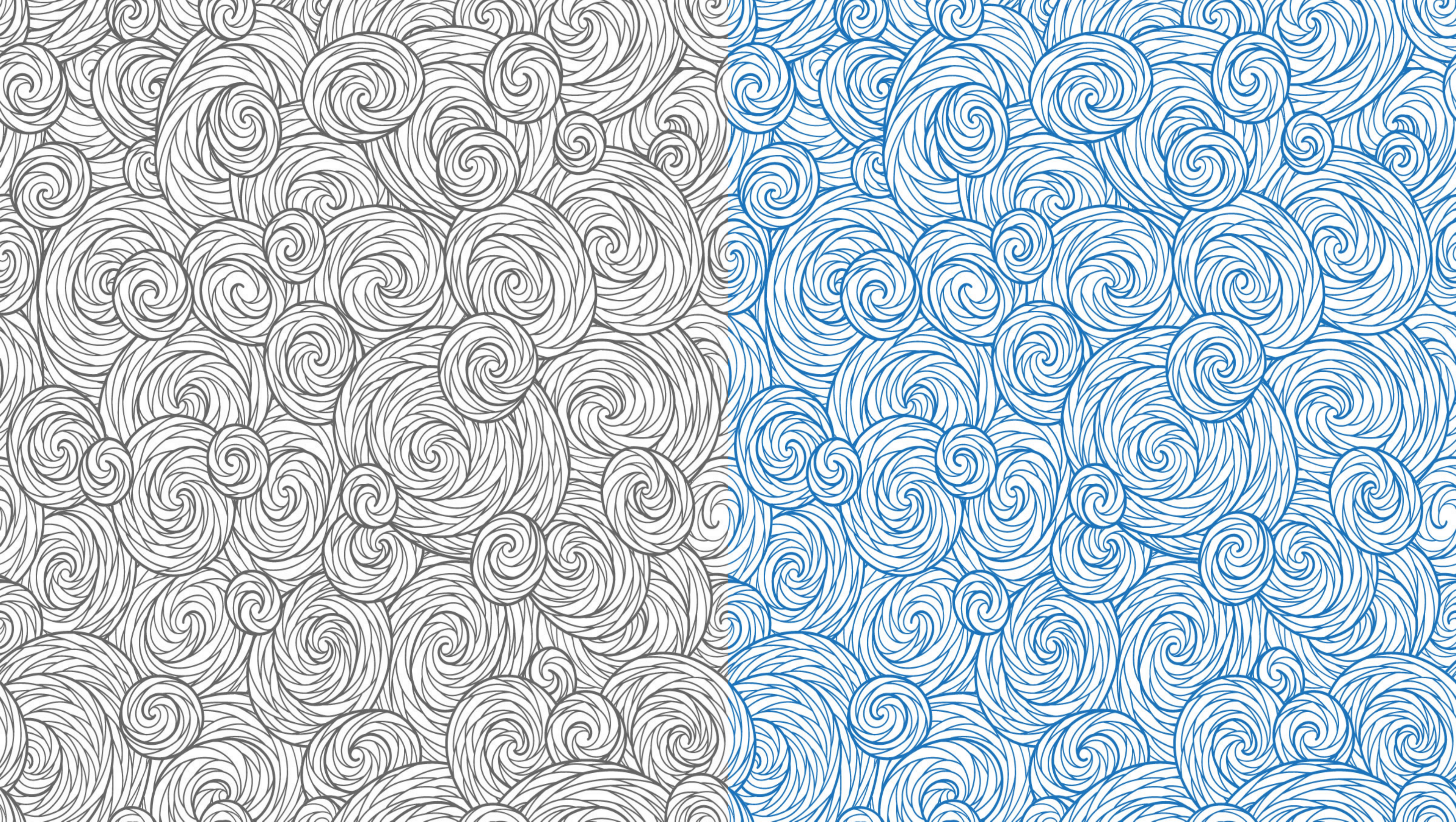

Hydrometeorological extremes in a warmer climate. A local scale assessment for the island of Crete.

