Setting the frame: sustainable dredging and climate change

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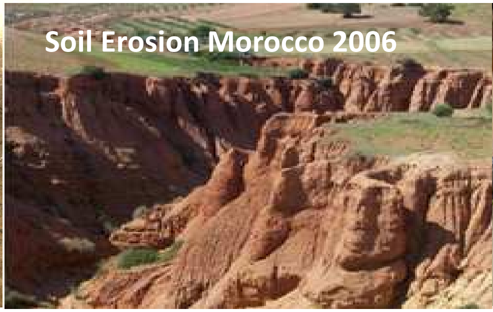
P I K



Leibniz Association

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What are the main known threats from Climate Change to the coasts (ecosystems, infrastructures)?

Could forces of nature be used in shaping Climate Change Adaptation measures?

Would the ecosystem's approach be applicable in Climate Change adaptation measures for coastal, estuarine and fluvial environments?

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Climate Change
&
Sea Level Rise

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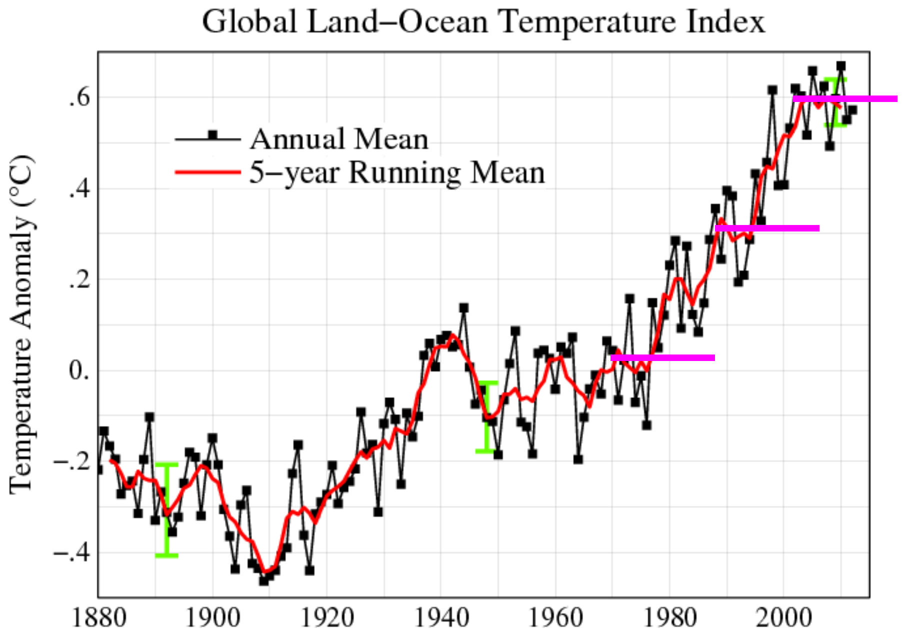
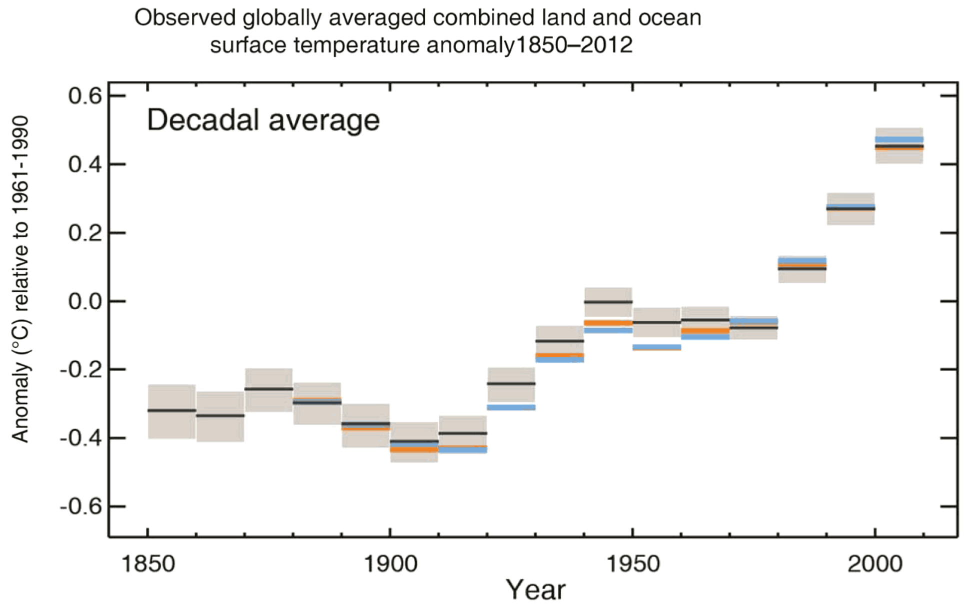
The ongoing threat of global warming

Each of the last three decades has been **successively warmer** than any preceding decade since 1850.



NASA GISS



The evidence for human influence has grown since AR4. It is **extremely likely** *[i.e. 95% certainty]* that **human influence has been the dominant cause** of the observed warming since 1950.

IPCC AR 5, Summary for Policymakers, 2013

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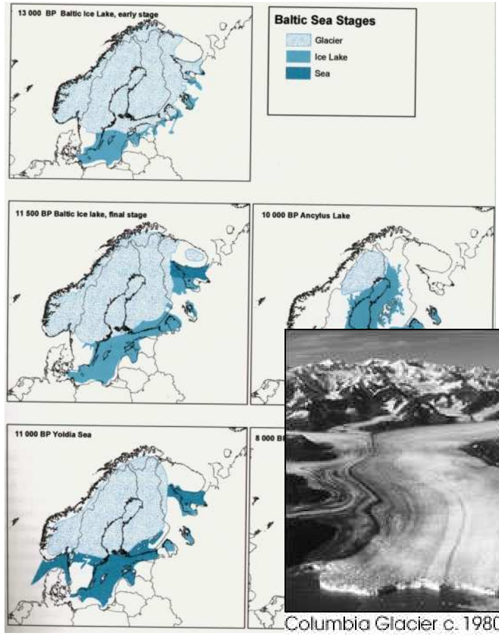
Drivers of Sea-Level Rise in Europe



Isostatic land up-/downlift

Melting of inland glaciers
Approx. 50% (eustatic)

Thermal Expansion
Approx. 50% (steric)

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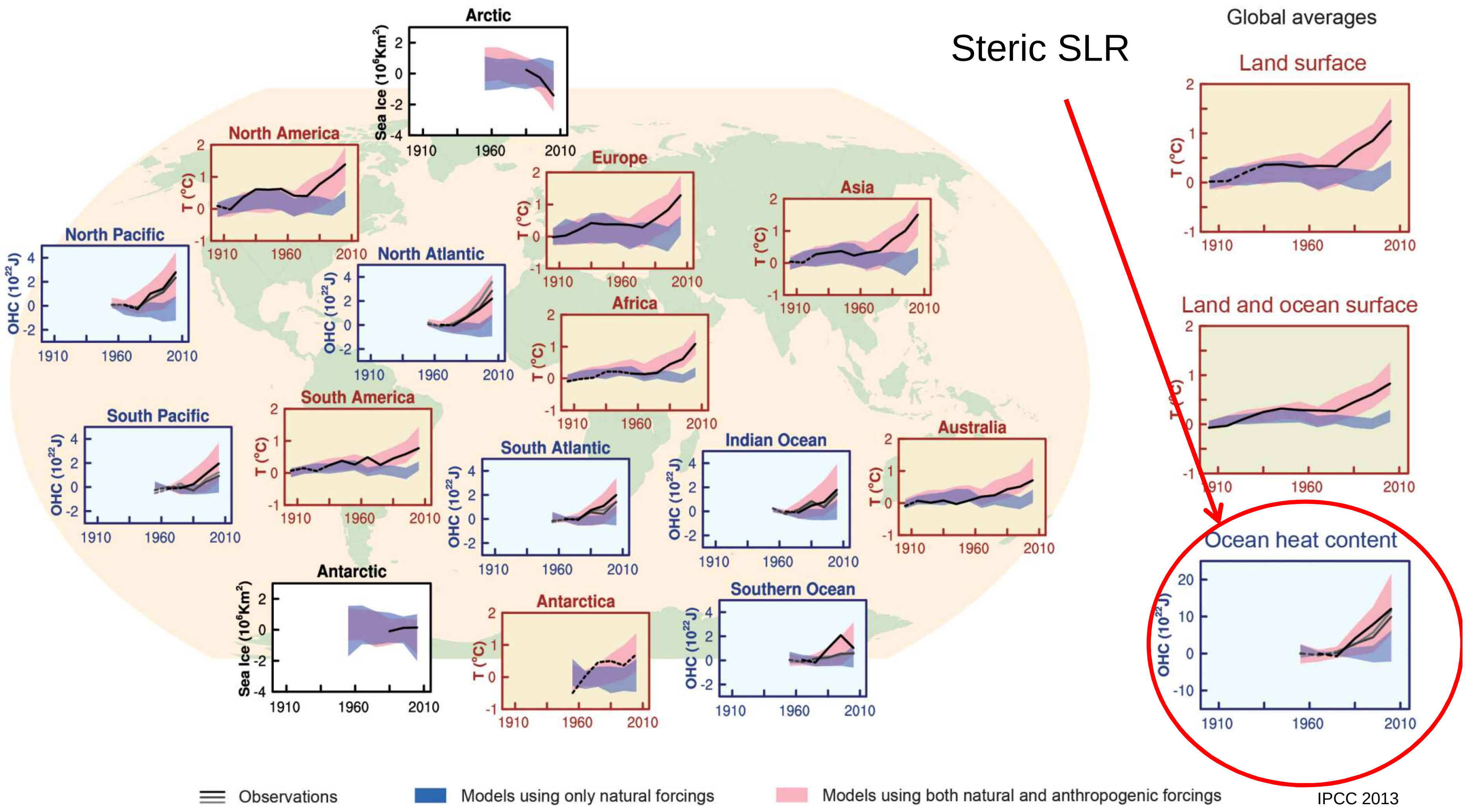
Root cause of warming: It is Mankind!



