Adaptation of the Dutch Building Sector to climate change

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TNO | Knowledge for business

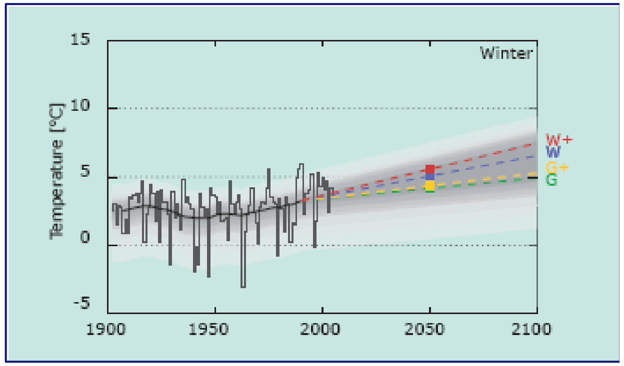
Focus

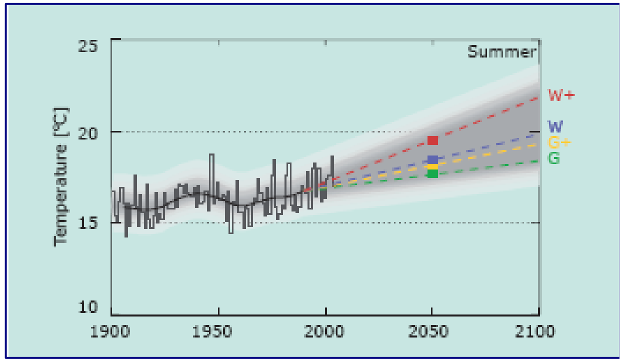
- Durability of building materials
- Structural safety
- Indoor environment

- Existing buildings
- New buildings

Climate change scenarios – KNMI’06

		G	G+	W	W+
	Global temperature rise	+1°C	+1°C	+2°C	+2°C
	Change in air circulation patterns	no	yes	no	yes
Winter	Average temperature	+0.9°C	+1.1°C	+1.8°C	+2.3°C
	Coldest winter day per year	+1.0°C	+1.5°C	+2.1°C	+2.9°C
	Average precipitation amount	4%	7%	7%	14%
	Number of wet days (≥ 0.1 mm)	0%	1%	0%	2%
	10-day precipitation ∑ exceeded once / 10 years	4%	6%	8%	12%
	Maximum average daily wind speed per year	0%	2%	-1%	4%
Summer	Average temperature	+0.9°C	+1.4°C	+1.7°C	+2.8°C
	Warmest summer day per year	+1.0°C	+1.9°C	+2.1°C	+3.8°C
	Average precipitation amount	3%	-10%	6%	-19%
	Number of wet days (≥ 0.1 mm)	-2%	-10%	-3%	-19%
	Daily precipitation ∑exceeded once / 10 years	13%	5%	27%	10%
	Potential evaporation	3%	8%	7%	15%





Building Materials

What happens to our cultural heritage ?

