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IMPACTS OF CLIMATE CHANGE ON WINTER MAINTENANCE AND ROAD INFRASTRUCTURE

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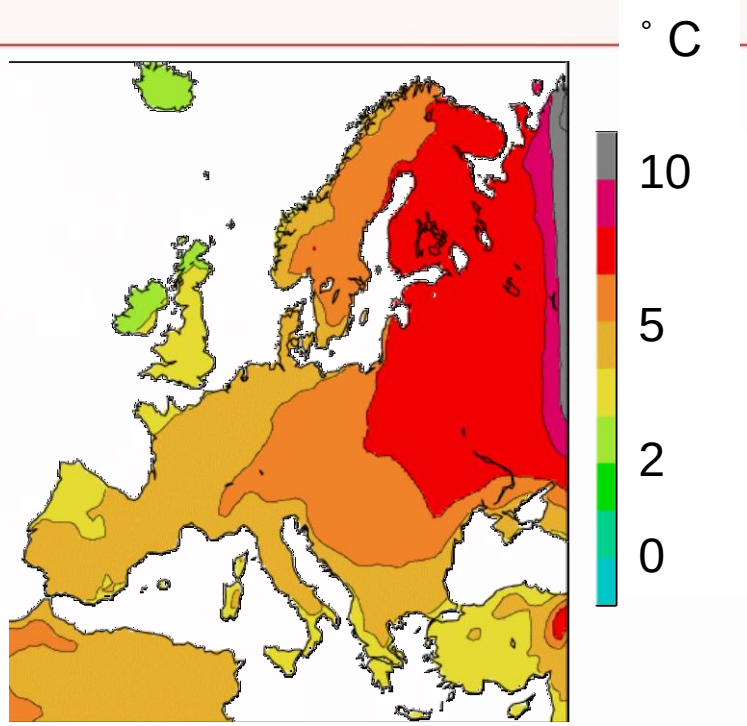
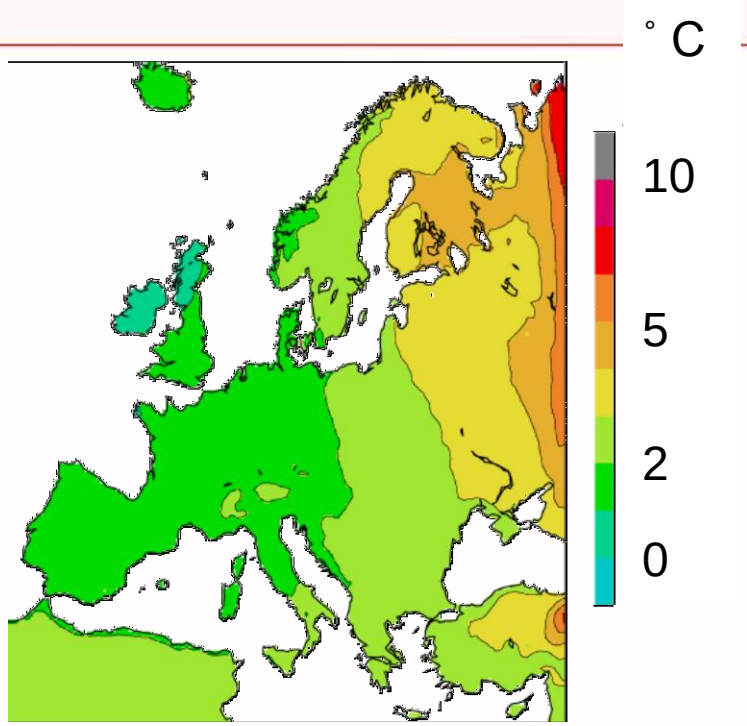
GLOBAL INCREASE OF TEMPERATURE - WINTER MONTH (2 m above surface)



