Investigating the added value of the Convection Permitting Model CNRM-AROME over the Mediterranean Island of Corsica

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Introduction

The mountainous Mediterranean island of Corsica is constantly affected by intense meteorological events: heavy precipitation, floods, windstorms, coastal erosion, lightning, forest fires and droughts (Lambert et al., 2011).

Recent studies focusing on daily and hourly extreme precipitation events in the Mediterranean region have shown an added value of the Convection Permitting Regional Climate Models (CP-RCMs, 1-4 km) when compared to Regional Climate Models (RCMs, ~10 km)(Ban et al., 2021; Caillaud et al., 2021; Fumière et al., 2020). In addition, the latest review on CP-RCMs (Lucas-Picher et al., 2021) emphasizes that the high resolution of CP-RCMs are not only able of a more realistic representation of complex terrain but also an improved representation of fine-scale processes such as deep moist convection, land / sea breezes, coastal effects and orographically induced rainfall, which are especially important to correctly simulate climatic conditions over islands.

The objective of this study is to investigate the benefits of the 2.5 km CP-RCM CNRM-AROME in reproducing Corsica climate, in particular precipitation extremes during the wet season.

Data and method

Simulations from two CP-RCMs and one RCM are compared with observation data in the Corsica region for the 2000-2018 period.

Model simulations

- The CNRM-AROME (hereafter **AROME)** is a 2.5 km CP-RCM developed by the CNRM, based on the numerical weather prediction model at Meteo-France. AROME is a non-hydrostatic and limited area model able to explicitly resolve deep convection (Seity et al., 2011; Caillaud et al., 2021).

The region of Corsica is inside two different simulation domains of AROME: **AROME ALP,** the pan-Alpine domain and **AROME NW**, the northwestern European domain (Figure 1a).

- **ALADIN** is a 12.5-km RCM using deep convection parameterization, driven by the ERA-Interim global reanalysis (80 km). This RCM is the intermediate driving model implemented to avoid the large scale resolution jump from 80 km to 2.5 km.

Observations

- 17 **weather stations** from Meteo-France available at an hourly frequency (Figure 1b).

- **COMEPHORE** is a 1-km hourly gridded dataset developed at Meteo-France which combines radar and rain gauge observations (Tabary et al. 2012; Fumière et al. 2020).

- **PRESCILIA** is a 1-km daily gridded precipitation dataset developed at Meteo-France, based only on rain gauges and on the Aurelhy method that considers an orographic correction (Soubeyroux et al. 2019).

This study also compares observations from three selected weather stations: Ajaccio, Sampolo and Bastia, and its corresponding closest grid point in model simulations.

The added value of the CP-RCM AROME is investigated in:

1. the seasonal mean of daily precipitation,
2. the precipitation extremes: daily (not shown) and hourly,
3. the Probability Density Function (PDF) of hourly precipitation,
4. the duration-accumulation-frequency of precipitation events.

Results

1. Figure 2. The observed daily mean precipitation is realistically represented by all model simulations. For the wettest seasons (DJF and SON) over mountainous elevations (> 800m), an overall overestimation of precipitation intensity is found in AROME ALP and AROME NW simulations. However, for the Corsica region, the quality of the observational datasets (COMEPHORE and PRESCILIA) decreases at mountainous elevations which constrains a fair comparison for such overestimation.

2. Figure 3. The added value of AROME ALP and AROME NW model simulations when compared to ALADIN simulation, is mainly found for the wettest seasons and for hourly precipitation extremes (the 99.9th percentile) with a more realistic representation of observed precipitation extremes along the east coast. In addition, when the difference between model simulations and COMEPHORE is analysed, higher negative differences found in ALADIN simulation (reddish colour) confirm the limited performance in reproducing this type of precipitation extremes.

