"Physics of Auroral Phenomena", Proc. XIX Annual Seminar, Apatity, pp.101-102, 1996

Polar Geophysical Institute

MHD-MAGNETOSPHERIC BLOCK FOR THE GLOBAL NUMERICAL MODEL OF THE EARTH'S UPPER ATMOSPHERE

M.A.Volkov, O.V.Martynenko, A.A.Namgaladze
(Polar Geophysical Institute, Murmansk, Russia)

The global numerical model of the Earth's upper atmosphere [*Namgaladze et al.*, 1988, 1995] has been supplemented with a new magnetospheric block containing the magnetohydrodynamic continuity, momentum and energy balance equations for the magnetospheric plasma:

$$\mathrm{div}\, \hat{\Sigma}\mathbf{E} = -j_{//}\,; \tag{1}$$

$$j_{//} = \frac{1}{B}(\mathbf{e}_z[\nabla v, \nabla p])\,, \quad v = B\int_0^l \frac{dz}{B} \quad [\,\textit{Boström},\ 1975;\ \textit{Twerskoy}, 1982]\,; \tag{2}$$

$$n_i\, e(\mathbf{E} + \mathbf{v}_i \times \mathbf{B}) = \nabla p\,; \tag{3}$$

$$\frac{d}{dt}(pv^{\gamma}) = 0\,; \quad \gamma = 5/3\ [\,\textit{Baumjohann et al.},\ 1989]\,. \tag{4}$$

In these equations $j_{//}$ is the field-aligned current density, **E** and **B** are the electric and geomagnetic fields, $\hat{\Sigma}$ is the integrated ionospheric conductivity tensor, $\mathbf{e}_z$ is the field-aligned (along **B**) unit vector positive when directed from the northern hemisphere, v is a half-volume of the geomagnetic field tube having the unit cross-section at the ionospheric level, z is a distance along the geomagnetic field line, l is the value of z at the top of the geomagnetic field line, p is the magnetospheric ion gas pressure considered isotropic and constant along the geomagnetic field line, n_i is the magnetospheric ion concentration, $\mathbf{v}_i$ is the magnetospheric ion drift velocity, e is the electron charge. The magnetospheric electrons are considered cold and their pressure is neglected in comparison with that of the magnetospheric ions.

These equations have been added to the modelling equation system for the ion, electron and neutral gases of the ionosphere, protonosphere and thermosphere including the equation for the electric field potential to be solved jointly. The geomagnetic field is considered as a dipole one at latitudes equatorward from the polar cap boundary taken at the geomagnetic latitude of 74° and having the field lines opened inside the polar cap. The initial values of p and n_i have been taken as 2×10^{-11} Pa and 0.2 cm^{-3} everywhere in the magnetosphere at the initial time moment (00:00 UT) when the potential drop of 40 kV across the polar cap suddenly appears. After that this potential drop has been kept constant as well as the magnetospheric plasma pressure and ion density inside of the polar caps

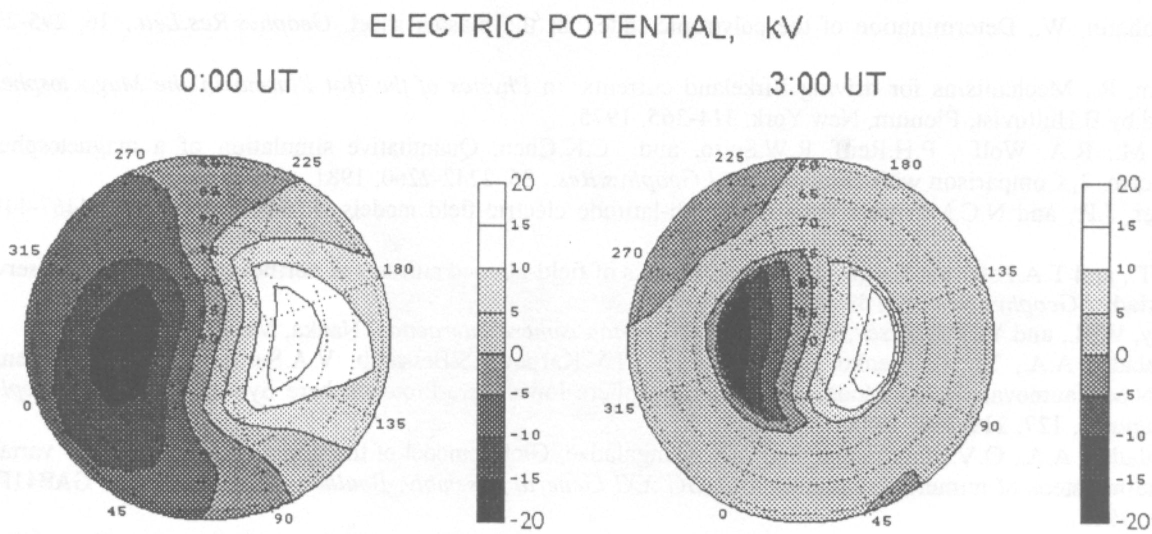

Fig.1. North polar geomagnetic plots (60-90°) of the calculated electric field potential at the ionospheric level. The sun position is at the top of the figure. The left plot shows the potential distribution at the initial time moment 00:00UT and the right plot shows the potential distribution at 03:00 UT.

