Improving the parameterization of aerosol wet scavenging in GEOS-Chem and global climate models

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1. Motivation

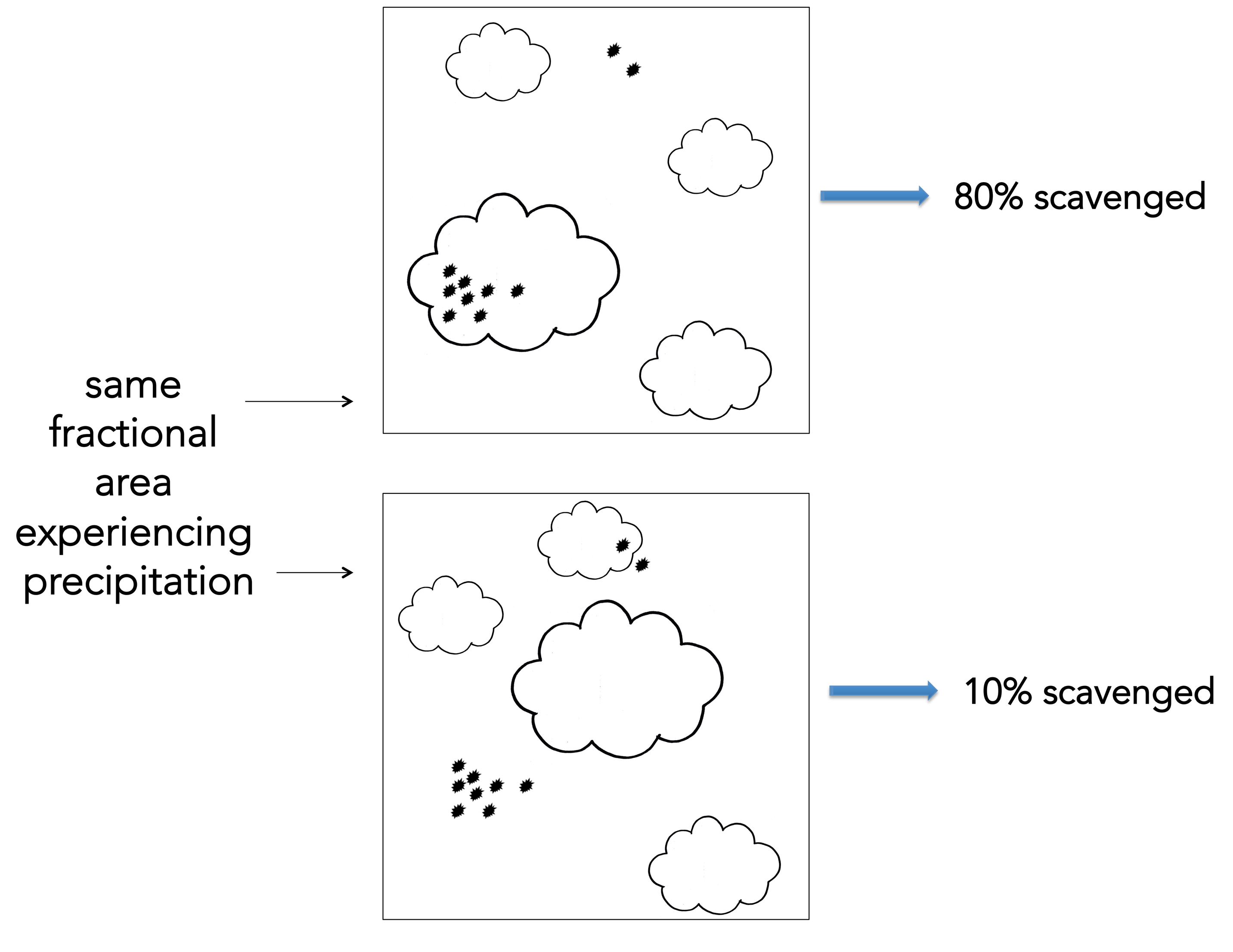
Wet scavenging of aerosols is currently a major uncertainty in GEOS-Chem and GCMs.

