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RAIN PROJECT

This project is funded by the European Union

Impacts of severe winter weather events on critical infrastructure

Andrea Vajda
Finnish Meteorological Institute

RAIN WP2 Workshop on
Past Severe Weather Hazards
Berlin, 27. 02. 2015

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Objectives within the RAIN project

- **Identification and analysis of past cases of severe winter phenomena and their impact and consequences**
  → selection of thresholds for the critical weather parameters

- **Assessment of the predictability of severe winter weather with current state-of-the art forecasting systems**

- **Analysis of the probability of severe winter weather hazards in the present climate**

- **Assessing the implications of climate change on the severity and occurrence of extreme weather**

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Severe winter phenomena

Snowfall

Snowstorm (blizzard)

Cold spell

Winter storm

Snow load

Freezing rain

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Identification and analysis of past cases of severe winter phenomena and their impact and consequences

- **Previous impact studies**: ROADIDEA, EWENT, MOWE-IT, EXWE
- **Literature review**: over 100 research papers, reports of research projects and research councils
- **Media reports** about the extreme weather cases and their impact starting from January 2000 up to date
- **Surveys conducted with CI operators**

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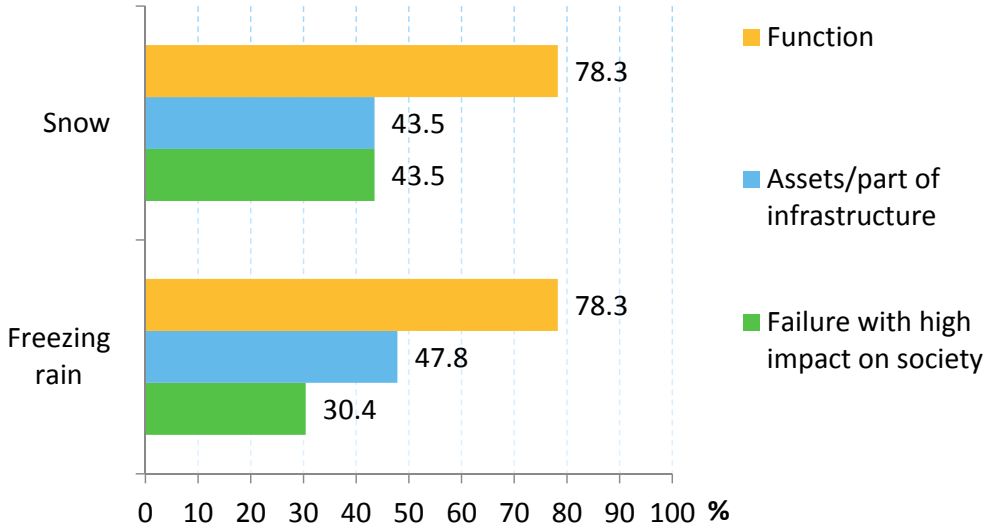
Winter events in the context of the survey conducted with CI operators



- Flow of road traffic
- Rail
- Aviation
- Shipping
- Power transmission
- Telecom and data grids
- Emergency management
- Rescue services

✓ Intensity of the winter events leading to infrastructure damage
✓ Preventive and response measures against the critical events
✓ Quality of warnings
✓ Severe winter events from the past 25 years: 14 snowfall/storm
2 freezing rain
1 heavy snow load
5 cold spell

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Cases identified based on media reports and previous studies

Snowfall

Helsinki metropolitan area, 17 March 2005

Snowstorm (blizzard)

Southern and Central Finland, 23-24 November 2008

Snow loading

Central Finland, Oct 30-Nov 1, 2001

Freezing rain

Slovenia, Jan 31-Feb 3, 2014

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Heavy snowfall: Helsinki metropolitan area, 17 March 2005

- Heavy snowfall during the morning rush hours → severe car pile-ups on four main roads near Helsinki
- ≈ 300 vehicles crashed, 3 fatalities, 60 injured
- badly disturbed traffic for the whole day in the Helsinki region
- Economical costs: high, but unknown

