

Solar Impacts on Atmospheric Electric Fields



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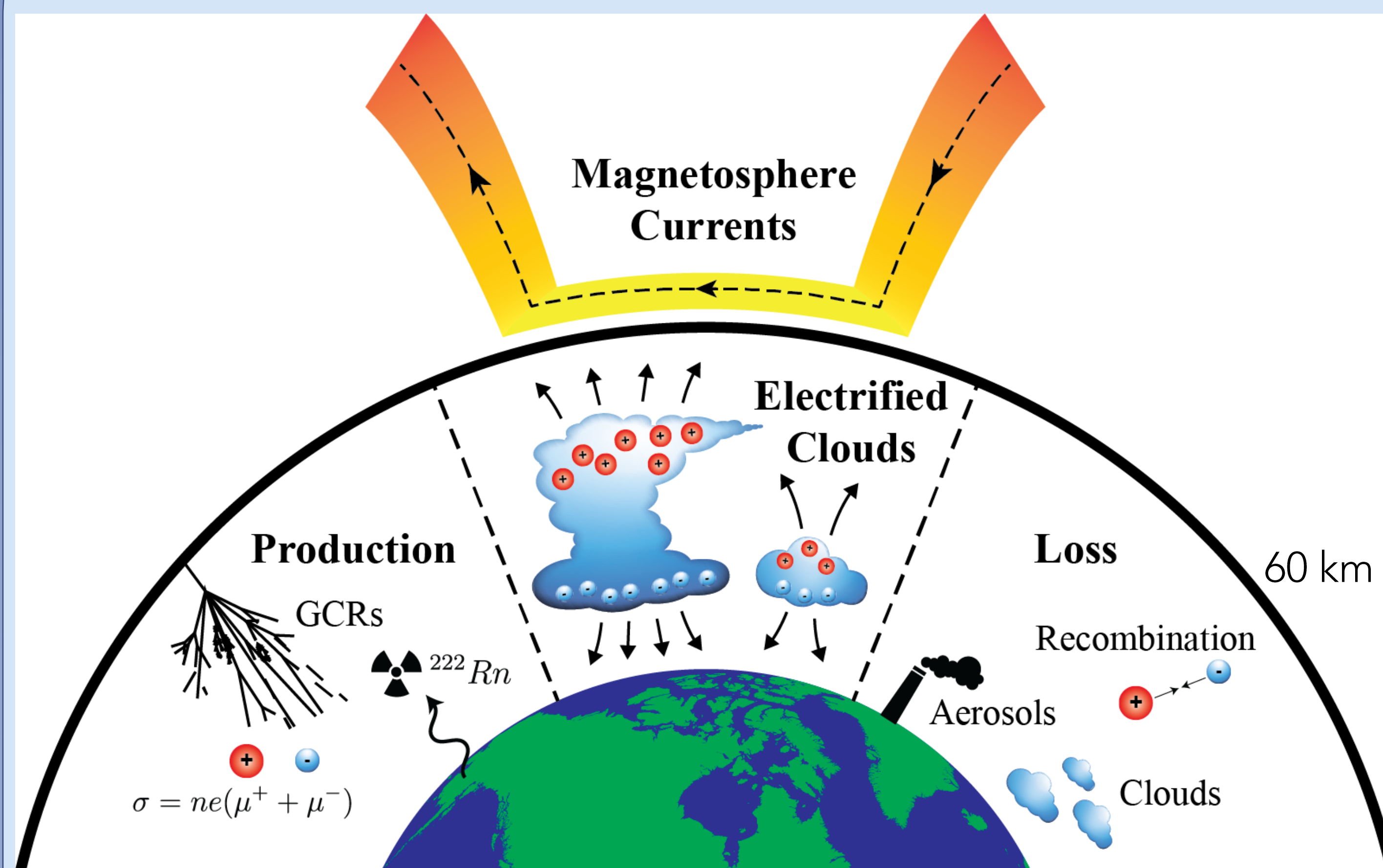
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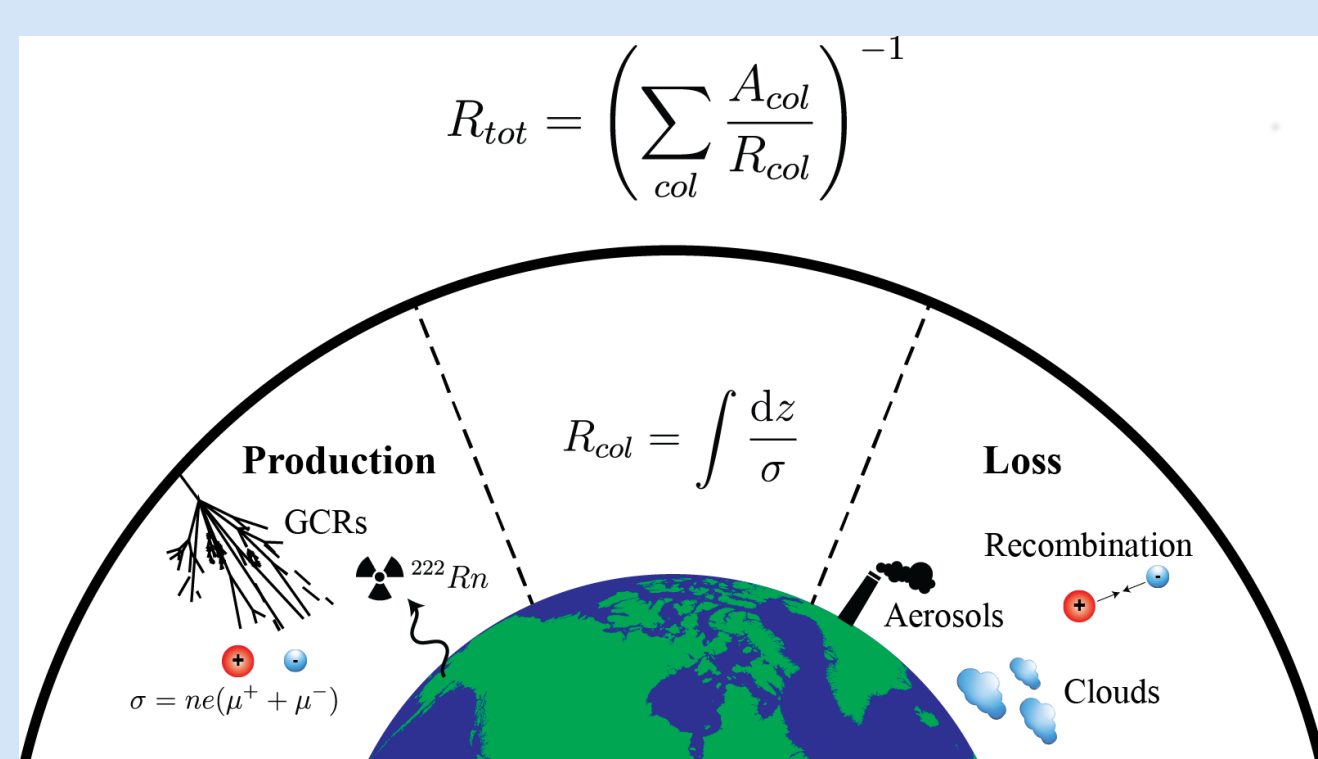
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Global Electric Circuit



