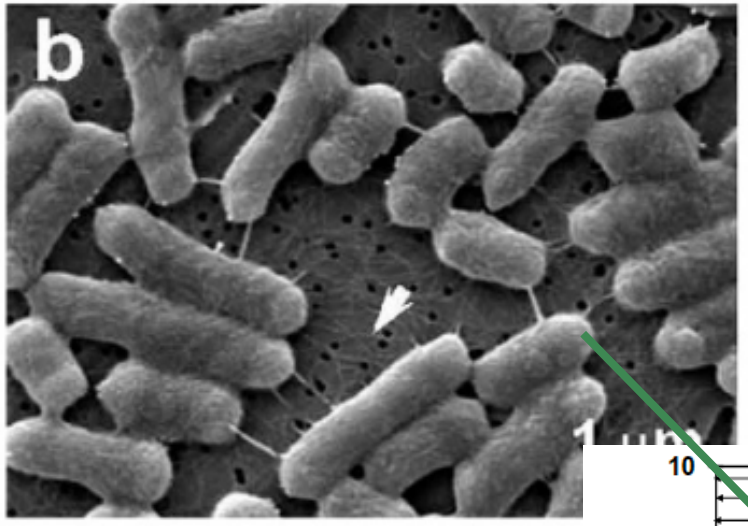
EMISSIONS AND FATE OF BIOLOGICAL PARTICLES IN THE ATMOSPHERE

CLIMATE AND SPACE SCIENCES AND ENGINEERING
UNIVERSITY OF MICHIGAN

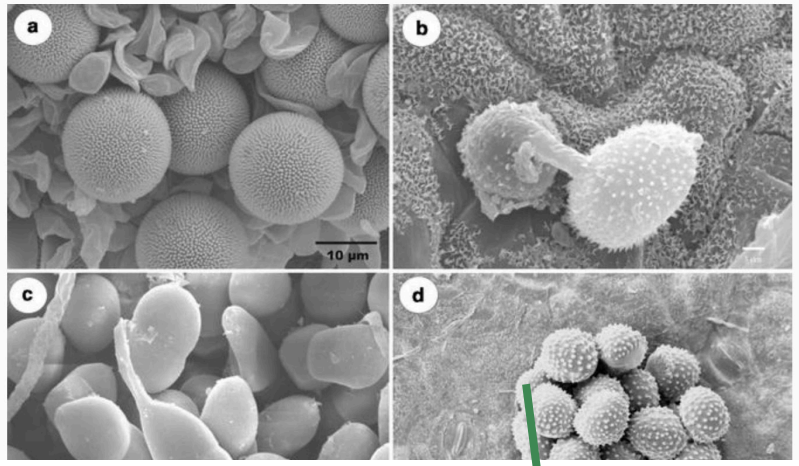
Allison Steiner
Tamanna Subba (now at BNL)
Yingxiao Zhang

