Impact du changement climatique sur les chaussées

Christ van Gurp - JERI 2017

Trust
Quality
Progress

Impact of climate change on road pavements

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Trust
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Intergovernmental Panel of Climate Change

IPCC report predicts:

- Earth will become warmer
- Some regions will become wetter, other will become drier
- Sea levels will rise
- Snow cover and the extent of sea-ice will reduce
- Frequency and severity of extreme weather events will increase

Warning IPCC

- Climate change has a significant impact on design, construction, maintenance and operation of global road infrastructure
- Action must be taken
- Road infrastructure owners must adapt their programmes, strategies, activities, policies and standards

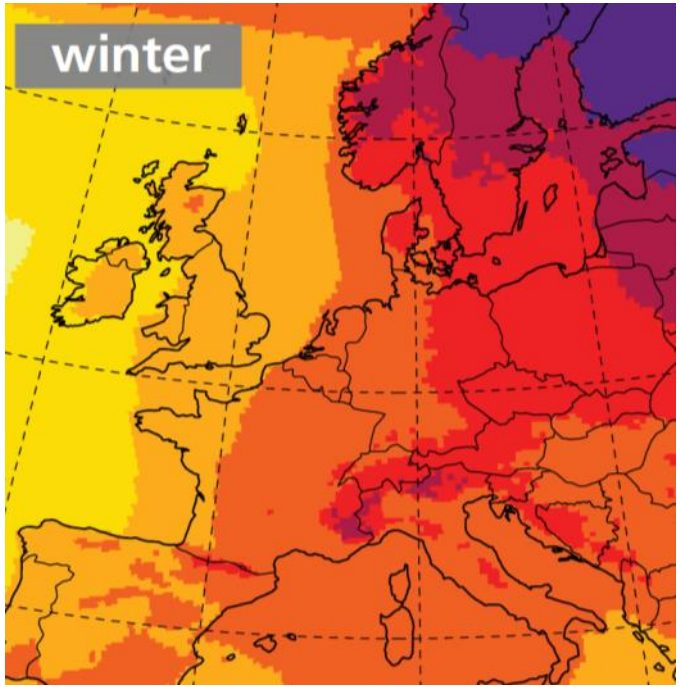
Climatic changes

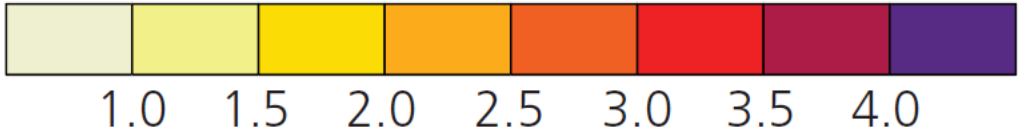
- Temperature
- Precipitation
- Wet and dry periods
- Wind, storm and gales
- UV radiation
- Rise of sea level

