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Observed and future changes of extreme winter events in Europe with implication for road transportation

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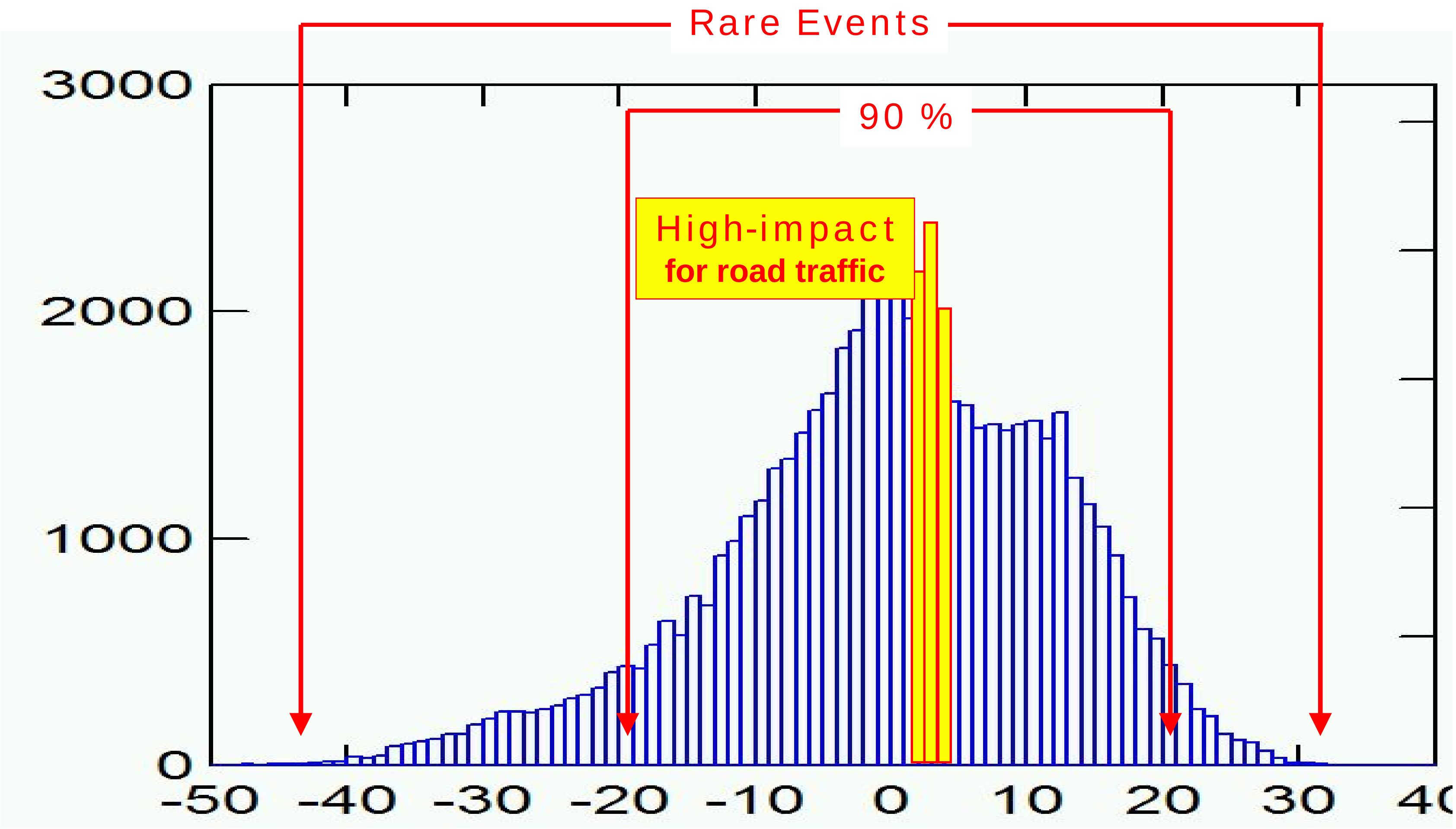
16th International Road Weather Conference,
Helsinki, May 23-25, 2012

Extreme OR adverse weather events?

Temperature distr. at a station in Finland (50 years, c. 55000 observations)



Courtesy of P. Nurmi (FMI)

Objectives

- To provide a comprehensive analysis of adverse and extreme winter weather events over Europe relevant to the transport system with primary focus on recent decades (1971-2000) by
  - → estimating the frequency/probability of phenomena
  - → describing the spatial variation of severe events

- To assess the projected changes in the severe winter phenomena in the future climate until 2070

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Area covered:
Lat: 32°N – 72°N
Long: 25°W – 45°E

Winter phenomena | Impact indices

Snowfall

≥ 1 cm / 24 hours
≥ 10 cm / 24 hours
≥ 20 cm / 24 hours

Cold spell

≤ 0 ºC
≤ -7 ºC
≤ -20 ºC

Daily precipitation sum and daily mean temperature E-OBS data-set (0.25°*0.25°), 1971-2000
(correction factor applied, Haylock et al. 2008)

