Geomagnetic Disturbance Observations in Alaska

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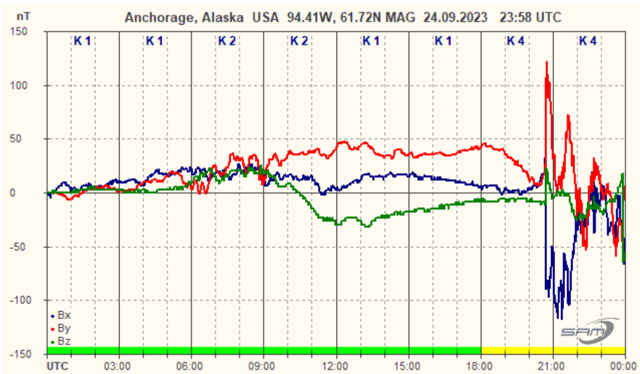
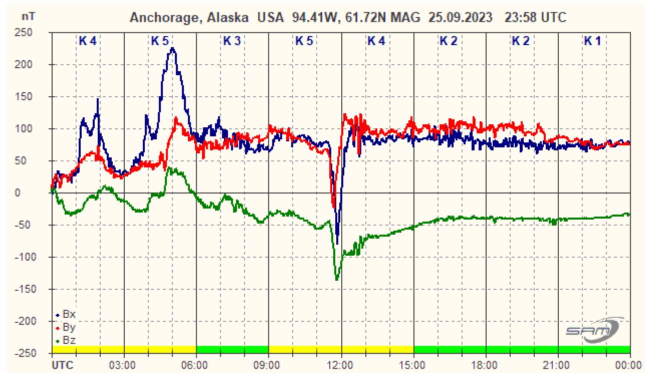
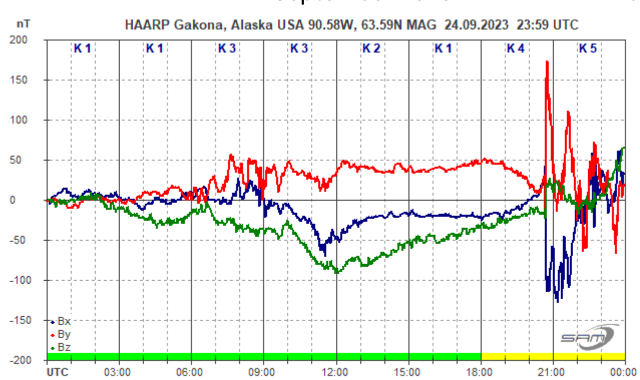
The magnetograms below were recorded by SAM-III Magnetometers at Anchorage, Alaska and the HAARP facility near Gakona, Alaska on two consecutive days during fall 2023.

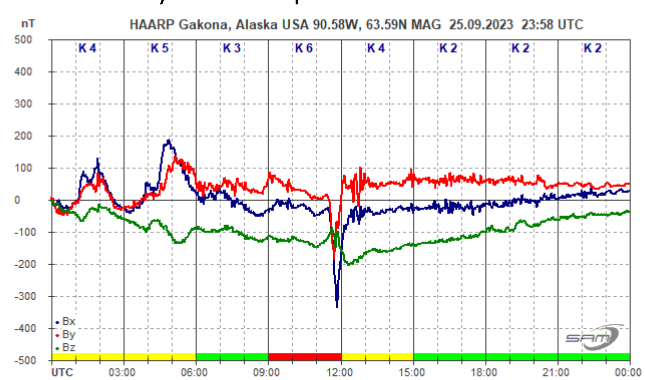
24 September 202 Anchorage Radio Observatory 25 September 2023



