Cloud thermodynamic phase distribution in midlatitude optically thin clouds

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Summary

The temperature range of transition from liquid to ice is an important but uncertain component of cloud feedback. The temperature at which 50% ice fraction (T50) occurs was found to be -6.5°C in airborne data collected near the British Isles (Bower et al. 1996), while MODIS cloud-top temperature for 50% ice fraction was found to be colder and to vary geographically and with location within a typical midlatitude storm (Naud el at. 2006). The onset of glaciation cannot be parameterized according to temperature only. Here we use ground-based lidar derived phase information to explore how the temperature of glaciation varies within clouds.

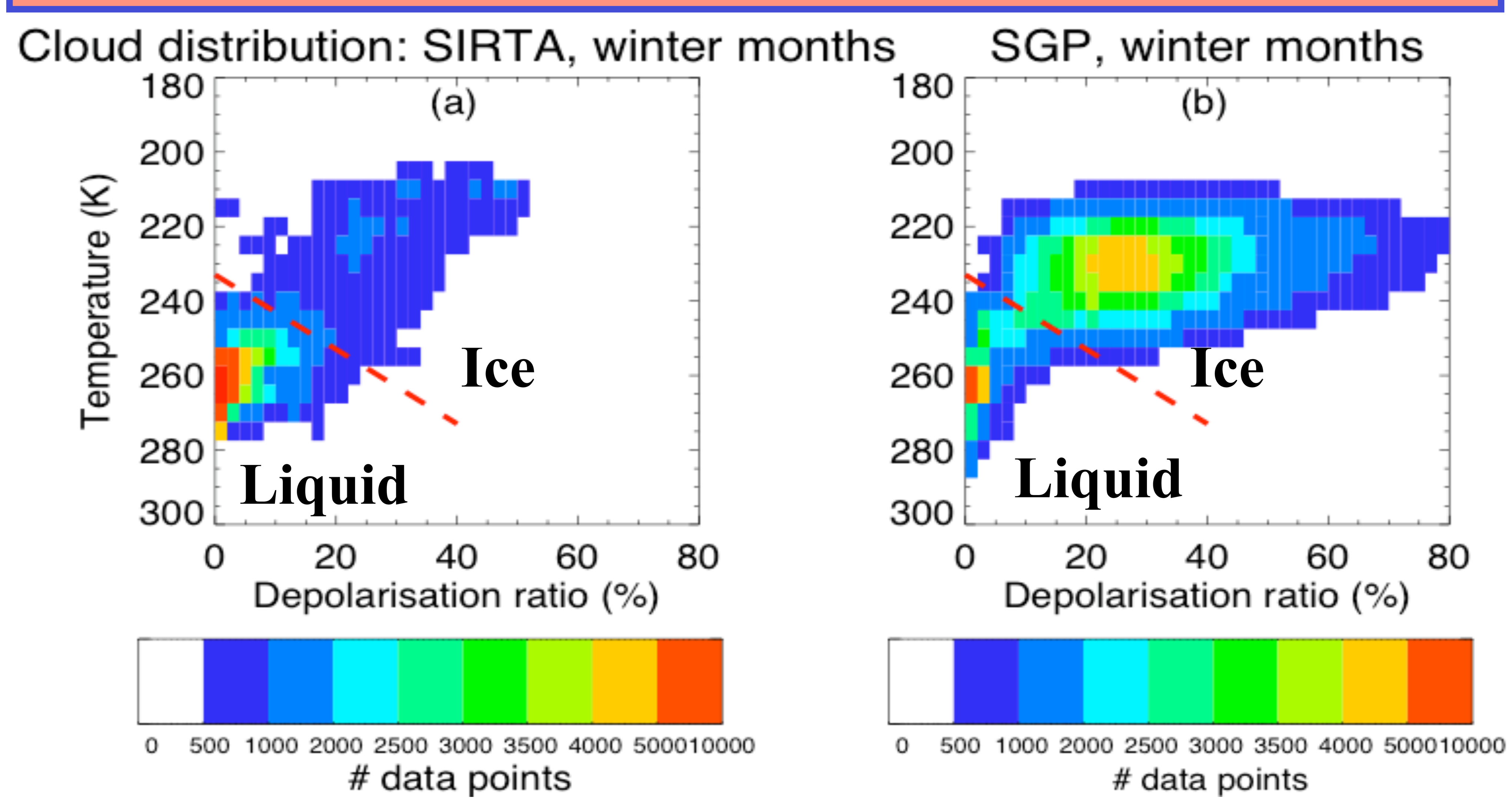
→ Bower et al. (1996) results valid only for frontal clouds to the east of the north Atlantic storm track, cannot be only reference for GCM parameterization or verification

→ Need consistency between different ground-based sites in instruments and techniques for climate applications

1. Two midlatitude sites (SGP and SIRTA): 2 different lidars, 2 different ways of extracting depolarization ratios, 2 cloud masks… Need consistency for climate studies

