Extreme rainfall intensification at warmer temperatures as observed from weather radar data

Other Conference Item

Author(s):
Peleg, Nadav; Marra, Francesco; Fatichi, Simone; Molnar, Peter; Morin, Efrat; Sharma, Ashish; Burlando, Paolo

Publication date:
2019

Permanent link:
https://doi.org/10.3929/ethz-b-000347560

Extreme rainfall intensification at warmer temperatures as observed from weather radar data

N. Peleg*[1], F. Marra[2], S. Fatichi.[1], P. Molnar[1], E. Morin[2], A. Sharma[3], P. Burlando[1]

1 Institute of Environmental Engineering, ETH Zurich, Switzerland
2 Institute of Earth Sciences, Hebrew University of Jerusalem, Israel
3 School of Civil and Environmental Engineering, University of New South Wales, Australia

*Corresponding author: nadav.peleg@sccer-soe.ethz.ch

Abstract

Data acquired by remote sensing can be used to contribute to the understanding of the relationship between air temperature and precipitation at large scales. This study (Peleg et al., 2018) focus on the analysis of heavy rainfall at the storm and convective rain cell scales using a high spatio-temporal resolution (1-km, 5-min) precipitation estimates. Rainfall data were obtained from a single C-band (5.35-cm wavelength) non-Doppler instrument located in the Ben Gurion International Airport, Israel (Fig. 1). Records from this radar have been archived from October 1990 to March 2014, with small data gaps due to malfunction or regular maintenance, and were processed to reduce the impact of the abovementioned errors. With 24 hydrological years of corrected and gauge-adjusted estimates, this represents one of the longest homogeneous archives of weather radar estimates worldwide. The study focuses on the eastern Mediterranean, a region characterized by a sharp change from Mediterranean to semiarid and arid climates (Fig. 1). Four 60 km x 60 km locations (A–D in Fig. 1) were selected to represent climatological diversity along the region (Mediterranean climate, A and B; semiarid climate, C and D) and geographical diversity (oversea, A; far inland, D). The selection was further based on the quality of the weather radar data, for example, ascertained by the distance from the weather radar, absence of known ground clutter, and beam blockages. The areal extent of the locations allows capturing the largest convective rain cells observed in the region while preserving a climatic homogeneity in each location.

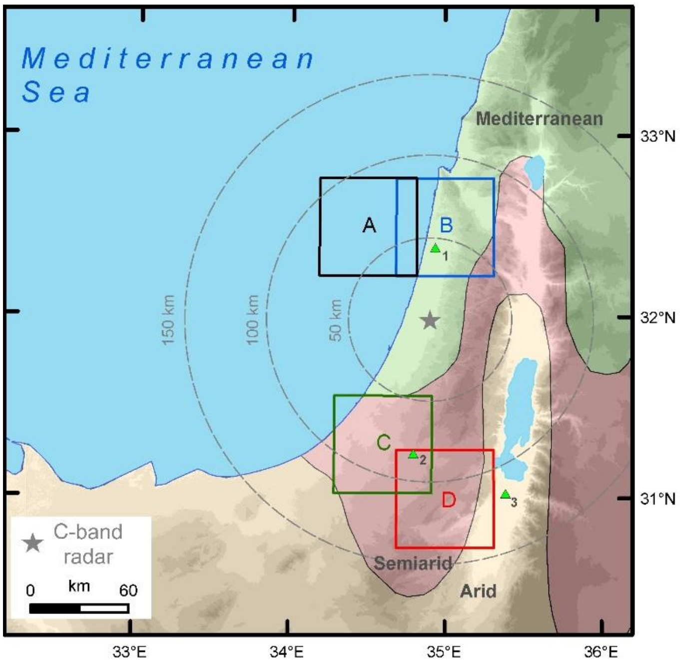

Fig1: Map showing the weather radar (gray star), climatic zones (Mediterranean, green; semiarid, red; arid, orange) and the four 60 km x 60 km locations that were studied (square areas, labeled A–D).

Convective rain cells were identified from the radar rain fields using the image processing algorithm presented by Peleg and Morin (2012). The area and peak rainfall intensity of convective rain cells were scaled with temperature. The wet area ratio, areal rainfall, convective areal rainfall, and non-convective areal rainfall were all calculated for convective rainfall fields, that is, for radar rainfall fields in which at least one convective rain cell is observed. Each convective rain cell was associated with the last temperature observation available before the rain cell detection time. The scaling was then objectively quantified using the quantile regression technique.

