Possible relation between the tropical lightning chimneys and the wavenumber-4 structure in the thermosphere/ionosphere

G. Sátori[1], P. Ortega[2], A. Guha[3], E. Williams[4]

[1] *Research Centre for Astronomy and Earth Sciences, Geodetic and Geophysical Institute, Sopron, Hungary*
[2] *Laboratory GEPASUD, Univ. of French Polynesia, Tahiti, French Polynesia*
[3] *Department of Physics, Tripura University, Tripura, India*
[4] *Parsons Laboratory, Massachusetts Institute of Technology , Cambridge, MA 02139 , USA*

The wavenumber-4 (WN-4) structure appears both in the thermosphere (neutral) and ionosphere parameters observed around the Earth above the near-equatorial zone. The WN-4 structure is attributed to latent heat release in deep tropospheric convection in the equatorial region where the three main tropical lightning chimneys are found. In addition to the three known chimneys (Africa, America, Maritime Continent), a smaller fourth chimney can be identified near Tahiti, in the Pacific Ocean. Some common features between the thermospheric/ionospheric WN-4 structure and the global tropical lightning characteristics have been identified.

1. Wavenumber-4 structures

The WN-4 structure in the thermosphere/ ionosphere in the equatorial belt (20°S – 20°N) is attributed to latent heat release in deep tropospheric convection in the equatorial region [1] just where the three main tropical lightning chimneys are found (see Fig.2.) spaced in longitude by roughly 90°.

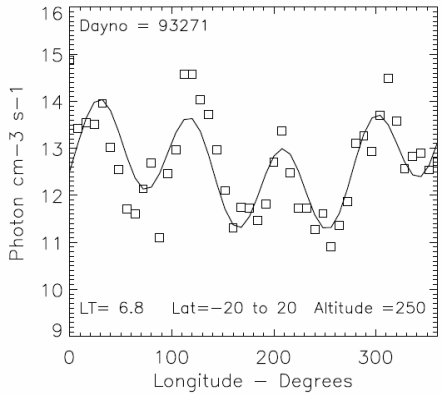

Figure 1 WN-4 structure in the thermosphere as shown in the O(1S) green line emission by the WINDII satellite [1].

One of the main questions is whether the 4th chimney exists in the Pacific (see Fig.2) where the lightning is rather sparse. The Schumann-resonance (SR) records at Tahiti show two maxima in the H_{NS} magnetic field component indicating the maximum lightning activity of Asia and America and two other maxima in the H_{EW} field component: one of them at around 16 UT when the African lightning activity maximizes, and another at around 3 UT evidently associated with the 4th lightning maximum at the local time of lightning activity in the Pacific (see Fig.3)

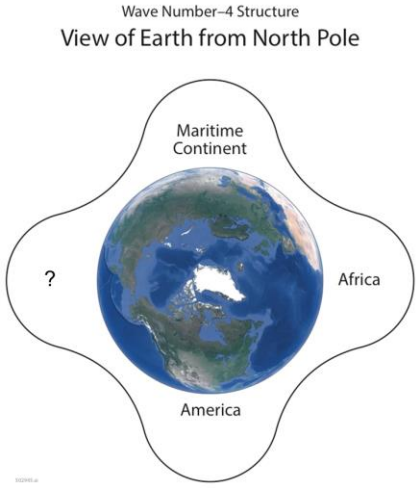

Figure 2 Sketch of the WN-4 structure.

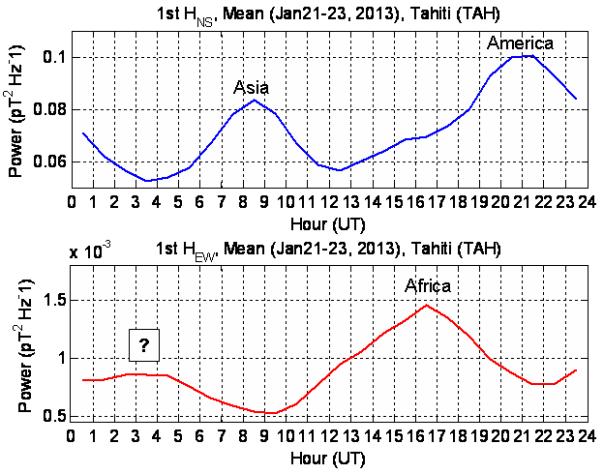

Fig 3 SR records at Tahiti. Diurnal variations of the horizontal magnetic field components: H_{NS} (top) and H_{EW} (bottom).

Map of the terrestrial gamma flashes (TGFs) also indicates WN-4 like structure [2].

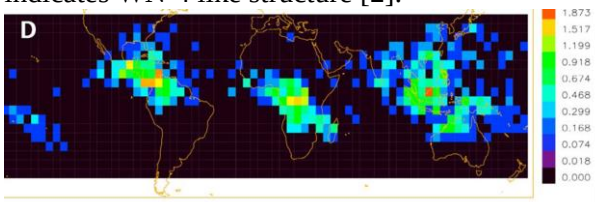

Figure 4. Location of TGFs by RHESSI satellite [2].

