Alaska Earthquake Center Quarterly Technical Report April-June 2021

N.A. Ruppert, S. Dalton, L. Gardine, M. Gardine, B. Grassi, S.G. Holtkamp, H. McFarlin, and M.E. West

August 2021

2156 Koyukuk Drive · Geophysical Institute · Fairbanks, Alaska 99775
earthquake.alaska.edu · (907) 474-7320

Contents

Contents 1

1. Introduction 2
2. Seismicity 2
3. Field network 9
4. Data Quality assurance 10
5. Real-time earthquake detection system 12
6. Computer systems 15
    6.1. Computer resources 15
    6.2. Waveform storage 15
    6.3. Metadata 16
    6.4. Software development 16
7. Fieldwork 16
8. Social media and outreach 17
    8.1. Website 17
    8.2. Twitter 18
    8.3. Facebook (Page) 21
    8.4. Facebook (Group) 23
9. Publications and presentations 25
    9.1. Publications 25
    9.2. Public Presentations 25
    9.3. Lunch Seminar Talks 27
10. References 27

Appendix A: Data availability for broadband stations from AK network. 28

Appendix B: Gaps for broadband stations from AK network. 35

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 April 1 and June 30, 2021 we reported 12,431 seismic events in the state and the neighboring regions (Figure 2.1), with depths ranging between 0 and 256 km and magnitudes between -0.4 and 6.1. The largest earthquake of Mw=6.1 occurred on May 31 at 6:59:56 UTC in central Alaska (Figure 2.2). Ten earthquakes had magnitudes between 5.0 and 5.7. Overall, we reported about 136 events per day, or one event every 9 minutes on average. This is 12% more events than in the first quarter of 2021 (Ruppert et al., 2021).

AEC data analysts also picked and catalogued 401,173 seismic phases, 264,252 of which were P-phase and 136,889 S-phase arrival picks (Figure 2.3). Fewer phase arrivals per event were catalogued for the Aleutian earthquakes due to sparser station coverage compared to mainland Alaska.

We reported 681 seismic sources caused by something other than regional tectonic earthquakes. 83 of these were suspected quarry blasts, the majority of which were located in the vicinity of Fort Knox and Healy mines in Interior Alaska (magnitudes M=0.4-2.7). 439 of the reported events were ice quakes (magnitudes M=-0.6-2.6), primarily located in the Prince WIlliam Sound, Icy Bay, and Yakutat Bay areas, and also under the Wright Glacier in Southeast Alaska (magnitudes M=0.6-3.0). This is 2.5 times as many glacial events as in the first quarter of 2021. This is a typical seasonal behaviour with glacial activity increasing in late spring-summer months. 151 events were characterized as seismic events associated with volcanic activity (M=0.3-3.1).

60 earthquakes were reported as felt (magnitudes M=2.1-6.1), 3 of which were located in Southeast Alaska, 5 in the Interior, 3 in the Aleutian Islands, 2 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, 4,651, came from the M6.1 earthquake near Chickaloon on May 31 (https://earthquake.usgs.gov/earthquakes/eventpage/ak0216xu2rod/dyfi/intensity).

The seismicity rate continued at a steady pace with the exception of a few-days-long increase following the May 31 M6.1 earthquake due to its aftershock sequence (Figures 2.4-2.6). We continued recording aftershock activity 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 Mountain Swarm (Table 1). There was no notable increase in seismicity within the 2018 Northeast Brooks Range swarm region.

Figure 2.1. *Earthquake map for Alaska and neighboring regions April-June, 2021.*

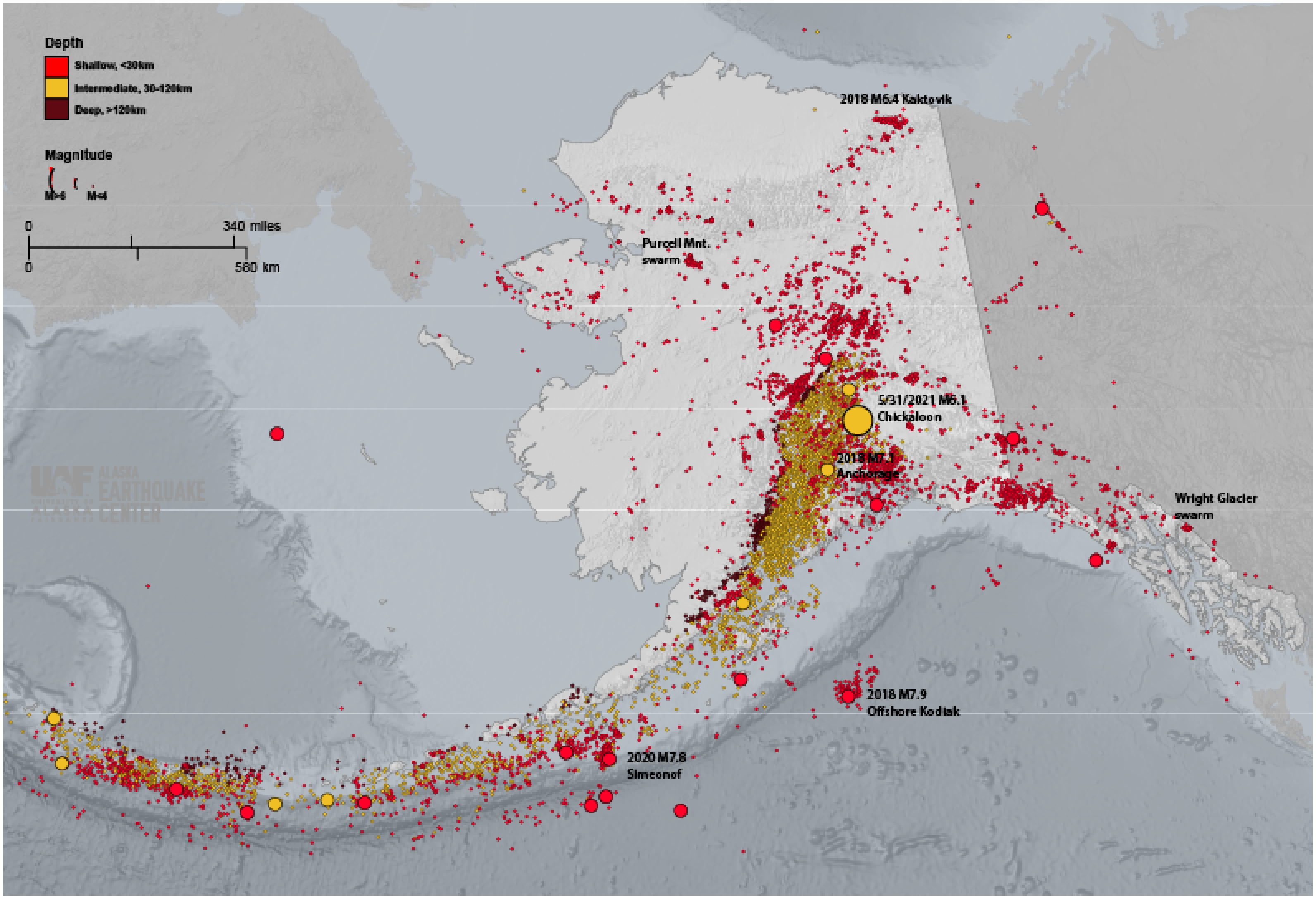


Table 1. *Notable Alaska seismic sequences in April-June, 2021 (listed in order of activity level).*

Earthquake	Number of aftershocks	Magnitude range	Magnitude of completeness (Mc)	Number of events per week
May 31 M6.1 Chickaloon	522	0.6-4.6	1.1	118
2020 M7.8 Simeonof	803 (489 in M7.6 zone)	1.1-4.2	2.0	62
2018 M7.1 Anchorage	262	0.6-4.8	1.1	20
Purcell Mountains Swarm	199	0.4-3.2	0.9	15
2018 M6.4 Kaktovik	126	0.6-3.5	1.1	10
2018 M7.9 Offshore Kodiak	101	2.1-4.4	2.5	8

A magnitude 6.1 earthquake on May 31 near Chickaloon in central Alaska generated an active aftershock sequence with 522 aftershocks between magnitudes 0.6 and 4.6 recorded through the end of the reporting period (Figures 2.2, 2.6, 2.7). This earthquake occurred at a depth of 45 km and was widely felt across Interior and southern Alaska. This was in an intraslab, normal faulting earthquake, e.g. typical location and mechanism for this region. However, it was the largest intraslab earthquake in this region in about 50 years. Since this earthquake occurred in the middle of the regional network, aftershocks with magnitudes as small as 1.0 were reliably detected and located (Figure 2.7).

The Purcell Mountains Swarm exhibited a different behavior this quarter. A new feature a short distance north of the main cluster became active between April 9-23 (Figures 2.8-2.10); the largest earthquake within this new cluster was M=2.1. This particular area did not exhibit much activity prior to this period of activation. Activity within the main cluster continued at a steady pace similar to the previous quarter.

The icequake swarm under the Wright Glacier (located about 40 miles east of Juneau) picked up pace around June 23rd (Figures 2.11, 2.12). This feature has been observed since the 1970s, with event rates usually peaking in summer and early fall. Some of the June events reached magnitude 3 level and were reported felt in Juneau. The levels of activity, however, are not the same every year. So far we recorded about 100 quakes within this cluster this year. We will continue to monitor this feature throughout the rest of the summer.

The Simeonof Earthquake continues to produce the most active ongoing aftershock sequence with 803 reported aftershocks between magnitude 1.1 and 4.2, continuing the 2020 trend. The M7.6 aftershock cluster continues to be more active than the larger M7.8 patch.

The 2018 M7.1 Anchorage Earthquake aftershock sequence continued with 262 events recorded this quarter. The largest aftershock of M=4.8 occurred on April 27 and briefly caused a slight increase in activity.

We continue to record aftershocks in the 2018 M6.4 Kaktovik and M7.9 Offshore Kodiak sequences. All above mentioned sequences, however, continue at notably decreased rates compared to 2020 (Ruppert and Gardine, 2021). See Table 1 for summary.

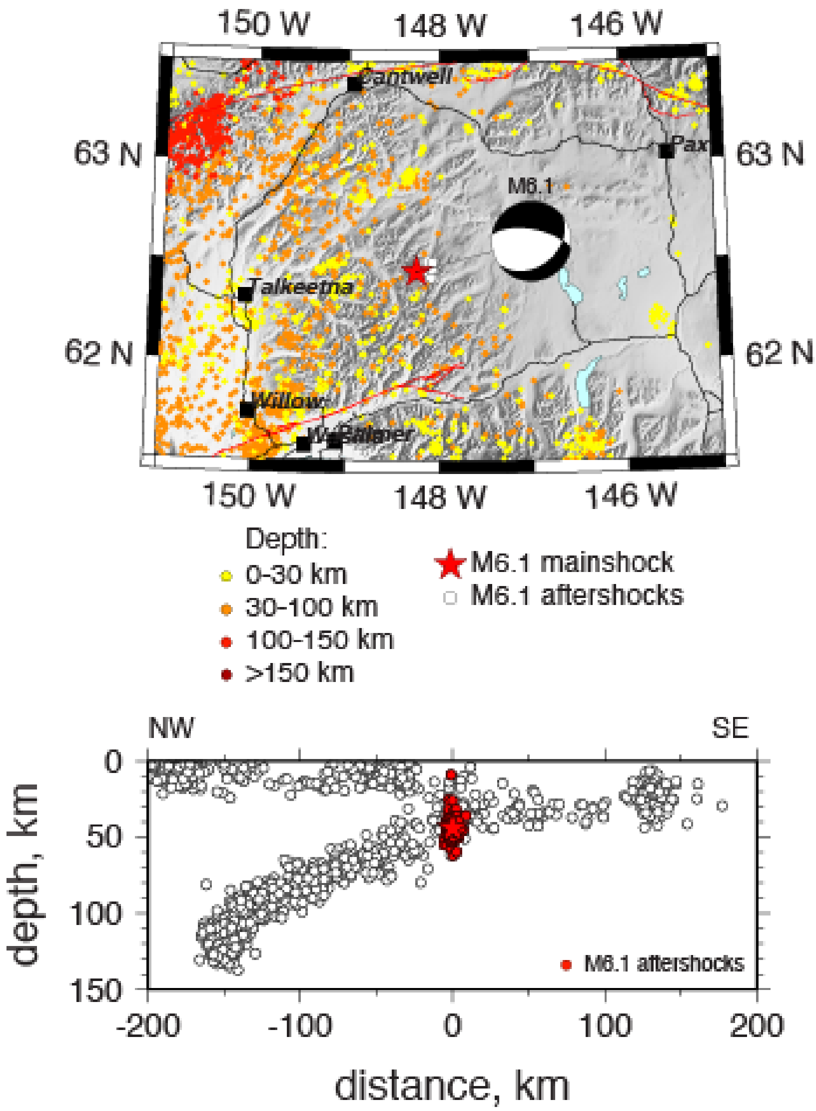


Figure 2.2. *Location map and cross-section for the May 31, 2021 M6.1 Chickaloon Earthquake. Cross-section trends from southeast to northwest across the M6.1 epicenter.*

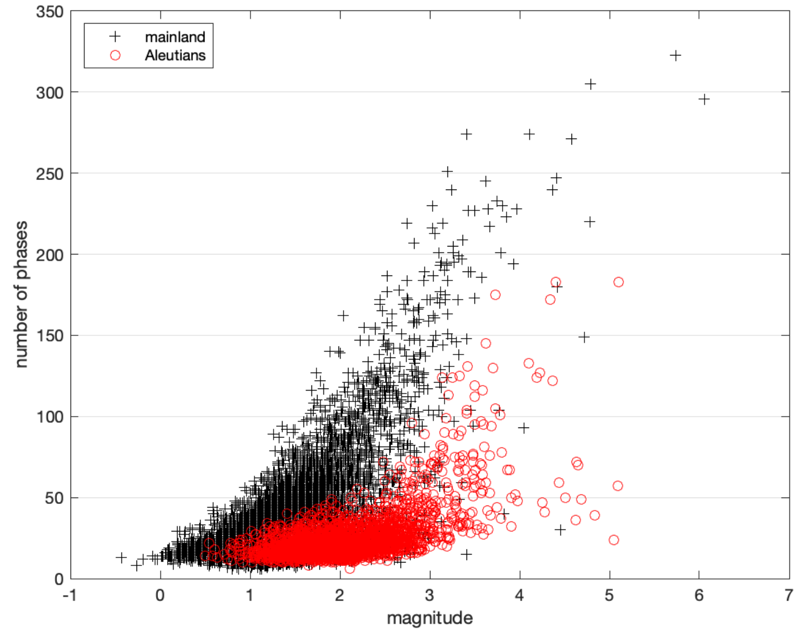


***Figure 2.3**. Phase picks depending on magnitude and region for April-June, 2021.*

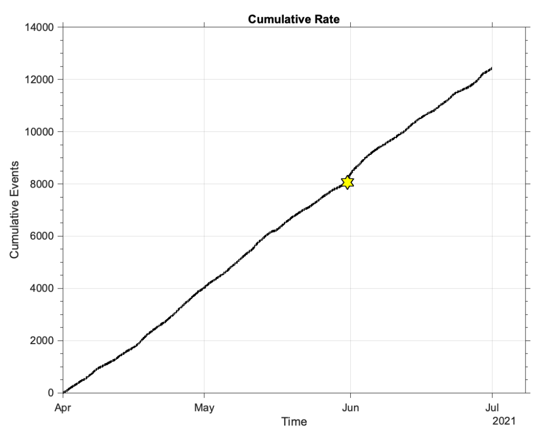


***Figure 2.4.** Cumulative number of seismic events in the Alaska catalog for April-June, 2021. Star indicates M6.1 earthquake on May 31, 2021.*

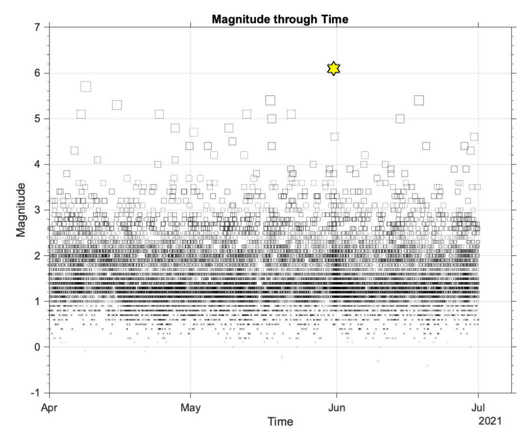


***Figure 2.5**. Time-magnitude plot of seismic events in the Alaska catalog for April-June, 2021.*

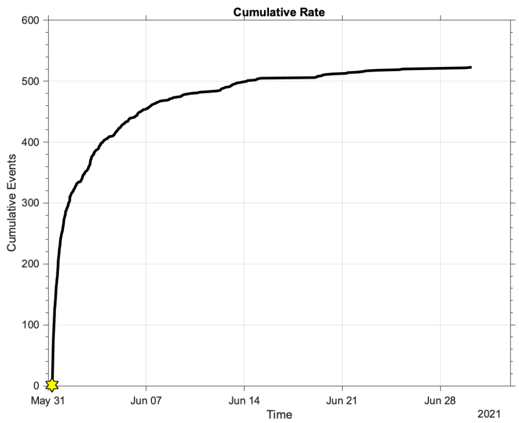


Figure 2.6. *Cumulative number of events for the May 31, 2021 M6.1 Chickaloon Earthquake aftershock sequence.*

