Long-term analysis of IHFACs and seasonal and disturbance time variations in dawn, noon, and dusk sectors utilizing equatorial magnetic fields at Davao station, Philippines

[1]Manjula Ranasinghe, [2]Akiko Fujimoto, [3]Akimasa Yoshikawa and [1]Chandana Jayaratne

[1] Astronomy and Space Science Unit, Department of Physics, University of Colombo, Sri Lanka.

[2] Faculty of Computer Science and Systems Engineering, Kyushu Institute of Technology, 680-4, Kawazu, Iizuka, Fukuoka 820-8502, Japan.

[3] International Research Center for Space and Planetary Environmental Science(i-SPES), Kyushu University, 744, Motooka, Nishi-ku, Fukuoka 819-0395, Japan

Summary

- An examination of geomagnetic data collected over a 20-year period from the MAGDAS station in Davao, Philippines, covering solar cycles 23 and 24, was conducted to study attributes related to inter-hemispheric field-aligned currents (IHFACs).
- The dusk sector peak-to-peak amplitude values of the yearly ΔD are around twice as high during the declining phase of the solar cycles compared to the rising and maximum phases.
- During high disturbances, the change in IHFACs direction occurs earlier in the day.
- During the main phase, there is a notable increase in the negative component of ΔD around noon and a significant increase in the positive component at night.

Introduction

- The westward ΔD (daily variation of the D-component relative to the midnight-midnight baseline) magnetic field corresponds to northward Inter-Hemispheric Field-Aligned Currents (IHFACs), while the eastward ΔD magnetic field corresponds to southward IHFACs.
- This study focuses on the long-term behavior of IHFACs during solar cycles 23 and 24.
- Specifically, the characteristics in the dawn, noon, and dusk sectors were investigated, revealing both long-term and short-term features of IHFACs.
- A comparative study of IHFACs during solar disturbed and quiet times was conducted to identify the characteristics of IHFACs during disturbed periods.

Method

- The daily baseline was calculated using midnight data points. This baseline was subtracted from the D-Component to calculate ΔD. The resulting ΔD variation patterns were then studied to identify the characteristics of IHFACs.
- Dst and Kp indexes were used to identify solar disturbances and to measure the intensity of solar disturbances. F10.7 index was used to measure solar active intensity in solar cycles [1,3].
- The average of the five quietest days of each month was used to determine the monthly quietest daily variation. Disturbance-time IHFACs variations were then studied in comparison to this derived monthly quietest daily variation[2].

Long-term variation

- The peak-to-peak amplitude values of the yearly ΔD were approximately 2–3 times greater in the dawn and noon sectors compared to those in the dusk sector.
- During the solar cycle SC24, the ΔD yearly amplitude decreased by about 35% in the dawn and noon sectors but increased by about 200% in the dusk sector.
- The peak-to-peak amplitudes of ΔD in the dusk sector showed enhancements during the declining phases of both solar cycles.

