How does rime accretion rate (RAR) influence charge transfer?

Saunders and Peck, 1998
Relative growth rate theory review

• “The particle growing faster by vapor diffusion charges positively”
• Negative transition layer which transfers mass and charge to other particles
• Usually graupel grows faster than ice, so has a positive charge
• But, latent heat from droplets can reduce growth by vapor diffusion and cause graupel to have negative charge

• Saunders et. al (1991) found charge of the rimer is related to temperature and effective LWC (EW)
Graupel charge phase space from Saunders et al. (1991)

- **Region A: low temp, low EW**
  - Weak surface heating (from low EW) so graupel still grows faster than ice = + graupel

- **Region B: low temp, higher EW**
  - Stronger surface heating reduces vapor diffusional growth of graupel, more droplets increase ice growth = - graupel

- **Region C: higher temp, higher EW**
  - Takes longer for droplets to freeze in warmer temps so more vapor gets to graupel, thicker transition layer on graupel = + graupel

- **Region D: higher temp, low EW**
  - Extension of B with stronger negative charging, ice crystal growth higher at warmer temps = - graupel

Figure 1 from Saunders and Peck (1998), taken from Saunders et al. (1991)
Rime Accretion Rate

RAR = EW × V

- EW = effective liquid water content
  - E is the collection efficiency for graupel/droplets
  - W is the liquid water content
- V = relative velocity of crystals/graupel

- This work extends data from Saunders et al. 1991 to lower and higher temperatures
Key points from Saunders and Peck (1998) experiments

- Temperature range: -2.3°C to -36.2°C
- Velocity range: 4 m/s to 11 m/s
- Size droplets: mean diameter 19μm with max > 30 μm (representative of thunderstorm conditions)
- Negatively charged graupel at warmer temps
Comparison with other groups

• Cordoba results can be compared since they have a similar drop spectrum to UMIST
• Negative graupel at lower temps and lower RAR
• Cordoba data has positive graupel in most other regions
  • Probably due to using ice spheres instead of crystals: spheres grow more slowly than crystals

Figure 7 from Saunders and Peck (1998) with data from Avila and Caranti (1994) and Avila et al. (1995)
Summary

• Authors found the critical RAR values where charge reversal occurs (depending on temperature)

• These results can be compared to other studies that have similar drop size distributions

• Sign of graupel charge depends on:
  • temperature
  • droplet collision efficiency
  • liquid water content, and
  • relative velocity of hydrometeors