

# Empirical Predictions of CCN

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# How well can aerosol optical properties predict CCN?

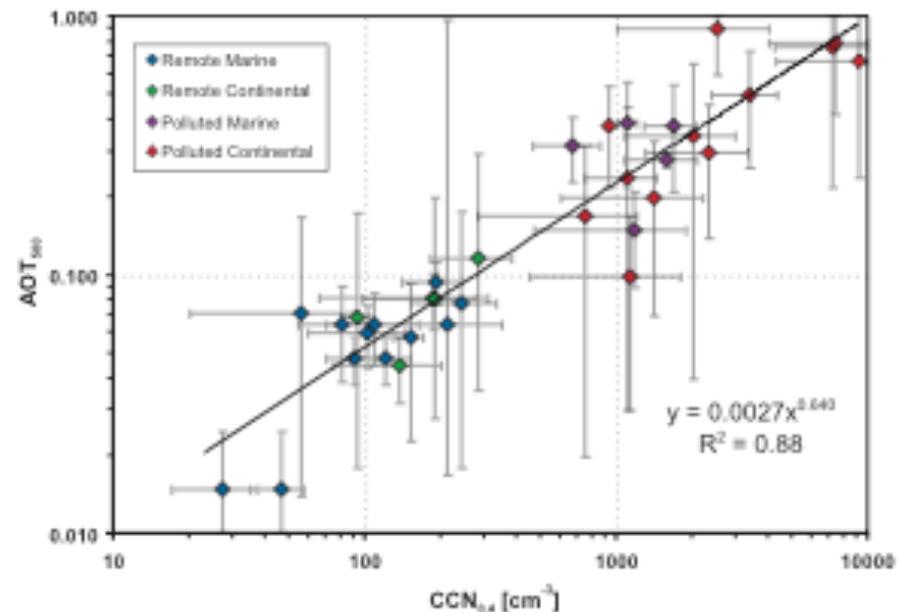
First principle calculations require size-dependent aerosol composition to model CCN

*Needed measurements are resource intensive and difficult to maintain long term*

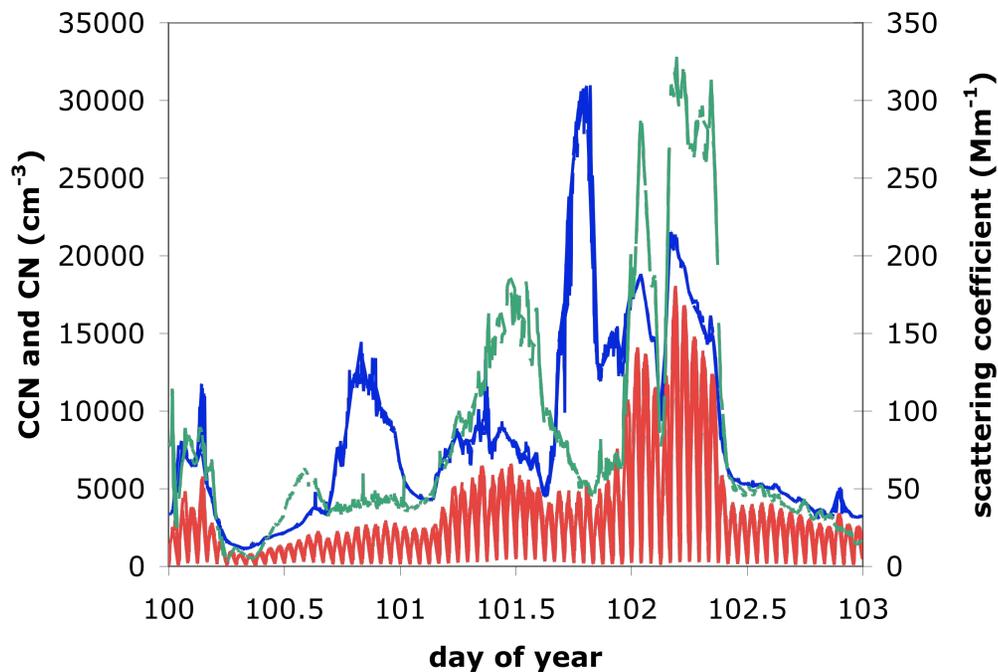
Aerosol optical measurements (scattering and absorption) are relatively inexpensive and well-suited for long term monitoring.

