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# Statistical study of Stream Interaction Regions at 1 and 1.5 AU


Geyer, P.[1], Temmer, M.[2], Guo, J.[3,4], Heinemann, S. [5]

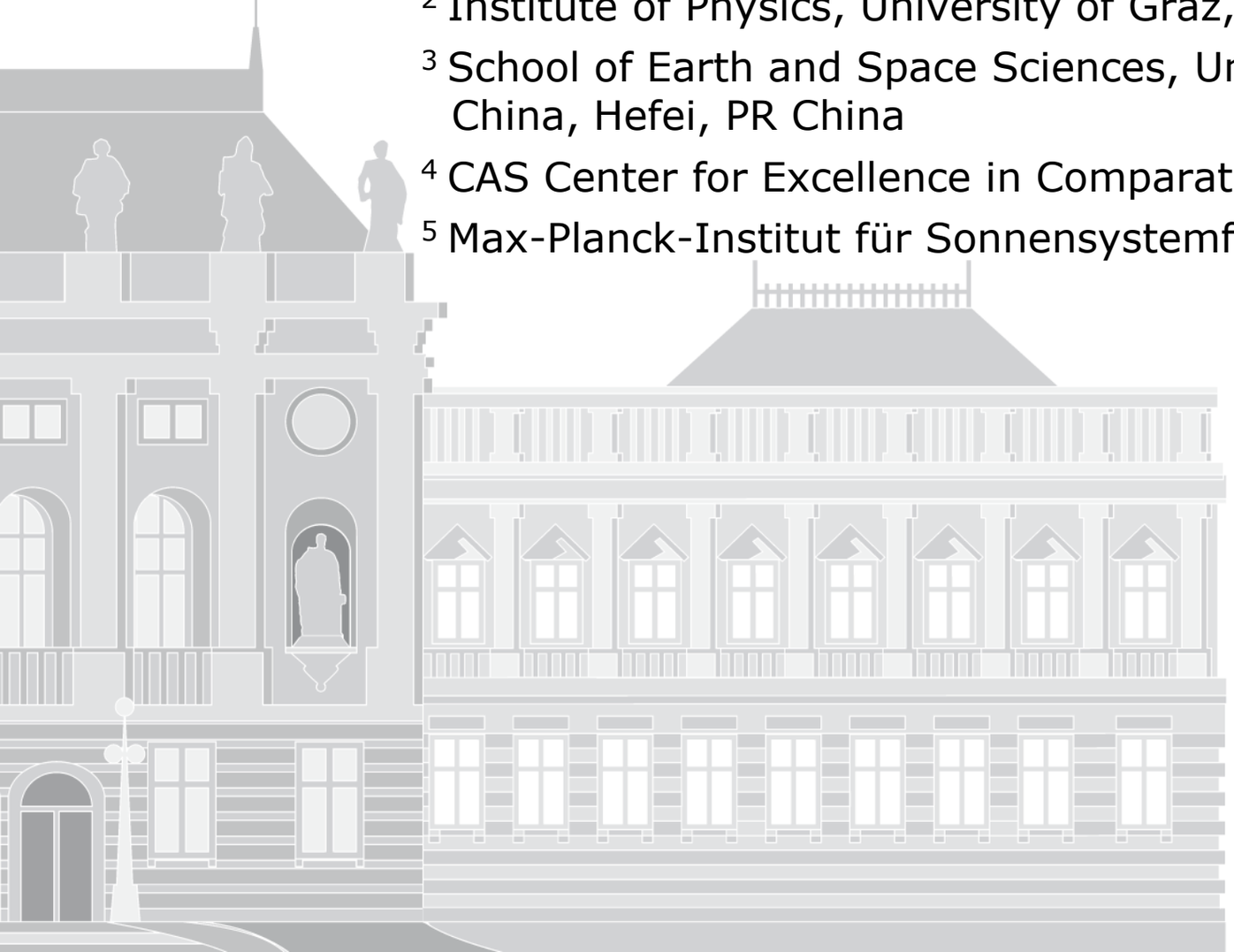
[1] Faculty of Geodesy, University of Zagreb, Croatia

[2] Institute of Physics, University of Graz, Austria

[3] School of Earth and Space Sciences, University of Science and Technology of China, Hefei, PR China

