ESWW-2

RELATIONSHIP BETWEEN GEOMAGNETIC DISTURBANCES AND FAILURES IN RAILWAY AUTOMATIC SIGNALING AND TRAIN CONTROL EQUIPMENT

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Abstract

Space weather changes, manifested as geomagnetic disturbances, produce geomagnetically induced currents (GIC) in ground-based long conductors as railways. Intense GIC can hamper rail traffic by disturbing signaling and train control systems. In one instance an induced voltage was believed to have affected signaling equipment in Sweden in 1982 (Jansen et al., 2000). However, there was no proof of such links based on any statistical data. For the first time we studied 4764 failures (disruptions) to signaling and train control equipment registered daily on Russian Trans-Siberian Railway System during January 1, 2004-March 11, 2005. Analysis of original failure reports showed that about 45% of failures can be clearly attributed to “non-geomagnetic” reasons. The remaining failures have been left to study possible links with space weather parameters. Our results indicate that durations of disruption to signaling and train control equipment are geomagnetically dependent. It was found a significant increase of the duration of disruptions (in 3-4 times) during geomagnetic storms observed from January 1, 2004 till March 11, 2005. Moreover, for these storms it was found a significant correlation during storm characteristic time period (10-20 days) between the daily sum of durations of disruptions to signaling and train control equipment and local A index of geomagnetic activity. The high correlation was obtained for two top storms of 2004: for 5-12 November (A_{max}=220, correlation coefficient k=0.71) and for 17 July-2 August (A_{max}=228, k=0.83).

Background and Objectives

Geomagnetic disturbances produce geomagnetically induced currents (GIC) in ground-based long conductors as railways. Intense GIC can hamper rail traffic by disturbing signaling and train control systems. In one instance an induced voltage was believed to have affected signaling equipment in Sweden in 1982 [Jansen et al. 2000]. However, there is no research on this links based on any statistical data. Objective of this report is to study for the first time a great amount of failures to signaling and train control equipment and their possible links with space weather parameters, in particular with geomagnetic disturbances.

Data

We studied 4764 failures (disruptions) to signaling and train control equipment registered daily on Russian Trans-Siberian Railway System during January 1, 2004-March 11, 2005. Analysis of original failure reports showed that about 45% of failures can be attributed to obviously "non-geomagnetic" reasons as heating (including UV heating), meteorologically connected reasons (snow or sand in automatic switches), mechanical wire breakage, staff errors, stealing, vandalism etc. The remaining failures have been left to study possible links with space weather parameters.

Method

1. Analysis of geomagnetic situation from January 1, 2004 till March 11, 2005 was done on the base of local A index in a Siberian Geomagnetic Observatory Podkamennaya Tunguska. Nine geomagnetic storms with A>30 observed in this period were considered. For these storms characteristic intervals of 15-20 days were defined.
2. Daily index T – daily sum of duration of disruptions (in minutes) to signaling and train control equipment - was calculated for each day for the chosen intervals.
3. The moving 5-day average for disruption time <T> and for local geomagnetic index <A> was calculated by the use of smoothing Sheppard filter.
4. Correlation between <T> and <A> during characteristic time of the geomagnetic storms was calculated.

Results

Main results are shown below in Figures 1 to 3.

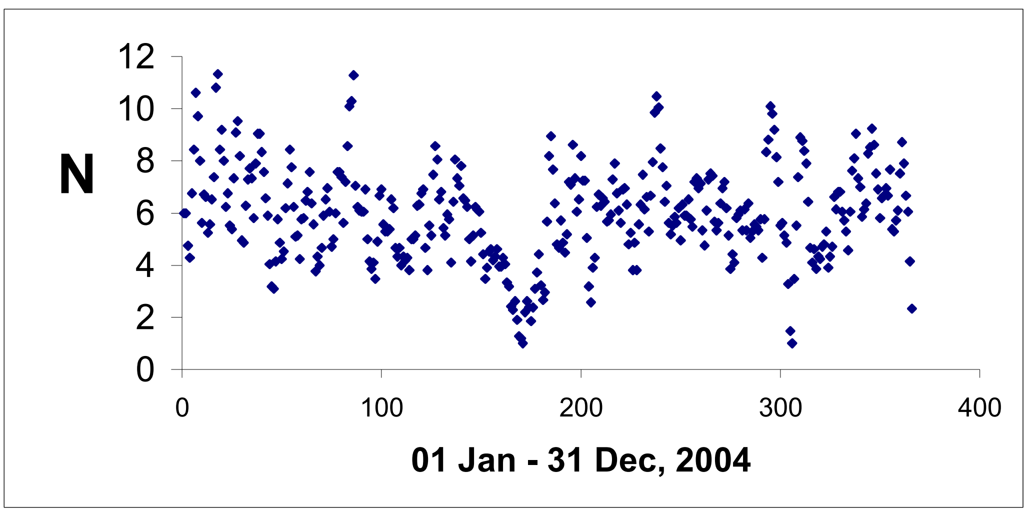

Figure 1. Failures in automatic signaling and train control equipment on Russian Trans-Siberian Railway in 2004.

