EXPLORING THE POTENTIAL OF MOBILE PHONE DATA (CALL DETAIL RECORDS) TO TRACK AND ANALYZE BACKCOUNTRY SKIERS' DYNAMICS IN AVALANCHE TERRAIN

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ABSTRACT: This paper uses mobile phone data (Call Detail Record) to analyze backcountry skiers' dynamics in avalanche terrain. A case study is conducted in Andorra using data from February 2018. In this study, mobile phone data is combined with the Avalanche Terrain Exposure Scale (ATES) cartography to analyze the behavior of people in ATES zones. The analysis is delimited in Sorteny valley, in Ordino (Andorra), a popular zone with a large number of backcountry routes, and includes different episodes based on the avalanche danger level and meteorological conditions of specific days. Previous results quantify changes in terms of terrain selection of skiers in different avalanche danger conditions. This case study shows the value of mobile phone data to explore people behavior in mountainous areas and identifies some limitations in terms of data accuracy.

KEYWORDS: Mobile phone data, ATES, avalanche terrain, behavior dynamics, human factor

1. INTRODUCTION

Data from mobile phone operators have been used in recent years in a long list of areas. The most notable applications are in the fields of tourism dynamics (Ahas et al., 2007; Tiru et al., 2010; Girardin et al., 2009; Raun et al., 2016), smart mobility (González et al., 2008; Kung et al., 2014), transportation (von Mörner, 2017), public safety or land-use analysis (Soto et al, 2011; Mamei et al., 2016) and mainly focused in urban areas.

The most common format used in mobile phone data analysis is the "Call Detail Record" (CDR) in which mobile phone activities are recorded each time a user uses a service (i.e. calls, sms messages, 3G and 4G data). In general, CDRs include at least: originating and destination hashed phone number, location activity (i.e. geolocation or associated cell), date and time of the activity and its duration.

In mountainous zones, this type of data could be useful in different areas such as management of avalanche risk or inventory of the most used routes of freeride, backcountry ski or alpinism. To the best of our knowledge, no study has yet used CDR data to analyze mobility dynamics in avalanche terrain. Although there are still few studies to date on this topic, several research groups were recently working on this topic. In general, current studies use a combination of tools such as GPS-tracking, surveys, interviews or participatory online platforms to collect the data for the analysis.

Hendrikx et al. (2016) used GPS-tracking and internet surveys focused on cross-country skiers to examine travel practices, group dynamics decisions and demographic data of 500 users in avalanche terrain. Buhler et al. (2016) analyze data shared by users from Avalanche Canada's Mountain Information Network online platform to understand how backcountry recreational users use terrain based on various field conditions and based on avalanche danger ratings in the public reports. Hendrikx et al. (2014) tracked heli-ski guides during 18 days at Majestic Heli-Ski in South Central Alaska to understand decision making in avalanche terrain. A common limitation of these studies is the size and the duration of the sample due to the costs of data collection.

The present study uses CDR data to analyze backcountry skiers dynamics in avalanche terrain. The analysis is conducted in Sorteny valley, in Ordino, Andorra, with data from 1st February to 20th February 2018 and includes crosses have

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been crossed with other sources of information such as ATES cartography, the avalanche bulletins and weather conditions.

2. METHODOLOGY

The analysis presented in this paper combines data from CDRs, avalanche bulletins, meteorological information and ATES cartography. As a starting point, we count the number of people each day in Sorteny valley using CDR data and compare it with the avalanche bulletin and meteorological conditions. Then, crossing CDR data and ATES cartography, we quantify the number of people each day in each type of terrain. Finally, we analyze two episodes in more detail. Episode A (3th February) presents a day with moderate avalanche danger level (2) and “bad weather conditions” (snow and wind). Episode B (15th February) presents a day with high danger level (4) and “good weather conditions” (sunny day).

2.1 CDR data

The main data source used in this paper is CDR from the national telecom company (Andorra Telecom) from 1st February to 20th February 2018 (103.189 registers). This data is collected in a national scale, as there is just one Telecom Company in Andorra. In the first step of this study, we have filtered CDR data to limit the variables included in the analysis and focalize the zone of study. This is an important step to limit the size of the database. Figure 1 shows a sample of the resulting database. It contains information on anonymized user identification (id), timestamp (in UNIX time format), latitude, longitude and Mobile Country Code (MCC).

id	timestamp	lat	long	mcc
135	1517439600	42.54223	1.732572	234
170	1517439600	42.50396	1.521486	213
170	1517439602	42.50396	1.521486	213
252	1517439603	42.54873	1.497054	214
379	1517439600	42.54396	1.732851	208
379	1517439602	42.54396	1.732851	208
423	1517439600	42.53955	1.732694	214
562	1517439601	42.50531	1.513455	213
562	1517439603	42.50531	1.513455	213
902	1517439600	42.54129	1.733509	234

Figure 1. Sample of the database used in the analysis.

