Investigations of ice nuclei dependence on aerosol composition

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Science Question

Do simplified relations exist between aerosol physical and chemical properties and the number concentrations of **ice nuclei (IN)** for improving global modeling of aerosol effects on mixed phase clouds and precipitation?

Approach

DeMott et al. (2010): Large data base of IN measurements (CSU continuous flow diffusion chamber) with co-sampled aerosol data used to parameterize IN number concentration as a power law function of aerosol concentration at sizes >0.5 μm and temperature.

Where does the DOE ISDAC study data fit in comparison?

Do compositional dependencies of ice nucleation explain remaining IN variability and what does specific new data tell us.

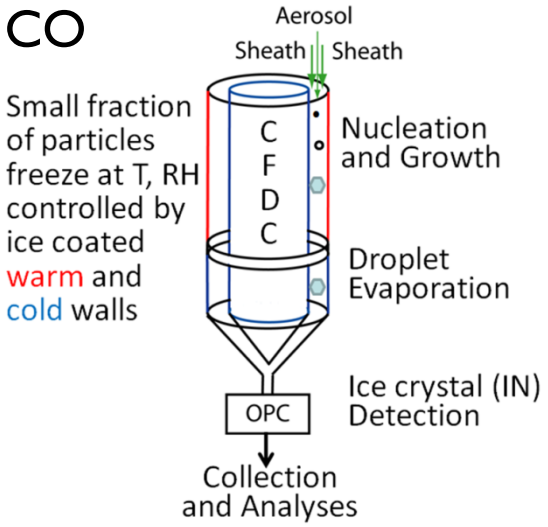
Sampling scenarios used for study

Smoke: prescribed burns (Longleaf Pine), Newton, GA

Dust: Saharan Aerosol Layer (SAL) from NSF/NCAR C-130, ICE-T experiment, St. Croix, USVI

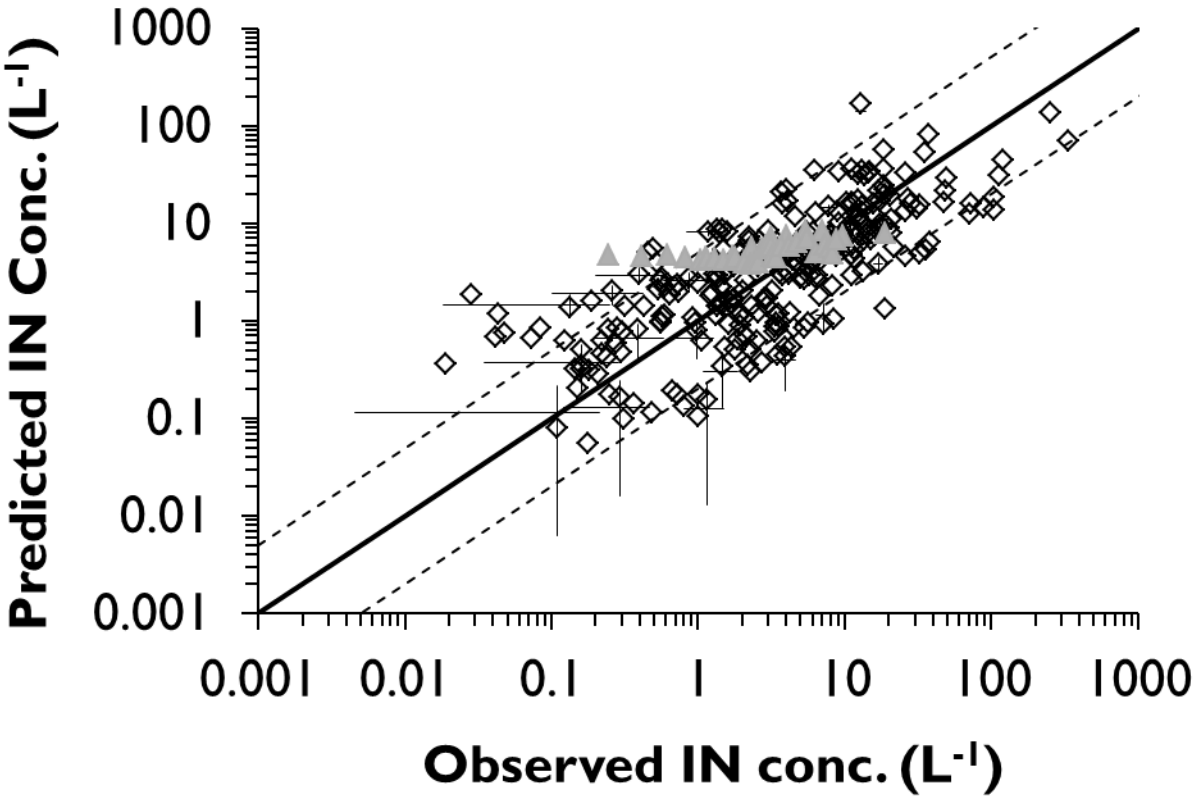
PBAP (primary biological aerosol particles) dominant in large aerosol, Manitou Forest, CO

