A COMPARISON OF AEROSOL OBSERVATIONS FROM FIRE-ACE AND ISDAC FIELD PROJECTS AND ICE CLOUD MICROPHYSICAL PROPERTIES

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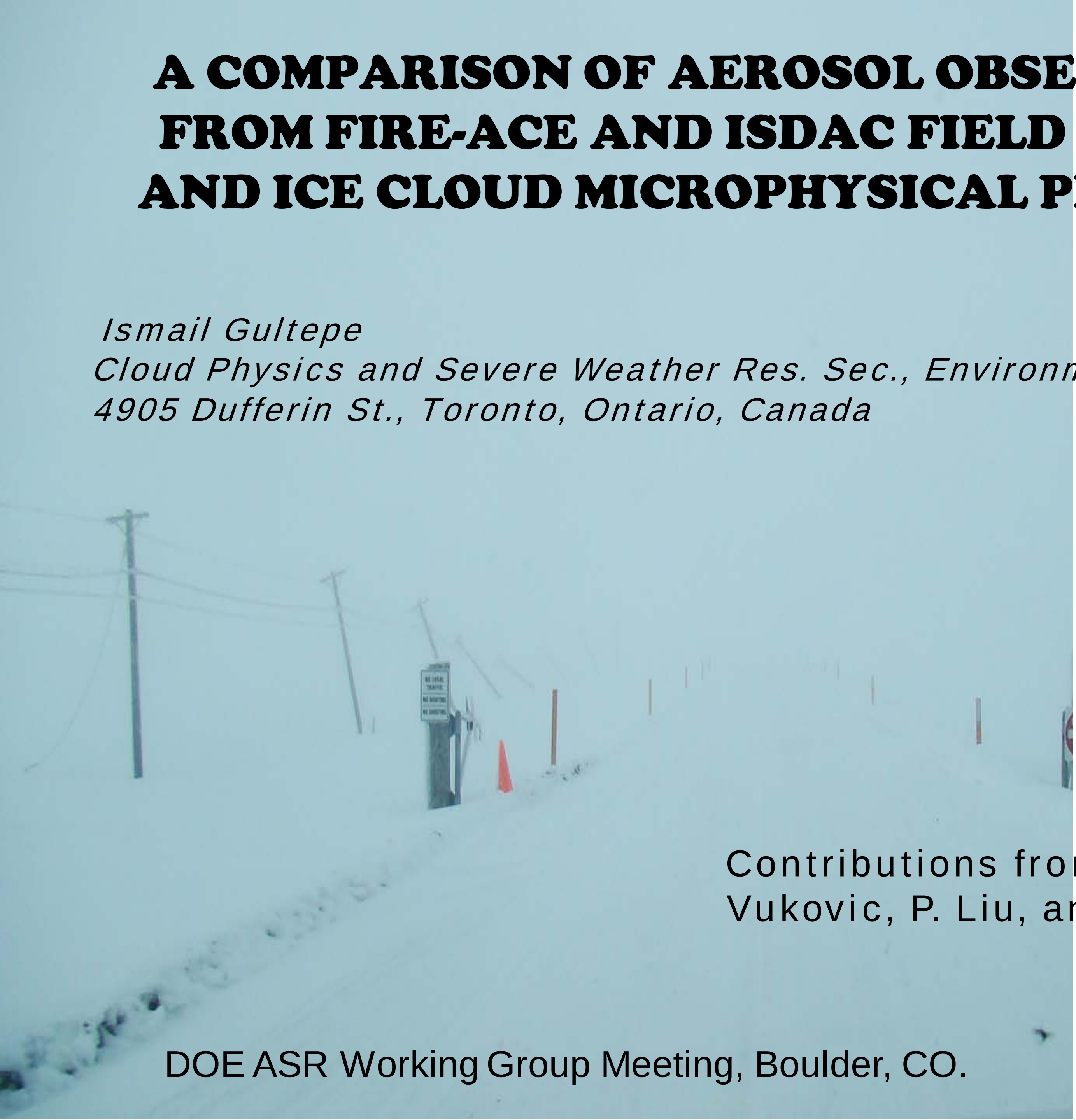


Contributions from N. Shantz, Z. Vukovic, P. Liu, and W. Strapp

DOE ASR Working Group Meeting, Boulder, CO.

Objectives

- **Show differences in ice crystal and aerosol number concentrations obtained during FIRE-ACE and ISDAC projects and previous work.**

- **Discuss parameterizations between Ni versus RHi, T, and/or Na, and understand variability.**

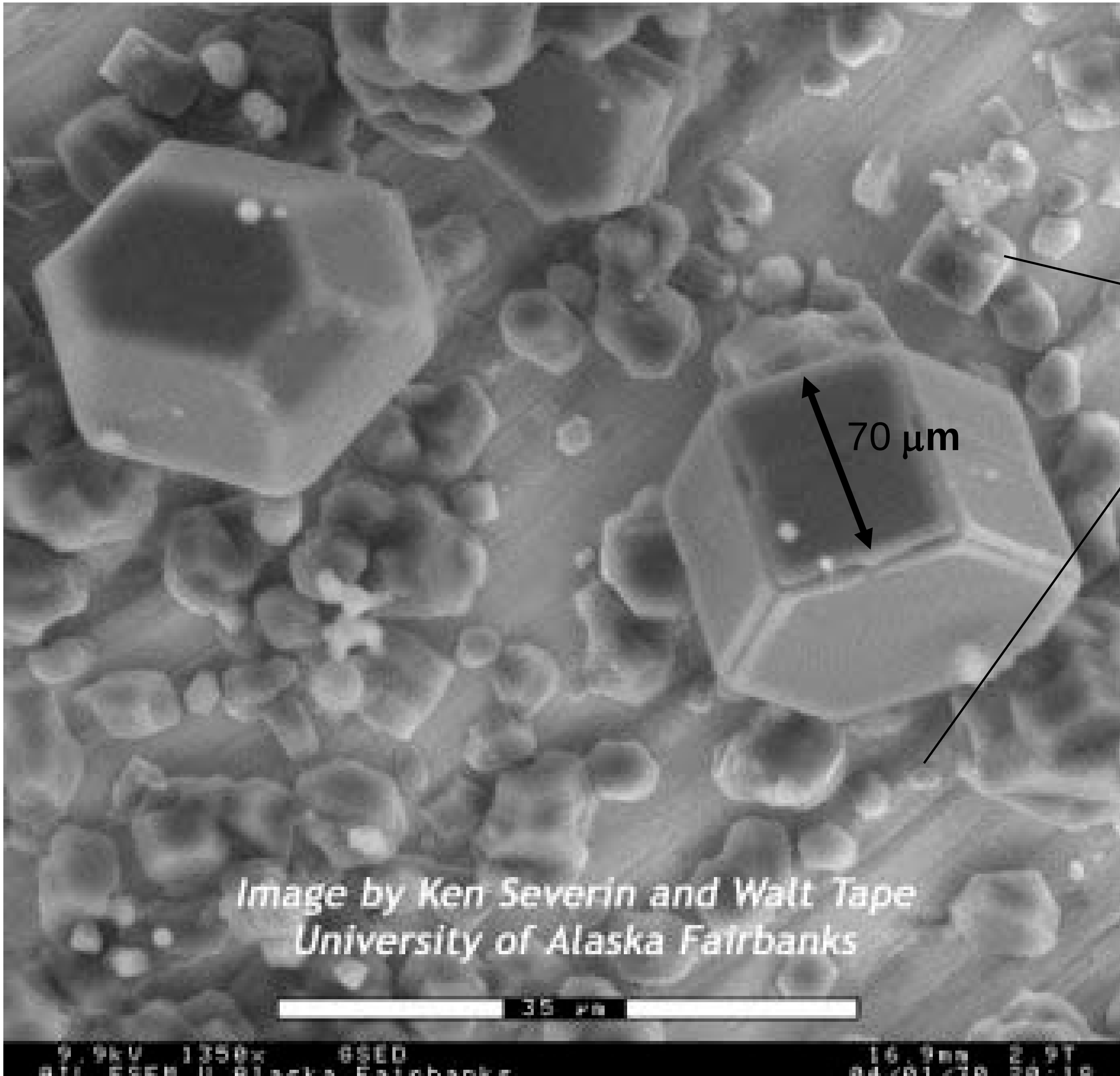
- **Emphasize the importance of ice crystal shape versus T, and existence of small ice crystals.**

AIRCRAFT OBSERVATIONS

- 2DC Ni (25-800 μm)/2DP (200-6400)
- FSSP/LWCk/CDP
- RID for icing
- T and RHw/RHi
- 2DS (SPEC) and CIP (DMT) measurements

FOCUS ON WORK OF

- Fletcher
- Meyers et al
- DeMott et al
- Ryan et al
- Gultepe et al
- Twohy et al
- Phillips et al
- AND
- ISDAC/FIRE-ACE observations



(photo courtesy Ken Severin)

ICE FOG

SMALL ICE CRYSTALS:

3-25μm

Ni=10-70 cm^{-3}

Ni(small size)= 100xNi(Large size)

