Comparison of SABRE and SOLVE late winter/early spring Arctic stratosphere aerosol measurements

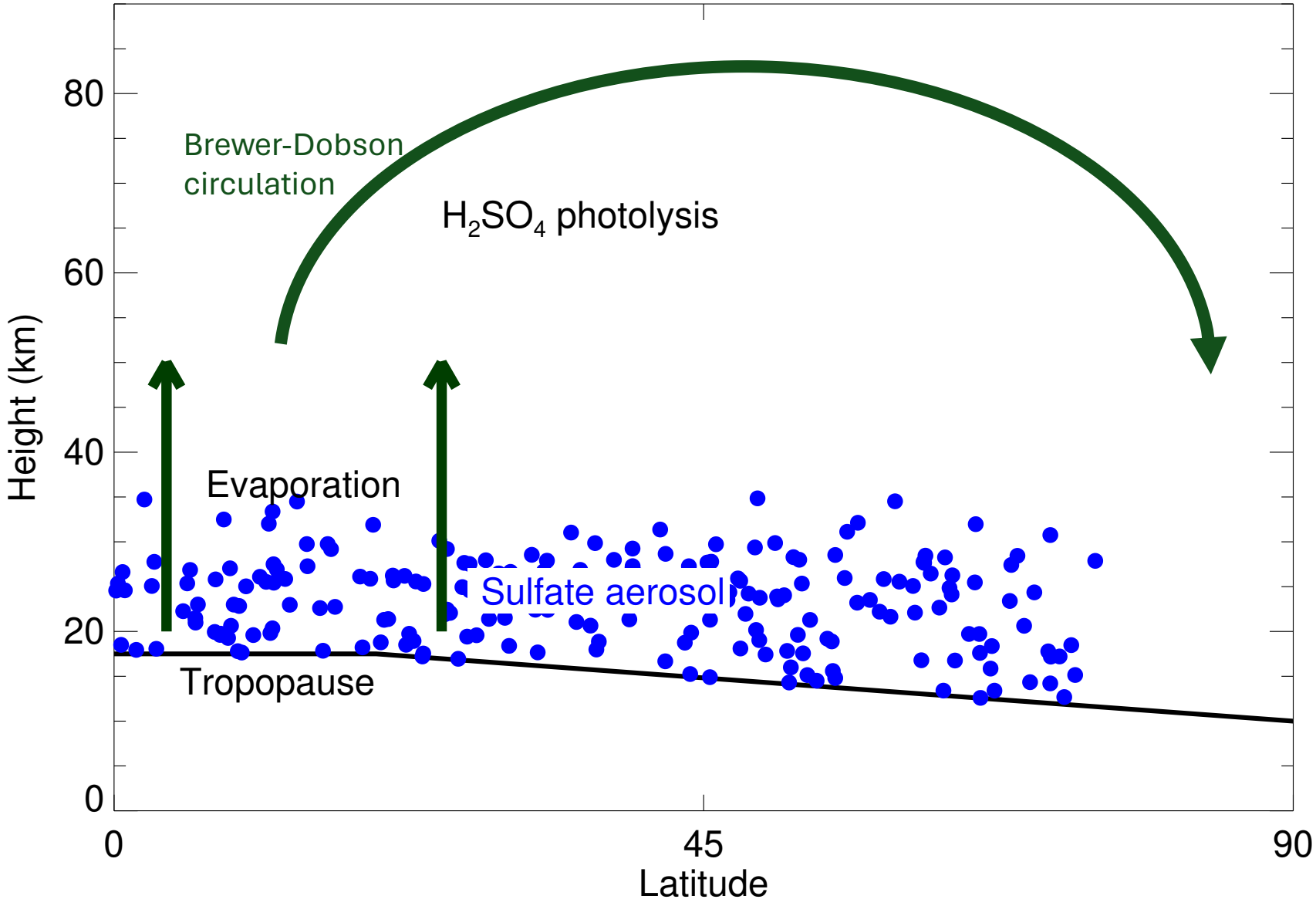
E. Jensen, C. Brock, E. Hintsa, etc.

SABRE: March, 2023, Fairbanks

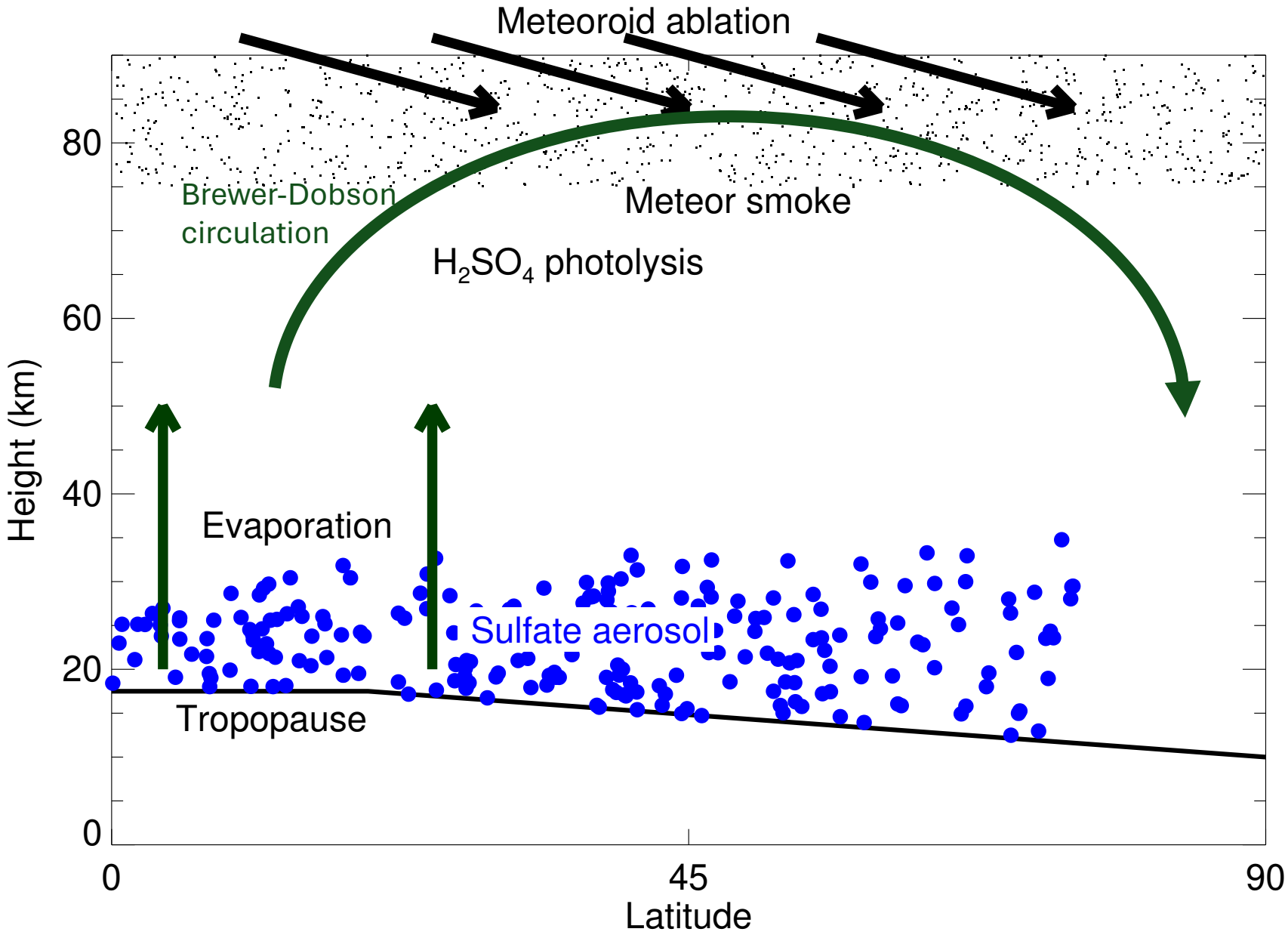
SOLVE: 5–12 March, 2000, Kiruna

- Vortex sampling indicated by tracer measurements
- Aerosol abundance and size distributions

