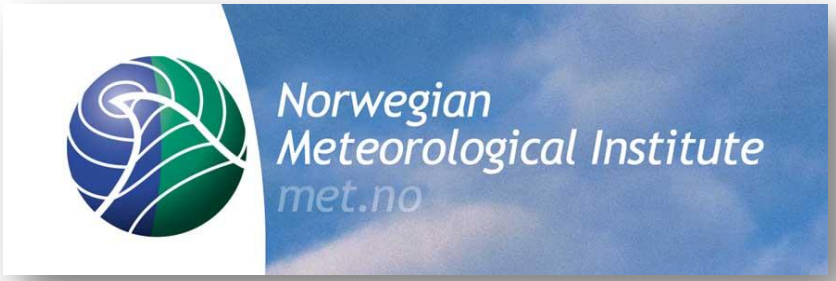
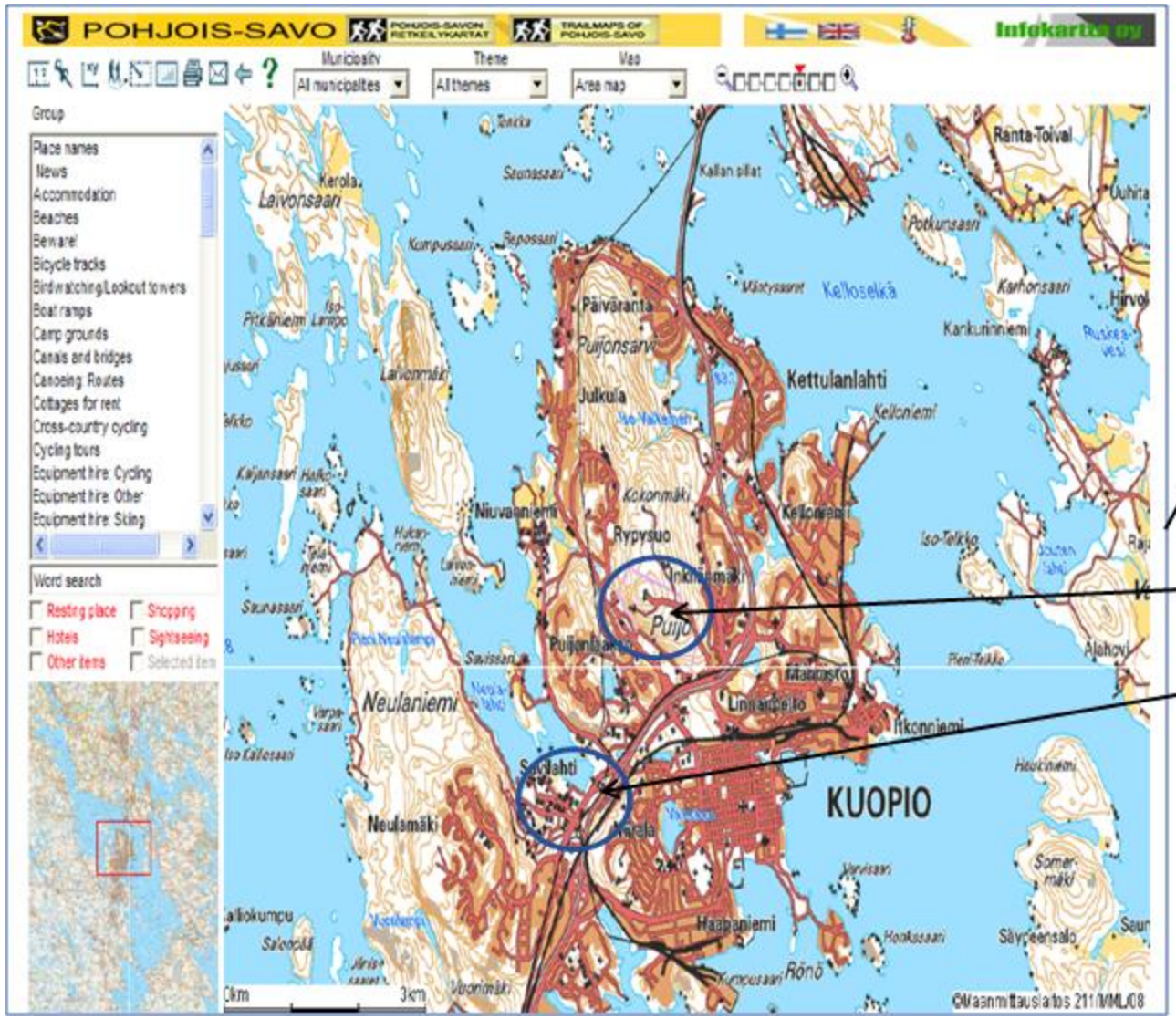


Measurements of the visibility and liquid water content of the air at the Puijo tower, Kuopio, related to meteorological conditions

