# Geomagnetic Disturbance Report – Reeve Observatory

Event type: Various geomagnetic disturbances including coronal hole high-speed stream, coronal mass ejection, sudden impulse and reverse shock effects

Background: This background section defines the various events covered.

A coronal hole is a large dark region of less dense and colder plasma in the Sun's corona where the solar magnetic field lines are able to stretch far out into the inter-planetary medium. These field lines may connect with Earth's magnetic field, causing a geomagnetic disturbance. During periods of sunspot minimum, the coronal holes usually are found in the Sun's polar regions, but as solar activity increases the coronal holes can be found at all latitudes. A *coronal hole high-speed stream* is high solar wind flow are attributable to coronal holes.

A *coronal mass ejection* (CME) is a strong surge in the emission of charged particles with a resulting increase in the velocity and density of the solar wind. A CME must be directed at Earth for it to disturb the geomagnetic field. When the surge hits the Earth's magnetosphere, usually 2 – 9 days after the solar event, the magnetic field is disturbed and oscillates. This in turn generates electric currents in the Earth's ionosphere and near-Earth space environment. The electric currents in turn generate additional magnetic-field variations.

If the Interplanetary Magnetic Field (IMF) associated with the arrival of a solar-terrestrial disturbance remains northward (+Bz) behind the shock caused by a CME then there usually is no subsequent geomagnetic storm, and the shock stands alone as a *sudden impulse*. The sudden impulse mostly is the effect of enhanced solar-wind pressure associated with a coronal-mass ejection (CME) and is caused by compression of Earth's magnetosphere. All interplanetary plasma parameters increase - solar wind speed, temperature and density). It is identified by a characteristic signature in terrestrial magnetometer data and is a positive pulse or jump in the horizontal component of the geomagnetic field. A sudden impulse is most clearly seen at low latitudes, where the field variations are generally less complex than at high latitudes. This means that a sudden impulse can be difficult to identify at high latitude observatories because it may be overshadowed by normal activity. If the IMF is directed southward (–Bz) behind the shock then a geomagnetic storm usually follows, and the impulse event is called a *sudden commencement*.

A *reverse shock* involves a pair of shock waves generated by the enhanced supersonic solar wind at the time of a CME. Both shocks are moving away from the Sun but one shock is moving toward the Sun relative to the other, that is, from the point of view of the solar wind, the second (driver, or slow) shock appears to move in reverse with respect to the first (ambient, or fast) shock. In a reverse shock, all interplanetary plasma parameters except solar wind speed suddenly decrease, resulting in a negative sudden impulse. The negative sudden impulse is less frequent and has lower amplitude than the positive sudden impulse discussed above.

Activity: The 6 d period from 1 to 6 February 2011 contained a variety of geomagnetic disturbances as listed in the Event Type and defined in the Background above. All dates and times are in UTC.

SAM Data: The following SAM_VIEW images are for the 24 h periods from 1 through 6 February 2011. The caption for each magnetogram describes the events as they were reported by Space Weather Prediction Center (SWPC) with additional information specific to Reeve Observatory.

