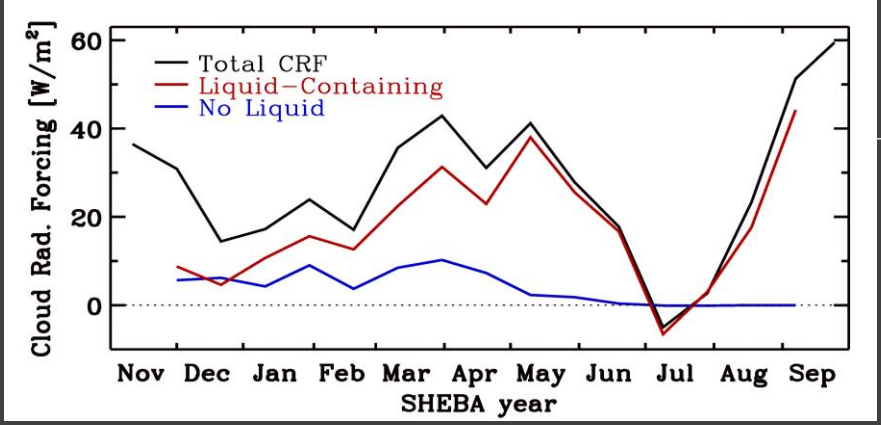
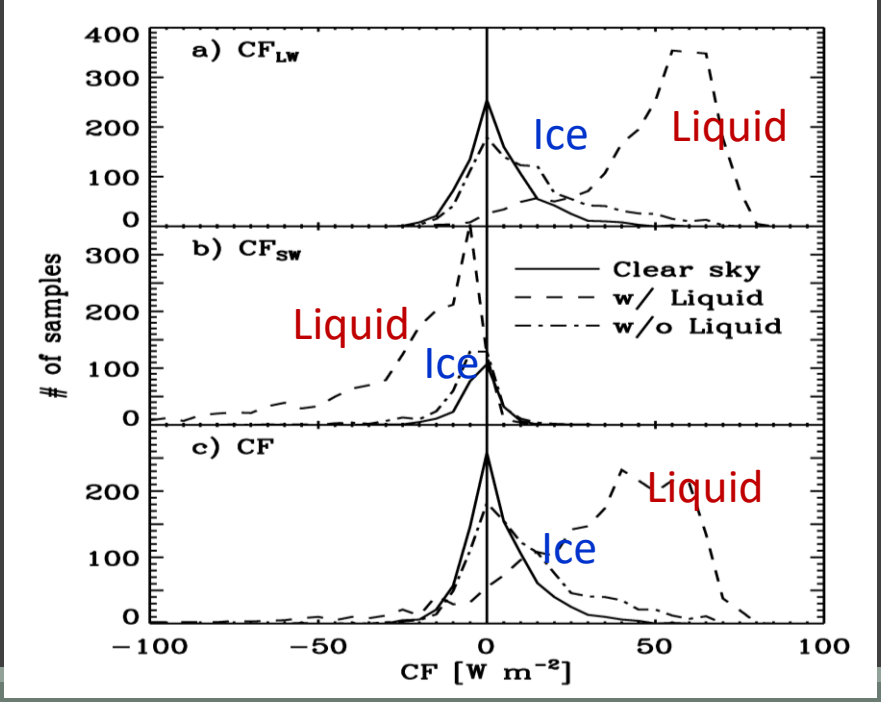
Alaskan Clouds in a Pan-Arctic Context: Synthesizing knowledge from ground-based observations

MATTHEW SHUPE

UNIVERSITY OF COLORADO / NOAA

View from the past





SHEBA 1997-1998

- First intensive, multi-sensor, year-round Arctic cloud observations
- Cloud (supercooled) liquid frequent
- Liquid dominates radiative forcing
- Bi-modal state of LW radiation (liquid vs. no liquid)