Seawater spray: CAICE wave channel, Scripps/UCSD, CA



DeMott et al. (2010, PNAS) parameterization (DM10)

$$n_{IN,T_k} = a\left(273.16 - T_k\right)^b \left(n_{aer,0.5}\right)^{(c(273.16-T_k)+d)}$$



(3 days) conc.
with global
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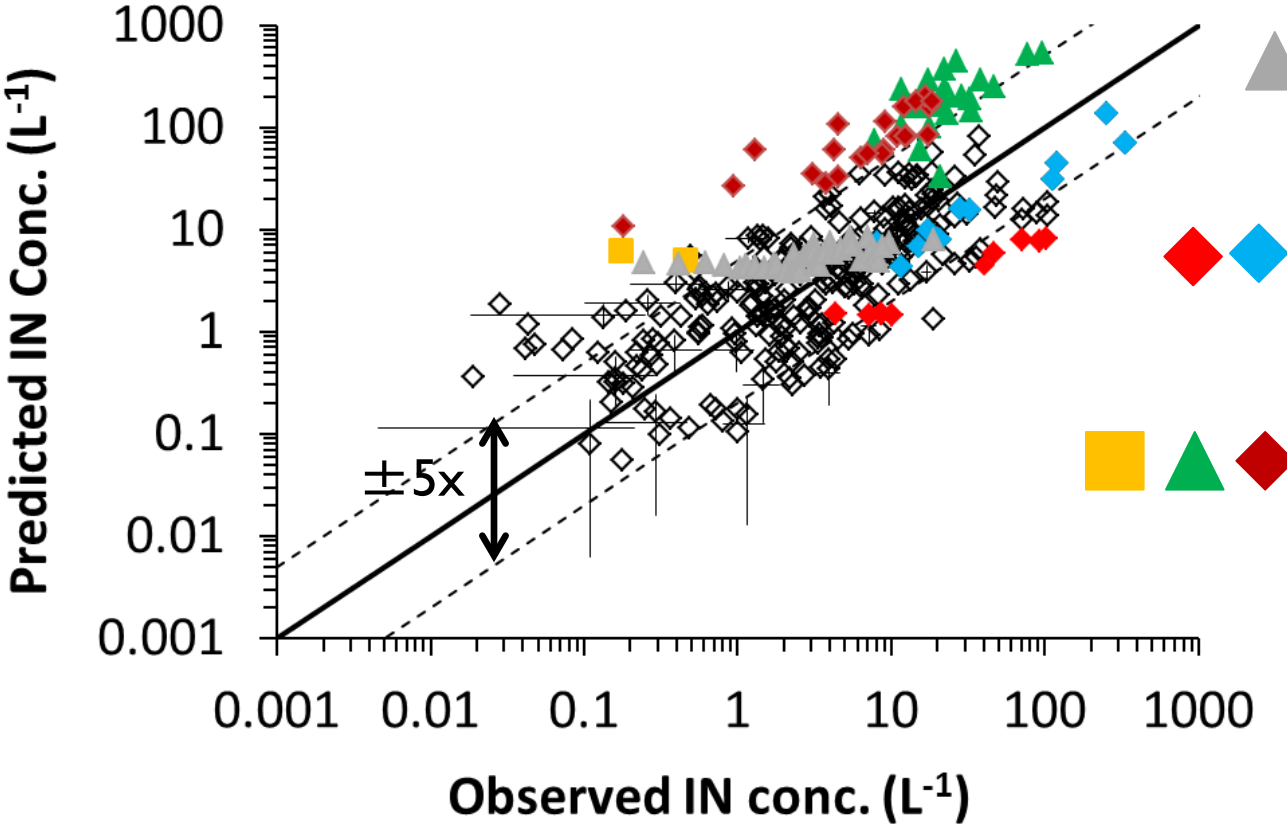
Compositional data compared to DM10



