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

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6 - Universidad de Castilla-La Mancha, Toledo, Spain
7 - CETEMPS and University of L'Aquila, Italy



DATASETS AND SETUP

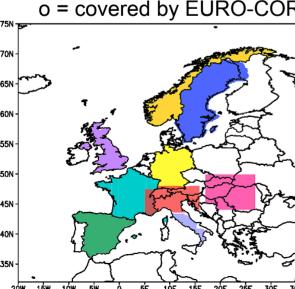
- 9 ERA-Interim driven, double nested Med- and EURO-CORDEX Regional Climate Models
- 3 common analysis grids at 0.11, 0.44, 1.50 degrees resolution
- HR observation datasets over 9 different European regions
- Precipitation undercatch correction with UDEL dataset (Matsuura and Willmott 2010, UDEL V3.01)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





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 yet released

o = covered by EURO-CORDEX only



+ = undercatch-corrected with UDEL data





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	WIEG-CONDLX						
PROMES	UCLM							

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





Statistical indices used

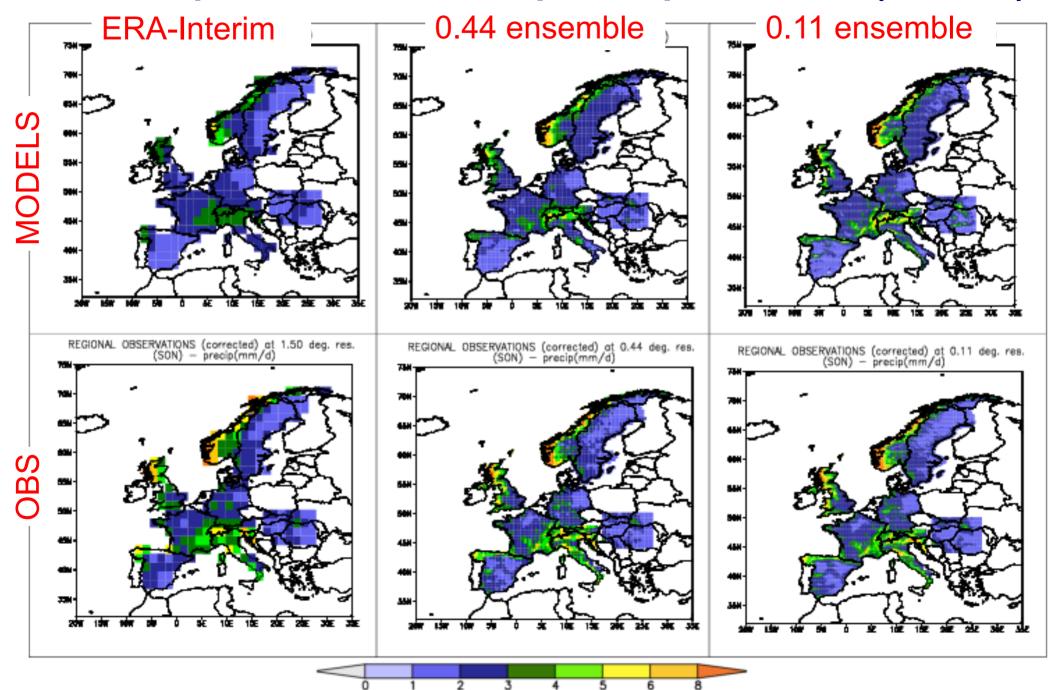
Index	Description
RMSE, mean, bias	Standard statistics.
TAYLOR	Taylor diagrams: spatial correlation, std.dev. and centered RMSE.
PDF, KL	Symmetrized Kullback-Leibler divergence for PDFs *. (>1mm / day)
SDII *	Mean daily precipitation intensity. (mm / day)
DDF *	Mean frequency of dry days. (%)
CDD95 *	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

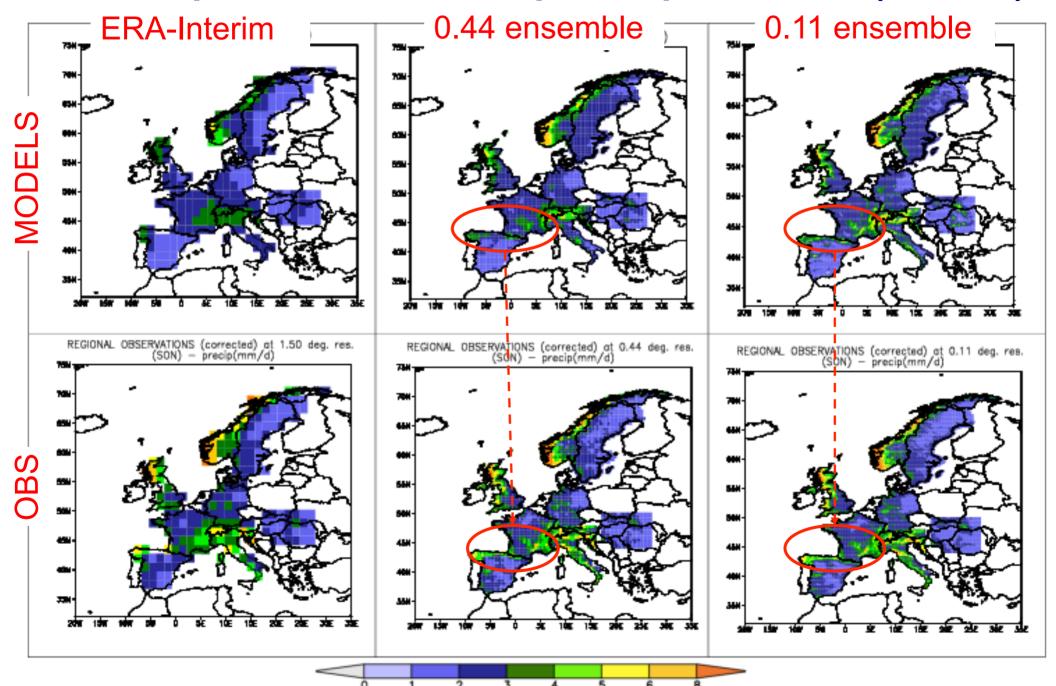




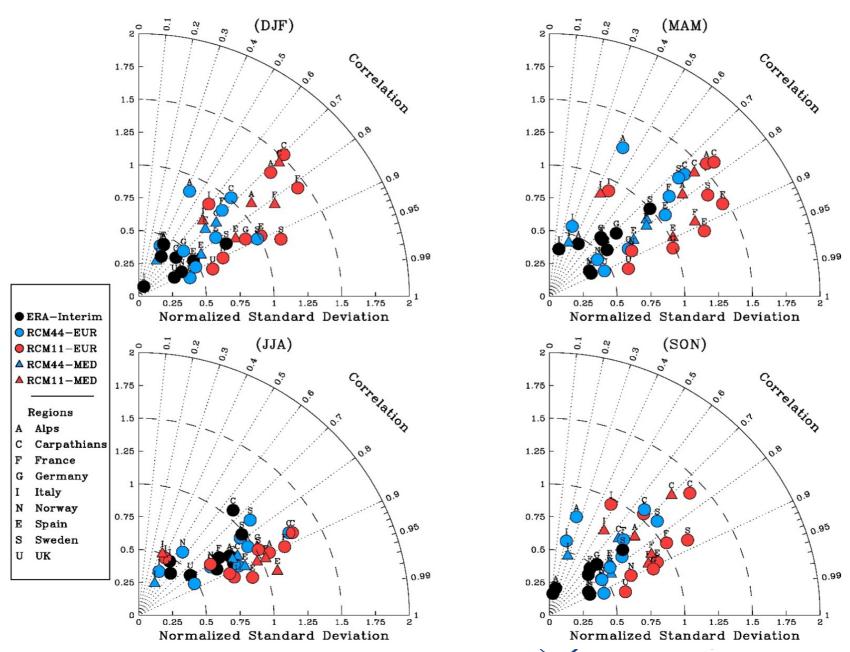
Example for mean precipitation (SON)



