Abiotic and Biotic Phenological Change in the Alaskan Arctic

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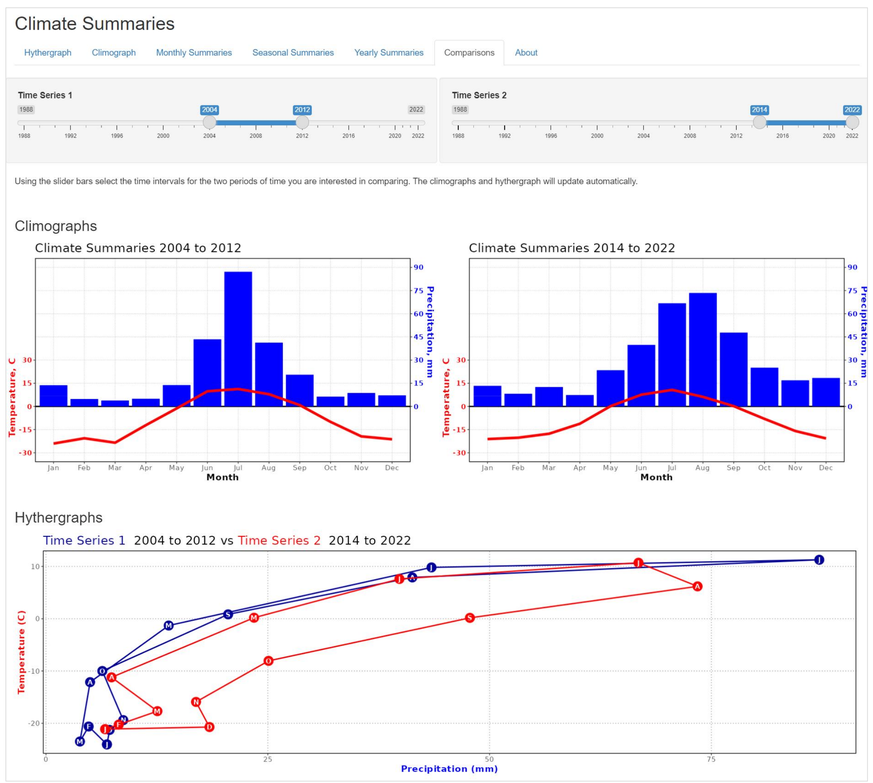
Abstract

Large changes to the biotic and abiotic phenology of the Arctic are occurring as a result of climate change; however, these changes are not occurring uniformly across the Arctic. At Toolik Field Station on the North Slope of Alaska, annual average temperatures over the past 20 years have been relatively stable, which can lead to some misleading conclusions about how the Arctic is changing. Here, we examine phenological changes in both abiotic (meteorological and cryosphere) and biotic (plants and animals) environments at Toolik Field Station to provide a broader assessment of the impact of climate change on our study region. The monitoring resolutions include daily, weekly, monthly, and seasonal data, and data were collected throughout the year through via ground observations and with autonomous equipment. The observed year-to-year variation at Toolik may not seem great compared with other arctic regions; however, changes to the precipitation regime, including an increase in storms, are due in part to changes in atmospheric circulation and sea ice coverage in the Arctic Ocean.

Abiotic – Temperature and Precipitation

Temperature at Toolik is relatively stable with few distinguishing trends currently apparent. Seasonal temperatures have been relatively constant since 1988, while precipitation has increased in the fall and winter months. Additionally, the range of potential temperatures on a given day is greatest in winter months, suggesting that this season experiences the largest magnitude of short-term fluctuations in temperature (see circular plot →).



How to read a hythergraph: each point is the mean temperature and mean total precipitation for the months selected in a timestep. Months are labeled based on the first letter of the month and are followed by the next month.