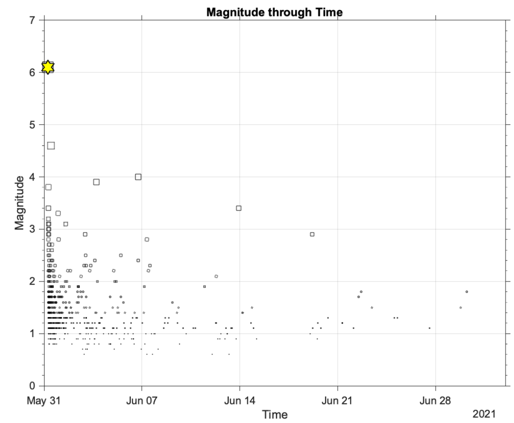


Figure 2.7. *Time-magnitude plot for the May 31, 2021 M6.1 Chickaloon Earthquake aftershock sequence.*

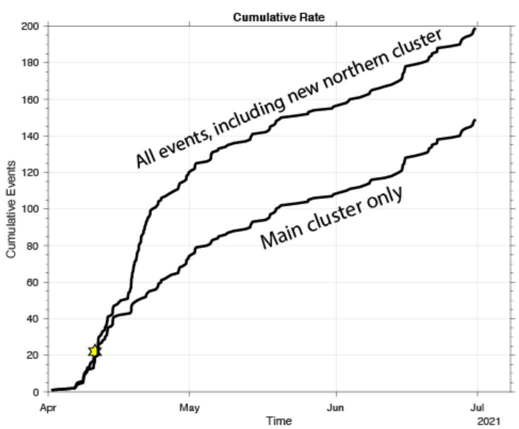


Figure 2.8. *Cumulative number of events within the Purcell Mountain Swarm for April-June, 2021. Increase in activity in late April is primarily associated with a new cluster located just north of the main swarm location.*

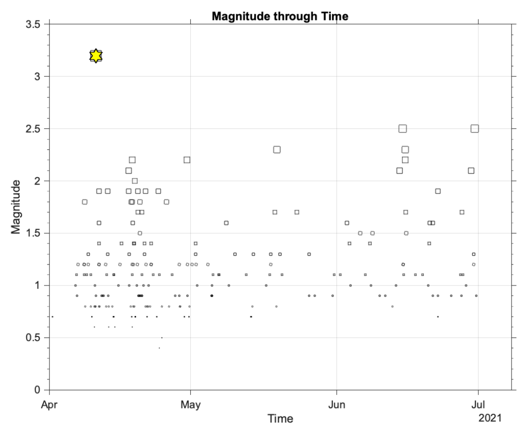


Figure 2.9. *Time-magnitude plot events within the Purcell Mountain Swarm for April-June, 2021. Star indicates the largest earthquake in this time period.*

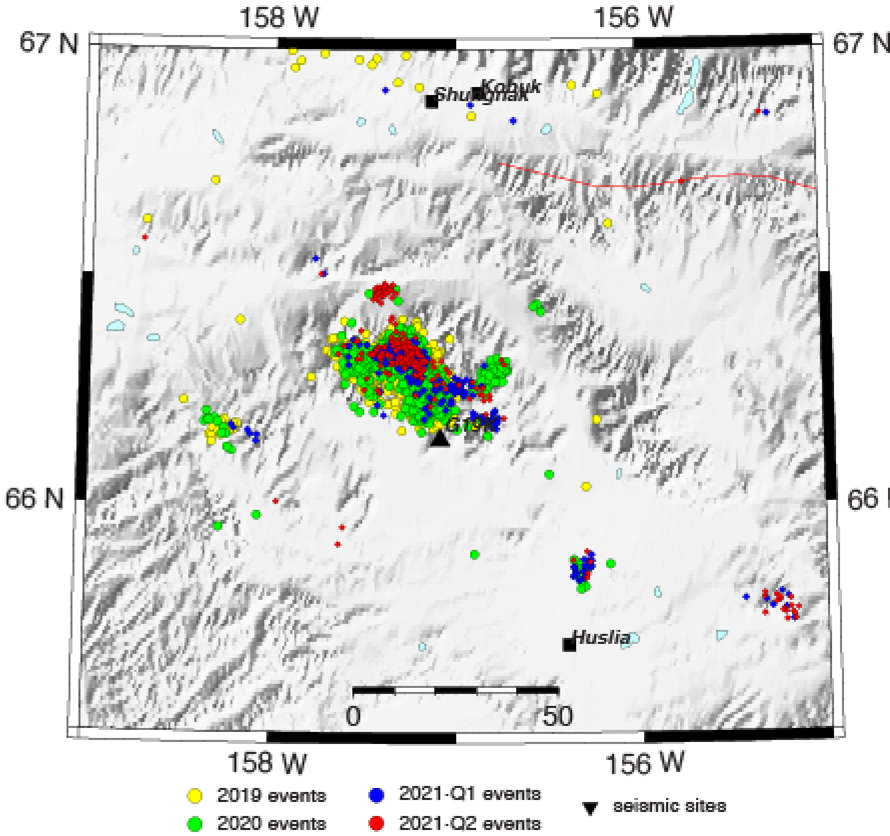


Figure 2.10*. Purcell Mountains Swarm location map. Events are color-coded by year and/or quarter of occurrence. Note the red cluster just north of the main swarm location, which appears to be a new feature.*

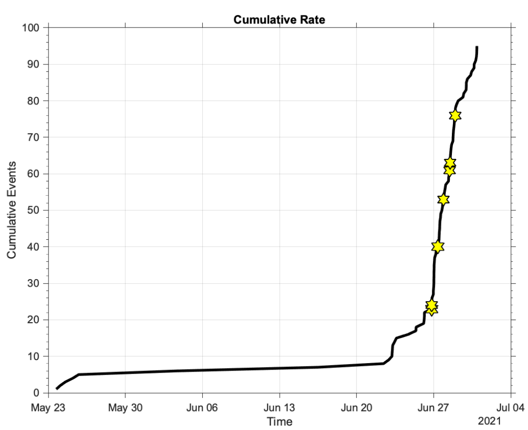


Figure 2.11*. Cumulative number of events within the Wright Glacier Swarm (about 40 miles east of Juneau). This swarm became quite active in late June. Stars denote events with magnitudes 2.8 and greater.*

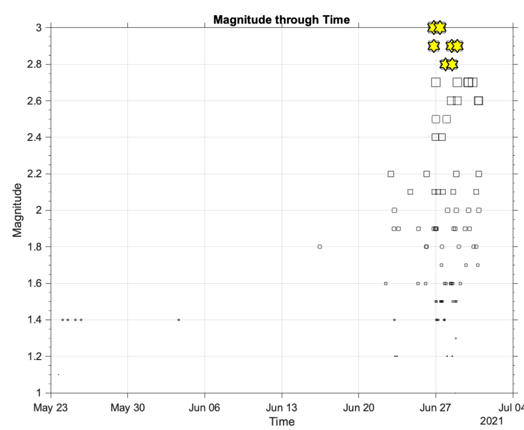


Figure 2.12*. Time-magnitude plot of events within the Wright Glacier Swarm (about 40 miles east of Juneau). This swarm became quite active in late June. Stars denote events with magnitudes 2.8 and greater.*

3. Field network

As of June 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, 78 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 April 1 and June 30 the network had an average data return rate of 83.7%, ranging from 38.8% to 88.9% (Figures 3.1 and 3.2). Scheduled power outages at the Butrovich datacenter on May 15-16 and May 22-23 resulted in a significant data loss. These days were taken out of the average monthly return rate averages since this circumstance was beyond our control. Another contributor to low return rates were GCI circuit outages between April 6-16 and a shorter one between June 15-18. This circuit carries about a dozen sites that come via State Microwave Network.

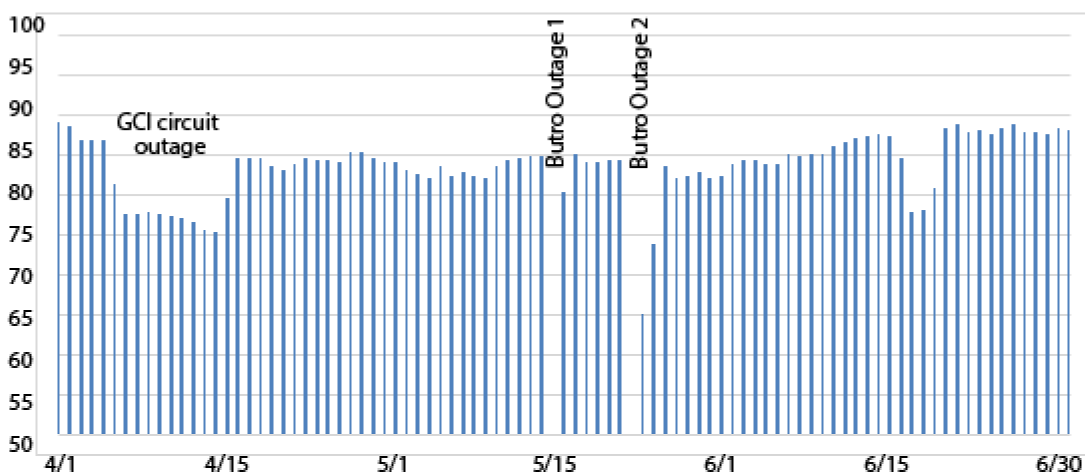


Figure 3.1. *Daily data completeness in percent for AK network April-June 2021.*

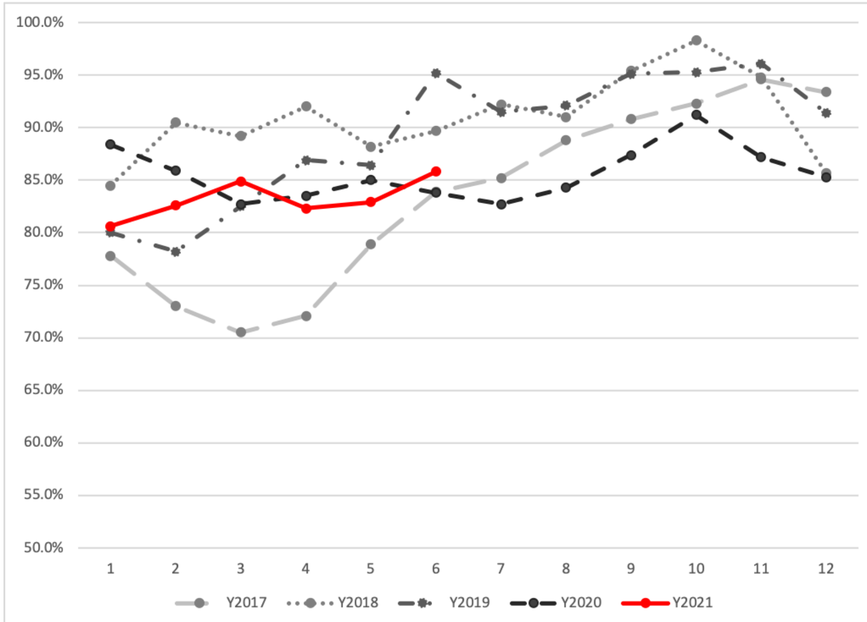


***Figure 3.2**. Average monthly data completeness in percent for AK network 2017-2021.*

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).

There were no long-term field data hub outages during this quarter. However, there was a 10-day outage in April of the GCI circuit that carries about a dozen field sites from the State Microwave Network. Data quality from Q1 did not improve as late spring snow cover prevented the field team from accessing most sites to replace bad instrumentation. Also, seasonal thaw cycles caused unstable conditions at a number of sites resulting in frequent re-centering and poor waveform quality. A prime example of such problem behavior is shown from site RAG located in the coastal region near Cordova (Figure 4.1).

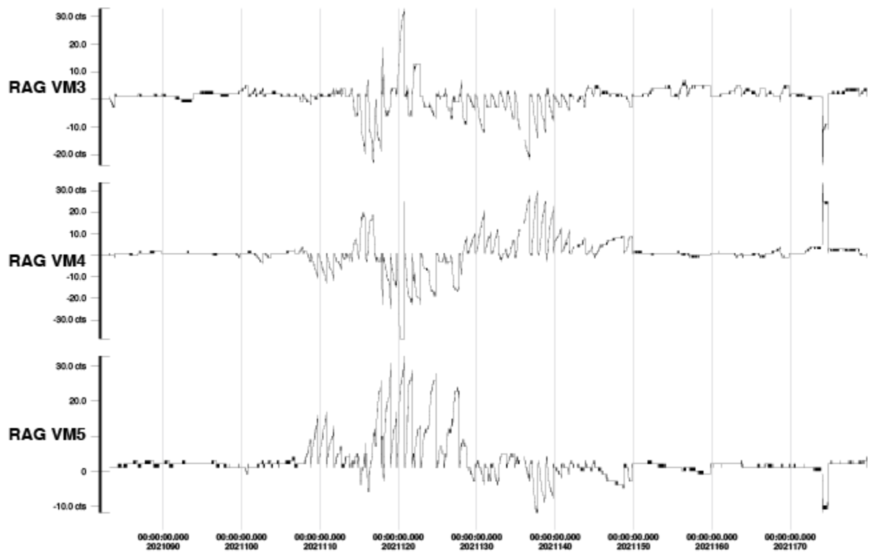


Figure 4.1*. Mass positions of the broadband sensor at site RAG. Note the extremely unstable behavior with large daily drifts and re-centers between Julian days 108 and 145 (mid-April to late-May).*

Stations with the lowest data availability and sensor/datalogger failures April-June, 2021:

1. Stations that continue to have 0% as compared to Q1:
   BWN, DAM1, DCPH, E22K, E25K, FALS, ISLE, K216, L26K, NICH, YAKA
2. Stations that now have 0% as compared to Q1:
   ATKA, BAE, BAGL, BAW, FA02, KHIT, TABL, WAX
3. Stations that continue to have 1-50% as compared to Q1:
   E18K, E21K, HARP, K15K, NIKH
4. Stations that now have 1-50% as compared to Q1:
   GRIN, I26K, K212, K221, KTH, L16K, L22K, MESA, MS03, P08K, R18K, RKAV, SWD, YAH
5. Stations that came back during Q2 but still had 1-50% for the entire period: BRSE, FID
6. BB data quality issues caused by faulty sensors and/or dataloggers:
   FID (starting in mid-June), J26L, L22K, P08K, PS01, PS07, TOLK
7. SM data quality issues caused by faulty sensors and/or dataloggers:
   L22K, PS06, PS07
8. 1 site continues to have bad timing (no reliable GPS clock):
   strong motion site K223 in Anchorage.

Stations that have come back to above 50% since Q1 due to field maintenance or on their own: A19K, A22K, B20K, BRSE, COLD, D17K, FID, G27K, H23K, TOLK. And lastly, we lost one station, BAW, in Barry Arm Fjord to a rock avalanche in mid-April. This site is not going to be re-installed.

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 April-June 2021 time period we reported 9,366 automated events in Alaska and neighboring regions. This is 30% more detections than in the previous quarter. 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. 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.

