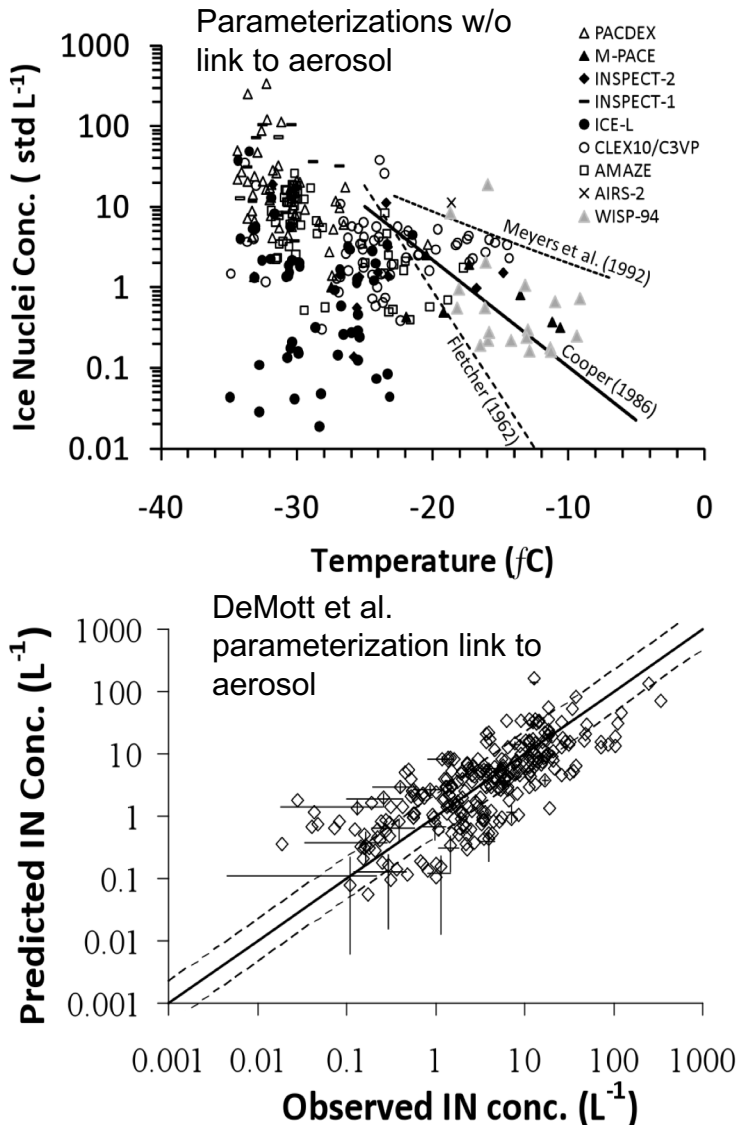
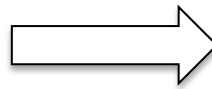


