Understanding Aerosol Indirect Effects Using a Simple Model

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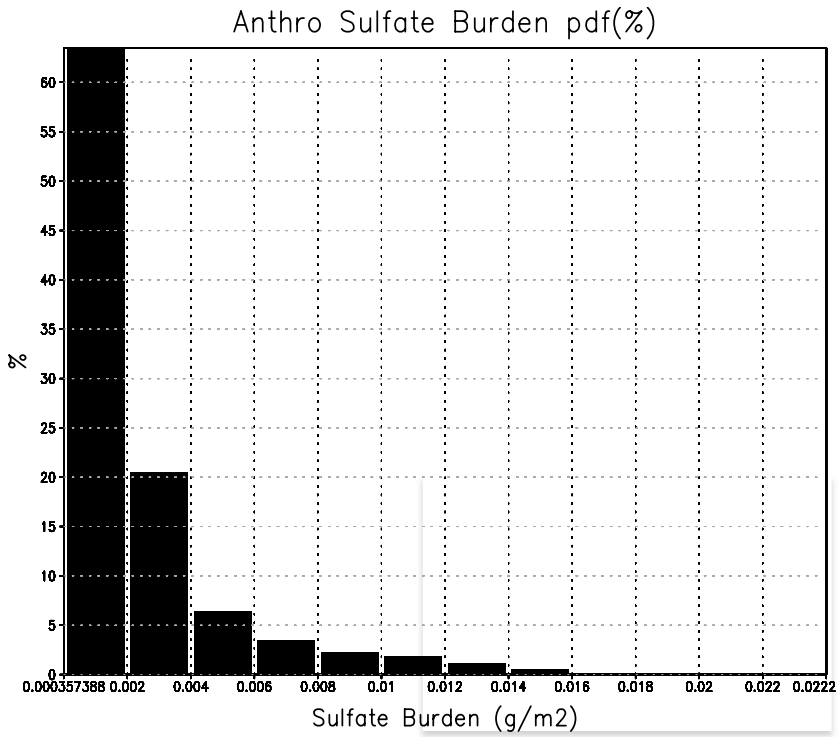
Model Description

- Natural aerosol from global mean of preindustrial simulations
- Primary and secondary anthropogenic aerosol added to both mass and number of multiple modes
- Prescribed fraction of secondary aerosol mass that forms new particles
- Prescribed aerosol emissions, lifetime and scale height
- Spatial variability in cloud and anthropogenic aerosol
- Adiabatic cloud model with Gaussian thickness PDF
- Mechanistic droplet nucleation
- Droplet effective radius limited by autoconversion
- Two-stream cloud albedo



Aerosol Number Balance

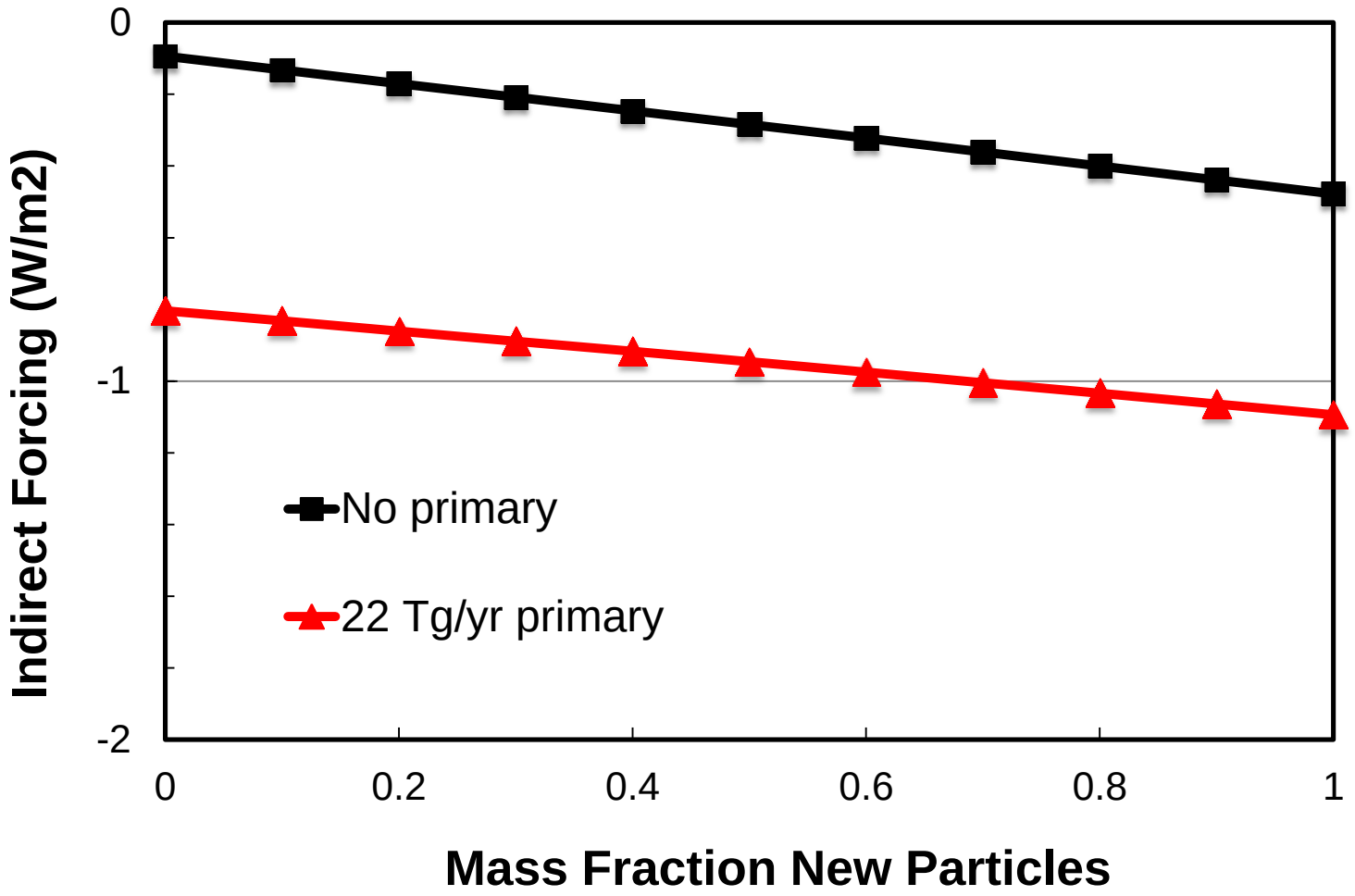
Assuming all particles have the same size distribution