- Aerosols affect climate directly by absorbing and scattering radiation and indirectly by altering cloud properties.
- IPCC: aerosols are the largest source of uncertainty in current model estimates of radiative forcing.[1]
- Aerosol Comparisons Between Observations and Models (AeroCom) Project: uncertainty in wet deposition is one of the primary sources of model-to-model differences in aerosol distributions.[2]
- Schwarz et al (2010): compared refractory black carbon aerosol vertical profiles from HIPPO observations and those from an ensemble of AEROCOM models => precipitation scavenging may be the major source of model bias.[3]

2. Problem

We suspect (a major part of) the problem is a failure to capture subgrid coupling between aerosols and clouds.

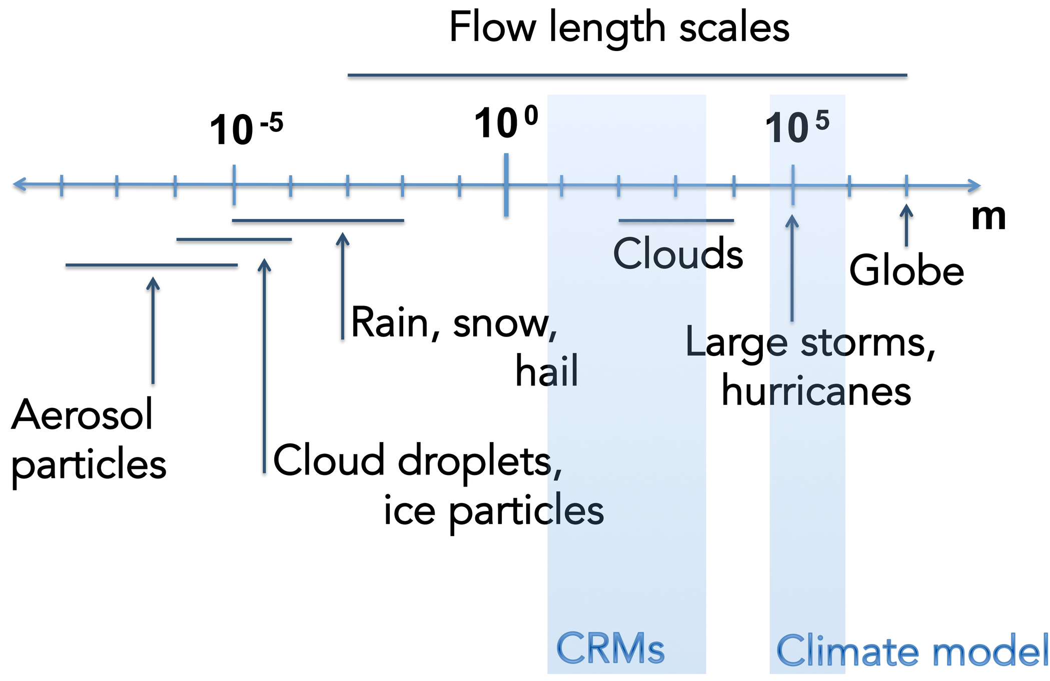
- Clouds and precipitation are subgrid in scale
- Aerosol concentrations are highly heterogeneous
- Current GEOS-Chem parameterizations of rainout and washout are directly related to the fractional area experiencing precipitation
- => The same fractional area experiencing precipitation can cause highly variable scavenging depending on the particular distribution of aerosol relative to clouds.



