UNIVERSITÀ DEGLI STUDI DI TRIESTE

dipartimento di matematica e geoscienze

Coastal Group

Sea level rise: willing to accept a new coastal landscape?

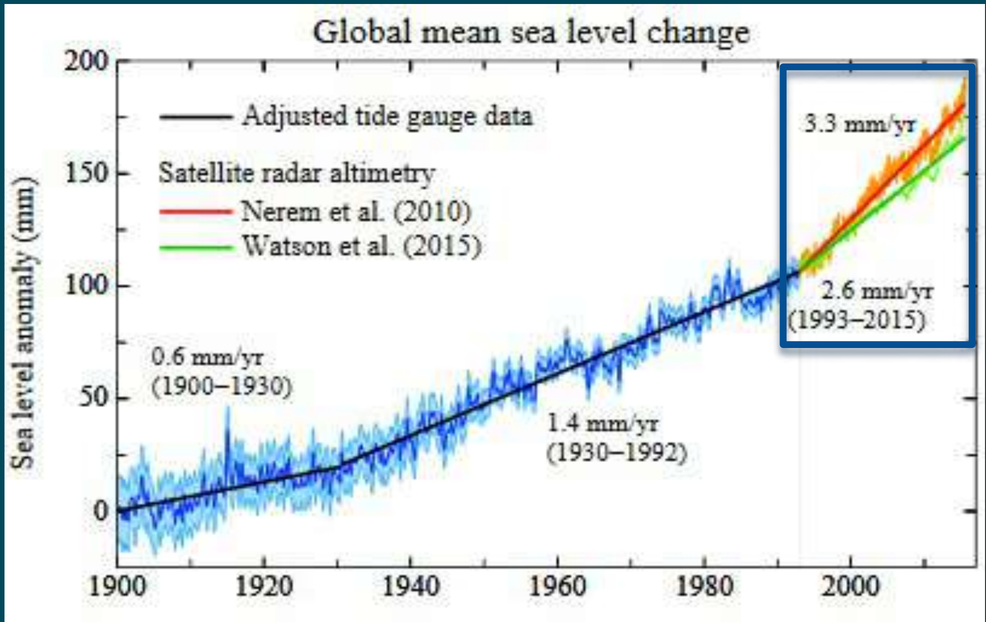
Giorgio Fontolan

Adapt your future. Let's talk about climate change

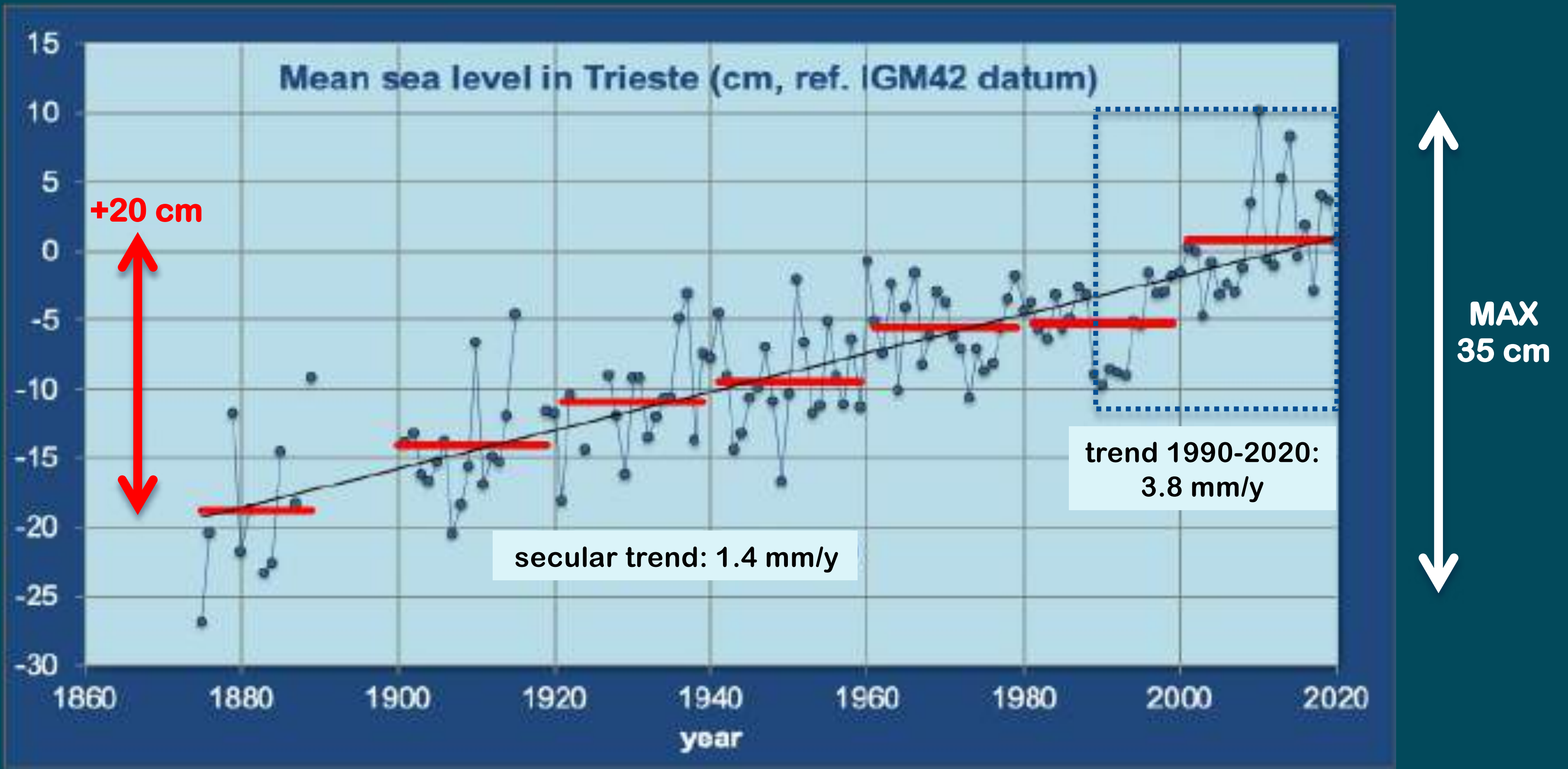
Trieste – 4 October 2022

Erasmus+

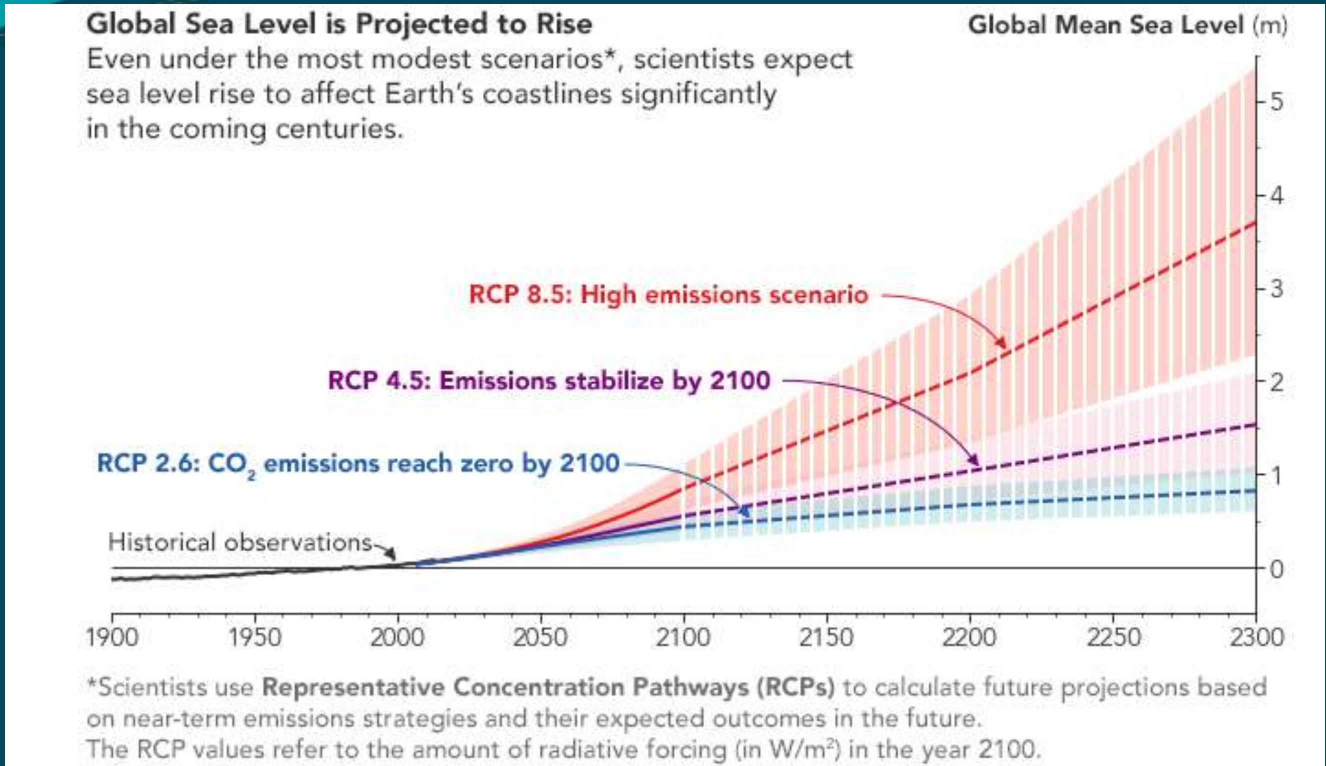
SEA LEVEL – the global signal

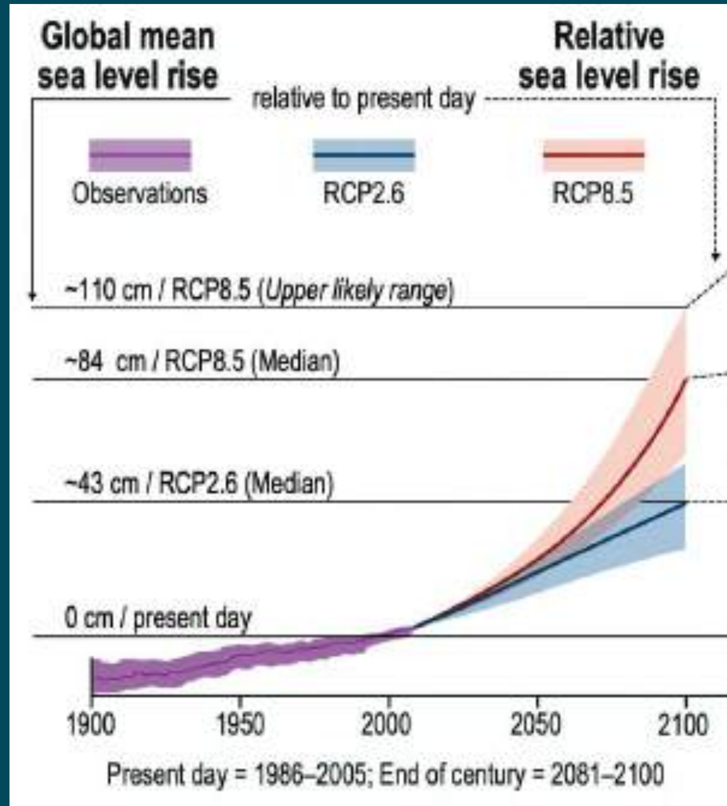


SEA LEVEL – the local signal



SEA LEVEL – the projections



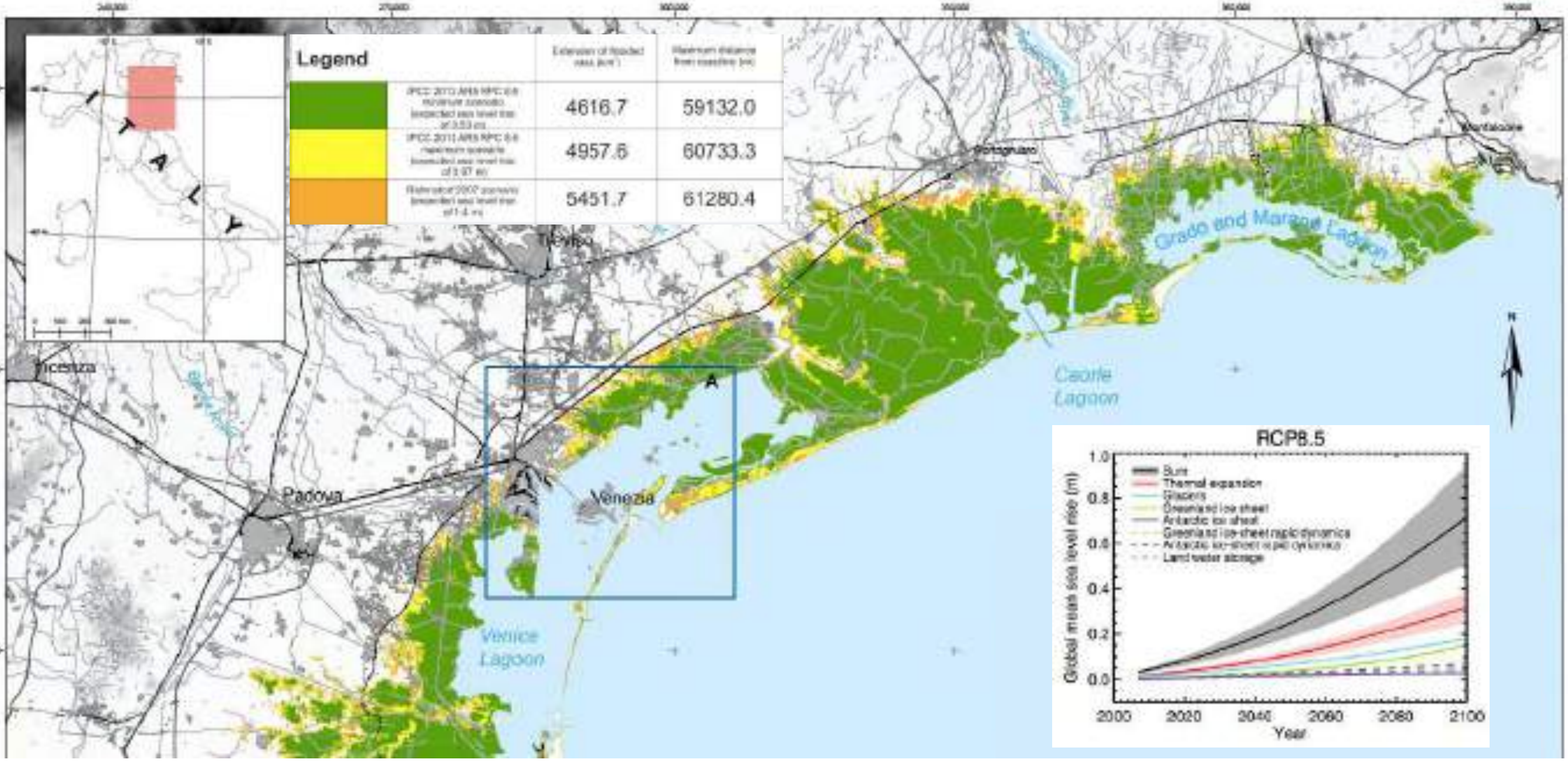


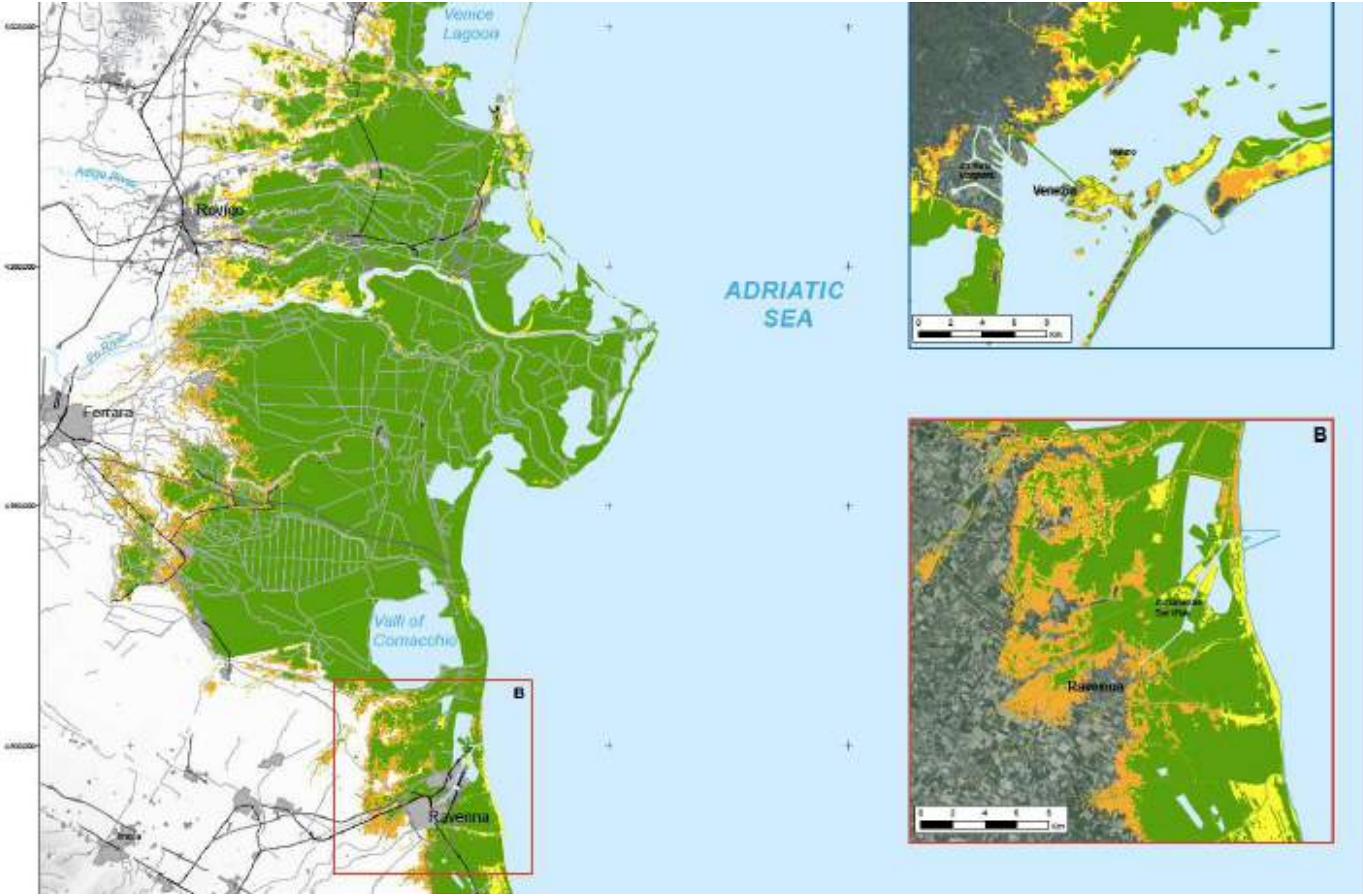
https://www.ipcc.ch/site/assets/uploads/sites/3/2019/12/SROCC_FullReport_FINAL.pdf