1998 > PRESENT

Many new observations across Arctic

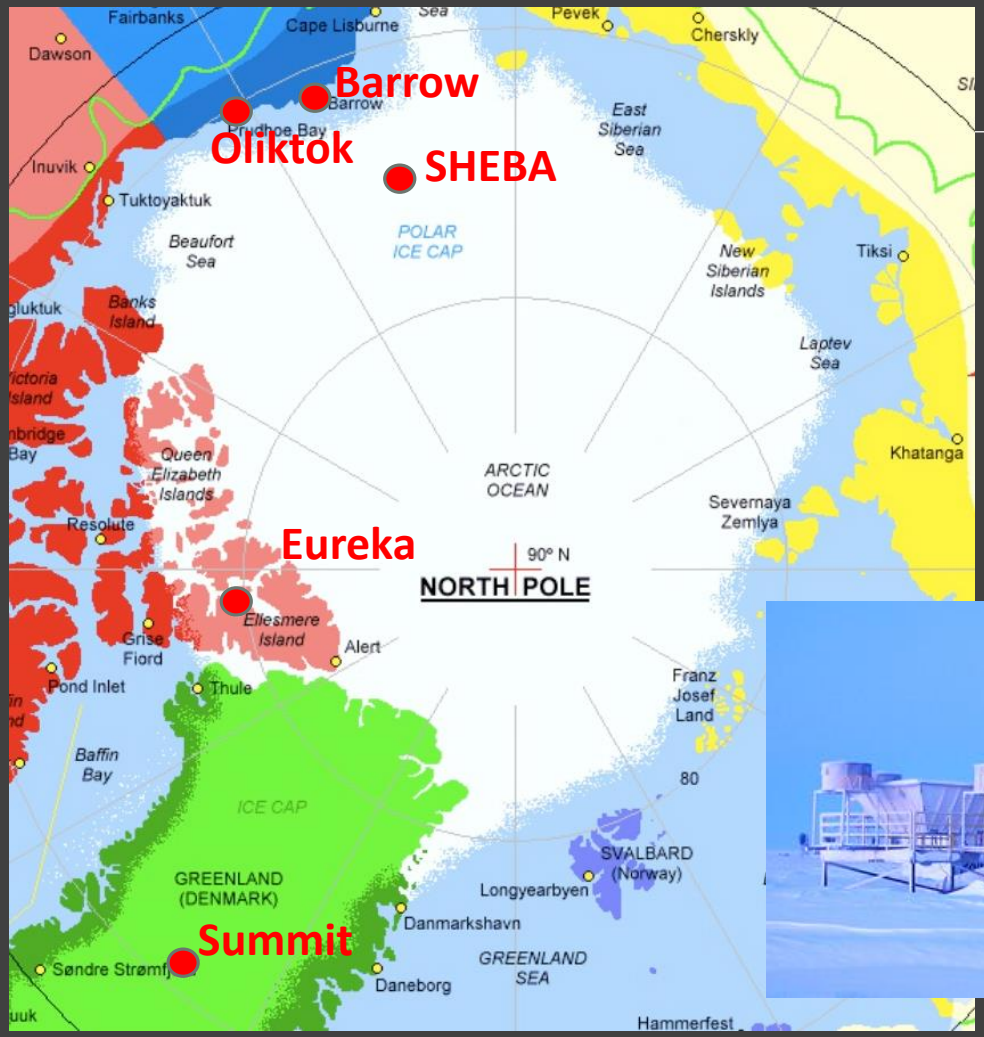
Motivating Questions:

Was SHEBA representative?

Do all Arctic clouds behave similarly (properties, processes, effects)?

Shupe and Intrieri 2004

Ground-based Observatories



Cloud Observatories

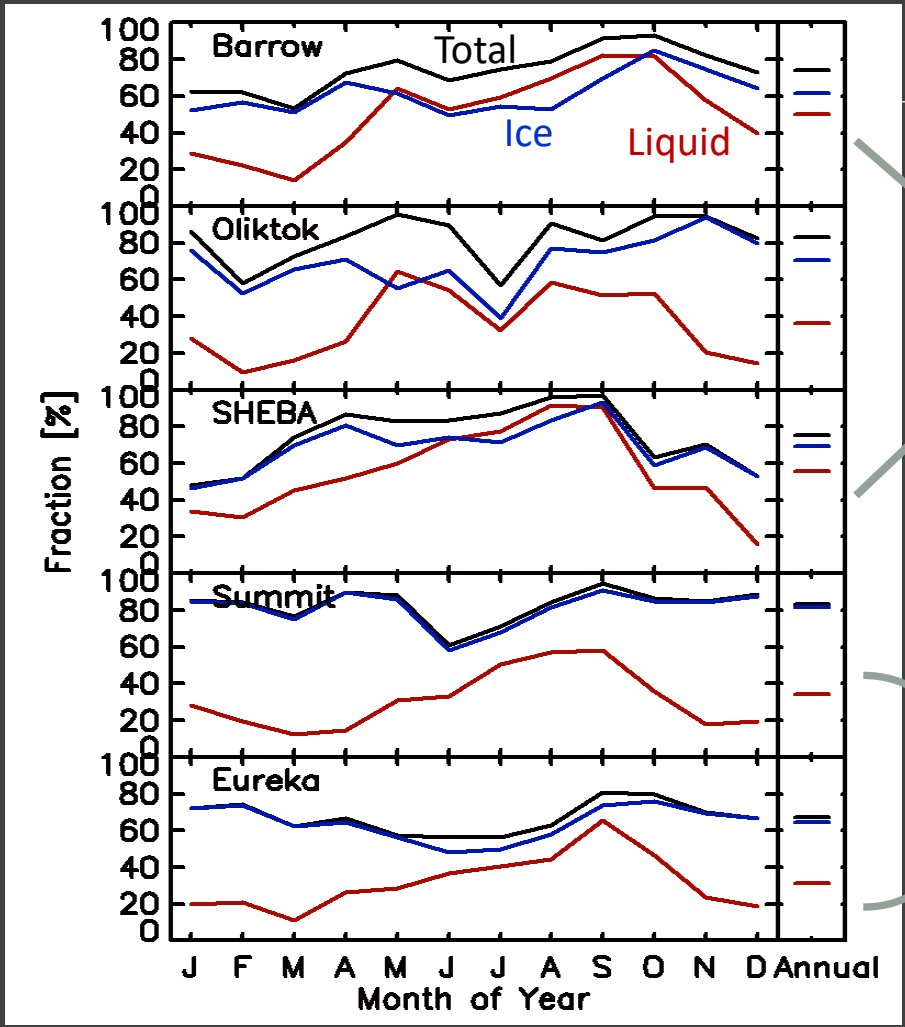
Phase: radar, lidar, microwave, sonde

LWP: microwave

IWP: radar

CRE: broadband radiation

Phase Occurrence



SHEBA & Barrow:

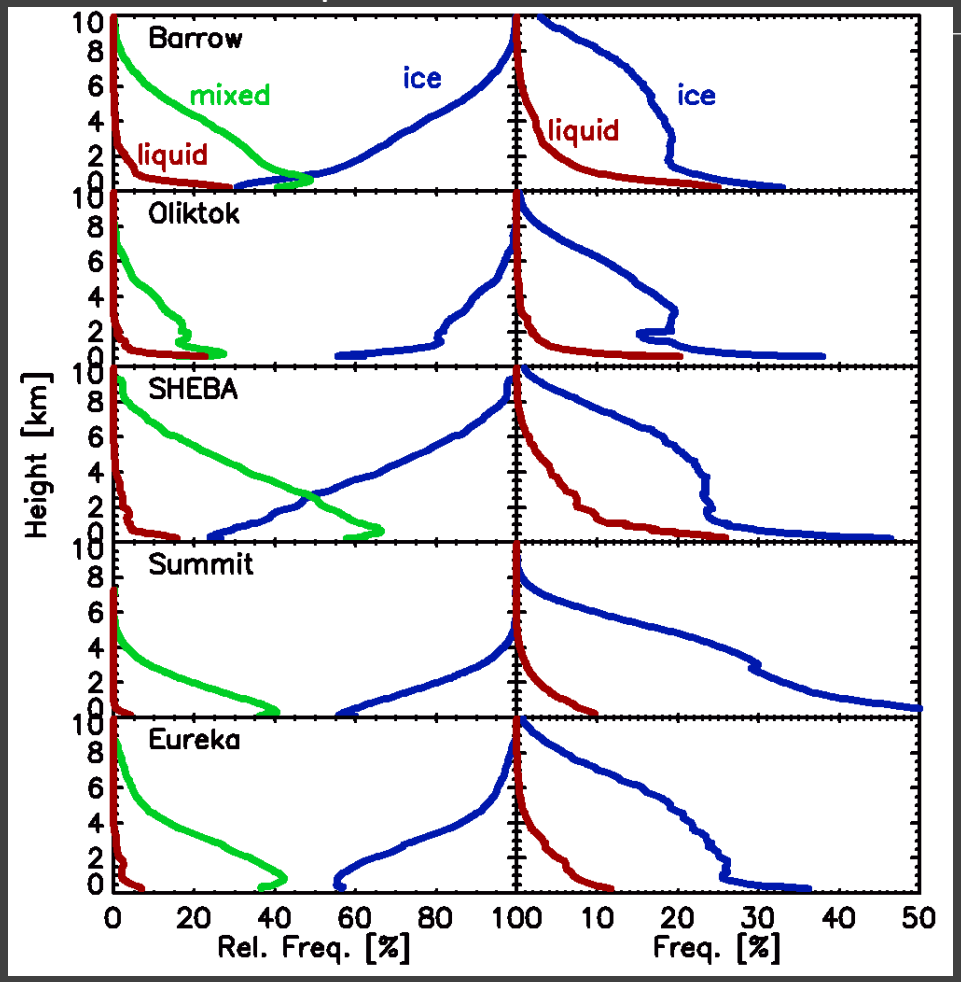
- Liquid 50-60% of the time
- Liquid-only clouds

Oliktok requires further work.

Summit & Eureka:

- Liquid 30-35% of the time
- Few liquid-only clouds

Vertical Distributions

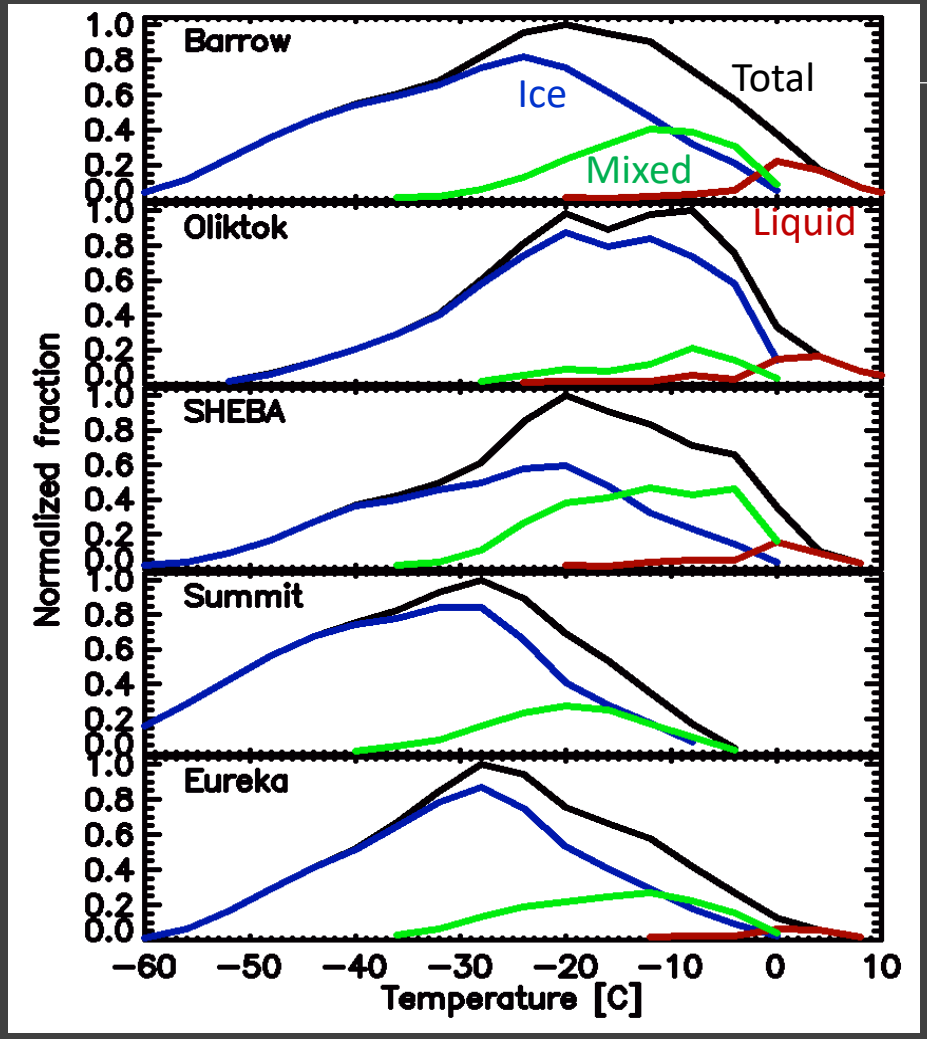


Qualitatively similar distributions

Less liquid at Eureka & Summit

Enhanced low-level ice at Summit

Dependence on Temperature

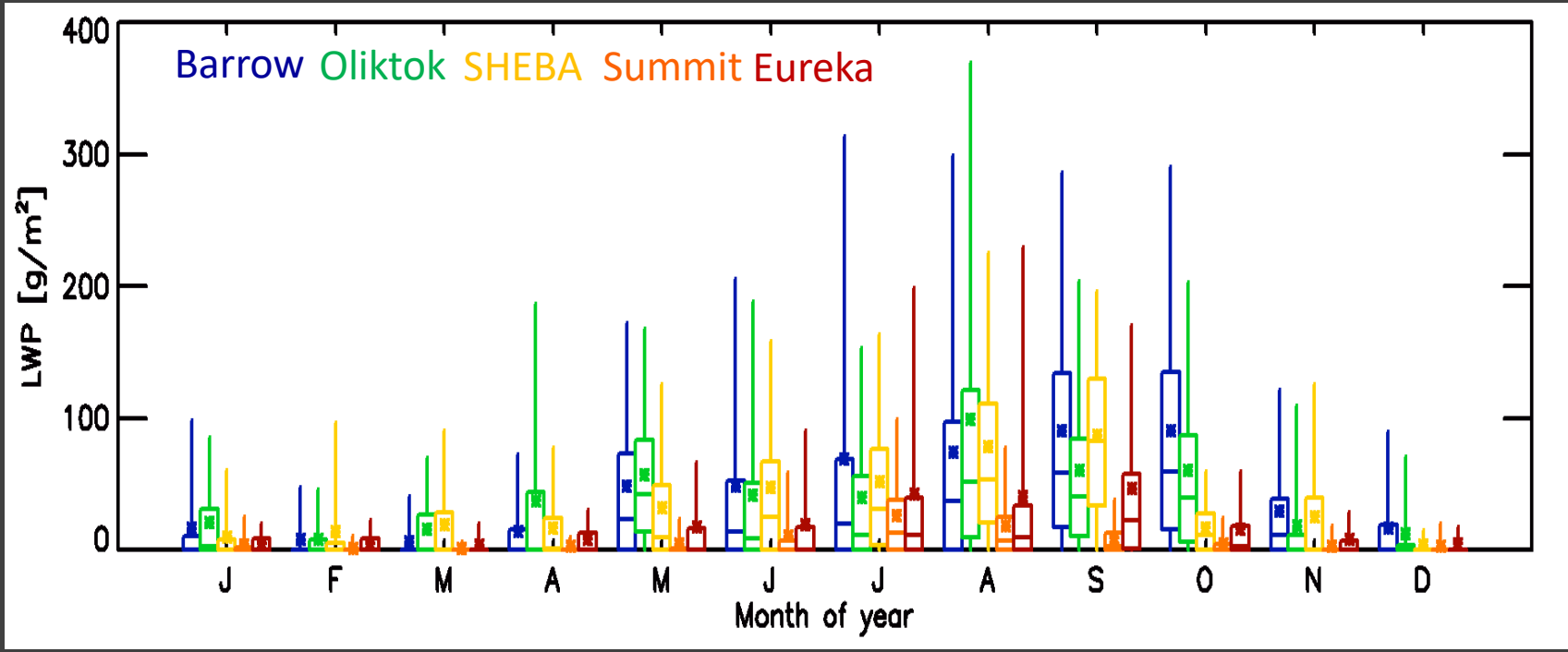


