Aerosol-Cloud interactions in CACTUS: Current and Future directions

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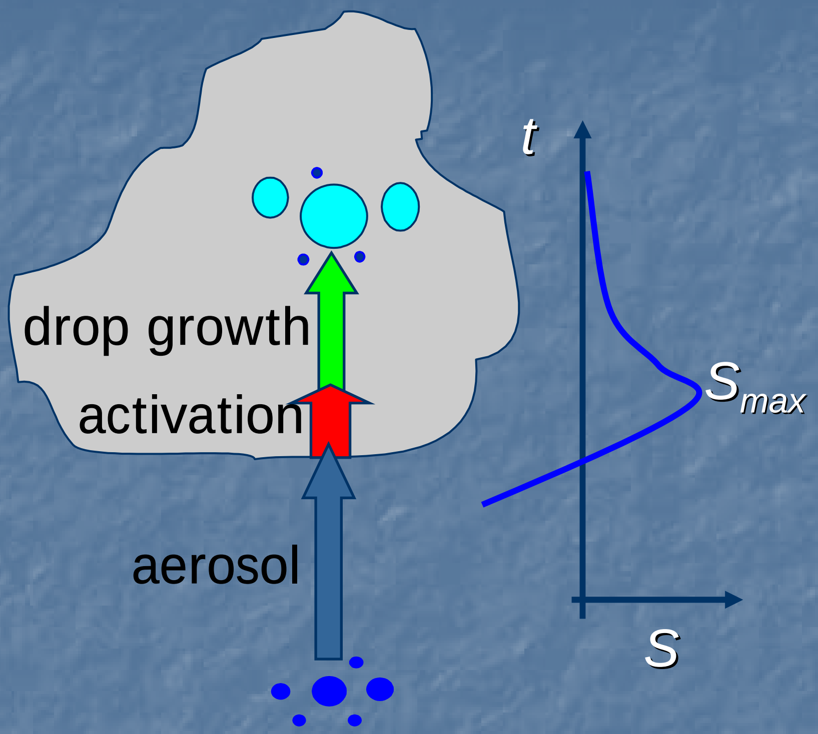
photo: S.Lance

