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Rn222 impact on GEC in CCM SOCOL simulations

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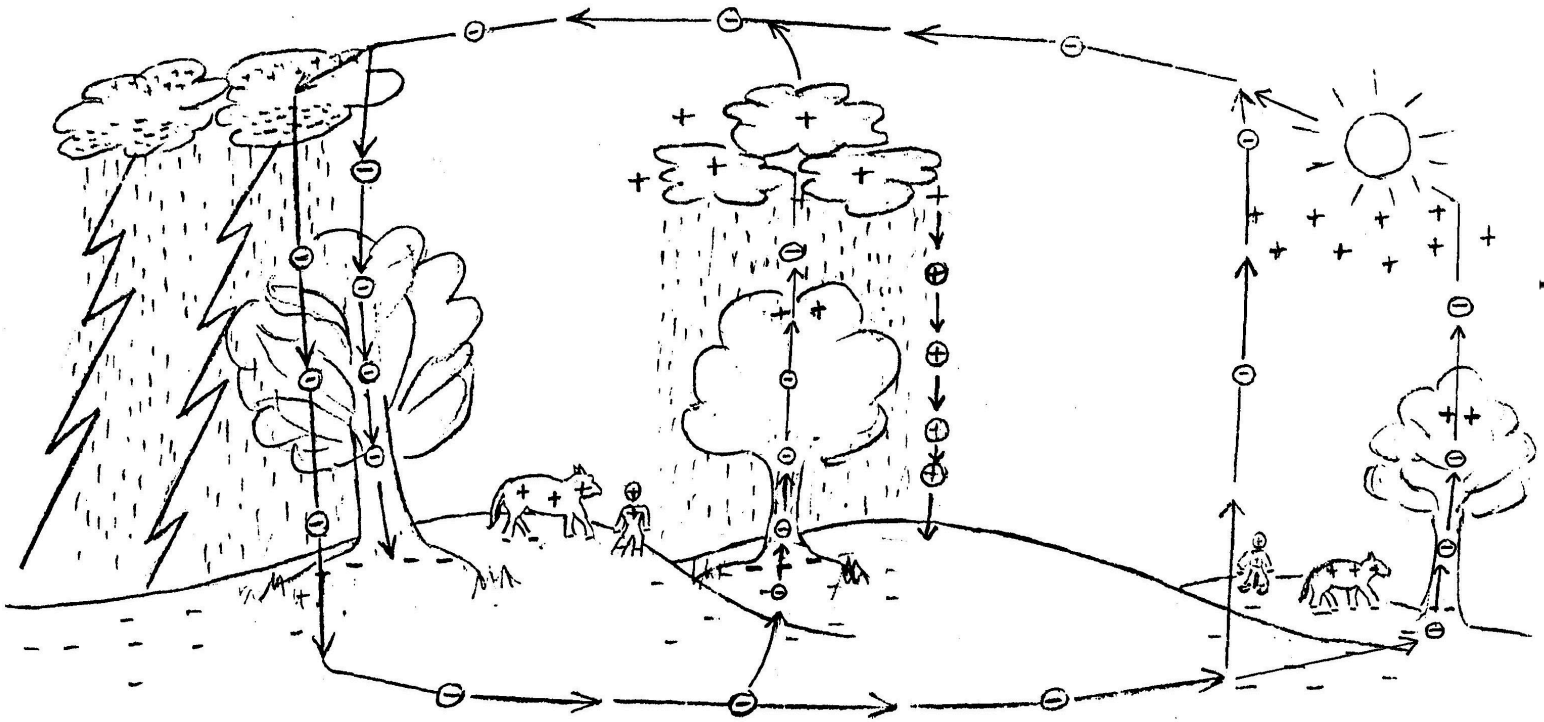
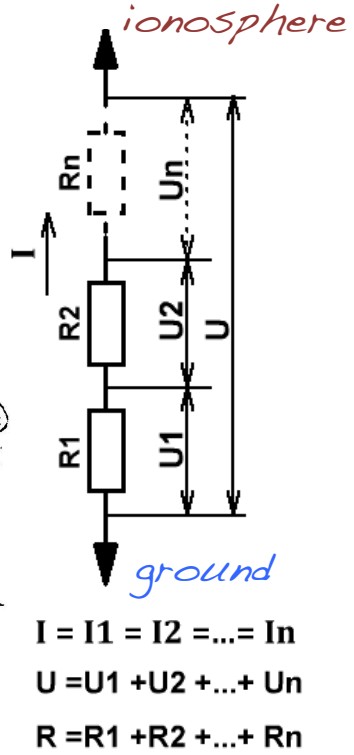
Global electric circuit