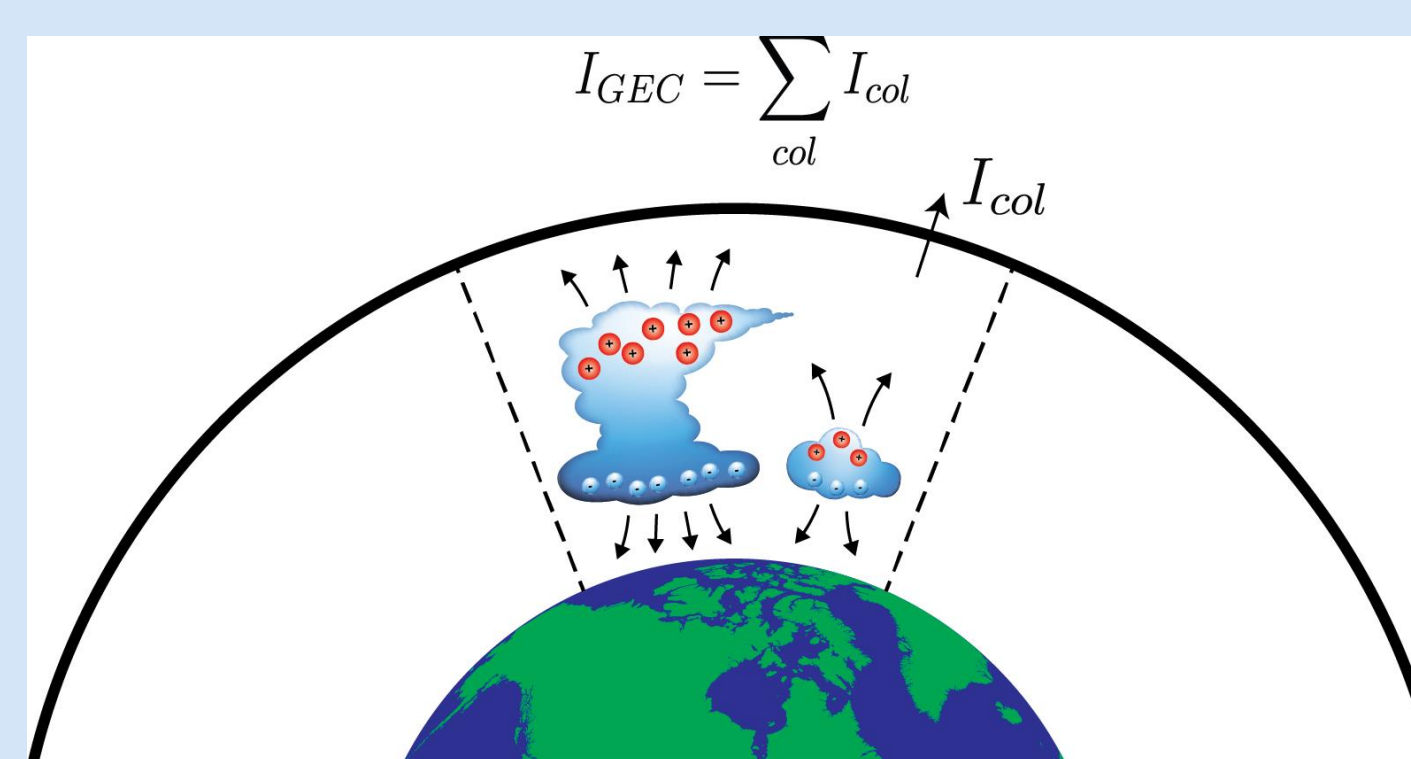
A persistent electrical system is present throughout the lower atmosphere that is produced by thunderstorms across the world. This electrical system can be thought of as a leaky capacitor with the ionosphere and ground held to different potentials by the global distribution of storms. We have developed a new model to represent this global electric circuit (GEC) within the Whole Atmosphere Community Climate Model (WACCM) and have integrated the magnetospheric current system.