PRIMARY BIOLOGICAL AEROSOL PARTICLES

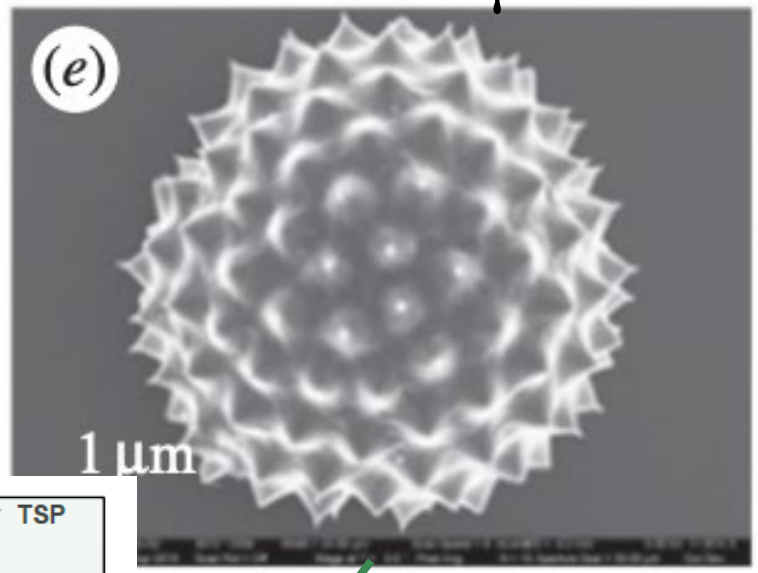
Bacteria
~ 1 μm

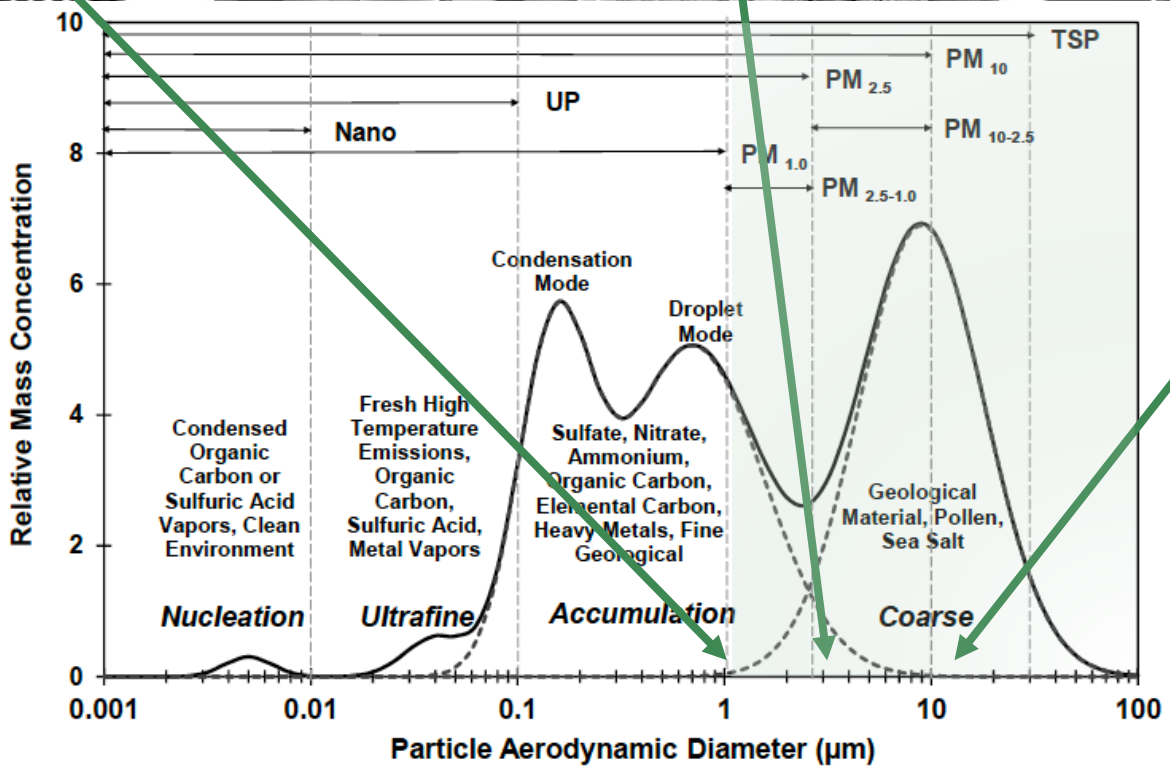


Fungal Spores
4-10 μm



Pollen
10-100 μm

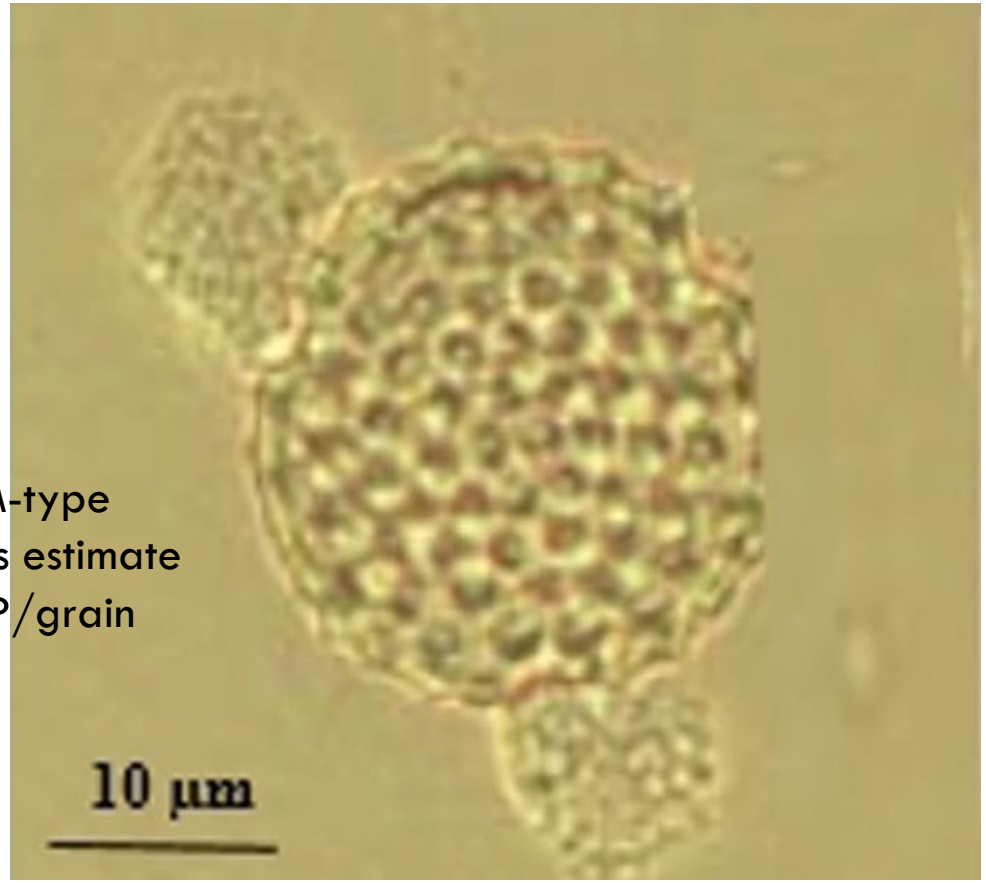




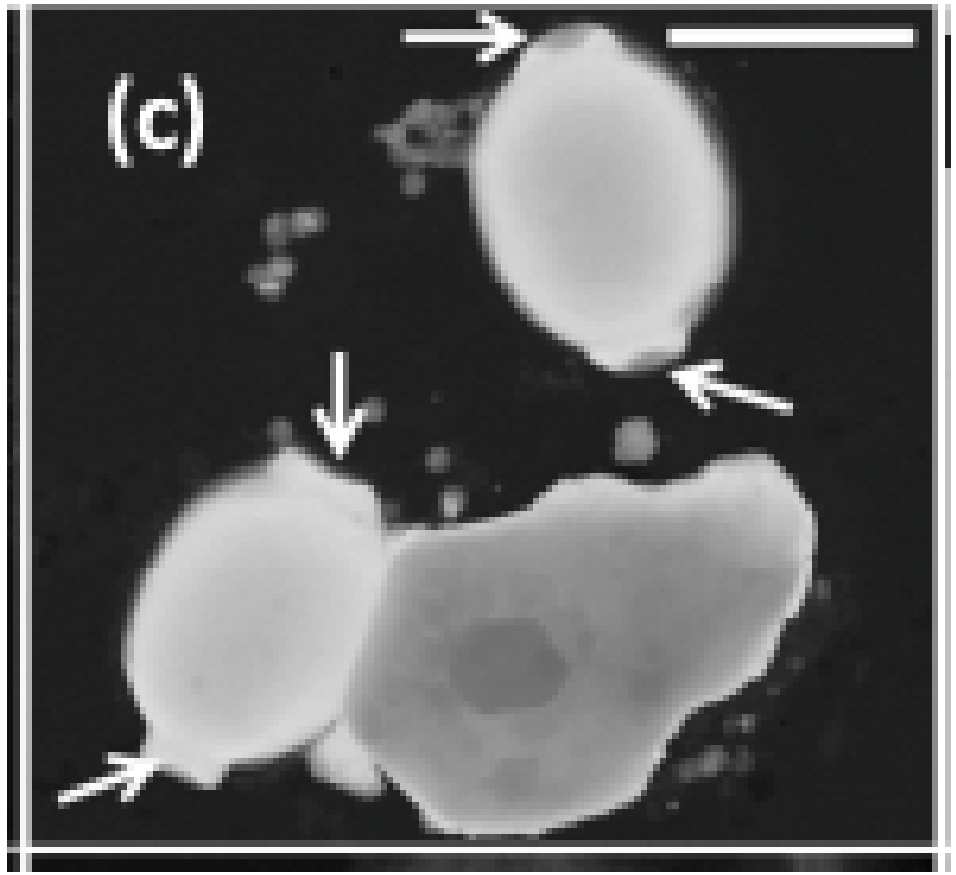
RUPTURE OF COARSE PARTICLES

HOW MANY SMALLER PARTICLES CAN BE FORMED BY RUPTURE?

