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APPLICATE

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Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with a Changing Arctic climaTE

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Second summary report of stakeholder interaction activities

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EXECUTIVE SUMMARY

The main objective of the APPLICATE project is to develop enhanced predictive capacity for weather and climate in the Arctic and beyond, and to determine the influence of Arctic climate change on the Northern Hemisphere. To produce usable and trustworthy predictive information for decision-making, APPLICATE actively engages with stakeholders, including representatives of various economic sectors and local communities.

This deliverable describes the different stakeholder interaction activities that have been undertaken in the last 18 months (from May 2018 to October 2019), including the meetings with the APPLICATE User Group, the interactions with stakeholders when attending relevant events, the development of case studies and the participation in the blog Polar Prediction Matters (PPM).

The User Group is composed of representatives from all the APPLICATE targeted stakeholder groups[1], including Arctic business and governmental stakeholders, local and indigenous communities, NGOs, meteorological and climatological services, the scientific community and business stakeholders from mid-latitudes. The fourth meeting of the APPLICATE User Group was held online in July 2018. The meeting was aimed to discuss the topics that the APPLICATE consortium could tackle and provide expertise and added value for, taking into account all the topics that were identified in the previous User Group meetings. This meeting was preceded by a preparatory meeting between WP7 partners and other scientific partners from the other technical WPs (WP1, WP2, WP3 and WP5).

Other chances to interact with stakeholders were provided through attendance to relevant events about the Arctic. WP7 partners attended and participated in various activities in the framework of the China-Nordic Arctic Research Seminars in Tromsø (Norway) in May 2018 the Polar2018 conference in Davos (Switzerland) in June 2018, the Arctic Circle Assembly in Reykjavik (Iceland) in October 2018 and October 2019, the ACI 13th Arctic Shipping Conference in Hamburg (Germany) in December 2018, the Korea Arctic Week in Busan (South Korea) in December 2018, the Arctic Frontiers conference in Tromsø (Norway) in January 2019, The Arctic Circle China Forum in Shanghai (China) in May 2019, and the Northern Forum Sustainable Development Forum in Yakutsk (Russia) September 2019.

All the described stakeholder interaction activities are key to identify and gather information on knowledge gaps in the Arctic. This is important in order to define what are the user-relevant variables and metrics that the APPLICATE project should focus on and to select which are the most relevant case studies[2] to illustrate how to move, with maximum impact, from project outputs to stakeholders' decision-making. So far, case studies addressed to the energy and risk prevention sectors have been developed and shared with stakeholders at Arctic Circle Assembly, in October 2019. In addition, the participation of

[1] After some inconsistencies identified in the DoA (workplan) the definition of the project stakeholder groups has experienced some modifications to adapt it to the actual project strategy. New stakeholder classification: Key- Business and governmental stakeholders in the Arctic within and outside the EU; Primary- Scientific community, meteorological and climate national services, NGOs and local and indigenous communities; Secondary- Business stakeholders from mid-latitudes.

[2] The development of case studies was proposed following the 1st Project Review in September 2018. Case studies from the past will be used to show how weather, climate and sea ice forecasts can be useful for specific events with significant impact on certain socio-economic sectors.

APPLICATE in the PPM blog, run by the Year of Polar Prediction (YOPP), also provides the project a unique chance to interact with other stakeholders.

1. INTRODUCTION

1.1. Background and objectives

This report summarizes the different stakeholder-interaction activities that have been undertaken by the APPLICATE user engagement team in WP7 from May 2018 to October 2019. It includes a description of the fourth User Group meeting as well as additional activities conducted to obtain stakeholder's feedback on the relevance of the results generated by the project and the way they are presented to relevant audiences. Interactions with stakeholders external to the project are expected to serve as an additional advisory and impact mechanism for the project.

1.2. Organisation of this report

The main activities in which APPLICATE has participated to gather stakeholder's feedback are described in the Methodology section. The Stakeholder discussion section summarizes the obtained feedback. The Conclusions and outlook section includes the main messages and the next steps that APPLICATE will follow to complete the User Group with participants from relevant sectors. This is important to guide the project's research and development of additional case studies that help enhance the communication of project outcomes to non-expert audiences.

2. METHODOLOGY

APPLICATE uses different approaches to interact with relevant stakeholders, with the aim of engaging, informing and empowering them to adapt to Arctic changes and their far-reaching impacts on the environment and communities. In turn, stakeholders provide the project with an external perspective and feedback, ensuring that the products generated are tailored to user needs, and maximising their relevance and usability. Applied activities for stakeholder interaction are user group meetings, attendance to relevant events, development of case studies and contribution to a blog.

2.1. User Group meetings

The APPLICATE User Group applies the focus group technique, a set of procedures to collect and analyse qualitative data that allows a guided discussion between a small but diverse group of stakeholders (Merton, 1987). A focus group involves usually a group of 6-12 participants who share a common interest, or are similar in some other way, and discuss together an issue of specific interest to research. This technique relies on a group interaction and dynamics to stimulate discussion, thinking and contributions from the participants, providing perspectives that could not be obtained with other participatory techniques (Asbury, 1995). In a focus group, the role of the facilitator is to study the reactions and answers of the

participants and keep the discussion at the same time dynamic and balanced, allowing all the participants to express their views.