Resistance



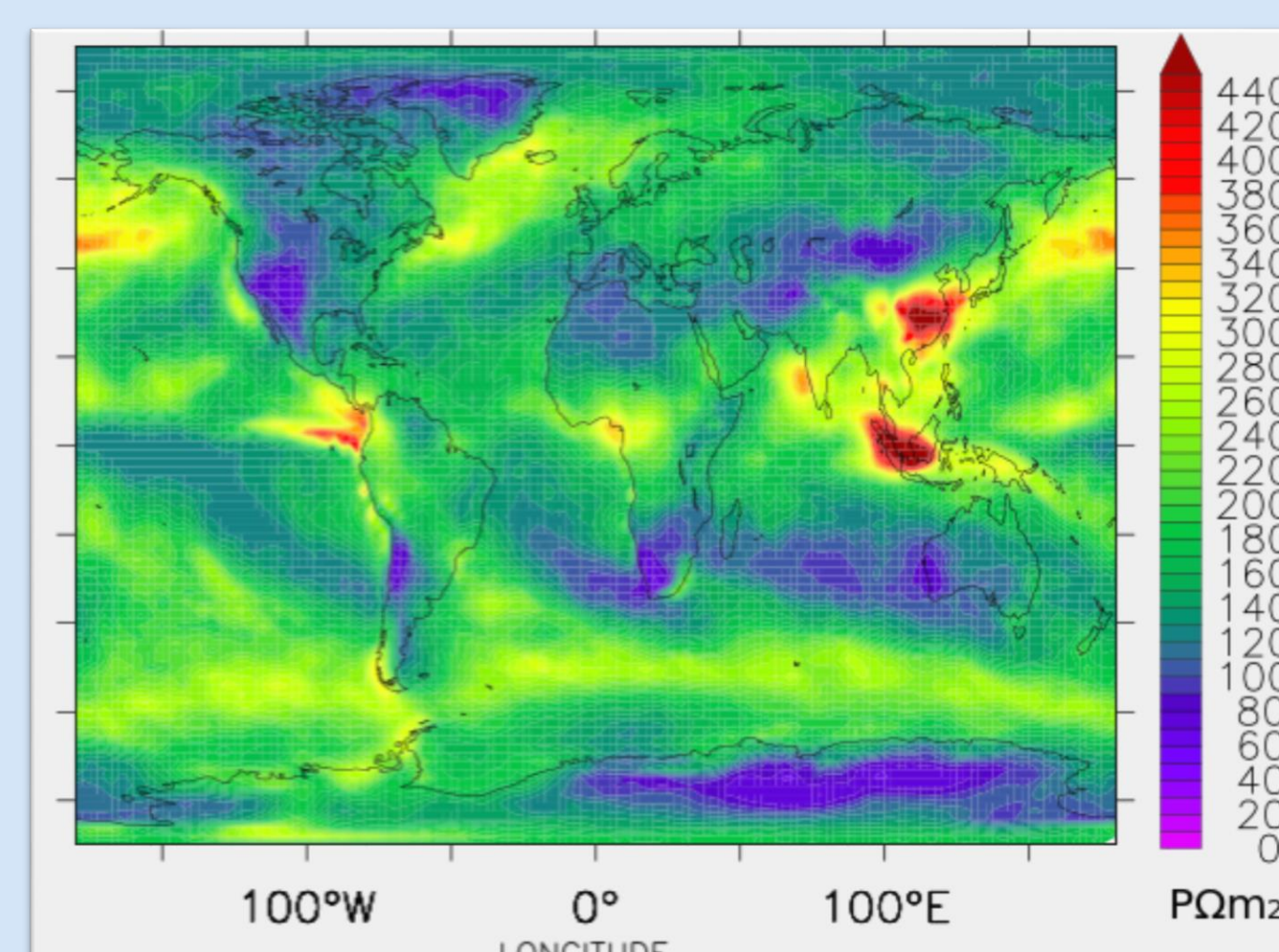
- Production and loss of ion pairs in the atmosphere produces a conduction mechanism
- Integrated column resistance leads to a total global resistance (~250 Ω)