Nenes and Seinfeld parameterizations

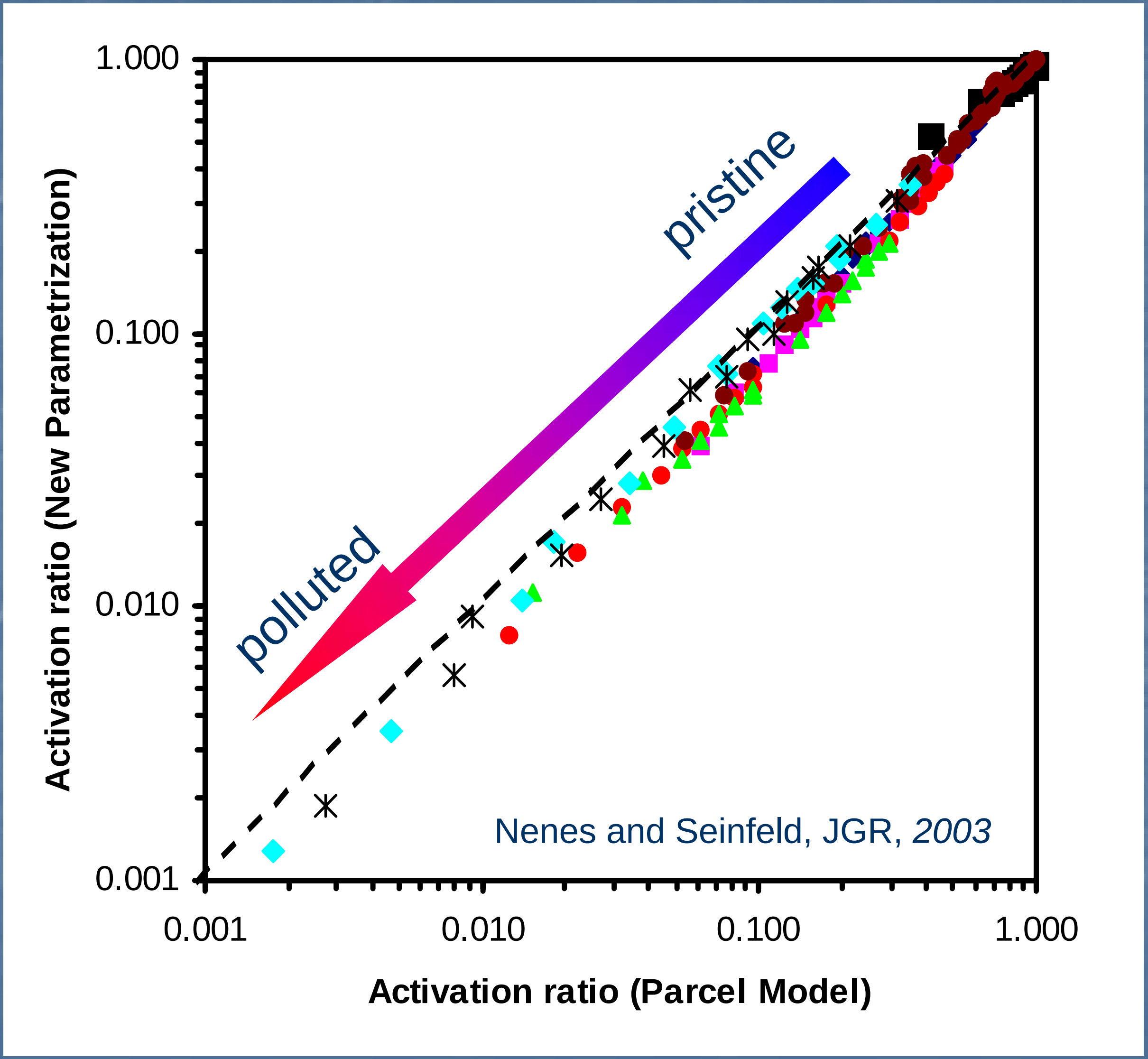
- **Sectional** or **lognormal** representation of aerosol chemistry and size distribution.
- Each section or lognormal mode has its own chemical composition
- Multiple populations can co-exist and compete for water vapor.
- Köhler theory for computing CCN properties.
- Lagrangian parcel framework used.



Derive expression for the condensational growth of CCN; include within the supersaturation balance for the parcel, and solve for the maximum.

Challenge: to derive an expression of the condensation rate at S_{max}.
Solution: “Population splitting” (Nenes and Seinfeld, JGR, 2003)

Nenes and Seinfeld (2003) activation parameterization



Features:

-10^3-10^4 times *faster* than full numerical model.

- uses *minimal* amount of empirical info.

- chemically complex and heterogeneous aerosol can be treated, including the effects of organic species.

Parameterization: current accomplishments

Expanded the parameterization capability

• Derived formulations for ***sectional*** (Nenes and Seinfeld, 2003) and ***lognormal*** (Fountoukis and Nenes, *in review*) aerosol.

• Included size-dependant mass transfer of water vapor to droplets which eliminated underestimation tendency in parameterized droplet number (Fountoukis and Nenes, *in review*).

• Explicitly can treat chemical effects that alter surface tension and accommodation coefficient (Fountoukis and Nenes, *in review*).

• Included the effect of condensable gases (Nenes, in preparation).

Evaluations & implementations

• Computational efficiency ***substantially*** improved.

• Parameterizations have been evaluated with *in-situ* data for both cumulus and stratocumulus cloud regimes

