ROOM VIII, Building E
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10-12 May 2016

UNITED NATIONS UNCTAD | The Commonwealth | IOI International Ocean Institute

Oceans economy and trade:
Sustainable fisheries, transport and tourism

Climate change impacts on Maritime Infrastructure: Assessing the risks

Dr Michalis Vousdoukas
Joint Research Centre, European Commission

Climate Risk Management Unit

Institute for Environment and Sustainability, Joint Research Centre, EC

Activity on river floods:

European/Global Flood Awareness System (EFAS/GLOFAS)

Climate change projections (Alfieri L., Rojas R., Feyen L)

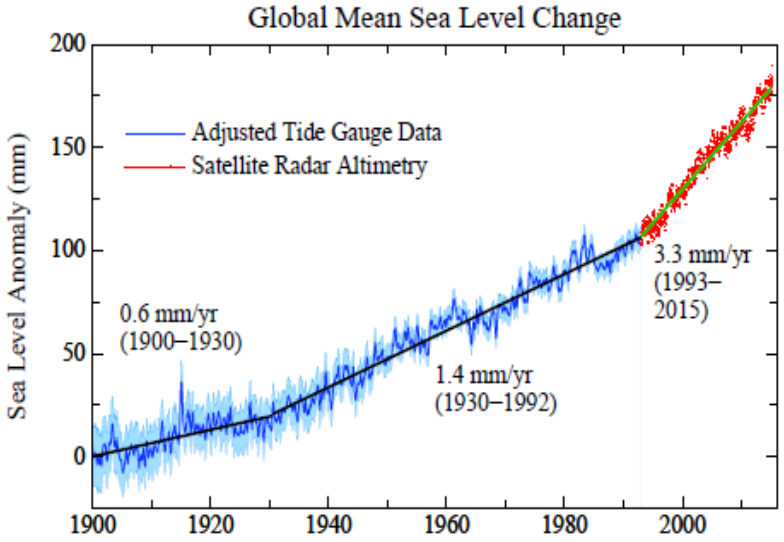
Coastal floods group:

Michalis Vousdoukas, Lorenzo Mentaschi, Evangelos Voukouvalas, Dimitrios Bouziotas, Francesco Dottori, Luc Feyen

Overview

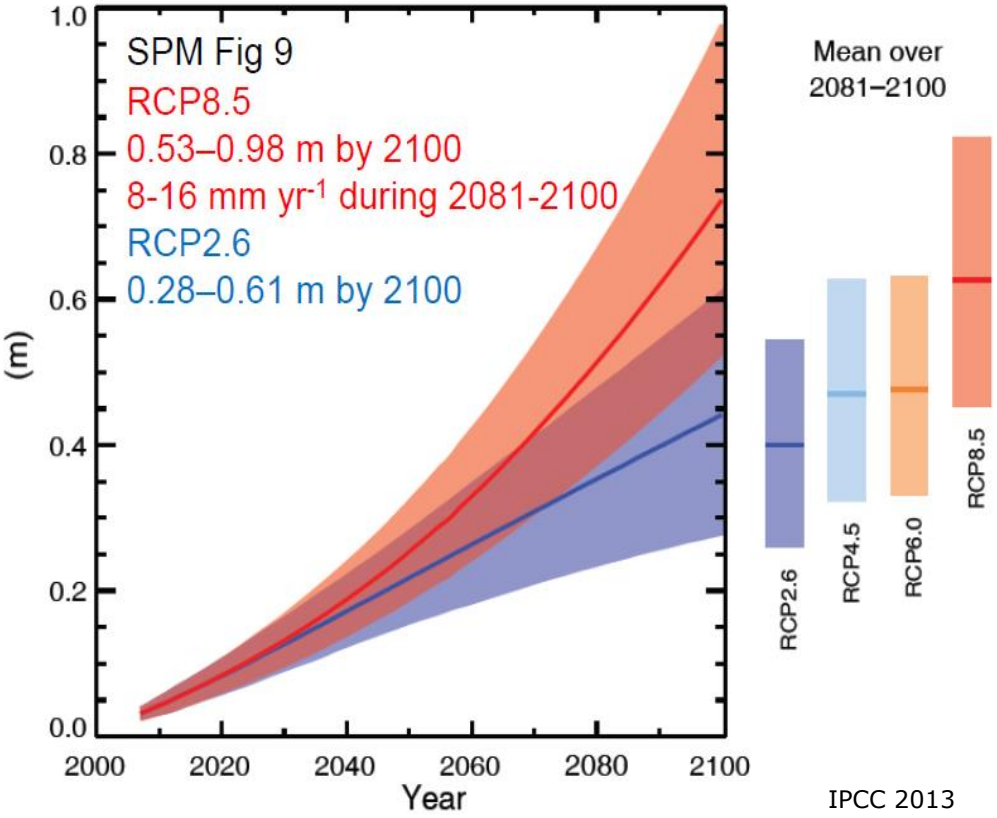
- Motivation, main objectives
- Presentation of the LISCOAST approach
- Results
- Foresight

Sea level rise



Hansen ACPD, 2015

- The ocean absorbs >90% of the increase in energy
- Past sea levels under +1.5-2°C were 6-10 m higher than present
- Expansion of sea water per °C of warming is greater at higher temperature and higher pressure

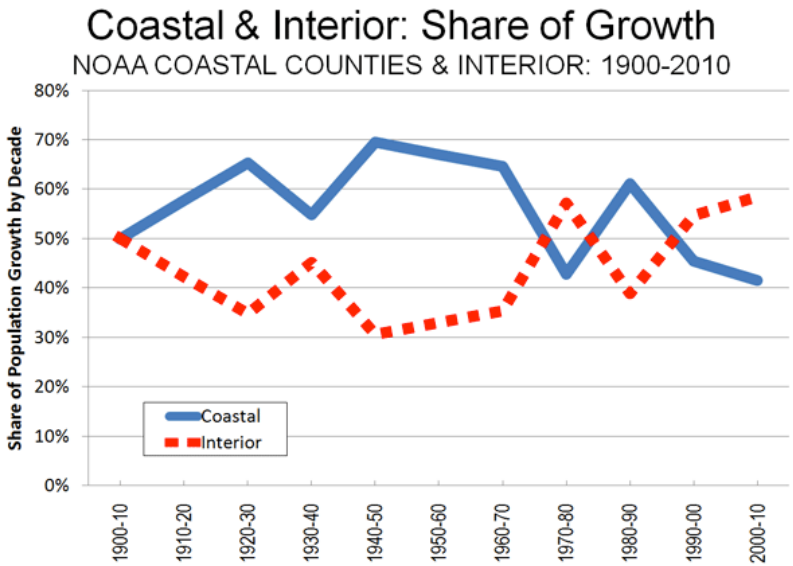


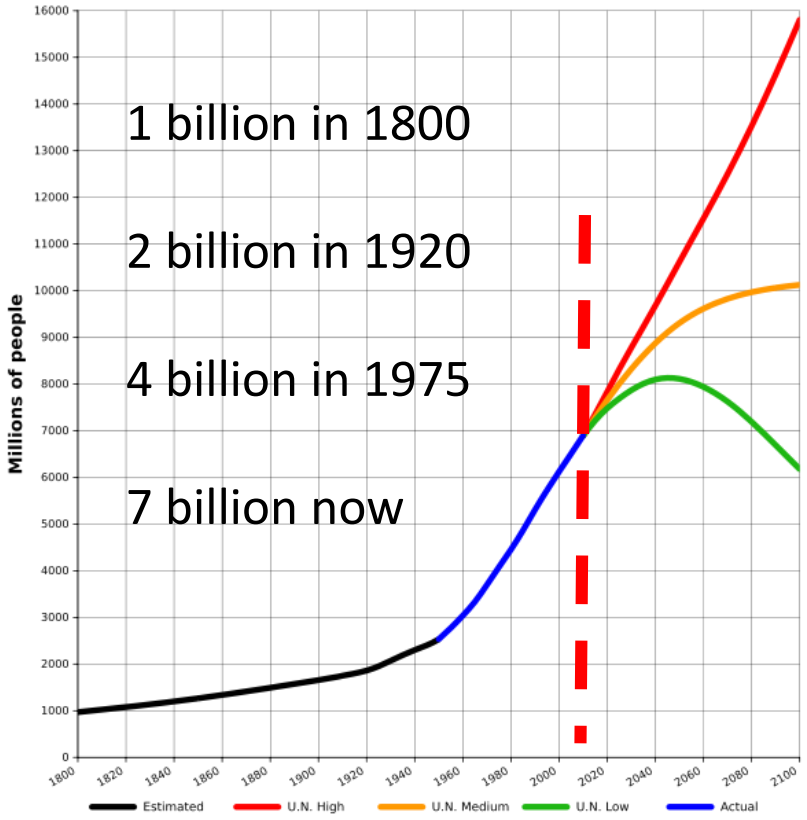
IPCC 2013

Are SLR, erosion and flooding the problems?

http://www.greekhotel.com/

Population growth



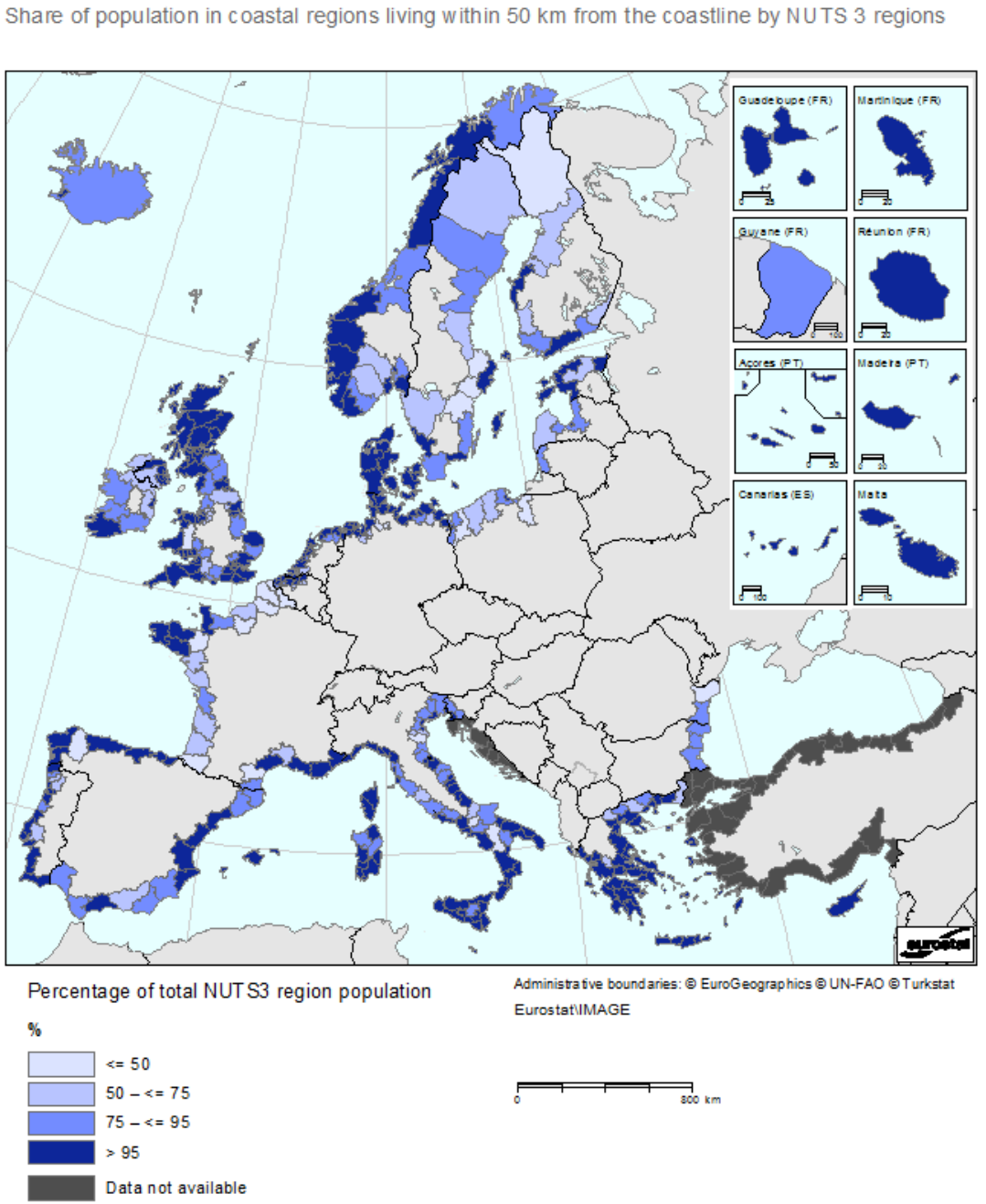


UN 2010


www.dailymotion.com

Pressure on the coast

- >50% of EU population lives within 50 km of the coast
- 44% of global population lives within 100 km of the coast (UN Atlas 2010)
- A great proportion below 10 m elevation