Example for mean precipitation (SON)

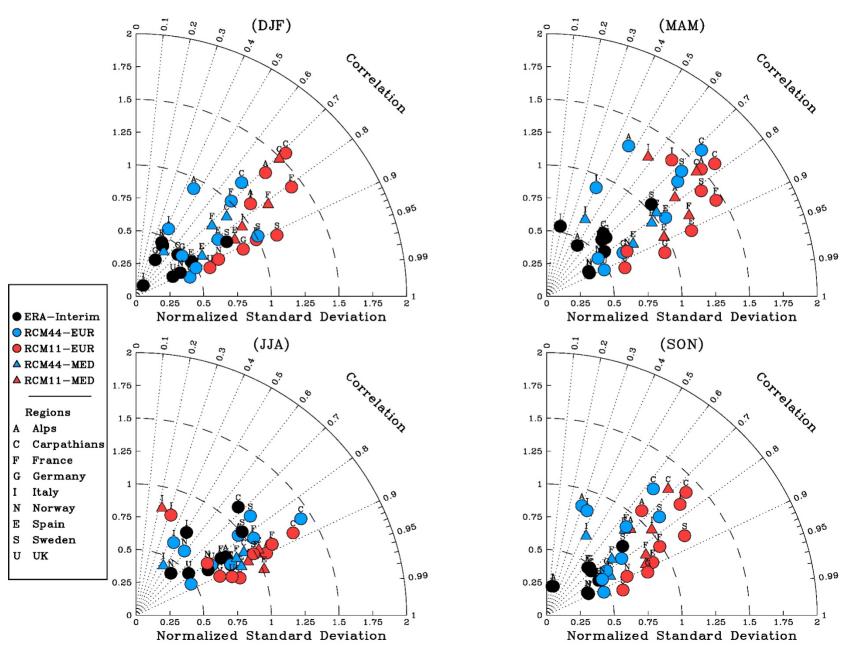


Taylor plots (0.11deg)





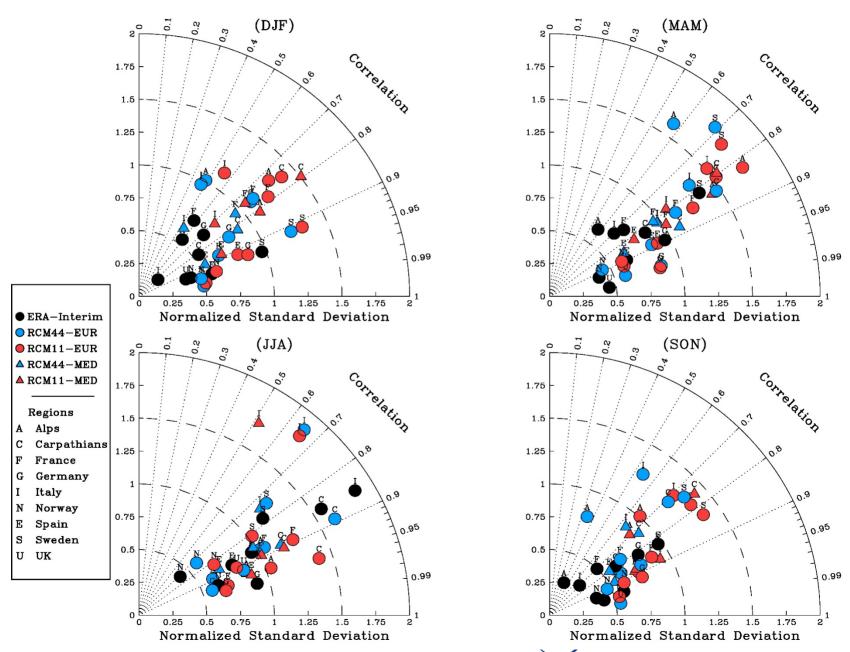
Taylor plots (0.44deg)







Taylor plots (1.50deg)







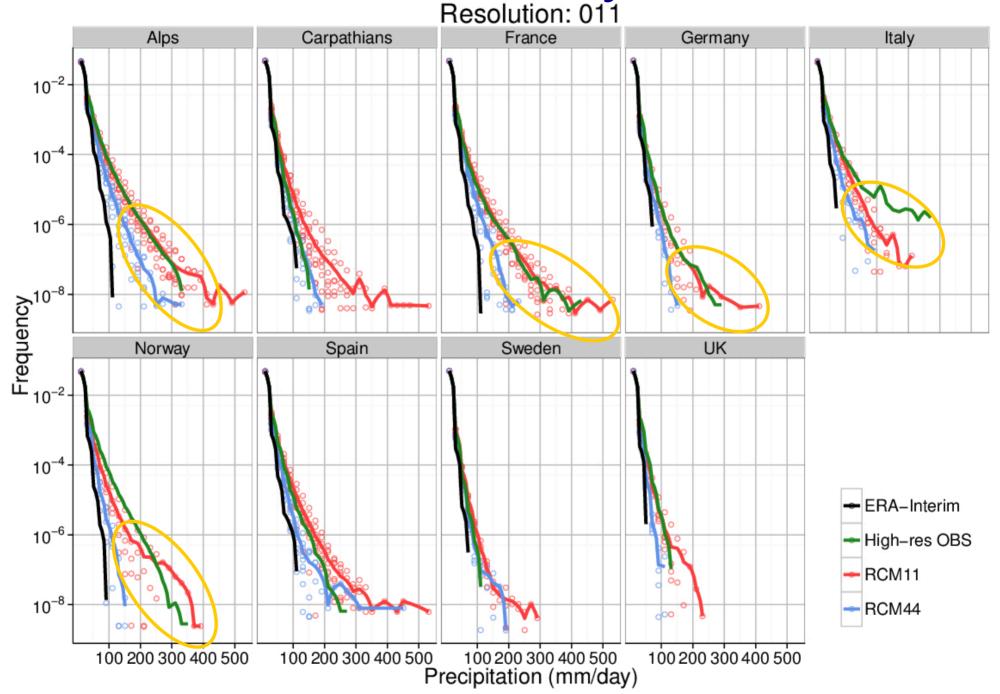
Results for daily PDFs
Resolution: 011

Carpathians Alps France Germany Italy 10⁻² 10 10⁻⁶ Frequency 0.00 Norway Sweden UK Spain 10^{-4} ERA-Interim 10⁻⁶ High-res OBS RCM11 10^{-8} RCM44 000 000 100 200 300 400 500 100 200 300 400 500 100 200 300 400 500 100 200 300 400 500 Precipitation (mm/day)