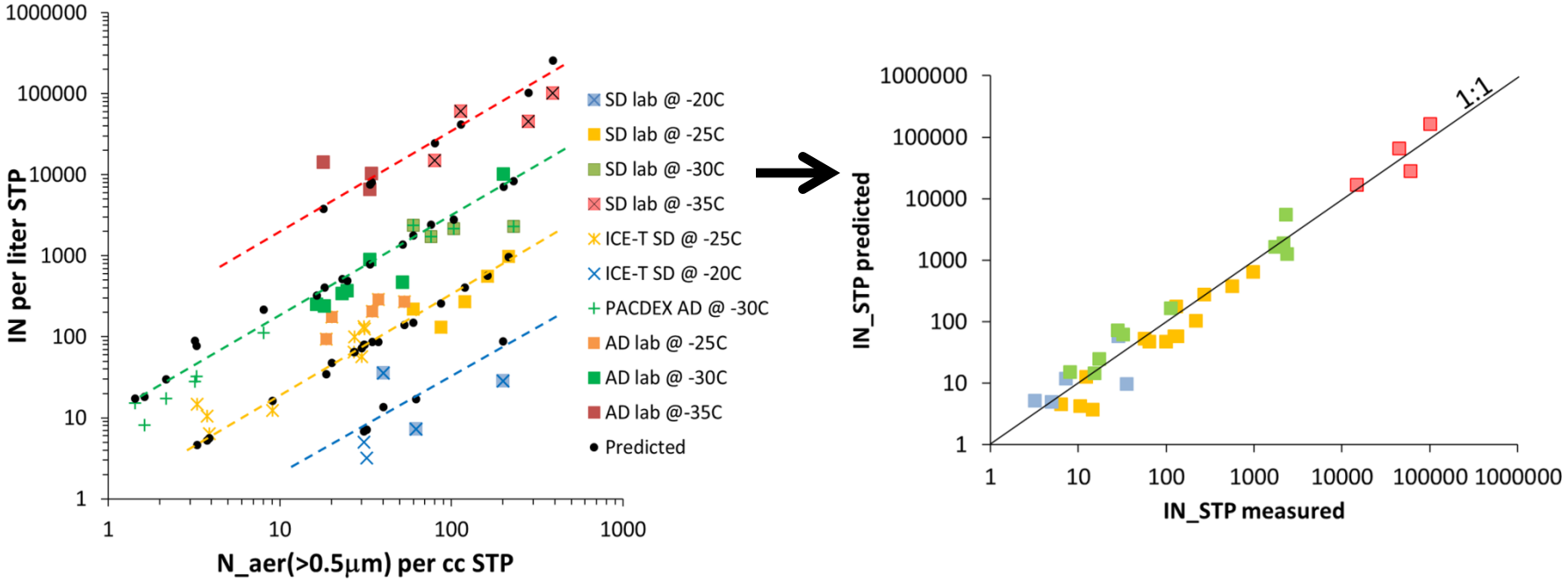
ISDAC IN (3 days) conc. consistent with global parameterization

IN conc. under-predicted in Saharan (red) and Asian (blue) dust plumes.