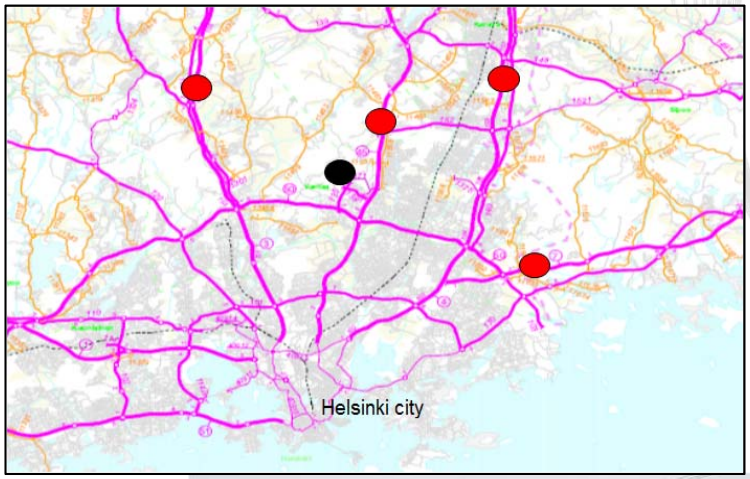

Photo: Board of Inquiry for Traffic Accidents

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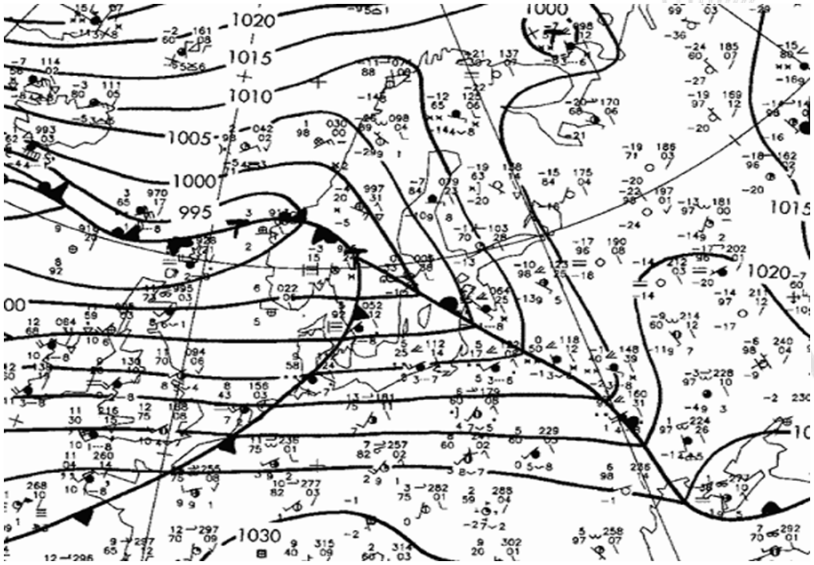
Heavy snowfall: Helsinki metropolitan area, 17 March 2005

Meteorological description:

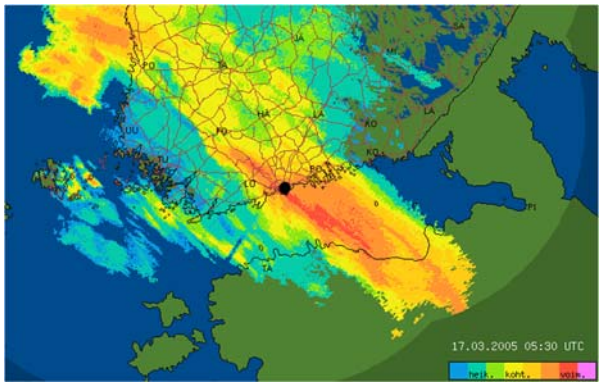
- Low pressure approaching Finland from the W
- Cold night, the morning T= -5…-8 °C
- A band of dense snowfall reached Helsinki around 7:30 LT
- Road grip and visibility decreased (locally 700-900 m)