Temperature range explains minimal liquid at Summit & Eureka

Consistent mixed-phase distributions at low Temp

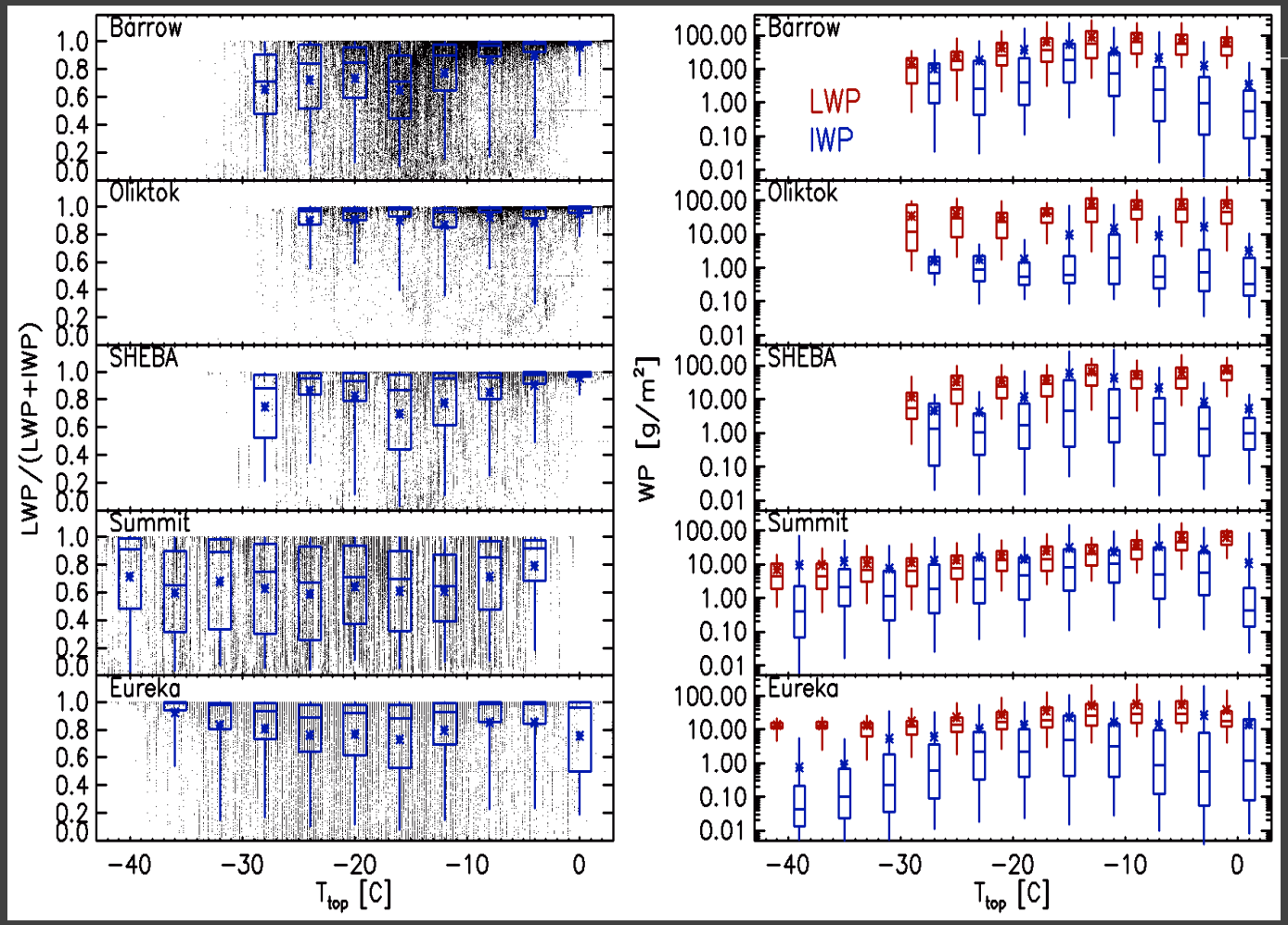
Consistent max mixed-phase occurrence at ~ -12C

Liquid Amount



- Barrow/Oliktok/SHEBA very similar
- Less liquid at Eureka
- Least liquid at Summit