JULY 1992 **IN/Ni versus T** MEYERS

1992

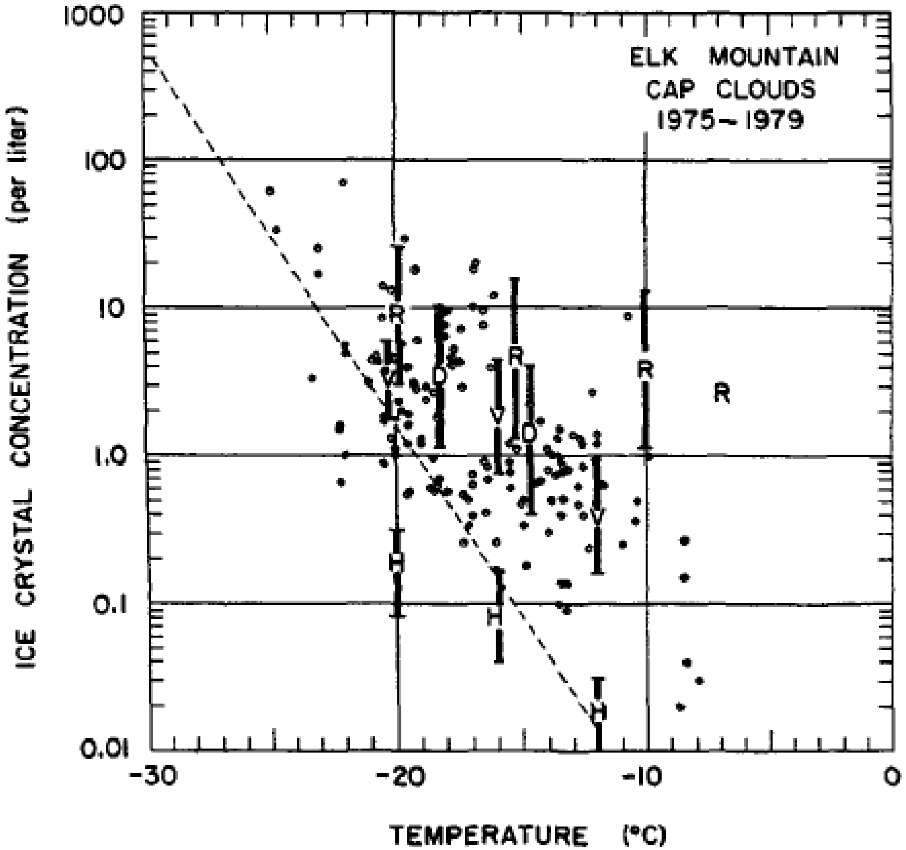


FIG. 2. Summary of ice-crystal concentration measurements in Elk Mountain cap clouds. Each aircraft data point (circle) represents a cloud penetration average (30 clouds on 26 days). Geometric means and standard deviations of ice-nucleus data are from (H) Huffman's (1973) membrane filter measurements, from (V) Vali's (1974 and 1976) and (D) Deshler's (1982) contact-freezing nucleus measurements, and from (R) Rogers (1982) continuous-flow diffusion chamber measurements. Fletcher's (1962) ice-nucleus curve is also

JULY 1992 MEYERS

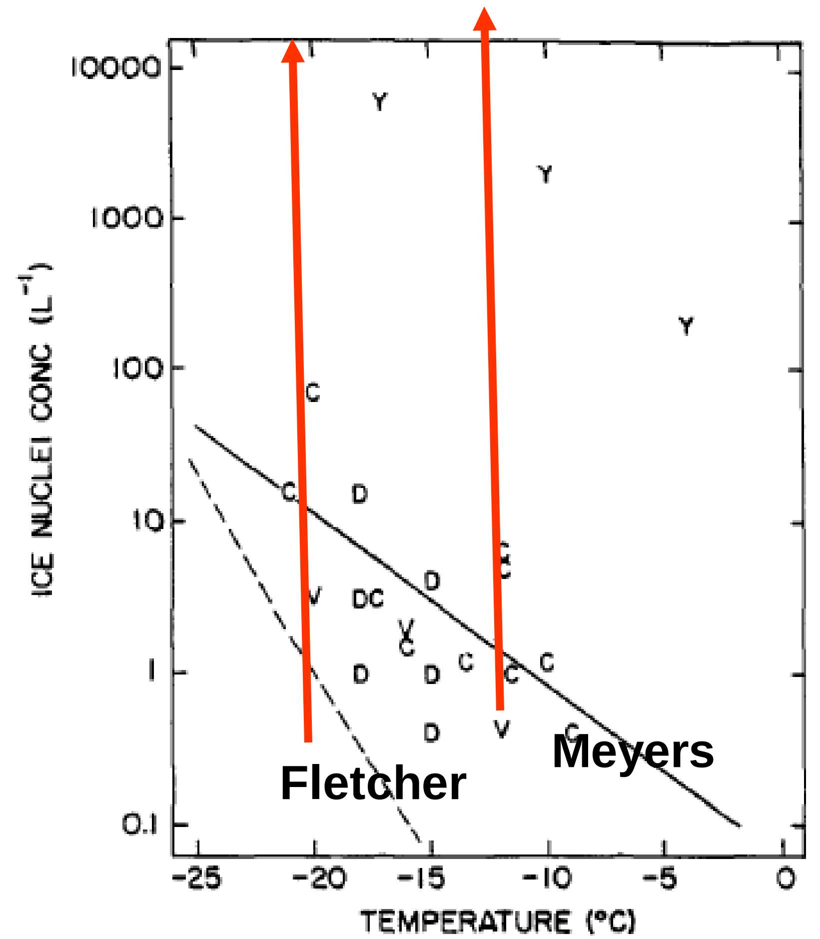
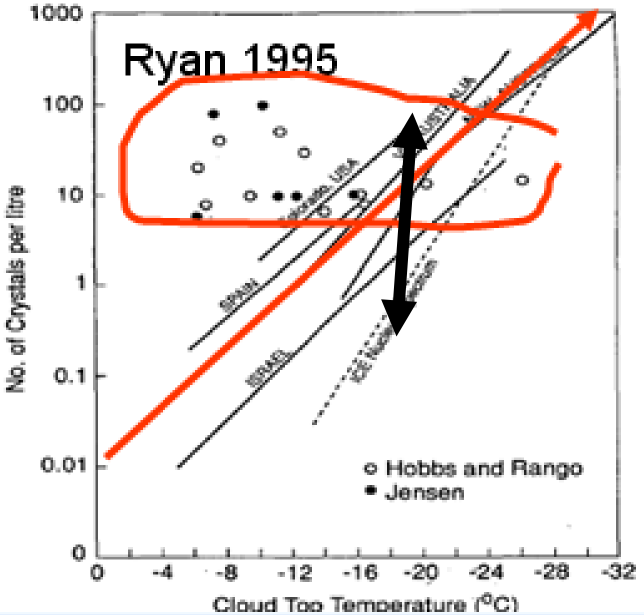


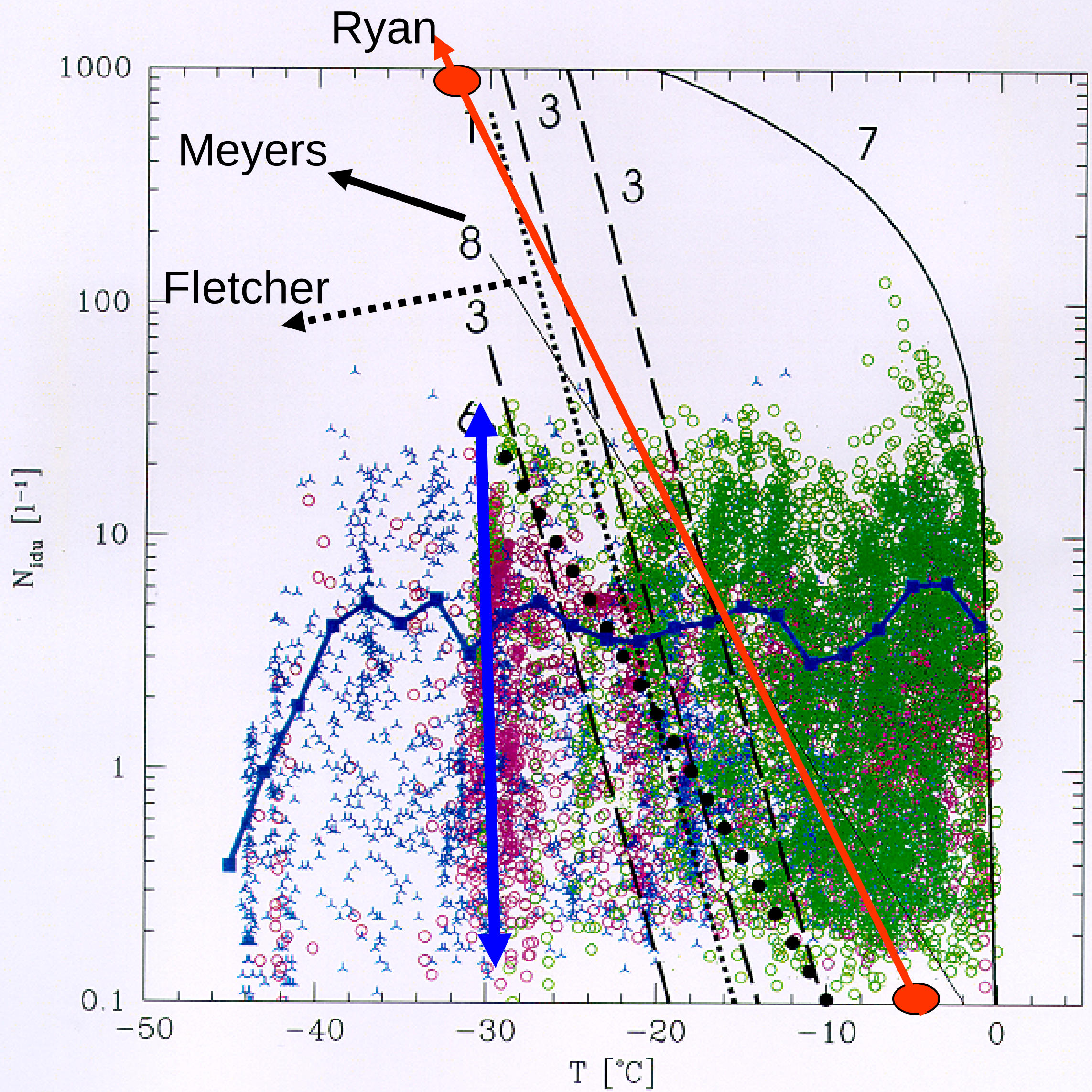
FIG. 4. Summary of measurements of contact-freezing ice-nuclei concentrations made by various authors (C, D, V) as discussed in text. For comparison, the estimates of Young (1974a) (Y) are shown. The regression line is an exponential fit to measurements. Fletcher's (1962) ice-nucleus curve is also shown for reference (– – –).

