ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

RAPORTTEJA
RAPPORTER
REPORTS

No 2014:10

Analysis of user trends and behavior in online and mobile weather and climate services

ATTE HARJANNE

TIINA ERVASTI

Helsinki 2014

RAPORTTEJA
RAPPORTER
REPORTS

No. 2014:10

159.9
551.5.001.92

Analysis of user trends and behavior in online and mobile weather and climate services

Atte Harjanne[1, 2]
Tiina Ervasti[1]

[1] Finnish Meteorological Institute
[2] Aalto University School of Business, Department of Management Studies

Ilmatieteen laitos
Meteorologiska Institutet
Finnish Meteorological Institute

Helsinki 2014

ISBN 978-951-697-854-6 (pdf)
ISSN 2342-7108 (pdf)

Unigrafia
Helsinki 2014

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Published by	Finnish Meteorological Institute (Erik Palménin aukio 1), P.O. Box 503 FI-00101 Helsinki, Finland	Series title, number and report code Reports 2014:10 Date 2014

Author(s) Atte Harjanne and Tiina Ervasti

Title Analysis of user trends and behavior in online and mobile weather and climate services

Abstract

This report presents an analysis of the online and mobile weather and climate services provided by the Finnish Meteorological Institute (FMI). Weather and climate services are services and products that consist of information about the past, present or future weather or climate, or their impacts or possible adaptation or mitigation measures to manage these impacts. The user behavior of such services is analysed here based on statistics on user activity, and for climate services also on a web survey and a user workshop. The analysed services are FMI weather information web site, two mobile applications and climate information portal Climate Guide, and the data used is from 2009-2014.

Online weather services have an established role as a major source for information. A more recent trend is mobility, and mobile use of traditional web services and dedicated weather apps are becoming increasingly popular. Mobility enables more tailored and flexible use of weather services which results in differences in how the use is distributed according to the time of day.

The report also discusses the relationship between weather and online weather service use. This is analysed based on data for four Finnish cities and for two weather parameters (daily mean temperature and daily precipitation). The results clearly indicate that the use of online weather services is strongly connected to the weather. During winter months the relationship between daily mean temperature and service use is very apparent. During summer, precipitation seems to have a major impact on user rates.

Weather and climate services respond to very different needs, and this is reflected in their use. The use of online climate services is very small compared to weather services. However, the studied service, Climate Guide, manages to reach thousands of users every month. Although the service offers detailed information on mitigation and adaptation to decision makers, most of the users seem to be interested mainly in general, introductory information about climate and climate change. Climate related media events, such as publications of IPCC reports, are connected to increased user interest.

Publishing unit IKE

Classification (UDK) 159.9, 551.5.001.92	Keywords weather services, climate services, meteorological services, weather salience

ISSN and series title
0782-6079 Reports

ISBN	978-951-697-854-6 (pdf)	Language English	Pages 54

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Julkaisija Ilmatieteen laitos
(Erik Palménin aukio 1), PL 503
00101 Helsinki

Julkaisun sarja, numero ja raporttikoodi
Raportteja 2014:10
Julkaisuaika 2014

Tekijä(t) Atte Harjanne ja Tiina Ervasti

Nimeke Analyysi verkko- ja mobiilikäytöstä sää- ja ilmastopalveluissa.

Tiivistelmä

Raportissa kuvaillaan Ilmatieteen laitoksen verkko- ja mobiilipohjaisten sää- ja ilmastopalveluiden käyttäjätutkimusta ja sen tuloksia. Sää- ja ilmastopalveluilla tarkoitetaan tuotteita ja palveluita, jotka tarjoavat tietoa menneestä, nykyisestä ja tulevasta säästä ja ilmastosta sekä niiden vaikutuksista ja näihin vaikutuksiin varautumisesta. Tässä raportissa tutkimuksen kohteena ovat Ilmatieteen laitoksen verkkosääpalvelut, kaksi mobiilisovellusta sekä ilmastotietoa tarjoava verkkosivusto Ilmasto-opas. Näiden palveluiden käyttöä tutkittiin käyttäjätilastoiden, web-kyselyn ja käyttäjätyöpajan perusteella. Tutkimusaineisto on peräisin vuosilta 2009–2014.

Verkkopalvelut ovat vakiintuneet merkittäväksi säätiedon lähteeksi. Uutena trendinä ovat mobiilipalvelut ja verkkosivujen mobiilikäyttö, joiden suosio on kasvanut nopeasti viimeisten neljän vuoden aikana. Mobiilialustat mahdollistavat entistä räätälöidymmän ja joustavamman palveluiden käytön, mikä näkyy myös uudenlaisina käyttötottumuksina ja käytön jakautumisena vuorokauden aikana.

Raportissa käsitellään myös sään ja sääpalveluiden käytön yhteyttä, jota analysoidaan neljän suomalaisen kaupungin ja kahden sääparametrin (vuorokauden keskilämpötila ja sademäärä) osalta. Tulokset osoittavat, että verkkosääpalveluiden käytöllä on selkeä yhteys vallitsevaan säätilaan. Talvikuukausina lämpötilan laskiessa kävijämäärät nousevat selkeästi. Kesällä sateella näyttäisi olevan merkittävä lisäävä vaikutus kävijämääriin.

Sää- ja ilmastopalvelut vastaavat hyvin erityyppisiin tarpeisiin, mikä näkyy niiden käytössä. Ilmastopalveluiden kävijämäärät ovat hyvin pieniä sääpalveluihin verrattuna. Raportissa tutkittu palvelu, Ilmasto-Opas, tavoittaa kuitenkin tuhansia käyttäjiä kuukausittain. Vaikka palvelu tarjoaa yksityiskohtaista tietoa ilmastonmuutoksen hillintä- ja sopeutumistoimista päätöksentekijöille, suurin osa käyttäjistä on kiinnostunut lähinnä yleisluontoisesta ja taustoittavasta ilmastotiedosta. Ilmastoa ja ilmastonmuutosta käsittelevät merkittävät uutistapahtumat näkyvät kasvaneena kiinnostuksena Ilmasto-oppaan käyttöön.

Julkaisijayksikkö IKE

Luokitus (UDK)
7159.9, 551.5.001.92

Asiasanat:
sääpalvelut, ilmastopalvelut,
käyttäjätutkimus

ISSN ja avainnimike
0782-6079 Raportteja

ISBN 978-951-697-854-6 (pdf) Kieli englanti Sivumäärä 54

Table of Contents

1 INTRODUCTION

1.1 Background

Weather and climate have fundamental impact on the economy and everyday lives of people around the world. Climatic conditions define to a large extent where and how goods are produced and consumed and weather affects nearly every activity from flight routes to leisure time choices. Information on these conditions, provided by weather and climate services, enables people and organizations to manage related risks and exploit opportunities.

The weather and climate services may not include only provision of direct information about meteorological phenomena. For example Hallegatte (2012) includes warning systems into the services and Changnon & Changnon (2010) extends the services to weather derivatives and weather risk models. In an earlier paper, Dutton (2002) stated that the role of meteorological experts is broadening to include greater involvement in decision processes besides the forecasts. Similarly, this report defines weather and climate services as *services and products that consist of information about past, present or future weather or climate, their impacts or possible adaptation or mitigation measures to manage these impacts*. Such definition captures the idea that these services extend beyond mere forecasts and can include detailed, application specific support for decision making. Indeed the value of weather and climate information depends on its proper use and the largest potential for value-creating innovations may often not lie in the quality of information but in its use (Perrels et al., 2013). Because of this broader view the term weather and climate services is preferred here over the term meteorological services.

Weather and climate services are provided both by public and private actors. Traditionally, the public actors, namely academic institutions, international research organizations and national hydro-meteorological services (NMHS) have been responsible for the basic research, observation infrastructure and advanced modelling, while the private companies have had a larger role near the end user. The market structure and value network however vary greatly between different countries and use contexts. New technical and social innovations are also transforming the service market (Perrels et al., 2013). Already over a decade ago Dutton (2002) recognized the developing trends in the economy, noting that the timescales of interest are expanding both to shorter and longer periods and that weather and climate services are becoming more distributed, varied and more widely available as a consequence of advances in information and communications technology and broader demand. This development is already taking place. Products such as location-specific nowcasts and seasonal forecasts have been introduced to the market, open data policies have boosted the involvement of enterprises and broadened the supply of tailored services (Perrels et al., 2013) and the uptake of mobile devices and broadband has brought on-time, site-specific weather information to everyone’s pockets. It should be noted, however, that the situation is radically different outside the developed world, in countries where the lack of the funding, skill and infrastructure results in inability to offer reliable meteorological services (see e.g. Hallegatte, 2012), and the poor often have limited access to modern communications technology (see e.g. Yonazi et al., 2012). The penetration rates for many new communication technologies such as mobile broadband are however growing fastest in the developing countries (ITU, 2014) and there seems to be potential to use the resources existing in developed countries and new remote observation technologies (Poolman, 2014) to address the problem. Therefore, the gap might be narrowing in the future.

At the same time the market has been developing, the growing concern of the impacts of climate change has perhaps increased the interest towards weather and climate services. During the last decade or so, the emphasis of academics and decision-makers alike has shifted from focusing mainly on mitigation of climate change to more and more towards looking also at adaptation to its impacts. Weather and climate services can play an important role in this adaptation. Weather services support in preparing for the adverse impacts of weather, increasing the so-called adaptive capacity and enable short-term reactionary measures. Climate services support long-term adaptation and proactive measures. Climate information also has a key role in the mitigation policies, as the costs and benefits of different emission reduction schemes are evaluated.

The development paths of technology, society and weather and climate services are therefore intertwined. Technology enables new services, but the demand of services can also drive technological innovations due to induced innovation. In a similar way, the socio-economic development creates new needs for improved services, yet the services themselves can enable new livelihoods and behavior. The weather and climate services thus coevolve alongside other societal and technological development.

1.2 Aims, objectives and methods

The aim of this report is to give an insight on how the coevolution of technology, society and weather and climate services is taking place. It presents an analysis on the current use of mobile and online weather and climate services in Finland based on observations made of the services provided by the Finnish Meteorological Institute (FMI). While the study is limited to only few media and one country, it illustrates how new technology and new services go hand-in-hand. The rapid rise of mobile computing has had a profound impact on the use of weather services that can now be accessed easier and faster than ever. Online climate services provide a centralized, public source of diverse climate information in a format that has been available only for a short period of time.

This study analyzes the patterns and trends in the use of online and mobile weather and climate services. The focus is on end-user services, as the services analyzed provide well-developed end-user interfaces. Automatic, machine-to-machine service provisions, although offered by the case service provider, are excluded from this analysis. The research questions were formulated as following:

1. What are the typical use patterns of online weather services?
2. How has the mobility altered the use of online weather services?
3. How are online climate services used?

These questions were approached by analyzing the use of four different services provided by FMI:

- The weather service at FMI's official web site, www.ilmatieteenlaitos.fi. While the web site provides other information than just the online weather service, the local weather forecasts, weather warnings and long range forecasts cover over 95 % of all the traffic on the site.
- Mobile weather application provided by FMI. The application can be installed free of charge to any iOS, Android or Windows Phone and it provides localized weather forecasts and warnings.
- RainMan mobile application provided by FMI. RainMan is available on any iOS, Android and Windows Phone devices free of charge, and it provides graphical map of weather radar observations.
- Climate information portal Climate Guide (www.ilmasto-opas.fi) operated by FMI jointly with several other organizations. The web site provides information on past, present and

future climate and climate change in various formats including articles, graphs and interactive infographics. It also includes sections about mitigation and adaptation options to climate change.

These services are described in more detail in the following sections. All of the services are provided by the same organization (FMI), which is naturally a limitation to the analysis. Still, FMI is a leading provider of consumer weather services in Finland so the identified patterns are likely to describe the market also on a general level. The market situation is discussed more specifically in the following chapters, and limitations to generalization of results are discussed further below.

The empirical data consists of user statistics coupled with data on external variables such as weather, significant events, web-based user-survey and a workshop for the service users. The main source for data is the user statistics for the four services, which were gathered using Google Analytics, and analyzed in Excel and R. Google Analytics collects data on the visitors and their behavior on the web page, on the downloads and use of the mobile applications. Despite its limitations, Google Analytics allows diverse possibilities to sort out and filter the data. The data collection is based on cookies and can be disrupted in case cookies are disabled, if the user uses dome advertisement blocking software or certain privacy measures. The error caused by this was assumed to be negligible. Some of the data is also based on sampling, and not all of the margins of error are available. For these concerns, the datasets that were based on sampling were avoided if possible. All the cases in which sampled data has been used are specifically mentioned. The data was collected mainly from September 2009 to June 2014. Since there have been changes in the services during this time period specific, representative periods were chosen for different analyzes. Some exclusions and filtering of data (e.g. sorting out weekends from weekdays) was also done depending on the analyzed phenomena – these selections are described in detail as the observations are discussed.

The main variables studied in the user statistics were sessions and users of the mobile applications. Sessions are unique visits or use sessions that can include browsing of multiple sites or use of multiple features. Users are unique users that may start multiple sessions. Because the interface of Google Analytics changed slightly during the conduction of the study in some graphs the variable of unique site visits is given. For practical purposes, unique site visits are comparable to sessions. For business confidentiality reasons absolute figures are often omitted and relative figures are used instead.

Google Analytics mobile application data was only available on users with devices running iOS or Android operating system. To include the number of Windows Phone users in the overall estimate, data on the market shares of different mobile operating systems in Finland was obtained from StatCounter.com for the analyzed time period. The popularity of the application among different operating systems was assumed to be the same.

Additionally, a user survey and a workshop to reach the end users of the Climate Guide were organized. The user survey was conducted for the Climate Guide users via online questionnaire using the Webropol service between May 5th and 25th 2014. The questionnaire was promoted to all users of the service via a pop-up window between 5 May and 18 May 2014. It was also promoted on the news section of the web site and related social media accounts. The aim of the survey was to collect answers to the questions such as: Who are the users of the Climate Guide? How is the service used? In what form do they prefer to have the information? Have they found what they came looking for? How would they prefer to see the service developed? The questions used in the survey are given in Appendix A. The questionnaire received 77 responses, which is considered to be enough to make preliminary conclusions and key observations, but not enough for detailed statistical analysis.

