

The production of patents related to snow avalanches and notes for the evolution of the production of knowledge around snow avalanches in a collaborative environment

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ABSTRACT: Scientific research on snow avalanches is relatively modern, yet in constant and rapid evolution, as the multiple disciplines involved in its development will, in turn, become more specialized and more technical. Patents are part of research and knowledge production.

The scientific community and policy makers are increasingly interested in the production of knowledge collaboratively.

Almost all of the research being conducted on snow avalanches uses some sort of technology, technique or instrumentation. One main objective of this study is to draw from the literature the many technologies, techniques and instrumentations that are being used in research related to snow avalanches. Thus, a textual analysis of the most significant literature in the field of snow avalanches was done. In this analysis, techniques, technologies and instrumentations have emerged.

A patent search has been done in databases. Subsequently, patents were conceptualized. The proportion of applicants for patents is higher in industry than in universities.

The measure of exploration of the ongoing sociocognitive transformations of science and technology systems present a useful tool to conduct a study to explore these transformations. It would be interesting for the scientific community, but also for the industry, to elaborate on Leydersdorff and Rafols methodology of concept mapping when applied to snow avalanche research, which would help in determining referents, in the determination of scientific collaboration and complementation in tracing the evolution of research both in universities, research funding agencies, and between the same themes or lines of research, as well as in the development of emerging research.

KEYWORDS: avalanches, patents, knowledge, conceptual map, technology, collaboration

1 INTRODUCTION

1.1 Patents

Based on a literature review of the concepts of dissemination of scientific knowledge, or the transfer of knowledge, between the scientific and patent or collaborative work between knowledge producers, we first have outlined a previous introduction to the current state of the patents in the field of knowledge.

There has been a search for patents related to snow avalanches and a descriptive analysis of the same. This search has defined patent categories and their time trends for the past 20 years.

Patents are part of research and knowledge production. Patents have advantages and disadvantages and some impact on the economy and society, Final report ETD/2004/IM/E3/77, 2006.

Complex interactions of science and technology between universities, public research institutions and industries does not follow a definite pattern, but depends on the organizations. As

for the publication of scientific results, lectures and technical bulletins play a substantial role in the dissemination of scientific results and technological patents by companies. In terms of methodology, patent citations presents gaps of traceability in interactions between science and technology. Tacit knowledge and other references appear in patents that are not documents set by the Science Citation Index (SCI), Bhattacharya and Meyers, 2003.

Furthermore, a study by Powell and Snellman, 2004, concludes that the scientific literature on the knowledge economy focuses much on production but poorly on the spread and impact of knowledge. Similarly, patents have become an appropriate stock of knowledge.

The interdependency of organizations, limited dissemination and the impact of knowledge are reflected in a study of Carayol and Matt, 2004a,b, who found that appropriate combinations of research staff can strongly influence productivity in publications and patents.

However, patenting capacity depends on the different scientific fields, Tuzi, 2005. In terms of

quality, there is a positive correlation between patent production and quality of the scientific product published in international journals mainly representing scientific research activity, Pavitt, 1988, quoted by Tuzi, 2005.

Analyzing interregional scientific collaboration as measured by scientific publications and patents, show the effects of geographical distance and institutional research collaboration. Elite structures were detected between regions of excellence and capitals regions, which may take into account the cohesion policies of the region and its policies on science, Hoekman, 2009. Physical distance and languages involved are a negative factor of scientific collaboration, despite the fact that a common language promotes intraregional collaborations. Europe is still far from being a fair field of collaborative research opportunities, Hoekman et al., 2010. As an example, the authors mention the life sciences and physical sciences as the most Europeanized, while engineering sciences and physical sciences both have a high level of regional embeddedness, and need a promotion of cross-border collaboration.

Entering the issue of international collaboration for knowledge production, intra-regional, interregional or international interchange are increasingly expanding through the use of participation in innovation networks by reducing the degree of uncertainty and providing different types of knowledge, including the tacit, Scherngell and Barber, 2009, cited by Gao et al., 2011.

There are different mechanisms for knowledge exchange: the patented invention and collaborative patent, technical collaboration between companies, universities and public research institutions, and the diffusion of knowledge and technology in enterprises adopting new technology and staff mobility between the public and private sectors. The scientific community and policy makers are increasingly interested in the production of knowledge collaboratively, Gao et al., 2011.