[4] CAS Center for Excellence in Comparative Planetology, Hefei, PR China

[5] Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany

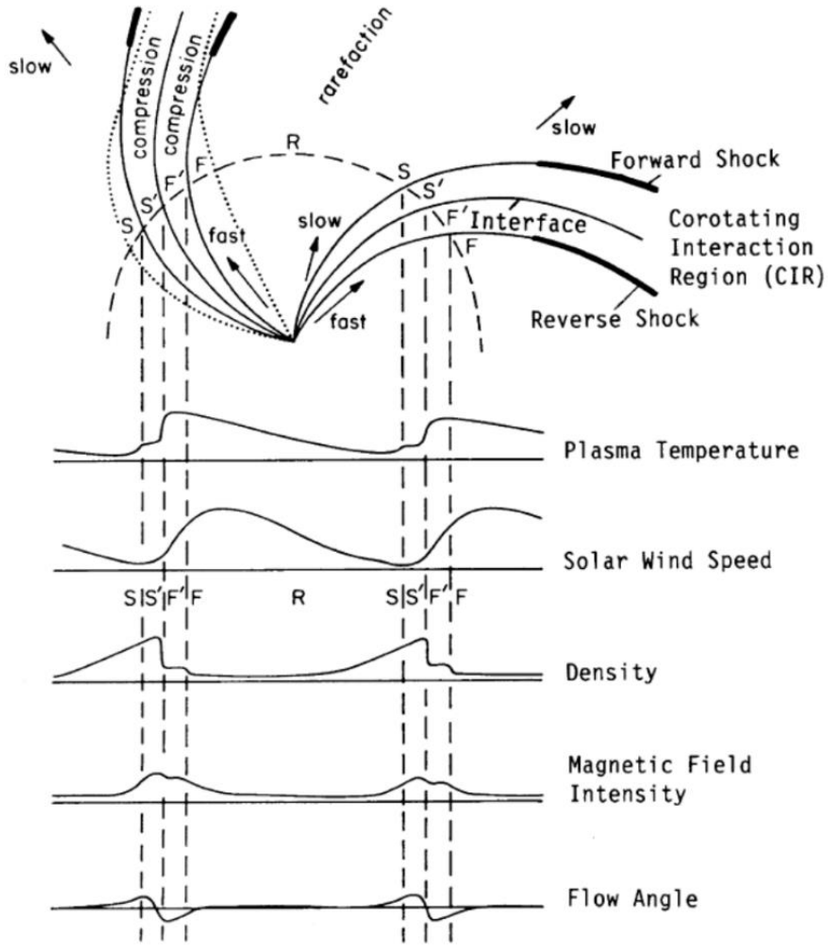
Der Wissenschaftsfonds.

FFG


email: paul.geyer@live.at

# State of the Art

- Stream expansion of SIRs at the interface and shock formation predicted by models:
  - Hundhausen 1973
  - Gosling and Pizzo 1999
  - Cranmer+ 2007

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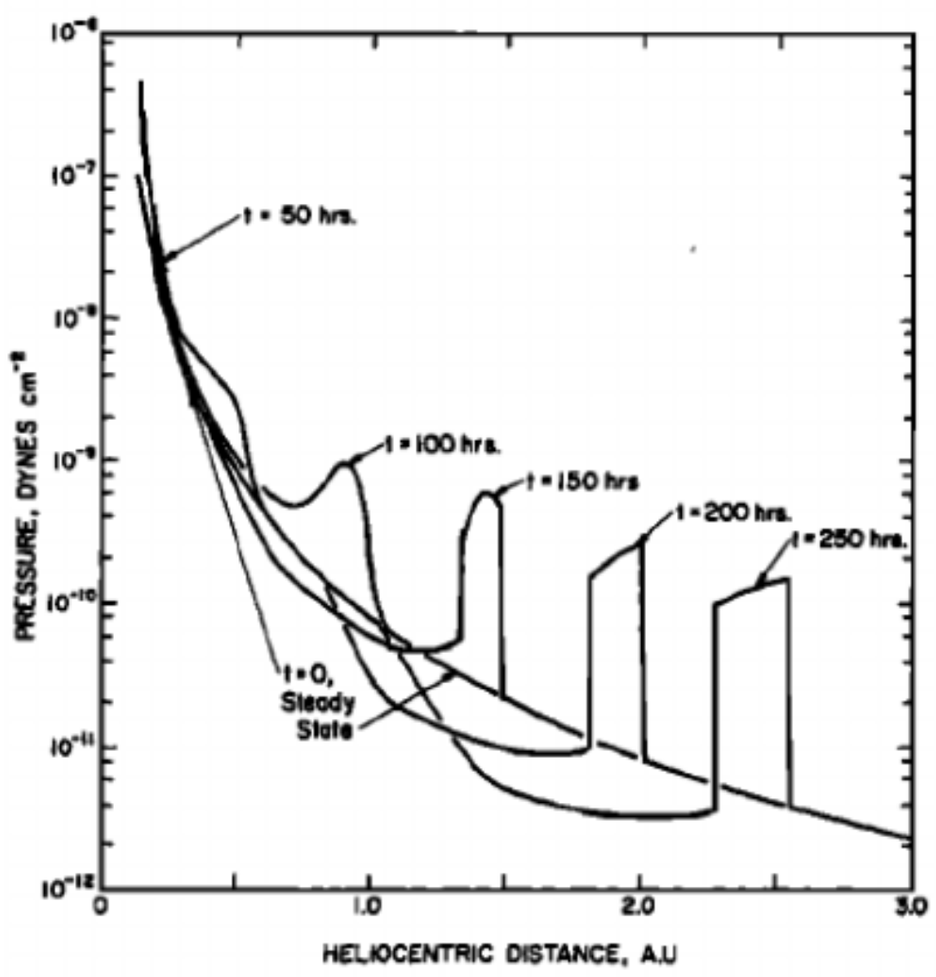



