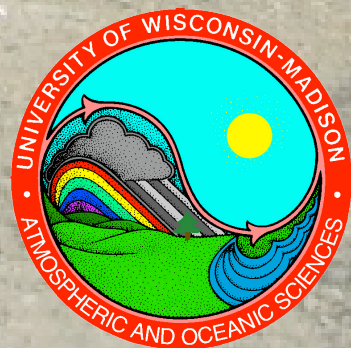


# **Understanding formation and maintenance of mixed-phase Arctic stratus through long-term observation at two Arctic locations**

**Gijs de Boer**

E.W. Eloranta, G.J. Tripoli

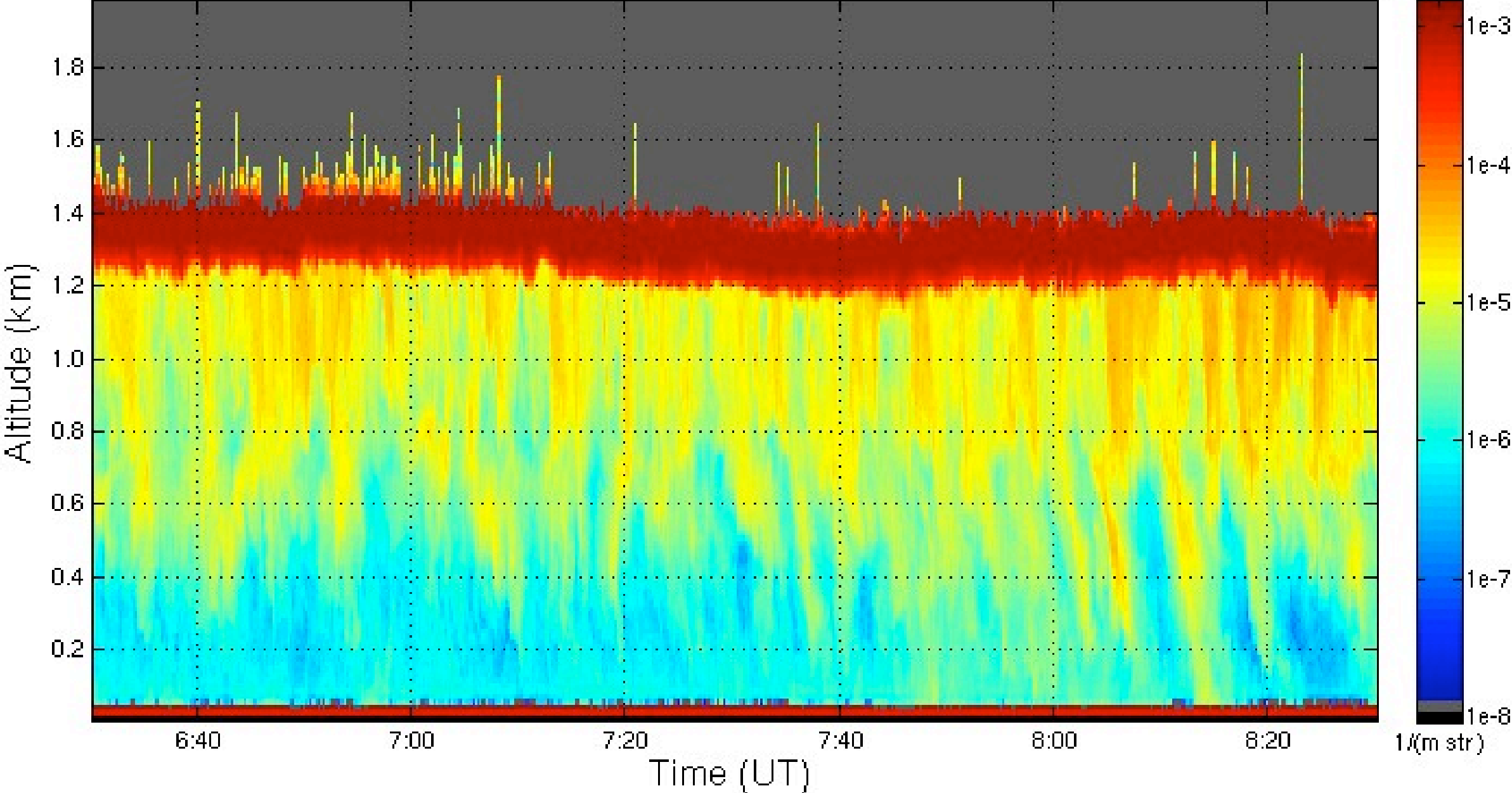
The University of Wisconsin - Madison



# Introduction

Aerosol backscatter cross section 27-Sep-2006

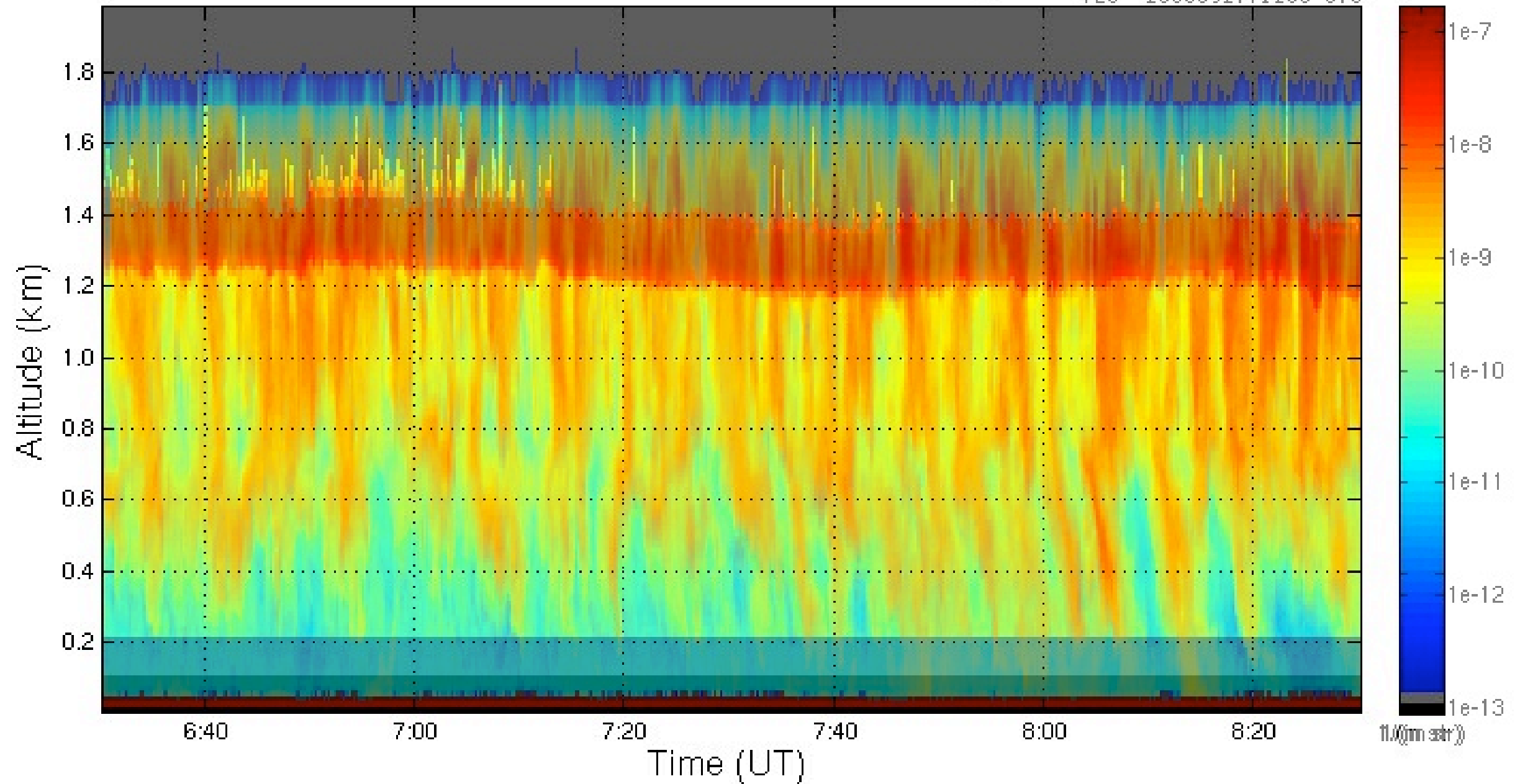
YEU 20060927T1200 UTC



# Introduction

Radar backscatter cross section 27-Sep-2006

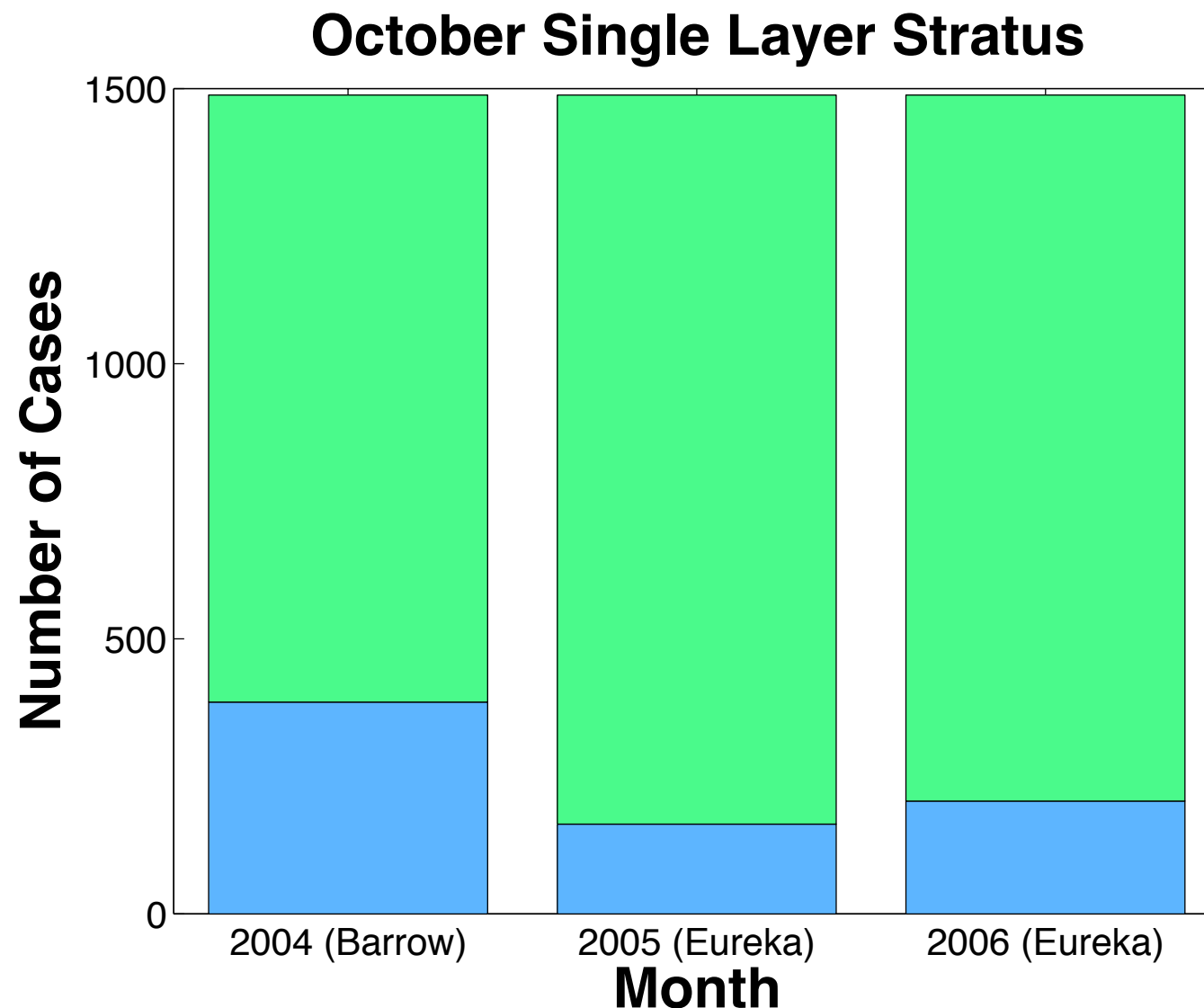
,EU 20060927T1200 UTC



# Introduction

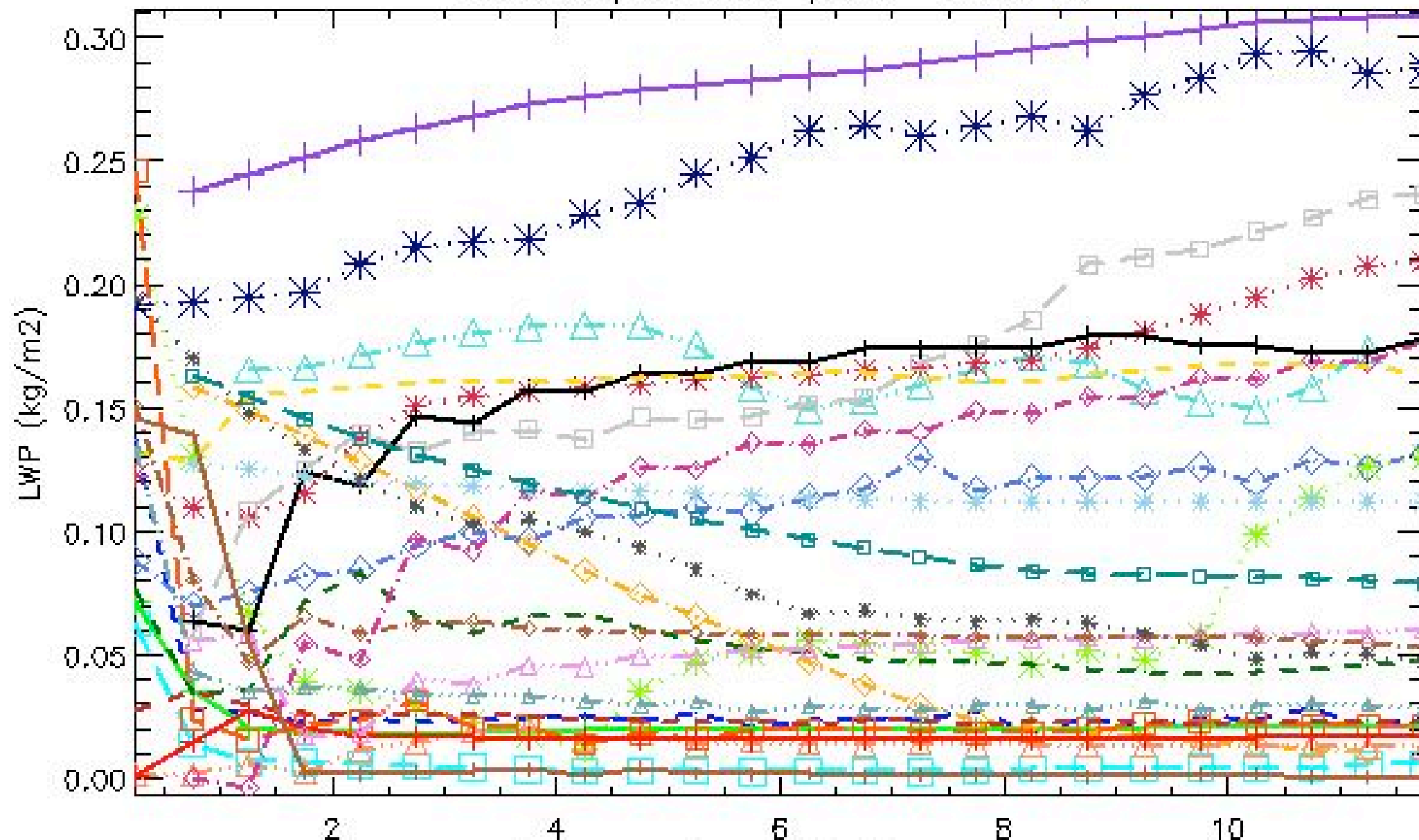
