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FINNISH METEOROLOGICAL INSTITUTE

Pedestrians' sidewalk slipperiness

EUMeTrain

High-Latitude Event Week

Marjo Hippi
Meteorological Research
30.1.2023

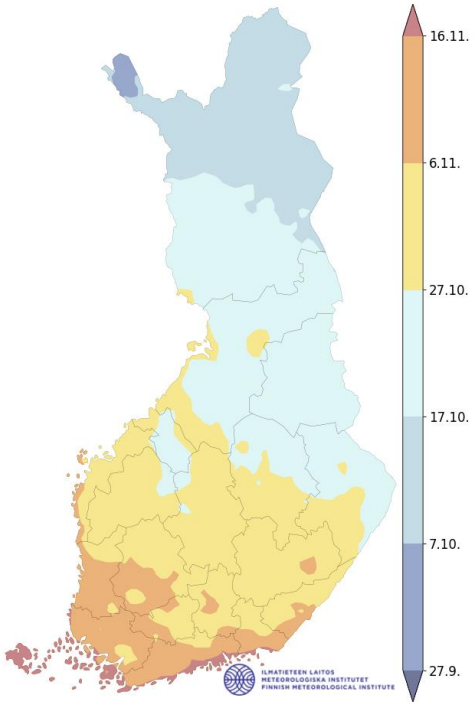
Content of the presentation

1. Background
   - Snowy season in Finland
   - Slippery sidewalk conditions
   - Statistics of the slipping injuries
   - Sidewalk maintenance in Finland
2. FMI’s sideway condition model and warnings of slippery sidewalk condition
   - Model description
   - Problems and problematic cases
   - Weather warnings
3. What has been done in other countries
4. Climate change
5. How to prevent slipping injuries

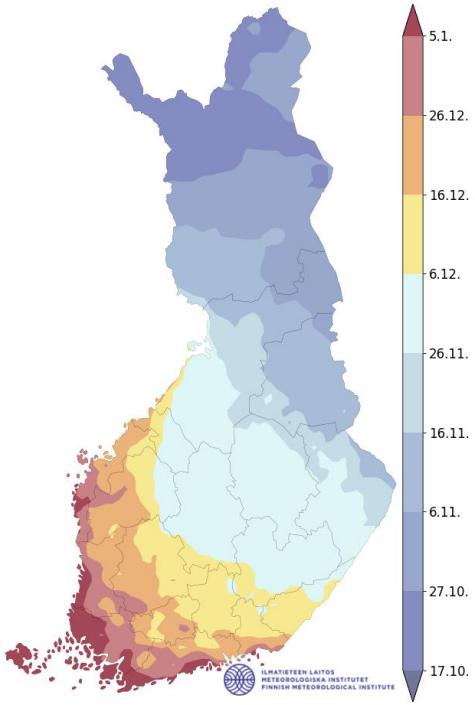
Background

Snowy season in Finland
Slippery sidewalk conditions
Statistics of the slipping injuries
Sidewalk maintenance in Finland

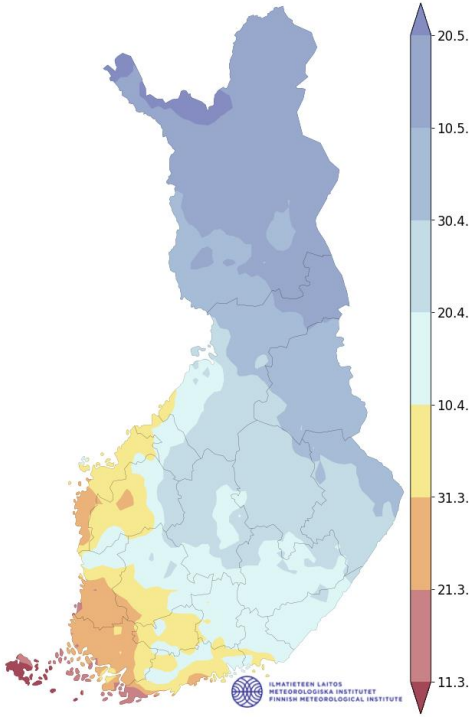
Snowy season in Finland



Average date of first snow cover (1991-2020)



Average starting date of permanent snow cover (1991-2020)



Average ending date of permanent snow cover (1991-2020)

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Snow on the ground typically 3 – 7 months

Background and motivation

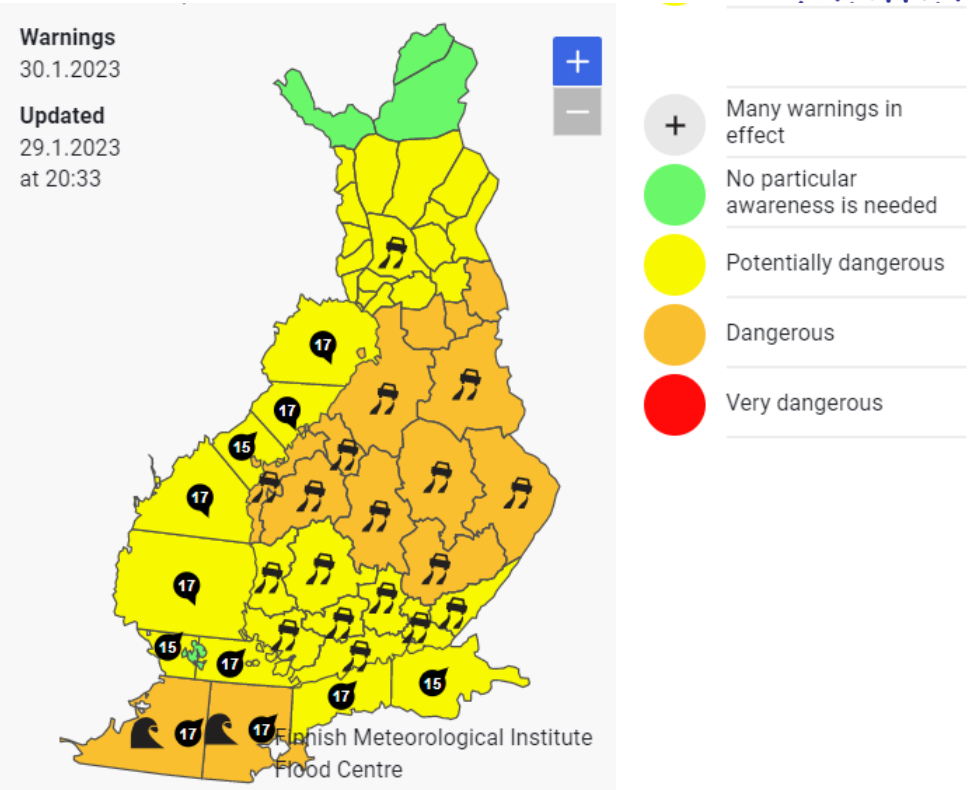
- Winter time slip and fall injuries are very typical in Finland causing human suffering, significant financial costs, sick leaves and reduced well-being
  - Slip injuries are not systemically recorded as they are typically single accidents and are not included into traffic accident statistics
  - On average every third person in Finland slips each winter and **more than 50,000 persons are injured needing medical attention → 1 % of Finnish population**
  - Technical Research Centre of Finland has estimated that the **slips and fall related injuries cost about 2.4 billion € annually** when considering the costs of medical care, loss of work input and reduced well-being

Background and motivation

- During the peak days of slipping injuries hospital emergency departments are crowded due slips and falls
- Sidewalk slipperiness and the risk of slips are complex phenomena, involving environmental (including weather) and human factors → weather has a strong impact on slip risk
- Sustainable transport modes, especially walking, are becoming more recommended in the future as the greenhouse gas emissions from transport need to be reduced → it is important to invest in safety of walking

FMI weather warnings

- FMI monitors the weather and depending on the situation, it issues warnings on dangerous or hazardous phenomena in Finland
- The severity of the warning is indicated by the color
- The warnings are normally updated every 3 hours. If necessary, the warnings are also updated at other times
- Very slippery sidewalk condition is one of the phenomena to be warned



