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В сборнике помещены работы, доложенные на Международном симпозиуме "Полярные геомагнитные возмущения", который состоялся в мае 1986 г. в г. Суале. Приведены результаты исследований по изучению структуры и динамики полярных токовых систем, динамических процессов во время суббуры, воздействия солнечного ветра на внутреннюю магнитосферу и особенностей протекания электродинамических процессов в высоких широтах. Сборник рассчитан на широкий круг специалистов, работающих в области исследования магнитосферы, ионосферы, солнечно-земных связей, а также радиофизиков.

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AN IMPROVED MAGNETIC COORDINATE SYSTEM FOR AURORAL OVAL STUDIES

ABSTRACT. Most studies related to auroral phenomena are carried out using magnetic coordinates that are based on the internal magnetic field of the Earth. Models, including external currents, are available representing the magnetic field at auroral oval latitudes rather well, at least during quiet conditions. A new coordinate system has been defined that is based on such a field model. A considerable improvement is obtained in the ordering of auroral data in this coordinate system which includes both diurnal and seasonal dependence on the magnetic field.

INTRODUCTION. Many auroral oval phenomena are caused by particle drift in the nearly east-west direction in the magnetosphere, and many auroral structures in the auroral oval are therefore approximately east-west aligned. In particular, long auroral arcs, as well as the statistical pattern of auroral arcs (so called auroral orientation curves, Gustafsson, 1967) are east-west oriented at auroral oval latitudes. There are also several auroral features that are drifting in the east-west direction. As auroral phenomena are mainly caused by precipitation of particles drifting in the magnetic and electric fields, it is expected that suitable models of the fields should order auroral data to a high degree.

Data from auroral observations are usually ordered in magnetic time and magnetic latitude coordinates based on the internal field of the Earth, which has no seasonal or magnetic activity dependence. The result is an oval shaped pattern that has the center displaced by several degrees of latitude towards the night side. The purpose of this report is to examine the importance of adding the external magnetic field of the Earth to the internal magnetic field model, when organizing the auroral data.

METHOD. The internal magnetic field is distorted beyond about four Earth radii by currents in the distant magnetosphere. The main sources are magnetopause currents, ring current, cross tail currents and field aligned currents. The magnetic field model by Tsyganenko and Usmanov (1982) that includes these currents has been used here. This model is modular and it is easy to find the contribution from the different current systems.

Particles mirroring near the magnetic equator drift on surface of constant magnetic field, around the Earth if the electric field is neglected. In the field model these drift paths represent lines of constant magnetic field in the equatorial plane, with slightly varying distance from the Earth for different local times. The field model used has only one minimum, when a certain field line is followed from one hemisphere to the other across the magnetic equator, in the latitude range corresponding to the auroral oval. The magnetic equator has been defined from this minimum. The lines of constant
magnetic field at the equator have been evaluated for a certain time of the year and universal time and projected along the magnetic field lines down to the ionosphere. The ovals may be labeled by the radius at the equator estimated from \( R = \left( \frac{H_0}{\text{Berm}} \right)^{1/3} \) where \( H_0 \) is the intensity of the dipole magnetic field at the equator of the earth.

**COMPARISON OF OVALS.** The auroral oval, especially the equatorward border, can be approximated with nearly circular patterns in corrected geomagnetic coordinates displaced towards midnight by a few degrees in latitude. Feldstein and Starkov (1967) found a displacement of about 4 degrees for low magnetic activity. Similar values of the displacement has been found in many other studies. Whalen (1963) studied the energy flux at E-layer altitudes by means of ionospheric sounders and obtained a displacement of 4.2°. Auroral observations from the ISIS-2 satellite of 630 nm emission (Shepherd, 1971) showed a displacement for the 500 R contour at noon and midnight of about 4 degrees.

The auroral orientation curves based on statistical studies of the orientation of auroral arcs show a pattern that is displaced 5.5° during sunspot maximum and 4.5° during sunspot minimum (Gustafsson et al., 1969). These studies show that there is a number of aurora-related phenomena that show patterns displaced about 4 degrees in latitude towards the night side of the earth.

The projection of the constant magnetic field (constant-B) contour at the equator down to the ionosphere using the magnetic field model has been shown in Figure 1. The B-value of the magnetic field has been selected to give an oval that is located near the equatorward border of the Feldstein and Starkov auroral oval. The equatorward border has been chosen in order to avoid the uncertainties in the field model near the dayside magnetopause. The calculated oval, taking into account external currents with parameters corresponding to rather quiet magnetic conditions, shows an offset of 2.5 degrees of latitude relative to the magnetic pole. Comparing this result with the above ovals based on observations, shows that the constant-B oval is displaced about 1.5 degrees less from the magnetic pole than the other ovals. Varying the parameters of the field model within reasonable limits for a quiet magnetosphere changes the center by less than 0.5 degrees.

![Fig. 1. Three oval displays in a geocentric coordinate system.](image)

1 - oval based on this study for December 21, 1960 at 0600 UT, with center at 79.0° of latitude;
2 - auroral orientation curve, center at 76.0°;
3 - corrected geomagnetic latitude for 70°, center at 81.5°.
SUMMARY. The constant B-ovals estimated from the Tayganenko and Usmanov magnetic field model for fields corresponding to the equatorward border of the auroral oval are displaced by 2.5 degrees of latitude towards the nightside of the earth (i.e. 5° closer to the magnetic pole on the dayside as compared to the nightside). This is somewhat less than the offset found in several auroral oval studies, which show a displacement of about 4.0 degrees. The present field model is rather insensitive to the variation of the parameters of the model. The center of the oval changes less than 0.5 degrees when varying the parameters corresponding to quiet magnetospheric conditions in the model. Calculations have also been carried out for parameters corresponding to disturbed magnetospheric conditions and the ovals are found to be concentric with those calculated for quiet conditions. However, as pointed out by Tayganenko (private communication) it is possible that an addition of a thin sheet current in the tail or an asymmetric ring current, will increase the offset. Both these currents may be physically significant and should be included in the model.

It should also be pointed out that the electric field has been neglected, which will have largest influence on particles of low magnetic moment.

The main conclusion from this study is that a considerable improvement in ordering of auroral data can be achieved, if a magnetic field model is used that includes external currents. The field model is estimated from "average" conditions which means that it is likely to represent only periods between substorms properly. It is also possible that future magnetic field models will include additional current systems which will improve the fit with auroral observations.

REFERENCES:


