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Space environment (natural and artificial) — Methods for estimation of future geomagnetic activity

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National foreword

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16698 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard provides guidelines for specifying the process of estimating future geomagnetic activity. Geomagnetic indices describe the variation of the geomagnetic field over a certain time period and provide a measure of the disturbance of the magnetosphere.

The accuracy and method of predicting geomagnetic indices depends on the time scale of prediction. This International Standard presents existing works based on three categories of time scale:

- a) short-term prediction (1 h to a few days);
- b) middle-term prediction (a few weeks to a few months);
- c) long-term prediction (half year to one solar cycle).

These are required as input parameters for the magnetospheric magnetic field (ISO 22009), upper atmosphere (ISO 14222), ionosphere, plasmasphere (ISO/TS 16457), magnetosphere charged particles, and other models of the near-Earth space environment. They also serve as the input parameters for orbital lifetime prediction and worst-case environment analysis of electrostatic charging.

Three International Standards deal with the Earth's magnetic field, including ISO 16695 on the internal magnetic field, ISO 22009 on the magnetospheric magnetic field, and this International Standard.

Space environment (natural and artificial) — Methods for estimation of future geomagnetic activity

1 Scope

This International Standard specifies the methods used for estimating geomagnetic indices for time intervals ranging from the short-term (hours to a few months) to the long-term (months to years).

Geomagnetic indices are used to describe the activity levels of the disturbance of the geomagnetic field. These indices can be used to estimate upper atmospheric and plasmaspheric densities and many other space environment models. They are also used as the input parameters for orbital lifetime prediction and worst-case environment analysis of electrostatic charging.

This International Standard is intended for use to predict future geomagnetic indices and space environment.

2 Symbols and abbreviated terms

Bs	Southward component of the interplanetary field ($B_s = 0$ when $B_z \geq 0$ and $B_s = B_z$ when $B_z < 0$)
Bz	North-south component of the interplanetary field
F10.7 flux	Measure of the solar radio flux at a wavelength of 10,7 cm at the earth's orbit, given in units of $10^{-22} \text{ W} \cdot \text{m}^{-2}$
GLat	Geographic latitude
GLon	Geographic longitude
IMF	Interplanetary magnetic field
MLat	Geomagnetic latitude
MLon	Geomagnetic longitude
MHD	Magnetohydrodynamics
Sq	Daily geomagnetic field variations during quiet conditions (Solar quiet)
UT	Universal time

3 General parameters

3.1 Geomagnetic field variations

The geomagnetic field consists of internal and external magnetic fields. The internal (main) magnetic field is produced by source currents that are mostly inside the Earth's core and by induced currents present in the solid Earth and the ocean, caused by the temporal variation of external magnetic fields. The external magnetic field is produced by magnetospheric and ionospheric currents.

The magnetosphere is highly dynamic with time scales ranging from minutes to days. Solar wind is the ultimate source of magnetospheric dynamics. The role played by the IMF (interplanetary magnetic field) north-south component, B_z , is particularly important, and its southward component, B_s , plays a

fundamental role in substorm and magnetic storm activity through the process of magnetic field line reconnection. Solar wind speed also plays an essential role in these dynamics.

3.2 Quiet level and disturbance fields

Five days of every month are selected as the Five International Quietest Days using the Kp index (see 3.4.1). Note that the five quietest days are selected regardless of the absolute level of quietness. Thus, in a disturbed month, the quietest days may not be very quiet.

Derivation: The quietest days (Q-days) of each month are selected using the Kp indices based on three criteria for each day: (1) the sum of the eight Kp values, (2) the sum of squares of the eight Kp values, and (3) the maximum of the eight Kp values. According to each of these criteria, a relative order number is assigned to each day of the month; the three order numbers are then averaged and the days with the first to fifth lowest mean order numbers are selected as the five international quietest days.

Reference: Website of the Deutsches GeoForschungsZentrum (http://www-app3.gfz-potsdam.de/kp_index/qddescription.html).

Once the quiet level is determined using the Five International Quietest Days, disturbance fields can be obtained as deviations from the quiet level of geomagnetic field.

3.3 K index (local 3 h range index)

The K index is a number in the range 0 (quiet) to 9 (disturbed) that provides a local classification of the variations of the geomagnetic field observed after subtraction of the regular daily variation (Sq). Each activity level relates almost logarithmically to the corresponding disturbance amplitude of the horizontal field component during a 3 h UT interval. In a day, eight K indices are given in successive 3 h UT (universal time) intervals (0 h to 3 h, 3 h to 6 h, ..., 21 h to 24 h UT).

Derivation: The ranges R for the H and D (or X and Y) components are defined as the expected difference between the highest and lowest deviation, within the three-hour interval, from a smooth curve (a regular daily variation) for that element on a magnetically quiet day. Only the larger value of R, i.e. R for the most disturbed element, is taken as the basis of K. To convert from R to K, a permanent scale prepared for each observatory is used. Table 1 is an example of the permanent scale for the Niemegk observatory.

References: Bartels et al. [1939], Mayaud [1980], Menvielle et al. [2011]

Table 1 — Permanent conversion scale from R to K for Niemegk observatory

Range (nT)	0-5	5-10	10-20	20-40	40-70	70-120	120-200	200-330	330-500	≥500
K value	0	1	2	3	4	5	6	7	8	9

3.4 Kp, ΣKp, ap, and Ap indices (planetary indices)

The planetary indices, Kp, ΣKp, ap, and Ap, are derived from 13 selected mid-latitude observatories (see Table 2). The derivation scheme for each index is described in the corresponding subsection.