The steps and challenges to recruit User Group participants are described in D7.11. The fourth User Group meeting (three previous meetings took place during the first 18 months of the project) was held online in July 2018. Rather than meeting with the whole User Group, the strategy in this second project period has been to work on the selected case studies together with a smaller group of stakeholders particularly related to the topic of study (i.e., ensuring a co-production process) as well as with the project climate scientists.

Fourth User Group online meeting

The APPLICATE User Group is formed at this point by 11 stakeholders, all from different institutions or companies spreading from Alaska to Korea, who were invited to take part in the User Group and to attend this fourth (online) meeting. Due to participants' availability and time zones, we needed to organise three different small sessions: one with a representative from Alaska, another with representatives from Alaska and Canada, and the last one with a participant from China. The meetings took place during the week of the 16-20 July 2018.

Previous to the User Group meeting, WP7 partners conducted different meetings with scientific partners from WP1 (13 June), WP2 (11 June), WP3 (27 June) and WP5 (27 June and 10 July). Such meetings had the aim to discuss and understand which type of information could be provided by each WP that could be of interest for project stakeholders. From these meetings, WP7 partners had a better idea of the potential project results, and gathered a list of variables that could be delivered from APPLICATE model outputs, including atmosphere and land variables, ocean variables, and sea ice variables, as well as examples of maps that could be generated. This information was presented to the User Group participants that joined the fourth meeting of the User Group.

The fourth User Group meeting was structured in three components:

1. Overview/reminder of the previous User Group discussions
2. Presentation of the list of variables and examples of maps that could be delivered by the APPLICATE models
3. Discussion on the relevant variables the project should be focusing on (according to participants' interests)

2.2. Stakeholder interactions in relevant events

There are many relevant events that provide chances to interact with stakeholders. Some of the attended events during the last 18 months are:

- China-Nordic Arctic Research Seminars in Tromsøö (Norway) May 2018, assembly attended by predominantly Chinese and Scandinavian participants from multiple backgrounds including policy, science, business and education. Presentation given in main panel on the need for knowledge based decision making.

- Polar 2018, Davos, Switzerland, June 2018: WP 7 partners had a presentation on stakeholder engagement and the need for cooperation among scientists in approaching and addressing stakeholder needs as well as a presentation on how to integrate science knowledge into education. Further partners where integrated into discussions with participants through poster presentation and by attending other sessions and meetings as by SAON.

- Arctic Circle Assembly, Reykjavik, Iceland, October 2018: WP7 partners attended and presented, including at a session organized by the Northern Forum on the need for knowledge based regional development. Project video and fliers presented in the EU and the EU Arctic Cluster booths.

- Korea Arctic Week in Busan (South Korea) in December 2018. Presentation in main panel on climate change, the APPLICATE project and the EU Arctic Cluster. Discussions with policy and industry leaders including the Chair of the Arctic Council, The EU Arctic Ambassador, President of the KMI, Director of Mearsk Shipping Asia and the vice president of Cosco Shipping in China.

- ACI 13th Arctic Shipping Conference in Hamburg (Germany) in December 2018. WP7 partner chaired the conference and led the discussion in a similar format and using the key questions posed in the Arctic Frontiers conference. A main outcome of the discussion was that there is an evident lack of sound information and knowledge which hinders or slows down business development in the Arctic. Shipping company representatives and participants from the financial and insurance industry claimed the uncertainty due to lack of sound knowledge is such that it is impossible to financially justify Arctic Shipping in the near future as an alternative to other current shipping routes, especially operations by SME shipping companies.

- Arctic Frontiers, Tromsø, Norway, January 2019: international conference on sustainable development in the Arctic that allowed interaction with various Arctic stakeholders. A side-event was organised by APPLICATE on behalf of the EU Arctic Cluster, with particular contribution of the INTAROS project, entitled “Improved safety and environmentally sound operations in the Arctic Ocean – How to move forward?” The workshop was mainly addressed to the shipping and maritime safety sectors, although it was open to other interested stakeholders. It was attended by 21 participants. The workshop was structured as follows:

  1. Welcome and introduction to the workshop and to the EU Arctic Cluster
  2. Presentations from invited speakers:
     - Jens Peter Holst Andersen, Chair of Emergency Prevention, Preparedness and Response (EPPR) working group of the Arctic Council, Denmark.
     - Oivin Aarnes, Principal specialist with DNV GL, Norway.
     - Kikki Kleiven, Associate Professor at the University of Bergen and Bjeknes Centre for Climate Research, Norway.
  3. Discussion around three main topics:

- Topic 1: How can improved operational weather and ocean (including sea ice) as well as climate forecast support for safer operations in the Arctic?
- Topic 2: Is co-developing new services, products and technologies for safe operations and improved joint monitoring in the Arctic Ocean the way forward for improving cooperation between ship operators, research institutions and local communities?
- Topic 3: How can we reduce the overall environmental footprint and prevent negative environmental impacts in the Arctic?

