# Addressing the Climate Adaptation Deficit in Water Management and Infrastructure

keynote at the
Pan European Symposium on
Water, Sanitation, Safety Planning,
and Extreme Weather Events.

April 6, 2017
Bilthoven, The Netherlands

by
Pier Vellinga
Scientific director
Knowledge for Climate Program (2007-2015)
em. professor Wageningen UR and Vrije Universiteit
Presently: Wadden Academy

Kennis voor Klimaat

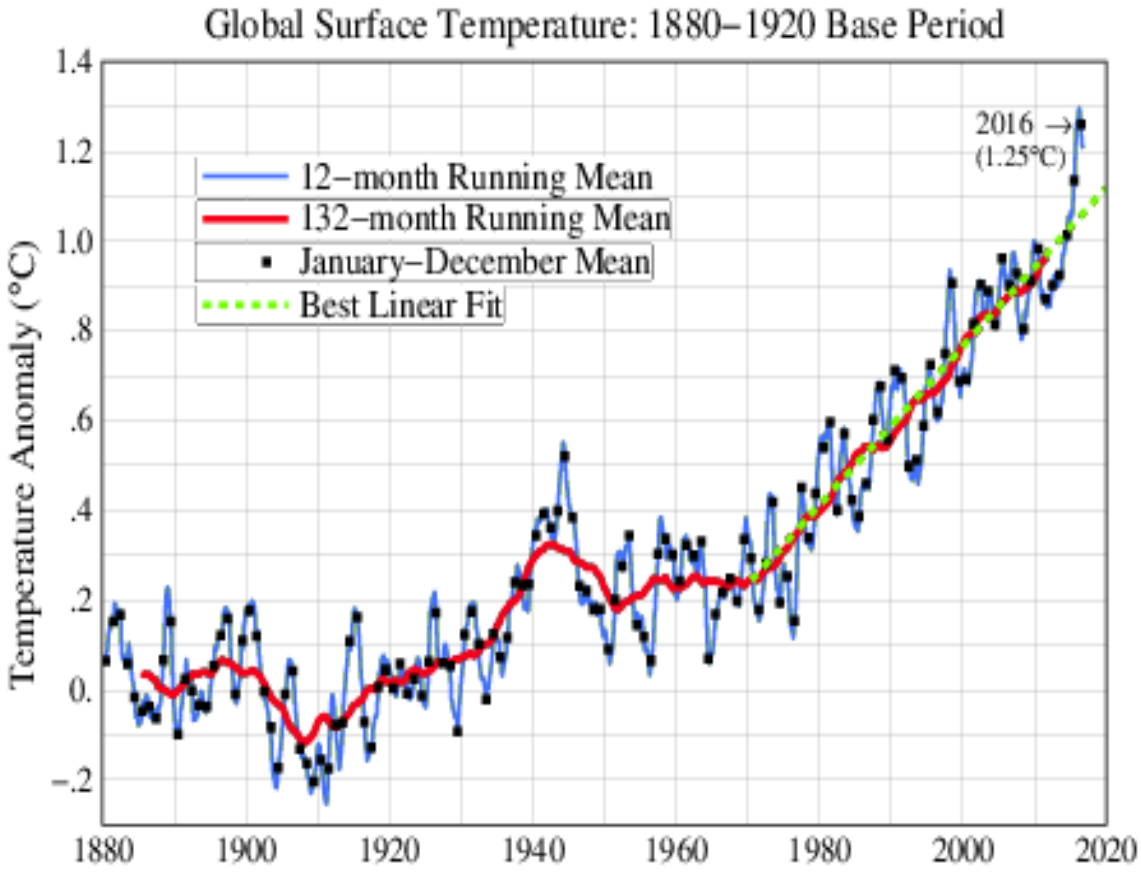
Waddenacademie

1. The world is warming up. A one and a half to two degrees global average warming will come with major changes in local temperature, precipitation, windpatterns and sea level;

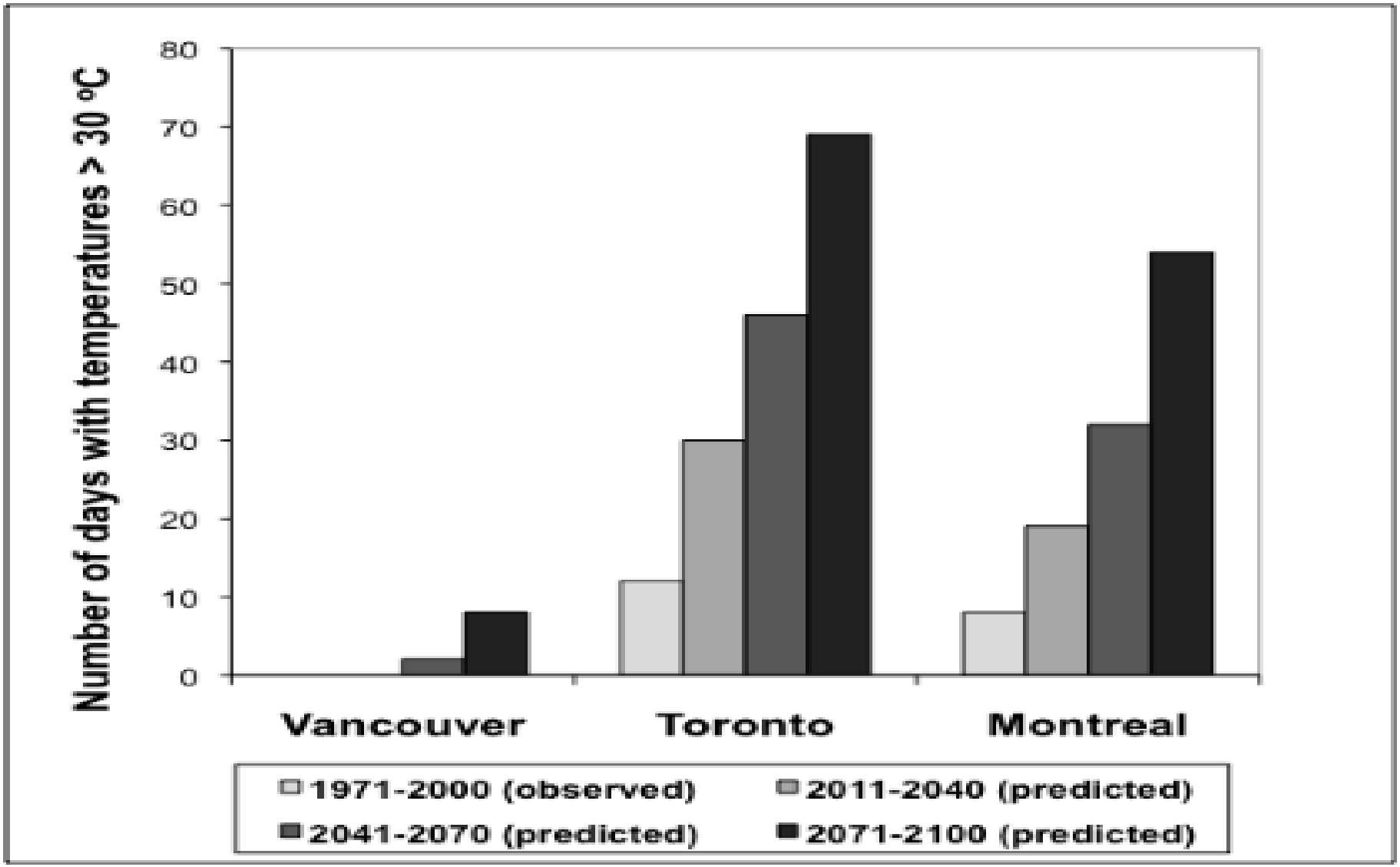
2. There is a growing gap between present systems of the built environment, water management, agriculture on the one hand and historic levels of robustness to weather extremes;

3. Information on future climate is usually presented as long term, geographically large scale with a range of uncertainties attached. Research shows that this type of information is not fit for purpose when it comes to awareness raising and decision making on adaptation at urban level.

4. Examples will be shown of how this can be improved;




This global temperature chart is updated at Columbia University by Dr. Makiko Sato.
Data is based on GISTEMP analysis (mostly NOAA data sources) as described by Hansen, Ruedy, Sato & Lo (2010).
The 1880-1920 average is used as best available base for pre-industrial global average temperatures.
See "A better graph" by Hansen and Sato (2016) for background info.




*Projected increase in the number of days above 30°C – Based on data from the Canadian Climate Change Scenarios Network, 2010. Source: Toronto Public Health*

# Average number of heat wave days in Northern Africa

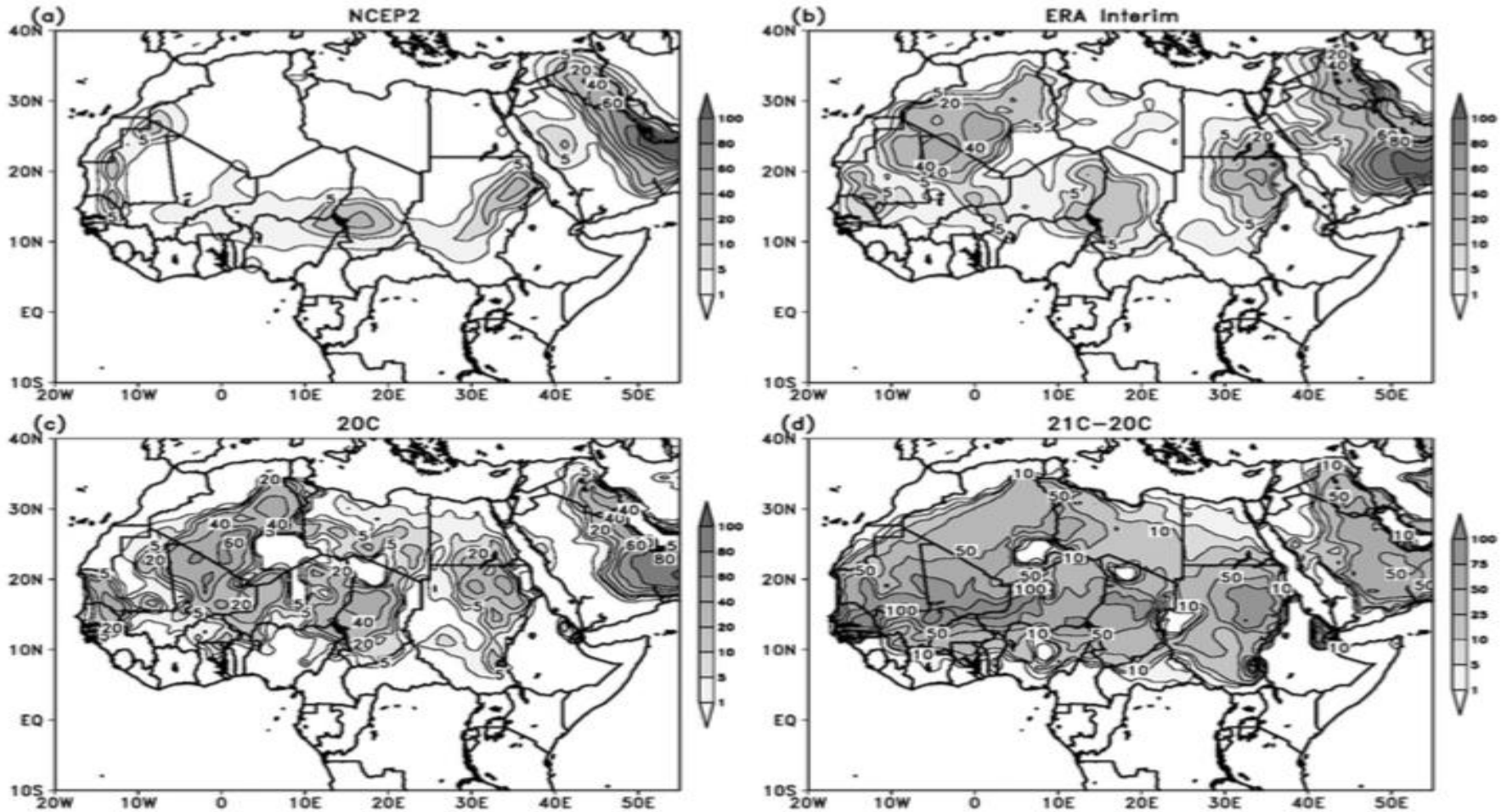
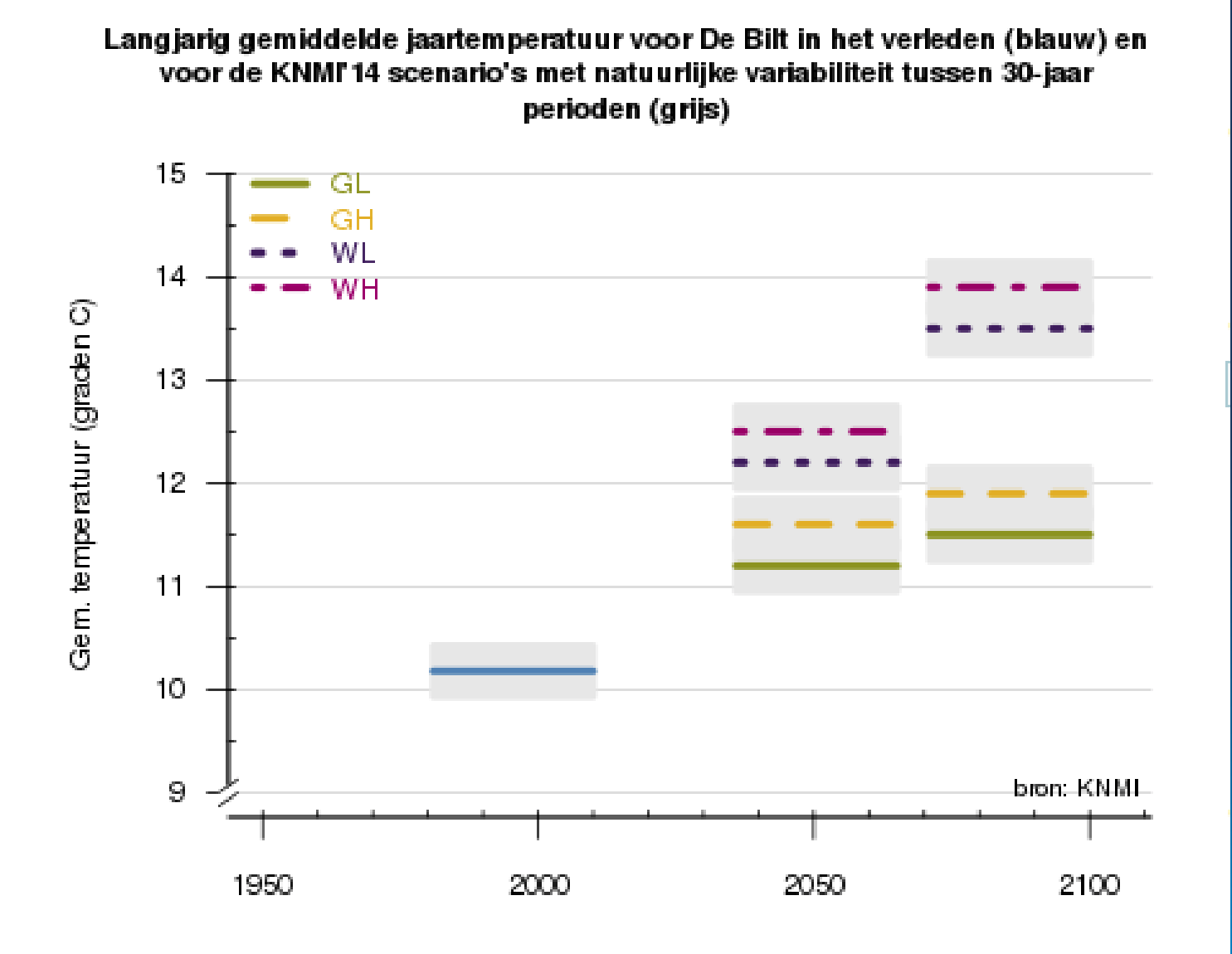
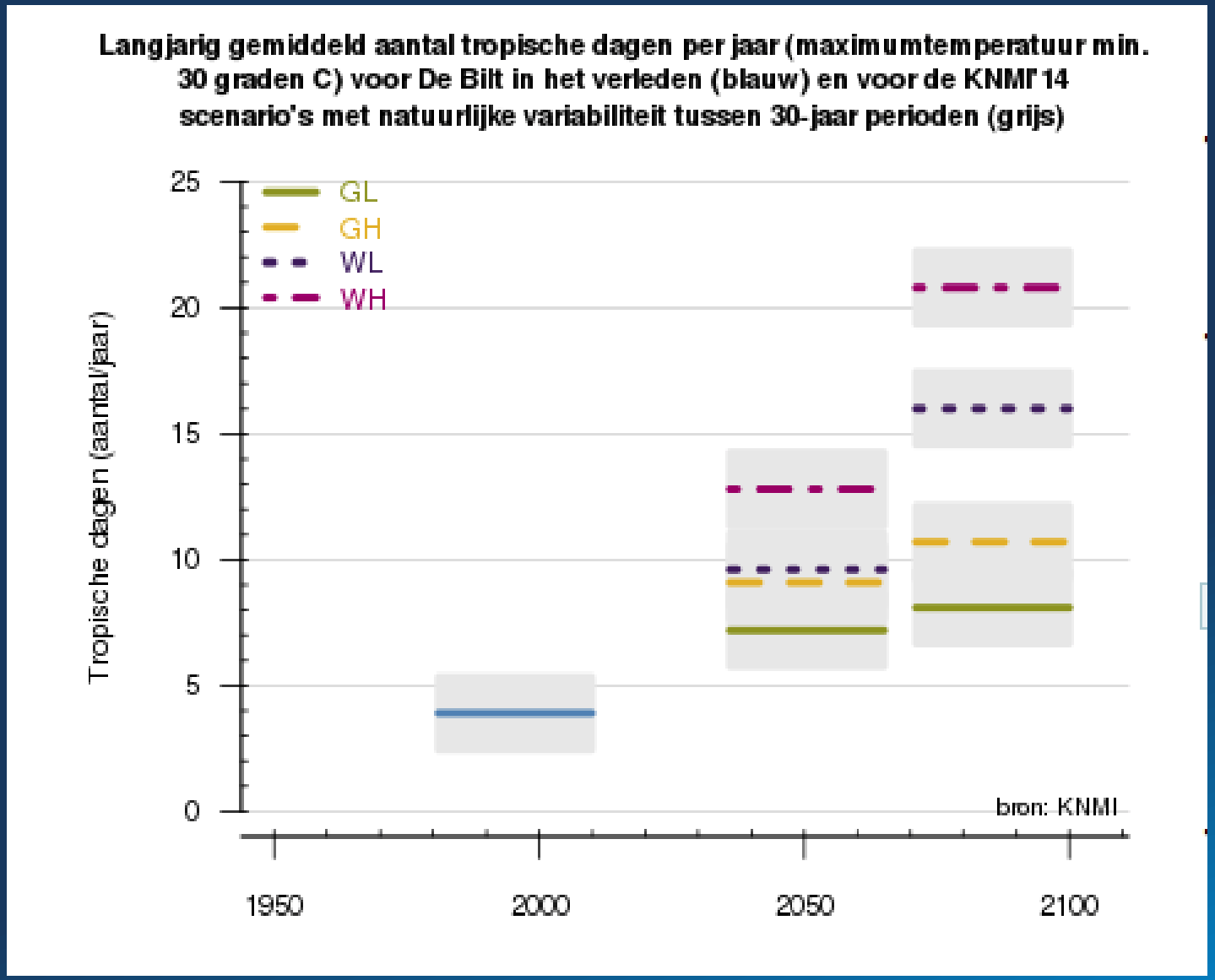