Sources

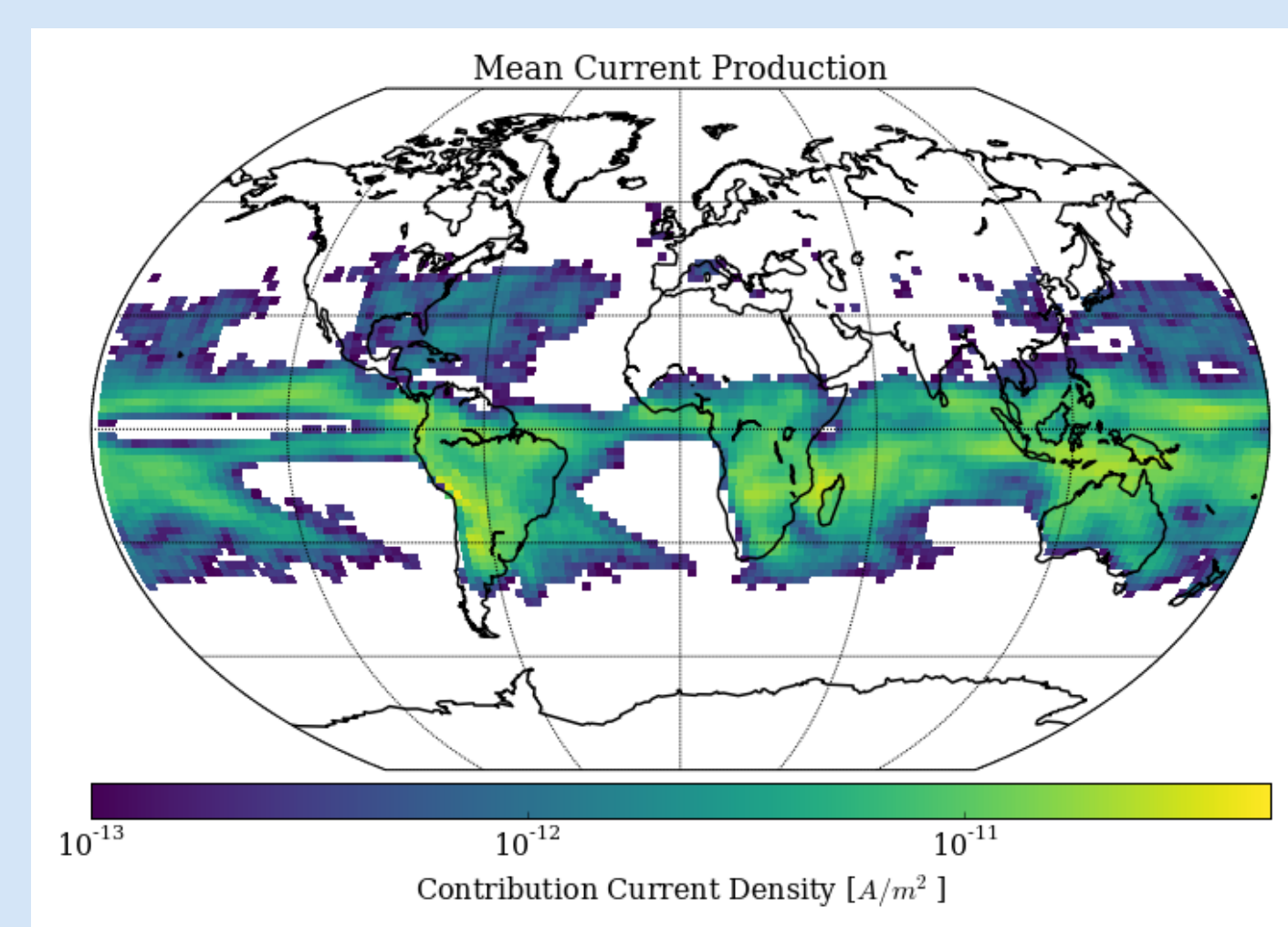


- Thunderstorms within a model column produce a source current
- These source currents (~1 kA) charge the ionosphere and return through fair-weather regions

