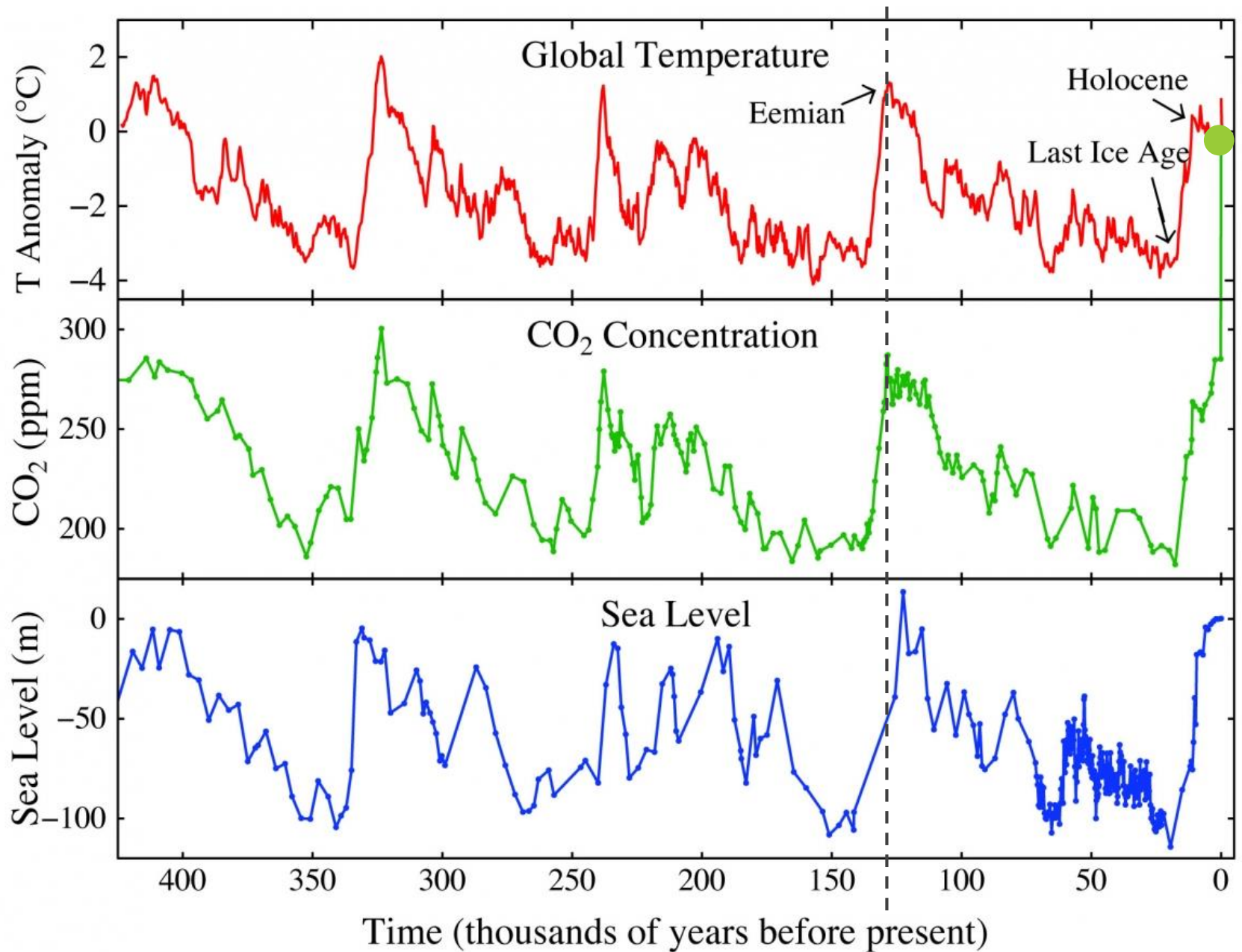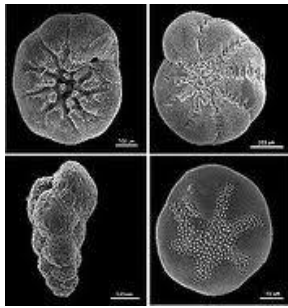# ASSESSING CLIMATE RISKS UNDER UNCERTAINTY:
AN APPLICATION TO MAJOR COASTAL CITIES