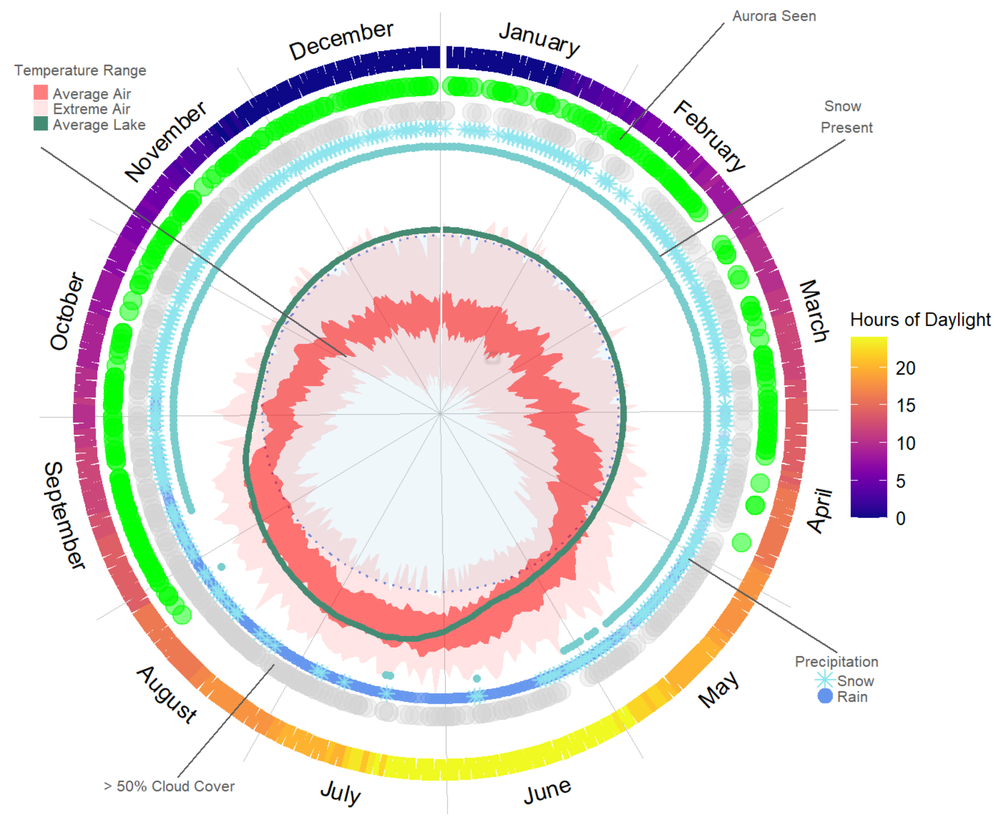
The **Climate Summaries Tool** provides researchers and educators with monthly, seasonal, and yearly summaries of temperature and precipitation at Toolik. Users can select the time period of interest and view the data as climographs, hythergraphs, or look at the average data and % of missing data for the selected period.

Scan the QR code below to check out the Toolik Met Station data and test out the Climate Summary Tool.

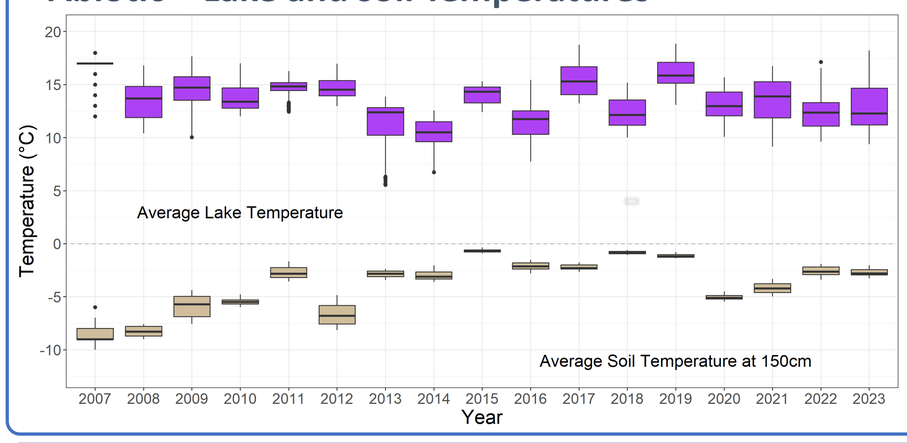
Climate Summaries

Snapshot of Toolik throughout the Year

Data from the TFS Met Station and Naturalist Journal (2007-2023)