Model Produced Resistance and Sources

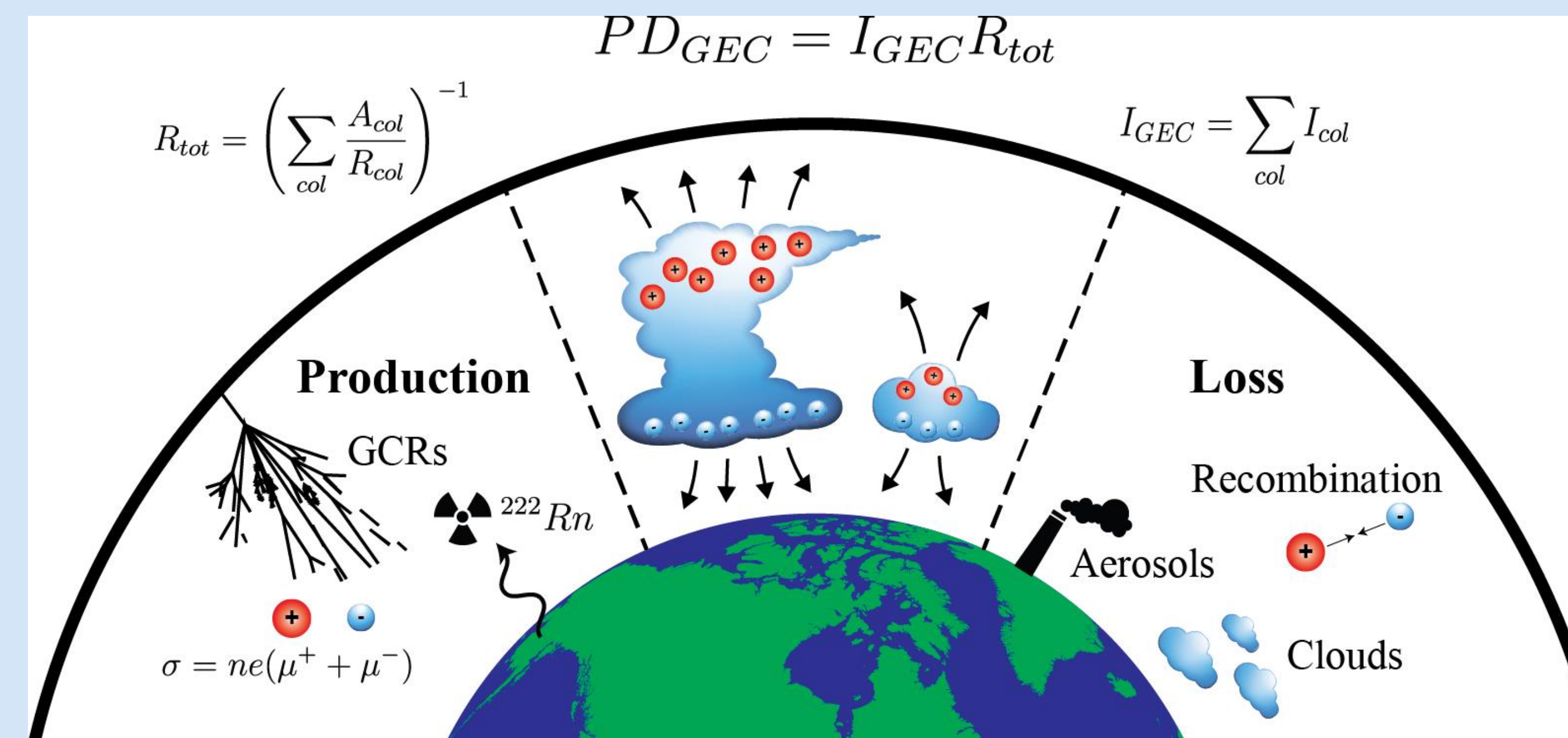


1-year average column resistance



Jan-Mar current production

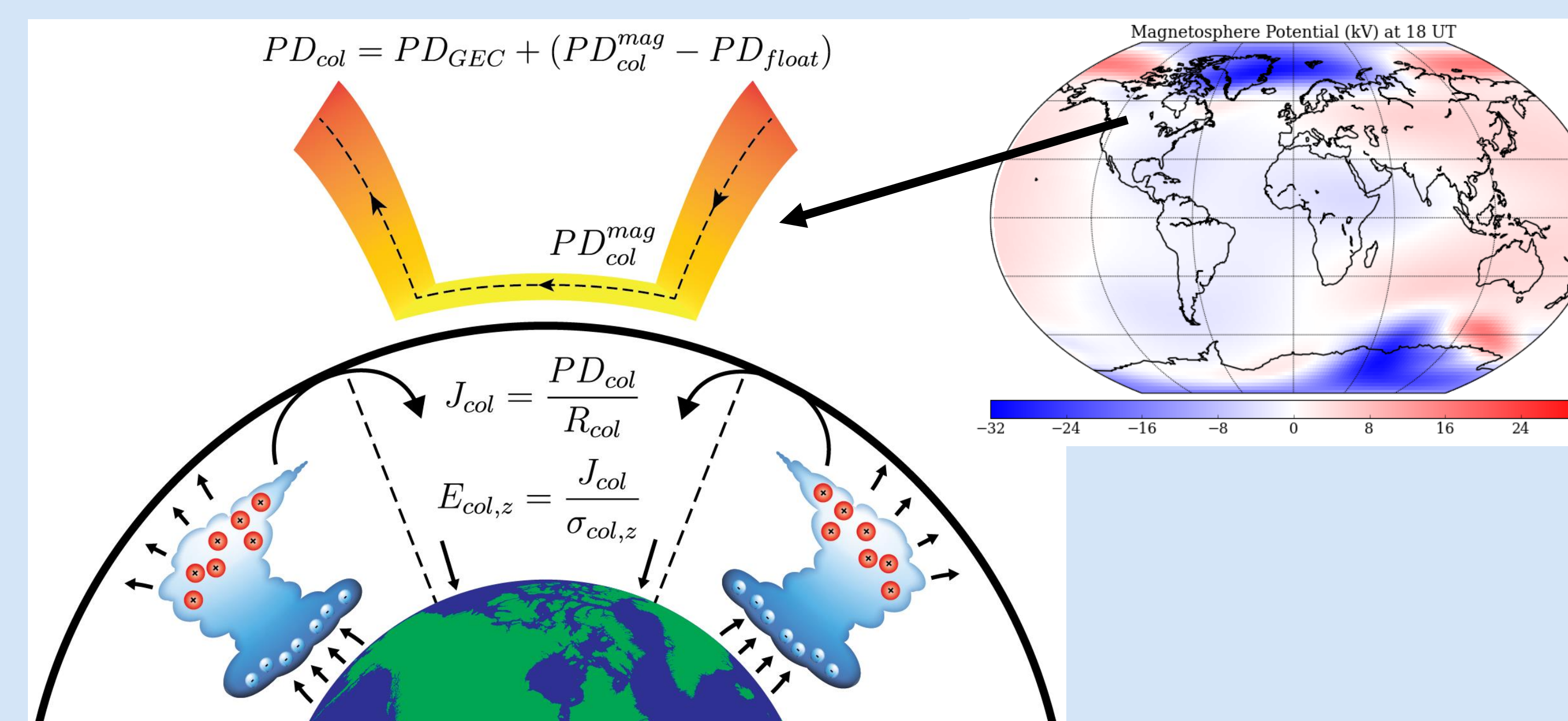
GEC Potential



Once the total current and resistance are calculated the total GEC potential is determined through Ohm's law (~250 kV).

