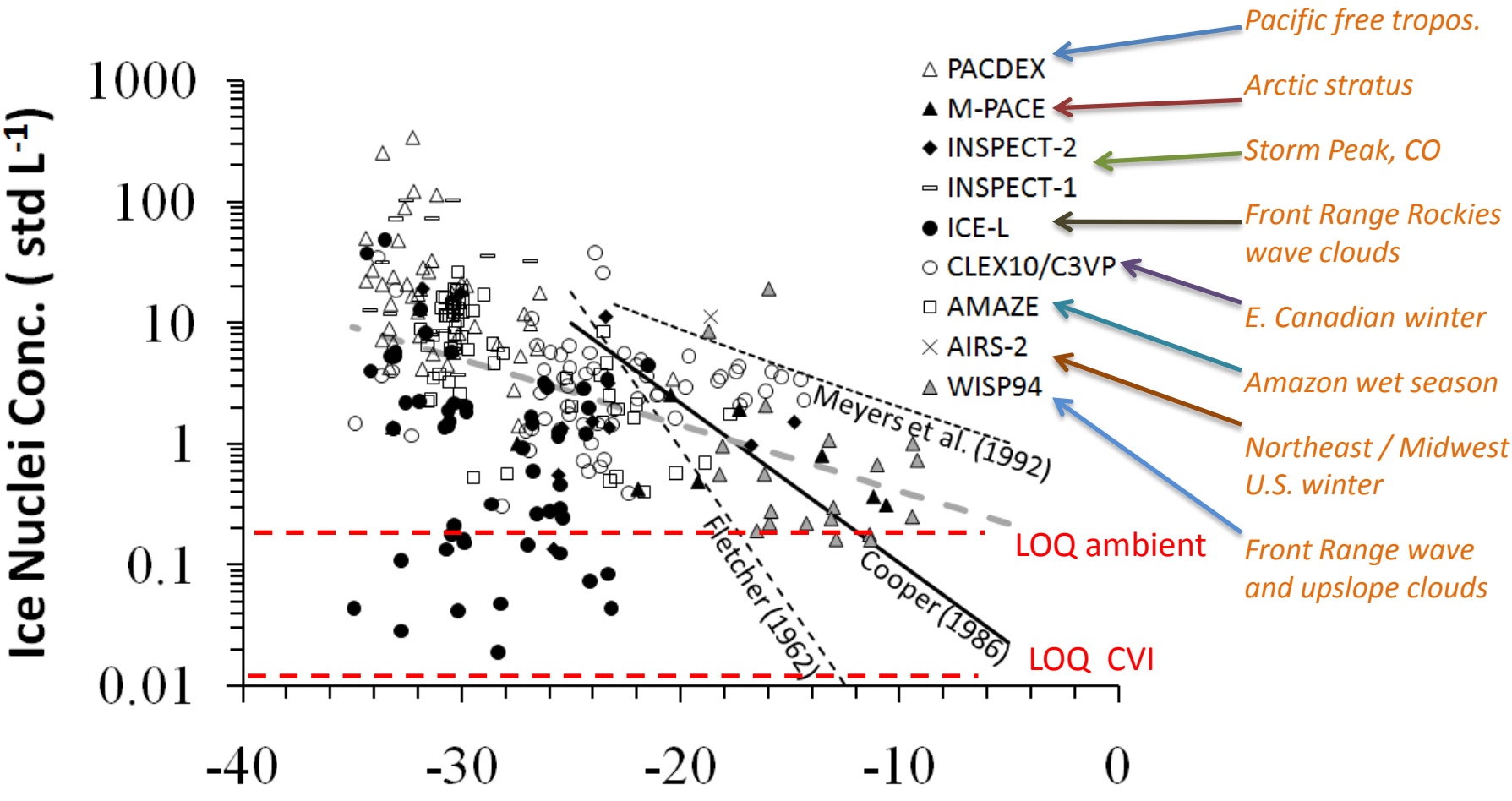
Some recent insights regarding atmospheric ice nuclei and validating/predicting their role in ice formation

