Drift trajectories of the main sites of the Distributed Network and the Central Observatories of MOSAiC 2019/2020

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Background

During the "Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC)" in 2019/2020 a Distributed Network (DN) of autonomous stations (buoys) was installed on the sea ice and drifted across the Arctic Ocean. This network consisted of >200 individual devices ranging from simple position buoys to complex and interdisciplinary multi-sensor platforms. Most comprehensive measurements were performed on sea ice floes (sites or nodes) with multiple complimentary co-located instruments. In addition, autonomous instruments were operated in the Central Observatory (CO), which consisted of the research ice breaker Polarstern and the adjacent ice camp.

The DN consisted of a hierarchy of sites, called medium (M) and large (L) sites. The 3 L sites (L1 to L3) were the most complex sites in terms of instrumentation. They consisted of ocean profilers, atmospheric stations and sea ice observations. The 9 M sites (M1 to M8 and LM) consisted of sea ice and snow mass balance measurements. The LM site had additional instrumentation and was maintained more often than the other stations. Initially, the L and M sites were installed around the CO at a distance of up to 40 km. However, over time the distances and relative positions changed due to the drift of the ice pack.

Over the course of the MOSAiC expedition, 3 different COs were established because of re-locations of RV Polarstern: CO1 started with the first drift of Polarstern on 04 October 2019; CO2 started with the second drift on 19 June 2020; and CO3 started with the third drift on 21 August 2020.

This technical report defines one position of each main site as a reference position over time. This definition is needed for consistency, but is not necessarily straight forward, as one site position might consist of elements of different time series due to data gaps or inconsistencies. The report describes the data sources of each site and their processing to retrieve the 16 final drift trajectories: one for each main DN and CO site during MOSAiC. More details on the DN and CO will be available from publications, which are currently in preparation lead by B. Rabe and M. Nicolaus.

Data sources

Drift trajectories from all sites are received from the Global Positioning System (GPS). The data were recorded by RV Polarstern and selected autonomous platforms (buoys). Table 1 lists all data sources and their properties used to create them. Data sources are individual buoys, which were installed on the given site. For some sites, data sets from different buoys / sources were merged. Data source names are consistent with the short names of sensor.awi.de and meereisportal.de, as well as with the tables in the MOSAiC cruise reports. In addition, the unique International Mobile Equipment Identity (IMEI) number is given. The original measurement frequency also depended on the platform technical properties and varied between 1 second and 1 hour. The resulting data set is interpolated to hourly position data.

The end dates given in Table 1 refer to the last position reported by the buoy. While all buoys were deployed on sea ice, most buoys melted out of the ice during their drift and continued in open ocean. Hence, positions are not necessarily sea ice drift / positions.

CO sites

The CO site positions are composites of two data sources: the position of Polarstern, while the vessel was drifting with the ice floe, and buoy position data after departure of the vessel. For the Polarstern position, the main GPS signal (internally defined as: system position) of the vessel was used.

CO1: Polarstern left the floe (CO1) on 16 May 2020 in order to sail to Svalbard for crew exchange and re-supply. The CO1 data set was complemented by the position of buoy 2020P225.

CO2: After returning from Svalbard, Polarstern drifted again with the floe starting on 19 June 2020, but anchored to another part of the former CO1 floe. CO2 had to be abandoned due to the disintegration of the floe in the marginal ice zone on 31 July 2020. The CO2 data set was complemented by the position of buoy 2020M26, representing one fragment of the former CO2 floe.

CO3: On 23 August 2020, Polarstern started drifting with a new stable floe much further north until the end of the expedition on 20 September 2020. The CO3 data set was complemented by the position of buoy 2020O10.

L and M sites

All position data of the L and M sites are based on autonomous platforms. Since typically several units were installed and reported positions, here we selected the formal site position based on the following criteria:
- Length of the time series: The aim is to cover the entire time series until the last unit stopped reporting positions
- Frequency of measurements: Higher frequency is preferred, as the final data product was chosen to have a temporal resolution of 1 hour, which was the reporting interval of most units.

Descriptions of each individual buoy as well as details on their deployments and other data recorded may be found in meereisportal.de and (partly) under the given reference of pangaea.de.

Table 1: Data sources of the drift trajectories for each site. Abbreviations: IMEI: International Mobile Equipment Identity, f: Original measurement frequency.

