GEOFIZIKA VOL. 8 1991

Preliminary communication
UDC 551.509.58

Some characteristics of convective cells in the Greek National Hail Suppression Program

Theodore S. Karacostas

Department of Meteorology and Climatology,
Aristotelian University of Thessaloniki, Thessaloniki, Greece

Received 30 April 1991, in final form 10 October 1991

The objective of this study is to provide first information on some characteristics of the convective cells observed within the Greek area. To meet this objective, a set of two years (1984–1985) of manually digitized weather radar measurements was used. The diurnal and interseasonal distributions of the maximum echo tops height of the convective cells are studied. Unimodal distributions for all the categories of convective cells are found except for those with tops between 12.0 to 13.5 km, which depict a binodal one. Finally, the life time of the convective cells, a very important factor for the better operations of the NHSP, is investigated. The resulting short-lived characteristics of the observed convective cells means that their probability to become potential hail producers is not very high.

Neka svojstva konvektivnih ćelija u Grčkom nacionalnom programu borbe protiv tuče

Predmet ove studije je dobivanje prvih informacija o nekim karakteristikama konvektivnih ćelija motrenih u području Grčke. U tu je svrhu upotrijebljen ručno digitalizirani dvogodišnji (1984–1985) niz mjerenja vremenskim radarom. Razmatrane su dnevne i međusezonske razdiobe maksimalnog odjeka vrha konvektivnih ćelija. Rezultat su jednomodalne razdiobe za sve kategorije konvektivnih ćelija, osim za one čiji su vrhovi između 12.0 i 13.5 km, koje opisuje bimodalna razdioba. Na kraju je istraženo vrijeme života konvektivnih ćelija, veoma važan faktor za bolju operativnost nacionalnog programa borbe protiv tuče. Rezultantne kratkotrajne karakteristike motrenih konvektivnih ćelija označavaju da njihova vjerojatnost da postanu potencijalni proizvođači tuče nije velika.

1. Introduction

Mesoscale convective storms are meteorological phenomena of great importance, since their manifestations are the damaging winds as well as heavy rain and hail, which are so often observed and experienced. It can be said that there is no »typical« thunderstorm, each one being unique in many aspects. Therefore it is not surprising that researchers and modelers meet difficulties while studying and trying to understand these phenomena.

Knowing the characteristics of convective cells and understanding the mechanisms of mesoscale convective storms is of great importance to several areas of atmospheric science, including weather modification, and a key component to any cloud seeding experiment. One of the primary scientific objectives of the Greek National Hail Suppression Program (NHSP) was to obtain a good knowledge of those characteristics and particularly of the maximum height and lifetime of the experienced convective cells. This information is fundamental for the success of the program (Karacostas, 1984), and moreover, for an improved design of a potentially more successful hail suppression program.

The objective of this contribution is to provide first information on the characteristics of the convective cells observed during the first two years (1984 and 1985) of the NHSP. To meet this objective, a set of manually digitized weather radar measurements was used. Diurnal and interseasonal distributions of the maximum echo tops height of the convective cells are studied. The lifetime of the convective cells, a very important factor for any weather modification program, is also investigated. It is defined here as the duration of the first echo observed.

2. The Greek National Hail Suppression Program

Following the progress of weather modification, a hail suppression program was started in Greece at the end of 1981 hail season, and went on during the 1982 hail season. The program was conducted solely as an operational cloud seeding effort, to reduce hail damage to an agricultural area of approximately 2000 km^2 in northern Greece. This program was conducted by the American company Atmospheric Incorporated and the French company Ruggieri. The experience gained during the two seasons provided information necessary to put forward, after a year of cease (1983 hail season), a new and considerably improved, randomized cross-over hail suppression experiment, known as the »National Hail Suppression Program«.

The Greek National Hail Suppression Program (NHSP) is the first weather modification program in the modern times of the Greek history. It began in 1984, and it was designed as an operational, and at the same time as a research, cloud seeding program. The main objectives were to reduce hail damage over three distinct agricultural areas in northern and central Greece, and simultaneously, to examine and study the thermodynamic, dynamic and microphysical characteristics of the potential hail producing clouds. This randomized cross-over design, being a »piggy-back« venture on the overall operational project, was highly desirable, because it provided the means for monitoring the optimal treatment for the given situation and conditions, and an opportunity to improve the meteorological understandings of the hail process present in this area of Greece (Flueck, 1976). The NHSP was carried out for five consecutive hail seasons, that is, from 1984 up to 1988. The exploratory stage covered the first three years, the confirmatory stage the last two.

