Integrating Activities for Advanced Communities

D6.3 - Popular Science summary of the action plan

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PP	Restricted to other programme participants (including the Commission Services)	
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Publishable Executive Summary

The report puts together the results from the Work Package 6 “Rapid response to environmental emergency alerts” to help protect the Arctic and global residents from the hazards of potential future environmental emergencies. The main goal was to identify the main potential hazards in the Arctic, find, contact, and establish collaboration with organisations and institutions that are monitoring these issues. All the results will be available at the INTERACT web page.

1. The identification of the potential hazards

As the hazard is considered anything, that could negatively affect:

i) the people living in the Arctic
ii) animals and plants
iii) environment and/or biodiversity

meaning loss of life, habitat destruction/damage, biodiversity loss (species decrease/extinction, species expansion), human settlement damage, hunting & grazing ground lost/damage/decrease, economic loss etc. Usually, there is not just a single factor causing the hurt/damage but several stressors working together, as illustrated in Figure 1.

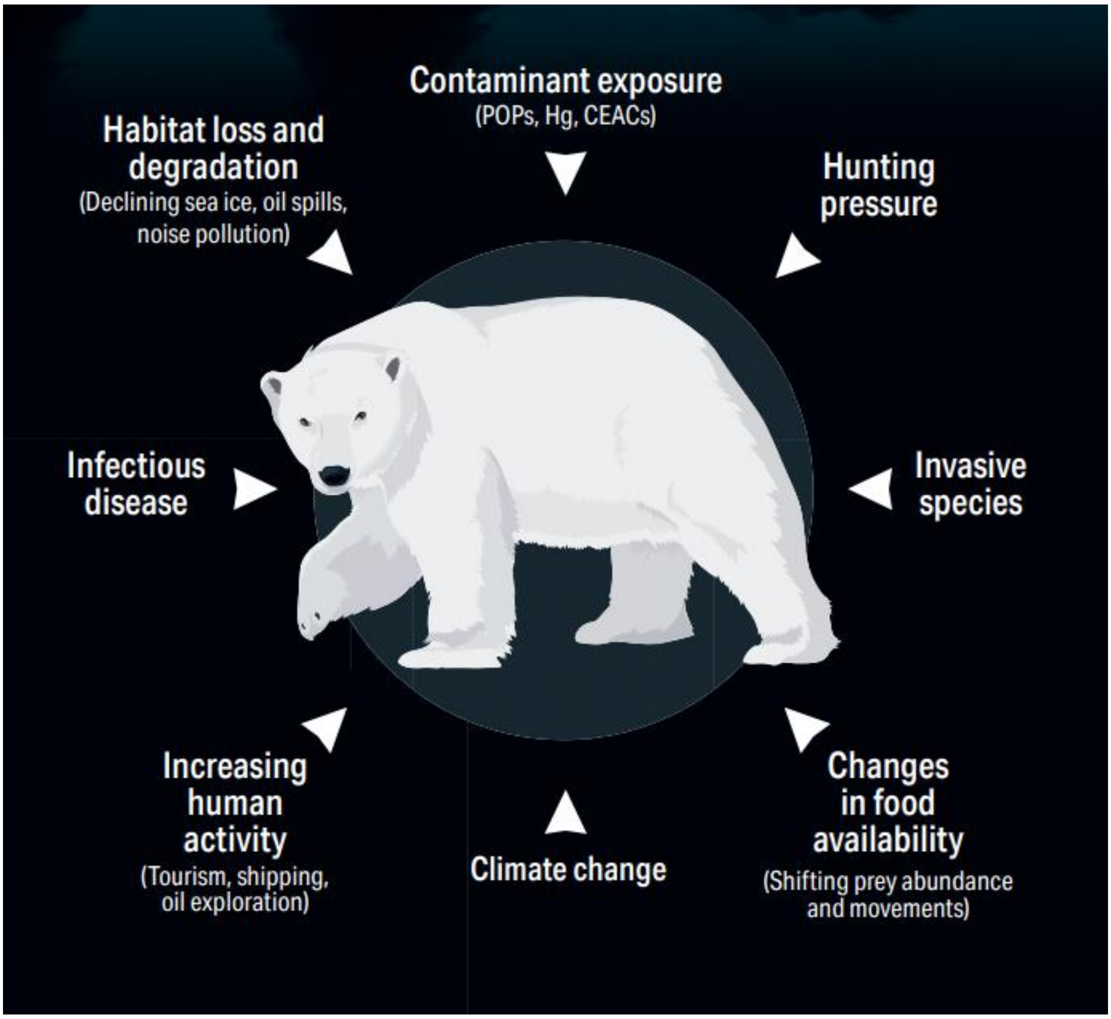

Figure 1: Natural and anthropogenic stressors affecting wildlife are diverse and highly complex and may act cumulatively to impact wildlife health. Source: AMAP

To assess the most important issues to focus on, a questionnaire was sent to INTERACT station managers, as well as we did a vast literature review. More than 40 potential hazards were identified.

Based on the results (Figure 2), the most important reported risks are (a) diseases (rabies, air-borne diseases, e.g. anthrax, tuberculosis), (b) pollutants (POPs, black carbon, plastics), (c) weather-related events such as instances of extreme weather (rain on snow, winter warming, extreme rain/snowfall), floods or avalanches, and (d) catastrophic events such as earthquakes, windfalls or volcanic eruptions.

