An Investigation of Proposed Aerosol Indirect Effect Mechanisms in Deep Convection

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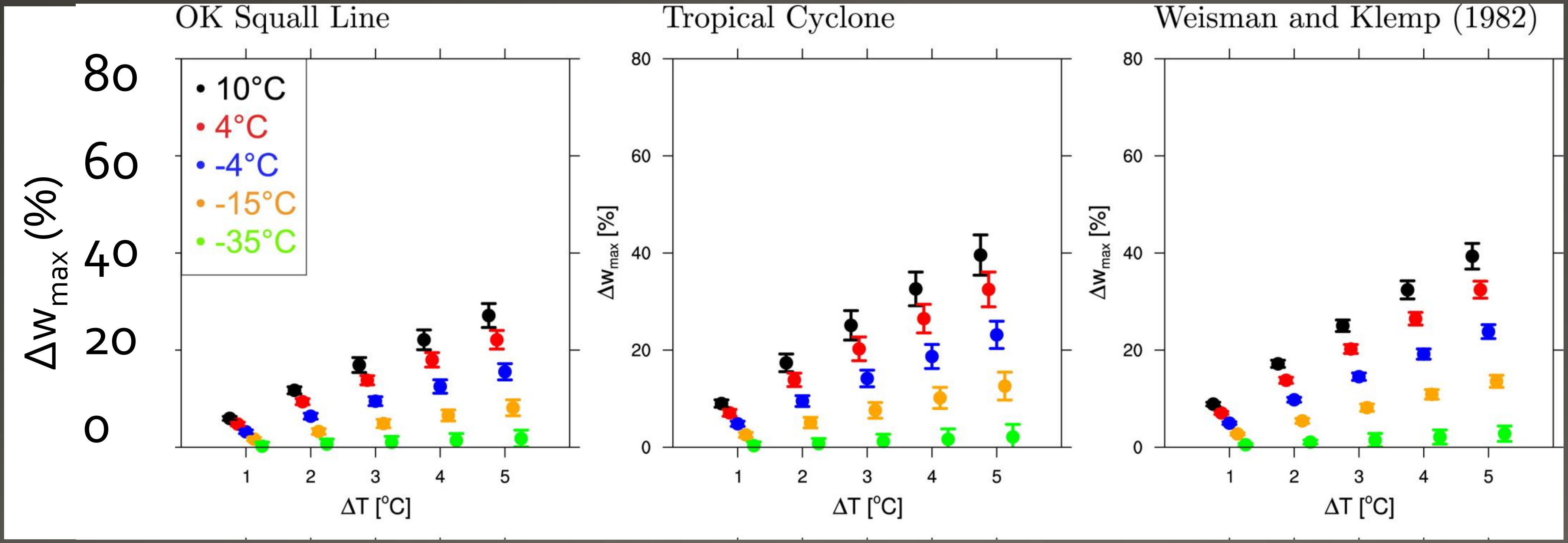
Introduction

- Invigoration (an increase in updraft strength) of convective storms by aerosols is not well understood
  - In terms of magnitude
  - In terms of the physical mechanisms that lead to it
- Invigoration has important implications for transport of air, chemical species, and precipitation production
- The driving mechanism has implications for how to account for the effect in convective parameterizations

