ABoVE: Climate Drivers of Pan-Arctic Tundra Vegetation Productivity, 1982-2015

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Data Set Version: 1

Summary

This dataset provides a summary of potential climate drivers of Arctic tundra vegetation productivity that have been compiled for growing seasons from 1982 to 2015. The scale of interest is the entire pan-arctic non-alpine tundra and the continental subdivisions of the North American and the Eurasian Arctic North of 70 degrees. These climate drivers include (1) maximum normalized difference vegetation index (MaxNDVI) and time-integrated NDVI (TI-NDVI), (2) summer sea ice concentrations, (3) oceanic heat content, (4) land surface temperature, and (5) summer warmth index (SWI). Data are provided variously as timeseries and weekly and bi-weekly averages over selected time ranges and study regions with calculated trends and trend significance. Data collected over 23 years were compiled to observe seasonal trends of vegetation productivity and to detect dynamics between arctic vegetation and climate drivers.

There are six data files in .csv format. Each file includes data as displayed in a corresponding figure in the related publication. Please refer to the variable descriptions below, and the respective figure's caption and descriptions in the related publication.

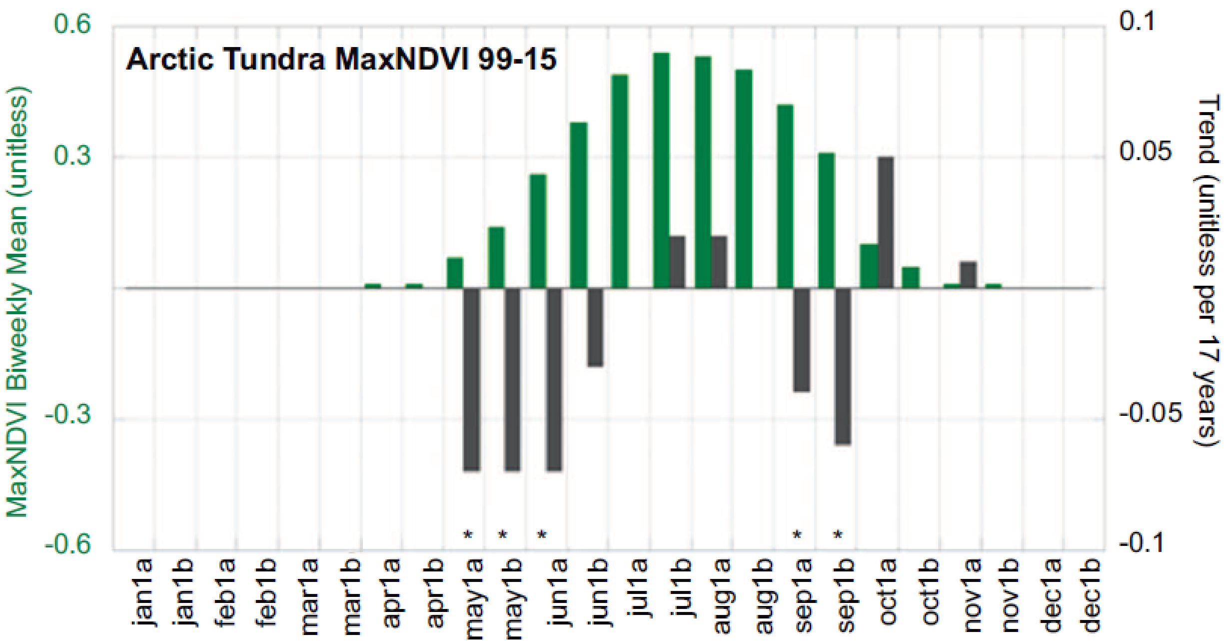

Figure 1. Arctic biweekly NDVI (green bars) and trend (grey bars) for full tundra for 1999-2015. Biweekly trends statistically significant at the 95% level or greater are marked with an asterisk on the x-axis. MaxNDVI is unitless and trend is change over time period. From Figure 9 (c) Bhatt et al. (2017).