Ni-T: earlier projects

1995

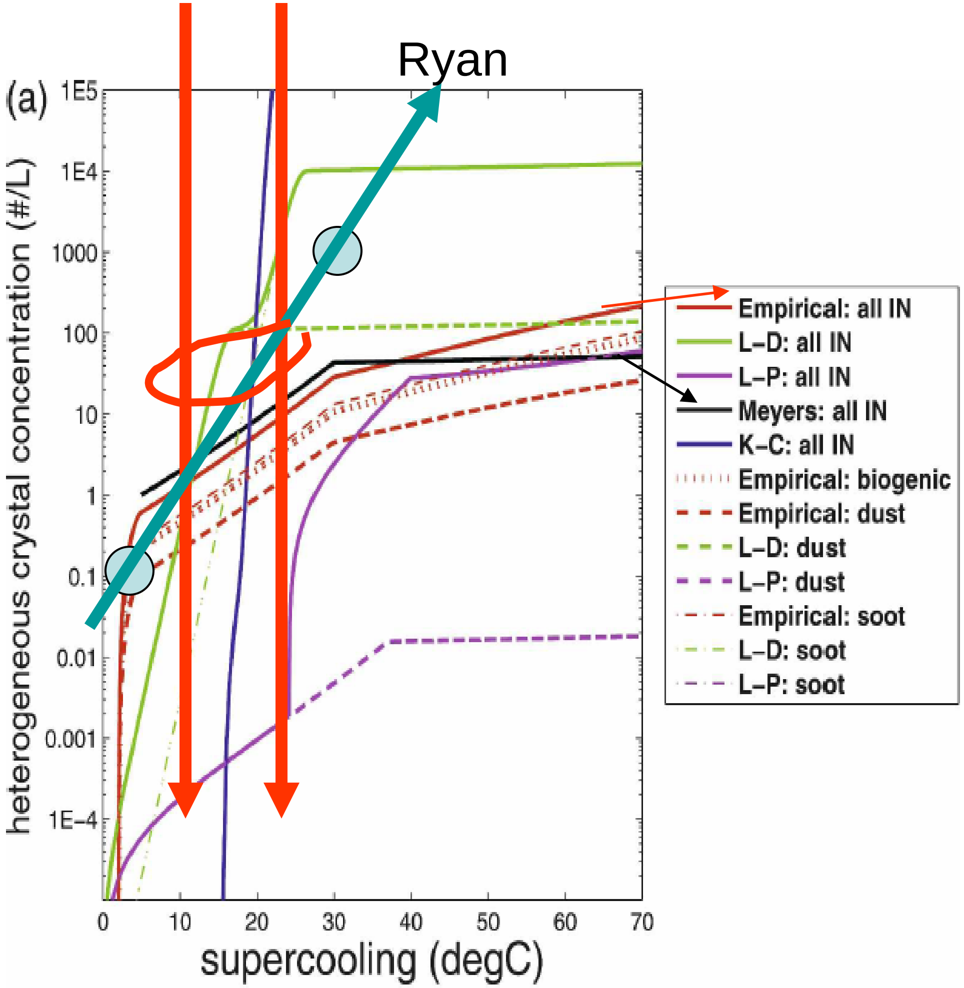


2001

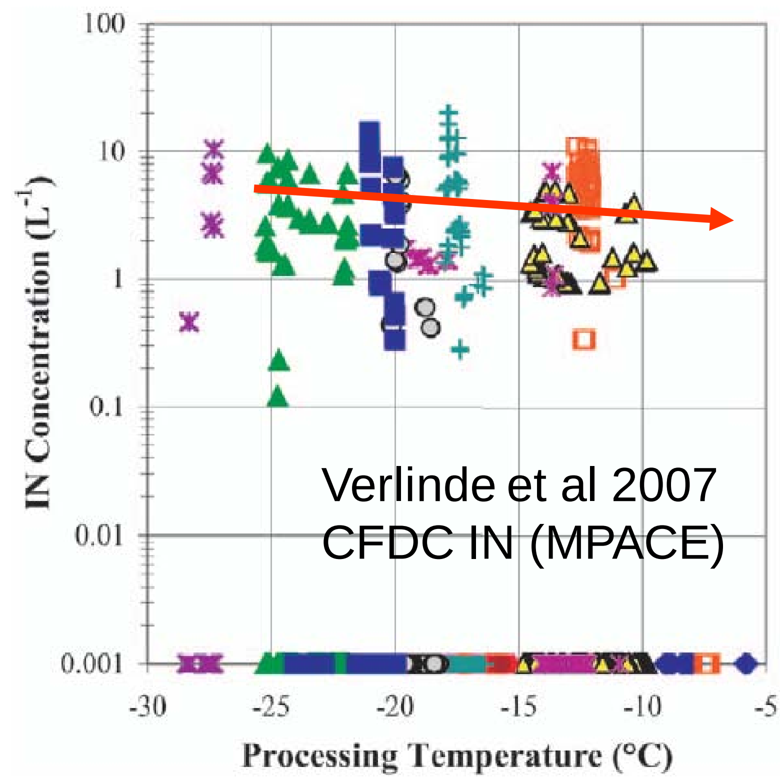


Gultepe et al., 2001; Inter J. climate

2008