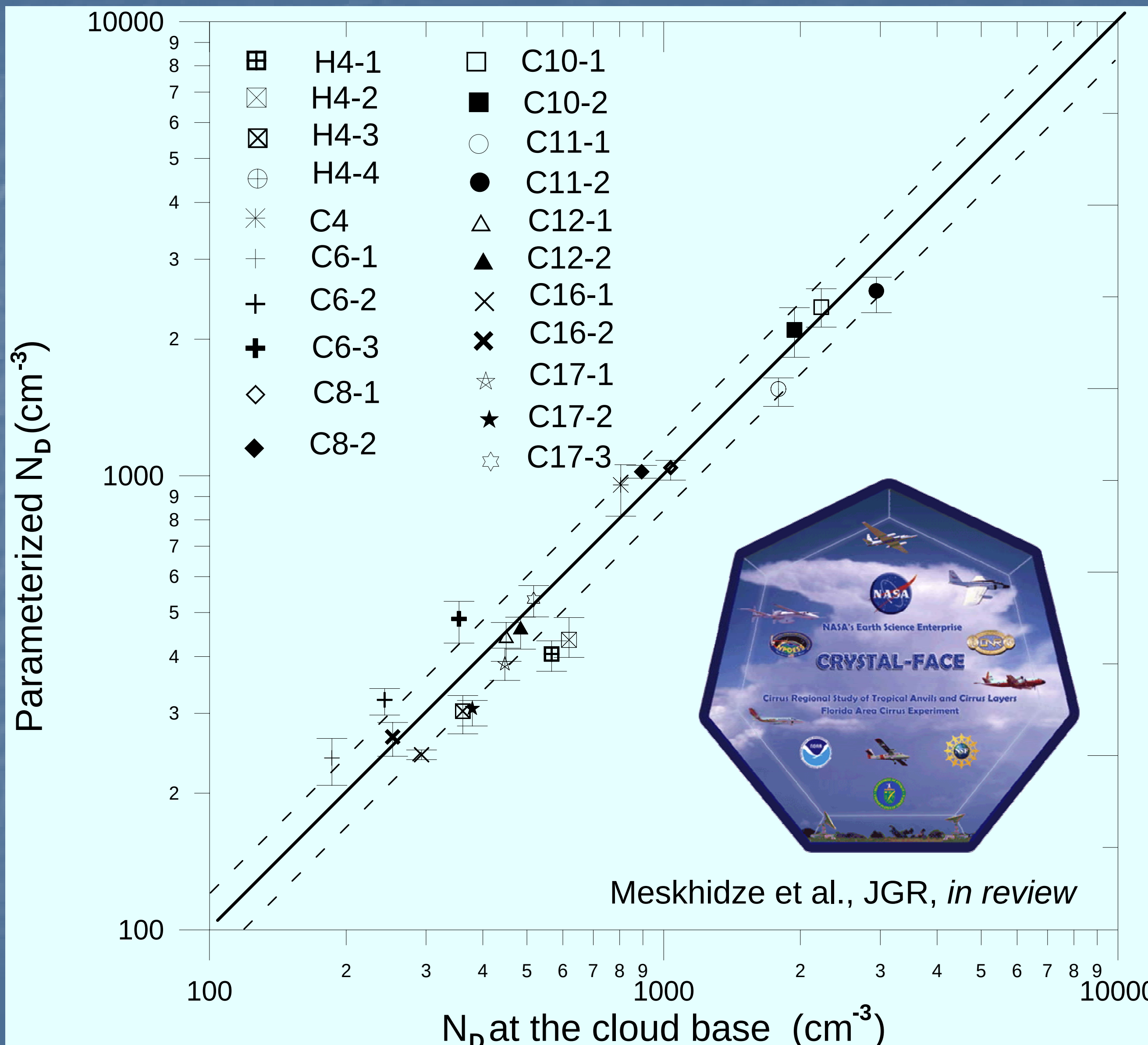
• Implemented in NASA GISS. Currently being implemented in NASA GMI, Goddard GCM

Parameterization evaluation: Field data comparison

Measure *in-situ* aerosol size/composition, updraft velocity and droplet concentration (CIRPAS Twin Otter).