© Hundhausen 1973

# Data & Methods I

- OMNI and MAVEN in-situ plasma and magnetic field data, SDO EUV images

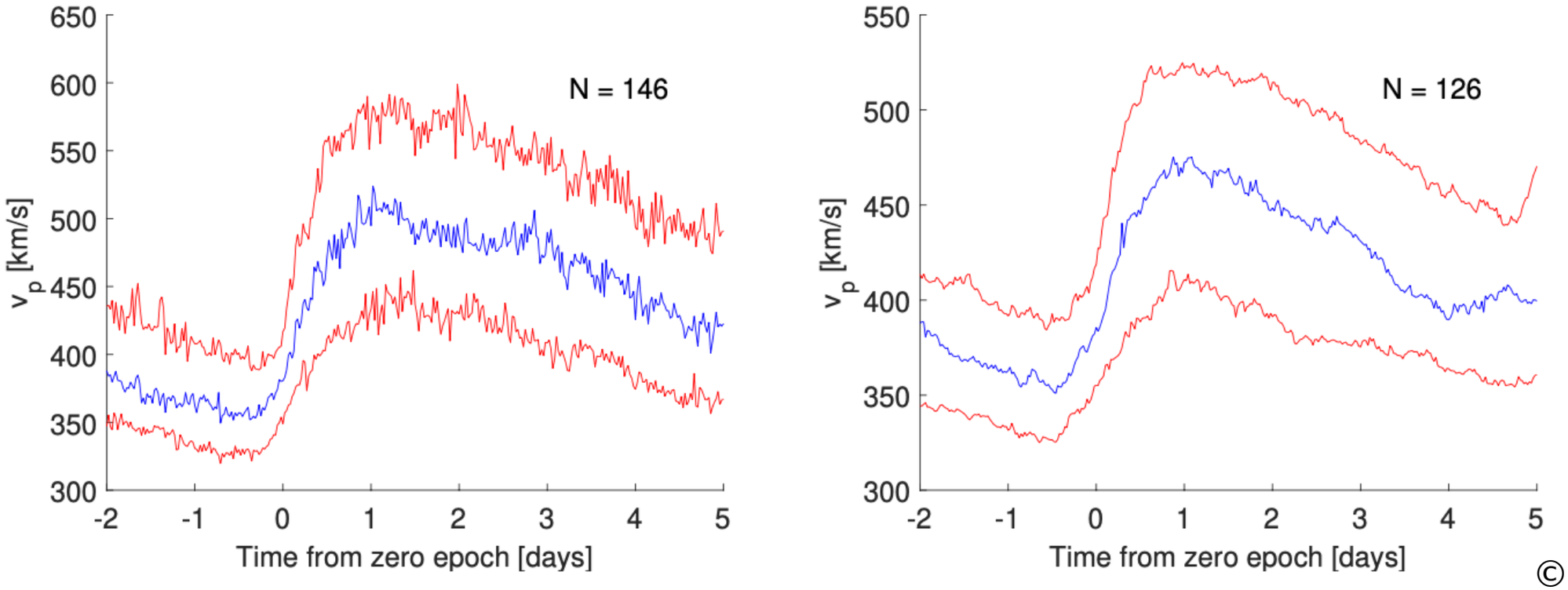
- Catalogs of Grandin+ 2019 and Huang+ 2019

- **Superposed epoch analysis**: Extraction of statistical parameters of events shifted to reference (“epoch”) time

