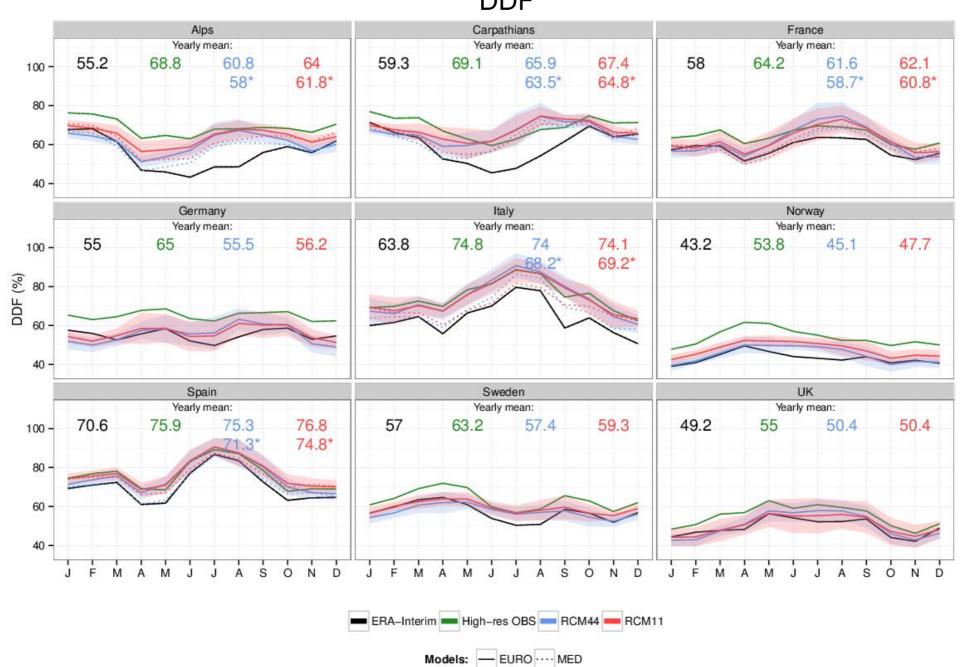


Selected maps: Psum>R95obs



Taylor plots





CONCLUSIONS

- The quality, homogeneity and resolution of observations is crucial to model assessment, especially for high resolution
- EURO-CORDEX and Med-CORDEX models perform on par
- The ensembles show high skill in reproducing most climate features of the observed regions, with some notable exceptions
- In most metrics, there is strong Added Value in the highresolution 0.11 degrees ensemble, even if upscaled (confirms Torma et al., 2015)
- Some metrics (e.g. DDF and CCD95 in some regions) still indicate deficiencies in the model's description of precipitation processes mainly due to the drizzle phenomenon that is not solved by the increased resolution

THANKS!

Paper reference:

Fantini A., Raffaele F., Torma C., Bacer S., Coppola E., Giorgi F., Ahrens B., Dubois C., Sanchez E., Verdecchia M. Assessment of multiple daily precipitation statistics in ERA-Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations.

Submitted to Climate Dynamics, 2016

Speaker: Adriano Fantini, 1st year PhD, University of Trieste

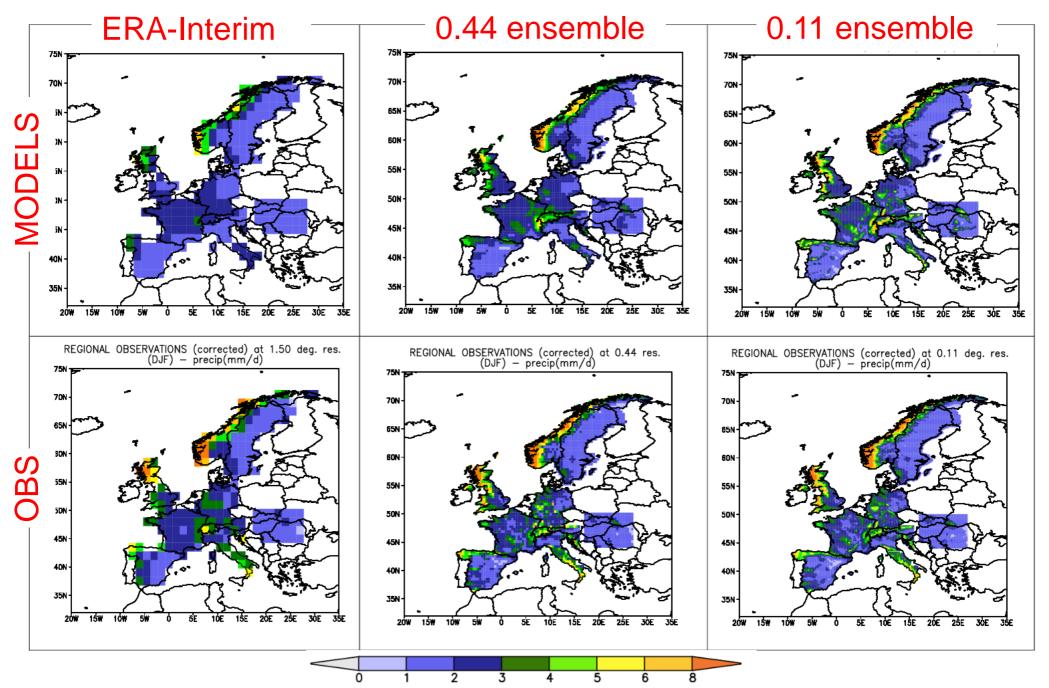
Supervisor: Erika Coppola, ICTP, Trieste