Longer stopping distances with less horizontal visibility

Total snow accumulation: ≈5 cm at 8.00 LT



The weather situation on 17 March 2005 00 UTC (analysis by DWD)



Radar image at 05:30 UTC (07:30 LT)

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Heavy snowfall: Helsinki metropolitan area, 17 March 2005

Forecast issued by FMI:

- ✓ snowfall event predicted, but underestimated
- ✓ warning issued on the preceding evening for bad driving conditions and possible snowfall during the following day

BUT

Warning for very bad driving conditions issued only after the occurrence of the crashes

Means to prevent such accidents in the future:

- More efficient combined use of weather observations and radar data, development of road weather forecasting models
- Provision of weather information and warnings into vehicles
- Usage of weather-controlled speed limits and displays

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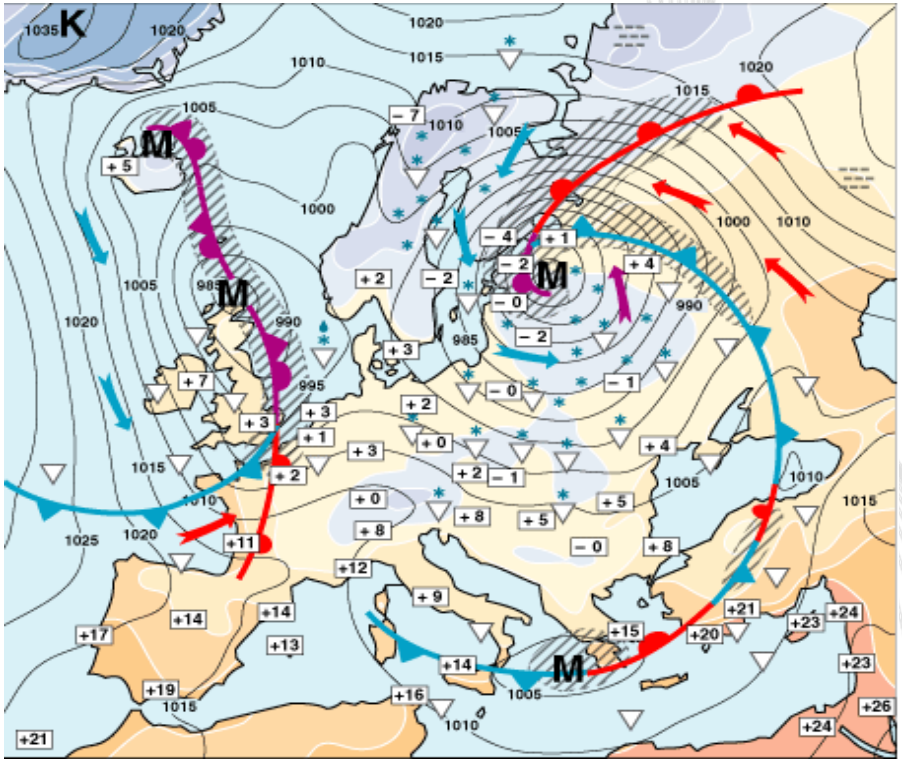
Snow storm: South and Central Finland, 23-24 November 2008

- Low pressure system over eastern Europe on 22 Nov 2008
- The rapidly deepening centre of low pressure moved towards Finland → strong and cold northerly winds and heavy snowfall.

WG max = 27 m/s locally in S Finland
T < 0°C
snow accumulation = 10-25 cm, locally > 30 cm

Blizzard criteria*) → fulfilled
*)T_day≤0 degC, WG≥17 m/s, SN≥10 cm (EWENT)



Weather situation on 23 November 2008 at 12 UTC (analysis by FMI).
Abbreviations: M=low pressure, K=high pressure centre.