Pollen: SEM-type assessments estimate ~1000 SPP/grain



Ambrosia (ragweed) rupture
Caronni et al., 2021; Aerobio



Fungal spore rupture
China et al., 2016; ES&T

LABORATORY STUDIES: RUPTURED POLLEN AS CCN

Live pollen collection in the field

Aqueous sample in lab

Atomize aqueous pollen sample

Dessicate

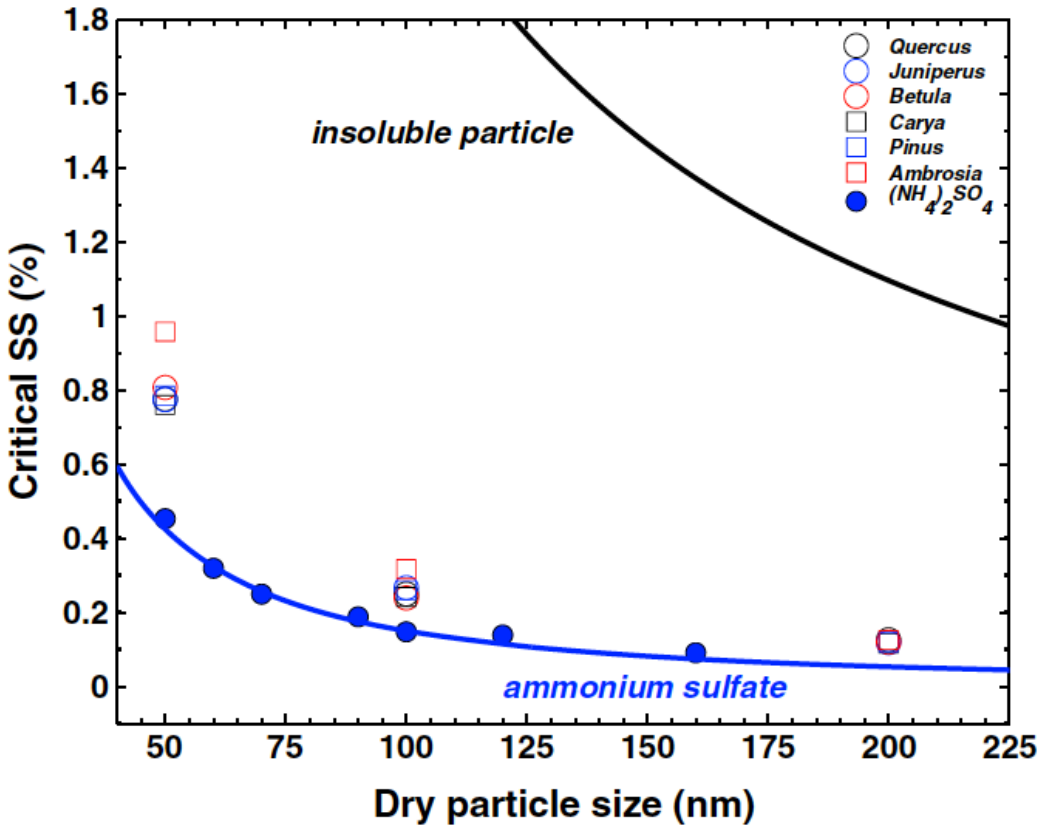
DMA Particle Sizer

Select SPP size (50, 100, 200 nm)

