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

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Dominant cloud type; Significant influence in radiation flux and climate feedback

Unexpected long lifetime of Artic 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

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**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?
4-5 March 2008

Relationship between mixed-phase cloud and T, q inversions

Vertical profile of temperature (red) and specific humidity (blue)
NSA Barrow site; Time period: 2006/10–2009/09

- Identification
  - Shupe [2007]

- Identification
  - Inversion intensity: difference in specific humidity/temperature between inversion base and top

### Instrument

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Measurement used</th>
<th>resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceilometer</td>
<td>Backscatter, cloud base</td>
<td>Δz = 15m</td>
</tr>
<tr>
<td>MPL</td>
<td>Backscatter, cloud base, depolarization ratio</td>
<td>Δz = 15m</td>
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<tr>
<td>MMCR</td>
<td>Reflectivity, Doppler velocity, spectral width</td>
<td>Δz = 45m</td>
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<td>MWR</td>
<td>Cloud LWP</td>
<td>Δt = 30s</td>
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<tr>
<td>Merged Sounding</td>
<td>Temperature</td>
<td>Δz = 20m (&lt;3km)</td>
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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
In winter, AMC occurrence strongly correlate with inversion intensity: increase 15%-35% as intensity 0.1→ 0.9 g/kg

In Summer, AMC occurrence is invariant with different intensities.

Intensity >0.9g/kg, ~40% of time AMC occurred with inversions, except for summer.
Q3: Inversion location relative to mixed-phase cloud (AMC)

Humidity inversions

- 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

- 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.
Humidity inversion occurrence for different intensities for the 12 months
Mixed-phase cloud occurrence for different humidity inversion intensities for the 12 months.
Mixed-phase cloud occurrence for different temperature inversion intensities for the 12 months.