The GEC resembles *a spherical capacitor*.



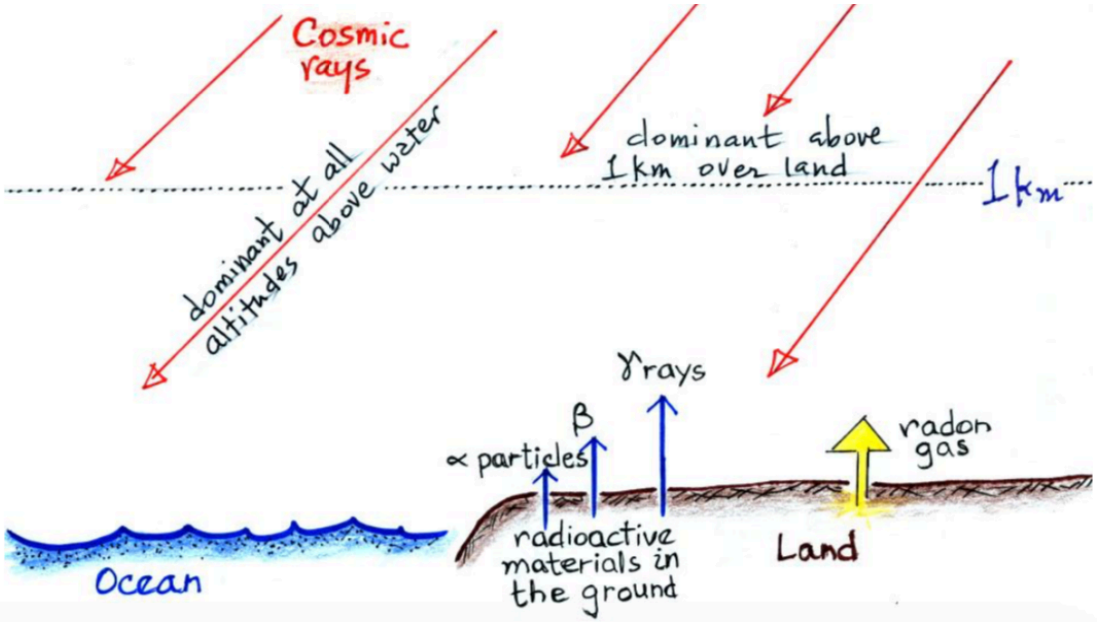
[Wood,, 2017]

