Assessing the importance of aerosol indirect effects on arctic boundary clouds using ISDAC data

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Three indirect effects proposed for mixed-phase arctic clouds

1. Glaciation indirect effect:
   - IN increase $\rightarrow$ Ni increase

2. Riming indirect effect
   - CCN increase $\rightarrow$ Ni increase $\rightarrow$ Di decrease $\rightarrow$ less riming growth $\rightarrow$ IWC decrease

3. Cold 2\textsuperscript{nd} indirect effect
   - CCN increase $\rightarrow$ Ni increase $\rightarrow$ Di decrease $\rightarrow$ less ice crystal formation $\rightarrow$ Ni decrease
Methodology

Data from 20 bulk & size-resolved probes combined to give value added product
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Fit: \( IWC_{SD} = 1.0168 \times IWC_{DeepCone} - 4.8477 \times 10^{-4} \), \( R^2 = 0.80094 \)
Glaciation indirect effect?

Data show little evidence of such an effect.

\[
R^2 = -0.13994 \quad SS_w \in (-10\%, 0\%)
\]

\[
R^2 = -0.35242 \quad SS_w \in (0\%, -10\%)
\]

Data show little evidence of such an effect.
Liquid indirect effect

Liquid concentrations and drop sizes well correlated with PCASP concentration below cloud
Other indirect effects?

Some correlation of IWC/Ni with PCASP below cloud concentration
Other indirect effects?

IWC has stronger correlation with PCASP D_{vm}
Cold 2\textsuperscript{nd} indirect effect

Ni also more strongly correlated with Dvm
April 8 flight 2 – single layer stratus – roughly homogeneous meteorology

- Dmmi = 4 mm
- 300 cm$^{-3}$
- 350 cm$^{-3}$
- 325 cm$^{-3}$
- 300 cm$^{-3}$
- 150 cm$^{-3}$
- 150 cm$^{-3}$
- 200 cm$^{-3}$
Smaller Ni matches with larger concentration of smaller aerosols -- & smaller liquid drops.
Larger liquid drops correlated with increased aerosol size & Ni.
Compare CFDC IN & PCASP aerosol data below liquid cloud with IWC/Ni in cloud and below cloud to assess importance of different effects.