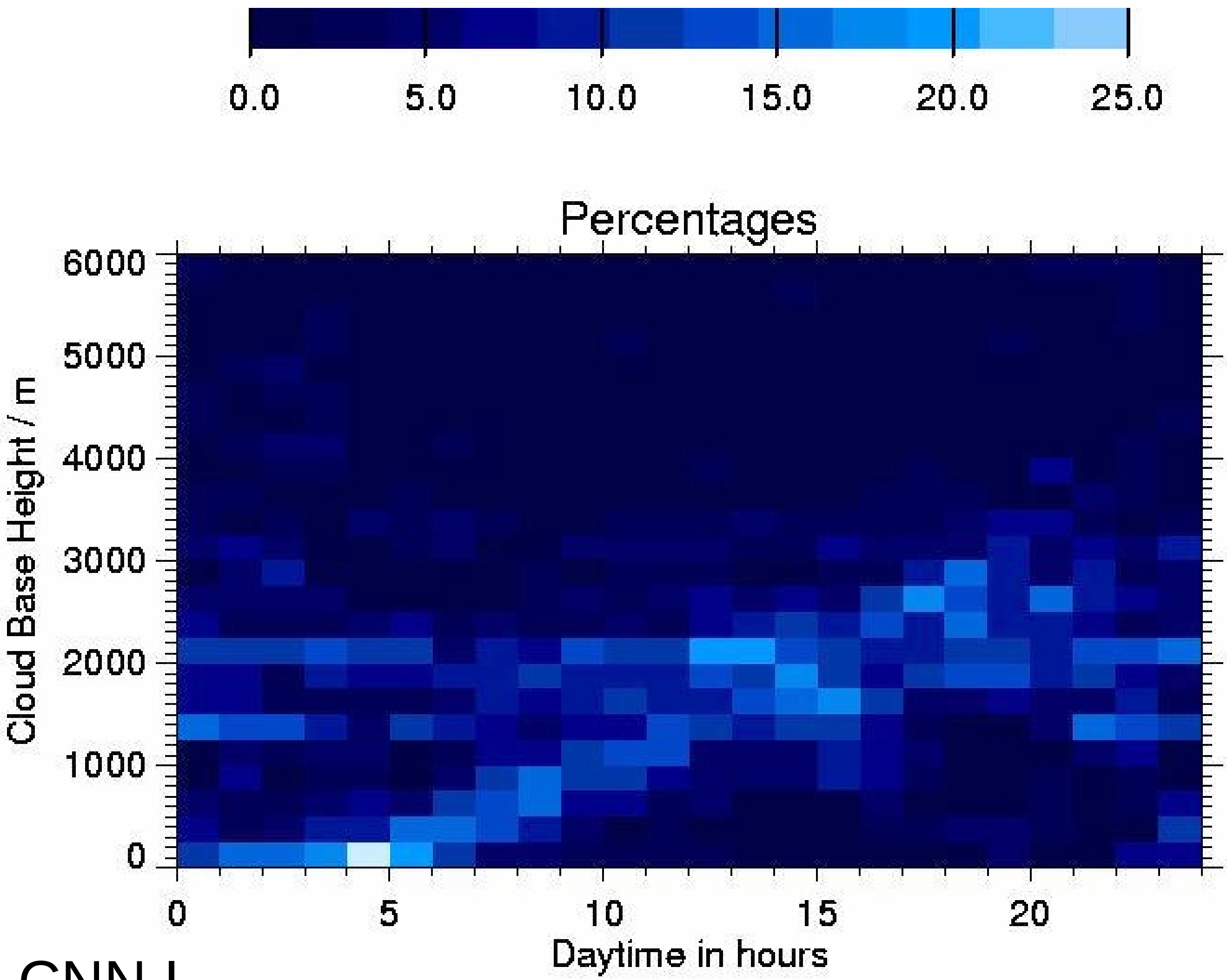
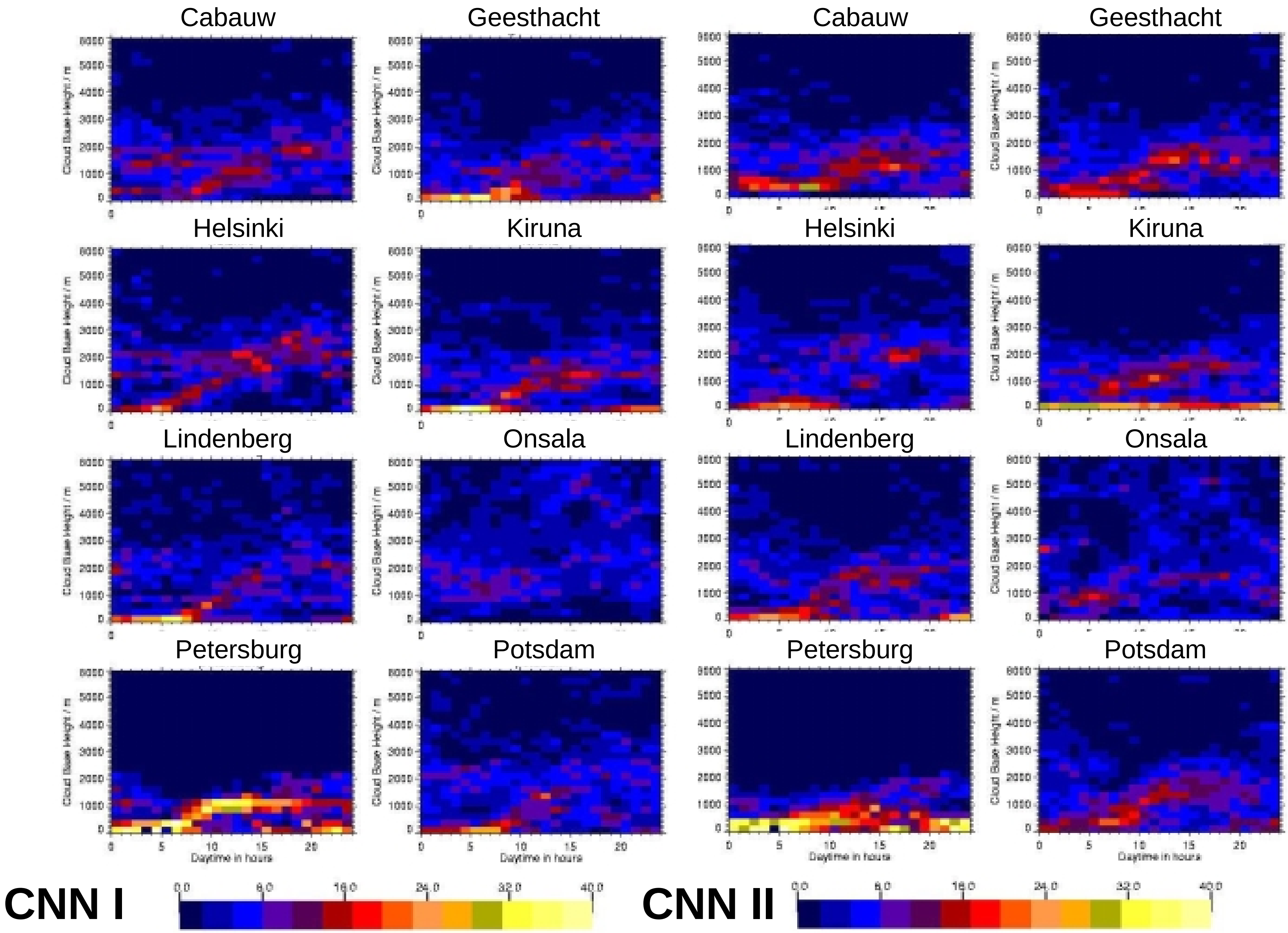
Diurnal Cycle: Cloud Base Height



