FINNISH METEOROLOGICAL INSTITUTE

O2.3 Cold-season thunderstorms and aviation

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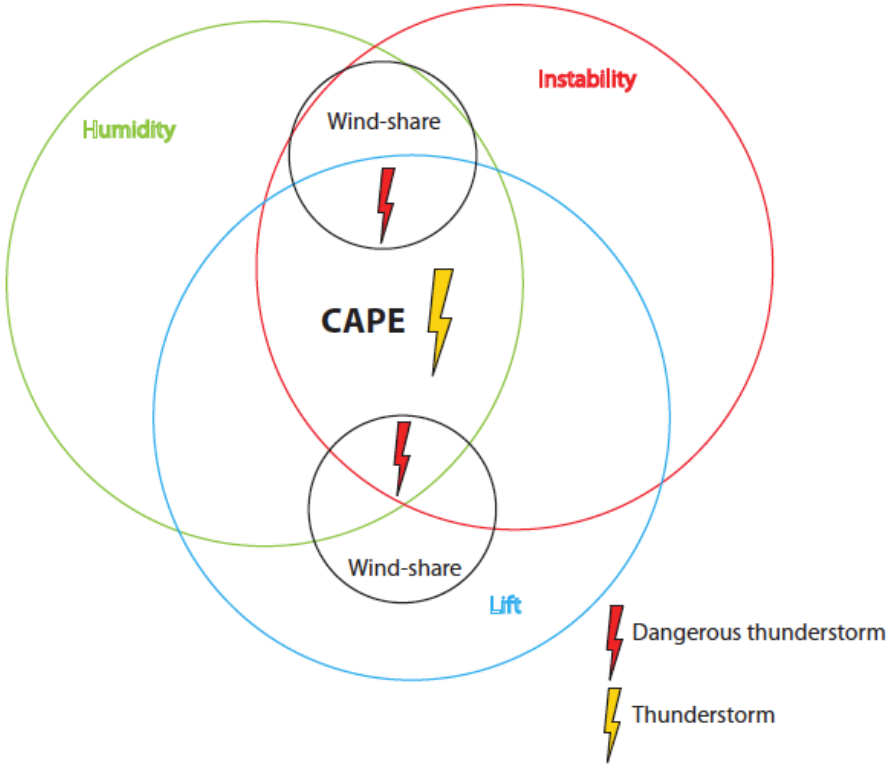
Overview of my masters thesis

- Research question: *Is it possible to improve the information of cold-season thunderstorms from weather models and observations near Helsinki-Vantaa airport?*
- *3 cases close to Helsinki-Vantaa airport*
- *Compared to other research studies:*
  - *Koninklijk Nederlands Meteorologisch Instituut, Netherlands*
  - *Met Office, UK*
  - *Meteorologiska Intitutt, Norway*
  - *Finnish Meteorological Institute, Finland*
  - *USA*

Convection theory



Conditions that are needed for development of convection and thunderstorms.

- If one of the three main conditions dosen’t appear, convection won’t occur.

Difference between warm- and cold-season thunder

Warm-season

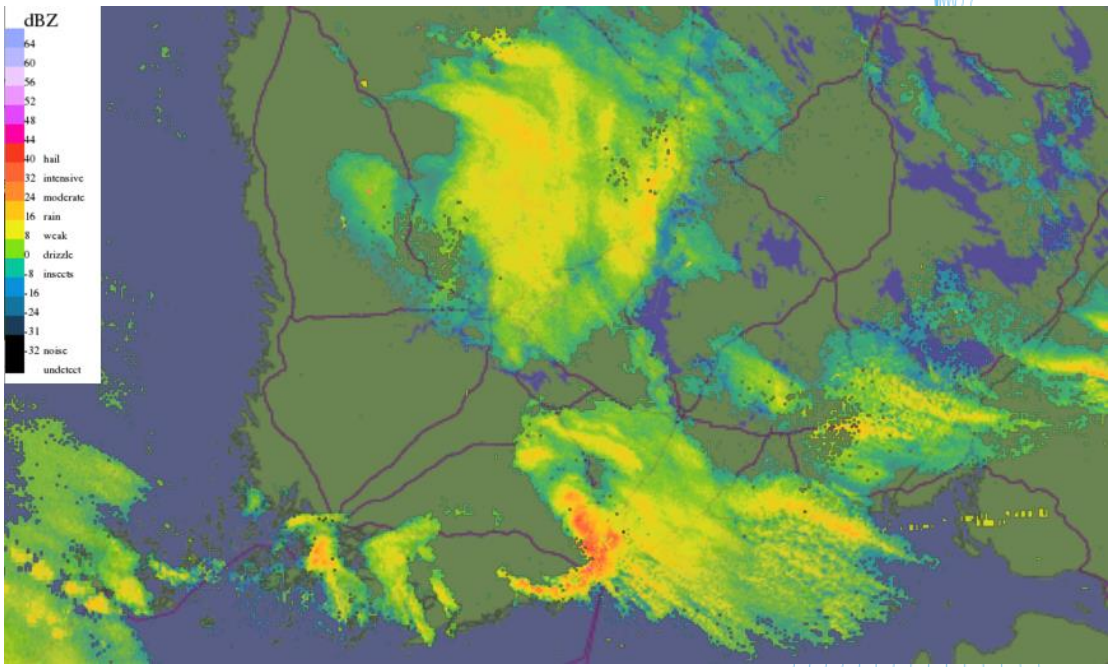
- The theory of thunder and deep convection is based on warm-seasons.
- One way to predict thunderstorms during warm-seasons is by using CAPE (Convective Available Potential Energy) and the equilibrium level.
- In Finland the CAPE threshold value for thunder is about 100 J/kg.
- The equilibrium level should be colder than -20°C.

