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EMS2015-388

RAIN PROJECT

Assessment of impact indicators for extreme winter phenomena considering critical infrastructure (CI)

Motivation

- Extreme winter weather events can cause significant damage and failure of land transportation, energy and telecommunication
- The projected climate change will alter the frequency and/or severity of weather extremes

Objective

- To define impact indicators for **snowfall, blizzard, snow load and freezing rain** in order to assess the changes in the probabilities across Europe

Methods

- **Literature review**
  > 100 studies
- **Media reports**
  (2000-2014)
- **Surveys:**
  CI operators (29) and NWS (18)
- **Warning practices**
  of EWS
- **Case studies**

Past cases with impacts on CI

Heavy snowfall
17 March 2005, Helsinki metropolitan area

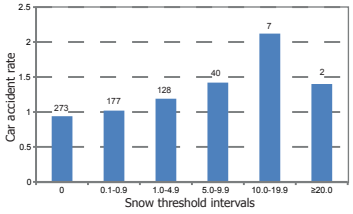
- dense snowfall (5 cm accumulated snow), low visibilty (700-900m) and road grip
- car pile-ups (≈ 300 vehicles), 3 fatalities, 60 injuries, high economical costs

Freezing rain
31 Jan. - 3 Feb. 2014, Slovenia

- 100-200 mm (locally > 250 mm) of precipitation as snow and freezing rain →10 cm of ice accumulation
- persistent situation for 4 days
- damaged and distroyed power lines and communication infrastructure, disrupted water supply, stopped traffic, severe forest damage, fatalities and many injuries

Blizzard
23-24 Nov. 2008, South and Central Finland

- low temperature, wind gusts up to 27m/s, snow accumulation of 10-30 cm
- power cuts, damaged buildings, fallen trees, closed roads, increased (locally fourfold) traffic accident rate



Mean relative car accident rate in function of snow for different precipitation categories. Based on weather observations and daily accident amounts in Kymenlaakso County, SE Finland during winters 2002/03-2007/08. The number of cases in each category is marked on the image.

Heavy snow load + strong winds
30 Oct.-1 Nov. 2001, Central Finland

- multiple heavy wet snowfall events (30 cm total snowfall) coupled with frozen snow load attached to trees branches, followed by stormy wind gusts > 30 m/s
- severe forest damage, trees fallen on the power transmission lines, sever power outages

Impact indicators for critical infrastructure

1st threshold: Some adverse impacts are expected, their severity depends on the resilience of the sytem, transportation is mainly affected.
2nd threshold: The weather phenomena are so severe that it is likely that adverse impacts will occur, CI system is seriously impacted.

Snowfall
(Rs/24h, 1 mm precipitation = 1 cm of snow)

Threshold	Impacts	Consequences
Rs ≥ 6 cm	Reduced friction and slipperiness on roads, when combined with low temperature and wind, rail points may get stuck.	Increased accident rate in road traffic, reduced road capacity, road closures, possible delays and cancellations.
Rs ≥ 25 cm	Slippery roads, accumulated snow banks. Poor visibility. Accumulated snow on power lines, structures and trees.	Disturbed traffic, high accident rate, closed roads, delays and cancellations of trains. Broken tree limbs or fallen trees on power lines, damaged or broken power lines, power outages. Limited access to repair equipment. Collapsed roofs.

Crown snow load (SL)

Threshold	Impacts	Consequences
SL≥20 kg/m2	Wet snow accreting on trees causes damage to forest: canopies and stems may break or lean and birches start to bend. If the soil is unfrozen, some trees may be also uprooted. Sliding snow on building's. roofs	Fallen trees may disturb transportation, resulting in reduced road capacity and inaccessible roads. Damaged trees leaned and bended over power lines interrupt the power transmission resulting in power outages. Snow falling from high structure may cause property damage, injuries or even fatalities.
SL≥60 kg/m2	Heavy wet snow or snow load combined with ice accretion causes serious forest damage. Even power poles may collapse and high voltage power transmission towers may crash.	Power transmission lines and communication wires will break due to heavy snow load and damaged trees fallen over the lines leading possibly to total failure in power grid system. Roofs at defectively constructed buildings may collapse.

Blizzard (Rs, Wg and T)

Threshold	Impacts	Consequences
Rs ≥ 10 cm, Wg ≥ 17 m/s, T ≤ 0 °C	Fallen trees on roads, rails and electricity lines; snow banks, slippery roads, poor visibility, rail points may get stuck. Accumulated snow on structures and power lines.	Increased rate of injuries and accidents in road traffic (2-4 times more accidents compared to the mean), delays, and cancellations in all transportation modes. Wind power failure, damaged buildings: detached roofs and falling scaffoldings.

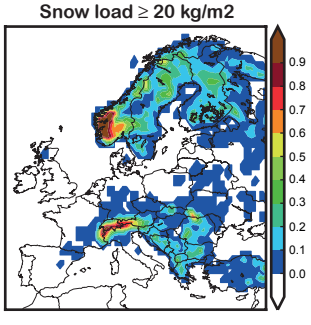
Freezing rain (RR/24 h)

Threshold	Impacts	Consequences
RR ≥ 5 mm	Accumulation of ice on roads, vehicles, trees, power lines and structures, slippery roads and bridges, hazardous driving conditions. The accumulated ice may cause forest damage, possible canopy and stem breakage.	Increased rate of accidents and injuries; disruptions of normal transportation. Broken trees might damage the power lines, lost in power transmission efficiency or even power outages.
RR ≥ 25 mm	Substantial damage to trees, e.g. excessive tree breakage, damaging ice thickness on electricity lines, pole-mounted communication system, cellular towers and other structures. Ice accumulation snaps the power cables or even failure of transmission towers. Roads and vehicles covered by thick ice.	Distribution and transmission line failure, power outages, severe disruption of transportation, collapses of communication towers and infrastructure that delays the emergency responses. Prolonged, widespread interruptions, outages lasting for 5-10 days. Serious disruption in transportation, road closures, villages and cities might be cut off for several days.

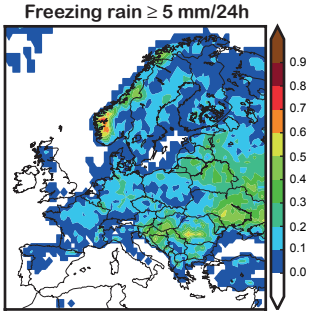
Conclusions

- The impact indicators allow the estimation of probabilities in the present and future climate of winter extremes
- The outcome furthers the development of strategies to minimize the impact of extremes on European transport, energy and telecommunication infrastructure

Snow load ≥ 20 kg/m2



Freezing rain ≥ 5 mm/24h



Annual probabilities (1981-2010) based on E-OBS and ERA-Interim data

The study is a part of the FP7 project RAIN

www.rain-project.eu