

Fall Mediterranean Heavy Precipitation Events as seen by a large ensemble of CP-RCMs future projections

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Introduction

The northwestern Mediterranean is affected by fall **Heavy Precipitation Events (HPEs)** with rainfall accumulations greater than 100 mm often within just a few hours leading to devastating flash floods and landslides that may cause widespread destruction and even fatalities (Khodayar et al. 2021).

Convection-Permitting Regional Climate Models (CP-RCMs, 2-3km resolution) have shown a step-change in the quality of reproducing these extremes events (Fumière et al. 2020, Pichelli et al. 2021) with respect to lower-resolution climate models.

The good behavior of CP-RCMs allows us to set up an **object-oriented Lagrangian approach** in order to explore the spatial and temporal connections that may exist within a given event. Evaluation studies using this approach have already been carried out for the CNRM-AROME CP-RCM model (Caillaud et al. 2021) and for an ensemble of CP-RCMs (Müller et al. in rev).

The object-oriented approach is here applied to the CP-RCM CNRM-AROME and to the CP-RCMs ensemble of the CORDEX FPS on Convection (Coppola et al. 2020, Ban et al. 2021, Pichelli et al. 2021) in order to investigate the **future changes of the Northwestern Mediterranean HPEs** at the middle and at the end of the 21st century (RCP85 scenario).

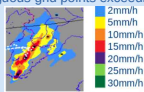
Methodology

The object-oriented approach : Precipitating system detection and tracking algorithm

Morel and Senesi, 2002; Caillaud et al. 2021

① Detection → Cells

(contiguous grid points exceeding thresholds)



② Tracking → Trajectories



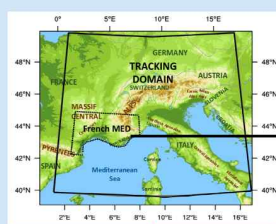
③ Characteristics

- duration
- mean and max intensity
- area
- velocity
- severity

TRACKING on 1-h accumulated precipitation

20-year simulations
CNRM-AROME
CP-RCM
(2.5km)

10-year simulations
FPS
convection
CP-RCMs
ensemble
(2-3km)



| Historical 20 years (1986-2005) | CNRM-AROME | CNRM-CM5 |
|----------------------------------|------------|------------------|
| Mid century 20 years (2041-2060) | CNRM-AROME | CNRM-CM5 RCP85 |
| End century 20 years (2080-2099) | CNRM-AROME | CNRM-CM5 RCP85 |
| Historical 10 years (1996-2005) | 11 models | GCMs CMIP5 |
| Mid century 10 years (2041-2050) | 9 models | GCMs CMIP5 RCP85 |
| End century 10 years (2090-2099) | 11 models | GCMs CMIP5 RCP85 |

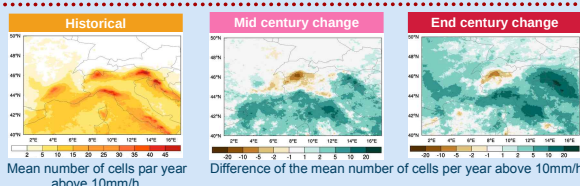
Focus on fall French Mediterranean HPEs

1. Area definition

2. Selection of tracks

- temporal (SOND) et spatial criteria
- heavy precipitation >10mm/h and >100mm/d

Fall Mediterranean HPEs changes as seen by CNRM-AROME (20-year simulations)



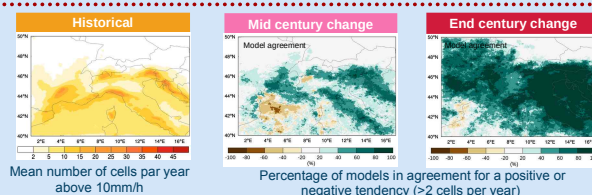
- > Good representation of areas known to be affected by fall HPEs by CNRM-AROME
- > Expected increase in the frequency of heavy precipitation and extension of the areas concerned, stronger at the end of the century

Results

Fall Mediterranean HPEs changes as seen by a CP-RCMs ensemble (10-year simulations)

NORTHWESTERN MEDITERRANEAN

Spatial density of
precipitating systems
above 10mm/h during
extended fall



- > Good representation of areas known to be affected by fall HPEs by the multi-model ensemble
- > Expected increase in the frequency of heavy precipitation and extension of the areas concerned, stronger at the end of the century, especially in the southeast of the area

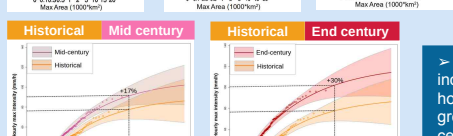
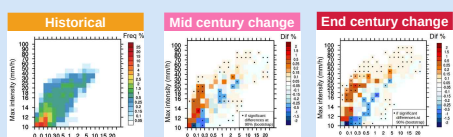
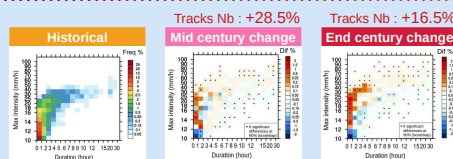
FOCUS ON FRENCH MED HPEs

SOND
>10mm/h
>100mm/d

Intensity Duration Frequency (IDF) plot

Intensity Area Frequency (IAF) plot

Return period for hourly maximum intensity



Tracks Nb: +28.5%

Tracks Nb: +16.5%

Tracks Nb: +12%

Tracks Nb: +29%

Percentage of models in agreement for a positive or negative tendency (>0.15%)

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Conclusions

- The CNRM-AROME CP-RCM (20-year periods) and the CORDEX FPS Convection CP-RCMs ensemble (10-year periods) agree on :
 - > Increased frequency of future Northwestern Mediterranean HPEs and extension of the areas affected
 - > In the French MED Area : more frequent and more intense events and for intensity events <40mm/h, shorter-lived and smaller precipitating systems
- These changes in HPEs are detected at mid-century and greater at the end of the century with better agreement among models

Perspectives

- > Complete the study of Mediterranean HPEs changes focusing on other characteristics (system move, severity...) and on other areas (Italian Ligurian coast, Croatian coast...)
- > Understand the future convective changes in Mediterranean HPEs and model behaviors by :
 - creating composites of in-storm (such as hail or wind) and environmental variables (temperature, humidity, precipitable water)
 - positioning the CP-RCMs and their driving models within the multi-model ensembles

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