Alaska Earthquake Center
Quarterly Technical Report
July-September 2021

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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 contributed 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.

2. Seismicity

Between July 1 and September 30, 2021 we reported 14,442 seismic events in the state and the neighboring regions (Figure 2.1), with depths ranging between 0 and 271 km and magnitudes between -0.15 and 8.2. The largest earthquake of Mw=8.2 occurred on July 29 at 6:15:49 UTC southwest of Kodiak Island. Fifteen earthquakes had magnitudes 5.0 or greater, including M6.1 earthquake on September 24 in the Andreanof Islands and M6.9 on August 14 southwest of Kodiak Island. Overall, we reported about 157 events per day, or one event every 9 minutes on average. This is 16% more events than in the second quarter of 2021 (Ruppert et al., August 2021).

AEC data analysts picked and catalogued 451,332 seismic phases, 307,316 of which were P-phase and 144,016 S-phase arrival picks (Figure 2.2). Fewer phase arrivals per event were catalogued for the Aleutian earthquakes due to sparser station coverage compared to mainland Alaska.

We reported 718 seismic sources caused by something other than regional tectonic earthquakes. Of these, 89 were suspected quarry blasts, the majority of which were located in the vicinity of Fort Knox and Healy mines in Interior Alaska (magnitudes M=0.3-2.5). The reported events included 522 icequakes (magnitudes M=0.5-3.1), primarily located in the Prince WIlliam Sound, Icy Bay, and Yakutat Bay areas, and also under the Wright Glacier in Southeast Alaska. This is 19% more icequakes compared to the second quarter of 2021. This is a typical seasonal behavior, with glacial activity increasing in late spring-summer months. The remaining 107 events were characterized as seismic events associated with volcanic activity (M=0.4-2.9).

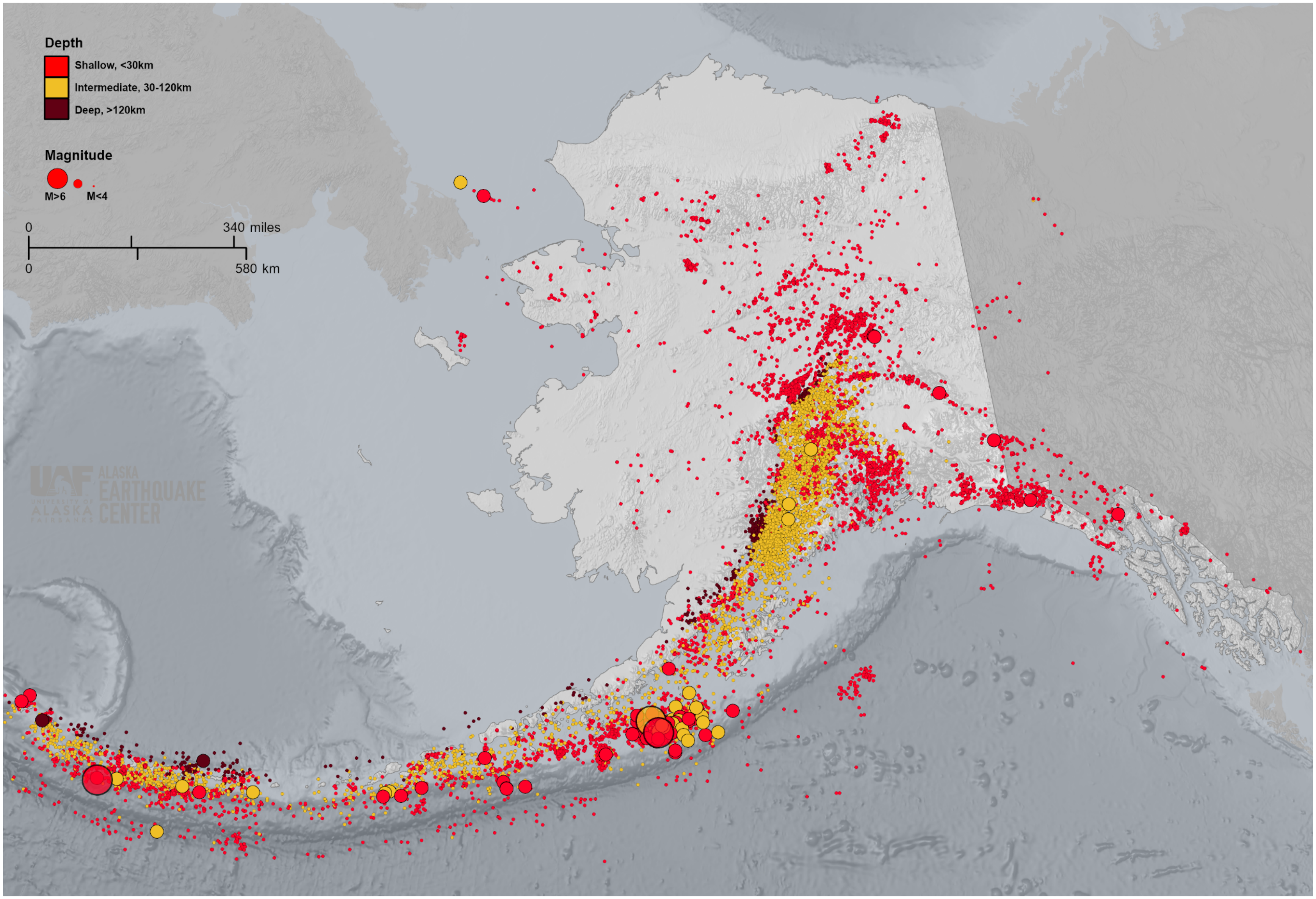
There were 61 earthquakes reported as felt (magnitudes M=2.1-8.2), two of which were located in Southeast Alaska, seven in the Interior, four in the Aleutian Islands, nine in the Kodiak Island region, and the remainder in the Cook Inlet and Southcentral region of Alaska. The largest number of DYFI (Did You Feel It) responses, 1,083, came from the M4.9 earthquake near Harding Lake on September 14 (https://earthquake.usgs.gov/earthquakes/eventpage/ak021bt4ffvw/dyfi/intensity).

The seismicity rate experienced a few periods of increase with the most significant ramp-up following the M8.2 Chignik Earthquake on July 29 (Figures 2.3, 2.4). Other increases were related to swarmlike activity in the northeast Brooks Range and under Wright Glacier in Southeast Alaska in July, M4.7 and M4.9 earthquakes and their aftershocks near Harding Lake in July and September, and M4.0 and M4.1 earthquakes and their aftershocks west of Yakutat Bay in September. We continued recording aftershock activity, all at decreased levels, for the following sequences: 2020 M7.8 Simeonof, 2018 M7.1 Anchorage, 2018 M6.4 Kaktovik, 2018 M7.9 Offshore Kodiak earthquakes, and the Purcell Mountains Swarm. With the exception of a localized activity in mid-July, there was no notable increase in seismicity within the 2018 Northeast Brooks Range swarm region. See Table 1 for summary.

Table 1. *Notable Alaska seismic sequences in April-June, 2021.*

Earthquake	**Number of aftershocks**	**Magnitude range**	**Magnitude of completeness (Mc)**	**Number of events per week**
New sequences this quarter (highest activity to lowest)				
July 29 M8.2 Chignik	1,054	1.3-6.9	2.5	117
Sept 5 M4.0 Sept 6 M4.1 Yakutat Bay	690	0.8-3.4	1.1	N/A
July 23 M4.7 Sept 14 M4.9 Harding Lake	150 (40+110)	0.1-3.2	0.8	N/A
Wright Glacier	131	1.0-3.1	1.8	N/A
Continuing sequences (in order of decreasing activity)				
2020 M7.8 Simeonof	685	1.1-4.4	1.9	52
Purcell Mountains Swarm	190	0.7-3.4	1.3	14
2018 M7.1 Anchorage	145	0.6-3.4	1.0	11
2018 M7.9 Offshore Kodiak	63	2.0-3.8	2.9	5
2018 M6.4 Kaktovik	61	0.9-3.4	1.5	5

Figure 2.1. *Earthquake map for Alaska and neighboring regions July-September, 2021.*



The following is a description of the most notable earthquake sequences for this time period, in an order of decreasing activity levels.

A magnitude 8.2 earthquake struck offshore of the Alaska Peninsula on July 29, the largest earthquake in the U.S. in 50 years. Perryville and Chignik were the nearest communities to the epicenter and the fault rupture zone, and felt the highest intensity of shaking. The earthquake did not produce a damaging tsunami, however. The M8.2 epicenter was located immediately east of the M7.8 July 21, 2020 Simeonof Earthquake and the fault rupture propagated for about 200 km towards Kodiak Island along a 100 km wide fault (Figure 2.5). This earthquake ruptured the subduction zone interface; previously this part of the Aleutian megathrust ruptured in a M8.3 earthquake in 1932. We recorded 1,054 aftershocks with magnitudes ranging between 1.3 and 6.9 through the end of the reporting period (Figures 2.6, 2.7). Due to the offshore location of this sequence, only aftershocks with magnitudes 2.5 and above can be reliably detected and located.

An earthquake sequence west of Yakutat Bay that began on September 5 with a M4.0 earthquake followed by a M4.1 earthquake on September 6 produced the second highest number of aftershocks after the Chignik Earthquake sequence (Figures 2.8, 2.9, and 2.10). We recorded 690 events in this sequence with magnitudes ranging between 0.8 and 3.4, with a low magnitude of completeness of 1.1. This area is characterized by complex faulting as the strike-slip Fairweather fault coming from the east bends and merges into the Chugach - St. Elias thrust-and-fold belt in the west. Both the M4.0 and M4.1 earthquakes indicate reverse faulting on a SW-NE trending fault resulting from the strong compressional stresses created around the Fairweather fault bend. The very high level of aftershock activity, however, was unexpected for such a sequence.

Another interesting earthquake sequence was recorded east of Harding Lake in Interior Alaska (Figures 2.11, 2.12, and 2.13). It began with an M4.7 earthquake on July 23 and culminated in an M4.9 earthquake on September 14. Both events were followed by aftershocks, with the M4.9 aftershock sequence being about 3 times as active as the M4.7 sequence. These events and some of the larger aftershocks were widely felt in the Interior. Both earthquakes indicate strike-slip faulting, typical of the crustal faulting in Interior Alaska, and occurred within the so-called Salcha Seismic Zone. This fault zone produced an M7 earthquake on July 22, 1937.

The icequake swarm under the Wright Glacier (located about 40 miles east of Juneau) had a few distinct periods of heightened activity throughout the reporting time period (Figures 2.14, 2.15). Some of the events reached magnitude 3 level and were reported felt in Juneau. This feature has been observed since the 1970s, with event rates usually peaking in summer and early fall.The levels of activity, however, are not the same every year. So far we recorded about 230 quakes within this cluster this year, including about 130 in the third quarter. The activity is expected to subside in mid-fall.

From the ongoing aftershock sequences, the Simeonof Earthquake had the highest level of activity with 685 reported aftershocks between magnitude 1.1 and 4.4. The M7.6 aftershock cluster continues to be more active than the larger M7.8 patch.

The Purcell Mountains Swarm activity continued, with 190 total events recorded. The earthquake rate was higher in August than in July or September. The largest earthquake was M3.4 on September 17 (Figures 2.16, 2.17).

The 2018 M7.1 Anchorage Earthquake aftershock sequence continued with 145 events recorded this quarter, a much lower rate than in the previous quarter. The largest aftershock was only M3.4.

We continue to record aftershocks in the 2018 M6.4 Kaktovik and M7.9 Offshore Kodiak sequences, both at decreased rates compared to the first half of 2021 (Ruppert et al., 2021a, 2021b).

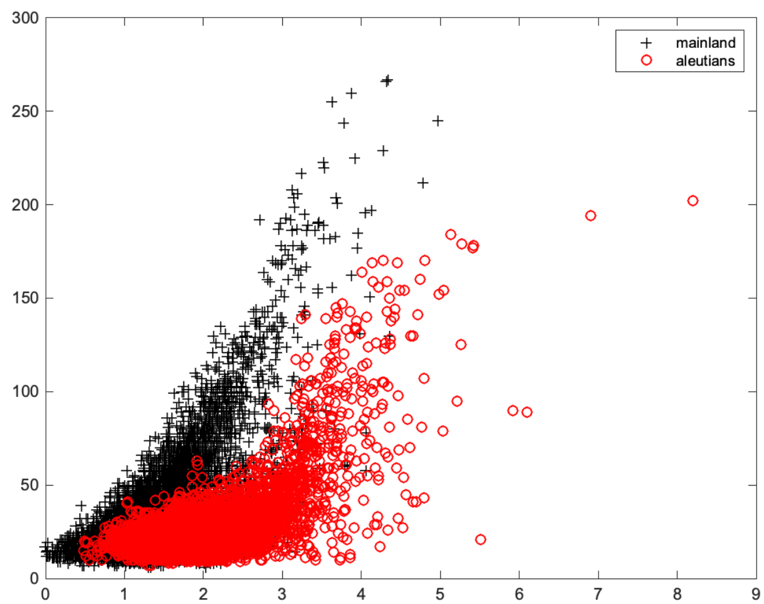
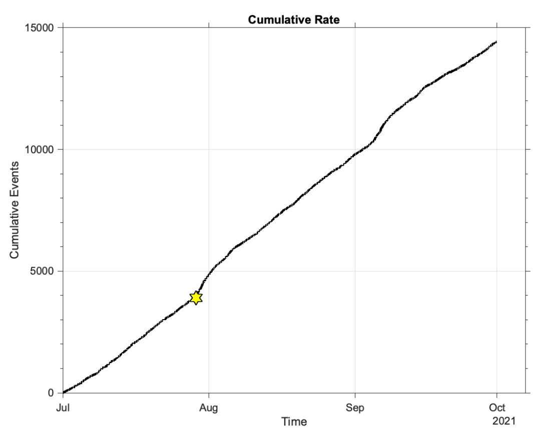


Figure 2.2*. Phase picks depending on magnitude and region for July-August, 2021.*



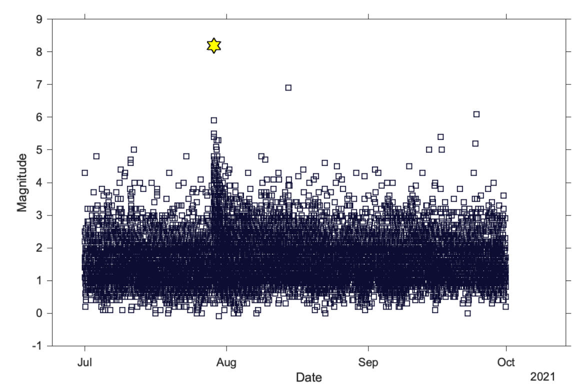


Figure 2.3. *Cumulative number of seismic events in the Alaska catalog for July-August, 2021. Star indicates M8.2 earthquake on July 29, 2021.*

Figure 2.4*. Time-magnitude plot of seismic events in the Alaska catalog for July-August, 2021. Star indicates M8.2 earthquake on July 29, 2021.*

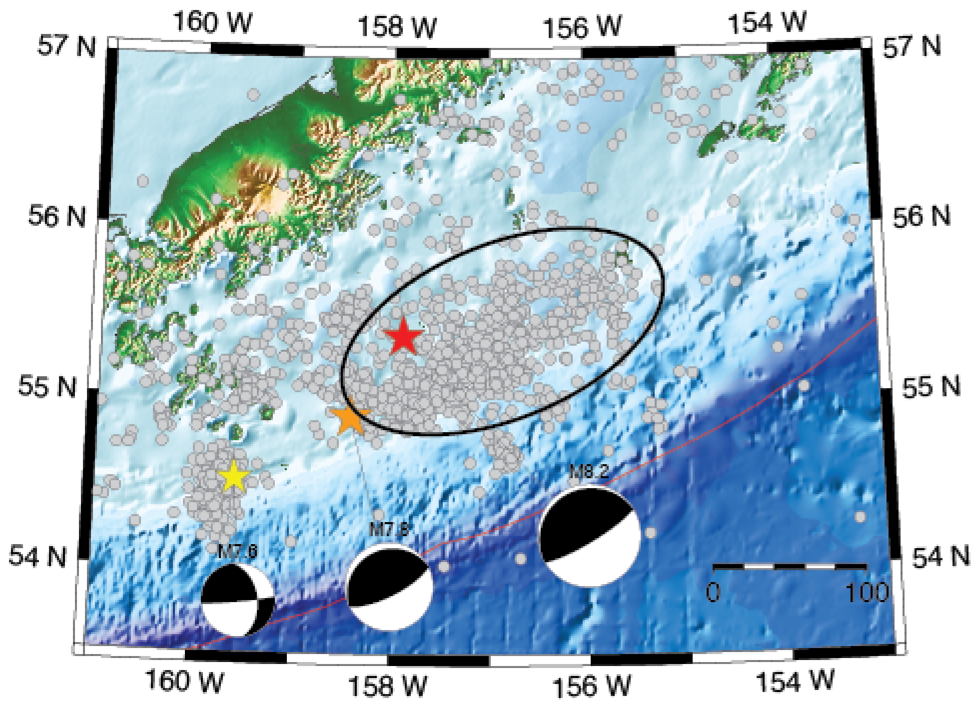


Figure 2.5. *M8.2 July 29, 2021 Chignik Earthquake location map. Grey circles are all earthquakes reported between July 29 and September 30, 2021. Red star - M8.2 epicenter, orange star - M7.8 July 22, 2020 Simeonof Earthquake epicenter, and yellow star - M7.6 October 19, 2020 earthquake epicenter. Black oval outlines the approximate extent of the Chignik Earthquake aftershock zone. Focal mechanisms are from the Global CMT catalog.*