Some decision makers argue that universities are under-exploited in their potential for accelerating industrial innovation. The traditional incentive of scientific research, characterized by the sharing of knowledge, seems to give way to others, where the selection of projects drives onto the detriment of basic research. The increasing funding from companies can reduce the production in quantity and quality of researchers, but can also produce a positive impact on the quality of applied research, as measured by patent citations. This carries implications for po-

licy makers and funding authorities for investigation, which stimulates technology transfer between science and industry, and Hottenrott and Thorwarth, 2011. In another study, Hussler and Penin, 2012, distinguish two motivations adopted by researchers from universities in relation to patent: a proactive, enthusiastic motivation and a reactive one.

Parent and LeSage, 2012, analyzed the production of knowledge and patents from the spatial perspective, with conclusions on technology transfer, considering variables such as regional knowledge stocks: humans drive to innovate, scientific and technical capabilities, public and private investments, government policy and the regional structure and indicators of regional technological gaps. Regional growth in innovation depends on human resources devoted to the development of research studies and technology, as well as the spatial interdependence between regions aimed at innovation. European technological change is largely determined by the diffusion of interregional technology. Human capital levels stimulate innovative activity in a region, and increase the ability to leverage technologies from neighboring regions.

1.2 Technologies

Scientific research on snow avalanches is relatively modern, yet in constant and rapid evolution, as the multiple disciplines involved in its development will, in turn, become more specialized and more technical.

The proposals of Leydesdorff and Rafols, 2009 and Rafols et al., 2010, in measuring exploration of the ongoing sociocognitive transformations of science and technology systems using 2D representations of scientometric indicators, present a useful tool we propose to the scientific community to conduct a study to explore these transformations in sciences that study snow avalanches. It is a complementary tool in the contextuality of different lines of research and can aid in the management and research policy.

The number and diversity of sciences and technologies applied to the investigation of snow avalanches is profuse and confusing for the neophyte. A literature review based on the scientific literature shows that the use of multiple technologies began with some significance from the 80s but its development has been explosive during the first decade of this century.

On the other hand, some lines of research have been identified among the most relevant literature related to snow avalanches. This non-exhaustive list compromises areas of research

that are making progress in the scientific community, which are interrelated, forming a conceptual map of this highly multidisciplinary research (see poster ISSW 2013 by the same author).

It could be shown with further study how the interplay of disciplines grows as the use of new technologies are incorporated into the research.

The main objective of this study is to draw from the literature the many technologies, techniques and instrumentations that are being used in research related to snow avalanches.

Later, with the diversity of technologies found, we propose the creation of a map similar to Leydersdorff and Rafols to explore the transformations in the sciences that study snow avalanches.

Leydersdorff and Rafols maps help in: determining referents, determining scientific collaboration and complementation or research collaboration and by tracing the evolution of research both in universities, research funding agencies, industry, between the issues or lines of research and in the development of emerging research topics.

It is impossible to show here all the technologies, techniques and instrumentations that are involved in the various stages of research that the international scientific community investigates in snow avalanches, given the methodological limitations of this study. Moreover, some of those, because of their recent introduction or development, are in continuous development and evolution.

We present results from a textual analysis of the most significant literature found in the bibliographic database Web of Science (WoS) of research related to snow avalanches.

In this analysis, techniques, technologies and instrumentations have emerged related to research of snow avalanches.

2 METHODS

2.1 Patents

For our patent search we have used the database World Intellectual Property Organization (WIPO). The search period comprises between 1992 and 2012.

The search results have been filtered by the disambiguation of keywords used to search in English: "snow" and "avalanches". Content analysis is used to identify the topics that appear in the texts. We proceed to identify texts in an objective and systematic way, arranged in patterns to classify patents into categories. This analysis examines only the manifest content as they are strictly technical texts.

Subsequently, patents are conceptualized, grouping them into categories based on the common attributes they share.

The result of the database search gave 344 gross patents. The refinement process is a result of the analytical result. This led to a final amount of 165 patents, most directly related to snow avalanches, but some of them indirectly related because of their possible usefulness in the context of snow avalanches.