FIG. 5. Average number of heat wave days per year from the (a) NCEP2 reanalysis (1989–2009 average), (b) ERA-Interim reanalysis (1989–2009 average), and (c) 20C ensemble (six-member average). (d) 21C minus 20C difference in the average number of heat wave days per year.

# Scenario's temperatuurstijging



# Scenario's tropische dagen



# Changes in daily rainfall in northern Africa



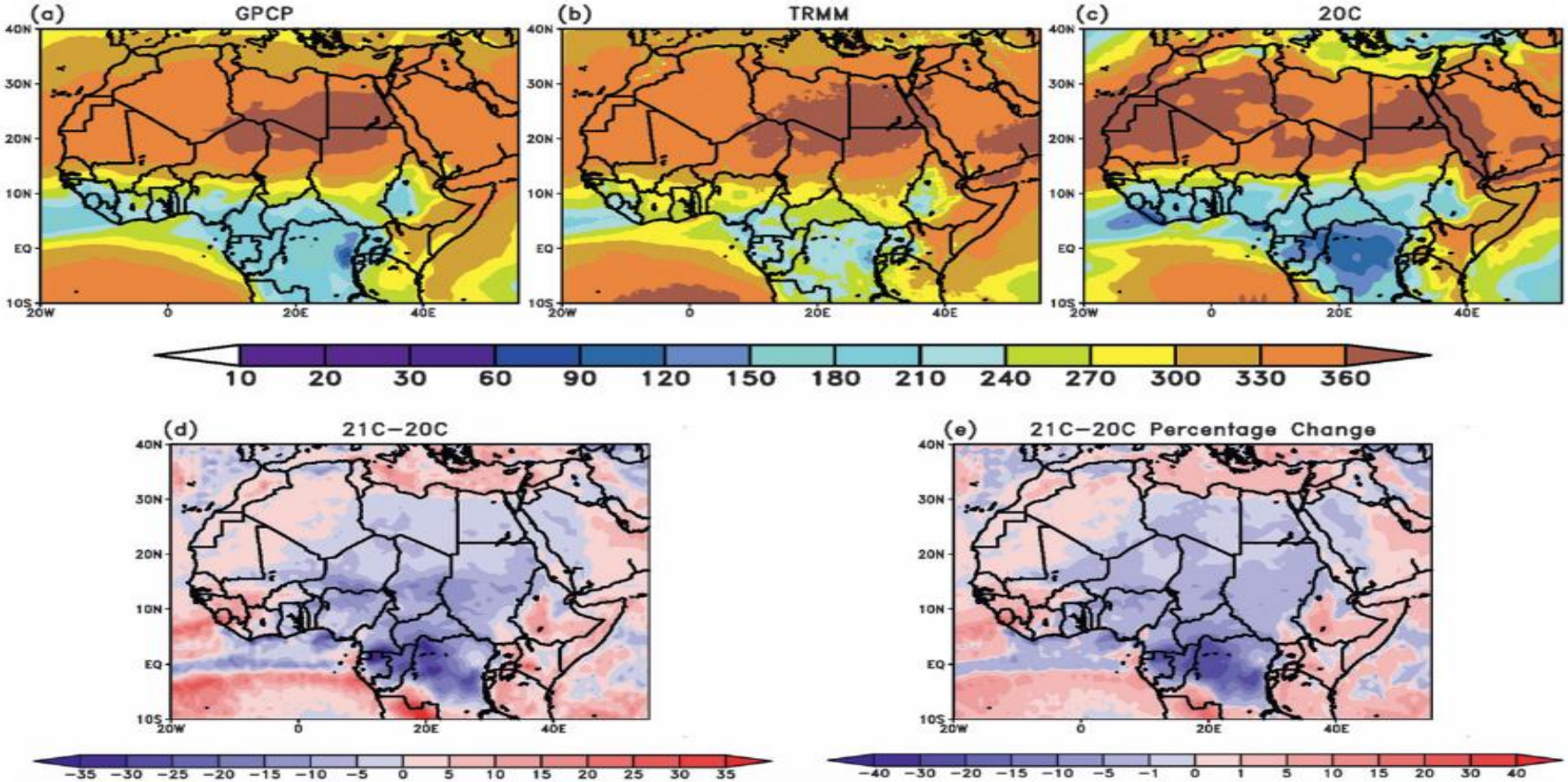
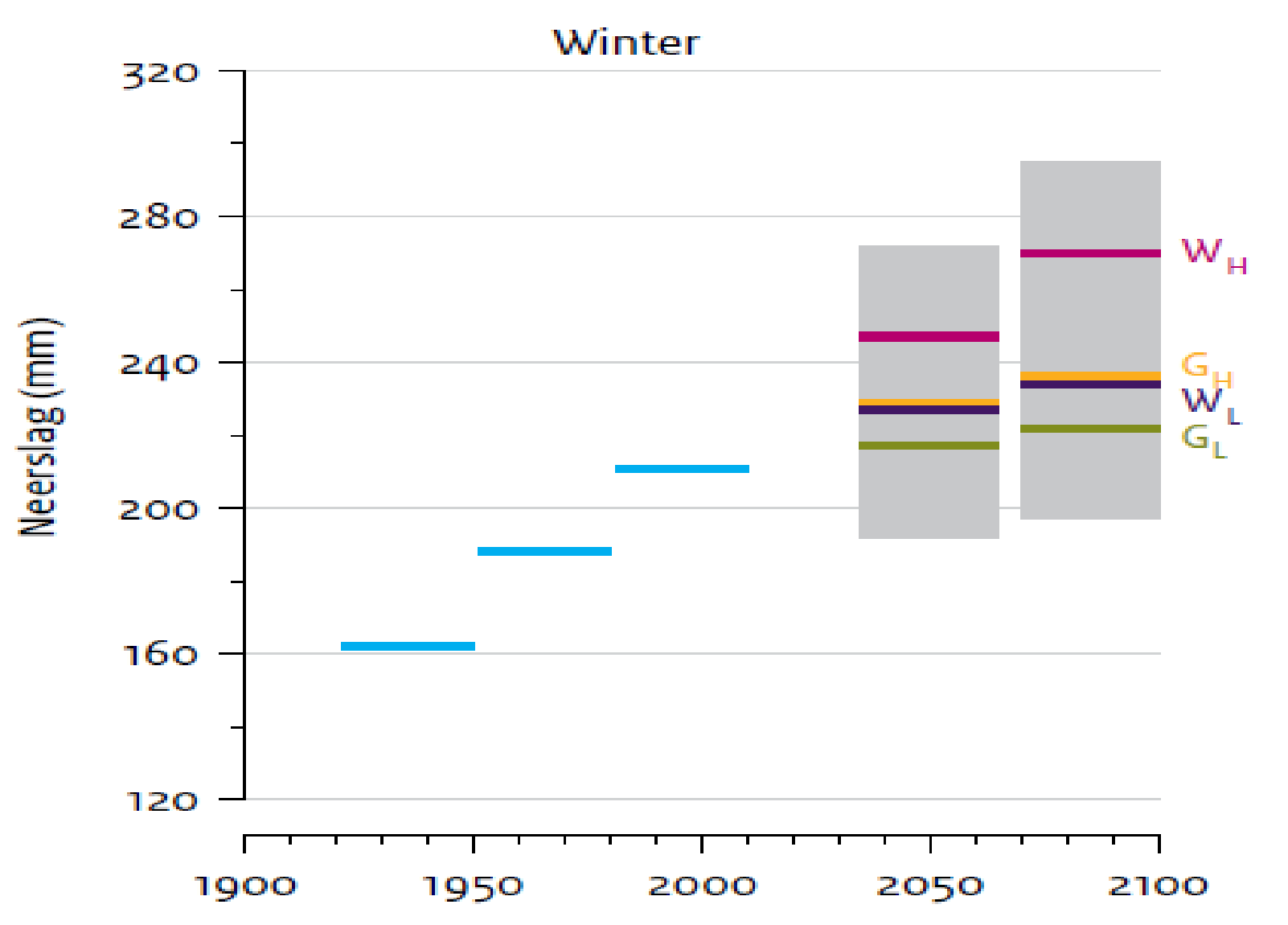
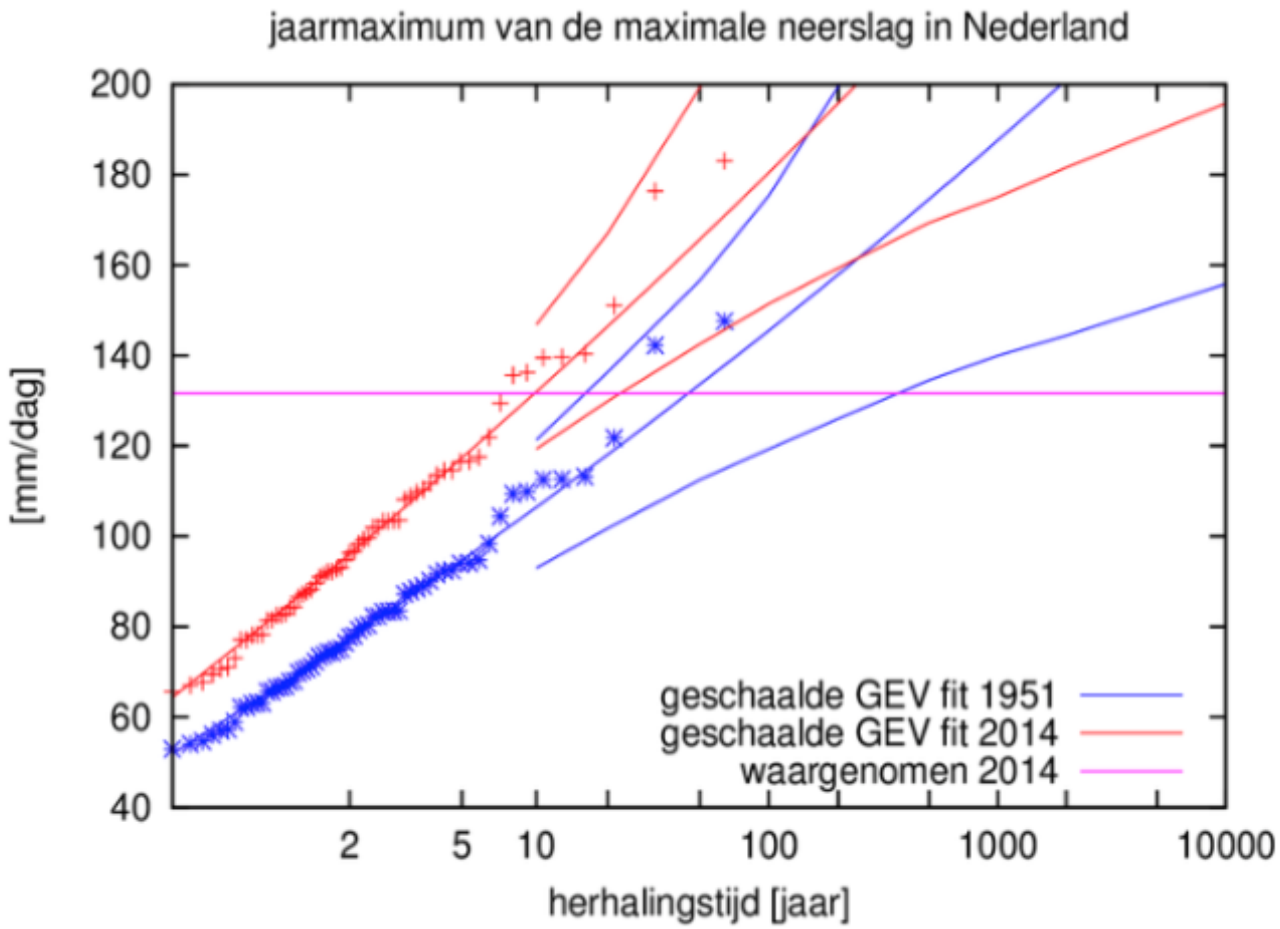



FIG. 6. Average number of days per year when the daily rainfall is less than 1 mm day$^{-1}$ in the (a) 1997–2008 GPCP 1° daily precipitation climatology, (b) 1998–2010 TRMM climatology, and (c) 20C ensemble (six-member average). The (d) difference for 21C minus 20C in the number of days per year when the daily rainfall is less than 1 mm day$^{-1}$ and the (e) 21C minus 20C percent change difference.