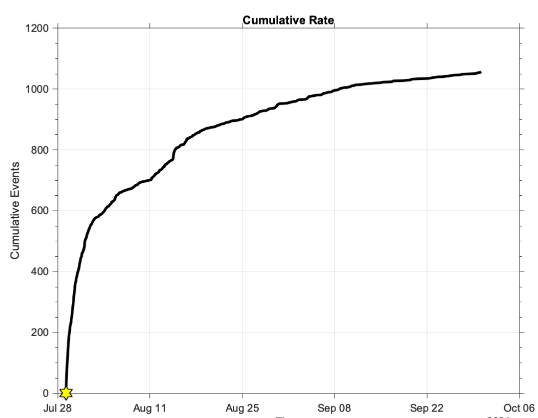


Figure 2.6. *Cumulative number of events for the July 29, 2021 M8.2 Chignik Earthquake aftershock sequence.*

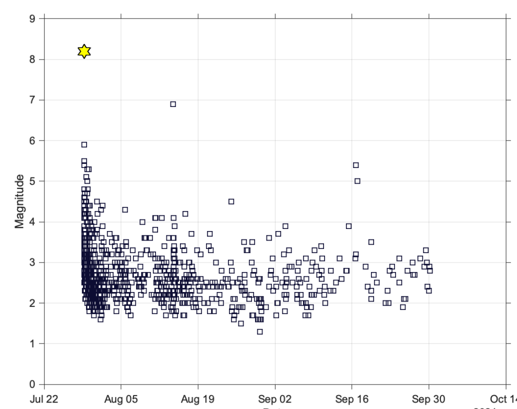


Figure 2.7. *Time-magnitude plot for the July 29, 2021 M8.2 Chignik Earthquake aftershock sequence.*

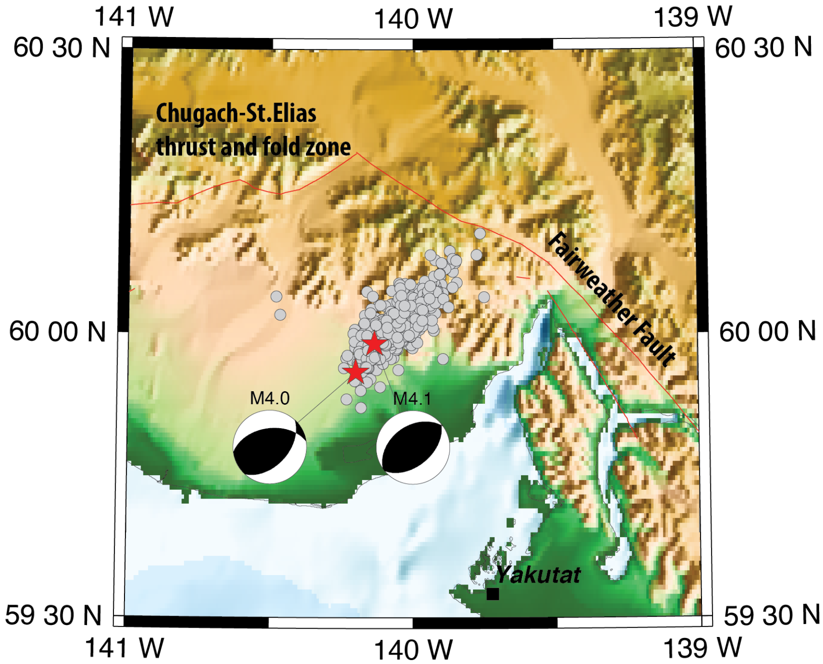


Figure 2.8. *M4.0 September 5 and M4.1 September 6, 2021 Yakutat Bay Earthquakes location map. Grey circles are all earthquakes reported between September 5-30, 2021. Red stars - M4.0 and M4.1 epicenters. Focal mechanisms are from the Comcat catalog.*

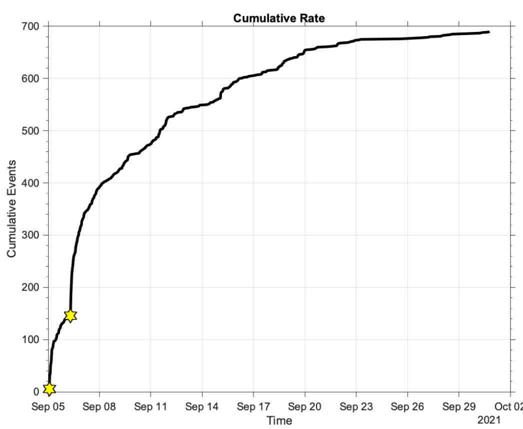


Figure 2.9. *Cumulative number of events for the M4.0 September 5 and M4.1 September 6, 2021 Yakutat Bay aftershock sequence.*

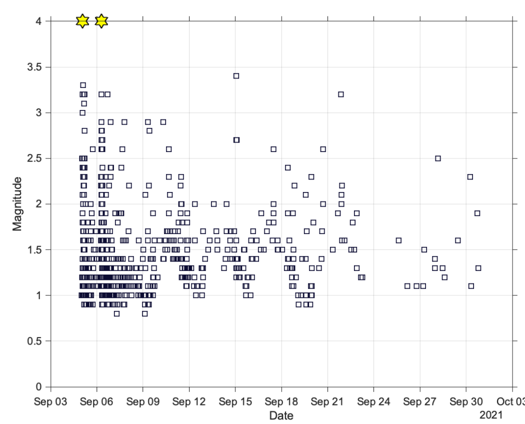


Figure 2.10. *Time-magnitude plot for the M4.0 September 5 and M4.1 September 6, 2021 Yakutat Bay aftershock sequence.*

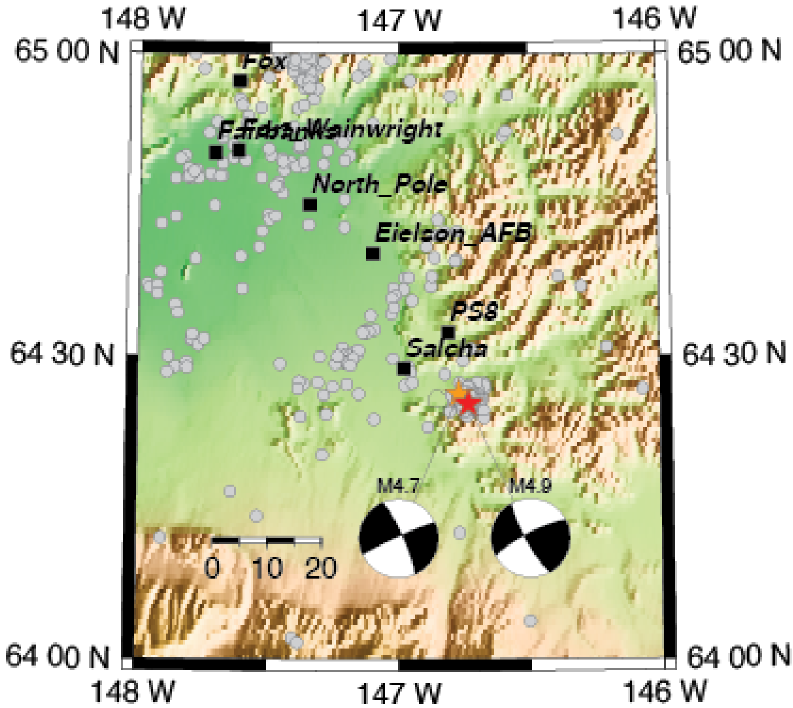


***Figure 2.11**. M4.7 July 23 and M4.9 September 14, 2021 Harding Lake Earthquakes location map. Grey circles are all earthquakes reported between July 1 - September 30, 2021. Red and orange stars are the M4.9 and M4.7 epicenters, respectively. Focal mechanisms are from the Comcat catalog.*

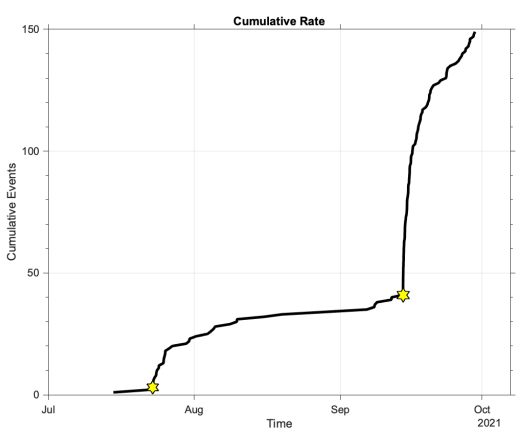


***Figure 2.12**. Cumulative number of events for M4.7 July 23 and M4.9 September 14, 2021 Harding Lake Earthquakes.*

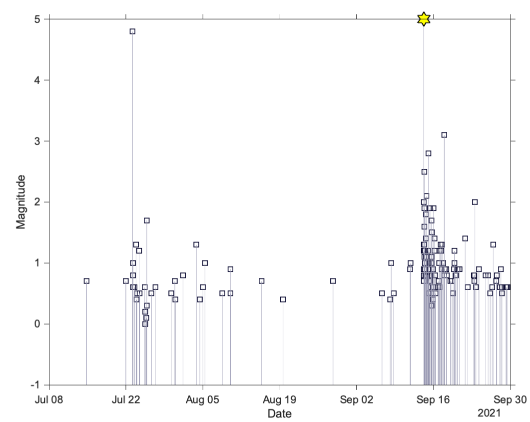


***Figure 2.13**. Time-magnitude plot for the M4.7 July 23 and M4.9 September 14, 2021 Harding Lake Earthquakes.*

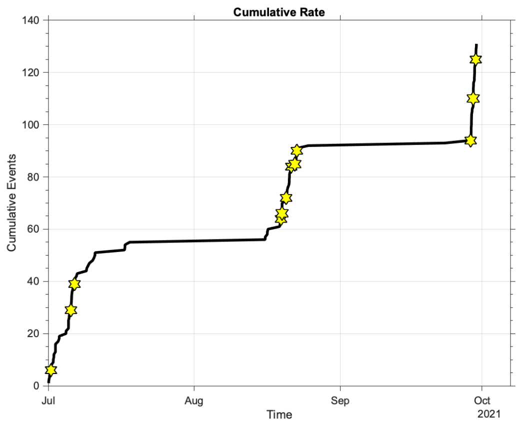


***Figure 2.14**. Cumulative number of events within the Wright Glacier Swarm (about 40 miles east of Juneau). This swarm became quite active in late June, 2021, with continued spurs in activity in July, August, and September. Stars denote events with magnitudes 2.8 and greater.*

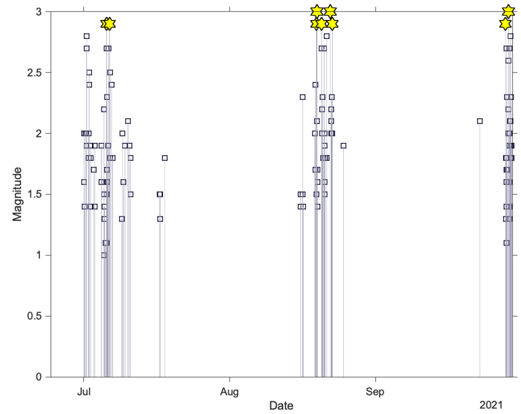


***Figure 2.15**. Time-magnitude plot of events within the Wright Glacier Swarm (about 40 miles east of Juneau). This swarm became quite active in late June. Stars denote events with magnitudes 2.8 and greater.*

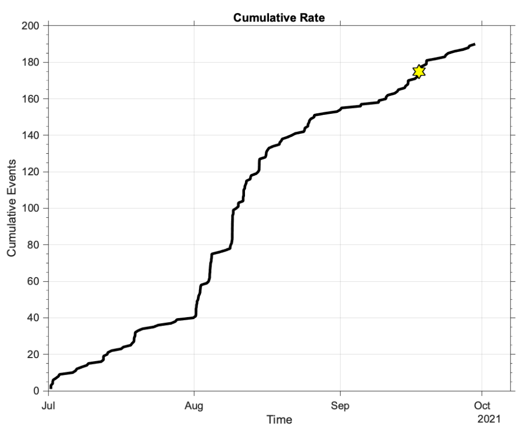


***Figure 2.16**. Cumulative number of events within the Purcell Mountains Swarm for July-September, 2021. The earthquake rate in August was higher than in July or September. Star indicates M3.4 earthquake on September 17, 2021.*

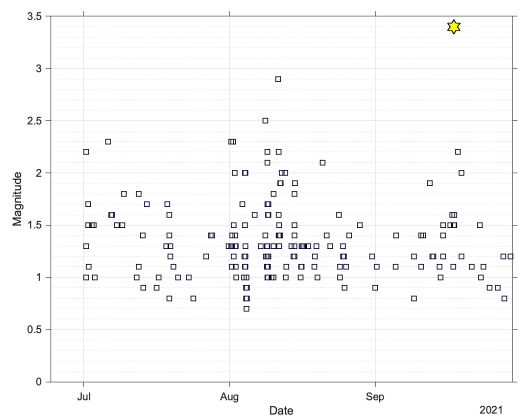


***Figure 2.17**. Time-magnitude plot events within the Purcell Mountains Swarm for July-September, 2021. Star indicates M3.4 earthquake on September 17, 2021.*

3. Field network

As of September 30, 2021, AEC maintains and acquires data from 252 seismic sites of the AK seismic network. The sites can be broken into the following groups based on their locations and sensor types:

- 208 free field broadband stations, 81 of which have co-located strong motion sensors, 107 of which have infrasound data streams, and 69 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;
- 7 strong motion sensor 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).

We will have an updated network map in the next report that will reflect all changes due to field maintenance and new/removed instrumentation.

Over the period between July 1 and September 30 the network had an average data return rate of 88.7%, with the daily rates ranging from 83.3% to 90.4% (Figures 3.1 and 3.2). There were a few multi-hour outages (up to 20 hours) of the pipeline sites due to the system malfunction that affected our return rates on those days. Otherwise, the network performance was consistent throughout this time period.

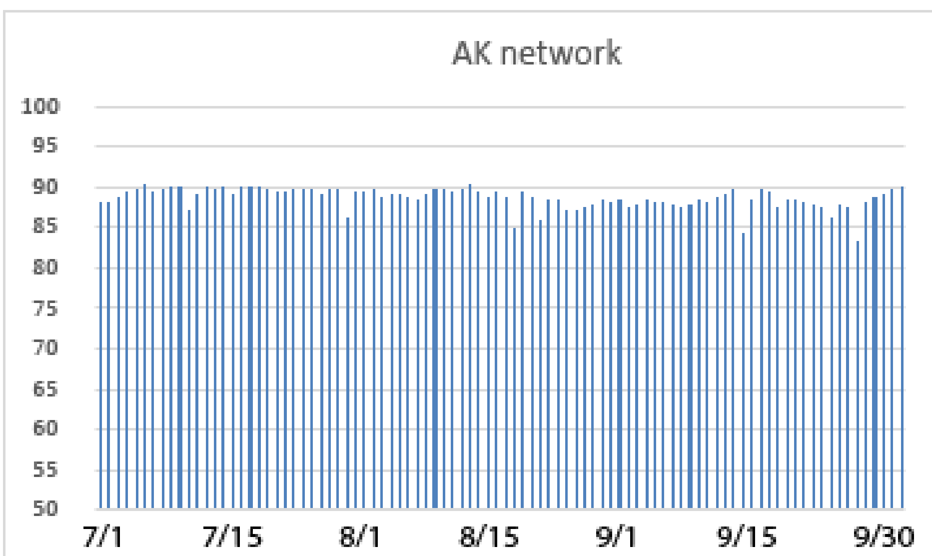


***Figure 3.1**. Daily data completeness in percent for AK network July-September 2021.*

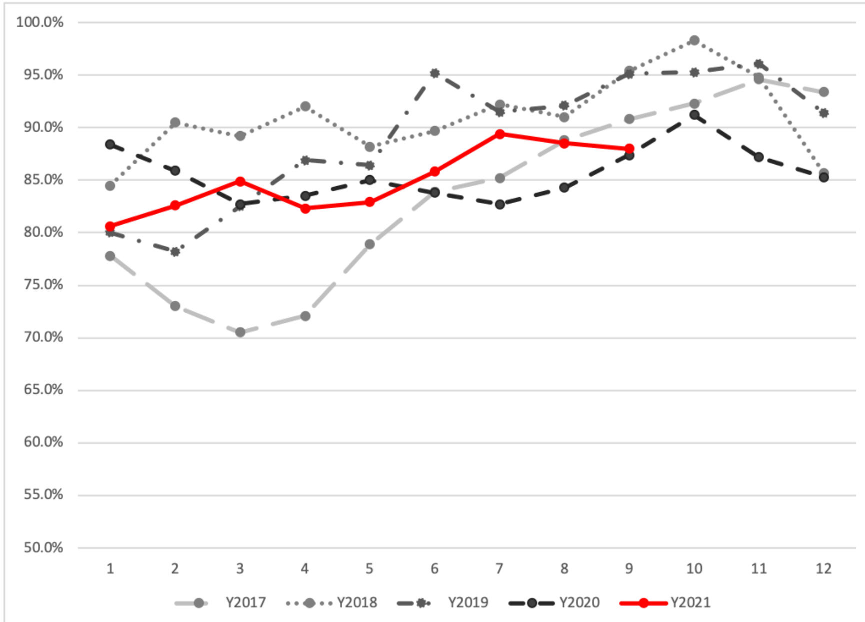


***Figure 3.2**. Average monthly data completeness in percent for AK network 2017-2021.*

4. Data Quality assurance

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-September, 2021 (also see Figure 4.1):

- Stations that continue to have 0% availability as compared to Q2:
  ATKA, BWN, DCPH, E25K, FA02, FALS, K216.DH, YAKA
- Stations that now have 0% as compared to Q2:
  C18K, L16K

- Stations that continue to have 1-50% availability as compared to Q2:
  E18K, E21K, I26K
- Stations that now have 1-50% availability as compared to Q2:
  BCP, CAPN, D25K, K203, K211, K216.00, K221, KTH, P23K, PAX, POKR, PPLA, SPIA, SSN,
- Stations that came back during Q3 but still had 1-50% availability for the entire period:
  DAM1, NICH, P08K
- BB data quality issues caused by faulty sensors and/or dataloggers:
  PS01 (BHN channel), PS06, PS07
- SM data quality issues caused by faulty sensors and/or dataloggers:
  PS06, PS07
- 2 sites continue to have bad timing (no reliable GPS clock):
  BAL, K223

Stations that have come back to above 50% availability since Q2 due to field maintenance or on their own: BAE, BAGL, BRSE, E22K, FID, GRIN, HARP, ISLE, K15K, KHIT, L22K, L26K, MESA, MS03, NIKH, R18K, RKAV, SWD, TABL, WAX, YAH.

