Assessment and Evaluation Methodology Report

Blue-Action Case Study Nr. 1

Picture 1 Credits: Rukakeskus Oy

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Summary for publication

The end-product of this case study will be a climate service for winter tourism centre Ruka in Northern Finland, with possibilities to replicate this service for other users. Snow security is of significant importance for winter tourism in North Finland and other comparable destinations in North Scandinavia and other snowy countries. The climate service for winter tourism centres aims to minimize energy consumption and other costs of snowmaking, while ensuring earliest possible skiing-season start. Additional costs caused by increased dependence on snowmaking for early season start will influence winter tourism centres' profitability, as climate change causes delay of the arrival of winter, as well as the environmental impacts of snowmaking as an adaptation strategy.

The main result of this deliverable is an assessment and evaluation scheme consisting of qualitative and quantitative (econometric) tools. A stated in the project plan, focus in the economic evaluation is on the value of the information for the end-user, particularly in terms of competitiveness and the willingness to pay for the service.

For this purpose, a review of economic feasibility analysis methods utilized in other climate service development projects has been made. The availability of scientific articles on comparable climate services is limited due to the novelty of the concept, but some lessons and good practices have been identified. Moreover, the evaluation scheme is based on discussions and other collaboration among the case study team and the work reported in D5.1 "End-users Needs Report: Weather and climate data for Northern Finnish winter tourism centers" in 2017 (Lesser et al. 2017).

As the purpose of climate services is to provide climate information to assist societal and business related decision-making, a core aspect is also the influence of the climate service to business operations by reducing uncertainties. Hence, qualitative methods for evaluating the capacity of the end-user to adjust its business operations to improved information, both in short-term and mid-term perspective, are presented. Moreover, evaluation of snowmaking as an adaptive strategy will be an additional feature that emerged from literature research and findings from the ongoing work in this case study.

In this report, a set of methods for assessing and evaluating the climate service and the co-design process from the aforementioned perspectives is introduced. The evaluation setting comprises both qualitative and quantitative (econometric) aspects.

Work carried out

The challenges that climate change poses to winter tourism and ski resorts industry are discussed in scientific literature widely. During the past decade, the importance of machine-made snow as an adaptation strategy in ski resorts has been widely noted. For reducing uncertainties on snowmaking conditions and for minimizing costs and emissions from energy consumption, this case study aims to develop a climate service for winter tourism in Northern Finland. The service can potentially be replicated in several ski resorts and destinations in Europe and elsewhere.

The European Commission's Roadmap to Climate Services[1] recognizes the relative novelty of climate services as a concept and notes that various definitions of them exist. In the roadmap, the European Commission gives the term a broad meaning, covering "the transformation of climate-related data — together with other relevant information — into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management" (European Commission 2015: 10). The European Commission's Roadmap notes the importance of climate services not only for adaptation actions, but also to mitigation. Stemming from the definition on climate services as "the provision of climate information to assist decision-making" (Buontempo & Hewitt 2017) it is of crucial importance to co-design a knowledge system in the interface of climate models and the practices of winter tourism business, ensuring also wide end-user involvement.

This deliverable builds on literature research and the multidisciplinary team work conducted from August 2017 to February 2018 by Ac UoL and Ruka (i.e. CS1 team) for developing and co-designing a climate service for Ruka. The work was conducted mainly via desktop work, online meetings and exchange of emails aiming at:

- collecting of requested data from the Ruka skiing resort and related parties such as the snow-machine producer, and
- testing of the available climate model data

The purpose of this collaboration between Ruka and AC UoL has been two-fold:

- to deepen the understanding on the knowledge needs and sources of uncertainty that Ruka faces in its business operations and decision-making that could be alleviated with better forecast; and
- to identify what kind of qualities of data on which key parameters (e.g. grid, distance of data points from Ruka, humidity, wind speed and temperature) are needed for developing the climate service.

The approach utilized has elements of service design and collaborative planning, although no specific service design method is meticulously applied. The iterative process as described in the project plan has not specified a service design method to be utilized in the project, but the CS1 team has applied such principles in practice. The interface of end-user needs and the ability of the currently available data in providing information matching the end-user needs is an essential part of the iterative process of developing the climate service.

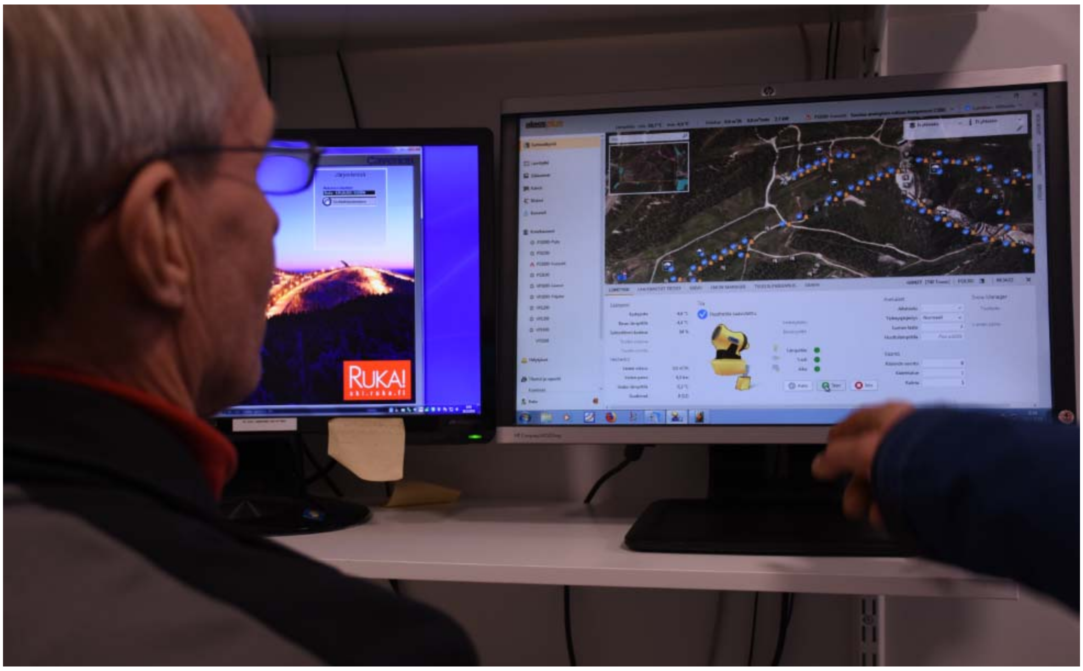
[1] https://ec.europa.eu/programmes/horizon2020/en/news/european-research-and-innovation-roadmap-climate-services