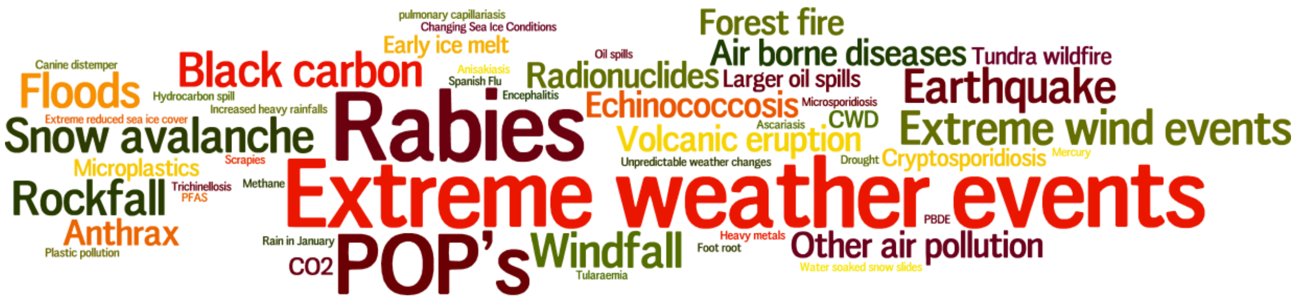

Figure 2: Word cloud diagram representing the severity or imminence of hazards in the vicinity of Arctic stations as reported by station managers

2. Hazard categories

The identified hazards could be grouped into six categories:

- Environmental contaminants (e.g. air pollution, chemical contaminants, POPs, radionuclides, plastics)
- Climate-sensitive infections (e.g. air-borne diseases, echinococcosis, toxoplasmosis)
- Non-native and range-expanding species (alien species/invasive species, expanding species, algal blooms)
- Environmental indicators of climate change events (extreme weather events)
- Hazards (e.g. snow avalanches, methane eruptions, tundra wildfires, volcanic ash)
- Miscellaneous (eg. noise and traffic, meteorite strike)

2.1. Environmental contaminants

The Arctic environment is under pressure from environmental pollutants (heavy metals, radioactive compounds, black carbon). Some may originate in the Arctic (oil and gas flaring, wood combustion) but more often they are transported there from lower latitudes (Figure 3). Most of the pollutants are bioaccumulative (so-called POP), which means they accumulate in the environment in animals or locked in surface soils, water, ice and sediments and pose a significant threat to people and animals. The accumulation rate of such pollutants is higher in the Arctic in comparison with other parts of the world especially due to the high food chains. Elevated levels of contaminants in wildlife species are not only threatening the species themselves but are important to the traditional diets of northern indigenous inhabitants.
The rapid climate change is affecting how contaminants enter and leave the Arctic, and how they move around within the Arctic, as well as the effects and concentrations of contaminants. Contaminants are mostly carried into the Arctic by the prevailing winds and ocean currents.

