Electrical Effects on Size Distributions of CCN

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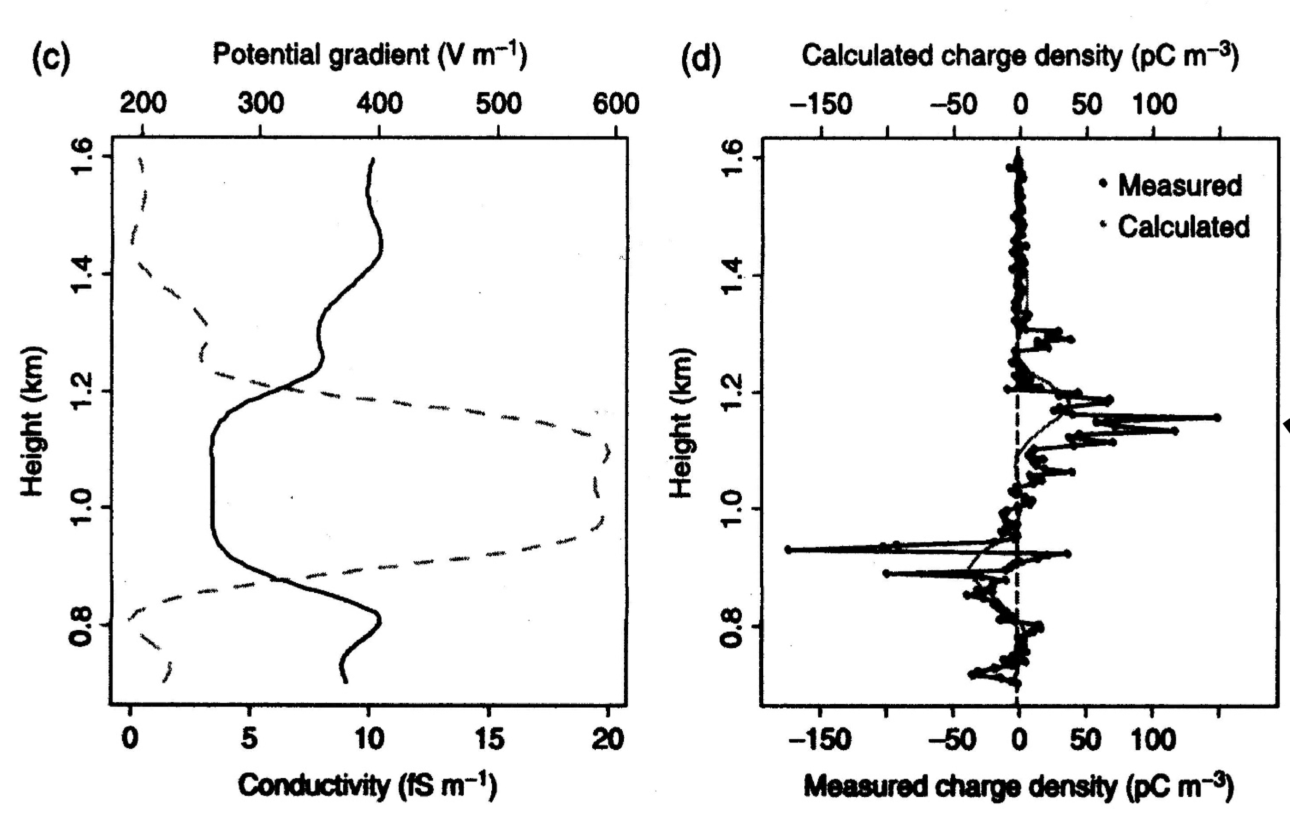
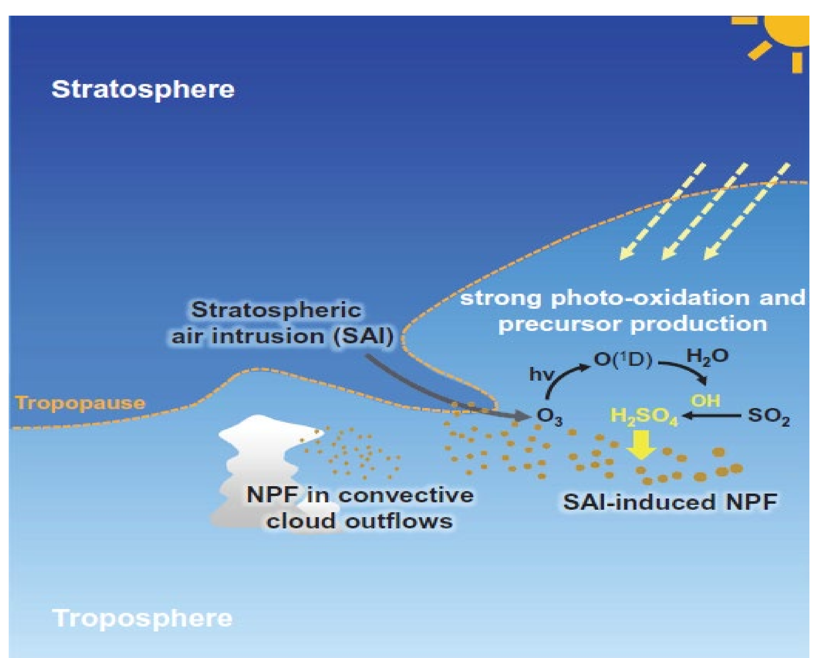