The workshop was arranged at the Finnish Meteorological Institute 10 June 2014. The aim of the workshop was to gather together people representing different user groups of the Climate Guide and to collect qualitative feedback and new ideas about the service and its use. The participants were invited through existing networks. Altogether 20 users participated in the workshop. These participants represented diverse user groups including teachers, public administration, research institutes and non-governmental organizations (NGO). The workshop agenda is given in Appendix B.

1.3 Previous research

Studies on the online use of weather and climate information are scarce, but the topic has been touched by some research in Northern America. Lazo et al. (2009) conducted a large scale survey about the use and sources of weather services in the United States. The studies suggest that nearly everyone uses weather services and that people obtain weather information on average 3.8 times a day although this is considered a conservative estimate. The most common reason to obtain weather information is general interest; 85 % of the survey respondents identified this as the reason for the use usually, nearly always or more than half of the time. Still, specific need driven use (e.g. deciding what to wear and planning travel, outdoor and weekend activities) is also very prevalent. Most important weather variables are related to precipitation: timing, occurrence, place and type of rain were all considered more important than temperature. Typically users are interested in the weather of their own city or region (87 % of respondents stated that this is the case usually or always), and the peak hours of use are early morning and early and late evening. Lazo et al. (2009) also studied the sources of weather information. The survey was conducted in 2006, and the rapid technological changes since are likely to mean that the results do not reflect the use today. For example, 90 % of the respondents stated that they use a mobile device to obtain weather information rarely or never. For the web sources, the same figures were also somewhat high (48 % for National Weather Service web pages and 39 % for other web pages). Lazo et al. themselves noticed the ongoing change and suggested updating the results later on. The report is part a response to these identified research needs.

A more recent, although smaller scale study was conducted by Silver (2014) which looked into the use of weather information by general public by the means of survey and interviews in Canada. In this study, 40 % of the respondents used cell phone app to obtain weather information at least once per week. The web service of Environment Canada was used by 67 % of the respondents at least once per week and the web service of the Weather Network was used by 63 % of the respondents at least once per week. These figures are only slightly lower than for the traditional media channels, television and radio. In the study the respondents also had a strong preference for mobile and/or automatically delivered information, especially for watch and warning information.

There are also some studies on the use of online and mobile services in general. Hong et al. (2008) studied the behavior of mobile data service consumers in Hong Kong. They observed that of the attitudinal beliefs (perceived usefulness, perceived ease of use and perceived enjoyment), the ease of use is most critical to intention to continue the usage. This is somewhat contrary to the traditional technology acceptance model (TAM) (Davis et Al., 1989), which emphasizes usefulness. Based on other studies, Hong et al. speculate that this is due to the nature of mobile services, which are largely about saving time, varying location and convenience. Mobile users also typically have a broad selection of alternative services. Hong et Al. (2008) also compared the behavior between different service categories, and found out that in information services (including weather services) the effect of social influence on the decision to continue use is insignificant, whereas for communication and entertainment services the effect is clear. The information content services are suggested to be more appropriate for individual-centric purposes. .

1.4 Theoretical considerations

The essence of weather and climate services is communication. In the end, they are about delivering useful information for end-users to aid them in their decision-making. Thus, communication theory can provide useful tools to analyze the use of these services. Weather and climate information also has its own characteristics, mainly determined by the inevitable element of uncertainty. Online and mobile technologies enable new kinds of behavior and communication as well. Theoretical models and related to these topics are discussed in this section.

One classic model of communication was presented by Lasswell (1948), who described communication as answering to *who says what to whom, how and with what effect*. Thus the process of communication is built on five elements:

1. The source: the originator of the message. In this study, the weather or climate service provider.
2. The message: the information from the source. In this study, the information about weather or climate, or related guidance.
3. The channel: the means or medium used to deliver the message. In this study web or mobile services.
4. The receiver: the audience of the message. In this study can be general public or professional user.
5. The effect: The possible effects of the message. Largely out of the scope of this study, since the emphasis is on seeking and delivering information.

In the context of this study, the source, message and the receiver are defined, and the interest is in the channel and destination. A similar model of communication was also proposed by Shannon and Weaver (1949), who as mathematicians reflected the technological design of communication systems in their model. They however acknowledged three main levels of communications problems, which can be studied in a very broad sense:

1. The technical problem: How accurately can the information be transmitted?
2. The semantic problem: How precisely is the meaning of the information conveyed?
3. The effectiveness problem: How effective impact does the received meaning have?

It could be hypothesized that online technologies provide new solutions for the technical problem, but the implications of these technologies to the semantic and effectiveness problem are less clear.

The main deficiency in these linear models is that they don't include any bi-directional processes or distinguish hidden factors altering the message and its reception. Elements such as feedback and noise have since been introduced to communication models (see i.e. Rothwell, 2004). The main mode of feedback in online services is perhaps the continuation or discontinuation in the use of the service; only small percentage of the users ever sends formal feedback to the service provider. In the context of this study, the most important sources of noise are most likely psychological, such as biases and assumptions of users and semantic, such as unclear communication of uncertainties or difficult professional language in climate services.

In the weather and climate services studied here, the process of information seeking is essential. All of the users of these services have made a deliberate choice to seek the provided information. A generalized information search process (ISP) was suggested by Kuhlthau (1991), consisting of six steps: 1) initiation, 2) selection, 3) exploration, 4) formulation, 5) collection and 6) presentation. ISP approach is broad and covers information search from the point where the exact information being sought is not yet clearly defined. Such a process could describe the use of climate services well, but might not reflect clearly the use of weather services, which is assumed to be rapid and on-the-spot. For such, the simpler model from information technology domain presented by Sutcliffe and Ennis (1998) could be more descriptive. The model describes information seeking by four steps: 1) problem identification, 2) articulation of information needs 3) query formulation and 4) results evaluation.

One especially relevant theory in information seeking is the principle of least effort, originally coined by George Zipf in 1949 (see i.e. Case, 2005). In general, the principle states that individuals adopt courses of action that they expect to require least work on average. In information seeking, this means using easily accessible and available sources that they are aware of. That is, people have a strong tendency to prefer sources they are familiar instead of trying out new sources. These tendencies can lead to sub-optimal or non-rational behavior at least in the short term, since individuals minimize the effort instead of comparing costs and benefits of acquiring more accurate information.

Non-rational behavior patterns and biases introduce complexity and dynamism to communication processes. An example is selective exposure observed in many forms of communication. It has been known for long that people have the tendency to favor information that reinforces their existing stance and to avoid information that contradicts it (see i.e. Frey, 1986). This tendency is suggested to stem from the general goal of reducing dissonance proposed by the cognitive dissonance theory (Festinger, 1957). Selective exposure and confirmation bias are only some examples of observed biased behavior patterns. Kahneman (2011) presented a broad overview of the non-rational thinking processes and the general biases people tend to express in their decision-making. These are naturally reflected in the seeking and reception of information as well.

Besides biased behavior, another aspect adding complexity to communication is uncertainty. Uncertainty is endemic to all weather and climate services, especially when predictions of future conditions are made. Uncertainty hinders the value of information for decision-making. Based on broad range of case studies Pielke Jr et al. (2000) proposed conditions that need to be fulfilled in order for uncertain prediction to be useful. The five conditions are the following:

1. Predictive skill is known, so that users have a basis for calibrating the expected accuracy of predictions
2. Decision-makers have experience with understanding and using predictions
3. The characteristic time of the predicted event is short; predictions of events far into the future cannot be verified or learned from on the timescale of decision-making
4. There are limited alternatives to using predictions (such as carrying umbrella all the time instead of relying to predictions)
5. The outcomes of various courses of action are understood in terms of well-constrained uncertainties

How these conditions are met in online weather and climate services depends on the use case. In general, they are mostly met in weather forecasts, but not so much in the long-term complex climate services. Pielke Jr's conditions are quite strict and the direct implications to usefulness can be challenged. Even if these conditions are accepted to describe limitations of predictions, it does not necessarily mean that services that do not meet them – such as climate predictions – are useless. They can be used in non-predictive way, such as a basis for scenario construction or general risk analysis.

Another view on the requirements for information to be used in decision-making was proposed by Cash et al. (2002) who state that salience, credibility and legitimacy determine the use and usefulness of scientific and technical information for practical decisions. Salience refers to the relevance of information (i.e. exact timing of rainfall instead of predicted monthly precipitation). Credibility refers to the scientific plausibility and technical adequacy of the information and legitimacy connects the information to the actors and processes that produced it and whether these are considered fair and trustworthy. These are highly relevant factors for weather and climate services and may to some extent explain why weather services are routinely used by nearly everyone but climate services are still rarely sought after.

Traditionally, the value of weather services is modelled based on a cost-loss framework presented by Katz and Murphy (1997). The model is based on comparing costs of protection from adverse weather to losses resulting from it without protection. The value of weather services in this kind of analysis is directly dependent on its accuracy compared to baseline knowledge, or so called climatological information; how well can a weather forecast help avoid adverse weather without causing too expensive protection measures when they are actually not necessary (false positives). While the original framework was used to describe single weather events, it is straightforward to expand it to series of events or climate adaptation as well.

As discussed, communication is a complex process that involves many factors besides just the information delivered. This highlights the limitations of the cost-loss model as well. An alternative tool – called Weather Service Chain Analysis (WSCA) – to model the value of weather services was proposed in Nurmi et al. (2013). The WSCA tool is illustrated in Figure 1. WSCA describes the information decay stage by stage as the information is produced, communicated and put to use. Earlier studies have shown that the most cost-efficient improvements in weather services may lie not in the forecast accuracy, but in its delivery and use (see e.g. Perrels et al., 2013). This is essentially the justification for this study as well: Improved understanding of how these services are used enables making better services.

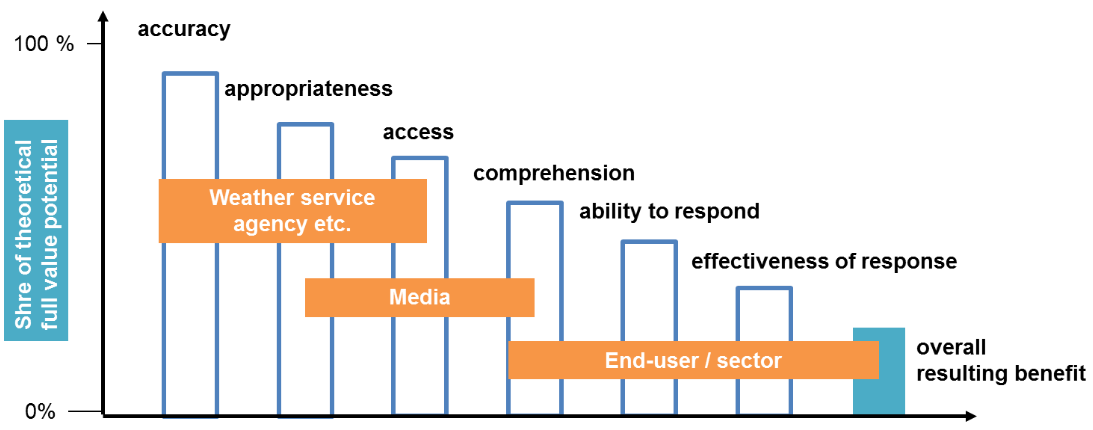

Figure 1: The Weather Service Chain Analysis (WSCA) – the realized value of weather information decreases compared to its potential as it is applied (modified from Perrels et al., 2013)

2 OBSERVATIONS: WEATHER SERVICES

2.1 Weather service market and trends in Finland

There are two main players in the Finnish weather service provision market. Despite the recent developments in the market, FMI is still among the leading weather service providers for end-users in Finland. The other main player in the market is Foreca, a private Finnish weather service provider. Together these two service providers cater the majority of both the end-user and re-user market. Additionally, there are several other suppliers of weather services in Finland.

Weather services are provided via practically all the different media from newspapers to television, radio and online (including mobile) services. Depending on the media, the value network may include one or more suppliers and re-users. In the traditional media – newspapers, TV and radio – the weather information is provided by a dedicated meteorological service while the media agency is responsible for the distribution. Many mobile and online services work with a similar logic. In some cases, the weather information is combined with other information to add value. Examples of such are mobile versions of newspapers that update the weather information according to user's location.

In traditional weather service chain basic weather information is produced by specialized agencies, mainly national hydro-meteorological services (NHMS) and international co-operative organizations combining them. This information is then refined by different re-users or directly used by the end-users. New trends in the market are the diffusion of meteorological expertise along the value chain and the increasing complexity or multi-channeled communication. The large media houses in Finland already employ their own meteorologists, and so do some of the large end-users as well. At the same time manufacturers of weather observation equipment are starting to provide observation services and weather data alongside private weather service companies with their own observation and modeling capacity. Another new development is the combination of several forecasters' data to provide end-user with a more detailed or diverse picture of the weather. An example in Finland is Supersää ("Super Weather") mobile app[1], which shows the user the forecasts from both of the leading weather forecast providers, FMI and Foreca, for comparison.

[1] see e.g. https://play.google.com/store/apps/details?id=fi.supersaafor the Android version (accessed 23.10.2014)

Traditionally the mass broadcast media has been the main source of weather forecast information. The public broadcasting company YLE approximates that its weather forecasts reach around 2 500 000 viewers and listeners every day[2]. Helsingin Sanomat, the largest newspaper in Finland, reaches 837 000 readers with their paper editions (Media Audit Finland, 2014). Helsingin Sanomat has a large weather forecast section on the back cover. These figures can be compared to the popularity of the online weather service of FMI. FMI web page has on average 280 000 daily users. There is strong variance, however, as on the quieter days the number of users is around 170 000 and on the busiest days it can reach over 500 000. Of all the site visits, over 95 % are directed to weather forecasts. Based on market studies conducted by FMI the user base of FMI's services reflects the demography of Finnish internet and mobile device users in general[3]. The mobile weather application has on average over 85 000 users[4] and its popularity is growing steadily. In addition, the RainMan weather radar application reaches nearly 40 000 users monthly. Since the popularity of competing applications is likely to be comparable to FMI's, the overall popularity of online services has likely already passed the printed media and might be close to the figures of traditional broadcasting. The difference is naturally that the online services are used proactively according to own interest or need, not passively according to timetables set by the media companies. Taking this into account it would be justified to claim that online services are the most important source of weather information for the general public in Finland. The approximated numbers of users for different weather service media are shown in Table 1. The mentioned Twitter account does not provide systematic weather forecasts but rather general updates and news about the weather, climate and meteorology in Finland.