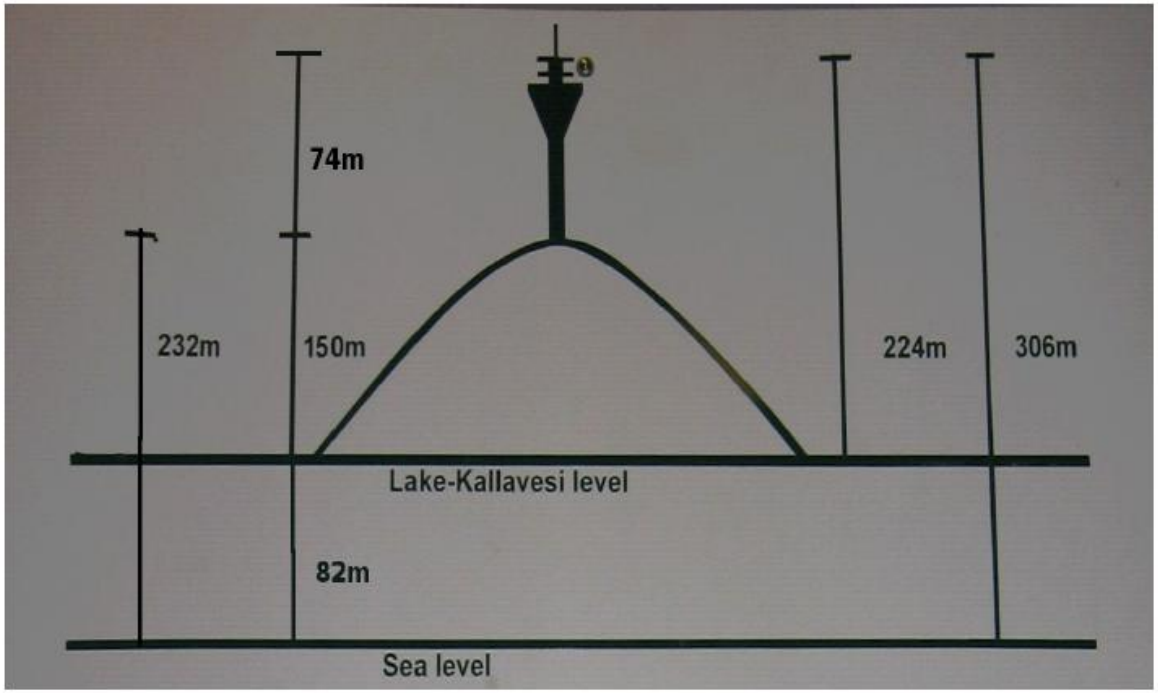
Knut Harstveit, Kjeller vindteknikk
Jarkko Hirvonen, FMI



Pujio tower

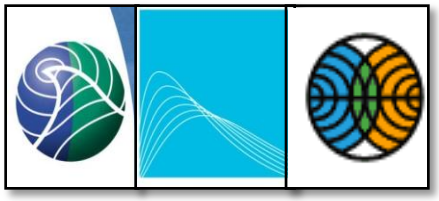
UKU - Campus

Elevations



adapted from the information board in the observation tower

Measurements



UKU - Campus, 2-10 m a.g.l.

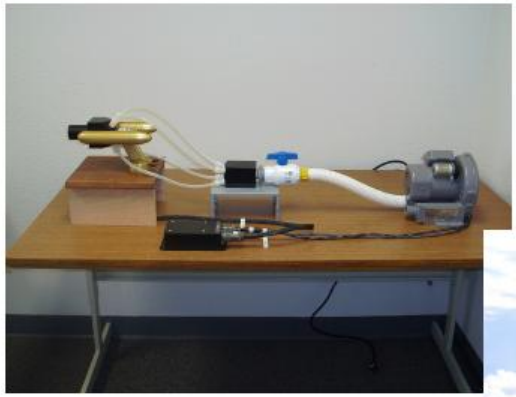
- Metar (wind, temperature, cloud height, cloud amount,…)

Pujio tower, 74 m a.g.l.

- Wind, temperature,….
- Visibility (Forward scattering)
- Cloud water(when T>°C):
  - Cloud water amount
  - Size distribution of cloud droplets

Cloud water sensor

CDP



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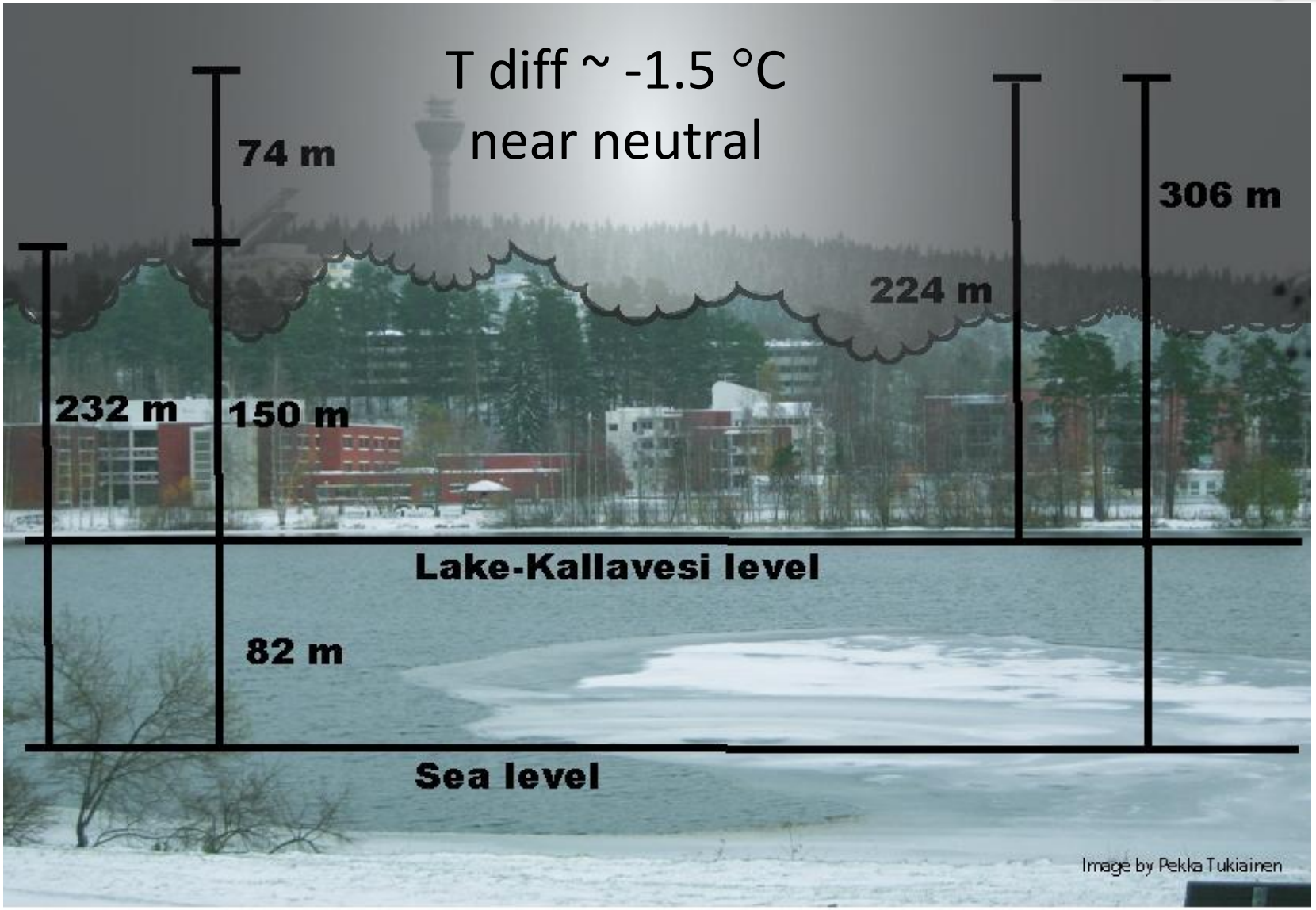
Grouping of MOR (visibility) and cloud base (Hc)