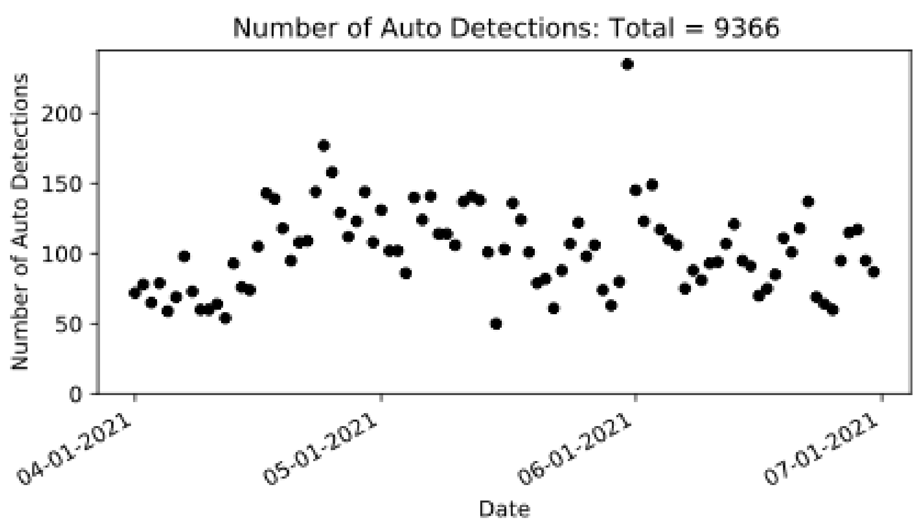


Figure 5.1*. Number of automatic event detections for each day. May 31, 2021 had the highest number of detections due to the M6.1 Chickaloon Earthquake aftershocks.*

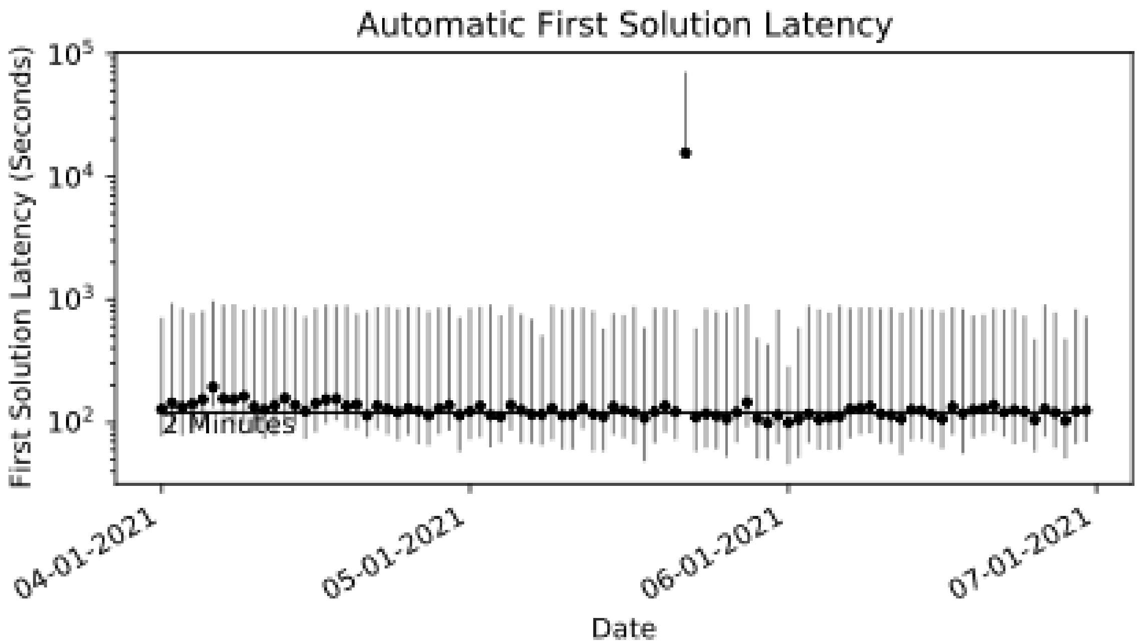


Figure 5.2. *Average daily latency (dots) and range (lines) of first automatic solution for each event. The single high outlier corresponds to the data processed after the Butrovich data center outage when the waveforms were backfilled with multi-hour delays.*

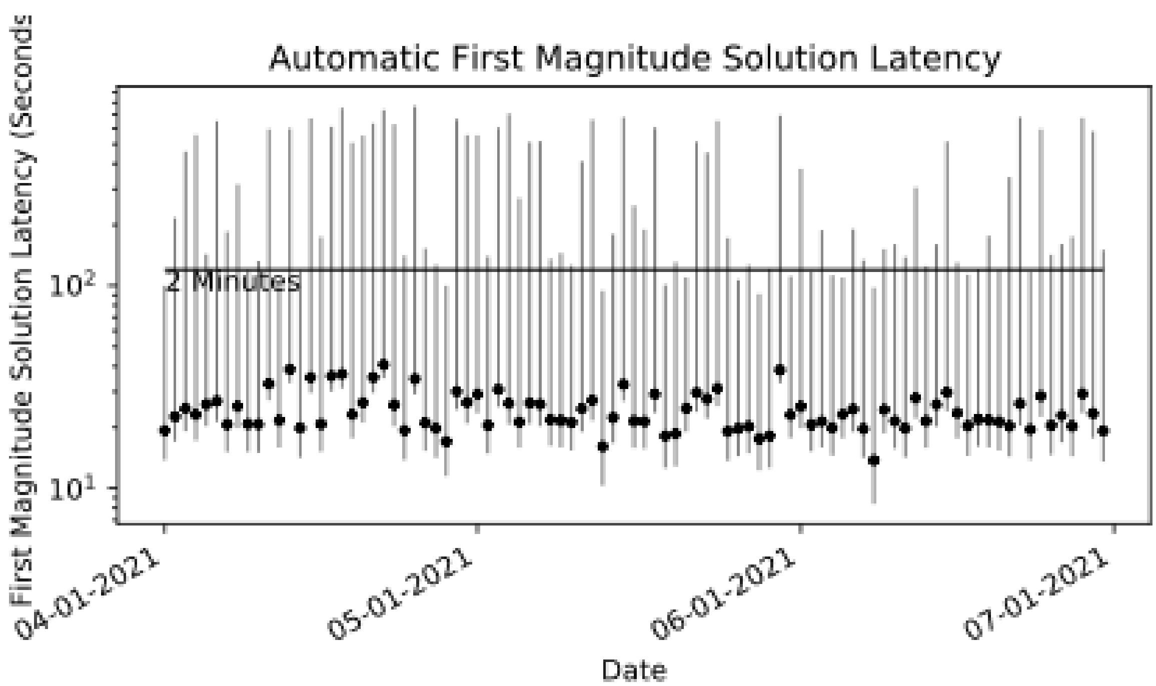


Figure 5.3. *Average daily latency (dots) and range (lines) of first automatic magnitude for each event after the event detection.*

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

Metric	April	May	June
Number of automatic event detections	2,986	3,386	2,994
First origin latency below ANSS 2 min standard	68%	72%	75%
Number of automatic events with magnitudes	2,441	2,801	2,587
Percent origins with magnitudes	82%	83%	86%
First magnitude latency below ANSS 2 min standard	49%	52%	53%
Magnitude latency from origin post time below ANSS 2 min standard	98%	99%	99%
Events deleted by duty seismologist	N/A	11%	5%
Magnitude of completeness	1.3	1.3	1.3
Number of earthquake alarms	5	9	9

There were 23 earthquake alarms during this reporting period. Our goal is to have duty-seismologist-reviewed solutions for alarm events within 20 minutes. Only 2 earthquakes were reviewed with slightly longer delays (Figure 5.4).

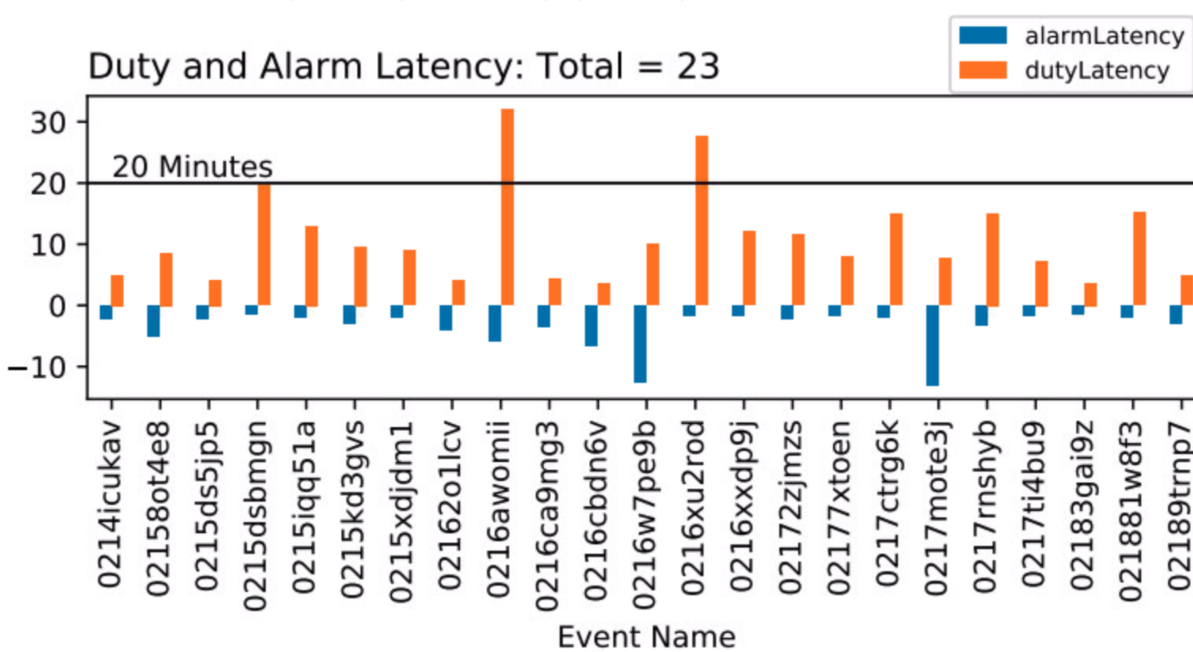


Figure 5.4. *Earthquake alarm and duty review latency from alarm time (bottom of the blue bar is origin time, top of the orange bar is duty review post time). Earthquakes are labeled with their event names.*

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	21	7	48	4

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 55.5 TB in continuous waveform data and 1.1 TB of segmented data. During the quarter, we acquired and archived 1.02 TB of new data (Figure 6.2.1).

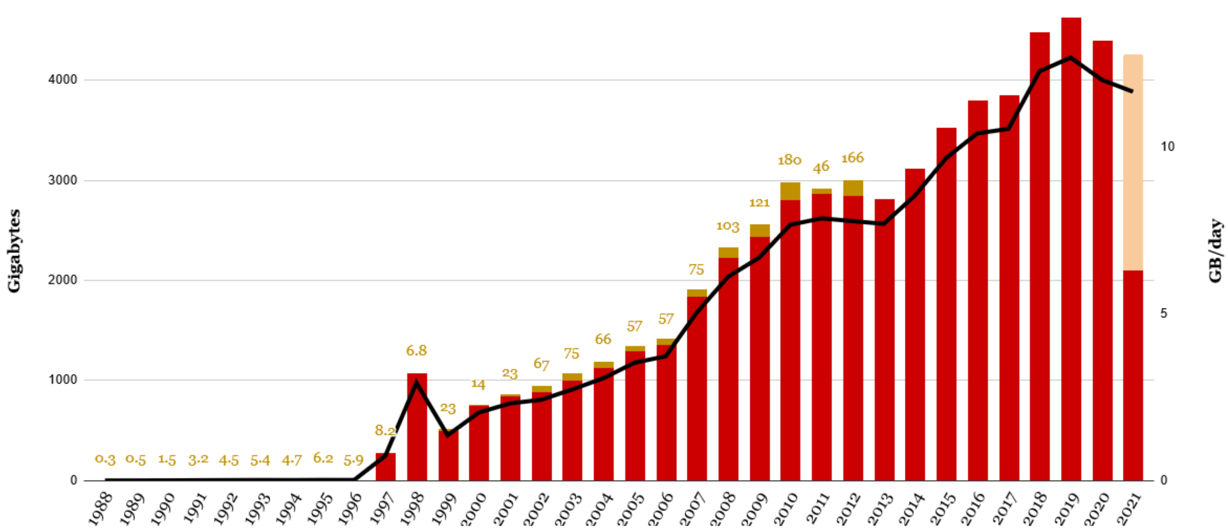


Figure 6.2.1. *Digital waveform archival storage for continuous (red) and segmented (brown) data. Pink color denotes projected data holdings for 2021.*

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: None
- Stations modified: L22K, E21K, F21K, I21K, L16K, MLY
- Stations removed: BAW

During this quarter, we have also begun the process to import some AEC stations into the Station Information System (SIS). We have had two conference calls with the SIS development team to demonstrate the import process as well as to lay out the short-term goals for the project.

6.4 Software development

During this time, no major software upgrades were performed. Total code commits under the following scopes of work were:

Antelope	Website	Station health	Other
71	361	5	24

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 designing and implementing a web-based checkout tool for seismic analysts. During this quarter, the project team completed 6 sprints, bringing the total development time to 12 sprints.

7. Fieldwork

During the reporting period, Earthquake Center staff visited 50 field sites to resolve data outages and to perform planned upgrades, cleanup, and preventative maintenance. Eight staff members participated in this work, spending 99 person-days in the field.

Preventative maintenance included battery replacements at COLD and RAG, modem upgrades at five stations, annual inspections of six Alyeska Pipeline monitoring sites, and antenna upgrades at two sites. As part of our ongoing effort to expand the Earthquake Center's strong-motion footprint, we installed new accelerometers at four sites—E21K, F21K, I21K, and L16K. We removed one site, CTG, as part of a multiyear effort to strategically thin the dense network in Wrangell-St. Elias.

In June we installed a new power system at D24K, one of five battery-powered VSAT sites that we operate where communications are subject to a duty cycle. The power systems at these sites are too small to operate the satellite communications modems continuously, so the modems are off 80% of the time while seismic data is stored in a local buffer to be transmitted during the next communications cycle. Our goal with the installation of the new power system at D24K was to increase battery and solar charging capacities in order to achieve real-time communications for most of the year. We did this using a lithium-iron-phosphate battery with a control system engineered for low-temperature applications. Data from D24K is now being transmitted in real-time and will be until late fall. We plan to revert to a duty-cycled communications regime between late October and February, but this upgrade enables real-time communications for more than seven months of the year and is an attempt at examining how we can use the energy density and low-temperature performance of modern battery chemistries to improve data latencies.

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. During early season visits we found borehole sensors frozen in place at former USArray sites D25K, J26L, and M11K. At D25K and M11K, water seems to have entered the boreholes through imperfect seals at the bottoms of the holes. At J26L, rain entered the borehole from above after the wellhead cap was damaged by an animal. During visits to J26L in May and June, field staff developed a technique to thaw a sensor frozen at the bottom of a borehole. J26L was repaired and is back online. D25K and M11K are both online and transmitting data, but will eventually need to be thawed when equipment changes become necessary.

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 330,000 users visit our website. This amounted to more than 400,000 sessions (number of times users entered our website) and nearly 700,000 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.

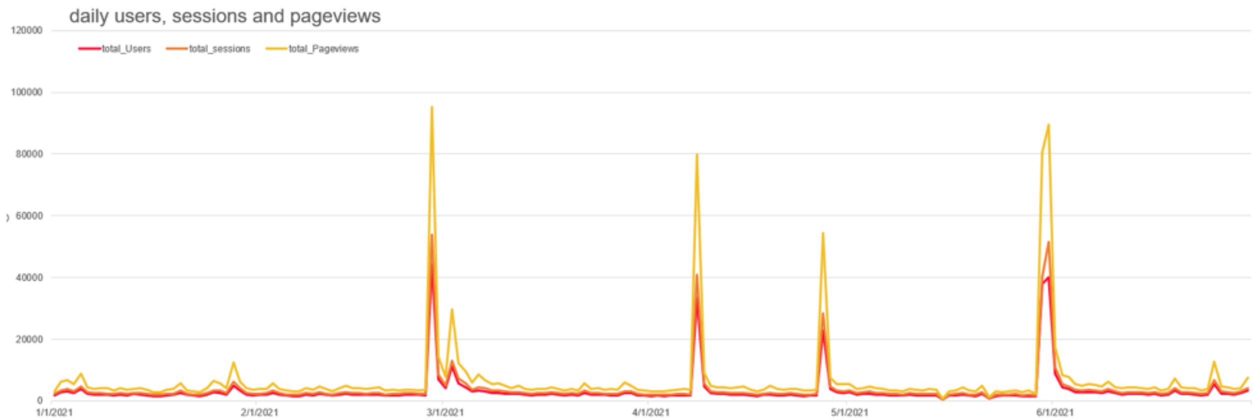


Figure 8.1.1. *Total number of website users (red), sessions (orange), and pageviews (yellow) per day.*

Our web traffic is rarely quiet. On our "slowest" day between April 1-June 30, we still had more than 400 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 on April 8 is due to the M5.5 near Cantwell that was felt across Alaska. The spike on April 27 was from a M4.8 aftershock from the 2018 Anchorage Earthquake that was felt widely through Southcentral Alaska. The spike on May 31 is due to a M6.1 in Interior Alaska that was felt widely. Earthquakes felt in Southcentral Alaska often result in a large influx of users to our site.