Figure 1 presents the daily failures registered in Russian Trans-Siberian Railway in 2004, cleaned by the failures resulting from obviously non-geomagnetic reasons (a total of 2182). The data are moving 7-day averages. It is seen that incidences of failures show a tendency for seasonal variation with a minimum in summer (around day 170) and maxima in spring and autumn. Such behavior is a characteristic feature of the yearly variation in geomagnetic activity.

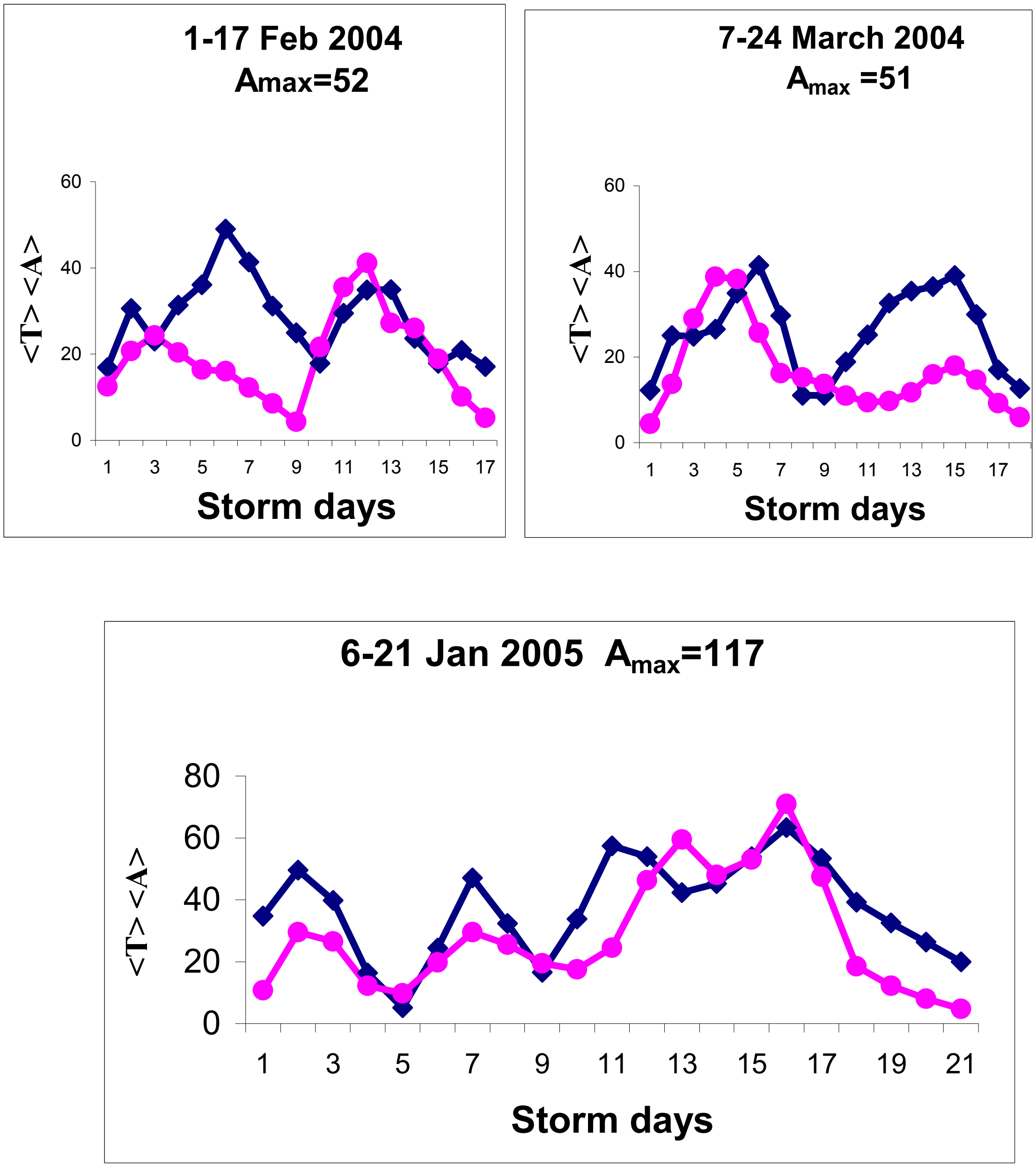

Figure 2. Examples of correlation between failures of signaling and train control equipment in Trans-Siberian railway and geomagnetic storm conditions
Disruption time to signaling and train control equipment <T> (in min/10) – blue lines.
Local geomagnetic index <A> - pink lines.