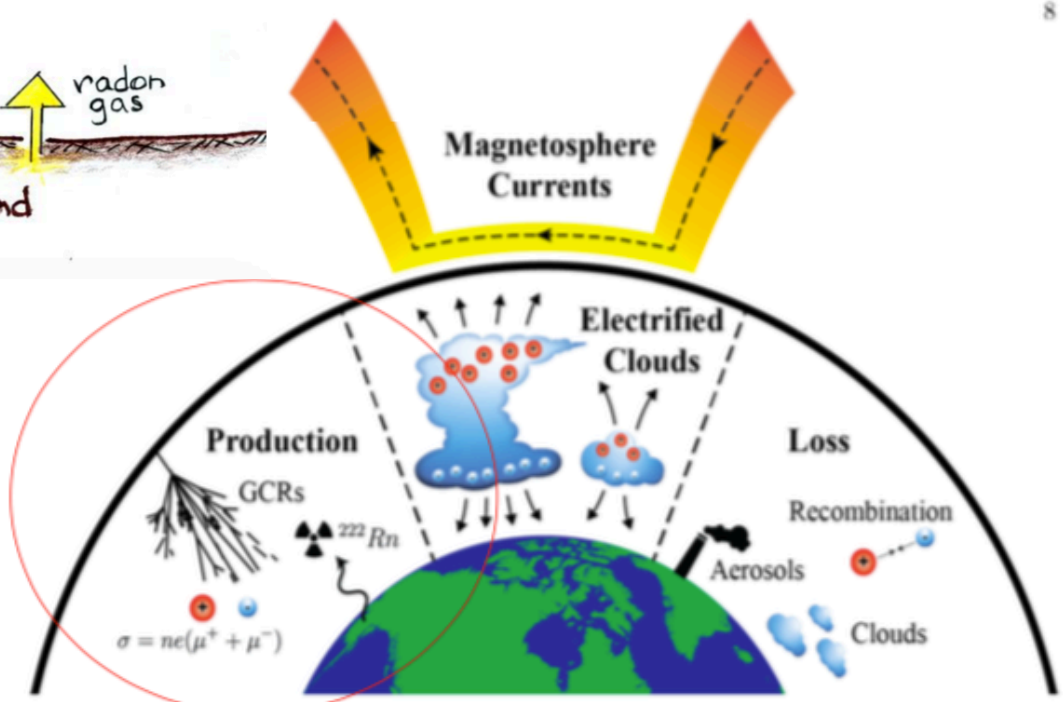


Is negatively charged during fair weather in the ground. Positive charge is found not on the second conductor but distributed in the air between the ground and the ionosphere (most of the charge is near the ground).

A weak current flows from the ionosphere to the ground.

Main sources of IR. Connection with GEC.





Conductivity (σ) in the boundary layer affect on the whole GEC (series connection)

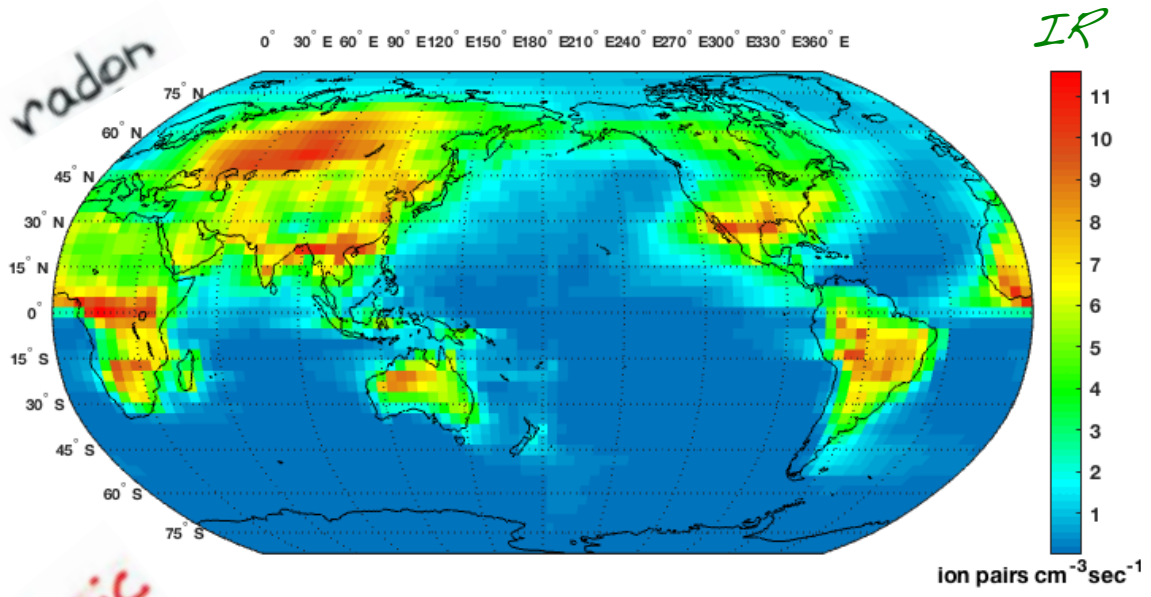
A representation of the major physical mechanisms that drive the electrical processes by Lucas [2010]