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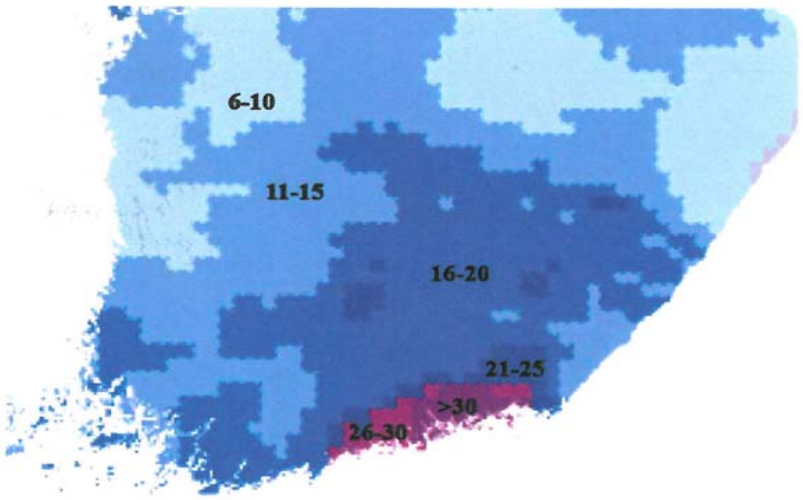
Snow storm: South and Central Finland, 23-24 November 2008



The 24h snow accumulation based on radar measurements

Impacts on critical infrastructure:

- Power cuts in 41 000 households
- Damaged buildings, e.g. detached roofs
- Number of traffic accidents increased by 73% in S and Central Finland, in SE Finland it was fourfold
- One fatality and 112 injuries
- A lot of trees fallen on the roads

Forecast issued by FMI: warnings for gusty wind, very poor driving conditions → GOOD!

In cases like this, different operators need to have extra personnel on alert, especially during weekends.

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Heavy snow loading combined with high wind speeds: Central Finland, 30 Oct-1 Nov 2001

Multiple event

Oct 29 — freezing fog, rime formation on trees

Oct 30 daytime — heavy fall of wet snow and sleet

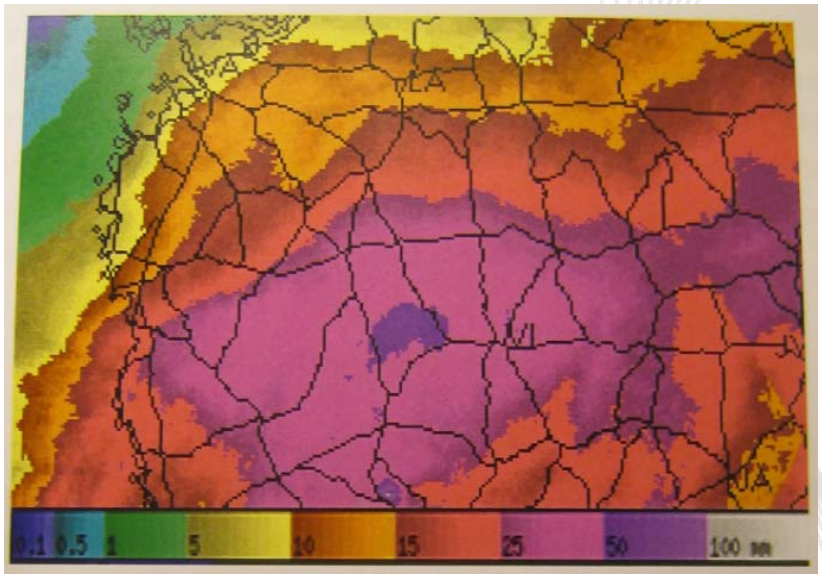
Oct 30 night — T < 0°C => snow load frozen and tightly attached to trees

Oct 31 — snowing, T > 0°C

Nov 1 — snowing, T > 0°C

30 cm of snow

Nov 1 afternoon — strong gusty wind, T < 0°C (Pyry storm)



Total precipitation Oct 30 - Nov 1:
30-50 mm wet snow

Widespread forest damage:

Oct 31→ snow load

Nov 1 → snow load and wind

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Heavy snow loading combined with high wind speeds: Central Finland, 30 Oct-1 Nov 2001

Impact to critical infrastructure

Severe forest damage

↓

over 20 000 trees fallen on the power transmission lines

↓

power outrages (177 000 houses without electricity)

