Geomagnetic Sudden Impulse Observation on 10 December 2020

Whitham D. Reeve

Magnetic field activity has been quite low for the last couple years with only a handful of disturbances related to solar coronal hole high-speed streams. Recently, however, with the start of the new solar cycle, solar flare activity and associated radio bursts have increased and it was only a matter of time when a flare released a coronal mass ejection (CME) toward Earth. At 1632 UTC on 7 December, that happened.

A CME was associated with a C7-class flare at Active Region 2790 (figure 1). The flare also produced radio bursts over a wide frequency range and the 10.7 cm radio flux doubled in value. A movie of the flare was produced at 131 Å (13.1 nm) wavelength from data sent by the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO) spacecraft {SDO-07Dec). The flare occurred when the active region was very close to the solar meridian. A good summary article about this event appeared in a Spaceweather.com article at {SW-08Dec}).

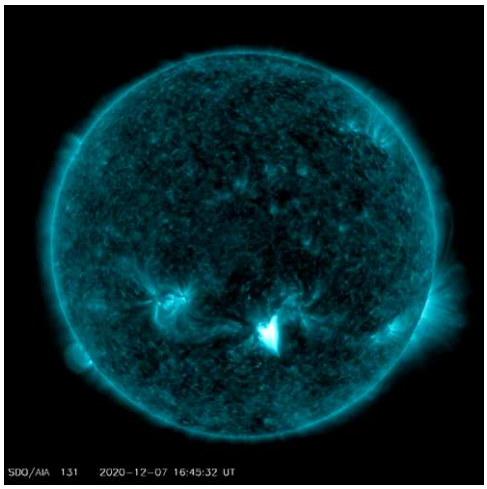

Figure 1 ~ Snapshot of the Sun at 1645 UTC on 7 December just after the CME was launched. The solar flare at Active Region 2790 is the bright spot just below center of this image. The flare was a long-duration event, lasting about 107 min. AR2790 has produced numerous flares including at least one M-class event. The snapshot was produced from data at 131 Å wavelength. This wavelength is used to show 10 million kelvin flaring regions. Image source: NASA {SDO-07Dec).

The initial forecast issued mid-day on 8 December by Space Weather Prediction Center (SWPC) indicated the CME could arrive at Earth in the latter half of the UTC day on 9 December (see Forecast Discussion at {SWPC-08Dec}). The CME arrival was a little late, hitting the DSCOVR spacecraft at 0132 on 10 December and Earth's magnetosphere 38 min later at 0210 as indicated on my SAM-III magnetometer at Anchorage, Alaska (figure 2). The DSCOVR spacecraft is about 1.5 million km from Earth on an Earth-Sun line, so the CME's approximate speed in our vicinity was 660 km/s. Additional details were provided in the SWPC Forecast Discussion for 1230 UTC on 10 December {SWPC-10Dec} and are included in the Appendix to this article.

I compared the SAM-III magnetic field plot with plots from two nearby magnetometers, one at Kenai Peninsula College about 100 km southwest of Anchorage and another at the HAARP facility near Gakona about 290 km east-northeast of Anchorage (figure 3). The data time-stamps on the peaks show a difference of about 1 min, probably due to the lower temporal resolution of the other magnetometers. The SAM-III at Anchorage is setup for a 10 s sampling interval, and the data are time-stamped by the PC that runs the associated SAM_VIEW software. The PC uses a GPS-based network time server for accurate time stamping.

