Evaluation of the performance of Regional Climate Models simulation at different spatial and temporal scale over the Alpine Region

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Centro Euro-Mediterraneo sui Cambiamenti Climatici

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Sixth Annual Conference

Recent trends in climate sciences, adaptation and mitigation

Foreword

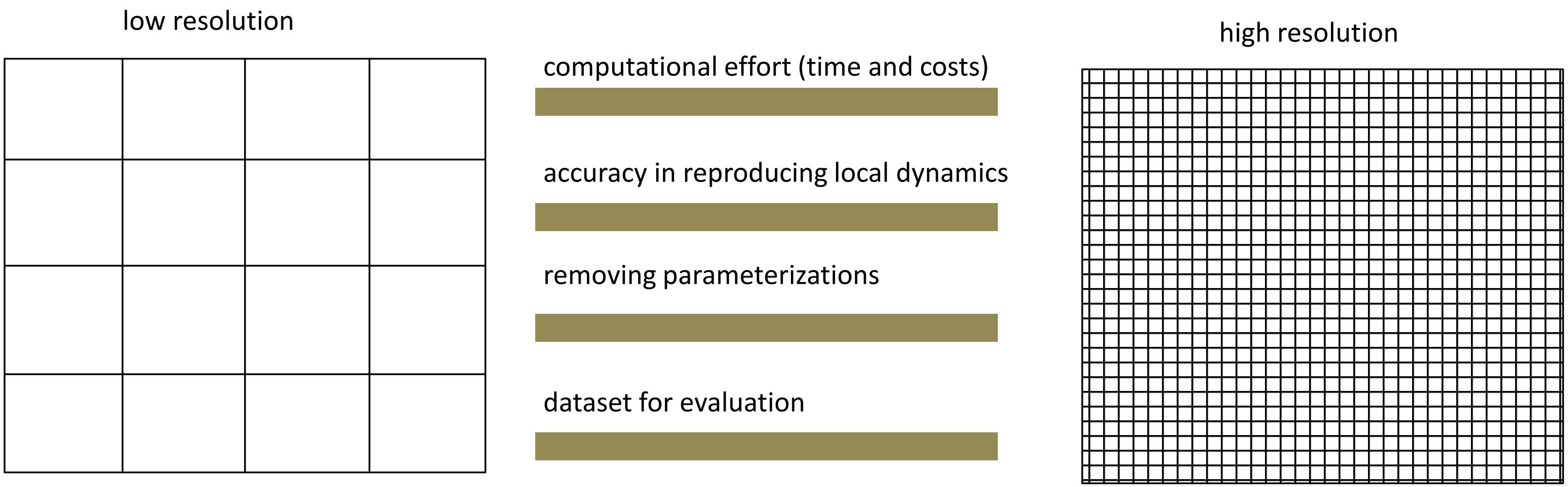
The need for climate change information at the regional-to-local scale represents a crucial goal within the global change debate to:

1) identify the best strategies to reduce the scale gap between time-spatial data projected by climate models

2) accommodate the requirements of impact practitioners involving in the management processes of stakeholders and policy-makers, such as the planning of climate policies for adaptation to climate change

From low to high resolution

Considering RCM projections at high resolution against forcing model (GCMs or reanalysis) or RCM projections at low resolution may result in gains and losses



It is important to quantify the **potential added value** of a spatial resolution refinement mainly considering the potential uncertainties

Complex orographic contexts

- Evaluating the added value of higher resolution models represents a relevant issue for RCMs trying to reproduce mean climate and extremes, in particular for precipitation, in complex orographic contexts

- Over small mountain catchments, the precipitation events, in particular those related to the convective instability, could have a significant impact for their short-duration

- Some studies have shown that very high resolution (VHR) simulations (about 1-3 km) could improve the models' capability to represent these phenomena thanks to the explicit treatment of the convective processes and a better representation of the orography (Ban et al 2014; Prein et al 2015)

Goals

- Investigate the performances of VHR simulations in terms of capability to represent daily and sub-daily precipitation dynamics
- Quantify gains and losses related to the enhancement of resolution at different time resolution for the present climate considering a complex orography like that of the Alpine Region

Outline

- Observation/simulation datasets
- Analysis at daily resolution: added value evaluation
- Analysis at daily resolution: effects of orography and of remapping
- Punctual analysis at sub-daily resolution
- Conclusion