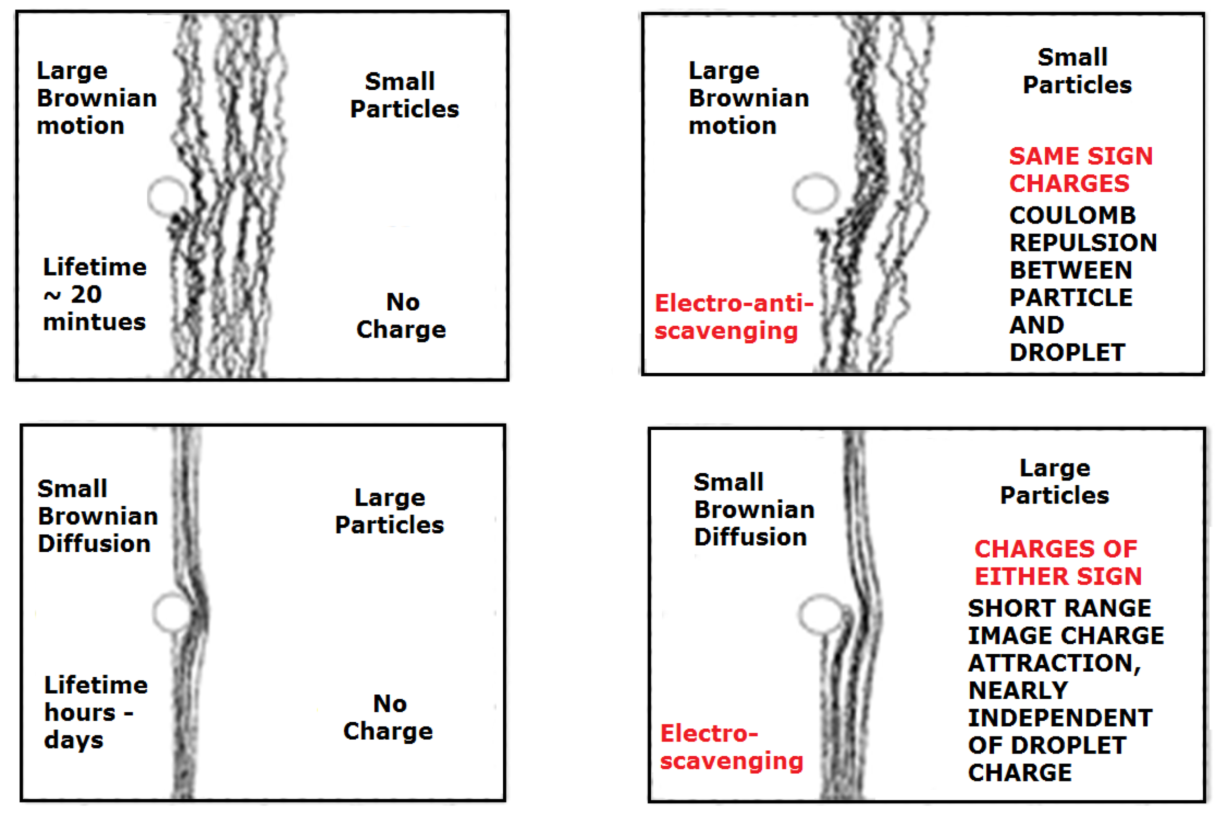
Observations of space charge in a cloud. Nicholl, 2012.