$$N_{PD} = N_N + N_P + f_n q_s \frac{N_{PD}}{q_{PD}}$$

Present Day	Natural	Primary anthropogenic	Secondary anthropogenic

- f_n: fraction of secondary mass q_s producing new particles
- If used to diagnose f_n from present day and preindustrial aerosol simulations, f_n is sensitive to assumed N_P
- Can be used to diagnose N_{PD} as function of f_n

Importance of primary aerosol and fraction of secondary aerosol forming new particles



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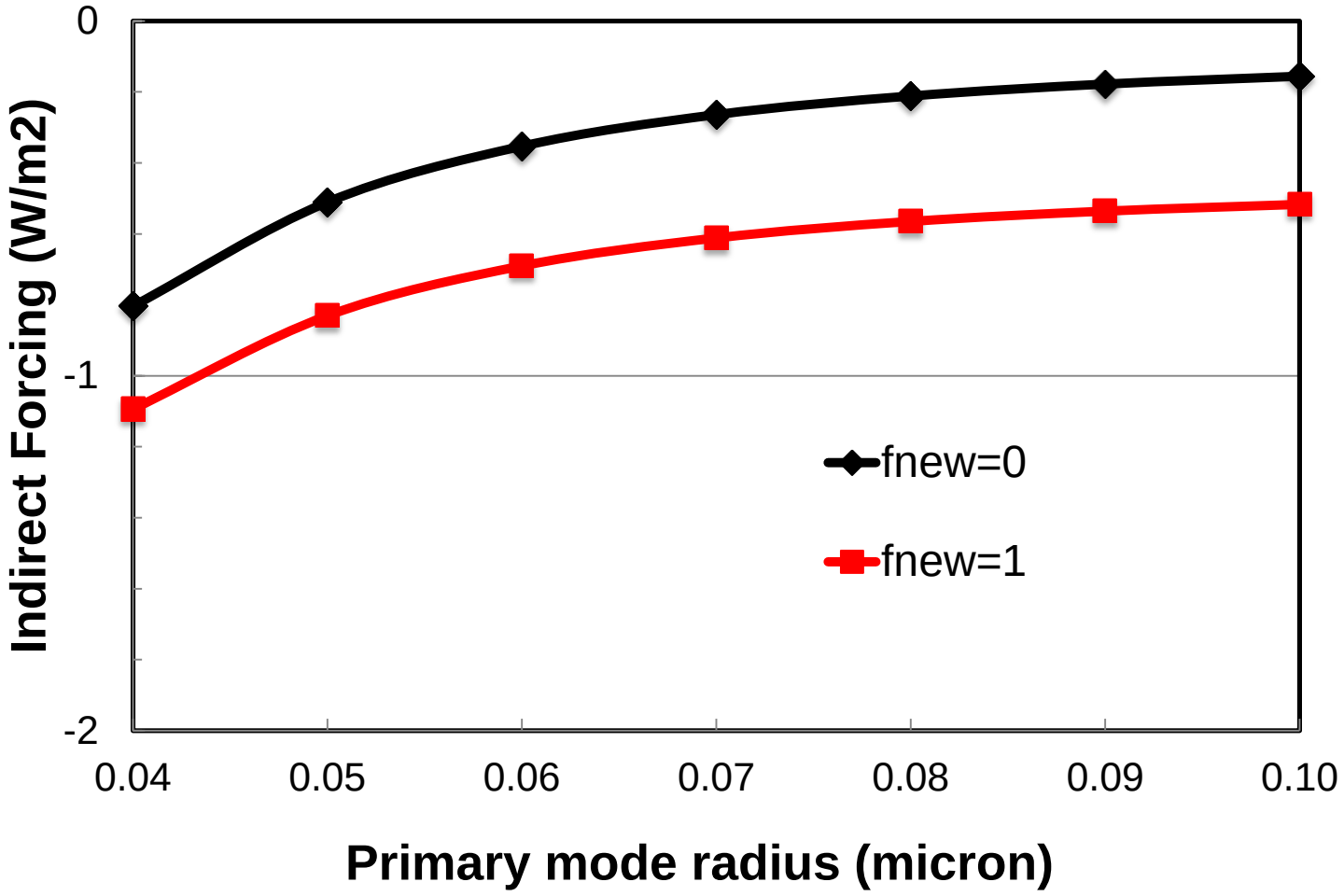
Dependence on size of primary particles