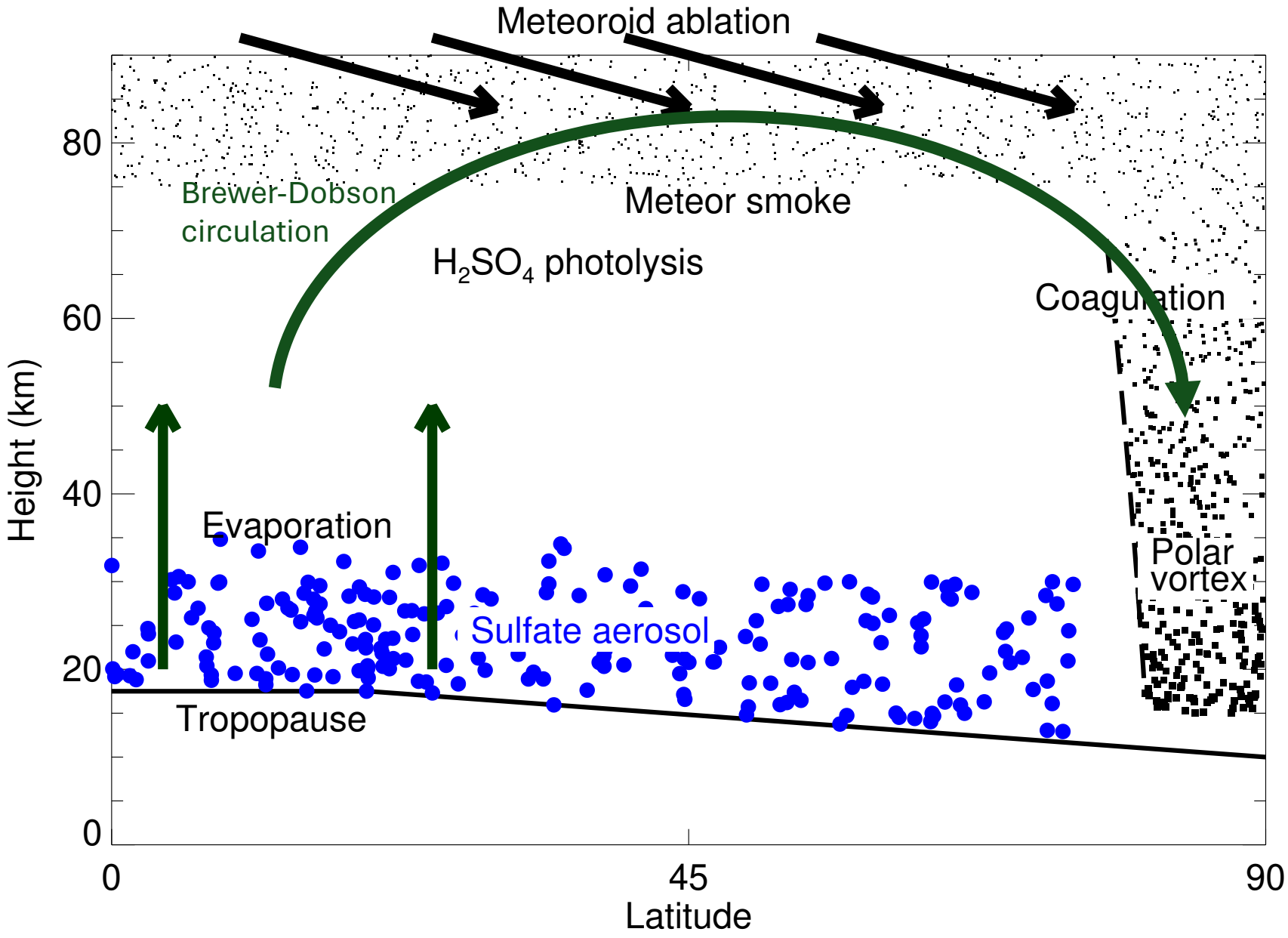
Aerosol formation in polar vortex



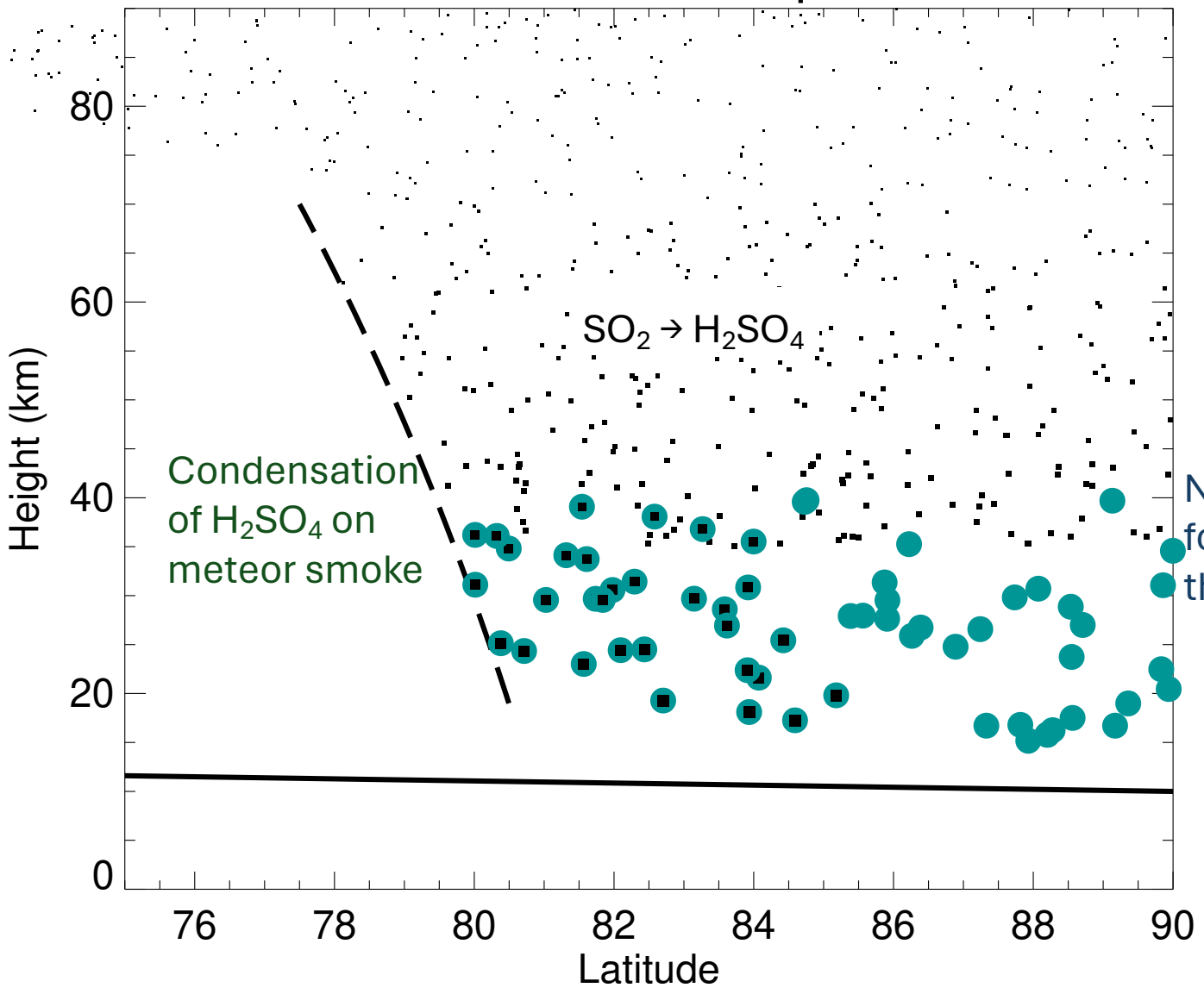
Aerosol formation in polar vortex



Aerosol formation in polar vortex



Aerosol formation in polar vortex

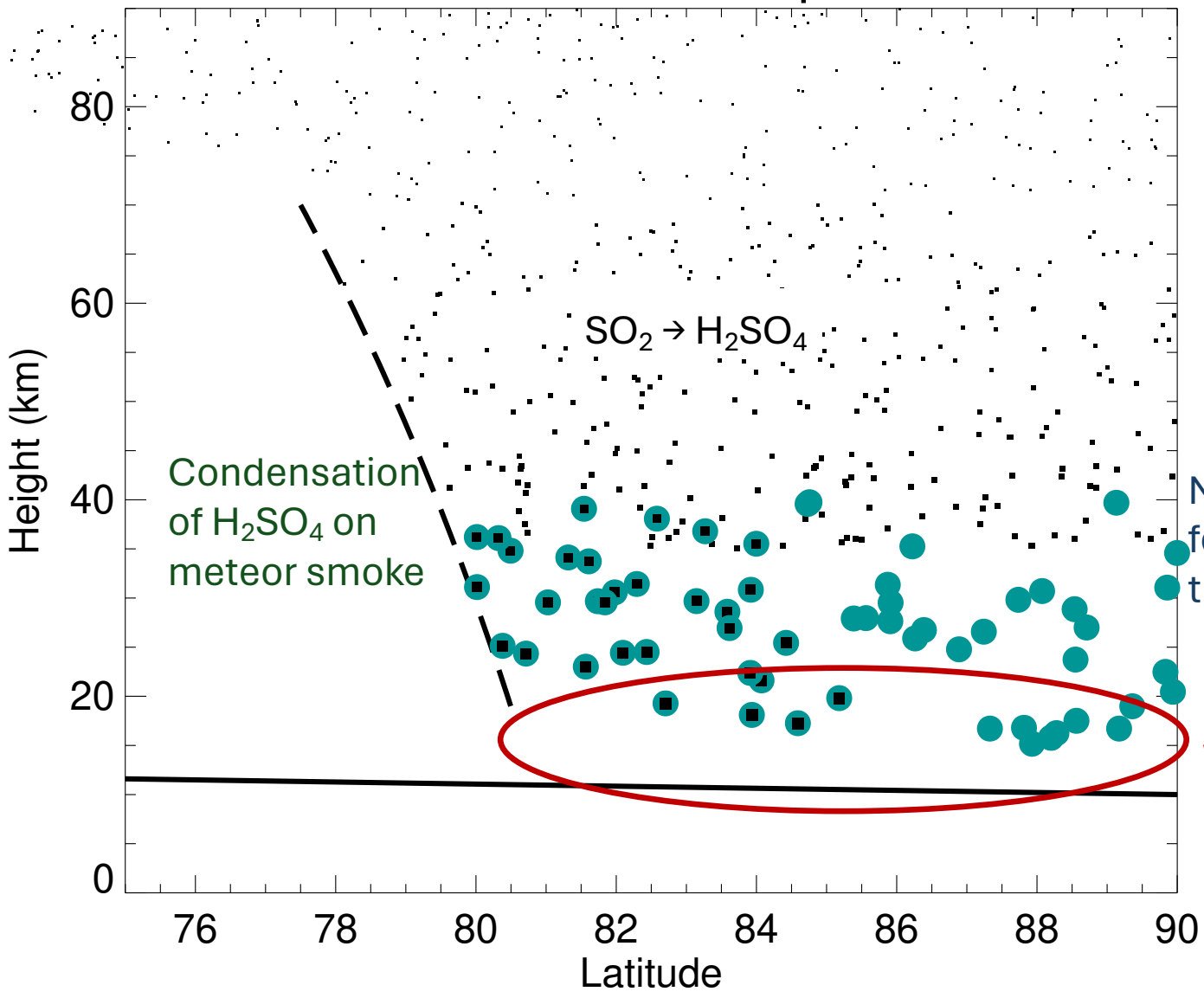


New particle formation from the gas phase

Meteor smoke found in most vortex sulfate aerosols could have resulted from coagulation

- Either or both of these processes could be occurring, with implications for sulfate aerosol number