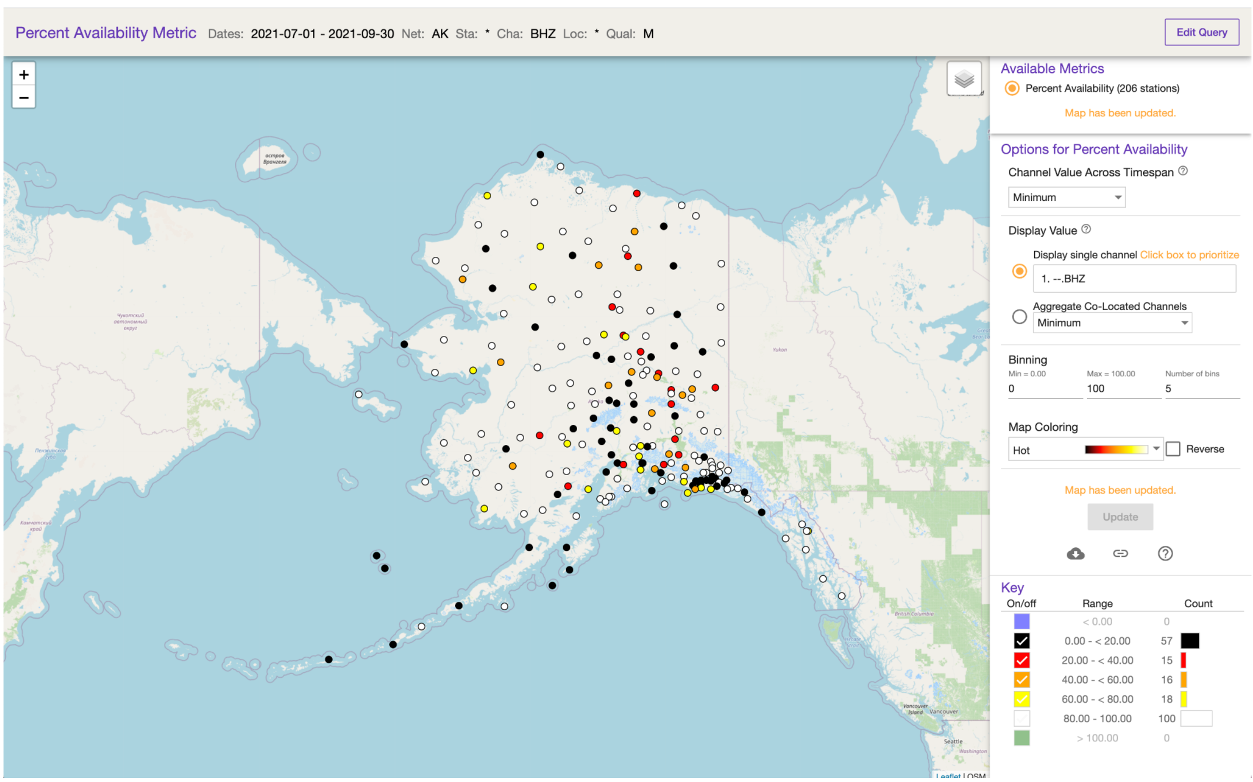


***Figure 4.1**. Map of Percent Availability for all AK network broadband stations, for Quarter 3, 2021 (*http://ds.iris.edu/mustang/mustangular/#/map?net=AK&cha=BHZ&sta=*&loc=*&qual=M&start=2021-07-01&end=2021-09-30&metric=PERCENT_AVAILABILITY&coloring=hot&invert=false&bincount=5&binmin=0&binmax=100&displayValue=Minimum&colocatedType=channel&aggregateValue=Minimum&channels=--.BHZ; *last visited November 11, 2021).*

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, *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 *orbgenloc* module. Once the event is located, its magnitude is calculated through *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 *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.

During the July-September 2021 time period we reported 11,141 automated events in Alaska and neighboring regions (Figure 5.1). This is 20% more detections than in the previous quarter. July 29, 2021 had the highest number of detections due to the M8.2 Chignik Earthquake aftershocks. High detections were also observed on September 5-6 due to the Yakutat Bay M4.0 and M4.1 earthquakes and their aftershocks. There were no notable delays observed during time periods with higher earthquake detection rates (Figures 5.2 and 5.3).

Beginning in January 2021, we have been producing monthly reports on 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.

There were 69 earthquake alarms during this reporting period, with the large increase in alarms following the M8.2 mainshock on July 29. Our goal is to have duty-seismologist-reviewed solutions for alarm events within 20 minutes. During the height of the Chignik Earthquake response we experienced delays up to 2 hours in reviewing alarm events (Figure 5.5).

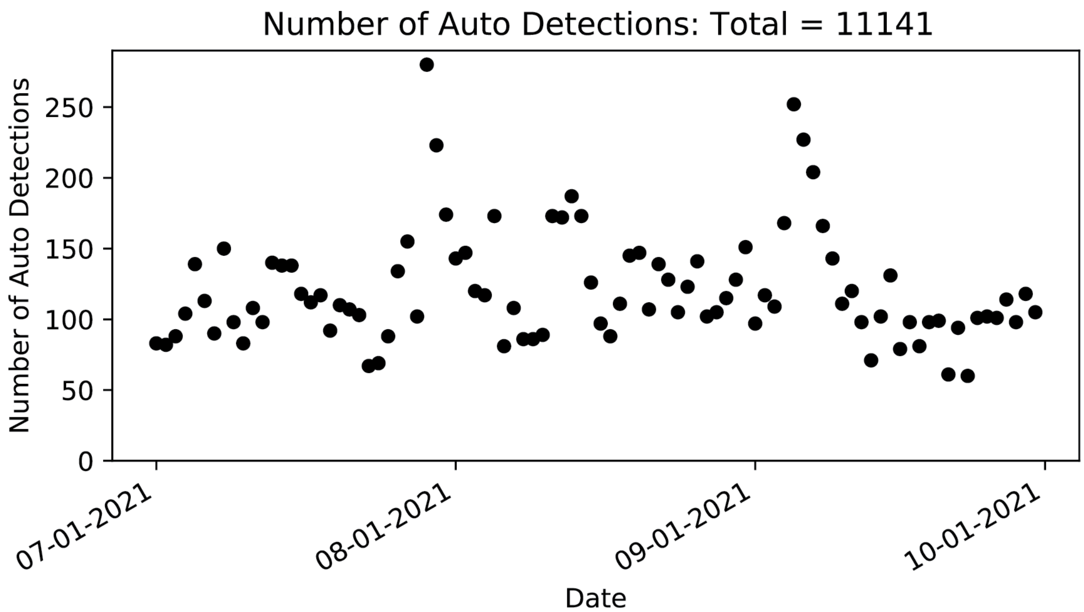


Figure 5.1. *Number of automatic event detections for each day. July 29, 2021 had the highest number of detections due to the M8.2 Chignik Earthquake aftershocks. High detections were also observed on September 5-6 due to the Yakutat Bay M4.0 and M4.1 earthquakes and their aftershocks.*

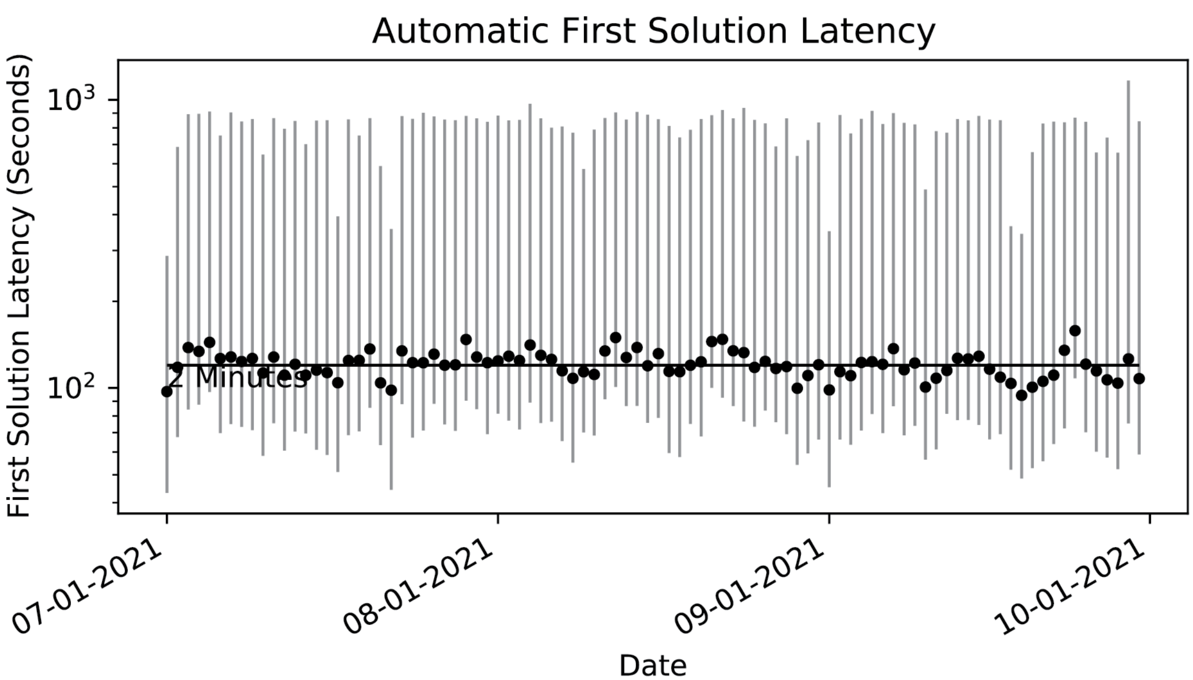


Figure 5.2. *Average daily latency (dots) and range (lines) of first automatic solution for each event. There were no notable delays observed during time periods with higher earthquake detection rates.*

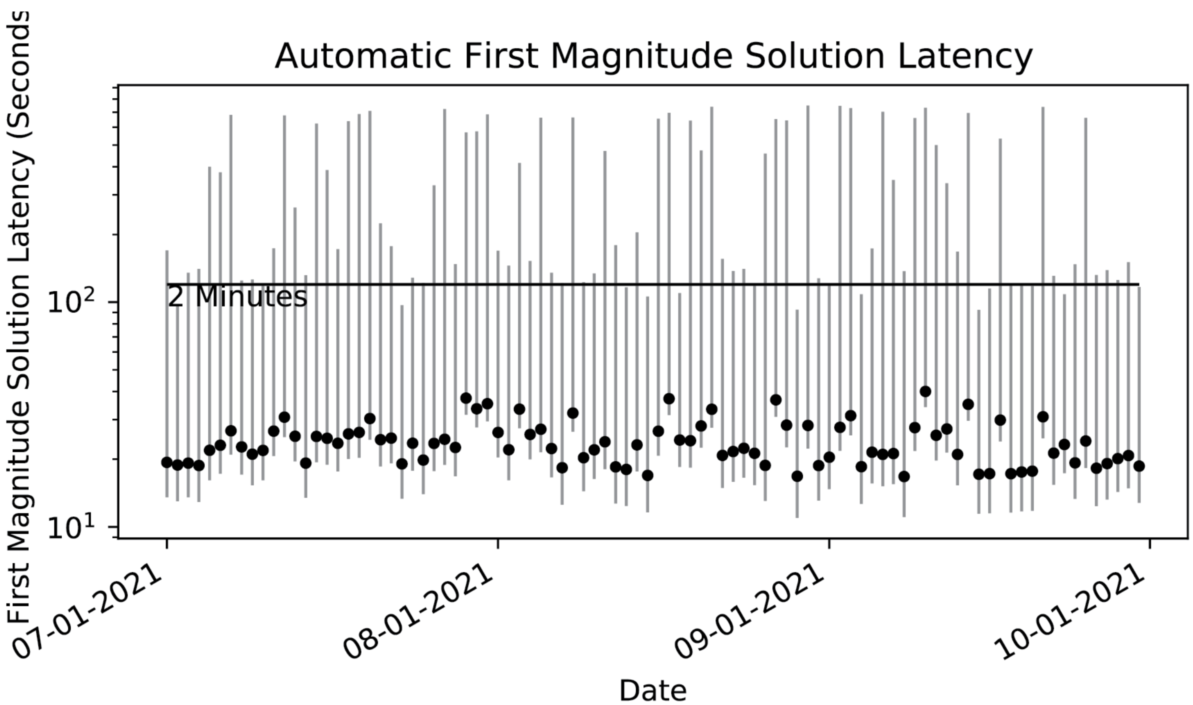


Figure 5.3. *Average daily latency (dots) and range (lines) of first automatic magnitude for each event after the event detection.*

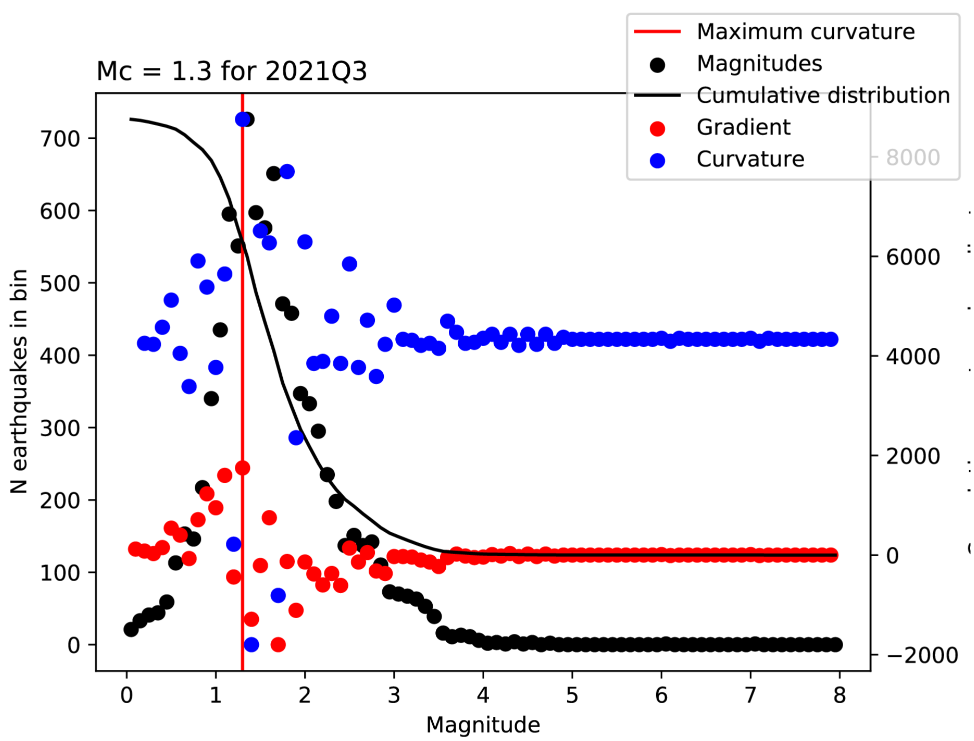


Figure 5.4. *Magnitude of completeness of the automatic catalog.*

Table 2. *Real-time earthquake detection system performance.*

Metric	**July**	**August**	**September**
Number of automatic event detections	3,703	3,913	3,525
First origin latency below ANSS 2 min standard	73%	72%	76%
Number of automatic events with magnitudes	3,177	3,293	2,991
Percent origins with magnitudes	86%	84%	85%
First magnitude latency below ANSS 3 min standard	51%	51%	57%
Magnitude latency from origin post time below ANSS 2 min standard	99%	99%	99%
Events deleted by duty seismologist	5%	14%	9%
Magnitude of completeness	1.6	1.3	1.3
Number of earthquake alarms	46	11	12

