Alaska Earthquake Center Quarterly Technical Report July-September 2022

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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 July 1 and September 30, 2022 we reported 11,121 seismic events in the state and the neighboring regions (Figure 2.1), with depths ranging between 0 and 274 km and magnitudes between 0.3 and 5.4. The largest earthquake of Mw=5.4 occurred on July 4 at 9:17:43 UTC 28 km east of St. George Island in the Bering Sea region. Eight more earthquakes had magnitudes 5.0-5.3, only one of which was located in mainland Alaska: M5.0 on September 29 at 23:08:10 UTC 111 km northwest of Yakutat. Overall, we reported about 121 events per day, or one event every 12 minutes on average. This is slightly less than in the previous quarter (Ruppert et al., August 2022).

AEC data analysts picked and cataloged 349,636 seismic phases, 228,644 of which were P-phase and 120,992 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 2.2).

We reported 499 seismic sources that were classified as something other than regional tectonic earthquakes. Of these, 90 were suspected quarry blasts (magnitudes M=0.3-1.7), the majority of which were located in the vicinity of Fort Knox and Healy mines in Interior Alaska, with the exception of one blast located along the Richardson Highway north of Delta Junction. The reported events included 295 icequakes (magnitudes M=0.5-3.0), primarily located in the Prince William Sound, Icy Bay, and Yakutat Bay areas. Also, a glacial swarm near Wright Glacier northeast of Juneau became more active in late August and once again in late September. This is twice as many icequakes as in the first quarter, but slightly less than in the second quarter of 2022 (Ruppert et al., May 2022, August 2022). This is typical seasonal behavior, with glacial activity increasing in spring and summer months. We characterized 100 quakes as seismic events associated with volcanic activity (M=0.3-3.1). The remaining 24 events were classified as “other” type (M=0.8-2.5). Two of these were confirmed landslide events, on September 15 on the Kenai Peninsula and September 19 in the Glacier Bay National Park region.

There were 53 earthquakes reported as felt (magnitudes M=2.0-5.4), one of which was located in Southeast Alaska, about ten in the Interior, three in the Aleutian Islands, one in the Kodiak Island region, one in the Pribilof Islands, one on the Seward Peninsula, and the remainder in the Southcentral region of Alaska. The largest number of DYFI (Did You Feel It) responses, 767, came from the M4.8 earthquake that occurred in upper Cook Inlet on July 12 (https://earthquake.usgs.gov/earthquakes/eventpage/ak0228vb1a7q/dyfi/intensity).

The seismicity rate remained at a steady pace, with no notable increases (Figures 2.3, 2.4). 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. See Table 1 for a summary.

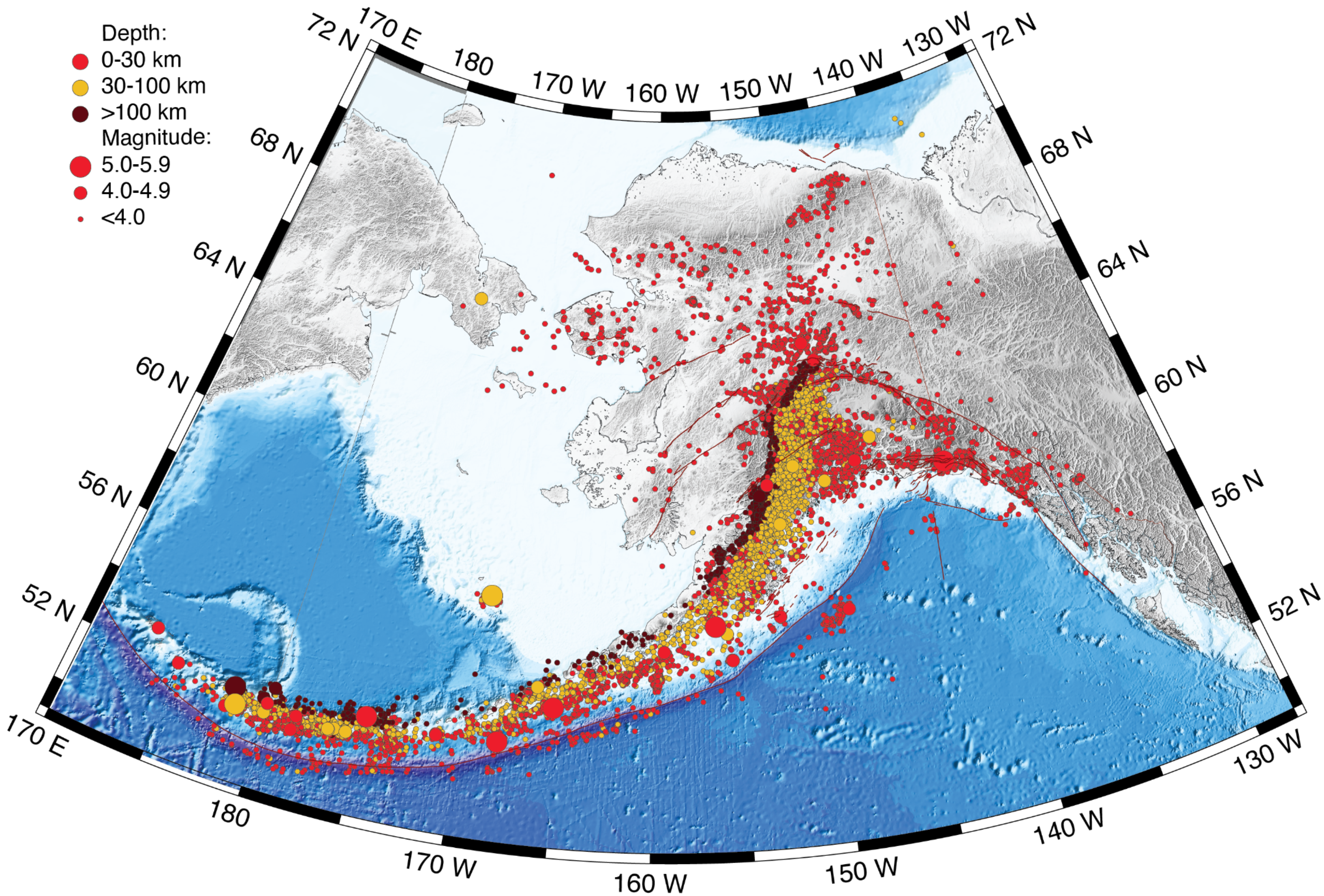
We continued to follow several processing changes that were implemented in January 2022 to accommodate staffing shortages and to decrease processing time lag. Beginning with mid-December 2021 data, only earthquakes with magnitude about 0.8 and greater were analyzed and cataloged; smaller events detected 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.

Table 2.1. *Notable Alaska seismic sequences in July-September, 2022. **

Earthquake	**Number of events**	**Magnitude range**	**Magnitude of completeness (Mc)**	**Number of events per week**
New sequences this quarter				
July 4 M5.4 St. George Island	40	2.5-5.4	2.8	N/A
Wright Glacier Swarm	97	0.9-2.8	1.6	N/A
Continuing sequences (in order of decreasing activity)				
2020 M7.8 Simeonof	454	1.0-4.0	1.8	35
2018 M7.1 Anchorage	214	0.8-2.8	1.1	16
July 29 M8.2 Chignik	89	1.6-4.9	2.3	7
Purcell Mountains Swarm	65	0.8-2.2	1.1	5

* The 2018 M6.4 Kaktovik and 2018 M7.9 Offshore Kodiak earthquake aftershock sequences decreased to less than 1 event per day on average and are no longer being tracked in the summary table. Also, this is the first time that activity in the Purcell Mountains Swarm and Chignik aftershock zone fell below 1 event per day.

Figure 2.1. *Earthquake map for Alaska and neighboring regions July-September, 2022.*



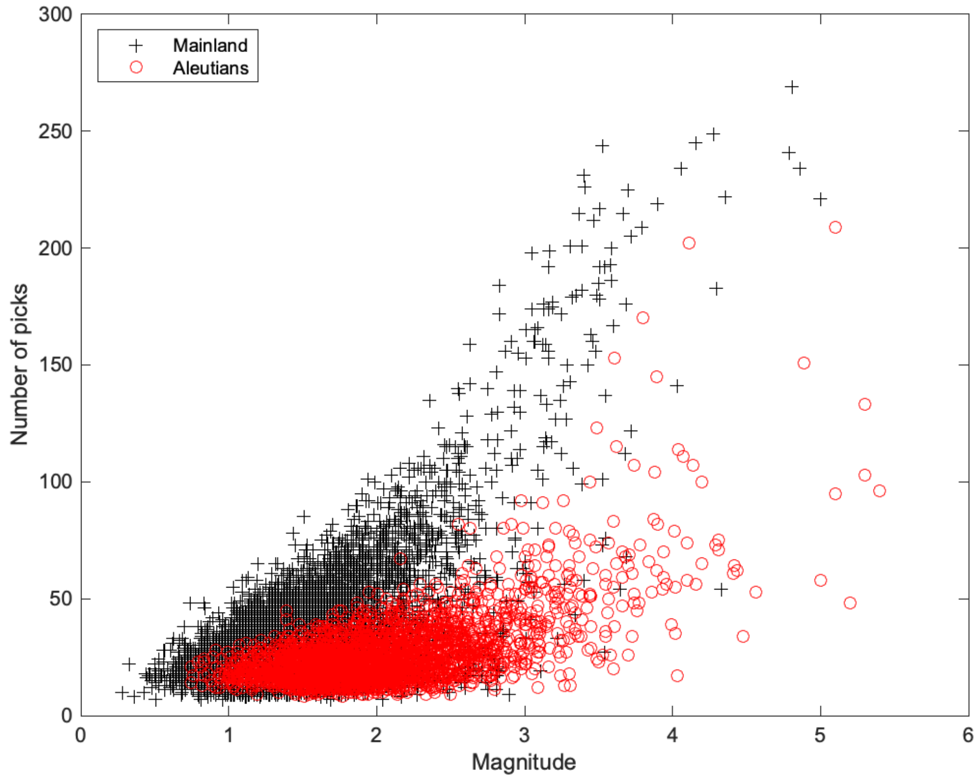


Figure 2.2. *Phase picks depending on magnitude and region for July-September, 2022.*

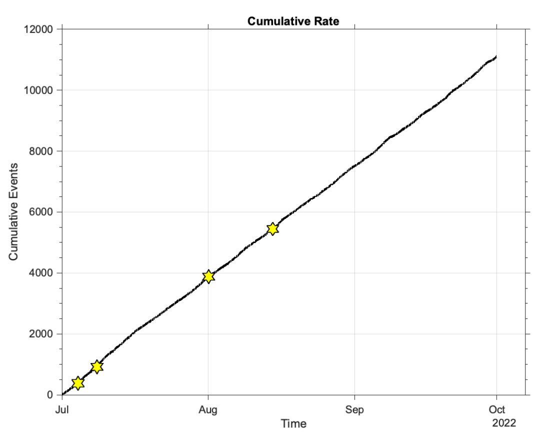


Figure 2.3. *Cumulative number of seismic events in the Alaska catalog for July - September, 2022. Yellow stars indicate earthquakes with magnitudes 5.2 or greater.*

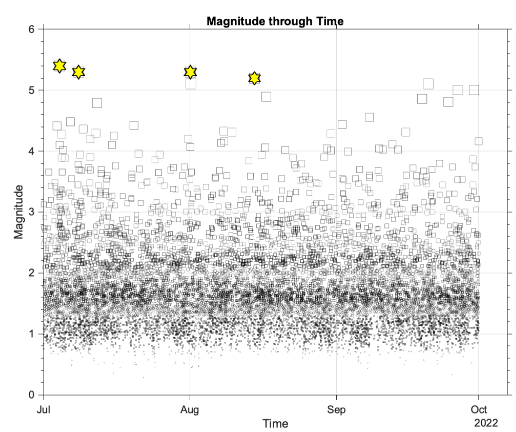


Figure 2.4. *Time-magnitude plot of seismic events in the Alaska catalog for July - September, 2022. Yellow stars indicate earthquakes with magnitudes 5.2 or greater.*

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

On July 4 a magnitude 5.4 earthquake occurred at 9:17:43 UTC 28 km east of St. George Island in the Bering Sea region (Figures 2.5, 2.6, and 2.7). We recorded about 40 aftershocks with magnitudes ranging between 2.5 and 4.1, most of which occurred within 3 days of the mainshock. Due to the lack of seismic stations in the region, only events with magnitudes about 3 or above can be reliably detected and located. A similar sequence occurred in the same location in January-February 2015. The normal faulting source mechanism for the mainshock is typical for events that occur along the continental shelf in this region.

Activity in the Wright Glacier Swarm northeast of Juneau began in mid-May and further accelerated in late June and late August (Figures 2.8 and 2.9). The largest recorded earthquakes reached magnitude 2.8-2.9 level. This cluster is known to become more active in the summer and the level of activity varies from year to year. The summer 2022 level of activity is very similar to what occurred in 2021 (Rupert et al., August 2021; Ruppert and Gardine, February 2022).

Both aftershock sequences of the 2020 M7.8 Simeonof and 2021 M8.2 Chignik Earthquakes remained active, but at further decreased levels compared to earlier in 2022 (Ruppert et al., May 2022, August 2022). The Chignik aftershock sequence remains far less active than the longer-lasting Simeonof sequence. We reported about 454 Simeonof and 89 Chignik aftershocks for this quarter. Magnitude of completeness of both sequences slightly improved this quarter due to field maintenance and improved network performance in summer months. For the first time since we began tracking these sequences, there were no aftershocks over magnitude 5 for the entire quarter. The Simeonof aftershock sequence is now in its third year and the Chignik sequence in its second (Ruppert and Gardine, February 2021, February 2022).

The 2018 M7.1 Anchorage Earthquake aftershock sequence continued at a decreased rate compared to earlier in 2022, with about 214 events reported (Ruppert et al., May 2022, August 2022). The largest aftershock this quarter was only M2.8. The aftershock sequence is in its fourth year (Ruppert and Gardine, February 2021, February 2022).

The Purcell Mountains Swarm activity continued at much decreased rates compared to the 2021 level or the previous quarter, with about 65 total events recorded this quarter, with magnitudes between 0.8 and 2.2 (Ruppert et al., May 2022; Ruppert and Gardine, February 2021, February 2022). Performance of the nearest seismic station G19K became intermittent in July, which compromised detection of smaller events in the swarm. This caused a slight increase in magnitude of completeness.

We continue to record aftershocks in the 2018 M6.4 Kaktovik and M7.9 Offshore Kodiak sequences, both at much decreased rates of less than 1 reported event per day (Ruppert and Gardine, February 2021, February 2022).

Starting in July, we observed a slight increase in activity in the northeastern Brooks Range region. This area at times produces area-wide swarm-like activity that lasts for a couple of months, typically in summer time (Ruppert and West, 2020; Ruppert and Gardine, February

2021, February 2022). This swarm will be documented in more detail in the annual Alaska seismicity report.

We also located three confirmed landslides: two on September 15 at 5:01 and 5:07 UTC on the Kenai Peninsula, located at 60.2824N and 149.1574W and equivalent to M2.1 and M1.4 earthquakes (Figure 2.10); and one on September 19 at 10:42 UTC in the Glacier Bay National Park area in southeast Alaska, located at 58.6934N and 136.6224W and equivalent to a M1.9 earthquake (Figure 2.11).

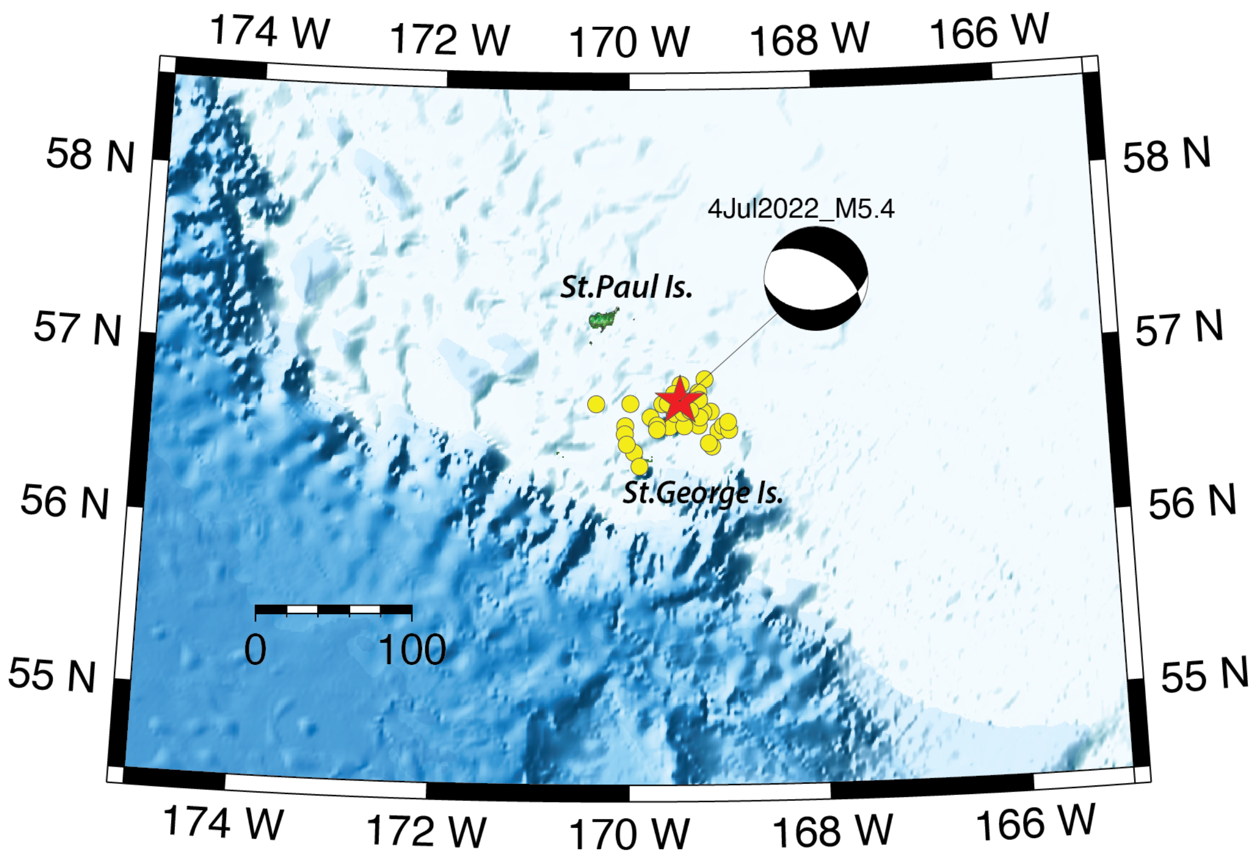


***Figure 2.5**. Earthquake location map for the M5.4 July 4, 2022 earthquake in the Pribilof Islands. Yellow circles are recorded aftershocks. The nearest seismic station is located on St. George Island (AK.P08K). The seismic site located on St. Paul Island (AK.SPIA) was inoperable at the time of this sequence. Focal mechanisms are from the Global CMT catalog.*

