Videosonde Observations of Supercooled Cloud Droplet Layers at the Tops of Wintertime Stratiform Clouds in Northern Japan

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Introduction

Importance of studies for supercooled cloud droplets:

Supercooled cloud droplets (SCDs) are widely present at the temperature range below 0℃. SCDs are closely related with nucleation and growth of ice particles and radiation, and therefore play important roles in precipitation formation and radiative transfer processes. Some previous literatures mention that information about SCD profiles contributes to improvements in the representations of clouds in numerical models, especially in climate models. In addition, SCDs affect aviation safety.

Unclear points of studies for stratiform clouds including SCDs:

Some recent studies have used remote-sensing instruments to estimate qualitative characteristics of SCDs and information of cloud-top phase. There are a large amount of observations of SCDs in the Arctic clouds. In contrast, fewer observations of SCDs have been reported in mid-latitudes.

We performed in-situ observation of cloud and ice crystal particles using hydrometeor videosondes in February 2011 at Rikubetsu in inland Hokkaido of Japan. During the observation period, SCD layers were found in some clouds. Characteristics of the clouds and SCD layers in the clouds were examined.

Summary

In February 2011, winter stratiform clouds formed over inland Hokkaido of northern Japan were observed mainly using hydrometeor videosondes (HYVISs).

In three of five HYVISs in non-frontal clouds, SCD layers were present at the cloud tops.

- Although the number of observation cases is small, SCDs were present at high frequency at the tops of non-frontal stratiform clouds formed in northern Japan. It is inferred that ice crystals formation in the SCDs at cloud tops and subsequent growth are one of the major snowfall formation processes in winter in this region.
- As compared to the Arctic clouds with long-lasting cloud-top SCD layers, the present cases were shorter in the lifetimes and smaller in the horizontal scales, and were characterized by dry profiles right above the SCD layers.
- Formation/maintenance mechanisms of clouds remain to be examined taking account of cloud radiation processes.

Observational characteristics of the clouds and SCD layers:

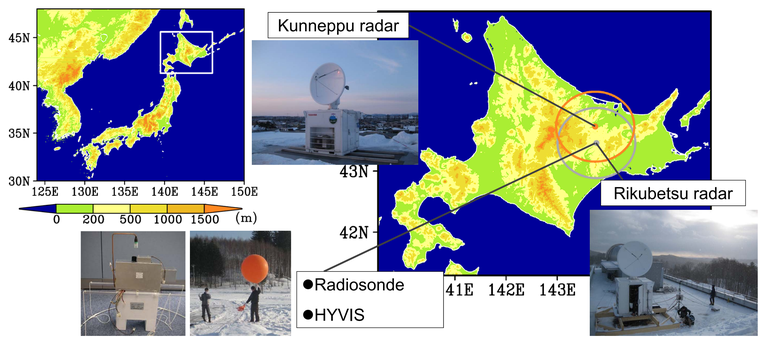
- The clouds were not associated with a cold-air outbreak and clear lows.
- The horizontal extents of precipitations for all the three clouds were a few tens of kilometers.
- Maximum (X-band) radar reflectivities were around 30 dBZ.
- Cloud-top heights were around 3000 m.
- Characteristics of the SCD layers at the cloud tops：
  - thicknesses：60-230 m
  - temperature ranges：−21.0℃ - −25.5℃
  - large static stabilities and dry layers above the layers
  - almost absolutely neutral static stability (dθ/dz ～0) within the layers
  - large vertical shear across the layers

For the case in 27 Feb.
- mode of SCDs: 10-20 μm
- Nc: 4.1 cm^{-3}
- LWC: 0.006 g m^{-3}

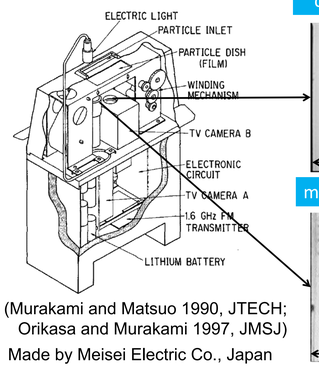
Observation

We conducted a special observation using hydrometeor videosondes and radars in February 2011.