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Normal winter weather

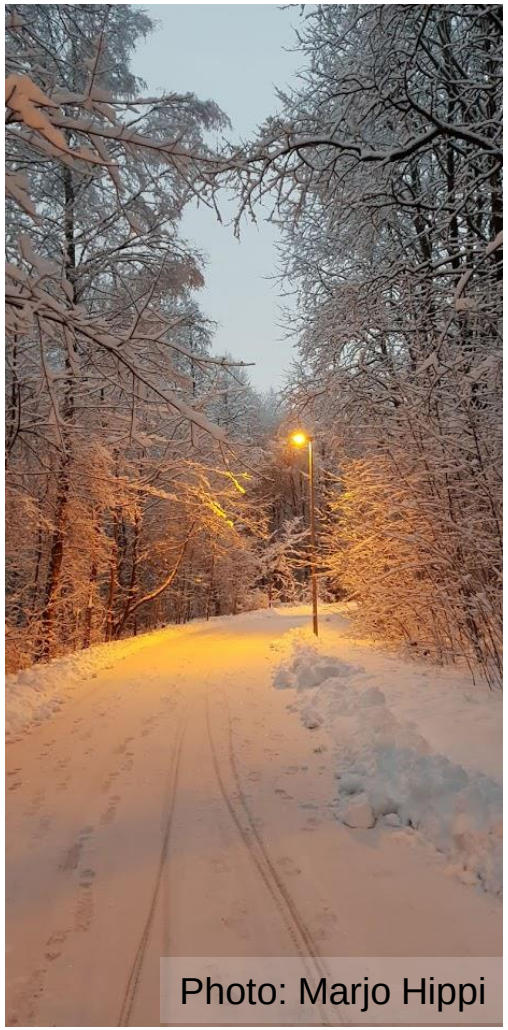


Photo: Marjo Hippi

Photo: Antonin Halas

Photo: Eija Vallinheimo

Extremely slippery

Photo: Pauliina Kuokka

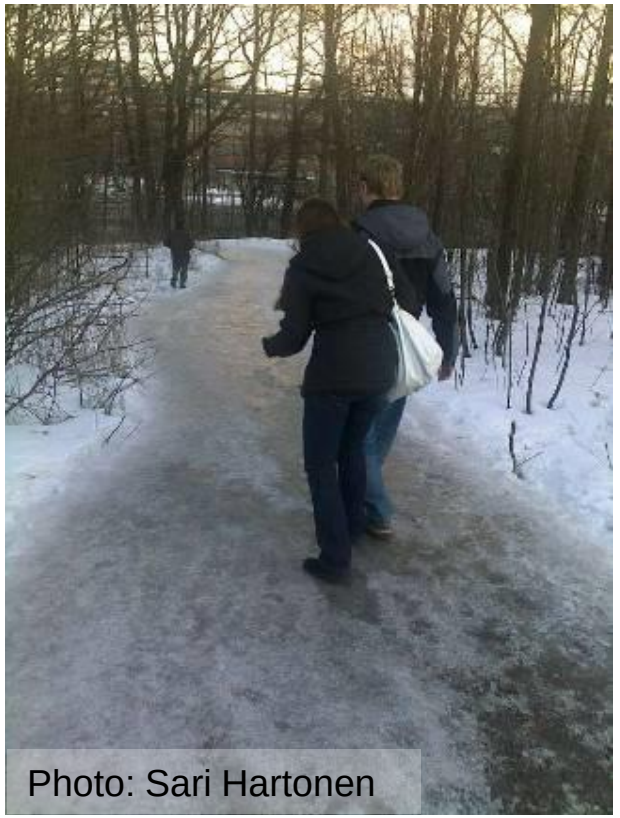
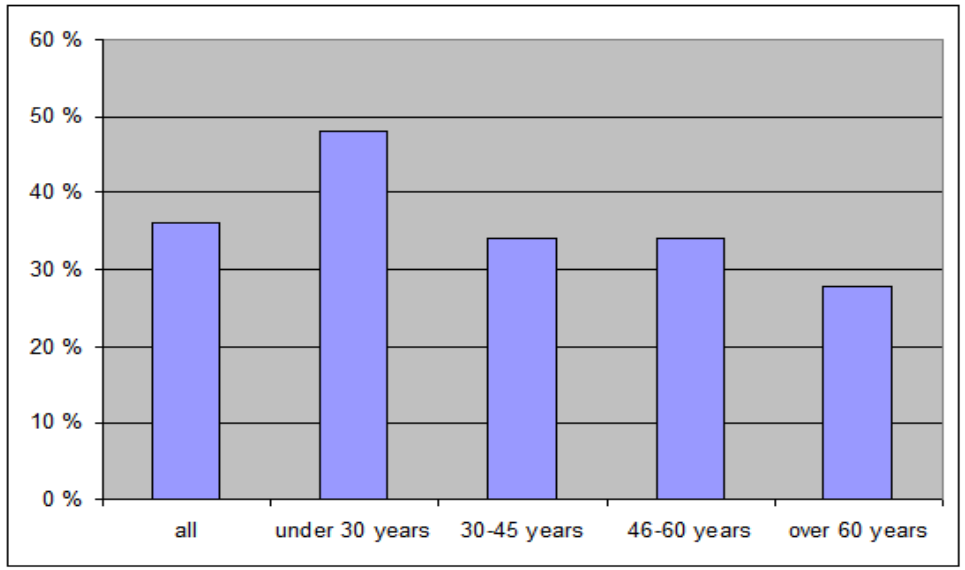


Photo: Sari Hartonen

Photo: Marjo Hippi

Who use to slip?

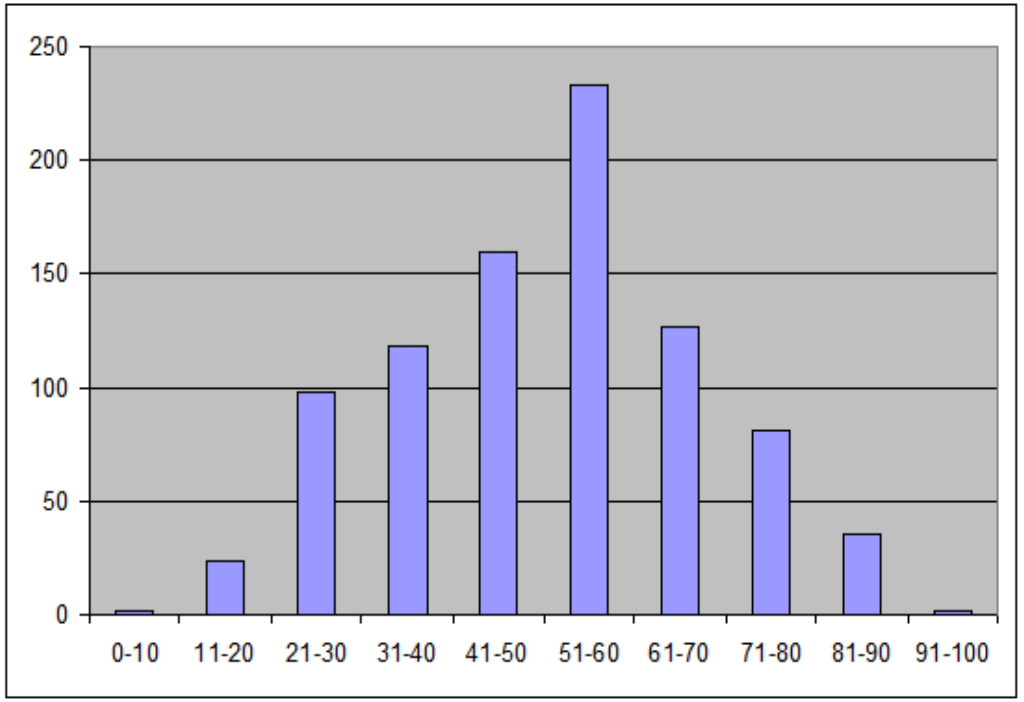


Wintertime slipping statistics – age distribution

People use to slip regardless of age and gender.