2.2 Use of online services

As stated, the online and mobile services are on their way to becoming the most important source for weather information for the general public. In contrast to traditional media, online services enable more localized and on-time delivery of weather information. As the weather services studied in this report are not embedded into other services or interfaces, they also require user proactivity, implying that using them is a conscious choice.

[2] Personal communication with YLE representative, May 2013
[3] These studies are not publicly available.
[4] Approximation including all the operating systems

Table 1: Approximated average daily user figures for different weather service media in Finland (includes only direct weather forecast services, not highly refined applications). Due to different use patterns, the figures are not suited for direct comparison but give a sense of scale.

Media	Users	Sources	Date of the figure
Printed media	3 408 000	Media Audit Finland. Figure Includes 5 largest newspapers (Helsingin Sanomat, Aamulehti, Hufvudstadsbladet, Turun Sanomat and Savon Sanomat). Only print media included.	Year 2013
Television	1 600 000	YLE, Finnpanel	Year 2013
Radio	2 200 000	YLE, Finnpanel	Year 2013
Web services	605 000	FMI, TNS Gallup (Foreca users assumed to be 1.2 times the FMI users, based on a sample of two weeks: 1/2014 ja 26/2014)	Based on years 2013 and 2014
Mobile applications	88 000 (FMI weather app) ~ 200 000 (all)	FMI, Google Play	Based on 2014
Twitter (FMI)	50800	Twitter	July 2014

The recent development of online and mobile user rates can be seen in Figure 2, which shows monthly user figures from January 2010 to June 2014. It shows that the overall popularity of the web service has remained on approximately the same level, but growing share of users use the service on mobile platforms (the orange line includes both mobile phones and tablets). In 2013, mobile use accounted for a quarter of the use of web site. The use of mobile applications has grown steadily since their introduction, but this use seems not to have impacted the popularity of the web services. Thus their use seems complementary. There is strong seasonality in the use of online weather services. The user rates are higher in the summer compared to winter. This may be explained by the fact that during summer there are more people engaged in weather dependent activities, although there are many popular wintertime activities that are very sensitive to weather conditions (such as cross-country skiing). The increase in use during summer is especially true in the case of mobile use, which sees a high rise during summer months. A possible reason is the holiday season, during which many Finns are traveling or spend time at their summer cottages, where they might not have their desktops and laptops with them. The use of mobile applications is also seasonal, although in the figure this is obscured by the general growth of the use. Besides seasonality, a large share of the deviation in user rates is highly dependent on variables such as the weekday and weather conditions, as is explained in section 2.3.

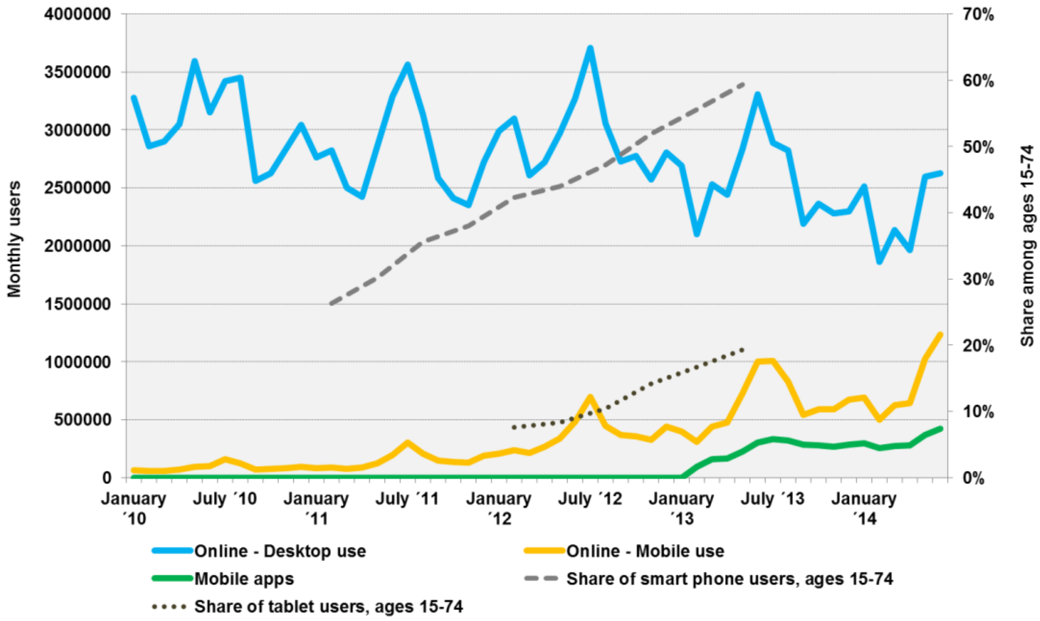

Figure 2: The monthly user rates for FMI's web site and mobile services. Laptops are included in the desktop use and tablets in the mobile use. (Source for the shares of tablet and smart phone users: Statistics Finland, 2013)

The dotted lines in Figure 3 present the share of Finns between 15 to 74 years of age that own a tablet or a smart phone. As can be seen, the diffusion of mobile technology has quite directly altered the user behavior of online weather services. This is no surprise, since the nature of weather information is such that the temporal and spatial accuracy and mobile usability add great value. This means that the weather services are quickly adapted to new platforms that enable more refined information dissemination. Thus the trend of increased mobile use is likely to continue, as these devices diffuse further. There is also some indication that the popularity of TV weather forecasts has declined during the last 5 to 8 years although the time spent watching TV has increased slightly (Finnpanel, 2014). However, the publicly available data is too scarce for strong conclusions.

The most popular month in the weather service is July, when the amount of users is around 15 % higher than on average. July is followed by June, August and May, in that order. During the winter, the most popular month is February when the user figures are near the annual average. Most of the Finnish schools have their winter holidays during February. Spring and fall months see the lowest user traffic. The use rates also deviate during the week. On weekdays, the number of users is around 17 % higher than on week-ends. The hourly distribution follows the daily activities. The hourly analysis is elaborated below in section 4.4.

Interestingly, the service use differs between different cities and regions. The quality of geographic information about the users attained from Google Analytics was not high enough to be useful, but local weather forecasts are separated into different sites (i.e. www.ilmatieteenlaitos.fi/saa/**helsinki** for Helsinki) so the user statistics from these sites can be used to approximate where the service is used. In general in the Northern regions (Oulu and further north, but also Jyväskylä) the user rates are highest during winter, as opposed to the summer peaks in the south. This is likely to reflect the higher importance of winter activities in these areas.

The user rates were also compared to the size of population. It seems that the online weather service are used significantly more in smaller cities and rural areas compared to the capital city, Helsinki. Whether this is because of the larger role of weather dependent economic activities or some other reason, such as higher market share of FMI's service, cannot be interpreted from the data.

Vast majority of the service users are interested in local short-range forecasts. This is hardly a surprise, since these forecasts are probably most relevant for any planning or reacting purposes. Examples of other types of services are long-range forecasts and warnings. Their shares of site visits are 0.36 % for the former and 0.76 % for the latter. While these seem very low figures, they still mean thousands of daily users, so they are important services as well.

Long-range forecast services site[5] includes forecast for the following month and the following season (three months). They are based on the European Centre for Medium-Range Weather Forecasts (ECMWF) models, and are in general not very accurate for Finland due to challenging forecasting conditions. The forecasts are given in verbal form but include some probability estimates on how the conditions are modeled to develop. According to the user data from 2013 and 2014, there is clear seasonality in the use of these services as well. The highest peak in use is in June, when there is over 60 % increase in unique site visits compared to the annual average. July figures are around 19 % above the average as well. Peculiarly, there is also a user peak in March, although lower (around 10 % increase in site visits). These are somewhat different from the short-range forecasts, where the summer peak is in July and the winter peaks in December and February. This could be a sign of differing user basis as the share of professional users (such as farmers or media representatives) could be higher for long term forecasts. Another explanation could be that

[5] http://ilmatieteenlaitos.fi/pitkan-ennusteen-seuranta

the long-term forecasts in March and June provide information for the time of most interesting weather (that is the holiday season; summer in general or July).

The site on warnings and safety[6] provides information on warnings declared for the next 24 hours and for the following 2 to 5 days. Additionally, general information on weather hazards and other warning services are provided. The use pattern of the warning services is different from the general weather services. The average daily unique site visits are in the order of few thousands, but these are increased ten to fifty fold during serious events. Warning information is provided also on the basic local weather forecast site.

Selected case studies from 2011 and 2012 illustrate the user behavior during extreme weather events. In December 2011, two consecutive storms hit Finland. Tapani storm occurred on December 26th and Hannu right on the next day, on 27th. The storms caused forest damage worth over 120 million euros and caused power outages for over 500 000 homes (Vattenfall, 2011; Fortum, 2012; MTV3, 2012). Antti storm took place in November 30th 2012 and caused forest damages worth of 10 million euros (Helsingin Sanomat, 2012a) and black-outs for at least 30 000 homes (Helsingin Sanomat, 2012b). Figure 3 illustrates how the unique site visits increased during these events. The highest peaks of web traffic occurred at the exact days when the storms happened, when there were approximately ten times more visits compared to before the event. The increase in traffic began in both cases three days before the event. The first warnings were issued already before this and communicated also in the local weather forecast site, so it is possible that awareness created by media and social media is what brings people to the service before the event. When the storm is already taking place, it might be the severe conditions themselves that alert people to view the warnings. The dip in the traffic two days before Tapani storm is Christmas Eve. Media agencies are not in full work force during Christmas holidays, so the awareness of the event was probably lower than it had been during regular days.

After the storm event, the interest to the warning service is quickly dissipated. There are instructions to post-storm actions on the site, but these are static information and not refined according to the specific event, so the informational value is perhaps not that high.

[6] http://ilmatieteenlaitos.fi/varoitukset

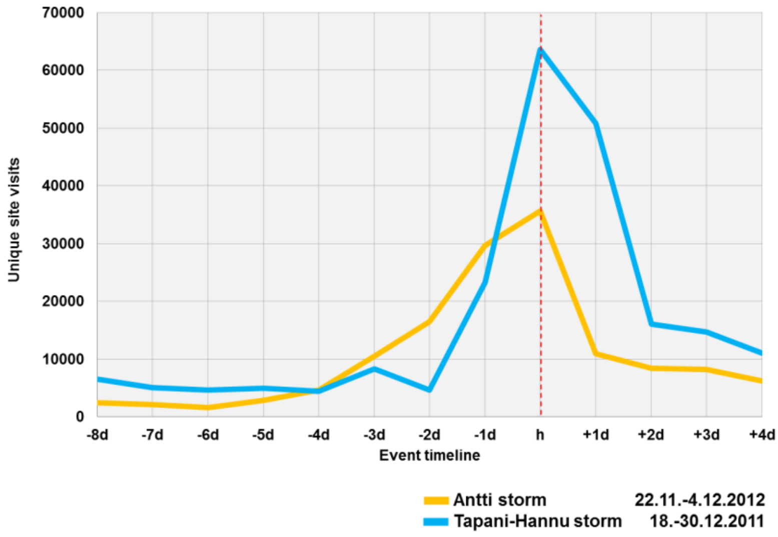

Figure 3: Unique site visits on the FMI's warning service web site during two storms.

2.3 Impact of weather conditions to the use

One of the factors influencing the use of online weather services is the weather itself. This impact was studied by comparing the user traffic to the weather observation record. Weather is a local phenomenon, and Finland is geographically a large and diverse country. For this reason, the location of the weather and the location of the weather forecast need to match. The location information about the users was not available to the necessary detail, but as mentioned the local weather forecasts are provided on separate sites (i.e. www.ilmatieteenlaitos.fi/saa/**helsinki** for Helsinki). User statistics from these sub-sites was then compared to the weather record from a nearby weather station. The data used in the below analysis is from January 2011 to May 2013. The analysis was conducted for four cities in Finland: Helsinki, Tampere, Oulu and Rovaniemi. The represented locations differ in their size and climate. Helsinki is the capital of Finland, located on a peninsula in the southern coast of Finland. Tampere is an inland city 170 km north of Helsinki. Both cities host a great deal of outdoor events during summer, but these do not attract high flows of external visitors compared to the population. Both also have facilities for winter activities but no major attractions for winter sports. Oulu is a city in northern Finland on the shore of the Bothnian Bay. The climate is significantly colder compared to Helsinki or Tampere. Rovaniemi is the northernmost city in Finland, and a major tourist attraction in winter time mainly due to the ski resorts nearby.

The weather parameters chosen for the analysis were daily mean temperature and daily precipitation. Temperature and precipitation are important determinants of observed comfort of the weather (Mieczkowski, 1985) and can be argued to be the most meaningful in terms of preparations like choices for clothing and outdoor activities. Several combined indices have been developed to describe the weather, such as the tourism climatic index (TCI) (Mieczkowski, 1985), but these were not tested in this study. The rationale to focus on single parameters was to avoid complexity in data gathering and processing. Also, the indices already have assumptions embedded in them about the pleasantness of certain weather for certain types of activity. In the end, the aim of the study was to explore whether weather affects service use and not to find the best possible predictors of the behavior.

First, the relationship between daily mean temperature and daily site visits was compared. Since weather can clearly affect the service use but service use can't affect the weather, the temperature was considered as the independent variable and the volume of unique site visits compared to the annual mean as the dependent variable. To reduce the impact of the other factors, weekends, special holidays and days with any precipitation were excluded from the data. The results are shown in Figure 4, where different seasons[7] are presented in different colors. Results from a single factor regression analysis are shown in Table 2. As the scatterplots and regression results show, there is a clear relationship between the daily temperatures and user traffic. The impact of temperature is clearest in the cold winter days, where the user traffic grows nearly linearly especially as the daily mean temperatures drop below -10°C. During summer the relationship is inverse, and the site visits increase during warmer days. The relationship between the variables is considerably weaker for the summer days, but still statistically significant for all the other cities except Helsinki. The reason might be that for cold winter days the temperature is a more descriptive variable for the overall weather and has more meaningful role in decision making (i.e. what to wear). In the warmer periods variables such as the amount of rainfall, cloud cover and wind affect the perception of the weather more. The use of weather services in planning purposes may also differ during the seasons. It is for example possible that during summer people plan their activities more according to forecast weather or weather somewhere else than in their own region (i.e. they might be more interested about the weather at their summer cottage than their home). Interestingly, the correlation between daily temperatures and user visits in both summer and winter is noticeably weaker in Helsinki than

[7] Summer consists of June, July and August; Winter consists of December, January and February; Spring consists of March, April and May; Fall consists of September, October and November

in the other locations. This could indicate that the role of weather dependent activities is smaller in the daily life in an urban city such as Helsinki compared to more dispersed, smaller towns.

