

Analysis of precipitation at convection permitting scale with COSMO-CLM over Alpine space

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(2) CIRA, Italian Aerospace Research Center, Capua, Italy



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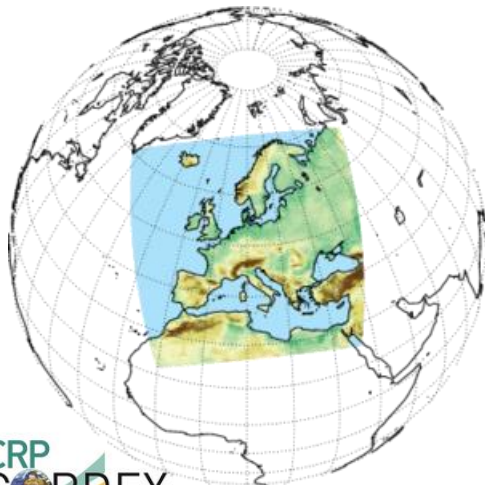
Overview

The aim of this work is to show the added value for the representation of the precipitation running regional climate model with a grid spacing at few kilometer scale (range from 1 to 3 km) and the parametrization of deep convection is switched off (i.e. convection-permitting).

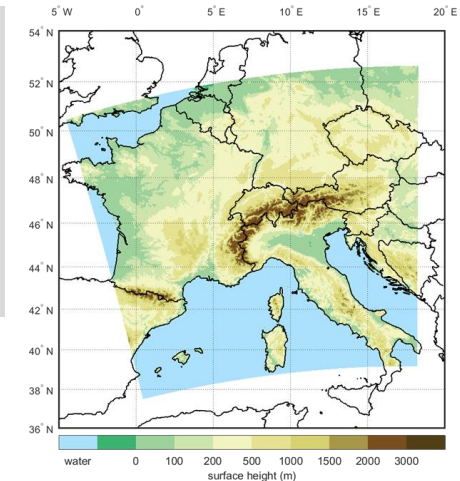
More specifically, the driving data provided by the GCM EC EARTH (r12 - CMIP5) are downscaled first at an intermediate resolution (12km) over the Euro-CORDEX domain. Then, a further downscaling at 3 km, nested into the previous one, is performed over the Alpine domain.



COSMO-CLM
EURO CORDEX DOMAIN
Resolution ~ 12 km



3 km convection permitting simulation (3km) over alpine domain
VS
convection parameterized intermediate simulation (12km)



COSMO-CLM
GREATER ALPINE REGION (GAR) DOMAIN
Resolution ~ 3 km



Summary

- Evaluation analyses on historical experiment (period 1996-2005)
 - Daily analyses
 - Hourly analyses
- Projections
 - Changes of daily precipitation in JJA and SON
 - Changes of hourly precipitation
- Conclusion and remarks



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The experimental setup

An historical period (1996-2005) and a far future one (2090-2099) under IPCC RCP8.5 scenario have been considered.

RCM version

- **COSMO-CLM v 5.00 clm9** with urban parametrization **TERRA-URB 2.2**

Computational Domain

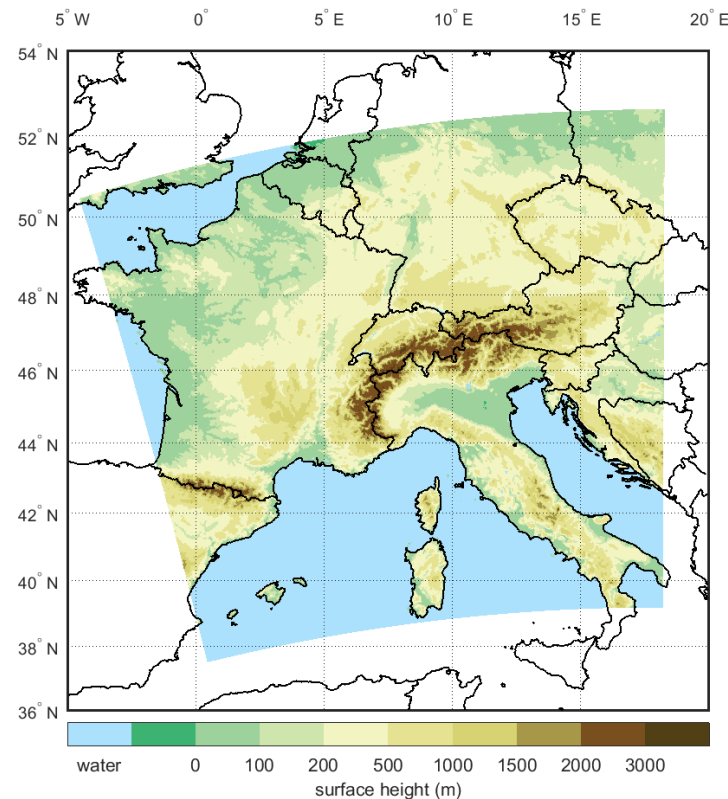
- Extended Alpine Region
5°W - 18°E, 38°N - 53°N
Nx=522, Ny=490, Nz = 50
- Resolution 0.0275°, ~3 km
- Sponge zone: 23 grid points

Forcing data:

- CCLM 0.11° over EURO-CORDEX domain

Experiments

Simulation type	Period
Historical run (EC-EARTH)	1996-2005 (1995)
Far future run (EC-EARTH, RCP8.5)	2090-2099 (2089)



European Climate Prediction system



FLAGSHIP PILOT STUDIES



Statistical indices and indicators

Some indices, such as mean daily precipitation, frequency, intensity and heavy precipitation are employed in daily and hourly analyses.

ABBREVIATION	DEFINITION	UNIT
Mean	Mean Precipitation	mm/d
Freq	Wet day/hour ^a frequency	[fraction]
Int	Wet day/ hour ^a intensity	[mm/d] / [mm/h]
pXX	XX percentile ^b of daily/hourly precipitation	[mm/d] / [mm/h]

^a A wet day (hour) is defined as a day (hour) with precipitation ≥ 1 mm/d (0.1 mm/h)

^b Percentiles are calculated using all events (wet and dry) following Schär et al., 2016

Ban et al. (2020) The first multi-model ensemble of regional climate simulations at kilometer-scale resolution, Part I: Evaluation of precipitation (under review)

