



# BC Seismic Research Consortium - Induced Seismicity Monitoring Project

May 2023 - April 2024 Report

August 15, 2024



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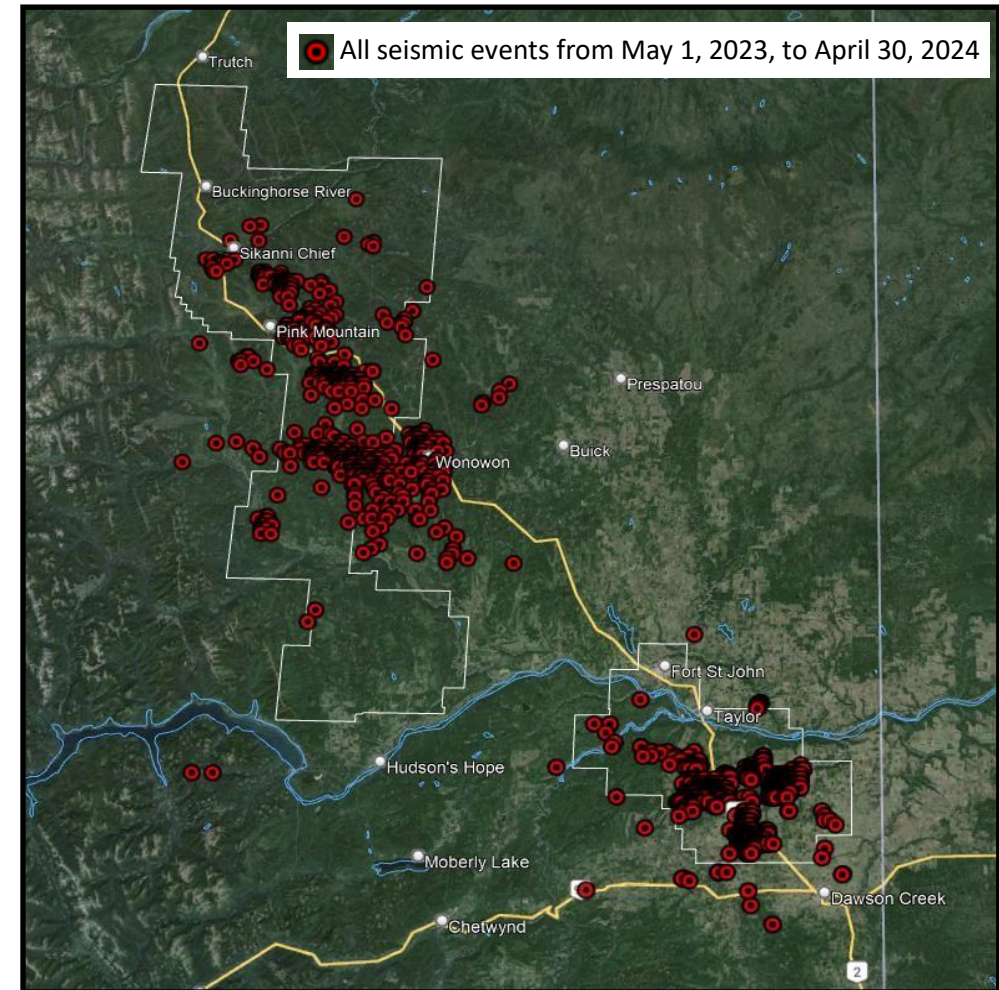
The BC Seismic Research Consortium (BCSRC or Consortium) was established by Geoscience BC, the Canadian Association of Petroleum Producers (CAPP), and the BC Energy Regulator (BCER) (formerly the BC Oil and Gas Commission) and works closely with Natural Resources Canada (NRCan) to monitor seismicity in Northeastern British Columbia (NEBC). It followed a recommendation from the BCER in response to concerns regarding induced seismicity associated with hydraulic fracturing in the Horn River Basin. The Yukon Geological Society (YGS) joined the consortium briefly in 2016 to provide an expanded and comprehensive network covering oil and gas activity in NEBC, but due to funding challenges, the YGS left the consortium the following year. The BCSRC is responsible for maintaining the PQ and 1E seismic networks and collaborates with McGill University for station maintenance of the XL network (see BCSRC Seismic Monitoring: Station Information, page 6). In addition, the BCSRC has access to data from the CN, EO, and S3 networks operated by NRCan, the University of Calgary (U of C), and Symroc (under a NRCan contract), respectively.

The BCSRC is made up of representatives from each of the consortium partners – Geoscience BC, CAPP, BCER, and the BC Oil and Gas Research and Innovation Society (BC OGRIS). Funding for the BCSRC is shared between Geoscience BC and BC OGRIS. NRCan provides critical in-kind technical and operational support, based at the Pacific Geoscience Centre in Sidney, B.C.

This report summarizes the actions and research taken by the BCSRC for the period May 1, 2023, to April 30, 2024. An update on the seismic monitoring efforts in NEBC is provided, along with an overview and seismicity catalogue (see Appendix C) of the seismicity detected during this period. At the time of writing this report, no seismicity data were available from the BCER for the month of October 2023. A report update will be provided pending availability of any data for that month.

During the monitoring period there were 4661 events detected, 120 of which surpassed a local magnitude of 2.0. The largest event occurred on April 13, 2024, with local magnitude 4.19. No reports of damage due to seismicity were relayed to the BCER.

- ESG Solutions began monitoring these regions on behalf of the Consortium on November 1, 2023, and incorporated earlier data to generate this report and event statistics. Events which occurred from May 1, 2023, to November 1, 2023, were taken from the BCER Northeast BC Seismicity App.
- During the annual period of May 1, 2023, to April 30, 2024, 4661 events (596 events  $\geq M_L 1.5$ ) were located in the BCSRC regions of the Kiskatinaw Seismic Monitoring and Mitigation Area (KSMMA) and Northern Montney.
- Events range from 0.13 – 4.19 in local magnitude.
- The BCER catalogue applies a magnitude cutoff of  $M_L 1.5$ . No data was recorded for October 2023.
- ESG Solutions data encompasses all local magnitudes greater than zero.
- It's worth noting that the BCER catalogue magnitude cutoff of  $M_L 1.5$  significantly influences the magnitude-related plots.





# Update on Seismic Monitoring in NEBC



A map view of seismic stations monitored by the Consortium is shown on page 7. During the reporting period, no stations were moved. From November 2023 to April 2024, several seismic stations experienced various operational disruptions. Station NBC7 had slight interruptions in November and December but was mostly offline for the entire reporting period. Stations BCH1A, BCH2A, MONT8, and MG08 were offline for almost the whole reporting period until they came online on March 8th. Station MONT2 had extended interruption gaps from December to February. Station MG01 had extended interruption gaps in January 2024 and timing issues due to GPS problems throughout February. Station MG04 experienced slight interruptions in January. MG03 and MG10 had extended interruption gaps in January 2024 and Station MG03 went offline on March 12th.

A Seismicity Catalogue for the reporting period has been developed and included with this report as Appendix C. Seismic event details are also available at [www.bc-er.ca/seismicmonitoring](http://www.bc-er.ca/seismicmonitoring) with information such as date, time (UTC), latitude, longitude, depth, and local magnitude.



# BCSRC Seismic Monitoring: Station Information



## Seismic stations used to locate KSMMA events

Network	Station name	Station number	Latitude	Longitude
1E	BCH1A	2001	55.832430	-120.258960
1E	BCH2A	2002	55.946070	-120.356100
PQ	NBC4	2003	55.687280	-120.660240
PQ	NBC7	2004	56.267790	-120.842620
1E	MONT1	2005	55.910150	-120.586540
1E	MONT2	2006	56.019720	-120.046970
1E	MONT3	2007	56.005780	-120.453880
1E	MONT9	2008	55.803900	-120.538760
1E	MONTA	2009	56.104320	-121.070040
1E	MONT8	2010	56.067310	-120.777430
XL	MG01	2011	56.054840	-120.637993
XL	MG03	2012	55.912151	-120.441360
XL	MG04	2013	55.991360	-120.338040
XL	MG05	2014	55.895142	-120.301949
XL	MG07	2015	55.788430	-120.454700
XL	MG08	2016	55.841160	-120.873070
XL	MG10	2017	55.722851	-120.063347

## Seismic stations used to locate Northern Montney events

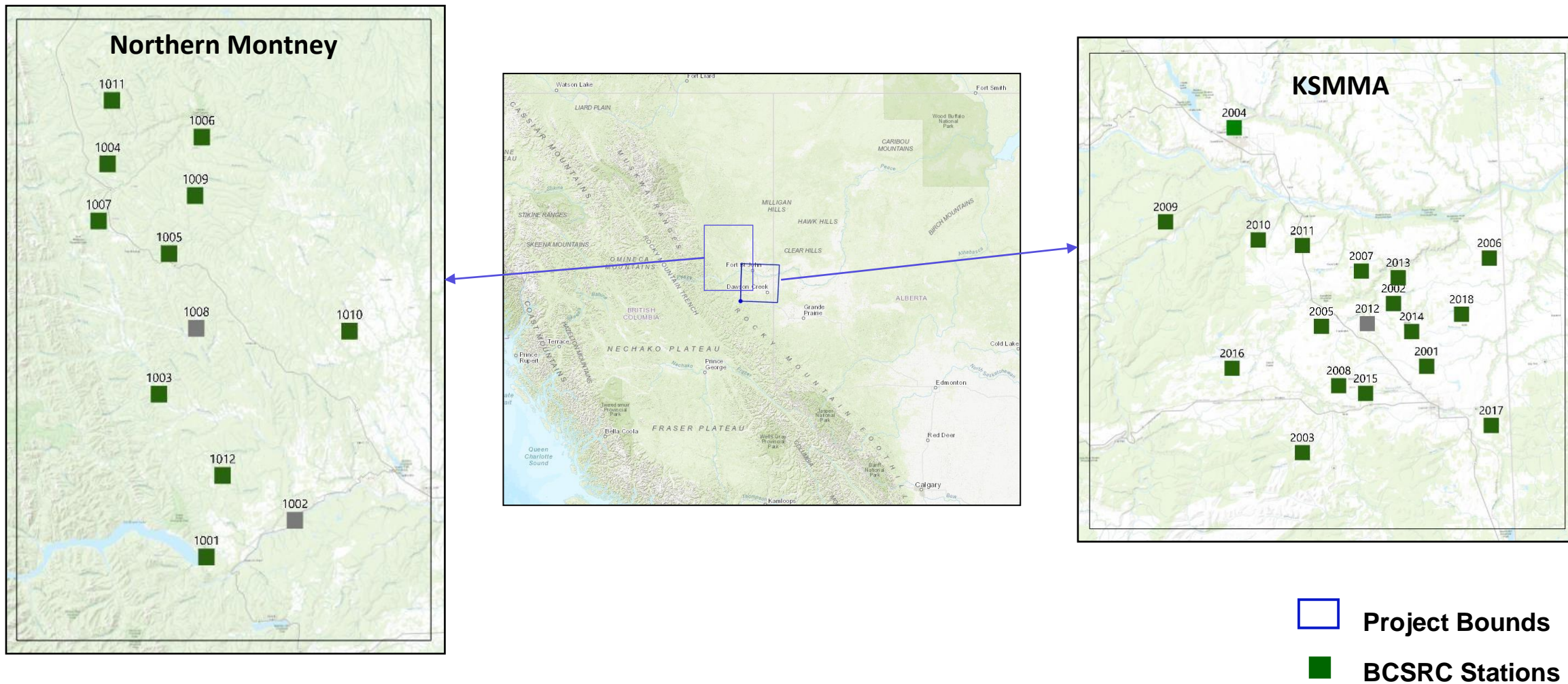
Network	Station name	Station number	Latitude	Longitude
CN	BMTB	1001	56.04510	-122.13320
XL	MG09	1002	56.15910	-121.60810
PQ	NBC8	1003	56.57308	-122.40441
1E	MONT4	1004	57.31841	-122.70567
1E	MONT5	1005	57.02691	-122.33603
1E	MONTB	1006	57.40256	-122.13022
1E	MONTC	1007	57.13378	-122.76222
1E	MONTD	1008	56.78477	-122.17777
1E	MONTE	1009	57.21385	-122.17446
PQ	NAB1	1010	56.76629	-121.25867
PQ	NBC5	1011	57.52311	-122.67763

ESG Solutions began monitoring KSMMA and Northern Montney regions for BCSRC from 2023-10-31 using the public stations listed in the tables above. ESG has labeled stations with numbers. The tables display the station numbers corresponding to their naming convention.



# BCSRC Seismicity Monitoring Array

The KSMMA ISM array consists of 18 public stations and the Northern Montney ISM array consists of 12 public stations.



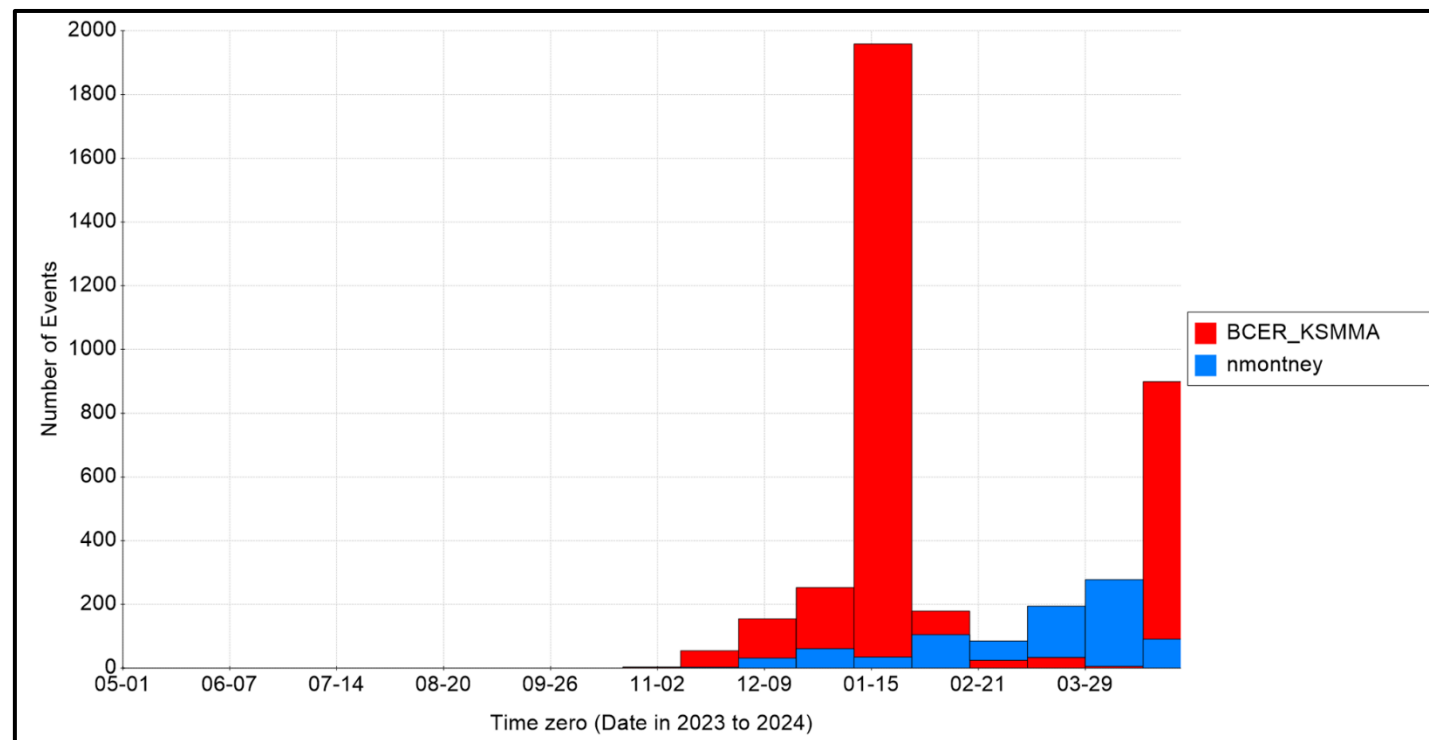
Numbers correspond to the ESG naming convention for the stations.