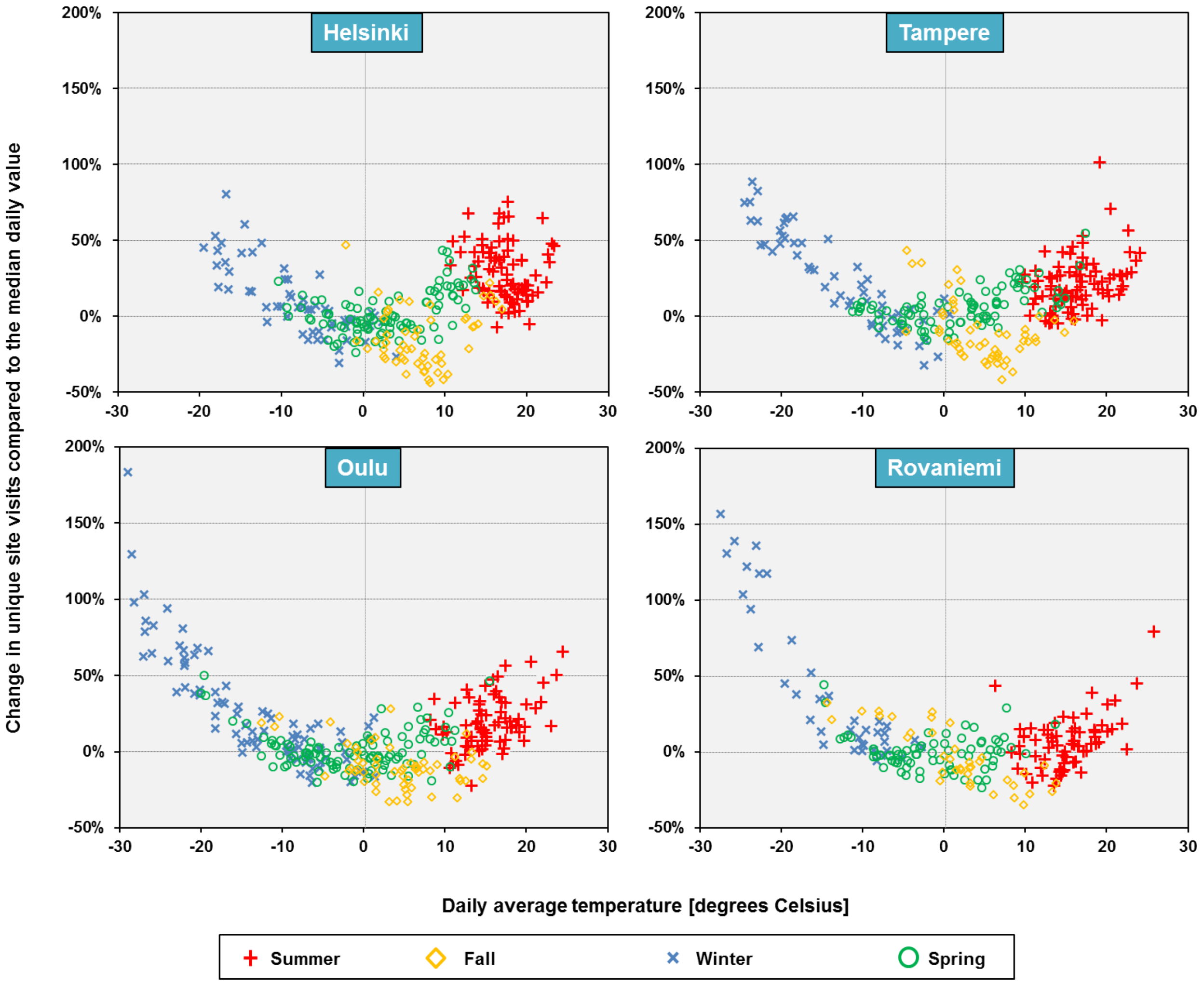

Figure 4: The relationship between daily average temperature and weather service by season for days without precipitation. Weekends and special holidays have been excluded from the data. Seasons are based on calendar months.

Spring and fall months produce more mixed results. One possible explanation is that these seasons cover broader variation in temperature and include many of the dynamics that explain the behavior during both winter and summer. There are large regional differences between the four cities as well. These are probably explained by the different climates. In the northern cities of Oulu and Rovaniemi the thermal winter typically starts much earlier and continues further than in the south, covering large part of spring and fall months as well.

Table 2: Results from the regression analysis comparing the daily site visits in four cities to daily mean temperature for days without rainfall. Seasons are based on calendar months.

City	Temperature & site visits, summer	Temperature & site visits, winter	Temperature & site visits, spring	Temperature & site visits, fall
Helsinki	R^2 = 0.03 p = 0.104 d% /d °C = -1.2	R^2 = 0.61 p = 9.36E-13* d% /d °C = -3.0	R^2 = 0.21 p = 1.55E-6* d% /d °C = 1.1	R^2 = 0.01 p = 0.474 d% /d °C = 0.4
Tampere	R^2 = 0.10 p = 0.004* d% / d°C = 1.7	R^2 = 0.83 p = 2.65E-23* d% /d °C = -3.8	R^2 = 0.30 p = 3.4E-08* d% /d °C = 0.9	R^2 = 0.21 p = 0.0007* d% /d °C = -1.8
Oulu	R^2 = 0.20 p = 6.42E-05* d% /d °C = 2.2	R^2 = 0.71 p = 1.93E-24* d% /d °C = -3.7	R^2 = 0.001 p = 0.73 d% /d °C = 0.6	R^2 = 0.16 p = 0.002* d% /d °C = -0.9
Rovaniemi	R^2 = 0.19 p = 0.0002* d% / d°C = 1.9	R^2 = 0.83 p = 4.6E-16* d% /d °C = -6.3	R^2 = 0.02 p = 0.27 d% /d °C = 0.2	R^2 = 0.70 p = 6.12E-11* d% /d °C = -2.3

d% / d°C describes the change in site visits compared to median day as the daily mean temperature rises by one degree Celsius

* Statistically significant relationship with 95 % confidence level

The second weather parameter tested was precipitation. Precipitation is different variable from temperature in three key ways. First it is non-continuous: it either rains or not. Secondly, the daily distribution can take many forms. There can be one massive cloudburst on an otherwise dry day or it may rain throughout the day. These two days might have the same amount of rainfall although they are experienced in very different ways by people. Thirdly, precipitation can come in many forms including rainfall, snow, sleet and hail. While the form is connected to the temperature, it cannot be reliably reasoned on the basis of daily mean temperature only. The first difference was addressed by analysing precipitation as an independent dummy variable, and the third one by analysing the seasons separately again. From the data in use the daily distributions of precipitation were not available, so they could not be factored out which is likely to result in larger variance in results. It should also be noted that temperature and precipitation are not independent variables. For example snowfall is considerably less likely on the very cold days. For this reason and because temperature was observed to have such strong relationship on the user traffic, days with mean temperature below -10°C were excluded from the analysis.

A single factor regression analysis comparing unique site visits to the annual mean value and daily precipitation was conducted, and the results are shown in Table 3. In the analysis, precipitation was set as an independent dummy variable so that it was 0 if there was no precipitation at all and 1 if there was any precipitation. The regression analysis shows that precipitation is connected to increased service use and that the relationship is statistically significant ($p < 0.05$) for all the cities during summer and spring and for Helsinki and Oulu during fall months. Figure 5 visualizes the difference by showing the box plots of the user traffic distributions for the four cities for summer months. The median values and the distributions are significantly higher for rainy days. For winter months, no statistically significant relationship was found. It should not be concluded that snowfall does not cause change in the service use rates. A connection might exist, but finding it would require a more sophisticated analysis taking more meteorological variables and interdependencies into account. Such analysis is beyond the scope of this report.

An explorative analysis was also conducted regarding the impact of the amount of daily precipitation. The results are shown in box plots in Figures 6 and 7 that show the distributions of user traffic during days of different amounts of rainfall[8] for summer months for Helsinki and Tampere. The results indicate that higher amount of daily rainfall is connected to higher service use, but to validation would require more data. Here the impact of the distribution and exact timing (i.e. day or night) is also probably very significant, and further analysis should be done with hourly data.

Besides the weather daily weather variables an interesting question is, whether it is the present or forecast weather that predicts the user behavior. Since record about the given forecasts was not available for the studied time period, the weather of the following two days were used (this equals to a 100 % accurate forecast). The results yielded weaker relationships compared to the analysis above, indicating that if there is some effect, it cannot be deducted from this data. Another tested hypothesis was that when the weather is predicted to change significantly, this would result in increased traffic. To test this, traffic figures were compared with the predicted absolute change in

[8] The categorization was adopted from the official FMI thresholds with slight changes: 0 – 0.9 mm of daily rainfall is light rainfall, 1.0 – 4.4 mm is medium rainfall, 4.5 – 20 mm is intensive rainfall and over 20 mm is heavy rainfall. Source: www.ilmatieteenlaitos.fi/sade (in Finnish)

temperature. Again, no significant impact was observed that would explain user behavior better than just the daily mean temperatures. A more detailed analysis with actual forecast data and more control variables would be needed to find out any possible effect. Similar analysis was conducted to test the impact of weather, i.e. the idea that exceptional weather on one day would result in higher user activity in the following day. Again, no significant relationship was found.

Table 3: Results from the regression analysis comparing the daily site visits in four cities to precipitation. Precipitation is considered as a dummy variable (0 = no precipitation, 1 = precipitation). Seasons are based on calendar months.

City	Precipitation & site visits, summer	Precipitation & site visits, winter [-10°C – 0°C]	Precipitation & site visits, spring [> -10 °C]	Precipitation & site visits, fall [> -10 °C]
Helsinki	R^2 = 0.24 p = 2.12E-9* d% = 23.5	R^2 = 0.03 p = 0.12 d% = 5.4	R^2 = 0.12 p = 8E-6* d% = 12.5	R^2 = 0.15 p = 4.88E-6* d% = 21.3
Tampere	R^2 = 0.24 p = 5.23E-9* d% = 21.7	R^2 = 0.04 p = 0.07 d% = 5.5	R^2 = 0.09 p = 0.0002* d% = 9.1	R^2 = 0.02 p = 0.12 d% = 5.0
Oulu	R^2 = 0.25 p = 1.53E-9* d% = 22.7	R^2 = 0.03 p = 0.08 d% = 4.3	R^2 = 0.19 p = 3.88E-8* d% = 13.3	R^2 = 0.13 p = 3.85E-5* d% = 12.8
Rovaniemi	R^2 = 0.15 p = 6.63E-6* d% = 16.4	R^2 = 0.01 p = 0.26 d% = -3.1	R^2 = 0.09 p = 0.0003* d% = 6.3	R^2 = 0.01 p = 0.28 d% = 3.8

d% describes the change in site visits compared to median day if the day had any amount of precipitation

* Statistically significant relationship with 95 % confidence level

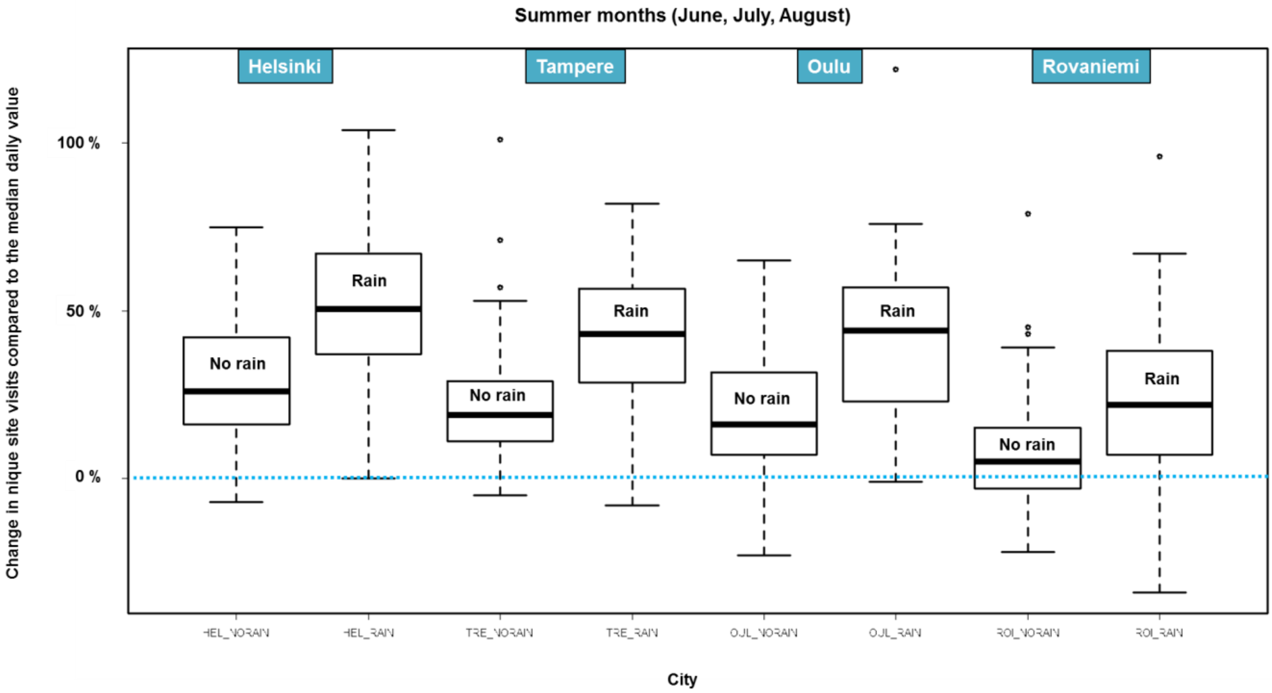

Figure 5: Comparison of unique site visits for days with and without rainfall for summer months for four cities (Helsinki, Tampere, Oulu, Rovaniemi). Values more than 1.5 times the interquartile range above or below the interquartile range are considered outliers and are drawn outside the distribution brackets.

