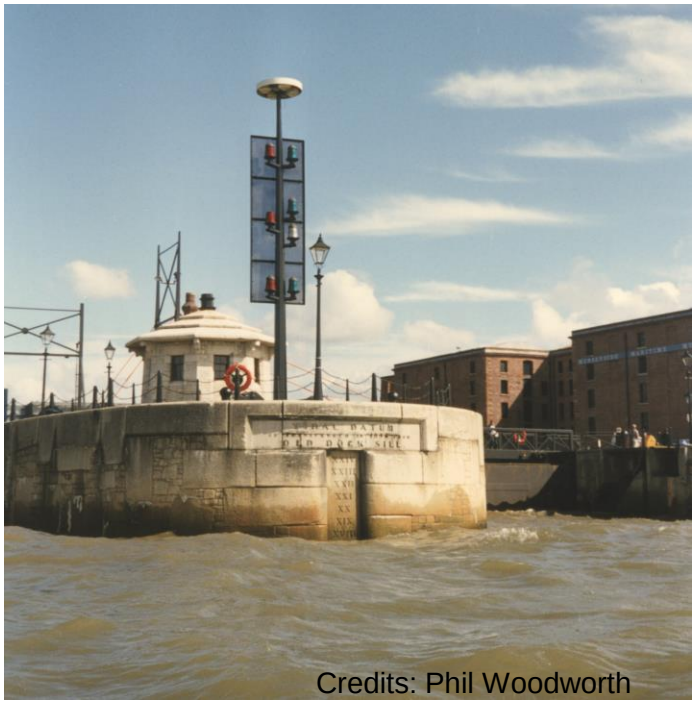
Sea level rise:
Recent progress and challenges


Credits: Phil Woodworth

S. Jevrejeva
National Oceanography Centre, Liverpool, UK

Co-authors:
L. Jackson, A. Grinsted, J. Moore, MI Vousdoukas, D. Lincke, Y. Qu, R. Riva and many other

Outline

1. Sea level changes, background information
2. Sea level projections after AR5 IPCC (2013):
   global, regional and local
3. Progress in understanding the main uncertainties in future sea level projections
4. Challenges for coastal sea level projections
5. Conclusion

Sea level rise today and by 2100

20th century sea level rise: **0.2 m**

Sea level rise by 2100 (scenarios: 1.5 ˚C… RCP8.5): **0.5-1.8 m**

20th century rate for sea level rise: **1.7 mm/yr**

Since 1990s rate: **3.4 mm/yr**

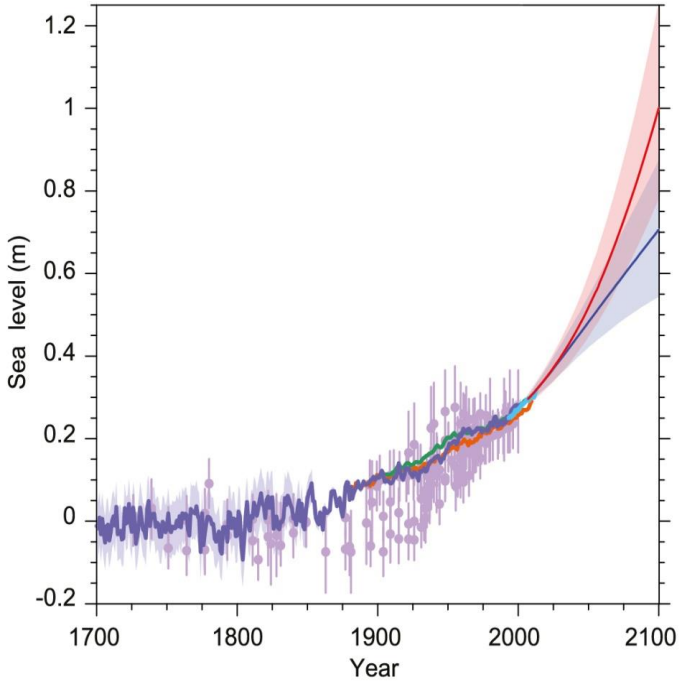
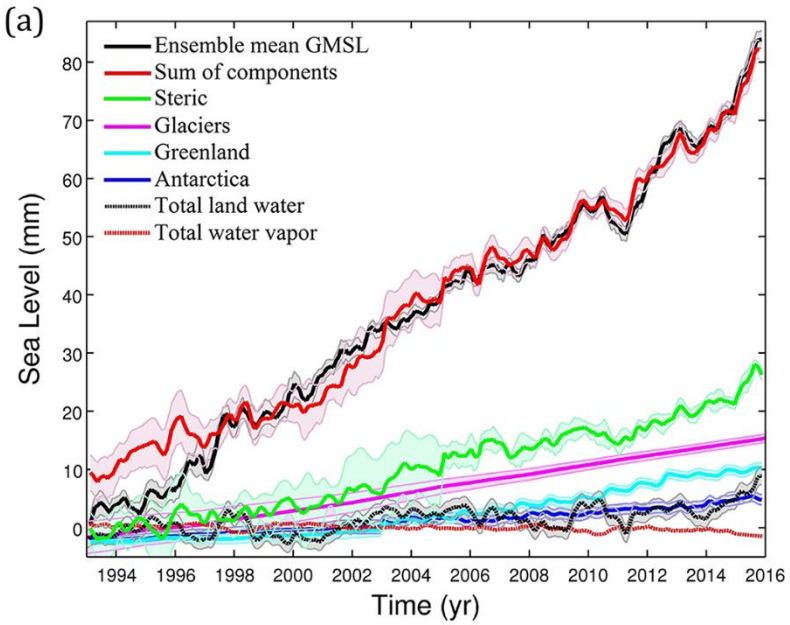


Figure 13.27, AR5 IPCC (2013)

Sea level budget since 1993

1993-2016

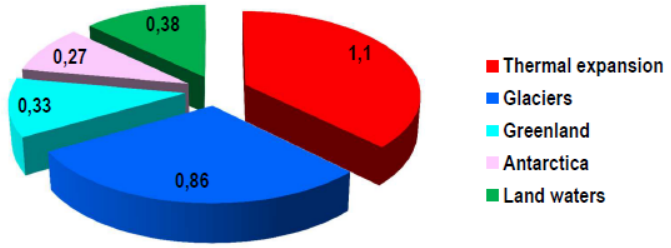


Dieng et al, 2017

1993-2010

Observed sea level budget 1993-2010 (IPCC AR5)

Individual contributions (mm/yr)

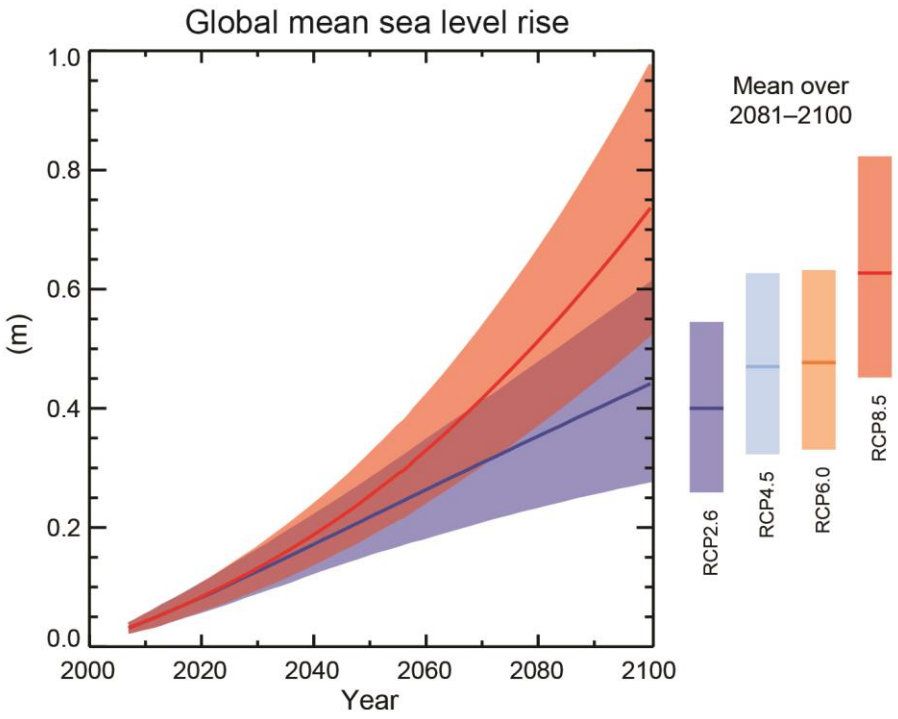


Sum of contributions : 2.8 +/- 0.5 mm/yr
Observed rate of rise: 3.2 +/- 0.4 mm/yr