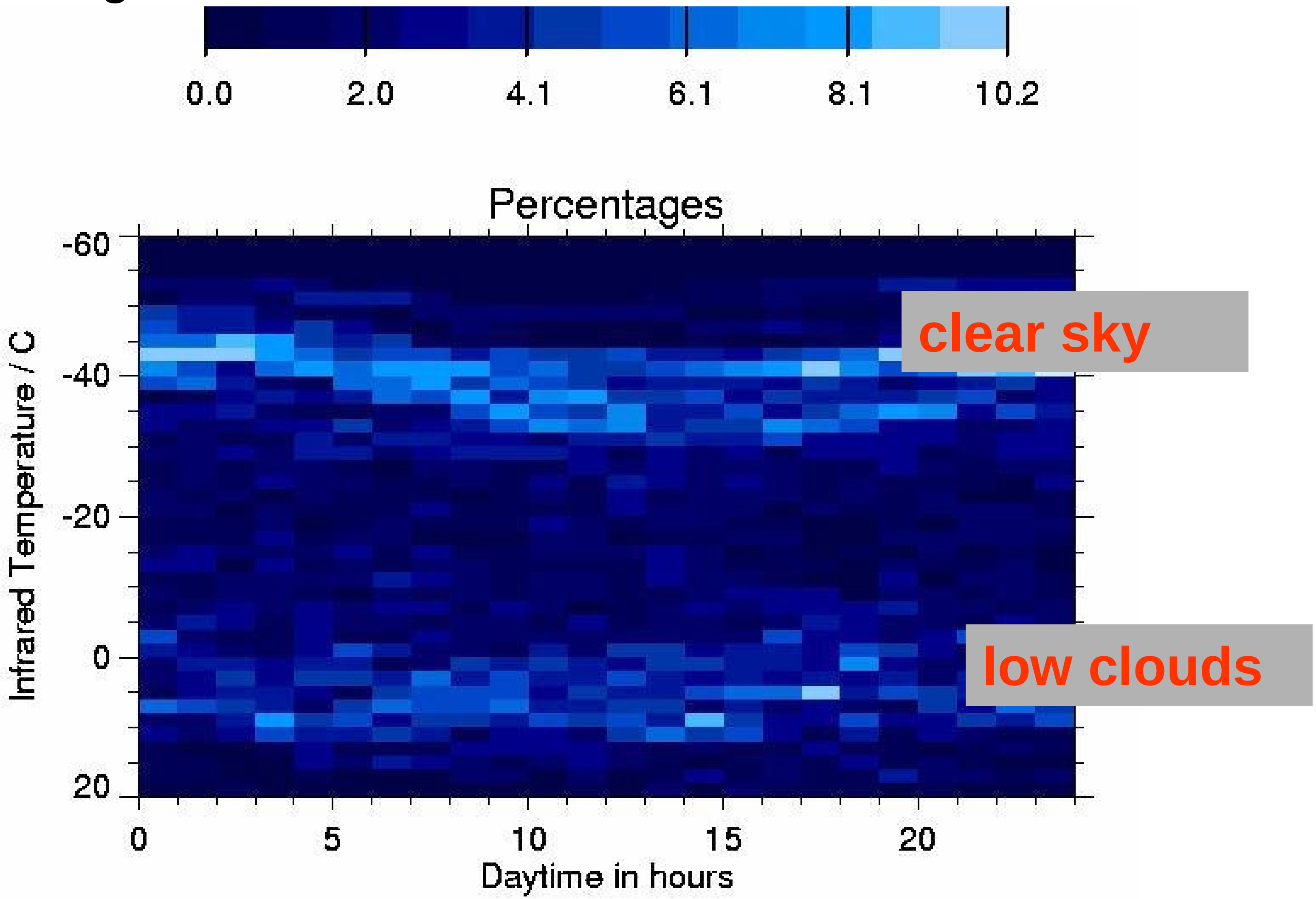
Helsinki CNN I

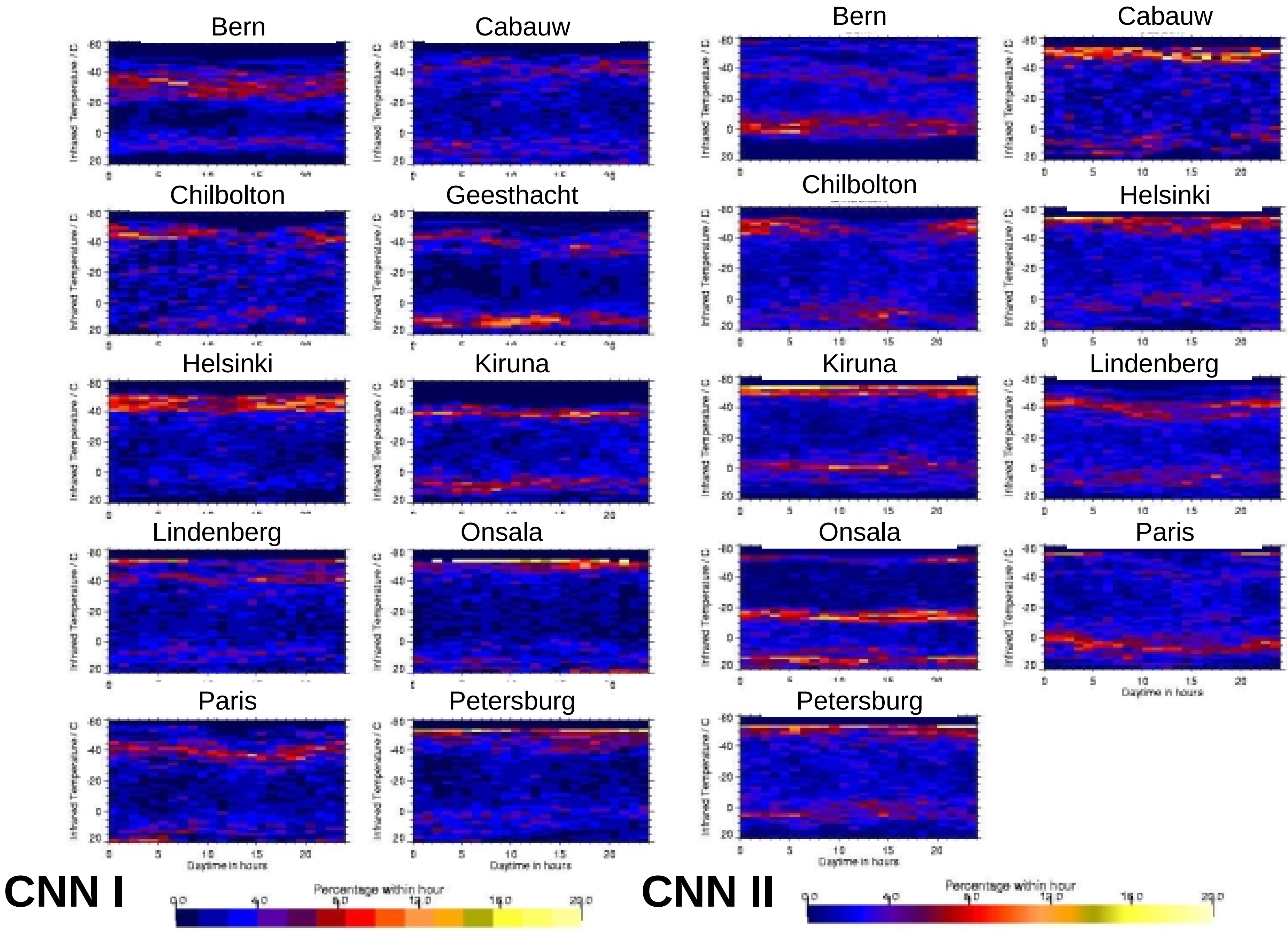


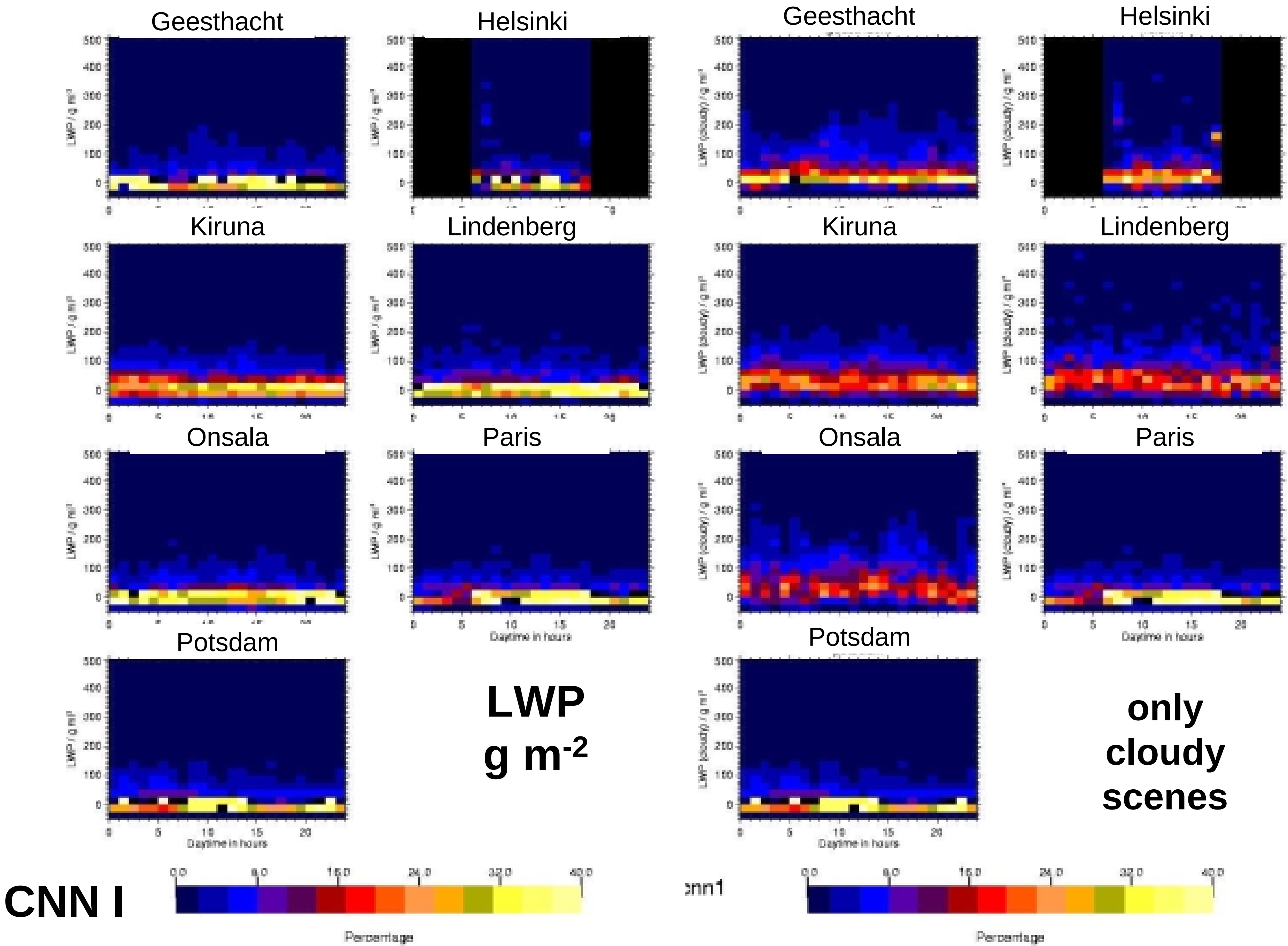
Cabauw
Geesthacht
Cabauw
Geesthacht
Helsinki
Kiruna
Helsinki
Kiruna
Lindenberg
Onsala
Lindenberg
Onsala
Petersburg
Potsdam
Petersburg
Potsdam
Cloud Base Height / m
Daytime in hours
CNN I
CNN II
0.0
8.0
16.0
24.0
32.0
40.0