T. Nijland, O. Adan, R. van Hees

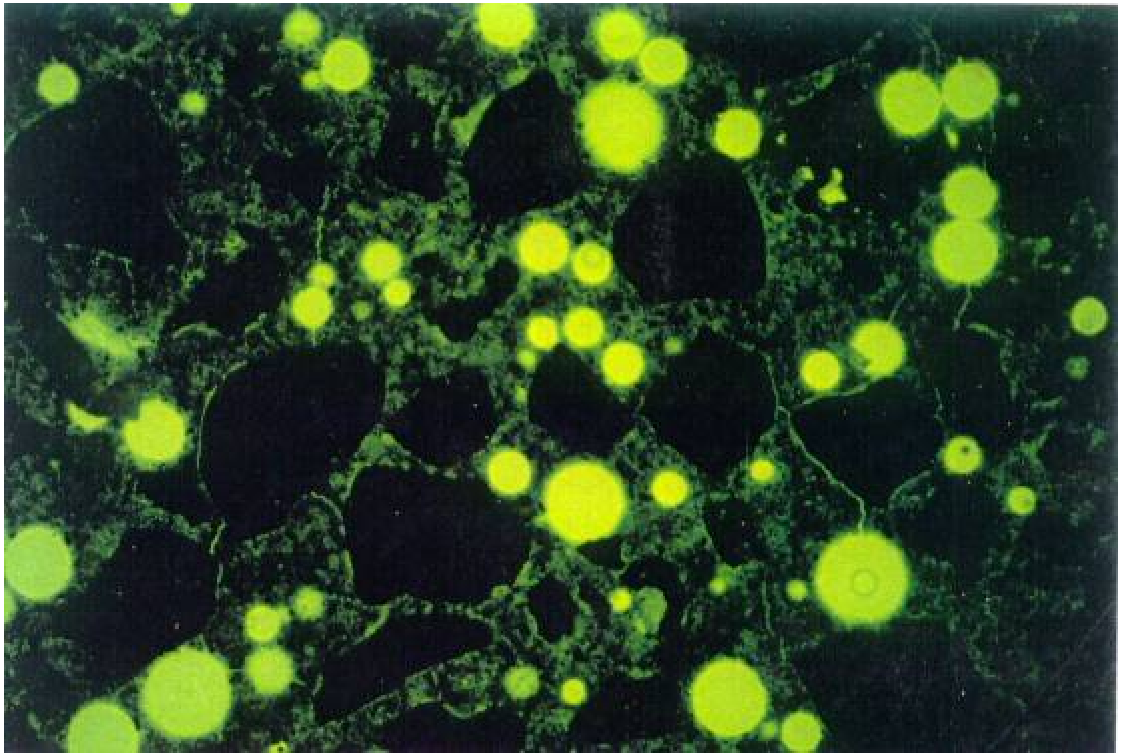
Salt damage:
possible increase

Biocolonization:

faster

Freeze-thaw damage:

application of more frost-resistant materials



Biodeterioration:

increasing

Rebar corrosion in concrete:

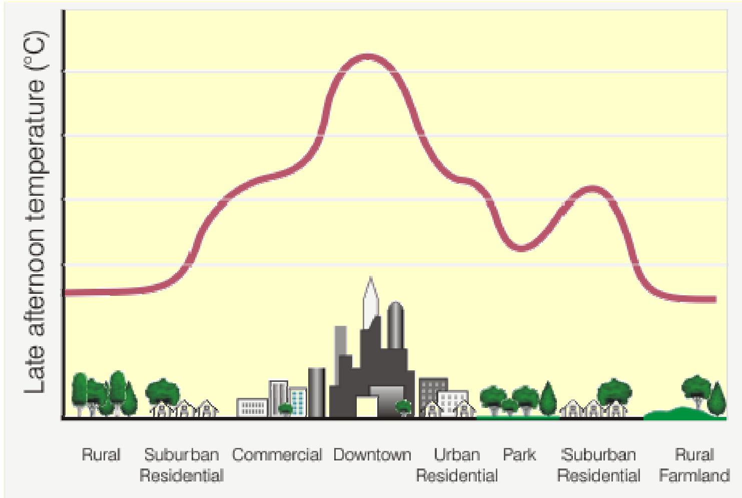
possible decrease due to less deicing salts ?

Indoor environment

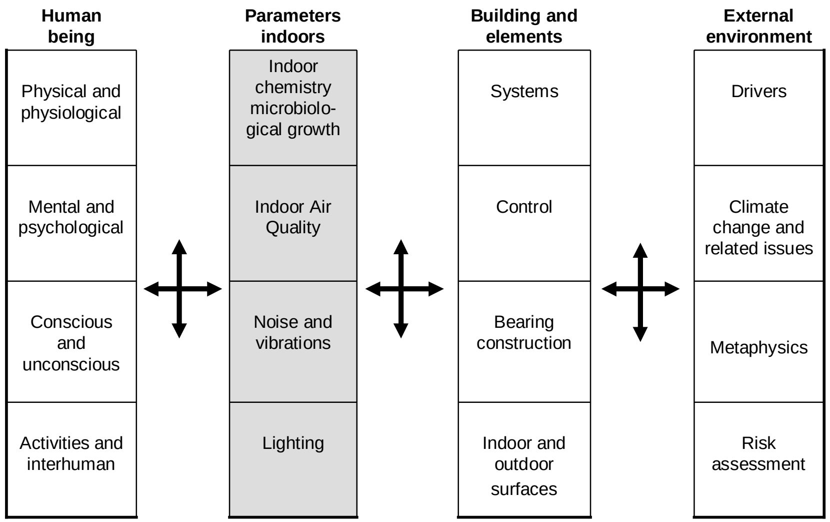
What measures do we need to cope with increasing indoor temperatures?

Indoor environment

- Urban Heat Islands



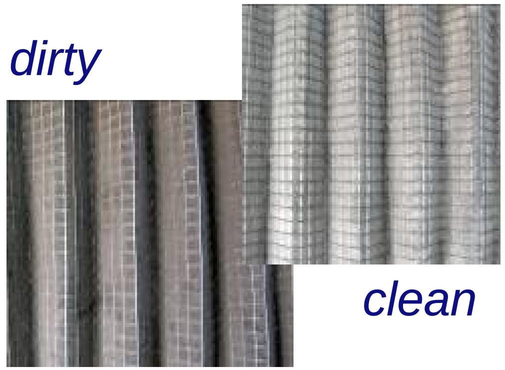
- Indoor environmental factors:
  - Indoor air quality
  - Thermal comfort
  - Acoustical quality
  - Lighting quality