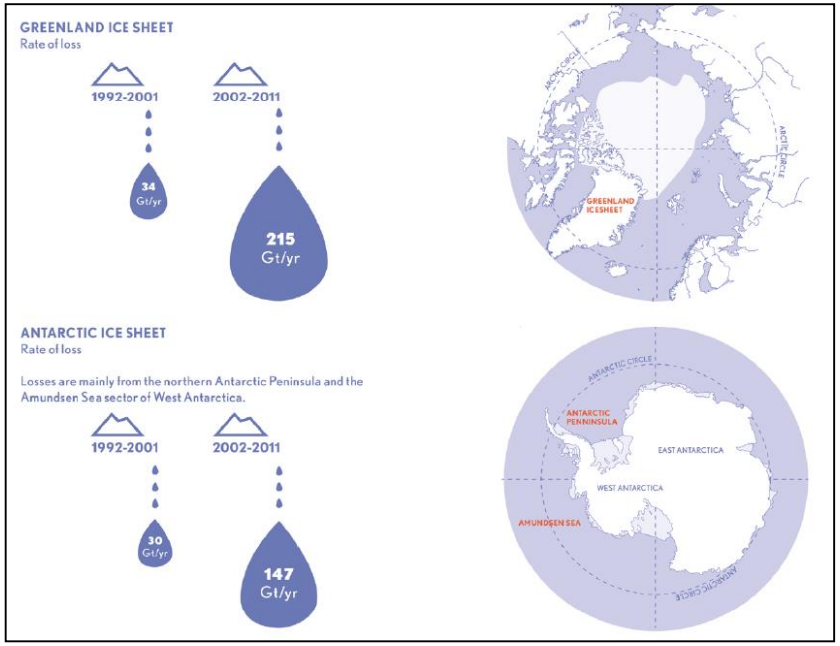
From A. Cazenave, http://www.psmsl.org/about_us/news/2013/workshop_2013/talks/02_PSMSL_Liverpool_28Oct2013_WEB.pdf

Sea level projections in AR5 IPCC (2013)

Likely range (66% probability)

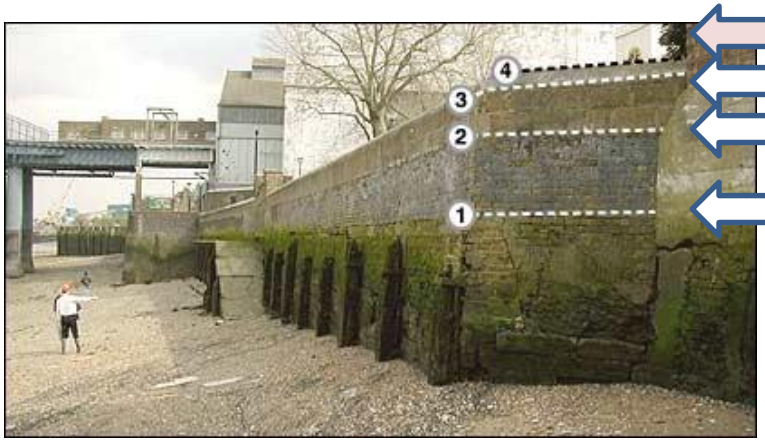


SPM.9, AR5 IPCC



Credits: Finnish Meteorological Institute

Risk and Impact assessment in coastal areas



1953
1928
1890

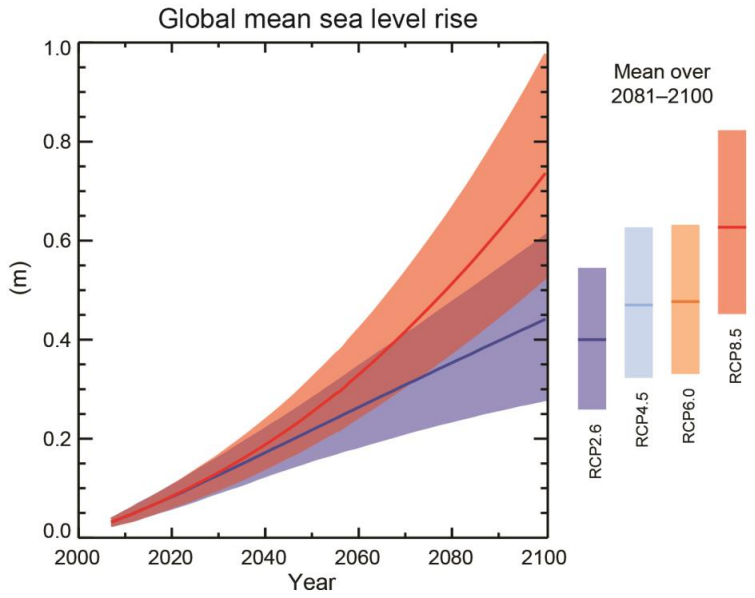
1879

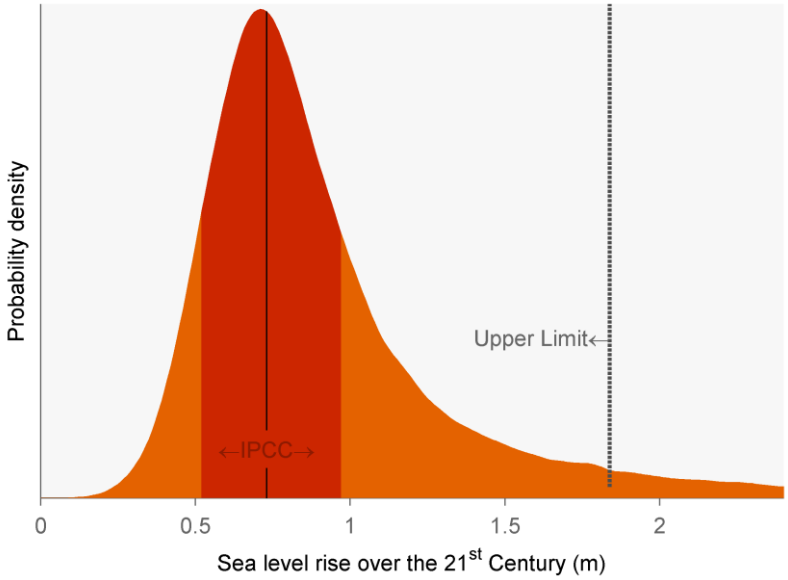
Photo from Environment Agency, UK

Photo from Environment Agency, UK

Probabilistic approach for global sea level rise

Likely range (66% probability)