How close is close enough in modeling CCN ?

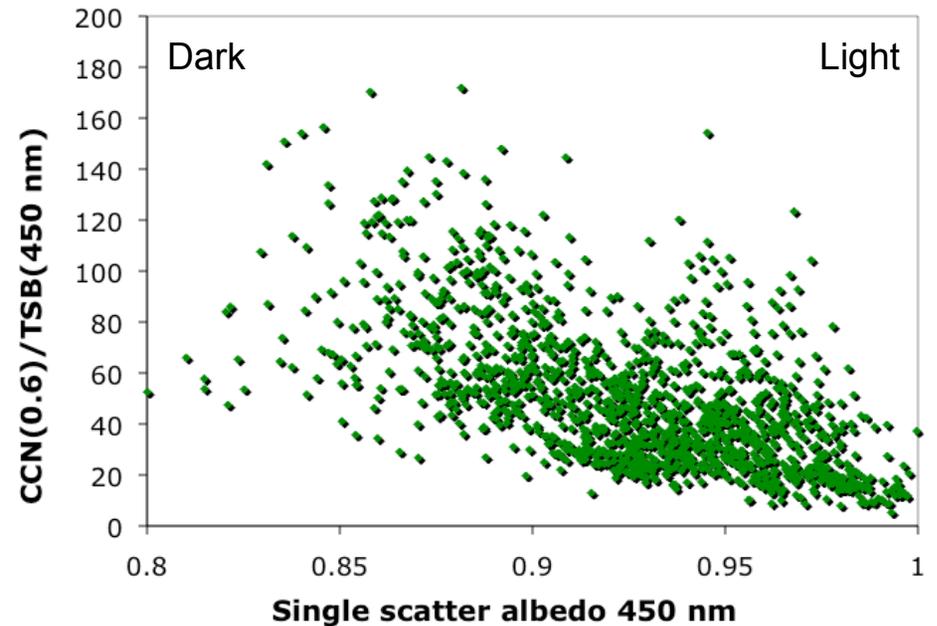
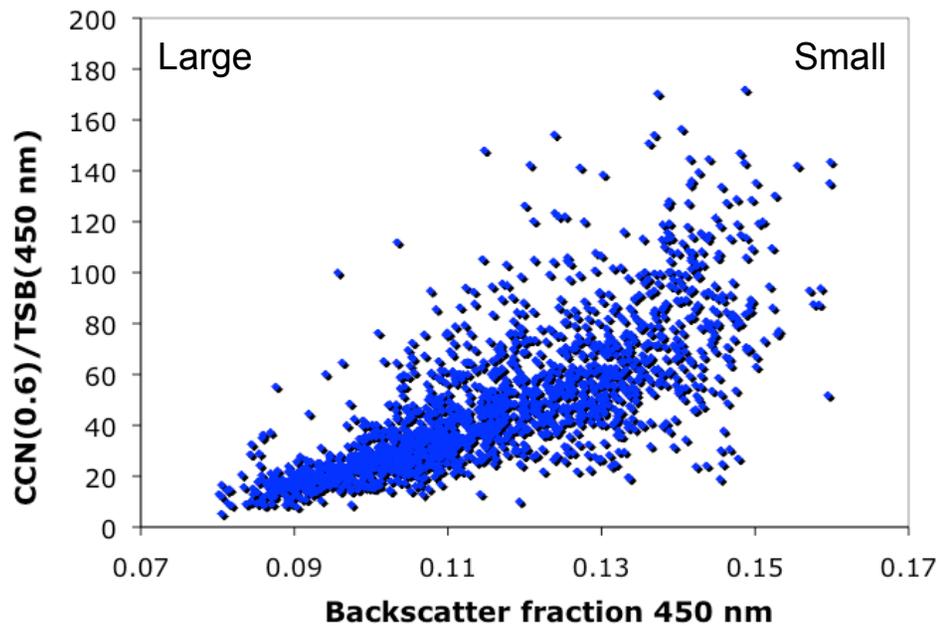
Can the empirical model extend across several %SS and aerosol types? How robust can it be?



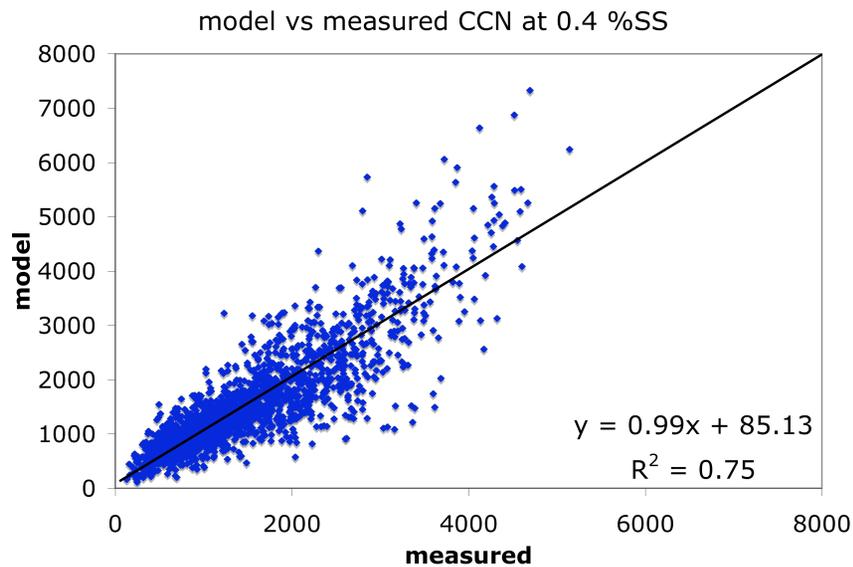
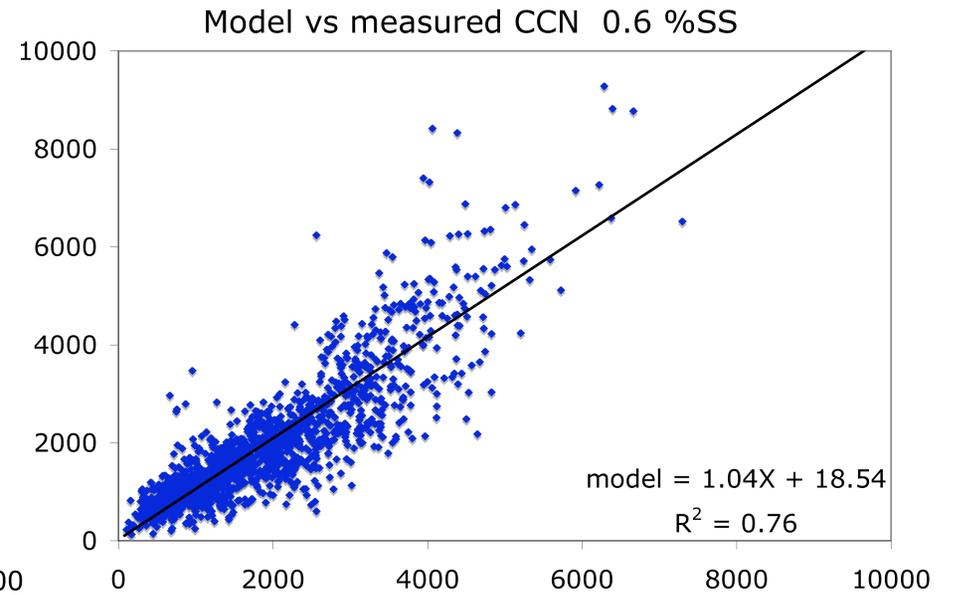
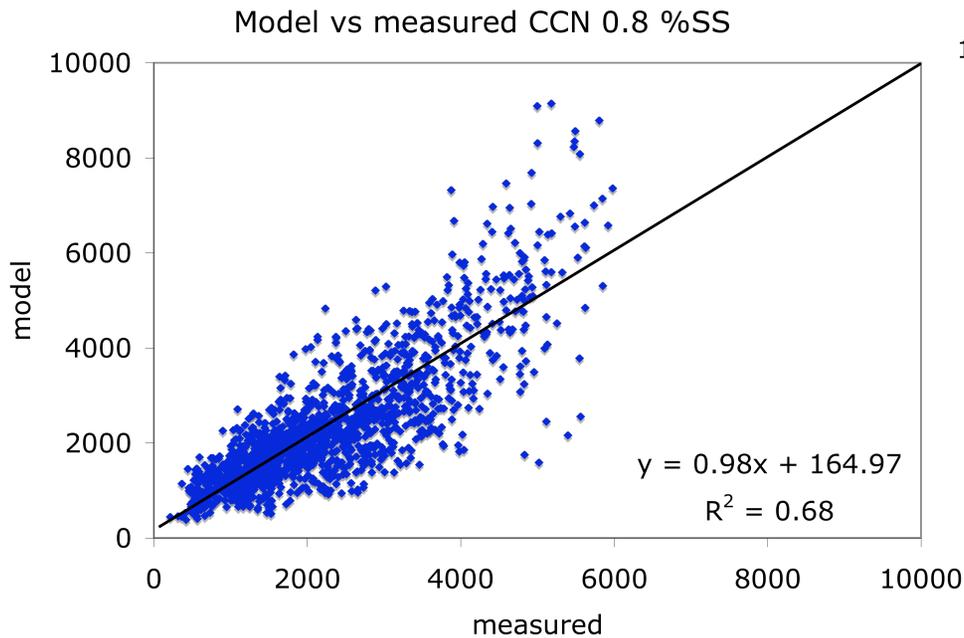
**M. O. Andreae**, Correlation between cloud condensation nuclei concentration and aerosol optical thickness in remote and polluted regions, *Atmos. Chem. Phys. Discuss.*, 8, 11293, 2008.



CCN and CN at SGP often don't correlate while CCN and scattering correlate well. The ratio of Bsp/CCN correlates with aerosol size and single scatter albedo.

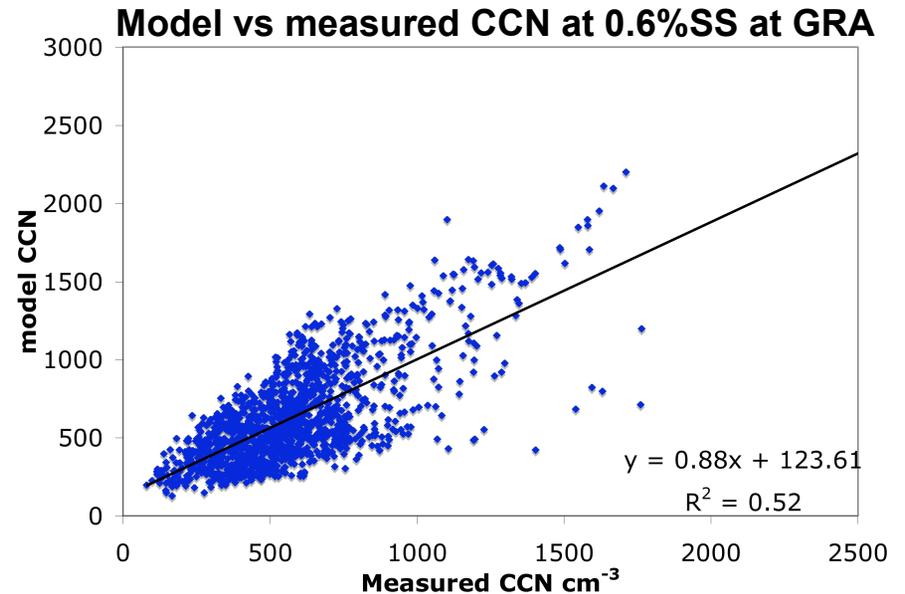
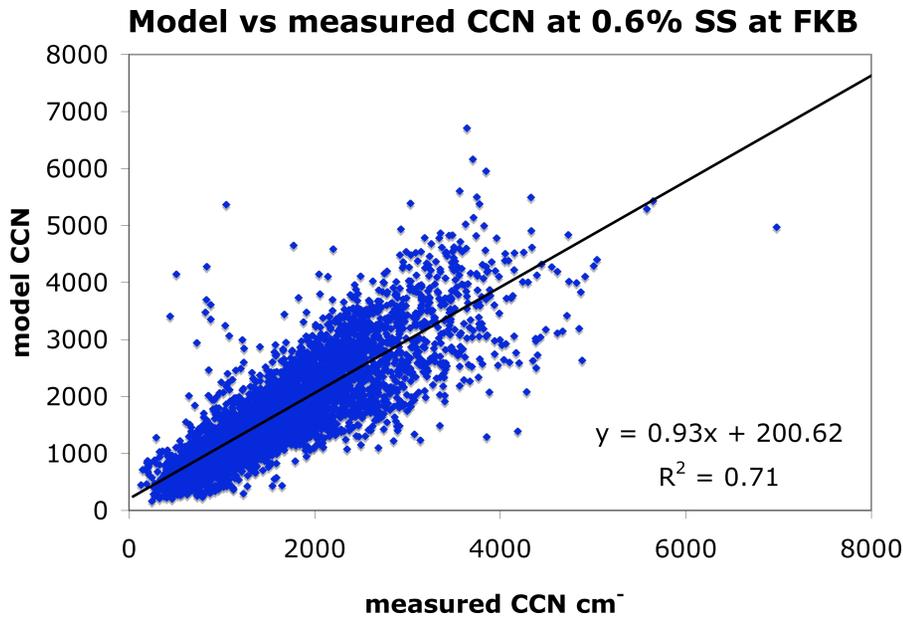


# Empirical calculations of CCN at a single %SS Feb. 9-May 20, 2009 at SGP



Fits depend only on the sub *um* total and  
back scattering coefficients at 450 nm