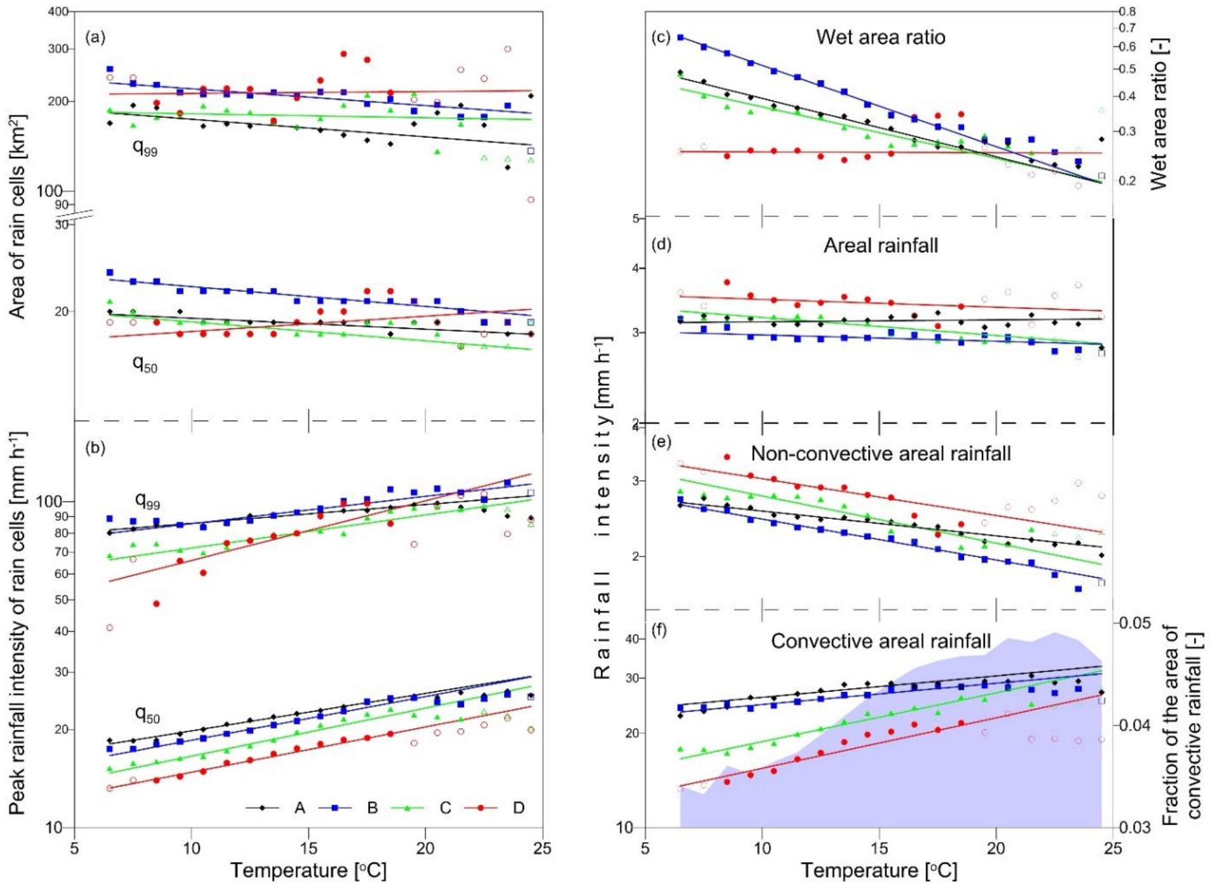

Fig 2: Results of the scaling of different rainfall variables with temperature.

The peak intensity of individual convective rain cells was found to increase with temperature, but at lower rate than the 7% $\circ C^{-1}$ scaling expected from the Clausius-Clapeyron relation, while the area of the individual convective rain cells slightly decreases or, at most, remains unchanged (Fig. 2a-b). At the storm-scale, the areal convective rainfall was found to increase with warmer temperatures, whereas the areal non-convective rainfall and the storm-wide area decreases (Fig. 2e-f). This suggests an enhanced moisture convergence from the storm-wide extent towards the convective rain cells. The results indicate a reduction in the total rainfall amounts (Fig. 2c-d) and an increased heterogeneity of the spatial structure of the storm rainfall.

References

Peleg, N., and E. Morin. "Convective rain cells: Radar-derived spatiotemporal characteristics and synoptic patterns over the eastern Mediterranean." Journal of Geophysical Research: Atmospheres 117, no. D15 (2012).

Peleg, N., F. Marra, S. Fatichi, P. Molnar, E. Morin, A. Sharma, and P. Burlando. "Intensification of convective rain cells at warmer temperatures observed from high-resolution weather radar data." Journal of Hydrometeorology 19, no. 4 (2018): 715-726.