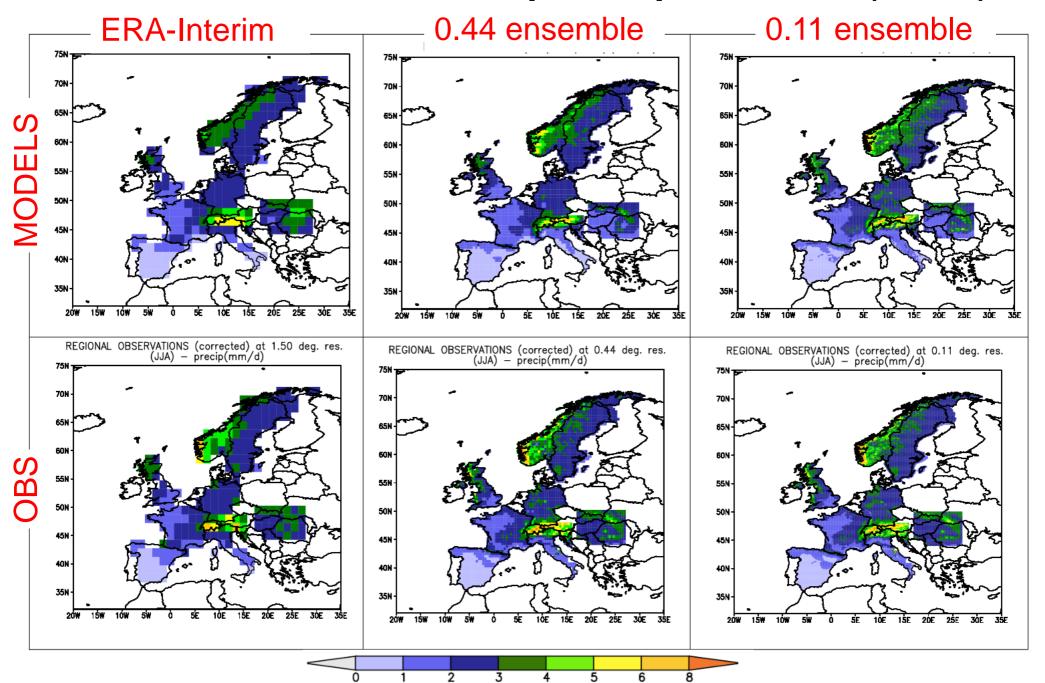
Contact: afantini@ictp.it

Precipitation performance indices with emphasis over extremes

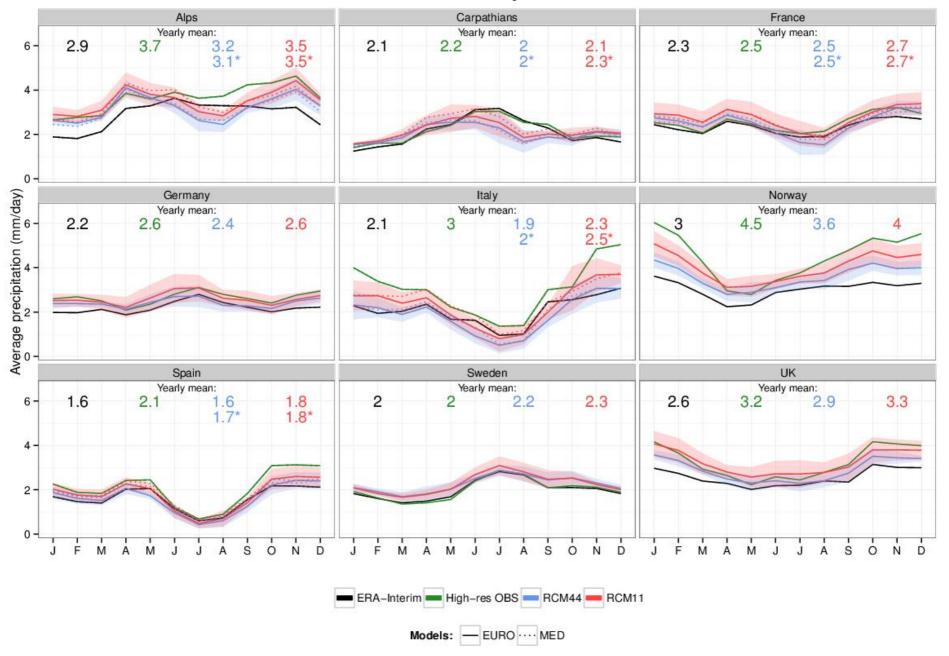
Index	Description
RMSE, mean, bias	Standard statistics.
TAYLOR	Taylor diagrams: spatial correlation, std.dev. and centered RMSE.
PDF, KL	Symmetrized Kullback-Leibler divergence for PDFs *. (>1mm / day)
SDII *	Mean daily precipitation intensity. (mm / day)
DDF *	Mean frequency of dry days. (%)
CDD95 *	95th percentile of dry spell length. Replaces CDD. (No. days / year)
Psum>R95 obs *	Total precipitation above the reference 95th percentile of observed daily precipitation. Replaces R95p. (mm / year)