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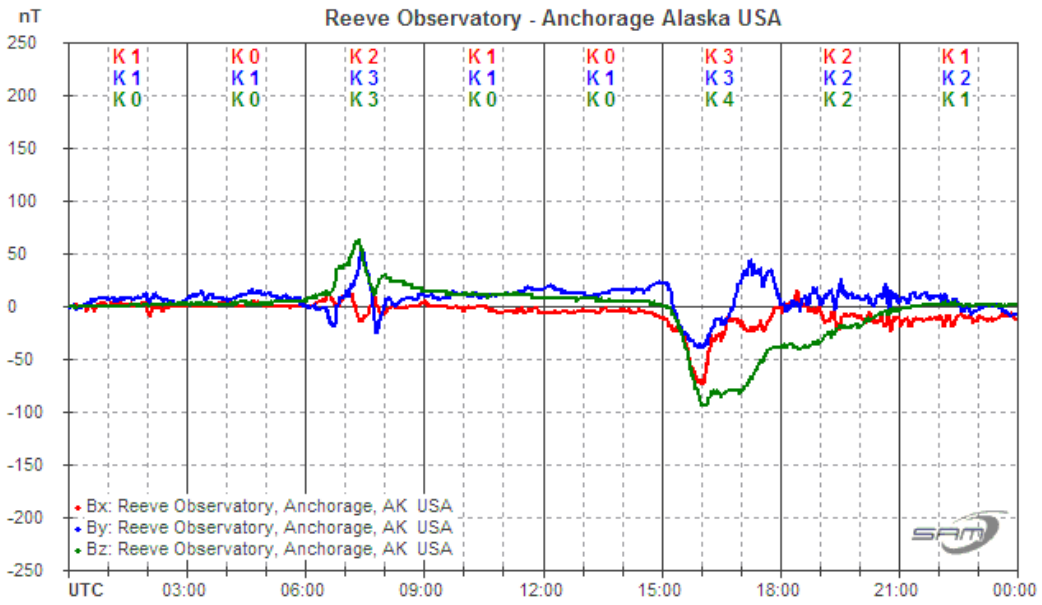
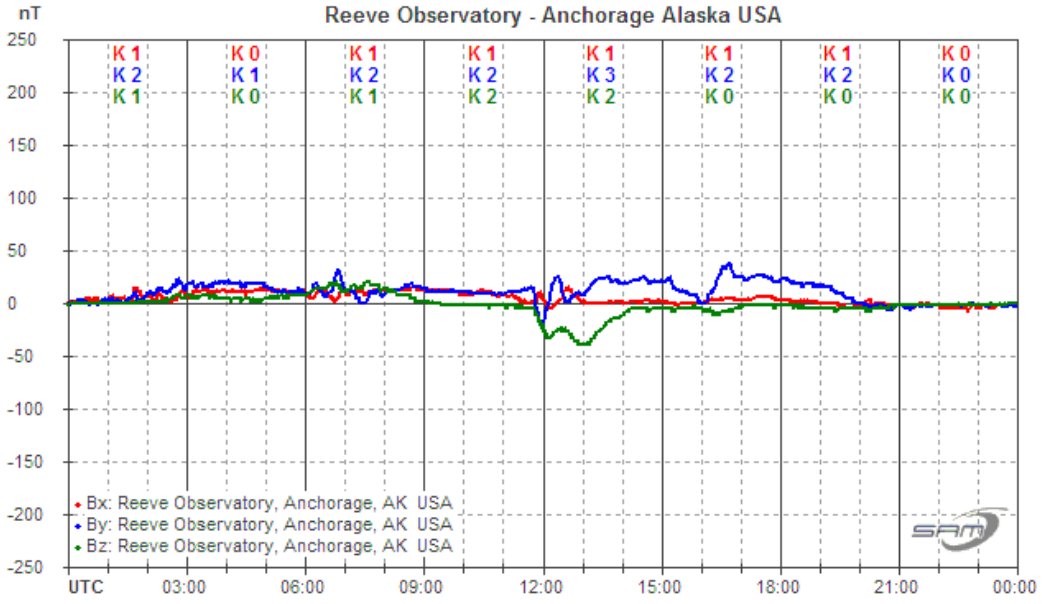
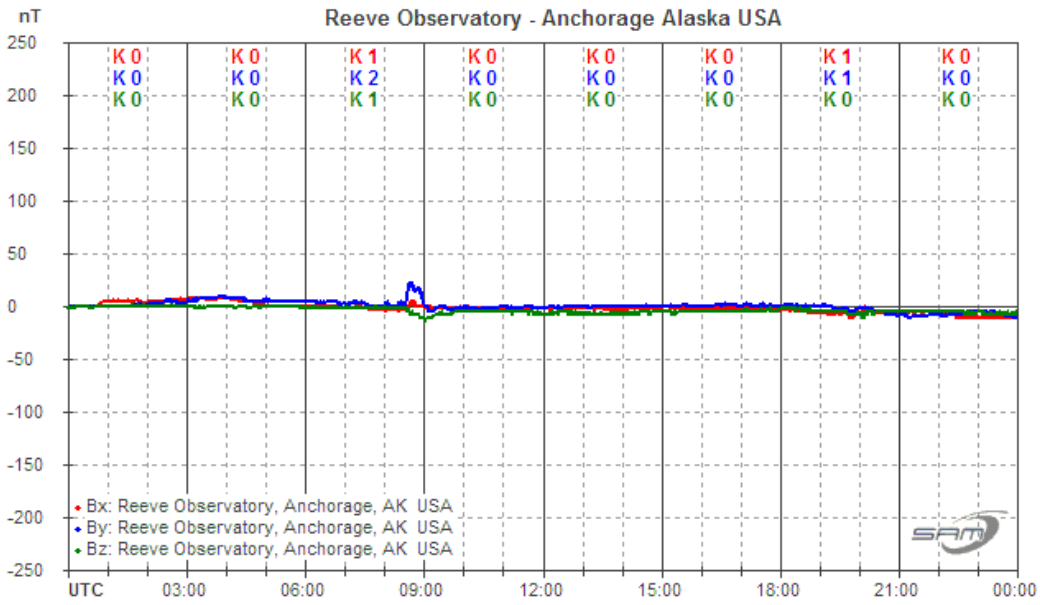
1 February 2011 (below)
The geomagnetic field was mostly quiet for the first half-day with an unsettled period between about 0630 and 0830. Around 1430 a 3.5 h period of active conditions occurred. This was reported by SWPC to occur at mid latitudes at 1800 and was associated with the onset of recurrent coronal hole effects.