Major climate hazards in road infrastructure

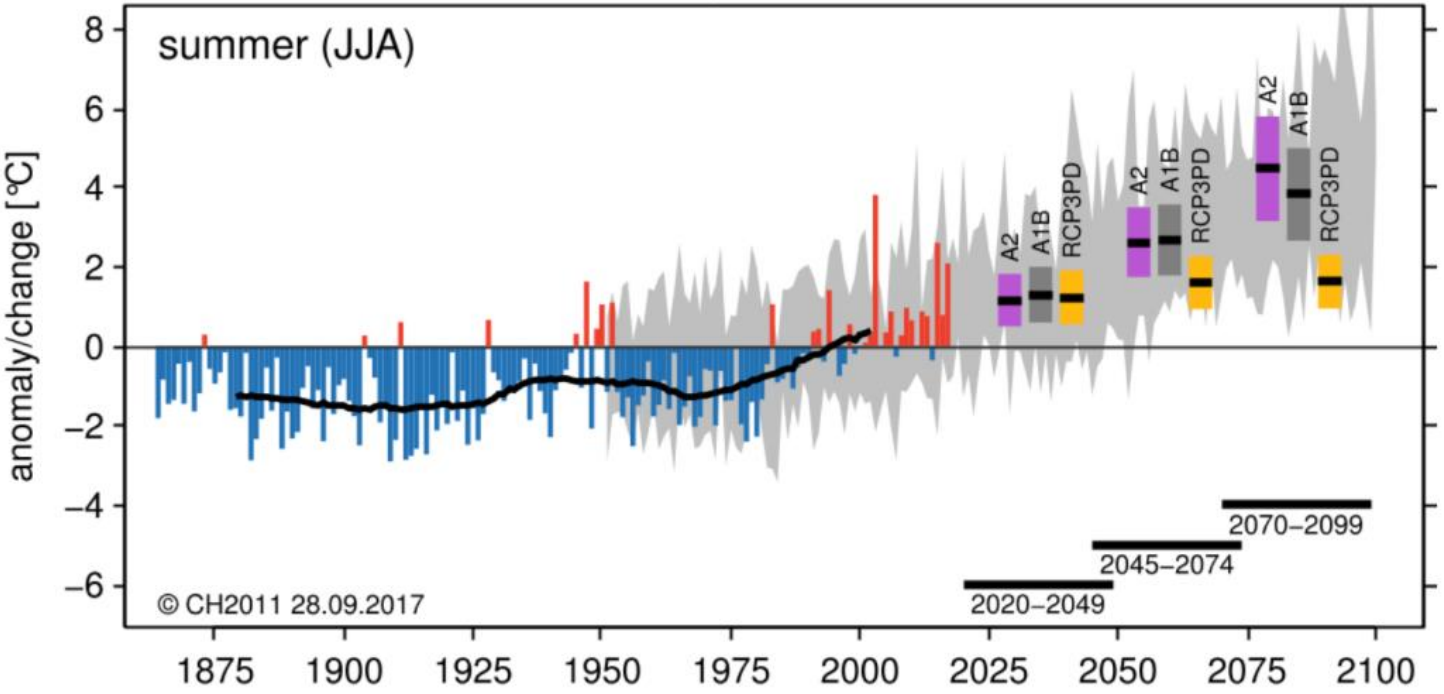
- Gradual changes to average climatic conditions
  - temperature
  - seasonal precipitation levels
- Changes to the frequency, severity, and location of extreme weather events
  - precipitation (hours) with risk of excess water
  - heat wave (days) with high pavement temperatures
  - drought (weeks) with large changes of moisture content

