ArcTiCA: Arctic Tidal Constituent Atlas

version 2

Summary

In the Arctic Ocean, tides affect ocean circulation and mixing, and sea ice dynamics and thermodynamics. Significant advances have been made in global ocean tide models; however, their performance in the Arctic is hampered by poorly-mapped bottom topography, the dynamical influence of sea ice on tides, and limitations on satellite altimetry measurements due to the high latitudes and presence of sea ice. An additional factor is the limited availability of sea surface height (SSH) data in the Arctic. In situ measurements from coastal tide gauges and ocean bottom pressure sensors are crucial sources of information that can be used to understand the spatial variability of tides, interpret satellite SSH records that are undersampled in time, and validate advances made in tide models. Existing global in situ tidal constituent databases contain a limited number of stations in the Arctic; for example, TICON-3 (Hart-Davis et al., 2022) has 111 stations above 60°N and 21 above 70°N, with most sites being around North America and Norway.

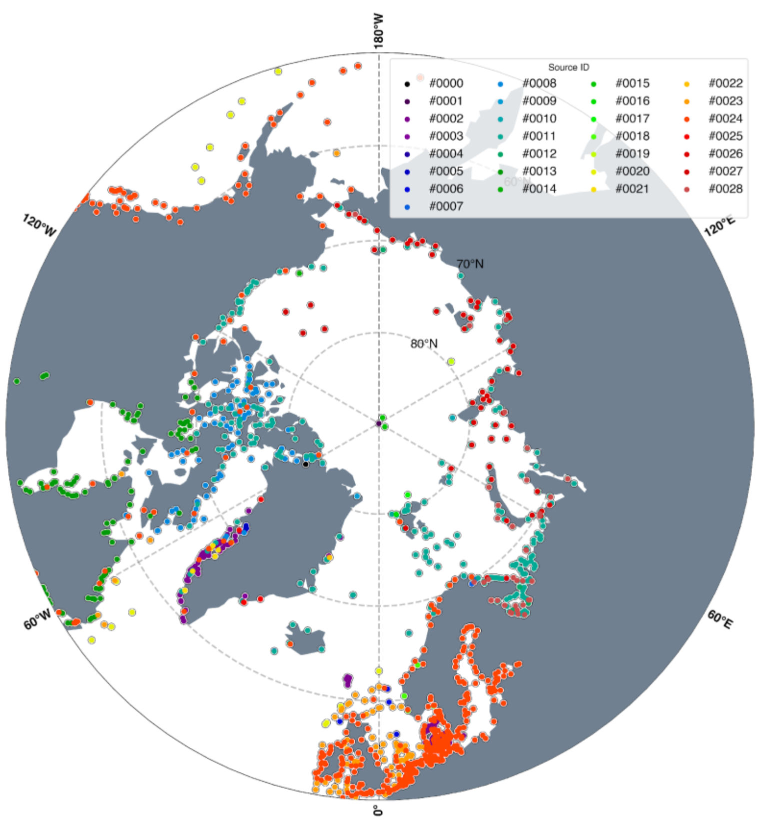

Figure 1. Distribution of data color-coded by data source, with the Source IDs listed in Table 1.

Here, we present the results of a concerted effort to produce a comprehensive dataset of tidal constituents in the Arctic region. This dataset combines analyses of in situ measurements from a variety of SSH records including from coastal tide gauges, ocean bottom pressure sensors and GNSS reflectometry, resulting in tidal constituent values from over 1900 sites between 50°N and 90°N (Figure 1). There are 914 sites above 60°N and 399 above 70°N, with a much greater spatial distribution across the full Arctic Ocean than for current global tide databases.

ArcTiCA Files

The following files are provided in this Arctic Tidal Constituent Atlas package:

Arctic_Tidal_Constituents_Atlas_v2.nc	the full dataset in NETCDF4 format including all the metadata
Arctic_Tidal_Constituents_Atlas_v2.csv	the full dataset in CSV format including all the metadata
ArcTiCA_README.pdf	(This file) Readme file for the Arctic Tidal Constituent Atlas
ArcTiCA_Revision_History.txt	Document describing package revisions

Methods

Data were collected from a variety of data sources to develop a harmonized dataset of tidal constituents in the Arctic Ocean. A total of 29 different sources were used which provide either raw sea level or bottom pressure time series, or previously published tidal constituent amplitude and phase values. The sources are listed below in Table 1.

Notes regarding data variables and sources:

From the time-series data, tidal constituents were determined using the methods described by Codiga (2011) and, where appropriate based on time-series length, the eight major tidal constituents (M2, S2, K2, N2, K1, O1, P1, Q1) were determined as a minimum.

For sources where constituents were provided directly, either taken from websites, tables or published literature, all provided constituents were included. There are two exceptions to this: The Mm amplitude and phase values were removed from the Voinov (2006) and Peralta-Ferriz et al. (2012) data when the signal-to-noise ratio was less than 2.

Amplitude data are provided either in centimeters (for tide gauges and GNSS reflectometry) or in millibars (for bottom pressure recorders), with the amplitude units identified in the dataset under the variable ‘amp_units’. Users wanting pressure-derived values (mbar) converted to equivalent SSH values (in cm) need to choose and apply their own model.

