Alaska Earthquake Center Quarterly Technical Report January-March 2023

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Contents

1. Introduction

This series of technical quarterly reports from the Alaska Earthquake Center (AEC) includes detailed summaries and updates on Alaska seismicity, the AEC seismic network and stations, field work, our social media presence, and lists publications and presentations by AEC staff. Multiple AEC staff members contribute to this report. It is issued in the following month after the completion of each quarter Q1: January-March, Q2: April-June, Q3: July-September, and Q4: October-December. The first report was published for January-March, 2021.

2. Seismicity

Between January 1 and March 31, 2023 we reported 12,103 seismic events in the state and the neighboring regions (Figures 2.1, 2.2), with magnitudes ranging between 0.4 and 5.4 and depths between 0 and 289 km (Figures 2.3, 2.4). The two largest earthquakes of Mw=5.4 occurred on February 21 at 5:35:25 UTC 42 km southeast of Old Harbor in the Kodiak Island region and on March 19 at 15:06:27 UTC 19 km southwest of Anchor Point in the Kenai Peninsula region. There were 5 other earthquakes with magnitudes 5.0-5.2. Overall, we reported about 134 events per day, or one event every 11 minutes on average. This is slightly less than in the previous quarter (Ruppert et al., February 2023).

The seismicity rate remained mostly at a steady pace, with one notable increase in the second week of March associated with a swarm under the Tanaga-Takawangha volcanic complex in the central Aleutian Islands (Figures 2.2, 2.3). The overall magnitude of completeness for this time period was Mc=1.1 (Figure 2.5), ranging from Mc=1.1 in mainland Alaska to Mc=2.0 in the Alaska Peninsula and the Aleutians (Figure 2.6).

AEC data analysts picked and cataloged 429,522 seismic phases, 272,941 of which were P-phase and 156,581 S-phase arrival picks. Fewer phase arrivals per event were cataloged for the Aleutian earthquakes due to sparser station coverage compared to mainland Alaska (Figure 2.7).

We reported 1,544 seismic sources that were classified as something other than regional tectonic earthquakes (Figure 2.8). Of these, 108 were suspected quarry blasts (magnitudes M=0.5-2.5), all of which were located in the vicinity of either Fort Knox or Usibelli mines in Interior Alaska. The reported events included 151 icequakes (magnitudes M=0.6-1.9), primarily located in the Prince William Sound, Icy Bay, and Yakutat Bay areas (Figure 2.9). Glacial activity was at a much lower rate than in the previous quarter. This is a typical seasonal behavior, with glacial seismicity subsiding in colder months. We characterized 1,267 quakes as seismic events associated with volcanic activity (M=0.6-4.3). This is much higher than in previous quarters of 2022. Increased seismic activity was observed at several volcanoes, such as the Katmai volcanic group, Aniakchak, Makushin, and Tanaga-Takawangha (Figure 2.10). The remaining 16 events were classified as “other” type (M=0.7-1.8).

There were 50 earthquakes reported as felt (magnitudes M=2.0-5.4), five of which were located in Southeast Alaska, three in the Interior, two in the Aleutian Islands and Alaska Peninsula, two in the Kodiak Island region, one in the southwestern region of Alaska, and the remainder in the Southcentral region of Alaska (Figure 2.11). The largest number of DYFI (Did You Feel It) responses, 1,267, came from the M5.4 earthquake that occurred March 19 at 15:06:27 UTC 19 km southwest of Anchor Point in the Kenai Peninsula region (https:/earthquake.usgs.gov/earthquakes/eventpage/ak0233l8vwxa/dyfi/intensity).

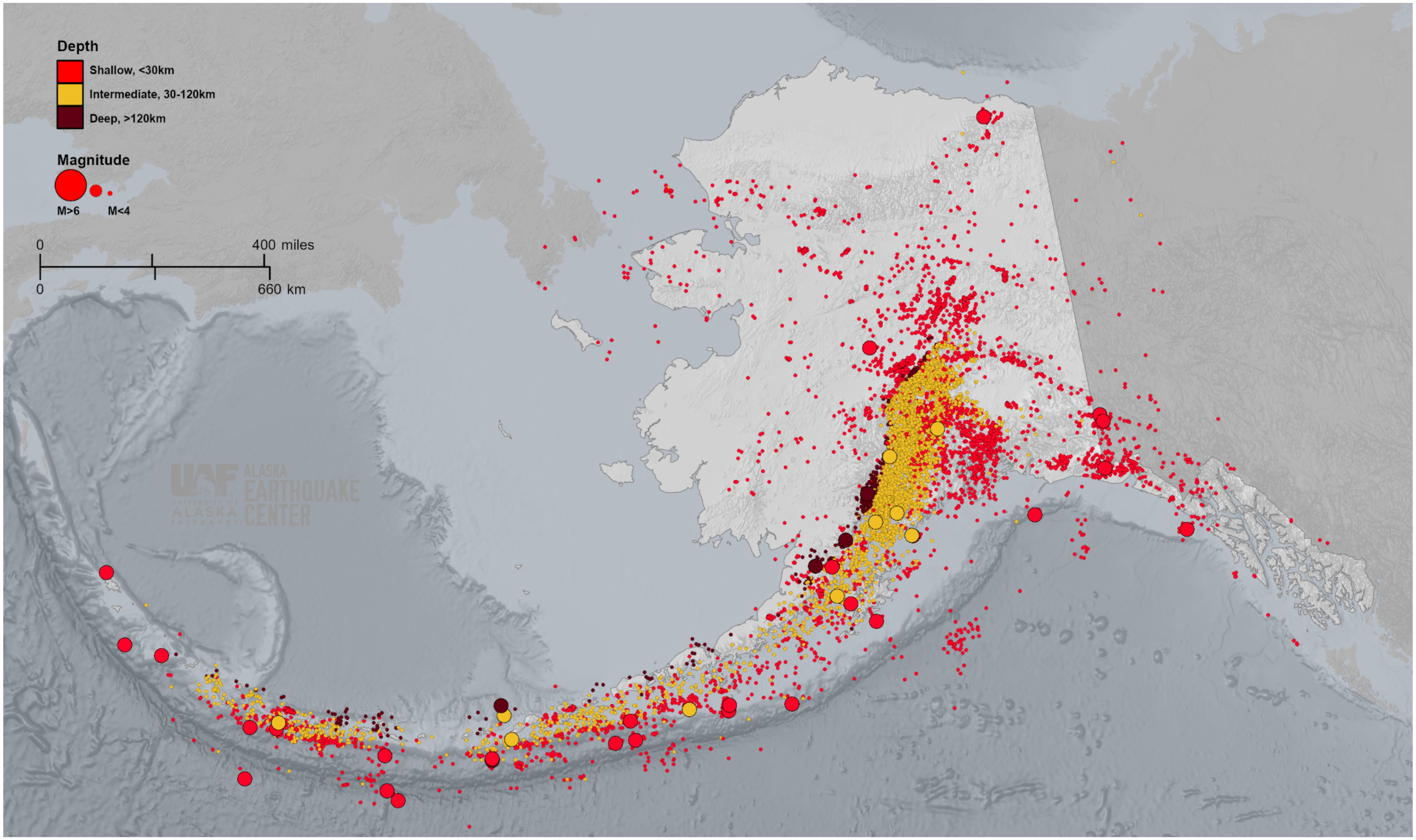
We continued recording aftershock activity for the following sequences: 2021 M8.2 Chignik, 2020 M7.8 Simeonof, 2018 M7.1 Anchorage, 2018 M6.4 Kaktovik, 2018 M7.9 Offshore Kodiak earthquakes, and the Purcell Mountains Swarm. The Chignik, Kaktovik, Offshore Kodiak and Purcell sequences have reduced to less than 1 event per day on average and are no longer tracked in detail. For the remaining sequences, see Table 2.1 for a summary.

This quarter we eliminated the processing backlog and switched back to regular processing guidelines. Between mid-December, 2021 and mid-January 2023, only earthquakes with magnitude about 0.8 and greater were analyzed and cataloged; smaller events detected by the automatic system were discarded. Also, analysts picked additional phase arrivals only up to 2 degrees distance; only automatic picks were reviewed beyond this distance, no new phase picks were added. Currently, all clear P-phase and S-phase arrivals are picked up to 10 and 3 degree distance, respectively. Also, all automatic events are being reviewed regardless of the magnitude.

Table 2.1. *Notable Alaska seismic sequences for January 1-March 31, 2023.*

Earthquake	Number of events	Magnitude range	Magnitude of completeness (Mc)	Number of events per week
New sequences this quarter				
Tanaga-Takawangha	770	1.5-3.8	2.0	N/A
Burwash Landing	422	0.7-4.7	1.0	N/A
Continuing sequences (in order of decreasing activity)				
2020 M7.8 Simeonof	268	1.5-4.4	2.1	20
2018 M7.1 Anchorage	172	0.6-3.2	1.1	14

Figure 2.1. *Earthquake map for Alaska and neighboring regions for January 1 - March 31, 2023.*



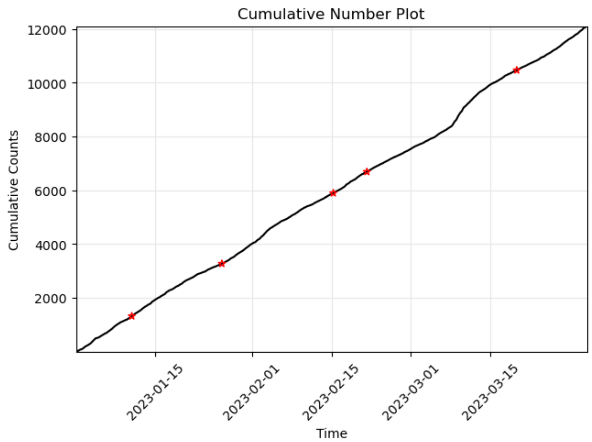


Figure 2.2. *Cumulative number of events for January 1 - March 31, 2023. Red stars indicate the five largest earthquakes.*

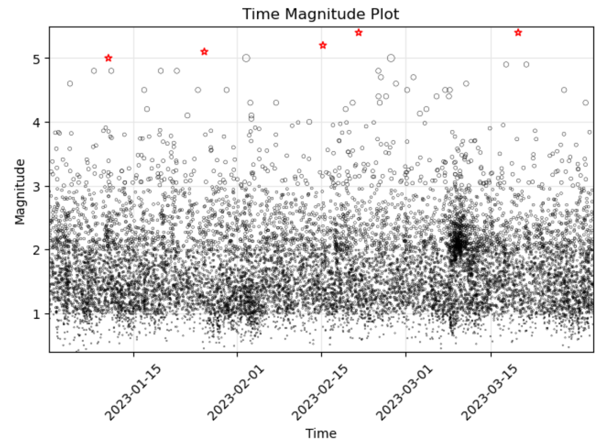


Figure 2.3*. Time-magnitude plot of events for January 1 - March 31, 2023. Red stars indicate the five largest earthquakes.*

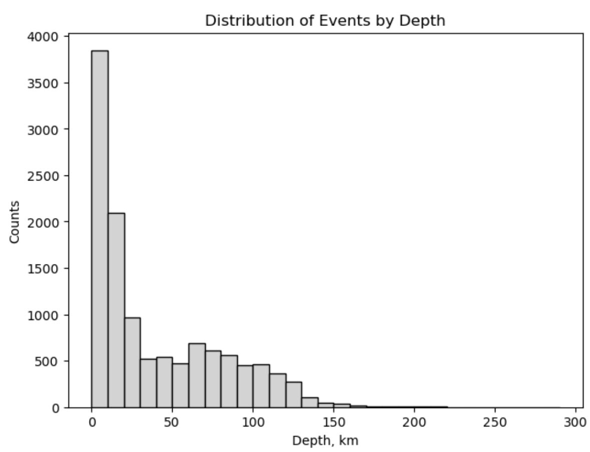


Figure 2.4*. Depth distribution of all events for January 1 - March 31, 2023.*

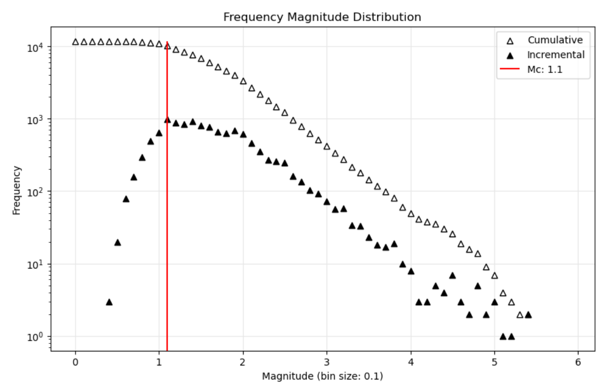


Figure 2.5*. Frequency-magnitude distribution of events for January 1 - March 31, 2023 (glacial, unknown, and quarry blast types are not included).*

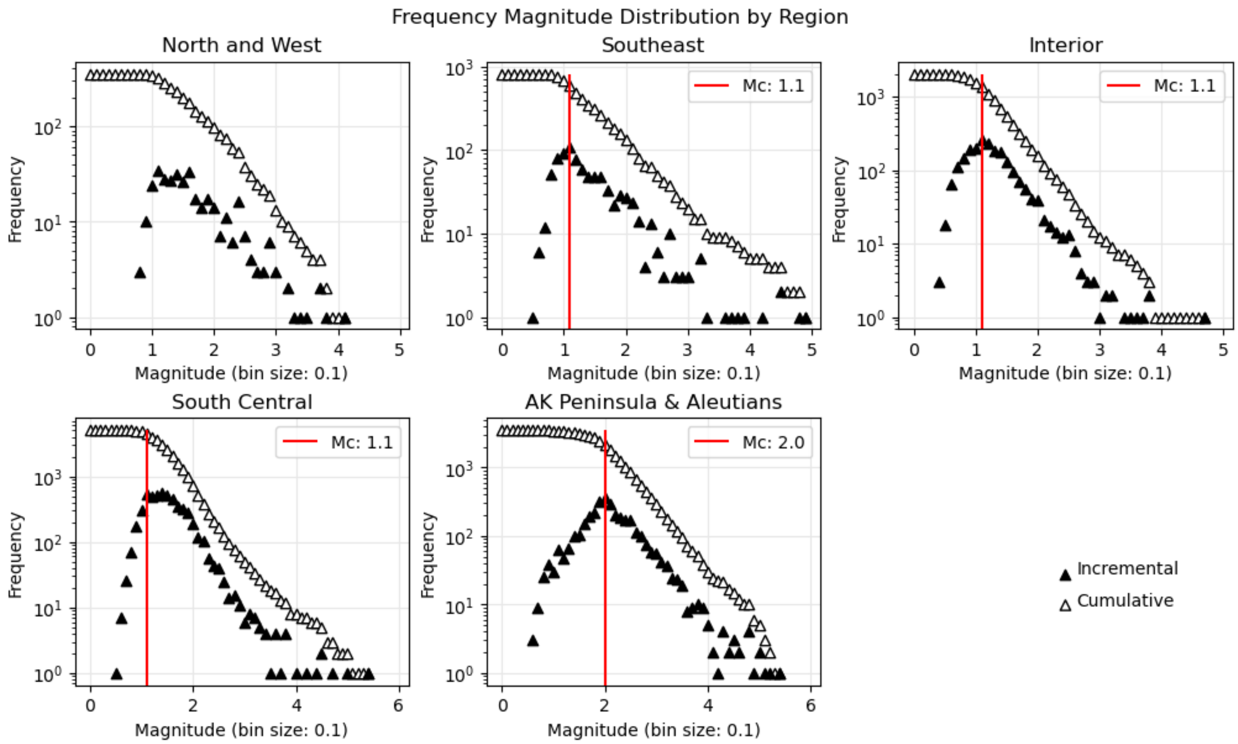


Figure 2.6. *Frequency-magnitude distribution of events for January 1 - March 31, 2023 grouped by geographic region (glacial, unknown, and quarry blast types are not included).*

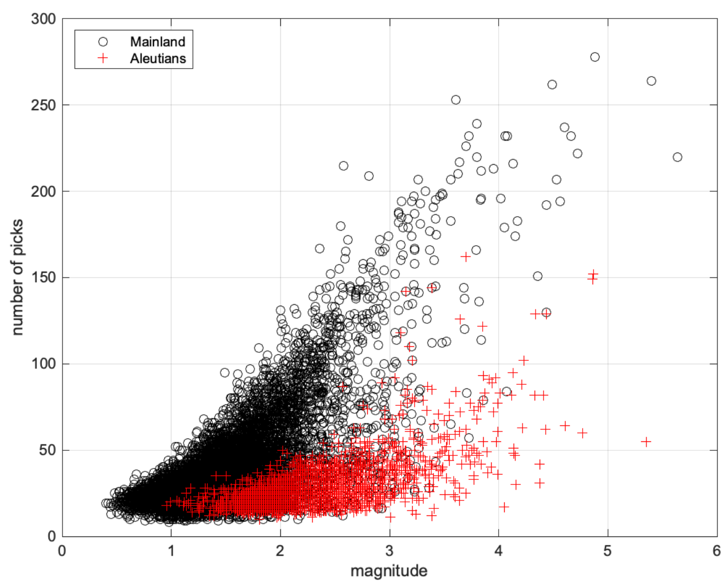


Figure 2.7. *Number of phase picks depending on magnitude and region for January 1 - March 31, 2023.*