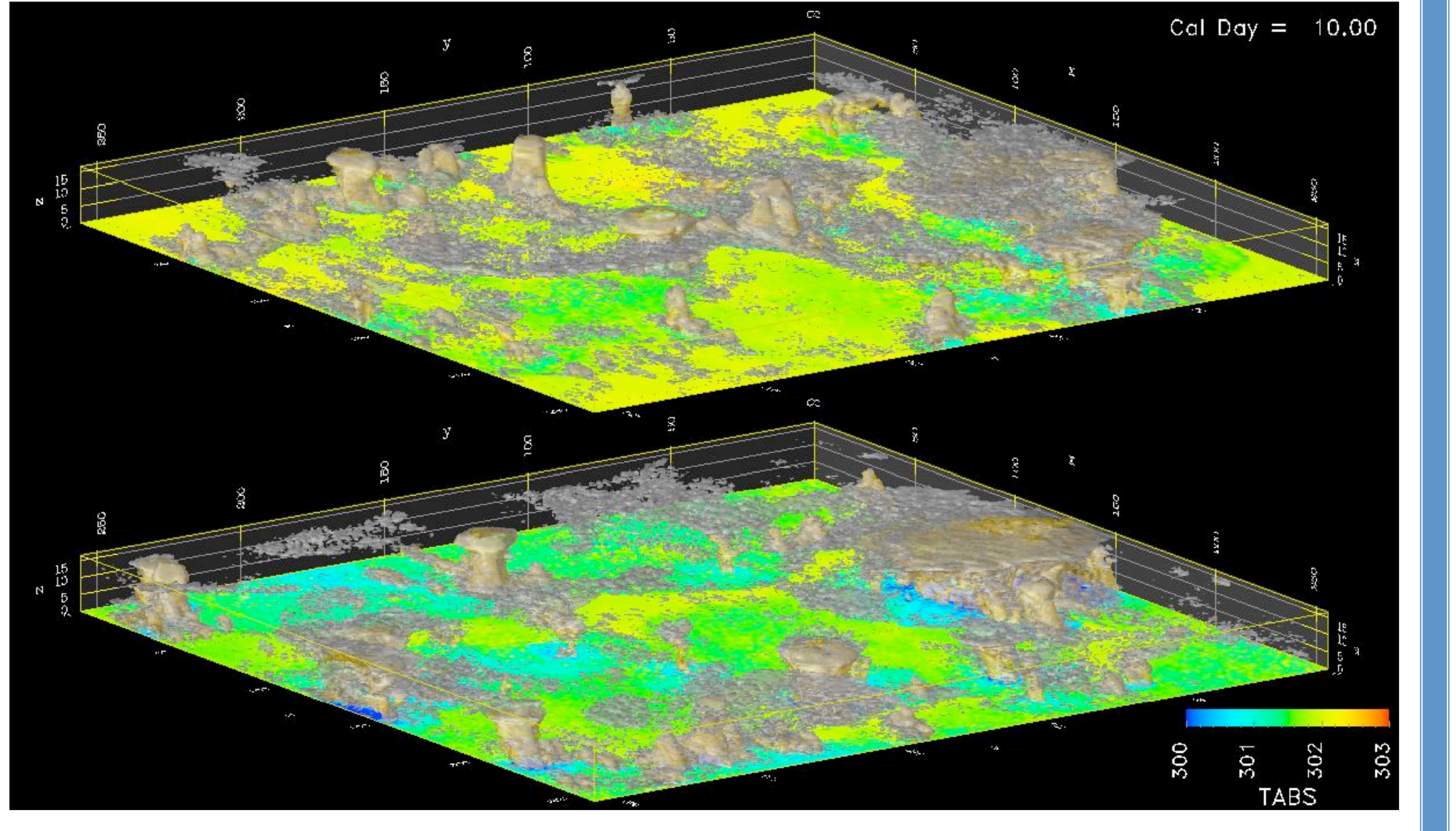
3. Research Plans

We propose to use a cloud resolving model (CRM) to better understand the coupling between aerosols and precipitation.