INP model evaluation: Motivations

Parameterized vs. observed INP

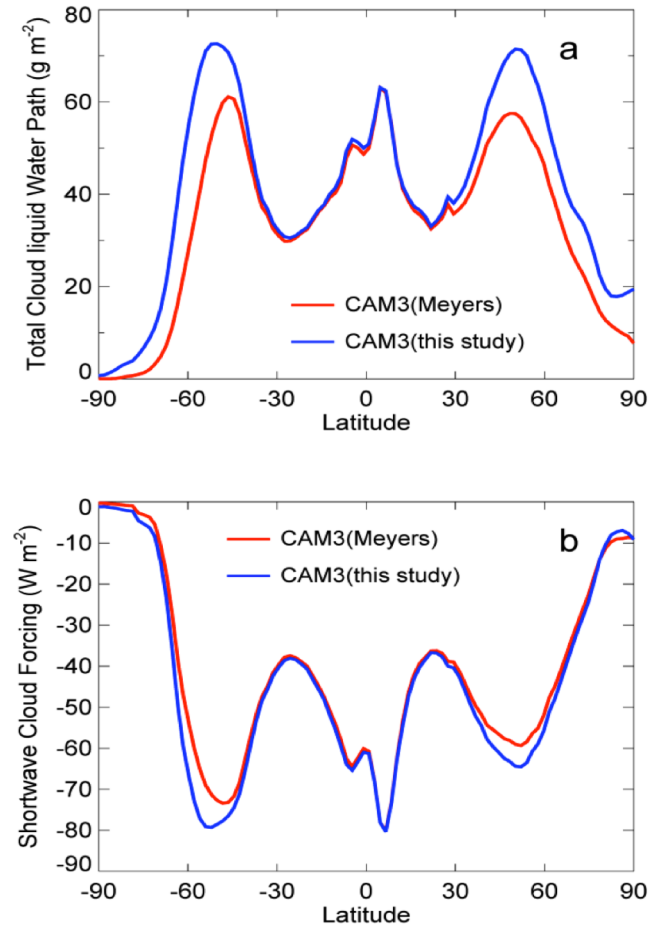


Multiple ice nucleation mechanisms related to aerosol & meteorological conditions



Uncertainties in IN parameterizations produce significant changes in CAM modeled LWP, cloud forcing and cloud fraction

LWP and SWCF with two INP parameterizations



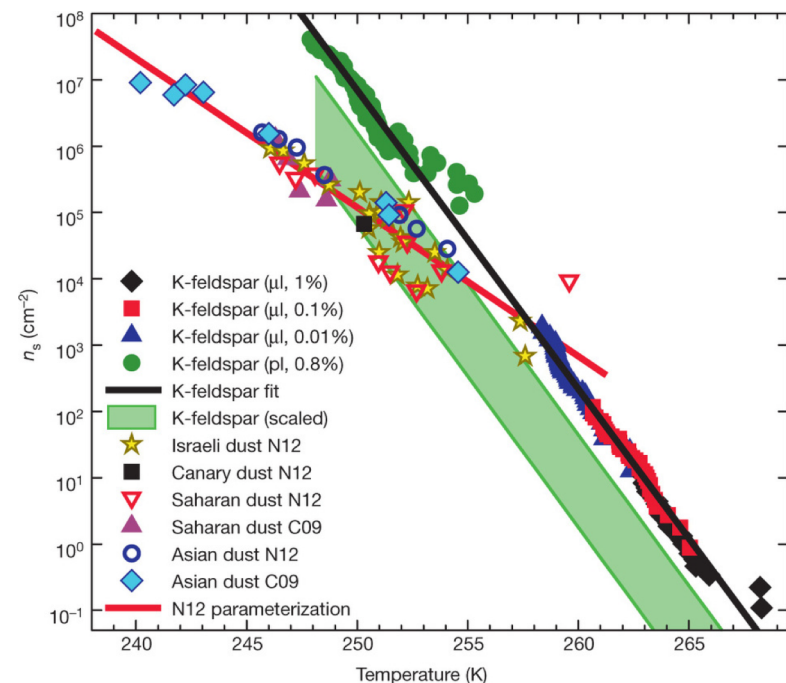
DeMott et al. (2010)

INP model evaluation: Challenges

- Model treatment of different ice nucleation mechanisms:
 - Immersion, deposition, contact, etc.
- Model uses of different parameterizations:
 - CNT (time-dependent) vs. empirical formulations
 - n_a ($D > 0.5 \mu\text{m}$) vs. n_s (bulk) vs. n_s (feldspar) vs. a_w
 - Links to different types of aerosols (dust, BC, and biological aerosol)