A) Refinement procedure on the first raw results, which implements the following criteria:

1 Date: publications after the first day of 1992. Patents eliminated = 24.

2 Relevance: Many patents appeared irrelevant by the polysemy of the search words. Patent removed = 155.

During the analysis we concentrated on the fields of patents database by following the following priority:

1st: title; 2nd: abstract; 3rd: full text content.

B) Analysis of the resulting patents by different criteria:

Classification of the 165 patents resulting from the refining of search categories: first conceptualization, then ranking not exclusive.

The analysis of trends over time category of patents.

The analysis according to International Classification code more abundant patent.

Analysis of the inventors based on their frequency of publication.

2.2 Technologies

The methodology establishes first a selection of information sources. It performs a search of scientific publications in the WoS database from the english keywords "snow" and "avalanches" between 1950 and 2011. Then we analyzed the 1254 results, sortable by the number of citations received.

Secondly we establish the criteria of content analysis, establishing the sequence of priorities

Patent classification by category

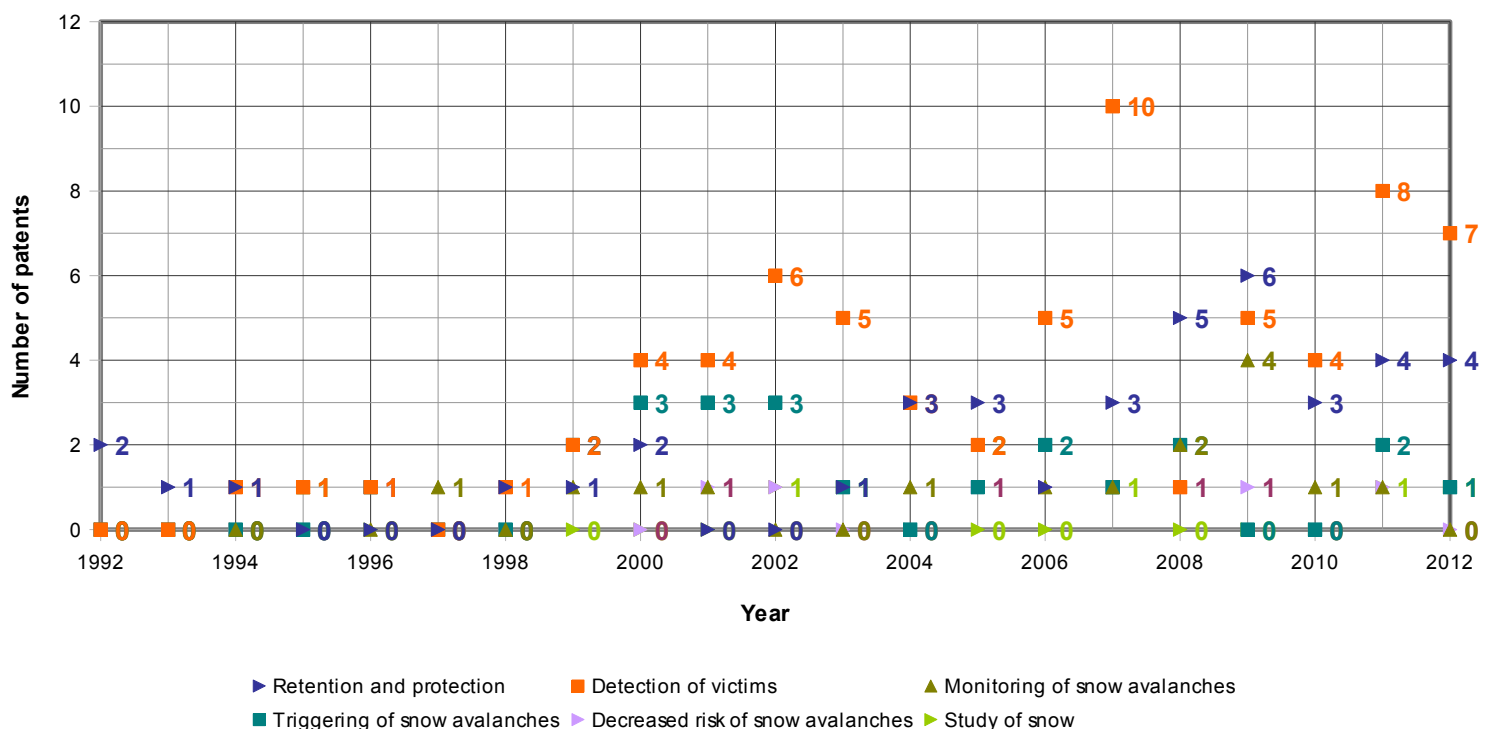


Figure 1: Classification by category and year of publication of patents related to snow avalanches, between 1992 and 2012.