Tropopause fold events bring sulfur-rich stratospheric air and new particle formation into the troposphere, as does down-welling in polar cells.

Zhang et al., 2024

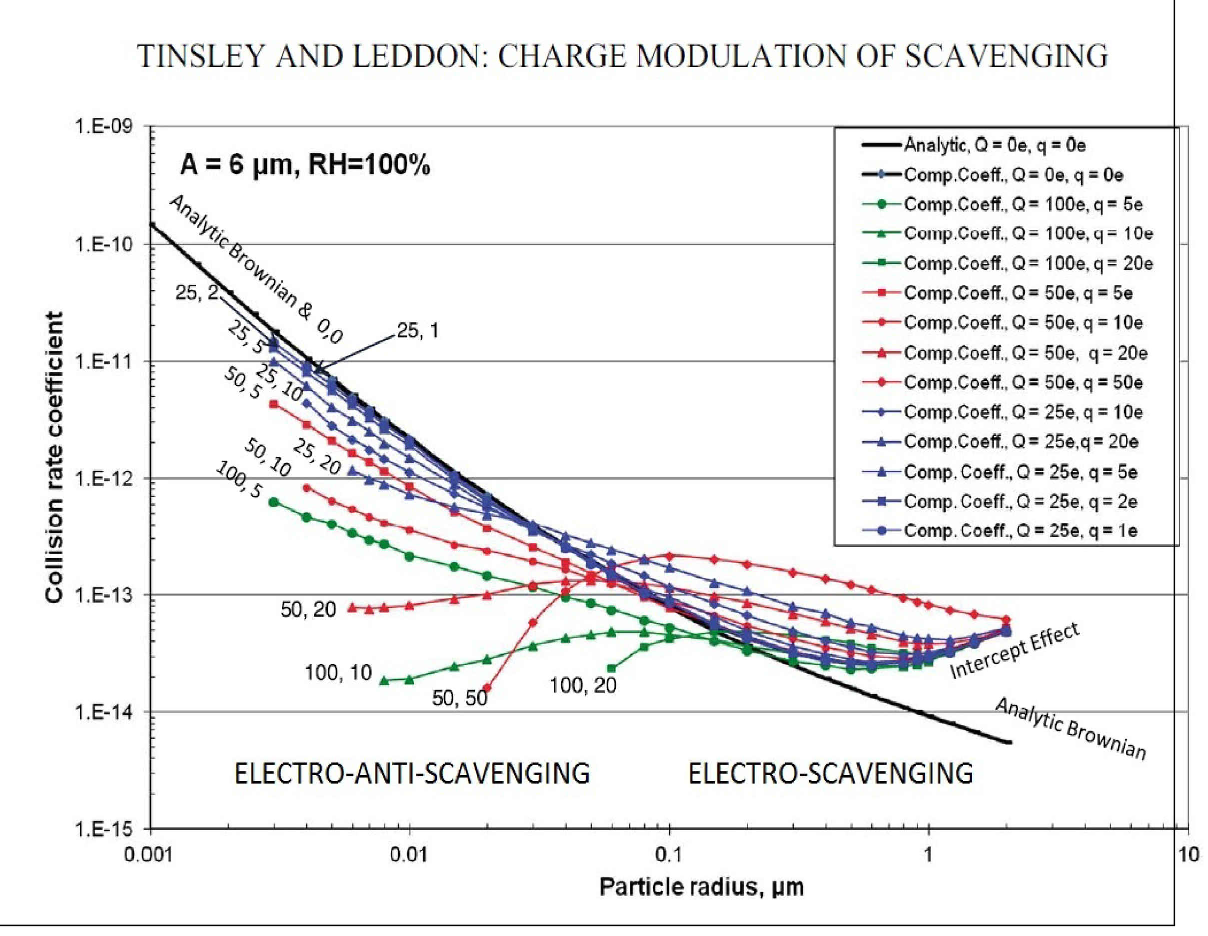


Modeling of Electric Charge Effects on Particle-Droplet Collisions With Diffusion (Tinsley, 2010)



Uncharged Particles: Lifetime and concentrations depend on Brownian diffusion.