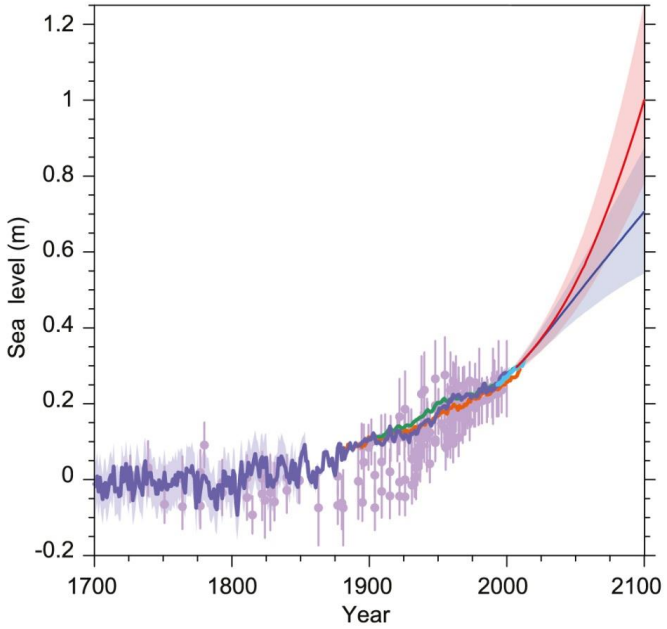




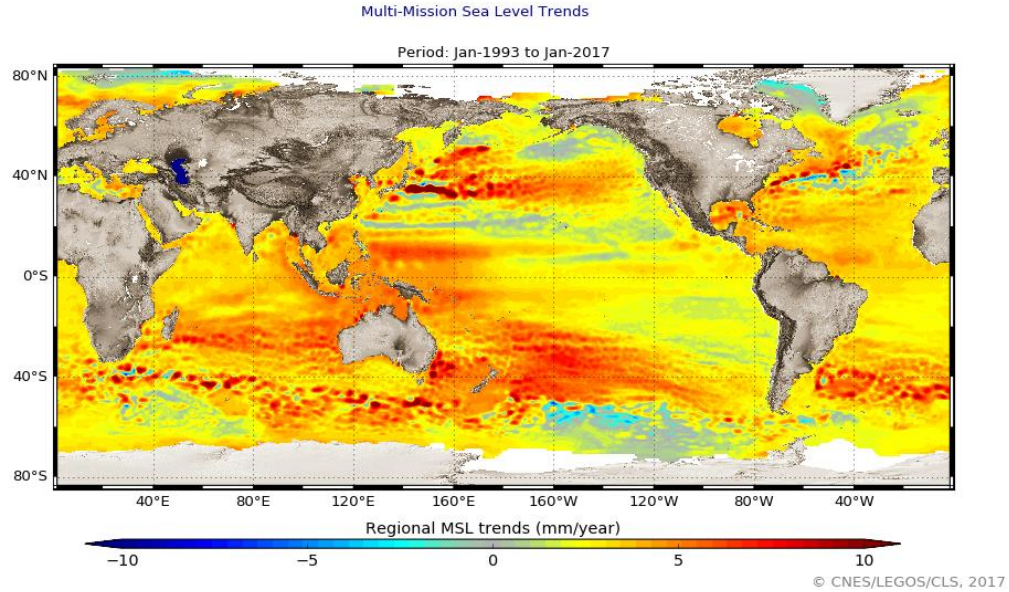
AR5 IPCC, 2013

Jevrejeva et al, 2014

Global Regional Local

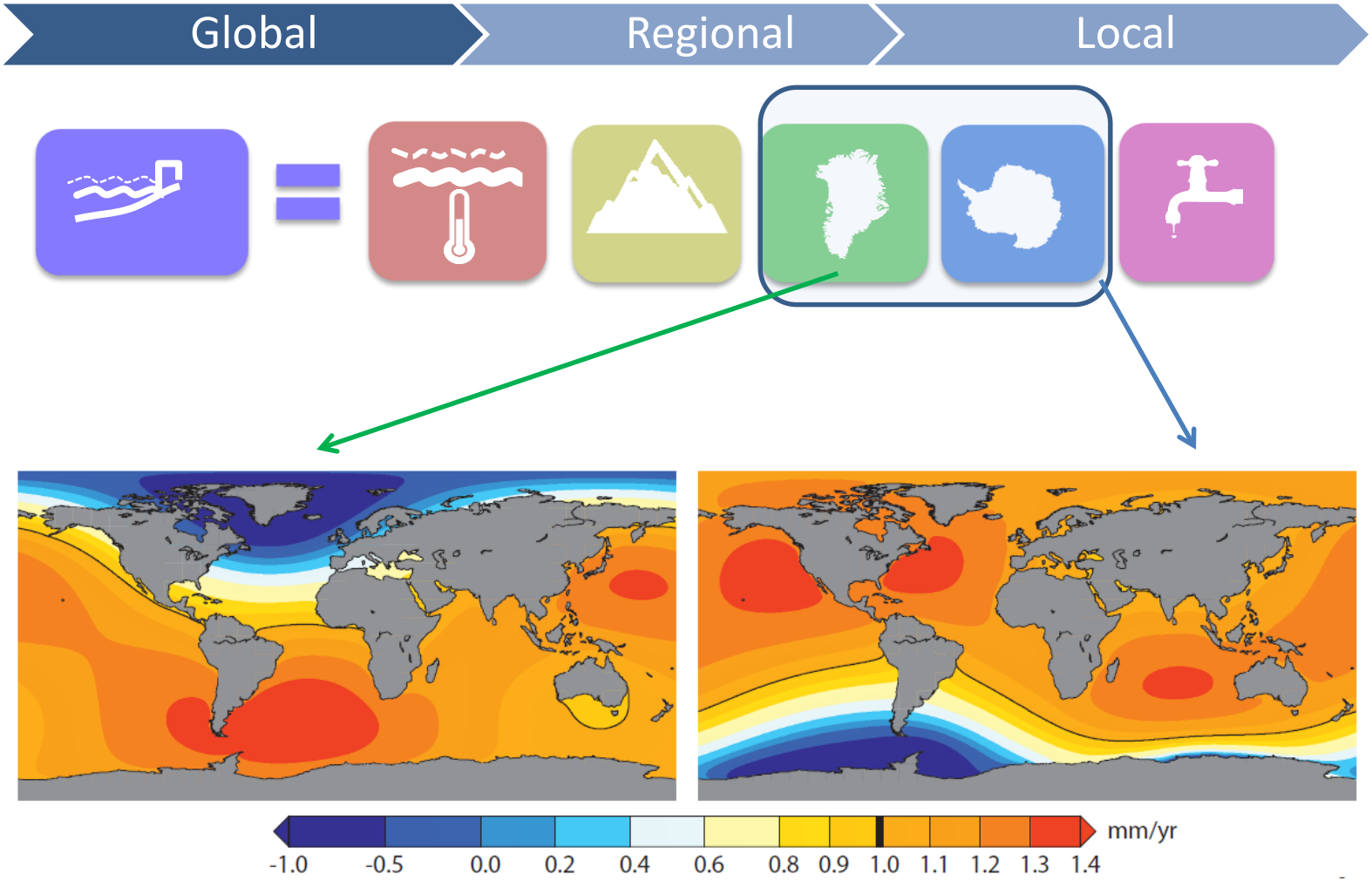


AR5 IPCC, 2013



http://www.altimetry.info/thematic-use-cases/ocean-applications/mean-sea-level

