

# A unified framework for global auroral morphologies of different planets

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## Supplementary Information for

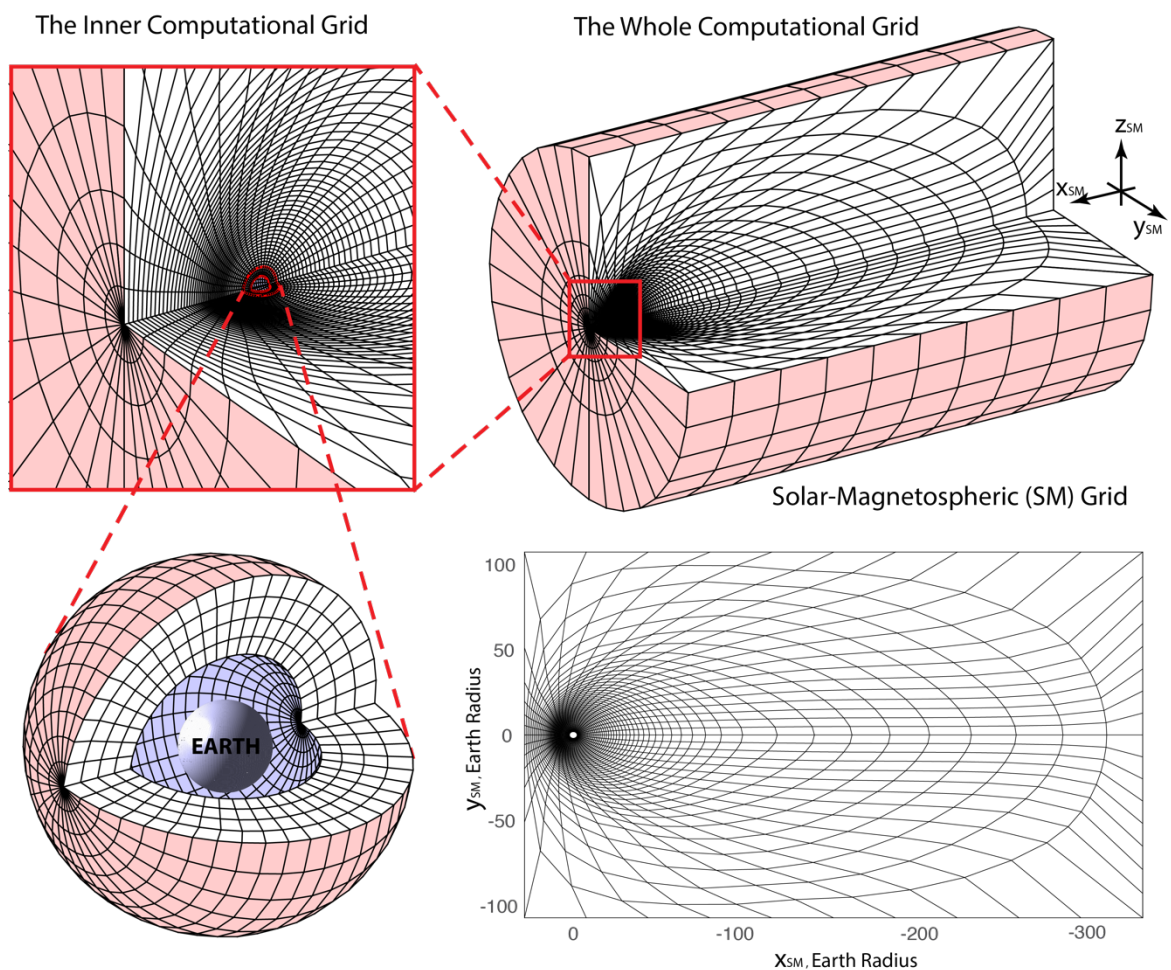
### A unified framework for diverse global auroral morphologies at planets