Paul DeMott

(informal presentation to ICE-T Steering Committee (Jan 5, 2011)

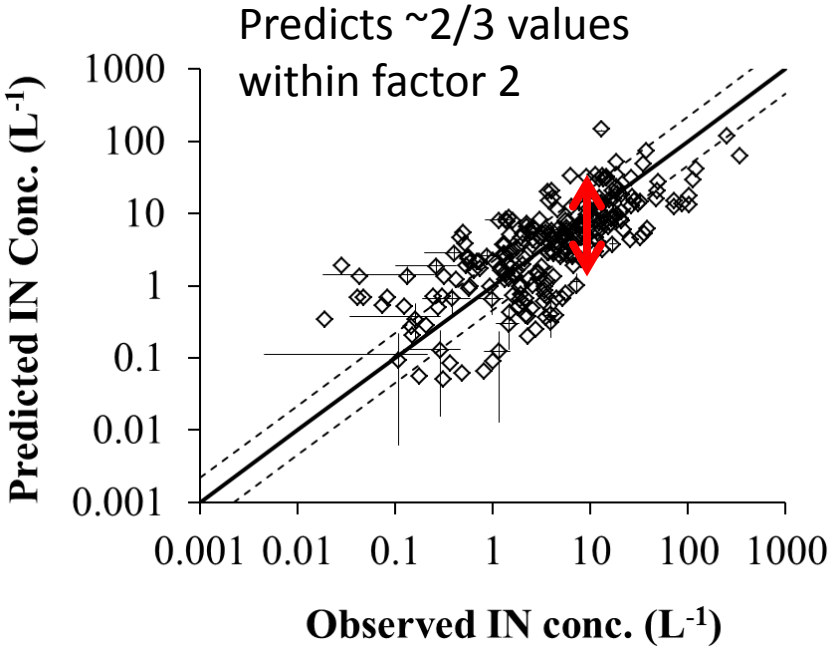
Ice nuclei concentrations (RH_w>100%) in projects over 14 years (292, 10-30 min. averages, coincident aerosol data)

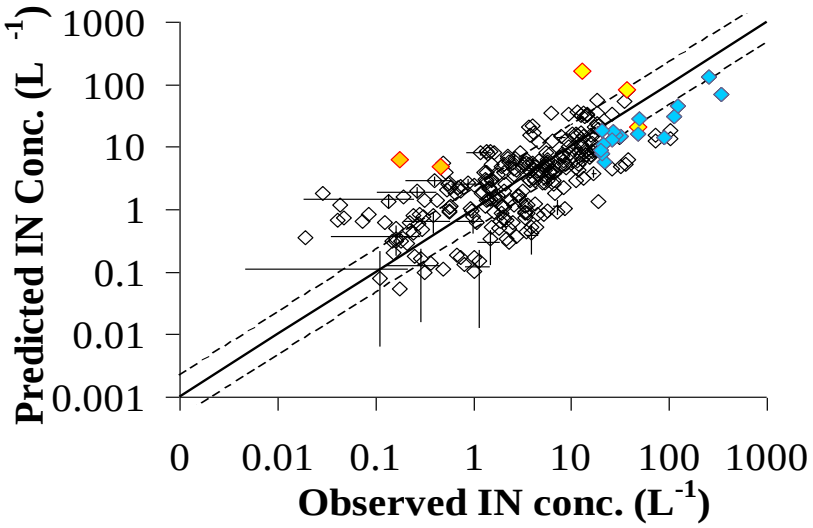


[*DeMott et al., 2010;* PNAS]

IN relation to aerosol size and extending this work to understand role of aerosol composition

