

# Arctic mixed phase cloud and its relation with humidity and temperature inversions using ARM NSA observations

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# Motivation

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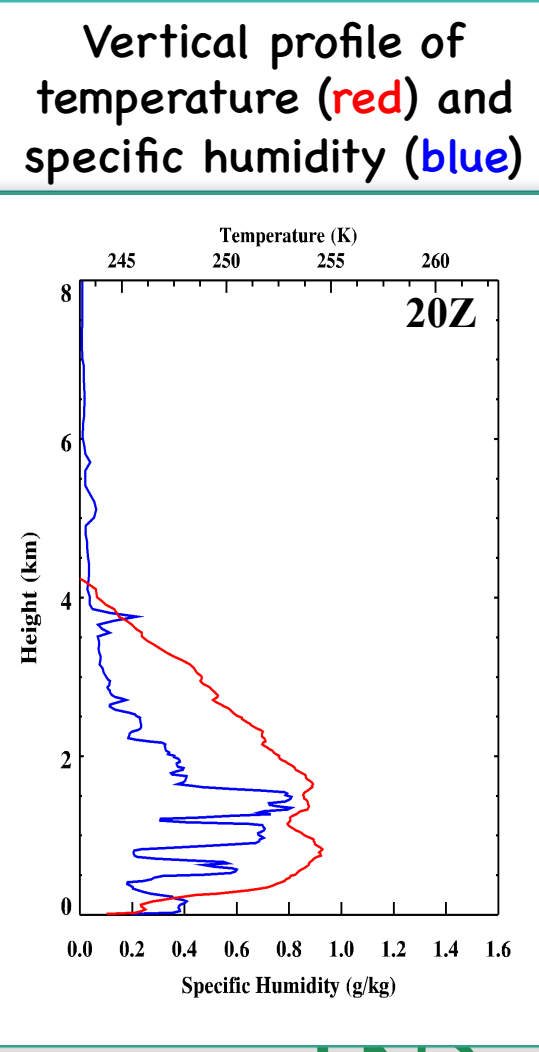
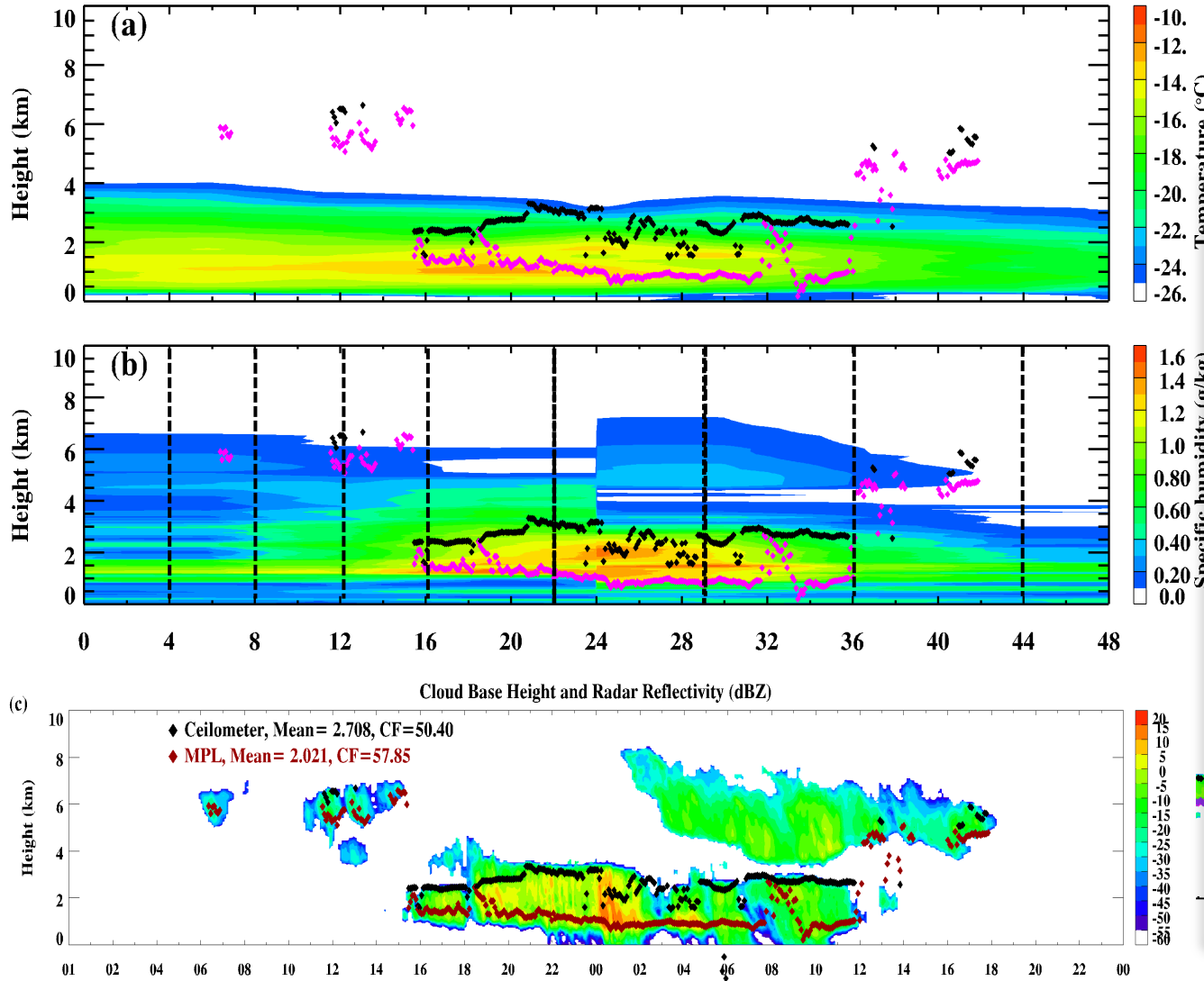
- ◆ Dominant cloud type; Significant influence in radiation flux and climate feedback
- ◆ Unexpected long lifetime of Arctic mixed phase cloud (AMC)
- ◆ Solomon et al [2011, 2014] found that coincidence of temperature and humidity inversions at AMC top can serve as moisture source