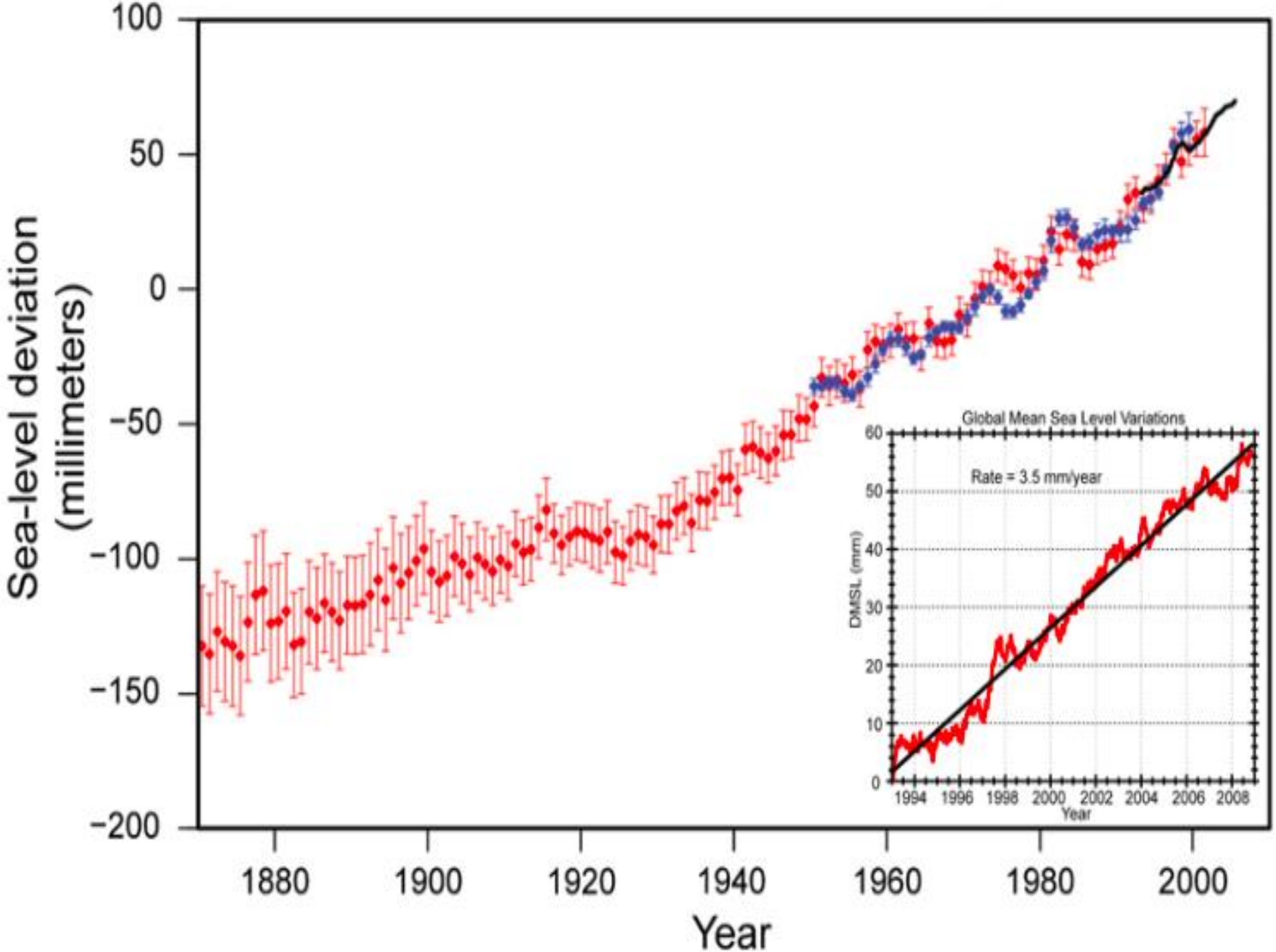
# Scenario's winter precipitation, The Netherlands (KNMI)

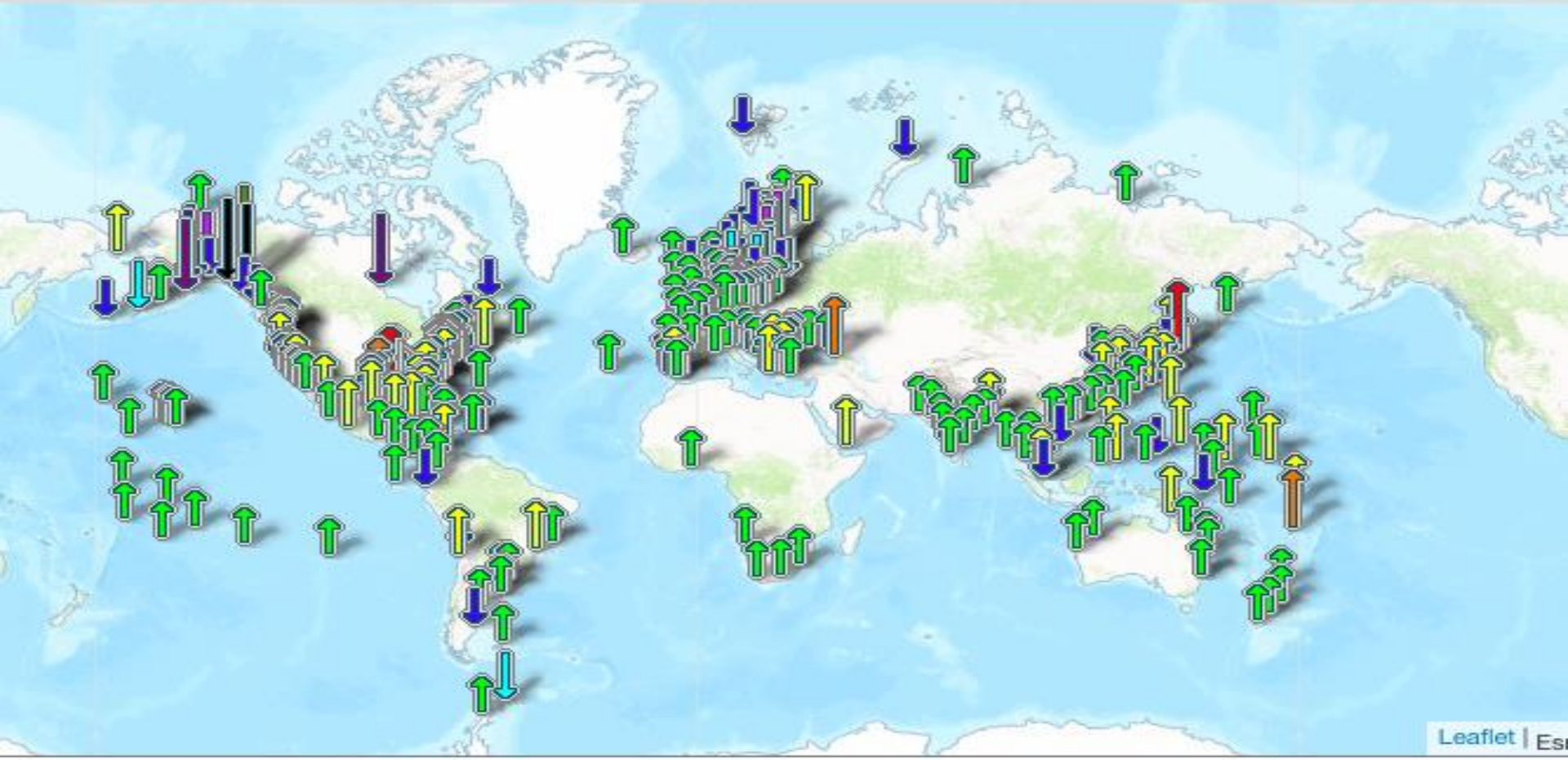


# The 1:100 year extreme rainfall event in 1900-1980 time frame has become the 1:30 year rainfall event in 2014.




Figuur 3. Aanpassing van de per jaar hoogste neerslag in Nederland gemeten op één van de 8–8 neerslagstations (64 waarden) aan een GEV verdeling die schaalt met de wereldgemiddelde temperatuur. De waarde van 131,6 mm voor 28 juli 2014 (horizontale lijn) i


Sea-level deviation (millimeters)
100
50
0
−50
−100
−150
−200
1880
1900
1920
1940
1960
1980
2000
Year
Global Mean Sea Level Variations
Rate = 3.5 mm/year
DMSL (mm)
60
50
40
30
20
10
0
1994
1996
1998
2000
2002
2004
2006
2008
Year




*lustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an ar*
*information about that station.*

**Sea Level Trends**
mm/yr (feet/century)

| | | | |
|---|---|---|---|
| 15 to 21 (5 to 7) | 6 to 9 (2 to 3) | -3 to 0 (-1 to 0) | -12 to -9 (-4 to -3) |
| 12 to 15 (4 to 5) | 3 to 6 (1 to 2) | -6 to -3 (-2 to -1) | -15 to -12 (-5 to -4) |
| 9 to 12 (3 to 4) | 0 to 3 (0 to 1) | -9 to -6 (-3 to -2) | -18 to -15 (-6 to -5) |

# Sea level rise scenario's (Rohling et al, 2013)

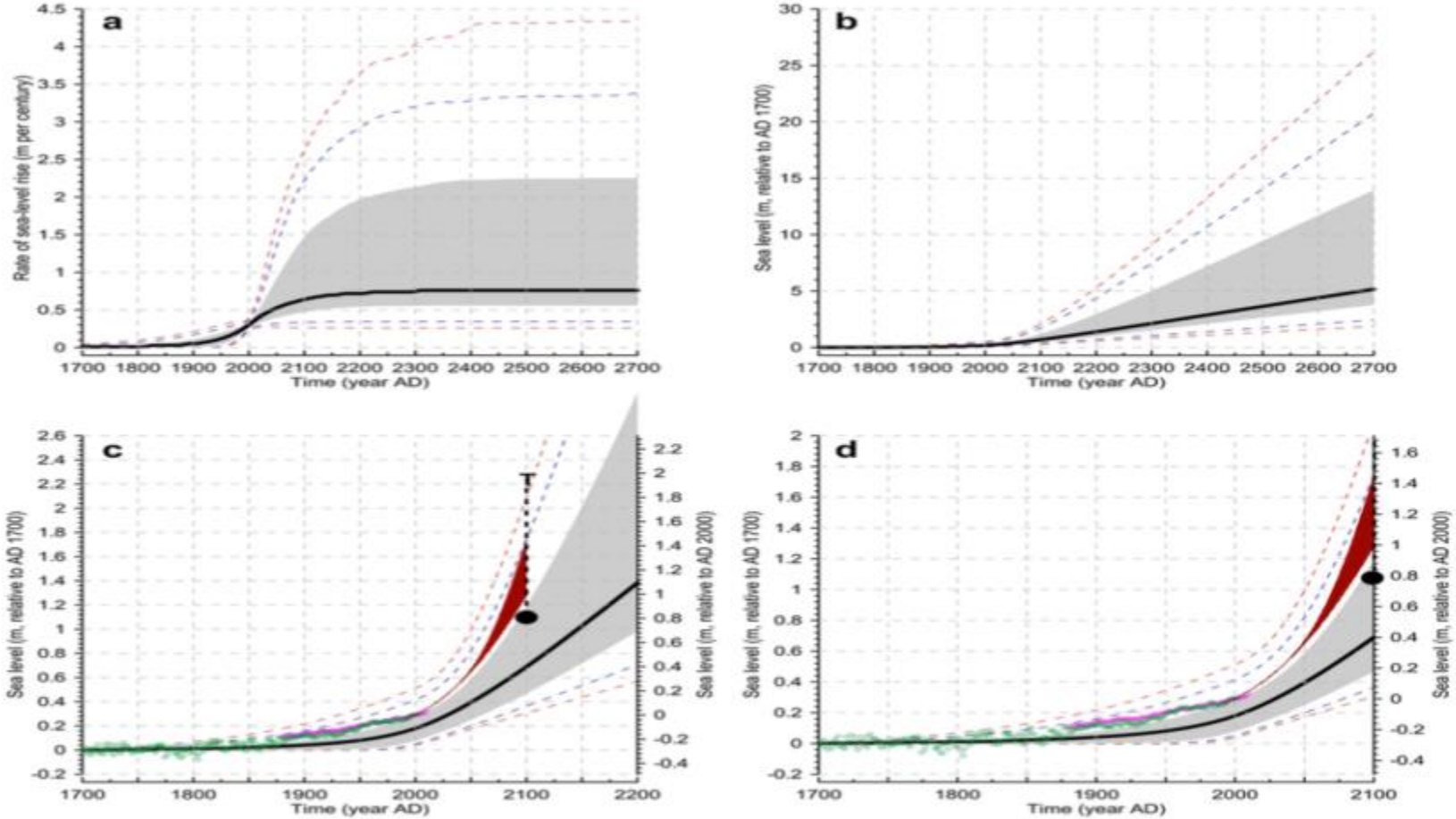
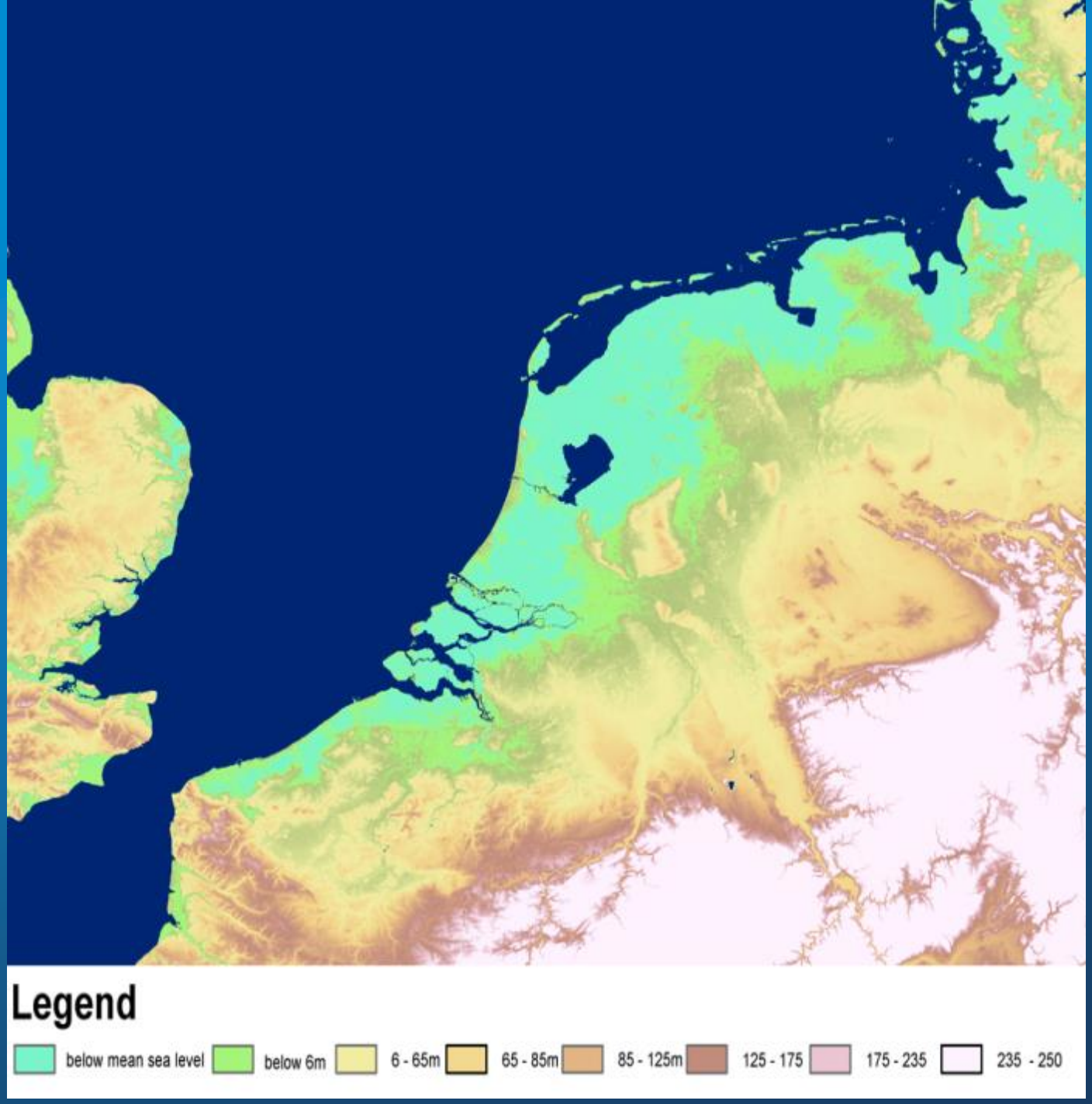
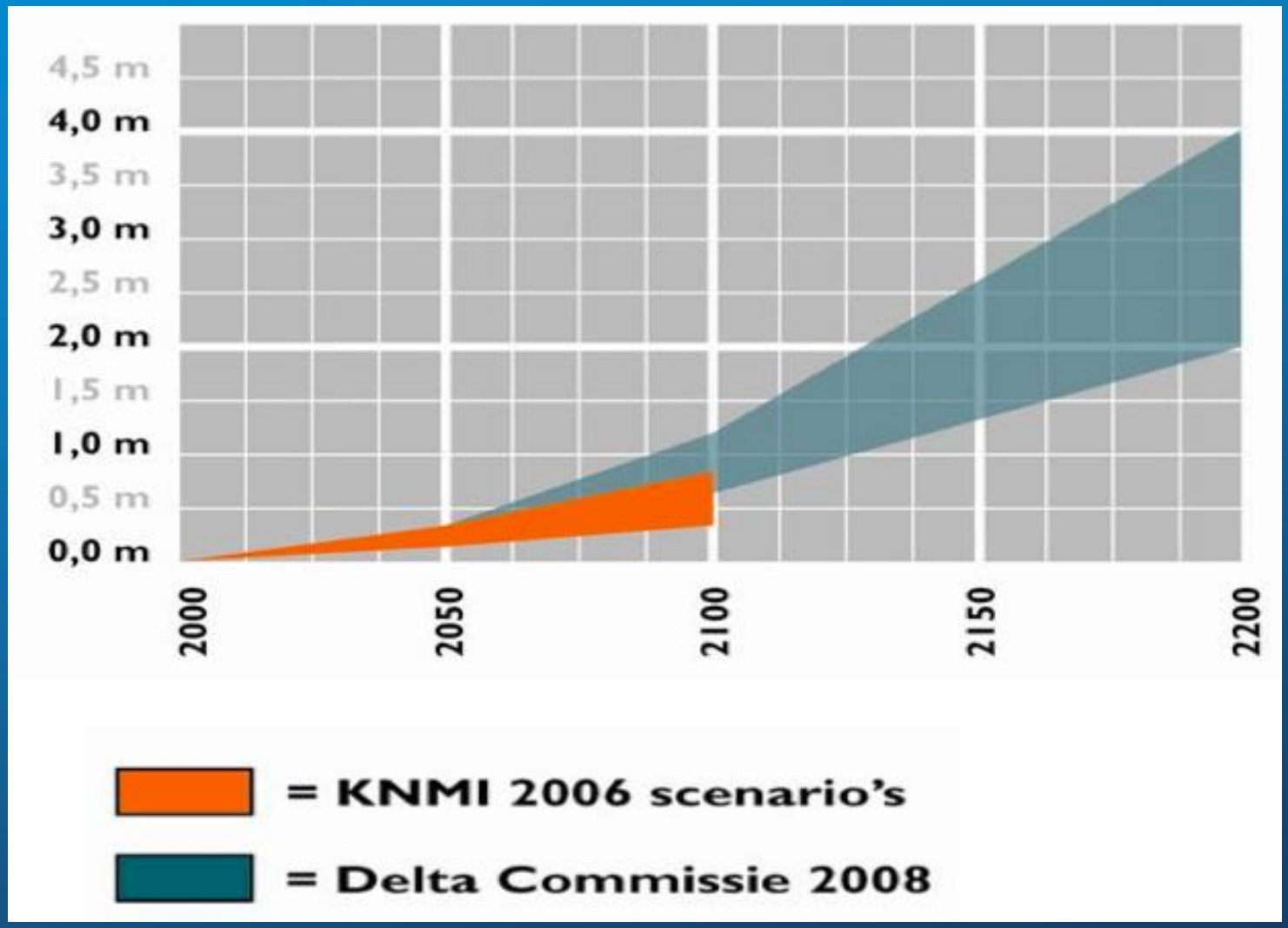