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



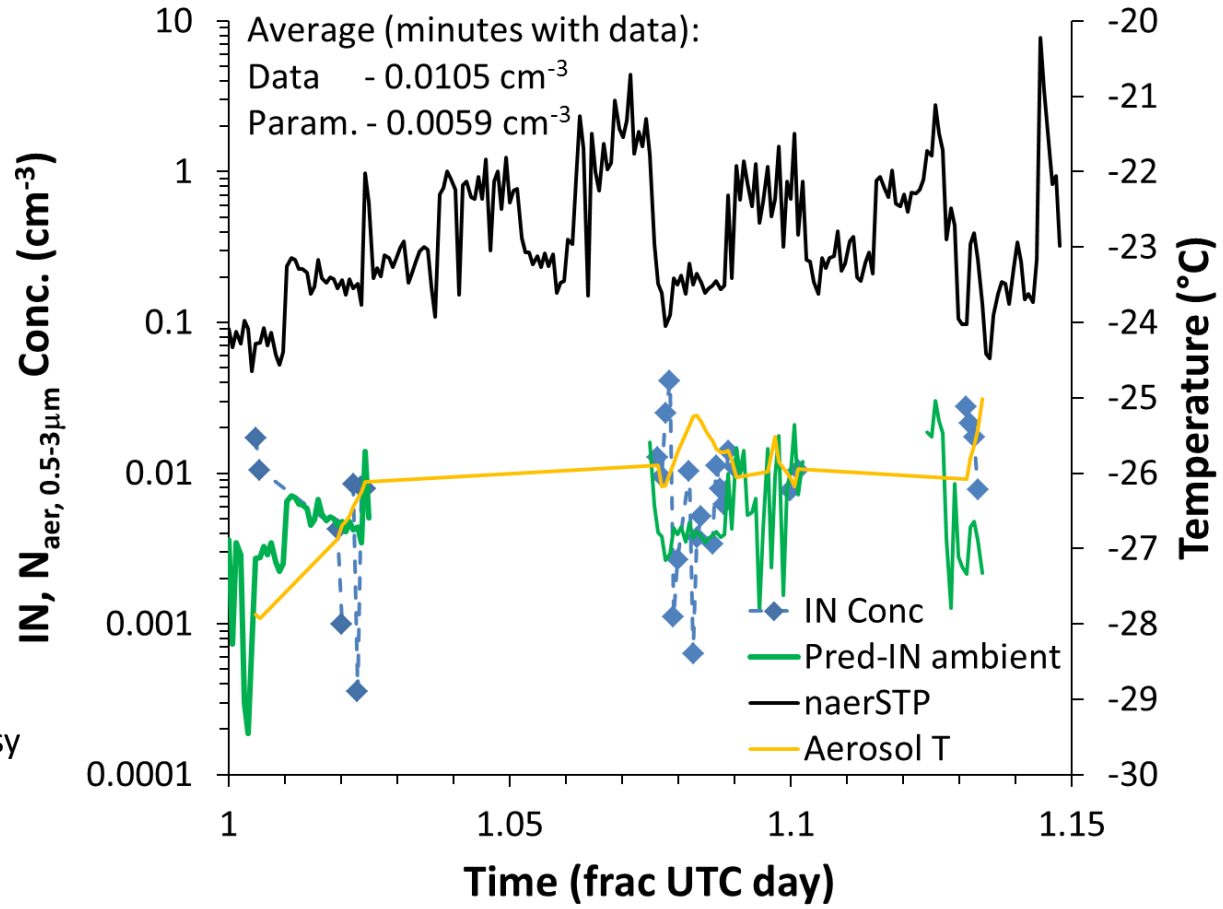


Side note: Recent lab studies at CSU and AIDA show virtually no impact of nitric acid or SOA processing on ice formation in the mixed phase regime warmer than -35C

- Heavy dust at high altitude near Japan (PACDEX)
- Prescribed burn plumes (ICE-L)
- Denver pollution (ICE-L)

