

Background and guidelines for contributors to the *Sea Ice Drift Forecast Experiment* (SIDFEx)

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*Feedback to this document and to SIDFEx generally to
sidfex<AT>polarprediction<DOT>net is more than welcome.*

Background

The Sea Ice Drift Forecast Experiment (SIDFEx, since 2017) is a community effort to collect and analyse sea-ice drift forecasts at lead times from days to a year, based on arbitrary methods, for assets drifting with the Arctic and Antarctic sea-ice. Assets are mostly drifting buoys, but also the research icebreaker *Polarstern* during the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) expedition. Numerous forecast centres provide their drift forecasts in near-real-time.

The examination of sea ice drift forecasts provides an integrated assessment of many aspects of the coupled atmosphere-ice-ocean system and will motivate in depth investigations into how key variables are measured, modeled, and forecast. In particular, we expect coordinated drift forecasts to draw attention to the interaction between sea ice physics and boundary layer physics in both atmosphere and ocean. We expect that a systematic assessment of real drift forecasting capabilities will improve our physical understanding of sea ice and enable us to identify and resolve model shortcomings and identify limits of predictability.

SIDFEx is the result of discussions in the context of the Year of Polar Prediction (YOPP; <http://www.polarprediction.net/yopp-activities/>), MOSAiC (<https://mosaic-expedition.org/>), the Sea Ice Prediction Network (SIPN; <https://www.arcus.org/sipn>), the Forum for Arctic Modeling and Observations Synthesis (FAMOS; <https://web.whoi.edu/famos/>) and the International Arctic Buoy Program (IABP; <http://iabp.apl.washington.edu>).

Timeline

Forecasts have been collected since the beginning of June 2017, simultaneous with both the start of the 2017 SIPN Sea Ice Outlook (SIO) season and the launch of the Year of Polar Prediction Core Phase (mid-2017 – mid-2019). In 2019, specific forecasts were solicited to help optimise the MOSAiC drift start. Subsequent forecasts (autumn 2019-2020) through autumn 2020 have projected the *Polarstern* trajectory as well as the trajectories of selected buoys of the Distributed Network around *Polarstern*. The collection of forecasts continues after the end of MOSAiC, yielding a growing database of currently (December 2021) more than 170.000 forecasts.

Forecast Targets

Initially (June 2017 – mid-2019), 5 to 10 selected sea-ice buoys of the International Arctic Buoy Program (IABP) were targeted. The currently active buoys are listed on a dedicated page of the website of the International Arctic Buoy Program (IABP; <http://iabp.apl.washington.edu/SIDFEX.html>), including near-real-time information on

their position. A text file that can be used to automate the process of identifying which buoys are current SIDFEx targets, and which buoys have been targets from when to when in the past (to be used for re-forecasts), can be found in the SIDFEx target table at https://swift.dkrz.de/v1/dkrz_0262ea1f00e34439850f3f1d71817205/SIDFEx_index/SIDFEx_targettable.txt).

Information on the retrieval of buoy positions are provided in the *Appendix*.

In summer/autumn 2019, additional forecast targets with relevance for the planning of the then-upcoming *Polarstern* drift were added. These targets were fixed virtual points distributed in the broader region of the possible drift start. These are also included in the SIDFEx target table (see link above) and pseudo observation files are provided for these, too (see the link in the *Appendix*).

In autumn 2019 – autumn 2020, *Polarstern* was included as a primary target, with ship locations providing initial positions for forecasts. In addition, buoys that were part of the Distributed Network around the ship were targeted so that information on large-scale ice deformation could be derived. The drift forecasts have been of considerable value to support MOSAiC operations, e.g., for the planning of supply operations and in particular the ordering of satellite imagery. All MOSAiC-related targets are included in the SIDFEx target table as well (see link above).

Since then, the SIDFEx array of targets has been updated more or less regularly to maintain a reasonable coverage of targets in the Arctic. As of November 2021, Antarctic targets have been added in the Weddell Sea to support the search for the Endurance wreckage in February/March 2022. Generally, the trajectory forecasts are collected on an ongoing basis to allow for broader evaluation of drift forecasts and method/model biases and for the development of more sophisticated calibration and multi-model combination methods.

Forecast methods and lead times

SIDFEx is open to any forecast methods as long as forecast method and source are identified and forecasts follow formatting conventions (see below). Example methods include drift trajectories derived from historical drift records (satellite, buoys, models), free-drift using atmospheric wind forecasts, as well as trajectories predicted from complex prognostic models. Following SIPN Sea Ice Outlook tradition, “heuristic” forecasts are also invited if the basis of the prediction (e.g., variables considered) are provided.

Timeliness of submissions

Forecasts can be submitted at any time and with any delay between the time of initialisation (initial buoy position and, if applicable, initialised physical model state) and the time of submission. We encourage submissions with as little delay as possible – ideally in (near-)real-time – because only then will they be useful to support actual campaigns such as the MOSAiC drift. However, re-forecasts are encouraged, too, as they can provide a better basis for forecast evaluation and system/method intercomparison.