M. Aries, P. Bluyssen

consequences for the indoor environment

- Direct consequences:
  - Effect on thermal comfort
    - changes in need space heating
    - risk summertime overheating
    - occurrence of need for comfort cooling
  - Effect on air quality
    - performance of mechanical air conditioning systems

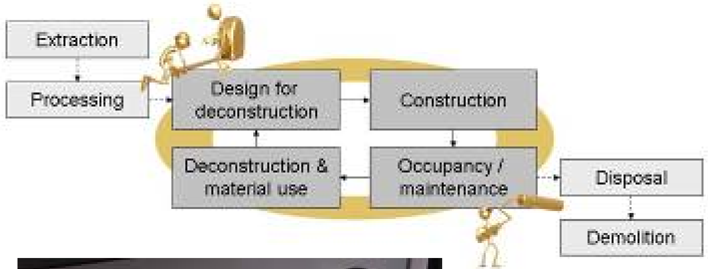


consequences for the indoor environment

- Indirect consequences
  - Effects on lighting quality
    - people stay inside and block sun light
  - Effects on acoustical quality
    - Disturbance due to vibrations or noise (AC)
  - Effects on psycho-social aspects
    - Stress, fear, obesity

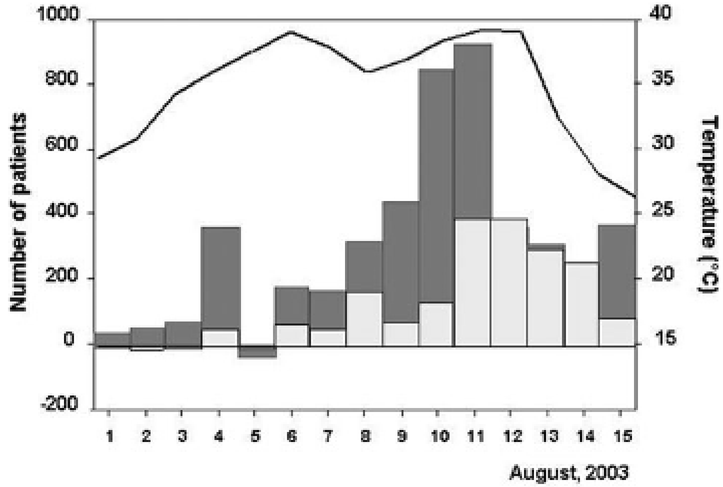
Adaptation

- The adaptation process at three levels:
  - Adjust the **source**
    - Smart metering
    - Solar energy
    - …
  - Adjust the **building**
    - Foliage as natural sun screen
    - Night cooling
    - …
  - Involve **people**
    - Building process
    - Personal environmental control
    - …



How to proceed

- Global warming inescapable for indoor climate
- Adaptations necessary to reduce impact
  ⇒ health effects!
- Understanding required:
  - Possible climate change effects on occupants' wishes and needs
  - Interactions of occupants with (building) environment
  - Quantified models to choose appropriate measures



Maximal temperature in the Paris area,
excess emergency department visits (grey bars),
and hospital admissions (white bars)

Discussion on some examples

- Green roofs
  - Claims: reduces urban heat island effect
    reduces fine particles in city
    buffers rain water
  - Only qualitatively described
  - Need for quantified information; performance based.

  - Water needed in dry periods
  - Maintenance during lifetime issue

- Solar-reflective materials
  - Lifetime of surface / coating
  - Performance indicators lacking

