Utilization of the Copernicus programme for the monitoring of the Arctic

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The Copernicus programme of the European Union offers an excellent opportunity to monitor the effects of climate change and other human activities in the Arctic region. The Arctic is warming twice as fast compared to the rest of the world and the effects of this can be seen as less extensive snow cover, earlier ice melt and changing ecosystems which, in turn, threaten the livelihoods of local inhabitants. To understand these changes and to mitigate the impacts of the warming climate, extensive and frequent monitoring of the Arctic environment is needed.

Satellite instruments measure electromagnetic radiation reflected or emitted by the target of interest. This radiation can then be converted into information about the geophysical characteristics of the target with mathematical models. Examples of this include the extent of snow cover, the presence of ice in lakes or the amount of phytoplankton and other substances in lake water. Collected over time, this information offers insight into the trends and changes taking place in the Arctic. This process is called Earth Observation (EO).

The aim of the Copernicus programme is to provide a stable series of data far into the future that can be used to monitor the environment and its changes. The first Sentinel satellite was launched in 2014 and when the constellation is complete there will be at least two satellites of each type in orbit at any time providing redundancy to the system. Replacement satellites will be launched when the end of the life time of the current satellites approaches and the specifications of the next generation are being defined. The availability of data in this scale and continuity is unprecedented.

EO is useful for:

1. Detecting and monitoring natural or manmade phenomena such as algal blooms, dredging, oil spills, floods, and accidents. For these it is often enough to utilize so called true color images (from cloud free optical data) without any complex processing.
2. Monitoring the state and the long term changes in nature such as climate change, eutrophication, and brownification. These usually require processing of satellite data into geophysical parameters.

The advantages of EO include excellent spatial (remote areas, areas covered completely and not just at sampling stations) and temporal coverage (daily observations in high latitude areas with some instruments). EO based monitoring is also cost effective since most of the infrastructure (satellites and ground stations) is already in place and the data is available free of charge.

The Finnish Environment Institute has developed EO based services for monitoring the environment in the Arctic together with national and international partners and with funding and support from the Finnish Ministry of Environment and Ministry for Foreign Affairs of Finland. Current applications include monitoring of water quality (Chlorophyll a as a proxy of phytoplankton biomass, water transparency, turbidity and CDOM), snow cover extent and lake ice extent. The data are publicly available through the TARKKA map application (www.syke.fi/tarkka/en) and are being used by authorities, researchers, companies and citizens. Satellite images support the daily operations of the public administration and provide material for their tasks of preparedness, risk mitigation, and adaptation.

In addition to maps, SYKE derives higher level products by collecting pixel values from an area of interest (e.g. a water body or a catchment area) and deriving statistics and time series plots for various applications. These are then presented to users together with in situ data e.g. for status assessment purposes. The reliability of the assessment can be improved by using EO and the spatial and temporal coverage it provides (Attila et al. 2018).

An example of the use of EO for monitoring lake ice cover is shown in Figure 1. The ice is clearly visible in the true color image. An automated algorithm can reliably differentiate ice from water and clouds. By processing all available satellite images it is possible to form a time series and determine the onset of the melting (first water pixels appear) and the end of the melting (ice pixels are no longer found).

It is important also to note that EO methods cannot observe parameters that do not have a clear effect on the measured electromagnetic signal. In the case of water quality, this includes, e.g., nutrients, bacteria, viruses, and toxins. Thus, an efficient monitoring system for the Arctic will include both EO and in situ data sources.

We will demonstrate how EO can benefit the monitoring of the Arctic through practical examples and aim to foster further Arctic collaboration for this topic.