biggest changes

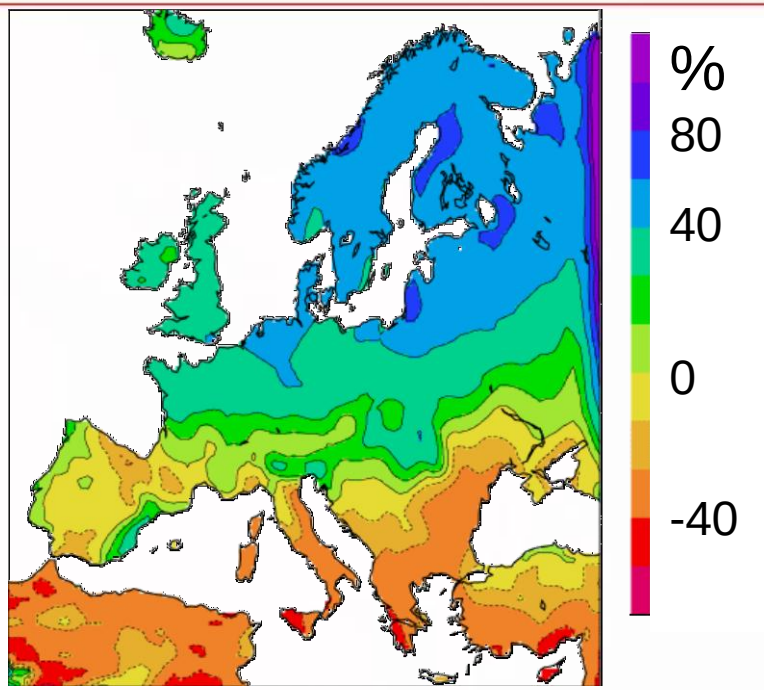


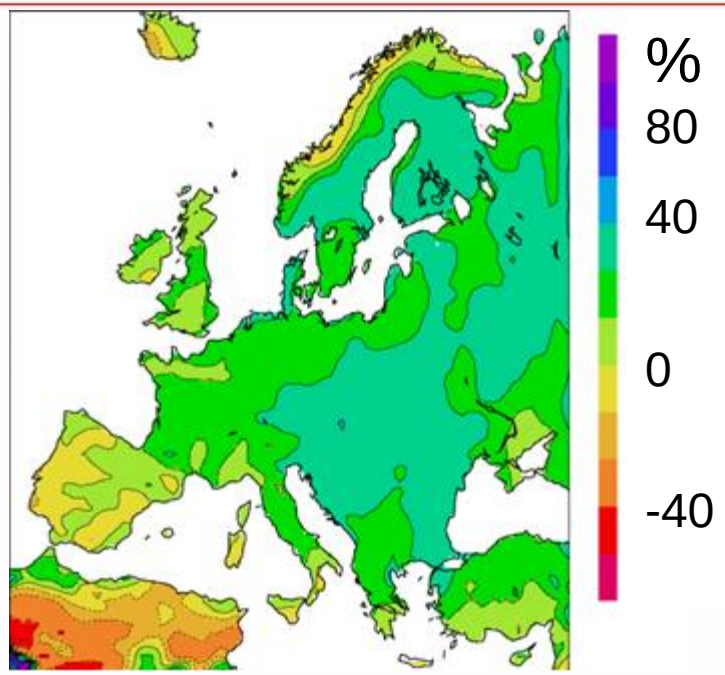
smallest changes

Changes from 1961-1990 to 2071-2100.

Rossby Centres scenarios *based on global simulations from Hadley Center in Great Britain and Max Plank Institute for Meteorology in Germany.*
A2- and B2-scenarios emission scenarios from United Nations climate panel

CLIMATE CHANGE – PRECIPITATION – WINTER MONTH





biggest changes smallest changes

Changes from 1961-1990 to 2071-2100

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EXPECTED IMPACTS ON WINTER MAINTENANCE

short term

- construction of winter budgets *(budget constraints, citizens expectations)*
-definition of appropriate contracts
(global amount ? number a winter operations ?)
-de-icers managements *(consumption, storage conditions, tons ordered, late order, emergency situations)*
- sustainable considerations *(dissemination into the environment, local consequences)*

long term

- investments on winter tools *(modularity of vehicles)*
- relevance of global RWIS
- development of tools dedicated to extreme, and sudden events
-manpower management *(massive retirements, loss of experience, training of winter staff)*

CLIMATE CHANGE EFFECTS ON WINTER MAINTENANCE
(literature)

- decrease in the number of frost days,
- decrease in the amount of snow precipitations,
- mild winters, and more humid ones,
- decrease in winter maintenance,
- decrease in the number of very cold days.

