# Geomagnetic superstorm of 1859 and sector structure of the IMF

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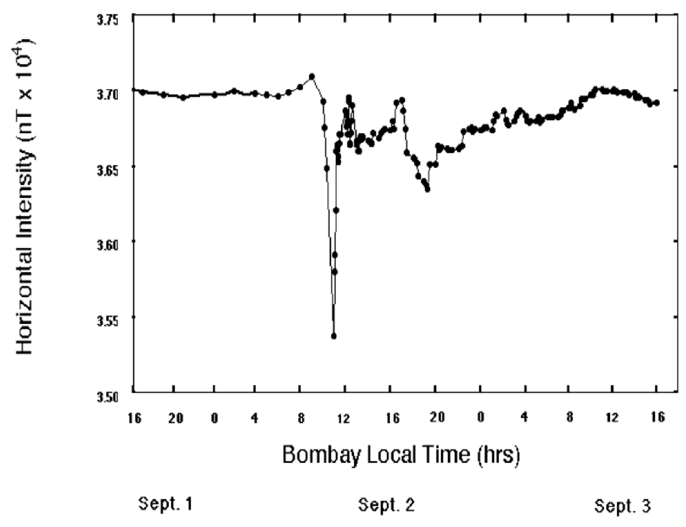
## 1. The 2 September 1859 superstorm

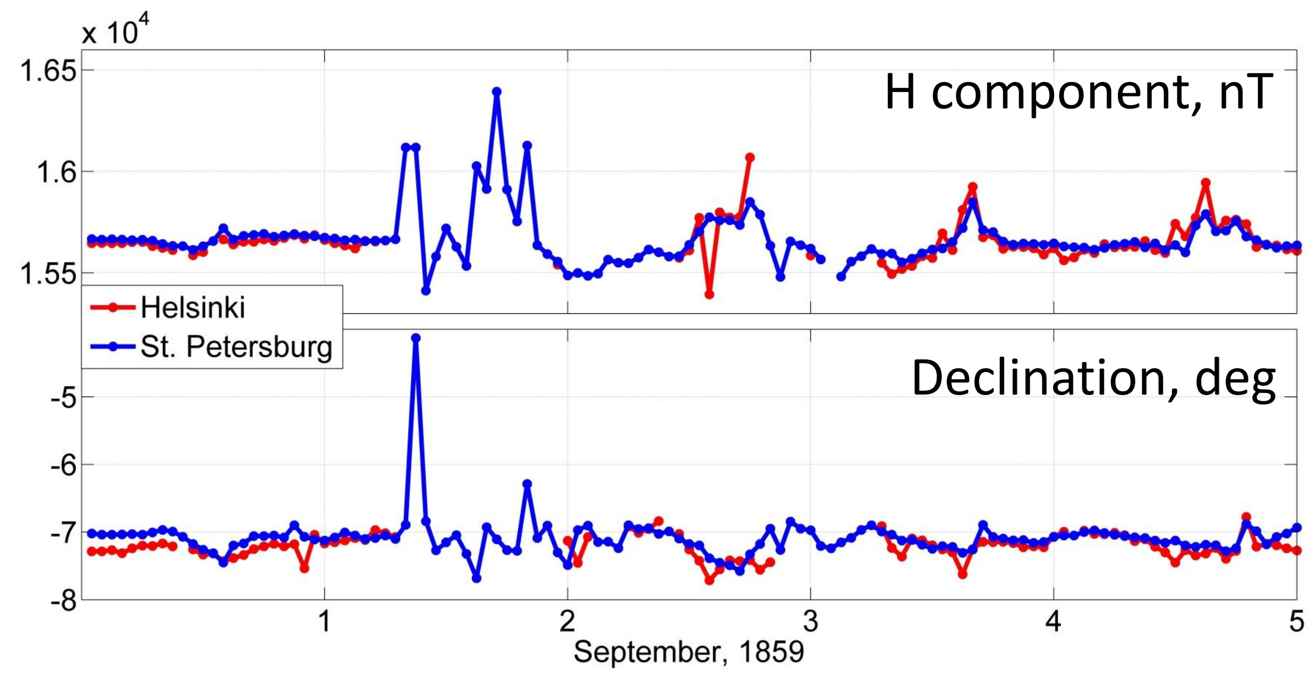
The 1–2 September 1859 magnetic storm intensity was the most intense magnetic storm in recorded history. The auroral sightings were as low as 23° magnetic latitude (Hawaii and Santiago), and the storm index was estimated to be ~1760 nT [1].