Two Case Study Meetings (CSM) for CS1 have been organized during the first 15 months of the Blue-Action project. The first meeting was held in 2017.
The second CSM of CS1 took place at Ruka resort on 15-16 February 2018.

Picture 2 Case study team discussing decision-making and practical knowledge needs of Ruka that our climate service could contribute to, and finding out about their information systems. Learning about operational and decision-making aspects of snowmaking from the

This meeting enabled the CS1 team to access the case study site for conducting fieldwork and learning more about snowmaking and decision-making in Ruka. The fieldwork in Ruka included a tour on snowmaking, where CS1 team got to observe and interview Rukakeskus Ltd. personnel on the operational level of snowmaking, the management systems and experience based knowledge in snowmaking. Also CS1 got to conduct collaborative working by visual methods with the end-user for the purposes of co-designing the climate service. The aim was to ensure the end-user's perspective to be heard and maximally incorporated in the design of the climate service. For this purpose, the CS1 team used visual working methods in the form of an "annual clock" for visualizing the interdependencies of snowmaking, snow storage, ski seasons, decision-making and related knowledge and knowledge needs. Moreover, by studying snow-machines and management systems and other sources of information more closely, CS1 team learned more about the potential interfaces to be built between the climate service and the operational activities in Ruka. Also, photographs and videos were taken for communications and dissemination purposes.

Picture 3 Pertti Määttä from Rukakeskus Ltd. tells the CS1 team about how snowmachines work and how they are operated. (Photo: Ilona Mettiäinen, Arctic Centre, UoL)



Picture 4 Learning about the information and management systems that Rukakeskus Ltd. uses in snowmaking (Photo: Ilona Mettiäinen, Arctic Centre, UoL)

Purpose of this deliverable

This Assessment Methodology Report at hand is the third step in the iterative process of creating a climate service for winter tourism companies and builds on the first step that was reported in the first deliverable of this case study "End-users Needs Report: Weather and climate data for Northern Finnish winter tourism centers" D5.1[2]. The current report has been produced simultaneously with D5.2 "Model Information Utilization Report", which also relates to our case study.

This report introduces and presents methods for assessing the economic feasibility of the climate service in quantitative terms and for evaluating by qualitative means the capacity of the end-user to adjust its business operations to better information provided by this service. Moreover, in addition to the requirements set in project proposal, a number of qualitative features of the project implementation, particularly the co-design work, are followed for identifying good practices as lessons to be learned for climate service projects in the future. Also, the impacts of the climate service on greenhouse gas emissions from snowmaking will be addressed.

For this purpose, a brief review on economic feasibility analysis methods used in other climate service projects has been conducted based on articles on other climate services that have been recently developed in Europe and elsewhere. However, given the novelty of developing climate services for winter tourism (skiing) industry, benchmarking from essentially similar cases/projects was not possible. Hence, to large extent, focus in quantitative issues will be on industry specific aspects such as the connections of snowmaking costs and weather phenomena, as identified in this project.

Machine-made snow as an adaptive action in winter tourism centers – economy related viewpoints

The climate service developed in this project focuses on snowmaking in a ski resort in Northern Finland. While at the project phase the climate service is co-designed with Ruka ski centre, the climate service can potentially be replicated for other ski centres in Europe and elsewhere after the project phase. The range of potential interested parties is large. Skiing is an important part of winter tourism in Northern Finland as well as in several mountainous regions in Europe, such as in the Alps (e.g. Damm et al. 2017, EUPORIAS 2015[3]) and in the Scandinavian mountains (e.g. Falk & Hagsten 2016), and also globally, for instance in New England and on the slopes of the Rocky Mountains in the USA (Burakovski & Magnusson 2012), and in New Zealand (Hopkins 2014).

Several authors have written about the economic impacts of climate change on winter tourism in general or for skiing tourism in particular. Yang & Wan (2010) have noted that "[artificial[4]] snowmaking has become an important integral component of the ski industry in many regions at present as it can effectively extend the skiing season." While about a decade ago snowmaking was not discussed very much in scientific literature, several recent articles see machine-made snow as an important adaptive action for ski resorts (e.g. Haanpää et al. 2015; Damm et a. 2014). Haanpää et al. (2015) call downhill skiing a "canary in a coalmine" type indicator of the impacts of climate change on the winter tourism industry due to its strong dependence on the climatic conditions for economically successful operation. Both climate change and interannual climatic variability have forced centres to invest in e.g. snowmaking.

[2] Lesser, Pamela, Toivonen, Jusu, Coath, Martin, & Contreras, Roxana. (2017). End-users Needs Report: Weather and climate data for Northern Finnish winter tourism centers (D5.1).