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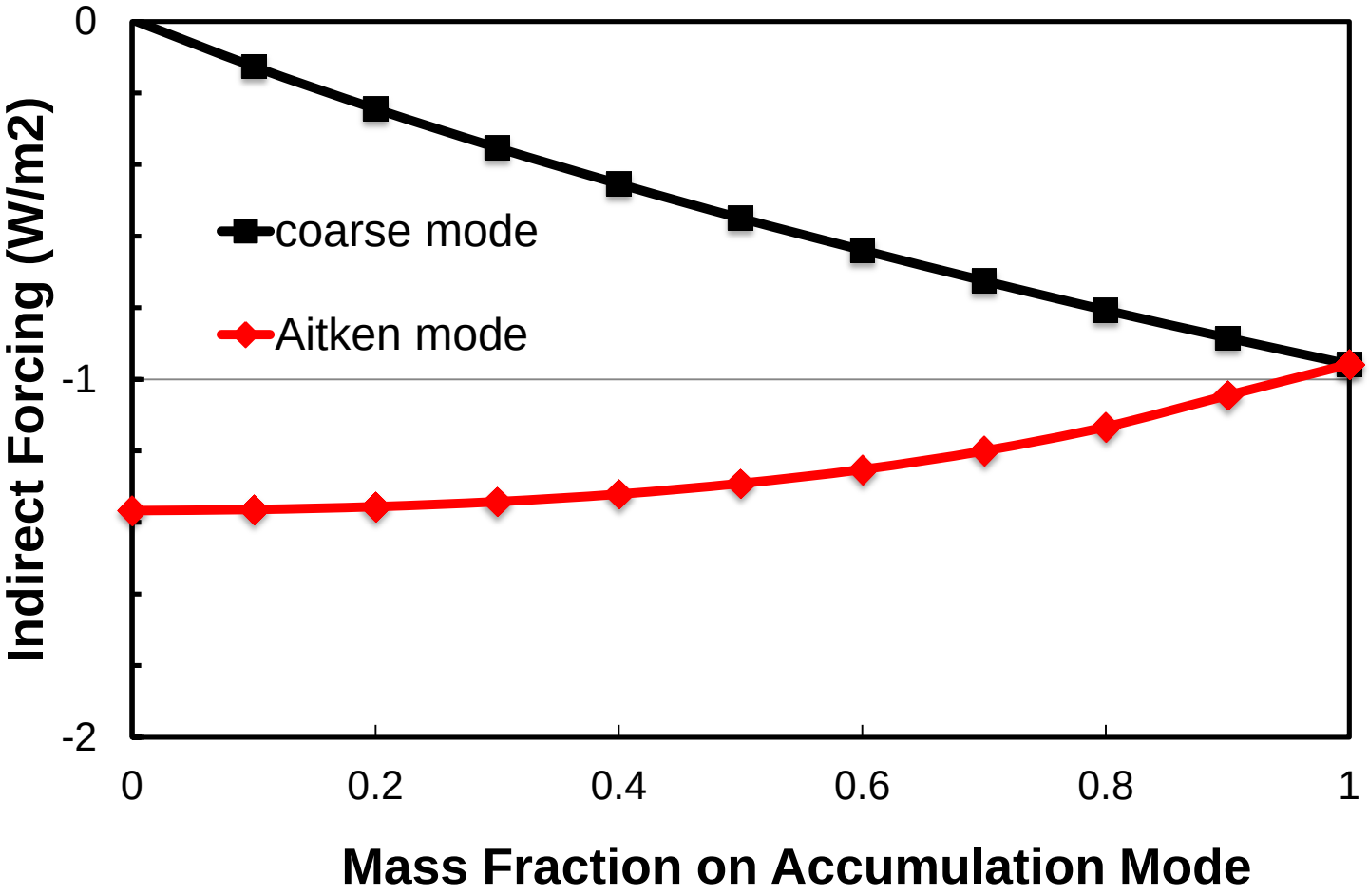
Dependence on partitioning of secondary aerosol across modes



