A comparison of arctic cirrus microphysical properties with mid-latitude and tropical cirrus features

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1. Motivation

In-situ measurements of arctic cirrus are scarce, but needed to understand cirrus impacts on radiation and to evaluate assumptions made in remote sensing retrievals and model parameterizations.

Objective

To compare size-resolved and bulk microphysical properties of arctic cirrus observed on the 17 and 18 Oct. 2004 University of North Dakota flights during the Mixed Phase Arctic Cloud Experiment (MPACE) against those of mid-latitude and tropical cirrus.

2. Vertical Profile/Crystal Shape

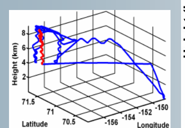

Figure 1

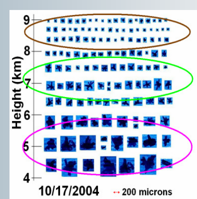

Figure 2

Figure 1: Flight track flown on 17 Oct. showing spiral ascents/descents through cirrus. Figure 2: Representative crystal shapes measured by Cloud Particle Imager (CPI) as function of altitude for spiral in red. Consistent with Heymsfield and McFarquhar (2002), the 3 distinct zones labeled characterize the profile (nucleation zone with small crystals highlighted by brown, growth zone with larger pristine crystals highlighted by green and sublimation zone with particles with rounded edges highlighted by pink).

3. Size Distributions

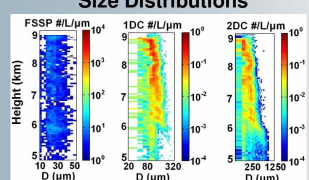

Figure 3: Number distribution function measured by forward scattering spectrometer (FSSP), one-dimensional cloud (1DC) and two-dimensional cloud (2DC) probes as function of altitude observed on 17 Oct. over Barrow, Alaska. Higher concentrations of small crystals between 7 and 9 km, and of larger crystals from 5 to 7 km suggest growth by aggregation.

4. Concentration of Crystals

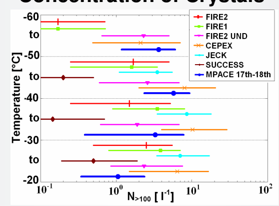

Figure 4: Mean (symbol) and quartiles (bars) of distribution of concentration of crystals with maximum dimension D > 100 μm, $N_{>100}$, obtained from 2DC and high volume precipitation sampler (HVPS) combined size distribution as function of temperature (T). Range of $N_{>100}$ in arctic cirrus comparable to those in cirrus in other locations with varying formation mechanisms; with only 2 flight days trends with respect to temperature not statistically significant.

5. Extinction

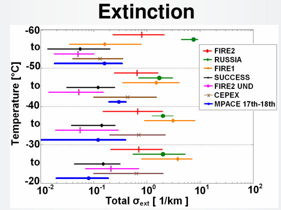

Figure 5: Volume extinction coefficient σ_{ext} derived from the 2DC and HVPS size distributions as function of T. σ_{ext} in arctic cirrus comparable to other projects. For T > -50ºC, σ_{ext} smaller than those in mid-latitudes/tropics, but for T < -50ºC σ_{ext} are similar; trends with T not statistically significant.

6. Ice Water Content (IWC)

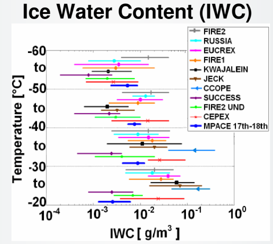

Figure 6: IWC derived from 2DC and HVPS size distributions as function of T. For T > -40ºC, IWC are smaller than those from other projects, for T < -40ºC IWC are similar. Trends with T based on limited data set on 2 specific days.

7. Fraction of IWC in Small Crystals

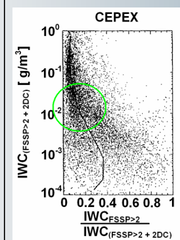

Figure 7

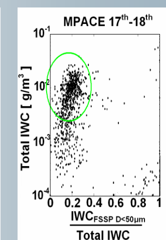

Figure 8

Figure 7: Fraction of IWC contained in crystals with D < 50 μm measured by FSSP to total IWC (FSSP + 2DC) during the Central Equatorial Pacific Experiment (CEPEX). Given uncertainties in FSSP measurements in ice, these are likely overestimates. Fig. 8: As in Fig. 7, except for MPACE cirrus cases and total IWC computed from 2DC and HVPS. Fractional contributions of small crystals to total IWC are comparable for 2 experiments. Small crystals had similar contributions in mid-latitude cirrus during SGP 2000 Cloud IOP; smaller crystals had greater fractional contributions during TWP-ICE.

8. Summary

- Vertical profiles of crystal shapes observed in arctic cirrus consistent with 3-layer conceptual model of mid-latitude cirrus (nucleation zone of small crystals, growth zone of pristine crystals and sublimation zone with sublimating crystals).
- $N_{>100}$, σ_{ext} and IWC in arctic cirrus comparable to those in cirrus from other locations; however, trends with respect to temperature may not be representative because of lack of data (only 2 flight days); more arctic cirrus data are needed.
- Assuming FSSP gives maximum contribution of crystals with D < 50 μm, these small crystals make similar fractional contributions to total IWC in arctic cirrus as in cirrus from some other locations.

Acknowledgements

This work was supported by the National Aeronautics and Space Administration (NASA) grants NASA NNG06GB92G and by the Office of Science (BER), U.S. DOE, Grant Number DE-FG02-02ER63337.

References

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