Yellow panels: land surface temperature
White panels: sea ice extent

IPCC AR5 WGI: Physical Science Basis (2013)

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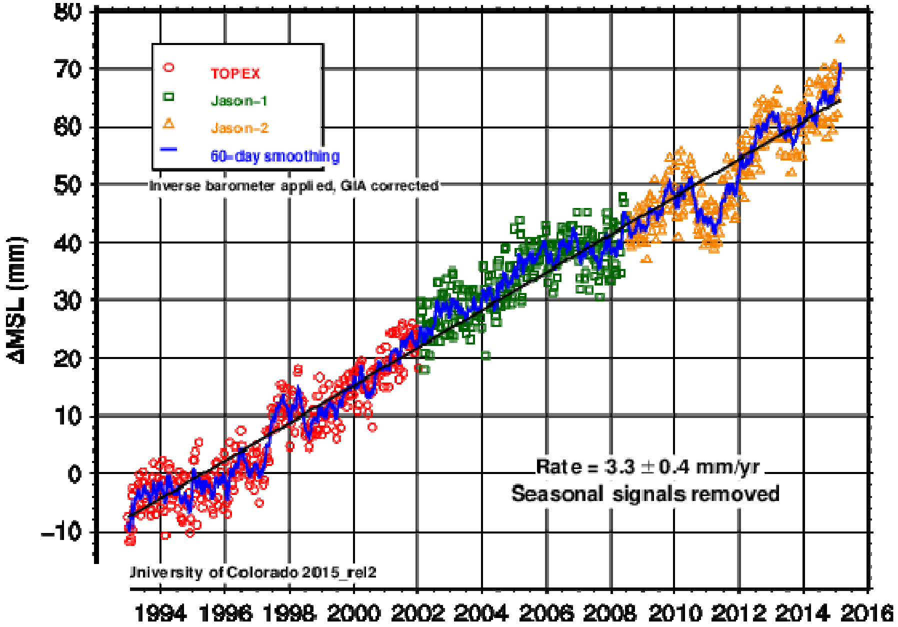
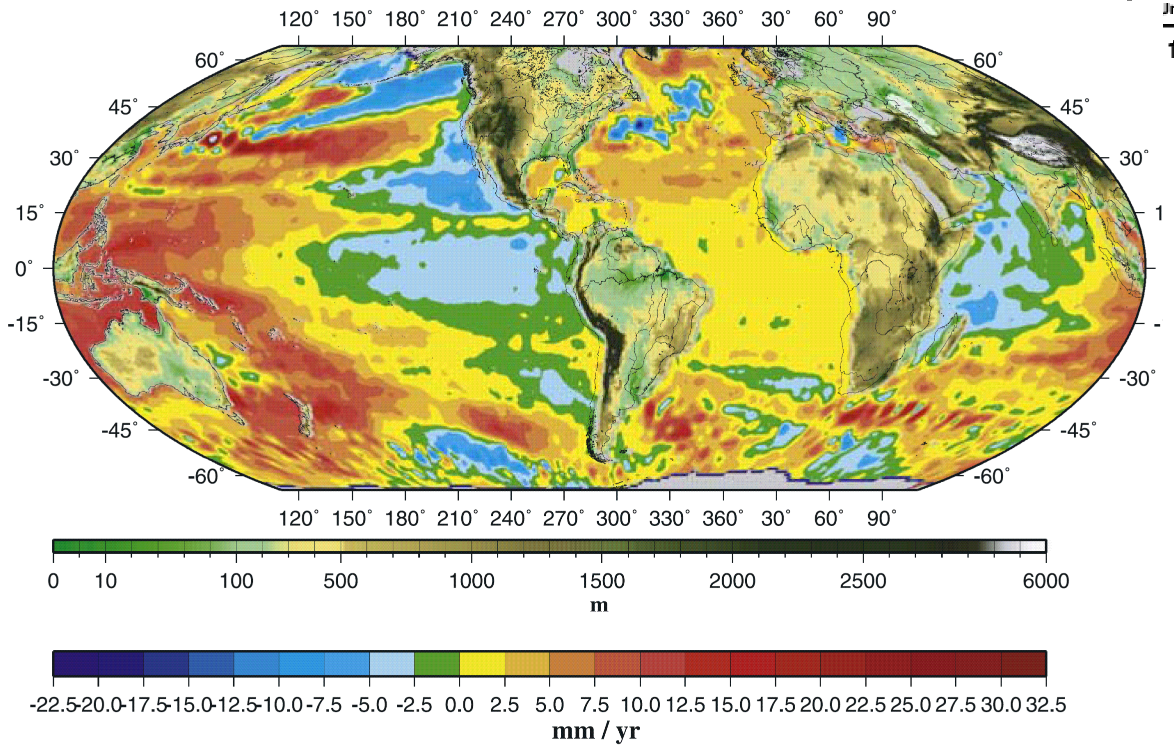
Global Sea-Level Rise: Topex/Poseidon/Jason measurements



Trend: 3.3mm/yr



The crux: SLR is globally not equally distributed

After: Cavenaze & Nerem 2004
U. Colorado 2015

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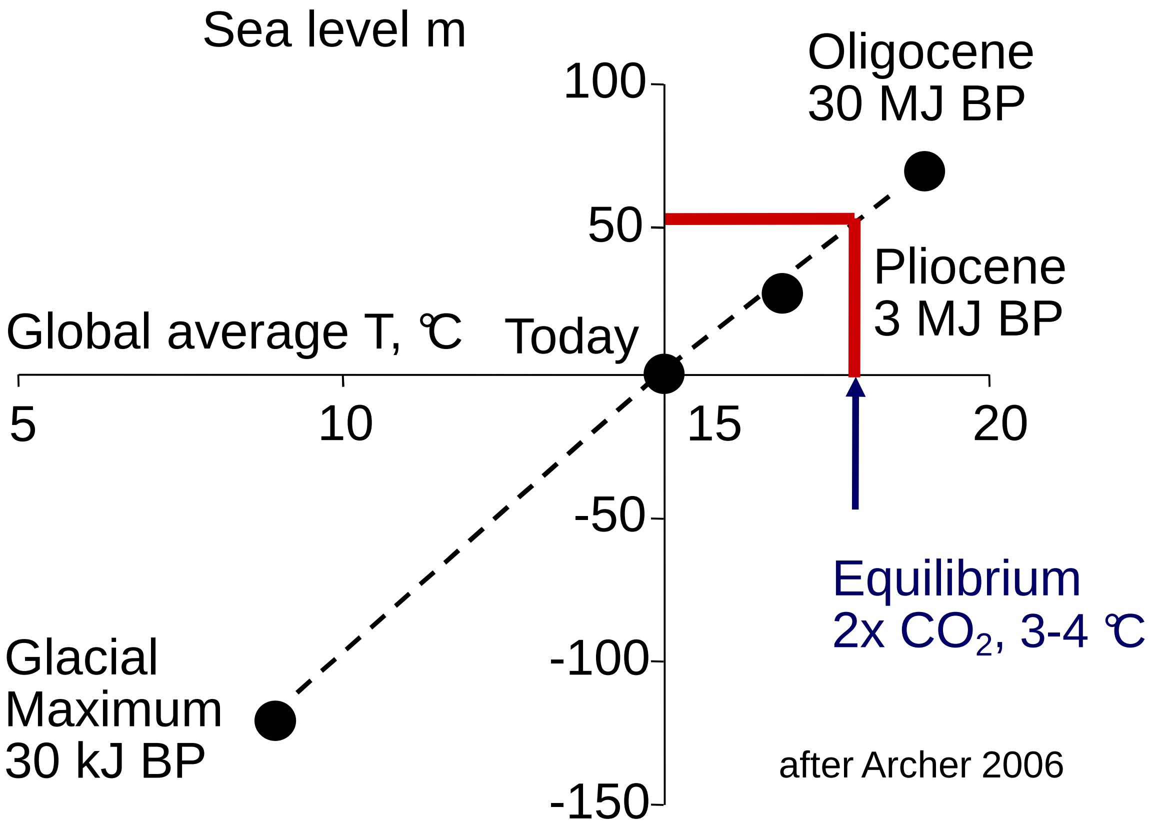
Sea level and temperature in an equilibrium