^{* =} daily precipitation indices

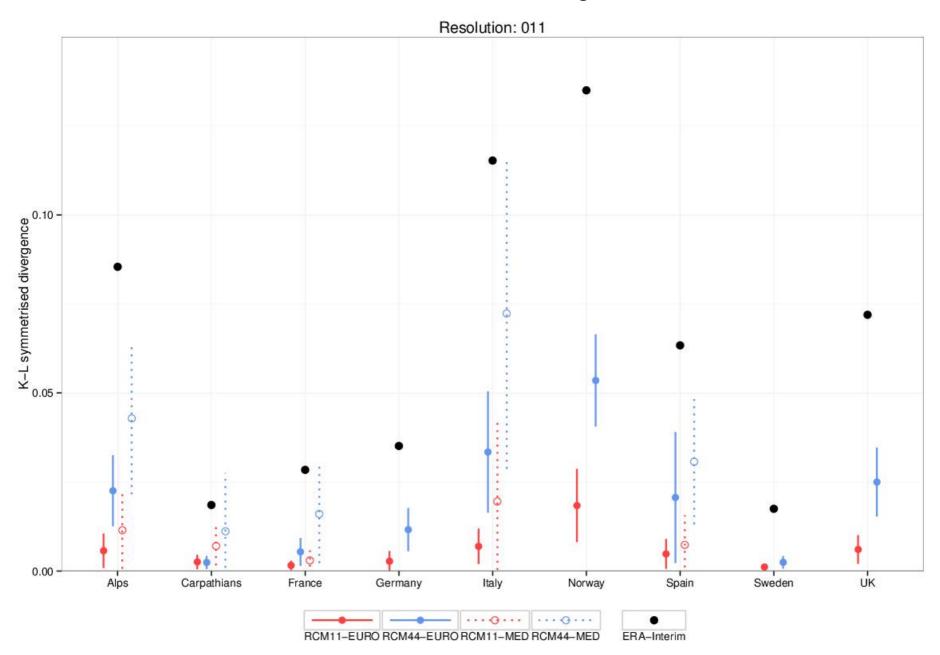




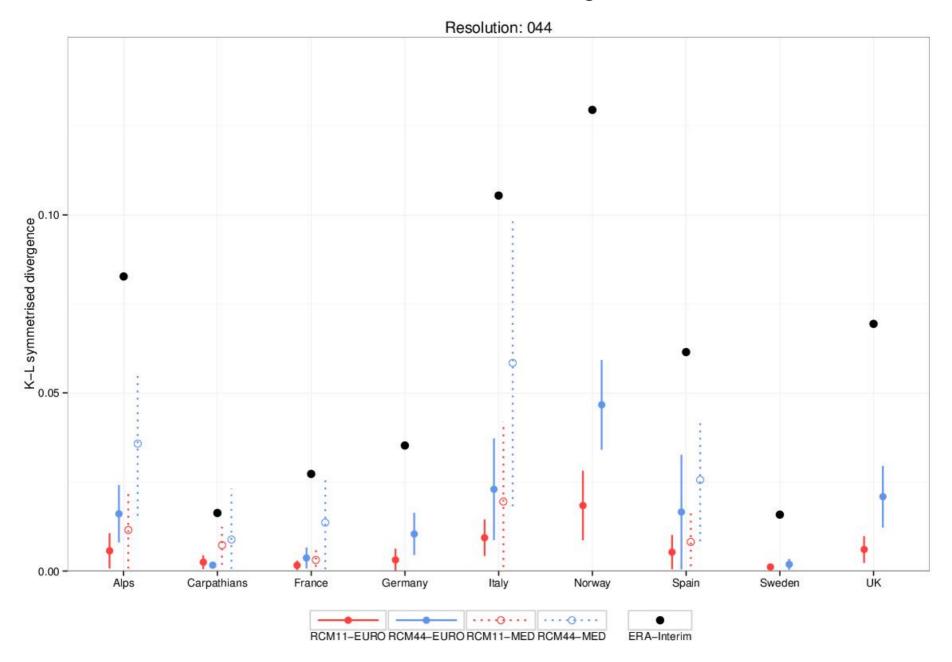
Annual cycle



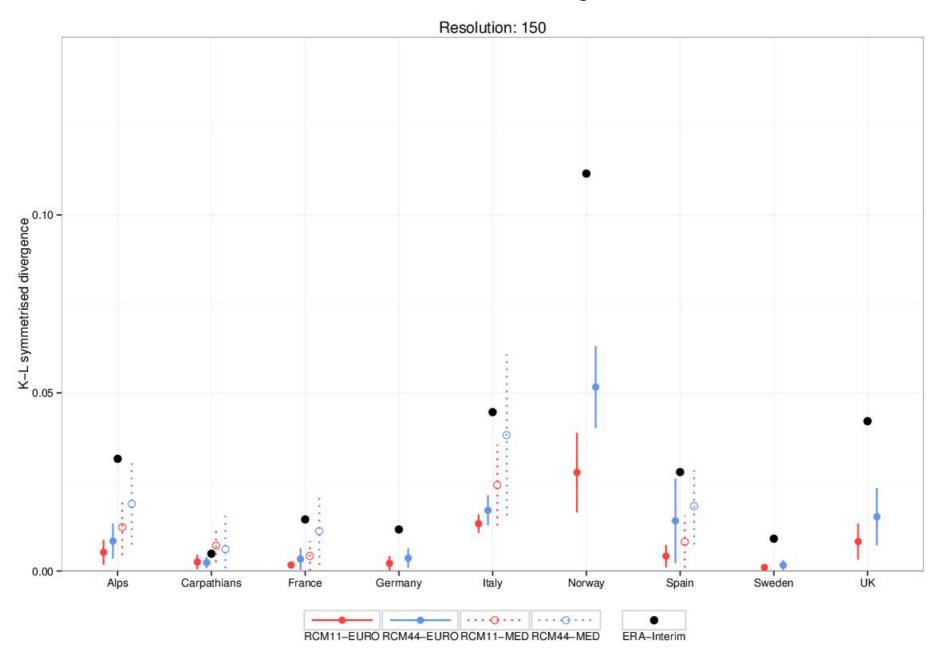
Kullback-Leibler divergence



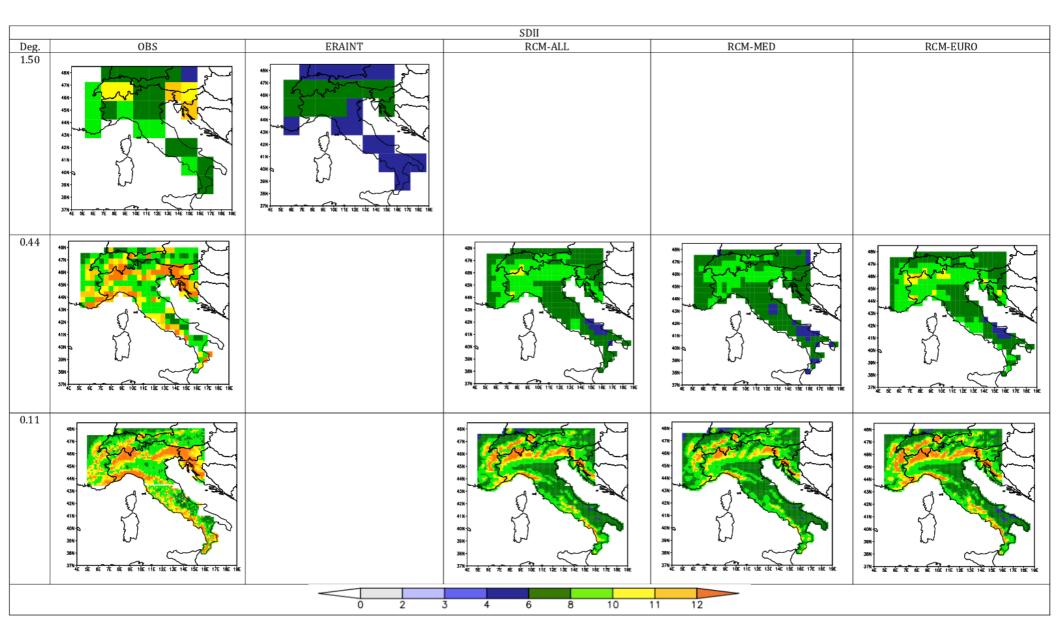
Kullback-Leibler divergence



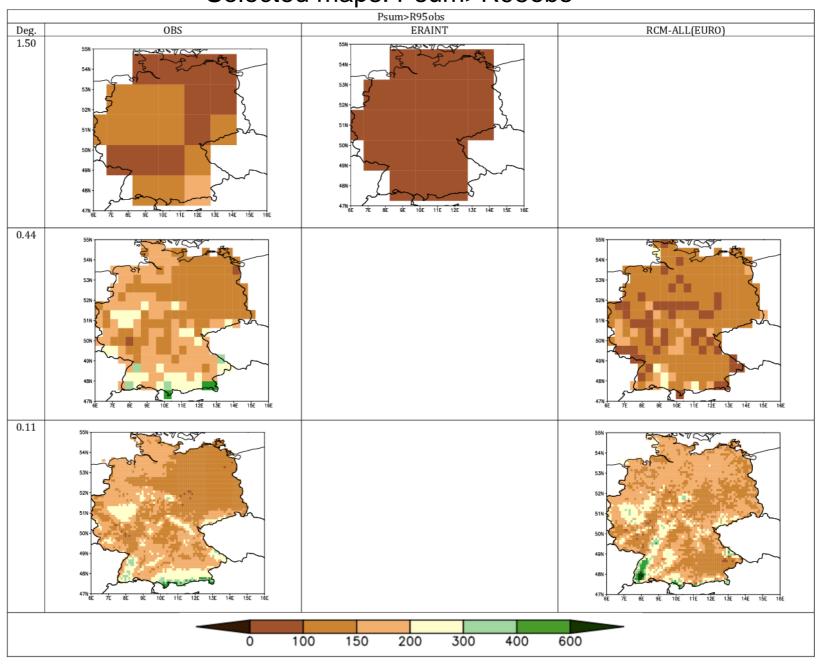
Kullback-Leibler divergence



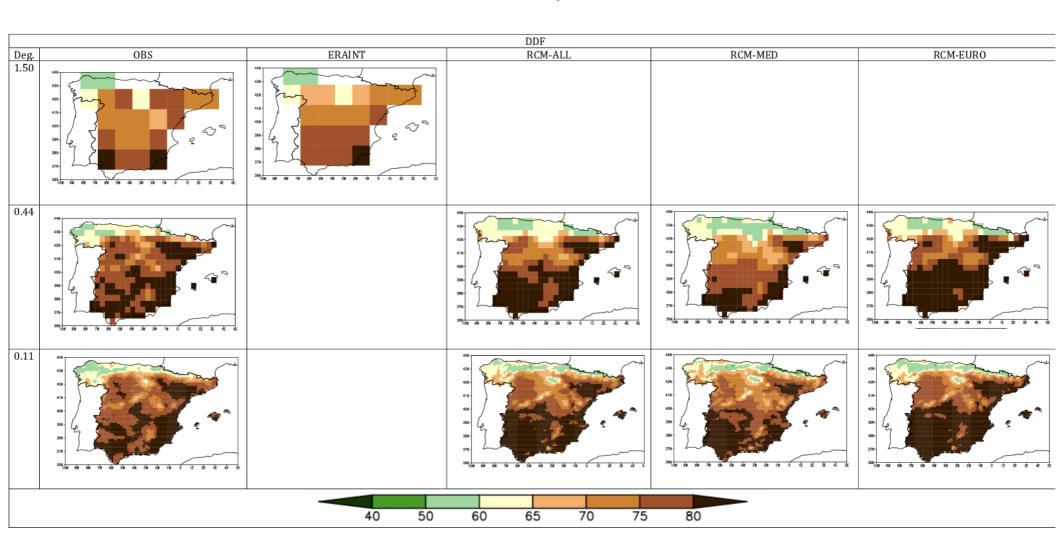
Selected maps: SDII

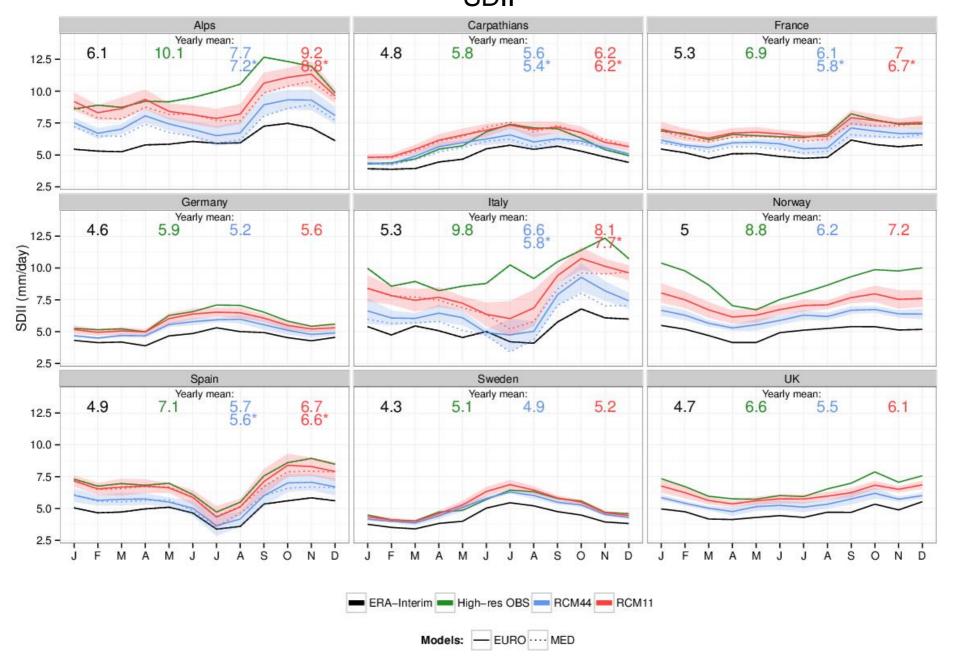


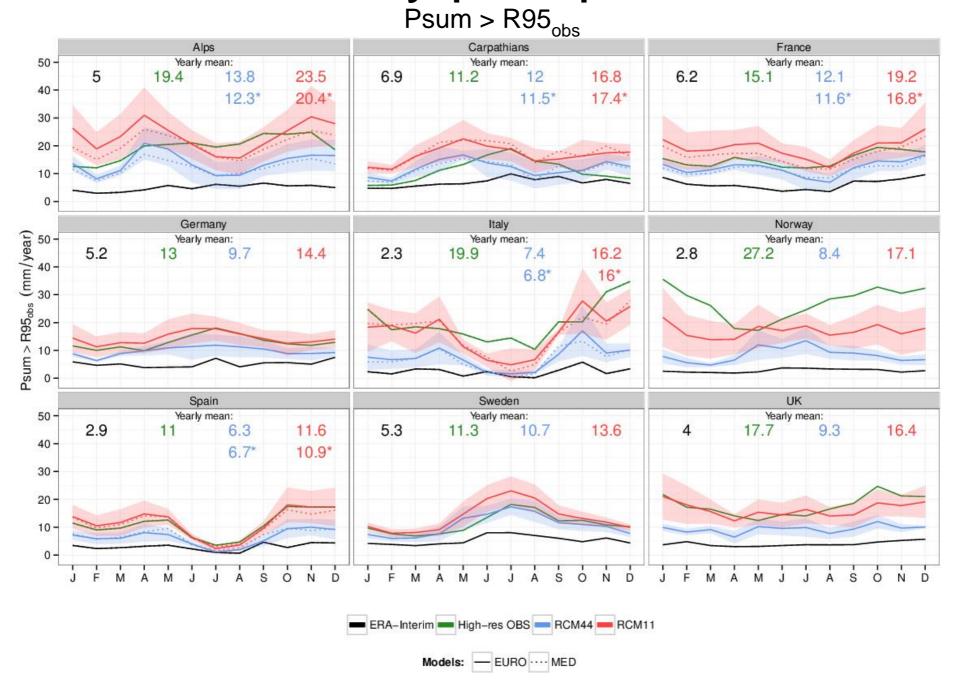
Selected maps: Psum>R95obs



Selected maps: DDF







	DJF bias % <mod obs="" –="">/<obs></obs></mod>																												
	current.resol: 011											current.resol: 044								current.resol: 150									
AVERAGE-	0.04	6.73	14.11	-5.36	-26.29	-16.51	-12.87	8.89	-21.83	-0.76	7.32	13.95	-5.92	-25.02	-17.51	-13.6	9.25	-21.87	-3.48	8.29	13.6	-5.6	-27.63	-21.8	-14.9	14.31	-23.69		
RCA4-	19.9	14.71	47.87	10.67	-13.53	-13.73	8.23	19.33	-5.19	18.63	15.24	47.2	9.91	-10.36	-14.88	6.32	19.77	-5.16	17.31	17.6	45.94	10.82	-15.53	-17.83	1	23.19	-5.88		