Pressure on the coast: Population

Pressure on the coast: extreme events

Katrina 2005 1400 dead, 108 billion $

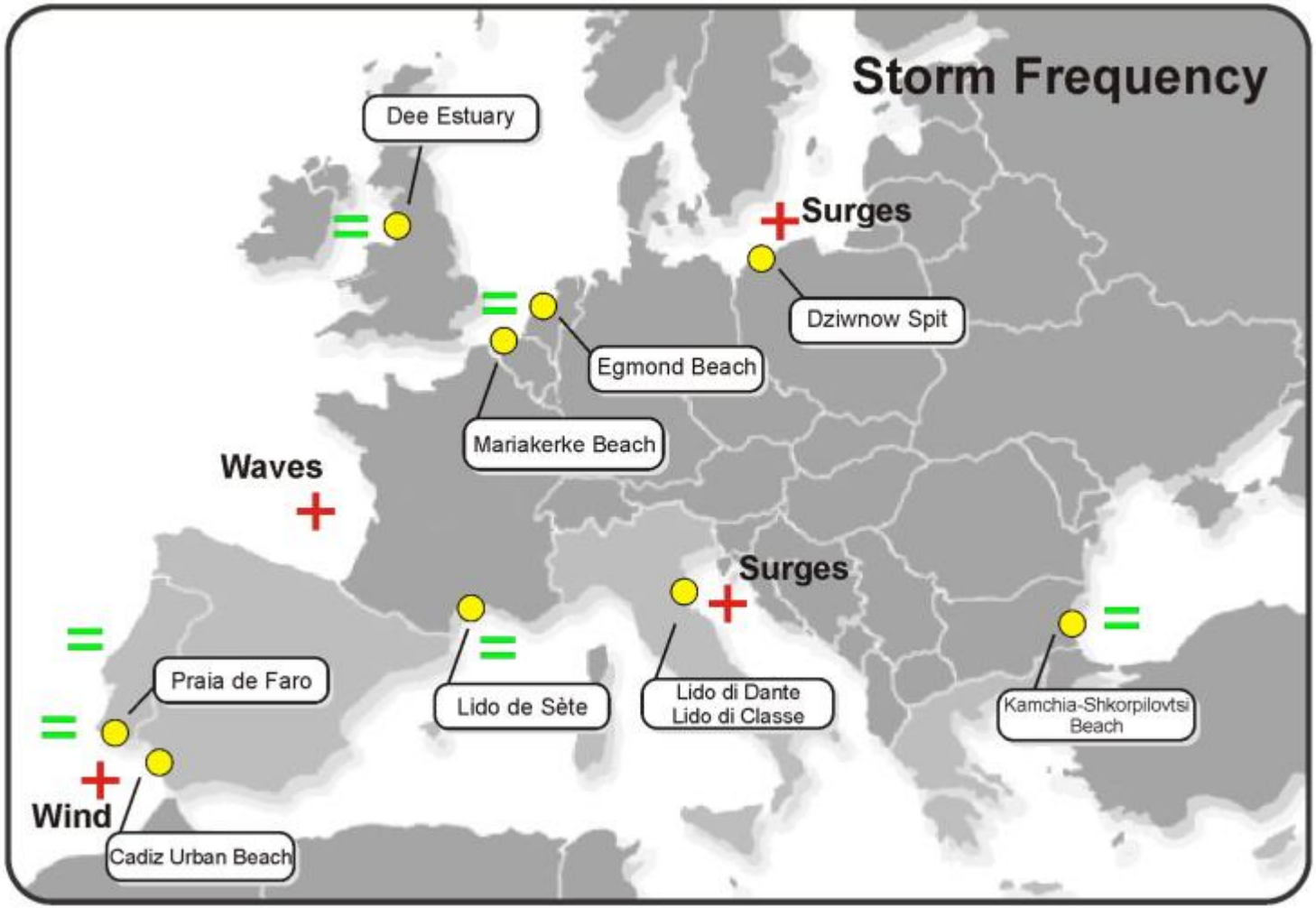
Rita 2005 120 dead, 12 billion $

Sandy 2012 2 dead, 0.7 billion $

Xynthia 2010 80 dead, 1.3 billion $

Joint Research Centre

Forcing trends of coastal hazard



Ferreira et al. (2009); Ciavola et al. (2011)

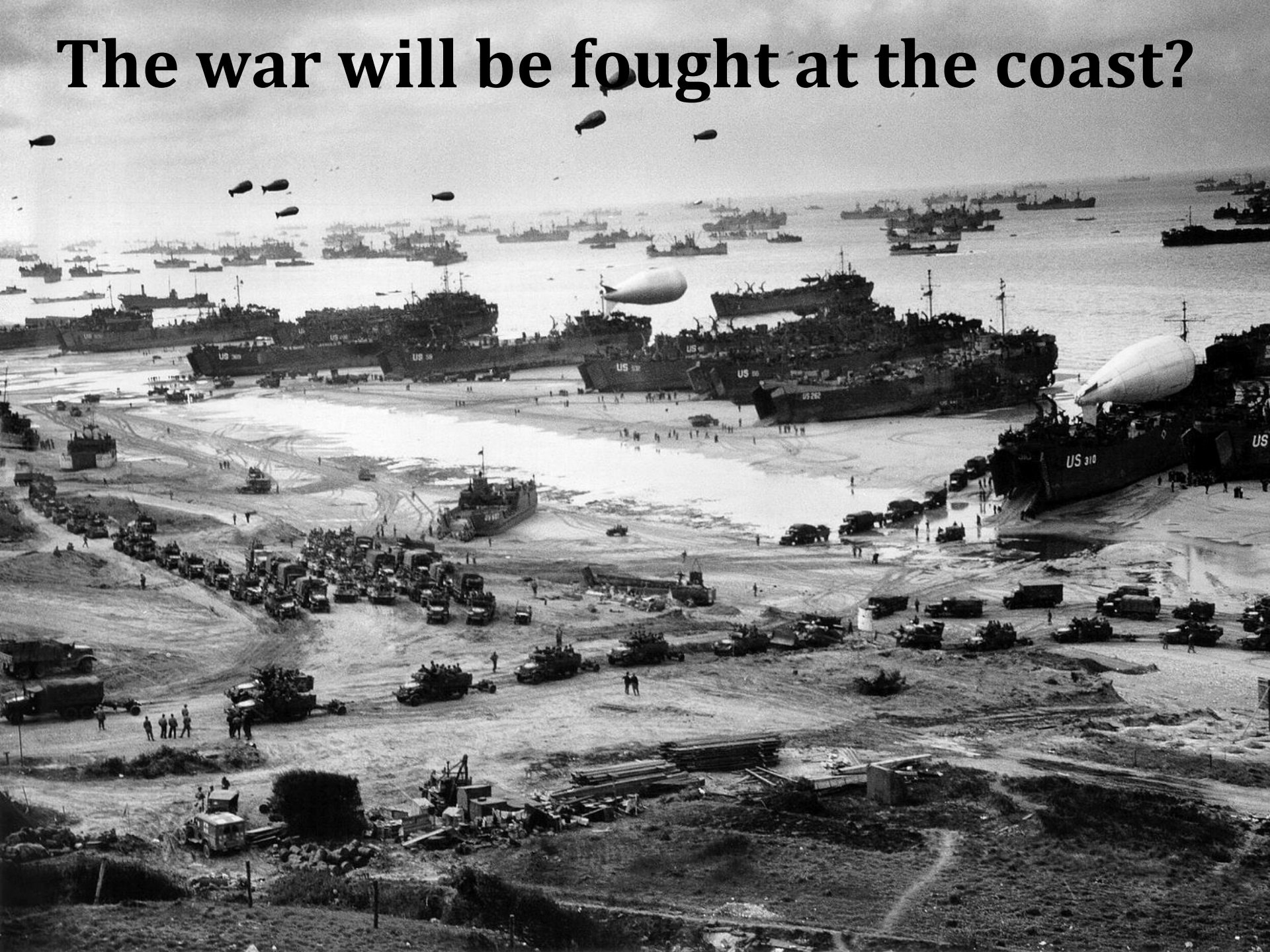
Vulnerability of ports and coastal infrastructure

Scott et al., 2016

Higher water levels
Vulnerability from sea and land
Sedimentation/dredging
Seiching

Changing weather patterns
Timing and characteristics of extreme events
Port orientation vs dominant wave direction

The war will be fought at the coast?



Open issues

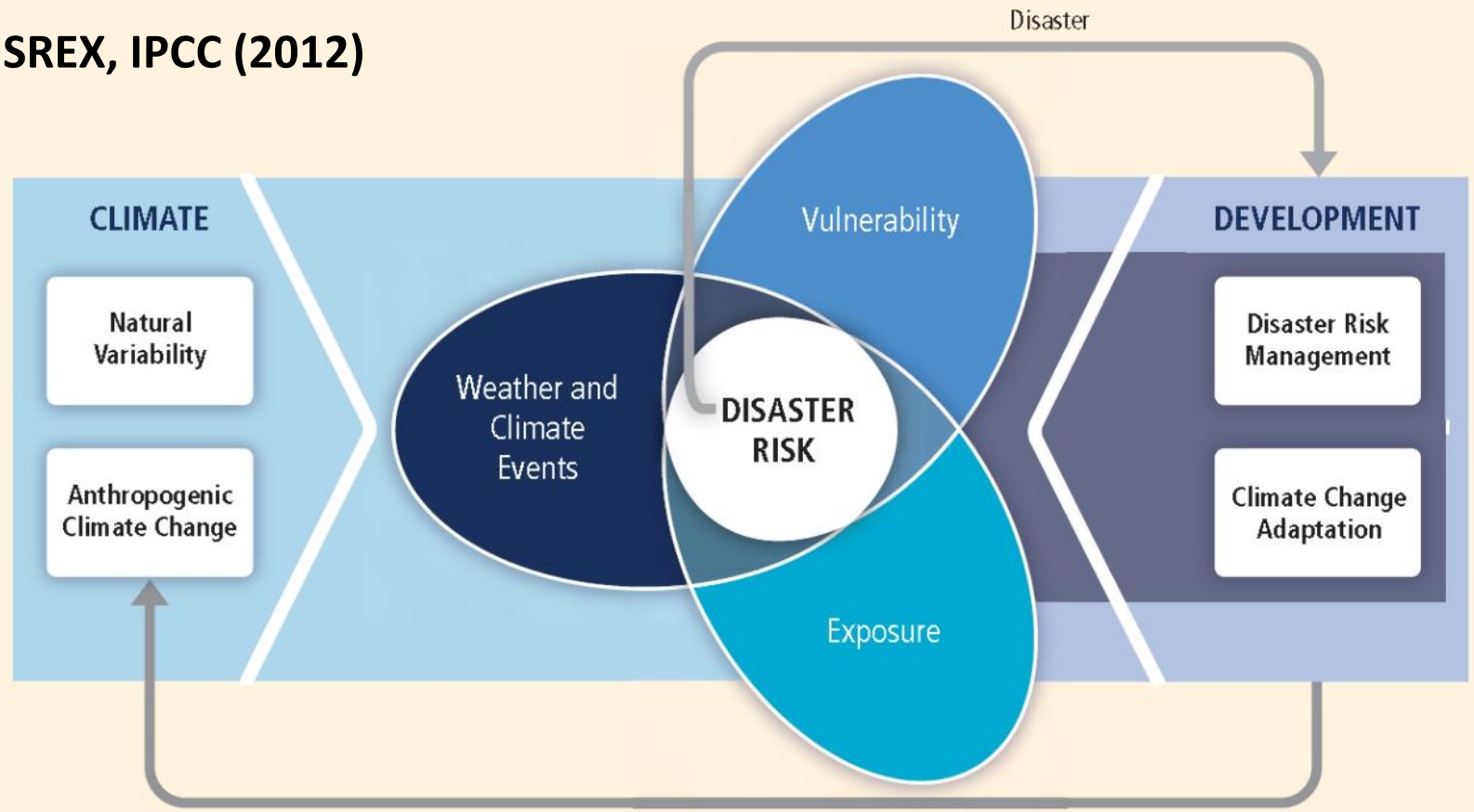
- Hazard under RCPs not studied in sufficient detail and with large climate model ensembles;
- Evolution of processes driving extreme water levels in view of climate change
- Waves presently completely omitted in inundation and impact assessment efforts
- No open-access databases of extreme water level projections
- Oversimplified large-scale inundation studies;
- Oversimplified impact assessment methodologies
- Socio-economic scenarios and adaptation pathways not sufficiently explored
- Still a lot to do on indirect impacts

LISCOAST

- A flexible coastal impact assessment tool
- Large scale, but not oversimplified
- Developed, validated and applied first for Europe and then implemented on global scale
- Building upon the group's expertise on inland flooding forecasting and impact assessment
- Collaborations with leading institutes of the field

Climate risk - framework

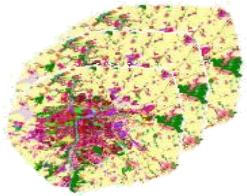
SREX, IPCC (2012)