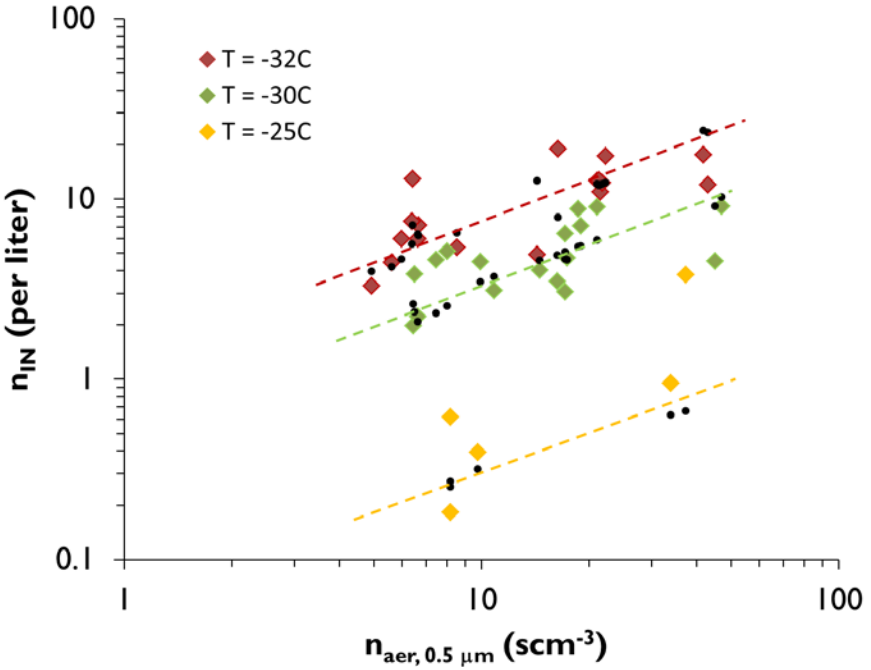
IN conc. over-predicted for pollution (yellow), smoke (green) plumes, and sea spray (maroon) particles.

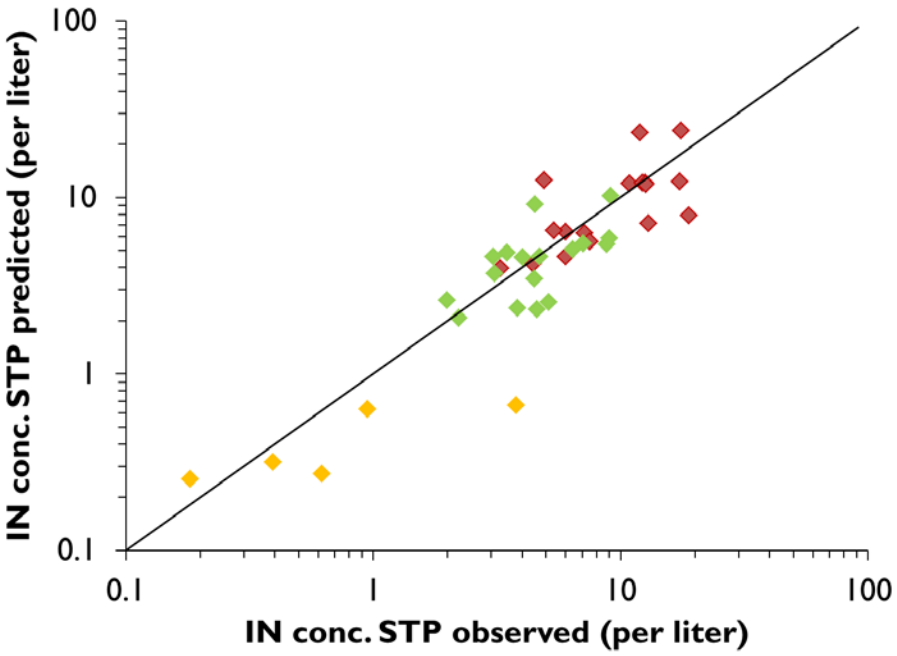
IN activity of dust particles alone (laboratory and field) and relation to size and temperature

