



# Forecasting fog and stratus in aviation weather service

About formation and dissipation of fog and stratus, their occurrence around the year and effects on the airport services in Finland.

3.12.2018

Aviation Event Week

EUMeTrain

Elina Tuhkalainen



# Where do you come from?



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Click your arrow in the group you belong to:

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# Content

- Fog types, definitions
- Formation and dissipation
- Occurrence of fog and stratus around the year (examples in Finland)
- Orography effects
- Tools we're using to forecast stratus and fog
- Effects on the airport
- Case studies





# Definitions

- Fog and mist
  - High humidity reduces visibility
    - 1-5 km: mist
    - $\leq 1$  km: fog
- Stratus
  - Low cloud
  - Base 0-1000 ft (approx. 300 m)
  - On ground  $\rightarrow$  fog
- TAF codes:
  - FG - fog
  - BR - mist
  - MIFG - shallow fog ( $\leq 2$  m)
  - PRFG - partial fog
  - BCFG - patches of fog
  - FZFG - freezing fog ( $T \leq 0^\circ\text{C}$ )

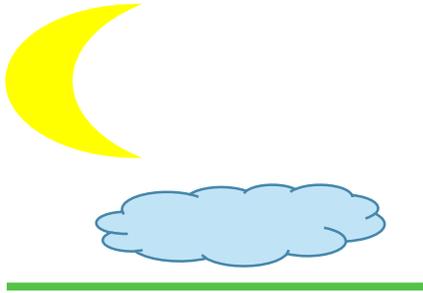




# Formation and dissipation

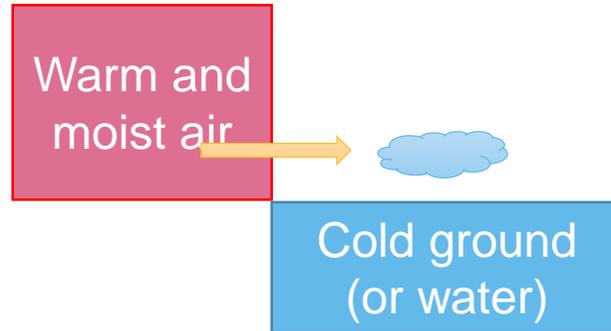
- Interaction between the air and the ground
- Formation: The air cools down or becomes more moist
- Dissipation of fog: air warms up or dries
  
- Radiation: cools the ground and the air (sunrise, sunset)
- Advection: brings cold air over moist surface
- Rain: can either clean the fog or make the low levels more humid and thus lower the ceiling
- Cloudiness above the fog:
  - Higher clouds may slow down the dissipation
  - It can also prevent the fog to develop





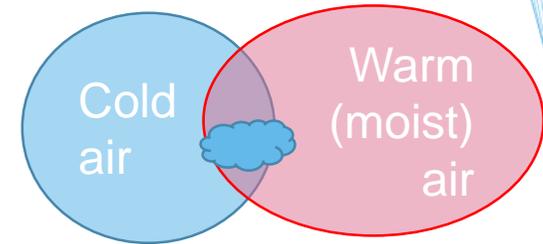
Radiation:

- Clear night
- T decreases

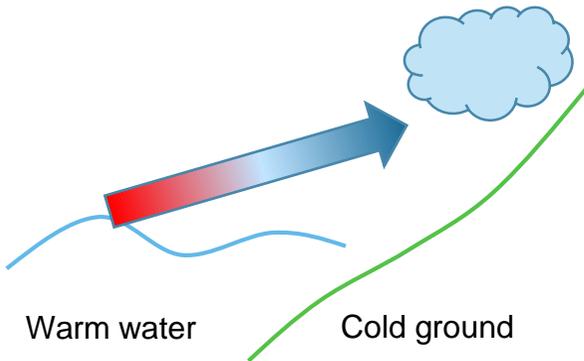


Advection:

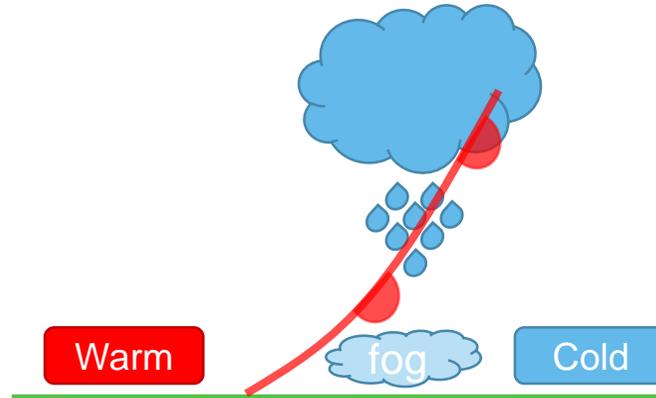
- Warm and moist air moves on cold ground
- Reverse: cold air over warm water



Warm and cold air mixing



Orography

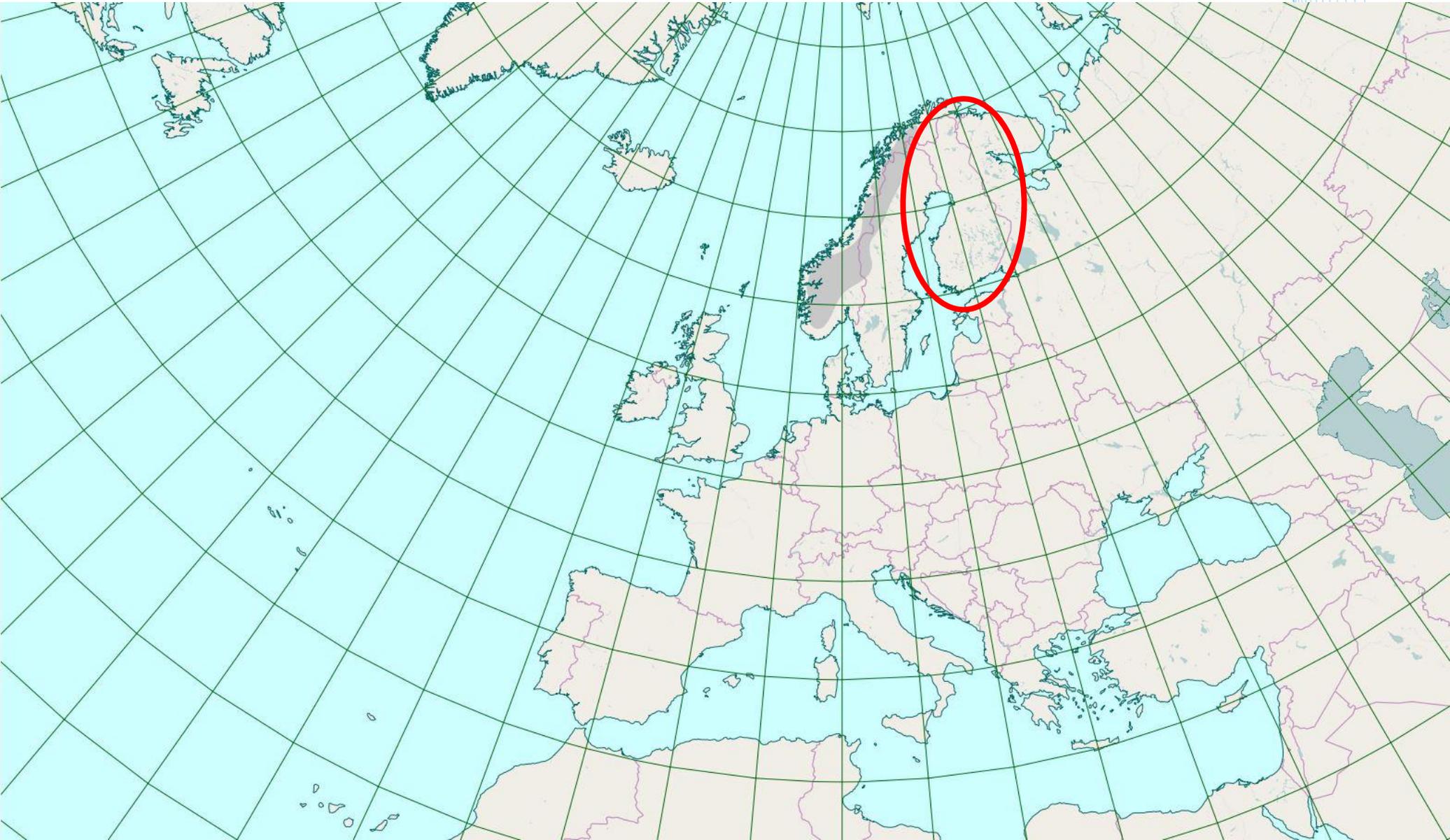


Warm front:  
Warm precipitation falls into cold air



Very cold air (<-20°C):

- Water vapour condenses into ice crystals



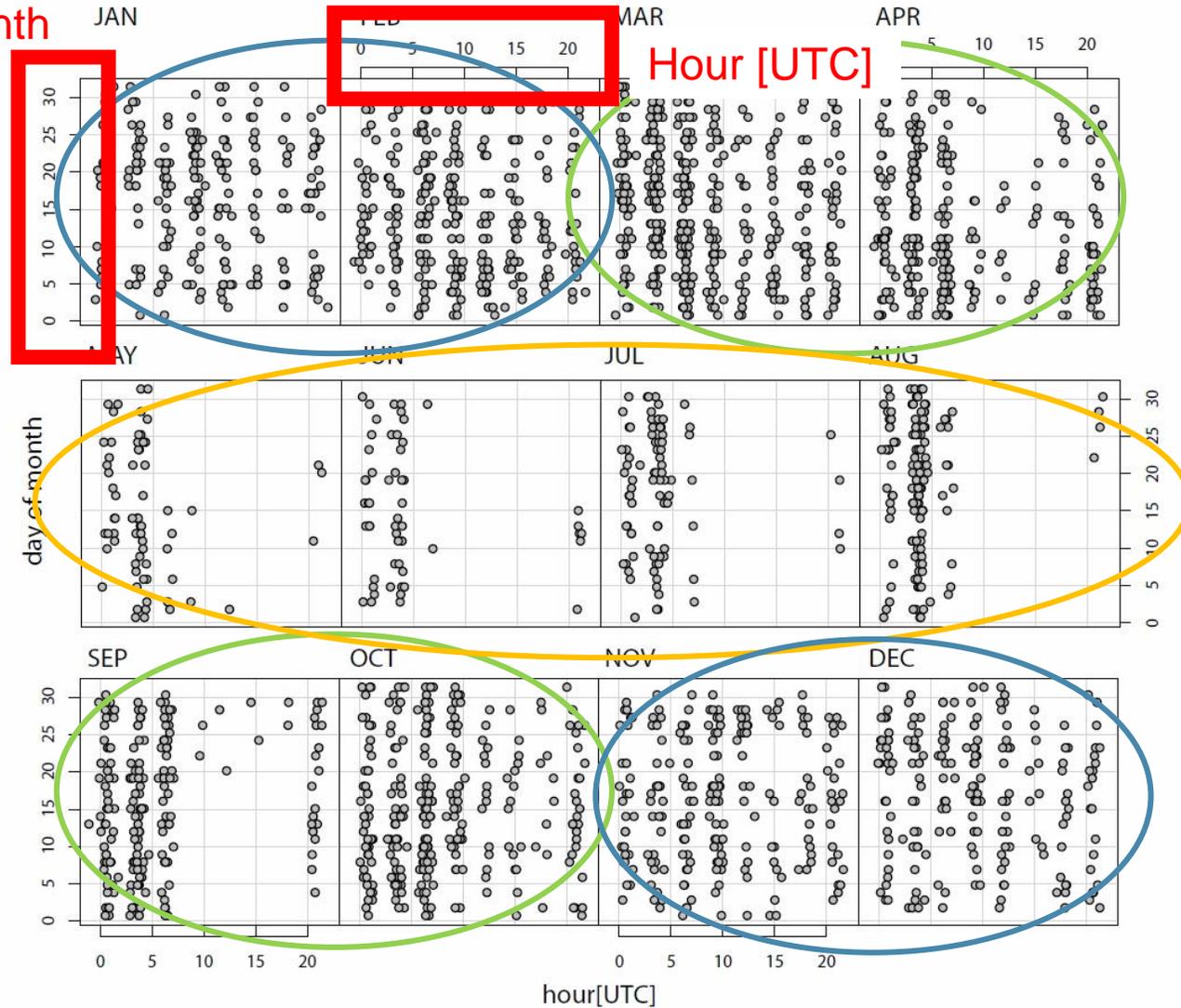




# Fog around the year at EFHK (Helsinki-Vantaa airport, Finland)

Monthly hour of the day/fog observations KENTTÄ

Day of month



1. Winter: no diurnal variation
2. Spring: mostly mornings
3. Summer: only mornings
4. Autumn: mostly mornings
5. Winter: no diurnal variation