after Archer 2006

Response time on warming stimulus of Cryo-/hydrosphere: 200-2500 yrs

Rates are different:
20-8 kyrs BP: 10mm/yr
Today: 3.4mm/yr

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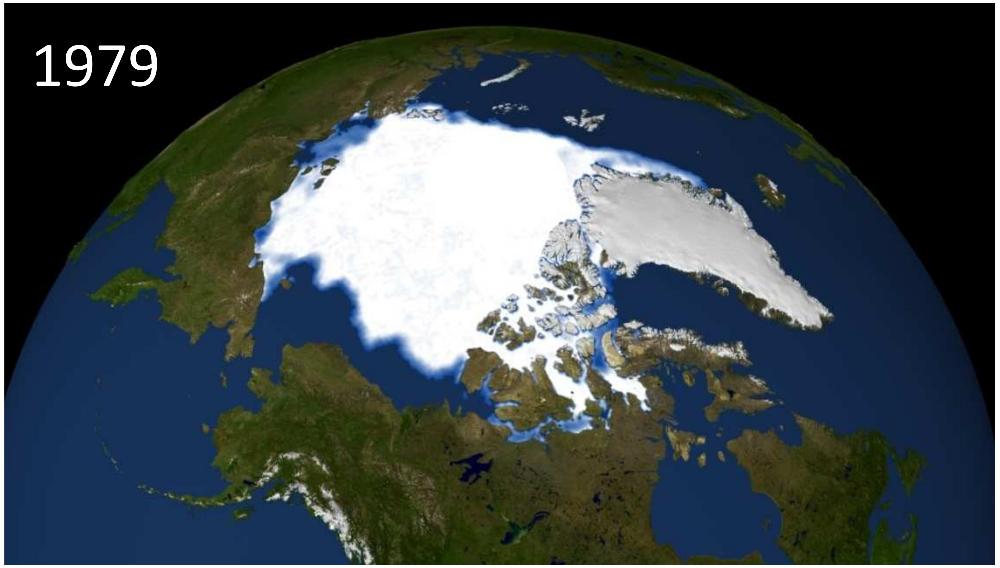
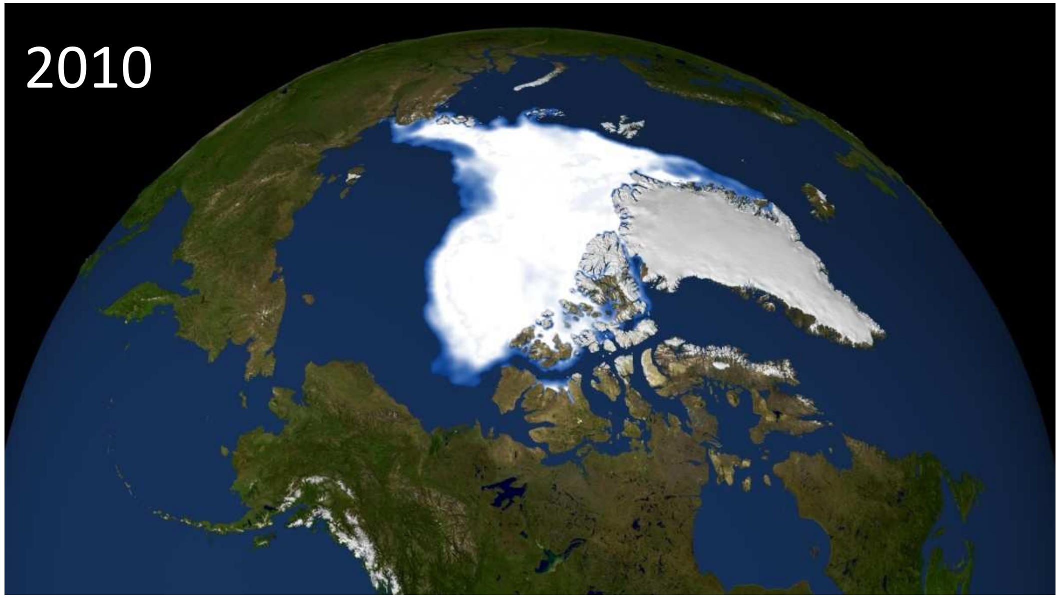


-49% in comparison to the 80ties



(U.S. National Snow and Ice Data Center) Arctic Sea Ice Decline

(Notz 2010 after Stroeve et al. 2007 GRL)

A warming stimulus in the cryo- and hydrosphere is not reversable on a short to mid-term time scale

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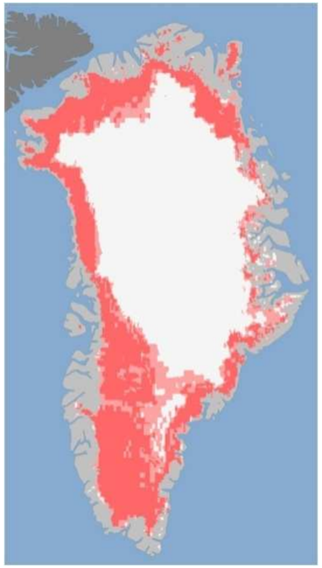
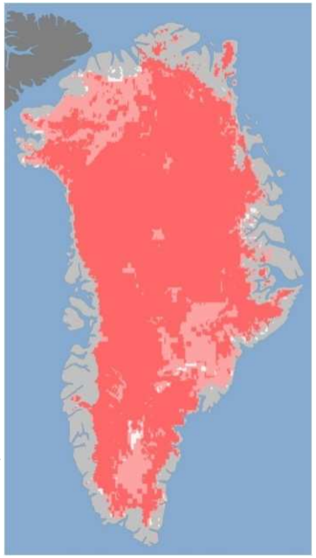
Ice sheet loss: Greenland/Antarctica



8 July 2012

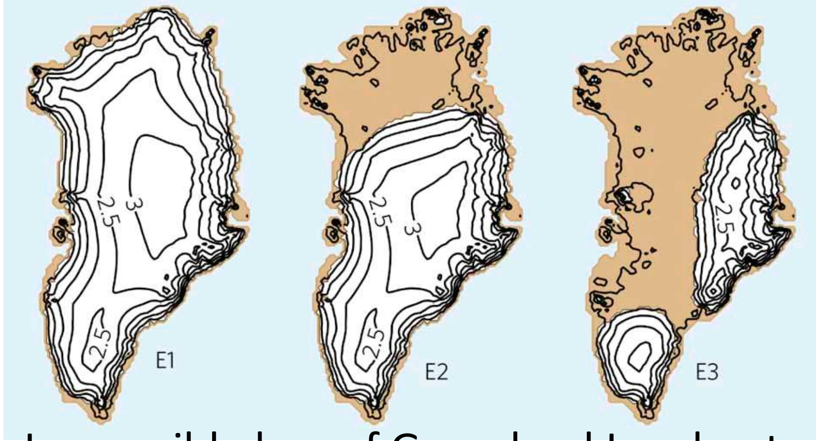
Thurface thawing

12 July 2012

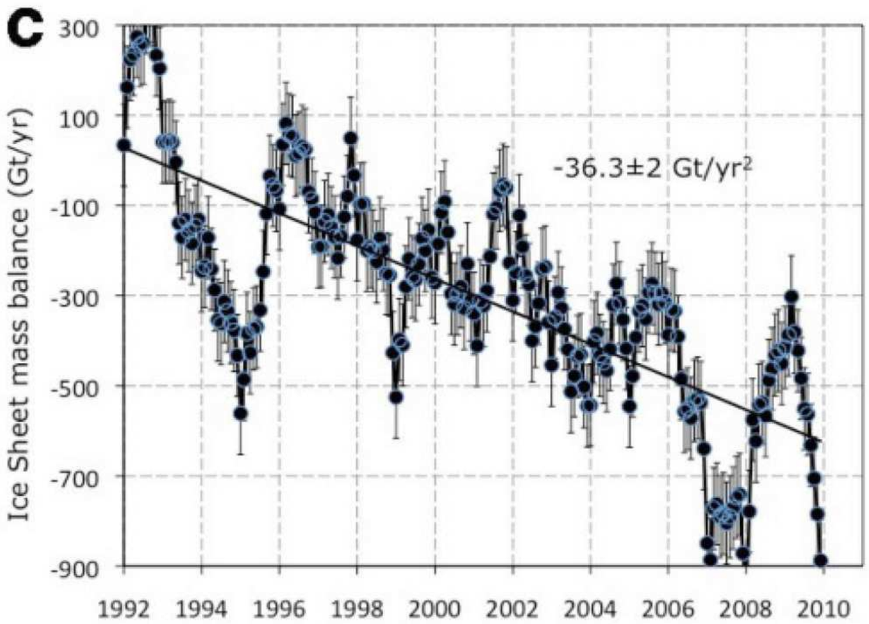


Nicolo E. DiGirolamo, SSAI/NASA GSFC, and Jesse Allen, NASA Earth Observatory 2012