Site	Operational time range	IMEI number	Data source	f	Reference
CO1	4 Oct 2019 - 23 Apr 2020	n/a	Polarstern	1 s	Rex (2020), Haas (2020), Kanzow (2020)
CO1	23 Apr 2020 - 11 Nov 2020	300234068210310	2020P225	1 h	Lei et al. (2021a)
CO2	19 Jun 2020 - 26 Jun 2020	n/a	Polarstern	1 s	Rex (2021a), Rex (2021b)
CO2	26 Jun 2020 - 19 Aug 2020	300025010649550	2020M26	1h	Granskog et al. (2021)
CO3	21 Aug 2020 - 28 Aug 2020	n/a	Polarstern	1 s	Rex (2021b)
CO3	28 Aug 2020 – 9 Aug 2021	300234068066320	2020O10	10 min	Hoppmann et al. (2021d)
L1	5 Oct 2019 - 6 Aug 2020	300234068704730	2019T67	30 min	Lei et al. (2021b)
L2	7 Oct 2019 - 18 Aug 2020	300025010524990	2019W2	1 h	Rabe et al. (2021)
L3	11 Oct 2019 - 7 Aug 2020	300234066081170	2019S94	1 h	Nicolaus et al. (2020b)
LM	29 Oct 2019 - 14 Aug 2020	300234068706330	2019T66	30 min	Lei et al. (2021c)
M1	5 Oct 2019 - 9 May 2020	300234067068380	2019V1	1 h	Li et al. (2021a)
M2	7 Oct 2019 - 9 Aug 2020	300234067064490	2019V2	1 h	Li et al. (2021b)
M3	7 Oct 2019 - 3 Aug 2020	300234066444880	2019S81	1h	Nicolaus et al. (2020a)
M4	8 Oct 2019 - 14 Aug 2020	300234068166760	2019O4	10 min	Hoppmann et al. (2021a)
M5	9 Oct 2019 - 17 Aug 2020	300234067066520	2019V4	1 h	Li et al. (2021c)
M6	10 Oct 2019 - 13 Aug 2020	300234068514740	2019O6	10 min	Hoppmann et al. (2021b)
M7	11 Oct 2019 - 25 Oct 2019	300234068519770	2019O7	10 min	Hoppmann et al. (2021c)
M8	11 Oct 2019 - 29 Sep 2020	300234068700320	2019T69	1 h	Lei et al. (2021d)

Data processing

Quality control has been applied to all data sets in a way that GPS outliers have been filtered out manually. All longitude and latitude positions were linearly interpolated to hourly frequency at the full hour. Existing data gaps have been filled by linear interpolation. Therefore, a GPS position exists for all DN sites at the same time steps in the given time interval listed in Table 1.

Resulting data set / drift trajectories

The resulting data set contains 5 files. Each file contains the drift trajectory of the site(s) at 1 hour time resolution. Each CO has its own file, because of their very short overlap in time. All M and L sites are merged into one file each with a common time stamp for every site. Note that the drift trajectories of the sites continue beyond the main expedition phase of MOSAiC in order to capture the following drift and fate of the sites. Although all reference buoys were deployed on sea ice, parts of the drift trajectory might relate to drift in open water, because some of the devices were able to float. Figures 1 to 3 show the resulting drift trajectories of all main sites.

All data from the individual autonomous platforms, including a detailed description, can be found and downloaded at meereisportal.de. Many data sets have been archived at PANGAEA already. All autonomous platforms of MOSAiC will be archived. All data from the 16 DN drift tracks have been archived at PANGAEA and are available for download as a combined data set under Nicolaus et al. (2021).
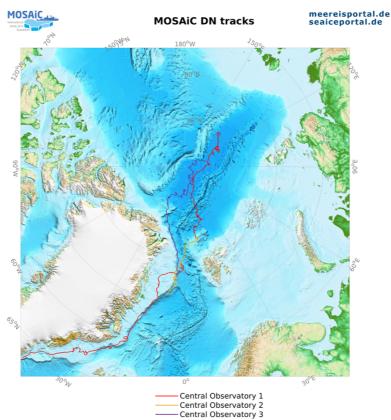

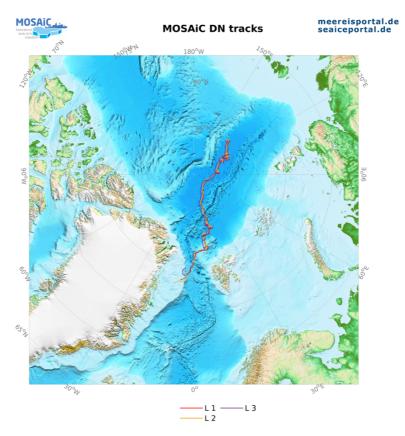*Figure 1: Drift trajectories of the Central Observatories 1 to 3.*

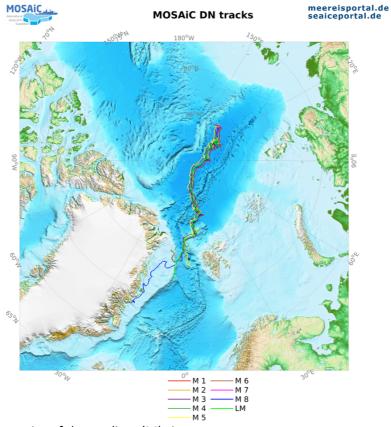*Figure 2: Drift trajectories of the large (L) sites.*

Figure 3: Drift trajectories of the medium (M) sites.

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