2.2 Meteorological data

Weather conditions are based on historic data from Sorteny meteorological station located at 2271 m.a.s.l. Available public data (temperature, wind and snow depth) have been complemented with solar radiation and precipitation measures from the Snow and Mountain Research Center of Andorra (CENMA).

2.3 ATES cartography

The Avalanche Terrain Exposure Scale (ATES) defines three terrain classes that describe the exposure of terrain to potential avalanche hazard (Statham et al., 2006). ATES has been recently implemented in Andorra and Sorteny valley is one the first mapped zones. In this paper, we use the ATES from Sorteny in a *shapefile* format in which the valley is divided by polygons identifying the type of terrain (simple, challenging and complex). This layer is crossed with daily CDR data to quantify people moving in each type of terrain.

3. RESULTS AND DISCUSSION

3.1 People in Sorteny valley

Figure 2 shows the number of people estimated with CDR data, the avalanche danger level and meteorological conditions in the zone of study from 1st to 20th February in a daily scale. Weekdays and weekends are represented in grey and dark grey dots, respectively. The resulting variability in estimated frequency of people in the valley is coherent with the expected dynamics of higher frequency on weekends during moderate (2) and considerable (3) danger level days and lower frequency during and after high avalanche danger level days and days with bad weather conditions.

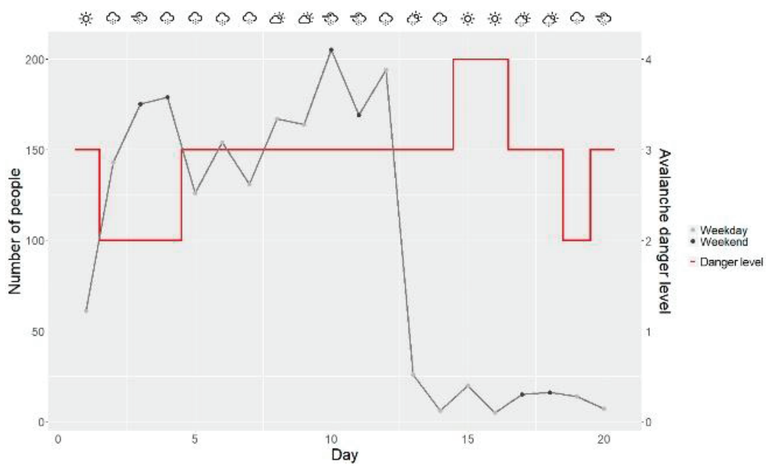

Figure 2. Daily frequency of people in Sorteny valley estimated with CDR data and avalanche danger during the period of study.

CDR data includes MCC field, which consists of three decimal digits to define the mobile country of origin. Thirty different nationalities have moved through Sorteny valley during the analyzed period. Table 1 shows some of them and the percentage associated with each nationality. During the period of study more than 70% of the people performing activity in the valley. Spanish and French are the second and third group with higher representativity (12% and 5% respectively).

Country	People (%)
Andorra	72.9
Spain	12.1
France	5.0
United Kingdom	3.8
Netherlands	1.3
Portugal	1.0
Belgium	0.4
United States	0.4
Others	3.1

Table 1. Share of people by nationality.

3.2 People in each type of terrain

The share of people in each type of terrain (i.e. simple, challenging and complex) is represented in Figure 3. It also includes meteorological conditions and avalanche danger level for the analyzed period. Share of people in simple, challenging and complex terrain remain rather constant during a period of continuous moderate (2) and considerable (3) avalanche danger with a predominance in challenging terrain even during changes of weather conditions. A change in the pattern is identified the 15 and in the following days when the avalanche danger was high (4) and many spontaneous avalanches occurred through all the country. After this episode most of the people stayed in simple terrain and the following days stayed mainly in simple and challenging terrain.