FLOODING SCENARIO AT FOUR ITALIAN COASTAL PLAINS USING THREE RELATIVE SEA LEVEL RISE MODELS: THE NORTH ADRIATIC AREA

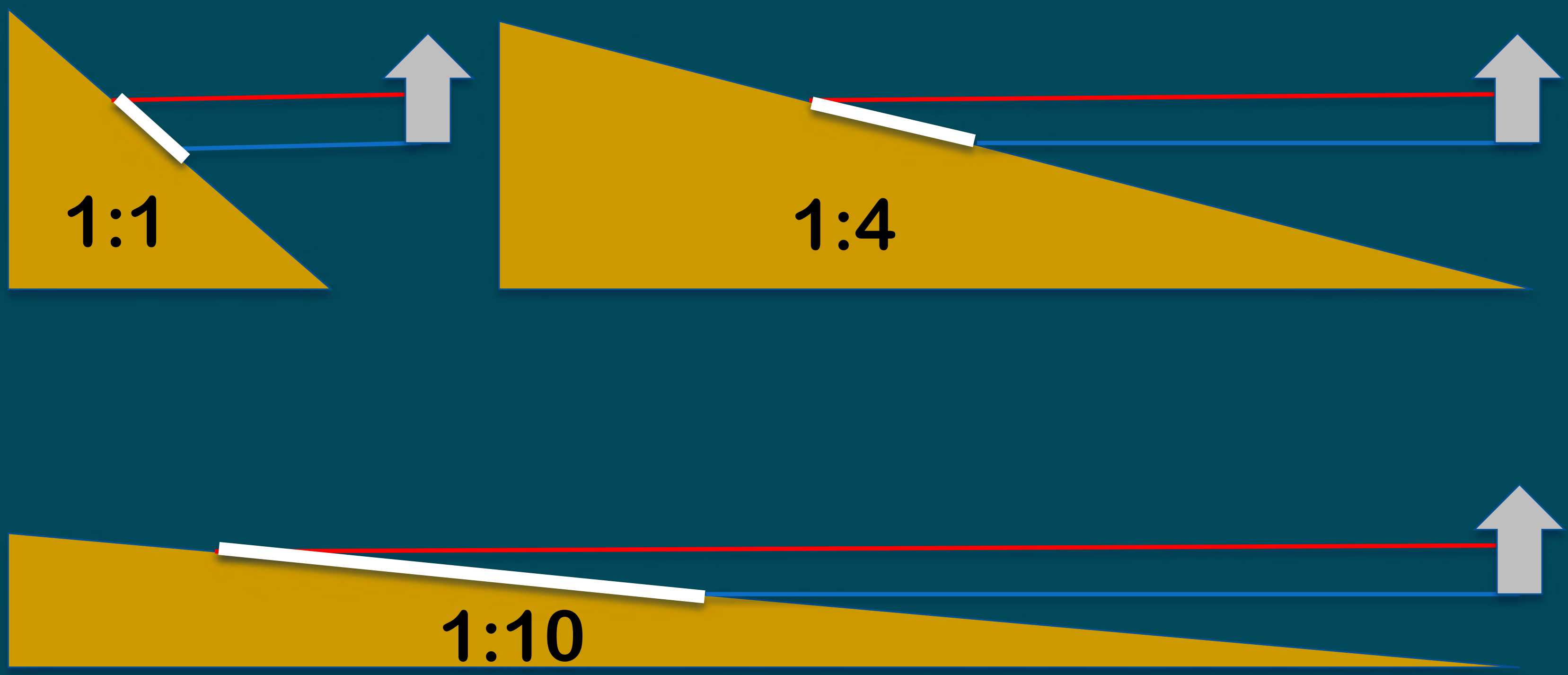
A. Marsico[1], S. Lisco[1], V. Lo Presti[2], F. Antonioli[2], A. Amorosi[3], M. Anzidei[4], G. Deiana[5], G. De Falco[6], A. Fontana[7], G. Fontolan[8], M. Moretti[1], P. Orru[5], G. Sannino[2], E. Serpelloni[4], A. Vecchio[9], G. Mastronuzzi[1]

[1]Dipartimento di Scienze della Terra e Geoambientali, University "Aldo Moro", CONISMA Italy; [2]ENEA, SSPT, Roma, Italy;
[3]Dipartimento di Scienze Biologiche, Geologiche e Ambientali, University of Bologna, Italy; [4]Istituto Nazionale di Geofisica e Vulcanologia, Italy;
[5]Dipartimento di Scienze Chimiche e Geologiche, University of Cagliari, CONISMA Italy; [6]CNR Oristano; [7]Dipartimento di Geoscienze, University of Padova, CONISMA Italy;
[8]Dipartimento di Matematica e Geoscienze, University of Trieste, CONISMA Italy; [9]Lesia Observatoire de Paris, Section de Meudon 5, France

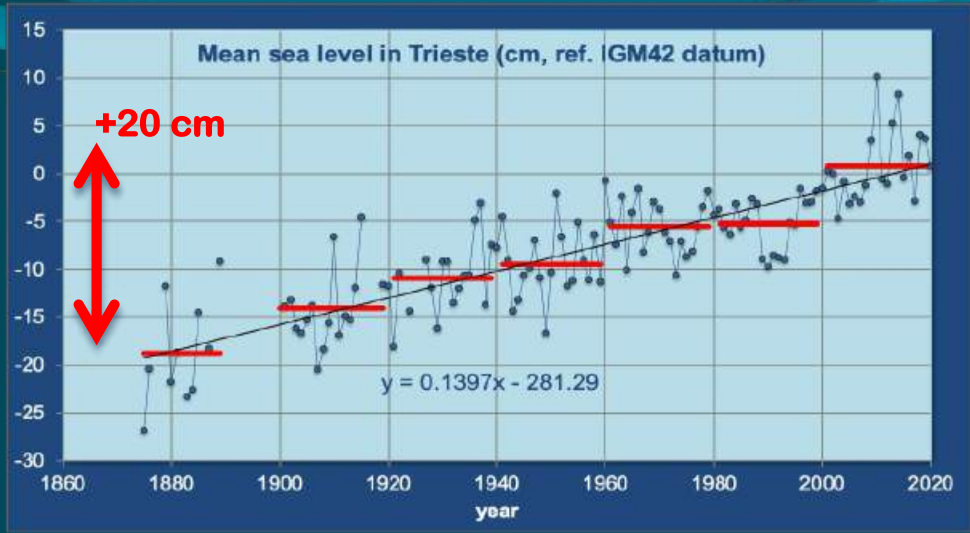



Venice
Lagoon
Adige River
Rovigo
Po River
Ferrara
ADRIATIC
SEA
Valli of
Comacchio
B
Ravenna
Venezia
B
Ravenna

It's a matter of geometry ....



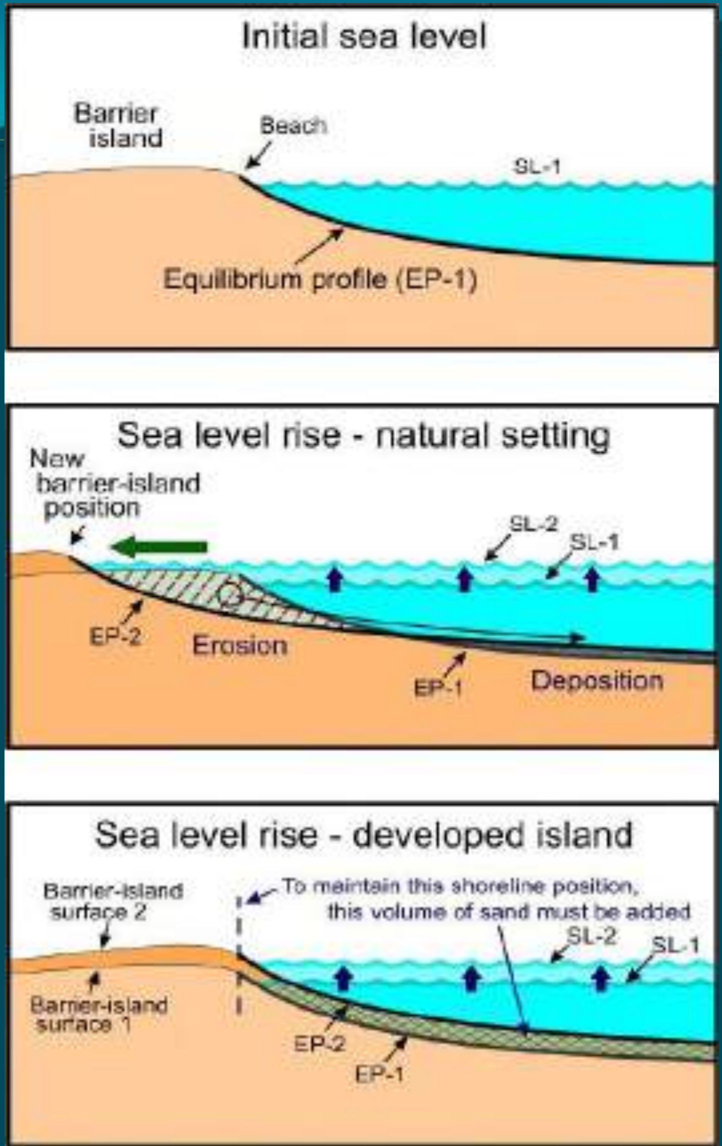
How much can a beach retreat if the sea level rises by 20 cm ?



1:10 → retreat: 2 m

1:100 → retreat: 20 m

1:1000 → retreat: 200 m

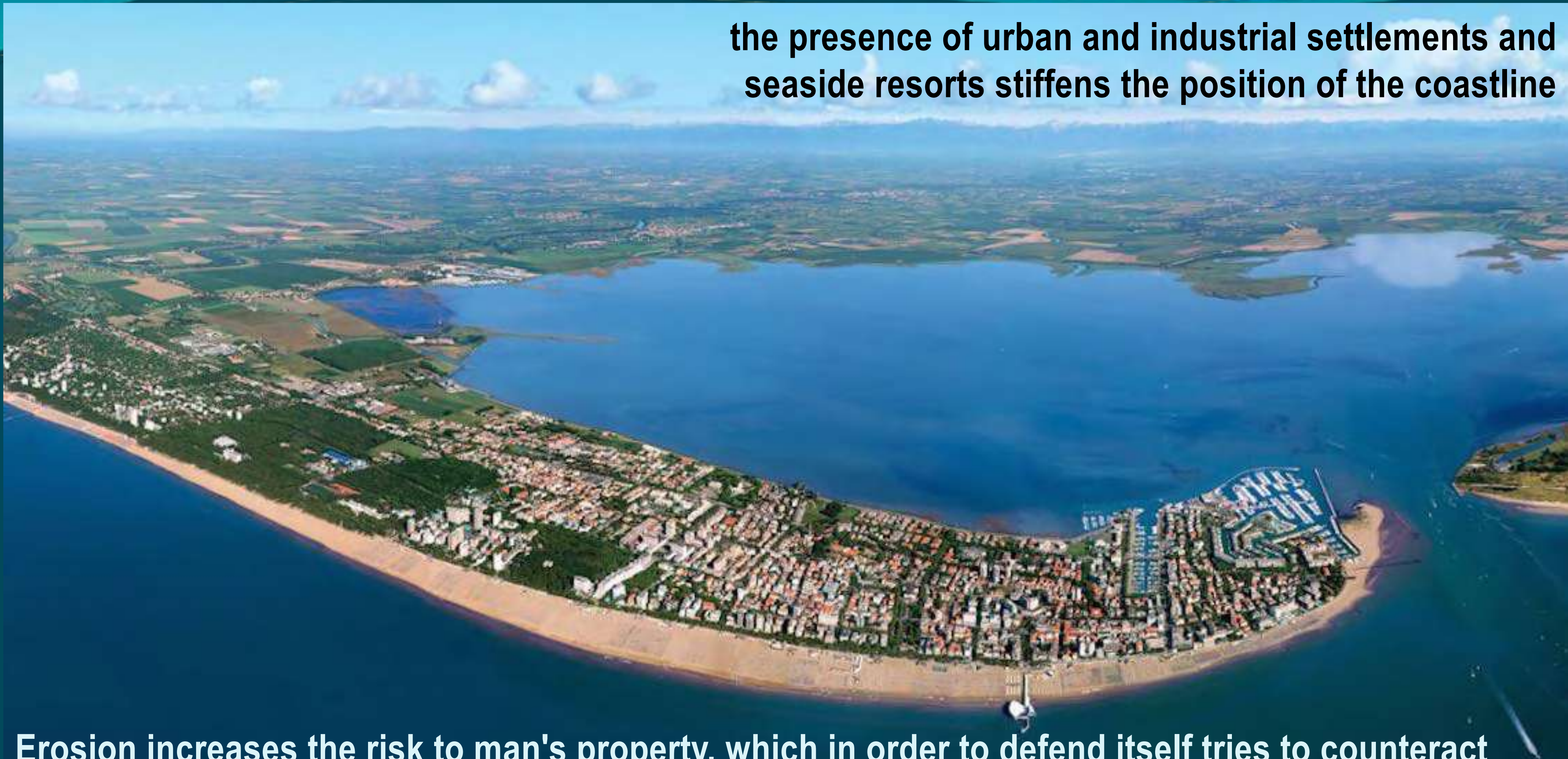


In a natural system:

the retreat of the coastline leads to the translation of morphologies; the new forms achieve equilibrium without creating imbalances of any kind

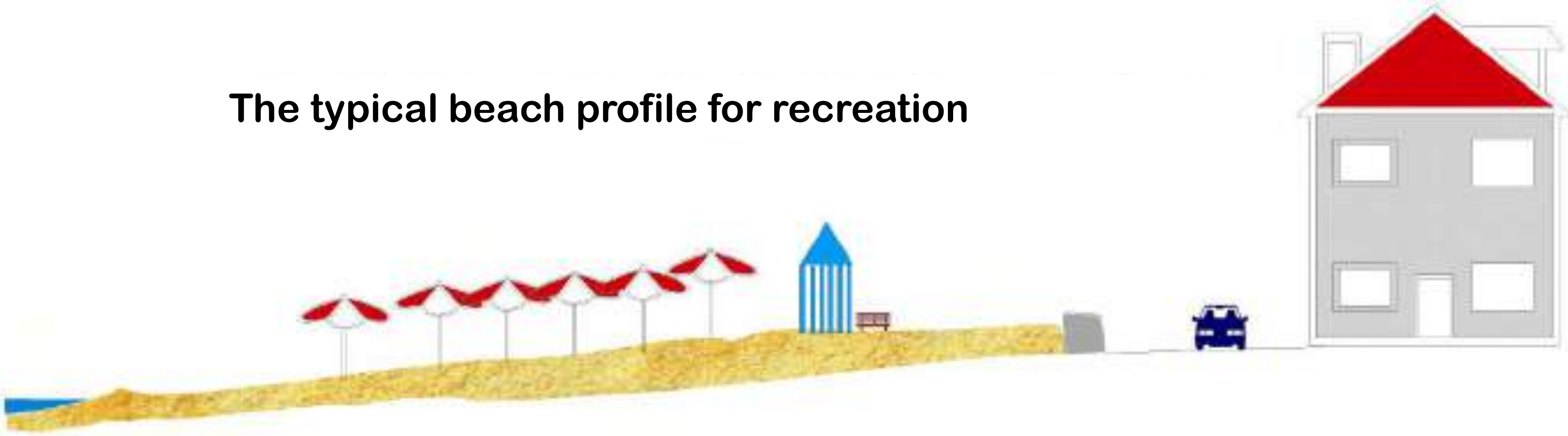
In a man-made system

the presence of urban and industrial settlements and seaside resorts stiffens the position of the coastline