Total parti
count (CP

CCN/CN

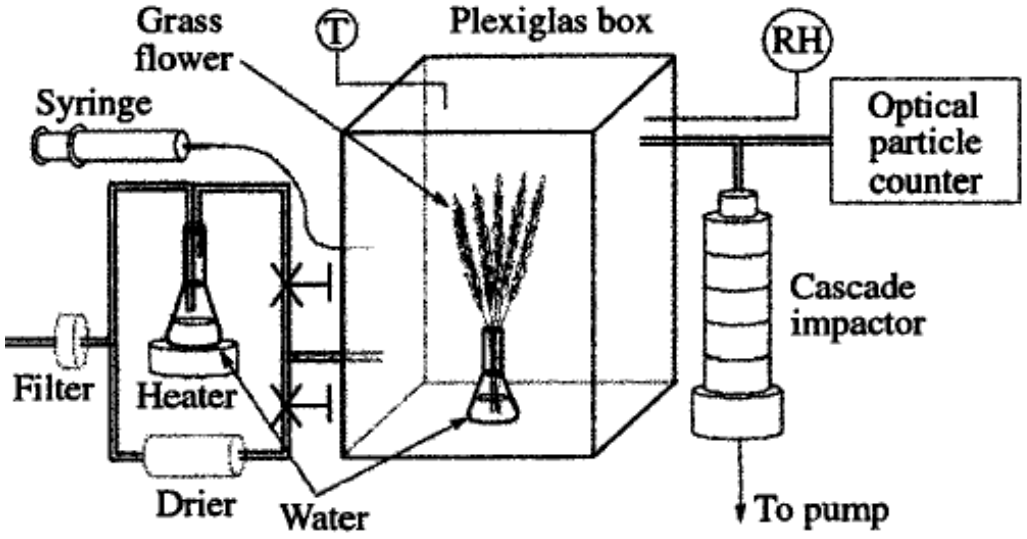
Cloud
condensat
nuclei cou



Steiner et al. 2015 GRL; Pummer et al. 2012 ACP

LABORATORY STUDIES: POLLEN RUPTURE RATE AND POLLEN AS ICE NUCLEATING PARTICLES

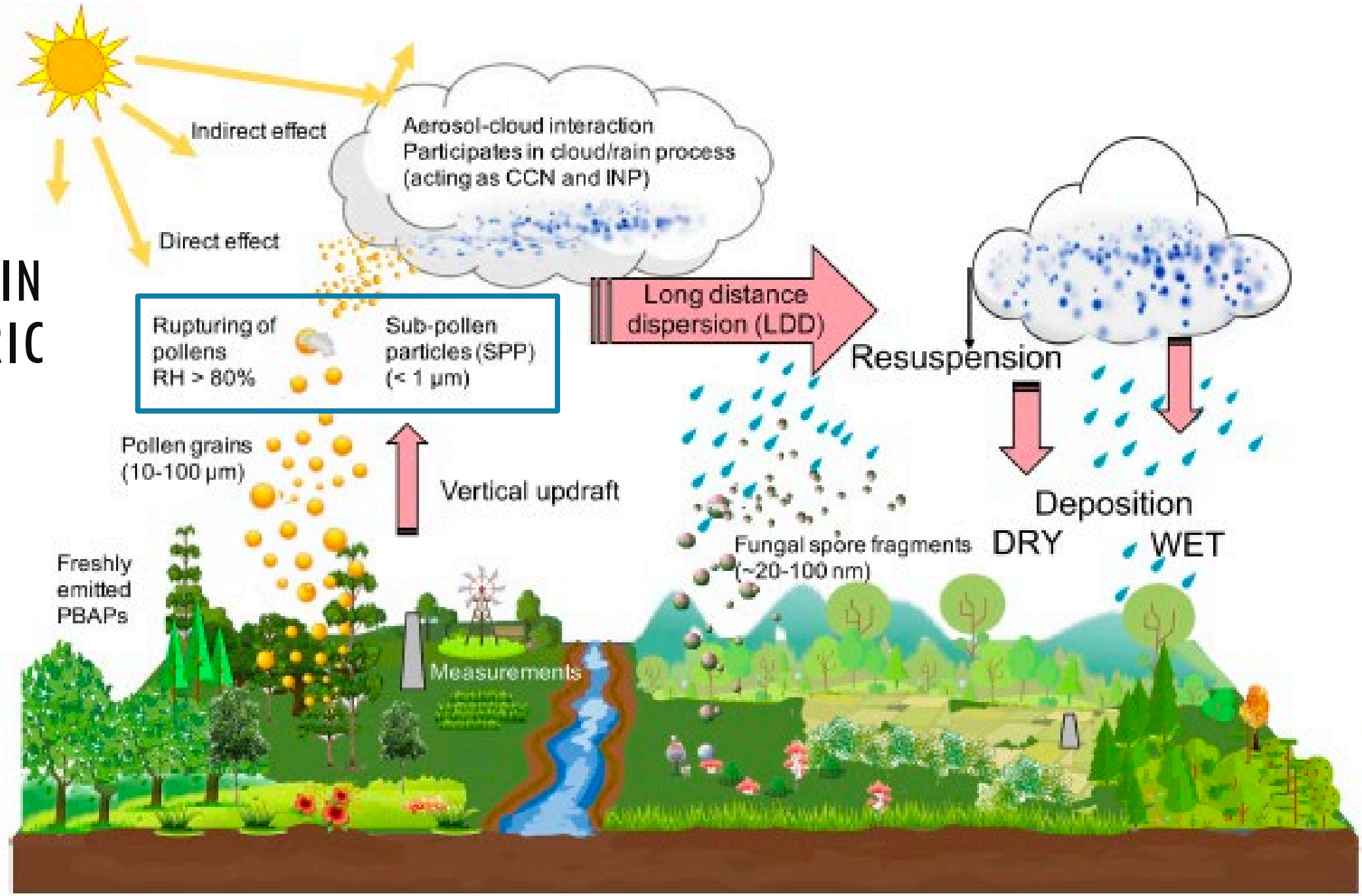
In the (Rag)weeds:
Collaboration with Sarah Brooks
Texas A&M University