Wind gust

WG ≥ 17 m/s
WG ≥ 25 m/s
WG ≥ 32 m/s

Blizzard

≥ 10 cm / 24 hours
≤ 0 ºC
≥ 17 m/s

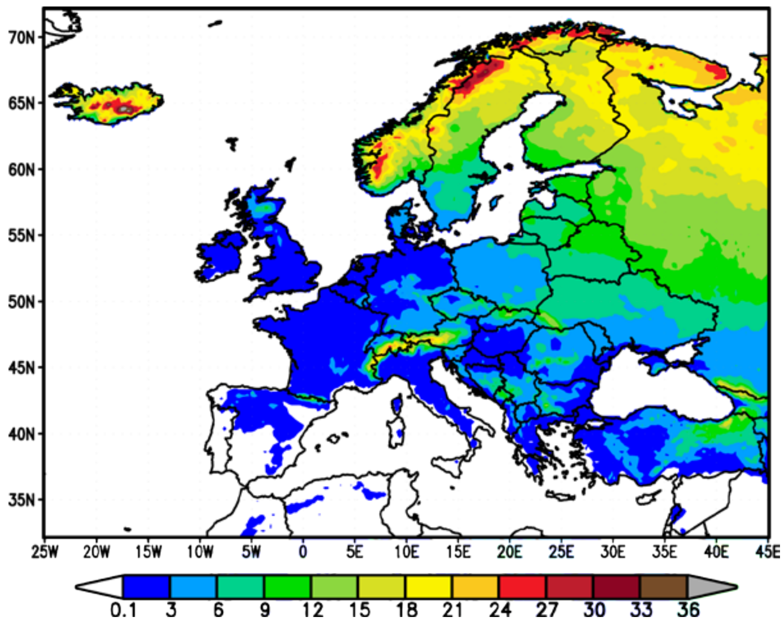
6-hour wind gust, precipitation (forecast), temperature (analysis)
ERA-Interim re-analysis full resolution (0.703°*0.703°) data-set (1989-2010)

1st threshold → Adverse impacts to the transport system may start to occur.
2nd threshold → Some adverse impacts are likely. Their severity depends on the resilience of the transport system.
3rd threshold → Weather phenomenon is so severe that it is virtually certain that some adverse impacts will occur.

For details on threshold definition please check the poster:
Juga I. & Vajda A.: Assessing the impact thresholds for adverse weather phenomena ID:0042

Probability and frequency of daily snowfall (1971-2000)

