The Importance of Ionospheric Conductivity to Magnetospheric Reconnection Rate and Cross Polar Cap Potential

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Introduction

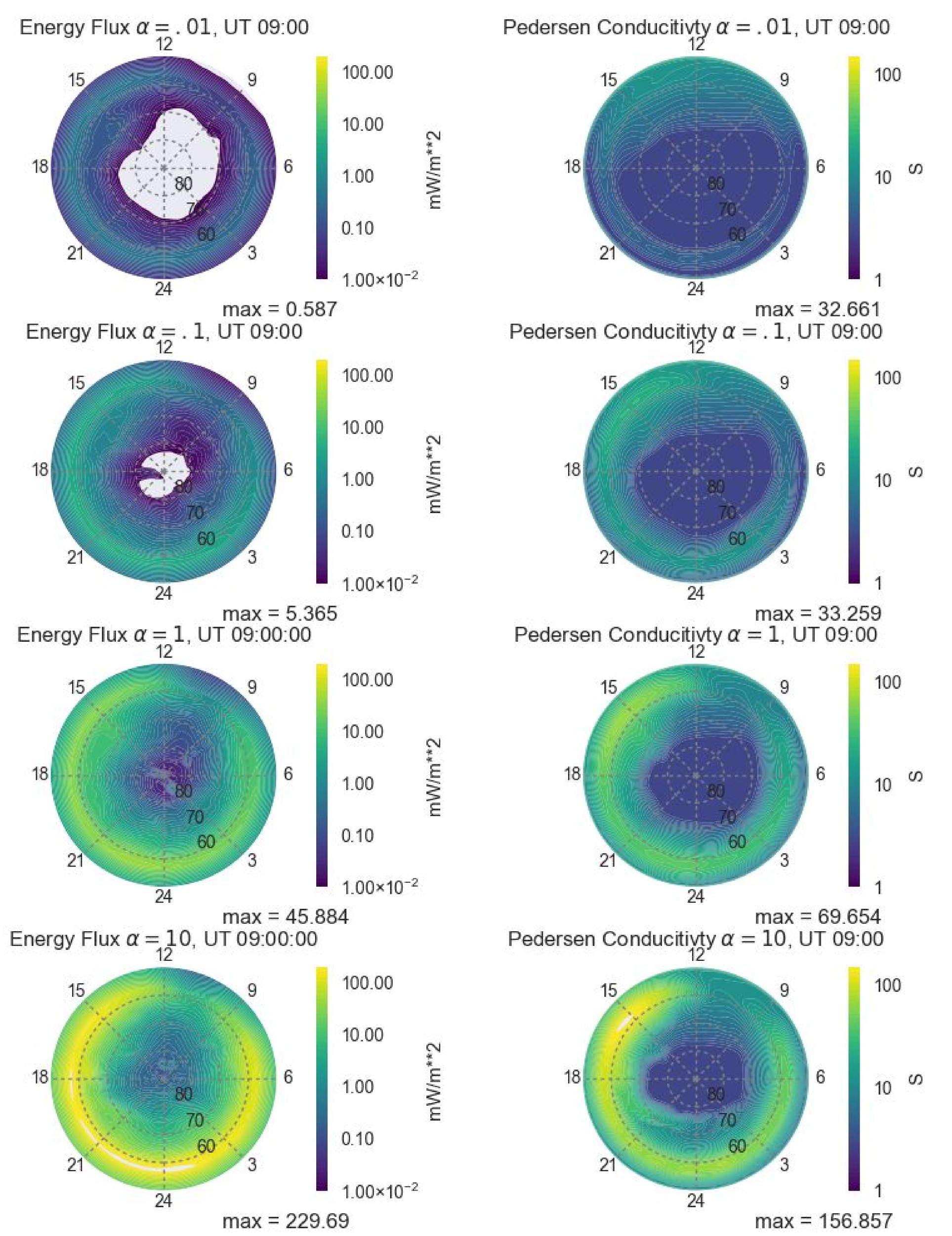


Figure 1: Shows the total energy flux of the incoming electrons on the left panels and the Pedersen conductivity on the right panels for the NH on March 17, 2013, 9:00. From top to bottom **α** = .01, .1, 1, and 10.

We have been using OpenGGCM to simulate how changes in particle precipitation affect the magnetospheric environment, focusing on the effect to cross polar cap potential (CPCP) and the reconnection rate. We have multiplied the number of electrons by 4 factors, α = .01, .1, 1, 10. Precipitation affects ionospheric conductivity, which in turn affect CPCP and the reconnection rates.