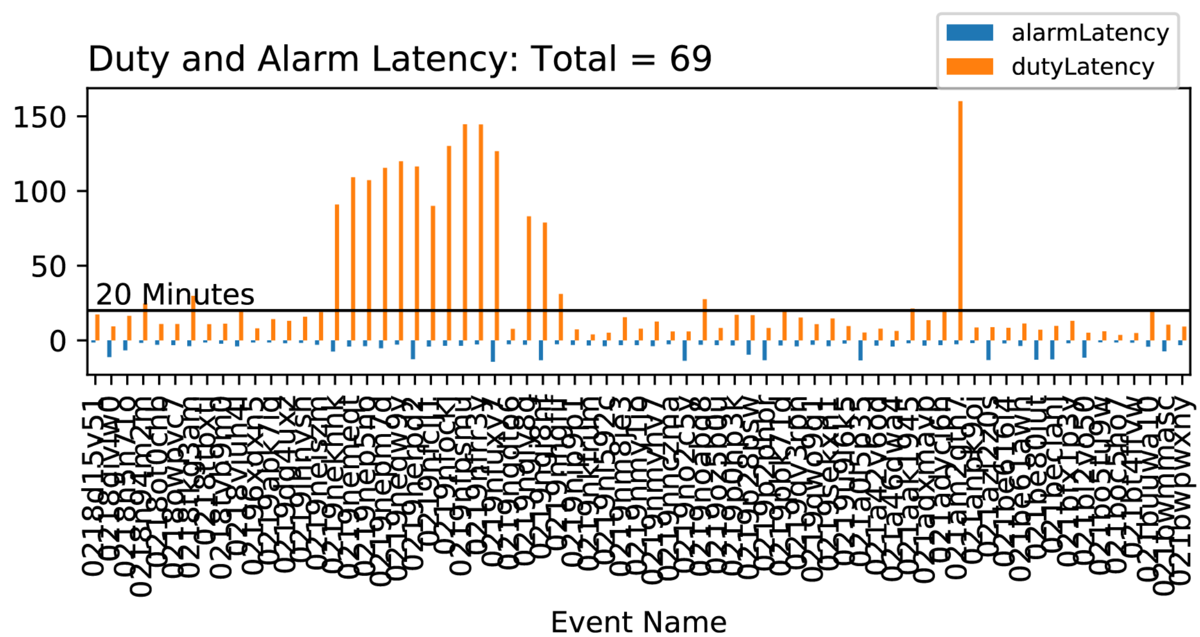


Figure 5.5*. Earthquake alarm and duty review latency from alarm time (bottom of the blue bar is origin time, top of the orange bar is duty review post time). Earthquakes are labeled with their event names.*

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
24	0	31	6	58	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 56.7 TB in continuous waveform data and 1.1 TB of segmented data. During the quarter, we acquired and archived 1.19 TB of new data (Figure 6.2.1).

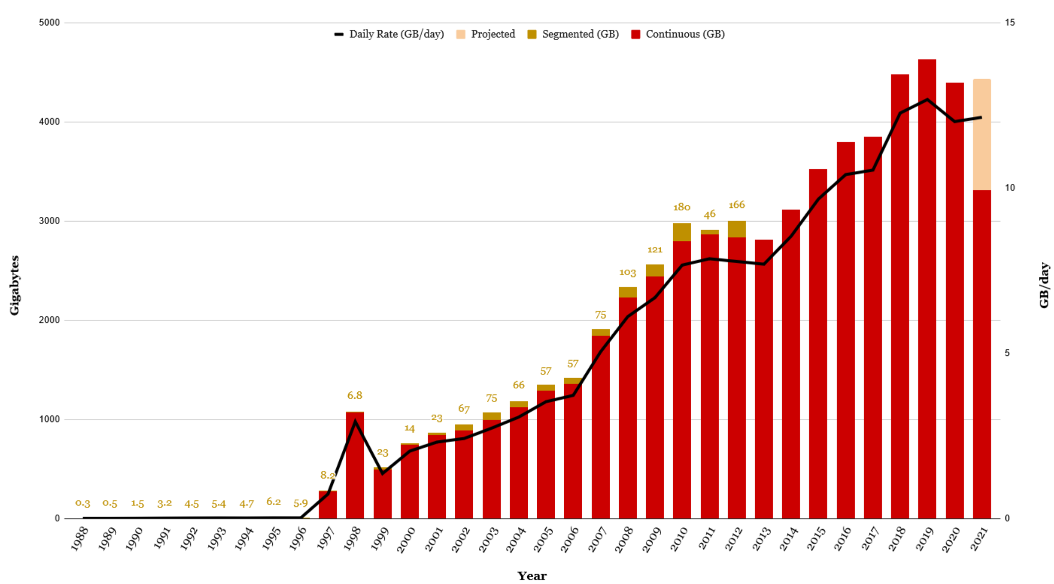


Figure 6.2.1. *Digital waveform archival storage for continuous (red) and segmented (brown) data. Pink color denotes projected data holdings for 2021.*

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: BAT
- Stations modified: J26L, BESE, L22K, SKN, ISLE, MCAR, KNK, GRIN
- Stations removed: CTG

We have continued to progress with integrating our metadata with the Station Information System (SIS). We have successfully loaded 11 sites into test SIS this quarter, which cover the majority of site configurations that are currently in operation in our network and are beginning to build out standard site templates for use in production SIS.

6.4 Software development

During this time, we upgraded Antelope, our seismic processing software, to the newest release, version 5.11. Total code commits under the following scopes of work were:

Antelope	Website	Station health	Other
12	353	5	139

The major development project during this quarter was continuing work on redesigning the catalog data workflow from the real-time system through final archival. Goals of this project include ensuring that analysts always have the most up-to-date information available when processing, ensuring that any catalog products remain in sync, and making the “best” catalog data access clear for internal and external users. Major work included building out the process to check-in data and moving into the testing phase of the project. During this quarter, the project team completed 6 sprints, bringing the total development time to 18 sprints.

7. Fieldwork

During the reporting period, Earthquake Center staff visited 66 field sites to resolve data outages and to perform planned upgrades, cleanup, and preventative maintenance. Ten staff members participated in this work, spending 130 person-days in the field.

Preventative maintenance included battery replacements at PPLA, ANM, MLY and RDOG, modem upgrades at four stations, annual inspections of six Alyeska Pipeline monitoring sites, and annual inspections at two Bradley Lake sites. As part of our ongoing effort to expand the Earthquake Center's strong-motion footprint, we installed new accelerometers at five sites - BAT, PPLA, WAT7, WAT1, and GHO.

After losing the Barry Arm West (BAW) site due to an avalanche in April 2021, it was determined that a replacement site was needed. BAW was briefly visited at the beginning of July to recover the buried sensors, however the remnants of the hut still remain downslope. In late

July, Barry Arm Top (BAT) was installed on the top of the ridge above the landslide. It includes a TA-style hut, direct-buried broadband sensor, strong motion sensor, and radome pointed to BAR. BAE also received a visit in July and had power rerouted to the radio to prevent the site going offline and the webrelay having to be reset.

PPLA received a bit of a facelift this quarter. In August, a new borehole was drilled and T120 was installed, and it received a battery swap and Q8 datalogger.

We continue to work to integrate the former USArray stations that we have adopted since 2019. For field staff this means working to understand the vulnerabilities of these sites and developing maintenance procedures to address those vulnerabilities. For example, P23K received multiple visits this quarter to solve its ongoing communications issue. Eventually, in September, a radio antenna to HIN was installed because of ongoing cellular outages in the area. P08K had been offline for a while and finally received a visit this season after 3 tries. It received a new AC-DC converter, router, sensor cable, and general cable cleanup. There was a wind noise reduction system installed at M26K with collaboration from WATC. Other sites such as L22K, L16K, L19K, etc. received visits for general troubleshooting and minor maintenance.

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 40 thousand 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 second quarter of 2021, we had more than 450,000 users visit our website. This amounted to more than 530,000 sessions (number of times users entered our website) and nearly 860,000 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.

Our web traffic is rarely quiet. On our “slowest” day between July 1-September 30, we still had more than 450 users on our site. The recent earthquake map page and recent earthquake list (a page for lower bandwidth users) accounted for a combined total of nearly 80% of pageviews during the reporting period. These two pages typically account for approximately 75% of site visitors. The large spike seen July 28 and subsequent days is due to the M8.2 Chignik earthquake off the coast of the Alaska 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 as seen in Figure 8.1.2. Tablets and mobile devices such as phones accounted for 68% of website sessions.

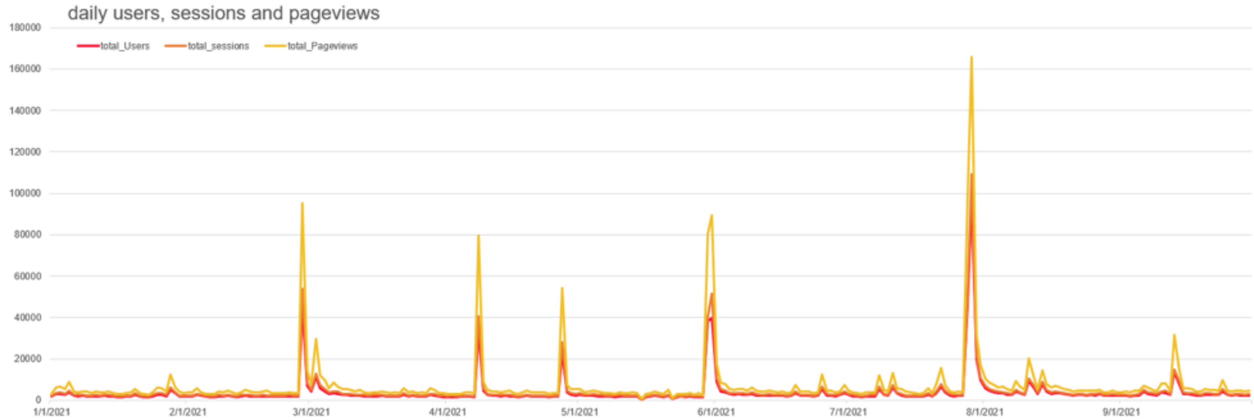


Figure 8.1.1. *Total number of website users (red), sessions (orange), and pageviews (yellow) per day.*

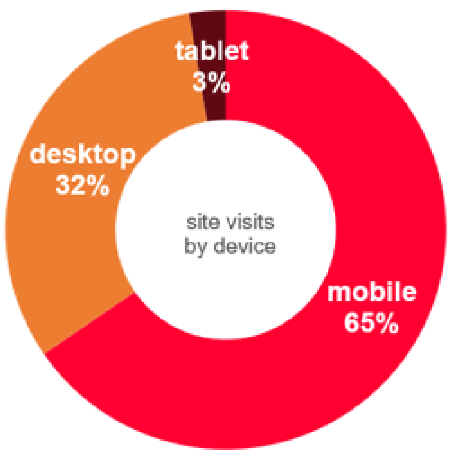


Figure 8.1.2*. Percentage of website sessions for the three major device types, mobile (e.g., phones), tablets, and desktop computers.*

8.2. Twitter

In the third quarter of 2021, we gained approximately 1,512 new followers, bringing our total following to 22,700. 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 79 tweets made this quarter. Figure 8.2.2 shows the number of posts made per day and the number of impressions per day. 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.

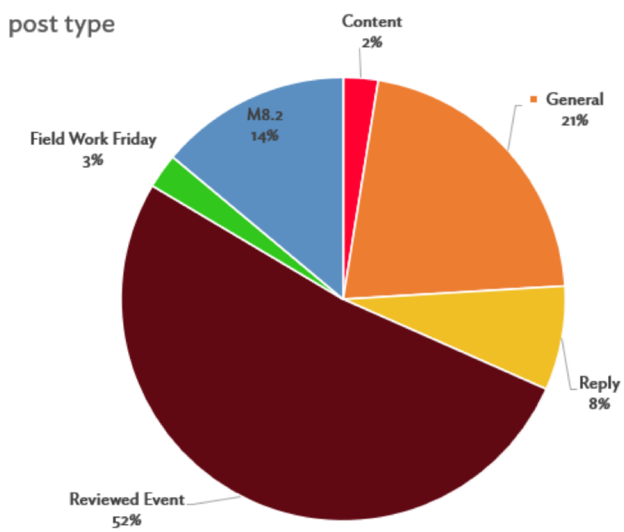


Figure 8.2.1. *Post type distribution for tweets in the first quarter of 2021.*

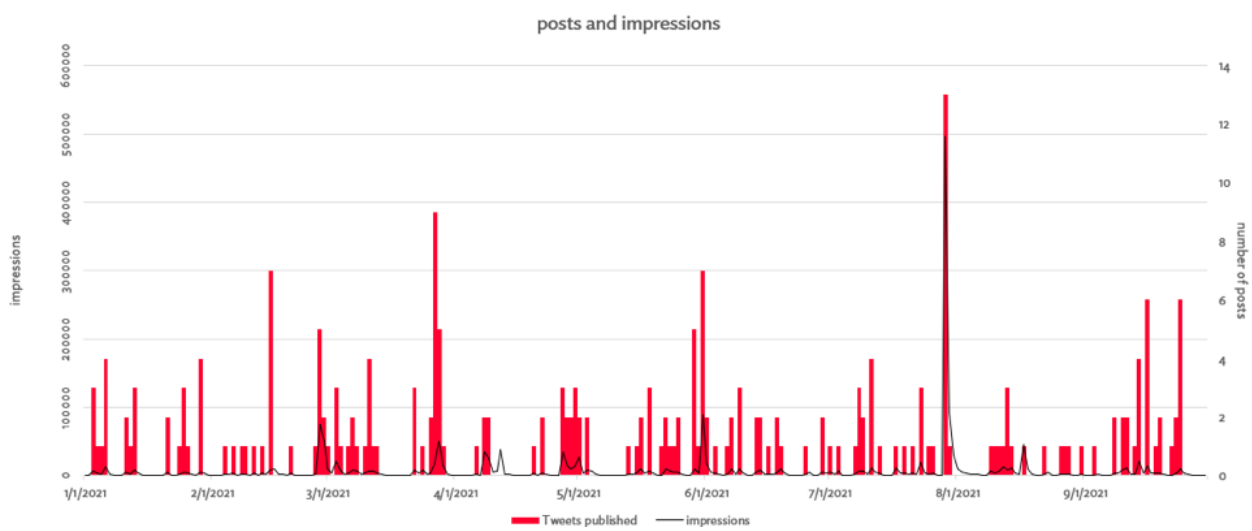


Figure 8.2.2*. Number of posts per day (right axis, red bars) compared to the number of impressions received per day (left axis, black line).*

The same spikes are seen in impressions as we see in the website traffic related to the M8.2 Chignik Earthquake. Our engagement rate with time (Figure 8.2.3) increased during this quarter, averaging around 2.7%, with a high nearing 9.5% for the September 14, M4.9 Harding Lake Earthquake.

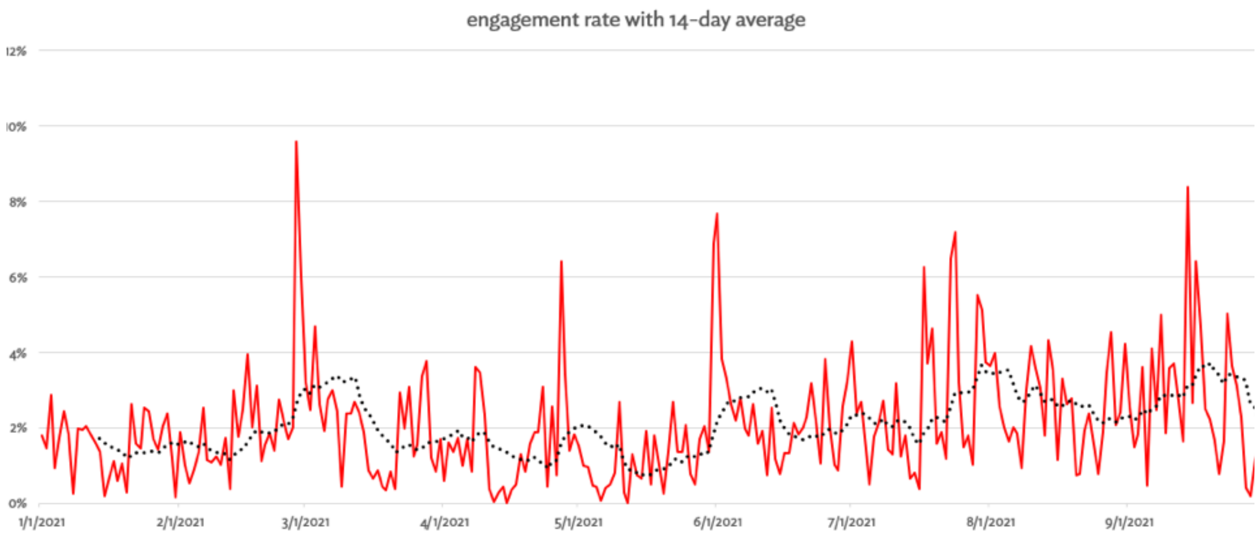


Figure 8.2.3. *Twitter engagement rates with time (red line) and 14-day moving average (black dotted line).*

Figure 8.2.4 shows impressions and engagements based on tweet type. Content and posts related to the M8.2 Chignik earthquake accounted for 63% of impressions and 75% of engagements during this quarter. Other reviewed events accounted for 25% of impressions and 15% of engagements, with the September 14 earthquake near Harding Lake dominating those.