[3] http://www.euporias.eu/ and http://prosnow.euporias.eu/

[4] Artificial snow and artificial snowmaking are widely used concepts also in academic literature such as in the article by Yang & Wan (2010), Damm et al. (2014) and Damm et al. (2017). However, the snowmaking industry prefers to use the concept "machine-made snow" when referring to actual snow made of water (although the snowflakes have slightly different shape than natural snowfall) and not fake or imitation snow (SnowMakers 2012) in the sense of being made from artificial materials like plastic or polymers (Gels Handbook 2001). For instance, plastic coating on ski-jumping towers and slopes enable practicing also in the summer time, and artificial snow made of plastic is used in e.g. film productions, science centers and display windows. Due to lack of precision in terminology there may be some ambiguity in some of the relevant literature, but it can be mostly mitigated based on the context of the articles.

Haanpää et al. (2015) have pointed out that as snowmaking generally requires sub-zero temperatures and the availability of water and energy, climatic conditions favouring snowmaking have become so important that vulnerability of the winter tourism areas "cannot be talked about without taking artificial[5] snowmaking possibilities into account." (ibid.).

According to Falk & Hagsten (2016), "[a] new empirical result is that a decline in snow depth in the early season has a strong negative impact on [skiing] lift ticket sales." As the number of snow-cover days is expected to decrease by 20 - 30 % by the end of the century, especially the arrival of snow cover is projected to be delayed (FMI and Regional Council of Lapland 2010), i.e. availability of snow in the early season will particularly be impacted.

Machine-made snow is already used throughout the skiing season also in Ruka, even if there is also a remarkable amount of natural snowfall. For early opening of the skiing season stored snow from previous season is used. The stored snow is a mix of natural snowfall and machine-made snow. As the skiing season may start much earlier than natural snow falls, it is possible that the slopes are opened relying on stored or recently machine-made snow.

It is in the business strategy of Ruka ski resort to be the most snow secure resort in Europe. For instance, in 2017, the skiing season was opened on October 6th. This was enabled by snow that was stored over the summer and by production of snow by machines in September-October.

Picture 5 Snow storage and a snowmachine in a ski slope in Ruka in February 2018. The thick layer of snow for opening the next ski season in October is stored in the ski slope. This is one of the first slopes that are opened in early October relying on stored snow. (Photo: Ilona Mettiäinen, Arctic Centre UoL)

[5] See footnote 4

Review on methods for economic feasibility analysis and process evaluation of climate services

For setting a scheme and method for assessing the economic feasibility of the climate service this purpose, a brief review on economic feasibility analysis methods used in other climate service projects has been conducted. The review is based on articles and other publications on climate services or their prototypes that have been recently developed in Europe and elsewhere.

Given the novelty of developing climate services in general and the limited availability of climate services made for businesses, winter tourism industry in particular, possibilities for benchmarking from essentially similar case studies has also been limited. Even if already in 2010 Yang and Wan (2010) considered studies on climate adaptation measures in tourism as mature, climate services are a relatively new tool in enhancing adaptation to and mitigation of climate change (European Commission 2015; Harjanne 2017).

So far, only a limited (even if growing) number of climate services have been developed, and to our knowledge[6] the only previous one developed for skiing tourism centers or other winter tourism industry is PROSNOW by EUPORIAS in mid-2010s. However, based on searches in ScienceDirect in January 2018, the only articles addressing even this service were on the EUPORIAS project in general. In addition to Blue-Action, another ongoing Horizon2020 funded project, EU-MACS EUropean MArket for Climate Services[7] is currently working on market development of climate services for tourism, but their first reports will not be published until March 2018. Hence also the availability of articles or other publications on comparable cases for benchmarking and review of economic feasibility analysis is limited.

Despite the lack of development projects of climate services that could be directly learned from here, some more general lessons have been identified also from cases that are directed to authorities. Keeping this limitation in mind, the specificities of a ski resort as the end-user of the climate service must be carefully considered when deciding the assessment and evaluation methods. Indeed, in the assessment and evaluation scheme presented here, emphasis is on industry and case specific aspects such as (for economic feasibility analysis) the connections of snowmaking and weather phenomena, as identified in this project. This conclusion is supported also by the service co-design approach of this project. In this pilot project, industry and even company specificity, as well as geographical specificity reduce the comparability and direct applicability of these results to other industries. However, applicability to other ski resorts should be relatively easy. Co-production of knowledge in this project has helped to identify the economically most important weather related factors for snow-production and their links to costs, and besides self-evaluation by Ruka ski resort these will be prioritized.

Having taken the aforementioned limitations into account, a review of existing methods of economic feasibility analysis from literature has been conducted focusing on recent scientific articles on climate services, which exist in limited numbers. The review is based on eight (8) articles or other publications representing cases from a variety of geographical locations including the Caribbean, Sweden, Austria, and Southern Finland. In addition to articles published in scientific journals, an EUPORIAS / PROSNOW

[6] Based on searches in ScienceDirect in January 2018 no climate services developed for ski resorts or other types of winter tourism industry have been reported to the scientific community as articles, including on PROSNOW by EUPORIAS.

[7] http://eu-macs.eu/tourism/

report on the usefulness of their climate service, made for ski resorts in the French Alps, was included in the review due to its matching theme, and EU-MACS project website has been visited.

Buontempo et al. (2017) and Buontempo & Hewitt (2017) have written about lessons learned from the several climate service prototypes that were developed under the EUPORIAS project within the EU 7th Framework Programme. They developed, for instance, Project UKKO that provides seasonal wind predictions for the energy sector (http://project-ukko.net/) and PROSNOW that – interestingly for this project – aims at better snow related forecast for tourism in French Alpine regions (EUPORIAS 2015). In their report on the potential usefulness of the prototype, PROSNOW (http://prosnow.euporias.eu/) saw the importance of establishing a financial model in covering the costs of providing information that is demanded by mountain tourism professionals. PROSNOW also highlights that the service provides data that has been interpreted and adapted to the specific target audience, instead of providing just raw or formatted data. In the climate service prototypes developed within EUPORIAS, the value of a climate service was defined roughly as an approximation of "the expected price the stakeholder would be happy to pay for the provision of the service." (Buontempo et al. 2017, Buontempo & Hewitt 2017). One of the main lessons from EUPORIAS is that two general principles are of primary importance: the **overall value of the impact predictions** and the **user engagement**, which, according to Buontempo et al. (2017) can to some extent depend on each other, one way or the other.