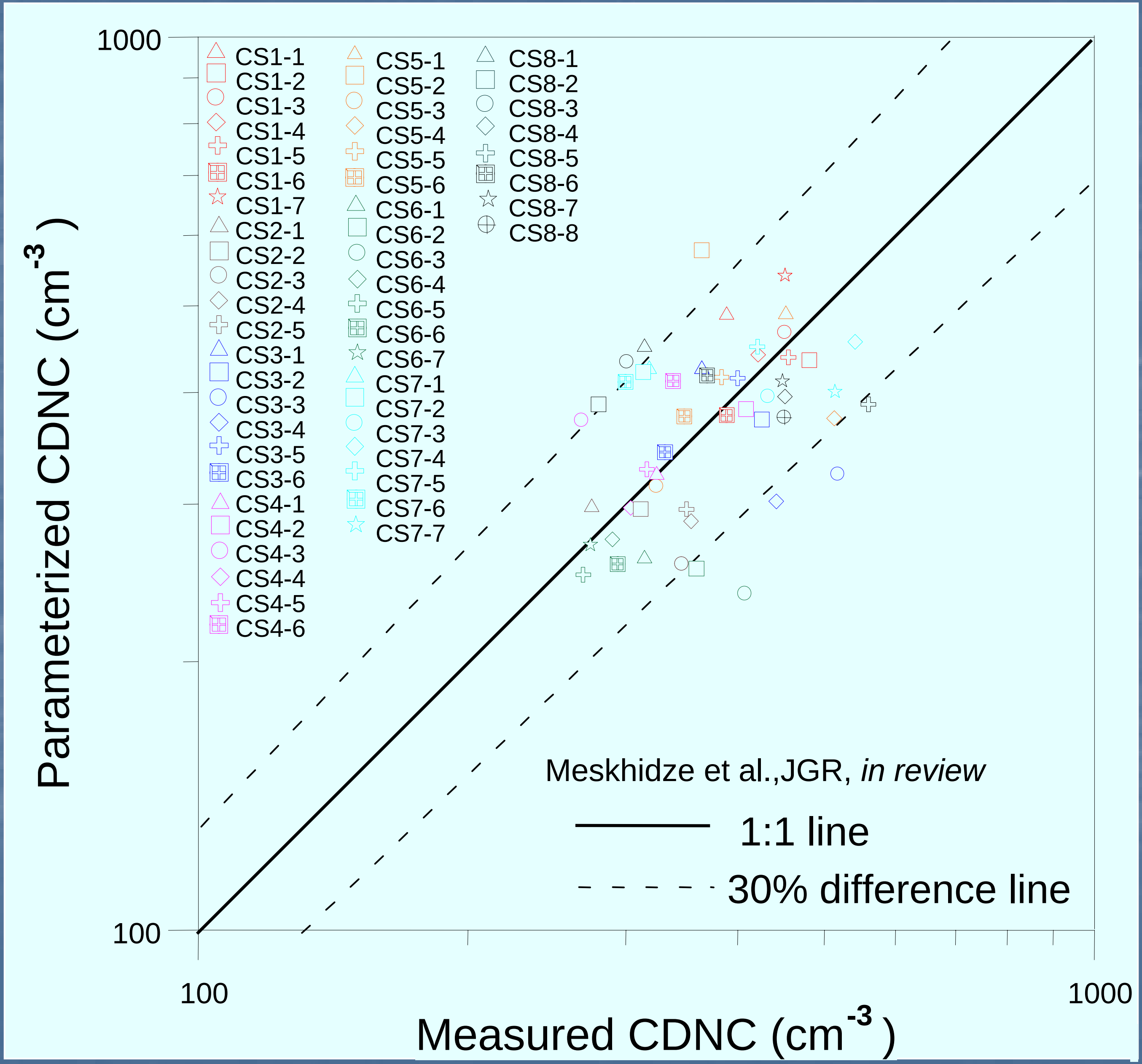
Will the parameterization calculate the right number?

Evaluation: cumulus cloud regime (CRYSTAL FACE)



Parameterization agrees with observed CDNC within experimental uncertainty

Evaluation: stratocumulus cloud regime (CSTRIPE)