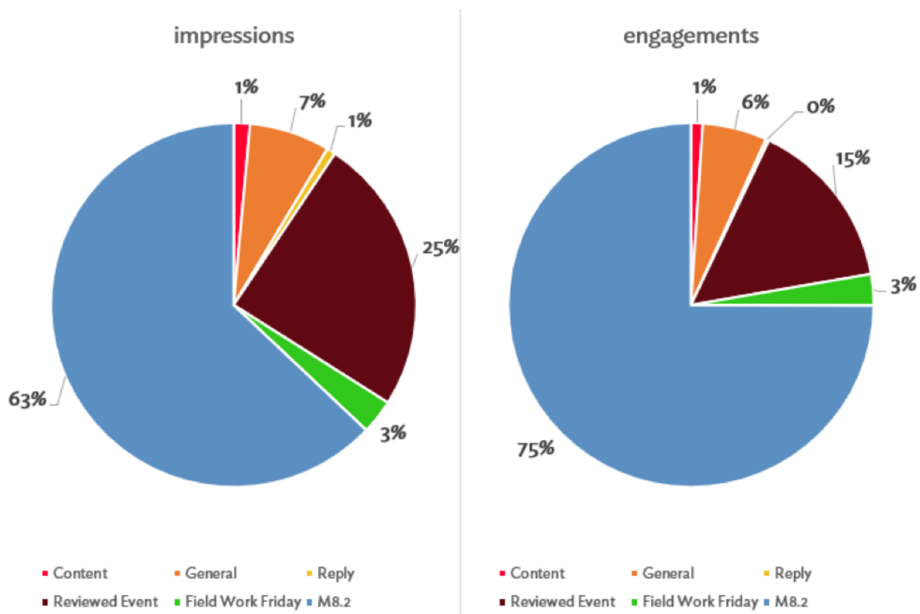


Figure 8.2.4*. Percentages of impressions and engagements based on tweet type.*

8.3. Facebook (Page)

Our Facebook Page is new as of December 2020. We are still assessing the best way to approach utilizing the page. Currently, we are posting reviewed event information to the page and not to the Facebook Group unless it is a significant event (see Section 8.4). We are also only posting weekly seismicity reports to the page. This is the primary difference between our posting strategies for our Facebook Page and Group.

During the third quarter of 2021, we attracted 1,545 new followers, bringing our current Page following to 5,537. As is the trend with felt earthquakes, we receive a follower boost after each event. The largest influx of more than 700 new followers occurred after the M8.2 earthquake on July 28. The distribution of post type is shown in Figure 8.3.1 below. Reviewed events accounted for 62% of the 66 posts made in the third quarter, however represented only 43% of reach. The July M8.2 earthquake comprised 21% of posts and resulted in 46% of reach. All other posts accounted for 17% of posts and resulted in 11% of reach.

We maintain an average 5% engagement rate based on reach (number of people who see our content) and impressions (how often our content appears on a screen). Engagement rates are generally higher based on reach than impressions because the same user may have the post appear multiple times in their feed. There is a noticeable increase in engagement rates of posts related to the M8.2 earthquake. On July 28, our engagement rate based on reach maxed out at 25%, while our engagement based on impressions remained average (Figure 8.3.2).

Our largest number of engaged users also occurred on July 28 and with the largest percentage of users engaged with posts related to the M8.2 earthquake (Figure 8.3.3).

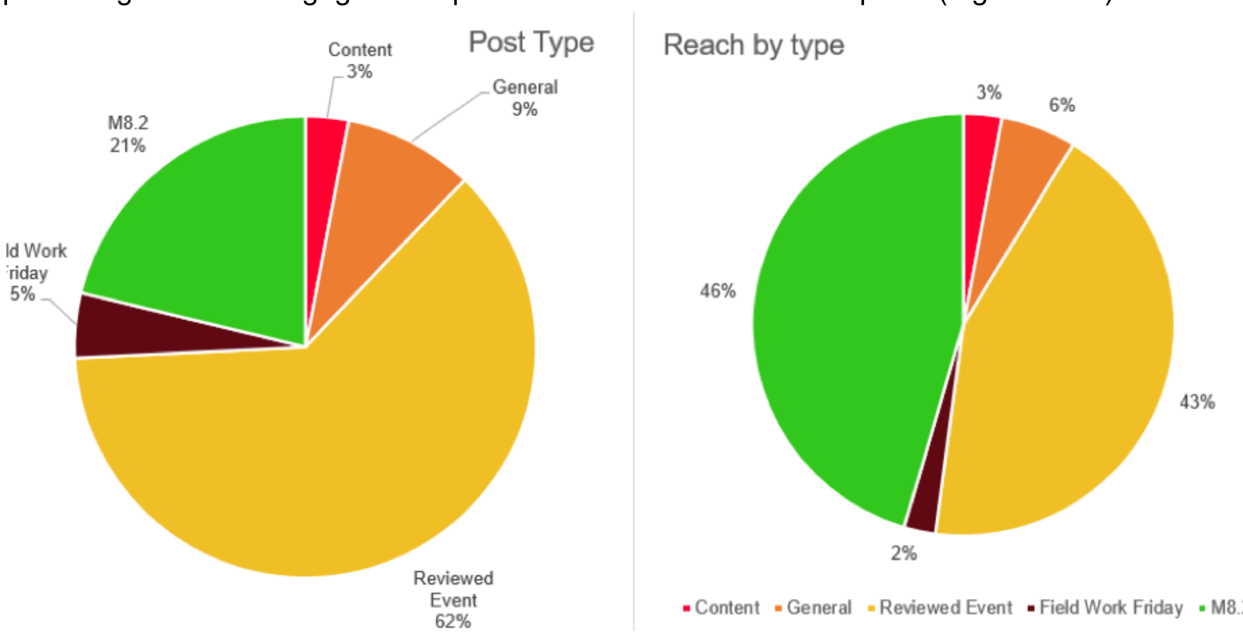


Figure 8.3.1. *Distribution of Facebook Page posts by type (left) and audience reach by type (right).*

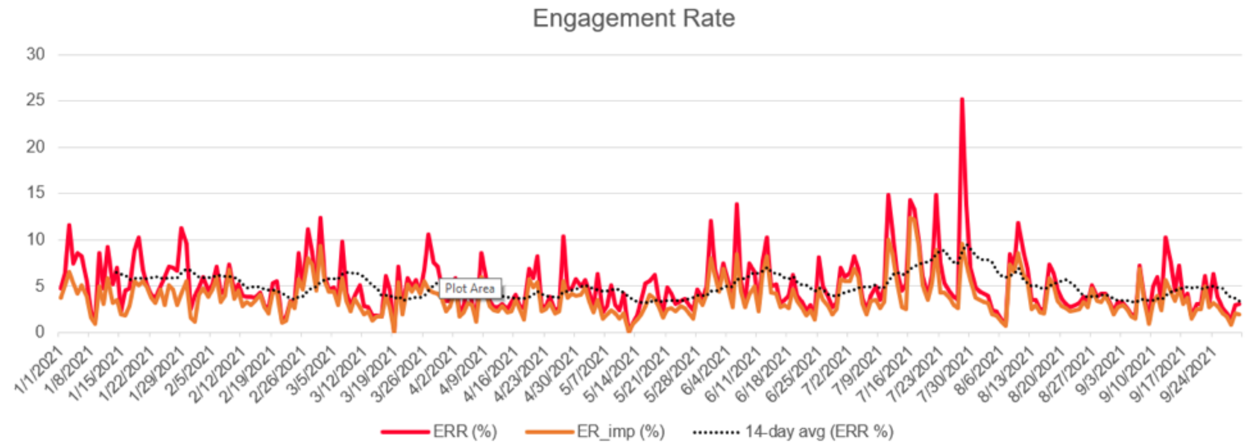


Figure 8.3.2. *Daily engagement rate based on reach (ERR) and impressions (ER_imp) plotted with a moving 14-day average of ERR.*

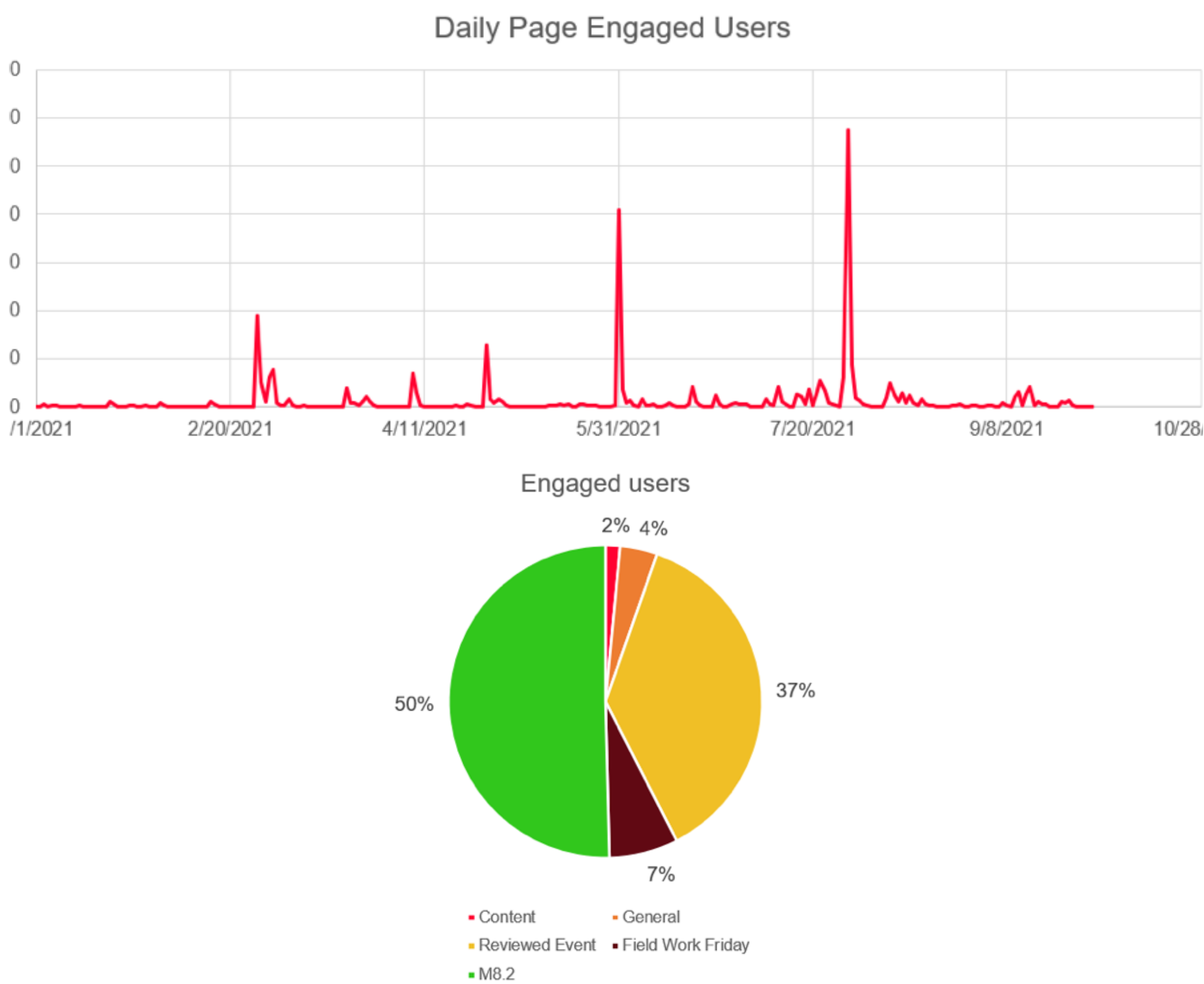


Figure 8.3.3*. Daily engaged users of our Facebook Page (top) with percentages of users by post type (bottom).*

8.4. Facebook (Group)

Analytics for Facebook Groups are more difficult to quantify. Groups are set up differently than pages, and engagement, impressions, and reach are calculated differently. Therefore, while some metrics are related, they are not directly comparable.

Currently we have more than 18,100 group members, with a net gain of 600 new members during the reporting period. The Group is designed to be a discussion forum and not a repository for reviewed event posting. Occasionally, we do post significant events to the group in the hopes of facilitating discussion, but we generally share it from the page with the page as the author and not an individual admin.

Figure 8.4.1 shows the daily count of active members with number of posts per day. During the third quarter we maintained an average engagement rate of 3%. Our maximum engagement rate of 29% occurred as a result of the July 28 M8.2 Chignik Earthquake.

During the third quarter of 2021, there were 89 posts to the group: 44 by AEC admins and 63 by other group members. Nearly all 63 member posts were earthquake felt reports. We moderate member posts; however, we do not include them in our analyses beyond count when they are felt reports. Members are encouraged to submit *"Did You Feel It?"* reports. Figure 8.4.2 shows the distribution of post type for posts made by admins to the group. While only 27% of posts made were related to the July 28, M8.2 earthquake, they resulted in 43% of our total engagement during the quarter (Figure 8.4.3).

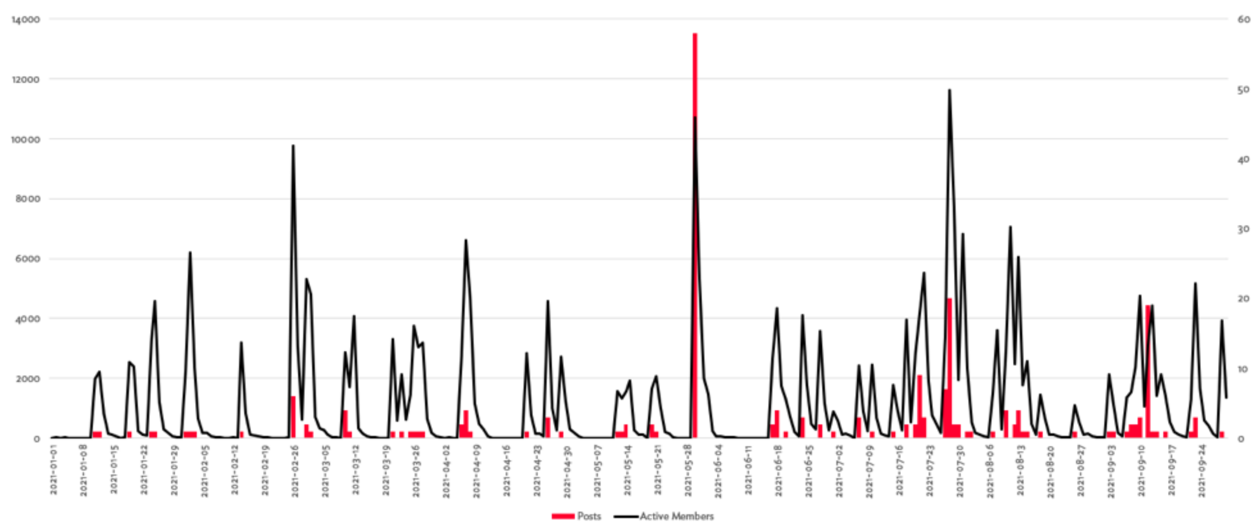


Figure 8.4.1. *Plot of active members (left axis) and number of posts (right axis) with time.*

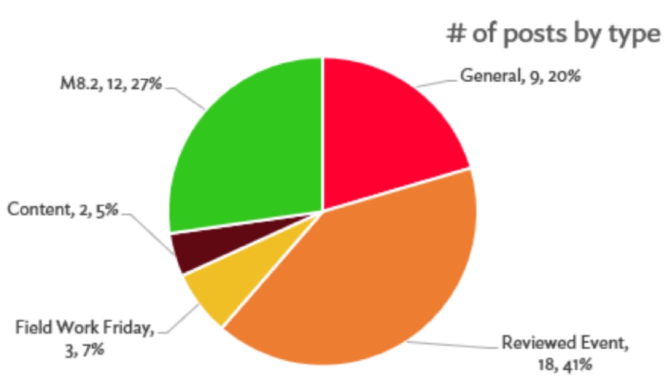


Figure 8.4.2*. Distribution of post type for the Facebook Group.*

Figure 8.4.3*. Distribution of our engagement as reactions, comments, and shares based on post type for the Facebook Group.*

9. Publications and presentations

Names in **bold** are Earthquake Center staff.