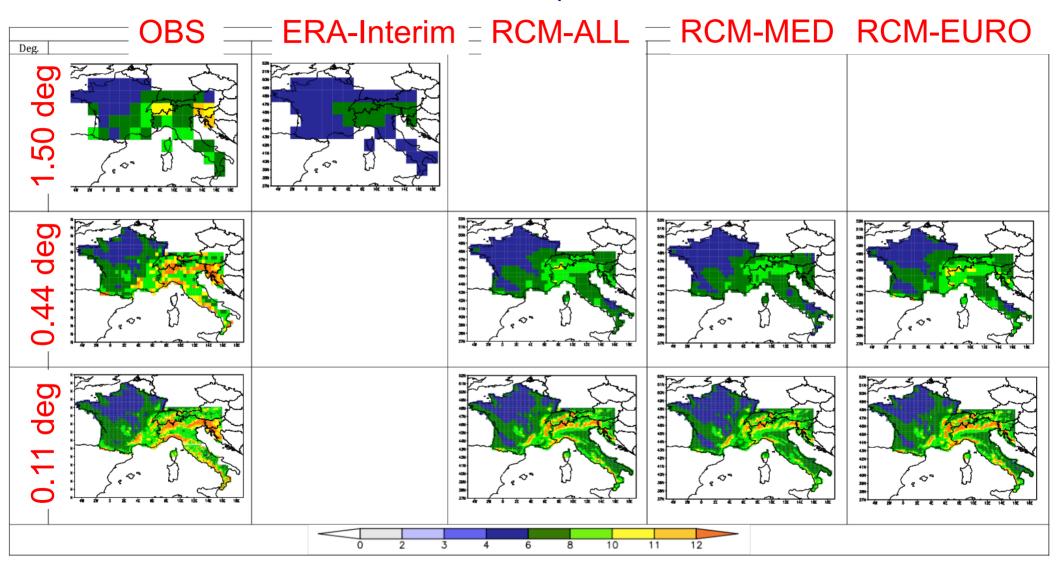




Results for daily PDFs Resolution: 011



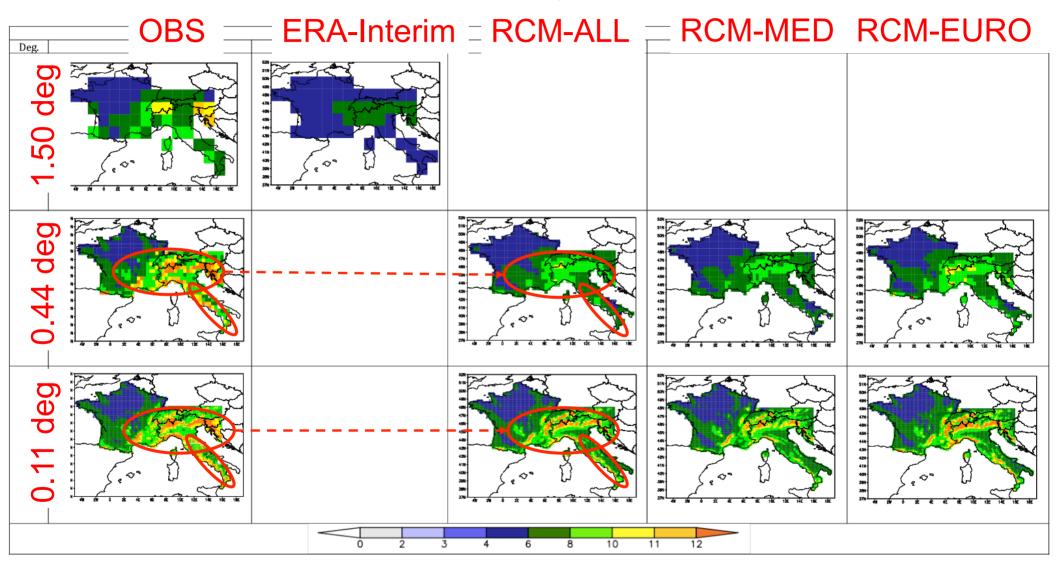
Selected maps: SDII







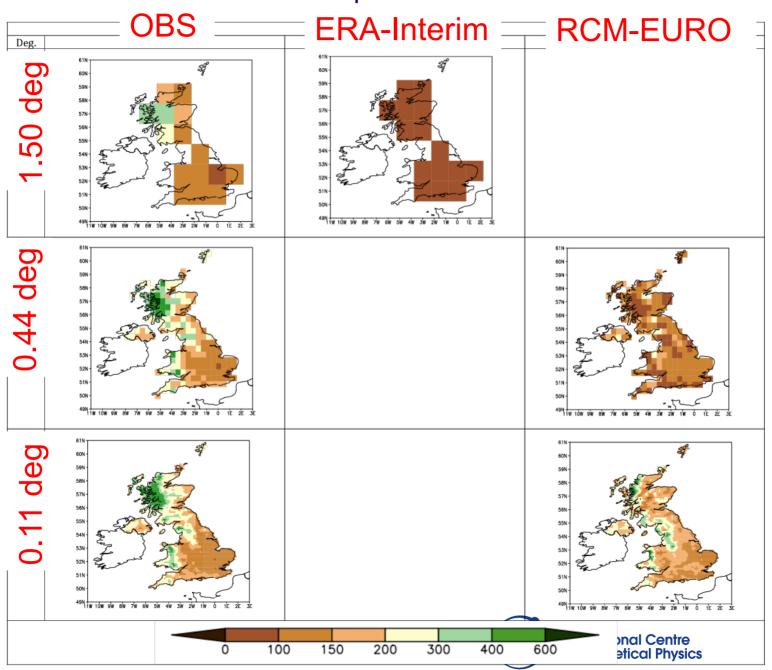
Selected maps: SDII





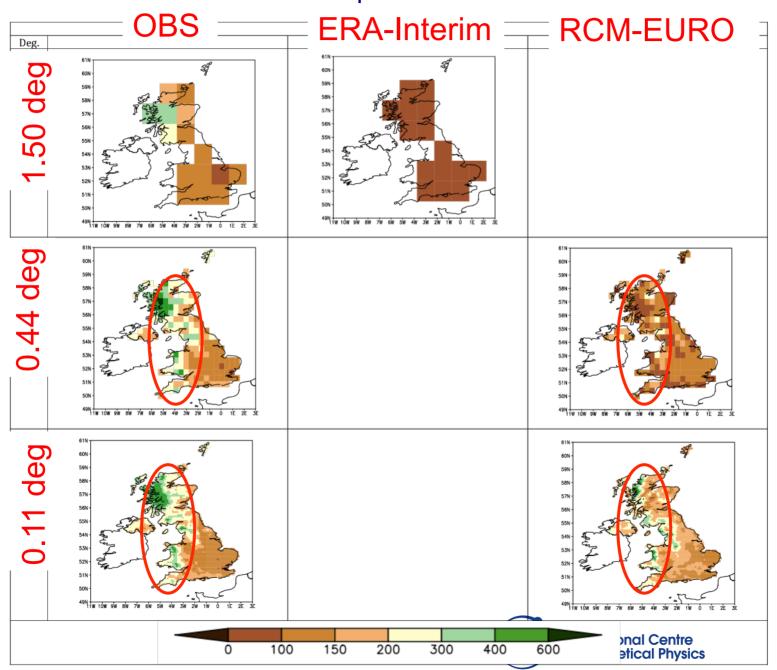


Selected maps: Psum>R95obs



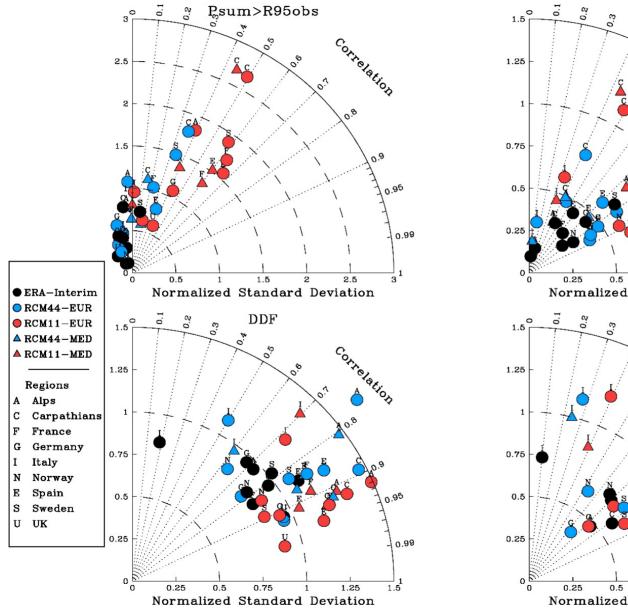


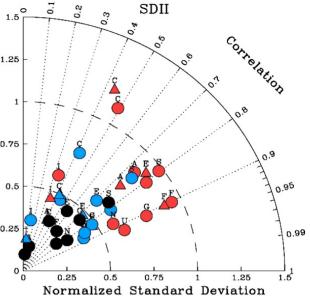
Selected maps: Psum>R95obs

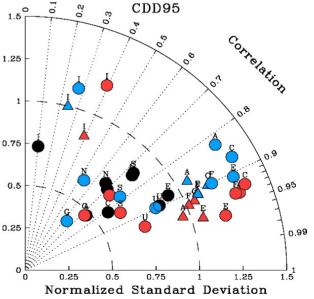




Taylor plots

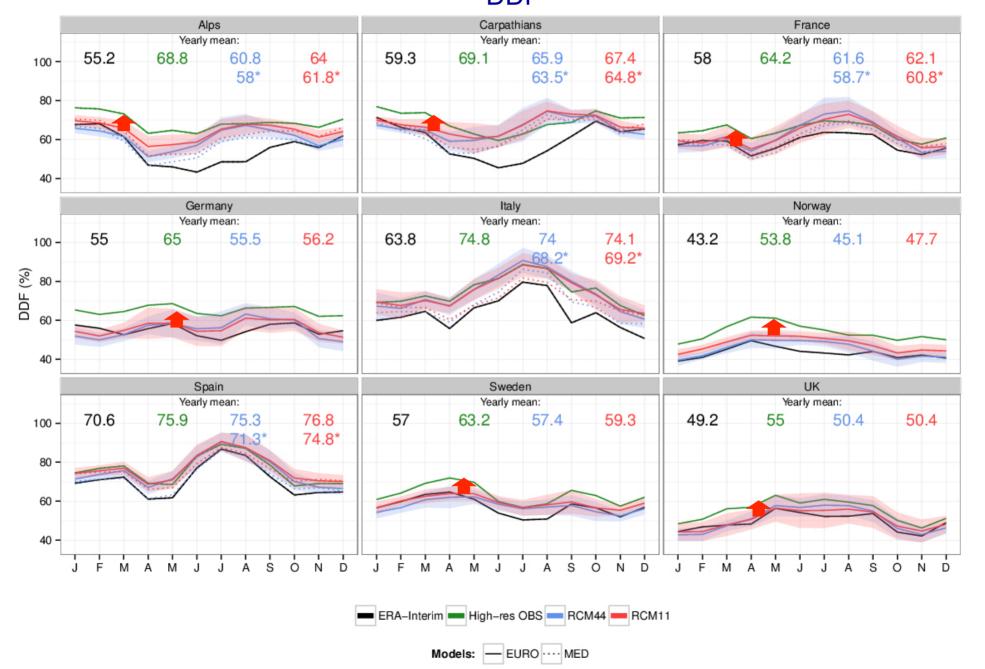












CONCLUSIONS

The model ensembles show **remarkable performance** in simulating the **spatial patterns and annual cycle of all metrics analyzed**, with a substantial improvement going from the low resolution of the ERA-interim data to the medium resolution RCM44ensemble and the high