4. Conclusions and feedback

- APPLICATE General Assembly (GA) 2019, Reading, UK, January 2019: on this occasion, rather than inviting the whole APPLICATE User Group, we decided to focus our efforts to engage with one particular sector, keeping in mind the development of a case study. With this purpose, we selected insurance as a sector that could be potentially interested in APPLICATE outcomes, and invited two representatives of the company AXA XL to attend the GA. Insurance representatives delivered presentations on their activities and joined the breakout session on case studies during the GA, where their needs in terms of weather, climate and sea ice knowledge were discussed.

- Arctic Circle Assembly in Shanghai (China) in May 2019, WP7 partners attended, distributed project information flyers and led a panel discussion on Science Communication to the public.

- CNARC Shanghai (China) in May 2019. Similar participants to the China-Nordic Arctic Research Seminars in Tromsø with diplomatic delegates from several countries. Presentation made in main panel introducing the APPLICATE project and the need for international cooperation and information and data sharing.

- Northern Forum Sustainable Development Forum in Yakutsk (Russia) in September 2019. Presentation on the need for information sharing and increased knowledge as the base for responsible regional development.

- Arctic Circle Assembly, Reykjavik, Iceland, October 2019: this annual event provides an excellent platform for networking, since it gathers a plethora of stakeholders representing different types of organizations, ways of life – from big city dwellers to reindeer herders and nomads, and regions all over the Arctic and beyond. Relevant projects and initiatives focusing on the Arctic are there. In this occasion, the projects from the EU Polar Cluster participated in the booth hosted by EC at the event. The APPLICATE project participated in the organization of a side event together with the EU-PolarNet and Nunataryuk projects, entitled ‘Connecting Arctic Science with society: lessons learned and progress’. Copies of the two available APPLICATE case studies were distributed to side event participants. APPLICATE partner Arctic Portal had two breakout session presentations, one access to and presentation of observation data for the benefit of all, in cooperation with among others PRIC in China and the Iceland Prime minister’s office and attended by a very international group of stakeholders, and secondly on Innovation and Regional development,

hosted by the Northern Forum and attended by key stakeholders including high level Russian officials. APPLICATE and its relevance was highlighted in both sessions. In addition, the case studies were shared and discussed in detail with five User Group representatives, who attended Arctic Circle Assembly.

Additionally, APPLICATE WP7 is participating in the Communication and Outreach task group, User engagement task group and the Training task group of the EU Arctic Cluster (now EU Polar Cluster), a network of different EU-funded H2020 projects with focus in the Arctic. This initiative has the aim to enhance outreach, the user engagement strategy and training of the individual projects through an effective coordination that allows to exploit synergies between the projects and to avoid user fatigue. It also facilitates the joint organisation of side events and participation in conferences. The last meeting of the cluster was held in Brussels, Belgium, in June 2019 and was attended by various APPLICATE representatives.

WP7 partners are in contact with the CER-ARCTIC research institute in Barcelona, which conducts research focusing on the social aspects of climate change in the Arctic. The meetings between both institutions have allowed the APPLICATE project to interact with external stakeholders, in particular local communities in Finland, regarding the topics of daily life in the Arctic, fishing and reindeer husbandry.

2.3. Case studies

Case studies are used in the project as a communication tool that helps translating how to move from scientific model outcomes to stakeholders' decision-making, and helping to communicate uncertainty. Case studies are built on past events that users have identified as relevant because they affected their activities or businesses. They are used to showcase the usefulness of enhanced weather, climate and sea ice information. Showing how this information would have been useful if available at the moment of the event, also helps to showcase the usefulness of such information in the future. Last but not least, case studies can also help identify knowledge gaps that would require further research efforts (i.e., aspects from the predictions that need to be better captured or understood).

It is important to mention that once the first draft of the case study is developed, it is shared with the APPLICATE User Group inviting participants to share their feedback as well as to propose other relevant topics. This is seen as an important milestone that keeps the contact with the User Group active during periods when face-to-face meetings are less prone to occur.

2.4. Blog

The Polar Prediction Matters (PPM) blog was launched in September 2017. The blog aims to become a discussion forum that helps to foster the dialogue between forecasters and climate data users. It hosts articles for and by stakeholders on the scientific outputs of Arctic research and how these can be transferred to other societal sectors beyond academia. In addition, it is a tool to engage with users and to gather information that helps define user-relevant metrics to develop within APPLICATE.

3. STAKEHOLDERS DISCUSSION

This section summarizes the discussion and main outcomes of the fourth User Group meeting, some lessons learned from other stakeholder interactions and the new developments in terms of case studies and blog articles developed in collaboration with stakeholders.

3.1. User group discussion

The fourth User Group discussion started with a very general overview provided as reminder of the previous User Group discussions, that mainly focused in knowledge gaps and priority topics and sectors in the Arctic. To complement the overview, the *First summary report of the stakeholder interaction activities* (APPLICATE D7.11) and a publication in the Polar Journal summarizing the User Group discussion during the project GA 2017 (Bojovic and Terrado, 2018), were shared with the participants.