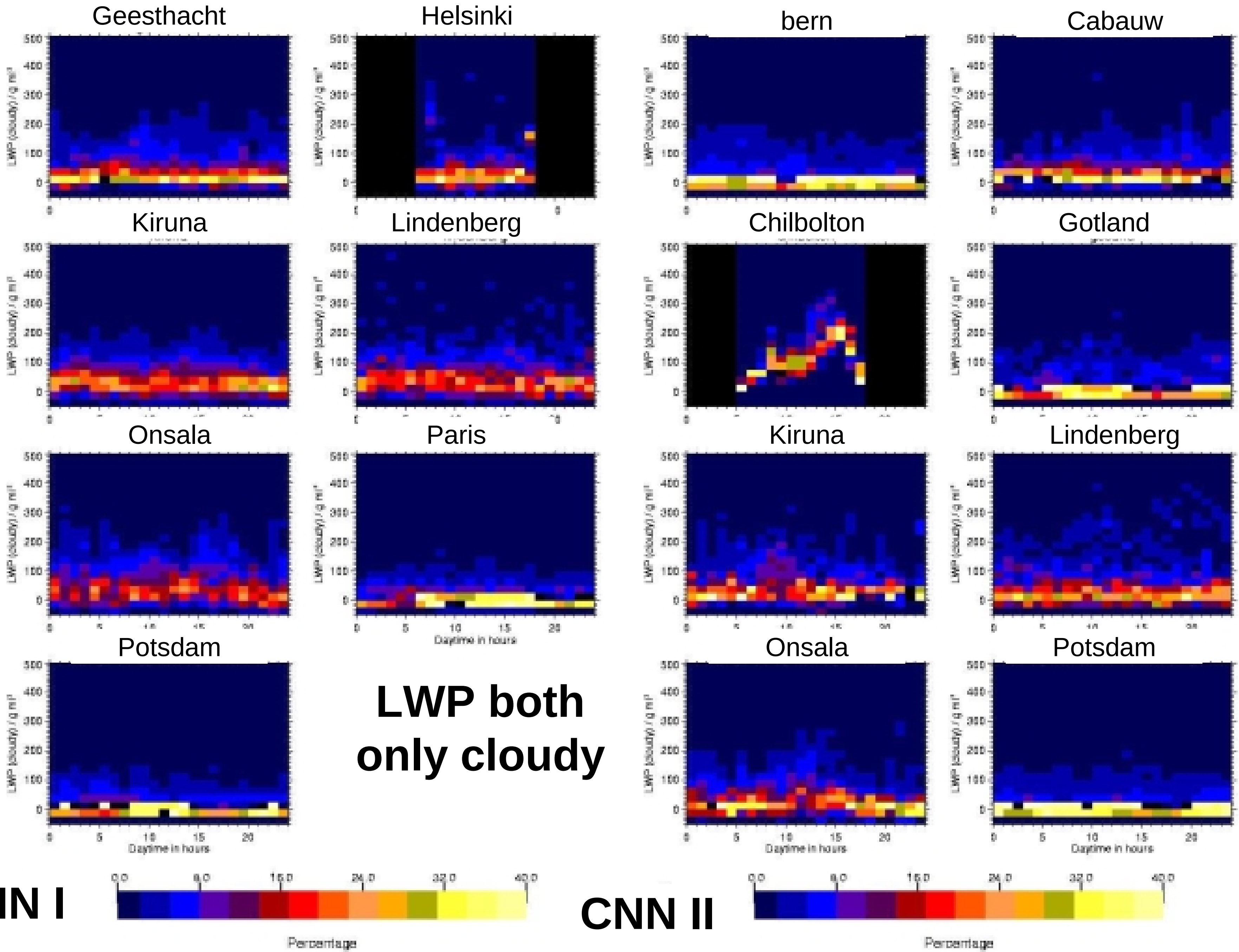
Diurnal Cycle: Infrared Temperature

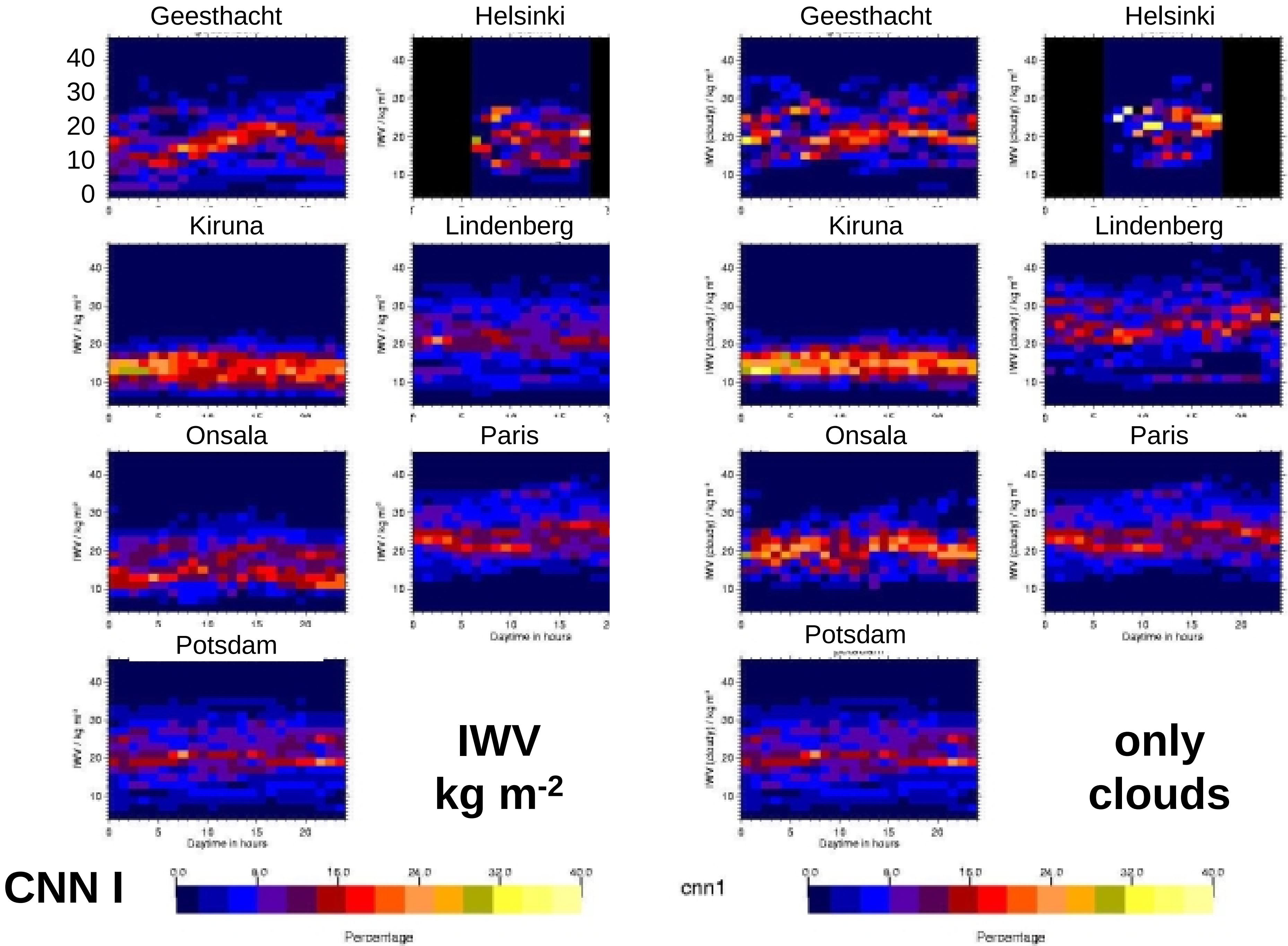
Lindenberg CNN II

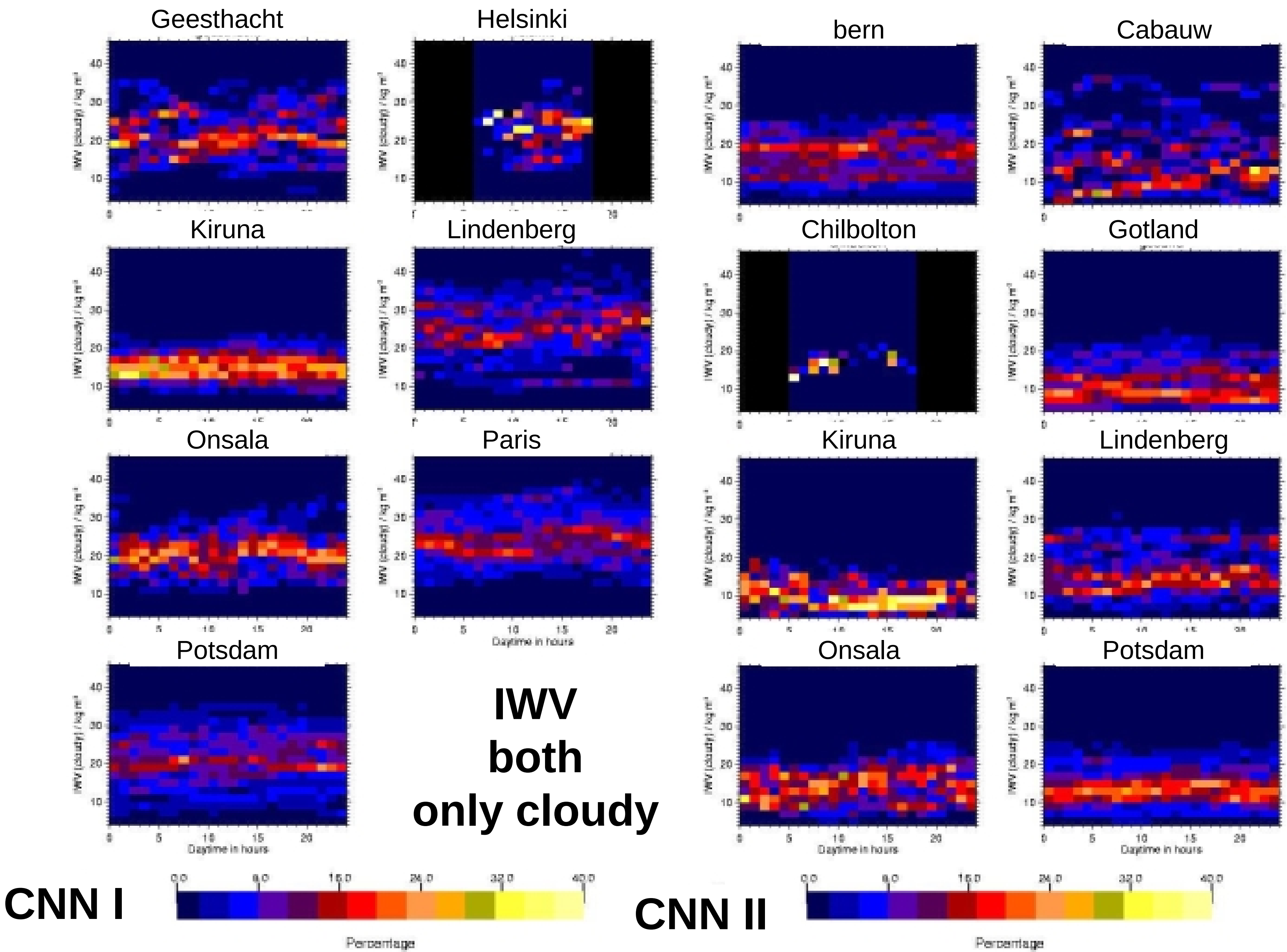



Bern
Cabauw
Chilbolton
Geesthacht
Helsinki
Kiruna
Lindenberg
Onsala
Paris
Petersburg
Infrared Temperature / C
Daytime in hours
CNN I
Percentage within hour
Bern
Cabauw
Chilbolton
Helsinki
Kiruna
Lindenberg
Onsala
Paris
Petersburg
CNN II
Percentage within hour


Geesthacht
Helsinki
Geesthacht
Helsinki
Kiruna
Lindenberg
Kiruna
Lindenberg
Onsala
Paris
Onsala
Paris
Potsdam
Potsdam
LWP
g m-2
only
cloudy
scenes
Daytime in hours
CNN I
0.0
8.0
16.0
24.0
32.0
40.0
Percentage
cnn1


Geesthacht
Helsinki
bern
Cabauw
Kiruna
Lindenberg
Chilbolton
Gotland
Onsala
Paris
Kiruna
Lindenberg
Potsdam
Onsala
Potsdam
LWP (cloudy) / g m⁻²
Daytime in hours
LWP both
only cloudy
CNN I
CNN II
Percentage


Geesthacht
Helsinki
Geesthacht
Helsinki
40
30
20
10
0
Kiruna
Lindenberg
Kiruna
Lindenberg
Onsala
Paris
Onsala
Paris
Potsdam
Potsdam
IWV
kg m-2
only
clouds
Daytime in hours
CNN I
0.0
8.0
16.0
24.0
32.0
40.0
Percentage
cnn1
0.0
8.0
16.0
24.0
32.0
40.0
Percentage