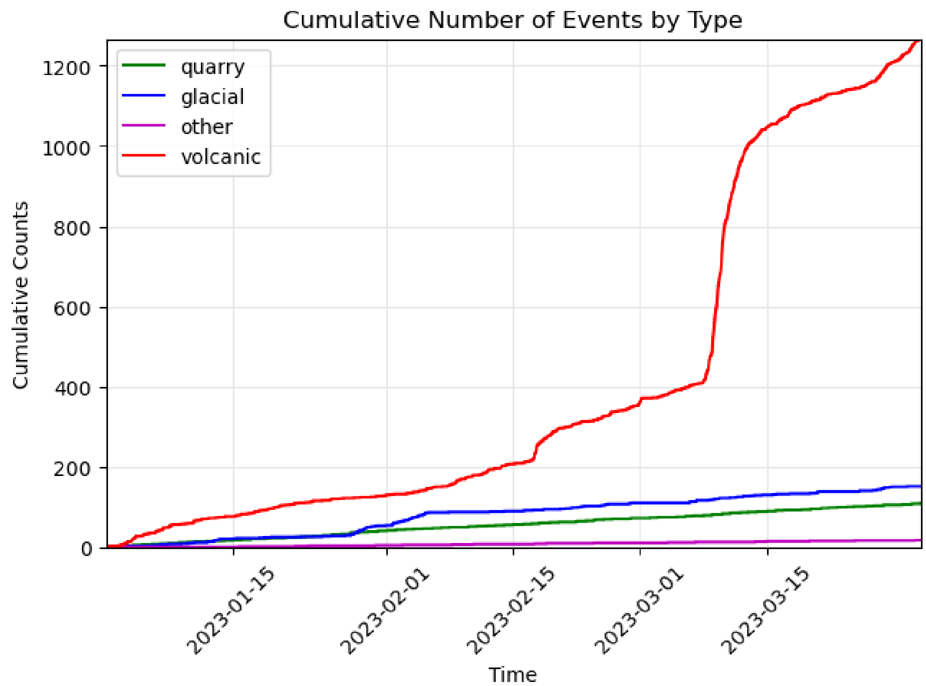


Figure 2.8. *Cumulative number of non-tectonic seismic events for January 1 - March 31, 2023 (volcanic, glacial, unknown, and quarry blast types).*

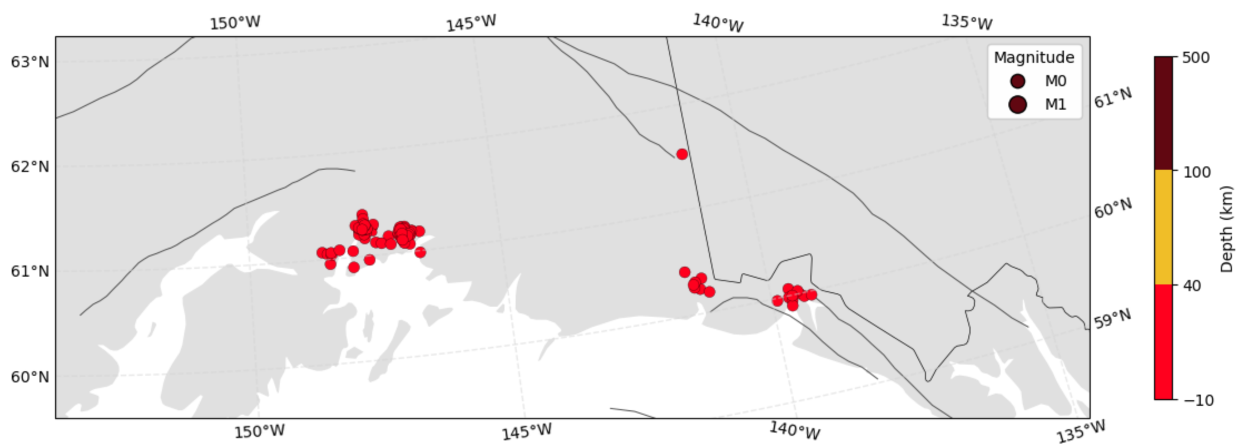


Figure 2.9. *Map of glacial events for January 1 - March 31, 2023.*

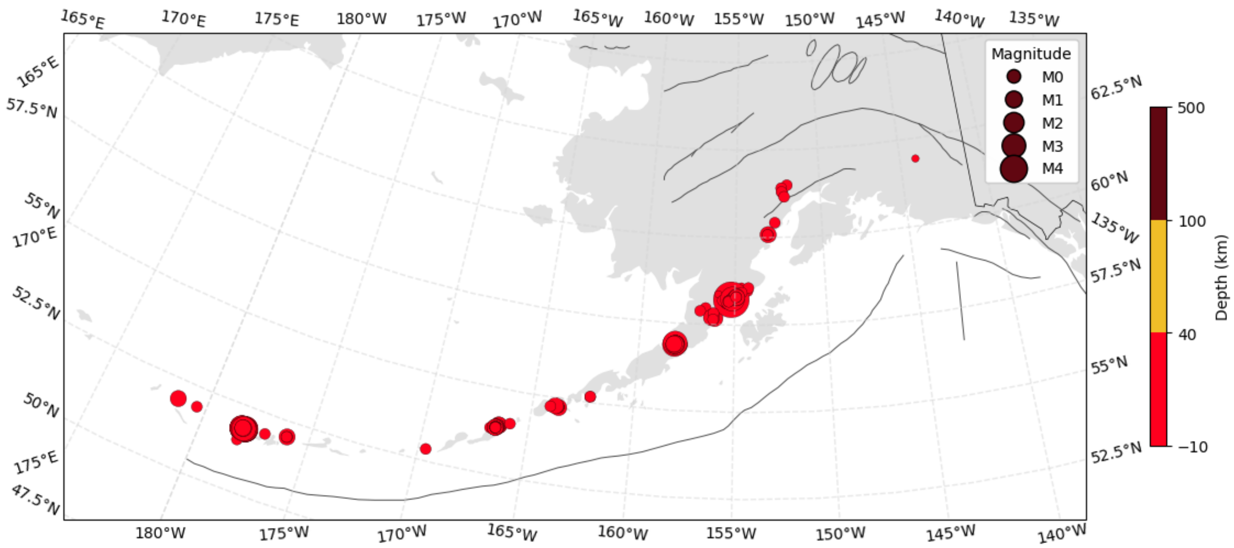


Figure 2.10. *Map of volcanic events for January 1 - March 31, 2023.*

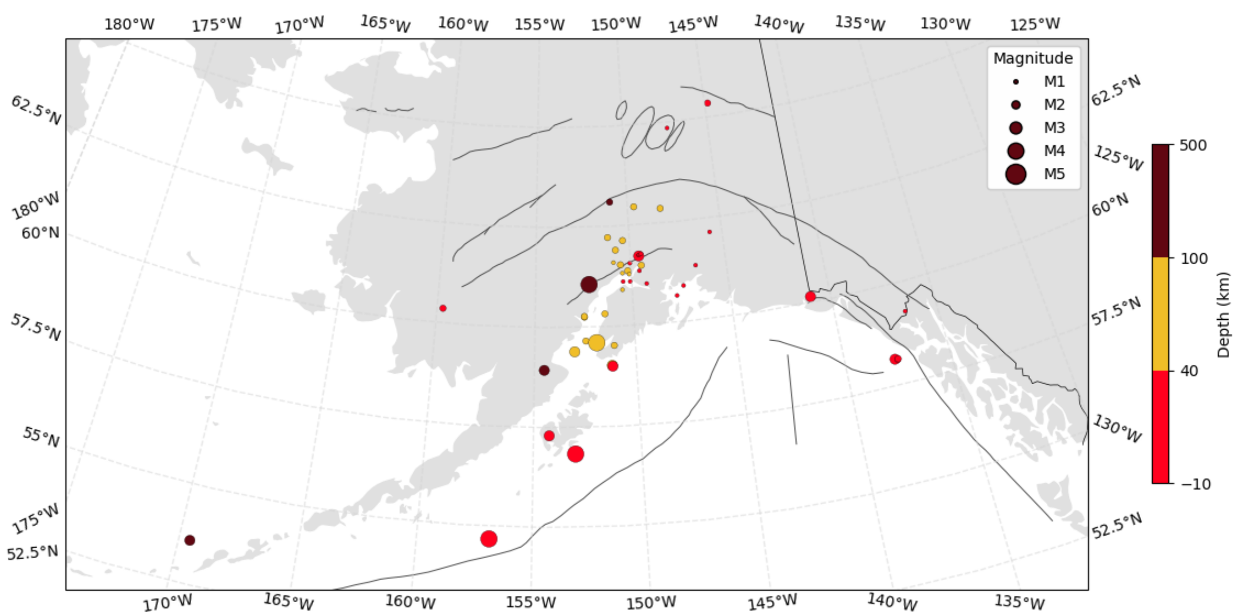


Figure 2.11. *Map of felt events (magnitudes M=2.0-5.4) for January 1 - March 31, 2023.*

The following is a description of the most notable earthquakes and sequences for this time period, starting with the new sequences.

Burwash Landing, Yukon earthquakes. An energetic sequence of three M4+ earthquakes with aftershocks began in late January and continued into March. It was located just east of the Alaska-Canada border in the Yukon, 50-55 miles west of Burwash Landing

(Figures 2.12-2.14). The first earthquake, M4.4, occurred on January 30 and was followed by an energetic aftershock sequence including a M4.1 aftershock on February 3. About a month later, on March 8, a M4.7 earthquake occurred about 20 km south of the M4.4 source region. We reported nearly 350 events combined for both source regions. The January-February sequence had twice as many events as the later March sequence. It could be due to differences in source mechanisms. Source parameters for the two earlier earthquakes indicate reverse faulting, while the March earthquake had a strike-slip mechanism. This area is characterized by interactions between the Totschunda Fault to the west, the Denali Fault to the east, and the Duke River fault system that connects these two right-lateral strike-slip faults. The Duke River Fault is mapped as a moderately to steeply southwest-dipping thrust fault, with evidence of some strike-slip motions with a reverse component (aka oblique thrust) (Cobbett et al., 2016).

Tanaga-Takawangha volcanic complex. In mid-February activity under the Tanaga-Takawangha volcanic complex in the central Aleutians picked up pace (Figures 2.15-2.17). In the second week of March the seismic activity accelerated even further to up to a hundred reported events per day. Six of these earthquakes had magnitudes between M4.0-4.4. The rate of seismic activity subsided after a few days, but still remained at an elevated level through the end of March. There is some evidence of east-to-west source migration from under Takawangha summit to under Tanaga summit. This area has experienced M6+ earthquakes in the past, such as the May 2, 2008 M6.6 and the January 23, 2020 M6.2 earthquakes. The 2008 and 2020 earthquakes had different fault plane orientations as evidenced by the aftershock distribution. While the 2008 earthquake was a left-lateral strike-slip event on a northerly-striking fault plane (Ruppert et al., 2012), the 2020 earthquake was a right-lateral event on an easterly-striking plane. The 2023 seismic activity overlaps with the westernmost part of the 2020 aftershock cluster and is located in much closer proximity to the volcanic centers. Over the course of this sequence, the Alaska Volcano Observatory elevated alert levels at both volcanoes to “advisory” and “watch”. No eruptive activity has been observed by the end of March; however, the alert level remained at “advisory.”

Simeonoff Earthquake. The 2020 M7.8 Simeonof Earthquake sequence continued at nearly the same rate as compared to the previous quarter (Ruppert et al., February 2023). We reported about 268 aftershocks for this quarter. Magnitude of completeness slightly increased this quarter due to the deteriorating network performance. Only three aftershocks were over magnitude 4 for the entire quarter. The Simeonof aftershock sequence is now in its third year (Ruppert and Gardine, February 2021, February 2022; Ruppert, February 2023).

Anchorage Earthquake. The 2018 M7.1 Anchorage Earthquake aftershock sequence continued at half the rate as compared to the previous quarter, but still remained above the background level (Ruppert et al., February 2023). The largest aftershock this quarter was only M3.2 on January 5. The aftershock sequence is now in its fifth year (Ruppert and Gardine, February 2021, February 2022; Ruppert, February 2023).

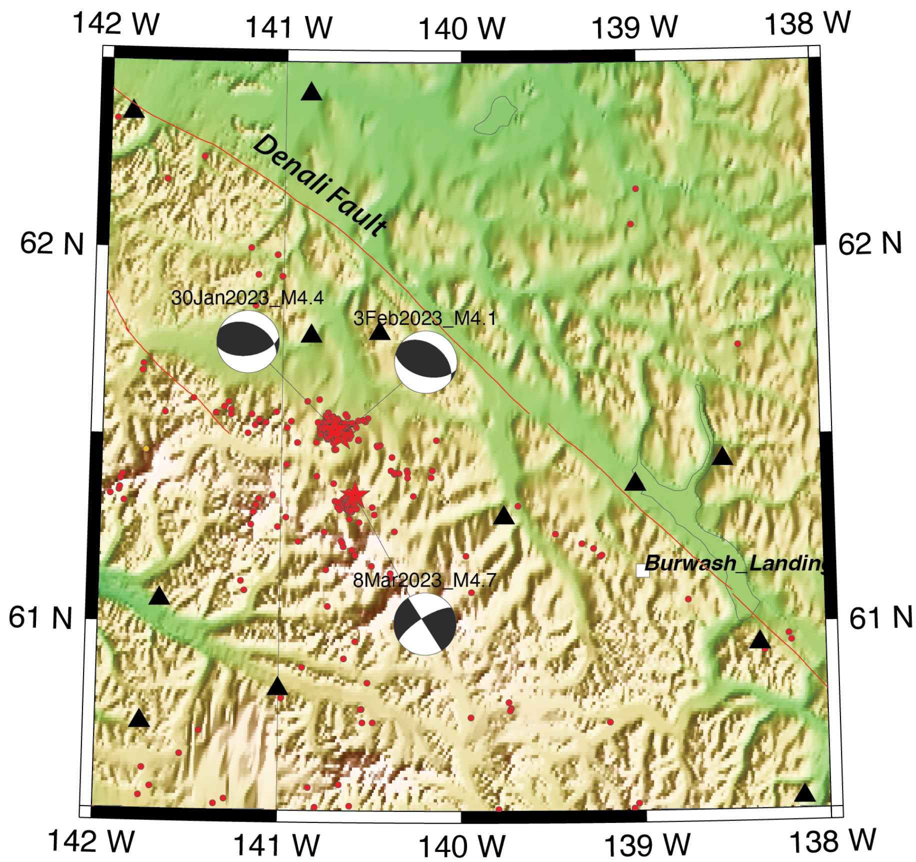


Figure 2.12. *Earthquake location map for the sequence in the Yukon, Canada. Red circles are earthquakes recorded in the region in January-March 2023. Focal mechanisms are from the ANSS Comcat catalog.*

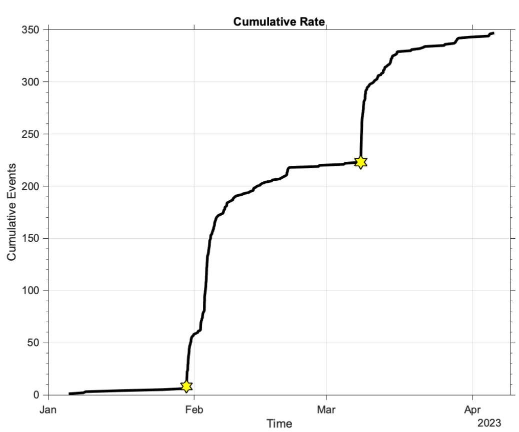


Figure 2.13. *Cumulative number of events in the Burwash Landing sequence. Stars indicate the two largest earthquakes.*

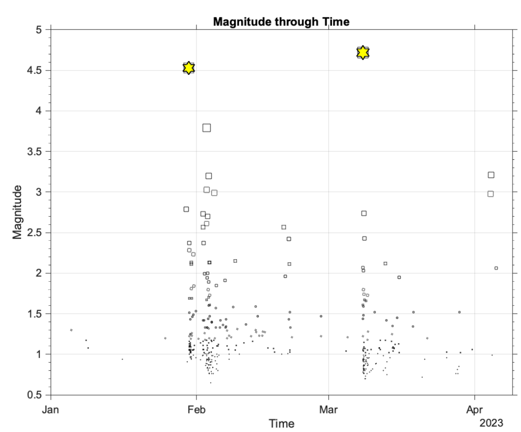


Figure 2.14. *Time-magnitude plot of events in the Burwash Landing sequence. Stars indicate the two largest earthquakes.*

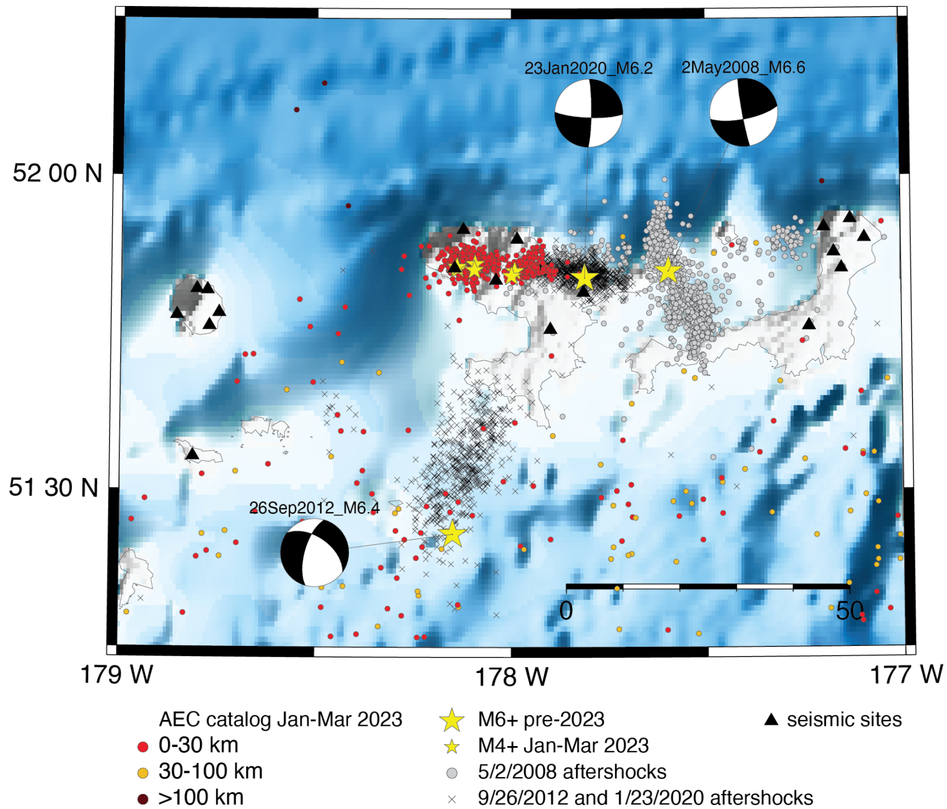


***Figure 2.15**. Earthquake location map for the sequence under the Tanaga-Takawangha volcanic complex recorded in February-March 2023. Focal mechanisms are from the Global CMT catalog.*