Citation

Bhatt, U.S. 2018. ABoVE: Climate Drivers of Pan-Arctic Tundra Vegetation Productivity, 1982-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1606

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1. Data Set Overview

This dataset provides a summary of potential climate drivers of Arctic tundra vegetation productivity that have been compiled for growing seasons from 1982 to 2015. The scale of interest is the entire pan-arctic non-alpine tundra and the continental subdivisions of the North American and the Eurasian Arctic North of 70 degrees. These climate drivers include (1) maximum normalized difference vegetation index (MaxNDVI) and time-integrated NDVI (TI-NDVI), (2) summer sea ice concentrations, (3) oceanic heat content, (4) land surface temperature, and (5) summer warmth index (SWI). Data are provided variously as timeseries and weekly and bi-weekly averages over selected time ranges and study regions with calculated trends and trend significance. Data collected over 23 years were compiled to observe seasonal trends of vegetation productivity and to detect dynamics between arctic vegetation and climate drivers.

Each file includes data as displayed in a corresponding figure in the related publication. Please refer to the variable descriptions below, and the respective figure's caption and descriptions in the related publication.

Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign based in Alaska and western Canada between 2016 and 2021. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis and modeling capabilities needed to understand and predict ecosystem responses and societal implications.

Related Publication:

Uma S. Bhatt, Donald A. Walker, Martha K. Raynolds, Peter A. Bieniek, Howard E. Epstein, Josefino C. Comiso, Jorge E. Pinzon, Compton J. Tucker, Michael Steele, Wendy Ermold, and Jinlun Zhang. 2017. Changing seasonality of panarctic tundra vegetation in relationship to climatic variables. Environmental Research Letters, 12 (5) 055003. https://doi.org/10.1088/1748-9326/aa6b0b

Acknowledgements:

This study was supported by NASA/NEESPI Land Cover Land Use Change Initiative, Grant No. NNG6GE00A, NNX09AK56G and NNX14AD90G; National Science Foundation grants ARC-0902175 and ARC-1203506; and NASA NNH16CP09C–Arctic Boreal Vulnerability Experiment.

2. Data Characteristics

Spatial Coverage: Circumpolar, North of 70 degrees latitude

Spatial resolution: 12 km

Temporal coverage: 1982-01-01 to 2015-08-31

Temporal resolution: Weekly to monthly

Study Areas (All latitude and longitude given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Circumpolar	-180	180	90	70

Data file information

There are six data files in .csv format. Each file includes data as displayed in a corresponding figure in Bhatt et al. (2017).

Table 1. File names and descriptions.

The file names contain "**_figX**" to indicate the corresponding published figure in Bhatt et al. (2017). Please refer to the variable descriptions below, the respective figure's caption, and description in Bhatt et al. (2017) for more complete information.

File name	Description
Time_series_SWI_NDVI_1982_2015_Fig2.csv	Time series of SWI, MaxNDVI, and TI-NDVI for growing seasons from 1982–2015 for the Arctic, Eurasia, and North America.
SWI_1982_2015_Fig4.csv	Time series SWI based on 2 m air temperature from the ERA-Interim reanalysis and AVHRR land surface temperature for North America and Eurasia.
Sea_ice_concentration_1982_2015_Fig6.csv	Arctic weekly sea ice climatology, trend, and trend statistical significance for 100 km zone for 1982–2015, 1982–1998, 1999–2015.
Ocean_heat_content_1998_2013_Fig7.csv	Arctic biweekly ocean heat content, trend, and trend statistical significance for 100 km zone from 1988–2013 for the Arctic, North America, and Eurasia.
Land_surface_temperature_1982_2015_Fig8.csv	Arctic weekly land surface temperature climatology trend, and trend statistical significance for the full tundra for 1982–2015, 1982–1998, 1999–2015.
MaxNDVI_1982_2015_Fig9.csv	Arctic biweekly NDVI, trend, and trend statistical significance for the full tundra for 1982–2015, 1982–1998, and 1999–2015.

