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Cosmic Ray Changes and Total North Atlantic Cyclonal Activities.

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Recently it was shown [1], [2] that there exist some interconnections between the cosmic ray changes in the days, preceding the appearance of the hurricanes over the North Atlantic Ocean. Here these interconnections are investigated on the basis of all recorded hurricanes and tropical storms in the 55 years period 1950 - 2004. The whole cyclonic process in every year was examined simultaneously with the corresponding changes in cosmic ray intensity, solar activity and global magnetic field disturbances. Specific Forbush cosmic ray decreases and magnetic oscillations was noticed before the start of practically every cyclonic activity. That could help the possibility of an early hurricane forecast.

1. Introduction

A connection between the changes of Cosmic Ray (CR) intensity and space weather was described [3]. From the other side, a link between the space weather and meteorological weather was established not only for the last century [4], but also for several centuries ago [5]. Lately some indications appeared that some purely meteorological processes in the terrestrial atmosphere are connected with the changes in CR intensity, and influenced by solar activity, and magnetosphere variations [6]. Because all of that, we tried to examine the eventual interference between the CR intensity and one of the most powerful bursts of the meteorological weather – the North Atlantic Hurricanes.

Here we analyzed data for all recorded North Atlantic Hurricanes and Tropical Storms (C) in the last 54 years (1951-2004), together with corresponding data for: CR intensity variation, Geomagnetic index KP, and Sunspot (SS) numbers in the same 54 year interval. **Still without specifying any mechanism of interdependence between these parameters and the cyclone formation**, we are trying to find a well-expressed parallel between them and possibly indications of specific persistent changes in some of these parameters, preceding the cyclone appearance. That could help the efforts for earlier and better hurricane forecast.

2. Data

A complete table of all **North Atlantic Cyclones** was made comparing many sets of available web data. For every one of them, its maximum sustained Rotational Wind Velocity (**V**) was tabulated in intervals of 6 hours. In that form, this basic table includes **16752** 6hour cyclone positions for **574** tracked cyclones, recorded in the **54year** period (1951 – 2004) and arranged chronologically. Tropical Depressions (cases when **V < 63** km/h) were not included.

Between the **CR data,** available on the Web, we chose the hourly Neutron Monitor Data received on Climax CR station, (39.37N; 106.18W; alt. 3400 m and 2.97 GeV Cut-Off rigidity). It appeared, that they cover totally this, more than half a century long, period with negligible instrumental changes, low percentage of missing data and wonderful stability. For the whole period of 54 years (19724 days) only 399 days are without any data, or only 2.02 %. That is a 97.98 % of effective measured CR intensity. We carefully interpolated the missing data.

We chose **geomagnetic data**, from NOAA in Boulder Colorado, USA, presented in a parallel table for: KP – the planetary geomagnetic index and SS – the International Sunspot Number.

3. Data elaboration.

In our earlier works we studied the behaviour of Cosmic Ray Intensity and other geomagnetic parameters prior the appearance of every separate cyclone. Here we used another approach, calculating:

$$E_n(t) = [V_n(t)]^2 . \tag{1}$$

$E_n(t)$ was defined as parameter, presenting rather well the energy of the cyclone n in the moment t. If N cyclones were overlapped in time, the total cyclonic energy, distributed over the Atlantic Ocean in that moment t was taken as:

$$E_1 + E_2 + \ldots + E_{n=N} = E. \tag{2}$$

Summing the 4 adjacent 6-hour intervals, we receive the corresponding daily energy E(d), where d varies from 1 to 365/366 for every year/leap year. Combining E (d,) for all investigated 54 years, we create a table E (d,y)(366 x 54). Summing by rows, we obtained interesting energy distributions: the average E(d), presented on (Figure. 1.)

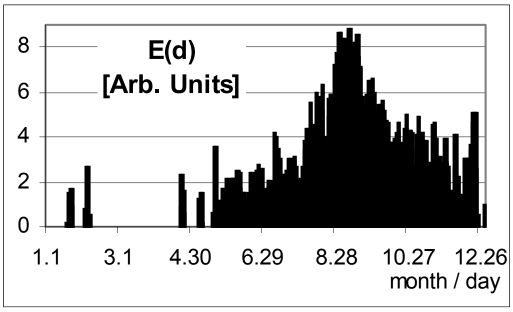

Figure 1. Average E(d) distribution.