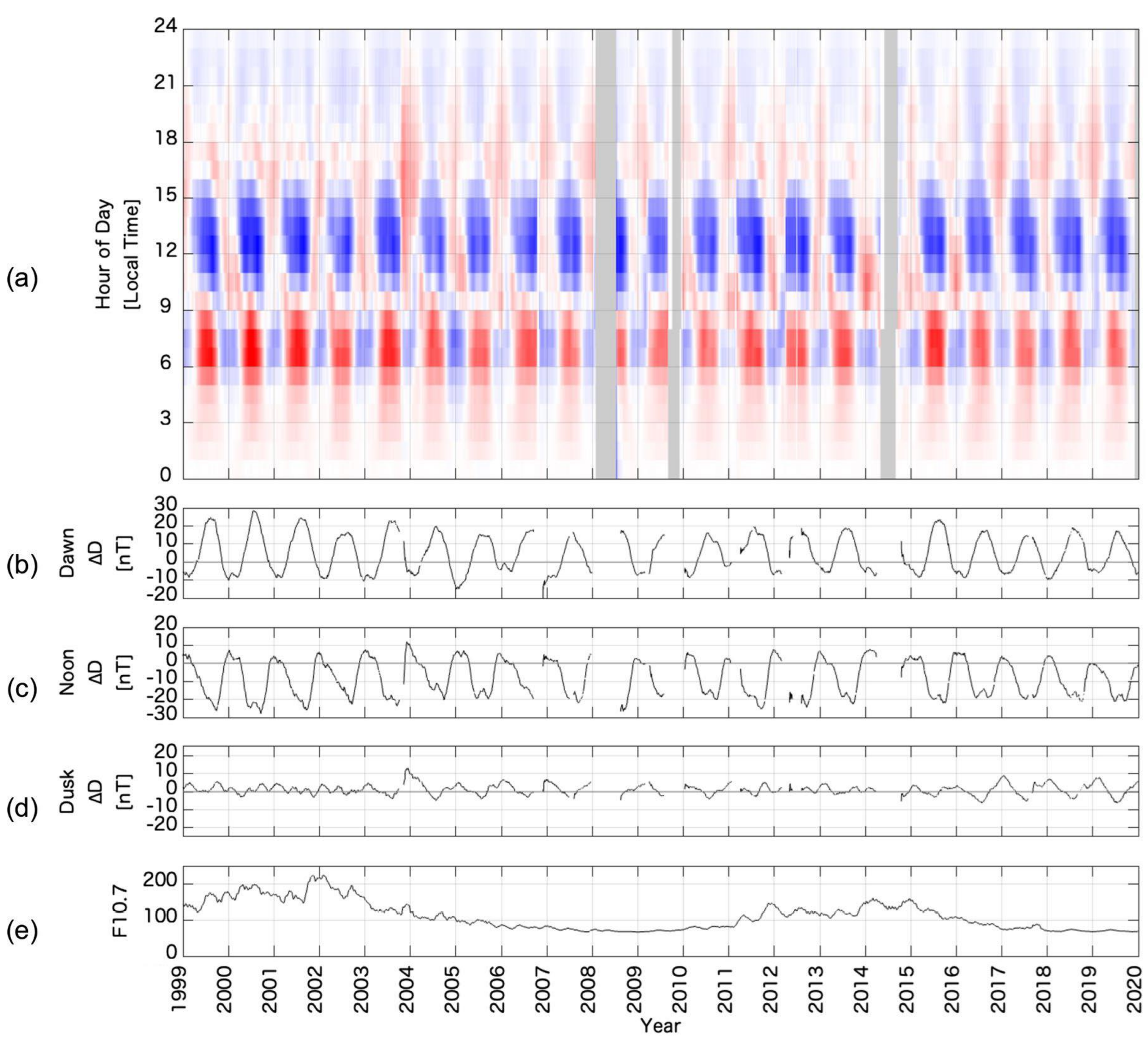

Figure 1 : Yearly ΔD variation in dusk, noon, and dawn sectors in solar cycles 23-24. Adapted from Ranasinghe et al., 2021[4]

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i-SPES, Kyushu University

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Disturbed time IHFAC variations

- Figure 3 illustrates the summarized variation in ΔD during disturbed and quiet times, with Dst and Kp indexes indicating the intensity of solar disturbances.
- During high solar disturbances, the change in ΔD direction takes place earlier in the day.
- When there is a rise in solar disturbances, the noon negative ΔD tends to persist for a longer period.
- When the intensity of solar disturbances increases, the noon negative ΔD intensity also increases. On the other hand, morning and night positive ΔD intensity decreases with high disturbances.
- In highly disturbed times, the night ΔD tends to be more negative.

