UNCTAD National Workshop Saint Lucia

24 – 26 May 2017, Rodney Bay, Saint Lucia

"Climate Change Impacts and Adaptation for Coastal Transport Infrastructure in Caribbean SIDS"

LISCoAsT – Large Scale Integrated Sea-level and Coastal Assessment Tool: Application for the SIDS (I)

By

Michalis Vousdoukas

European Commission, Joint European Research Centre, Ispra, Italy

LISCoAsT – Large scale Integrated Sea-level and Coastal Assessment Tool: Application for the SIDS

UNCTAD National Workshop Saint Lucia
"Climate change impacts and adaptation for coastal transport infrastructure in Caribbean SIDS"

Michalis Vousdoukas, Lorenzo Mentaschi, Evangelos Voukouvalas, Luc Feyen

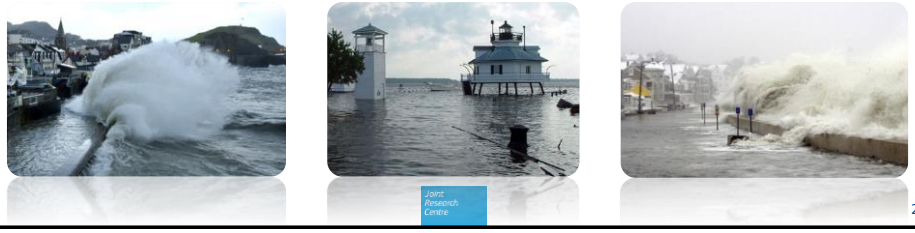
European Commission, Joint Research Centre, Ispra, Italy

Disaster Risk Management Unit

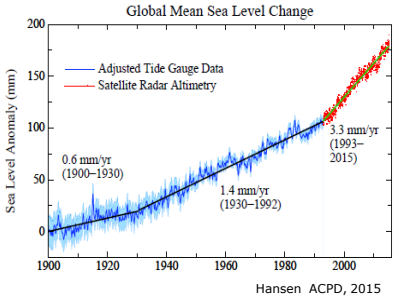
Directorate E, Joint Research Centre, EC

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, Tomas Montblanc, Georgia Kakoulaki, Francesco Dottori, Luc Feyen

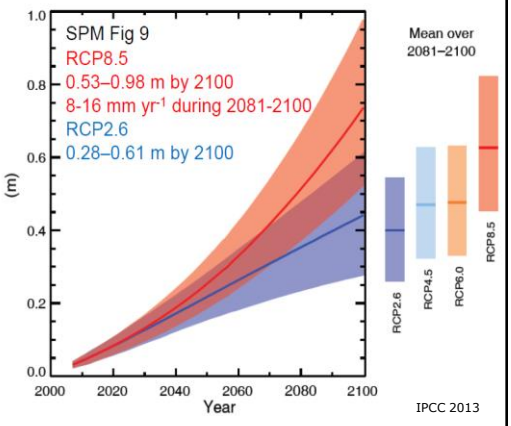


Sea level rise



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

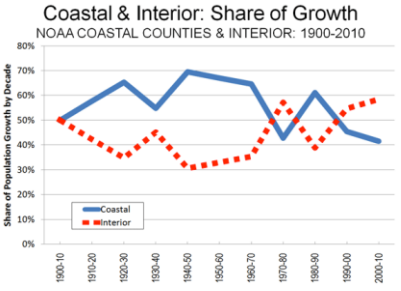


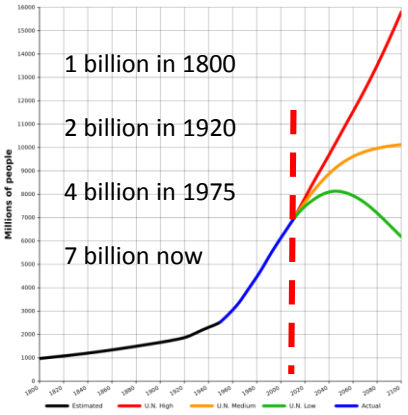
IPCC 2013

Are SLR, erosion and flooding the problems?

http://www.greekhotel.com/

Population growth





UN 2010

Joint Research Centre

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
- Population in St Lucia is increasing by 1-2%