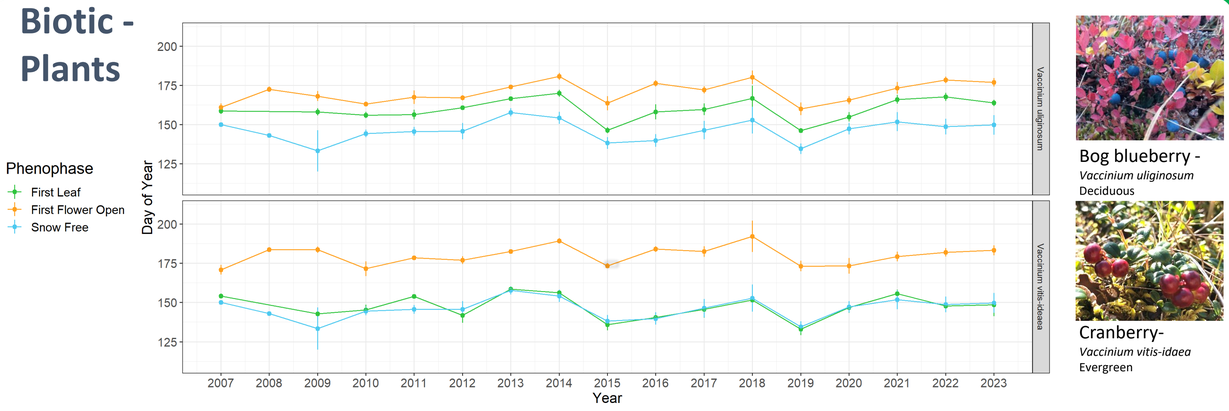


Abiotic – Lake and soil Temperatures



Lake temperatures during the warmest month of the year (July) oscillate between warmer and cooler years without displaying any long-term trend, while soil temperatures are rising at a depth of 150 cm, though not near the soil surface (data not shown).

Biotic - Plants



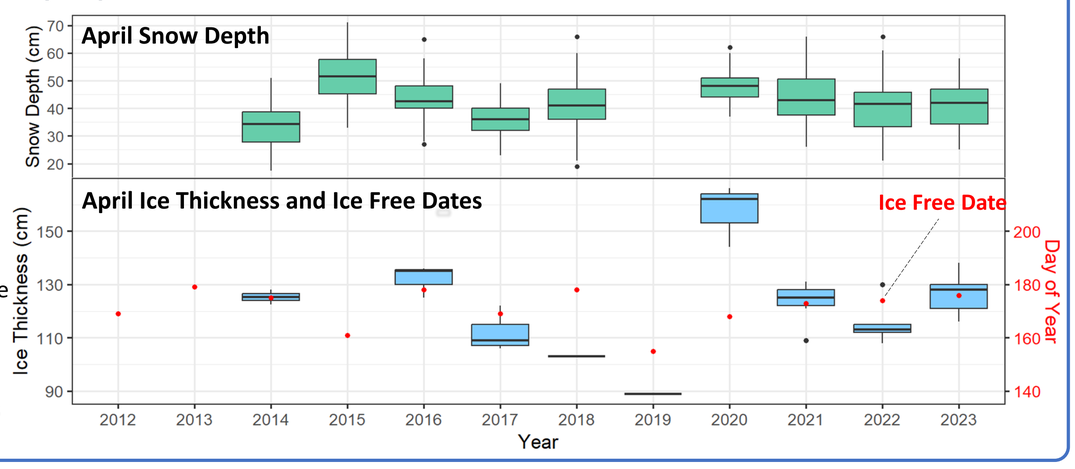
Bog blueberry - *Vaccinium uliginosum* Deciduous

