Report: Ocean current, temperature and salinity measurements from the mooring Y7 at the Yermak Plateau, Jul 2022 - Jul 2023

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1 Background

The data set described herein was collected as a part of the ATWAICE (Atlantic Water pathways to the Ice in the Nansen Basin and Fram Strait) project.

The objectives of ATWAICE related to the eastern Fram Strait addressed the ocean-sea ice coupling in the marginal ice zone and controls on the ecosystem, and long-term monitoring of the West Spitsbergen Current. In addition to high-resolution and targeted process studies during the research cruise, a mooring program aimed to provide year-around time series observations across the marginal ice zone from summer 2022 to summer 2023. University of Bergen (UoB) supplemented the 5 moorings deployed by the Alfred Wegener Institute (AWI, Y1 to Y5), with two additional moorings (Y7 and Y8, Figure 1). While mooring Y7 was recovered one year later in summer 2023, Y8 was left behind because of challenging sea ice conditions.

The mooring Y7 was deployed during the expedition PS131 with RV Polarstern, on 27 July 2022 and recovered from RV Polarstern on 28 June 2023, returning an 11-month time series on the western flank of the Yermak Plateau in Fram Strait at a depth of 1535 m. This report summarizes the details of the mooring, instrument setups, and processing, and provides an overview of the data collected. The data set is prepared as one netCDF file including hourly-averaged time series of ocean temperature, salinity and currents at the Yermak Plateau on a 5-m vertical grid. The data are openly available from the Norwegian Marine Data Centre, from https://doi.org/10.21335/NMDC-550637823, under a CC BY 4.0 license.

The Norwegian contribution to the program was supported by the Office of Naval Research Global, award number N62909-22-1-2023.

This report is an attachment for the data set:
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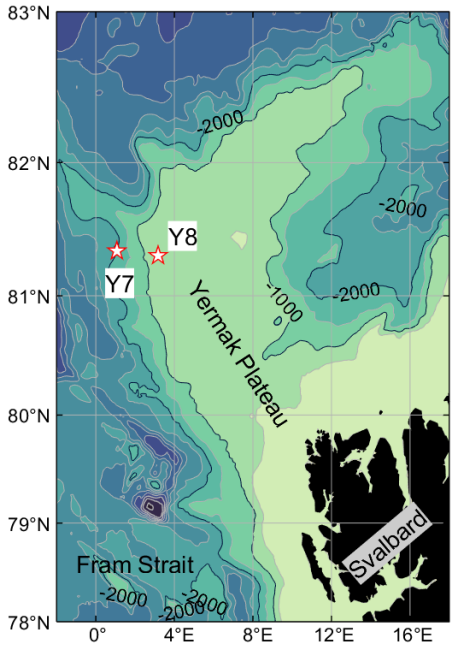

Figure 1. Map showing the location of the UoB moorings Y7 and Y8. At the time of writing of this report, Y8 is still in water, with an opportunistic planned recovery in August 2025. Bathymetry is from ETOPO1 shaded every 200 m, thin contours every 500 m and black contours for 1000 and 2000 m. Y7 location was covered with sea ice throughout the measurement period.

2 Mooring overview and sampling

The mooring Y7 was deployed anchor first from RV Polarstern on 27 July 2022 at 18:20 UTC and recovered from RV Polarstern on 28 June 2023, at 14:05 UTC. The location of the mooring was 81 ˚20.9691' N and 1 ˚ 4.335' E, and the bottom depth was 1535 m (Figure 1). The mooring diagram is shown in Figure 2. An overview of the instruments mounted on the mooring is given in Tables 1 and 2. CTD refers to conductivity-temperature-depth. ADCP is an acoustic Doppler current profiler.

Temperature, and in some instruments salinity and pressure, were measured using Sea-Bird Scientific (SBE) instruments (MicroCats, unpumped SBE37 and temperature loggers, SBE39 and SBE56) as well as RBR instruments (temperature logger Solo, and CTD logger Concerto). Additionally, the current profilers and meters had temperature and pressure sensor, and two AADI SeaGuards were equipped with conductivity sensors.

Ocean currents were measured using ADCPs from RDI and Nortek, at different frequencies and two current meters (AADI SeaGuards). Two Nortek Signature ADCPs were mounted on the same flotation at 318 m (Signature S55 facing downward and S100 facing upward). A RDI 75kHz LongRanger ADCP was mounted in a spherical flotation facing downward at 1011 m. An RDI 300kHz ADCP deployed upward facing at 80 m depth was targeted for high-resolution (2 min) sampling for up to 3 months starting from 1 September 2022 and depleting batteries on 25 November. The records from the 300 kHz RDI are not integrated to this gridded data set. The sampling interval was set to 5 min for all SBE instruments and 10 s for RBR instruments. Both SeaGuards sampled at 20 min, Nortek ADCPs every 30 min, and the RDI LongRanger every 60 min.