B. Zhang, Z. Yao\*, O. J. Brambles, P. A. Delamere, W. Lotko, D. Grodent, B. Bonfond, J. Chen<sup>1</sup>, K. A. Sorathia, V. G. Merkin, J. G. Lyon

\*To whom correspondence should be addressed. Email: yaozh@hku.hk

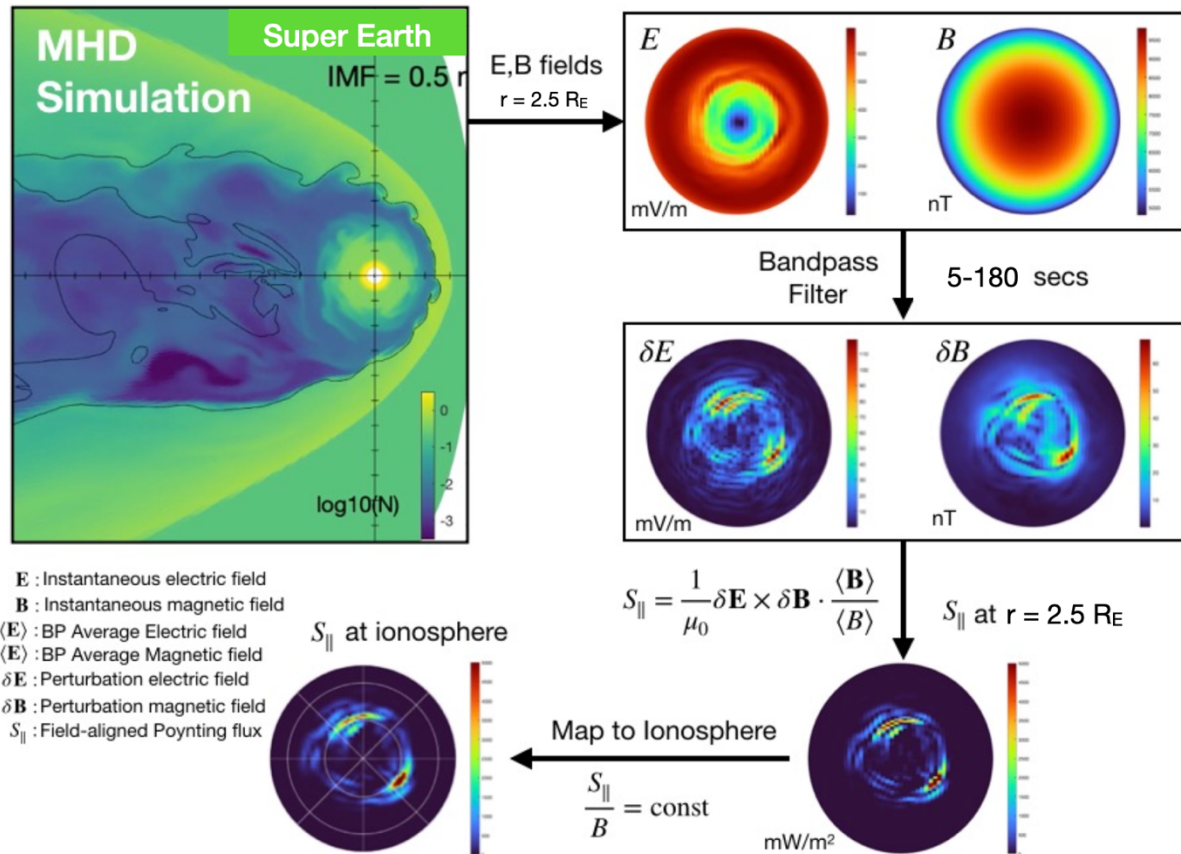
## Figures

Supplementary Fig. 1 Three-dimensional view of the computational grid. The grid shown is down-scaled to a resolution of  $32 \times 32 \times 32$ , which is eight times coarser than the grid used in this study.



