Understanding the Seasonal and Interannual Variations of Boundary-layer Mixed-phase Cloud Properties Observed at the ARCF NSA site

Zhien Wang, Ming Zhao, and Min Deng

University of Wyoming , Laramie, Wyoming, 82071, zwang@uwyo.edu

1. Introduction

To improve Arctic cloud simulations in climate models, a better understanding of factors controlling the seasonal and interannual variations of Arctic mixed-phase cloud properties are needed.

A suit of remote sensing algorithms are developed to better characterize the macrophysical and microphysical properties of arctic mixed-phase clouds over a wide range of liquid water path and applied to the ARCF observations at the North Slope of Alaska (NSA) site, generating a multi-year mixed-phase cloud dataset including:

- *Cloud boundary and phase*
- *Liquid water path (LWP) and effective radius (r_{eff})*
- *Ice water content (IWC) and general effective radius (D_{ge}) profiles*

The dataset is combined with other data to understand the seasonal and interannual variations.

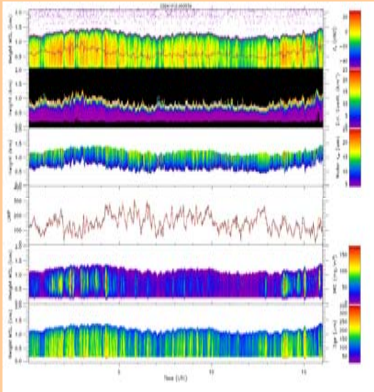

Fig1. A retrieval example of mixed-phase cloud observed at the Barrow site on October 10, 2004 from MMCR, MPL, MWR, and radiosonde data.

2. Dynamics and Cloud Properties

a) *Cloud Formation Mechanisms*

Arctic boundary layer clouds can form under **warm moisture air (WMA) or Cold dry air (CDA)** advection.

Fig. 2 shows that boundary layer clouds at the NSA site mainly form under warm moisture advections and there are noticeable differences in cloud top height and LWP for clouds formed under warm and cold advections.

b) *Low cloud properties under upward and subsidence conditions*

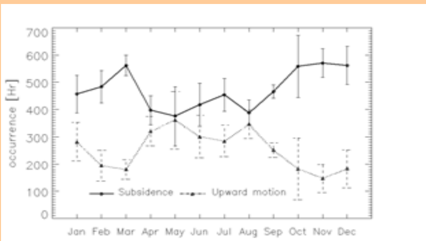

Fig. 3 Occurrence of subsidence and upward conditions associated with low clouds over the NSA site from 1999 to 2003.

ARM Observations **ECMWF Forecast**

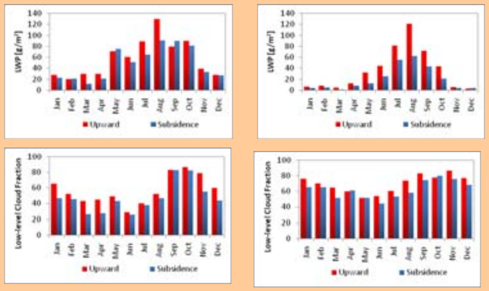

Fig. 4 Comparison of LWP and low cloud fraction under upward and subsidence conditions.

3.Correlation Between Sea Ice and Cloud LWP

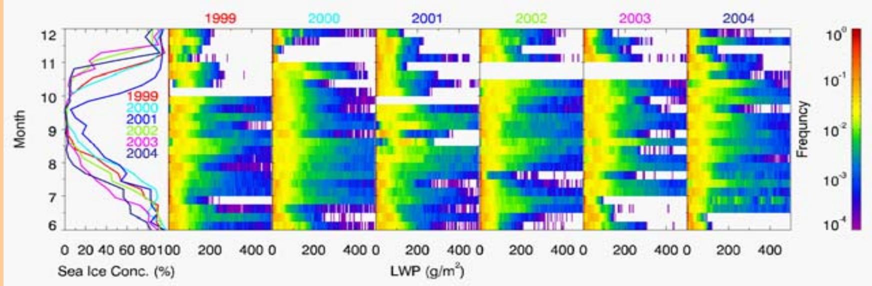

Fig. 5 The correlation between sea ice in 2 degree area around Barrow and cloud LWP seasonal variations

Sea ice cover has a larger impact on cloud LWP during the fall transition period than the spring transition period.

4. Aerosol and Cloud Properties

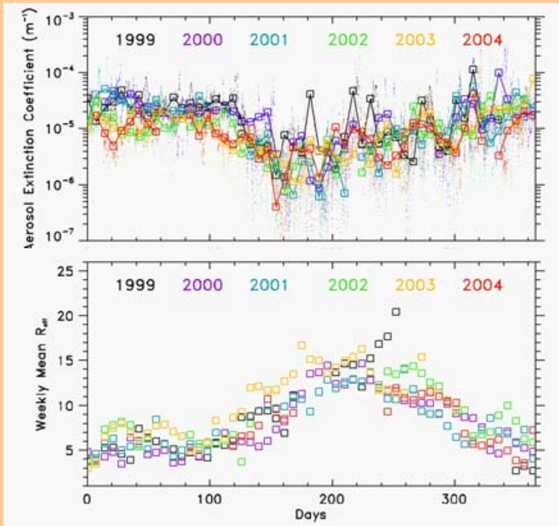

Fig. 6 The annual cycle of near surface aerosol extinction coefficient and water cloud effective radius at the NSA site.

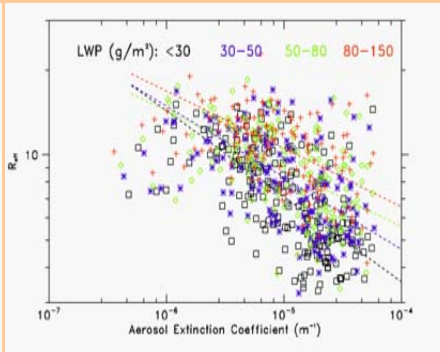

Fig. 7 The scatter plot of weekly means aerosol extinction and cloud effective radius for different groups of LWP ranges

The cloud effective radius seems correlated with near surface aerosol extinction. However, these simple correlations do not directly indicate a strong aerosol indirect effect at the NSA site. Further detailed analyses are needed to better understand cloud and aerosol interactions at the NSA site.

5. Summary

- **Over the Barrow site, boundary clouds mainly form under WMA and subsidence conditions. Cloud properties are significantly dependent on dynamical conditions**
- **Nearby sea ice condition also affects LWP annual variations, especially in fall.**
- **Multiple year cloud microphysical dataset can be used to better study cloud-aerosol interactions at the NSA site.**
- **Further analysis of ice phase cloud properties and cloud-aerosol interaction is under way.**

References

Curry, J. et al., 1996: Overview of Arctic cloud and radiation characteristics. *J. Climate.*, **9**, 1731–1764.

Wang, Z. and K. Sassen, 2002: Cirrus cloud microphysical property retrieval using lidar and radar measurements, I: algorithm description and comparison with in situ data. *J. Appl. Meteor.*, **41**, 218-229.

Wang, Z., K. Sassen, D. Whiteman, and B. Demoz, 2004: Studying altocumulus plus virga with ground-based active and passive remote sensors. *J. Appl. Meteor.*,**43**, 449-460.

Wang, Z., 2007: Refined Two-channel Microwave Radiometer Liquid Water Path Retrieval at Cold Regions by Using Multiple-sensor Measurements. *IEEE Geoscience and Remote Sensing Letters*, **4**, 591-595.