Cold-season

- Cold-season thunderstorms occur in Finland a couple of time a season.
- Studies have shown about cold-season thunderstorms:
  - The CAPE value is really low during cold-season thunderstorms.
  - In some cases the equilibrium level is warmer than -20°C.

Cases

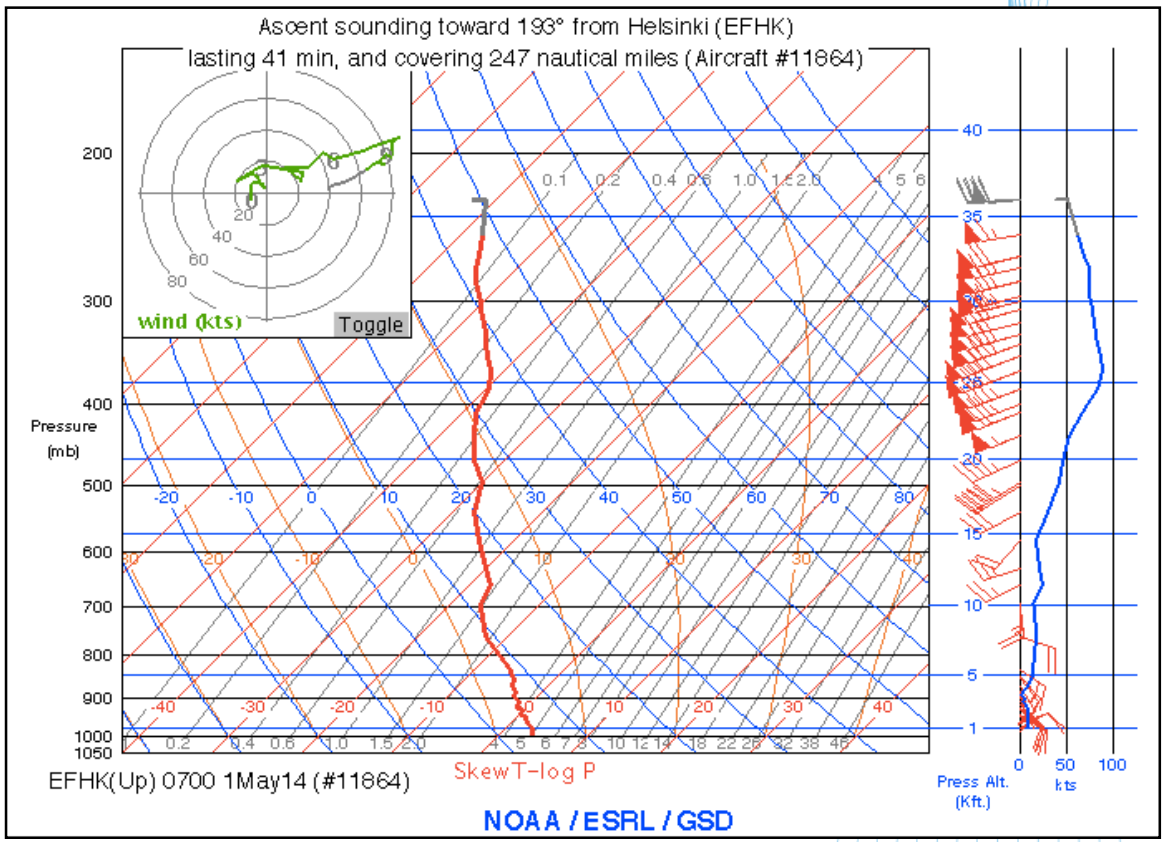
- Dates:
  - 3rd of January 2017
    - Lake-effect
  - 23rd of April 2016
    - Surface trough
  - 1st of May 2014
    - Lake-effect
- 14 lightning strikes totally, where of 5 airplanes got hit
  - Hit rate 36 %



Radar image (PPI) over southern Finland 3rd of January 2017 22:25 UTC, from where you can clearly see a lake-effect occuring over the southern Finland. Retrieved from radar.fmi.fi.

