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SCIENTIFIC INVESTIGATIONS

Generalized SemiKinetic (GSK) Model

The basic semikinetic model has been revised, incorporating new techniques which greatly improve its performance. The revised model is described in a paper recently submitted to the Journal of Computational Physics [Ref. 1].

We have modified an O^+ transport code to add wave heating. This code has been used to carry out local calculations of the effects of wave heating in a collisional environment.

The JGR paper on GSK modeling of the synergistic interaction of transverse heating of ionospheric ions and magnetospheric plasma-driven electric potentials on the auroral plasma transport [Ref. 2] was accepted and should appear shortly.

The GSK papers on effects of auroral precipitation on ionospheric plasma outflows [Ref. 3], on **E**×**B** effects on such outflows [Ref. 4], and warm trapped ion thermalization by Coulomb collisions with dense plasmaspheric ions [Ref. 5] were submitted and accepted for publication in the AGU monograph on "Cross-Scale Coupling in Space Plasmas" [Ref. 6]. This monograph should be published and distributed to all workshop participants in the November-December 1995 time frame.

Our paper on substorm dipolarization effects on middle magnetosphere plasma sheet plasmas [Ref. 7] was submitted, reviewed, revised, and has just been returned to JGR. A further paper [Ref. 8] concerned with the simulation of dipolarization-driven ionospheric outflows is being readied for submission to GRL.

Field-Aligned Flows and Trapped Ion Distributions

The JGR submission [Ref. 9] on the statistical study of the L ~ 4.6 streaming-trapped ion interface in the equatorial magnetosphere was further revised, but still elicited concerns from one of the referees. We have withdrawn this paper temporarily, with the intent of revising it and re-submitting in the next few months. Our further analysis to characterize the near-equatorial trapped ion distributions as bi-Maxwellian distributions has been temporarily stalled awaiting

resolution of differences between analysis results from the programs employed by B. Giles and by S. Boardsen.

A paper on the detailed model-data comparison of F-region ionospheric features as subjected to measured soft-electron precipitation and convection-driven frictional ion heating was submitted to GRL [Ref. 10]. Referees' comments were received, the paper was revised accordingly and sent back to GRL, a further minor comment by one referee was received, and the paper further revised and sent back. We expect that the paper will now be accepted by GRL.

Plasmasphere-Ionosphere Coupling

Our initial study of thermal conductivity in a low density plasma flux tube has been concluded. In this study we proposed that when ion mean free paths extended from the location of interest to or beyond the ionosphere, only those particles in the loss cone would be effective transporters of heat out of the plasmasphere, since other particles would be trapped and retain the heat in the plasmasphere. We derived a simple mathematical model to represent this situation and applied it in place of the standard Spitzer-Harm thermal conductivity coefficient. Heat conduction was significantly reduced, so that less heat was required in the simulations to raise ion temperatures at high altitudes to observed levels, simulated temperatures at low altitudes were lower, and simulated concentrations of O^+ at high altitudes were reduced to levels much closer to those observed. These results were described in a paper [Ref. 11] submitted to GRL; it has subsequently been revised in accordance with referee comments, returned, and accepted. A paper [Ref. 12] on this topic was also presented to the IUGG meeting in Boulder, CO.

In the study of temperature profiles based only on heat flow [Ref. 13], with a Spitzer-Harm thermal conductivity, we have reassessed our original intent. Based on comparisons of FLIP simulations with the analytical profiles, which was motivated by referee comments, we find that the source terms (primarily heating from photoelectron-heated thermal electrons) in the energy equation are significant, particularly in the daytime, to the extent that they cannot be ignored in determining a temperature profile. We have withdrawn our original paper to Annales Geophysica and are revising it substantially. The new paper will probably be submitted to JGR.

HARDWARE

SCIFER and TIDE

We have both assisted in initial analysis of TECHS electron data from the January 25, 1995 SCIFER launch and have participated extensively in TIDE calibration activities.

MEETINGS

Dr. Horwitz presented an invited talk on "Multiscale Processes in Ionospheric Outflows" at the Cambridge Symposium on Multi-Scale Phenomena in Space Plasmas in Bermuda, in February 20-25, 1995, and his paper has been submitted for publication in the proceedings [Ref. 14]. Four students---Dan Ober, Yi-Jiun Su, Jinsoo Lee, and Ron Caton---also attended, largely at conference expense, and three presented posters which were submitted as papers for the proceedings. These concerned modeling of the effects of SAID on the plasmasphere [Ref. 15], evolution of compressed Alfven wave trains [Ref. 16],and degradation of warm trapped ion populations in the plasmasphere [Ref. 17]. Drs. Horwitz and Liu and Mr. Ober also presented papers at the Spring AGU meeting [Refs. 18-20]. Ms. Su and Mr. Caton attended the CEDAR meeting and Mr. Caton presented a poster on ionospheric upflows[Ref. 21].

