Atmospheric Research 138 (2014) 268–277

Contents lists available at ScienceDirect

Atmospheric Research

journal homepage: www.elsevier.com/locate/atmos

Hail occurrence in Italy: Towards a national database and climatology

Marina Baldi [a,*], Virginia Ciardini [b,c], John David Dalu [b], Tiziana De Filippis [d], Gianpiero Maracchi [b], Giovanni Dalu [a,b]

[a] Institute of Biometeorology, IBIMET-CNR, Roma, Italy
[b] Fondazione per il Clima e la Sostenibilità, FCS, Firenze, Italy
[c] Present affiliation: Agenzia Nazionale per le nuove tecnologie, l'energia e lo sviluppo sostenibile, ENEA, Roma, Italy
[d] Institute of Biometeorology, IBIMET-CNR, Firenze, Italy

ARTICLE INFO

Article history:
Received 24 June 2013
Received in revised form 10 October 2013
Accepted 18 November 2013

Keywords:
Climatology
Hail
Italy

ABSTRACT

Although the effects of hailstorms usually interest limited areas, the damages can be severe. These, damages can be potentially reduced by a reliable hailstorm forecast. In Italy, only few regions have a network for monitoring hail events, the coverage of these networks is limited to small areas, and long-term and nationwide time series of hail events are not available, therefore the chances of improving the quality of the hail forecast are severely reduced.

The aim of the present study is to collect data and information from different sources on hailstorms in order to evaluate the annual hailstorm frequency in Italy. In order to obtain more complete information about the hail distribution, different datasets have been used: i) daily information about hailstorm occurrence at fixed meteorological stations from the NCDC dataset; ii) events information (date, location, and hailstone size) obtained using hailstorm reports available from different agencies. In this study the hail events are classified according to the hailstone size, then a statistical approach is used in order to evaluate the mean annual frequency of the events at the municipality scale for each hailstone size class. The atmospheric parameters, known as hailstorm precursors, are estimated using the NCEP/NCAR daily reanalysis at 2.5 degree horizontal resolution.

As a final result, this study presents a step forward towards a climatology of hail frequency in Italy at municipality scale for the period 1971–2009.

1. Introduction

Hail is a meteorological phenomenon which occurs in the mid latitude regions confined between the latitudes 30° and 50°. Since this latitudinal belt is rather wide, hailstorms can occur in quite different climatic conditions. In too cold or too warm climate, the atmospheric conditions are unfavorable: in cold climates, the limited depth of the cumulus clouds hinders the formation of hailstorms; while, in warm climate, the presence of warm air aloft weakens the chances of hailstorm development (Eccel et al., 2012; Hand and Cappelluti, 2011). Moreover, the hailstorm formation is related to the average position of the upper level jet and tends to be more frequent in the leeward side of the mountains (Eccel et al., 2012). Hailstorms do occur in most of the European Countries; specifically, in Italy, hailstorms are more frequent in its northern part (Berz and Siebert, 2000); although, severe episodes have been observed also in Lazio and Campania, i.e. in the Central-South Italy (see Fig. 1 for the boundaries of the Italian regions). These events often can cause injuries and/or can seriously damage crops, cars and buildings (Ruggeri, 2004). For their nature, hailstorms are rather localized and show a large spatial and temporal variability. Due to the absence of a nation-wide hail climatology in Italy, hail forecast is not an easy task, consequently, as of

* Corresponding author at: Institute of Biometeorology, IBIMET-CNR, Via Taurini 19, Roma, Italy.
E-mail address: m.baldi@ibimet.cnr.it (M. Baldi).

0169-8095/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.atmosres.2013.11.012

Fig. 1. Topography and regional boundaries of Italy. Regions are numbered as follows: 1 — Liguria; 2—Piemonte; 3—Valle d'Aosta; 4—Lombardia; 5—Trentino Alto Adige; 6—Friuli Venezia Giulia; 7—Veneto; 8—Emilia Romagna; 9—Toscana; 10—Marche; 11—Umbria; 12—Lazio; 13—Abruzzo; 14—Molise; 15—Campania; 16—Puglia; 17—Basilicata; 18—Calabria; 19—Sicilia; 20—Sardegna.

today, considerable damages to properties, crops, and valuable infrastructures, especially in densely populated areas, cannot be avoided. Hailstorm damage is usually proportional to the hailstone size and density (number of hailstones per unit area), and to the strength of the winds associated with the storms (Changnon et al., 2009). Since damages can be extremely severe, the burden for the insurance industry is considerable. Property damage is particularly severe when the hailstone diameter exceeds 4 cm; and, since vehicles can be already damaged by hailstones of just 2 cm in diameter, the burden on car insurers is even higher (Munich Reinsurance Company, 2008). Damages to crops range from limited loss to total yield loss, consequently, there is a substantial load on the National Solidarity Fund (Fondo di Solidarietà Nazionale, FSN); this institution operates in the country since the early 70s, largely contributing to the financial compensation for the loss in agriculture due to adverse meteorological events. Taking into account that rural Italian municipalities are quite small, an analysis done by FSN in North-East Italy has shown that, in the period 1990–2004, 226 hail events affected 1080 municipalities, therefore, in the average, each event affects about 5 municipalities (Politeo, 2008).

Several authors dedicated their interest to the damages produced by hailfall on crops, buildings and infrastructures as a function of hail size distribution and intensity (Changnon, 1971; Hohl et al., 2002; Omoto and Seino, 1978; and Seino, 1980). Several studies have shown that among all the available indicators, energy well correlates to crop damage (Vinet, 2001 and references therein). Hailpad networks are usually used for monitoring hailfalls, and the analysis of data collected has shown that the number of extreme events has increased in recent years. Recently many authors have shown that in Europe the number of extreme events has increased in the last decades as a result of climate change (Brunetti et al., 2001), with an increased interest and sensitivity of the people for these phenomena (e.g. Pielke, 2004). Therefore, there is an increased interest for those severe convective storms, which can lead to the hail formation (Sander et al., 2008). Recently Eccel et al. (2012) focused on the link between the atmospheric instabilities and the hail formation in Trentino Alto Adige (central-eastern Italian Alps). In their study, authors show a trend towards more "extreme" hail events, in terms of their intensity, expressed by energetics index, although no significant trend is found in terms of hail frequency or cumulative hit surface. Changnon et al. (2009) have emphasized the need of the prediction of the location and of the time of hail occurrence.

On the other hand, many studies have been focused on the importance of hailstone size: Schleusener and Jennings