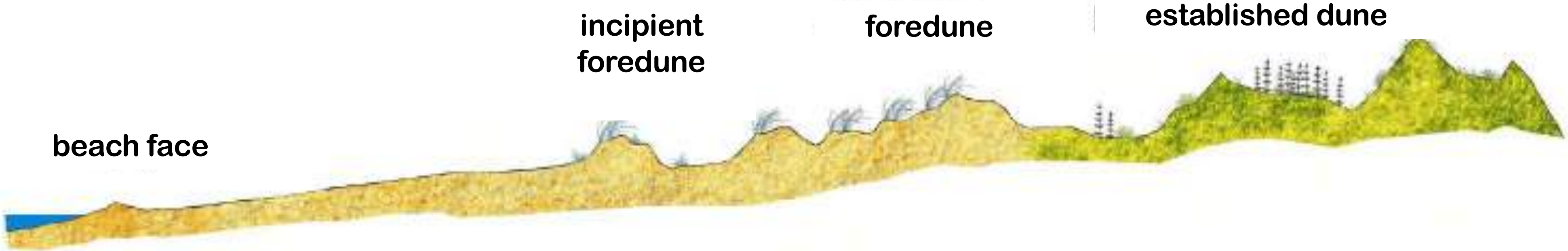


Erosion increases the risk to man's property, which in order to defend itself tries to counteract natural dynamics

The typical beach profile for recreation



The natural beach profile




Rimini

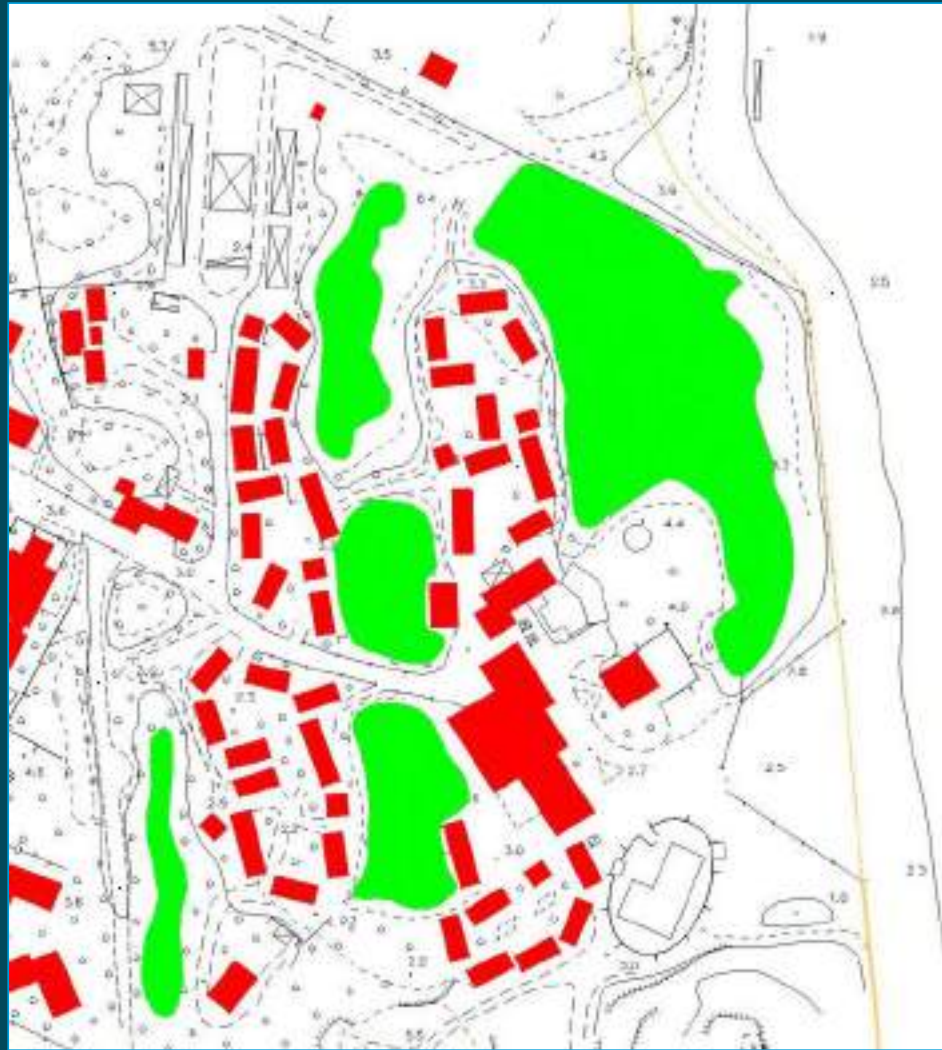

…. A general problem
Miami Beach, USA


Gold Coast, Australia


Land-sea: a rigid boundary for man
Bibione

There are few cases where intact dune and beach systems survive.
In Eraclea Mare (Veneto), for example, the dunes are 'fixed' by the rigidity of the coastal defences

In some cases the dunes have been incorporated into the urban system or within resorts and beach villages...



..... sometimes even running into problems

On a global scale, there is a generalised coastal erosion trend, linked to both natural and man-made causes

Natural

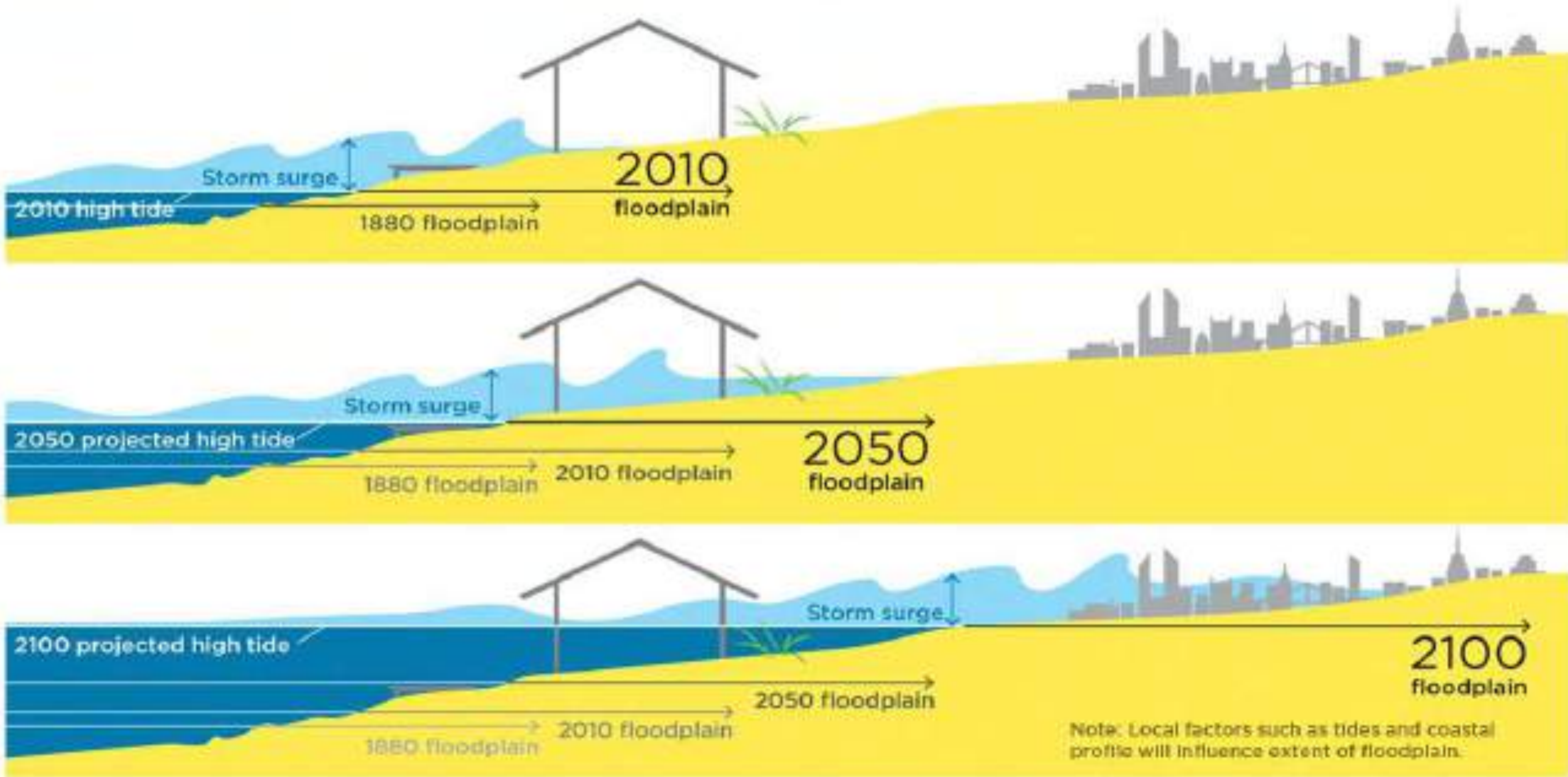
- ✓ sea level rise (*increased by man*)
- ✓ subsidence *(natural sinking due to lithostatic load)*
- ✓ sea storms, river flooding

Anthropic

- ✓ urbanization, hard engineering defences
- ✓ reduction of river sediment supply (river embakments, dams, mining, irrigation derivations)
- ✓ subsidence (due to fluid and gas extractions)
- ✓ smoothing, sand extraction, excavations

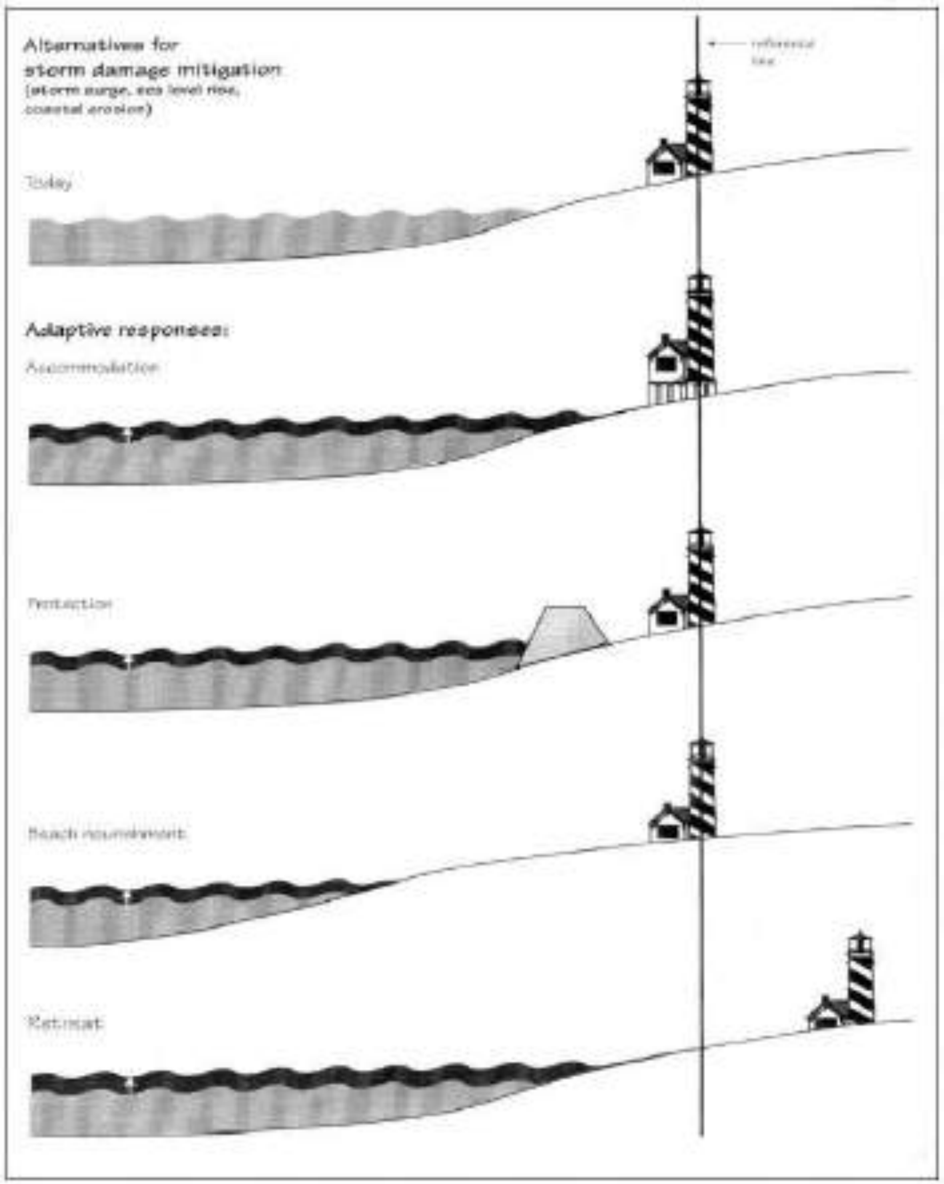
Sea storms in an increasing sea level

FIGURE 3. Storm Surge and High Tides Magnify the Risks of Local Sea Level Rise



Sea level sets a baseline for storm surge—the potentially destructive rise in sea height that occurs during a coastal storm. As local sea level rises, so does that baseline, allowing coastal storm surges to penetrate farther inland. With higher global sea levels in 2050 and 2100, areas much farther inland would be at risk of being flooded. The extent of local flooding also depends on factors like tides, natural and artificial barriers, and the contours of coastal land.

COASTAL EROSION



Types of response to coastal risk and SLR

Current situation

Accommodation

Adaptative response

Protection

Defence using the hard engineering approach

Beach nourishment

Beach is artificially replenished or newly designed

Retreat

By moving landward the structure/settlement in danger

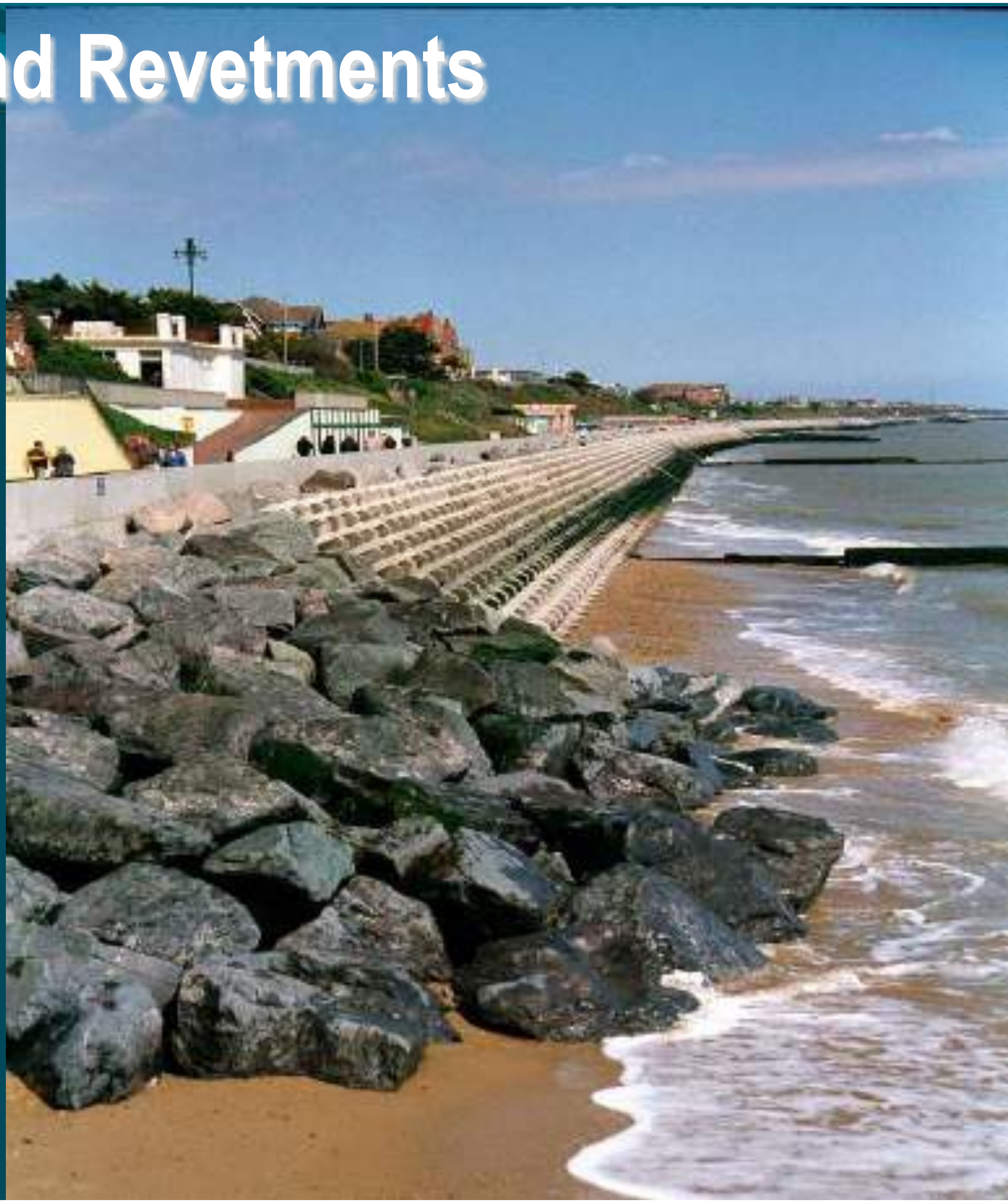
The Brighton Hotel on Coney Island in New York State was set back more than 150 metres in 1888. 120 railway wagon platforms and 6 locomotives were used to move the entire structure weighing 6,000 tonnes. The undertaking took about three months, and not a single pane of glass was broken in the move.

http://www.arrts-arrchives.com/brbchmove.html

Protection: hard engineering

Stepped seawall in Valle Altanea (Caorle)

Gabions and Revetments



Reshaping the shoreline

Malaga (Spain)