Table 1

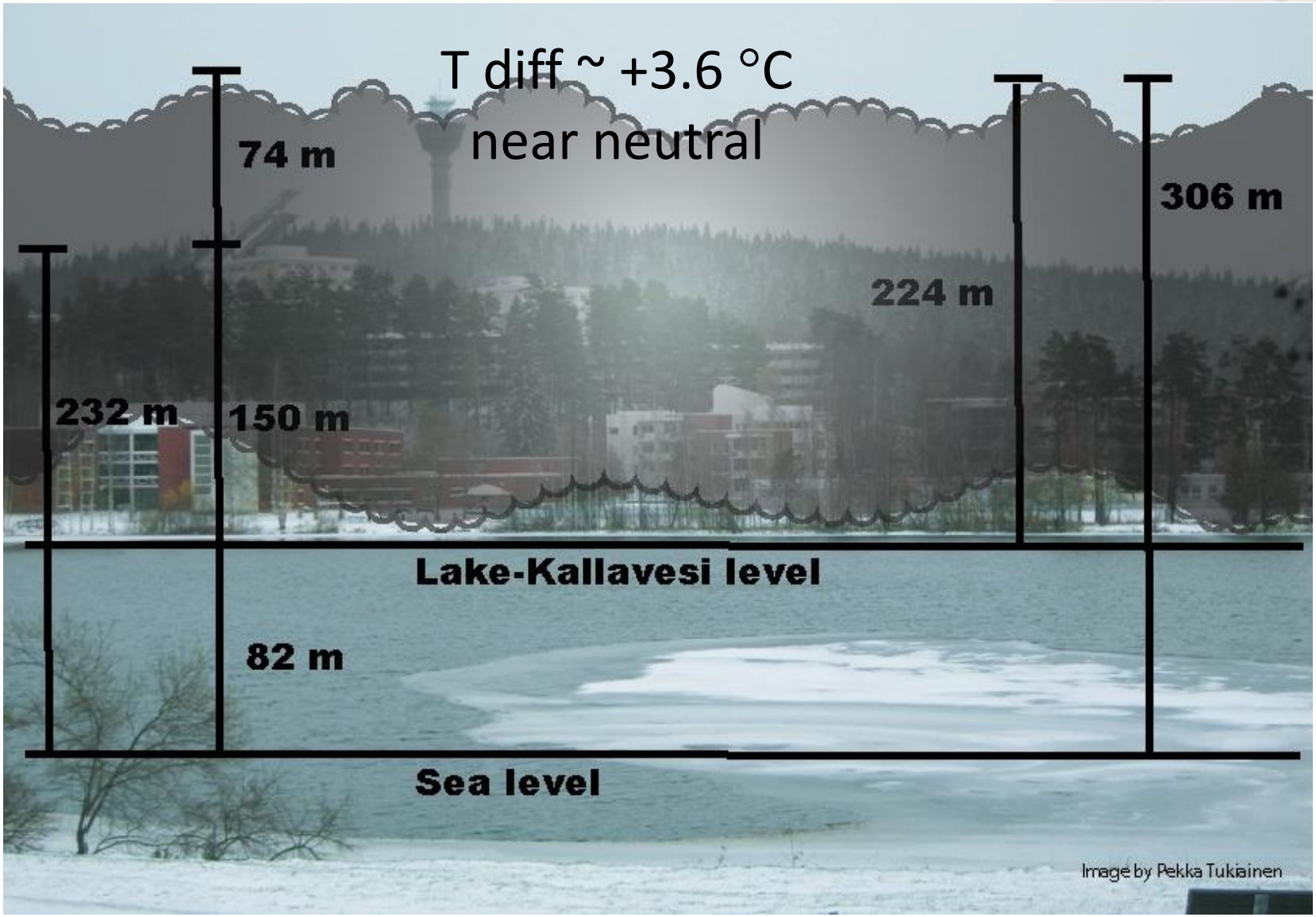
Frequency of MOR/Hc – groups for all data, 1.1 – 31.03.07 with valid MOR and Hc data. Also shown is the median and mean temperature difference between the two sites.

MOR	Hc	Freq	Median MOR	Median Hc	Median Tdiff	Mean Tdiff	Group number
<500	<195	19.1 %	134 m	120 m	-1.59 °C	-1.37 °C	1
>500	<195	4.3 %	9379 m	90 m	3.72 °C	3.58 °C	2
<500	>194	4.3 %	298 m	230 m	-1.68 °C	-1.32 °C	3
>500	>194	72.4 %	28485 m	>2000 m	-0.33 °C	1.65 °C	4
All observations			14611 m	600 m	-1.18 °C	1.03 °C	