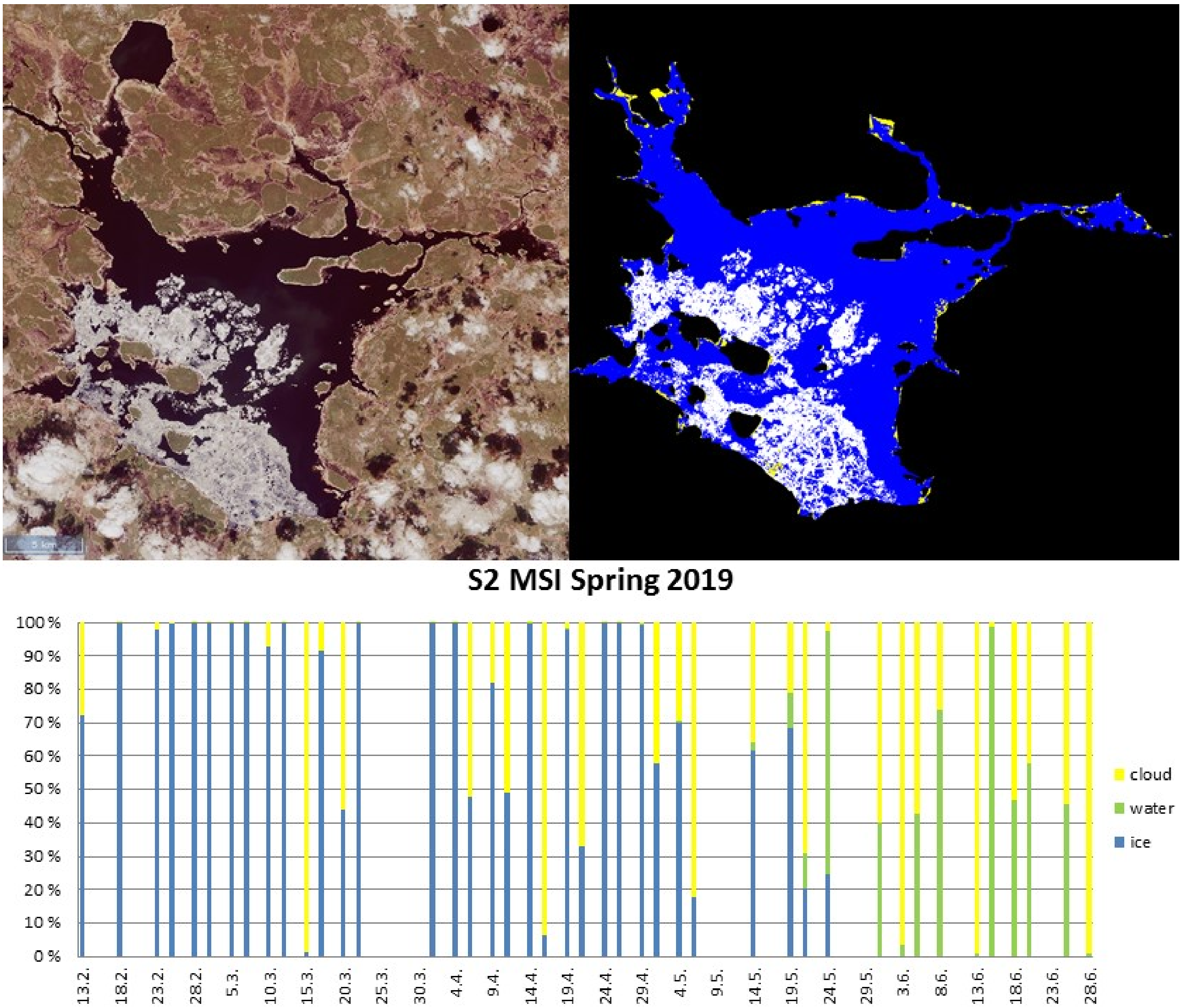

Figure 1. Lake ice cover at Lokka Reservoir in Northern Finland. Top left: Sentinel 2 MSI true color image acquired on May 24, 2019. Top right: Lake ice product of the same day. Bottom: Lake ice cover time series of spring 2019.

References

Attila, J., Kauppila, P., Kallio, K., Alasalmi, H., Keto, V., Bruun, E., Koponen, S. 2018. Applicability of Earth Observation chlorophyll-a data in assessment of water status via MERIS — With implications for the use of OLCI sensors. Remote Sensing of Environment. Volume 212, June 2018, Pages 273-287.