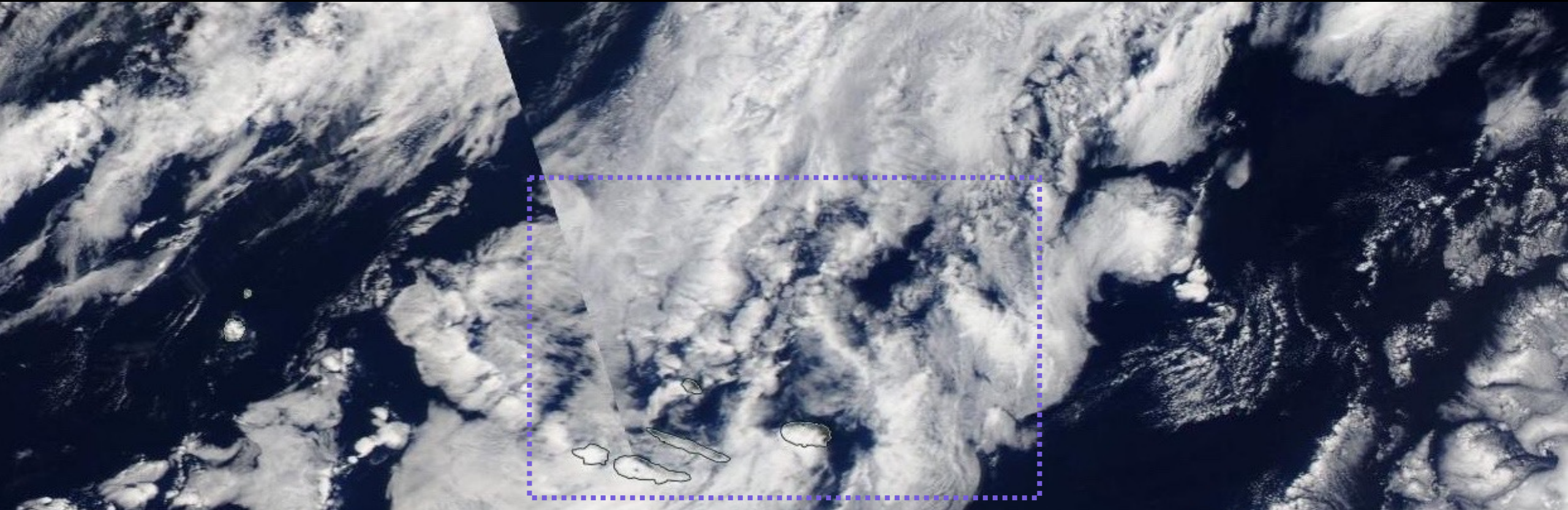


Aitken-mode Aerosol Influence on Mid-Latitude Mesoscale Cloud Morphology



Isabel McCoy^{1,2,3,4}, Matthew Wyant¹, Peter Blossey¹, Christopher Bretherton⁵, & Robert Wood¹

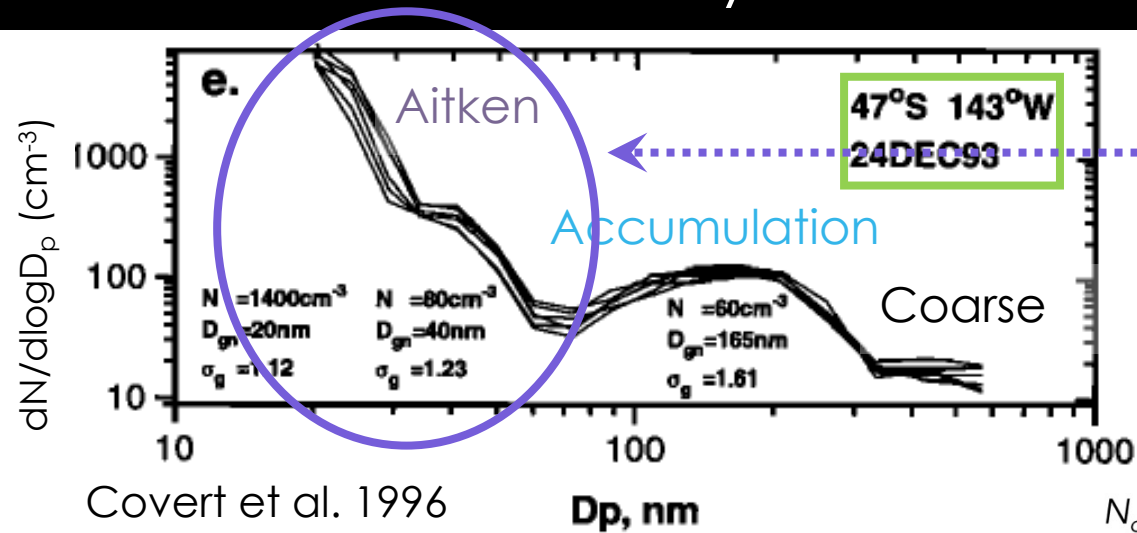
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Why do we care about Aitken aerosols?