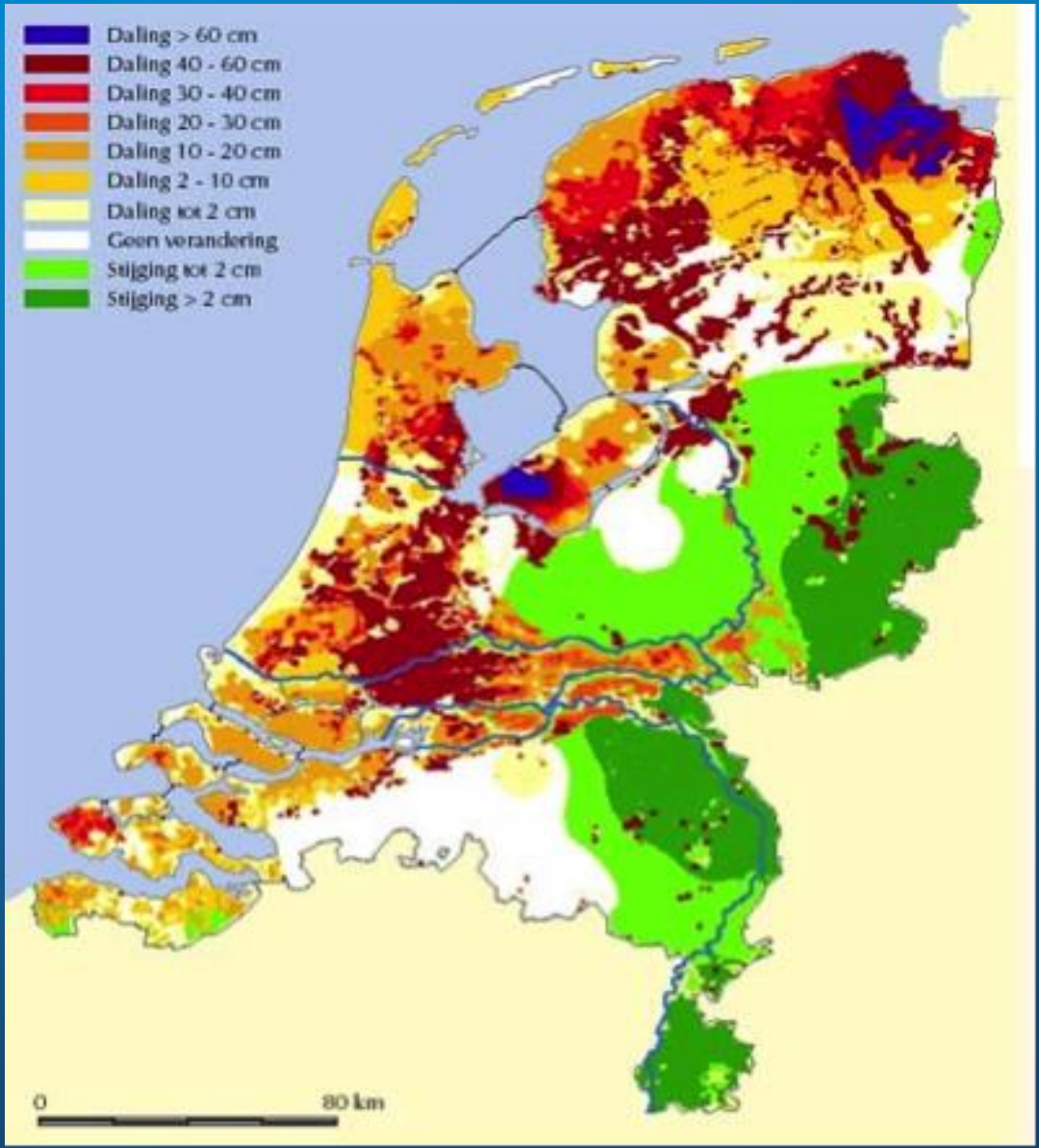

**Figure 3 | Probabilistic assessment of natural sea-level change based on equations 1–3.** The heavy line is the probability maximum (peak of the probability distribution), the grey envelope marks the 68% probability interval, and the dashed blue (red) lines mark the 90% (95%) probability intervals, respectively. (a). Rates of SLR relative to 1700, in m $cy^{-1}$ (i.e., 100 × result from equation 1). (b). SLR after equation (2). (c). Zoomed-in portion of (b), ending at 2200. The brown wedge is the range of semi-empirical projections by Vermeer and Rahmstorf[7], the heavy dot outlines the most-likely projection by Pfeffer et al[9]., and the heavy dashed black line represents the full range of SLR estimates of Pfeffer et al[9]. Historical sea-level reconstructions of Jevrejeva et al[11]. (green dots) and Church and White[51] (magenta dots) are also shown. (d). As (c), but zoomed in on 1700–2100.


Legend
below mean sea level
below 6m
6 - 65m
65 - 85m
85 - 125m
125 - 175
175 - 235
235 - 250

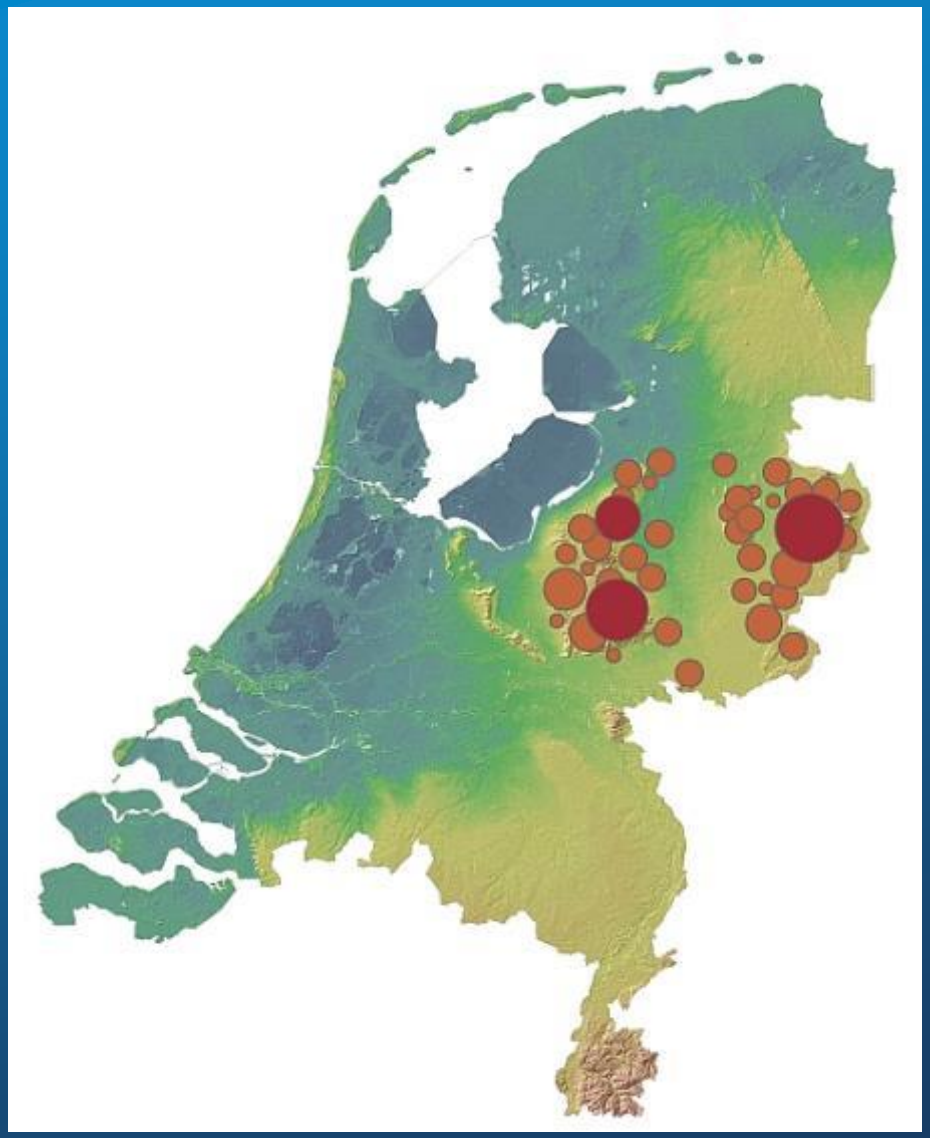
# Sea-level rise projection (m)
# most likely (KNMI) and upper end scenario



# Subsidence by 2050



# Option 1: retreat to higher grounds



# Option 1: offensive strategy

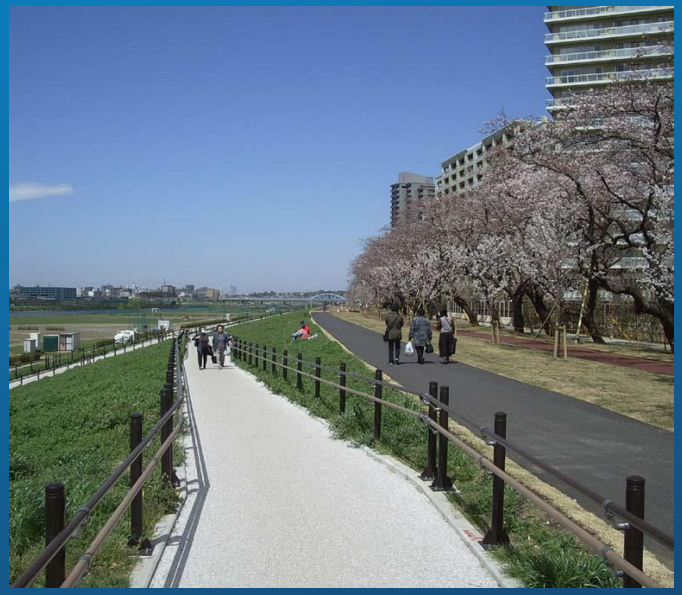
# Option 2: protecting within existing boundaries, closed version”

# Option 2: protecting within existing boundaries, “open version”

# Nourishment of the coastal sand-river


# De Hondsbossche zeewering van hard naar zacht

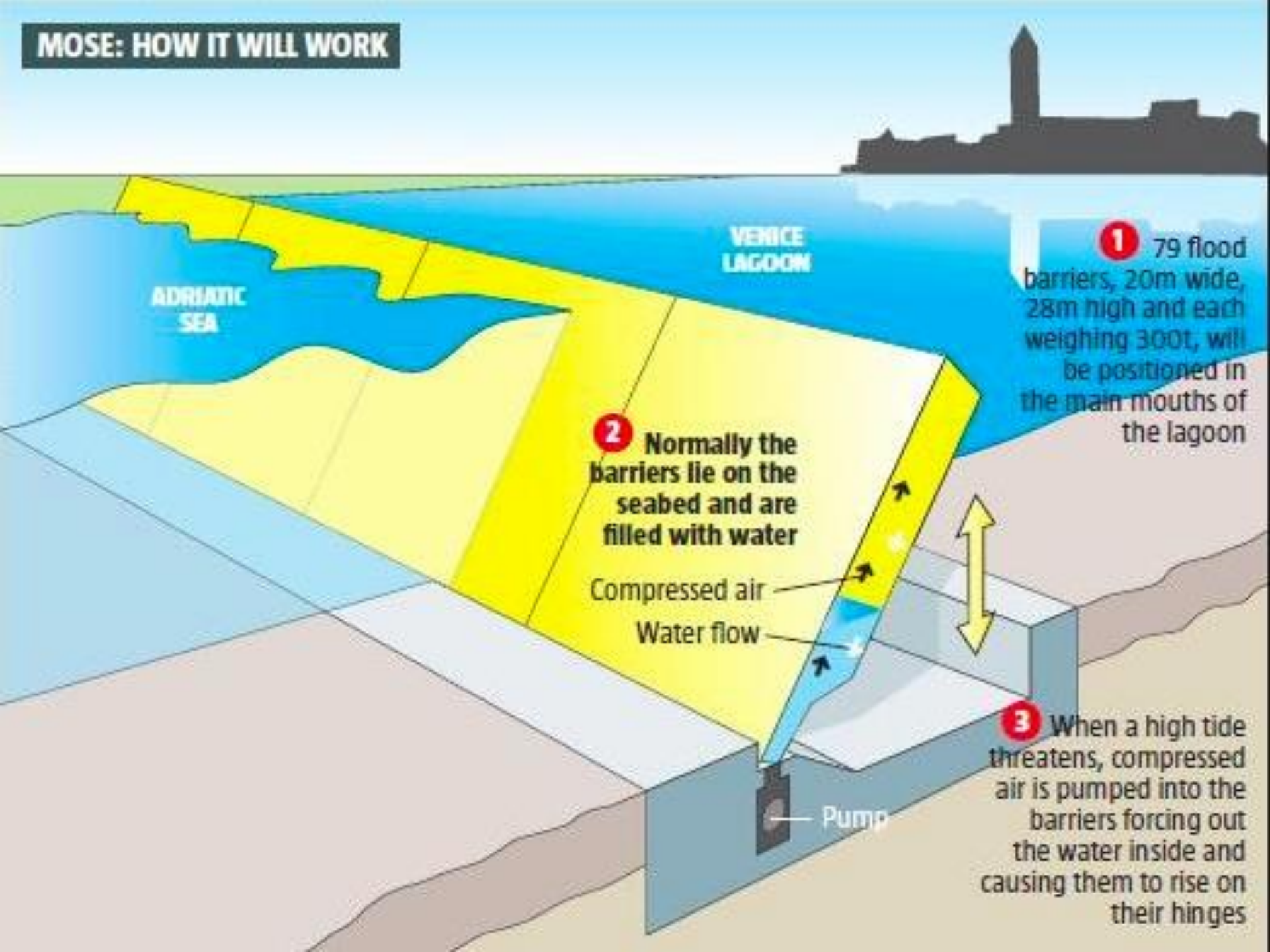
# Examples of existing broad (super) dikes, “unbreakable dikes”