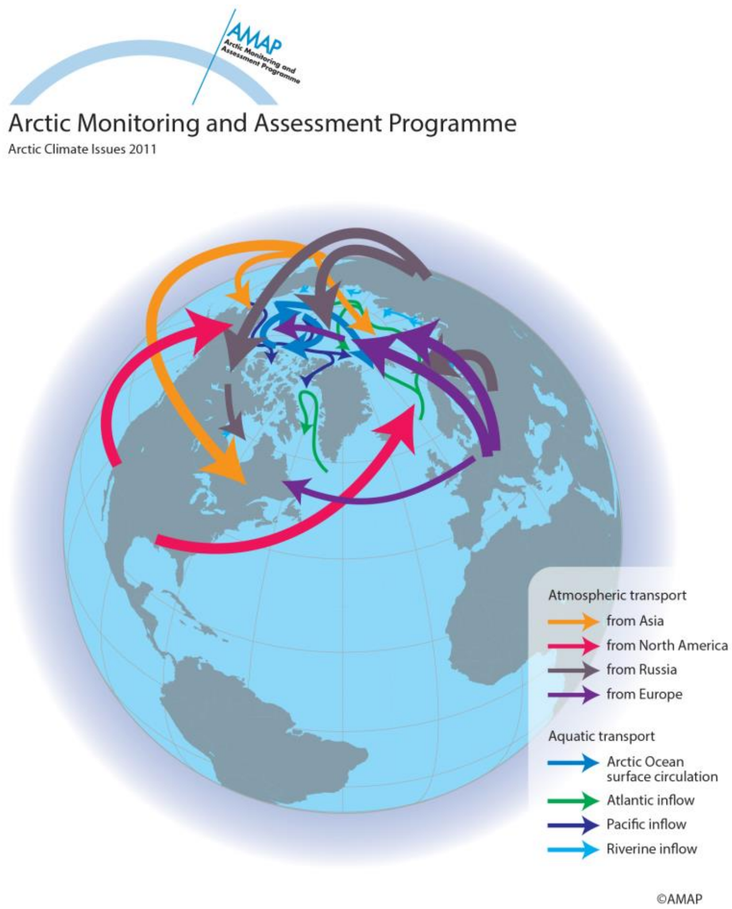

Figure 3: Transport of contaminants to the Arctic - atmospheric and aquatic transport. Source: AMAP 2012.

Other pollutants as black carbon or methane are contributing to warming due to the cumulation in the atmosphere. Furthermore, black carbon causes surface darkening, which accelerates the melting of snow and ice.

Heavy metals accumulation in Arctic soils and marine and terrestrial animals is known to be an issue, though why do these metals, emitted mostly from industries, accumulate in higher latitudes is not fully understood. Most likely it is due to the lack of vegetation in the Arctic and long periods when soil is covered by snow and ice.

For instance, Arctic soils are known to have very high levels of mercury, one of the most carcinogenic heavy metals. As a consequence, elevated levels of mercury in the Arctic have been found in beluga whales, polar bears, seals, fish, eagles and other birds. Mercury mainly targets the brain, causing neurological damage but also affects the lungs, heart and kidneys. This strongly impacts on people, especially the local Inuit who get their food from traditional hunting and fishing practices.

Another example is cadmium, which occurs naturally and is also released by human activity. It is found throughout the Arctic, but its levels vary geographically. Cadmium tends to accumulate in living organisms; high levels reduce the growth and reproduction of invertebrates, and interfere with calcium metabolism in fishes, while in mammals it accumulates in kidney and liver and causes bone damage as it disturbs calcium and vitamin D metabolism.