Young people (under 30 years) use to slip more often than older people

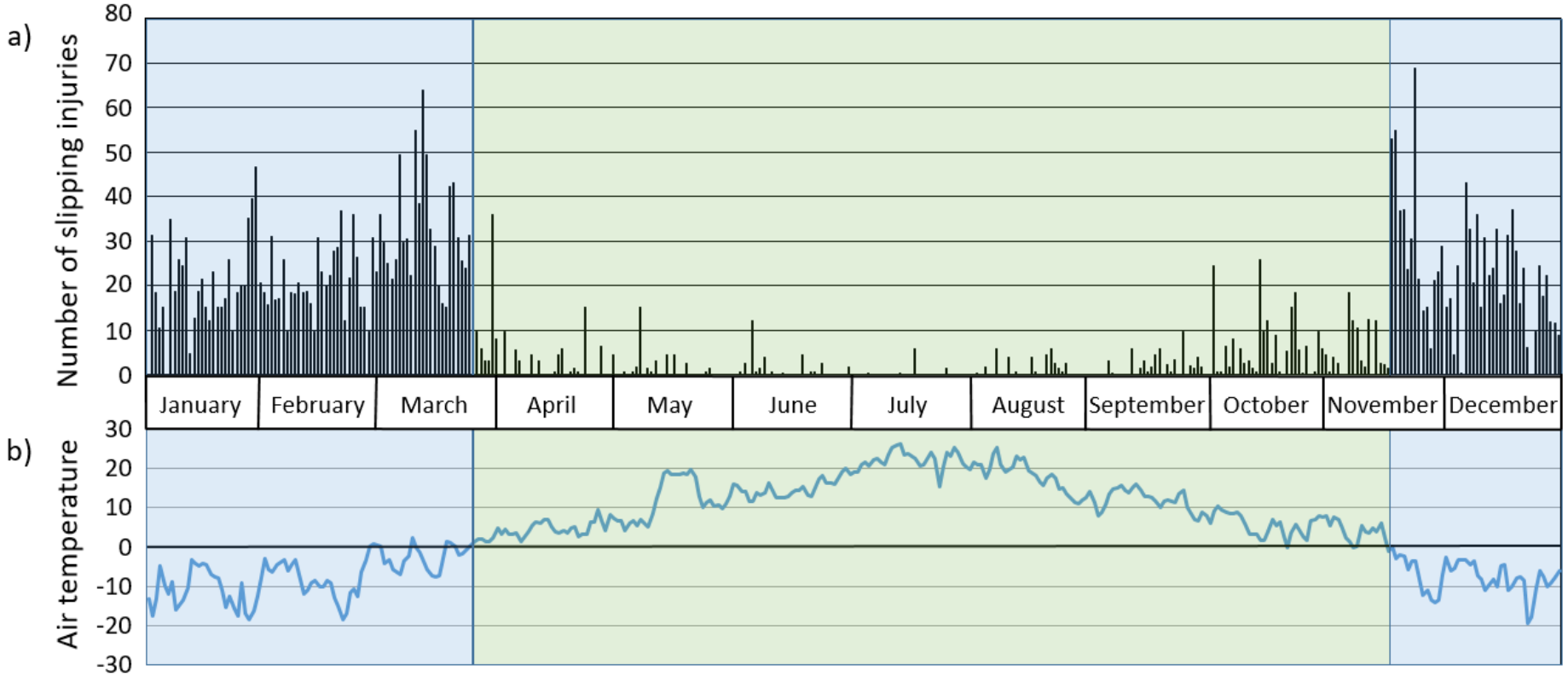
Who use to hurt him/herself when slipping?



The number of slipping injury patients and different age ranges in Helsinki (Töölö) Hospital Emergency on years 2003-2006 (winter)

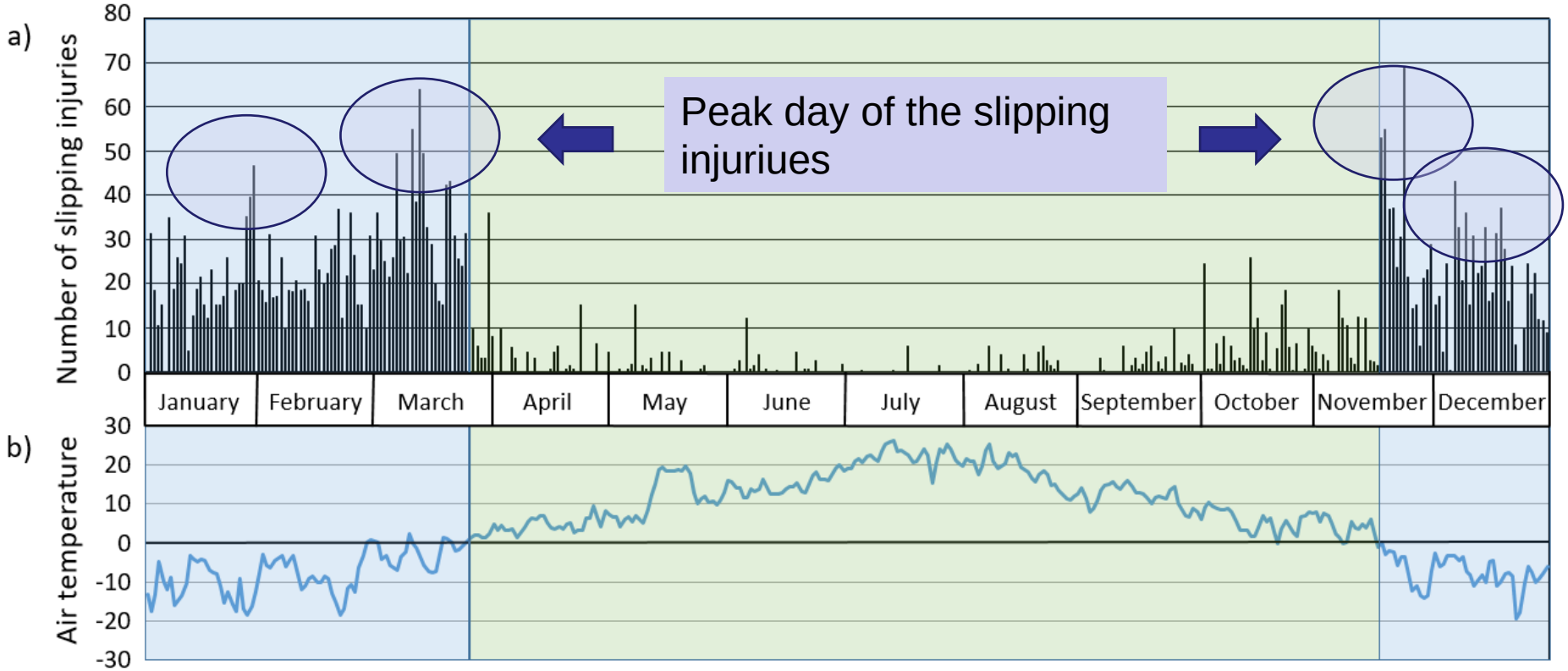
People between ages 40 and 70 need most often medical attention.

Daily slip amounts* (Uusimaa region) compared to daily mean temperature (Helsinki) from year 2010



Number of daily pedestrian slipping injuries happened on the way from home to work or vice versa.
Data includes injuries happened on Uusimaa province between 1.1.2010 and 31.12.2010.
*) based on TVK's data (Tapaturmavakuutuskeskus = Finnish Workers' Compensation Center)

Daily slip amounts* (Uusimaa region) compared to daily mean temperature (Helsinki) from year 2010



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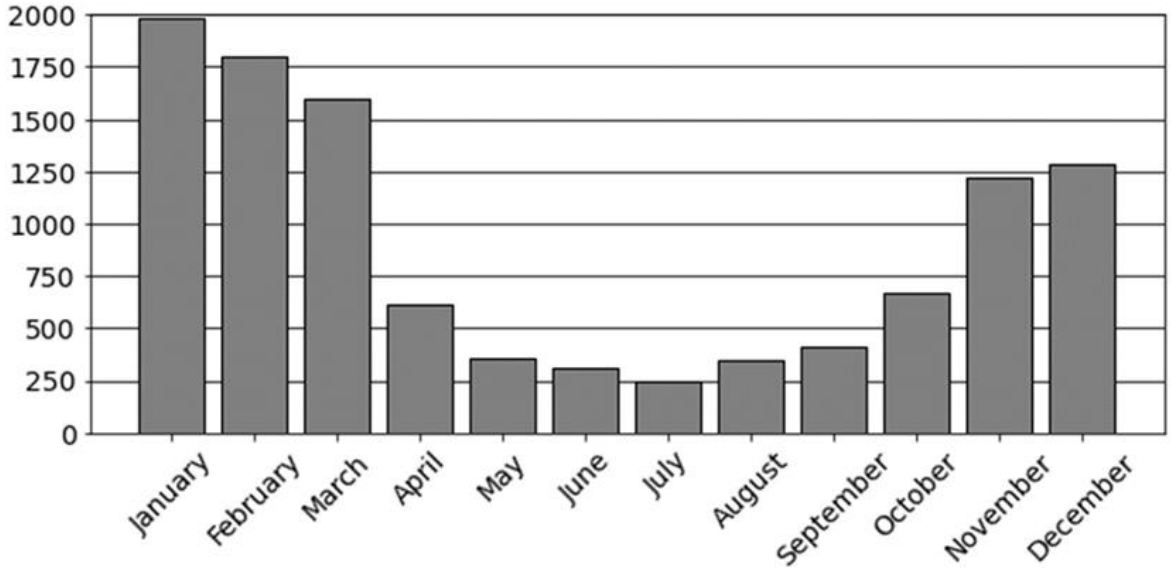
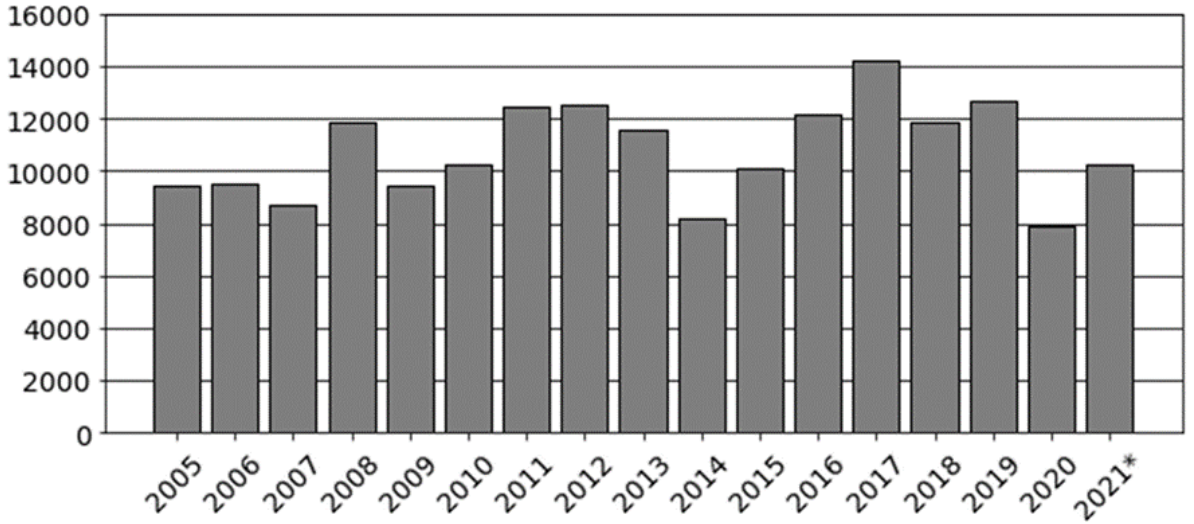
The number of monthly and yearly commuting accidents when the injured were walking*



The number of average monthly commuting accidents



The number of yearly commuting accidents

Data cover the whole of Finland, years 2005–2021

*) based on TVK's data (Tapaturmavakuutuskeskus = Finnish Workers' Compensation Center)

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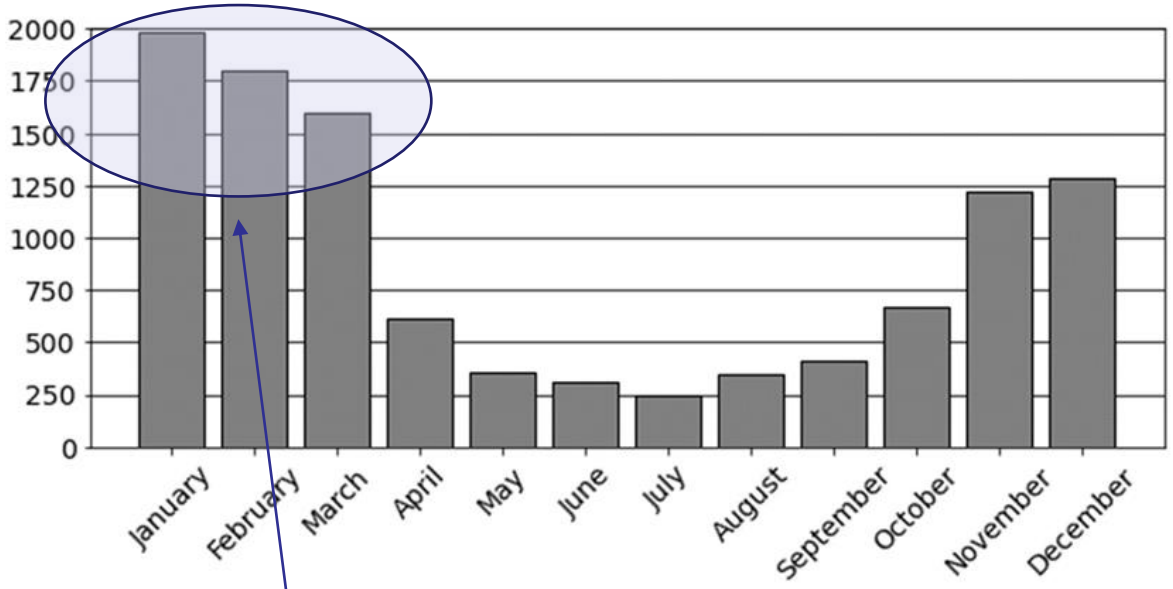
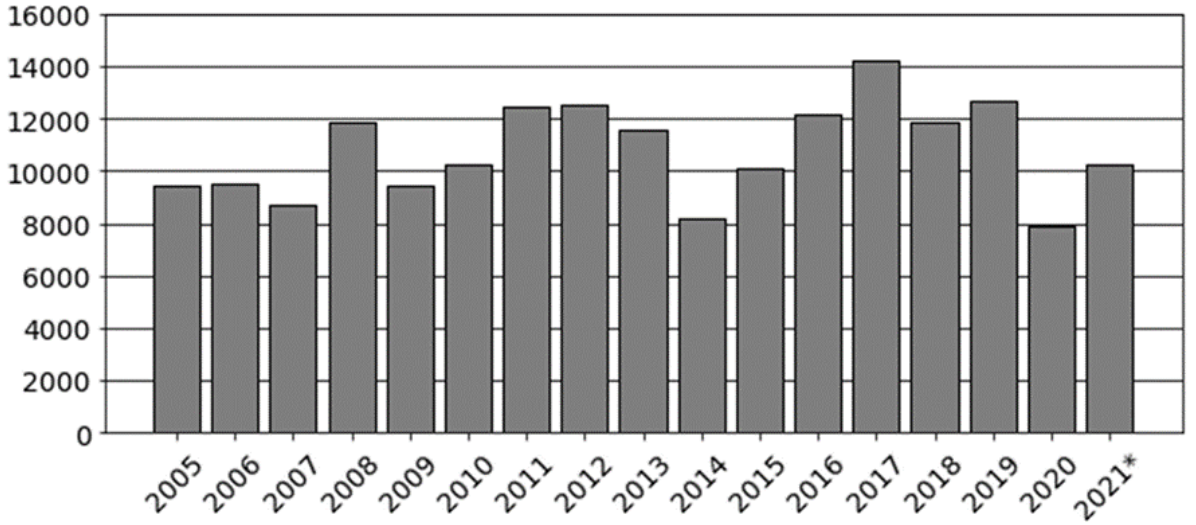


The number of average monthly commuting accidents

50 % of the yearly incidents



The number of yearly commuting accidents

Sidewalk maintenance in Finland

- Calcium chloride (salt) mainly not in use
- No clear rules for sidewalk maintenance, e.g. snow removal, roughening or sanding/gritting (compare: very tight rules for highway maintenance)
- Different rules in different cities
- Streets and roadways are maintained before pedestrian sidewalks in many cities

