P 5.16 Documentation of Convective Activity in the North-eastern Italian Region of Veneto

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1 INTRODUCTION

Forecasting thunderstorm activity during the convective season is one of the major challenges in the operational setting of the Centro Meteorologico di Teolo (CMT), the regional met service of the North-eastern Italian region Veneto. CMT has a relatively long tradition in using radar for monitoring convection, but a systematic thunderstorm climatology based on radar has never been constructed. The purpose of this study is to take a first step in filling this gap by means of radar imagery. More precisely, the records of the Storm Cell Identification and Tracking (SCIT) are exploited, an algorithm developed by NSSL and available in the Hydromet Decision Support System (HDSS) recently installed at CMT. Such a characterization of convective activity can be used as the basis for the evaluation of new generation operational numerical weather prediction guidance related to severe weather.

The CMT has recently installed the Hydromet Decision Support System (HDSS) supplied by Weather Decision Technologies Inc. HDSS is an advanced radar based decision support system, conceived as an integrated tool to extract maximum information from the weather radar data for nowcasting purposes. It incorporates the latest state-of-the-art in radar data analysis and is based in large measure on technology transfer from National Severe Storms Laboratory and McGill University of Montreal, Canada. The present study is focused on the Storm Cell Identification and Tracking Algorithm (SCIT), an important part of the HDSS system, and on its application to build a climatology of convective cells (Johnson et al (1998).

Whereas a number of studies exist that investigated the frequency of particular threats connected to severe convection like hail and tornadoes (e.g. Giaiotti et al., 2007, Tuovinen et al. 2006), this is not the case for the observation of the single convective cells, being themselves isolated or parts of a larger system. In the region of Veneto, several studies have been carried out that describe the areal distribution of rainfall amount but the same can not be stated for the convective activity. Likewise, the mean distribution of storm cells along the hours of the day and monthly/yearly variation of convective activity have never been objectively investigated in our region.

For the present study, data for the summer seasons 2005 - 2006 were analyzed in terms of distribution of convective activity in terms of presence of cells over the CMT radar domain. Section 2 contains a brief description of the methodology, while the final section documents the outcome.

2 METHODOLOGY

2.1 THE SCIT ALGORITHM

The SCIT algorithm, described in detail in Johnson et al (1998), uses 3D centroid identification and tracking. It processes volumetric reflectivity information from radar base data on a radial by radial basis. Three dimensional storm identification is performed in subsequent stages. First, storm segments are identified in the radial data. This process is repeated using seven different reflectivity thresholds (30,35,40,45,50,55,60 dBz). Then individual segments are combined into 2D storm component based on spatial proximity and finally 2D features are correlated in the vertical to give 3D storm centroid locations.

Storm cells identified in two consecutive volume scans (10 minutes apart) are associated temporally to determine the cell track. Figure 1 shows an example of cell identification and tracking. Each circle along the track corresponds to the position of the cell at each time step. Numerous storm attributes are derived with the

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SCIT algorithm, as Maximum Reflectivity, Probability of Hail, Circulation Type etc. As an example in the Figure the circles marking the centroid positions have been filled with a colour based on the value of the associated Probability of Hail (white < 30%, blue 30-50 %, red 50-75%, pink >75%).

2.2 THE REFLECTIVITY SCALE FILTER

The base radar data have decreasing resolution along a radial. This means that a storm close to the radar is sampled with a higher detail than far away leading to a more cells detections by the SCIT algorithm.
Thus, before passed to SCIT, the data are filtered such that the fine resolution reflectivity peaks at close ranges are smoothed out while the peaks at farther ranges are retained. This task is accomplished by use of a kernel of constant size (the "filter size"), centered on each data bin, so the number of azimuth bins within the kernel increases with decreasing range.

The impact of two different values of "filter size" (5 and 3 km) has been evaluated in individual cases and on the entire data set. Figure 1 shows that the 3km filter is able to identify many more cells than the 5km filter, particularly in the mountainous region and at longer ranges (see white arrows in Fig. 1). Figure 2 confirms this idea and reveals that the 3km filter 'sees' roughly twice as many cells as the 5km filter.