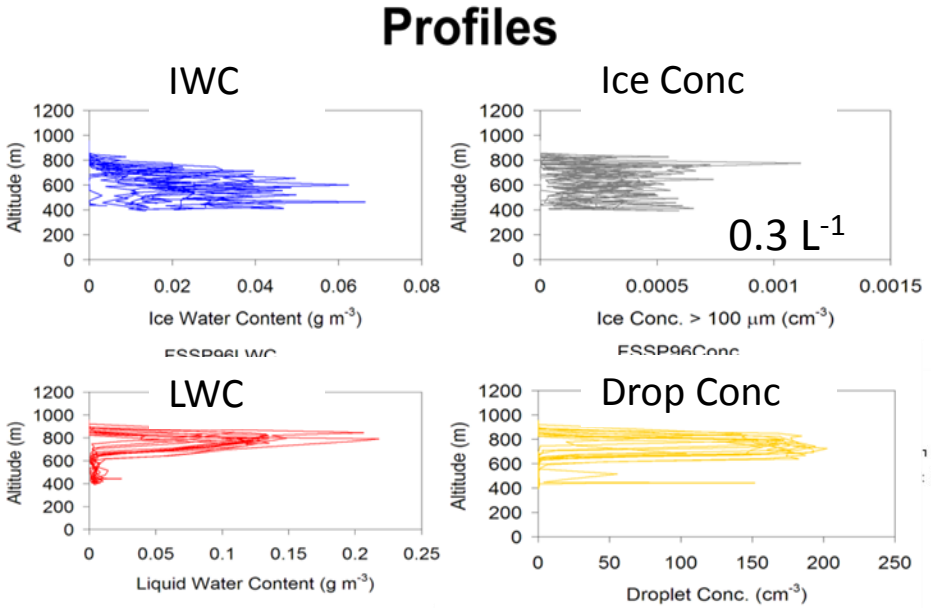
Use of ISDAC out-of-cloud PCASP number concentrations to predict IN versus TAMU CFDC

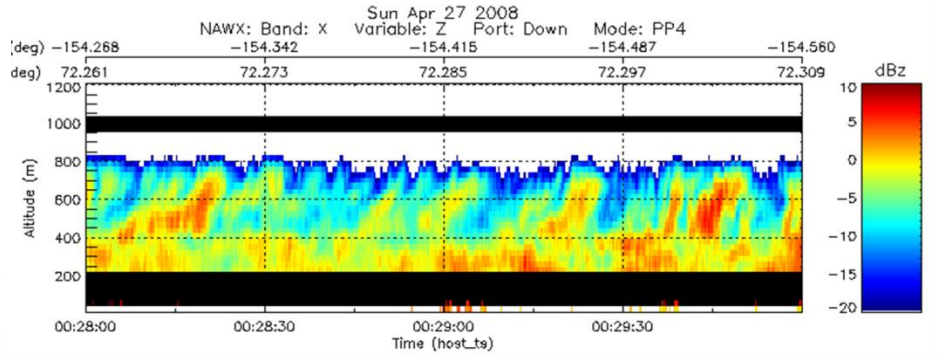
Flight 31 (April 26, 2008) – 1 min IN for $RH_{TAMU\text{-}CFDC}$ > 101%

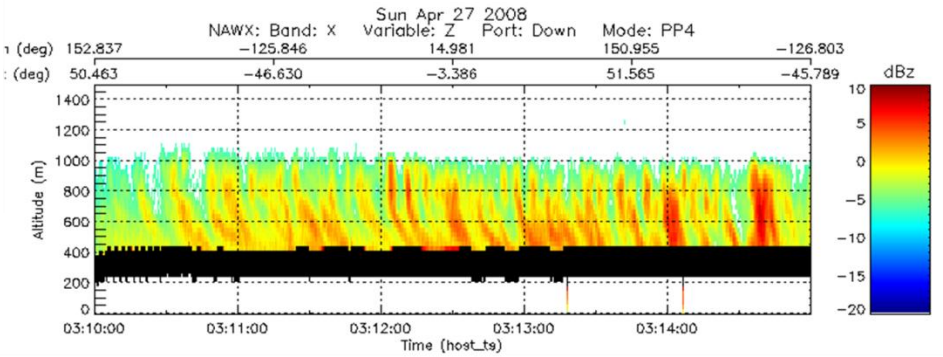


PCASP data courtesy of W. Strapp, P. Liu

DOE-ISDAC Flight 31 (April 26, 2008) case study – single layer, upper region liquid dominant, lower region ice- dominated, precipitating ice at times