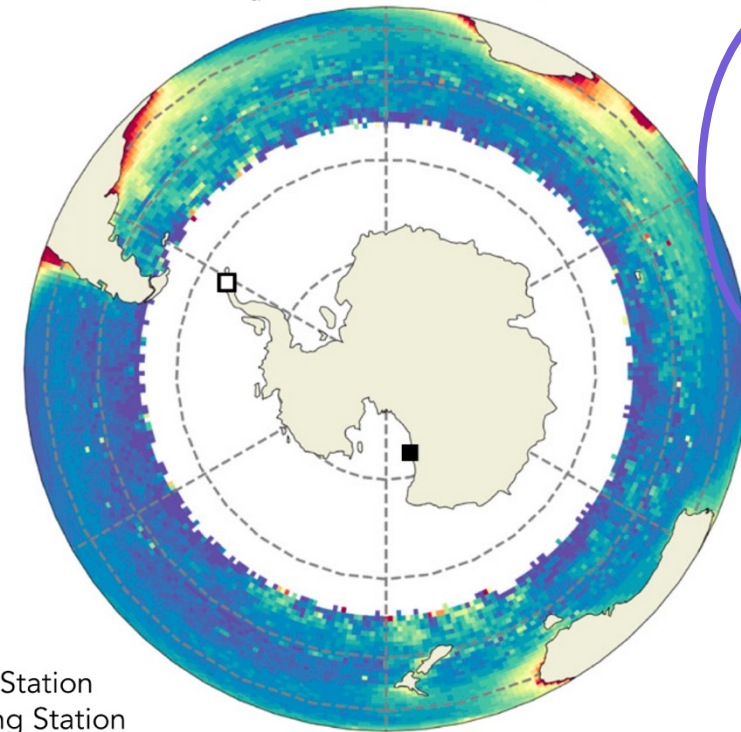
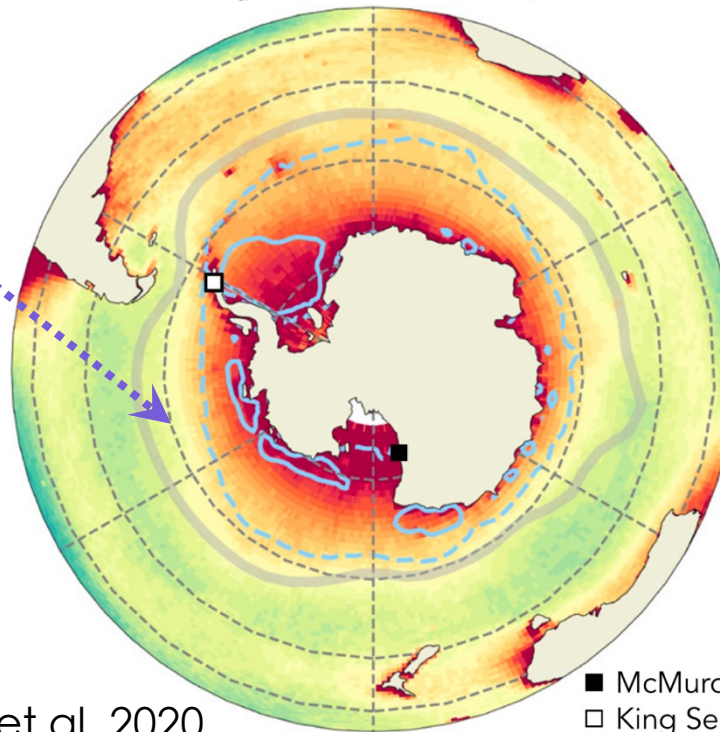
Southern Ocean observations show large boundary layer (BL) Aitken concentrations, few precipitation depleted (optically thin) cloud features (McCoy et al. 2021)...



...and very high cloud droplet number concentrations (N_d) in a pristine, biologically active environment (McCoy, McCoy et al. 2020).