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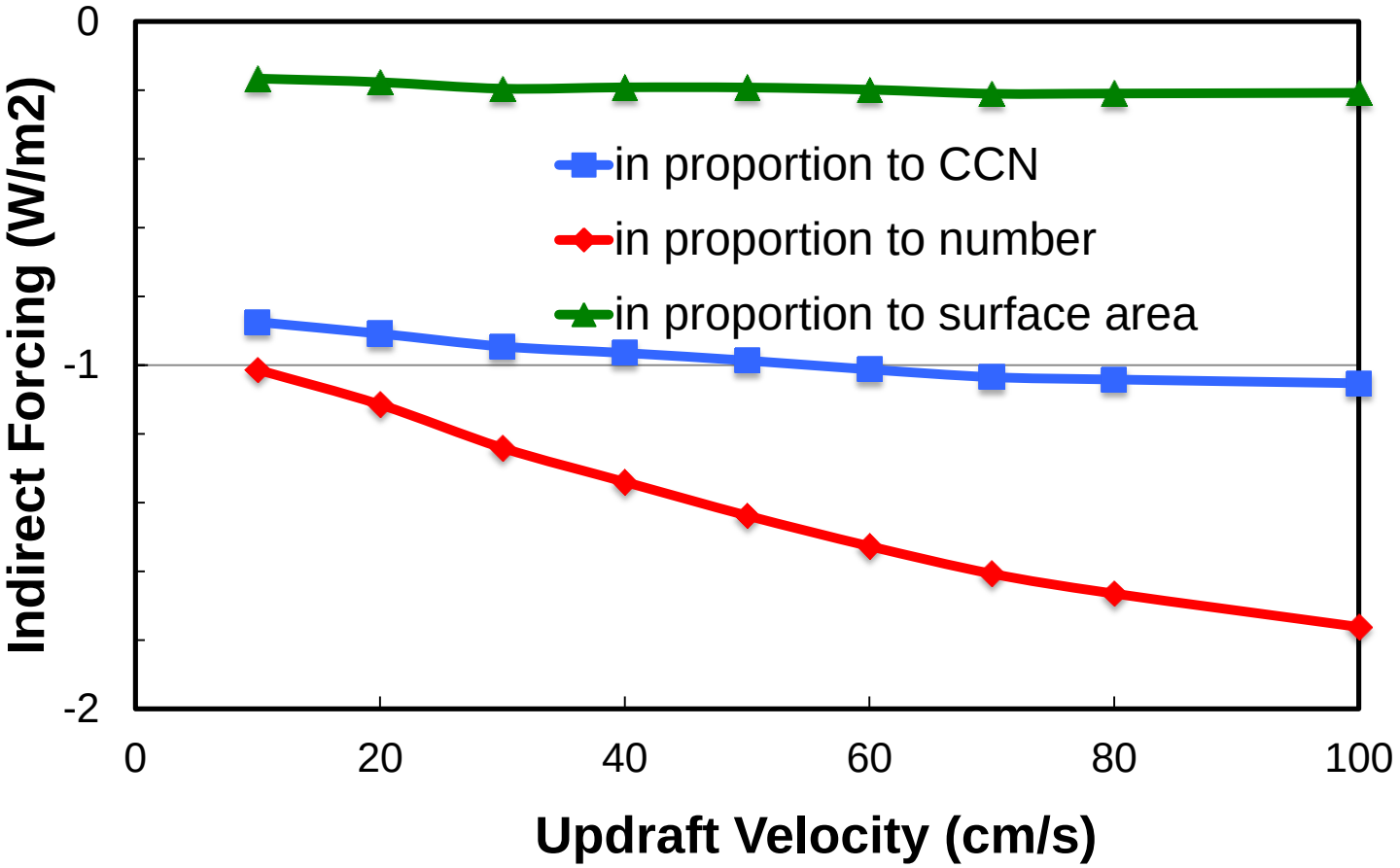
Dependence on updraft velocity and partitioning across modes