# Predicted CCN at ~0.6 %SS at GRA and FKB using aerosol optical data

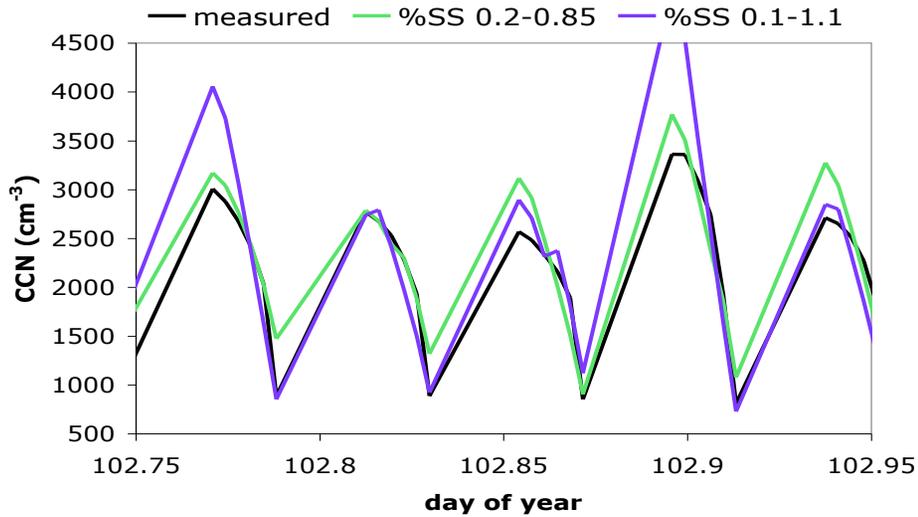


FKB data uses only sub  $\mu\text{m}$  total and backscatter data at 450 nm

GRA data uses only sub 10  $\mu\text{m}$  total scatter and Angstrom exponent

Fits are site specific. Want to fit data to an intrinsic aerosol parameter or function that can be compared with aerosol type.