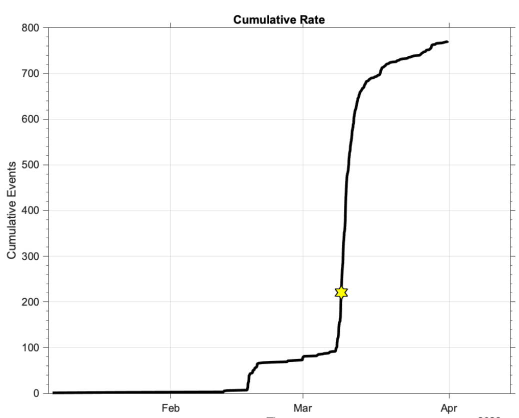


***Figure 2.16**. Cumulative number of events under the Tanaga-Takawangha volcanic complex. The star indicates the largest earthquake.*

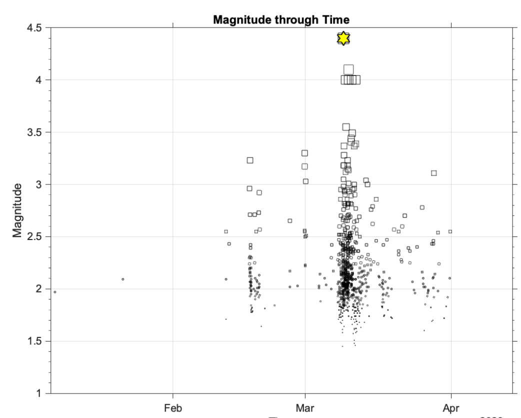


***Figure 2.17**. Time-magnitude plot of events under the Tanaga-Takawangha volcanic complex. The star indicates the largest earthquake.*

3. Field network

As of March 31, 2023, AEC maintains and acquires data from 255 seismic sites of the Alaska Geophysical Network (https://earthquake.alaska.edu/network). The sites can be divided into the following groups based on their locations and sensor types:

- 209 free field broadband stations, about 85 of which have co-located strong motion sensors, 107 of which have infrasound data streams, and 67 of which have meteorological sensor packages;
- 25 strong motion sites in the greater Anchorage and Mat-Su Valley region;
- 9 strong motion sites in Fairbanks;
- 9 strong motion sites located in coastal communities from Chignik to Yakutat and Bethel;
- 1 structural array located in the Engineering Learning and Innovation Facility on the University of Alaska Fairbanks campus;
- 2 Netquake sites in Fairbanks that record only triggered data (these are not included in the data return rates).

Between January 1 and March 31, the network had an average data completeness rate of 76.1%, with the daily rates ranging from 73.0% to 80.5% (Figures 3.1 and 3.2). There were no significant outages of critical data hubs or telemetry circuits. Overall performance remained stable, with no major gains or losses. The overall performance was still lacking and below marks of the previous five years.

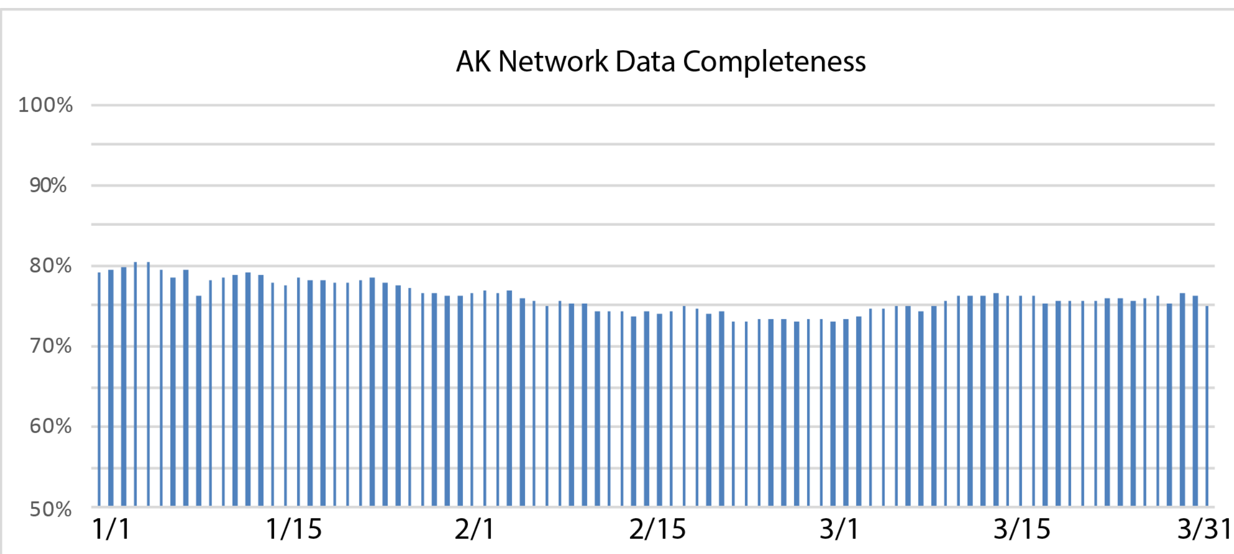


Figure 3.1. *Daily data completeness in percent for AK network in January-March 2023.*

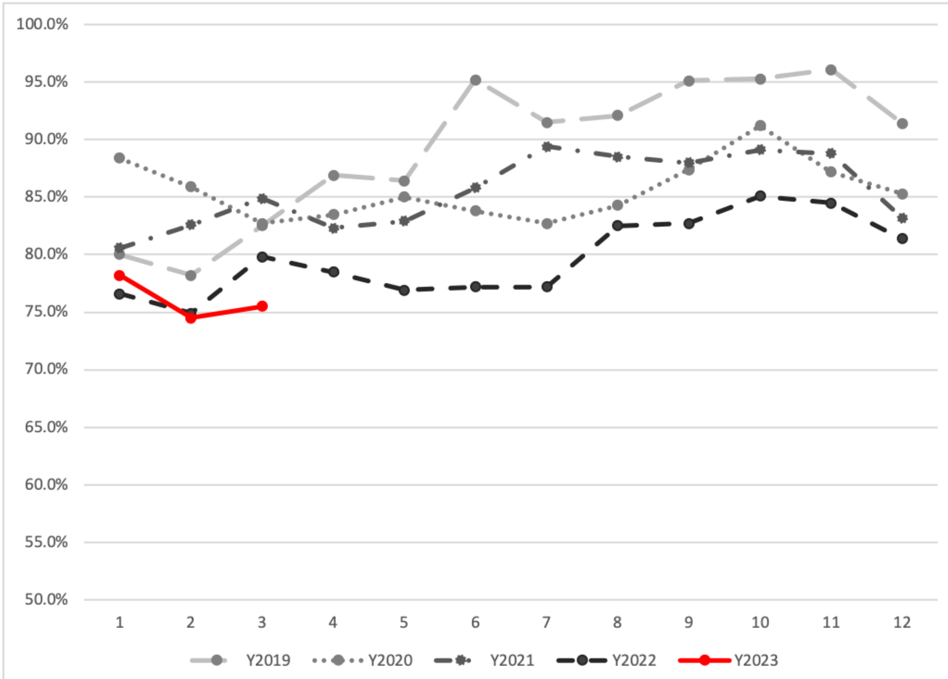


Figure 3.2. *Average monthly data completeness in percent for AK network 2019-2023.*

4. Data Quality assurance

4.1 Seismic data

Data Quality Control (QC) efforts at the center consist of data integrity (up-time, completeness, latencies) and quality (signal quality/noise performance). We define "QC" broadly as quantitative data that help assess the performance of our stations. This includes data on the overall health of the station (data completeness, clock quality, latency, etc.), as well as data specific to individual channels (broadband, strong-motion, weather, infrasound, etc.). QC metrics are values derived from the data and state-of-health channels (SOH), as well as from the IRIS MUSTANG website (http://services.iris.edu/mustang/measurements/1/). Standardized QC reports are produced weekly and include percent availability, gaps, and amplitude-related metrics (dead and pegged channel, spikes, high and low amplitudes compared to the global New High and New Low Noise Models, flat amplitudes for strong motion sensors, and dc offset).

Each piece of our QC information has multiple end-users. Maintaining a comprehensive set of QC products allows us to feed these end-uses while minimizing the need to perform one-off QC requests. Internal end-users include the field team to help steer repairs and upgrades, the analyst team to identify stations that should not be used for routine earthquake analysis, as well as project reports specific to certain stations (TsuNet, Greely, Pipeline, Donlin, etc.). We also communicate performance issues to the research community and partner organizations (Alaska Climate Research Center and the Wilson Alaska Technical Center).

Stations with the lowest data availability or sensor/datalogger failures January 1-March 31, 2023 (also see Figure 4.1):

- Stations that continue to have 0% availability as compared to 2022 Q4: A21K, B18K, BCP, BWN, C18K, CHX, D25K, DCPH, DOT, FA09, YAH, YAKA
- Stations that now have 0% as compared to 2022 Q4: ATKA, BAE, BAGL, CHI, D24K, E18K, GRIN, H17K, H23K, M26K, PIN, PPD, PPLA, SAMH, SII, SSN, TABL
- Stations that continue to have 1-50% availability as compared to 2022 Q4: B22K, COLD, E21K, G19K, G27K, L18K, L19K, M20K, M23K, R18K, RKAV, TRF
- Stations that now have 1-50% availability as compared to 2022 Q4: A19K, B20K, CHN, E25K, F21K, FID, GOAT, HIN, K218, KAI, K27K, MESA, MS02, RAG, S19K, SPIA, TNA, WAX
- Stations that came back during 2023 Q1 but still had 1-50% availability for the entire period: I26K, K216_00 (surface sensor), K216_DH (borehole sensor)
- BB data quality issues caused by faulty sensors and/or dataloggers: A19K (BHN and BHZ channels), BARK (all channels), PS01 (BHN channel), PS07 (all channels), PS09 (all channels), TOLK 01 (both horizontal channels), WAT7 (BHZ channel).
- SM data quality issues caused by faulty sensors and/or dataloggers:
  PS07 (all channels)
- Stations that have come back to above 50% availability since 2022 Q3 due to field maintenance or on their own: ER03, FA02, K203, K220, K221, K222, K223, M19K
- Stations that had data quality issues that were fixed during 2023 Q1: C21K (all channels), D20K (all channels), K15K (all channels)

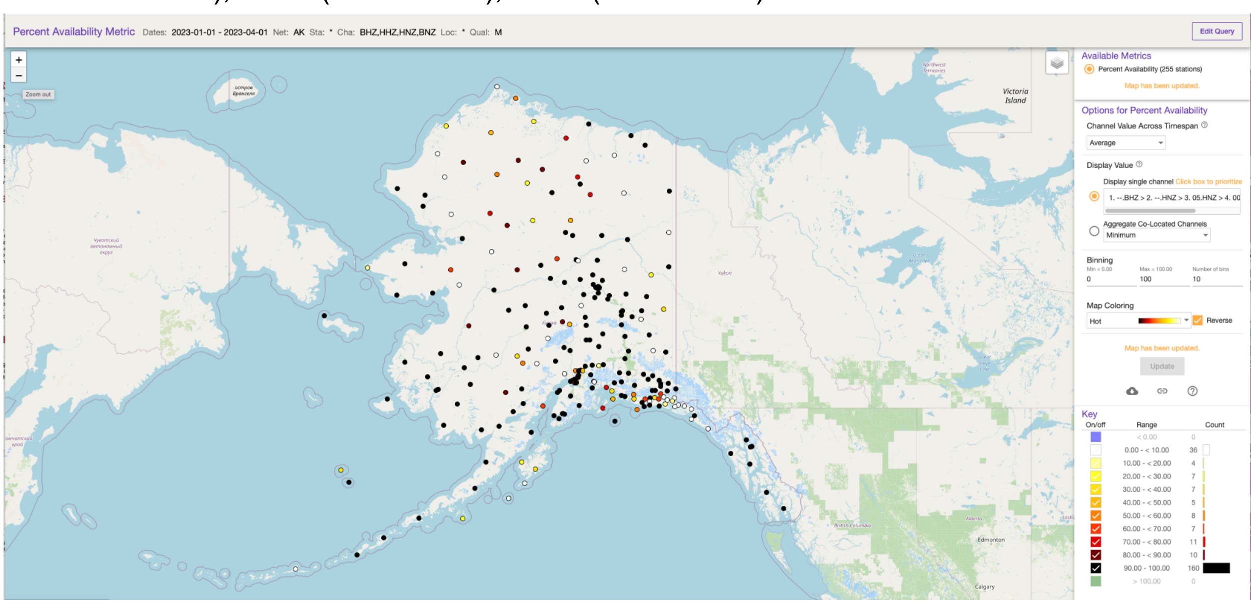


***Figure 4.1**. Map of average percent availability for all AK network broadband and strong motion stations for January 1-March 31, 2023. Black circles represent stations at 90-100% availability, white circles represent stations at 0-10% availability. Other colors represent a gradient of availability.*

4.2 Environmental data

The Earthquake Center adopted 89 stations with non-seismic instrumentation from the Earthscope Transportable Array project. All 89 stations have Hyperion infrasound and Setra microbarometer instruments. Of these stations, 67 are equipped with Viasala WXT weather packages (7 channels recording wind speed and direction, humidity, barometric pressure, temperature, and rain/hail gauges). In total, we record 825 individual environmental channels.

We run monthly QC checks of these environmental channels, quantifying the percent availability for each instrument, as well as scanning for periods of non-physical values and flat data return. A channel will flag as “flat” if over 20% of the samples are non-unique. For non-physical values, we conducted a literature review of the global maximum/minimum values for each of the environmental channels we acquire. For example, if a temperature sensor reports a measurement below -60 C or above 70 C, we flag that as non-physical. Please note that these monthly environmental QC reports do not fall on calendar months, but instead run from the 7th to the 6th of the next month, due to reporting requirements of the Synoptic National Mesonet Program. This report is for January 6 through April 7, 2023.

First quarter of 2022 was marked by very poor performance, with 75% of the network experiencing instrumentation malfunctions at some point. We attributed these difficulties to harsh winter conditions. However, the first quarter of 2023 demonstrated a notable improvement in station performance.

In January 2023, 46% of the stations reported data availability of 90% or higher, while 21% of the stations had less than 25% data availability. In February, the stations with data availability of 90% or higher increased to 52%, and those with less than 25% data availability rose to 27%. By March, 64% of stations had a data availability of 90% or higher, and the stations with less than 25% data availability dropped to 18%. Over the first quarter of 2023, there was an average of 54% of stations reporting over 90% of their data.

5. Real-time earthquake detection system

The Earthquake Center is the authoritative source of earthquake information in Alaska. Our real-time automated earthquake detection system is tuned to rapidly determine locations and magnitudes of seismic events in the state and disseminate this information to state and federal agencies, scientists, and the general public via website and other data feeds. The real-time earthquake detection system at AEC is based on the Antelope software package from BRTT, Inc.

First, waveforms are being continuously scanned by the *orbdetect* module to identify seismic arrivals. When a group of concurrent arrivals is identified, the *orbassoc* module searches over several pre-calculated three-dimensional grids to find the best fit for the set of arrivals. Each successful association is relocated by the *orbgenloc* module. Once the event is located, its magnitude is calculated through the *orbevproc* module. Automatic and reviewed locations and magnitudes along with the set of associated arrivals and other information are written into the real-time earthquake database (CSS3.0) by the *orb2dbt* module.

Beginning in January 2021, we have been producing monthly reports on the performance of the real-time detection system. We document numbers of detected events (Figure 5.1), percent of bogus events that get deleted by the duty seismologist, percent of events with automatic magnitudes computed, location errors, detection latencies (Figures 5.2 and 5.3), and overall magnitude of completeness (Figure 5.4). We compare some metrics to ANSS (Advanced National Seismic System) performance standards, for example 2 minutes latency post time for hypocenters in High-Risk areas. See Table 5.1 for detailed information on some of the current metrics.

During the January-March 2023 time period, we reported 9,736 automated events in Alaska and neighboring regions (Figure 5.1). This represents a 13.6% increase in detections compared to the previous quarter. March 8, 2023 had the highest number of detections. February 16 experienced several events with longer detection delays but recovered quickly (Figure 5.2). No days had significant delays in magnitude calculations (Figure 5.3). There were 35 earthquake alarms during this reporting period. Our goal is to have duty-seismologist-reviewed solutions for alarm events within 20 minutes. Six alarm events were reviewed with a larger delay (Figure 5.5).