FMI’s sideway condition model and warnings of slippery sidewalk condition

Model description
Problematic cases
Weather warnings

Photo: Pauliina Kuokka

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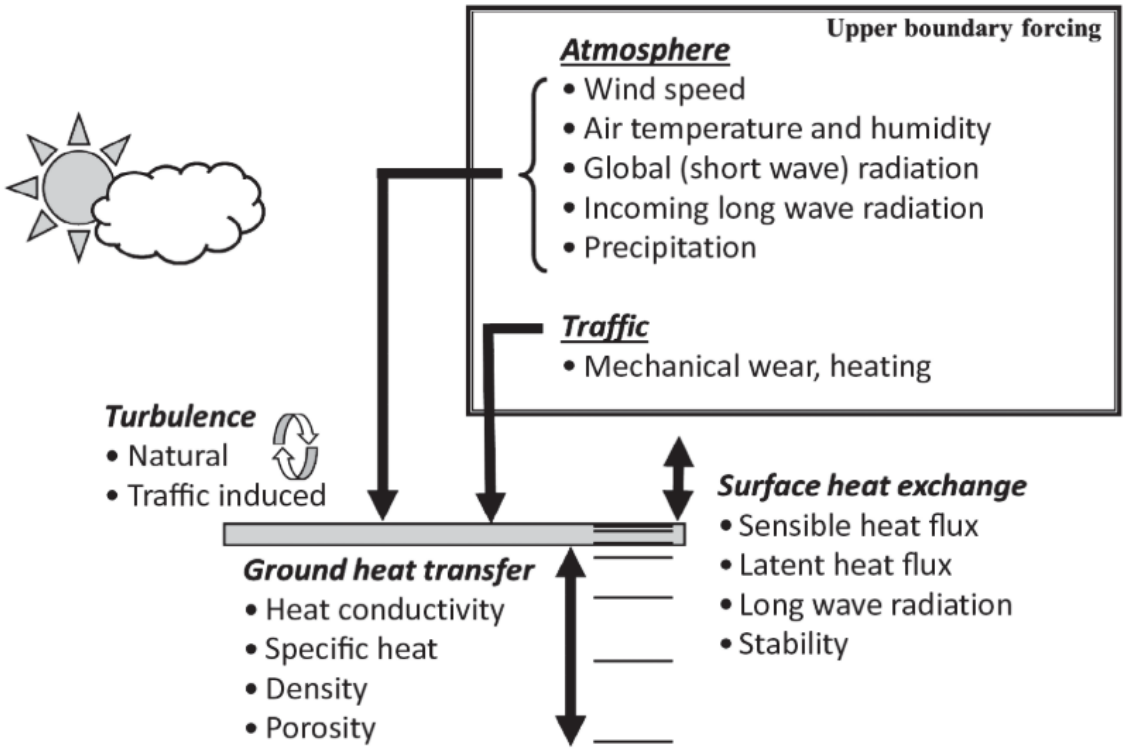
FMI's sidewalk condition model



RoadSurf model details

RoadSurf-Pedestrian model details

- 1-point energy balance model
- Calculate vertical heat transfer in the ground and at the ground–atmosphere interface
- Take into account the special conditions prevailing at the road surface and in the ground below it
- Tool for meteorologists

Model details

- **Past, present and forecasted weather**
  - Observation part: input weather observations (4 days)
  - Forecast part: input numerical weather prediction model
- **Model have storages for water, snow, ice and frost**
  - Weather has an impact for storages
  - Storages are interacted with each other
- Two types of model run:
  1. ice on the surface
  2. no ice on the surface
- **Output: Slipperiness index**
  - **normal**
  - **slippery**
  - **very slippery ← warnings are issued**

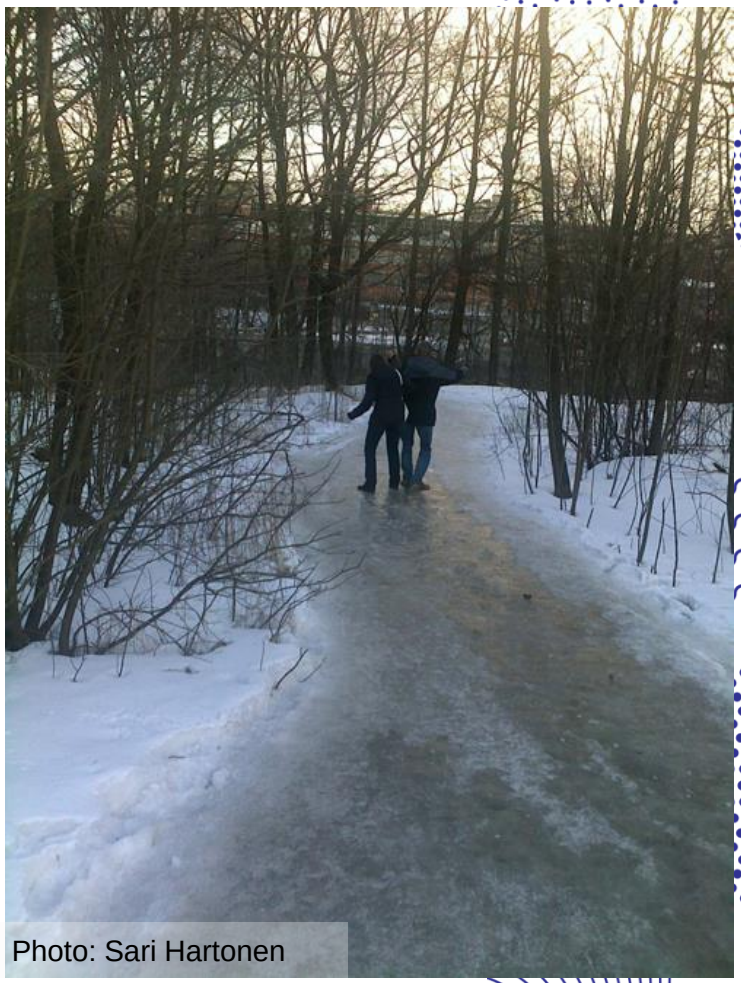


Photo: Sari Hartonen

Slipperiness classification

5 different slipperiness classes

1.	No slipperiness	normal
2.	Slippery	difficult
3.	Foot-packed snow	very difficult
4.	Freezing	
5.	Water above the ice layer	
6.	Snow above the ice layer	


Photo: Eija Vallinheimo

- Warning given in case of classes 3,4,5 and 6
  - Normal walking is difficult and the risk of slipping injuries increase
- Very slippery days typically 5-15 per winter

Very slippery sidewalk conditions

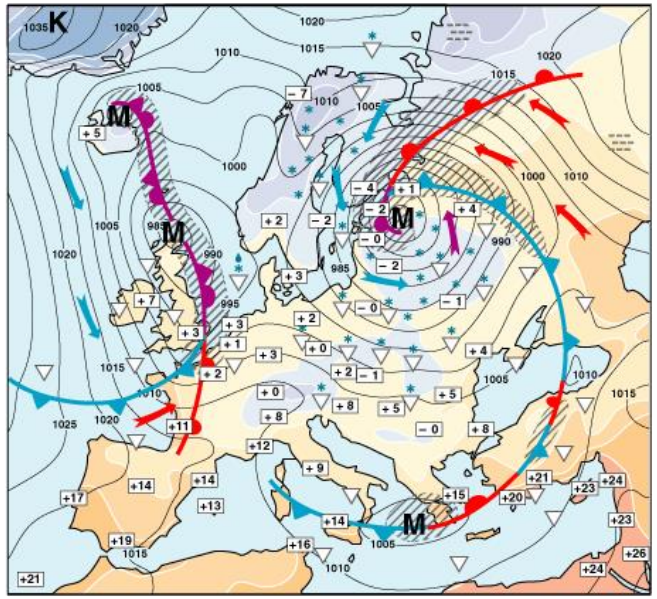
Photos: Marjo Hippi

Very slippery cases are divided into four different classes

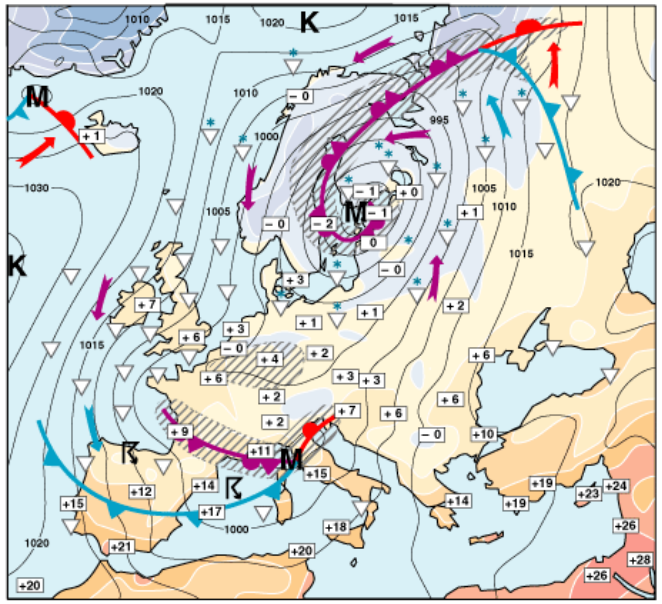
a) Freezing
b) Foot-packed snow
c) Snow above an ice layer
d) Water above an ice layer