N_d MODIS DJF (cm^{-3})

N_d MODIS JJA (cm^{-3})



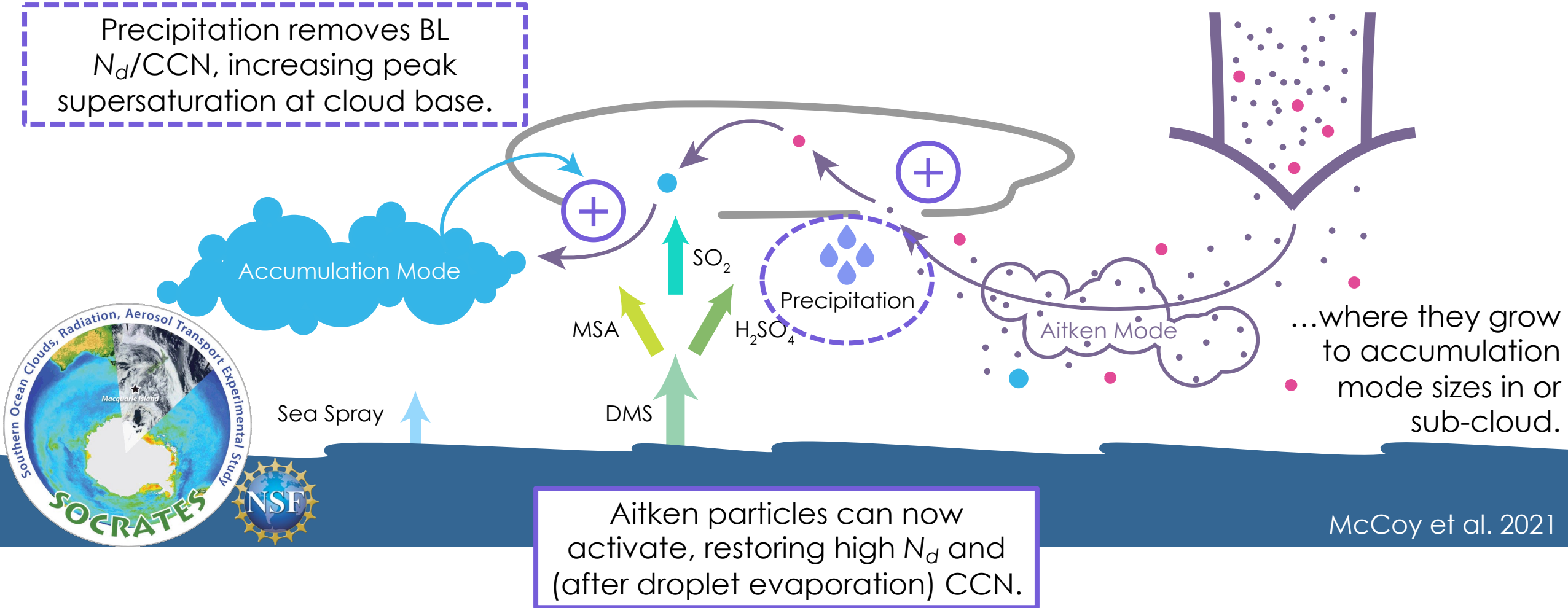
McCoy, McCoy et al. 2020

■ McMurdo Station
□ King Sejong Station

Hypothesis: Aitken-buffering maintains N_d against precipitation depletion

Free tropospheric (FT) Aitken aerosols are brought into or generated in the BL...