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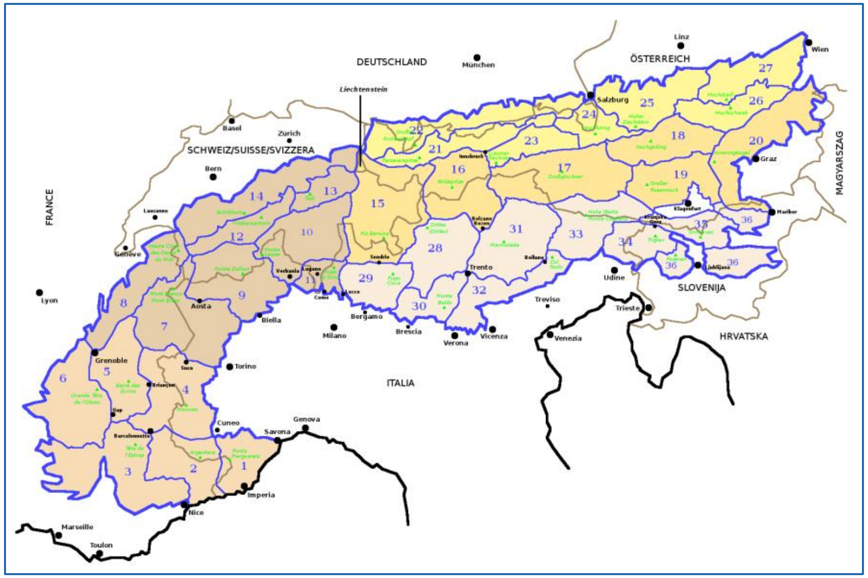
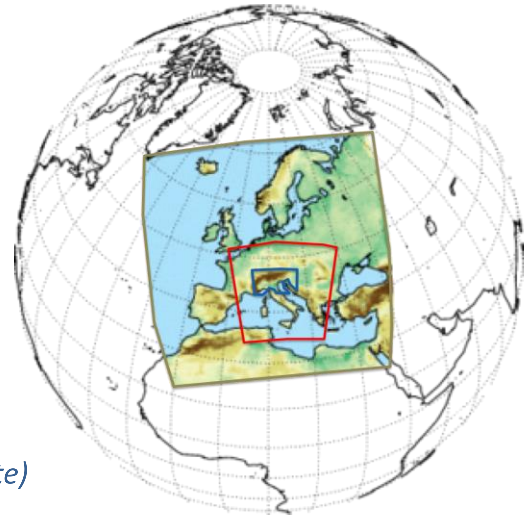
Simulation datasets



Alps domain



Domains of models
(modified from CORDEX site)

ENSEMBLE EURO-CORDEX 12

Spatial resolution of 0.11° (about 12 km) – Time resolution = 1 day

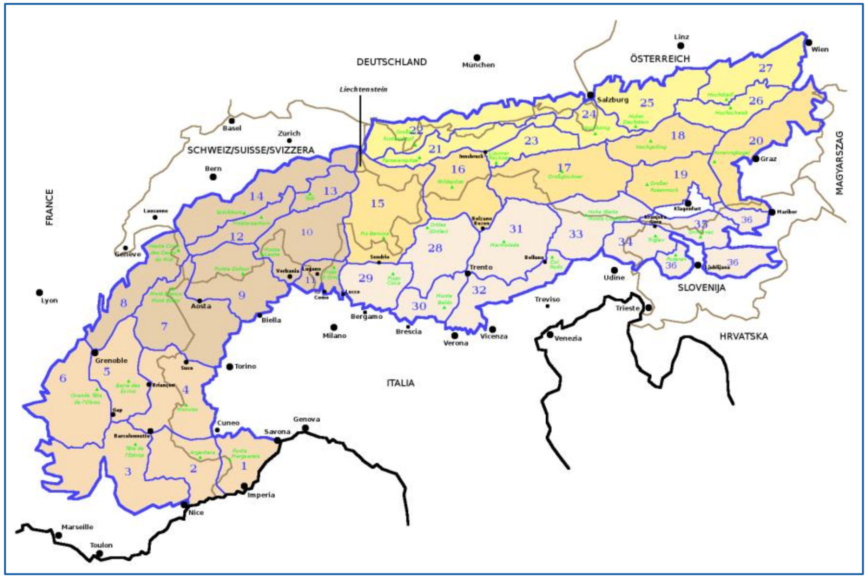
CCLM 8

Spatial resolution of 0.0715° (about 8 km), driven by ERA-Interim (1981-2010) – Deep convection parameterization = YES – Time resolution = 6 hr

CCLM 2.2

Spatial resolution of 0.02° (about 2.2 km), nested into CCLM 8 (1981-2010) – Deep convection parameterization = NO – Time resolution = 3 hr

Observation datasets



Alps domain

EURO4M

Daily precipitation high-resolution gridded dataset (spacing of about 5 km) (1971-2008) – Time resolution = 1 day

LOCAL DATA

Automatic local weather station managed by ArpaLombardia (1995-2010) – Time resolution = 1 hr

ID	Station	Height (m a.s.l)
108	Samolaco	206
133	Bema	800
567	Chiavenna	333
569	Sondrio	307
570	Tirano	439
571	Bormio	1225

ID	Station	Height (m a.s.l)
832	Lanzada	2155
833	Gerola Alta	1845
835	Valdisotto	2295
836	Aprica	1950
848	Livigno	2655

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Quantifying the added value: DAV method (Soares et al. 2017)

- To assess the performances of climate projections and quantify the added of high resolution RCMs, data obtained have been elaborated considering the **distribution added value** (DAV) as metric

- Such a metric provides a normalized measure of the added value in terms of potential gain due to the higher resolution, comparing higher- and coarser-resolution simulation Probability Density Function (PDFs) mediated by the observational PDF

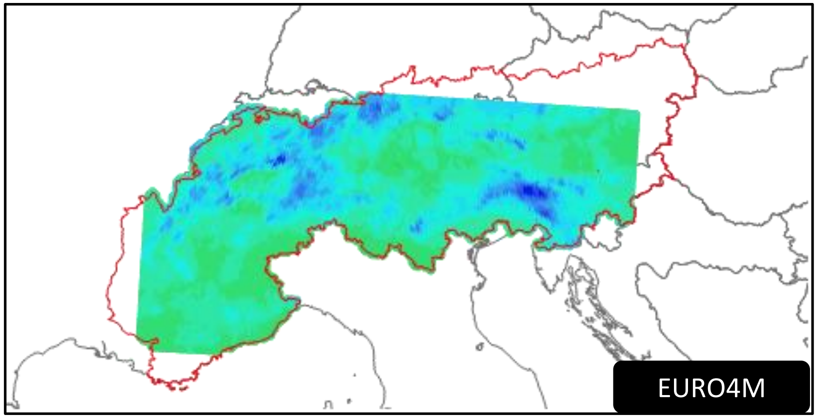
$$\mathrm{DAV} = \frac{\mathrm{S_{hr}} - \mathrm{S_{lr}}}{\mathrm{S_{lr}}} = \frac{\sum_1^n \min(\mathrm{Z_{hr}}, \mathrm{Z_{obs}}) - \sum_1^n \min(\mathrm{Z_{lr}}, \mathrm{Z_{obs}})}{\sum_1^n \min(\mathrm{Z_{lr}}, \mathrm{Z_{obs}})}$$