A list of variables that can be delivered by the APPLICATE models was presented to the User Group participants. Variables were classified in the groups 'Atmosphere and land variables', 'Ocean variables' and 'Sea ice variables' (see Table 1). At this stage, UG participants were asked which variables they found more relevant for their activities (or other activities they could think of) and how much in advance should the information be available (e.g., days, months, years, etc.). Participants were also shown predictions illustrating the capacity of Numerical Weather Prediction models to capture a February 2018 Arctic heatwave 7-9 days in advance. Apart from illustrating one of the possible types of information that could be provided by the project, these maps were also useful to foster discussion about other types of information available, timescales and possible applications.

Atmosphere and land variables	Ocean variables	Sea ice variables
Surface air temperature (to detect the development of ice layers on land, cold spells or heatwaves)	**Ocean Circulation index**	**Sea ice extent** (based on the 15% sea ice concentration threshold)
Snow cover (to detect extreme early snow melt)	**Sea surface and Subsurface temperature**	**Location of sea ice edge** (to detect the opening of the Northwest passage or other Arctic routes)
Snow thickness	**Freshwater content of the upper ocean** (related to salinity changes)	**Sea ice thickness**
Surface winds patterns (to detect cold air outbreaks, high winds, moisture intrusions)	**Sea surface height**	**Age of sea ice**
Arctic Oscillation index	**Stratification of the upper ocean** (related to potential temperature & density)	**Onset of freezing/ onset of melting, from the seasonal cycle of sea ice** (to detect an early melt onset or a late freeze up)
Polar vortex strength (related to cold waves)	**Ocean heat influx towards the Arctic** (provides predictability)	**Sea ice drift**
Storminess index	**Greenland current index** (provides predictability	**First ice free date**
	Beaufort high index (to detect collapse of the Beaufort high)	**Ridged ice area and melt pond area**

Table 1. Variables that can be delivered from APPLICATE model outputs

3.2. Selecting relevant topics and sectors

Participants to the fourth UG discussion were invited to comment on the information presented to them. The main discussion outcomes are listed below. These outcomes, as well as the presentation used in the online meeting, were shared by e-mail with all User Group participants. Those who could not attend the meeting were also encouraged to comment on the outcomes and provide feedback.

Main topics & sectors discussed:

- **Changing Arctic summers**: important temperature and precipitation variations in summer. Whereas some places experience colder than usual summers (e.g., Iceland, where tourism is affected), other places have high precipitation and humidity (e.g., inland Yukon). Heatwaves and ice-free summers are becoming common in other places (e.g., coastal Nunavut).
- **Prediction of heatwaves**: interesting at the long term for governmental regulations (e.g., house building, health, etc.) and at the short term for the prediction of forest fires, which are becoming an issue in the Arctic.
- **Impacts of moisture on health and farming**: a mention of the difficulty of collecting hay and potatoes because they are spoilt by moisture.
- **Navigation constraints**: the prediction of sea ice thickness is interesting for fleets that cannot break thick ice (e.g. ice thickness above 1.5m can affect vessels navigation). The sea ice concentration metric, which is an important variable for detecting sea ice extent, could be rethought using different definitions besides the 15% concentration that is commonly used to denote presence of ice.
- **Storm surges preparedness**: storm surges are increasingly common in the Arctic with declining fast ice. Forecasting this phenomenon at short time scales could be interesting (e.g. in Alaska).
- **Permafrost melting**: permafrost is degrading along the coast and rivers and is affecting coastal and river communities. Forecasts would be useful for long-term planning of communication and infrastructure and for the allocation of communities.
- **Ecosystem shifts**: related to vegetation changes (e.g. from tundra to higher shrubs and forests) that can affect food security and render local knowledge less reliable. Apart from resources availability, times to access resources will be affected, influencing transportation. New transportation times might demand new routes.
- **Renewable energy planning and production**: there is a lack of consistency in the climate data. Predictions at the annual scale are relevant.

3.3. Lessons learned from stakeholders' interactions

Initial interactions with the **insurance sector** during the APPLICATE GA served to identify some of the needs of users from the insurance sector. In general, users from insurance recognised not to be interested in the short-term, but rather in the long-term (e.g., decadal time scale), since they do not expect things to change at short time scales in the Arctic. Users from the insurance sector mentioned that a higher catastrophic activity is expected to

occur as a consequence of sea ice decline, and therefore they would be interested in knowing the onset of this catastrophic activity. Knowing more about current risks is important, but knowing how the risk to hazards (e.g., storms, icebergs, cold spells, etc.) is going to change in the future is also crucial. Examples mentioned were the risks for ships and energy assets, and also how changes in sea ice may affect mid-latitude hazards. Having information on the probabilities for catastrophic events in terms of return periods would be useful, and so will be knowing whether these events will be more frequent in the future. The associated uncertainty of predictions was highlighted as a very important piece of information. Risks such as wildfires and floods were acknowledged as current hot topics in the insurance industry, whereas other issues get less attention. The issue about climate change affecting the location of aquaculture activities (moving further north) due to an increase of SST was also mentioned.