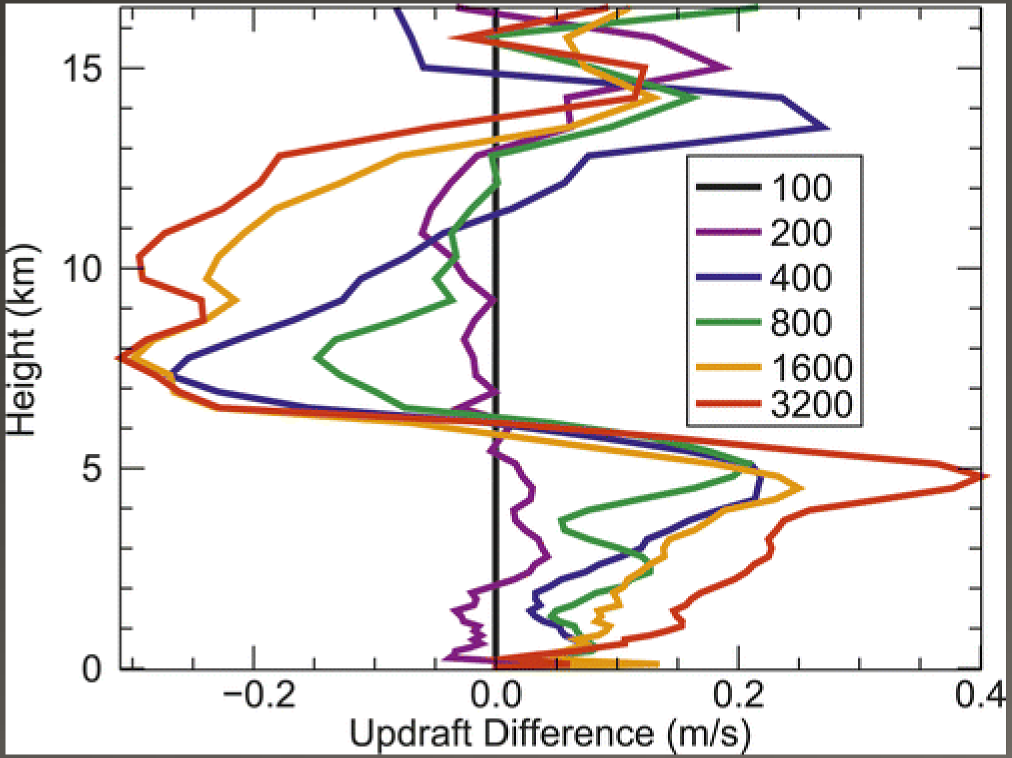
Aerosol-Induced Invigoration Magnitude

Lebo 2018

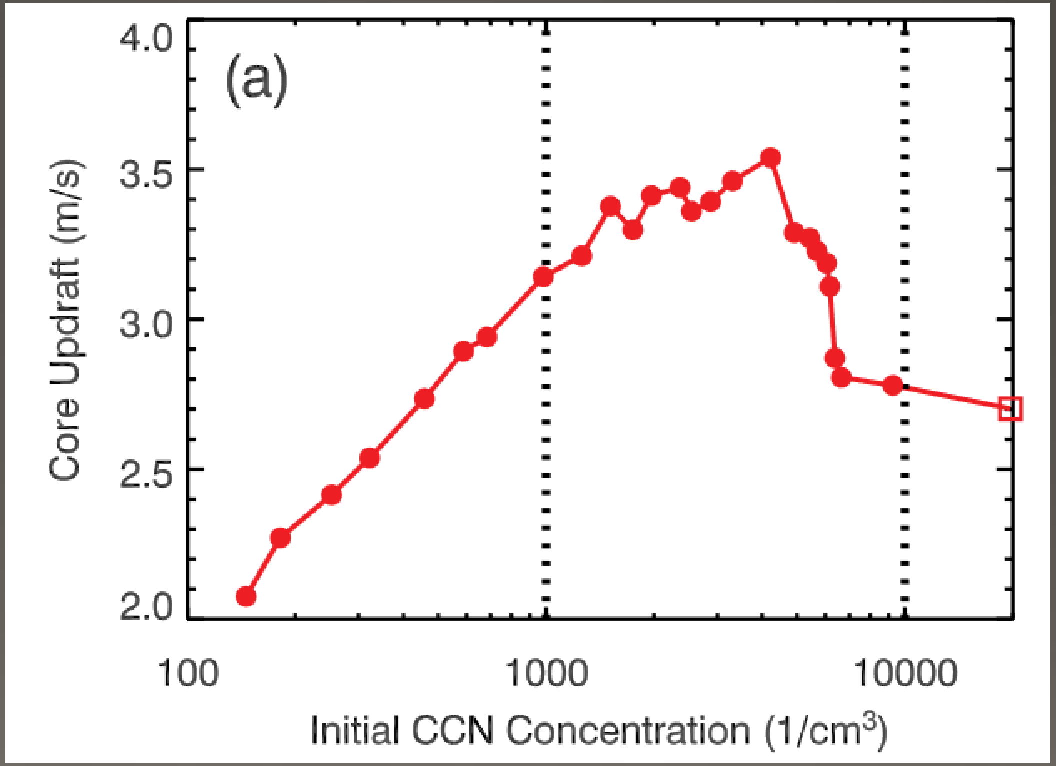


Aerosol-Induced Invigoration Magnitude

Storer and van den Heever 2013



Li et al 2008



Aerosol-Induced Invigoration Mechanisms

1. Additional Freezing of Liquid

- Suppressed rain production
- Increased lofting of liquid above the freezing level
- Increased latent heat release from freezing

Rosenfeld et al. (2008) and many others

2. Faster Condensation

- More efficient condensation on more numerous, smaller cloud droplets
- Increased latent heat release from condensation
- Decreased supersaturation

Lebo et al. (2012); Grabowski and Morrison (2016)

Conclusions

- In our simulations of tropical and midlatitude convection …
- **Convective invigoration is weak**
  - Our simulations show updraft speed changes of 1-2 m/s
  - But in tropical convection this may be a large percent increase

- **Additional freezing of liquid does not appear to drive invigoration**
  - In the midlatitude case, rain is not large enough to fall out of strong updrafts and/or the latent heat of freezing is small compared to that of vaporization

- **Supersaturation appears to be critical for convective invigoration**
  - Secondary nucleation can enhance updrafts, but may not be necessary to explain invigoration
  - Impacts of the Aitken mode differ from those of the accumulation mode and require more investigation