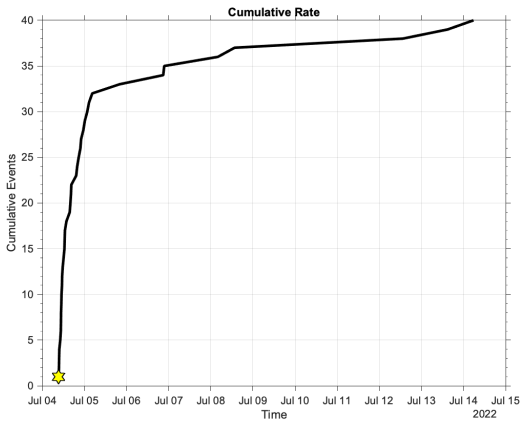


***Figure 2.6**. Cumulative number of events in the vicinity of the M5.4 July 4, 2022 earthquake in the Pribilof Islands. Star indicates the M5.4 mainshock.*

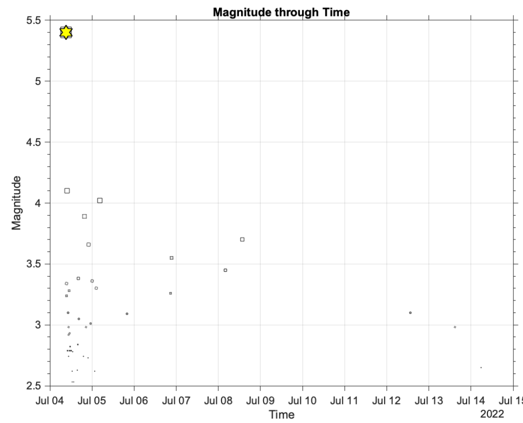


***Figure 2.7**. Time-magnitude plot of events in the vicinity of the M5.4 July 4, 2022 earthquake in the Pribilof Islands. Star indicates the M5.4 mainshock.*

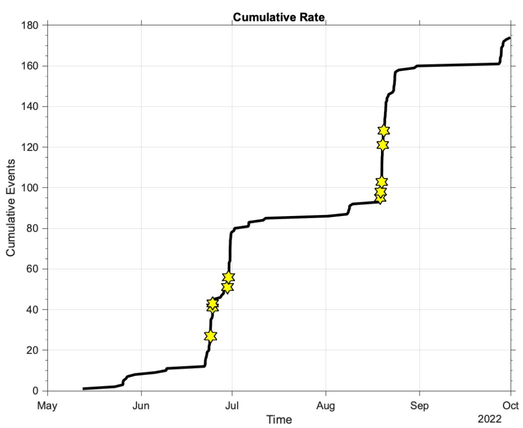


***Figure 2.8**. Cumulative number of events in the Wright Glacier Swarm between May and September, 2022. Stars indicate earthquakes with magnitudes between 2.7 and 2.9.*

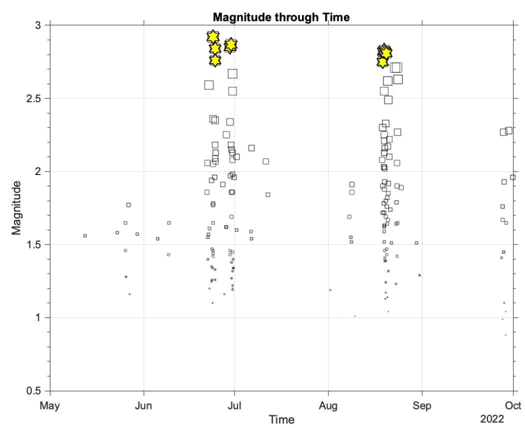


***Figure 2.9**. Time-magnitude plot of events in the Wright Glacier Swarm between May and September, 2022. Stars indicate earthquakes with magnitudes between 2.7 and 2.9.*

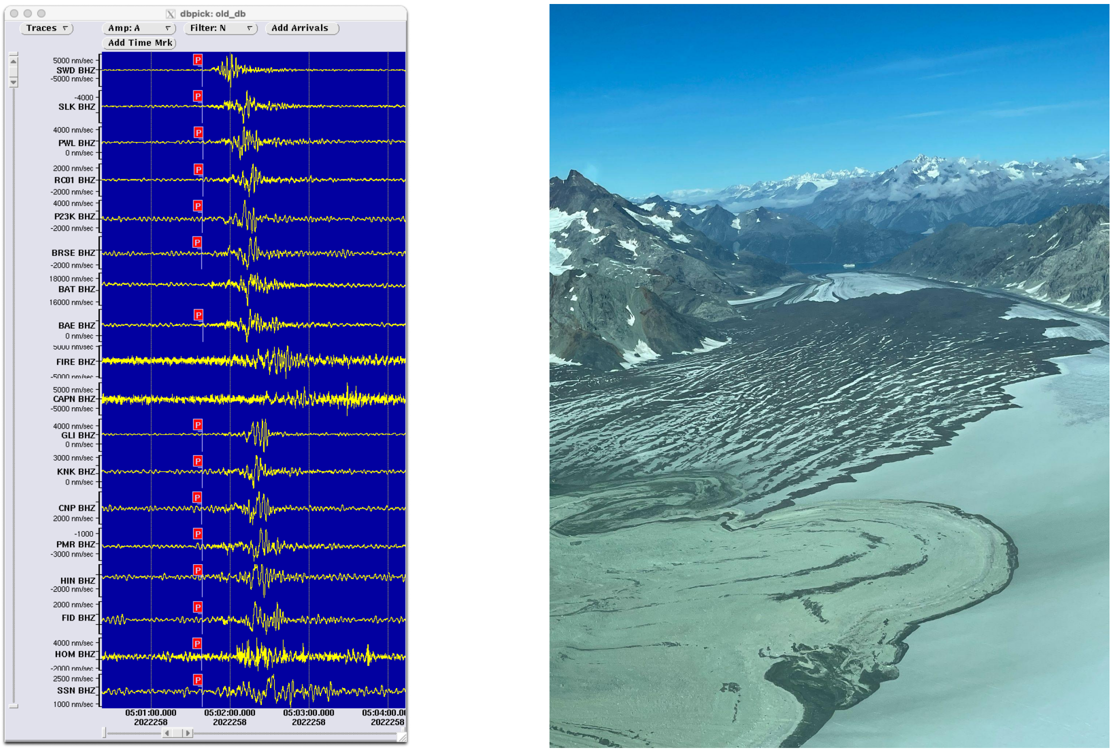


Figure 2.10. *Unfiltered landslide waveforms (left panel) and landslide deposit (right panel) that occurred on September 15, 2022 near Seward on the Kenai Peninsula.*

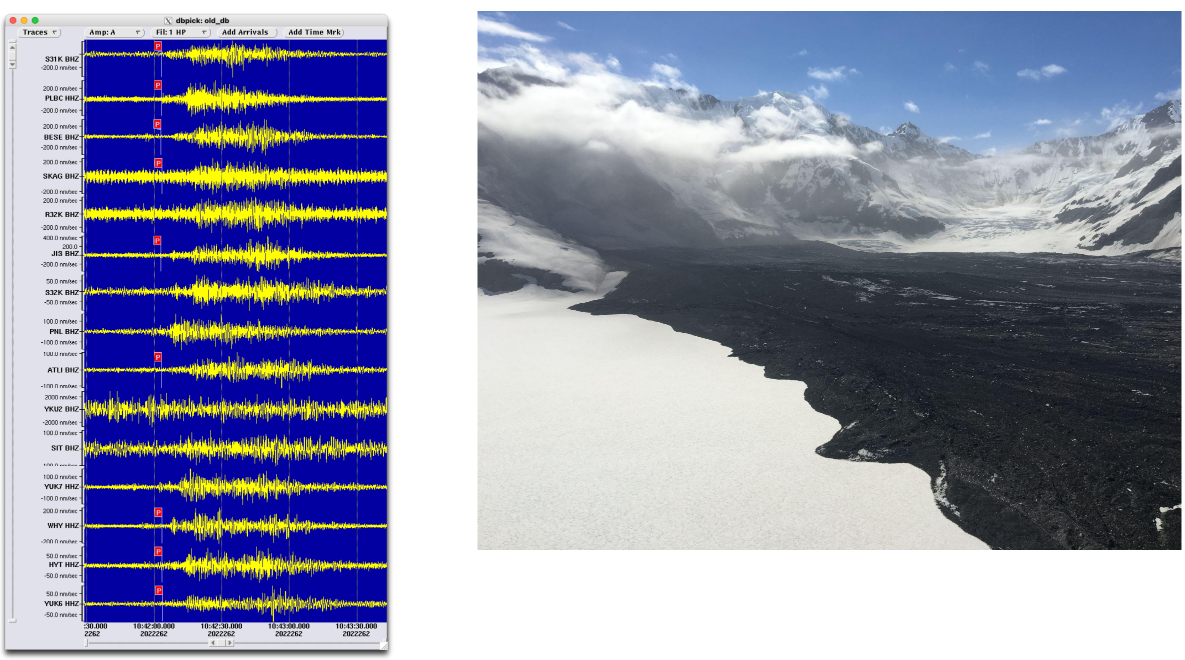


Figure 2.11. *Filtered landslide waveforms (left panel) and landslide deposit (right panel) that occurred on September 19, 2022 in the Glacier Bay National Park region in Southeast Alaska.*

3. Field network

As of September 30, 2022, AEC maintains and acquires data from 253 seismic sites of the AK seismic network (see map in Figure 3.1 of Ruppert et al., May 2022). 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;
- 23 strong motion sites in the greater Anchorage and Mat-Su Valley region;
- 8 strong motion sites in Fairbanks;
- 7 strong motion sites located in coastal communities from Chignik to Yakutat;
- 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 July 1 and September 30, the network had an average data return rate of 80.8%, with the daily rates ranging from 73.8% to 85.1% (Figures 3.1 and 3.2). There were no impactful data hub outages during this quarter. Overall performance continued to improve due to ongoing field maintenance efforts, however it was still lacking and below marks of the previous five years.

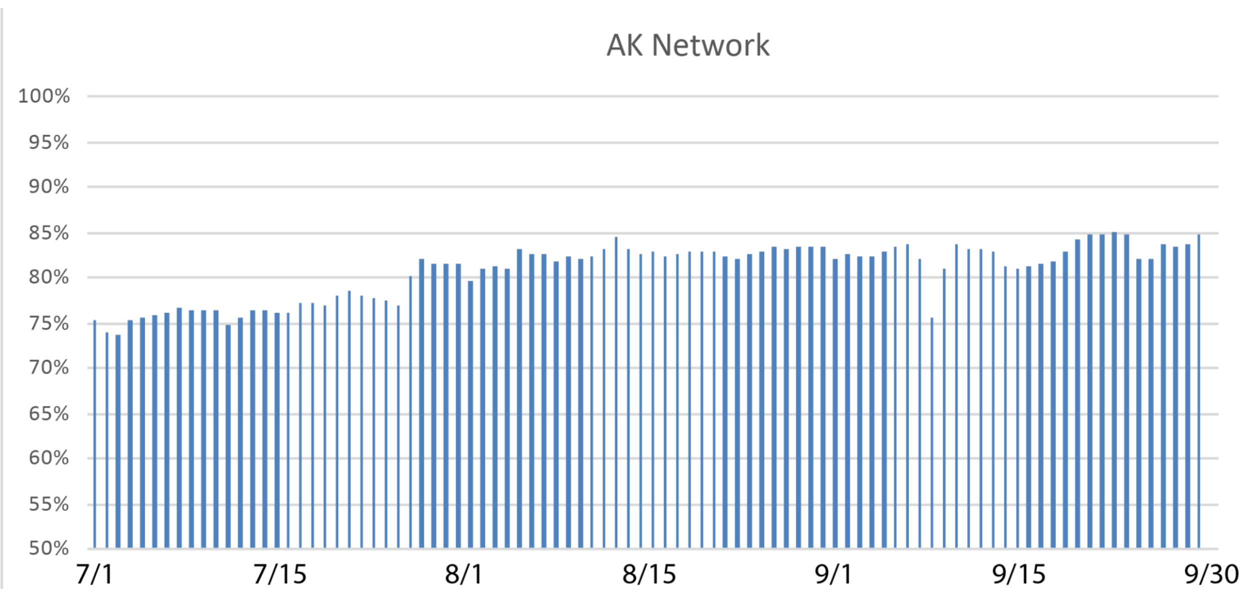


Figure 3.1. *Daily data completeness in percent for AK network in July-September 2022.*

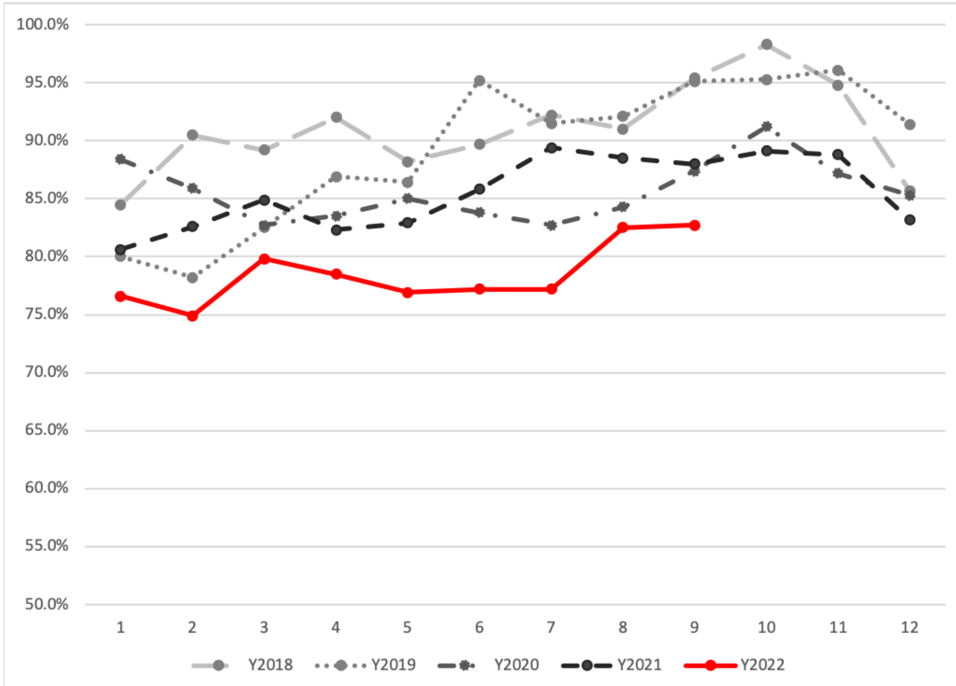


Figure 3.2. *Average monthly data completeness in percent for AK network 2018-2022.*

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 July 1 - September 30, 2022 (also see Figure 4.1):

- Stations that continue to have 0% availability as compared to 2022 Q2: BWN, C18K, CHX, D25K, DCPH, E25K, FA02, GIB, K203, K216.00, K221, K223, L16K, MDM, O20K, SPIA, TNA, YAH, YAKA.
- Stations that now have 0% as compared to 2022 Q2: B18K, DOT, FA09, TRF, U33K.
- Stations that continue to have 1-50% availability as compared to 2022 Q2: BAGL, BARK, CHI, E18K, E21K, ISLE, KTH, L18K, SII, TRF.
- Stations that now have 1-50% availability as compared to 2022 Q2: A21K, CYK, FYU, G19K, K220, K27K, M20K, MS02, PPD.
- Stations that came back during 2022 Q3 but still had 1-50% availability for the entire period: BCP, D24K, O19K, PIN, PPLA, PWL, SLK.
- BB data quality issues caused by faulty sensors and/or dataloggers: PS01 (BHN channel), PS07 (all channels), PS09 (all channels).
- SM data quality issues caused by faulty sensors and/or dataloggers: PS07 (all channels)
- 1 site now has bad timing (no reliable GPS clock): S19K.
- Stations that have come back to above 50% availability since 2022 Q2 due to field maintenance or on their own: BAE, BERG, BGLC, BRSE, COLD, CRQ, DAM1, FID, GAMB, GRIN, HIN, I26K, KHIT, L22K, MESA, NICH, P23K, PNL, R18K, RKAV, SAMH, SUCK, TABL, WAX.

