MOMENT-ENERGY RELATIONSHIP: A CRITERION TO DISTINGUISH BETWEEN CONVECTIVE AND STRATIFORM PRECIPITATION

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I. INTRODUCTION

The type of precipitation –convective or stratiform– provides information that may be useful from different points of view:

- With respect to the thermodynamics of the atmosphere, the energy balance is very different in the two types of precipitation, and this affects the warming of the various layers of the atmosphere;
- With respect to natural hazards, one of these types of precipitation is mainly associated with convective phenomena;

One of the criteria for classifying precipitation is the relationship between the reflectivity factor *Z* and precipitation intensity *R* such as $Z = a\ R^b$ (Doelling et al, 1998)

However, on occasions it is convenient to use variables other than Z and R for specific objectives. For example, in studies on splash erosion the two most important characteristics of raindrops are the kinetic energy *E* and the linear moment *p*. It may therefore be interesting to search for a relationship between these two parameters to analyze their relevance in a hypothetical classification criterion to distinguish between convective and stratiform precipitation.

This study is aimed at finding a relationship between the momentum and energy of raindrops in 8 rainfall events recorded in the province of León (Spain).

II. STUDY ZONE

The study focused on rainfall recorded between October 2006 and August 2008 in the city of León, in the north-west of Spain (Fig. 1). During this interval, a total of 1083 mm were collected.

The climate of this zone belongs to the Mediterranean type with a continental influence, which differs in some areas due to the Atlantic influence. It is characterised by having a wide range of temperatures, with very cold, long winters and a permanent risk of frost throughout the whole year, short springs and autumns, and moderate temperatures during the short summers. Precipitation is distributed irregularly, concentrated in the winter and autumn months, despite the presence of dry summer periods during the months of July and August (del Rio et al, 2005).

III. MATERIALS AND METHODS

The characteristics of the raindrops in the city of León were analysed using an optical disdrometer. The properties of this device are described in Fernández-Raga et al. (2009).

From the total number of precipitation events recorded during the study period, the rainfall episodes that could be clearly classified as convective or stratiform were selected, eliminating the minutes from the storms with intensities of less than 2 mm/h. For each minute of rain the following parameters were determined: *Z*, *R* and the size spectrum, together with the total momentum *p* and the total energy *E* of the drops.

FIG. 1: Study zone, in the city of León

IV. RESULTS AND CONCLUSIONS

By representing all of the minutes of rainfall indicated in the previous section, it may be seen that the convective storms are aligned following the equation curve $Z = 38.892\ R^{0.106}$ while in the case of the stratiform storms, these are adjusted to the equation curve $Z = 23.907\ R^{0.178}$ (Fig. 2). The equidistant curve for these two that is also shown in the figure may serve as a classification criterion of the rainfall.

Having found the threshold equation, the general database for the whole of the period studied was examined, and the minutes of rainfall were classified as stratiform or convective, using the previously developed specific equation for León (Fig.3).

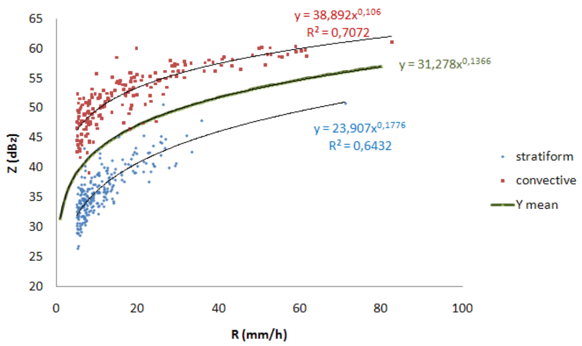

FIG. 2: *Z-R* ratio for selected convective and stratiform events recorded in the city of León.