- Benefits of using a CRM: finer resolution; explicitly simulate larger scales of aerosol transport; gain physical insight into aerosol-cloud coupling



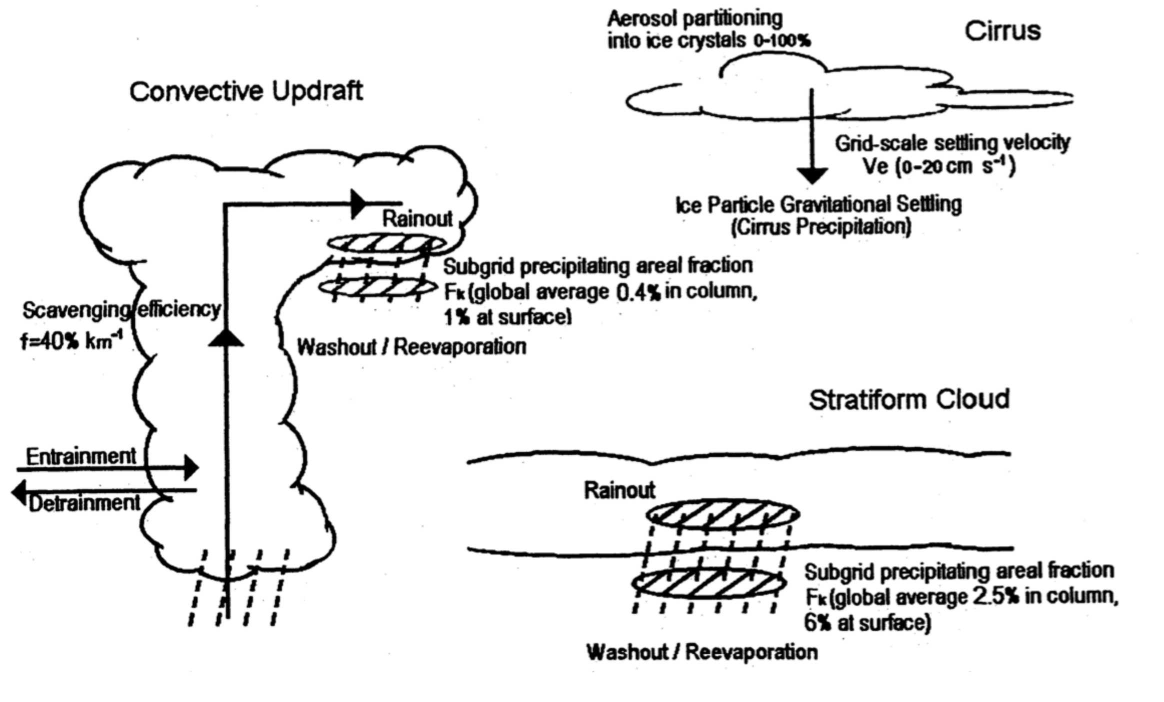
- In-cloud scavenging: fixed fraction of aerosol mass incorporated into water
- Initial and boundary conditions from sampling representative GEOS-Chem columns



CRM simulation showing surface temperature (colors), non-precipitating clouds (silver), and precipitating clouds (gold) in a typical domain size (250 km x 250 km x 15 km).

4. Research Questions

- **How do different types of cloud systems interact with aerosols?**
  - Over continent vs. over ocean
  - Shallow vs. deep convection
- **How does aerosol removal efficiency depend on initial and boundary conditions?**
- **What are the key relationships/covariances between aerosol distributions and water fields? How do these relationships affect aerosol concentrations over different time scales?**
- **By comparing resulting aerosol distributions to those from the GEOS-Chem parameterization, what are the sources of error in the GEOS-Chem parameterization?**



5. Objectives and Future Work

- Develop representation of aerosol scavenging in the CRM
- Diagnose dependence of aerosol scavenging efficiencies on initial and boundary conditions and cloud system type
- Assess the importance of accounting for the cloud-scale covariance between aerosol and water fields
- Characterize errors in GEOS-Chem parameterization by comparing scavenging efficiencies in GEOS-Chem parameterization to those in CRM

6. Acknowledgments

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7. References

[1] IPCC AR4 (2007)

[2] Koch et al. (2009), *Atmos. Chem. Phys.*, 9.

[3] Schwarz et al. (2010), *Geophys. Res. Lett.*, 37