resolution RCM11. This conclusion is **retained** even when the data are **upscaled** to the lower resolution (confirms Torma et al., 2015)

The performance of the **models** appears **improved** compared to **previous generation** RCMs

EURO-CORDEX and Med-CORDEX models **have similar performance**; both ensembles are of **sufficient quality** to be applied in **climate projections**

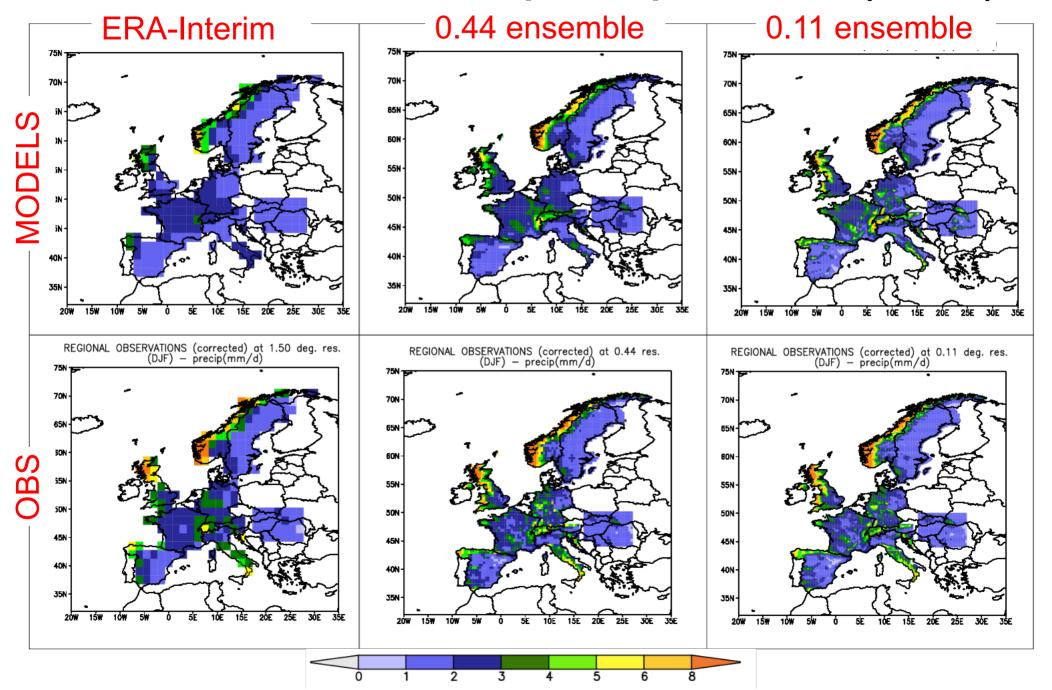
Some metrics (e.g. **DDF** and **CCD95** in some regions) still indicate **deficiencies** in the model's description of precipitation processes mainly due to the **drizzle phenomenon** that is **not solved** only by **increasing resolution**, but there are indications that this problem might be ameliorated which cloud and **convection** processes are **explicitly described**.

