

HAIL RESEARCH WITH HAILPADS: A BIBLIOMETRIC REVIEW

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(Dated: April 27, 2007)

I. INTRODUCTION

Schleusener and Jennings (1960) developed the hailpad as a system for measuring hailstones that was both cheap and reliable.

Towery and Changnon (1974) described different types of hail detectors according to whether they were passive or could register data. In the study mentioned above these authors included *hailpads* (horizontal plates), *hailstools* (cylindrical sensors), *hailcubes* (formed by five sides of a cube), *hail-wind detectors* (for detecting wind direction), *Illinois recording hailgages* (for determining the exact moment and duration of a hail fall), *NOAA momentum sensors* (to determine the moment, but too sensitive to wind), *NHRE non-recording rain-hail separators* (separate rain and hail in two different containers), *recording hail-rain separators* (similar to the previous one, but keeping a register of the volume of rain and hail), and *geophone gages of South Dakota* (a plate which transfers the impact and the moment of the hail fall, and by means of a number of electrical circuits transmits a pulse according to the moment of the hail fall).

But of all the different types of hailpads initially designed, the only one that is still in use today, with small variations, is a simple horizontal plate of a sensitive material (Styrofoam or other similar materials) (Palencia et al., 2007). In some places the hailpad is covered with a thin sheet of aluminum (Colorado), and in some other places it is simply painted white, e.g. Spain and France (Palencia et al., 2007).

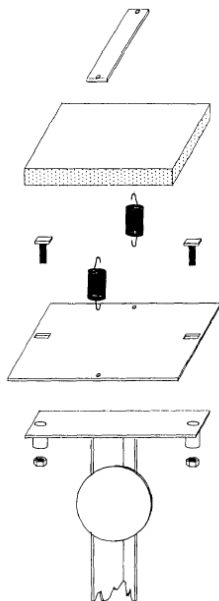


FIG. 1: Hailpad used in Spain (Fraile, et al., 1992)

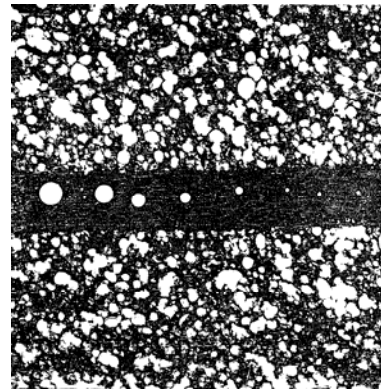


FIG. 2: Hailpad after a hail fall.

Figure 1 shows a hailpad used in Spain and Figure 2 a Styrofoam plate after having been exposed to a hail fall. A band in the middle has been reserved to throw calibration balls. The indents are in white and the whole surface of the hailpad has been painted black to increase the contrast and measure the hailstones more effectively. In some other places no part of the hailpad is reserved for calibration in order to expose a larger surface, and the calibration is done later on other plates of the same assortment.

II. BIBLIOMETRIC STUDY

Hailpad research has materialized in the form of a number of papers published in international journals. The database of bibliographic references employed has been one of the most prestigious ones: the Web of Science (ISI). The search was carried out on April 27th April de 2007. Among the $3 \cdot 10^7$ scholarly documents included in the Science Citation Index Expanded (SCI-EXPANDED) -1945 to present-, the searching engine located 41 containing the word "hailpad*", where the asterisk acts as a wildcard for any letter or group of letters. Of these, 30 were classified as articles, 5 as abstracts, 4 as notes and 2 as letters. These documents have been published in 10 different journals, although two are particularly recurrent: *The Journal of Applied Meteorology*, with 15 published documents and *Atmospheric Research*, with 13 articles.

A geographic analysis of these articles has been carried out in an attempt to determine in what parts of the world research projects were making use of hailpads. The results are summarized in Fig 3, with all the countries in which scientific articles of any type have been found on the study of hail by means of hailpad networks. It can be noted that European countries dominate, particularly countries with a Mediterranean climate.

It is interesting to analyze the evolution of research by means of hailpads. Figure 4 shows the number of documents published every decade from 1971.

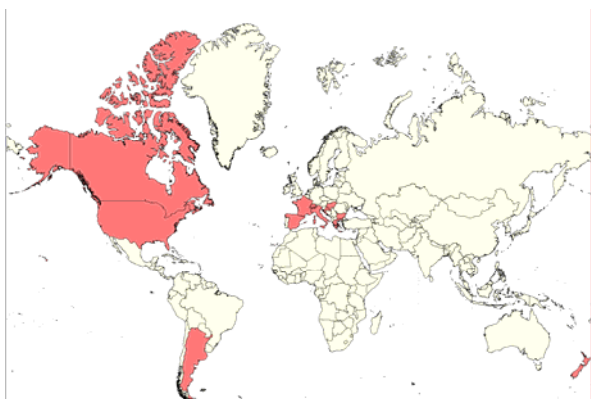


FIG. 3: Countries with hailpad networks or studies based on hailpad data cited in the bibliometric sources used

Various aspects need to be commented:

- With the exception of the first decade, with a strong initial boom of hailpad research, the other decades show a gradual increase in the number of publications.
- The line in the figure represents the rise in the number of publications: on average, there are two more documents every decade.
- The last decade included began in 2001 and has not finished yet. This, together with the fact that this is a time of more publications on hailpads, leads us to predict a strong boost in research in this particular field.

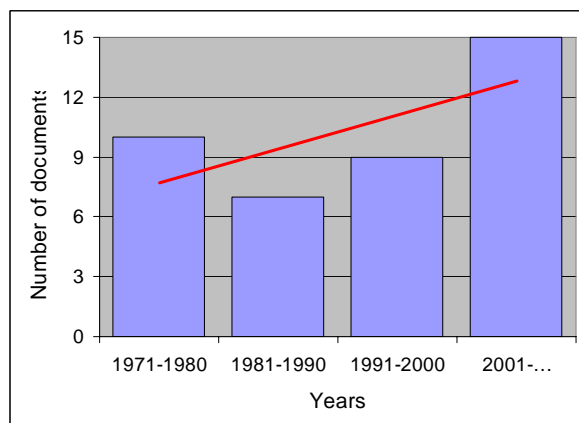


FIG. 4: Evolution of documents published per decade.

It is also worthwhile to consider briefly the main concepts dealt with in the documents published:

- The first stage (1971-80) is mainly devoted to describing hailpads (7 documents on calibration and errors in measuring with hailpads).
- From 1981 to 1990 we have 3 studies on the correlation between hailpad data and radar data, and there are also some articles on the application of hailpads in hail suppression activities.
- Between 1991 and 2000 we find that the three main research lines today are already defined: the support of atmospheric modification, climatic studies (sufficiently large databases are available), and purely meteorological-instrumental studies (relationship with atmospheric variables and accuracy of the measurements).
- The current decade is characterized by an increase in research using hailpads (in this decade we will pass from an average of one to an average of two documents per year) following the three lines of interest described in the previous point in almost equal parts.

Summing up, the research that is being carried out using hailpads is evolving towards an increasing number of projects, countries, and especially, papers published in prestigious scientific journals.

III. ACKNOWLEDGMENTS

The authors are grateful to Dr. Noelia Ramón for translating the paper into English.

IV. REFERENCES

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