Variations very heterogeneous,

Function of regions (close sea shore, altitude, ...),

Occurrence of climate change on more regions as time goes,

Projections over extreme events too difficult to be properly considered

CLIMATE CHANGE IMPACTS ON INFRASTRUCTURES

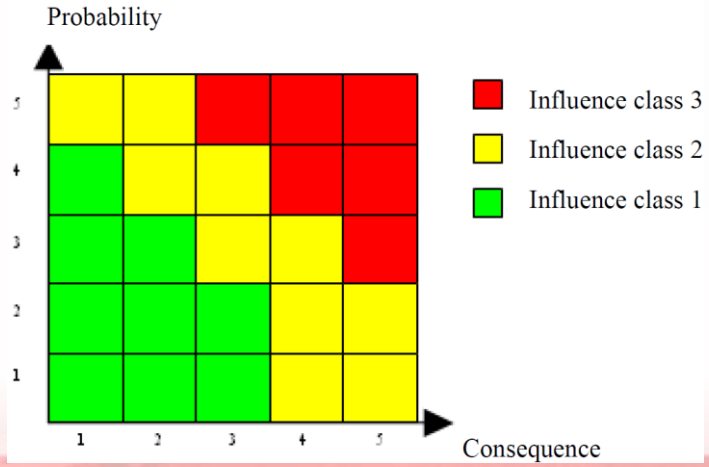
Necessity to establish risks analysis grids

Changes in precipitation and flow

Changes in temperature.

Changes in wind

Changes in sea level



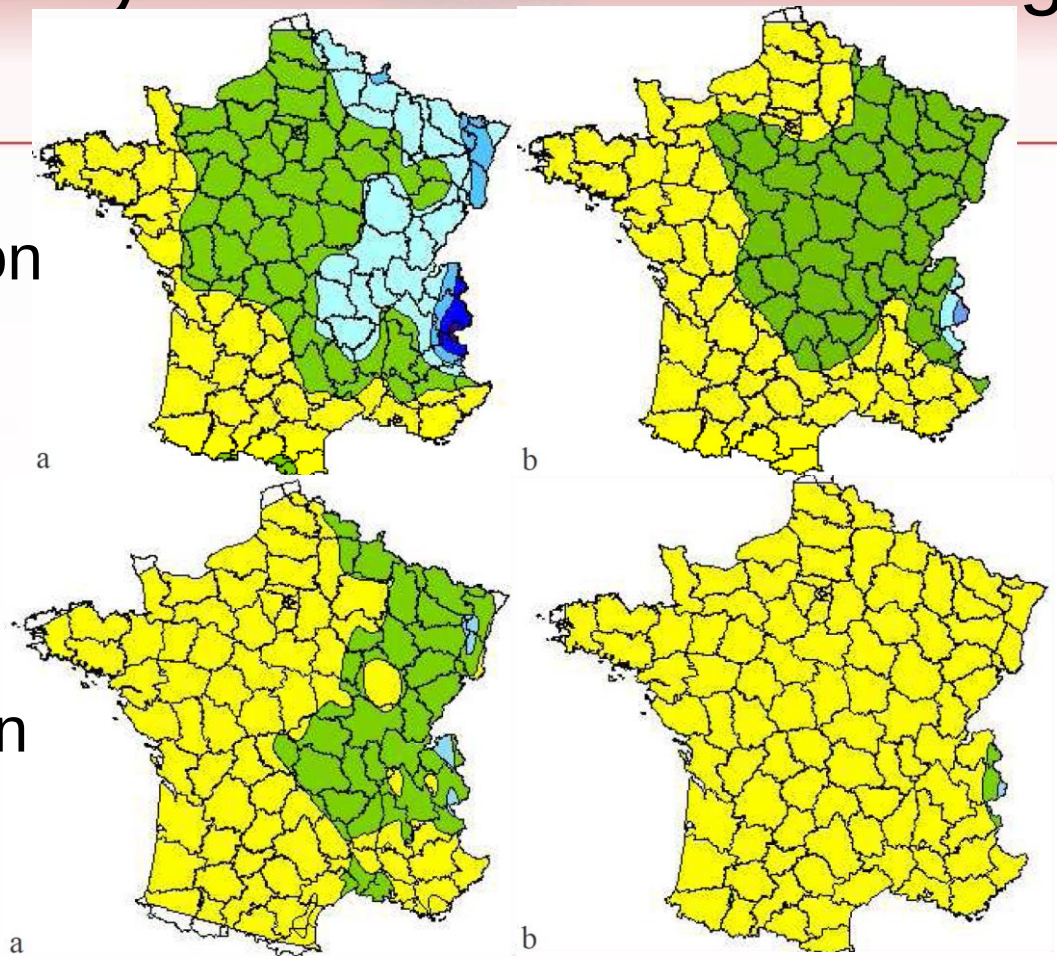
Effect of climate change and extreme weather events	Sweden	Norway	Finland	Denmark	Iceland	Faroe Islands
Changes in precipitation and flow						
Bigger landslides						
Roads and bridges washed away						
Flood						
Changes in temperature						
Wear of pavements						
Deformation of road construction						
Winter transport on frozen roads						
Break down of concrete constructions						
Icing of bridges						
Temperature effect on bridges						
Winter service						
Falling stones						
Changes in wind speed						
Big bridges and other vulnerable places						
A lot of fallen trees over the road after a storm						
Closing of high mountain roads						
Changes in sea level						
Tunnels						
Roads						
Ferry births						