9.1. Publications

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, 43pp, http://hdl.handle.net/11122/12243

9.2. Public Presentations

Date	Presenter(s)	Event/Workshop	Title	Virtual/ In person
9/10	Ezgi Karasözen	UAF GI Department Seminar	How can we better assess earthquakes?	Virtual
9/21	Heather McFarlin	1st International Workshop on Seismic Resilience of Arctic Infrastructure and Social Systems	A Review of Recent Northern Alaska Seismicity	Hybrid
9/24	Ezgi Karasözen	37th General Assembly (GA) of the European Seismological Commission	The 2020 October 30 Mw 7.0 Samos earthquake	Virtual
9/28	Elena Suleimani	Meeting with the City of Old Harbor and emergency officials	Tsunami hazard map of Old Harbor	In person
9/29	Elena Suleimani	Meeting with the Port Lions emergency officials and the City of Port Lions	Tsunami hazard map of Port Lions	In person
9/29	Elena Suleimani	Presentation to the school students and teachers in Port Lions	Tsunamis in Alaska and around the world	In person
9/30	Elena Suleimani	Presentation to the Kodiak High School Environmental Science class.	Tsunamis in Alaska: Are we ready for the next big one?	In person
9/30	Elena Suleimani	Presentation to the Kodiak High School Environmental Science AP class	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
7/30	Steve McNutt, University of South Florida	Urban Seismology Update: Quarry Blasts in Miami Lakes and Preliminary Evaluation of the Surfside Condo Collapse	hybrid
8/11	Gabrielle Davy, UAF	Tracking Seismicity at the Barry Arm Landslide	hybrid
8/11	Cade Quigley, Colorado College (AEC summer intern)	Environmental influences on seismic noise across the U.S. Arctic	hybrid

10. References

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

Ruppert, N. A., S. Dalton, L. Gardine, M. Gardine, B. Grassi, S. G. Holtkamp, H. McFarlin, and M. E. West (May 2021). Alaska Earthquake Center Quarterly Technical Report January-March 2021. ScholarWorks@UA, 38 pp., http://hdl.handle.net/11122/11966.

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, 43pp, http://hdl.handle.net/11122/12243.

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

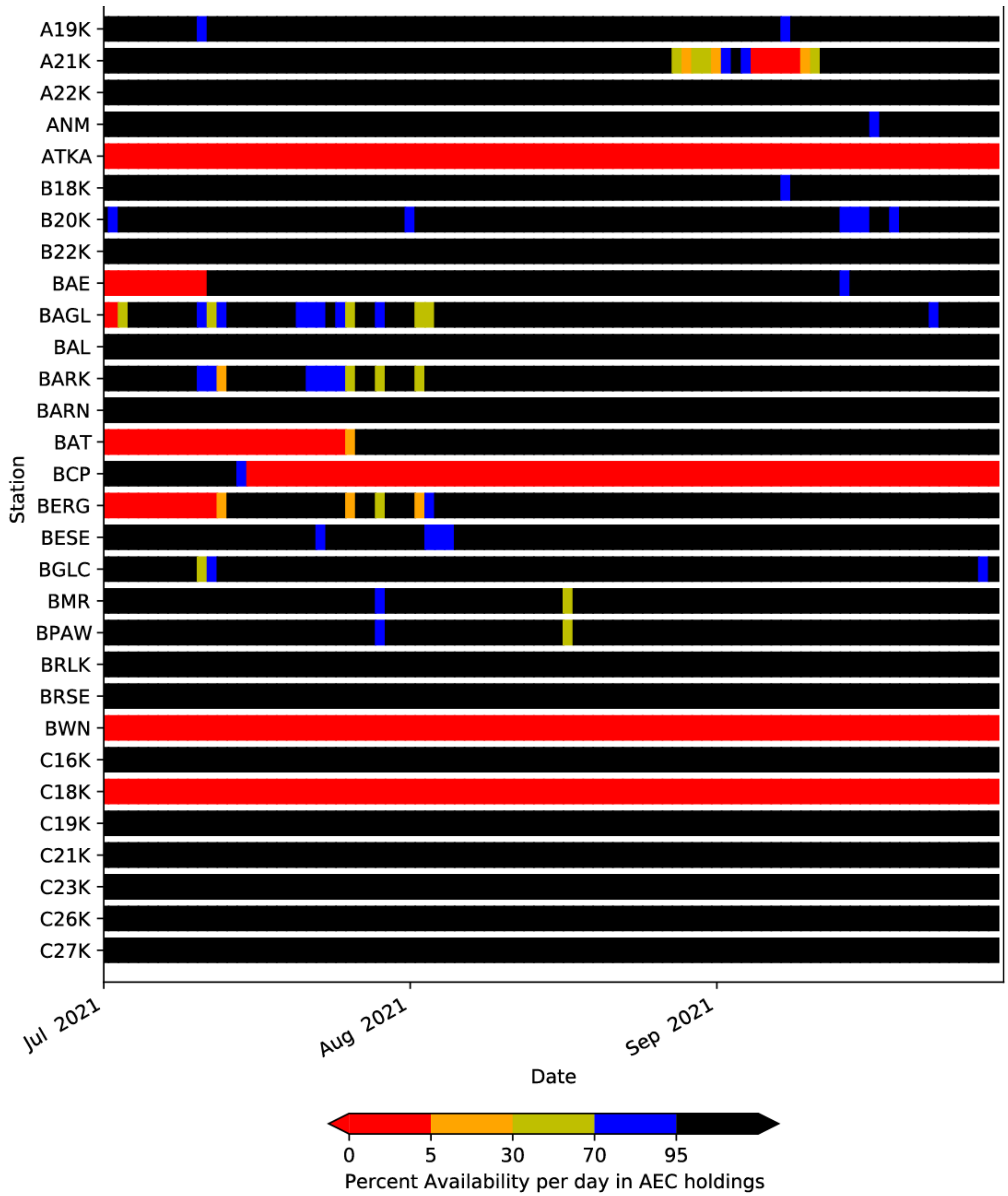


***Figure A1**. Data availability for stations A19K-C27K (listed alphabetically). BAT is a new site installed in July 2021.*