The LISCoAsT approach

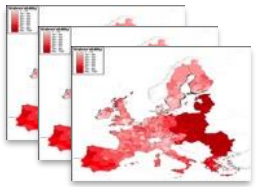
Socio-economic drivers

Land Use Scenarios



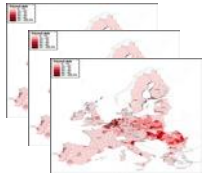
Exposure

Vulnerability



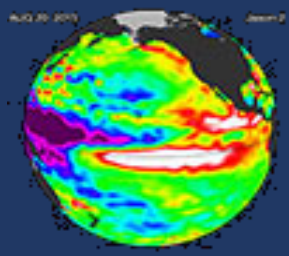
Hazard

Impact



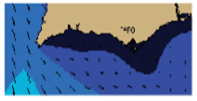
Adaptation

Climate



CMIP5 | TOPEX-POSEIDON | LISFLOOD-FP | XBeach | Delft-3D | WW3 | DFLOW

Coastal erosion and inundation



TWL + Inundation

SLR, Tide, Waves, Storm Surge

European Commission

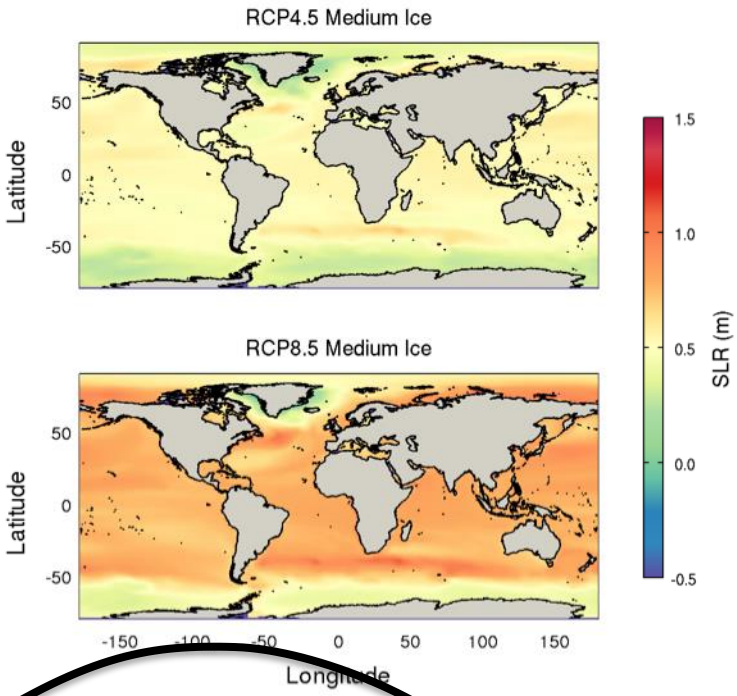


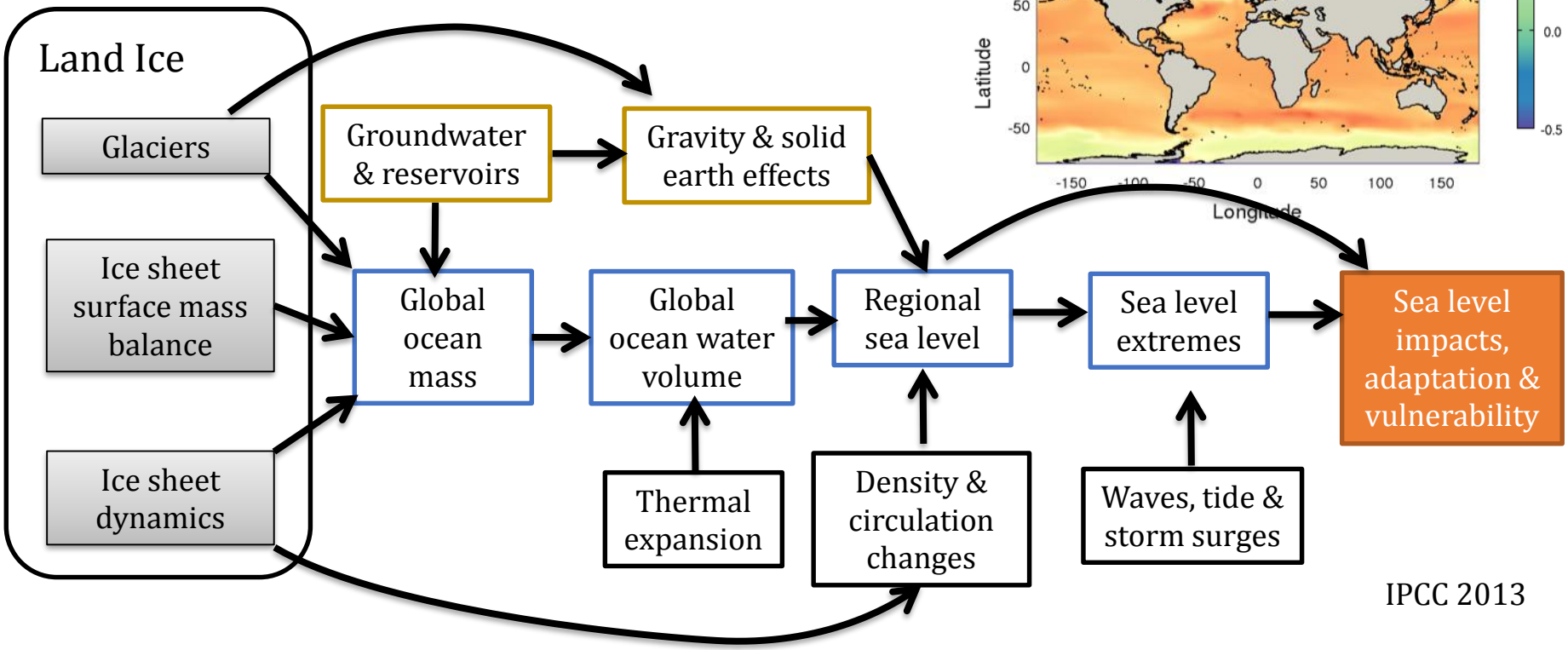
The LISCoAsT approach

HAZARD PROJECTIONS

Joint Research Centre

Sea Level Rise and beyond





IPCC 2013

European Commission

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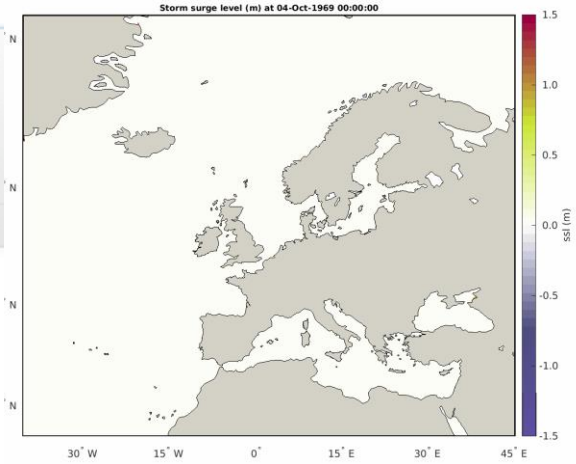

Article
Climate Dynamics
pp 1-20

First online: 20 February 2016

Open Access

Projections of extreme storm surge levels along Europe

Michalis I. Vousdoukas , Evangelos Voukouvalas, Alessandro Annunziato, Alessio Giardino, Luc Feyen

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NATURE CLIMATE CHANGE | RESEARCH HIGHLIGHTS

IMPACTS

European storm surges

Bronwyn Wake

Nature Climate Change **6**, 339 (2016) | doi:10.1038/nclimate2986
Published online 24 March 2016

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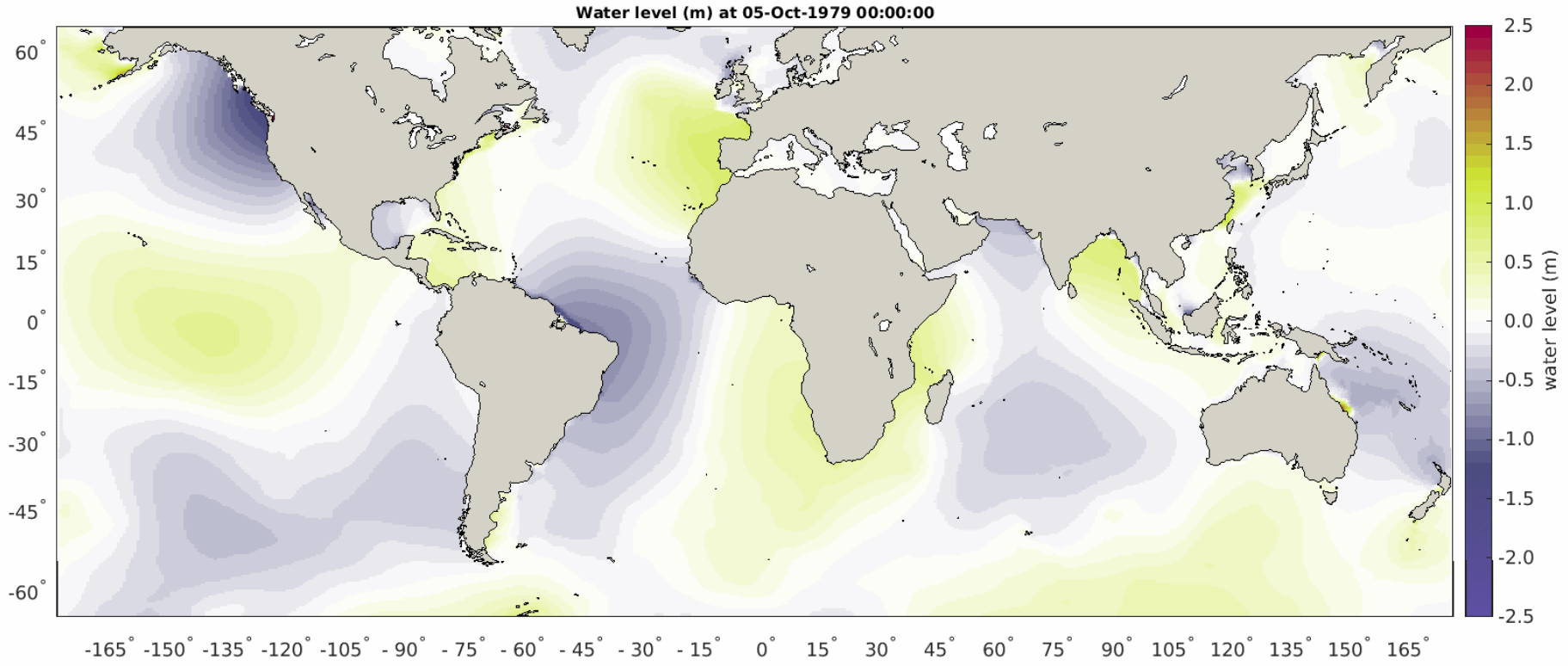
Clim. Dynam. http://doi.org/bc6v (2016)

Coastal areas have high population density so changes in water level, both sea-level rise and surges associated with extreme events, are a serious threat. While there is much research on sea-level change, less is known of how storm surges, driven by winds and atmospheric pressure fields associated with storm systems, will change in coming years.

Sea level extremes: Global Storm Surge Model

Model used: DFLOW
Simulated tidal, wind and pressure driven ocean circulation

Flexible mesh
Nearshore resolution 0.11° x 0.05°
Offshore resolution 0.94° x 0.42°



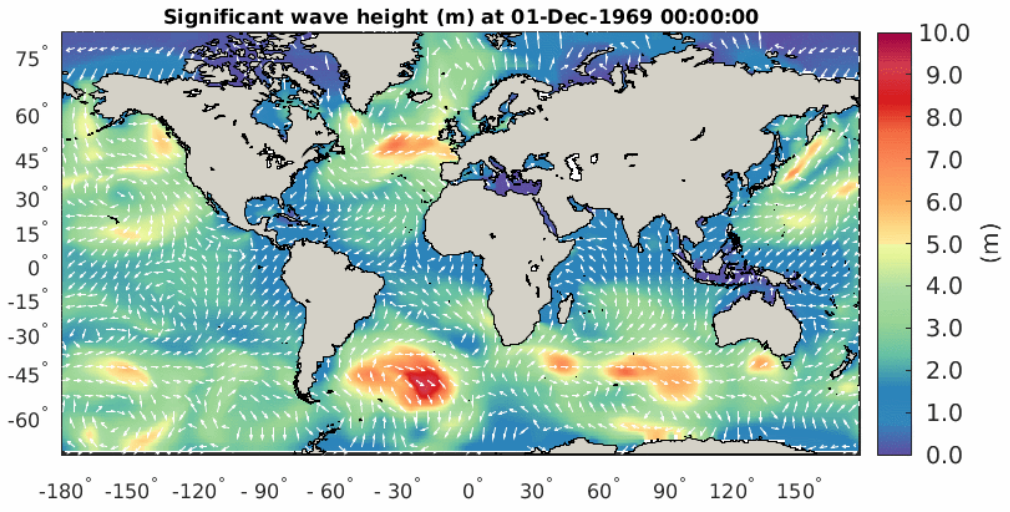
Sea level extremes: Global wave model

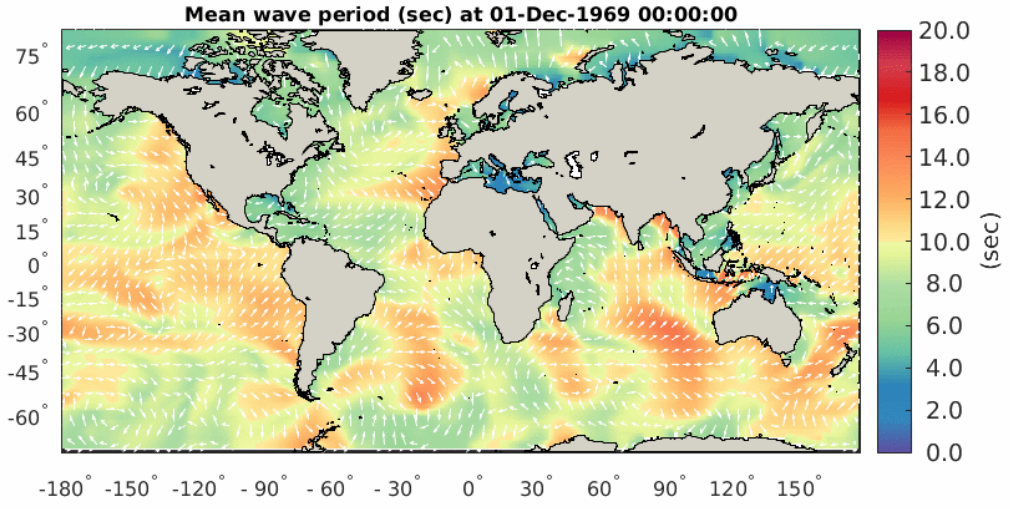
Model used: WaveWatch3 v4.18

Generates waves from wind fields

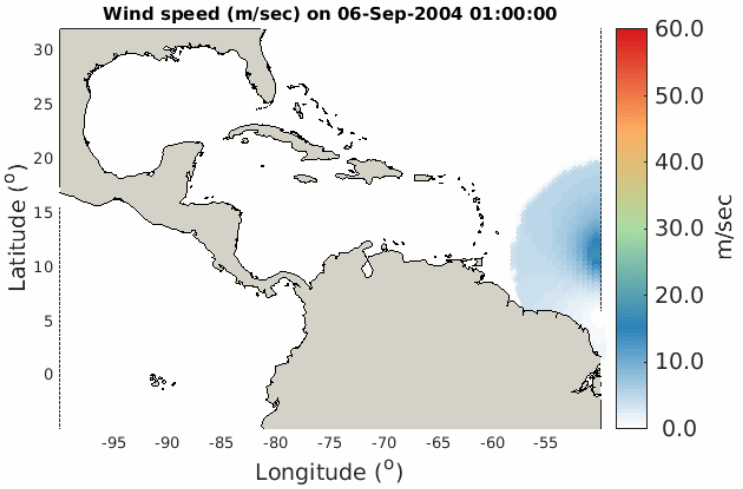
Resolves all wave directions and frequencies

