Structure functions and intermittency in ionospheric plasma turbulence

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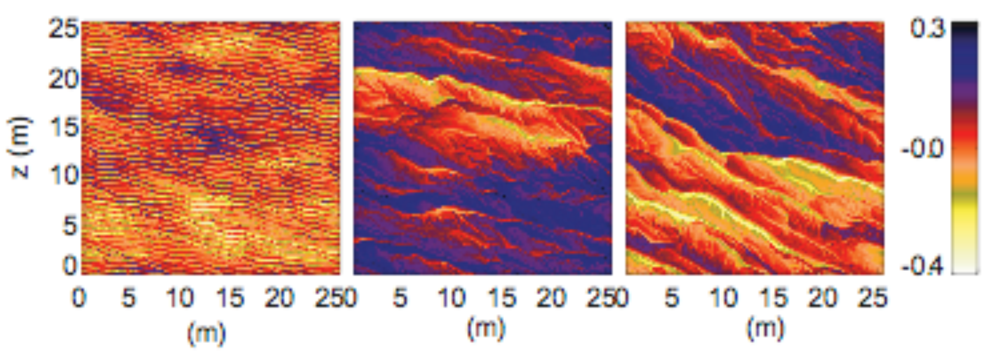
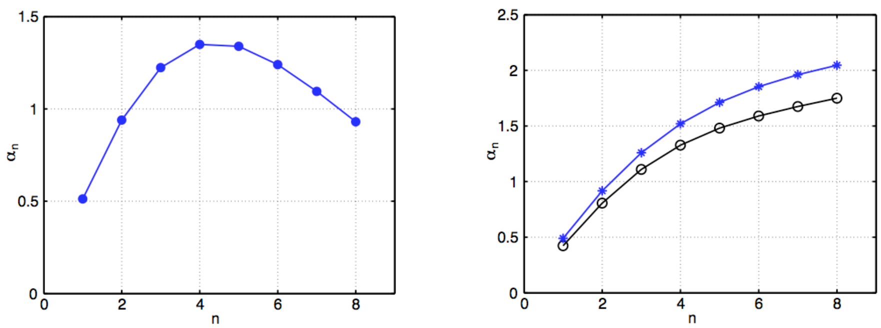
Abstract

Low frequency electrostatic turbulence in the ionospheric E-region is studied by numerical and experimental methods. We use the structure functions obtained for the electrostatic potential as diagnostics of the fluctuations, and demonstrate an inherently intermittent nature of the low level turbulence in the collisional ionospheric plasma using results from two dimensional numerical simulations [1]. It is, however, evident that an instrumented rocket, because of a lacking ground potential reference can not directly detect the one-point signal analyzed here. We also demonstrate that standard potential difference measurements give significantly different results. It was found, in particular, that the intermittency signatures become much weaker, when the proper probe configuration is implemented. We analyze also signals from an actual ionospheric rocket experiment, and find a reasonably good agreement with the appropriate simulation results, demonstrating again that rocket data, obtained as those analyzed here, are unlikely to give an adequate representation of intermittent features of the low frequency ionospheric plasma turbulence for the given conditions.

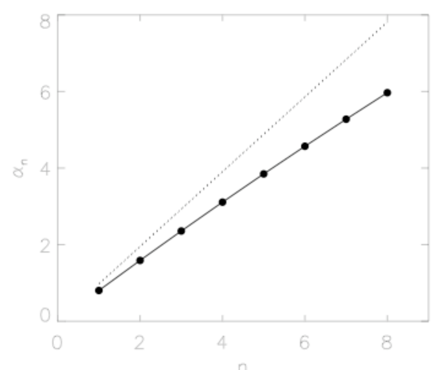


The figure shows the spatial variation of the numerically simulated electrostatic potential for three different times, where the last two are in the saturated stage of the Farley-Buneman instability.

We have demonstrated the presence of a power-law subrange for the structure functions associated with the electrostatic potential in turbulent plasma fluctuations for conditions appropriate for the ionospheric *E*-region. We found clear indications for intermittent fluctuations in the sense that the power-law index for the structure functions of order n deviated from a simple n-proportionality. In order to identify the *physical* reason for the intermittency, we give particular attention to the secondary instabilities developing on the gradients of the large scale structures.



The figures show the power law exponent α_n variation with varying order n for one-point signal (left) and for the two-point time varying potential difference signal (right) obtained for 3 m position separation in the numerical simulations. We note the significant difference between the two representations. We take this as an indication that intermittency effects are present in the simulations, but are difficult to identify by potential difference measurements as those carried out by instrumented rockets.



The last figure shows the power law variation with varying order n for the two-point time varying potential difference signal obtained for 3.6 m probe separation on the Rose-4 rocket [2], launched in 1989 from Kiruna. We find an almost linear relationship between α_n and n, demonstrating again that intermittency effects will be difficult to identify with the present probe set-up for the instability studied here.

References

1 L. Dyrud, B. Krane, M. Oppenheim, H. L. Pécseli, K. Schlegel, J. Trulsen, and A. W. Wernik, " Low-Frequency Electrostatic Waves in the Ionospheric E-Region: a Comparison of Rocket Observations and Numerical Simulations", *Ann. Geophysicae*, **24**, 2006, pp. 2959-2979.

2 G. Rose, K. Schlegel, K. Rinnert, H. Kohl, E. Nielsen, G. Dehmel, A. Friker, F. J. Lubken, H. Lühr, E. Neske, and A. Steinweg, "The ROSE project - scientific objectives and discussion of 1st results", *J. Atmos.Terr. Phys.*, **54,** 1992, pp. 657–667.