- **Aligned events analysis**: Correlation of CHs extent with SIR plasma properties

# Data & Methods II

SEA example, SW bulk speed (Earth: left; Mars: right)

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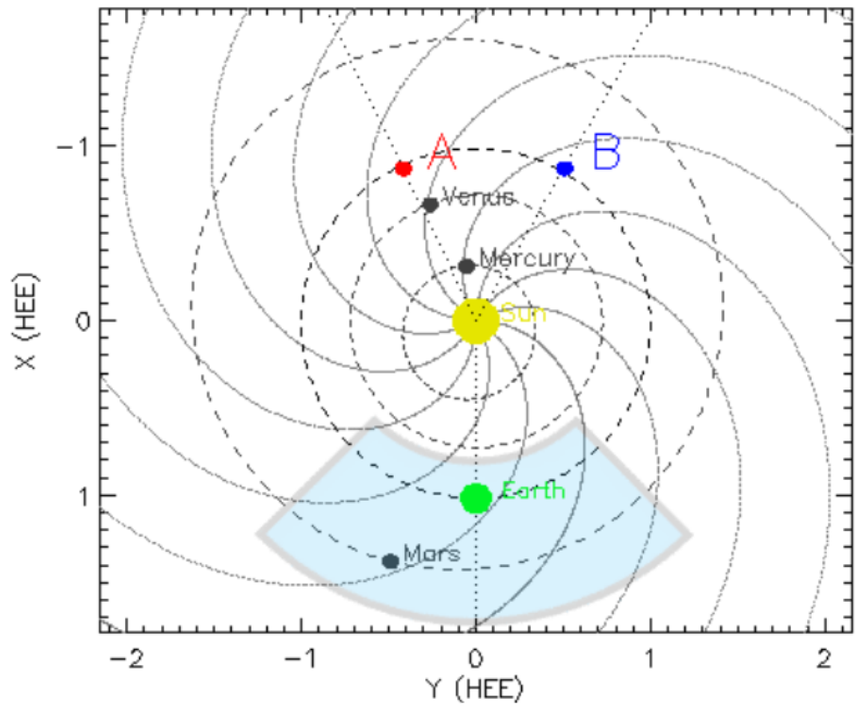
Aligned events constrain:




$$\Delta t = t_M - t_E = \frac{\phi_M - \phi_E}{\omega_{sun}} + \frac{r_M - r_E}{v_{SW}}$$