Vogel et al. (2017) proposed a framework for climate services evaluation based on a case study on the Caribbean Agrometeorological Initiative. They offer a full lifecycle approach to the evaluation of the CAMI (Caribbean Agrometeorological Initiative) program. As Vogel et al. (ibid.: 67) note, "[n]ovel approaches to project evaluation are needed to document the outcomes and lessons to be learned from the investments international donor organizations are making." Vogel et al. (ibid.) set forth that their agriculture-based model "could serve also as a guide in non-agriculture contexts as well".

However, many of the evaluation questions suggested by Vogel et al. (2017) are irrelevant for this project - either in general or at this stage. For instance, questions on "who will be using the information" or "where the information will be used", are irrelevant for this case study, as in this project we have a designated business partner from North Finland: Rukakeskus Ltd. and Ruka ski resort as the case study location. Another downside in Vogel et al.'s evaluation model is that it focuses mostly on capacity-building related aspects, and economic feasibility has not been calculated or evaluated directly. The authors also note that "[t]here is almost no way to quantitatively determine how much of the economic success of farmers is due to good farming practise (or the use of climate information). Definite metrics of "increased agricultural productivity" are at present hard to come by." (ibid.: 74). Despite the above described problems in the applicability of their model for our case study, Vogel et al. highlight the **process dimension** of (the development of) climate services. This is an interesting point for Blue-Action as well, and resonates with the findings of Buontempo et al. (2017) on user engagement viewpoints.

Based on a Swedish ski resort case study and literature research, Falk and Hagsten (2016) have formed an equation that models lift ticket sales as "a function of relative lift ticket prices, GDP in constant prices, average snow depth in the ski area and the time trend. Given the availability of monthly data, the model can be specified for each month separately. This makes it possible to separate out sub-seasonal factors." (Falk & Hagsten 2016: 63). However, this equation that addresses the economic impact of snow conditions is not meant for evaluating a climate service, but the importance of early snowfall for the Swedish ski resort. Still it may be useful for us in putting a price tag for ensuring enough snow on slopes.

Michailidou et al. (2016) have suggested a **Multi-Criteria Decision Analysis** (MCDA) on mitigation and adaptation options in tourism areas based on research done in Greece. In this, economic aspects are also included. The chosen MCDA criteria included environmental benefit, applicability, cost and social acceptance. However, Michailidou et al. have not studied the development of a climate service but provided a method for assessing the most preferred options for adaptation and mitigation in tourism areas.

Damm, Greuell, Landgren and Prettenthaler (2016) have used time series regression models to study the relationship between natural snow conditions and monthly overnight stays in twelve major skiing tourism intensive NUTS-3 regions in Europe, including Northern Finland. Applying the **Weather-Value at Risk** concept that provides a method for measuring economic risks resulting from weather fluctuations and + 2 °C temperature increase, they "quantified the risk of tourism demand losses due to weather variability and assess the potential impacts of climate change." According to Damm et al. (ibid.), the highest weather-induced risk of losses in winter overnight stays was found in Central and Southern European countries, particularly in Austria. Interestingly, the losses were found to be higher in Sweden than in other Scandinavian countries.

Damm, Köberl and Prettenthaler (2014) carried out a **Cost–Revenue Analysis** of snowmaking under future climate conditions in a case study from Styria, Austria, for addressing the knowledge gap on the economic profitability of snowmaking. They point out that the use of snowmaking involves high investment and operating costs, including from energy consumption. Hence they suggest that increasing temperatures, the growing frequency of winters with little snow as well as the rising energy prices raise questions about the profitability of snowmaking in the future. Damm et al. (ibid.) conclude that "ski area operators are at risk of facing a substantial increase in total energy costs due to expected rising electricity costs". This is expected to happen despite the shortening of the feasible time for snowmaking, considering current snowmaking infrastructure, as the total amount of snowmaking hours is projected to slightly decrease. However, Damm et al. (ibid.) state that the economic limits of snowmaking are poorly understood.

In their cost-revenue analysis, Damm et al. (2014) used factors such as projected daily snowmaking hours, projected daily visitor numbers, increasing energy prices due to higher taxes or shortages of fossil fuel, ski lift ticket price and discount rate scenarios. While this article does not discuss climate services itself, its focus on ski resorts and snowmaking means that our case study can learn from their economic analysis.

In one of the few studies on the economic impacts of climate change on skiing industry in Finland, Haanpää et al. (2015) identified "climatic factors that are crucial for economically successful operation of low-lying ski areas in Southern and Middle Finland and contemplated how these factors are seen to change with climate change." They see snowmaking "[a] key adaptation strategy to respond to uncertain snow conditions (…), which lowers the vulnerability of the areas to the impacts of climate change."