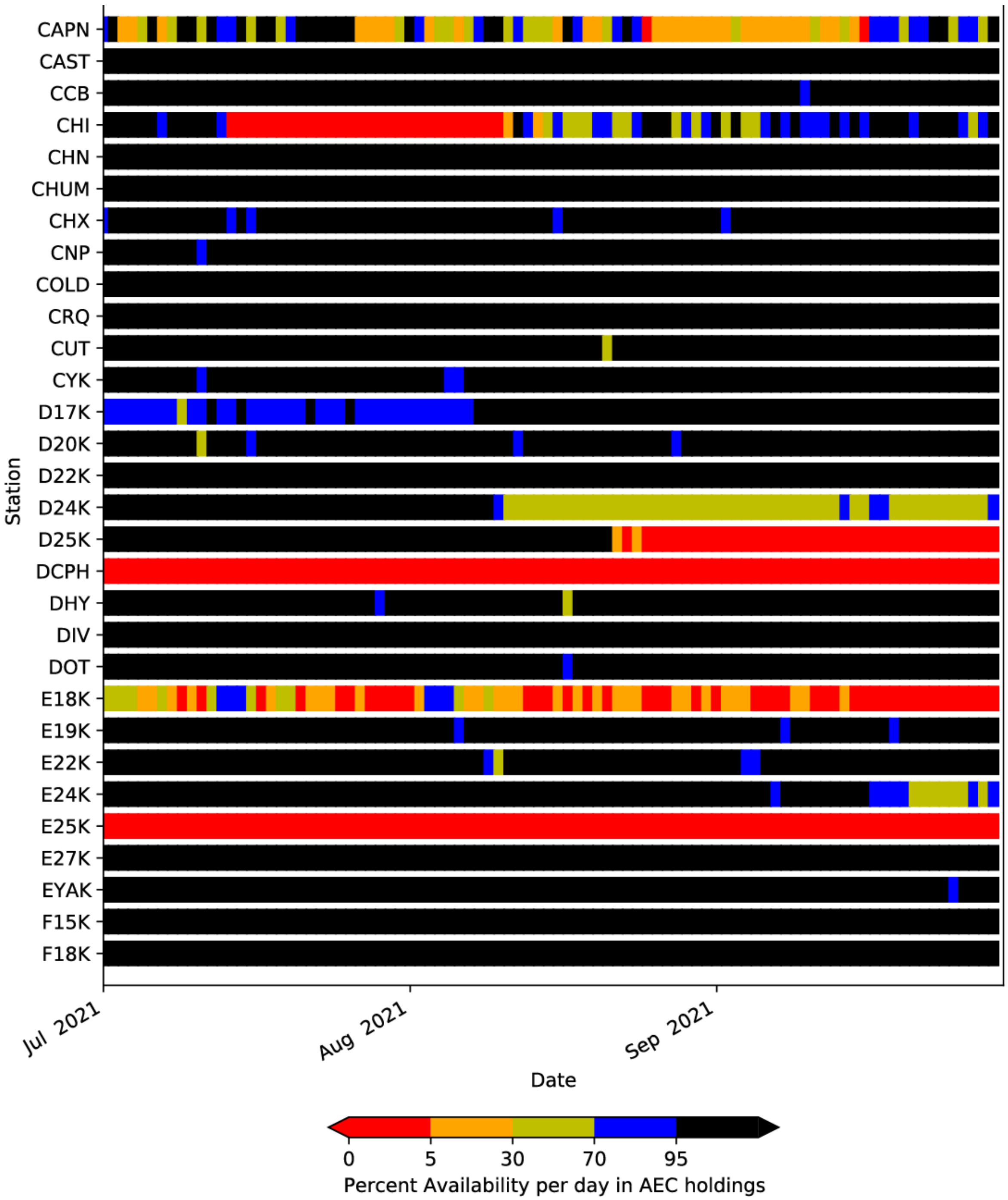


Figure A2. *Data availability for stations CAPN-F18K (listed alphabetically).*

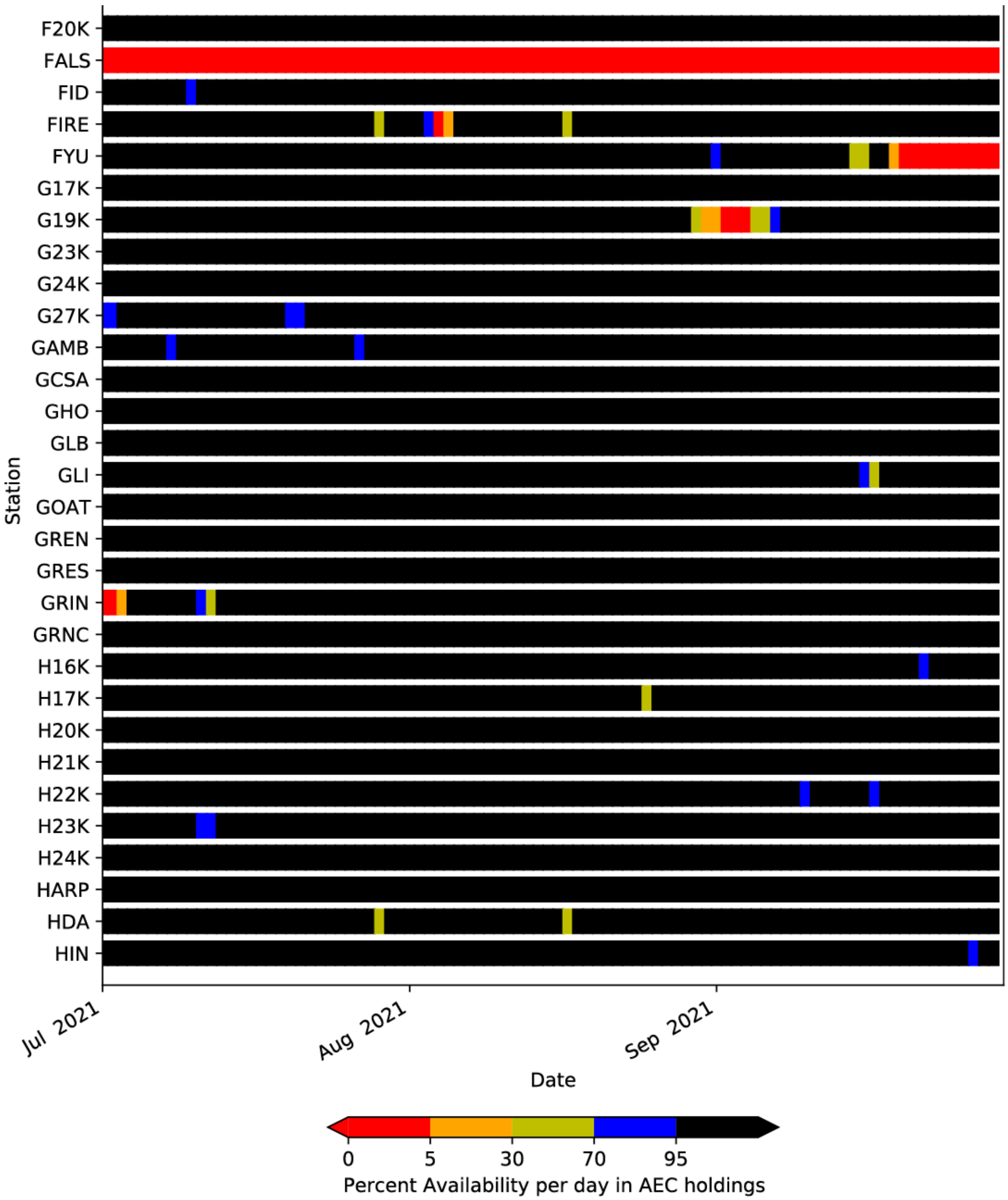


***Figure A3**. Data availability for stations F20K-HIN (listed alphabetically).*

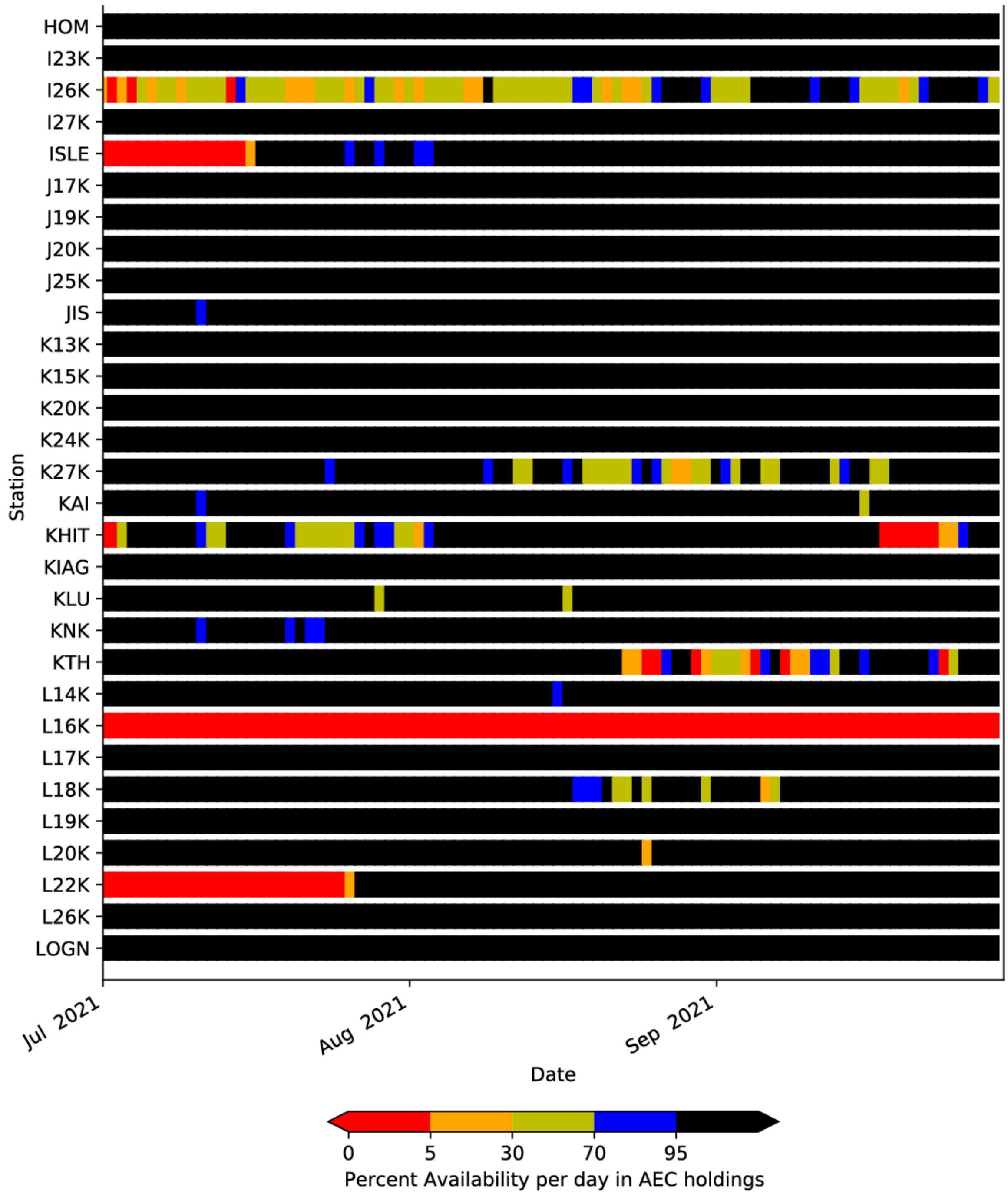


Figure A4*. Data availability for stations HOM-LOGN (listed alphabetically).*

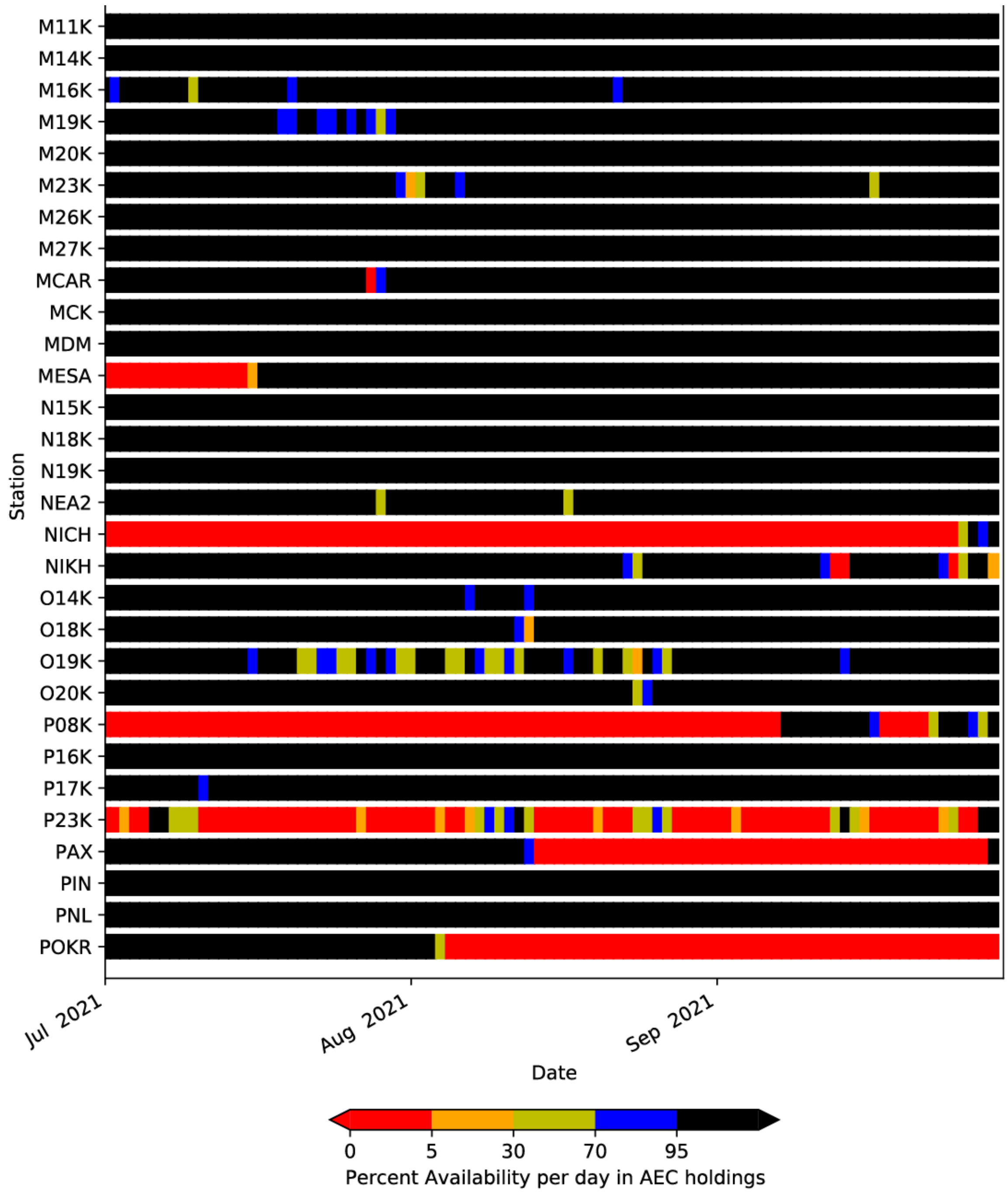


Figure A5. *Data availability for stations M11K-POKR (listed alphabetically).*

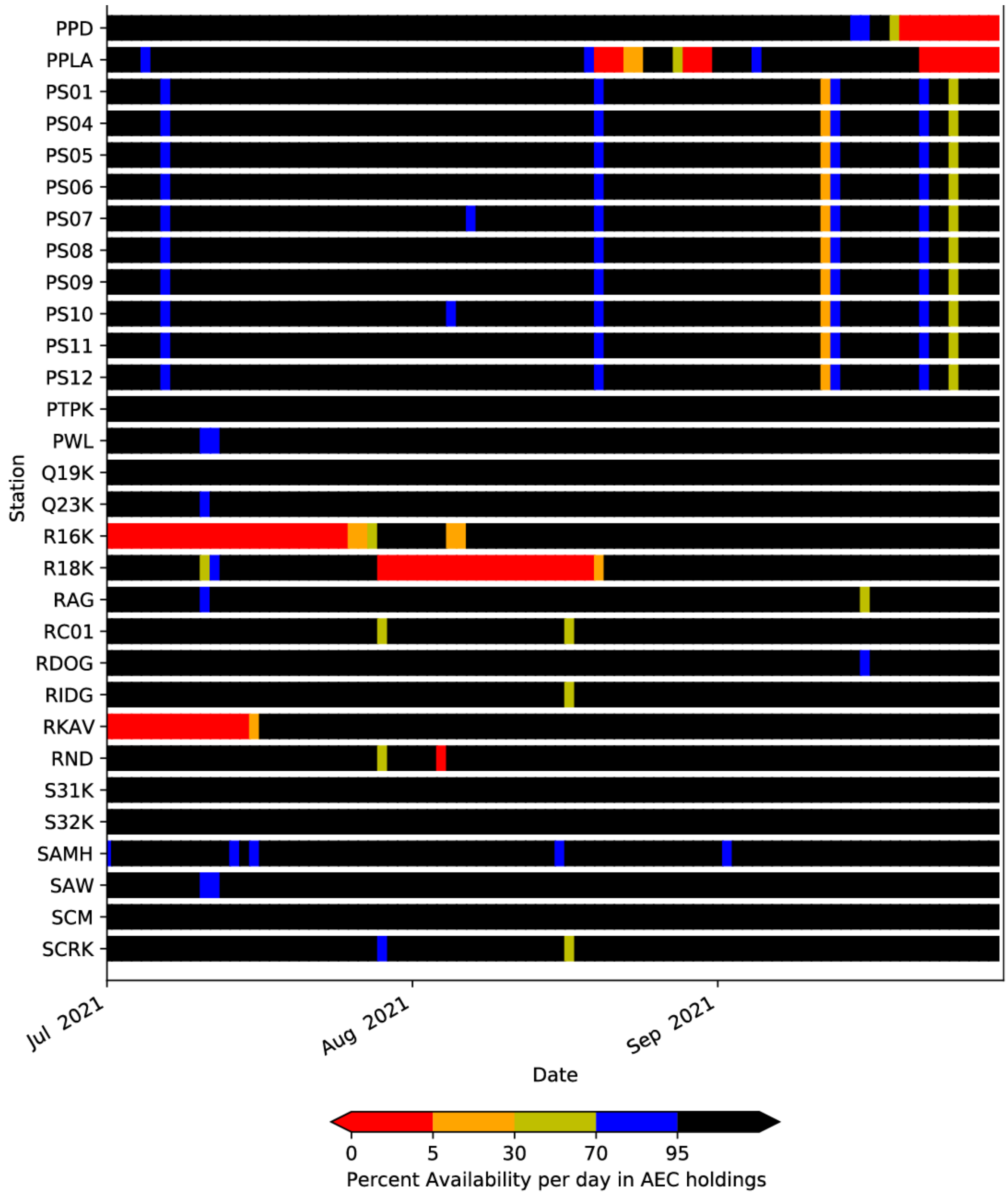


***Figure A6**. Data availability for stations PPD-SCRK (listed alphabetically).*

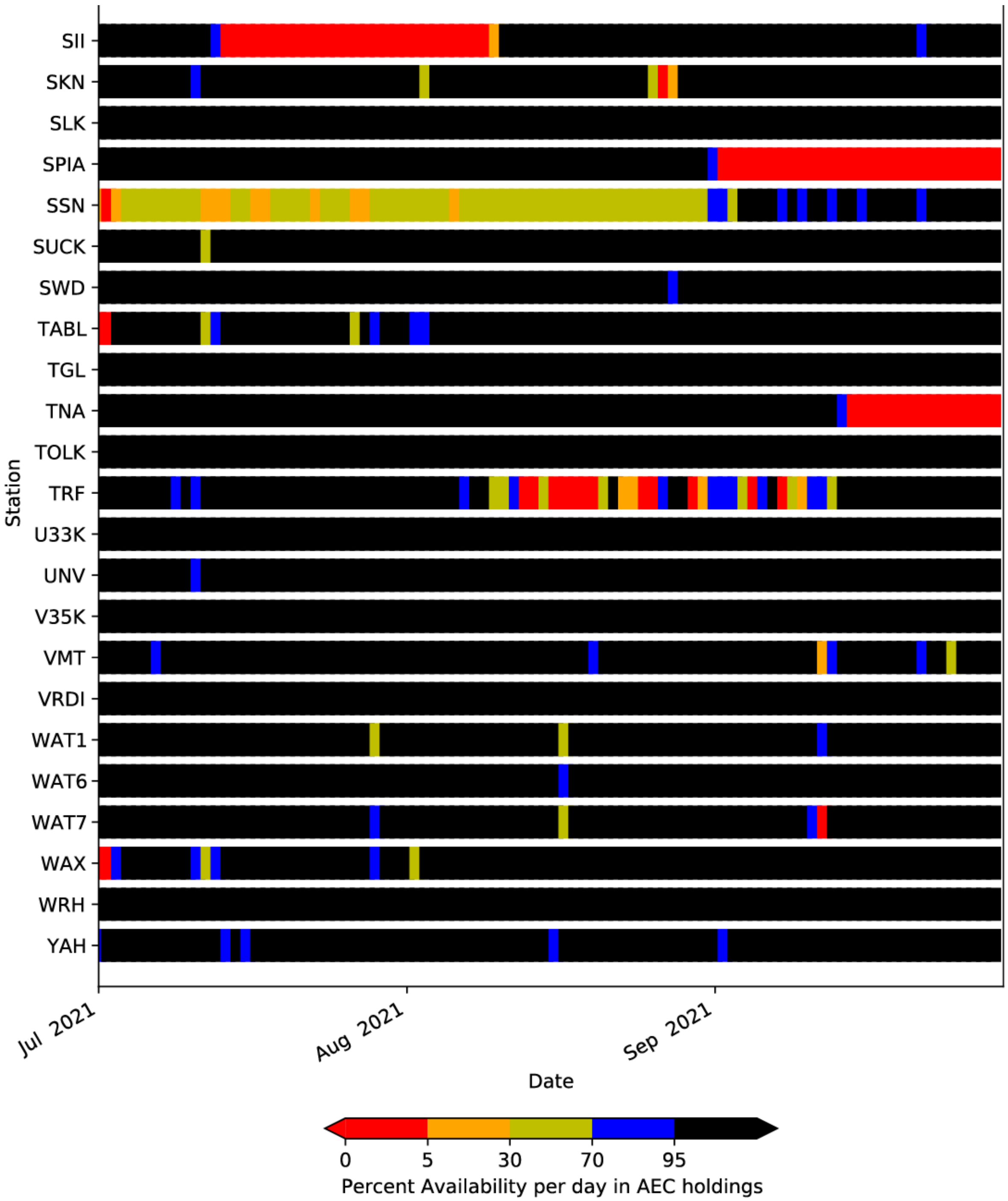


***Figure A7**. Data availability for stations SII-YAH (listed alphabetically).*

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

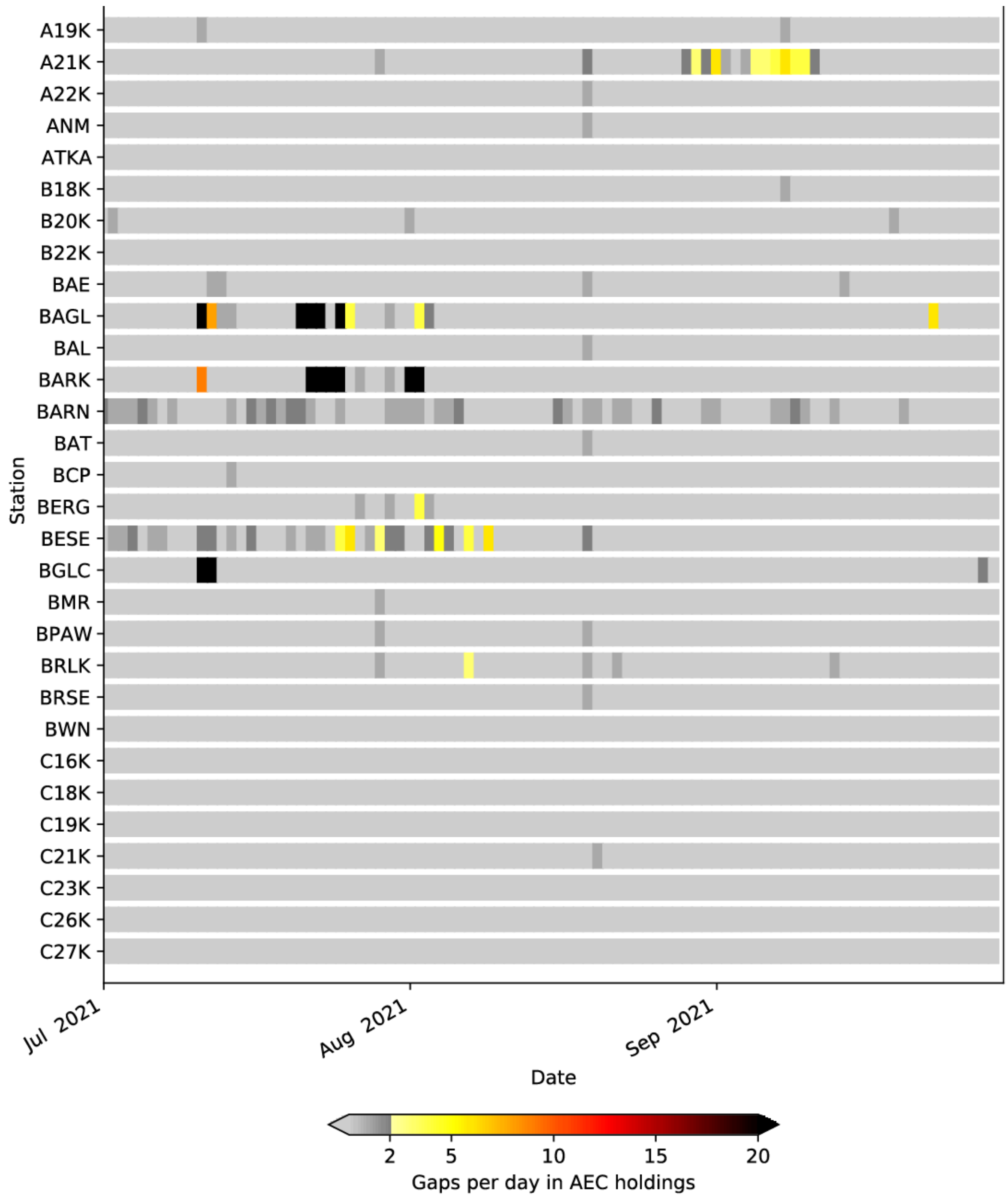


Figure B1. *Number of gaps per day[1] for stations A19K-C27K (listed alphabetically). BAT is a new site installed in July 2021.*

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

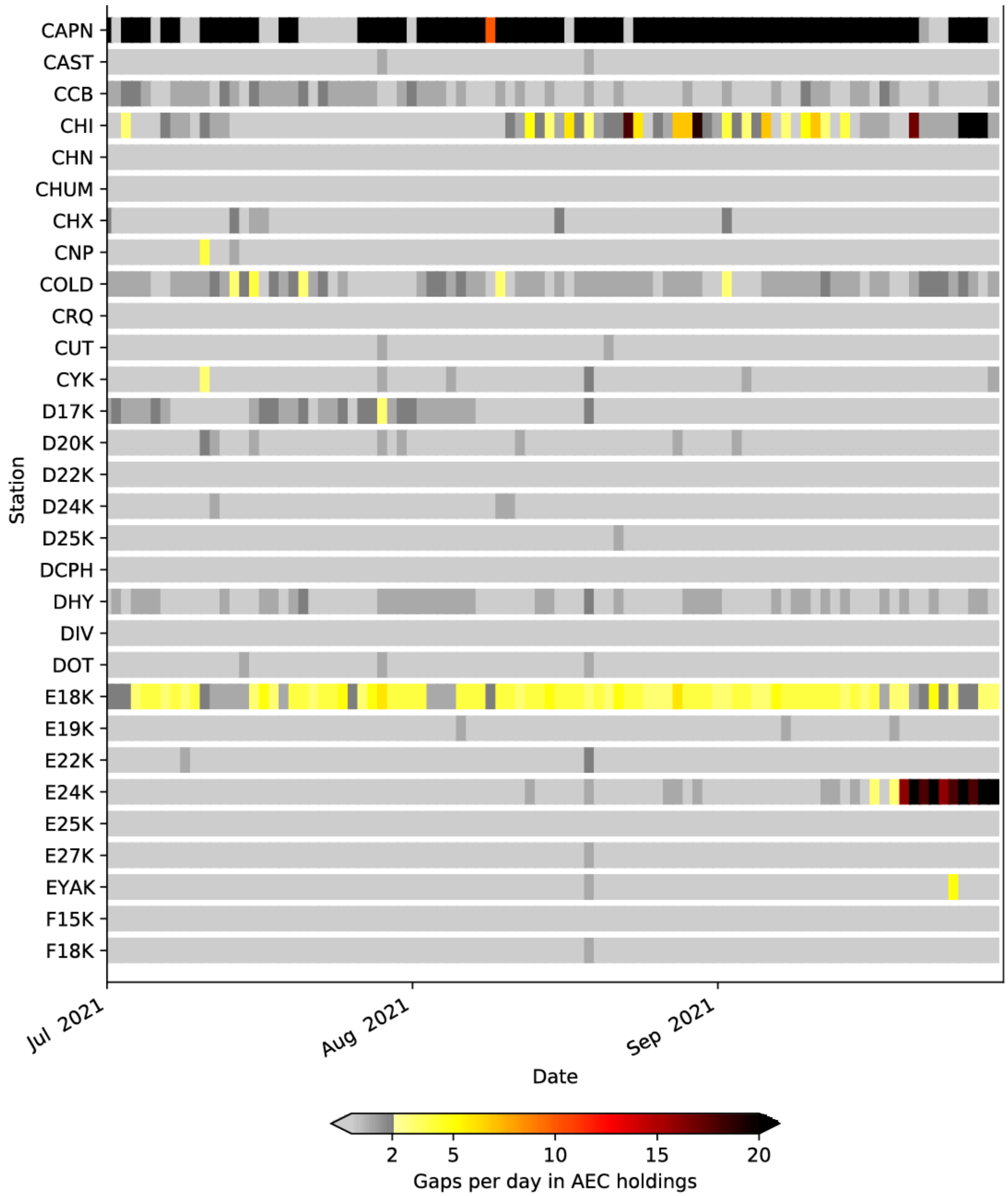


Figure B2. *Number of gaps per day for stations CAPN-F18K (listed alphabetically).*