Discussions during the workshop on *Improved safety and environmentally sound operations in the Arctic Ocean* organised by APPLICATE at Arctic Frontiers were majorly around three topics:

- **Data collection and data sharing:** are key to produce the forecasts needed by ship operators to improve safety and avoid environmental impacts in the Arctic. However, there are still many challenges to achieve data collection and sharing in an effective way. Three aspects were highlighted as important: using open source data, tailoring data to users, and identifying new variables that are needed by users. The Ship Of Opportunity Program (SOOP) was mentioned as a reference system for data collection. To successfully move forward with an improved SOO network, a cooperation with the ship owners is vital, and for that ship crews need to be involved and trained accordingly. Such initiative should collect data from routinely shipping routes, most of them in open waters and some in ice-infested waters. Some workshop participants were skeptical about the increase of SOO capabilities and pointed at satellite data as a useful asset. Sustaining Arctic Observing Networks (SAON) were mentioned as an umbrella to organise the work on data sharing and archiving and support the coordination of data management among different projects, provided that appropriate funding is assured.

- **Weather and sea ice forecasting:** importance to identify issues that need improvement (e.g. are there any examples of past events in which something was not managed appropriately? What information would have been needed in order to improve decision-making in such particular cases?). A combination of waves and sea ice information was highlighted as important for warning and safety issues for ships. However, there is currently little information on ocean waves in northern regions. Satellite data (e.g. from Copernicus Earth Observation Programme) was mentioned as a potential alternative to fill this gap. In addition, cruise operators are interested to extend their operations in the Arctic and possibly go further north in ice-free waters. This will increase emissions and discharges, bringing additional challenges for emergency prevention and safety.

- **Communication and outreach:** should be an integral part of all Arctic projects. Interaction with the media should be improved, since due to the very rapid Arctic

changes media has become more interested in Arctic issues. On a different line, the limitations of internet connection in the circumpolar Arctic were mentioned as a reminder that indigenous peoples cannot be reached via online consultations frequently used in projects.

Relevant topics emerging from discussions at the other events attended are, among others:

- Combination of 3 spheres of knowledge (traditional, local and scientific)
- Ice open waters and need for icebreakers (e.g. Northern Sea route)
- Increase of plankton due to a decrease in sea ice thickness. Relationship with ocean biodiversity and tourism traffic relocation
- Possibilities for renewable energy use in local communities
- Infrastructure needs for supporting a sustainable and low emission arctic
- Increased tourism, related services and security support – search and rescue knowledge and capacities.
- Providing case studies relevant for various areas of the Arctic
- The need for an integrated business plan for the Arctic including and addressing environmental, economic and social factors.

3.4. Case studies to bring the science closer to stakeholders

Two case studies have been developed by the APPLICATE project so far. They can be accessed online on the APPLICATE website and have been distributed at Arctic Circle 2019.

- **Energy case study – Effects of Arctic sea ice on energy production in mid-latitudes**. This case study contributes to understanding of the linkages between the Arctic and mid-latitudes. The document is mainly addressed to policy makers, although it can also be of interest for big energy associations (e.g., EWEA, IRENA, AREA) and global networks of Transmission System Operators (e.g., ENTSO-E), among others. This work has been the result of a joint effort between climate scientists, social scientists and science communication specialists taking part in the consortium and has counted with the collaboration of partners from the European H2020 project Sub-seasonal to seasonal predictions for energy (S2S4E). The case study describes a cold spell in winter 2016-17 that some energy producers, interviewed in S2S4E, identified as a relevant event affecting their businesses. The cold spell was accompanied by record-breaking low precipitation and wind speed over parts of western Europe, increasing energy demand and reducing renewable power generation, which contributed to an energy-security risk situation in France. In this first case study, the APPLICATE project explores potential linkages of the event highlighted by energy producers with Arctic changes in sea ice. Once these linkages are well-established and understood, future forecasts of extremely low sea ice extent (that also relate with forecasts of electricity demand and power generation) could be potentially valuable for assessing the risk for European energy systems.

A User Group participant from the Institute of the North, Alaska, mentioned that his institution is organizing a new Arctic Energy Summit in early 2020, and invited us to present the case study there.

- Risk management case study – Population preparedness for extreme rainfall in Svalbard. This case study presents an event that occurred in November 2016 in the Svalbard archipelago, characterised by anomalously high temperature, followed by extreme precipitation that, due to the warm temperatures, partly fell in the form of rainfall. It discusses the risk of increased frequency of this type of events and the accompanying impacts, such as landslides and slash avalanches. The case study presents how better understanding of extreme weather and climate events in Svalbard can lead to better predictions that can improve preparedness and adaptation of local population.