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 67% of website sessions. These numbers have only increased with time, up 2% since the first quarter.

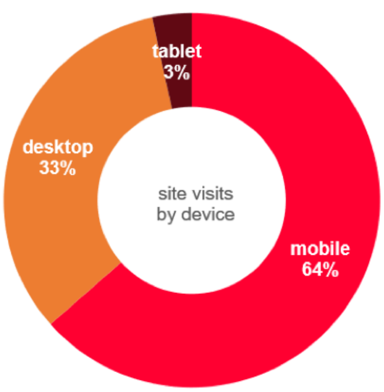


Figure 8.1.2*. Percentage of website sessions for the three major device types, mobile (e.g., phones), tablets, and desktop computers.*

8.2. Twitter

In the second quarter of 2021, we gained approximately 515 new followers bringing our total following to 21,200. 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 69 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.

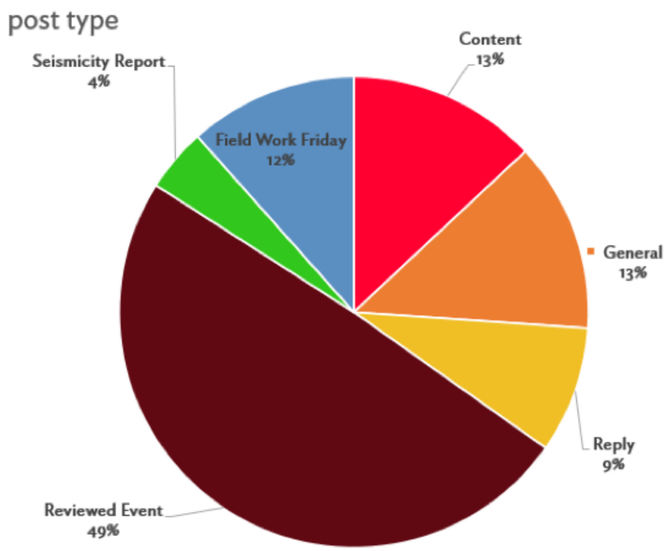


Figure 8.2.1. *Post type distribution for tweets in the first quarter of 2021.*

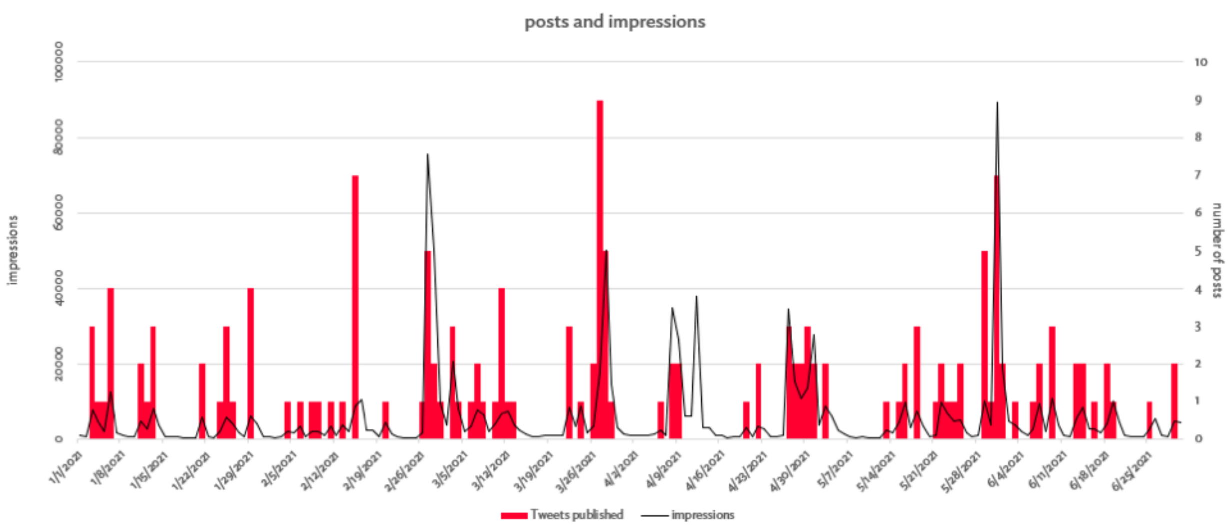


Figure 8.2.2*. Number of posts per day (right axis, red bars) compared to the number of impressions received per day (left axis, black line).*

The same spikes are seen in impressions as we see in the website traffic, April 8, April 27, and May 31 related to felt earthquakes. The additional spike around March 27 is related to a series of posts for the anniversary of the 1964 Great Alaska Earthquake. Our engagement rate with time (Figure 8.2.3) remained consistent, averaging around 1.8%, with a high nearing 8% for the May 31, M6.1 earthquake.

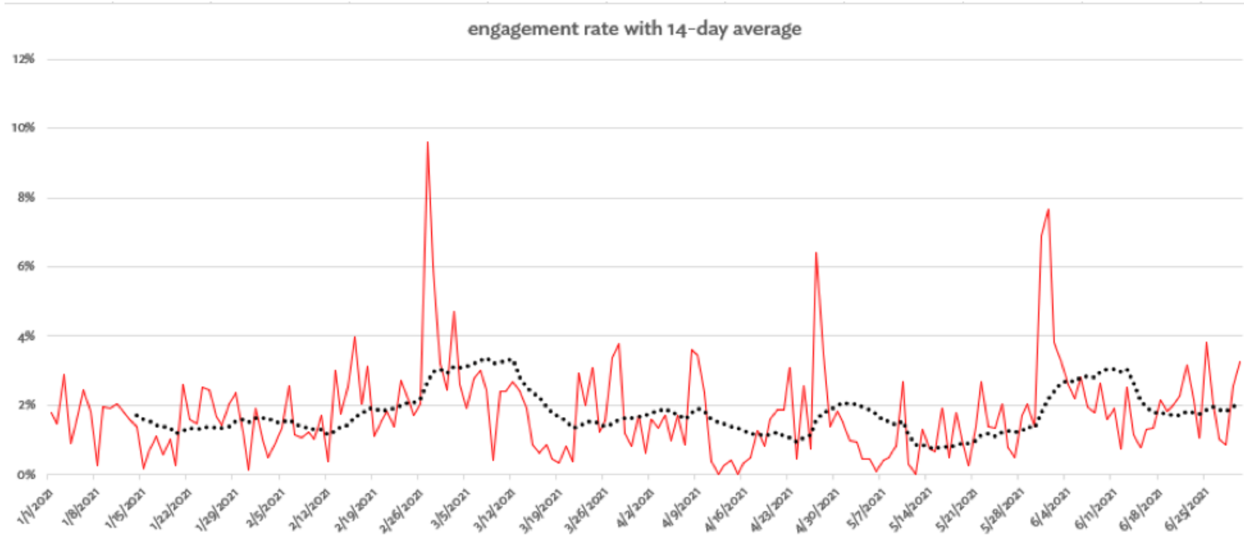


Figure 8.2.3. *Twitter engagement rates with time (red line) and 14-day moving average (black dotted line).*

Figure 8.2.4 demonstrates that felt earthquakes, especially those felt in Southcentral Alaska (e.g., Anchorage aftershocks) account for 53% of impressions, however they garnered 60% of engagement. This is a trend seen consistently with time. During the second quarter we began #FieldworkFriday posts. As mentioned above we made a series of posts related to the M9.2 anniversary. This is categorized as 'Content'. While it only garnered 14% of overall impressions it did yield 29% of all engagements during this period.

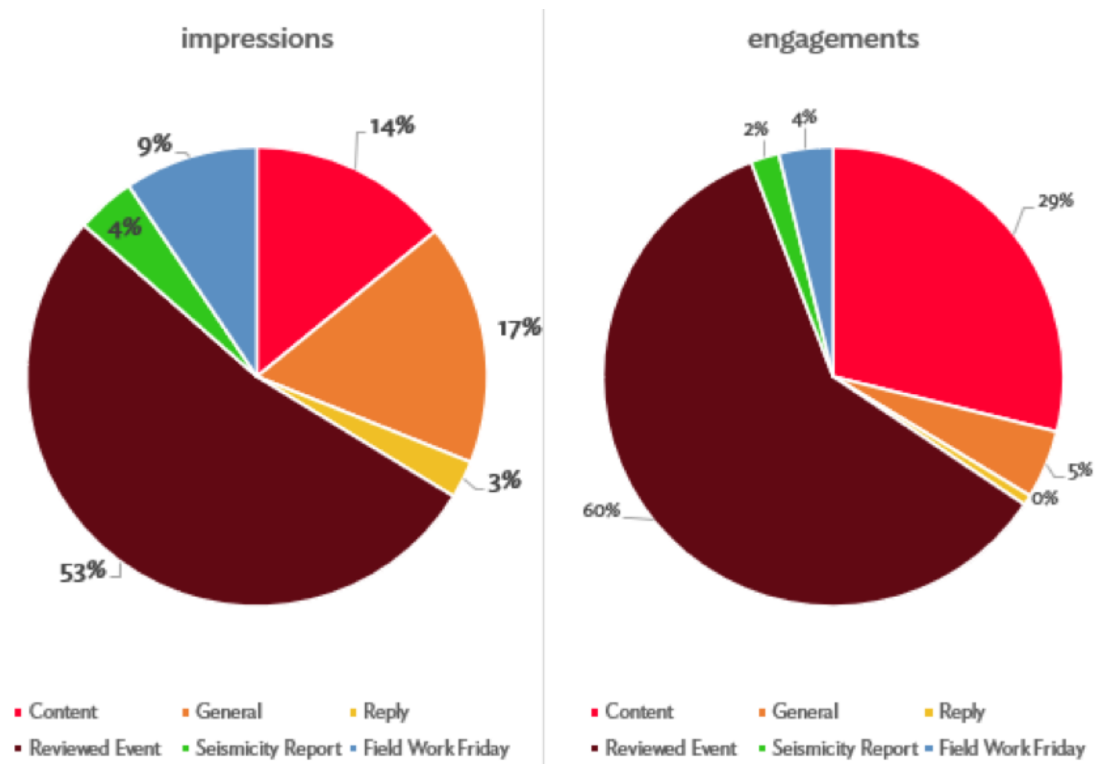


Figure 8.2.4*. Percentages of impressions and engagements based on tweet type.*

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 second quarter of 2021, we attracted 1,350 new followers bringing our current Page following to 4,050. As is the trend with felt earthquakes, we receive a follower boost after each event. The largest influx of more than 600 new followers occurred after the M6.1 earthquake on May 31. The distribution of post type is shown in Figure 8.3.1. Reviewed events accounted for 64% of the 55 posts made in the second quarter. Curated content and weekly seismicity reports accounted for 13% and 5%, respectively. As with Twitter, we have reintroduced #FieldworkFriday with 9% of our posts. After reviewed events, our "Content" type posts had the second largest reach (the number of people who actually see our content).

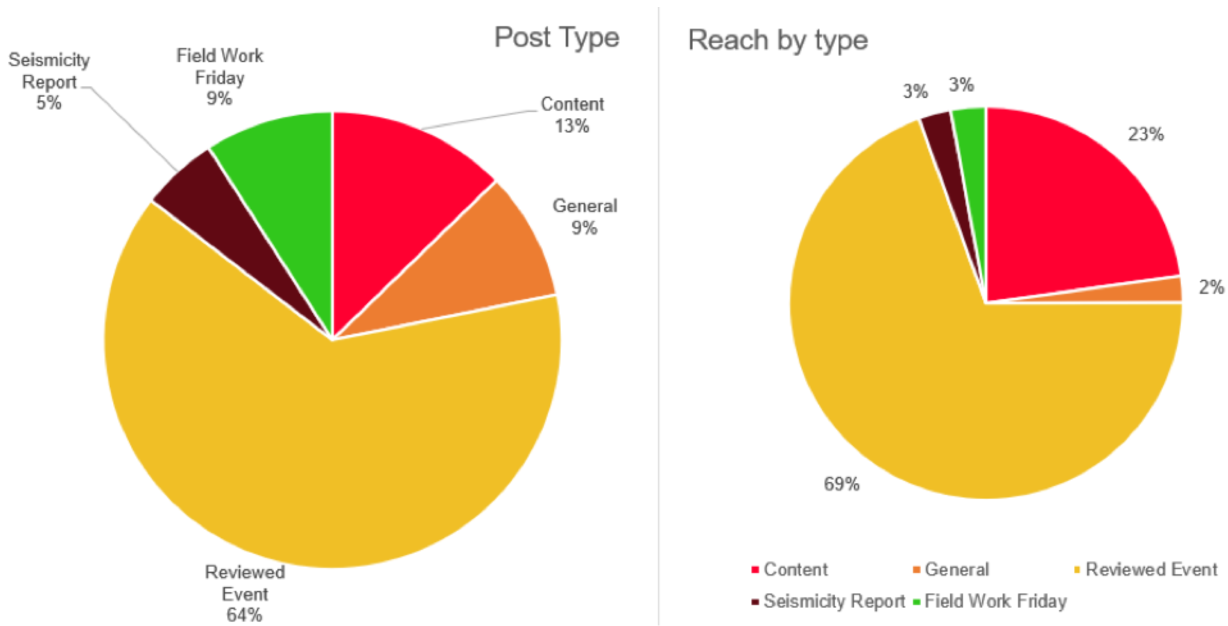


***Figure 8.3.1**. Distribution of Facebook Page posts by type (left) and audience reach by type (right).*

We maintain an average 6.8% 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 little overall difference between the engagement rates for reach and impressions in our analysis, on average 7.0% and 6.73% respectively (Figure 8.3.2).

Our largest percentage of engaged users occurred as a result of the M6.1 May 31 earthquake. Our series of posts related to the M9.2 anniversary resulted in 17% of our engaged users (Figure 8.3.3).

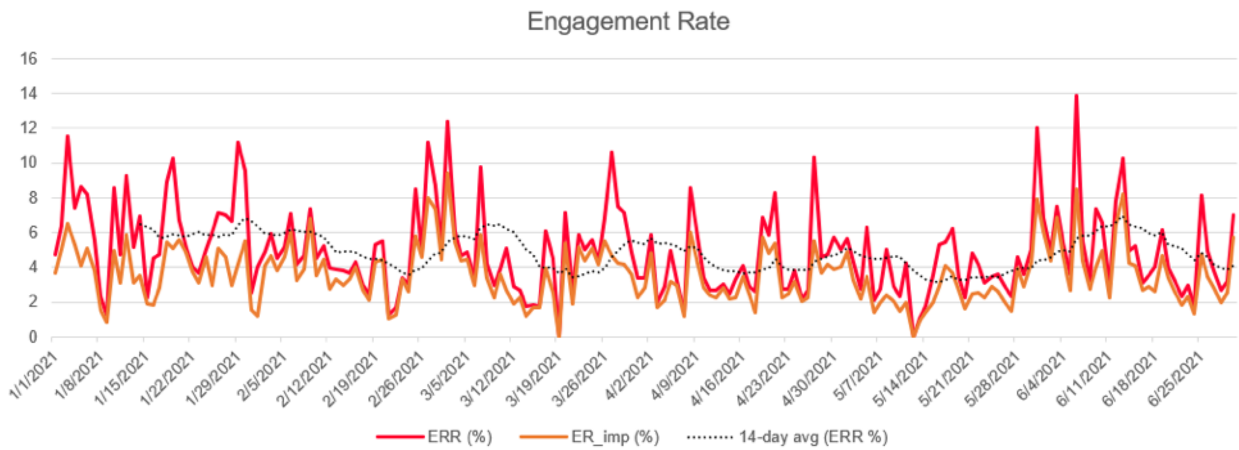
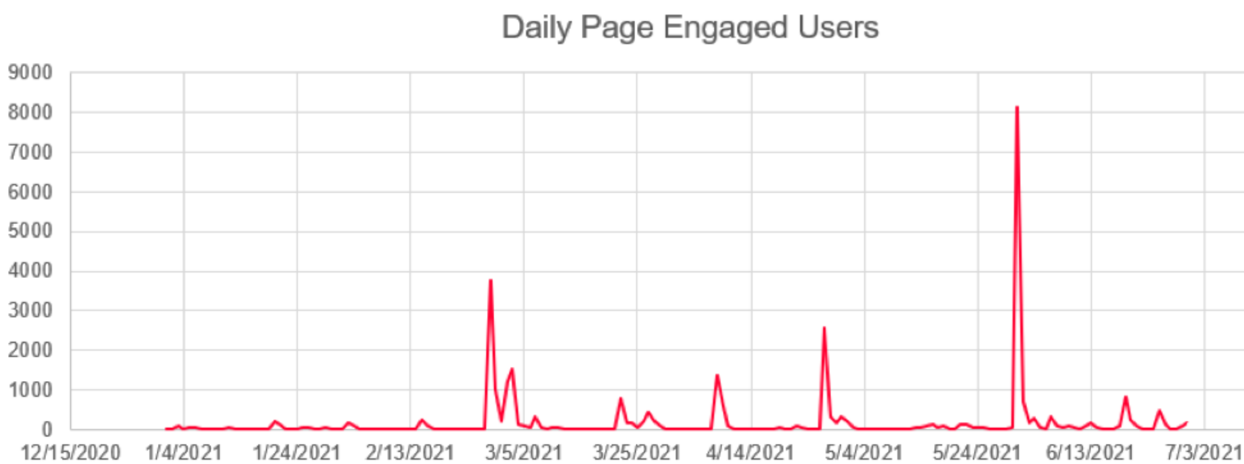


Figure 8.3.2. *Daily engagement rate based on reach (ERR) and impressions (ER_imp) plotted with a moving 14-day average of ERR.*



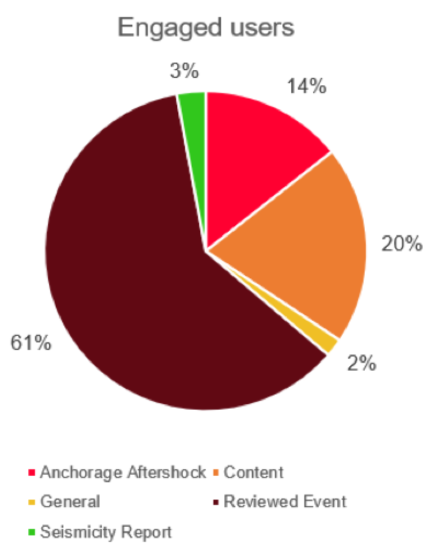


Figure 8.3.3*. Daily engaged users of our Facebook Page (top) with percentages of users by post type (bottom).*

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 17,500 group members, with a net gain of 300 new members during the reporting period. One interesting trend noticed in membership this quarter was the expected uptick in membership following the May 31, M6.1 earthquake was followed by a significant drop in group members. This drop lasted about a week before returning. We've never seen a change like this before and can't readily explain it.