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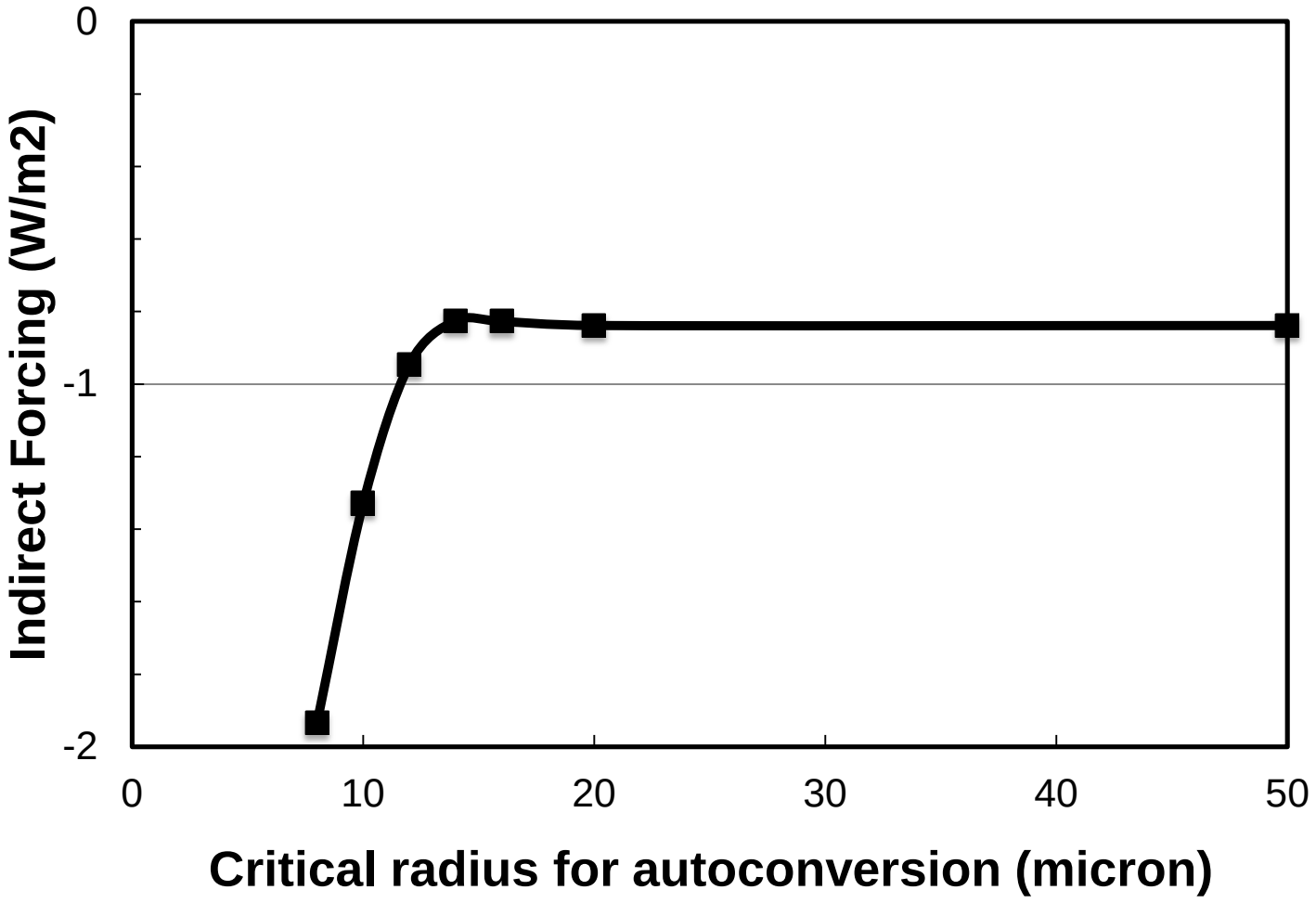
Second aerosol indirect effect