Several pollutants are being regulated or banned, but these changes reflect the Arctic environment very slowly. Moreover, some compounds were often replaced by other chemicals with similar properties and pose also a similar threat to the environment. The cold climate also causes a slower degradation of chemical pollutants.

A lot of attention is currently focused on plastic pollution, which circulates the earth in the oceans and affects the Arctic coasts and the animals.

There are several initiatives concerning environmental contaminants. The most important and global is AMAP (Arctic Monitoring and Assessment Programme) working under the Arctic Council which works circum-Arctic. Concerning the marine litter, there operate PAME (Protection of the Arctic Marine Environment) Working Group. PAME is currently developing a Regional Action Plan on Marine Litter in the Arctic in close collaboration with other Arctic Council working groups (ACAP - Arctic Contaminants Action Program and the SDWG Sustainable Development Working Group).

The Task Force on Hemispheric Transport of Air Pollution (TF HTAP) is an international scientific effort putting together the data and coordinating the research and monitoring force for the Northern Hemisphere. For the region of Northern Canada, there is The Northern Contaminants Program (NCP) that concerns about human exposure to elevated levels of contaminants in wildlife species.

2.2. Climate-sensitive infections

Accelerated warming already significantly changes the Arctic environment, resulting in the thawing of permafrost and glacier and sea ice loss. Rising temperatures, increased precipitation and glacier retreat allow plants and animal species to expand their territory to further North. All these changes also enhance the various zoonoses and vector-borne diseases transmitted by mosquitoes and ticks or water and foodborne pathogens to spread.

Most diseases are often common from the tropics to temperate regions, but with increased warming, they are likely to spread to northern latitudes, where they may pose a threat to both humans and animals. Such diseases spreading northwards are called "climate-sensitive infections (CSI)".

As the most important infectious diseases with a potential to impact the human health in the Northern societies due to their transmission-mode, type of vectors, type of reservoir/ intermediate host animal, clinical, temporal and spatial relevance are considered: Anthrax, Babesiosis, Borreliosis, Brucellosis, Canine distemper, Chronic wasting disease (CBD), Cryptosporidiosis, Echinococcosis, Encephalitis, Fascioliosis, Leptospirosis, Nephropathia epidemica, Q-fever, TBE, Toxoplasmosis, Tularaemia.

The most documented diseases affected by climate factors in the Arctic are tick-borne diseases, tularemia, anthrax, and vibriosis. Tick-borne encephalitis and tick-borne borreliosis are spreading in warmer Arctic, as greater temperatures accelerate the ticks' development and reproduction.

Anthrax is a zoonotic disease seen at increasing occurrences with the permafrost thawing, in particular in the Russian Arctic. Thawing permafrost exposes buried carcasses of infected animals, ensuing flooding and soil disruption releases thawed anthrax spores. The disease is very infectious and humans are often affected through contact with infected animals, animal products and spores, but can be infected through an insect vector. There was a large outbreak of anthrax in Yamal, Russia during a very hot summer in 2016.

Human health in the Arctic is one of the priorities of the Sustainable Development Working Group (SDWG) panel under the Arctic council. There is an ongoing Nordic Centre of Excellence project, the CLINF, investigating the effects of climate change on the prevalence of infectious diseases in humans and animals in Northern regions; this project aims to predict the impact that changed risks of infections may have on northern societies, their culture, and their economy. Geographically the project covers the area from Nuuk in Greenland to Yakutsk in eastern Siberia. For the area of US (Alaska) there is a Wildlife Disease and Environmental Health in Alaska under the U.S. Geological Survey with the laboratory capacities to analyze the molecular samples.