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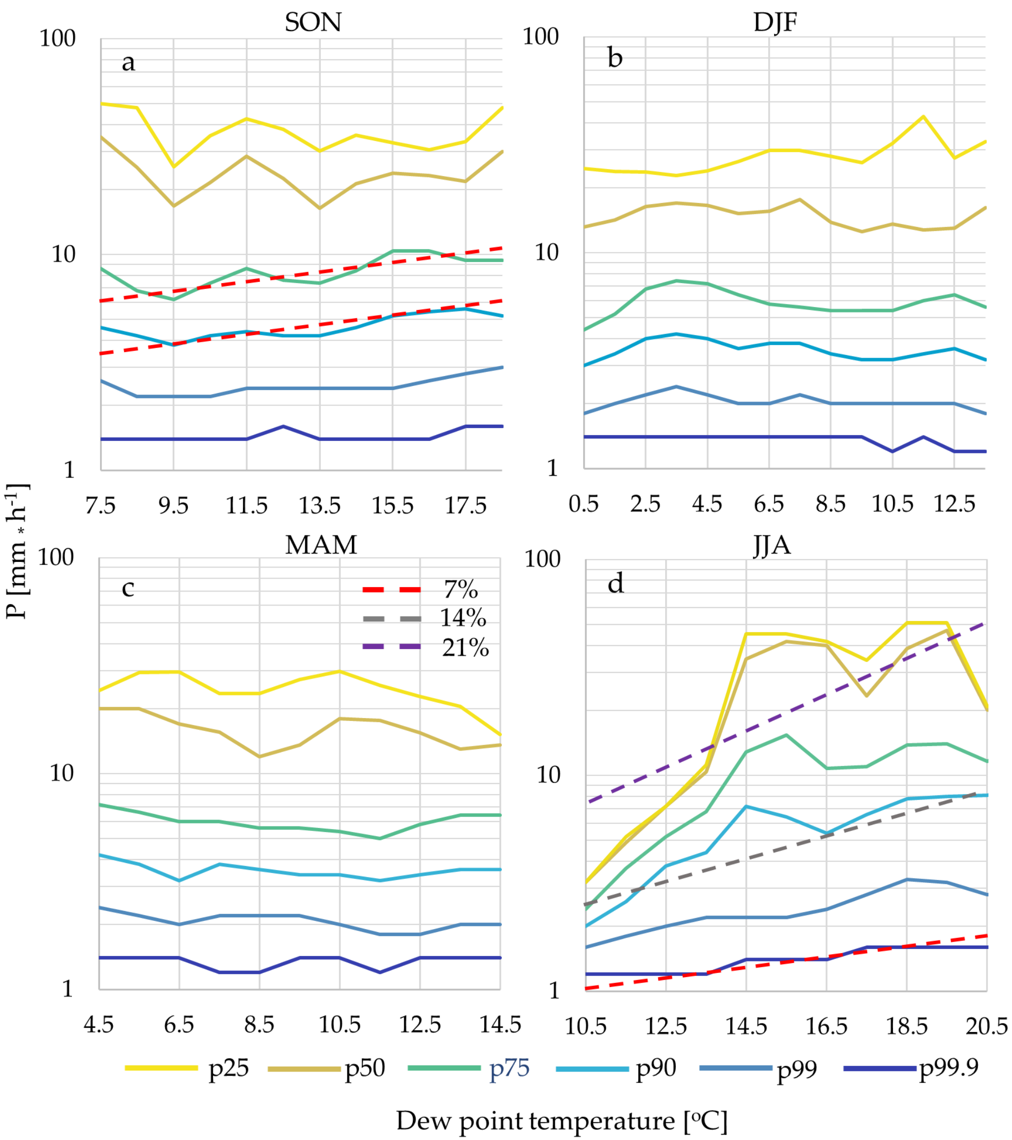
Introduction

- Clausius–Clapeyron (CC) equation estimates that the saturation vapor pressure increases by a rate of 7%/K of temperature increase.
- This relationship gives a useful indication about the magnitude of expected changes in future precipitation rates in a warmer atmosphere.
- Studies have shown that for short temporal scales the increase may by far exceed the CC theory.
- Here, we examine high temporal resolution data from meteorological stations to estimate the saturation vapor pressure increase to the precipitation intensity.
- We then use our estimations to scale precipitation of past a flash flood event to a +2°C temperature.
- Results are compared to three convection permitting regional climate models (CPRCM) simulations of the same storm event under reference climate and under +2°C warming perturbation to the boundaries conditions.
- Hydrological simulations of reference and +2°C are performed and compared.

Results

Analysis on 30 high temporal resolution rain gauges show a diverse scaling behavior for each season, which is related to the different nature of precipitation types.



- During the cold months (DJF), precipitation is occurring in the form of stratiform and orographic and less on convective (Figure 1b).
- During the summer (JJA) months precipitation occurrence is usually triggered by convection patterns with high available potential energy that can result to torrential rainfall and locally severe thunderstorms (Figure 1d).
- In the September to November (SON) period, both forms of precipitation occur.

