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Hydrology and Earth System Sciences Discussions

Interactive comment on "Characteristics of 2-D convective structures in Catalonia (NE Spain): an analysis using radar data and GIS" *by* M. Barnolas et al.

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We believe that reviews are very constructive and do contribute to improve substantially the final form of the paper. Please find below an item-by-item response to all the comments (general and specific) provided.

«1) page 4708 lines from 10 on. The review of the rain cell models is quite generic and should be improved. It is not clear to the reader if the authors make specific reference to one of them for what concern the parametrization of the rain cells used troughout the work or if they are proposing a different one (see page 4716). The

author could benefit to have a look to the following papers: a) C. Capsoni, F. Fedi, C. Magistroni, A. Paraboni, A. Pawlina, "Data and theory for a new model of the horizontal structure of rain cells for propagation applications," Radio Science, Volume 22, Number 3, Pages: 395-404, May-June 1987. b) C. Capsoni, M. D'Amico, P. Locatelli, "Statistical properties of rain cells in the Padana Valley," Journal of Atmospheric and Oceanic Technology (JTECH), Vol. 25, Issue 12, December 2008 where the same issues have been already faced.»

Thank you very much for the reviewer comment, these references have been very useful and should be included in our paper. They have showed us similar studies as the presented in the introduction but with a different application. As the reviewer remarks, this paper is a first step towards the development of a complete rain cell model for hydrological purposes, where papers commented in the introduction have been used in order to research which kind of rainfall model is needed for our purposes. Some things (commented in the conclusions) are left for a future work. The principal difference between the present paper and the others commented is that rainfall entities are described under a meteorological point of view (as explained in comment 7). We will introduce the proposed references in the new version.

«2) page 4709 line 13. Why small (?) cells can be neglected? Could this assumption impact on the statistical results? Please discuss this point.»

We could add the following sentence: "This size threshold has been imposed in order to eliminate regions of anomalous echoes (small size) and to select the most important cells".

«3) page 4710 line 23. The radar database used in the study should be better introduced with emphasis on the pre-processing used to generate the rain maps. I am wondering if it is really possible to use data coming from a C band radar up to 240 km. As well known, the %GHz frequency suffers from non negligible attenuation due to rain, when crossing heavy rain (convective precipitation). My strong feeling is that long

range data are likely to be biased in many cases. (You "see" rain less/far less intense than the actual one or you could not see any rain)»

Because of signal and beam properties, the measure of precipitation is worst as far away is the echo from the radar. For the radars of C-band, as the one the Spanish Meteorological Agency placed closed to Barcelona which is used in this work, the range threshold for the Quantitative Precipitation Estimation (QPE) is 150 km. Using the long range product (until 240 km) it is possible to detect thunderstorms which are well-developed in the vertical. In fact, the center of the beam radar is placed at a height between 6 and 8 km (depending of different factors, such the altitude of the radar) when the distance to the radar placement is 240 km. For this reason, it results impossible to detect stratiform precipitation, and also, convective precipitation associated to orographic triggering (with developments not exceeding the 5-6 km). The analysis realized by Trapero et al (2009) with C-band weather radars in the same region showed that there practically no differences between results of short and long range product, when the QPE is compared with rain gauges values.

Ref: Trapero, L., J. Bech, T. Rigo, N. Pineda, and D. Forcadell, 2009: Uncertainty of precipitation estimates in convective events by the Meteorological Service of Catalonia radar network, Atmospheric Research, Volume 93, Issues 1-3, 4th European Conference on Severe Storms - 4ECSS, 4th European Conference on Severe Storms, July 2009, Pages 408-418

«4) page 4710 line 27. Where the 12 dBz value comes from?»

This value has been obtained using the Marshall-Palmer (1948) Z/R relationship. It corresponds to a rain rate value closer to 0.1 mm/h. In this way, reflectivity values underneath 12dBZ will correspond to rain rate values underneath 0.1mm/h.

«5) page 4711 first paragraph. Is the database used in this study statistically meaningful? This statement is not given in the paper. Does it represent a correct statistical description of the convective structures in Catalonia? If yes, please support this point.

This is a key issue; otherwise the statistical analysis that follows looses and meaning (see reference b) above).»

In the present study 5 years of data have been analyzed. Rainfall events with a high amount of total daily precipitation (60 mm/24 h at least in one rain gauge) are chosen, and 13472 convective cells detected. We think that this high amount of convective cells analyzed is enough to describe statistically the convective structures present in heavy rainfall events

«6) page 4713 line 4. The actual meaning of the parameter thickness is not clear. Please specify better.»

Thickness is the radius (in cells) of the largest circle that can be drawn within a structure without including any cells outside the zone. This parameter is not needed for the parametrization of convective cells, it has been calculated because it can be used to reject cells (very thick cells can be radar echoes). In our case finally none of them has been rejected for this.

«7) Sect. 5. The authors should give a clear analytical definition of the parameters (rainfall field, convective structure....) used to describe the rain cells by showing the relationships for their computation. Other authors use different parametrizations. (for instance Feral et al. cited in the introduction, seems to use a completely different parametrization from the one here proposed, but no mention of this issue was made)»

Some papers describe rain cells with respect to a rain rate threshold, where the rain cell is defined as the area inside which the rain rate is higher or equal to the threshold (as in the paper cited). In some cases this threshold implies high intensities (and then rain cells are assumed as convective cells). It the present paper convective cells are identified applying the 2-D algorithm based on Steiner et al. (1995) and Biggerstaff and Listema (2000), adapted to the Spanish region by Rigo and Llasat (2004). This algorithm considers three requirements, independent one from another. In the first requirement a reflectivity a threshold (43 dBZ) is applied. The algorithm also considers

two other requirements based on the nature of convective rainfall, with a high variability and a great gradient of reflectivity values between close pixels.

«8) Is equation 1 used throughout this study? »

It only has been used to obtain reflectivity value which corresponds to rainfall rate of 0.1mm/h. To obtain the rainfall field of convective structures it has been used equation 2.

«9) sect. 6 Is there any other similar study to which compare the results presented in this paper? The paper could benefit of it.»

From the point of view of the identification of convective cells for its parametrization with hydrological purposes we haven't found a similar paper. From the point of view of the parametrization of rain cells two papers consulted have been cited in the conclusions

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 4705, 2009.