Structural safety

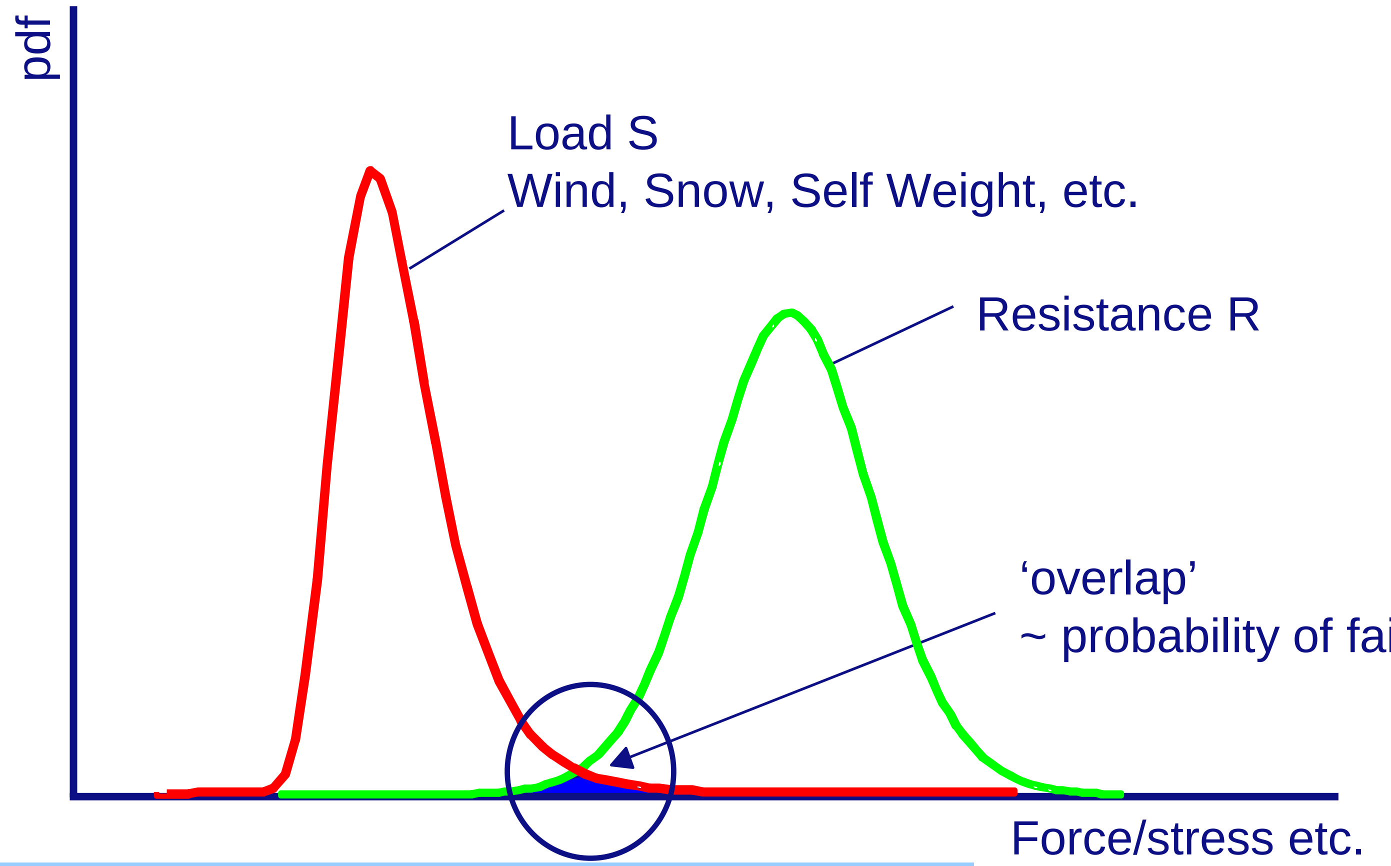
Do we need to change our design loads for

Wind

Rain (ponding)