## Purpose of this study

1. What are the characteristics of Arctic humidity inversions and does it have seasonal variation?
2. Does humidity inversion favor the occurrence of mixed-phase cloud/ does the occurrence of mixed-phase cloud increase with stronger humidity inversions?
3. Does the relative location of inversions (above or below cloud) influence mixed phase cloud occurrence?

# Relationship between mixed-phase cloud and T, q inversions

4-5 March 2008



# Data and methodology

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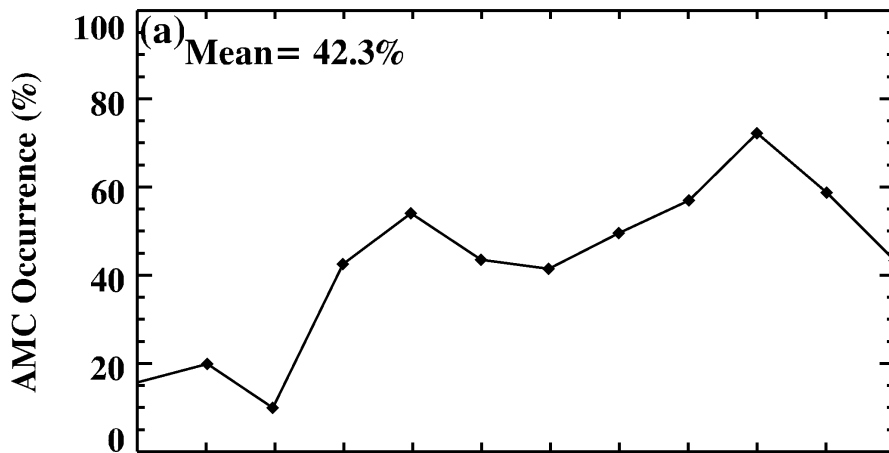
NSA Barrow site; Time period: 2006/10–2009/09

Identificator

➤ Shupe [200

Identificator

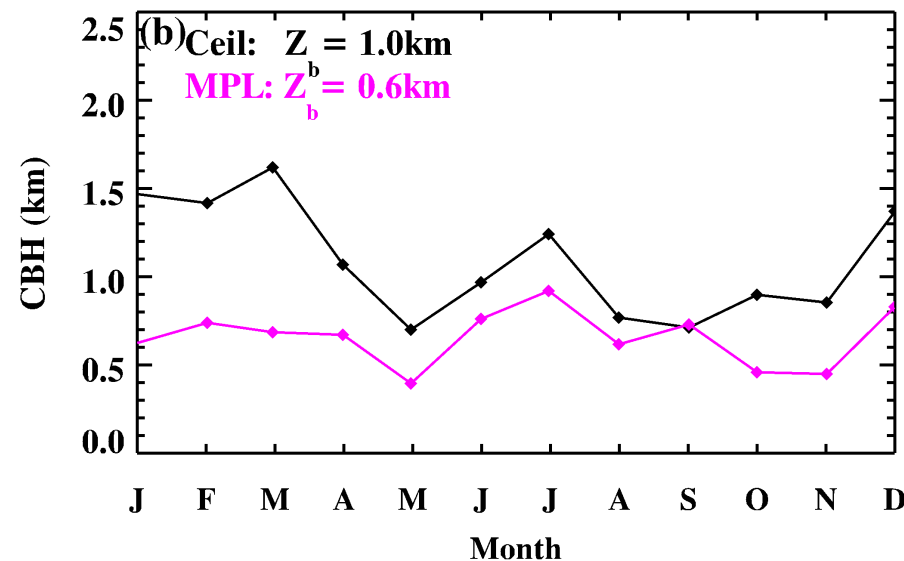
➤ Inversion ini  
between inv



C)