Climatic changes in Europe – Temperature

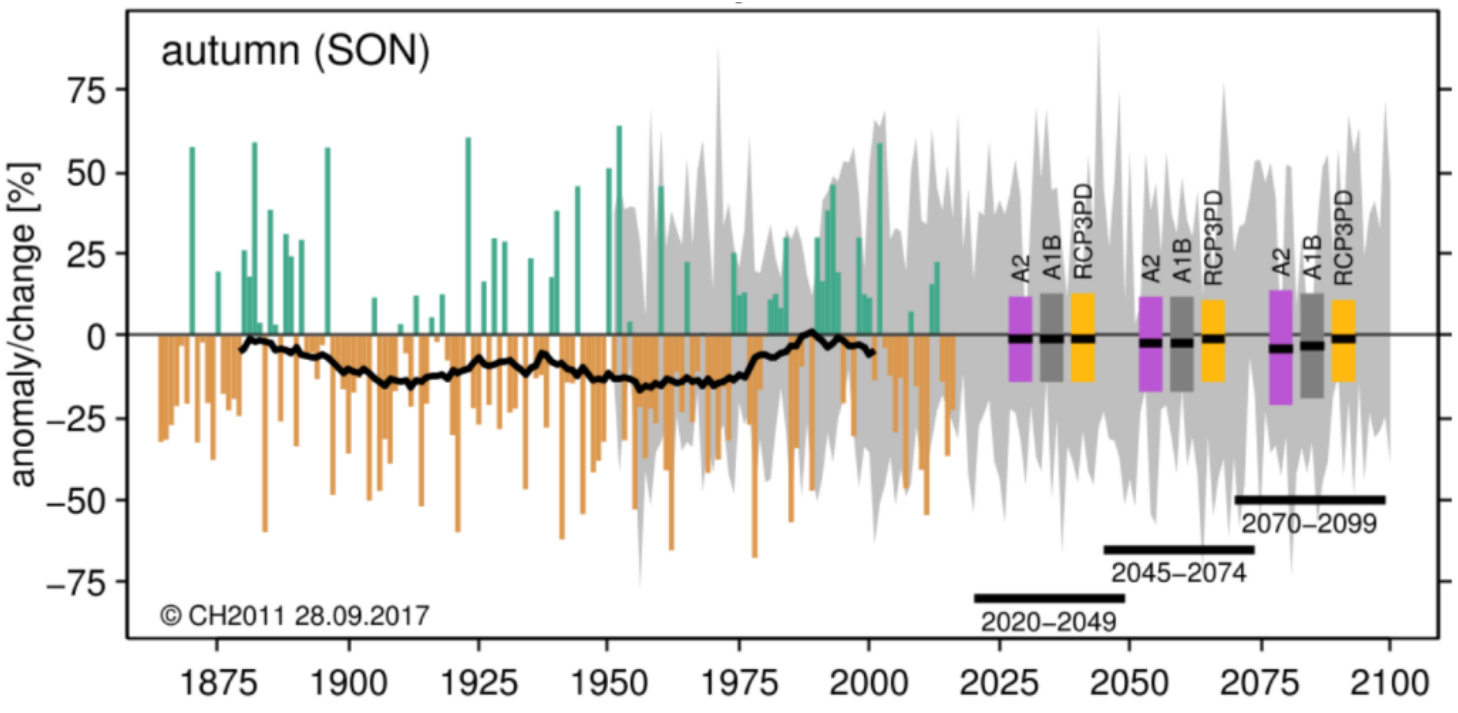




Temperature deviation from norm Western Switzerland - Summer



Precipitation deviation from norm
Western Switzerland - Autumn

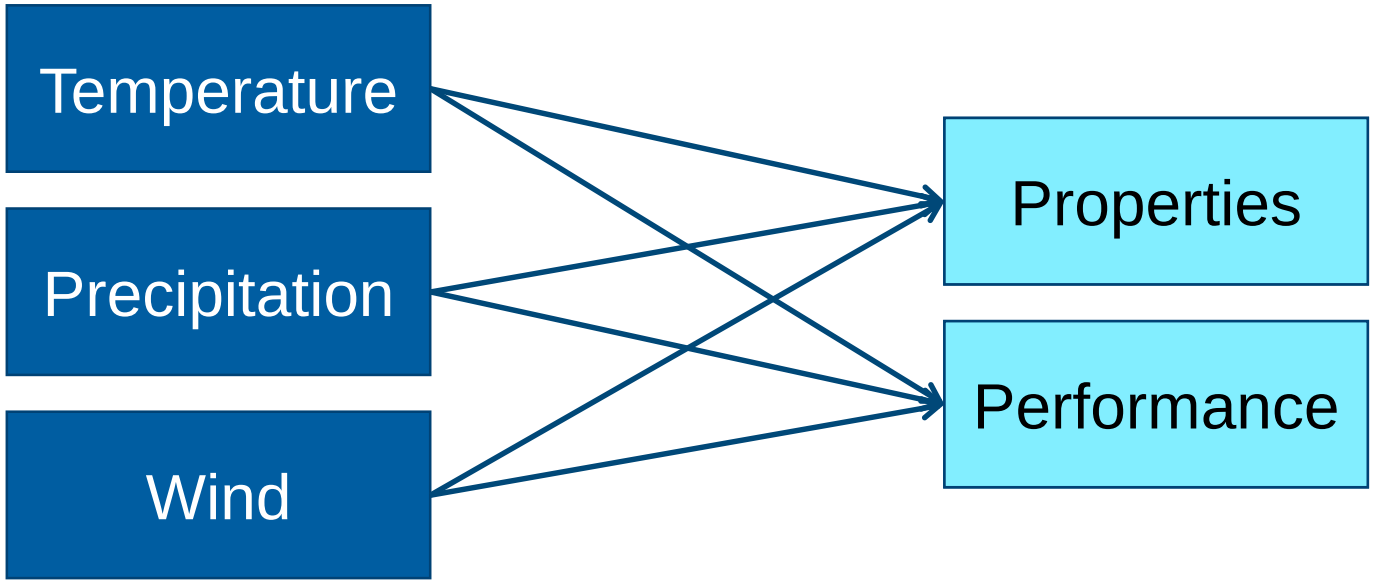


The risks of a changing Alpine climate

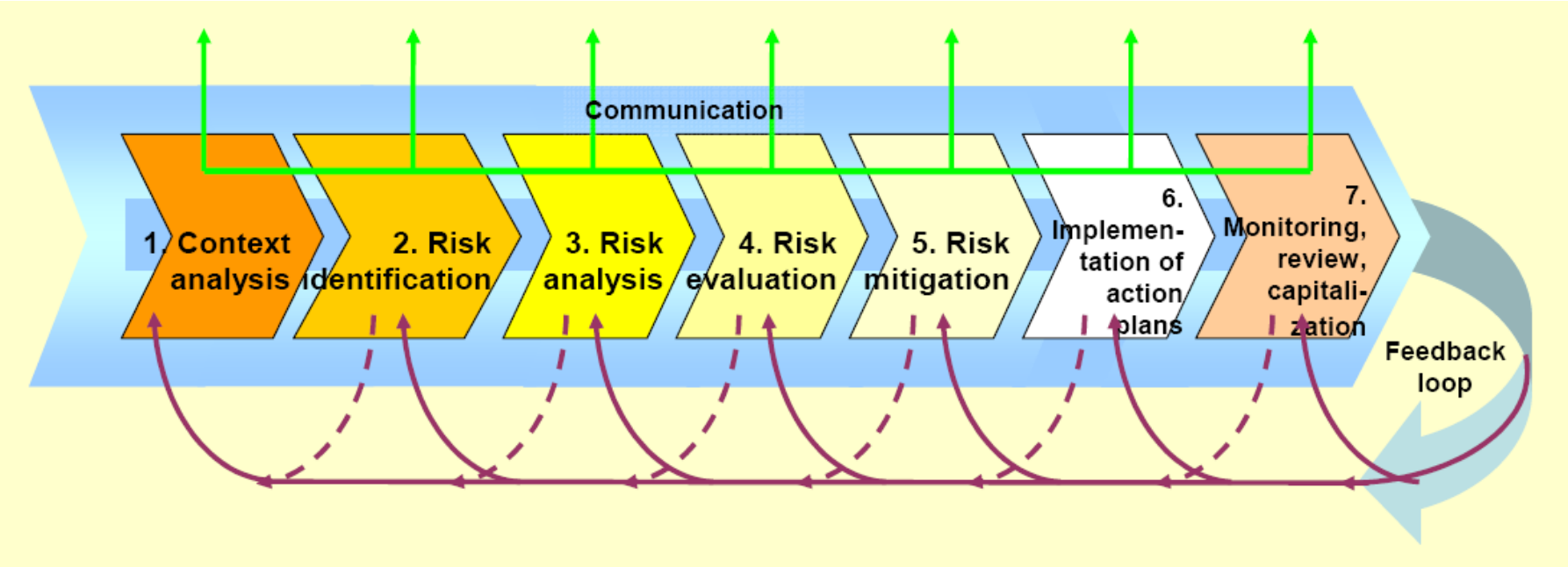
- Summers are expected to keep getting warming and drier (whole year gets hotter)
  - temperature rise between 2.7 and 4.8°C
  - reduced temperature rise between 1.2 and 1.8°C in stabilisation scenario
- Winters are expected to become moister
  - shift from snow to a greater amount of rain
  - risks of rock falls, more melting water and more flooding
- Heavier rainfall is becoming more frequent
  - but 18 to 28% less precipitation in summer
  - and 8 to 10% less precipitation in summer in stabilisation scenario
  - uncertain projections of total and intensity of precipitation