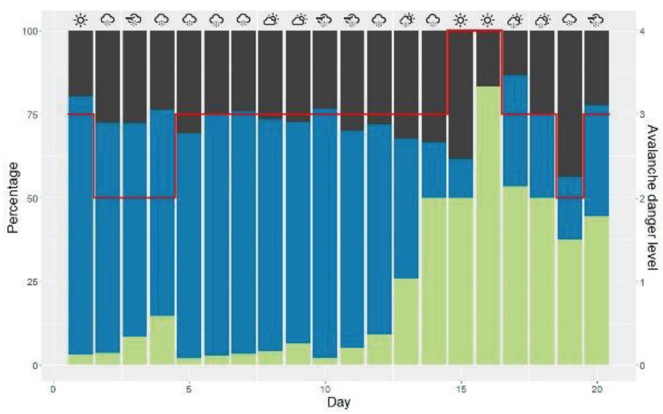

Figure 3. Daily share of people in each type of terrain and avalanche danger.

3.3 Episodes

As can be observed in Figure 3, Episode A (3th February) was a snowy and windy day with moderate avalanche danger (2). According to CDR data, people moved mainly in challenging and complex terrain being the challenging terrain with less exposition to wind the most frequented area during this day. Figure 4 represents ATES in Sorteny valley extruded according to the number of skiers in each type.

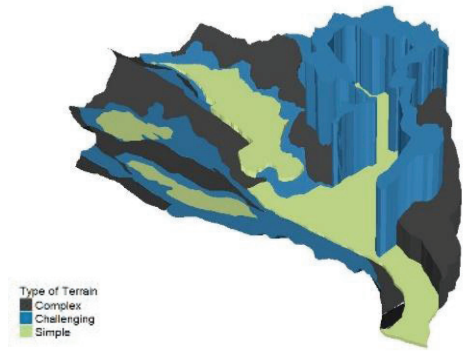

Figure 4. Extruded ATES by share of people in each type of terrain in Episode A.

Episode B (15th February) was a sunny day but with a high activity of spontaneous avalanches in all aspects. The avalanche bulletin at 8AM stated a moderate level but later was updated to a high avalanche danger (4). That day, people prioritized its movements in simple terrain (see Figure 5).

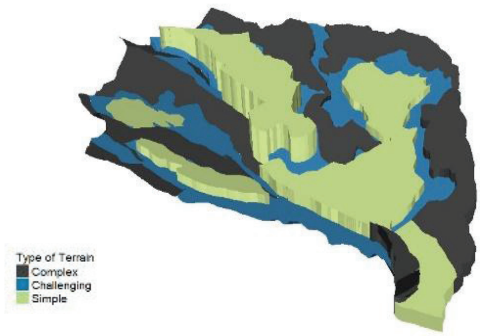

Figure 5. Extruded ATES by share of people in each type of terrain in Episode B.

4. CONCLUSIONS

This case study is presented as a first exploration of the use of mobile phone data in mountainous areas. CDR data can provide better knowledge about behaviors, decision making and circulation patterns in avalanche terrain. A benefit of this research is that data is collected passively, without the need to interact with users through a survey or tracking its activity via GPS. In addition, the duration (continuous records every 30 minutes and size of the sample used in the analysis can be higher than in traditional methods. Potential uses of CDR data in mountain activities research are numerous (i.e. study of circulation patterns, pre and post-accident analysis, design of prevention and educations campaigns for specific areas and behaviors, etc.).

However, nowadays the main technical limitation for the use of CDR data is the accuracy of geolocation. Theoretically, it is around 150 m in mountainous areas, higher than in urban areas as it is calculated using the antennas' signal. So, accurate tracking of the route cannot be achieved using this methodology. It is expected that the accuracy and quality of CDR data will improve substantially with future mobile phone generations. These data records can be a reliable source to be used in research with a need of higher spatial resolution and accuracy. On the other hand, no profile information is achieved from this source of data except the nationality. In order to characterize profiles of users, this data should be combined with a sample of surveys in order to identify in deep profiles and potential different behaviors and patterns based on these different mountain users profiles. With the combination of these two methodologies and the GPS tracking of some samples we could achieve detailed behaviors and patterns associated to different mountain user's profiles with a continuous and larger sampling of to capture the effect of factors such as weather conditions, avalanche danger or type of the day (weekend, weekday, holiday).

Further work will be devoted to combine these different methodologies in order to help in the validation of the accuracy of the CDR data and to improve the analysis of circulation patterns and dynamics in avalanche terrain and the influence of different factors such as the avalanche danger, the weather conditions and the type of the mountain user profile.

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