LWP

Temperature



resolution

$\Delta z = 15\text{m}$

$\Delta z = 15\text{m}$

$\Delta z = 45\text{m}$

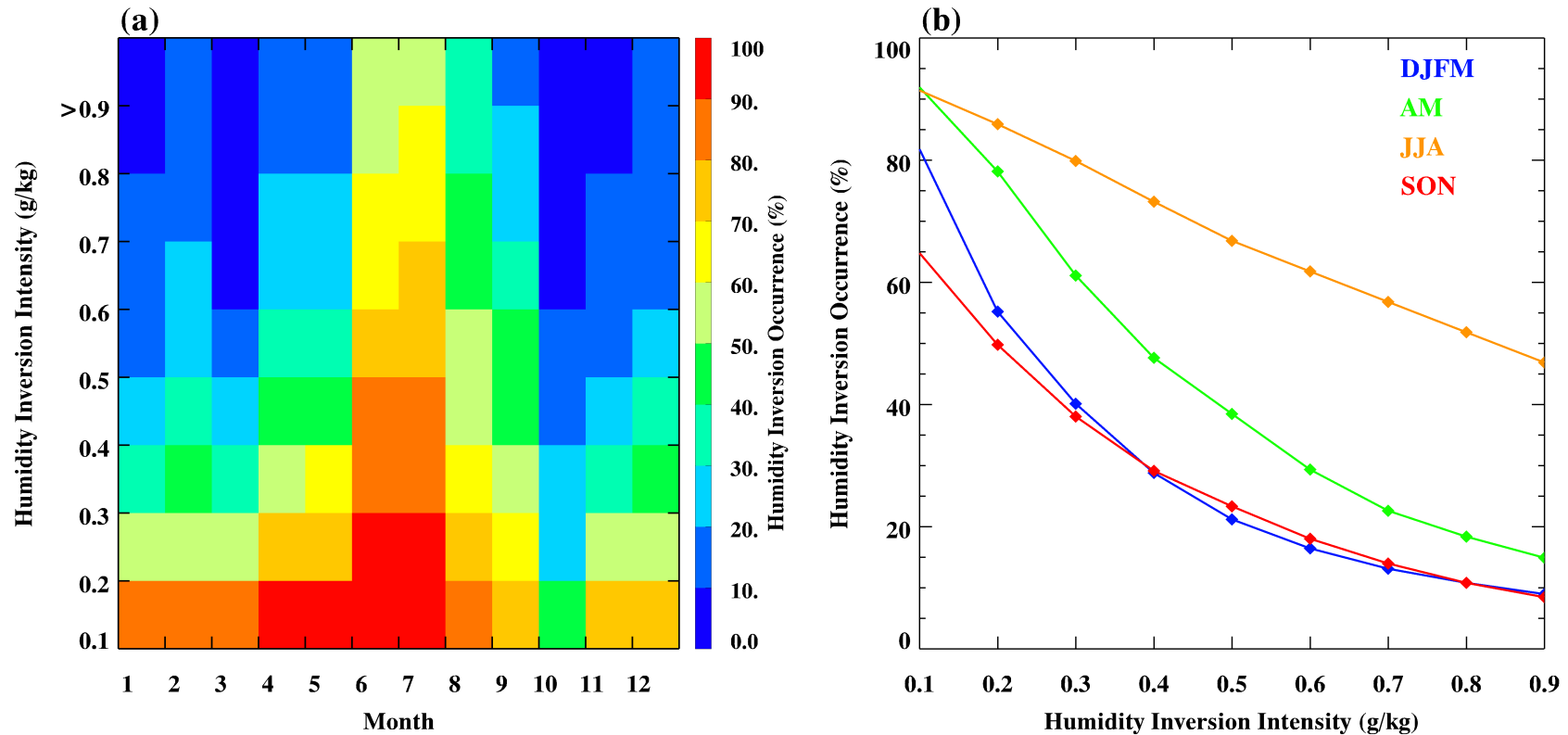
$\Delta t = 30\text{s}$

$\Delta z = 20\text{m} (<3\text{km})$

Instrument	
Ceilometer	
MPL	B
MMCR	F
MWR	
Merged Sounding	

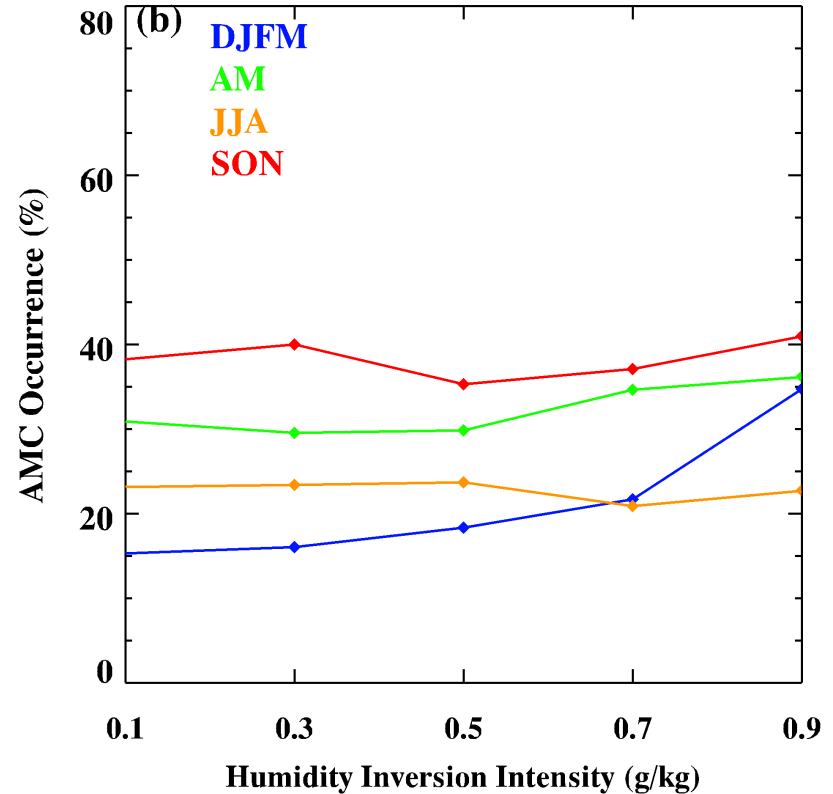
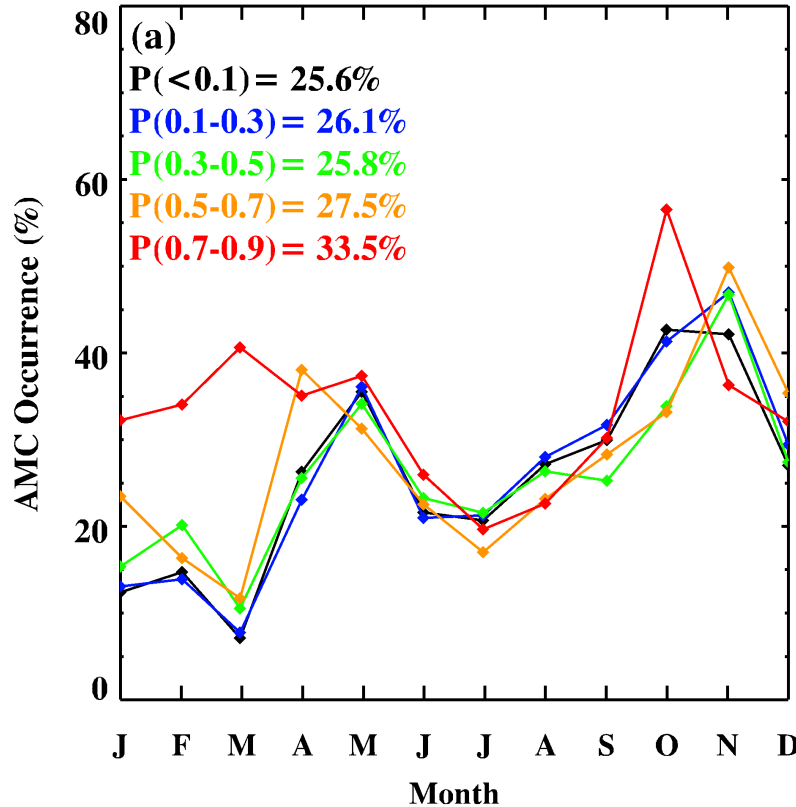


# Q1: What are the characteristics of Arctic humidity inversions and does it have seasonal variation?



- Humidity inversion: >80% with intensity >0.1g/kg; lowest in October
- Winter: weak inversions; <30% of inversions with intensity >0.4g/kg
- Summer, strong inversion >50% of inversions with intensity > 0.5 g/kg