General information about actual situation and warnings, diseases, geographical distribution and prevention are available at CDC and/or National Center for Emerging and Zoonotic Infectious Diseases (NCEZID) webpage (see the example of Antrax) for the USA, for Europe is available at European Centre for Disease Prevention and Control (ECDC).

2.3. Non-native and range-expanding species

Non-native species are organisms that are not originally living within a given area/biotope. Apart from their deliberate dispersion by a human, they may be unintentionally introduced by global trade, tourism, animal transport, escaping from gardens, culture collections etc. When those introduced species became naturalized – and hence can reproduce, they may pose a serious threat to native species. A further spreading may eventually lead to environmental or economic harm, including harm to subsistence species and activities, or harm to human health. Usually, the non-native species could outcompete the native ones due to the lack of natural enemies and hence may become invasive.

Importantly, there exist various human-related vectors: for instance, ticks might arrive together with pets, shoes serve as a perfect vector for plant seeds or microorganisms, and fishing equipment for some water invaders. Care should hence be taken by all travellers in diminishing the risk of non-intentional transport of non-undesirable alien organisms.

Easy and informative is a short video made by the Norwegian Institute for Nature Research (NINA), the Swedish Environmental Protection Agency (SEPA) and the Finnish Ministry of Agriculture and Forestry (MMM).

The importance of monitoring and taking action of invasive alien species in the Arctic is also one of the key findings (#6) of the Arctic Biodiversity Assessment. CAFF produced the Arctic Invasive Alien Species (ARIAS) Strategy and Action Plan which one of the main actions are: " Develop a strategy for the prevention and management of invasive species across the Arctic, including the identification and mitigation of pathways of introduction of invasions. Include involvement of indigenous observing networks, which include invasive and new species reporting, to assist with early detection" and "Incorporate common protocols for early detection and reporting of non-native invasive species in the Arctic into CAFF's Circumpolar Biodiversity Monitoring Program (CBMP)."

There are several databases, where to find information about non-native species for each country/region and find the information about the invasive status. The most comprehensive is the Global Register of Introduced and Invasive species (GRIIS), Global Naturalized Alien Flora (GloNAF) and Nobanis for Europe.

However, several invasive cases may already serve as an early warning of the potential magnitude of invasion threats to biodiversity. A notable example among plants can be *Lupinus nootkatensis*. This ornamental plant of North American origin was introduced to Iceland as a protection against erosion, become invasive and is continuously overgrowing the whole island outcompeting Icelandic native plant communities. The animal counterpart of lupine is a red king crab native to the Pacific Ocean, which started to fast decimate benthic communities along Norwegian coast after its introduction in the '60s, and population numbers are steadily increasing thanks to lack of its natural predators. Both these examples have large socio-economic impacts frequently largely overweighing their benefits. While these above-mentioned examples needed active human introduction, ongoing climate change together with increasing tourism may help natural invasion to become a much more significant threat in the future. Indeed, there is a range of often less ornamental (or potentially less beneficiary) species that have most likely been introduced non-intentionally: at one hand, leafy spurge (*Euphorbia esula*) became a noxious weed in Canadian fields, at the other hand, a current spreading of winter moose tick (*Dermacentor albipictus*), in Alaska has impacted the health of both human and wildlife are only a few examples of these non-intentional invasions.

Concerning the Arctic, usually, each state has its centre providing the information and collecting the data about the observation of non-native species (mostly in national languages): National Invasive Species Council (NISC) for the United States, Invasive Species Centre for Canada, Norwegian Institute for Nature Research (NINA), Finnish national alien species portal, Danish Environmental Protection Agency, The Icelandic Institute of Natural History. Data for Russia are available within the GloNAF database.

2.4. Environmental indicators of climate change events

There is no doubt that the Arctic is one of the fastest warming regions on the planet due to climate change. This involves, for example, a gradual summer season lengthening as well as a range of rather unpredictable events, which nevertheless existed in the Arctic since long ago. However, what is changing the most, is the frequency of those events, and hence inevitably also their severity.