One of the worst slipping days in Uusimaa region 24.11.2008

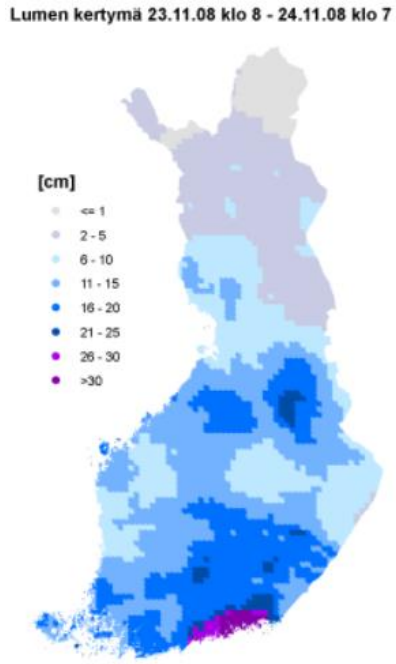
Photo: Helsinki 24.11.2008
Niklas Sjöblom / Taivasalla.net



Sunday 23.11.2008



Monday 24.11.2008

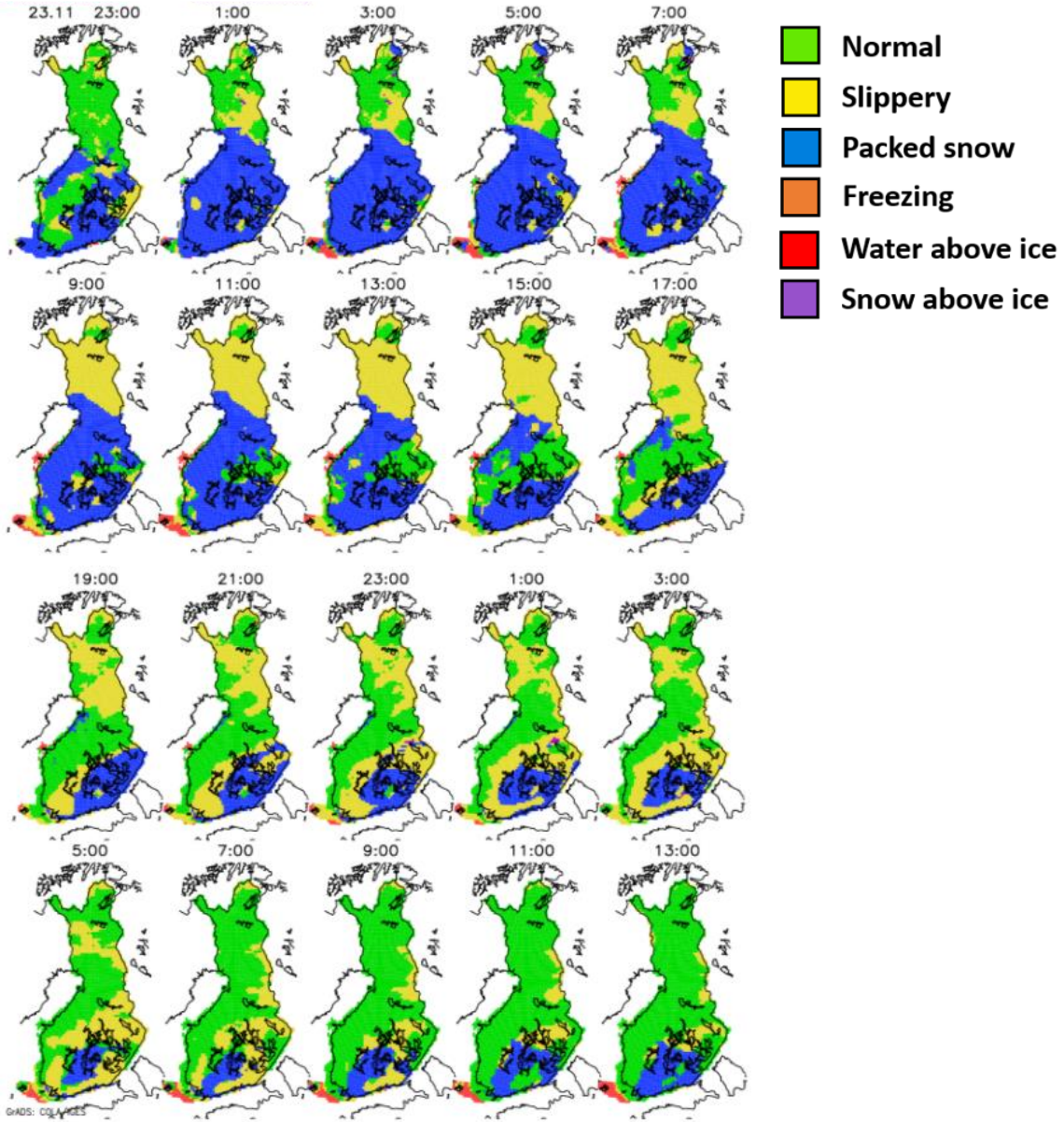


Snow accummulation
23.-24.11.2008

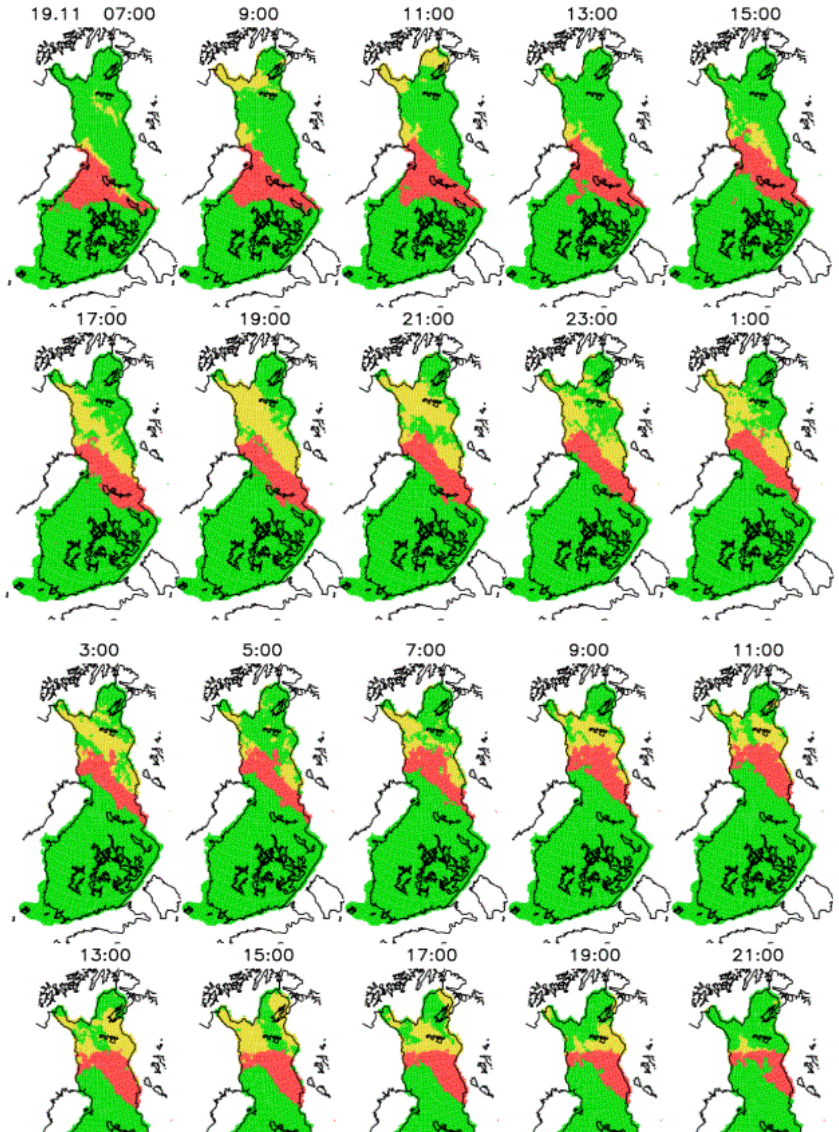
Typical situation for **foot packed snow**:

- Lots of new snow, temperature slightly below zero degrees.
- Unevenness, unevenly distributed slipperiness and snowbanks could also increase the risk of falling and slipping
- Also, this case was the first snowy day in the southern part of Finland

Photo: Helsinki 24.11.2008
Niklas Sjöblom / Taivasalla.net

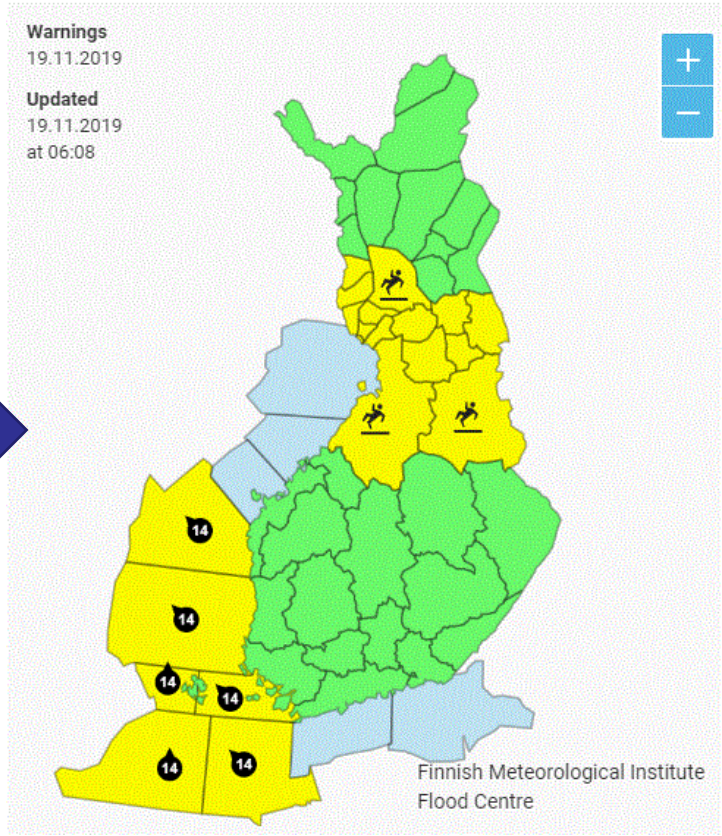


From model to warning



An example of FMI's sidewalk condition model output

- Normal
- Slippery
- Packed snow
- Water above ice
- Snow above ice



Weather warning map provided by Finnish Meteorological Institute

From model to warning

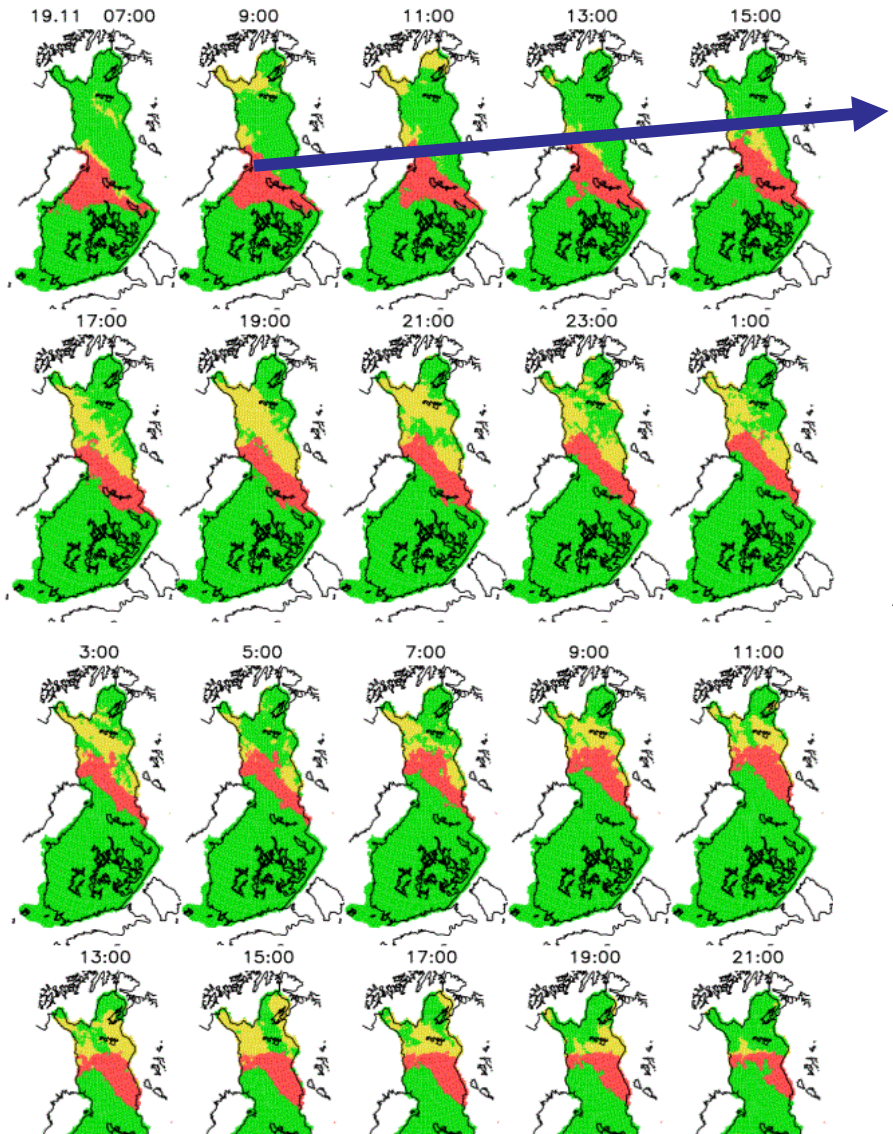


Photo: https://www.ouka.fi/oulu/english/oulu-webcams

An example of FMI's sidewalk condition model output

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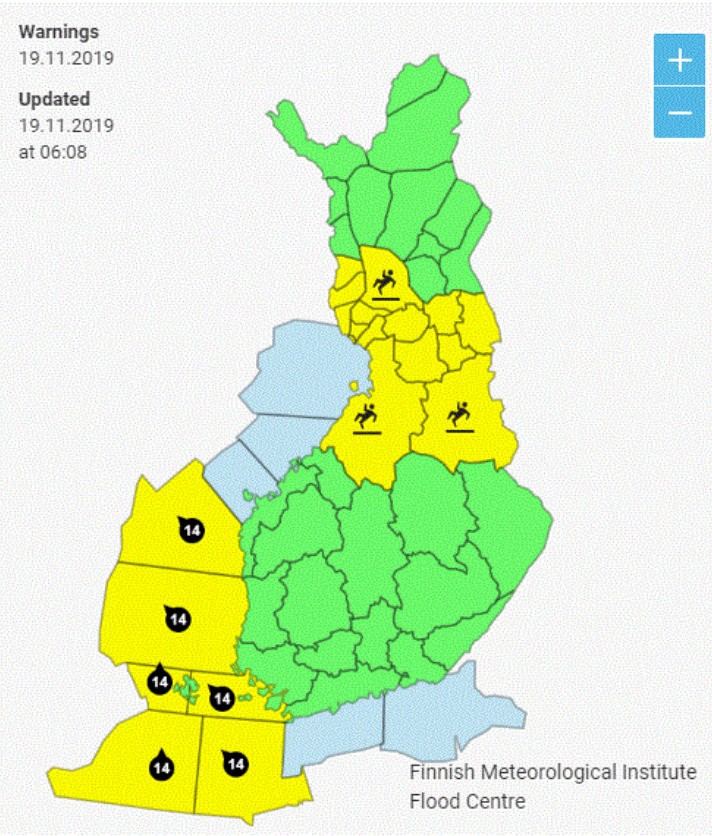