1st: title and abstract; 2nd: full paper, when it is arranged; 3rd: title, in the absence of abstract and full paper.

Third, in a first analysis of debugging the search results of scientific publications we discarded irrelevant publications grouped in this study, either by the subject or for reasons of disambiguation. This group is composed of 201 publications discarded.

Finally, we separated techniques, technologies and instrumentations into categories, with their references associated.

3 RESULTS

3.1 Patents

1 Table purged of patents related to snow avalanches.

2 The categories of patents related to snow avalanches that have been generated, Figure 1:

- Retention and protection

- Detection of victims
- Monitoring of snow avalanches
- Triggering of snow avalanches
- Decreased risk of snow avalanches
- Study of Snow

3 Other results:

The analysis of trends over time of categories of patents.

The analysis according to the International Classification code more abundant patent.

Analysis of the inventors based on their frequency of publication.

3.2 Technologies

Almost all of the research being conducted on snow avalanches uses some sort of technology, technique or instrumentation. Despite of this, we have selected 98 outstanding publications in these areas.

The results are limited by the methodology used.

The various technologies, techniques and instrumentation categorized, could be grouped in a significantly lower number of families, and in turn establish the relationships between them in the practice of investigating snow avalanches.

However, we preferred to keep the list to not remove ungrouped details. They are:

Automatic acoustic detection, Chritin et al., 1996; **Automatic digital photography**, Christiansen, 2001; Tape et al., 2010; **Automatic Weather Stations**, Negi et al., 2007; **Avalanche dynamics models**, Buehler et al., 2011; **Decision trees and knowledge-based models**, Nares and Pant, 1999; **Digital image**, Latombe et al., 1997; Tape, 2010; Tsuda, 2010; **Digital scanner**, Buehler, 2009; Buehler et al., 2009; **Electronic sensors**, Henderson et al., 2004; Alippi et al., 2007; Andrae et al., 2009; Vilajosana et al., 2009; Techel and Pielmeier, 2011; Vilajosana et al., 2011; **ELF Extreme Low Frequency detection**, Cechak and Biolek, 2005; **Extended Kalman Filter**, Pinies and Tardos, 2006; Pinies et al. 2006; Vilajosana et al., 2011; **FMCW Radars High Frequency Microwave**, Gubler and Hiller, 1984; Marshall et al., 2007; Ash et al., 2010; **Gaussian sums Filter SOGS**, Pinies and Tardos, 2006; Pinies et al., 2006; **Geographic Information Systems**, Walsh et al., 1990; Barka and Rybar, 2003; Weibel et al., 2003; Fluera et al., 2005; Foppa et al., 2007; Tao, 2007; **GPS Global Position System**, Stepanek and Claypool, 1997; Shamshi, 2004; Schleppe and LaChapelle, 2006, 2008; Suter and Harvey, 2009; Klimanek et al., 2011; **High speed video**, Schaefer and Kern, 2009; **Images MODIS Moderate Resolution Spectroradiometer**, Negi et al., 2007; **Images X and Ku band satellite**, Wiesmann et al., 2007; **Impact pressure sensors**, Salway, 1978; Henderson et al., 2004; **Indices**, Kogelnig et al., 2011; **Infrasound**, Adam et al., 1998; Scott et al., 2007; Kogelnig et al., 2011; **Inverse analysis techniques**, Gauer et al., 2010; **Laser rangefinder**, Hood and Hayashi, 2010; **Low Frequency Radar penetrating earth (GPR)**, Jaedicke, 2003; Modroo and Olhoef, 2004; Heilig et al., 2008; Fruehauf et al., 2009; **Microtomography**, 3D computed microtomography X-ray, Schneebeli, 2002; **Microwave images**, Sharma et al., 2004; Mishra et al., 2005; Singh et al., 2006, 2007, 2010; **Microwave radiometry**, Macelloni et al., 2000; **Numerical models of stratigraphy**; **Numerical prediction models**, Egli et al., 2010; **Optical reflectance measurement wavelengths near infrared**, Satterwhite et al., 2003; Tape et al., 2010; **Optoacoustic Spectrometry**, Kapil et al., 2003; **Penetrometers and micropenetrometers**, Marshall et al., 2007; Satyawali et al., 2009; Andrae et al., 2009; **Phones with tracking systems**, Suter and Harvey, 2009; **Probabilistic models of avalanches**; **Pulsed Doppler Radar**, Schreiber et al., 2001; **Radar Images**, LISA, GB-SAR, Martinez-Vazquez and Fortuny-Guasch, 2006, 2007, 2008; Mardirossian, 2007; Brennan et al., 2009; Bueh-