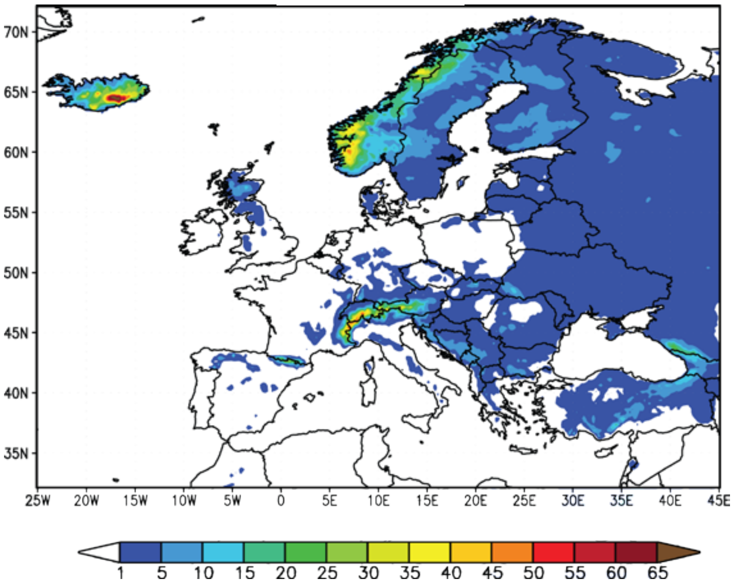
≥ 1 cm



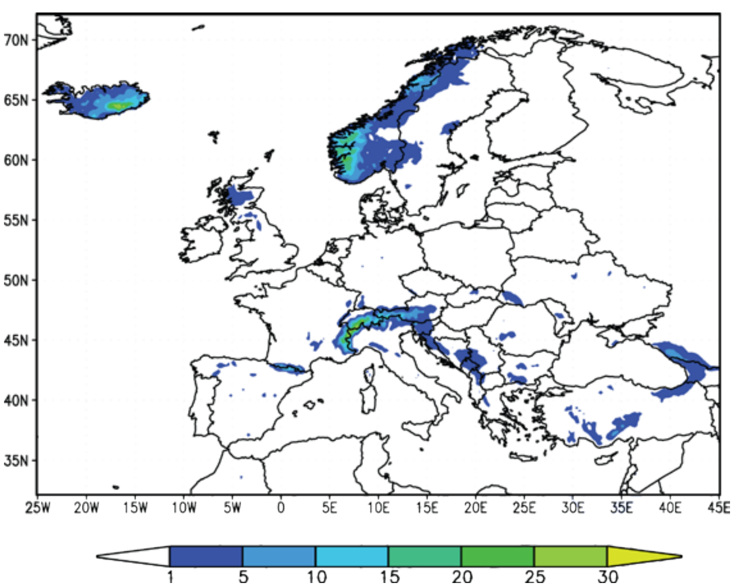
1 11 22 33 44 55 66 77 88 99 120

# of days per year

≥ 10 cm

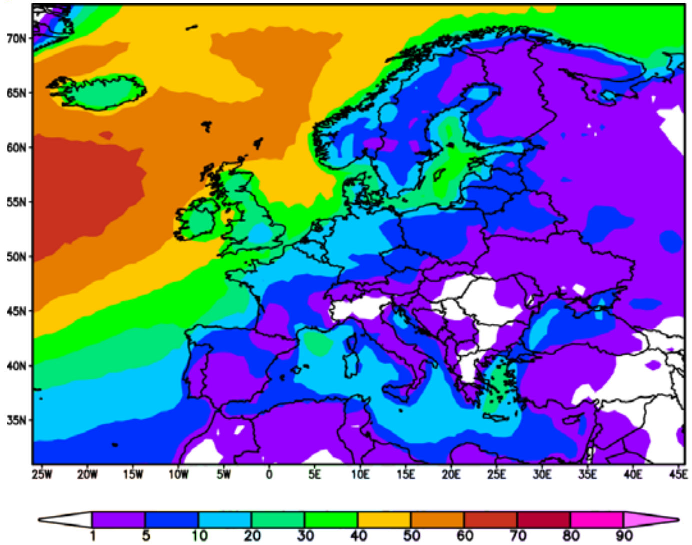


≥ 20 cm

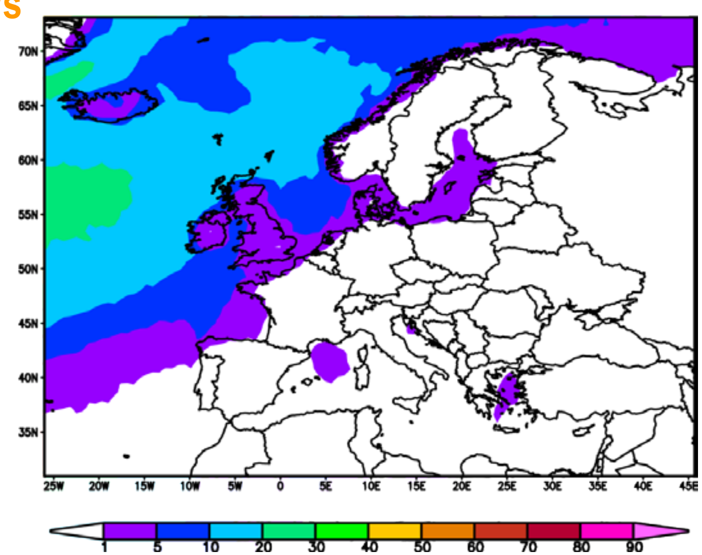


Average number of days/winter (DJF) with wind gust exceeding

≥ 17 m/s



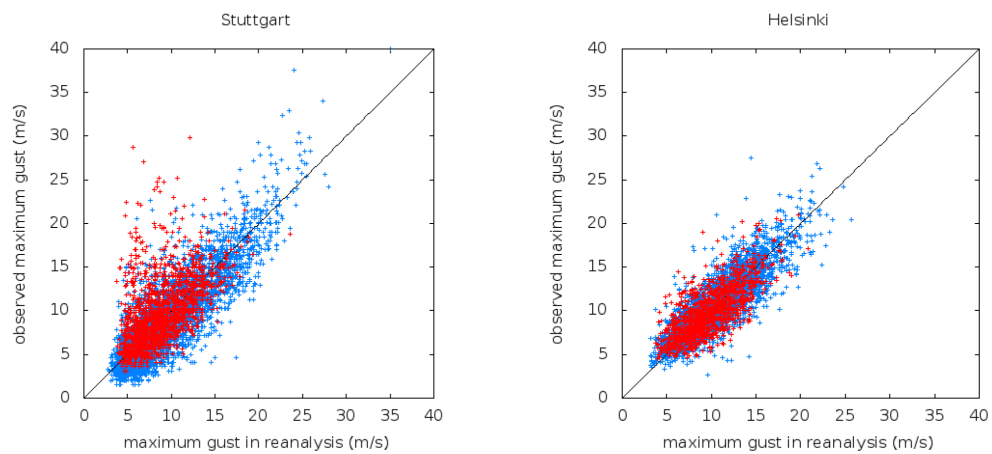
≥ 25 m/s



- high frequency over western coastal region → exposure to the Atlantic storms
- gusts ≥ 32 m/s inexistent over the continent

How well is the maxima estimated in ERA-Interim?