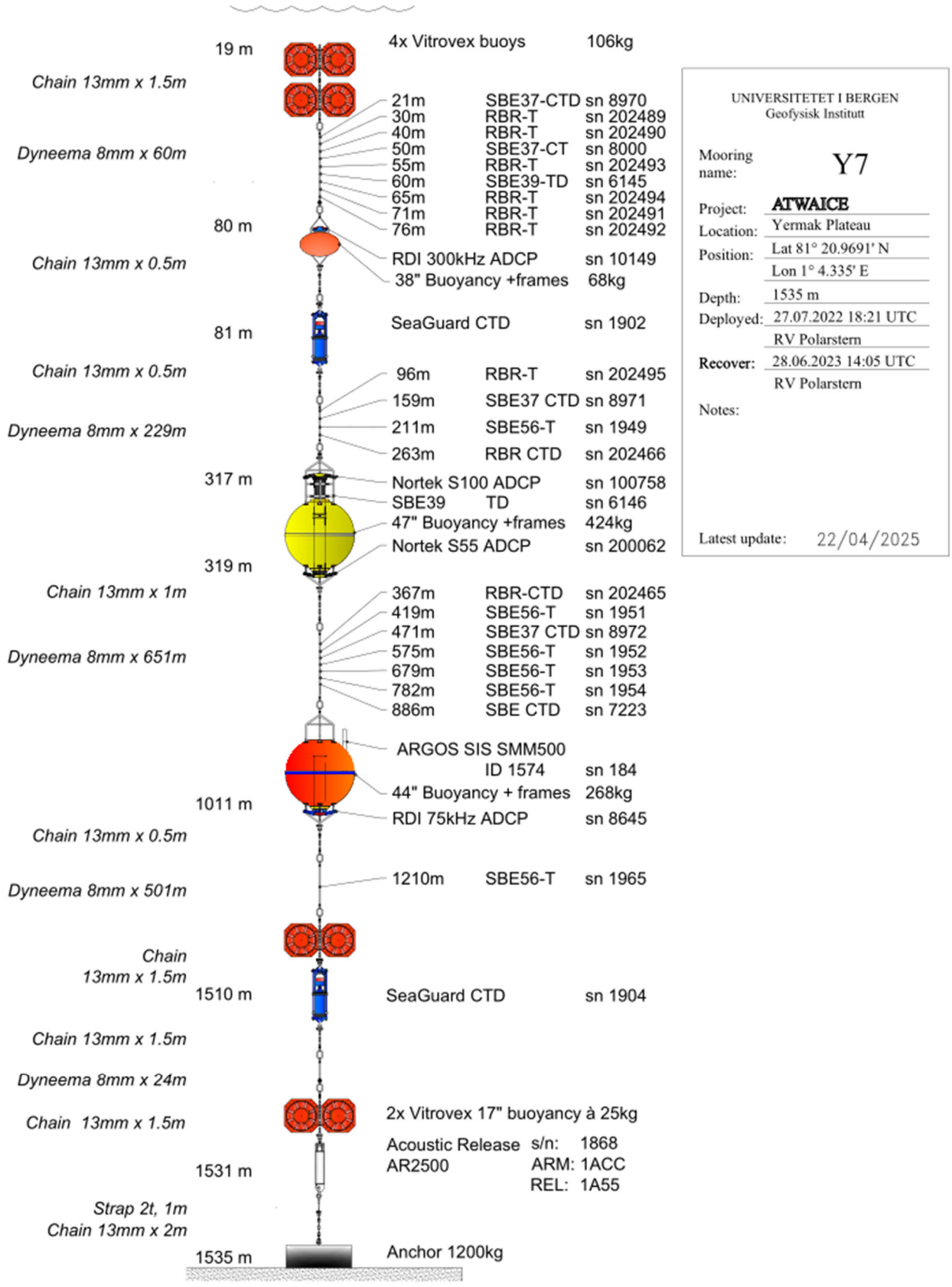

Figure 2. Mooring diagram, not-to-scale. Instrument types, target depths and serial numbers are listed, together with other hardware details of the mooring construction. The diagram is drawn by Helge Bryhni.

3 Target depth adjustment and mooring motion correction

Adjusted target depths are estimated using mooring line lengths and pressure records from the instruments. When a pressure (or depth) record is available, we use the lowest 5 percentile value and convert to saltwater depth using the mooring latitude to assign a time-averaged target depth. The lowest percentile ensures that this value is representative of minimal blowdown. Measurement uncertainty can be large, especially for instruments with high pressure ratings, such as the 1500-m rated RDI 75kHz. In some cases, we adjusted the target depth to fit the intended mooring design.

Statistics of measured depth from instruments equipped with pressure sensors are given in Table 1. The uppermost SBE37 sn8970 moved slightly (1.7 m) upward on 15 April, and SBE37 sn8971 slid down about 50 m on 10 Aug 2022; statistics for these instruments are listed separately for the periods before and after depth changes. When preparing the gridded data set, these records are treated as separate instruments in their corresponding time period and target depth before and after the depth changes.

Using the piecewise known target depth for these instruments with pressure sensors, and the mooring construction details, we estimate the target depth of the remaining instruments at each time. Records from all instruments are first hourly bin-averaged and interpolated to a common time array. The time-constant target depth list (with minimal mooring blowdown) is then used to vertically interpolate, at each time step, the instrument positions in a time-variable depth level (using the time-variable depth record with instruments equipped with pressure sensors).

Table 1. Statistics of depth in m from instruments with pressure sensor.

Instrument	Sn	%5	Median	95%	Mean	STD
SBE37 [1]	8970	20.7	21.2	22.4	21.4	0.7
SBE37 [2]	8970	19.0	19.3	19.8	19.3	0.4
SBE39	6145	59.9	60.4	61.4	60.5	0.7
RDI 300kHz [3]	10149	79.8	80.3	81.0	80.3	0.3
AADI SeaGuard	1902	81.0	81.8	83.7	82.0	1.0
SBE37 [4]	8971	158.8	159.2	161.5	159.5	0.9
SBE37 [5]	8971	209.9	210.4	211.2	210.4	0.8
RBR	202466	263.4	263.8	264.8	264.0	0.5
Nortek S100	100758	316.7	317.1	318.0	317.2	0.4
SBE39	6146	319.3	319.8	320.7	319.8	0.5
Nortek S55	200062	319.3	319.7	320.6	319.8	0.5
RBR	202465	367.0	367.5	368.4	367.6	0.5
SBE37	8972	471.4	471.8	472.7	471.9	0.5
SBE37	7223	886.4	886.8	887.5	886.9	0.3
RDI 75kHz	8645	1011.0	1011.5	1012.1	1011.5	0.3
AADI SeaGuard	1904	1510.8	1511.4	1512.3	1511.5	0.5

[1] until 15 April 2023; [2] after 16 April 2023

[3] 1 Sep 2022 09:00 – 25 Nov 2022 08:00

[4] until 10 Aug 2022; [5] after 11 Aug 2022

Time series of estimated instrument depths and of temperature, salinity and current from time-variable instrument levels (i.e., not gridded vertically) are also provided in the dataset.

Final estimates of the target depth for each instrument are listed in Table 2 (for temperature and/or salinity measurements) and Table 3 (for current meters and current profilers).

Table 2. List of C/T/D instruments from top to bottom. Target depth is estimated as described in the text. C = conductivity, T = temperature, D = depth (P = pressure). Bottom depth is 1535 m.

C/T/D instrument	Serial number	Target depth [m]	Variables
SBE37 [1]	8970	21	T, P, C
RBR-Solo	202489	30	T
RBR-Solo	202490	40	T
SBE37	8000	50	T, C
RBR-Solo	202493	55	T
SBE39	6145	60	T, P
RBR-Solo	202494	65	T
RBR-Solo	202491	71	T
RBR-Solo	202492	76	T
RBR-Solo	202495	96	T
SBE37 [2]	8971	159	T, P, C
SBE56	1949	211	T
RBR-Concerto	202466	263	T, P, C
SBE39	6146	318	T, P
RBR-Concerto	202465	367	T, P, C
SBE56	1951	419	T
SBE37	8972	471	T, P, C
SBE56 [3]	1952	575	T
SBE56	1953	679	T
SBE56	1954	782	T
SBE37	7223	886	T, P, C
SBE56	1965	1210	T

[1] sn8970, 19 m (2m shallower) from 15 April 23 03:50
[2] sn8971, slid to 210 m on 10 Aug 2022, 05:30
[3] sn1952, no data return

Table 3. List of current instruments from top to bottom. Target depth is estimated as described in the text. Bottom depth is 1535 m.

Instrument	Serial number	Target depth [m]
RDI 300kHz ADCP, upward facing [1]	10149	80
AADI SeaGuard RCM with CTD	1902	81
Nortek S100 ADCP, upward facing	100758	317
Nortek S55 ADCP, downward facing	200062	319
RDI 75kHz ADCP, downward facing	8645	1011
AADI SeaGuard RCM with CTD	1904	1510

[1] RDI 300 kHz was set up to sample at high temporal resolution for up to three months from 1 Sep 2022 for a targeted study and not included in the gridded product.