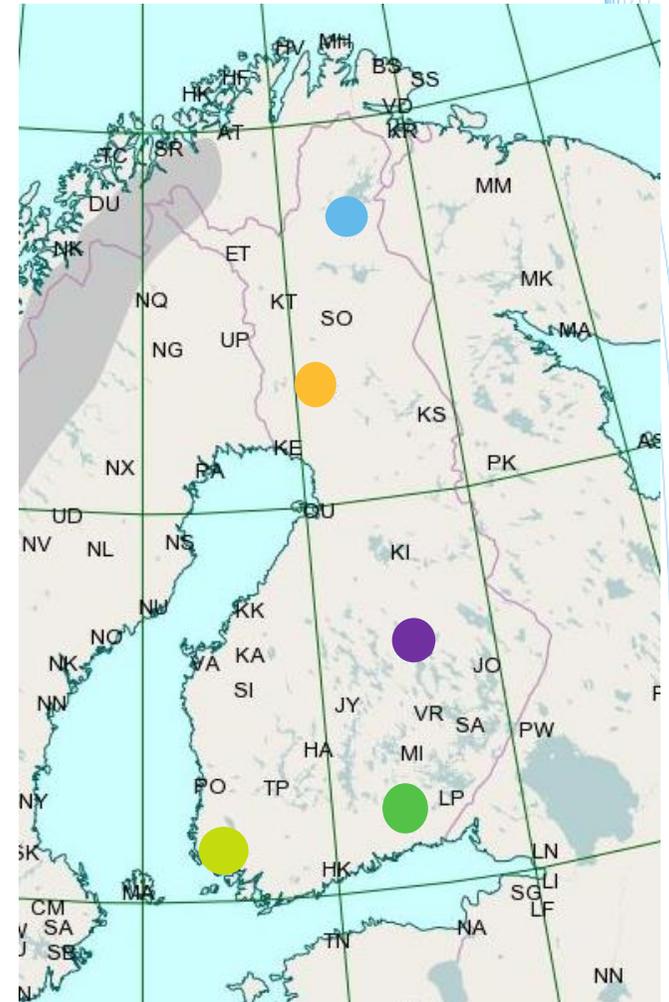
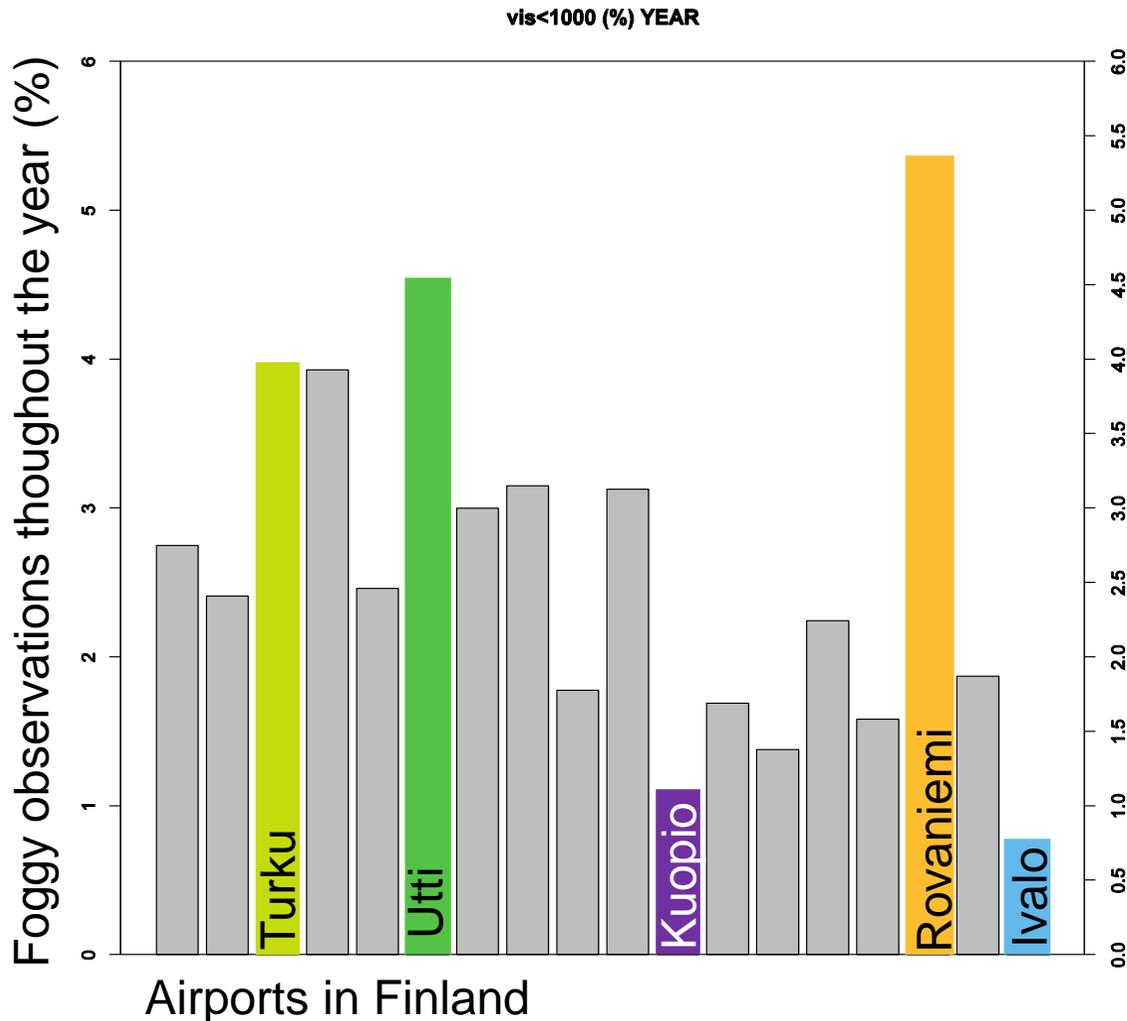


### Rovaniemi:

- On a hill, 100 m (300 ft) higher than the surrounding area

### Turku:

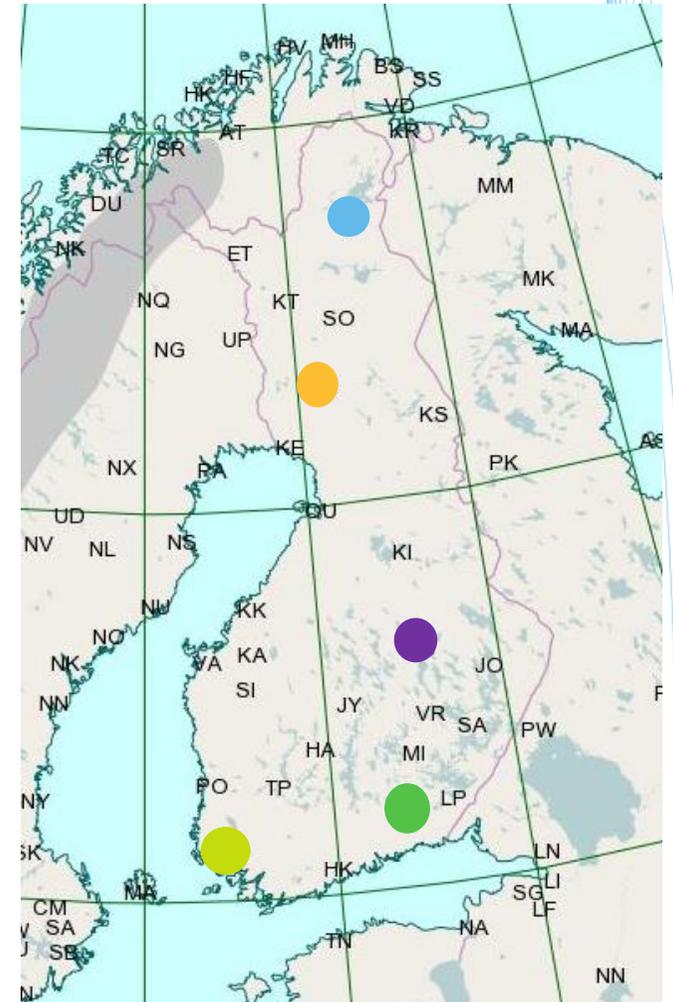
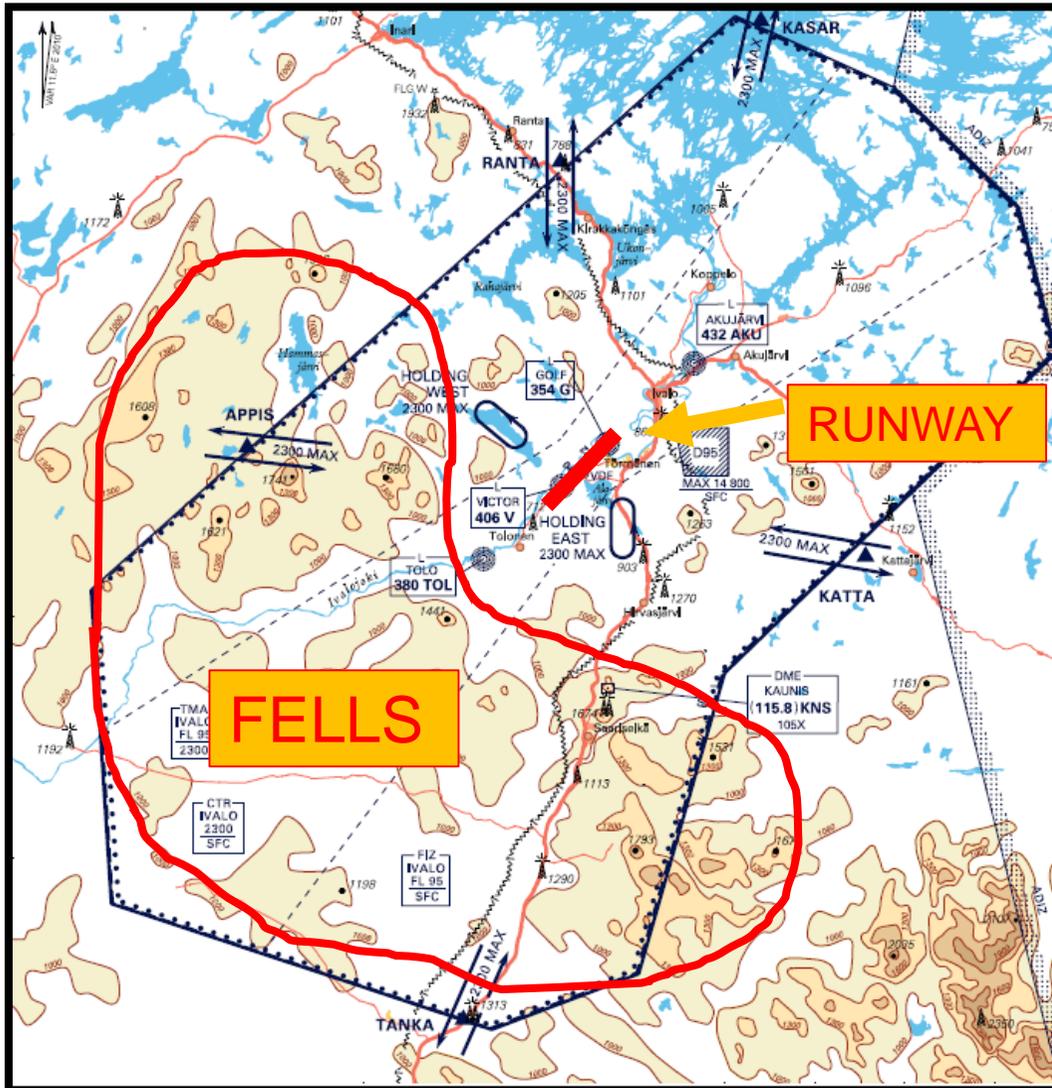
- The Baltic Sea is usually open here around the year → a lot of moisture





### Ivalo:

- Fogs are rare here
- Surrounded by hills (1400-1700 ft high) from west, southwest and south



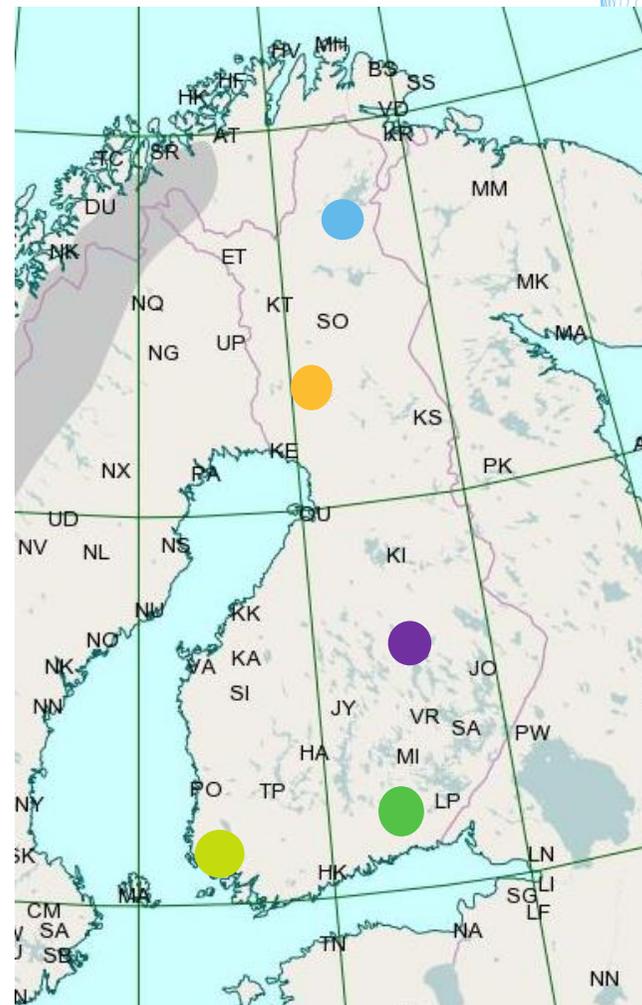
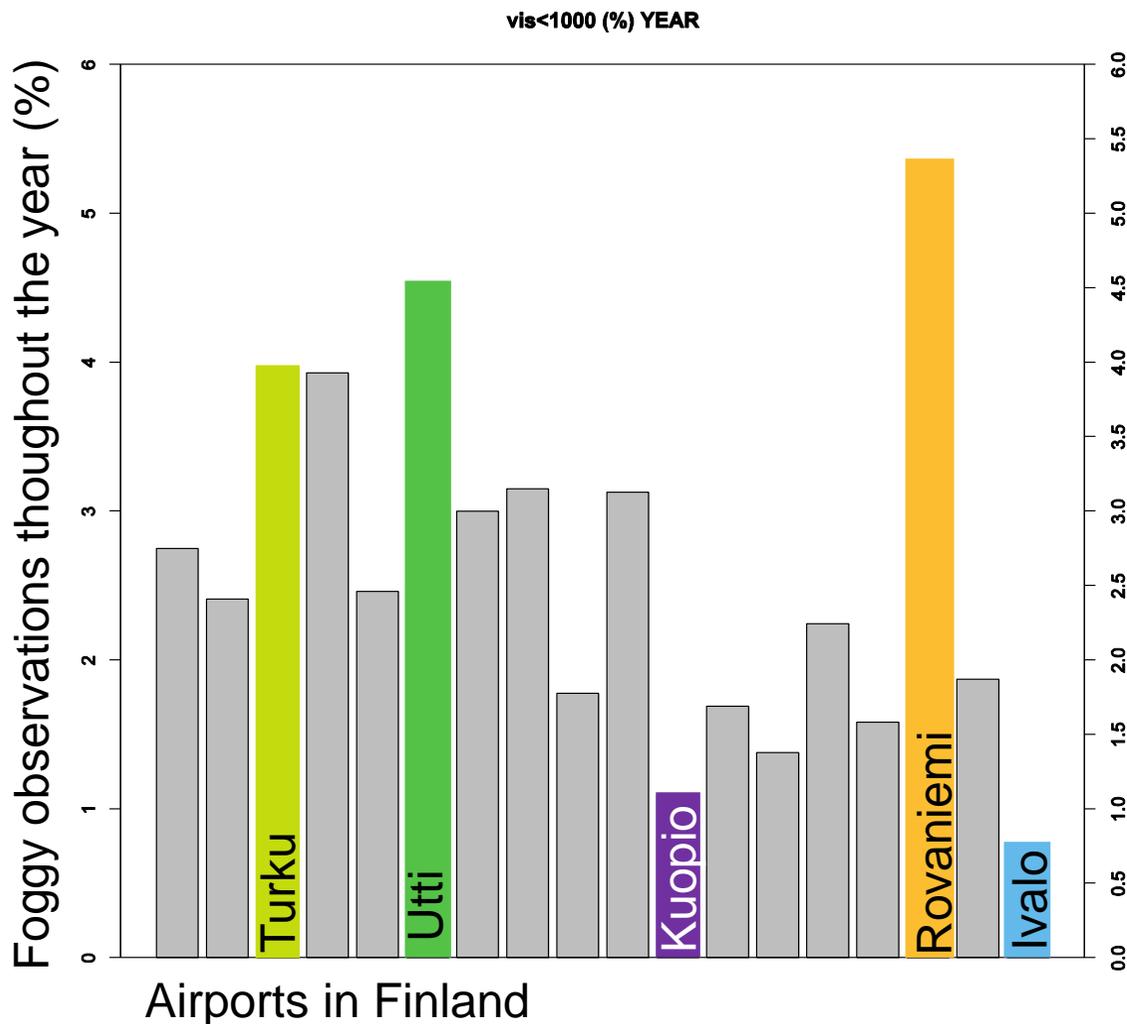


### Utti:

- On a hill
- Swamps south of the airport

### Kuopio:

- Surrounded by lakes, which keeps the area warm
- Hills SW of the airport.