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 second quarter we maintained an average engagement rate between 4-6%. Our maximum engagement occurred as a result of the May 31, M6.1 earthquake. The high number of posts on that day is related to group members posting that they felt an earthquake, instead of replying to another thread. This is an ongoing issue and often hides our authoritative information.

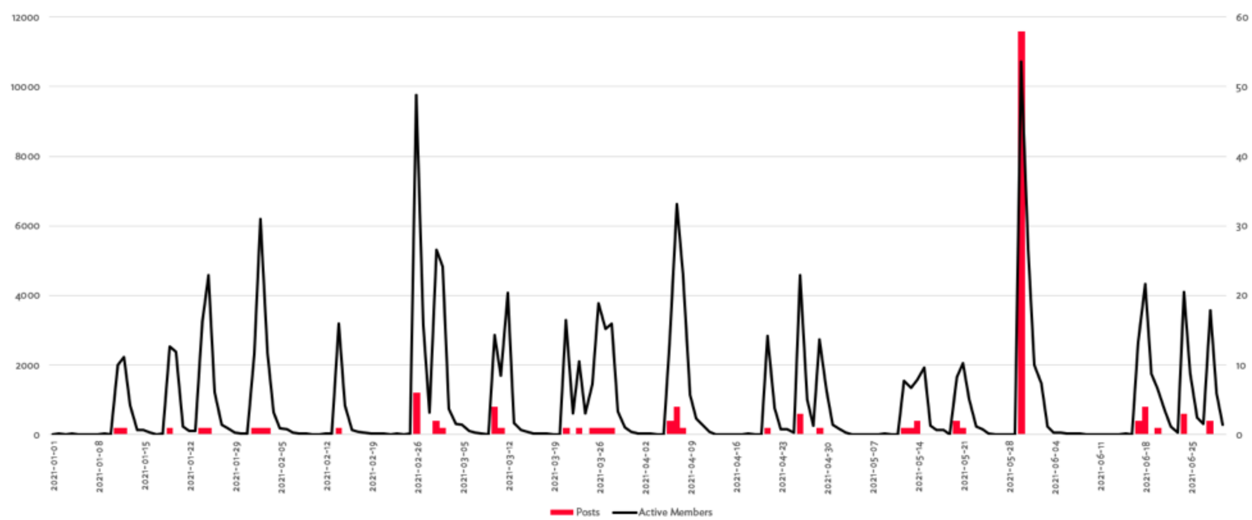


Figure 8.4.1. *Plot of active members (left axis) and number of posts (right axis) with time.*

During the second quarter of 2021, there were 89 posts to the group: 28 by AEC admins and 60 by other group members. Nearly all 60 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 reporting. 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. This quarter we had two planned power outages and a lot of our general posts during this time were keeping people informed of the outage status since it affected our ability to report on earthquakes.

While reviewed event posts to the group comprise less than 30% of our posts, unsurprisingly, they receive nearly half the comments and more than 60% of shares. Our content posts comprised 25% of our posts, but garnered 37% of comments. The biggest surprise is the lack of engagement our #FieldworkFriday posts received.

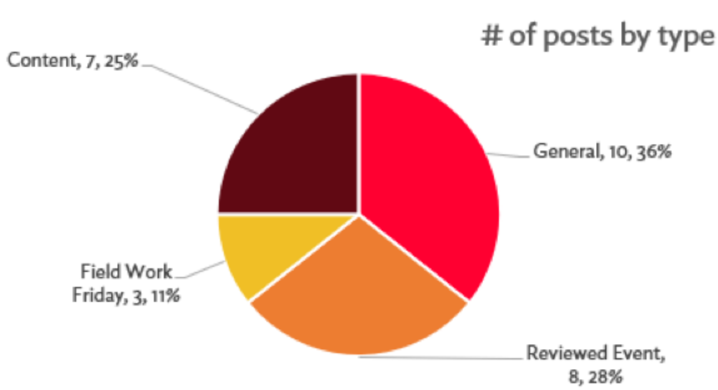


Figure 8.4.2. *Distribution of post type for the Facebook Group.*

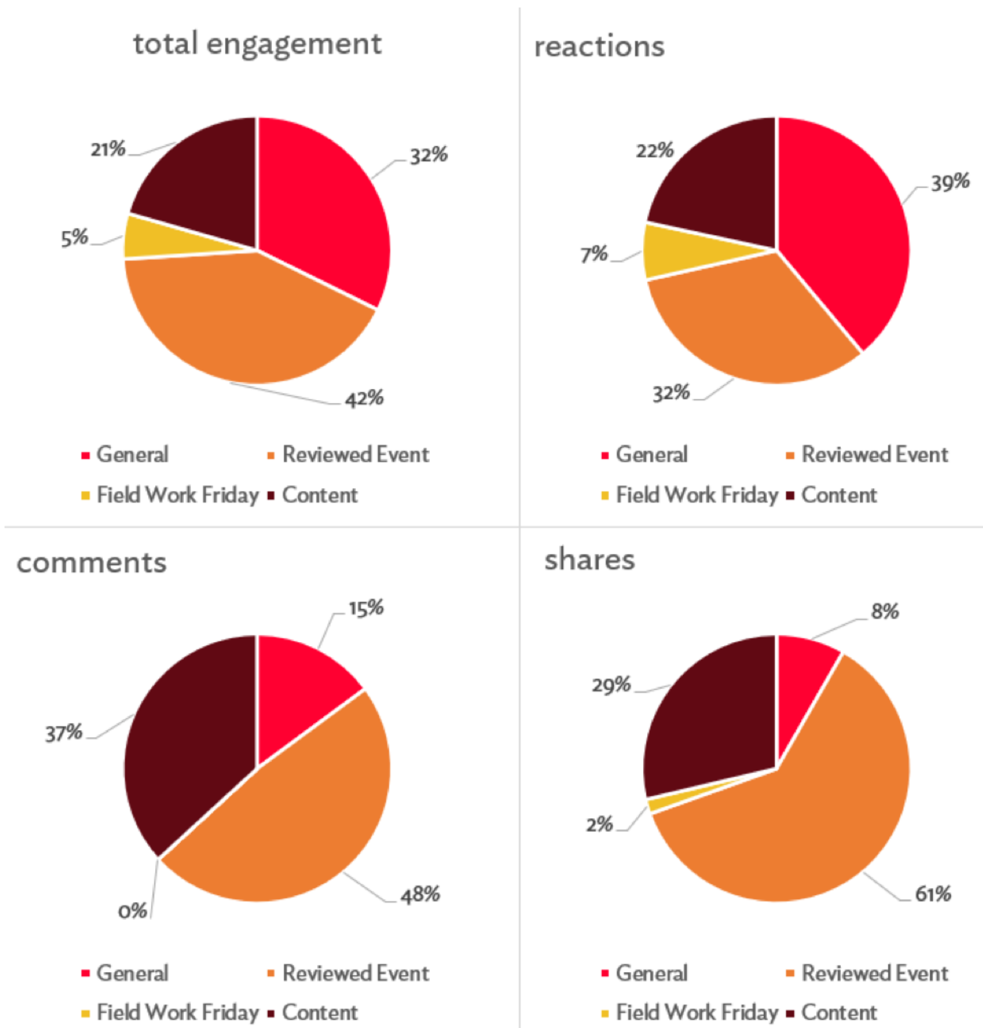


Figure 8.4.3. *Distribution of our engagement as reactions, comments, and shares based on post type for the Facebook Group.*

9. Publications and presentations

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

9.1. Publications

Freymueller, J. T., **Suleimani, E. N.**, & **Nicolsky, D. J.** (May 2021). Constraints on the slip distribution of the 1938 M_W 8.3 Alaska Peninsula earthquake from tsunami modeling. *Geophysical Research Letters,* v.48:9, e2021GL092812. https://doi.org/10.1029/2021GL092812

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, 38pp, http://hdl.handle.net/11122/11966.

Ruppert, N.A., Barcheck, G., and Abers, G. (May 2021). *AACSE earthquake catalog: January-August, 2019.* ScholarWorks@UA, http://hdl.handle.net/11122/11967.

Wei, S. S., P. Ruprecht, S. L. Gable, E. G. Huggins, **N. Ruppert**, L. Gao, and H. Zhang (June 2021). Along-strike variations in intermediate-depth seismicity and arc magmatism along the Alaska Peninsula. *Earth and Planetary Science Letters*, v.563. doi: 10.1016/j.epsl.2021.116878.

9.2. Public Presentations

Date	Presenter(s)	Event/Workshop	Title	Virtual/ In person
4/20	**Natalia Ruppert,** Grace Barcheck, Geoffrey Abers	SSA 2021 Annual meeting	Enhanced Regional Earthquake Catalog With Alaska Amphibious Community Seismic Experiment Data	Virtual
4/21	**Natalia Ruppert, Ezgi Karasözen**	SSA 2021 Annual meeting	Aftershock Sequence of the 22 July 2020 M7.8 Simeonof Earthquake, Alaska-Aleutian Subduction Zone	Virtual
4/21	**Natalia Ruppert**	Kodiak Area Marine Science Symposium	23 January 2018 magnitude 7.9 Offshore Kodiak Earthquake: What we learned and ongoing studies (abstract on p. 25)	Virtual

Date	Presenter(s)	Event/Workshop	Title	Virtual/ In person
4/23	**Michael West**, Jessica Feenstra, Sterling Strait, Zahraa Saiyed	EERI Webinar Series Alaska Chapter meeting	Advocating for Earthquake Safety in Alaska	Virtual
5/12	**Michael West**	USGS Landslides Hazard Program meeting	Barry Arm: Coming to terms with coastal landslides	Virtual
6/9	**Nate Murphy**	ANSS Annual NIC Meeting	AEC Network Expansion and Telemetry Improvements	Virtual
6/9	**Elena Suleimani**	Prince William Sound Rural Resilience Workshop (June 7-11)	Tsunamis in Alaska: Are we ready for the next big one?	Valdez
4/27	**Elena Suleimani**	Community tsunami presentation	Tsunami hazard map of Ketchikan	Ketchikan
4/27	**Elena Suleimani**	two presentations in Ketchikan High School	Tsunamis in Alaska and around the world	Ketchikan
4/28	**Elena Suleimani**	School tsunami presentation	Tsunamis in Alaska and around the world	Hydaburg
4/29	**Elena Suleimani**	Community tsunami presentation	Tsunami hazard map of Hydaburg	Hydaburg
4/29	**Elena Suleimani**	presentation for several schools in the Prince of Wales school district (zoom from Craig)	Tsunamis in Alaska and around the world	Craig

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
4/7	Alberto Roman	Dynamics of large effusive eruptions driven by caldera collapse	virtual
6/8	Revathy M. Parameswaran	Deep nucleation on an oceanic listric-like fault: The 2012 Mw 8.6 Indian Ocean Earthquake	virtual

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.

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

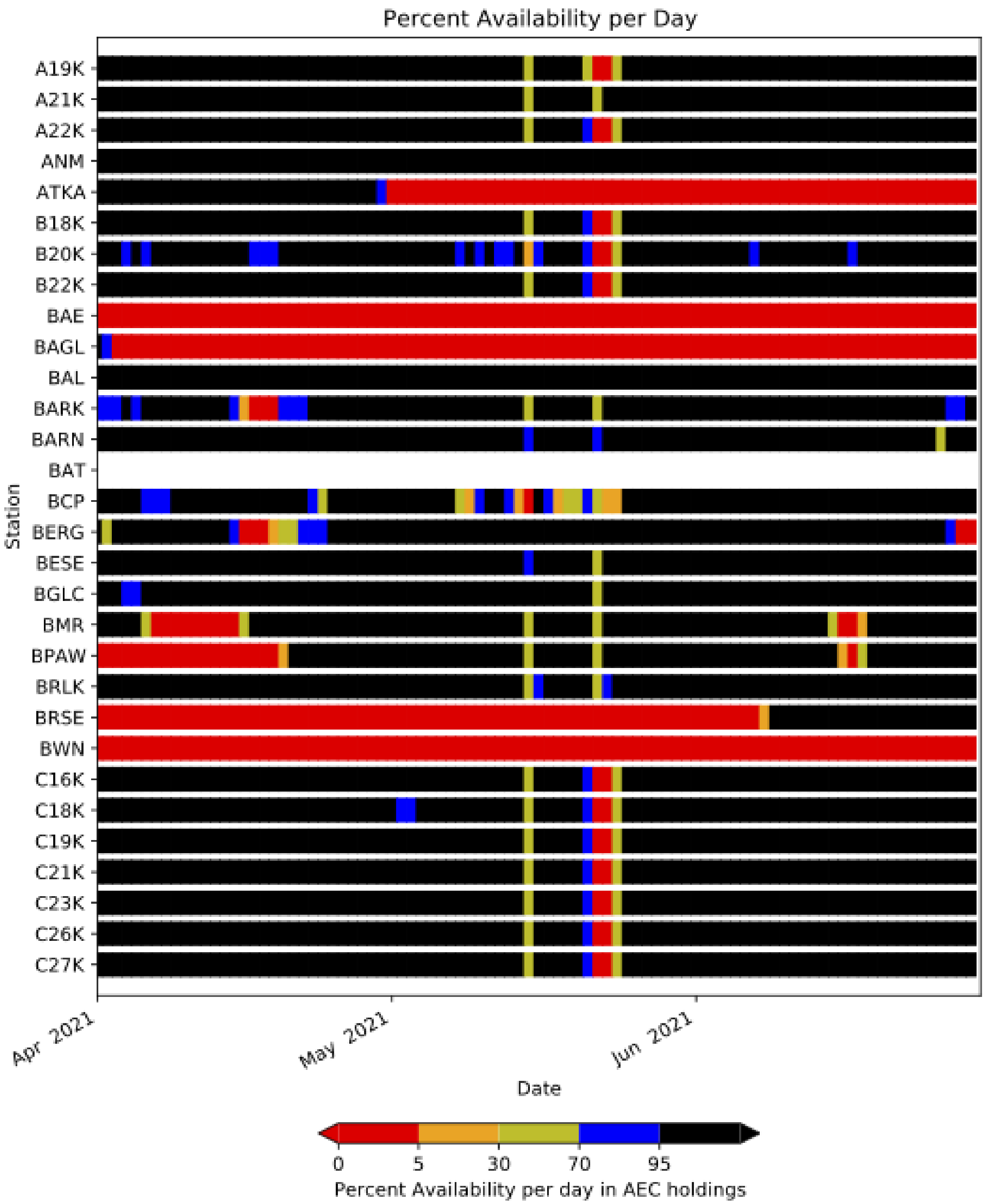


***Figure A1**. Data availability for stations A19K-C27K (listed alphabetically). BAT is a new site installed in July 2021.*