Phillips, DeMott, and Andronache, 2008



2007

- No correlation between IN and T

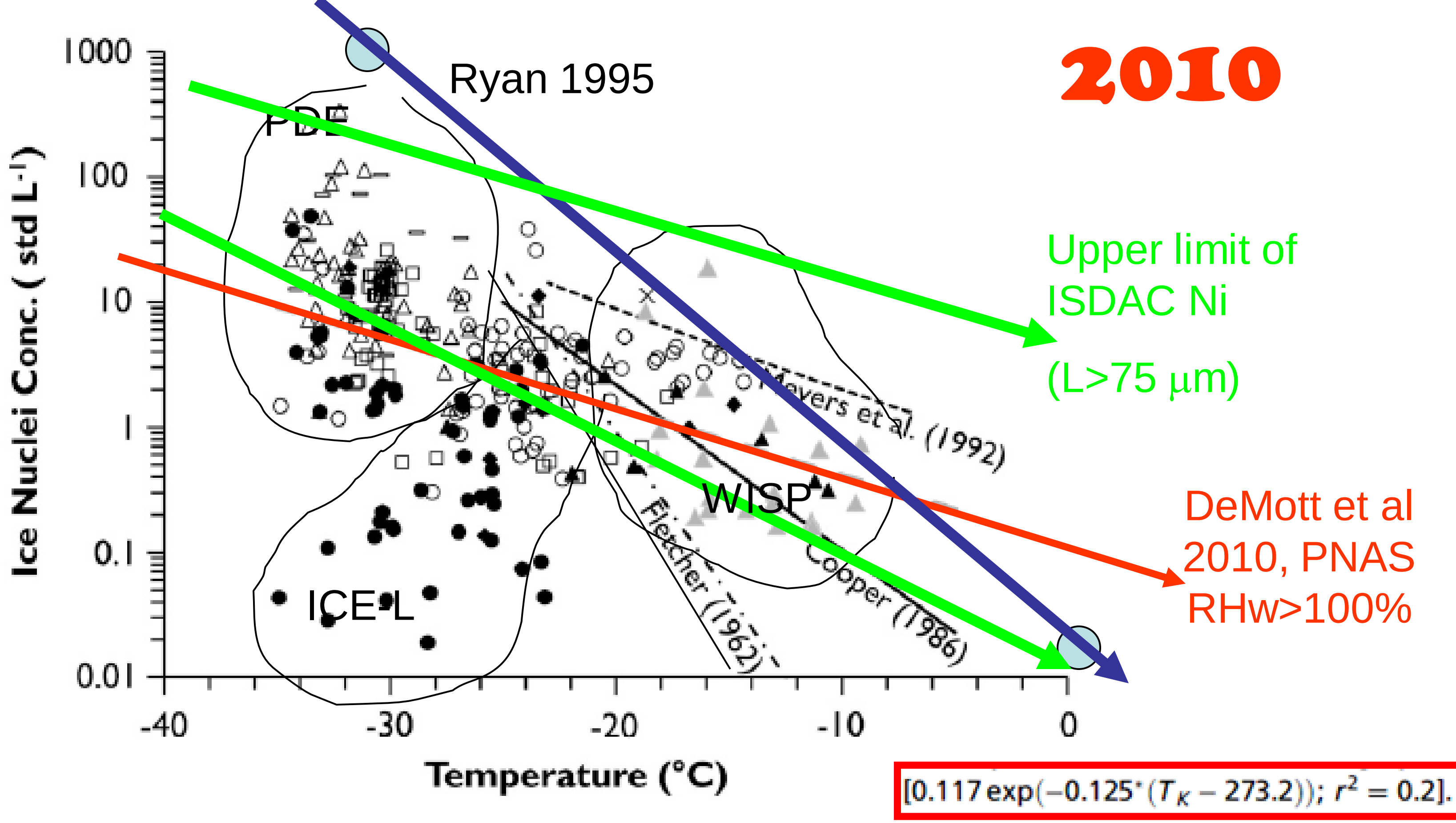
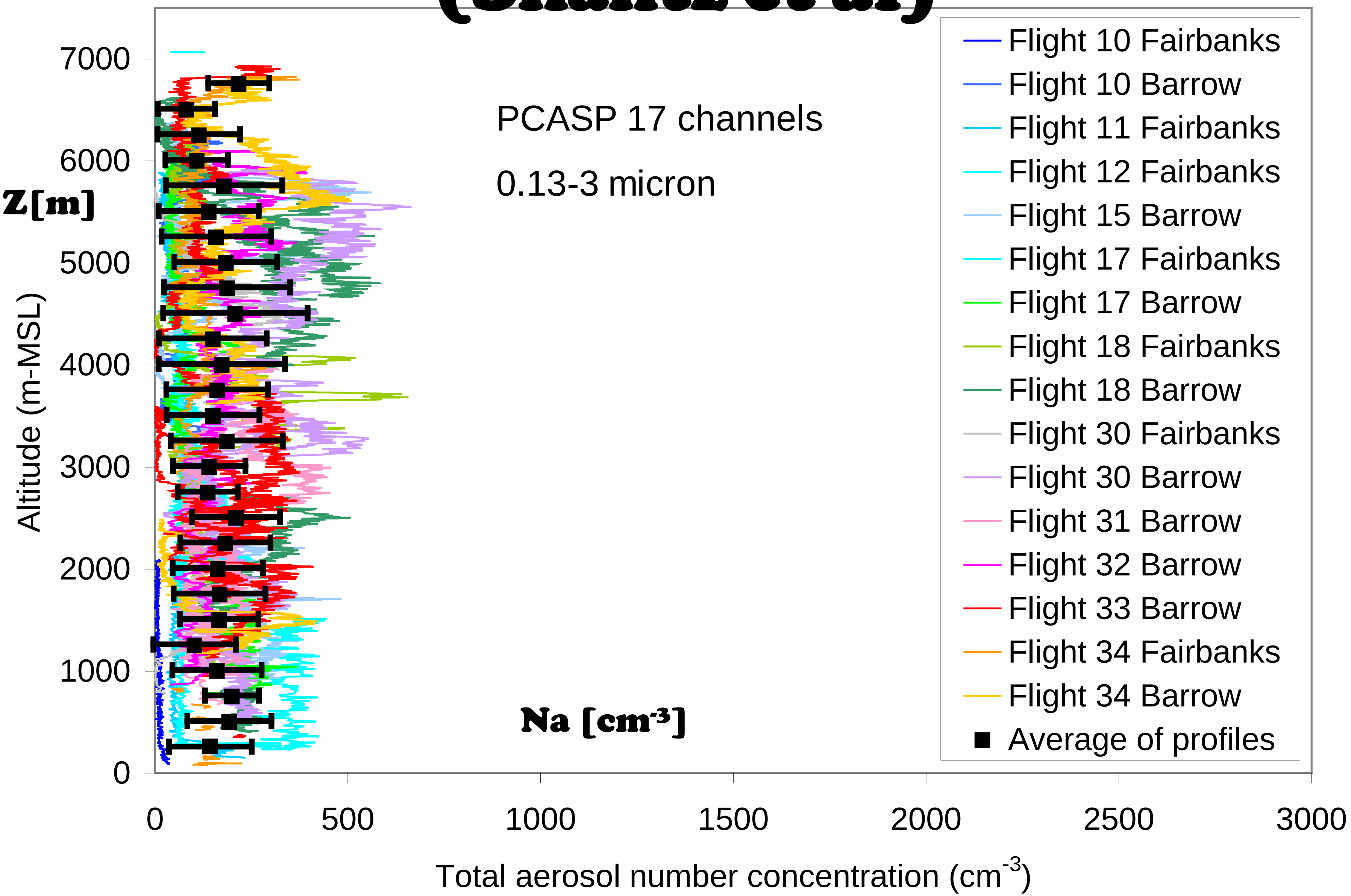
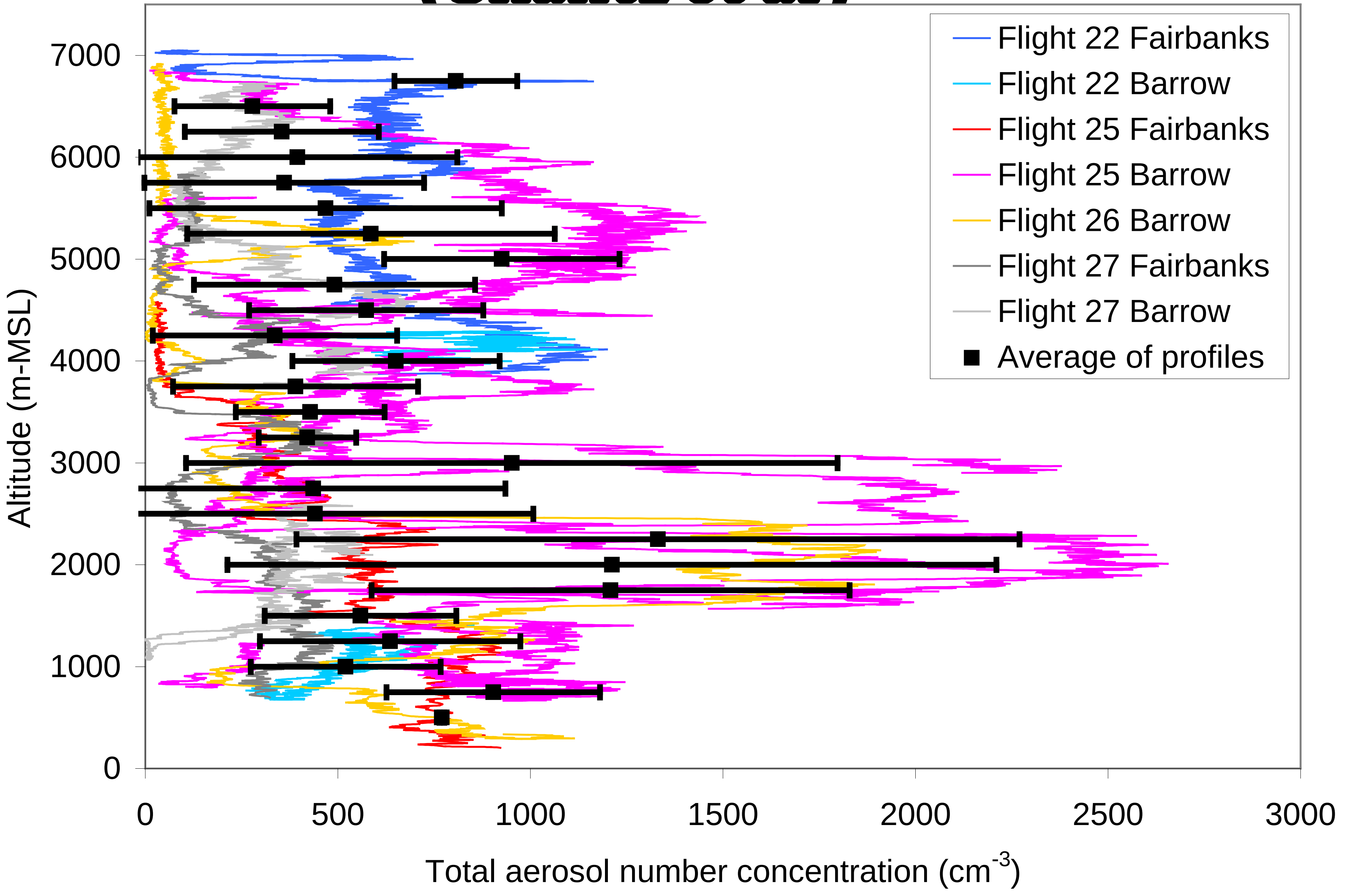