# Seismicity from May 1, 2023, to April 30, 2024

- A total of 4661 seismic events were detected between May 1, 2023, and April 30, 2024. These events were distributed as follows:
  - KSMMA: 3663 events
  - North Montney: 998 events
    - 120 events exceeded a local magnitude of 2.0:
  - KSMMA: 51 events
  - North Montney: 69 events
- There were 11 events (all in North Montney) which surpassed a local magnitude of 3.0.
- Seismicity peaked in January 2024 in the KSMMA.
- The magnitude cutoff of  $M_L$  1.5, applied from May to October 2023, impacts the magnitude-related plots in this report.

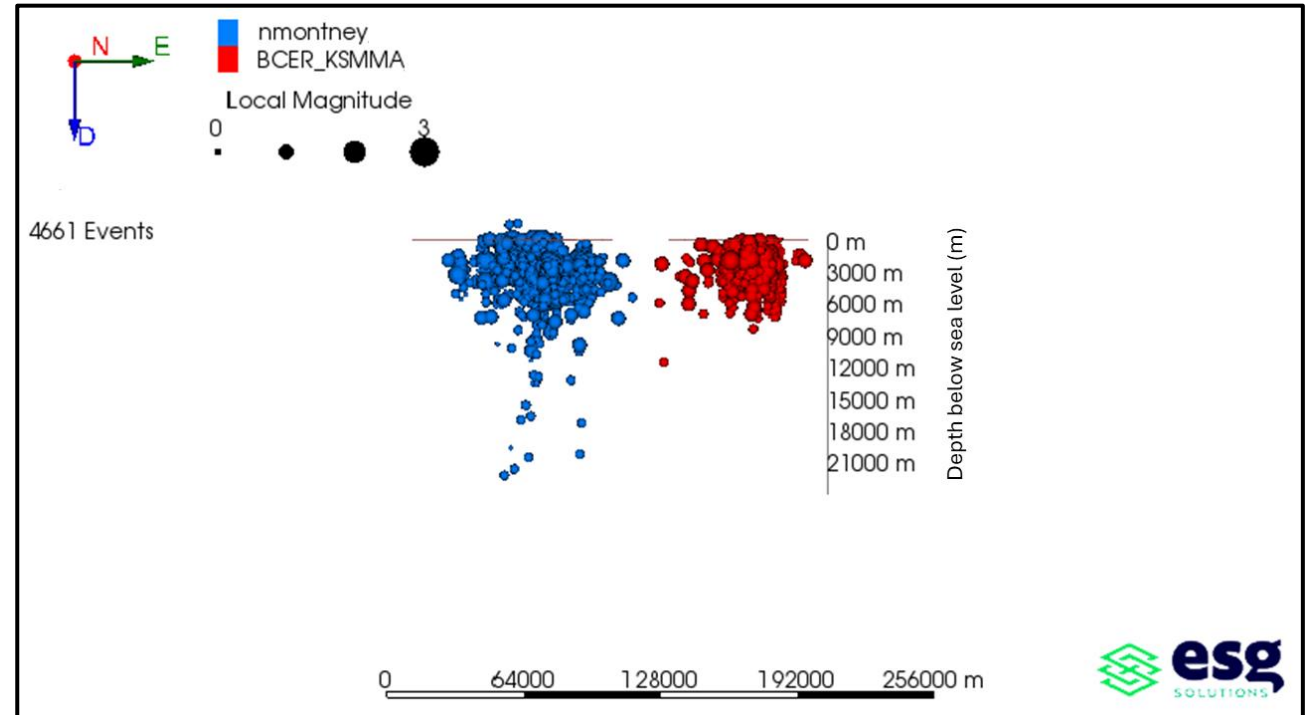
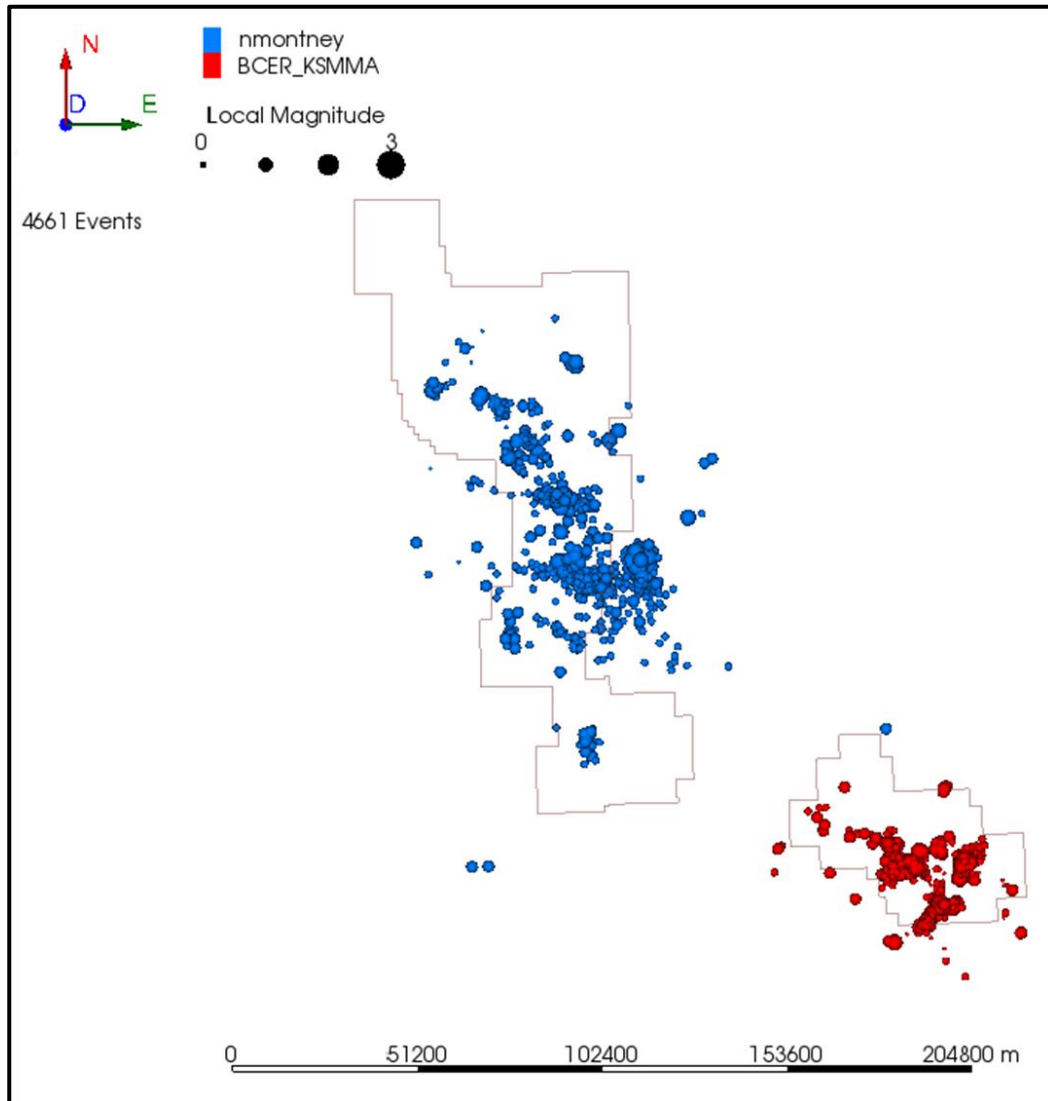
Trigger type	Trigger count	Min-Max $M_L$ range
Real events ( $M_L > 0$ )	4661	0.13 – 4.19
Real events ( $M_L > 2.0$ )	120	2.00 – 4.19
Real events ( $M_L > 3.0$ )	11	3.00 – 4.19







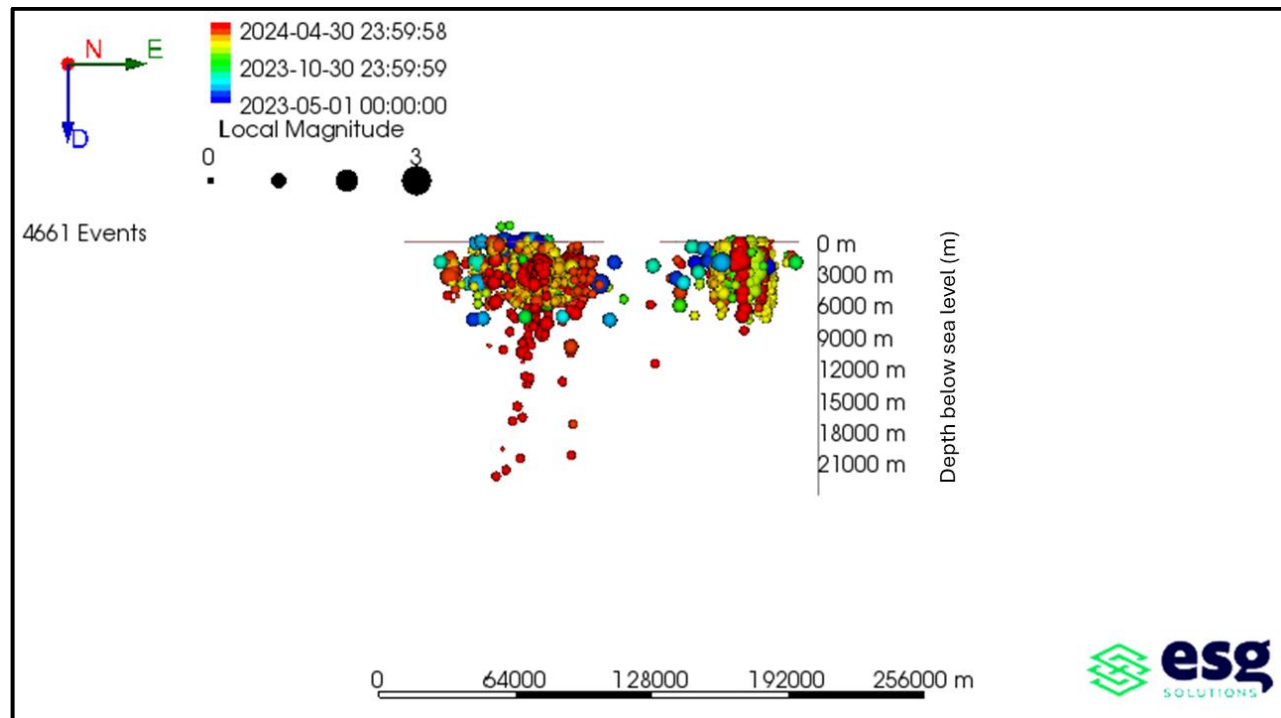
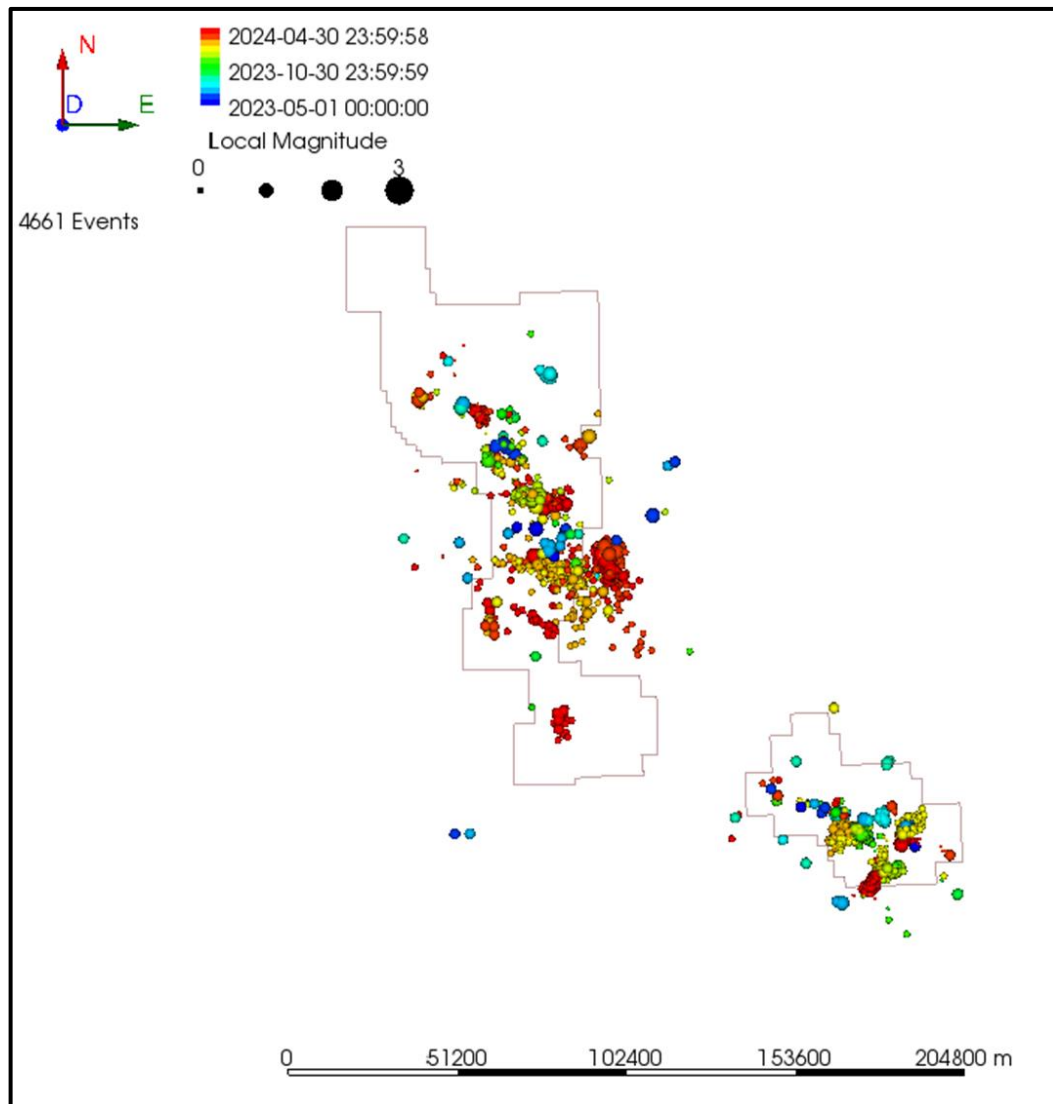
# All BCSRC Events: May 2023- April 2024



- 4661 events were captured during the monitoring period of May 2023- April 2024.
- Note the map is coloured by site and sized by local magnitude.



# All BCSRC Events: May 2023- April 2024



- 4661 events were captured during the monitoring period of May 2023- April 2024.
- Note the map is coloured by time and sized by local magnitude.