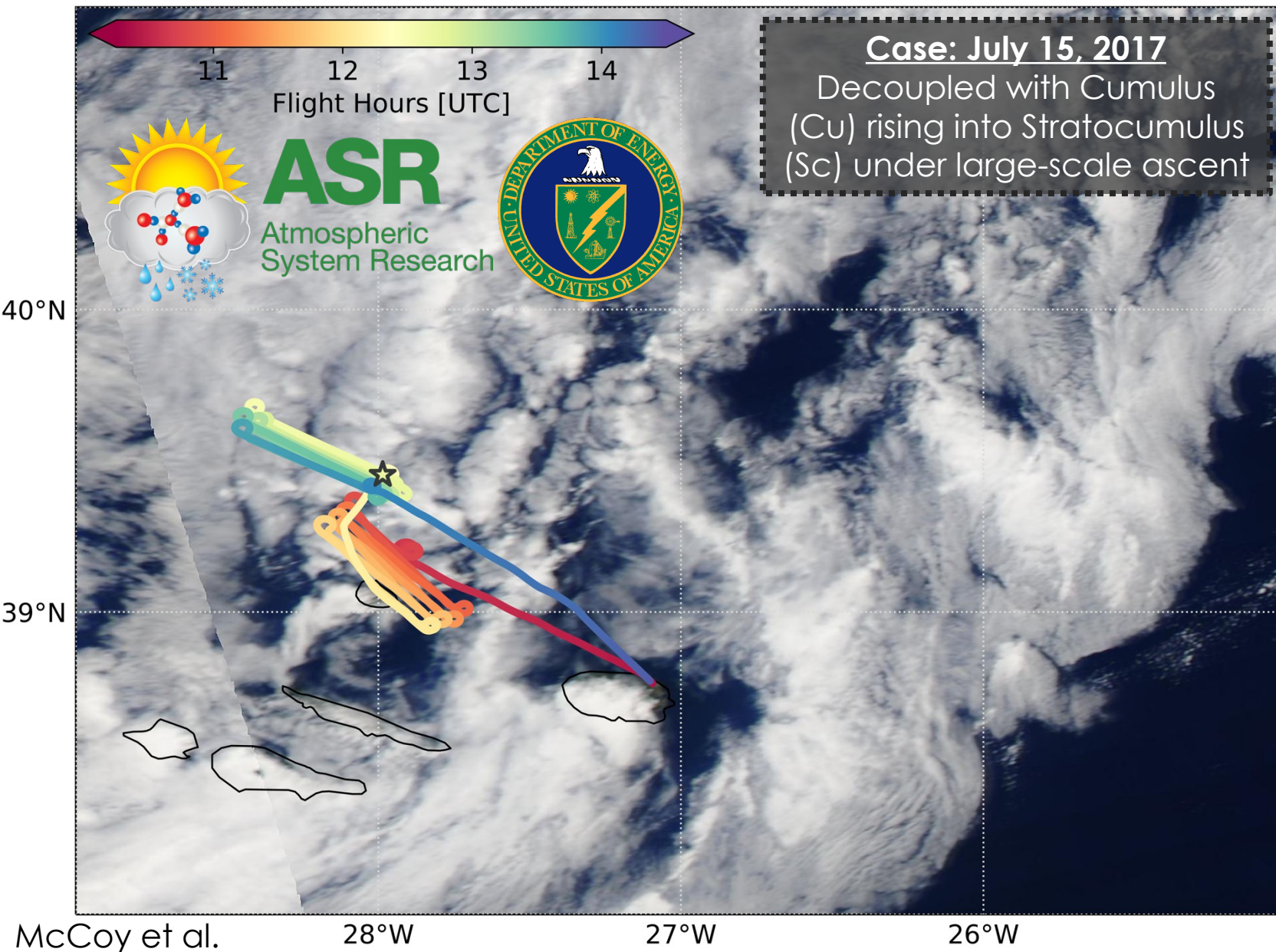
Precipitation removes BL N_d /CCN, increasing peak supersaturation at cloud base.



McCoy et al. 2021

e.g., Raes 1995, Covert et al. 1996, Sanchez et al. 2018, Zheng et al. 2018, Zheng et al. 2021

Is Aitken-buffering influential in the real world?



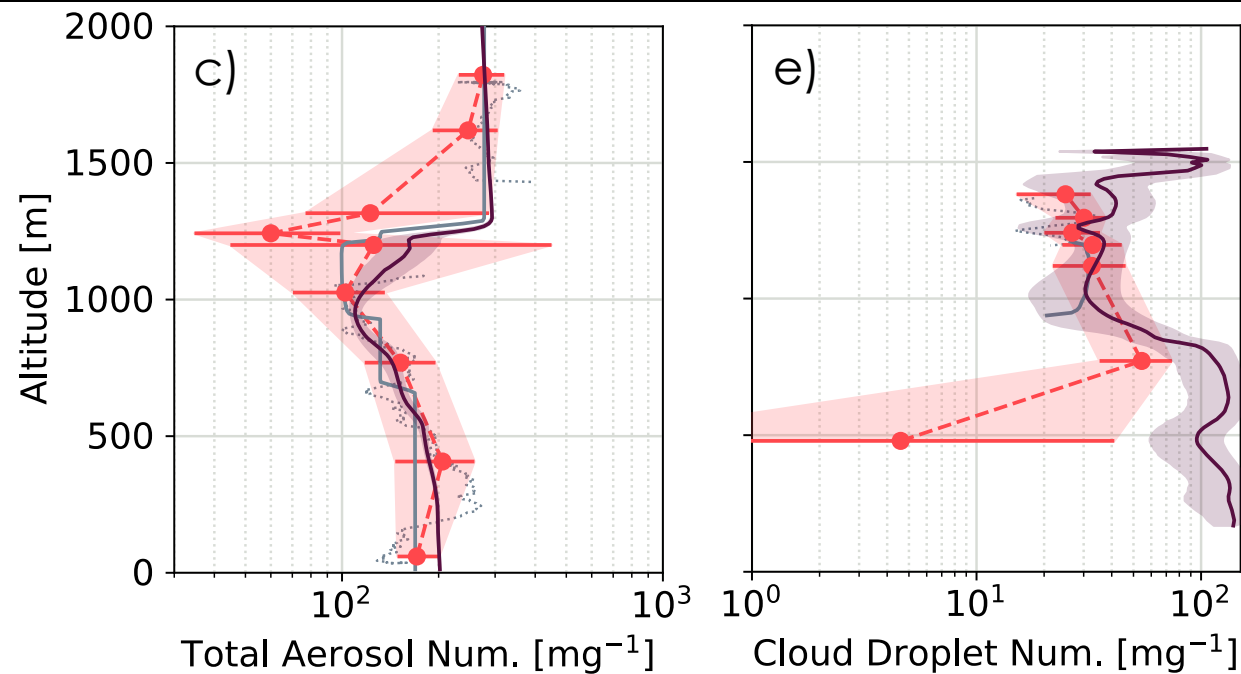
Hypothesis

Aitken-buffering maintains N_d against precipitation depletion, leading to brighter, less heterogeneous clouds.