Aerosol formation in polar vortex



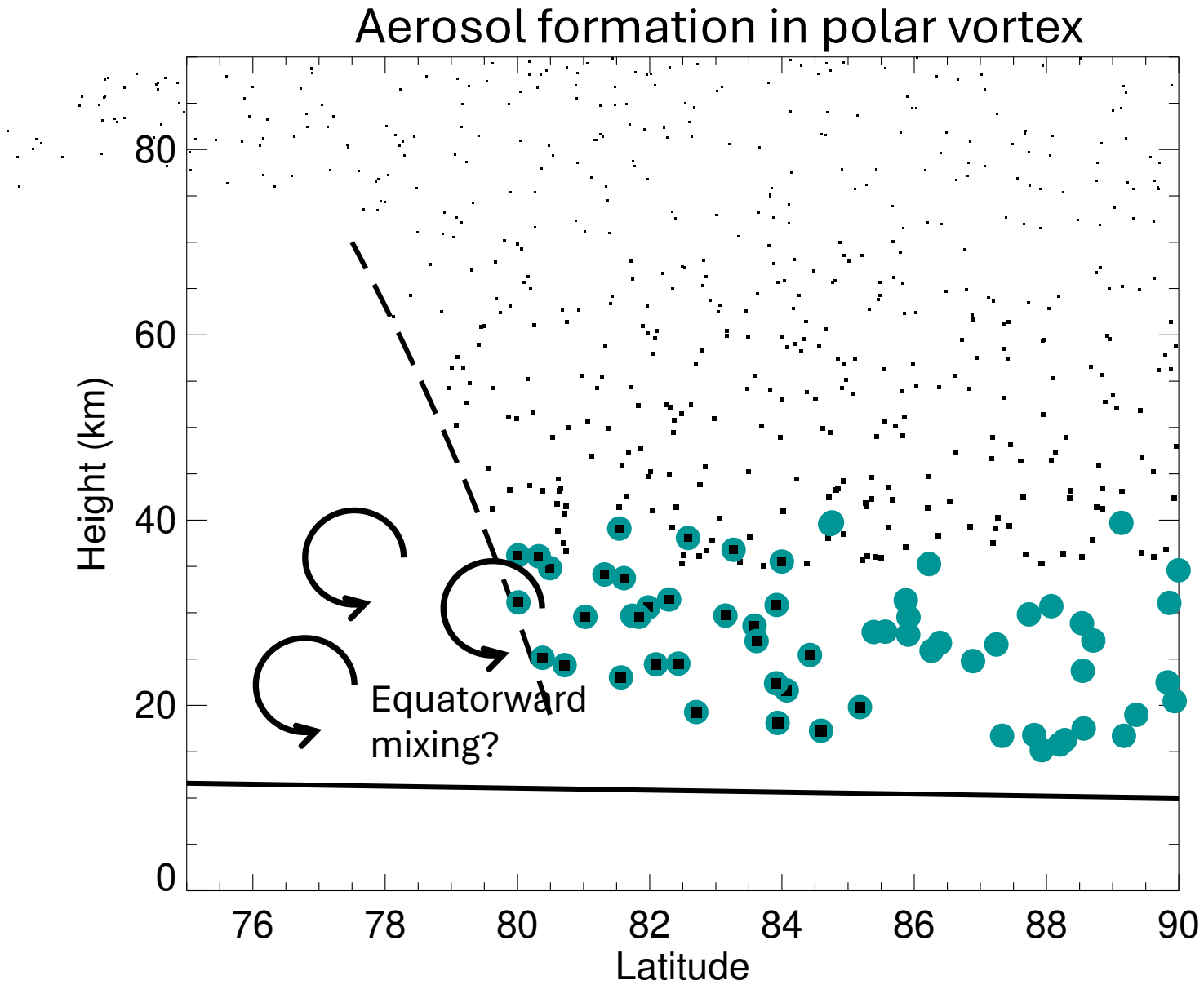
Condensation of H_2SO_4 on meteor smoke

New particle formation from the gas phase

WB-57/ER-2 sampling

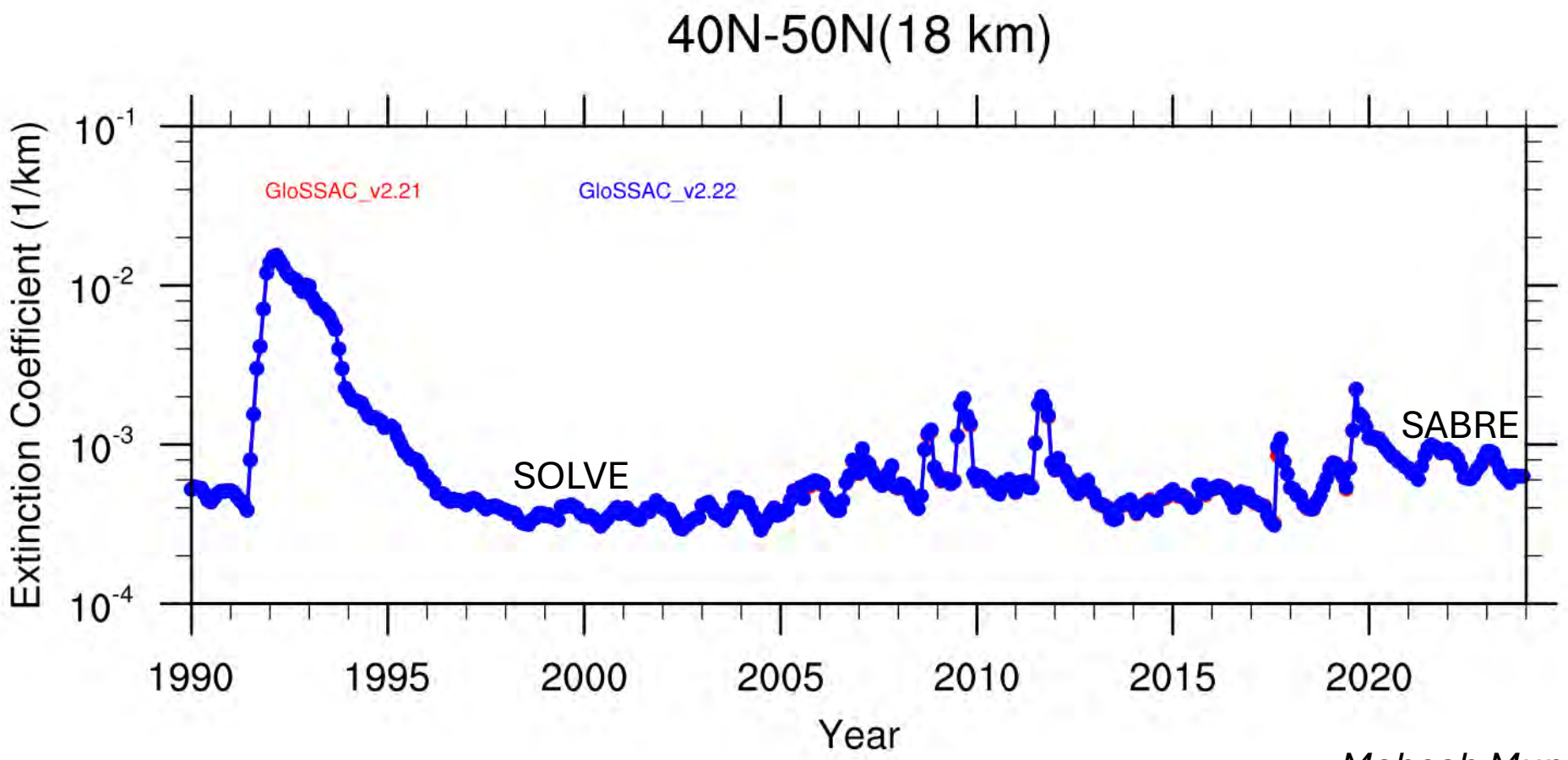
Meteor smoke found in most vortex sulfate aerosols could have resulted from coagulation

- Either or both of these processes could be occurring, with implications for sulfate aerosol number



- How much do aerosols formed in polar vortex contribute to overall stratospheric aerosol budget?

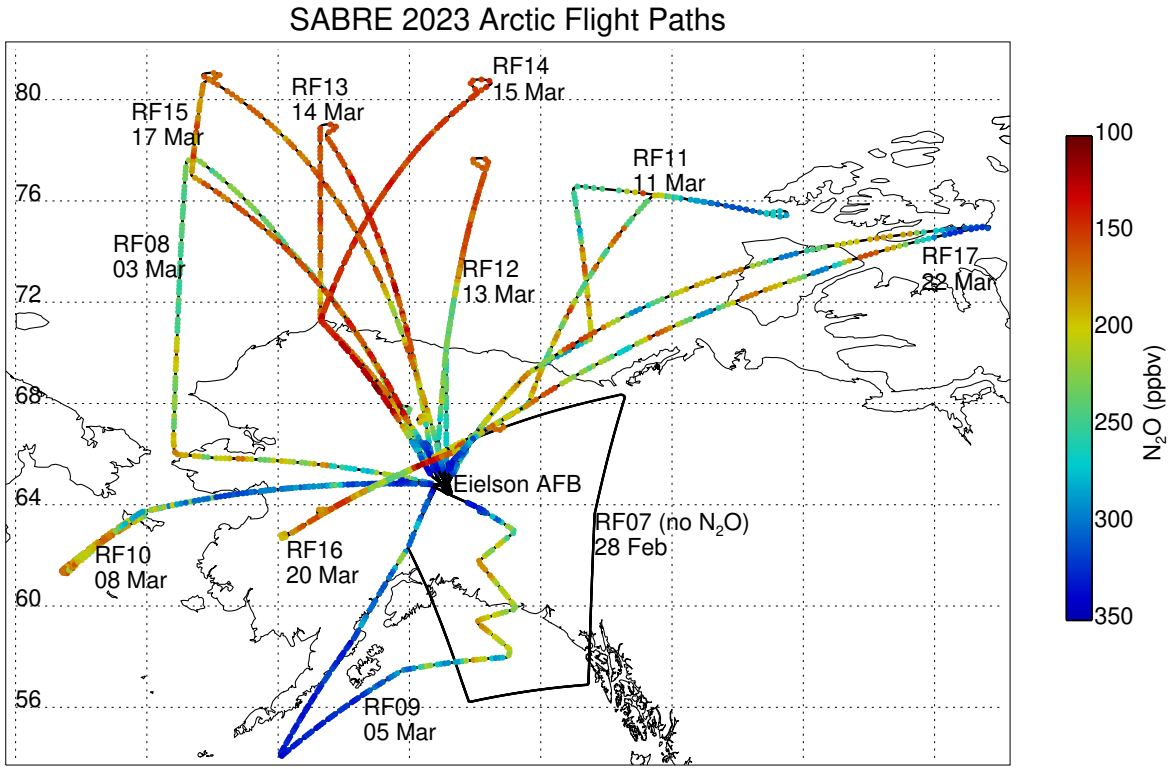
Lower-stratosphere aerosol loading history

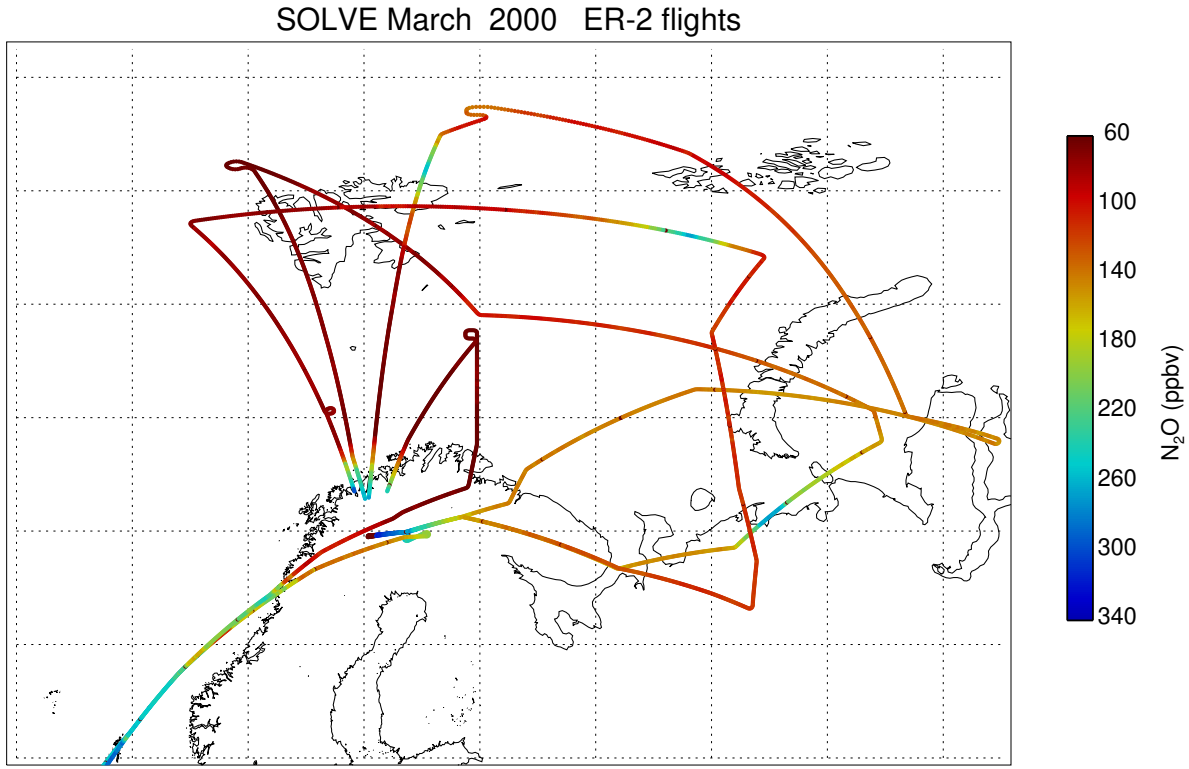


Mahesh Mundakkara

Slightly higher mid-latitude, lower-stratospheric aerosol extinction during SABRE than during SOLVE

