

## International collaboration in ground-based magnetometer observations via ULTIMA: A tribute to Professor Kiyohumi Yumoto

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Ground-based magnetometers provide not only the measurements of the geomagnetic field but also integrative information about of the electric currents in the magnetosphere and the ionosphere, revealing the dynamics of the magnetic storms, substorms, and various types of MHD and plasma waves in the geospace. Ground-based magnetometers are installed and operated by university teams and government agencies, most of which manage regional arrays for specific scientific objectives or national interests. Nonetheless, a global network of ground-based magnetometers is required to understand the complex geospace and its response to solar activity.

As the Principal Investigator of the world's largest magnetometer array operated by a single group, Professor Kiyohumi Yumoto envisioned that international collaboration was the only way to global magnetometer observations. In 2006, he and six other magnetometer arrays in Australia, Canada, and the United States founded the Ultra Large Terrestrial International Magnetometer Array (ULTIMA) consortium, of which he was elected as the first Chair. The main objective of ULTIMA is to promote collaborative research on the magnetosphere, ionosphere, and upper atmosphere through the use of ground-based magnetic observatories. The number of ULTIMA members doubled in size during Professor Yumoto's tenure between 2006 and 2014. Today, ULTIMA consists of 17 member arrays with over 250 stations located in all continents of the world. ULTIMA also received recognition from the International Association of Geomagnetism and Aeronomy (IAGA) in 2013.

We present a review of the establishment and development of ULTIMA, as well as lessons learned regarding collaboration among magnetometer teams in multiple nations. As geospace research has moved into a new era where collaborative opportunities among different types of observations are growing, we also demonstrate ongoing and upcoming synergetic activities participated by ULTIMA.

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