Geesthacht
Helsinki
bern
Cabauw
Kiruna
Lindenberg
Chilbolton
Gotland
Onsala
Paris
Kiruna
Lindenberg
Potsdam
Onsala
Potsdam
Daytime in hours
IWV
both
only cloudy
CNN I
0.0
8.0
16.0
24.0
32.0
40.0
Percentage
CNN II
0.0
8.0
16.0
24.0
32.0
40.0
Percentage

Supercooled Water Layers

H.I. Bloemink

- Hogan et al. [2002a]: Detection of super-cooled water layers during CLARE from corresponding lidar/radar measurements; mostly embedded in ice clouds; strong impact on radiative budget although little LWP

- Hogan et al. [2002b]: climatological analysis of Chilbolton and Cabauw ceilometer measurements; investigation of temperauture influence, layer duration and extent

Instrumentation

- Vaisala CT75K ceilometer
  wavelength 905 nm,
  time resolution: 30 s   height resolution: 30 m
  $\Rightarrow$ calibrated backscatter profiles,
  up to three cloud base heights
- Radio soundings at De Bilt: Vaisala RS 90 sondes
- 22 channel microwave radiometer MICCY
  $\Rightarrow$ liquid water path LWP
- 3.3 GHz radar TARA
  time resolution: 10.2 s   height resolution: 20 m.
- 95 GHz cloud profiling radar MIRACLE
  time resolution: 5 s   height resolution: 82.5 m.

Detection of super-cooled layers

- A cloud base must be detected (using the algorithm from the ceilometer)
- The temperature of the cloud base has to be below 0 °C
- The maximum backscatter coefficient b_{max} has to be larger than a threshold (6×10^{-5} (sr m)$^{-1}$)
- The backscatter coefficient at 300 m above the altitude where the maximum backscatter has been detected should be at least 20 times weaker than b_{max}

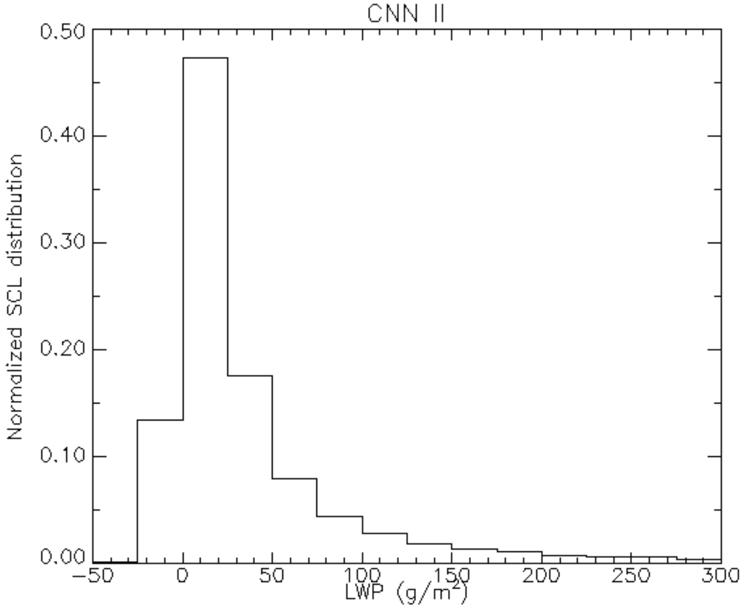
Statistics during CLIWA-NET

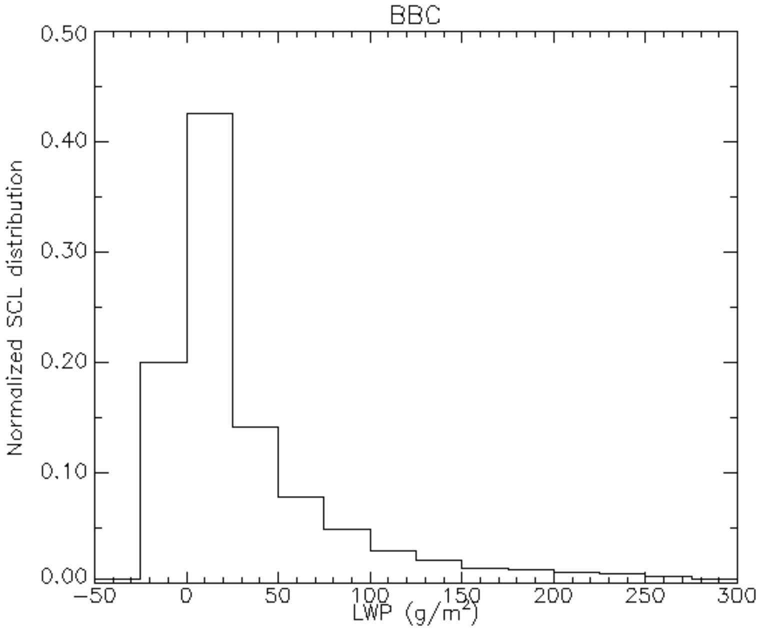
Period	a) Base/time (%)	b) <0 °C/time (%)	c) SCL/time (%)	d) <0 °C/base (%)	e) SCL/base (%)	f) SCL/<0 °C (%)
CNN I	52	10 (2)	9 (2)	20 (4)	16 (3)	83 (2)
CNN II	49	23 (3)	21 (3)	48 (6)	43 (6)	90 (2)
BBC*	56	14 (2)	12 (2)	26 (5)	21 (4)	83 (2)

Percentage of occurrence of:
a) cloud bases detected, b) cloud bases below 0 ºC detected, c) Super-Cooled Layers (SCLs) detected, d) cloud bases below 0 ºC if a cloud base is detected, e) SCLs if a cloud base is detected and f) SCLs if a cloud base below 0 ºC is detected.

Uncertainty introduced by a 1K error in temperature is given in brackets.
* Measurements at 90 deg