# Q2: Inversion intensity and mixed-phase cloud occurrence

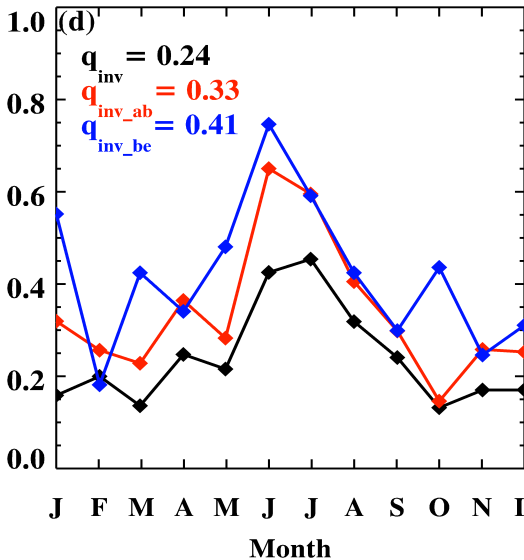
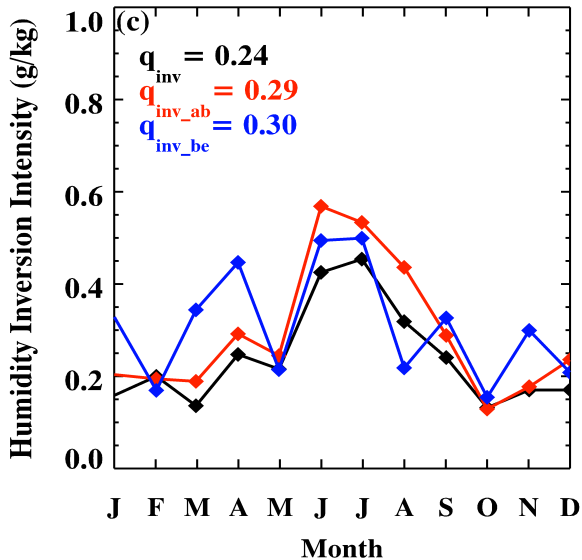
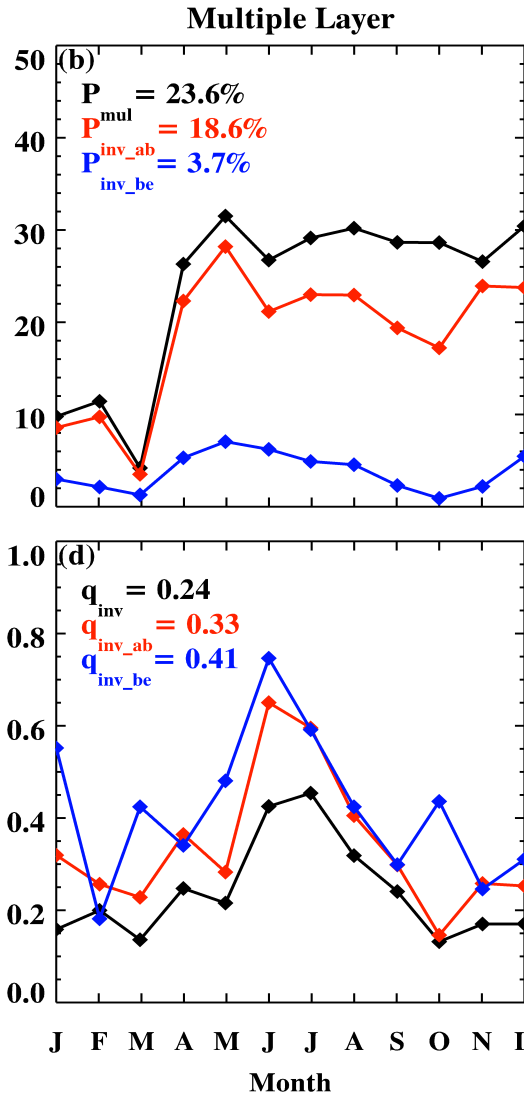
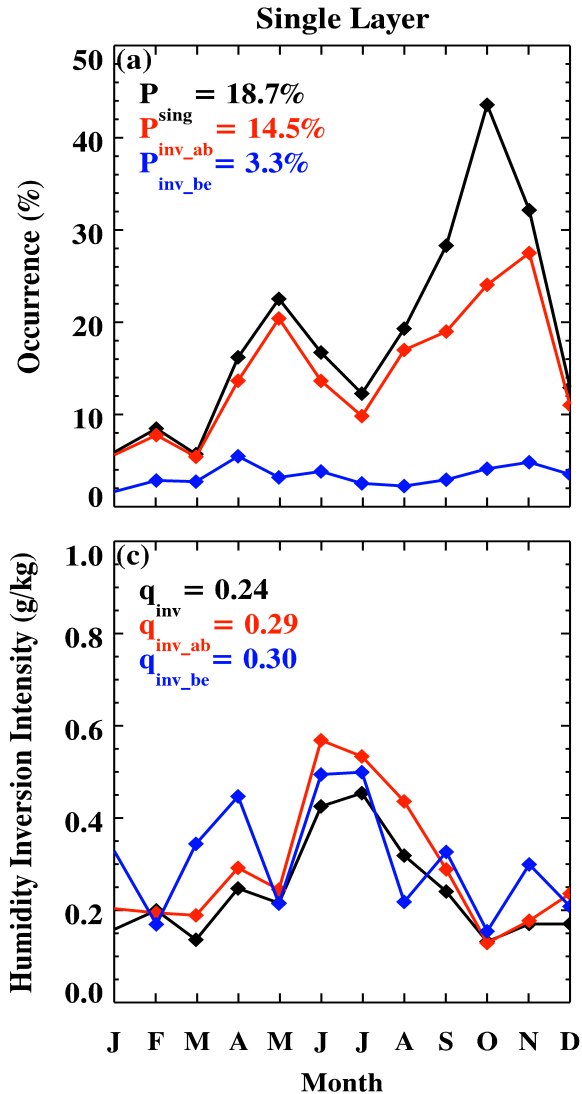


