Local time dependece of ULF wave activity driven by interplanetary shocks and foreshock transients

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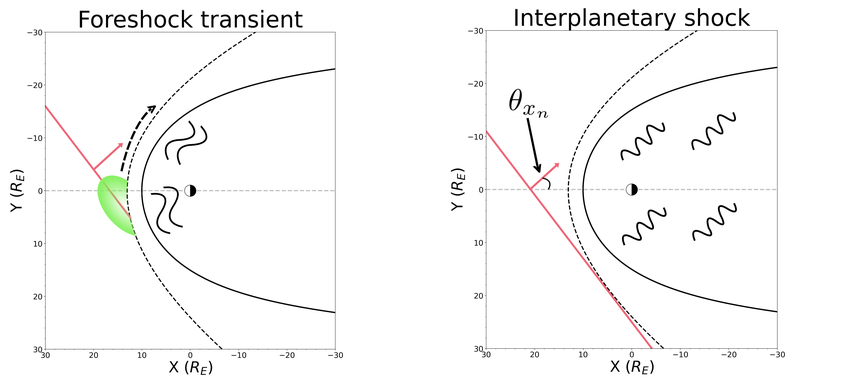
WAVESTORMS

BACKGROUND



Foreshock transients are mesoscale events that generate magnetospheric waves as they propagate.

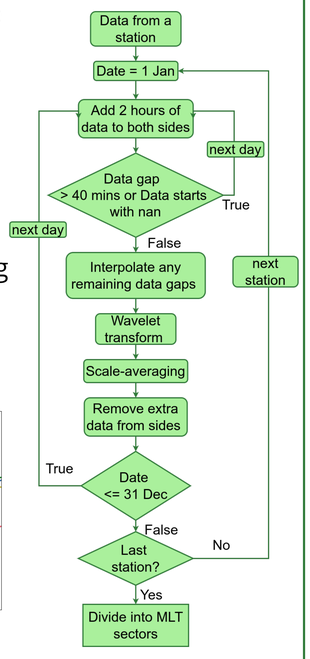
Interplanetary (IP) shocks are large-scale events that can generate global magnetospheric wave activity.

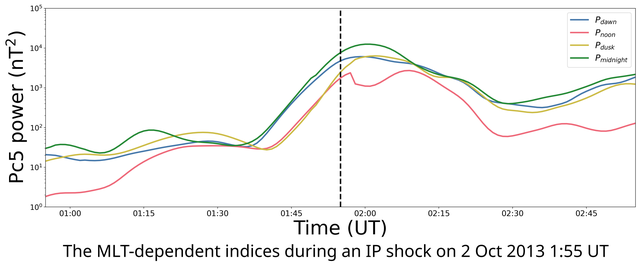
1. Does the impact angle θ_{x_n} of an IP shock affect where the peak ULF wave activity is observed?
2. Can a new Pc5 index reveal wave activity driven by foreshock transients?
3. How does the wave activity driven by transients compare to the wave activity driven by IP shocks?

MLT-DEPENDENT GROUND-BASED Pc5 ULF INDEX

We constructed a new Pc5 ULF index *P* to determine magnetic local time (MLT) dependence of waves

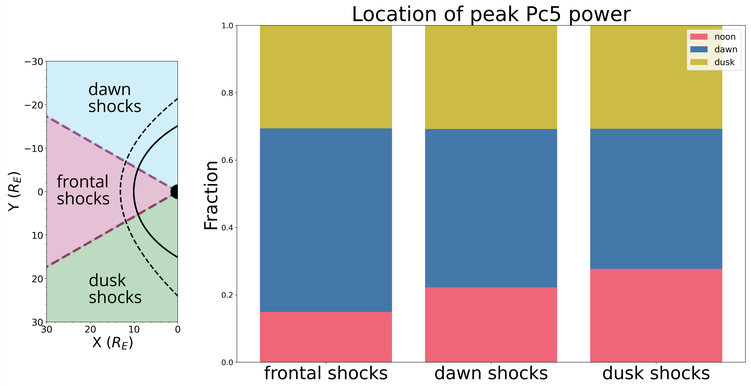
- SuperMAG 1-minute data
- Magnetometers at magnetic latitudes 65°-70°
- Wavelet transform
- Pc5 power by scale-averaging the wavelet between 150 s and 600 s
- Compute MLT-dependent wave power by averaging the power over all the stations in a given MLT sector: Dawn (3-9 MLT), Noon (9-15 MLT), Dusk (15-21 MLT) and Midnight (21-3 MLT)