Elisa Sainz de Murieta
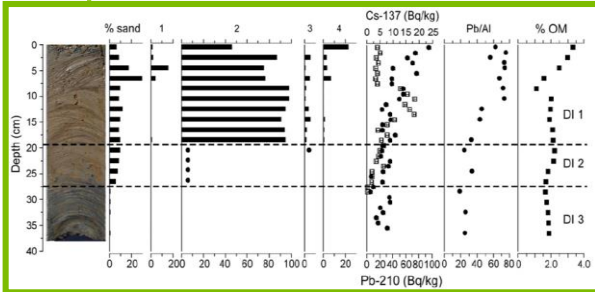**Basque Centre for Climate Change (BC3)**
Grantham Research Centre (LSE)
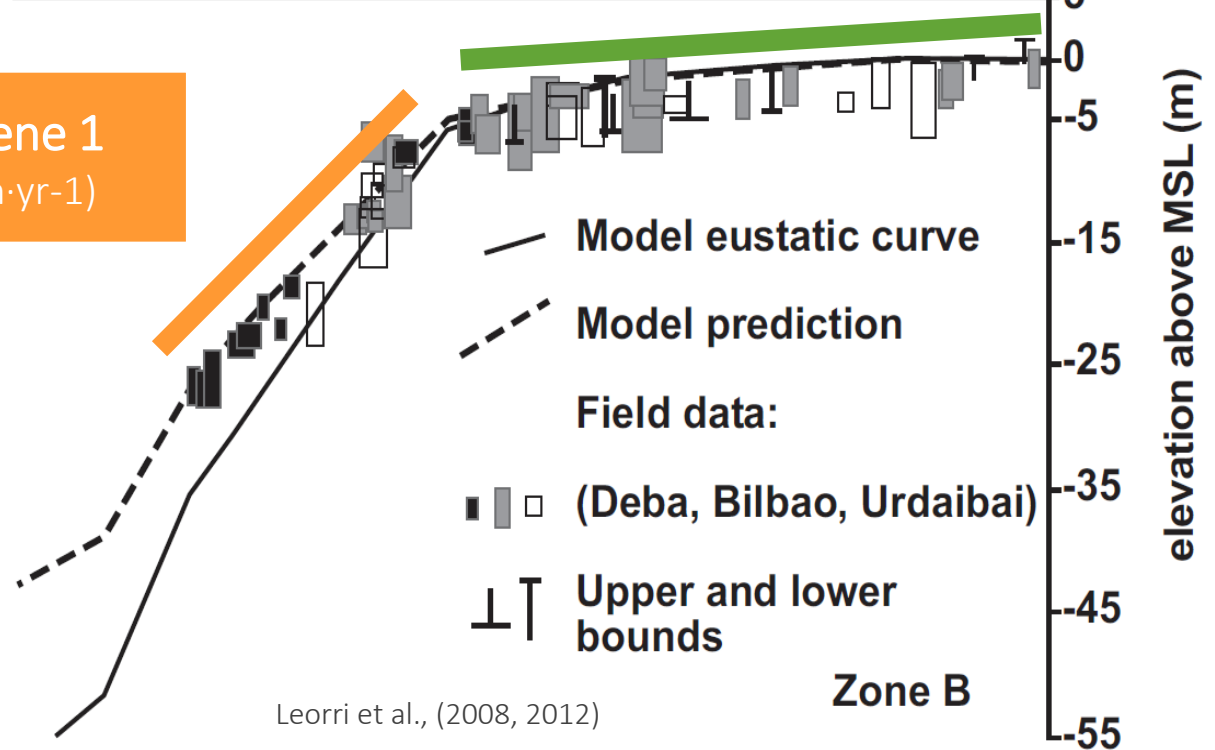
Donostia, 6th June 2017

bc³ | summer school

Johnenglander.net

2

eman ta zabal zazu

UPV EHU

Holocene 2
(0.5 mm·yr⁻¹)

^{14}C cal yr BP (x1000)

12   10   8   6   4   2   0

Holocene 1
(10 mm·yr-1)

Model eustatic curve

Model prediction

Field data:

(Deba, Bilbao, Urdaibai)

Upper and lower bounds

Zone B

elevation above MSL (m)

5   0   -5   -15   -25   -35   -45   -55

Leorri et al., (2008, 2012)

Harea-Coastal Geology
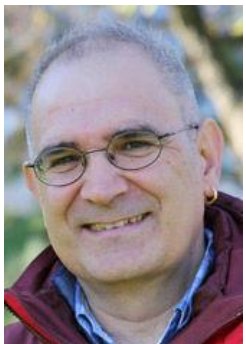
Global Mean Sea Level Change

Sea Level Anomaly (mm)

— Adjusted Tide Gauge Data
— Satellite Radar Altimetry

0.6 mm/yr
(1900–1930)

1.4 mm/yr
(1930–1992)

3.4 mm/yr
(1993–2016)

Source: Church and White (2011)
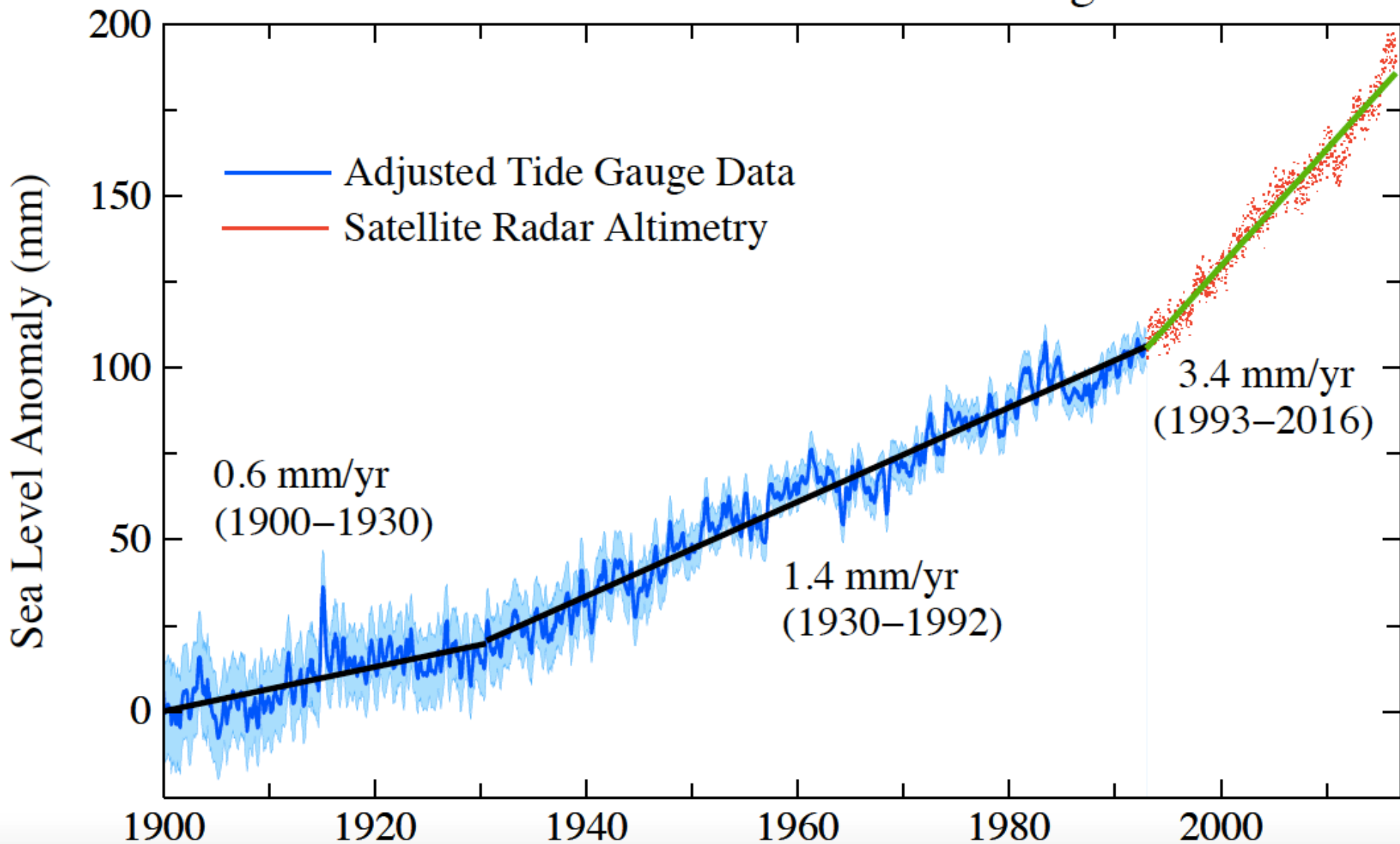
WE ALSO KNOW THAT...