3.5. Does 'Polar Prediction Matter'?

The answer to that question is 'yes', and the PPM blog has already a few examples of that. Whereas the articles published during the first months of the blog lifetime had safe Arctic shipping as an important component (see description of topics 1-5 in D7.11), in the last 18 months the variety of topics has increased considerably, going from shipping (6-7) to food security (8), risk management, including aviation, search and rescue and landslides (9, 13), local communities (10, 12), and fishing (11). A list and a summary of these articles is provided below:

6. Looking North: Perspectives of European Arctic users (May 2018) by Rick Thoman, Climate Science and Services Manager at the U.S. National Weather Service of Alaska, and Machiel Lamers, Associate Professor at Wageningen University, the Netherlands. The article describes the role of the Polar Prediction Project Societal and Economic Research Applications (PPP-SERA) task team, which consists in helping the PPP advance its mission for the development of improved weather and environmental prediction services for polar regions on hourly to seasonal time scales. The task team brings social science expertise to better understand user needs and feed their decision-making processes. A summary of an open session at the European Polar Board in 2018 is provided, including aspects such as the incongruence between micro-scaled spatial and temporal experience of indigenous communities travelling across sea ice and the resolution of currently available weather and sea ice projections. During the session, Tecla Sailing, a family owned and operated sailing venture, explained that they rely on both modern weather forecasts and own experience in interpreting winds, waves and atmospheric pressure patterns. They mentioned that they look into the possibility of offering voyages through the Northwest Passage next year, and for that would need to access additional types of weather and ice information. Another user, a Ship Master operating in the Baltic Sea region, explained that ice navigation requires specific information for often rapid decisions associated to sea ice and superstructure icing. These kinds of information needs will be applicable to larger areas of the Arctic during the coming decades, as the region becomes a first-year ice regime. Finally, the director of a Simulator Maritime Training Academy strengthened the importance of human interpersonal dynamics and the criticalities arising when environmental information is needed.

7. Predictive images – An ESA-kick start project (June 2018) by Lasse Rabenstein and Panagiotis Kountouris, managing director and head of remote sensing respectively, at the start-up and spin-off company Drift & Noise Polar Services in Germany. In this contribution, they provide insights into new sea ice forecast products that might become instrumental for tactical decision-making in and near ice-covered waters. The company works closely with marine operators that need to find the fastest and safest way through ice when transporting goods. As ice drifts several kilometres a day, Arctic stakeholders are in need for up-to-date ice forecasts. However, presently, there is no high-resolution ice forecast on the market providing information on the typical scales of situations encountered by marine activities. For instance, open leads in the ice cover of only 200 meters wide are preferred pathways for ice breaking vessels. Open leads are visible on satellite images but are not represented in model-based sea ice forecasts. Therefore, information on whether such a crack closes or opens within the next 24h is crucial. Also cruise ships need information on whether a beautiful bay with floating icebergs is accessible over the next 24 hours. The PRIIMA project will deliver ice forecasts with the resolution of a satellite radar image, a product developed in close collaboration with test users from the sectors of cargo shipping, ice breakers and cruises. One of the addressed challenges is nowcasting (forecasting of current conditions based on the most recent observations) in areas with free drifting sea ice. The project has the aim to correct the large offset between the present position of ice and its position during recording of the satellite image in and apply this correction not only to nowcasting but also to forecasting.

8. Polar forecasts against impacts of declining Bering Sea ice on Alaska coastal communities (July 2018) by Richard Thoman, Becki Heim and Gene Petrescu from the U.S. National Weather Service, describes how Alaska coastal communities are affected by changing sea ice conditions. The article provides context to understand how polar environmental forecasts can help mitigate adverse impacts of regional climate change. The example of autumn and winter 2017-18 was taken as departure point, when sea ice in the Pacific side of the Arctic was characterized by a very late formation, a low extent and for being generally thin. This poor quality ice broke very easily and not only made travel dangerous for subsistence activities, but also left coastal communities at risk of erosion and flooding. Most Alaska communities rely on subsistence hunting for their food supply. Even where stores are available, food is shipped in and is quite expensive. Hunters often need to travel longer distances to find ice, leading to increased fuel costs, time and danger (e.g., hunters' reports from Norton Sound in May 2018 indicated travel of over 160 km to harvests walrus). In addition, spring is the breeding season for seals and walruses, which are marine mammals that rely on sea ice to give birth and that are important food sources for the Bering and Chukchi communities. Therefore, a low extent of spring ice has a significant impact on subsistence activities and nutritional community access. Hunters also need to adapt to changes in animal behaviour as ice patterns change compared to the historical trend (e.g., bowhead whaling season at Gambell is typically finished in late November, but this season whales were not seen until mid-December and the first whale was not harvested until early February). Given the importance of food security for coastal communities, a Sea Ice for Walrus Outlook is produced among different organisations and issued every two weeks from April to June to assist Alaska communities to safely hunt marine mammals. The outlook contains current and forecast information about weather, water and sea ice. The goal is to

provide the data in a concise and low band-with format as possible due to the lack of modern internet communication capabilities in many communities.