Controls on Phase Partitioning

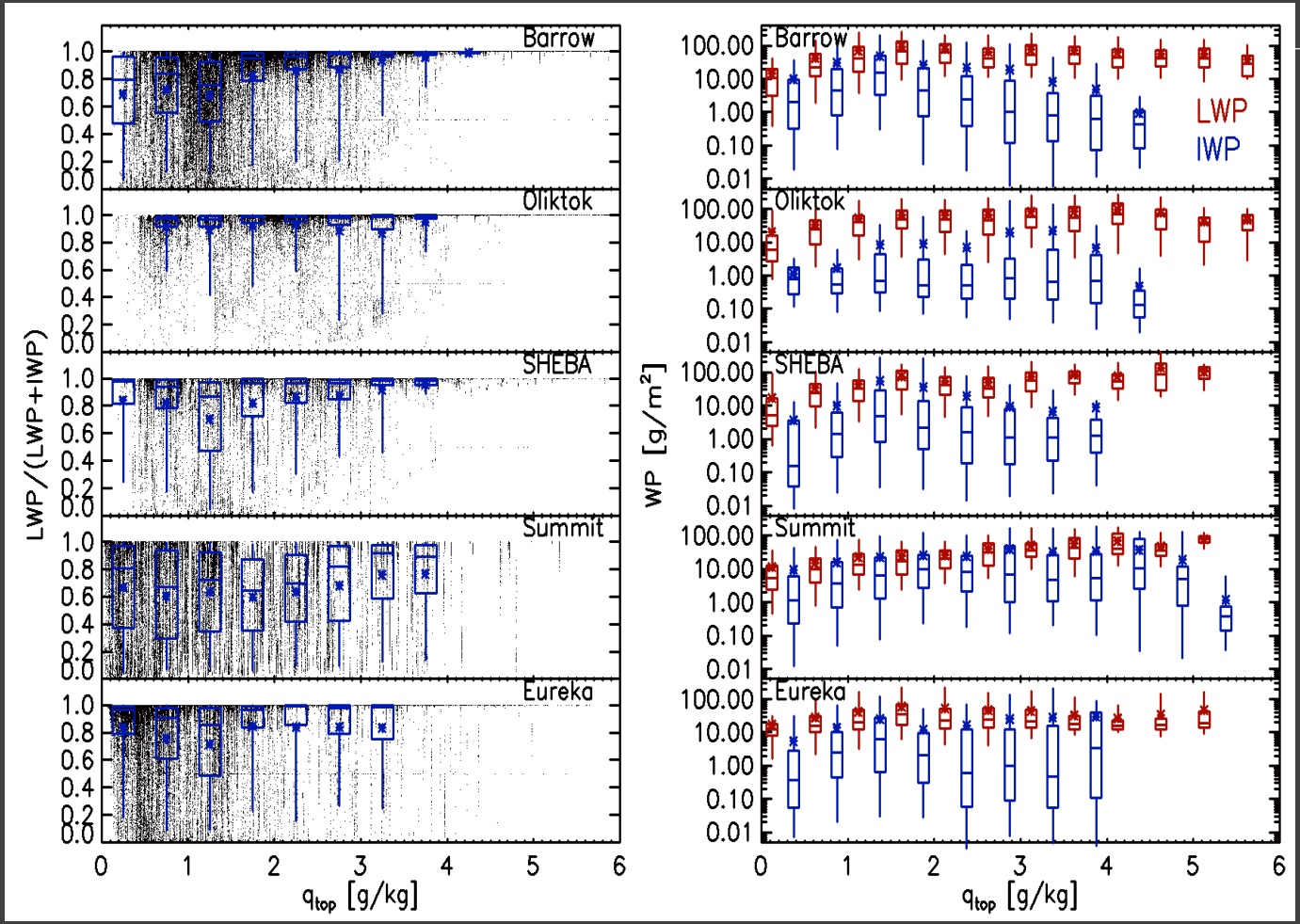


T a poor constraint on liquid fraction

T increase -> LWP increase up to -15C

T increase -> IWP max at -15C (except Summit)