Cloud data courtesy of W. Strapp, A. Korolev

Cloud radar data courtesy of M. Wolde

$N_1 = 206.9\ cm^{-3}$; $N_2 = 8.5\ cm^{-3}$

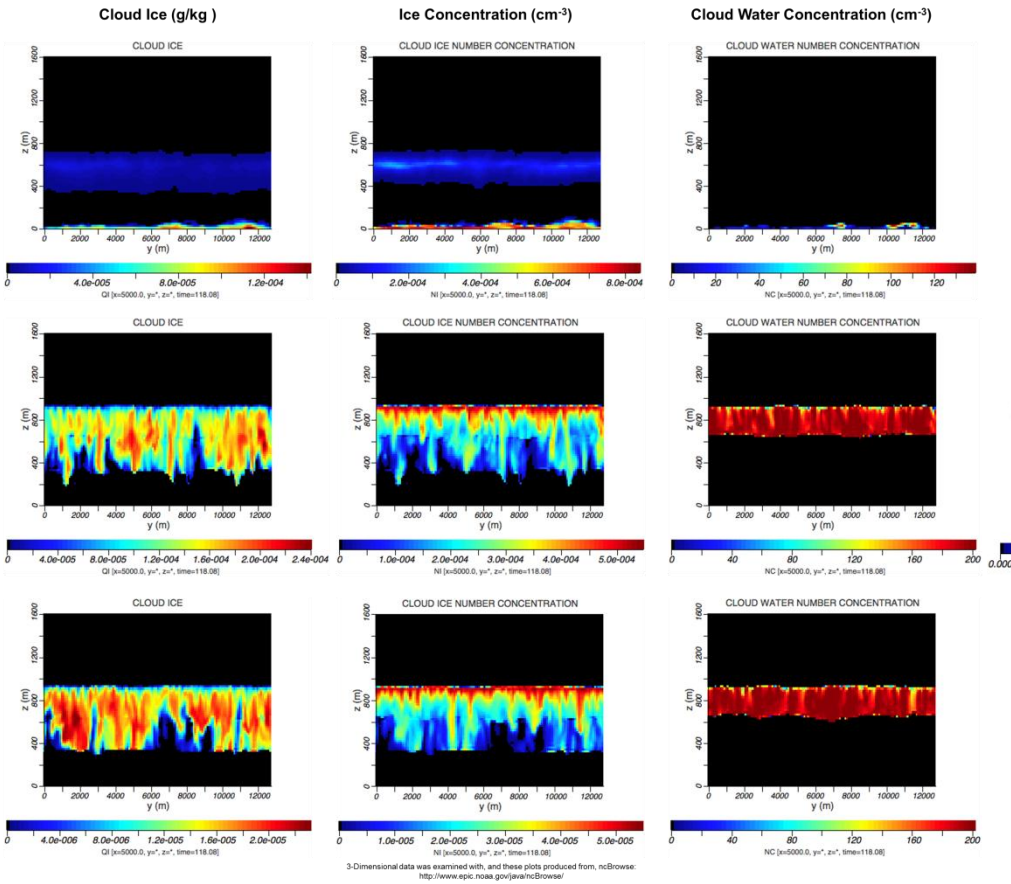
$s_1 = 1.50$; $s_2 = 2.45$

$d_1 = 0.2\ \mu m$; $d_2 = 0.7\ \mu m$

Aerosol data courtesy of Mikhail Ovchinnikov, Michael Earle

Simulations and sensitivity studies of ISDAC cases using the System for Atmospheric Modeling (SAM v 6.8.2) CRM w/ 2-moment microphysics