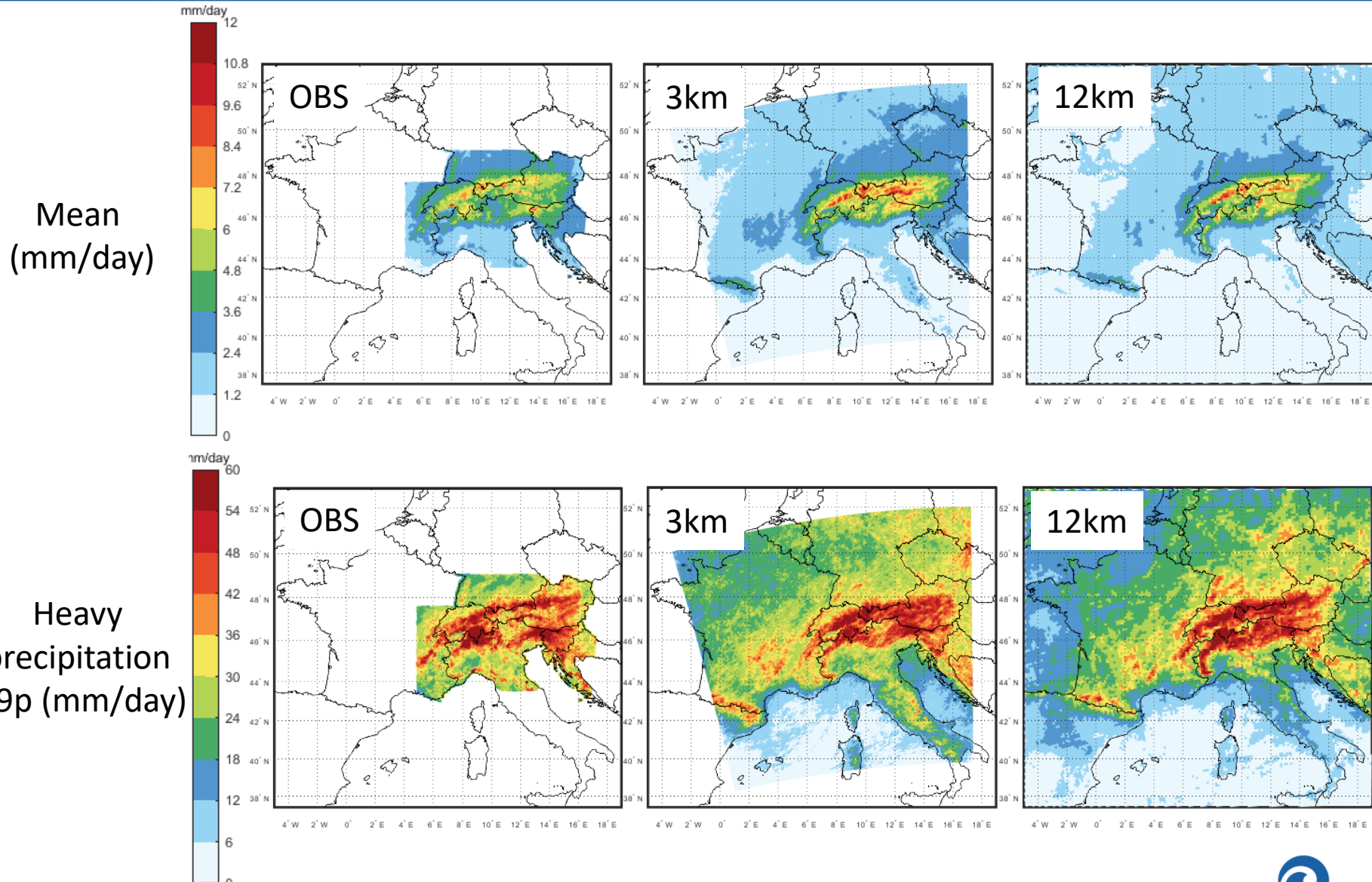
Available daily observations

Dataset	Spatial resolution	Variable	Period	Temporal resolution	Reference
EURO4M	5 km	Tot prec	1979-2008	daily	Isotta et al., 2014



Daily analyses of precipitation

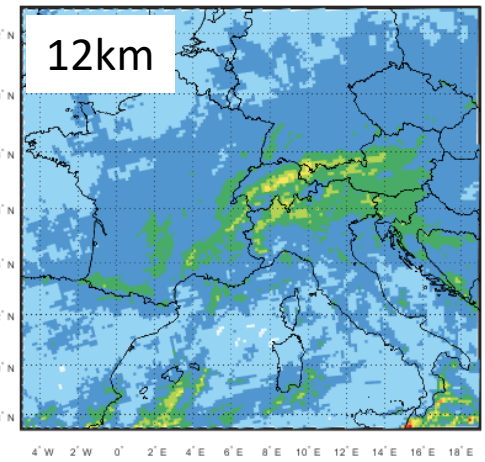
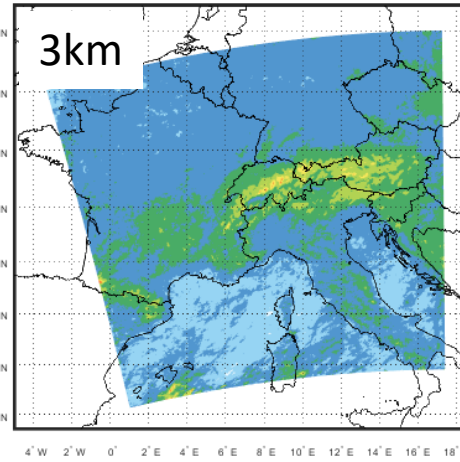
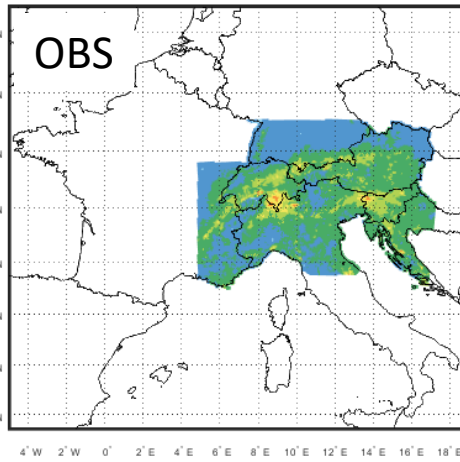
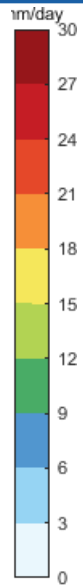
HISTORICAL (1996-2005)
SEASON: JJA



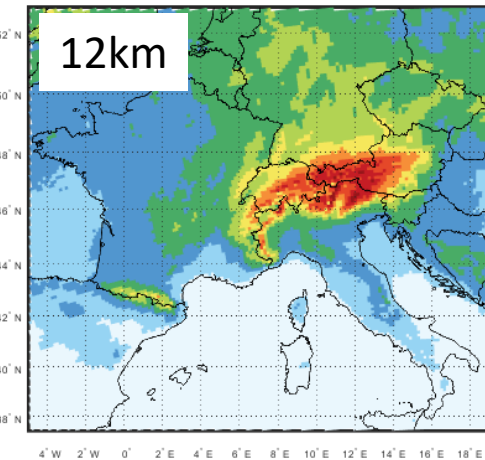
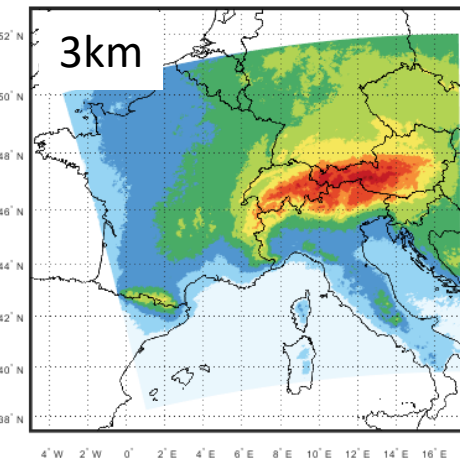
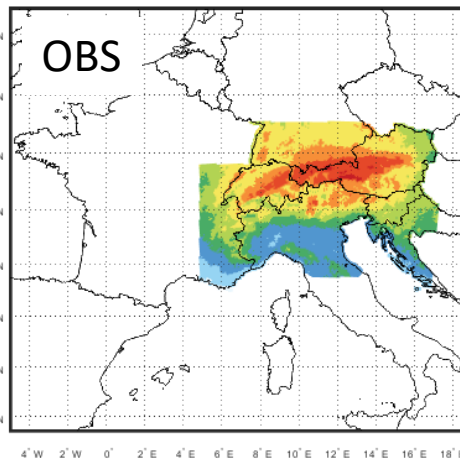
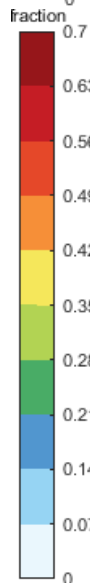
Daily analyses of precipitation

HISTORICAL (1996-2005)
SEASON:JJA

Intensity
(mm/day)