- large scale variability described fairly well
- smaller temporal/spatial scale phenomena deficient



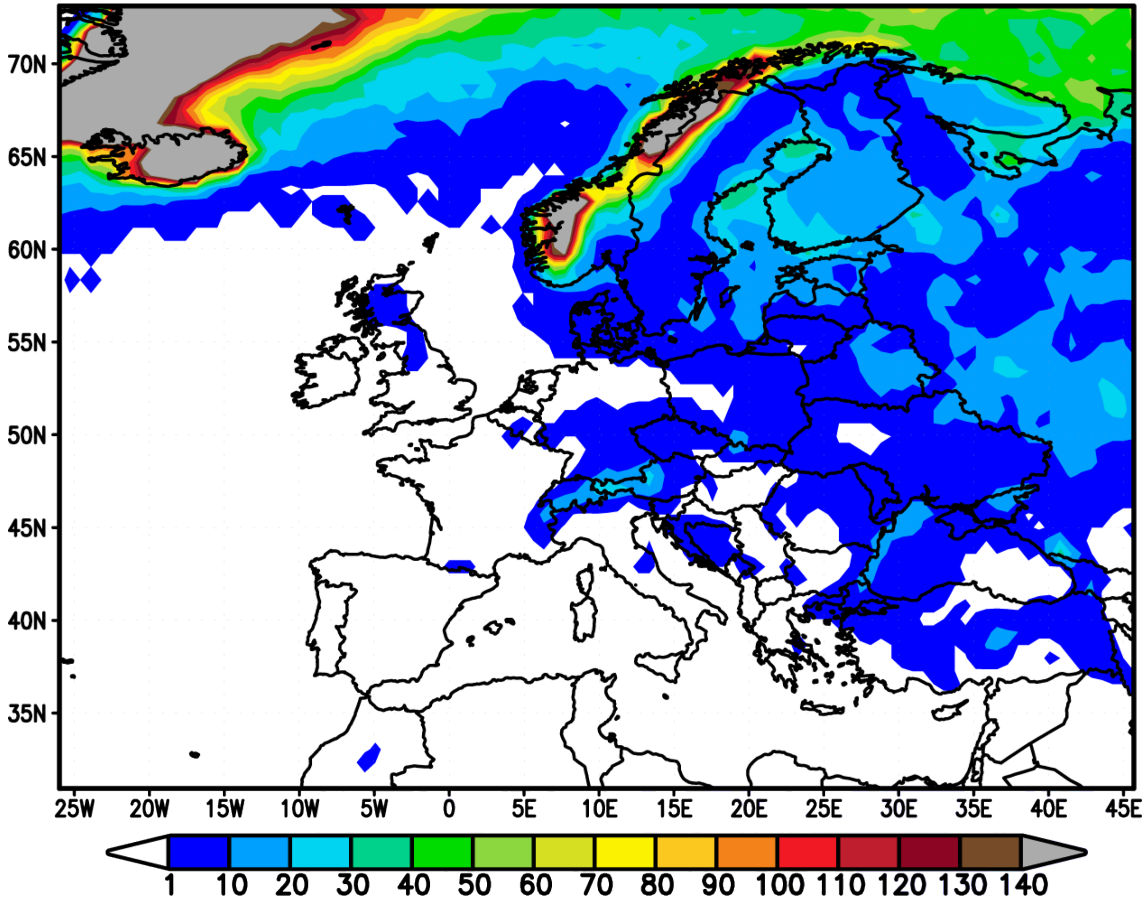
Observed gust vs. ERA-Interim gusts during 1990(97)-2009

+ Sep-Apr + May-Aug

Ref: Vajda et al. 2012

Total number of blizzard events during 1989-2010

≥ 10 cm / 24 h
≤ 0 ºC
≥ 17 m/s



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What are the projections for the adverse/extreme winter events?

Winter and summer (A) mean surface air temperature (°C) and (B) mean precipitation (mm/day) change for the

e

to

the 1980-1999 for the multi-model ensemble mean

ENSEMBLES

Multi-model ensemble regional climate simulations of extreme weather events from 1971 until 2070

6 RCMs produced in the ENSEMBLE project

→ driven by 3 GCMs

→ A1B emission scenario (medium, non-mitigation)