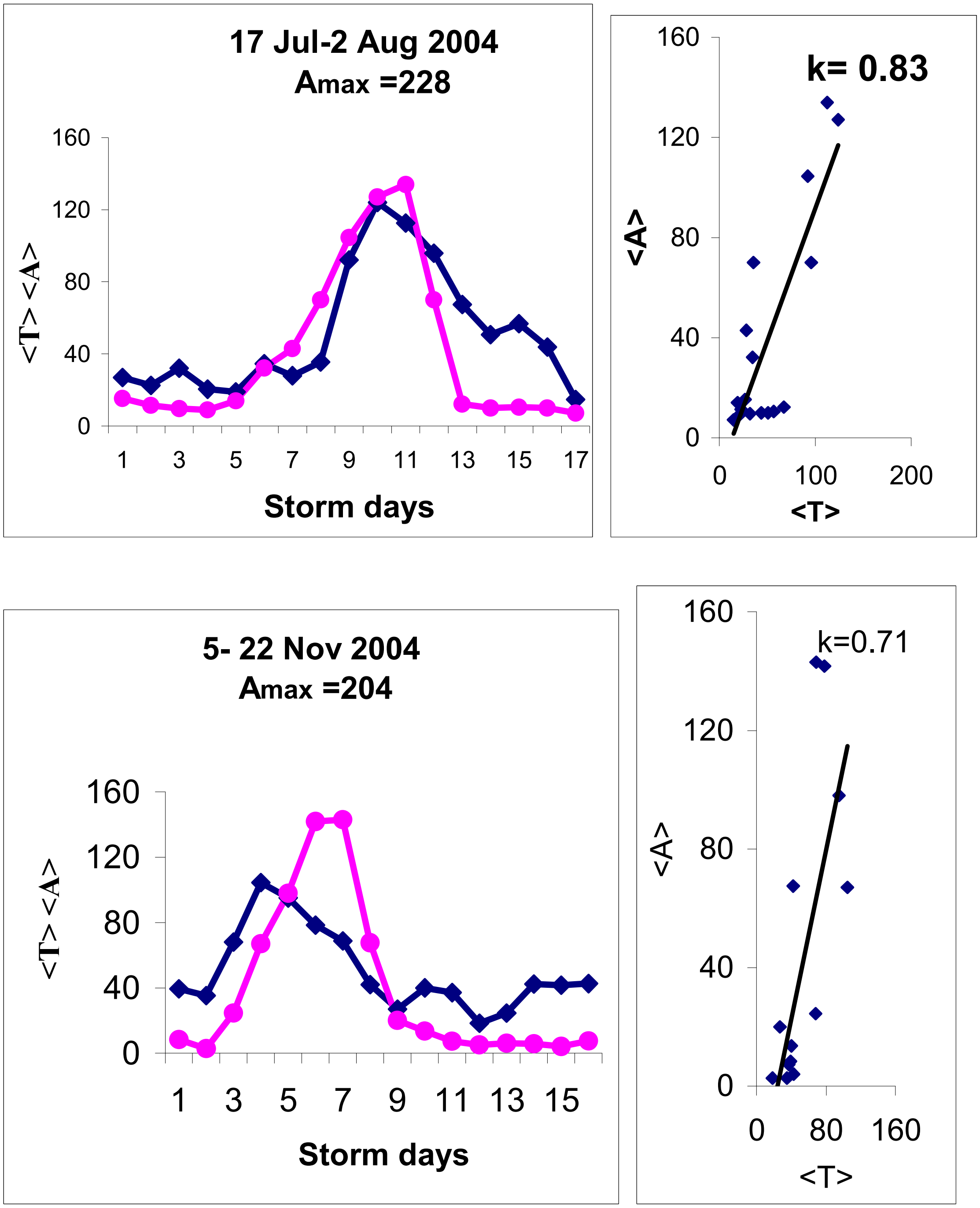

Figure 3. Rail traffic failures during two top geomagnetic storms in 2004 (A>200). Disruption time to signaling and train control equipment <T> (in min/10) – blue lines. Local geomagnetic index <A> - pink lines.

Conclusions

Our results indicate that durations of disruption to signaling and train control equipment are geomagnetically dependent. It was found a significant increase of the duration of disruptions (in 3-4 times) during geomagnetic storms observed from January 1, 2004 till March 11, 2005. Moreover, for these storms it was found a significant correlation during storm characteristic time period (10-20 days) between the daily sum of durations of disruptions to signaling and train control equipment and local *A* index of geomagnetic activity. A high degree of correlation was found during two top storms observed in 2004: for 5-12 November (A_{max}=204, correlation coefficient k=0.71) and for 17 July-2 August (A_{max}=228, k=0.83).

References

Jansen, F., R. Pirjola, and R. Favre, “Space Weather, Hazard to the Earth?” Swiss Reinsurance Company, Zurich, 2000.