# Multifunctional flood defence in Hamburg, Germany


GONDOLE

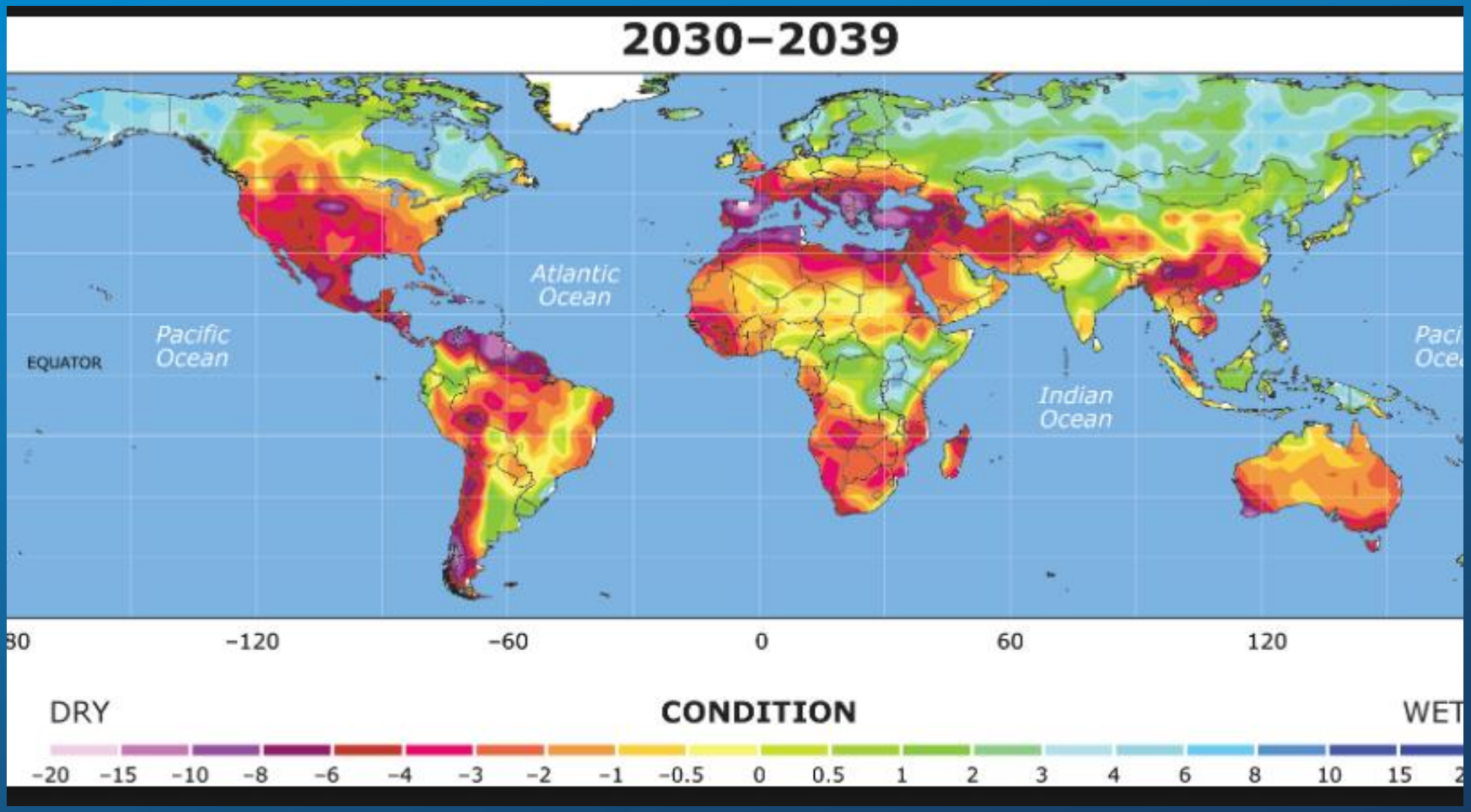
# Venetië
# De werken om overstroming te beperken


MOSE: HOW IT WILL WORK
VENICE LAGOON
ADRIATIC SEA
1 79 flood barriers, 20m wide, 28m high and each weighing 300t, will be positioned in the main mouths of the lagoon
2 Normally the barriers lie on the seabed and are filled with water
Compressed air
Water flow
Pump
3 When a high tide threatens, compressed air is pumped into the barriers forcing out the water inside and causing them to rise on their hinges

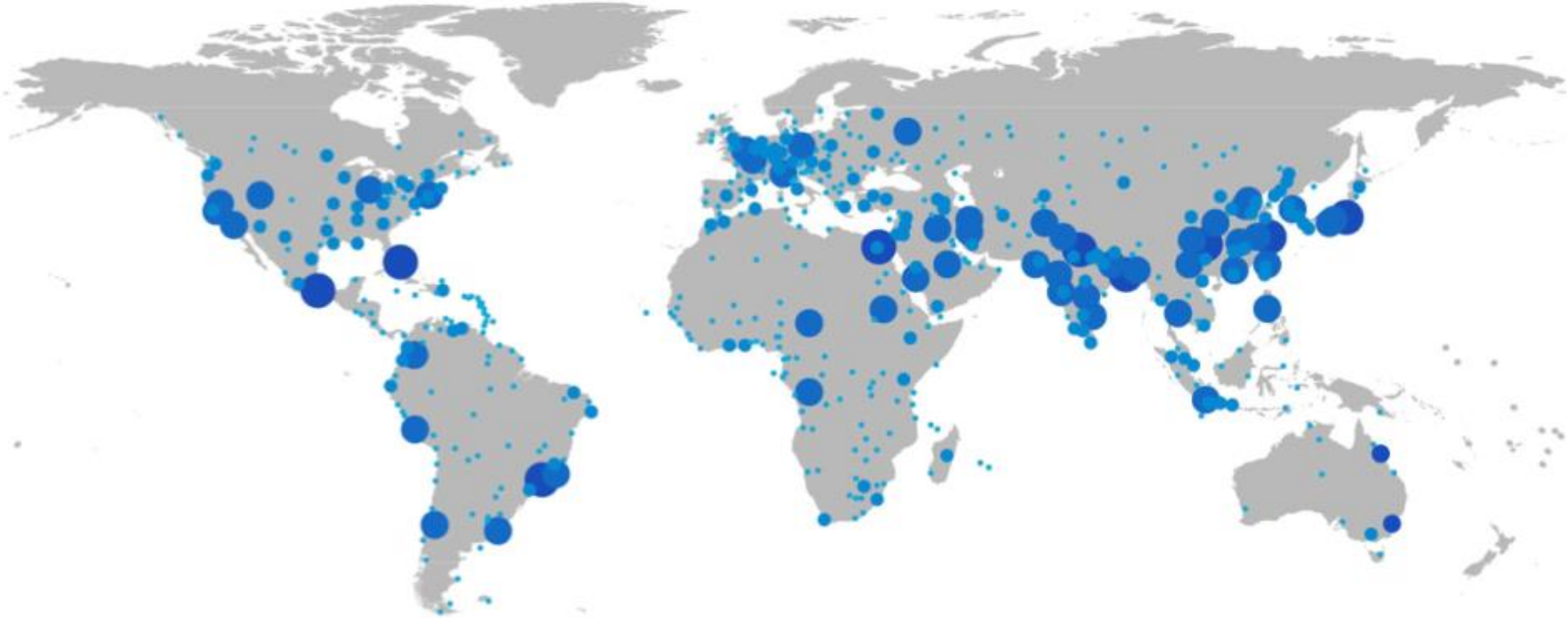
# Hydro-meteorological effects of Climate Change

- Sealevel rise and higher peak flows in rivers;
- Temperature rise in cities: year average plus 2 to 6 degrees Celsius;
- More frequent and more intense heat waves;
- More frequent prolonged drought;
- More frequent and more intense peak rainfall;

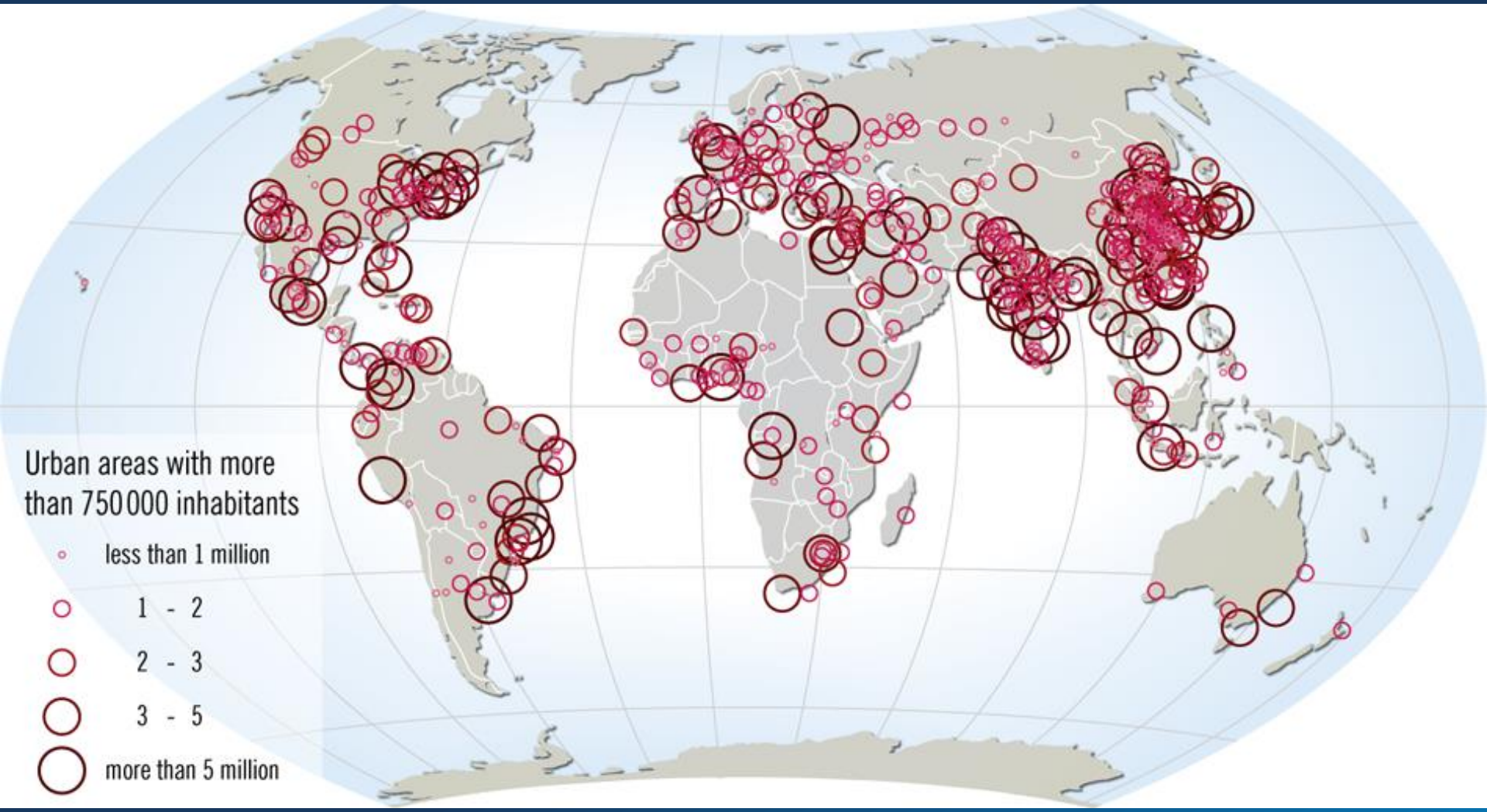
# Drought areas as projected for the period 2030-2039
# National Centre for Atmospheric Research



# Flood exposure is everywhere!



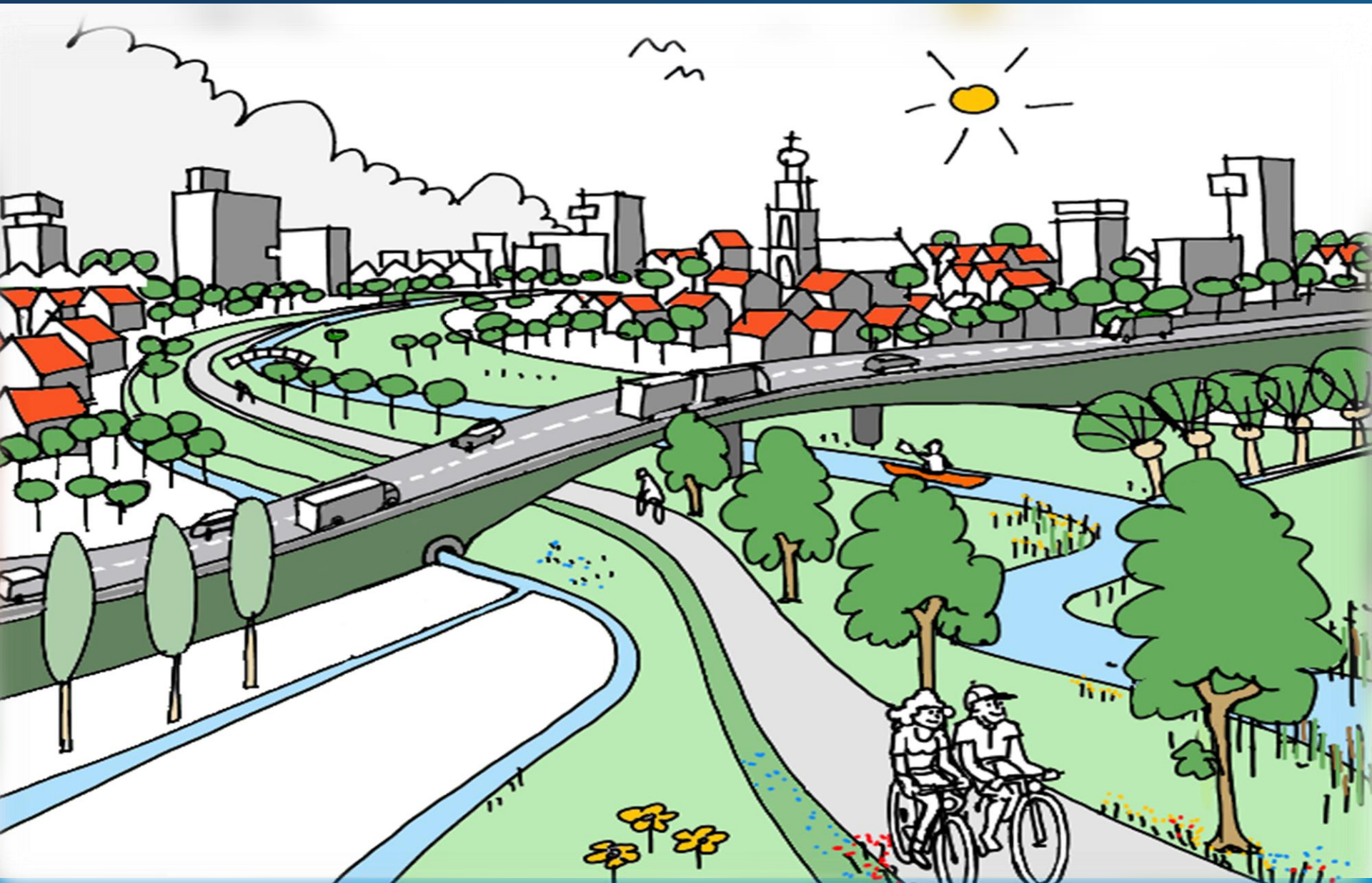
Exposure is growing, especially in high hazardous areas close to rivers and coastlines