4 Processing of ocean current measurements

For all instruments, the records before and after the mooring was placed at location and released from its anchor were removed. All ADCPs were compass calibrated on land away from magnetic interference before the deployment cruise. All current measurements are corrected for magnetic declination using 1.5°. Using the WMM-2020 model at the mooring location the declination is 1.29°E ± 0.98° on 1 Aug 2022, changing by 0.57° E per year.

RDIs were set to process ensemble-averaged profiles onboard in Earth coordinates, and these were downloaded, together with sensor data and quality control parameters, exported (using the standard RDI WinADCP software) and further postprocessed in MATLAB. RDI 75kHz was set to record in broadband mode (short range, 500 m, but high accuracy, single ping std was 1.2 cm/s), with 40 pings at 3 s intervals every 1 hour, in 8-m thick vertical bins. During postprocessing, we allow 3-beam solutions, require more than 50% good pings in an ensemble profile, exclude error velocities exceeding 1 m/s and excessive tilt (>20°), and outliers of the error velocity above a 3 std envelope at each level, smoothed using a 10 by 10, 2D moving average. In both RDIs the data from the first bin was bad and removed. In RDI 75kHz bins 23-24 (about 190-200 m range) were slightly obstructed and removed.

Full resolution data (every ping) were recorded on board Nortek Signatures (S55 and S100). The raw data were processed using the Ocean Contour software. S55 and S100 are on the same float and the pressure difference from their records is about 2, which is consistent with the deployment. Pressure records also match well with the SBE39-P on the float. Ocean Contour allows compass calibration using in situ data. Both Signatures' compass were 2D in situ calibrated using a selection of data giving excellent quality and coverage. During quality screening, side lobe interference was removed and minimum correlation of 50%, maximum acceleration of 2 m/s, max amplitude spike of 50 dB/s, fish filter threshold of 2.7 and a maximum tilt of 15deg thresholds were applied. In averaging, percent good threshold of 50% and a maximum interpolation gap of 2 were used. Ensemble averaged profiles are then obtained using 8 m cell size and every 30 min for both instruments, using 50 pings for S50 (broad bandwidth, horizontal vel precision 1.3 cm/s, blanking distance 4 m), and 73 pings for S100 (narrow bandwidth, horizontal vel precision 0.99 cm/s, blanking distance 4 m). An additional small heading correction (constant in time) of 3° was applied to S100, to match the velocity record from the first bin with that of the downward facing S55 on the same flotation.

RDI75 direction was corrected using a constant 10° offset (corrected=measured + offset), to better match the profile between S55, RDI75 and the bottom SeaGuard.

Salinity records from the SeaGuards (SG sn 1902 and 1904), compared to the salinity measured by SBE37s (sn8971 80 m below SG1902; sn7223 600 m above SG1904),

suggest they are not reliable and cannot be confidently corrected, hence we do not use salinity records from the SeaGuards.

Current measurements from all instruments are bin-averaged to a common hourly resolution time array, and they are assigned a (time-variable) depth as described above. These records are also provided with the data set. Every hour, the profiles are linearly interpolated to a common 5-m vertical resolution depth array. Vertical coverage of the current measurement is reasonable and this approach is acceptable. We excluded the upper SeaGuard from the interpolation as this depth level is consistently covered with the Nortek S100 (the records at the corresponding level agree). In the gridded product, we excluded (filled with NaN) isolated short record segments less than 5 days length.

The vertical resolution of temperature measurements is very good and the gridded (vertically interpolated) set is reliable. This is not the case for salinity measurements. We provide the gridded salinity field for completeness but strongly advise caution as the vertical structure is not resolved. The vertically interpolated salinity profile (and density) may not be representative of the water column when the vertical separation between sensors is substantial.

5 Procesing of temperature and salinity records

Records from the SBE and RBR sensors are the most reliable temperature and salinity measurements, and are used instead of records from a nearby current meter or profiler. Furthermore the salinity records from the SeaGuards proved unreliable and not used. The data were downloaded, converted and exported using the manufacturers' standard software. In an initial treatment of the data (for quality screening, despiking etc.), all SBE and RBR measurements were time averaged to a common 5-min time array (RBRs sampled every 10 s). Time variable instrument target depths are obtained as described above, and small offsets to temperature and salinity were applied. These offsets, described below, were obtained using a calibration cast where the mooring instruments were attached to the shipboard CTD rosette.

Instruments that slid were duplicated at two levels, assigning their corresponding time-variable depths, and setting the records to NaN after and before the slide event at these levels.

In this 5-min resolution data set, temperature and pressure records were free from outliers and spikes. From the salinity records outliers were removed by imposing instrument dependent hard limits by inspecting the time series, and then despiked. The resulting records were inspected and short segments of suspect data (time ranges detected manually) were replaced with NaNs.

Monthly averaged temperature and salinity profiles were inspected to confirm that the profiles were consistent and no additional offset was needed for a particular

instrument. This clean data set is then averaged hourly, to the common time array of the current measurements. Short gaps with less than 6 hour are interpolated linearly in time. In the gridded product, we excluded (filled with NaN) isolated short record segments less than 5 days length.

5.1 Comparison with shipboard CTD

Before the mooring deployment, one deep and one shallow calibration cast were made using the ship's SBE 911plus CTD system. The mooring instruments (SBE37 and RBR CTDs) were attached to the CTD rosette and set to sample at 10 s intervals. Deep-rated (>2000m) SBE37s were profiled with the deep cast, with approximately 5-min stops at 1000, 750, 500 and 250 m depth during the upcast. The ship CTD file was PS131_053_1.hex. The shallower-rated instruments, including 2 RBR CTDs from Y7, were profiled with the shallow cast with approximately 5-min stops at 150, 60 and 10 m depth during the upcast. The ship CTD file was PS131_065_05.hex. The profiles from the shipboard system were processed as 1-s time averaged profiles for this comparison. Temperature and salinity corrections (Tcorrected = Tmeasured+0.0003; Scorrected = Smeasured-0.00045) were applied to the shipboard CTD profile, which were obtained using calibration water samples analysed on board, before obtaining offset corrections detailed below.

Of the two RBR CTDs attached to the shallow cast, sn 202466 did not log data. The results for the other instruments are shown below. Pressure differences were small, when considering mooring blow-down and 5-m vertical gridding, and therefore no pressure offset was applied. For the estimates from the deep cast, we obtain the offset values as the average over all stops. For the RBR sn 202465, from the shallow cast, we use the offset from the deeper (150 dbar) stop, which is closer to the target deployment pressure.