DAV = Distribution Added Value
S = Perkins skill score for high (hr) and low (lr) resolution
n = number of PDF bin
Z =values frequencies in a given bin for high resolution (hr), low resolution (lr) and observations (obs)

PRCPTOT

Index	Description
PRCPTOT	Annual total precipitation in wet days

- < 300
- 300 - 600
- 600 - 900
- 900 - 1200
- 1200 - 1500
- 1500 - 1800
- 1800 - 2100
- 2100 - 2400
- 2400 - 2700
- > 2700



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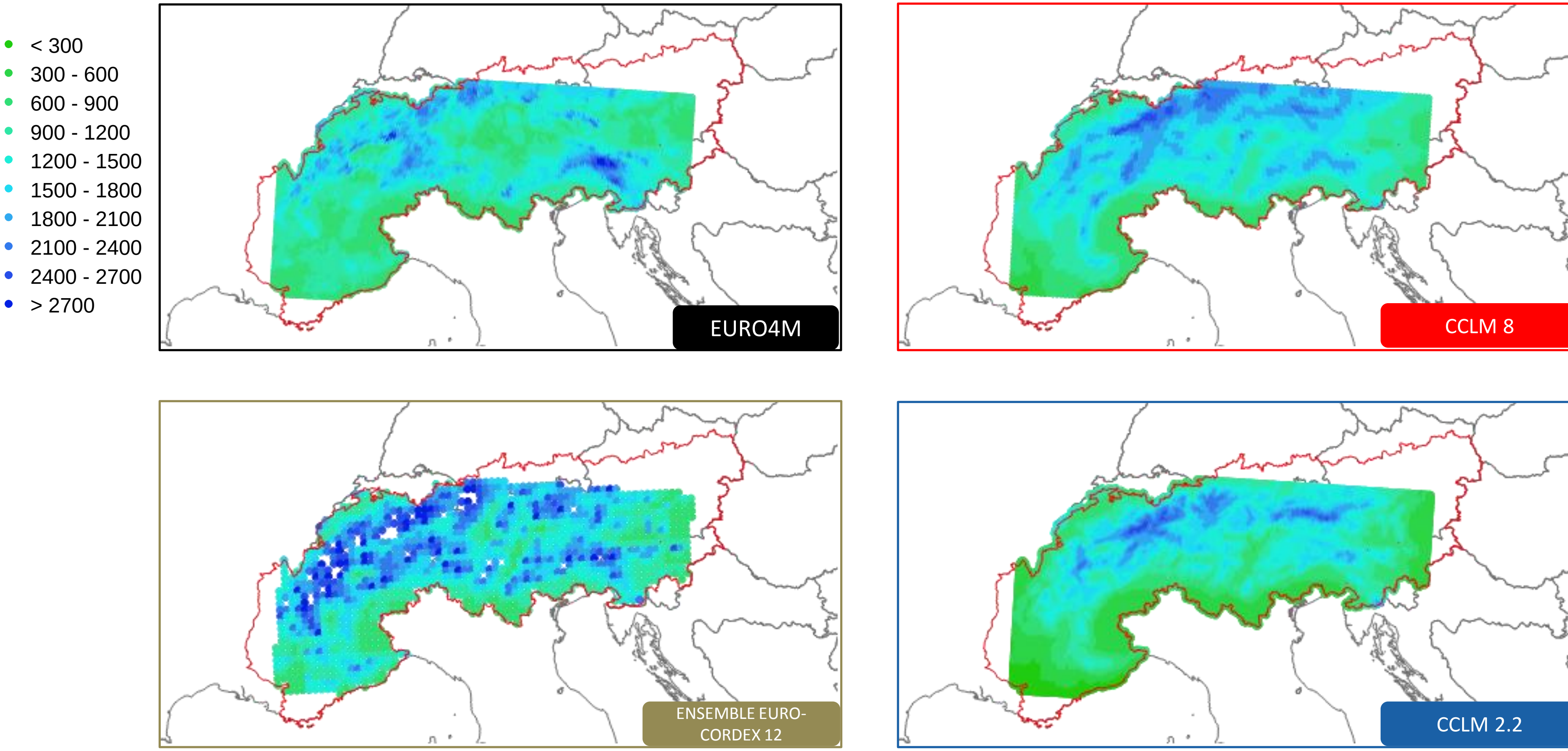