- Low elevation coastal zones (LECZ) concentrate 10% of world population.

- About 2/3 of mega-cities with population over 5 million are located in coastal areas (McGranahan et al., 2007).

- Urban areas have been identified as main coastal vulnerability hotspots (Newton and Weichselgartner, 2014).

@ranzadi

PAST AND CURRENT EVIDENCES ARE CLEAR

so…

"There's no doubt that there's a lot of cause for concern in the report, about what we can expect in terms of impacts around the world. But there's also a lot in it about what we can do in terms of generating solutions. I think that's the big difference compared to past reports. In this one, we know a lot more about what you might call the "solution space" — about where adaptation works, where mitigation works and how they can work together."
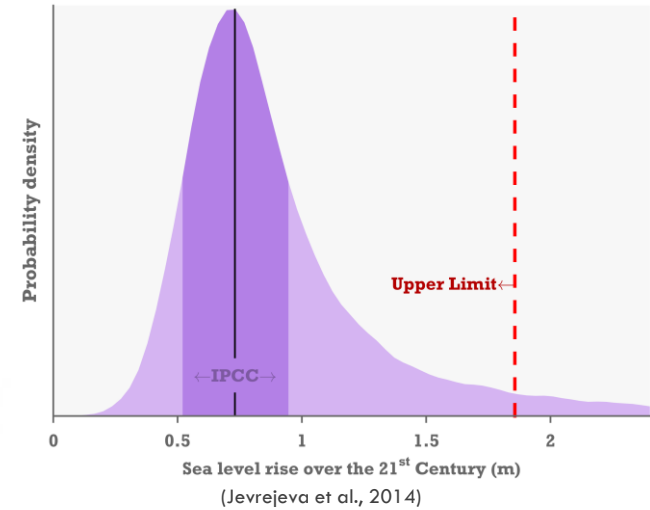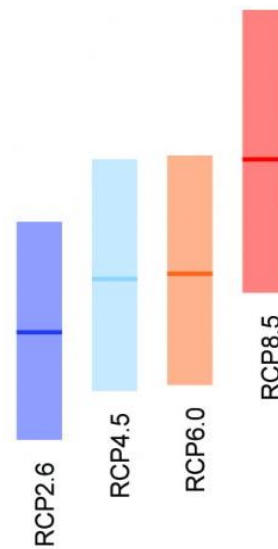
Chris Field (IPCC WGII Co-Chair)[4]

"Expanding the solution space for adaptation"

SCENARIOS

Global mean sea level rise
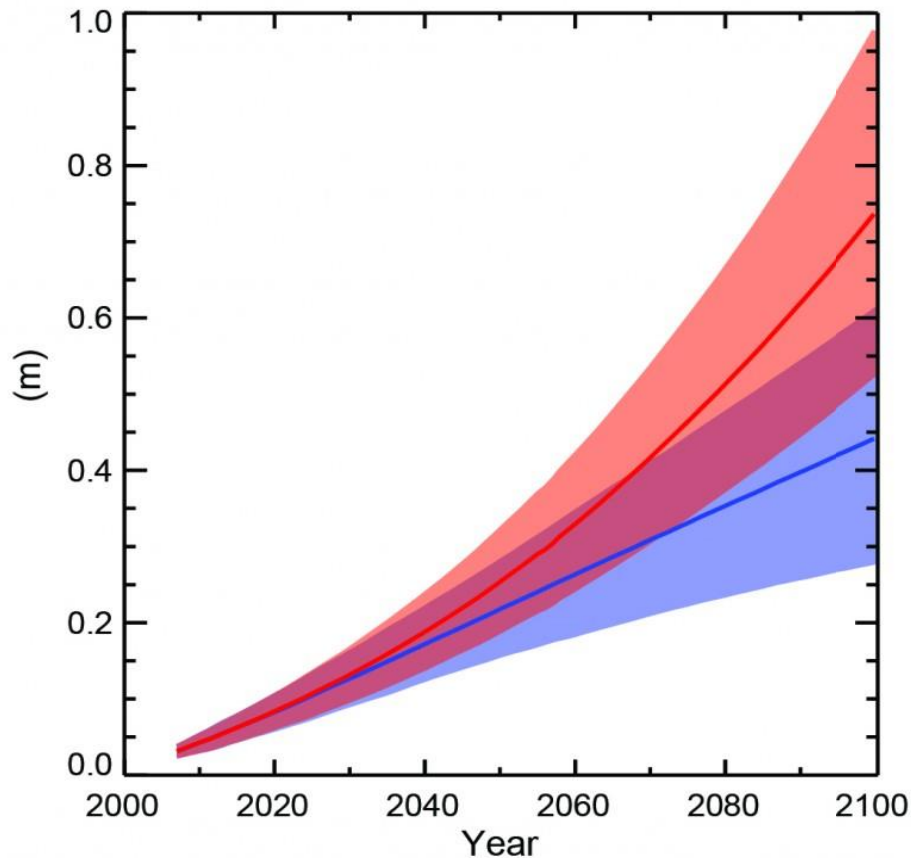
Mean over 2081–2100