3. Figure 4. At three weather station locations: Ajaccio, Sampolo and Bastia, the observed PDF of hourly precipitation during winter and autumn seasons are better reproduced by AROME ALP and AROME NW simulations (red and green curves, respectively). This is particularly clear for the tail of the distribution (i.e higher precipitation intensity) where ALADIN simulations (blue curve) fail to capture it. In addition, a comparison of the hourly mean precipitation (*pr*) and the total number of precipitation events (n), confirms that AROME ALP and NW have superior performance with similar values to the observations while ALADIN underestimates *pr* values and overestimates *n values* (i.e more frequent but less intense precipitation).

4. Figure 5. In this study, the duration-accumulation-frequency diagram associates the duration and the accumulation of continuous hours of precipitation (pr >= 0.2 mm in an hour). A comparison of duration-accumulation-frequency with the observations shows the highest frequency (20%-30%) but less intense 1-hour precipitation events while the least likely and more intense events last from 24 to 48 hours. These features are better reproduced by AROME ALP and AROME NW simulations while ALADIN simulations tend to underestimate the cumulative precipitation but overestimate the duration (up to 96 hours).

The main results are summarised in table 1.

Conclusions and future work

The added value of the CP-RCM AROME ALP and AROME NW in comparison to the RCM ALADIN simulations was found in hourly precipitation extremes during winter and autumn over the region of Corsica. This added value is confirmed with a more realistic representation of the location and intensity of observed hourly precipitation extremes.

A more detailed comparison using weather stations also shows the better capacity of AROME ALP and AROME NW simulation to better capture the distribution of hourly precipitation and to better reproduce the less frequent but more intense precipitation. In addition, AROME simulations are able to better reproduce the duration-accumulation-frequency of precipitation events with more realistic durations and associated intensities found in the observations.

Considering the potential found in these high-resolution climate simulations, the following step will consist in investigating important island weather processes such as the land / sea breezes, and the orographic and coastal effects over Corsica.

Acknowledgements

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Results

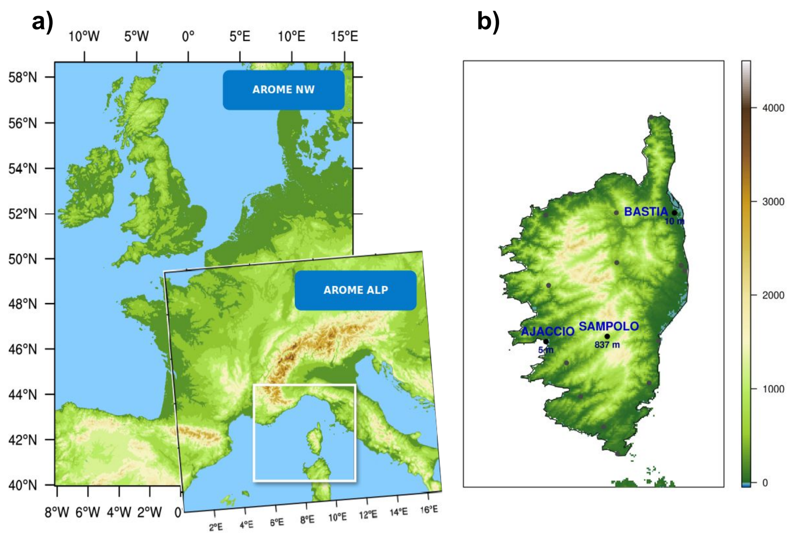

Figure 1. a) The study region of Corsica (white square) inside two different AROME simulation domains: AROME ALP, the pan-Alpine domain (according to the CORDEX FPS Convection project) and AROME NW, the northwestern European domain (defined through the EUCP H2020 project).
b) Location of the 17 weather stations (gray dots) with hourly observational data in Corsica. Selection of three weather stations (in bold) located in the east coast (Bastia), centre (Sampolo) and west coast (Ajaccio) of Corsica.