About 17 h 40 min before the storm Carrington observed the very bright solar flare. During 5 min (from 11:18 to 11:23 UT), an astonishing formation moved a distance of about 56 000 km over the solar surface and in no way affected the shape and dimensions (~95000 km) of passed sunspots. This made it possible to conclude that the formation passed at a high altitude over the surface of the sunspots [2].



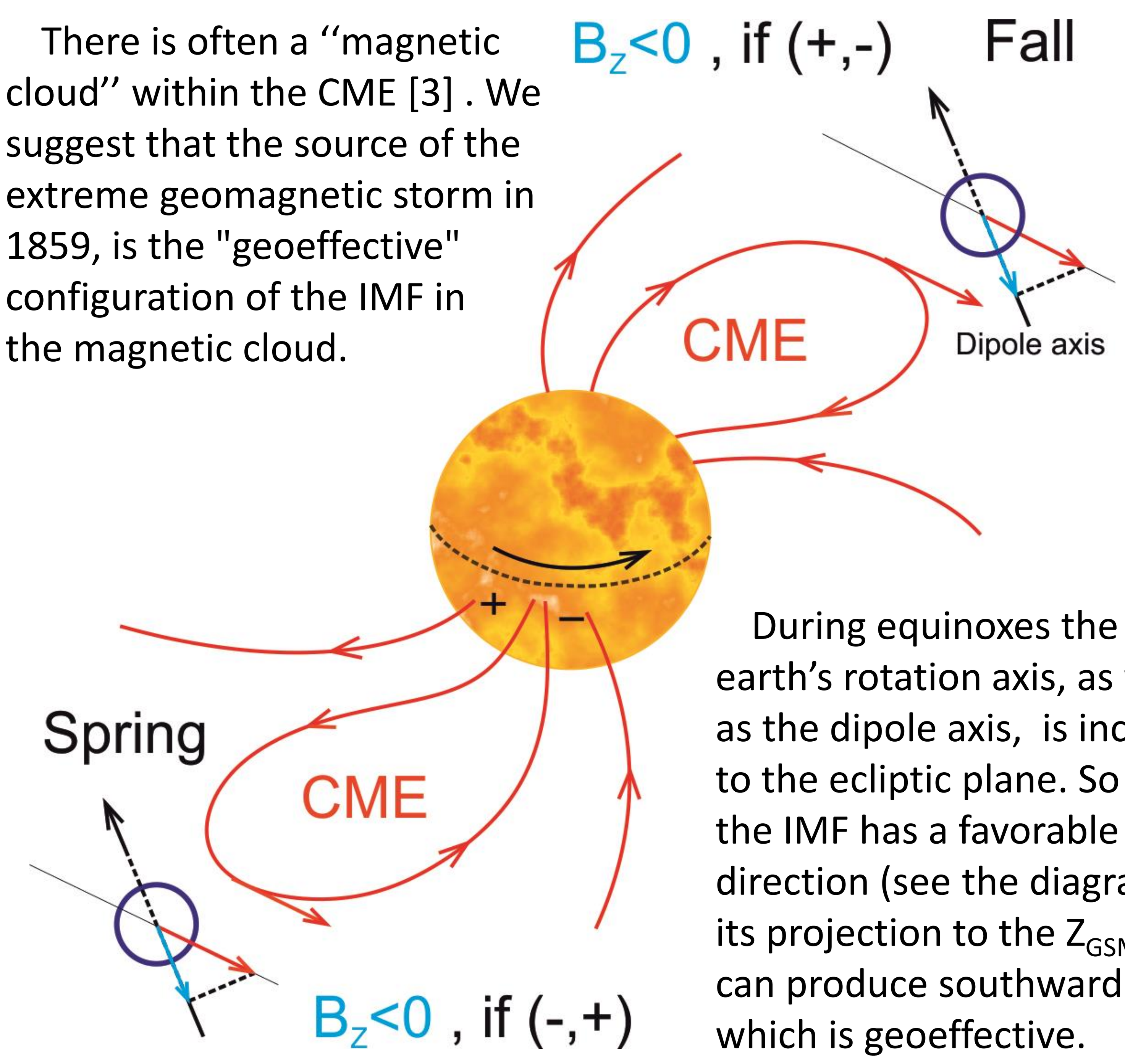

The storm started quickly reaching the peak in development in 2 hours and just as quickly , in 1 hour, weakened by more than half. The most likely mechanism for this intense, short duration storm would be a magnetic cloud (within the CME) with intense $B_S$ fields [1].