9. Automated products for forecasting blizzard conditions in the Arctic (October 2018) by William Burrows and Curtis Mooney, from the Observation Based Research Section and the Meteorological Service, respectively, of Environment and Climate Change Canada (ECCC). The authors discuss blizzard conditions in recent years in the Canadian Arctic and some automated blizzard prediction products they have developed in consultation with forecasters. Blizzards occur regularly from October to May in the Canadian Arctic and constitute a major forecasting challenge. The combination of low temperature, strong wind, and reduced visibility to near 0 km in blowing snow makes a blizzard one of the most disruptive and hazardous of Arctic weather events. The Meteorological Service of Canada considers blizzard conditions to be temperature below 0°C, wind 40 km/h or stronger, and visibility ≤ 1/4 statute miles (about 0.4 km) in blowing snow or concurrent precipitating snow and blowing snow. In this article, the authors show some of the automated research products they have developed that run in real time to aid forecasters in predicting where and when blizzard conditions are likely to occur. Since blizzard conditions are determined from a combination of weather elements, outputs from numerical weather prediction models are post-processed to derive forecasting products:

(a) Blizzard Potential: to identify areas where blizzard conditions could develop over land and ice-covered areas with at least 1 cm of snow on the ground. This product is intended as 'heads-up' guidance to alert forecasters a few days in advance to regions where blizzard conditions might occur;

(b) Forecast of the probability of visibility ≤ 1 km;

(c) Prediction of the likelihood of blizzard conditions. The authors are now working on a product that combines products a-c to highlight in a single figure the most likely areas predicted to see blizzard conditions. Such forecast products cover the entire Arctic region from near term to five days.

Groups who need to know about potential harsh weather conditions can benefit from these products, including aviation agencies, search and rescue, military and civil defence, policing and those who travel for hunting, visiting and trade between Arctic communities.

10. Everyday life in the Arctic (November 2018) by Tanja Joona, Senior Researcher at the University of Lapland and reindeer herder in Finnish Lapland. In her article, Tanja criticizes generalisations about 'Arctic challenges' or 'Arctic indigenous peoples', and presents the Arctic as a heterogeneous territory with many different states and actors. She describes her life in a small reindeer herding community 60 km west of Rovaniemi. Some challenges in her area are the lack of roads and railway connections, a shortage of job opportunities and a sparse population. She describes migration from small villages of the north to big cities of the south as a serious challenge to the preservation of 'indigenous identity'. In communities that depend on traditional livelihoods, people live in annual rhythm: At the end of April, reindeers that are fed at home during winter are released back into the forest to breed. In some areas, the herd has to cross the frozen lake to the forest, so the ice needs to resist the herd and the herders with snow scooters. 1st of June is the beginning of the new reindeer herding year. In

the early summer weeks, new calves are born and in the mid-summer they get ears marked. Summer is also the time to make hay for the animals and prepare for the coming winter. From the beginning of December to the end of April, many reindeers are fed with extra food, which means that some are kept in home fences and some are in the forest and mountain areas. Before the real winter comes and covers the landscape with soft snow, weather can be rainy and icy so that it is very difficult for a reindeer to dig through the ice, and extra feeding is needed even more. With the current increased frequency of extreme weather events triggered by climate change, traditional knowledge and weather and climate knowledge from previous years are becoming less reliable for local communities. For example, calve marking is traditionally done in mid-summer, when is the time of mosquitos. This practice might be affected if the season gets drier and hotter. In Finland, Norway and Sweden, rain and mild weather during the winter season often prevents reindeer from accessing lichen, which is a vital food source. This has caused massive loss of reindeer, which are vital to the culture, subsistence and economy of the Sámi communities.

11. Cloudy with passing schools of tuna – why don't we have forecasts of fish? (January 2019) by Mark Payne, Senior Researcher at the Technical University of Denmark. In his article, Mark writes about the challenges for regular fish forecasts (better models, new observations and regular production of forecasts are needed) and explains that the Blue Action project is developing improved forecast systems based on understanding of the linkages between the Arctic and lower-latitudes. The article explains that developing successful forecast products is not just a question of forecast skill, but requires striking the balance between what is scientifically feasible and what is useful to end-users. The products developed so far illustrate that marine ecological forecasting is possible, but there is a need to reach the point where marine ecological forecasts are regularly used in decision-making.

12. Giving the people what they want: 'translating' weather and climate information in the North American Arctic (May 2019) by Richard Thoman, Climate Specialist at the University of Alaska, and Gita Ljubicic, Associate Professor at Carleton University, Canada. In this article, they describe the mismatch of scales and relevant indicators between national service providers of weather, water, ice and climate (WWIC) information and Northern user needs. They also provide examples of northern and indigenous initiatives being undertaken to make more relevant WWIC information available. They mention that information and services have historically been provided according to standards of lower latitudes, which are different from those of indigenous and northern residents. Anticipating rapid changes in weather and ice conditions at time scales of minutes, hours or days, and over local or regional spatial scales, is important for community members making decisions about when or where to travel. Such variations in cold environment with limited search and rescue capacity can be a matter of life and death. National service providers tend to predict weather and ice at daily, weekly or long-term at national or circumpolar scales. They may also focus on different seasons (e.g. summer ice prediction supports Arctic shipping, but not the winter sea ice use by communities). Traditional radio and newspapers are still important in many regions, and shortwave radio is still regularly used for intra-community communications and activities beyond the community. A number of community and regional efforts have been initiated to overcome the mismatch of scales. These range from coordinated platforms for collecting community-based environmental events, such as the Local Environmental Observer (LEO) Network to sophisticated local wind monitoring at Clyde River, Nunavut,

Canada. However, assessing the impact and value of improvements in physical understanding, modeling and forecasting must consider more than reducing numerical uncertainty. Improved weather and climate models will be of little value within the Arctic without similar improvements in production and dissemination of the kinds of information in languages, formats and methods that facilitate access.