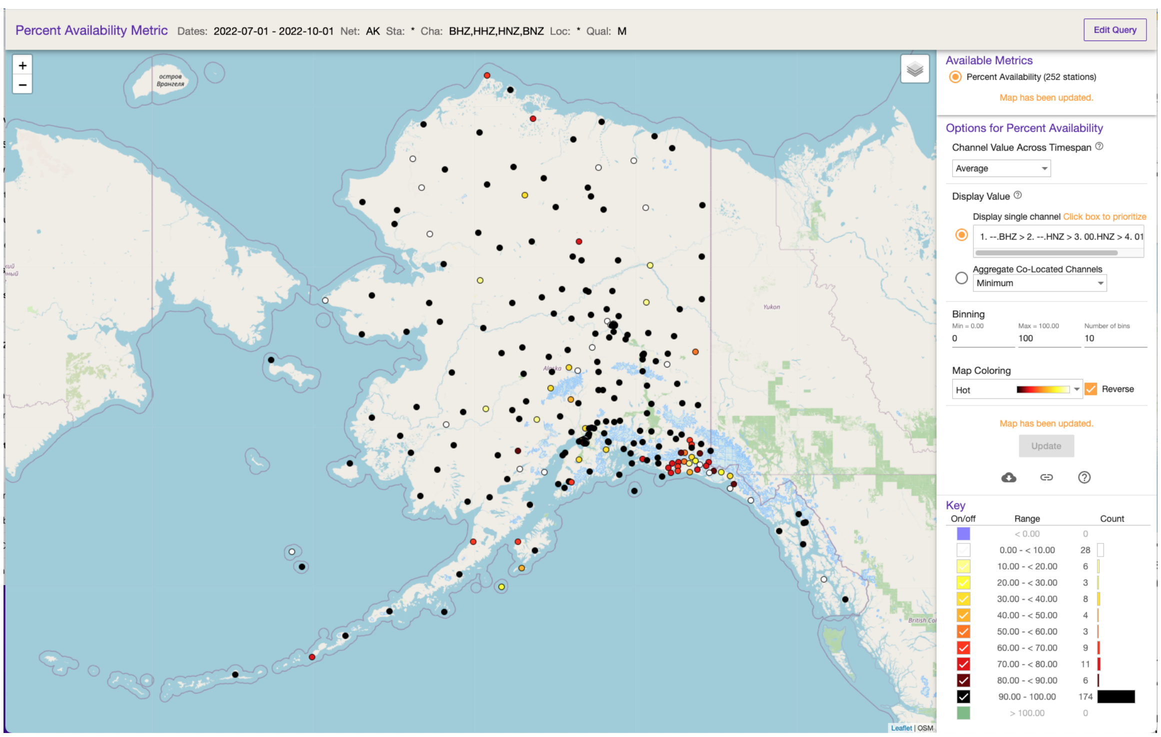


Figure 4.1. *Map of average percent availability for all AK network broadband and strong motion stations for July 1-September 30, 2022. Black circles represent stations at 90-100% availability, white circles represent stations at 0-10% availability. Other colors represent a gradient of availability.*

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 April 7th through July 6, 2022.

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. Second quarter of 2022 was significantly better, confirming our hypothesis that harsh winter weather conditions were to blame for instrument failures. By June, 74% of stations were reporting data availability over 90%, compared to only 25% of stations in February. The third quarter of 2022 was stable, with 73% of stations reporting over 90% data availability from July through September. The September record is incomplete, since acquisition was shut off for three days in response to an earthquake. The data for these days exists on a virtual machine, but has not yet been merged back into the main database.

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. The real-time earthquake locations and magnitudes are determined within 2-5 minutes of the event occurrence, depending on the event location and size.

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. This performance evaluation project is still in its initial testing stages; we expect it to evolve in future quarterly reports. See Table 2 for detailed information on some of the current metrics.

During the July-September 2022 time period we reported 7,889 automated events in Alaska and neighboring regions (Figure 5.1). This is 4% fewer detections than in the previous quarter. September 6, 2022 had the highest number of detections. July 14, August 8, and August 29 had several events with longer detection delays but recovered fairly quickly (Figure 5.2). Nevertheless, these delays are observed in higher mean values for those days. August 17 had some slight delays in magnitude calculations, but were still well within the ANSS standard of 2 minutes (Figure 5.3).

There were 32 earthquake alarms during this reporting period. Our goal is to have duty-seismologist-reviewed solutions for alarm events within 20 minutes. Only 2 alarm events were reviewed with a larger delay (Figure 5.5).

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

Metric	July	August	September
Number of automatic event detections	2,641	2,497	2,751
First origin latency below ANSS 2 min standard	72%	77%	74%
Number of automatic events with magnitudes	2,271	2,160	2,336
Percent origins with magnitudes	86%	86%	85%
First magnitude latency below ANSS 3 min standard	43%	50%	49%
Magnitude latency from origin post time below ANSS 2 min standard	98%	99%	99%
Events deleted by duty seismologist	12%	9%	16%
Magnitude of completeness	1.3	1.3	1.3
Number of earthquake alarms	10	11	11
Number of ShakeMaps	46	31	23
ShakeMap latency below ANSS 15 min standard	83%	97%	83%

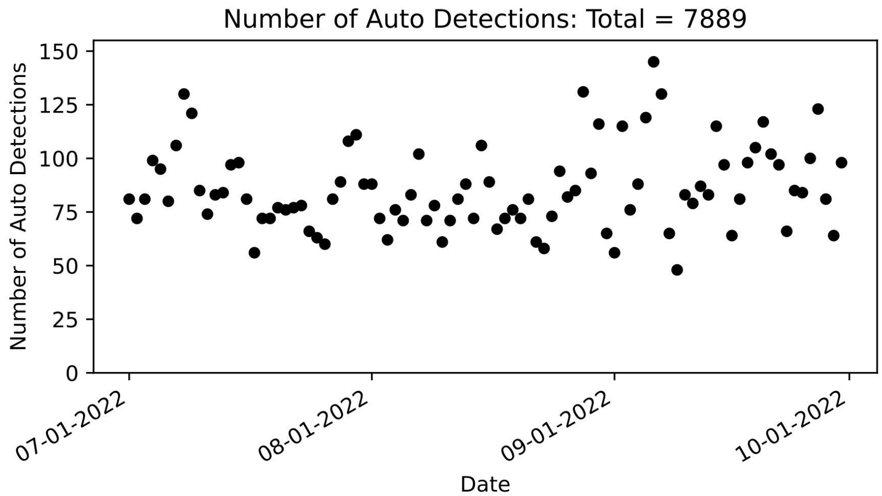


Figure 5.1. *Number of automatic event detections for each day. September 6, 2022 had the highest number of detections.*

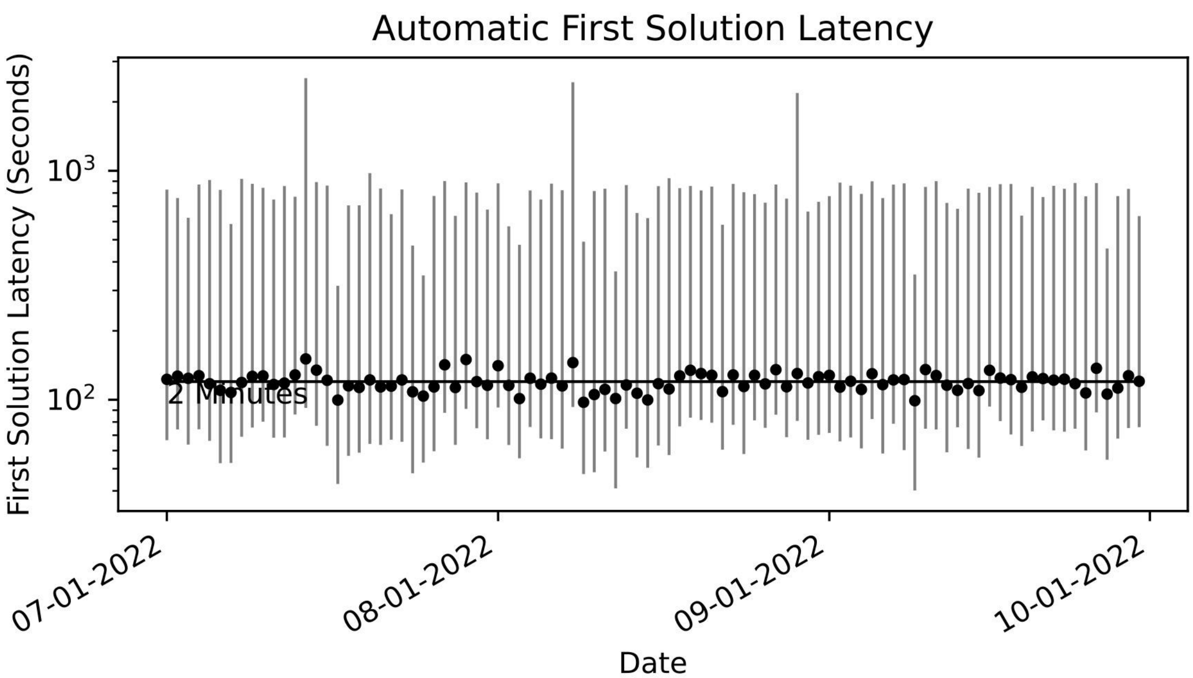


Figure 5.2. *Average daily latency (dots) and range (lines) of first automatic solution for each event. July 14, August 8, and August 29 had several events with longer detection delays but recovered fairly quickly.*

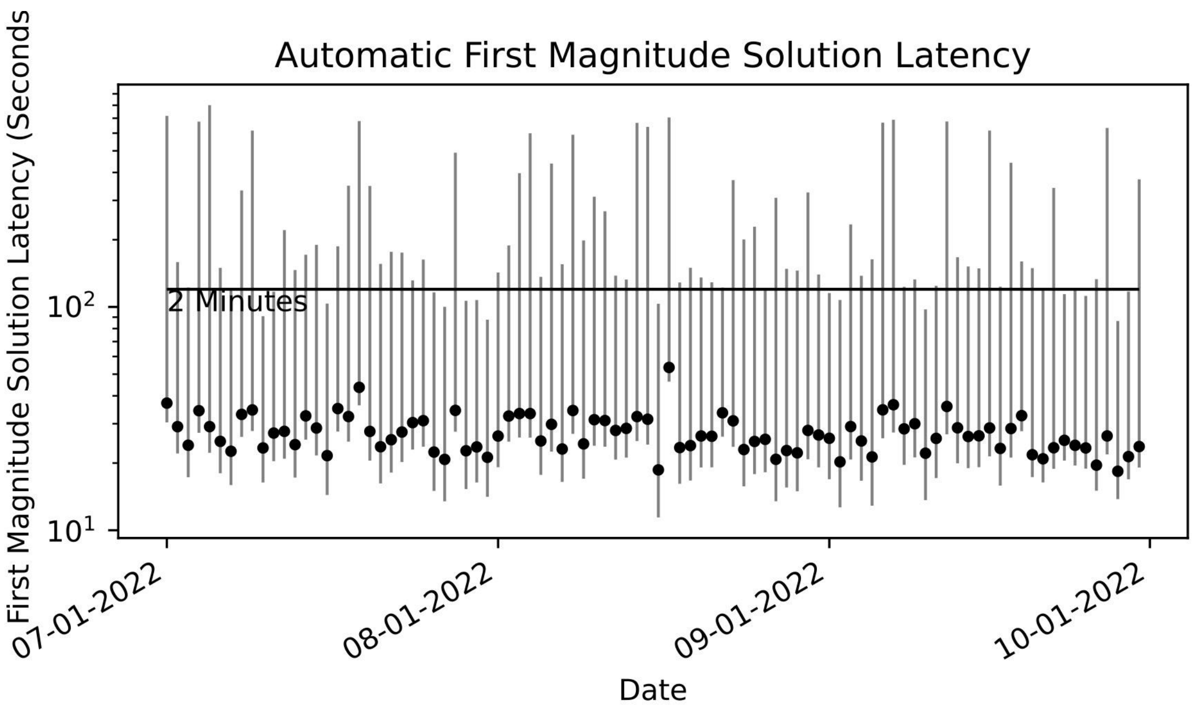


Figure 5.3. *Average daily latency (dots) and range (lines) of first automatic magnitude for each event after the event detection.*

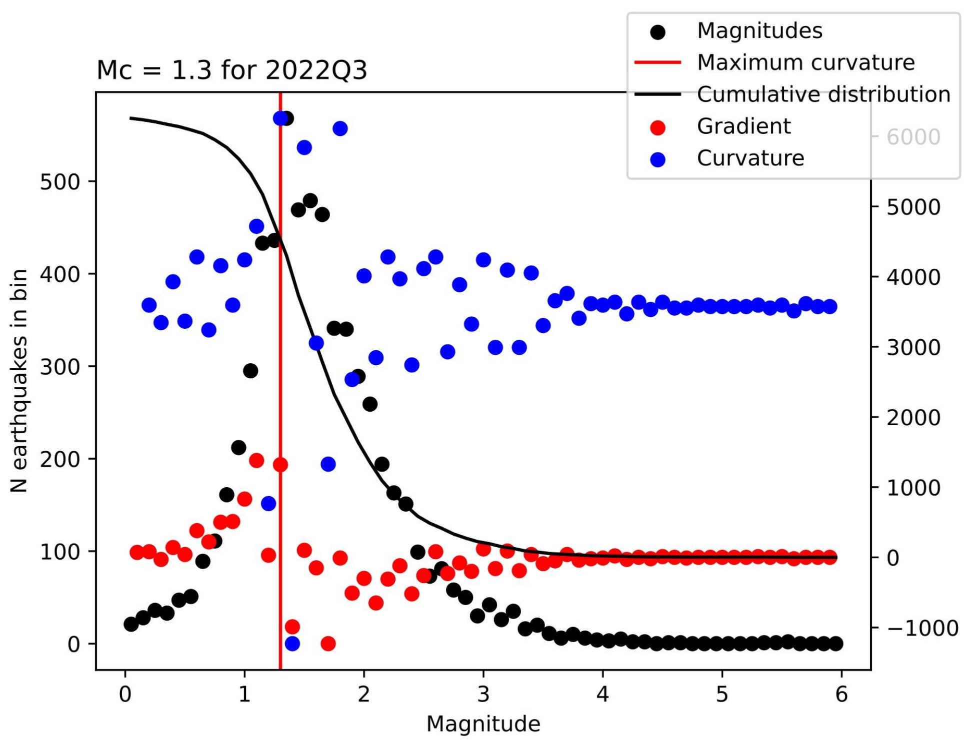


Figure 5.4. *Magnitude of completeness of the automatic catalog for the reporting time period.*

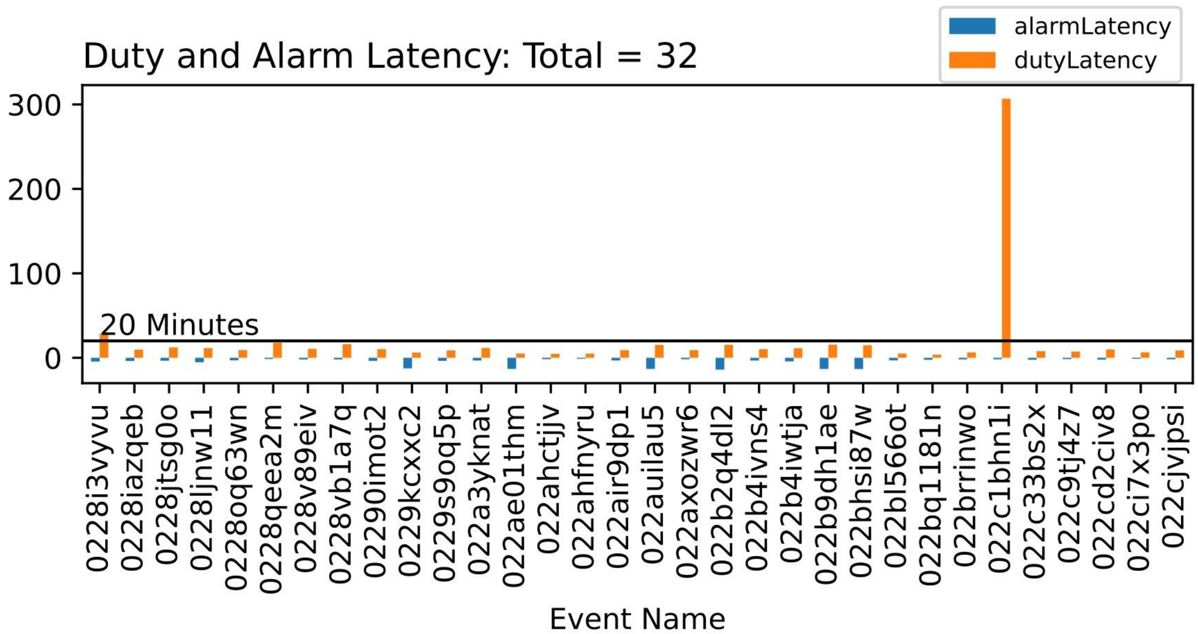


Figure 5.5*. Earthquake alarm and duty review latency from alarm time (bottom of the blue bar is origin time, top of the orange bar is duty review post time, 0 is time of the alarm). Earthquakes are labeled with their event names.*

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.

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	0	21	6	46	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 60.6 TB in continuous waveform data and 1.1 TB of segmented data. During the quarter, we acquired and archived 1.05 TB of new data (Figure 6.2.1).

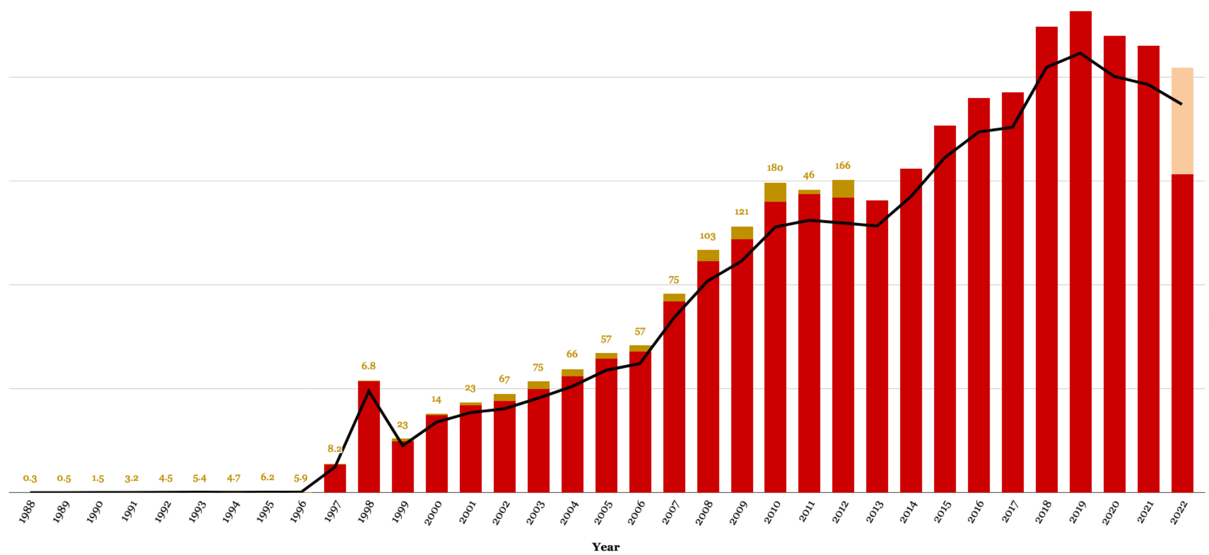


Figure 6.2.1. *Digital waveform archival storage for continuous (red) and segmented (brown) data.*

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: P16K, J17K, K13K, L18K, N15K, N19K, O18K, P23K, WRH, C21K, H23K
- Stations removed: None

We have paused adding new station metadata into the Station Information System (SIS). At the end of this quarter, we have successfully loaded 48 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 Q4 of 2022.

