1 Introduction

MURATA Ken T.

Today, since the onset of this century, outer space has been the subject of a broadening sphere of human utilization and activity, with our daily lives increasing dependent on outer space either directly or indirectly. Since the start of the International Geophysical Year (IGY) about 50 years ago, the utilization of outer space has become fully entrenched in our lives, including the day-to-day usage of communications and broadcasting satellites, human activities aboard international space stations and other spacecraft, and ground positioning by GPS satellites. The operational stability of such facilities is of vital importance from the standpoint of daily life in society. However, solar activity can dramatically influence the space environment in which artificial satellites and international space stations orbit. Satellite or communications failure, increased positioning errors, and other problems that might result from space environmental disturbances can therefore have a serious impact on our daily lives.

In this context, space weather prediction serves to promote better understanding of current space environmental conditions and predict upcoming changes in those conditions. Japan's National Institute of Information and Communications Technology (NICT) has operated a space weather prediction center of the International Space Environment Service (ISES), a subordinate organization of UNESCO since 1965, providing a constant source of space environment information. NICT exchanges data and information with 13 member nations, forecasts solar activity, geomagnetic activity, solar radiation activity, and radio wave propagation based on daily observation data derived from its own space weather observation networks, and disseminates such forecasts at home and abroad via the Web, e-mail, and other means.

As stated earlier, NICT has built observation networks at home and abroad to disseminate space environment information, thereby supporting its space weather research and prediction services. In Japan, NICT conducts solar optical and broadband spectral observations based on the Hα line, and solar activity F10.7-index observations for monitoring solar activity (such as solar flares and CME) as a source of space weather phenomena. In addition, long-term ionospheric observations are underway at four ionosonde stations in Japan to monitor ionospheric disturbances that may cause GPS signal-based positioning errors and radio wave propagation failure.

In terms of global activities, NICT has set up geomagnetic observation stations at 10 locations and HF radar at one location—mainly in the Far Eastern region of Siberia—in an international cooperative endeavor to monitor variations in geomagnetism and plasma, (i.e., sources of radiation belt variations and lower-latitude ionospheric disturbances) in the polar region. Another effort in international cooperation now in progress is the deployment of an ionospheric observation network built of ionosondes, GPS scintillation/TEC monitors, and magnetometers set up at eight locations in Southeast Asia to monitor plasma bubbles, a source of GPS positioning errors, in order to study their mechanism of formation and propagation.

NICT also implements numeric forecasting based on a supercomputer to complement the observation data collected from these networks, and predicts the space environment from that data. It implements real-time simulations of the sun and solar wind, the terrestrial magnetosphere, ionosphere and thermosphere, and then uses the resultant data to predict space data several days to several weeks ahead. Each simulation code uses sun/solar wind observation data and upstream magnetospheric simulation internal boundary data as input parameters. Therefore, simulations conducted based on such measurement values or the results of other simulations enable predictions of higher practical value.

NICT has also recently initiated research on space weather by leveraging informatics based on information and communications technology. This endeavor employs high-speed networks, such as JGN2plus, and high-speed numeric computing, data processing and large-scale distributed data storage based on GPGPU to process the aforementioned observations and simulations in an integrated fashion and thus to provide a revolutionalized solution to predicting and forecasting the space environment. NICT expects to achieve an even higher level of numeric data integration through data standardization, the use of cloud computing, implementation of a semantic Web database, and other advances, and learn about various cause and effect relationships from past case studies in order to improve the accuracy of space environment prediction.

This special issue summarizes and reports on the achievements of NICT's space environment and space weather studies based on its past and ongoing observations, simulation programs, and informatics. Seven years after the previous special issue on space weather was released, NICT's space weather studies have achieved significant progress. Now the present pace of progress in observation, numeric calculation, and communications /information processing technologies promises a further leap, making the compilation of research findings achieved thus far in a special issue more meaningful. The author regrets that the present status of space weather prediction has yet to reach a stage of practical use, but hopes that NICT's endeavors as reviewed in this paper will continue expanding toward realizing space weather prediction in its truest sense.

***MURATA Ken T.**, Ph.D.*

Group Leader, Space Environment Group, Applied Electromagnetic Research Center

Information Communication Technology