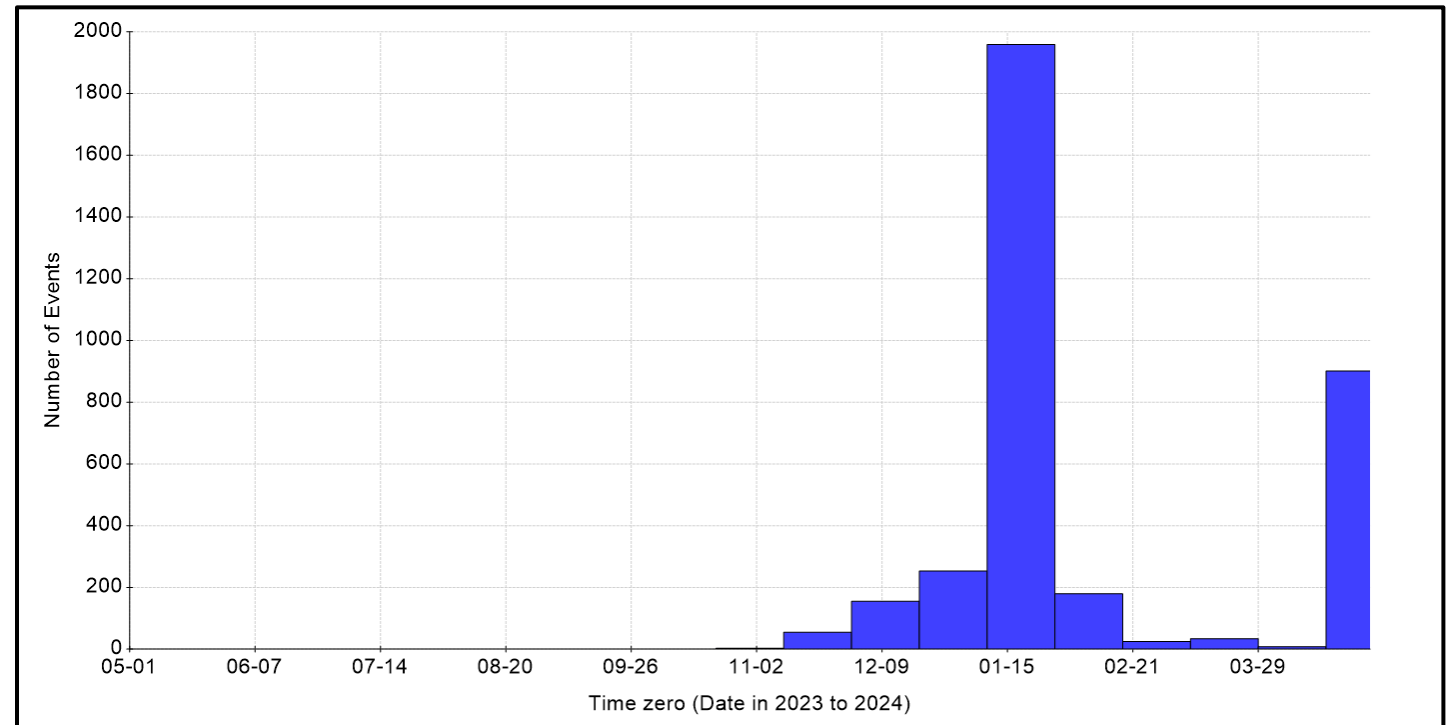


# KSMMA Project Summary: May 2023- April 2024



- 3663 events were confirmed as real since the start of the project, with 344 of these events having a local magnitude of 1.5 or greater.
- Seismicity peaked in January 2024 in the KSMMA.

Trigger type	Trigger count	Min-Max $M_L$ range
<b>Real events (<math>M_L &gt; 0</math>)</b>	3663	0.13 – 2.8
<b>Real events (<math>M_L &gt; 1.5</math>)</b>	344	1.50 – 2.8
<b>Real events (<math>M_L &gt; 2.0</math>)</b>	51	2.00 – 2.8





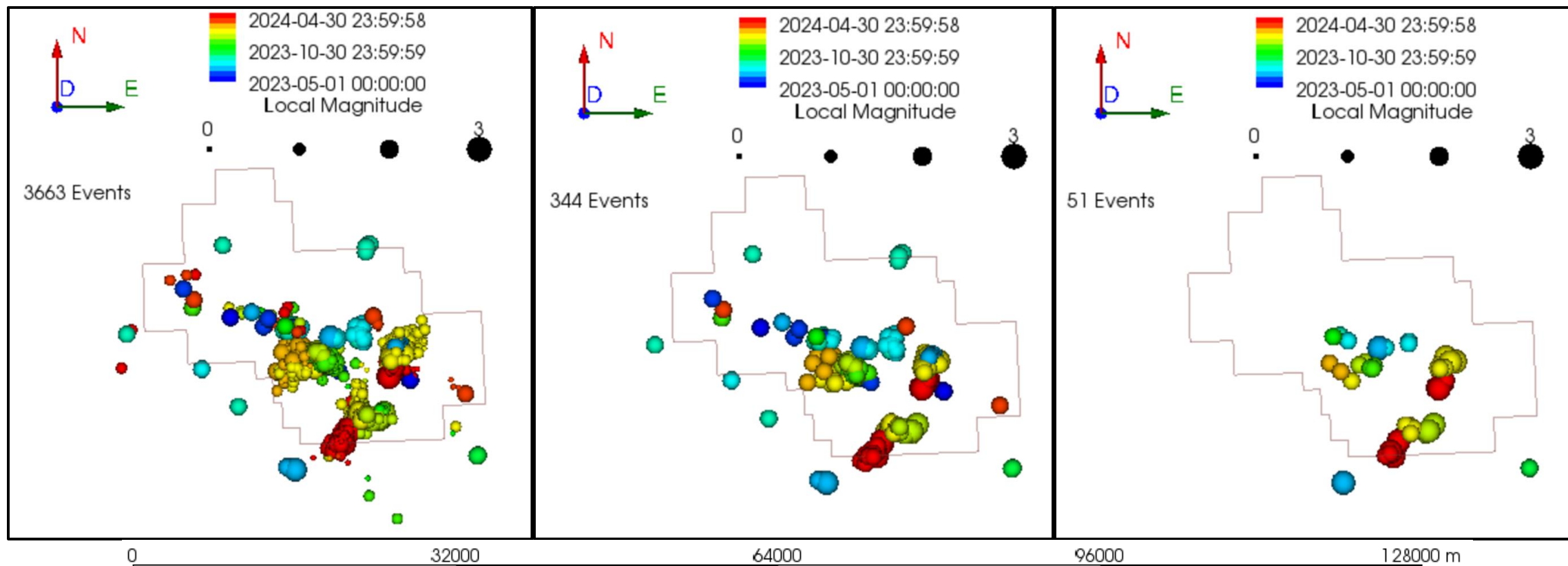
# All Confirmed KSMMA Events: May 2023 – April 2024



All Events

$M_L \geq 1.5$

$M_L \geq 2.0$



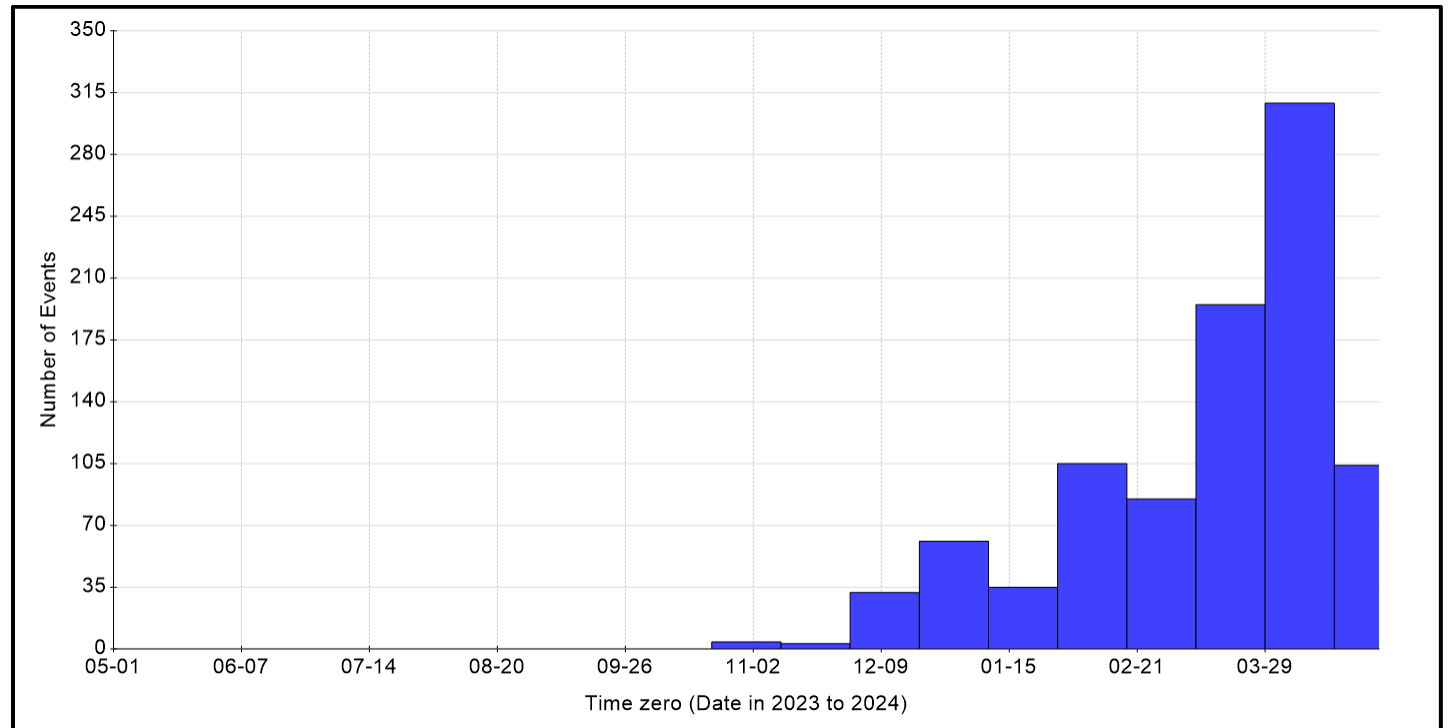
All confirmed KSMMA events from May 2023 to April 2024. Note that events are coloured by time and scaled by local magnitude.

# Northern Montney Project Summary: May 2023- April 2024

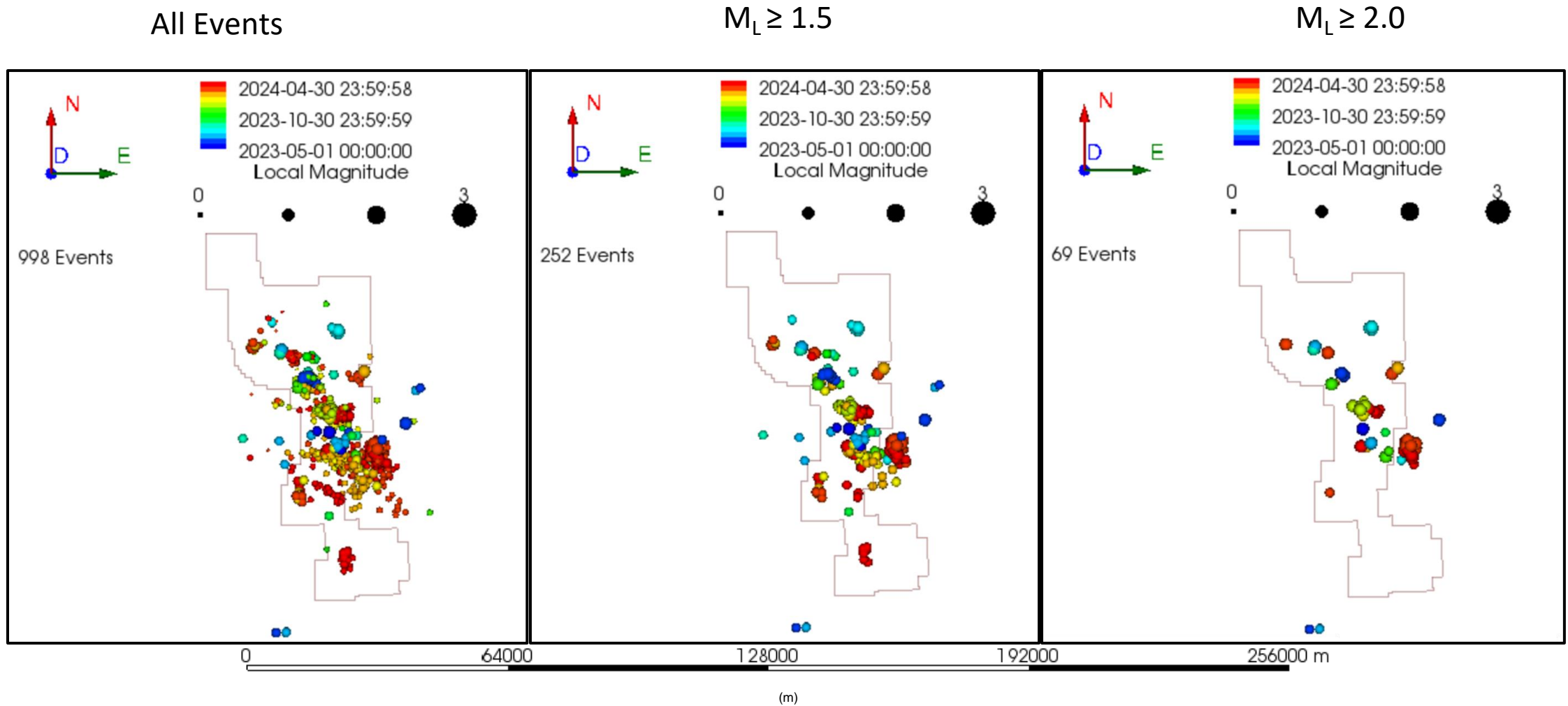


- 998 events were confirmed as real since the start of the project, with 252 of these events having a local magnitude of 1.5 or greater.
- Seismicity has increased in 2024 compared to 2023.