Dr. Comfort attended the XXI General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Boulder, CO, July 2-14, 1995. He was author or co-author of 4 papers presented to various IAGA (International Association of Geomagnetism and Aeronomy) symposia there [Refs. 12, 22-24]. He was also co-author of a paper presented to the Spring AGU Meeting [Ref. 33].

PUBLICATIONS

In addition to those noted above, the following papers are at the indicated stage in the publication cycle:

Papers published:

The IUGG 1991-4 Quadrennial report on ionospheric plasmas in the magnetosphere [Ref. 25]; and the study on ray tracing of Pc3 Alfven waves [Ref. 26]; and the paper on centrifugally accelerated polar O+ outflows [Ref. 27].

Papers accepted and in press:

The paper on plasmasphere thermal structure [Ref. 28]; the kinetic study of the transition from collisional to collisionless ion outflow [Ref. 29]; modeling of the azimuthal variation of the plasmapause [Ref. 30]; problems in simulating ion temperatures in low density plasma flux tubes [Ref. 31]; and the effects of nonlocal collisions on ion distribution functions [Ref. 32]

REFERENCES

1. Wilson, G. R., J. L. Horwitz, C. W. Ho, and D. Brown, Time-dependent semikinetic (hybrid) modeling of mesoscale plasma transport, submitted to J. Comp. Phys., 1995.
2. Brown, D. G., J. L. Horwitz, and G. R. Wilson, Synergistic effects of hot plasma-driven potentials and wave-driven ion heating on auroral ionospheric plasma transport, *J Geophys. Res.*, in press, 1994.
3. Brown, D. G., P. G. Richards, G. R. Wilson, J. L. Horwitz, and C. W. Ho, Effects of precipitating auroral electrons on ionospheric plasma transport: A dynamic semikinetic model,

AGU monograph on *Cross-scale Coupling in Space Plasmas*, in press, ed. J. L. Horwitz, N. Singh, and J. L. Burch, 1995.

4. Ho, C. W., J. L. Horwitz, G. R. Wilson, and D. G. Brown, Field-aligned transport of ionospheric O^+ ions from 200 km to 1 R_E due to **E**×**B** convection heating and centrifugal acceleration: A generalized SemiKinetic (GSK) treatment, AGU monograph on *Cross-scale Coupling in Space Plasmas*, in press, ed. J. L. Horwitz, N. Singh, and J. L. Burch, 1995.
5. Lee, J., J. L. Horwitz, G. R. Wilson, J. Lin, and D. G. Brown, On the interaction of cold ionospheric plasma inflows with the preexisting equatorial warm plasmas on inner magnetospheric flux tubes: warm plasma thermalization and effects of varying ionospheric inflow speeds, AGU monograph on *Cross-scale Coupling in Space Plasmas*, ed. J. L. Horwitz, N. Singh, and J. L. Burch, in press, 1995.
6. Horwitz, J. L., N. Singh, and J. L. Burch (editors), "Cross-Scale Coupling Processes in Space Plasmas", American Geophysical Union Monograph, Washington, D. C., in press, 1995.
7. Liu, C. and J. L. Horwitz, Formation of low-energy trapped and field-aligned ion populations during substorm dipolarization events, submitted to *J Geophys. Res.*, 1995.
8. Liu, C., and J. L. Horwitz, Simulation of ionospheric outflows driven by substorm dipolarization events, to be submitted to *Geophys. Res. Lett.*,, 1995.
9. Lin., J., J. L. Horwitz, D. L. Gallagher, and C. J. Pollock, Streaming/trapped ion interface in the equatorial inner magnetosphere, submitted to *J. Geophys. Res.*, 1995.
10. Liu, C., J. L. Horwitz, and P. G. Richards, Effects of convection ion heating and soft-electron precipitation on high-latitude F-region upflows, *Geophys. Res. Lett.*, in press, 1995.
11. Comfort, R. H., and P. D. Craven, Modification of thermal conductivity for outer plasmasphere, low density flux tubes, *Geophys. Res. Lett.*, in press, 1995.
12. Comfort, R. H., P. G. Richards, and P. D. Craven, Inner magnetosphere ion thermal conductivity modified for low densities, presented to *Symposium GA2.14/G3.04 Inner Magnetosphere: Ring Current, Radiation Belts, and Plasmasphere*, International Union of Geodesy and Geophysics, XXI General Assembly, Boulder, CO, USA, July 2-14, 1995.
13. Neergaard, L. F., J. L. Horwitz, R. H. Comfort, and P. C. Anderson, Dual spacecraft estimates of semi-analytic temperature profiles and heat flows, submitted to *Ann. Geophys.*, 1994.
14. Horwitz, J. L., Multiscale processes in ionospheric outflows, submitted for *Physics of Space Plasmas*, Cambridge, MA, 1995.
15. Ober, D., J. L. Horwitz, and D. L. Gallagher, Convection effects on global plasmasphere evolution, submitted for *Physics of Space Plasmas*, Cambridge, MA, 1995.
16. Su, Y.-J., L. H. Lyu, and J. L. Horwitz, The evolution of nonlinear compressed Alfven wave trains, submitted for *Physics of Space Plasmas*, Cambridge, MA, 1995.
17. Lee, J., J. L. Horwitz, G. R. Wilson, J. Lin, and D. G. Brown, GSK simulation of warm ion thermalization on inner magnetospheric flux tubes, submitted for *Physics of Space Plasmas*, Cambridge, MA, 1995.
18. Horwitz, J. L., C. Liu, and P. G. Richards, Effects of convection ion heating and soft-electron precipitation on high-latitude F-region upflows, *EOS, 76*, S265, 1995; presented to the Spring Meeting of the American Geophysical Union, Baltimore, MD, May 30-June 2,1995.