Robinson et al. 2012



Irreversible loss of Greenland Ice sheet could start at +1.6°C



~ 50/50 Greenland/Antarctica

After: Rignot et al. (2011)

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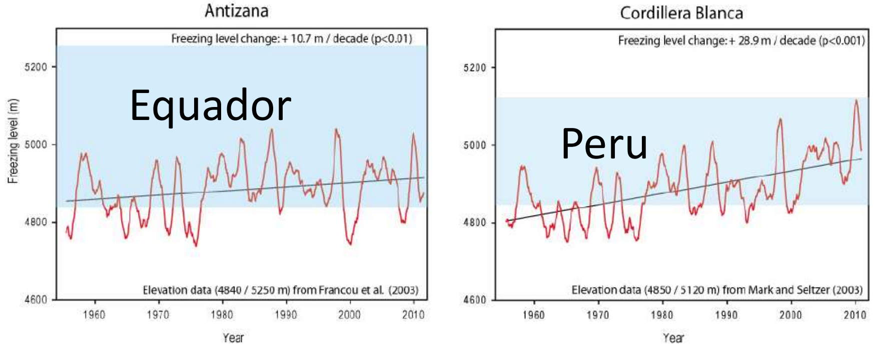
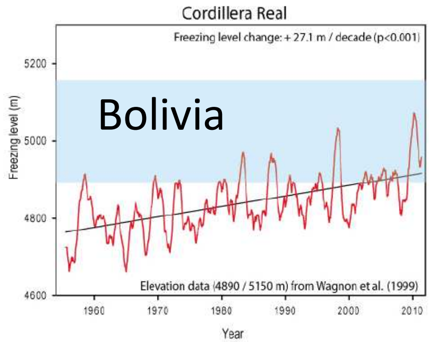
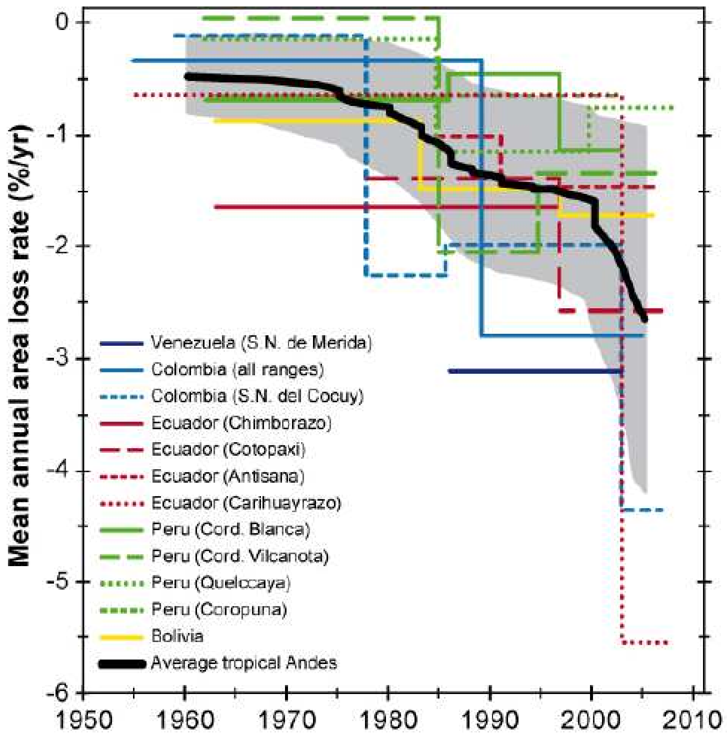
SA Western Coast "Water Towers" are disappearing:
Shrunk at unprecedented rate since the 70ties: 30-50%

Upward moving of frost border

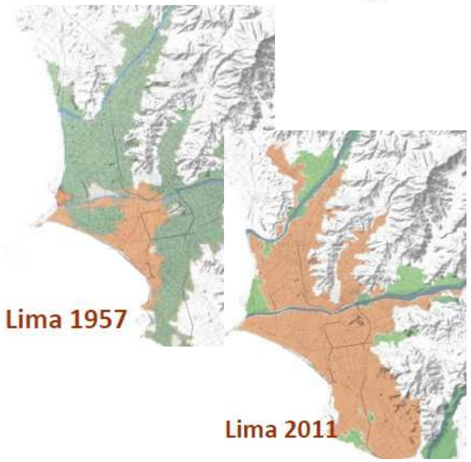


Rabatel et al. 2013,
Cryosphere





Sample: 50% of all glacier`s in SA Andes



Rio Rimac:
streamflow, mid-term increase, long-term decrease.
window of opportunity for development of a city vision

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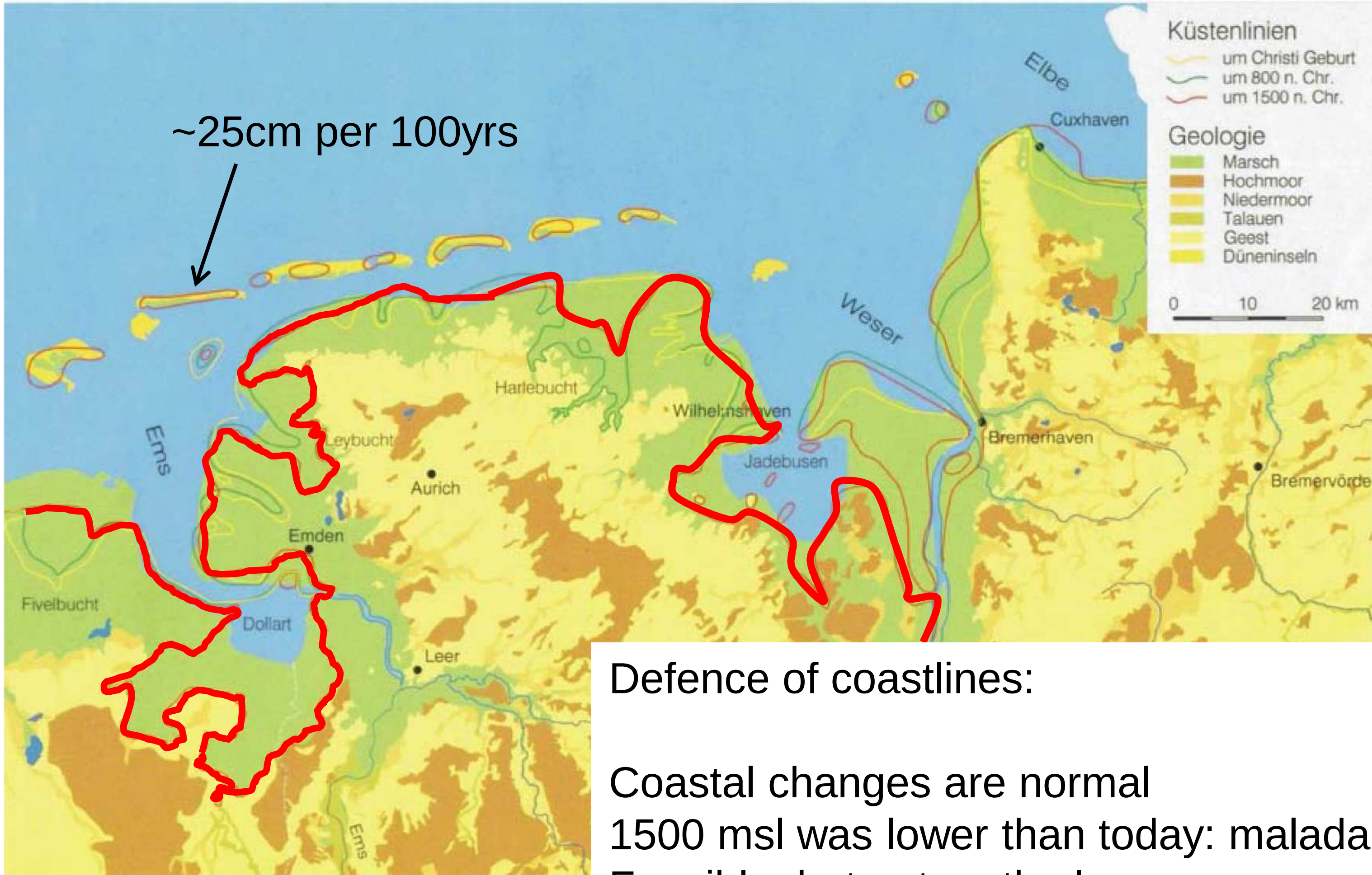
On the long run: land-loss, retreat, etc. are unavoidable, but…….

on the short run it depends, i.e. willingness to pay, accepted risk level, etc.