ler et al., 2009; Wang and Brennan, 2009; **LiDAR**, Guan et al., 2008; Chrustek and Wezyk, 2009; Pershin et al., 2009; Singh et al., 2010; Buehler et al., 2011; **Rain gauge high precision**, Onacak and Yurur, 2007; **Remote Aviation small format (UASs)**, McCormack and Stimberis, 2010; **Remote Sensing**, Walsh et al., 1990; Buchroithner, 1995; Brandelik et al., 2002; Naugolnykh and Bedard 2002; Schmitt et al., 2002; Weibel et al., 2003; Sharma et al., 2004; Fluera et al., 2005; Rao et al., 2006; Foppa et al., 2007; Mardirossian, 2007; Tao, 2007; Wiesmann et al., 2007; Schaffhauser et al., 2008; Buehler et al., 2009a, 2009b, 2011; **Rescue transceivers**, Schweizer and Kruzi, 2003; Salos et al., 2007; Schleppe and LaChapelle, 2008; **Scanning electron microscopy**, Foster et al., 2006; **Seismic sensors**, Salway, 1978; Surinach et al., 2001; Shamshi, 2004; Hikida et al., 2007; Navarre et al., 2009; Valt and Pesaresi, 2009; Kogelnig et al., 2011; van Herwijnen and Schweizer, 2011; **Seismometers**, Navarre et al., 2009; **SLAM Simultaneous Localization and Mapping**, Pinies et al., 2006; **Snow microwave resonant “snow fork”**, Techel and Pielmeier, 2011; **Software**, Shultz and Albert, 1998; Andrae et al., 2009; Tsuda et al., 2010; **Space systems risk management**, Shamshi, 2004; **Spatial patterns**, Kronholm and Birkeland, 2007; **Statistical methods**; **Tachymetry**, Gubler and Hiller, 1984; Prokop et al., 2008; **Terrestrial Laser scanners**, Gubler and Hiller, 1984; Prokop, 2008, Prokop et al., 2008, 2009; Schirmer et al., 2011; **Time Domain Reflectometry**, Lundberg, 1997; Stein et al., 1997; **Time-frequency representations**, Leprettre and Martin, 2002; **Total Stations**; **Ultra Wideband Radar**, Denis et al., 2005; Lipkova and Cechak, 2005; Chamma et al., 2007; **Up Impulse Radar Systems upGPR**; **Virtual network models**, Egli et al., 2010; **Wi-Fi**, Vilajosana et al., 2009, 2011.

4 CONCLUSIONS

4.1 Patents

There is a significant increase since the year 2000 in the number of patents issued annually related to avalanches.

The victims detection category is the one that has increased most in the study period.

The triggering of avalanches category has a continuous presence since 2000.

The international classification code most often appeared is E01F 7/04 involving devices which provide protection against falling rocks and avalanches, eg. avalanche structures, galleries. The retention and protection category, that contains this classification code, is the

category most evenly distributed among all categories of patents. And it is holds the oldest patents in the study period.

Applicants for patents are both from research centers, universities, industries and individuals. But the proportion is higher in industry and lower in universities.

4.2 Technologies

The study of snow avalanches as a field of science is both multidisciplinary and multi-technological.

It would be interesting for the scientific community, but also for the industry, to elaborate on Leydersdorff and Rafols methodology of concept mapping when applied to snow avalanche research, which would help in determining referents, in the determination of scientific collaboration and complementation in tracing the evolution of research both in universities, research funding agencies, and between the same themes or lines of research, as well as in the development of emerging research.

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