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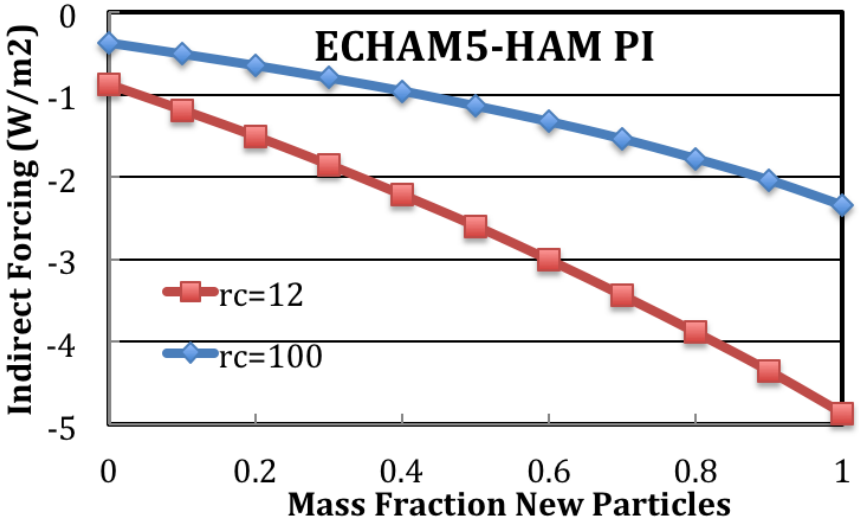
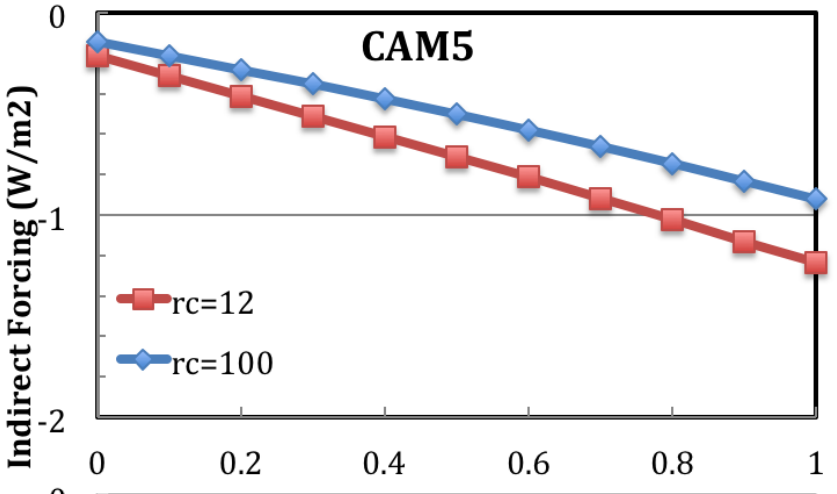
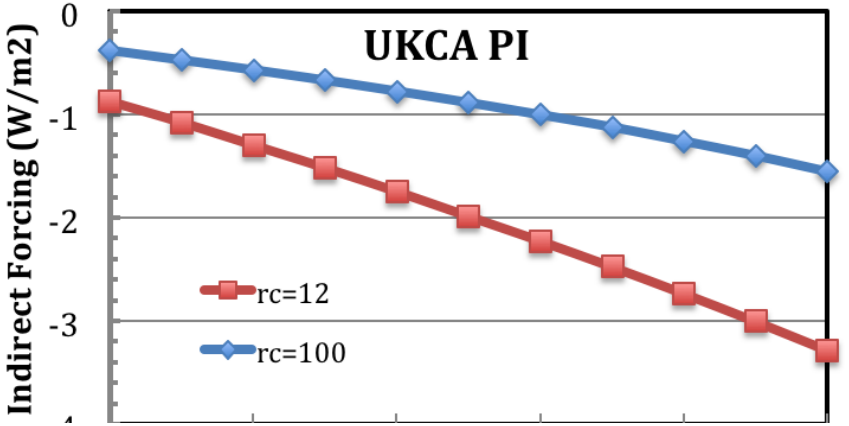
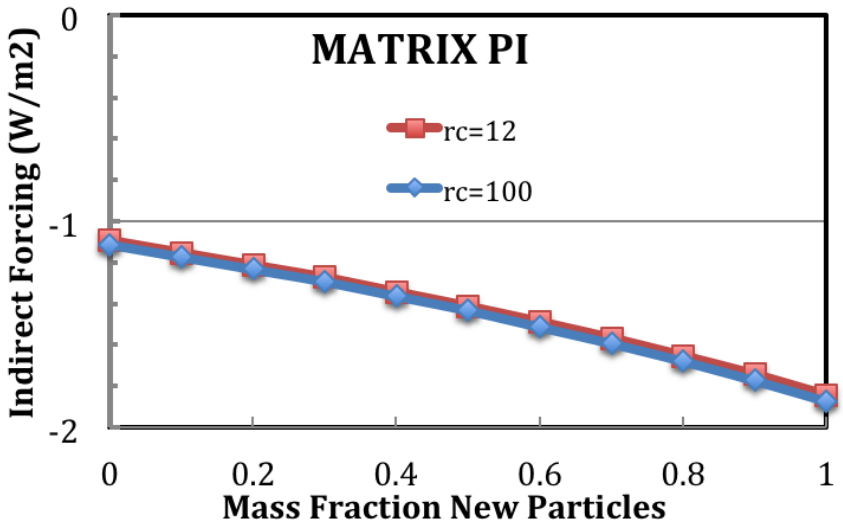
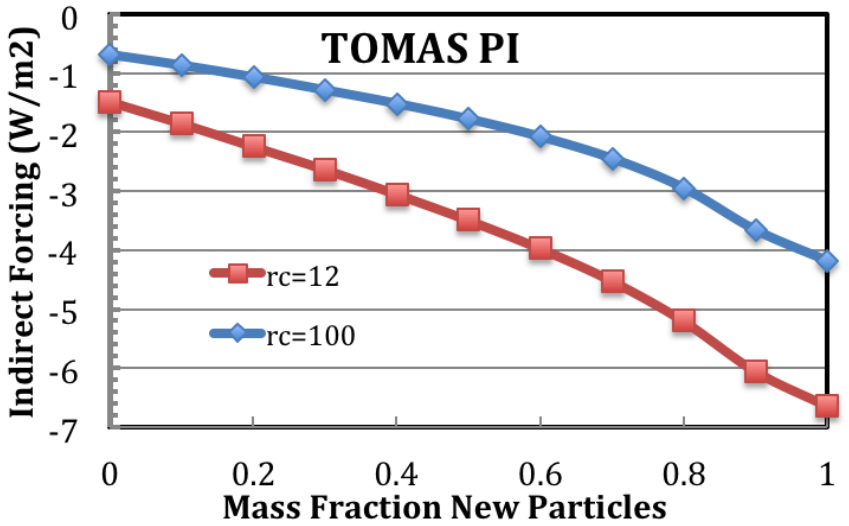
Preliminary results using PI aerosol from different models