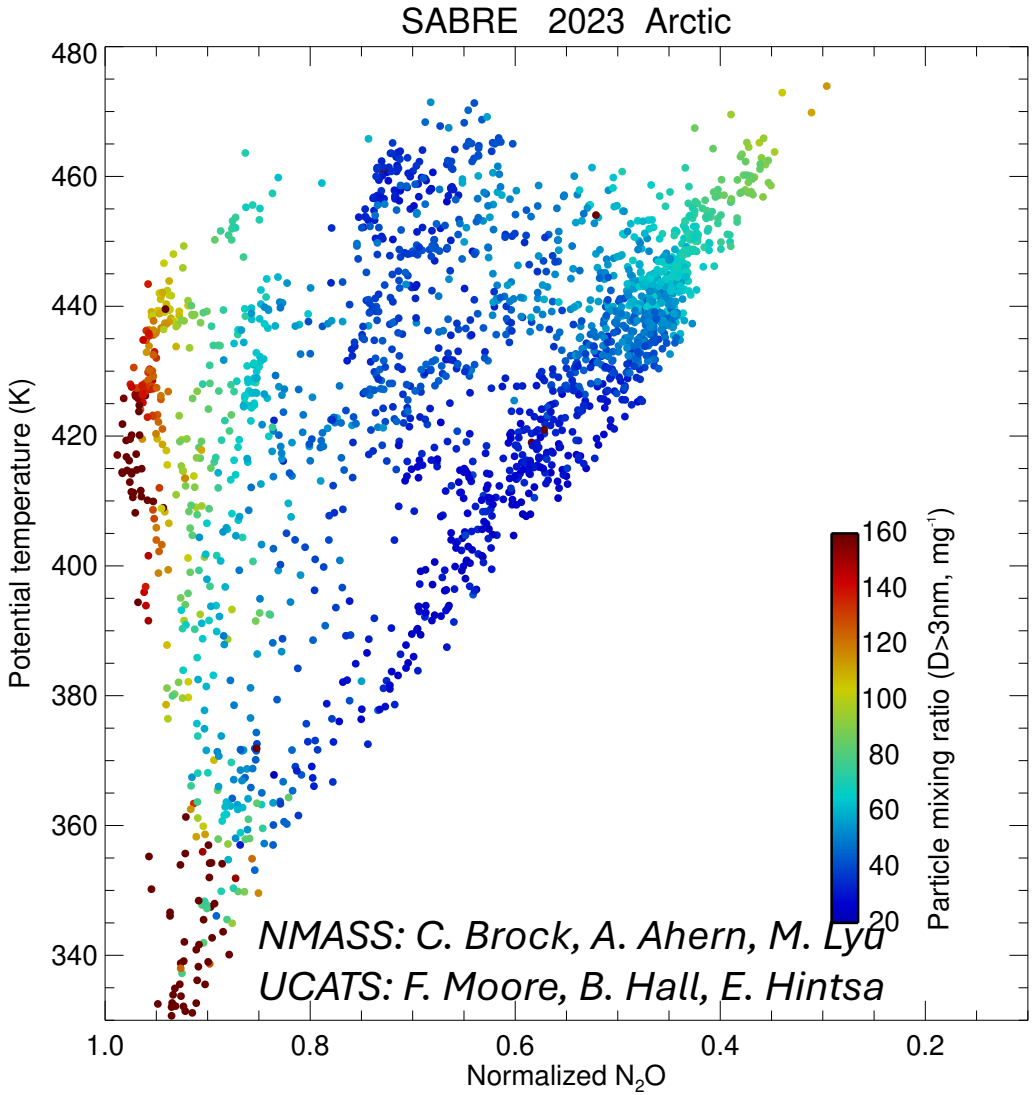
SABRE and SOLVE Arctic lower stratosphere sampling: flight paths

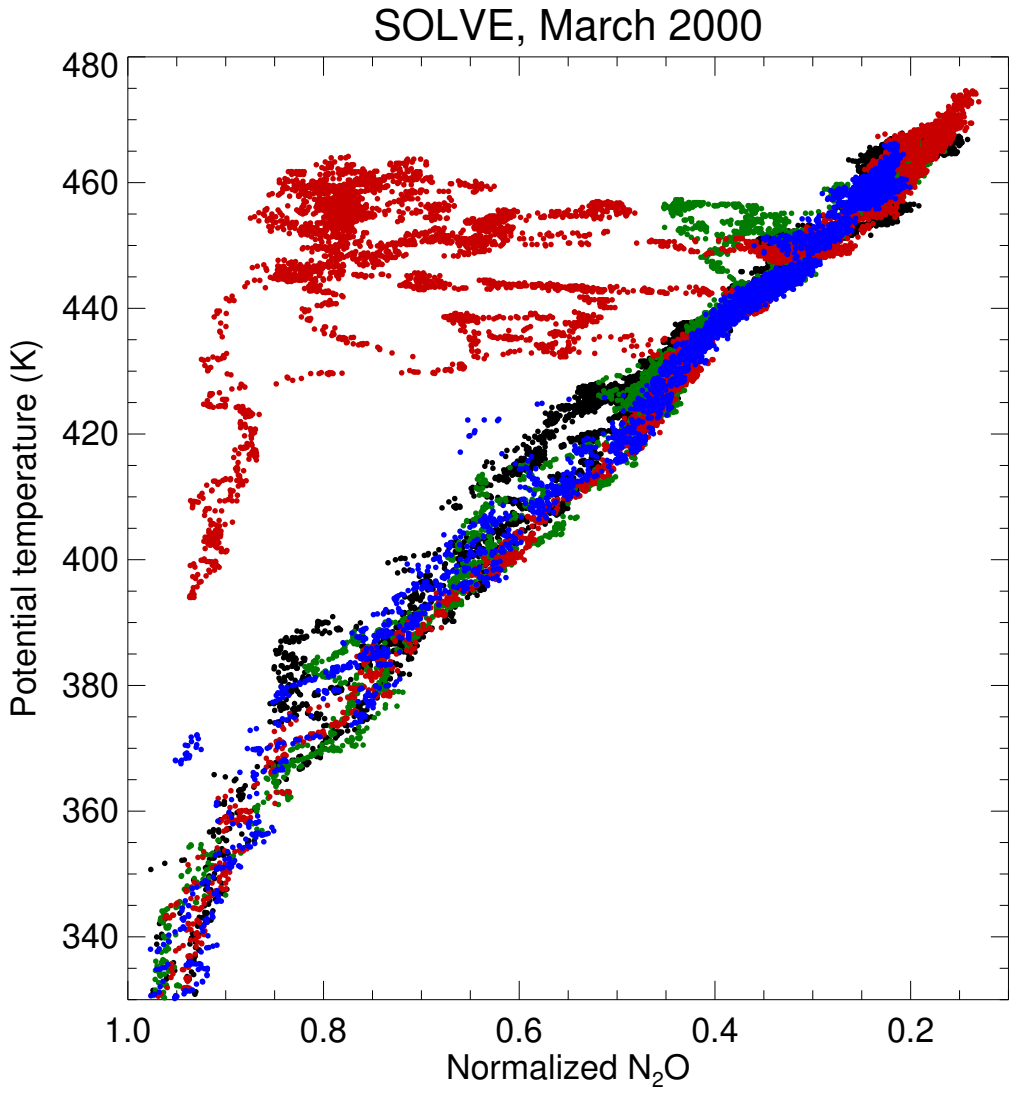




- SABRE included ~4 flights with extensive sampling inside the vortex
- The SOLVE flights provided considerable sampling of the overhead vortex

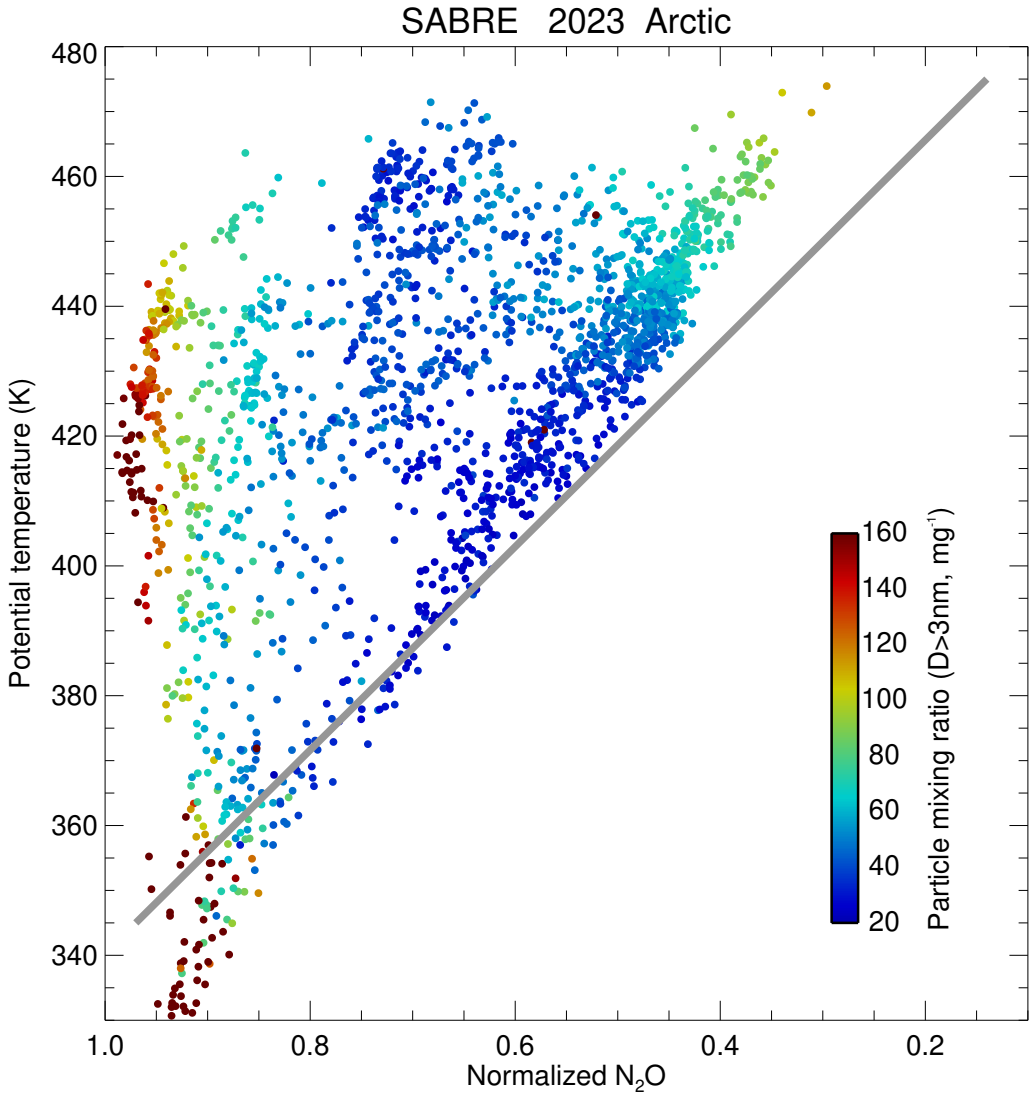
SABRE and SOLVE Arctic lower stratosphere sampling: tracers