Geomagnetic records in Helsinki and St. Petersburg during the storm, September 1-5:




## 2. The equinoctial effect in CME

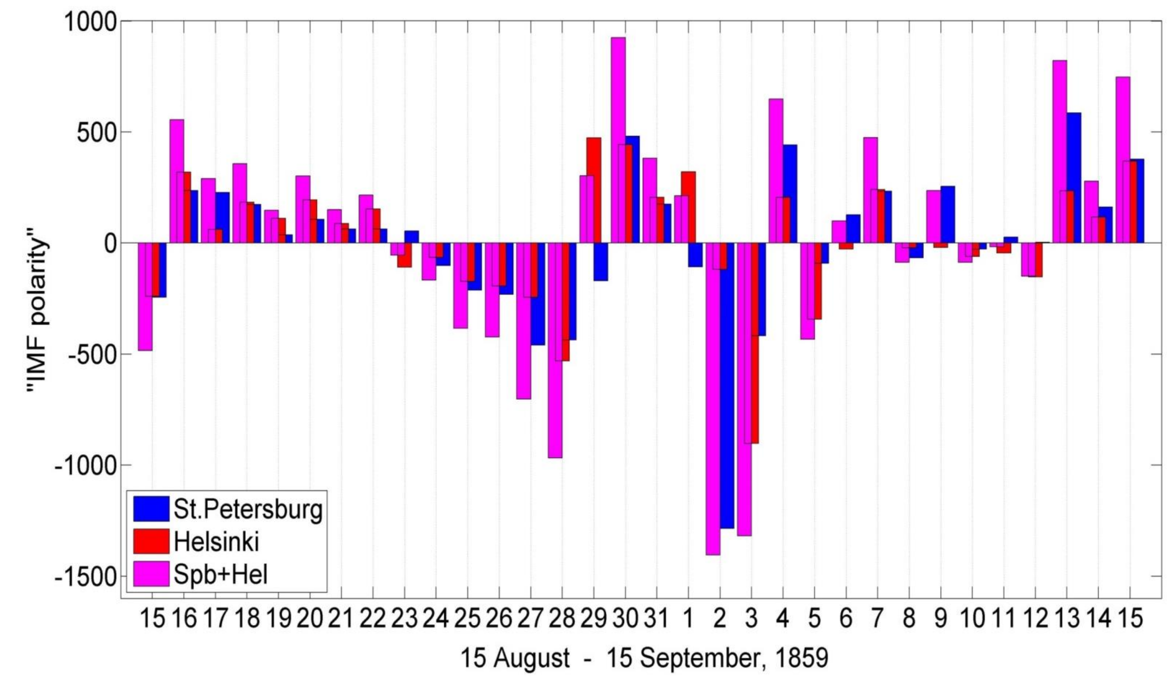
There is often a ''magnetic cloud'' within the CME [3] . We suggest that the source of the extreme geomagnetic storm in 1859, is the "geoeffective" configuration of the IMF in the magnetic cloud.



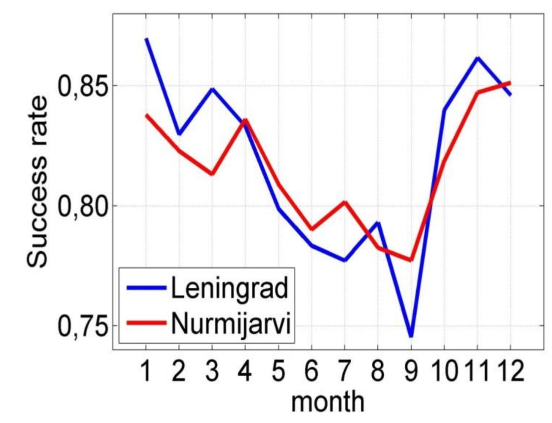

During equinoxes the earth's rotation axis, as well as the dipole axis, is inclined to the ecliptic plane. So when the IMF has a favorable direction (see the diagram), its projection to the $Z_{GSM}$ axis can produce southward $B_Z$ which is geoeffective.