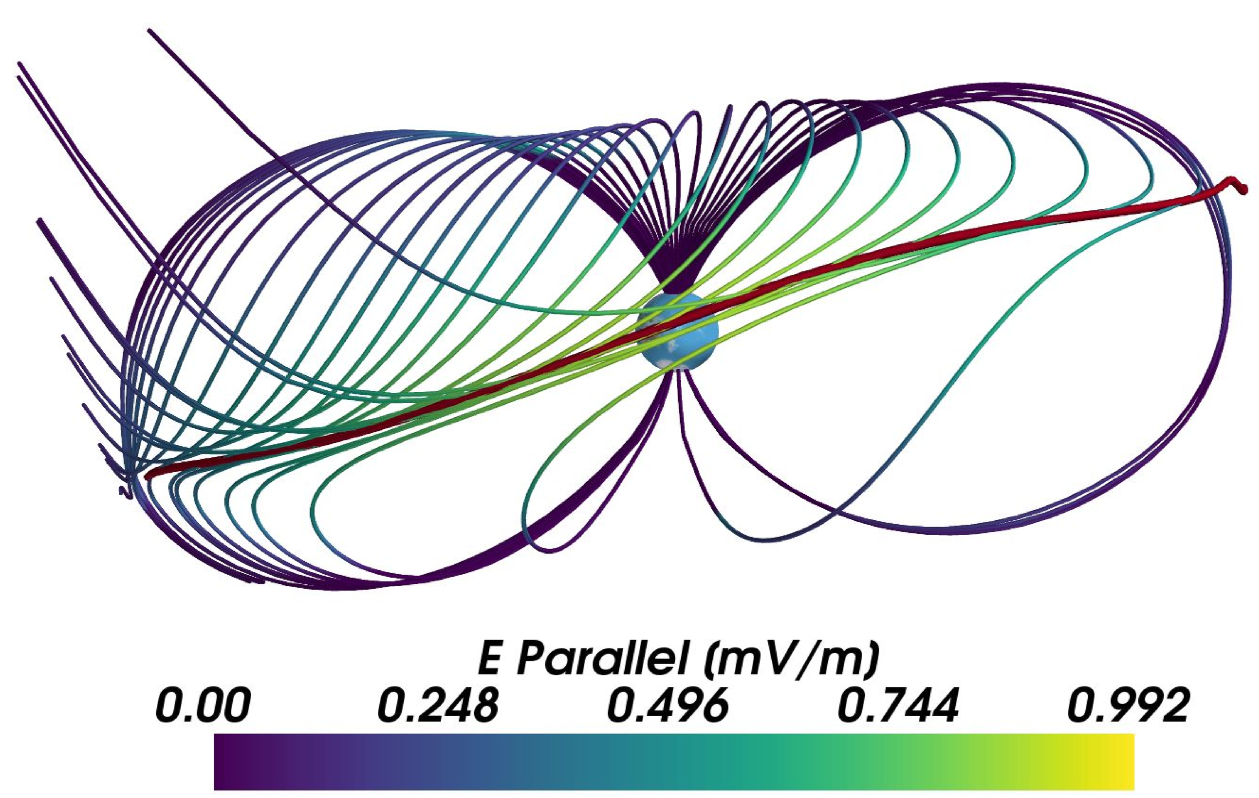
Hesse-Forbes-Birn Method

To calculate the reconnection rate we use a method developed by Hesse-Forbes-Birn (Hesse et al 2005). We do this by calculating the quasi potential, Ξ, along every magnetic field line and then reconnection rate is determined by,

$$R = \Xi_{max} - \Xi_{min}$$

The benefit of this method is we don't have to identify the separator, which in simulations of real events is almost impossible.

Figure 2: Shows a subset of the traced dayside magnetic field lines in a test simulation to determine the accuracy of the HFB method. E parallel is in color along the magnetic field line and the red line is the separator. Earth is shown for scale.