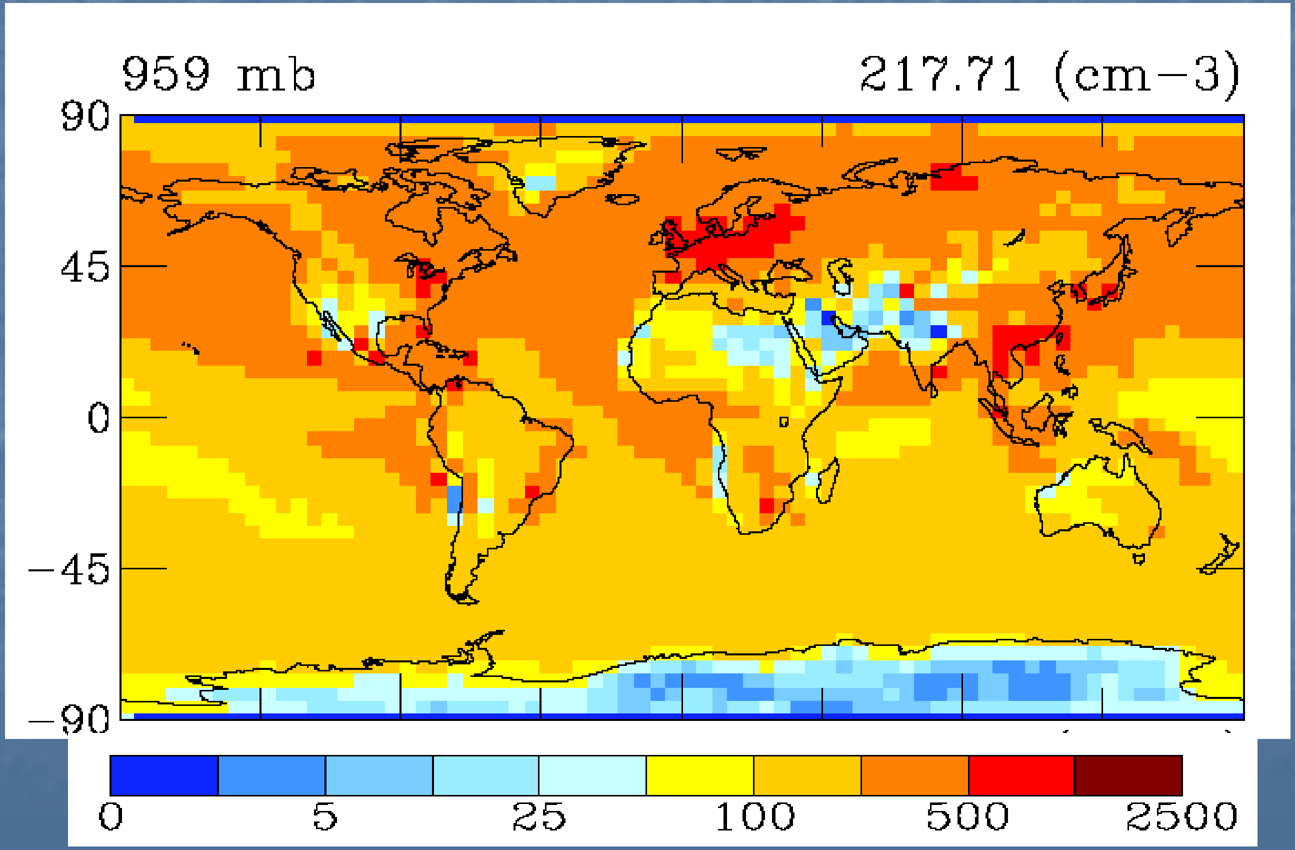
Parameterization agrees with observed CDNC within experimental uncertainty

GCM implementation: NASA GISS

a) Indirect forcing assessments

New parameterization with full aerosol microphysical simulation (TOMAS model, Adams and Seinfeld, 2002).

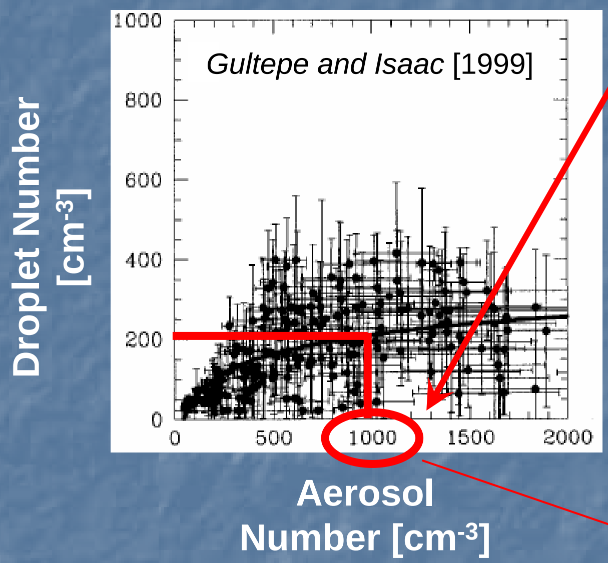
Present day – preindustrial TOA sulfate forcing: -1.4 W m^{-2}