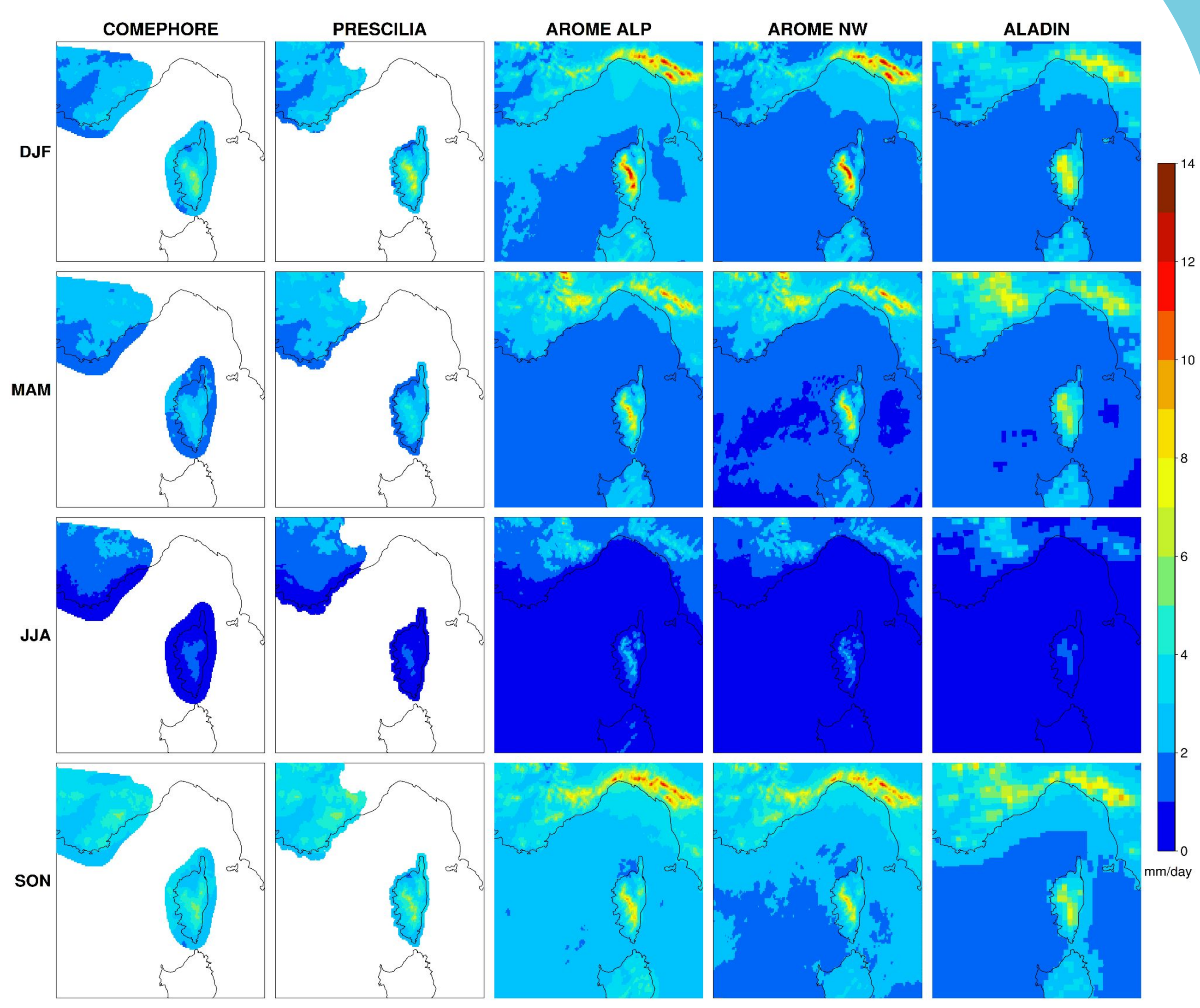

Figure 2. Mean of daily precipitation by season from observation data: COMEPHORE and PRESCILIA and from the model simulations: AROME ALP, AROME NW and ALADIN during the 2000-2018 period.