Forecast range, initial time, and temporal resolution

The lead-time range, initial time, and temporal resolution of forecasts are not prescribed, but each contributor can determine these based on individual requirements and considerations. However, the practice so far has revealed two main clusters of forecast types, described in the following. Adjusting new contributions to correspond to one of these clusters helps to streamline the subsequent analyses and use of the forecasts.

Many of the seasonal-to-annual contributions are initialised on the respective first day of a month (at 00:00 UTC). This includes modelling groups participating in the SIPN Sea Ice Outlook that contribute to SIDFEx by computing trajectories based on their simulated ice velocity fields. The temporal resolution of these longer-term trajectories is typically daily.

Another cluster of forecasts are shorter-term (typically 10-day) forecasts initialised daily at 00:00 UTC, often submitted in (near-)real-time. Some of these forecasts have a daily trajectory resolution, whereas others provide a higher temporal resolution. Most contributions in this cluster also provide re-forecasts to enhance the data basis for evaluation. Note that, if forecasts are to be used for near-real-time applications where timeliness is crucial and if target location observations are available with more delay than the model data required to generate the forecasts, it is encouraged to use the most recent observed position as initial location and generate the forecasts right away instead of waiting until the observed location data has caught up (as long as the temporal gap is not longer than 2 days or so). This is because the SIDFEx tools adjust initial location offsets automatically.

Ensembles

As described below, it is possible and encouraged to submit ensembles of trajectories instead of only single (deterministic) forecasts. So far, all of the (sub)seasonal-to-annual contributions have provided ensembles of varying size (up to 50 members), whereas the shorter-term forecasts are so far all deterministic. However, we encourage to submit ensembles also for shorter-range forecasts where that is possible.

Individual forecast trajectories belonging to the same ensemble should be different from each other only in terms of the ensemble member number (and the evolution of the trajectory after the initial time, of course). Ensembles that are based on lagged-time initialisation complicate subsequent analyses because for these it is not straight forward to determine which individual forecasts comprise an ensemble, and the computation of ensemble statistics is complicated. Lagged-time initialisation ensembles are thus not recommended, but still possible.

IDs and forecast output format

Each contributing group (or individual) is assigned a **GroupID** (a short unique text string) in consultation with the SIDFEx team (contact *sidfex<AT>polarprediction<DOT>net*). Each group or individual can define and “register” one or more **MethodIDs** that should be short (< ~20 characters, avoiding fancy ones) and more or less meaningful. For each MethodID a concise method description should be sent to *sidfex<AT>polarprediction<DOT>net*. **TargetIDs** are identical with IABP BuoyIDs (integer IMEI numbers) in case of those. TargetIDs for other types of targets, such as some of those related to the MOSAiC drift, include characters to be more descriptive.

Forecasts shall be provided in simple ASCII text files that follow the below described file naming convention and content format.

File naming convention:

<GroupID>_<MethodID>_<TargetID>_<InitYear>-<InitDayOfYear>_<EnsMemNum>.txt

Example:

GroupX_MethodY_300234060834110_2017-61.417_001.txt

File content (example for a 12-day buoy drift forecast):

--- example file begins below this line

GroupID: GroupX
 MethodID: MethodY
 TargetID: 300234060834110
 InitYear: 2017
 InitDayOfYear: 61.417
 InitLat: 85.24160
 InitLon: 26.39600
 EnsMemNum: 001
 ### end of header

Year	DayOfYear	Lat	Lon
2017	62.000	85.22420	26.40660
2017	63.000	85.21800	26.00540
2017	64.000	85.30060	25.86140
2017	65.000	85.20860	26.14940
2017	66.000	85.05520	26.85060
2017	67.000	84.97160	27.07000
2017	68.000	84.87860	26.95040
2017	69.000	84.76520	27.44780
2017	70.000	84.68420	27.60120
2017	71.000	84.61000	27.05020
2017	72.000	84.56660	27.68280
2017	73.000	84.55160	27.62280

--- example file ends above this line

In case of single (“deterministic”) forecasts, the ensemble member (*EnsMemNum*) number shall be *001*. In case of ensemble (“probabilistic”) forecasts, one file for each member shall be submitted. The table may or may not contain the initial time and location of the target. Note however that, if an initial location is not included in the table, the initial location information from the header is used to generate a forecast trajectory starting from forecast time zero, meaning that the header information must be consistent with the trajectory in the table. ***If your forecast trajectory actually starts from a slightly shifted location, e.g. because you use some nearest-neighbour point of an ice/ocean model grid to start the tracing, either the InitLon and InitLat must denote that shifted location, or the shifted initial location must be included in the table*** (“contradicting” the header information which may then point to the actually observed location). Only then is it possible to detect and correct for the initial shift (which is automatically done by the SIDFEx tools).

Following the IABP convention, all *DayOfYear* values start from *1.000* at the beginning of January 1st of each year.

The data table must start after the row “### end of header” with the column names provided in the example. The table can be space or tab delimited.

Apart from numeric values, the *Lat* and *Lon* columns may contain only the string “NaN”.

The file name elements must exactly match the corresponding elements provided in the file header.