RACMO22E-	-0.8	2.68	14.34	-12.78	-18.21	-16.46	-14.92	0.22	-24.73	-2.25	3.31	14.15	-13.3	-18.37	-17.1	-15.79	0.78	-24.15	-6.19	6.37	12.85	-13.07	-22.26	-21.37	-18.32	7.83	-27.86		
WRF331F-	-7.93	7.54	4.38	-8.65	-38.67	-22.68	-29.72	6.6	-27.1	-9.24	8.54	4.07	-9.26	-40.44	-23.02	-30.49	6.89	-27.14	-12.34	9.77	2.81	-10.07	-38.08	-28.46	-29.62	11.6	-28.01	oric	
HIRHAM5-	9.17	9.1	16.8	-1.55	-20.6	-3.1	-6.54	7	-19.57	11.7	9.33	17.68	-1.4	-14.27	-5.63	-8.28	6.6	-20.04	6.99	7.22	18.32	-0.85	-24.06	-12.08	-14.59	13.79	-24.03	J.res	
CCLM-	0.21	8.63	-0.9	-14.49	-42.6	-26.59	-17.21	11.31	-32.56	-1.85	9.77	-0.85	-15.55	-42.06	-26.92	-17.68	12.22	-32.85	-4.61	11	-2.9	-14.81	-44.09	-29.26	-18.74	15.14	-32.66	orig.resol: 011	
PROMES-	-15.89	-22.29	24.66		-24.46		-6.56			-17.27	-22.29	24.15		-20.47		-7.07			-19.09	-20.6	28.04		-39.36		-8.91			91	
RegCM4-	13.41	28.23	0.97		-7.36		-10.34			11.85	28.16	1.1		-10.33		-10.18			9.18	27.62	0.09		-0.65		-6.92				
GUF-CCLM-	2.45	23.54	20.55		-35.25		-18.07			0.76	25.26	20.2		-34.28		-18.24			-2.8	27.31	17.84		-38.23		-18.84				