Projections of global mean sea level rise over the 21st century (relative to 1986–2005) from the combination of the CMIP5 ensemble with process-based models) for a high emissions (RCP8.5) and low emissions scenario (RCP2.6). The assessed likely range is shown as a shaded band. Source: IPCC 2013

(Jevrejeva et al., 2014)

UNCERTAINTY

- Uncertainty has become a major challenge in relation to decision making in climate change adaptation.

- Adaptation has been acknowledged to be dynamic, as preferences may vary over time as new or improved climate information becomes available or technologies emerge or evolve (Hallegatte, 2009).

- Resilient or robust approaches that consider flexibility and the time dimension can be very valuable in supporting decision-making under uncertainty.

- Developing approaches that support decision making under uncertainty have become one of the main priorities for adaptation to climate change.

RISK MEASURES AND HIGH END SEA-LEVEL RISE
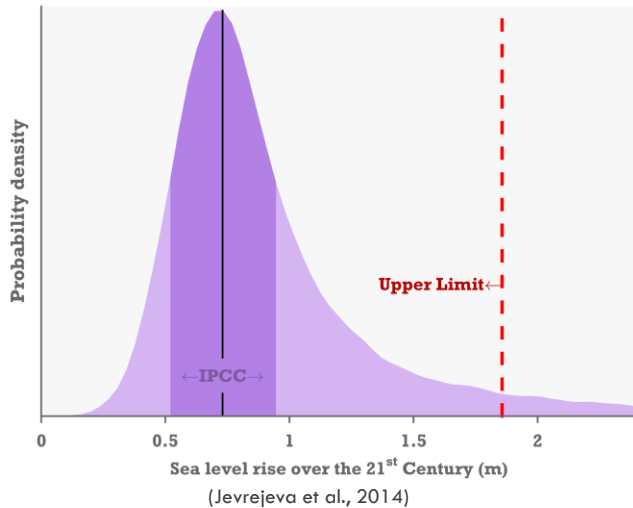
From likely ranges…

To upper-tail events
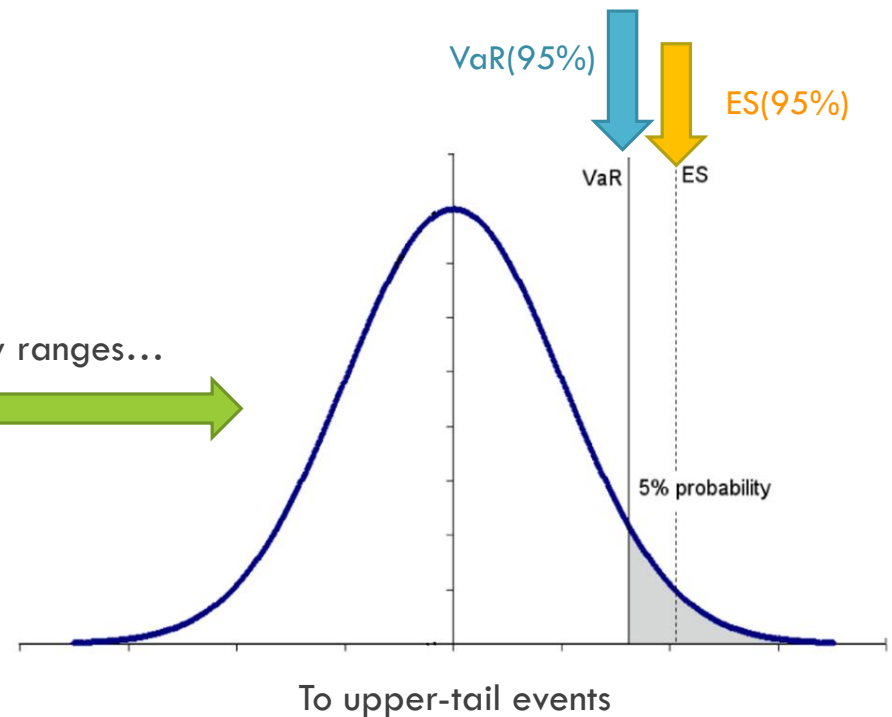
- Risk-based approaches incorporate uncertainty, which is one of the key issues for defining, investing and implementing adaptation.

- There is an increasing demand for more robust economic approaches, such as real options analysis. Estimating risk measures enables this kind of analysis.

