Waves In Random & Complex Environments : A Stochastic Approach .

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In this paper we propose a methodology for the study of some issues in probabilistic interpretation of polarized waves propagating in Random and Complex Environments (RCE) which present heterogeneities and are not known precisely. Typical examples of these RCE are atmospheric turbulence, ionospheric irregularities, and rainfall, among others.

Firstly, turbulence (irregular phenomena related to flows in gases and liquids) although having been studied extensively, remains one of the principal unsolved conceptual problems in many applications like wave propagation in atmosphere and oceans, meteorology, and astrophysics. Difficulties in the theory of turbulence are mainly due to nonlinear interactions between motions on different spatial and temporary scales which generate random flow fields; moreover, these turbulent flows may be affected by spatial anisotropy as is the case in geophysics (the anisotropic irregularities in the ionosphere are aligned with the terrestrial magnetic field) and astrophysics (anisotropic turbulence in the interstellar medium and solar wind due to the presence of strong and quasi-uniform magnetic fields).

Secondly, ionospheric irregularities and their effects on radio systems represent an important topic in many areas, as is well-known for example, in long-distance radio-communications and in ionospheric probing. The main reason of this topic is the high ionization variability in space (low, middle, high latitudes) and time (time of day, season, year) of the ionosphere (ionized layers at latitudes ranging from roughly 90 to 500 km), also called Space Weather, that is driven by solar and geomagnetic disturbances. Space weather phenomena like solar flares or coronal mass ejections, eject energetic radiations (UV radiation, X-rays and particles) towards the Earth and may lead, for example at high latitudes, to various effects such as Polar Cap absorption which can totally "blackout" the whole HF band for many days, Auroral absorption, signal Doppler spread, or signal rapid and deep fading (scintillation effects). Some other significant effects are also of importance to mention particularly to satellites operators, like energetic charged particles which can cause risks to onboard electronics (surface charging and electrostatic discharge), thermal expansion of Earth's atmosphere increases drag on objects in low Earth orbit, which can lead to shortening the working lifetime of operational satellites, or GPS signals which may be affected, leading to signal timing and position errors.. Moreover, data from some satellite observations can also be affected over a large range of spatial (~ few km to 1000 km) and temporal (~ 1 to 15 mn) scales. In many applications including HF communications, a reliable performance requires statistically accurate ionosheric predictions under all kind of geophysical conditions at all times. Hence, in order to reach a better quantitative understanding of the mechanisms of such effects, It is crucial to know how to characterize ionospheric variability. Despite the large number of publications devoted to this topic, many practical problems and theoretical open questions with different levels of complexity still exist.

The radiative transfer theory (or transport theory) generalized to include polarization effects, and based on Markovian Jump Processes, is used to describe the electromagnetic wave-energy propagation through the previous random and complex environments. Some applications and their results will be presented and discussed, as well as the validity of their predictions.