Table 2. Frequently used abbreviations

Abbreviation	Description
MaxNDVI	The maximum NDVI (MaxNDVI) is the highest summer NDVI value, representing peak vegetation photosynthetic capacity, and serves as an indicator of tundra biomass. MaxNDVI is unitless.
SWI	Summer warmth index (SWI), the sum of the monthly mean temperatures above 0 °C from April to September.
TI-NDVI	The time-integrated NDVI (TI-NDVI) is the sum from May to September of biweekly values above a threshold value of 0.05, low enough to capture the often abrupt snowmelt. TI-NDVI incorporates the length of the growing season and phenological variations, better represents gross primary production than MaxNDVI

<u>**Data Dictionary**</u>

Variables in the respective data files

Time_series_SWI_NDVI_1982_2015_Fig2.csv

Column name	Units/format	Description
Analysis_domain		Results in this data file/figure (a,b,c) are for listed regions.
Reference		Please reference this figure (a,b,c) in Bhatt et al. (2017) for more details and clarifications.
Analysis_interval		Range of year(s) over which results were calcuated for this observation.
Avg_interval_year		Interval (year) over which results were averaged for this observation.
SWI_TS_Arctic	Degrees Celsius	Time series of SWI (°C) based on landsurface temperature from AVHRR source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
SWI_TS_N_America	Degrees Celsius	Time series of SWI (°C) based on landsurface temperature from AVHRR source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
SWI_TS_Eurasia	Degrees Celsius	Time series of SWI (°C) based on land surface temperature from AVHRR source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
MaxNDVI_Arctic		The maximum NDVI (MaxNDVI) is the highest summer NDVI value, representing peak vegetation photosynthetic capacity, and serves as an indicator of tundra biomass. MaxNDVI is unitless.
MaxNDVI_N_America		The maximum NDVI (MaxNDVI) is the highest summer NDVI value, representing peak vegetation photosynthetic capacity, and serves as an indicator of tundra biomass. MaxNDVI is unitless.
MaxNDVI_Eurasia		The maximum NDVI (MaxNDVI) is the highest summer NDVI value, representing peak vegetation photosynthetic capacity, and serves as an indicator of tundra biomass. MaxNDVI is unitless.
TI_NDVI_Arctic		The time-integrated NDVI (TI-NDVI) is the sum from May to September of biweekly values above a threshold value of 0.05, low enough to capture the often abrupt snowmelt. TI-NDVI incorporates the length of the growing season and phenological variations, better represents gross primary production than MaxNDVI. TI-NDVI is unitless.
TI_NDVI_N_America		The time-integrated NDVI (TI-NDVI) is the sum from May to September of biweekly values above a threshold value of 0.05, low enough to capture the often abrupt snowmelt. TI-NDVI incorporates the length of the growing season and phenological variations, better represents gross primary production than MaxNDVI. TI-NDVI is unitless.
TI_NDVI_Eurasia		The time-integrated NDVI (TI-NDVI) is the sum from May to September of biweekly values above a threshold value of 0.05, low enough to capture the often abrupt snowmelt. TI-NDVI incorporates the length of the growing season and phenological variations, better represents gross primary production than MaxNDVI. TI-NDVI is unitless.
Reference_file		Data file provided by Investigator.

SWI_1982_2015_Fig4.csv

Column name	Units/format	Description
Analysis_domain		Results in this data file/figure (a,b,c) are for listed regions.
Reference		Please reference this figure (a,b,c) in Bhatt et al. (2017) for more details and clarifications.
Analysis_interval		Range of year(s) over which results were calculated for this observation.
Avg_interval_year		Interval (year) over which results were averaged for this observation.
SWI_TA-2m_N_America	Degrees Celsius	Time series of SWI (°C) based on 2-m air temperature from the ERA-Interim reanalysis source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
SWI_TS_N_America	Degrees Celsius	Time series of SWI (°C) based on landsurface temperature from AVHRR source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).