12 **Supplementary Fig. 2 The calculation of the Alfvénic Poynting flux from the MHD electric**  
 13 **and magnetic fields.**

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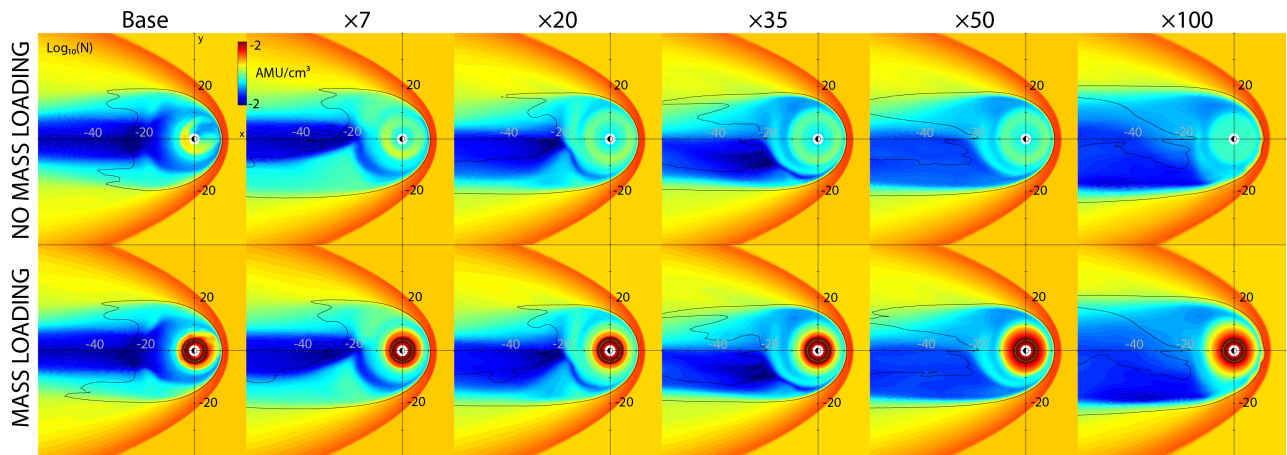


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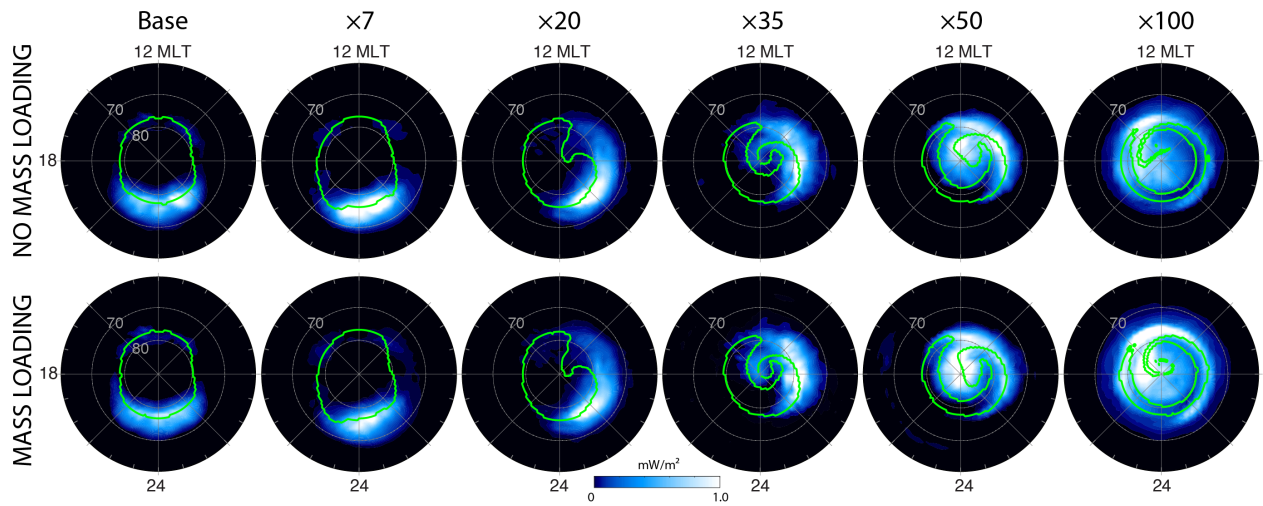
17 **Supplementary Fig. 3 Number density distribution of super-rotating Earth systems under**  
18 **mass loading and no mass loading conditions.**

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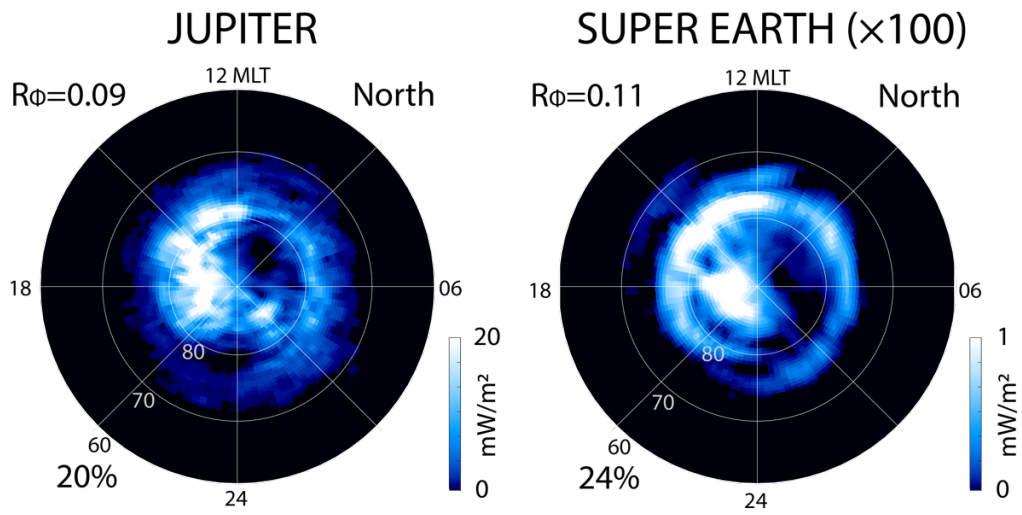
21 **Supplementary Fig. 4** Alfvénic auroral morphologies of super-rotating Earth systems  
22 **under mass loading and no mass loading conditions.**

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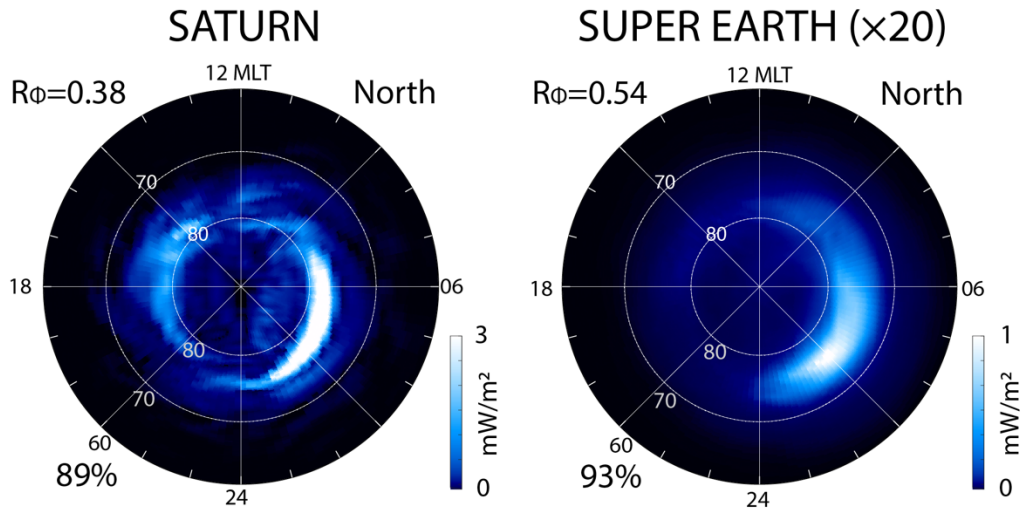