Figure 1: Precipitation intensity as a function of dew point temperature for September to November (a), December to February (b), March to May (c) and June to August (d), for different percentiles (25th to 99.9th). Dashed lines represent the 7%, 14% and 21% of positive correlation, or 1, 2, 3 times the CC ratio.

Results

The established relationships between precipitation and dew point temperature are used to scale the reference precipitation of the 17 October 2006 Almirida event to a +2°C precipitation event.

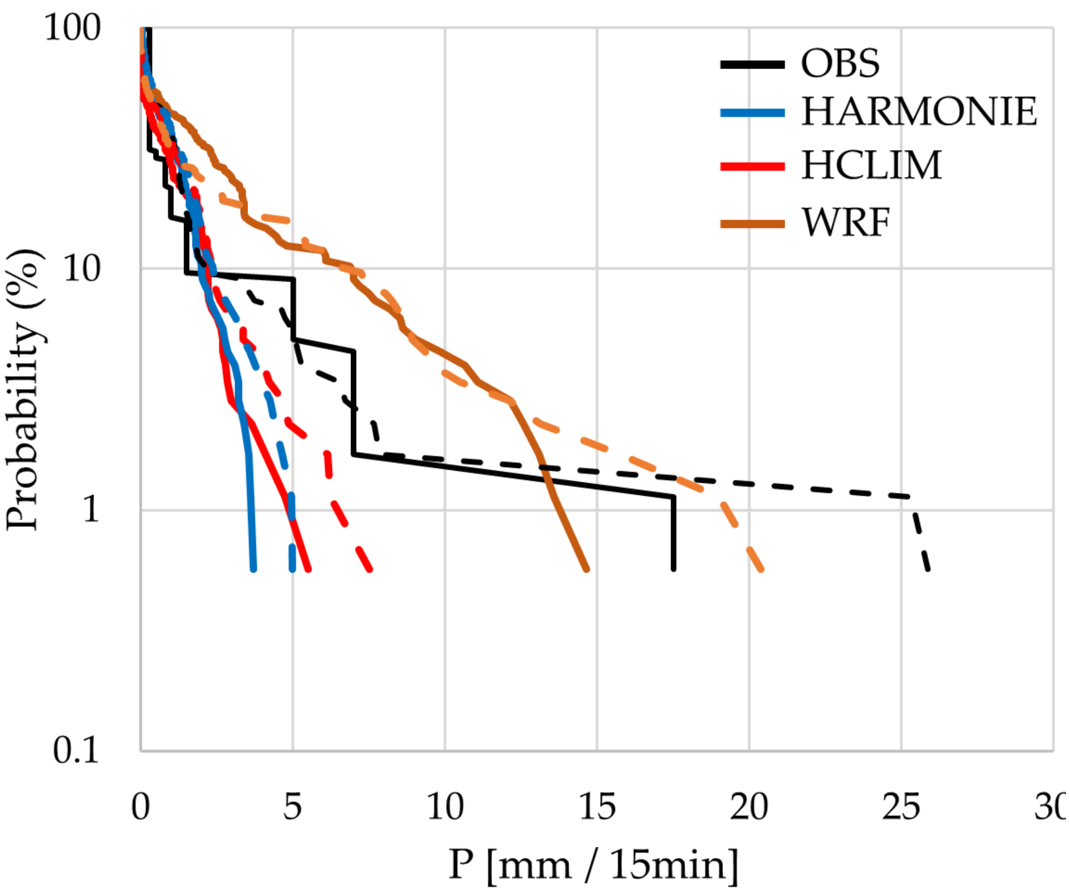


Figure 2: Probability distributions of precipitation. The solid lines correspond to the present day simulations while the dashed lines to the +2oC weather.

- Comparison of the reference climate and the scaled future precipitation is shown in Figure 2.
- Scaled observations at +2°C show 12% increase in the total precipitation with a 47% increase in the peak 15min precipitation.
- The CPRCM simulations (also shown in Figure) simulate 30% (HCLIM), 17% (HARMONIE) and -7% (WRF) change in the total precipitation for the +2°C simulation.
- The respective changes in the peak 15min precipitation were estimated at 40%, 35% and 40%.

Results

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The different precipitation representations for the present day and the warmer climate were used to force a calibrated rainfall-runoff model to simulate the Almirida flash flood event.