Column name	Units/format	Description
SWI_TA-2m_Eurasia	Degrees Celsius	Time series of SWI (°C) based on 2-m air temperature from the ERA-Interim reanalysis source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
SWI_TS_Eurasia	Degrees Celsius	Time series of SWI (°C) based on landsurface temperature from AVHRR source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
SWI_TA-2m_Arctic	Degrees Celsius	Time series of SWI (°C) based on 2-m air temperature from the ERA-Interim reanalysis source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
SWI_TS_Arctic	Degrees Celsius	Time series of SWI (°C) based on landsurface temperature from AVHRR source. Summer warmth index (SWI, the sum of the monthly mean temperatures above 0 °C from April to September).
Reference_file		Data file provided by Investigator.

Sea_ice_concentration_1982_2015_Fig6.csv

Column name	Units/format	Description
Analysis_domain		Results in this data file/figure (a,b,c) are for listed regions.
Reference		Please reference this figure (a,b,c) in Bhatt et al. (2017) for more details and clarifications.
Analysis_interval		Range of year(s) over which results were calculated for this observation.
Avg_interval_week		Interval (weekly) over which results were averaged for this observation.
Sea_ice_percent_conc_avg	%	Sea ice is in units of percent concentration for time period.
Sea_ice_percent_conc_std	%	One standard deviation.
Sea_ice_percent_conc_trnd	%	Trend is percent concentration over time period.
Sea_ice_percent_conc_trnd_sig		Trends statistical significance.
Reference_file		Data file provided by Investigator.

Ocean_heat_content_1998_2013_Fig7.csv

Column name	Units/format	Description
Analysis_domain		Results in this data file/figure (a,b,c) are for listed regions.
Reference		Please reference this figure (a,b,c) in Bhatt et al. (2017) for more details and clarifications.
Analysis_interval		Range of year(s) over which results were calculated for this observation.
Avg_interval_biweekly		Interval (biweekly) over which results were averaged for this observation.
Heat_1988–2013_avg	MJ m-2	Arctic ocean heat content is in units of MJ m-2
Heat_1988–2013_std	MJ m-2	One standard deviation.
Heat_1988–2013_trnd	MJ m-2/time period	Trend is MJ m-2 over 26 years (1988–2013).
Heat_1988–2013_trnd_sig		Trends statistical significance.
Heat_1982-1990_avg	MJ m-2	Arctic ocean heat content is in units of MJ m-2
Heat_1991-2000_avg	MJ m-2	Arctic ocean heat content is in units of MJ m-2
Heat_2001-2013_avg	MJ m-2	Arctic ocean heat content is in units of MJ m-2
Reference_file		Data file provided by Investigator.

Land_surface_temperature_1982_2015_Fig8.csv

Column name	Units/format	Description
Analysis_domain		Results in this data file/figure (a,b,c) are for listed regions.
Reference		Please reference this figure (a,b,c) in Bhatt et al. (2017) for more details and clarifications.
Analysis_interval		Range of year(s) over which results were calculated for this observation.
Avg_interval_week		Interval (weekly) over which results were averaged for this observation.
Land_surface_temp_avg	Degrees Celsius	Arctic weekly land surface temperature climatology. Temperature is in units of °C.
Land_surface_temp_std	Degrees Celsius	One standard deviation.
Land_surface_temp_trnd	Degrees Celsius	Trend is °C over time period.

Column name	Units/format	Description
Land_surface_temp_trnd_sig		Trends statistical significance.
Reference_file		Data file provided by Investigator.

MaxNDVI_1982_2015_Fig9.csv

Column name	Units/format	Description
Analysis_domain		Results in this data file/figure (a,b,c) are for listed regions.
Reference		Please reference this figure (a,b,c) in Bhatt et al. (2017) for more details and clarifications.
Analysis_interval		Range of year(s) over which results were calculated for this observation.
Avg_interval_biweekly		Interval (biweekly) over which results were averaged for this observation.
MaxNDVI_avg		The maximum NDVI (MaxNDVI) is the highest summer NDVI value, representing peak vegetation photosynthetic capacity, and serves as an indicator of tundra biomass. MaxNDVI is unitless.
MaxNDVI_std		One standard deviation.
MaxNDVI_trnd		Trend is change over time period.
MaxNDVI_trnd_sig		Biweekly trend statistical significance.
Reference_file		Data file provided by Investigator.