CCM SOCOL

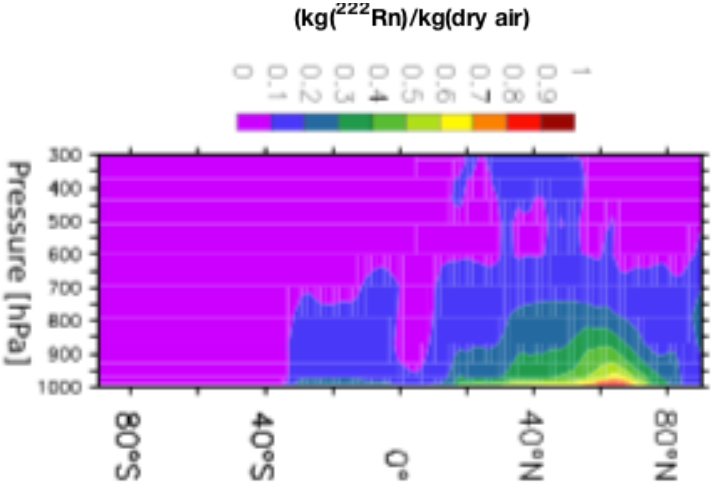
- ✓ Is a combination of a modified version of the MA-ECHAM4 and the CTM.
- ✓ 39 levels in a hybrid sigma-pressure coordinate system spanning the model atmosphere from the surface to 0.01 hPa (≈80 km).
- ✓ A geographical grid spacing of about 3.75◦.
- ✓ 41 chemical species of the oxygen, hydrogen, nitrogen, carbon, chlorine and bromine groups, which are determined by 118 gas-phase reactions, 33 photolysis reactions and 16 heterogeneous reactions in/on aqueous sulphuric acid aerosols, water ice and nitric acid trihydrate (NAT).

[M. Schraner et al., 2008].