Atkinson et al. (2013) – immersion on K-feldspar

$$n_s(T) = \exp(-1.038T + 275.26) \quad \text{for } 248 < T < 268\text{K}$$

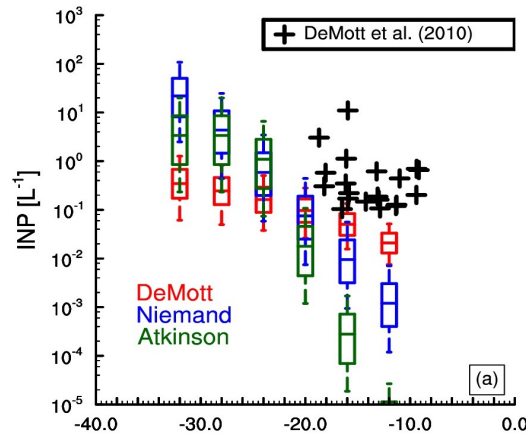


INPs model evaluation with observations

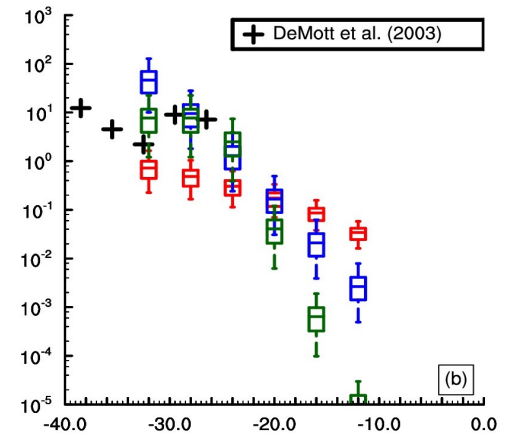
- CAM5 model diagnosed INP concentrations from DeMott et al. (2015), Niemand et al. (2012), and Atkinson et al. (2013) compared with CFDC observations

- Model does better at lower temperatures ($T < -20^{\circ}\text{C}$) than at higher temperatures (missing biological INPs?)
- Model significantly underestimates INPs at Barrow, indicating generally model low biases of aerosols at high latitudes

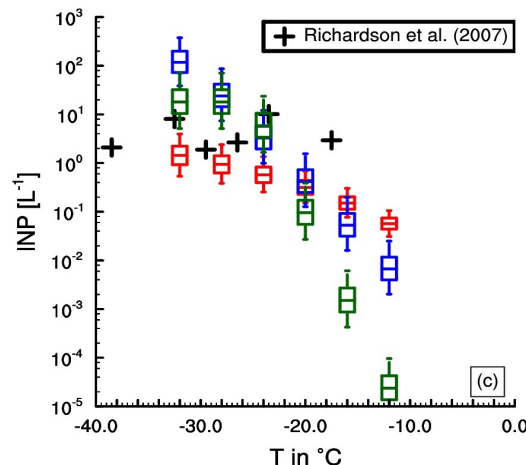
(a) Colorado region from WISP94 (February/March)



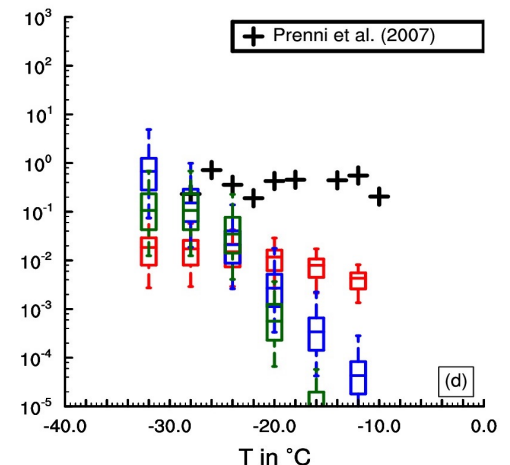
(b) Storm Peak, Colorado (November)



(c) Storm Peak, Colorado (April/May)