Opitz+ 2009

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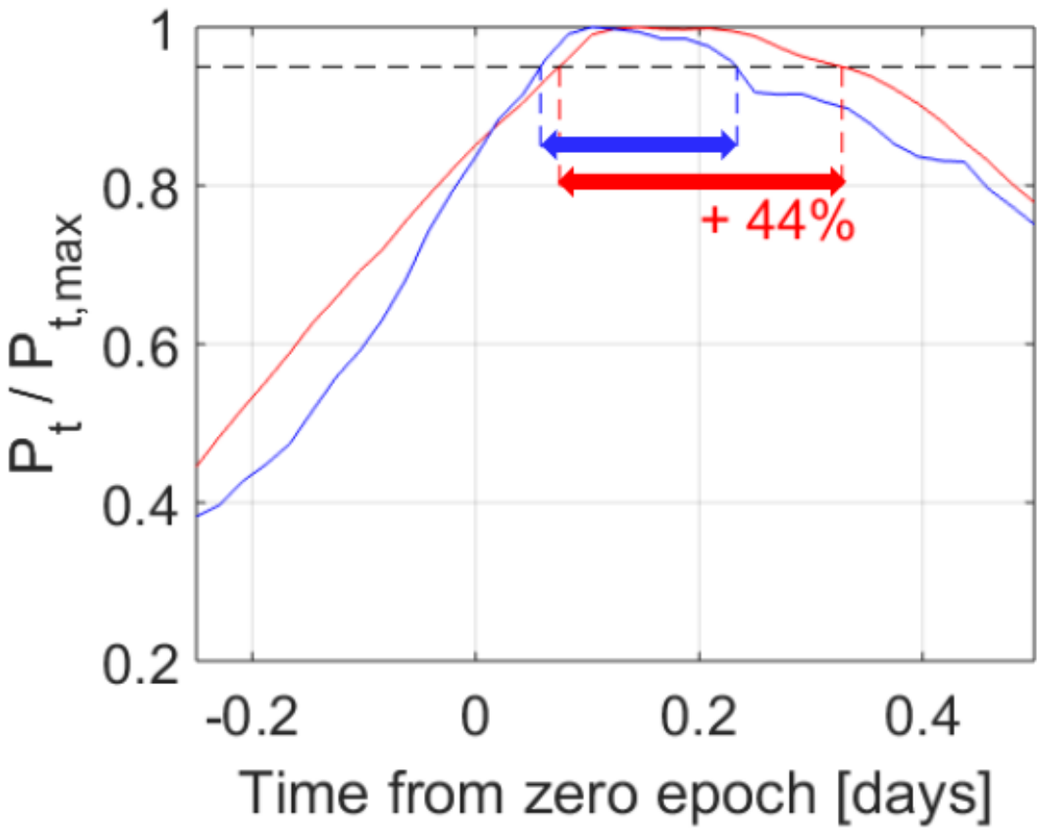
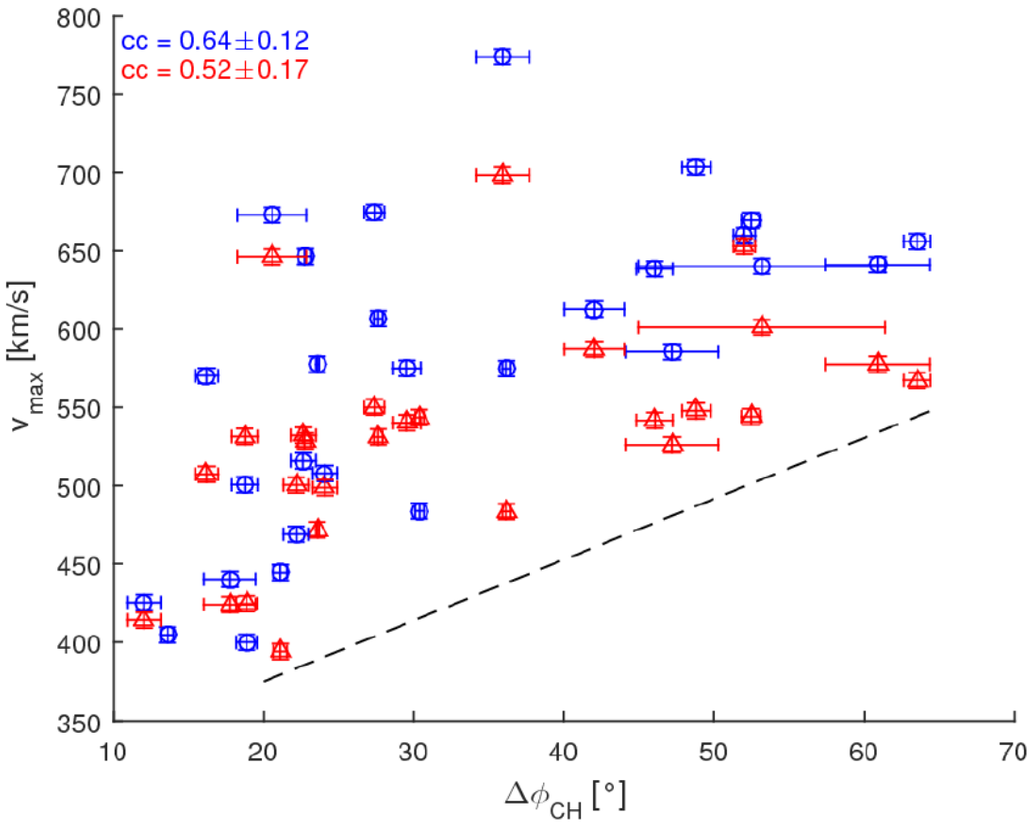
# Results

- Expansion of wave crest from 1 – 1.5 AU:




- Good correlation of maximum SW speed with CH $\Delta\varphi$:




- Shock occurrence rate:

| Shock type | Earth | Mars |
|---|---|---|
| FF only | 6.7% (3) | 20.0% (9) |
| FR only | 6.7% (3) | 6.7% (3) |
| FF and FR | 0 % (0) | 8.9% (4) |
| FF and/or FR | 13.3% (6) | 35.6% (16) |

# Discussion & Conclusion

- Most evolution happens on front side of SIRs from 1 – 1.5 AU, as shock occurrence rates imply

- Expansion of streams linked to higher shock occurrence rate (Gosling and Pizzo 1999, Hundhausen 1973)

- Steepening of waves also consistent with amplitude analysis of Richter and Luttrell (1986, 0.35 – 0.95 AU)

- High correlation of HSS maximum speed with latitudinal extent → only valid for small to medium sized CHs? (c.f. Garton+ 2018)

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