The relevant background and the overall design were first touched upon in Karacostas (1984). An analysis of the first two years of the exploratory randomized cross-over experiment was presented by Flueck et al. (1986), while an overall picture of the NHSP was presented by Karacostas (1989, 1990). Detailed descriptions concerning the operations, data collection and analysis, preliminary evaluation, training procedures of Greek personnel etc., are provided within the Interim Report issued by Atmospheric Incorporated and Intera Technologies. The influence of the surrounding topography on the development of convective clouds within the area of the NHSP is presented by Karacostas and Ganniaris (1984).

3. Data analysis and discussion

The data analysed in this study were obtained from an S-band (10 cm) weather radar, being located at the Thessaloniki Airport, and used for the needs of the Greek NHSP. The operation of the radar system was manual. However, observations were made almost every 10 minutes during the 24-hour day. The hail period chosen for this study included May through August 1984 and 1985, resulting in a complete and adequate set of data observations, related mostly to the maximum echo tops height of the convective cells and their lifetime duration.

Figure 1 depicts the percent relative frequency distribution of the observed convective cells as a function of the ten classes of their maximum echo tops height, for the two-year hail season and for the two individual hail seasons. Since the sample sizes were not equal, the percent relative frequencies were preferable for direct comparison purposes. It is obvious that the two-year seasonal percent relative frequency line is skewed to the right, with a peak at the class of 7.5–9.0 km (MSL). The 1984 relative frequency line follows a similar course, indicating its peak at the same class. On the contrary the 1985 relative frequency line is almost normal, with a peak at the class 9.0–10.5 km. In spite of these differences, which indicate inhomogeneity between the two hail seasons, it is evident that the convective cells observed during the first two years of the Greek NHSP are not as well developed as those encountered during the National Hail Research Experiment (NHRE) (Foote et. al., 1979). In addition, it can be concluded that the less developed cells should also have shorter lifetime.

It is of some interest to investigate the frequency distribution of the convective cells as a function of their maximum echo tops height for the different parts of the day. By diving the 24-hour period into four parts, this objective is met in Figure 2. Although the sample sizes are different, the use of the percent relative frequency allows for direct comparisons. It is important to point out that the best

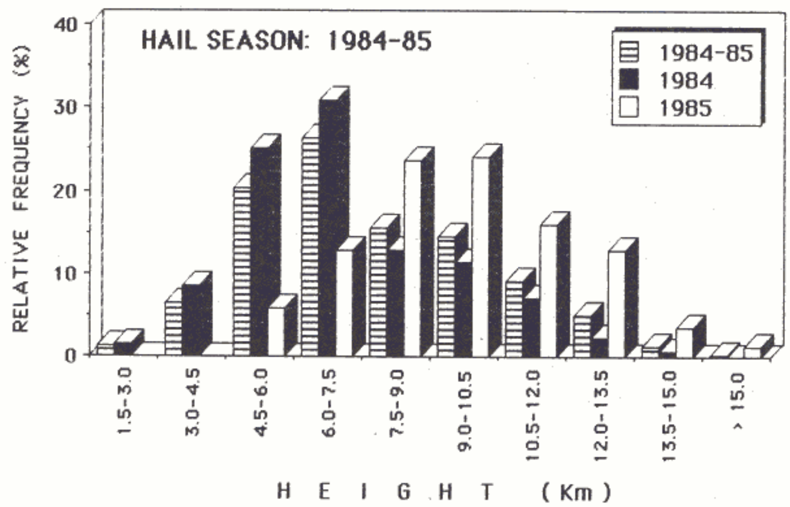

Figure 1. The percent relative frequency distribution of the observed convective cells, as a function of the maximum echo tops height.

developed convective cells are observed within the time interval of 12:00 to 18:00 local time, with second being the last time interval of the day.

The relatively high frequencies encountered at the classes 10.5–12.0 and 12.0–13.5 km (MSL) within the time interval 00:00 to 06:00 local time are probably due to cells developed during the previous day, which persisted after midnight. The diagram corresponding to the second part of the day indicates that almost 85 % of the observed convective cells have maximum echo tops height less than 9.0 km (MSL). By combining these four diagrams together it may be concluded that the majority of the convective cells occur during the third part of the day. This becomes obvious from Figure 3.