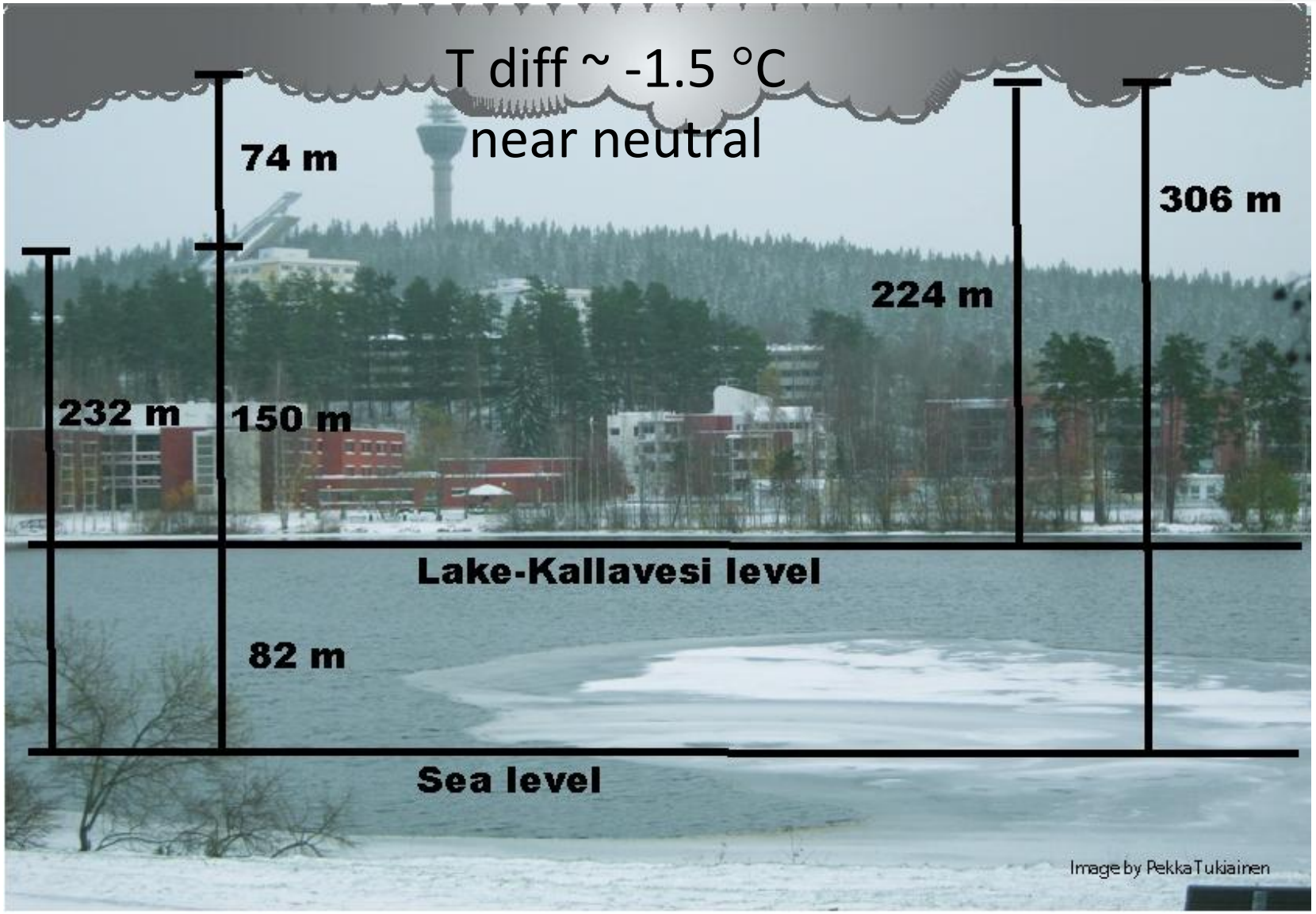
Group 1: in-cloud, 19 %



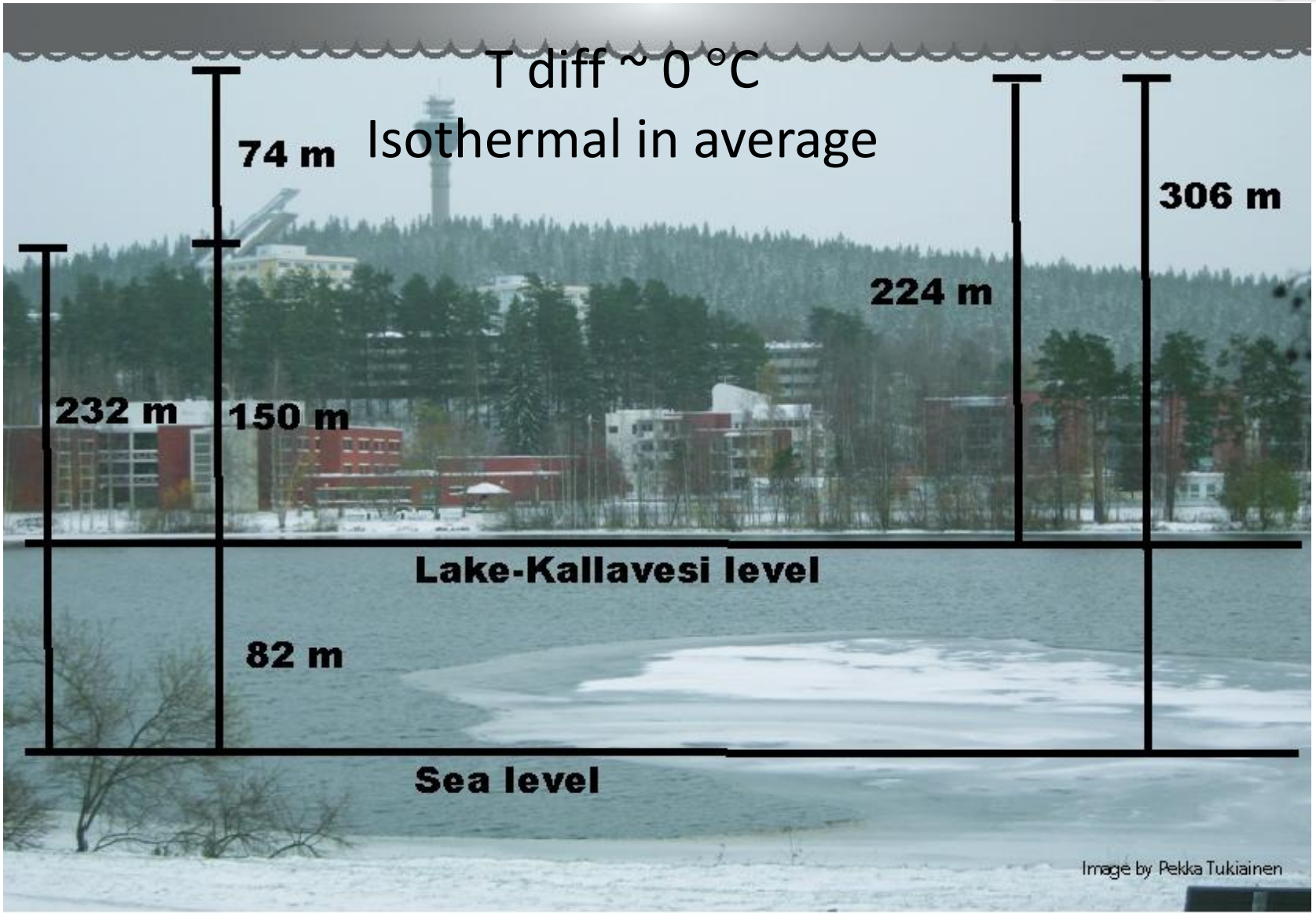
Group 2: fog or low fog clouds, 4 %



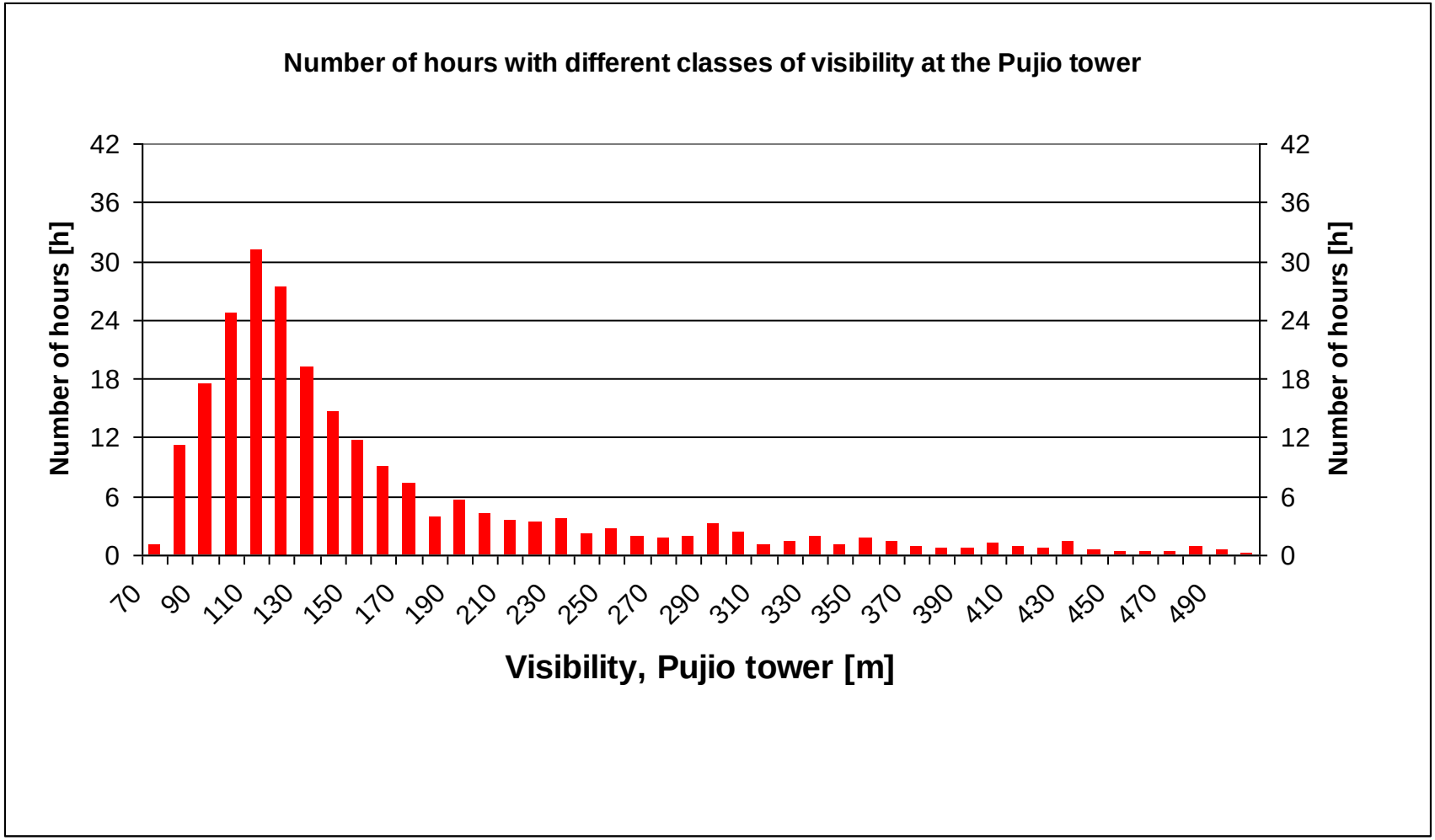
Group 3: cloud base at tower, 4 %



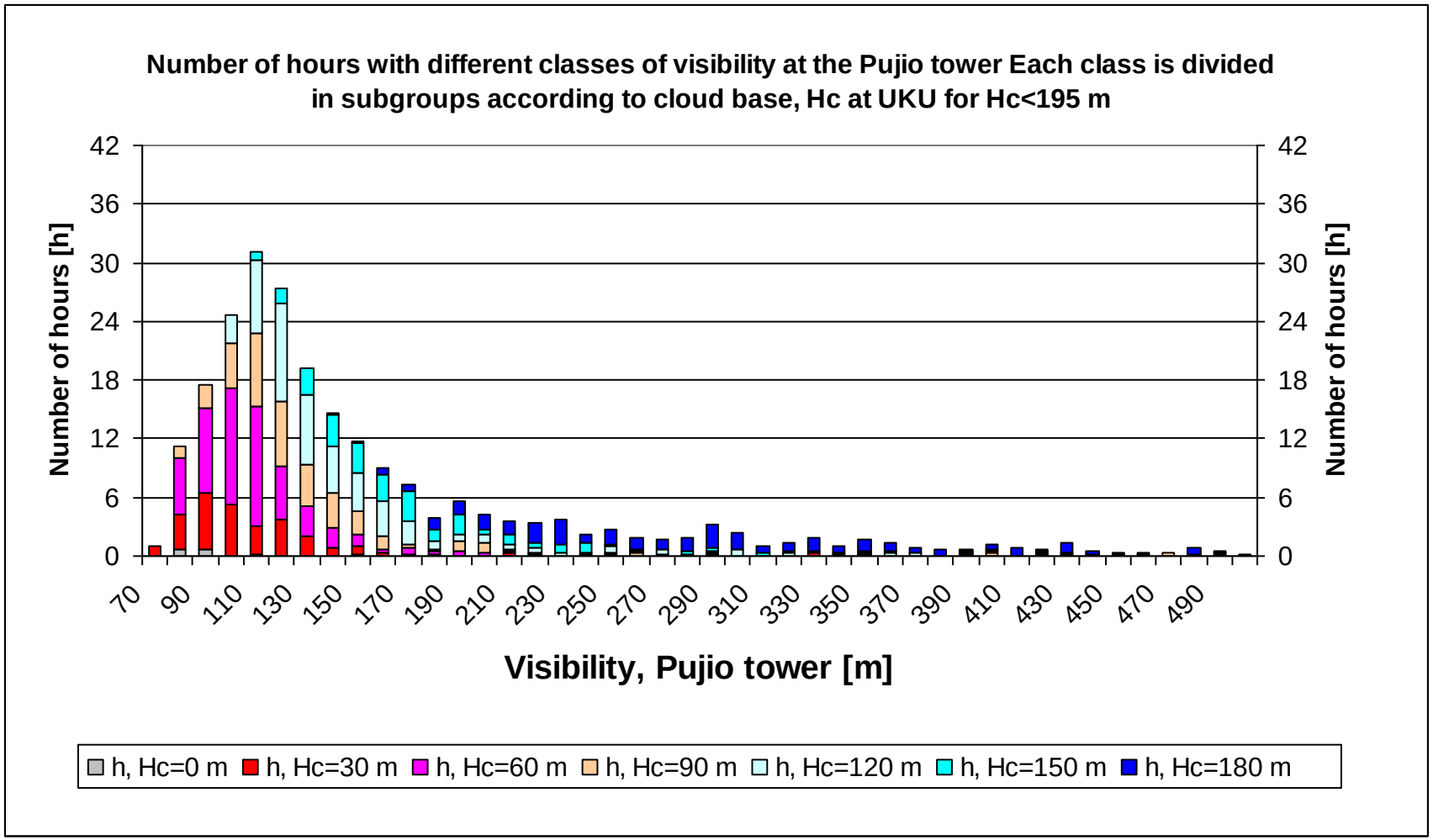
Group 4: tower normally visible, 73 %



Distribution of low visibility at the Pujio tower



Distribution of low visibility at the Pujio tower combined with different cloud heights at UKU



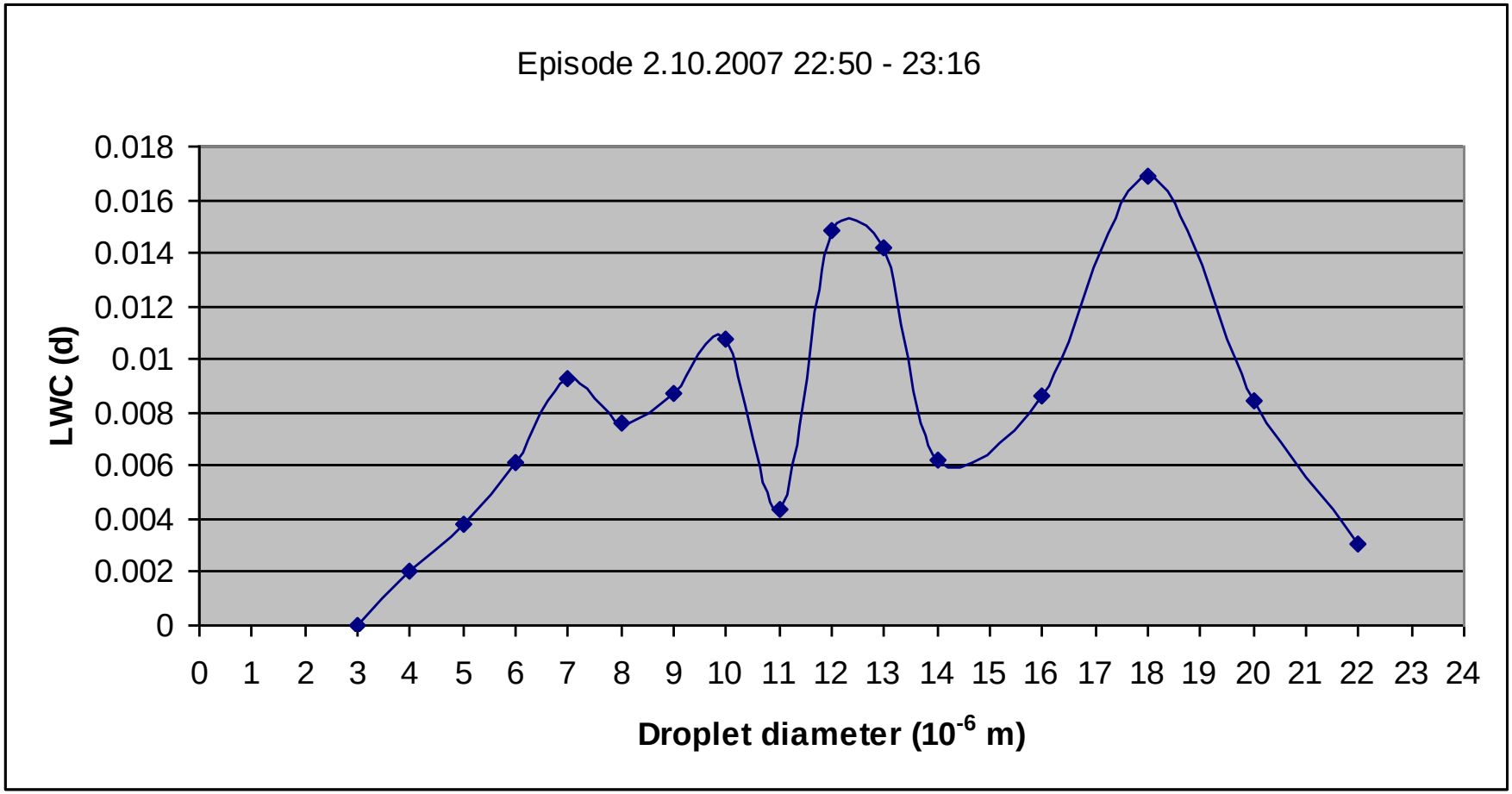
Vavr\Hc	0	30	60	90	120	150	180	Total
7		205						205
8		255	162	148				189
9		173	182	181	223			182
10		203	206	203	189	226		203
11		188	208	218	196	193		203
12		181	200	228	223	188	176	211
13		170	222	208	222	208	180	210
14		165	211	213	228	212	188	213
15		182	232	217	252	215	192	221
16				215	211	217	191	208
17			218		207	234	207	217
18					211	257	180	221
19				192	197	219	213	209
20				219	190	225	195	206
21					273	240	222	232
22					245	248	225	231
23					218	210	204	209
24						231	218	212
25					165		224	226
26							189	186
27							249	208
28							214	228
29							227	232
30					207		221	216
31							199	212
32					151		217	187
33							212	207
34							212	245
35							197	203
36							200	211
37							157	187
38							191	201
39								168
40								210
41							180	185
42								194
43							174	178
44								
45								232
46								
47								105
48								164
49								
50								
Total	226	193	201	211	214	217	201	208