## 3. IMF polarities of the past

Due to the Svalgaard-Mansurov effect [4-8] it is able to infer the IMF polarities (toward or away from the Sun) using only geomagnetic data. At the present moment we have obtained IMF polarities back to 1844 using data from Helsinki (1844-1897) and St. Petersburg (1878-1905) observatories. The success rate of the inferring technique is 80-82% according to the polarities obtained from Nurmijarvi and Leningrad stations.

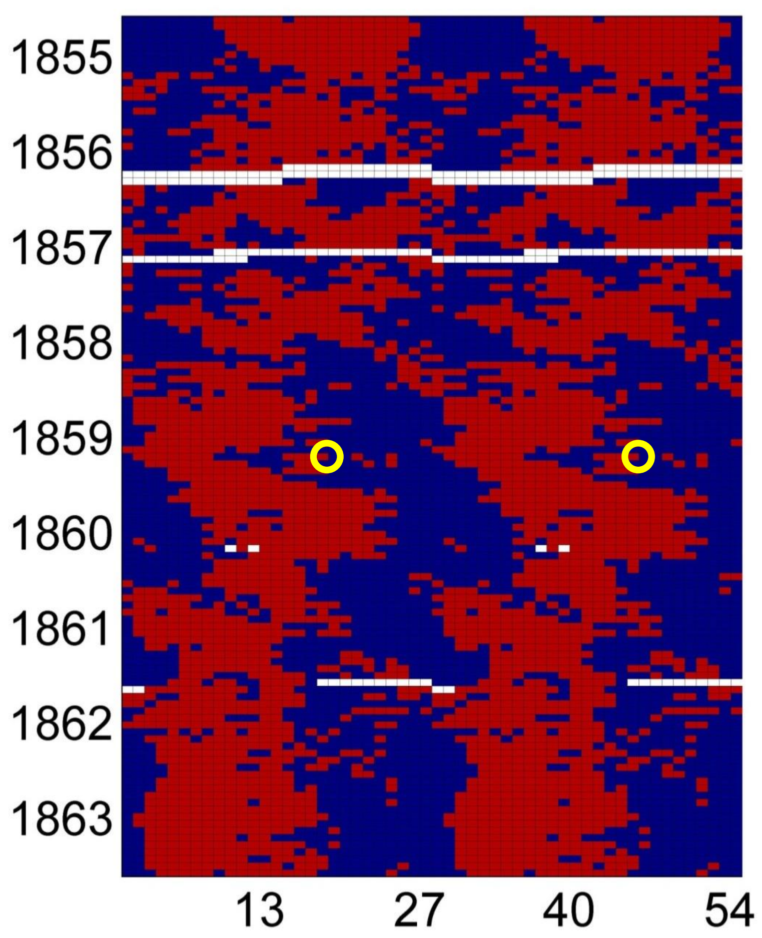



The Figure shows the inferred IMF polarities from Helsinki (red) and St. Petersburg (blue) geomagnetic records, and their sum (purple). It is seen that both observatories provide quiet similar results. The geomagnetic superstorm coincides with favorable sector boundary crossing: negative polarities follow positive polarities.




Unfortunately, the technique provides the worst results exactly in September. Nevertheless, as it can be seen from the Bartels diagram in section 4 the storm (circle) most likely occurred within the sector boundary crossing (from "+" to "–") .

## 4. Sector structure of the IMF




List of other great geomagnetic storms by *Chapman and Bartels* [1940] plus the storm of the 13 March 1989:

| | | |
|---|---|---|
| 1859 | *2 September* | ✓ |
| 1882 | *17 November* | |
| 1903 | *31 October* | |
| 1909 | *25 September* | ✓ |
| 1921 | *13-16 May* | ✓ |
| 1938 | *16 April* | |
| 1989 | *13 March* | ✓ |

+ → –    – → +

✓ – "geoeffective" CME configuration

## Conclusions

1. We have restored for the first time the interplanetary magnetic field polarity in the 19th century by using geomagnetic observations in Helsinki and St.Petersburg.

2. The inferred large-scale configuration of the magnetic fields at the site of Carrington flare was favorable to generate geomagnetic superstorm in September 1859.

## References

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