EUROSTAT 2013

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 $

Tomas 2010 killed 14, 500 m $ in St Lucia

Vulnerability of ports and coastal infrastructure

Scott et al., 2016

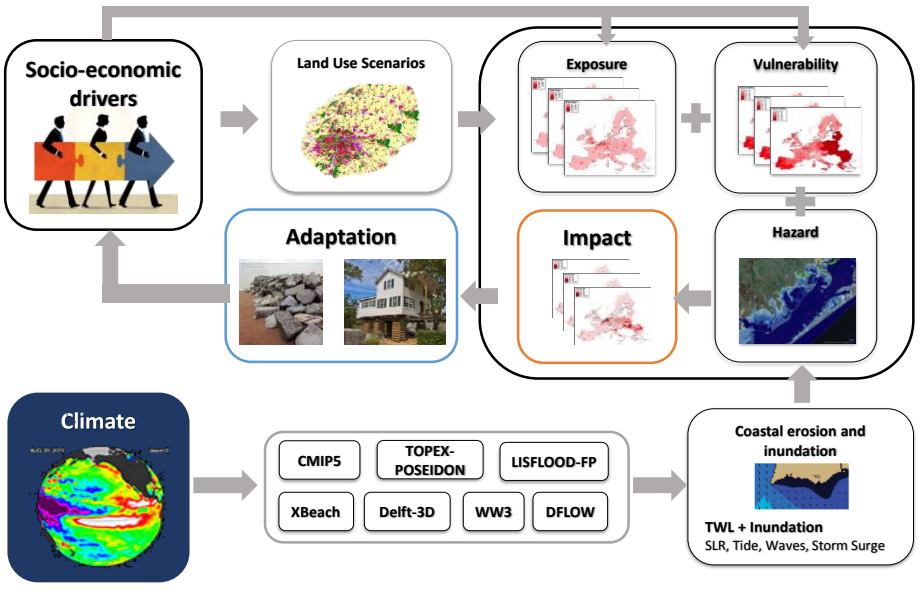
Higher water levels
Vulnerability from sea and land
Sedimentation/dredging
Seiching