Trigger type	Trigger count	Min-Max $M_L$ range
<b>Real events (<math>M_L &gt; 0</math>)</b>	998	0.22 – 4.19
<b>Real events (<math>M_L &gt; 1.5</math>)</b>	252	1.50 – 4.19
<b>Real events (<math>M_L &gt; 2.0</math>)</b>	69	2.00 – 4.19



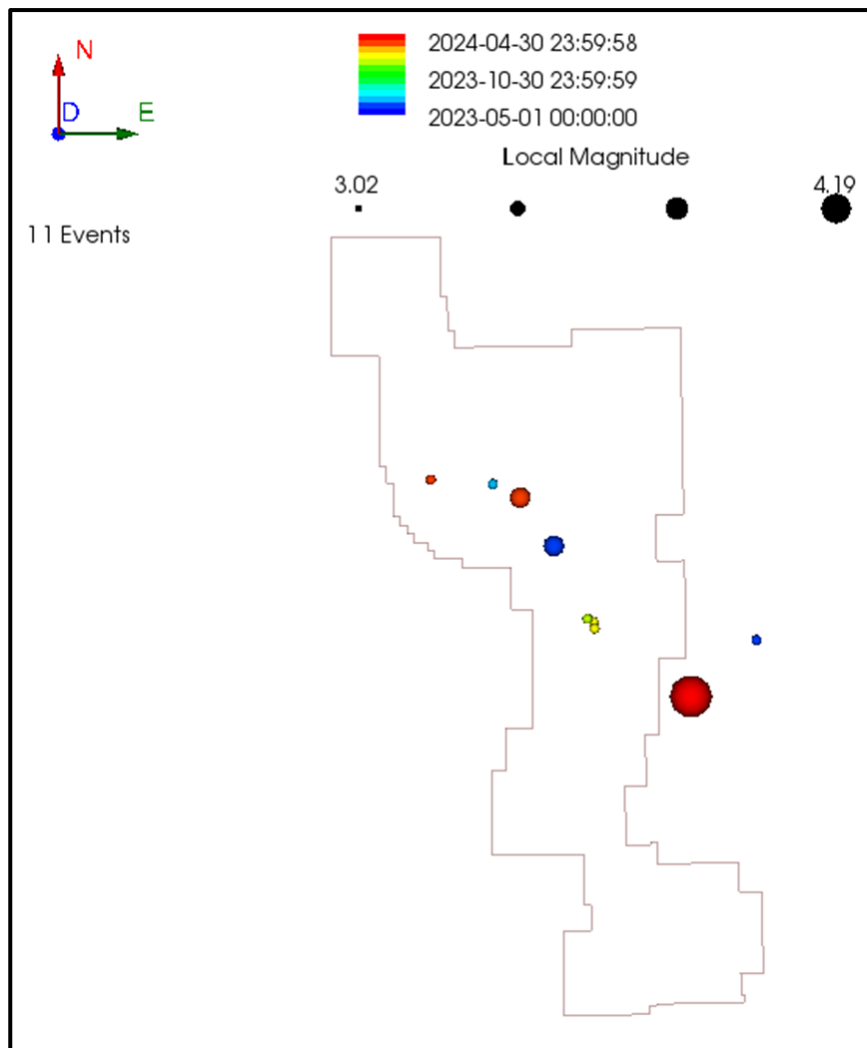
# All Confirmed Northern Montney Events: May 2023 – April 2024



All confirmed Northern Montney events from May 2023 to April 2024. Note that events are coloured by time and scaled by local magnitude.



# All BCSRC Events with $M_L \geq 3.0$ (Northern Montney)



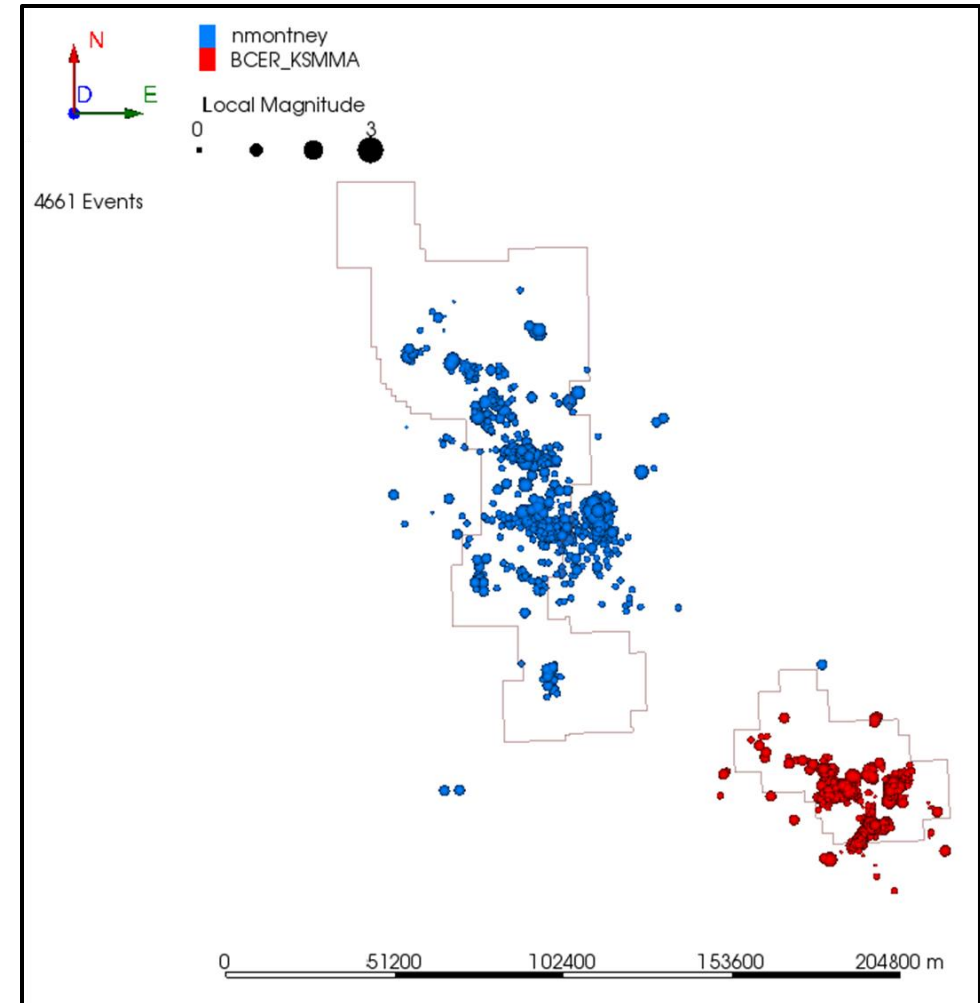
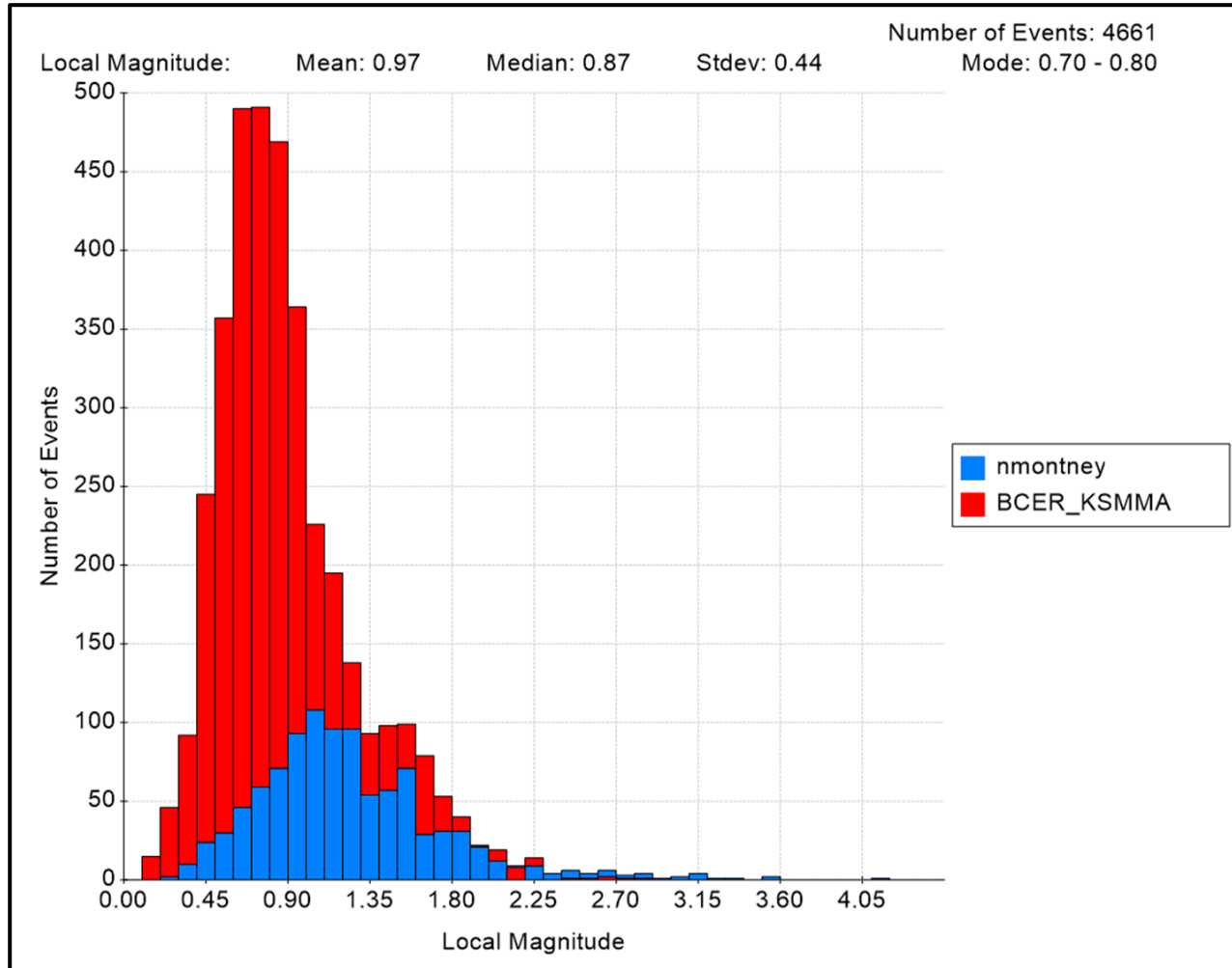
Date	Time	Local Magnitude	Northing (m)	Easting (m)	Depth (m)
2023-06-16	21:00:00	3.582	6322929	542012	1570
2023-06-21	18:09:00	3.311	6302279	586341	4031
2023-07-17	21:21:00	3.103	6336451	528638	1992
2024-01-02	0:43:40	3.212	6306946	549329	2422
2024-01-13	16:18:44	3.188	6306250	550695	4930
2024-01-23	4:27:46	3.138	6304811	550902	2137
2024-03-20	8:23:17	3.558	6333494	534642	3539
2024-03-20	16:43:53	3.112	6290860	572614	5535
2024-03-21	9:45:28	3.015	6337426	515089	3332
2024-03-22	11:31:45	3.053	6290010	571661	2821
2024-04-13	11:21:50	4.191	6289950	572009	2896

- 11 BCSRC events surpassed a local magnitude of 3.00, with the highest having a local magnitude of 4.19 on April 13<sup>th</sup>, 2024.
- All confirmed events greater than  $M_L$  3.0 were recorded in the North Montney region.
- Note events on map are coloured by time and scaled by local magnitude.





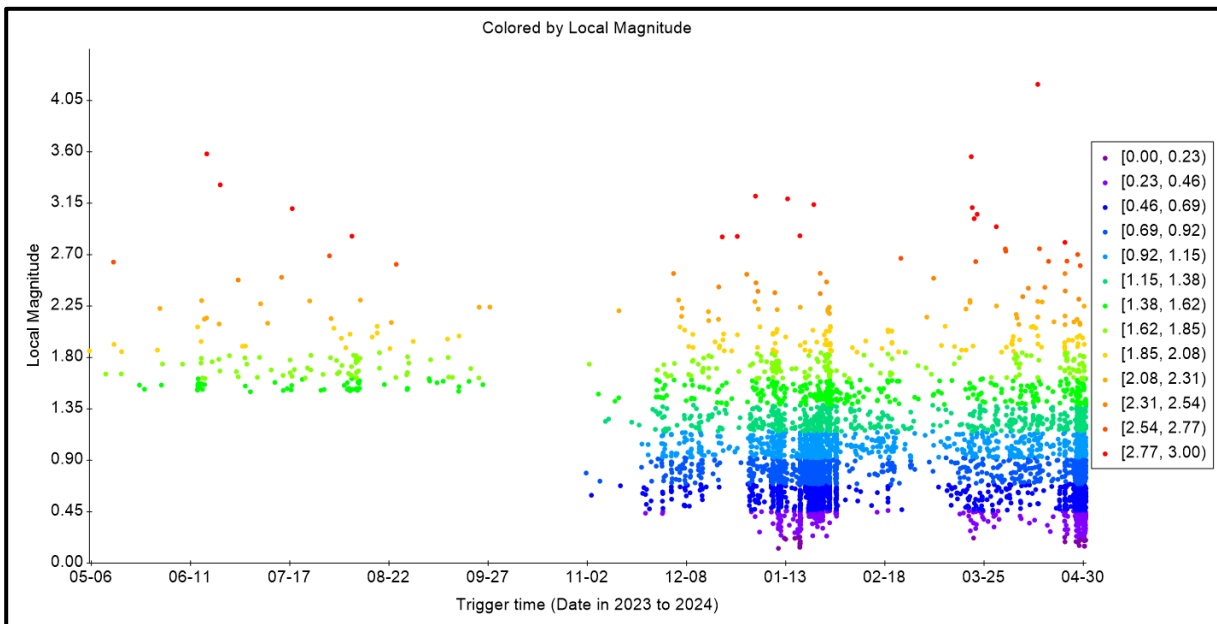
# Local Magnitude Histogram: May 2023 - April 2024



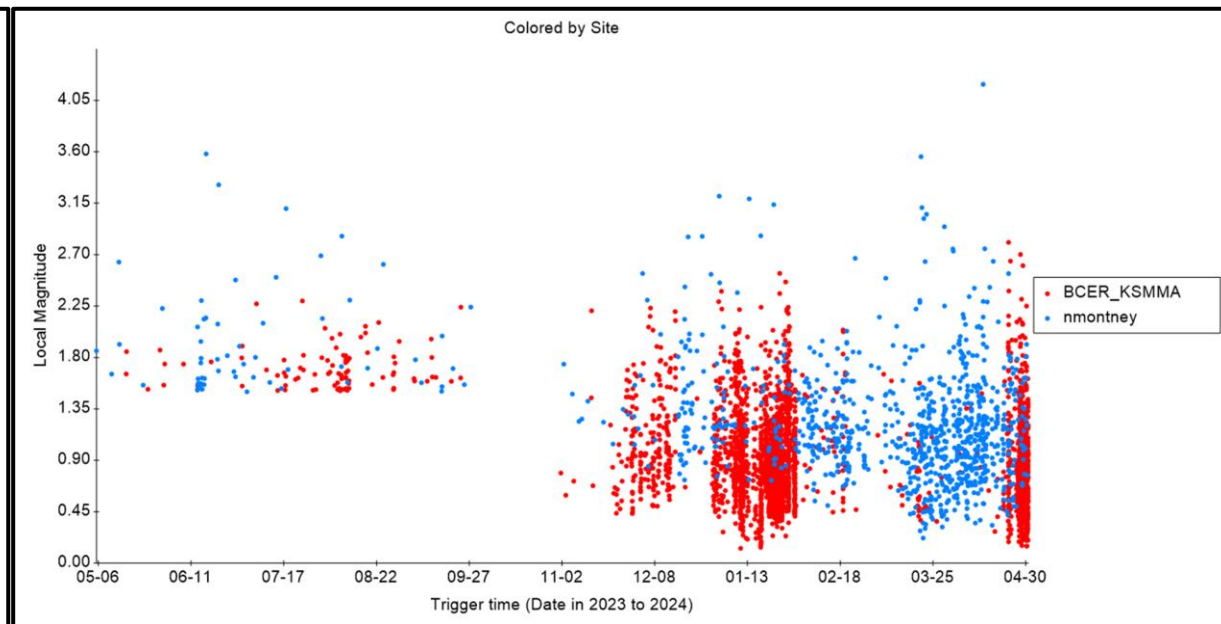


# Magnitude vs. Time Plot: May 2023 – April 2024

a)



b)

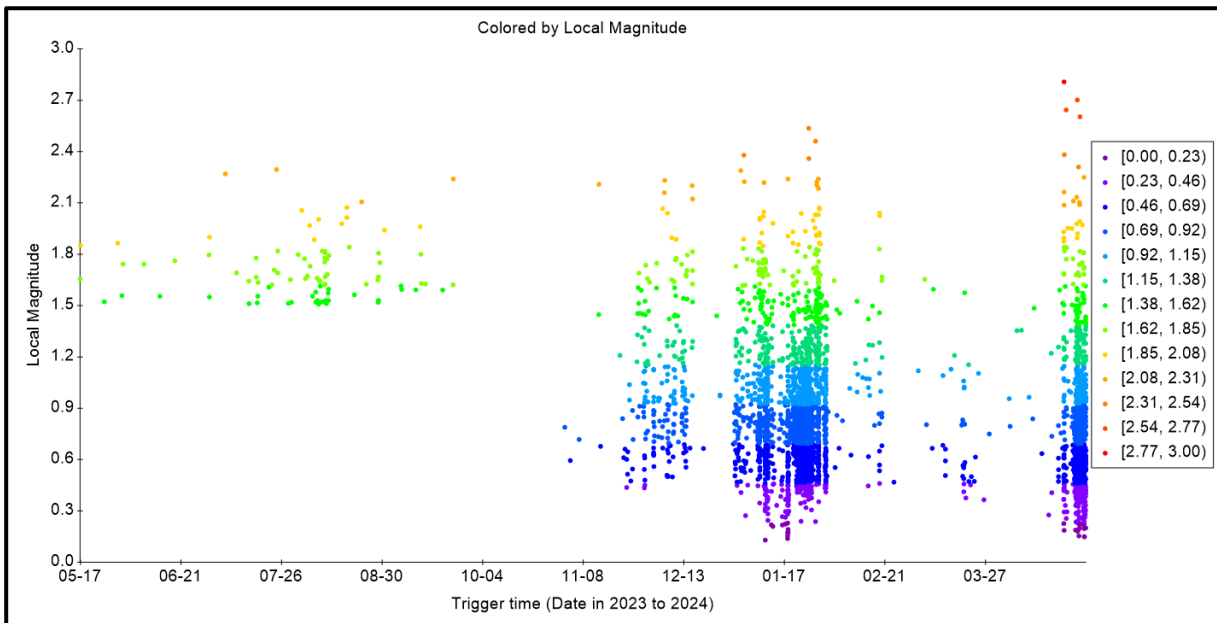


Magnitude vs. Time plot for all events in the KSMMA and Northern Montney area colored by a) local magnitude and b) areas of interest (KSMMA in red and North Montney in blue). No data has been recorded for October 2023.