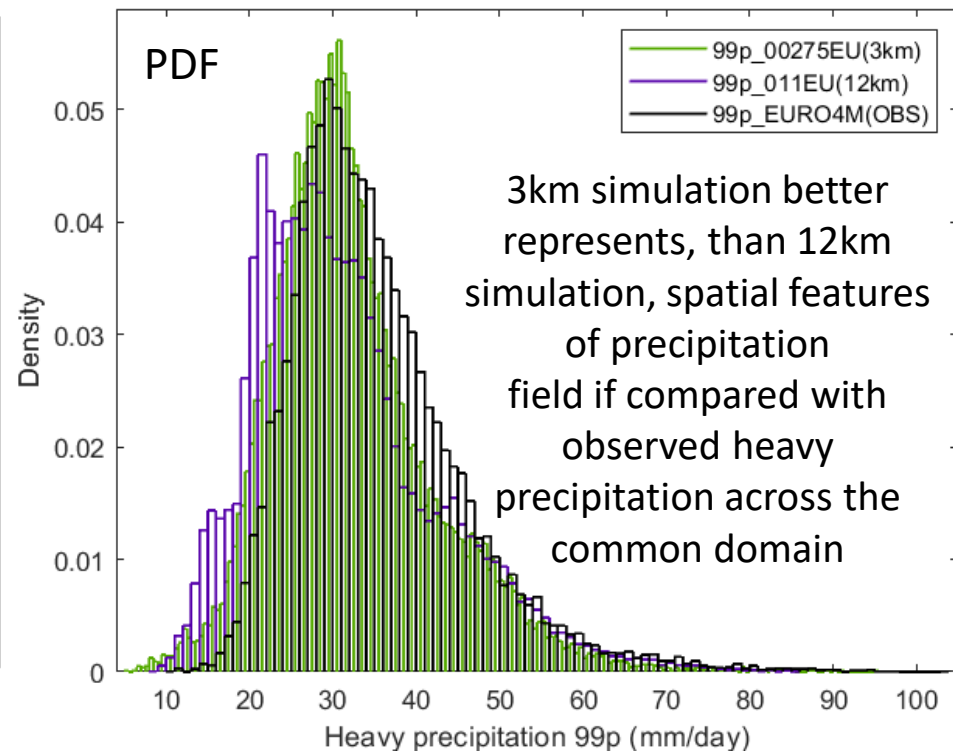
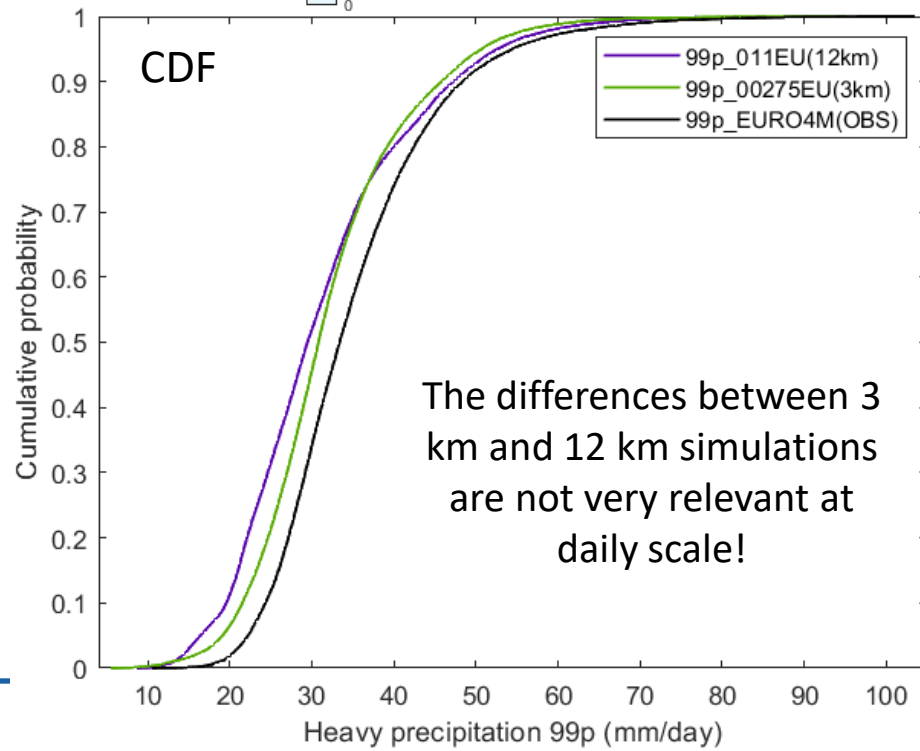
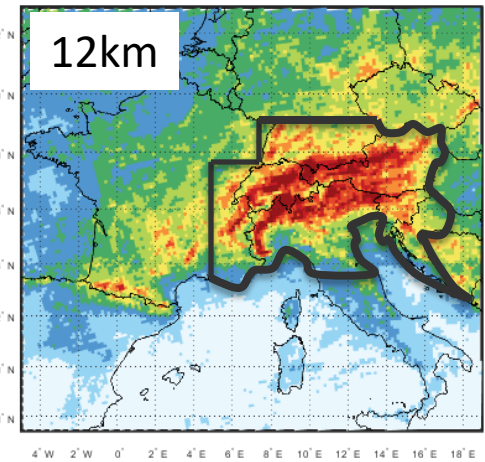
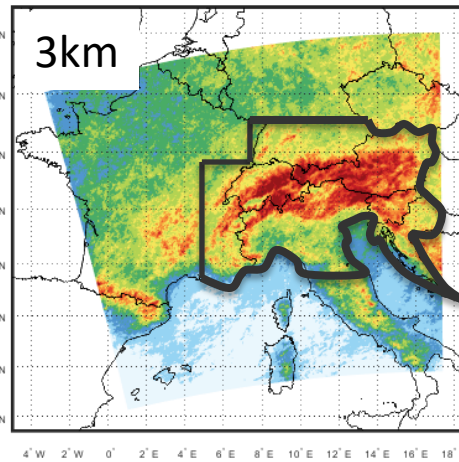
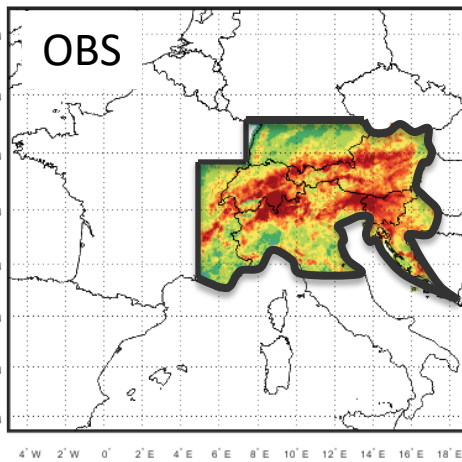
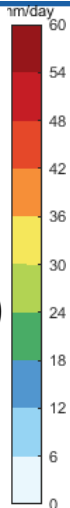
Frequency
(fraction)



Daily density functions

HISTORICAL (1996-2005)
SEASON:JJA

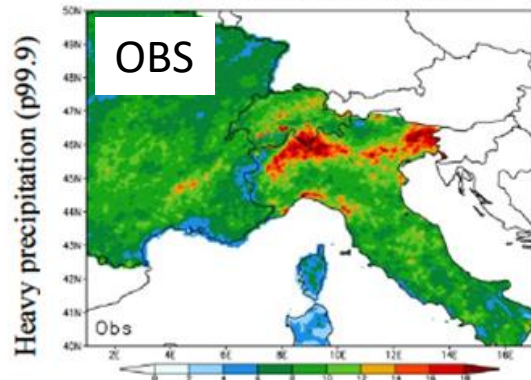
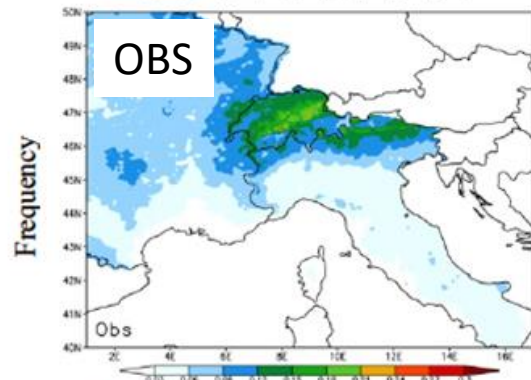
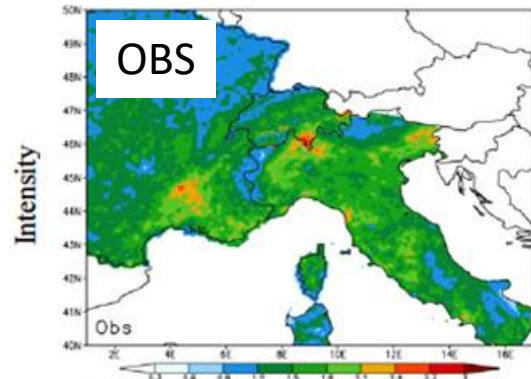
Heavy
precipitation
99p (mm/day)



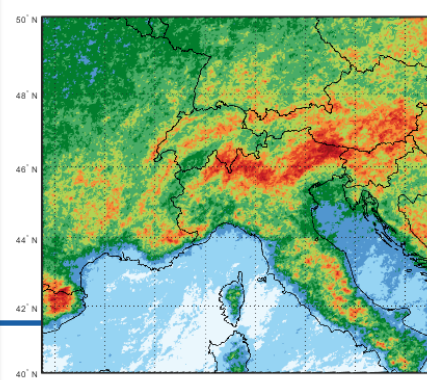
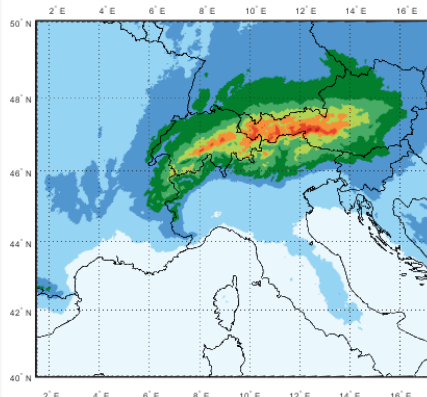
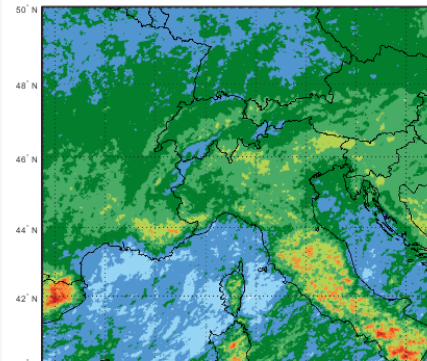
Hourly analyses of precipitation