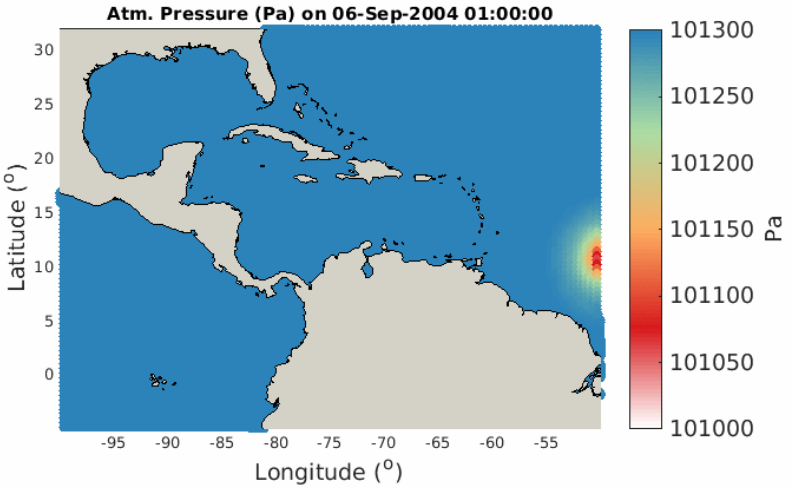
Considers several parameters including temperature, ice concentration

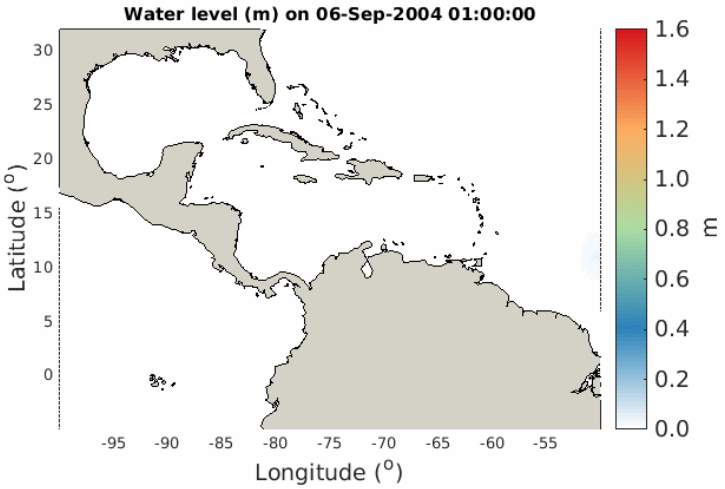


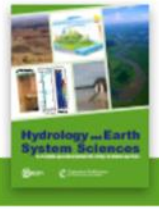


Sea level extremes: Tropical cyclones









Hydrology and Earth System Sciences
An interactive open-access journal of the European Geosciences Union

doi:10.5194/hess-2016-65

Research article

25 Feb 2016

Non-stationary Extreme Value Analysis: a simplified approach for Earth science applications

Lorenzo Mentaschi[1,2], Michalis Vousdoukas[1], Evangelos Voukouvalas[1], Ludovica Sartini[2], Luc Feyen[1], Giovanni Besio[2], and Lorenzo Alfieri[1]

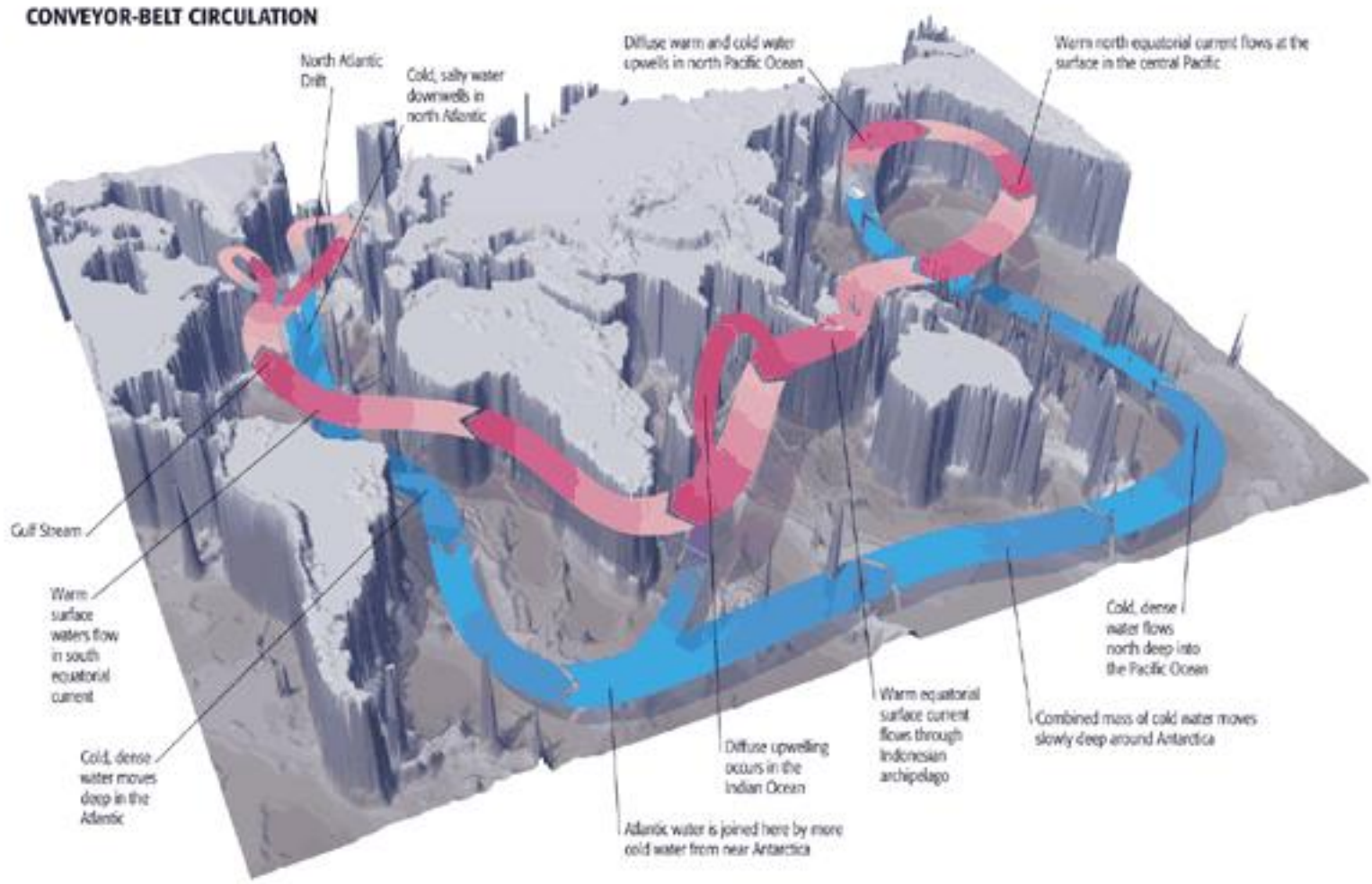
[1]European Commission, Joint Research Centre (JRC), Institute for Environment and Sustainability (IES), Climate Risk Management Unit, via Enrico Fermi 2749, 21027 Ispra, Italy
[2]Università di Genova, Dipartimento di Ingegneria Chimica, Civile ed Ambientale, via Montallegro 1, 16145 Genova, Italy

Review status
A revision of this discussion paper is under review for the journal Hydrology and Earth System Sciences (HESS).

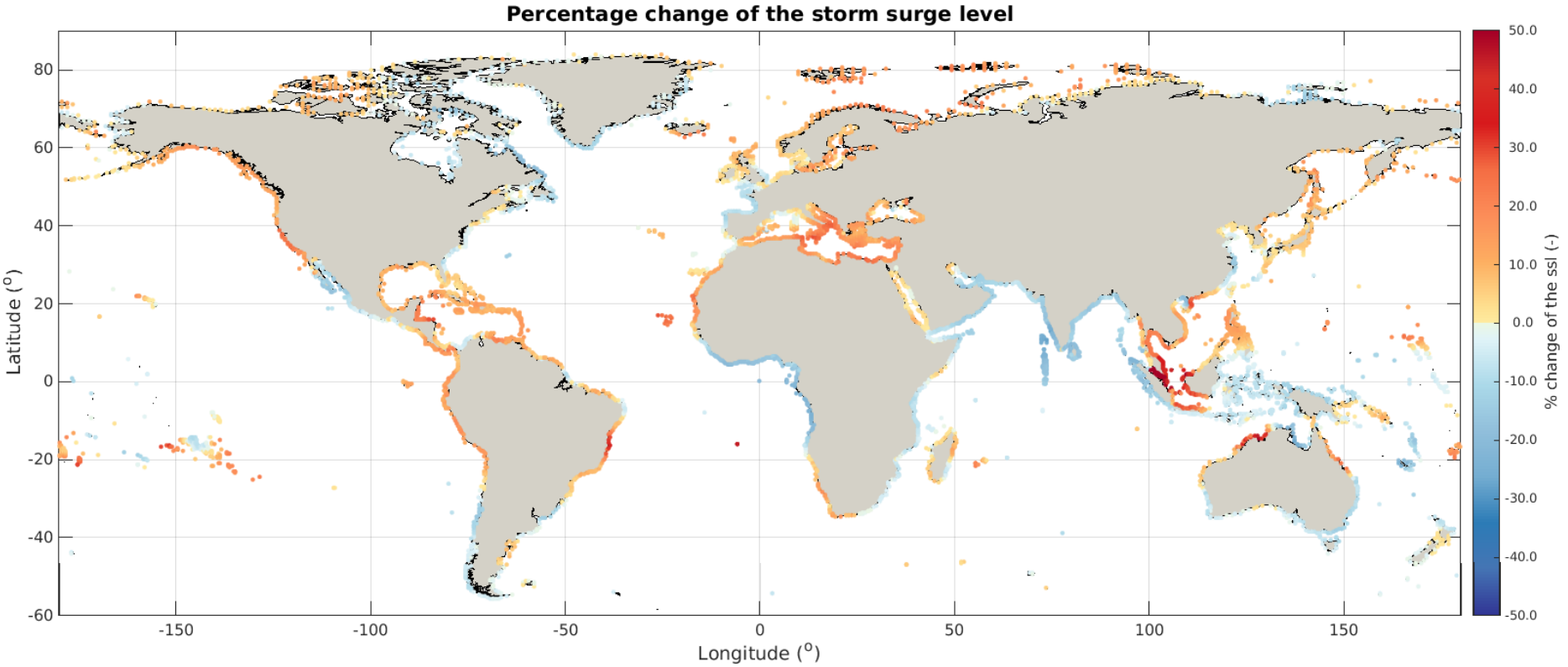
Received: 10 Feb 2016 – Accepted: 24 Feb 2016 – Published: 25 Feb 2016

Abstract. Statistical approaches to study extreme events require by definition long time series of data. The climate is subject to natural and anthropogenic variations at different temporal scales, leaving their footprint on the frequency and intensity of climatic and hydrological extremes, therefore assumption of stationarity is violated and alternative methods to conventional stationary Extreme Value Analysis (EVA) need to be adopted. In this study we introduce the Transformed-Stationary (TS) methodology for non-stationary EVA. This approach consists in (i) transforming a non-stationary time series into a stationary one to which the stationary EVA theory can be applied; and (ii) reverse-transforming the result into a non-stationary extreme value distribution. As a transformation we propose and discuss a simple time-varying normalization of the signal and show that it allows a comprehensive formulation of non stationary GEV/GPD models with constant shape parameter. A validation of the methodology is carried out on time series of

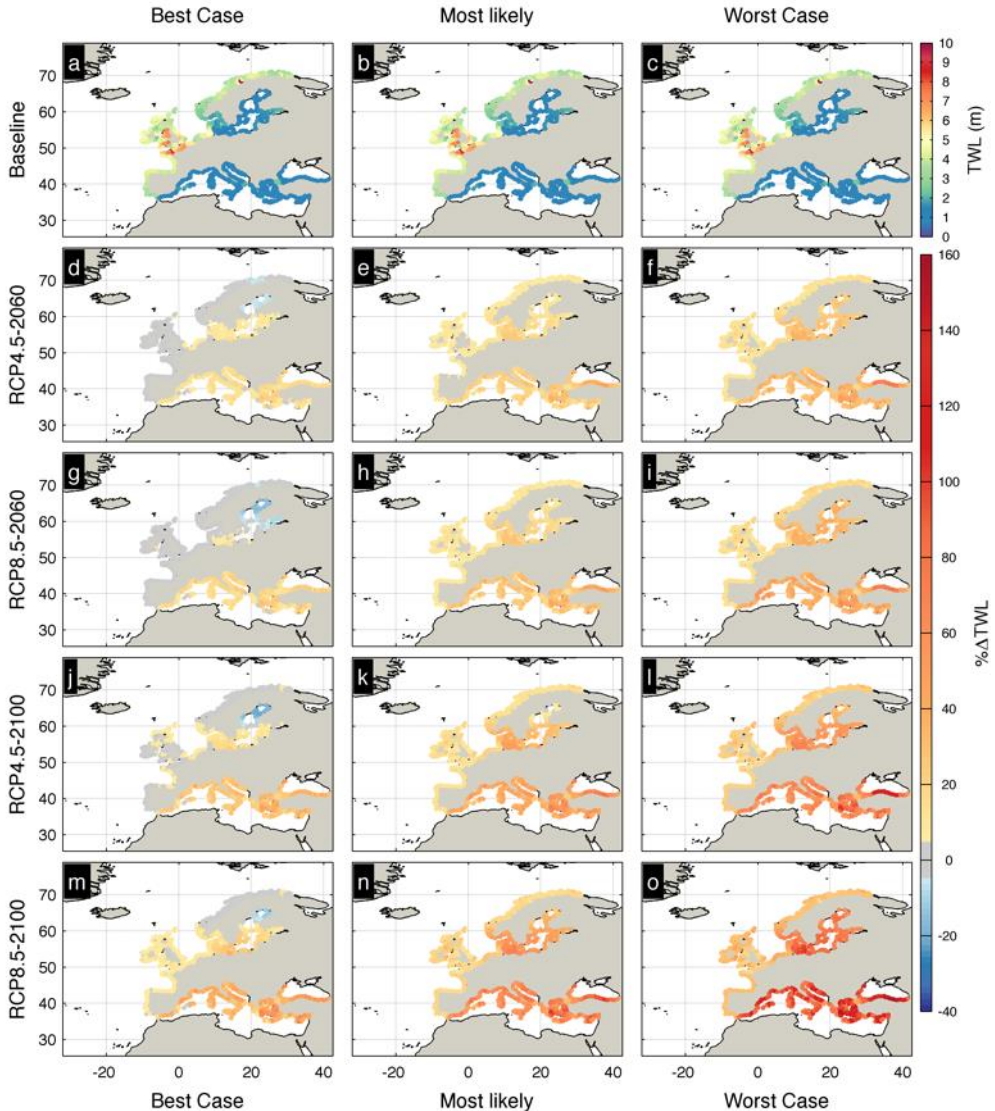
Climate tipping points: Thermohaline circulation



Climate tipping points: Thermohaline circulation



European TWL projections for the 100-year event



European Commission

Natural Hazards and Earth System Sciences
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doi:10.5194/nhess-2016-124

Research article

11 Apr 2016

Developments in large-scale coastal flood hazard mapping

Review status
This discussion paper is under review for the journal Natural Hazards and Earth System Sciences (NHESS).