Coastlines in Lower Saxony/Germany & Eastern Netherlands: 0-2000AD

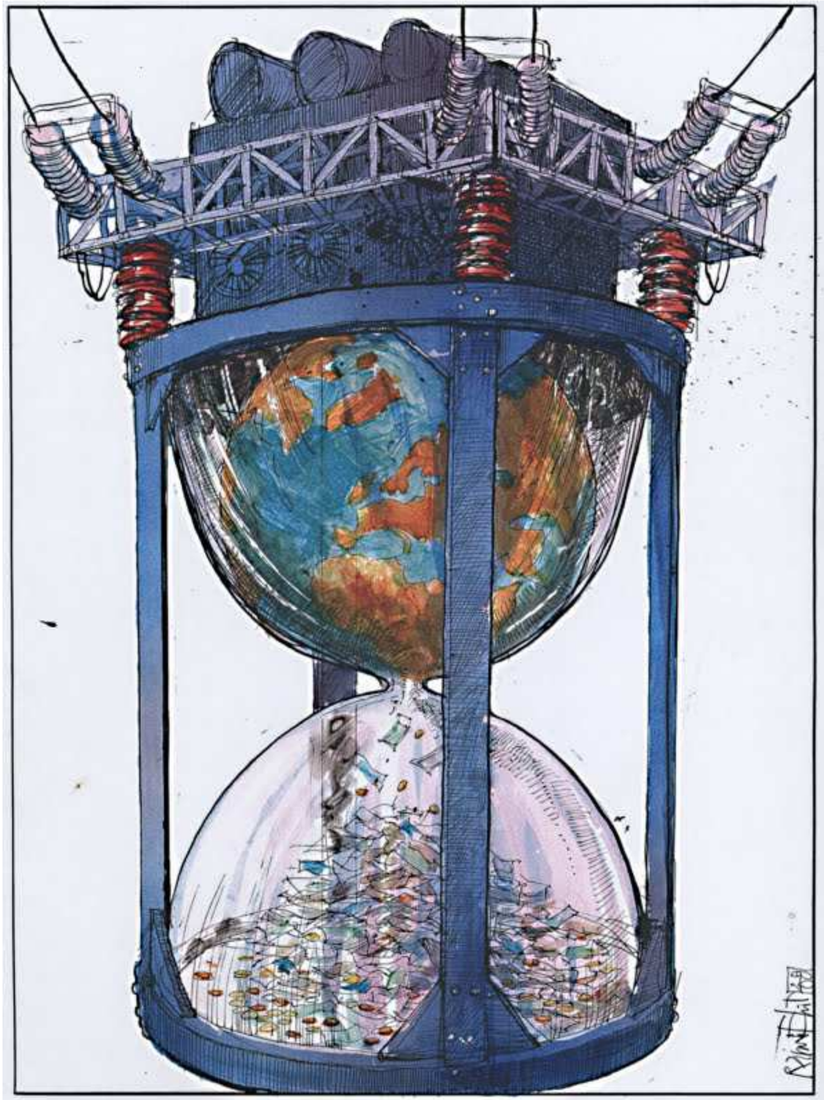


Source: Behre 1999

Defence of coastlines:

Coastal changes are normal
1500 msl was lower than today: maladaptation
Feasible, but not on the long run
Depends on willingness to pay

Observed challenges and things to come...



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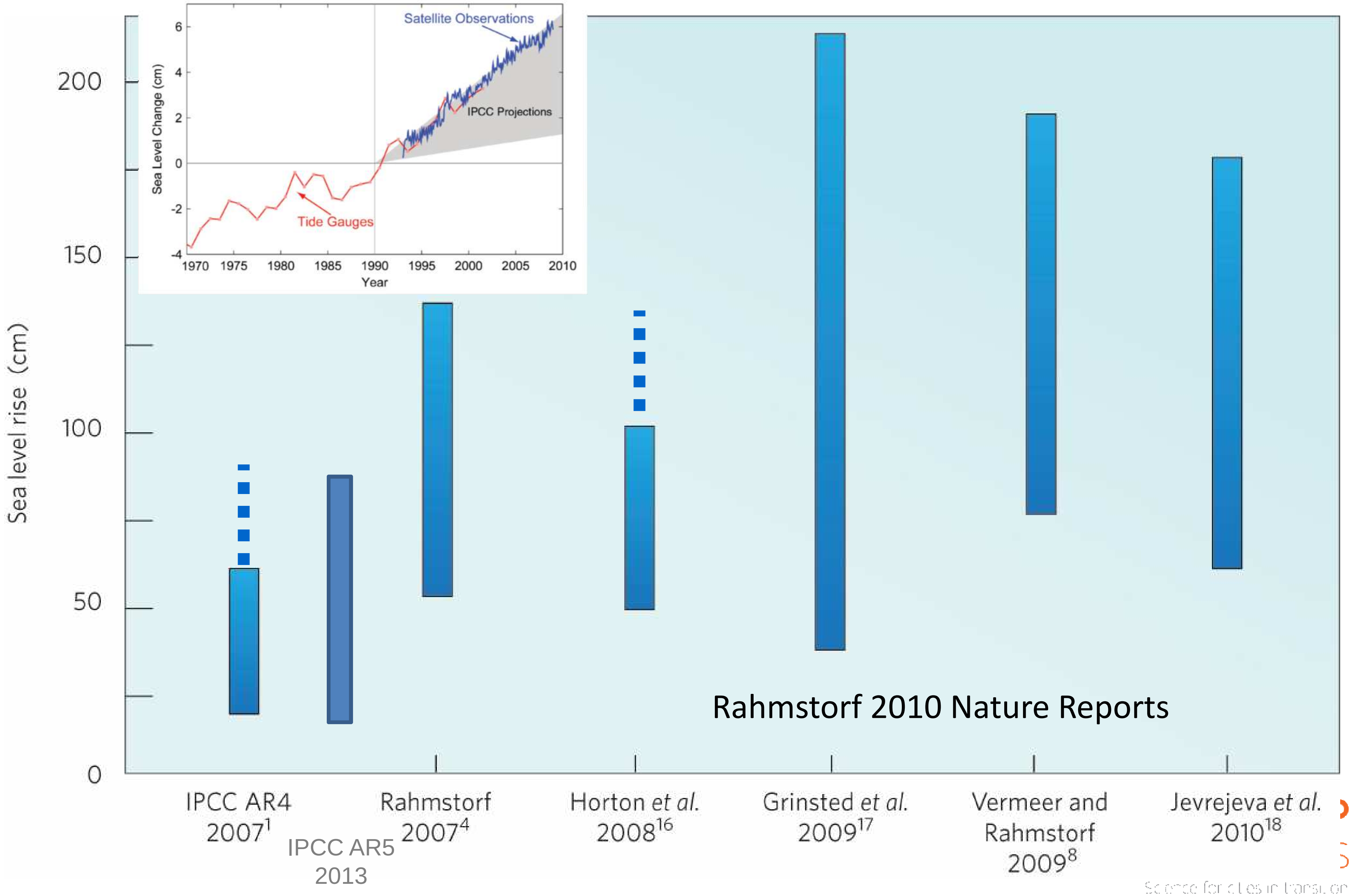
Underestimated the Risk of Sea- Level Rise:

Geo-data show larger and faster increases, the crux: response time



Dredging activities are often disputed in public and policy

Reasons:

Negative side effects, e.g. changing natural habits, instable dikes, changing stream dynamics, economic benefits unclear,....

Positive effects: higher protection level, constant and/or increased employment opportunities, active ecosystem management,.....