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

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

The LISCoAsT approach

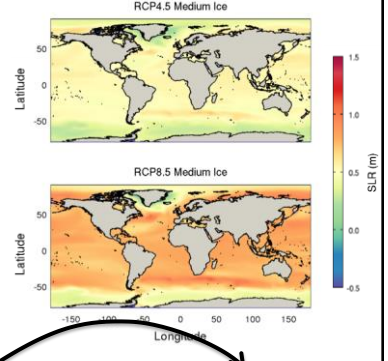


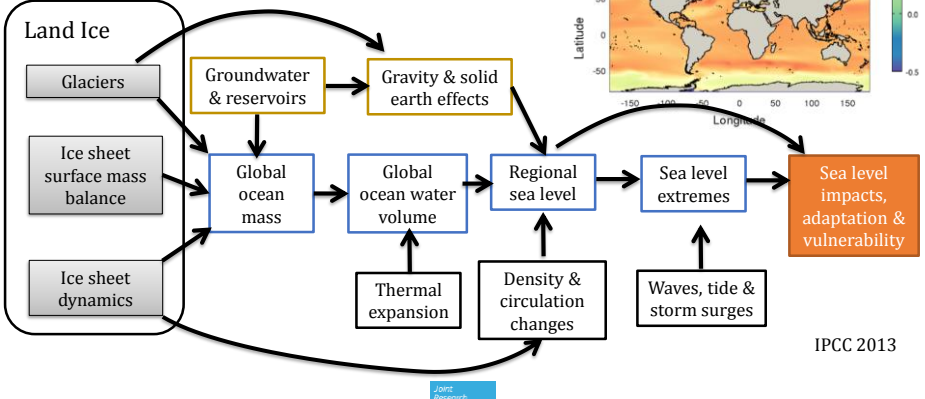


The LISCoAsT approach

HAZARD PROJECTIONS

Sea Level Rise and beyond



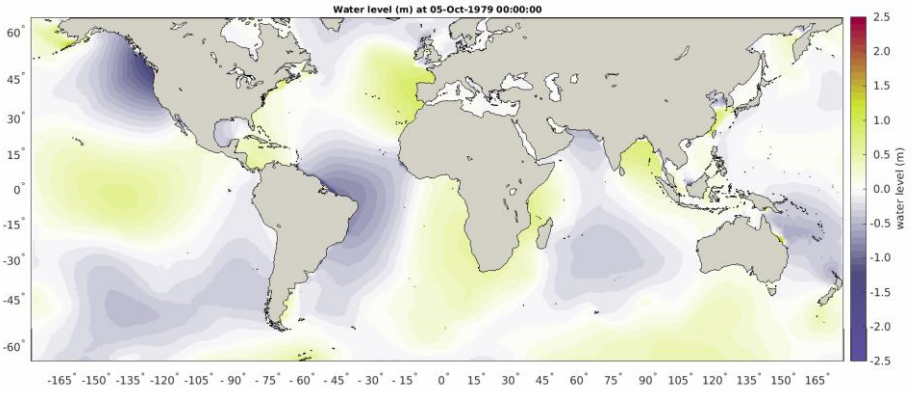


IPCC 2013

Sea level extremes: Global Storm Surge Model

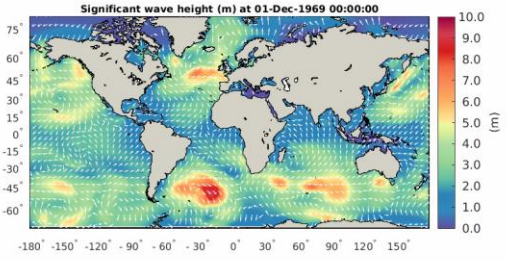
Model used: DFLOW
Simulated tidal, wind and pressure driven ocean circulation

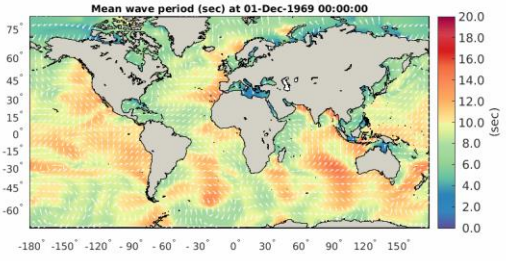
Flexible mesh
Nearshore resolution 0.11° x 0.05°
Offshore resolution 0.94° x 0.42°



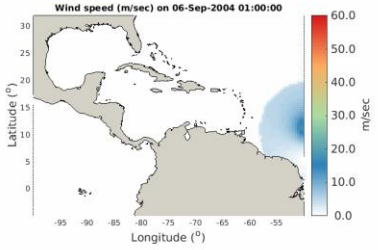
Sea level extremes: Global wave model

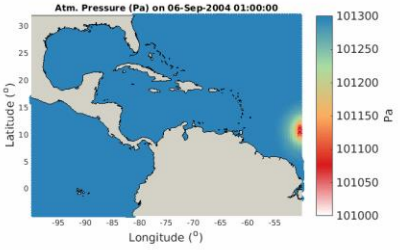
Model used: WaveWatch3 v4.18
Generates waves from wind fields
Resolves all wave directions and frequencies
Considers several parameters including temperature, ice concentration

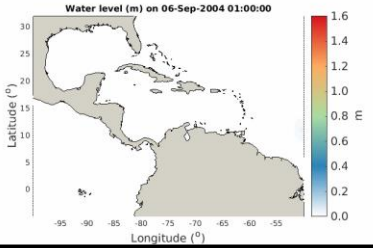




Sea level extremes: Tropical cyclones







AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2016GL072488

Key Points:
- Extreme waves will change along a large portion of the coasts generally increasing in the S. Hemisphere and decreasing in the N. Hemisphere
- The projected changes of extreme waves can be explained with a projected intensification of climatic patterns such as AAO, ENSO, and NAO

Supporting Information:
- Supporting Information S1

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lorenzo.mentaschi@ec.europa.eu

Citation:
Mentaschi, L., M. I. Vousdoukas, E. Voukouvalas, A. Dosio, and L. Feyen