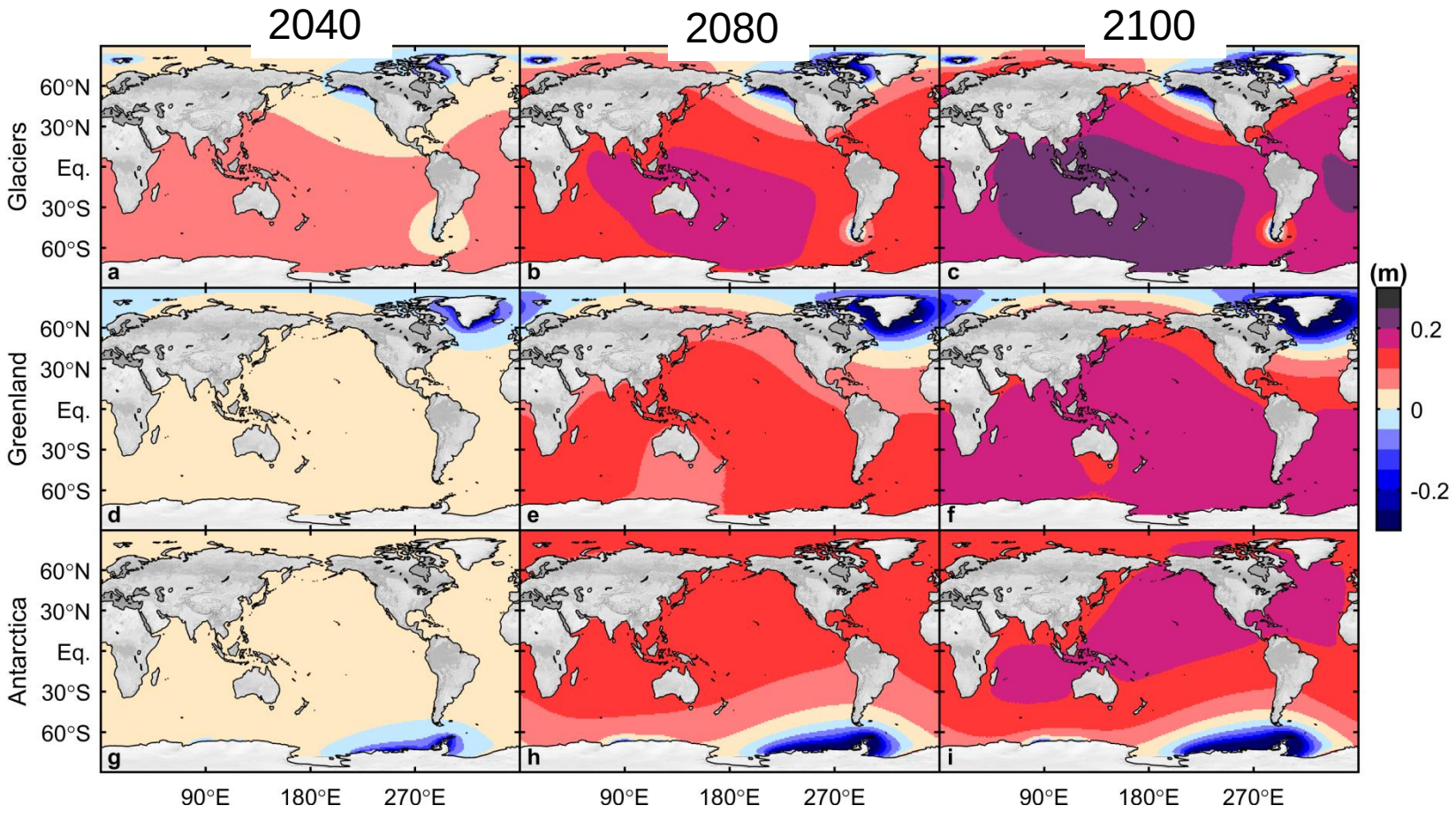
Probabilistic approach for regional sea level projections



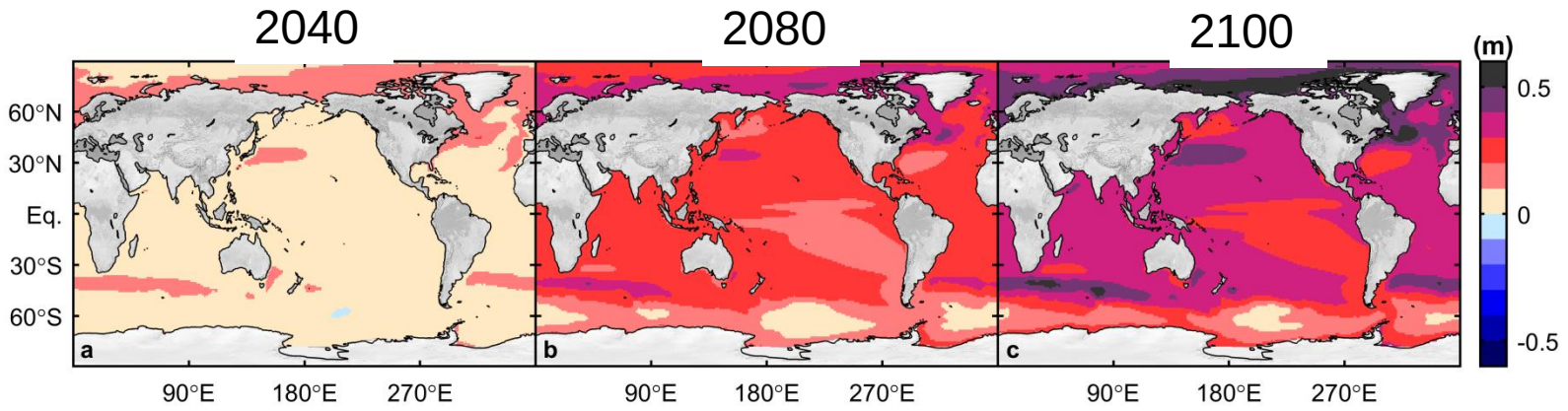
Tamisiea and Mitrovica, 2011

Future contribution from cryosphere (median)