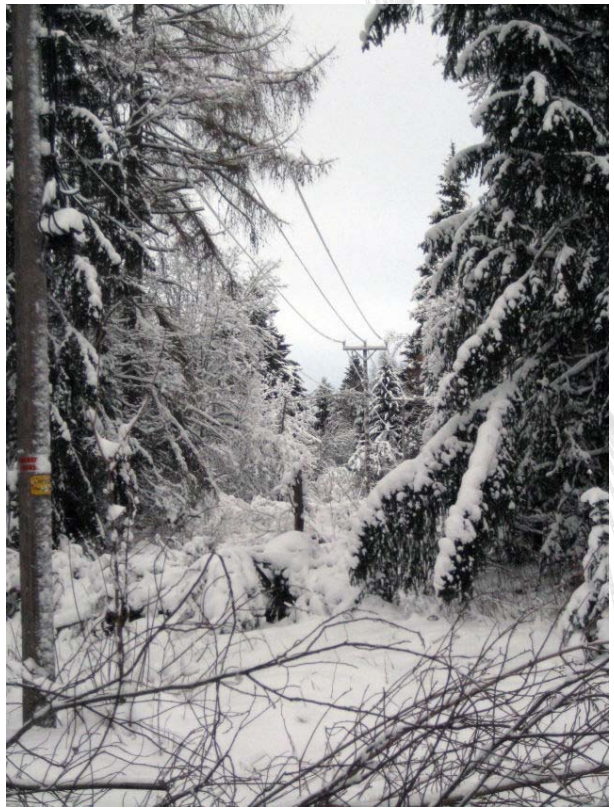

Photo: Eija Vallinheimo (FMI)

- Over 100 trunks had fallen over electric wires between two adjacent power poles => slow repair work
- Economical losses: unknown

Heavy snow load criteria: T=0-0.5 ˚C, W= 3-6 m/s, RR>25 mm.

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Freezing rain: Slovenia, 31 Jan - 3 Feb 2014

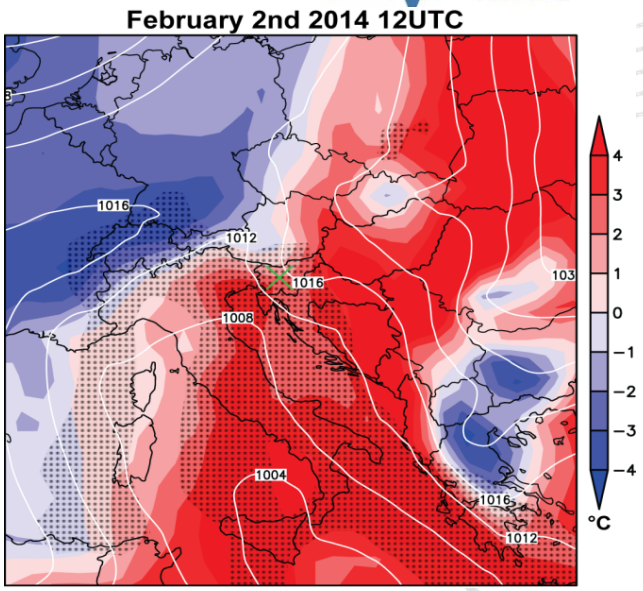
- **Freezing rain** and blizzard, the worst situation in Notranjska region (SW)
- Warm air from S-SW in upper air, T ≈ 3 °C on Feb 2
- Cold surface air from E, T < 0 °C
- Large amount of precipitation, 5-days RR = 100-200 mm, locally > 250 mm