ALADIN-	-20.14	-11.55	-1.68		-35.9		-20.72			-19.2	-11.39	-2.17		-34.6		-20.98			-19.81	-11.7	-0.6		-26.38		-19.19				
AVERAGE-	-8.8	3.24	6	-10.14	-39.94	-27.73	-17.62	11.46	-30.94	-10.71	4.25	5.76	-11.06	-38.62	-27.82	-18.38	11.61	-30.79	-9.45	6.69	2.67	-8.21	-38.22	-30.64	-19.82	14.74	-30.63		
E RCA4-		10.59	14.07	-10.52	-36.01	-31.06	-11.73	17.82	-28.75	-4.96	11.23	14.4	-11.7		-31.24	-13.21	18.26	-28.8	-2.33	12.57	9.32	-7.67		-34.94	-19.9	19.33	-28.62		
RACMO22E-		-2.78	9.57	-13.17	-28.45	-27.96	-18.52	0.89	-31.43	-8.06	-1.88	9.26	-14.16	-25.5	-27.92	-18.89	0.81	-31.12	-8.47	0.75	5.53	-11.43	-29.15	-30.81	-19.71	5.48	-31.56		
WRF331F -		6.33	2	-7.7	-52.11	-30.06	-34.72	6.8	-33.72	-13.16	7.6	1.35	-8.51	-53.71	-30.08	-35.6	6.83	-33.48	-11.53	11.52	-1.46	-5.52		-32.26	-35.57	10.48		9	
HIRHAM5-		15.3	19.95	0.45	-27.88	-17.7	-2.94	22.38	-25.37	5.64	16.32	20.96	-0.32	-23.83		-4.65	22.43	-25.23	6.19	18.11	17.53	1.95	-25	-22.19	-11.4	26.76	-24.19	ig.re	
CCLM-		-2.27	-4.75	-19.79	-52.52	-31.87	-24.62	9.39	-35.43	-17.52	-1.11	-5.27	-20.61	-52.56	-32.24	-25.06	9.69	-35.33	-16.72	1.91	-8.39	-18.4	-51.2	-32.98	-23.56	11.64	-35.77	Sol	