Jevrejeva et al., 2016

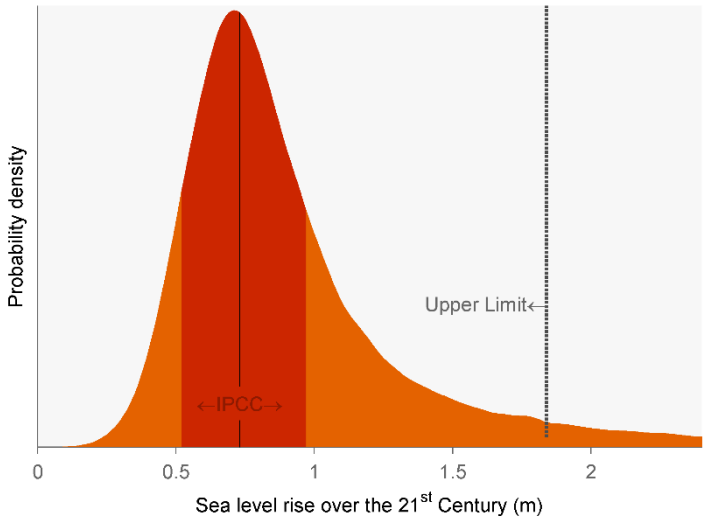


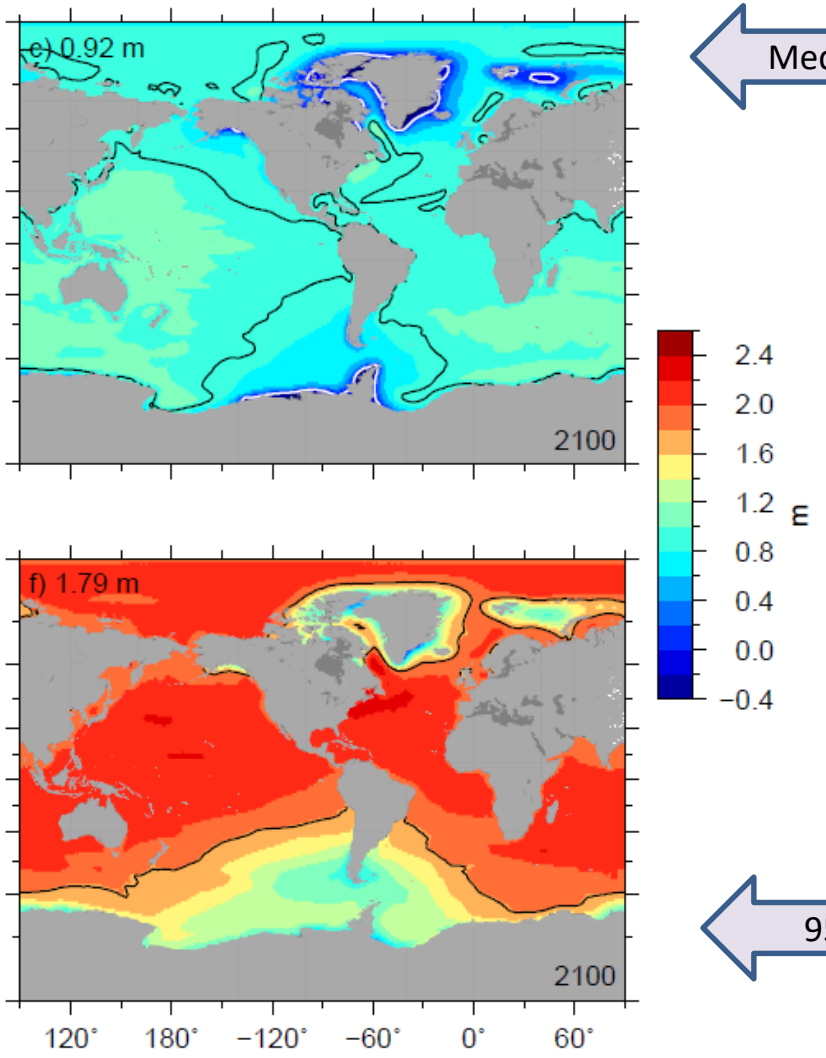
Contribution from ocean component (CMIP5), median



Jevrejeva et al., 2016

Probabilistic approach for regional sea level projections



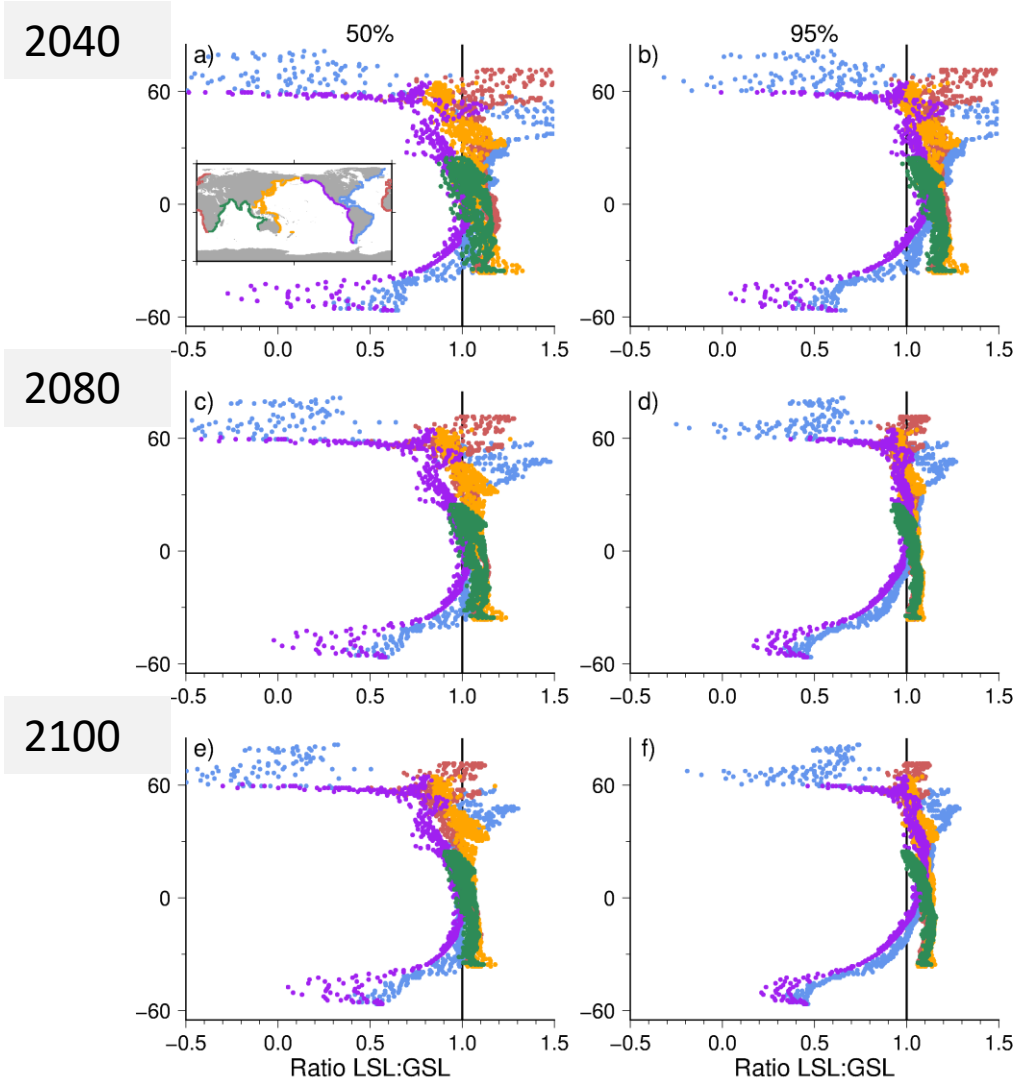


Median

95%

Jevrejeva et al, 2016

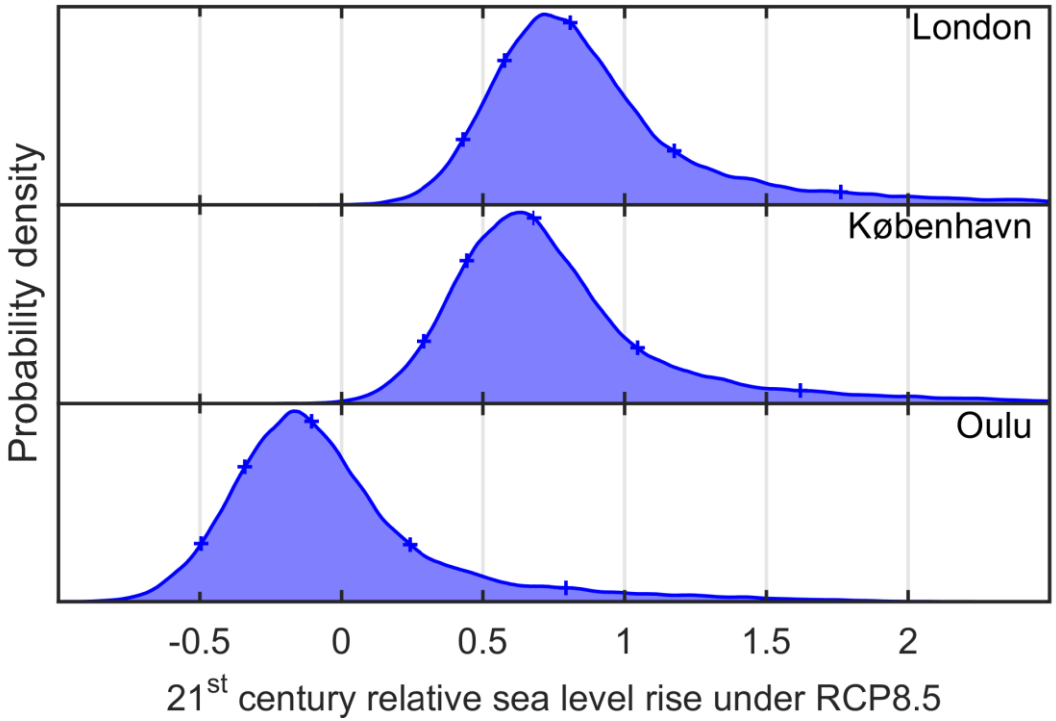
Regional vs global sea level rise



Jevrejeva et al, 2016

Ratio of projected local (1° grid cells close to coastline) median and upper limit (50%/95%) sea level rise to global median sea level rise