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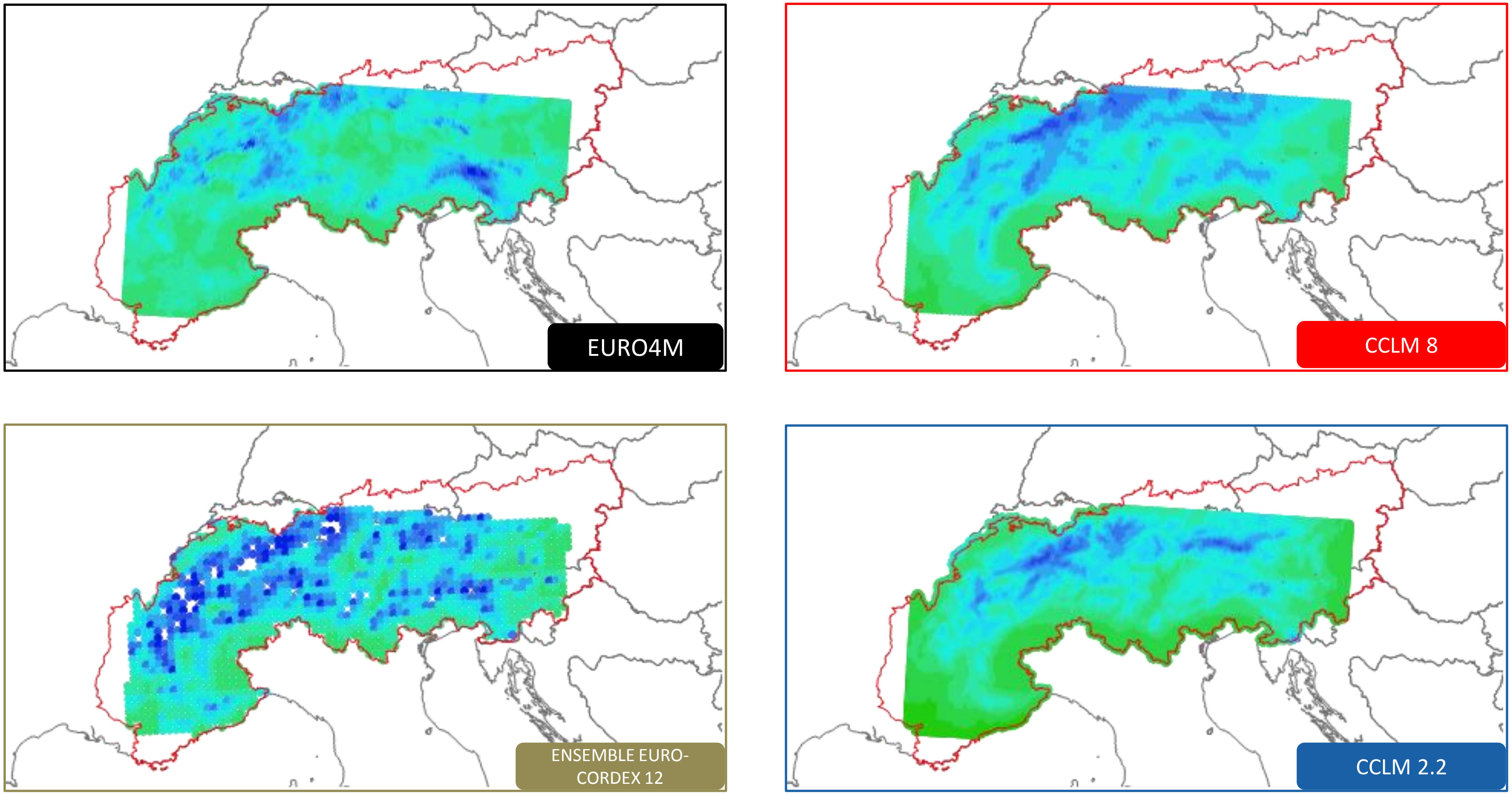
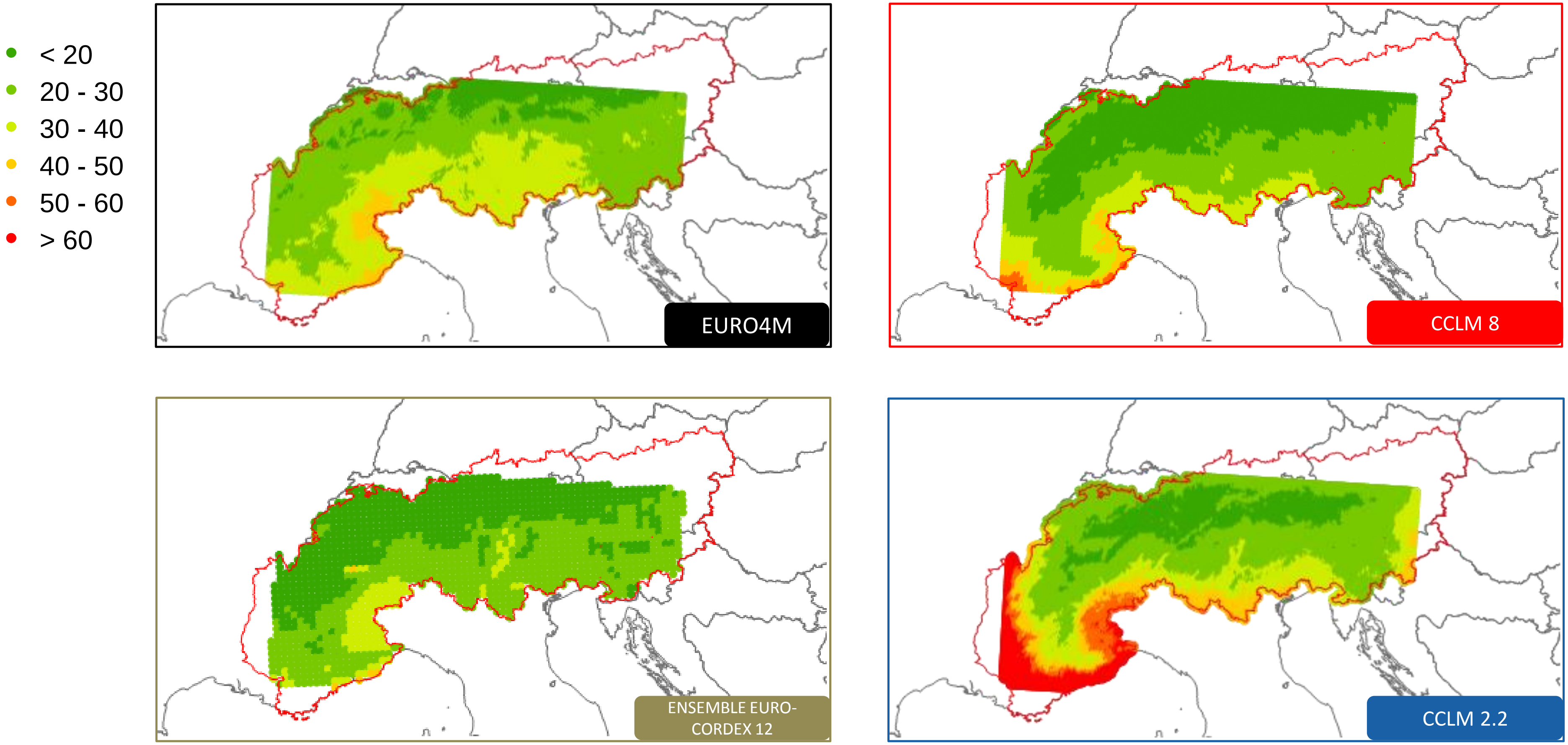