Urban areas with more than 750 000 inhabitants
less than 1 million
1 - 2
2 - 3
3 - 5
more than 5 million

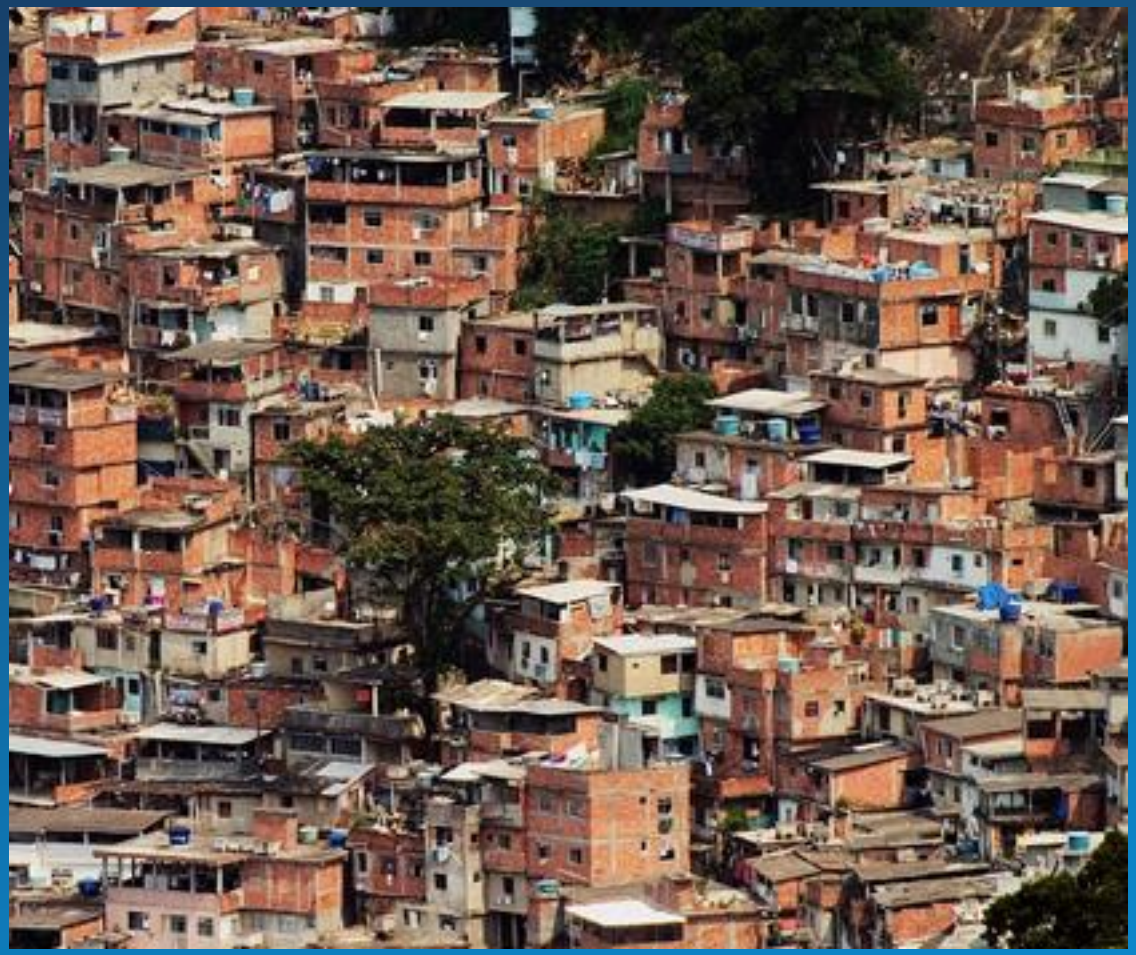
# Urban adaptation to climate change: a range of measures:

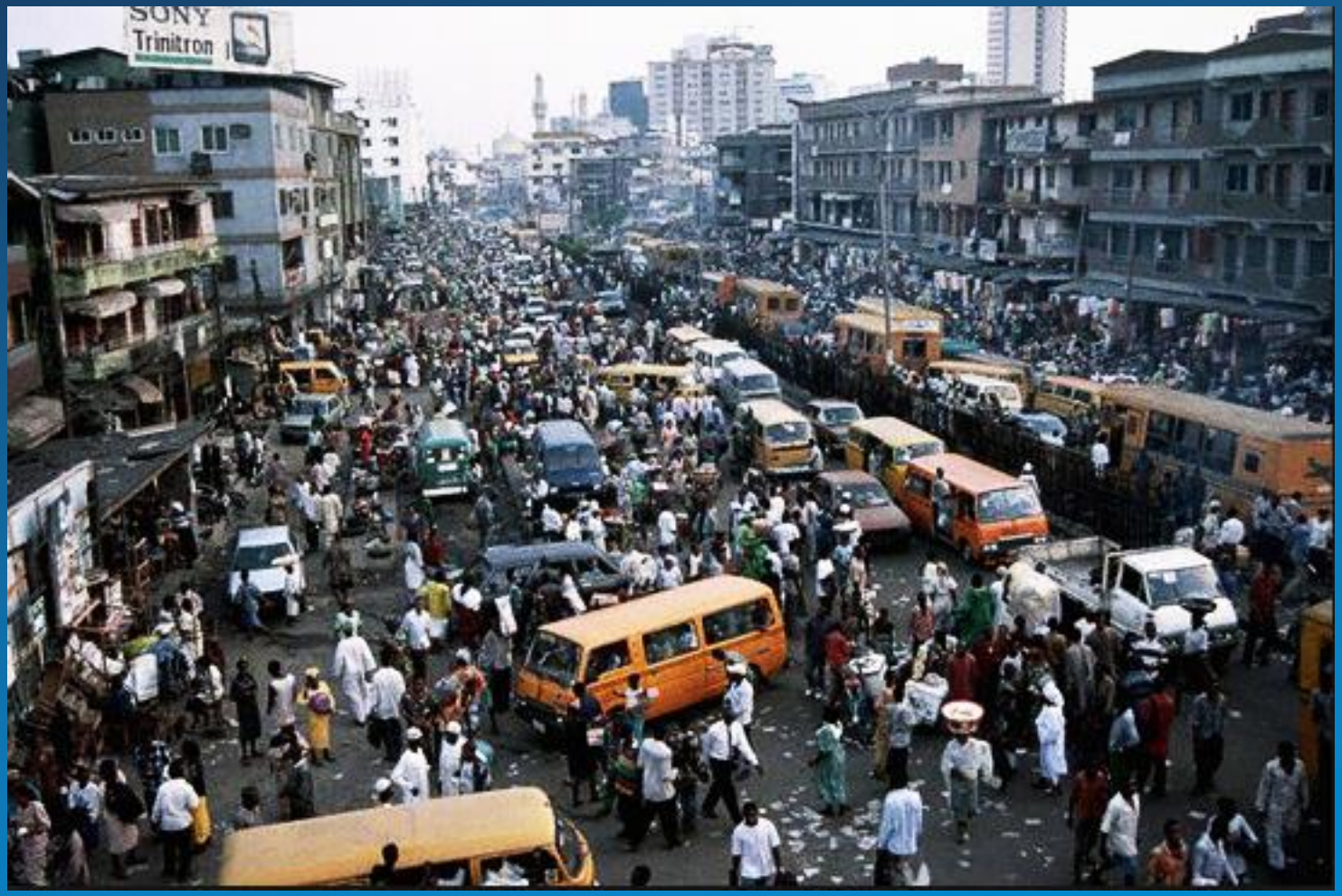
- More insulation and shade from heat: adjustments of buildings; aircondition (renewable energy) ;
- More green in the cities including green rooftops;
- More water buffering to overcome long periods of drought at all scales: garden, neighbourhood park, suburb and city;
- Better drainage and protection from rain- and riverwater flooding at the scale of: buildings, neighbourhood, suburb and city;

# Adaptation to Climate Change

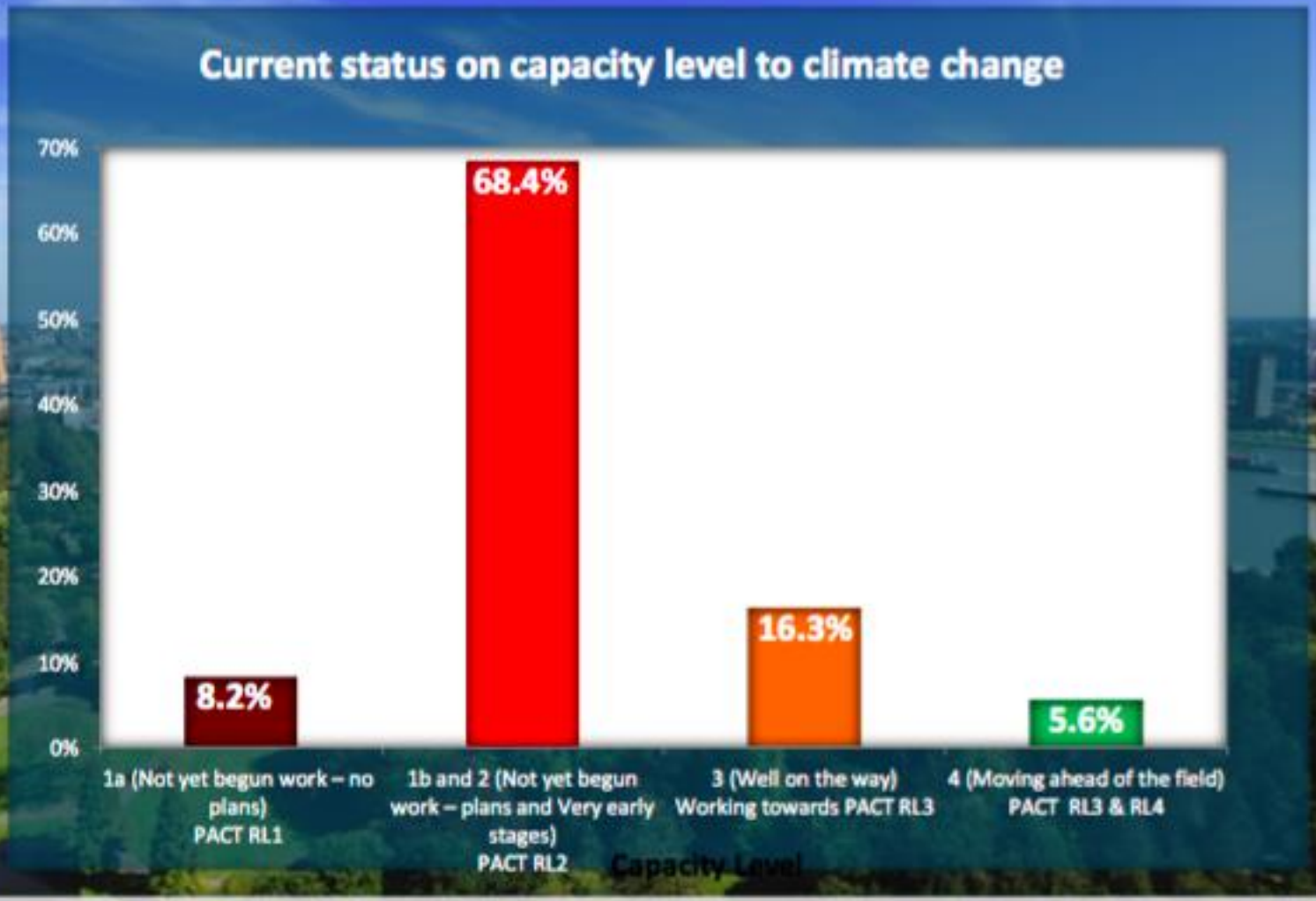



CLUB INDI
CONTINENTAL
SINGH EXP
PEARL




SONY
Trinitron

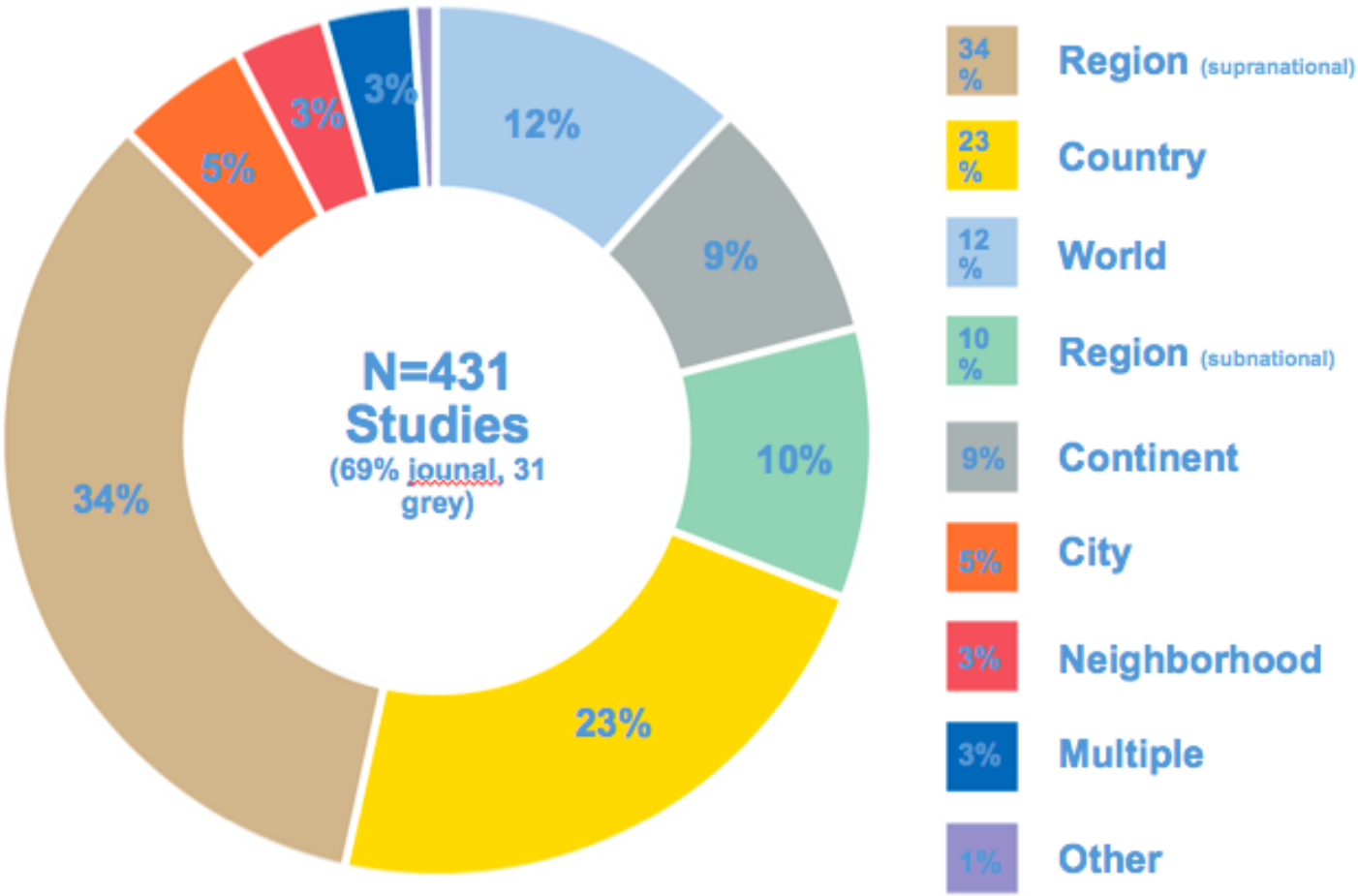
# Capabilities in European cities




196 cities were asked to select the option that best describes their **current status on adaptation**

Results confirmed by detailed questions and by in-depth review of 21 cities using the **PACT framework**