Table 4. Results of the calibration cast

Instrument	Practical Salinity offset	Temperature offset (°C)
SBE37 sn 7223	+11e-3	-3.0e-3
SBE37 sn 8970	+17e-3	-2.0e-3
SBE37 sn 8971	+15e-3	-3.2e-3;
SBE37 sn 8972	+12e-3	-1.8e-3
RBR sn 202465	-2e-3	+5.0e-3

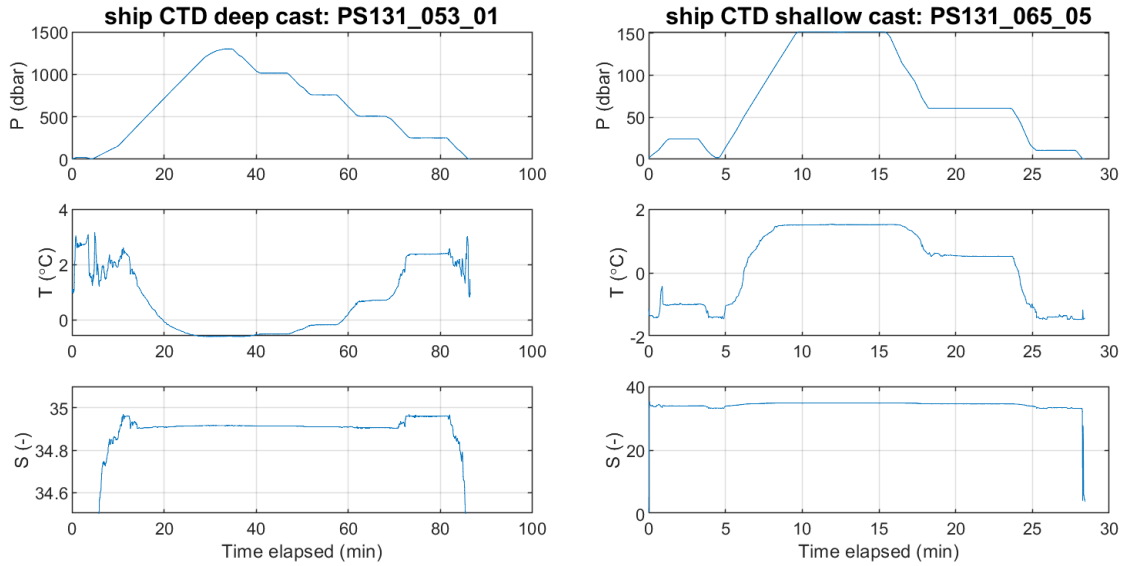

Figure 2. Records of pressure, temperature and practical salinity from the ship's CTD system during the deep and shallow calibration casts.

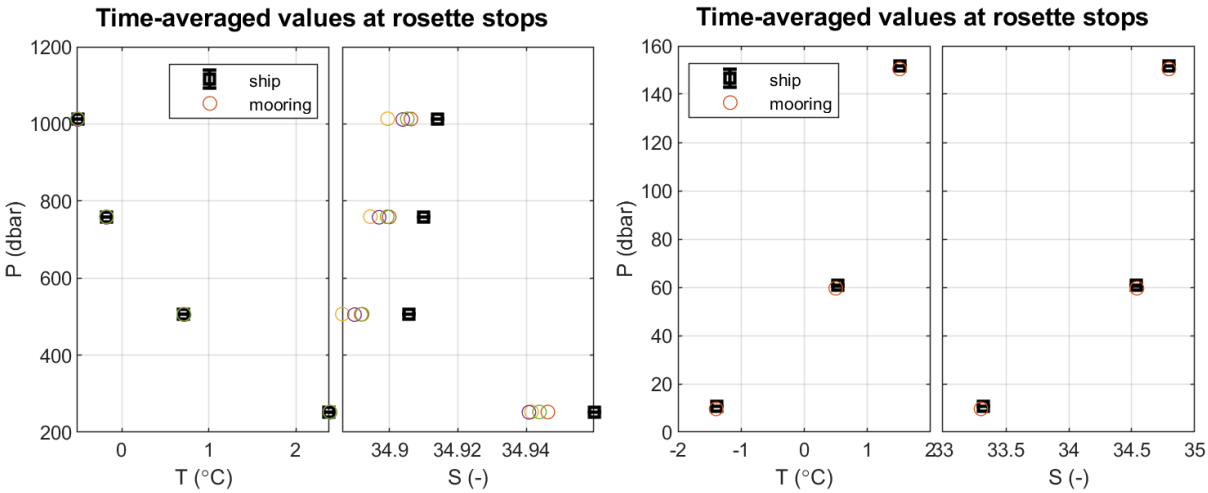

Figure 3. Time-averaged values for temperature and practical salinity against time-averaged pressures from the mooring instruments and the ship's CTD system (also showing the error bars as one standard deviation during each stop).