Testing Framework

- Use Aitken-mode enabled microphysics scheme (Wyant *et al.* 2022) in SAM LES.
- Construct SAM case study from ACE-ENA (**Ctrl**) and constrain with observations (Wang *et al.* 2022).
- Develop aerosol sensitivity studies (**NoAit**, **HfAc**, **HfAcNoAit**) to evaluate Aitken aerosol influence on cloud properties.

The control simulation captures essential behaviors

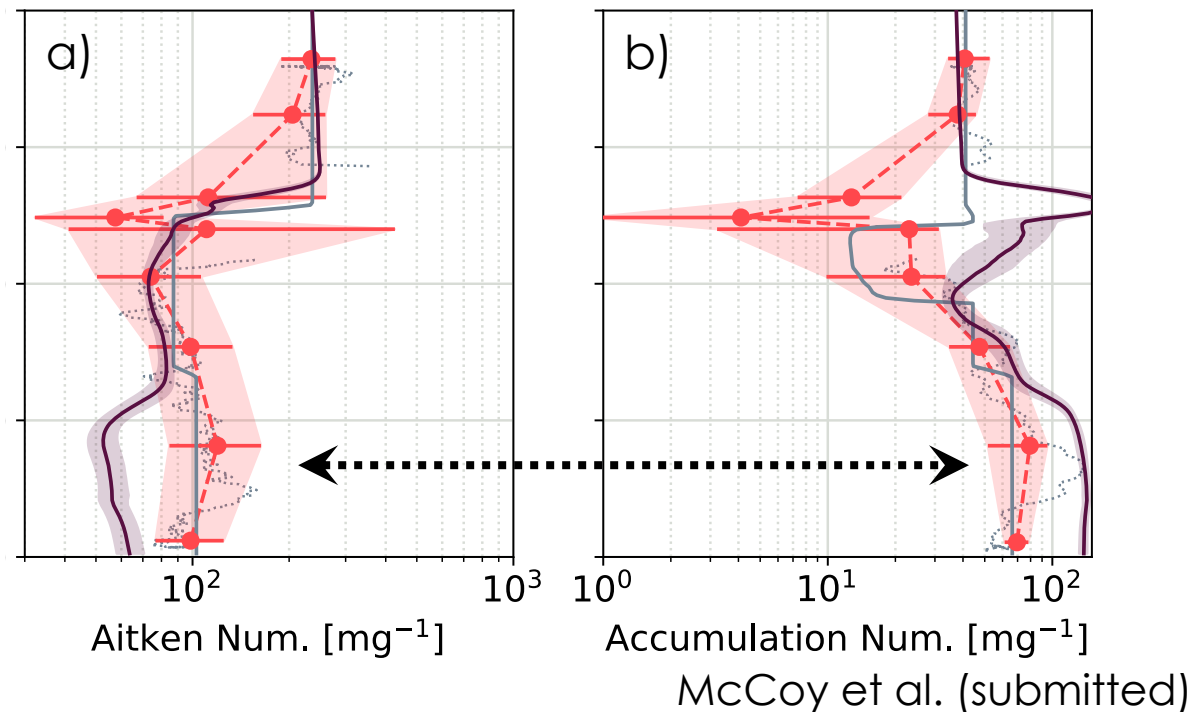


Total aerosol concentrations match observations...

...as does N_d , indicating net cloud-aerosol-precipitation processes are captured by SAM.