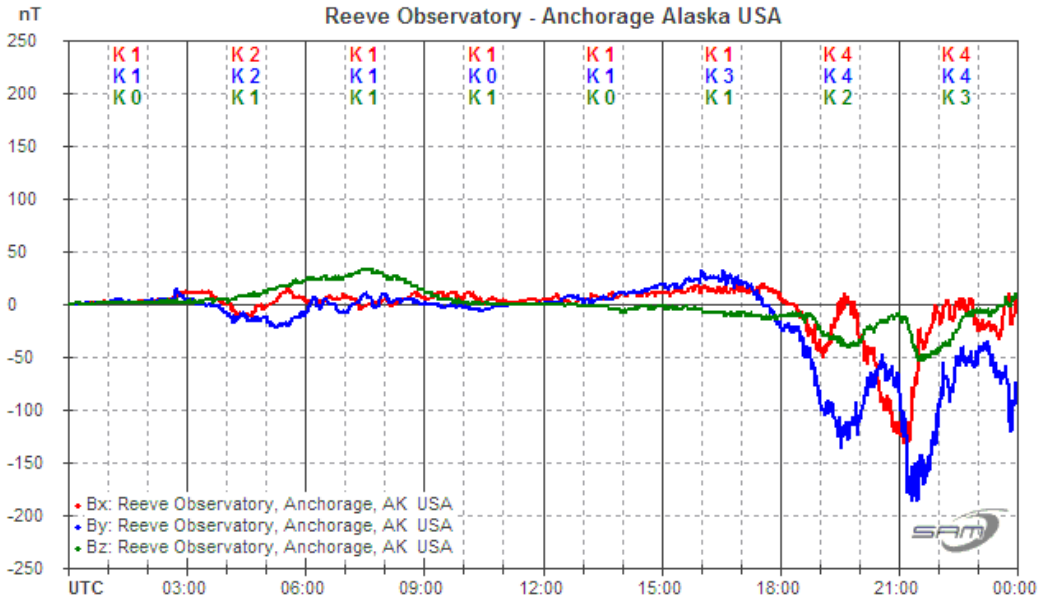

2 February 2011 (below)
The geomagnetic field was mostly quiet to unsettled throughout the period. The unsettled conditions were due to continued effects of a recurrent *coronal hole high-speed stream*.



