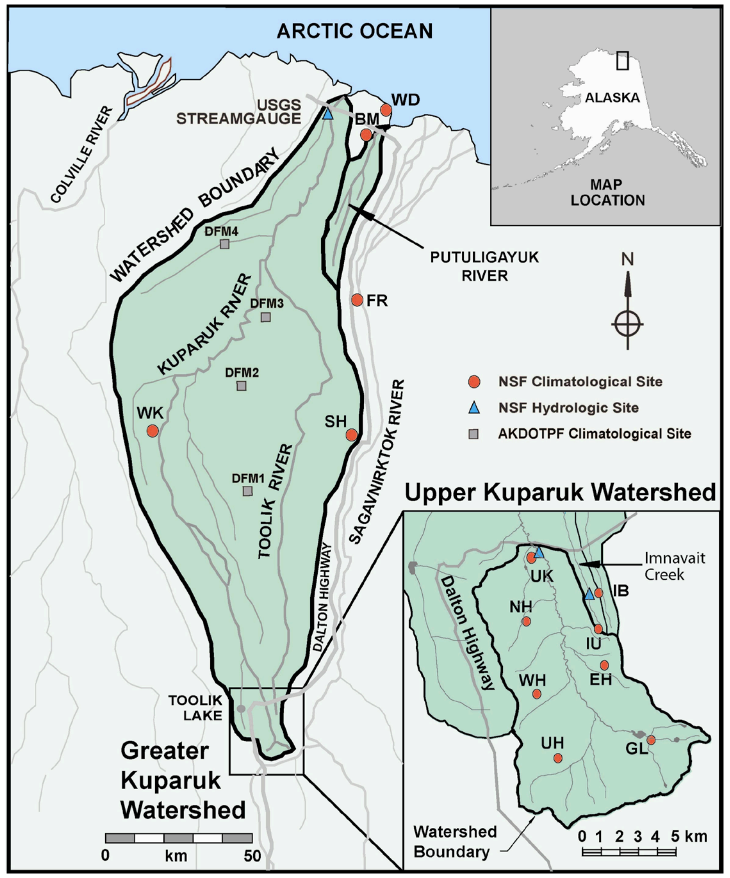
Kuparuk River Basin Nested Watershed Study, Arctic Alaska, USA

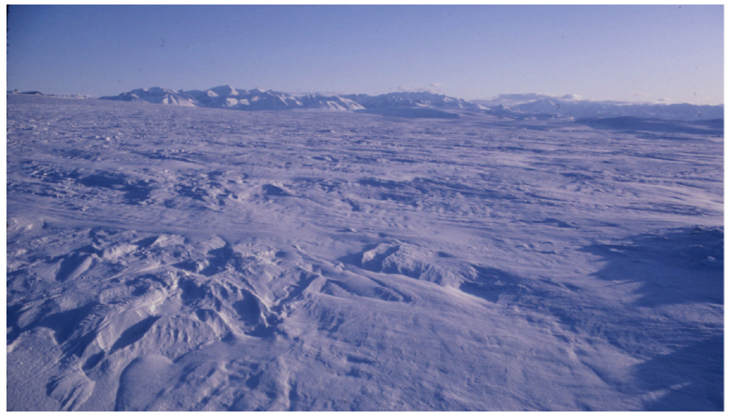
Arctic-HYDRA

The Arctic-HYDRA project is a network for the observation and studies of the Arctic Hydrological Cycle.

Setting



Location map of nested watershed boundaries and sites of hydrological and meteorological sites for the Kuparuk River study on the Alaskan North Slope.



Late winter snowpack sculptured by the wind in the Kuparuk Basin, Brooks Range in background.

Upper reaches of the Kuparuk River during mid-August, can barely see the Brooks Range in the background.

Photgraphs

North meandering Kuparuk River on the Arctic Coastal Plain; note the abundance of lakes, ponds and wetlands.

Drainage network highlighted by early winter snowfall; note the parallel water tracks separated by 10s of meters in the Northern Foothills of the Brooks Range within the Kuparuk River Basin.

Summary

We propose that the Kuparuk River and some surrounding nested drainages on the North Slope of Alaska be viewed as a Long-Term Hydrologic Observatory (LTHO). The Kuparuk River originates in the northern foothills of the Brooks Range (Rocky Mountains) and flows northward out of the foothills onto the coastal plain before emptying into the Arctic Ocean.