Controls on Phase Partitioning

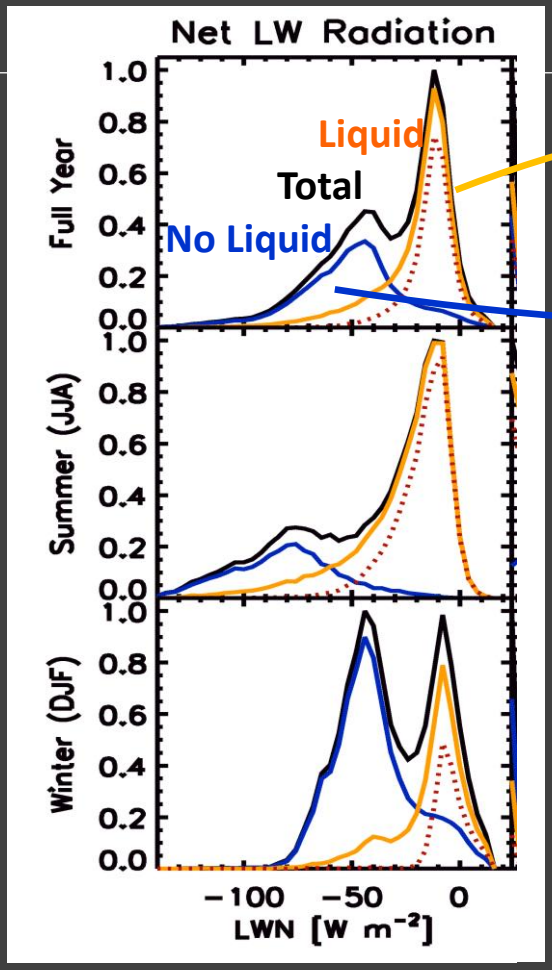


q also a poor constraint on liquid fraction

q increase -> LWP increase, or flat

q increase -> IWP max at ~1.5 g/kg (except Summit, Eureka in between)