A NEW ASSESSMENT OF FLOOD-RISK IN MAIN COASTAL CITIES
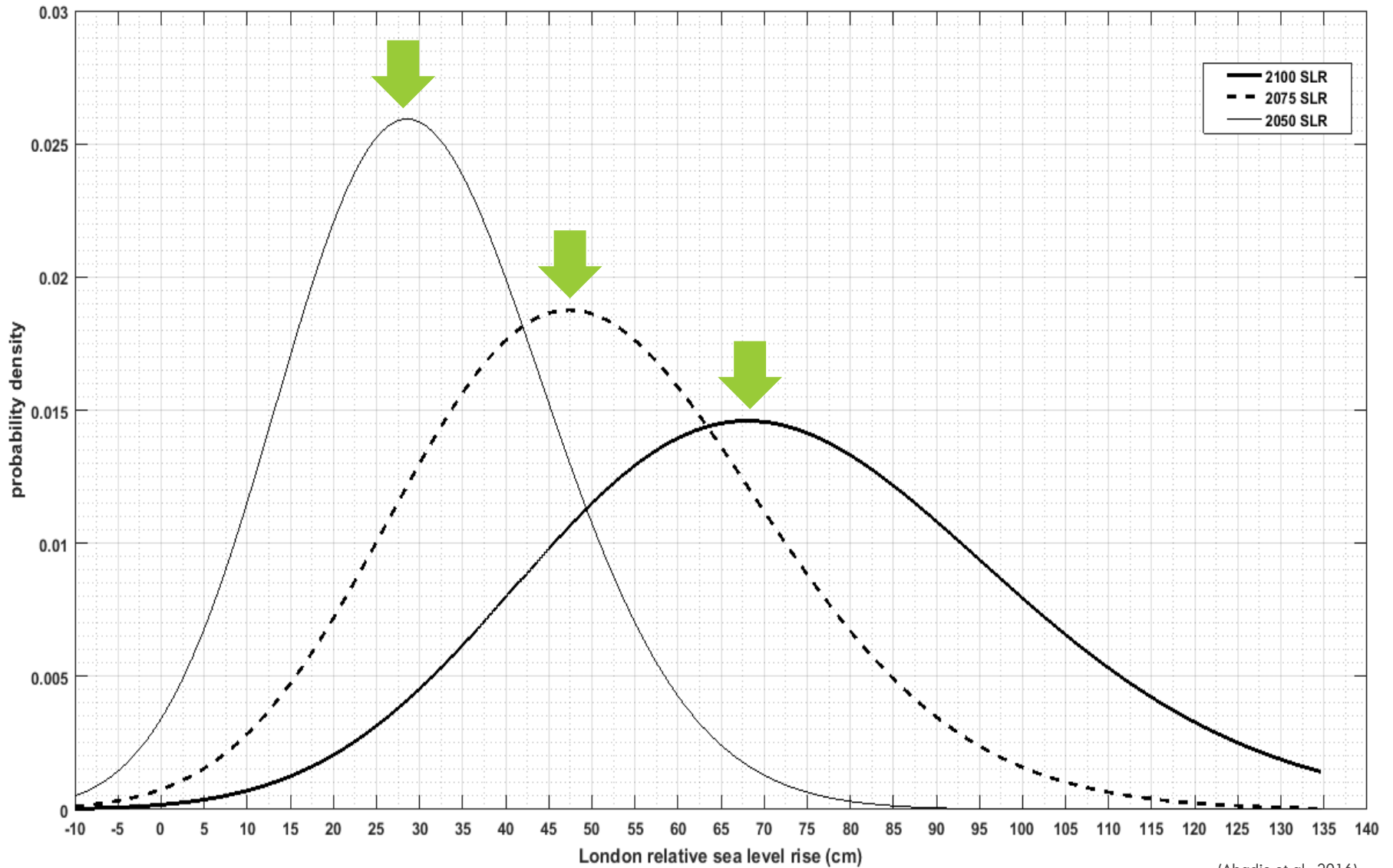## A. THE PROBABILITY DISTRIBUTION OF SLR

Definition of STOCHASTIC

1 : RANDOM; *specifically* : involving a random variable • a *stochastic* process

2 : involving chance or probability : PROBABILISTIC • a *stochastic* model of radiation-induced mutation

- **Sea-level rise projections**:

  Local sea-level rise projection RCP8.5 (Kopp et al., 2014)

- We calibrate a Geometric Brownian Model (GBM) **stochastic model** for SLR (RCP8.5):

  - Median SLR data for 2030, 2050, and 2100

  - The 95% percentile in 2100

PROBABILITY DISTRIBUTION OF SEA-LEVEL RISE

(Abadie et al., 2016)

A NEW ASSESSMENT OF FLOOD-RISK IN MAIN COASTAL CITIES

## B. THE PROBABILITY DISTRIBUTION OF ECONOMIC DAMAGES

- Damage functions:

  We develop a damage function for each city based on the stochastic SLR modelling (based on Hallegatte et al. 2013).

  A time based damage function, incorporates on socio-economic scenarios.

- We use the GBM model to calculate through MonteCarlo simulation (5 million cases) annual average damages and the two risk measures, VaR(95%) and ES (95%).