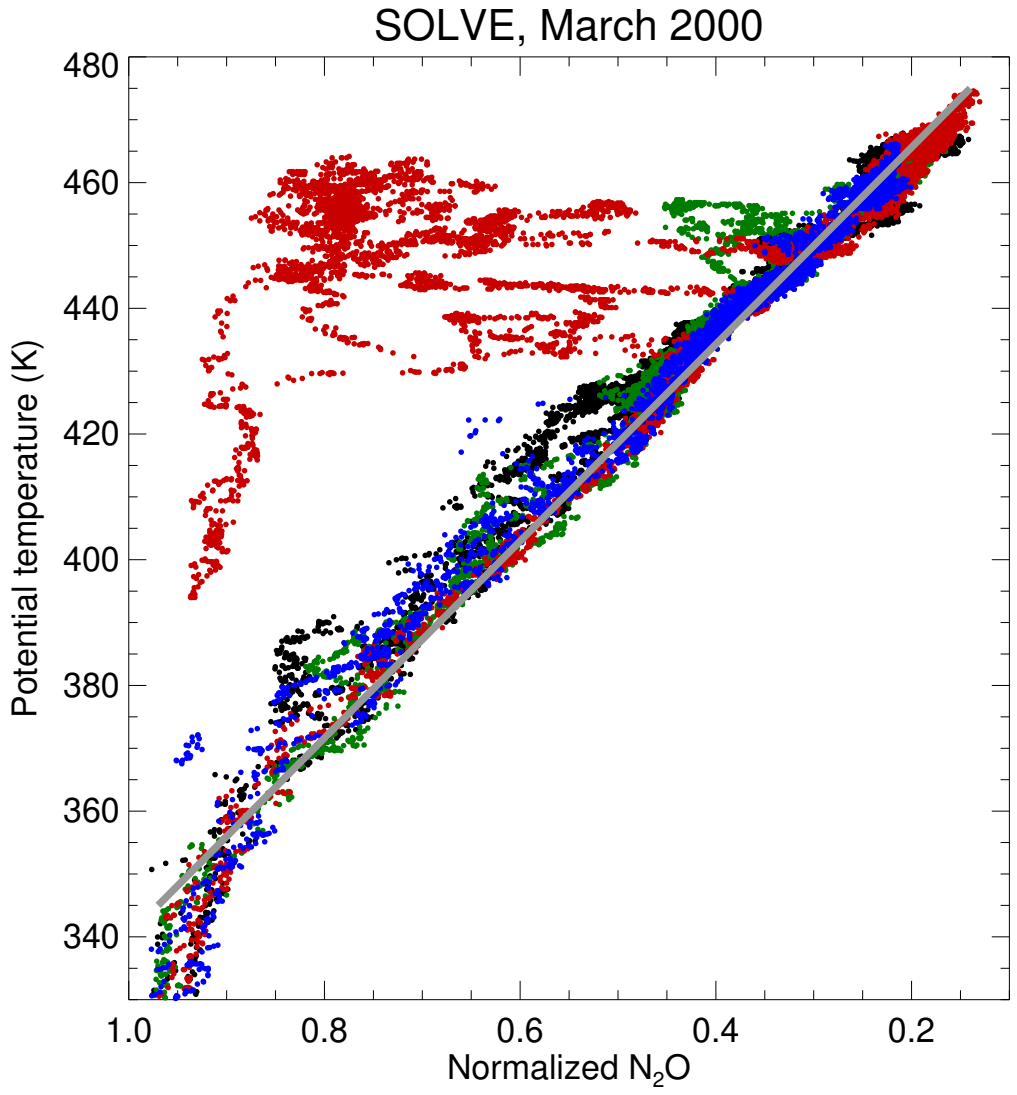




- SOLVE flights spent larger fraction of time inside vortex

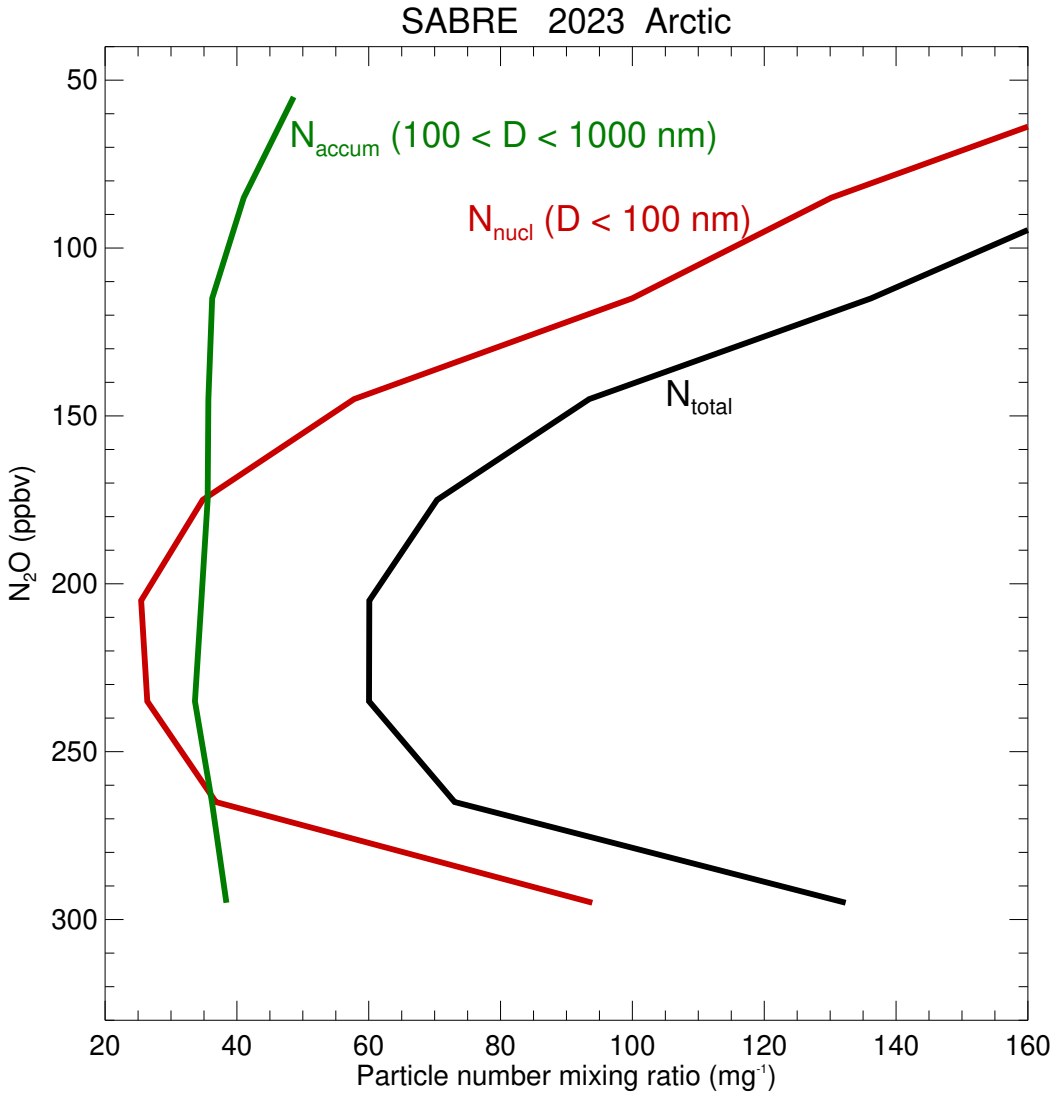
SABRE and SOLVE Arctic lower stratosphere sampling: tracers



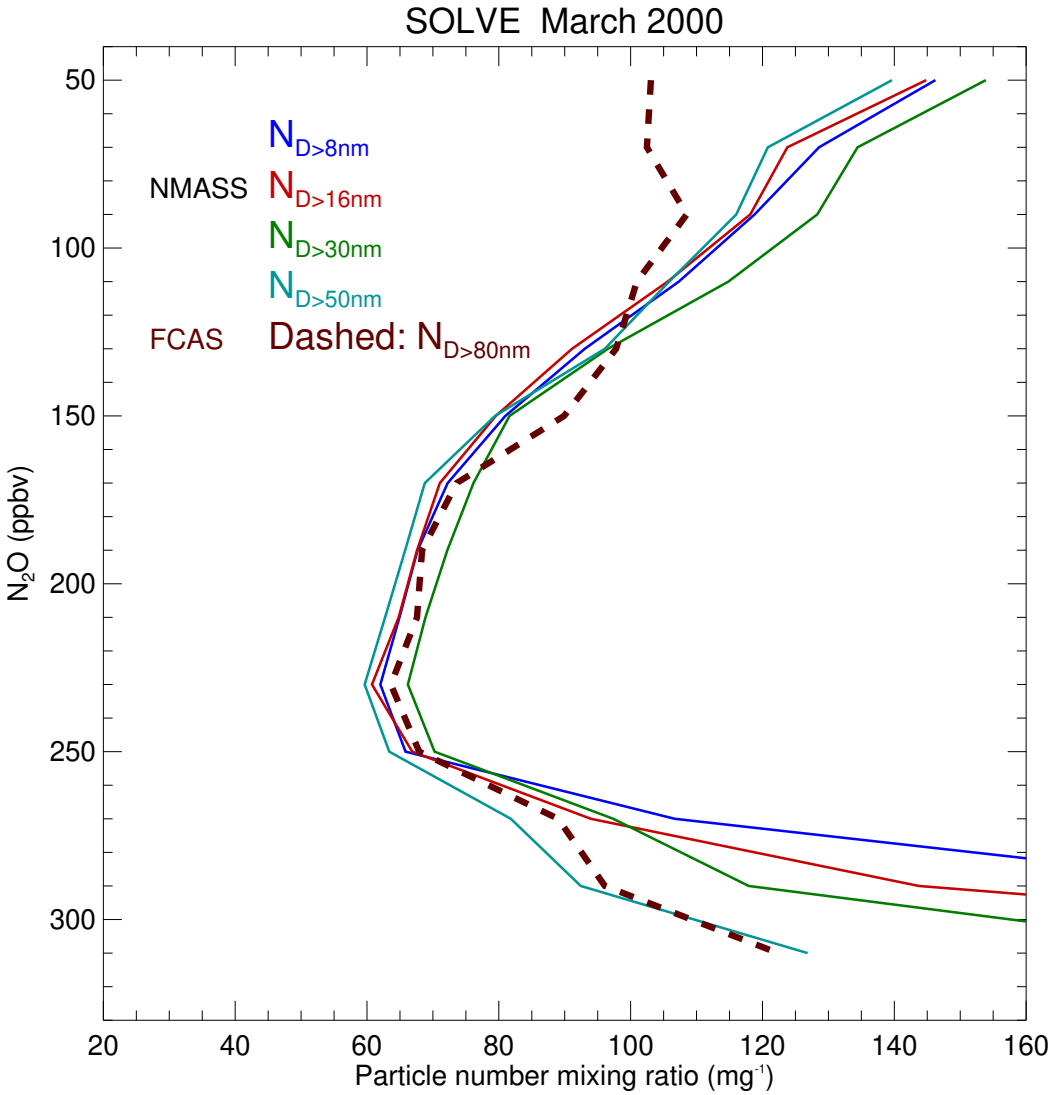


- Different slopes of the vortex N_2O vs θ in the two campaigns (different vortex dynamics, vortex isolation, entrainment mixing, sampling altitudes?)