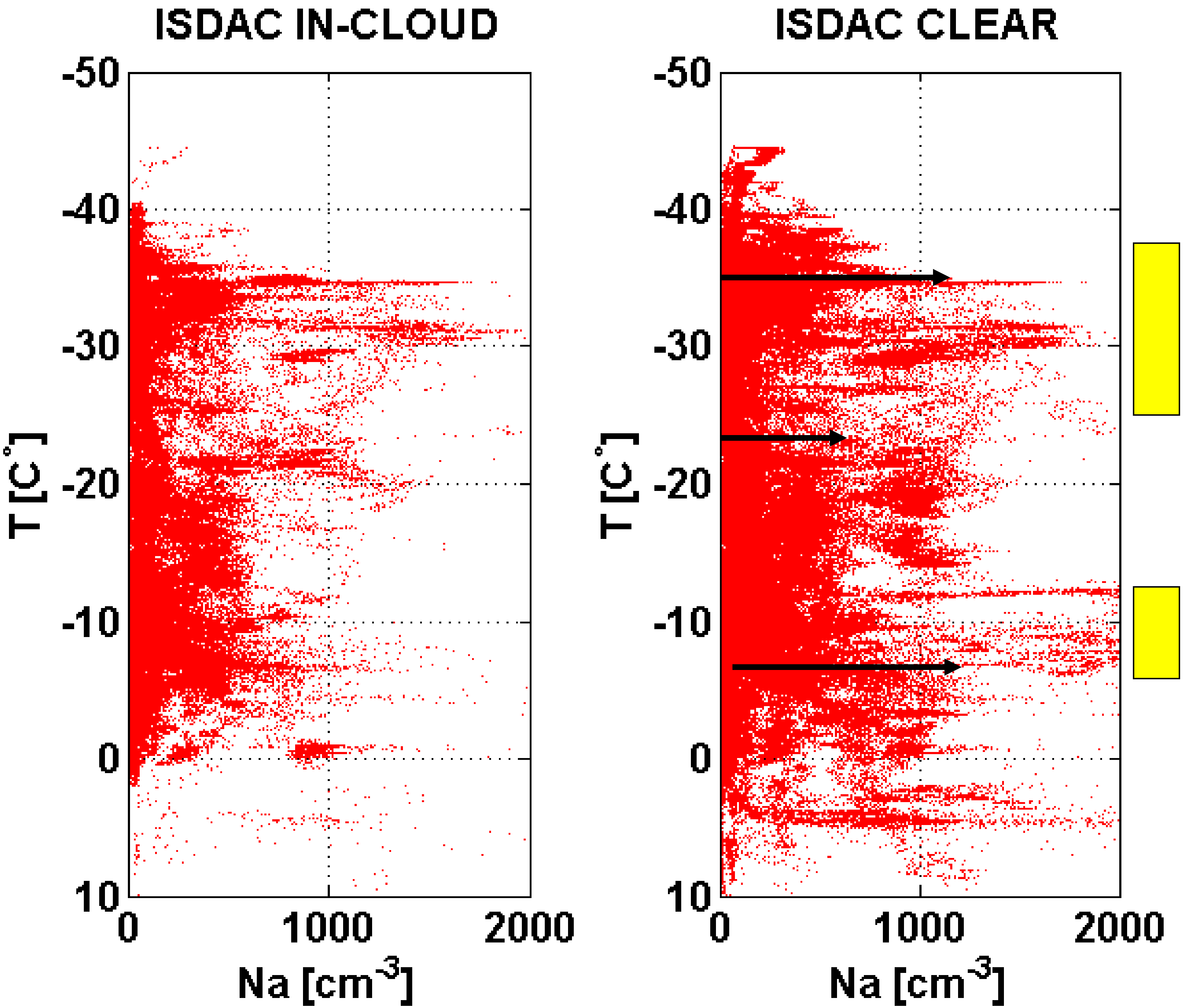
Fig. 2. IN number concentration (at STP) active at water saturation or above vs. temperature. Projects (see *SI Text*) are WISP-94 (gray triangle), Alliance Icing Research Study—2 (X), AMAZE-08 (square), Cloud Layer Experiment-10/ Canadian Cloudsat/CALIPSO Validation Project (open circle), Ice in Clouds Experiment—Layer Clouds (solid circle), Ice Nuclei SPECTroscopy-1 (–), Ice Nuclei SPECTroscopy-2 (diamond), Mixed-Phase Arctic Cloud Experiment (black triangle), and Pacific Dust Experiment (open triangle). Parameterizations described in the text are labeled and are plotted over the experimental measurement range on which they were based. The dashed gray line is a T-dependent fit to all data $[0.117\exp(-0.125^*(T_K - 273.2));\ r^2 = 0.2]$.

ISDAC CLEAN (Shantz et al)



ISDAC POLLUTED
(Shantz et al)

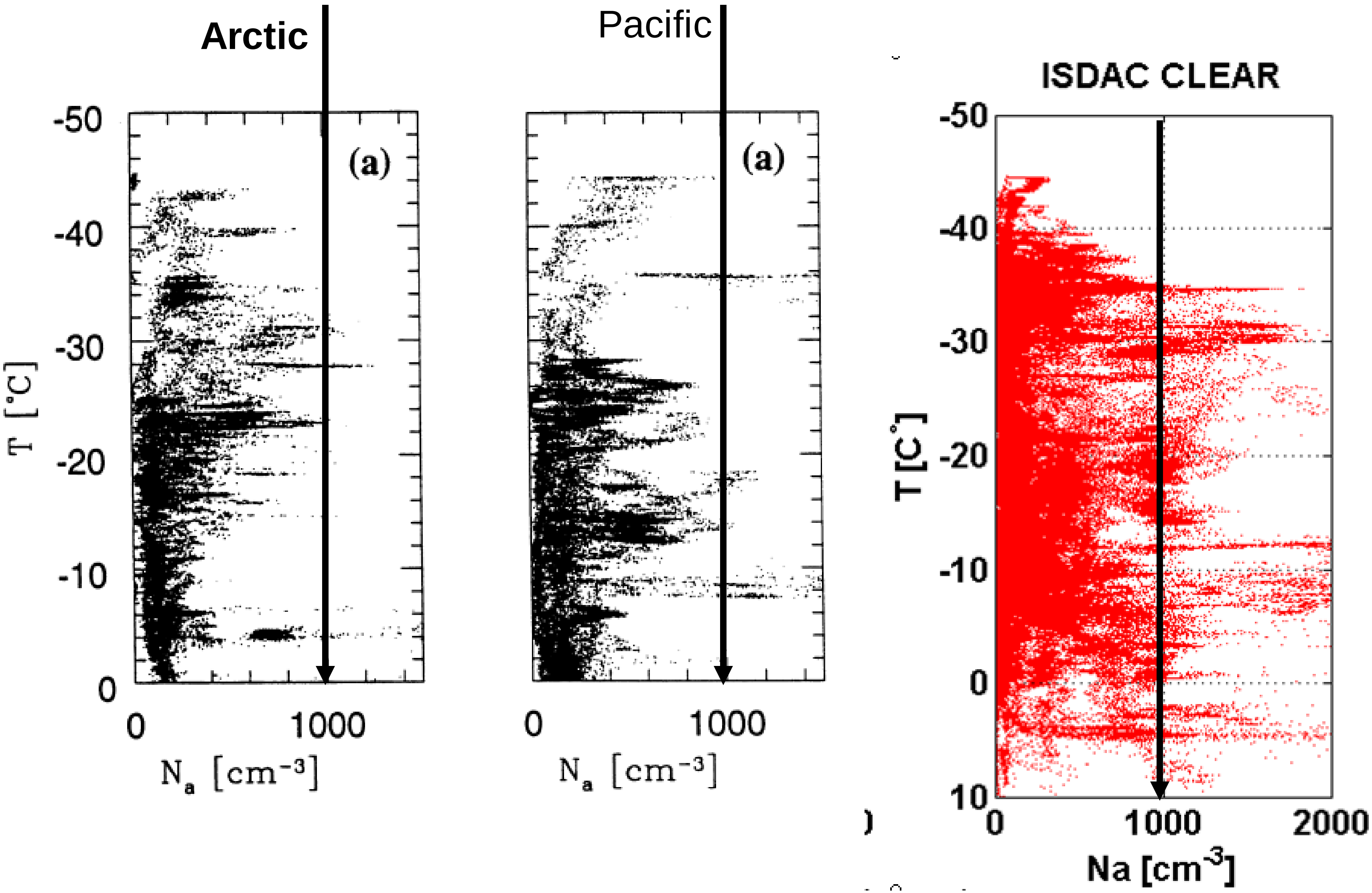




ISDAC IN-CLOUD
ISDAC CLEAR
-50
-40
-30
-20
-10
0
10
T [C°]
0
1000
2000
Na [cm-3]