# Effects on the airport services

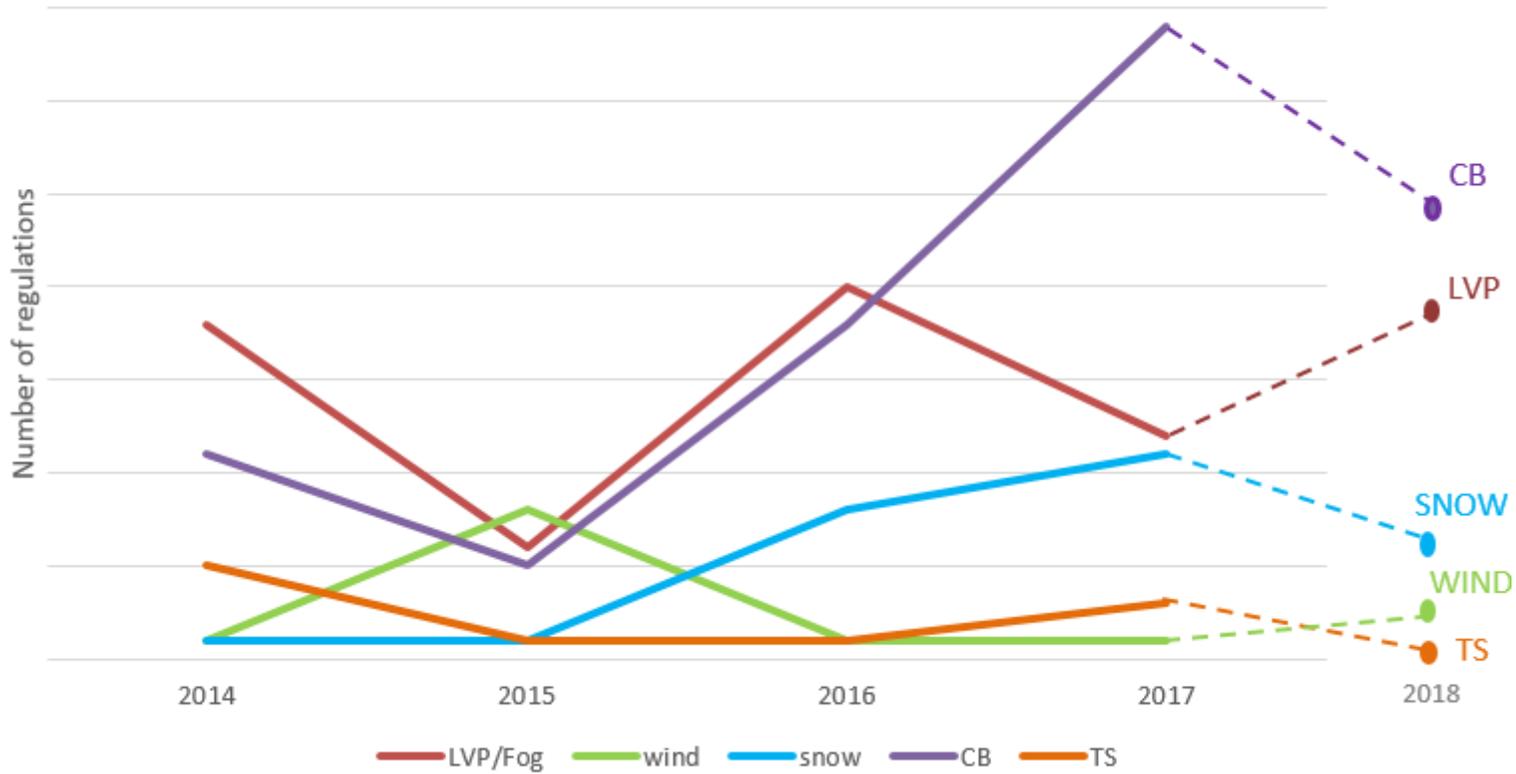
- LVP = low visibility procedures
  - Horizontal and vertical visibility
  - Airport-specific thresholds
- For safe operations
  - Increasing spacing between aircrafts (approach, taxi)  
→ Reduced capacity
- Alternative airports → fuel costs
- Cancelled flights





# Effects at EFHK

EFHK weather related regulations





# Our products (with stratus and fog)

## TAF

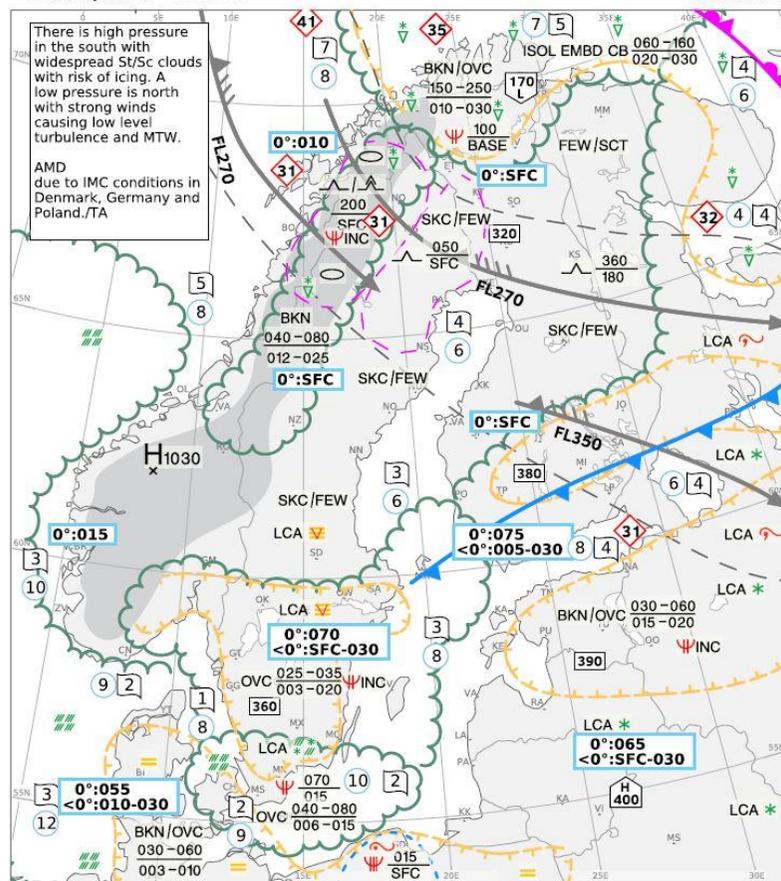
TAF EFHK 222325Z 2300/2324 VRB02KT 5000 BKN005  
 TEMPO 2300/2309 0500 FZFG VV001  
 TEMPO 2306/2309 2000 BR BKN004  
 BECMG 2309/2311 27010KT 9999 BKN012  
 BECMG 2311/2313 BKN015=

## TREND forecast in the end of METAR:

METAR EFHK 222220Z 01005KT 0900  
 R04R/P1500N R15/P1500N R22L/P1500N  
 R04L/P1500N FZFG VV002 M02/M02 Q1025  
 TEMPO 0700=

GA-FCST FOR AREAS 11/17 VALID 0312 WX LAAJALTI  
 ST/SC-PILVISYYTTÄ, AAMULLA PAIKOIN UTUA TAI  
 JÄÄTÄVÄÄ SUMUA. LÄNNESSÄ PAIKOIN ON SELKEÄÄ.  
 WINDS 11/17 SFC VRB-320/01-08KT MAR 08-20KT  
 2000FT 250-320/10-35KT 5000FT 280-340/15-35KT 0-C  
 LEVEL 11/17 NIL/NEAR SFC PS DEG BTN 200-1000FT  
 AND 3000FT-FL080 ICE NIL LCA MOD INC TURB NIL  
 GAFOR EFHK 0312 BBBB 11/15,17 M/X ST/BR/FZFG  
 BECMG 0810 O/D LCA M ST 16 O LCA 0307 M/X  
 FZFG/BR=

SWC SFC-FL450 AMD valid time 18 UTC 23.11.2018  
 Issued by FMI at 1642 UTC © FMI / SMHI



Prognostic chart		Symbols	
<p>Symbols "CB" and "TCU" imply moderate or severe icing, turbulence and hail. Light icing ("V") is not considered on this SWC. Units used: speed in knots; pressure in QNH; altitude in flight levels at FL050 and above, in hectofeet above ground level below FL050. IMC is not detailed in mountain areas (shown with grey shading).</p>	<p>Boundary for SIGWX            Boundary for ceiling&lt;1000ft and/or visibility&lt;5km (IMC)            Boundary for high level turbulence (CAT)            Boundary for low level turbulence            Boundary for icing            Moderate, Severe turbulence            Moderate, Severe icing            Rain, Snow, Sleet            Showers</p>	<p>Freezing precipitation (implies mod to sev icing)            Thunderstorm, Hail            Drizzle, Snow grains            Mist, Fog, Freezing fog            Haze, Smoke, Blowing snow            Mountain waves            0°C level            Widespread sfc wind &gt;30kt            Sea surface temperature, Sea state (index)</p>	<p>Convergence line at the sfc            Severe squall line at the sfc            Position, speed, direction and level of max wind            Tropopause level            Tropopause high            Tropopause low            Radioactive materials in the atmosphere</p>





# Airport Forecast

Time (UTC)	00	01	02	03	04	05	06	07	08
Visibility	8000	8000	8000	8000	8000	8000	8000	8000	8000
Weathercode									
TEMPO visibility	0800	0800	0800	0800	0800	0800	2500	2500	2500
TEMPO weathercode	FZFG	FZFG	FZFG	FZFG	FZFG	FZFG	BR	BR	BR
Cloud ceiling	500	500	500	500	500	500	500	500	500
TEMPO Cloud ceiling	200	200	200	200	200	200	400	400	400
LVP (probability %)	80	80	80	80	80	80	20	20	20

In this case the taf would have been like this:

8000 BKN005 TEMPO  
2300/2106 0800 FZFG  
BKN002 TEMPO 2106/2108  
25000 BR BKN004

- The form is filled automatically with TAF or model values and LVP-probability is calculated automatically
- You can change all the values

The customer product

DATE	23 November 2018								
TIME (UTC)	00	01	02	03	04	05	06	07	08
Visibility/Weather									
TEMPO VIS/WX	FZFG	FZFG	FZFG	FZFG	FZFG	FZFG	BR	BR	BR
Cloud ceiling									
TEMPO Ceiling									
LVP-prob (%)	60	60	60	60	60	60	20	20	20



# Forecasting tools

## Model:

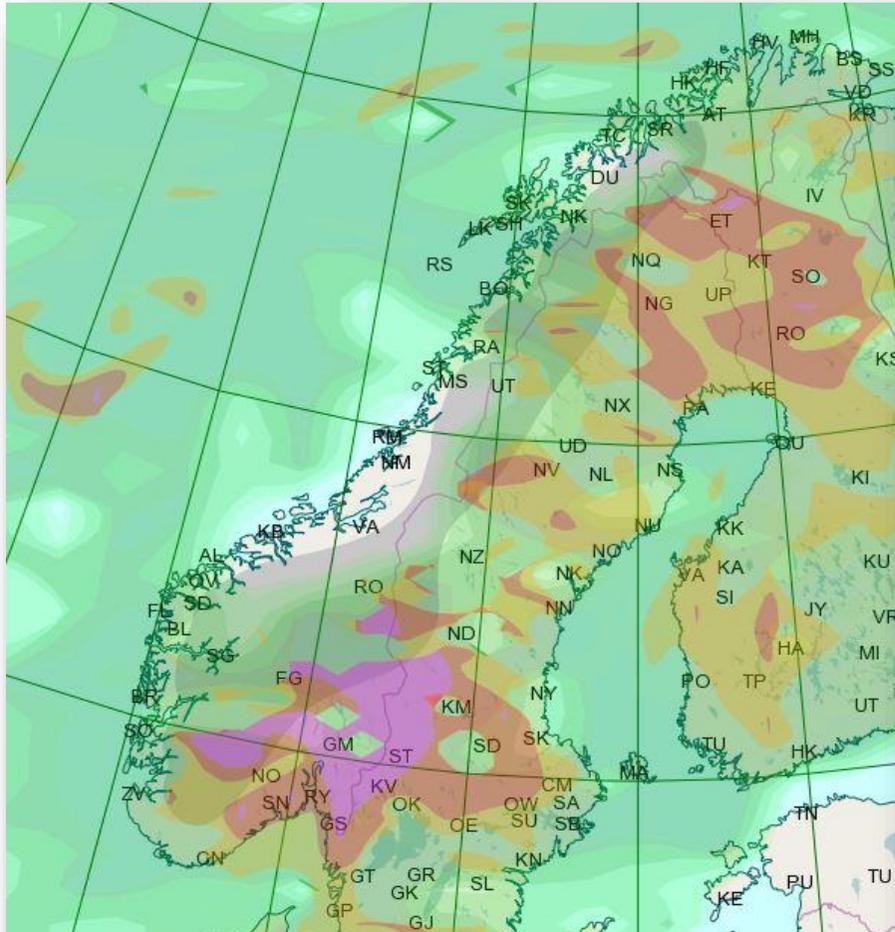
- Model fields on map (cloud base, visibility, IMC)
- Meteograms
- Airport forecast model (+ taf) input

