

Honolulu Magnetic Observatory



Tucked in a grove of thorny mesquite trees, on an ancient coral reef on the south side of the Hawaiian island of Oahu, west of Pearl Harbor, a small unmanned observatory quietly records the Earth's time-varying magnetic field. The Honolulu Magnetic Observatory is 1 of 14 that the U.S. Geological Survey (USGS) Geomagnetism Program operates at various locations across the United States and its territories.

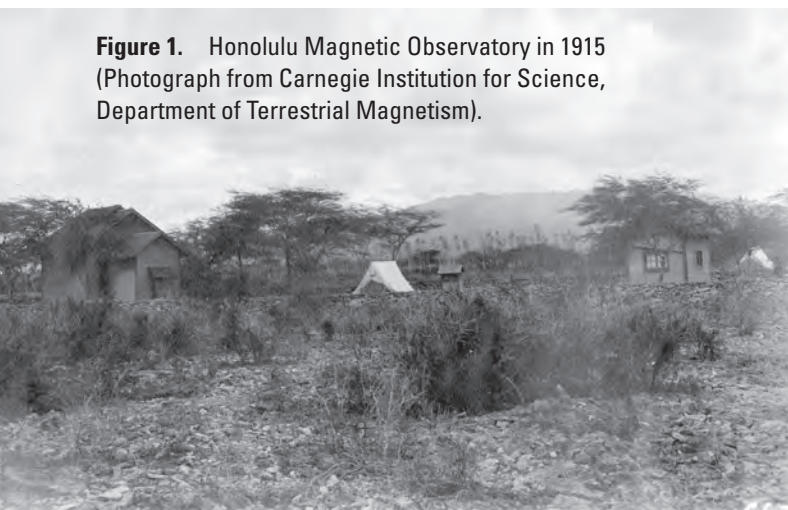
Data from these observatories, Honolulu, and those operated by institutions in foreign countries, record a variety of magnetic signals related to a wide diversity of physical phenomena in the Earth's interior and its surrounding outer-space environment. USGS magnetic observatory operations are an integral part of a U.S. National Space Weather Strategy for monitoring and assessing natural hazards that potentially threaten important technological systems (National Science and Technology Council, 2015).

History

In support of a national project for geomagnetic field mapping and for investigating the complex time dependence of the geomagnetic field, in 1899, the U.S. Congress appropriated funds to the Coast and Geodetic Survey for the establishment of magnetic observatories (Pritchett, 1899). Plans were made for installing several observatories at a geographically widely distributed set of sites across the country (Bauer and Fleming, 1903), including on what was then the newly acquired territory of Hawaii.

The Honolulu Magnetic Observatory was built in 1901, and routine data-acquisition operations started in 1902 (Hazard, 1909); an early photograph of the observatory is shown in figure 1. Since the Honolulu Magnetic Observatory was first installed, it has been moved twice, once in 1947 and once in 1960, but each location was within a 10-kilometer distance of the original site (Coast and Geodetic Survey, 1963). In 1965, geomagnetic monitoring operations and the administration of the Honolulu Magnetic Observatory were transferred to the short-lived Environmental Science Services Administration. Soon after the creation of the National Oceanic and Atmospheric Administration in 1970, the Geomagnetism Program was transferred to the USGS; a 2013 photograph of the observatory is shown in figure 2.

Figure 1. Honolulu Magnetic Observatory in 1915 (Photograph from Carnegie Institution for Science, Department of Terrestrial Magnetism).



From 1902 to 1984, the recording of geomagnetic time variation at the Honolulu Magnetic Observatory was accomplished through measurements using automatic photographic systems; hourly magnetic-field values were estimated by hand-scaled measurements of paper magnetograms. In 1983, 1-minute resolution data from the Honolulu Magnetic Observatory began to be routinely acquired using digital-electronic magnetometer systems, and in 2004, 1-second resolution data began to be routinely acquired. From 1902 to present, auxiliary calibration measurements (typically once per week) have been made at the Honolulu Magnetic Observatory site so that accurate definitive data can be produced.

Today, the Honolulu Magnetic Observatory is an integral part of the USGS geomagnetic observatory network that is supported by the U.S. Government for a variety of pure and applied geomagnetic science applications (Love and Finn, 2011). The Honolulu Magnetic Observatory is 1 of more than 120 observatories operated around the world and whose operations are coordinated and promoted through the INTERMAGNET Consortium (Love and Chulliat, 2013).

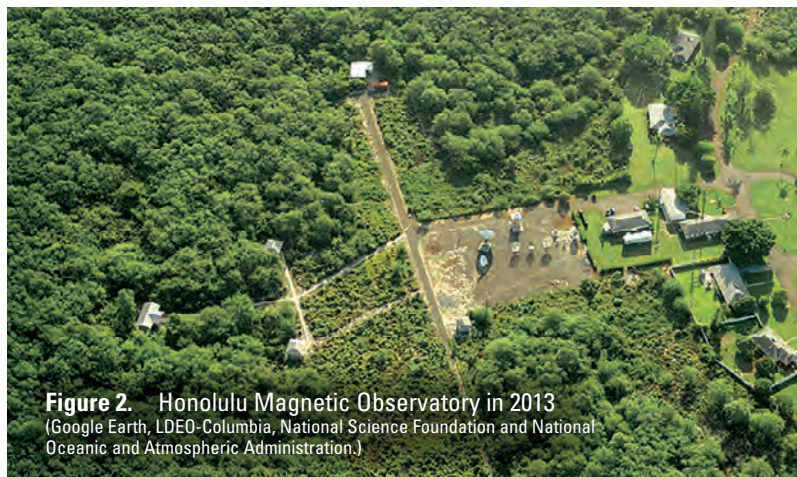


Figure 2. Honolulu Magnetic Observatory in 2013 (Google Earth, LDEO-Columbia, National Science Foundation and National Oceanic and Atmospheric Administration.)