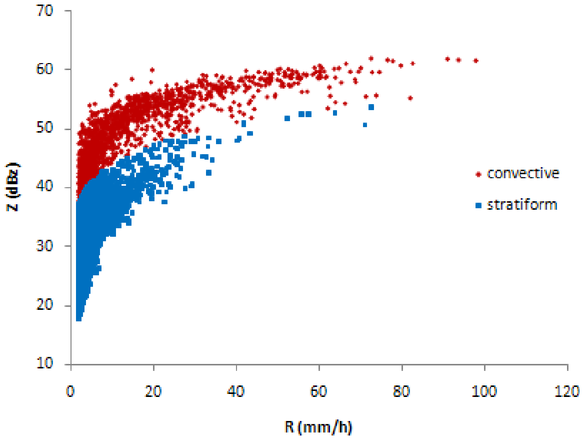

FIG. 3: *Z-R* ratio for convective and stratiform events recorded in the city of León.

In order to corroborate these results, the process was repeated with data from another weather station in the Iberian Peninsula, with very different rainfall characteristics. As may be seen in Figure 4, the discrimination between convective and stratiform rainfall is clearer.

The next step was to determine the kinetic energy and momentum of the raindrops corresponding to each of the minutes of rainfall recorded in the city of León. These were plotted to a graph in order to check if it was possible to identify a pattern of behaviour.

The result is shown in Figure 5. Here we can see two clouds of points aligned along two lines with very different slopes, one of which is some 5 times greater than the other. It would have been ideal for each cloud of points to correspond to each of the types of precipitation; however, as may be seen in the figure, this is not strictly true: in the cloud of points with the lesser slope, minutes of both types

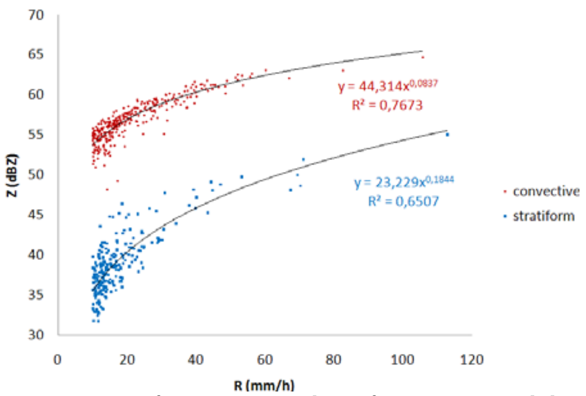

FIG. 4: *Z-R* ratio for convective and stratiform events recorded in another weather station in the Iberian Peninsula.

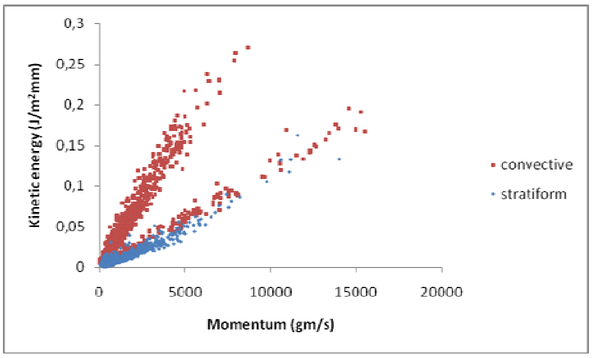

FIG. 5: Distribution of kinetic energy according to momentum for each minute of precipitation in León.

of rainfall coexist with an apparent predominance of stratiform precipitation. However, in the cloud of points with the steeper slope, only minutes of convective precipitation appear.

In conclusion, we can affirm that:

- The distinction between convective and stratiform precipitation, and in particular the Z-R ratio, depend on the pluviometric characteristics of the study.
- The energy-momentum ratio could be used to classify a rainfall event as convective or stratiform. In particular, if the quotient between energy and momentum is high, it could be unarguably stated that the event is convective.

An interesting subject for future work will be to analyse the characteristics of these minutes of convective rainfall which have not been discriminated using the *p-E* ratio presented in this study.

V. ACKNOWLEDGMENTS

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