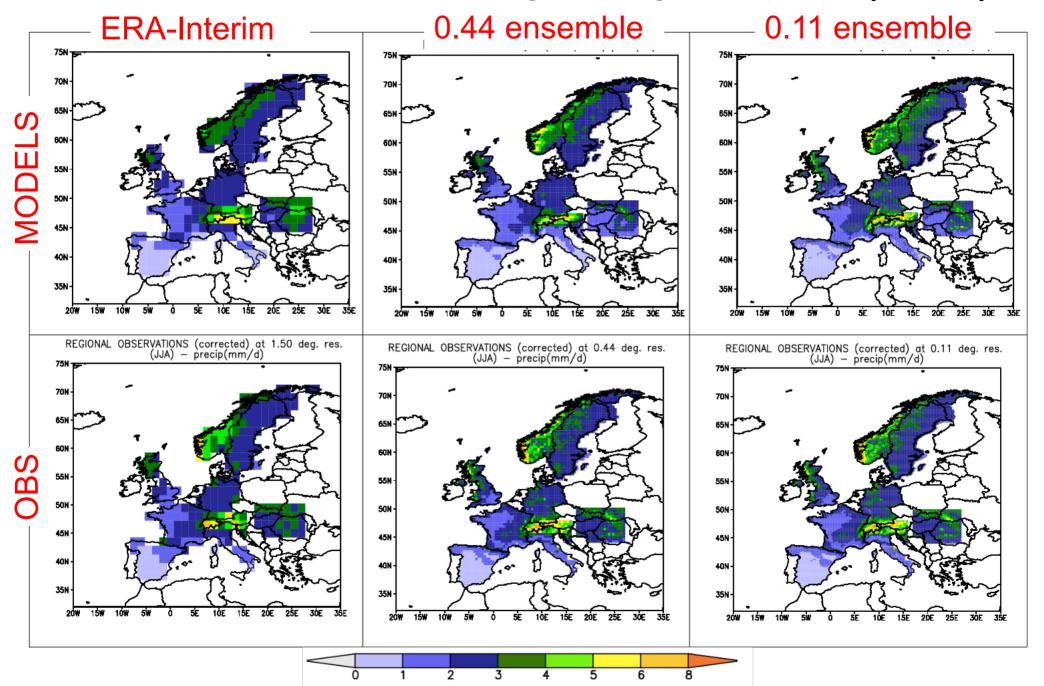
Need to develop a homogeneous and internally consistent **high resolution**, **quality checked**, **observation dataset** for the entire European territory which can be used for future development of very high resolution, European-wide models.

Paper reference:

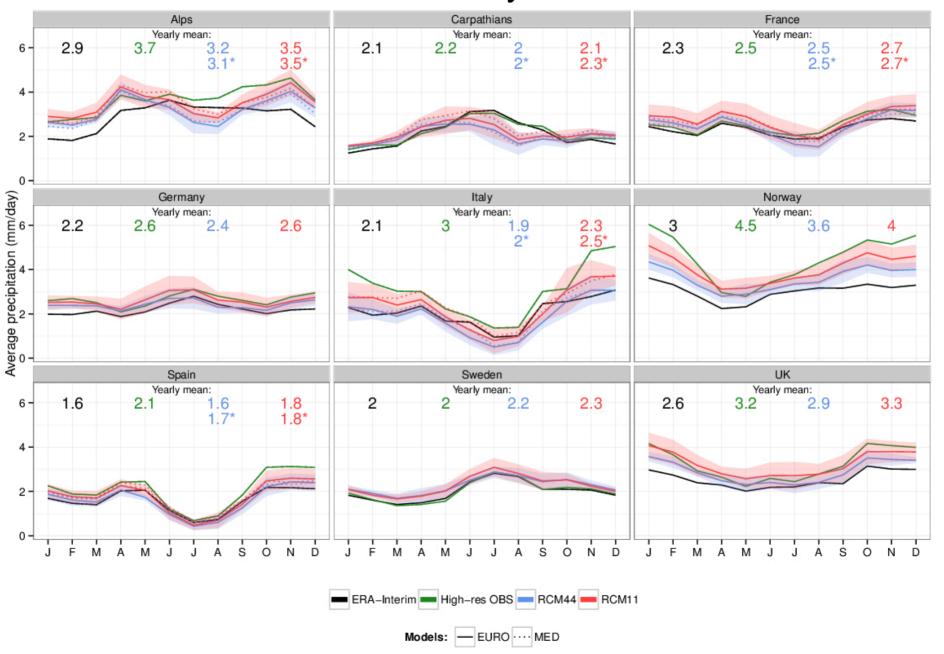
Fantini A., Raffaele F., Torma C., Bacer S., Coppola E., Giorgi F., Ahrens B., Dubois C., Sanchez E., Verdecchia M. Assessment of multiple daily precipitation statistics in ERA-Interim driven Med-CORDEX and EURO-CORDEX experiments against high resolution observations.

