Alternate Formalism for Computing Likelihood of Scintillation Effect from Inferred Vertical Drift in the Absence of Direct Measurements

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ABSTRACT

Vertical plasma transport process in the ionospheric equatorial region is known to be controlled by the equatorial zonal electric fields, which drives the *EEJ* current and consequently, the equatorial ionization anomaly. At night-time, the electric fields uplifts the plasma to greater heights thus increasing the linear instability growth rate of spread-F instabilities (*ESF*) and/or scintillation effect [1]. Scintillation effect, if not well monitored/forecasted can have devastating effect on radio frequency signals. In this work, the alternate method of computing and investigating the likelihood of ionospheric scintillation effect was effected. This was done using available and computed ionospheric F-layer height profile (*h'F*) data and the vertical plasma drift (V_d) pattern obtained from the height profile in the absence of direct drift measurement.

The data used was made available by the Ecole Nationale Sup´erieure de T´el´ecommunications de Bretagne (ENST Bretagne) database, and comprises of *h'F* observations obtained from Ouagadougou (12^{0}N, 357^{0}E), a station in the African equatorial ionization anomaly trough, for a period of 32 years (1966 – 1998) covering sunspot cycles (*SCs*) 20 -22. The hourly monthly mean value of *h'F* for each night-time hour were computed from the daily values. Vertical drift velocities were then computed by measuring the time rate of change of *h'F* from this hourly monthly mean values (*d(h'F)/dt*) [see 2]. However, for the scintillation observation, daily values of *h'F* around the post-sunset period which were manually traced out were employed for the entire 32 years, so as to give a better interpretation of the effect; since it is a daily phenomenon.

Only the evening/night-time (16 – 06 LT) observations were considered. This is because [3] had highlighted some physical limitations to inferring drift pattern from *h'F* during the daytime. Our drift observations revolved around the evening time pre-reversal enhancement (*PRE*) period since there is a direct link between *PRE* and *ESF* or/and Scintillation effect [4], either as inhibiting/seeding mechanism. Seasonal and annual observations were considered. To make up for uniformity in the analysis, the percentage rate of scintillation inhibition was calculated for the seasonal and annual observations following the assertions of [5] by satisfying certain conditions.

The result obtained for the drift showed a good relationship between the PRE peak and sunspot number (*Rz*) having a correlation percentage of 98.7, projecting well with the 11-year sunspot cycle evolution for each of the SCs considered (Figure 1)

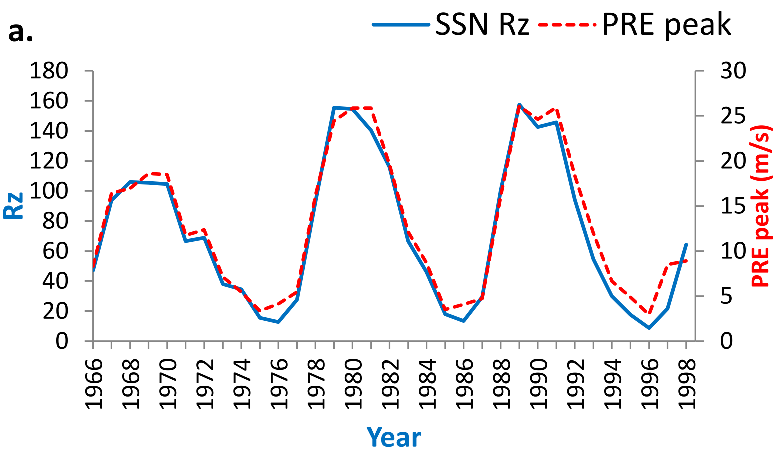


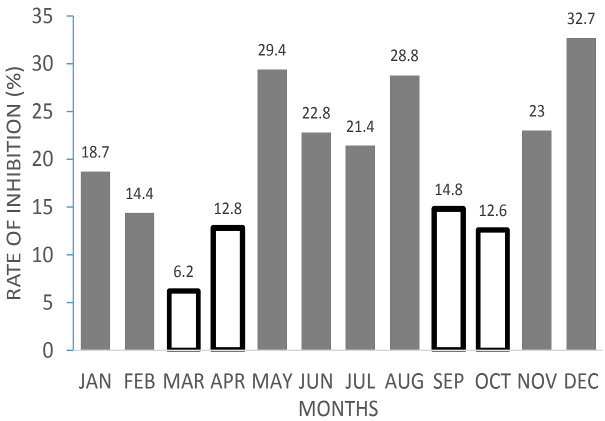
Figure 1: 11-year sunspot cycle evolution relationship between PRE peak velocity and sunspot number.

A mathematical model equation of the form

$$peak\ PRE = 0.1582Rz + 1.495 \tag{1}$$

was developed for the relationship, which performed excellently when reviewed with another equatorial station dataset in the African sector, and hence may be incorporated into the African regional model. For the inhibition rate of scintillation, it minimizes/maximizes at sunspot maximum/minimum, and increases/decreases at descending/ascending phases of sunspot activities (Figure 2b). The inhibiting rate was also lower during equinoxes that during solstices (Figure 2a). This is consistent with the report of [4] who suggested that scintillation is higher during equinox than the solstice.

In conclusion, the formalism used in the computation and analysis of the inhibiting characteristics of scintillation effect in this study had proven to be reliable, if it can be employed in the absence of direct scintillation measurements. The only likely limitation to the methodology is in its manual tracing, which may take longer time to compute. The trendline shown in Figure (2b) revealed that the rate of inhibition of scintillation effect is reducing right from SC 20 through 22. This may be a big concern/threat for our communication operators with respect to signal generation. This by implication suggests increased activity of communication network distortion.



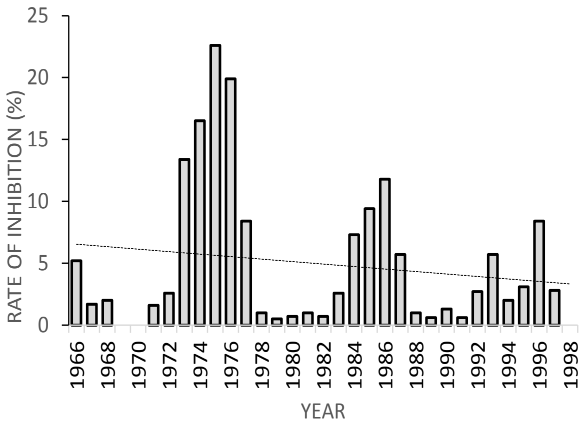


Figure 2: (LHS) 32-year average seasonal rate of inhibition of the likelihood of scintillation effect. The white/black bars are the equinox/solstice seasons. (RHS) Annual rate of inhibition of scintillation effect. The dotted line across the plot shows the trendline in the inhibition activity from sunspot cycle 20 through 22.

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