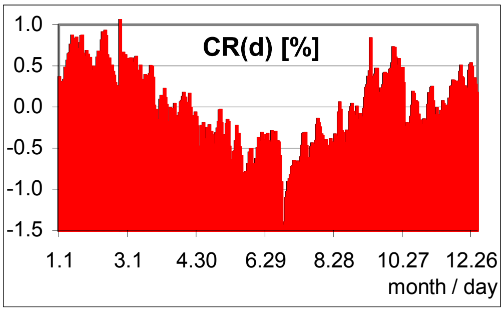

Figure 2. Average CR(d) intensity distribution.

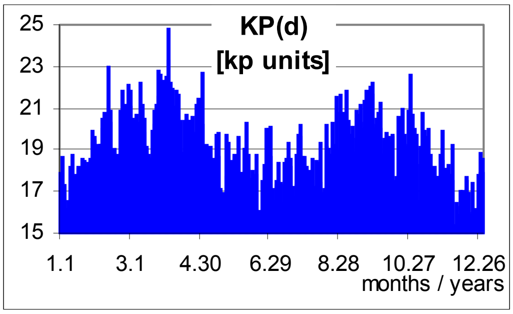

Figure 3. Average AP(d) distribution.

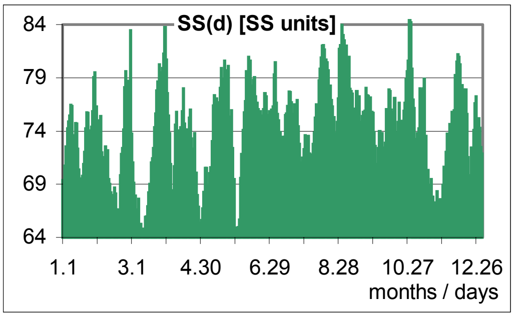

Figure 4. Average SS(d) distribution.

The same procedure was applied for the CR, KP and SS data. The results are depicted correspondingly on Figure. 2., Figure. 3., and Figure. 4. As it is known, the cyclonal activity is well expressed in August, September and October. It is insignificant in July and November and practically zero in the other months of the year. The same distribution could be observed for E(d) on Figure. 1. To establish a similarity, or parallel changes between E(d) and either one of the distributions: CR(d), KP(d), SS(d) we have to concentrate on the active months. Interesting shape has the CR(d). It appears that something like gigantic Forbush for these 54 years was strongly concentrated on July 14. (Bastille Day). KP(d) presents an interesting double hump distribution. Its minimum is around the end of June, which means 2 weeks earlier. SS(d) shows one of its sharpest minimums a month earlier - around the beginning June.

We correlated E(d) and either one of: CR(d), KP(d), SS(d) in the 100day interval between July 11 and October 19, as well as in 40day interval of between July 31 and September 9. Then we smoothed all these distribution with a step of 27 and correlated them again. The obtained correlation coefficients were systemized on Table 1.

Table 1. Correlation Coefficients between E and CR, KP, SS

			direct			smoothed		
From	Till	Days	CR	KP	SS	CR	KP	SS
11.Jul	19.Oct	100	0.38+_0.04	0.50+_0.06	0.42+_0.07	0.69+_0.16	0.91+_0.04	0.64+_0.20
31.Jul	9.Sep	40	0.41+_0.13	0.62+_0.08	0.61+_0.06	0.93+_0.25	0.92+_0.08	0.98+_0.20

Obviously the correlation coefficients rose after smoothing. But their values showed very a well-expressed parallel in this part of the year, when the cyclonic activity increases strongly.

A careful examination of the shown graphs disclosed an interesting secondary modulation, overlapping the basic change of all curves. We filtered them suitably, suppressed the main extremes and extracted the remainder waves. They are shown on Figure. 5.