Taylor et al. 2002; J Allergy Clin Immun

Chamber-type assessment estimates ~10^4-10^5 SPP/grain

INCLUSION IN ATMOSPHERIC MODELS



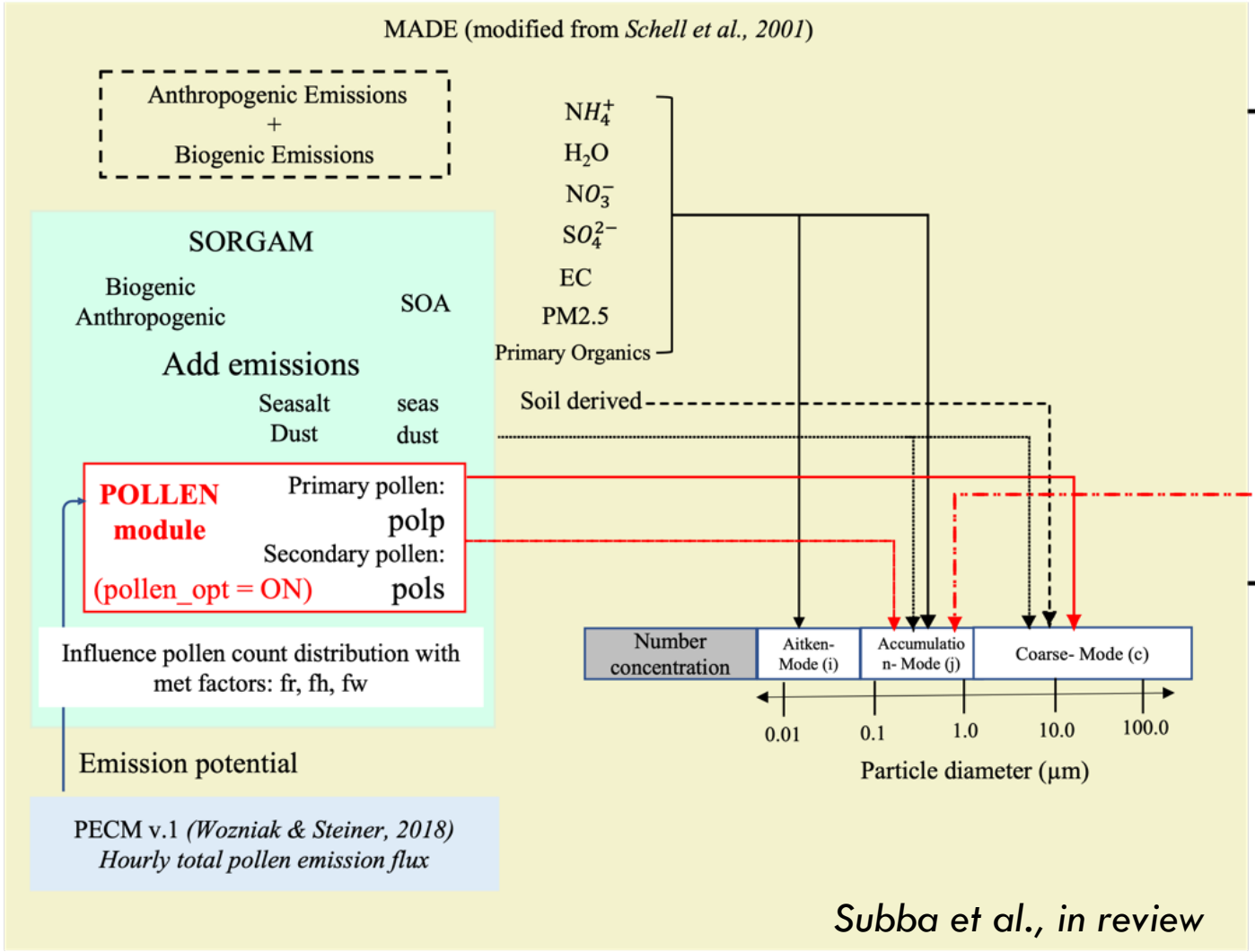
Subba et al., 2021; JGR-Atm

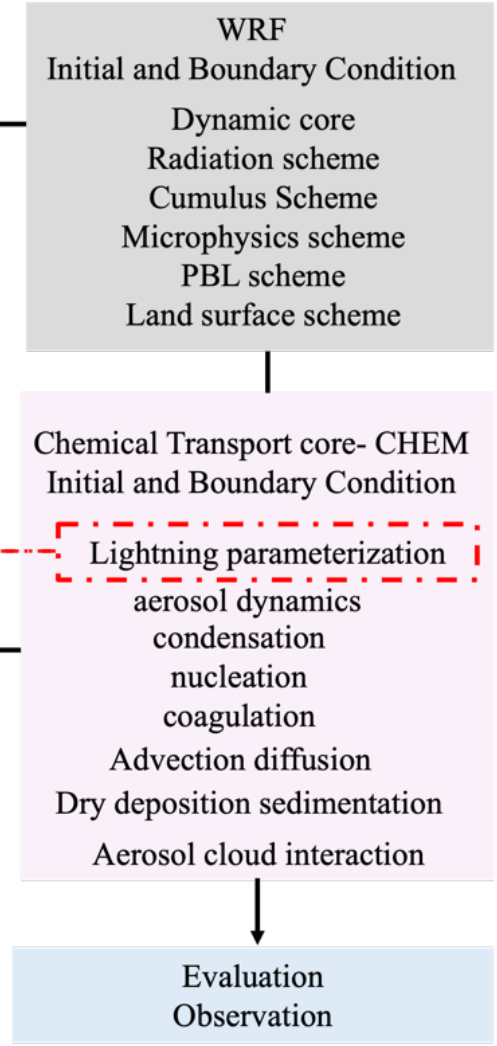
MODELING FRAMEWORK: WRF-CHEM
POLLEN AND RUPTURE POLLEN AS CCN ONLY

Tested several different rupture parameterizations

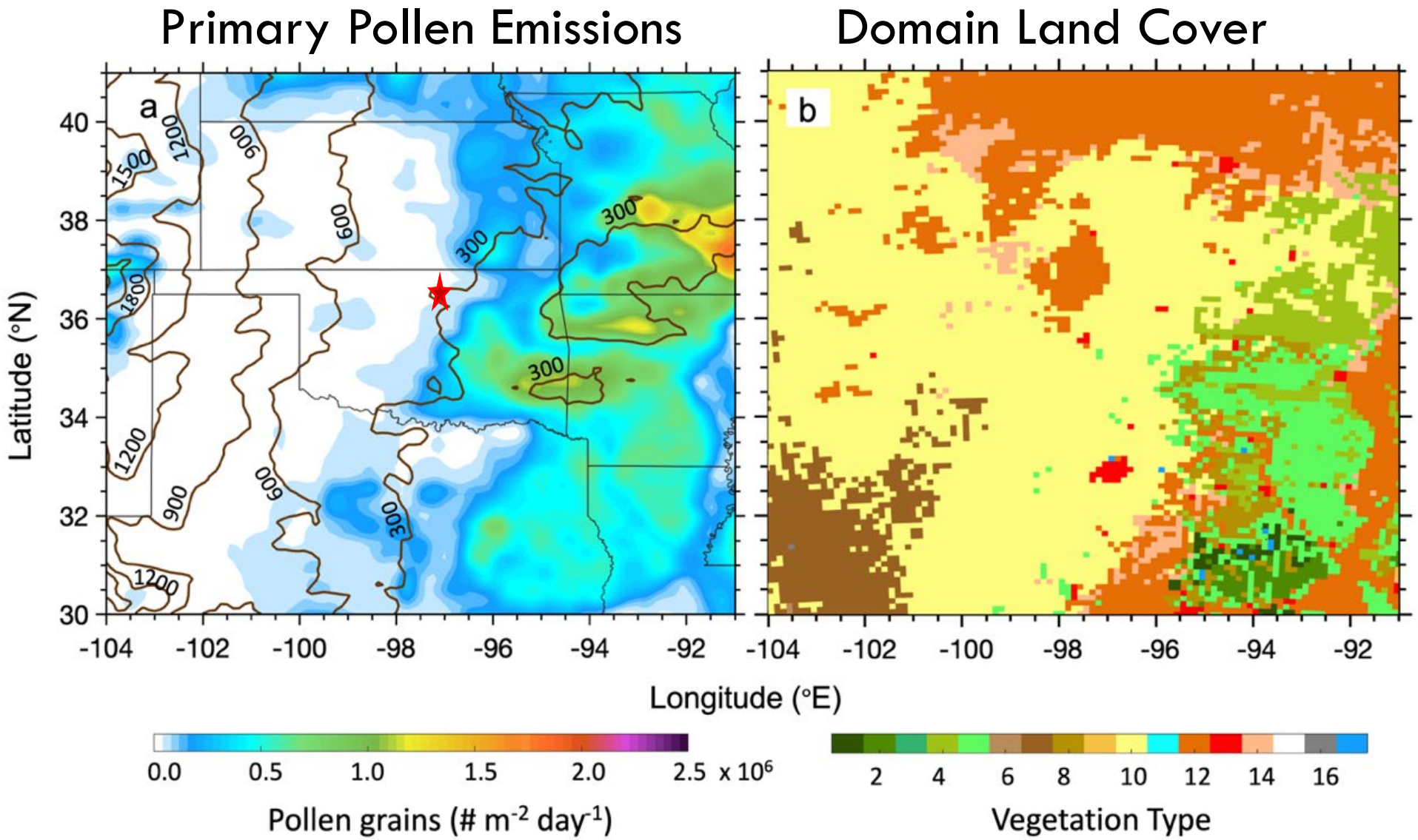
1. No rupture
2. Surface rupture
3. Surface and in atmosphere rupture
4. Lightning rupture

