The recently released IPCC report states that hydrological changes resulting from the shrinking cryosphere have already impacted terrestrial and freshwater ecosystems in the Polar Regions (IPCC, 2019). The observed changes in air temperature in the Atlantic sector of the Arctic are one of the largest on Earth. The analyses of the long term climatic variables at Svalbard indicated warming of $+1.14^{0}$C/decade at the Polish Polar Station Hornsund and that in the last four decades is more than 6 times higher than the global average ($+0.17^{\circ}$C/decade, Wawrzyniak & Osuch 2020). The changes in air temperature are also coupled to a reduction in snow cover and an increase in precipitation +61.60 mm/decade. The climate projections show further changes. It is therefore clear that Polar Regions in the future will be very different from what we observe today, and the level of change will depend on climate-related variables intrinsically linked to the water budget. Yet, current hydro-meteorological observations in the High Arctic are scarce and incomplete, and we lack appreciation for the heterogeneity of this vulnerable environment. As a result, **recognition of the hydrological processes and their changes in Svalbard is named as one of the most important research needs in the High Arctic** (SIOS KLEO; Hanssen-Bauer et al. 2019).

The **main objective** of this proposal is **a first ever comprehensive water balance study in two High Arctic mountainous catchments located in Svalbard to investigate the heterogeneity in the cryo-hydro-meteorological conditions and their seasonal dynamics**.

We will, therefore: (1) Perform hydrological, meteorological, and permafrost monitoring in two mountainous High Arctic catchments located in SW Spitsbergen Svalbard (Fuglebekken and Ariedalen). The use of remote sensing methods allows capturing the heterogeneity of the conditions. (2) Investigate and model relationships between permafrost and hydrology to understand the dynamics of the cryo-hydro-geological system in the mountainous catchments. (3) Through the aforementioned 1 and 2, we will provide crucial data resources for High Arctic hydrological models to limit uncertainty in simulations and create better predictions for climatically induced changes of hydrological regime in the High Arctic environment.

Such complex investigation will be achieved by interdisciplinary approach:

1. **Investigation of water balance** in each catchment taking into account new measurements of runoff, precipitation gradient, evapotranspiration, soil moisture, glacier mass balance, snow cover, ground temperature, and groundwater.
2. **Analyses of hydro-meteorological time series** using **in-situ and remote measurements (GPR and UAV)**, to recognize the **dynamics of hydrological and topoclimatological processes** at a range of temporal scales in different sites.
3. **Analyses of the added value of new time series** (evaporation, precipitation, soil moisture, groundwater) on the constraining hydrological models to **limit uncertainty of simulations**.

We propose an integrated approach taking into account the freeze-thaw cycles of water in the soil, to describe and to model hydrological processes. These cycles influence river discharge by changing the hydraulic properties of the soil and by either contributing to or preventing infiltration. It is planned to use cryo-hydro-geological models for **better understanding of processes linking hydrology and permafrost under varying climatic conditions for the first time in Svalbard**. In particular, we would like to analyse (i) **an influence of active layer thickness on the surface and near-surface water storage, drainage, and routing**; (ii) **test the effect of surface water, soil moisture, and groundwater on permafrost distribution and degradation**; (iii) **analyse how active layer thickness changes in the past have altered observed discharge patterns**; (iv) **and how future permafrost degradation will influence the hydrological regime**.

In the final step, **hydrological projections will be developed using newly constructed hydrological models and climate simulations** with different spatial and temporal scales available from the POLAR-CORDEX initiative. For the development of projections, multiple hydrological models will be applied, both conceptual and process-based, that take into account changes in different components that influence runoff. Based on an ensemble of projections, the hydrological indices will be derived: flow seasonality, mean annual runoff, and indices related to extreme events (droughts and floods). The obtained results will be compared with those presented in the report “Climate in Svalbard 2100”, which contains many simplifications.