# Prediction of CCN as a function of %SS



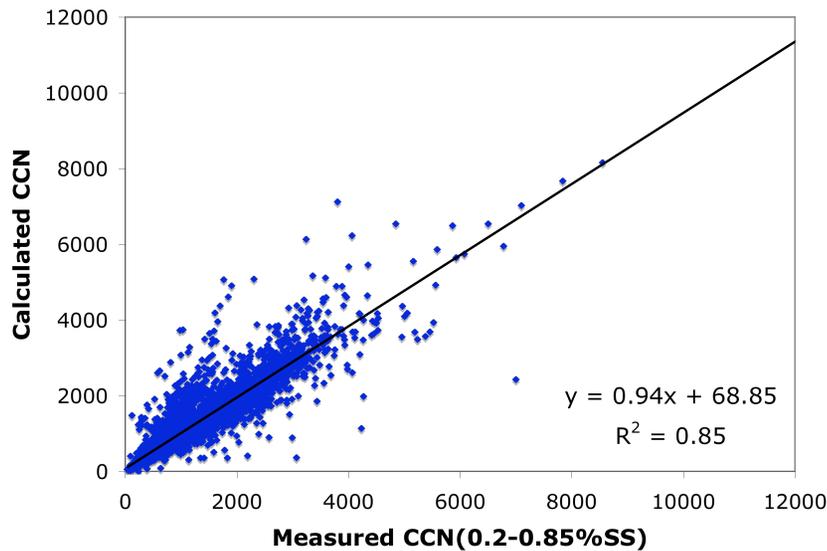
Twomey Power Law fit:  $CCN = C(\%SS)^k$

Fits over predict CCN at high %SS

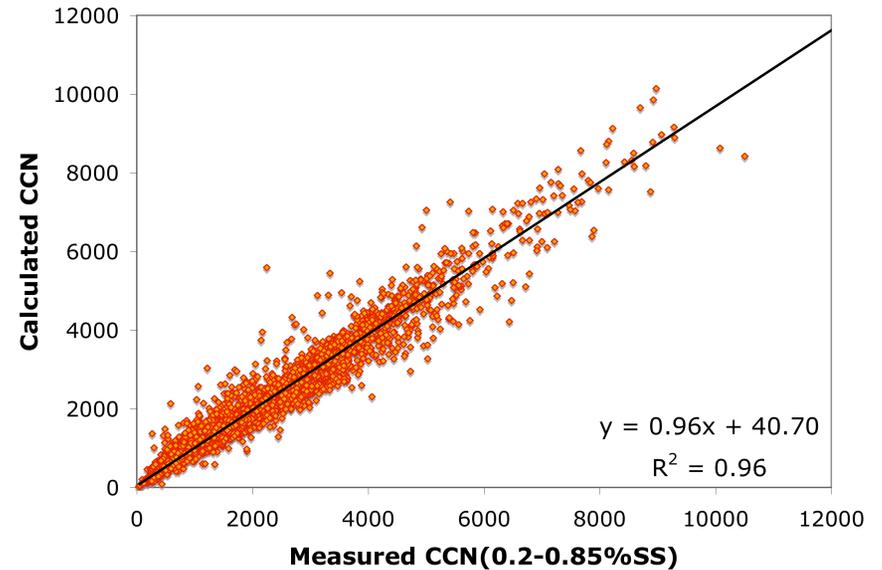
*Gahn et al. 1995, Khvorostyanov and Curry, 2006*

Limit range of fit from 0.2-0.85 %SS to improve correlation with measured CCN  
(possible VAP of  $C$  and  $k$  parameters?)