Submitted to Climate Dynamics, 2016

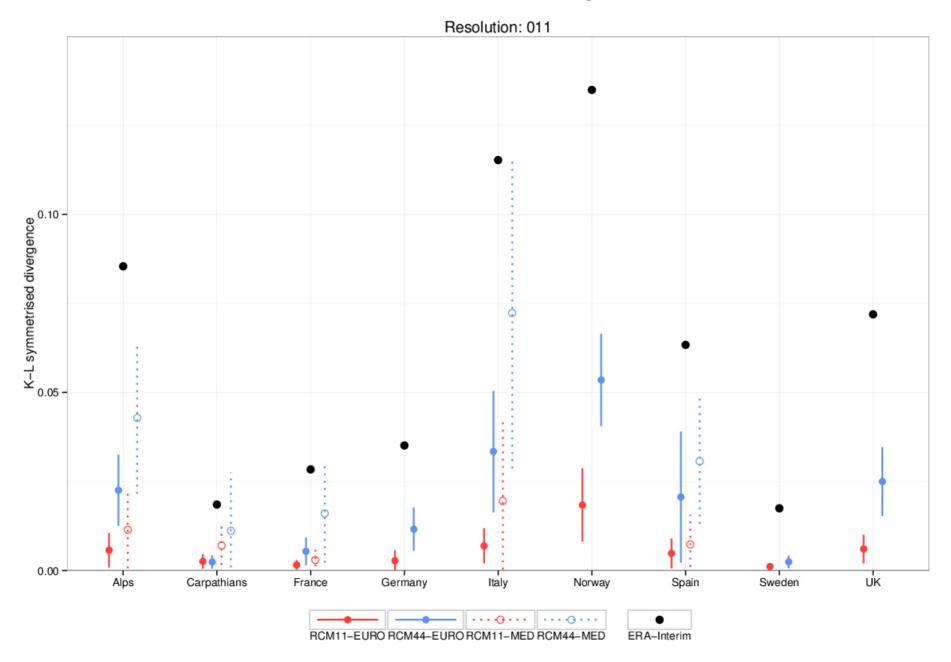




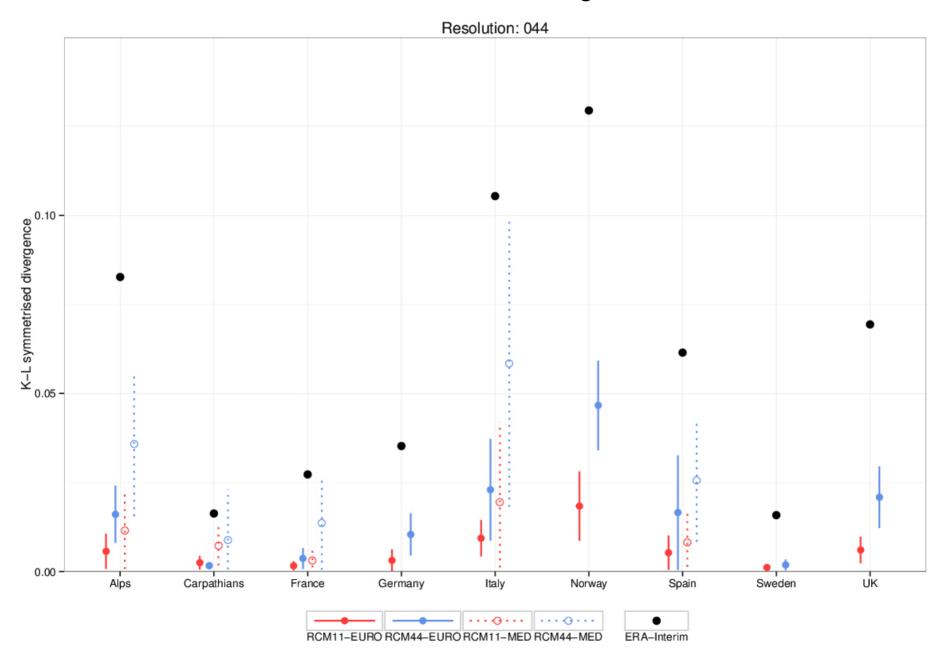
Annual cycle



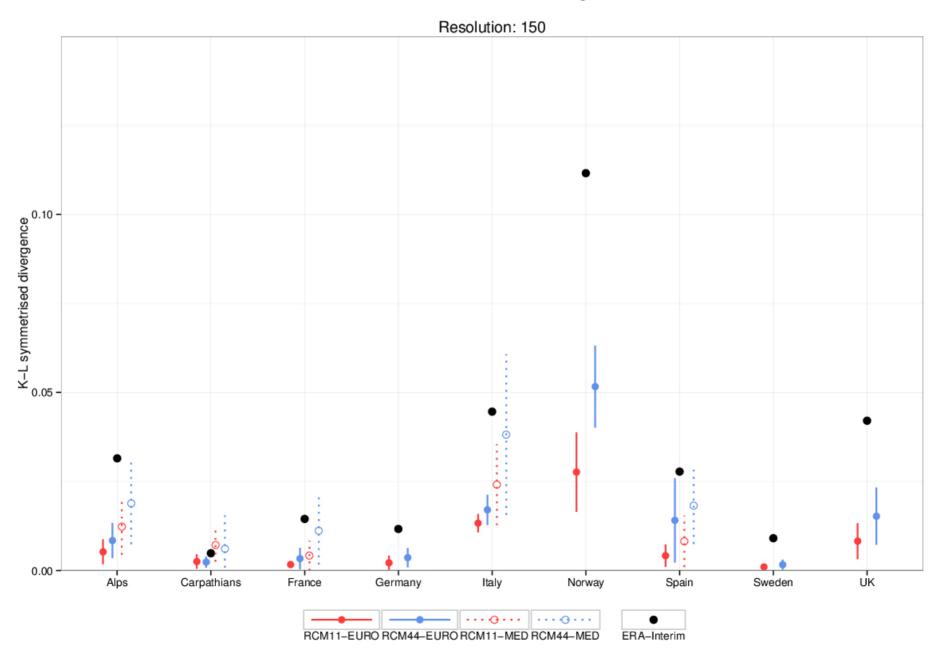
Results for daily PDFs Kullback-Leibler divergence



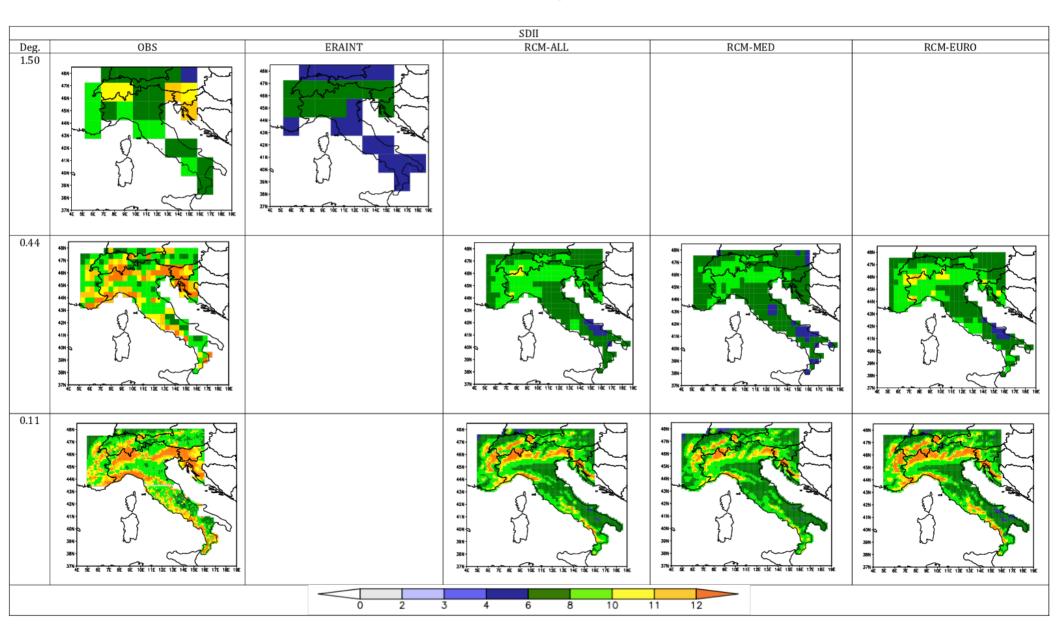
Results for daily PDFs Kullback-Leibler divergence



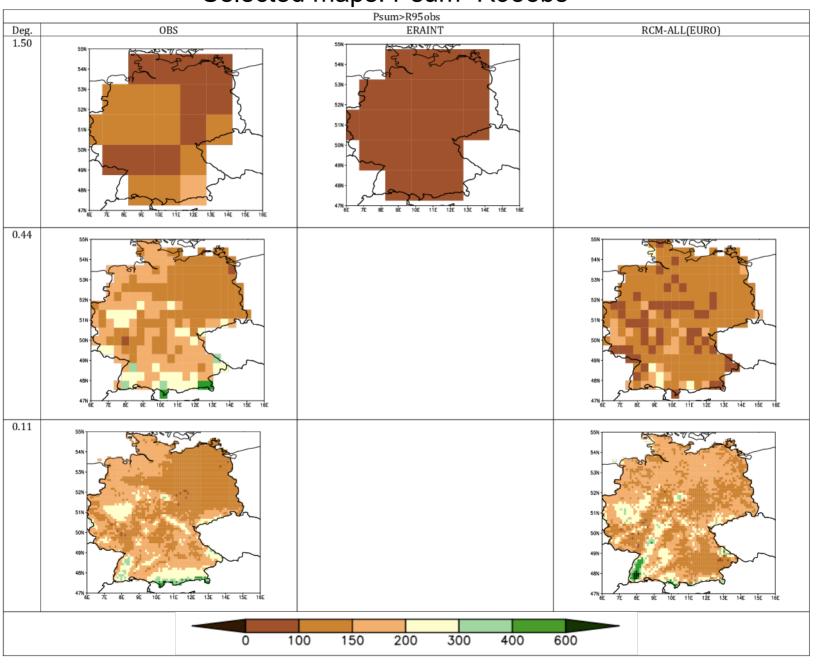
Results for daily PDFs Kullback-Leibler divergence