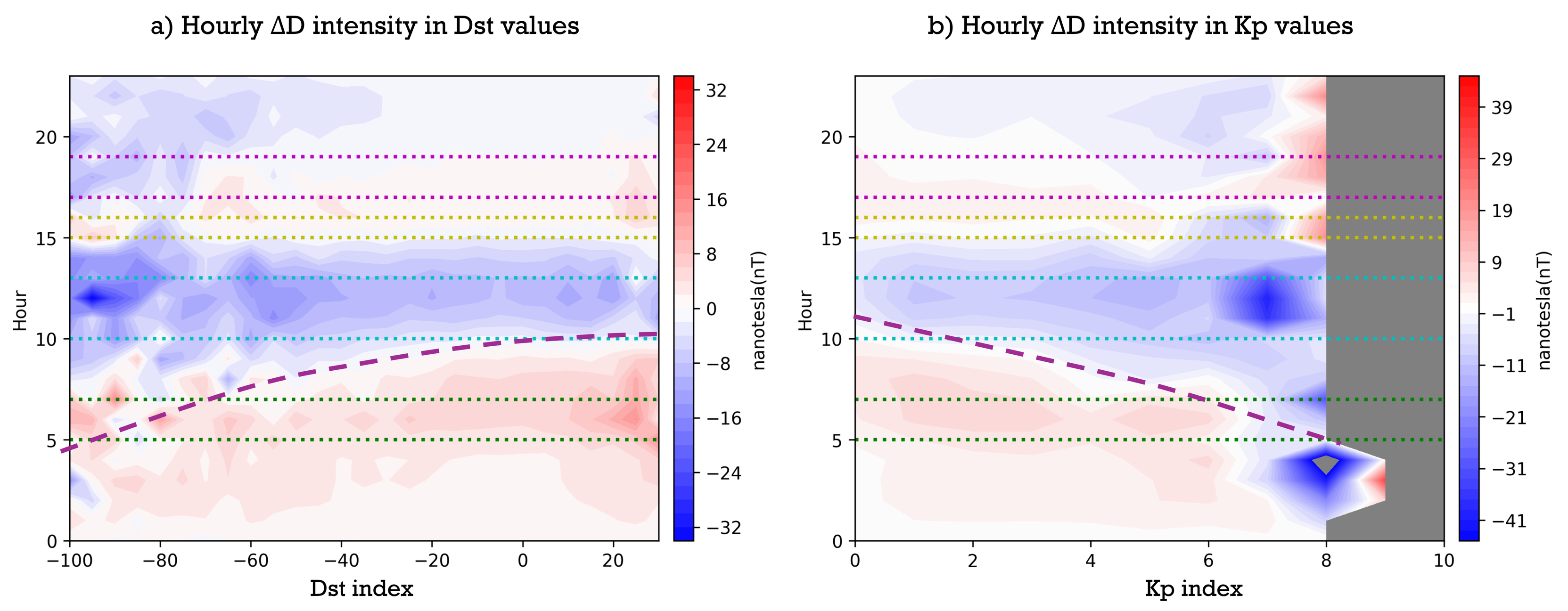

Figure 2 : Hourly ΔD intensity in different Dst and Kp indexes values

IHFACs in high intensity geomagnetic storms events

- Figure 4 illustrates the variations in geomagnetic field ΔH, ΔD, and ΔZ during high-intensity geomagnetic storms.
- Significant enhancements in the negative component of ΔD are visible during the main phase around local noon time, while a significant enhancement in the positive component of ΔD is visible during the main phase at night.
- In the recovery phase, the daily amplitude of the positive component of the ΔD variation gradually decreases over several days, while the negative component does not show significant deviation compared to quiet-time variation.

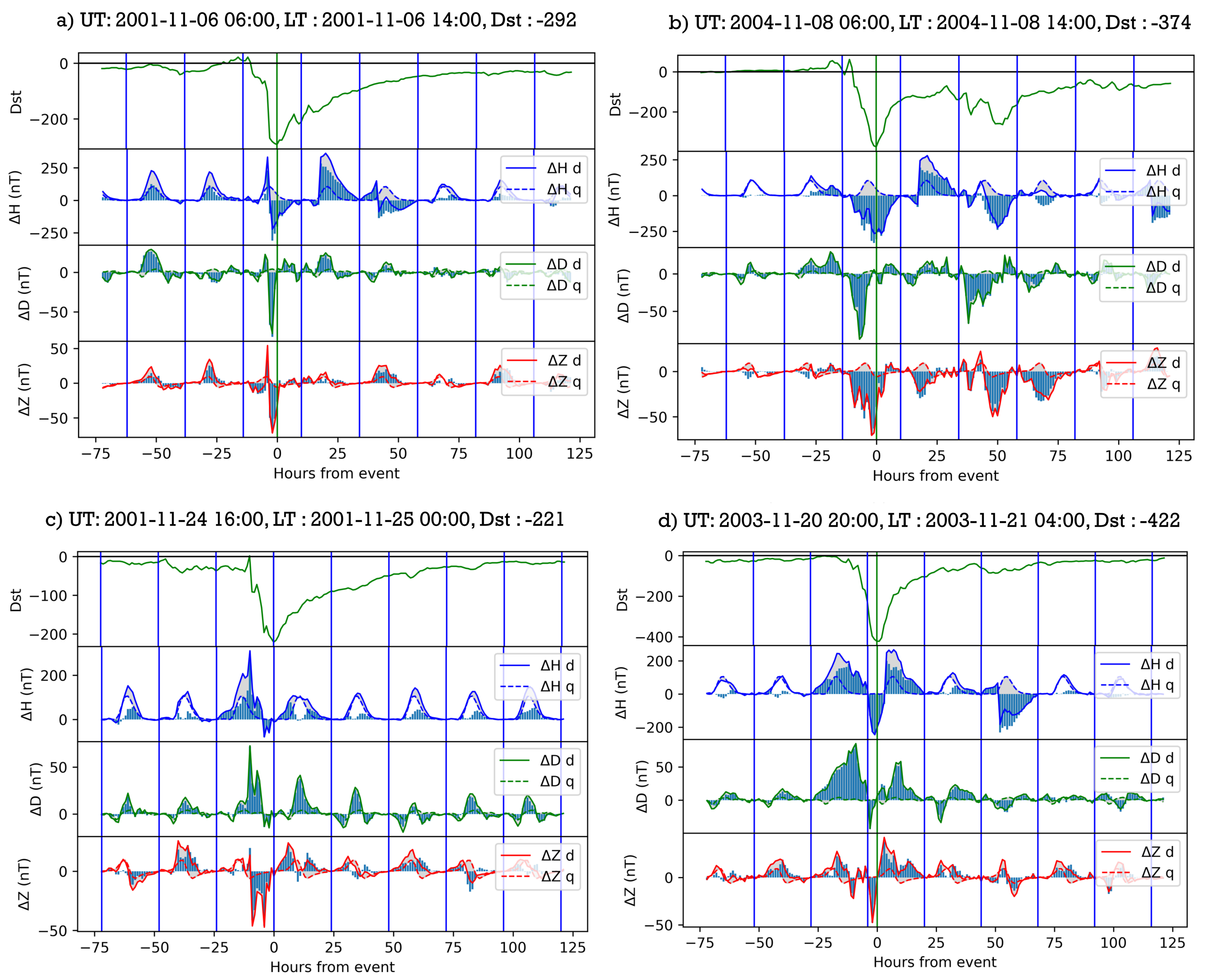

Figure 3 : Geomagnetic ΔH, ΔD, ΔZ component variations in extreme geomagnetic storm events.

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Manjula Ranasinghe
manjula@phys.cmb.ac.lk