6.4 Software development

During this time, our total code commits under the following scopes of work were:

Antelope	Website	Other
52	5	8

During Q3, we completed the transition of our production website from Drupal 7 to Drupal 9. We also made an effort to update and enhance GUIs such as those for the magnitude calculator and the mapping interface based on feedback from analysts. We have also begun the process of porting legacy code over to Python, where possible. We started, and then abandoned due to inconsistencies in results, with the local magnitude calculator (aeic_dbml), but were successful in porting db2ewpg, a code used to compute spectral amplitudes for ShakeMap.

7. Fieldwork

During the reporting period, Earthquake Center staff visited 53 field sites to resolve data outages, GPS timing issues, and to perform planned upgrades, cleanup, and/or preventative maintenance. Twelve staff members conducted visits, for a total of 182 person-days of site maintenance work during the reporting period.

Our field season work was ongoing throughout the end of this quarter. At the start of July 2022 a field crew of three was in the middle of a field campaign, conducted from June 26 through July 7, visiting sites out of McCarthy. This work included solar battery replacements at two sites, repairing down radio links to bring three sites back online, replacing a malfunctioning cell modem to restore communications to five sites, repairing damage to the Q330 GPS system at a site, and completing the removal of infrastructure at the decommissioned site, AK.CTG.

During July 9-15 a field crew of three visited four sites located in Southeast Alaska, which included reconfiguring a site in Ketchikan to accommodate landowner changes to the property, replacing the weather sensors and repairing infrastructure at two sites, and installing a cell modem at AK.BESE in preparation to discontinue the old 56k copper circuit communications historically used for that site.

Over July 25-August 8, a crew of four visited sites out of Cordova. Work on this campaign included replacing solar batteries at one site, installing backup air cell batteries at two sites, repairing the offline satellite system that provides internet communications for thirteen sites in the Bering Glacier region, repairing a down radio link affecting one of those thirteen sites, installing a radio link to provide alternative access to some of the thirteen sites on the satellite system, and repairing infrastructure at a site damaged by heavy snow loads during the previous winter.

Concurrent to the Cordova work, a separate field crew of three visited sites out of Yakutat July 7-August 3. Despite challenging weather conditions, the Yakutat crew was able to replace depleted air cell batteries at two sites, attempt to repair radio communication outages affecting three sites, and install a cell modem at our network receive site in Yakutat, which will replace the old 56k copper circuit for our Yakutat network internet connection. During this period an AEC worker also visited Bethel July 28-31 to assist with two strong motion sensor installations organized by UAA researchers.

A crew of four worked out of Kotzebue from August 14-19 to visit five sites. This work included installing a new strong motion sensor at AK.F18K, troubleshooting poor communication performance at three sites, and replacing malfunctioning weather sensors at two of the sites. This trip was followed up by work by two AEC technicians working out of Nome during August 19-24 to install a strong motion sensor at AK.ANM and repair damage to the radio link at AK.GAMB.

Three AEC technicians worked out of Talkeetna and then the Anchorage area over August 23-September 3 to service multiple sites throughout the Southcentral, Kenai, Iliamna, and western Prince William Sound regions. This work included repairing site outages at five sites, replacing solar batteries at three sites, replacing depleted air cells at a remote non-solar site, adding air cell batteries at two solar-powered sites located in Barry Arm, installing a cell modem to improve telemetry at one site and upgrading a router at another site, installing a GNSS antenna and receiver at AK.BAT, and inspecting four sites at the Bradley Lake Dam near Homer. At the end of August (August 31-September 1), two other AEC technicians visited Arctic Village to assist a UNAVCO-NOTA technician with the satellite communications system at a UNAVCO-AEC cooperative site.

In September, AEC used the posthole drill developed by the IRIS-TA project to install boreholes at three sites. This included work out of Cordova over September 15-20 to install boreholes at AK.GRIN and AK.GOAT and working out of Anchorage September 21-24 to install a borehole at AK.FIRE. While working in Anchorage, the AEC crew also visited two other sites to resolve site outages caused by malfunctioning power systems at both sites and a fourth site (AK.RC01) to upgrade the infrasound sensor shielding.

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 nearly 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 third quarter of 2022, we had nearly 250,000 users visit our website. This amounted to 287,000 sessions (number of times users entered our website) and 426,000 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.

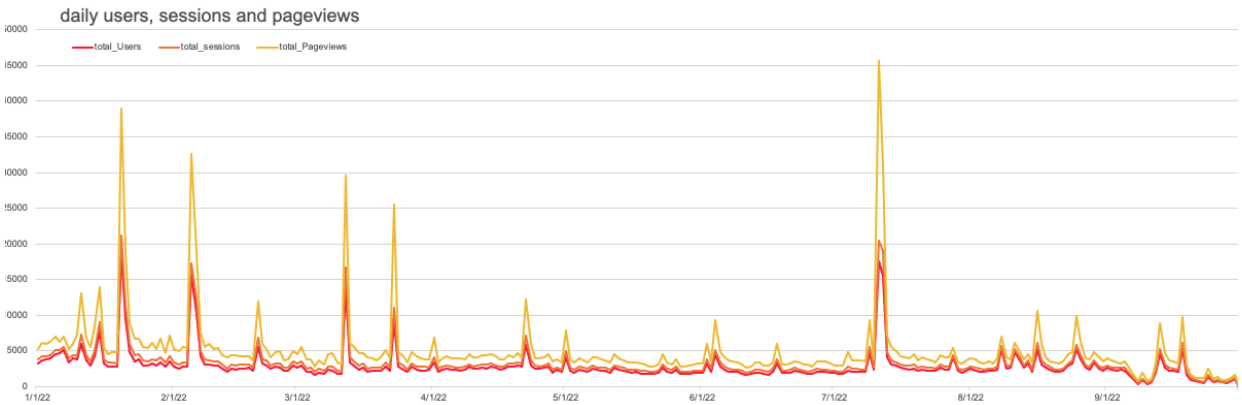


Figure 8.1.1. *Total number of website users (red), sessions (orange), and pageviews (yellow) per day in 2022.*

We had several days with very low traffic recorded to our website. The low numbers are related to the Drupal changeover, and do not represent the actual traffic to the 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 July 11, following two felt earthquakes near the Kenai Peninsula.

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 73% of website sessions.

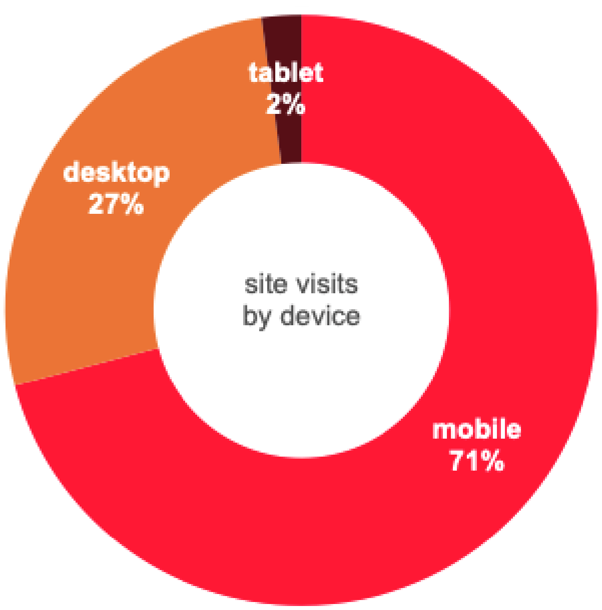


Figure 8.1.2*. Percentage of website sessions for the three major device types, mobile (e.g., phones), tablets, and desktop computers.*

8.2. Twitter

In the third quarter of 2022, we gained approximately 450 new followers, bringing our total following to over 25,000. 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 46 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.

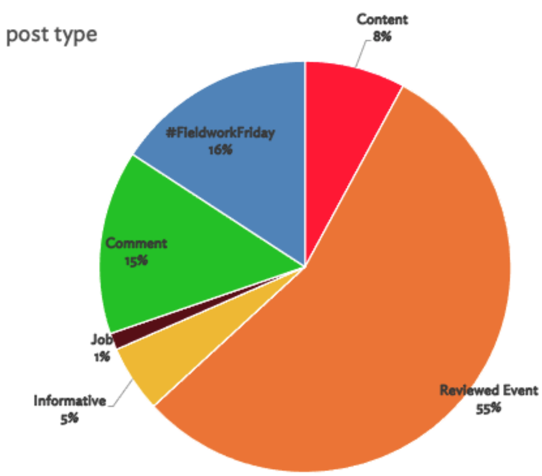


Figure 8.2.1. *Post type distribution for tweets through the third quarter of 2022.*

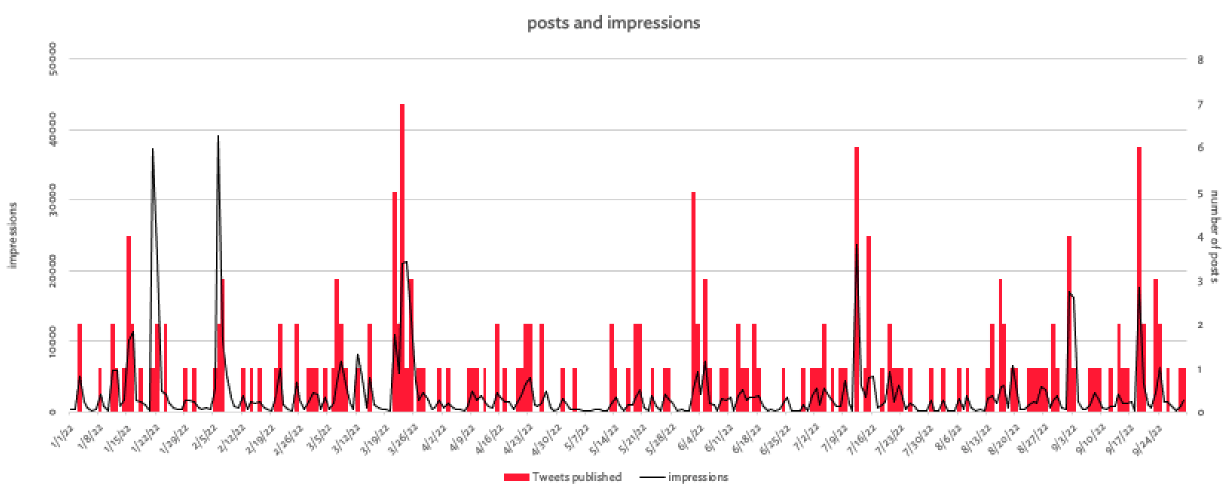


***Figure 8.2.2**. Number of posts per day (right axis, red bars) compared to the number of impressions received per day (left axis, black line) in 2022.*

There were several spikes in impressions (Figure 8.2.2) during this period, related to felt earthquakes. Our engagement rate with time (Figure 8.2.3) increased again during this quarter, averaging around 5%, with a high around 10% on July 11.

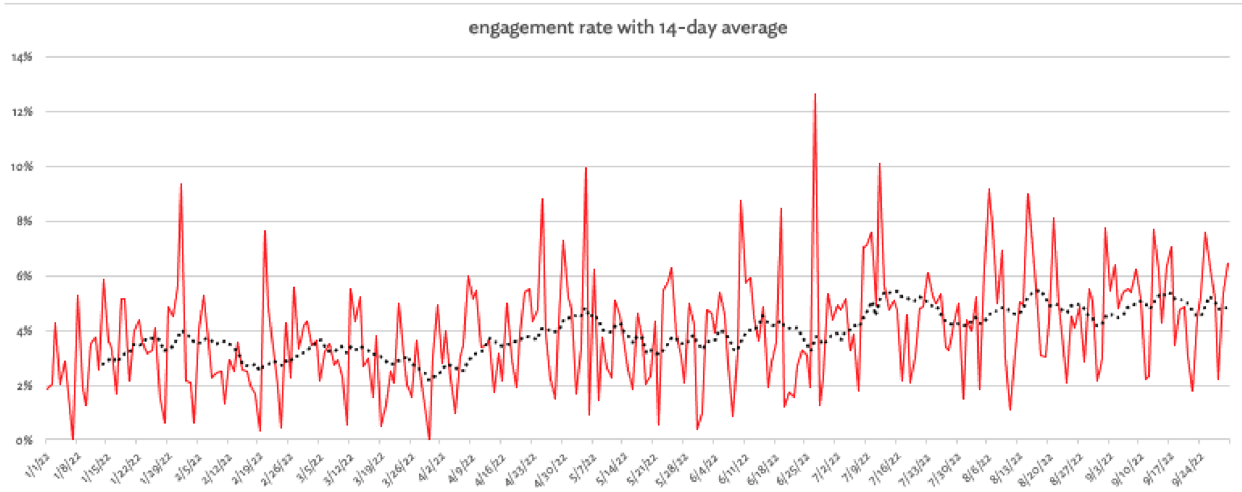


Figure 8.2.3. *Twitter engagement rates with time (red line) and 14-day moving average (black dotted line) in 2022.*

Figure 8.2.4 shows impressions and engagements based on tweet type. Reviewed events accounted for 49% of impressions and 52% of engagements. #FieldworkFriday posts accounted for 17% of impressions and 16% of engagements, while other content posts drew 16% of impressions and 21% of engagements. All other posts (comments, informative, and job) accounted for 18% of impressions, but only 11% of engagements.

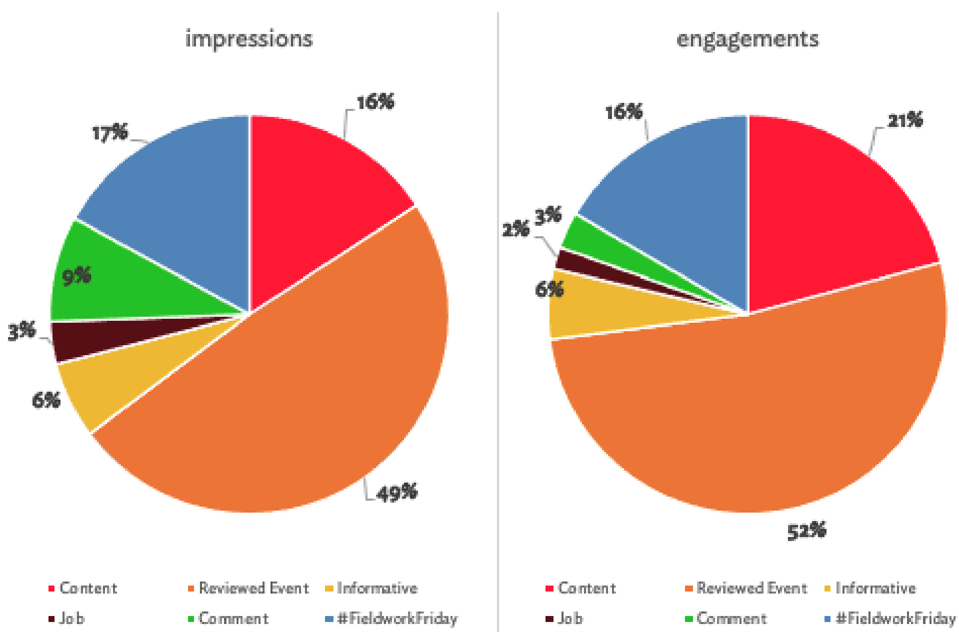


Figure 8.2.4*. Percentages of impressions and engagements based on tweet type.*

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 nearly 20,000.

During the third quarter of 2022, we attracted about 2,000 new Page Likes/Follows, bringing our count to about 11,000. As is the trend with felt earthquakes, we receive a follower boost after each event. Our largest increase was following two M4 events that occurred near the Kenai Peninsula on July 11.

The distribution of post type is shown in Figure 8.3.1. Reviewed events accounted for 56% of the 70 posts made in the third quarter and represented 65% of reach. Thirty-seven percent of posts were content related, and represented 25% of reach. Job and informational posts accounted for a combined total of 7% of posts and 10% 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. The number of daily engaged users was higher than expected for job posts, due to a paid advertisement we ran for the GNSS Specialist position (Figure 8.3.2).