↓

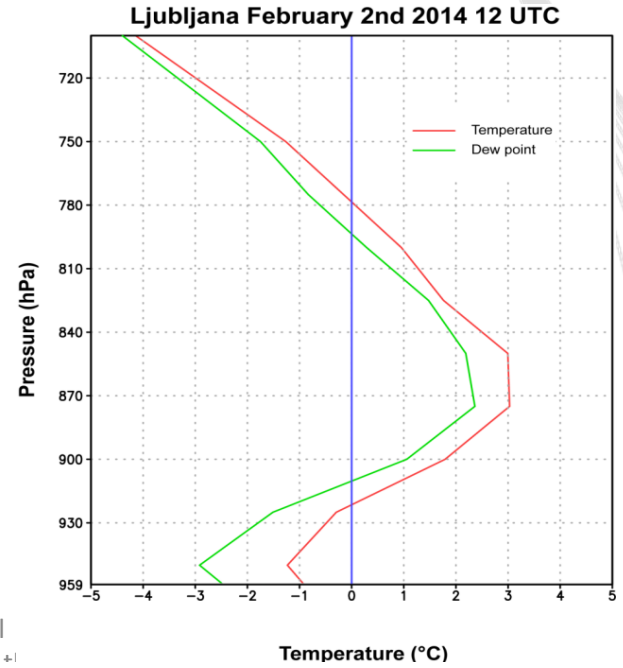
10 cm of ice accumulation

- Persistent situation for 4 days => massive damage to infrastructure

State of emergency proclaimed on February 2.



ERA-Interim 850 hPa temperature, mean sea level pressure, six-hour precipitation of at least 1mm (stippled)



Vertical profile of temperature and dew point (ERA-Interim)

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Freezing rain: Slovenia, 31 Jan - 3 Feb 2014

Impact to critical infrastructure

- ✓ Power lines broke down: 30 km completely destroyed, 170 km inoperative → 250 000 people without electricity for days
- ✓ Damaged telecommunication installation
- ✓ Disruption on water supply
- ✓ Stopped railway and road traffic
- ✓ Town and villages cut off for days
- ✓ 500 000 ha of forest destroyed
- ✓ 2 fatalities and many injuries

Estimated total damage: 430 million €

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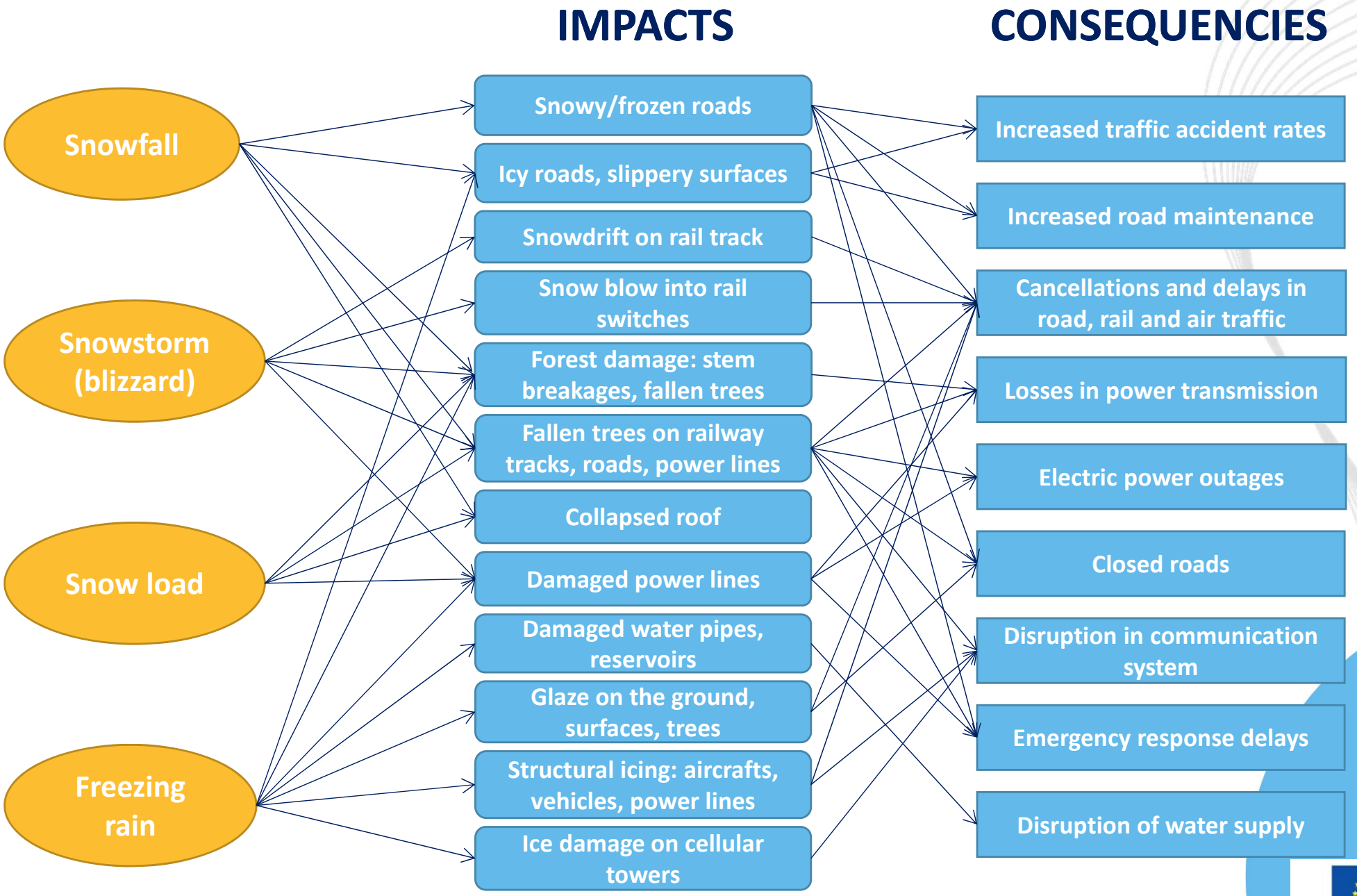