LR → HR	DAV
Ensemble Euro-CORDEX 12 → CCLM 8	**39%**
CCLM 8 → CCLM 2.2	**7%**

CDD

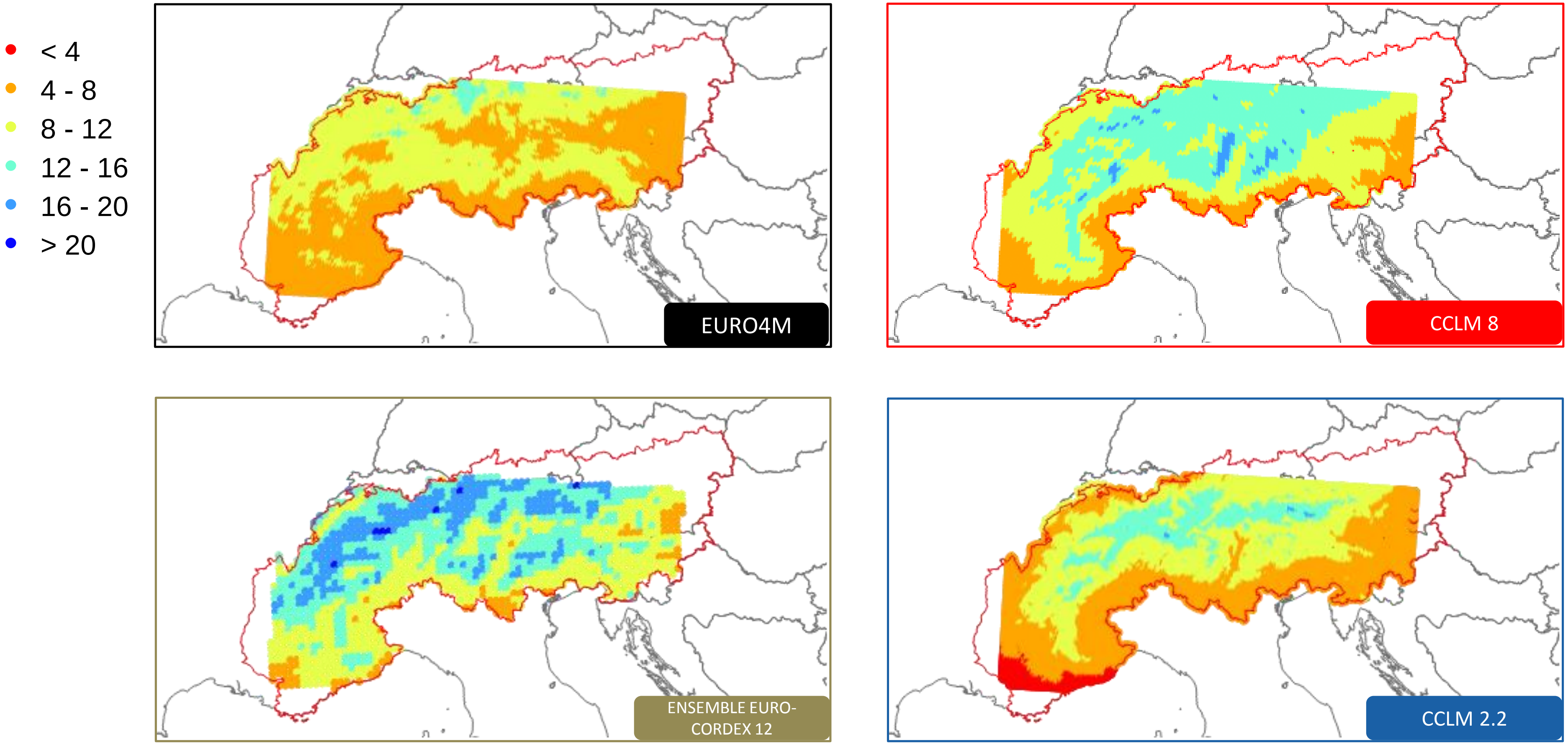
Index	Description
CDD	Maximum length of dry spell maximum number of consecutive days with RR < 1mm