3. Application and Derivation

These compiled data were used to document panarctic trends within a season over the period 1982–2015 for the Bhatt et al. (2017) paper. It focused particularly on seasonality of trends to investigate the times of year that are changing the most, and relating these to interactions between the vegetation and associated climate drivers.

4. Quality Assessment

Details of data compilation and processing methods, and statistical treatment of the data are described in Bhatt et al. (2017)

5. Data Acquisition, Materials, and Methods

Climate Driver Data

The sources of the climate driver data and their individual processing steps are described in Bhatt et al. (2017).

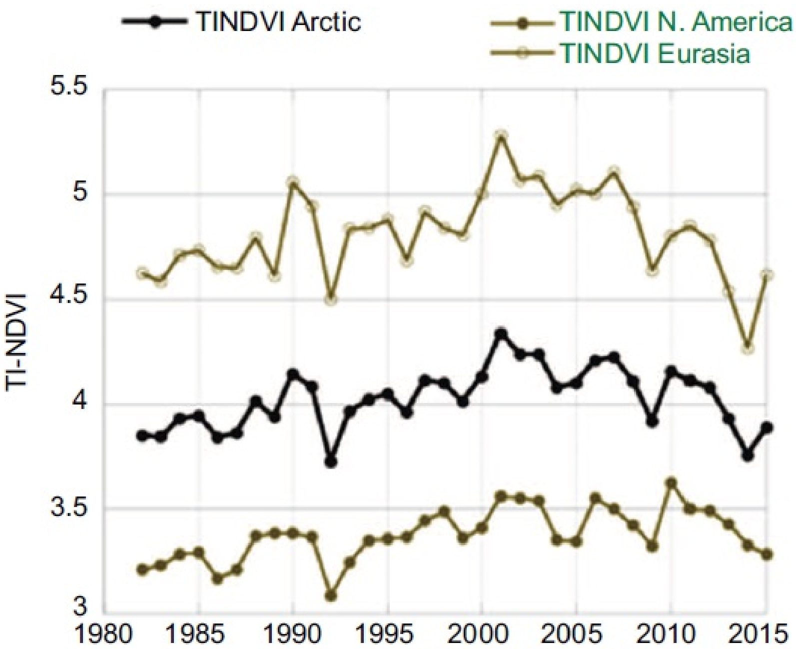

Figure 2. Time series of TI-NDVI (unitless) for each growing season from 1982–2015 for the Arctic, Eurasia, and North America. From Figure 2 (c) of Bhatt et al. (2017).

Analysis Methods

The scale of interest in the study is the Arctic non- alpine tundra and its continental divisions of North America and Eurasia. The analysis employs time series averaged over oceanic regions within 100 km of the Arctic coastline and over the full tundra domains at elevations < 300 m.

The least-squares-fit method was used to determine the trends of open water, SWI, MaxNDVI, and TI-NDVI in the spatial presentation. Spatial trends are shown as a magnitude change for Open Water, SWI, TI-NDVI, and MaxNDVI over the 34 years period and are based on the pixel size of the given data set.

The statistical significance of correlations and trends was assessed using the two-tailed Student's t-test at the 95% or greater level. Climate data variability in the Arctic displays large-amplitude multi-decadal variability along with trends (Polyakov et al 2013) which reduces the degrees of freedom due to large autocorrelations from year-to-year. For significance testing the reduced degrees of freedom were calculated using a lag-1 autocorrelation method outlined by Santer et al (2000).

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

ABoVE: Climate Drivers of Pan-Arctic Tundra Vegetation Productivity, 1982-2015

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Uma S. Bhatt, Donald A. Walker, Martha K. Raynolds, Peter A. Bieniek, Howard E. Epstein, Josefino C. Comiso, Jorge E. Pinzon, Compton J. Tucker, Michael Steele, Wendy Ermold, and Jinlun Zhang. 2017. Changing seasonality of panarctic tundra vegetation in relationship to climatic variables. Environmental Research Letters, 12 (5) 055003. https://doi.org/10.1088/1748-9326/aa6b0b

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