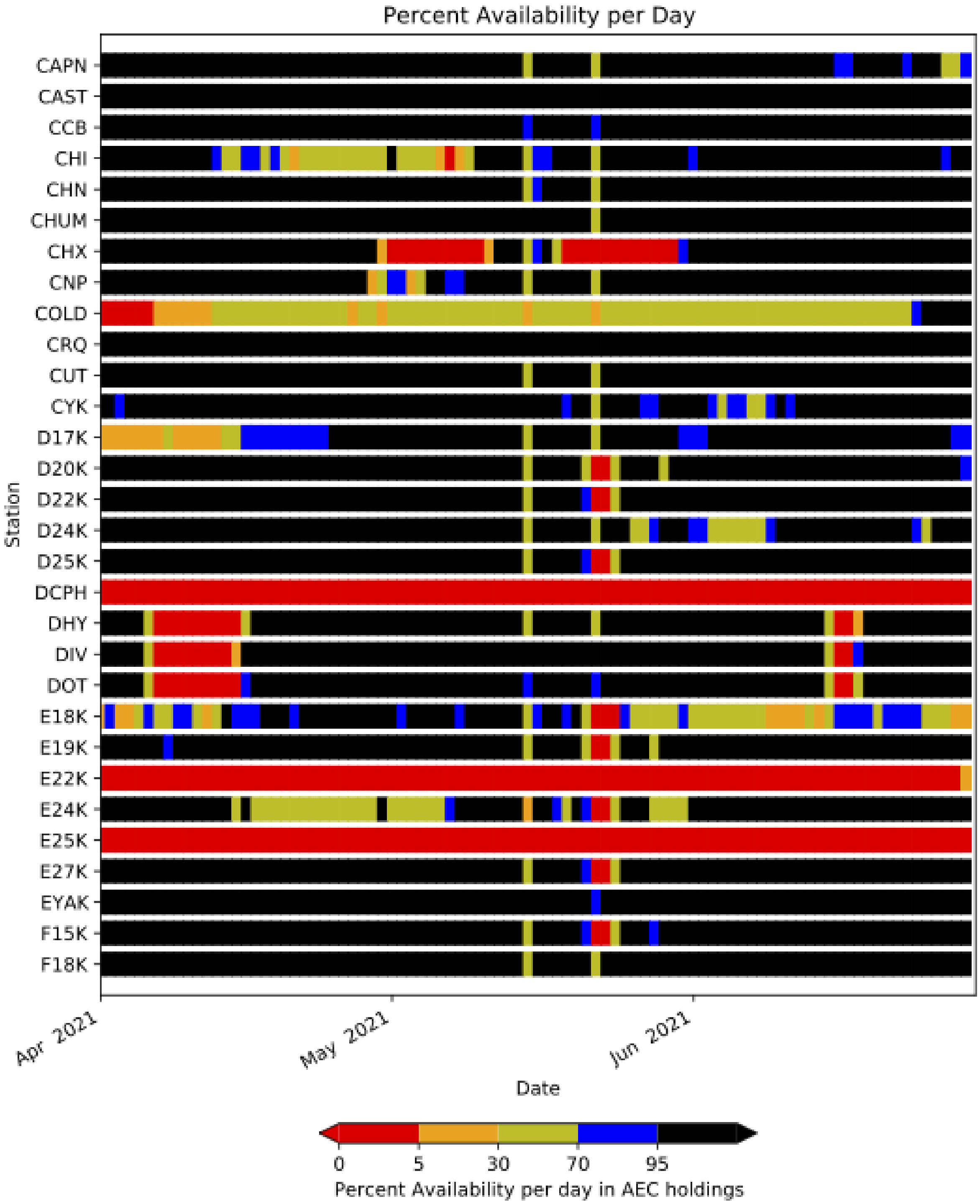


***Figure A2**. Data availability for stations CAPN-F18K (listed alphabetically).*

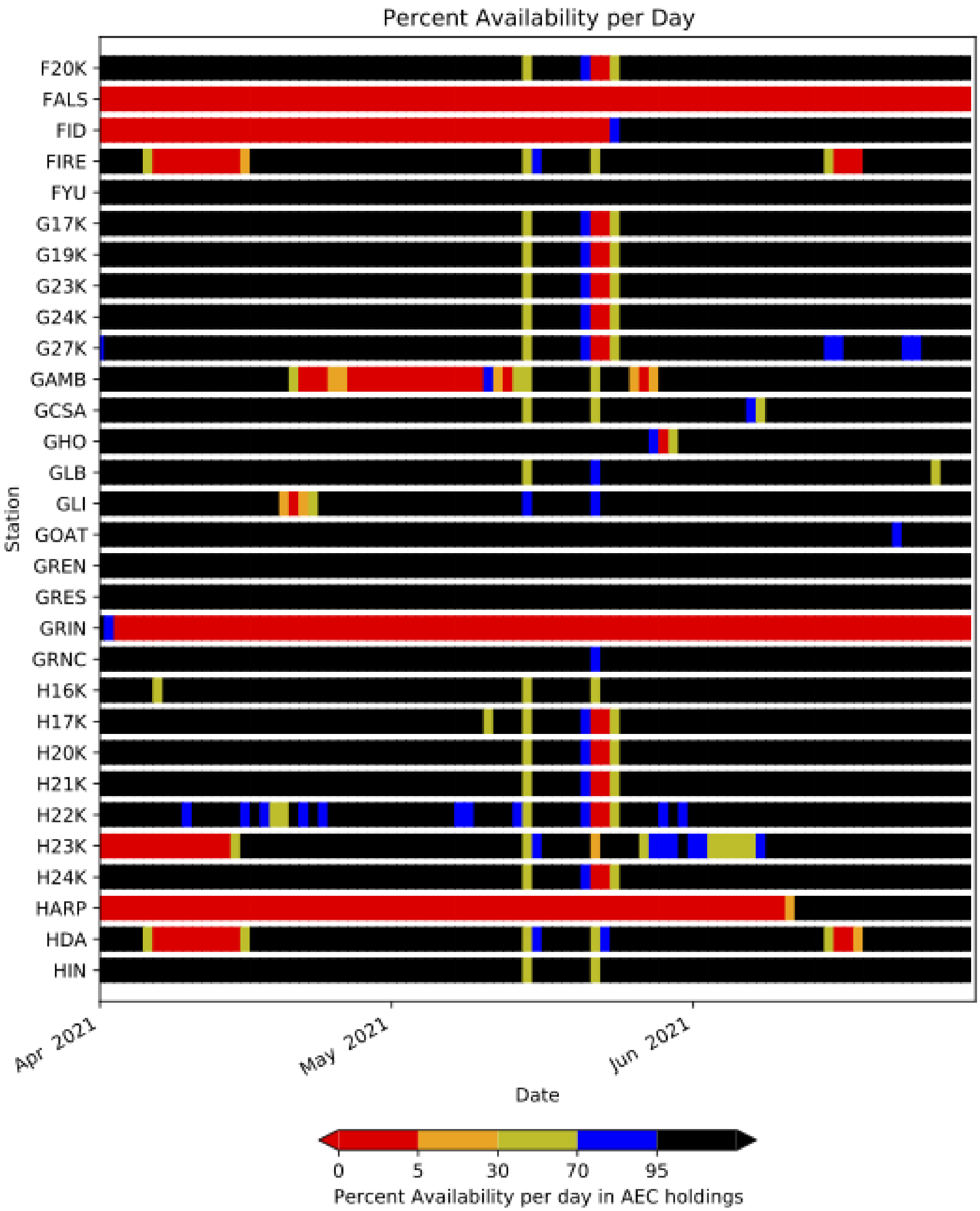


***Figure A3**. Data availability for stations F20K-HIN (listed alphabetically).*

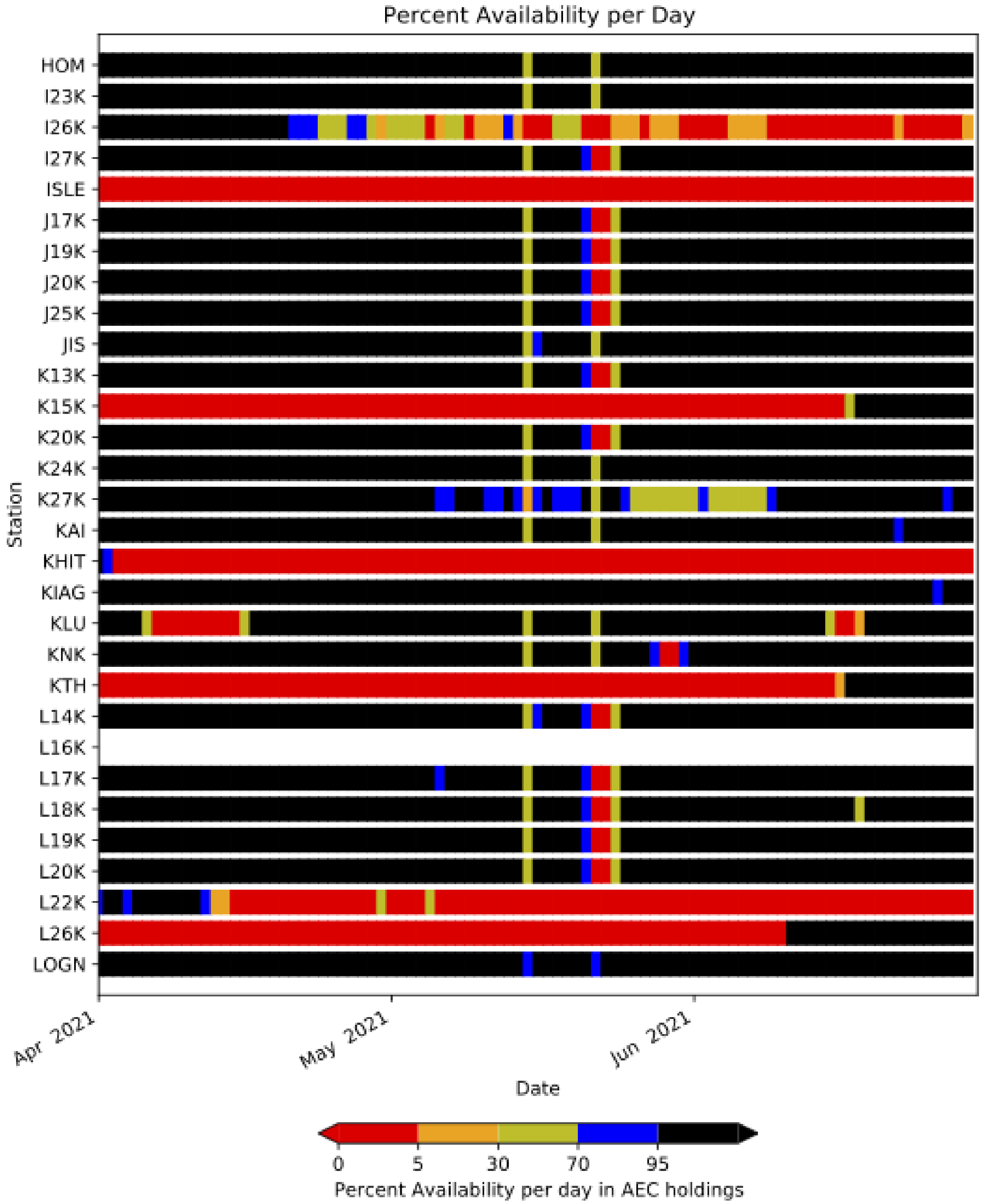


Figure A4. *Data availability for stations HOM-LOGN (listed alphabetically).*

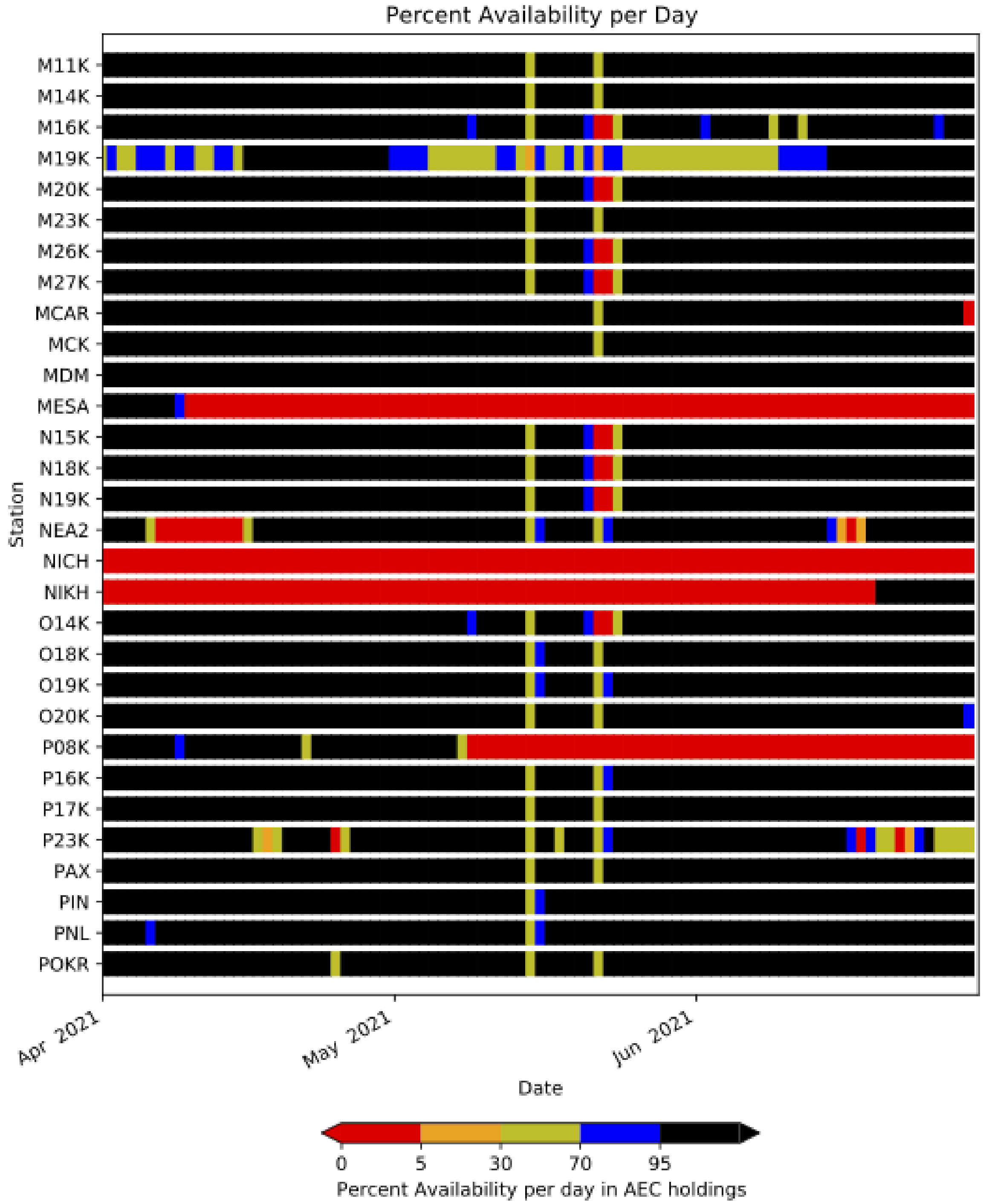


Figure A5. *Data availability for stations M11K-POKR (listed alphabetically).*