ROAD CONSTRUCTION

Frost/thaw cycles. Frost dimensioning in France

current situation

future situation (2100)



exceptional winters

non-exceptional winters

Frost index less crucial

⇒ leniency on pavement construction rules

reduction in the amount of materials to improve frost susceptibility

or decrease of layers to stand winters

(yellow: 0-100°C.day, green: 100-200°C.day, clear blue: 200-300°C.day,mid blue, dark blue: >300°C.day)

Climate Event	Potential Impacts	Vulnerable Element and Design Parameters
Temperature	...se in annual temp... ...e the deterioration rate of ...withstand ...uts as load spre... ...pavements will decrease ...mer months. ...er stiffness. Furt... ...d permanent deformatio... ...es can be used in bitumen bounde... ...tension strain at the bo... ...s to withstand thermal ...resulti... ...gue live. ...raction related problems. ...n tempe... ...ll affect road transport operation a... ...ance cos... ...now and ice removal, salt for snow me...	
Frost thaw	...ased number of frost thaw cycles in pavements will affect su... ...wear. Drivi... ...ions will be affected. It will cause higher frequency of thawing ...reased seasonal degradation.	Surface aggregate requirements, frost susceptible design.
Rainfall and precipitation	...ty of summer and winter precipitation can create floods and ...with increased erosion and scouring as results. Probability of ... characteristics will be affected and wear due to higher frequency ... will increase. Driving conditions and visibility will be affected. ...nt in unbound layers increases causing softer layers with lower ...manent deformation.	Flood estimation analysis, return periods, design discharge, high flood level, river bank protections, drains size and shape. Slope protection. Design of base and subbase layers and material selection.
Storms and storm surges	...ated rainfall can create flooding and inundation on road ...using erosion and disrupt traffic safety. It can affect emergency ...tion as well as traffic signs and other road furniture.	Drainage capacity enhancements, increased height of road embankments. Wind load on road sign. Structural design, foundation.
Sea level rise	...evel will affect coastal roads. They may need to be realigned or ...dation in some areas.	Protection walls and berm – breakwaters, realignment of road sections, edge strengthening.

CONCLUSIONS – ROAD CONSTRUCTION

- The main climate factors that affect pavement performance are temperature, water (moisture content) and frost thaw.
- A mechanistic empirical approach can predict performance of pavement structures. However, the accuracy of the method needs be improved.
- Model describing the temperature dependency of material behaviour are working quite satisfactorily.
- Moisture content (MC) within the pavement structures varies in time and space. MC has a great impact on the material behaviour of unbound granular material and soils and is therefore affecting the pavement performance. Enhanced knowledge is needed to improve our understand of how water is affecting the pavement structure.
- Seasonal variation and frost thaw cycles have great impact on the performance of pavements. No performance models are available that links frost thaw with performance.

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Thank you