Used a rupture rate of 1000 SPP/grain





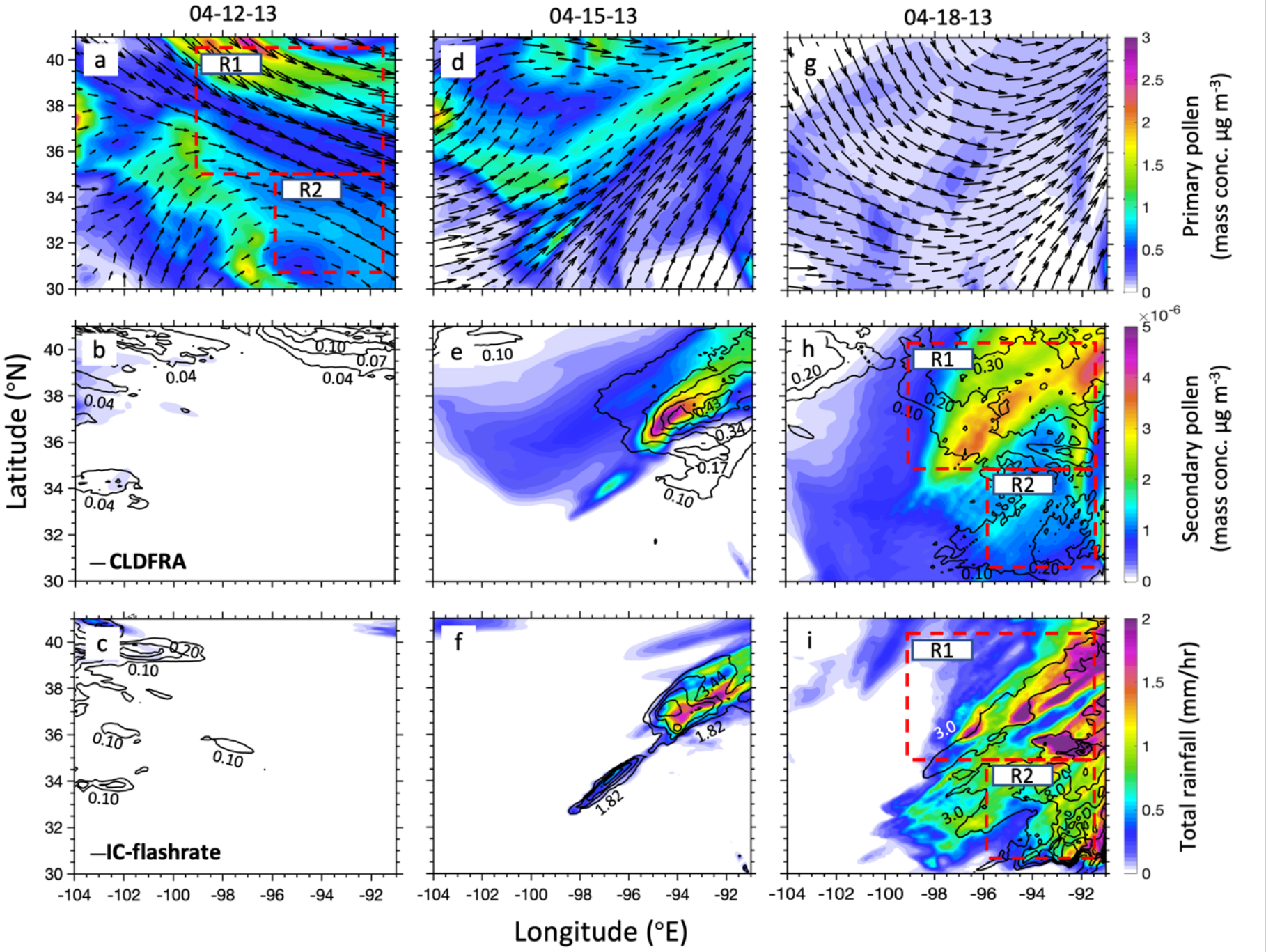
SGP-CENTERED SIMULATIONS: APRIL 2013



Primary Pollen

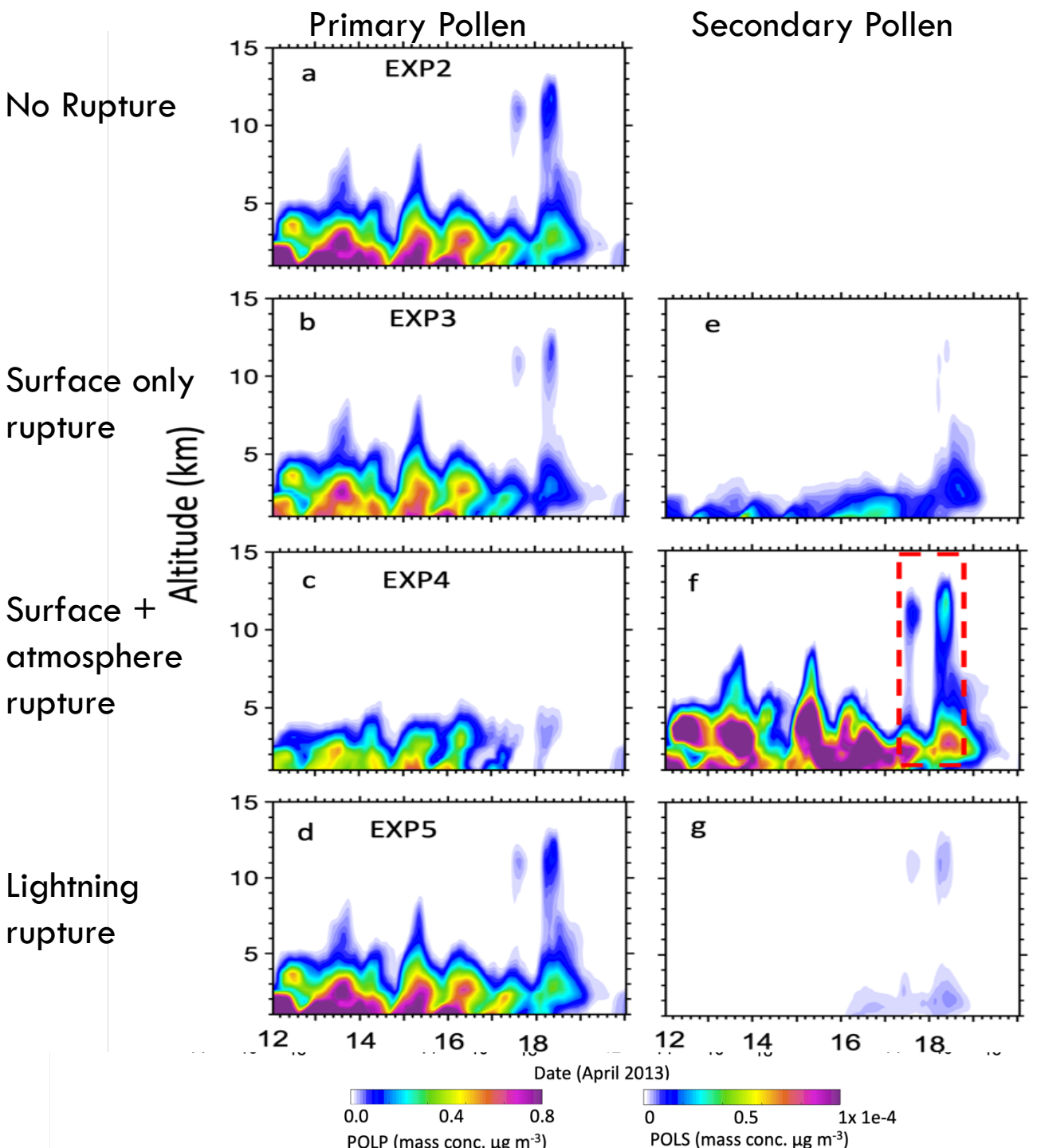
Secondary Pollen

Precipitation

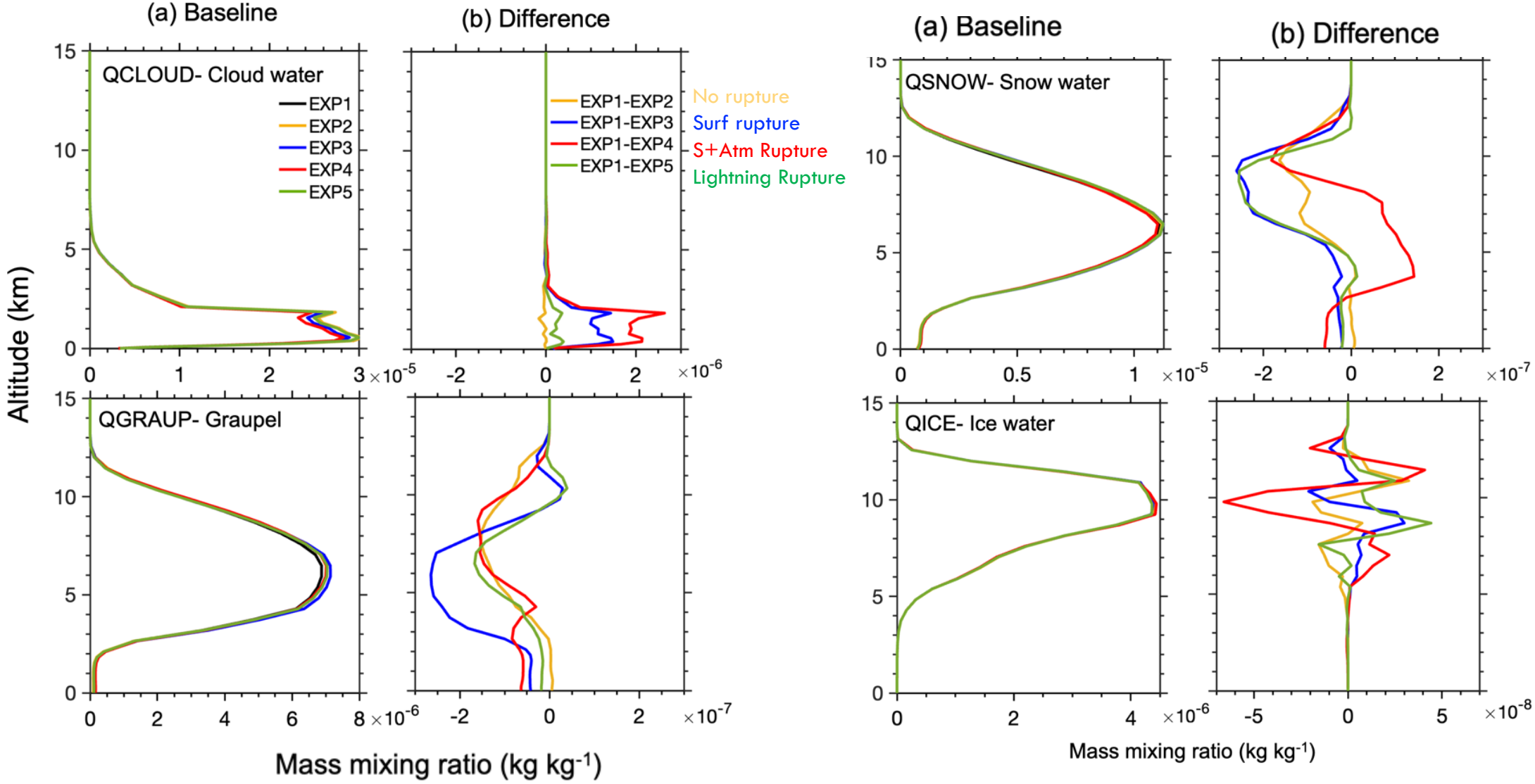


VERTICAL PROFILES OF POLLEN

