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# Chaos and Predictability in vTEC time series

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Modeling the Earth's ionosphere is a big challenge, due to the complexity of the system. Any ionospheric model misses the behavior of the real system for some fluctuating component, that appears almost impossible to predict, and is particularly threatening for the human technologies (e.g., GNSS navigation). While producing models extremely rich, including many physical agents acting on the Earth's ionosphere, it is necessary to understand whether the residual, non-modeled component is predictable in principle as a "simple" dynamical system, or is conversely *so chaotic to be practically stochastic*, and should be treated probabilistically.

The question of how chaotic and how predictable the time series of *vertical total electron content* (vTEC) are, depending on the different locations and solar activity conditions, is dealt with by employing tools of dynamical system theory.

In particular, we calculate the correlation dimension $D_2$ and the Kolmogorov entropy rate $K_2$ for the vTEC time series at different latitudes in both northern and southern hemispheres and during both high and low solar activity periods.

The quantity $D_2$ is a proxy of the degree of chaos and dynamical complexity: the larger $D_2$ is, the higher the number of dynamical variables needed to describe the phenomenon is. Instead, $K_2$ measures the speed of destruction of the mutual information between the signal and a delayed copy of it, so that $(K_2)^{-1}$ is a sort of maximum time horizon for predictability.

The analysis of the $D_2$ and $K_2$ for the vTEC time series will then allow to give a measure of chaos and predictability of the Earth ionosphere. Being such analysis performed for different locations and different solar activity conditions, these characteristics will indicate possible differences depending on location.