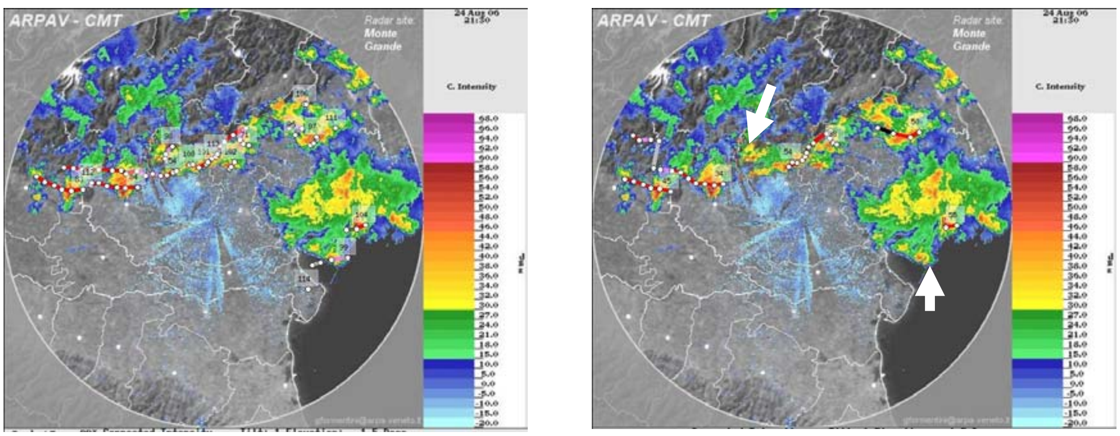

Fig. 1 Left panel shows SCIT analysis for 24 Aug 2005 21:30 with filter size parameter value 3km, whereas the right panel is for the same time with filter size 5km.

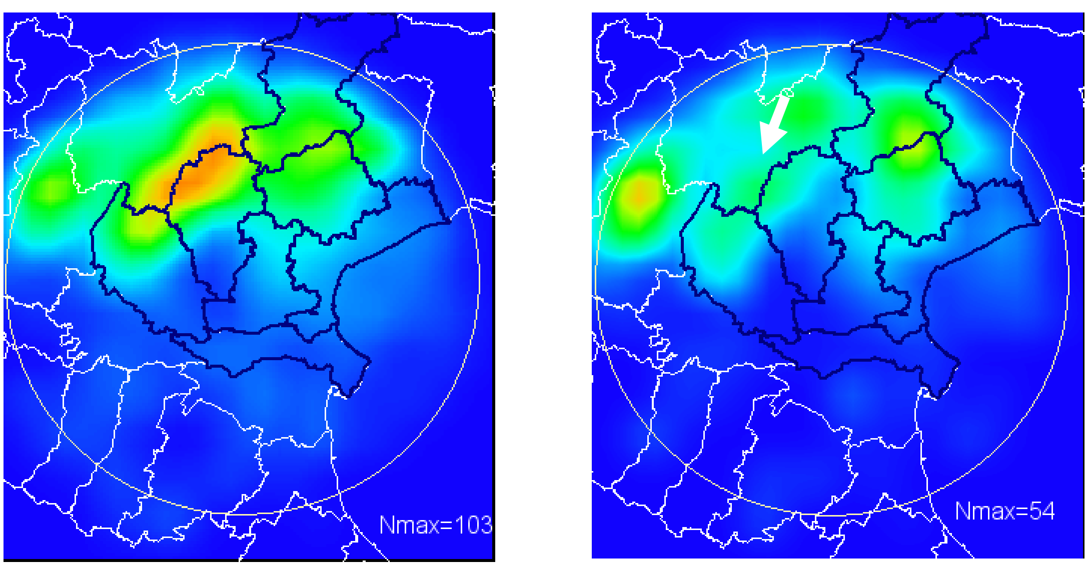

Fig. 2 Left panel shows SCIT cell density on a 0.2x0.2° lat/lon grid for the month of July 2006 with filter size parameter value 3km, whereas the right panel is for the same month with filter size 5km. Color scale is from 0 (blue) to 100 (red) and denotes the cell count normalized with the maximum number of cells in a grid mesh (Nmax).