Table 5.1. *Real-time earthquake detection system performance.*

Metric	January	February	March
Number of automatic event detections	2,987	2,999	3,750
First origin latency below ANSS 2 min standard	72%	72%	76%
Number of automatic events with magnitudes	2,301	2,300	3,019
Percent origins with magnitudes	77%	76%	80%
First magnitude latency below ANSS 3 min standard	53%	53%	58%
Magnitude latency from origin post time below ANSS 2 min standard	98%	98%	98%
Events deleted by duty seismologist	12%	12%	11%
Magnitude of completeness	1.6	1.6	1.8
Number of earthquake alarms	10	12	13
Number of ShakeMaps	43	44	44
ShakeMap latency below ANSS 15 min standard	88%	84%	91%

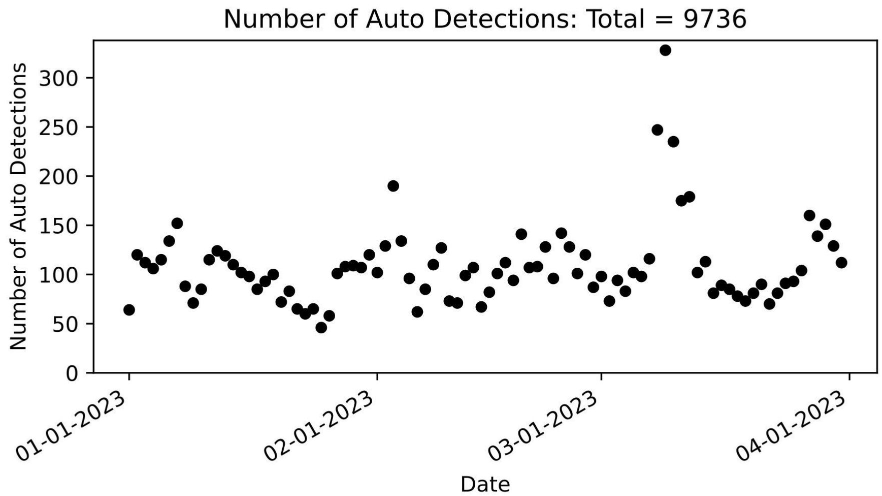


Figure 5.1. *Number of automatic event detections for each day. March 8, 2023 had the highest number of detections.*

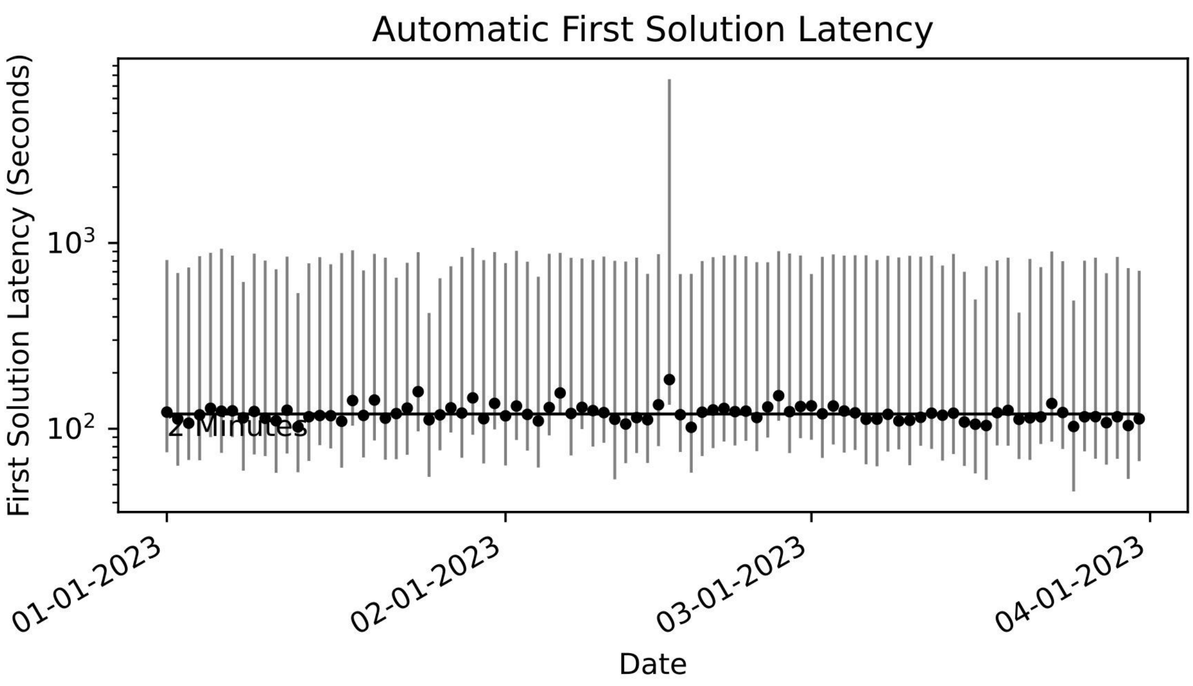


Figure 5.2. *Average daily latency (dots) and range (lines) of the first automatic solution for each event. February 16 had longer detection delays but recovered fairly quickly.*

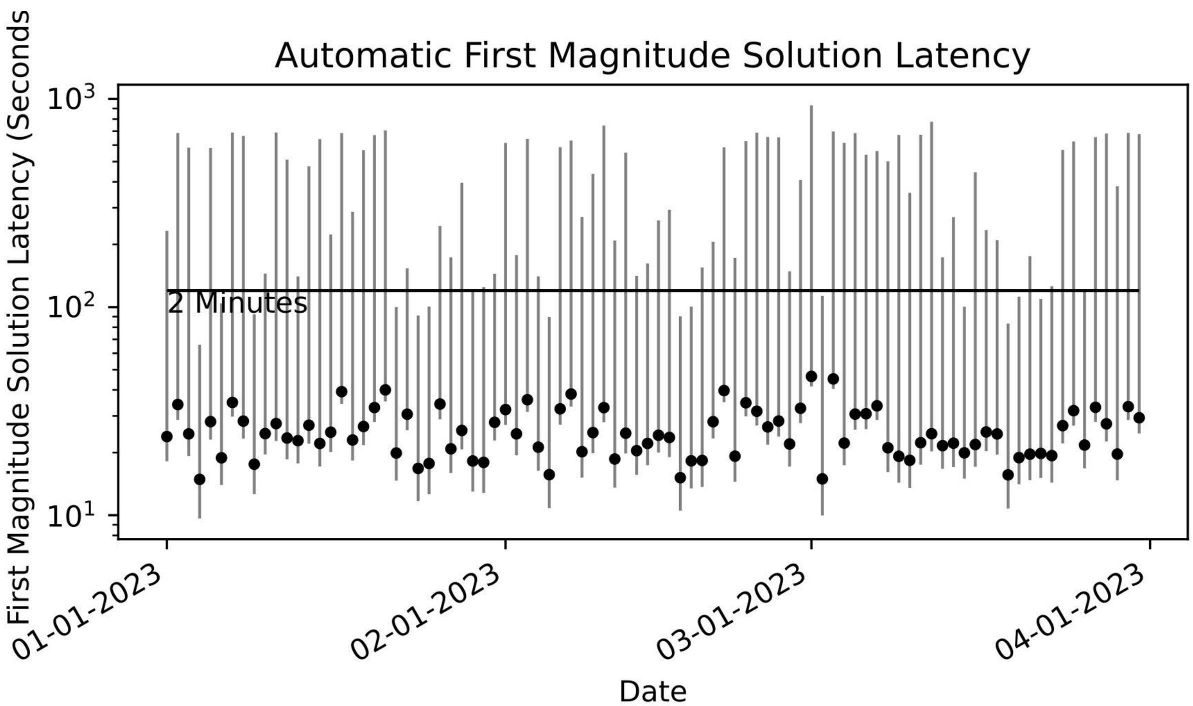


Figure 5.3. *Average daily latency (dots) and range (lines) of the first automatic magnitude for each event after the event detection.*

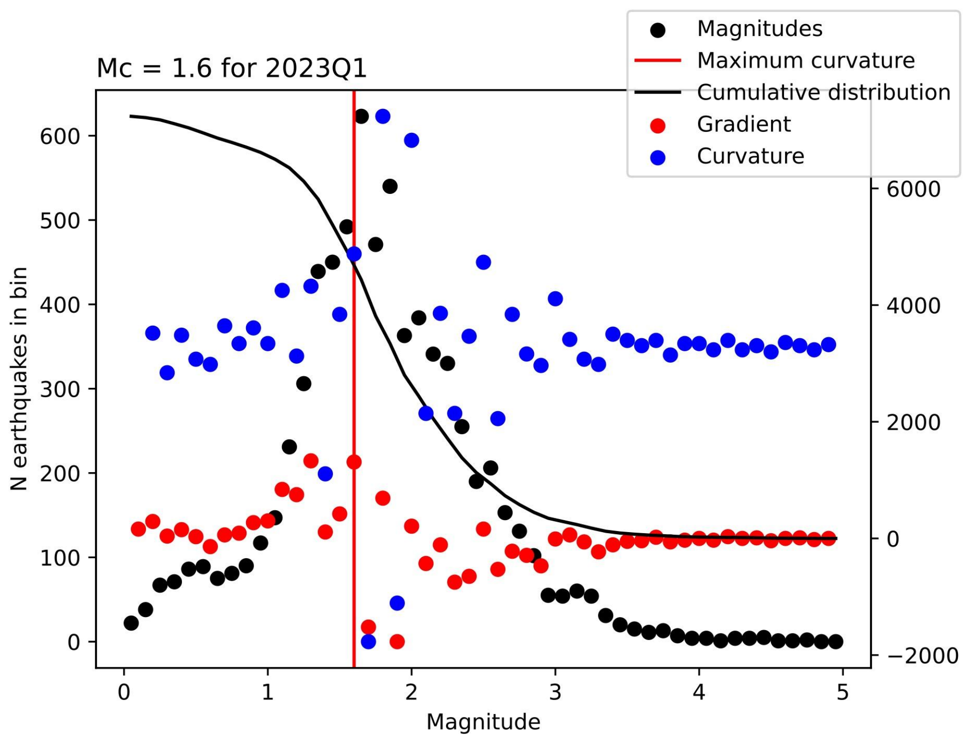


Figure 5.4. *Magnitude of completeness of the automatic catalog for the reporting time period.*

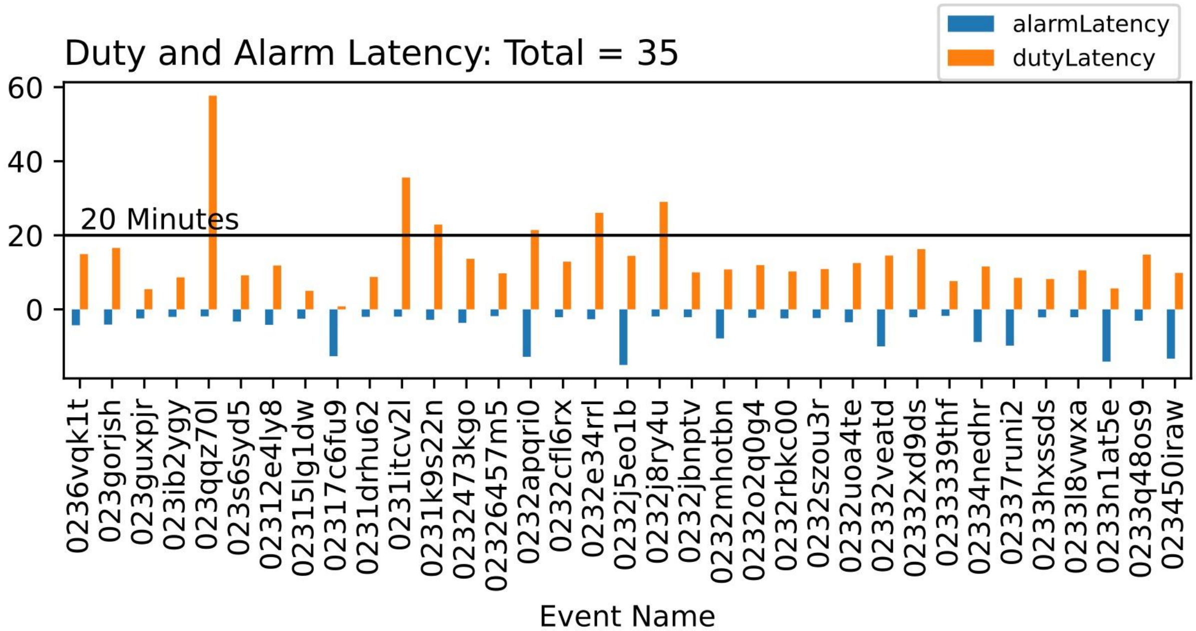


Figure 5.5. *Earthquake alarm and duty review latency from alarm time (bottom of the blue bar is origin time, top of the orange bar is duty review post time, 0 is time of the alarm). Earthquakes are labeled with their event names.*

6. Computer systems

6.1 Computer resources

The Earthquake Center operates a computing cluster hosting an enterprise-grade virtual environment for nearly all operational needs. During this quarter, no major hardware upgrades were performed. We have begun to deploy staging virtual systems, which mirror production systems but operate in a separate environment to allow for consistency and testing prior to deploying major software changes.

Current status is as follows:

Number of hosts	Total CPUs	Total CPU (GHz)	Total RAM (GB)	Total vSAN storage (TB)
4	96	258.62	1022.49	41.92

Resource utilization is as follows:

Virtual Systems				Operating System	
Production	Staging	Development	Users	CentOS	Windows
22	16	20	6	61	3

6.2 Waveform storage

The Earthquake Center maintains a permanent archive of all available seismic data in the state in miniSEED format. Continuous waveforms have been stored since 1997, and segmented data is available from 1988-2012. Currently, AEC has 63.9 TB in continuous waveform data and 1.1 TB of segmented data. During the quarter, we acquired and archived 1.08 TB of new data (Figure 6.2.1).

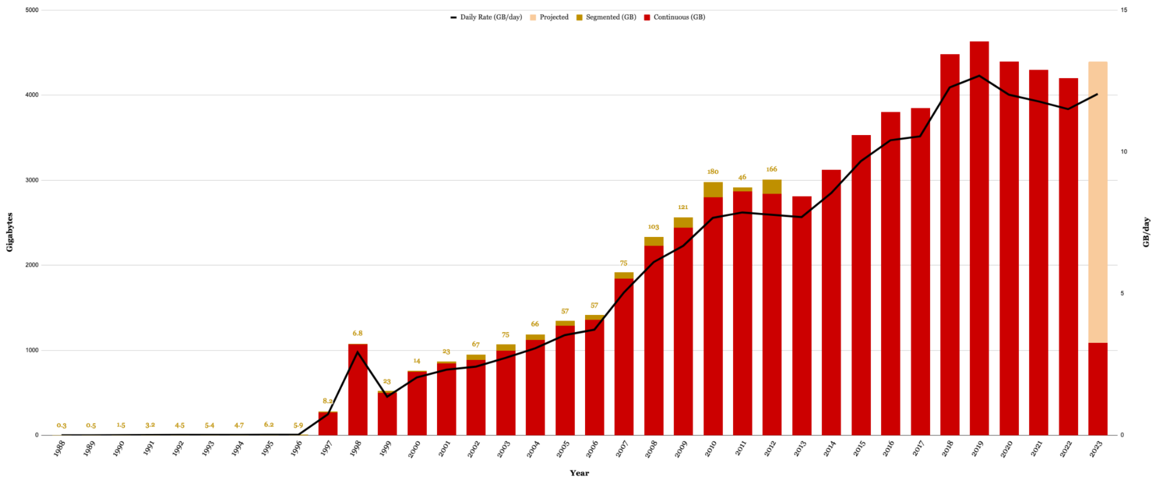


Figure 6.2.1. *Digital waveform archival storage for continuous (red) and segmented (brown) data.*

6.3 Metadata

AEC maintains metadata in css3.0 format for internal use, and provides dataless SEED volumes to IRIS for public distribution. During this quarter, the following station entries were modified:

- Stations added: None
- Stations modified: 8036, K223, K203, P16K, BCP, FA02, RND, PPLA, UAFE
- Stations removed: None

We have paused adding new station metadata into the Station Information System (SIS) while we determine potential errors in our own metadata. At the end of this quarter, we have successfully loaded 51 sites into production SIS. These sites cover the entire Southern Tier adoption, as well as a few additional sites that shared a similar configuration with Southern Tier sites. Additional sites will be loaded in Q2 of 2023.

6.4 Software development

During this time, our active code branches under the following scopes of work were:

Antelope	Website	Other
9	2	4

With new staff onboard, we implemented a new software development workflow which emphasizes branching of repositories instead of commits into the 'master' branch. As a result, our previous metric tracking number of commits in a repository has been replaced by a metric tracking the number of active branches in a given repository. This captures the active work being performed in a given code segment better than a simple raw count of commits.

During Q1 of 2023, we continued to unify our Antelope codebase into Python. Most codes have now been ported and are being tested. We have continued to transition our primary website host from on-premises virtualized machines into an Amazon Web Services (AWS) framework, and anticipate rolling out a beta version of the site for testing in Q2.

We completed the project on tuning the real-time system automatic earthquake detection and location algorithms, a report tool for generating catalog statistics on-demand, and for generating reports tracking processing consistency.

7. Fieldwork

During the reporting period, Earthquake Center staff visited 11 field sites to resolve data outages, GPS timing issues, and to perform planned upgrades, cleanup, and/or preventative maintenance. Four staff members conducted visits, for a total of 12 person-days of site maintenance work during the reporting period.

The majority of the fieldwork completed in January and February were at local strong motion sites in Anchorage and Fairbanks. This included a one-day visit to the Fairbanks strong motion site, FA09, but the field workers discovered the site had been destroyed by a snow plow and so the site will remain offline until warmer temperatures. Multiple sites in the Anchorage strong motion network were visited during the week of January 22 to restore offline sites and replace sensors at sites with data quality issues.

In late March, a collaborative visit with EarthScope Consortium staff was conducted at E25K in Arctic Village to restore satellite communications for the site.

8. Social media and outreach

The Alaska Earthquake Center maintains a vibrant and dynamic social media presence on Facebook and Twitter. Since its initiation in 2013, we have amassed over 50,000 followers across the two platforms. Our social media posting strategy takes a multifaceted approach to public engagement. Social media is one of the primary ways that earthquake information is shared and that remains our primary focus. We also seek to highlight the human element of the center. We do not produce autogenerated posts. We aim to have 50% of our posts be related to recent earthquakes. The remaining 50% is divided between topics that highlight the various aspects of the center itself. We also acknowledge that we can fill a vital role in helping to amplify the messaging of our partner agencies.