## Observations:

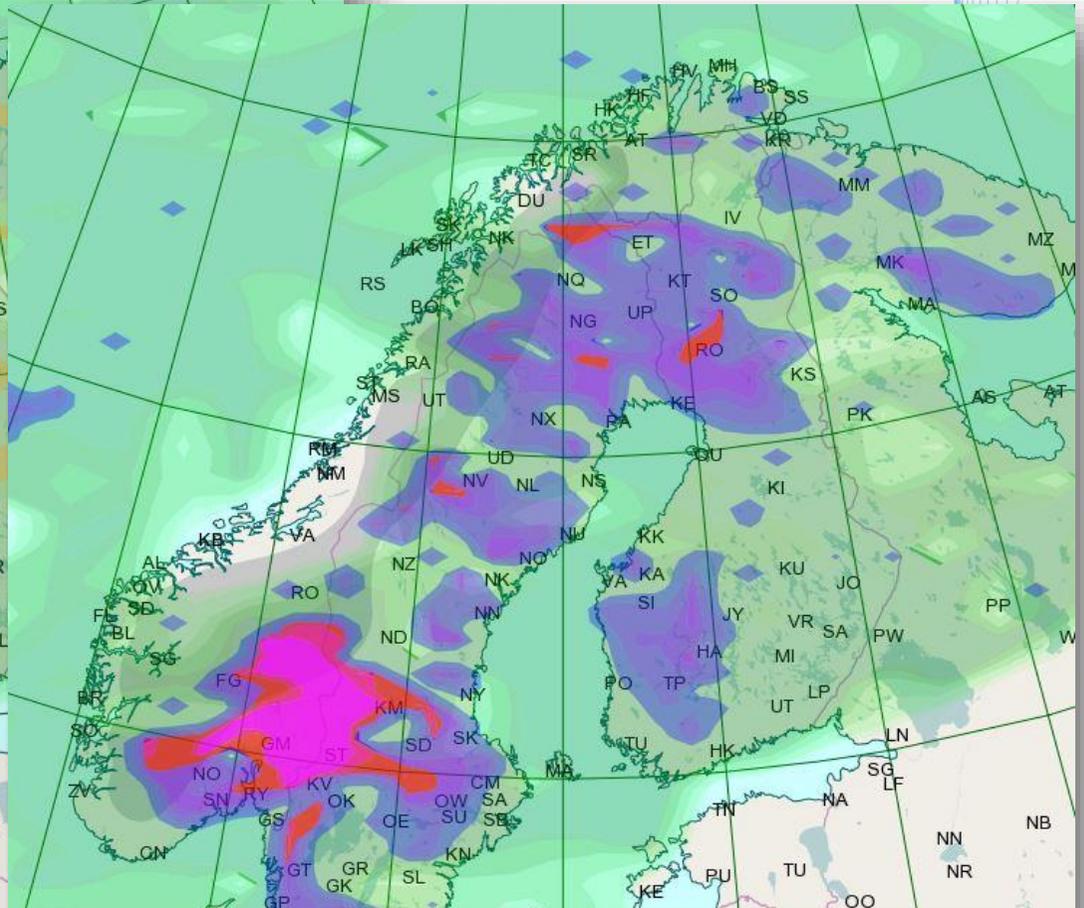
- Metars on map with colours
  - Advection with ground wind speed
- Satellite
- Web-cameras
- Mast-observations, wind speed on different levels
- Radar
  - Does the rain clean the fog or just increase humidity
  - What is actually coming down. Some particles make the visibility even worse
- Sunrise and sunset: radiation effects both ways
- Higher clouds
- Ice chart
- Ceilometer data



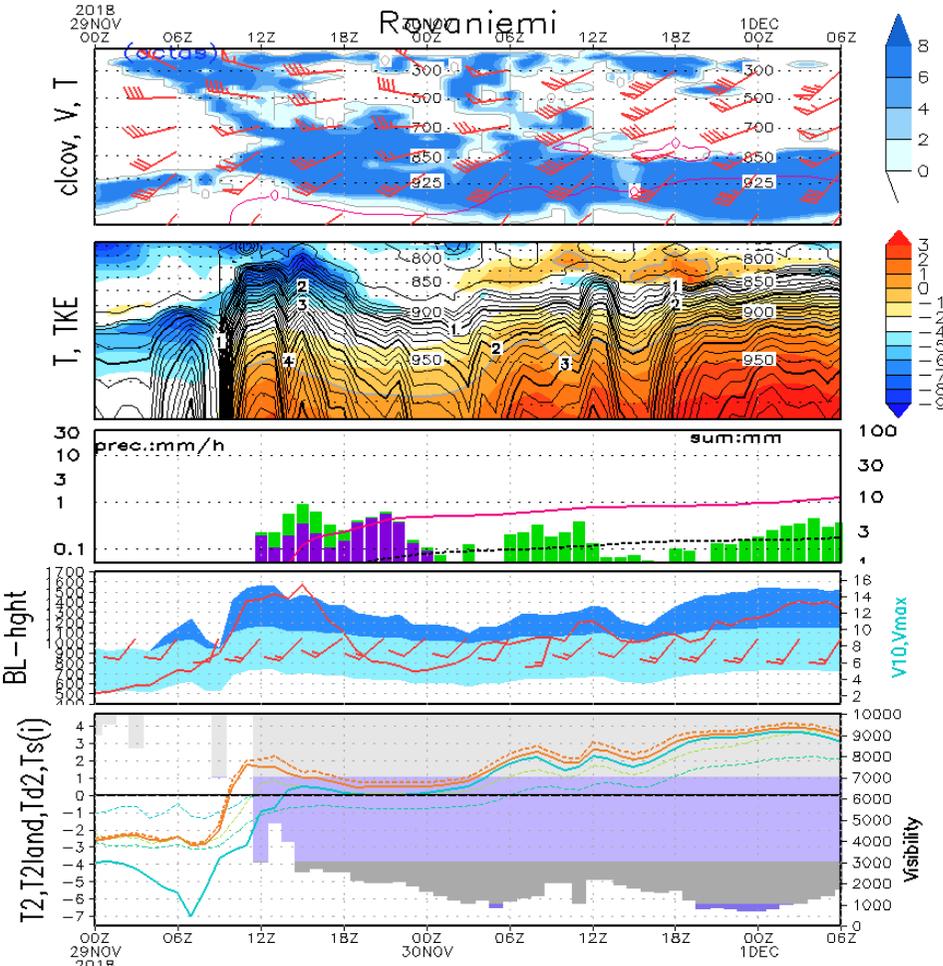
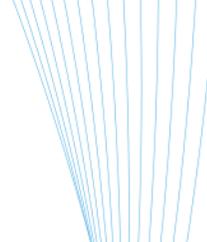
# Model fields



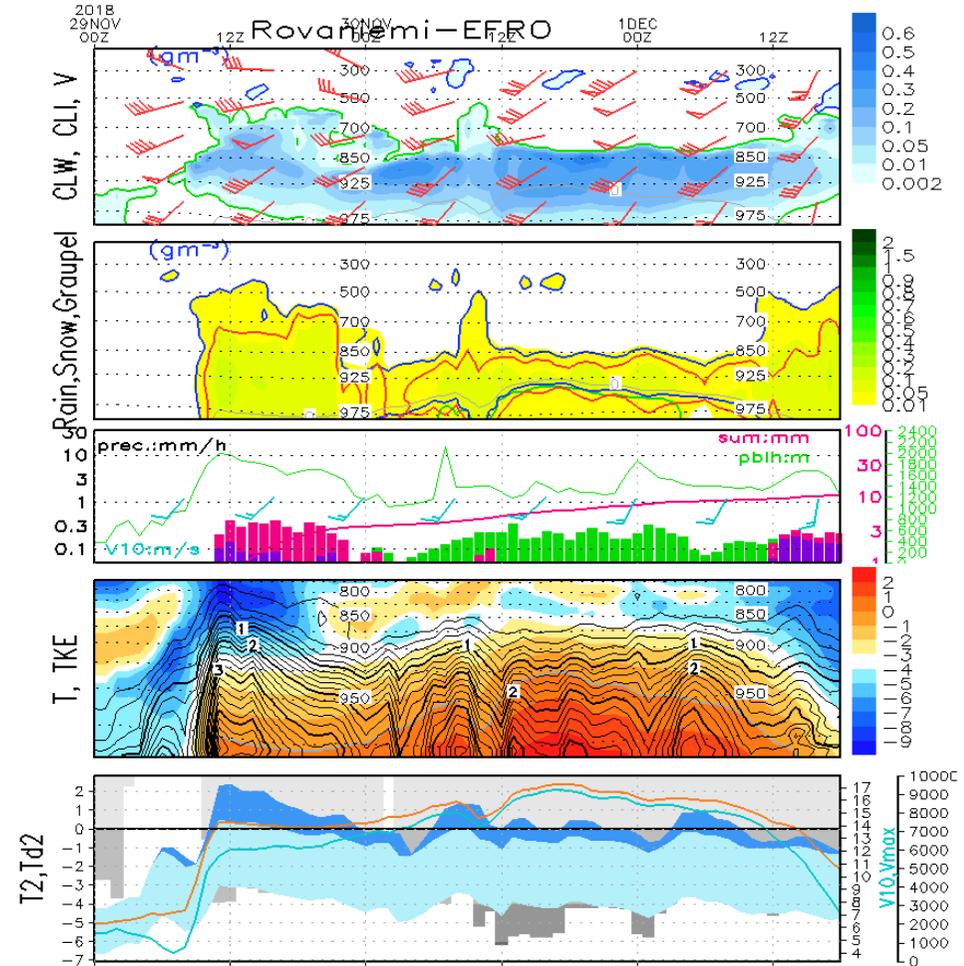
Green: low clouds (< FL060)  
Yellow/orange/red/pink: ceiling  $\leq 1500$  ft



Green: low clouds (< FL060)  
Purple/red/pink: IMC (vis < 5 km and/or ceiling < 1000 ft)



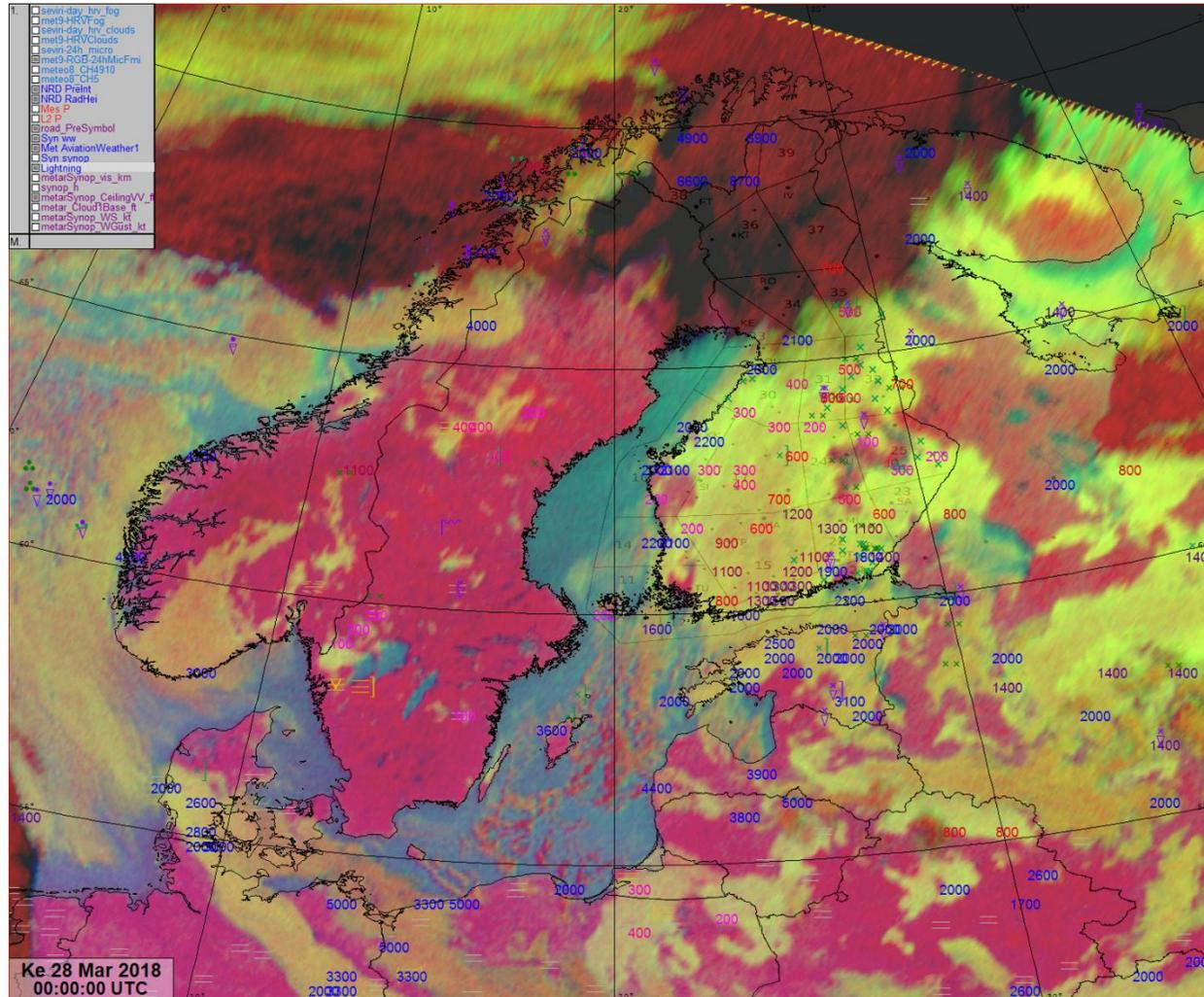
Selected grid-box: Lon=25.83 Lat=66.57 Elevation=140. m  
 Fractions: Land=0.95 Water=0 Ice=0.04 Bare land=0 Low veg=0.05 Forest=0.89



Selected grid-box: Lon=25.83 Lat=66.57 Elevation=-9. m  
 Fractions: Land=Operand Water=Operand Nature=Operand Urban=Operand Sea