HISTORICAL (1996-2005)
SEASON: JJA

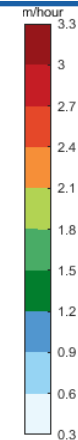
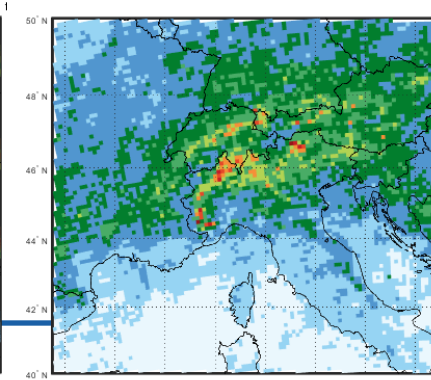
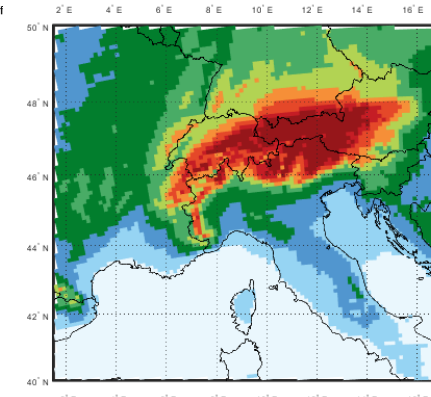
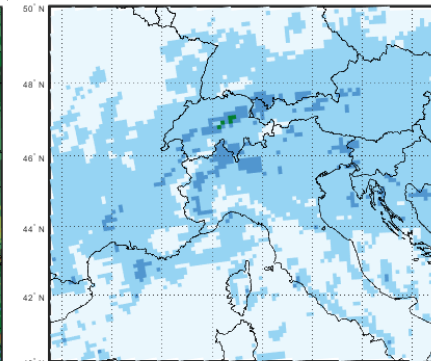
OBS from Pichelli et al. (2020)



COSMO 3km



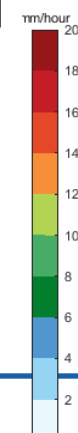
COSMO 12km



Intensity (mm/h)
Low intensity at 12km!!



Frequency (fraction)
High frequency at 12km!!

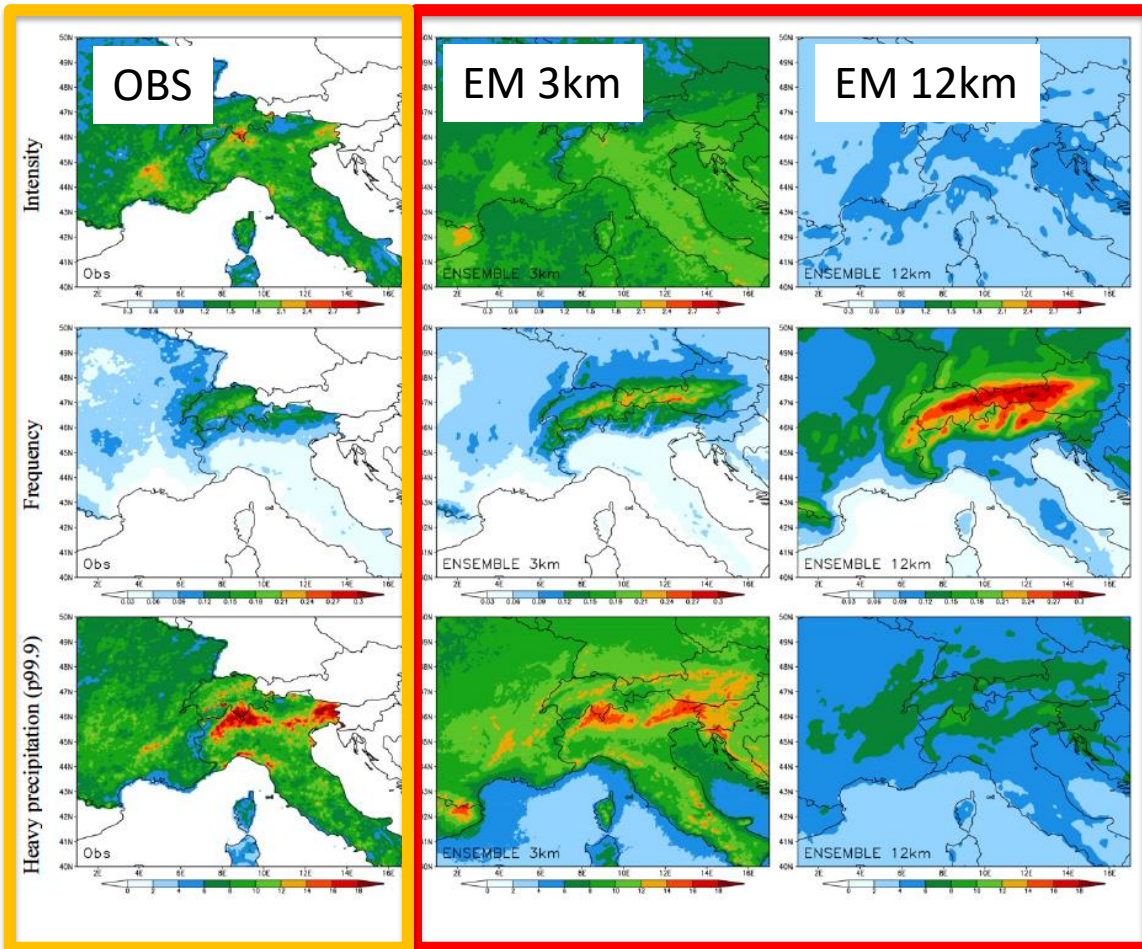


Heavy precipitation 99.9p (mm/h)



Hourly analyses of precipitation: comparison with ensemble mean and observations

Pichelli et al. (2020) Precipitation projections of the first multi-model ensemble of regional climate simulations at convection permitting scale – EGU 2020



OBSERVATION DATASETS

	Dataset	Grid Res.	Time Res.	Period
1	REGNIE (D)	0.02x0.008 deg	daily	1996-2005
2	COMEPHORE (FR)	1 km	hourly	1997-2006
3	RdisaggH (CH)	1km	hourly	2003-2010
4	EURO4M-APGD	5 km	daily	1996-2005
5	GRIPHO (IT)	3 km	hourly	2001-2010
6	Spain02 (SP)	12 km	daily	1996-2005