19. Liu, C. and J. L. Horwitz, Formation of low-energy trapped and field-aligned ion populations during substorm dipolarization events, *EOS, 76*, S262, 1995; presented to the Spring Meeting of the American Geophysical Union, Baltimore, MD, May 30-June 2,1995.
20. Ober, D., J. L. Horwitz, and D. L. Gallagher, Global plasmasphere evolution during a subauroral ion drift (SAID) event, *EOS, 76*, S243, 1995; presented to the Spring Meeting of the American Geophysical Union, Baltimore, MD, May 30-June 2,1995.
21. Caton, R., J. L. Horwitz, C. Liu, and P. G. Richards, Effects of convection ion heating and soft-electron precipitation on high-latitude F-region upflows, presented at CEDAR meeting, Boulder, Co., 1995.
22. Richards, P. G., R. H. Comfort, and D. G. Torr, Simulation of nighttime electron temperature enhancements over Millstone Hill, presented to *Symposium GA2.14/G3.04 Inner Magnetosphere: Ring Current, Radiation Belts, and Plasmasphere*, International Union of Geodesy and Geophysics, XXI General Assembly, Boulder, CO, USA, July 2-14, 1995.
23. Gallagher, D. L., P. D. Craven, R. H. Comfort, J. L. Green, and S. F. Fung, Remote observations of the Earth's plasmasphere, presented to *Symposium GA3.14 Magnetospheric models and their critical evaluation*, International Union of Geodesy and Geophysics, XXI General Assembly, Boulder, CO, USA, July 2-14, 1995.
24. Gallagher, D. L., P. D. Craven, and R. H. Comfort, Modeling of the Earth's Plasmasphere, presented to *Symposium GA3.13 Modeling and Theory for Mission Design and data Interpretation*, International Union of Geodesy and Geophysics, XXI General Assembly, Boulder, CO, USA, July 2-14, 1995.
25. Horwitz, J. L., The ionosphere's wild ride in outer space, *Rev. Geophys.*, Suppl. , 703, 1995.
26. Zhang, X., R. H. Comfort, D. L. Gallagher, J. L. Green, Z. E. Musielak, and T. E. Moore, Magnetospheric filter effect for Pc 3 Alfven mode waves, *J. Geophys. Res.*, *100*, 9585, 1995.
27. Ho, C. W., J. L. Horwitz, and T. E. Moore, Observations and simulations of centrifugally-accelerated polar O+ outflows, *Proceedings of theSecond International Conference on Substorms*, ed. J. R. Kan, J. D. Craven and S.-I. Akasofu, 577, 1995.
28. Comfort, R. H., Thermal structure of the plasmasphere, *Adv. Space Res.*, in press, 1995.
29. Wilson, G. R. , B. L. Giles, and M. O. Chandler, Collisional to collisionless ion outflow at the ionosphere-magnetosphere interface, *Adv. Space Res.*, in press, 1995.
30. Gallagher, D. L., P. D. Craven, R. H. Comfort, and T. E. Moore, On the azimuthal variation of the equatorial plasmapause, *J. Geophys. Res.*, in press, 1994.
31. Comfort, R. H., Problems in simulating ion temperatures in low density flux tubes, AGU monograph on *Cross-scale Coupling in Space Plasmas*, in press, ed. J. L. Horwitz, N. Singh, and J. L. Burch, 1995.
32. Wilson, G. R., The development of non-Maxwellian velocity distributions as a consequence of nonlocal Coulomb collisions, in *Cross-Scale Coupling in Space Plasmas,* AGU Monograph, ed. J. L. Horwitz, N. Singh, and J. L. Burch, in press, 1995.
33. Richards, P. G., R. H. Comfort, and D. G. Torr, Simulation of nighttime electron temperature enhancements over Millstone Hill, *EOS, 76*, S243, 1995; presented to the Spring Meeting of the American Geophysical Union, Baltimore, MD, May 30-June 2,1995.