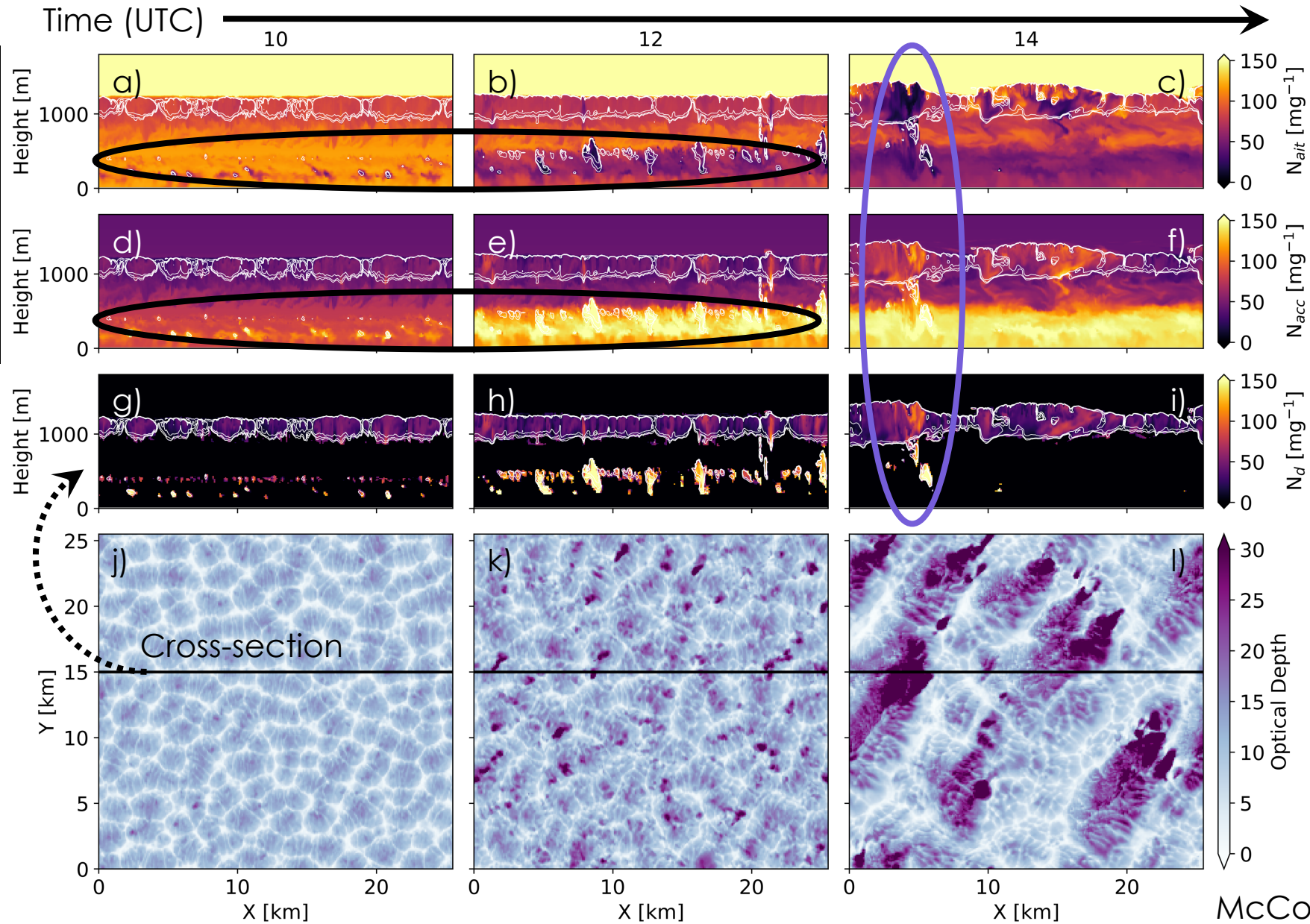
- SAM Median
- Obs Median All
- SAM t0
- P2 10sRM
- SAM 25-75%
- Obs 25-75%

Disagreement in Aitken-accumulation partitioning in the lower BL (may be resolved by improving initialization method).



What drives this aerosol-cloud-precipitation system?