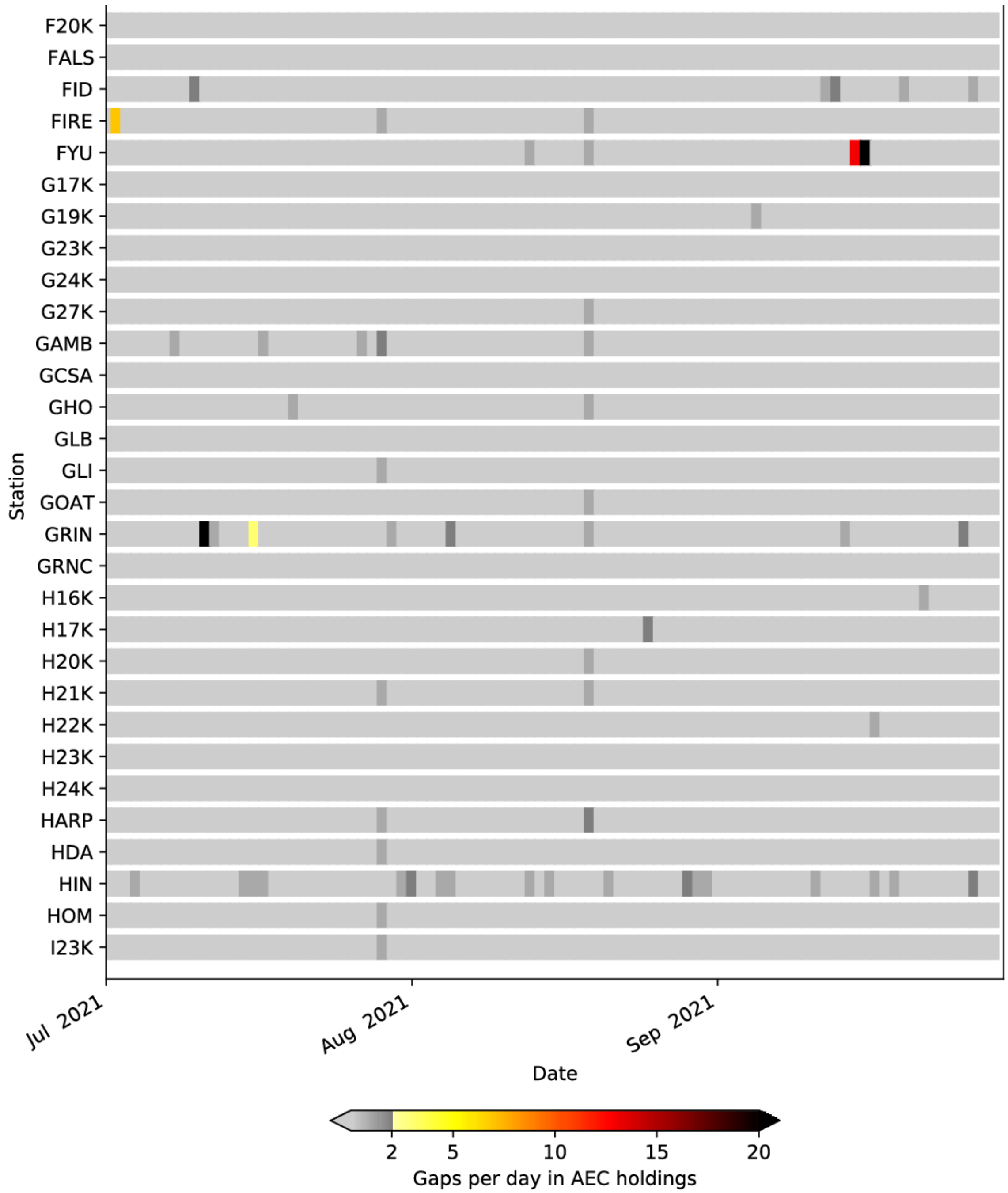


Figure B3*. Number of gaps per day for stations F20K-I23K (listed alphabetically).*

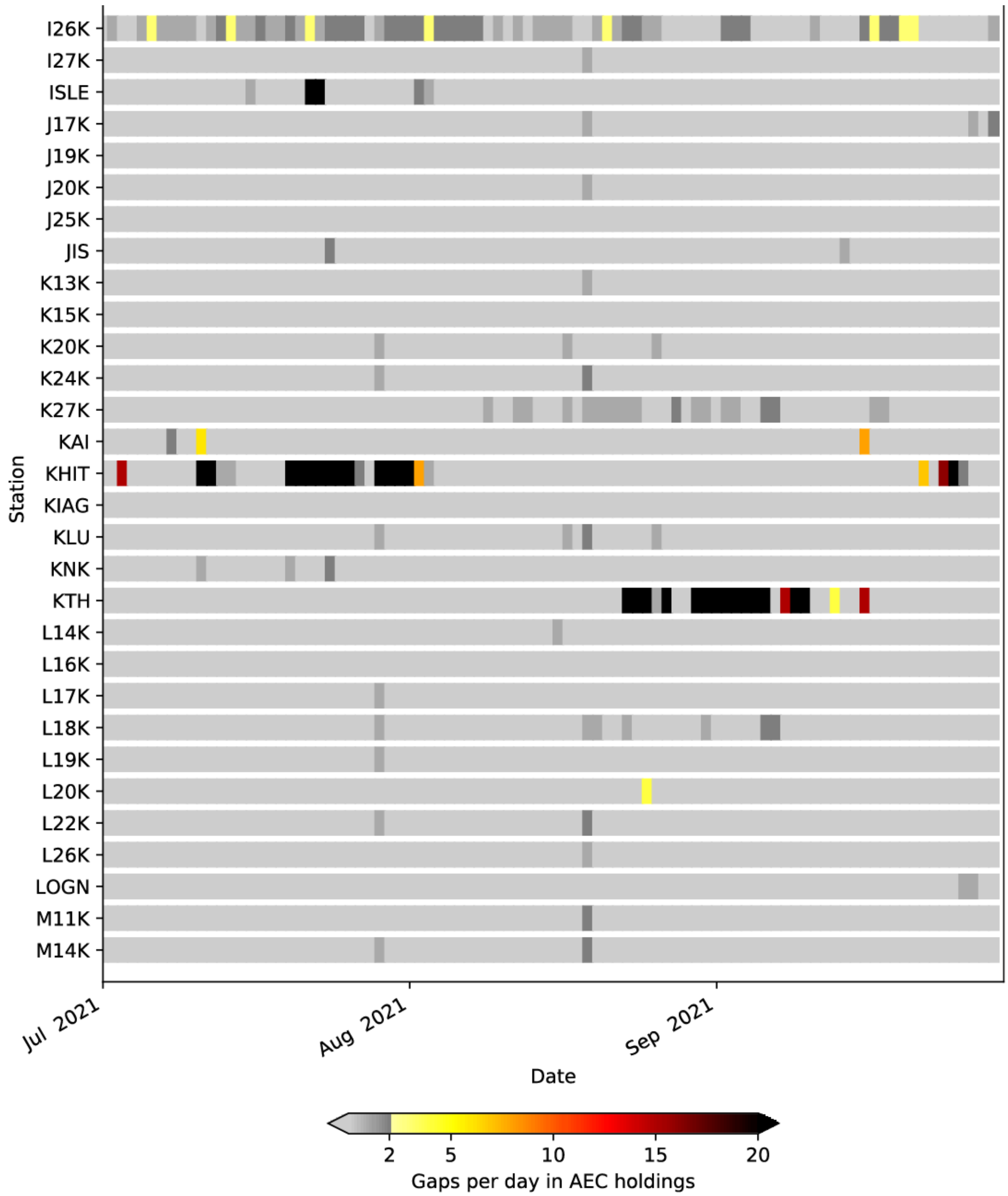


Figure B4*. Number of gaps per day for stations I26K-M14K (listed alphabetically).*

Figure B5. *Number of gaps per day for stations M16K-PPLA (listed alphabetically).*

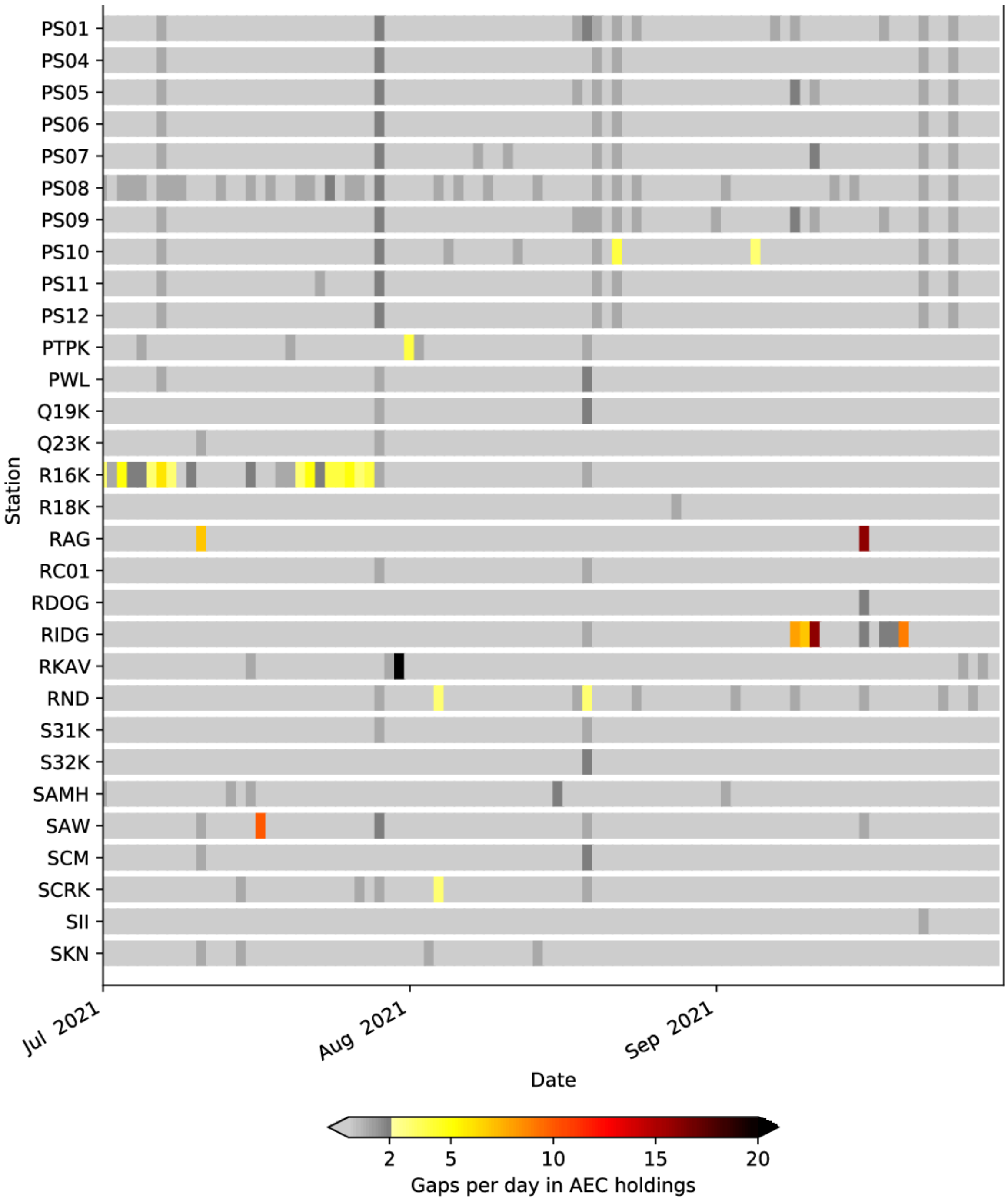


Figure B6. *Number of gaps per day for stations PS01-SKN (listed alphabetically).*

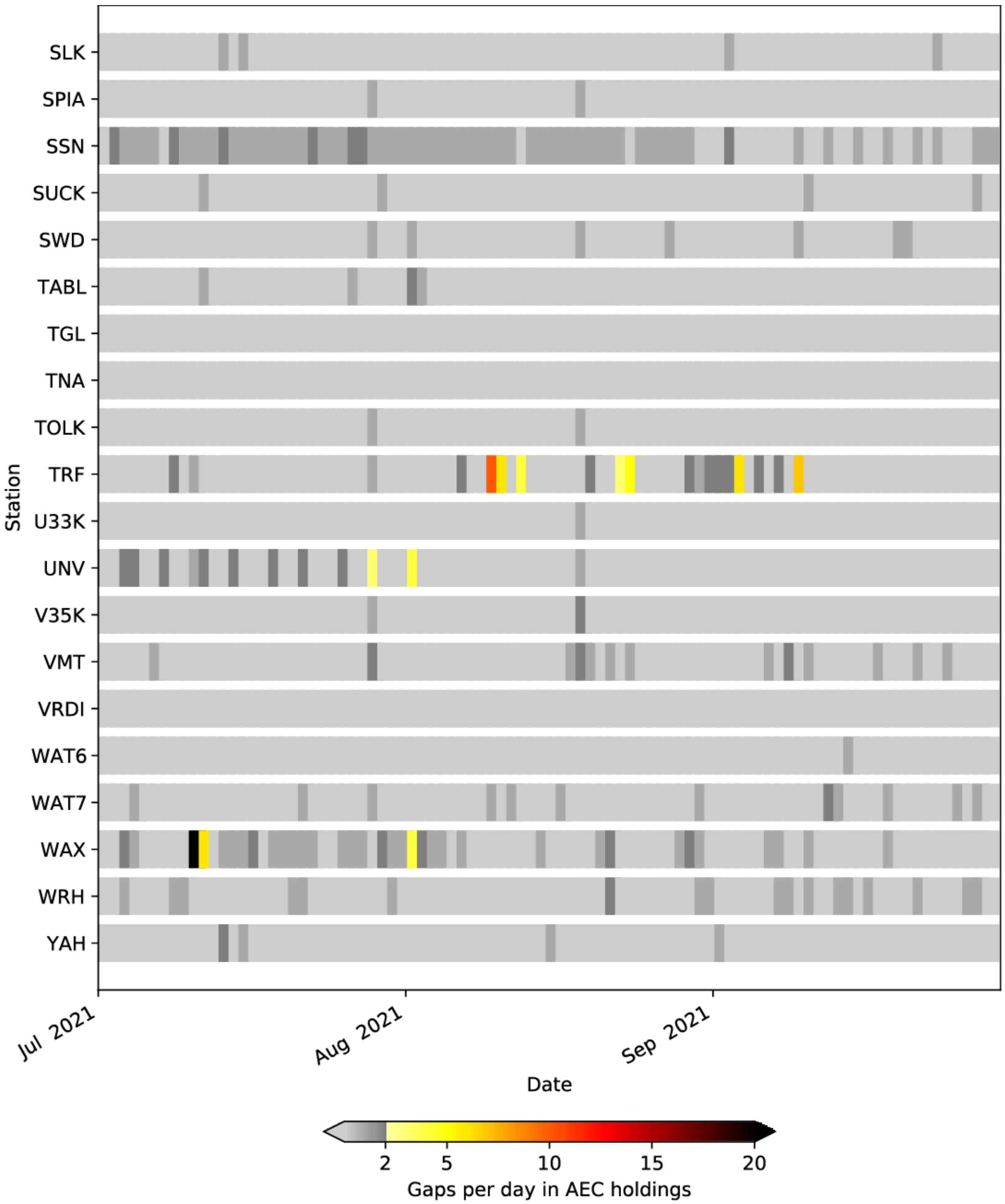


***Figure B7**. Number of gaps per day for stations SLK-YAH (listed alphabetically).*