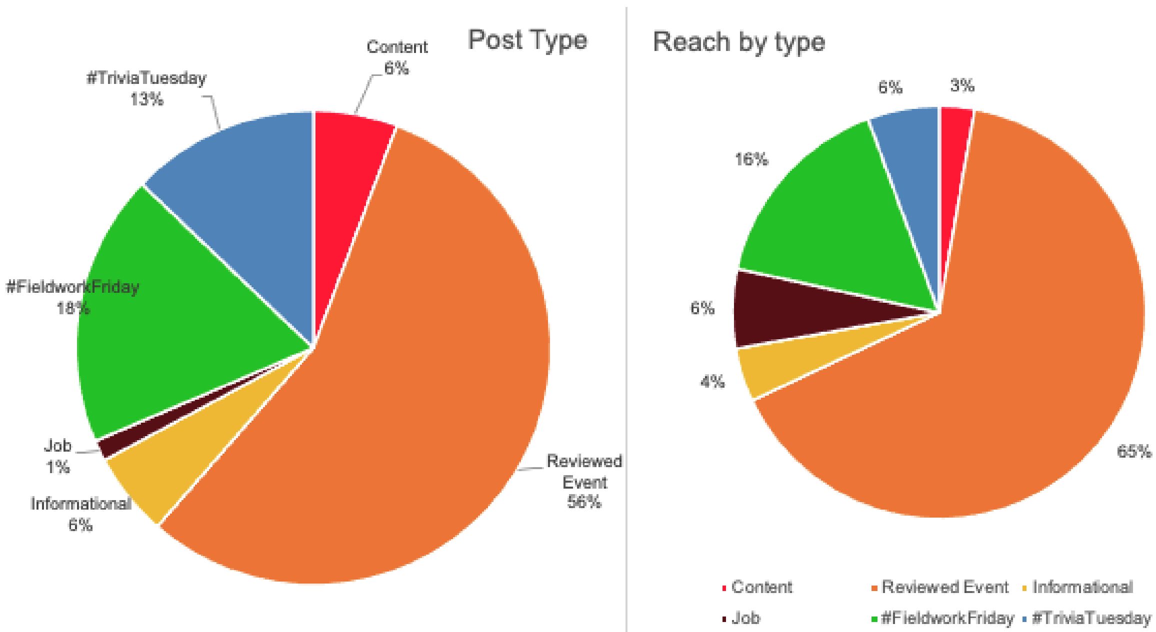


Figure 8.3.1. *Distribution of Facebook Page posts by type (left) and audience reach by type (right).*

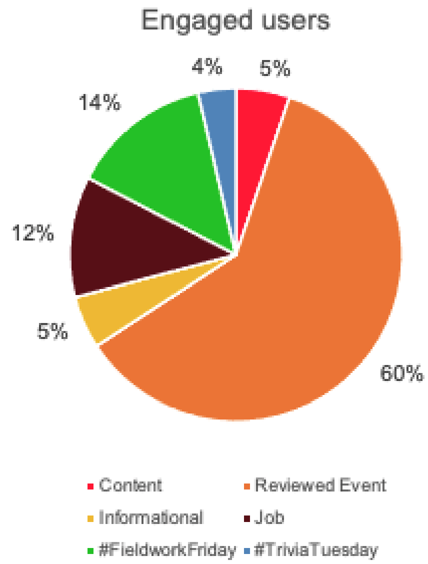


Figure 8.3.2. *Percentages of daily engaged users by post type.*

8.4 K-12 and community outreach

During the third quarter of 2022, K-12 outreach was slower due to summer break. In early September the Alaska Earthquake Center partnered with the Alaska Division of Homeland Security and Emergency Management to bring the Earthquake Simulator to Fairbanks. During this event we hosted 18 classes (over 400 students) on campus for tours, talks about preparedness, and the Quake Cottage experience. We also hosted a public event at Pioneer Park which, despite the cold and rain, brought in a steady flow of people. The collaboration continued a few days later in Chugiak, when members of the AEC communications team participated in a Boy Scouts of America preparedness event alongside the Quake Cottage. AEC provided demonstrations, resources, and preparedness talks to approximately 60 Scouts and family members.

8.4.1 Alaska Seismology in Schools (ASeiS)

The Alaska Earthquake Center's Seismology in Schools (ASeiS) program launched three new initiatives during the third quarter of 2022: (1) the Shake Ambassador Club; (2) the "Shake Challenge" design competition, and (3) the "T3 Seismic Studies" dual credit course through UAF eCampus. These initiatives build on the ASeiS network of student-maintained school seismographs, which began rollout in Fall 2021. As of September 2022, there are 14 participating ASeiS schools around Alaska hosting a seismograph, as seen on the site map in Figure 8.4.1.

During the 3rd quarter of 2022, four new sites joined the program (Wrangell, Sitka, Brevig Mission, and Shishmaref). See Table 8.1 for detailed information for each site. Stations noted as offline were not displaying data on the Raspberry Shake *Stationview* and *Dataview* web apps for more 30 days on September 30th, 2022.

***Table 8.1**. Status of participating ASeiS sites as of September 30, 2022. Schools with an active Shake Ambassador club are listed first, then schools without a club; within these groupings, schools are listed alphabetically. The RS Model(s) column displays model of station named in the previous column first, then other models if sites have multiple instruments.*

Site	**Station Name**	**RS Model(s)**	**Shake Club?**	**Last visited**
Bethel Regional High School	R80AD (offline)	RS3D, 1D (offline)	Yes	April 2022
Brevig Mission School	RA037 (offline)	RS1D	Yes	N/A
Chevak School	R1292 (offline)	RS3D, 1D (offline)	Yes	April 2022
Cordova Jr/Sr High School	R2C02	RS3D, 1D (offline)	Yes	May 2022
Mt. Edgecumbe High School (Sitka)	RFC9C (offline)	RS1D, 3D (offline)	Yes	N/A
Quinhagak School	RA725	RS4D, 1D (offline)	Yes	November 2021
Seward High School	R7841 (offline)	RS4D, 1D (offline)	Yes	November 2021
Shishmaref School	RB140 (offline)	RS3D, 1D (offline)	Yes	N/A
Wrangell High School	RE54C (offline)	RS3D, 1D (offline)	Yes	N/A
Dillingham High School	R4FDA	RS3D	No	May 2022
Hydaburg School	RBD7D	RS1D	No	February 2022
Perryville School	R05D1 (offline)	RS1D	No	April 2022
West Anchorage High School	RCD01 (offline)	RS1D	No	September 2021
West Valley High School (Fairbanks)	R32F6 (offline)	RS3D	No	March 2022

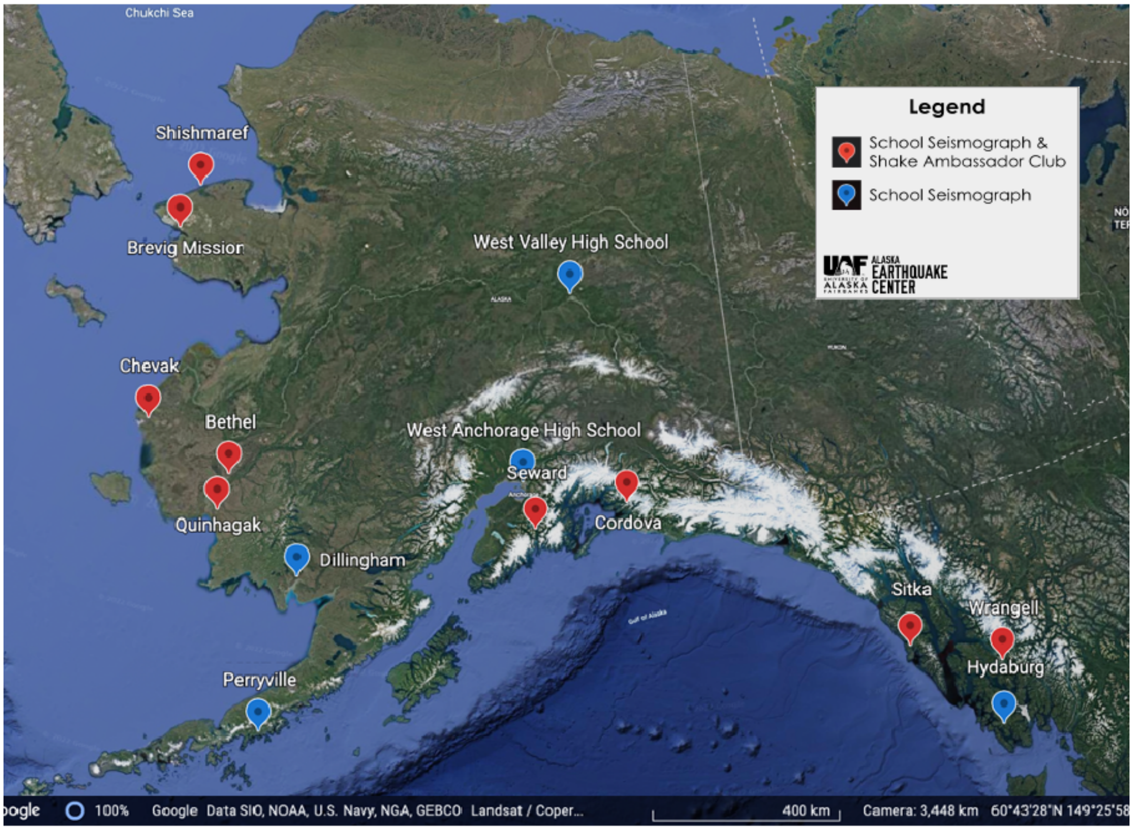
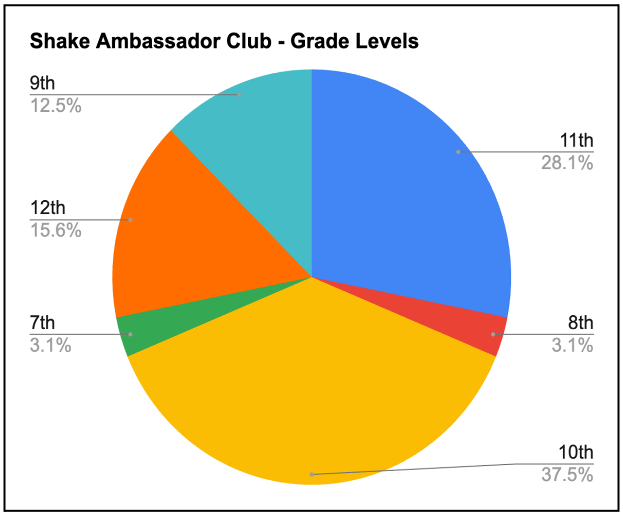


***Figure 8.4.1**. Map of 14 communities participating in the ASeiS program.*

8.4.2 Shake Ambassador Club

This extracurricular academic club provides the opportunity for interested middle and high school students from rural Alaska to be a part of a statewide group of engaged peers, brought together by their curiosity and desire to learn about the geophysical world around them through the lens of seismology. At their schools, students meet in-person with fellow "Shake Ambassadors" to monitor their seismograph and participate in related activities. The larger, statewide club meets weekly on Zoom and stays connected continuously via the online communication platform Discord. Shake Ambassadors monitor and maintain their school seismographs, spread seismic literacy with their communities and peers, and engage with additional educational opportunities, such as the Shake Challenge competition and the Seismic Studies dual credit course.

Thirty-three students from nine ASeiS communities (Table 8.1) have joined the Shake Ambassador Club. Figure 8.4.2 highlights the age and demographic diversity of the Shake Ambassador students.



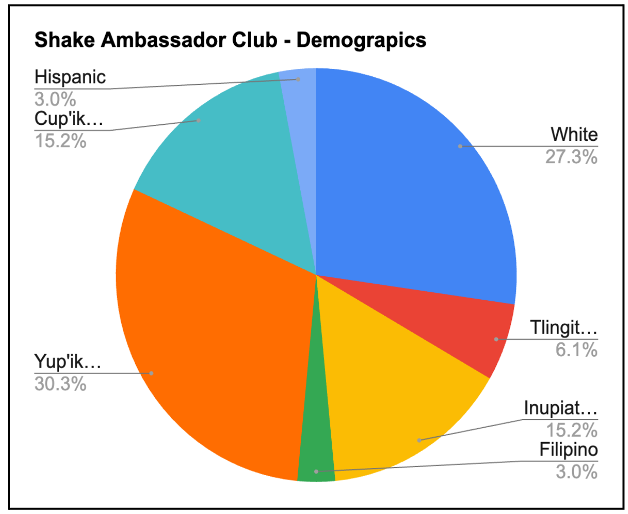


***Figure 8.4.2**. Pie charts showing the distribution of grade levels and ethnicities within Shake Ambassador Club members. (In the Demographics chart, labels with "..." are where the words "Alaska Native" were shortened for this internal report.)*

8.4.3 Shake Challenge competition

This academic problem solving event challenges teams of Shake Ambassadors to build a geohazard-alert system utilizing live data streams from their school's Raspberry Shake seismograph. The competition began in late September and will run through March 2023, culminating in a final presentation and awards ceremony at UAF. There are currently ten teams competing, one from each school with an active Shake Ambassador Club (except Wrangell with two teams), totaling over 30 participants.

8.4.4 GENR F120 "T3 Seismic Studies" dual enrollment course

In September of 2022, ASeiS also launched the GENR F120 "T3 Seismic Studies" course through UAF eCampus. The goals for the course are to provide Shake Ambassador Club participants with an avenue for furthering their academic learning about geohazards, seismology, and scientific data analysis. Students who enroll and complete the course receive 1.0 UAF credit and credit towards high school graduation. We partnered with the Alaska Advantage program to apply a discounted tuition rate of $165 per credit, and AEC and Upward Bound fully covered tuition costs for students. As of late September, there are 22 students enrolled in the GENR F120 "T3 Seismic Studies" course.

9. Publications and presentations

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

9.1. Publications

Gardine, L., B. Grassi, D. J. Nicolsky, and E. N. Suleimani (August 2022). *Know Your Tsunami Hazard in Craig*. Alaska Earthquake Center, University of Alaska Fairbanks. (brochure)

Gardine, L., B. Grassi, D. J. Nicolsky, and E. N. Suleimani (August 2022). *Know Your Tsunami Hazard in Homer*. Alaska Earthquake Center, University of Alaska Fairbanks. (brochure)

Gardine, L., B. Grassi, D. J. Nicolsky, and E. N. Suleimani (August 2022). *Know Your Tsunami Hazard in Hydaburg*. Alaska Earthquake Center, University of Alaska Fairbanks. (brochure)

Gardine, L., B. Grassi, D. J. Nicolsky, and E. N. Suleimani (August 2022). *Know Your Tsunami Hazard in Kodiak.* Alaska Earthquake Center, University of Alaska Fairbanks. (brochure)

Gardine, L., B. Grassi, D. J. Nicolsky, and E. N. Suleimani (August 2022). *Know Your Tsunami Hazard in Seward*. Alaska Earthquake Center, University of Alaska Fairbanks. (brochure)

Gardine, L., B. Grassi, D. J. Nicolsky, and E. N. Suleimani (August 2022). *Know Your Tsunami Hazard in Sitka*. Alaska Earthquake Center, University of Alaska Fairbanks. (brochure)

Karasözen, E. and **M. E. West** (July 2022). An Adaptive Spectral Subtraction Algorithm to Remove Persistent Cultural Noise. *Bulletin of the Seismological Society of America,* 112 (5): 2297–2311. https://doi.org/10.1785/0120210317

Nissen, E., M. D. Cambaz, É. Gaudreau, A. Howell, **E. Karasözen**, E. Savidge (August 2022) A reappraisal of active tectonics along the Fethiye–Burdur trend, southwestern Turkey, *Geophysical Journal International*, Volume 230, Issue 2, Pages 1030–1051. https://doi.org/10.1093/gji/ggac096

Ruppert, N. A., S. Cotton, L. Gardine, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, N. Murphy, M. E. West, and S. Wiser (August 2022). *Alaska Earthquake Center Quarterly Technical Report April - June 2022*. ScholarWorks@UA, 42 pp, http://hdl.handle.net/11122/12956.

Suleimani, E. N., J. B. Salisbury, and **D. J. Nicolsky** (August 2022). *Tsunami inundation maps for Karluk and Larsen Bay, Kodiak Island, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2022-2*, 42 p., 2 sheets. https://doi.org/10.14509/30892.

Suleimani, E. N., J. B. Salisbury, and **D. J. Nicolsky** (August 2022). *Updated tsunami inundation maps for Seward and northern Resurrection Bay, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2022-3*, 51 p., 4 sheets. https://doi.org/10.14509/30893.

9.2. Public Presentations

Date	Presenter(s)	Event/Workshop	Title	Virtual/ In person
7/20	**Dmitry Nicolsky,** Barrett Salisbury, **Elena Suleimani**	NTHMP Annual Meeting, Palm Springs, CA	State of Alaska Program Activities	In Person
8/31	Lia Lajoie, **Joanne Heslop, Alexa Winter**	Arctic Village School	Earthquakes in Alaska	In Person
9/3	**Gabriel Low**	T3 Alliance Training	Shake Ambassador Club Recruitment	In person
9/10	**Gabriel Low** and **Lea Gardine**	Chugiak Eagle Scout Preparedness Event	Earthquake Preparedness in Alaska	In person
9/16	***Alexander Fozkos,*** *Heather Shaddox,* Elizabeth Duffy (IRIS)	Geoscience Congressional Visits Day	Research on Alaska earthquake early warning; the importance of funding geoscience programs.	Hybrid
9/19	**Elena Suleimani**	Ketchikan Fire Station	Tsunami Evacuation Line for Ketchikan	In Person
9/19	**Elena Suleimani**	Ketchikan High School	Tsunamis in Alaska and around the World	In Person
9/20	**Elena Suleimani**	Klawock Fire Station	Tsunami Evacuation Line for Klawock	In Person
9/20	**Elena Suleimani**	Klawock School	Tsunamis in Alaska and around the World	In Person
9/21	**Elena Suleimani**	Craig High School (presentation 1)	Tsunamis in Alaska and around the World	In Person
9/21	**Elena Suleimani**	Craig High School (presentation 2)	Tsunamis in Alaska and around the World	In Person
9/22	**Elena Suleimani**	Interview at the Ketchikan local TV channel	What Are Tsunamis and How Big Is the Tsunami Risk in Alaska?	In Person
9/22	**Elena Suleimani**	Ketchikan Public Library	Tsunamis in Alaska: Are We Ready for the Next Big One?	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
8/9	Stephen McNutt	The Generic Volcanic Earthquake Swarm Model, and Estimates of Size and Water Content of the Hunga Tonga Eruption	Hybrid
8/18	*Suzie Duran* (IRIS intern at WATC for the summer)	Investigation of atmospheric acoustic wave signals from the January 15th, 2022 Hunga, Tonga volcanic eruption recorded by Alaska's dense network of multi-sensor stations	Hybrid

10. References

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., and M. E. West (2020). The impact of USArray on earthquake monitoring in Alaska, *Seism. Res. Lett.*, 91(2A), 601-610, doi: https://doi.org/10.1785/0220190227.

Ruppert, N. A., S. Cotton, L. Gardine, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, N. Murphy, and M. E. West (May 2022). *Alaska Earthquake Center quarterly technical report January-March 2022*, ScholarWorks@UA, 40 pp., http://hdl.handle.net/11122/12880.

Ruppert, N. A., S. Cotton, L. Gardine, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, N. Murphy, and M. E. West (August 2022). *Alaska Earthquake Center quarterly technical report April-June 2022*, ScholarWorks@UA, 40 pp., http://hdl.handle.net/11122/12956.