Figure 3 illustrates the percent relative frequency distribution of the observed convective cells as a function of the twelve classes of the hours of the day, for the two-year hail season and for the two individual hail seasons. Once again, the percent relative frequencies were used for comparison purposes. The two-year-seasonal percent relative frequency line, and the one corresponding to 1984, follow similar courses, as opposed to the one of 1985, which shows some differences at the classes 10 to 12 and 16 to 18 of local time. In spite of these differences, the three curves indicate negative skewness and reach their maximum frequency at the class 14–16 local time.

The percent relative frequency distribution of the observed convective cells as a function of their lifetime, is shown in Figure 4, for each of the five months of the hail season. It is obvious that the longer lived convective cells are those

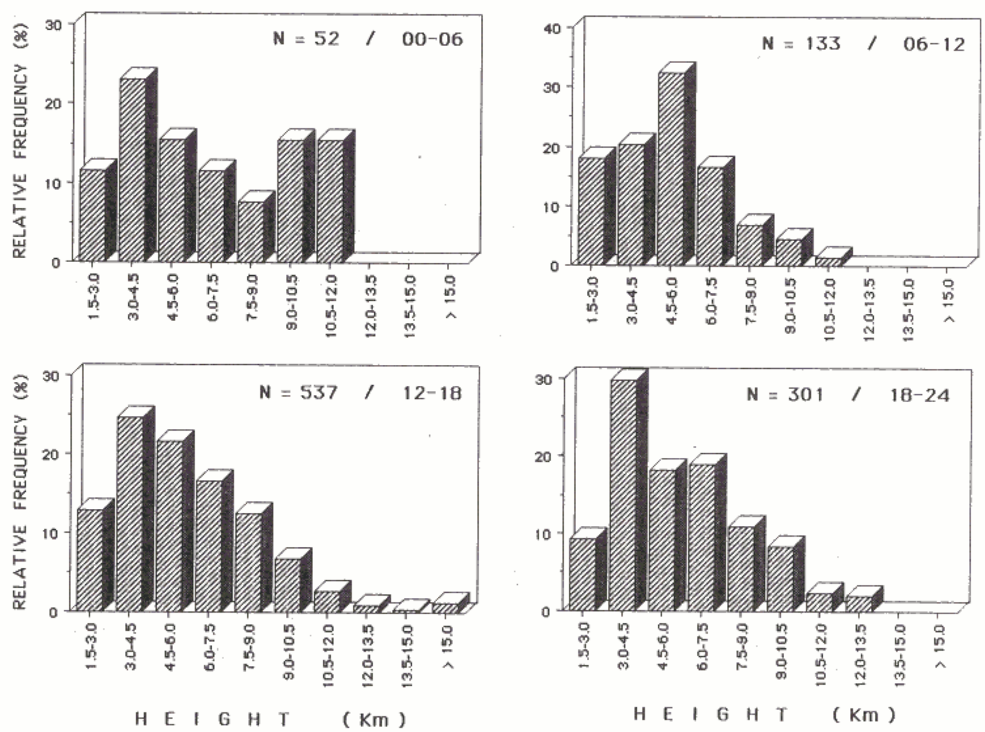

Figure 2. Frequency distribution analysis of the convective cells, as a function of their maximum echo tops height, for four different time periods of the day.

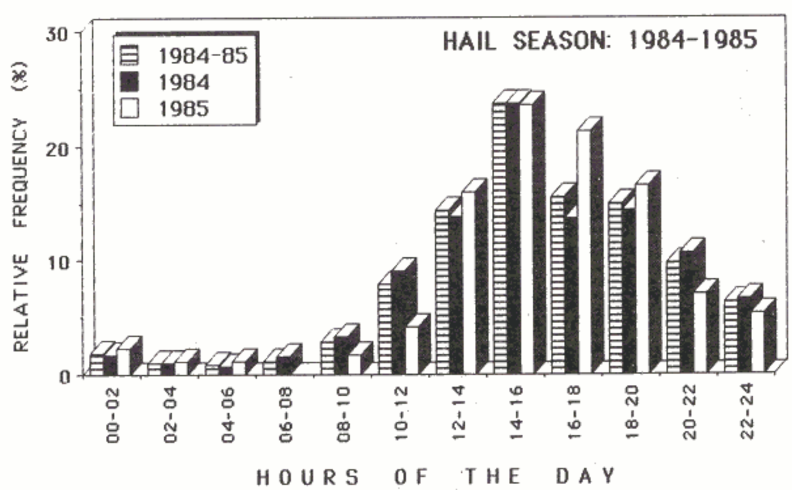

Figure 3. The percent relative frequency distribution of the observed convective cells, as a function of the hours of the day.