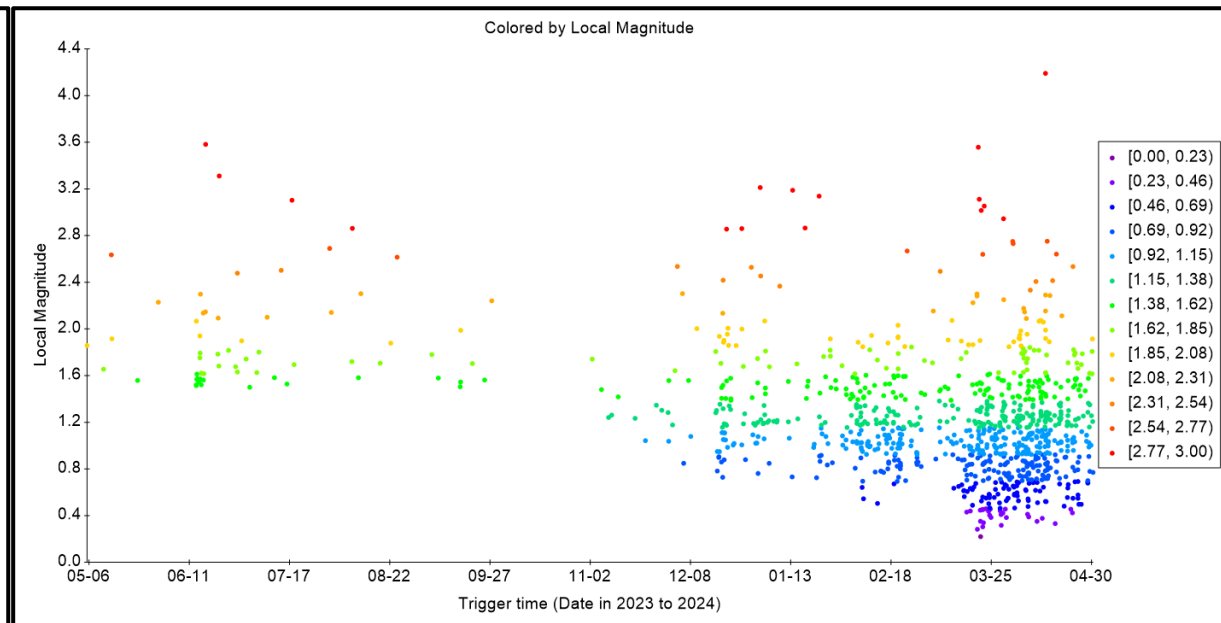
# Magnitude vs. Time Plot: May 2023 – April 2024



a)



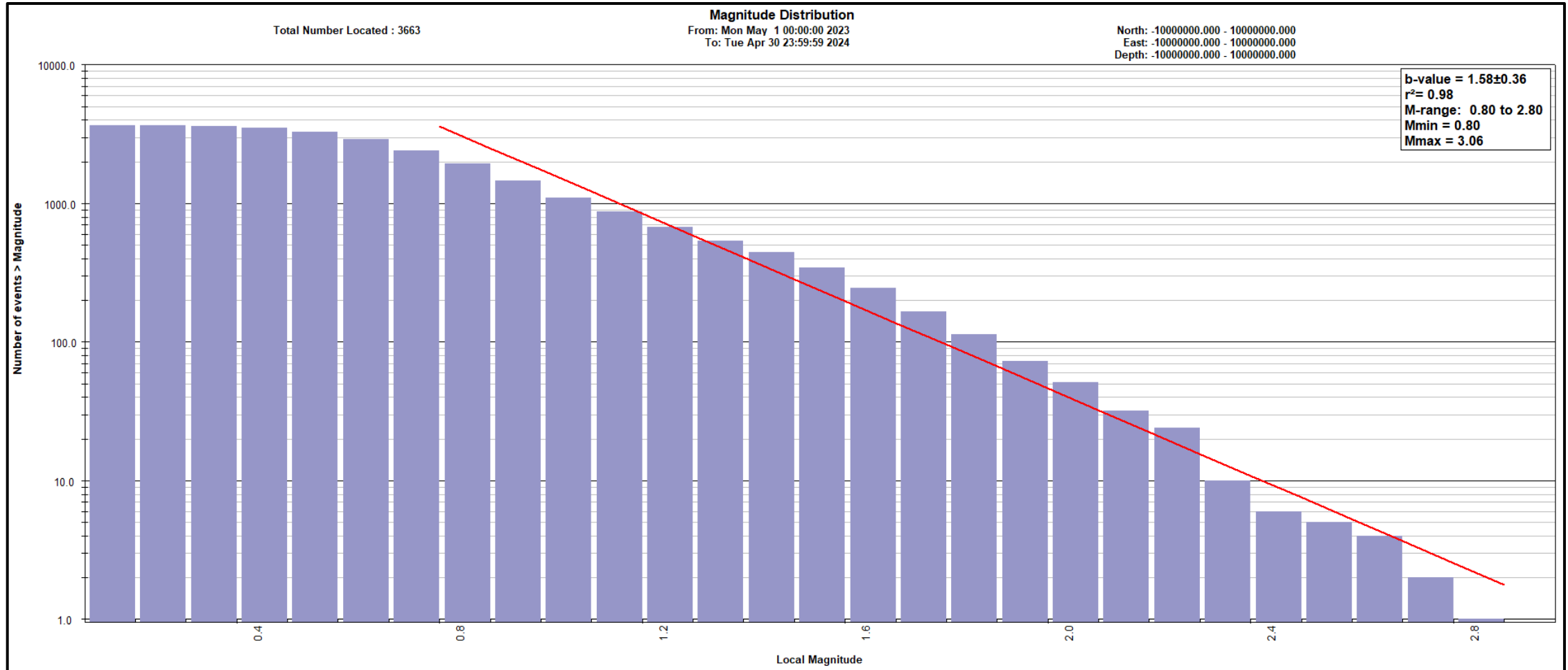
b)



Magnitude vs. Time plot for the a) KSMMA and b) Northern Montney. No data has been recorded for October 2023.



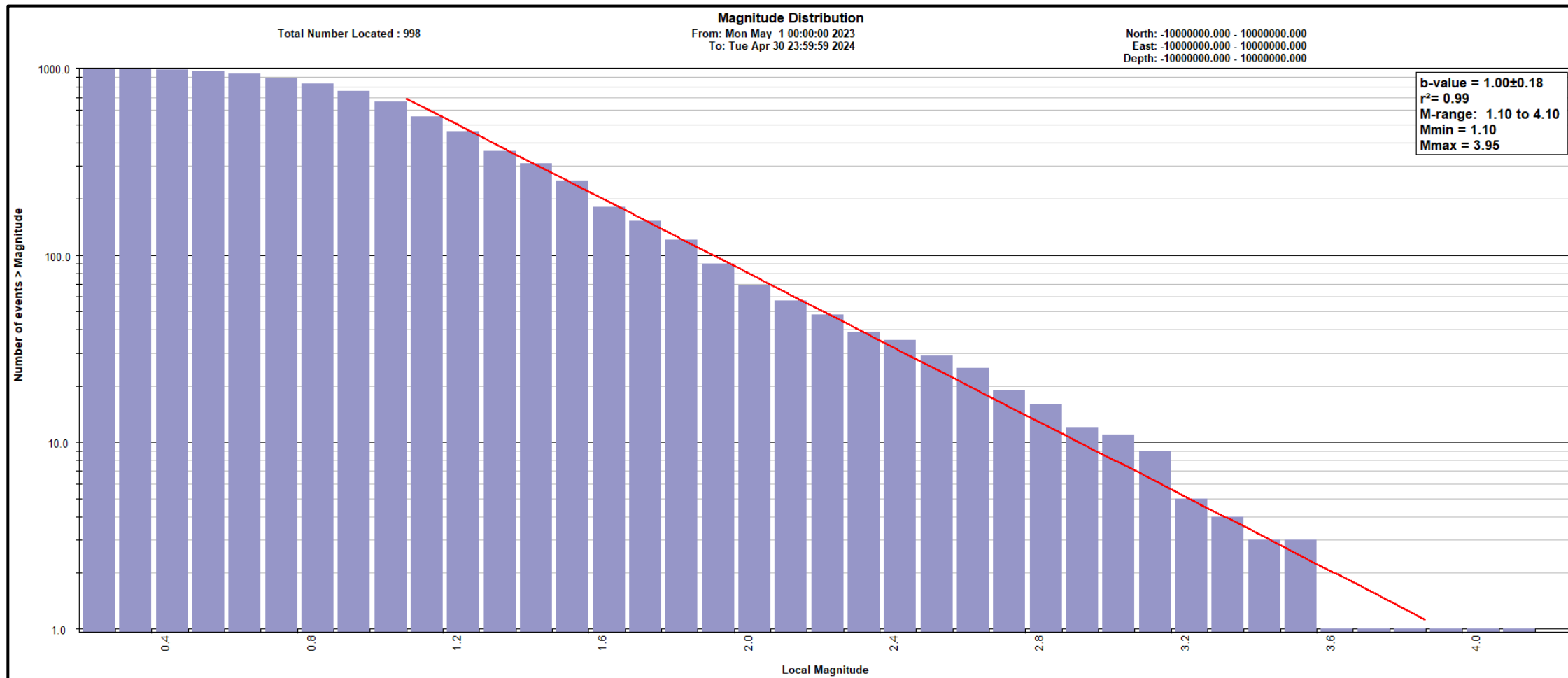
# Magnitude Distribution: May 2023 – April 2024



Local magnitude frequency distribution for the KSMMA.



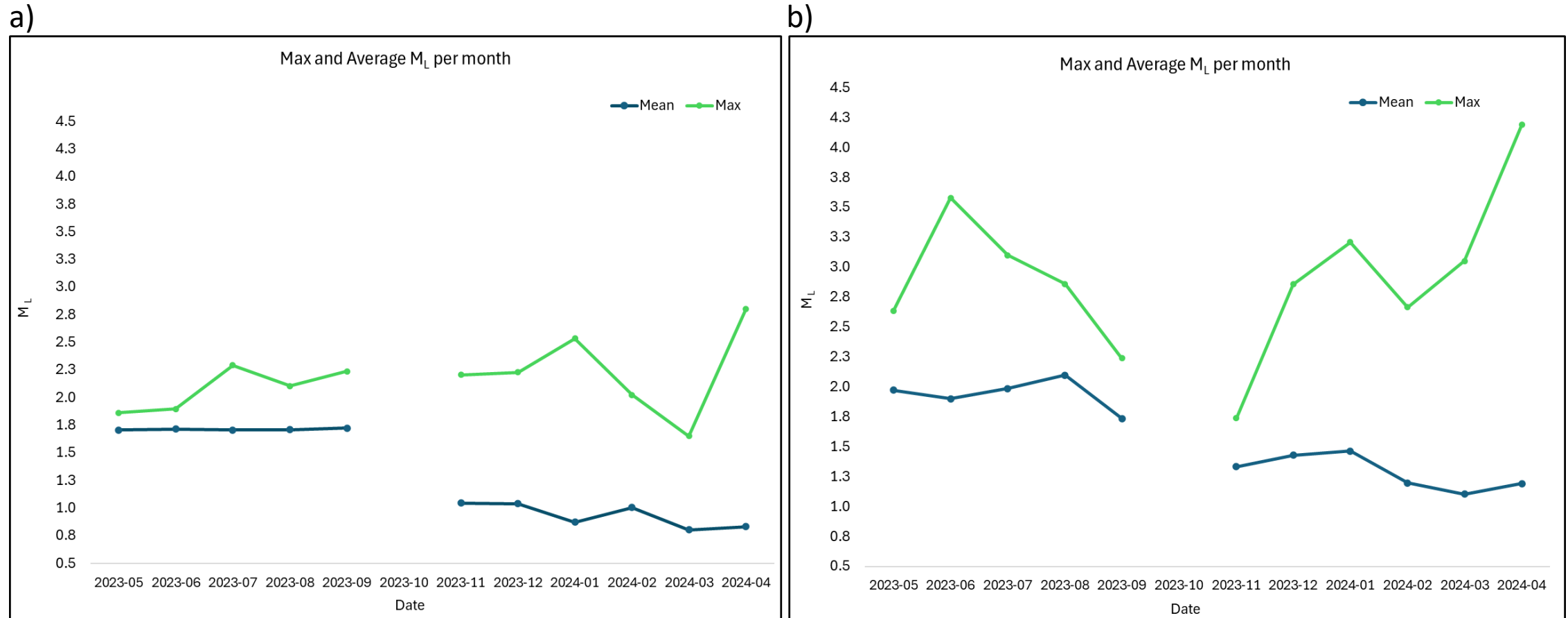
# Magnitude Distribution: May 2023 – April 2024



Local magnitude frequency distribution for the Northern Montney region.