# Observations

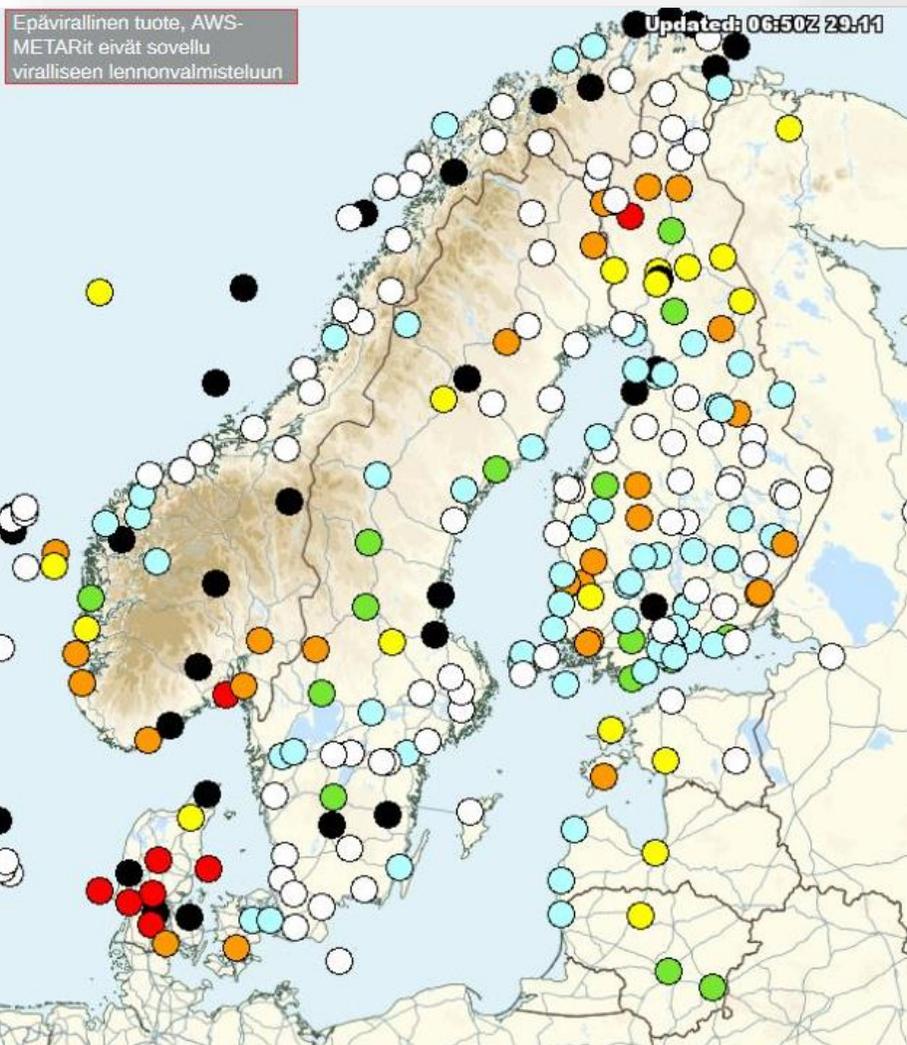


24h microphysical satellite image and Metar cloud ceiling (the numbers on the map)



# Observations (ilmailusaa.fi)

Epävirallinen tuote, AWS-METARit eivät sovellu viralliseen lennonvalmisteluun



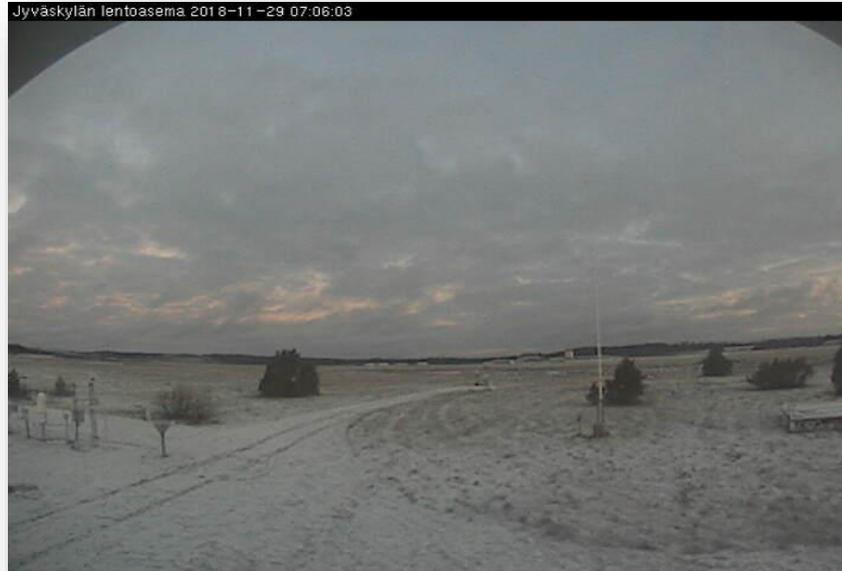
Epävirallinen tuote, AWS-METARit eivät sovellu viralliseen lennonvalmisteluun



- Ceiling (BKN/OVC)**
- over 5000 ft
  - below 5000 ft
  - below 2000 ft
  - below 1500 ft
  - below 1000 ft
  - below 500 ft
  - missing
- Visibility**
- △ over 10 km
  - △ below 10 km
  - △ below 8000 m
  - △ below 5000 m
  - △ below 3000 m
  - △ below 1500 m
  - ▲ missing



Jyväskylän lentoasema 2018-11-29 07:06:03



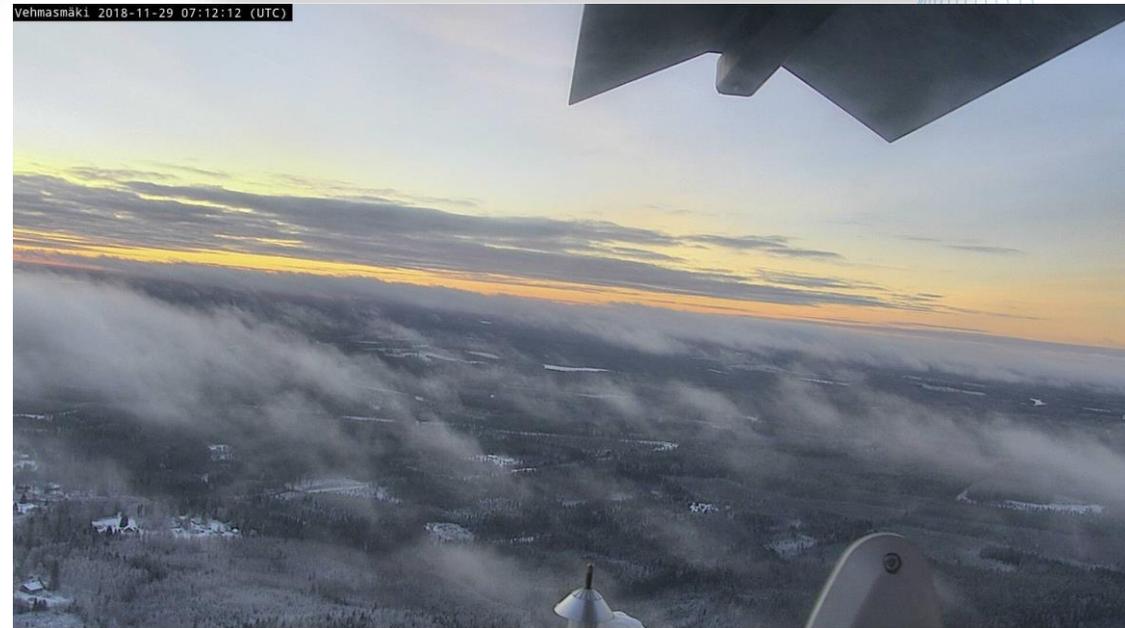
Helsinki-Vantaa N, cam#1 (GMT) 2018-11-29 08:04:10



Rissala I.a. S 2018-11-29 07:11:02 UTC



Vehmassäki 2018-11-29 07:12:12 (UTC)





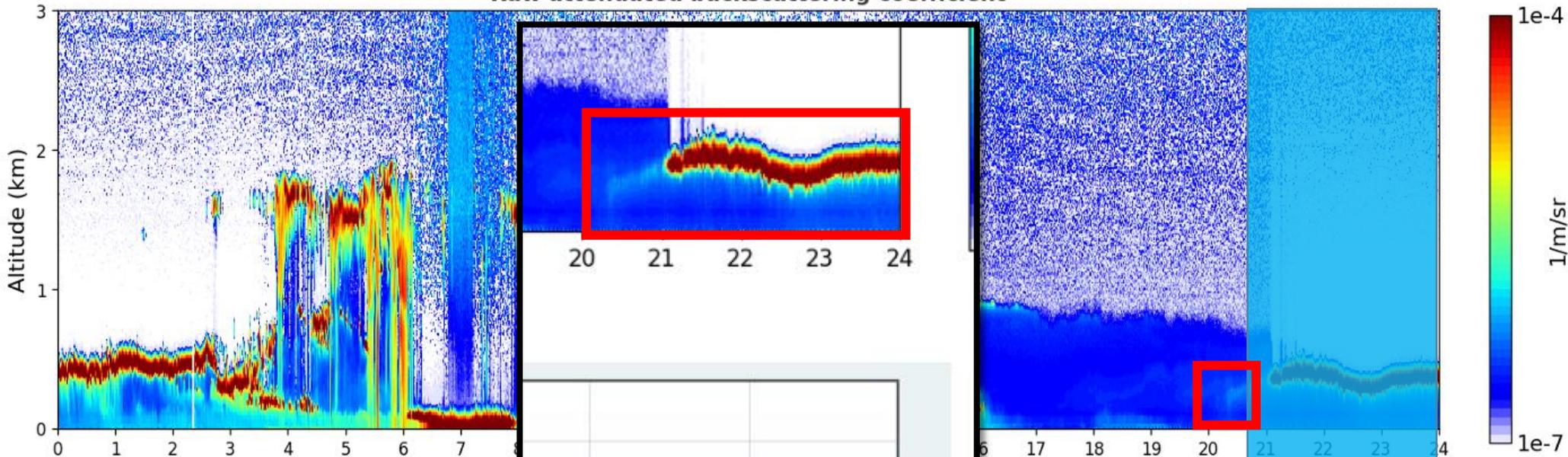
# Mast observations





# Nowcasting with ceilometer

Raw attenuated backscattering coefficient



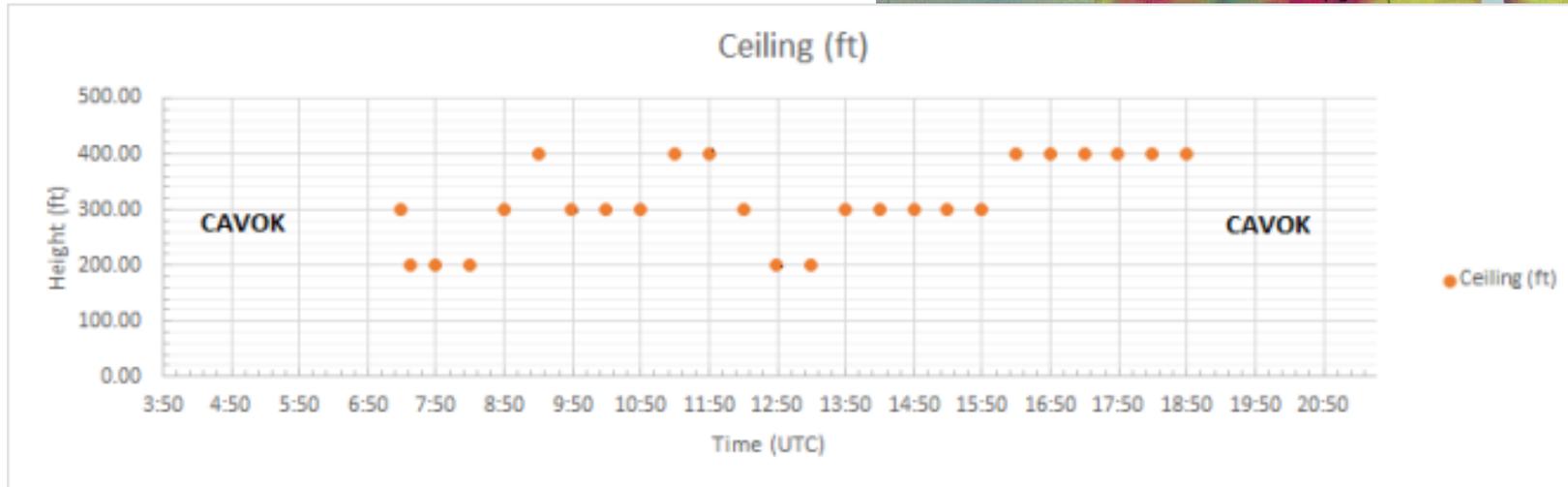
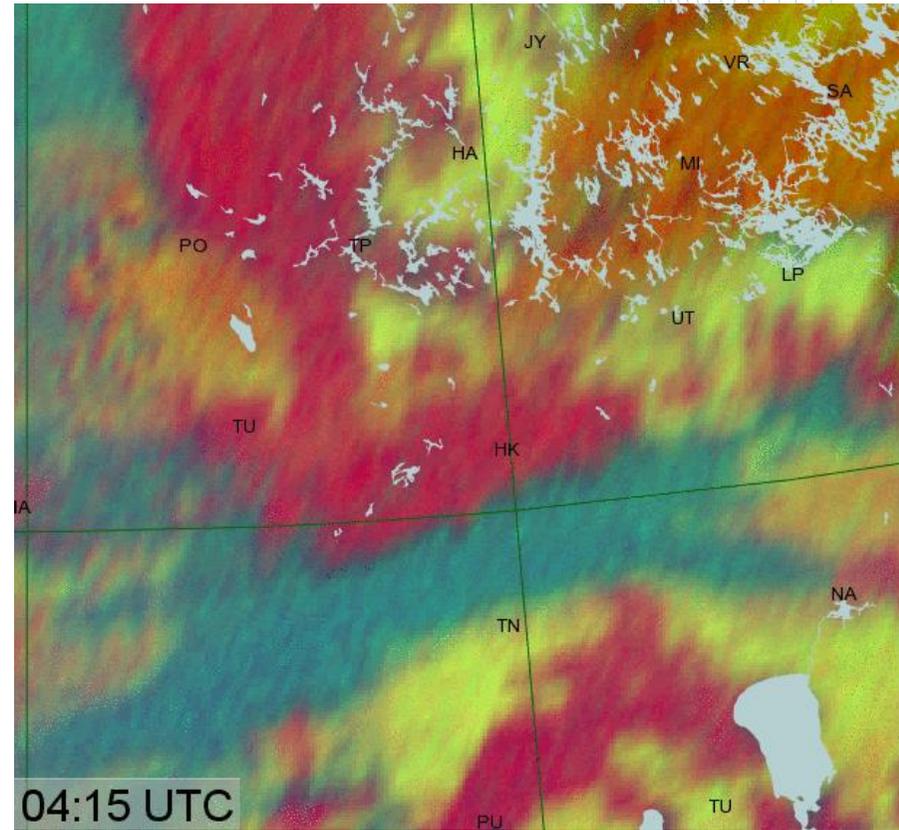
Cloud base (m)