Reshaping the shoreline
according to the Emir's dreams

Soft engineering:

beach nourishment

before

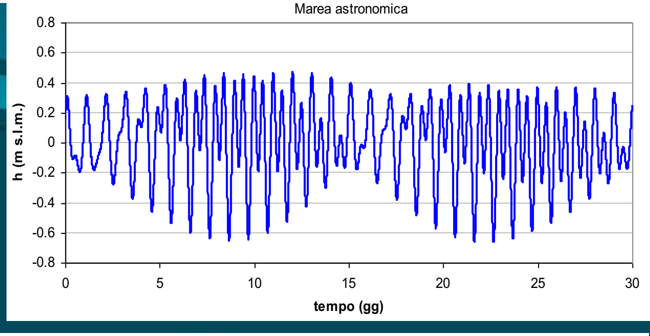
after

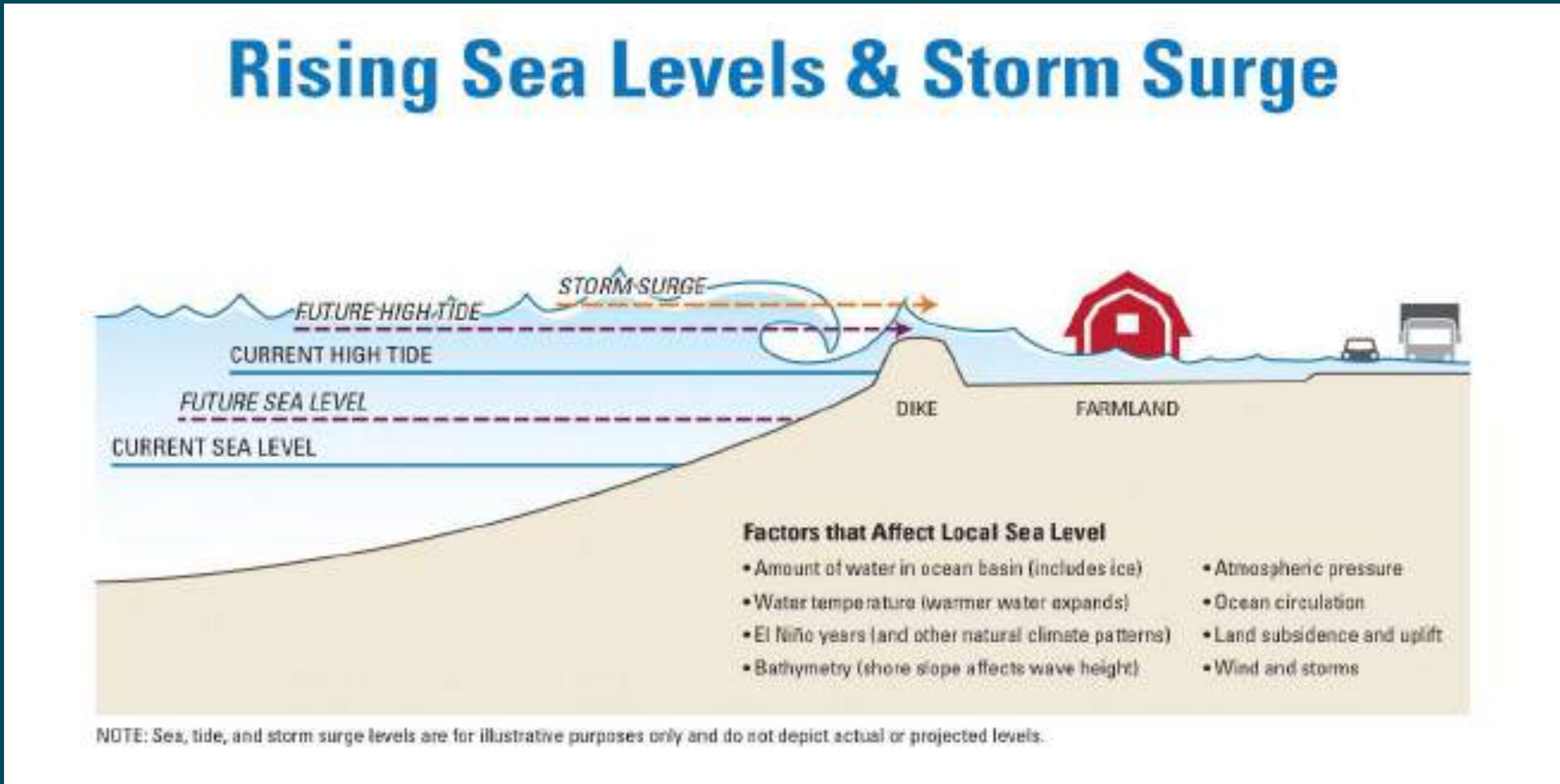

Miami Beach (USA)

Copacabana (Rio de Janeiro)

Pellestrina Island (Venice)

Sea level………… + WHAT ELSE ?





The «acqua alta»

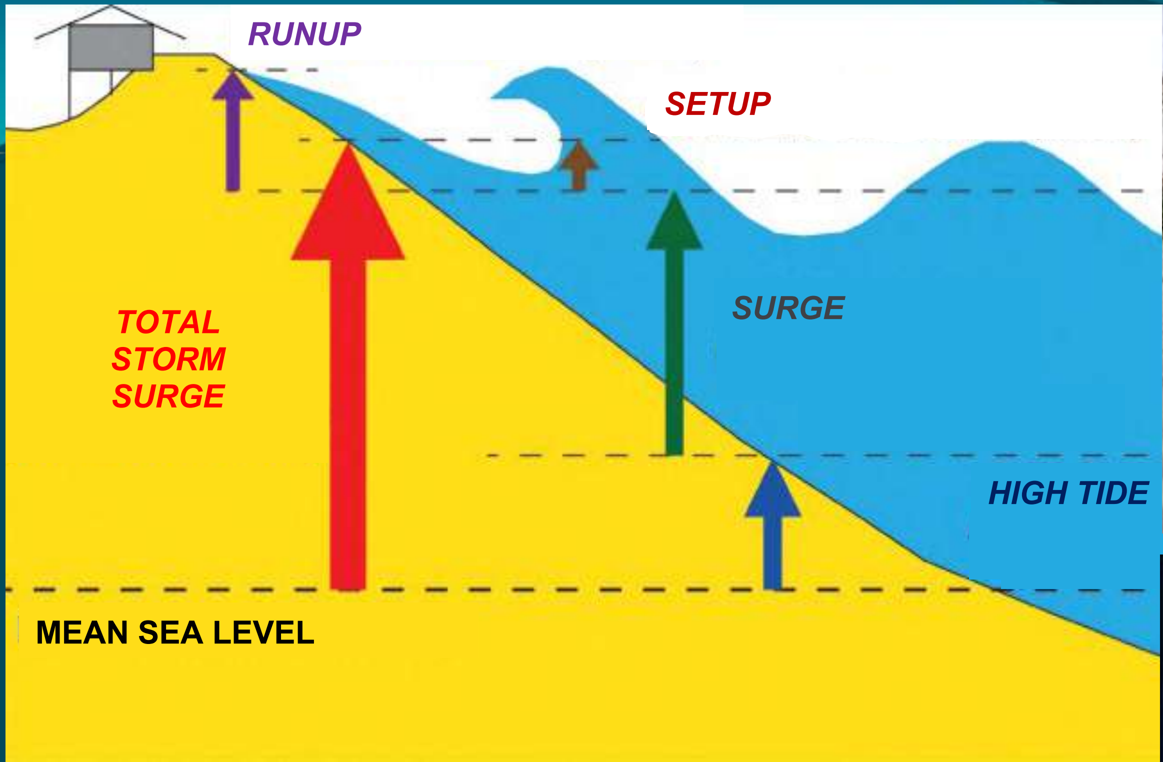
Decennial frequency of tides ≥ 110 cm

Acqua alta in Venice 1.11.2012 (www.mosevenezia.eu)

Exceptional events ≥140 cm

day-month	year	height (cm)
12-nov	1951	151
15-ott	1960	145
04-nov	1966	194
03-nov	1968	144
14-feb	1979	140
22-dic	1979	166
01-feb	1986	159
08-dic	1992	142
06-nov	2000	144
16-nov	2002	147
01-dic	2008	156
23-dic	2009	144
25-dic	2009	145
24-dic	2010	144
01-nov	2012	143
11-nov	2012	149
12-feb	2013	143
29-ott	2018	156
12-nov	2019	187

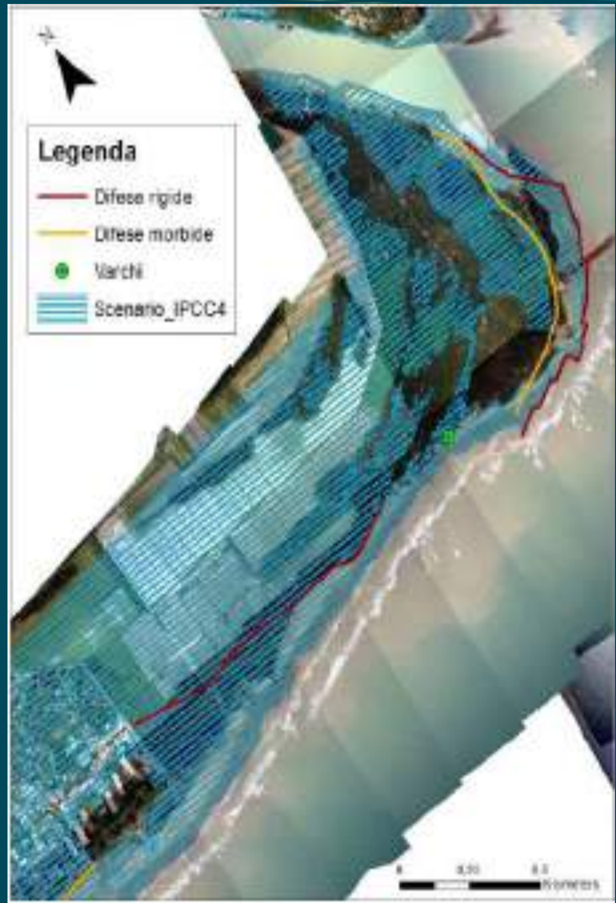
Flooding scenarios in Grado's area: the episodic event (30-year RP = 140 cm) with and without the RSLR projection (**no setup**)



Flooding scenarios in Trieste’s area: the episodic event (30-year RP = 140 cm) without the RSLR projection (**with setup = 40 cm**)

Flooding scenarios: RSLR + surge

Scenario 1 → 0 - 0,57 m
Scenario 2 → 0,57 - 0,99 m
Scenario 3 → 0,99 - 1,41 m

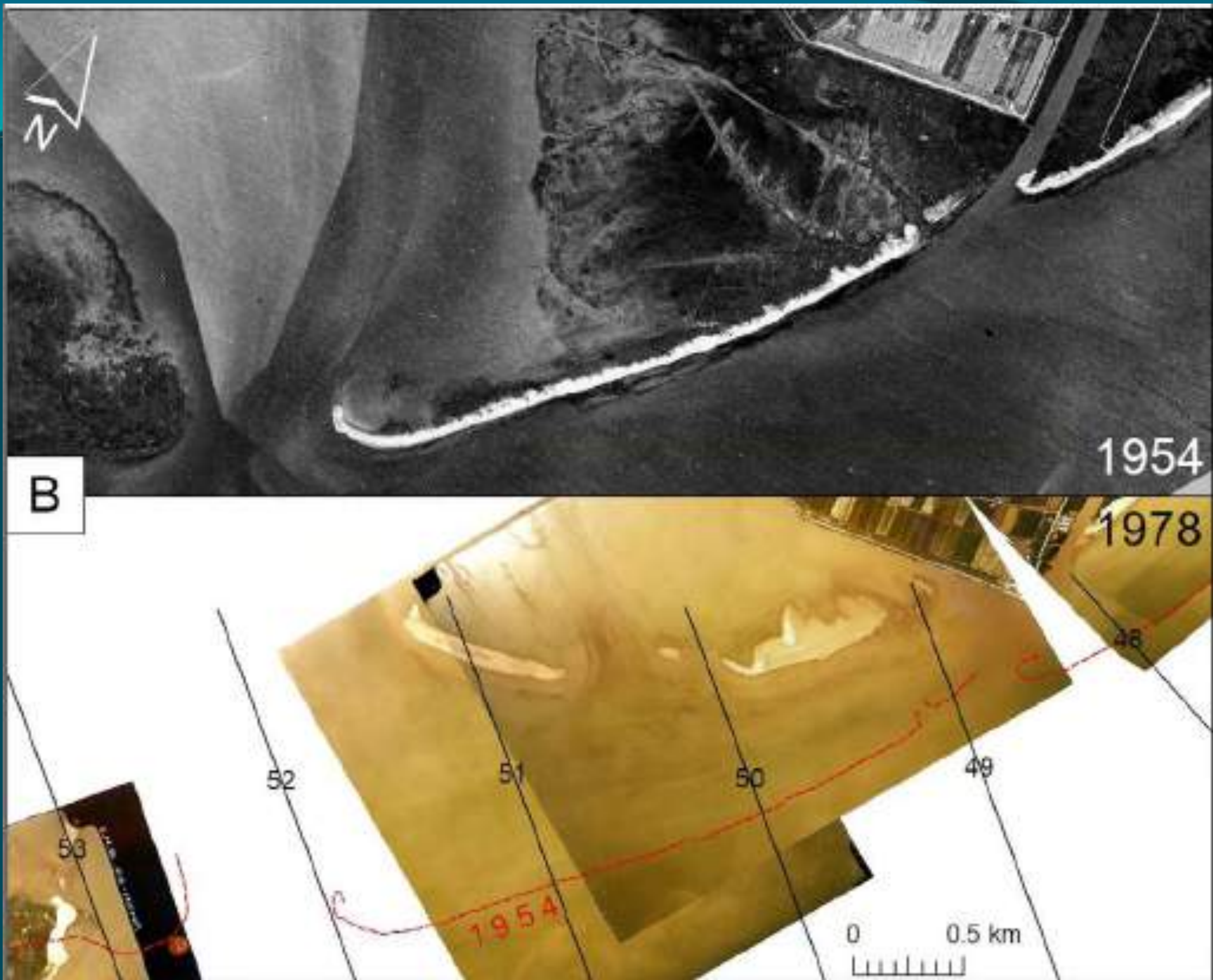


Scenario 4 → 1,41 – 2,00 m

Scenario 5 → 2,00 - 2,50 m


The fragile environments
Deltas and lagoons

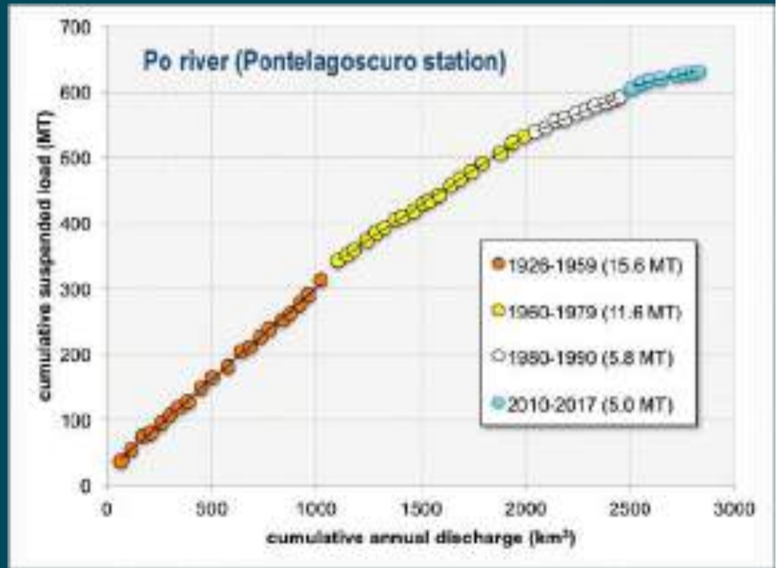

The Tagliamento delta retreat
and dune erosion



The retreat of the Po delta:

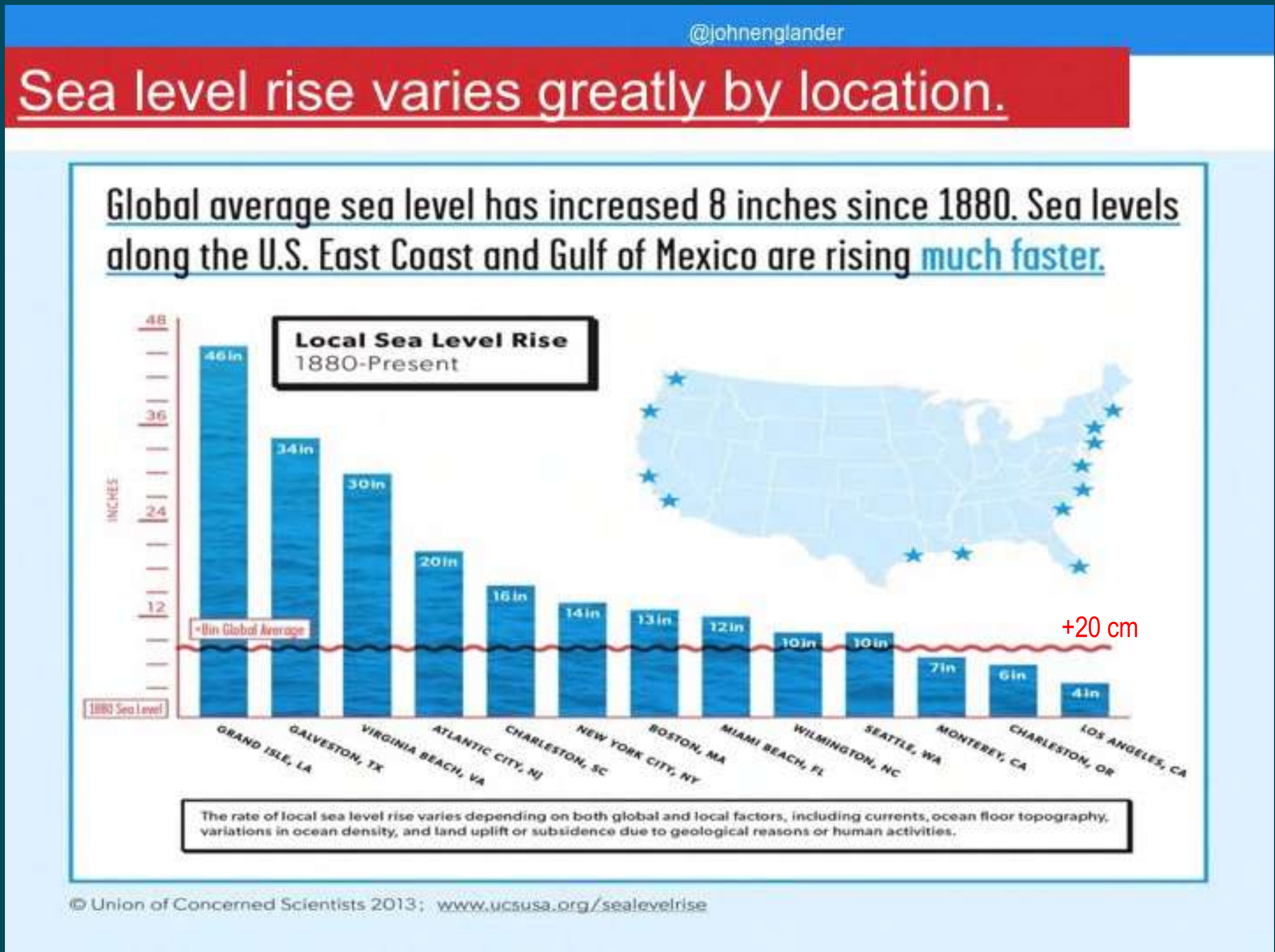
A combination of effects, due to

- sediment supply reduction



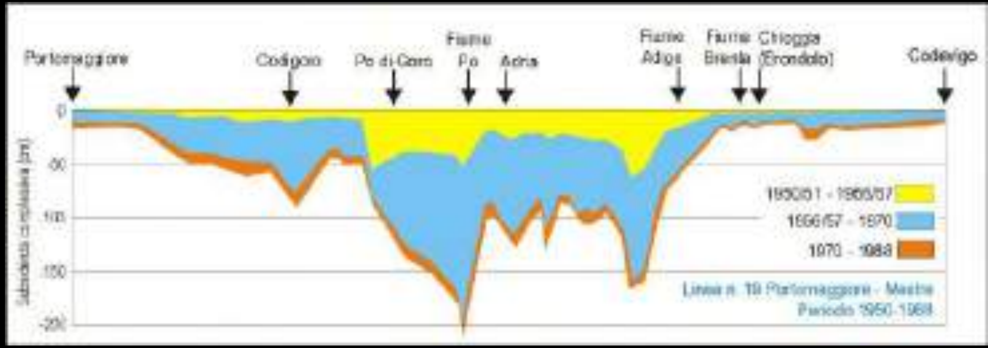
….. and SUBSIDENCE

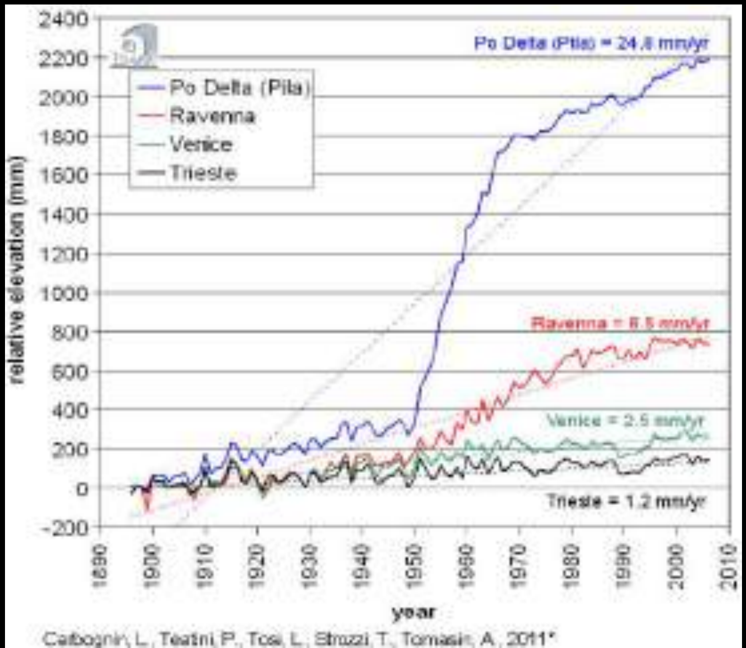
Land slowly sinks … and the sea rises more and more



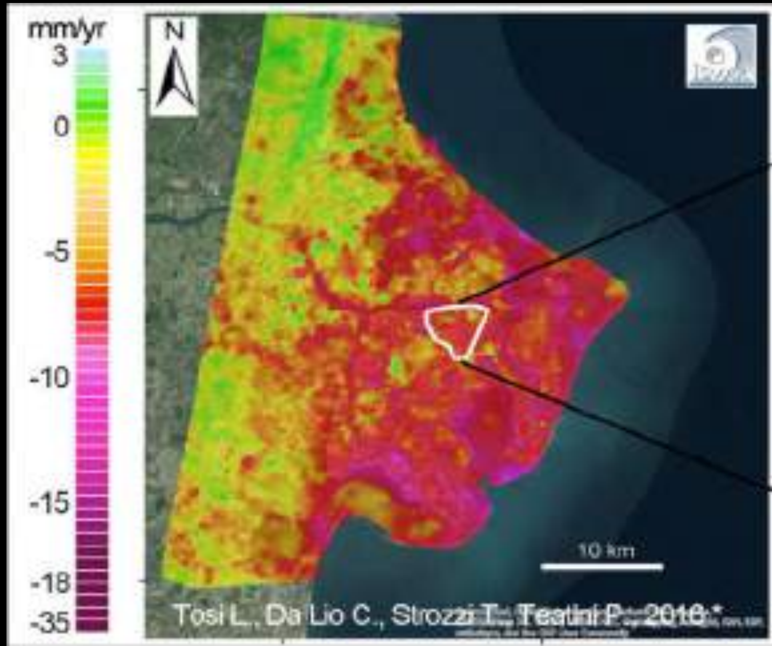
SUBSIDENCE

In the Po delta





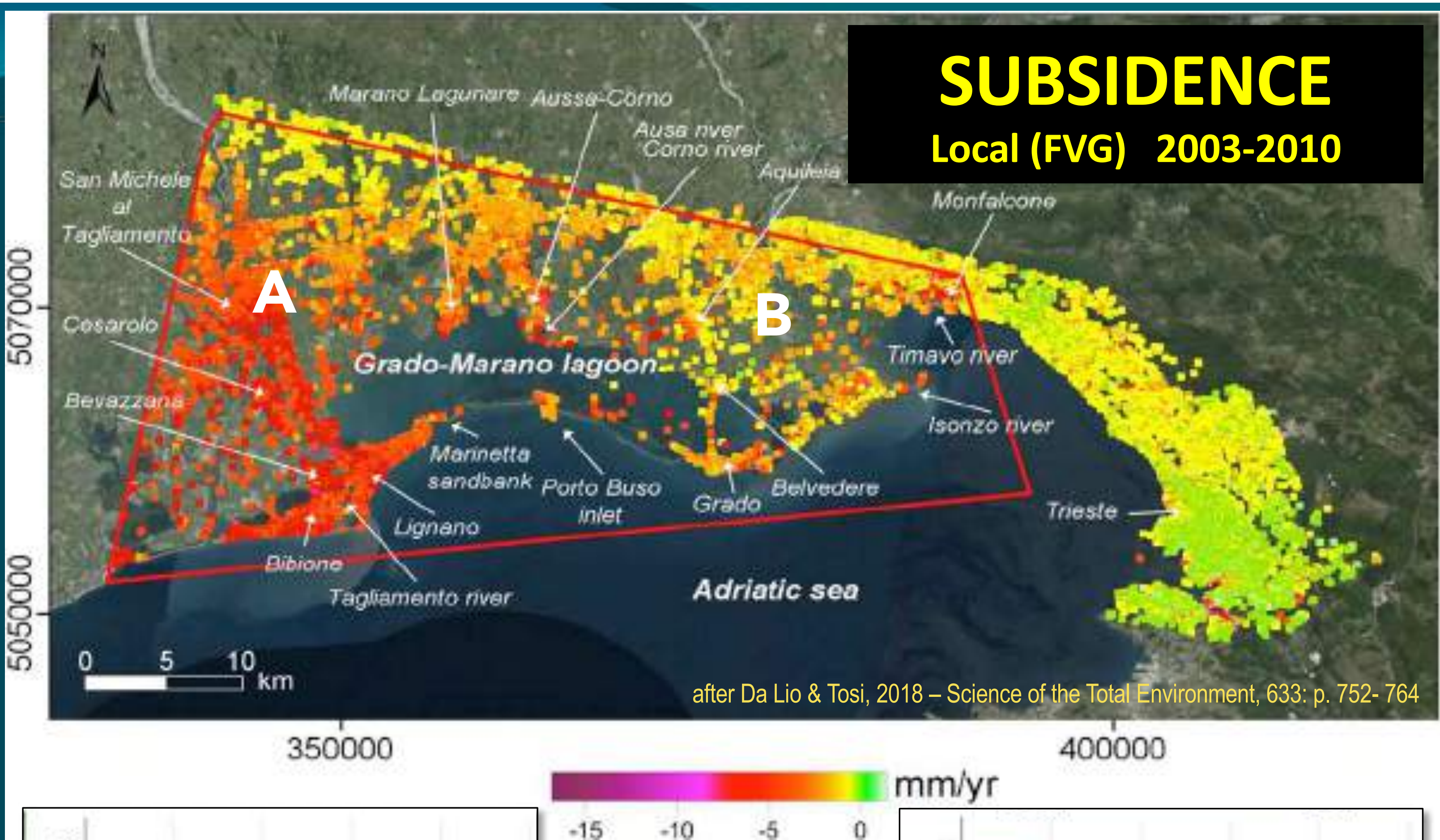
Mean sea level records in Trieste, Venezia, and Ravenna from 1896 to 2006. Linear regressions are reported as dashed lines.



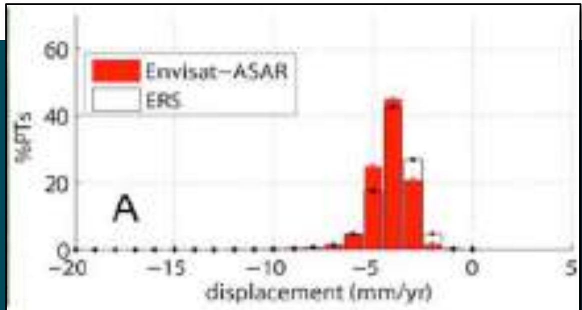
Subsidence map of the Po Delta (multi-band combination). It can be seen that the 'modern' Delta is more subsident than the inland area that corresponds to the ancient littoral belts.

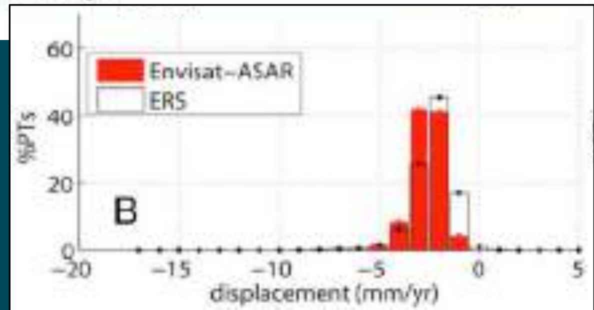
After Di Giulio et al., 2017 – Selective retreat scenarios for the Po river delta. The Plan Journal, 2(2), open access

SUBSIDENCE
Local (FVG) 2003-2010

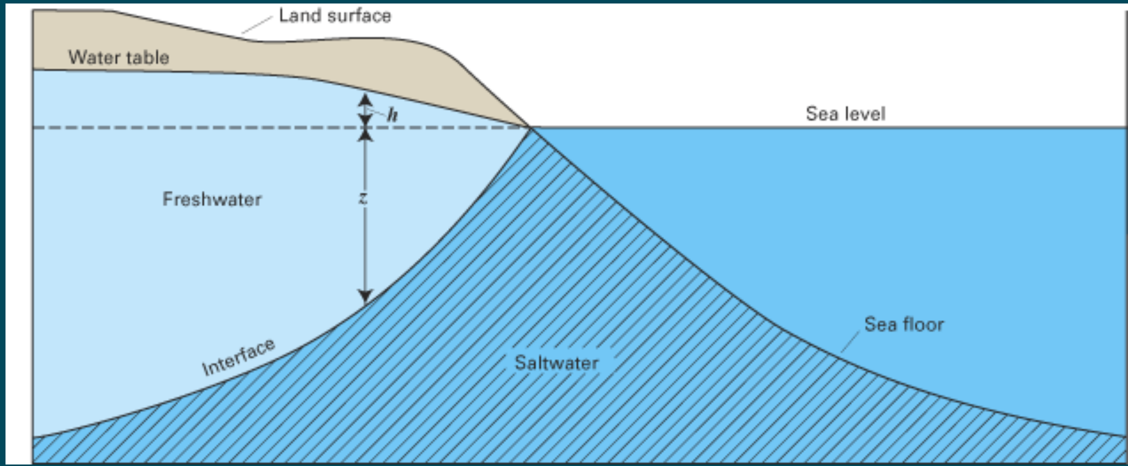


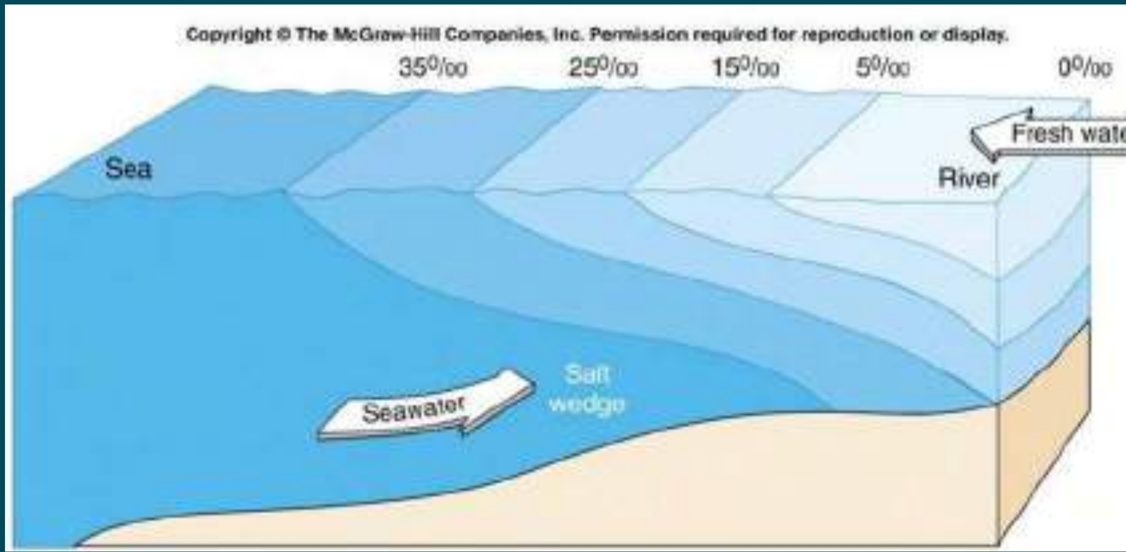
after Da Lio & Tosi, 2018 – Science of the Total Environment, 633: p. 752- 764