Na COMPARISONS FROM ISDAC AND FIRE PROJECTS

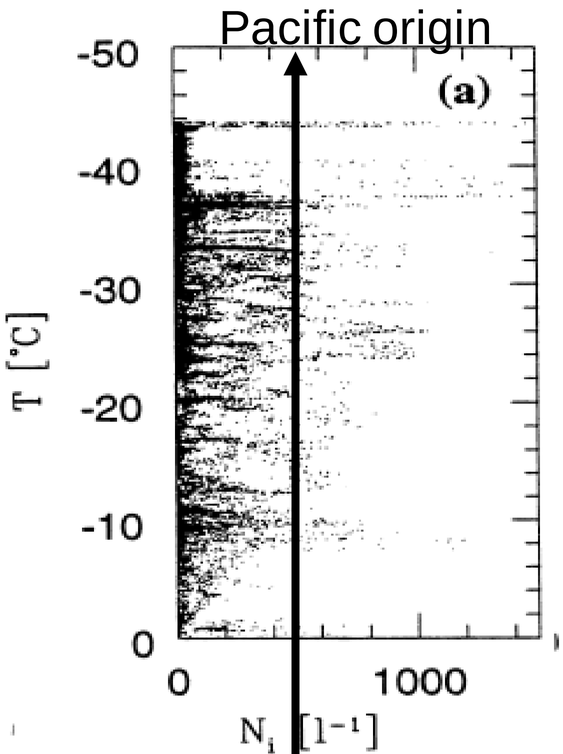
JGR OCEAN/Gultepe and Isaac, 2001

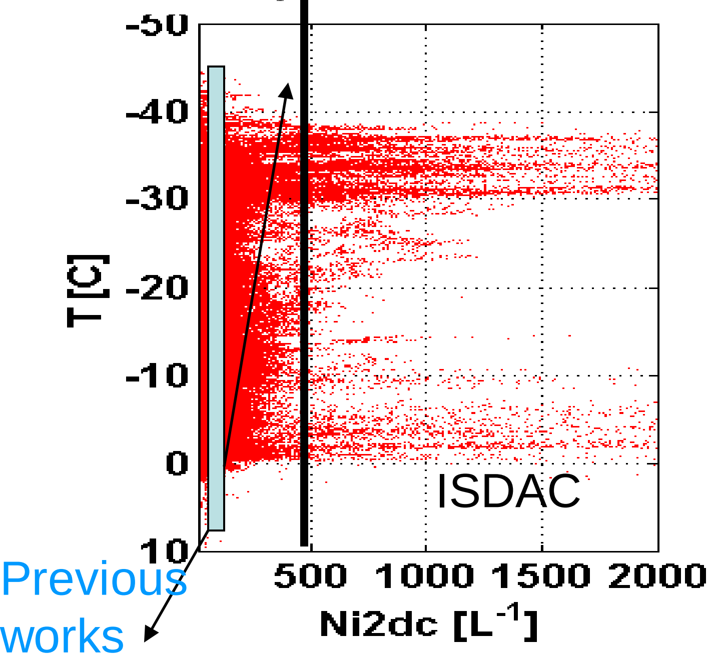


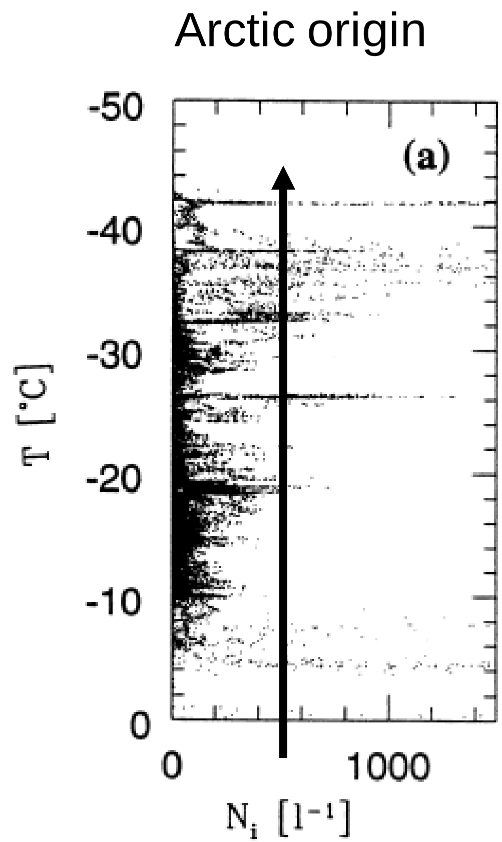
Ni comparisons

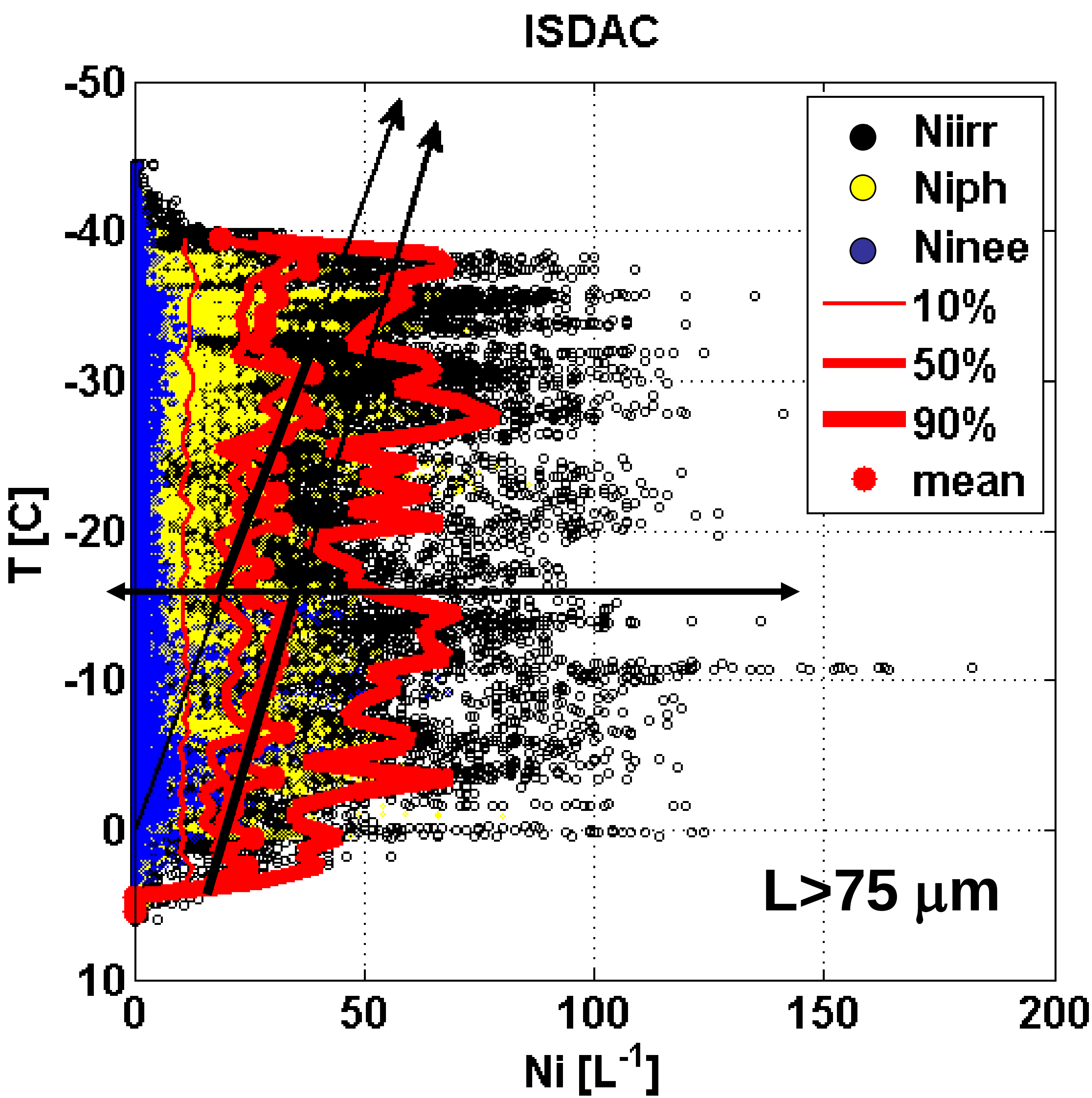
FIRE-ACE & ISDAC

- Shattering