These cloud structures are extremely prevalent in the Arctic:

- SHEBA: 48% occurrence in May (Rogers et al., 2001)
- Low altitude stratus frequency of up to 70% during transitional seasons (Curry et al., 1996; Herman and Goody, 1976)
- From Eureka: over 1700 30 minute cases for September 2005-December 2006.
- From M-PACE: over 500 30 minute cases for mid September-mid November, 2004.



# Introduction

Cloud liquid water path, Case: b1



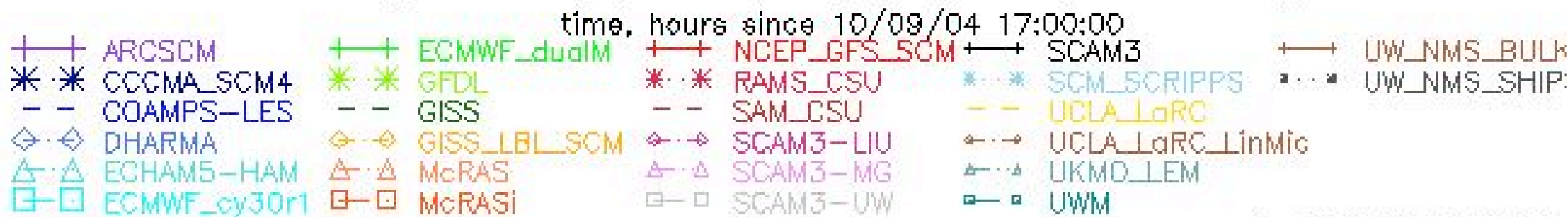
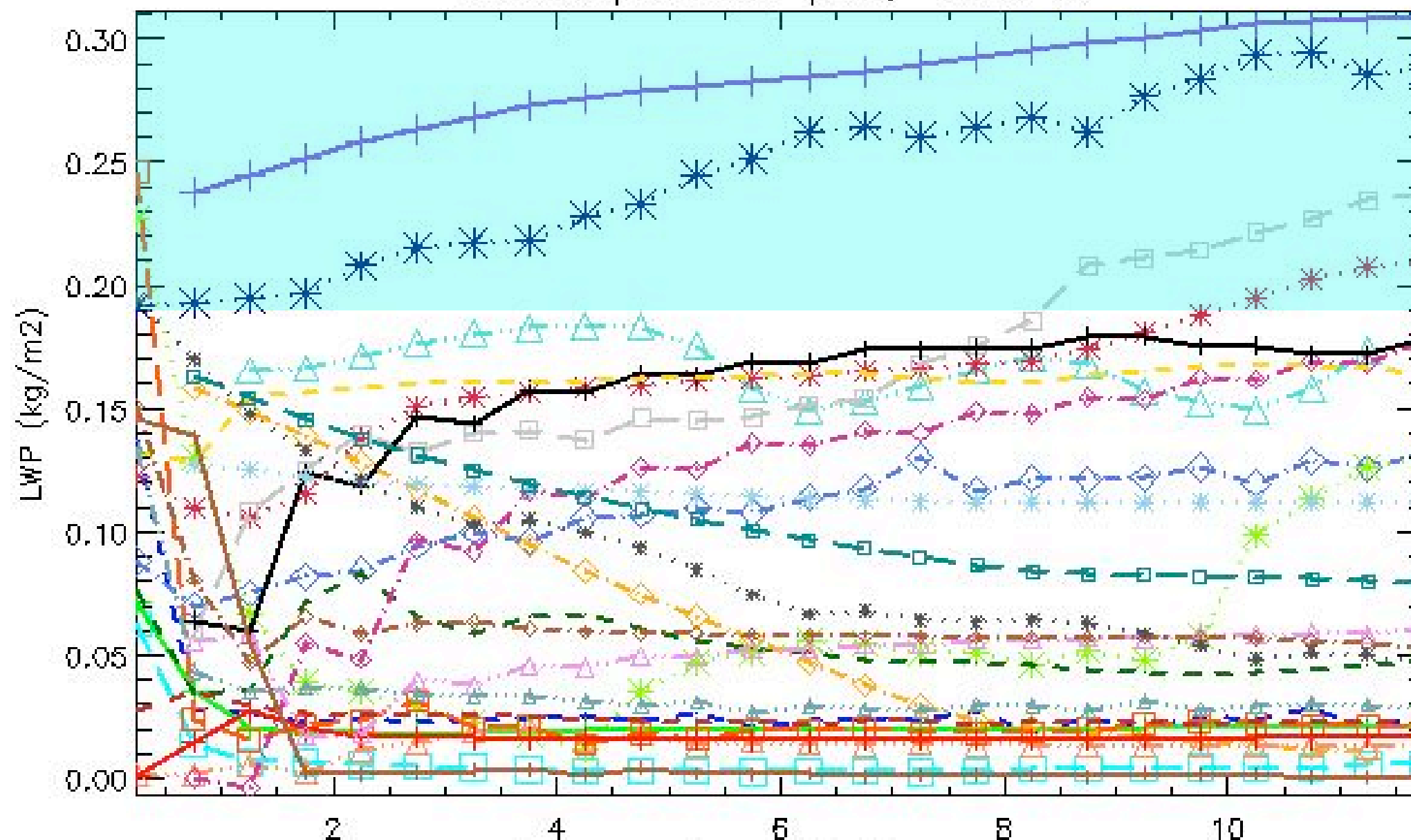
- |                  |                  |                |                      |                 |
|------------------|------------------|----------------|----------------------|-----------------|
| ++ ARCSCM        | + ECMWF_dualM    | + NCEP_GFS_SCM | + SCAM3              | + UW_NMS_BULK   |
| * * CCCMA_SCM4   | * * GFDL         | * * RAMS_CSU   | * * SCM_SCRIPPS      | * * UW_NMS_SHIP |
| - - COAMPS-LES   | - - GISS         | - - SAM_CSU    | - - UCLA_LaRC        |                 |
| ◇ ◇ DHARMA       | ◇ ◇ GISS_LBL_SCM | ◇ ◇ SCAM3-LIU  | ◇ ◇ UCLA_LaRC_LinMic |                 |
| △ △ ECHAM5-HAM   | △ △ McRAS        | △ △ SCAM3-MG   | △ △ UKMO_LEM         |                 |
| □ □ ECMWF_cy30r1 | □ □ McRASI       | □ □ SCAM3-UW   | □ □ UWM              |                 |