Michalis I. Vousdoukas[1,2], Evangelos Voukouvalas[1], Lorenzo Mentaschi[1], Francesco Dottori[1], Alessio Giardino[3], Dimitrios Bouziotas[1,3], Alessandra Bianchi[1], Peter Salamon[1], and Luc Feyen[1]

[1]European Commission, Joint European Research Centre (JRC), Institute of Environment and Sustainability (IES), Climate Risk Management Unit, Via Enrico Fermi 2749, I-21027-Ispra, Italy
[2]Department of Marine Sciences, University of the Aegean, University hill, 41100, Mitilene, Lesbos, Greece
[3]Deltares, P.O. Box 177, 2600 MH Delft, The Netherlands.

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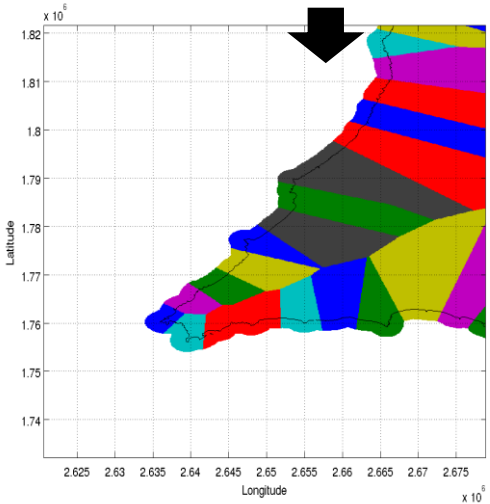
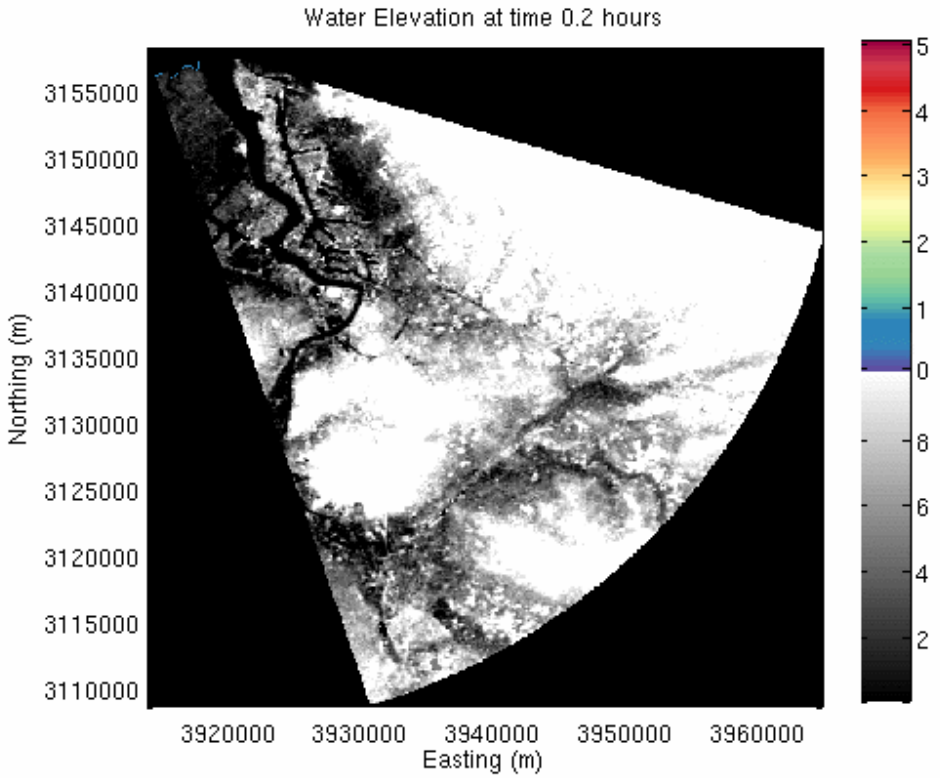
Abstract. Coastal flooding related to marine extreme events has severe socio-economic impacts, and even though the latter are projected to increase under the changing climate, there is a clear deficit of information and predictive capacity related to coastal flood mapping. The present contribution reports on efforts towards a new methodology for mapping coastal flood hazard at European scale, combining (i) the contribution of waves to the total water level; (ii) improved inundation modelling; and (iii) an open, physics-based framework which can be constantly upgraded, whenever new and more accurate data become available. Four inundation approaches of gradually increasing complexity and computational costs were evaluated in terms of their applicability for large-scale coastal flooding mapping: static inundation (SM); a semi-dynamic method, considering the water volume discharge over the dykes (VD); the Flood Intensity Index approach (Iw); and the model LISFLOOD-FP (LFP). A validation test performed against observed flood extents during the Xynthia storm event showed that SM and VD can lead to an overestimation of flood extents by 232% and 209 %, while Iw and

Coastal Inundation on EU scale

- TWL components estimated every 25 km of coast
- SRTM DEM
- Similarly coastline and all data divided in 25 km long segments, extending 50 km inland

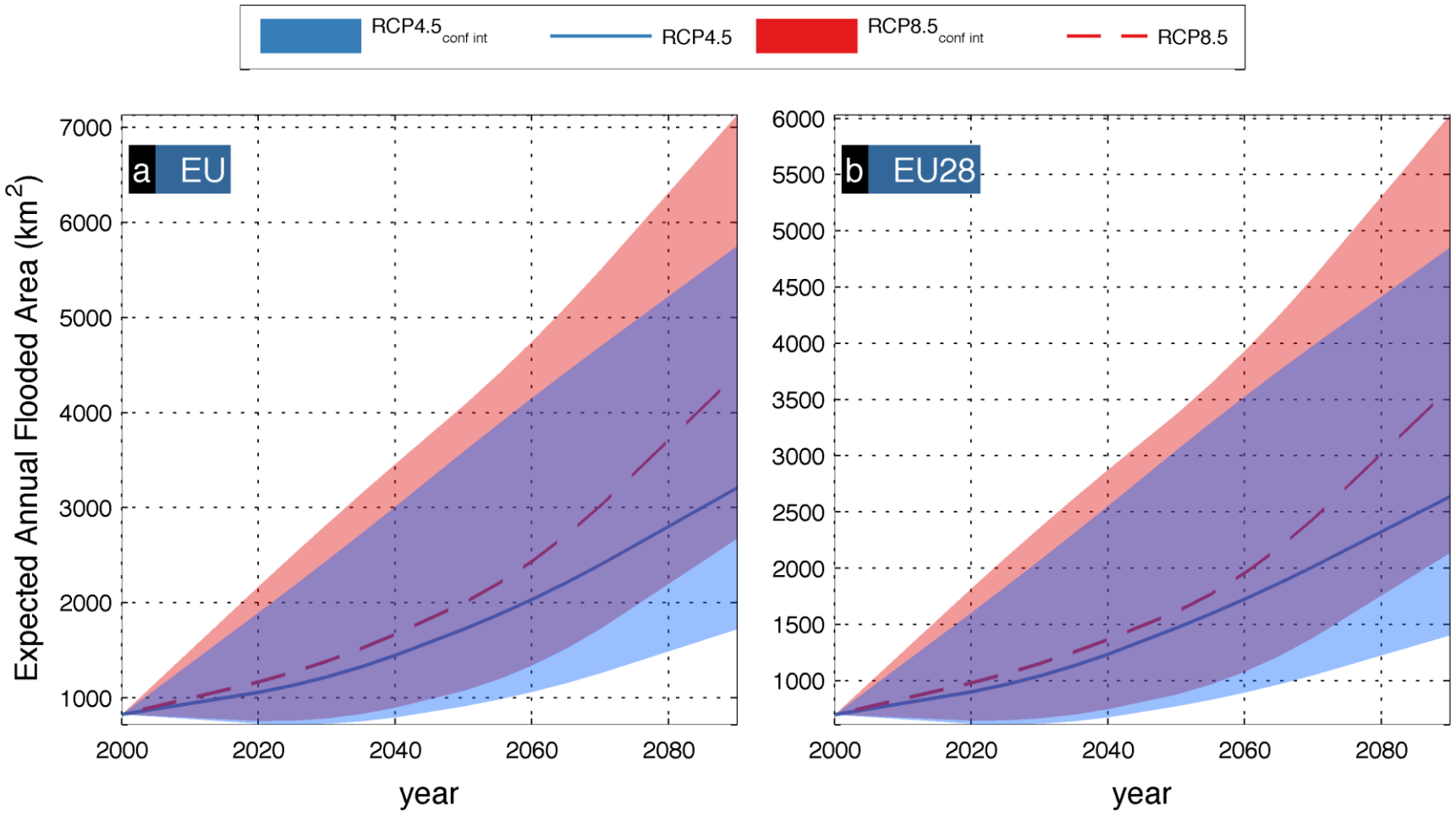




$$\eta_{TWL} = \eta_{MSL} + RSLR + \eta_{tide} + \eta_{stormsurge} + \eta_{wave}$$

Joint Research Centre

European coastal flooding projections



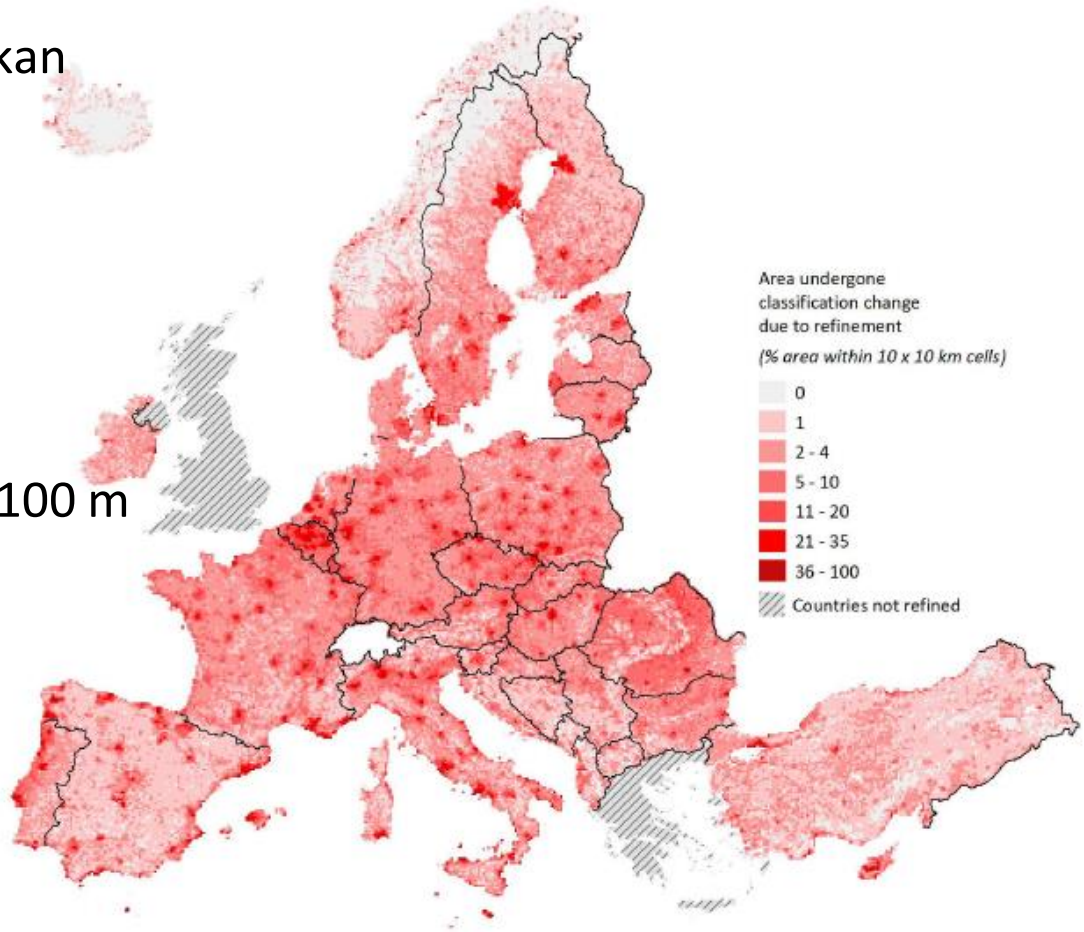


The LISCoAsT approach

EXPOSURE-VULNERABILITY

Exposure: current land use and population

- 2006 land use map, 100x100 m
- EU27 + EFTA + Turkey + Balkan
- 45 thematic classes
- Refined CORINE land use
  - Soil Sealing Layer
  - TeleAtlas®
  - Urban Atlas
- 2006 population map, 100x100 m
- EU27 + EFTA

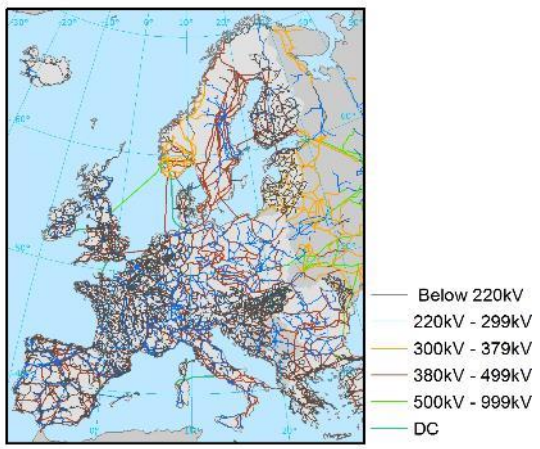


Batista e Silva, F., Lavalle, C., Koomen, E., 2013. A procedure to obtain a refined European land use/cover map. Journal of Land Use Science, 8 (3), pp. 255-283.
Batista e Silva, F., J. Gallego, C. Lavalle, 2013. A high-resolution population grid map for Europe. Journal of Maps, 9, 16-28.