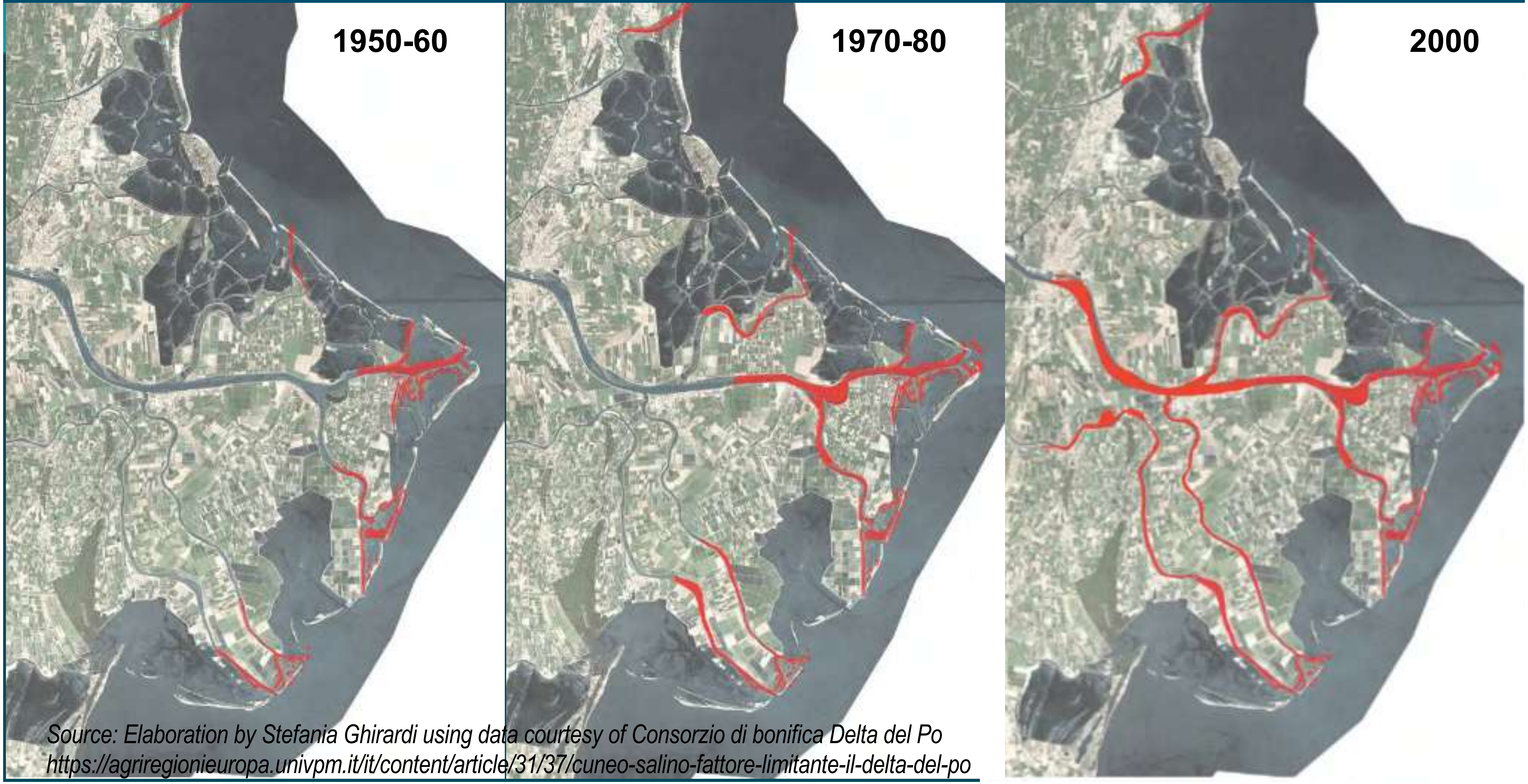


The saltwater and salt wedge intrusion





THE RSLR EFFECTS: the salt wedge intrusion



Source: Elaboration by Stefania Ghirardi using data courtesy of Consorzio di bonifica Delta del Po
https://agriregionieuropa.univpm.it/it/content/article/31/37/cuneo-salino-fattore-limitante-il-delta-del-po

THE RSLR EFFECTS: the salt wedge intrusion

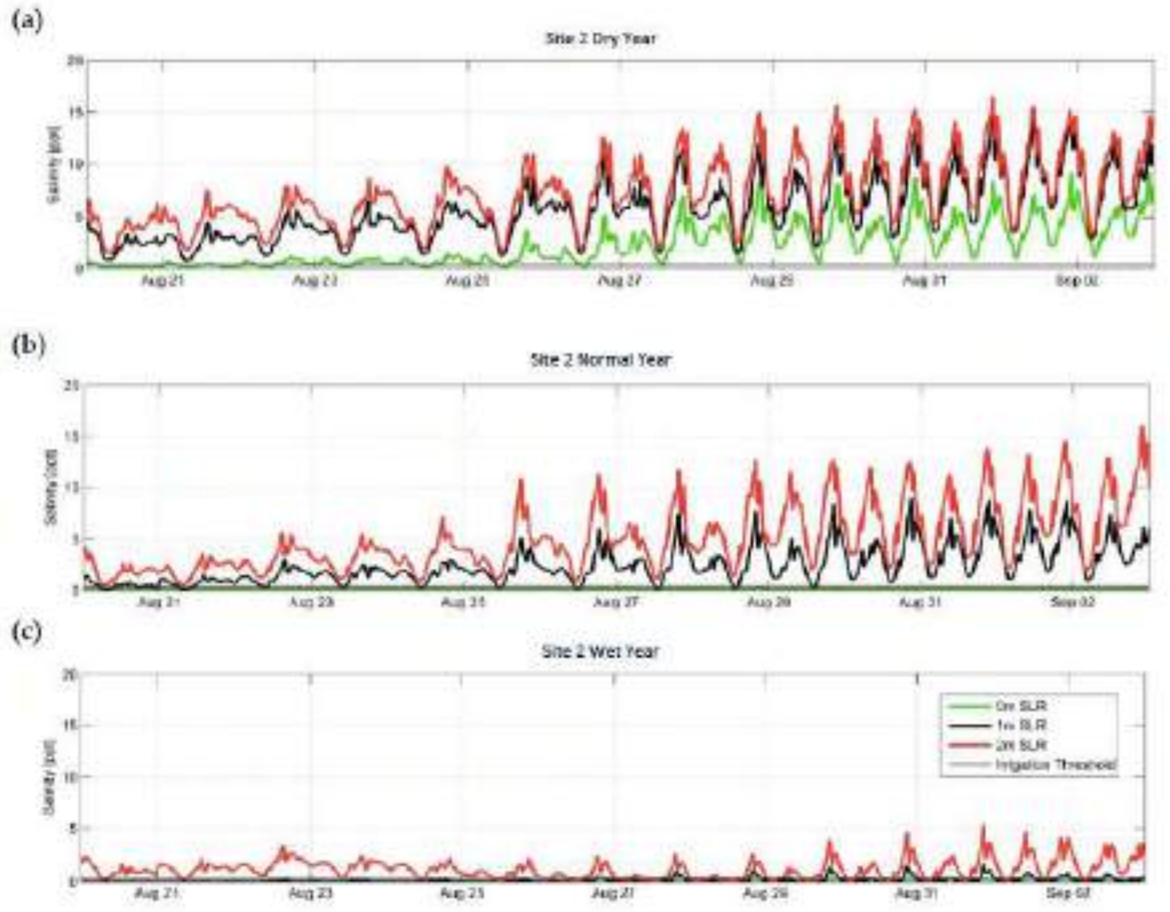
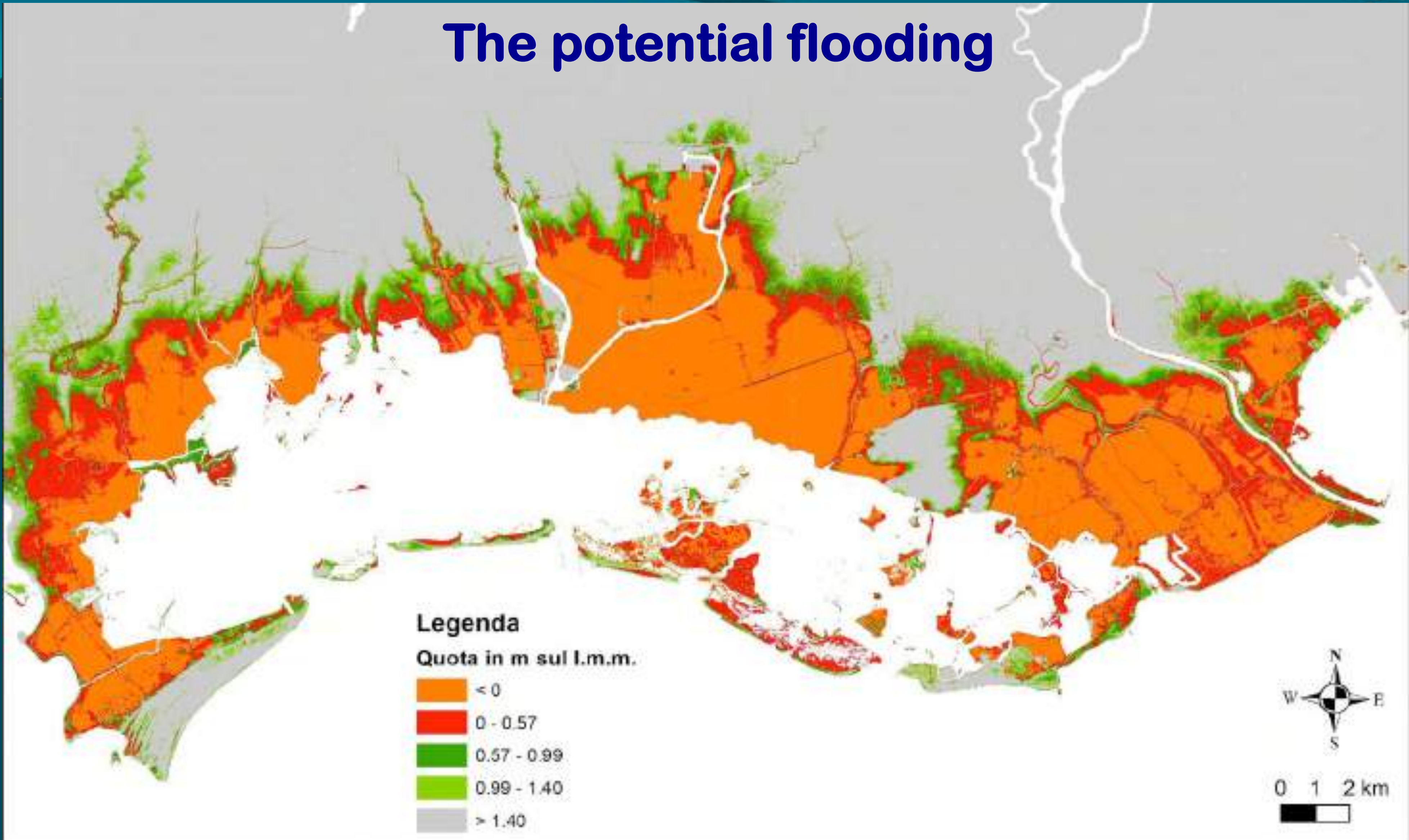


Figure 15. Surface salinity at site 2 in August with 0–2 m SLR: (a) dry year; (b) normal year; (c) wet year.

Simulation along the terminal tract of the Fraser River Delta, British Columbia, Canada

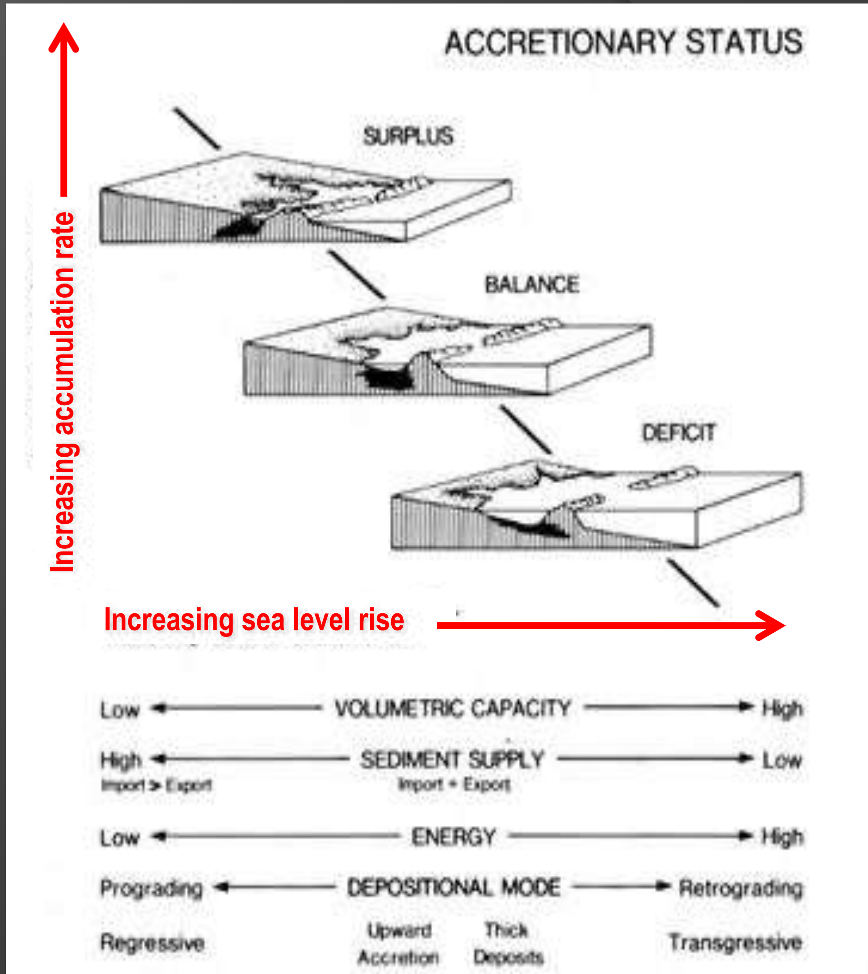
J. Mar. Sci. Eng. 2018, 6, 130; doi:10.3390/jmse6040130

The potential flooding

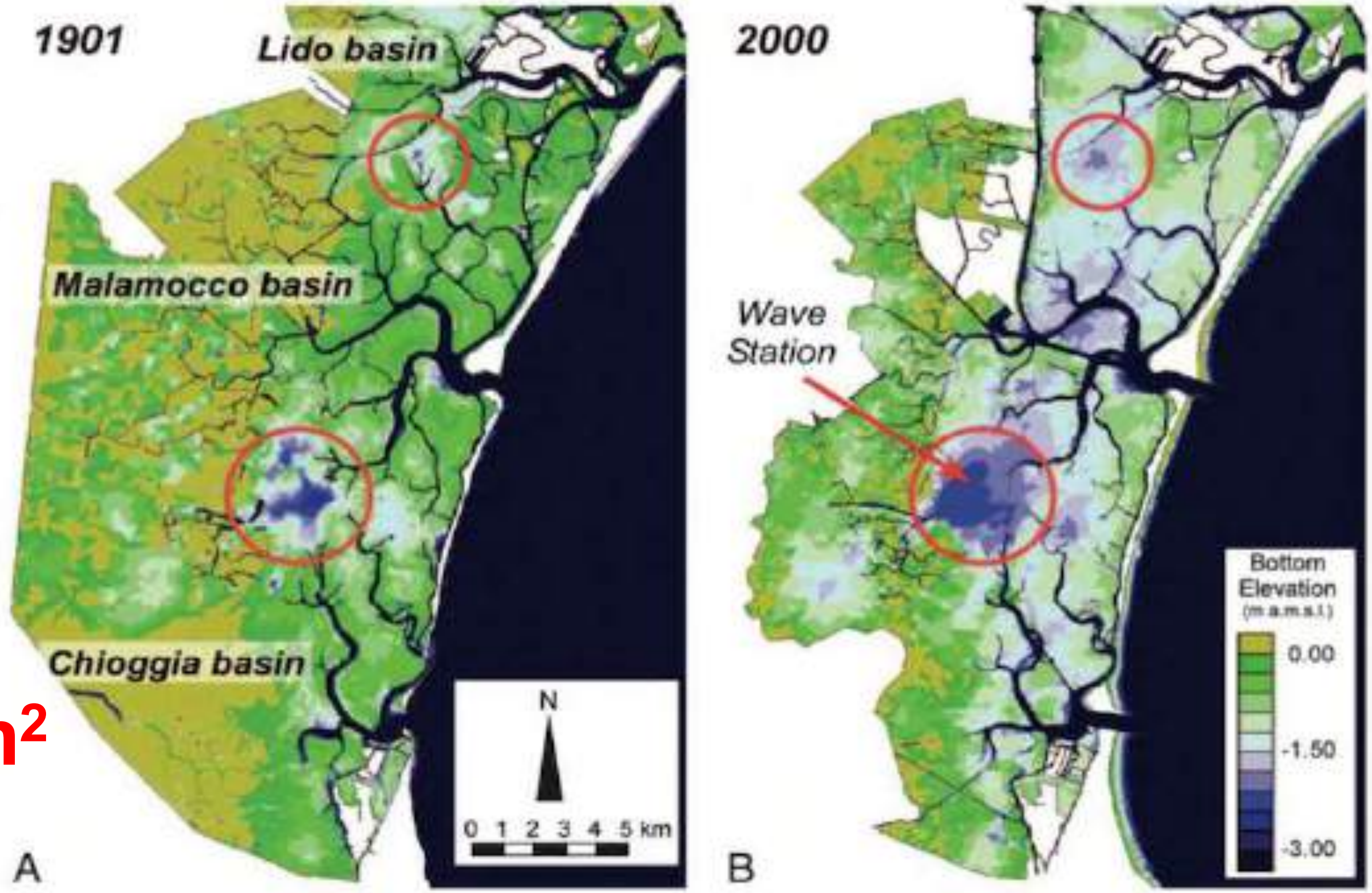


The real flooding
(salt marshes and tidal flats)