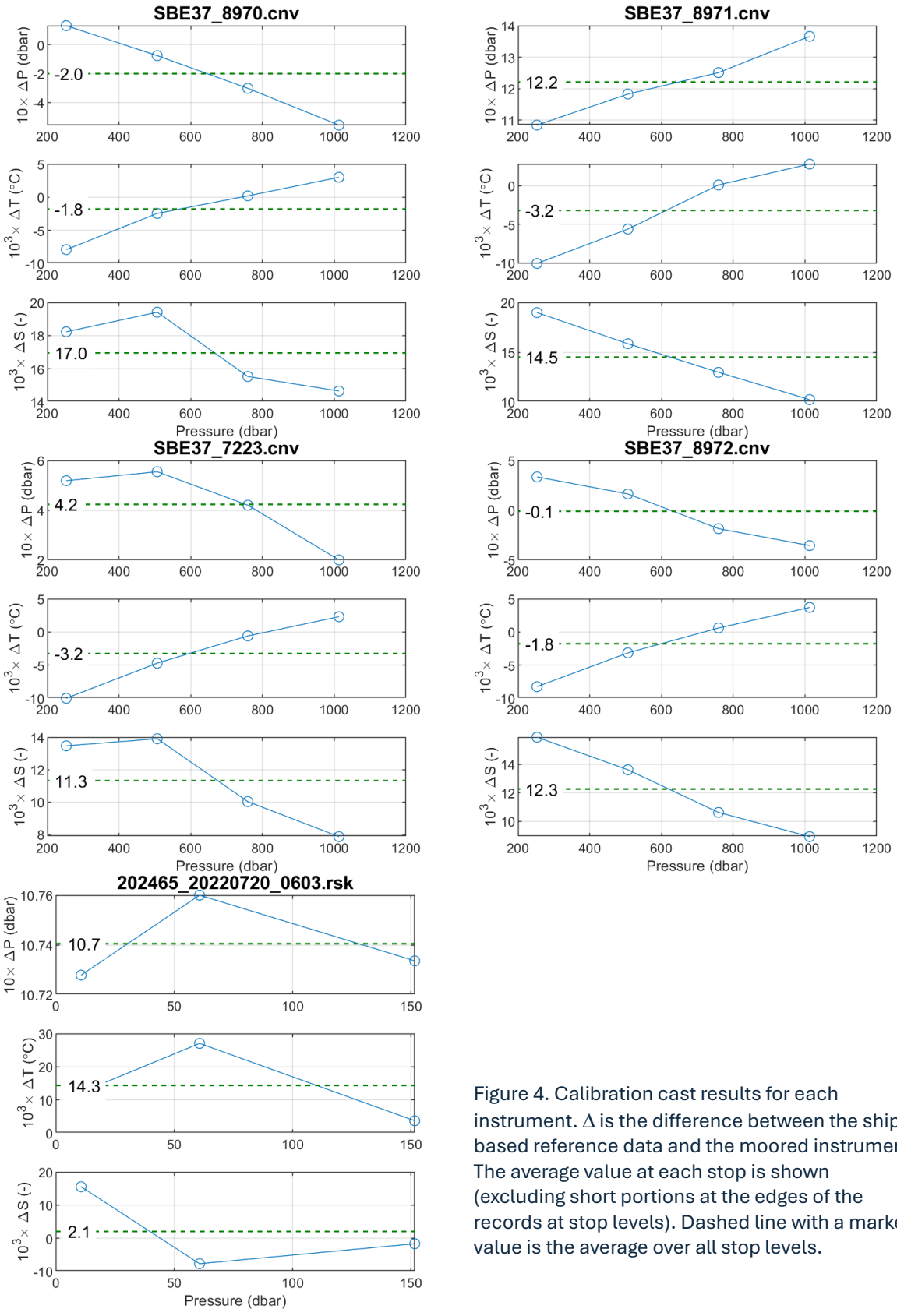

Figure 4. Calibration cast results for each instrument. Δ is the difference between the ship-based reference data and the moored instrument. The average value at each stop is shown (excluding short portions at the edges of the records at stop levels). Dashed line with a marked value is the average over all stop levels.

6 Overview of data

Below figures shown an overview of the gridded data as time-averaged profiles, time-depth fields as well as time series at measurement levels.

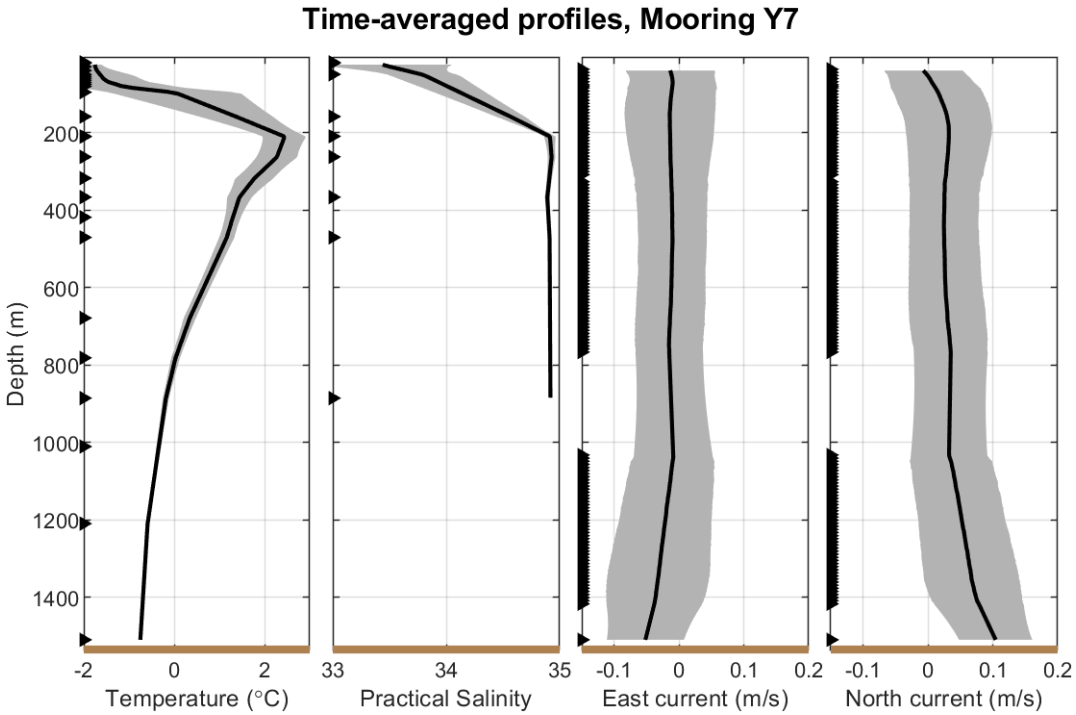

Figure 5. Time-averaged profiles from the gridded data set. Target measurement levels are marked on the vertical axis. Envelope is one standard at each vertical level over the entire record. Only levels with temporal data coverage more than 50% are shown.