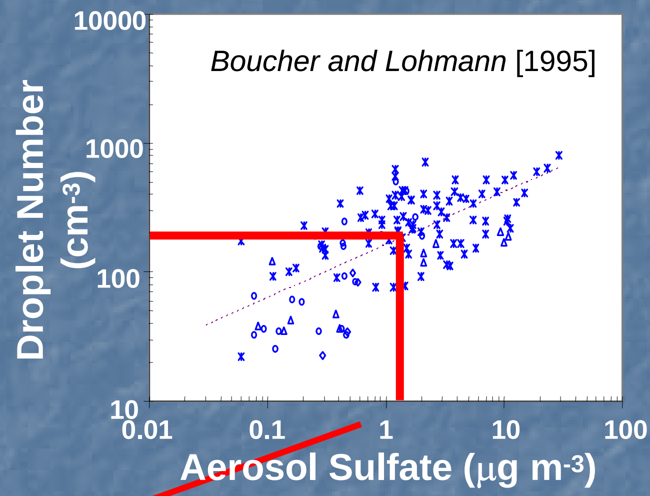


Empirical aerosol-CNDC relationships

They can be used together with parameterization to obtain "effective" updraft for calculating activation.

Prescribed or Simulated Size Distribution from GCM





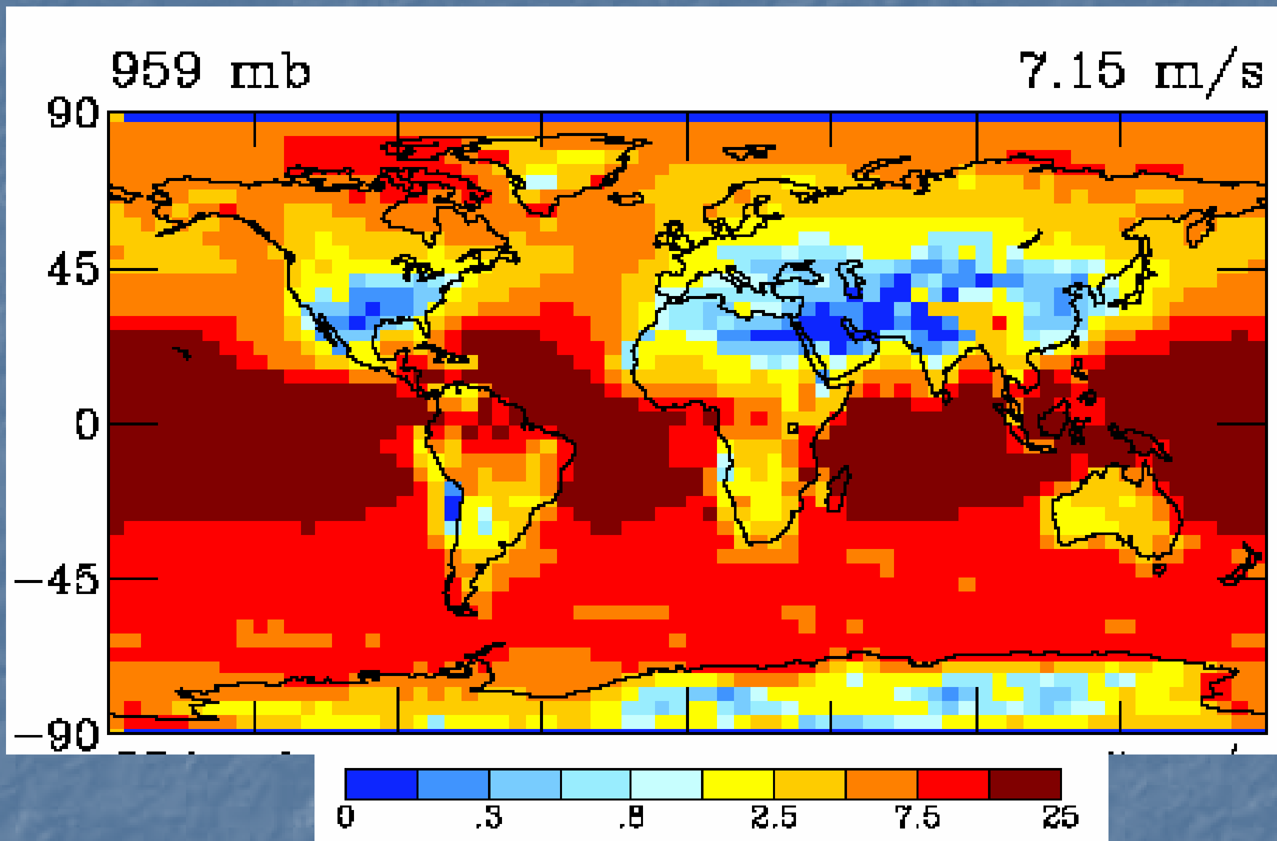
N_d, N_{total}, m_{so4} + Parameterization