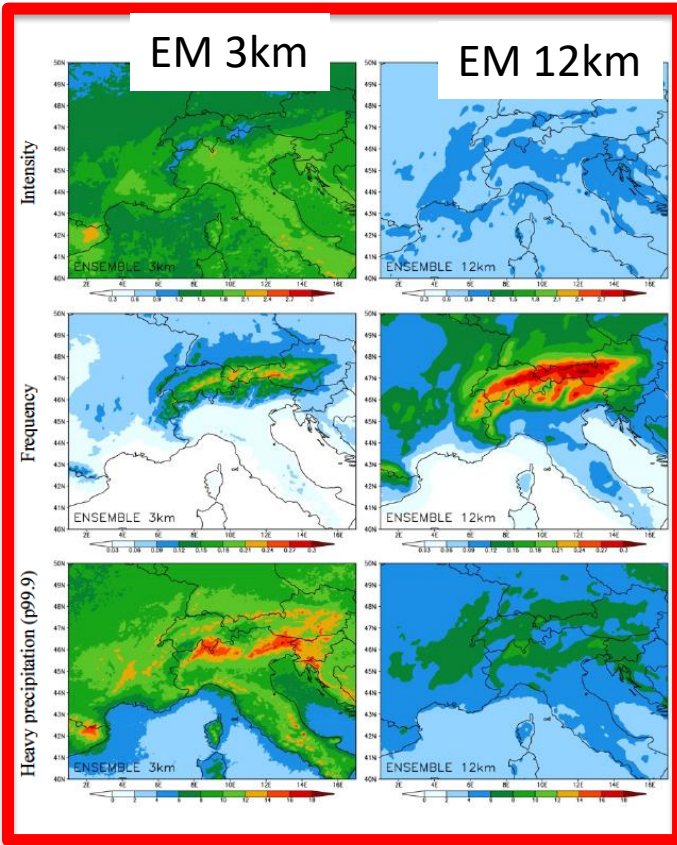
ENSEMBLE MEAN

INSTITUTE	CP-RCM	Resoluti on (km)	Driving RCM	Resoluti on (km)	GCM
KNMI (**) The Royal Netherlands Meteorological Institute	HCLIM38-AROME	2.5	RACMO	12	EC-Earth
ICTP (**) Abdus Salam International Centre for Theoretical Physics	RegCM4	3	RegCM4	12	HadGEM
CNRM (**) Centre National de Recherches Meteorologique	CNRM-AROME41t1	2.5	CNRM-ALADIN63	12	CNRM-CM5
KIT Karlsruhe Institute of Technology	CCLM5	3	CCLM4	12	MPI-ESM-LR
BTU Brandenburg University of Technology	CCLM5	3	CCLM4	12	CNRM-CM5
ETHZ (**) (a) Federal Institute of Technology, Institute for Atmospheric and Climate Science	CCLM	2.2	CCLM	12	MPI
ETHZ (**) (b) Federal Institute of Technology	CCLM	2.2	CCLM	12	pgw
FZJ-IBG3-IDL Research Centre Jülich Institute Dom Luis	WRF3.8	3	WRF3.8.1CA	15	EC-EARTH
DMI- MET Norway- SMHI (**) HARMONIE-Climate community	HCLIM38-AROME	3	HCLIM38-ALADIN	12	EC-EARTH
UNIGRAZ-WEGC Wegener Center for Climate and Global Change, University of Graz	WEGC-CCLM5	3	WEGC-CCLM5	12	MPI-ESM-LR
UK Met OFFICE (**) Met Office Hadley Centre Exeter	UM	2.2	No intermediate RCM		HadGEM
BCCR The Bjerknes Centre for Climate Research	WRF3.8	3	WRF3.8.1CA	15	NorESM1

Hourly analyses of precipitation

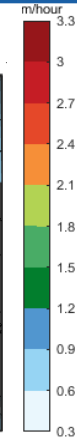
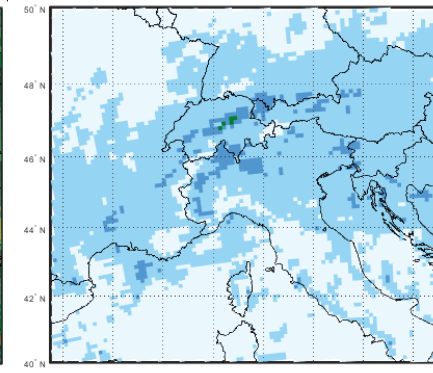
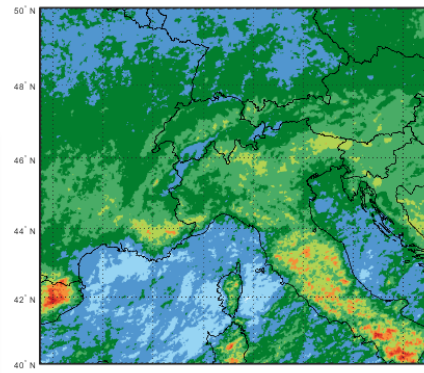
HISTORICAL (1996-2005)
SEASON:JJA

ENSEMBLE MEAN
from Pichelli et al. (2020)

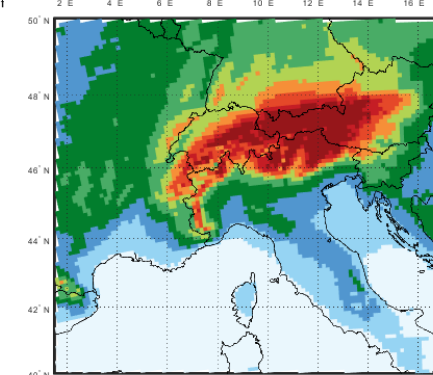
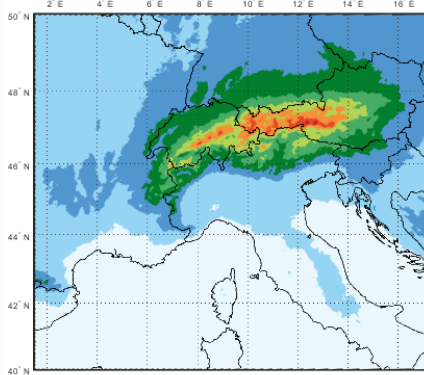


COSMO 3km

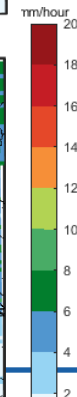
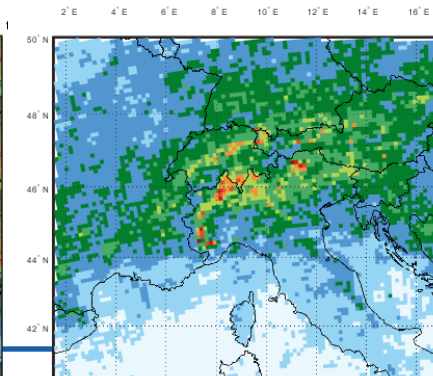
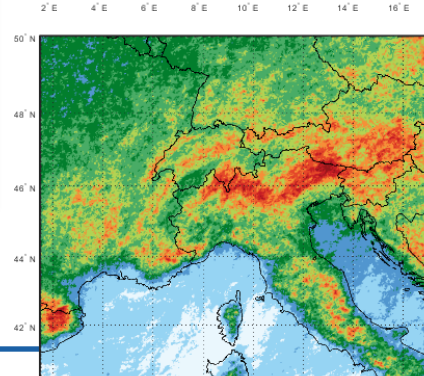
COSMO 12km



Intensity
(mm/h)



Frequency
(fraction)