Changes of primary parameters

- Climate
- Infrastructure



Risk Management for Roads in a Changing Climate



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Local hazard points

- Geology
  - type of soil
- Geography
  - close to river
  - cutting, embankment
- Drainage
  - run-off, maintenance level
- Pavement condition
  - cracks, joints
- Traffic
  - cars or trucks

Local hazard points

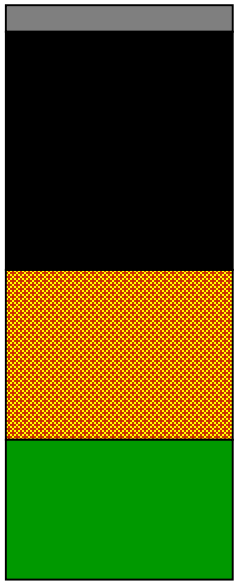
- Pavement type
  - asphalt pavement
  - rigid pavement
  - modular pavement (blocks)
  - bound or unbound road base
- Pavement material
  - type of mineral aggregate

Consequences of higher temperatures in asphalt pavements

- Accelerated ageing of bitumen
  - higher risk of surface cracking and fretting, ravelling
  - especially at top of pavement and in open graded mixes
- More bleeding or flushing
- More surface rutting
  - depends on number of very hot days
  - traffic safety issue when water ponds in the ruts
- Effect on cracking is complex
- Potentially reduced skid resistance
  - more dirt on pavement surface at end of dry periods
  - more cleaner pavement and better skid resistance after periods of heavy rain

Assessment sensitivity of pavement performance to temperature

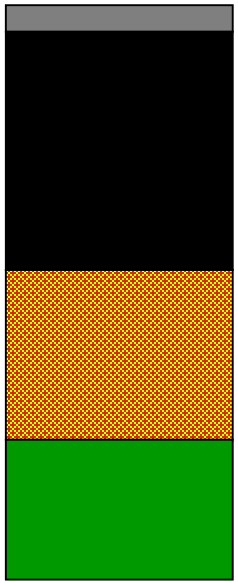
Fully flexible pavement structure



35 mm AC wearing course	E = 2000 MPa
315 mm AC base layers	E = 5400 MPa
225 mm Granular sub-base	E = 150 MPa
Semi-infinite soft subgrade	E = 50 MPa

Assessment sensitivity of pavement performance to temperature

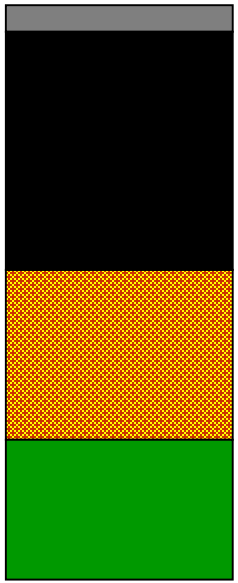
Fully flexible pavement structure



		Pavement temp rise 1°C
35 mm AC wearing course	E = 2000 MPa	E = 1840 MPa
315 mm AC base layers	E = 5400 MPa	E = 4970 MPa
225 mm Granular sub-base	E = 150 MPa	E = 150 MPa
Semi-infinite soft subgrade	E = 50 MPa	E = 50 MPa

Assessment sensitivity of pavement performance to temperature

Fully flexible pavement structure



Pavement design life N = 36 Mio ESALs

Loss of design life by 16%?