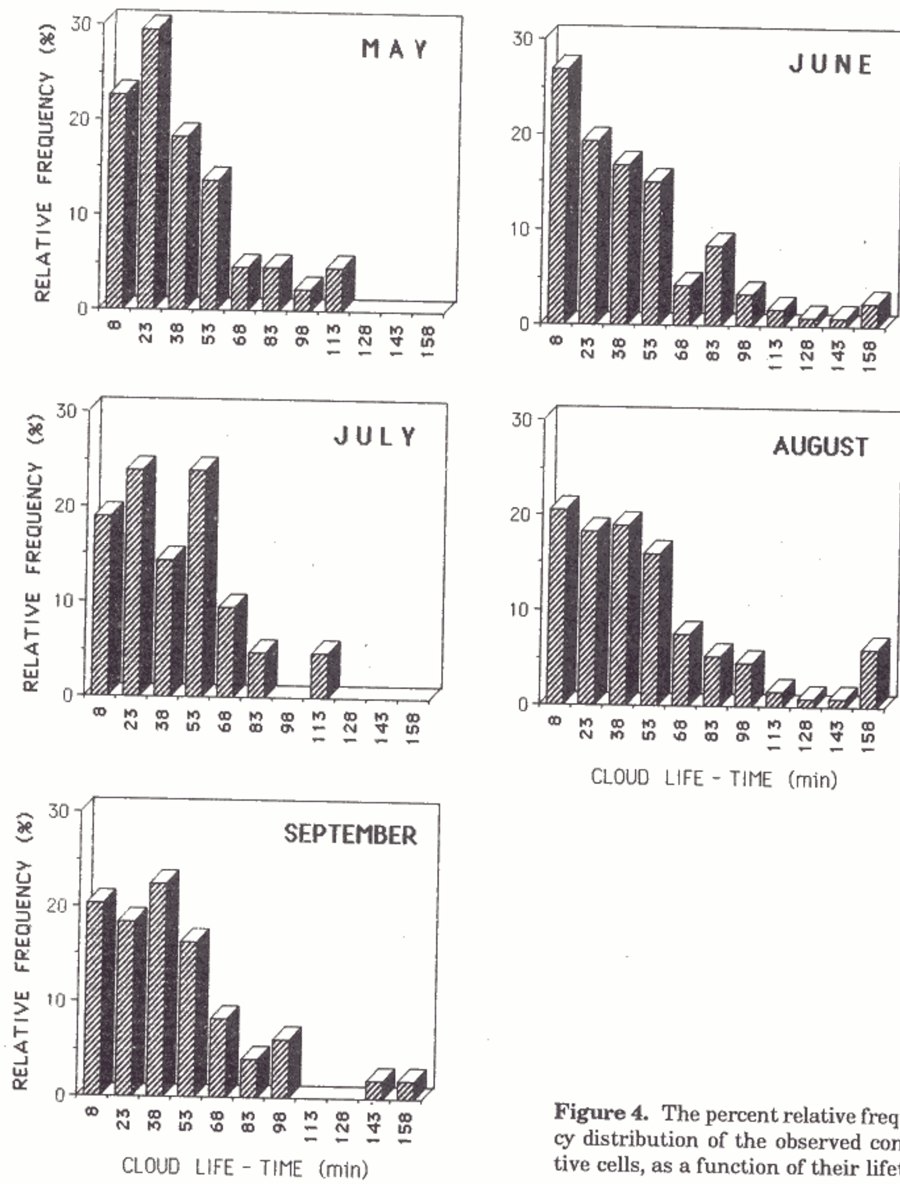

Figure 4. The percent relative frequency distribution of the observed convective cells, as a function of their lifetime

encountered during the months of June and August. This is probably associated with the fact that the most intensive hailstorms are encountered during the month of June, while the air mass storms are more frequent during the month of August.

July is considered to be the driest month, and hence the observed convective cells are short-lived. The month of September seems to incorporate some longlived cells. These cells are probably embedded to often observed stratiform clouds, and thus justify their tail end in the histogram.

Figure 5 depicts the diurnal distribution of the maximum echo tops height of the convective cells, observed during the first two seasons of the Greek NHSP, as a function of the time of the day. Considering each category of the maximum echo tops height separately, a unimodal distribution was obtained as is presented for the two categories: 6.0–7.5 km and 9.0–10.5 km. A bimodal shape diurnal distribution is indicated for the convective cells with maximum echo tops height between 12.0 and 13.5 km. This is probably due to the fact that these well developed cells, having longer lifetime, can last more, and thus extend their presence during the early morning hours.