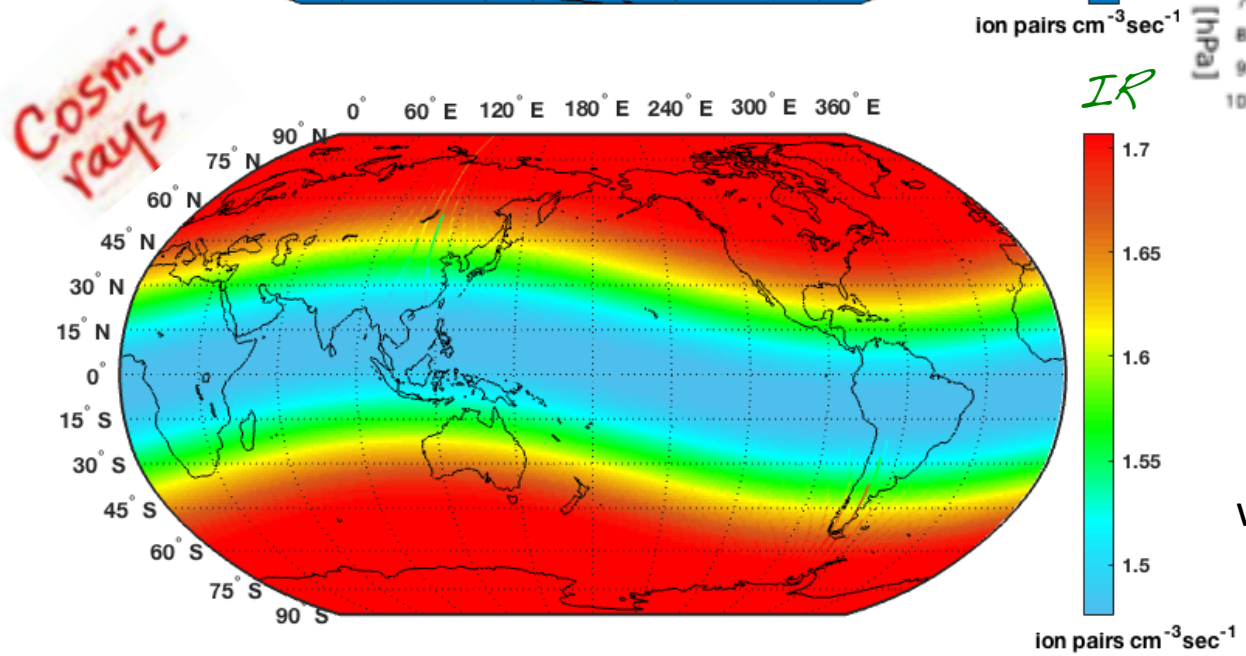
IR in boundary layer



High radon-related IR caused by a strong and stable source of Rn-222 emission.



Zonal average vertical distribution of RN-222

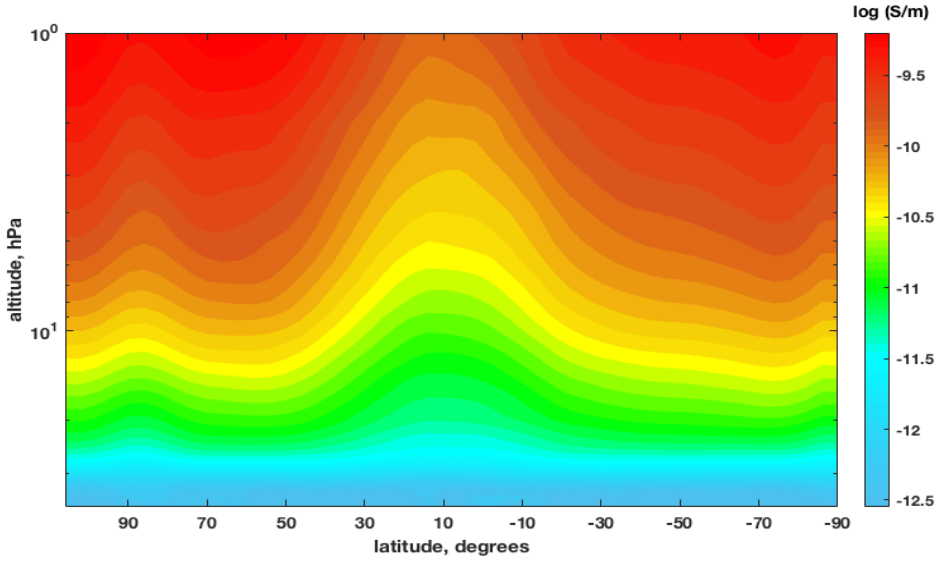


GCR ionization rates are higher over the polar areas with the reduced geomagnetic shielding.