These results show that weather impacts the use of weather services significantly. Both temperature and precipitation are correlated with changes in the user activity. The effects differ according to the time of the year so that temperature matters on the cold winter days whereas precipitation has a more significant impact on summer. Comparing continuous and categorical variables is challenging, but it could be stated that during summer rainfall has somewhat stronger impact. In interpreting tables and figures above it should be noted that all user volume values are compared to annual means, and the levels of use fluctuate considerably by month (as seen in Figure 2). In general great consideration should be used in the interpretation, since even the strong correlations may not be a result of direct causality. For example the services are used more during summer independent of weather, and the peak use season tends to overlap with the warmest days as well. However the results are clear enough that it is unlikely that the relationships are merely artifacts produced by the analysis.

Interestingly it seems that the current weather that explains user behavior, not the past or forecasted future weather. It may thus be that people tend to use the weather service to confirm their own perceptions or to see if the existing conditions are likely to resume. These conclusions would however need further research with actual data about the given forecasts.

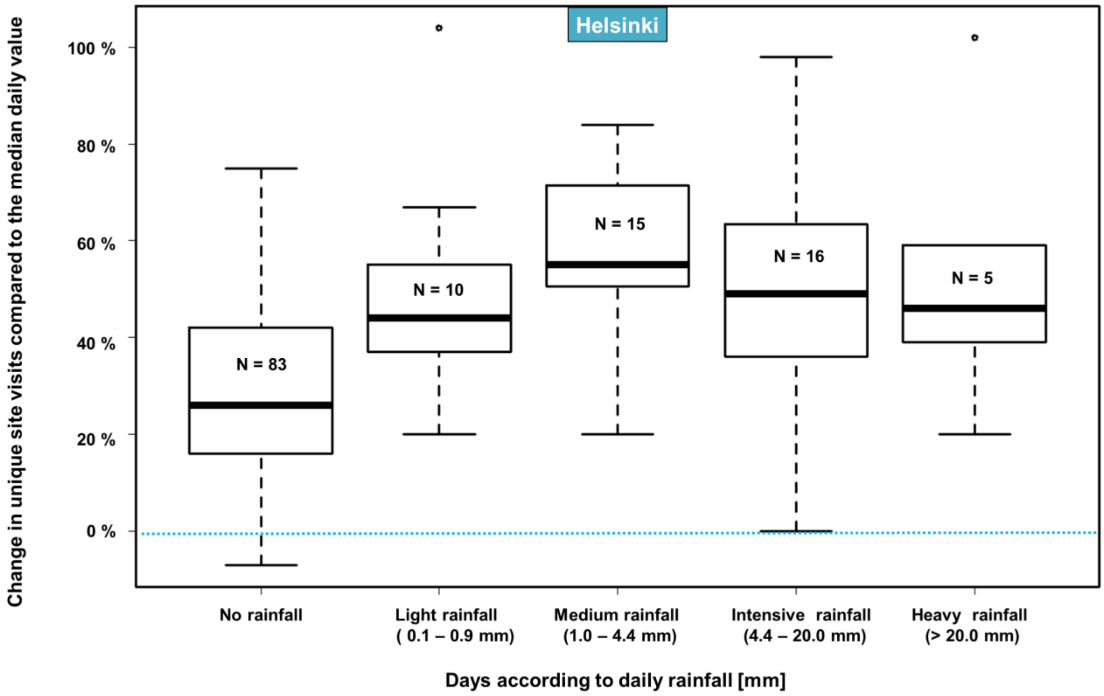

Figure 6: Comparison of unique site visits for days with different amounts of daily rainfall for Helsinki. Values more than 1.5 times the interquartile range above or below the interquartile range are considered outliers and are drawn outside the distribution brackets.

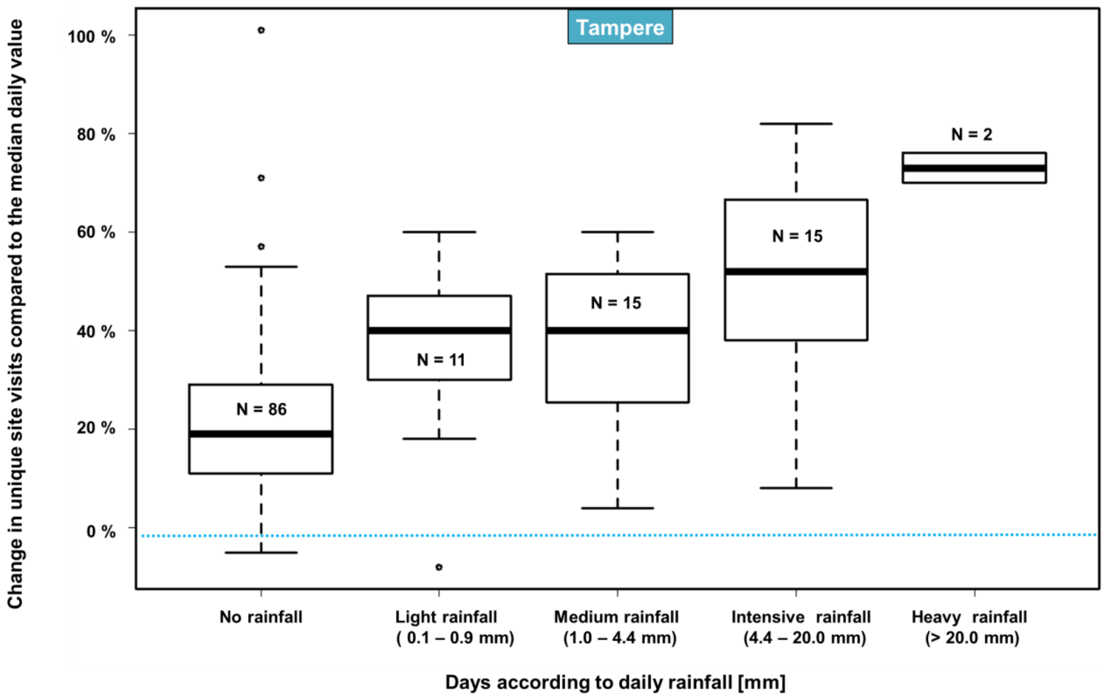

Figure 7: Comparison of unique site visits for days with different amounts of daily rainfall for Tampere. Values more than 1.5 times the interquartile range above or below the interquartile range are considered outliers and are drawn outside the distribution brackets.

2.4 Impact of mobile services on use patterns

As was previously shown, the mobile use of weather services is increasing as the mobile technologies are becoming more popular. This shift in technology is also likely to impact how the services are used. Just as the original introduction of online services enabled mass delivery of localized, continuously updated weather forecasts, mobile technology enables users to access this information practically anywhere.

To illustrate this impact, Figure 8 shows the differences in hourly use curves between the web services and the mobile application. The activity curve is based on hourly unique site visits between 19.7.2009 and 21.4.2013. Again, only data from weekdays was used, and national holidays were removed from the data as well. Fridays were excluded too, as the use pattern for Fridays is on average slightly different from other weekdays (no evening user peak was observed).

As Figure 8 shows, there is a significant difference on how these services are used. The use of the web service seems to follow the daily activity curve so that the service is used during work days, mainly after arriving to work. The first peak occurs right in the beginning of the work day, and the second one before leaving work. The peak hour for the mobile app occurs earlier in the morning instead, actually before leaving to work. The peak is also much higher. There are small peaks around lunch time and in the evening as well. This makes sense: In the morning people check the weather before leaving to work and in the evening they probably want to know the weather forecast for the next day. The practical implication of this is that the mobile users are more aware of the weather, and are in better position to react to the forecast.

The weather radar application is yet another case. Similarly to the other services studied, it has more users during summer months than in winter. The difference is larger though (about three times more users in the summer) so it seems that the main use of the service is to seek information on rain, not snow. Difference between the radar service and the other services is that it is used more often during weekends than weekdays. The most popular day is Friday, followed by Saturday. The daily distribution is also different, with highest figures occurring in the afternoon hours (see Figure 9). All this supports a conclusion that the main use context of the radar application is the planning of leisure activities that take place outside working hours.

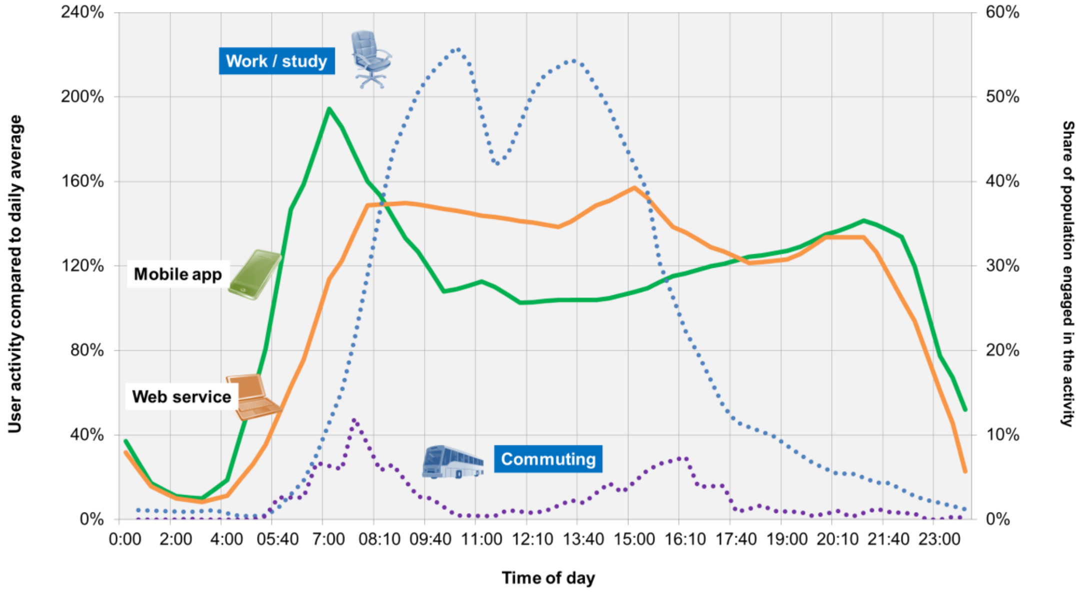

Figure 8: The hourly user curves for mobile application and the web service. The dotted lines show the hourly activity curves of population in Finland (Source for activity data: Statistics Finland, 2009)

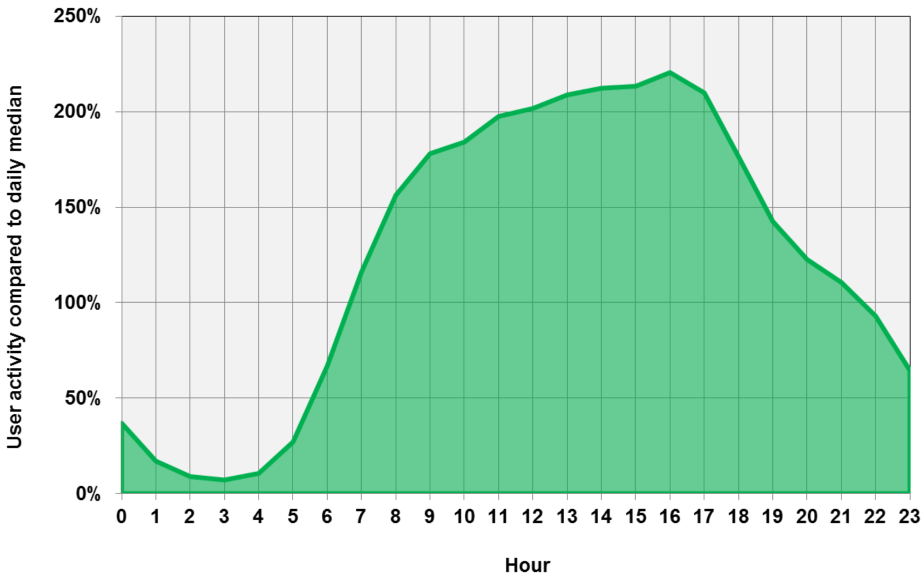

Figure 9: Daily use pattern of the weather radar application RainMan. Data from June 2014.

3 OBSERVATIONS: CLIMATE SERVICES

3.1 Climate service market and trends in Finland

Compared to weather services, the concept of climate services is not as established. Basic information about climate is typically produced by scientific research organizations or NHMSs. This information includes records about past climates, mapping of current climate and its change and modeling future climate. Such information provides guidance for climate change mitigation and adaptation measures.

World Meteorological Organization (WMO) has presented a Global Framework for Climate Services (WMO, 2011). A schematic of the components of the framework is presented in Figure 10. While the framework depicts a yet-to-be-implemented grand plan of global service, it also describes the components linked to climate services in general. Climate information is produced based on research, modeling and predictions, which are accompanied with observations and monitoring. The information is provided to users via a user interface. Capacity building refers to developing these components to improve the climate resilience in general. The service studied in this report (Climate Guide) covers the information system and interface components. The difference is that the vision of WMO emphasizes interaction in order to develop new and improved applications of climate information, whereas Climate Guide is designed to be more traditional source of information.

During the work leading to the framework, WMO identified needs for improvement in existing climate services. One conclusion was that the existing services are not properly focused on user needs, and to be useful the climate information must be tailored to meet the needs of the users. WMO also called for improved interaction between the providers and users and noted that the users need expert advice in selecting and applying climate information (WMO, 2011).

While the concept of climate services remains somewhat ambiguous, there are several examples of online service portals that are focused on climate information. The studied Climate Guide is one example; another is the European Union sponsored European Climate Adaptation Platform[9] (Climate-ADAPT). As the name suggests, Climate-ADAPT is focused on providing information relevant for adapting to climate change. Services include general background information, scenarios, search tool for case studies and an adaptation support tool for users designing climate

[9] http://climate-adapt.eea.europa.eu/

change adaptation strategies and plans. The geographical scope is mainly limited to Europe. Another example of such online information site is www.climateadaptation.eu, a privately run site that brings together adaptation data from European countries. The site is originated in the Netherlands, but has wide international audience. Around half of the users of the site are from outside the European Union.