A NEW ASSESSMENT OF FLOOD-RISK IN MAIN COASTAL CITIES

B. THE PROBABILITY DISTRIBUTION OF ECONOMIC DAMAGES

New Orleans - Damages in 2050 (US$ million)
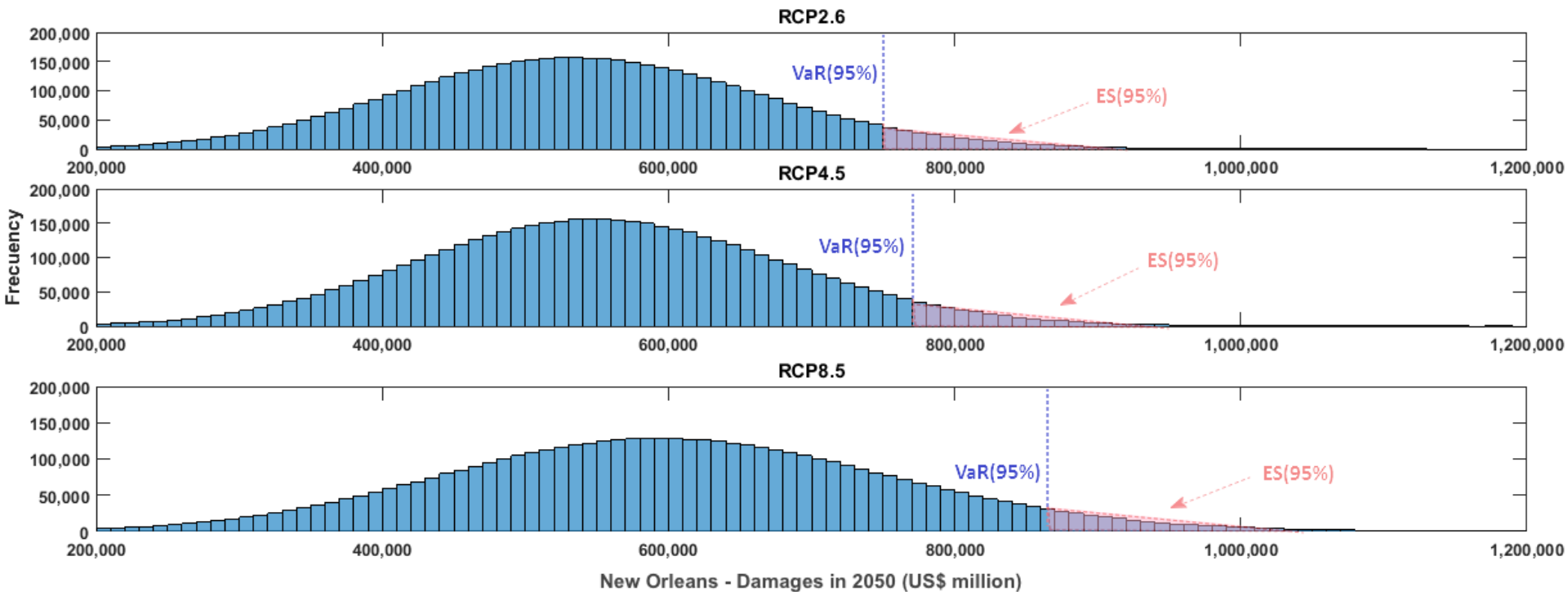
(Abadie et al., 2017)

RESULTS:
A. ANNUAL AVERAGE LOSSES

City	Annual average losses (million US$)			
	2030	2050	2070	2100
Istanbul	201	1400	3837	9806
Odessa	116	836	2432	6577
Izmir	132	915	2442	5746
Rotterdam	237	1219	2716	5511
St. Petersburg	106	577	1435	3274
Lisbon	65	354	862	1891
Glasgow	30	218	631	1558
Dublin	48	272	681	1504
Marseille	13	101	318	810
Barcelona	18	124	339	797
Hamburg	68	221	422	775
London	56	190	375	703
Amsterdam	39	137	275	523
Porto	19	87	210	460
Copenhagen	22	81	176	368
Naples	10	52	128	290
Stockholm	–	0.6	5	91
Athens	–	0.5	3	86
Helsinki	3	8	19	53
Total loss	1181	8842	19,376	42,924

(Abadie et al., 2016)

(Abadie et al., 2016)