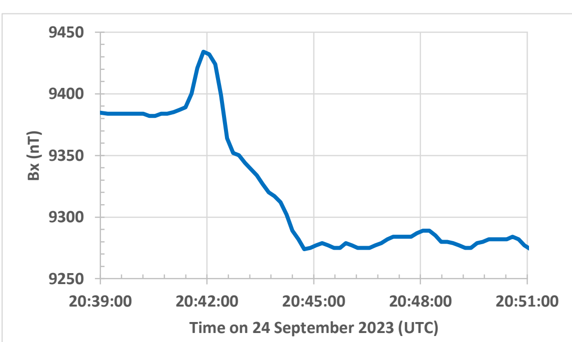


24 September 2023 HAARP Radio Observatory 25 September 2023





<u>Step-Changes in Natural Phenomena</u>: Natural phenomena, such as geomagnetic field intensities, normally do not change instantly, although the magnetograms above appear to show a step-change at 2041 UTC on 24 September. The rapid changes occurred in all three magnetic field components Bx (blue trace), By (red trace) and Bz (green trace). However, zooming into the traces shows they do have a relatively steep slopes but are not vertical (12 min of Bx with 10 s resolution shown in plot left).



The deflections in Bx and By are much larger than Bz (table below). The field changes likely resulted from rapidly changing auroral electrojet and associated return currents that, in turn, were caused by a *sudden impulse*. The sudden impulse resulted from the collision with Earth's magnetic field of the shock front of a coronal mass ejection (CME) blown away from the Sun on 22 September.

Approximate magnetic field changes during sudden impulse on 24 September

Location	**Bx (nT)**	**By (nT)**	**Bz (nT)**
Anchorage	–80	+110	+40
HAARP-Gakona	–100	+150	+40

Parts of the Sun's magnetic field are carried along with the solar wind and coronal mass ejections. If this interplanetary magnetic field (IMF) has a component opposite of Earth's north-south component, the two fields merge and allow the transfer of energy into the geomagnetosphere. This very often leads to a geomagnetic storm as was the case immediately after the sudden impulse and the next day.

Normalization and Vertical Scales: The SAM-III Magnetometer operates as a variometer. The SAM_VIEW software that collects and displays the data from the magnetometers is setup at both sites to *Normalize* the displayed traces at the end of each UTC day such that the three traces are zeroed at 0000 UTC.

The software also is setup to *Autoscale* the displayed vertical axis. The scaling of all three traces is determined by the component with the highest normalized amplitude. Geomagnetic activity at higher latitudes generally has higher amplitudes than lower latitudes. In this case a geomagnetic latitude difference of only about 2° caused the HAARP magnetometer to Autoscale by a factor of 1.3 on 24 September and 2 on 25 September compared to Anchorage. At higher latitudes, the magnetic flux density measured on the ground is heavily influenced by the auroral electrojet. The HAARP magnetometer was closer to the electrojet and more affected by it. The autoscaling appears to lessen the displayed geomagnetic activity the day after the sudden impulse arrival.

K-Index: The K-index shown along the top of the magnetogram indicates the peak-to-peak geomagnetic activity on a quasi-logarithmic scale of K0 to K9 in 3 hour synoptic periods. The higher the K-index, the higher the local magnetic activity. The K-index is a software (computer display) and firmware (SAM-III controller built-in display) function in the SAM-III Magnetometer system. The magnetograms above also show a colored bar along the bottom horizontal scale that corresponds to the K-index.

The K-index thresholds are adjusted at each site to provide approximately the same index value in any given 3-h time period as other sites; for example, if K4 is indicated in the 0300-0600 synoptic period at Anchorage, a K4 is indicated at HAARP and other geomagnetic observatories during the same period even though the magnetic deflection at those observatories was higher or lower due to their different latitudes. Examination of the Anchorage and HAARP magnetograms shows general agreement for almost all synoptic periods.

ULF Waves: ULF Waves are indicated by rapid, periodic changes in the magnetic flux density and have the appearance of noise. Low amplitude ULF Waves can be seen on 25 September in the east-west component By between 0600 and 1000 at Anchorage and between 0600 and 0800 at HAARP. ULF Waves also appear in the north-south component Bx and also By at both Anchorage and HAARP after about 1200 on the same day. The ULF Waves on 25 September probably resulted from the sudden impulse and following geomagnetic storm. No ULF Waves are obvious in the magnetograms for 24 September.