Calculate the updraft needed to obtain N_d from empirical correlations

From Lance *et al.*, JGR (in press)

Empirical aerosol-CNDC relationships: issues

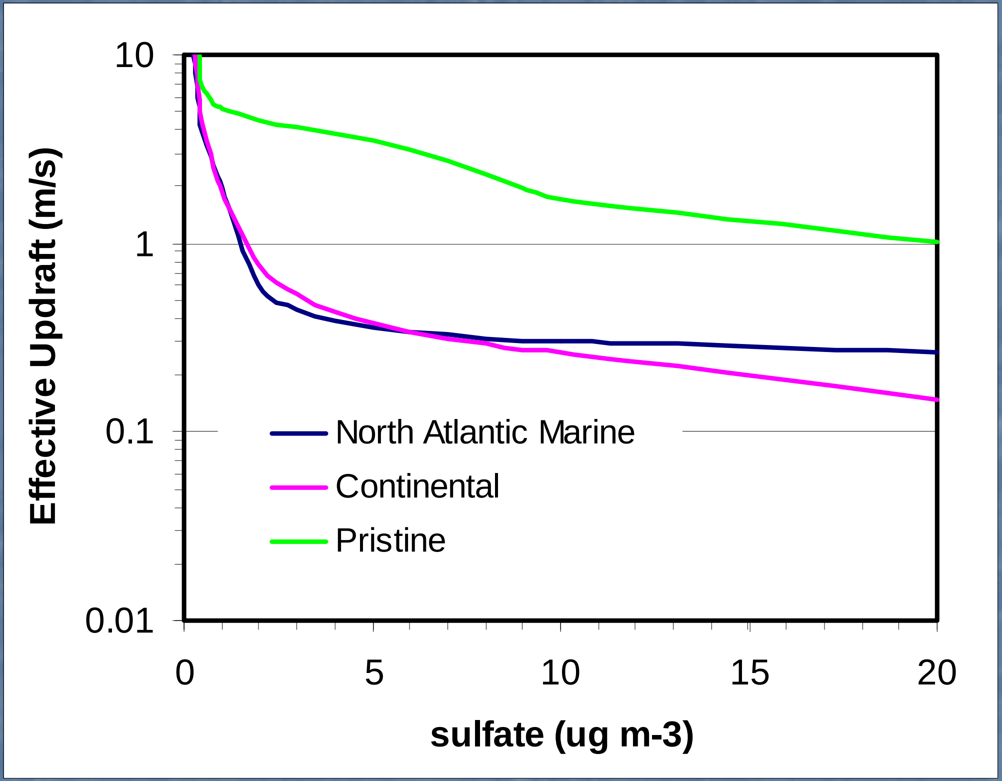
The "effective" updrafts implied can be very high



Empirical correlations may imply unrealistic cloud dynamics.
The problem is most prominent at marine/clean environments

Empirical aerosol-CNDC relationships: issues

The "effective" updrafts implied can be very high…
…but not always



- The high updrafts appear when [SO4] < 2 ug m^{-3}
- Pristine (clean) environments always have high W
- This is an inherent feature of the correlations

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For more information and PDF reprints, http://nenes.eas.gatech.edu

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