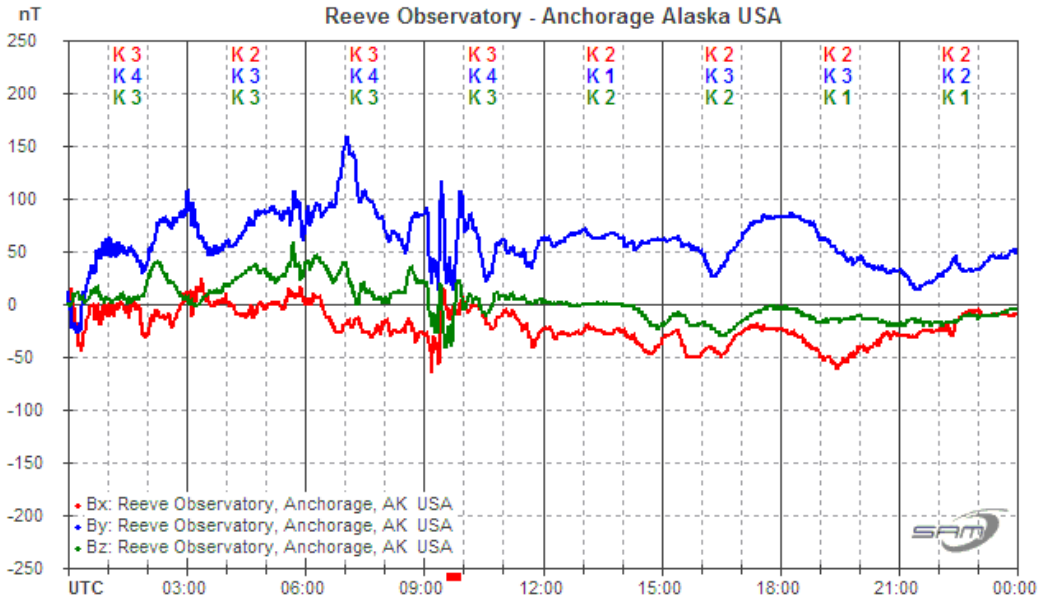
3 February 2011 (below)
The geomagnetic field activity was very low throughout the period. SWPC had forecasted mostly unsettled conditions until mid-day, when a *CME* from 30 January was to arrive and result in a minor storm; however, the anticipated conditions did not materialize.



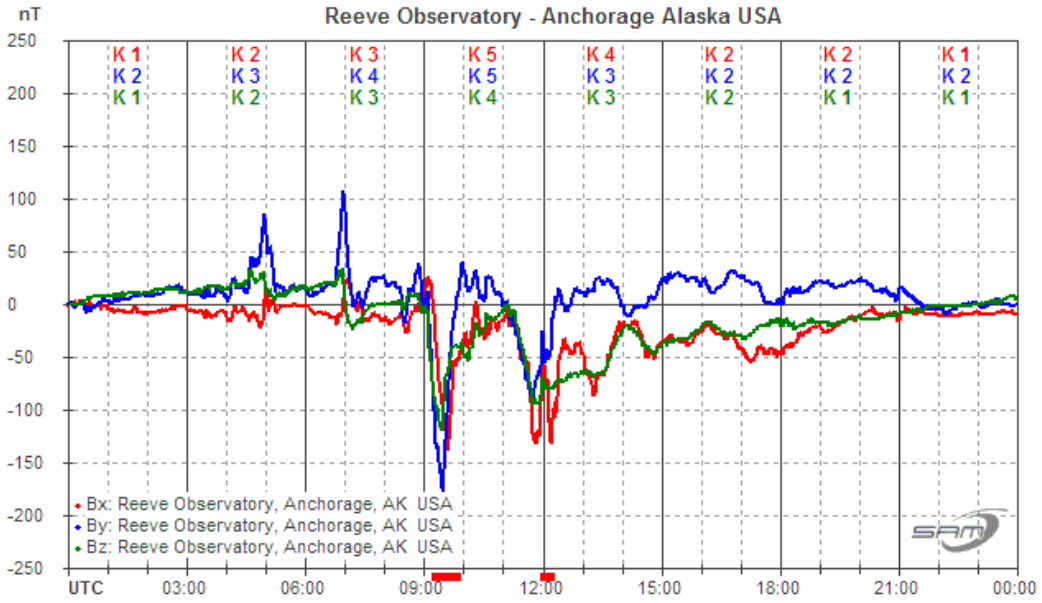

4 February 2011 (below)
The geomagnetic field was predominately quiet with an isolated unsettled period between 0300 and 0600 and an active period between 1800 and 2400. A *sudden impulse* of 8 nT was observed at 0236 in association with a *reverse shock* behind the slow moving *CME* from 30 January (the *CME* had been forecasted to arrive the day before). The *sudden impulse* is clearly seen in the magnetogram below as a positive pulse in By, but the *reverse shock* is not clearly evident (the negative pulse at ~0410 may be the *reverse shock*). Observations from the ACE spacecraft indicated the effects of the shock subsided around 0421, as a recurrent *coronal hole high speed stream*, in which the *CME* was embedded, regained dominance. Solar wind speeds reached almost 500 km/s and Bz was sustained between –15 and –20 nT between 1800 and 2100 according to SWPC. A K4 index threshold (minor storm level) was reached at 2053 and K5 index threshold (storm level) was reached at 2333 according to SWPC but only K4 was recorded in the magnetogram below at Reeve Observatory.