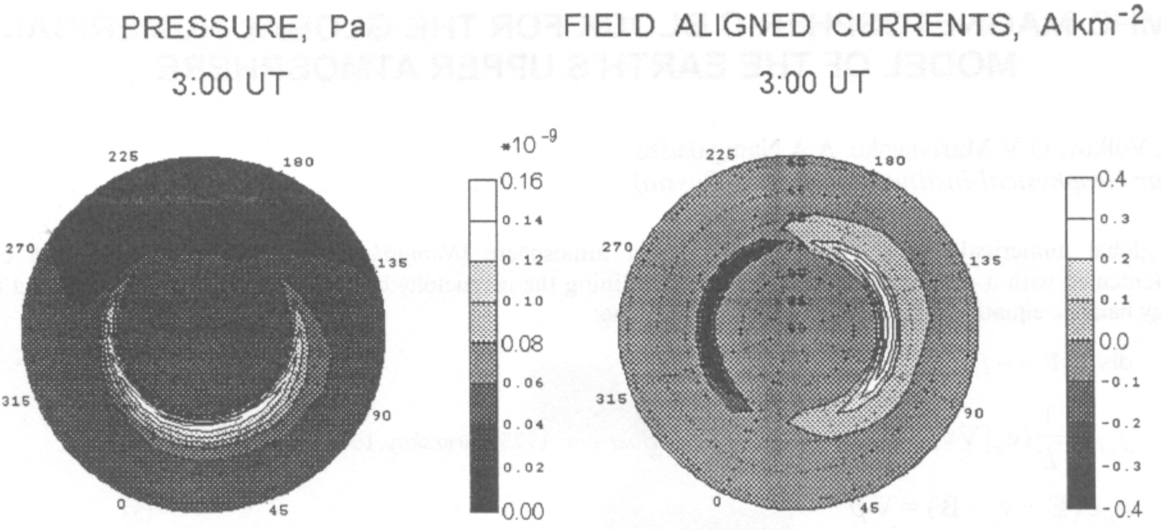

Fig.2. The same as in Fig.1 but for the calculated magnetospheric plasma pressure (left plot) and zone 2 field-aligned current density (right plot) at the time moment 03:00UT.

acting as electric field and plasma sources. As a sequence of this the redistribution of the plasma pressure takes place at the closed geomagnetic field lines leading to the plasma sheet and zone 2 field-aligned current formation. Some of the results of the numerical calculations are shown in Figs.1 and 2.

As we can see in Figs.1 and 2 the results of the calculations demonstrate good accordance with the well known experimental and theoretical data concerning development of the magnetospheric electric field potential, plasma sheet and zone 2 field-aligned currents [*Ijima and Potemra,* 1978; *Harel et al.,*1981; *Lyatsky and Maltsev,* 1983; *Pudovkin and Zakharov,* 1984; *Heppner and Maynard,* 1987; *Peymirat and Fontaine,* 1994]. It means that the global numerical model of the Earth's upper atmosphere [*Namgaladze et al.,* 1988, 1995] being supplemented with the MHD magnetospheric block (equations (1)-(4)) allows to investigate the responses of the Earth's upper atmosphere to the magnetospheric processes more self-consistently than earlier when, for example, the zone 2 field-aligned currents were not calculated but taken as given. We are planing to present the results of these investigations in our future publications.

References

Baumjohann, W., Determination of the polytropic index in the plasma sheet, *Geophys.Res.Lett.,* 16, 295-298, 1989.

Boström, R., Mechanisms for driving Birkeland currents, in *Physics of the Hot Plasma in the Magnetosphere,* edited by B.Hultqvist, Plenum, New York, 314-365, 1975.

Harel, M., R.A. Wolf , P.H.Reiff, R.W.Spiro, and C.K.Chen, Quantitative simulation of a magnetospheric substorm, 2, Comparison with observations, *J.Geophys.Res.,* 86, 2242-2260, 1981.

Heppner, J.P., and N.C.Maynard, Empirical high-latitude electric field models, *J.Geophys.Res.,* 92, 4467-4489, 1987.

Ijima, T., and T.A.Potemra, Large-scale characteristics of field-aligned currents at northern high latitudes observed by Triad, *J.Geophys.Res.,* 83, 599-615, 1978.

Lyatsky, W.B., and Yu.P.Maltsev, *The magnetosphere-ionosphere interaction*, Nauka, Moskow, 192 p., 1983.

Namgaladze A.A., Yu.N.Korenkov, V.V.Klimenko, I.V.Karpov,F.S.Bessarab, V.A.Surotkin, T.A.Glushchenko, and N.M.Naumova, Global Model of the Thermosphere-Ionosphere-Protonosphere System, *Pure and Applied Geophysics*, 127, 219-254, 1988.

Namgaladze, A.A., O.V.Martynenko, and A.N.Namgaladze, Global model of the upper atmosphere with variable latitudinal steps of numerical integration, *IUGG XXI General Assembly, Boulder, 1995, Abstracts,* GAB41F-6, B150, 1995.

Peymirat, C., and D.Fontaine, Numerical simulation of magnetospheric convection including the effect of field-aligned currents and electron precipitation, *J.Geophys.Res.,* 99, 11,155-11,176, 1994.

Pudovkin, M.I., and V.E.Zakharov, An inevsigation of the dynamic processes in the magnetospheric plasma, *Magnetosph.Investigations,* Sov.Radio, Moscow, No.3, 67, 1984.

Twerskoy, B.A., About field-aligned currents in the magnetosphere, *Geomagn.Aeronomy,* 22, 991-995, 1982.