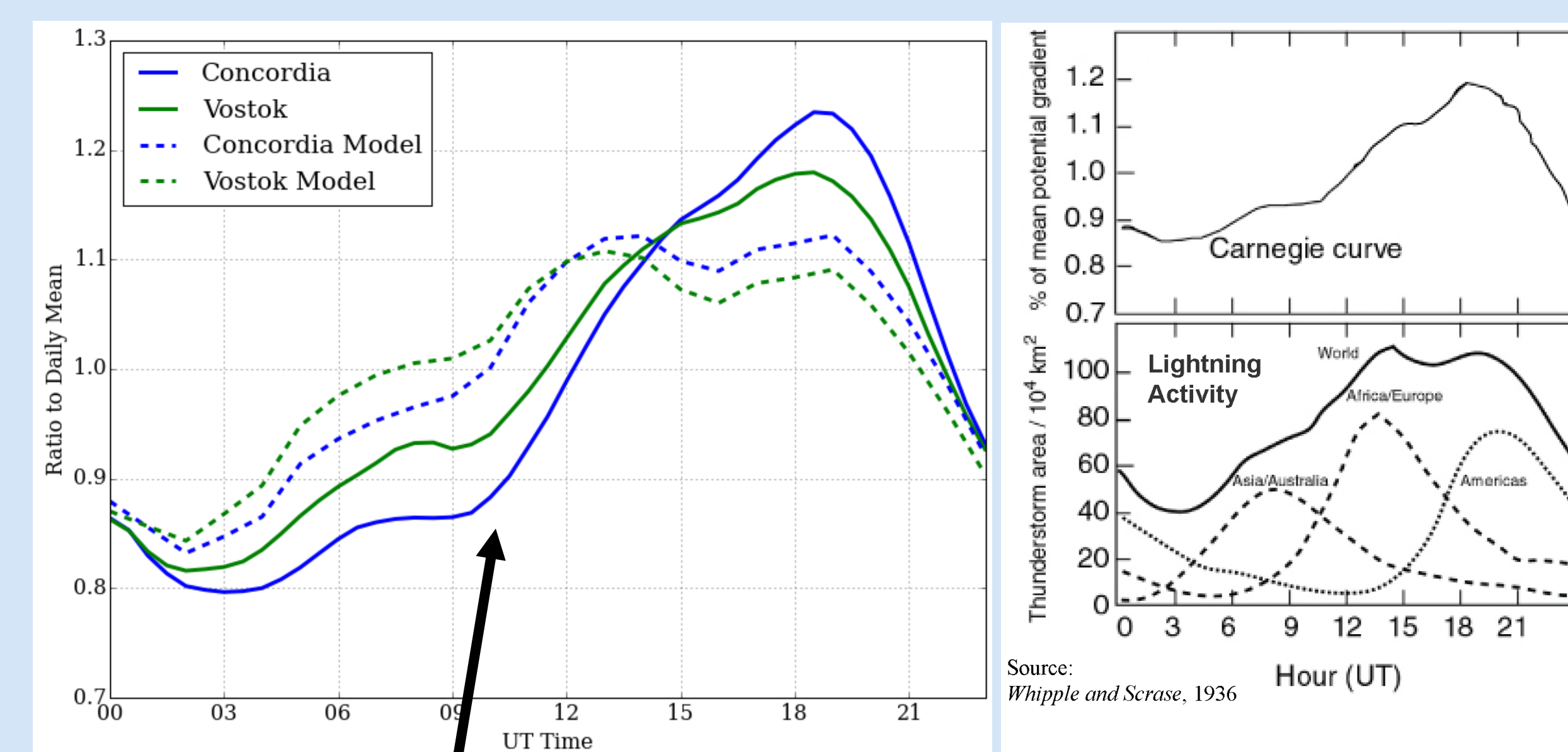
Solar Coupling

The solar wind produces cross-cap potentials that modify the uniform upper boundary GEC potential assumption. Calculating this magnetospheric potential over each model column provides the solution for the currents and electric fields throughout the domain.



Measurements

Model output of the surface electric field agrees well with the measured surface electric fields from Vostok and Concordia stations in the Antarctic.