Ruppert, N. A., S. Dalton, L. Gardine, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, and M. E. West (August 2021). *Alaska Earthquake Center quarterly technical report April-June 2021,* ScholarWorks@UA, 43 pp., http://hdl.handle.net/11122/12243.

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

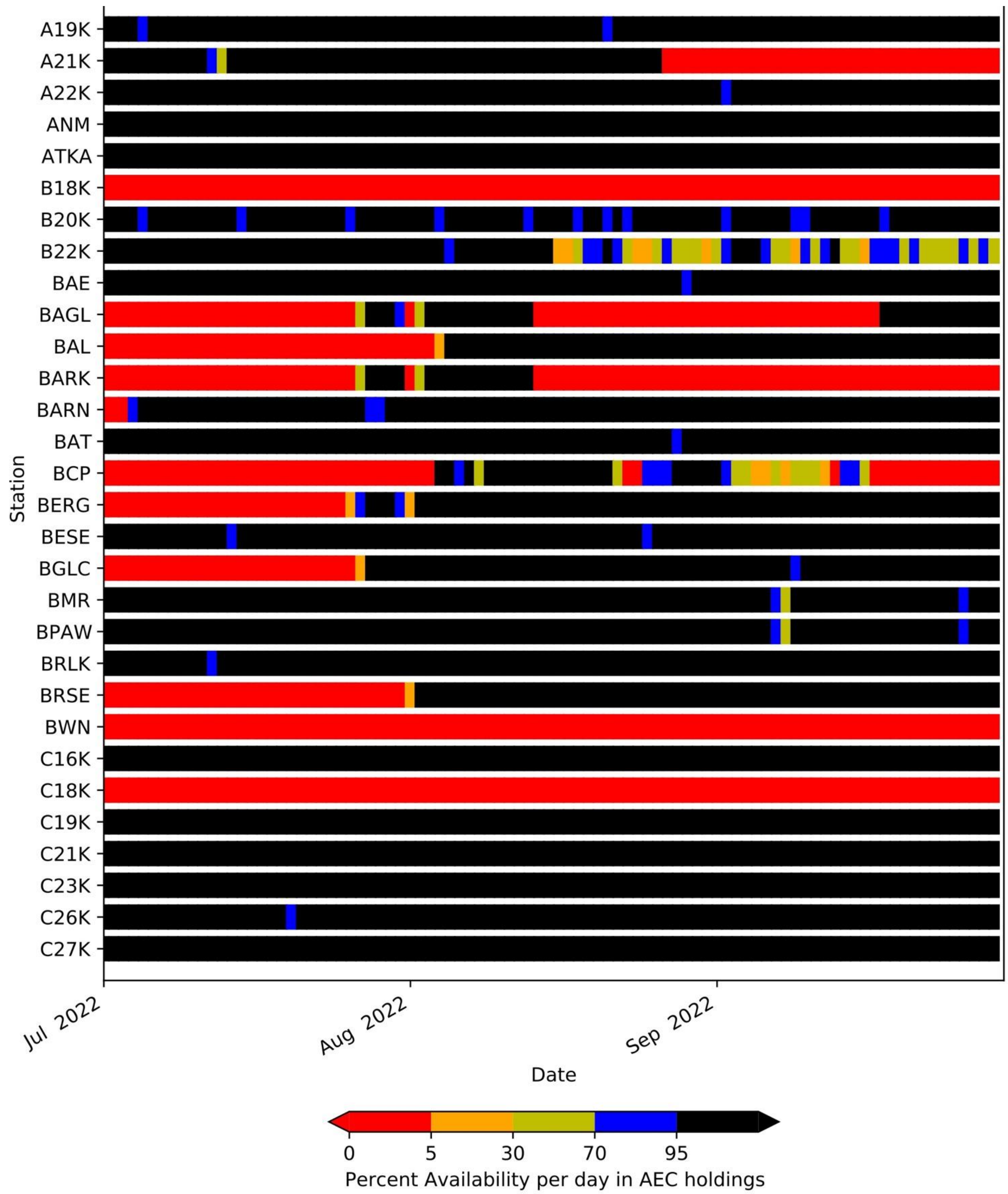


***Figure A1**. Data availability for stations A19K-C27K (listed alphabetically). BAT is a new site installed in July 2021.*