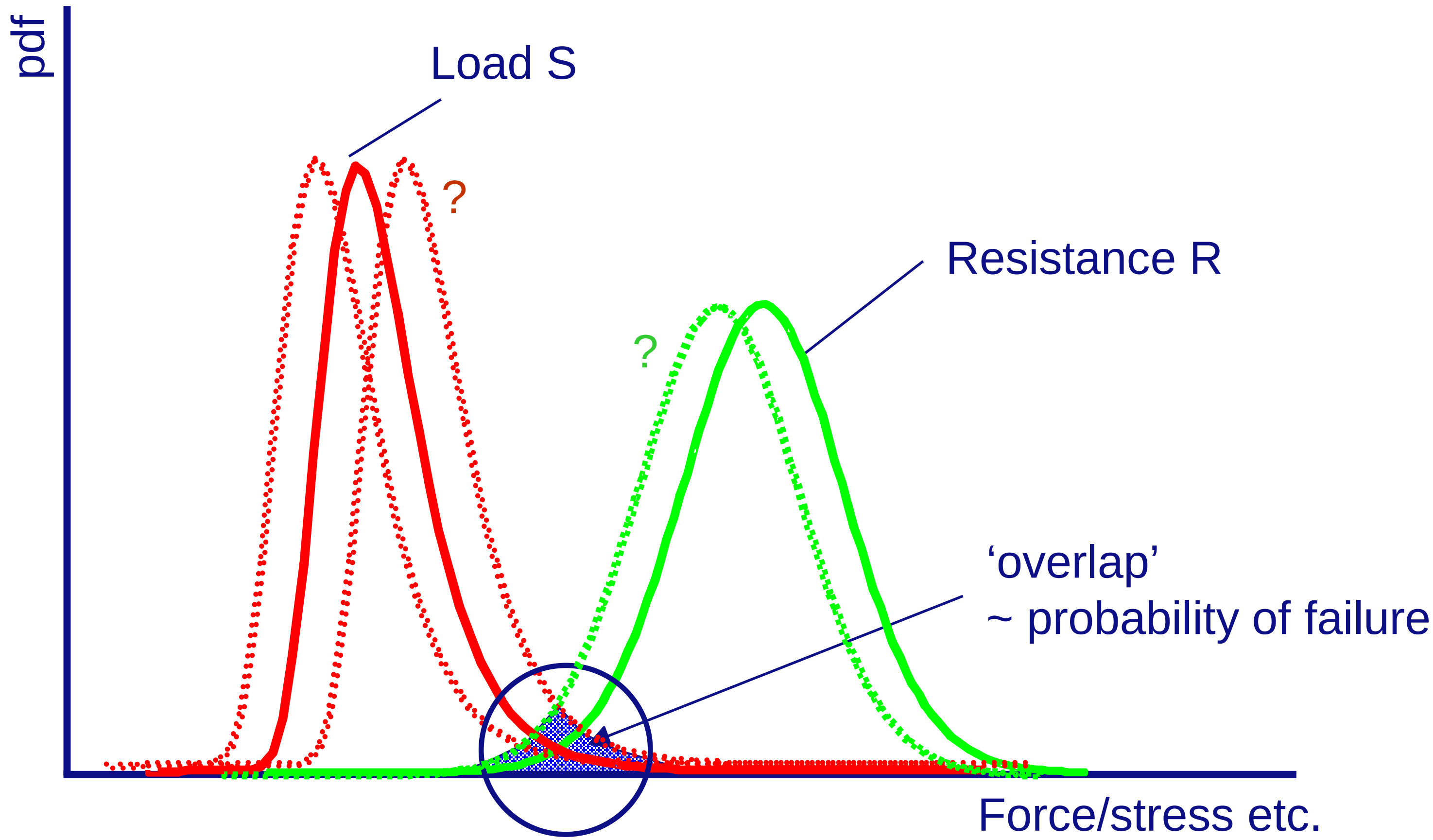
Snow

Structural Safety: Performance based



R. Steenbergen, C.P.W. Geurts, C.A. .van Bentum

Impact of climate change



Climate factors and structural safety

- Focus on extreme events
  - Typically once in 1000 years
  - Short duration events
    - Wind: 1 to 3 seconds
    - Rain: 5 minutes
    - Snow: hours (1 event)

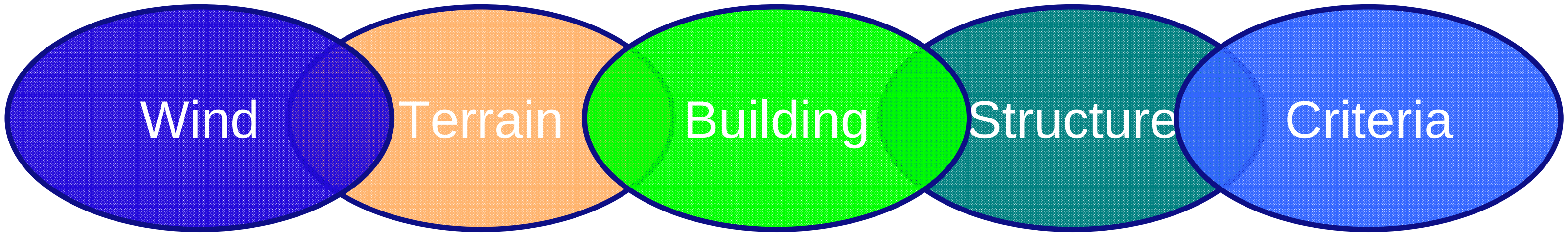
- Structural safety depends on
  - Climatic actions
  - Local effects
  - Size of building
  - Material properties

Developments in building technology

- Exposed value
- Designing on the edge
- New materials
- New functions added

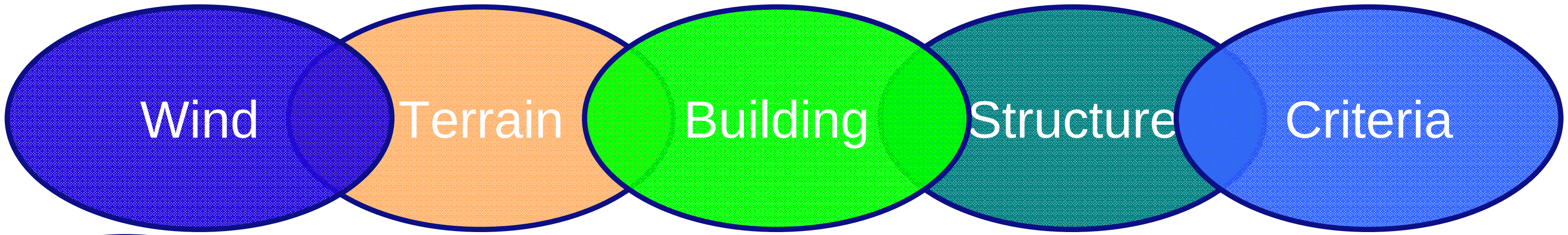
Example: storm damage to buildings

Wind loading chain



Wind climate	Terrain roughness	Shape	Material properties	Strength
Statistics	Turbulence	Dimensions	Structural properties	Stiffness
Reference period	Gust factor	Pressure coefficient	Natural frequency	Accelerations
Basic wind speed	Spectral density	Force coefficient	Damping	
	Peak dynamic pressure	Coherence		