LWP Distribution



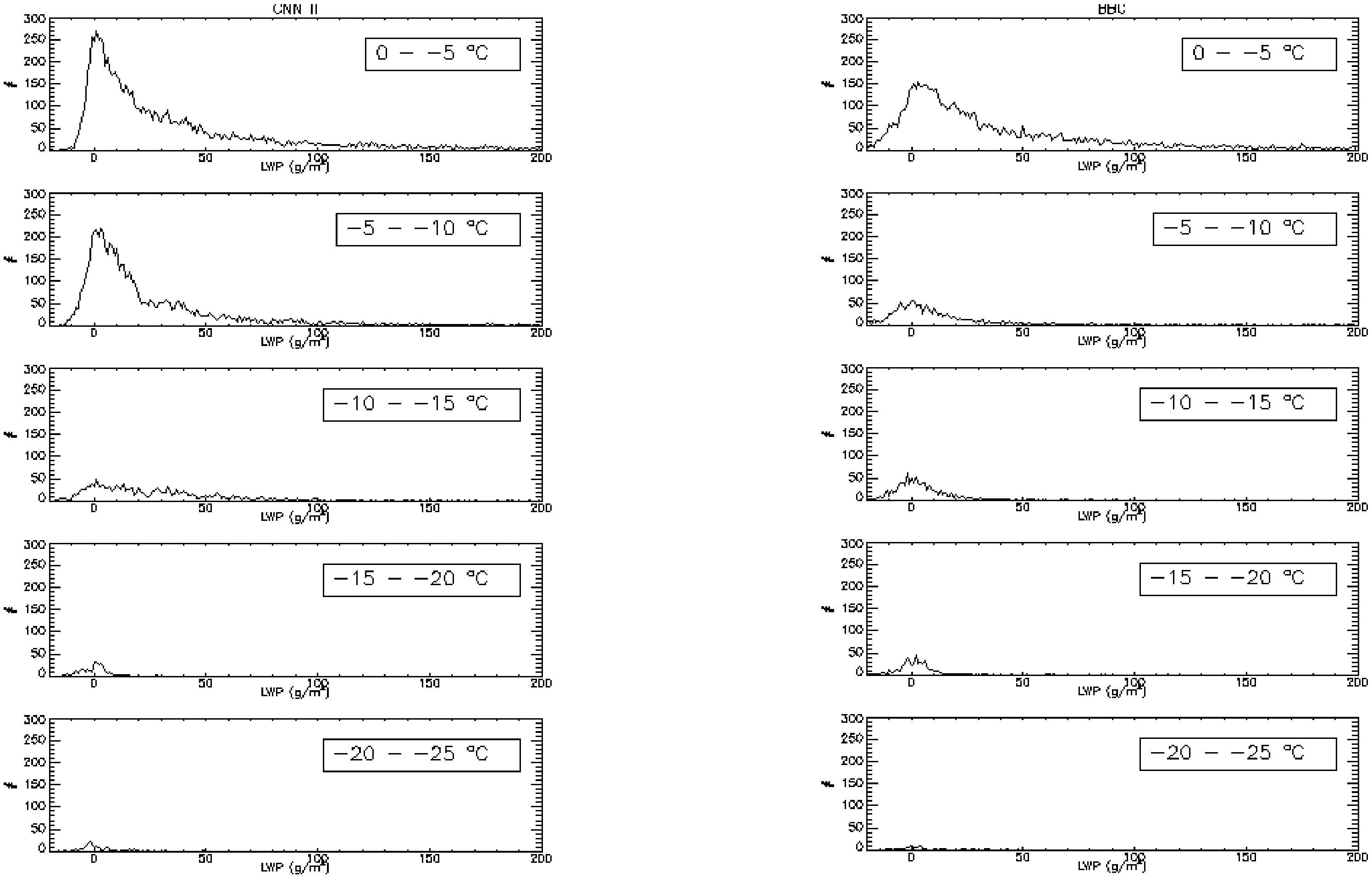


Liquid Water Path distribution for the super-cooled layers detected during CNN II (N=17830) and BBC (N=10963). Time resolution is 30 s.

$$\tau = \frac{3}{2}\frac{LWP}{\rho_w r_{eff}}$$

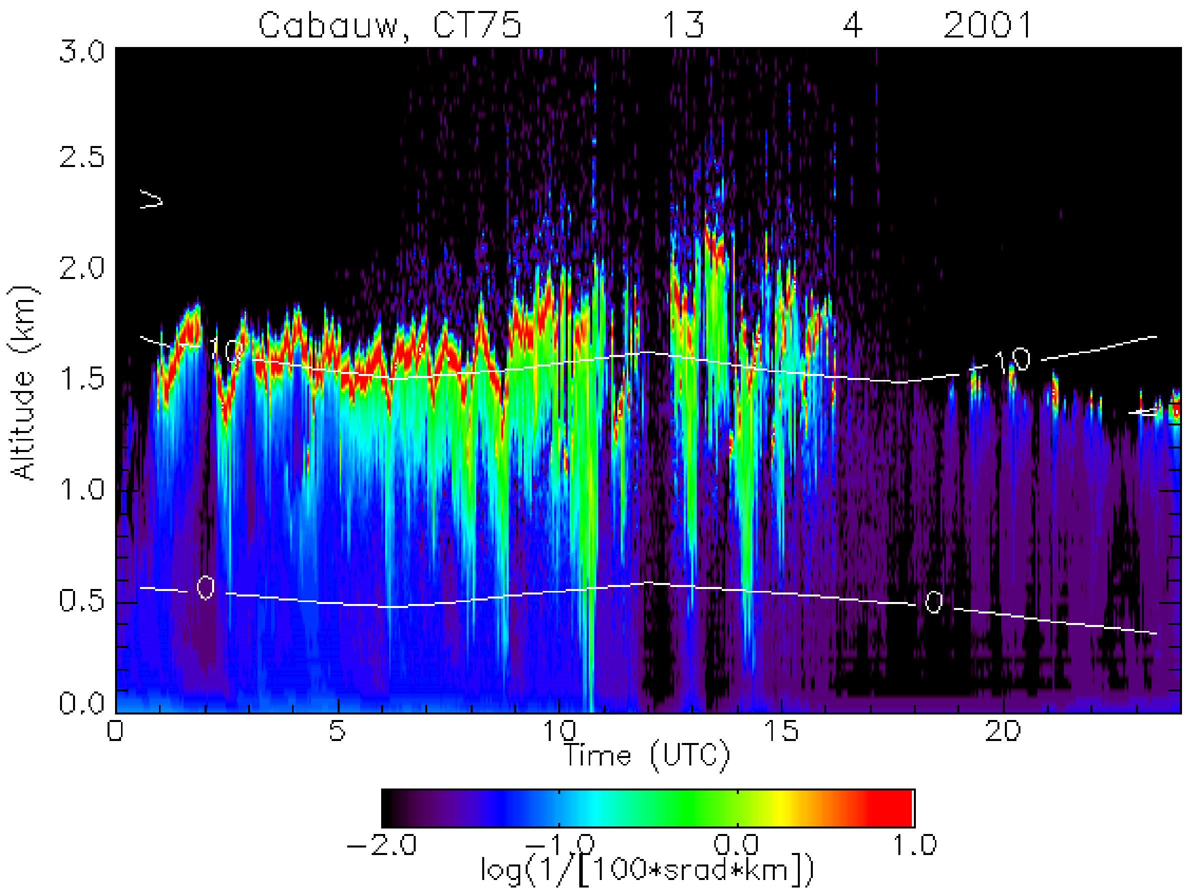
LWP = 25 g m^{-2} r_{eff}=10 µm $\Rightarrow$ τ= 4

LWP Distribution II



Function of temperature. The y-axis indicates the number of measurements having the LWP value indicated on the x-axis (with a 1 g/m^{-2} resolution).

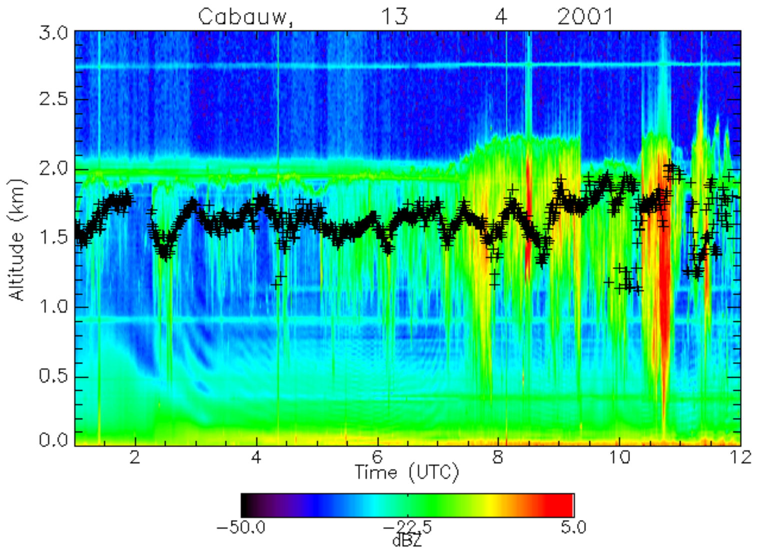
Case study 13 April 2002 I



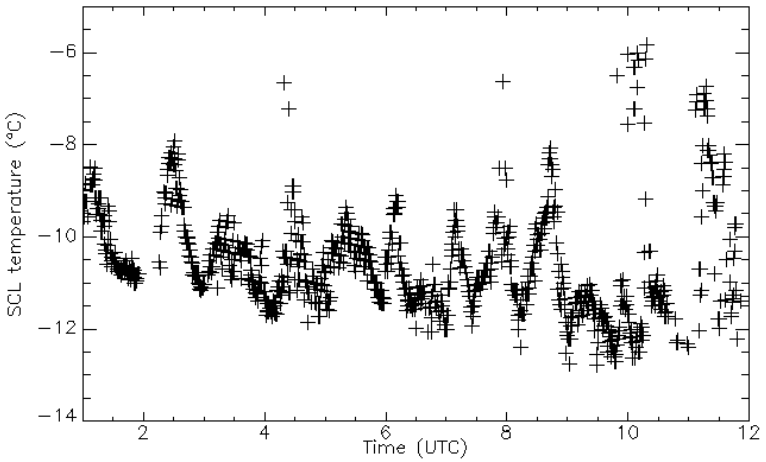
Ceilometer backscatter profile (colours) and radiosonde temperatures (white contours) for 13 April 2001 at Cabauw, The Netherlands. Wind from the North at 11 m/s.