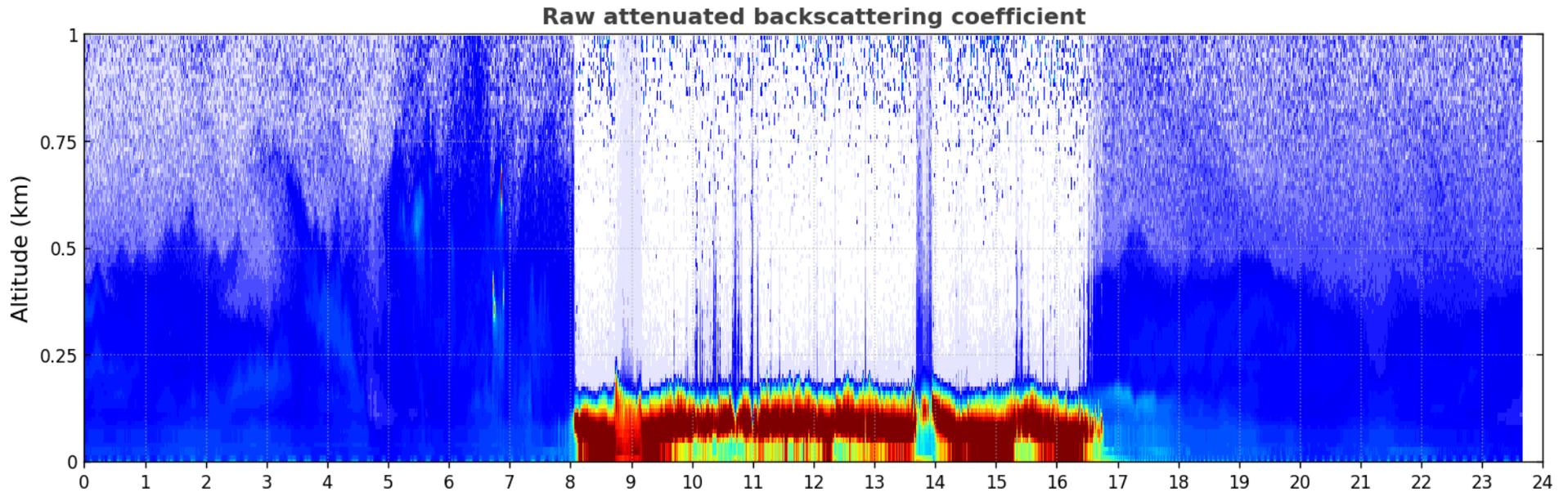
# Case 25.11.2018 at EFHK

- Low cloud came from the north
- Big lakes probably increased the humidity
- Small area of stratus stayed long right over EFHK
- AWS-Metars north of EFHK detected the cloud



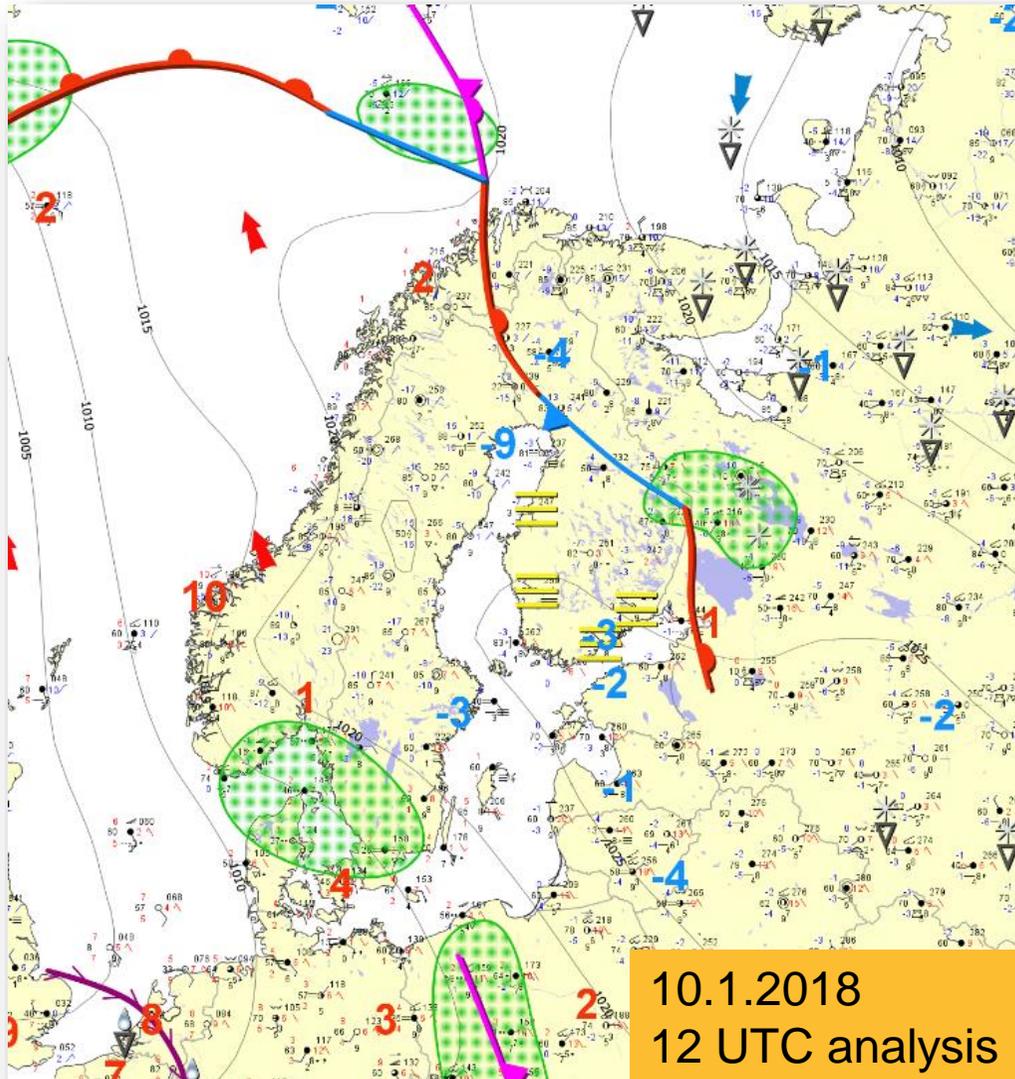


# Case 25.11.2018 at EFHK





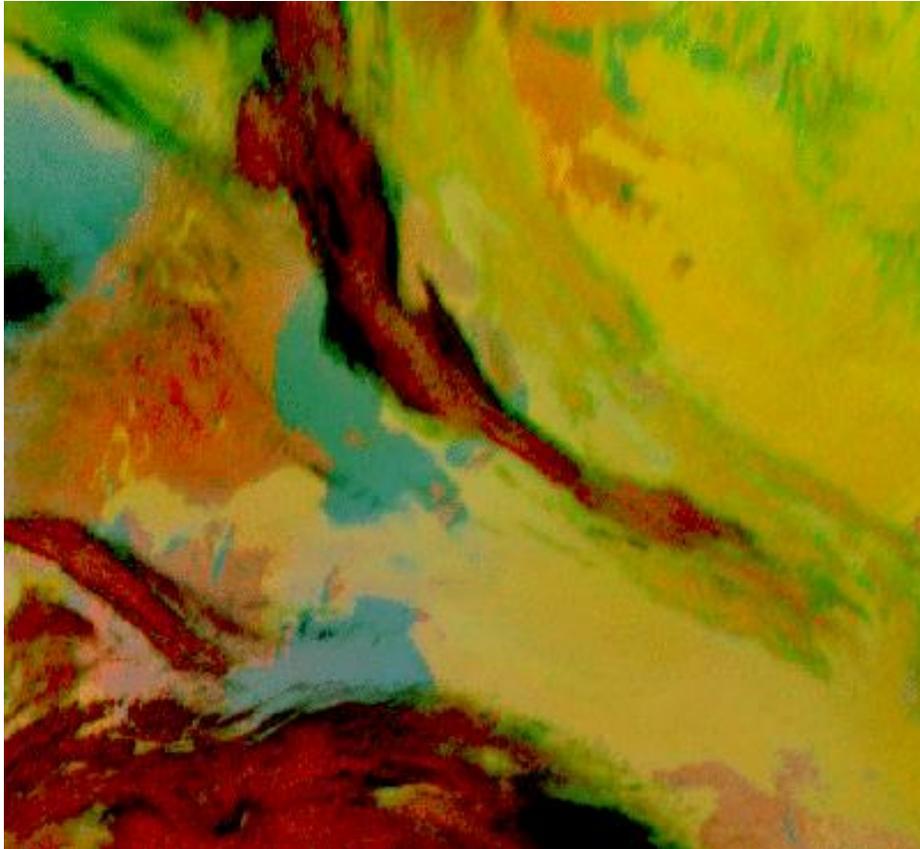
# Case 10.1.2018 at EFHK



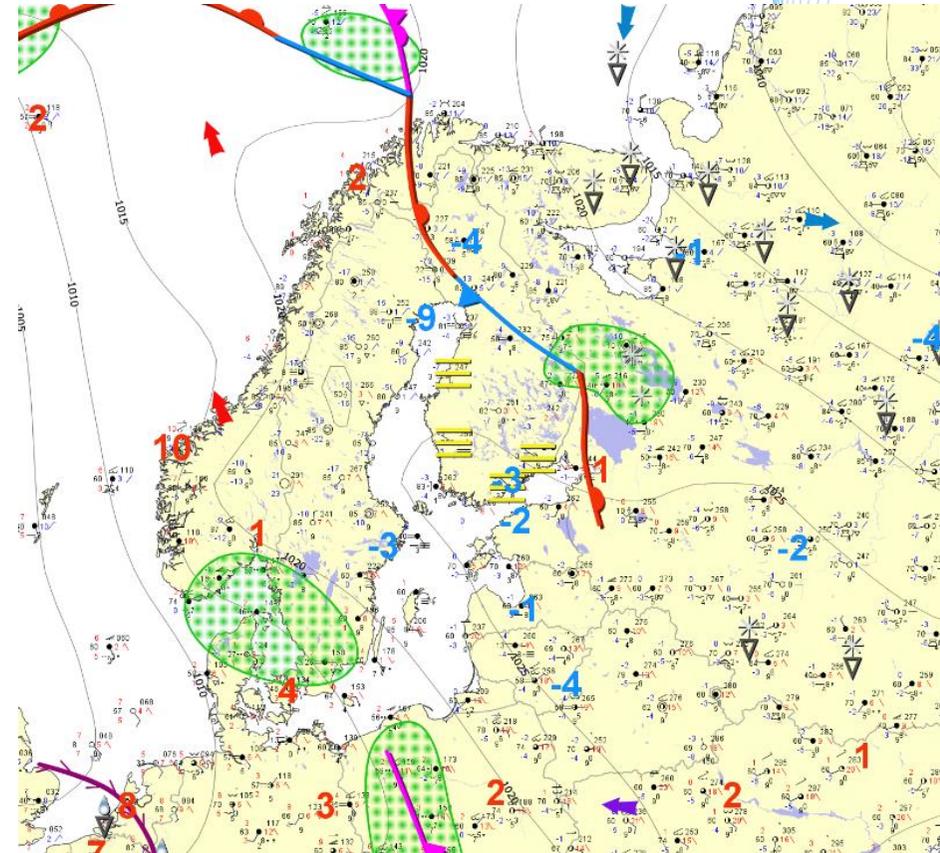
- High pressure over southern Finland
- Wintertime
- Temperatures in southern Finland 0...-5°C
- Large area of fog in southern Finland
- Weather related regulations at EFHK:
  - Average delay 20 min