LR → HR	DAV
Ensemble Euro-CORDEX 12 → CCLM 8	**13%**
CCLM 8 → CCLM 2.2	**10%**

CWD

Index	Description
CWD	Maximum length of wet spell maximum number of consecutive days with RR ≥ 1mm



LR → HR	DAV
Ensemble Euro-CORDEX 12 → CCLM 8	**28%**
CCLM 8 → CCLM 2.2	**20%**

Summary and other indices …

Index	Description	DAV [Ensemble Euro-CORDEX 12 → CCLM 8]	DAV [CCLM 8 → CCLM 2.2]
PRCPTOT	Annual total precipitation in wet days	39 %	7 %
Rx1day	Annual maximum 1-day precipitation	-	6 %
R10mm	Annual count of days when PRCP≥ 10mm	16 %	0 %
R20mm	Annual count of days when PRCP≥ 20mm	14 %	- 7%
CDD	Maximum length of dry spell	13 %	10 %
CWD	Maximum length of wet spell	28 %	20 %

Gain **Neither gain nor loss** **Loss**

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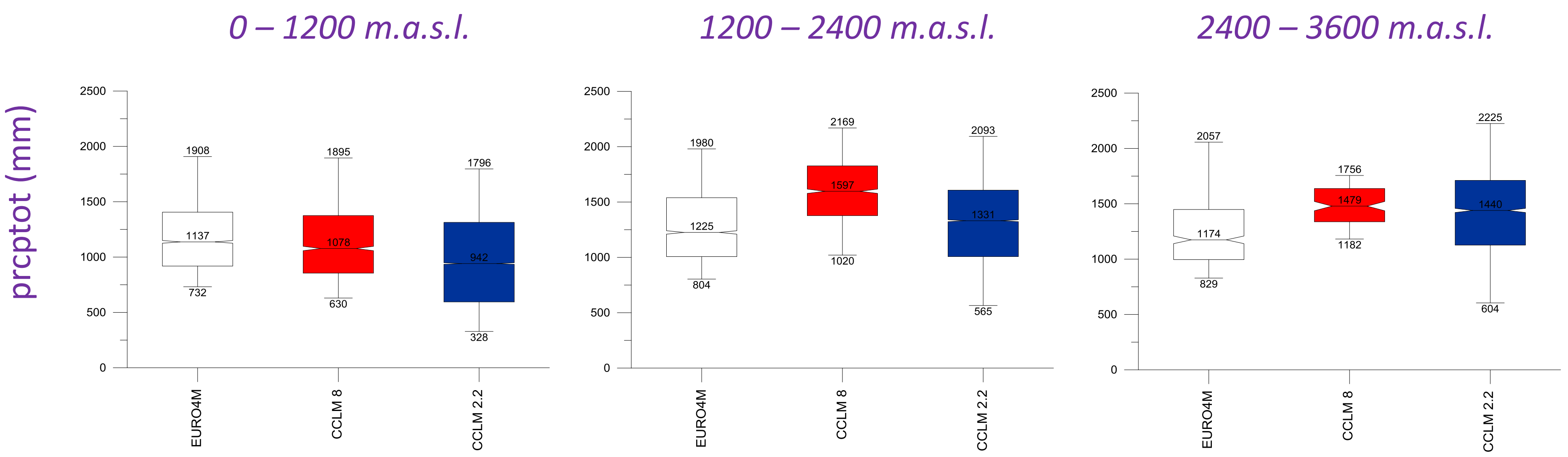
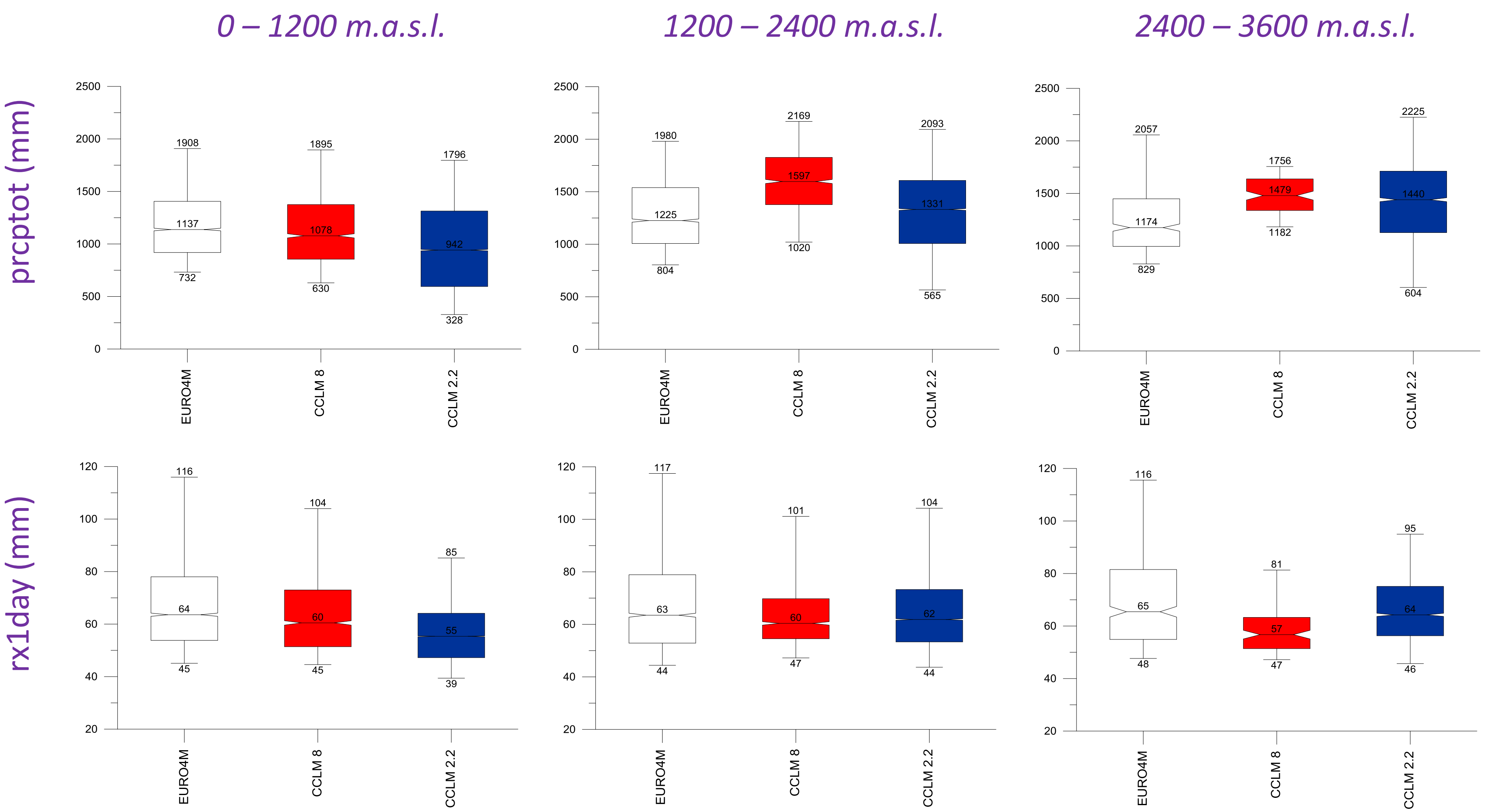
Effects of orography