While Haanpää et al. (2015) present a list of weather-related factors potentially affecting the economic success of a skiing season in Finland, their article does not suggest any methods for analysing and quantifying how these factors influence the economic success and to what extent. Haanpää et al. (ibid: 974) describe that for skiing resorts the operational perspective is very short, in their sample 2-5 years for operative maintenance and around 5-10 years for strategic planning and development. Haanpää et al. note that Southern skiing destinations tend to have longer time spans for these as compared to more Northern ones, probably due to the larger uncertainty of annual weather conditions, but this needs further investigation. On the comparability of their results, Haanpää et al. note (p. 975) that "[d]ue to

being in high latitude locations, the ski areas are not entirely comparable to low-lying ski areas in other parts of the world."
As a conclusion, it can be said that the availability of comparable cases that have done economic feasibility analysis on climate services is very limited. Among the existing ones, some reasonable points can be identified. Here, based on EUPORIAS, we intend to assess the economic feasibility of the climate service by understanding the value of the service as "a measure of the overall benefit to the stakeholder associated with the prototype (…) approximated by the expected price the stakeholder would be happy to pay for the provision of the service." (Buontempo & Hewitt 2017). Also EU-MACS project on tourism assesses the potential use of customized climate services for tourism by the concept of WTP (willingness to pay). Given both the limited number of comparable cases i.e. lack of possibilities for very wide benchmarking for methods used for economic feasibility analysis, and particularly the service design approach of this project means industry and company specificity in the service development which reduces the comparability, to large extent our case study must rely on the information provided by the climate service itself. This is further determined by aspects that are listed in the evaluation setting.

Moreover, on the qualitative aspects, end-user involvement and improvements in the decision-making procedures on and the operational level of snowmaking due to decreased uncertainty are to be addressed.

Main results achieved

The main result of this deliverable is the assessment and evaluation scheme for quantitative (econometric) and qualitative aspects. It is based on the review on articles on economic feasibility and development of climate services and, for addressing case specific factors and the specificities of winter tourism industry and particularly of Ruka, on aspects identified in the CS1 work.

The climate service that is co-designed in this case study is expected to:

- reduce uncertainties around timing of snowmaking and the beginning of the skiing season,
- reduce the costs of snowmaking as an adaptive action,
- support the economic success of the ski resort also in the future, and
- from an environmental viewpoint, help avoiding the increase of environmental impacts, particularly the carbon footprint, of snowmaking, and hence help avoiding snowmaking from being, in fact, maladaptation, i.e. adaptive action that actually accelerates climate change by causing greenhouse gas emissions.

The purpose of this deliverable is to provide a method for assessing and evaluating the economic feasibility of the service. This lays ground for potential commercialization of the climate service. The assessment and evaluation setting is the next step in the iterative process of co-designing a climate service for Ruka ski resort.

The assessment and evaluation setting presented in this deliverable lays ground for finding out the economic significance of the climate service for Ruka, and may give some directions on the potential impact for winter tourism industry in general. Also, the work reported in this deliverable is a map for estimating the ways in which Ruka will be able to adjust its business operations based on improved knowledge and foresight, as well as factors that may hinder the adjustment of the decision-making. As an additional feature, it was identified in this deliverable that economic aspects go hand in hand with energy consumption, which again leads to environmental impacts such as greenhouse gas emissions and can turn snowmaking from an adaptive action to maladaptative.

Methods of assessing and evaluating the climate service

The assessment and evaluation of the climate service focuses on two aspects:

- on **the value of the information for the end-user**, particularly in terms of economic feasibility and competitiveness, and
- on **the capacity of the end-user to adjust business operations to improved information**, in the short-term and mid-term perspective.

As for the first dimension, we have focused on identifying the core factors in the interface of weather and costs of snowmaking and the timing aspects of snowmaking (early season).

As for the second dimension: the assessment will be made by Ruka "in terms of the value of possible investments in which the data is used as well as the value of activities". However, it must also be stated that tourism business is not only dependent on climatic conditions in the ski resort itself, but a number of external factors influence the business as well. These include tourism trends, new innovations in the service industry, competition between skiing destinations (e.g. between the Alps and Northern Scandinavia), the development of world economy and global safety. Hence there are several factors that may make it very difficult to evaluate the influence of the service especially in the long run.

Evaluation setting

The evaluation setting here is a formative one. Formative evaluation takes place before or during the project, and its purpose is to find out what works and what doesn't, for the purpose of learning for the following projects.

The evaluation takes place in the form of project diaries, case study team meetings and the analysis of the indicators of the economic aspects of snowmaking, as provided by the climate service.

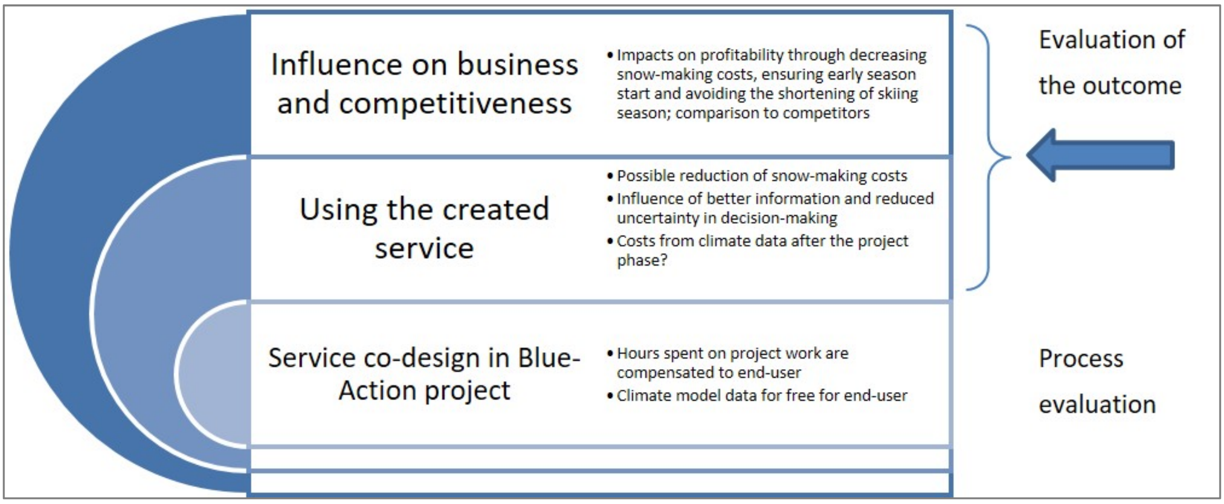
The project learning diaries were started already in March 2017 in the first CS1 case study meeting. The purpose has been to write down what the project participants have learned during the project work. As it has been recognized from early on, this project involves learning across professional or disciplinary "borders", while venturing into largely unknown terrain: climate services as such are a rather new phenomenon, and one built for business, particularly winter tourism business, is globally rather new, to our knowledge.