2.3 BUILDING A DENSITY OF CONVECTIVE CELLS BASED ON THE SCIT ALGORITHM

SCIT cell detection counts were performed on a lat/lon grid with a mesh size of 0.2°x0.2°. For each grid element the count of the total number of SCIT detections, the cell density, for the warm season months (May-Sep) of 2005 and 2006 was performed. In order to investigate the preferred hours of the day for storm genesis, a histogram showing the number of first-time detections as a function of the hour of the day has been derived. A further histogram shows the monthly variation of the convective activity for different duration of cells as tracked by SCIT (duration < 1h, 1-3 h, > 3h). For each period of reference the cell density has been normalized, that is, divided by the maximum number of cells detected over the grid elements. This allows an easier visual comparison among maps of different cell densities.

3 RESULTS AND CONCLUSIONS

In the present study radar volumes for the summer seasons 2005 - 2006 were analyzed to document the convective activity in terms of presence of cells over the CMT Mt. Grande radar domain in the Veneto region of north-eastern Italy. In more detail, preferred times of the day, geographical distribution and tracks for convective activities were identified with the help of the Storm Cell Identification and Tracking (SCIT) algorithm developed at NSSL (Johnson et al. 1998) in dependence of the various months of the convective seasons. The main findings are summarized in the following:

a) The convective activity in Veneto was documented for the two warm seasons 2005 and 2006. The distinct maximum detected west and north west of the radar, located at the southern foothills of the Alps, agrees well with the general observation that convective storms often enter Veneto, moving slowly, from west and then undergoing an acceleration when propagating eastward and decaying.

b) Significant month-to-month variability can be detected. In particular, months with a predominance of thermal convection which then affects mainly the mountainous parts of Veneto (e.g. Jul 2006) are distinctly different from months where a synoptic influence prevails (e.g. Sep 2006).

c) Short-lived convection (lifetimes < 1h) increases from May to reach a clear maximum in August, while the time of the day with most pronounced convective activity seems to be in the afternoon to evening hours, the minimum, on the other hand, in the morning hours.

d) Tuning of the filter size of SCIT in order to overcome the cell detection bias close to the radar seems to call for a trade off between efficiency of detecting cells at longer ranges that occur in the mountains and over-counting cells close to the radar.

e) For the present study the 3km filter size was preferred to the 5km filter size in that it performed more reliably on a few distinct cases examined and missed less cells at longer ranges and, especially, over the mountains to the northwest. However, the cells count with the 3km filter size is roughly twice as high as with 5km, hence still may suffer from over-detection at closer ranges. This is consistent with the rather bell-shaped distribution of the two-warm season data set.

A validation of the SCIT in Veneto was performed on a case study basis. A more systematic evaluation is being performed with regard to the cell identification. The cell tracking, however, has yet to be examined in detail. This is important in such a climatological study as it provides information on the preferred genesis regions for convective activity and its growth and decay. Indeed, if a cell is not consistently tracked SCIT classifies a 'lost' cell as a newly generated cell.