SABRE and SOLVE total aerosol mixing ratio

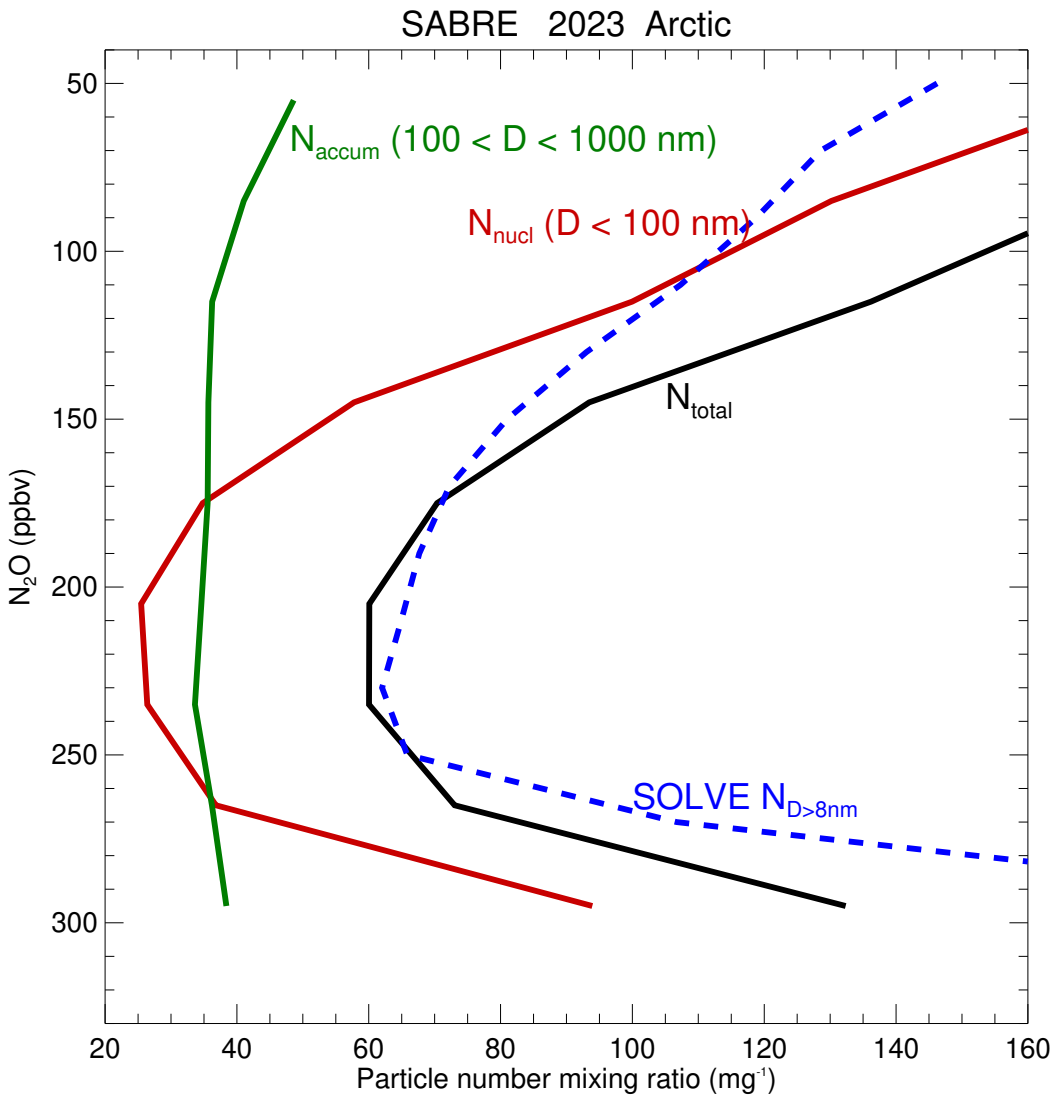


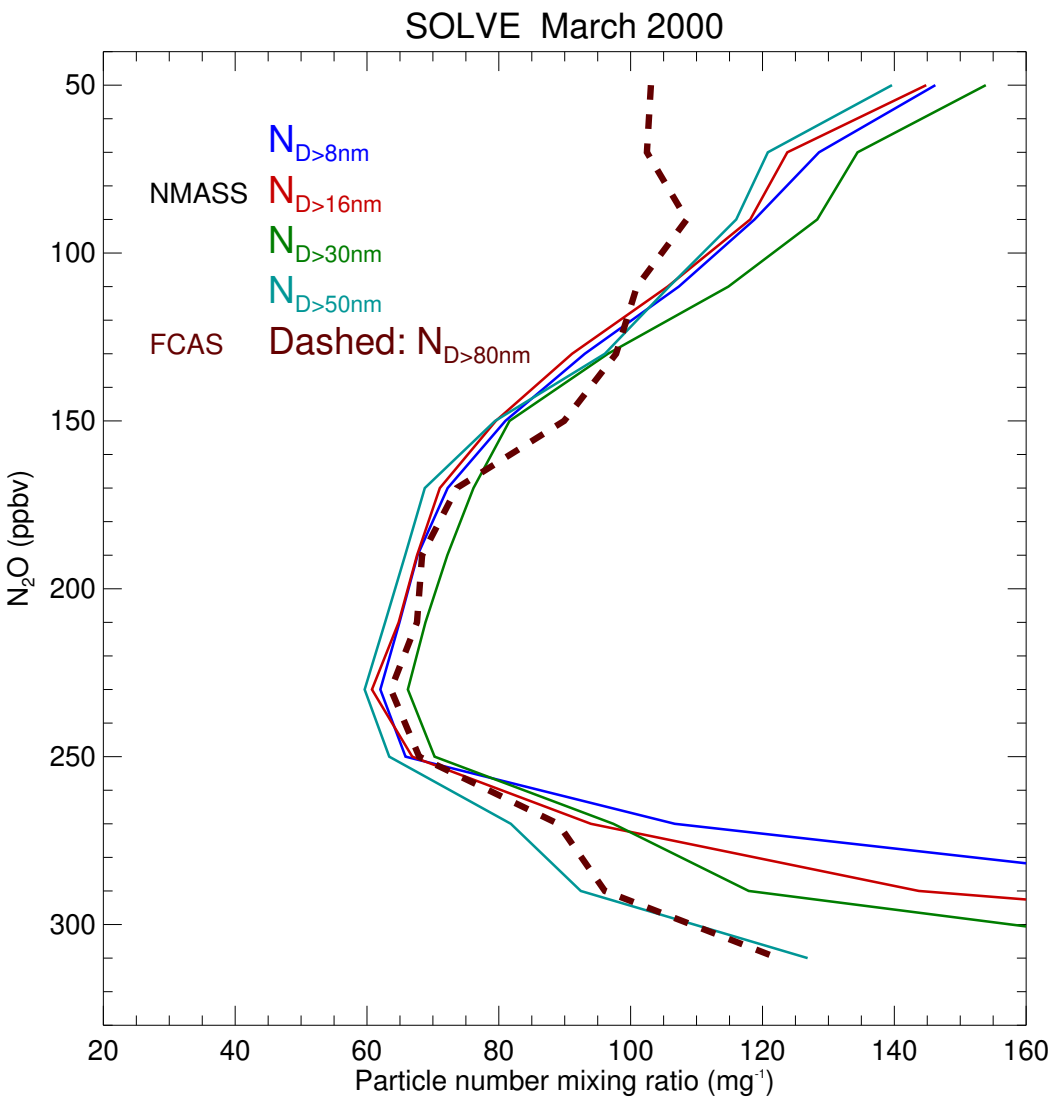
NMASS: C. Brock, A. Ahern, M. Lyu
UCATS: F. Moore, B. Hall, E. Hintsa



J. Wilson, C. Brock, J. Reeves, D. Gesler,
H. Jost, M. Loewenstein

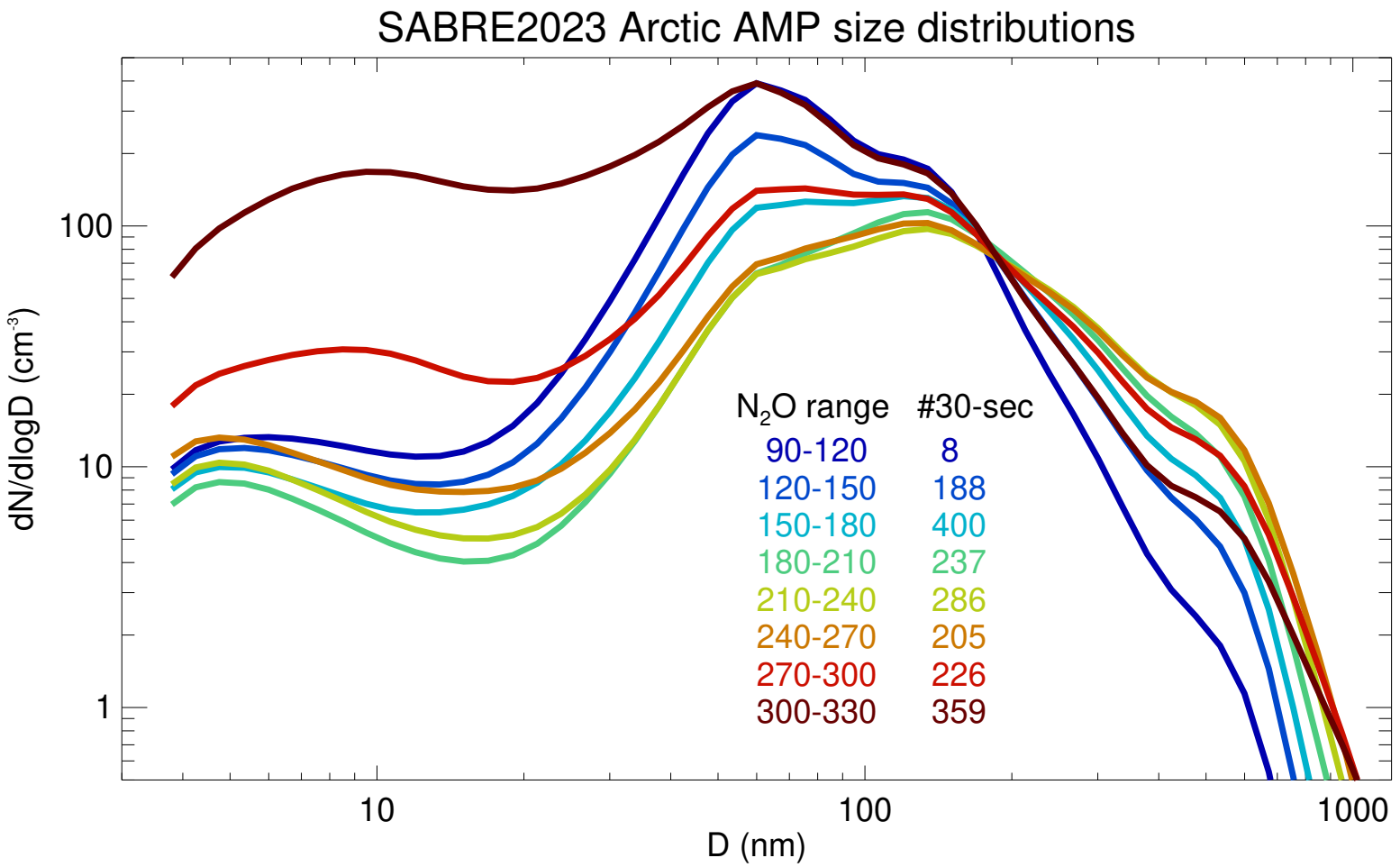
SABRE and SOLVE total aerosol mixing ratio