# Case 10.1.2018 at EFHK



24h Microphysical animation  
9.1. 19:45 – 10.1. 23:45

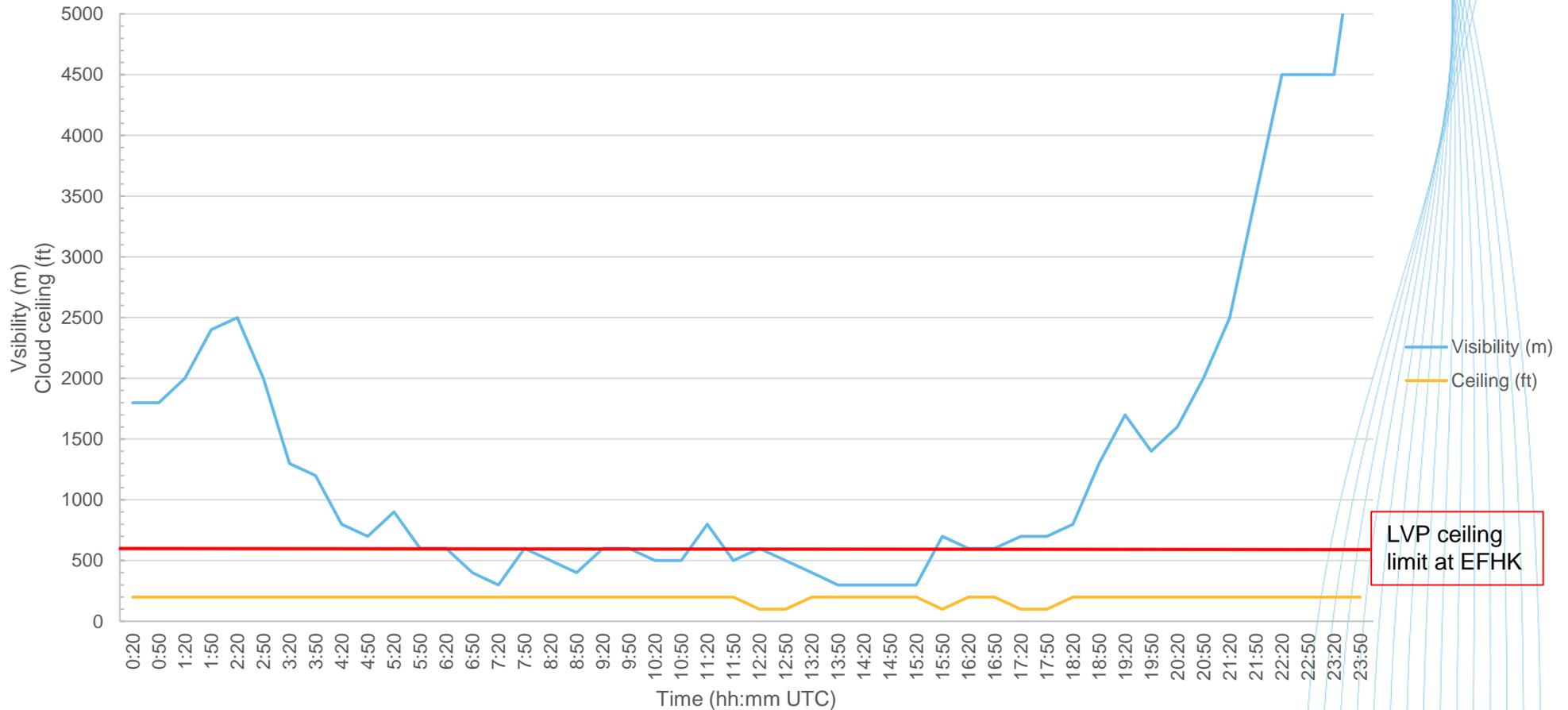


Analysis 10.1.218 12 UTC

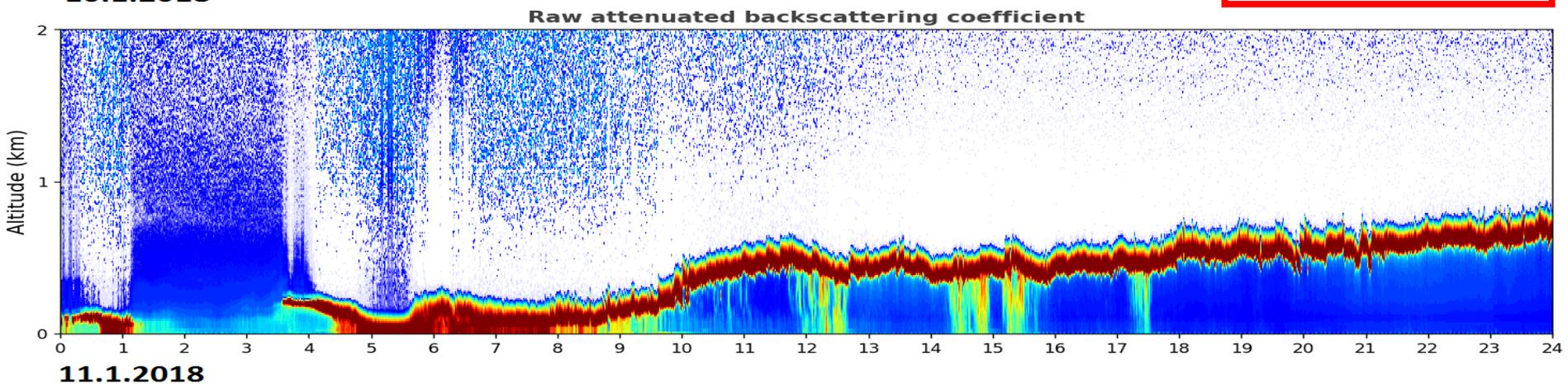
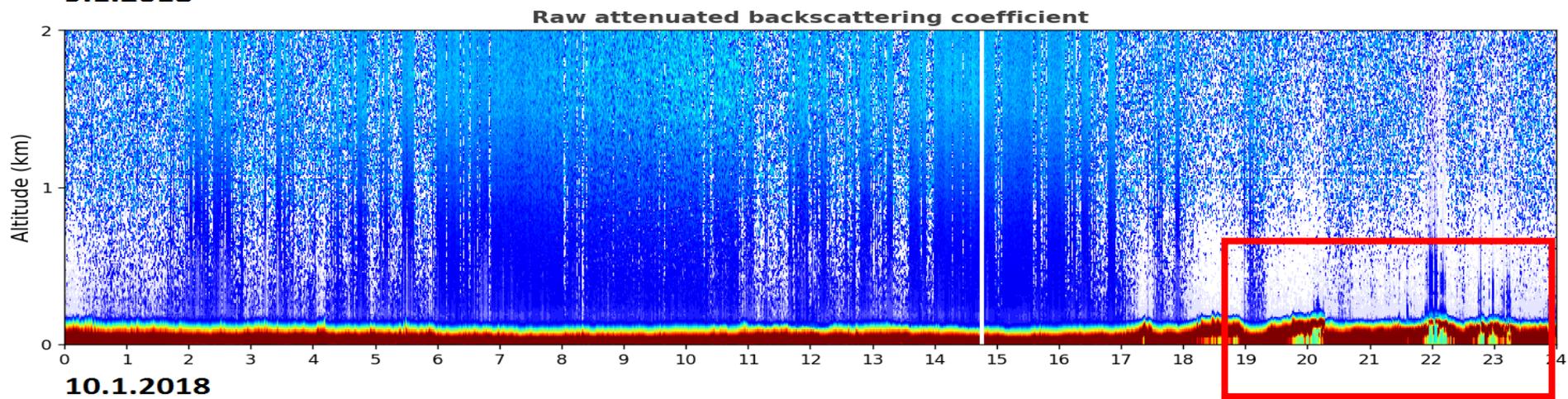
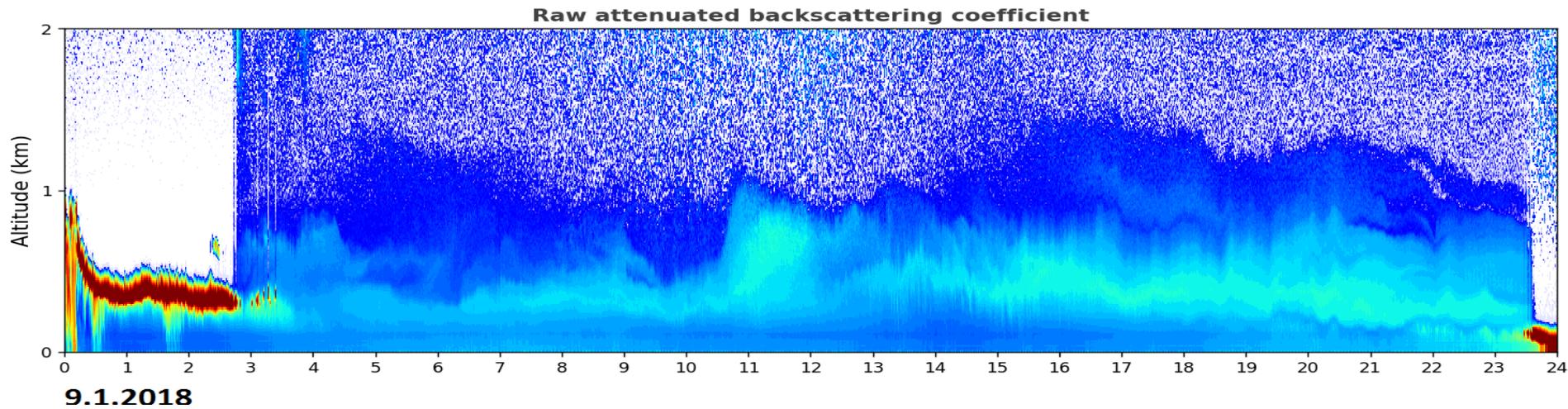