CPCP and Reconnection

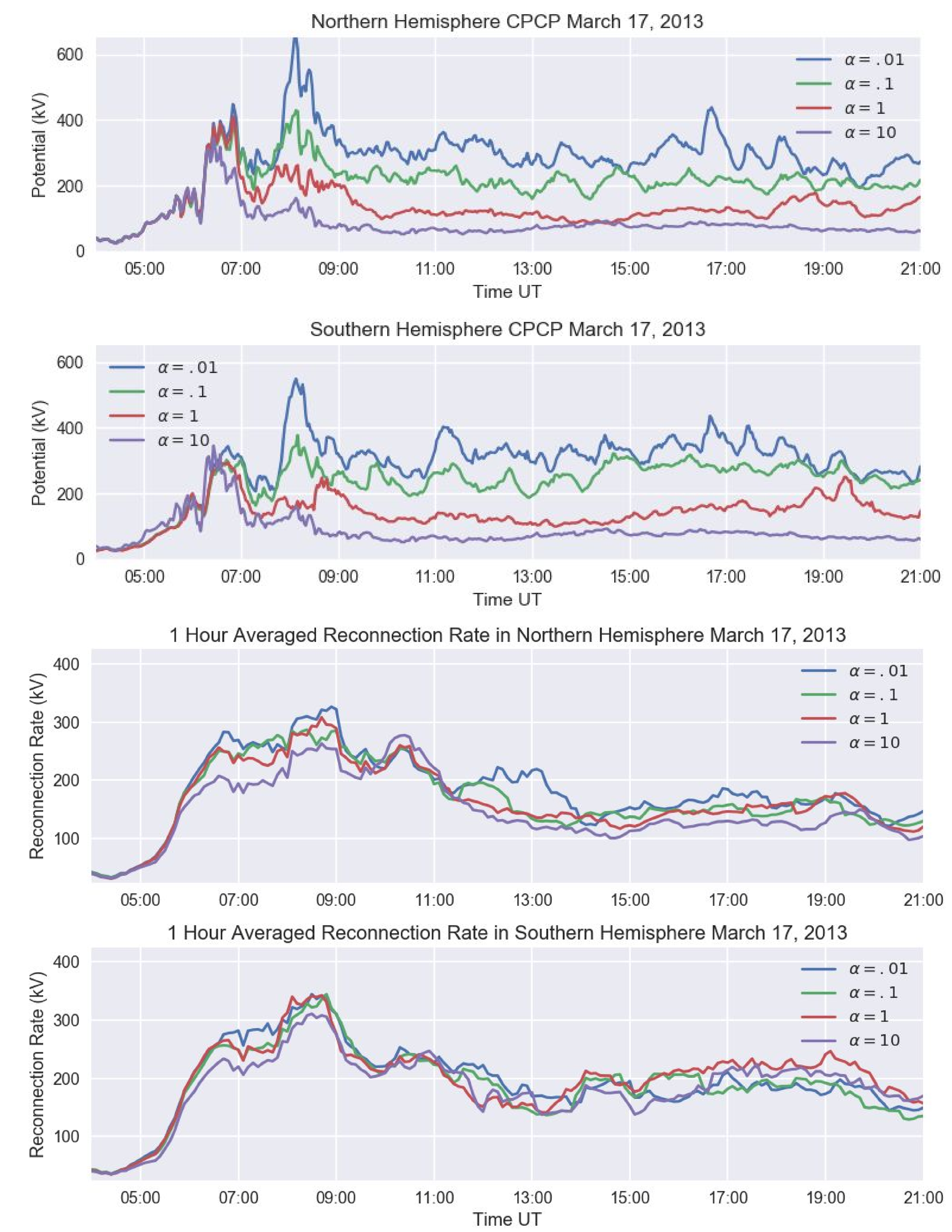


Figure 3: Shows the time evolution of CPCP and R. CPCP for NH and SH are the top two panels, and R for NH and SH are graphed in the bottom two panels. The CME hit at 6:00 UT march 17, 2013.

Figure 3 shows the CPCP and reconnection rates for the 4 simulations. CPCP is more affected by changes in conductivity, with rapid time variations. R is not as affected and the time variations are not as large, but still do occur. Figure 4 shows the averaged CPCP and R. CPCP and R are not the same for all the simulations, CPCP varies greatly while the reconnection remains the same.