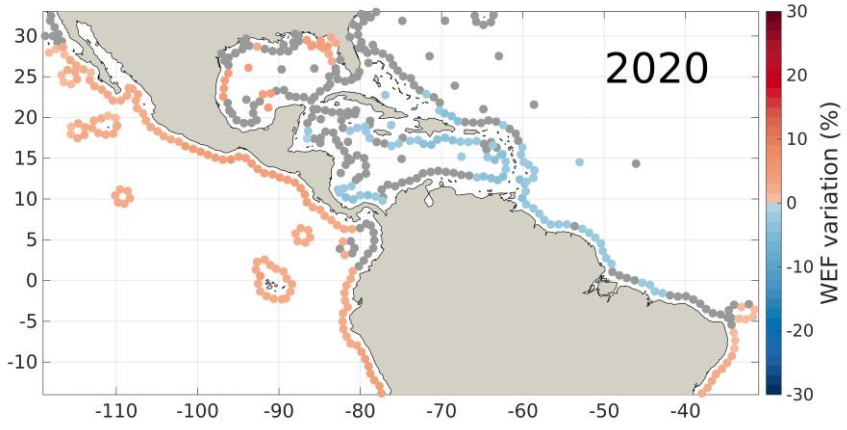
Global changes of extreme coastal wave energy fluxes triggered by intensified teleconnection patterns

Lorenzo Mentaschi[1], Michalis I. Vousdoukas[1,2], Evangelos Voukouvalas[1], Alessandro Dosio[1], and Luc Feyen[1]

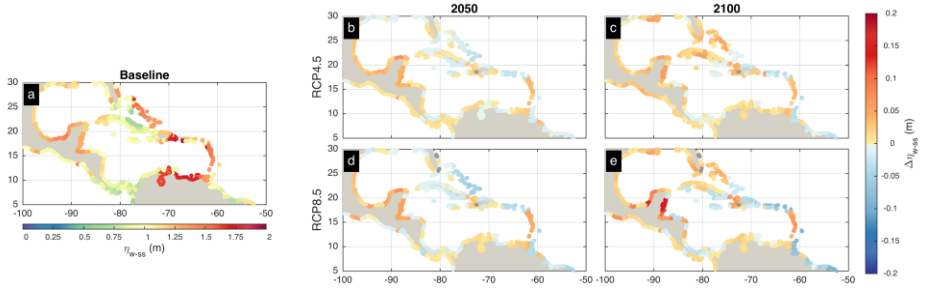
[1]Joint Research Centre, European Commission, Ispra, Italy, [2]Department of Marine Sciences, University of the Aegean, Mitilene, Greece

Abstract In this study we conducted a comprehensive modeling analysis to identify global trends in extreme wave energy flux (WEF) along coastlines in the 21st century under a high emission pathway (Representative Concentration Pathways 8.5). For the end of the century, results show a significant increase up to 30% in 100 year return level WEF for the majority of the coastal areas of the southern temperate zone, while in the Northern Hemisphere large coastal areas are characterized by a significant negative trend. We show that the most significant long-term trends of extreme WEF can be explained by intensification of teleconnection patterns such as the Antarctic Oscillation, El Niño–Southern Oscillation, and North Atlantic Oscillation. The projected changes will have broad implications for ocean engineering applications and disaster risk management. Especially low-lying coastal countries in the Southern Hemisphere will be particularly vulnerable due to the combined effects of projected relative sea level rise and more extreme wave activities.