# Monthly Max and Mean $M_L$ : May 2023 – April 2024



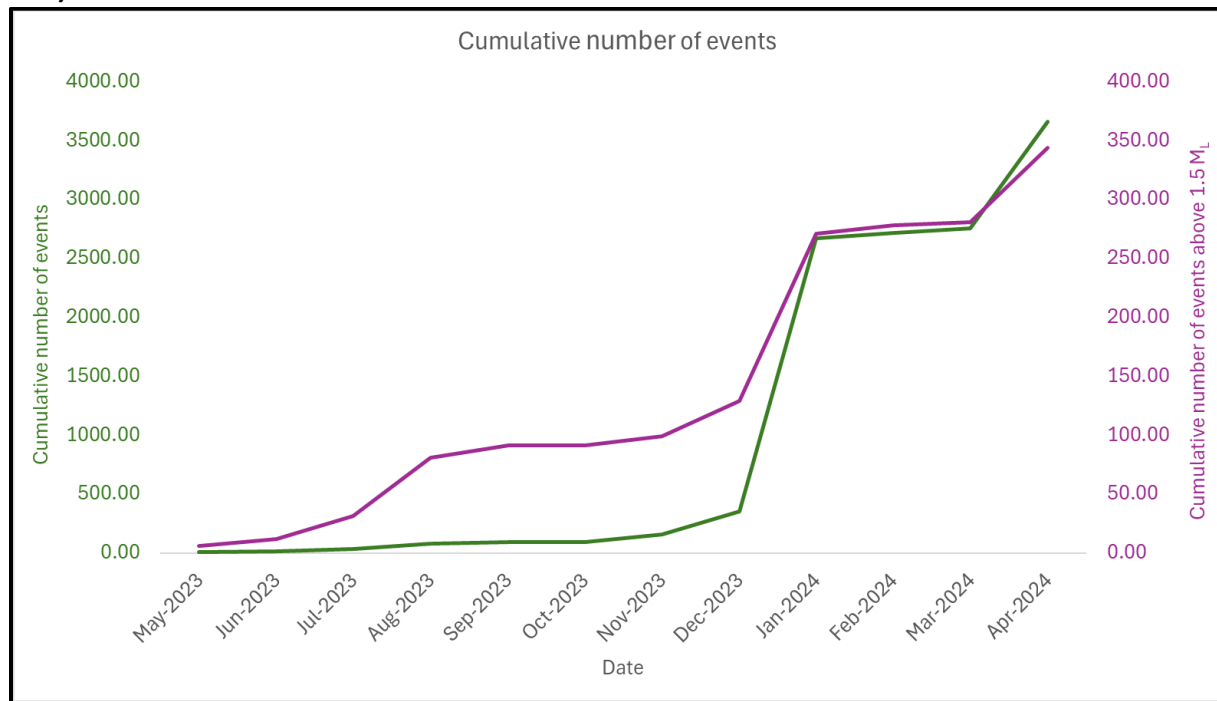
Monthly Max and Mean  $M_L$  for the a) KSMMA and b) Northern Montney region.



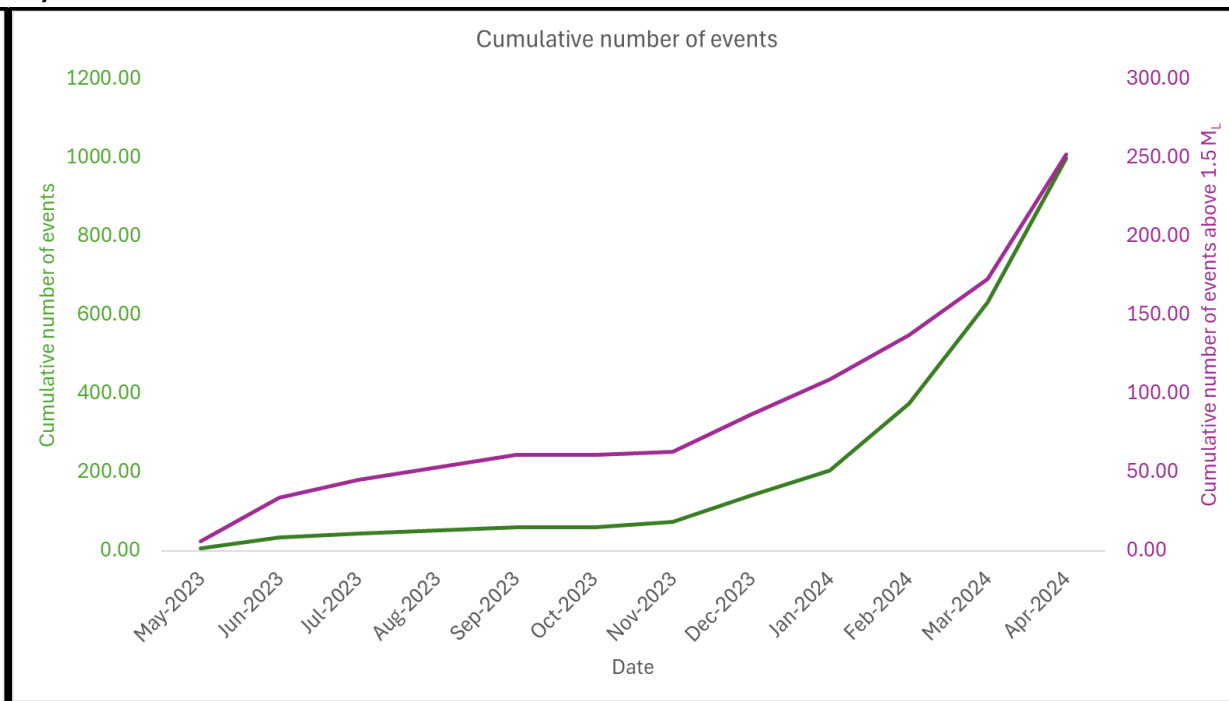
# Cumulative Event Count: May 2023 – April 2024



a)



b)



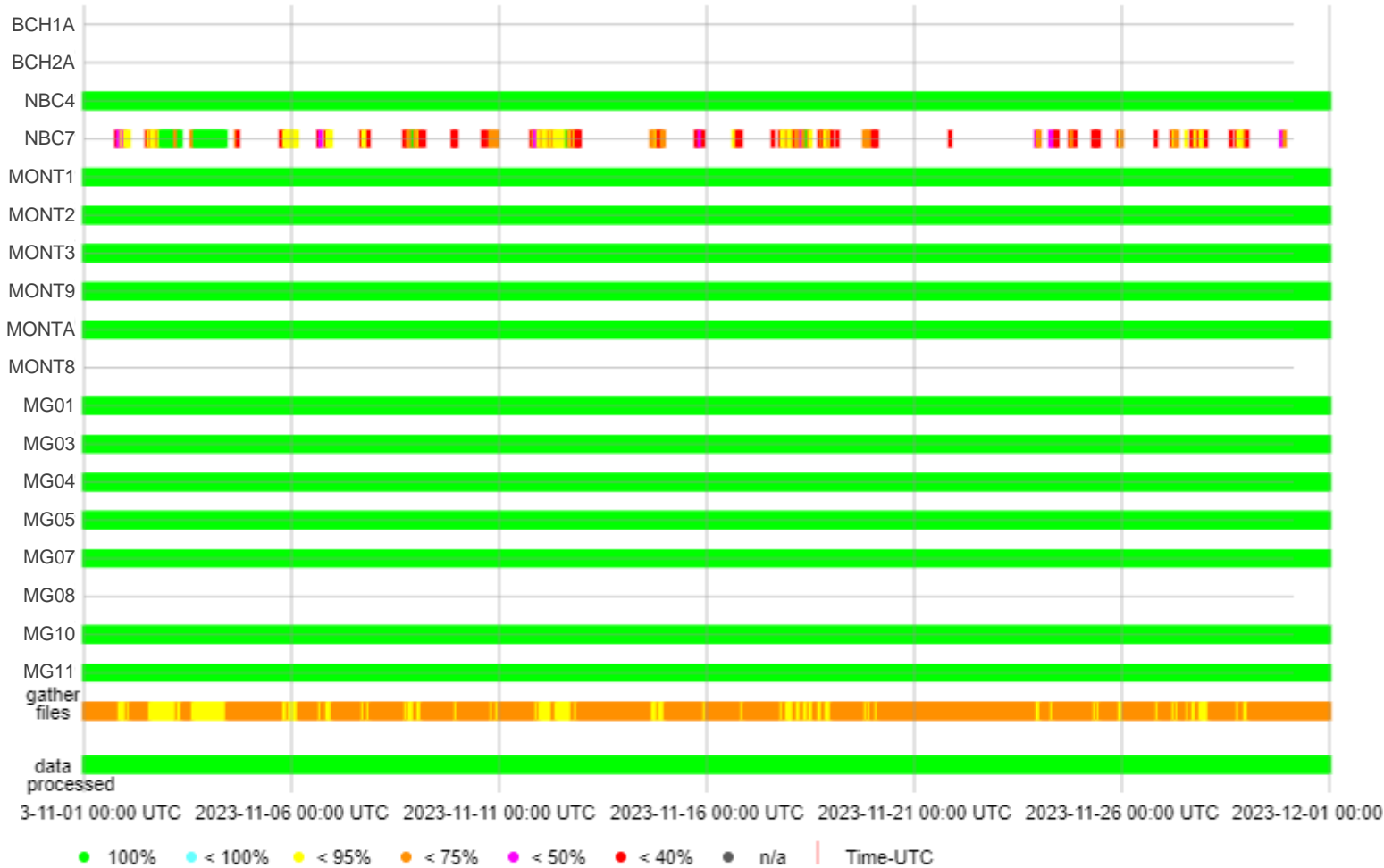
Cumulative Event Count for the a) KSMMA and b) Northern Montney region.



## Appendix A: KSMMA System Health



# Project Summary: System Health November 2023



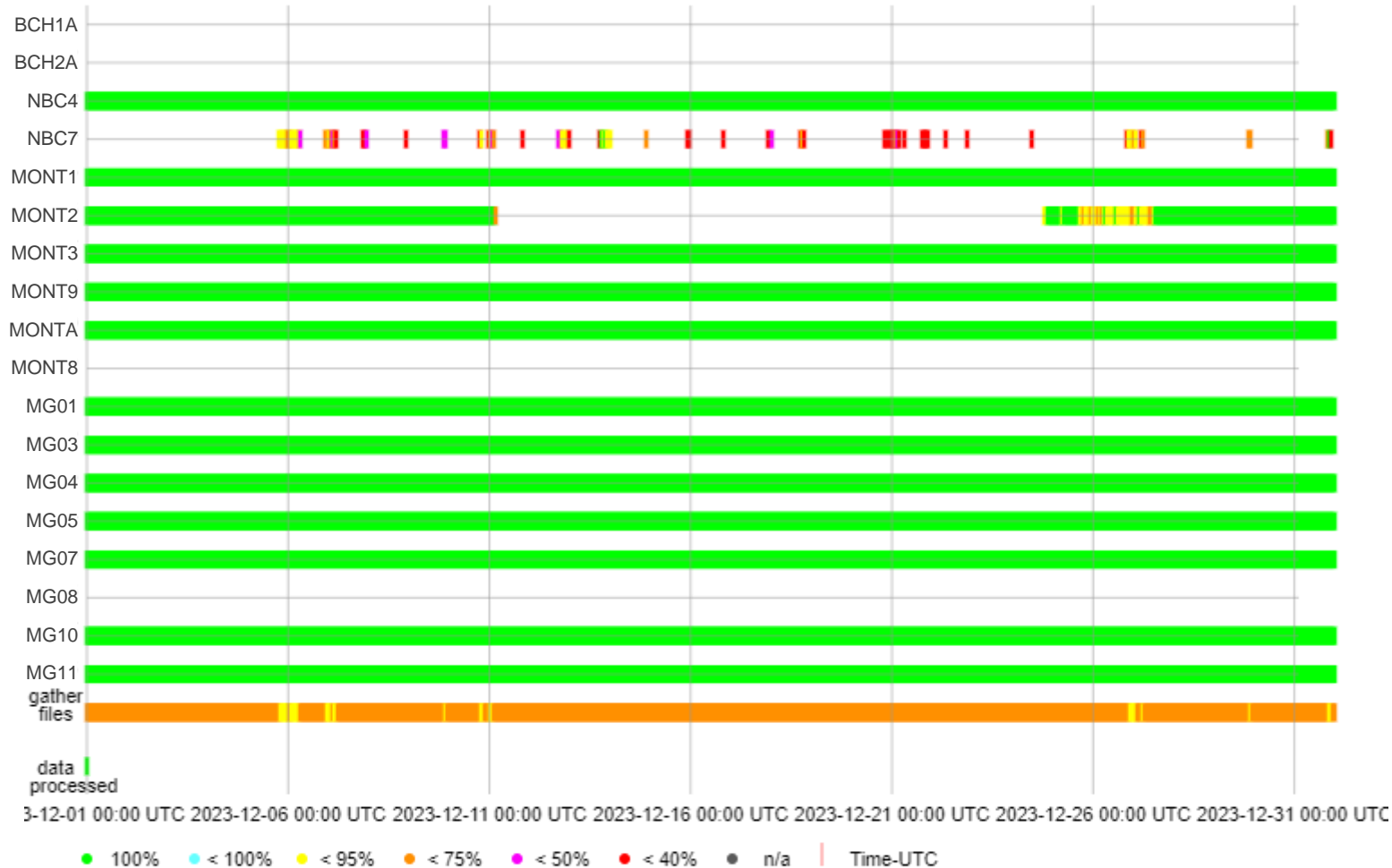
## System health notes:

- Station NBC7 had slight interruptions through the month.
- Stations BCH1A, BCH2A, MONT8 and MG08 were offline for the whole or nearly-whole report period.





# Project Summary: System Health December 2023

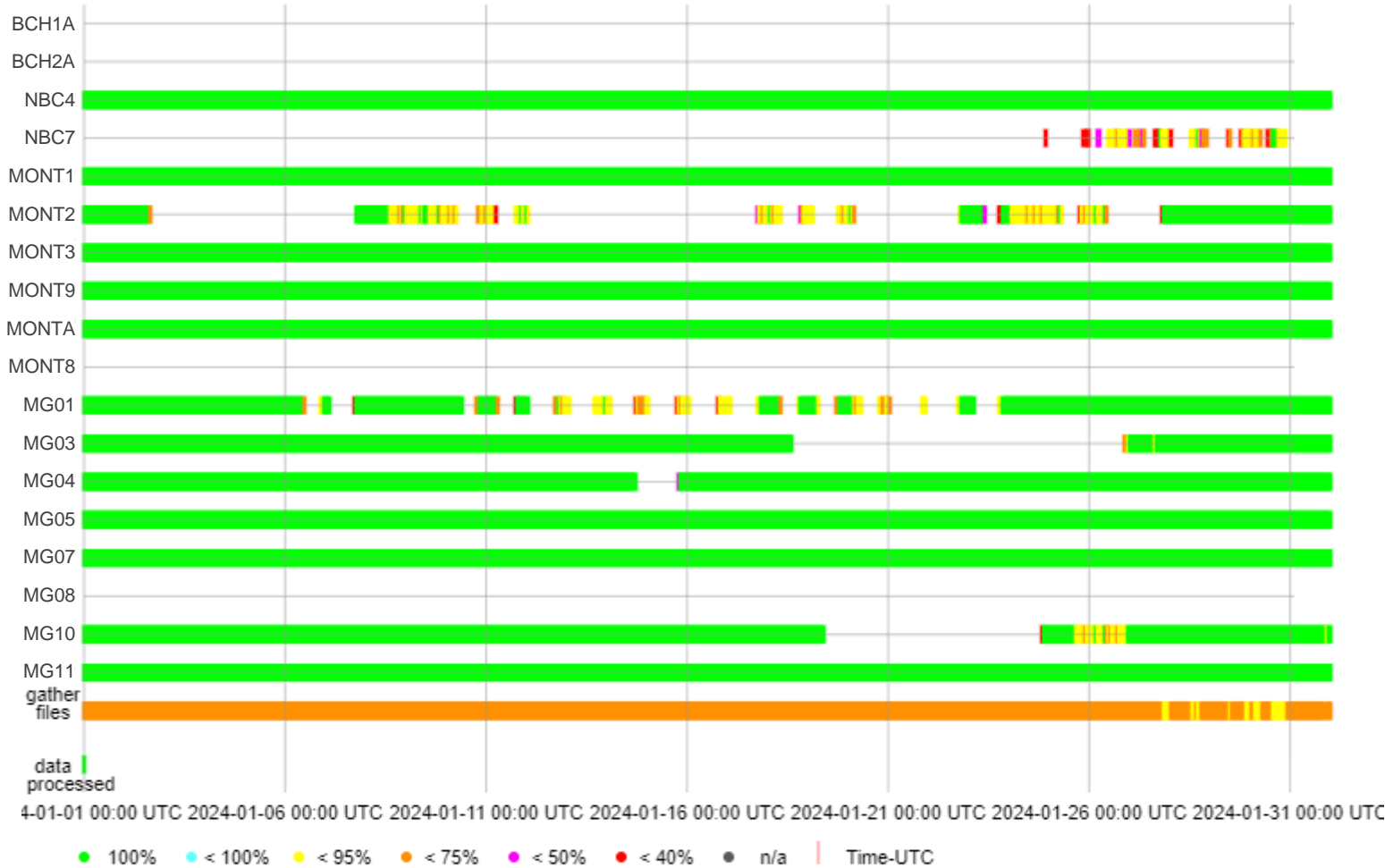


## System health notes:

- Station NBC7 had slight interruptions through the month.
- Station MONT2 was offline for the middle of the month.
- Stations BCH1A, BCH2A, MONT8 and MG08 were offline for the whole or nearly-whole report period.