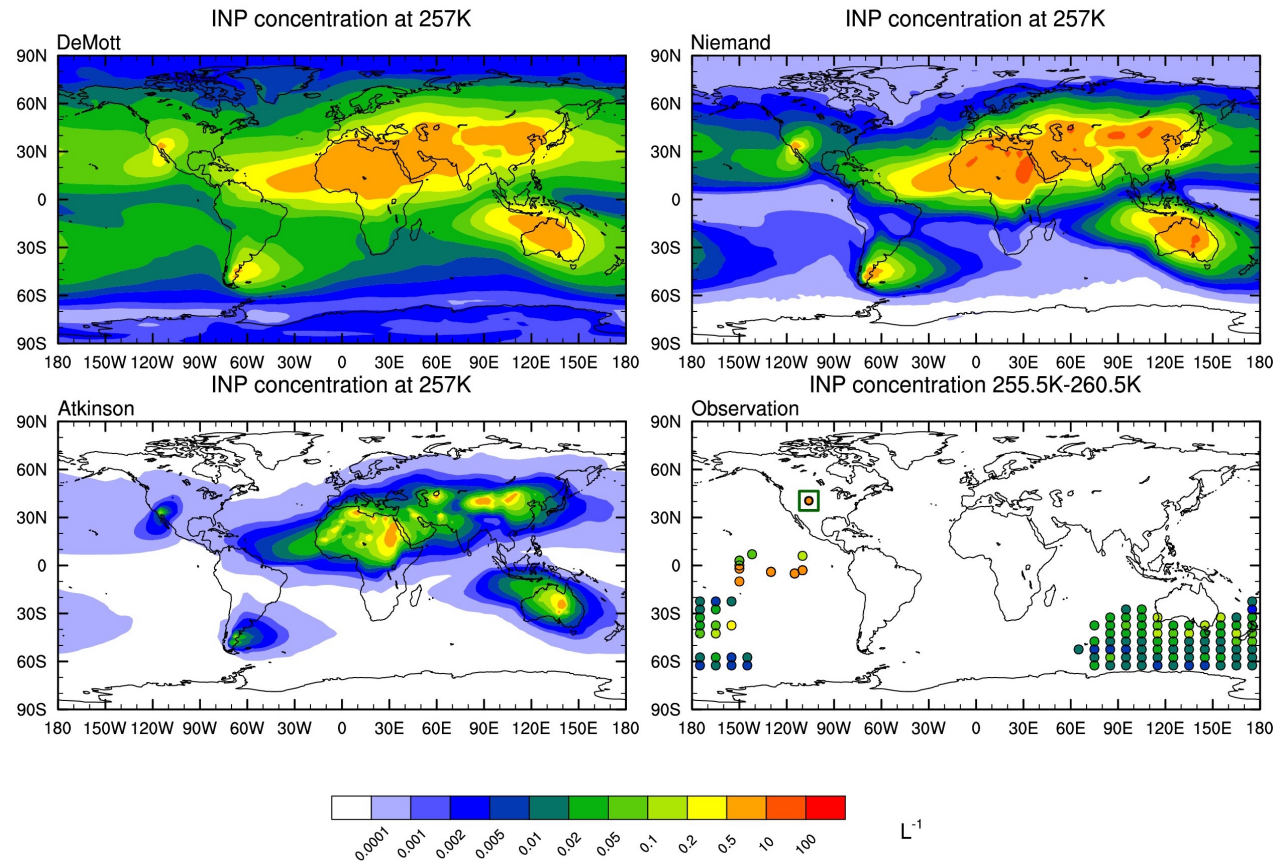


(d) Barrow, Alaska (October)