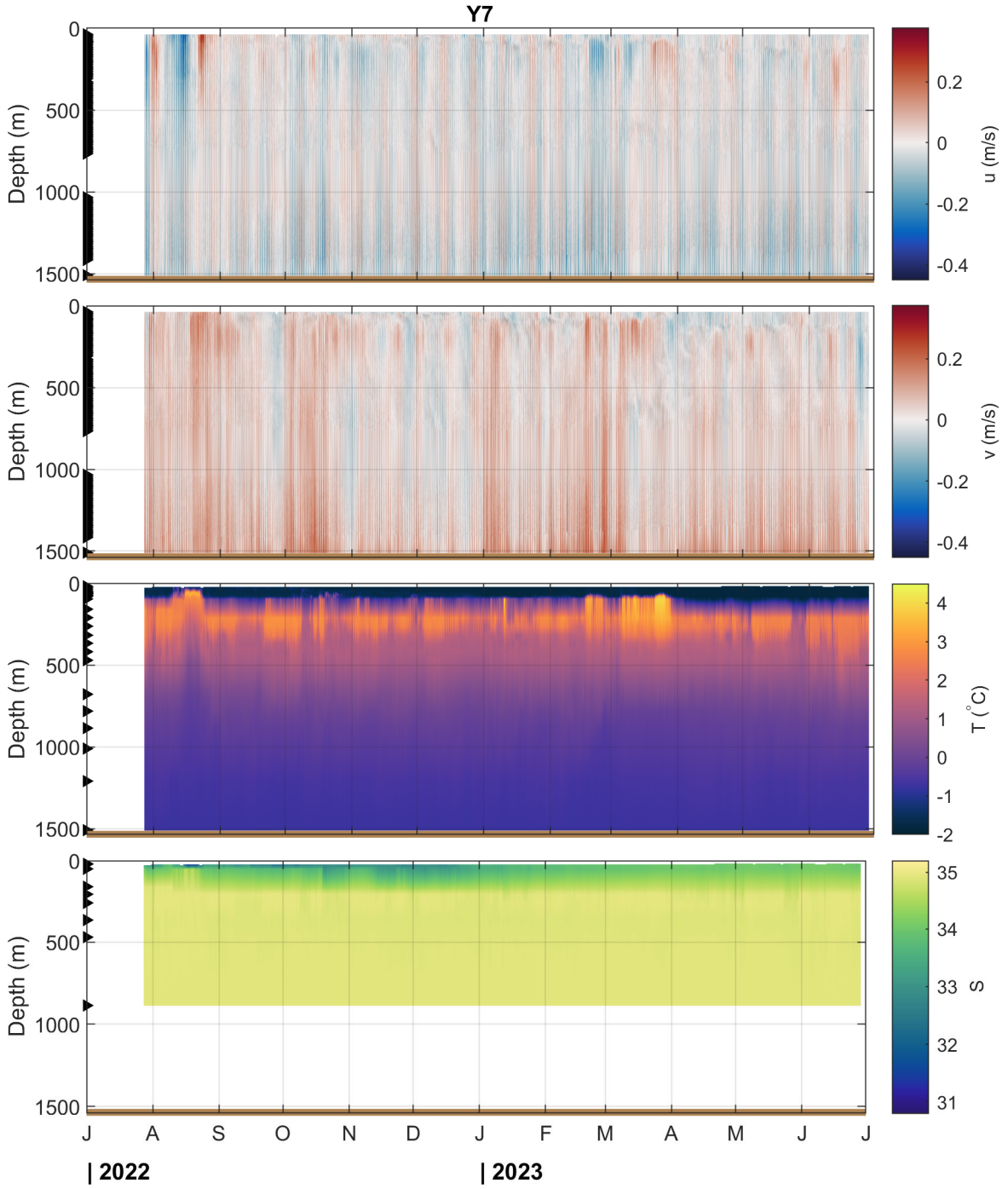

Figure 6. Time-depth plots of horizontal velocity components (u, East; v, North), temperature and practical salinity. Fields are from the 1-h – 5-m vertically gridded data set. Target measurement levels are marked on the vertical axis. Brown horizontal line marks the seafloor.

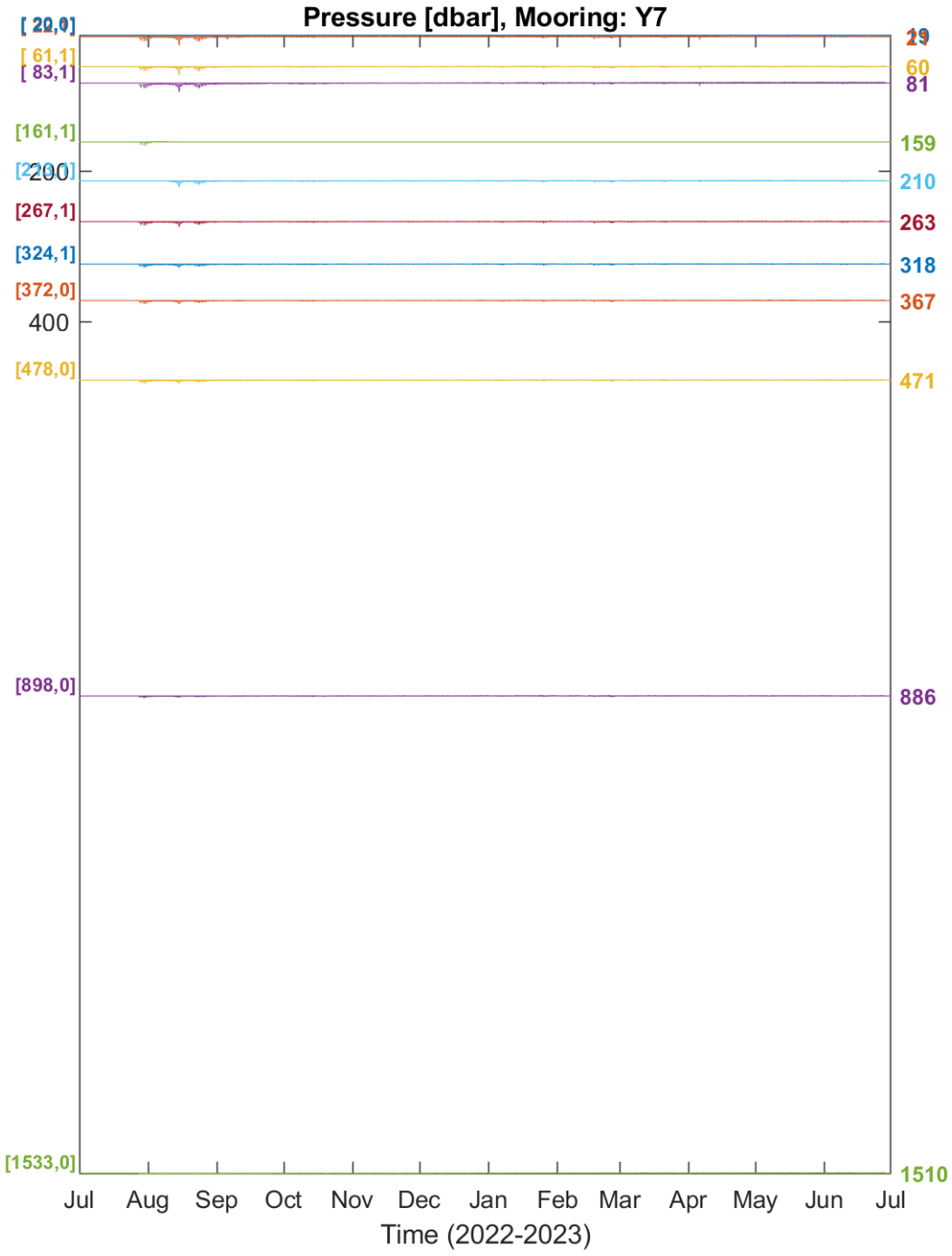

Figure 7. Summary plots of pressure time series. Numbers on the right (and the reference line) are the target depths. Numbers on the left are time-average and 1 STD values of the parameter. Records (except pressure) are offset as indicated in the titles.