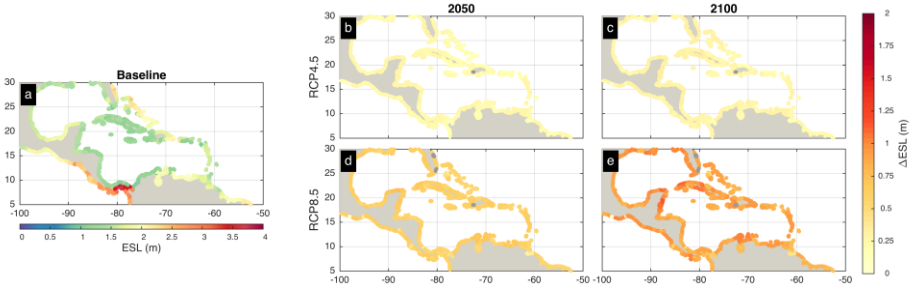
Caribbean TWL projections: Waves



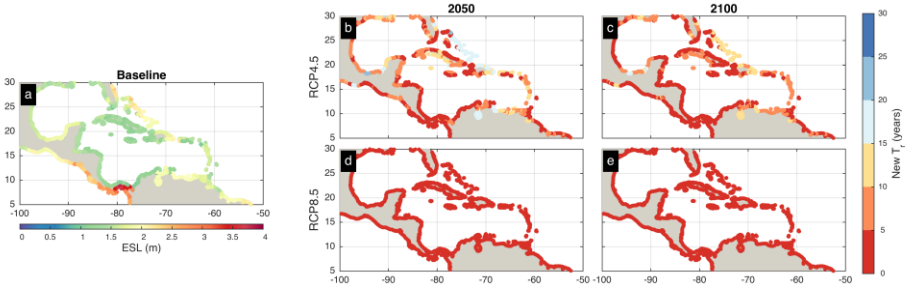
Caribbean TWL projections: Waves and storm surge



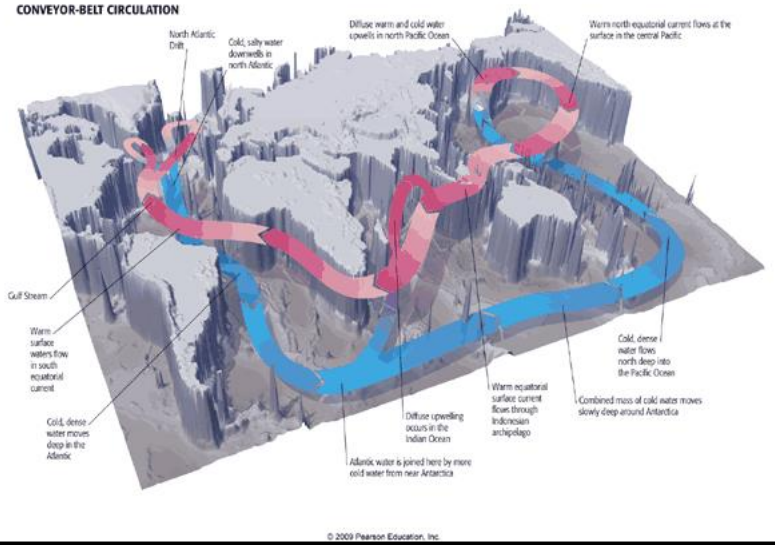
Caribbean TWL projections: All components



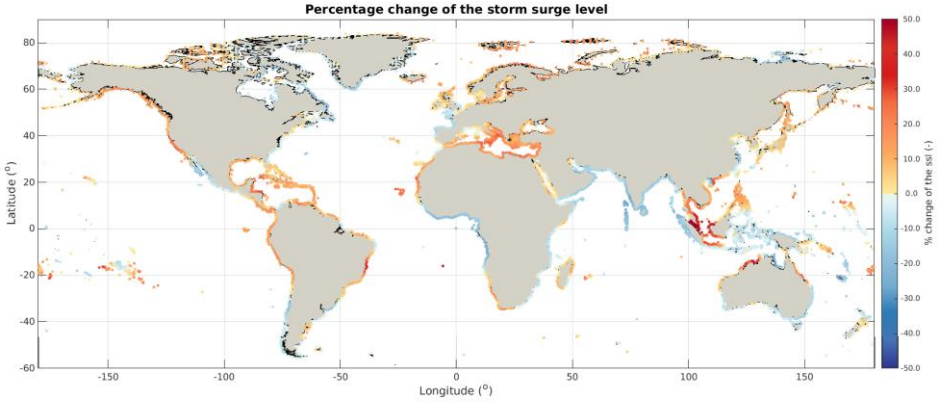
Caribbean TWL projections: Changes in frequency