Facts anyway:
Any kind of dredging/coastal protection are buy time options
EIA is necessary in any case – including CBA

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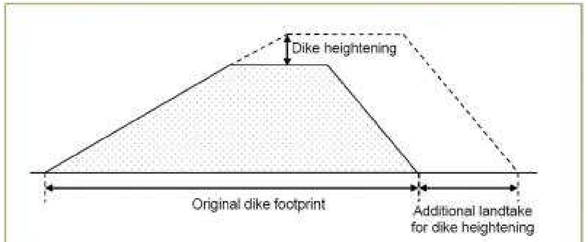
Coastal protection and safeguarding investments is expensive; examples from Vietnam, Netherlands, Germany



Schematic illustration of the large land areas required for dike construction and the additional land take required upon dike heightening

Construction costs:
0.9 to 29.2 mln US$ per meter rise in height, per km length (linear) – Vietnam-Netherlands

Maintenance costs: 0.03 mln in Vietnam to 0.14 mln US$ in the Netherlands

(after Hillen et al. 2010, Hillen 2008, AFPM, 2006)

Deepening of river Elbe between mouth and Hamburg by 1.50m: 380-600 mln €

(pers. Comm.)

Costs for beach norishment Sylt Island

Approx. 182,5 mln €/40 yrs
2009-2012: 26,2 mln €

(pers. Comm.)

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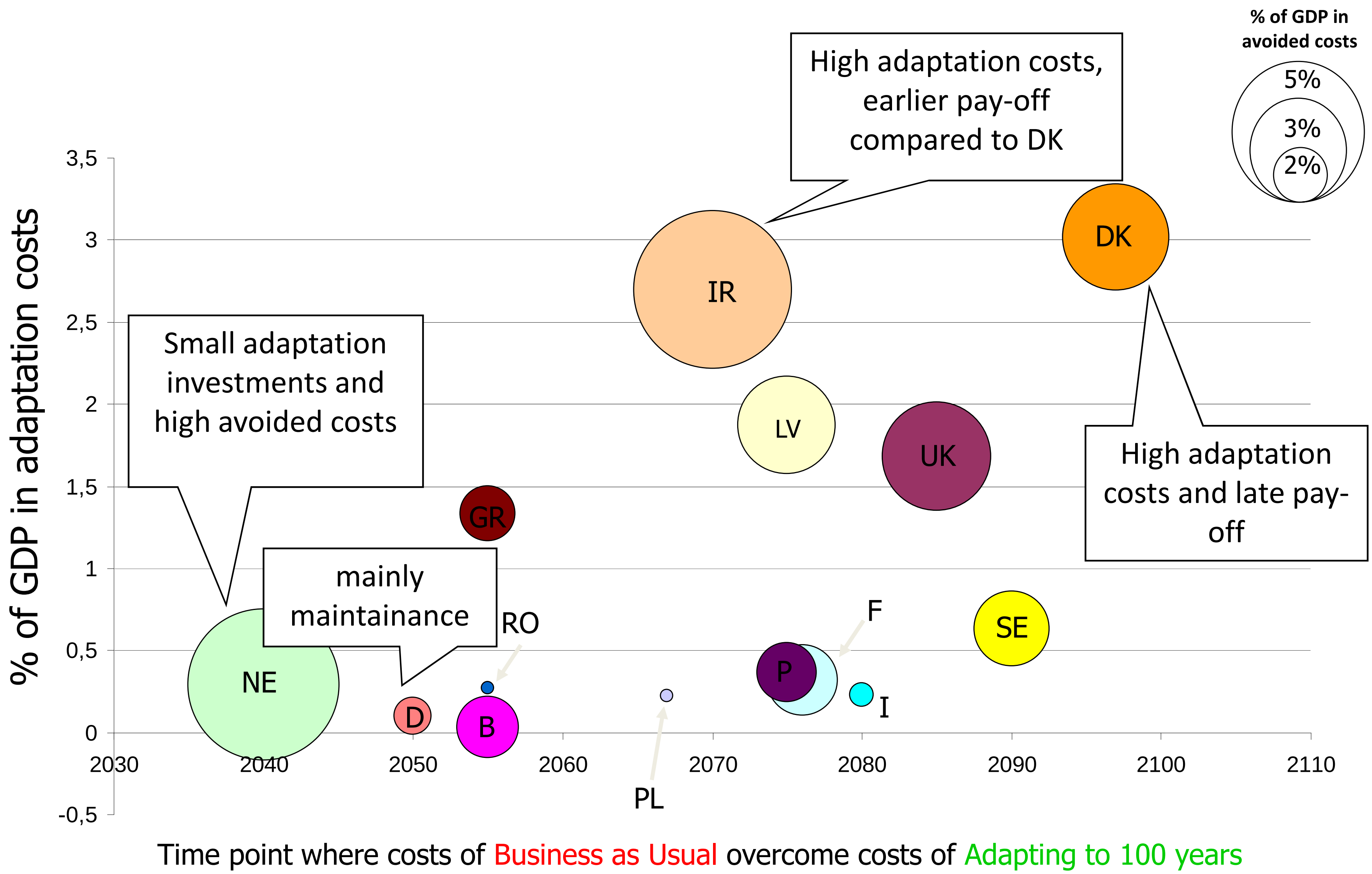
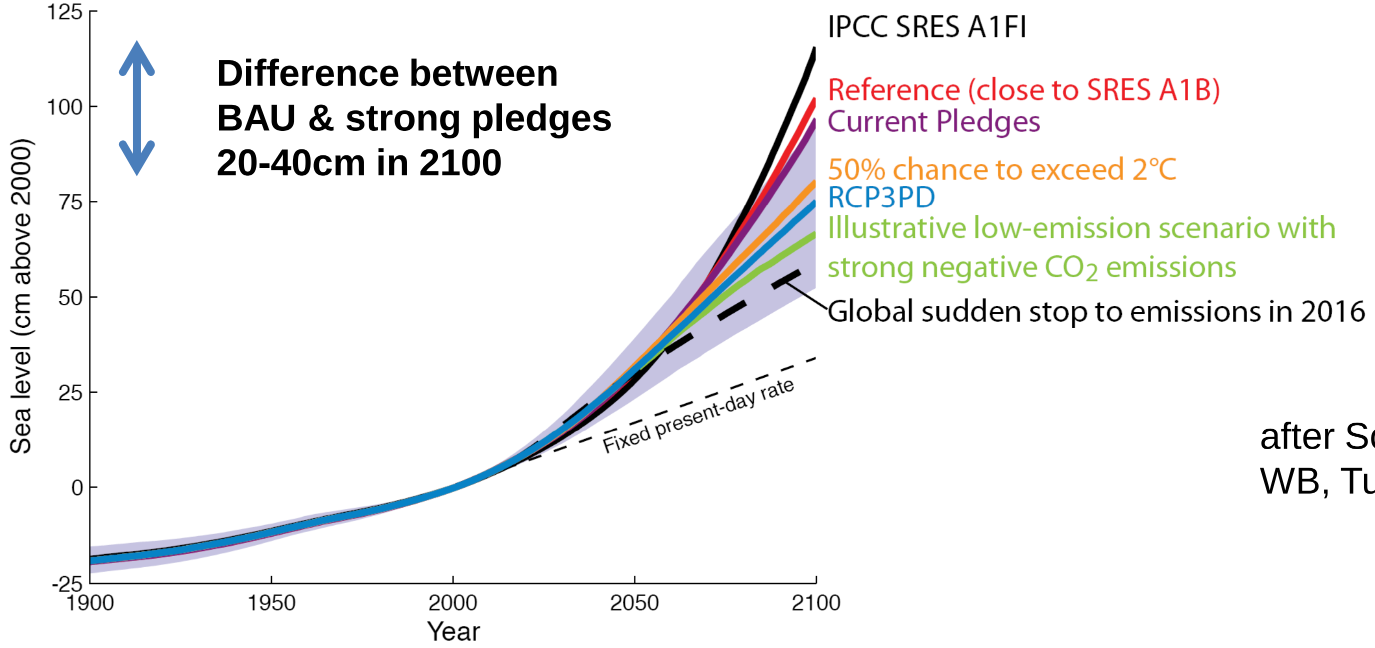
Adapting to a 100yr event, business as usual, 2007 GDP