The sedimentary balance



Loss of salt marshes: 50% in Venice



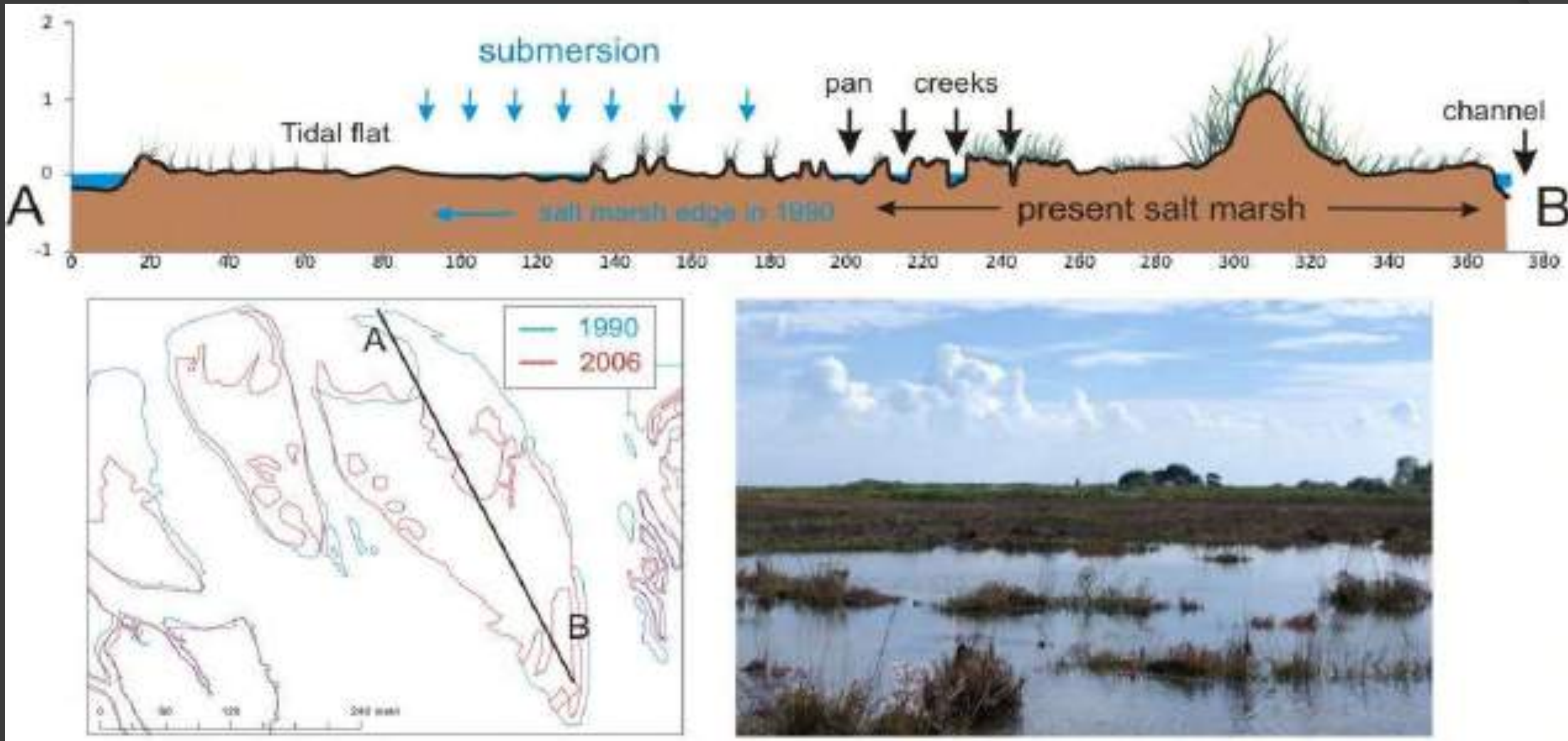
68 km²

32 km²

Fig. 1. Distribution of channels, salt marshes, and tidal flats in the Venice Lagoon in 1901 (*A*) and 2000 (*B*). The elevation is expressed in meters above MSL (a.m.s.l.). Areas within the circles are tidal-flat locations away from the channels in which the deposition rates are very low.

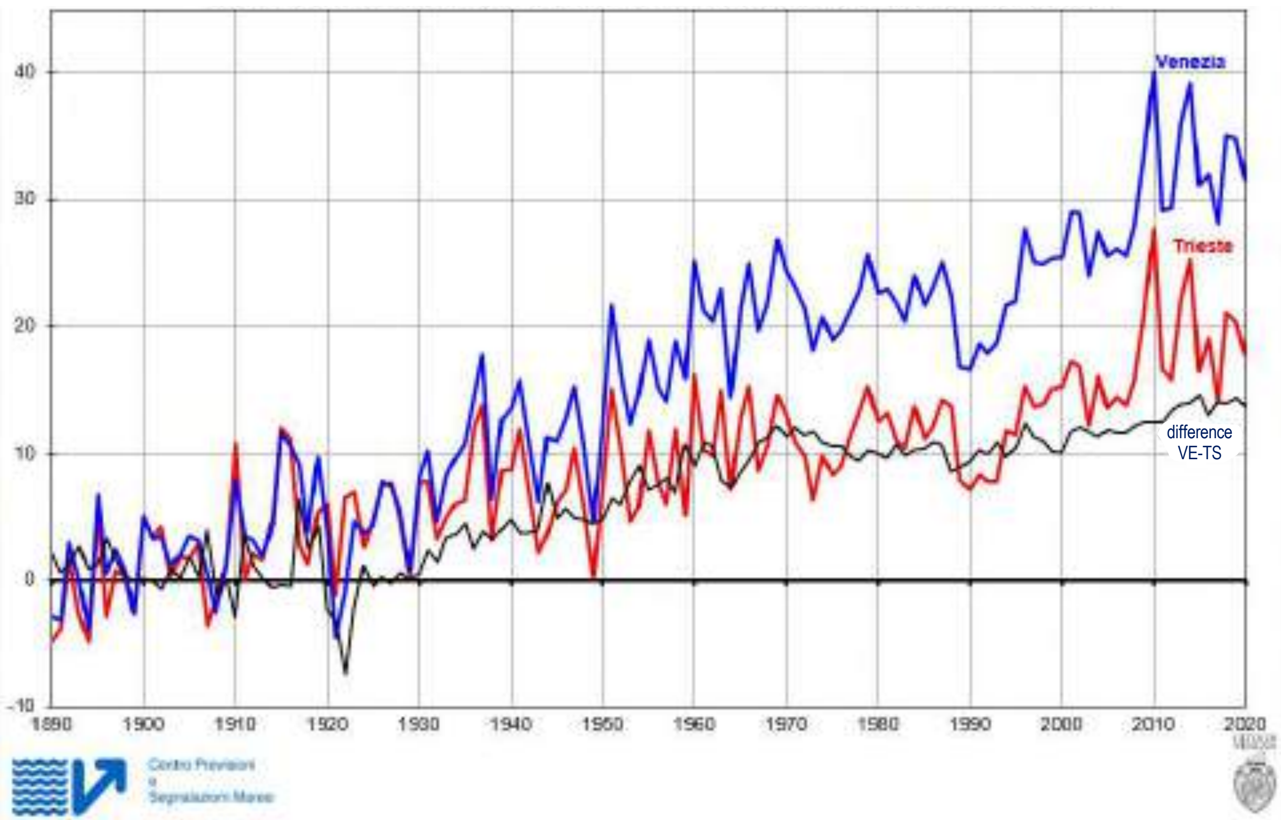
Fagherazzi et al. (2006)

Loss of salt marshes: 16% in Marano-Grado



904 ha → **761 ha**

Mean sea level recorded in Venice and Trieste from 1890 to 2020



Submergence of the Venice Lagoon (1927-2002)

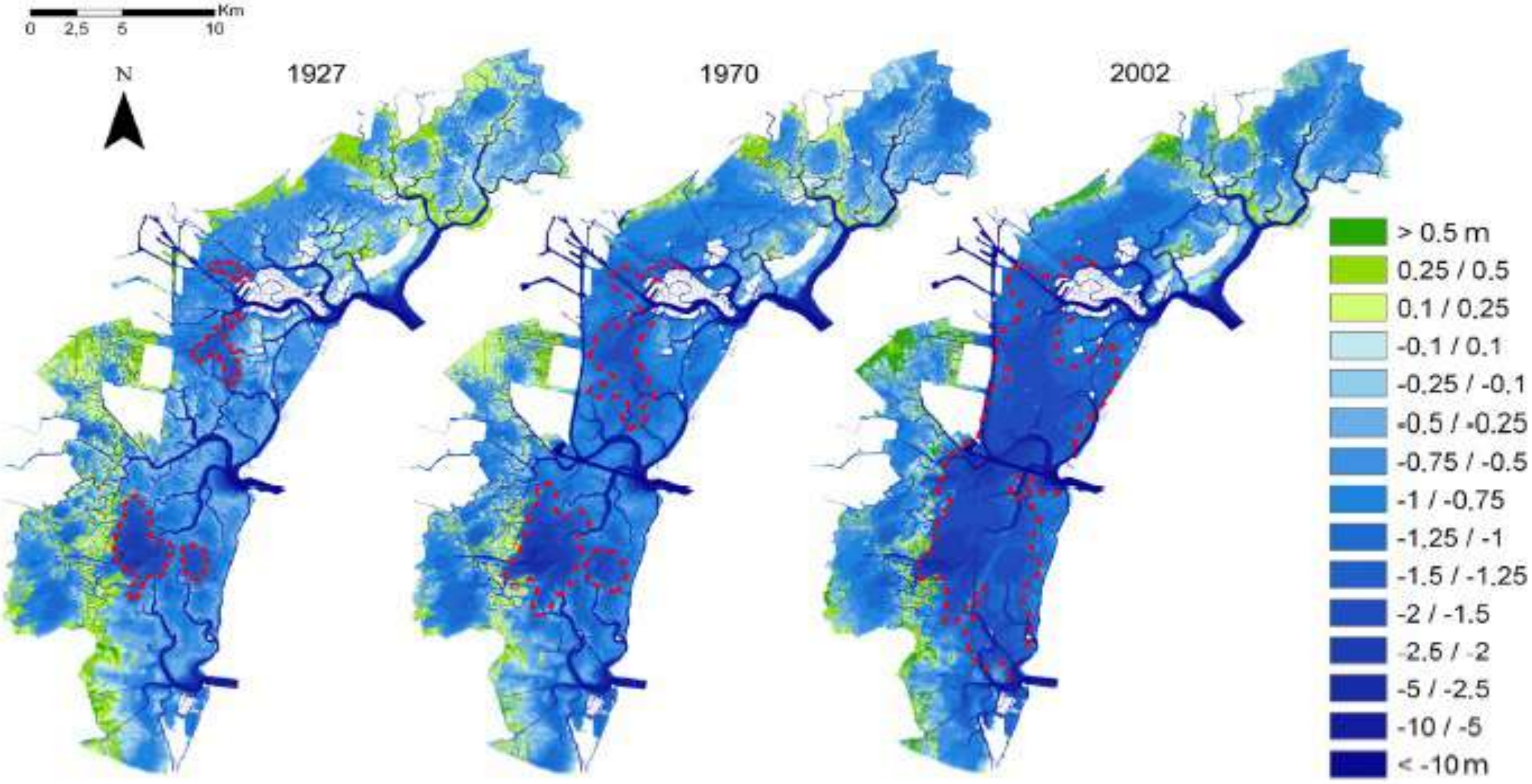
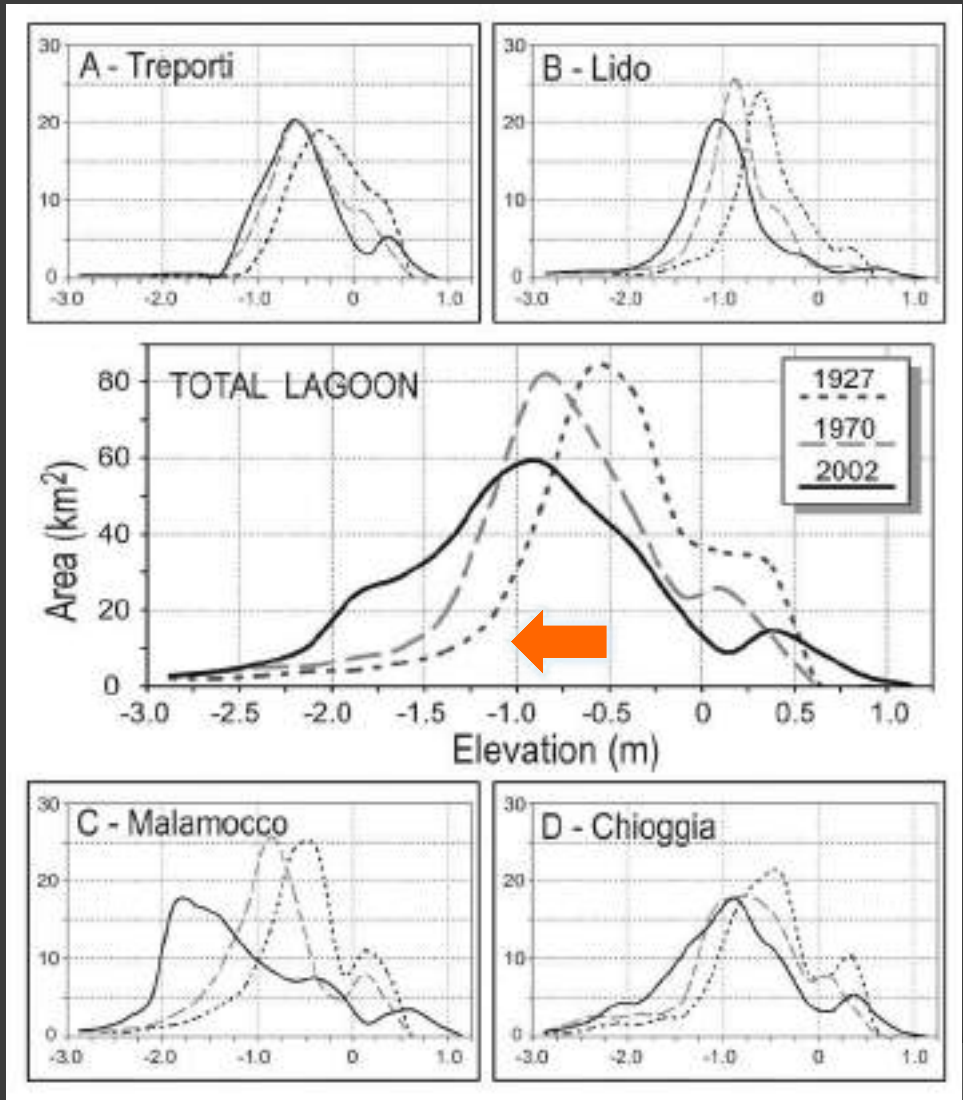


Fig. 3. Colour-shaded bathymetric maps of Lagoon of Venice (from left to right: 1927, 1970; 2002). Dotted red line indicates migration of −1.2 m contour line, showing an overall increase in depth (progressively darker blue colour). Emergent areas are indicated in green. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

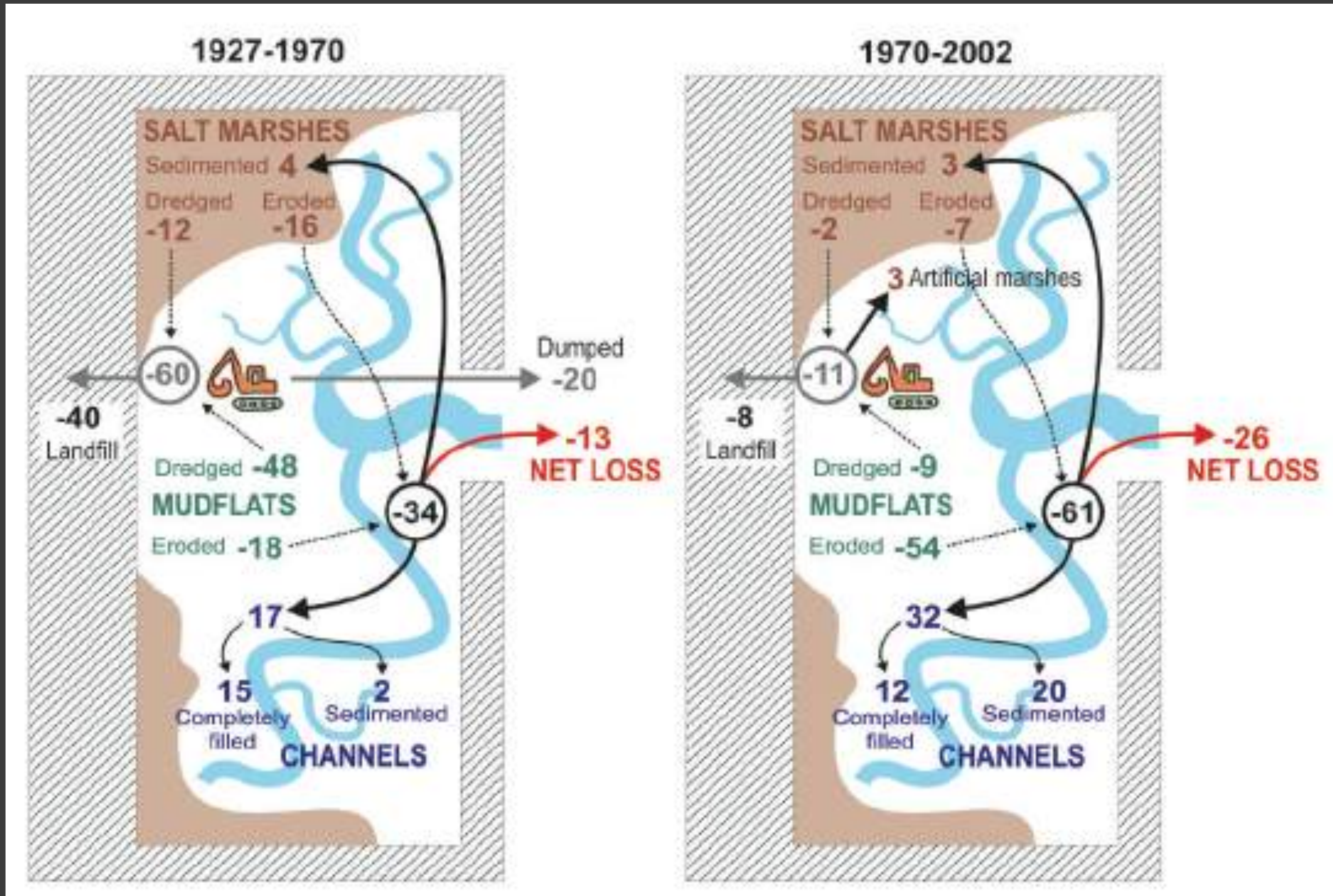
A. Sarretta et al. / Continental Shelf Research 30 (2010) 934-949