SIRTA-LNA	SGP- Raman lidar
- 532 nm channel with depolarization	- 355 nm channel with depolarization
- Total depolarization ratios with scattering ratio (SR) >2	- Particle depolarization ratios
- Elaborate cloud mask (STRAT,Morille et al. 2007)	- Cloud mask from threshold on SR
- 15 m vertical resolution	- 39 m resolution
- Day-time operations in non-precipitating periods	- Continuous operations day and night
- Winters 2002-2007	- Winters 1998-2003

2. Thermodynamic phase from lidar: determined at all lidar cloud levels from depolarization ratios and temperature profiles

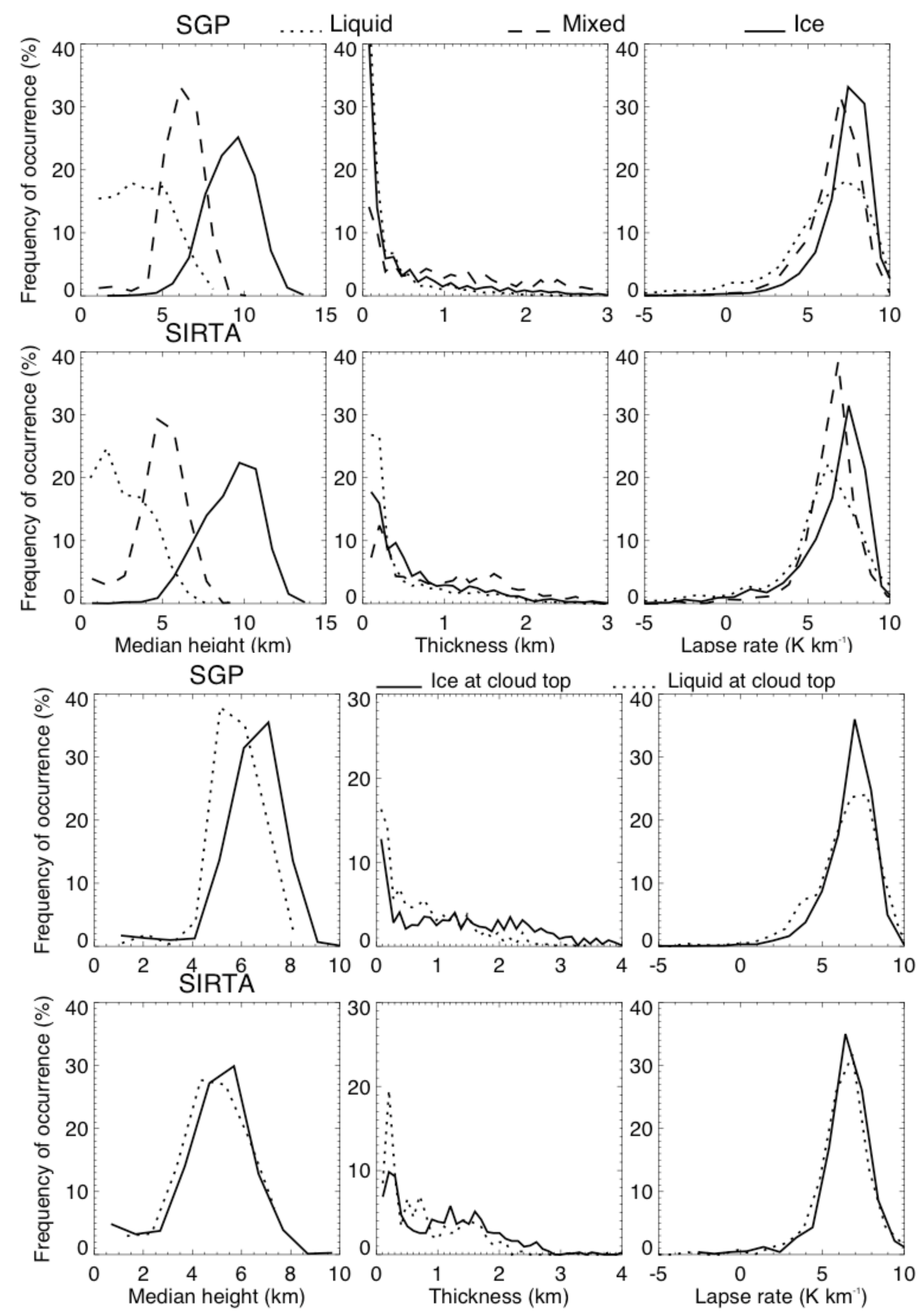


Normalized number of cloudy lidar bins in 2K temperature and 2% depolarization ratio intervals. (a): SIRTA; (b): SGP