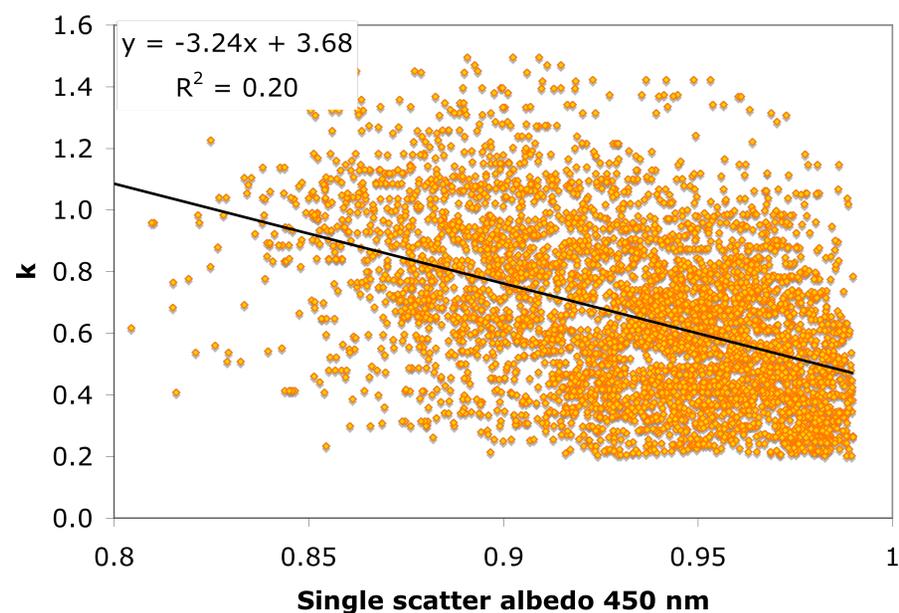
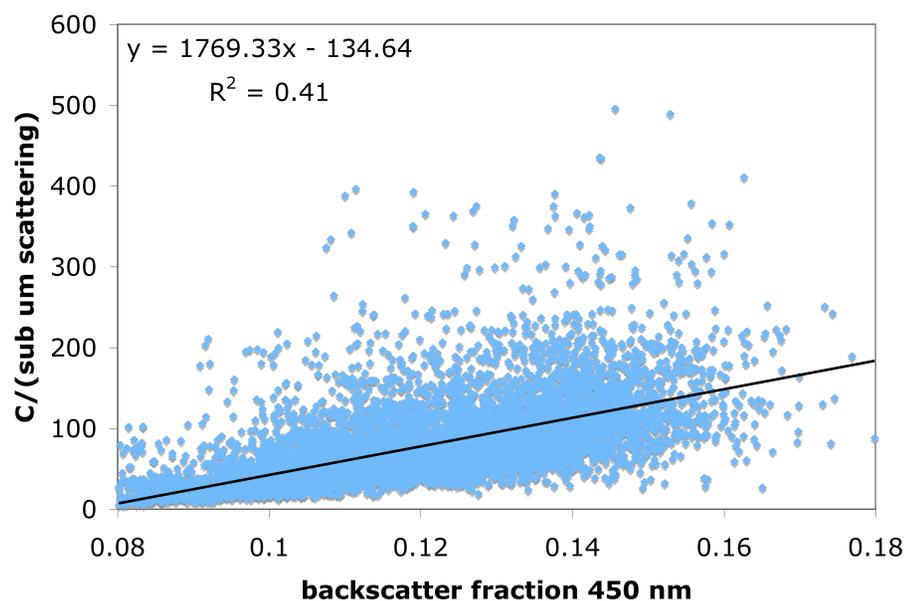
### C and k fit from 0.1-1.1%SS