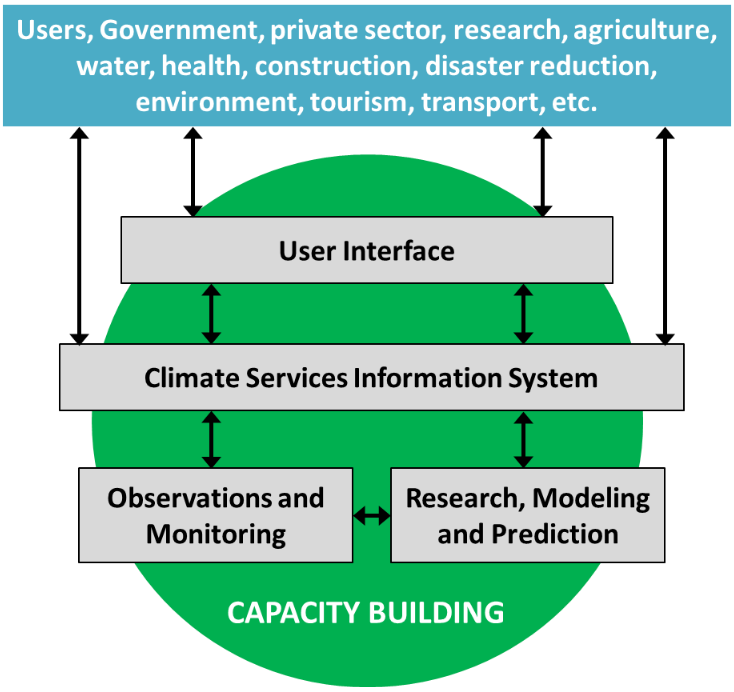

Figure 10: A Schematic of the Global Framework for Climate Services and its components. Capacity building occurs within and between all the other components (edited from WMO, 2011)

Besides Climate Guide, there are some other online services that can be labeled as climate services in Finland. Ilmastoinfo[10] is a site run by the Helsinki Region Environmental Services Authority (HSY). It provides information on local and personal mitigation actions to consumers and enterprises and promotes different campaigns. Information on climate change impacts or adaptation is not included. Ilmasto.org[11] is a climate information site run by Finnish environmental NGOs. It provides background information on climate change, including mitigation and adaptation, and provides activities by the involved NGOs. The site is mainly run by volunteers, and some sections are no longer updated – instead the visitors are guided to Climate Guide.

[10] www.ilmastoinfo.fi
[11] www.ilmasto.org

There are comparable services in other countries as well. For instance Klimatanpassningsportalen[12], part of the National Knowledge Centre for Climate Change Adaptation operated by the Swedish Meteorological and Hydrological Institute, is the Swedish portal for climate change adaptation. The main target groups of the portal are municipalities and county administrative boards, but the idea is also to serve as the national focal point for information about adaptation. Because of the geographical and societal similarities of Finlad and Sweden, Klimatanpassningsportalen is perhaps the most relevant service to be compared with the Climate Guide.

While there are private companies providing climate services (typically advice on mitigation and adaptation) there are no private providers of online climate services in Finland that would compare to Climate Guide. In comparison to the above mentioned Finnish, Swedish and European services, Climate Guide does well in popularity. Figures on the user rates are presented in Table 4.

Based on these figures it is justified to state that Climate Guide is among the leading online climate services in Finland, and unique in the sense that it combines information and data services for climate, adaptation and mitigation.

Table 4: User rates for selected online portal providing information on climate change (sources: Facebook, Twitter and the service administrators)

Service portal	Monthly users	Facebook followers[13]	Twitter followers[14]
Climate Guide	7510	956	-
Climate-ADAPT	3700[15]	-	-
Ilmastoinfo	700[16]	1593	416
Ilmasto.org	3300[17]	791	975
Klimatanpassningsportalen	5000[18]	-	-
climateadaptation.eu	5200[19]	-	-

[12] www.klimatanpassning.se
[13] On 31.7.3014
[14] On 31.7.2014
[15] Average between January and March 2014. Data from EEA.
[16] Average between July 2013 and June 2013
[17] Average between July 2013 and June 2013
[18] Based on March 2014 figures
[19] Average between January 2013 and August 2014.

3.2 User behavior in general

Climate Guide web site was launched in October 2011 for public. It has since gained popularity, and in 2013 it had on average 7510 monthly users, and 2014 is likely to see even more traffic. The development of monthly user volumes is presented in Figure 11. Some key content publication dates are also included. As can be seen, the service has gained popularity during its existence with the peak user rates experienced in January 2014 when over 12 000 people used the service.

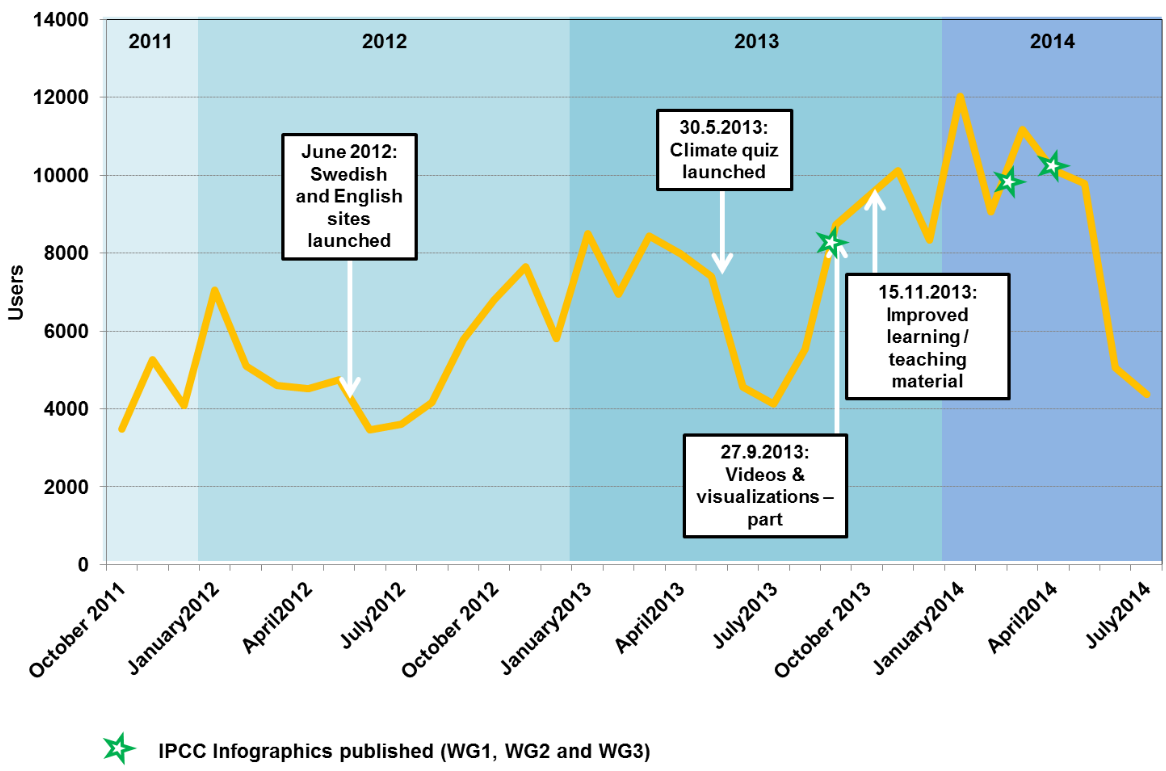

Figure 11: The development of the monthly user rates in the Climate Guide

The annual rhythm in the use is quite the opposite compared to that of online weather services. This is probably because the use is mainly related to work, education or teaching, and such activities are affected greatly by the holiday season. Schools in Finland are closed in June, July and most of August. Christmas holidays result in similar drop in user rates, although lower.

The results from the user survey support these ideas. In the survey, the respondents were asked to identify the organization they present (see Figure 12). The largest group of users were from primary or secondary schools, followed by private enterprises and universities and research institutes. In the analysis it should be kept in mind that the sample size (77 respondents) was small and some groups may be more inclined to answer the survey than others. Strikingly, no respondent identified themselves as representatives of media.

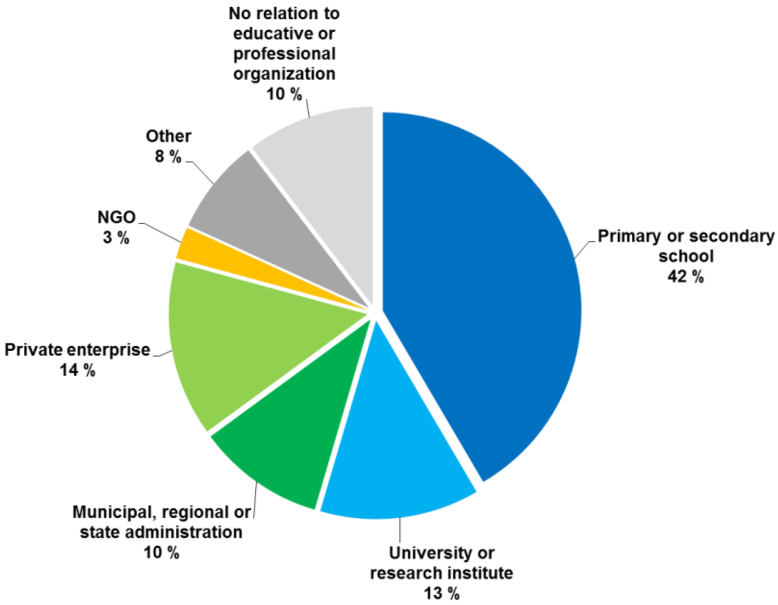

Figure 12: The user background distribution in the online questionnaire (N=77)

If the survey answers reflect the broader use, educational and research purposes account for over half of the use based on the respondent organizations. Representatives of administration and private sector could be assumed to use climate information for planning and decision-making purposes, accounting for nearly a quarter of use. Although the sample size does not enable meaningful general cross-comparison between the organization represented and the purpose of visit, some of the questions shed light on the issue.

For organizations outside education and research sector, the vast majority of respondents (78 %) were either salaried employees or senior officials. Of the private sector respondents who specified their industry, a majority were from basic (including energy) or technology industries. These are sectors were for example the impacts of climate change start to be meaningful in the time horizon of investments. These results could indicate that the service is used to gather information for professional decision-making, although again this is speculation based on small sample. Of the educational and research organizations most of the respondents were pupils or students (25 compared to 6 teachers). This indicates that the service provides relevant information for student work.

According to Google Analytics data, a vast majority of the service users are based in Finland (88 %), but there were visits from altogether 170 countries. A similar share of users also uses the Finnish version of the site; 6% used English and 3% Swedish. The relatively high share of English indicates that the service has raised some interest outside Finland as well. The share of Swedish language users is a bit smaller than the share of Swedish-speakers among Finns. Most of the users find their way to the service via search engines. The role of social media in guiding traffic has remained small (around 4 % of the users come by clicking a link in a social media site).

The rise of mobile technologies can be seen also in the use of Climate Guide, as in 2013 already 18% of the site visits were from mobile devices. The share is still significantly lower than for weather services. This is no surprise, since climate services are presumably used more often during working on something (e.g. making notes or writing homework or report), for which desktop and laptop use is perhaps still more convenient than most mobile devices.

3.3 User interest on different contents

Site user data and the survey responses also reveal some information about the content that users of Climate Guide are interested in. The web site is organized in three major sections: 1) Climate Change Explained, which provides up-to-date background information on climate change and its impacts 2) Maps, graphs and data, which provides interactive tools to search for data and graphs about past and future climate and impact scenarios and 3) Community Response Wizard, which provides information on mitigation and adaptation solutions directed to municipalities and members of local communities.

Site views categorised on the content during a sample period from November 2013 to May 2014[20] are presented in Table 5. As the figures show, a vast majority of the users visit the section that explains background information about climate change. More specified and targeted tools offered by the other sections gather only small percentage of the site visits. This distribution of interests was reflected also in the survey responses. When asked about the information searched for, both the

[20] Half year sample period selected so that all the biggest publications of new content types were done before it. Exact period: 15.11.2013 – 15.5.2014.

first-time users and the returning users mentioned general topics such as “How will the climate change globally in the future?” most frequently. The ten most popular topics (from a fixed list in the survey) were:

1. Changes in the future weather conditions in Finland
2. The contents of Climate Guide (to form a general impression about the site)
3. Global changes in climate in the future
4. Global impacts of climate change
5. Changes in the climate of the respondent’s region
6. Factors driving climate change
7. Impacts of climate change to Finnish environment and livelihoods
8. The impacts of climate change to seas, ice cover and glaciers
9. Adaptation and preparation measures to the impacts of climate change
10. Something else (defined by the respondent)

The survey questions (translated from Finnish into English) are presented in Appendix A. The answer options included also more solution-oriented and specific choices, but these did not gain much popularity. The results from both the site visit data and survey indicate that the bulk of the users are still looking for general information about climate change instead of looking for specific guidance for mitigation or adaptation.

User interest to specific articles or tools is spread out quite widely across the service. Between the release in October 2011 and June 2014 only four pages gathered over 10 000 unique site visits. Table 6 lists the ten most popular articles or tools and their unique site visits between October 2011 and June 2014. Again, the most popular topics are mostly general background information about climate change. The most popular adaptation and solution articles had all less than a thousand unique site visits during the same time frame.

Table 5: Distribution of site visits according to service section

Service section	Climate Change Explained	Maps, Graphs and Data	Community Response Wizard	Other (incl. front page, contact information etc.)
Share of site views	77.27 %	3.97 %	3.26 %	15.5 %

Based on the list in Table 6, the most popular content form are the short text articles which are written by experts but popularized to target the general public and they include links and references to the original sources of information. The survey responses showed similar popularity for such forms of information. Both the first-time users and returning users stated that they mostly look for text articles, followed by statistics and numerical information.