→ 0.22º (25 km) resolution

SMHIRCA-ECHAM5-r3
SMHIRCA-BCM
SMHIRCA-HadCM3Q3
KNMI-RACMO2-ECHAM5-r3
MPI-M-REMO-ECHAM5-r3
C4IRCA3-HadCM3Q16

Time periods: 2011-2040, 2041-2070

Major uncertainties due to → natural climate variability
→ model uncertainties

0.22 degree (25km) grid mesh

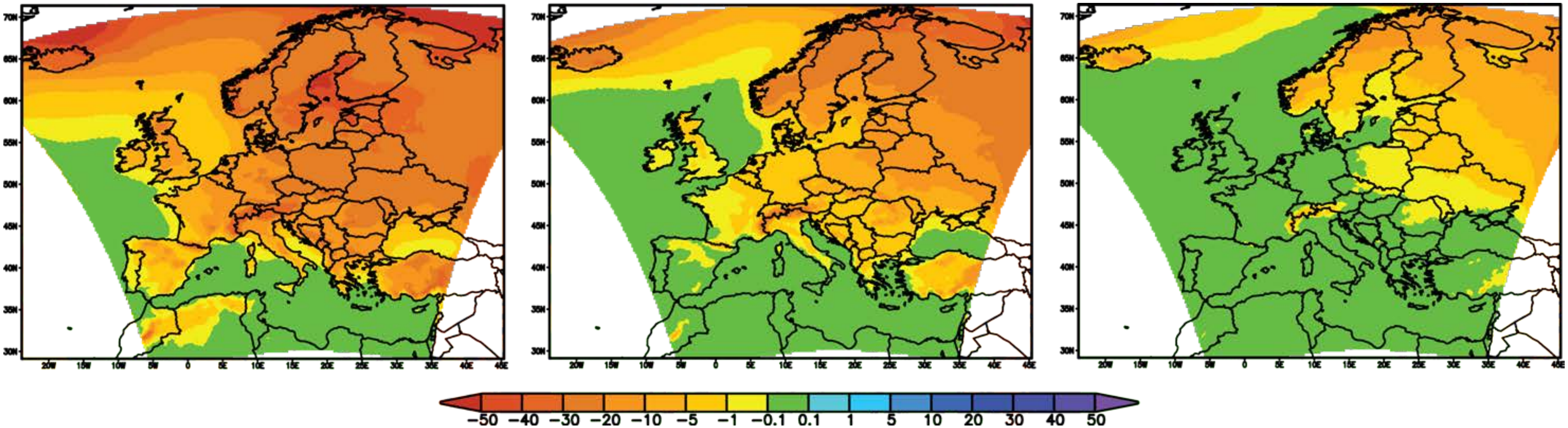
- Multi-model mean: the mean change of six models compared to the main period, for all the thresholds
- For each grid point is shown the range of changes, i.e. upper limit and lower limit.

Changes in annual cold spell days from 1971-2000 to 2041-2070

≤ 0 ºC

≤ -7 ºC

≤ -20 ºC



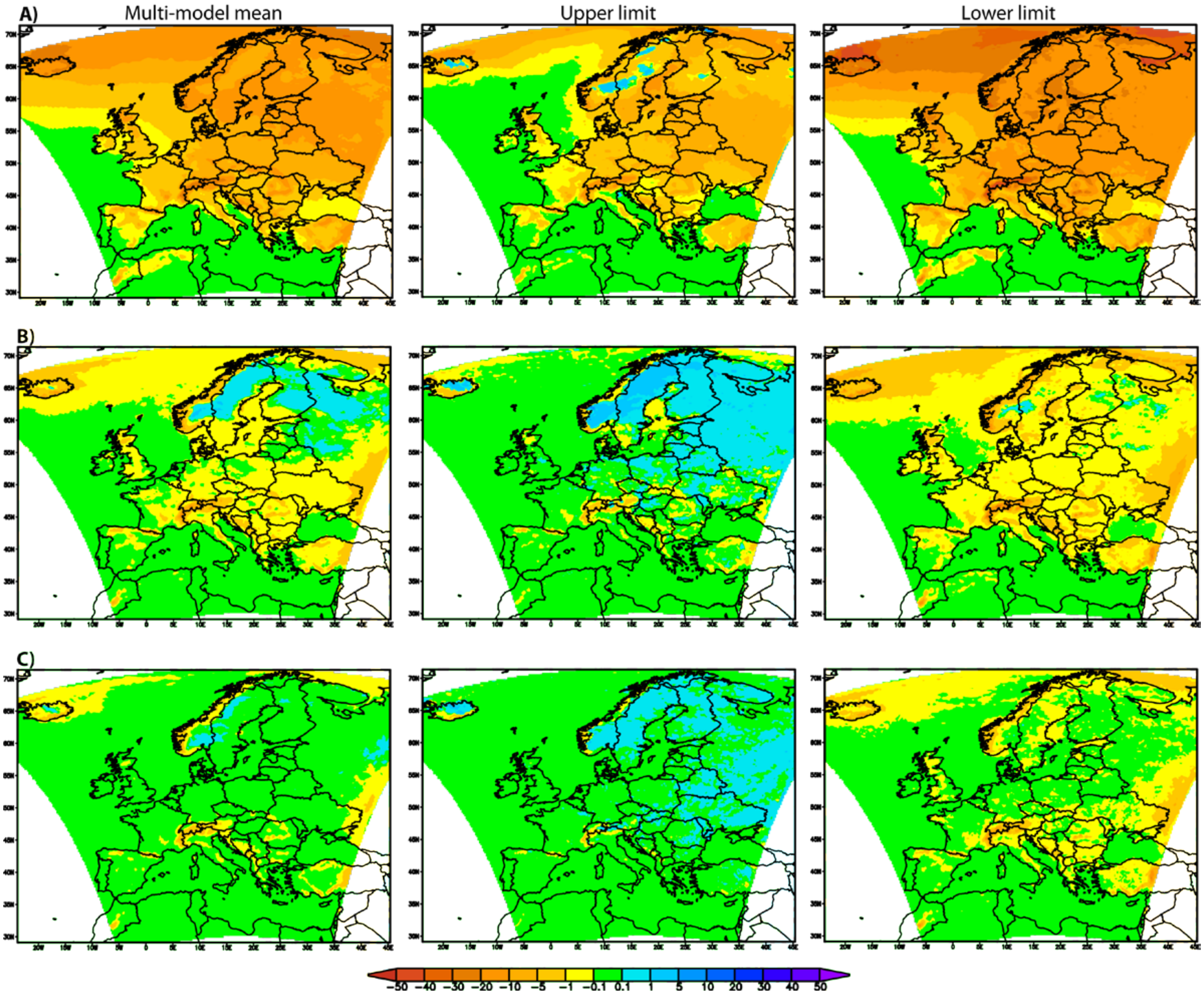
- The largest changes at high latitudes
- As many frost days in Scandinavia by 2050s as in some mid-latitude countries in the present climate
- Good agreement among the 6 RCMs on the variation of upper and lower limits