Sea level rise for individual locations



RCP8.5

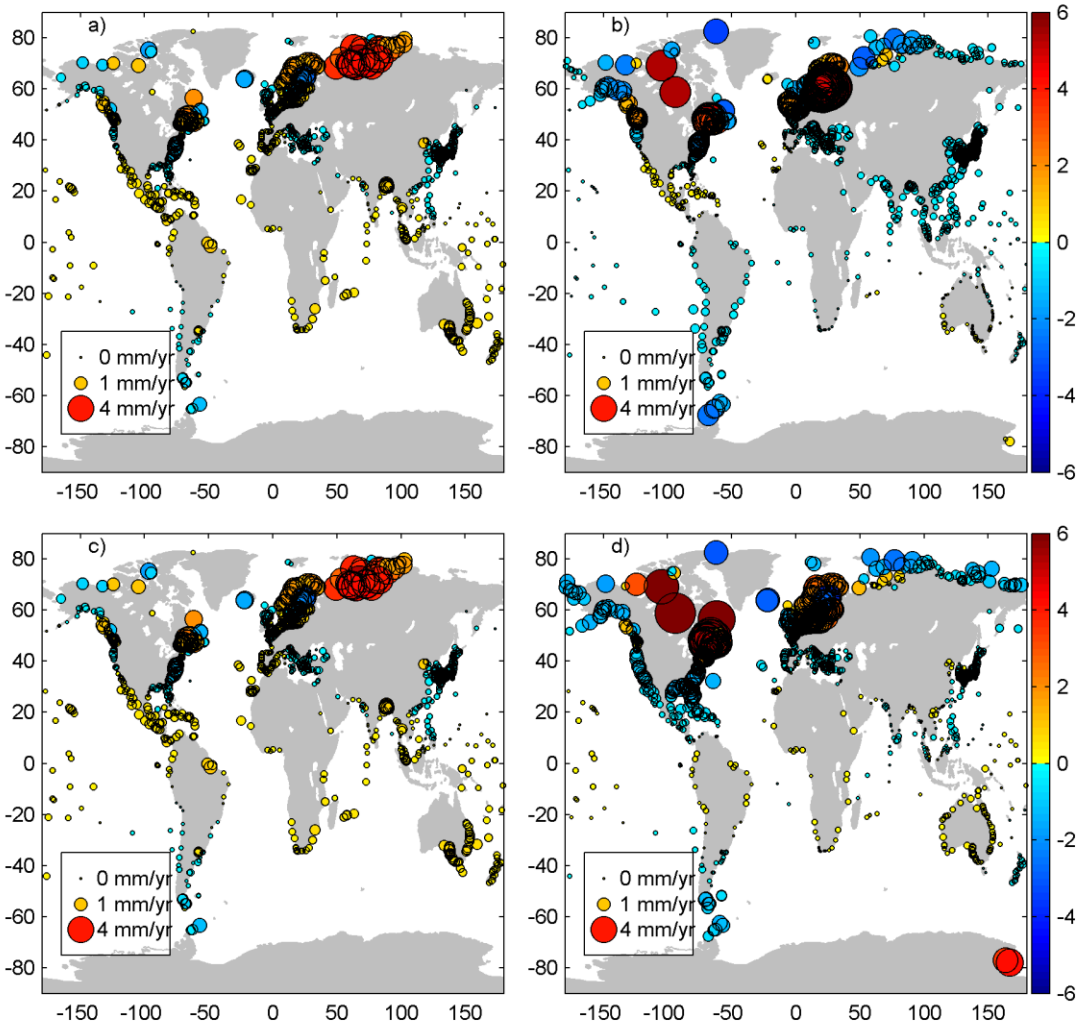
	5%	50%	95%	99%
Belfast	0.27	0.64	1.57	2.22
Newlyn	0.45	0.82	1.81	2.49
Cardiff	0.40	0.77	1.73	2.40
Edinburgh	0.26	0.64	1.56	2.20
Liverpool	0.35	0.71	1.66	2.31
Aberdeen	0.27	0.66	1.58	2.21
London	0.43	0.81	1.76	2.43