$$n_{IN,T_k} = (n_{aer,0.5})^a \cdot 10^{(b(273.16-T_k)+c)}$$



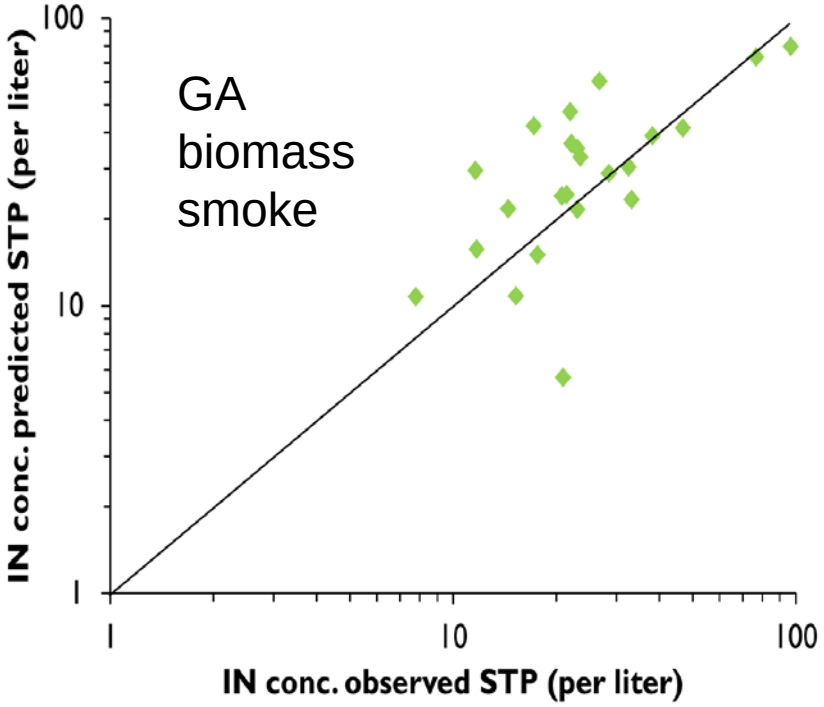
IN activity of sea-spray particles alone (laboratory) and relation to size and temperature