25 **Supplementary Fig. 5 The Alfvénic oval from a) a Jovian magnetosphere simulation and b)**  
26 **the “super Earth” case with 100x enhancement in the rotation speed.**

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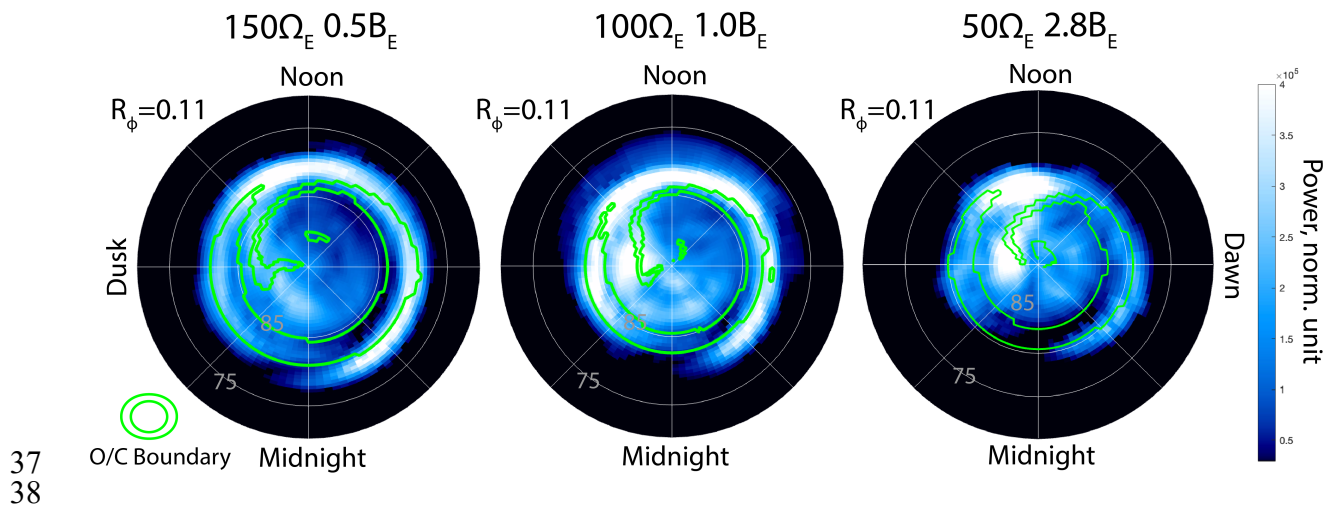
28 **Supplementary Fig. 6 The Alfvénic oval from a) a Kronian magnetosphere simulation and**  
29 **b) the “super Earth” case with 20x enhancement in the rotation speed.**