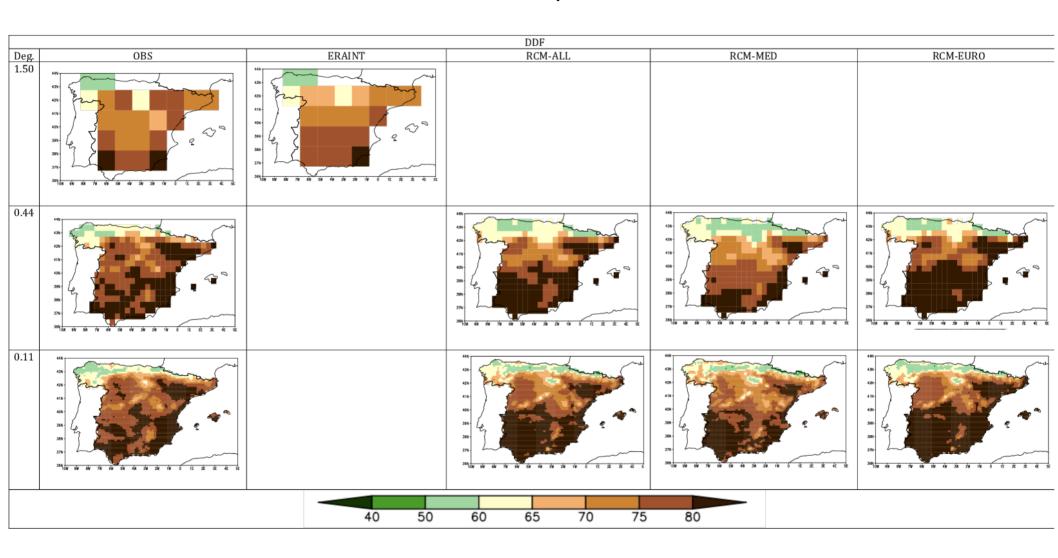
Selected maps: SDII

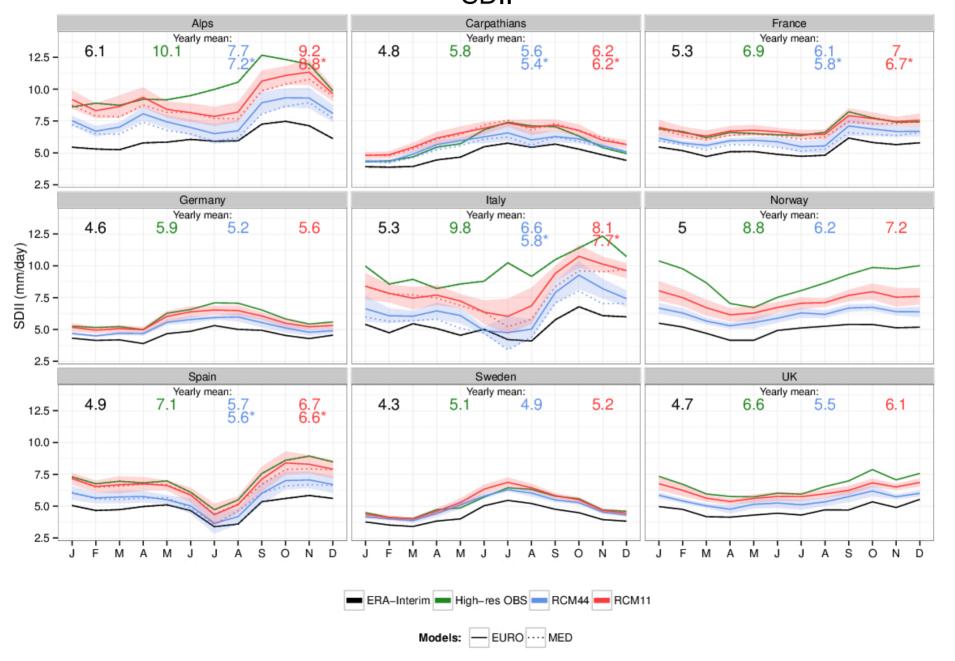


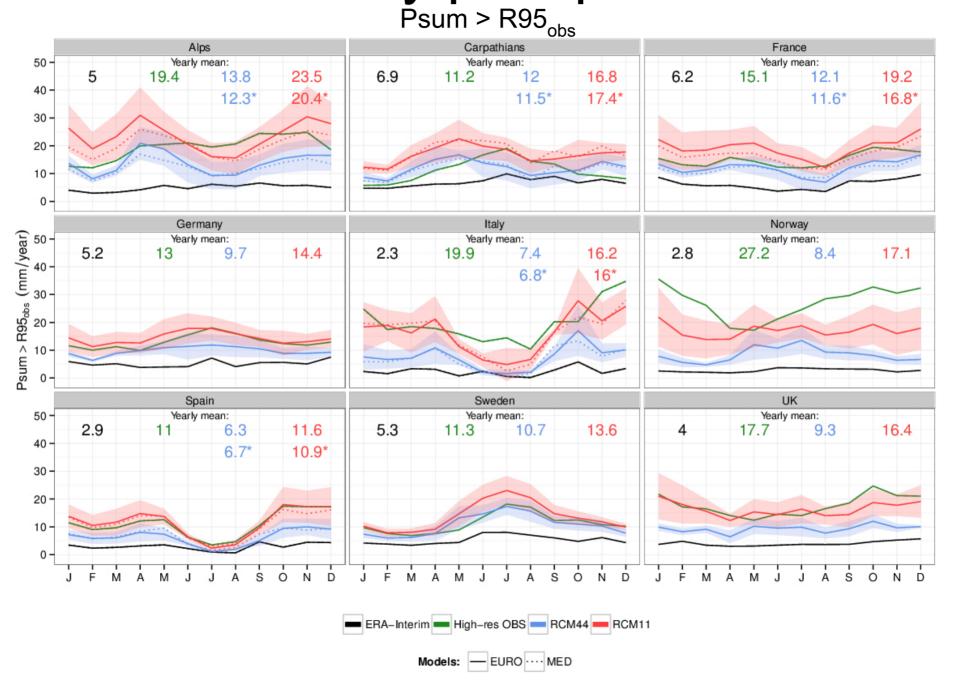
Selected maps: Psum>R95obs



Selected maps: DDF







DJF bias % <mod - obs>/<obs> current.resol: 011 current resol: 044 current.resol: 150 AVERAGE-6.73 14.11 -26.29 -16.51 -12.87 -21.83 7.32 13.95 -21.87 8.29 13.6 -27.63 -21.8 -14.9 14.31 -23.69 0.04 -5.368.89 -0.76-5.92-25.02 -17.51 -13.6 9.25 -3.4819.9 19.77 17.6 14.71 10.67 -13.538.23 -5.19 18.63 15.24 9.91 6.32 -5.1617.31 45.94 10.82 -15.5323.19 -5.88-10.360.22 -13.3 0.78 -24.15 -13.07-21.37 7.83 -27.86 RACMO22F--0.814.34 -12.78-24.73 -2.253.31 14.15 -15.79 -6.196.37 12.85 -18.32 4.38 -22.68 -9.24 8.54 4.07 -9.26-23.02 -12.34 9.77 2.81 -10.0711.6 HIRHAM5-9.1 16.8 -1.55-20.6 -3.1 -6.54 -19.57 11.7 9.33 17.68 -14.27 -5.63 -8.28 6.6 -20.04 6.99 7.22 18.32 -0.85-24.06 -12.08 13.79 -24.03 CCLM-0.21 8.63 -0.9-14.49-42.6 -26.59 -17.21-1.859.77 -0.85 -15.55 -42.06 12.22 -32.85 -4.61 11 -2.9 -14.8115.14 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 -39.36 -8.91 RegCM4-13.41 0.97 -7.36 -10.34 11.85 1.1 -10.33 -10.18 9.18 0.09 -0.65 -6.92 GUF-CCLM-2.45 23.54 20.55 -35.25 -18.0725.26 20.2 -18.24 -2.8 17.84 -38.23 -18.840.76 ALADIN--35.9 -20.72 -19.2 -11.39 -2.17 -34.6 -20.98 -19.81 -11.7 -0.6 -19.19 AVERAGE-14.74 3.24 -10.14-39.94 -10.71 4.25 5.76 -18.38 -9.45 6.69 2.67 -8.21 -2.5 10.59 14.07 -10.52 -36.01 -11.73 17.82 -4.9611.23 14.4 -11.732.56 -13.21 18.26 -28.8 -2.3312.57 9.32 -7.67 36.53 -34.94 -19.919.33 -28.62 RACMO22E--6.71-2.789.57 -13.17 -18.52 0.89 -1.889.26 -14.16-25.5 -18.89 0.81 -8.470.75 5.53 -11.43 -19.71 5.48 _8.06 WRF331F -10.696.33 2 -7.7 -52.11 6.8 -13.16 7.6 1.35 -8.51-53.71 -35.6 6.83 -33.48 -11.5311.52 -1.46-5.52 48.26 10.48 -32.99 HIRHAM5 8.11 15.3 19.95 0.45 -2.94 22.38 -25.37 5.64 16.32 20.96 -0.32-23.83 -17.6 -4.65 22.43 6.19 18.11 1.95 -11.4 26.76 -24.19 -16.24 -2.27 -4.75 -52.52 -24.62 -5.27 -52.56 -25.06 9.69 1.91 -51.2 -23.56 11.64 -17.52 -1.11-20.61 -16.72-8.39 -32.44 -35.14 PROMES: -8.95 13.64 -11.56 -8.5 13.21 0.37 -11.01 -6.719.91 -1.991.51 18.27 0.42 -19.36 0.21 -34.94 -19.51 23.6 -2.24 RegCM4--0.9519.64 1.14 -19.69 GUF-CCLM--1.92-55.75 -25.51 -55.06 -56.34 -29.49 -0.95-0.57-1.71-24.63 2.26 -5.18 ALADIN--37.28 -17.3-20.34 -36.98 -18.18 -17.1-5.460.04 -4.48-0.56-17.68-3.78_41.85 - 8 ERAIN-Spain-Spain-Alps-France-Sweden-Sarpathians-France-Alps. Sarpathians Germany. Italy. ¥ Alps pathians France Italy. ¥ Germany Italy: ¥ Germany region bias -40 -20 20

	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	oric
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.resol: 011
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	<u>ö</u>
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			91