Grinsted et al, 2015

Challenges: Uncertainties due to Glacial Isostatic Adjustment (GIA) corrections

ICE 5G- ICE 4G

ICE 5G- ICE 3G

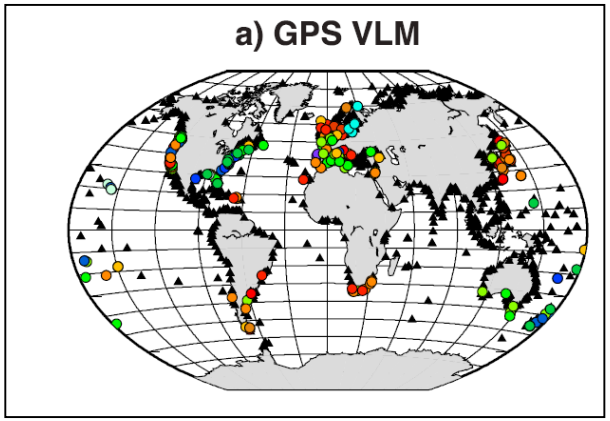


ICE 5G- ICE 1

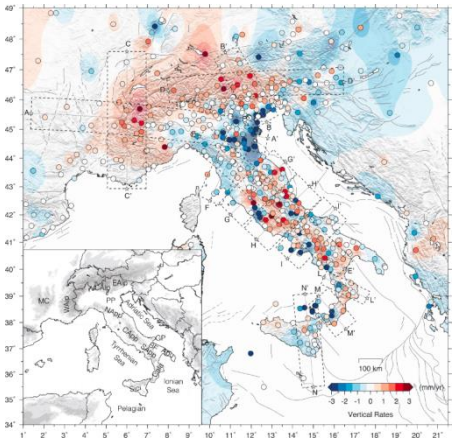
ICE 5G- KL05

Jevrejeva et al, 2014

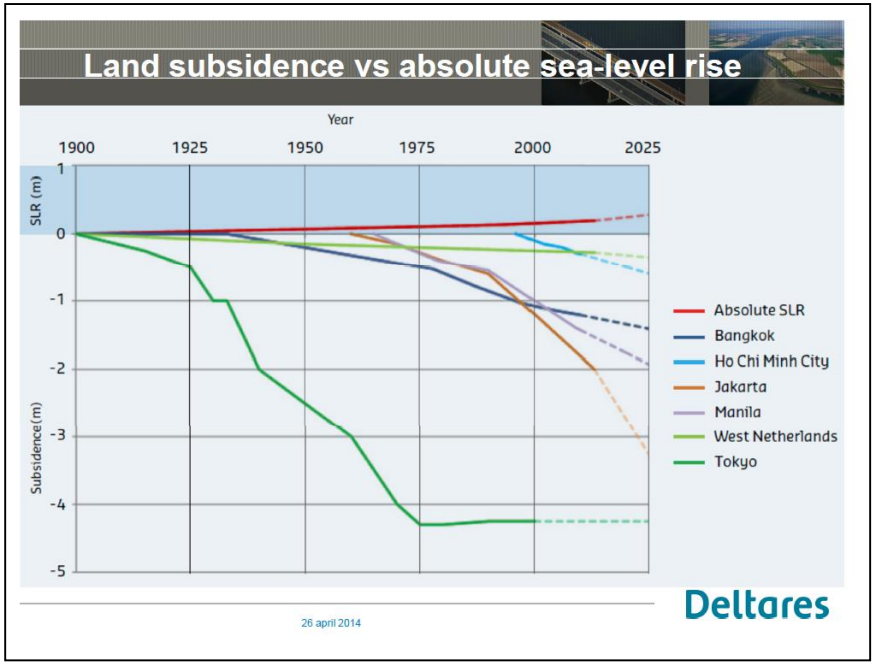
Challenges: Local vertical land movement



King et al, 2012



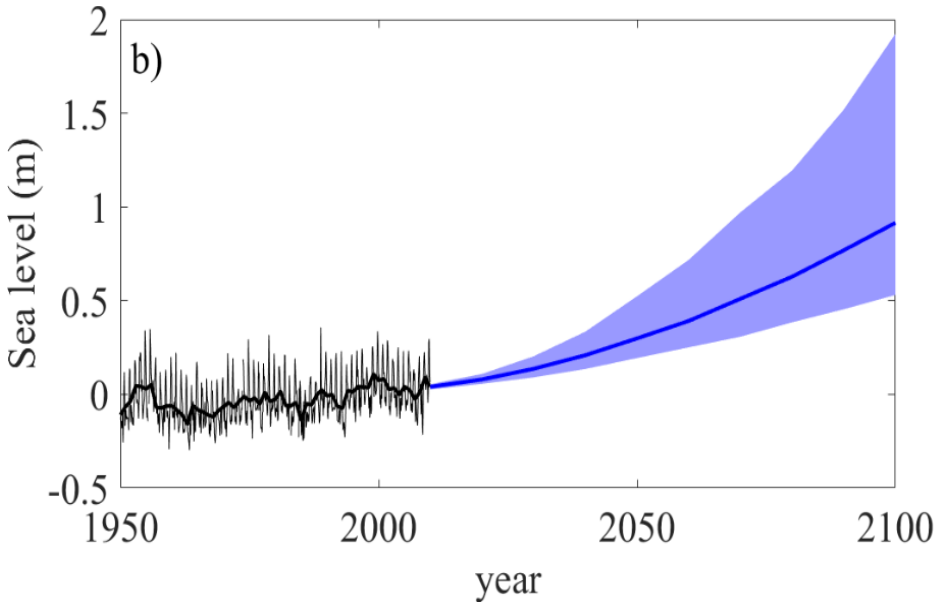
Serpelloni et al., 2013



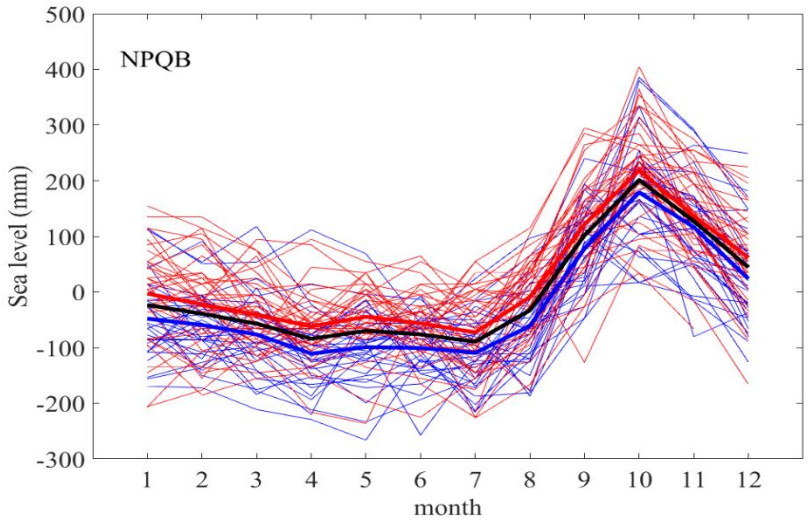
Bucx et al., 2015

Challenges: variability at the coast

RCP8.5



1950-2017



Sea level observations and projections in Hong Kong

Qu et al., 2018 (submitted)

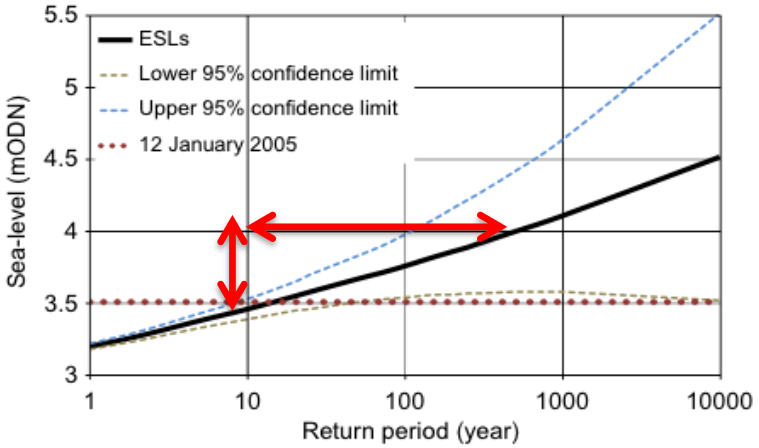
Sea level rise and changes in extreme sea levels

Sea level rise (m) for the UK cities by 2100 with RCP8.5 scenario

	5%	50%	95%	99%
Belfast	0.27	0.64	1.57	2.22
Newlyn	0.45	0.82	1.81	2.49
Cardiff	0.40	0.77	1.73	2.40
Liverpool	0.35	0.71	1.66	2.31
Aberdeen	0.27	0.66	1.58	2.21
London	0.43	0.81	1.76	2.43