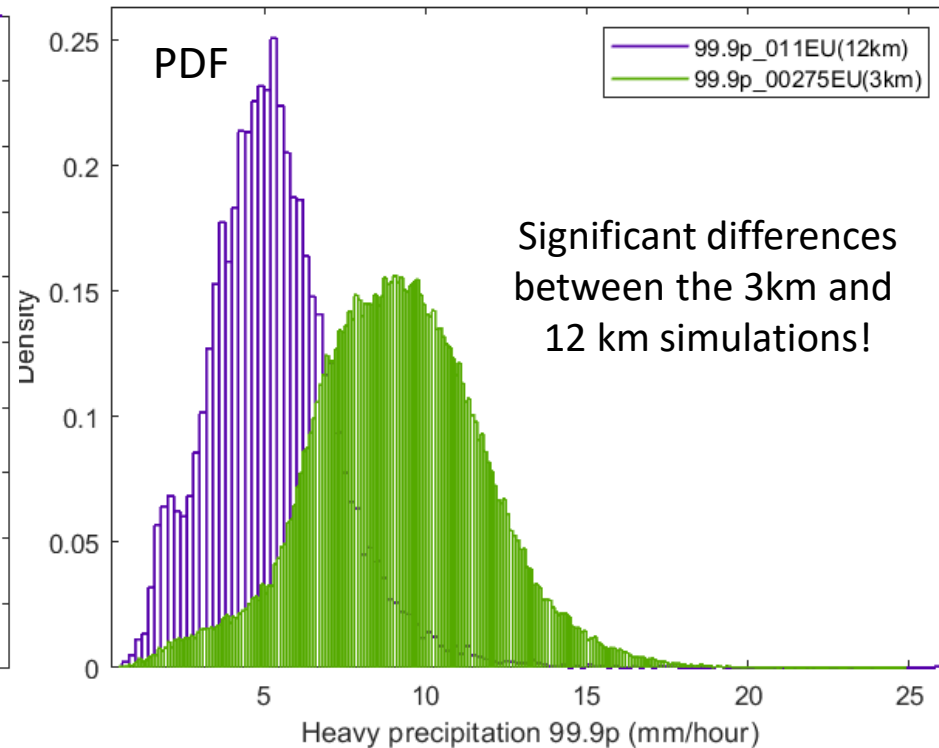
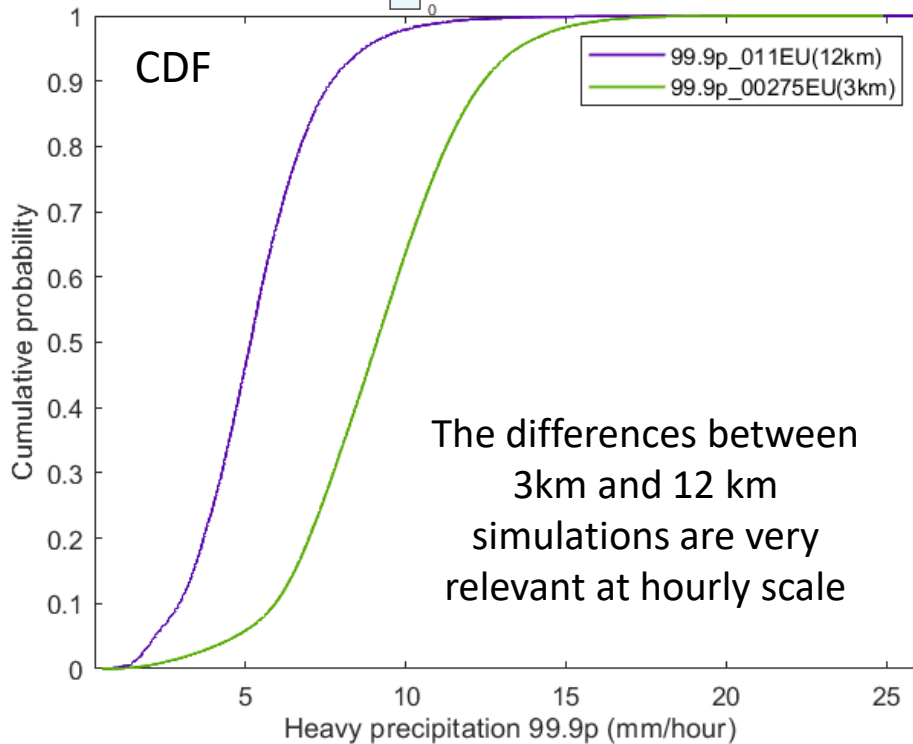
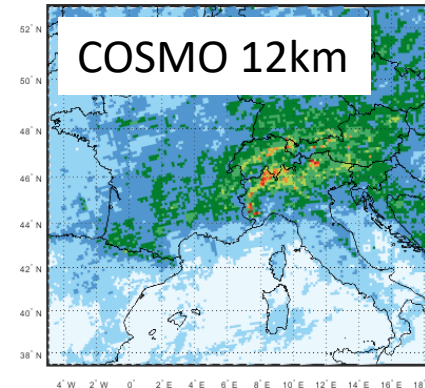
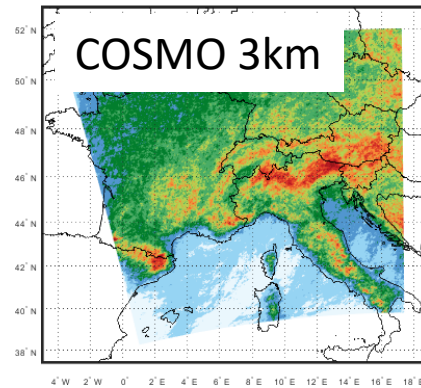
Heavy
precipitation
99.9p (mm/h)



Hourly density functions

HISTORICAL (1996-2005)
SEASON:JJA

Heavy
precipitation
99.9p (mm/h)



Summary

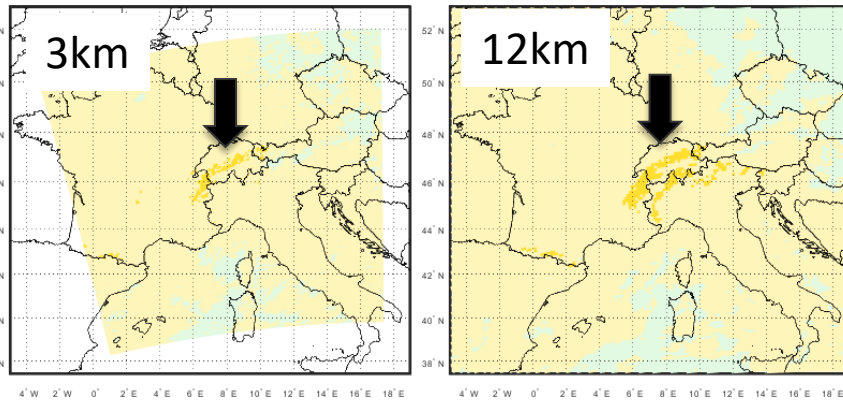
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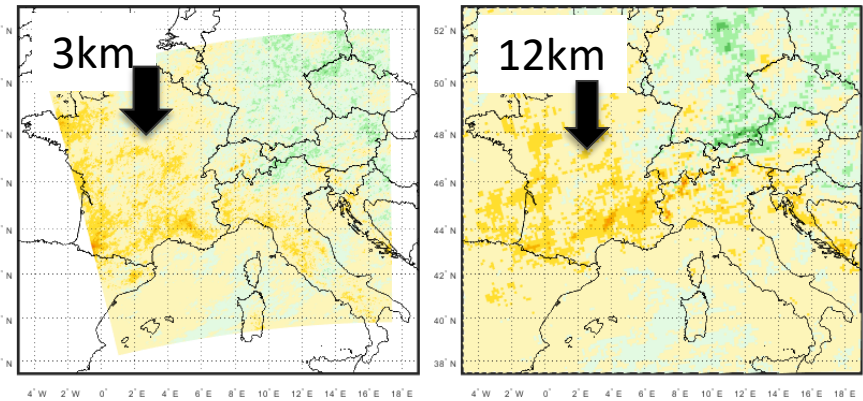
Changes of daily precipitation in JJA and SON

RCP85(2090-2099) - HISTORICAL(1996-2005)

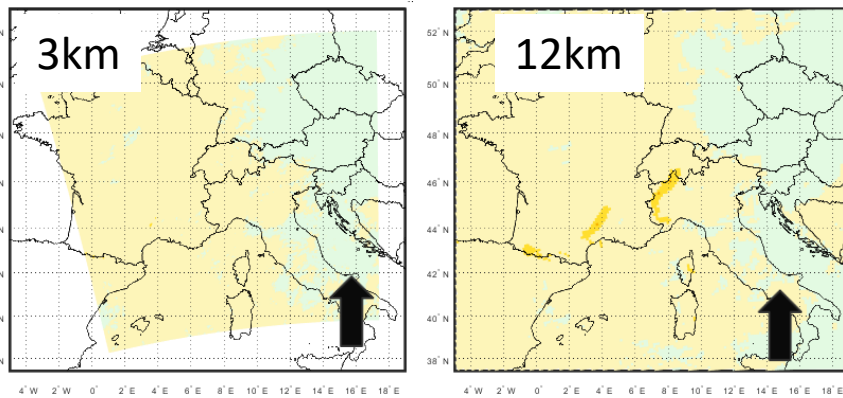
Mean JJA (mm/day)



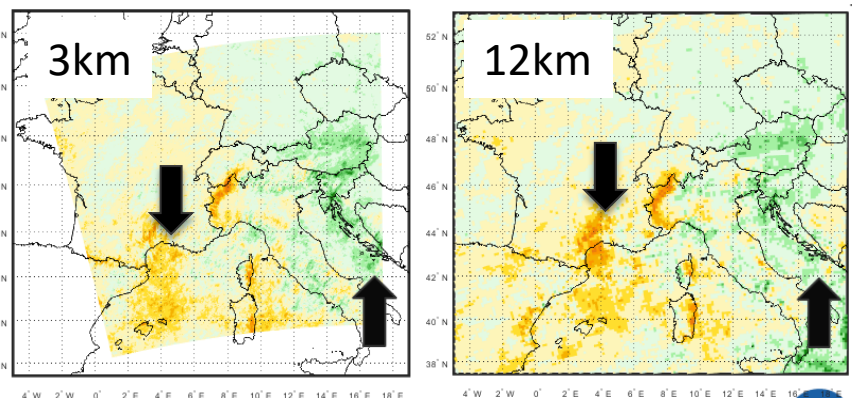
Heavy precipitation 99p JJA (mm/day)



Mean SON (mm/day)



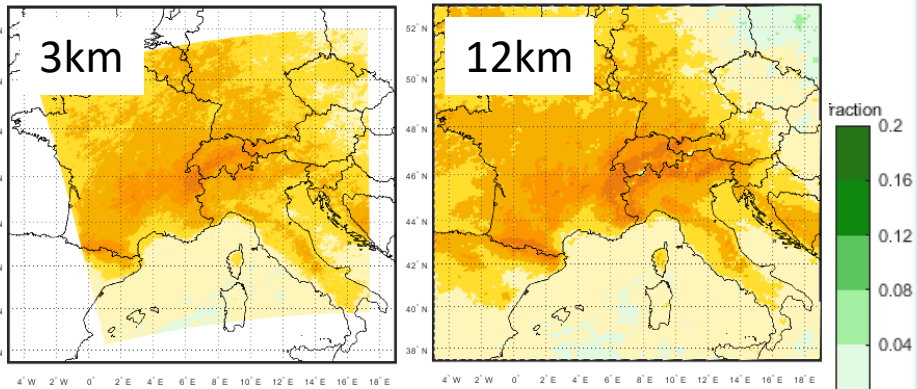
Heavy precipitation 99p SON (mm/day)