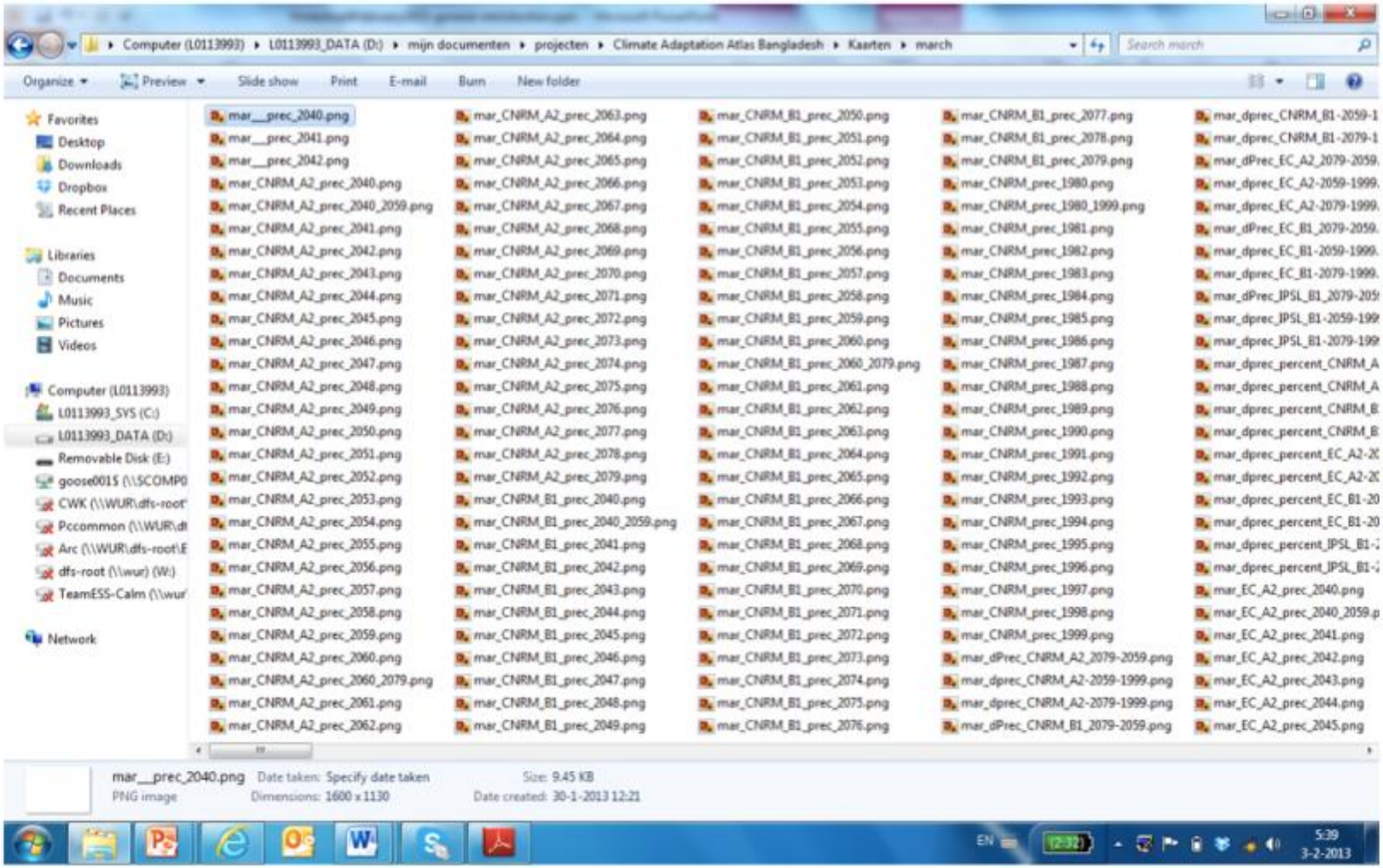
# Vulnerability assessments (maps)




De Groot Reichwein and Masselink in prep.

# User needs: ‘Heat map city of Gent’

# Climate Impacts on rainfall extremes in Bangladesh



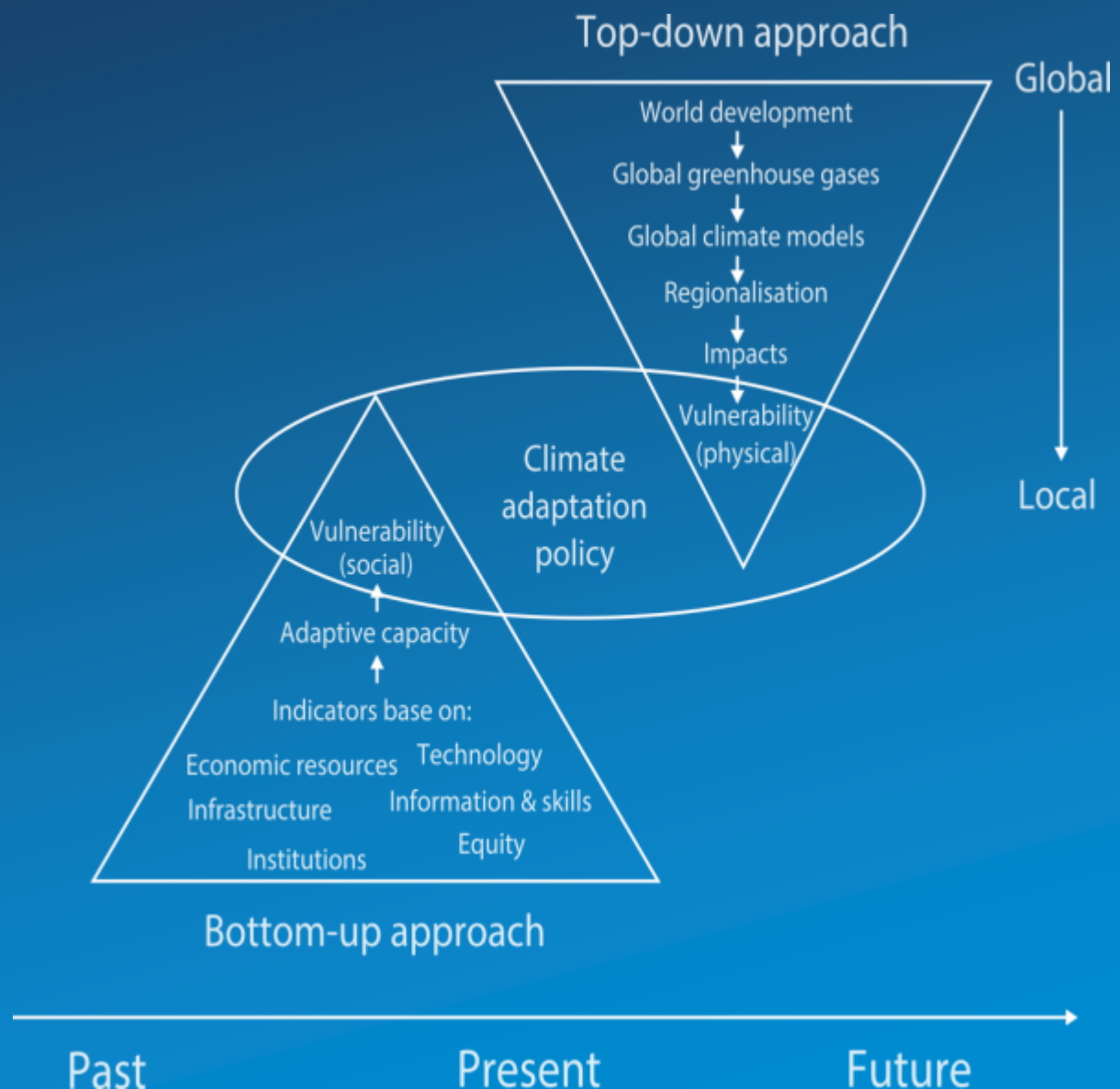
# Disclosing climate impact information

Regionaler klimaatlas (German Climate Portal)

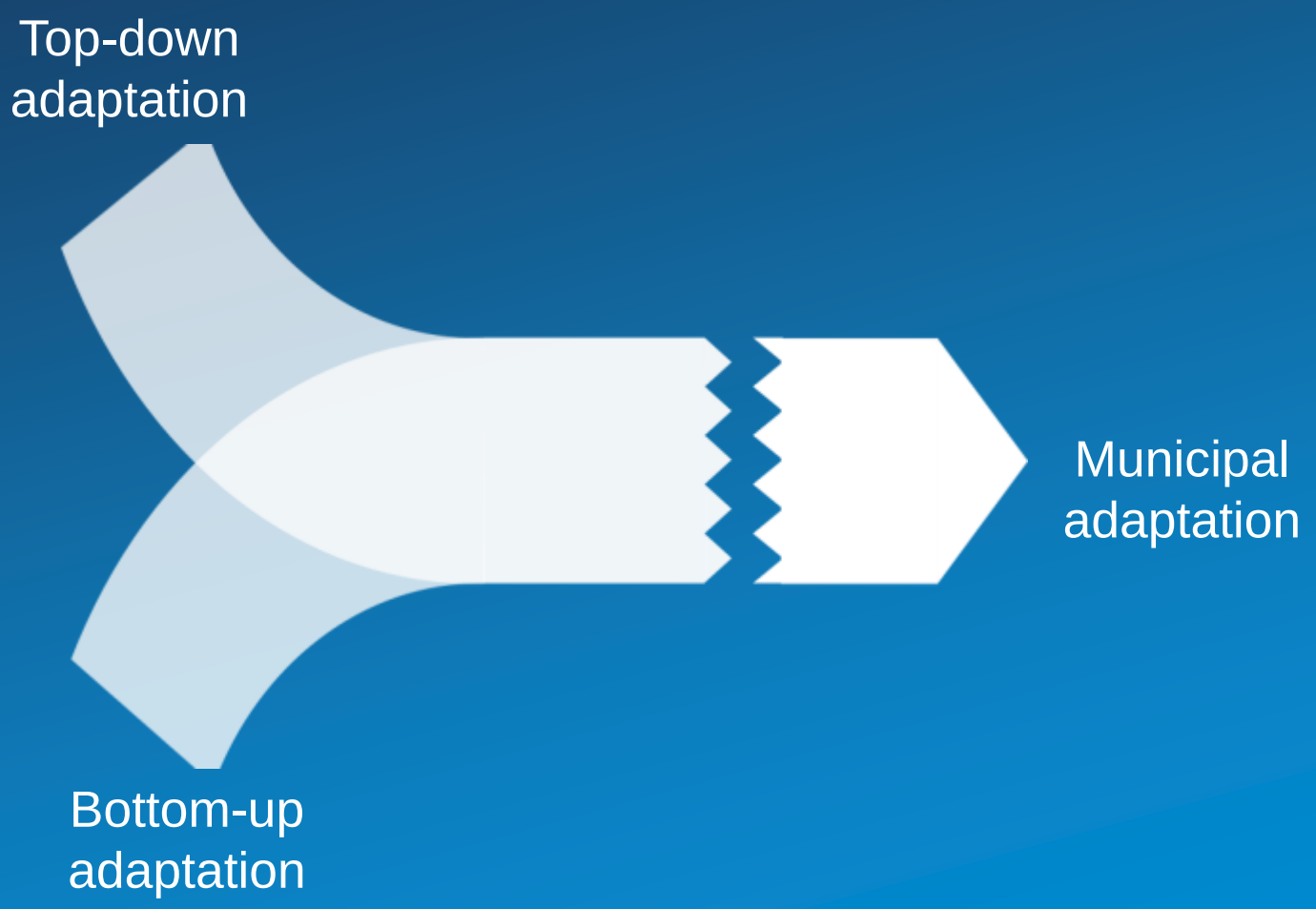
15 scenarios and model combinations
13 time steps
4 seasons and yearly average
975 maps per climate indicator

# Approaches to adaptation

(Dessai and Hulme 2004)



# The ‘last mile’



# Municipal challenges; climate is just no priority

Aging population

Environmental pollution

Social issues

Population decline

Climate change

And many more...

# Municipalities and climate change

- Adaptation is one of many issues
- Mitigation has priority
- Limited resources
- If addressed; then often top-down sectoral and ad-hoc

Hurlimann and March 2012;
Goosen et al. 2014
Maesham et al. 2011

# Solution:
# “ adaptation-as-you-go “

Focus on existing urban problems, ambitions and plans, and introduce climate resilient solutions / alternatives

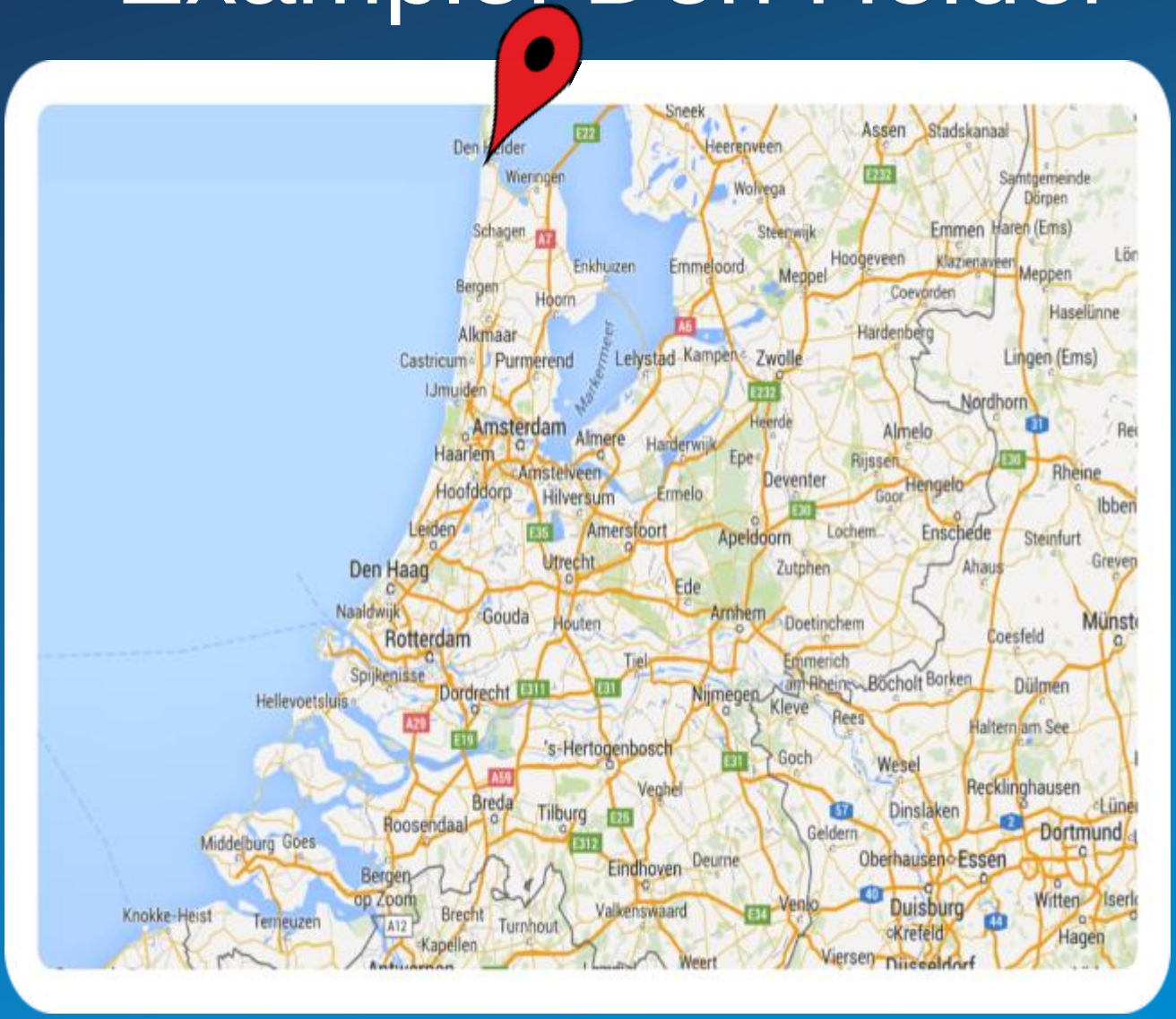
# Adaptation-as-you-go in three steps

1. Inquire about major plans urban plans, issues and investments;

2. Develop simple, easy accessible and relevant climate information;

3. Organise a participatory and multidisciplinary process to discuss options for making the plan more climate robust.

# Example: Den Helder



# Den Helder

Low income housing, many social issues

Central question:
How to restructure this neighbourhood?



# Example: Rheden

# Rheden (Netherlands)

- City shrinkage
- Demographic change

| Age | 0-15 | 15-25 | 25-45 | 45-65 | 65+ |
|---|---|---|---|---|---|
| % of pop. | 15% | 10% | 22% | 29% | 23% |

Central question:

How to keep the city attractive?

# Example: Menzelen

# Menzelen (Germany)

- City shrinkage
- Soil subsidence (Salt mining)

How to maintain water safety with soil subsidence and fluctuating river discharge and extreme precipitation?