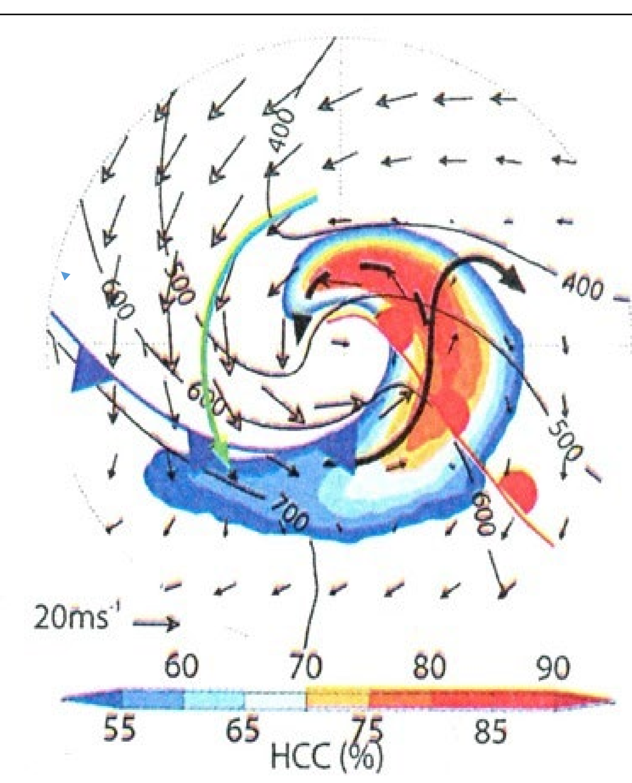
Charged Particles: Increases or decreases in lifetime and contact ice nucleation rates depending on charges.



ELECTRO-ANTI-SCAVENGING in the presence of space charge increases concentration of small particles, and small droplets after cloud processing. Tinsley and Leddon, 2013).
ELECTRO-SCAVENGING reduces concentration of large and giant CCN. reducing concentration of large droplets (Tinsley, 2010).

‘Conveyer belts’ transport and uplift **clouds** with new smaller droplets into winter cyclones.

Dacre et al., 2012.



At high latitudes in winter with stratiform clouds the changes in droplet size distribution and increased opacity and/or cloud cover increases cloud longwave radiative forcing. The shortwave forcing is minimal in polar night. (Twomey, 1977; Kniveton and Tinsley, 2004; Kniveton et al., 2008; Tinsley, 2022, 2024)

End result for winter at high latitudes on day-to-day timescale is temperature and surface pressures increases (Burns et al., 2007; Lam et al.,2013, 2018; Zhou et al., 2018) .

Observations show winter cyclone vorticity correlates with proxies for downward current density Jz, which changes with space weather variations.

PROCESSES CONNECTING CYCLONE VORTICITY TO DROPLET SIZE DISTRIBUTION

Fewer large droplets and more smaller droplets reduces the rate of coagulation, reducing production of rain.
Reduced production of rain in updrafts increases amount of liquid water carried above the freezing level.
Latent heat of freezing of extra water invigorates updrafts (Rosenfeld et al., 2008).
Stronger updrafts increase storm vorticity (Tinsley, 2010)

PROCESSES CONNECTING CYCLONE INVIGORATION TO DOWNSTREAM BLOCKING, COLD AIR OUTBEAKS, AND COLDER EUROPEAN WINTERS

Increase in cyclone vorticity observed to be associated with downstream anticyclonic vorticity and blocking (Pfahl, et al., 2015).
Blocking of warm, moist oceanic winds from N. Atlantic and cold air outbreaks from the east average to colder winters in Europe (Lockwood, 2010; Huth et al., 2006).

NEEDS FOR MODELLING

Charge distributions on aerosol particles and droplets
The redistribution of charge by attachment among air ions and polydispersive aerosols by Yair and Levin (1989) needs to be extended to include polydispersive droplets

Cloud processing and scavenging
Modelling of cloud processing of the polydispersed charged aerosol particles and droplets is needed. There is simultaneous growth from CN to CCN with loss by activation and electrostatic and phoretic scavenging. Experimental and theoretical aspects are presented by Chandrakar, Cantrell and Shaw (2024)

Cloud resolved cyclone c model with latent heat release.

Downstream blocking and cold air outbreaks in northern European winters. (Tinsley, 2024)

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