Sites and instruments



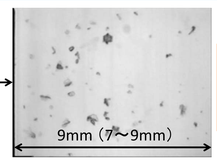
Hydrometeor Videosonde (HYVIS)



(Murakami and Matsuo 1990, JTECH; Orikasa and Murakami 1997, JMSJ)

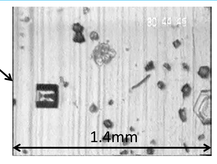
Made by Meisei Electric Co., Japan

close-up camera image

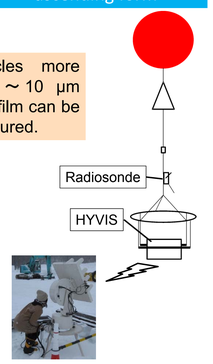


Particles more than ～10 μm on a film can be measured.

microscopic camera image

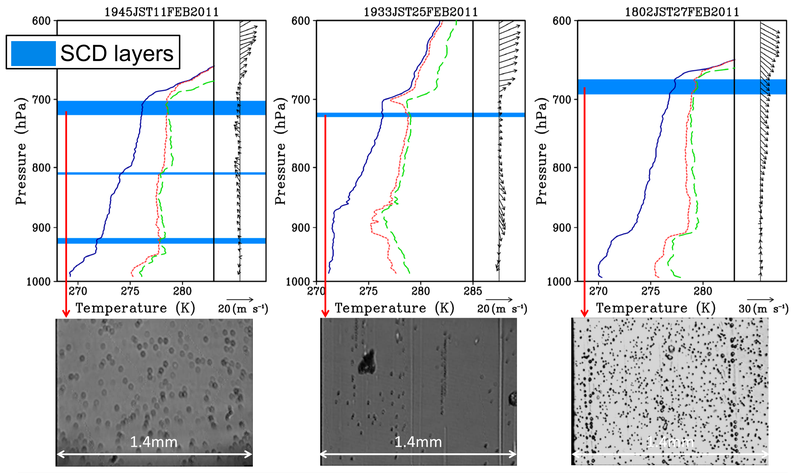


ascending form



Vertical distributions of SCDs

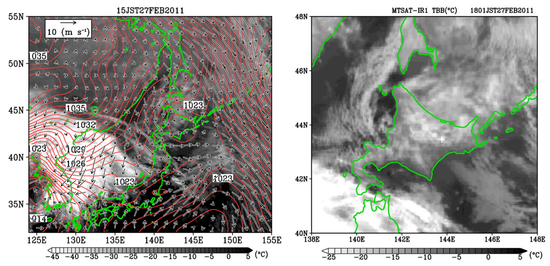
・SCD layers are confirmed at the cloud tops in three of five cases for non-frontal clouds.
・The thicknesses of the cloud-top SCD layers are around 100 (60–230) m for the cases.
・The temperature of the layers ranges from −21℃ to −25.5℃.
・Strong stable and very dry layers are present right above the cloud-top SCD layers.



Date	Time [JST]	Ts [℃]	SCD	Characteristics of SCD layers			Cloud Top [m]
				P [hPa]	Height [m] (Thickness) [m]	T [℃]	
11 Feb.	19:45:33	−4.7	○	929-919 811-808 722-702	745-830(85) 1790-1815(25) 2660-2860(200)	−7.0- −7.5 −15.1- −15.1 −21.5- −23.3	2880
18 Feb.	17:28:30	−4.7	−				?
25 Feb.	19:33:43	−3.2	○	725-719	2580-2640(60)	−21.0- −21.8	2785
27 Feb.	18:02:47	−3.2	○	693-672	2975-3205(230)	−23.8- −25.5	3205
27 Feb.	19:45:29	−4.4	−				?

A case in 27 Feb. 2011

Synoptic situation and satellite cloud images

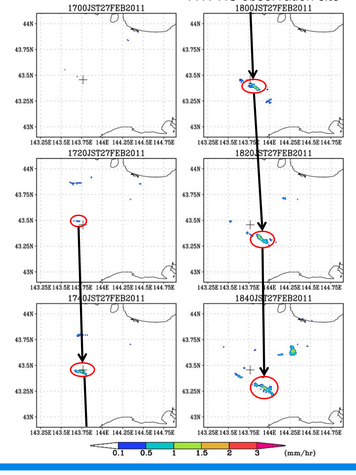


・Stratiform clouds with low cloud tops are present around the observation site.
・The clouds are not associated with a cold-air outbreak and clear synoptic-scale and mesoscale lows, although a weak low-pressure area is present around the target cloud.

Horizontal scale and lifetime

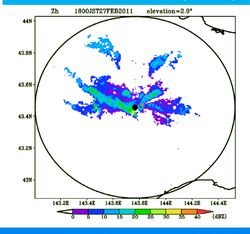
JMA radar precipitation intensity

+: HYVIS observation site



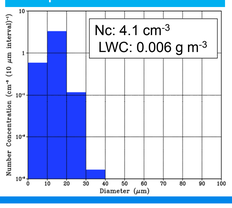
・Lifetime：
2 hours at least
(17:00−19:00 JST)
・Horizontal scale
20−40 km at least
・Radar reflectivity
25-30 dBZ in the max.

Rikubetsu radar PPI (2.9°)



Microphysical quantities of cloud-top SCDs

droplet size distribution



・The mode of size is present between 10-20 μm.
・There is almost no particles greater than 30 μm and, therefore, LWC is very small.
・Small Nc might attribute to very low collection efficiency of HYVIS at the size less than 10 μm.