Table 6: The ten most popular articles and tools in Climate Guide

Article / tool	Unique site visits	Section	Type of page
Greenhouse effect and the composition of the atmosphere	11 553	*Climate Change Explained*	Article
The observed change – 160 years of measurements	10 218	*Climate Change Explained*	Article
Past and future climate	10 137	*Maps, Graphs and Data*	Data tool
Current climate – 30 year averages	10 024	*Climate Change Explained*	Article
Forecast climate change in Finland	9234	*Climate Change Explained*	Article
Climate-friendly food	9004	*Climate Change Explained*	Article
Global climate in the future	8161	*Climate Change Explained*	Article
Measurement show change is occurring	7075	*Climate Change Explained*	Article
Scenarios on climate change impacts	6016	*Maps, Graphs and Data*	Data tool
Carbon dioxide and the carbon cycle	5345	*Climate Change Explained*	Article

3.4 Impacts of external events

Since the largest share of the use of the Climate Guide is information seeking about climate change in general, it is interesting to see whether significant media events affect the use of the service. During the period the portal has been available, perhaps the most significant events have been the publications related to the Fifth Assessment Report by the International Panel on Climate Change (IPCC, 2013; IPCC, 2014a; IPCC, 2014b). Another visible event was the announcement from the Finnish government about the acceptance over climate law.

These events are listed with site visit values in Table 7. The user volumes in Climate Guide have this far followed roughly the normal distribution, so the daily figures are compared to relevant averages and standard deviations[21]. As it can be seen, the IPCC's Assessment Report publications for Working Group 1 and 2 seem to have caused clear peaks in site visits. The publication of Working Group 3 report was scheduled on Sunday, which might explain why it did not cause such reaction. The announcement from the Finnish Government was not related to a significant reaction either, perhaps because it was a smaller piece of news, and more interesting in the context of politics than climate change.

Another way to analyze the impact of external events is to identify the peak use days and speculate the likely reasons behind them. As the user base has grown since the introduction, the peak days were selected not according to just the highest user rates but also comparing to the annual averages and visually inspecting the graph drawn from user statistics. This way, four peak events were identified besides the two IPCC release dates (27.9.2013 and 31.3.2014) already discussed. These peak dates are listed in Table 8. The earliest peak was experienced on the day of the launch of the service, when nearly a thousand users visited the site. In mid-June 2012 there was a heightened interest to the site for two days, coinciding with the announcement from the Finnish Government about the climate policy strategy within EU (Prime Minister's Office, 2012). In the end of July 2013 there was a user peak but no plausible explanation was found. Then again the summer user rates are low, and not much would be required to create extra traffic; the explanation could be a link within a popular blog if not just a mere chance. In January 2013, a user peak occurred on the date following the European Commission announcement on a proposal for new targets for climate and energy

[21] In calculating these statistics the weekends and summer months were sorted out, and to compensate the growth in user base each figure was compared to the same year's average and distribution.

policies up to 2030 (European Commission, 2014) The event gained visibility in Finnish media as well (Helsingin Sanomat, 2014).

Table 7: The visit rates of Climate Guide during selected public events.

Event	Date	Site visits compared to average	Statistical distance from mean
IPCC Working Group 1 (The Science of Climate Change) report released	27.9.2013	+ 165.5 %	13.7σ
IPCC Working Group 2 (Impacts, Adaptation and Vulnerability) report released.	31.3.2014	+ 81.2 %	3.2 σ
IPCC Working Group 3 (Mitigation of Climate Change) report released.	13.4.2014 (Sunday)	+12.5 %	0.5 σ
Finnish Government announces agreement over Climate Law	22.5.2014	- 28.4 %	-0.9 σ

Table 8: Identified peaks in user activity and possible explanations

Date	Users compared to annual averages	Users	Possible explanation
20.10.2011	313 %	958 (all-time second highest)	Official release date of the service
13. and 14.6.2012	12% and 14 %	272 and 276	Finnish Government announces strategy of addressing climate change in EU.
30.7.2013	18 %	433	Unknown.
23.1.2014	55 %	686	European Commission Announces 2030 Climate and Energy Goals

Naturally the climate discussion cannot be proven to be the cause for heightened interest to the online climate service, but from the figures above it seems plausible. The conclusions are however limited to isolated peak incidents. The possible processes that lead decision-makers to become frequent users of climate services do not show in this kind of analysis. Discovering them would require more in-depth research, including qualitative methods.

3.5 Workshop feedback

As part of the ViVoTiVi project, a workshop for the professional users was arranged at FMI June 10th, 2014. The main focus was on service development, not user research, but the feedback from the participants provided interesting information to complement the observations from statistical data and survey responses.

The workshop was arranged in a two-round learning café format, in which the workshop participants were divided into four groups around four thematic tables each managed by a facilitator. Each group spent 10 minutes on a thematic table, and then moved to another table and so on, until all the groups had discussed all the themes. The first round was focused specifically on the use and development of the Climate Guide as it is. Specific themes were user experiences, triggers to use the service, new information products and ways to increase interest in the solution (both mitigation and adaptation) content in the service. The second round was then used to discover ideas and probe responses on a broader level about online climate services. The specific themes were the influence and visibility of the Climate Guide, the level of popularization of scientific information, interactivity and vision for the service for 2020. As an introduction to the workshop the participants were presented with a summary of the survey results and a presentation about visualizing information.

According to the workshop participants, there is lot of information available about climate and climate change in general. The problem is fragmentation, and the user needs to compile and combine the information they need from multiple sources. The most typical sources for such information are research institutes, governmental and inter-governmental agencies and the research reports, slides and publications they produce. Information is sought also from the EU and other national agencies besides Finland. Since Climate Guide is aimed to be an aggregate site that would combine such information on an easily available, usable and accessible form, it should at least in theory meet an existing need.

Climate Guide was said to be used to form an overall picture about climate change and related issues, to find references for information and to support teaching. Direct use of the visualized information was criticized by some to be technically inconvenient and the participants expressed interest to unformatted data to draw own figures and illustrations.

Workshop participants requested more information about the societal and economic impacts of climate change, and also in a quantitative form. There was also interest to get information about the issue from the point of view of different industries and private sector in general. Some participants also voiced a need to receive more information about the ongoing policy making, legislation and policy implementations regarding climate change as well as procedural information about the roles and responsibilities of different decision-makers and officials in the process. It was also said that many users do not know what information they are exactly looking for, so the site structure and easy search tools are important.

Language and forms of communication were also addressed in the workshop. Good and apprehensible language was considered important, but it was stated that popularization should never compromise the scientific trustworthiness. References to source literature were considered important. Overall, Climate Guide was seen as a sort of a foundation of Finnish climate information; a source one can always trust. Some participants commented that there should be a clear distinction between the roles of official climate service such as Climate Guide and the role of NGOs. The responsibility of the former is to distribute correct information, while the role of the latter is then to influence the public.

Uncertainty of information was mentioned as a challenge to the impact and credibility of presented information. Use of scenarios and descriptions of the research methods were suggested to tackle the problem. Both of these are already used by the site, but perhaps could be emphasized even more. When discussing on how to exactly provide the information, infographics were seen as useful for getting a quick overview. Longer text articles were still seen as essential, and many participants mentioned that quantitative data should be available for downloading for the user to modify for his/her own use.

One of the themes introduced by the workshop facilitators was interaction. The participants viewed interaction in the context of Climate Guide mostly as getting experts answer questions asked by users. User-to-user activities or social-media-like interactions were not seen particularly interesting; although considering possible games or tests the ability to share results was mentioned. Games and applications were seen as a possible means to engage users, but participants noted that the quality of the design in these is critical.

Another theme fed into the discussion by the organizers was the improvement of the use of mitigation and adaptation information. Participants suggested that different user groups need information tailored according to their needs. Positive messages were also emphasized; the participants asked for emphasizing the benefits of mitigation and adaptation and examples of success stories. Overall, they emphasized that the information needs to be concrete and personally relevant. Illustrations of the scale of different impacts and actions were also asked for.

In their visions of the future of the service the participants envisioned a broader Climate Guide that is able to cater tailored information for various user groups. Workshop participants believed in general that the need for mitigation and adaptation information will increase as the emphasis in society is shifting from growing awareness of the basic phenomena to implementing actions. To provide useful, practical information about solutions, it was thought that new kinds of information providers (e.g. public and private organizations across different sectors) could be involved in the service. In the context of this study, it is interesting that workshop participants expressed interest to have a mobile version of the site. At the moment around 20 % of the use is via mobile devices.

Overall, the views expressed in the workshop were mostly aligned with the survey results. Since the workshop participation was based on invitations, there is naturally some bias in the results, probably even more than in the survey. The participants were oriented towards developing the service from a broader point of view instead of commenting it merely from the perspective of their own organization. Accordingly, a lot of feedback was gathered to guide the development work in the future.

In summary, the workshop participants wished the Climate Guide to act as a trustworthy, comprehensive source of information about climate change. Popularized, understandable texts and illustrations were seen as the primary means of dissemination, but the service should enable the user to find the original sources of information and get their hands on the data in a usable format.

4 DISCUSSION AND CONCLUSIONS

The study represented here describes the use and trends in online and mobile use of weather and climate services based on user statistics, a survey and a workshop. The results indicate certain patterns and trends in the use of these services and add to the scarce existing literature that describes the weather and climate services with the focus on user behaviour. The results have practical use in the development of such services and also in prospective studies considering weather salience, disaster risk management or adaptive capacity in the future.

The rapid uptake of mobile solutions suggests that weather services are quickly adopted for new, suitable communication platforms. This all follows the established theories in communication and technology acceptance, since the mobile services can be argued to be easier to use in terms of work and more useful in terms of timely access and spatially tailored information. Mobility enables new kind of active consumption of weather information, as the user can access localized, near real-time information anywhere with little effort. This is already showing in the use, as the daily patterns of mobile use seem to differ significantly from traditional web services – although there is still the possibility that this difference stems from differing user bases.

Another finding is that weather has a significant impact on the use of weather services. In winter, when the temperature decreases under -10 ºC the correlation between the temperature and the use is especially clear. During summer months, precipitation is linked to increased user activity. Interestingly it seems that the weather of the given day – not the forecast weather for coming days or major changes in weather – shows the strongest correlation. Possible explanations include the following (the explanations are mutually non-exclusive):

- Most of the weather service use is not decision oriented, but driven by general interest in weather. And the more unusual the weather is, the more interesting it is. This explanation complies with the results presented in Lazo et al. (2009).
- On-going weather affects the plans considered by an individual in their decision-making. This means that during a clear, snowy winter day people are more likely to consider outdoor activities and then go to see if the weather is going to remain as it is.

The aim of the study here was not to find the most fitting predictors of user activity. If it truly is so that large share of use is driven by present weather, some combined indices that weigh weather variables in terms of their significance to social and economic activities may be found to have even stronger correlations with the user rates. Based on the results here, such indices are likely to be different in different seasons and perhaps for different regions as well.

In terms of user traffic, online climate services are far behind weather services. This is only natural, since the role of the information they provide is very different. What is actually common is that according to the results, the use of such services is also mainly oriented in general interest and not related to any specific decision-making. Public discussion seems to increase the interest, as events such as the publications of IPCC reports show rise in user volumes. Although it wasn't tested in this study, major weather anomalies or severe weather could have similar impact, at least if they are connected to climate change in the media. Among the portals compared, Climate Guide seems to have attracted audience well. This may be a result of systematic development work, broad coverage and diverse content both in subjects and media and targeting schools and teachers as users. Still, even in Climate Guide the interest of the audience is biased heavily on general background topics, such as physics of climate change or observed changes. It thus seems that information about climate change is not yet decision-relevant for large masses. The concept of climate services also remains somewhat ambiguous.

These results have some implications on policy and service development. The rapid rise in mobile weather service use show that people are quick to adopt new sources for weather information. The mobile device may be on the way to become the primary weather media fairly fast. This has implications on disaster management and adaptation planning, if people can be assumed to be more accurately informed. There is however the risk of inequality, since some user groups – perhaps the most vulnerable ones, such as elderly people – might not adopt these services as broadly. Also in all service development it should be kept in mind that models of people seeking information to support their explicit decision making do not represent reality well. In practice the motifs of the use seem to be fuzzier, driven largely by general interest and also external weather conditions. In climate services, it seems that merely bringing the information available and accessible does not create large interest. Whether this is a genuine problem of communication (getting people to know about the service) or content (whether people have incentives to seek such information or act accordingly) is unclear.

Considering the analysis and application of the results, it should be noted that there are clear limitations in the methodology applied in the study. Relying on the statistics of only one service provider and the use of a data from only one source which cannot be objectively validated means that strong conclusions cannot be made. Presented theorizing about causalities in the use would require more in-depth research and more varied methodology in order to be convincingly validated. In the web survey, the sample was small and not controlled for the likely biases Also, FMI is only one of the weather and climate service providers in the Finnish market, albeit a leading one. This might induce some selection bias for the results, since the user base of FMI’s services might differ from other providers or the population in general. This bias might be emphasized on a regional level. Another limitation is the lack of background knowledge of the users in itself, which limits the conclusions that can be drawn from the statistical data. Most likely there are user segments that have very different use patterns, but identifying these would require a targeted survey. Still, taking these limitations into account, the results presented in the study provide improved insight in the online use of weather and climate services. The results seem logical and are in line with the few studies published earlier.

It is clear that more research on the topic is needed. The behavioural changes induced by the improved availability and accessibility of weather information, as well as the triggers of adopting new services require a more in-depth research, preferably combining quantitative and qualitative methods. To understand the role and use of climate services, it would be beneficial to study further the drivers of use and the needs of users. Why is climate information sought for, and why is it not? This research should preferably be conducted separately for professional users both in public and private sectors as well as the general public. The benefit of any investments in the generation of new knowledge on weather and climate can perhaps be multiplied with better understanding on how the information is used and why.

ACKNOWLEDGEMENTS

This research was enabled by data produced by two distinct projects. The use data and behavior was studied as part of European Union funded ToPDaD[22] (Tool-Supported Policy Development for Regional Adaptation) project. The use of climate service portal was analyzed as a part of ViVoTiVi (Visuaalista voimaa tiedeviestintään) project funded by Tieteen Tiedotus Ry. The authors would like to thank the European Commission and Tieteen Tiedotus ry for their role in funding the study. Colleagues from the Finnish Meteorological Institute helped in analysing and compiling the results and provided valuable advice; contributions of Väinö Nurmi, Adriaan Perrels and Karoliina Pilli-Sihvola were especially significant, but many others helped as well. Karoliina Pilli-Sihvola, Riina Haavisto and Adriaan Perrels deserve special thanks for their role in reviewing the text.