Climate tipping points: Thermohaline circulation



Climate tipping points: Thermohaline circulation

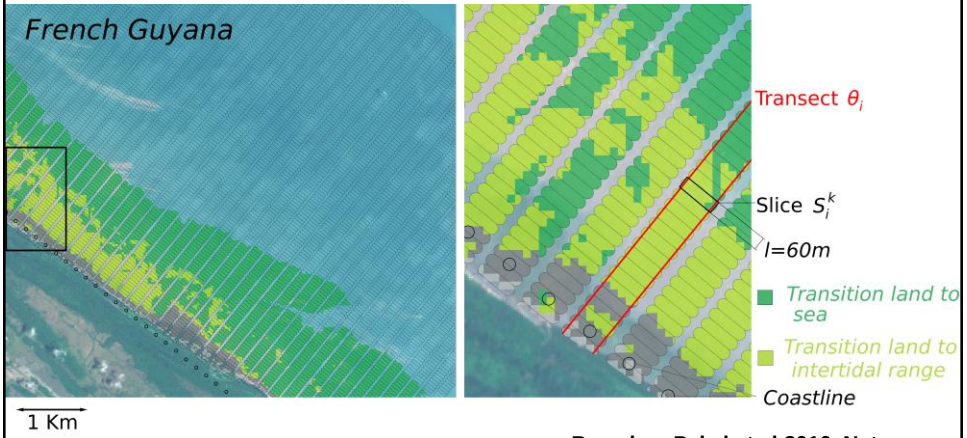


https://global-surface-water.appspot.com

Current Global Erosion Trends

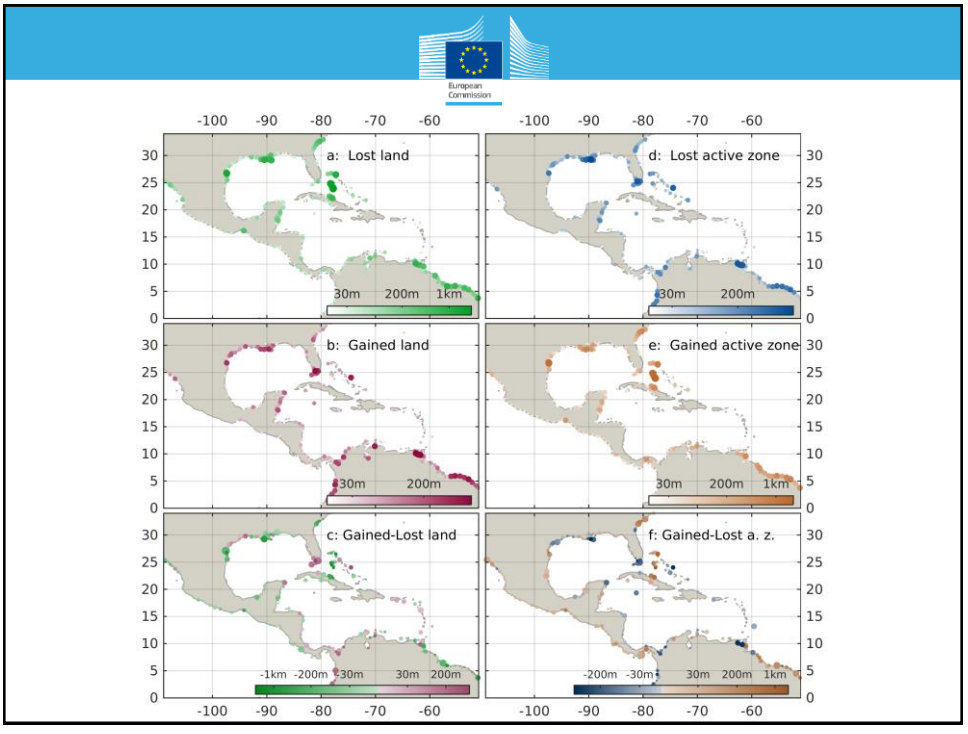
Joint Research Centre

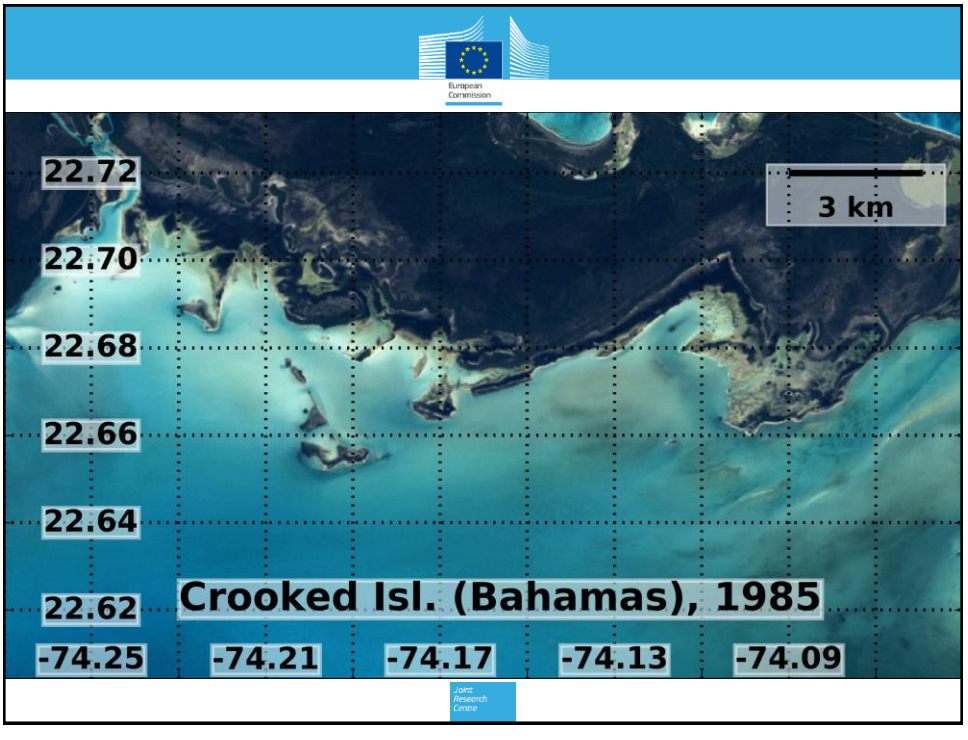
Long-term shoreline dynamics



Based on Pekel et al 2016, Nature
3000000 Landsat satellite images
Past 32 years
30 m resolutionc

Joint Research Centre


European Commission
a: Lost land
b: Gained land
c: Gained-Lost land
d: Lost active zone
e: Gained active zone
f: Gained-Lost a. z.
30m 200m 1km
-1km -200m -30m 30m 200m
-200m -30m 30m 200m 1km
-100 -90 -80 -70 -60
0 5 10 15 20 25 30


European Commission
22.72
22.70
22.68
22.66
22.64
22.62
3 km
Crooked Isl. (Bahamas), 1985
-74.25 -74.21 -74.17 -74.13 -74.09