Effects of orography



Effects of orography: DAV [CCLM 8 → CCLM 2.2]

Index	0 – 1200 m.a.s.l.	1200 – 2400 m.a.s.l.	2400 – 3600 m.a.s.l.
PRCPTOT	6 %	47 %	221 %
Rx1day	-4 %	19 %	54 %
R10mm	-8 %	34 %	50 %
R20mm	-8 %	9 %	26 %
CDD	-8%	44 %	95 %
CWD	-5%	134 %	84 %

Gain **Neither gain nor loss** **Loss**

Effects of remapping

What happen in terms of added value when datasets are remapped ?

Datasets remapped with bilinear interpolation over the EURO4m grid

Index	Description	DAV No-Remapping [CCLM 8 → CCLM 2.2]	DAV Remapping [CCLM 8 → CCLM 2.2]
Rx1day	Annual maximum 1-day precipitation	6 %	-4 %
CDD	Maximum length of dry spell	10 %	14 %
CWD	Maximum length of wet spell	20 %	20 %

Gain **Neither gain nor loss** **Loss**

The horizontal resolution of the observational dataset (5 km) may not capture all the dynamics of the finer resolution (e.g. CCLM 2.2)

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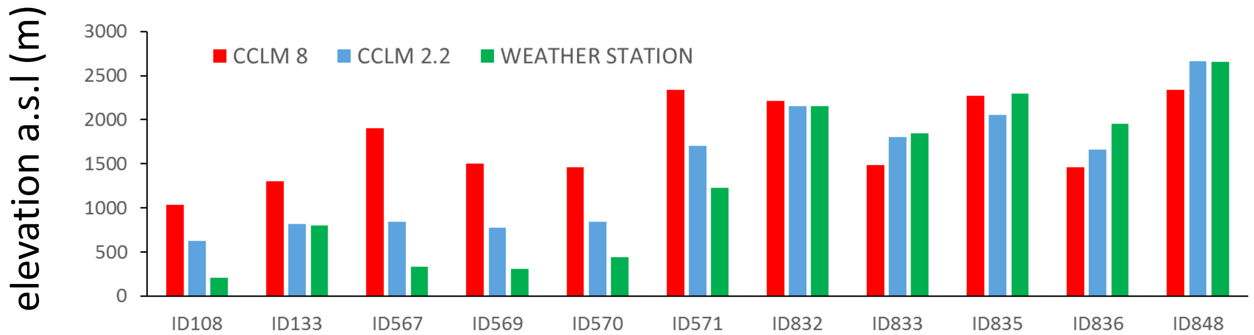
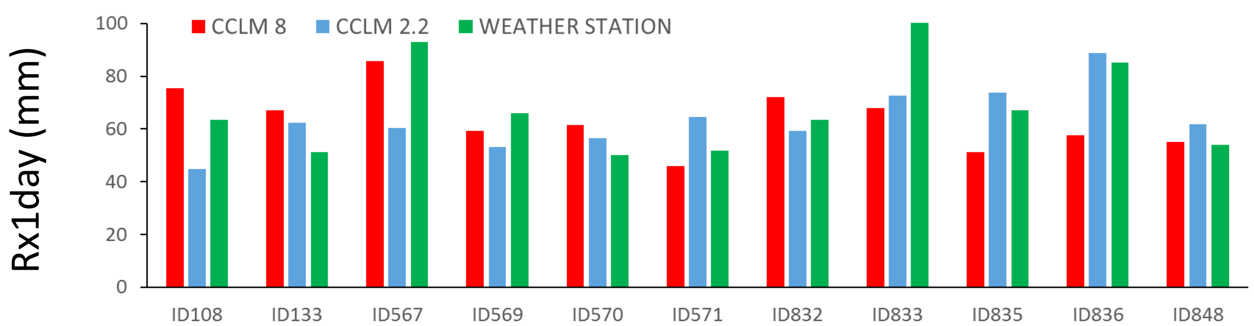
Effect of resolution in orography representation

The position of local stations is considered to select a corresponding grid point from the CCLM 8 and CCLM 2.2 grids using the nearest neighbor interpolation with a specific refinement for the CCLM 2.2 for which also an altitude constraint is introduced.