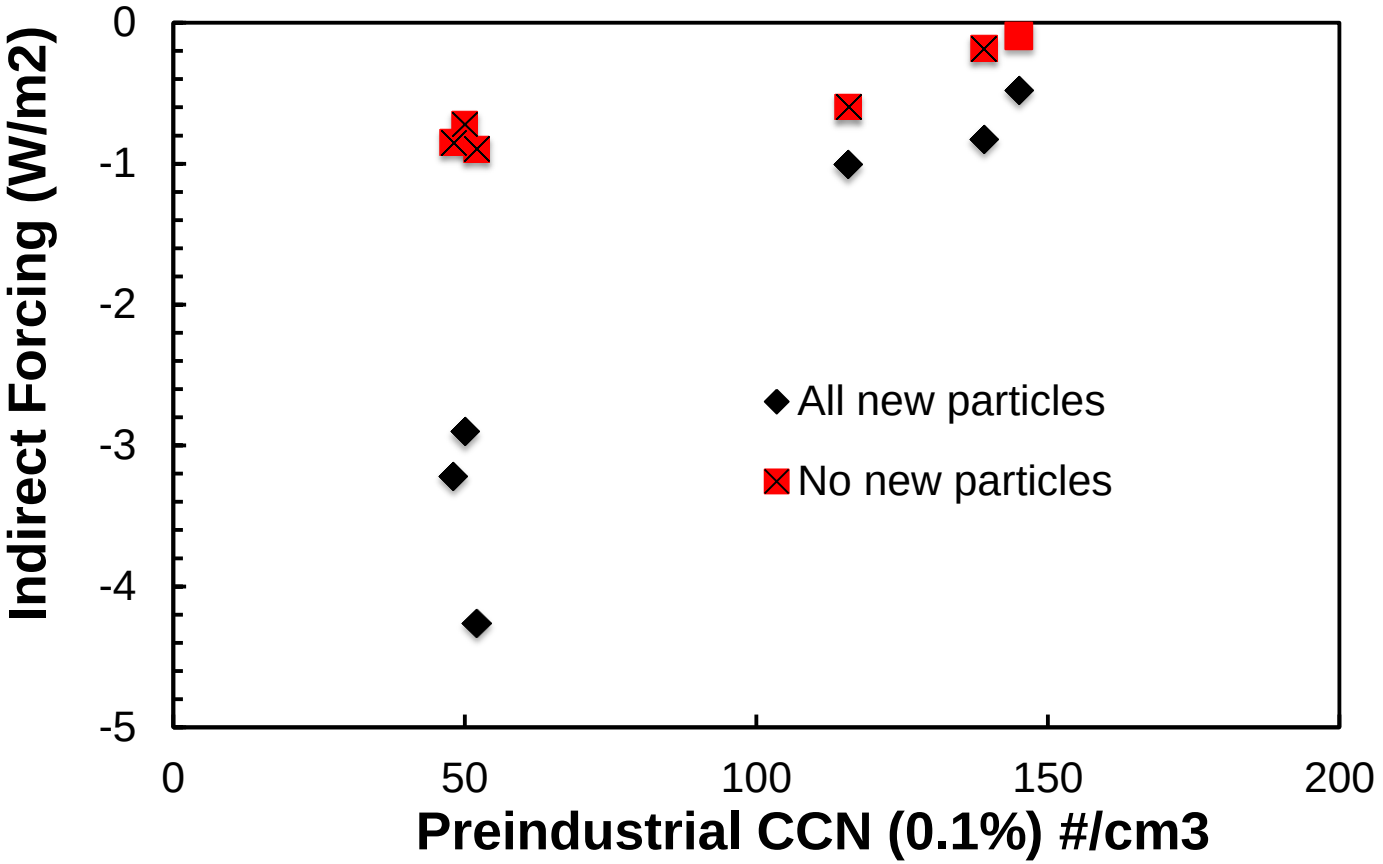








Preindustrial CCN influence on indirect forcing



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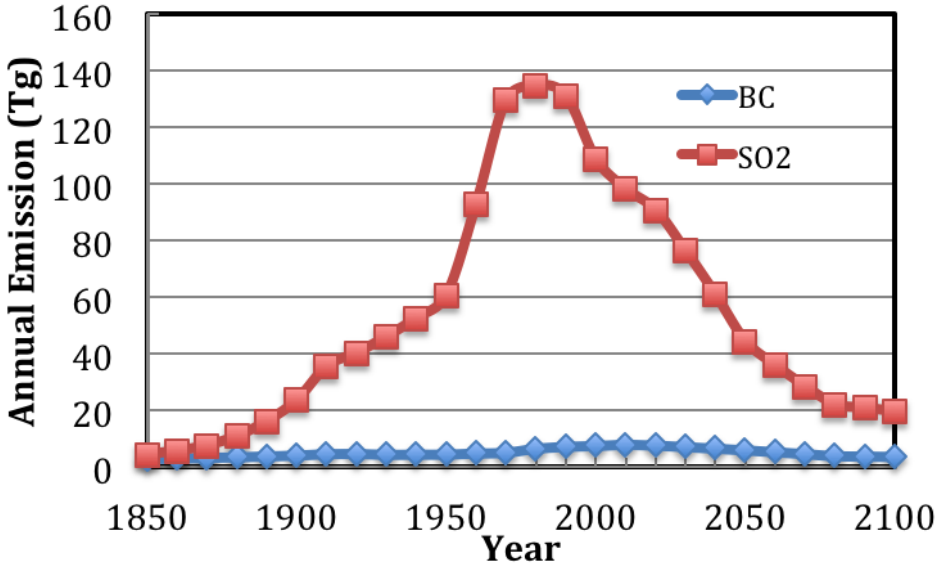
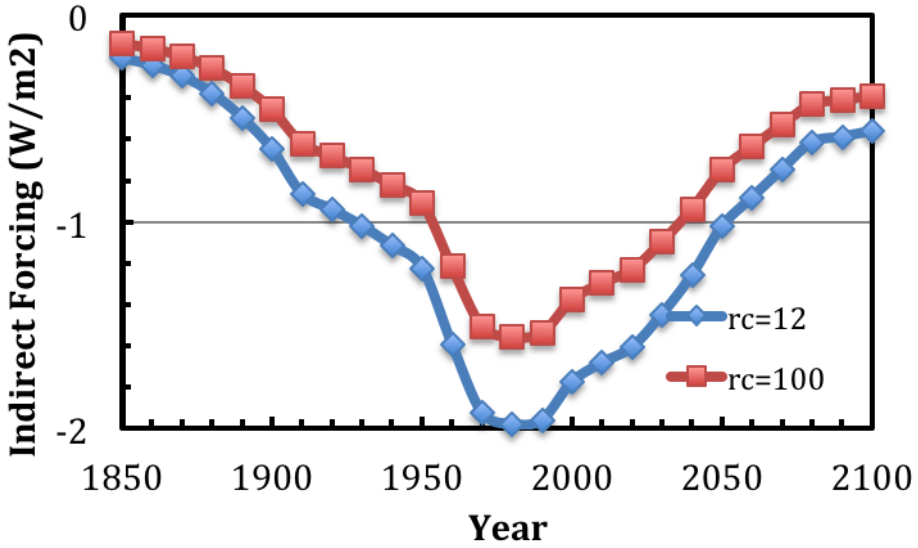
Historical and Future Forcing





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Summary

- Simple forcing model could be used in Integrated Assessment Models
- Model produces parameter dependence similar to that of complex models
- Number of anthropogenic accumulation mode particles is most important parameter
- Indirect forcing is also sensitive to natural aerosol from global aerosol models
- Further work is needed to reconcile differences between simple model and global aerosol model estimates of indirect forcing

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