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doi:10.5194/nhess-2016-124

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Research article

11 Apr 2016

Developments in large-scale coastal flood hazard mapping

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.

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

Received: 04 Apr 2016 – Accepted: 08 Apr 2016 – Published: 11 Apr 2016

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

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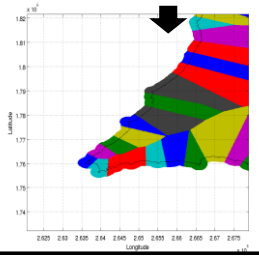
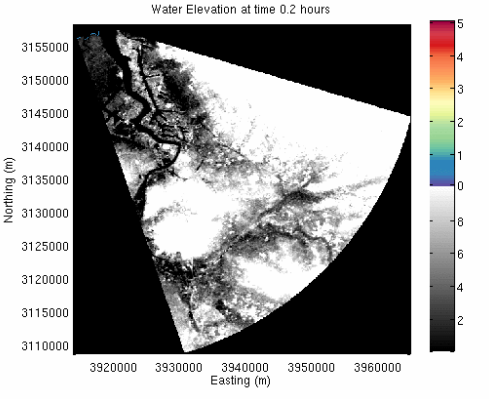
Coastal Inundation on EU scale

- 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

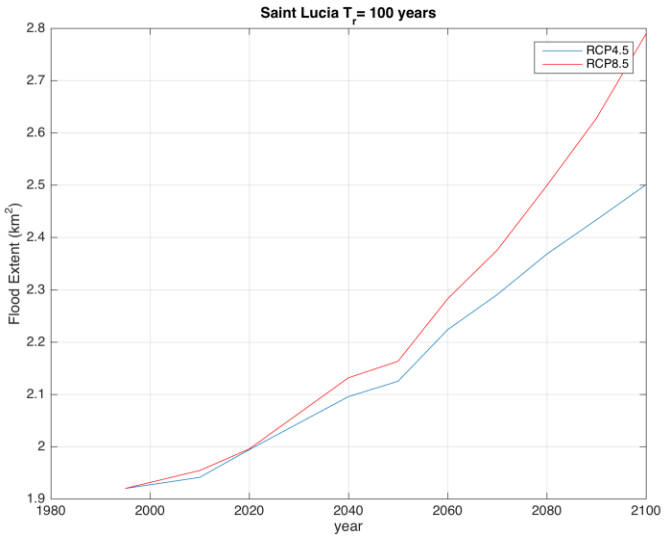




$$\eta_{TWL} = \eta_{MSL} + RSLR + \eta_{tide} + \eta_{stormsurge} + \eta_{wave}$$