# Project Summary: System Health January 2024

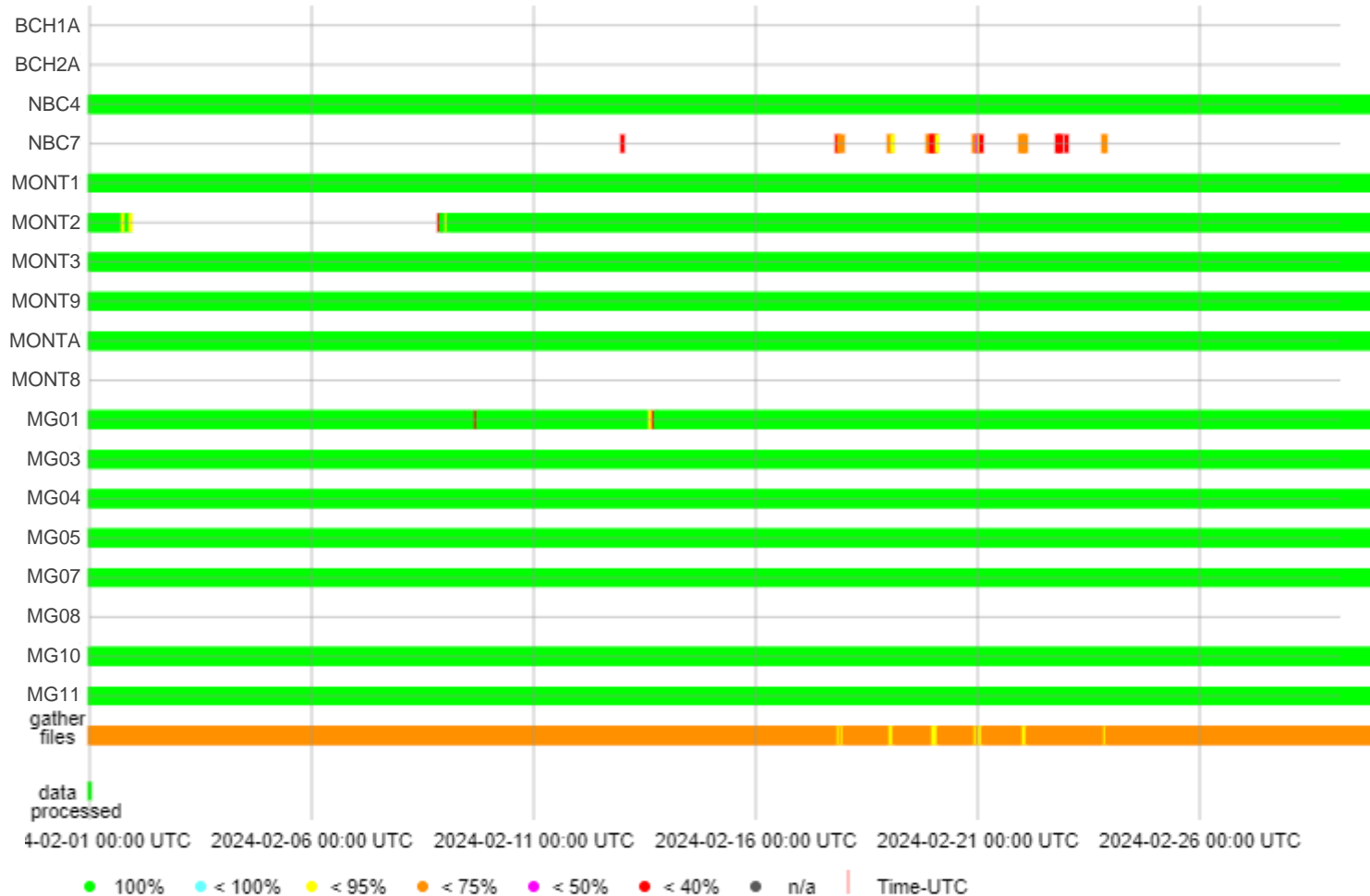


## System health notes:

- Station MG04 had slight interruptions through the month.
- Stations MONT2, MG01, MG03 and MG10 had extended interruption gaps.
- Stations BCH1A, BCH2A, NBC7, MONT8 and MG08 were offline for the whole or nearly-whole report period.



# Project Summary: System Health February 2024

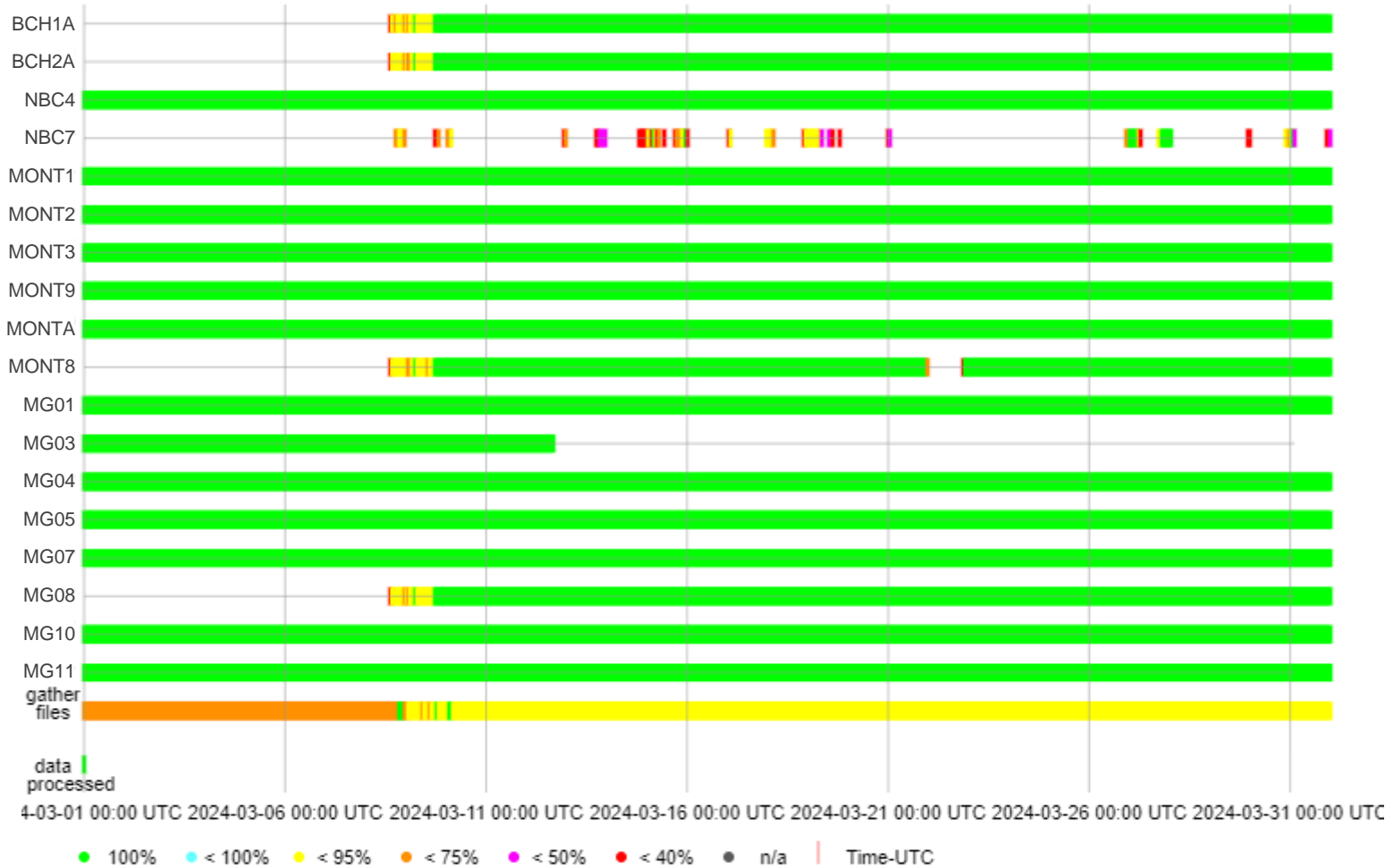


## System health notes:

- Station MONT2 had extended interruption gaps.
- Stations BCH1A, BCH2A, NBC7, MONT8 and MG08 were offline for the whole or nearly-whole report period.
- Station MG01 had timing issues due to GPS problems for the entirety of the month.



# Project Summary: System Health March 2024



## System health notes:

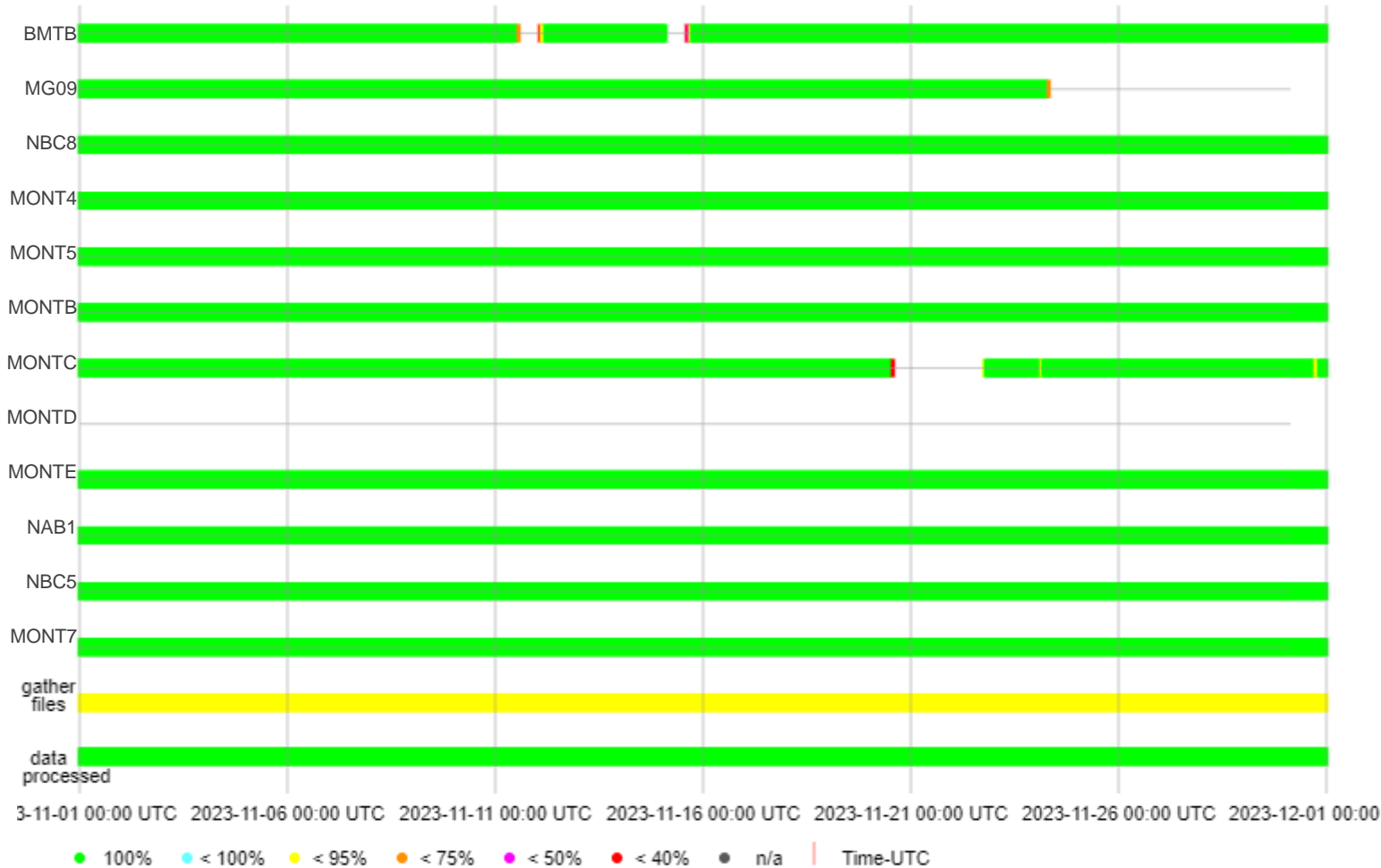
- Stations BCH1A, BCH2A, MONT8 and MG08 came online on March 8<sup>th</sup>.
- Station NBC7 was offline for most of the reporting period.
- Station MG03 went offline on March 12<sup>th</sup>.