Changes in annual snowfall days from 1971-2000 to 2041-2070

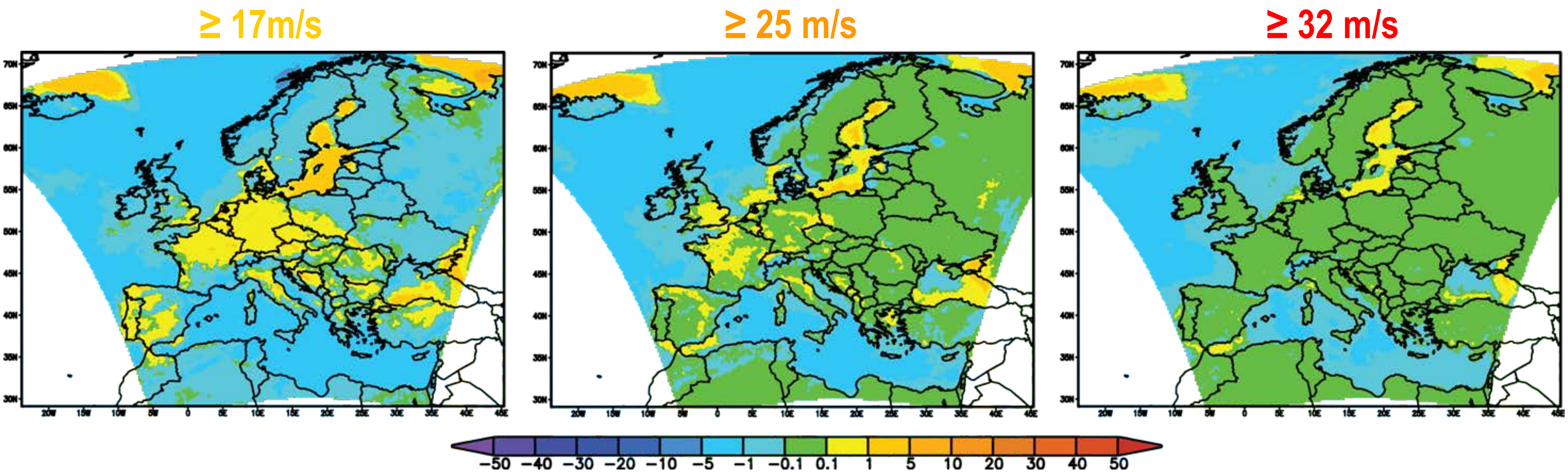
≥ 1 cm

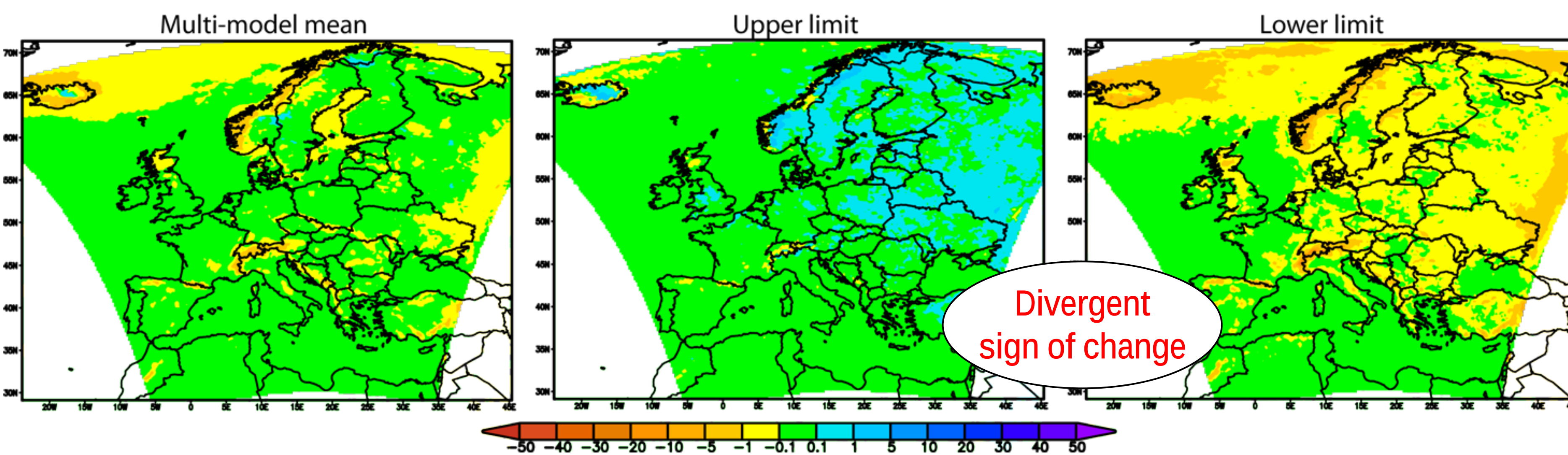
≥ 10 cm

≥ 20 cm

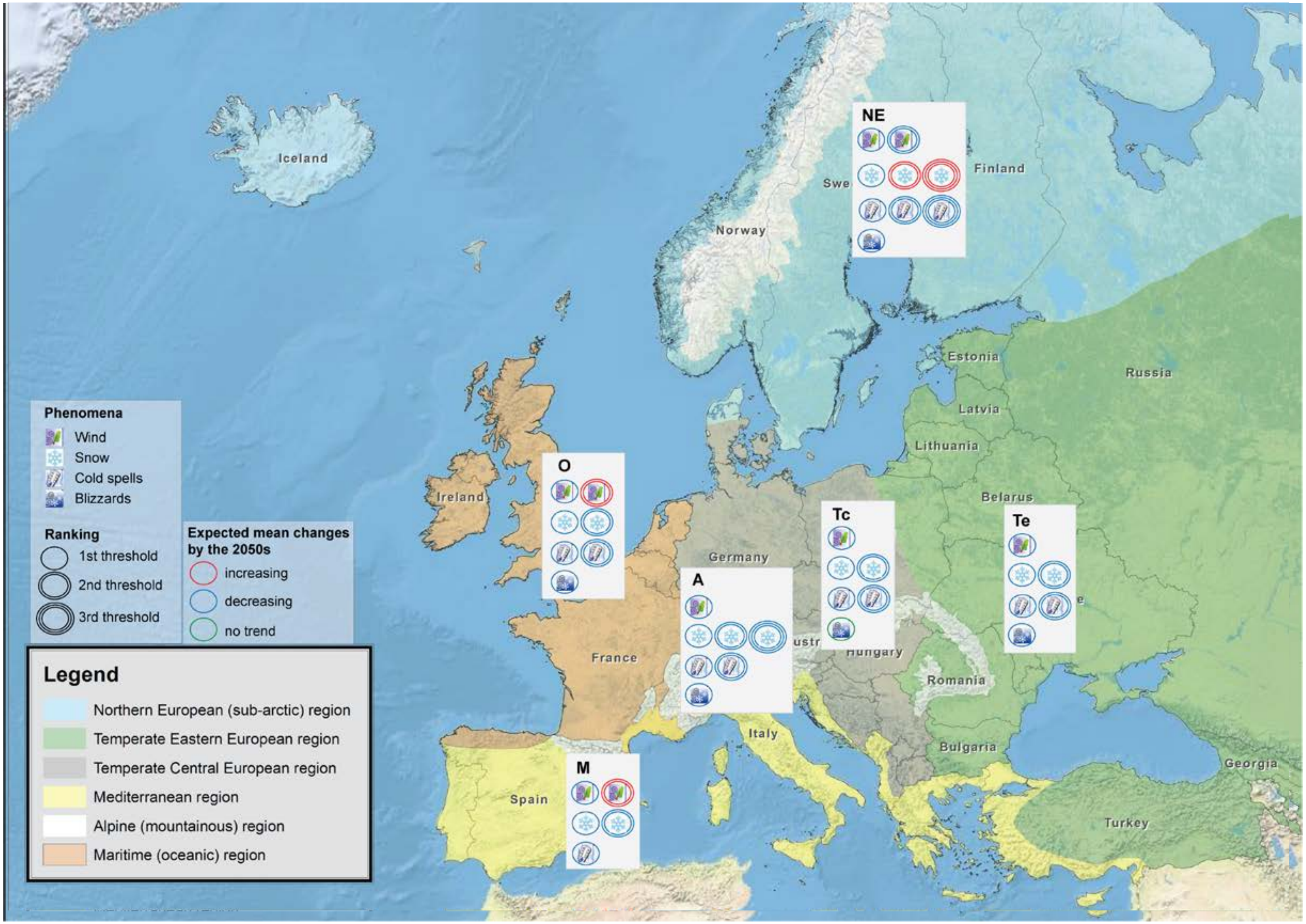


Changes in wind gust (top) and blizzard (bottom) days





Summary map of the mean changes / European regions



Risk indicators for road transportation (present climate)