Thu Oct 4 14:12:58 2007

From ARM Model intercomparison (Klein et al.)

# Introduction

Cloud liquid water path, Case: b1



Thu Oct 4 14:12:58 2007

From ARM Model intercomparison (Klein et al.)

# Introduction

## - **Ice Formation**

(Pruppacher and Klett, 1997)

- **Homogeneous nucleation**

- **Heterogeneous nucleation**

- Deposition freezing

- Contact freezing

- Condensation freezing

- Immersion freezing

- **Some Multiplication Processes**

- Drop shattering

- Ice-ice collisions

- Splinter ejection during riming



# Observations



## Instruments

- UW Arctic High Spectral Resolution Lidar
- NOAA ETL Millimeter Cloud Radar
- 12-hr. Radiosonde Frequency
- In-situ from M-PACE
- Microwave Radiometer
- U. Idaho Polar AERI
- CALIPSO
- CloudSAT



# Observations

## Where does the ice come from?

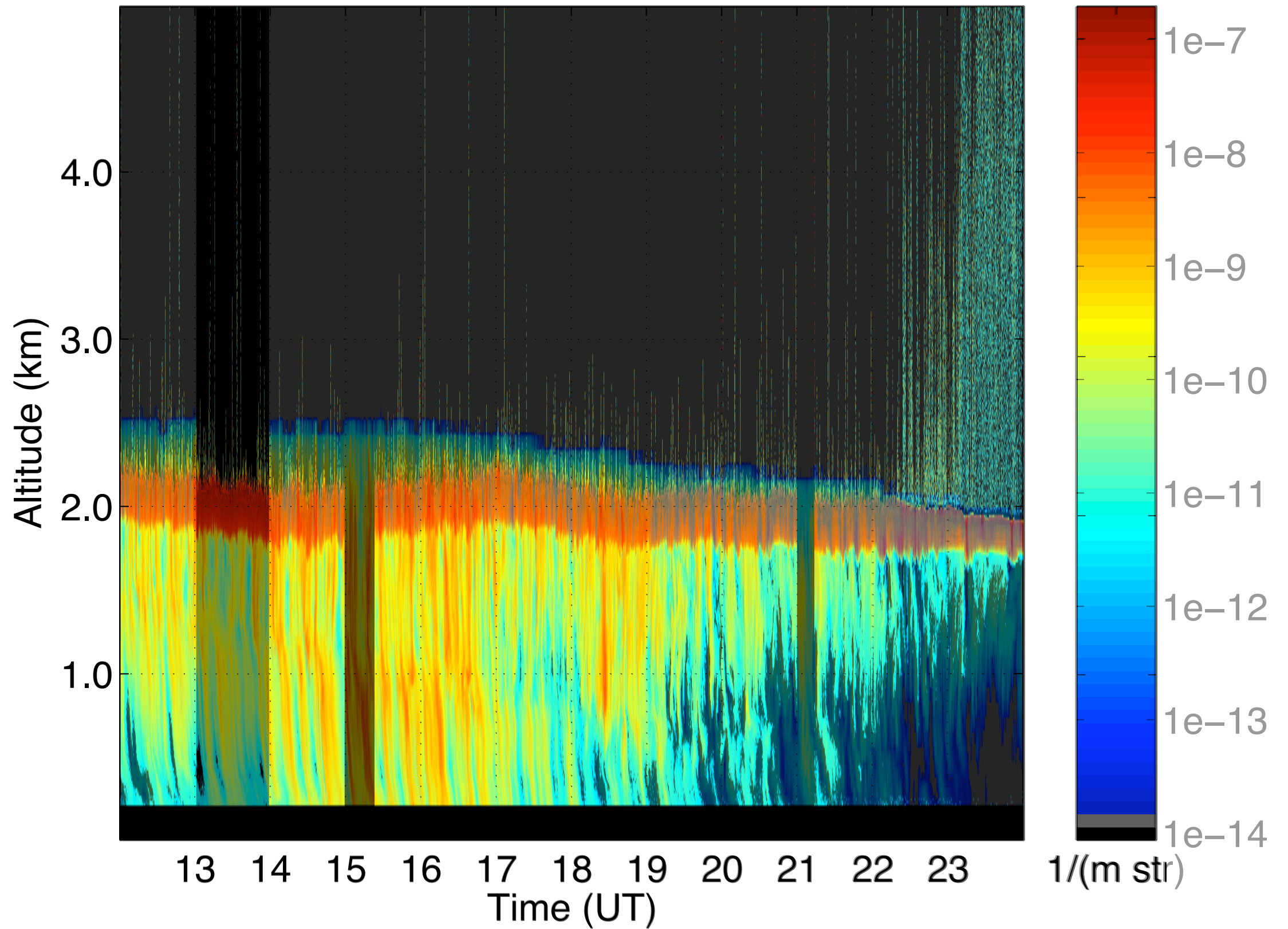
Low IN, but substantial ice...