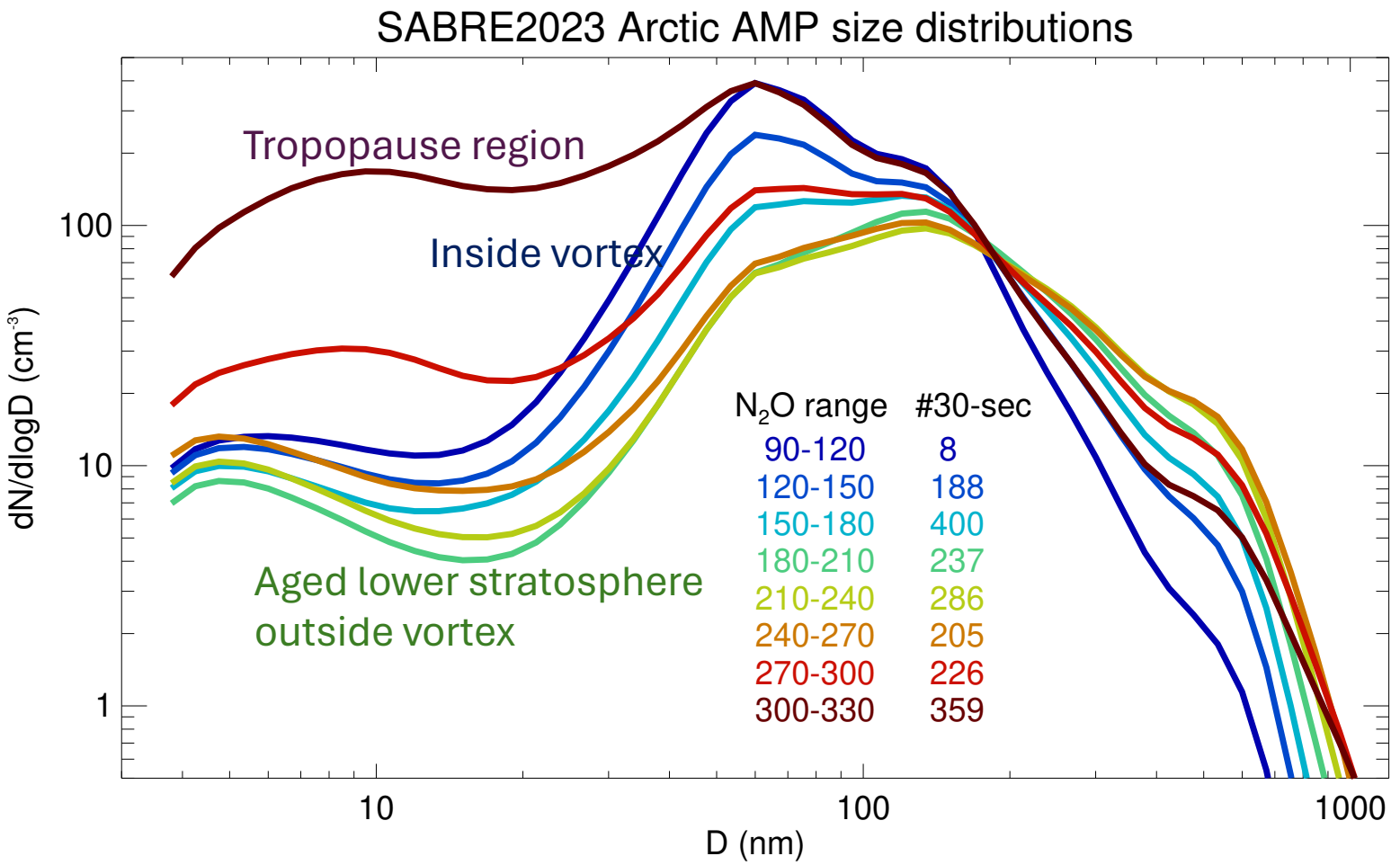


- Higher aerosol abundance in within vortex during SABRE than during SOLVE

SABRE Arctic aerosol size distributions



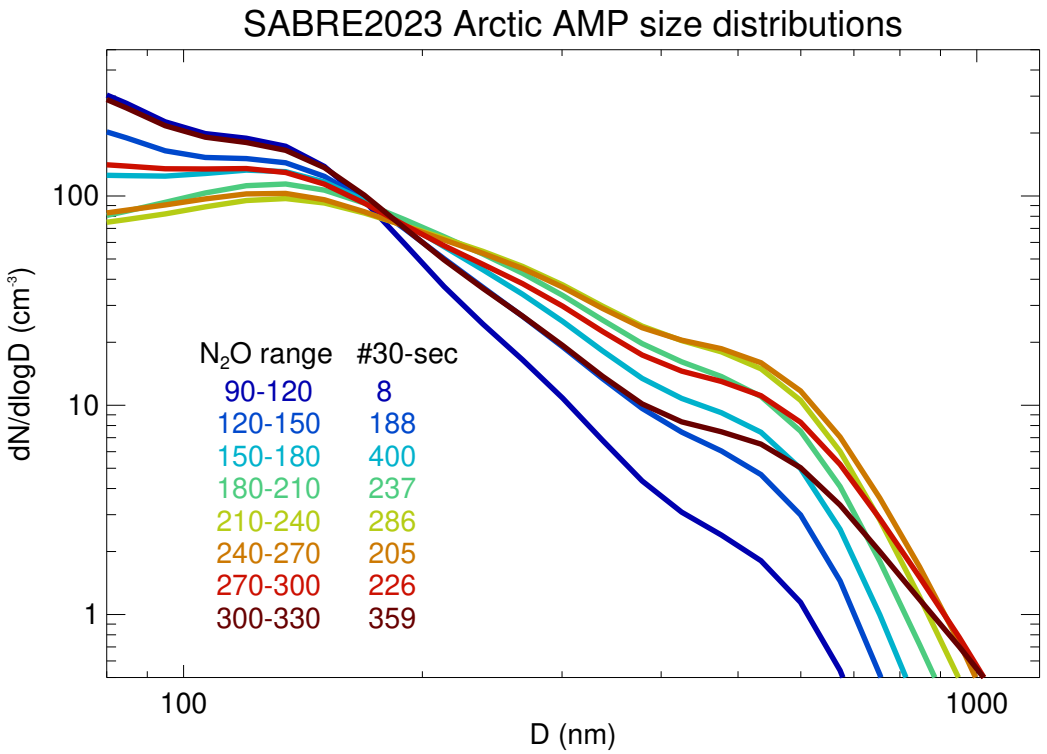
SABRE Arctic aerosol size distributions

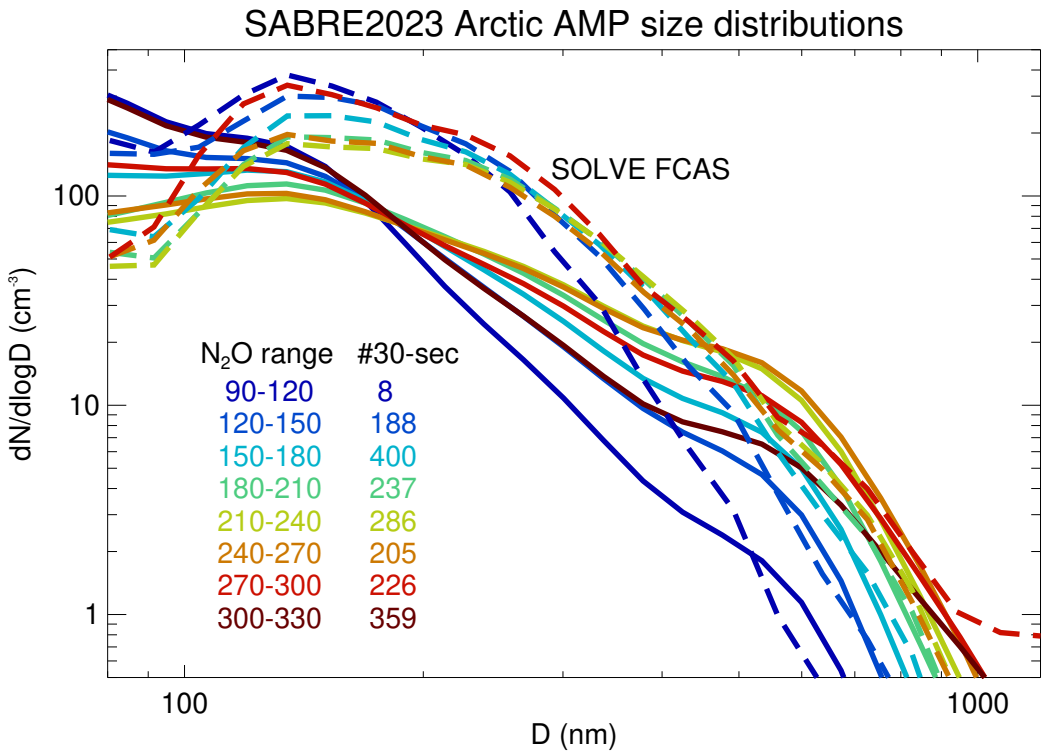


NMASS: C. Brock, A. Ahern, M. Lyu
UCATS: F. Moore, B. Hall, E. Hintsa

- Within the vortex, the peak in the size distribution shifts toward smaller sizes with decreasing N_2O
  - Consistent with aerosol growth during vortex descent and/or mixing with air outside the vortex

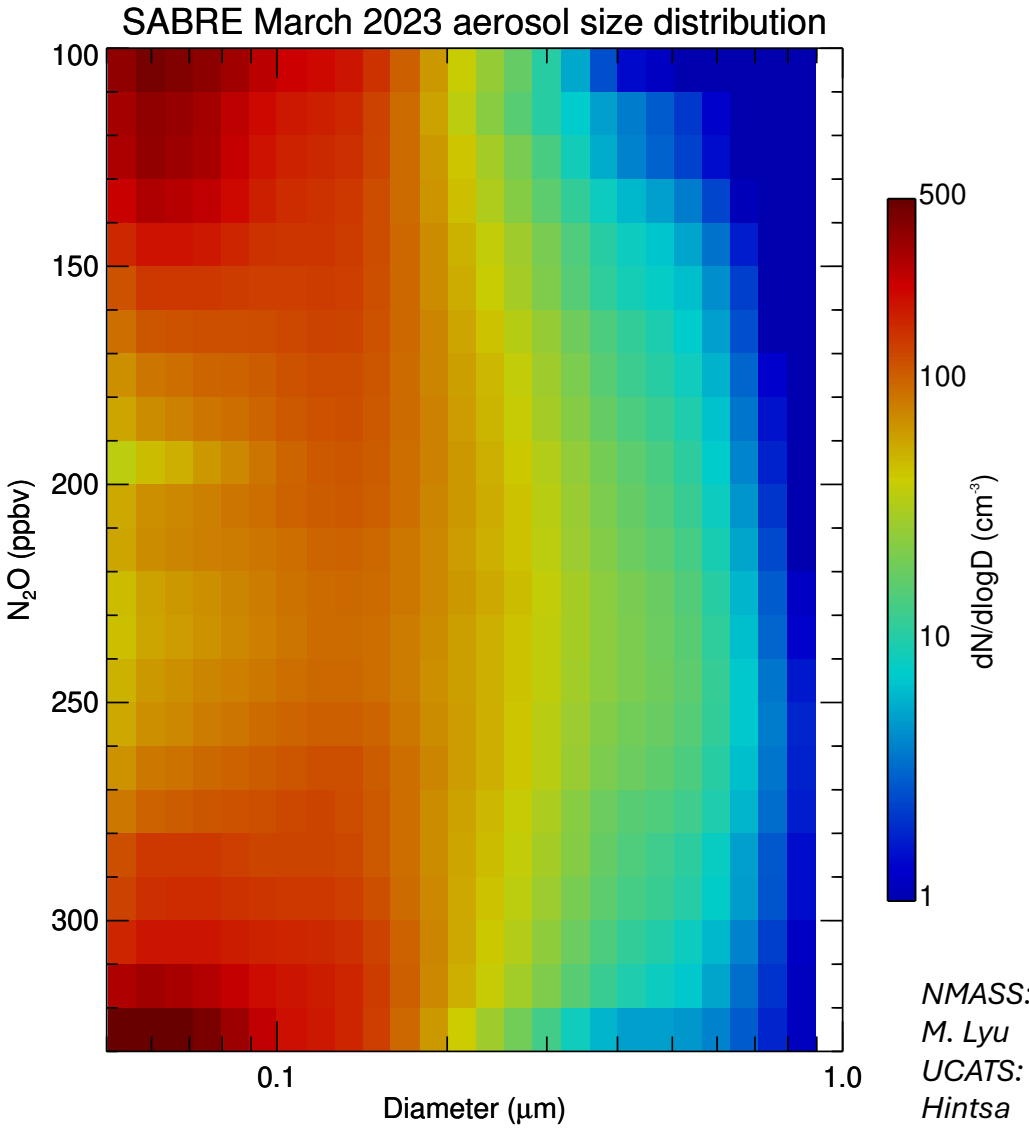
SABRE and SOLVE accumulation-mode size distributions