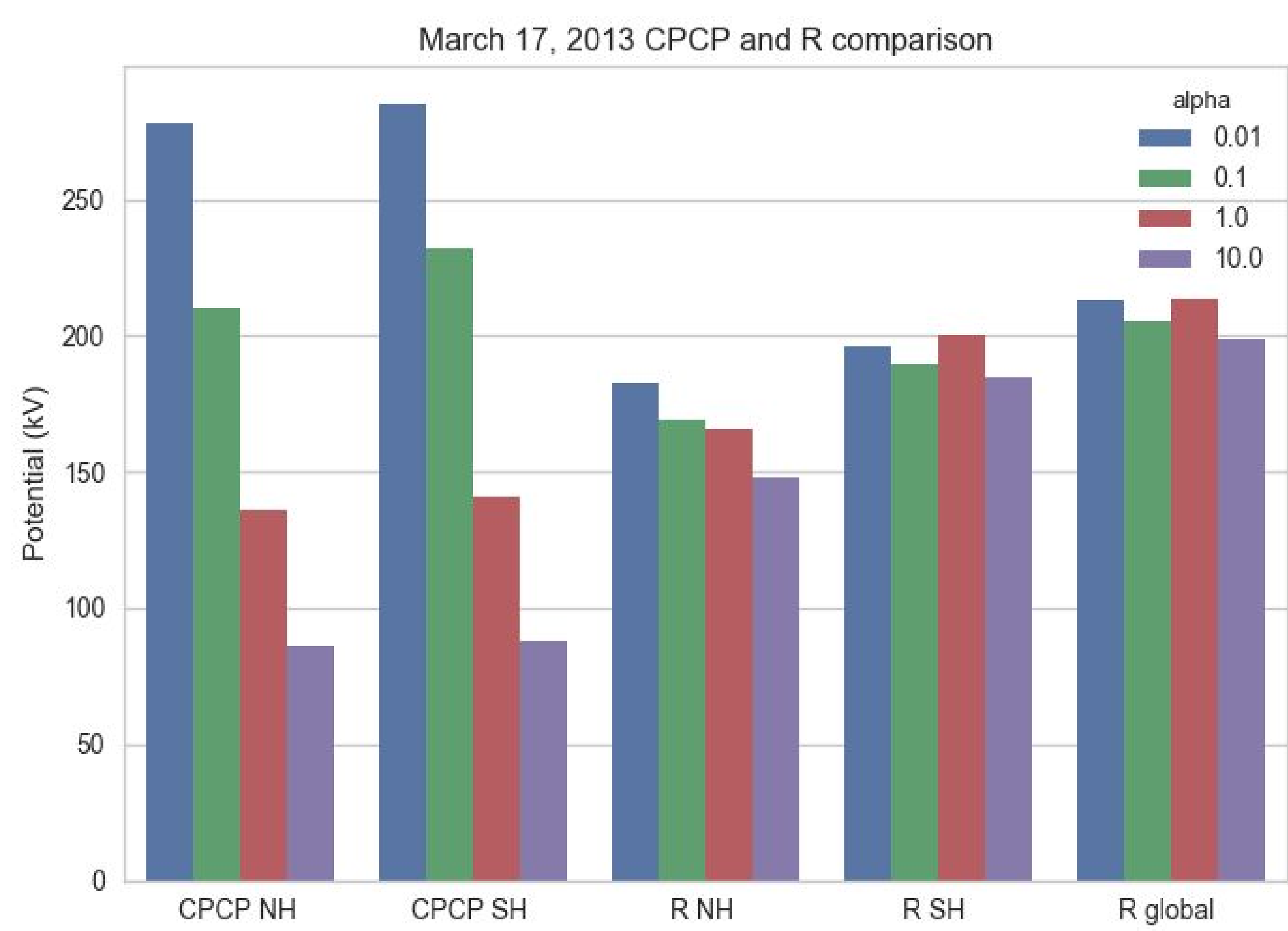


Figure 4: The results of our four simulations with scaling factors of precipitation, alpha. CPCP and R are graphed globally and for each hemisphere as an average over the whole simulations time.

Viscous Interaction, CPCP Saturation

Why are CPCP and R different? In Figure 5 Nagatsuma et al 2004 showed the conductivity dependence of CPCP. As conductivity increases CPCP decreases. We found this same trend, but that R remained the same. For high conductivity CPCP was lower than R.