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-		25.5	16.61	6.42	-26.39		-10.15	37.7	-2.48	7.16	25.26	17.87	5.27	-21.69	-7.83	-12.48		-2.67	9.67	22.66	11.5	8.01	-23.02		-23.42	39.2	-0.85	
RACMO22E-		-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	-4 7	-16.63	-31.96	24.97	-24.94	resol: 044
PROMES-	13.68	29.49	21.7		-21.47		7.16		$\overline{}$	11.58	30.15	21.8		-17.4		5.92		$\overline{}$	14.32	31.53	16.66		-22.77		-0.49			044
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	ose
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JJA bias % <mod - obs>/<obs> current.resol: 011 current resol: 044 current.resol: 150 AVERAGE-0.07 0.61 -24.4 -10.95 7.62 -12.52 -12.76 7.74 -12.26 -12.52 -10.04 -17.09 8.61 -9.9 -12.6_6.49 -4.1 -9.37 0 0.12 -21.74 -6.5 -4.22 -11.08 -0.010.63 -4.8 -9.9 17.22 22.53 -33.76 4.92 -1.92-15.17 -10.4417.23 22.21 -11.7-9.91 20.44 2.23 -11.0826.95 4.9 -4.8-0.96 -34.46 -5.33-21.18 -1.05-8.64 -20.7 -8.84 RACMO22F--8.03-17.08-10.4-8.56-17.09-11.54 -5.09 -18.25 -0.41-28.25 -19.38 -4.92-10.715.85 -8.36 3.63 17.55 16.63 16.31 -4.742.97 6.82 26.92 16.79 15.85 14.07 2.29 8.62 17.48 33.4 -14.91 14.29 HIRHAM5--66.16 -17.34 -10.130.16 5.7 -11.37-11.72 -17.11 -60.34 0.04 47.28 -12.29 -13.64 -22.47 -15.67 -7.49 -57.29 -5.26-9.47 -50.67 -59.29 -23.58-16.23 -50.94 -59.95 -23.52-18.06 -32.14 -18.42 -39.89 -62.7-1.57 -25.63 PROMES-6.14 9.41 13.01 8.36 2.23 6.19 9.49 12.69 15.33 -1.19 -0.07 9.03 15.05 -7.75 RegCM4--31.79 -26.16 -7.02 -22.79 -8.05 -26.05 -7.1 -7.77 -32.45 -25.71 -8.63 12.72 -14.42GUF-CCLM--13.24-13.94 -55.35 48.13 -13.93 -13.82 -18.43 -55.01 -48.96 -19.14 -13.81 -45,44 -50.13 ALADIN-18.58 56.15 12.22 0.09 17.93 52.58 11.28 0.61 13.12 48.38 AVERAGE--49.55 -21.86 -25.33 -14.21 -11.54 -17 -23.48 -24.91 -14.38-13.51 1.55 -21.34 -24.61 -15.79 -10.75 2.22 -15.19 -24.22 -15.88 47.42 -7.89-15.3210.65 -4.03-23.66 -7.24 -19.09 10.71 -3.96-26.27 -43.11 -14 10.95 -0.68RACMO22E--13.89 -45.6 -22.9 -15.76 -10.12 -18.18 -24.25 -26.94 -14.2 -15.93 -22.2 -17.23 -9.98 -17.94 -22.49 -26.79 -15.51 -14.89 -45.75 -25.56 -9.19 -17.22WRF331F -9.6 -1.5115.13 11.05 -25.85 -16.75 -1.156.85 -16.2-11.11 -0.6314.35 10.28 -24.18 -16.23 -4.78 7.13 -16.33 -9.67 1.03 13.21 11.71 -16.15 -19.95 -8.7 8.27 -16.26HIRHAM5--5.06 45.99 -12.18 -17.22 -12.36 -4.21 -50.27 8.9 -12.41 -24.16 -10.37 -11.61 -56.33 -7.89 -47.22 -79.5 -63.73 -8.97 -46.85 -25.99 -79.55 -17.7 26.51 -45.99 -65.01 -8.33 -79.11 PROMES: -7.06 2.22 -10.84 6.44 -58.29 4.66 -9.46 -10.226.07 -55.61 -6.8 -9.91 3.83 -25.03 -0.62-26.76 -5.93 -23.31 -2.27 -26.43 -6.94 -9.44-15.47 RegCM4 GUF-CCLM -83.3 -62.88 -45.57 -33.89 -82.29 -64.07 -44.92 -86.24 -65.18 25.96 ALADIN- -8.89 -10.14-10.91 -20.46 -6.3 -5.96 -6.92 -19.62 4.44 23.47 -18.6 es ERAIN--6.7 -12.04Alps-Alps-Sweden-France-Spain-Sarpathians-France-Sarpathians: Germany Italy: France Germany Italy. ¥ Germany region bias -40 -20 20