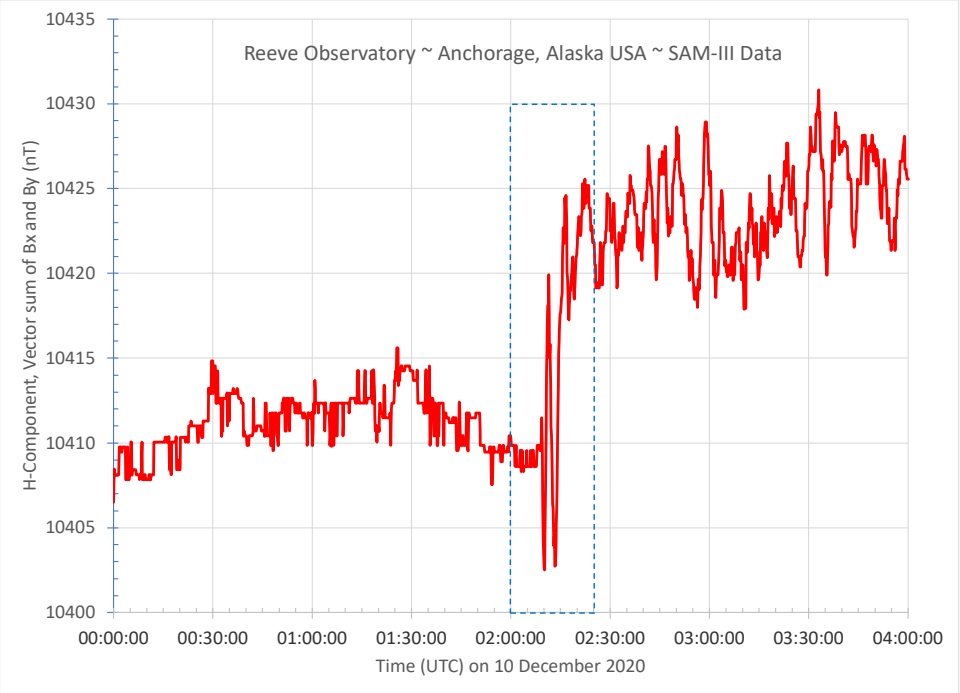

Figure 2.a ~ Horizontal (H) component of the local magnetic field for a 4 h interval recorded by the SAM-III magnetometer at Anchorage, Alaska. The H-component is the vector sum of Bx and By components of the magnetic field measured by the SAM-III. A slight positive bay is seen in the 2 h run-up to the sudden impulse at 0210. Following the impulse, the field showed a positive offset with interesting oscillations having a 6 to 7 min characteristic time period. The blue-dashed box outlines the area shown in the expanded plot below.

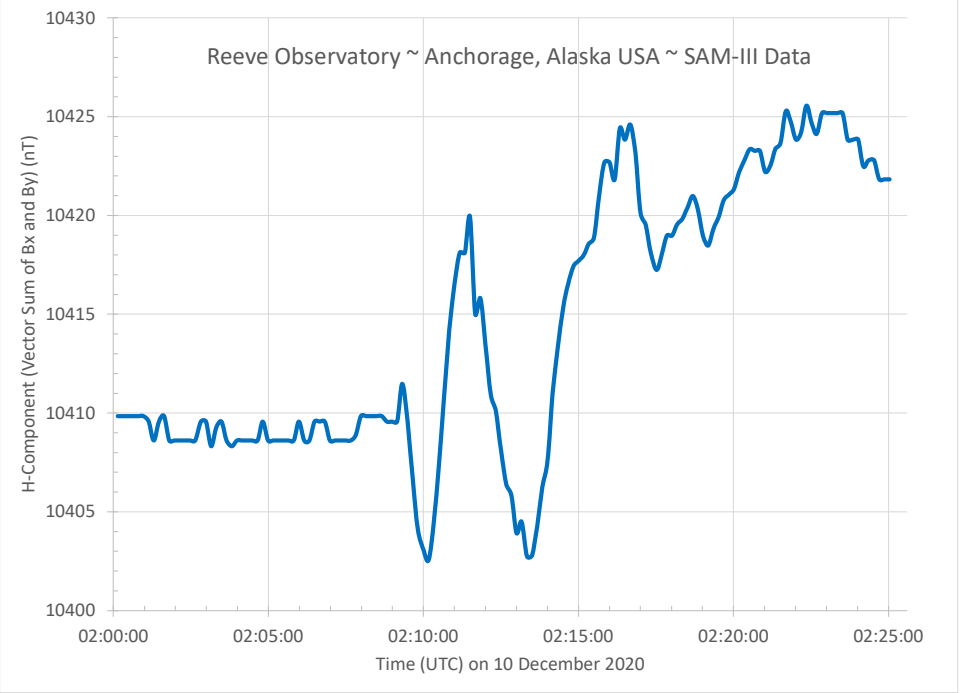

Figure 2.b ~ Expanded plot showing more detail of the sudden impulse. Prior to arrival of the CME, the field was relatively quiet at around 10 410 nT. Just before 0210, a small positive bump appeared followed immediately by a negative dip, which peaked at 0210:00. This was followed by a couple more peaks over the next 5 min, ending in a positive offset. At this point the magnetic field oscillated for at least 2 h afterwards.

Except for the sudden impulse and positive enhancement in the magnetic field as measured at Anchorage and elsewhere, there was little activity following the impulse (figure 4). Although SWPC issued a Watch message at 1634 on 10 December that forecasted magnetic storm levels, they never materialized and the Watch was cancelled at 1157 on 11 December.