- In winter, AMC occurrence strongly correlate with inversion intensity: increase 15%-35% as intensity  $0.1 \rightarrow 0.9$  g/kg
- In Summer, AMC occurrence is invariant with different intensities.
- Intensity  $>0.9$ g/kg,  $\sim 40\%$  of time AMC occurred with inversions, except for summer.

# Q3: Inversion location relative to mixed-phase cloud (AMC)

## Humidity inversions

## phase cloud (AMC)



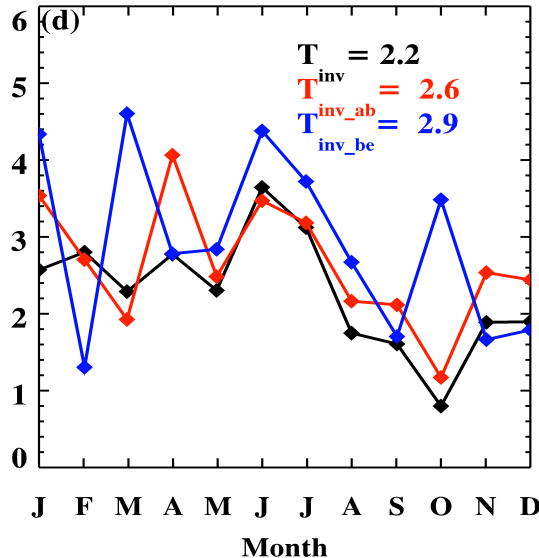
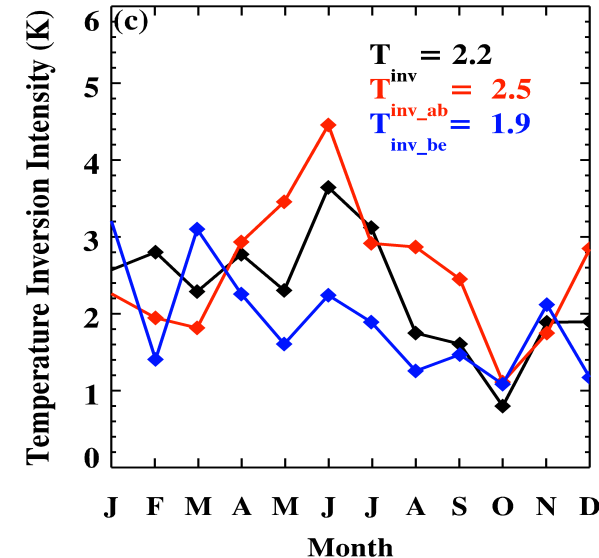
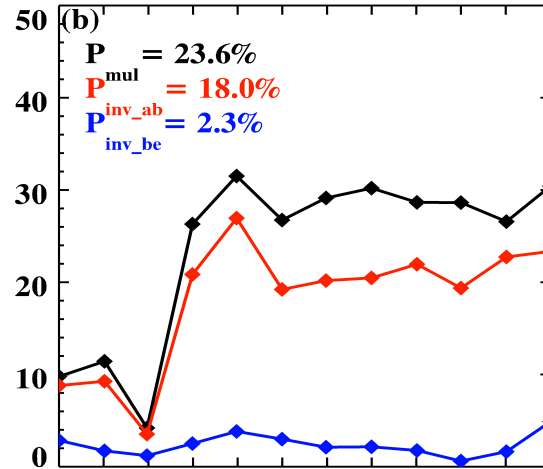
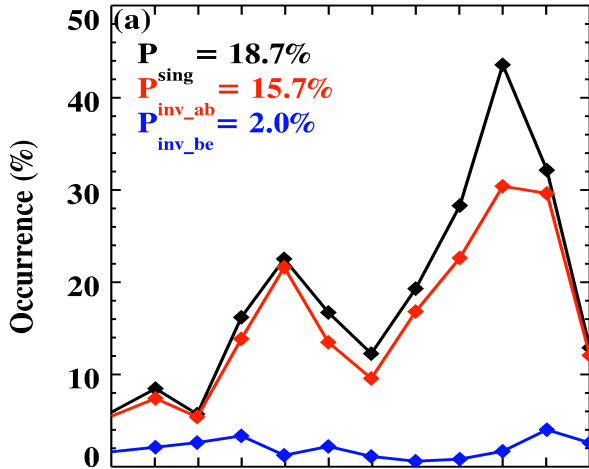
- 18.7% AMC single layer; 23.6% multiple layer
- Humidity inversions ~ 5 times more often above than below
- AMC ~ 100% time coexist with humidity inversions, except autumn
- Intensity above or below cloud, little difference
- Humidity inversion stronger in summer