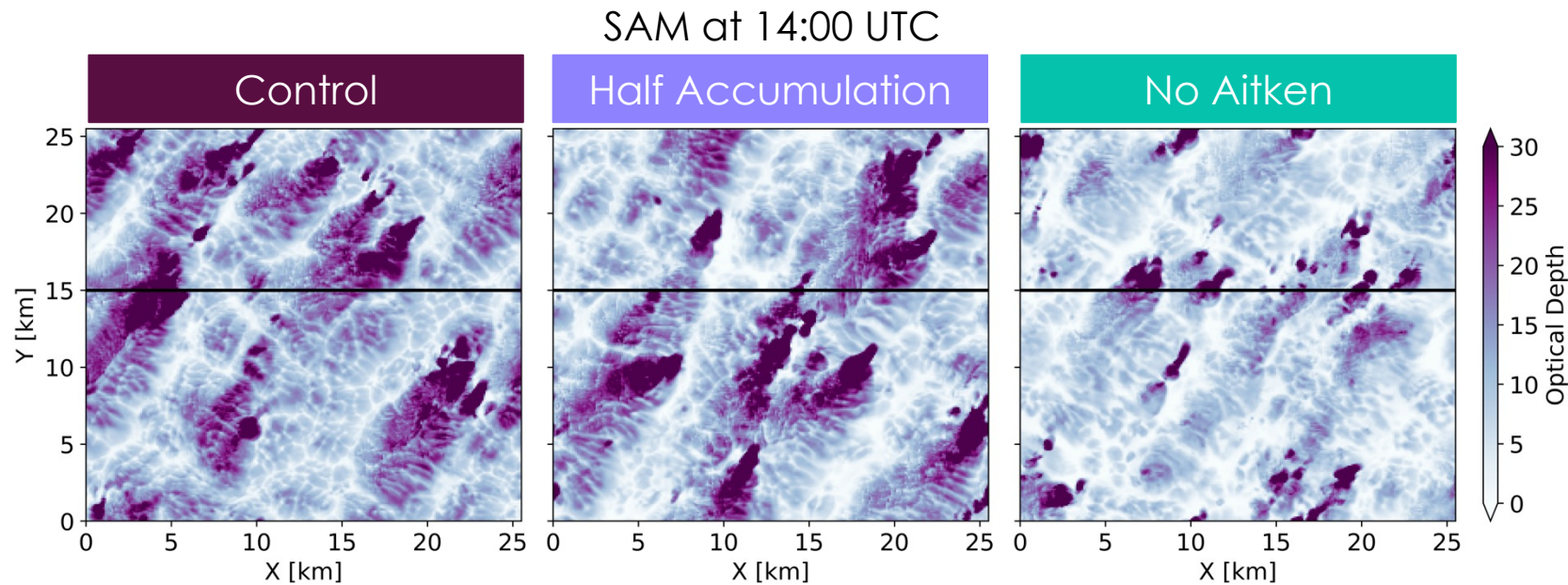
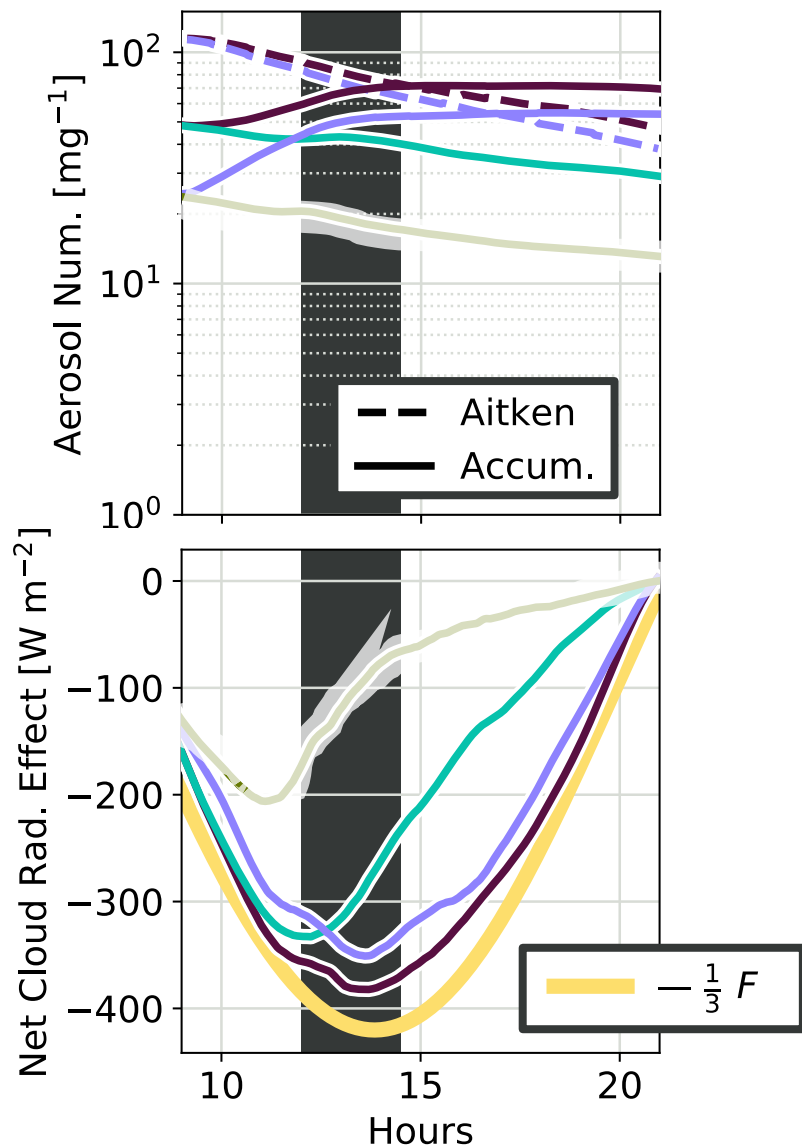
Aitken activation + chemical growth generates BL accumulation aerosols



Turbulence & convection carry accumulation aerosols up to support Sc Nd, increasing optical depth

Large-scale uplift encourages cloud moistening and organization

What happens when we remove Aitken aerosols?