Extreme events generally involve short-term events that are rarely observed across climatic time-scales. Defining, quantifying and predicting these events yet remains very difficult. 2012 IPCC special report on extreme events defines an extreme event as: “The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. “

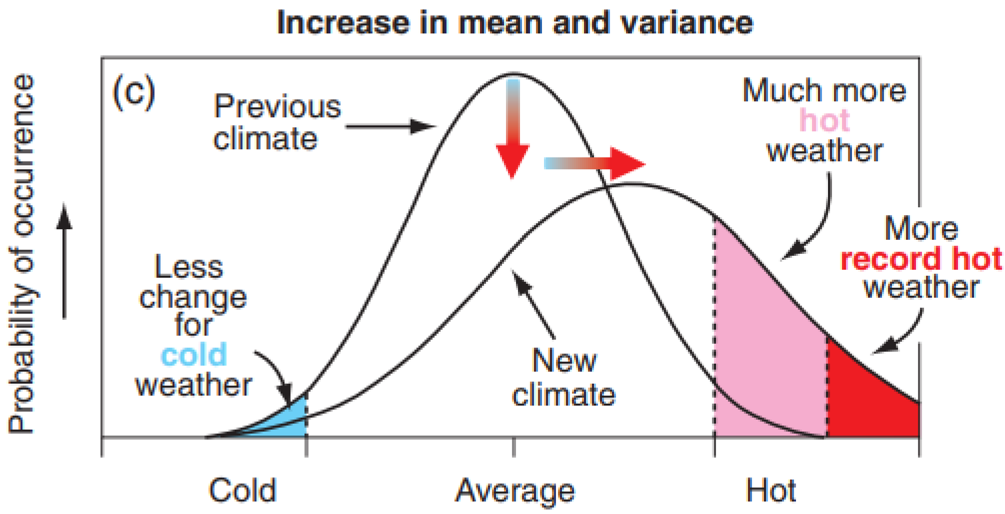

Figure 4: Schematic showing the effect on extreme temperatures when both the mean and variance increase for a normal distribution of temperature. Source: IPCC, 2001

While some decades ago, heavy rain on snow events during winter season were rather rare on Svalbard, it has become a common phenomenon during the last years (winters). As such, a joint effect of frequency, extemporaneousness and severity of the climate extremes cause serious problems for both human and wildlife. Staying with the example of rain on snow, the decimation of Svalbard reindeer population became much more severe than used to be due to repetition of this event in successive winters, causing difficulties to access the usual food of reindeer. This has a cascading effect on hunting regimes, as well as on intensity of herbivory during the following seasons.

Apart from the above mentioned increasing frequency of rain on snow events, there are indications that other phenomena are becoming more frequent and severe as well. These include intense activity of storms or cyclones, heatwaves and droughts, rapid iceberg calving events, permafrost thaw, coastal erosion and slope instabilities, or anomalous ice sheet surface melt resulting in polynya openings. Every single enumerated phenomenon may have a devastating effect on Arctic human and wildlife inhabitants.

Prediction weather models can be found at Models and European Centre for Medium-Range Weather Forecast (ECMWF). Weather and environmental prediction services for the polar regions secure The Polar Prediction Project (PPP). APPLICATE is a multinational and multidisciplinary project funded by the EU HORIZON 2020 Research and Innovation programme to enhance weather and climate prediction capabilities not only in the Arctic, but also in Europe, Asia, and North America.

Within INTERACT III there is a special work package dedicated to document and improve awareness of the many consequences of extreme weather events in the Arctic to secure the appropriate response.