Pavement temp rise 1°C

N = 30 Mio ESALs

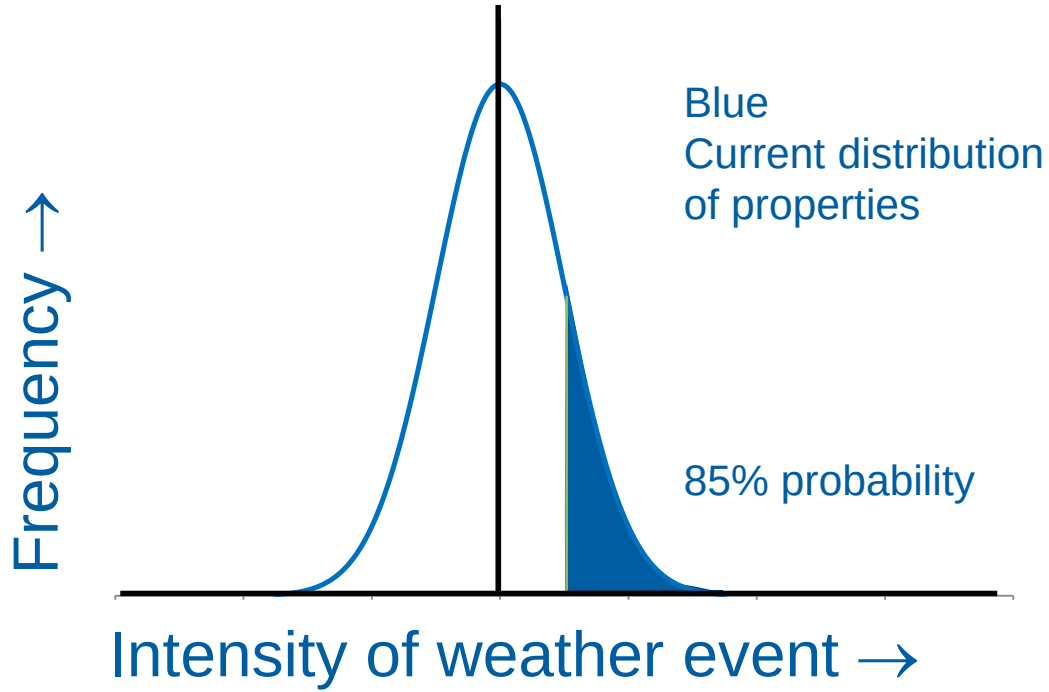
Better to express effect of temperature change in probability

Standard procedure:	85%
Temp. rise 1°C:	81.8%
Compensation needed:	3% of AC thickness

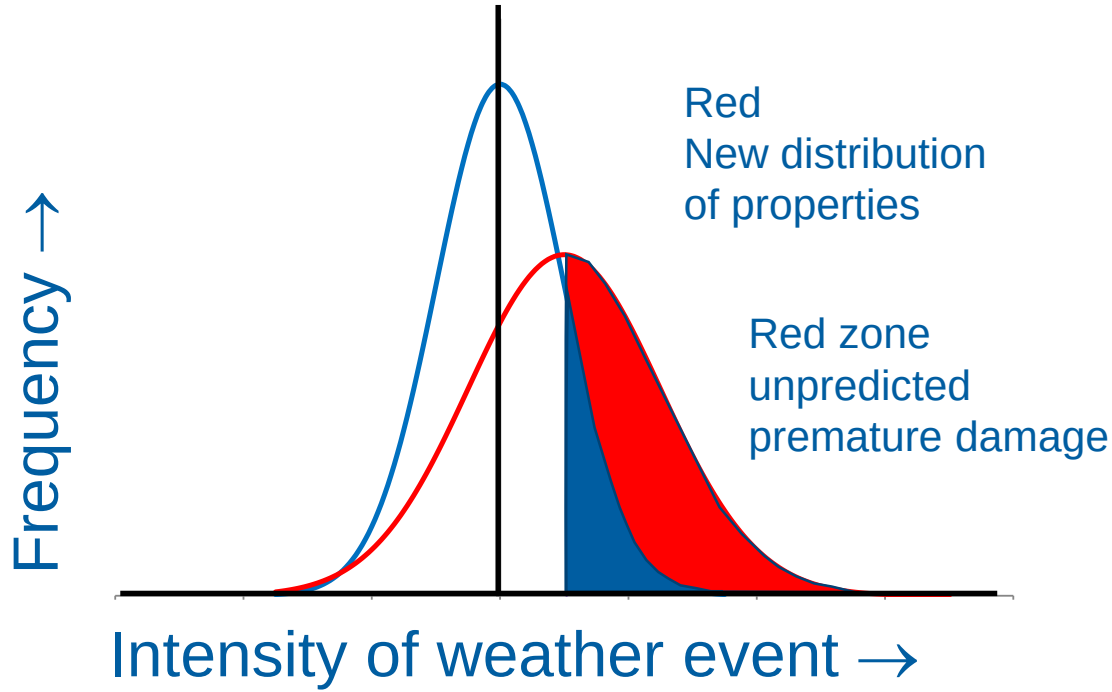
Climatic influences on design temperature