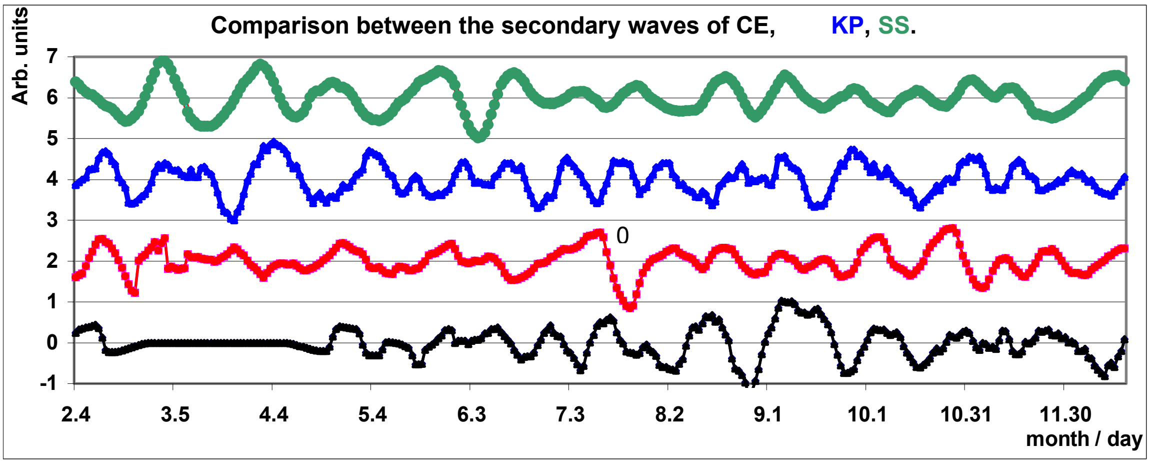

Figure 5. Extracted secondary wave over the averaged yearly distributions of CE, CR, KP, SS.

For the first time such a wave, similar to that extracted of the yearly distributions of KP, SS and CR is found overlapped over the cyclonal energy curve. The periods of these waves are very close. Their average values are around 20–25 days. The correlations between these waves are strongly reduced, because the instable phases. Nevertheless, their similarity could suggest a common source of influence.

All that is over a long period of time and with a vast amount of basic data. To be sure of the continuity of these results, we divided in 5 groups all considered year, depending the value of their yearly averaged E(y).

In Group1 were included the most cyclonically active 10 years – in the Group 5 the quietest 14 years. The average yearly distributions of Eav(d, g) [g=1,2,3,4,5] for these 5 groups are depicted on Figure.6.

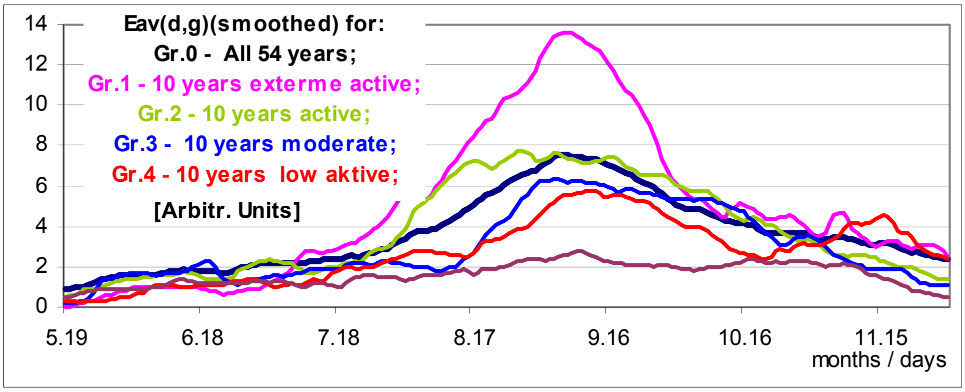

Figure. 6. Yearly cyclonic Energy distributions in 5 Groups.

It could be noticed that with the decrease of the averaged energy, the peak around September 10 becomes flatter and less pronounce. Simultaneously, the corresponding differences between the yearly averaged MAX and MIN CR intensity decrease from 1.5% (for Group 1) to 1.04% (for Group 5).

4. Conclusion.

For the first time the rotational energy: **E~V^2** at a recorded point and time of the cyclonic development is used as a basic cyclonic parameter. That is an additive characteristic and we defined the total cyclonic energy **E(d)** in the day **d** over the Atlantic Ocean .The result, obtained here showed unambiguously **that in specific months of the year there are parallels in the total increase of cyclonic energy E and the changes of CR intensity, geomagnetic planetary disturbances KP and Sunspots SS variations.** Their similarity is farther emphasized with the presence of a secondary practically equal overlapped wave. Generally greater amplitude in CR intensity changes is connected with a greater cyclonic activity. From the other side, the enormous difference of the energy engaged in these processes and the reduced correlation between them in the other parts of the year assume complicated interconnections. The coincidence of the yearly minimum of CR and KP in the middle July with the averaged start of cyclonic development is promising for an earlier hurricane forecast.

References

[1] S.P. Kavlakov, Intern. J of Modern Physics A. (in press).
[2] J.A. Perez- Peraza et. all. Proceedings COSPAR, Paris, **2004.**
[3] K. Kudela et al, Space Sci. Rev., 93, 153-174, **2000**
[4] S.J. Mason and P.D. Tyson, J.Geophys.Res-Atmospere (D5): 5847-5856 APR 20 **1992**
[5] F.S. Rodrigo et al., Intern. J, of Climatology 20 (7): 721-732 June 15, **2000**
[6] B.A. Tinsley and K.V. Beard, Bulletin of American Meteorological Society, 78, 685-687. **1997.**