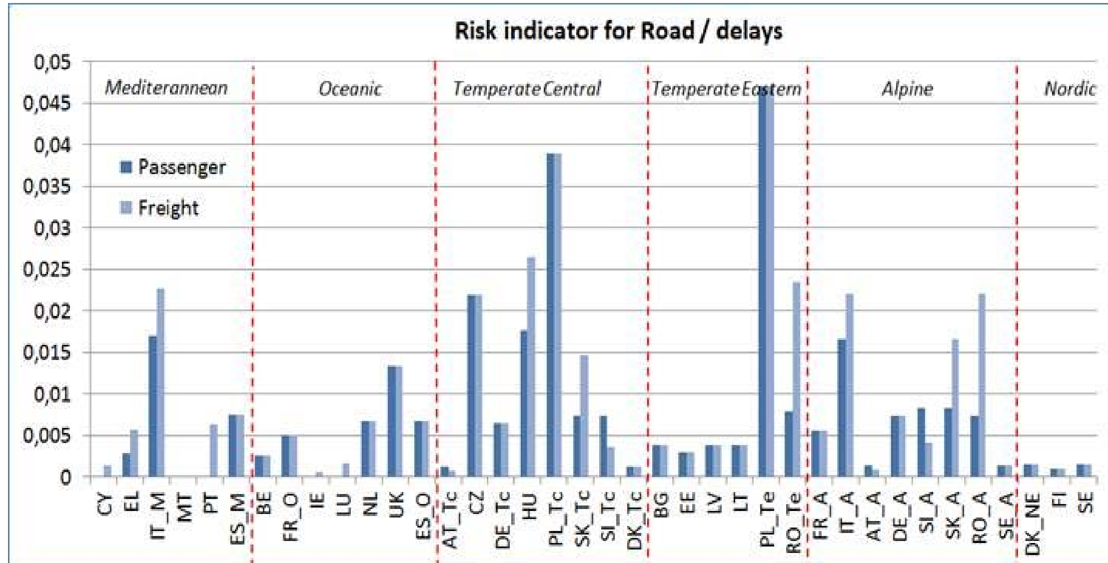
Risk = f (Hazard, Vulnerability)

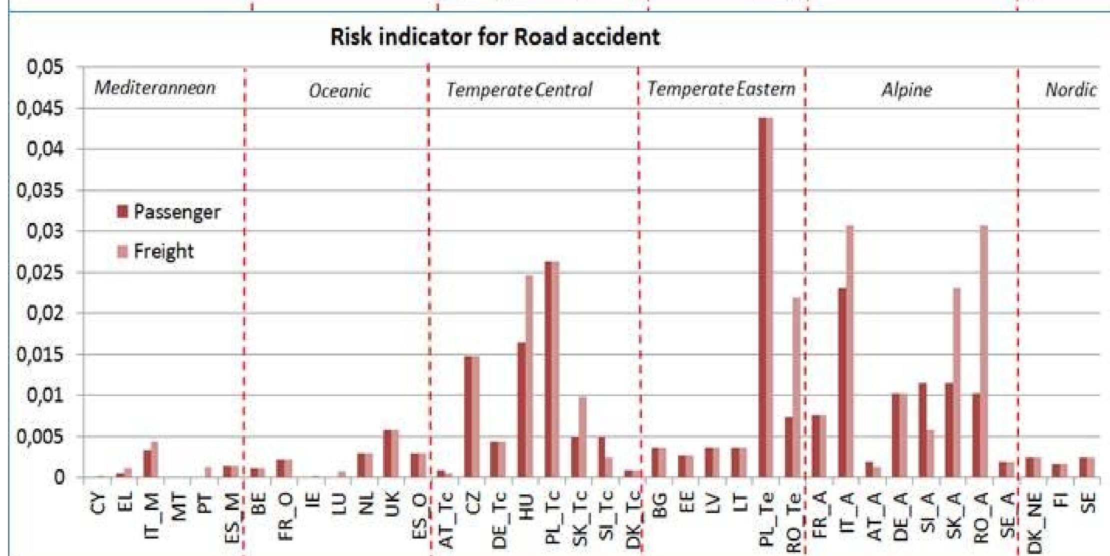
V = f (exposure, susceptibility, coping capacity)

Exposure
-Amount of passenger and freight
- Population density

Susceptibility
- Index of infrastructure quality

Coping capacity
- Gross domestic production (GDP)





Reference:
EWENT D.5.1 Risk panorama - Extreme weather hazards and vulnerability of European transport network

Conclusions

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

- The frequency and intensity of adverse and extreme winter phenomena is the highest in Northern Europe and Alpine regions → *The severity of disruptions and damages caused by these phenomena highly depends on the climatic zone and preparedness of the country.*

- The projected changes are expected to have both negative and positive impacts on road transportation:

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

  → Robust decrease in the probability of cold spells

  → The projections are less coherent with regard to extremes in wind and blizzard

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