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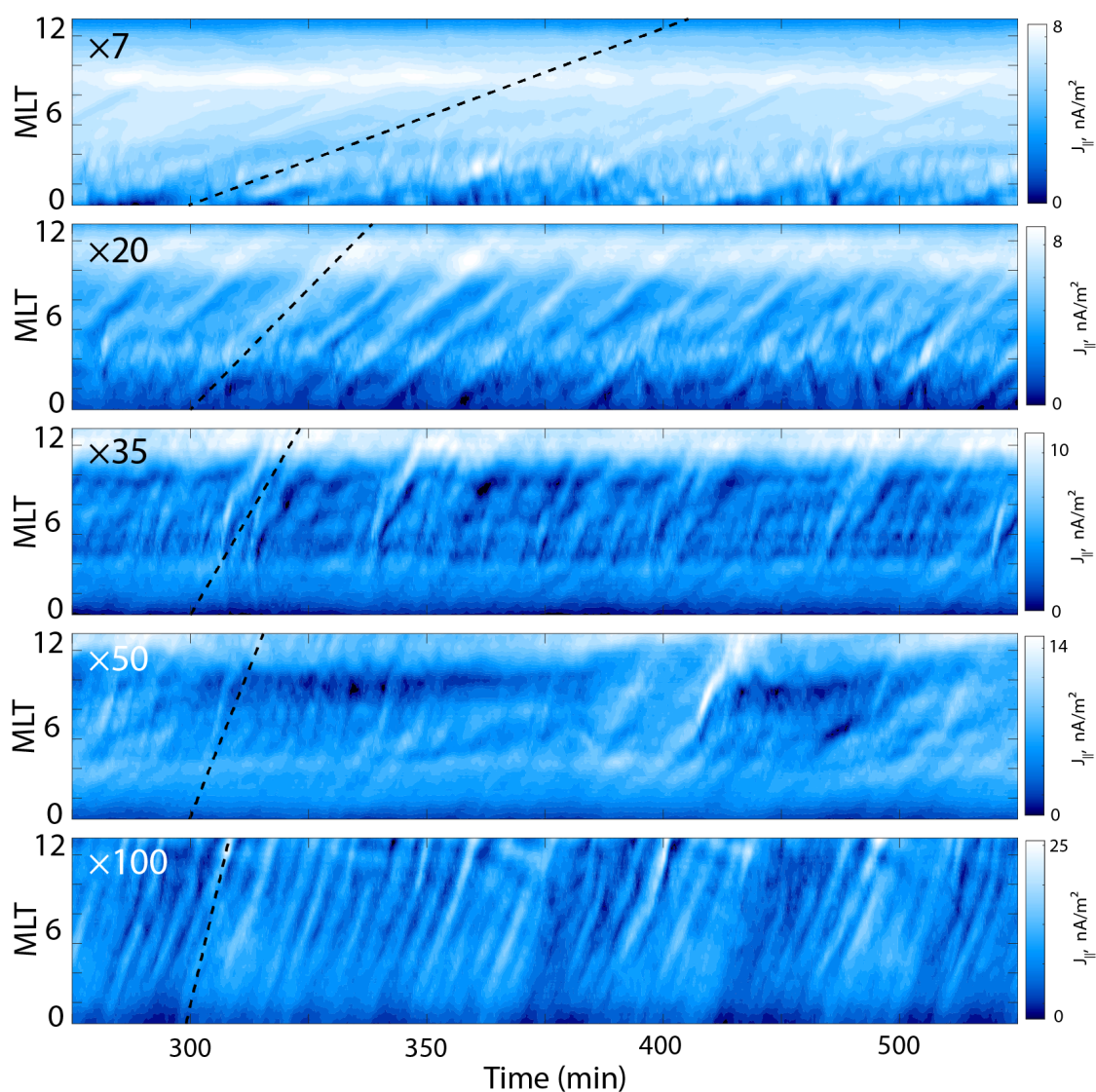
32 **Supplementary Fig. 7 A comparison between the global auroral morphologies at Saturn**  
33 **and Super-rotating Earth. Simulated open flux boundary and one-hour averaged Alfvénic**  
34 **power (in normalized units) from three test simulations with the same  $R_\phi$  value but**  
35 **different magnetic field strength.**

36



39 **Supplementary Fig. 8 Demonstration of corotating field-aligned current system in the**  
40 **ionosphere in the super-rotating models. The color shows the latitude-averaged (70-80**  
41 **MLAT) intensity of  $J_{\parallel}$  on the dawnside (0-12 MLT) as a function of time. The dashed line**  
42 **in each panel mark a given fixed point in the ionosphere to corotate with the planet,**  
43 **providing a reference of planetary rotation. The strips correspond to enhanced current**  
44 **structures that rotate with the planet.**

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