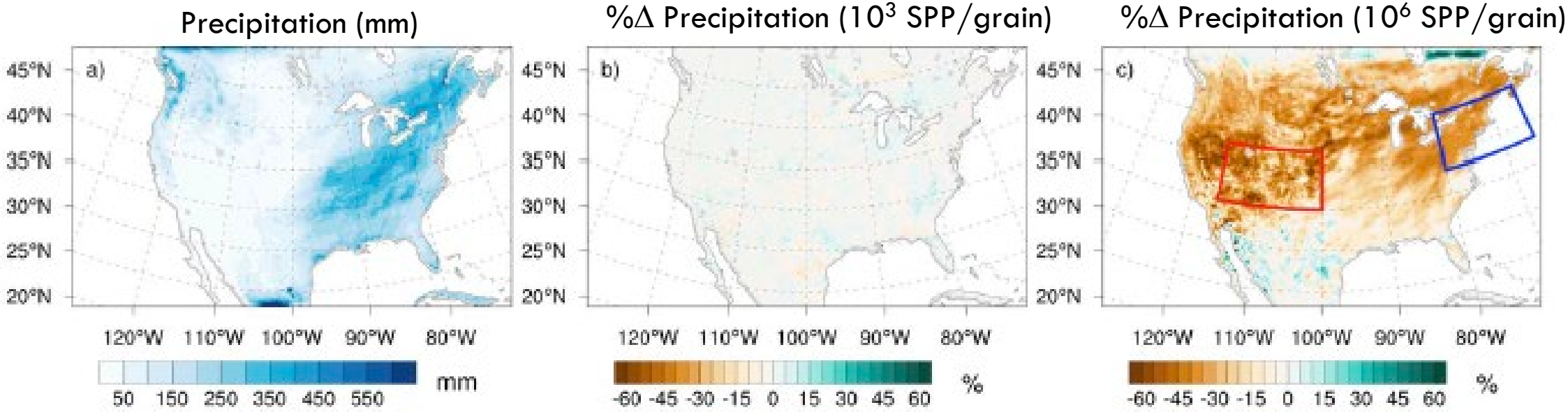
- Model simulates mixing of the primary pollen up to about 5km and up to 10km under deep convection
- Ruptured pollen depends on the mechanism and the number of grains produced
- Most produced when accounting for surface and atmospheric rupture