Without Aitken aerosols, clouds do not reflect as much sunlight back to space over the day.

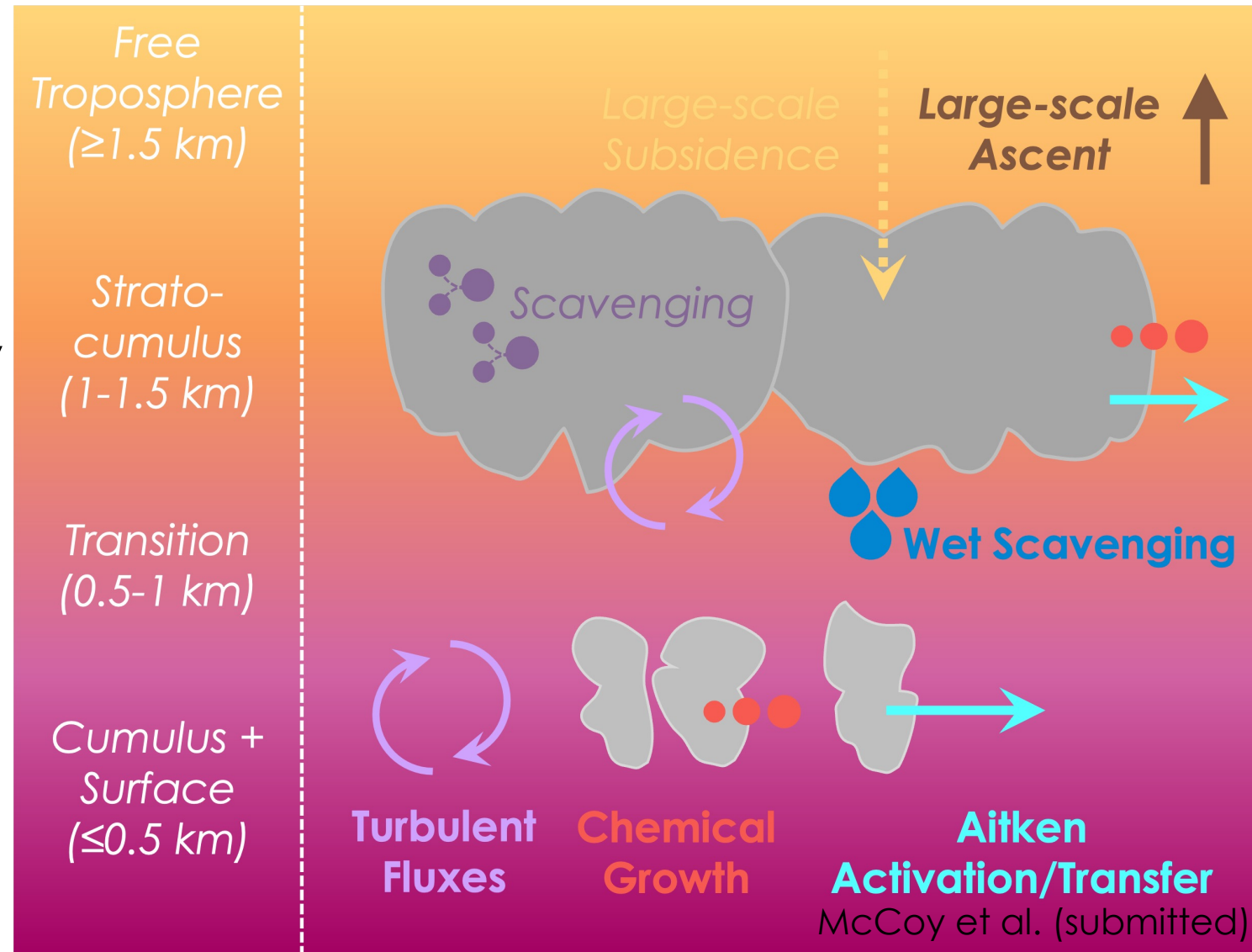
Aitken aerosols restore (buffer) reduced accumulation mode, resisting precipitation depletion

Removing Aitken aerosol leads to reduced cloud optical thickness and homogeneity.

Summary

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- *In situ* observations of mid-latitude decoupled low clouds constrain a large eddy simulation investigating aerosol-cloud-precipitation interactions.
- Aitken activation and turbulent and convective fluxes within the boundary layer restore accumulation mode aerosols against losses to precipitation.
- Large-scale ascent moistens and brightens clouds while Aitken-buffering acts to sustain brighter, more homogeneous clouds.
- Check out our [preprint on Authorea](#)
- Thanks to:



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McCoy et al. (submitted)

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