8.1 Website

During the first quarter of 2023, we had nearly 244,000 users visit our website. This amounted to 296,000 sessions (number of times users entered our website) and 506,000 pageviews (number of individual web pages visited). Figure 8.1.1 shows the daily distribution of users, pageviews, and sessions for the year to date.

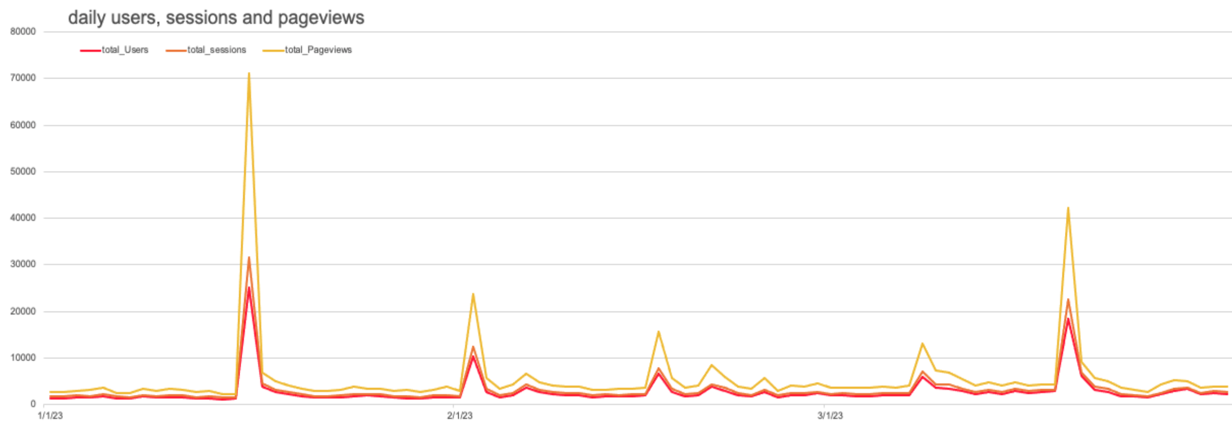


Figure 8.1.1. *Total number of website users (red), sessions (orange), and pageviews (yellow) per day in 2023.*

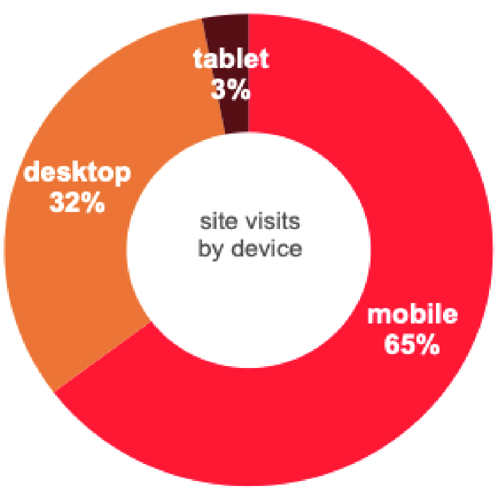


Figure 8.1.2*. Percentage of website sessions for the three major device types, mobile (e.g., phones), tablets, and desktop computers.*

Our web traffic is rarely quiet. On our "slowest" day between January 1 to March 31, we still had about 750 users on our site. The recent earthquake map page and recent earthquake list (a page for lower bandwidth users) combined accounted for 70% of users during the reporting period. These two pages typically account for approximately 75% of site visitors. There was a significant spike in activity on January 16th after two M4+ earthquakes that were felt in Southcentral and Southeast.

In recent years we have made our website and content more mobile friendly, based on trends seen in device usage. More people visit our site on mobile devices (Figure 8.1.2). Tablets and mobile devices such as phones accounted for 68% of website sessions.

8.2 Twitter

In the first quarter of 2023, we gained approximately 300 followers, bringing our total following to over 25,500. Because of the nature of Twitter, we often post frequent or threaded content to convey our messages. Figure 8.2.1 shows the distribution of post types for the 57 tweets made this quarter. Figure 8.2.2 shows the number of posts made per day and the number of impressions per day for the entire year. Impressions represent the number of times our tweet is shown on a screen. The number of impressions does not scale directly with the number of posts based on the Twitter algorithm, as evidenced by the days with impressions and no posts. This is used to determine how often our followers view our posts.

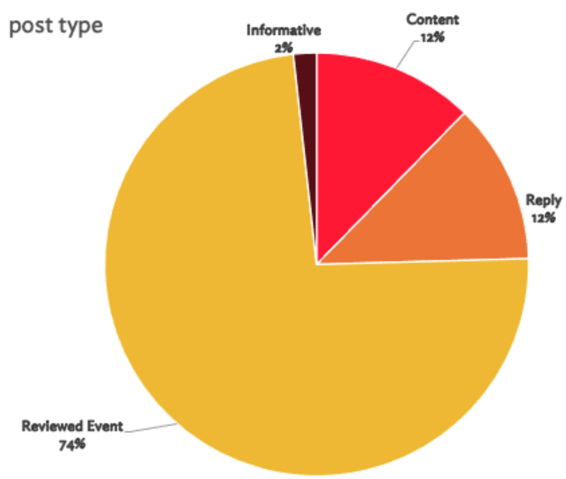


Figure 8.2.1. *Post type distribution for tweets for the first quarter of 2023.*

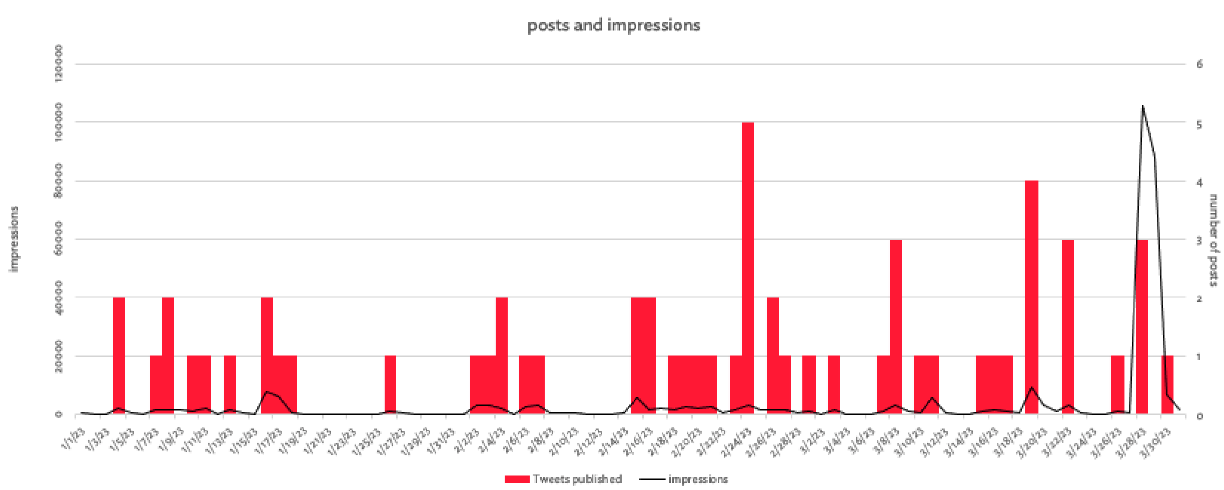


Figure 8.2.2*. Number of posts per day (right axis, red bars) compared to the number of impressions received per day (left axis, black line) in 2023.*

There was a spike in impressions (Figure 8.2.2) during this period, related to a couple of posts about the anniversary of the Great Alaska Earthquake at the end of March. Our engagement rate with time (Figure 8.2.3) remained consistent during this quarter, averaging around 5%, with a high around 20% on January 27 (there was no obvious event on that date to account for the increase).

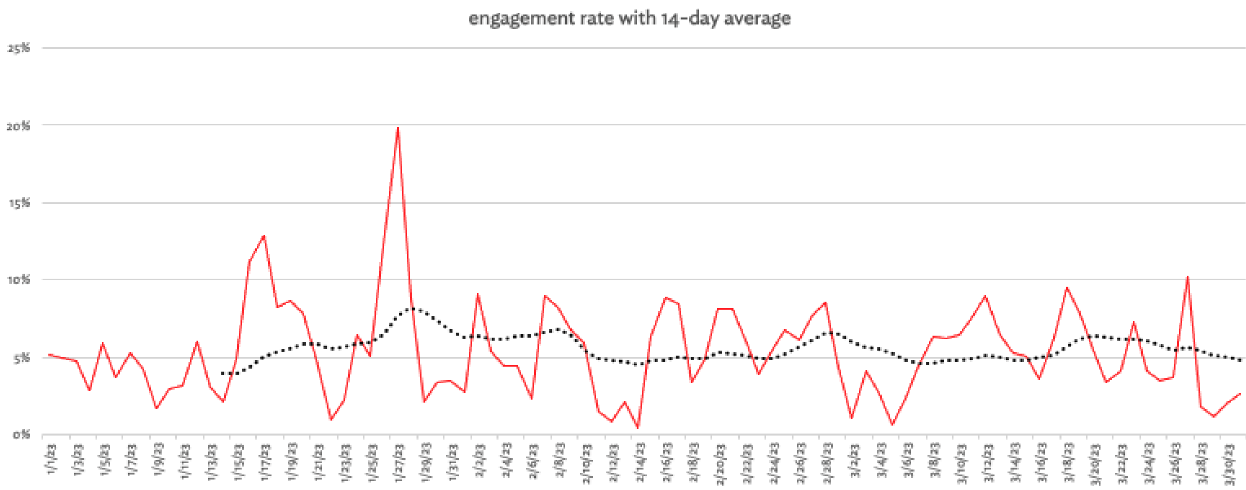


Figure 8.2.3. *Twitter engagement rates with time (red line) and 14-day moving average (black dotted line) in 2023.*

Figure 8.2.4 shows impressions and engagements based on tweet type. Content posts accounted for 70% of impressions and 36% of engagements. Reviewed event posts accounted for 25% of impressions and 55% of engagements. All other posts accounted for 5% of impressions and 9% of engagements.

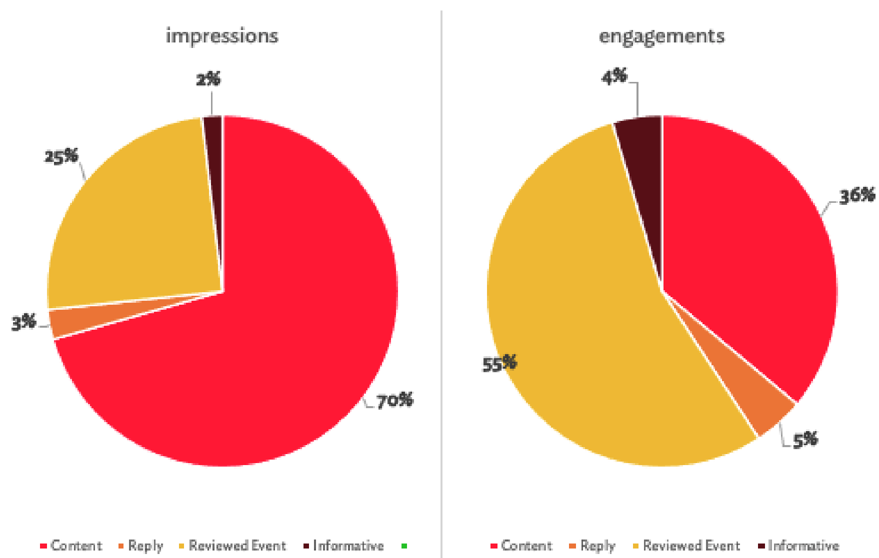


Figure 8.2.4*. Percentages of impressions and engagements based on tweet type.*

8.3 Facebook

Our Facebook Page was created in December 2020. It is our primary posting platform on Facebook. Our Facebook Group, created in 2013, is mainly used to share content posted to our page, and occasional posts from group members. Membership to the group remains high, at roughly 20,000.

During the first quarter of 2023, we attracted about 200 new followers to the Facebook Page, bringing our count to about 13,000. As is the trend with felt earthquakes, we receive a follower boost after each event. Our largest increase was following two M4+ earthquakes that occurred on January 16.

The distribution of post type is shown in Figure 8.3.1. Reviewed events accounted for 69% of the 55 posts made in the first quarter and represented 45% of reach. Fifteen percent of posts were content related, and represented 30% of reach. Trivia Tuesday posts accounted for a total of 16% of posts and 25% of reach.

Facebook has once again changed how they show metrics, making it impossible to track daily engagement rates using their Meta Business Suite. We can track the engagement rate of posts, and more widely felt events tend to receive the most engagement. (Figure 8.3.2).

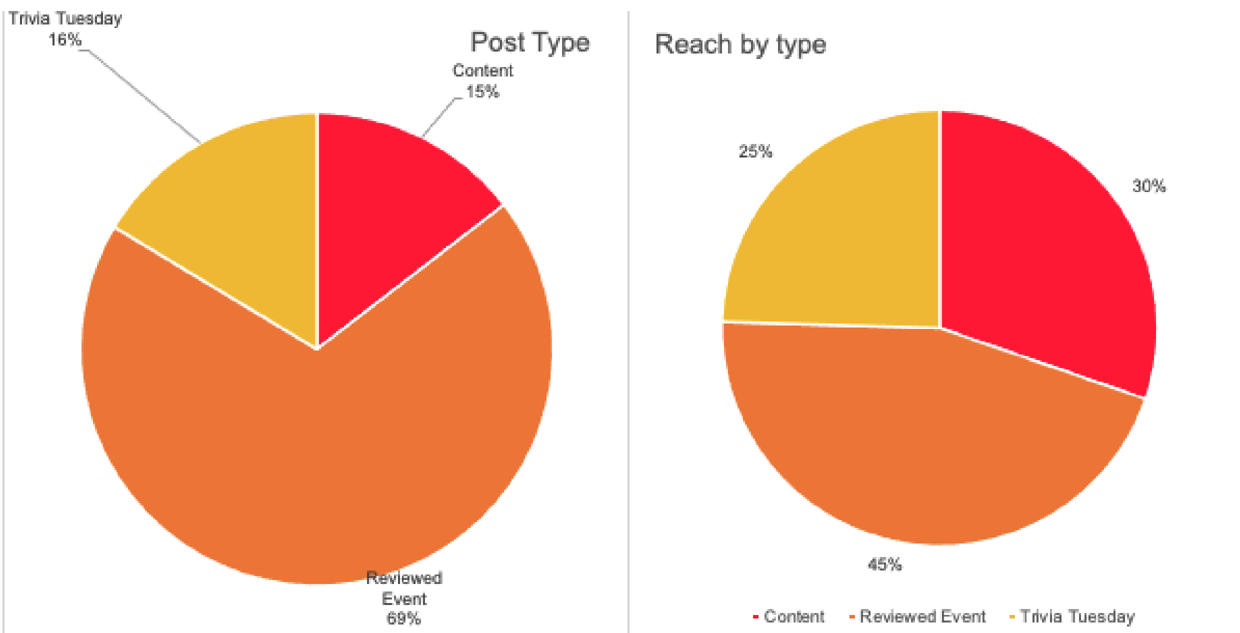


Figure 8.3.1*. Distribution of Facebook Page posts by type (left) and audience reach by type (right).*

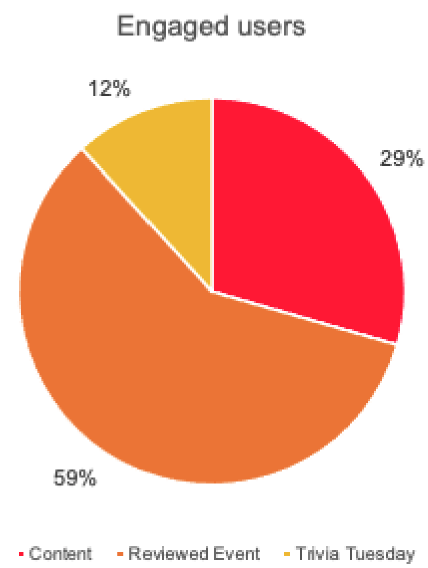


Figure 8.3.2. *Percentages of daily engaged users by post type.*

9. Publications and presentations

Names in **bold** are Earthquake Center staff. Names in ***bold italic*** are students and postdocs affiliated with the Earthquake Center, and names in *italic* are students and postdocs not directly affiliated with the center.

9.1 Publications

Parameswaran, R. M., **R. Grapenthin, M. E. West,** ***A. Fozkos*** (3/8/2023) Interchangeable Use of GNSS and Seismic Data for Rapid Earthquake Characterization: 2021 Chignik, Alaska, Earthquake. *Seismological Research Letters* 2023. https://doi.org/10.1785/0220220357.

Ruppert, N. A. (February 2023). *2022 Alaska Seismicity Summary.* UA ScholarWorks, 21 pp., http://hdl.handle.net/11122/13139.

Ruppert, N. A., S. Cotton, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, N. Murphy, M. E. West, and S. Wiser (February 2023). *Alaska Earthquake Center Quarterly Technical Report October-December 2022*. UA ScholarWorks, 42 pp., http://hdl.handle.net/11122/13109.