Case study 13 April 2002 II

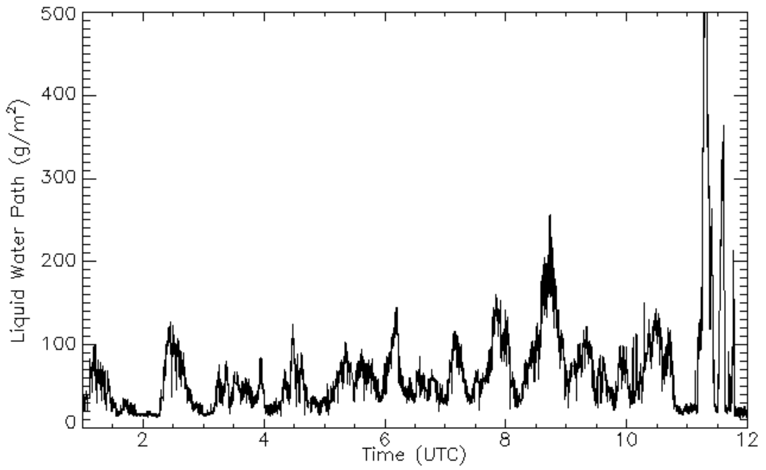
a)



b)

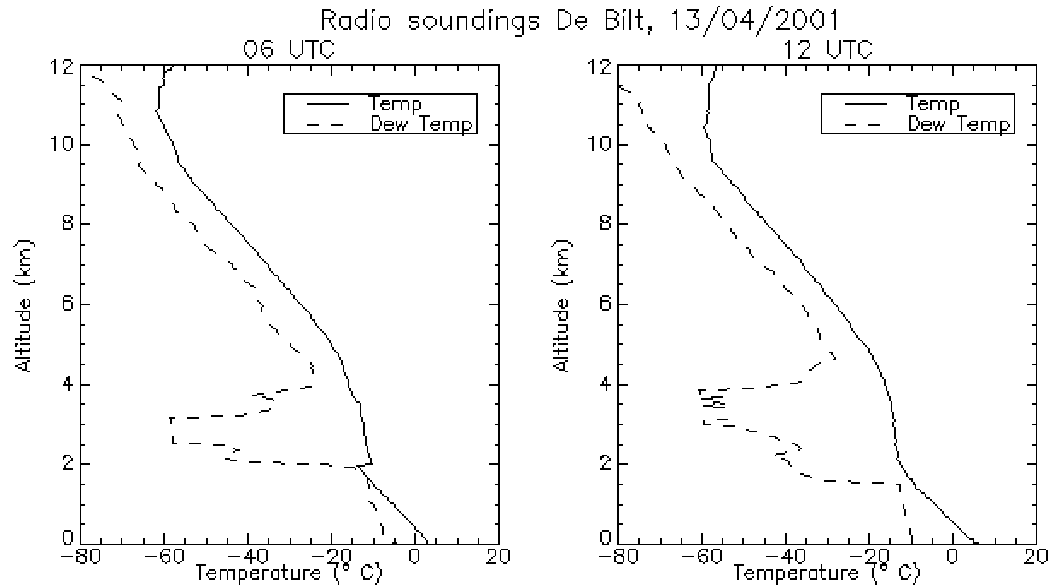


c)



a) backscatter profile for the 3 GHz radar TARA (colours) and cloud base altitude from the CT75K ceilometer.
b) cloud base temperature of the super-cooled water layer (RS)
c) liquid water path from the microwave radiometer MICCY.

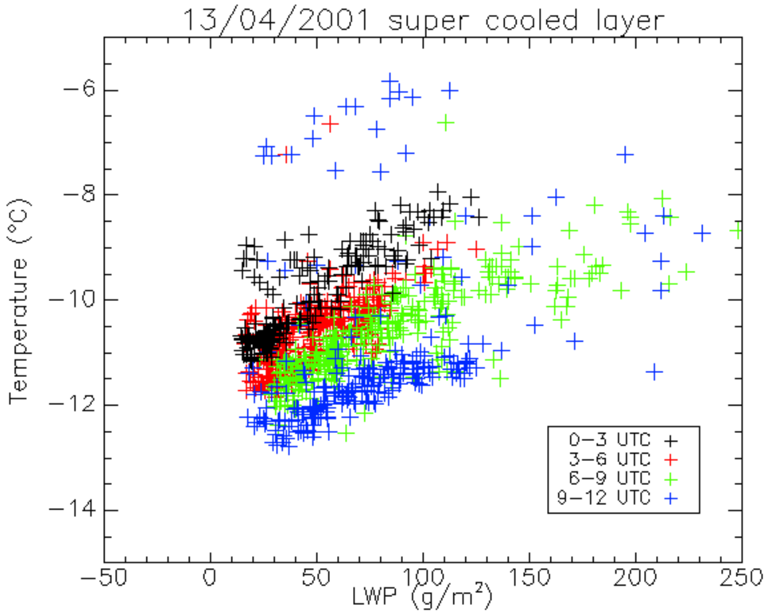
Case study 13 April 2002 III



Radio soundings on 13/04/01 from De Bilt (23 km NE from Cabauw). Shown are temperature (solid line) and dewpoint temperature (dashed line) for 6 and 12 UTC.

Non continuous layers (celluar structure also on satellite images)

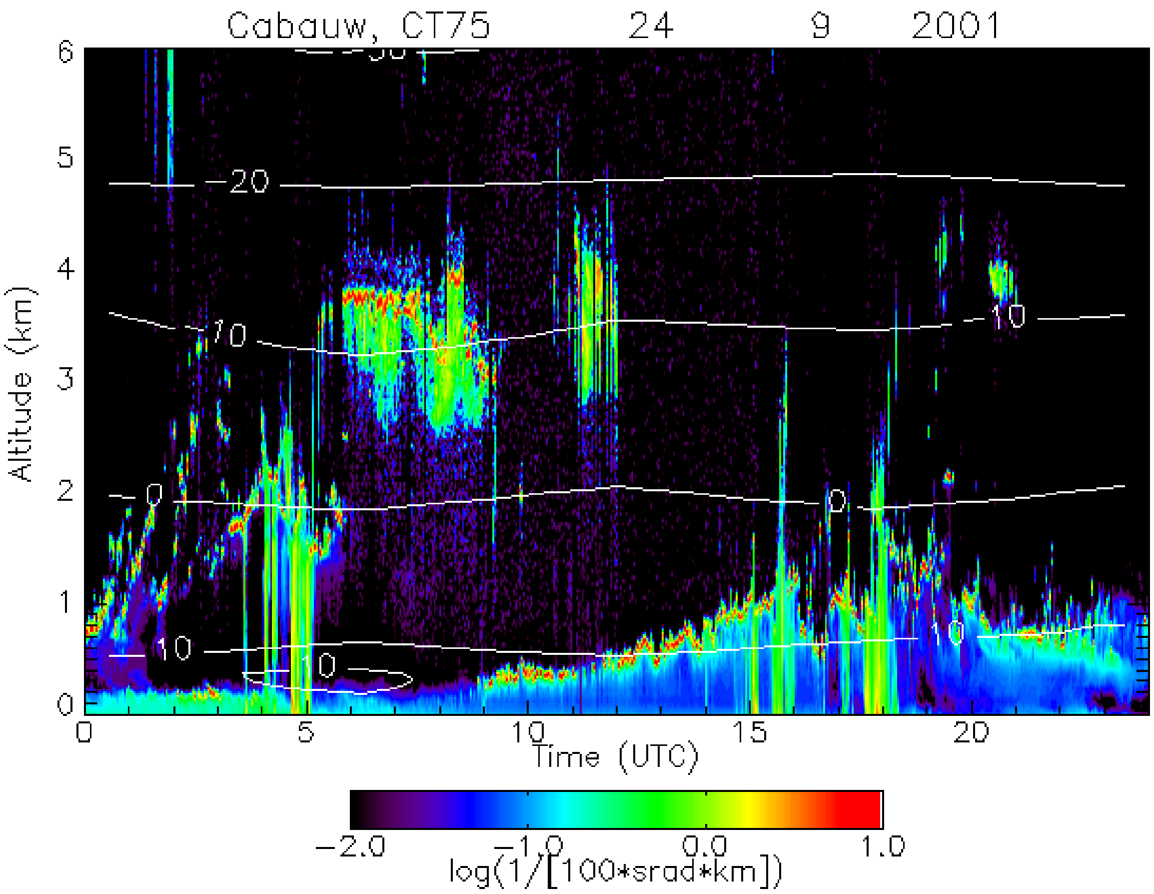
Case study 13 April 2002 III



Cloud base temperature vs Liquid Water Path for 12 hours of the super-cooled layer observed on 13 April 2001.

