Cellular model analogy of the magnetosphere-ionosphere substorm activity driven by solar wind with finite velocity of penetration into magnetosphere

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The cellular model as an analogy of the dynamic magnetosphere-ionosphere system related with the substorm activity is presented. Each cell in the model contains two connected parts, one of which may be associated with the magnetosphere current sheet pieces, and other – with ionosphere region at the same magnetic field line. The magnetospheric part of the model system is organised as a rectangular cellular automation with local redistribution of the stored energy from the cells where the threshold value is exceeded. We suppose that the threshold value in each cell depends on external driver (solar wind parameters) which influences on the long boundaries of the rectangular array. The finite velocity is assumed for the influence penetration into the array and along boundaries.
Observational studies of magnetospheric activity suggest that the magnetosphere-ionosphere coupling plays a critical role in the physical processes leading up to substorm onset. The local reallocation of energy in the magnetosphere causes a local change of conductivity of the ionosphere in the same magnetic tube (the particles, diffused by pitch-angle, are precipitated in the loss-cone along the magnetic field, and ionize atmospheric gases). In turn, the ionospheric conductivity influences the value of energy, which may be reallocated in the magnetic tube at the following time moment. This positive feedback has been included in the model also. The state (conductivity) of the ionospheric part of a cell is supposed to depend on the cell history (by analogy with the recombination coefficient).
Dynamics of the model for different parameters and for driving by real Bz IMF is discussed. The model demonstrates the small-scale transients which are directly driven by Bz, and the large-scale transients which depends on the system history also. The onsets of the large scale-transients (which associate with substorms) are occurred at the different positions in the array (as near Earth as tailward).
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