4 REFERENCES

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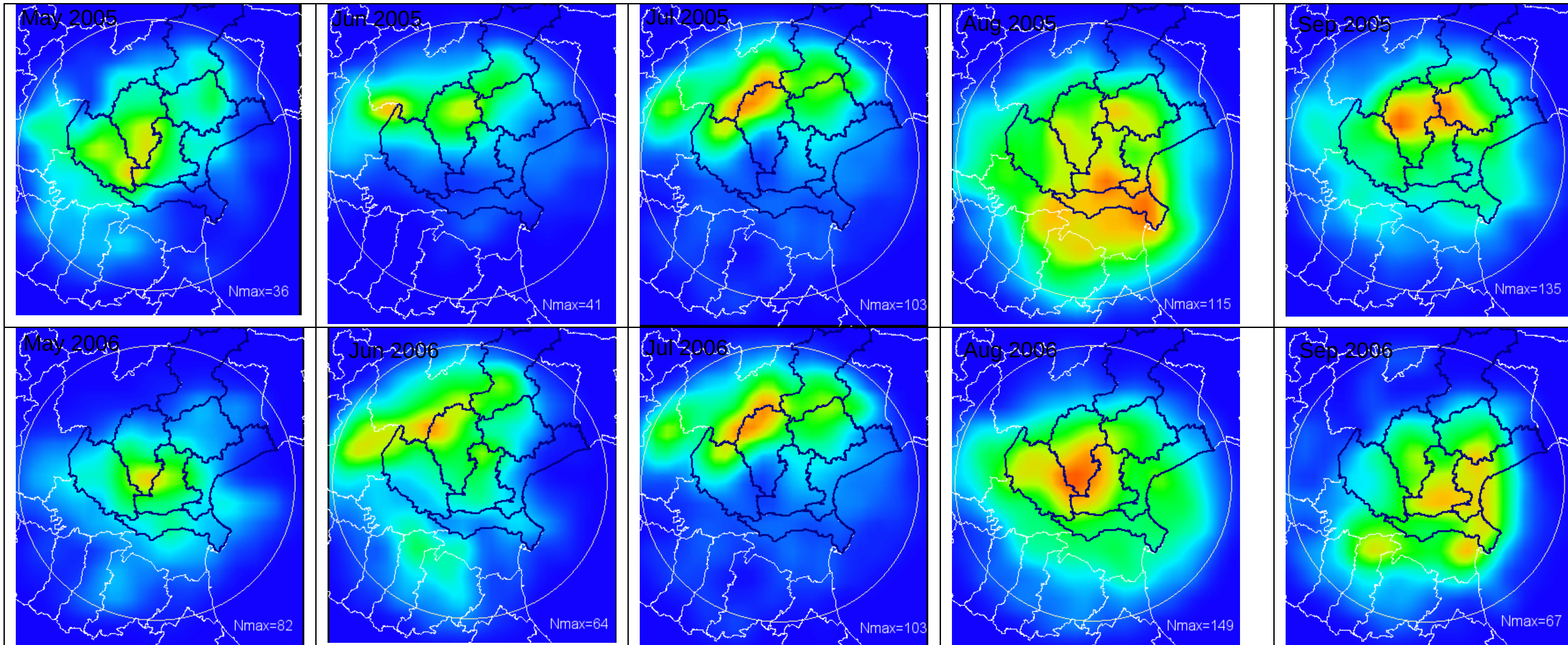

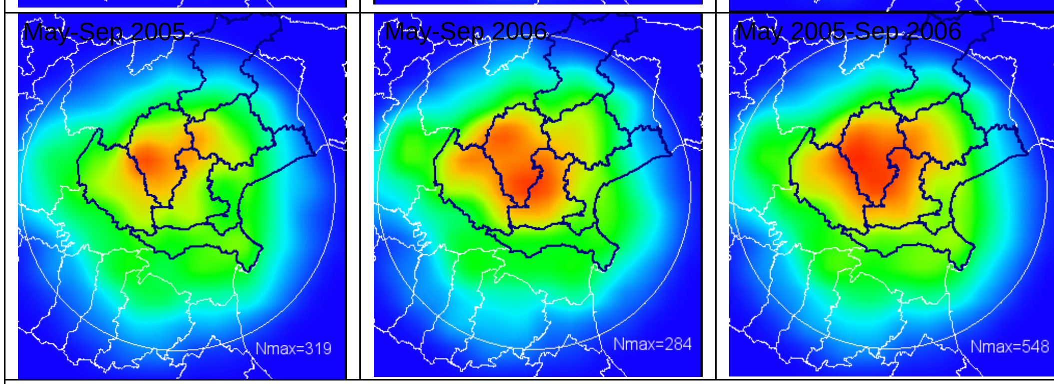

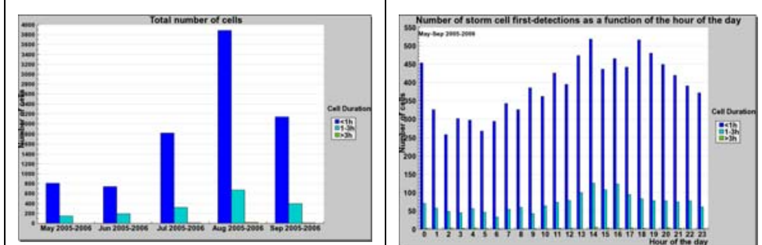

Fig. 3 Density maps (as in Fig. 2) for the individual warm season months 2005 (upper row) and 2006 (middle row), the entire warm season (May-Sep) 2005 and 2006, as well as both seasons combined (third row).

Fig. 4 Histograms , stratified according to different lifetimes (<1h, 1-3h, > 3h) of cells for the individual warm season months (left panel) and for the hours of the day (right panel), both for period 2005-2006.