For evaluation, an evaluation setting must be first planned. This consists of deciding what will be followed, formulation of a set of questions (both qualitative and quantitative) that will be followed and answered. It is noteworthy that "what you follow you will get", i.e. a successful and strategic selection of evaluation questions can also help with running a successful project.

In this case study, both quantitative and qualitative aspects will be evaluated. The quantitative aspects will focus around economic feasibility aspects, and qualitative aspects will involve aspects related to the significance of improved information, as provided by the climate service, to decision-making in Ruka.

Spheres of economic feasibility of the climate service for winter-tourism business

In analysing the economic feasibility of the climate service, focus will be on assessing and evaluating the influence on business that the climate service may have. The model data are provided free of charge by the other partners of the Blue-Action project (MPI-M and UHH).



Picture 6 The spheres of evaluation of the project

The final economic feasibility can only be analysed several years after initial implementation, and it is expected that Ruka will need time to rely on the serviced data and to rely on it in the decisions on snowmaking and season-opening. This means that also the decision-making process in Ruka will be slowly adapted to using this service. For this reason, an ex-post evaluation on the reliability of the service in 2025-2028 is suggested, i.e. when it can be estimated that the service may have been fully adopted and data on its economic benefits will have been made available.

Econometric (quantitative) evaluation of the climate service

The economic value of improved weather and climate information for the end-user, provided by the climate service is understood as the price that the end-user would be willing to pay for the service. The economic feasibility of the climate service designed in this project depends first and foremost on the ability of the model created to reduce uncertainty reliably so that a) energy efficiency and monetary savings from the energy consumed for snowmaking can be reached and b) the start of the skiing season can be done early at minimal costs.

Key parameters at Ruka to follow as “indicators” of economic viability:

- Amount of energy used for snowmaking and the cost of energy.
- Skier days to indicate the beginning of the skiing season and success of the opening (e.g. 6 October as in 2017).
- Use of water (cubic meters): the efficiency of snowmaking can be measured by comparing use of energy and water amounts.
- The number of days it takes to get all slopes opened / snowmaking done (salary, energy and fuel costs). The weather conditions are the most significant factor. The more a resort knows about the weather beforehand the better.

Answers to many of these will be provided by the climate service itself, once it is ready, as there the connection between weather conditions, climate and snowmaking costs is made. However it must be noted, as stated in D5.1, that it will take some time before Ruka will trust the service and won’t fully rely on the suggestions of the service but maybe 30 % first (Lesser et al. 2017). That's why it is likely that the assessment of the economic importance of using the climate service will only give partial results until Ruka feels safe to trust the service. Any mistakes may cause economic losses to Ruka, and hence precaution and some reservations in trusting the service right away is warranted. The economic importance of using the climate service can hence probably be better analysed after the project phase.

An important aspect to consider on the economic feasibility analysis is, that some of the information on competitiveness aspects (skier days, for instance) is commercially sensitive. This may pose challenges to reporting the assessment on competitiveness. As Ruka is the business partner in this research project, access to such information is expected to be available for the CS1 team, but consideration must be put on reporting the results to wider audiences in scientific articles or in public project deliverables.

Evaluating the capacity of the end-user to adjust business operations to improved information

The decision-making procedure on snowmaking and season start has been described, along with the challenges posed to it due to lack of foresight information, in D5.1. To sum up, while formal procedures for decision-making on season start, snowmaking and snow storage do exist, decisions are also based on informal, experience based knowledge.

The basic setting for the qualitative part of this evaluation on the capacity of the end-user to adjust business operations to improved information is as presented in Figure 8.

Picture 7 The basic qualitative evaluation setting

Qualitative aspects to be evaluated include:

- To what extent Ruka starts to rely on the information provided by the climate service in their decision-making on snowmaking, snow storage and on setting the date of opening the skiing season?
- Does the climate service provide answers to questions that are useful for Ruka and fit its business operations and decision-making process?
- Will the climate service be used after the Blue-Action project phase?
- How is the climate service incorporated in the management and operational systems of snowmaking in Ruka?
- End-user involvement in the co-design process: timing, methods, challenges and good practices

The qualitative evaluation will be done based on discussions in case study team meetings led by the resort director or the ski operations manager. Moreover, the case study team will write down their learning process to learning diaries as well as in the Blue-Action intranet. Aspects to write about in the learning diaries include observations concerning development of the knowledge co-production process, end-user involvement, and learning across professional and disciplinary borders. For evaluating the potential change in decision-making of Ruka on snowmaking based on better information from the climate service will be evaluated by describing the decision-making procedure as it was before the project and again revisiting it during the testing rounds of the climate service, and in the end of the project phase.

Progress beyond the state of the art

Snow security is of significant importance for winter tourism in North Finland and other comparable destinations in North Scandinavia and other snowy countries. Climate change is expected to lead to decrease of snow cover days, for example in Northern Finland by 20-30 % by the end of the century (Finnish Meteorological Institute 2010), which means particularly the shortening of winters from the beginning, i.e. delay of the arrival of snow. The climate service we are co-designing in this case study can potentially be valuable for winter tourism industry in Northern Finland, as well as other skiing areas in European Union (e.g. the Alps) and even globally. Moreover, good snow conditions on ski slopes are important also for major sports events such as the Winter Olympic Games and Alpine Ski World Cup competitions.