Wind loading chain



Wind climate
Statistics
Reference period
Basic wind speed

Terrain roughness
Turbulence
Gust factor
Spectral density
Peak dynamic pressure

Shape
Dimensions
Pressure coefficient
Force coefficient
Coherence

Material properties
Structural properties
Natural frequency
Damping

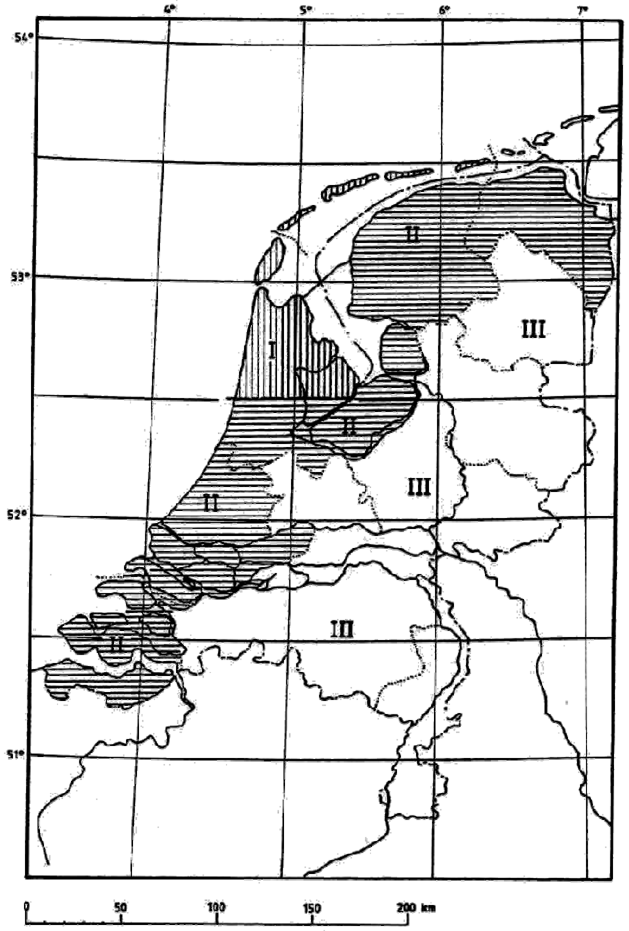
Strength
Stiffness
Accelerations

Wind climate; European building codes

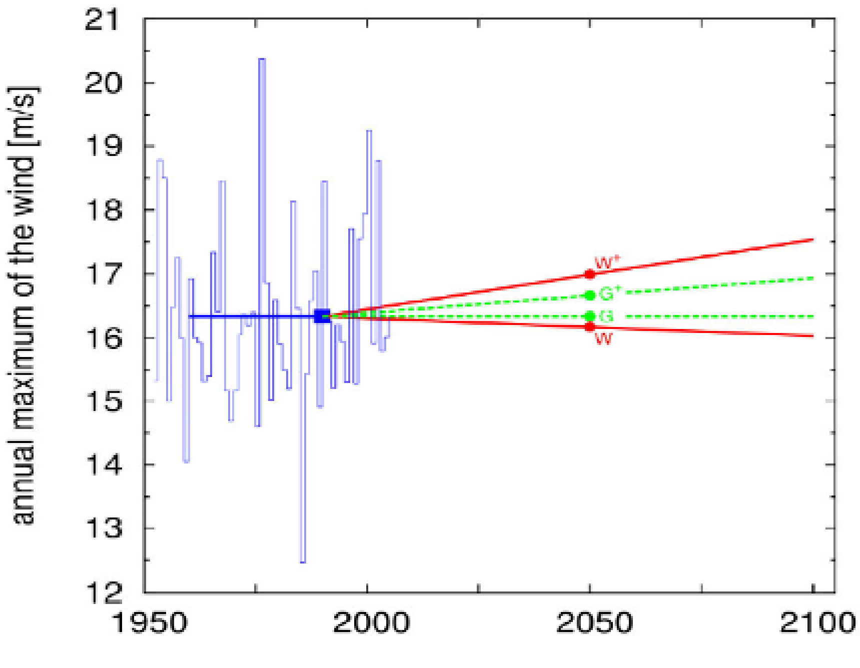
Basic wind speed:

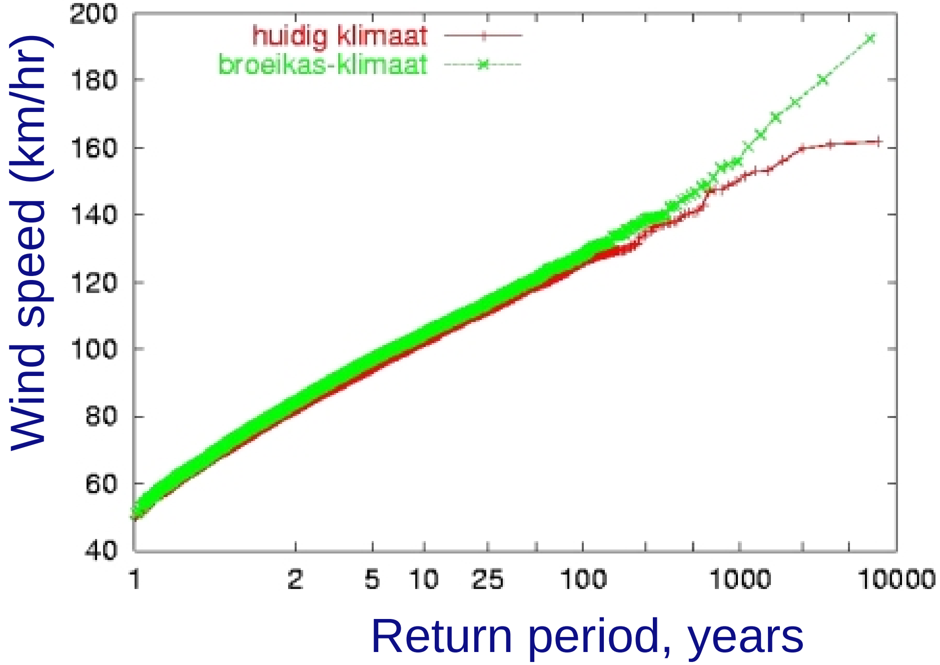
10 minute mean wind speed
at 10 metres height
above standard smooth terrain (z_0 = 5cm)
with a return period of 50 years

Do we need to adjust this basic wind speed ?



Impact of climate change on storms





Annual maximum

Extremes at large heights

Storm damage and adaptation

- Slight increase in basic wind speed in building codes needed; may be dependent on year of construction
- First estimates: 27.5 m/s -> 28 m/s (W+); load increases 4%
- Existing buildings; lower level of safety accepted.
  - If properly designed and maintained, no adaptation
  - Monumental buildings need careful attention

Ponding

1: Roof deflects under rainwater loading
2: Additional rainwater runs to the deflected spot
3: This leads to additional loading ->larger deflection, etcetera.
4: Ultimately, the roof collapses

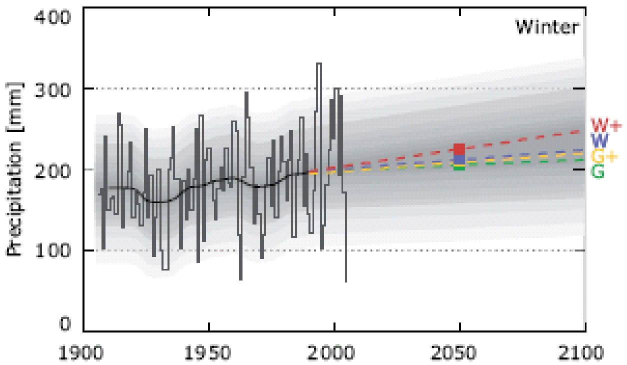
In the Netherlands, 20 collapses per year.

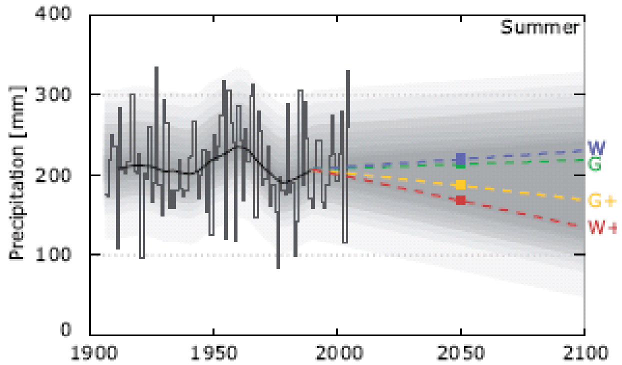
Picture from: Register Makelaar 5 2003, Ing. R.H.C. Govaert re

Ponding

- Basis in Dutch building standard:
  - extreme in 5 minutes, R = 50 years
  - Observation period 1906-1990

- KNMI’06 scenarios
  - Winter: average precipitation (+4% .. +14%)
  - Summer: 1-day precipitation (+5% .. +27%)
  - 5 minute extremes not estimated
  - Indicates increase of extremes