9.2 Public Presentations

Date	Presenter(s)	Event/Workshop	Title	Virtual/ In person
1/18	**Alexandra Farrell, Matthew Gardine**	Virtual Antelope User Group Meeting 2023	Reimagining How the Alaska Earthquake Center Authoritative Catalog is Generated – Part 1	Virtual
1/18	**Alexandra Farrell, Matthew Gardine**	Virtual Antelope User Group Meeting 2023	Reimagining How the Alaska Earthquake Center Authoritative Catalog is Generated – Part 2	Virtual
1/18	**Michael West, Ezgi Karasözen, Nate Murphy, *Gabrielle Davy,* Elena Suleimani,** Gabe Wolken	University of Washington Earth and Space Science Department	Barry Arm: Coming to Terms with Coastal Landslides	In Person
1/31	**Gabriel Low, Beth Grassi**	Ninilchik High School science class	Let's Get Shaking: Seismology and Tsunami Crash-Course with the Alaska Earthquake Center	Virtual
2/28	**Beth Grassi, Alex Farrell**	Open Arms Child Care Center (5 preschool classes, ages 2-4)	What Is an Earthquake? for Preschoolers	In Person
3/2	**Elena Suleimani,** Barrett Salisbury	Seldovia City Hall	Updated Tsunami Hazard Map of Seldovia	In Person
3/22	**Natalia Ruppert**	Fairbanks Chamber of Commerce Leadership Program	Earthquakes in Alaska	In Person
3/28	**Elena Suleimani**	Tsunami Operations Workshop	Modeling and Mapping Tsunami Inundation	In Person
3/29	**Elena Suleimani, Dmitry Nicolsky**	Tsunami Operations Workshop	Tsunami Maritime Guidance for Ports and Harbors in Alaska	In Person

9.3 Lunch Seminar Talks

Lunch seminar talks are informal opportunities for faculty, staff, students, and guest speakers to present their research.

Date	**Presenter**	**Title**	**Virtual/ In person**
1/12	Jeffrey Freymueller	Postseismic Deformation Following the 2016 Pedernales, Ecuador earthquake	Hybrid
1/19	Kenneth Macpherson	Using Ground-Motion Generated Local Infrasound to Estimate Seismic Velocity and Earthquake Magnitudes	Hybrid
1/24	***Amanda McPherson***	Regional Alaska earthquake moment tensors inverted using 3D Green's Functions	Hybrid
2/21	**Mathilde Wimez**	Systematic Exploration of a Volcanic Long-Period Earthquake Swarm with a Recursive Matched-Filter Search	Hybrid
2/28	*Kyungmin Kim*	Characterization of the 2021-2023 Great Sitkin dome-building eruption through Bayesian inversion of LP seismicity	Hybrid
3/28	***Sarah Noel***	Evaluation of Machine Learning Assisted Earthquake Phase Detection Performance on the Alaska Seismic Network	Hybrid

10. References

Cobbett, R., S. Israel, J. Mortensen, N. Joyce, and J. Crowley (2016), Structure and kinematic evolution of the Duke River fault, southwestern Yukon, *Canadian Journal of Earth Sciences*. 54(3), 322-344, doi: 10.1139/cjes-2016-0074.

Ruppert, N. A. (February 2023), *2022 Alaska Seismicity Summary,* UA ScholarWorks, 21 pp., http://hdl.handle.net/11122/13139.

Ruppert, N. A., S. Cotton, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, N. Murphy, M. E. West, and S. Wiser (February 2023), *Alaska Earthquake Center Quarterly Technical Report October-December 2022*, UA ScholarWorks, 42 pp., http://hdl.handle.net/11122/13109.

Ruppert, N. A., and L. Gardine (February 2021), *2020 Alaska seismicity summary*, ScholarWorks@UA, 16 pp., http://hdl.handle.net/11122/11865.

Ruppert, N. A., and L. Gardine (February 2022), *2021 Alaska seismicity summary*, ScholarWorks@UA, 23 pp, http://hdl.handle.net/11122/12683.

Ruppert, N. A., N. P. Kozyreva, and R. A. Hansen (2012), Review of crustal seismicity in the Aleutian Arc and implications for arc deformation, *Tectonophysics, 522-523*, 150-157, doi: 10.1016/j.tecto.2011.11.024.

Appendix A: Data availability for broadband stations from the AK network.