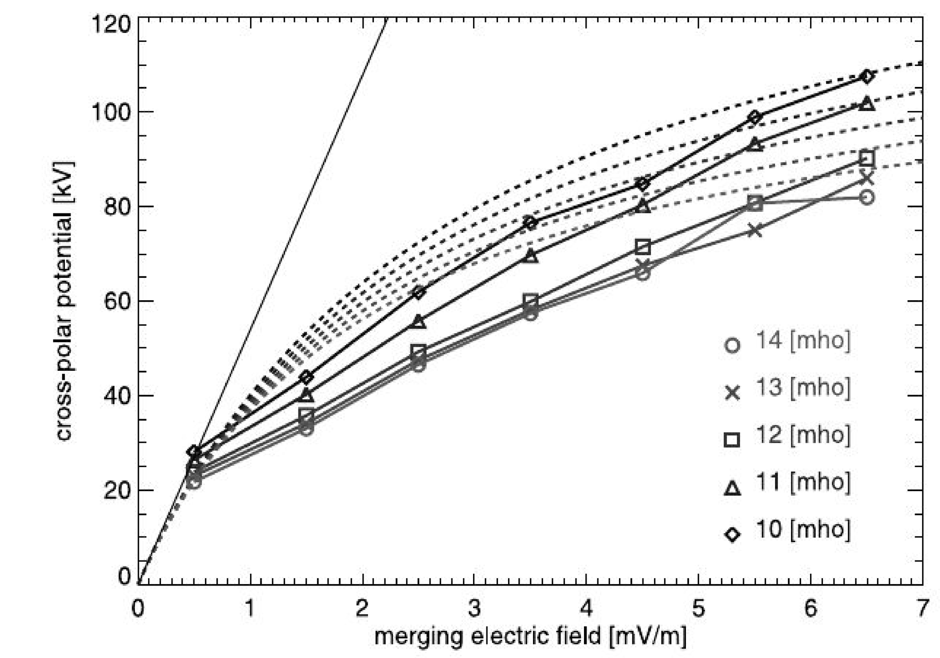


Figure 5: The merging electric field compared with the CPCP for various conductivities. This figure is taken from Nagatsuma [2004] their Figure 4.

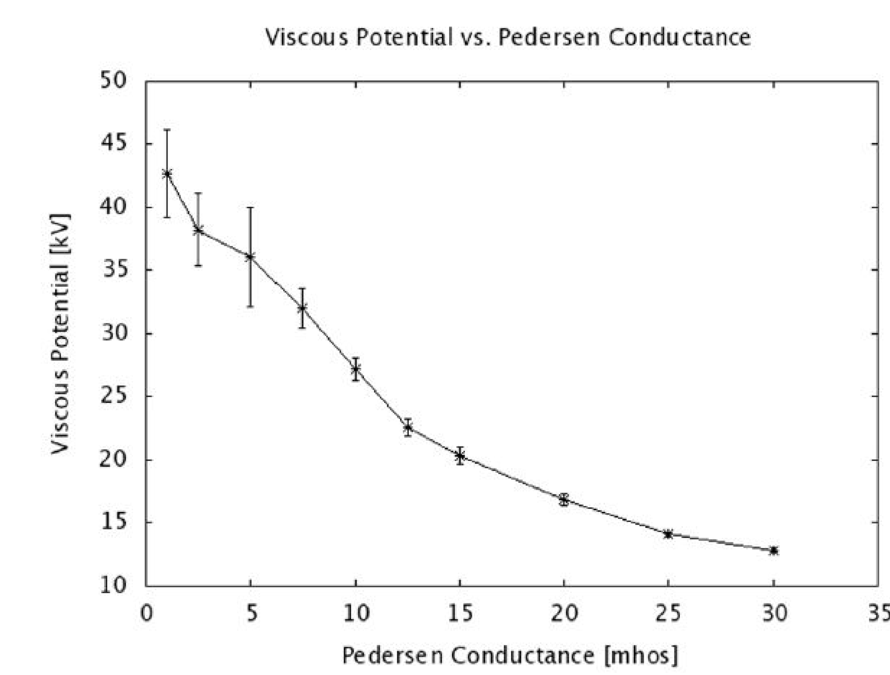


Figure 6:Graph of the pedersen conductivity dependence of viscous potential. Taken from Bruntz et al [2012]

Figure 6 shows a figure from Bruntz et al 2012 showing the viscous interactions dependence on conductivity, this can explain times when CPCP is higher than R. Conductivity is low and viscous interactions cause the CPCP to be elevated higher than R.

Conclusion

Using computer simulations and a novel approach to calculating the reconnection rate we have shown that

- There is an inverse relationship between the amount of precipitation and the CPCP.
- On short time scales (hours) the reconnection is modified by different conductivities, but for longer time scales (tens of hours) the reconnection rates average out.
- For low conductivity cases, viscous interactions are strong and CPCP is higher than R. For high conductivity cases the polar cap is in the saturation regime and CPCP is lower than R.

References

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