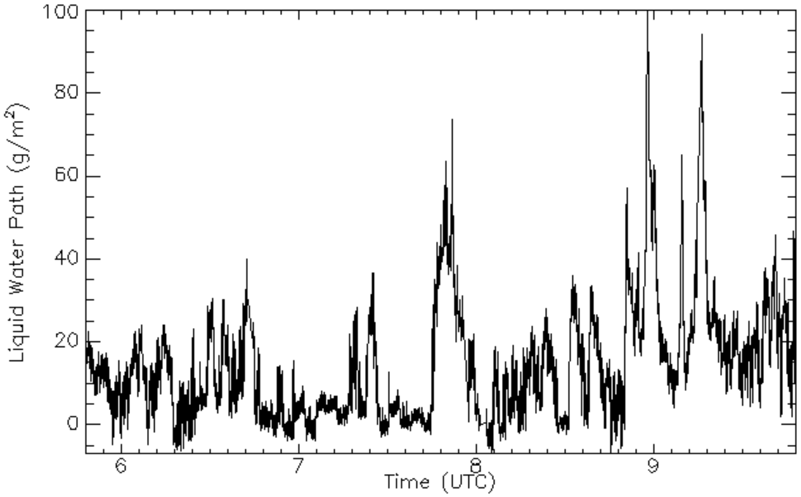
Correlation between LWP and ceilometer (0.85, 0.63, 0.82 and 0.57) is stronger than the one between LWP and infrared radiometer

Case study 24 September 2002 I



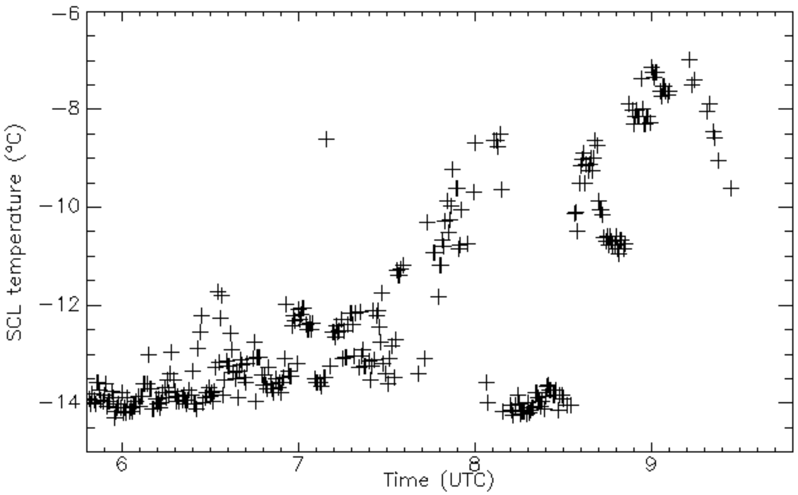
Ceilometer backscatter profile (colours) and radiosonde temperatures (white contours) for 24 September 2001. The wind is easterly (110°) at about 5.5 m/s at cloud height.

Case study 24 September 2002 II



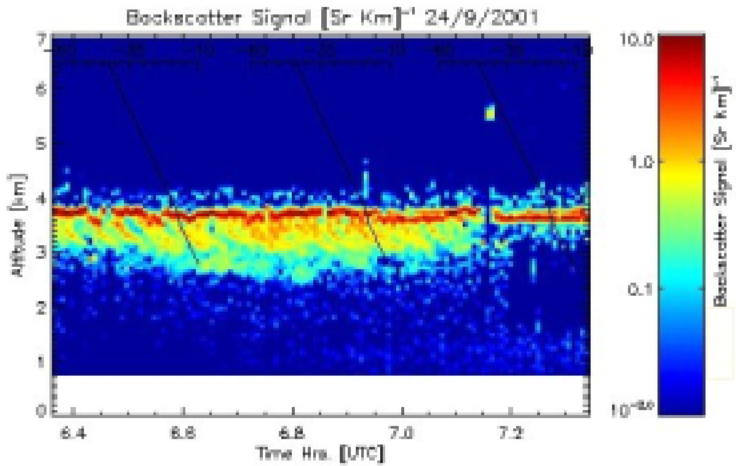
LWP/Temperature

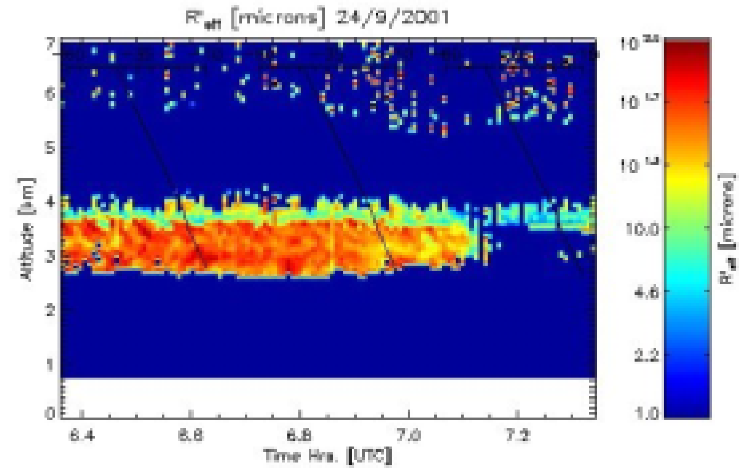
Liquid Water Path from the radiometer MICCY for 24 September 2001.

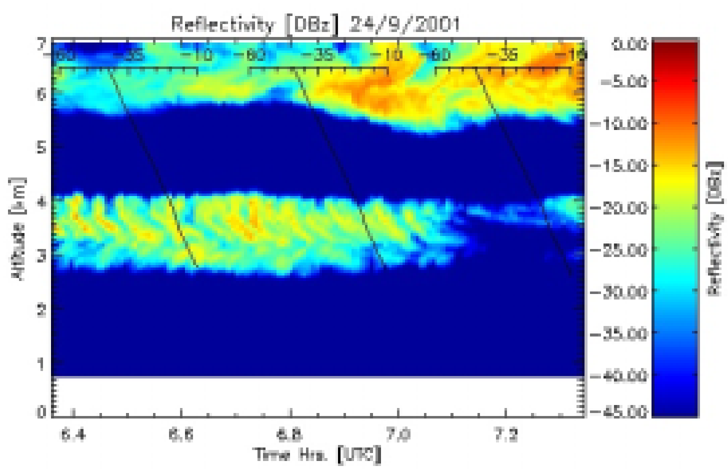


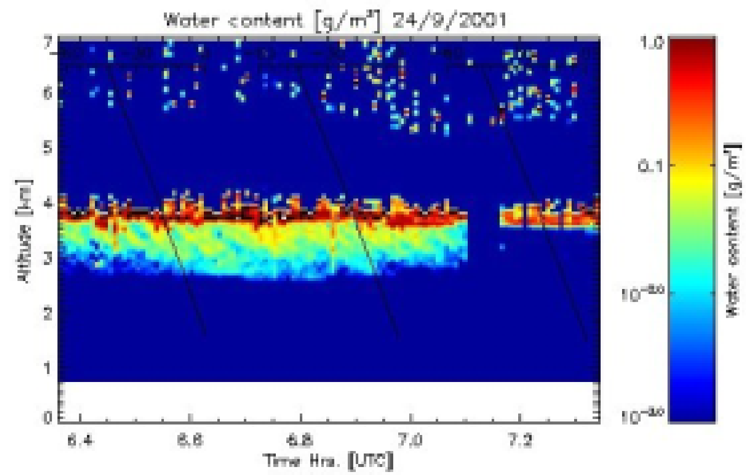
Cloud base temperature of the super-cooled water layer.

Lidar / Radar Retrieval









Conclusions

- Super-cooled water occurs quite frequently at mid-latitudes
- LWP of these clouds is quite variable
- Super-cooled clouds
  case study 13 April 2001
  $\Rightarrow$ important for aircraft icing
- Super-cooled layers
  case study 14 September 2001
  $\Rightarrow$ important in radiative aspects