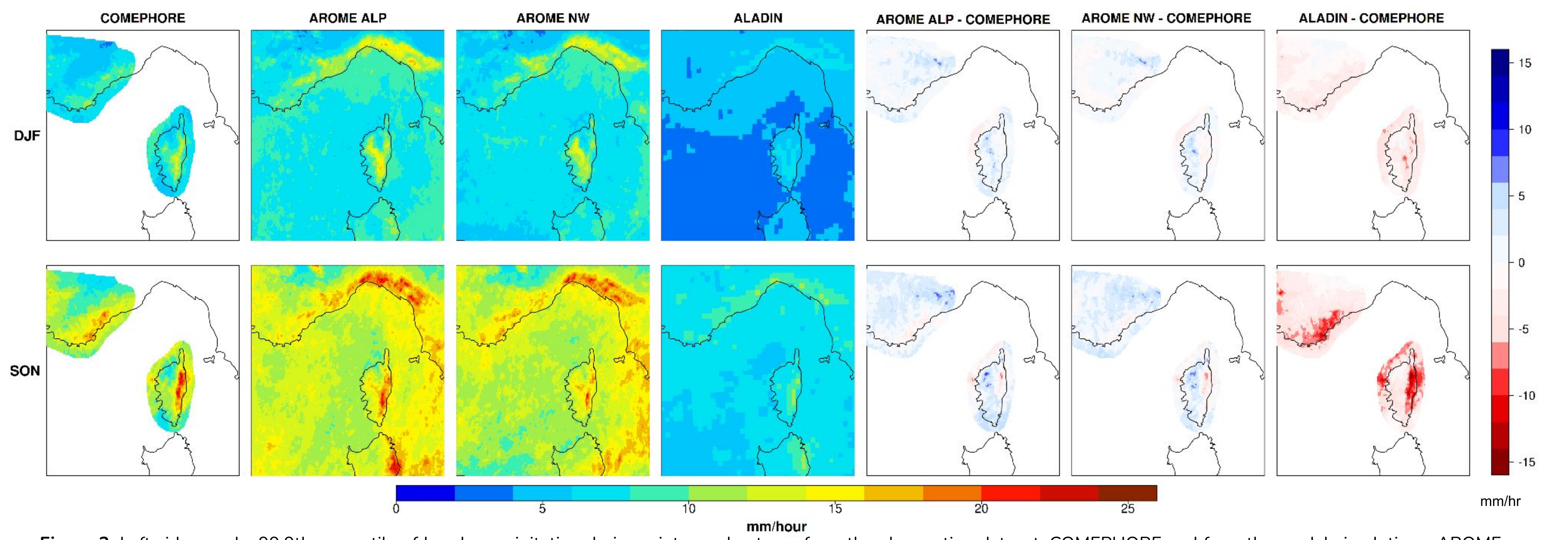

Figure 3. Left side panels: 99.9th percentile of hourly precipitation during winter and autumn from the observation dataset: COMEPHORE and from the model simulations: AROME ALP, AROME NW and ALADIN. Right side panels: Difference of the 99.9th percentile of hourly precipitation between model simulations (AROME ALP, AROME NW and ALADIN) and COMEPHORE.