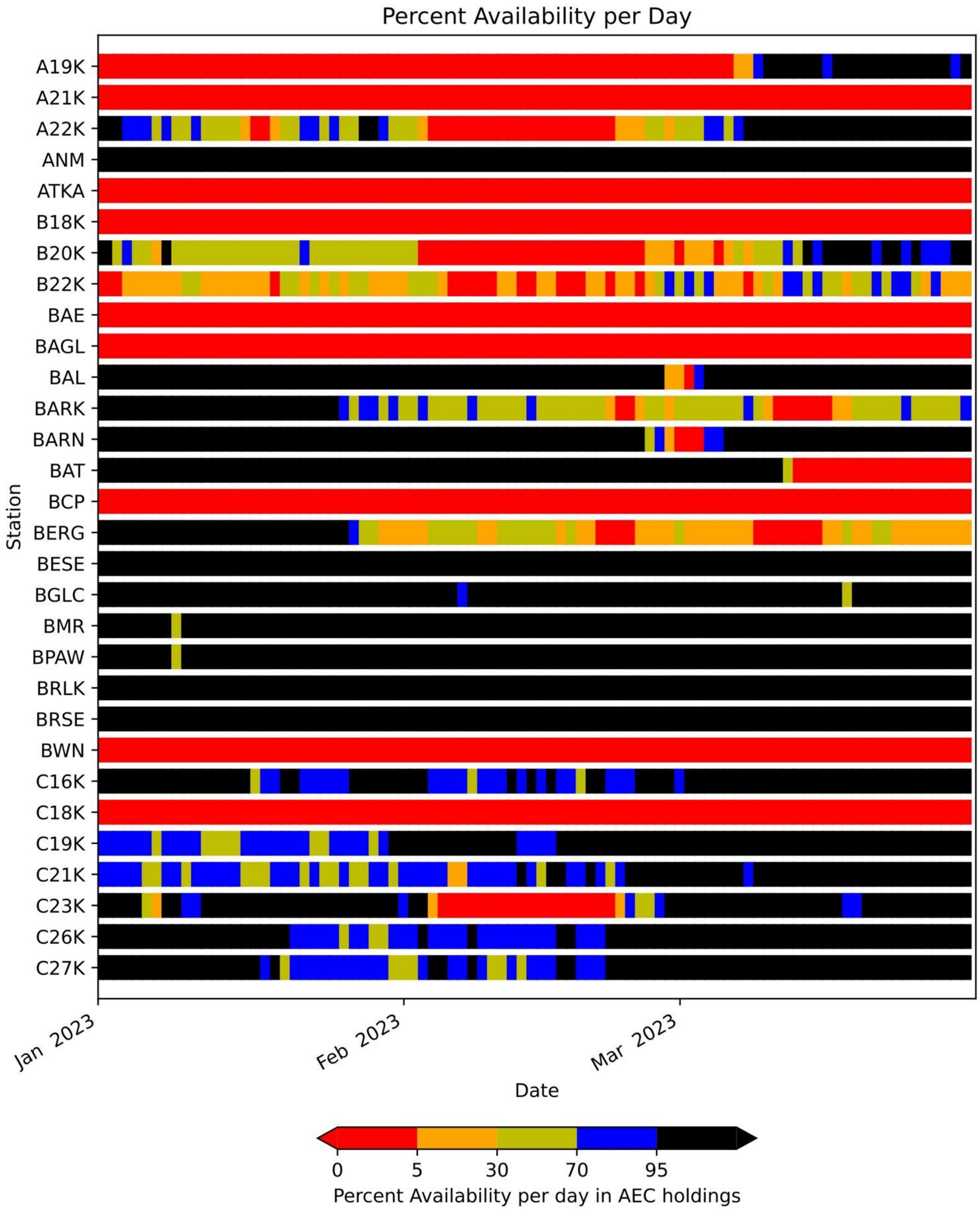


***Figure A1**. Data availability for stations A19K-C27K (listed alphabetically).*

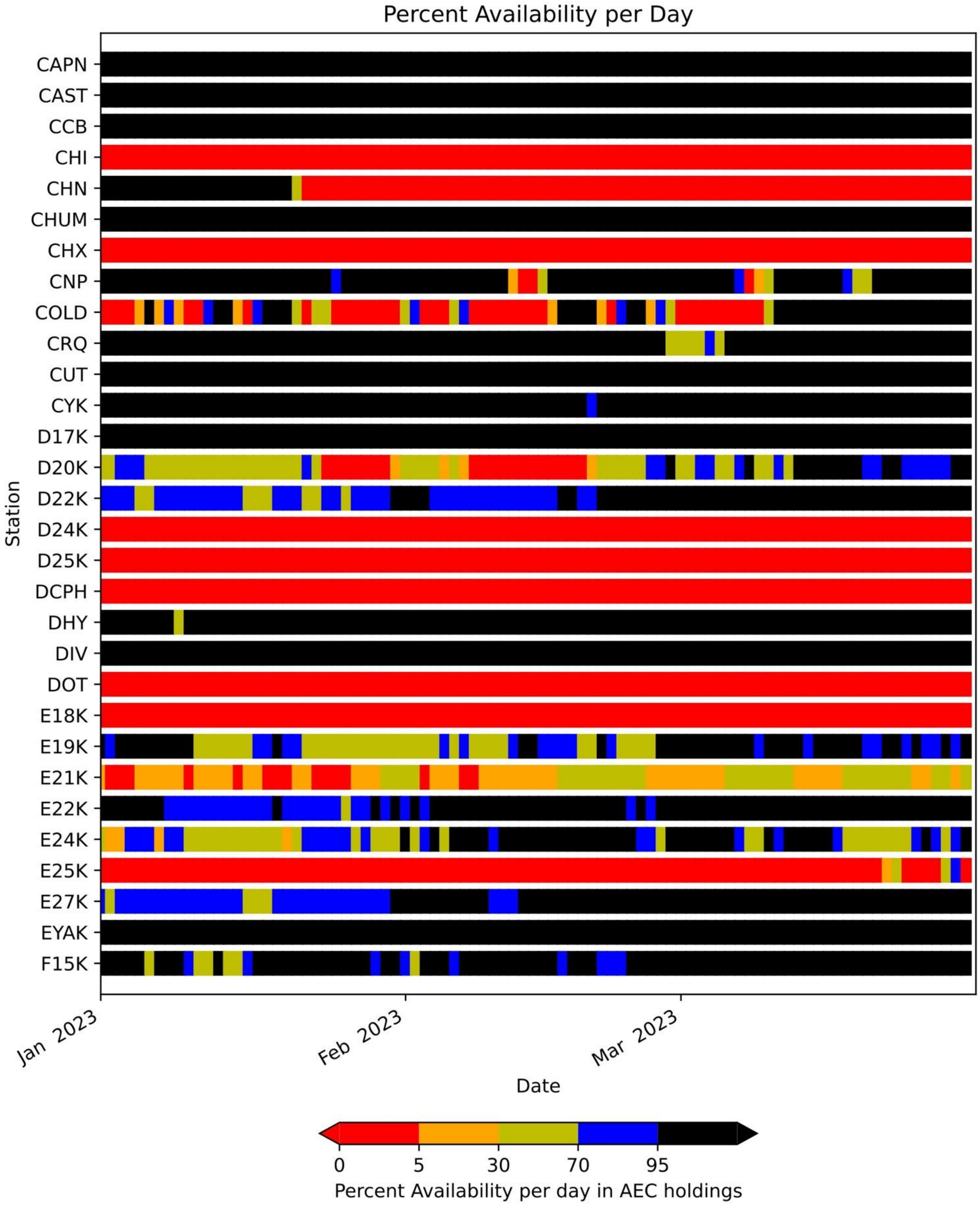


***Figure A2**. Data availability for stations CAPN-F15K (listed alphabetically).*

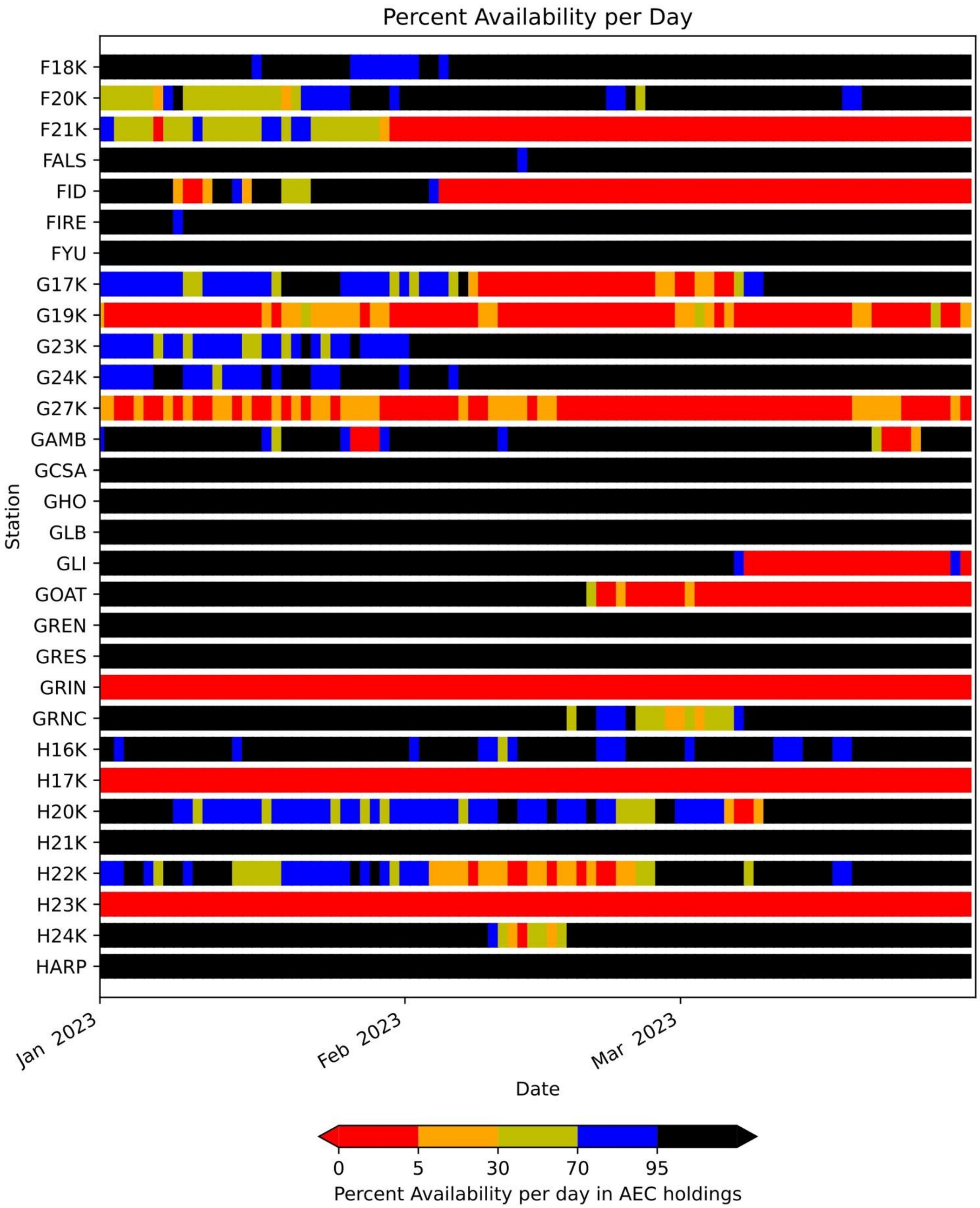


Figure A3. *Data availability for stations F18K-HARP (listed alphabetically).*

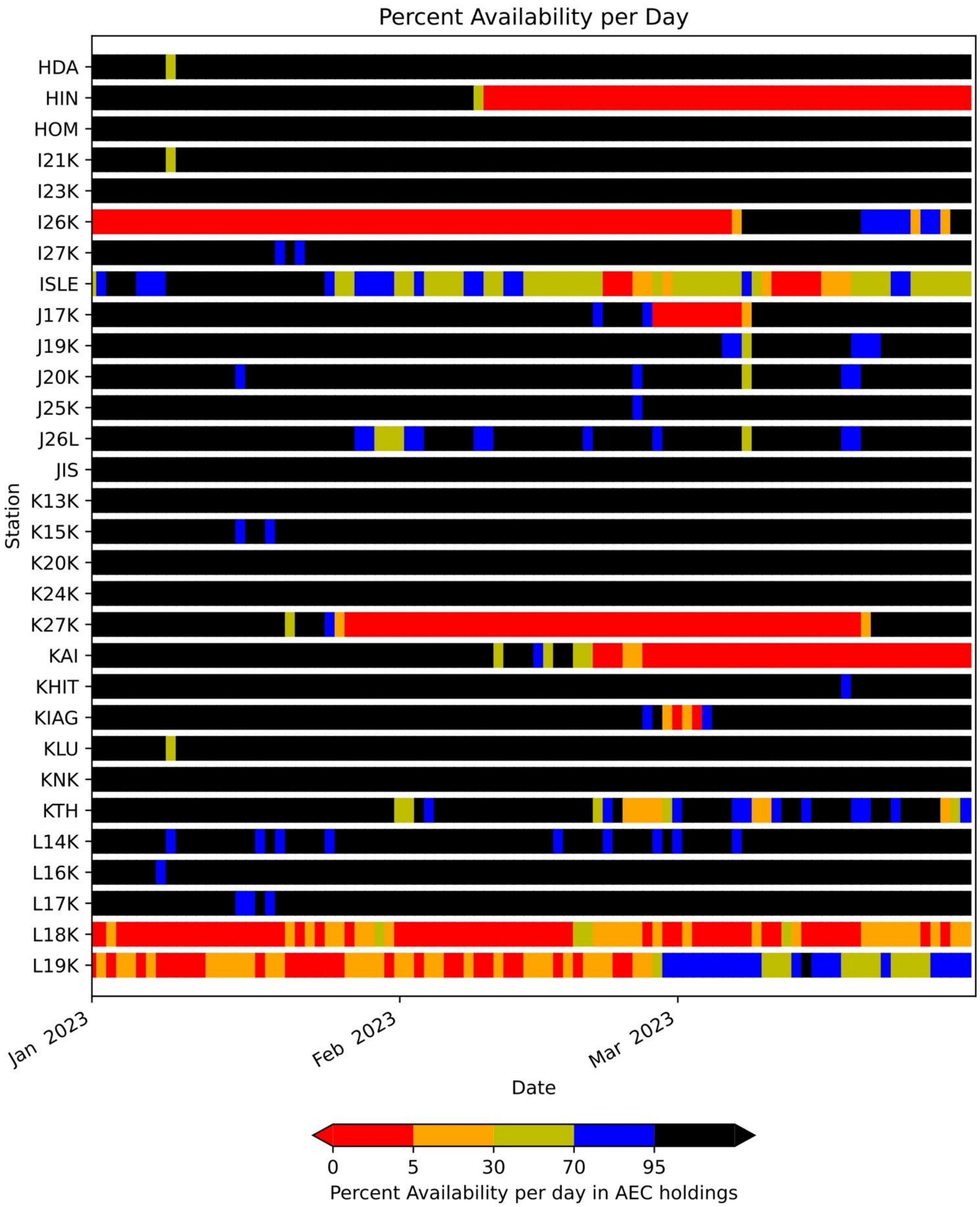


***Figure A4**. Data availability for stations HDA-L19K (listed alphabetically).*

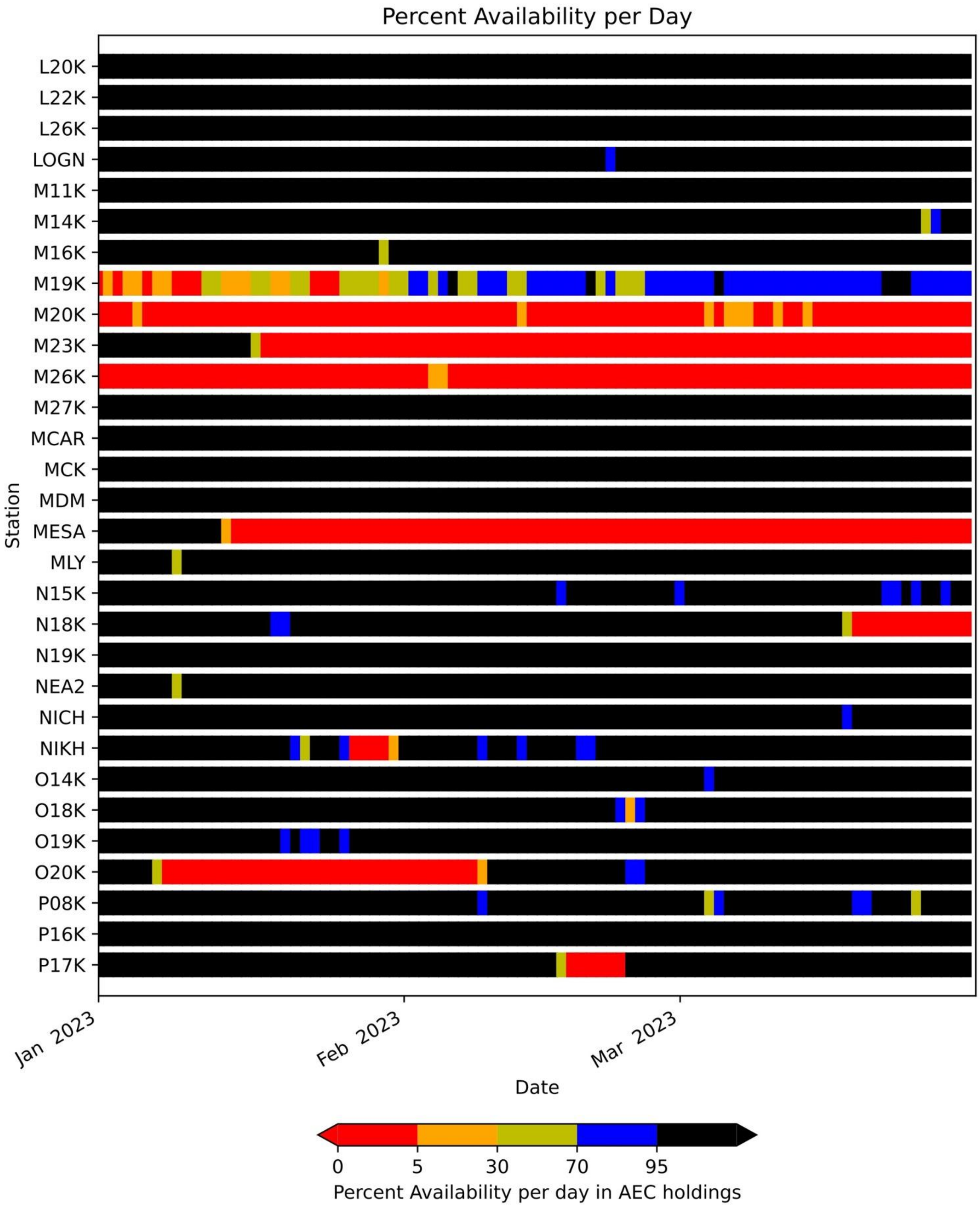


***Figure A5**. Data availability for stations L20K-P17K (listed alphabetically).*

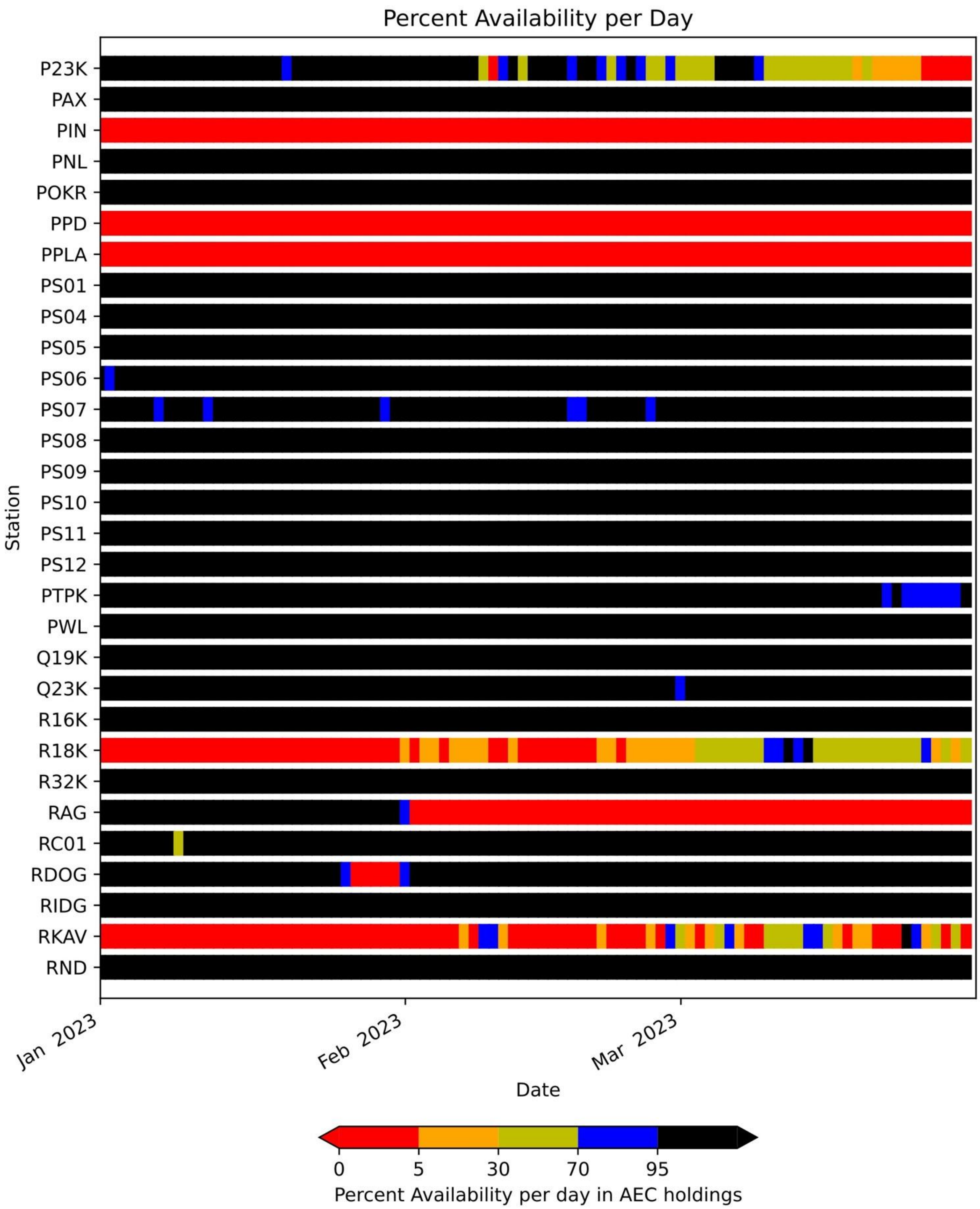


***Figure A6**. Data availability for stations P23K-RND (listed alphabetically).*

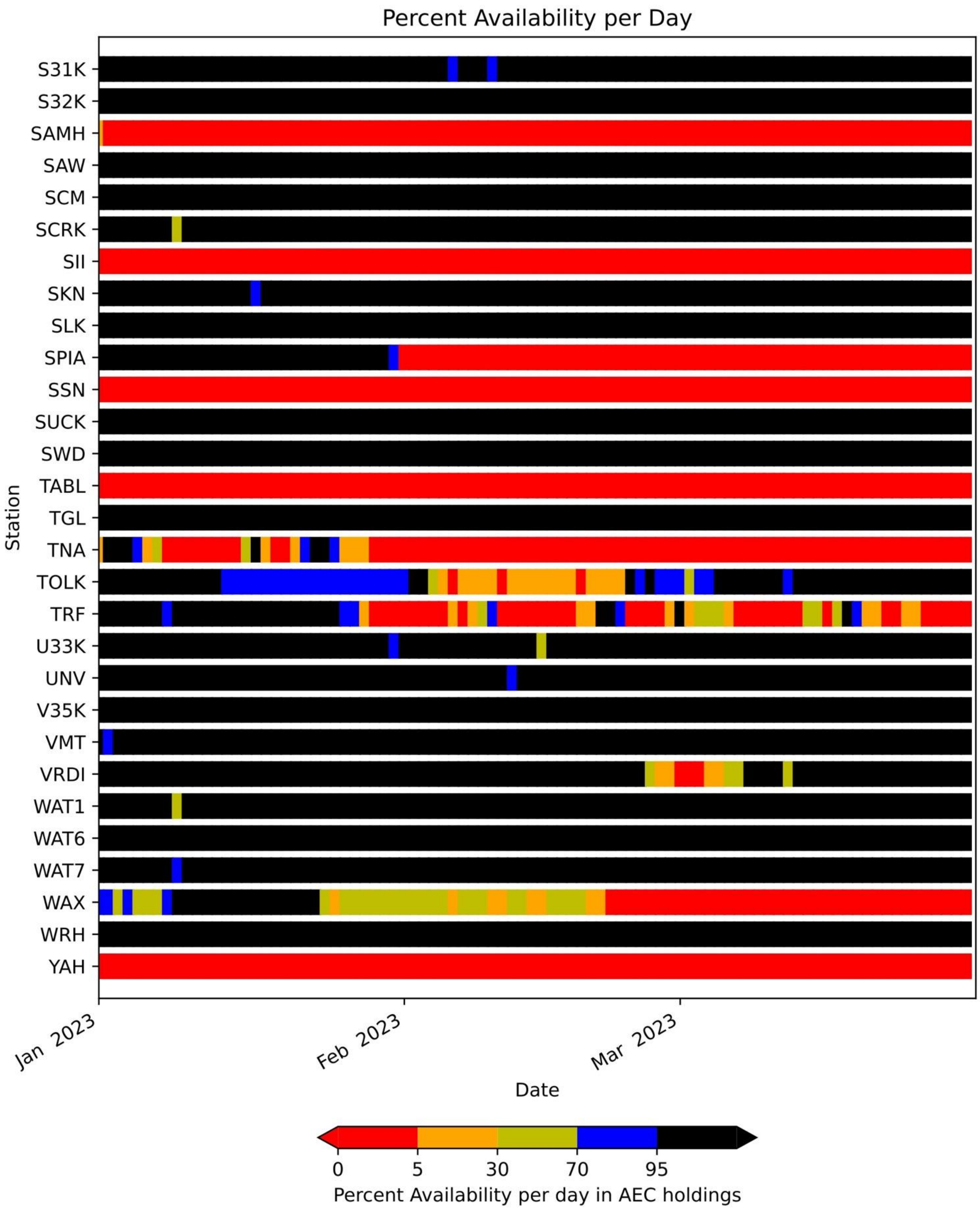


***Figure A7**. Data availability for stations S31K-YAH (listed alphabetically).*

Appendix B: Gaps for broadband stations from the AK network.

***Figure B1**. Number of gaps per day[1] for stations A19K-C27K (listed alphabetically).*

[1] Stations with 0% data availability are denoted in the same color as stations with 0 gaps.

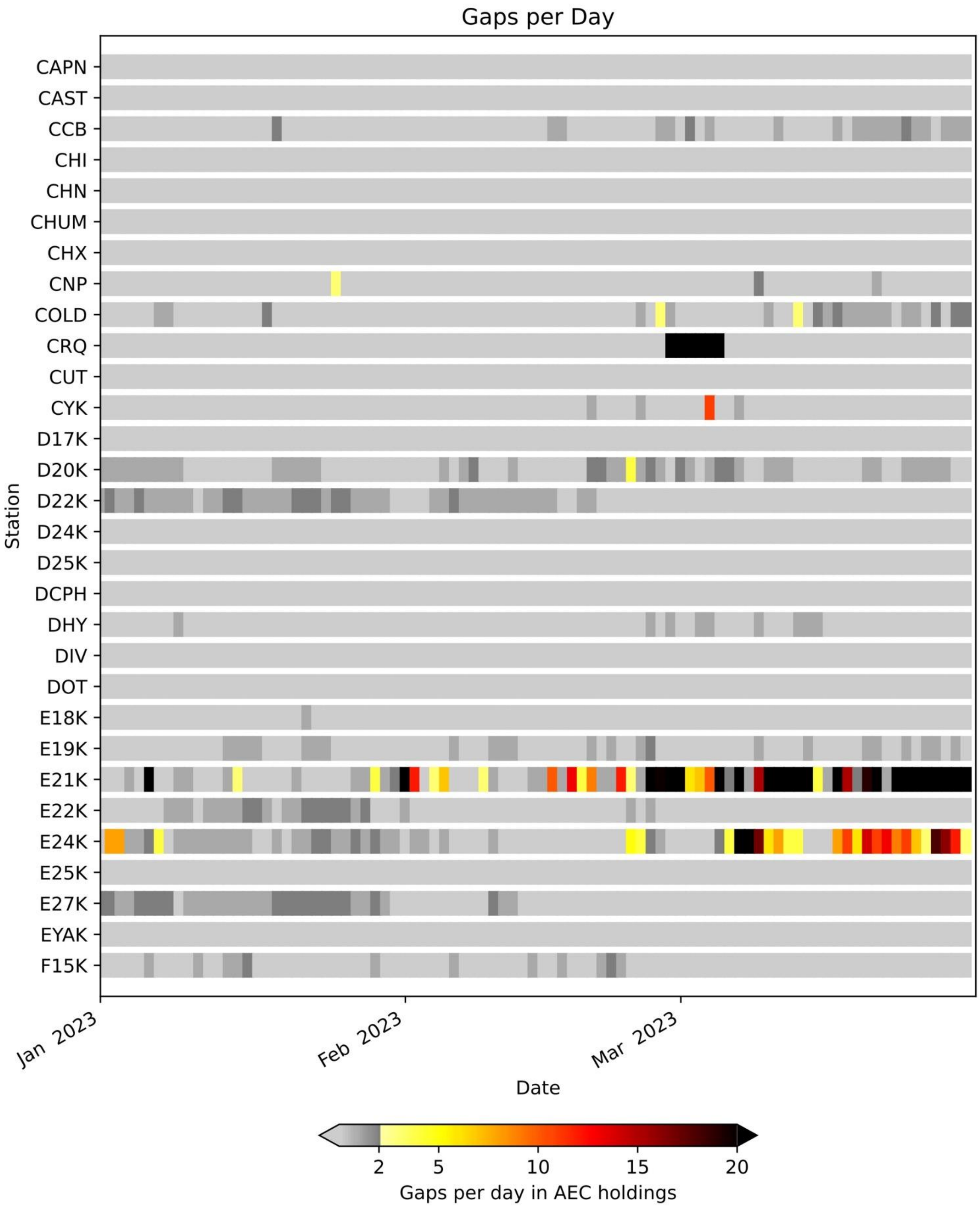


Figure B2. *Number of gaps per day for stations CAPN-F15K (listed alphabetically).*

