Extreme Weather Phenomena Affecting Transportation Systems in Europe: Identification, Climatology, and Projections

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Based on work at the "Extreme Weather impacts on European Networks of Transport" (EWENT) - project

Identification
D1 Review on extreme weather impacts on transportation systems

Climatology
D2.1 Probabilities of adverse weather affecting transport in Europe: climatology and scenarios up to the 2050s

Scenarios

Conclusions

Finnish Meteorological Institute
VTT Technical Research Centre of Finland
European Severe Storms Laboratory (Germany)
Cyprus Meteorological Institute
Foreca Consulting Ltd (Finland)
Identification of adverse weather

• A review of extreme weather phenomena to identify their impacts and consequences on European transport system
  • an extensive literature review (150 publications)
  • review of media reported cases (200 cases)
• Identify critical phenomena and their impacts and consequences
• Select threshold values for critical weather parameters
Identification: selecting thresholds

The resilience of transport systems vary across Europe -> use three thresholds for each parameter (when possible)

<table>
<thead>
<tr>
<th>1. Threshold</th>
<th>2. Threshold</th>
<th>3. Threshold</th>
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<tbody>
<tr>
<td>Adverse impacts to the transport system may start to occur. For example, if the resilience of the transport system against the phenomena in question is at low level.</td>
<td>Some adverse impacts are likely. Their severity depends on the resilience of the transport system.</td>
<td>Weather phenomena is so severe that it is virtually certain that some adverse impacts will occur.</td>
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</table>
Climatology and projections

<table>
<thead>
<tr>
<th>Phenomena</th>
<th>Threshold indices</th>
<th>Data used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snowfall</td>
<td>Rs $\geq$ 1 cm / 24 hours</td>
<td>Daily precipitation sum</td>
</tr>
<tr>
<td></td>
<td>Rs $\geq$ 10 cm / 24 hours</td>
<td>E-OBS data-set (0.25°*0.25°)</td>
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<tr>
<td></td>
<td>Rs $\geq$ 20 cm / 24 hours</td>
<td></td>
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<tr>
<td>Cold spell</td>
<td>T $\leq$ 0 °C</td>
<td>Daily mean temperature</td>
</tr>
<tr>
<td></td>
<td>T $\leq$ -7 °C</td>
<td>E-OBS data-set (0.25°*0.25°)</td>
</tr>
<tr>
<td></td>
<td>T $\leq$ -20 °C</td>
<td></td>
</tr>
<tr>
<td>Hot days</td>
<td>Tx $\geq$ 25 °C</td>
<td>Daily maximum temperature</td>
</tr>
<tr>
<td></td>
<td>Tx $\geq$ 32 °C</td>
<td>E-OBS data-set (0.25°*0.25°)</td>
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<tr>
<td></td>
<td>Tx $\geq$ 43 °C</td>
<td></td>
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<tr>
<td>Heavy rainfall</td>
<td>R $\geq$ 30 mm</td>
<td>Daily precipitation sum</td>
</tr>
<tr>
<td></td>
<td>R $\geq$ 100 mm</td>
<td>E-OBS data-set (0.25°*0.25°)</td>
</tr>
<tr>
<td></td>
<td>R $\geq$ 150 mm</td>
<td></td>
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</tbody>
</table>
Climatology and projections (cont.)

### Phenomena

- **Wind gust**
  - $\text{WG} \geq 17 \text{ m/s}$
  - $\text{WG} \geq 25 \text{ m/s}$
  - $\text{WG} \geq 32 \text{ m/s}$

- **Blizzard**
  - $\text{Rs} \geq 10 \text{ cm} / 24 \text{ hours}$
  - $T \leq 0 \degree \text{C}$
  - $\text{WG} \geq 17 \text{ m/s}$

### Threshold indices

### Data used

- 6-hour wind gust (forecast)
- ERA-Interim re-analysis full resolution (0.703°*0.703°) data-set (1989-2010)
- 6-hour wind gust (forecast)
- 6-hour precipitation (forecast)
- 6-hour temperature (analysis)
- ERA-Interim re-analysis full resolution (0.703°*0.703°) data-set (1989-2010)

### Scenarios only

- **Baltic Sea ice cover and thickness**
  - FMI report in 2010 (in Finnish)