### C and k fit from 0.2-0.85%SS



## Fit of C and k Twomey parameters to aerosol optical values



Optimize fits by neglecting data with high uncertainty or anomalous behavior

Select data that meet the following criteria

CCN/CN < 0.99

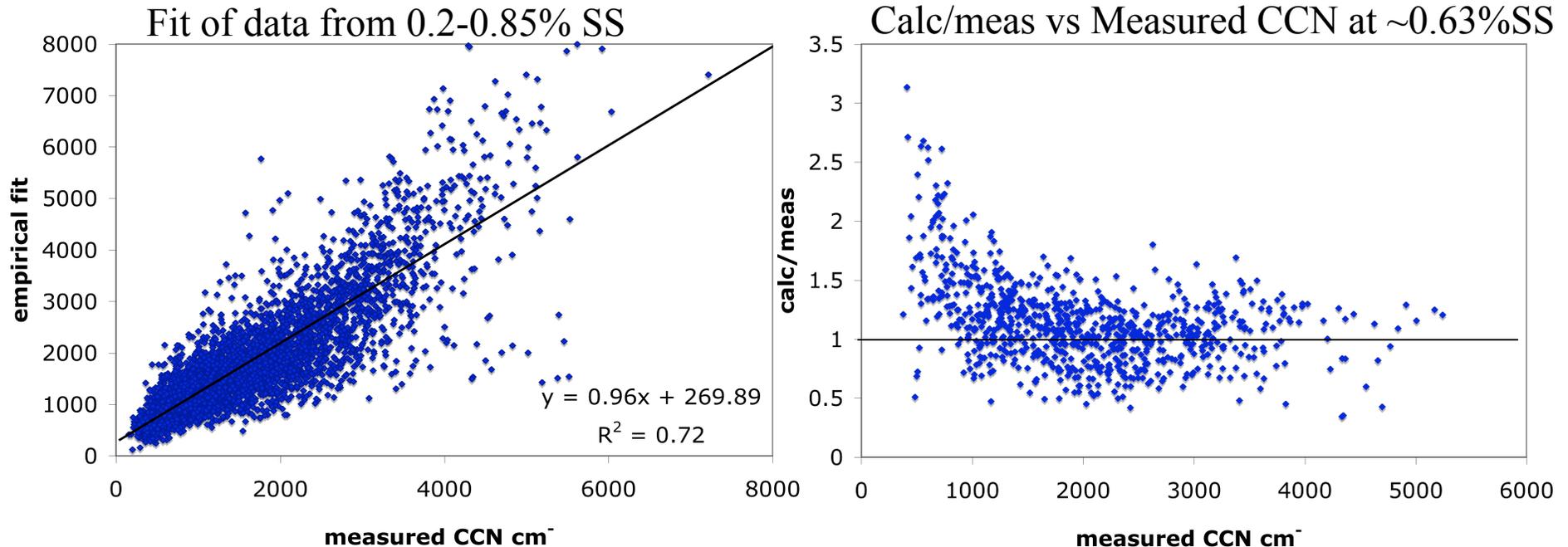
Backscatter coefficient > 2.0 Mm<sup>-1</sup>

Angstrom Exponent > 1.0

CCN < 8000

0.8 < backscatter fraction < 0.18

Empirical fit results for days 40-140 2009 at SGP using only sub  $\mu\text{m}$  scattering coefficient, backscatter fraction and albedo



Higher offset at low CCN values

Expand to full data set at SGP

Analysis using Twomey fit works only in limited cases

For CCN with steep growth curves, values of  $k$  change with %SS

## Future direction

Need a more sophisticated way predict CCN behavior that will work for several aerosol types

Ways to better constrain the data:

- Fit data to  $(CCN(x\%ss)/CCN(1\%ss))$
- Add another parameter to constrain the fit better
- Exploit wavelength dependence of aerosol optical properties and size

Perform model calculations with an ideal aerosol of a known composition and size to:

- determine how well the method can constrain the CCN
- Help find a semi-empirical or analytic solution to predicting CCN with aerosol optical properties