Conductivity and current

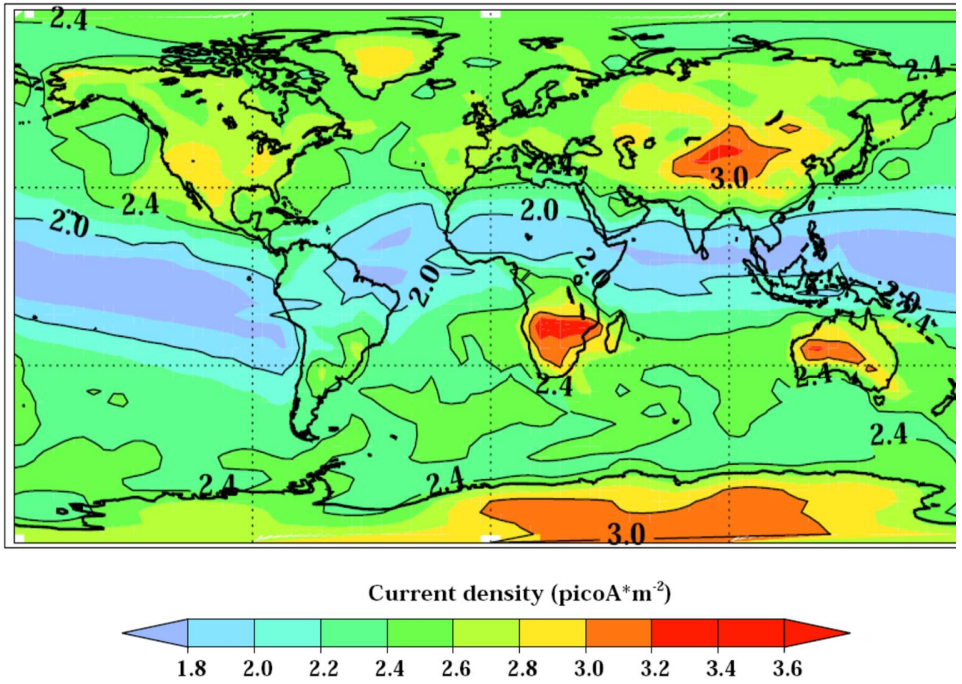
$$\sigma = n \times e \times (\mu^{+} + \mu^{-})$$

$$Rc = \Sigma \sigma_i^{-1} \, dz_i$$



The increase in ionization toward the geomagnetic poles results in an increase in conductivity toward high geographic latitudes.