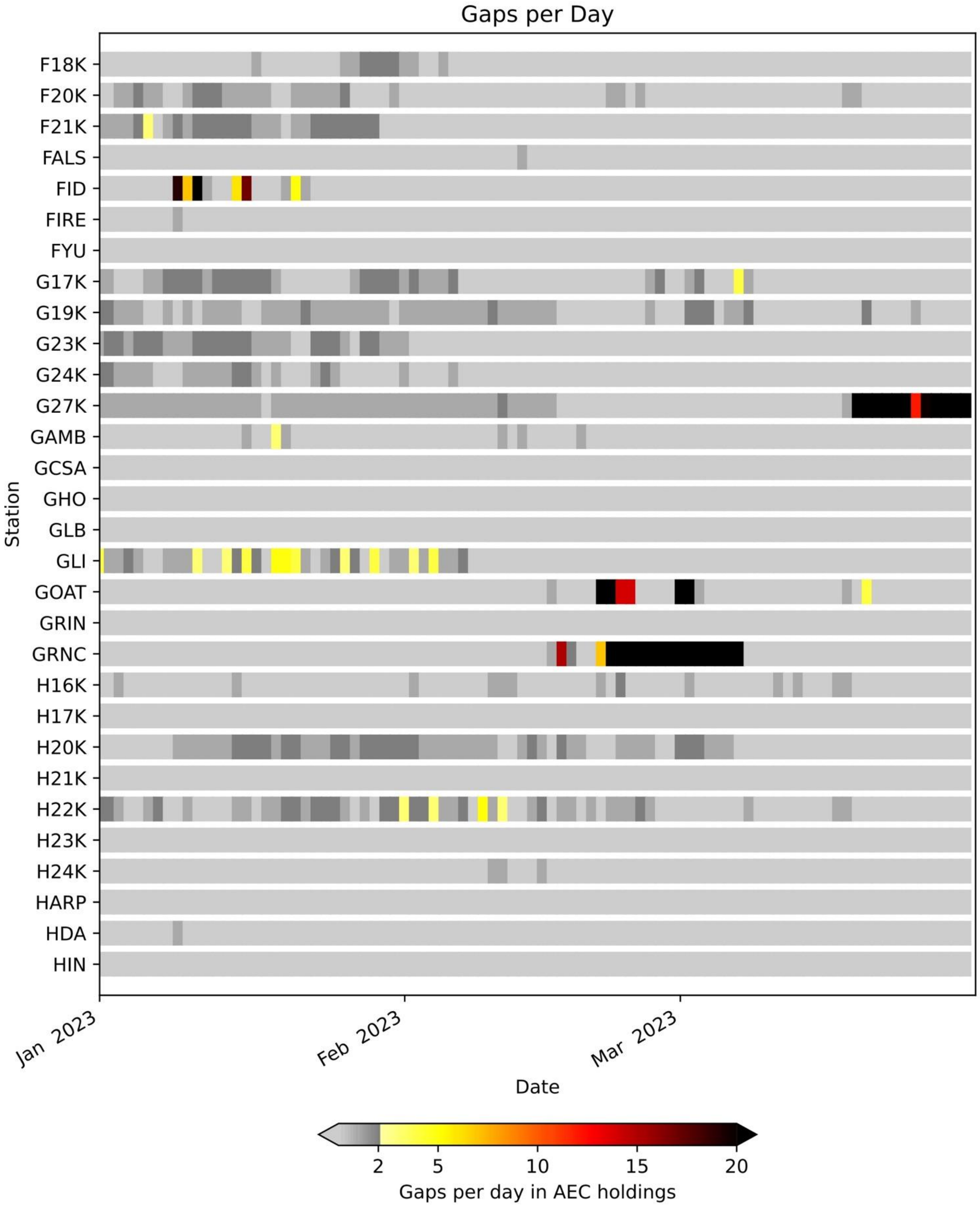


***Figure B3**. Number of gaps per day for stations F18K-HIN (listed alphabetically).*

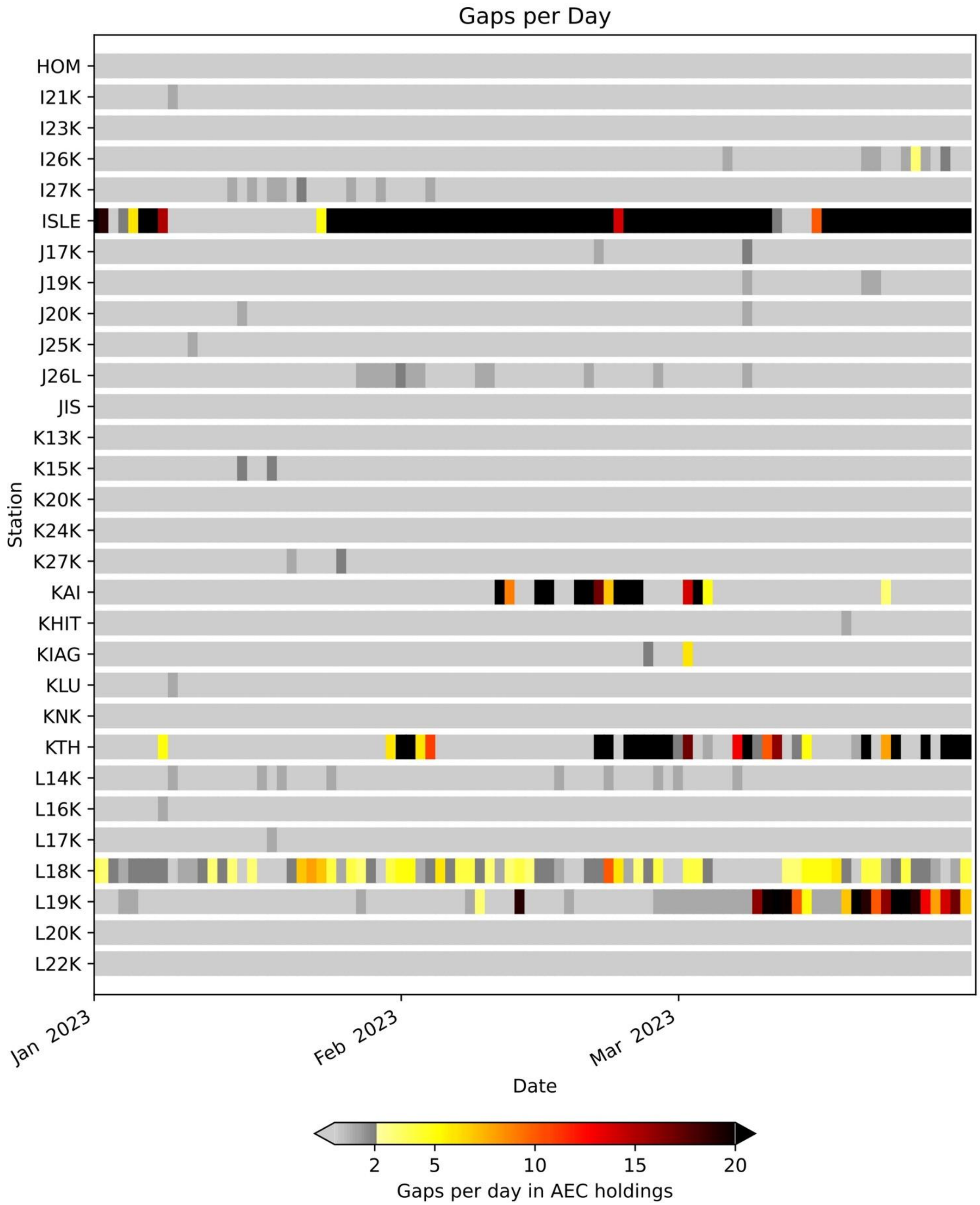


***Figure B4**. Number of gaps per day for stations HOM-L22K (listed alphabetically).*

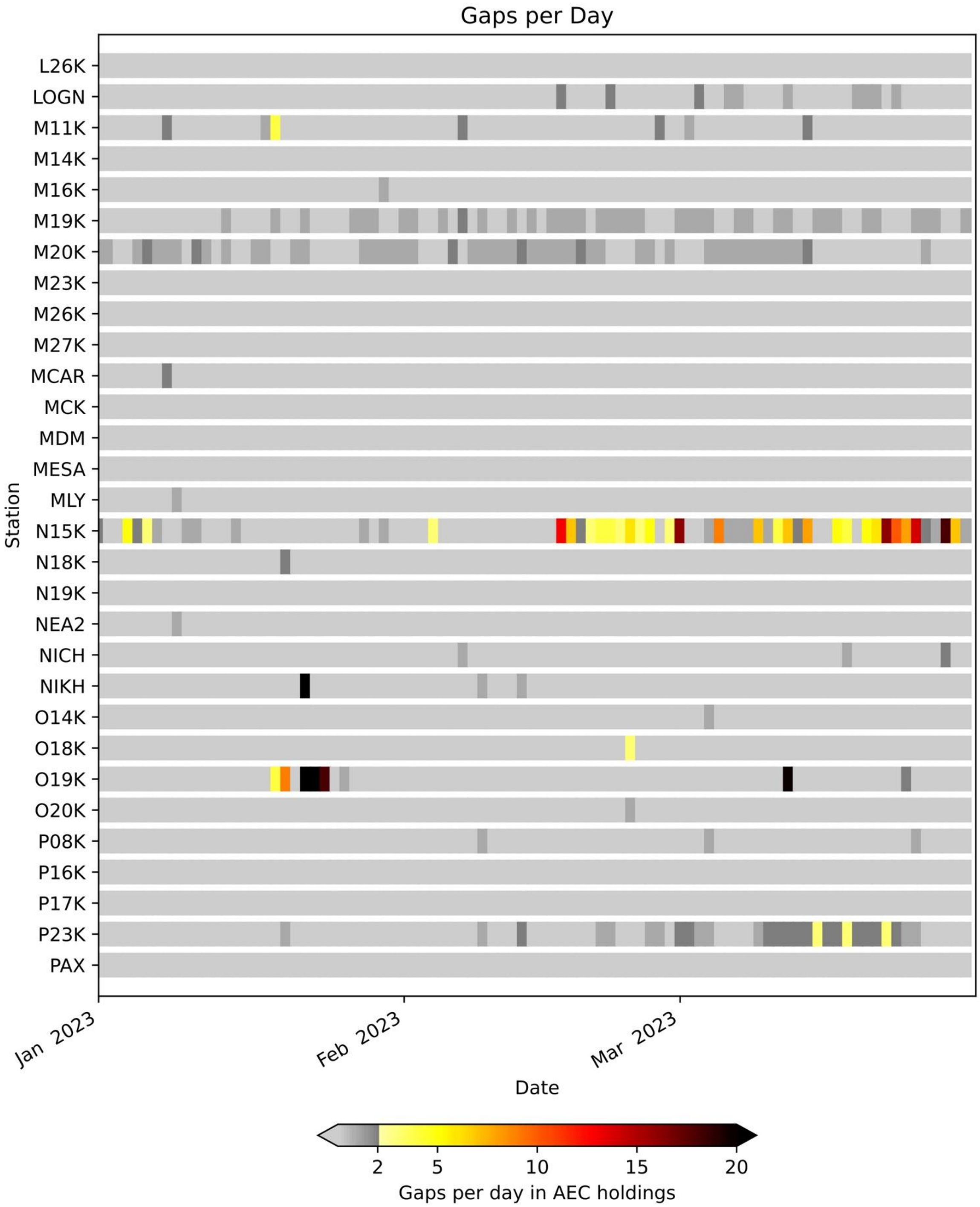


***Figure B5**. Number of gaps per day for stations L26K-PAX (listed alphabetically).*

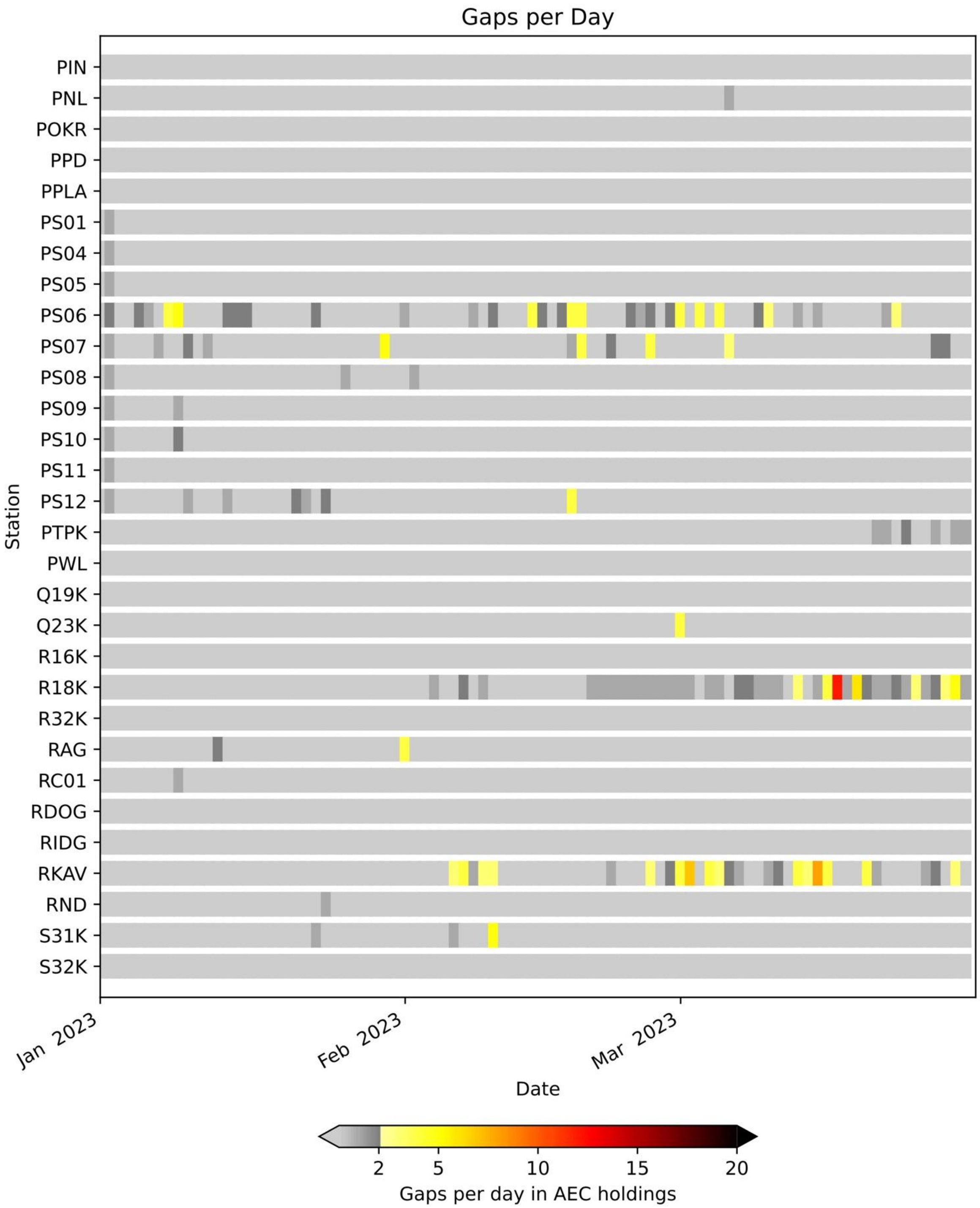


Figure B6*. Number of gaps per day for stations PIN-S32K (listed alphabetically).*

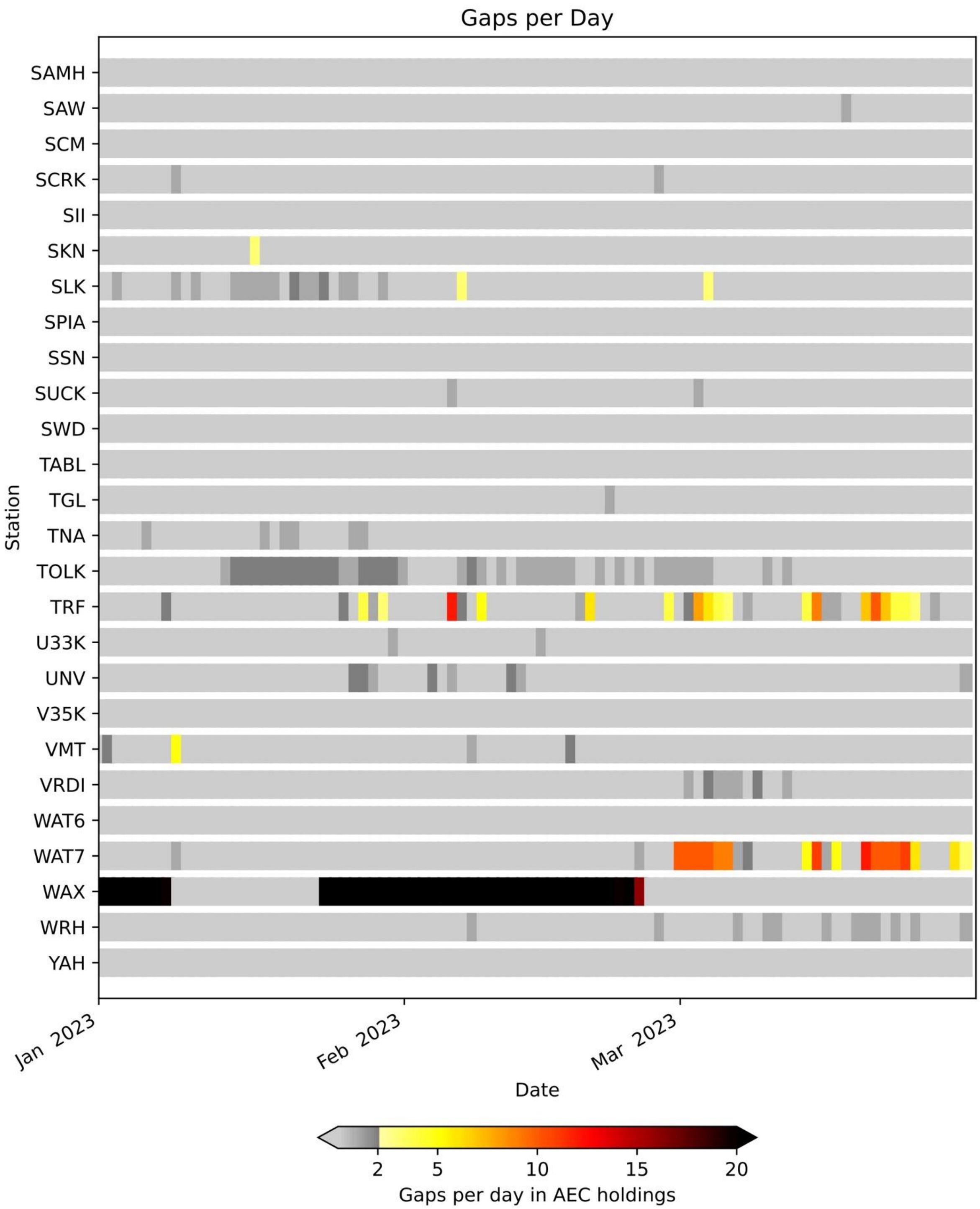


Figure B7. *Number of gaps per day for stations SAMH-YAH (listed alphabetically).*