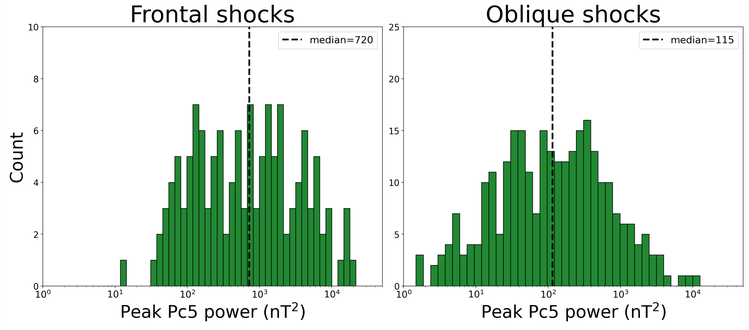
The MLT-dependent indices during an IP shock on 2 Oct 2013 1:55 UT

WAVES BY INTERPLANETARY SHOCKS



The left panel displays the shock category assigned according to the orientation of the shock's normal and the right panel shows the fraction of peak Pc5 power observed at each MLT sector for frontal, dawn and dusk shocks.

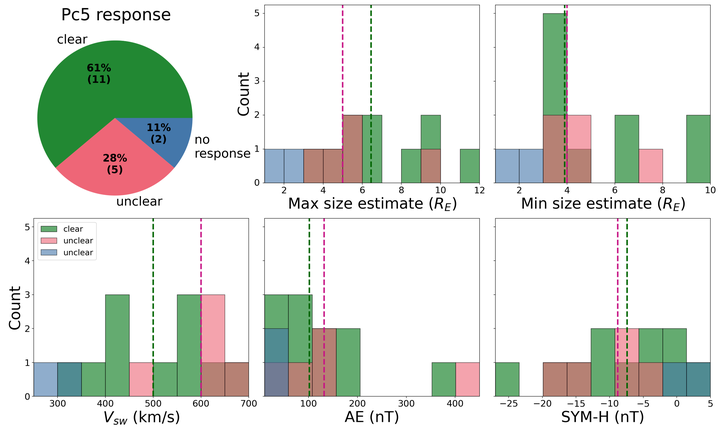
- We investigated 520 IP shocks between 1995-2023 [Oliveira, 2025]
- Shocks were divided into three categories by their impact angle
- We study where the largest Pc5 power peak is observed in the 15 minutes following the shock arrival
- 30% of peaks happen at dusk regardless of the shock category
- 15% of frontal shocks, 22% of dawn shocks and 28% of dusk shocks have peak power at noon
- Peak power is most often observed at dawn



- Oblique shocks = dusk + dawn shocks
- Peak powers of frontal shocks are concentrated at higher levels
- The median peak power of frontal shocks is over six times larger than the median of oblique shocks

WAVES BY FORESHOCK TRANSIENTS

- We studied the Pc5 wave response to 18 foreshock transients (8 foreshock bubbles and 10 hot flow anomalies)
- Some events show a clear response, i.e. the wave power increases significantly, and others no response at all
- Event is defined to have an unclear response if:
  - power was elevated before the transient arrived
  - a response is observed over 10 minutes after the arrival
- Size of the transient and solar wind speed affect the most how clear the response is, smallest events have no response



- We also find that for clear events, the position of the Pc5 wave power peak follows the motion of the transient, with one exception

CONCLUSIONS

- IP shock impact angle does not affect where the peak Pc5 power is observed, but it affects how strong the response is
- The index suggests similar responses as previous studies
- Propagation direction, size and solar wind speed play the most important role in the wave generation by transients
- Transients can drive Pc5 power comparable to IP shocks

REFERENCES

Denny M. Oliveira. (2025). Interplanetary shock data base [Data set]. Zenodo. https://doi.org/10.5281/zenodo.15121223

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