While at this stage the work to produce the climate service for winter tourism centres is in progress and in relatively early stage, the end result is expected to have significant economic and environmental importance, as snowmaking can be optimized in a way that ensures the opening of the ski season early while energy consumption and hence economic costs as well as greenhouse gas emissions are reduced. This is policy relevant both in terms of climate adaptation of important livelihood branches and climate mitigation.

Already at this stage we can estimate that once the project is completed, we will have created a service that may be very significant for skiing industry for informed decisions on investments, reducing costs of snowmaking while helping to ensure an early beginning of skiing season and hence supporting profitability of skiing industry also in the future when climate change has altered the business conditions in largely less favourable ways. Potentially the service can be important for other types of winter tourism businesses as well.

Building a climate service for winter tourism industry may be, to its part, also an example of the much sought-after successful collaboration between science and business, as well as public engagement in science. This is realized in two senses:

- **SCIENCE-TO-BUSINESS:** by creating a practical tool for tourism industry for planning short-term and longer-term activities and investments in ski resorts from climate model data that is otherwise not accessible and interpretable by non-technical / non-scientific people; reducing uncertainty on long-term investments based on science and reducing costs and GHG emissions
- **BUSINESS-TO-SCIENCE:** scientific research and climate model data can be developed and designed so that they would be better suited to answer societally or commercially important questions.

Also scientifically, knowledge co-production, science-policy nexus and service design are emerging and developing research settings. This project contributes to understanding of those by providing experience and knowledge on the interfaces of climate modelling and business related decision-making. How science could inform societal and business related decision-making is a highly policy-relevant question, and thus this research has potential to create and identify good or best practices for collaboration between scientists and businesses.

In developing a climate service, it is important to identify challenges in the co-design process and solutions to them, as well as build means to assess the economic importance of the climate service by assessment and evaluation. Assessment and evaluation of the pilot phase (Blue-Action project) and identification of good practices will lay ground for climate service work with winter tourism industry in general after the project phase.

Impact

How has this work contributed to the expected impacts of Blue-Action?
The work conducted for this deliverable is a step towards reaching the ultimate goal of a climate service for winter-tourism industry in Northern Finland. Interaction with the winter-tourism business partner Ruka in co-designing the service has been active. The climate service is expected to improve the capacity of winter-tourism centres to predict the weather and climate conditions and plan and adjust their operations accordingly. This can also be estimated to enhance the capacity of the winter-tourism industry to adapt to the changing climate.

An open dialogue is expected in the future with also the wider winter-tourism industry in Northern Finland, when results have been created with Ruka during the Blue-Action project. Moreover, it is in the core of this case study to contribute to Blue-Action goals by creating knowhow in creating climate services that answer to end-user needs and help them economically succeed in a changing climate. This improves the winter tourism industry’s ability to adapt to climate change in a sustainable way.

By maximizing energy efficiency and hence minimizing the GHG emissions and, simultaneously, costs from snowmaking, both environmental and economic benefits can be reached. This also ensures that increased snowmaking as an adaptive action does not actually become maladaptation.

The iterative transdisciplinary co-design process involves learning across and beyond one’s disciplinary / professional expertise. A translation process between business practices and climate modelling is needed and takes place when creating the service.

Impact on the business sector
Knowledge co-production on snowmaking, skiing-industry and the ways in which weather and climate influence these is crucial in understanding how or to what skiing industry must adapt. This can also help skiing industry to enhance their existing core business activities that rely on improved forecasting capacity. The evaluation of the climate service’s economic feasibility in the pilot phase informs also about the commercialization potential of the service for the wider skiing tourism industry.

Lessons learned and Links built

Lessons learnt so far are largely related to the transdisciplinary nature of our case study. As this case study is truly venturing into something new (industry specific climate service for winter tourism centres), also borders of disciplinary and professional expertise need to be crossed in the service development process.

The co-design process involves close collaboration between the case study team for knowledge co-production. Based on literature research on climate services, collaborative planning approaches and service design, end-user involvement is an essential success factor for tailoring a climate service that will answer to the end-user's knowledge needs. This also facilitates and ensures that the climate service will actually be used by the end-user.

While skiing tourism industry in Northern Finland gladly shares useful information between ski resorts in the spirit of collaboration, the need to protect some commercially sensitive data on our end-user and project partner Ruka and Rukakeskus Ltd. makes it important to consider carefully the contents of outreach activities and public project deliverables such as this.

Links to other Blue-Action WPs include particularly WP1 and WP4, as we need better climate model data from them for further developing the service. Also, when Copernicus climate model is available later on in 2018, more accurate forecasts are enabled. Within Blue-Action, strong collaboration is made with WP8 "Communication, Dissemination, Engagement and Exploitation". CS1 team members have strong expertise and experience in science communications, including exhibitions and other creative outreach efforts, and in CS1 work attention has already been given to outreach aspects.

Our case study has already noted based on previous expertise and on literature research that the involvement of the end-user in the co-design process is a success factor. On end-user involvement, industry-specific aspects to consider include the need to schedule fieldwork and collaboration with the end-user outside of the peak tourism and snowmaking seasons.

Beyond the Blue-Action project, strong thematic connections with EUPORIAS project exist, particularly with the PROSNOW climate service. Articles written by researchers in EUPORIAS project have been referred to in the review of existing methods on economic feasibility analysis of climate services and PROSNOW project deliverable on the usefulness of the service has been studied for this deliverable. While there are differences between snow issues in the Alps and in Northern Finland, useful lessons can be learned from the work done for PROSNOW. Also, thematic connections exist with the on-going EU-MACS project that works on analysing markets for climate services in tourism.