PROMES-		-8.95	13.64		-35.31		0.8			-11.56	-8.5	13.21		-32.44		0.37			-11.01	-6.71	9.91	1011	-35.14		-1.99			orig.resol: 044	
RegCM4-		18.27	0.42		-34.1		-19.36			-0.95	19.64	0.21		-34.94		-19.51			1.14	23.6	-2.24		-29.81		-19.69			4	
GUF-CCLM-		-1.92	-0.95		-55.75		-30.2			-25.51	-0.57	-1.71		-55.06		-30.67			-24.63	2.26	-5.18		-56.34		-29.49				
ALADIN-		-5.46	0.04		-37.28		-17.3			-20.34	-4.48	-0.56		-36.98		-18.18			-17.68	-3.78	-1		-32.52		-17.1				
ERAIN-	-32.23	11.05	6 77	04.00	44.50	20.04	-27.06	0.05	44.00	22.54	10.00	7.04	05.00		40.47	-27.44	0.04	41.00	-31.03	0.40	0.54	00.40		41.10	-27.33	1.00	44.05	g	
ERAIN-		-11.95	-6.77	-24.96	-41.53	-39.94		-3.25	-41.86	-33.51	-10.86	-7.61	-25.89	-41.19	-40.47		-2.94	-41.92		-8.46	-9.51	-23.46		-41.16		-1.63		eso	
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		Carpathians	Ë	Germany.		2	S	Sweden			pathians	Ë	Germany		2	S	Sweden			Carpathians	Ţ.	Germany		2	S	Sweden			
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MAM

