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Exploring the Multi-Scale Statistical Analysis of Ionospheric Scintillation via Wavelets and Empirical Mode Decomposition

Mirko Piersanti (1), Massimo Materassi (2), Luca Spogli (3), Antonio Cicone (4), and Tommaso Alberti (5)

(1) University of L'Aquila, Department of Physical and Chemical Sciences, L'Aquila, Italy (mirko.piersanti@aquila.infn.it), (2) National Research Council, Institute for Complex Systems ISC-CNR, Italy, (3) National Institute for Geophysics and Volcanology INGV, Italy , (4) Department of Information Engineering, Computer Science and Mathematics, University of L'Aquila, Italy., (5) Dipartimento di Fisica, Università della Calabria, Rende (CS), Italy

Highly irregular fluctuations of the power of trans-ionospheric GNSS signals, namely radio power scintillation, are, at least to a large extent, the effect of ionospheric plasma turbulence, a by-product of the non-linear and non-stationary evolution of the plasma fields defining the Earth's upper atmosphere. One could expect the ionospheric turbulence characteristics of inter-scale coupling, local randomness and high time variability to be inherited by the scintillation on radio signals crossing the medium. On this basis, the remote sensing of local features of the turbulent plasma could be expected as feasible by studying radio scintillation.
The dependence of the statistical properties of the medium fluctuations on the space- and time-scale is the distinctive character of intermittent turbulent media. In this paper, a multi-scale statistical analysis of some samples of GPS radio scintillation is presented: the idea is that assessing how the statistics of signal fluctuations vary with time scale under different Helio-Geophysical conditions will be of help in understanding the corresponding multi-scale statistics of the turbulent medium causing that scintillation. In particular, two techniques are tested as multi-scale decomposition schemes of the signals: the discrete wavelet analysis and the Empirical Mode Decomposition. The discussion of the results of the one analysis versus the other will be presented, trying to highlight benefits and limits of each scheme, also under suitably different helio-geophysical conditions.