Magnetic Signals

Data from the Honolulu Magnetic Observatory provide us with a history of geomagnetic field variation; in figure 3A an hourly and annual-mean time series of the horizontal intensity of the field from 1902 to 2016 is shown. Over this long duration of time, the horizontal intensity at the Honolulu Magnetic Observatory has exhibited a general decrease—part of a global diminishment in geomagnetic field intensity caused by dynamic geophysical processes in the Earth's deep interior. More rapid variation, caused by transient change in the Earth's surrounding outer-space environment, especially during transient geomagnetic storms, are caused by occasional disturbances in the solar wind plasma—electrically charged particles that are emitted from the Sun.

In figure 3B a 1-minute resolution time series of variation in horizontal geomagnetic intensity at the Honolulu Magnetic Observatory during the great magnetic storm of March 1989 is shown. During this storm, geomagnetic field variation generated electric fields in the Earth's electrically conducting interior that caused the collapse of the entire high-voltage transmission system

of Québec, Canada, plunging the province into an electricity blackout (Allen and others, 1989). The March 1989 and Halloween (October 2003) storms caused operational stress in high-voltage electricity systems across the United States as well.

The Honolulu Magnetic Observatory is one of only four observatories in the world which contribute data used to calculate the storm-time disturbance index, a fundamental measure of magnetic-storm intensity (Sugiura and Kamei, 1991). Data from the Honolulu Magnetic Observatory are used by USGS scientists for analysis of storm-time magnetic disturbance (Rigler, 2017), and to analyze the statistics of magnetic storms that have occurred

in the past, enabling forecasts of the probability of their occurrence in the future (Love and others, 2015).

Detailed analysis of Honolulu data allow scientists to test physics-based theories and to develop hazard assessments useful for mitigating the deleterious effects of magnetic storms. Honolulu Magnetic Observatory data are used by the Space Weather Prediction Center of the National Oceanic and Atmospheric Administration, the U.S. Air Force, and the National Aeronautics and Space Administration; they are used for academic research into the nature of Earth's interior (for example, Kelbert and others, 2009), and they are used by scientists in other countries and by the private sector.

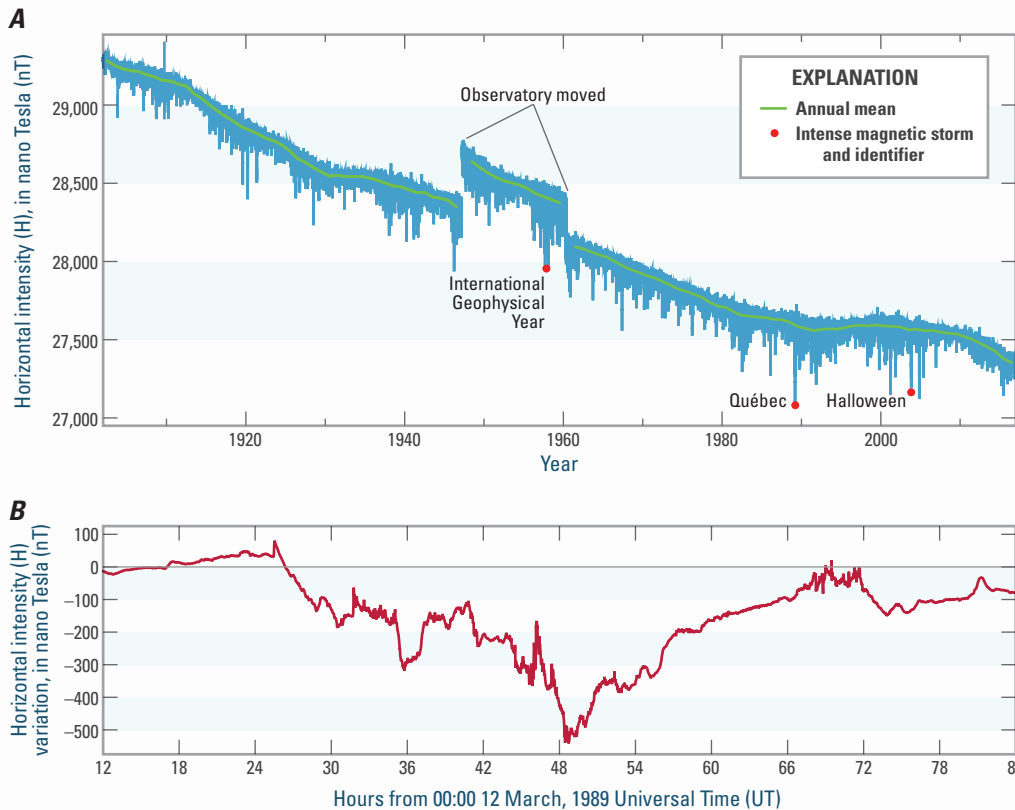


Figure 3. Time series of horizontal intensity measured at the Honolulu Magnetic Observatory. (A) Hourly measurements (blue); annual means (green). Observatory relocation, in 1947 and 1960, introduced discontinuities. Intense magnetic storms, usually seen as transient negative perturbations in the time series, were seen, for example, during the International Geophysical Year (IGY); the great Quebec (March 12–15, 1989) and Halloween (October 29–31, 2003) storms are also indicated (red). A long-term decrease in horizontal intensity at Honolulu is seen since the observatory commenced operation in 1902. (B) One-minute resolution measurements recording the Quebec storm (12:00 March 12 to 12:00 March 15, 1989).

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