Grinsted et al, 2015

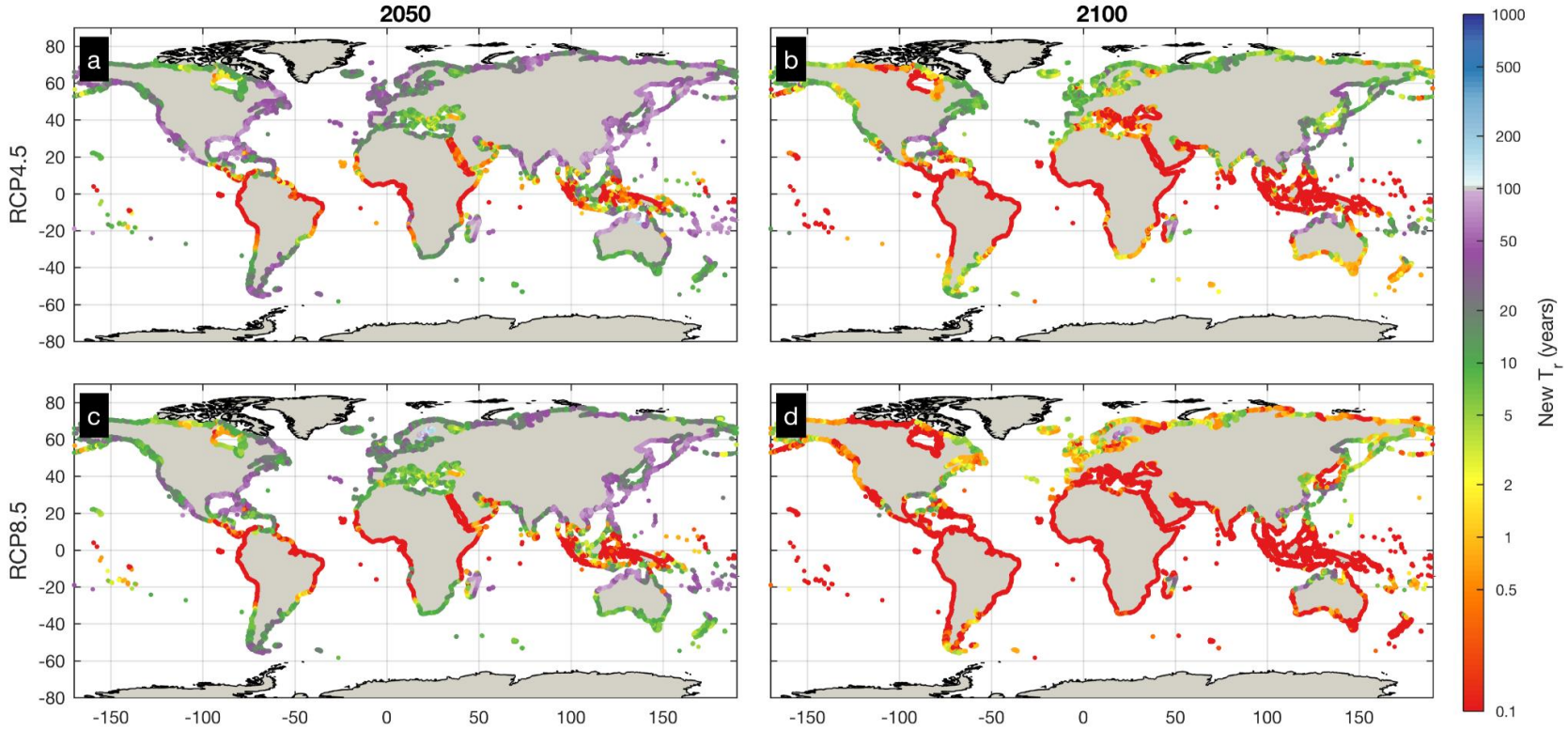
0.5 m



Sea level rise of 0.5 m will change the return period from **800 yrs** to **10 yrs** (individual locations)

Projections of extreme sea levels (sea level rise +waves+storm surges)

Return period of the present day 100-year ESL under RCP4.5 and RCP8.5 in 2050 and 2100



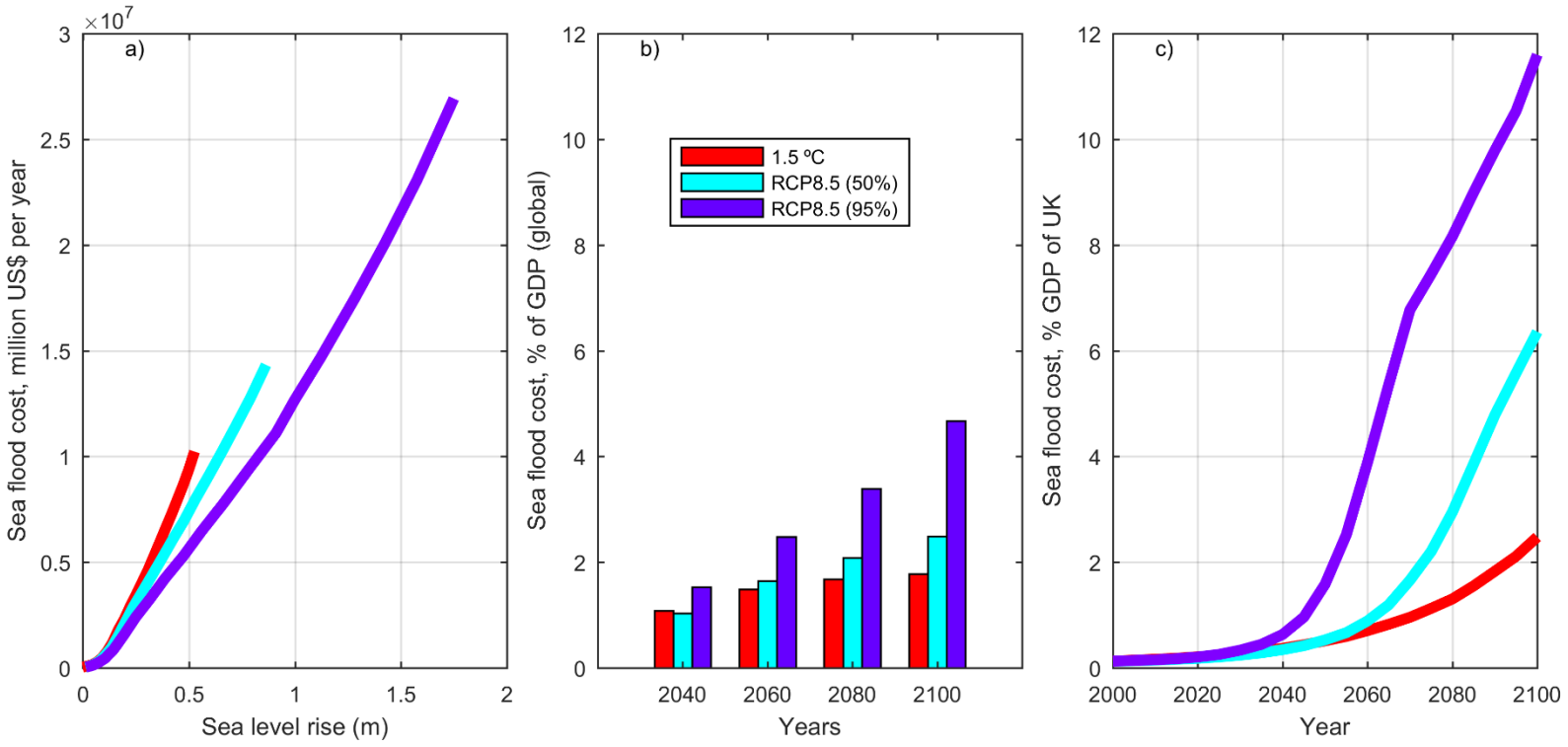
Vousdoukas et al., 2018

Sea flood damage costs with the sea level rise by 2100

Global sea flood cost, Million US$ per year

Global sea flood cost, % of GDP (global)

UK sea flood cost, % of UK GDP



UK flood cost in 2100

US$ 241 billion per year (2.5 % UK GDP) with warming of 1.5 degree (0. 5 m sea level rise)

US$ 619 billion per year (6.5% UK GDP) with RCP8.5 (0. 8 m sea level rise)

US$ 1.1. trillion per year (11.1 % UK GDP) with RCP8.5J14 (1.8 m sea level rise)

Jevrejeva et al., 2018

Conclusion

1. Sea level community is making a substantial progress in understanding of global and regional sea level rise and variability

2. Coastal sea level projections are considerably different from the global one

3. The key uncertainty in any sea level projections is **emission scenarios**

4. The largest uncertainties in sea level projections associated with contribution from **ice sheets in Antarctica** and Greenland, **ocean dynamics** and **vertical land movement**

5. Impact of sea level rise in the coastal areas is already seen and every 10 cm by 2100 could result in additional global annual flood damages of US$ 1.5 trillion per year (0.25% of global GDP) without adaptation