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Atlantic Hurricanes, Geomagnetic Changes and Cosmic Ray Variations. Part II. *Forbush Decreases and Hurricane Velocity Changes.*

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Abstract: In the previous paper we have found a significant statistical relationship between geomagnetic activity as measured by the KP index and hurricane intensification calculated as the time derivative of wind speed for a certain type of higher-latitude hurricanes. Here we examine similar relationship comparing Forbush Events and hurricane intensification rates.

Introduction

In part I of that paper [1] it was shown that high geomagnetic activities, presented with the KP index have been statistically linked to hurricane intensification over two separate regions in the North Atlantic It was also found that that 2-3 days before and after the maximum KP values, the hurricane intensification is much higher than the average.

Earlier a positive correlation between the averaged KP index of global geomagnetic activity and hurricane intensity as measured by maximum sustained wind speed was identified [2].
In another work [3] specific changes in Cosmic Ray CR intensity, Geomagnetic disturbances KP and Sun Spots (SS) were observed before the hurricane appearances.
Some repeatedly observed coincidences between the Hurricane appearances and preceding Forbush Events (FE) (as for example Hurricane ABBY 1960 and CELIA 1970- Fig.1 and Fig. 2) suggested a possibility for closer relationship between the FE and hurricane intensification.
To reveal any possibility for immediate (not delayed) relationship between the hurricane intensification and Cosmic ray intensity sharp decreases, here, using the method developed in [1] we examine the hurricane intensification around the day "0" of (FE).

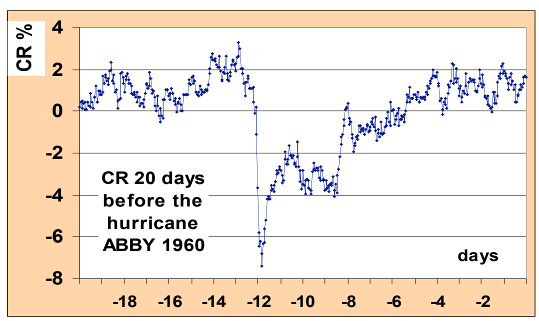

Figure 1: A 7.6 % Forbush Event 12 days before the start of hurricane ABBY 1960.

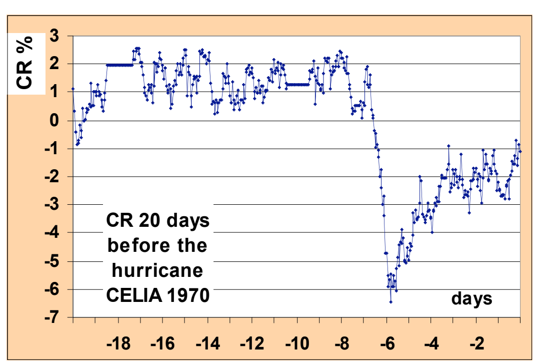

Figure 2: A 6.57 % Forbush Event 6 days

before the start of hurricane CELIA 1970.

Data

Hurricane Data

We use the same hurricane data used in [1].

Cosmic Ray Data

Earlier [3] we used data from several Neutron Monitors (NM), situated around the Atlantic Ocean. But the gain for the statistics, achieved in this way, was suppressed by the difficulties of combining together the different data, available in different intervals. So we accepted that the use only one, but long running continuous CR measurement could be much more suitable. That is why we took the whole Neutron Monitor data set received on Climax CR station, (39.37N; 106.18W; alt. 3400 m and 2.97 GeV cut-off rigidity). They covered the period 1951 - 2005 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.

The general interconnection between the data from practically all NM stations, measured on different geographical places, permit us to consider the CLIMAX data as globally representative.

The values presented in counts per hour were transformed in daily percent deviations from the general 55 years average value (394,600 counts/hour, or 9,470,400 counts/day). The statistical error then is 0.032 % for a single day..

Data processing

From the whole set of Climax CR data we extracted all Forbush effects

We define as FE "0" day when the sudden decrease in CR intensity (or Forbush Event) is below -3 %. It could be seen that these events are equally spread throughout the year. That means there are no significant monthly changes in their number (Fig. 3).

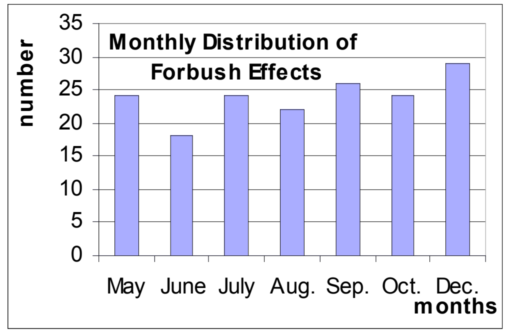

Figure 3: Monthly distribution of Forbush effects

As we mentioned before [1], in contrast the hurricane season is strongly peaked around the month of September and spread practically only over the months from May till November

In these 7 months long hurricane seasons over the period 1951-2005 we identify 166 FE "0"days.