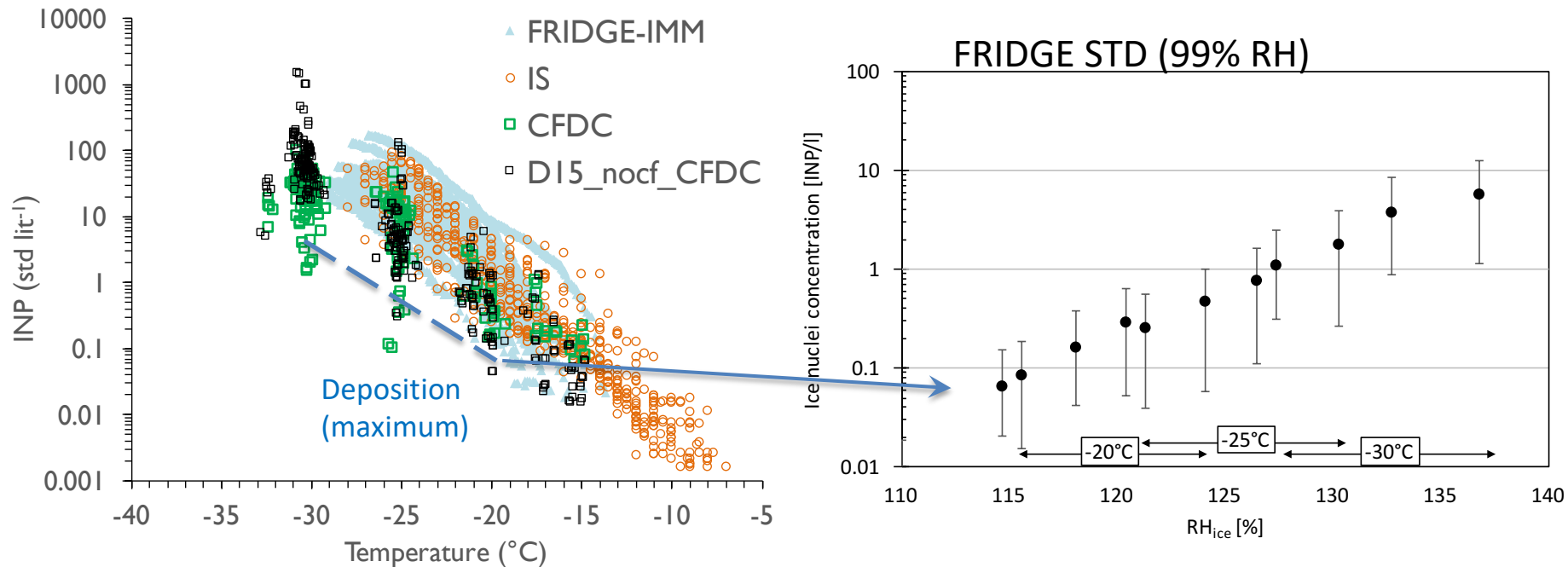
INPs model evaluation with observations

- CAM5 model diagnosed INP concentrations from DeMott et al. (2015), Niemand et al. (2012), and Atkinson et al. (2013) compared with CFDC observations
- Model significantly underestimates INPs over Southern Oceans, indicating model missing of marine biogenic INPs
- Modeled INP from Niemand et al. is higher near sources than others, DeMott et al. gives higher INPs in remote regions, while Atkinson et al. is lowest almost globally, indicating different dependences on T and aerosols of the three parameterizations.