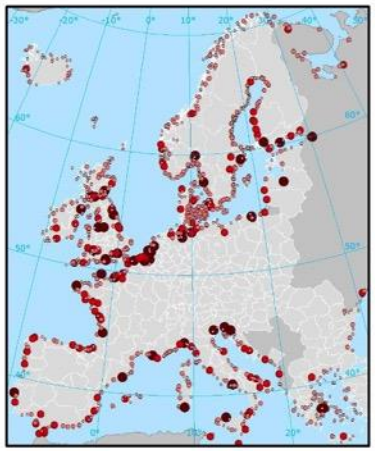
Mapping of large infrastructures and key economic assets

- Non renewable Power Plants (MW)
- Electricity distribution lines (km)
- Unesco cultural sites (number)
- Social infrastructure (number)
- Ports/Airports (No People Served)
- Transport networks (No People Served)
- Urban transport (No People Served)

Transmission lines



Ports



Railway network

European Commission

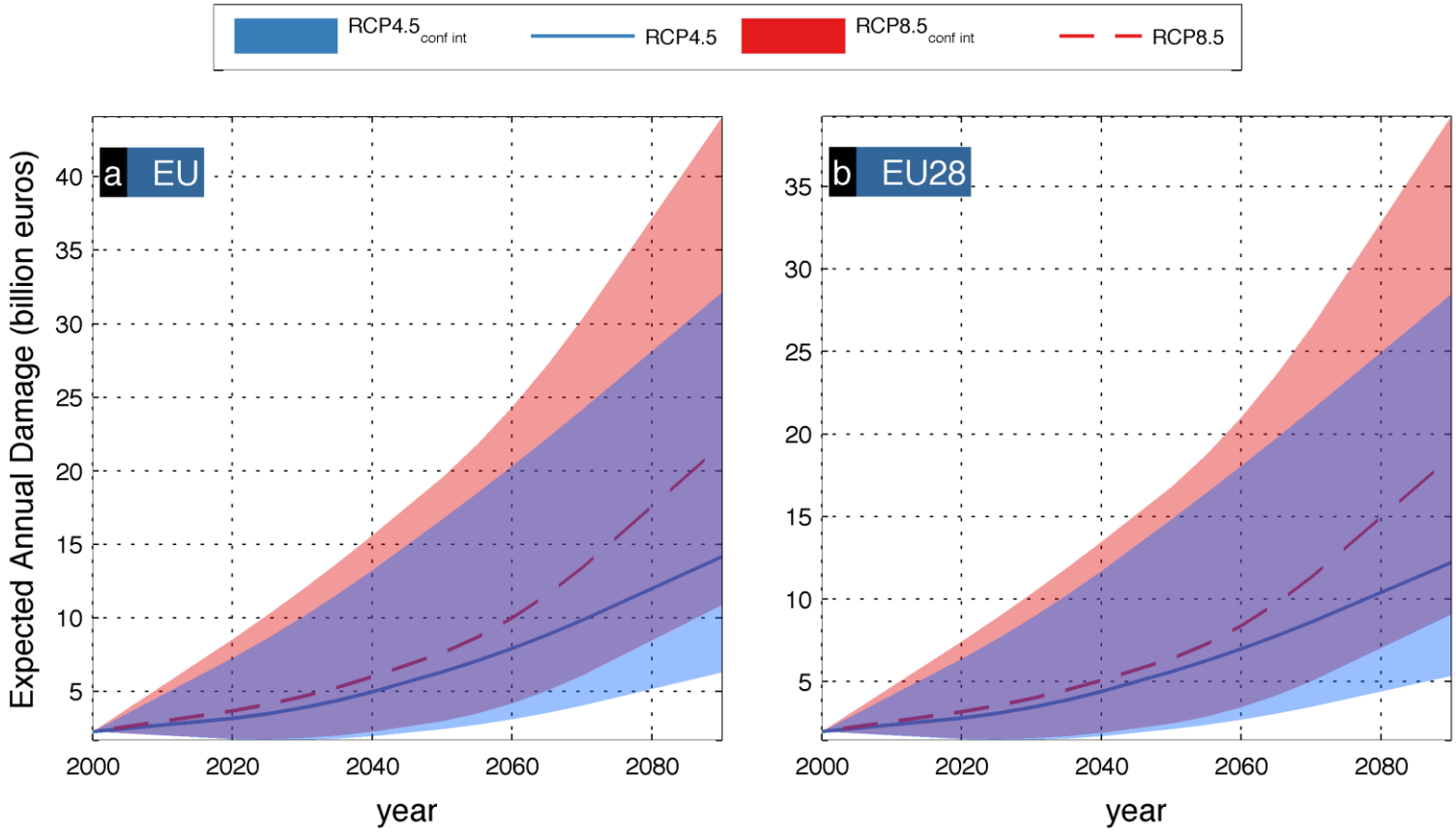


Results

PROJECTIONS OF COASTAL IMPACTS FOR EUROPE

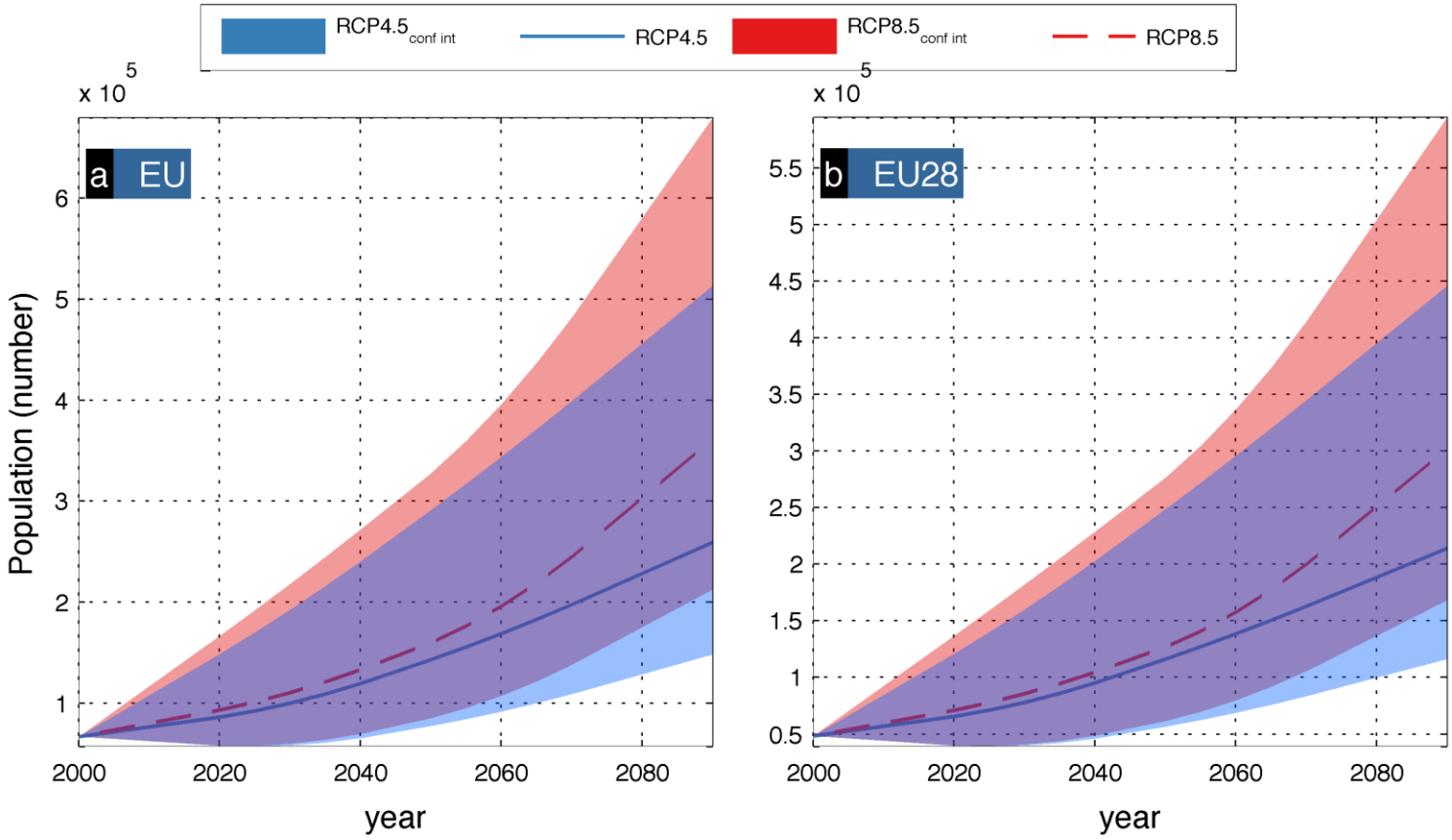
Joint Research Centre

Projections of EAD for RCP4.5 and 8.5



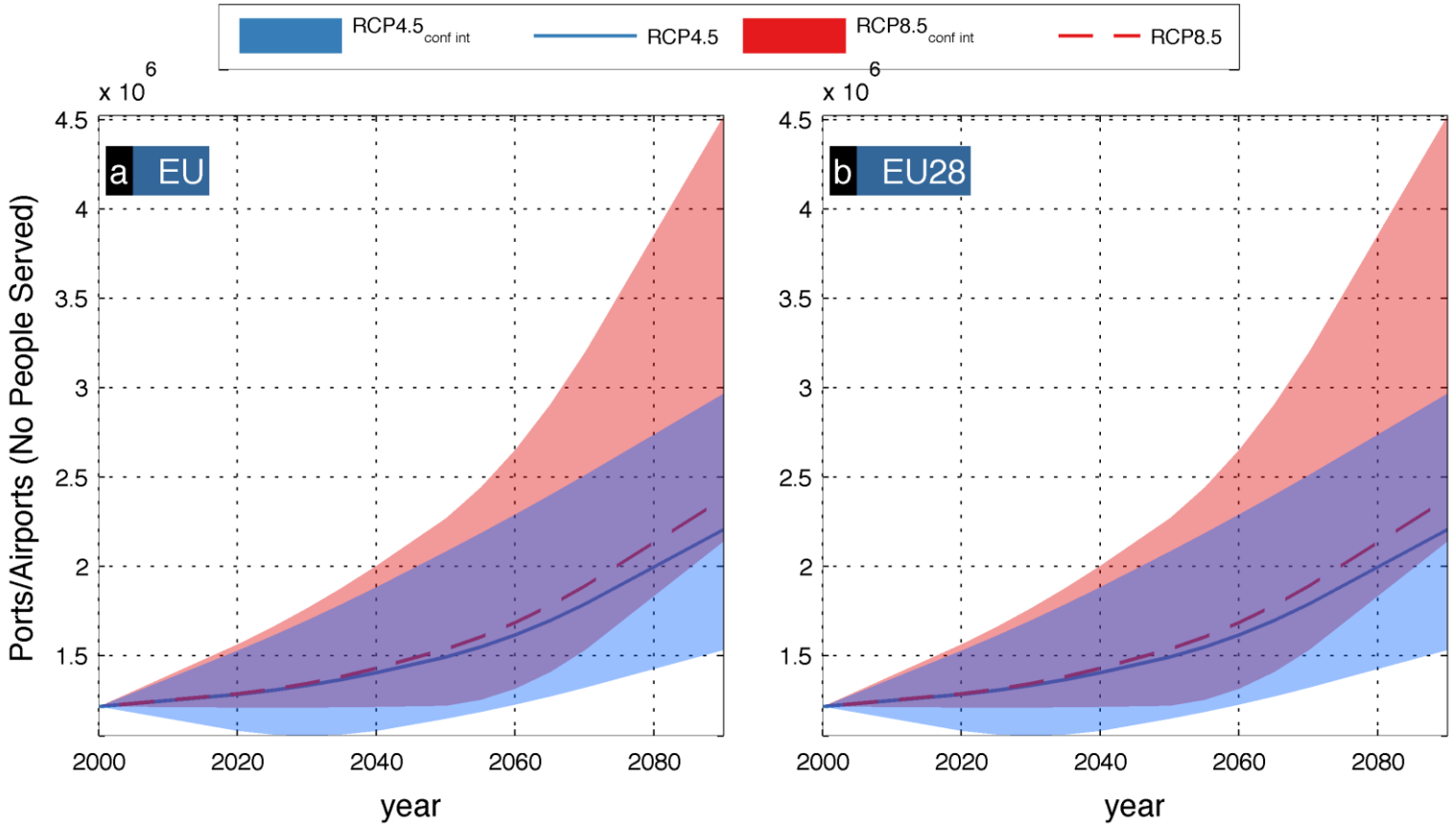
Only direct impacts!

Projections of EA number of people affected



Only direct impacts!