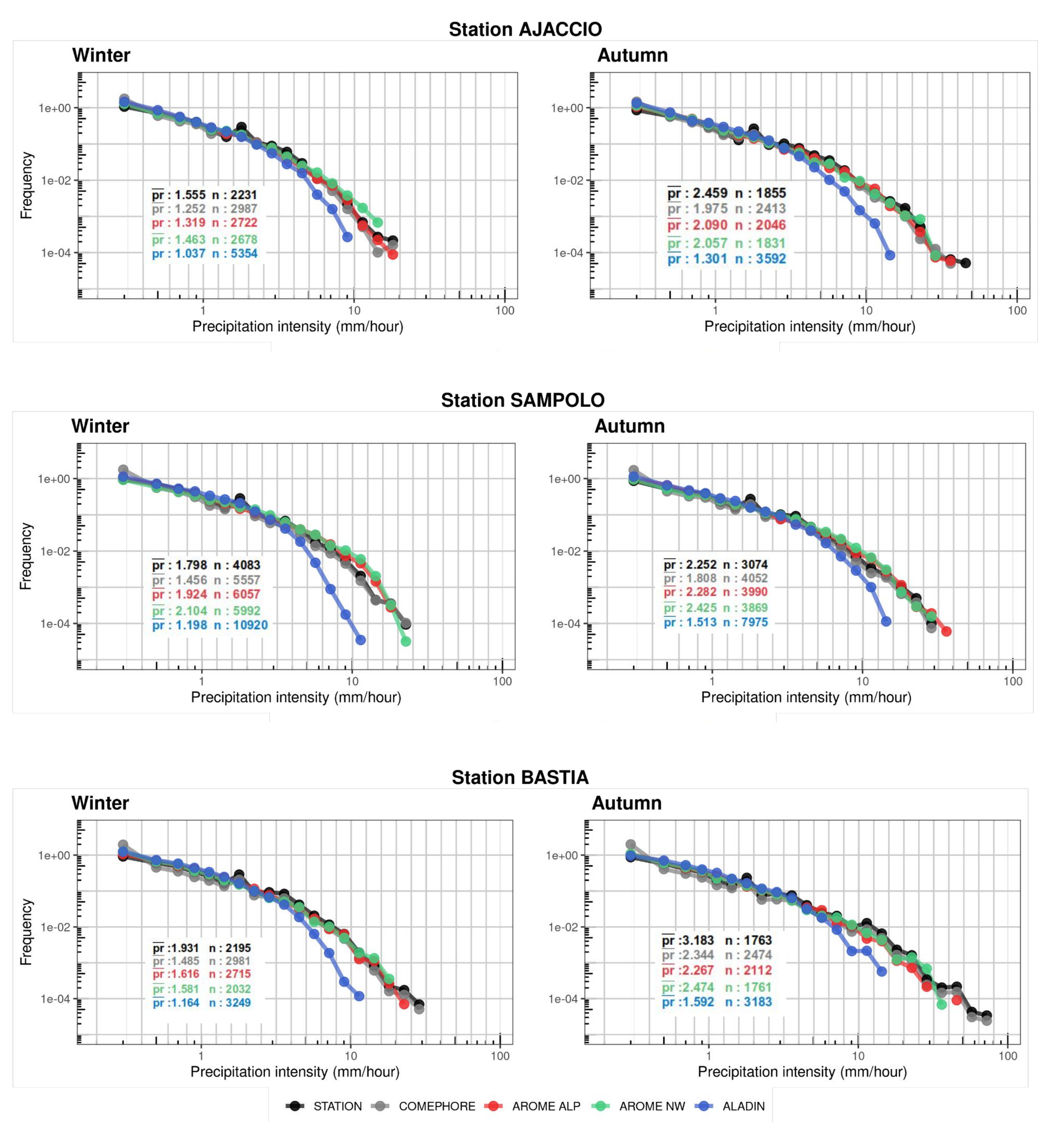

Figure 4. Probability Density Function (PDF) for hourly precipitation for three locations: Ajaccio, Sampolo and Bastia.

Table 1. Summary of the performance of each model simulation.

	Daily mean of precipitation	99.9 th percentile of precipitation	PDF of hourly precipitation	Duration-accumulation-frequency of precipitation events during Autumn
AROME ALP	good performance, overestimation at mountainous elevations	good representation of hourly extremes	good agreement with the PDF	satisfactory representation of precipitation events
AROME NW	good performance, overestimation at mountainous elevations	good representation of hourly extremes	good agreement with the PDF	satisfactory representation of precipitation events
ALADIN	good performance	fail to reproduce hourly extremes	fail to reproduce the tail of the PDF	limited representation of precipitation events