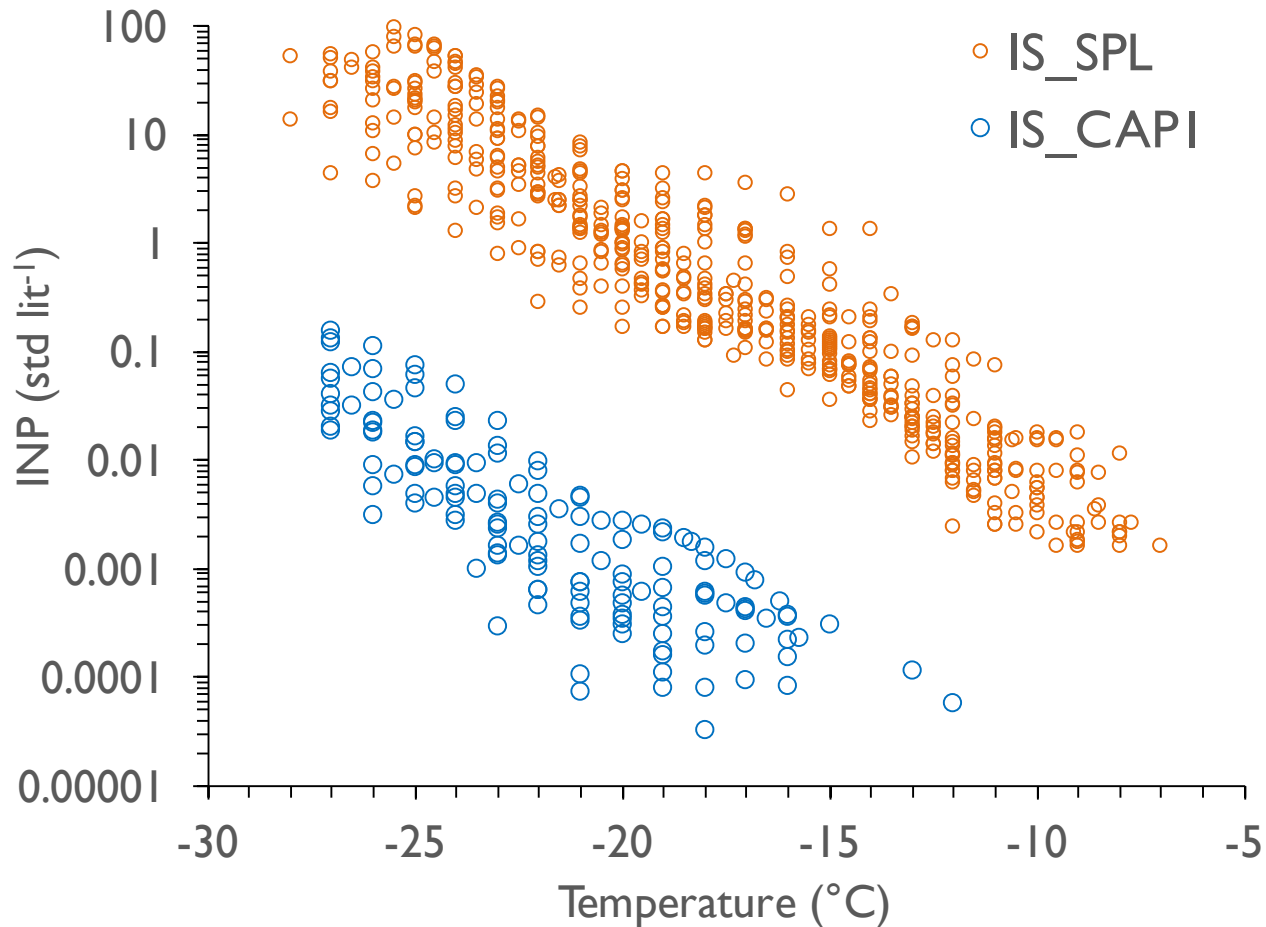
Top-level data set example: FIN-03 at Storm Peak Lab

(data set includes size, composition, thermal testing of INPs etc...)



Other recent or upcoming regional data from:
Oliktok, Svalbard, Cyprus, Mace Head, Puy de Dome

NH continental vs SH remote ocean



More Southern Ocean databases (existing or forthcoming):
MARCUS, MICRE,
SOCRATES, TANGAROA,
circum-Antarctica

Pre-campaign modeling activities?

- Potential objectives
 - establish global model spread by location, season, nucleation mode, environmental conditions
 - identify largest differences and first-order causes (e.g., dust loading differences?)
 - identify radiatively most relevant differences?
 - establish availability of existing INP measurements by mode
 - identify existing colocated data suitable to further evaluation
 - work out methods for comparing differing model schemes with differing measurements
 - suggest field measurement priorities
- Model sensitivity to different aerosols and ice nucleation parameterizations
 - CAM6/MAM vs. ModelE3/MATRIX vs. any other participating
 - idealized aerosols vs. modeled aerosol fields
 - which current observational data sets most suited?