# Q3: Inversion location relative to mixed-phase cloud (AMC)

## Temperature inversions

Single Layer

Multiple Layer



- Temperature inversion mostly above cloud, hardly below
- AMC ~ 100% time coexist with temperature inversions in winter, spring
- Temperature inversion stronger in summer, weaker in autumn

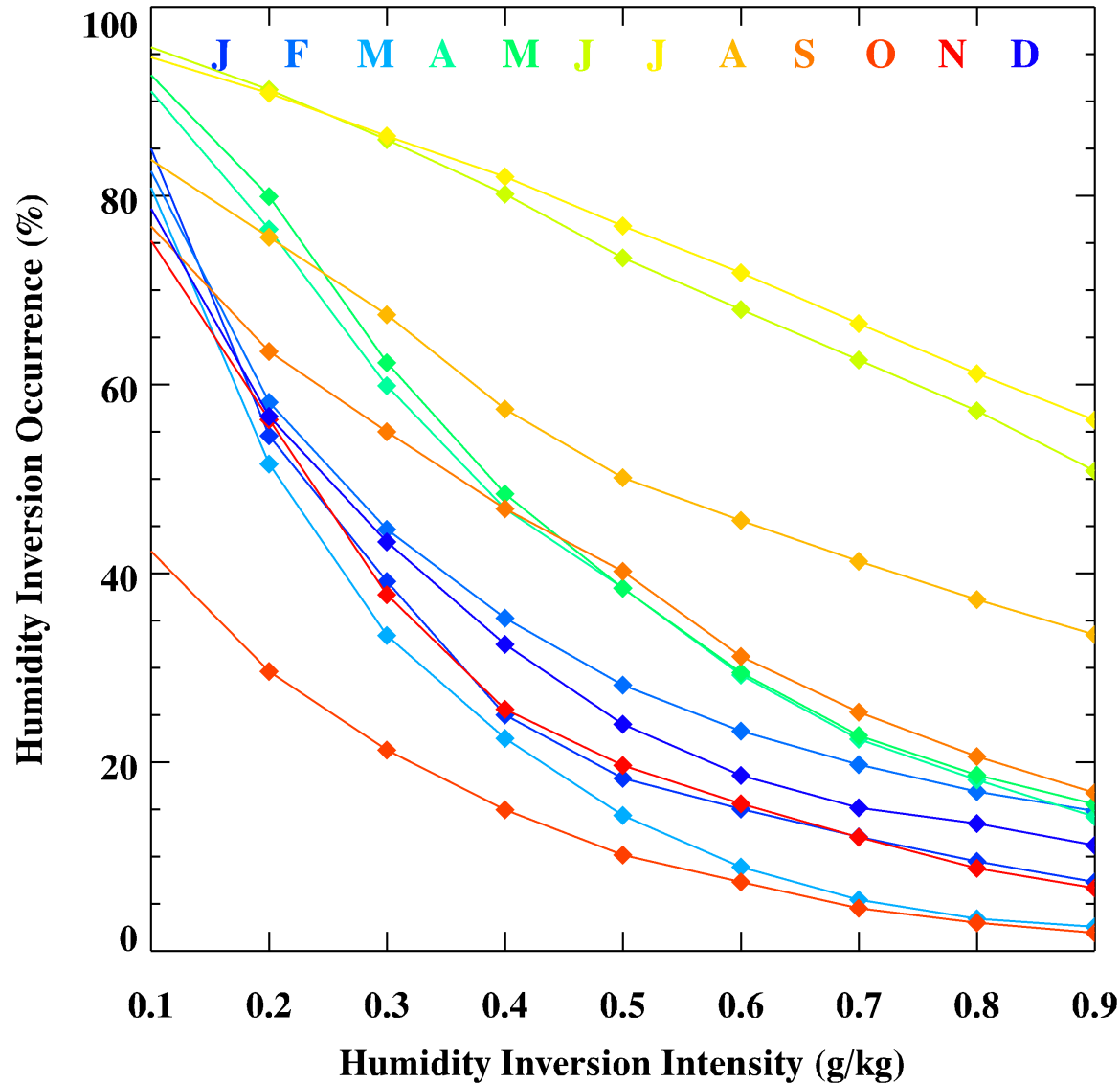
- From **October 2006 to September 2007**, mixed phase cloud occurrence: 42.3%, with single layer: 18.7%, multiple layer: 23.6%;
- >80% of time, **humidity inversion** occurs; **weak in winter** (<30% with intensity >0.4g/kg) and **strong in summer** (>50% with intensity >0.5g/kg);
- Mixed phase cloud occurrence increase** with stronger humidity inversion **in winter** but **does not change in summer**;
- When **intensity >0.9g/kg**, ~40% of time **mixed-phase cloud occurred** with inversions, except for summer;
- Both temperature and humidity **inversions** occur **5-8 times more often above** the cloud **then below**; in winter and spring, mixed-phase cloud coexist ~100% with inversions.