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How did we define the impact thresholds for the critical weather parameters?

- Impact indices defined in the **previous impact studies** (EWENT, EXWE)
- Thresholds provided in the **surveys conducted with CI operators**
- **Studied past cases**: analyzed the values of relevant weather parameters against the impacts and consequences
- **Warning practices** of the European Weather Services, www.meteoalarm.eu

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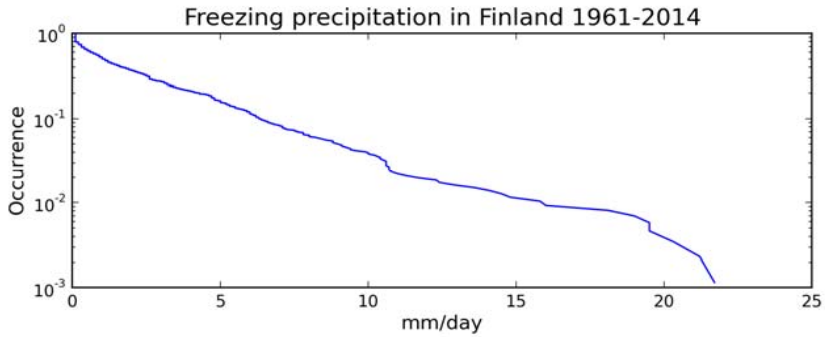
Challenges in defining the impact thresholds

- The vulnerability of different CI varies, e.g. transportation ↔ power lines
- The resilience of some infrastructure types, e.g. road, rail, aviation, vary across Europe
- Real measurements for heavy snow loading are not available → thresholds based on modelled values
- Very little observations of freezing rain in Finland: 8 cases (4-7 mm) were found (1959-2012) based on archives and interviews



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Selected thresholds

PHENOMENA	THRESHOLDS	
	1st	2nd
Snowfall	Rs ≥ 6 cm/24h	Rs ≥ 20 cm/24h
Snow load	20 kg m-2	40 kg m-2 ← for crown snow load
Freezing rain	5 mm/24 h	25 mm/24 h
Blizzard	Rs ≥ 10 cm/24h, Tmean ≤ 0 °C, WG ≥ 17 m/s	

1st threshold → Some adverse impacts are likely. Their severity depends on the resilience of the system.
2nd threshold → Weather phenomenon is so severe that it is virtually certain that some adverse impacts will occur.

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