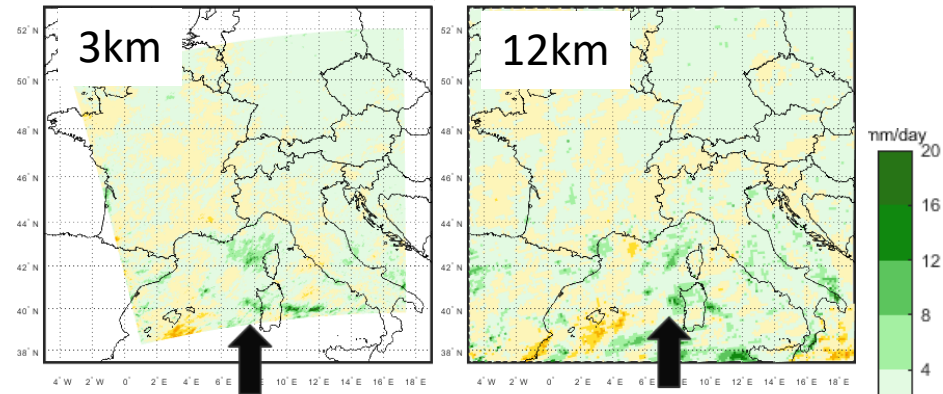
Changes of daily precipitation in JJA and SON

RCP85(2090-2099) - HISTORICAL(1996-2005)

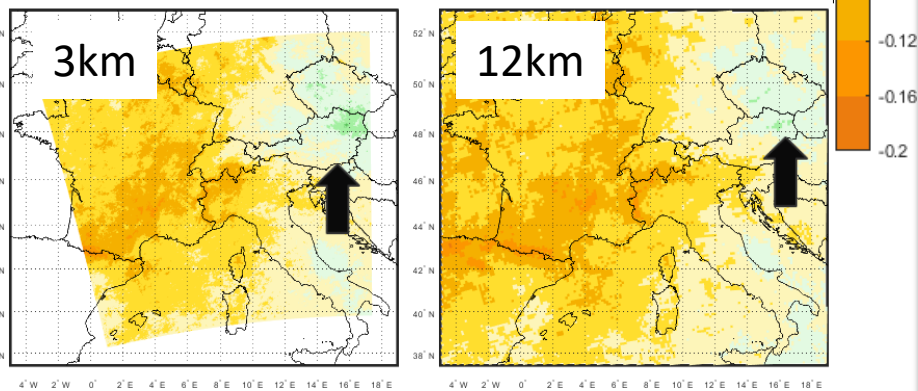
Frequency JJA (fraction)



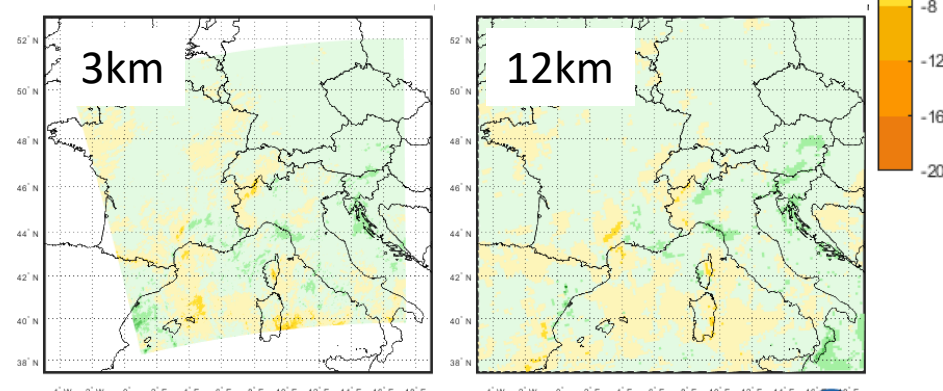
Intensity JJA (mm/day)



Frequency SON (fraction)



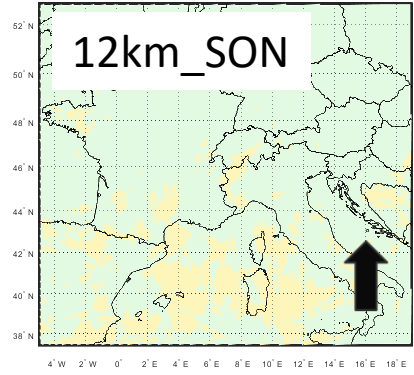
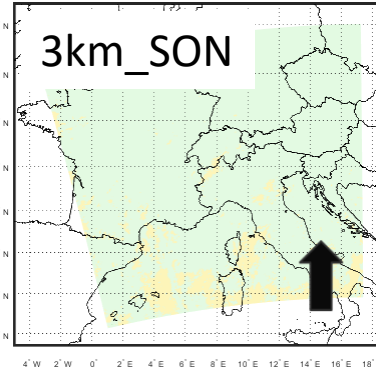
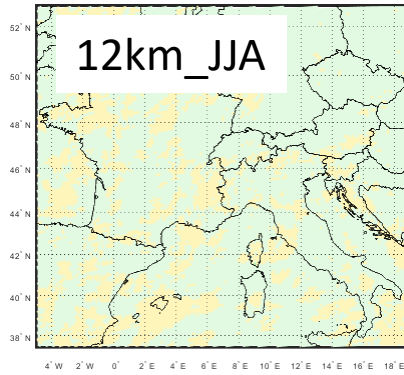
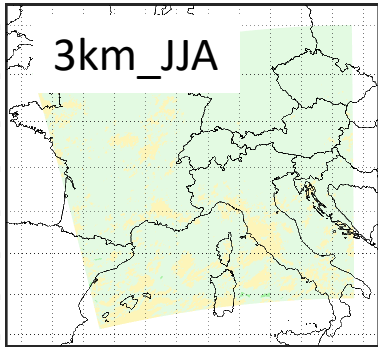
Intensity SON (mm/day)



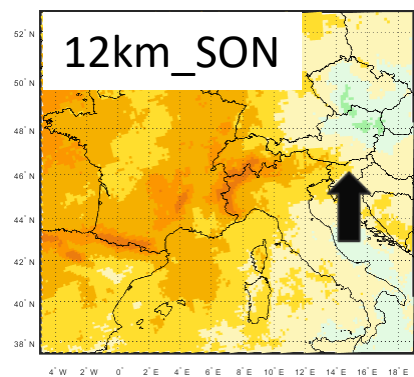
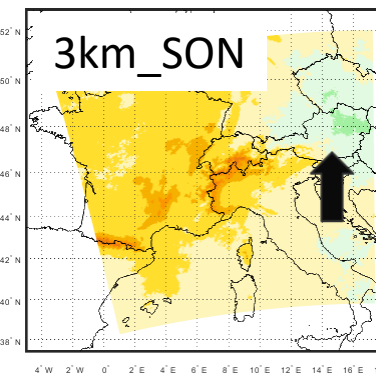
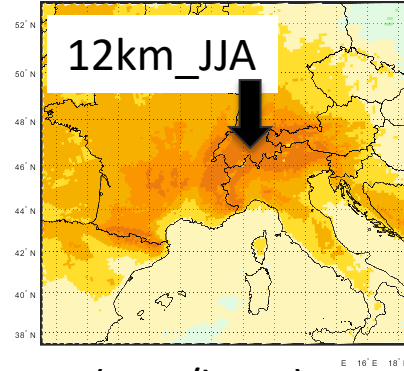
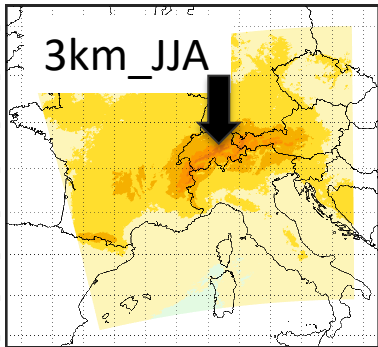
Changes of hourly precipitation

RCP85(2090-2099) - HISTORICAL(1996-2005)