Joint Research Centre

Flood extent projections for St Lucia



Closing Remarks

SUMMARY AND WORK IN PROGRESS:

METHODOLOGICAL GAPS, IDEAS, CRITICAL QUESTIONS

What we have…

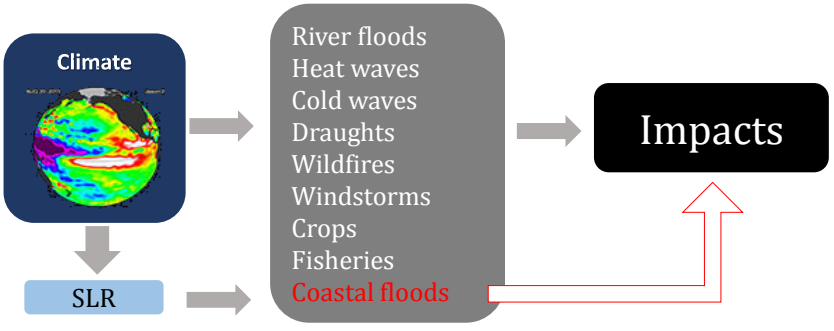
State of the art projections of extreme TWLs

A set of calibrated models for all hazard components

What is on the way…

Impact assessment, SSPs, Adaptation…

What is really at stake?



What is really at stake?

- The ocean absorbs >90% of the increase in energy
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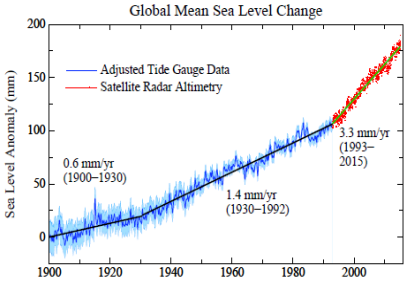
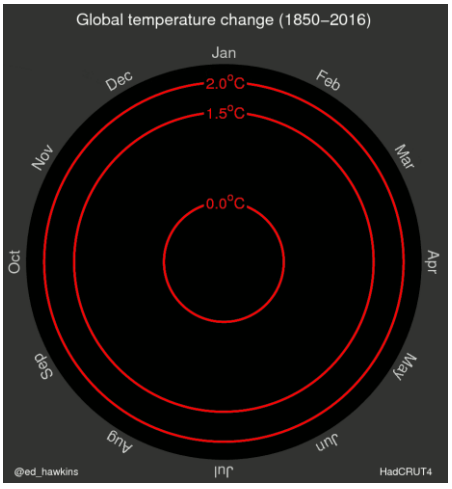
- Expansion of sea water per °C of warming is greater at higher temperature and higher pressure





Hawkins, MetOffice, 2016

What is really at stake?

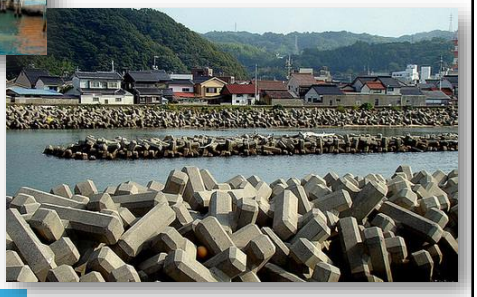
- Projections indicate an order of magnitude increase of direct impacts by the end of the century
- Without considering tipping points
- Without considering indirect impacts
  - Business interruption
  - Ecology
  - Sector interactions
  - Criticality of transport hubs
  - Etc….

Intangible/indirect impacts

www.wikipedia.org

Intangible/indirect impacts

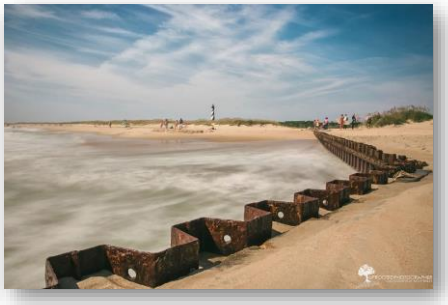
www.miriadna.com



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