→ Fewer high clouds at SIRTA due to use of threshold SR>2

→ Lidar attenuation: only optically thin clouds in advance of cold or warm front

4. Uniform vs Mixed phase: 87% of clouds are pure liquid or ice

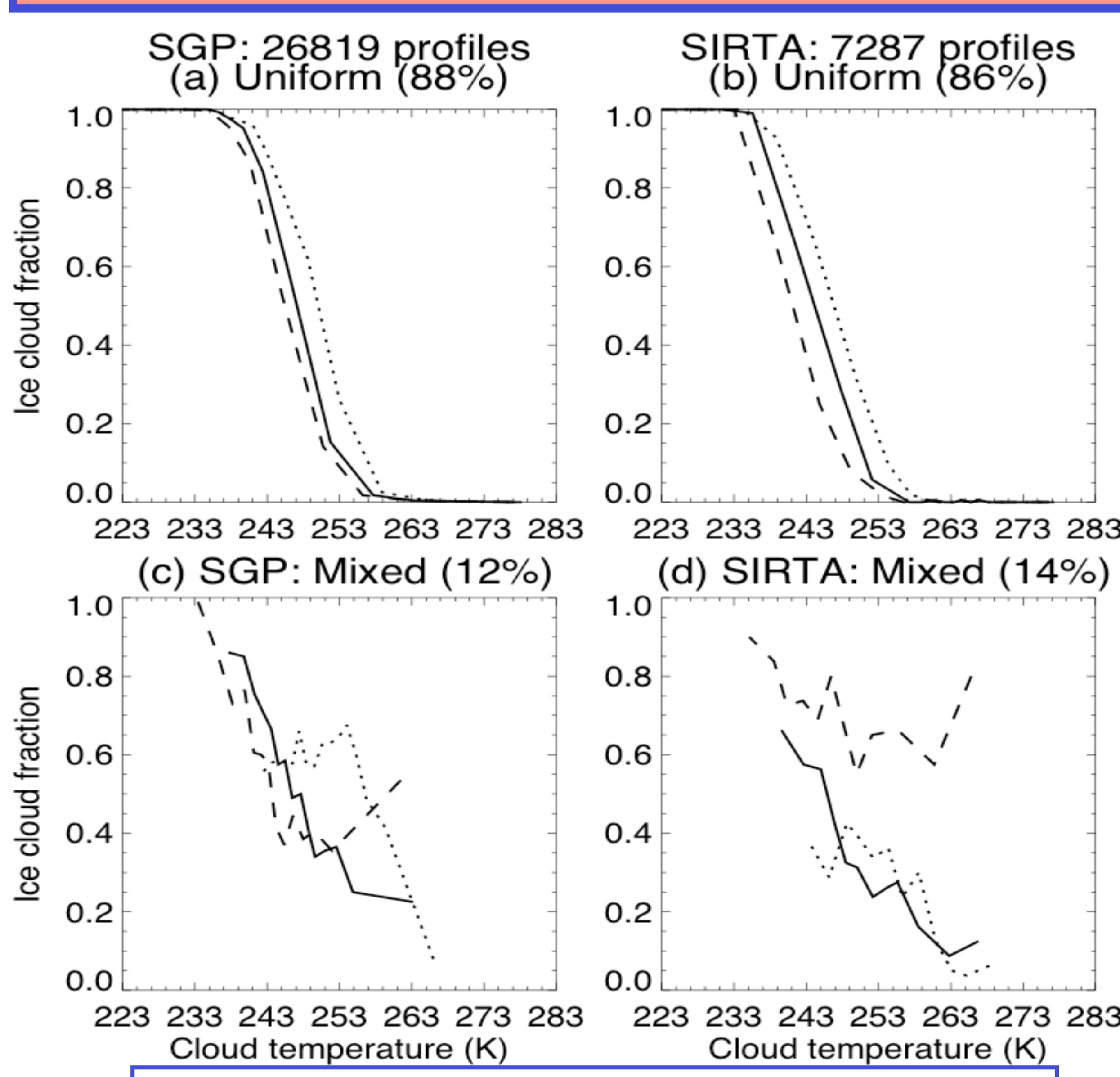


Cloud phase	SGP Fraction of all clouds (%)	SIRTA Fraction of all clouds (%)
Uniform (liquid and ice)	88	86
Mixed (all)	12	14
Mixed: Ice at cloud top	7	10
Mixed: liquid at cloud top	5	4

Above: Cloud type frequency of occurrence at the two locations

Left: Distribution of cloud properties: median height, thickness and lapse rate for pure liquid, mixed and pure ice clouds (top) and for mixed phase (bottom) with ice at cloud top and liquid at cloud top

5. Ice fraction vs temperature: similar relation at all cloud levels



Ice fraction vs temperature at cloud median, top and base from lidar

→ similar at cloud base, top and median very similar: conclusions drawn from satellite cloud-top observations OK for lower cloud levels.

→ Supercooled liquid persists to slightly colder temperatures at SIRTA than SGP, probably not instrument related (all assumptions tested, including phase determination technique vs Wang and Sassen 2001). Not found with MODIS but sampling issues and sensitivity to thin clouds cause errors larger than the difference in T50

6. Cloud temperature for 50% ice fraction (T50): liquid persists to colder temperatures than in Bower et al (1996)

T50	Lidar (median height)	MODIS	POLDER Giraud et al. (2001)	Bower et al. (1996)
SGP	248 K	242 K	240 K	266.5 K
SIRTA	246 K	248 K		