The dataset uses GMT as a time reference so, where necessary, the time series were converted to GMT prior to tidal analysis, or the phase lag of the tidal constituents themselves were converted following Schureman (1958). The phase lags are kept between 0 and 360 degrees.

Where possible, several different metadata variables are provided. These metadata give users further justification for the appropriateness of the estimates in specific applications and should be used as guidance when interpreting results using these data.

An expert opinion flag (EO flag) is provided within the dataset. This flag is provided by the dataset's authors and is based on their confidence in the accuracy of the tidal coefficients given the available metadata. Entries flagged as 0 are described as 'excellent' down to flags of 3 indicating 'low confidence: use with caution'.

A single site can have records from multiple sources. The variable **'**site_total' states the number of records at a site. In some cases these records are for different time periods and so may contain information on time-dependence of tidal coefficients. However, for validation studies, to reduce biasing a user should either select a single record or down-weight each dataset at that site.

The database contains a large number of sites outside the Arctic Ocean, especially around the UK and in the North and Baltic seas. These may not be relevant for specific Arctic studies; however, a user can easily filter the data by latitude and/or longitude range.

The data flag denotes how the data were obtained. The following is a description of the flag meanings:

0: Constituents derived from a time series directly by the authors of ArcTiCA

1: Constituents provided by someone directly [pers comms]

2: Dataset provided by external source

3: Constituents extracted from a paper

File Formats

We provide the dataset in two formats: a NetCDF file and a CSV file. Each version of the dataset provides the variables shown in Table 2, for each record, when the data are available. A "NaN" is given when metadata values are missing.

Known Issues

- The Instrument Type was not included for several of the data sources, and shows up as NaN in the 'instrument' variable. These will be included in v3 of the dataset.
- Currently, the 'inference' variable is often listed as NS (not stated). We will improve on accurately defining the data sources that do or do not include inference.
- Caution is advised when browsing the CSV file in Excel. Due to an issue in Excel, dates before 1900 will show up with a different format than those after 1900.

Final Notes

It is the intent of the authors to improve and grow this dataset. Please check back at the Arctic Data Center for updated versions. If you have any comments, concerns, or feedback, please contact Michael Hart-Davis at michael.hart-davis@tum.de and Susan Howard at showard@esr.org. Additionally, please contact us if you have any data you would like to be included.

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Tables and references on following pages

Table 1. List of sources used in the creation of this dataset.

Source ID	Source	Data flag
000	DMI (Ribergaard, 2023)	2
001	Davis et al., 2014	3
002	Dietrich et al., 2007	3
003	Emily Shroyer, data from pers. comm.	0
004	Gjevik and Straume, 1989	3
005	Gjevik et al., 1992	3
006	Greisman et al., 1986	3
007	J. Mortensen, data from pers. comm.	0
008	Janout et al., 2023	0
009	Kowalik and Proshutinsky, 1994	2
010	Kulikov et al., 2018	1
011	MEDS (https://isdm-gdsi.gc.ca/)	0
012	McRaven and Pickart, 2022	0
013	Morison et al., 2007	0
014	Nilsen et al., 2021	0
015	Frank Nilsen pers. comm.	0
016	Norwegian Hydrographic Service (https://www.kartverket.no/)	0
017	Peralta-Ferriz et al., 2012	3
018	Peralta-Ferriz et al., 2014	3
019	Polyakov, 2016	1
020	Ray, 2013	0
021	Richter et al., 2011	3
022	Soren Rysgaard, data from pers. comm	0
023	Stammer et al., 2014	2
024	TICON-3 (Hart-Davis et al 2022)	0
025	Tabibi et al., 2020	0
026	Voinov, 2006	3
027	WHOI (https://www2.whoi.edu/site/beaufortgyre/)	0
028	Russian Geographical Society (https://elib.rgo.ru/)	3

Table 2. The list of variables in this dataset, along with a brief description.

Dataset variable	Description of variable
source_id	the provided ID number for the respective source
lon	the longitudinal position (in degrees 0 to 360) of the measurement
lat	the latitudinal position (in degrees) of the measurement
cons	the respective tidal constituent
amp	amplitude of the tidal constituent
pha	phase lag of the tidal constituent (from 0 to 360 degrees)
amp_uncert	the standard deviation of the amplitude (cm)
pha_uncert	the standard deviation of the phase lag (in degrees)
start	start time of the in-situ measurements
end	end time of the in-situ measurements
number_of_obs	the number of observations available within the in-situ timeseries
missing_obs	the number of missing observations within a time series, i.e., gaps in the time series
source	the source of the tidal constants or time series used for tidal constituent estimation
instrument	the type of instrument: tide gauge, ocean bottom pressure sensor or GNSS-R
site	the site name of the instrument
rec_length	the total record length in days
sampling_rate	the sampling rate of the measurement in minutes
inference	whether inference is used in this measurement. The options are: yes, no, or NS (not stated)
data_flag	data origin flag providing a description of how the data itself was obtained
expert_flag	expert opinion flag based on whether the metadata provided suggests appropriateness for tidal estimation
site_record	the observations record number for the particular site
site_total	the total number of sources for the same particular site
amp_units	the units of the amplitude estimations (cm or mbar)
uncert_info	the type of uncertainty information provided, either standard deviations (STD), confidence intervals (CI) or none.
notes	any notes about this particular measurement

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