Ground-Based Observations of Clouds in the Arctic -- Implications for CloudSAT-related studies

Gijs de Boer (1)  
Edwin W. Eloranta (1), Gregory J. Tripoli (1), Jennifer Kay (2), Matthew D. Shupe (3)

(1) The University of Wisconsin, Madison  
(2) NCAR  
(3) CIRES

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Introduction

Barrow 9/04-11/04

Eureka 8/05-present

70 N 80 N
Introduction

1) Observation of Mixed-Phase Stratus clouds
Introduction

1) Observation of Mixed-Phase Stratus clouds
2) Representativeness of “point” comparisons

Barrow
9/04-11/04

Eureka
8/05-present

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Introduction: Mixed-Phase Stratus

Lidar backscatter cross section (Masked values shown in black and white)
Introduction: Mixed-Phase Stratus

Radar Reflectivity (Masked values shown in black and white)
Introduction: Mixed-Phase Stratus

• Low altitude stratus frequency of up to 70% during transition seasons (Herman and Goody, 1976; Curry et al., 1996)
• Reduces wintertime net surface cooling by 40-50 W/m² (Curry et al., 1996)
• Commonly observed during several recent Arctic experiments (SHEBA, MPACE, SEARCH, ISDAC)
• Often long-lived, surviving up to several days at a time (de Boer et al., 2008)
• Difficult to simulate because of unstable state (Klein et al., 2008)
Property Statistics

Single-layer mixed phase stratus observations
- 216 hours from Barrow
- 1143 hours from Eureka
Cloud Height

Cloud Base Altitude (DJF)

Cloud Base Altitude (MAM)

Cloud Base Altitude (JJA)

Cloud Base Altitude (SON)

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Cloud Thickness

CloudSAT Vertical Resolution: ~500 m
Cloud Mean Reflectivity

CloudSAT sensitivity: $\sim-29$ dBZ
Cloud Mean Reflectivity

Cloud Mean Reflectivity (DJF)

Cloud Mean Reflectivity (MAM)

Cloud Mean Reflectivity (JJA)

Cloud Mean Reflectivity (SON)

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Precipitation Mean Reflectivity

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Cloud Temperature

Temperature range for mixed-phase clouds used in CloudSAT Radar-Only Microphysical Retrievals: -20-0 C
Cloud Temperature

Cloud Minimum Temperature (DJF)

Cloud Minimum Temperature (MAM)

Cloud Minimum Temperature (JJA)

Cloud Minimum Temperature (SON)
Summary #1

Single Layer Mixed-Phase Stratus

• Significant amounts have cloud bases <1000 m, particularly during transition seasons (MAM, SON)
• Low Reflectivities (<-30 dBZ) can often be found in the cloud layer, particularly during summer (JJA), when less ice is present
• Precipitation typically has reflectivities higher than -30 dBZ, but often falls within 1 km of the surface
• Mixed-phase layer is often <500 m thick
• Cloud minimum temperatures range from 0 to -40 C, with a maximum of occurrence at around -20 C.
Introduction: Representativeness
Introduction: Representativeness

- Distance of overpass from ground site
Introduction: Representativeness

- Distance of overpass from ground site
- Along-track averaging window
Introduction: Representativeness

- Distance of overpass from ground site

- Along-track averaging window

- Ground-based averaging window
Introduction: Representativeness

- Distance of overpass from ground site
- Along-track averaging window
- Ground-based averaging window
- Wind Direction, etc.
Introduction: Representativeness

- Distance of overpass from ground site
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- 437 cases @ <50km
- 181 cases @ <20km
Ground Track Averaging Interval

CloudSAT 10km
CloudSAT 5km
MMCR 5min

Cloud Fraction (%) vs. Altitude (m)

Overpasses < 50 km

(CloudSAT data from Jennifer Kay)

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Ground Track Averaging Interval

Overpasses < 50 km
(CloudSAT data from Jennifer Kay)

CloudSAT 10km
CloudSAT 5km
MMCR 5min

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Ground-Based Averaging Interval

Altitude (m)

CF Difference (%)
Overpass Distance

Overpasses < 20 km
(CloudSAT data from Jennifer Kay)

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Summary #2

Single Location Comparison

- Some significant differences (up to ~5%) exist between original CloudSAT and ground-based estimates.
- Ground-based and along track averaging intervals seem to have little effect on cloud-fraction calculation (within reason)
- Overpass distance considered has significant effect
- Future work will broaden this topic to come up with statistical analysis on how representative “point” comparisons are for different distances, averaging intervals, etc.
References

de Boer, G., E.W. Eloranta and M.D. Shupe (2008), Arctic Mixed-Phase Stratus Properties from Multiple Years of Surface-Based Measurements at Two High-Latitude Locations. In Preparation.
2B-RO Microphysical Retrievals

Radar Reflectivity (Liquid Cloud Shown by Gray Shading)

Altitude (km)

10 Minutes

30 October 2006
17 December 2006
16 August 2007
23 August 2007
2 November 2007

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Cloud Maximum Reflectivity

Cloud Max Reflectivity (DJF)

Cloud Max Reflectivity (MAM)

Cloud Max Reflectivity (JJA)

Cloud Max Reflectivity (SON)

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Precipitation Maximum Reflectivity

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Precipitation Max Reflectivity (DJF)

Precipitation Max Reflectivity (MAM)

Precipitation Max Reflectivity (JJA)

Precipitation Max Reflectivity (SON)