IMPACT ON HYDROMETEORS
USING A LOW RUPTURE RATE, CCN IMPACT IS SMALL



IMPACT OF POLLEN ON WARM CLOUDS



- Need a large amount of SPP to influence warm clouds

Estimates of SPP produced per grain

$10^{4\text{-}5}$ SPP/grain
(Hendrickson et al., in review)

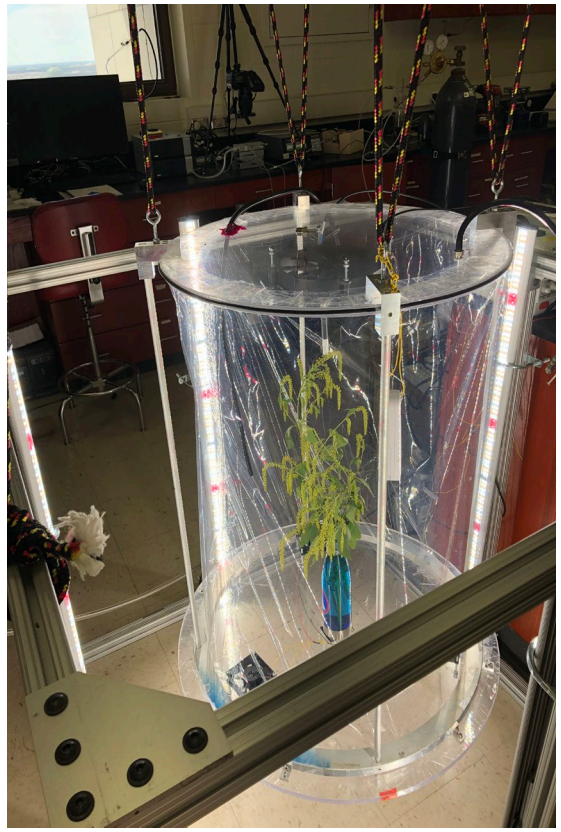
10^3 SPP/grain
(Suphioglu et al. 1992; Stone et al. 2021)

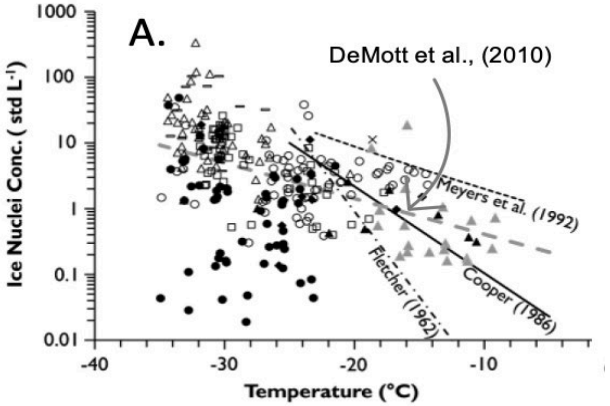
10^6 SPP/grain
(mass conservation)

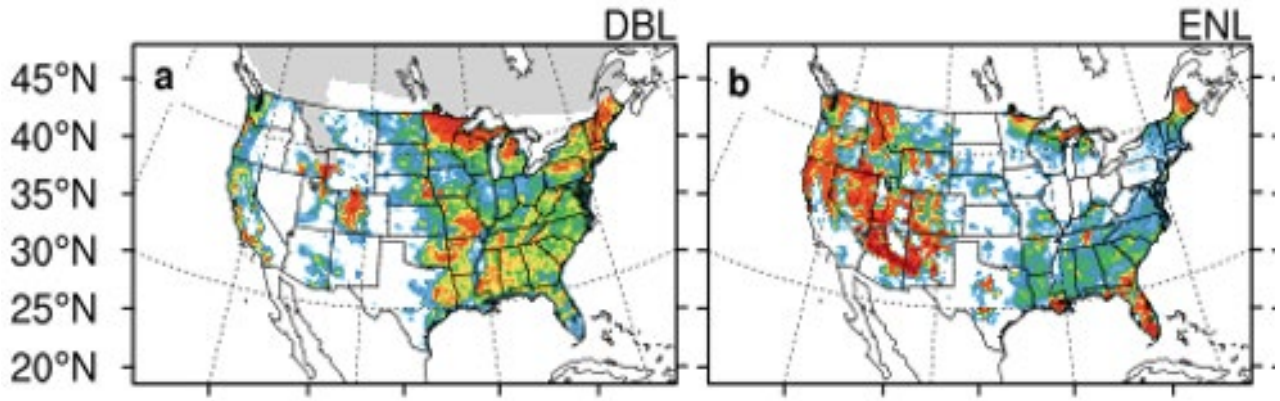
Wozniak et al. 2018; GRL

NEXT STEPS: MODELING POLLEN AS INP

1. Implementation of pollen as an INP: using lab results in conjunction with models
2. Is this relevant to clouds at some locations and some times?







ACKNOWLEDGEMENTS

- Department of Energy Atmospheric Science Research Program Grant DE-SC0019084
- EMSL research grants in 2016-7 and new FICUS grant in 2022-3
- National Science Foundation CAREER AGS 0952659 and Collaborative Proposal AGS 1821173
- AAAAI for providing pollen count data from over 100 sites in the United States
- Collaborators
  - Sarah Brooks @ Texas A&M
  - Jordan Schnell @ NOAA
  - Swarup China @ PNNL

Former graduate student Matthew Wozniak

Former Postdoc Tamanna Subba (now at BNL)

Graduate Student Yingxiao Zhang