	MAM bias % <mod -="" obs="">/<obs></obs></mod>																											
	current.resol: 011										current.resol: 044								current.resol: 150									
AVERAGE-	10.78	19.97	18.35	4.64	-10.47	0.4	-7.4	26.36	-5.65	11.08	19.67	18.78	4.17	-8.05	-0.46	-8.72	26.59	-6.05	8.33	19.67	17.11	3.83	-9.32	-6.01	-13.11	29.8	-7.44	
RCA4-	31.54	45.89	54.33	35.01	4.06	-0.39	10.45	36.79	17.43	33.79	44.3	54.79	34.58	9.18	-1.27	7.95	37.02	17.15	35.08	46.29	53.19	32.63	2.36	-5.16	-0.07	38.28	17.31	
RACMO22E-	-5.9	-4.75	9.01	-12.59	-20.78	-6.2	-9.87	1.64	-12.26	-6.73	-4.93	9.25	-13.13	-20.37	-6.59	-11.02	1.89	-12.04	-9.04	-4.17	7.22	-14	-18.88	-11.79	-15.86	7	-15.75	
WRF331F-	8.06	28.93	19.64	12.81	-12.3	-4.88	-16.16	23.11	-10.53	7.31	28.73	19.36	12.27	-14.28	-5.18	-17.36	23.49	-10.88	5.2	29.35	18.06	11.68	-10.27	-12.15	-20.13	26.91	-11.38	orio
HIRHAM5-	6.36	-1.47	6.61	-8.53	-24.74	21.96	-13.63	41.09	-5.4	12.24	-2.8	8.4	-8.47	-15.25	19.36	-15.61	40.73	-6.58	9.74	-4.68	8.81	-7.09	-21.32	11.48	-23.79	44.58	-8.7	orig.res
CCLM-	12.97	10.01	2.97	-3.48	-28.28	-8.48	-20.76	29.15	-17.49	10.79	10.3	3.37	-4.37	-27.57	-8.59	-21.64	29.83	-17.9	6.14	9.99	0.42	-4.06	-29.02	-12.44	-25.61	32.23	-18.69	sol: 011
PROMES-	5.98	21.06	24.85		5.34		-2.14			5.99	21.19	25.22		10.43		-3.41			3.16	21.24	26.91		-5.99		-7.88			9
RegCM4-	7.54	17.79	4.74		10.2		-9.88			8.06	17.3	5.35		7.49		-10.08			4.07	16.84	3.03		26.39		-10.11			
GUF-CCLM-	15.61	29.84	13.56		-28.55		-21.41			14.12	30.3	13.95		-27.53		-22.19			8.13	30.44	11.04		-28.28		-26.2			
ALADIN-	14.84	32.47	29.49		0.78		16.76			14.14	32.66	29.3		5.47		14.92			12.49	31.7	25.32		1.11		11.66			
AVERAGE-	3.48	13.51	8.53	-0.66	-27.68	-10.18	-15.51	27.76	-15.73	2.04	13.91	8.94	-1.28	-25.22	-9.87	-16.89	27.82	-15.8	3.02	14.4	4.62	0.06	-25.24	-14.55	-22.14	30.26	-14.29	
E RCA4-	8.71	25.5	16.61	6.42	-26.39	-7.98	-10.15	37.7	-2.48	7.16	25.26	17.87	5.27	-21.69	-7.83	-12.48	38.03	-2.67	9.67	22.66	11.5	8.01	-23.02	-14.42	-23.42	39.2	-0.85	
RACMO22E-	-5.43	-2.79	6.68	-6.48	-27.42	-20.44	-19.26	3.32	-18.56	-6.43	-2.62	6.82	-7.16	-24.76	-20.07	-20.14	3.18	-18.42	-6.4	-2.84	2.67	-6.23	-27.03	-23.81	-26.02	6.72	-18.15	
WRF331F-	5.51	21.48	12.32	9.14	-26.49	-12.71	-28.01	21.64	-18.82	4.04	22.14	12.1	8.63	-26.83	-12.33	-29.45	21.6	-18.91	4.3	24.13	8.63	9.62	-19.84	-16.29	-32.31	24.35	-17.64	orig
HIRHAM5-	10.33	10.29	6.26	-1.99	-28.68	5.01	-15.75	53	-13.62	8.91	10.37	8.08	-2.44	-24.38	5.61	-18.57	53.06	-13.8	9.94	9.18	3.42	-1.2	-25.91	-1.6	-29.47	56.04	-9.84	
CCLM-	2.4	2.58	-4.08	-10.39	-46.41	-14.76	-29.62	23.1	-25.15	0.8	3.05	-4.05	-10.69	-45.51	-14.74	-30.47	23.23	-25.17	0.02	4.55	-8.49	-9.91	–47	-16.63	-31.96	24.97	-24.94	resol: 044
PROMES-	13.68	29.49	21.7		-21.47		7.16			11.58	30.15	21.8		-17.4		5.92			14.32	31.53	16.66		-22.77		-0.49			24
RegCM4-	-2.37	7.44	0.17		-5.09		-15.79			-3.12	8.04	0.61		-3.81		-16.36			-2.38	9.25	-1.91		5.51		-21.07			
GUF-CCLM-	-6.52	7.29	-1.48		-50.98		-33.73			-7.98	7.88	-1.61		-49.67		-34.56			-8.42	9.37	-5.88		-52.83		-36.19			
ALADIN-	4.98	20.3	18.62		-16.21		5.55			3.41	20.9	18.84		-12.91		4.08			6.15	21.81	14.95		-14.31		1.67			
ERAIN-	-15.83	1.75	-2.68	-12.71	-26.63	-26.35	-18	5.85	-26.29	-16.74	2.33	-2.91	-13.29	-25.43	-26.61	-18.62	6.04	-26.41	-14.42	3.78	-5.85	-12.07	-24.33	-28.15	-20.27	7.57	-25.47	eso
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JJA bias % <mod - obs>/<obs> current.resol: 011 current.resol: 044 current.resol: 150 AVERAGE--9.9 -12.60.07 0.61 -24.4 -6.49 -10.95 7.62 -4.1 -12.52 0 0.12 -12.76 7.74 -4.22 -11.08 -12.26 -0.01 0.63 -12.52 -10.04 -17.09 8.61 -4.8 -9.37 -6.522.53 17.23 26.89 20.44 26.95 -9.9 17.22 -33.76 4.92 -1.92-15.17 -10.44 22.21 4.9 -4.8-11.7-9.91 19.85 2.23 -11.08RACMO22E--0.96-8.03-34.46 -17.08-10.4-5.33-8.56-17.7 -21.18 -1.05-8.64-17.09 -11.54 -5.09 -8.28-18.25-20.7-0.41-8.84 -19.38 _19 -4.92-10.717.55 16.63 16.31 14.45 -4.74 26.92 16.79 15.85 14.99 -5.13 17.48 15.85 -8.36 WRF331F-3.63 6.52 -11.57 6.82 -11.79 14.07 2.29 8.62 33.4 -14.91 14.29 HIRHAM5--21.55 -17.34 -10.13-66.16 0.16 45.44 5.7 -11.37-11.72 -21.94 -17.11 -10.32-60.34 0.04 47.28 5.46 -12.29-13.64-22.47 -15.67 -7.49-57.29 -5.26-51.41 6.75 -9.47 -50.67 -59.29 -23.58-50.94 -59.95 -23.52-18.06 -39.89 -12.88 -62.7-1.57-25.63PROMES-6.14 13.01 9.41 8.36 2.23 6.19 9.49 12.69 15.33 -1.19-0.079.03 15.05 -7.75-7.02-7.1-8.63 RegCM4--31.79 -26.16 -22.79-8.05-26.05 -7.77-32.45 -25.7112.72 -14.42GUF-CCLM--13.24 -13.94 -55.35 -48.13 -13.93 -13.82 -55.01 -48.96 -13.81 -45.44 -50.13 -18.43-19.14 ALADIN-18.58 0.09 17.93 26.55 52.58 13.12 48.38 12.22 11.28 0.61 AVERAGE--21.86 -14.21 -11.54 49.55 -17 -13.51 1.55 -21.34 -24.61 2.22 -15.19 -24.22 -15.88 47.42 -7.89-15.3210.65 -4.03-23.66 42.56 -7.24-19.09 10.71 -3.96-26.27 -43.11 -14 10.95 -0.68-13.89 -15.33 -45.6 -14.2RACMO22E--22.9-15.76 -10.12 -18.18-24.25 -26.94 -15.93 -22.2 -17.23 -9.98 -17.94-22.49 -26.79 -15.51 -14.89-45.75 -25.56 -9.19 -17.2215.13 11.05 -25.85 -16.75 -1.1514.35 10.28 -24.18 -16.23 13.21 11.71 -16.15 -19.95 -8.7 8.27 WRF331F -9.6 -1.516.85 -16.2-11.11 -0.63-4.78 7.13 -16.33 -9.67 1.03 -16.2645.99 -4.21 -10.37 -11.61 -56.33 HIRHAM5--24.42 -17.45 -11.74-70.79 -5.068.81 -12.18-17.22-12.36-69.14 -50.27 8.9 -12.41-24.16 -17.74-66.53 9.38 -7.89-37.95 -38.3 -20.58 CCLM--47.22 -25.82 -79.5 -63.73 -46.85 -25.99 -79.55 -17.7 -64.72 -26.51 -45.99 -39.04 -79.11 -65.01 -8.33 PROMES: -7.06-10.84 -58.29 4.66 -9.46 -10.22 6.07 -55.61 2.22 -9.91 -55.7 -6.8-25.03 -23.31 -9.44 ReaCM4--0.62-26.76 -5.93-2.27-26.43 -15.47-62.88 -45.57 -33.89 -82.29 -64.07 -86.24 -65.18 GUF-CCLM -44.92 ALADIN- -8.89 25.96 -10.14-10.91 -20.46 -6.3-5.96-6.92-19.62 4.44 23.47 -18.6 es ERAIN--6.7 -12.04Sweden-Alps-Alps-France-Sweden-Italy. ¥ Italy Sweden: Sarpathians-¥ Germany Germany Norway region bias