[22] www.topdad.eu

REFERENCES

Cash, D., Clark, W., Alcock, F., Dickson, N., Eckley, N. & Jäger, J., 2002, Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making, Joh F. Kennedy School of Government, Faculty Research Working Papers Series, RWP02-046, November 2002, Harvard University.

Case, D. O., 2005, Principle of Least Effort, in Theories of Information Behavior, Fisher, K.E, Erdelez, S. & McKechnie, L. (ed.), Information Today, Inc.

Changnon, D., Changnon, S.A, 2010, Major Growth in Some Business-Related Uses of Climate Information, Journal of Applied Meteorology and Climatology, Vol. 29, pp. 325-331.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R., 1989, User acceptance of computer technology: A comparison of two theoretical models. Management Science, vol. 35, pp. 982–1003.

Dutton, J.A., 2002, Opportunities and priorities in a new era for weather and climate services, Bulletin of American Meteorological Society, Vol. 83, pp. 1303-1311.

European Commission, 2014, 2030 climate and energy goals for a competitive, secure and low-carbon EU economy, European Commission press release, IP/14/54, 22.1.2014.

Festinger, L., 1957, A Theory of Cognitive Dissonance, Stanford University Press, Stanford, California.

Finnpanel, 2014, TV audience measurements, web site. [URL: http://www.finnpanel.fi/tulokset/tv.php] Accessed 7/2014

Fortum, 2012, Tapani-myrskyt katkoivat sähköt laajoilta alueilta ja aiheuttivat Fortumille noin 45 miljoonan euron kustannukset, Stock Exchange news release (in Finnish) 5.1.2012. [URL: https://www.fortum.fi/fi/media/Pages/tapani-myrskyt-katkoivat-sahkot-laajoilta-alueilta-ja-aiheuttivat-fortumille-noin-45-miljoonan-euron-kustannukset.aspx] Retrieved 7/2014.

Frey, D., 1986, Recent research on selective exposure to information, Advances in Experimental Social Psychology, Vol.19., pp. 41 – 76, Academic Press, Inc. Orlando, Florida.

Hallegatte, S., 2012, A Cost Effective Solution to Reduce Disaster Losses in Developing Countries Hydro-Meteorological Services, Early Warning, and Evacuation, Policy Research Working Paper 6058, Sustainable Development Network, Office of the Chief Economist, The World Bank.

Helsingin Sanomat, 2012a, Antti-myrsky kaatoi 10 miljoonalla eurolla puita, news article (in Finnish) 4.12.2012. [URL: http://www.hs.fi/kotimaa/a1305625318933] Retrieved 6/2014.

Helsingin Sanomat, 2012b, Osa kotitalouksista vielä ilman sähköä Antti-myrskyn jäjiltä (in Finnish), newspaper article, 30.11.2012. [URL: http://www.hs.fi/kotimaa/Osa+kotitalouksista+viel%C3%A4+ilman+s%C3%A4hk%C3%B6%C3%A4+Antti-myrskyn+j%C3%A4jilt%C3%A4/a1305624119200] Retrieved 6/2014.

Helsingin Sanomat, 2014, EU luopuu sitovista tavoitteista uusiutuvalle energialle (in Finnish), newspaper article 23.1.2014. [URL: http://www.hs.fi/paivanlehti/23012014/kotimaa/EU+luopuu+sitovista+tavoitteista+uusiutuvalle+energialle/a1390432207961] Accessed 8/2014.

Hong, S-J., James, Y.L., Moon, J-Y. and Tam, K-Y., 2008, Understanding the behavior of mobile data services consumers, Information Systems Frontiers, Vol. 10, Iss. 4., pp. 431-445.

IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

IPCC, 2014a, Summary for policymakers. In: Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken,P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

IPCC, 2014b, Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K.

Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

ITU (International Telecommunication Union), 2014, The World in 2014 – ICT Facts and Figures, ICT Data and Statistics Division, Telecommunication Development Bureau, Geneva, Switzerland.

Kahneman, D.,2011, Thinking Fast and Slow, Allen Lane.

Katz, R.W. and Murphy, A.H., 1997, Economic value of weather and climate forecasts, Cambridge University Press, U.K.

Kuhlthau, C.C., 1991, Journal of the American Society for Information Science, Vol. 42, Iss., 5, pp. 361-371.

Lasswell, H.D., 1948, The Structure and Function of Communication in Society, The Structure and Function of Communication in Society, in The Communication of Ideas, Lyman Bryson (ed.), New York: Harper and Brothers.

Lazo J., Morss R.E. and Demuth J.L., 2009, 300 billion served: sources, perceptions, uses, and values of weather forecasts, Bulletin of American Meteorological Society, Vol. 90, Iss. 6, pp. 785–798.

Media Audit Finland, 2014, KMT lehtien kokonaistavoittavuus 2013, online article. [URL: http://mediaauditfinland.fi/wp-content/uploads/2014/05/kokonaistavoittavuus_2013.pdf] Retrieved 1.9.2014.

Mietczkowski, Z., 1085, The Tourism Climatic Index: a method of evaluating world climates for tourism. The Canadian Geographer, Vol. 29., Iss. 3., pp. 220-233.

MTV3, 2012, Tätäkö on luvassa taas keskiviikkona? – Tapani- ja Hannu-myrskyt lukuina, online news article (in Finnish), 2.1.2012. [URL: http://www.mtv.fi/uutiset/kotimaa/artikkeli/tatako-on-luvassa-taas-keskiviikkona----tapani--ja-hannu-myrskyt-lukuina/18756650] Retrieved 7/2013.

Nurmi, P., Perrels, A., Nurmi, V. (2013), Expected impacts and value of improvements in weather forecasting on the road transport sector, Meteorological Applications, Vol 20, Iss. 2, pp. 217 – 223.

Perrels, A., Harjanne, A., Nurmi, V. and Pilli-Sihvola K., 2013, Sector specific and generic impacts of enhanced weather and climate services in a changing climate, Deliverable 2.2 for FP7 funded ToPDaD Project. [URL: http://www.topdad.eu/upl/files/98674] Retrieved 9.6.2014

Pielke Jr , R. A. , Sarewitz , D. and Byerly Jr , R., 2000, Decision making and the future of nature: understanding and using predictions', in Sarewitz , D. , Pielke Jr , R. A. and Byerly Jr , R. (eds.) Prediction: Science, Decision Making and the Future of Nature. Washington, DC : Island Press , pp. 361 –387

Poolman, E., 2014, The SWFDP (Severe Weather Forecasting Demonstration Project): Improving severe weather warnings in Southern Africa, Presentation at the World Weather Open Science Conference, Wednesday 20 August 2014, Montreal, Canada.

Prime Minister's Office (Finland), 2012, Climate change mitigation, economic growth prospects and Finland's special characteristics at the focus of Finland's EU strategy on climate and energy issues, Finnish Government Communications Department Press release 194/2012, 13.6.2012.

Rothwell, J.D., 2004, In the company of others: an introduction to communication, 2nd edition, New York: McGraw-Hill.

Shannon, C.E. and Weaver, W., 1949, The Mathematical Theory of Communication, 10th printing (1964), The University of Illinois Press, Urbana.

Silver, A., 2014, Watch or warning? Perceptions, preferences, and usage of forecast information by members of the Canadian public, Meteorological Applications, doi: 10.1002/met.1452.

Statistics Finland, 2009, Official Statistics of Finland (OSF): Time use survey, Changes 1979-2009, e-publication [URL: http://tilastokeskus.fi/til/akay/2009/02/akay_2009_02_2011-02-17_tie_001_en.html?ad=notify] Accessed 6/2013.

Statistics Finland, 2013, Official Statistics of Finland (OSF): Consumer Survey, e-publication. [URL: http://www.tilastokeskus.fi/til/kbar/index_en.html] Accessed 8/2013.

Sutcliffe, A. and Ennis, M., 1998, Towards a cognitive theory of information retrieval, Interacting with Computers, Vol. 10, Iss. 3., pp. 321-351.

Vattenfall, 2011, Tapani- ja Hannu-myrskyt faktoina ja lukuina, Corporate news release 30.12.2011. [URL: http://corporate.vattenfall.fi/uutiset/uutiset/tapani-ja-hannu-myrskyt-faktoina-ja-lukuina/] Retrieved 6/2014.

WMO, 2011, Climate Knowledge for Action: A Global Framework for Climate Services – Empowering the Most Vulnerable, The Report of the High-Level Taskforce for Climate Services, WMO Report No. 1065, Geneva, Switzerland.

Yonazi, E., Kelly, T., Halewood, N. and Blacman, C. [eds.], 2012, The Transformational Use of Information and Communication Technologies in Africa, eTransform Africa report, The World Bank and the African Development Bank, U.S. and Tunisia.

APPENDIX A: Questions in the online survey for the users of Climate Guide

1. **What organization are you representing at the moment?** (Answer choices: School or educational institute / Research institute or university / Municipality / Regional government / State government / Private enterprise (describe the nature of the business in the open comments) / Non-profit organization / Media / Not employed or studying / Other, what?)

   A) If school or educational institute:

   2. **What is your role in the organization?** (Answer choices: Teacher / Student or pupil)
   3. **Have you used the material provided by Climate Guide in your teaching or studies?** (Answer choices: Yes / No / No, but I'm interested in the possibility / No, but I plan to do so in the future)

   B) If municipality:

   2. **What is your role in the organization?** (Answer choices: Employee / Officer / Supervisory officer / Elected representative / Higher management position / Other)
   3. **Would it be possible for your municipality to produce example case material about good practices or experiences in mitigation or adaptation to climate change for the Climate Guide?** (Answer choices: Yes / Possibly / No)

   C) If research institute or university:

   2. **What is your area of work in the organization?** (Answer choices: Research / Communications / Administration / Other)
   3. **Have you used Climate Guide to communicate your research results?** (Answer choices: Yes / No / No, but I'd be interested in the possibility to do so in the future)

   D) If any other type of organization:

   2. **What is your role in the organization?** (Answer choices: Employee / Official / Management or other higher official / Other)

4. **How often do you visit the Climate Guide?** (Answer choices: This is the first time / Daily / Weekly / Monthly / Less frequently than once a month)

5. **I have searched for information in Climate Guide about the following topics:**
   (Answer choices:)
   - Overview of the content of the site
   - How climate is changing globally
   - How the climate in my region is changing
   - What the climate in my region is
   - What has the global climate been in the past
   - What factors affect climate change
   - How climate change impacts glaciers and oceans
   - How the weather conditions in Finland are changing
   - How is climate researched and modeled
   - What are the global impacts of climate change
   - What are the impacts of climate change to the environment and livelihoods in Finland
   - What measures there are to adapt or prepare for the climate change
   - How can climate change be mitigated (how can emissions be reduced)
   - What can municipalities do in different sectors
   - Examples of concrete actions undertaken in the municipalities
   - News or other topical material on climate issues
   - Other, what?

6. **I came to search for the following information in the Climate Guide:**
   (Answer choices identical to question 5).

7. **In what form or media have you searched for in the Climate Guide?**
   (Answer choices:)
   - Text articles
   - Statistics or numerical figures
   - Maps
   - Videos
   - Graphs
   - Infographics
   - Interactive content
   - Learning exercises

- Quizzes
- Other, what?

8. **In what form or media did you come to search for in the Climate Guide?**
   (Answer choices identical to question 7)

9. **Have you found the information you looked for?**
   (Answer choices:)
   - Always
   - Most of the time
   - Rarely
   - No, but Climate Guide helped me further
   - No

10. **Have you found the information in the form you looked for?**
    (Answer choices identical to question 9)

11. **Which parts of Climate Guide have you looked into?**
    (Answer choices: 21 sections and types of material)

12. **Which ways to visualize information did you prefer especially?**
    (Answer choices:)
    - Climate related maps and graphs
    - Learning exercises
    - Researcher interview videos
    - Fact sheets on climate change
    - Lecture and seminar videos
    - Interactive content
    - Climate quiz
    - IPCC infographics
    - I can’t tell.
13. Have you identified other interactive databases, material or visualization tools that you think would fit well in the Climate Guide?

(Open question)

14. **What topics you would want to find more information on in the Climate Guide?**

(Answer choices:)

- Climate change as a phenomenon and climate scenarios
- Climate change in Finland
- Impacts of climate change
- Mitigation of climate change
- Adaptation to climate change
- Climate related news
- Adaptation and mitigation in different municipal sectors
- Implemented municipal level solutions
- Addressing some new target group, what?
- Other, what?

15. **What forms or media would you like to see more in the Climate Guide?**

(Answer choices:)

- Text articles
- Pictures
- Infographics
- Researcher interview videos
- Videos on climate change
- Lecture and seminar videos
- Map tools
- Interactive content
- Learning exercises
- Presentation slides
- Other, what?

16. **From where did you learn about Climate Guide?**

(Answer choices:)

- Training or education (workshop, seminar, course etc.)
- Colleague or other contact

- Search engine
- Facebook
- Some other site
- Fair or expo
- Printed article
- Marketing campaign
- Other, where?

APPENDIX B: Workshop learning café agenda

Climate Guide 2020: Visions for long-term development.		**Round two: Wild ideas**	
Table	**Topic**	**Table**	**Topic**
1.	User experiences from climate services: What climate information is used and how?	**1.**	The visibility and impact of the Climate Guide: How to better market the services? How to improve communication?
2.	Using scientific knowledge: What factors drive or enable the use?	**2.**	Popularization: How much can be popularized without losing credibility? How?
3.	New services and products in the Climate Guide: What are the most useful forms of information?	**3.**	Interaction: Opportunities of two-way interaction in Climate Guide. Possible platforms or functions?
4.	Adaptation and mitigation: making available information more usable	**4.**	Climate Guide 2020: Visions for long-term development.

The workshop was held in the FMI premises June 10th, 2014.

ISBN 978-951-697-854-6 (pdf)
ISSN 2342-7108 (pdf)

Unigrafia
Helsinki 2014