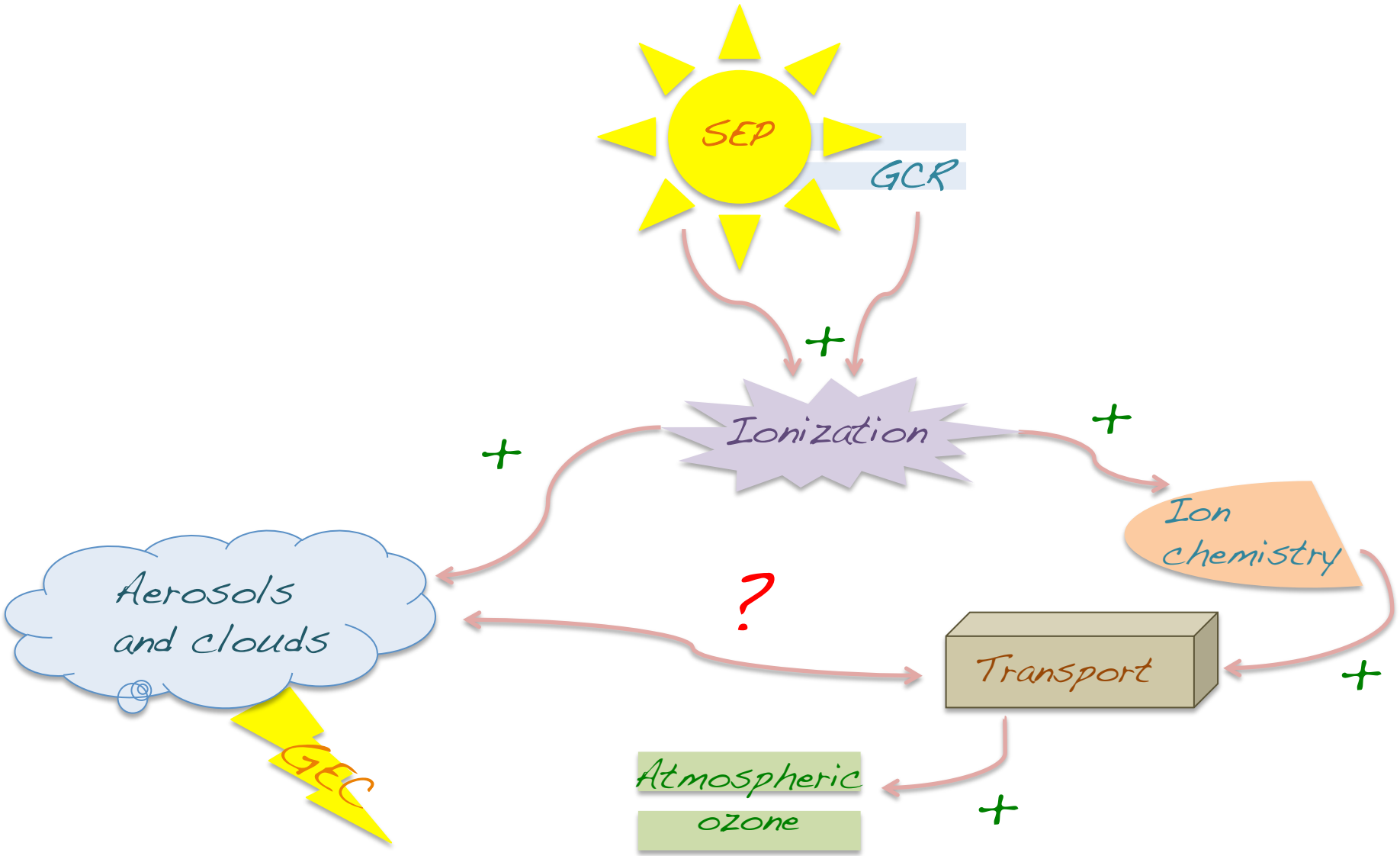
$$J_z = IP/Rc$$



The atmospheric current density is affected by:

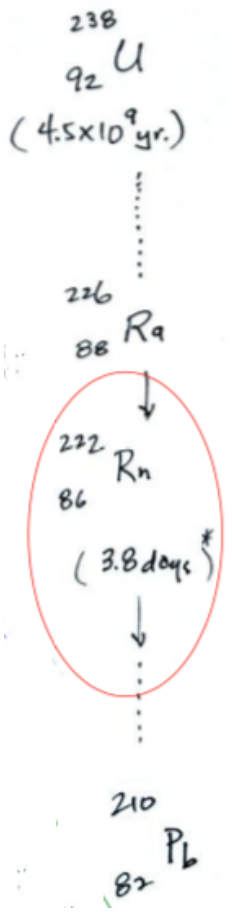
- ✓ the geomagnetic shielding of GCR;
- ✓ orography;
- ✓ Rn-222 emission.

Systems connection



Conclusions

- ✓ Radon dominates in ionization near the surface above ground, but its effect quickly fades with altitude.
- ✓ The increase in ionization toward the geomagnetic poles results in an increase in conductivity toward high geographic latitudes.
- ✓ The atmospheric current density is affected by several competing processes: the geomagnetic shielding of GCR; orography; Rn-222 emission
- ✓ The GEC impact on clouds and atmospheric transport.



Reference

- ✓ Lucas, G. M. (2010), Investigating the physical mechanisms that impact electric fields in the atmosphere. Thesis, B.S., University of Wisconsin.
- ✓ Schraner, M., E. Rozanov, C. Schnadt Poberaj, P. Kenzelmann, A. M. Fischer, et al.. Technical Note: Chemistry-climate model SOCOL: version 2 with improved transport and chemistry microphysics schemes. Atmospheric Chemistry and Physics Discussions, European Geosciences Union, 2008, 8 (3), pp.11103-11147.
- ✓ J. Wood, The Invisible Rainbow: A History of Electricity and Life (2017), Chapter 9, “Earth’s Electric Envelope”