- DOF
- Wetting issues



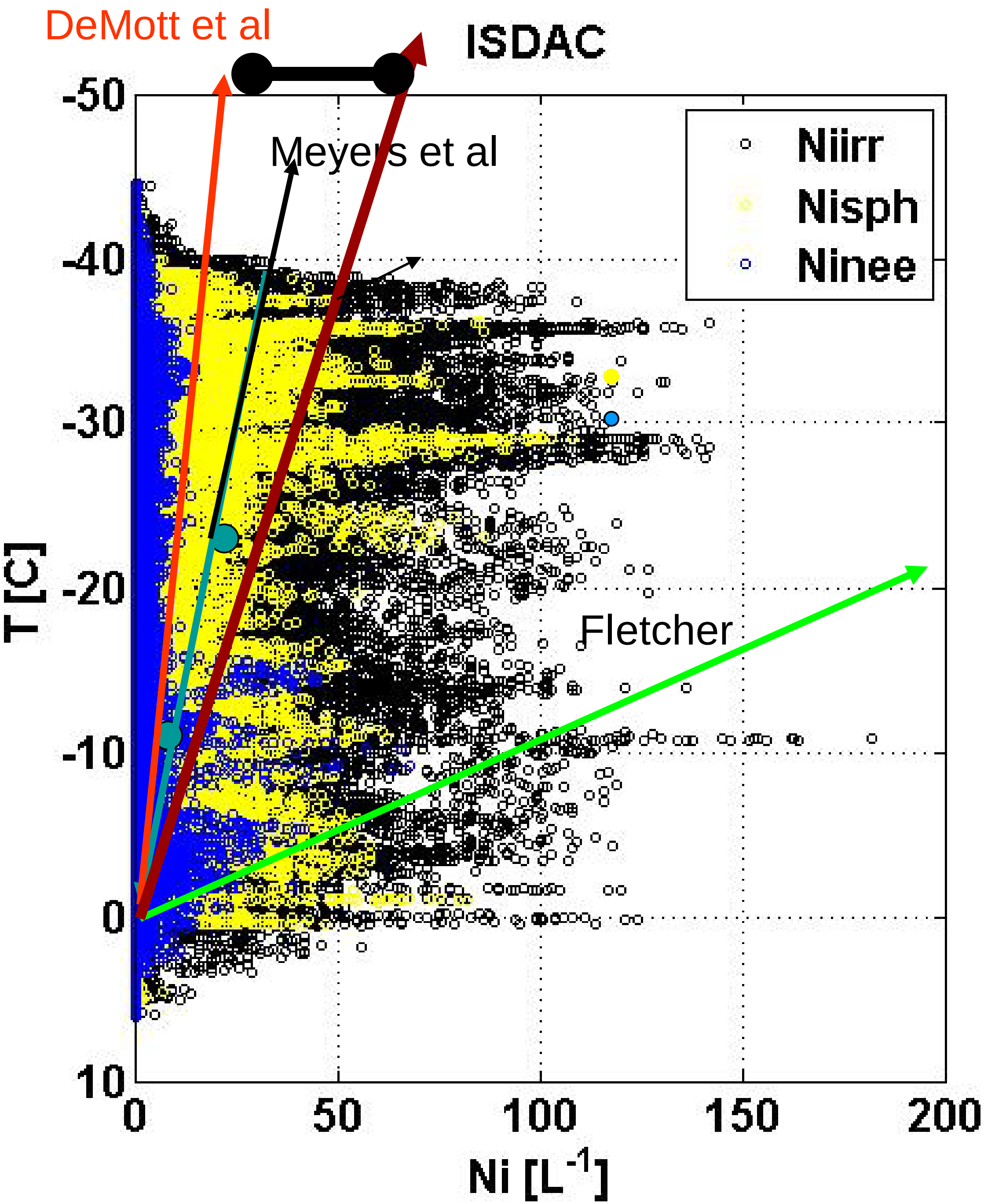






ISDAC Ni evrsus T after removing artifacts

- Shattering
- DOF
- Wetting issues



Process 2DC

Ni (L>=75 μm)-T

ISDAC ALL DATA

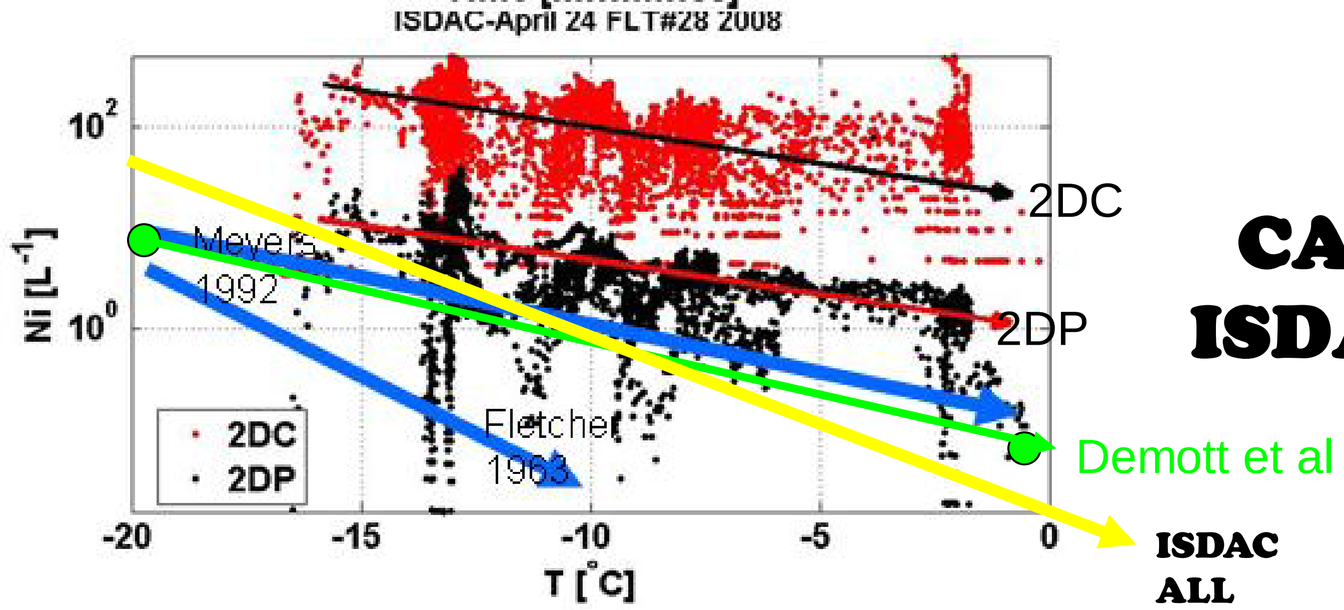
DeMott et al CFDC IN observations (RHw>100)