In expanding this research program as a Long Term Hydrological Observatory, we intend to focus upon facets of arctic hydrology that interplay strongly with ecosystem dynamics, climate change, geophysics, near shore estuarine processes, energy dynamics and geomorphology. The climate is currently undergoing significant, broad scale change in the Arctic. The hydrological cycle is an integral component of the climate system, both moderating and driving changes in meteorology, coastal processes, and terrestrial and aquatic ecology (freshwater and marine). Warming of permafrost, a decrease in sea ice extent, thinning of the sea ice, later freeze-up and earlier break-up of lakes, reduction of snow cover extent in northern hemisphere and shorter season of snow on the ground are a few indications of warming in the Arctic and targets of important hydrological research.

The importance of the high latitudes in the global climate must be emphasized. It is apparent that climate driven changes are presently ongoing. This is impacting the hydrologic cycle, not only through the land/atmosphere interactions, but also the physical structure of the basin. The development of thermokarst, deeper active layer and an increase in shrubs (vegetative shift) are changes that will be reflected in the hydrologic response of these catchments. Quantifying the role of hydrology in a changing climate is critically important for U.S. and global science policy.

Objectives

Why should we study the hydrology of an arctic region?

1. Most detailed hydrologic studies are carried out in tropical and temperate regions of the world where there is a net positive flux of radiative energy into earth's system. But arctic regions of the world, with a net negative radiation flux, are equally as important in earth's climate machine. Generally energy is transferred towards the poles by water fluxes in our oceans and the atmosphere. The hydrologic cycle in the Arctic plays a central role in moderating the climate dynamics of the more temperate regions.

2. Arctic regions of the world are predicted to have the greatest climate change with increased concentrations of greenhouse gases in our atmosphere. In fact, there is already evidence of climatic warming in many areas through the warming of permafrost, reduced spatial coverage of snow, reduced sea ice distribution and thickness and later freeze-up and earlier break-up of water bodies. Is this induced anthropogenic change or does it represent natural variability?

3. Like everywhere in the world, water is a valuable resource. To manage this resource properly, it is important that we have a sound understanding of the underlying hydrologic processes.

4. Although the watersheds discussed here are quite pristine, future resource development and atmospheric transport of contaminants (locally and from Eurasia) into this region of the Arctic is a likely scenario.

5. We are starting to build a strong foundation in our individual disciplines in the Arctic but we have done little to understand the scientific bridges between linked systems (hydrology/atmospheric science; hydrologic and biogeochemical cycles; hydrologic and ecosystem interactions).

6. Due to the limited hydrologic data collection in the Arctic (sparse network, short record, poorly distributed stations), extreme events are poorly documented. There is past evidence of low probability hydrologic events. What does this mean? Will climatic warming increase the occurrence of such events (warmer atmosphere capable of transferring more moisture)?

Site Charecteristics

The Kuparuk River is a north-draining river that originates in the northern foothills of the Brooks Range (Rocky Mountains) and flows out of the foothills onto the coastal plain before emptying into the Arctic Ocean. The foothills represent 56% of the basin and the coastal plain the remainder. The elevation range is from 0 to 1464 m. There are some scattered pockets of lakes in the foothills; on the coastal plain, lakes, ponds and wetlands dominate. The watershed is treeless (except for some riparian areas) and underlain by continuous permafrost from ~250 to 600 m in thickness. The area is relatively undeveloped or in a natural state except at Prudhoe Bay on the Arctic Ocean. The Dalton Highway and the Trans-Alaska oil pipeline run north/south along and across the Kuparuk River basin and represent the only land-based access to the basin.

Describing the environment of this watershed as extreme is justified. Winter minimum temperatures drop below –40 °C, while maximum summer temperatures have exceeded +30 °C. Freezing temperatures and snow are possible during any month. Mean annual temperatures are approximately –5 to –10 °C; these low temperatures sustain the deep permafrost that exists continuously throughout the proposed LTHO watershed. As this area is north of the Arctic Circle, a fall and winter period of no direct solar radiation is experienced and this is offset by a period of no sunset in spring and summer.

Relevant publications

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