Example from M-PACE: CFDC Average out of cloud IN concentration for 9 and 10 October 2004: **0.16 I/L**  
Ice particle concentrations: **~10 I/L**

So nucleation not by:

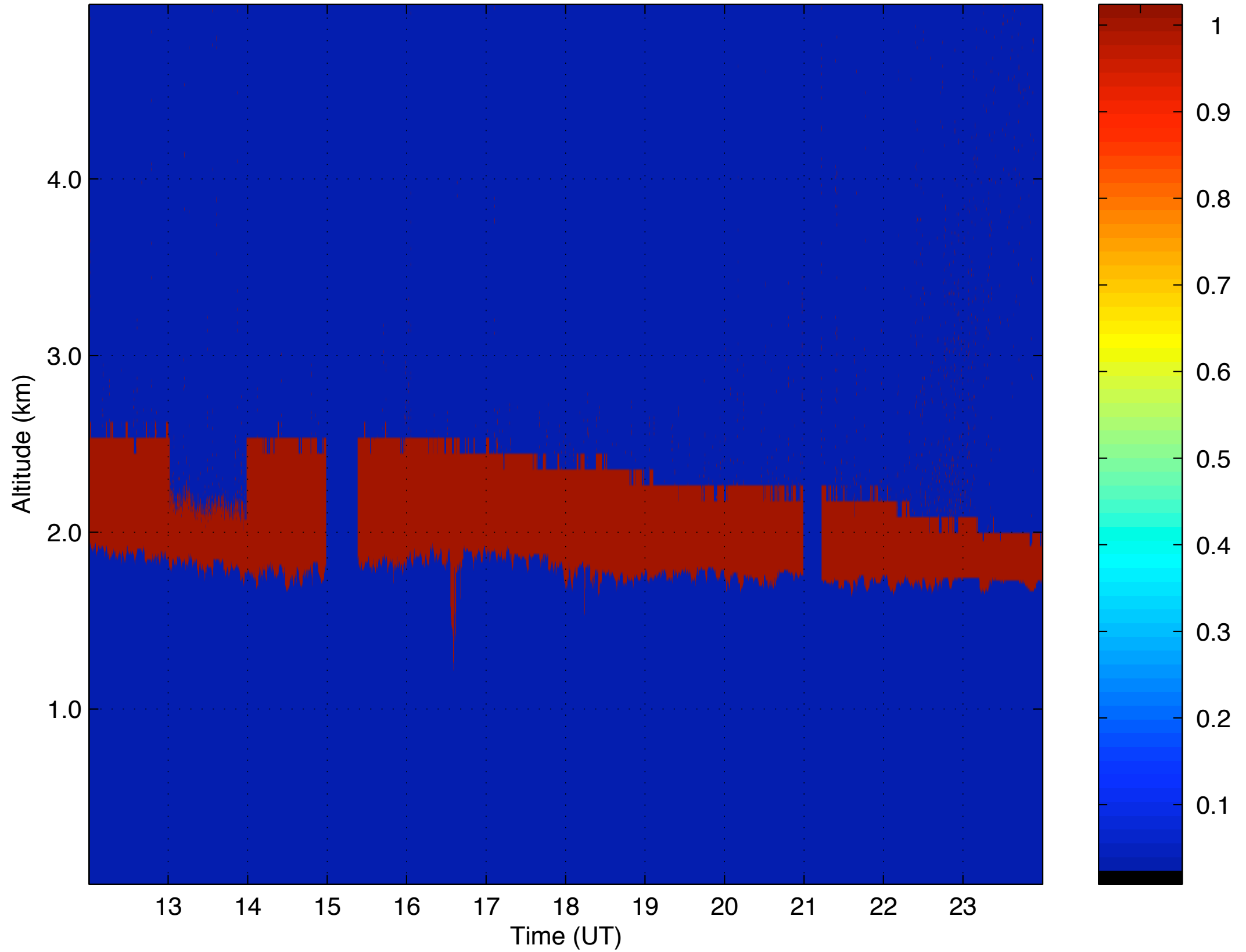
- Deposition freezing
  - Condensation freezing
  - Contact freezing
- alone

# Observations



# Observations

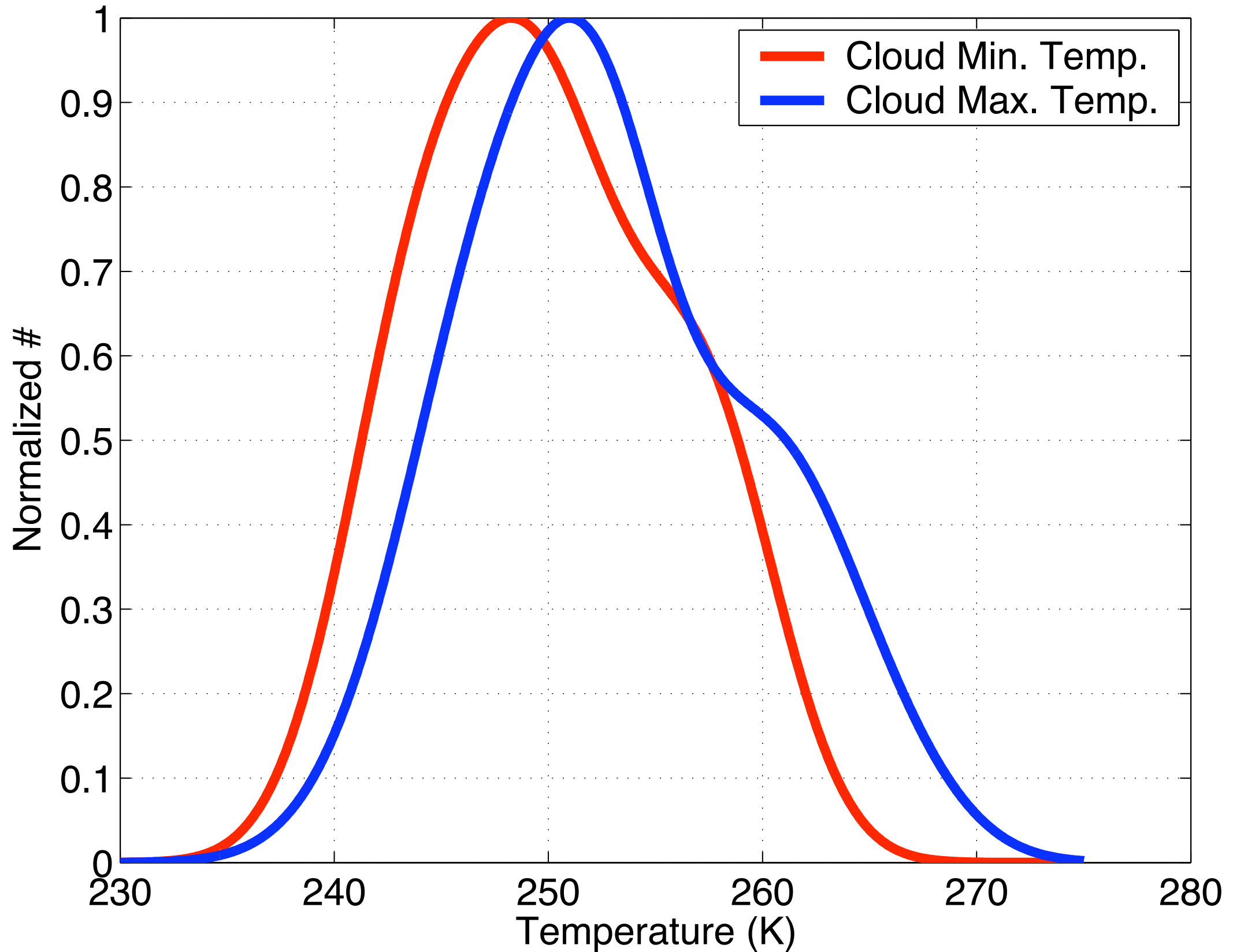
Cloud Mask (Masked values shown in black and white)



