Phase transition-like behavior of the magnetosphere during substorms

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The behavior of substorms as sudden transitions of the magnetosphere is studied using the Bargatze et al. [1985] data set of the solar wind induced electric field vBs and the auroral electrojet index AL. The data set is divided into three subsets representing different levels of activity, and they are studied using the singular spectrum analysis. The points representing the evolution of the magnetosphere in the subspace of the eigenvectors corresponding to the three largest eigenvalues can be approximated by two-dimensional manifolds with a relative deviation of 10-20%. For the first two subsets corresponding to small and medium activity levels the manifolds have a pleated structure typical of the cusp catastrophe. The dynamics of the magnetosphere near these pleated structures resembles the hysteresis phenomenon typical of first-order phase transitions. The reconstructed manifold is similar to the "temperature-pressure-density" diagrams of equilibrium phase transitions. The singular s