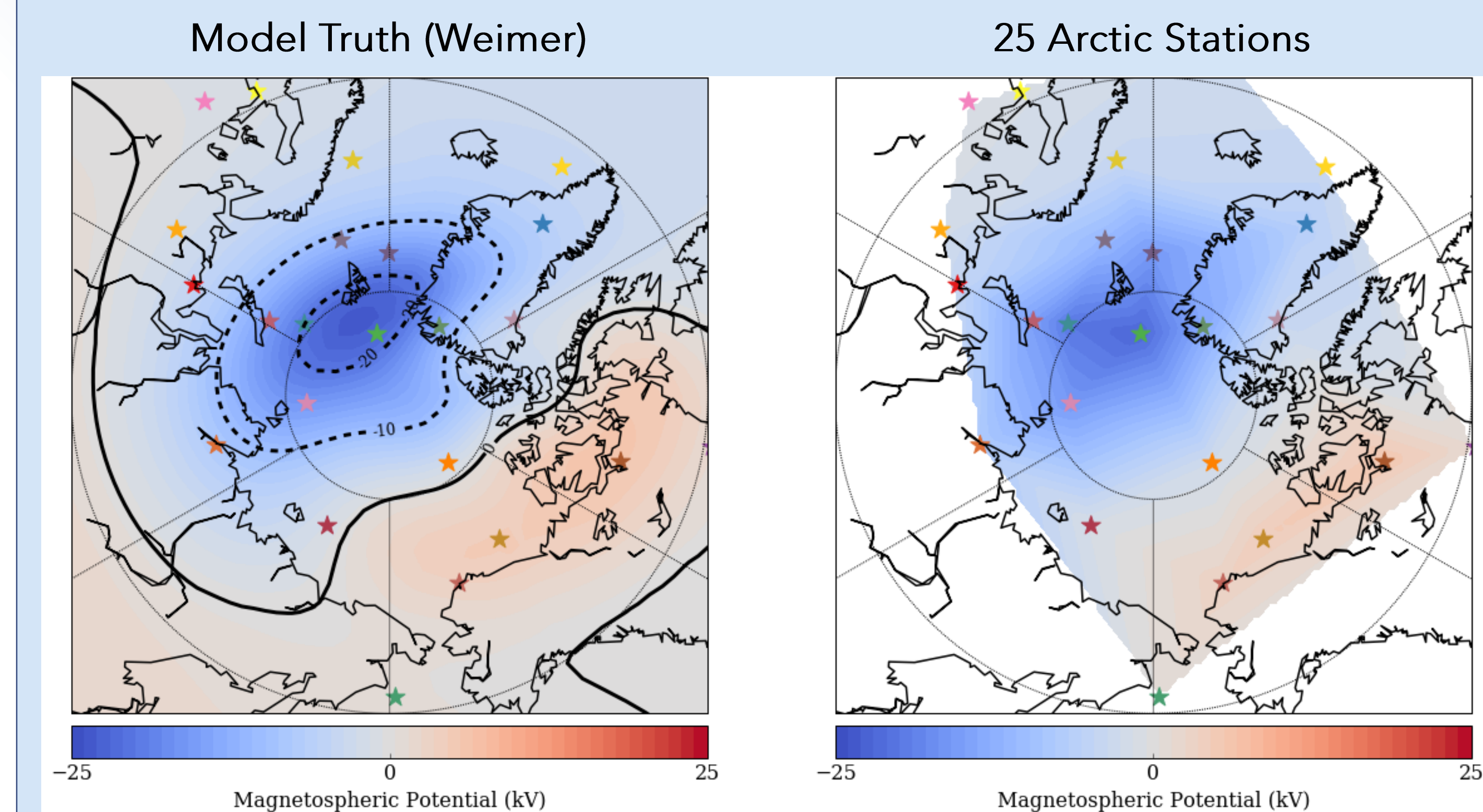


Phasing caused by magnetospheric coupling

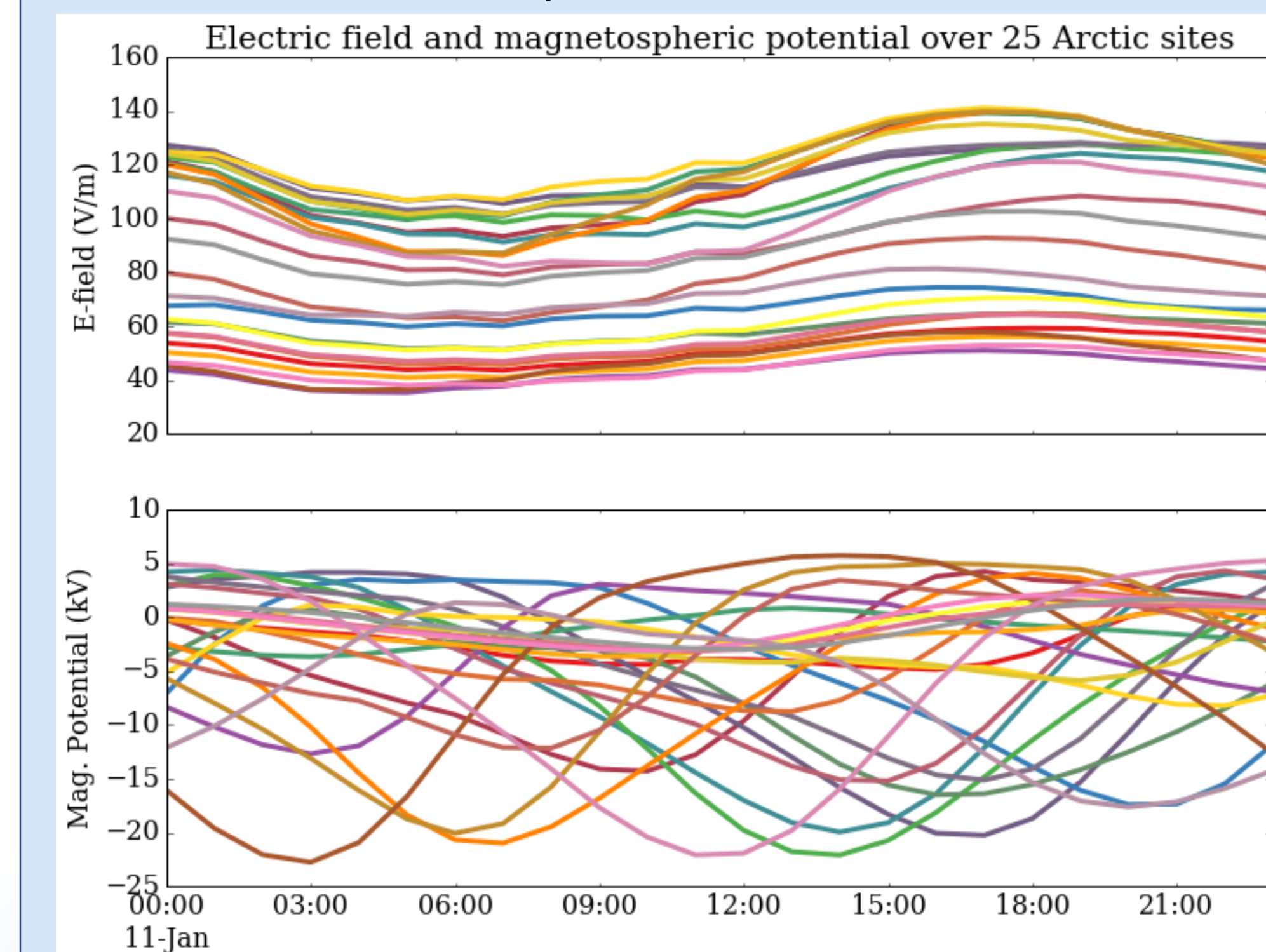
Typical diurnal variation of the electric field over oceans

Distributed Array of Field Mills

Large-scale (>100 km) potential patterns in the ionosphere are able to map down to surface electric field measurements, perturbing the electric field due solely to the GEC potential.



Temporal Variations



- Amplitude differences are caused by column resistance and local conductivity
- Phase differences are caused by the magnetospheric potential
- Measurement with a distributed array provides a means of determining these phase differences

Conclusions

- We have developed a new model within WACCM called WACCM-GEC that calculates the currents and electric fields throughout the lower atmosphere.
- A distributed array of field mills at high latitudes would be able to determine the strength and pattern of the ionospheric potentials.

References

- Lucas, G. M., Baumgaertner, A. J. G., Thayer, J. P., A global electric circuit model within a community climate model. J. Geophys. Res. Atmospheres, 2015. doi: 10.1002/2015JD023562
- Baumgaertner, A. J. G., Thayer, J. P., Neely III, R. R., Lucas, G. M., Towards a comprehensive Global Electric Circuit model: Conductivity and its variability in CESM1 (WACCM) model simulations, J. Geophys. Res., Vol. 118, 2013. doi: 10.1002/jgrd.50725

Acknowledgements

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