Statistical analysis

We analyze statistically this relationship between dW/dt and FE by averaging intensification rates over 5 days centered on the FE "0" day and comparing this mean intensification with the overall average intensification. We used the same geographical area as in [1] to classified the hurricane intensification over the whole Atlantic area and over hot waters with practically constant temperature. The results are shown on Table 1.

Table 1. Intensification rates

	"0" days	Cyclones n	h	Average (dW/dt) [kts/hour]	Average (dW/dt) [kts/5days]
	Over whole Atlantic region				
All		603	105638	0.0342+/-0.006	4.10+/-0.07
FE	166	96	7691	0.0546+/-0.0095	6.56+/-1.1
	Over hot waters				
All		131	17579	0.313+/-0.04	37.6+/-1.9
FE	166	25	2104	0.363+/-0.216	43.6+/-25.9

It could be noticed that about 7 – 10 % from the hurricane hours are in the interval of 5 days around the FE "0" days.

From all 105,638 hours of tropical cyclone activity, the mean intensification rate is +0.0342 kt/h, which equals 4.1 kt over any 5-day period. This compares with a mean intensification rate of +0.0546 kt/h or 6.5 kt over the 5-day period based on 7691 hours of intensification (96 separate tropical cyclones). We note weak rise of the intensification rates surrounding the FE "0" day, on average, for tropical cyclones.

There are 17,579 cyclone hours within the hot water control region over the 55-year interval (1951-2005).

As expected the mean intensification rate is considerably higher at 0.313 kt/h (37.6 kt/5 days). The mean intensification for the 5 days centered on a FE "0" day is 0.363 kt/h (43.6kt/5 days). This is based on 25 separate tropical cyclones

To test the significance of these differences we randomly assign days as FE "0" days and compare the mean intensification rate (bootstrapped rate) over the 5 days centered on these random dates. So we could estimate a 17 % accuracy.

While suggestive, the results are inconclusive regarding the relationship between Cosmic Ray decreases and hurricane intensification.

The 2-day window surrounding the FE "0" day is arbitrary so we also consider the mean hurricane intensification for storms before, during, and after the KP day.

Figure 4. shows the mean intensification rate as a function of lag time from the FE "0" day.

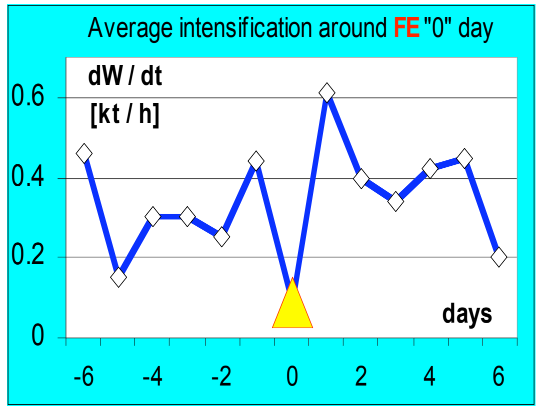

Figure 4: Hurricane intensification in [kt /h] around the average FE "0" day.

Conclusions

Here we find a slight rise of the hurricane intensification around the FE "0" days over both investigated regions. But that difference as well as the form of the curve on Fig. 4 show statistically insignificant relationship between Cosmic Ray sudden decreases (the Forbush Effects) and hurricane intensification in the interval of +/-5 days.

Taking in consideration the persistent appearance of FE from 5 to 20 days before the hurricane start (Fig.1) and (Fig. 2) we could deduce that any suggested mechanism that relates the FE with the hurricane formation needs considerable time for activation. As could be seen here the direct impact is negligible.

Along the lines of our earlier study we suggest that a possible physical mechanism is related to increased ionization of the upper extent of the tropical cyclone vortex leading to increased condensation and additional warmth throughout the column. The change in the ion concentration in the upper layers either helps to go over certain threshold, or contributes continuously to attain a specific starting level. But it is still difficult to establish an acceptable mechanism unifying all these physical phenomena. Our farther efforts will be concentrated in that direction.

Still remain the main practical question:

Could we forecast the creation of a dangerous vortex on the basis of preceding KP and CR, Forbush Effects data changes?
Well, we are still not able to do that firmly.
But, looking in our results we could be strongly alerted if a sharp rise in KP index is recorded during the hurricane season, or a Forbush Event appears at the end of the summer. Then investigating all the parallel atmospheric data we could be closer to a true prediction.

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