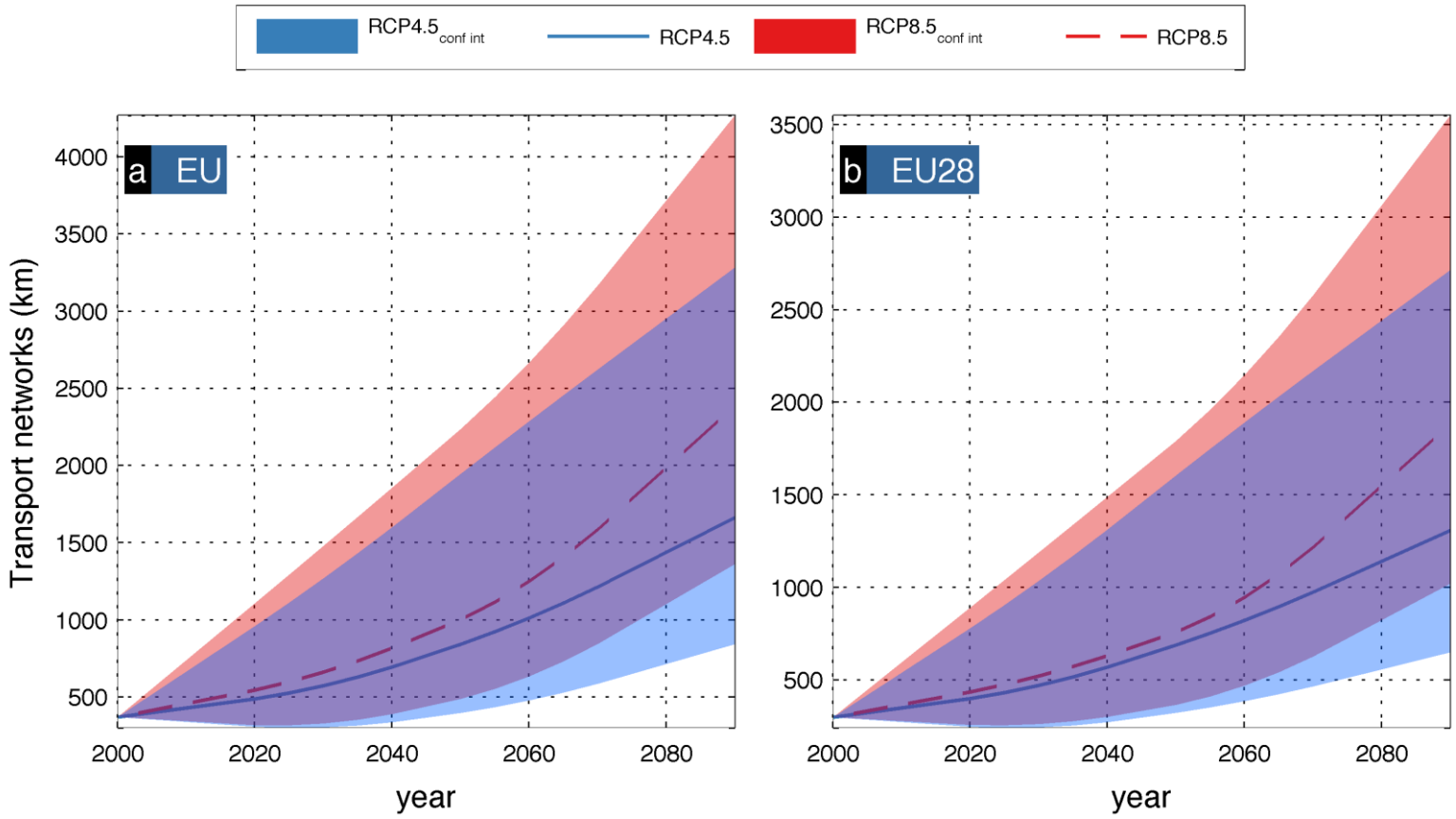
Projections of EA number of people served by affected ports and airports



Only direct impacts!

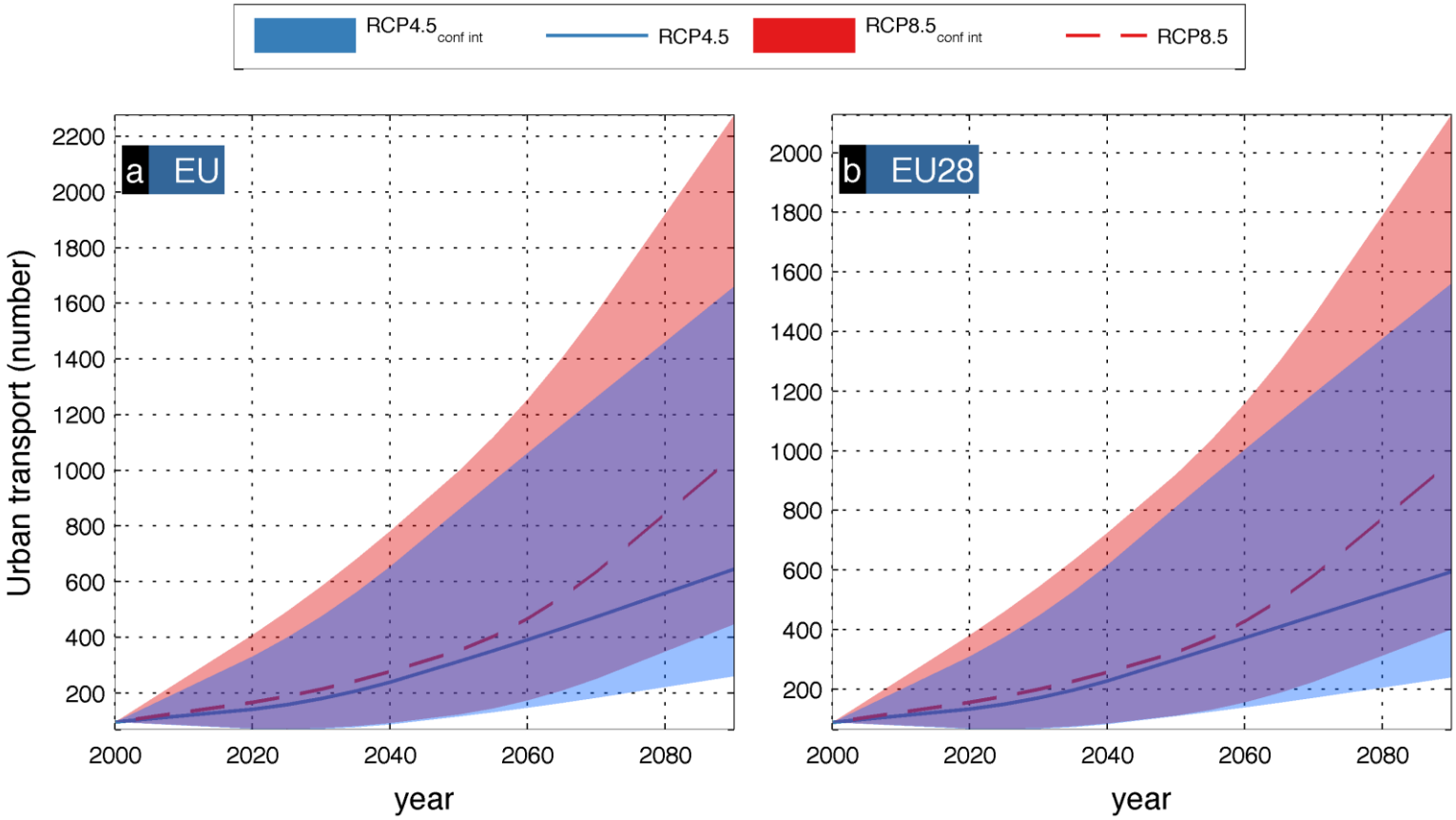
Joint Research Centre

Projections of EA number of km affected transport networks



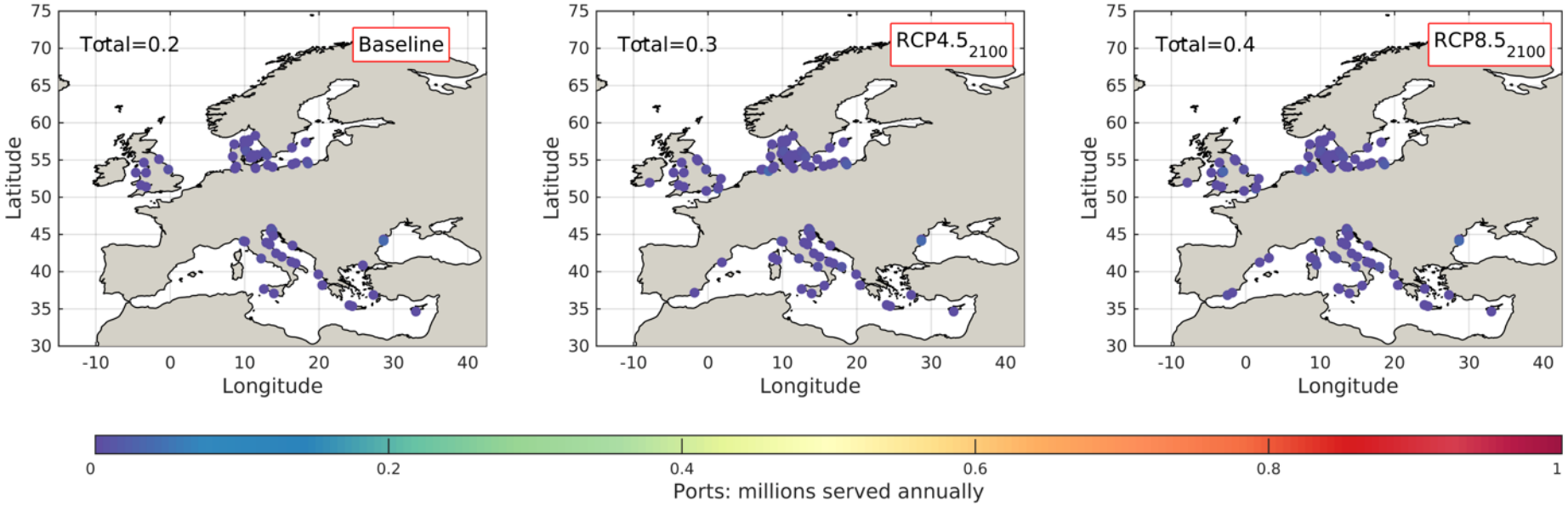
Only direct impacts!

Projections of EA number of urban transport facilities affected



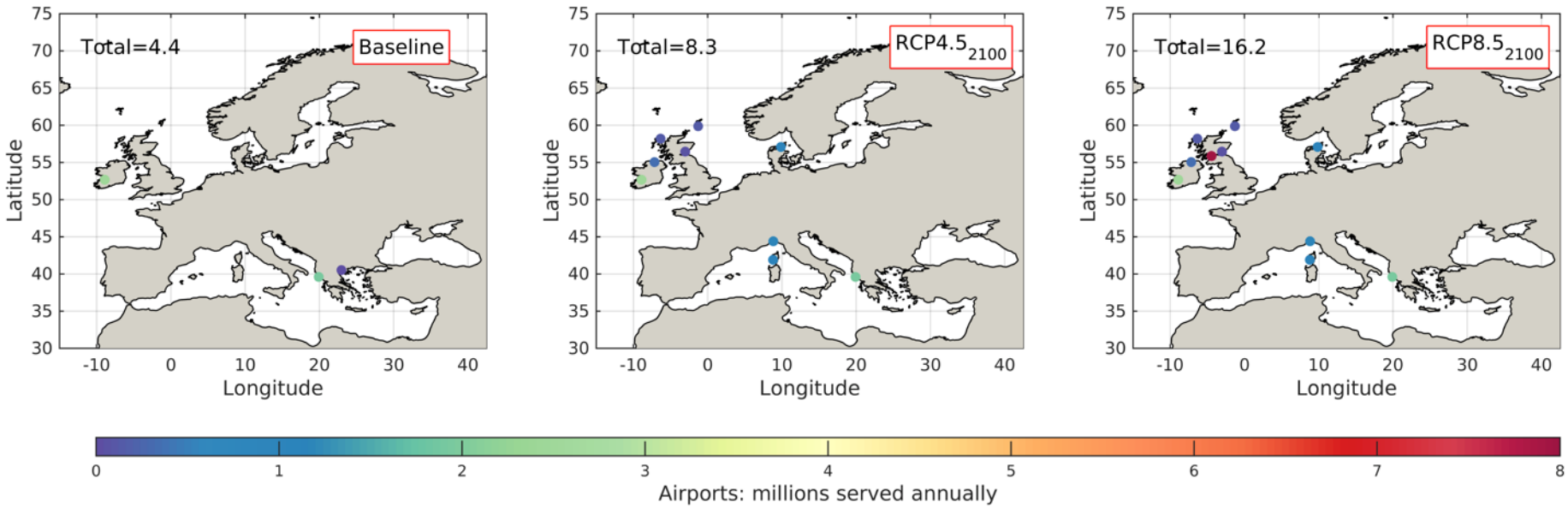
Only direct impacts!

Projections of number of people served by affected ports (100 year event)



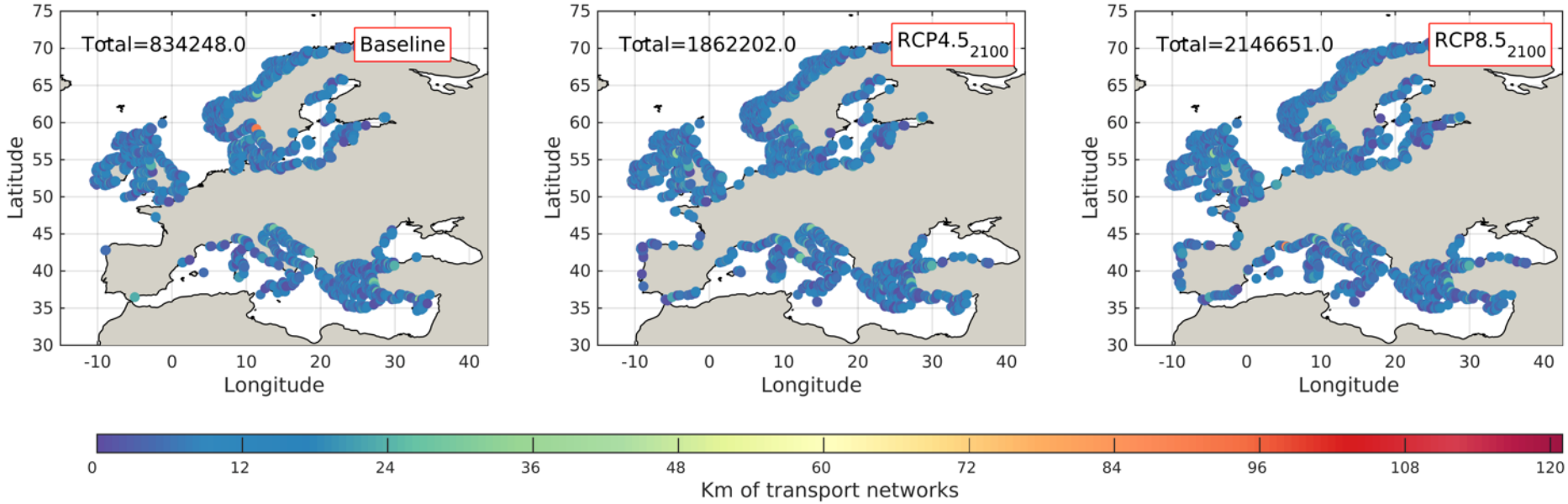
Only direct impacts!