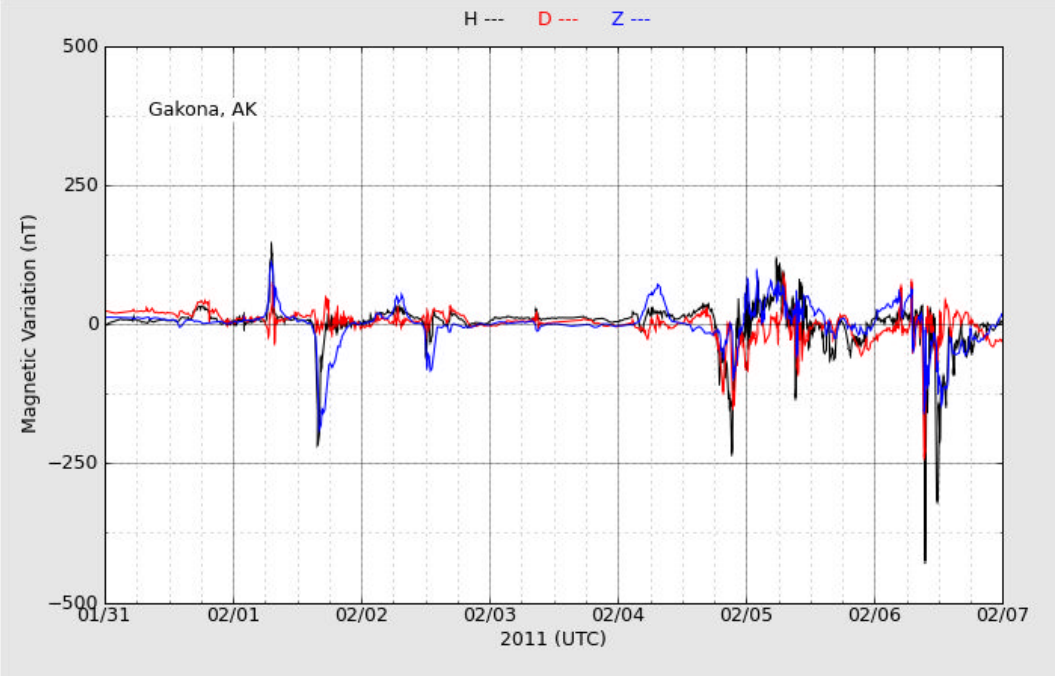
5 February 2011 (below)
Throughout the period, the total Interplanetary Magnetic Field (IMF) decayed from 17 nT at 2106 on 04 February to 3nT at 2008 on 05 February. Solar wind speeds peaked at around 675 km/s at 0536, but speeds began to decrease as the day progressed. Aurora was visible at Reeve Observatory a little after local midnight 5 February (0900 UTC). The aurora was brightest to the northwest with another bright area to the northeast and a faint curtain between. The bottom of the curtain had a bright band, like a frill, about 90 deg. long and 1 deg. high.