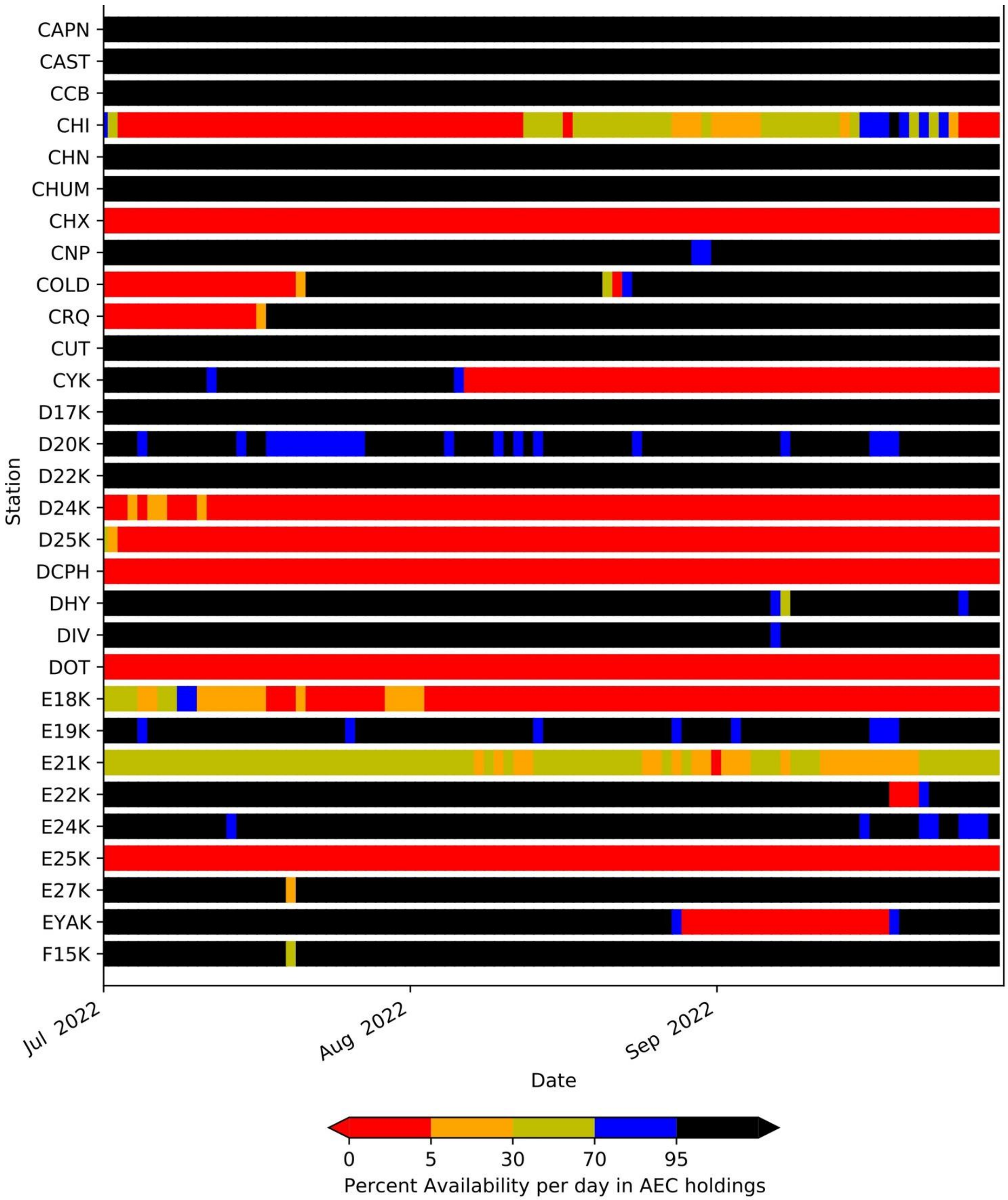


***Figure A2**. Data availability for stations CAPN-F15K (listed alphabetically).*

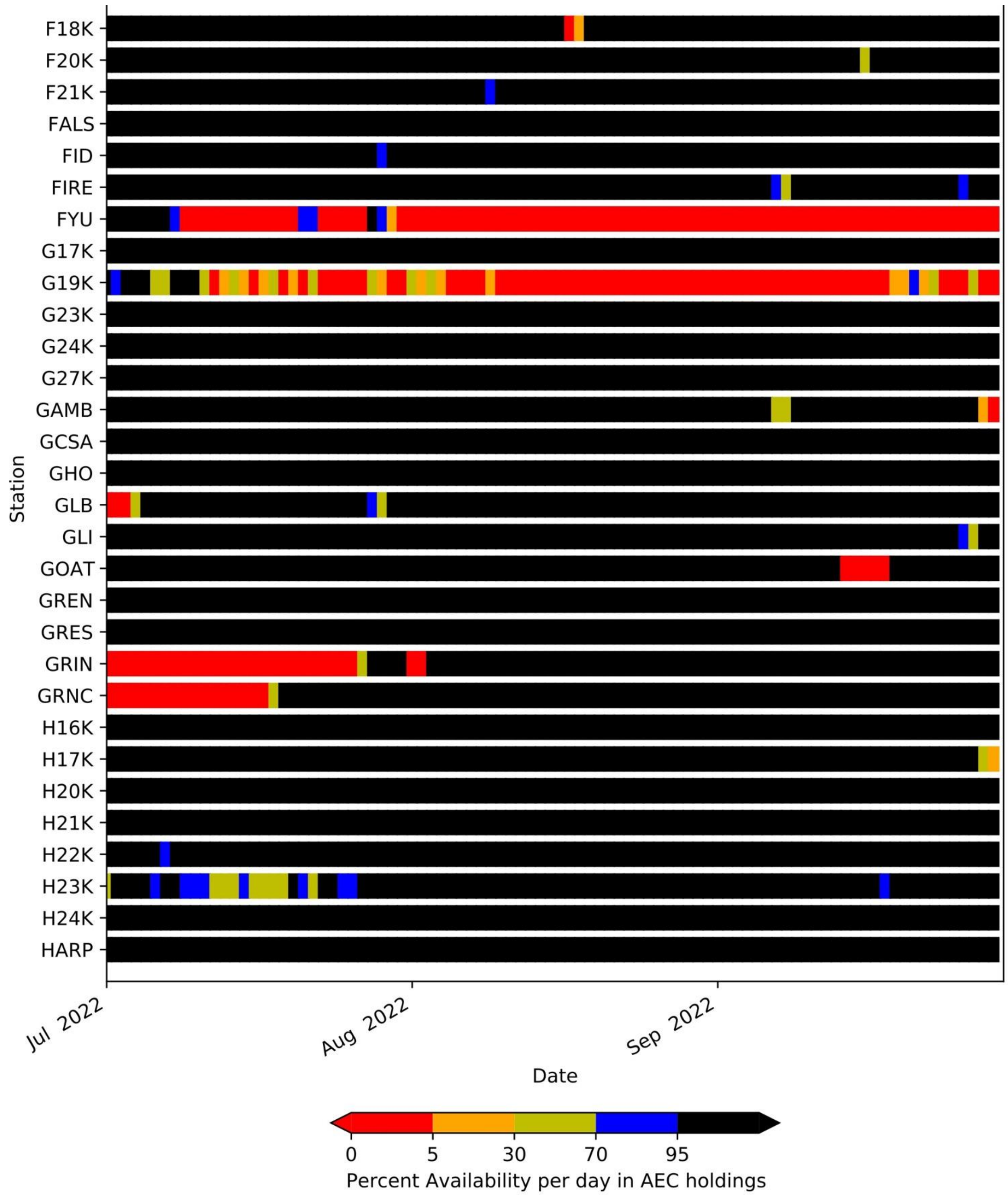


***Figure A3**. Data availability for stations F18K-HARP (listed alphabetically).*

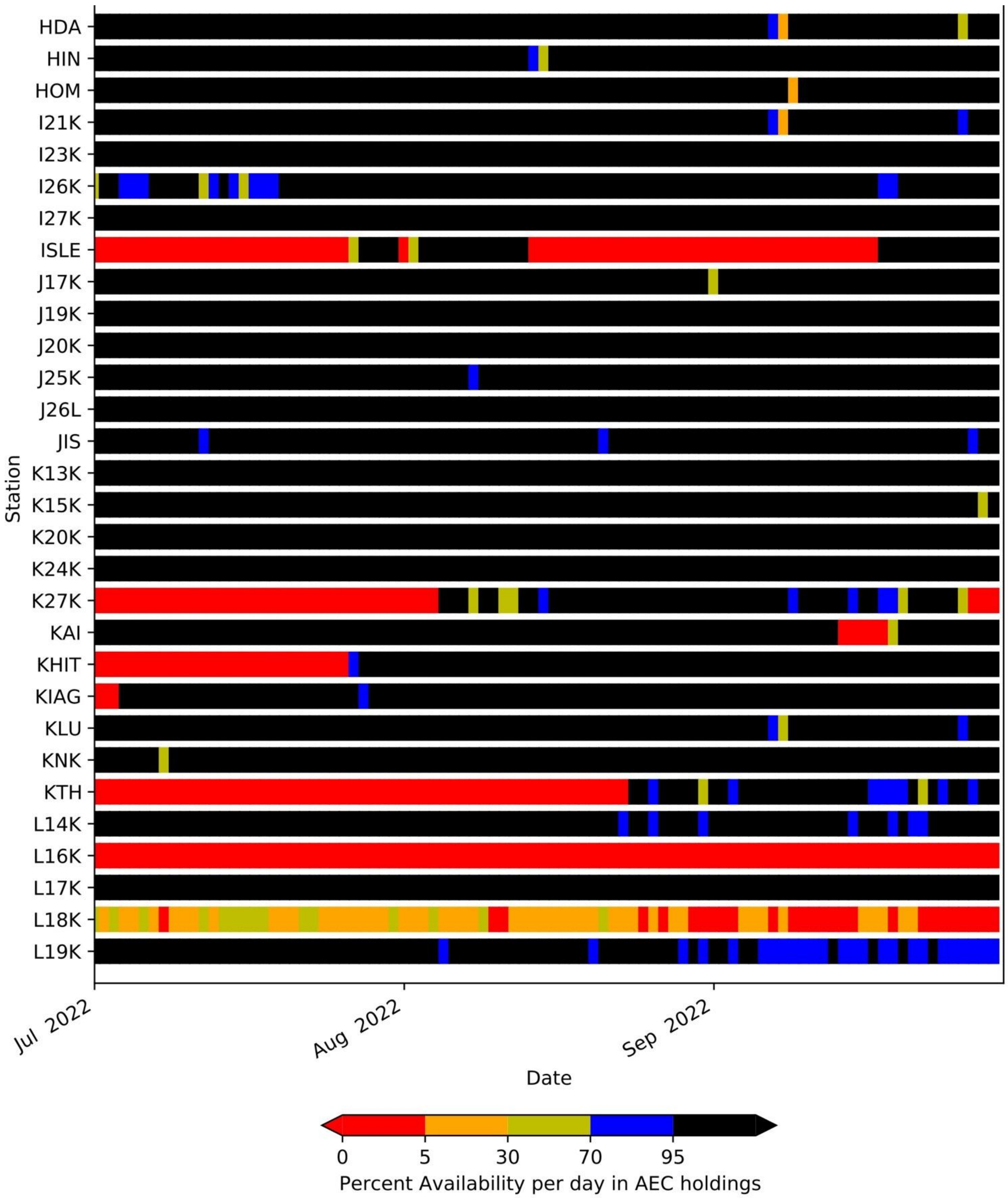


***Figure A4**. Data availability for stations HDA-L19K (listed alphabetically).*

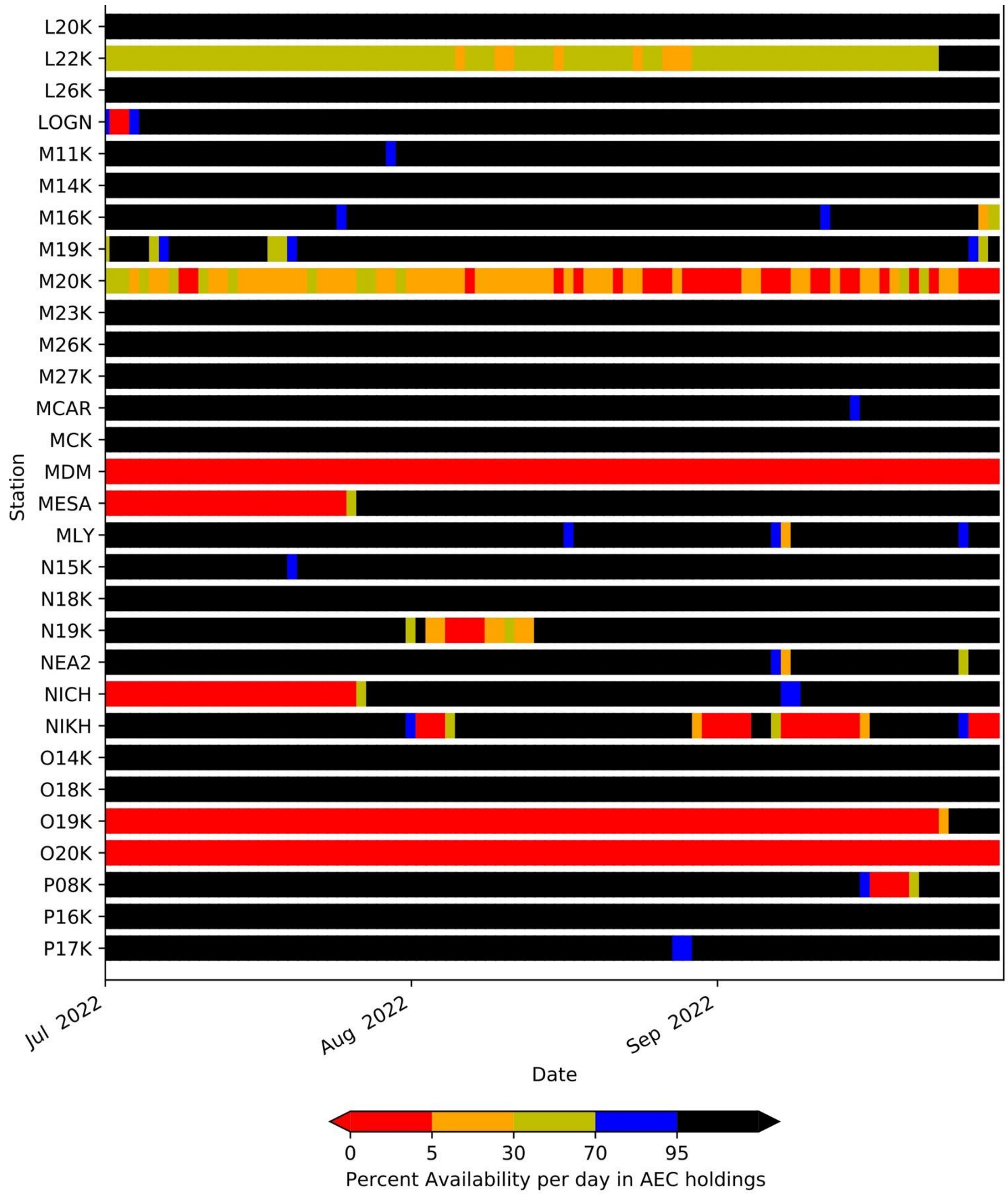


***Figure A5**. Data availability for stations L20K-P17K (listed alphabetically).*

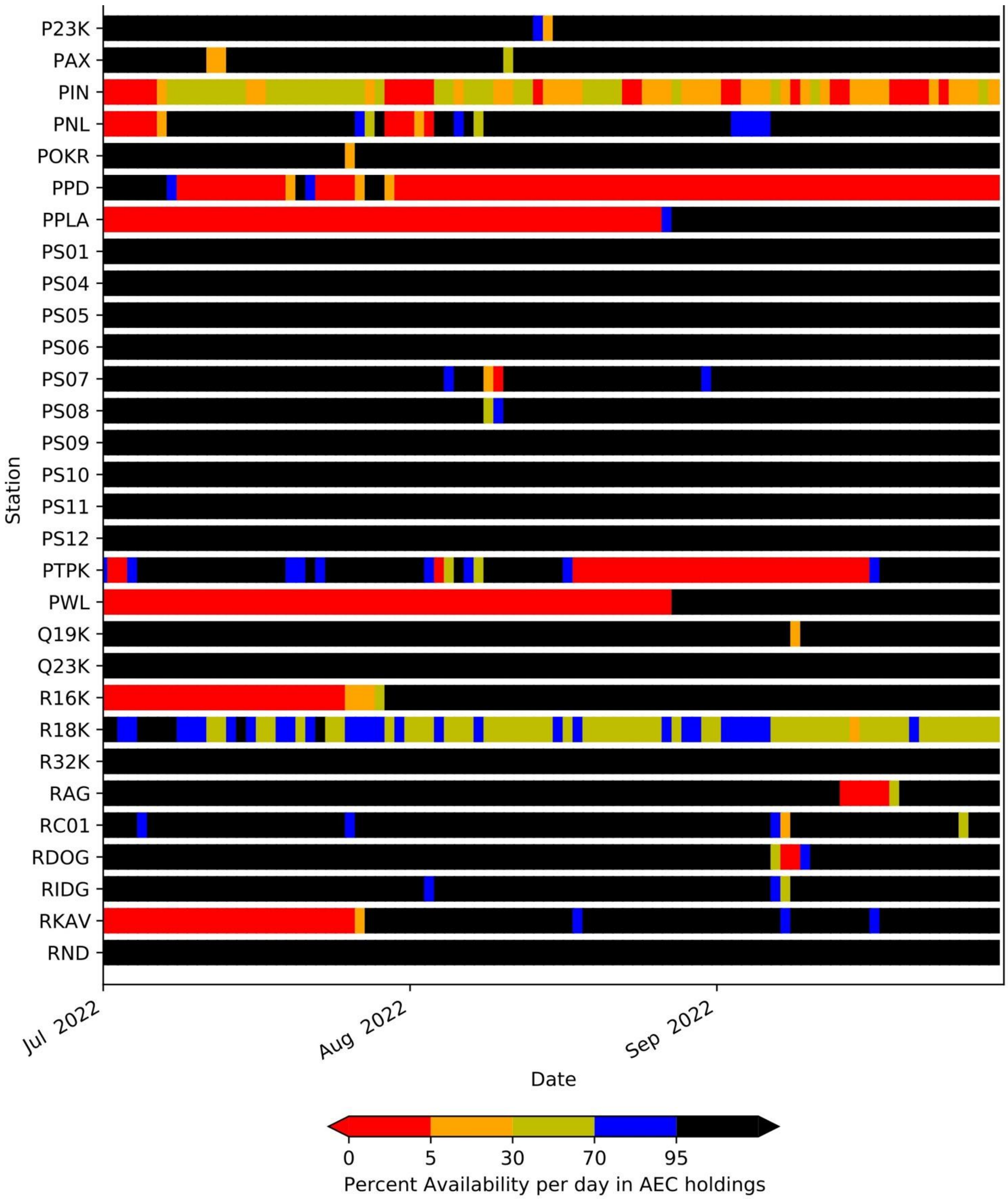


***Figure A6**. Data availability for stations P23K-RND (listed alphabetically).*

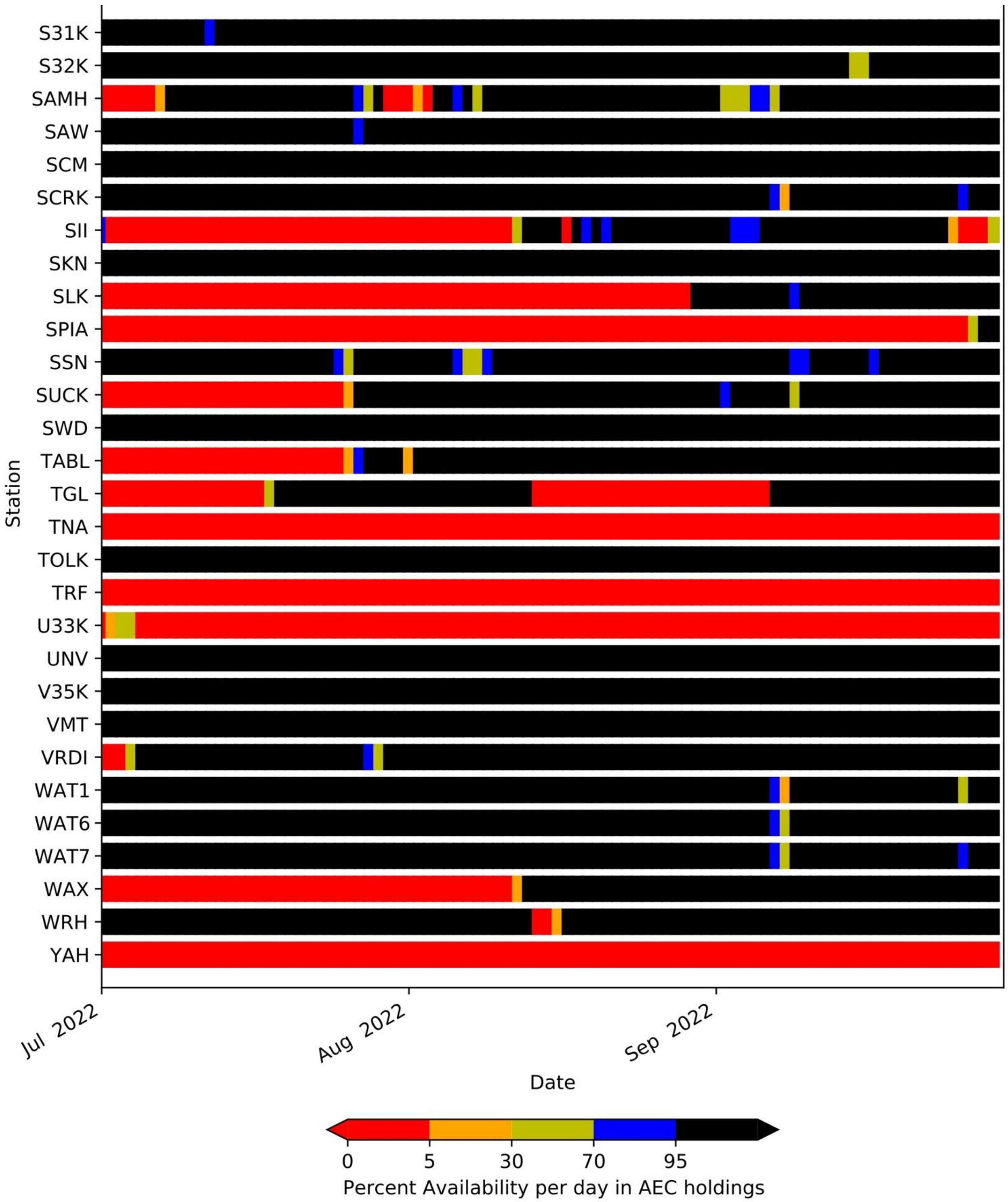


Figure A7. *Data availability for stations S31K-YAH (listed alphabetically).*

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

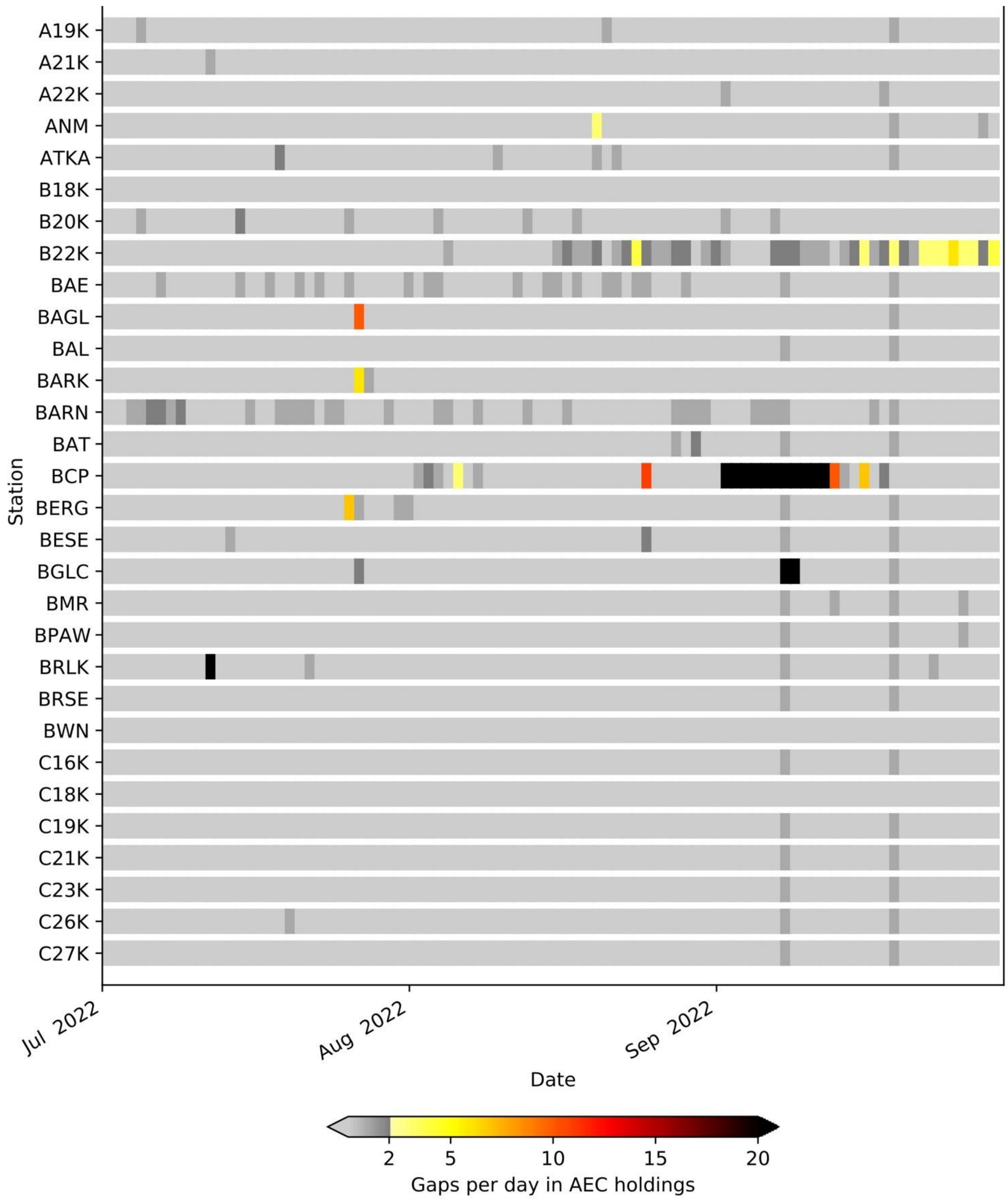


***Figure B1**. Number of gaps per day[1] for stations A19K-C27K (listed alphabetically).*

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

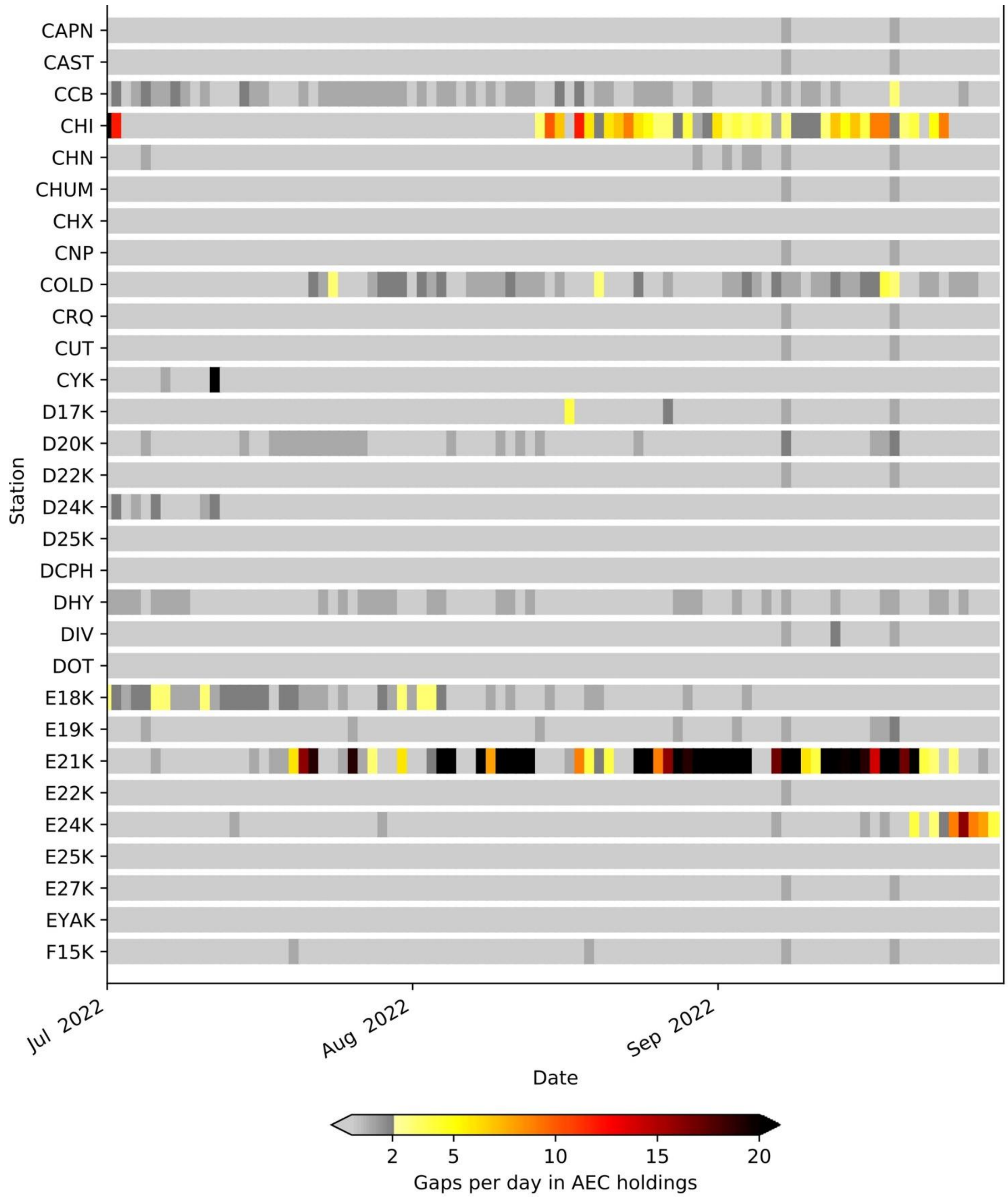

Figure B2*. Number of gaps per day for stations CAPN-F15K (listed alphabetically).*