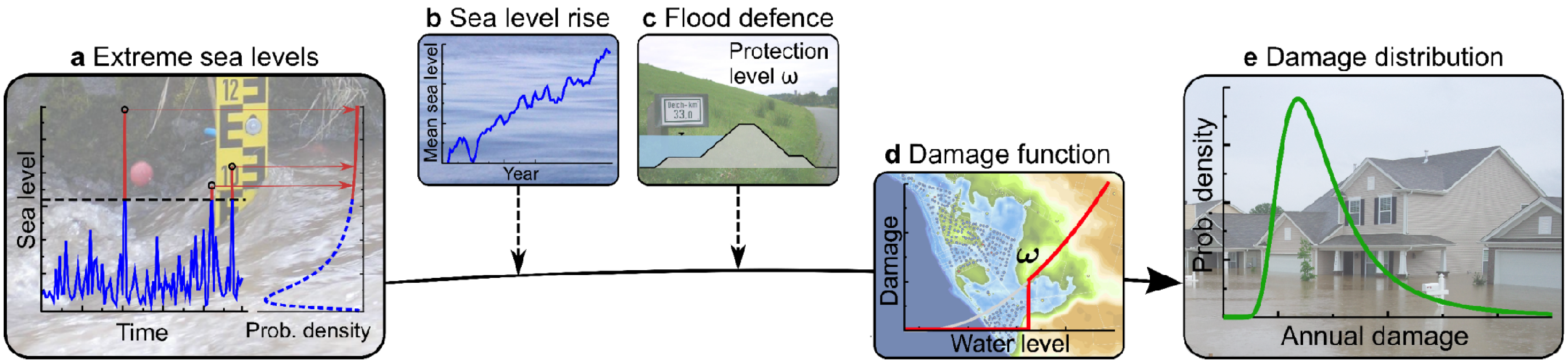


Costa/Tekken/Kropp (2009)

Assessing Risks & Costs Adequately



after Schaeffer et al. (2012)
WB, Turn down the Heat (2013)



after Böttle/Rybski/Kropp (2015)

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Land Use Damage Functions

Relative stage-damage functions for several *land uses* (Huizinga, JRC, 2007):

	Flood level								
Land use	0 m	0.5 m	1 m	1.5 m	2 m	3 m	4 m	5 m	6 m
Residential (incl. inventory)	0	0.25	0.4	0.5	0.6	0.75	0.85	0.95	1
Commerce (incl. inventory)	0	0.15	0.3	0.45	0.55	0.75	0.9	1	1
Industry (incl. inventory)	0	0.15	0.27	0.4	0.5	0.7	0.85	1	1
Infrastructure (roads)	0	0.25	0.42	0.55	0.65	0.8	0.9	1	1
Agriculture	0	0.3	0.55	0.65	0.75	0.85	0.95	1	1

X

Exposed values (Huizinga, JRC, 2007):

Land use	Average maximum damage value [€/m^2]
Residential buildings	750
Commerce	621
Industry	534
Roads	24
Agriculture	0.77

X

Economic scaling based on GDP data (Huizinga, JRC, 2007):

Country	Factor	Country	Factor
EU27	0.96	Spain	1.00
Norway	1.49	Cyprus	0.88
Iceland	1.31	Malta	0.75
⋮		⋮	
Germany	1.06	Romania	0.48
France	1.03	Bulgaria	0.42
Italy	1.03	Albania	0.22

=

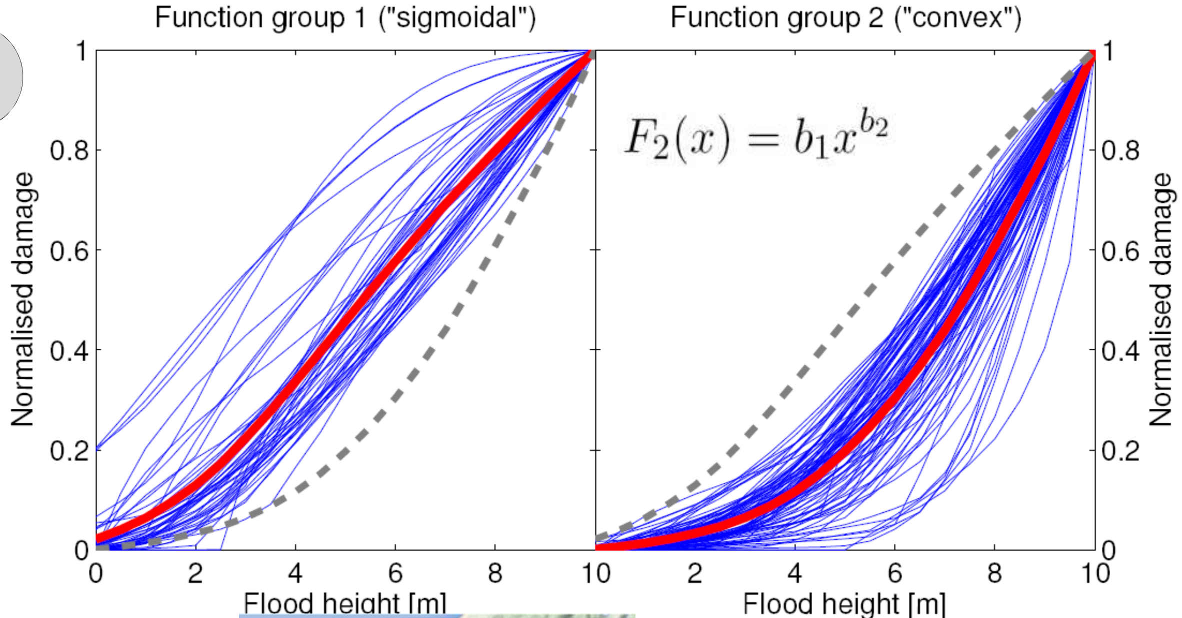
Country-specific damage functions for various *land uses* [€/m^2]

Damage functions for 140 European Coastal Cities (SEA-DAM)

1

$$F_1(x) = \frac{a_1}{1 + \left(\frac{x+a_2}{a_3}\right)^{-a_4}}$$

$$\approx c(x+a_2)^{a_4}$$



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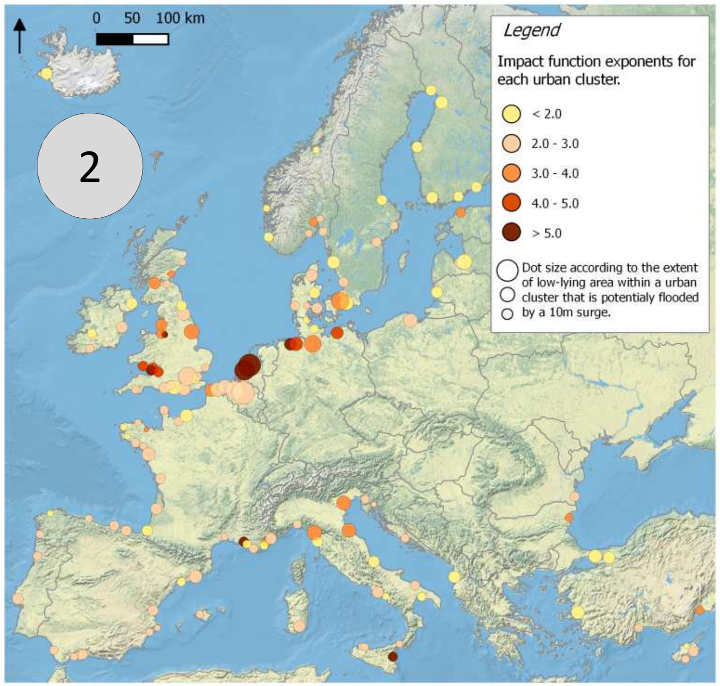
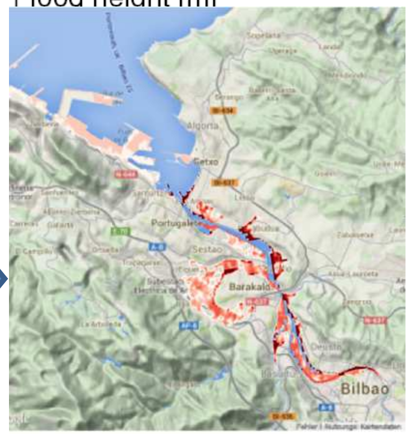


3



Damage (in EUR/m2) from a 5 m surge

< 50

50 - 100

100 - 150

> 200

0 1 2 3 km

Example: Bilbao

flood protection?