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SON bias % <mod - obs>/<obs> current.resol: 011 current.resol: 044 current.resol: 150 AVERAGE--10.61 1.29 -3.13-5.11 -19.97 -11.47 -19.25 13.19 -19.44 -10.34 1.39 -3.24 -19.69 13.58 -11.5 2 -3.35-4.8 -22.32 -16.86 -19.72 16.65 -20.02 -5.64-19.24 -12.28 -0.59-0.037.71 22 33 17.59 1.94 -7.52-1.468.36 16.31 21.77 17.03 5.48 -8.58-2.99-0.2110.77 17.08 21.18 16.93 -2 -12.01 -6.05-15.34 RACMO22E--10.81-8.24-0.4-9.31-7.08-12.35-14.46 -19.19 -11.29-8.02 -0.5-9.91-6.55 -12.84-14.92 6.47 -18.62-13.13-6.68-1.64-9.5-14.9-16.910.79 -21.22 -14.95 -35.12 2.69 -29.69 -15.24 -20.33 -29.28 -15.64-26.14 5.93 WRF331F--20.7-10.23-15.92 -21.49 -9.71 -16.5-35.02 3.15 -22.02 -8.17 -12.89-34.92 HIRHAM5--4.71 1.68 -0.320.12 -25.5 3.77 -17.0322.14 -16.2-1.10.86 0.34 0 -18.03 1.76 -18.422.05 -17.01-3.03-0.50.68 2.17 -29.66 -4.69-21.6 25.97 -17.81CCLM--15.9341.01 -17.93 -7.39-15.86-40.35 -31.43 -20.14 -7.1-18.25-17.96-24.55 PROMES--2.617.52 -24.58 4.22 -6.88-8.51-12.16 6.18 3.89 -9.13-12.31 6.97 -11.55RegCM4--12.44-13-7.78-21.04-11.8415.64 -12.87-15.76-20.47-13.1216.19 -13.665.68 -18.16GUF-CCLM--3.71-37.93 -33.39 -37.48 -38.73 -32.54 -12.047.4 -3.86-15.578.51 -5.21ALADIN--6.45-14.45 -24.65 -15.03 -13.55 -8.76 -6.87-14.94 -8.87-11.81AVERAGE- -17.46 -24.95 13.97 -26.48 -18.21 -9.3714.17 -17.57 -26.89 16.43 -25.82 -18.83 -6.82-10.91-28.65 24.39 -19.03 -19.69 -2.31-6.02-22.3 24.75 -19 -2.53-10.33-8.67 -30.95 -24 25.56 -18.494.43 4.57 -17.7 7.74 RACMO22E--13.94-1.01-11.61-19.15 -16.23-24.77 -14.28 -1.16-12.48-23.01 -16.67 -24.46 -15.38 -10.85-5.17 -10.15-23.88 -26.66 -24.74-18.07 -13.07 -41.92 -40.71 -32.88 -43.73 -25.62 -41.64 9.53 -11.33 -37.65 -39.47 12.34 WRF331F-9.37 -24.07 -8.04 -18.6-13.68 -23.76 -5.13 -9.2 -8.92 HIRHAM5--3.2210.59 1.42 2.66 -18.41-19.55 -4.6510.97 2.54 2.09 -20.87 -19.65-3.4411.66 -2.274.48 -15.04 -25.59 -17.82CCLM--24.09 -21.26 -18.89-21.83 -51.99 -36.78 -24.88 -20.77 -19.16 -22.33 -51.43 1.12 -25.1 -19.15 -22.25 -20.57-54.75 -36.093.36 PROMES: -10.97 -1.45-2.23-21.82 -11.25-12.3 -0.91 -2.38-18.03 -11.92 1.04 -6 -9.43 -13.34ReaCM4-9.8 -6.34-22.66-15.27 10.57 -13.14-6.2-22.62 -16.313.28 -15.61.06 -23.69 -41.87 -42.43 -55.26 -41.55 GUF-CCLM -16.02-51.06 -15.13 -14.29 -16.42-11.63 ALADIN--17.9 -15.89 -18.76 -8.73-17.08-7.88-15.58 ERAIN--26.62 -3.23Alps-Sweden-France-Alps Italy ¥ Germany. Italy Sweden: ¥ Carpathians-¥ Germany Germany region bias -40 -20 20 40