Ponding

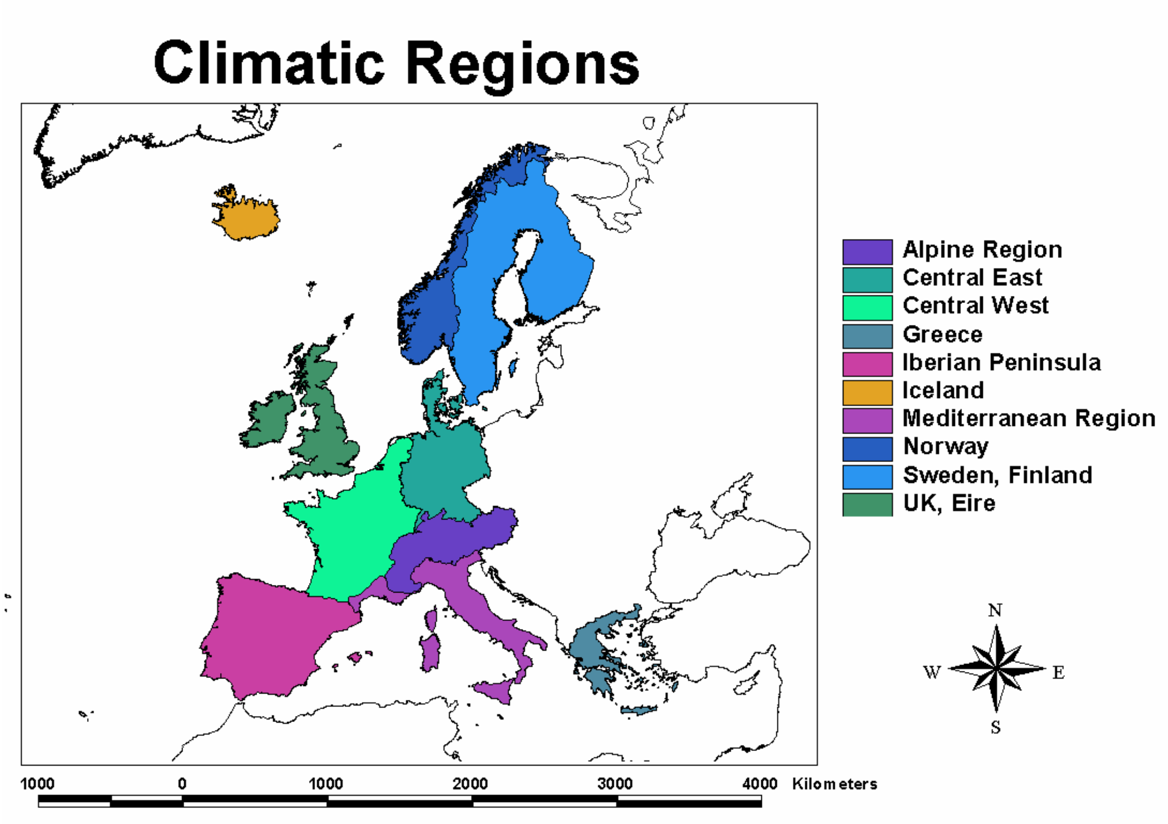
- Measures
  - New buildings
    - more rainwater discharge capacity
    - Higher roof pitch
    - additional stiffness of structure
  - Existing buildings:
    - lower level of safety required, probably not sufficient
    - more rainwater discharge capacity (retrofitting)

- Quantification of climate effect on rain extremes is missing.
  - Design load depending on year of construction ?
  - Adjusting codes regularly

Snow loads

Values in codes based on European Research Project

- Climatic regions, over national borders
- Shape factors for buildings
- Accumulation included
- 1 extreme event



Snow loads

- Increasing temperatures may lead to less snow,

But

- Increased extreme precipitation may lead to higher extremes

- No information from scenario's
  - Adaptation required ?

Concluding remarks

- Climate scenarios versus actions on buildings
  - Different time scales
  - Combined climate effects
  - Introduction of additional uncertainties

- Uncertainties relative to other influences
  - Errors in design, construction and maintenance, e.g.
    - Installations
    - Materials
    - Structural parts
  - Influence of user
  - Local effects
  - Calculation models

3 papers submitted to HERON,

Journal of the Netherlands School for Advanced Studies in Construction

Announcement

The 13th International Conference on Wind Engineering

Will be held in Amsterdam;
RAI, second week of july, 2011

Items covered:

wind climate, wind modelling, urban climate, high rise buildings, bridges, CFD, Wind tunnel technique, Wind energy, pollution dispersion, wind comfort, bluff body aerodynamics, vehicle aerodynamics, driving rain, wind breaks, etcetera

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