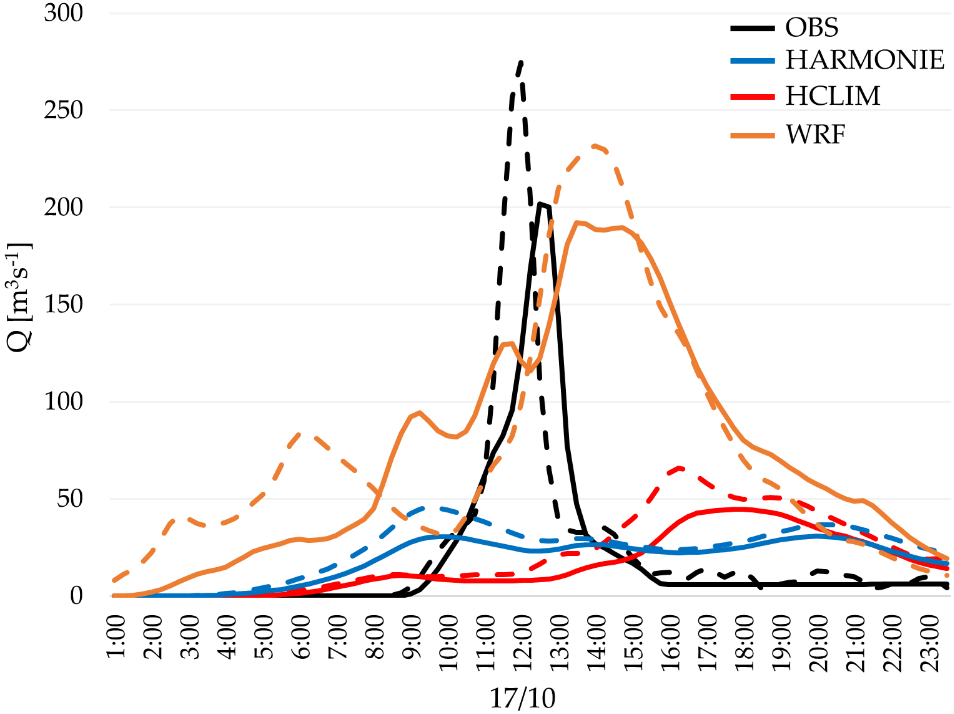

Figure 3: Flash flood events runoff hydrographs. The full lines represent the present day simulation while the dashed lines shows results from the warmer atmosphere.

- Significant increase in the peak discharge due to a potential +2°C warming.
- The simulation of the scaled observations at +2°C shown a 36% increase in the peak.
- Similar changes also derived from the +2°C CPRCM simulations, with increase in the peak discharge of 47% (HCLIM), 49% (HARMONIE) and (WRF) 20%.
- The hydrological simulations driven by the WRF data were found to be closer to the observations, in terms of magnitude and timing of the peak discharge.

Conclusions

- The analysis of the precipitation intensity and the dew point temperature shown diverse results for the different seasons that were analyzed. This is in line with other studies which denotes that the correlation can vary with region, season, duration, and form of precipitation, and is different for low and high temperatures, ranging from below CC rate or exceeding it by far.

- While large discrepancies were found among the CPRCM simulations of the reference climate, the relative changes to the +2°C in total precipitation and peak intensity were found to be consistent. Moreover, they were found to be consistent with the relative changes estimated between the observed data and the scaled +2°C observations.

- The hydrological simulations revealed significant increase in the flood peak that can consecutively result to higher maximum depth and wider flood inundation. The hydrological simulations also shown that the increased precipitation intensity also affect the timing of the peak discharge which also reduces the reaction time.

Methods

Precipitation and dew point temperature observations were obtained from 30 weather stations operating on the island of Crete (10 minute gauging frequency). The operation period of Each station varied between 0.1 and 5.6 years. The total length of the data from all weather stations, used to establish the precipitation – temperature correlation was 101years of records. The correlation considers the hourly precipitation data and the dew point temperature, 4 hours prior the precipitation occurrence.

The CPRCM data were provided by HARMONIE (SMHI), HCLIM (KNMI) and WRF(UNI) models.

- HARMONIE is a NWP model framework that contains a suite of physical parameterization packages, developed to be applicable to convective permitting resolutions of ~2 km.
- HCLIM is a different version of HARMONIE that runs in climate model setting using different physics package that enables the model to be run at very high horizontal resolution while retaining the convection parameterization.
- WRF - Weather Research and Forecasting Model (WRF) version employed by Uni Research is a fully non-hydrostatic modeling system with the ability to resolve strongly nonlinear small scale processes.

The hydrological simulations were performed with HEC – HMS 4.2 model. The model was set up using a variant of Clark's unit hydrograph technique to accommodate spatially distributed rainfall data. The model was calibrated to simulate the peak discharge.

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