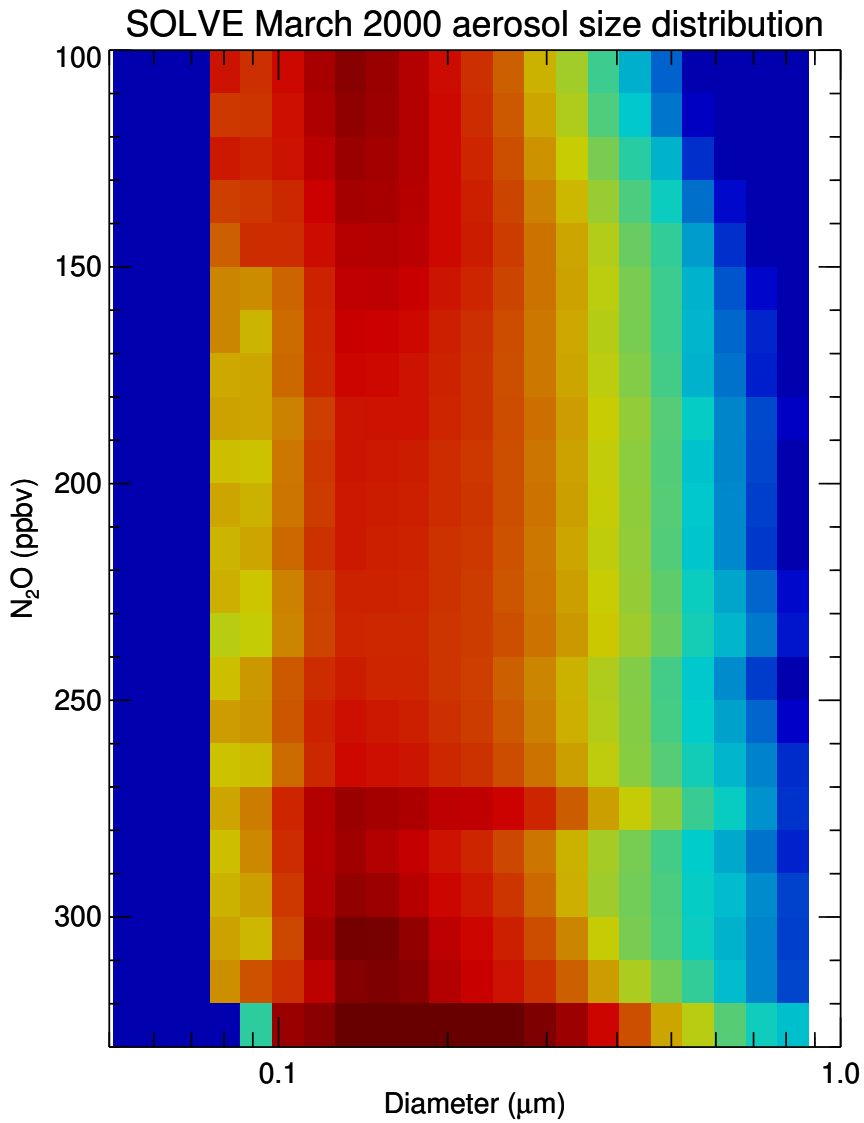


- Significant differences in size distributions during SABRE and SOLVE (real or instrumental?)

SABRE and SOLVE aerosol size distributions



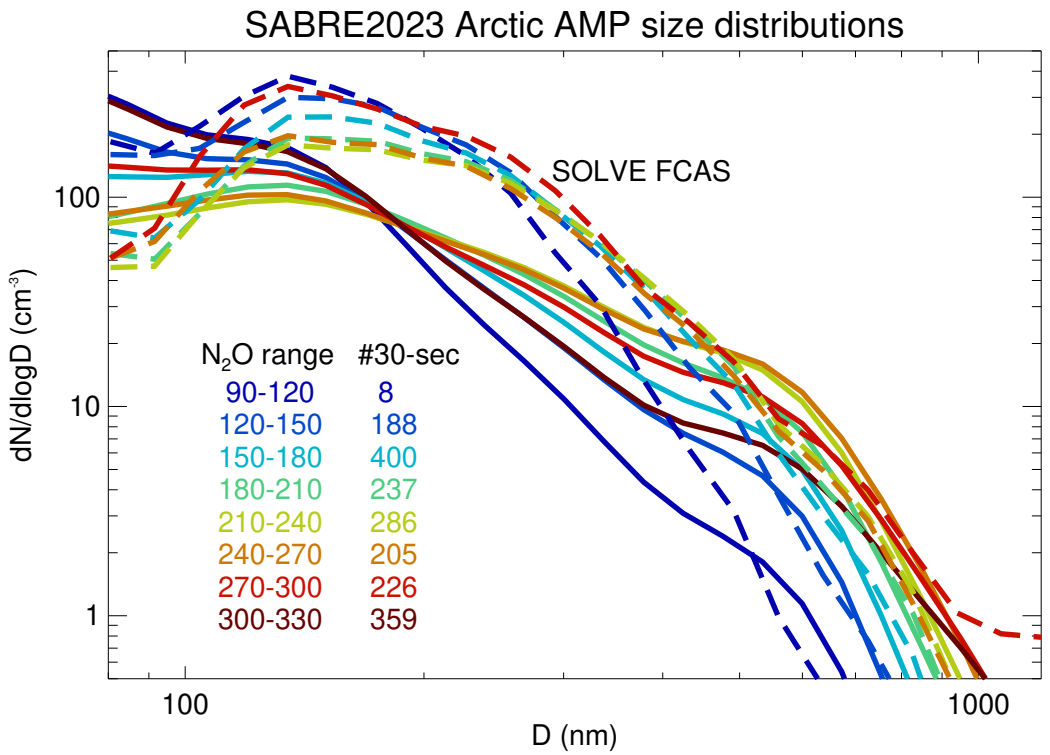
NMASS: C. Brock, A. Ahern, M. Lyu
UCATS: F. Moore, B. Hall, E. Hintsa

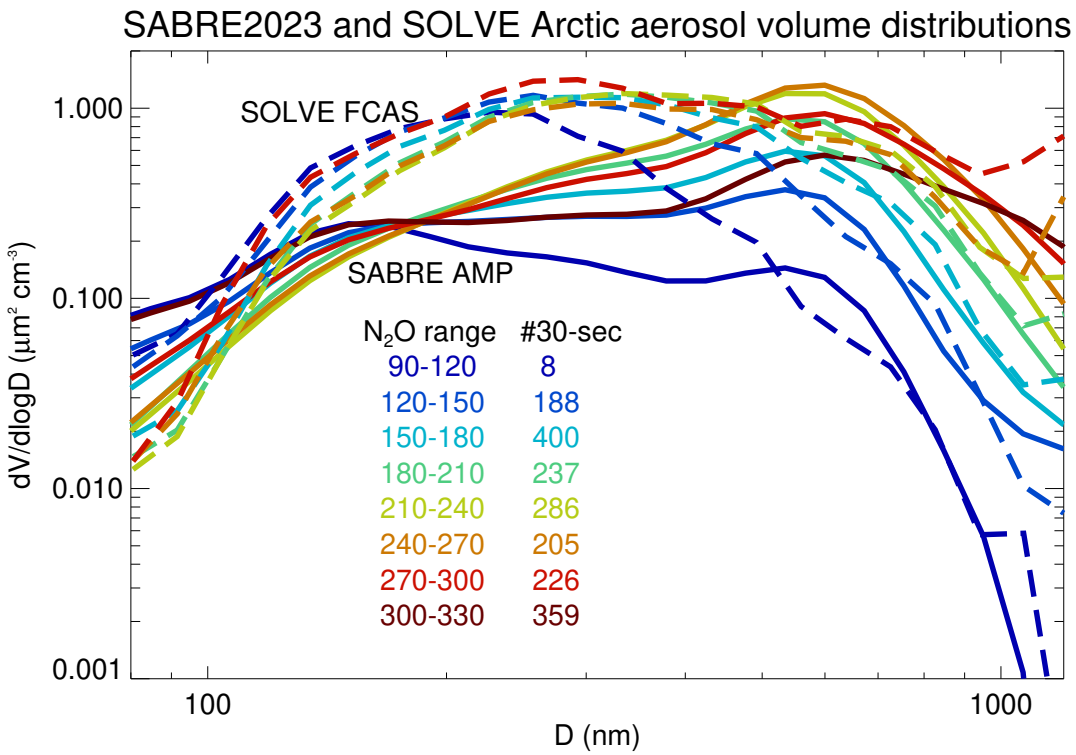


J. Wilson, C. Brock, J. Reeves, D. Gesler, H. Jost, M. Loewenstein

- Qualitative similar variations with height
- Significant differences in size distributions during SABRE and SOLVE (real or instrumental?)

SABRE and SOLVE accumulation-mode volume distributions





- The peak in volume distributions from SOLVE FCAS measurements are shifted toward smaller sizes compared to the SABRE AMP measurements

Summary

- Both SABRE and SOLVE show clear evidence for sulfate aerosol formation in the vortex
  - European Geophysica Arctic measurements also gave consistent results
  - Observed in several Arctic winters

- Height variations of aerosol properties are quantitatively similar in the two datasets

- Significant differences in measured size distributions – potentially related to differences in vortex dynamics

Arctic vortex aerosol science questions

- Which formation process (condensation on meteor smoke versus new particle formation) dominates production of sulfate aerosols in vortex?

- How much do aerosols formed in the vortex contribute to the overall stratospheric aerosol budget?

  - **Combination of modeling studies with measurements will be needed to answer these questions**