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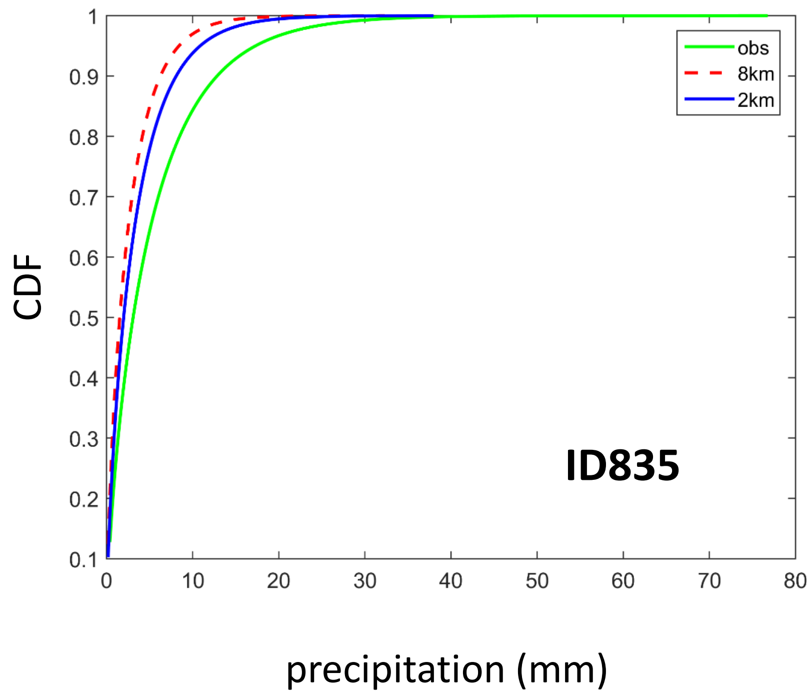
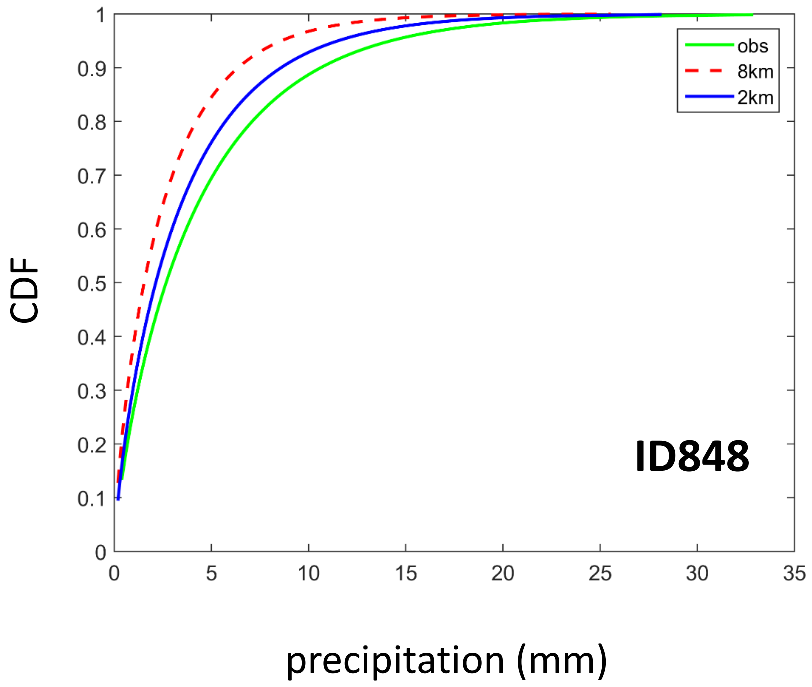
Comparison of elevation and Rx1day between CCLM 8, CCLM 2.2 and data provided by LOCAL WEATHER STATION (1995-2010)

Distribution of sub-daily precipitation during JJA

The statistical distribution of precipitation is evaluated fitting data at time resolution of 6hr through Gamma distribution





Distribution of sub-daily precipitation

The statistical distribution of precipitation is evaluated fitting data at time resolution of 6hr through Gamma distribution

ID	Height (m a.s.l)	DAV (JJA)	DAV (DJF)
108	206	-11%	1 %
133	800	-7 %	2 %
567	333	-13 %	4 %
569	307	-5 %	-2 %
570	439	-7 %	-4 %
571	1225	8 %	5 %
832	2155	5 %	1 %
833	1845	-1 %	6 %
835	2295	10 %	0 %
836	1950	2 %	-1 %
848	2655	12 %	0 %

Gain **Neither gain nor loss** **Loss**

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Conclusion

- This work have presented a quantitively and objectively assessment of the added value obtained moving from a coarser to a finer resolution

- The spatial analysis over the Alpine domain at daily resolution returns a gain in moving from 12 km to 8 km to 2 km. Such a gain is more evident in the passage from 12 to 8 then from 8 to 2 km

- At the same time the effect of the orography was analyzed showing how high resolution is able to better capture local dynamics; this is evident from the analysis at daily and sub-daily resolution

- This study, such as others performed in the same way, returns encouraging findings suggesting the development and using of finer high-resolution climate models for regional and local impact studies

Thank you

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