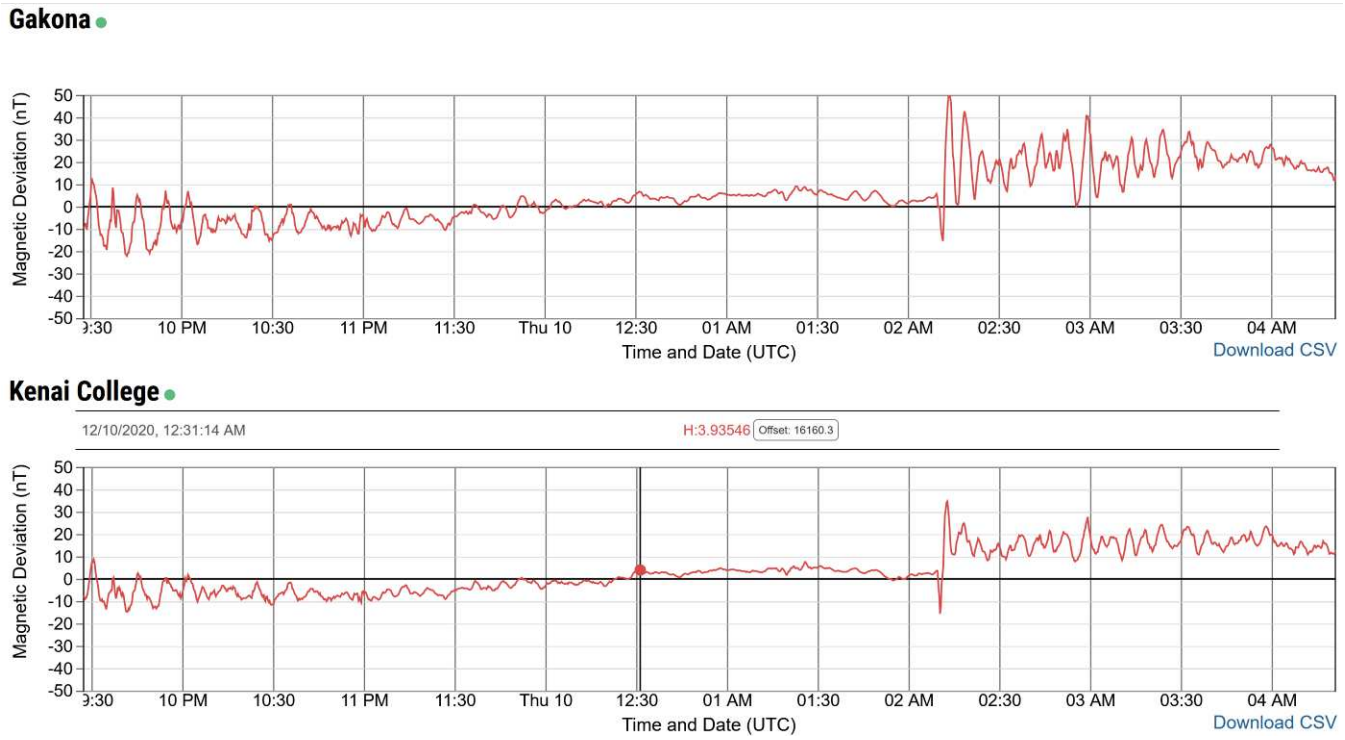

Figure 3 ~ Plot of the H-component of the magnetic field measured by magnetometers at Gakona and Kenai Peninsula College. These magnetometers are operated by University of Alaska Fairbanks – Geophysical Institute. Note the similar signature of the sudden impulse compared to the SAM-III at Anchorage. However, the UAF-GI magnetometers have lower time resolution. Image source: {UAF-GI}. Magnetometer data, Geophysical Institute, UAF 2020. Retrieved from Research Computing Systems 10 December 2020.