12-Hour Simulation Results



10 x IN_D

Early glaciation of cloud water and early precipitation

IN_D (from DeMott et al. (2010))

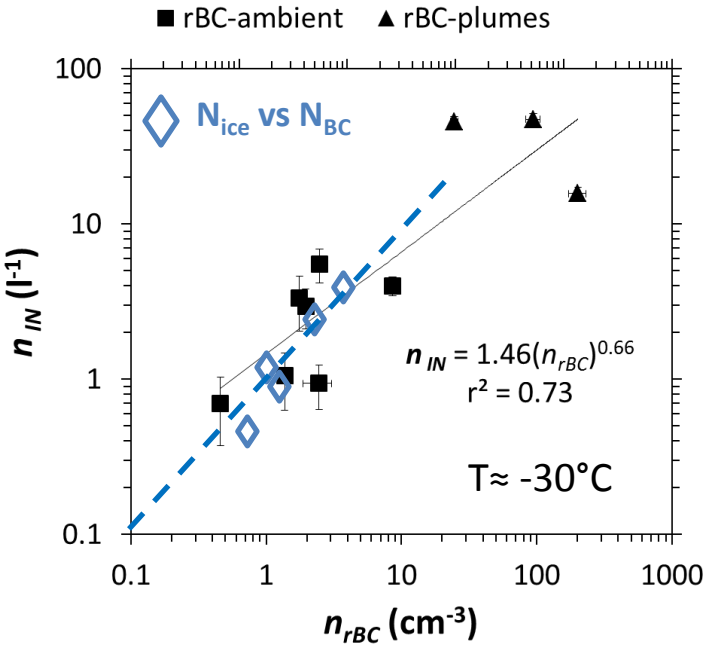
Ice conc. (0.2-0.3 L^{-1}) and precipitation to surface

0.1 x IN_D

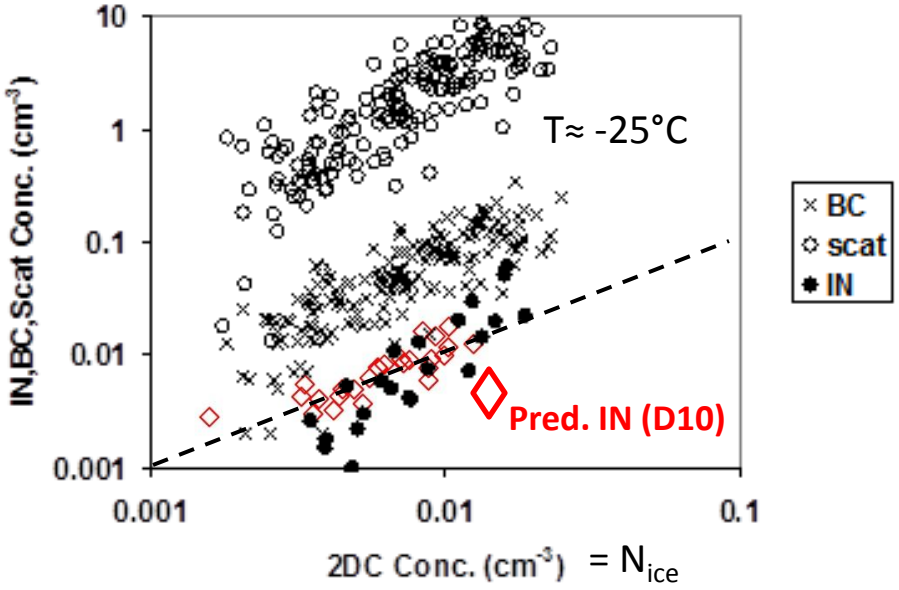
Ice conc. low by ~10; no precipitation to surface

IN and ice concentration relations to black carbon: direct (ice nucleation) or due to scavenging?