Projections of number of people served by affected airports (100 year event)



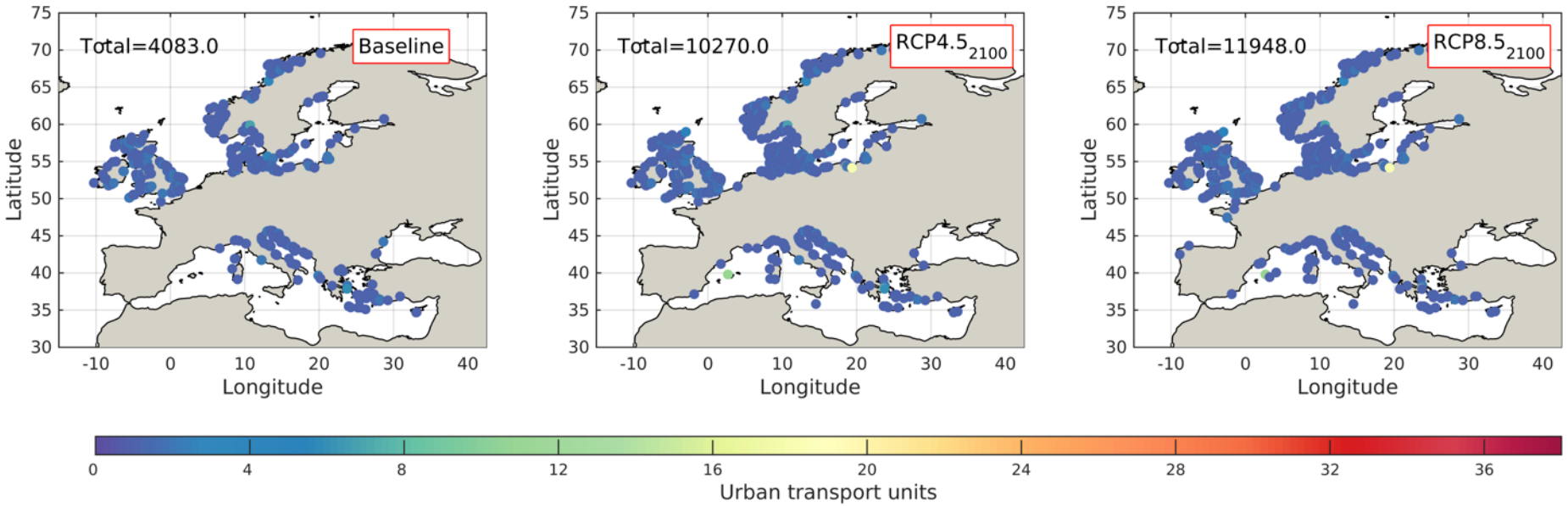
Only direct impacts!

Projections of EA number of km affected transport networks



Only direct impacts!

Projections of EA number of urban transport facilities affected



Only direct impacts!



Closing Remarks

SUMMARY AND WORK IN PROGRESS:
METHODOLOGICAL GAPS, IDEAS, CRITICAL QUESTIONS

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What we have…

State of the art projections of extreme TWL for EU and soon globally

An impact assessment methodology adapted to the coastal problem

An algorithm which can incorporate certain coastal protection standards

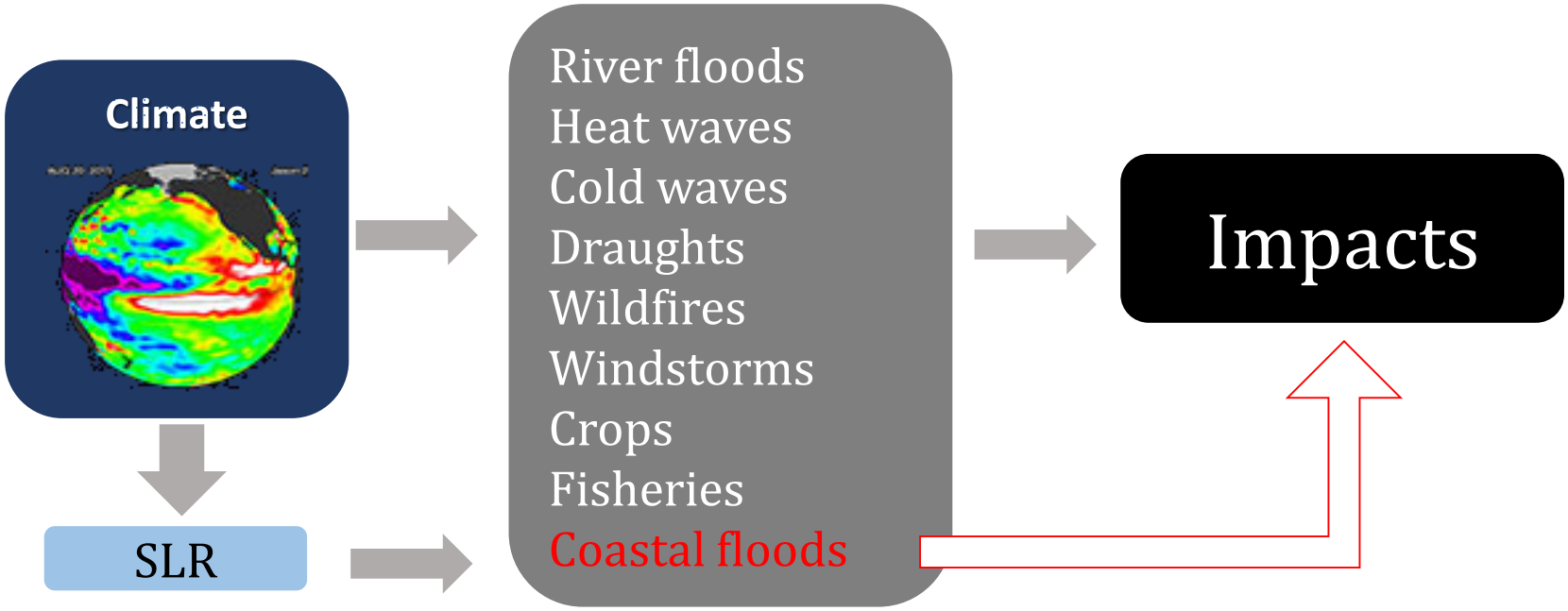
….and that can lead to an evaluation of adaptation scenarios

A set of calibrated models for all hazard components

What is on the way…

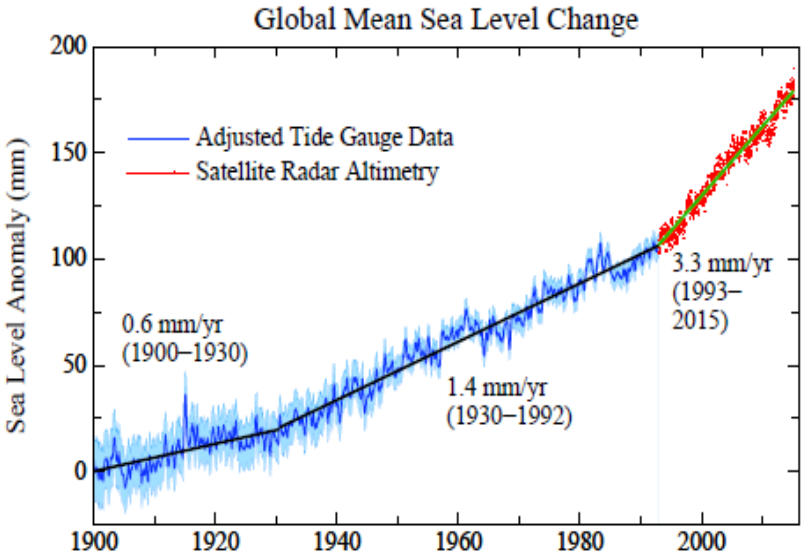
Global Waves, Storm Surge, Improved impact assessment, SSPs, Adaptation…

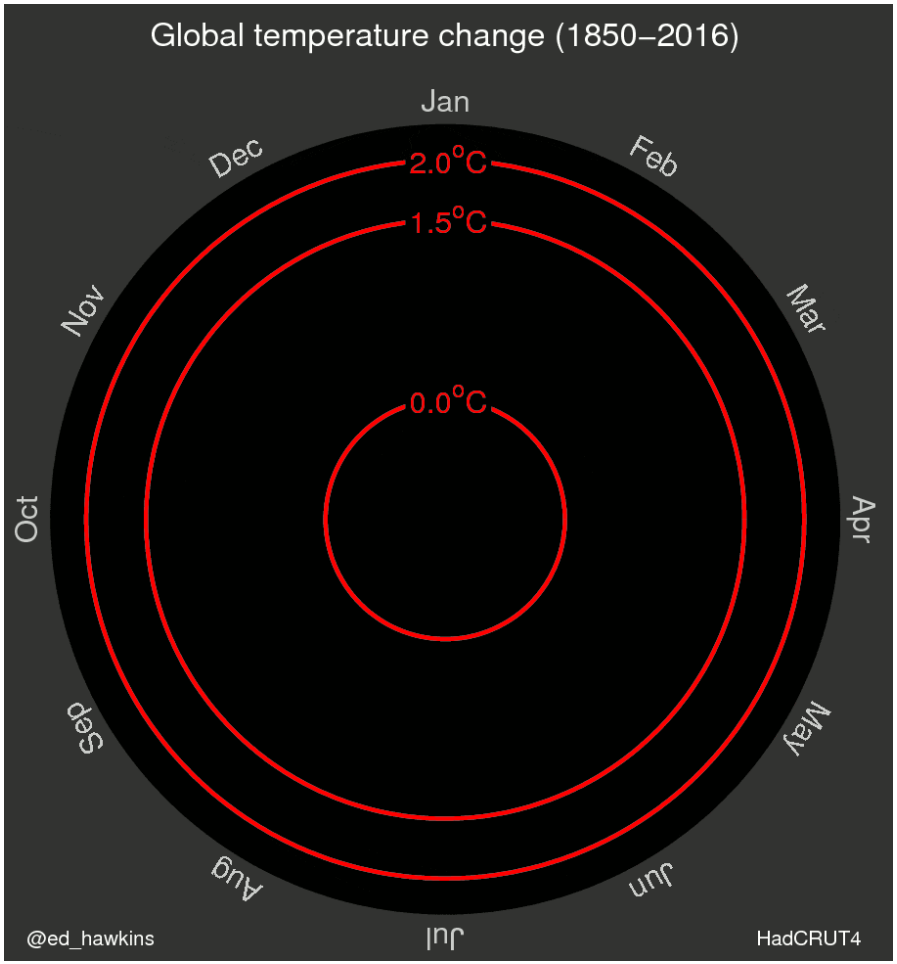
What is really at stake?



What is really at stake?

- The ocean absorbs >90% of the increase in energy
- Past sea levels under +1.5-2°C were 6-10 m higher than present
- Expansion of sea water per °C of warming is greater at higher temperature and higher pressure





Hawkins, MetOffice, 2016

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What is really at stake?

- Projections indicate an order of magnitude increase of direct impacts by the end of the century
- Without considering tipping points
- Without considering indirect impacts
  - Business interruption
  - Ecology
  - Sector interactions
  - Criticality of transport hubs
  - Etc….

Intangible/indirect impacts

www.wikipedia.org

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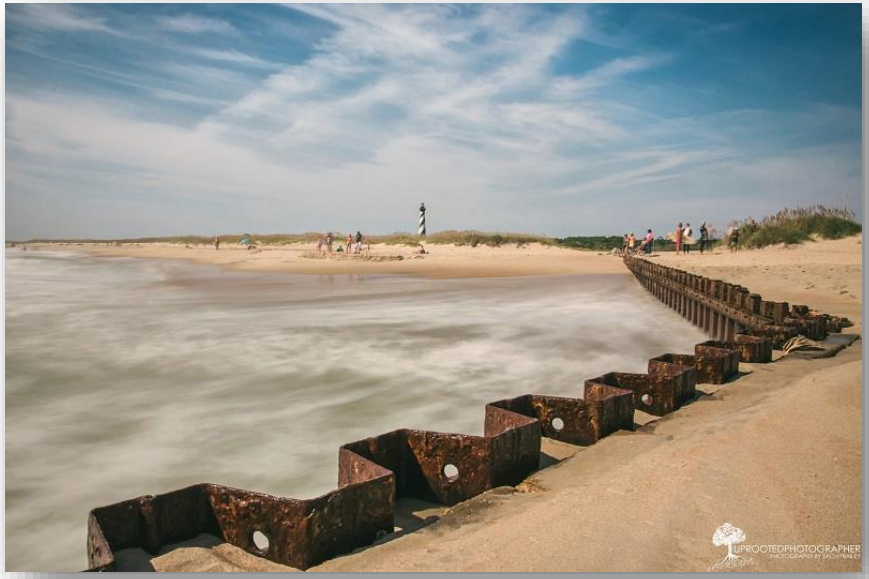
Intangible/indirect impacts

www.miriadna.com

www.wikipedia.com

Adaptation and social justice

James G. Titus and Michael Craghan (2009)



http://porterbriggs.com/

- Need to acknowledge the challenging nature of coastal adaptation in view of climate change
- Urgency of moving towards the direction of a timely response, taking coordinated and fair measures

Thank you very much…