Cranberry- *Vaccinium vitis-idaea* Evergreen

Plant phenology is monitored semi-weekly during the snow free period for grasses, forbs, and shrubs (deciduous and evergreen). Phenological states are synchronous between deciduous and evergreen species of *Vaccinium*. The evergreen species's first leaves green up when plots are 100% snow free. Neither species is trending earlier or later.

Abiotic - Cryosphere

April typically has the greatest snow depth and ice thickness of the year. Snow depth is fairly constant year to year, while ice thickness varies by 60 cm. The ice free date for Toolik Lake is within a 20-day range regardless of ice thickness.

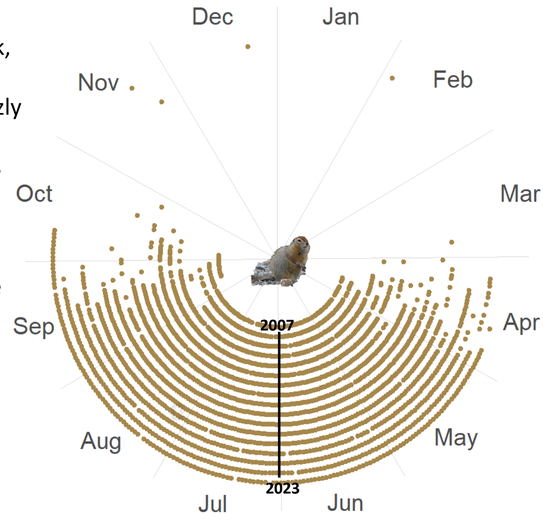


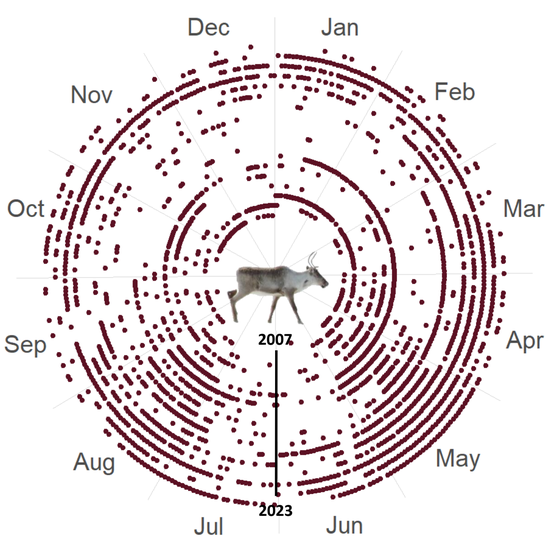
Biotic - Mammals

Throughout the year, daily observations of animal sightings are recorded in the Toolik Naturalist Journal, which captures the many migrating populations as well as occupancy by resident populations.

Animals and Birds of TFS

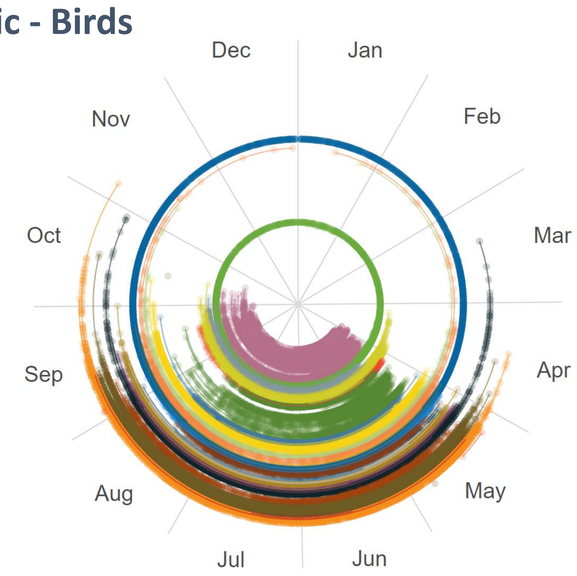
Two species at Toolik, the Arctic ground squirrel and the grizzly bear, have clear hibernation patterns and are only seen during the warm portion of the year. While the rest of the species stay active throughout the year.