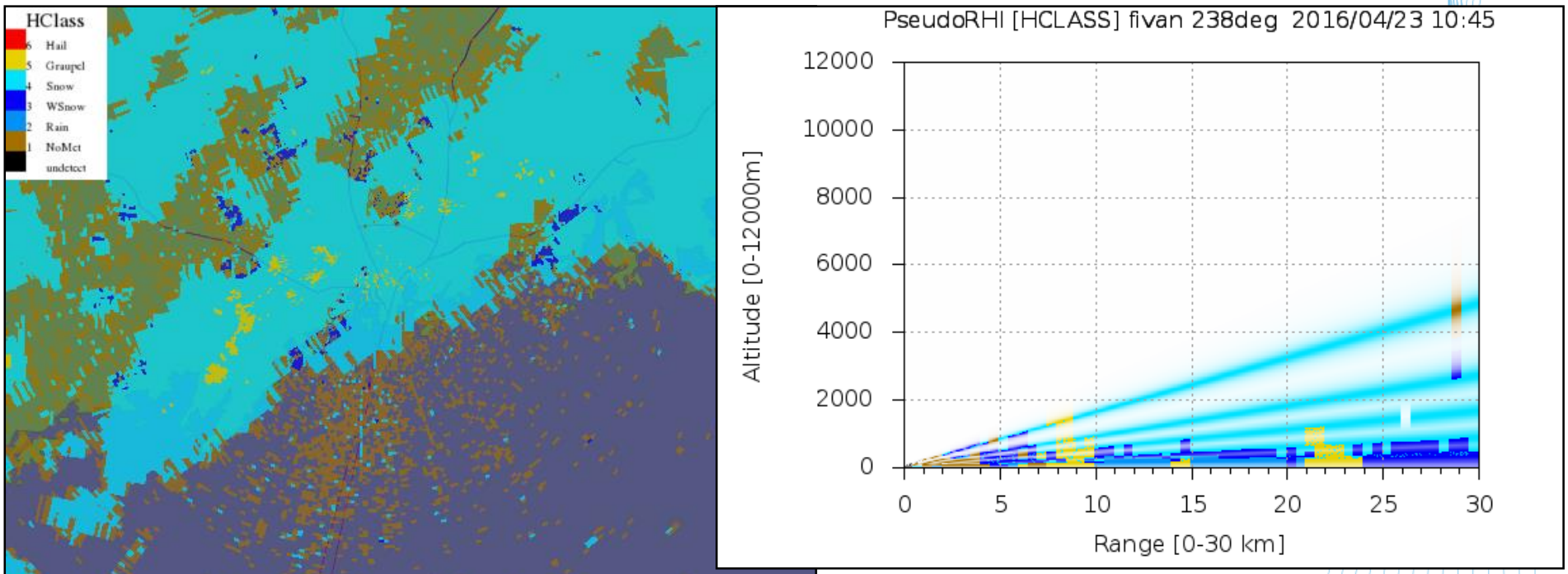
Cases

- Equilibrium level from the AMDAR-soundings:
  - -22°C (12 000 feet)
  - -40°C (20 000 feet)
  - -16°C (10 000 feet)
- Respective CAPE values from the sounding in Jokioinen:
  - 0.70 J/kg
  - 5.53 J/kg
  - 1.38 J/kg



AMDAR-sounding from an ascending airplane at EFHK, 07:00 UTC on 1st of May 2014. Retrieved from amdar.noaa.gov.

Cases



Hydroclass radar image from over Helsinki region, 23rd of April 2016 10:45 UTC. Also a cross-section radar image from Vantaa radar in direction 238°. The yellow color indicates graupel. Retrieved from radar.fmi.fi.

Other research studies

- Netherlands, KNMI
  - Algorithm requirment:
    1. [illegible] temperature is colder than -10°C at the 700 hPa height
    2. Freezing level below 3000 feets height
    3. A cold advection from the north

Suits for the previous cases

- United Kingdom, Met Office
  - Algorithm requirment:
    1. Average temperature between 2000 and 3000 feets height is between -6°C and -1°C.
    2. Freezing level between 2000 and 3000 feets height
    3. Precipitation over 4 mm/h.

The previous cases are too cold

- Norway, MET

$$Helictopter\ Trigged\ lightning\ potential = \frac{T_{ind} + W_{750m\,ind} + Precip_{ind} + LowCloud_{ind}}{4}$$

T_{ind} = 1 when -6°C <T < -1°C
$W_{750m,ind}$ = max value in the neighbourhood area [min(1, W/0.75)]
$Precip_{ind}$ = max value in the neighbourhood area [min(1,precp/0.75)]
$LowClouds_{ind}$= maximum cloud cover minus minimum cloud cover in the neighbourhood area

The previous cases are too cold

Own thoughts

1. Answer to my research question: YES, it's possible.
2. By using hydroclass radar, it gives a chance to tell if there's any risk for cold-season thunder.
3. KNMI's algorithm more of a guideline to creating an own algorithm.
4. Weak and low CB clouds - related with airplanes?
5. Is wind-shear a significant factor during the cold-season?
6. By improving the AMDAR-program, it would give better observation for cold-season thunderstorms.

Thank you!

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More references can be found in my master thesis…