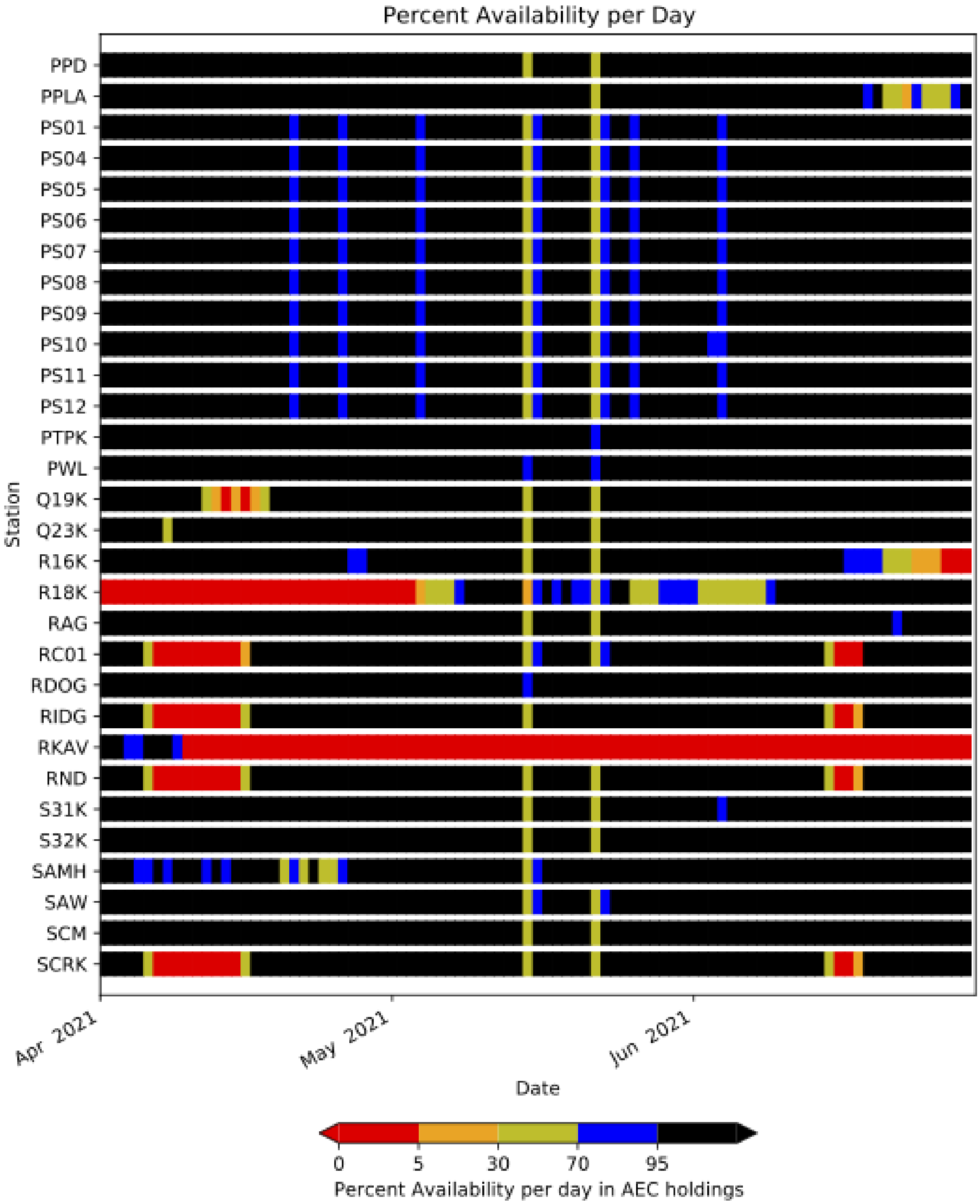


***Figure A6**. Data availability for stations PPD-SCRK (listed alphabetically).*

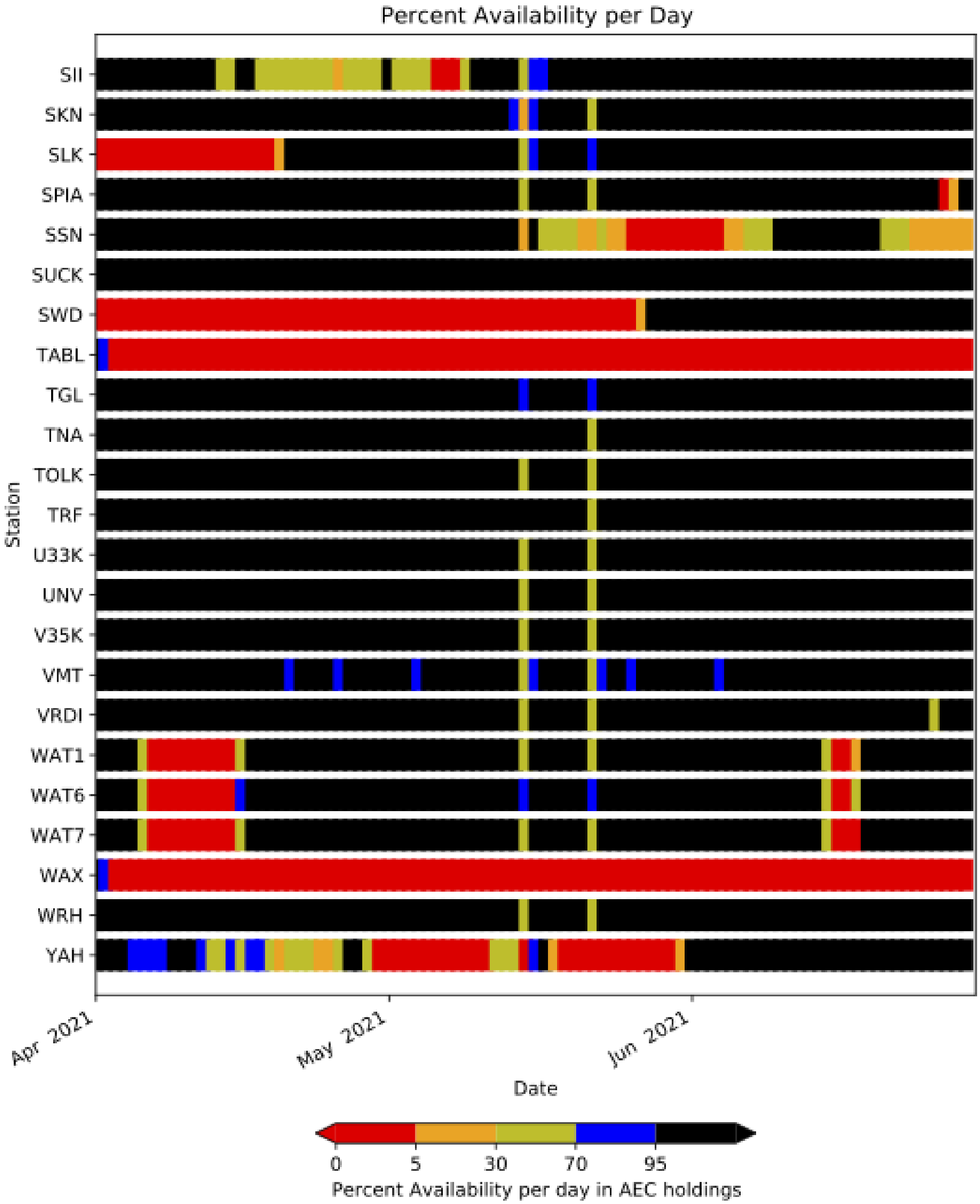


Figure A7. *Data availability for stations SII-YAH (listed alphabetically).*

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

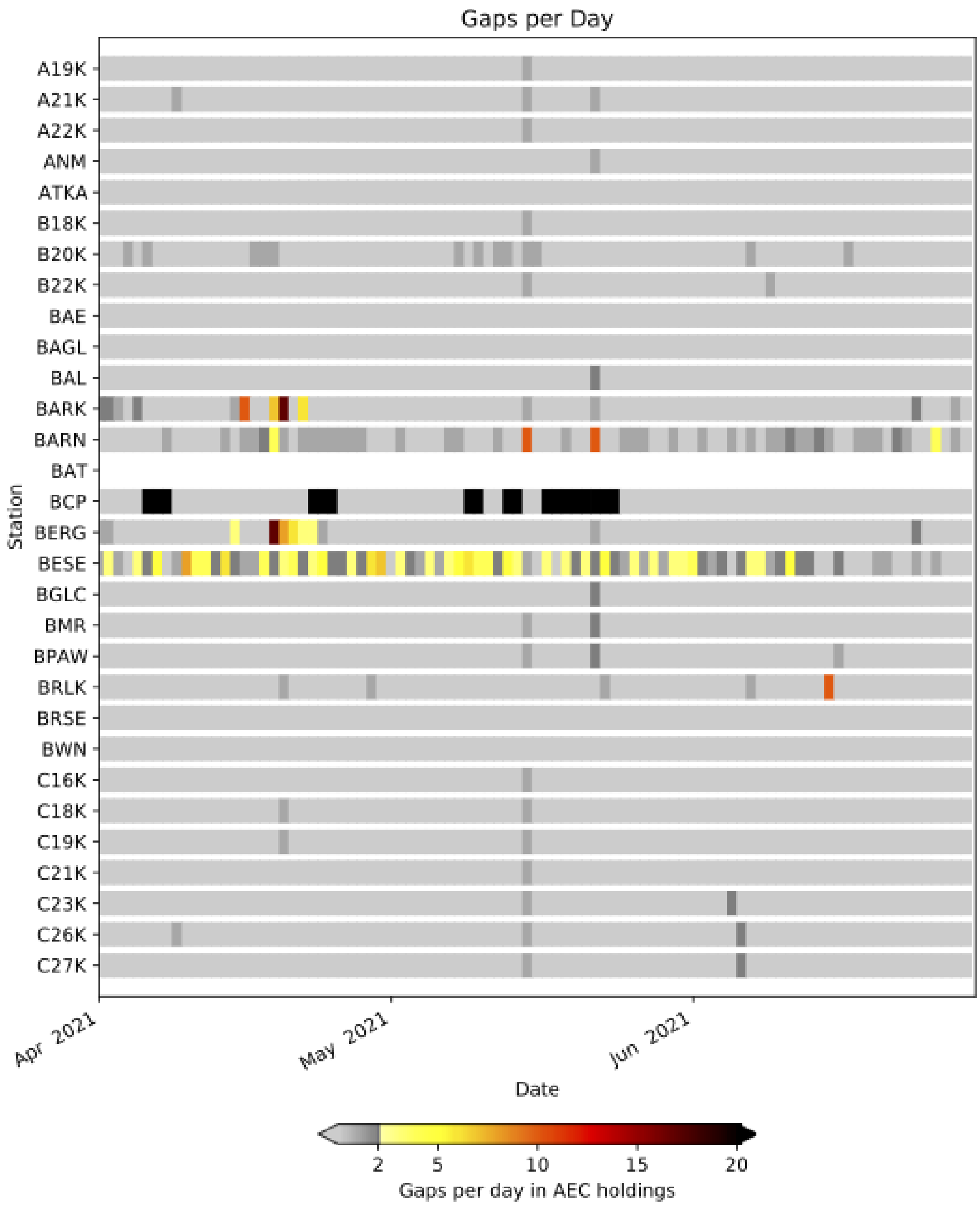


Figure B1*. Number of gaps per day*[1] *for stations A19K-C27K (listed alphabetically). BAT is a new site installed in July 2021.*