2.5.Hazards

In the group of the hazards, we combined risks, that are relatively rare and happen either accidentally or are unrepeatable and/or unpredictable as earthquakes and resulting tsunami, volcano eruptions, wildfires, methane eruptions etc.
Earthquake hazards are recorded by the U.S. Geological Survey and observations reported here. There is a webpage dedicated to Alaska providing data about not only earthquakes, as well as volcanic and tsunamis. Aerosols and ash released during the volcanic eruptions cause short-term climate changes and play an important role in the global change processes, especially in affecting the Arctic Oscillation. Ice melt caused by the eruptions could lead to island uplift as documented in Iceland. Current volcano activity worldwide could be observed here. For individual countries or areas with high volcanic activities, information can be found at Volcanic Ash Advisory Center for the area of Alaska (and/or USGS for the whole US), Kamchatka Scientific Center for Russia, or at the webpage of Icelandic Meteorological office. Scientific protocols on how to collect data to assess the health impacts of the eruption and how to collect data for analyses of ash are available at the webpage of The International Volcanic Health Hazard Network (IVHHN), as well as the information about the preparedness for ashfall.
Tsunami is usually a consequence of the seismic or volcanic activity. The forecast could be found at the webpage of NOAA Center for Tsunami Research or Tsunami Warning Centre. In the Arctic, tsunamis are very often triggered by the landslides or ice sheet melting and very often reach intensity higher than the devastating, earthquake-triggered tsunami (e.g. as was in 2004 in Indonesia, Sri Lanka, India and Thailand or in Japan 2011).

Wildfires are a natural part of many ecosystems, however, in recent time the fires became more frequent and severe, especially due to the hot and dry conditions in many areas. Moreover, the intensity increased as well as the fires are usually well and fast treated and a lot of burning material accumulates in the forests.
Wildfires in the Arctic receive more attention due to the vast consequences they bring along. Burning the topsoil opens the permafrost to thaw releasing the greenhouse gases into the atmosphere. Wildfires also release large amounts of pollutants and gases, which can travel far and wide by winds, deposits on the sea ice, glaciers and snow, lower the albedo and speed up the thawing and are harmful to the respiratory and cardiovascular systems. The process is described in a short video released by the World Meteorological Organisation.

Copernicus Atmosphere Monitoring Service (CAMS) incorporates observations of wildfires from NASA's satellites (Terra, Aqua) into Global Fire Assimilation System (GFAS) to monitor the fires and estimate the emission of pollutants from them. Some of the results (small particulate matter) could be visualised in the weather forecast application Windy.
Global Earth Observation (GEO) work programme Global Wildfire Information System (GWIS) developed a platform with the cooperation of European commission, NASA and CAMS providing the fire information and fire warning.

Oil and Chemical Spills are very common worldwide and the Arctic coastline is no difference in that regard. Oil originates mainly from drilling activity and during transportation. Especially in the Arctic could be the impact of the oil spills much destroying, as the operations in the ice are more complicated and difficult to address.
There is an Arctic Council Working Group - The Emergency Preparedness, Prevention and Response Working Group (EPPR) focused on the prevention, preparedness and response to environmental emergencies, search and rescue, natural and manmade disasters and accidents in the Arctic, including the oil spills. PAME working group also released an Arctic Offshore Oil and Gas Guidelines. For the USA, NOAA provides an Environmental Sensitivity Index (ESI) Maps and Data which could help to reduce the environmental consequences of the spill and the cleanup efforts.

3. Observing networks and public science

Local Environment Observation Network (LEO) is a network of local observers and topic experts who share knowledge about an unusual animal, environment, and weather events. It is not intended for the scientific community only but is also focused on submitted observations from the public which could increase the scope of the area. The goal is to share an (unusual) observation and raise awareness of various events as well as to find answers about submitted observations. Every submission is reviewed by the topic expert and the data stored. Even though the project serves worldwide, the original idea started in Alaskan native tribes, most of the users, experts and observations come to focus the Arctic. Mobile application for easy reporting is also available.

iNaturalist is an application where various observation could be shared and asked a question to the community of users. The main advantage in using this tool we find in the possibility of creating various projects where the users could be asked/encouraged to collect specific data – e.g. the occurrence of non-native species in the area or monitoring the phenology of plants as a consequence of the warming as already done in Abisko.