13. Winter is coming: how do we prepare? – Communicating avalanche risk in northern Norway (July 2019) by Gunnar Noer and Rafael Grote, Developer for Polar Meteorology and Researcher, respectively, at MET Norway. They present the problem of snow avalanches in mountainous parts of Norway and explain how MET Norway has moved to consequence-based forecasting, adjusting the scale of avalanche risk to the international classification. Applying this scale, skiers normally stay away from areas with red warning, but when levels are yellow and the weather is sunny and dry, mountain sides are soon crowded. However, in these cases, natural or unprovoked avalanches can also occur, related to skiers or snowmobiles moving in the area. Hence, the hazard level at which most avalanche accidents occur is actually yellow. Reliable weather forecasts are therefore crucial to protect life and property. In northern Norway, the main part of snowfall is associated with spells of cold air outbreaks from the Arctic. As cold air crosses the Norwegian Seas, it picks up large amounts of heat and moisture and becomes highly convective, giving place to associated wintry showers. Forecasting these events is crucial to determine the location and intensity of snowfall. However, it has proven to be especially challenging in the Arctic, where fine-scale models are necessary to capture local conditions. The AROME Arctic model is currently the main tool used by MET Norway to forecast polar lows and other meteorological phenomena that cause convective snowfall in northern Norway. As part of the Alertness project, researchers are developing an ensemble setup adapted to Arctic conditions and challenges. One of the most prominent research issues for short-range predictability in polar areas is to understand complete forecast misses of polar lows; i.e. cases in which a polar low was not predicted or cases where a polar low was predicted but did not develop.

4. CONCLUSIONS AND OUTLOOK

APPLICATE is having a fruitful collaboration with various stakeholders. User consultation and engagement activities included the meetings with the APPLICATE User Group, the interactions with stakeholders when attending relevant events, the co-development and dissemination of case studies, and the participation in the Polar Prediction Matters blog.

Whereas we went for a broad stakeholders' definition in the first part of the project, after the project review in September 2018, target groups were defined in more detail in order to focus better and maximize the impact made by the project. Thus, target stakeholders are users from the energy, shipping and insurance economic sectors as well as local and indigenous communities and policy-makers. Although we are also interested in engaging with the conservation/ecology community, engagement with such stakeholders is still being sought. Other groups such as mining companies or oil and gas were finally excluded, as not sufficiently involved in the project to be accountable.

Interactions with stakeholders from the selected sectors were useful to define the first project case studies addressed to the energy sector (including linkages with mid-latitudes, also of

interest for the policy community) and risk management sector (for landslides and avalanches). Next case studies that we plan to work on include: 1) Impacts of rain on snow events on reindeer husbandry (of interest for local and indigenous communities), 2) Heatwaves and wildfires in the Arctic (of interest for planning and civil protection), 3) Policy brief on the optimal locations to describe variability of Arctic sea ice (of interest for policy-makers and the scientific community) and 4) A case study of interest for the insurance sector. In order to expand the topics for case studies, the project is organizing a webinar in the framework of the upcoming APPLICATE-YOPP online course, where students enrolled in the course will be selecting and developing particular case studies.

Some stakeholder interactions were also useful to find candidates to participate in the PPM blog, which is a useful platform to share user insights with the rest of the polar prediction community. A success story is the case of the article 'Everyday life in the Arctic', that was the result of an interaction between APPLICATE and the Arctic stakeholder Tanja Joona. New blog articles are going to be prepared monthly to evidence the diverse views and needs from Arctic stakeholders.

Next steps in the APPLICATE interaction with stakeholders will consist in reinforcing our interactions with the User Group. We will continue meeting with the representatives of the User Group at the events we attend and seek their feedback to the new developments in the project. We will continue developing the project case studies in tight collaboration with stakeholders.

We expect to reach out to new audiences by participating in upcoming events such as: the Sustainable Ocean Shipping Conference in Paris in November 2019; ACI 15 th Arctic Shipping Conference in Hamburg in December 2019; Korea Arctic Week in December 2019; Arctic Science Summit Week and Arctic Observing Summit in Iceland in March/April 2020; China-Nordic Arctic Research Seminar in May 2020; Arctic Energy Summit and Arctic Circle in Iceland in October 2020; in events at regional level with local and indigenous involvement as by the Northern Forum and lastly at the third Science Ministerial meeting to be held in Japan in November 2020.

Cooperation with projects of particular relevance to the case studies as the Arctic Council's SDWG Arctic Renewable Energy Atlas and Community Preparedness as well as the Northern Forum Arctic Business Information Systems will be sought.

WP 7 partners will continue to maintain active participation in the EU Polar Cluster for enhancing collaboration with other related EU funded projects and cooperation with organizations as the European Polar Board and the Sustaining Arctic Observations Networks (SAON).

2. REFERENCES

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- Merton, R. K. (1987) The focused interview and focus groups. Public Opinion Quarterly, 51: 550-566

3. ACRONYMS

User Group (UG)
Polar Prediction Matters (PPM)
Year Of Polar Prediction (YOPP)
General Assembly (GA)