- Road infrastructure is typically designed to withstand local weather and climate
- Temperature predictions are different from historical data
- Rise of air temperature by 1°C results in rise of asphalt temperature of 2°C
- Truck intensities and weights increase annually
- Trucks predominantly travel during daylight with higher temperatures

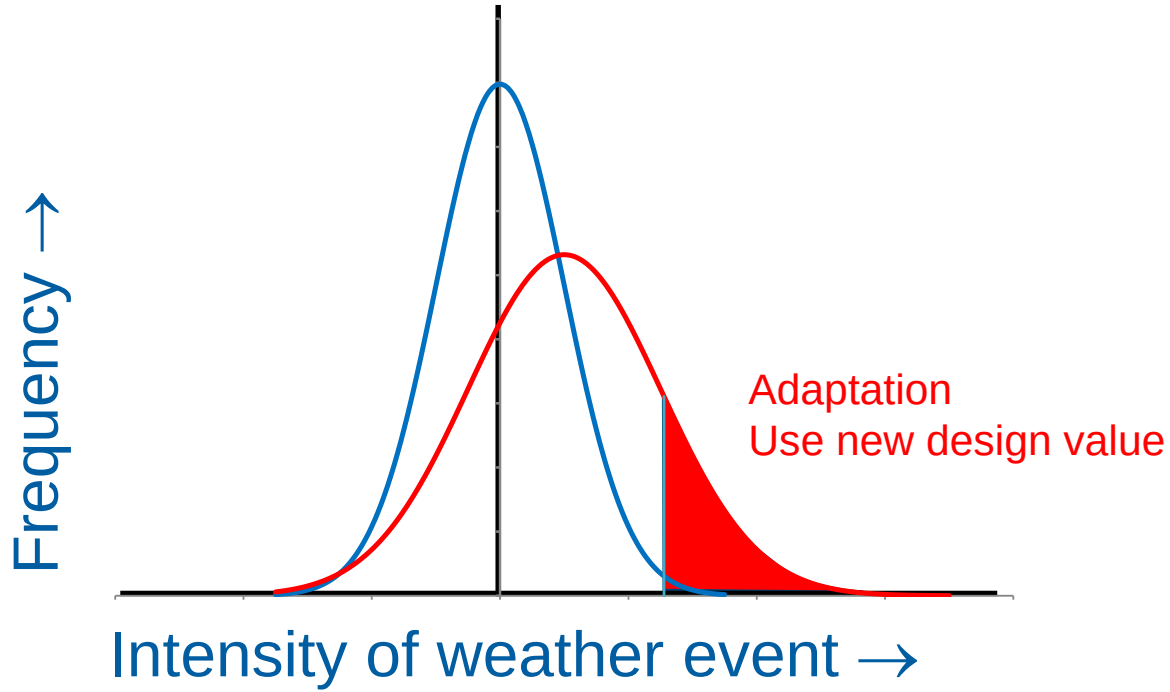
Critical design value



Critical design value



Critical design value



Consequences of higher temperatures in asphalt pavements with cement bound bases

- Higher temperatures in bound base due to higher temperatures at pavement surface
- Higher temperature gradient in bound base
- Higher tensile stresses at the bottom of the bound base
- In most countries cement bound bases are pre-cracked
  - reduction or prevention of thermal movements
  - thermal movements cause reflection cracking