AGU San Francisco, 14 December, 2007

# Observations

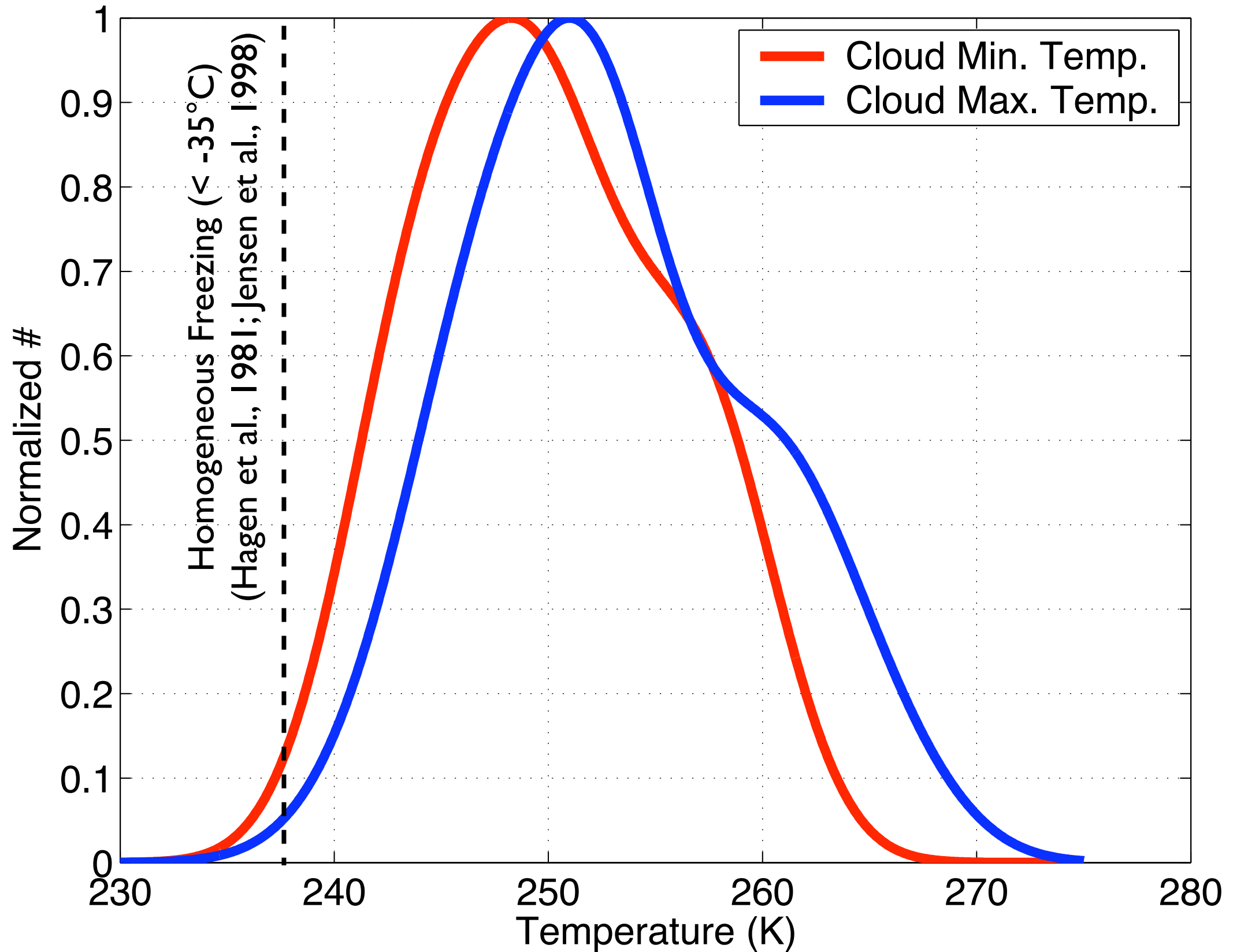
Probability Density Function



AGU San Francisco, 14 December, 2007

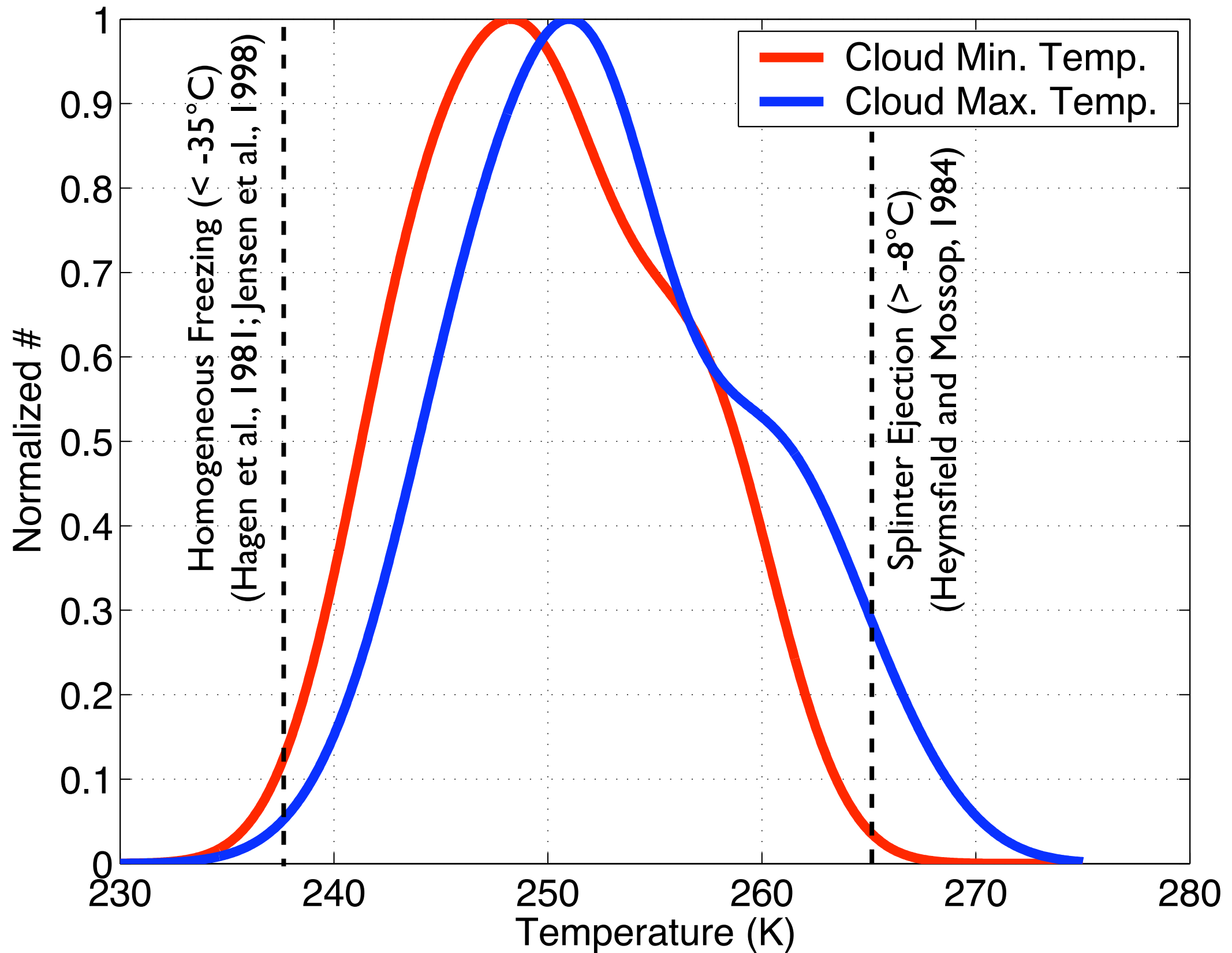
# Observations

Probability Density Function

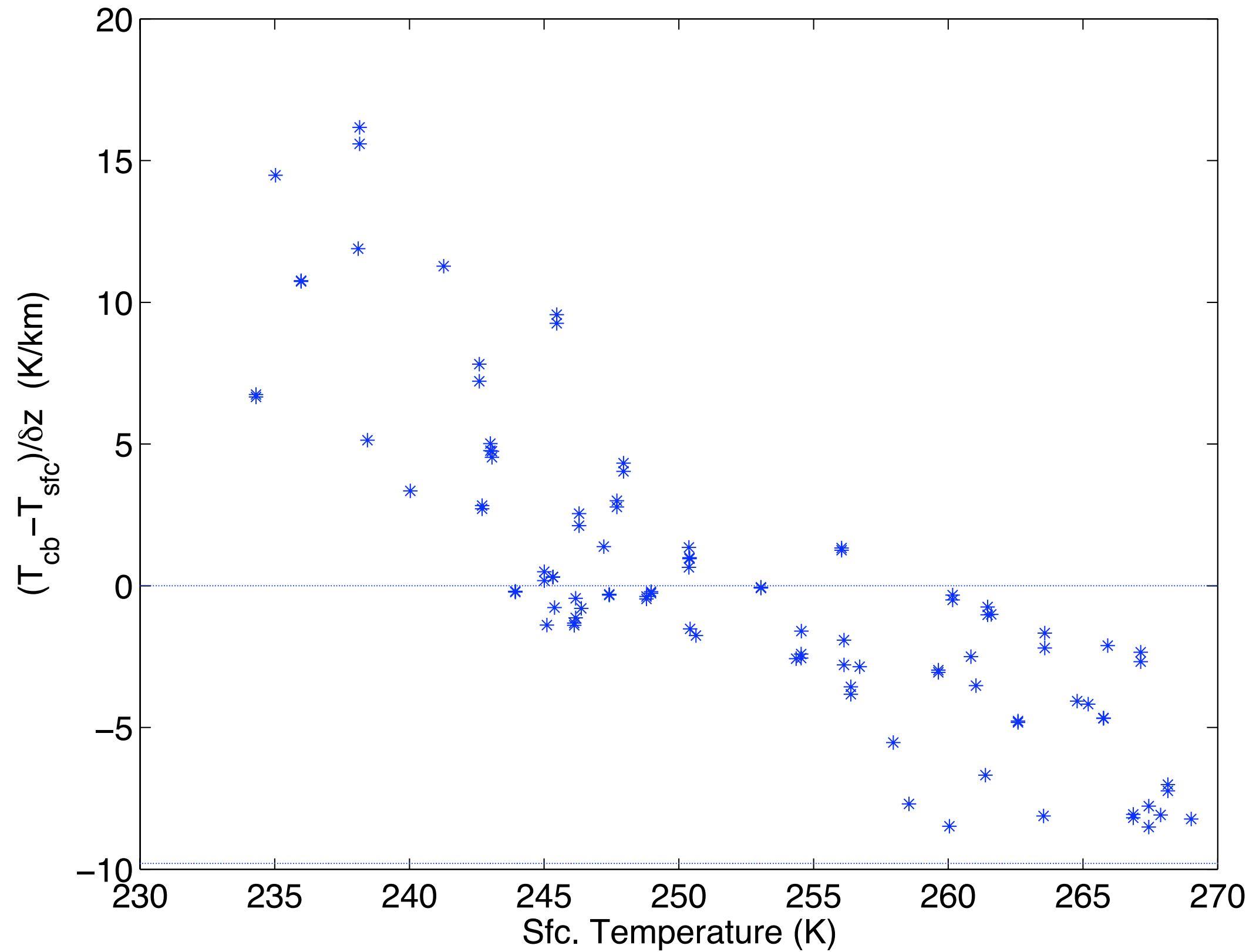


# Observations

Probability Density Function