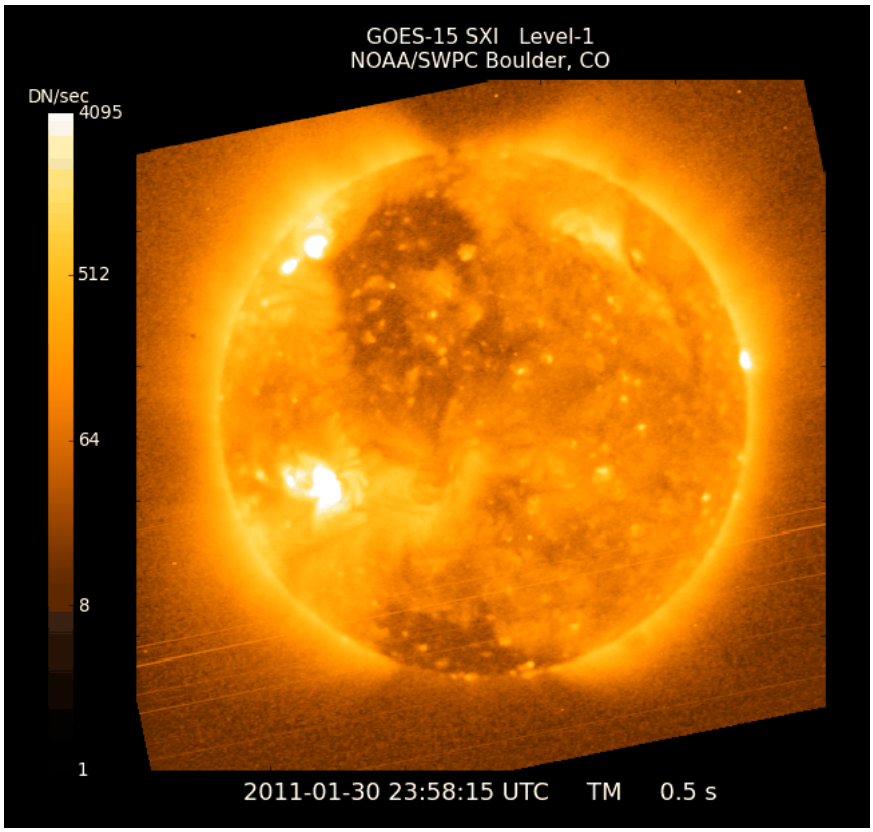

6 February 2011 (below)
The geomagnetic field was predominantly unsettled with an isolated active storm period from 0900-1200 bracketed by minor storms from 0600-0900 and 1200-1500. The activity was due to the effects of a waning *coronal hole high-speed stream* that has been affecting the geomagnetic field for the previous five days. The SWPC reported a K4 index threshold at 0701. The SWPC also reported the greater than 2 MeV electron flux at geosynchronous orbit reached high levels during the period. Quiet conditions returned about 2200 and continued for at least the next 24 h.



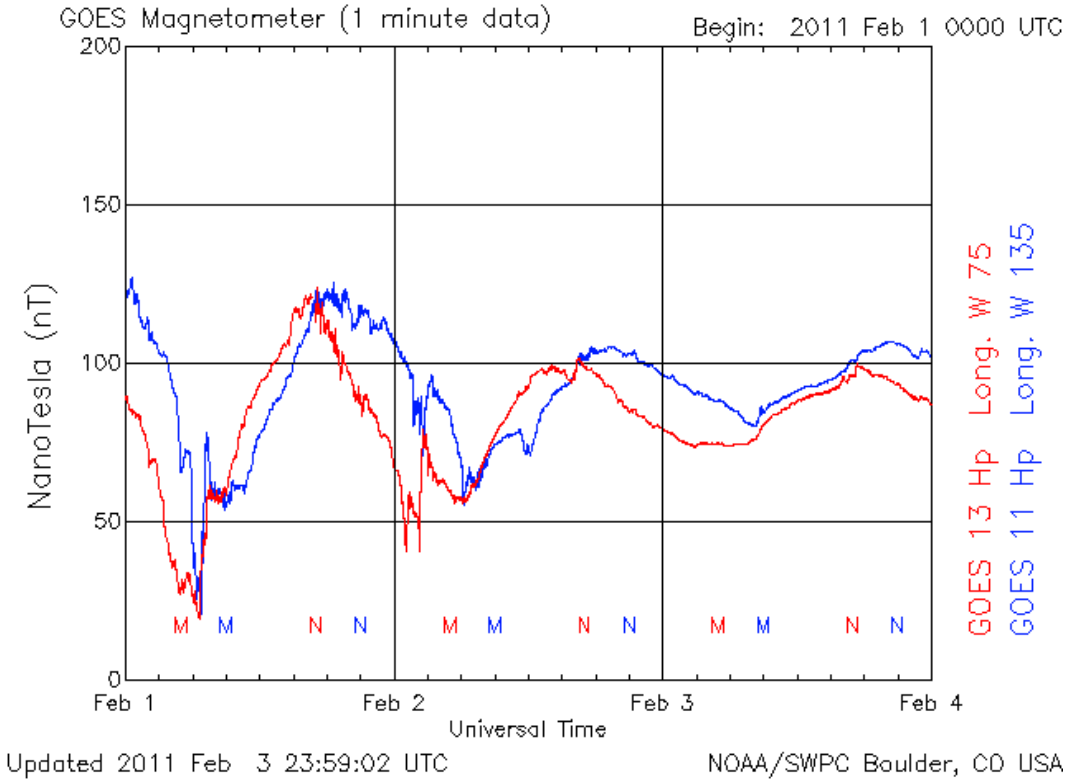
Alaska Magnetometer Chain (Gakona station, approximately 290 km ENE of observatory) covering the 6-d period:

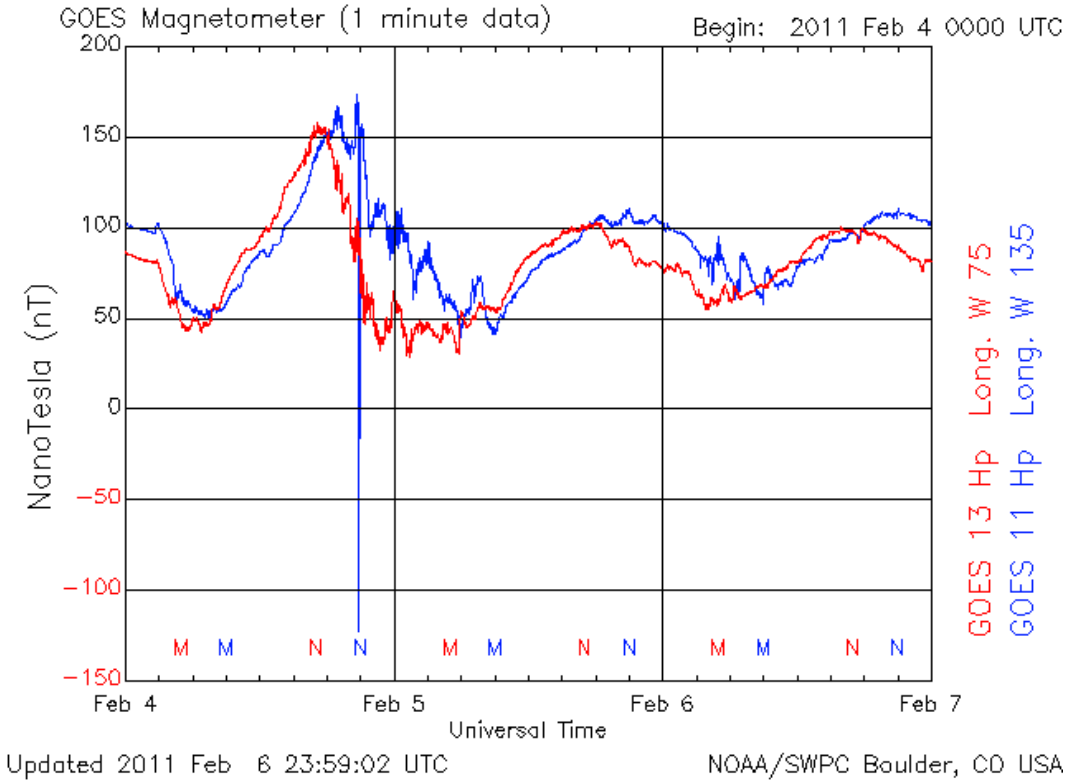



GOES 15 SXI (Solar X-ray Imager) for 30 January 2011 showing coronal holes (dark regions) on 30 January:



GOES data (GOES 11 is most relevant to Reeve Observatory):



Equipment:
Simple Aurora Monitor (SAM-III) located at geomagnetic coordinates: 61.63 °N : 262.89 °E
Equipment description: www.reeve.com/SAMDescription.htm

Resources:
Reeve Observatory SAM-III real-time data: www.reeve.com/SAM/SAM_simple.html
Alaska Magnetometer Chain – 137.229.36.30/cgi-bin/magnetometer/magchain.cgi
Geostationary Operational Environmental Satellites – www.swpc.noaa.gov/rt_plots/mag_3d.html
Space Weather Prediction Center – www.swpc.noaa.gov/
SOHO – http://sohodata.nascom.nasa.gov/cgi-bin/data_query
SDO – http://sdo.gsfc.nasa.gov/

Geomagnetism Tutorial:
www.reeve.com/Documents/SAM/GeomagnetismTutorial.pdf

Image sources:
GOES: NASA
Alaska Magnetometer Chain: University of Alaska Fairbanks, Geophysical Institute