## Terrestrial

*State-of-the-art and challenges*: The Arctic and boreal land surface is home to a wide range of coupled processes with major feedbacks on the Earth System and/or which have significant societal effects on the vulnerable economies of northern latitudes and Europe's welfare. A major challenge is to estimate the Arctic GHG budget. The *in situ* observing network, established in Siberia and western Russia, Canada, Alaska and Eastern Siberia, is focussed on the two major carbon species $CO_2$ and $CH_4$. However, the network is still too sparse and most records are too short for differentiating inter-annual variability from long-term trends in GHG exchange processes. Due to this, an upscaling of fluxes to e.g. regional domains (1000km) and longer-term averages (decadal means), needed to assess spatial and temporal variability in pan-Arctic GHG patterns, remains highly challenging. Upgrades are particularly important for the network of flux sites, where lacking infrastructure (power supply) and instrumentation problems (e.g. de-icing) is still a challenge.

Changes in the Arctic hydrological regime and river discharge are key components for understanding the Arctic Ocean freshwater balance. About 50% of the freshwater inflow to the Arctic Ocean is river discharge from the surrounding landmasses in Eurasia and North America. The Global Runoff Data Center (GRDC) has collected data from about 2400 stations within the Arctic Ocean drainage basin in a subset called Arctic Runoff Database. Changes in surface properties arise from changes in the spatial distribution and properties of vegetation, surface water (e.g. in seasonal lakes) and ice and snow; though mainly measured from satellite data, in situ data are crucial for calibration and to measure properties inaccessible from space.

For changes in the hydrological regime and river discharge to the Arctic Ocean, the key need is to address inadequacies in the current network of in situ river discharge observations. About 30% of the drainage basin is ungauged, so we must exploit the existing data to estimate discharge from such areas through modelling or spatio-temporal interpolation methods. It is also crucial to address the loss of existing stations, failure to report regularly to open databases, and unknown quality control status. More generally, in situ measurements are important to estimate parameters for land surface models, which are critical for integrating the diverse measurements provided by an iAOS.

*Expected progress beyond state of the art:*

- The Alaskan transect of 5 eddy covariance towers measuring $CO_2$, $H_2O$, $CH_4$ and energy fluxes will be enhanced to provide continuous, year-round data on GHG concentrations and fluxes, as well as active layer depth, water table depth and snow depth.
- These measurements will be closely linked to airborne meteorology and eddy covariance measurements of sensible and latent heat, $CO_2$ and $CH_4$ flux in the Alaskan and NW Canadian Arctic
- A new flask sampling instrument will be installed at a key location in Northeast Siberia to extended data streams (e.g. isotopes) to identify processes related to Arctic GHG exchange. The representativeness of the currently existing network of tall towers around the Arctic will be assessed for constraining GHG exchange processes in different Arctic regions.
- The unique infrastructure for long-term multi-disciplinary measurements of soil, ecosystem, cryosphere and atmosphere at the FMI Sodankylä-Pallas research station (a cal/val site for the SMAP and SMOS missions) will be enhanced to create new satellite retrieval methods for snow and atmospheric properties.
- The network of 9 monitoring stations in the Eastern Canadian Arctic will be enhanced by use of a new airborne LIDAR to map snow depth, to investigate the rapid modifications of snow depth caused by vegetation growth and the coupled evolution of vegetation, snow depth and permafrost temperature.
- SMHI will develop: (a) methods to fill spatial and temporal gaps in river discharge observations and predict freshwater flow into the Arctic Ocean from ungauged basins, and (b) strategies to improve data delivery chains and data accessibility for iAOS. River discharge and satellite data will be assimilated into the pan-arctic hydrological model Arctic-HYPE to predict freshwater flow to the Arctic Ocean.