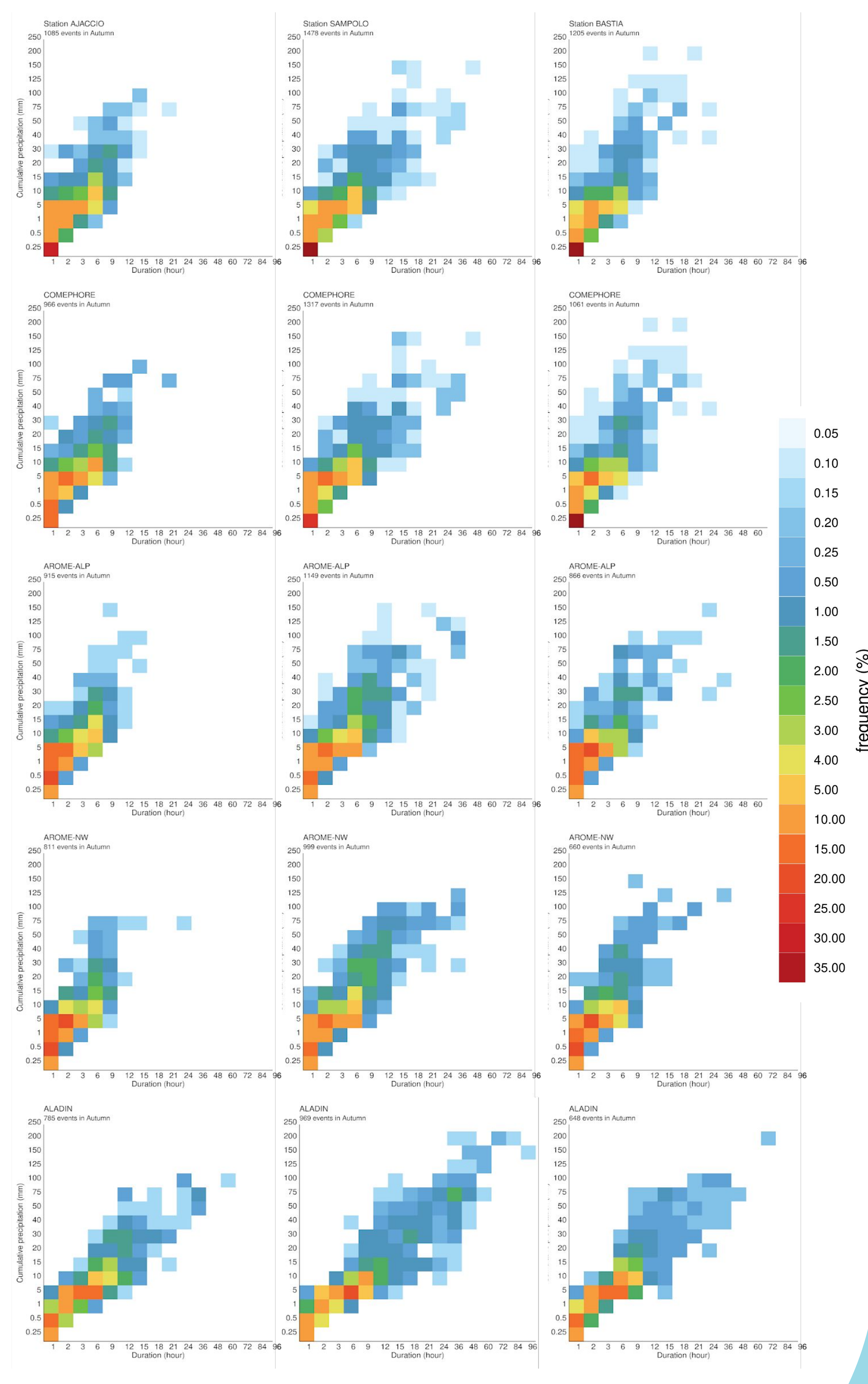

Figure 5. Diagrams of duration-accumulation-frequency of precipitation events in autumn for three locations: Ajaccio, Sampolo and Bastia.

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