Weather warning map provided by Finnish Meteorological Institute

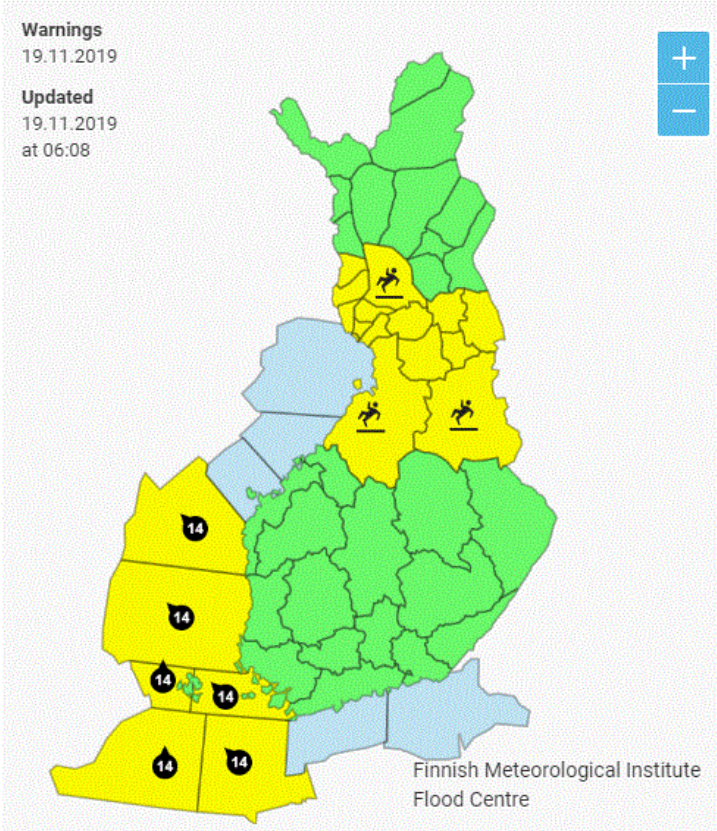
Problems and problematic cases

- No slipperiness observations available
- Slipperiness can be local
- Phenomena like the number of pedestrians, sidewalk maintenance, local parameters (shadows etc.) have a great impact to local slipperiness
- Input data of the model can be wrong
- Sometimes slipperiness is very difficult to predict

Services and applications

- FMI is giving warnings when slippery sidewalk condition is expected
  - Warnings can be checked from FMI's internet site or from FMI weather app (mobile phone)
  - TV news and some local radio stations are presenting/reading warnings
  - SMS service
    - Available for cities and companies
    - SMS is sent automatically if very slippery sidewalk condition is expected, and warning has been given to area

- Services for road maintenance companies
  - Information about snowfall, road surface temperature, friction etc



Warning map by Finnish Meteorological Institute

What has been done in other countries

What has been done in other countries

- Finland
  - https://liukastumisvaroitus.fi/en/
  - Slipping warning service for some Finnish cities (sms service)
- Japan
  - http://tsurutsuru.jp/english/index_e.html
  - Walk Smart website, which provides tips for not falling on icy roads
  - Sapporo area
- Canada
  - SureFoot service in Winnipeg was running on years 2012 – 2013 giving information about the slipperiness
  - http://pcag.uwinnipeg.ca/Prairie-Perspectives/PP-Vol18/Sylvestre.pdf

Climate change

How slipperiness will change in the future when climate is warming

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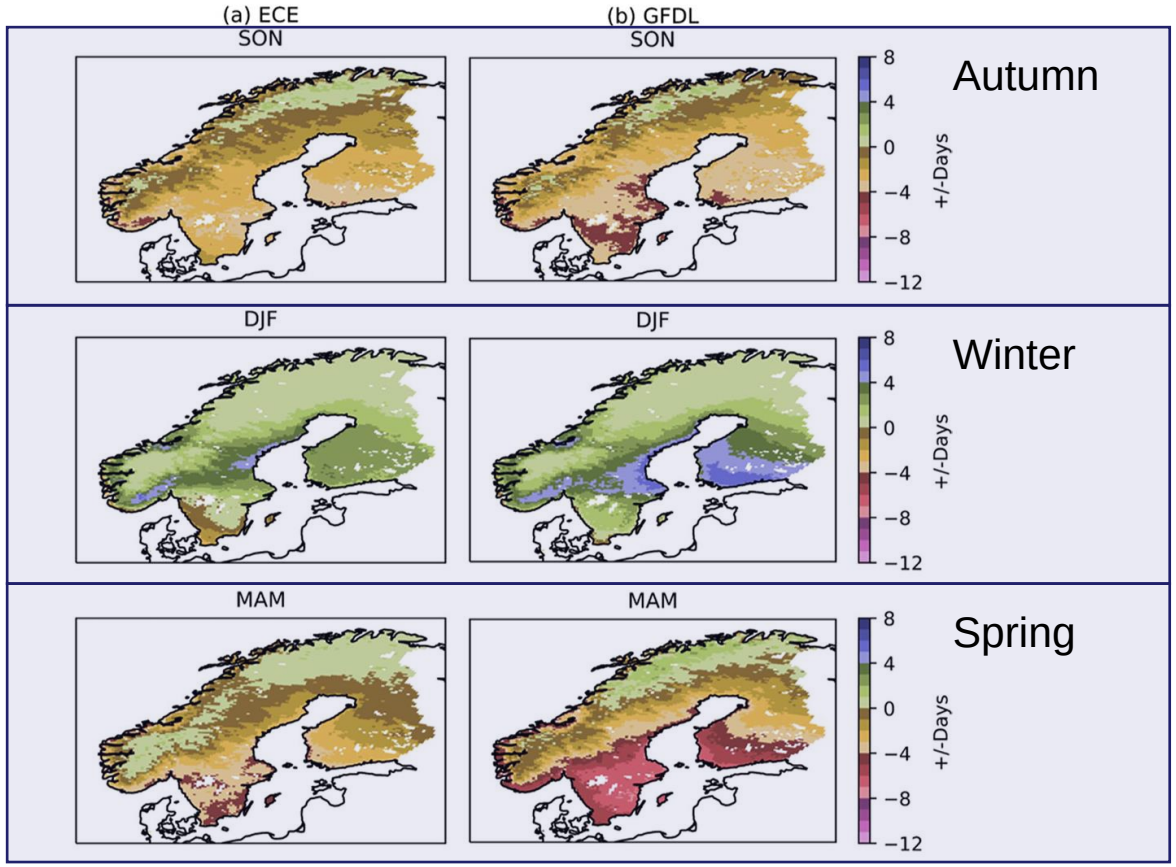
Climate change and slipperiness

More info in this article
doi:10.1007/s10113-022-01920-4

- RoadSurf-Pedestrian model was run by climate model data as input to get information about the change of slipperiness when climate is warming
- Simulations were done using two different global climate models driven by HCLIM38 as an input data of RoadSurf-Pedestrian model



An example of the climate model runs
The change of zero-degree-crossing days

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Climate change and slipperiness

- Results
  - The surface temperature will rise
  - The occurrence of ice and snow on the sidewalks will decrease
  - Very difficult walking conditions will decrease except the cases with index ”water above the ice layer”
  - In southern and western Finland slip season will become shorter, but probably more intensive in the future
  - In the eastern and northern part of Finland near zero temperatures and slipperiness will become more frequent in the mid-winter compared to prevailing climate

How to prevent slipping injuries

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How to reduce the number of slipping injuries?

1. **Improve winter maintenance of sidewalks**

2. **Awareness of slipperiness**
   - timing and route of walking
   - way of travelling (walking, public transport, car)
   - decision of travelling

3. **Foot wear with good grip**
   - shoes with good grip, anti-slip device

Road weather forecasts and warnings of slippery sidewalk conditions help both pedestrians and winter road and sidewalk maintenance

Photo: Eija Vallinheimo

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Thank You for Your Interest!

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