# Observations



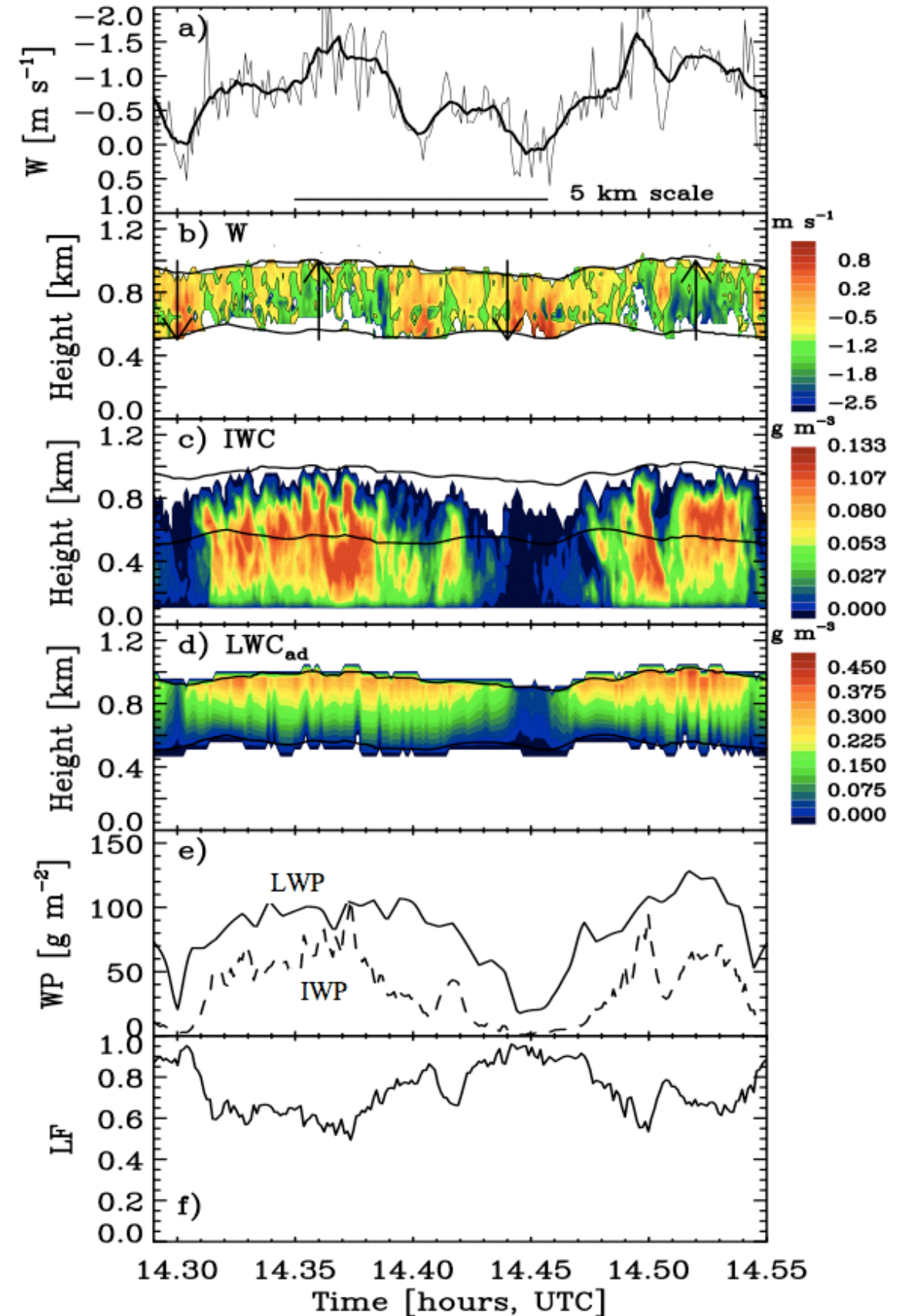
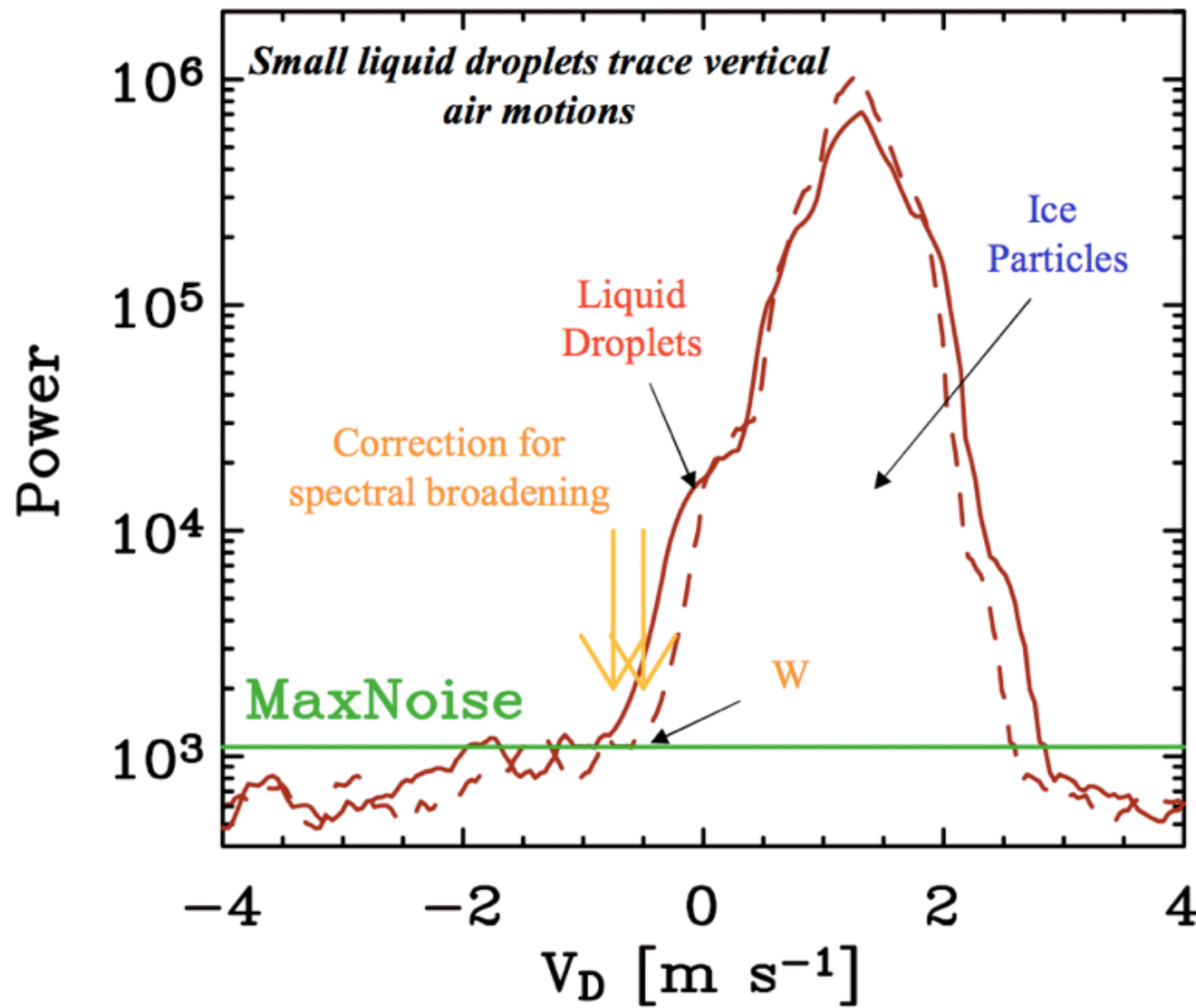


# Observations

Why the horizontal  
variability in ice production?

# Observations

Why the horizontal variability in ice production?



Figures courtesy of M. Shupe (NOAA)

# Summary

## **Ice production likely not due to:**

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- Condensation, deposition or contact freezing alone (too few IN)
- Drop splinter ejection during riming (too cold)

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## **Future investigation**

- Numerical sensitivity experiments to look at individual processes.
- Evaluate role of vertical velocity in cloud layer