## Appendix B: Northern Montney System Health



# Project Summary: System Health November 2023

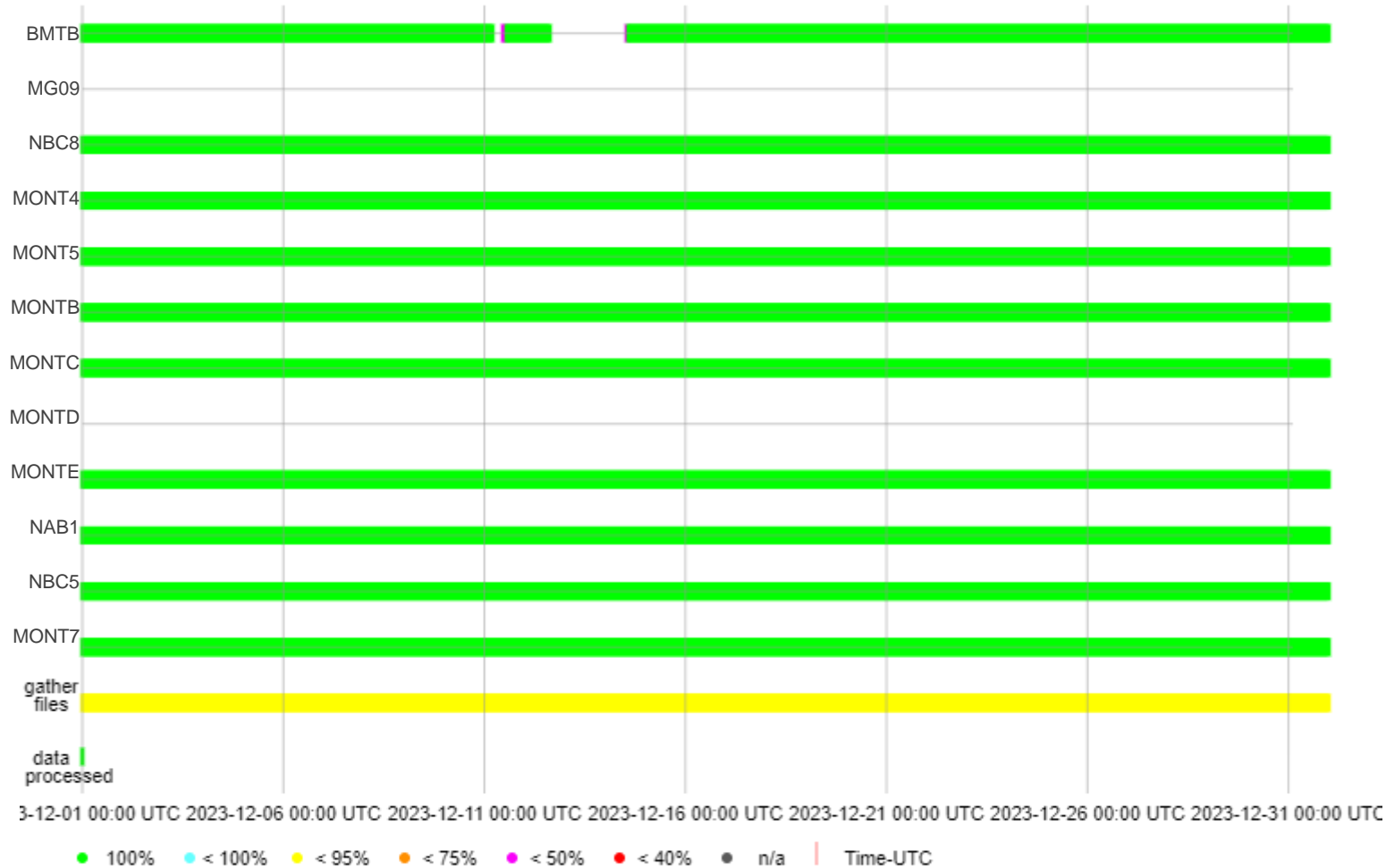


## System health notes:

- Station BMTB had slight interruptions through the month.
- Stations MG09 and MONTC had extended interruption gaps.
- Station MONTD was offline for the whole report period.



# Project Summary: System Health December 2023

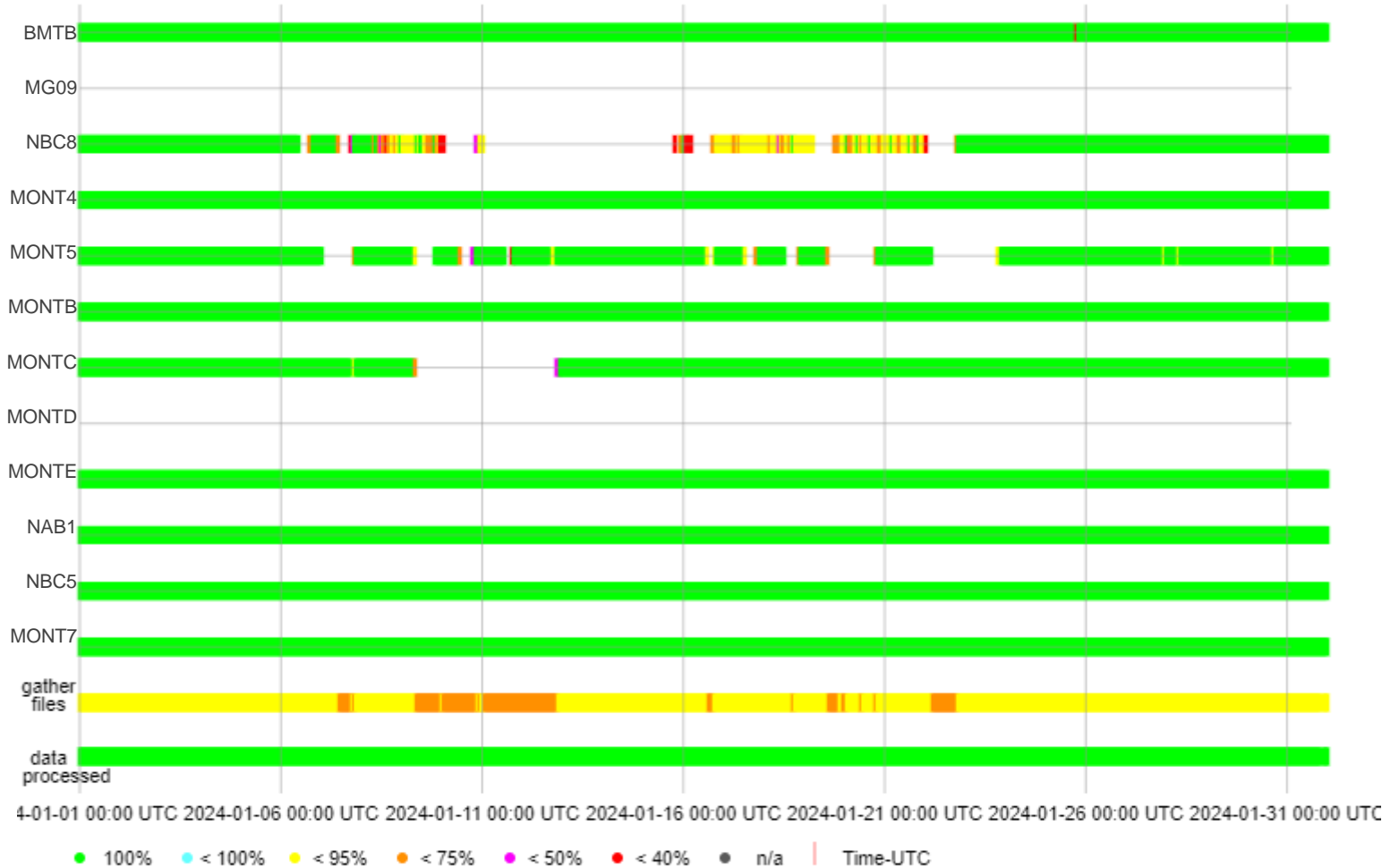


## System health notes:

- Station BMTB had slight interruptions through the month.
- Stations MONTD and MG09 were offline for the whole report period.



# Project Summary: System Health January 2024



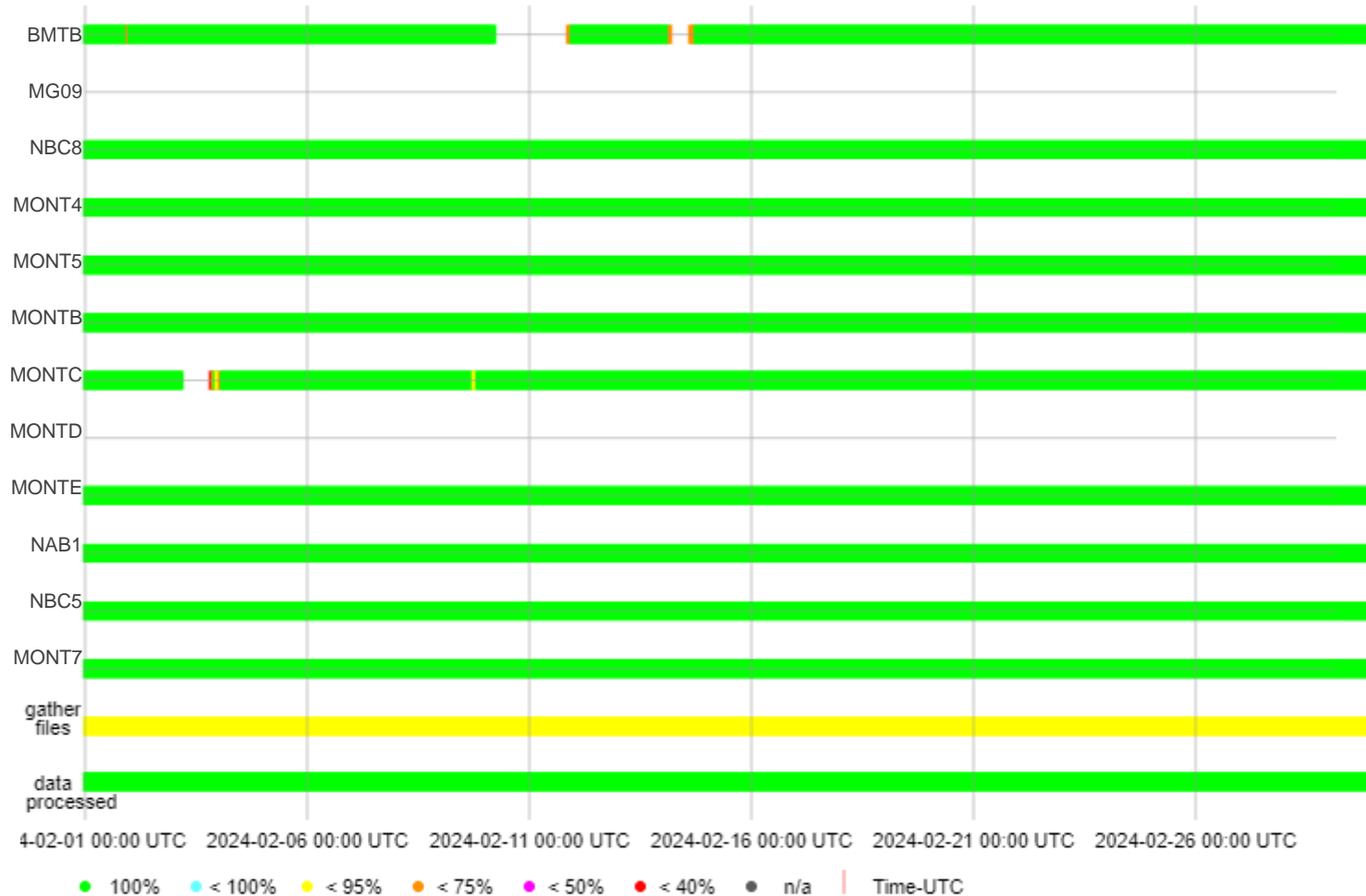
## System health notes:

- Station MONT5 had slight interruptions through the month.
- Stations NBC8 and MONTC had extended interruption gaps.
- Station MG09 was offline for the whole report period.





# Project Summary: System Health February 2024

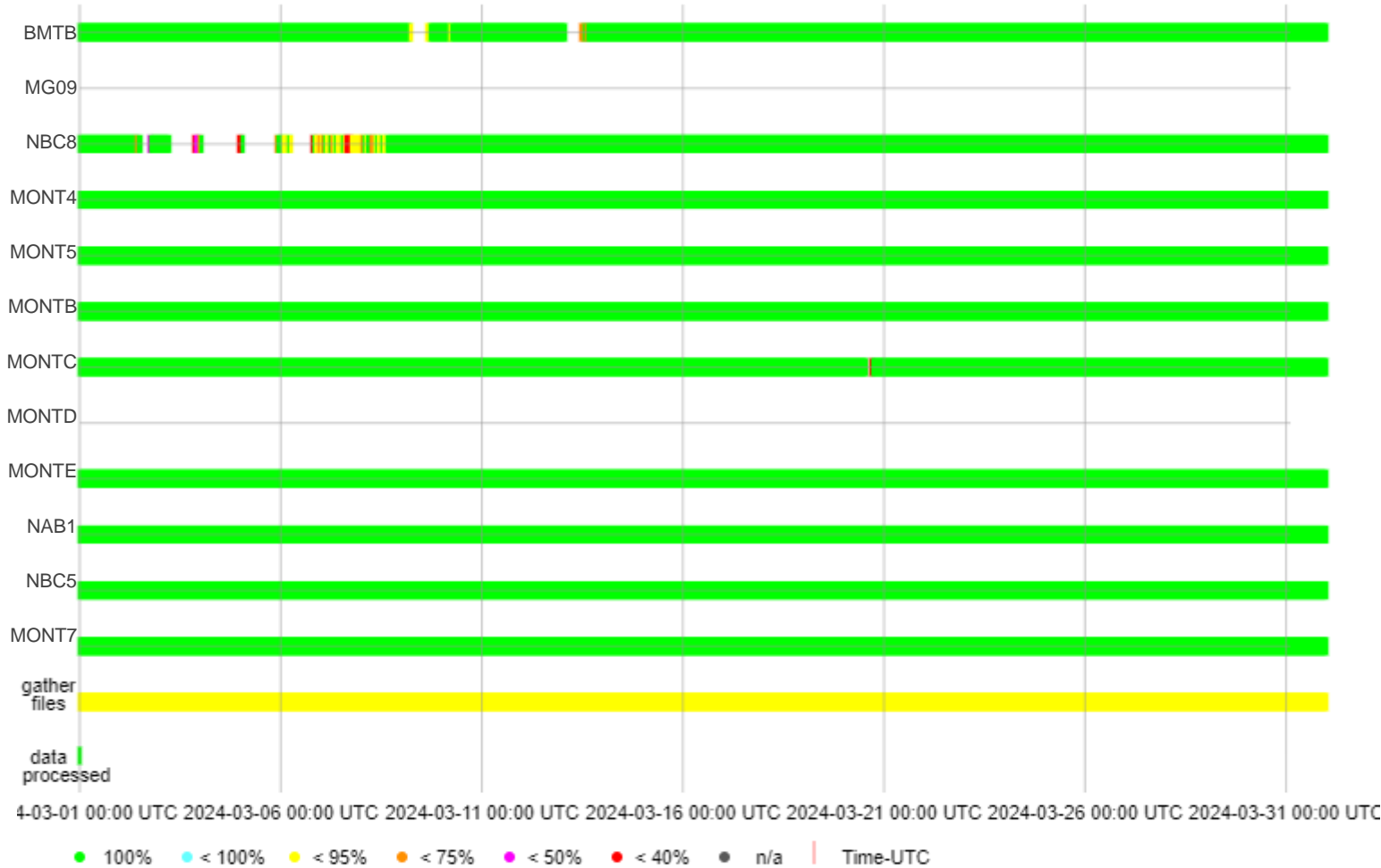


## System health notes:

- Station MONTC had a slight interruption through the month.
- Station BMTB had extended interruption gaps.
- Stations MG09 and MONTD were offline for the whole reporting period.



# Project Summary: System Health March 2024



## System health notes:

- Station BMTB had slight interruptions through the month.
- Station NBC8 had extended interruption gaps.
- Stations MG09 and MONTD were offline for the whole reporting period.
- Station NBC5 is having GPS issues and was not used for processing during the reporting period.



## Appendix C: Seismicity Catalogue (provided separately)



# Seismicity Catalogue: May 2023 to April 2024



Appendix C contains KSMMA and North Montney seismicity data in CSV format. This catalogue provides records of seismic events, including dates, magnitudes, locations, and depths. Data from May to September 2023 are taken from the BCER Northeast BC Seismicity App. Catalogues from November 2023 to April 2024 include events captured by ESG. At the time of writing this report, no seismicity data were available from the BCER for the month of October 2023. A report update will be provided pending availability of any data for that month.