Research objective

The main objective of the project is to identify and describe the mechanisms causing the reduction of the sea ice cover in the European Arctic. Many processes affect the concentration and extent of sea ice, and their intensity and frequency are intrinsically linked to the research area. Therefore, to recognize the mechanisms that shape the Arctic sea ice cover, it is necessary to understand the interactions between the ocean, atmosphere and sea ice in different regions of the Arctic Ocean. The project will be focused on two research areas, Fram Strait and the southern part of the Nansen Basin. Fram Strait is the only deep passage linking the North Atlantic and the Arctic Ocean. The northward transport of warm and salty Atlantic water, carried by the West Spitsbergen Current, has a significant impact on conversion and circulation of water masses, and heat content of the Arctic Ocean. North of Svalbard, in the southern Nansen Basin, Atlantic water occupies the upper layer and has a direct contact with sea ice. As a result, oceanic heat flux can contribute to sea ice melting and atmospheric warming in ice-free areas. The increase of air temperature also contributes to greater melting of sea ice. Changes in concentration and extent of sea ice also result from the ice drift, mostly forced by local or large-scale winds. Sea ice melt due to oceanic heat carried by Atlantic water further increases mobility of ice floes and therefore can intensify sea ice drift. The primary research question addressed by the project is to elucidate how the changes in the temperature and strength of the Atlantic water inflow, observed in the recent decades, as well as the large-scale and local atmospheric circulation impact the extent and variability of sea ice concentration in Fram Strait and in the southern part of the Nansen Basin.

Research methodology

The study area comprises Fram Strait and the southern part of the Nansen Basin, which play a key role in controlling the oceanic heat supply to the Arctic Ocean due to strong interactions between the ocean, atmosphere and sea ice. Observational data collected by the Institute of Oceanology Polish Academy of Sciences in the Nordic Seas, Fram Strait and north of Svalbard cover almost two decades. In addition to oceanographic data, comprising temperature, salinity and ocean currents measured at fixed stations during the annual AREX surveys of RV Oceania, the continuous year-round time series, collected by instrumented moorings located in Fram Strait and north of Svalbard will be utilized in this study. These complementary datasets provide an excellent basis for analysing the impact of oceanic variability on the Arctic sea ice cover. Combined with the publicly available satellite data sets (including sea ice concentration and drift, and an extent of sea ice cover) and atmospheric data from the latest reanalyses (atmospheric pressure, air temperature, wind, and ocean-atmosphere heat fluxes), the collected data will allow for comprehensive examination of what mechanisms, on which timescales and to what extent are responsible for changes of the sea ice cover in the studied areas. Variability of sea ice concentration (and, if possible, also sea ice volume) in the studied Arctic regions will be analyzed on monthly, seasonal and inter-annual time scales for the period 1996-2021 to assess the impact of Atlantic water variability on the sea ice loss in the recent decades. The preparation of relevant data sets, calculation of derived parameters, statistical analysis of time series and a description of possible relationships between the key sea ice variables and selected oceanic and atmospheric parameters will be a substantial part of this research.

Motivation

The causes and mechanisms of decreasing concentrations and thickness of sea ice in the Arctic Ocean, observed in recent decades, are still one of the most challenging questions related to accelerated climate changes in the Arctic. One of the possible reasons can be sought in the observed warming of Atlantic water, carried through Fram Strait into the Arctic Ocean. In the inner part of the Arctic Ocean, Atlantic water occupies a relatively warm intermediate layer, separated from the sea ice and the atmosphere by a strong halocline (a layer of a strong salinity gradient between intermediate and surface water). This layer isolates Atlantic water from the surface and inhibits the vertical heat flux from ocean to ice and atmosphere. However, in Fram Strait, as well as north of Svalbard, warm Atlantic water extends into the surface layer where it has a direct contact with sea ice and atmosphere. As a result, available oceanic heat can contribute to accelerated sea ice melting and increase the ocean-atmosphere heat flux. Additionally, the warm Atlantic-origin water recirculates westward directly in Fram Strait, which may affect the sea ice extent and location of the ice edge in the strait. Southward transport of drifting sea ice and freshwater from the Arctic is mostly carried through Fram Strait by the cold and fresh East Greenland Current and depends on the large-scale and local atmospheric circulation. Therefore, variability of sea ice concentration and extent is possibly linked to oceanic changes (warming of Atlantic water, circulation patterns) as well as atmospheric variability (air temperature, prevailing winds, systems of atmospheric lows). Mechanisms responsible for decreasing sea ice concentration and extent in the European Arctic are currently the subject of extensive research and the recent studies show that diminishing sea ice cover can impact not only the Arctic climate but also the entire Northern Hemisphere, including Europe.