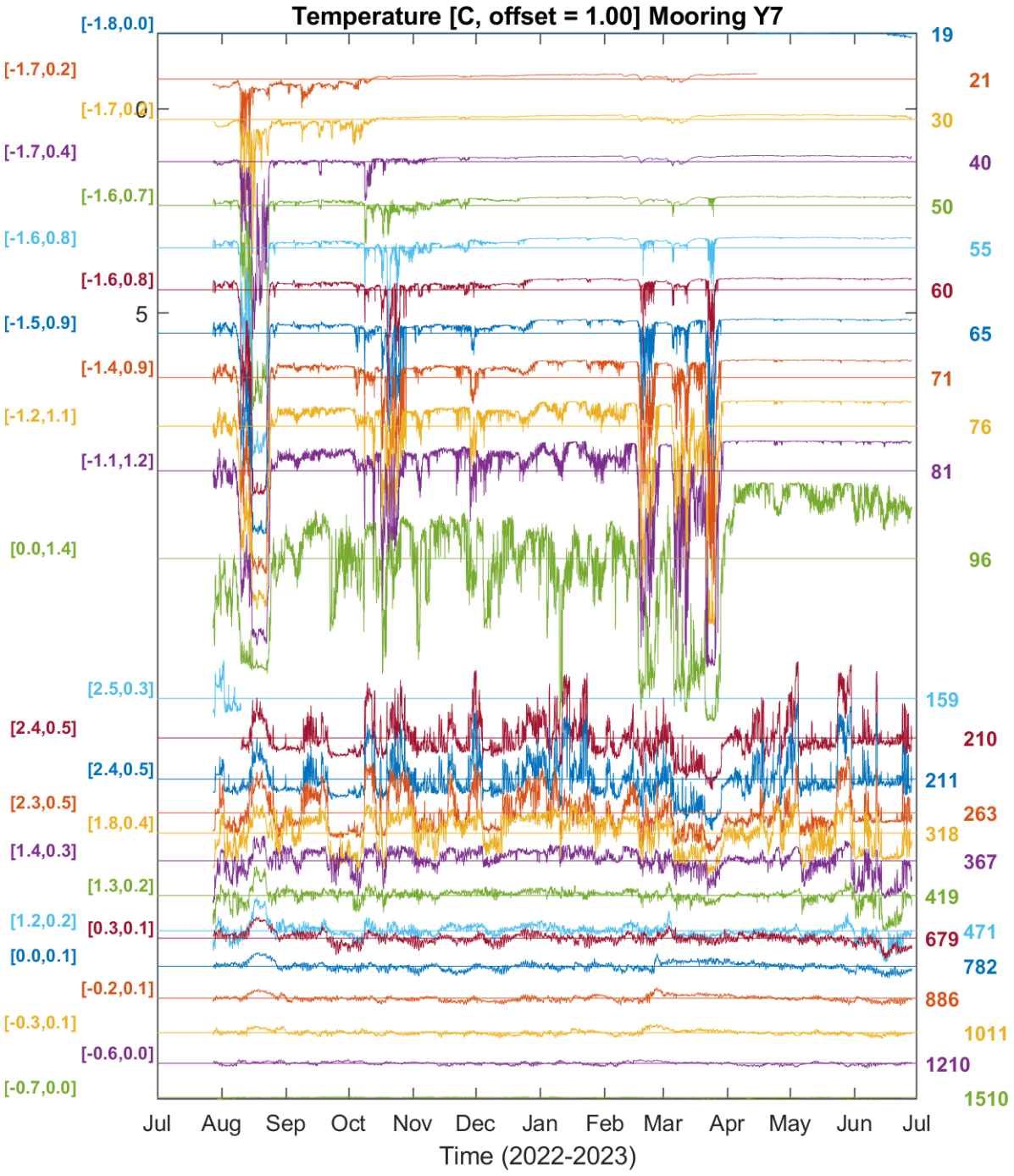

Figure 8. As Figure 7 but for temperature.

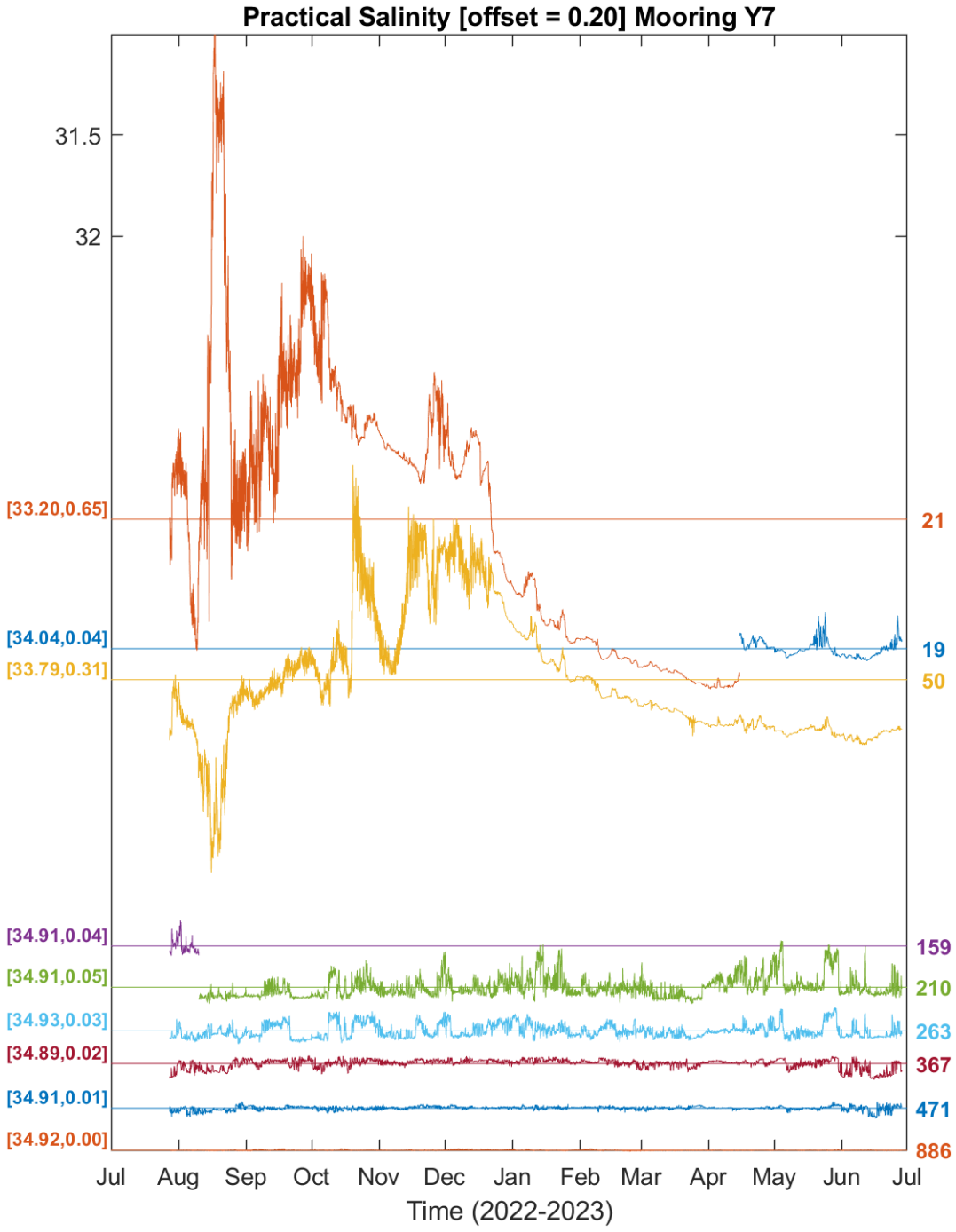

Figure 9. As Figure 7 but for Practical Salinity.