The format will be checked automatically for any submission and must be followed carefully. Those familiar with the programming language *R* may use the function *sidfex.checkfileformat()*, provided in a corresponding script on the SIDFEx website and contained in the SIDFEx R-package (<https://github.com/helgegoessling/SIDFEx>), to check their files ahead of submission.

After submission (and a successful format check), five lines of the form

SubmitYear: 2017

SubmitDayOfYear: 62.621

ProcessedYear: 2017

ProcessedDayOfYear: 62.643

end of auto header

will be added automatically as first lines to the file header to document the submission time.

Forecast submission

Forecasts can be submitted through the cloud service of the German Climate Computing Centre (DKRZ) at any time. Permissions and instructions for the submission (e.g., using the UNIX tool *curl*) can be obtained by contacting *sidfex<AT>polarprediction<DOT>net* .

Note that the time of upload is noted and added automatically to enable a later assessment from a real-time and timeliness perspective.

If a submission does not pass the automatic file format check, no processed file will appear under the link provided below. Instead, the contributor will be contacted by the SIDFEx team with instructions as soon as possible. If a processed file appears, the format check was successful. When contributing for the first time, it is advisable first to submit only one file to see whether it passes the format check. It is recommended to check the file format in advance using the function *sidfex.checkfileformat()* of the SIDFEx R-package, available here: <https://github.com/helgegoessling/SIDFEx> .

Getting and exploring the forecast data

After submission, each forecast is automatically processed and made publicly available in real-time (<2h delay) at the Cloud Service of the German Climate Computing Centre. Individual files, ordered by contributor GroupIDs, can be obtained from this link:

https://swiftbrowser.dkrz.de/public/dkrz_0262ea1f00e34439850f3f1d71817205/SIDFEx_processed/ .

In addition, a tar.gz archive of all forecasts and an index of these (in R binary as well as plain text (csv) format) are available here:

https://swiftbrowser.dkrz.de/public/dkrz_0262ea1f00e34439850f3f1d71817205/SIDFEx_index/ .

The SIDFEx R-package available at <https://github.com/helgegoessling/SIDFEx> allows one to download and analyse the SIDFEx forecast and corresponding observational data. The package is developed on an ongoing basis, so that feedback is very much appreciated. Furthermore, there is a web tool (based on R-Shiny and the SIDFEx R-package) at <https://sidfex.polarprediction.net/> that allows exploring the SIDFEx data in a very easy way.

Contact

For any questions related to SIDFEx, please contact the SIDFEx team at *sidfex<AT>polarprediction<DOT>net* .

SIDFEx team:

Helge F. Goessling (1), Axel Schweiger (4), Valentin Ludwig (1), Laurent Bertino (2), Ed Blockley (3), Frédéric Dupont (6), Wendy Ermold (4), Rüdiger Gerdes (1), Robert Grumbine (5), Yukie Hata (6), Jennifer Hutchings (7), Frank Kauker (1), Thomas Krumpfen (1), Jean-François Lemieux (6), François Massonnet (8), E. Joseph Metzger (9), Malte Müller (10), Cyril Palerme (10), Michael W. Phelps (11), Thomas Rackow (1), Till A. S. Rasmussen (12), Simon F. Reifenberg (1,13), Ignatius Rigor (4), Suman Singha (18), Greg

Smith (6), Amy Solomon (14,15), Nick Szapiro (16), Steffen Tietsche (17), Jinlun Zhang (4)

Affiliations:

- 1) Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
- 2) Nansen Environmental and Remote Sensing Center, Bergen, Norway
- 3) Met Office Hadley Centre, FitzRoy Road, Exeter, UK
- 4) University of Washington, Applied Physics Laboratory, Polar Science Center, US
- 5) National Centers for Environmental Prediction, USA
- 6) Environment and Climate Change Canada, Canada
- 7) Oregon State University, College of Earth, Ocean, and Atmospheric Sciences, USA
- 8) Université catholique de Louvain, Belgium
- 9) Naval Research Laboratory, Ocean Sciences Division, Stennis Space Center, MS, USA
- 10) Norwegian Meteorological Institute, Norway
- 11) Perspecta, Inc., Stennis Space Center, MS, USA
- 12) Danish Meteorological Institute, Denmark
- 13) Johannes Gutenberg-Universität Mainz, Germany
- 14) Cooperative Institute for Research in the Environmental Sciences, University of Colorado, Boulder, CO, USA
- 15) Earth System Research Laboratory, National Oceanic and Atmospheric Administration, Boulder, CO, USA
- 16) University of Oklahoma School of Meteorology, USA
- 17) European Centre for Medium-Range Weather Forecasts, UK
- 18) German Aerospace Center (DLR), Germany

Appendix: Retrieving observed positions

Observations of the current and past positions of all SIDFEx targets can be obtained from this URL (e.g., with *wget*), where <TargetID> needs to be replaced by a valid TargetID (as listed in the SIDFEx target table (see link above), e.g., 300234060834110):

https://swift.dkrz.de/v1/dkrz_0262ea1f00e34439850f3f1d71817205/SIDFEx_index/observations/<TargetID>.txt .

For convenience, observation files are also available for fixed-location targets (TargetID starting FIXED...).