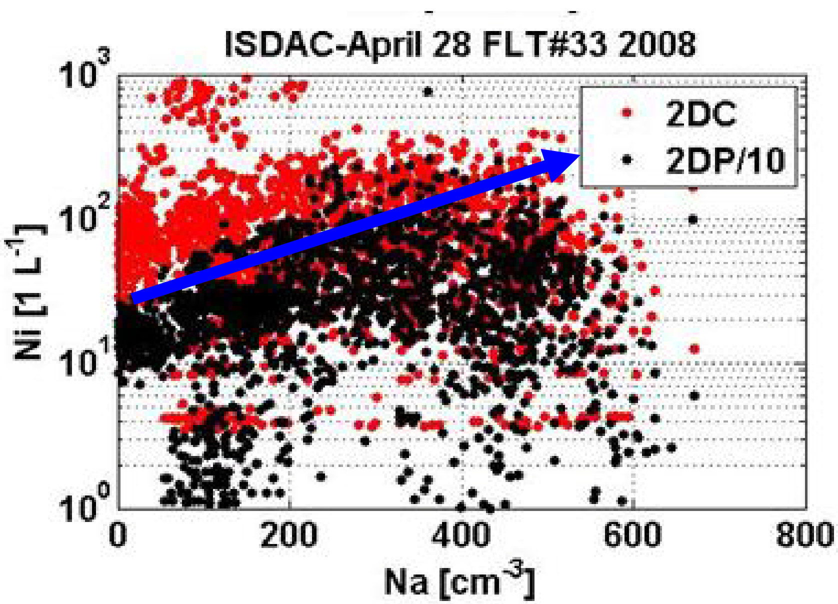
minus

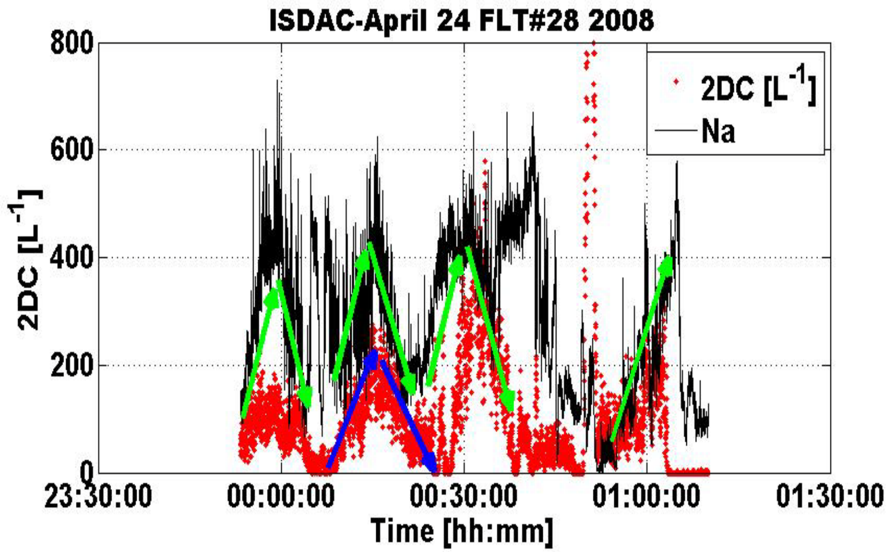
ISDAC Ni observations

=**Secondary Ice Production**

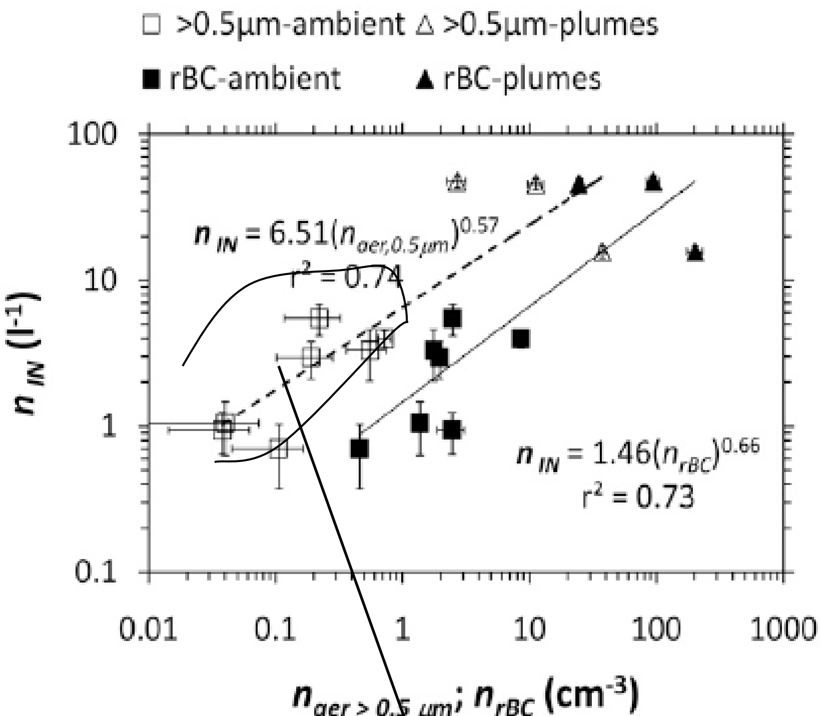
CASE STUDY ISDAC: April 24



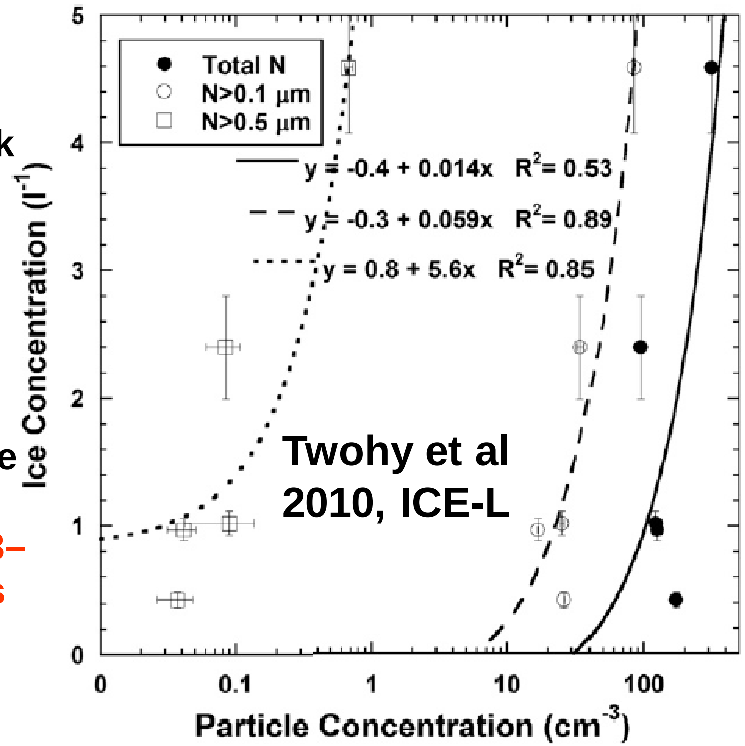


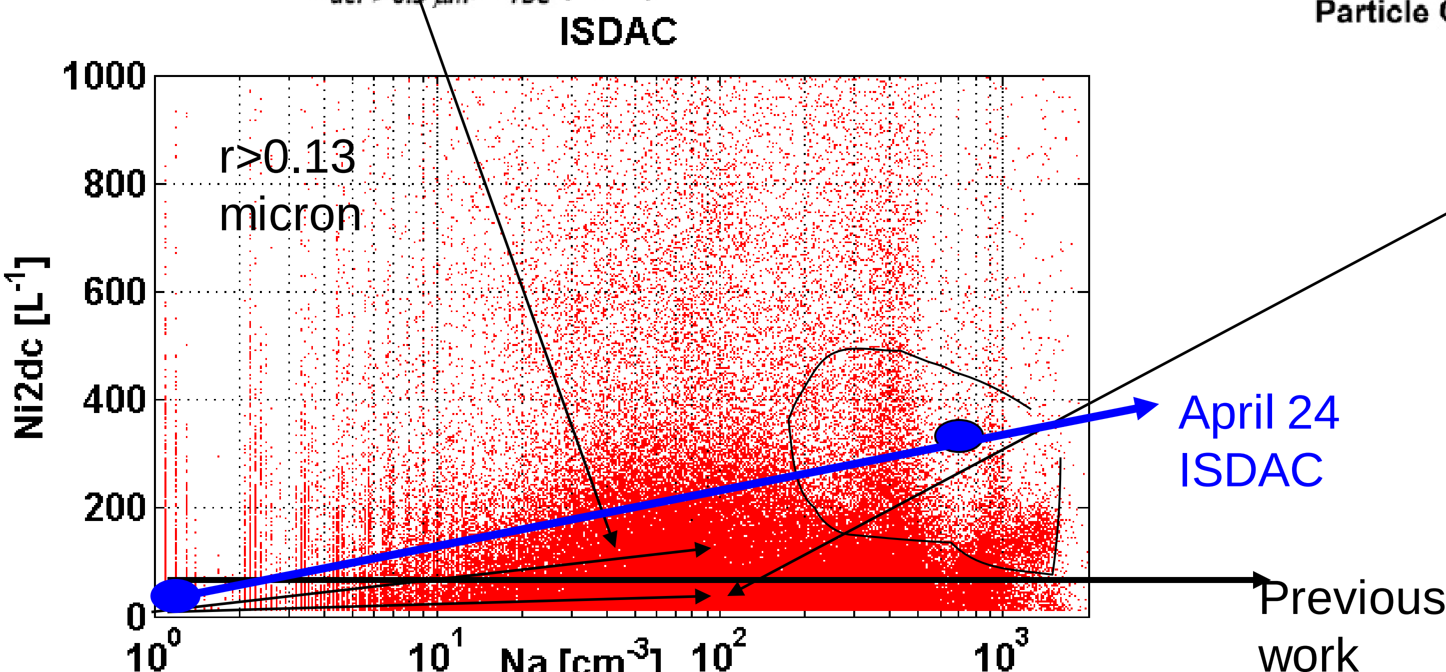


Ni versus Na



Refractory black carbon concentration (total measured by the SP-2, black symbols) vs mean IN measured by the CFDC. Data averaged over 3–15-min intervals





CONCLUSIONS

- **Variability in Na and Ni versus T is very large. Depends on which fit is used we can control SIMULATION of the cloud microphysics; therefore, precipitation amount is controlled.**

- **There are many issues related to small ice crystals and not all of them shattered particles.**

- **Earlier work usually use very few data points to make fits between observations of Ni and Na and/or T/RH, and combined various clouds in the same data set that results in likely large uncertainty in the model simulations.**

- **Based on low T and high RHi over Arctic atmosphere, increasing pollution (having a source of IN) may result in an increase in Ni and its variability, and this increases extinction of SW radiation.**

- **Need well designed field programs for accurate IN and Ni measurements that include sizes >100 micron and <100 micron.**

- **Ice/freezing fog are like clouds at the surface, and conditions are similar to these of the cloud chambers. But, we have no control of the conditions. Understanding fog can help to reduce the uncertainties in IN and Ni measurements, and improve parameterizations.**