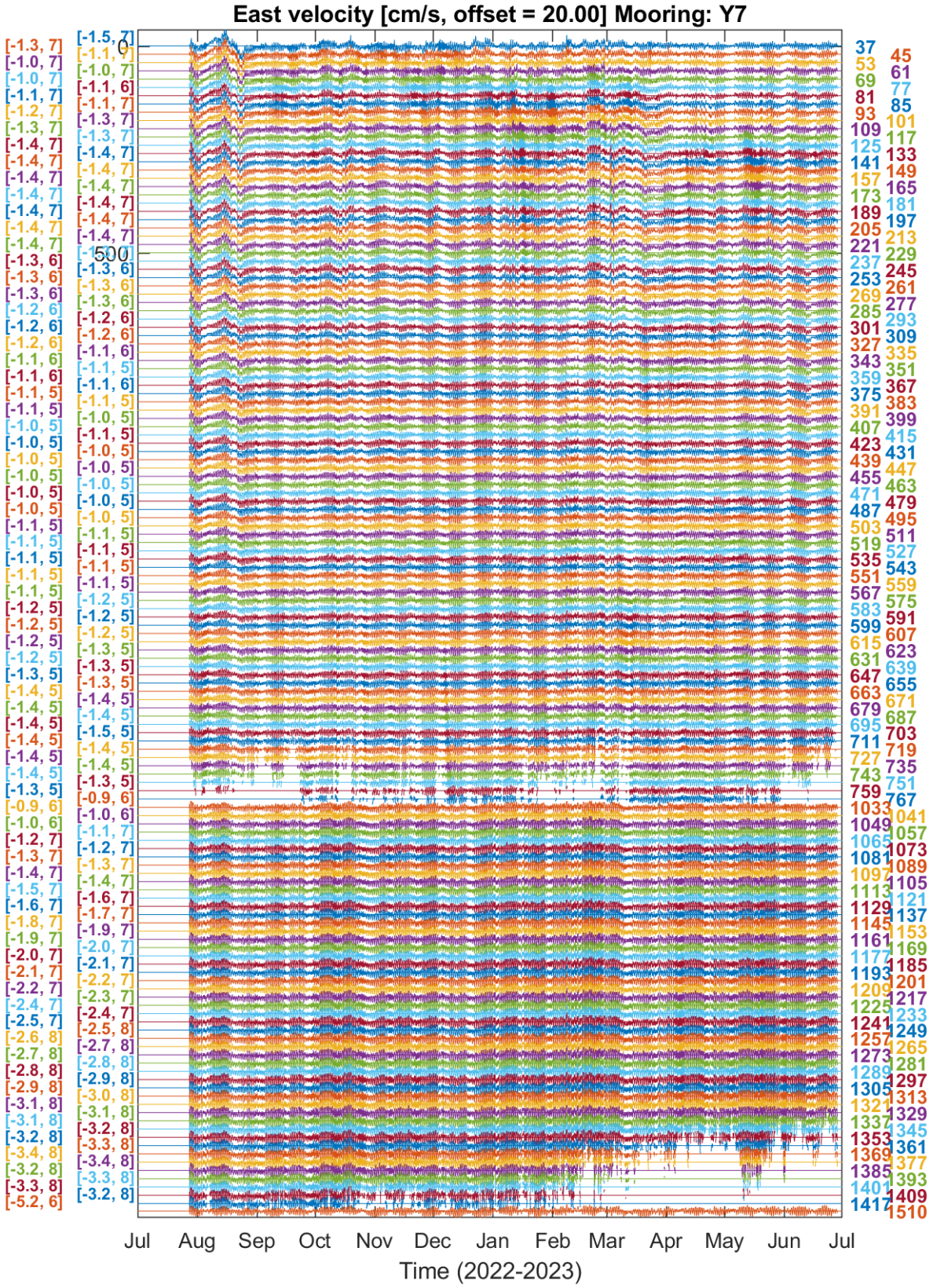

Figure 10. As Figure 7 but for the East component of velocity.

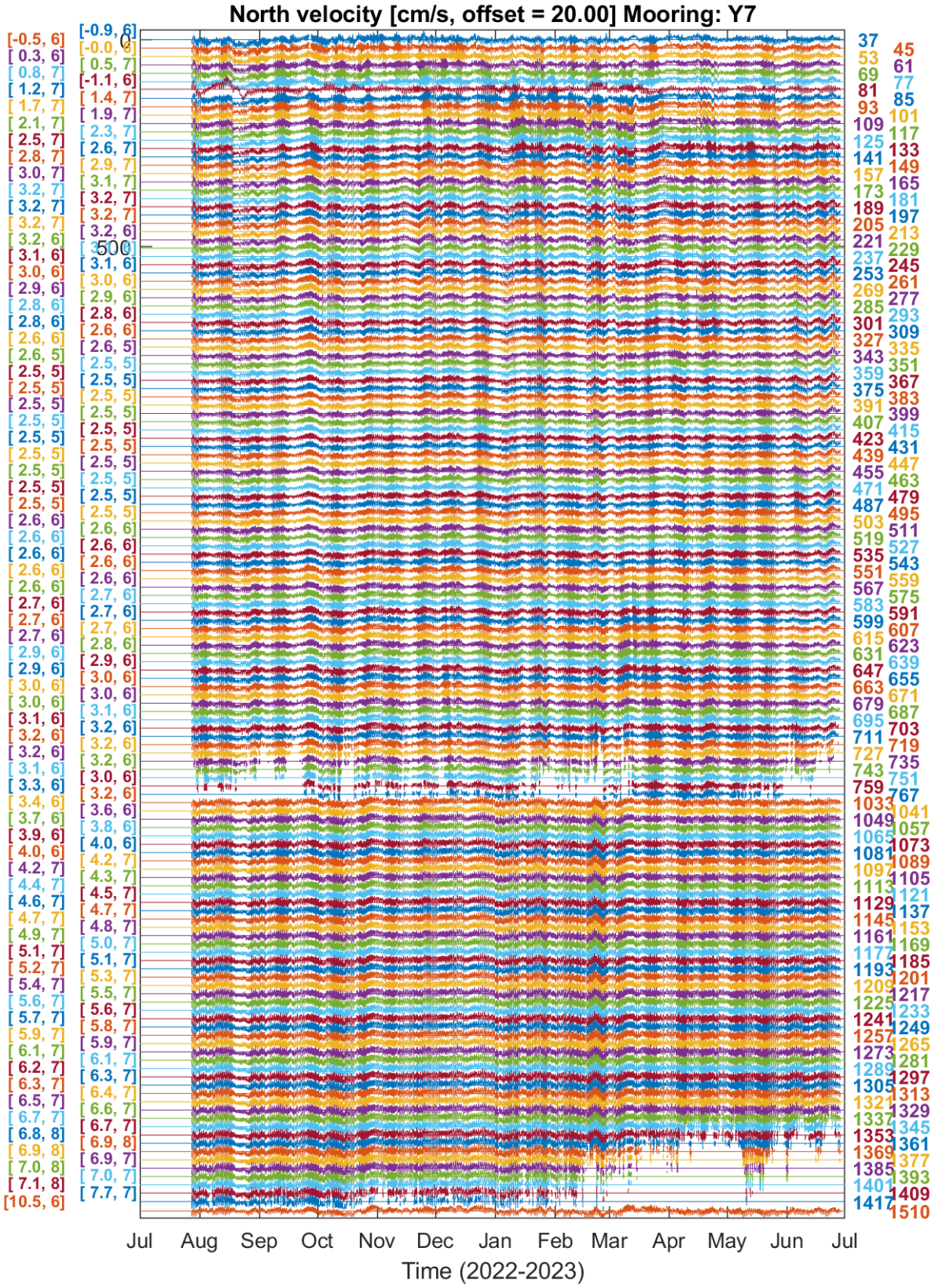

Figure 11. As Figure 7 but for the North component of velocity.