12th Hel.A.S Conference
Athens, 28 Juny - 2 July, 2015
CONTRIBUTED POSTER

The extended geomagnetic storm of March 17, 2015

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Abstract: On March 2015 the most intense geomagnetic storm (G4) of the current solar cycle was recorded. It started on March 17, 2015 and it was the result of the interaction between the complex solar activity which spotted on the active region AR2297 (S22W29) and a high speed solar wind stream from a huge south polar coronal hole with Earth's magnetosphere (umtof.umd.edu; www.lmsal.com). Analysing cosmic ray intensity data among polar and middle latitude neutron monitor stations the existence of a geomagnetic storm was observed, resulting to the variation of the energy threshold and magnetic rigidity of the middle latitude stations. Moreover an extended study of the asymptotic cones of the neutron monitor stations during this event according to Tsyganeko T96 model showed that the disturbances of Kp index were recorded before those of Dst index. Interesting results on the geomagnetic indices are also discussed.

1 Description of the event

March 2015 was one of the most active months of the solar cycle 24 in solar activity and especially in coronal mass ejections (CMEs) as well as solar flares (SFs) with the most energetic one being an X2.1 on 11/03/2015 at 16:22 UT from the AR 2297 (S17E22) (solarmonitor.org), which area gave some days after a CME which was responsible for the G4 geomagnetic storm started on March 17. Data for the solar events were obtained from the GOES satellites (ftp.ngdc.noaa.gov) and from the SOHO space telescope (cdaw.gsfc.nasa.gov). As a result of this activity an extended Forbush decrease, with a recovery phase which lasted up to the end of the month, was recorded at neutron monitors (www.nmdb.eu) (Fig. 1). Especially a magnetic filament accompanied by a C9.1 solar flare with peak time at 02:13 UT hurled an Earth directed CME into the interplanetary space. This ICME arrived at Earth in the first hours of March 17 and a minimum of Dst index of -223 nT (preliminary data, wdc.kugi.kyoto-u.ac.jp) was noticed at 22:00-23:00 UT, while some hours before at 12:00-15:00 UT the Kp index reached the maximum value of 8. The daily value of Ap index was 108, that is the highest daily Ap from September 2005 [1].

2 The geomagnetic effect & asymptotic cones of acceptance

Comparing cosmic ray data between polar and middle latitude stations a big decrease of cosmic ray intensity on polar stations was observed, while on middle latitude stations the intensity of cosmic rays remained unaffected. This fact proves the existence of a geomagnetic effect as the abnormally increased cosmic ray intensity on middle latitude stations can be explained by the compression of Earth's magnetic field affecting mainly middle latitude stations, such as Athens (Fig. 1). Another proof of this effect was the variation of the energy threshold, rigidity, of middle latitude stations. In the case of Athens NM the value of the cut-off rigidity was decreased by 0.5GV while polar stations remained unaffected [2], [3]. For our cut-off rigidity changes the global survey method (GSM) has been utilized described by Belov et al. [2]. It is assumed that only the first harmonic of cosmic ray anisotropy contributes significantly. The optimal isotropic part of cosmic ray variations together with its anisotropic

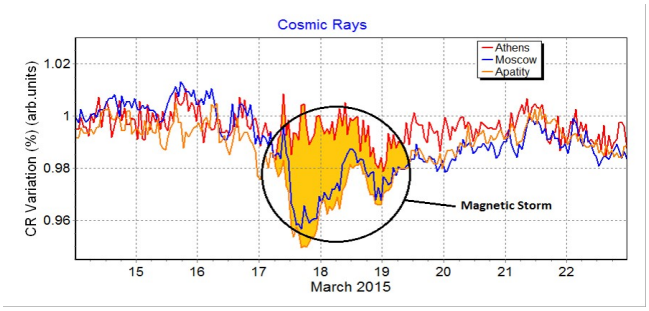

Figure 1: Time profiles of the cosmic ray intensity for middle latitude (Athens) and polar (Moscow, Apatity) stations for the time period of March 15 to March 22, 2015. The different behavior of the cosmic ray intensity during the magnetic storm is indicated.

components can be calculated by the data of the available NM stations.

Moreover an extended study of the asymptotic cones of middle latitude neutron monitor stations during this event was done [4]. Disturbances in the interplanetary medium lead to compress the cones from their normal shape. It was showed that negative values of the Dst index lead the cones to be moved to bigger geographic latitudes. It is seen that the disturbance in the interplanetary medium is first registered from Kp-index and later from Dst-index.

3 Results and conclusions

- The event of March 17, 2015 was the most intense geomagnetic storm (G4) that has been observed in solar cycle 24. The daily geomagnetic index Ap reached the unexpected value of 108 beyond of every forecasting value.
- A Forbush decrease of the cosmic ray intensity was recorded on neutron monitor stations with an average amplitude of 4.2% on polar stations, while on the middle latitude stations it was covered by the geomagnetic effect [2].
- The cut-off rigidity variations caused by the magnetospheric ring current during the main phase of the magnetic storm do not show a significant longitudinal dependence because of the ring symmetry [2].
- The effect of the shock wave caused by the CME on the Kp index was responded earlier than in the Dst index.

Acknowledgements: Special thanks to the colleagues of the NM stations for kindly providing the cosmic ray data used in this study in the frame of the High resolution Neutron Monitor database NMDB, funded under the European Union's FP7 Program (contract no. 213007). Thanks are also due to Dr. Tsyganenko for providing the GEOPACK routines as well as to the IZMIRAN group for providing the programs for the asymptotic cones calculations.

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