Wave clouds from Twohy et al,. (J. Atmos. Sci., 2010)



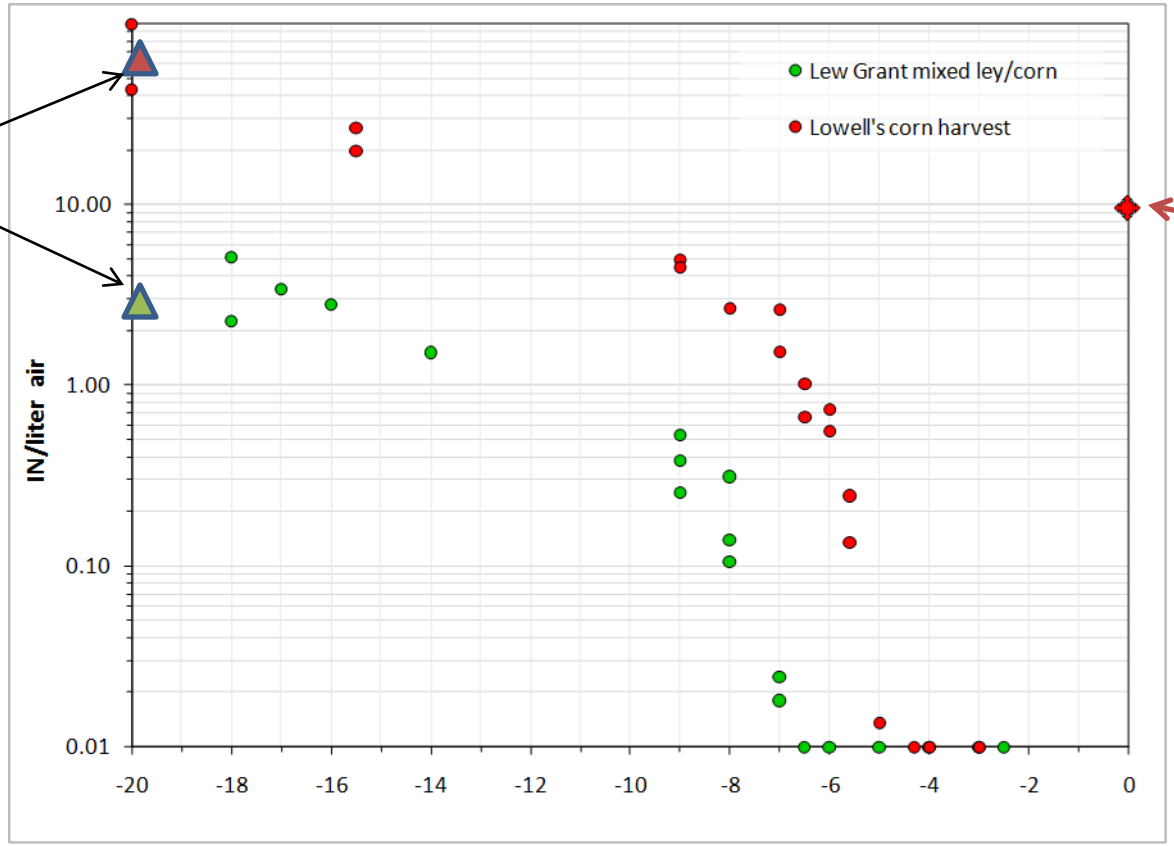
Extratropical warm frontal clouds from Stith et al. (ACPD, 2010)



- Apparent relation of IN and ice to BC in two cloud types, but no consistent relation between number concentrations – suggests scavenging
- Relation between IN and ice in clouds at same temperature
- Parameterization predicts ice in case of Pacific warm frontal ice clouds

Recent investigations of biological IN collected over agricultural fields

CFDC IN measurements in real-time



Measured number of INA bacterial cells in air based on genomic analyses

What we will be doing and looking for in ICE-T

- Emphasis on attempting to extend measurements to somewhat larger particle sizes to emphasize dust and biological IN.
- Emphasis on adding much more IN data in the temperature regime > -20C.