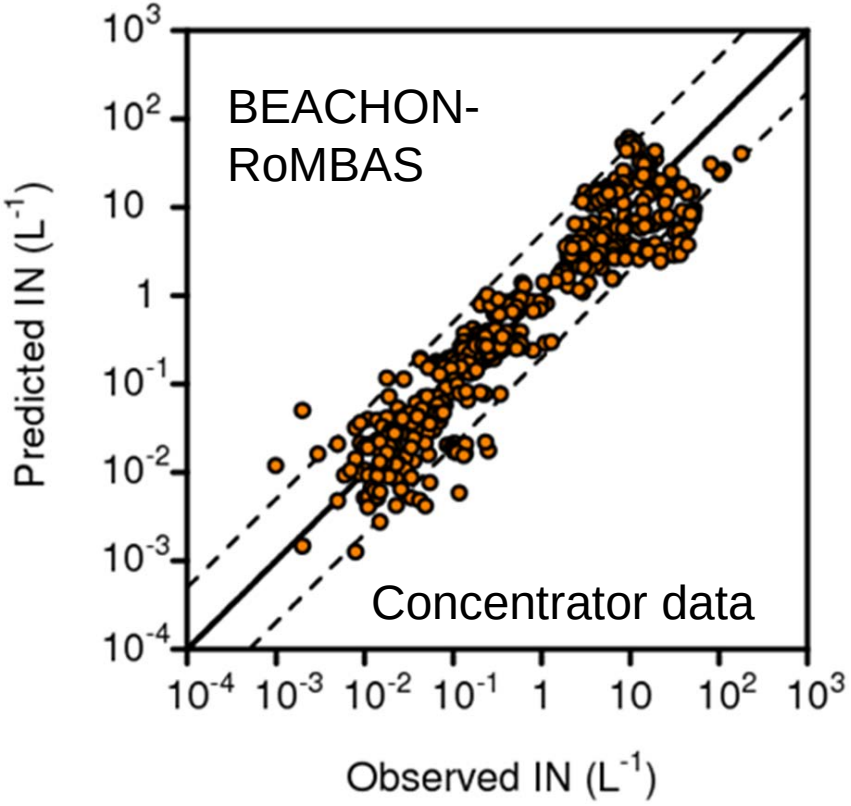




IN activity of smokes and aerosol in a strongly PBAP influenced environment

Only -30C represented here: in progress



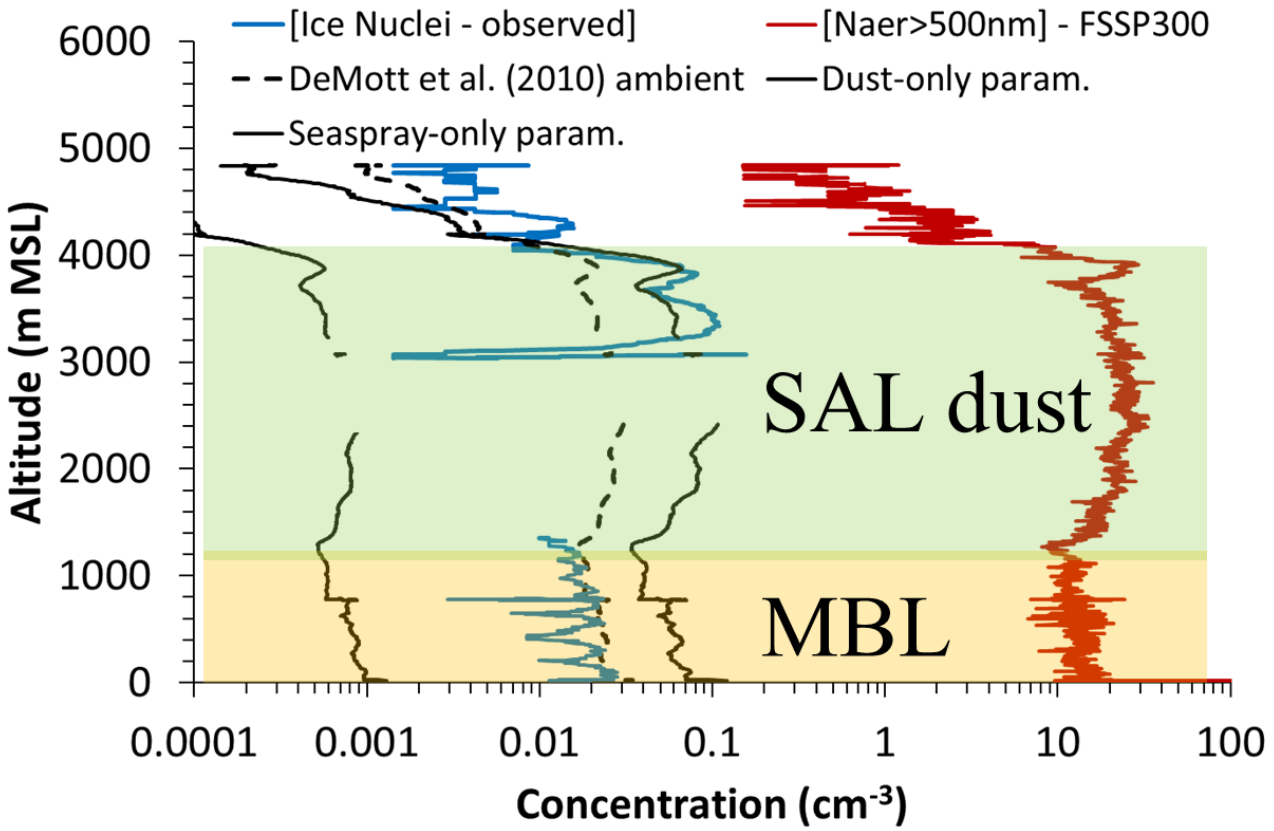


Simplified parameterizations for each IN particle type

$$n_{IN,T_k} = (n_{aer,\,0.5})^a \cdot 10^{(b(273.16-T_k)+c)}$$

Aerosol type	$T_{Exp.}$ (°C)	a	b	c
Saharan/Asian dust	-15 to -35	1.25	-0.2	-5.05
Smoke (GA)	-20 to -32	0.707	-0.2	-5.95
Seaspray (CAICE)	-20 to -32	0.695	-0.2	-6.23
Forest site (PBAP)	-10 to -32	1.5	-0.2	-4.6

Ice in Clouds Tropical vertical profiles including dust and MBL aerosols



Conclusions and outlook

- IN predicted by parameterization linking to aerosols (numbers and size alone: DM10) agrees within expectations with observed values during ISDAC – still compiling a comprehensive comparison.
- Aerosol composition clearly assists in delineating ice nucleation activity. A power law form dependence on temperature and aerosol concentration, independently, describes most IN types.
- Inference that what is realized In any atmospheric situation is a combination of distinct behaviors of various IN.
- Analyses are continuing