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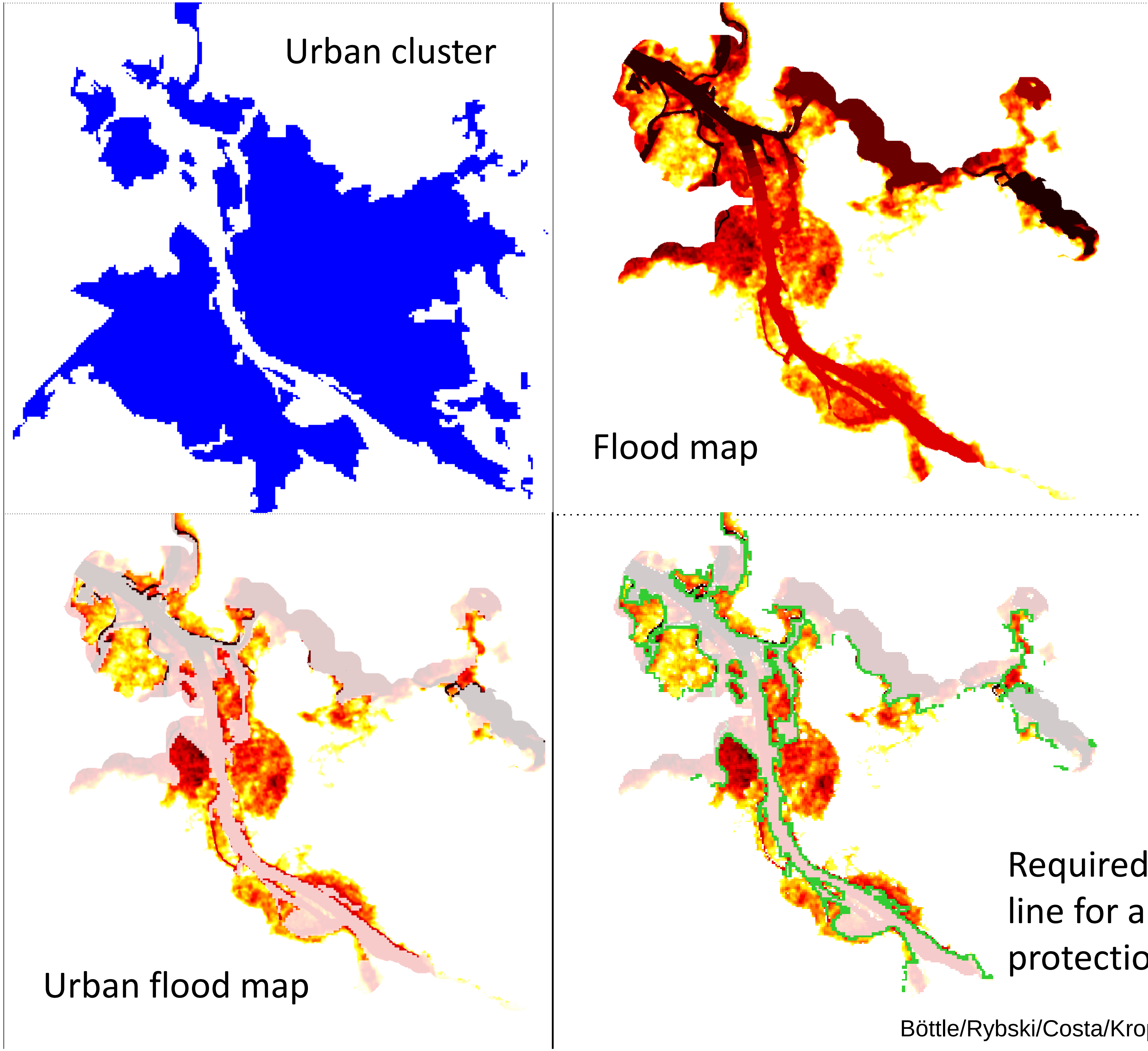
Example of Riga



Böttle/Rybski/Costa/Kropp (2015)

The „sand thieves“

2012, Germany mined 235 million tons of sand and gravel, with 95 percent of it going to the construction industry

UNEP estimates global consumption at an average of 40 bn to/year, with close to 30 bn tons for concrete

Sand is the most widely consumed natural resource on the planet after fresh water.

In poor countries beaches become victims of construction boom, e.g. Cape Verde, Morocco, India (“sand mafia”)

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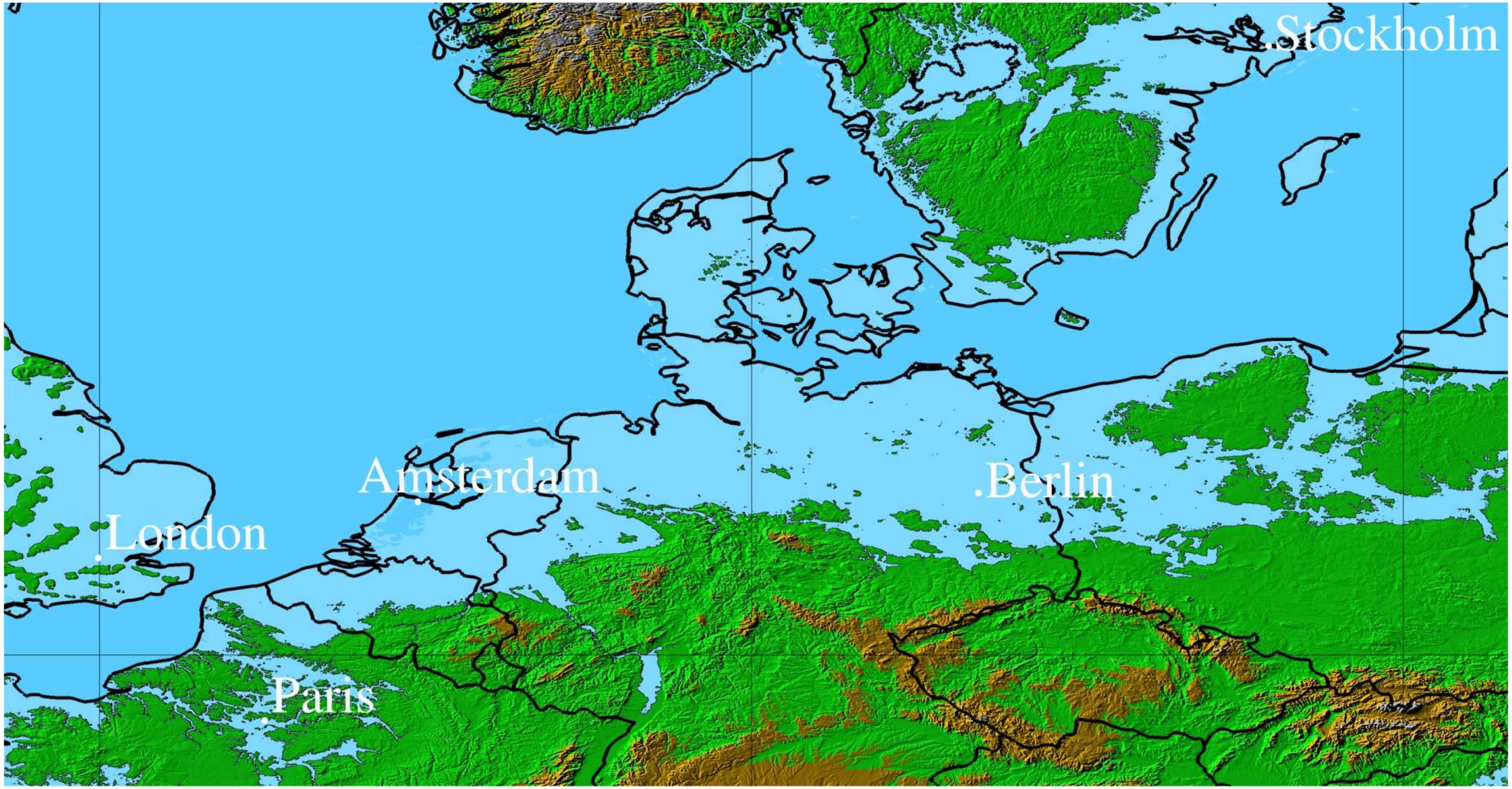
The long run: Central Europe



"An End to Global Warming", L.O. Williams, Elsevier 2002

*) maximal value in case of thermal equilibrium

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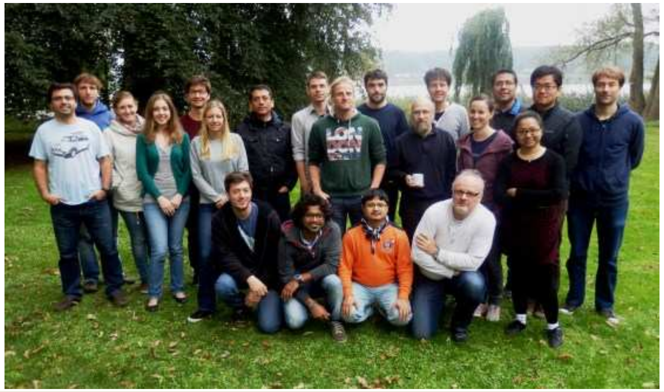
Thank you very much for your attention



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