# Climate workshops; design





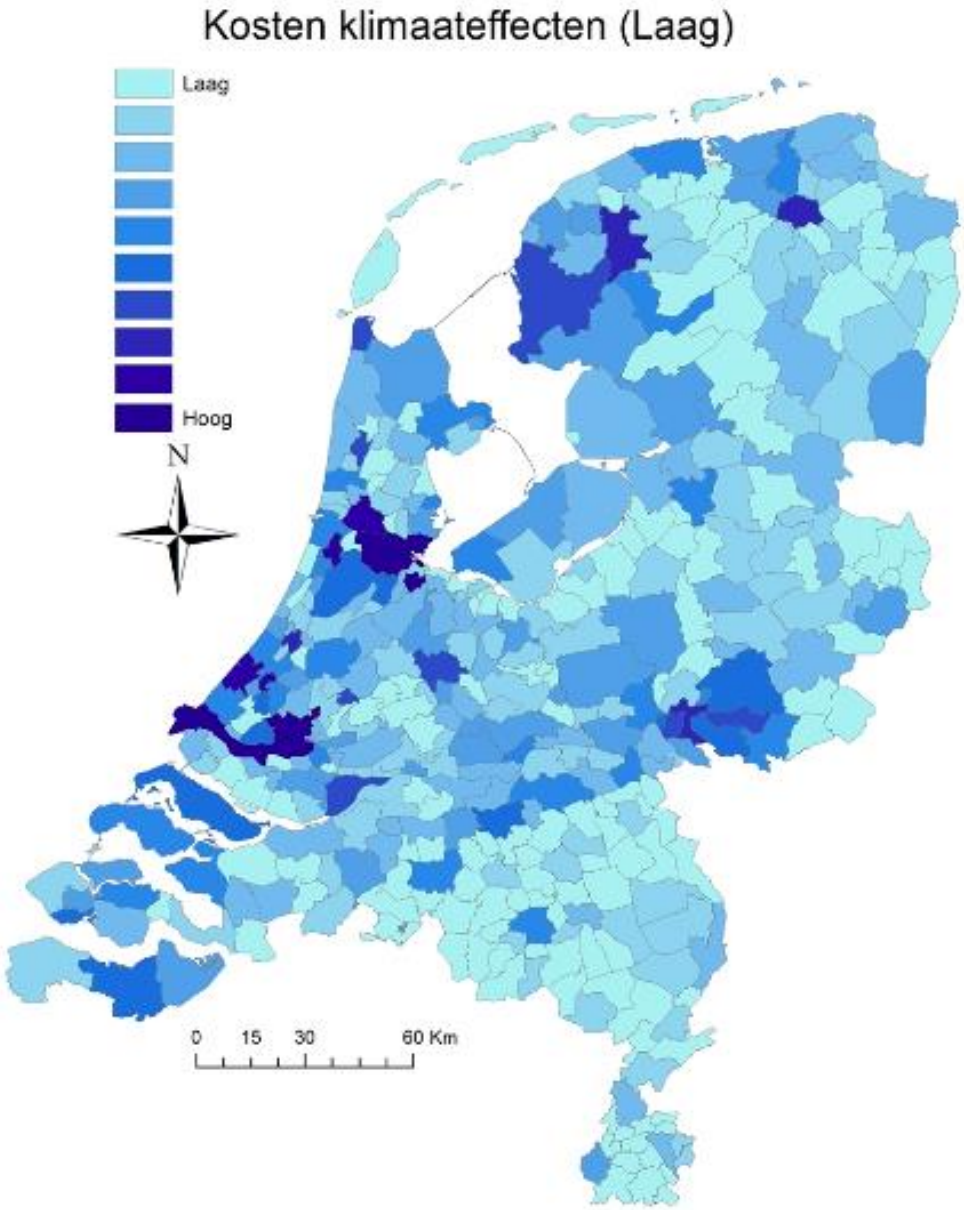

# Climate scenarios, data and visualisation examples

- The Hague, heat stress in 2050, analysis for different climate and city development scenario's;
- Amsterdam climate effects atlas; heat and flooding;
- Bangladesh climate effect atlas; data as called for by the users managers and planners;
- Future land use scenario's combined with future climate schenario's .
- Examples from Climate Adaptation Services web site:

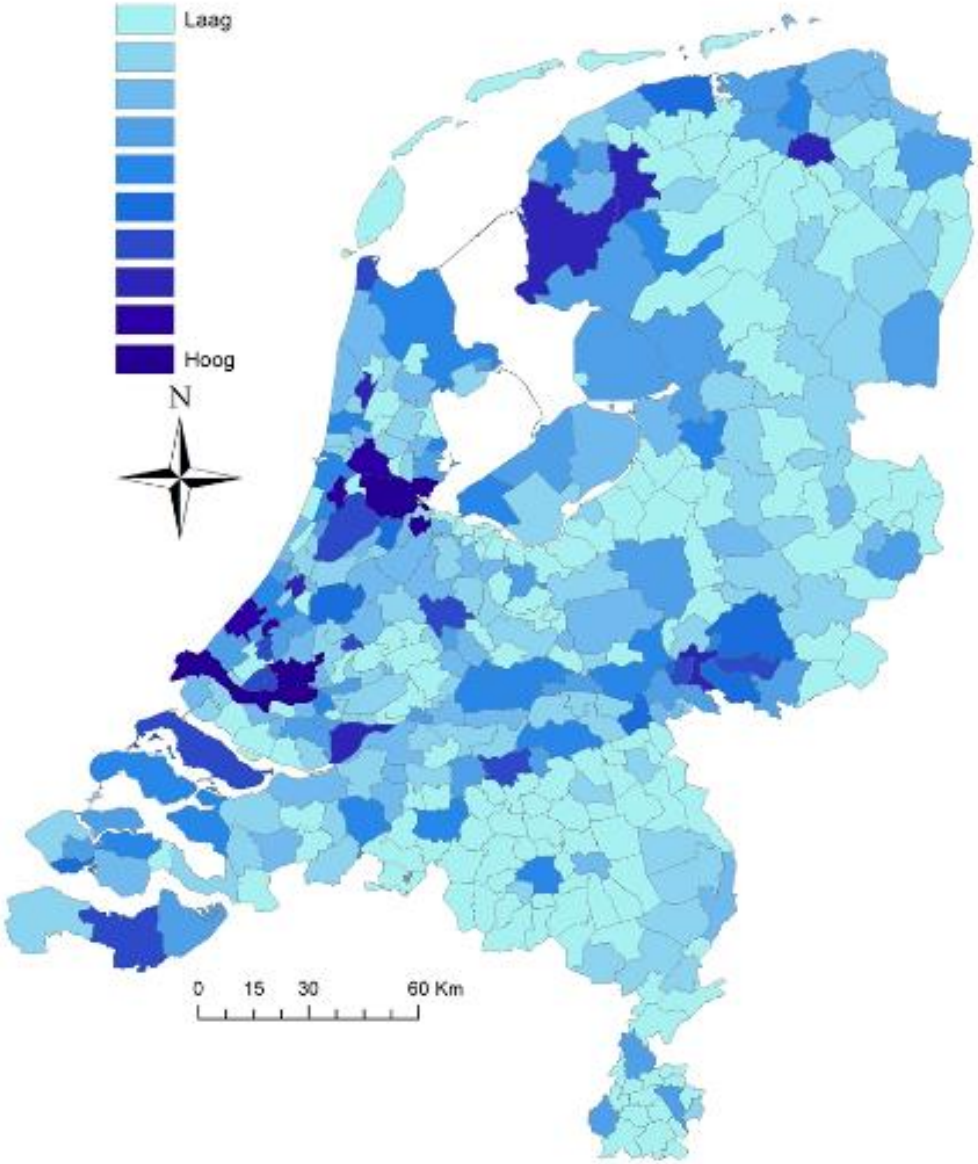
  http://www.climateadaptationservices.com

# Adaptation deficit in aggregated monetary value

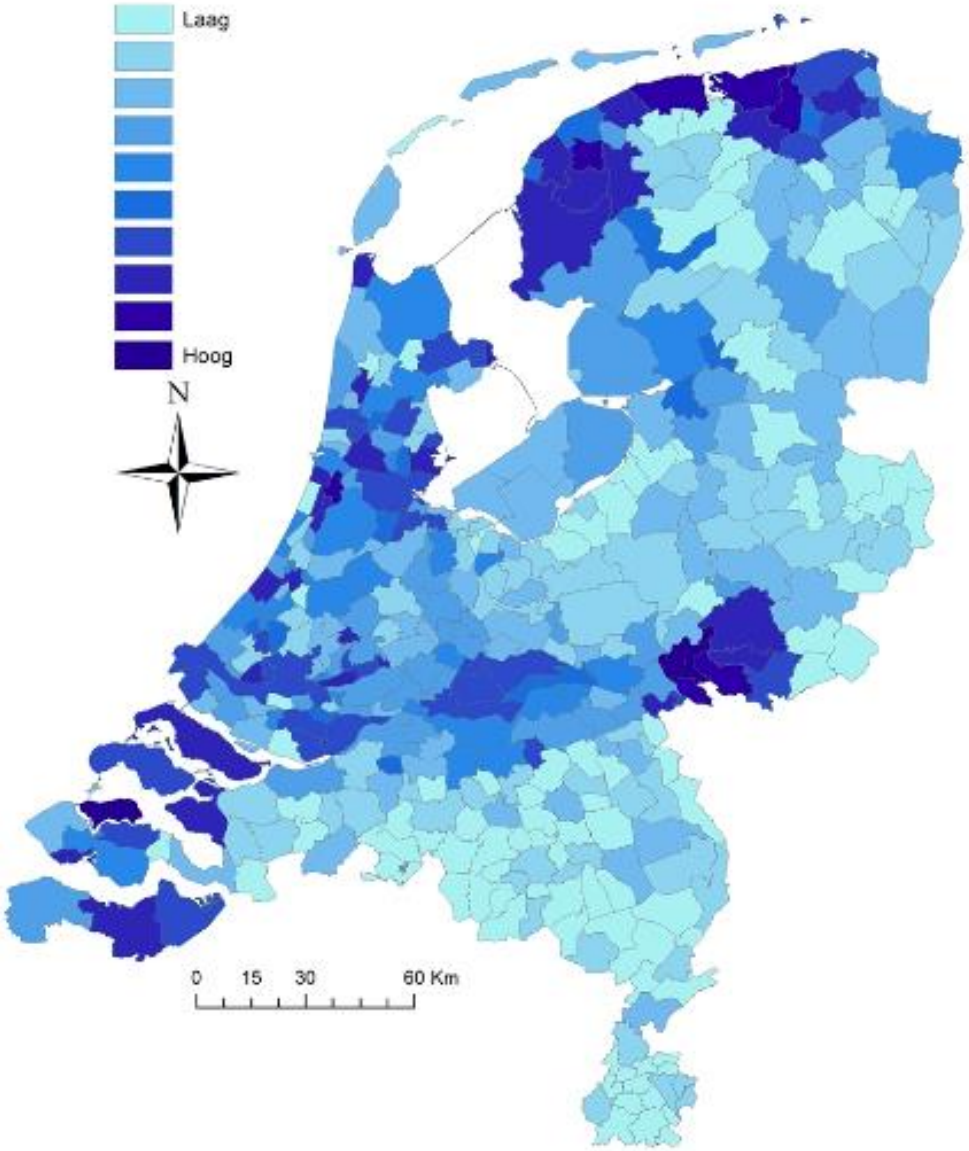
preliminary calculations per municipality / county / city

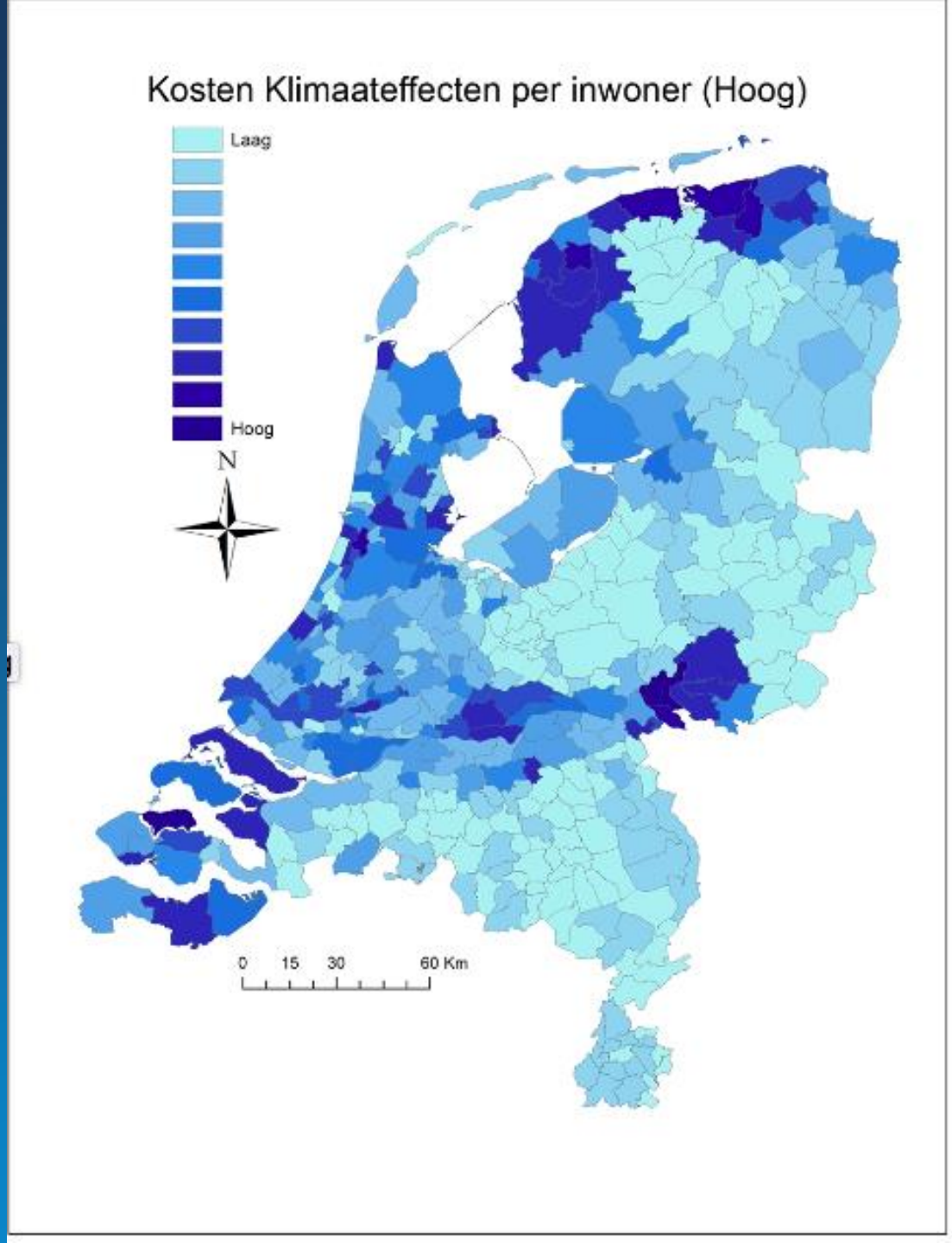

Kosten klimaateffecten (Laag)
Laag
Hoog
N
0 15 30 60 Km

# Kosten Klimaateffecten (Hoog)



# Kosten Klimaateffecten per inwoner (Laag)




Kosten Klimaateffecten per inwoner (Hoog)
Laag
Hoog
N
0 15 30 60 Km

# Nexus issues / synergies (1)

- Increasing the organic carbon content of soils reduces the CO-2 atmospheric concentrations and helps to bufffer extreme rainfall and;

- Shifting to more organic food diets reduces CH-4 emissions and reduces the water needs and thus climate vulnerability in agriculture;

# Nexus issues / synergies (2)

- Planting trees reduces the atmospheric concentrations of CO-2 and helps to store/buffer water and lower the temperature;

- Water is a good medium to  store/buffer heat/energy and as such an excellent medium for use in heat pump systems for electrifying heating systems in homes and offices;

# Final recommendations

- Make sure that climate information is presented in a simple way;

- When in consultation with stakeholders on adaptation: start with analysis of and solutions for other issues or plans and identify alternative, or additional climate robust solutions;

- Transitions towards a climate neutral society are generally considered more urgent than adaptation; thus in efforts for adaptation start from plans and investments aimed at emission reduction and present adaptation as an additional sustainability issue;

Thank you for your attention