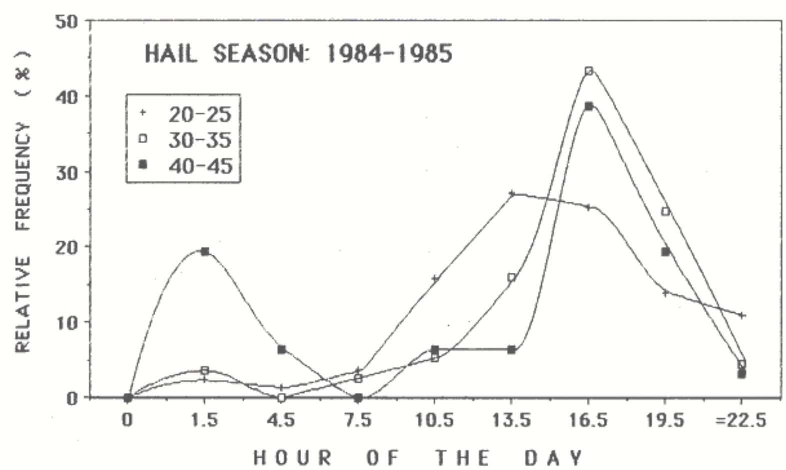

Figure 5. The diurnal distribution of the maximum echo tops height of the convective cells, as a function of the time of the day.

4. Concluding remarks

Some characteristics of the convective cells observed during the first two years of the Greek NHSP have been presented and discussed. In spite of the fact that the data consisted of manually digitized radar measurements, quite important conclusions can be drawn, which can considerably improve the operations of the NHSP.

It is shown that almost 70 % of the observed convective cells have maximum echo tops height below 9.0 km, while only 7 % of them reach beyond 12.0 km (MSL). This implies that the convective cells experienced in our area are not very well developed, and hence their potential to be hail producers is not very high, as opposed to those observed during the NHRE in north-east Colorado. On the other hand, most of the convective cells were encountered during the late afternoon and evening hours, when convection is heavily reduced. It is apparent that 47 % of the convective cells are well developed after 16:00 local time, while 16 % of them persist after 20:00.

The lifetime of the convective cells, as it is defined here, is quite short, which probably does not allow for major formations and developments, like those encountered during NHRE (Foote and Mohr, 1979), and the thunderstorms on the Transvaal Highveld of South Africa (Mader et al, 1986). This short-lived characteristic of the observed convective cells implies that the probability of these clouds to become potential hail producers is not very high, which probably represents an additional reason for the very promising preliminary results of the Greek NHSP.

References

Flueck, J. A. (1976): Evaluation of operational weather modification projects. Journal of Weather Modification, **8**, 42-56.

Flueck, J. A., Solak, M. E. and T. S. Karacostas (1986): Results of an exploratory experiment within the Greek National Hail Suppression Program. Journal of Weather Modification. **18**, 1, 57-63.

Foote, G. B., Rinehart R. E. and E. L. Crow (1979): Results of a randomized hail suppression experiment in Northeast Colorado. Part IV: Analysis of radar data for seeding effect and correlation with hailfall. Journal of Applied Meteorology, **18**, 12, 1569-1582.

Foote, G. B. and C. G. Mohr (1979): Results of a randomized hail suppression experiment in Northeast Colorado. Part VI: Post hoc stratification by storm intensity type. Journal of Applied Meteorology, **18**, 12, 1589-1600.

Karacostas, T. S. (1984): The design of the Greek National Hail Suppression Program. Proc. Ninth Conference on Weather Modification, American Meteorological Society, Park City, Utah, 26.

Karacostas, T. S. (1989): The Greek National Hail Suppression Program: Design and conduct of the experiment. Fifth WMO Scientific Conference on Weather Modification and Applied Cloud Microphysics. Beijing, China, 605-608.

Karacostas, T. S. (1990): Hail suppression in Greece. Weather Modification International Seminar. Palermo, Italy (In Press).

Karacostas, T. S. and C. Ganniaris-Papageorgiou (1984): The effects of mountainous topography upon the convective cloud development during the National Hail Suppression Program in Greece. Zbornik meteoroloških i hidroloških radova, Yugoslavia, No. 11, 55-58.

Mader, G. N., Neishlos, H., Saunders, M. M. and A. E. Carte (1986): Some characteristics of storms on the Transvaal Highveld. Journal of Climatology, **6**, 173-182.

Corresponding author's address: T.S. Karacostas, Department of Meteorology and Climatology, Aristotelian University of Thessaloniki, GR-540 06, Thessaloniki, Greece.