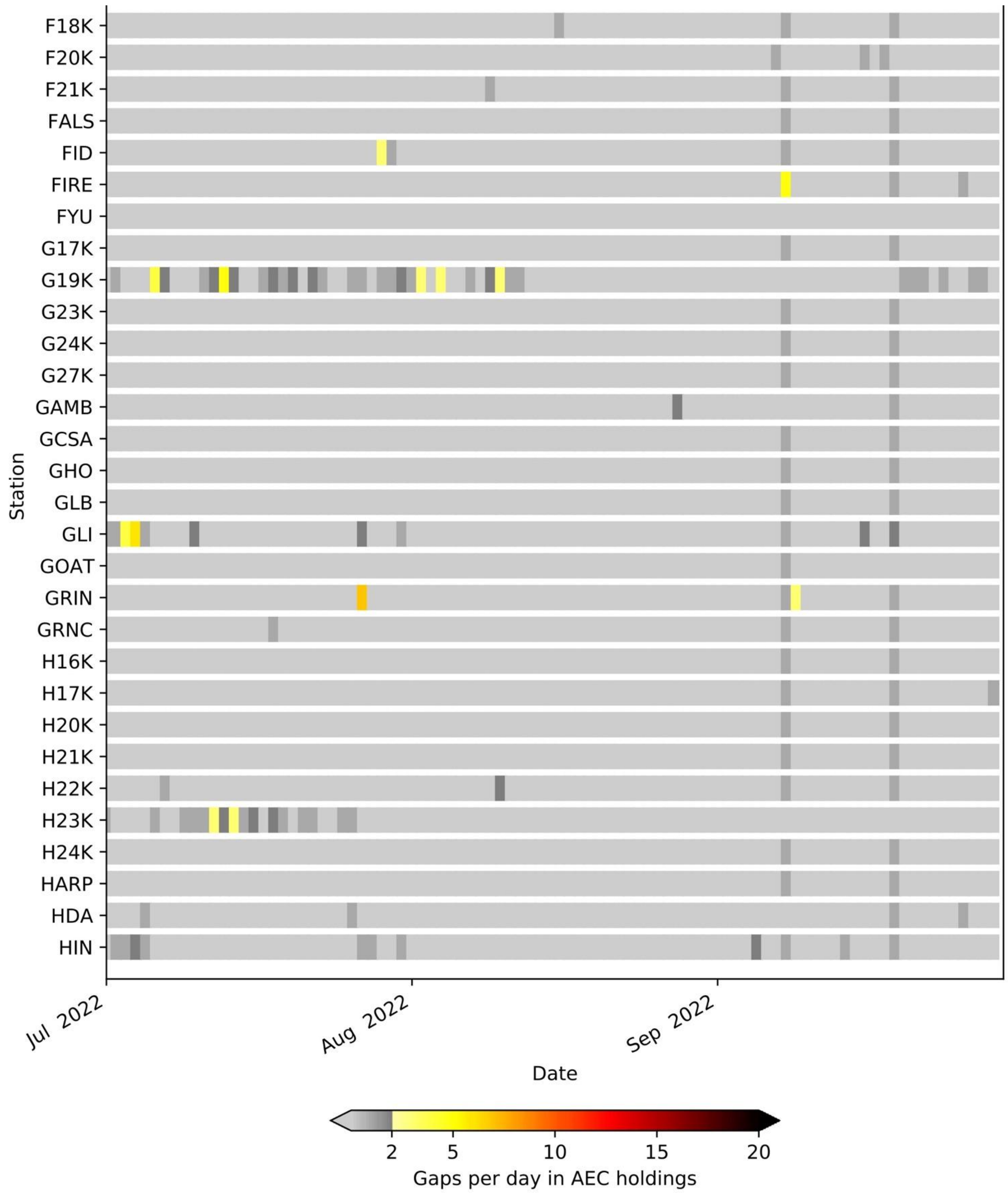

Figure B3*. Number of gaps per day for stations F18K-HIN (listed alphabetically).*

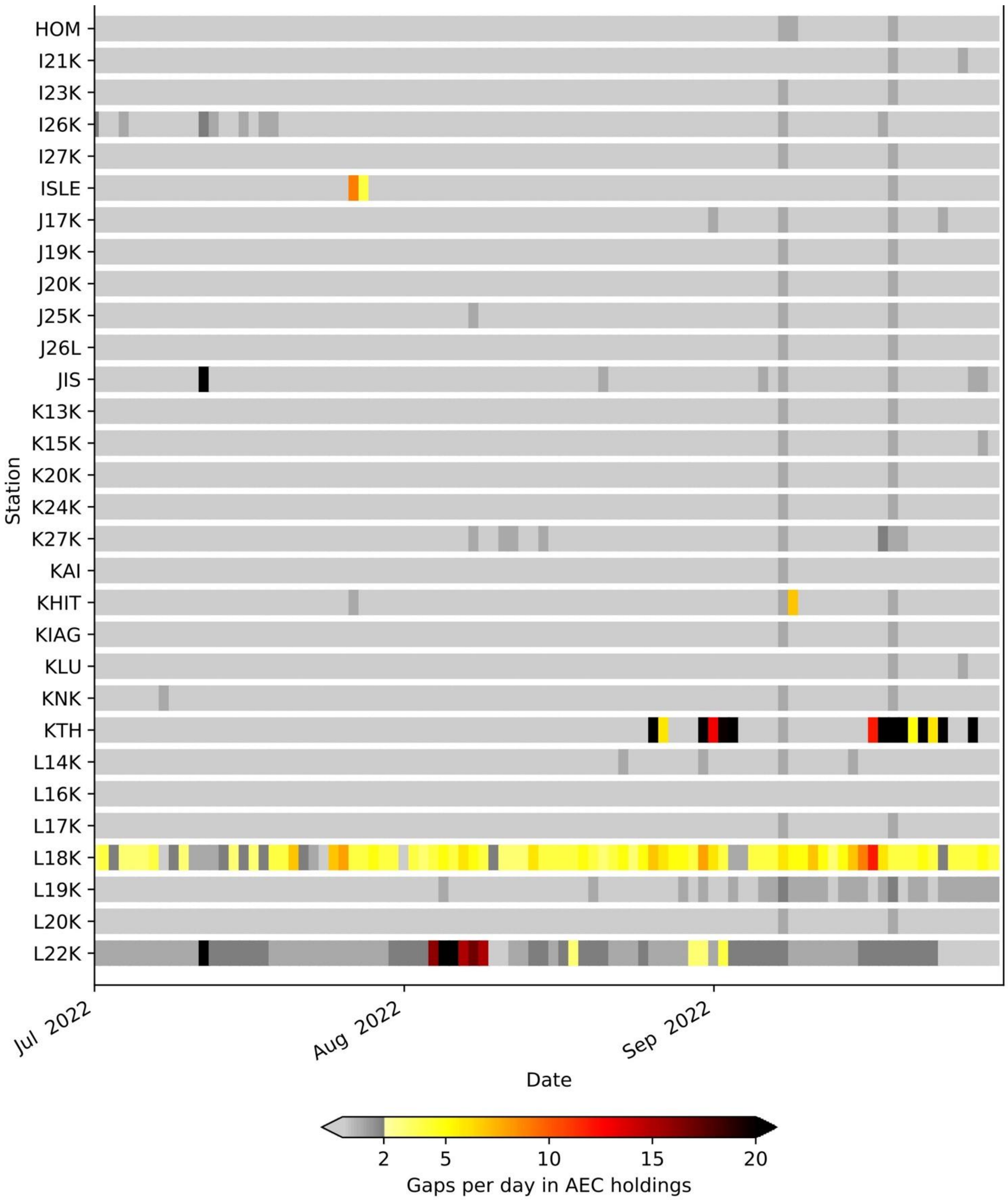

***Figure B4**. Number of gaps per day for stations HOM-L22K (listed alphabetically).*

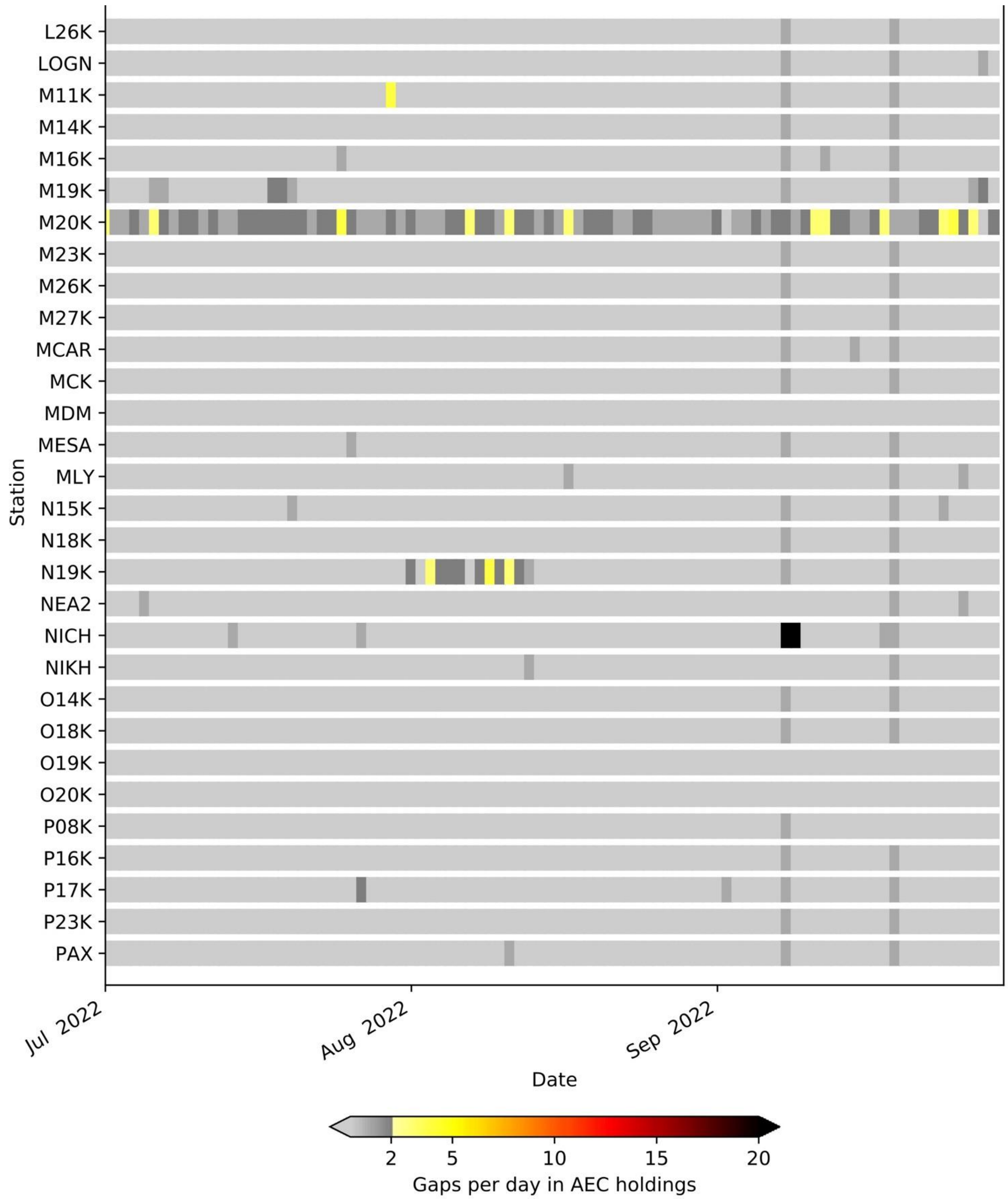

Figure B5*. Number of gaps per day for stations L26K-PAX (listed alphabetically).*

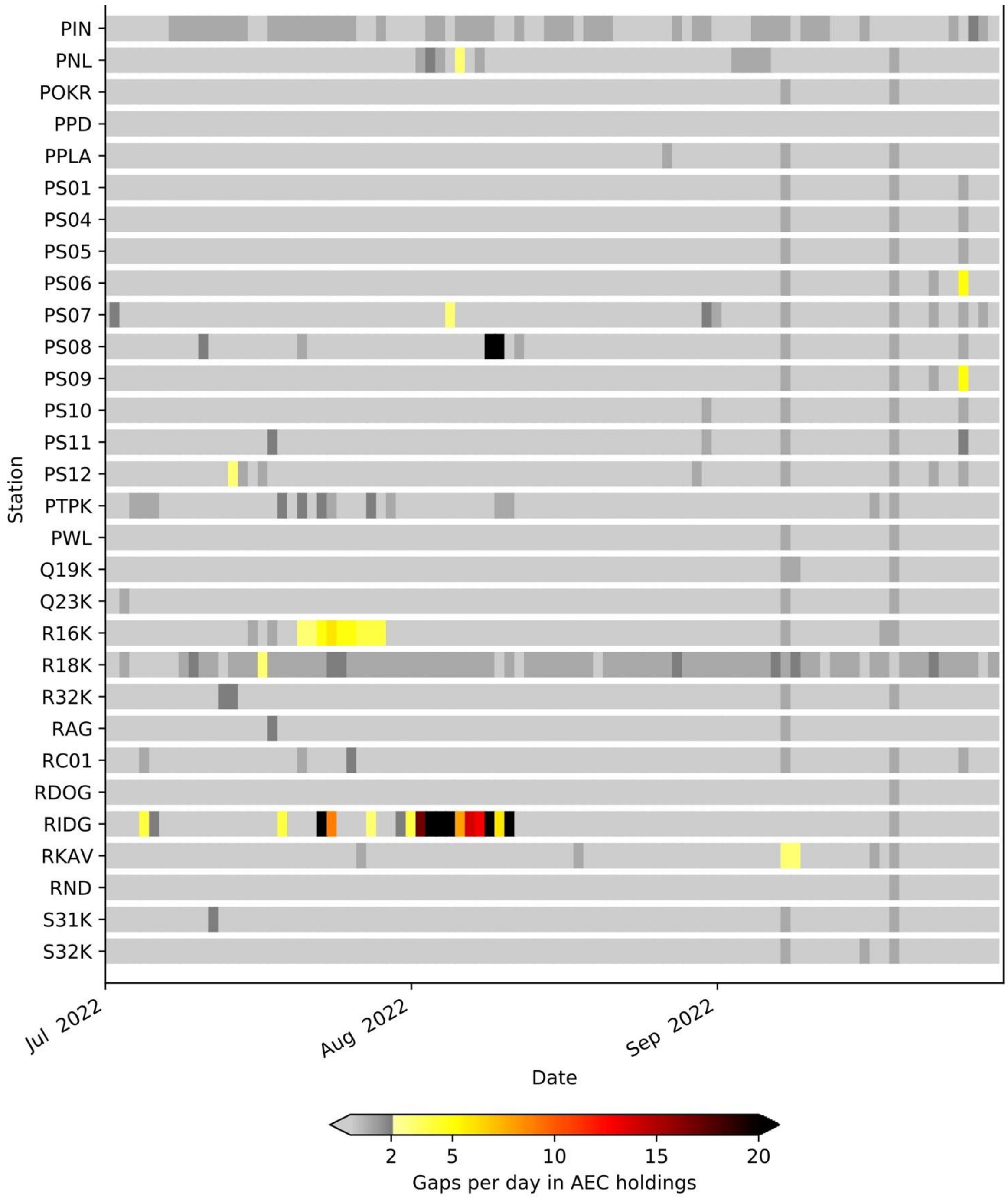

Figure B6. *Number of gaps per day for stations PIN-S32K (listed alphabetically).*

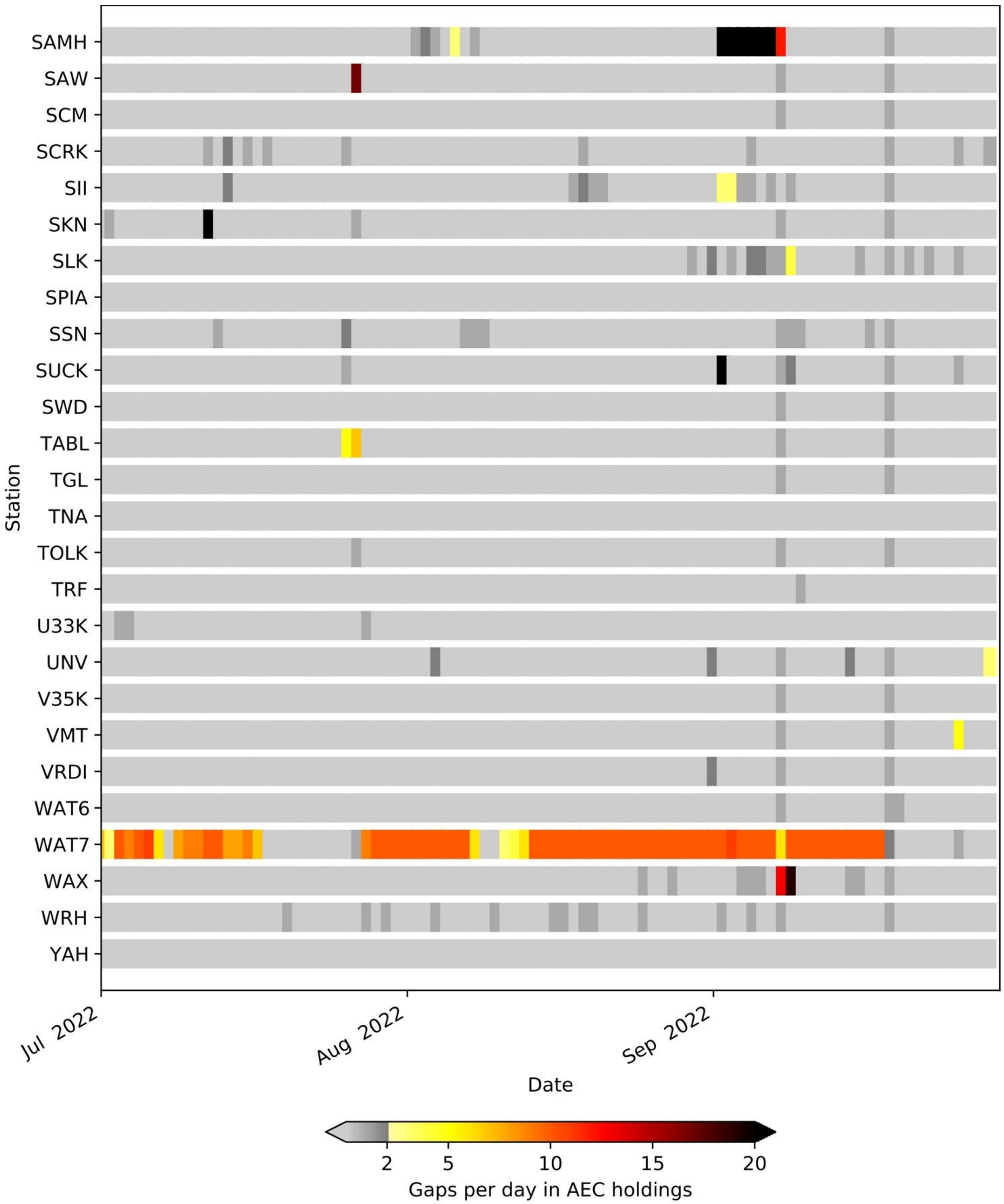

***Figure B7**. Number of gaps per day for stations SAMH-YAH (listed alphabetically).*