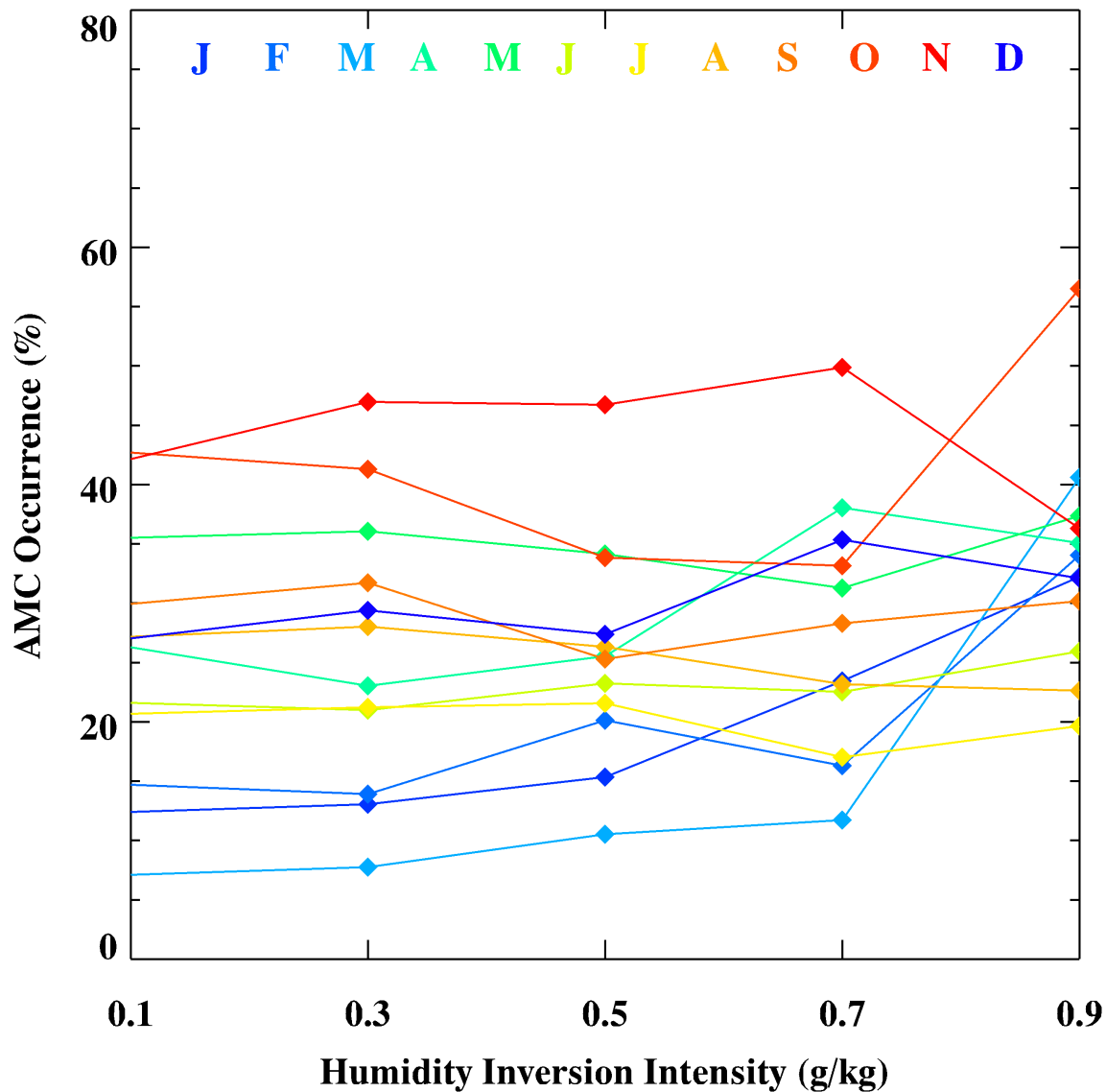
# BACKUP SLIDES



# Humidity inversion occurrence for different intensities for the 12 months



# Mixed-phase cloud occurrence for different humidity inversion intensities for the 12 months 12



# Mixed-phase cloud occurrence for different temperature inversion intensities for the 12 months