- Adaptation: None; no effect on behaviour and performance by climate change

Consequences of changes of precipitation and wet/dry periods in asphalt pavements

- Effect of granular layers, substructure and local environment
  - cutting, embankment, along a river, etc.
- Effect on asphalt mix

Extreme weather events - Precipitation

- Reduced bearing capacity
- Flooding of the road
- Erosion, debris and mud deposits
- Infrastructure might wash away.
- Slope instability
- Landslides of infrastructure
- Damage to embankment

- Reduce risk of water and mud flow

Extreme weather events - Drought

- High plasticity soils
  - Only 0.5% of CH countryside
- Moisture dry-out via vegetation
- Salinity problems
- Soil shrinkage
  - subsidence
  - increased roughness
  - cracking

- Be selective in choice of trees

Impact of moisture on asphalt mixes

- Run-off problems
  - especially at wide motorways

- Adaptation
  - consider porous asphalt
  - apply transverse grooving
  - no increase of cross fall

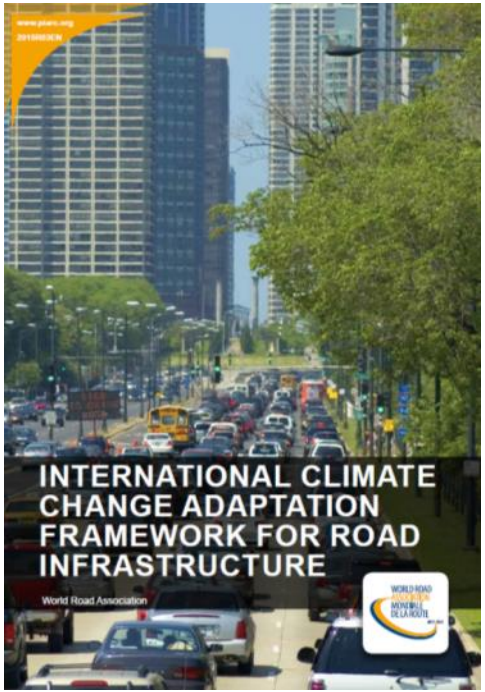
Impact of moisture on asphalt mixes

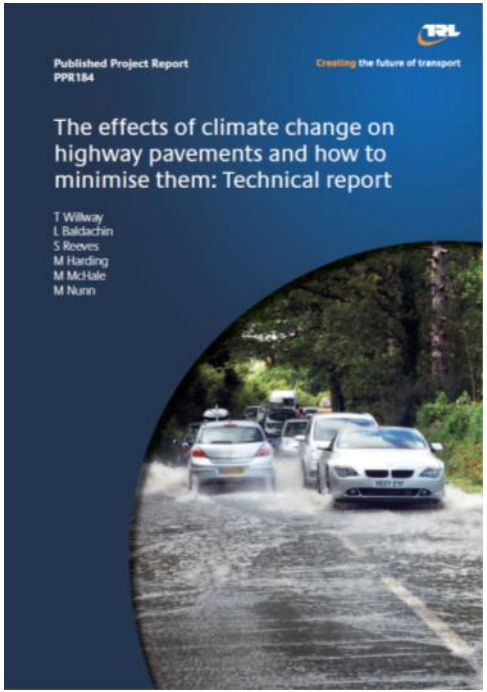
- More splash & spray in PA
- AC stripping
  - adhesion water-stone is better
  - more in open graded mixes
  - increased fretting and potholes
- Adaptation
  - prevent water ingress
  - use good aggregate skeleton
  - less temperature sensitivity

Conclusions

- Climate change, and especially extreme weather events, will impact on the performance and the costs of operating a road network
- Road owners/operators should quantify their risk profile
- Technical solutions are available
  - proper drainage
  - stable skeletons in asphalt mixes with robust components
  - more appropriate target values of principal design parameters
- Adaptation can be combined with normal rehabilitation
- Focus on durability to moisture effects
- Climate change has become a reality; need to start acting now

Guidance





- Thank you for your patience
- Questions?