Average wind direction in the Pujio tower for groups of Hc and MOR (x10m), for cells from 5 to 19 observations (yellow) and 20 or more (red)

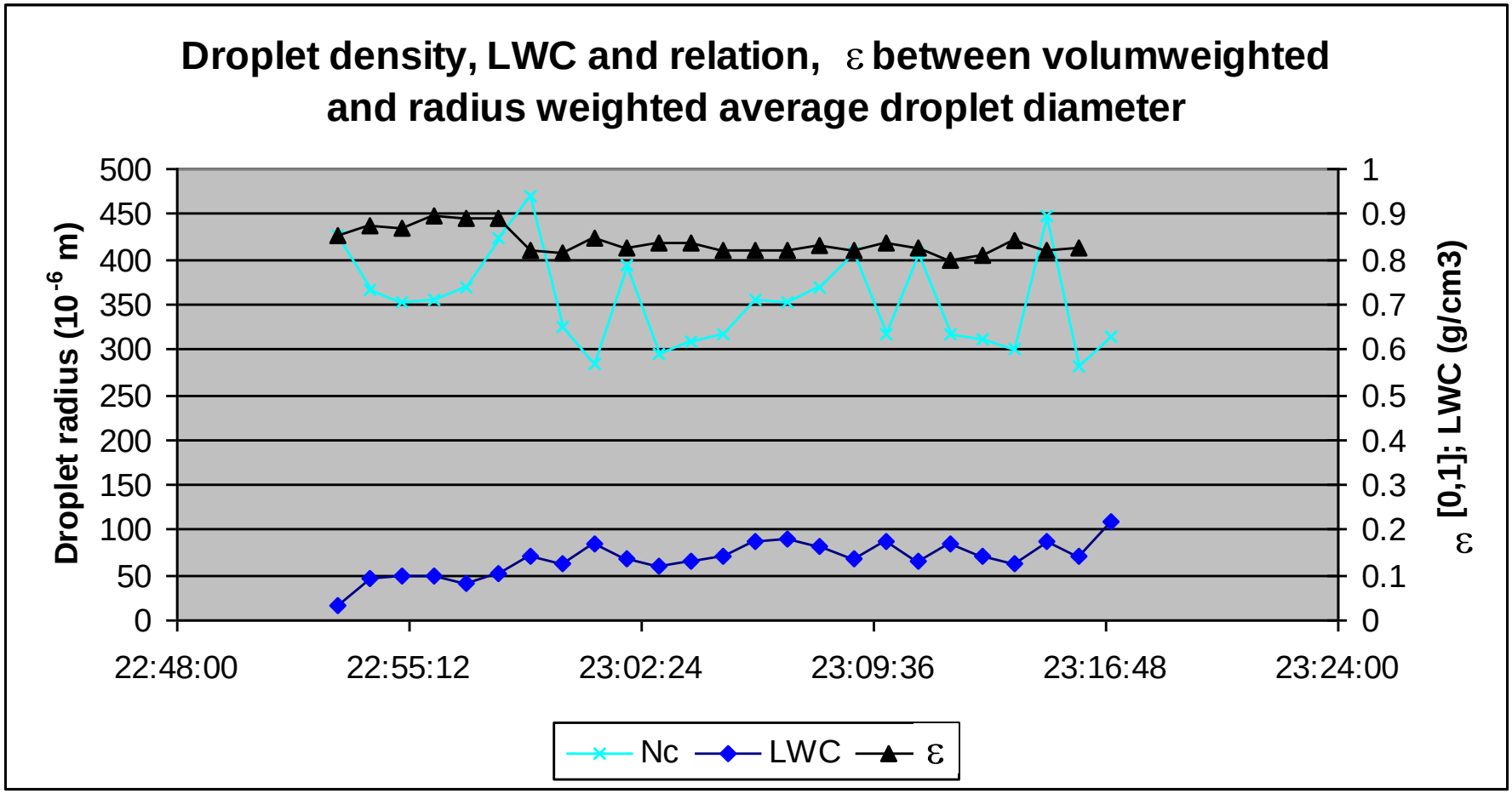
Pujio tower

Conclusion:
Wind from the Baltic dominate for in-cloud icing conditions

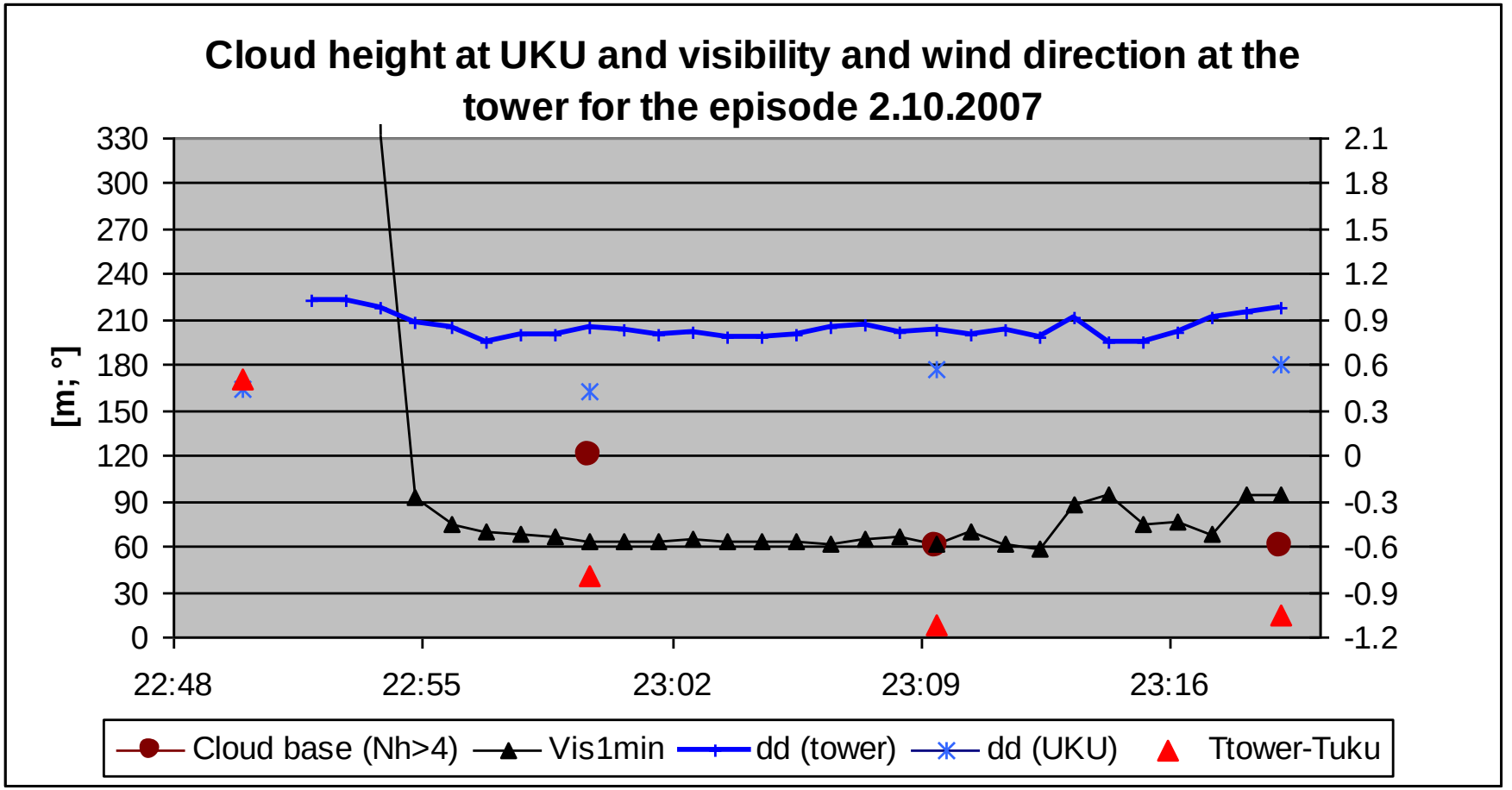
Measured spectral cloud water (LWC) in an episode of warm cloud with low visibility at the tower position



Measuring droplet density, size and LWC in an episode of warm cloud with low visibility at the tower position



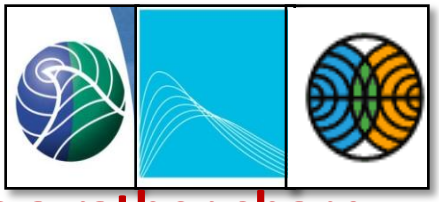
Meteorological conditions 2.10.2007



Calculation of the droplet concentration - tuning the Nc/LWC to measured values

	Adiabatic cloud water gradient. Narrow droplet spectrum	Adiabatic cloud water gradient. Measured droplet spectrum	Tuned cloud water gradient. Measured droplet spectrum
Tw (°C)	8.8	8.8	8.8
Deposition factor, b	1	1	1
Cloud water gradient factor, a	1	1	0.62
Droplet spectrum factor, ε	1.00	0.82	0.82
Meas cloud base (m)	60	60	60
Meas visibility (m)	64	64	64
Mod Nc (cm^{-3})	71	129	340
Meas Nc (cm^{-3})	340	340	340
Mod LWC (gm^{-3})	0.27	0.27	0.17
Meas LWC (gm^{-3})	0.15	0.15	0.15

Conclusions



- **When the winter time visibility in the tower is low, it is a rather sharp distribution around visibilities of 90 – 150 m**

- **When there is low visibility in the tower there typically is low clouds at UKU-campus, indicating in-cloud conditions**

- **When there is in-cloud conditions at the tower, the temperature typical drops with 0.7°C/100 m in the area**

- **When there is fog or low clouds below the tower station there is several degrees warmer in the tower than in town**

- **There was significant deviation from a narrow droplet spectrum in the analyzed in-cloud situation 2.10.2007**

- **The cloud water gradient was 60% of the adiabatic gradient 2.10.2007**