Cloud Radiative Effect



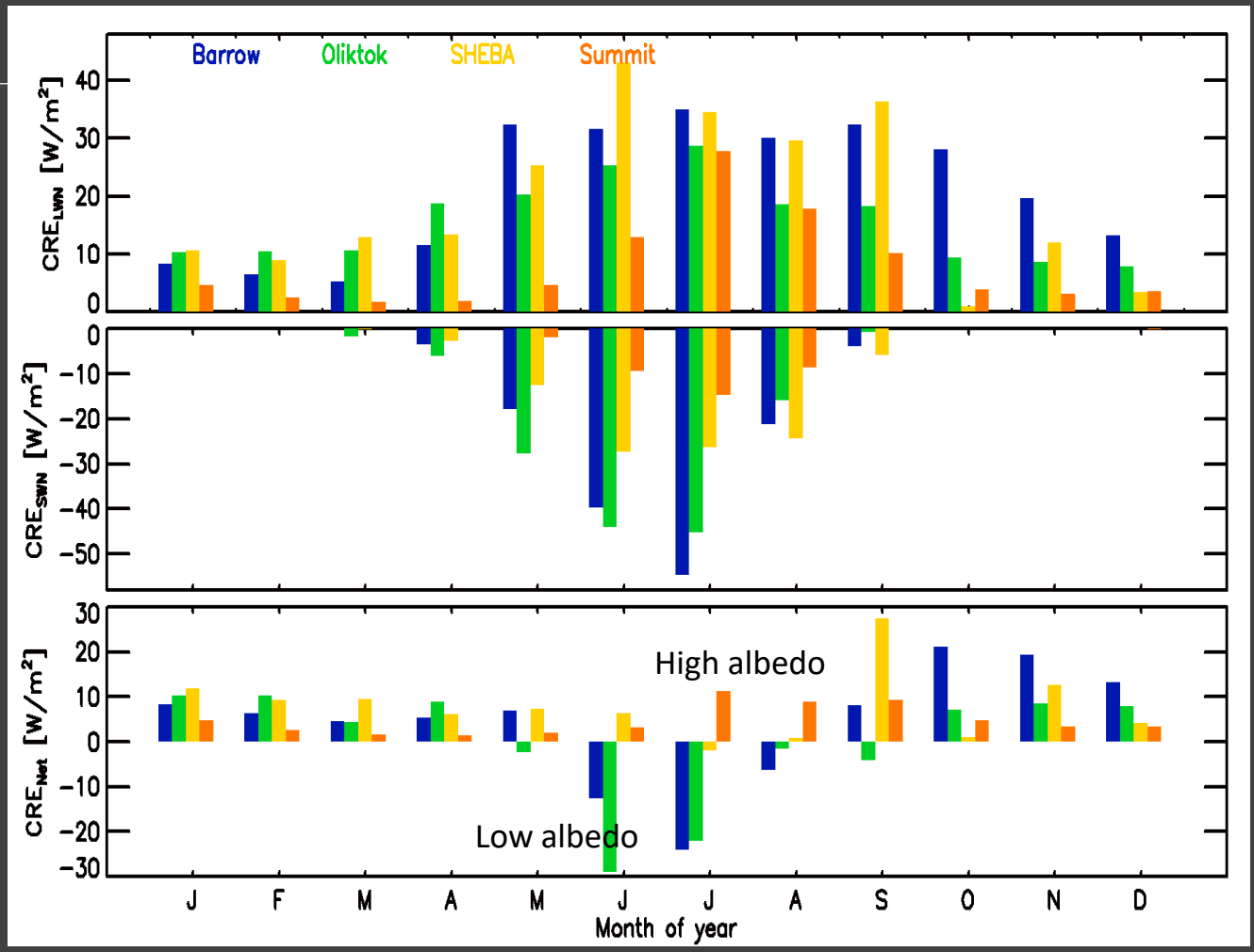
$CRE_{max} = (F_{liq} - F_{noliq})$

$CRE_{net} = CRE_{max} * Liq\_fraction$

Cloud Radiative Effect

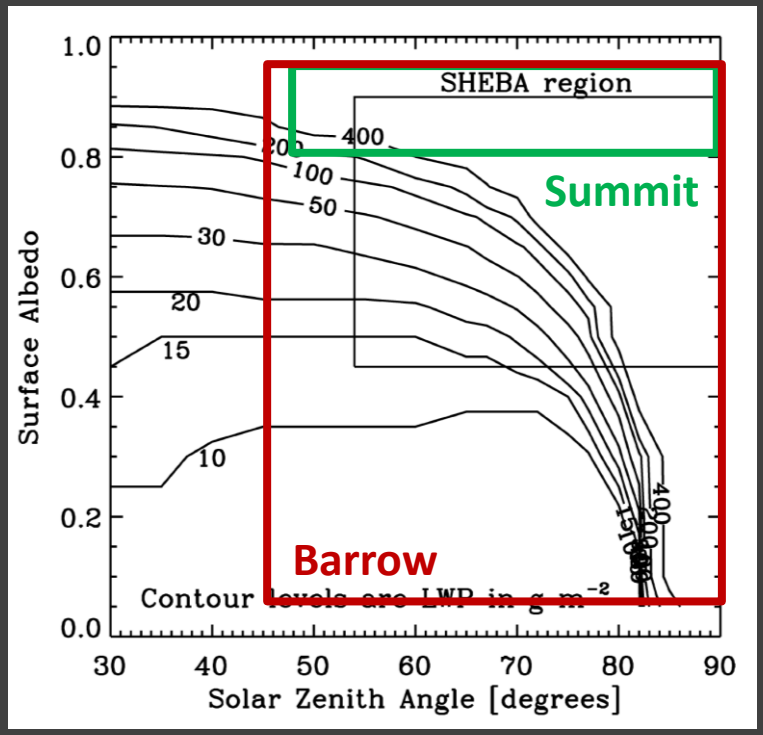
LW warming
> controlled by LWP

SW cooling
> controlled by albedo, sun angle, and LWP



Pan-Arctic CRE

View from SHEBA



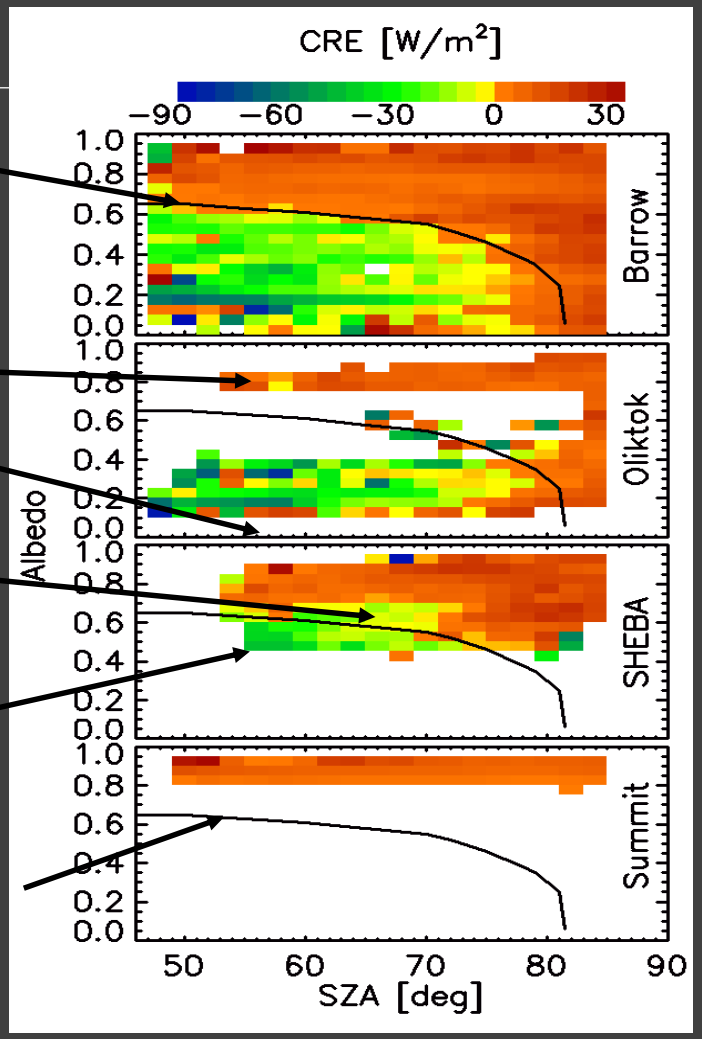
LWP = 30 g/m2

Snow on surface plays big role

LWP > 30 g/m2

Bare ice = low enough albedo

Only cooling with largest LWP (rare)



Shupe and Intrieri 2004

Conclusions

Cloud phase occurrence similar across sites, except for differences in temperature range. -> **Pan-Arctic consistency**

Cloud mass and Phase partitioning are not cleanly constrained by T or q. -> **Further work needed** to examine the role of aerosol, air motions, etc.

Radiative effects of clouds vary substantially, but are generally consistent with a simple model. -> **Pan-Arctic consistency**, but dependence on controls on LWP.