# Case 10.1.2018 at EFHK

Visibility and cloud ceiling on 10.1.2018 at EFHK

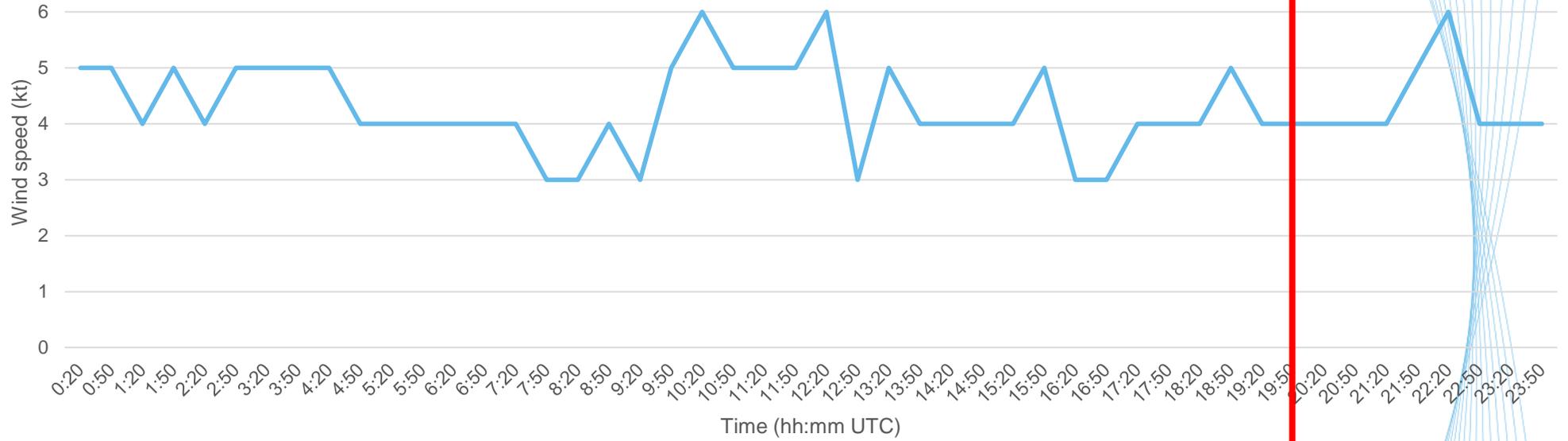


LVP ceiling limit at EFHK

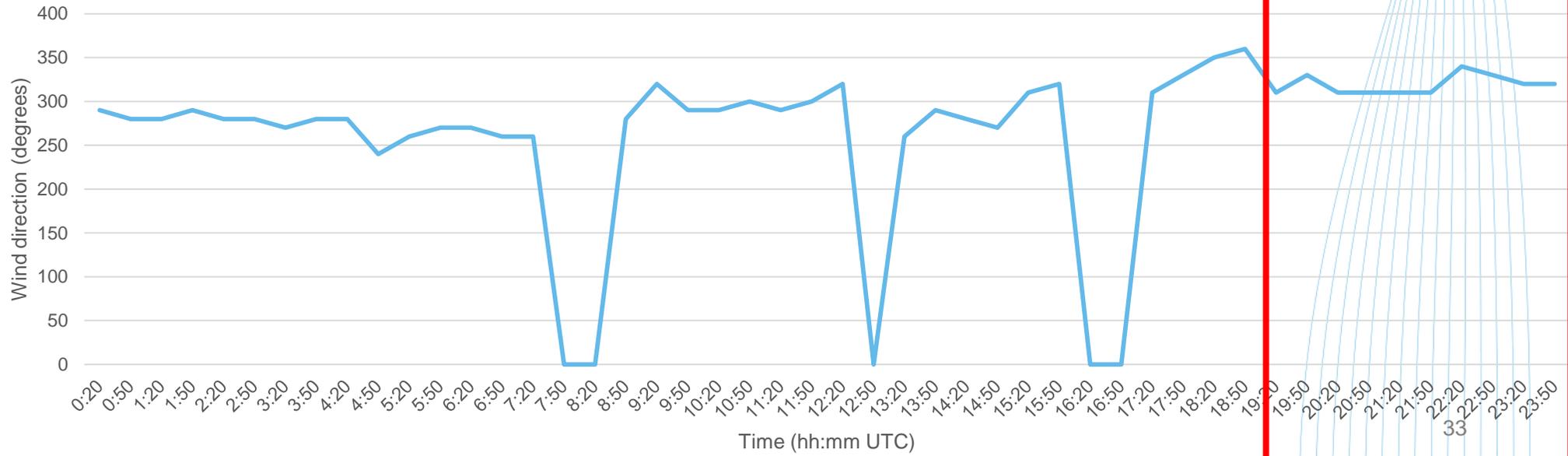


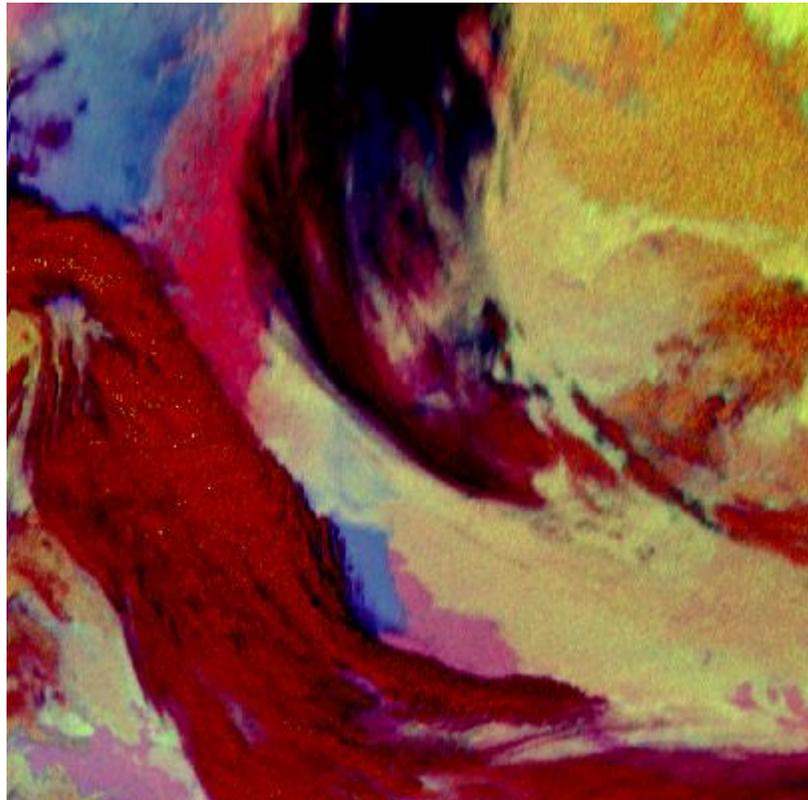


### Wind speed (kt) at EFHK 10.1.2018

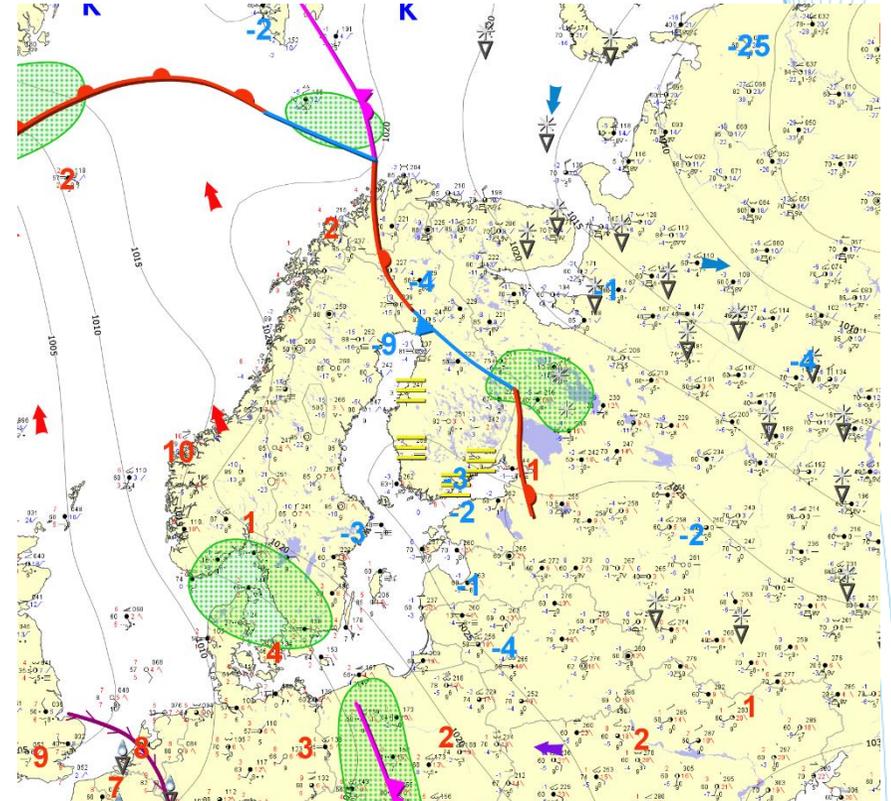


### Wind direction at EFHK 10.1.2018





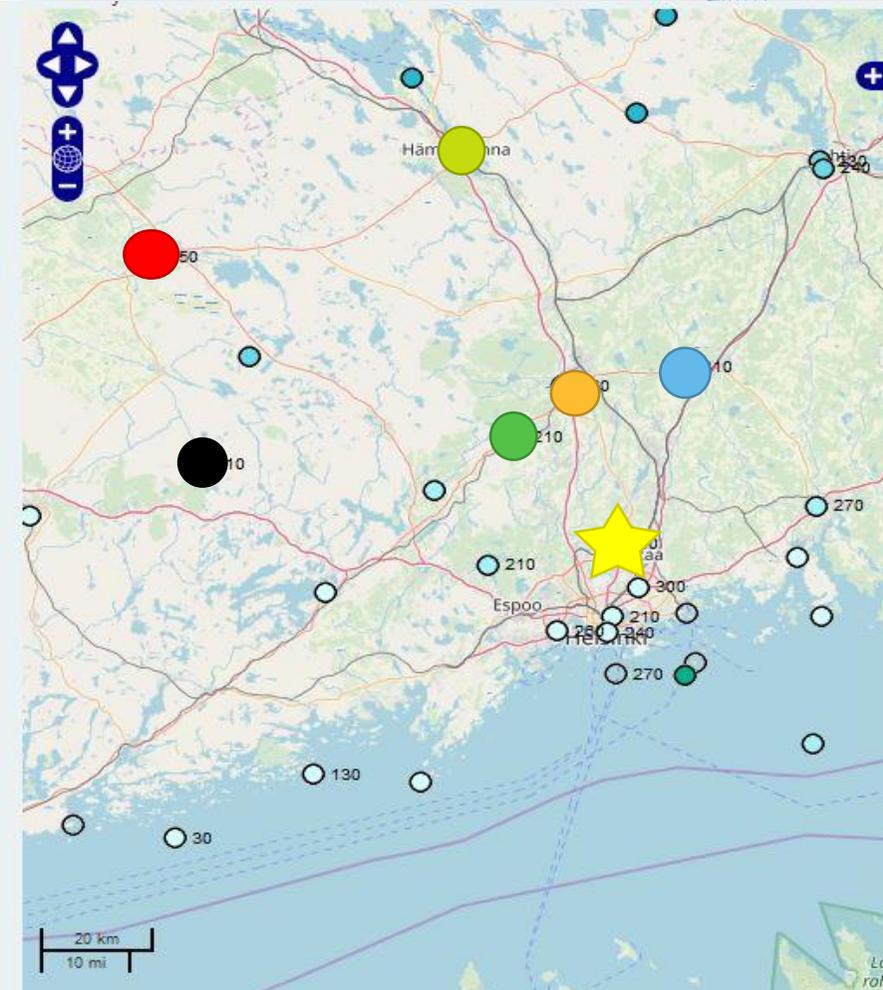
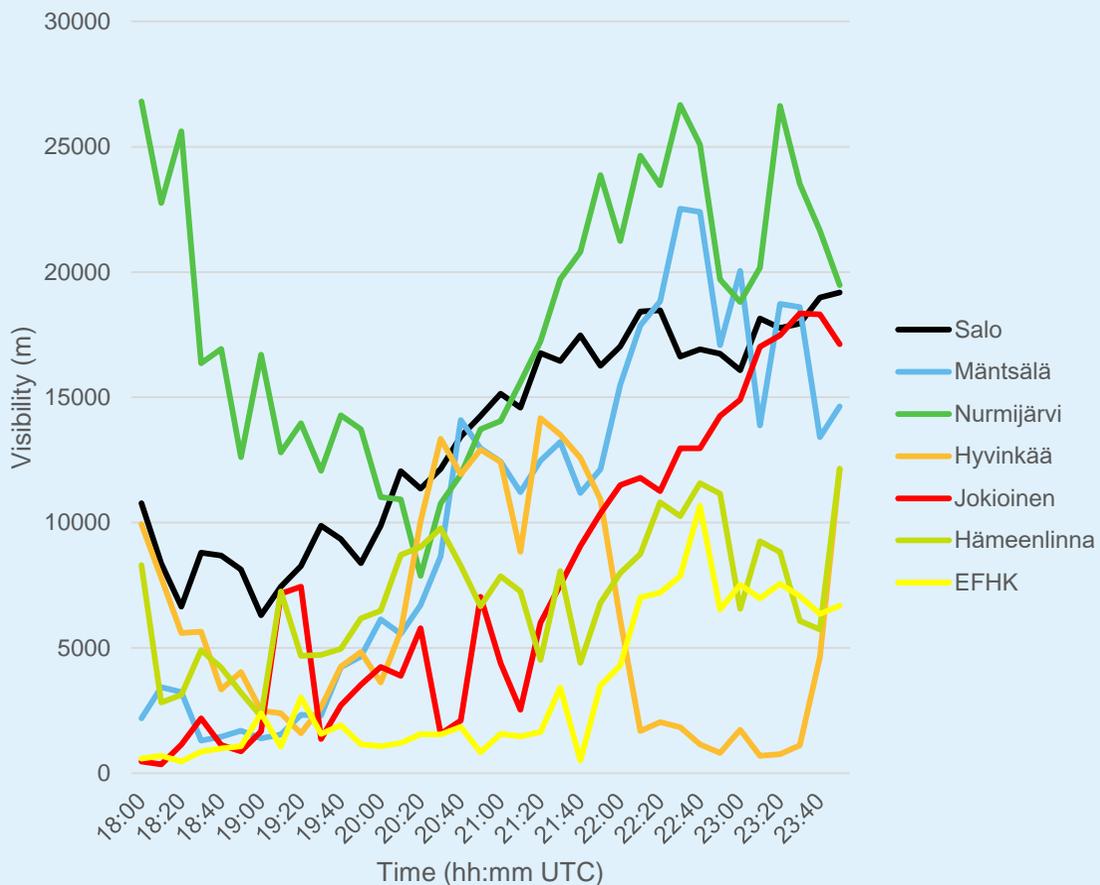
23:45 UTC





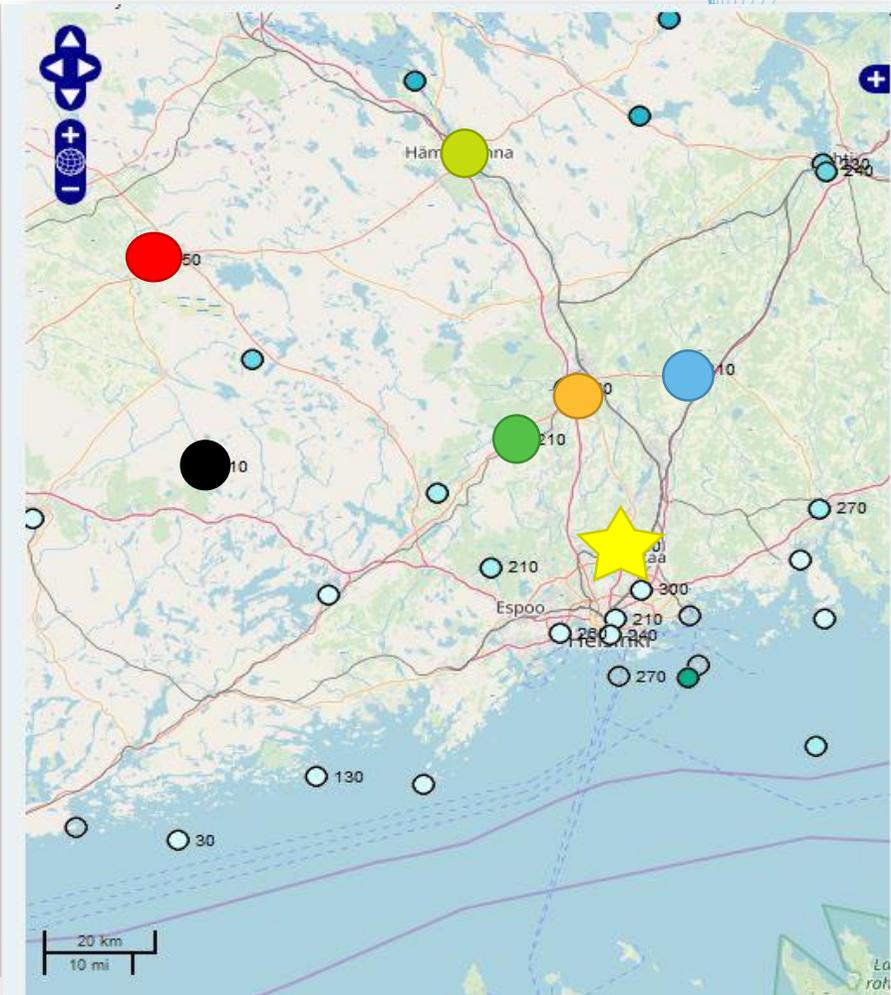
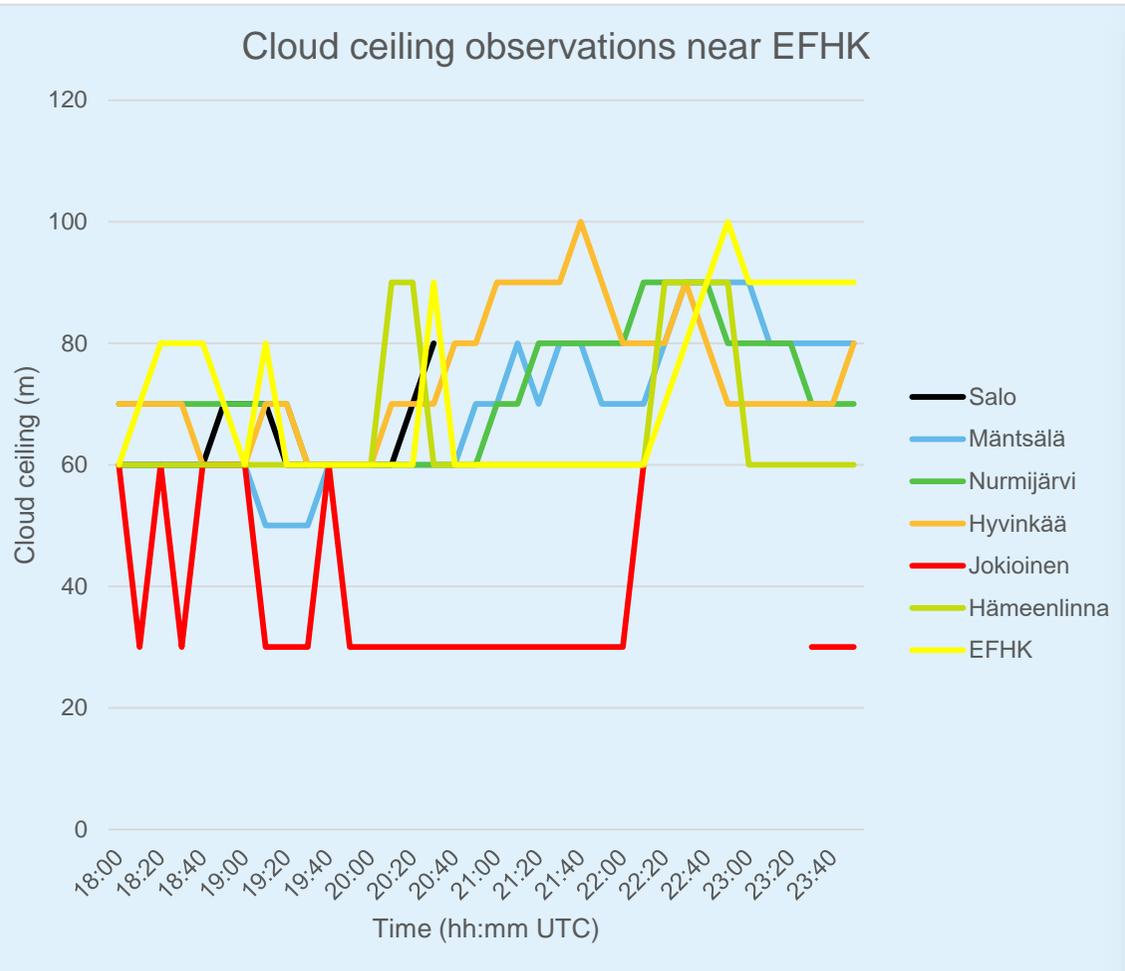
# Visibility observations near EFHK

Visibility observations near EFHK





# Cloud ceiling observations near EFHK





**Thank you for  
participating!**

**Questions?**



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