(Abadie et al., 2016)
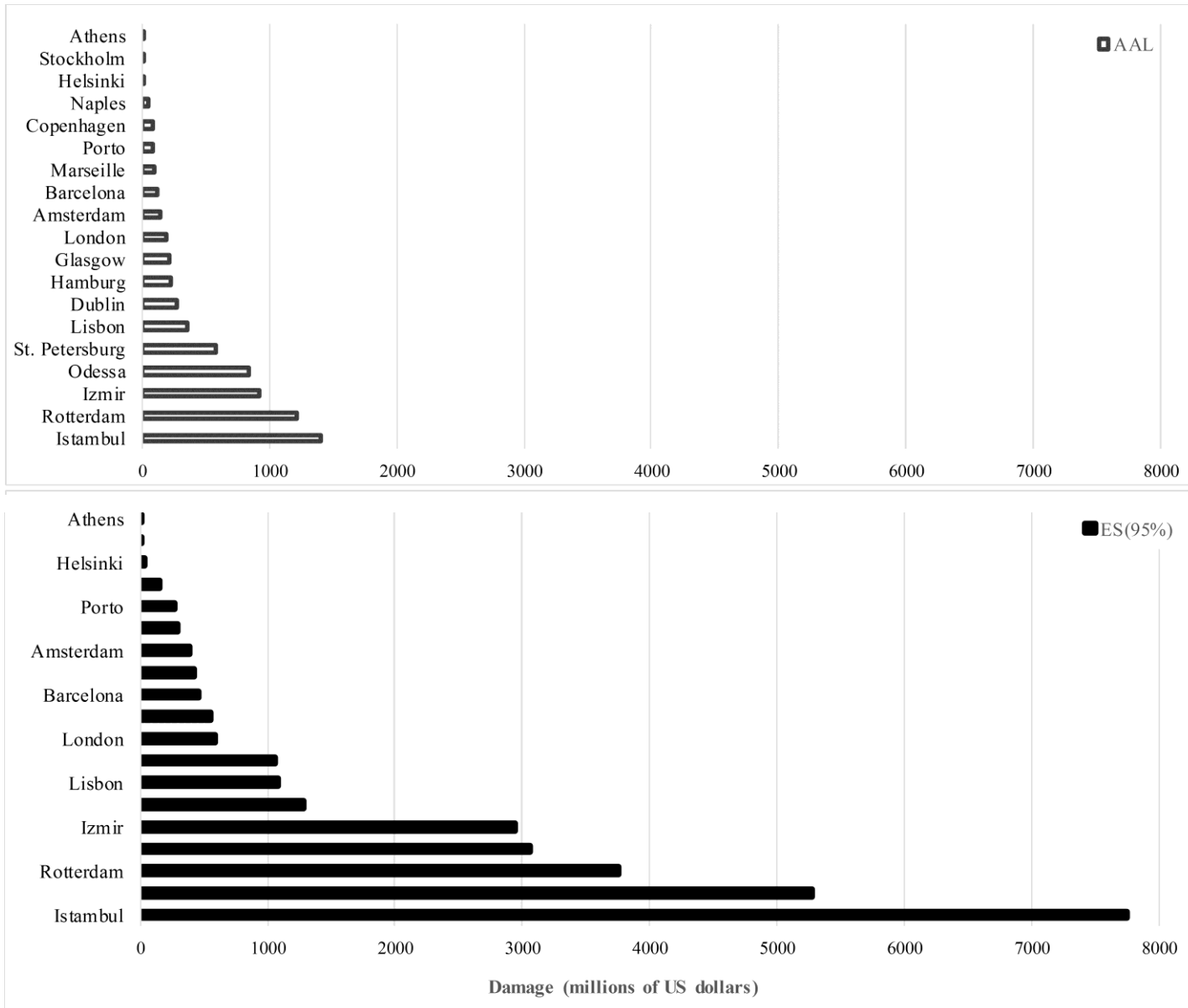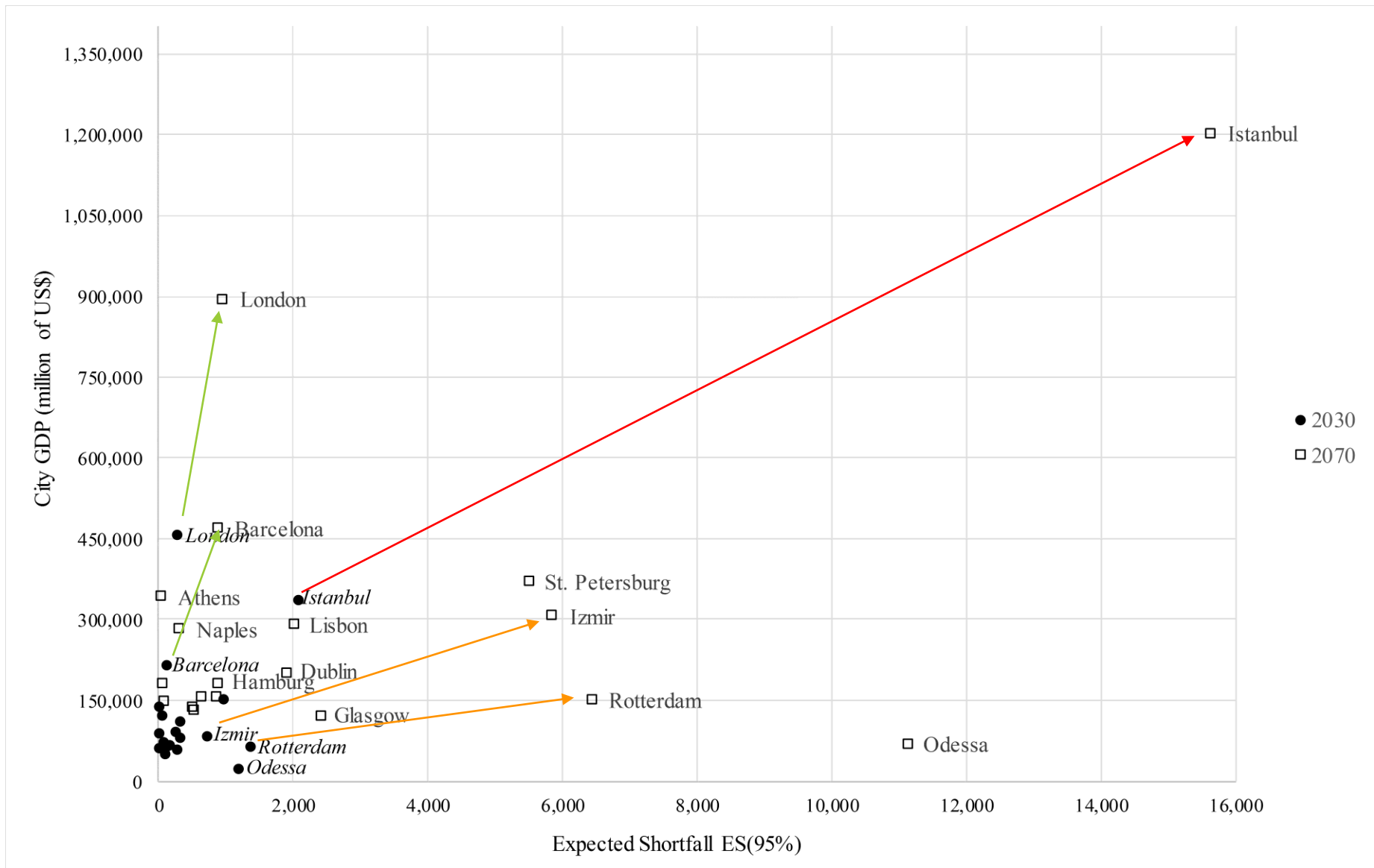
A NEW ASSESSMENT OF FLOOD-RISK IN MAIN COASTAL CITIES
SOME POLICY IMPLICATIONS

- This approach allows defining an acceptable risk threshold: for illustrative purposes, we used 1% of each city's GDP in 2020.