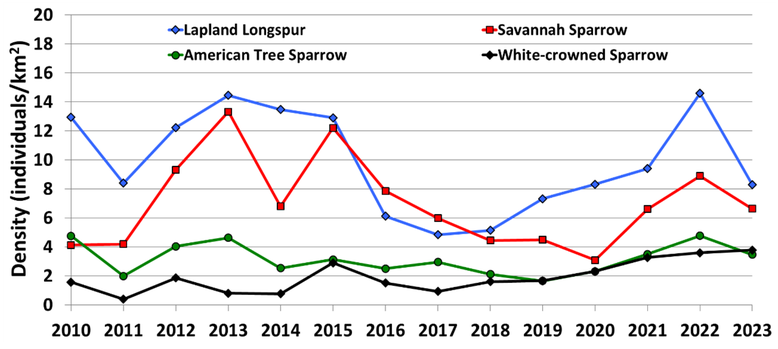
Caribou are the only mammal species in the region that migrates. In some years, they pass Toolik in May on their way to the Coastal Plains, and in late July and August, they return south to the Brooks Range. In other years, caribou remain in and around Toolik throughout the winter months.

Biotic - Birds



The timing of the annual spring migrations of songbirds and waterfowl to the region is fairly synchronous. For a given species, small differences in the timing of arrival may have a large impact reproductive success during such short summers. Using the Animals and Birds of TFS QR code, you can examine the variation in these arrival dates. By contrast, the timing of departure dates is more variable among species, indicating southward migration is less synchronous.

Individual species dynamics vary from year to year, as well. Lapland Longspur and Savannah Sparrow populations both declined in 2016 and 2023, possibly due to snowstorms in May 2015 and July 2023. American Tree Sparrows and White-crowned Sparrow populations remained relatively constant throughout this time period, though at lower densities.



Summary

- Toolik Field Station collects a variety abiotic and biotic baseline data to provide context researchers' projects at and near the station.
- There are few consistent trends found in the baseline meteorological datasets across years. However, further analyses, such as investigating the variation in maximum and minimum temperatures and precipitation totals over time, are warranted, especially given the size and quality of the datasets.
- Subtle interannual variation, such as in the timing of snow melt and frequency or magnitude of summer snow storms, may be biologically important, particularly for susceptible species of birds and mammals.
- Given the continued acceleration of global climate change, especially in the Arctic, maintaining monitoring of a range of parameters is vital for contextualizing ongoing and future research.
- The creation of accessible tools for data exploration to allow both researchers and educators to discover and use the data will help in expanding the public's understanding of the Arctic and how it is, and is not, responding to global climate change.
- There is much room for more exploration and analysis of interactions among species, particularly framed by the many abiotic parameters.

Huge appreciation to the Toolik Management team, the Toolik Steering Committee, and the NSF Office of Polar Programs for their continued support of the Environmental Data Center and long-term environmental monitoring. And another huge thank you to all of the seasonal technicians who have worked at Toolik over the past 15 years collecting these valuable data.

All data presented in this poster are available either through the Arctic Data Center, Toolik website, or by contacting Amanda Young.

For more information about the Spatial and Environmental Data Center and Toolik Field Station, please reach out to Amanda Young (ayoung55@alaska.edu) or the Toolik Management Team (uaf-iab-toolik@alaska.edu). Additionally, feel free to reach out about any ideas for future projects at the station.

Scan the QR code → to check out the Toolik Naturalist Journal.