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Interactive comment on "Atmospheric Conditions Leading to an Exceptional Fatal Flash Flood in the Negev Desert, Israel" *by* Uri Dayan et al.

Anonymous Referee #2

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General comments

This manuscript deals with a very interesting case of a high-impact storm. There were floods in the Negev desert in southern Israel, in which unfortunately 10 people died. The event had not been expected as it hit at the end of the cold season.

A scientific investigation of this storm is important in order to understand the underlying processes and to improve the forecast for such flooding events. Additionally, a climatological classification as carried out in the work, helps to better estimate the potential of these events.

However, the work is essentially limited to large-scale processes that are also not completely discussed. In addition, there are attempts to connect small-scale processes to

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the synoptic scale, which fail because of the separation between dynamics and thermodynamics and not least because of the selection of data and the way these are presented. Finally, the manuscript gives repeatedly undisputed hypotheses, as well as some inconsistencies.

The main goal of this work as given in lines 50-52 ("In section 3 we describe the event and identify the unique dynamic and thermodynamic conditions that lead to the severe convection, as well as the sources of moisture for the rain formation in this storm.") needs to be elaborated more, especially with respect to across-scale processes with respect to rain production. Evidence needs to be given to the hypotheses that are presented.

Specific comments

The manuscript is focused on the analysis of the large-scale flow, which is compared with similar flooding events. The intensity and track of the corresponding cut-off low in 500 hPa is unusual for the season. Parts of the work, however, disagree on whether the event is a typical weather situation, with flooding occurring outside the rainy season in the desert or whether it is a unique situation (compare lines 42-45: "The rest of the annual rainfall occurs in the transitional seasons and is contributed by precipitating tropical synoptic-scale systems and by Cyprus Lows. A significant part of them occur in the desert areas and are characterized as intense rain events of small spatial extent and short duration, some of which produce flash floods (Kahana et al. 2002; Dayan and Morin 2006, Greenbaum et al. 2010)." and lines 245-247: "The location of the surface cyclone was similar to the 'Syrian low', defined by Kahana et al. (2002) as one of the major systems causing floods in the Negev Desert." with line 51: "unique dynamic and thermodynamic conditions"). The impression is that the large-scale weather conditions are well known for flooding, whereas only the temporal appearance and the intensity and coverage were unique. Readers unfamiliar with the given weather patterns, i.e. 'Syrian low' and 'Cyprus Lows', can be confused which of these two is mainly associated with flooding events. It would be good to explain these weather patterns at the

beginning of the text in some detail, e.g. mid-level flow and surface pressure field.

Apart from this analysis of mid-level and SFC flow, hypotheses are (repeatedly) raised that are not discussed further:

Lines 311-312 "The combination of a cut-off low with small radius and large hypsometric depth, implies high curvature relative vorticity, with strong dynamical forcing on rain formation." At this point, the authors need to be more precise. "Strong dynamical forcing" refers to quasi-geostrophic processes, and large-scale lift is the order of cm/h. Does QG lift affect rain formation directly? Moreover, only the contribution by differential cyclonic curvature vorticity advection to QG lift is mentioned. Since the weather charts indicate north-westerly flow, the reader may wonder if a cold air advection maximum may cancel QG lift in a similar event. And what about shear vorticity?

Lines 193-195: "It should be noted that the three rain centers are located within a region of negative Omega (ascendance, Fig. 7c), with an extremum value of -10 Pa s-1. This implies that these rain systems are dynamically supported." In this manuscript, the "dynamic factor" (quasi-geostrophic lift) is analyzed separately from the "thermodynamic factor" (thunderstorm) (lines 123-125: "Two complementing factors contributed to the rain formation. One is dynamic, i.e., vertical ascent, associated with the cyclonic system described below (Sec. 3.2). The other is thermodynamic, which is composed of instability and moisture supply, described in Sec. 3.3."). There are two criticisms to approach. First, the omega fields show a combination of lift on different scales, including convection parametrization. It is therefore not possible to conclude that the given omega fields indicate just dynamic lift. Secondly, both factors influence each other, so that a separate analysis cannot be recommended (see also Doswell, C.A. III, 1987: The distinction between large-scale and mesoscale contribution to severe convection: A case study example. Wea. Forecasting, 2, 3-16).

In addition, it is confusing that all three rain events are supported by the dynamic factor, while in other places in the manuscript the opposite is written, such as in lines 119-122:

"The maximum rainfall was obtained in the rain shadow of the Negev Mountains, and the second most intense one was found in the Jordan valley, again, in the lee side of the Samarian Mountains. The dominance of convective over orographic elements suggests that sub-synoptic scale factors took place in this storm." These two statements can be confusing since it is not clear whether strong synoptic-scale forcing is important to these events or not.

Furthermore, the profile of one radiosonde is discussed (in 24-hour intervals). Unfortunately, the authors limit themselves to standard indices for analyzing the general thunderstorm potential. A discussion about whether the vertical profile supports the potential of heavy rain is not provided. In addition, the authors give no evidence to the hypothesis that the modified K-Index (MKI) gives better results in the east Mediterranean compared to standard indices (lines 321-324: "Despite the universality of stability indices developed to illustrate the potential for convection, few of them require adjustments and modifications to fit the area being analyzed. In this study, the modified KI version adopted for the eastern Mediterranean region, has shown to be a reliable predictor for convective rain centres and therefore a good precursor for floods." In this manuscript, the MKI just indicates the possibility of thunderstorms (as well as all other listed indices; lines 218-220 "The MKI distribution over the study region for the April 26, at 03, 09, 15 and 21 UTC, is shown in Figs. 7i-l, respectively. Values exceeding 25°C, indicating potential for thunderstorms, are co-located with the major rain centres at the hours 09, 15 and 21 UTC."). To convince the reader, a comparison with the K-Index can be useful.

A large part of the work is focused on the transport of moisture to the desert. The prevailing north-westerly flow and the transport of Mediterranean air are mentioned several times in the manuscript. However, based on WV satellite images it is also hypothesized that moisture from tropical regions had been advected, according to 315-317: "Moisture originating from tropical sources during such rainstorms enriches the mid-atmospheric levels, which makes the rain formation less sensitive to availability of

moisture in lower levels. Hence rain cells are not expected only over mountain upslopes, but also over low terrains such as the one that caused the deadly flood in Tzafit creek." The authors may imply greater precipitation efficiency here, but this hypothesis is not further elaborated. Finally, in the conclusions, a hypothesis appears that is not given in the previous manuscript (lines 313-314: "Quasi-stationary upper level systems allow moisture accumulation causing the increase in precipitation amounts from one day to the next."). Without discussion, this hypothesis also remains without any evidence.

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