- As the damage function is continous, we can estimate the damage at any time.

- This allows us to obtain when the previously defined aceptable risk would be exceeded, which would be a very relevant input to timeframe adaptation efforts.

A NEW ASSESSMENT OF FLOOD-RISK IN MAIN COASTAL CITIES

DEFINING ACCEPTABLE RISK LEVELS?

Time frame for adaptation

- 🔴 By 2020
- 🟠 By 2030
- 🟠 By 2050
- 🟡 By 2080
- 🟢 Beyond 2080
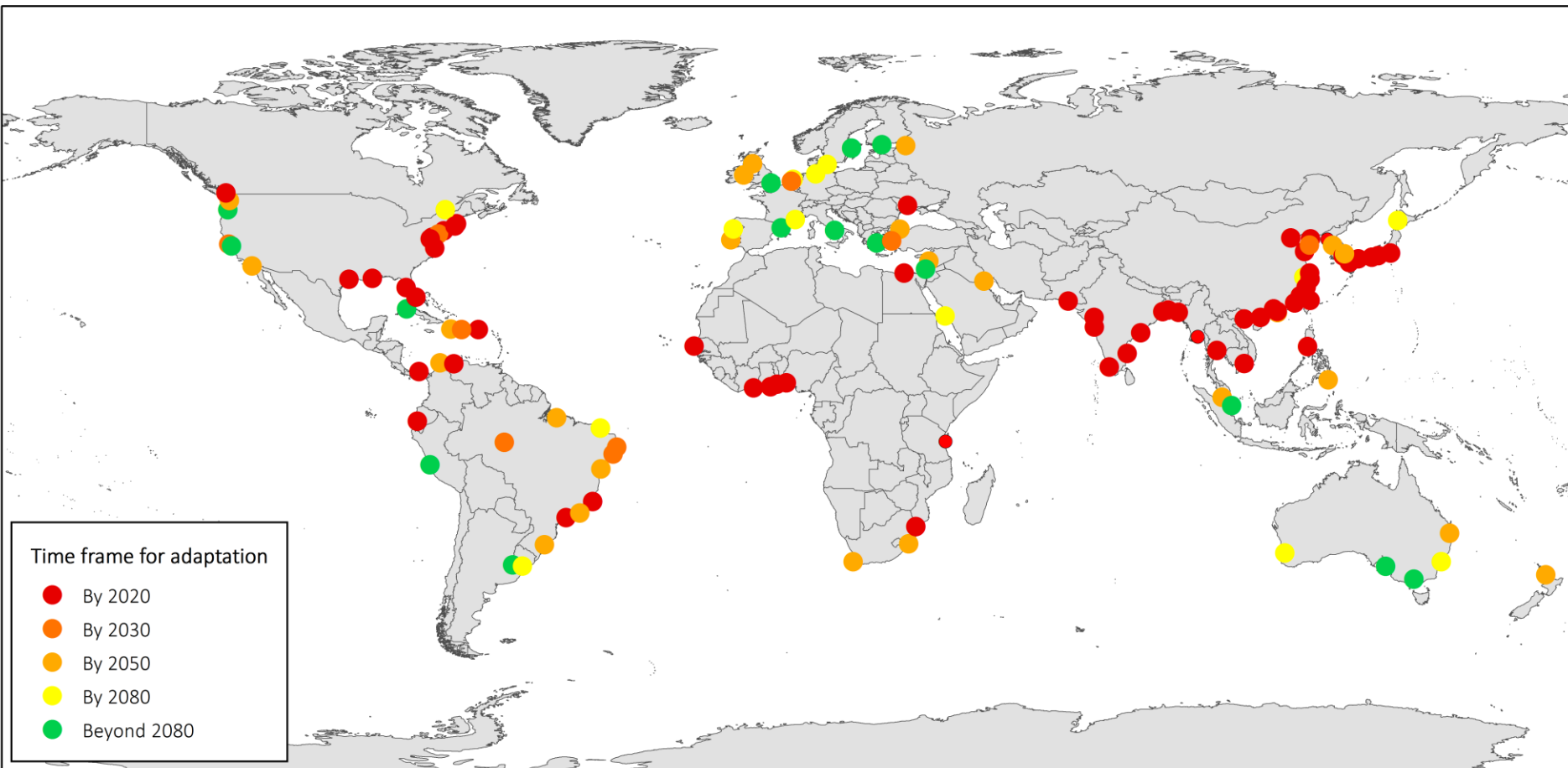
▪ Adaptation time frame in each city under RCP8.5.   ▪ Acceptable risk level has been defined as 1% of each city's GDP in 2020.

ACKNOWLEDGEMENTS

ECONADAPT / THE ECONOMICS OF CLIMATE CHANGE ADAPTATION

Ibon Galarraga
BC3 Research Prof.

Luis M. Abadie
BC3 Research Prof.

Environmental Research Letters

LETTERS

Understanding risks in the light of uncertainty: low-probability, high-impact coastal events in cities

Luis Maria Abadie, Ibon Galarraga* and Elisa Sainz de Murieta
Basque Centre for Climate Change (BC3), 48940 Leioa, Spain

ORIGINAL RESEARCH ARTICLE
Front. Mar. Sci., 16 December 2016 | https://doi.org/10.3389/fmars.2016.00265

Climate Risk Assessment under Uncertainty: An Application to Main European Coastal Cities

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Eskerrik asko!

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