Nonlinear Processes
in Geophysics

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Interactive comment on "Nonlinear vortex solution for perturbations in the Earth's Ionosphere" *by* Miroslava Vukcevic and Luka Č. Popović

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We are grateful to all comments given by Referee. We hope that our answers will improve our manuscript and make it more undersrtandable. 1. "I am very surprised by this application of conventions and for- malism of neutral atmosphere to plasma environment. Electromagnetic effects are dominant in the ionosphere. Well-studied approximations and corresponding transport equations are described in textbooks. One of the latest and highly regarded is Schunk, R. W., & Nagy, A. F. (2009). Ionospheres: Physics, plasma physics and chem- istry (2nd ed.). Cambridge, UK: Cambridge University Press." Answer: We have not applied formalism of neutral atmosphere to plasma environment. We have considered ionosphere as ionized gas with certain degree of ionization; in higher altitudes ionization becomes higher and effects in F region are

predominant by electromagnetic force. However, formalism in our manuscript agrees in all steps with the formalism given in mentioned reference: Schunk, R. W., & Nagy, A. F. (2009). Ionospheres: Physics, plasma physics and chemistry (2nd ed.). Cambridge, UK: Cambridge University Press. Namely, we treat one fluid but conducting gas. Interaction between neutrals and charged particles is given by conductivity tensor as result of collision between these particles. Even more, we have discussed separate influence of ions and electrons due to their different mass. If necessary, we can add one more appendix in the manuscript with brief derivation of the equation (2) in the manuscript, which coincide with (7.32) in the reference, after application of the equations (7.44) and after. Simplification of the general MHD equations is necessary because they are rather complicated, as mentioned in the reference. 2. "It is well-accepted that main drivers for the ionosphere-thermosphere (that is a neutral counter-part) are related to space weather and complex electrodynamic coupling with the solar wind and the Earth's magnetosphere. Driving by lower atmosphere (tides, acoustic gravity waves) contributes to the ionospheric dynamics, e.g., Immel, T. J., E. Sagawa, S. L. England...." Answer: The aim of the paper is not to discuss any of drivers of the ionosphere but to derive strict analytical solution of simplified but still valid model of ionosphere and to use this type of solution in order to explain and follow up either of mentioned drivers or some phenomena detected within the ionosphere. Also, we have found the condition for the derived solution, in terms that ad hock assumption of the constant thickness of the ionospheric layer can be misused in conclusion. It is similar with Jeans assumption on the constant density for the unstable gas cloud, leading to the condition of the wavelength of instability (and consequently to the frequency) that contradict to the initial assumption. That is why this type of approach has been used. 3. "However, gravitational (and Coriolis force) influence on the ionosphere is negligible compared to electrodynamical processes. " Answer: This conclusion is not in contradiction what we have derived, but not for all ionosphere long. Equations (8), (9), (10) and (11) are used to discuss influence by rotation and electromagnetic force via exact values of concentration of charged particle n and gas density rho, which can be under-

stood as ionization degree (see discussion I, II and III for each layer separately). 4. "In my opinion, the manuscript is an interesting theoretical exercise, but I will wait for conclusive observations of vortex structures in the ionosphere. " Answer: We hope that the Referee is assured (answer 2) that this unusual approach is not just for exercise and elegance but rather for re-investigation of the assumption used for many years in number of publications. We underline that the aim of the paper is not to support ionosphere as a whole but to offer 'simple' solution for general probe of the ionosphere dynamics as a control for input parameter in simulations or to explain density/charge particles drop that are observed in many measurements of the ionosphere. Enhancement of the potential given in the figures means that density depletion follows the same shape since particles are trapped within that potential. It confirms even the reference suggested by Referee "L. J. Pax- ton (2006), Control of equatorial ionospheric morphology by atmospheric tides, Geo- phys. Res. Lett., 33, L15108, doi:10.1029/2006GL026161" as well as some others given in the paper: Yumoto K., Ishitsuka M. & Kudeki E. 2002, Geophys. Res. Lett. 29, No. 12, 1596. We have not mentioned many of them as aurora borealis and so. We hope that Referee will find our answers useful. If there is any more, we will try to answer.

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