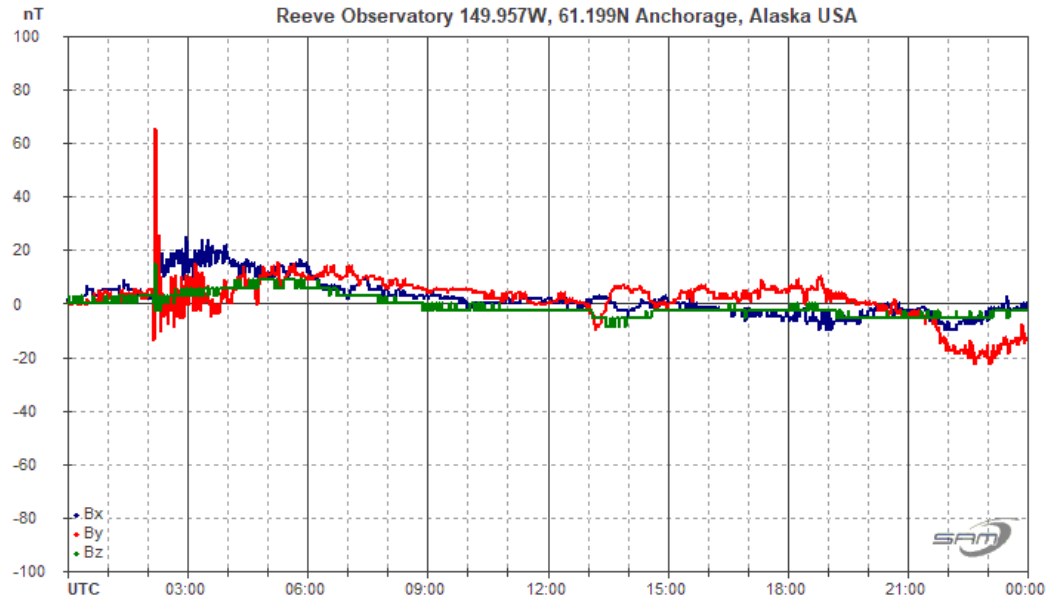

Figure 4 ~ 24 h magnetogram for 10 December 2020 produced by the SAM-III magnetometer at Anchorage, Alaska. This plot shows the individual magnetic field components, Bx (north-south), By (east-west) and Bz (vertical). The sudden impulse at 0210 is clearly visible as a spike in the By trace, visible as a step in the Bx trace and not at all in the Bz trace.

Weblinks and References:

{SDO-07Dec) https://sdo.gsfc.nasa.gov/data/dailymov/movie.php?q=20201207_1024_0131
{SW-08Dec} https://spaceweather.com/archive.php?view=1&day=08&month=12&year=2020

{SWPC-08Dec} ftp://ftp.swpc.noaa.gov/pub/forecasts/discussion/12081230forecast_discussion.txt
{SWPC-10Dec} ftp://ftp.swpc.noaa.gov/pub/forecasts/discussion/12101230forecast_discussion.txt
{SWPC-11Dec} ftp://ftp.swpc.noaa.gov/pub/forecasts/discussion/12110030forecast_discussion.txt
{UAF-GI) https://www.gi.alaska.edu/monitors/magnetometer

Appendix

Space Weather Prediction Center, Forecast Discussion (partial) as of 0030 UTC, 11 December 2020 {SWPC-11Dec}:

Solar Wind, 24 hr Summary...
Solar wind parameters began the period indicative of a weak, negative polarity CH HSS with total field at about 5 nT, the Bz component was at +5 to -4 nT and wind speeds were at an average of 450 km/s. At 10/0132 UTC a shock, likely associated with the 07 Dec CME, was observed in the IMF by the DSCOVR satellite. Total field briefly reached 15 nT, the Bz component reached -10 nT while wind speeds peaked at 596 km/s. However, this enhancement was short-lived as total field weakened to 5-7 nT, Bz became mostly neutral or weakly northward and wind speeds declined to an average of about 475 km/s. Phi was in a predominantly negative solar sector through the period.

Solar Wind, Forecast...
The solar wind environment is anticipated to remain slightly enhanced through 11 Dec due to lingering CME effects. A weak, positive polarity CH HSS is expected to keep the solar wind environment enhanced on 12-13 Dec.

Geospace, 24 hr Summary...
The geomagnetic field was at mostly quiet levels with unsettled to active intervals early in the period due to the aforementioned shock arrival.

Geospace, Forecast...
G1 (Minor) geomagnetic storm conditions are likely early on 11 Dec due to lingering CME effects. 12-13 Dec is expected to see quiet to unsettled conditions due to weak CH HSS influence.

Author: Whitham Reeve obtained B.S. and M.S. degrees in Electrical Engineering at University of Alaska Fairbanks, USA. He worked as a professional engineer and engineering firm owner/operator in the airline and telecommunications industries for more than 40 years and now manufactures electronic equipment used in radio astronomy. He also is a part-time space weather advisor for the High-frequency Active Auroral Research Program (HAARP) and a member of the HAARP Advisory Committee. He has lived in Anchorage, Alaska his entire life. Email contact: whitreeve@gmail.com

---