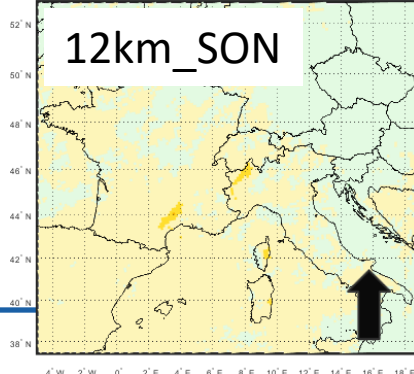
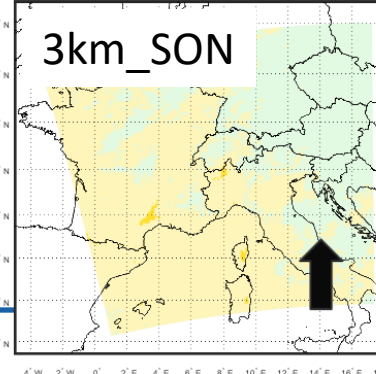
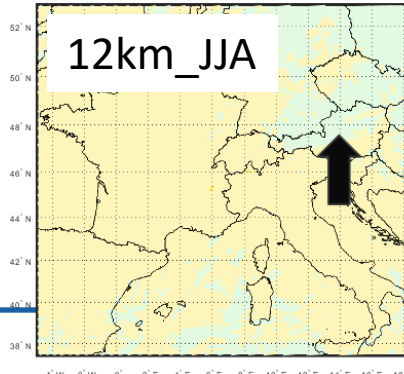
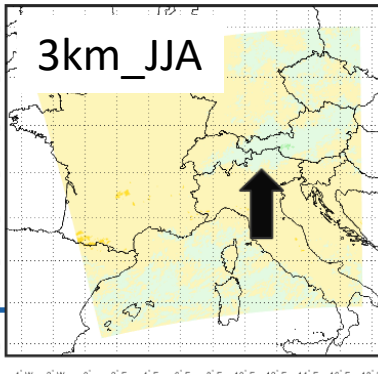
Intensity (mm/hour)



Frequency (fraction)

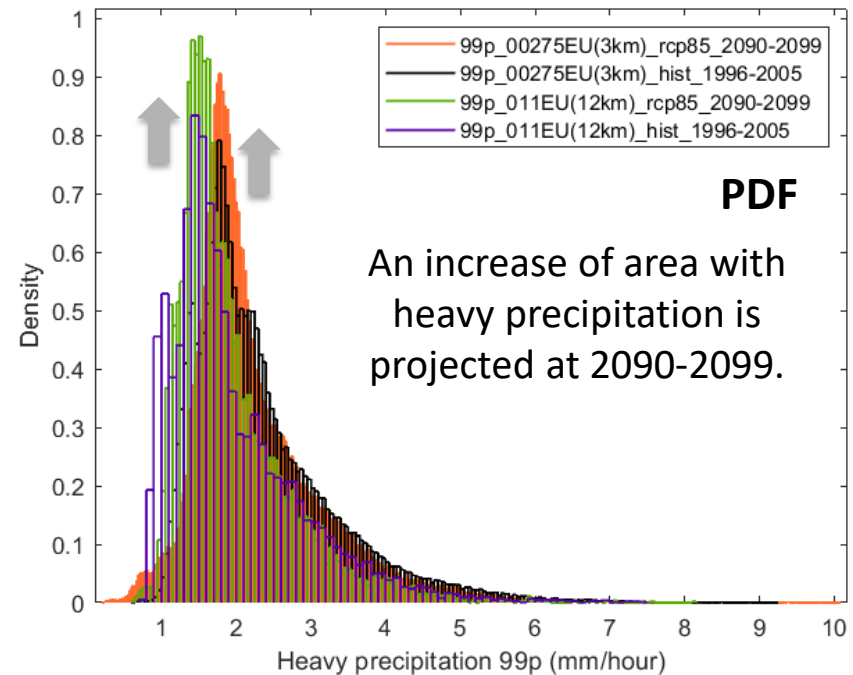
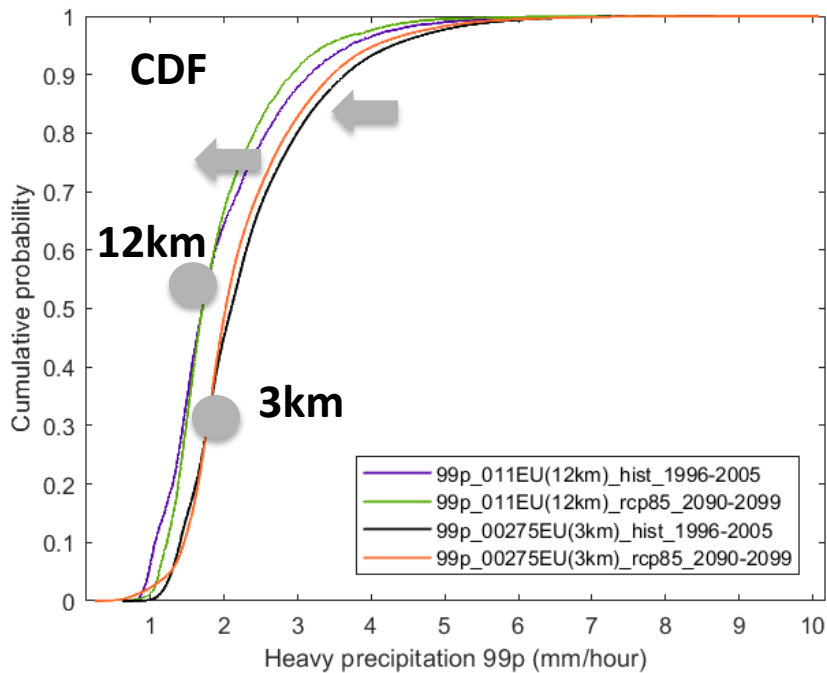
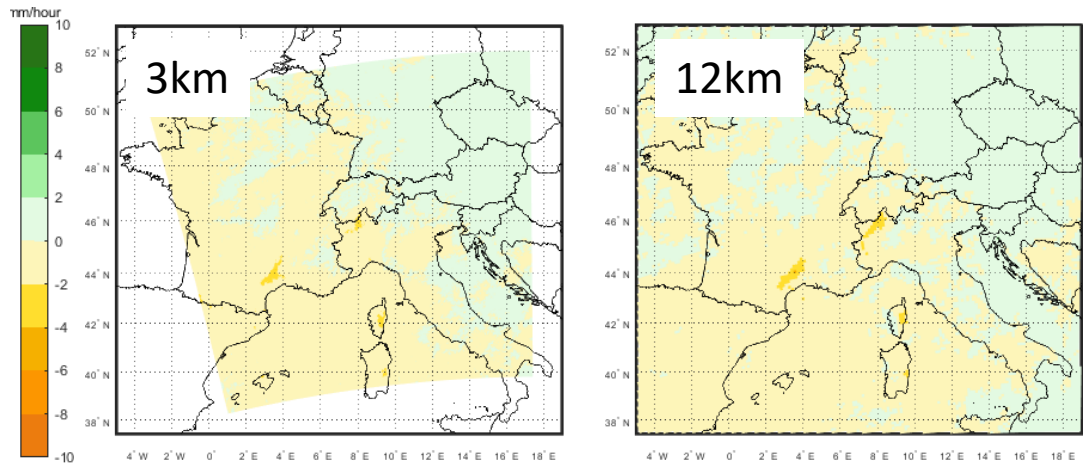


Heavy precipitation 99p (mm/hour)



Changes in hourly probability density functions

Changes of hourly heavy precipitation 99p SON (mm/hour)



Summary

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Conclusion and remarks

Evaluation analyses:

- The spatial patterns of precipitation are better represented by the 3km-scale simulation than by the coarse resolution driving one;
- Large difference exists between 3km and 12km simulations especially at hourly time scale.

Projection analyses:

- The km-scale simulations refine and enhance the projected patterns of change from coarser resolution ones and modify the sign of the daily precipitation intensity change over some targeted regions;
- Both simulations agree in projecting a general decrease of the daily mean precipitation in summer and an increase of the intensity and of the heavy precipitation in autumn over Adriatic coasts and eastern Alps at daily and hourly scales.

General remarks:

- An ensemble-based approach at the convection permitting scales should be used to prevent possible misleading conclusions from a single model.
- Although 10 years-long simulations do not represent a sufficiently long period to identify climatologic trends, the present findings could provide preliminary indications about the expected changes in future precipitation projections.



Thanks

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