2. Semiannual variations

Semiannual variations with quasi equinoxial maxima appear both in the total electron content (TEC) [3] and in the tropical lightning activity, as shown by SR records [4]

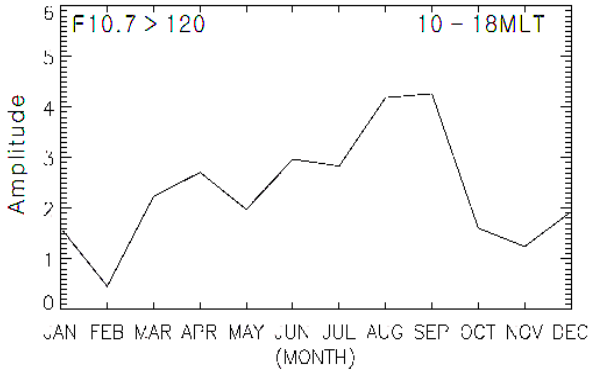

Figure 5. Monthly variations of the amplitude of the WN-4 component computed from TECs within ± 5~20° MLAT along the longitude around the Earth in the 10-18 local time sector [3].

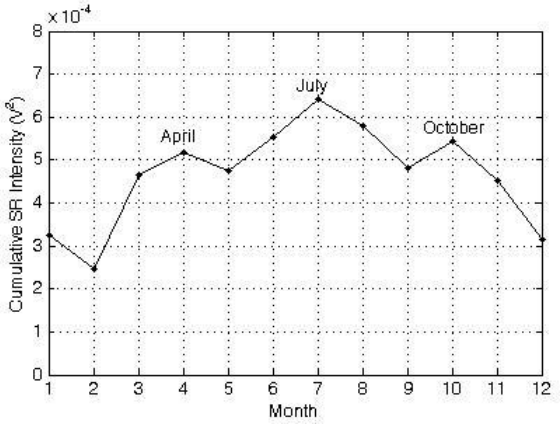

Figure 6. Semiannual variations of SR intensity with April, October maxima at Nagycenk, Observatory, Hungary.

3. Variations on the ENSO time scale

Both the ionospheric F2 layer and the global lightning activity show variations related to the ENSO phenomenon [5],[6].

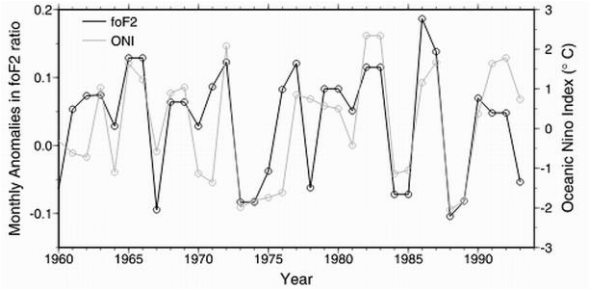

Figure 7. Yearly extreme value of ONI (Oceanic Nino Index) (grey) and the extreme value of the f_oF_2 ratio anomalies between the ionosondes at Maui and Yamagawa (black) [5].

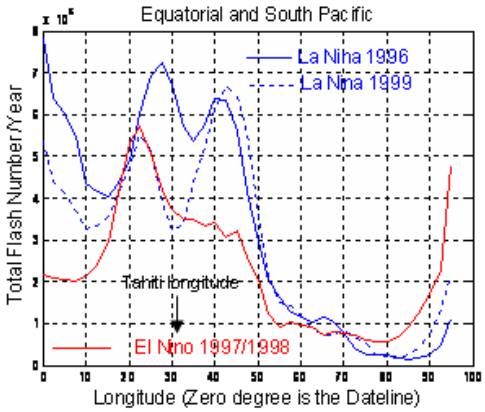

Figure 8. Lightning activity is diminished in the Tahiti region during the warm El Nino period (red curve).

References

[1] G. G. Shepherd, Thermospheric observations of equatorial wavenumber-4 density perturbations from WINDII data, Geophysical Research Letters Vol. 38, Issue 8, April (2011)

[2] D. M. Smith, B. J. Hazelton, B. W. Grefenstette, J. R. Dwyer, R. H. Holzworth, E. H. Lay, Terrestrial gamma ray flashes correlated to storm phase and tropopause height, J. Geophys. Res., 115, A00E49, doi:10.1029/2009JA014853 (2010)

[3] E. Kim, G. Jee,Y. H. Kim, Seasonal characteristics of the Longitudinal Wavenumber-4 Structure in the Equatorial Ionospheric Anomaly, J. Astron. Space Sci. 25(4), 335–346. (2008)

[4] G. Sátori, B. Zieger, Spectral characteristics of Schumann resonances observed in Central Europe, J. Geophys. Res. 101:(D23) pp. 29663-29669. (1996)

[5] N. M. Pedatella, J. M. Forbes, Interannual variability in the longitudinal structure of the low-latitude ionosphere due to the El Nino–Southern Oscillation, J. Geophys. Res., 114, A12316, doi:10.1029/JA014494 (2009)

[6] G. Sátori, E. Williams, I. Lemperger, Variability of global lightning activity on the ENSO time scale, Atmos. Res., 91:(2-4) pp. 500-507. (2008)