- **Downscaling to Nordic road network**
  - Road weather measurements (IRWIN)

- **Thunderstorm related hazards**
  - Sander (2011, PhD Thesis)
Probability of daily snowfall $\geq 1$ cm (1971-2000)

U.K. Feb 2009: Total cost of damages: £ 1.3 billion

Helsinki metropolitan area, March 17, 2005

Worst chain accident: 300 cars, with several human casualties
Average number of days/year with snowfall exceeding:

- ≥10 cm/24 h
- ≥20 cm/24 h

- Heavy snowfall occurs mainly over N, E and Central Europe
- More intense over N Europe (Norway, Iceland) and Alpine region: ~900 events with 20 cm snowfall/30 years
- Scandinavia, E. Europe, Balkan ~ 30-40 events/30 years
Climatology only

Phenomena
- Freezing rain, Low visibility on land
- Dust episodes in Cyprus
- Lightning
- Hail, tornadoes
- Events affecting infrastructure
  - Extremely high temperatures
  - 50-yr return value of the 10-min mean wind speed
  - Probability of the annual-max. 5-day precipitation total exceeding 100 mm in the present climate

Data used
- METAR reports (hourly)
- Atmospheric circulation patterns
- NOAA ESRL (satellite)
- ESWD database
- E-OBS, ERA-Interim

LOW VISIBILITY
Annual numbers of hours with visibility <200 m at the airports
Climate projections

• Data source: ENSEMBLES project EU FP6
• Two future periods: 2020s and 2050s (2041-2070)
• 6 regional climate model (RCM) simulations (25x25km²)
• Moderate A1B emission scenario
• Major uncertainties due to
  • Natural climate variability
  • Model uncertainties
• 6-RCM multi-model mean change
• For each grid point is shown the range of changes, i.e.
  upper limit and lower limit
Change in annual snowfall days from 1971-2000 to 2041-2070

- ≥ 1 cm
- ≥ 10 cm
- ≥ 20 cm
Summary map of the mean changes
Conclusions

Problems with the climate data: temporal/spatial resolution, reliability, ”non-existent” → *Improvements in data collection and exchange are needed.*

There are large differences in the probabilities and intensity of extremes affecting transport systems across Europe. → *This need to be considered in EU transport policy as well as by private international traffic operators.*

• The multi-model approach adopted by the researchers indicates robust changes in temperature extremes: less cold days and more hot days. Less severe ice winters in the Baltic Sea. Extreme heat is likely to intensify across the entire continent, being more accentuated in the south.
Conclusions (cont.)

• The projections are less coherent with regard to extremes in precipitation and wind: an increase is likely in parts of Central and Northern Europe.

• Snow events are likely to become rarer by the 2050s. However, frequency of heavy snowfalls may increase over Scandinavia.

Climate change is expected to have both negative and positive impacts on the transport sector.

Uncertainty in climate projections are relatively large. In addition, some regions may have to deal with increasing variability (rainfall, heavy snowfall). → Large challenges for risk management and climate change adaptation. Besides old solutions new innovations are needed.
THANK YOU FOR YOUR ATTENTION!

EWENT REPORTS:


Web site: ewent.vtt.fi
**Example: Snowfall** (road and rail traffic)

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<th>≥1 cm/24 h</th>
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<td>This is the practical lower limit of snowfall occurrence that is reasonable to use in climatic calculations. In some situations can cause slipperiness, for example combined with very cold conditions (&lt;-10ºC, increased accident rate observed in Finland). In the Mediterranean countries, where it seldom snows, it can also cause trouble. The shallow snow layer might melt and then form an icy layer (if the road is not salted).</td>
<td>Causes slipperiness on roads when combined with low temperature and wind; rail points may get stuck. Increased accident rate in road traffic (double accident rate compared to the mean, observed in Finland); delays and cancellations in road traffic (e.g. serious problems in public transport in Central/Southern Europe, such as the “London buses” situation), in rail traffic.</td>
<td>Slippery roads and runways; accumulated snow banks. Quite rare event in lowlands. Disturbed traffic, high accident rate, temporary closed roads (e.g. trucks stuck in snow banks, Sweden, highway E4, on 17 Dec. 2009), airfields temporarily closed (as during winter 2009/10 in many cities in Central and Southern Europe), delays and cancellations in rail traffic.</td>
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