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

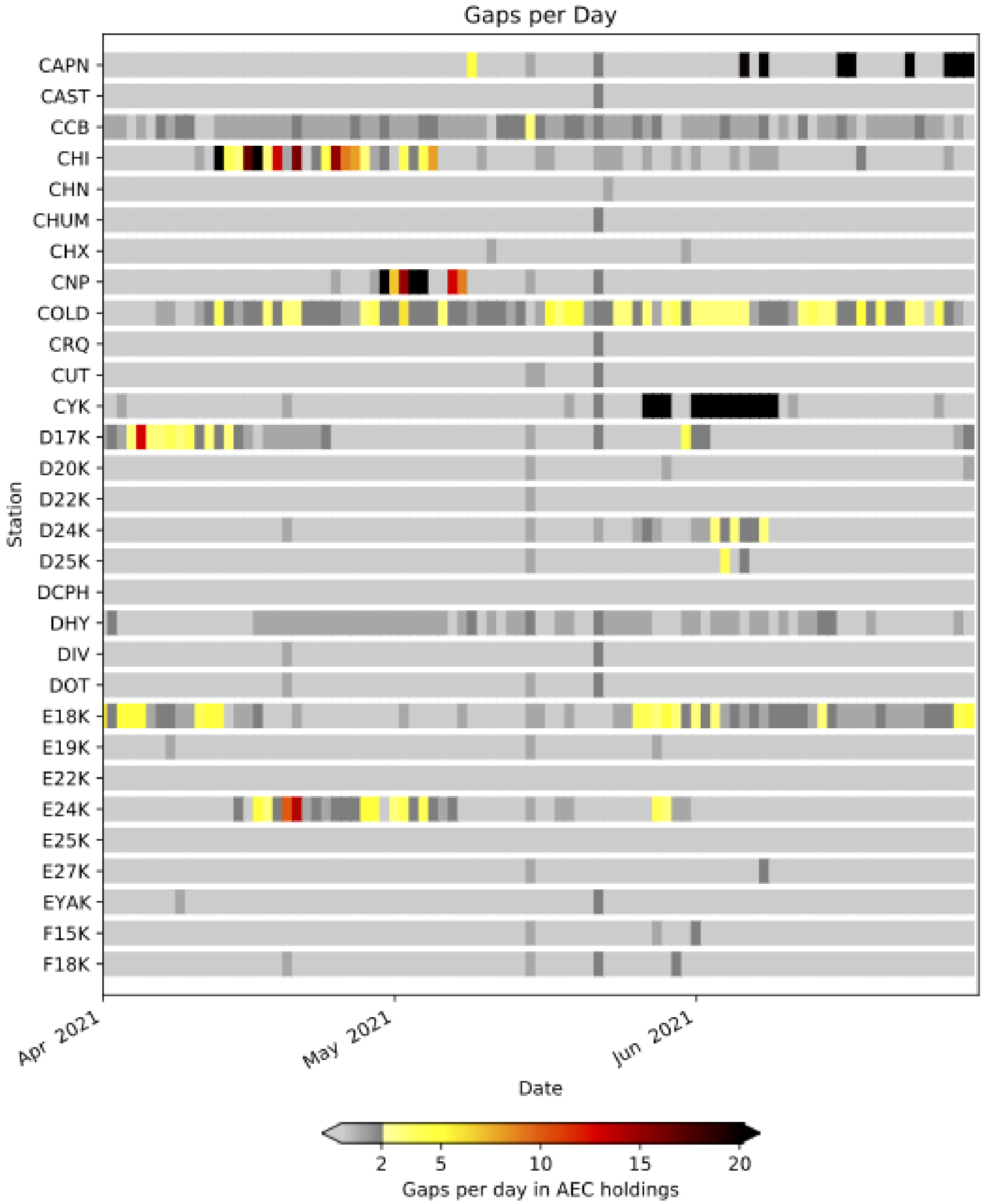


***Figure B2**. Number of gaps per day for stations CAPN-F18K (listed alphabetically).*

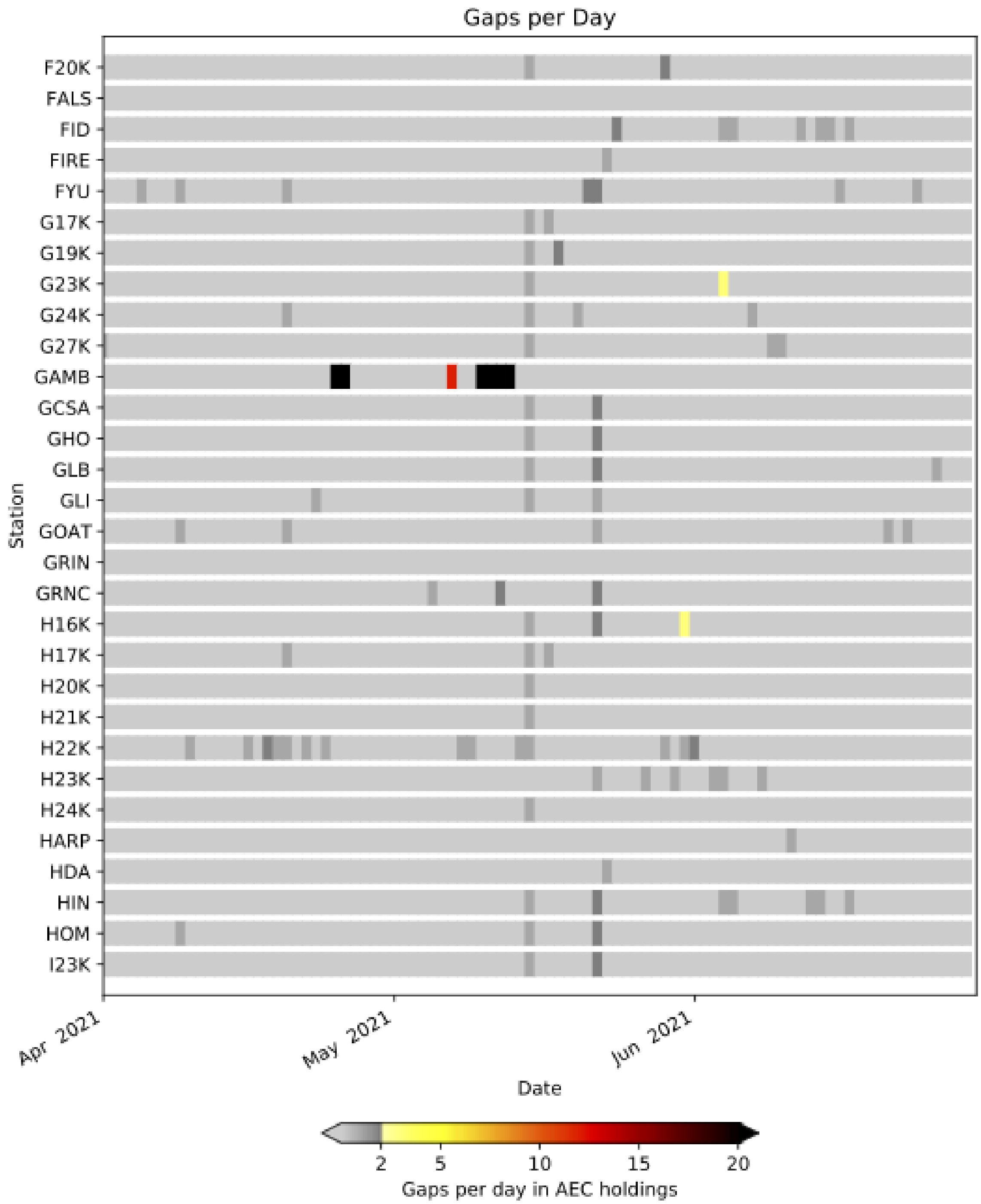


***Figure B3**. Number of gaps per day for stations F20K-I23K (listed alphabetically).*

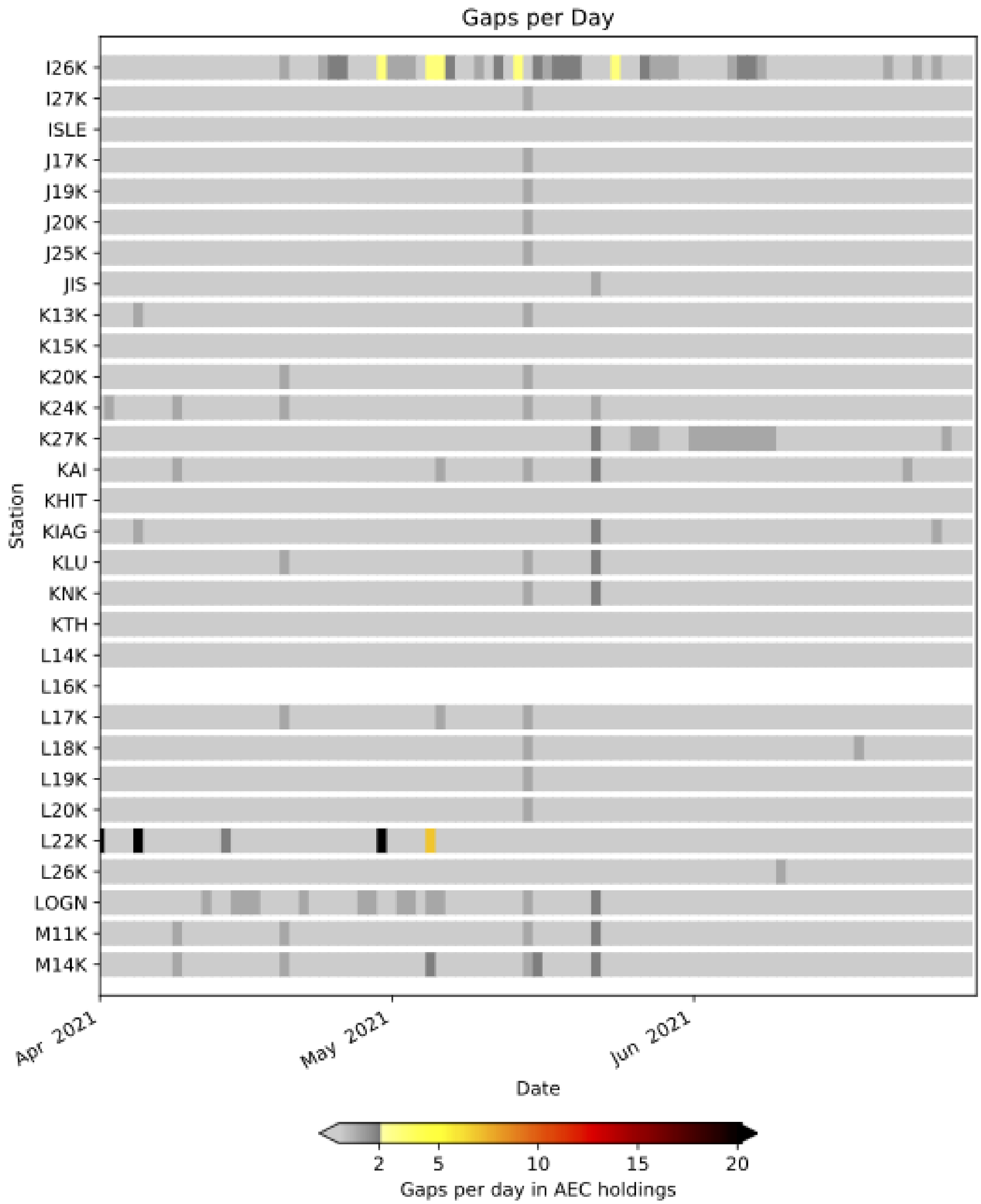


Figure B4. *Number of gaps per day for stations I26K-M14K (listed alphabetically).*

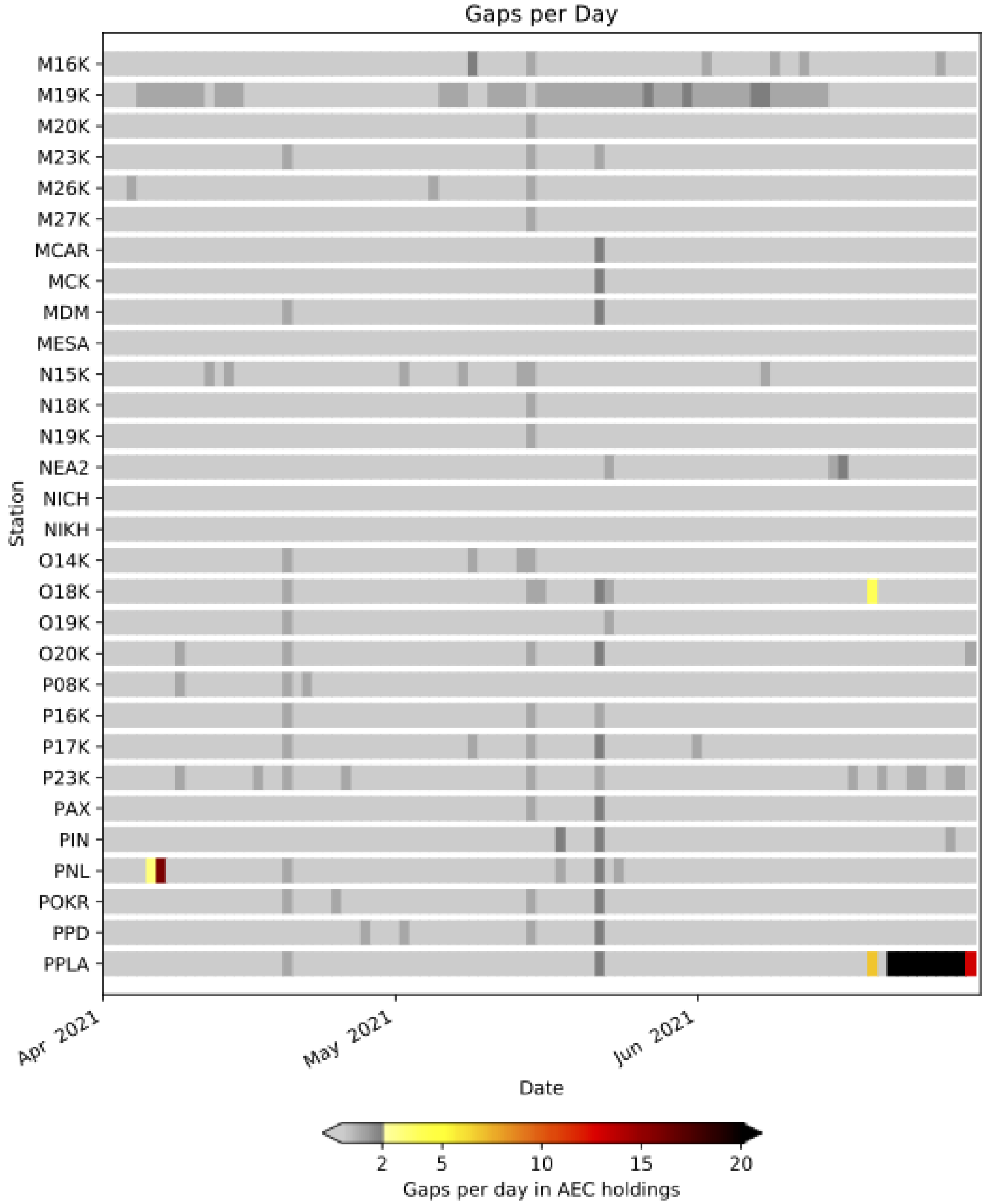


Figure B5*. Number of gaps per day for stations M16K-PPLA (listed alphabetically).*

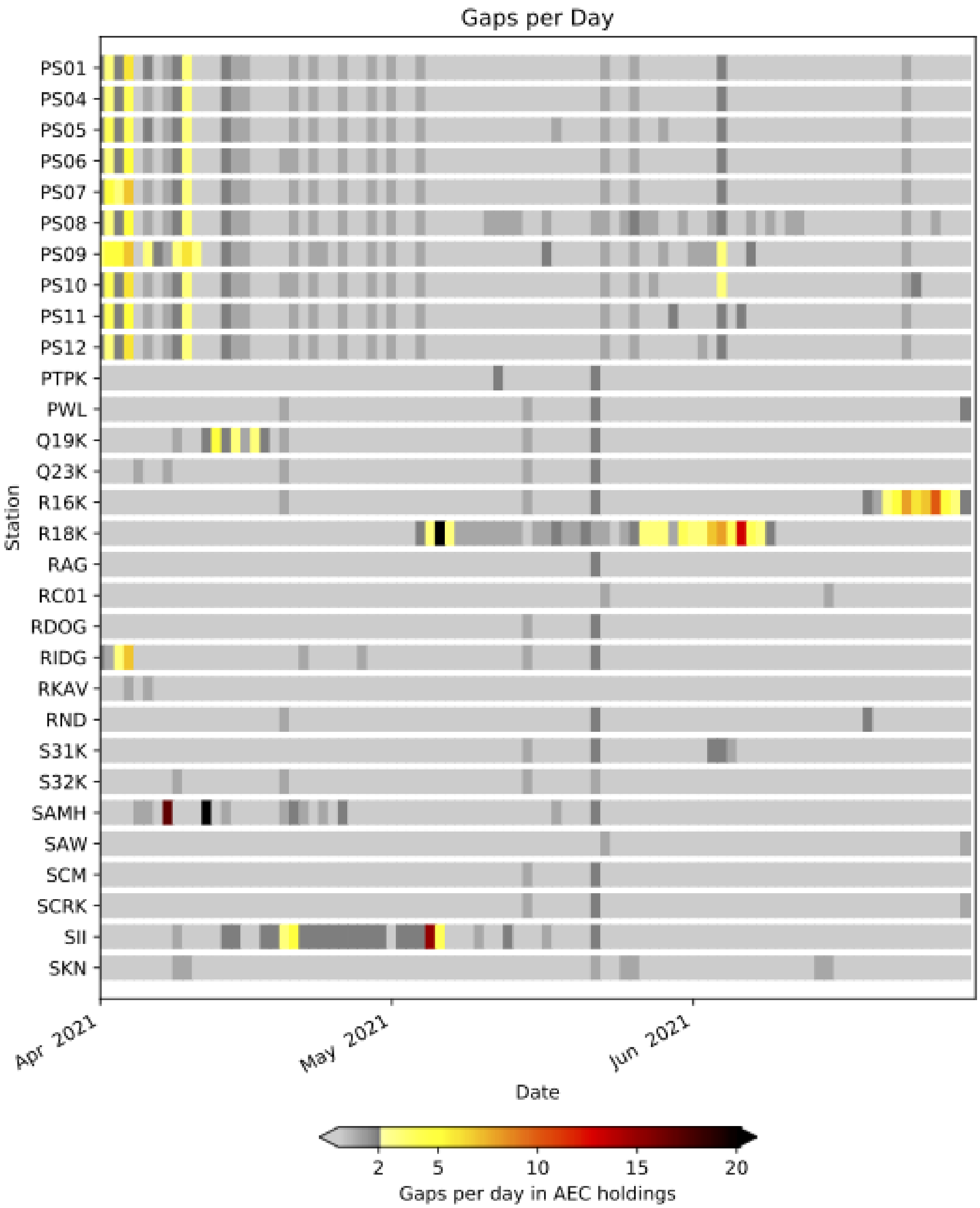


Figure B6. *Number of gaps per day for stations PS01-SKN (listed alphabetically).*

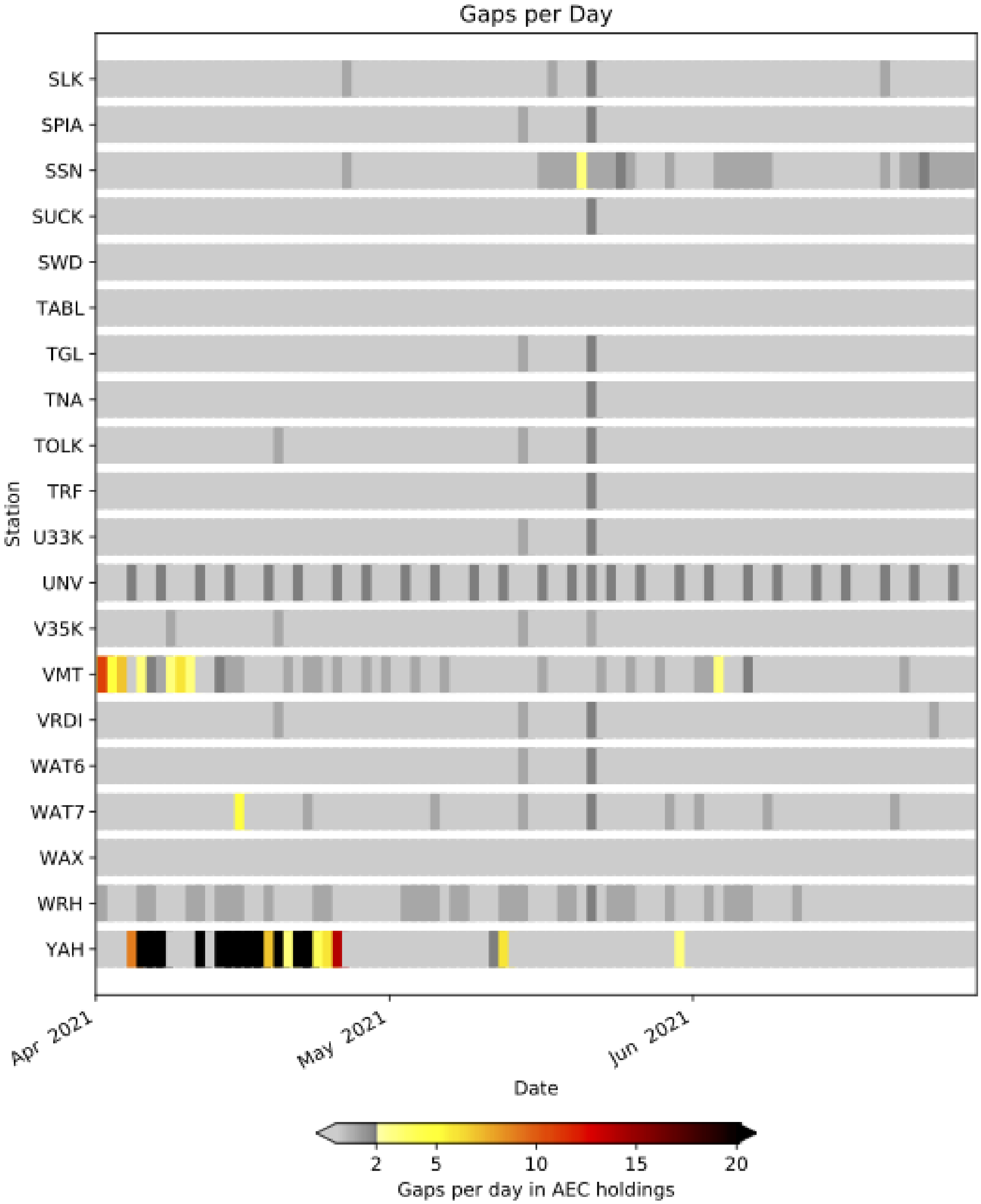


***Figure B7**. Number of gaps per day for stations SLK-YAH (listed alphabetically).*