Contribution to the top level objectives of Blue-Action

This deliverable contributes to the achievement of some of the objectives and specific goals indicated in the Description of the Action, part B, Section 1.1: http://blue-action.eu/index.php?id=4019 , in particular to:

- **Objective 7 Fostering the capacity of key stakeholders to adapt and respond to climate change and boosting their economic growth** by presenting an assessment and evaluation scheme, which help with assessing the economic value of the climate service for the end-user and on evaluating qualitatively the benefits of the climate service for the decision-making process in the end-user organization.
  Objective 8 Transferring knowledge to a wide range of interested key stakeholders by allowing full access to the content of this deliverable. While this deliverable focuses on aspects relevant particularly for the case study itself, assessments and evaluation done according to the scheme described in this deliverable can contribute to the objective of transferring knowledge to the interested key stakeholders. Also, the assessment and evaluation planned here enables identifying lessons learned and good practices in the end of the project and then reporting them in the form of project deliverables and scientific articles to stakeholders. Moreover, the case

study intends to approach winter tourism industry of North Finland directly in related professional events, when the development of the climate service is in a more advanced state.

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Dissemination and exploitation of Blue-Action results

Dissemination activities

Type of dissemination activity	Title	Date and Place	Estimated buget	Type of Audience	Estimated number of persons reached
Organisation of a workshop	1st Workshop Ruka-AC UoL, in Rovaniemi (FI)	16 March 2017, Roveniemi (FI)	See form C of partners involved	Scientific community and industry partner in the case study	6
Organisation of a workshop	2nd Workshop Ruka-AC UoL, at Ruka ski resort	15-16 February 2018, Ruka (FI)	See form C of partners involved	Scientific community and industry partner in the case study	6
Participation to a conference	Rovaniemi Arctic Spirit 2017, Participant: Ilona Mettiäinen (AC UoL) with the poster "Payne, Mark, Keil, Kathrin, Kolstad, Erik, Ballester, Joan, Mettiainen, Ilona, Vangsbo, Peter, … Olsen, Steffen. (2017). Translating advances in Arctic climate science to climate services across the Northern Hemisphere (Version November 2017). Zenodo. http://doi.org/10.5281/zenodo.1065467	Rovaniemi (FI) 14-16 November 2017 http://www.rovaniemiarcticspirit.fi/EN	See form C of partners involved.	Scientific Community (higher education, Research), Industry Civil Society, Policy makers, Media	300
Publication	Dale, Thomas, Miller, Raeanne, Vangsbo, Peter, Mettiäinen, Ilona, Ballester, Joan, Kolstad, Erik, … Nikitina, Elena. (2018, January 18). Climate Service Case Studies Booklet. Zenodo http://doi.org/10.5281/zenodo.1154792	18 Jan 2018	See form C of partners involved.	General public, policy makers	200
Poster	Payne, Mark, Keil, Kathrin, Kolstad, Erik, Ballester, Joan, Mettiainen, Ilona, Vangsbo, Peter, … Olsen, Steffen. (2017). Translating advances in Arctic climate science to climate services across the Northern Hemisphere (Version November 2017). Zenodo http://doi.org/10.5281/zenodo.1065467 Presented at the EASME workshop „Climate services at work, Projects exchange and networking lab, Brussels (BE)" Presenter: Steffen Olsen (DMI)	29-30 Nov. 2017, Brussels (BE)	See form C of partner involved.	General public, policy makers	200
Poster	Miller, Raeanne, Payne, Mark, Keil, Kathrin, Kosltad, Erik W., Ballester, Joan, Lesser, Pamela, & Vangsbo, Peter. (2017). Translating advances	5-9 June 2017, Glasgow (UK)	See form C of partners	Scientific community and policy-makers	200

	in Arctic climate science to climate services across the Northern Hemisphere. Zenodo. http://doi.org/10.5281/zenodo.827081 5-9 June 2017, 3rd European Climate Change Adaptation Conference, Glasgow (UK) Presenter: Raeanne Miller		involved.		
Participation in a workshop	WP5 workshop on Climate Services, 10-12 July 2017, Hamburg (DE)	10-12 July 2017, Hamburg (DE)	See form C of partners involved.	Scientific community	30

Peer reviewed articles

No peer reviewed articles have been published or submitted so far. One article with the working title "Snowmaking as an adaptation strategy in skiing tourism centers – from maladaptation to adaptigation by development of a climate service" is under progress. First author: Ilona Mettiäinen. Examples of possible journals: Climate Services; Tourism Management; Journal of Sustainable Tourism.

Uptake by the targeted audiences

As indicated in the Description of the Action, the audience for this deliverable is the general public.

This is how we are going to ensure the uptake of the deliverables by the targeted audiences:

Despite of the PU nature of the deliverable, priority in dissemination will be given to the consortium and Arctic cluster partners:

- This deliverable will be shared with the consortium in the project intranet.
- We plan to share it with the Arctic Cluster project teams and EU-PolarNet CSA.
- We also plan to share this document the RIAG and SEG advisors of Blue-Action.

For reaching out to the general public, the contents of this deliverable will be taken up by WP8 and disseminated broadly using the social media of the project.

Additionally, the deliverable will be archived in Zenodo for granting open access to larger audiences.

Intellectual property rights resulting from this deliverable

For the time being, we keep on monitoring the development of the work performed by RUKA and The Univ. Lapland and the connection with the Blue-Action WP1-4: we will check if the IP emerging from the research need to be protected and how with the legal advisors of the organisations involved.