Ipsometric changes

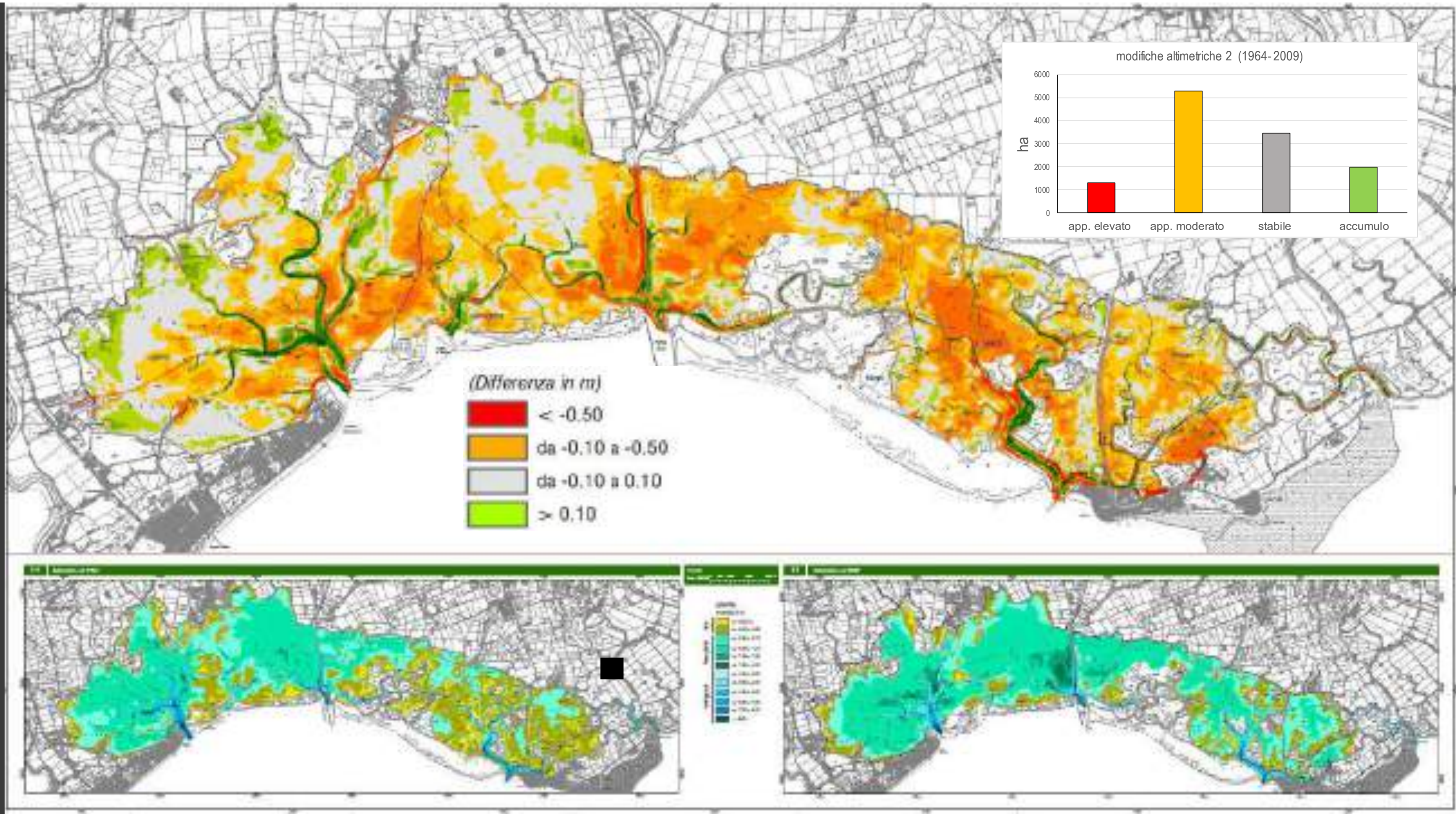
Venice Lagoon

Venice Lagoon



-300.000 m^3/y

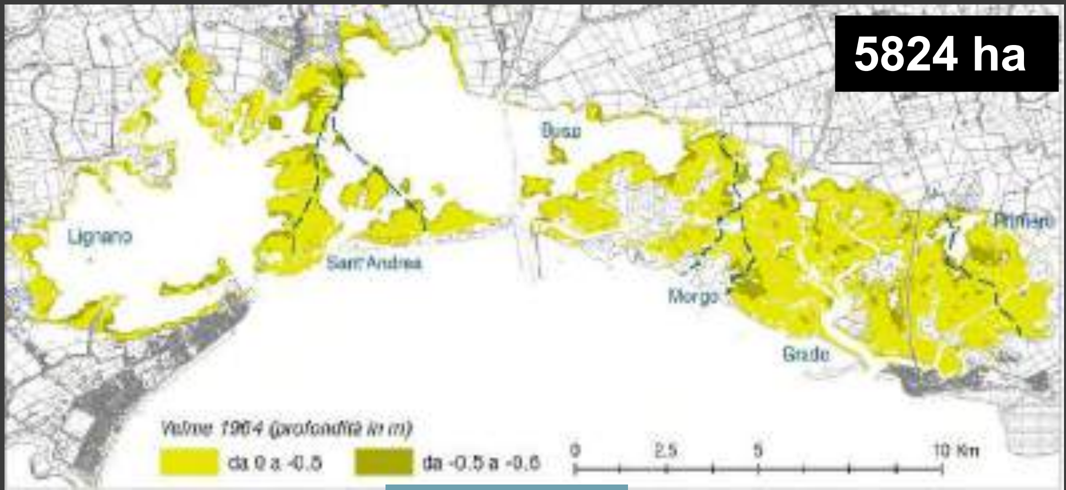
-800.000 m^3/y



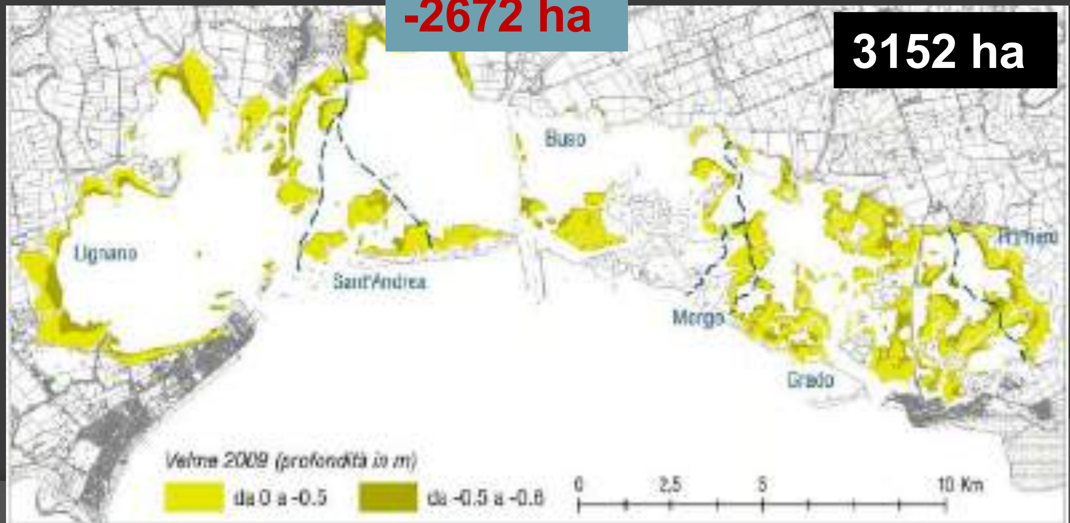
Elevation changes in the Marano and Grado Lagoon (2009-1964)

Mean loss: 300.000 m^3/y

TIDAL FLATS

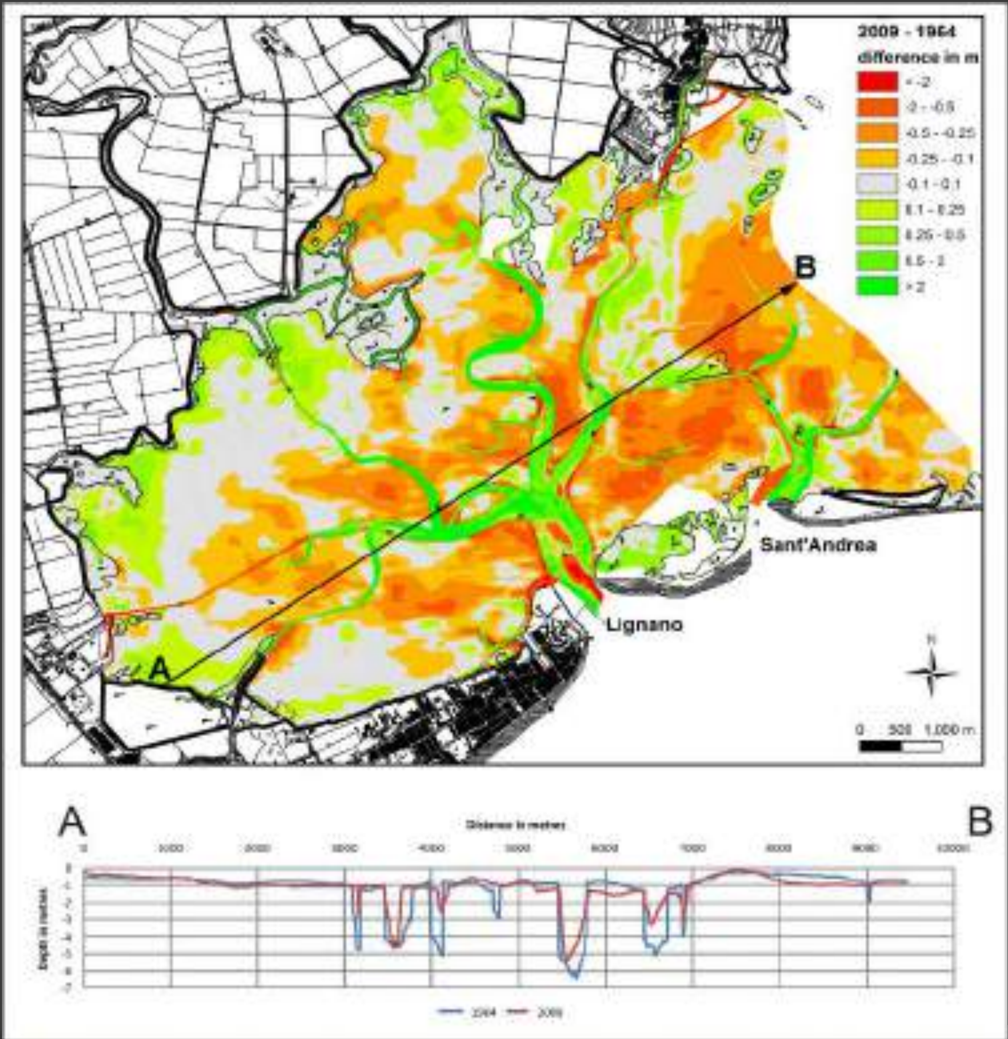


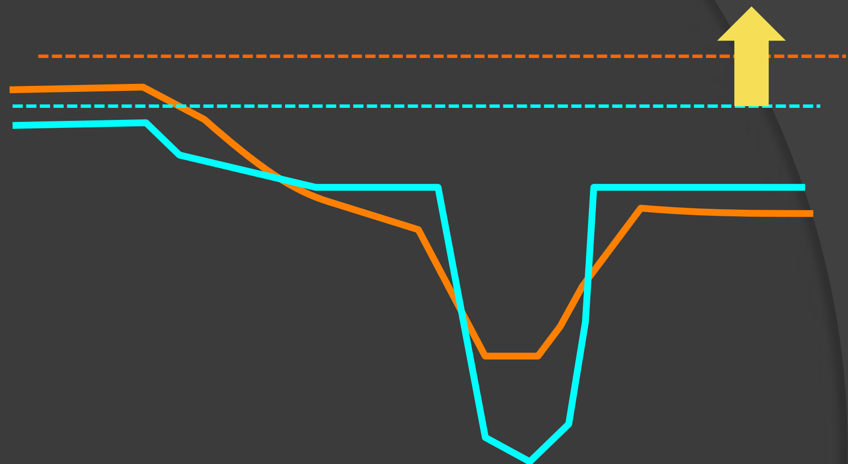
-2672 ha

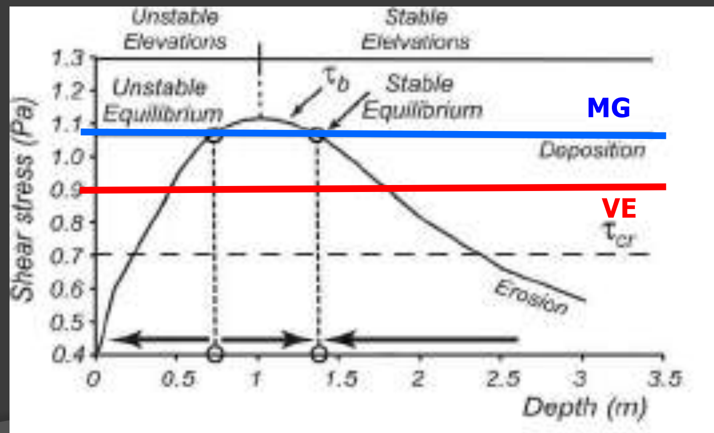


- ✓ They are within the lower half of the tidal range, between -0.60 and 0m
- ✓ They suffer the erosive action of wind waves
- ✓ The secondary channels tend to disappear
- ✓ The RSLR induces a morphological simplification

The evolutionary asymmetry caused by RSLR







Autoerosion of the tidal flats

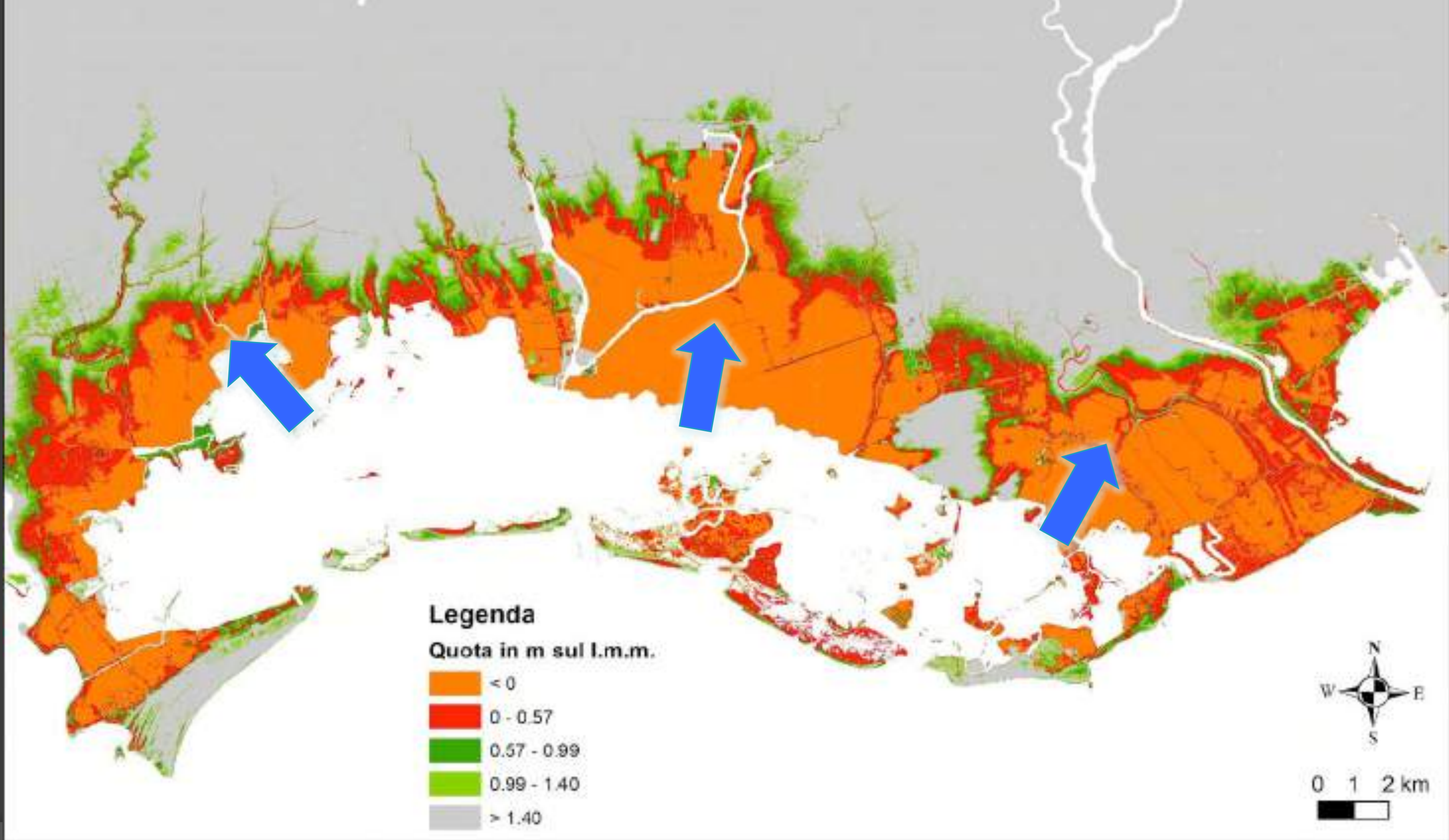

What solutions?

INTERVENTION STRATEGIES

- RECOVER SEDIMENTS
- PROMOTE SEDIMENTATION
- PROTECT THE EDGES

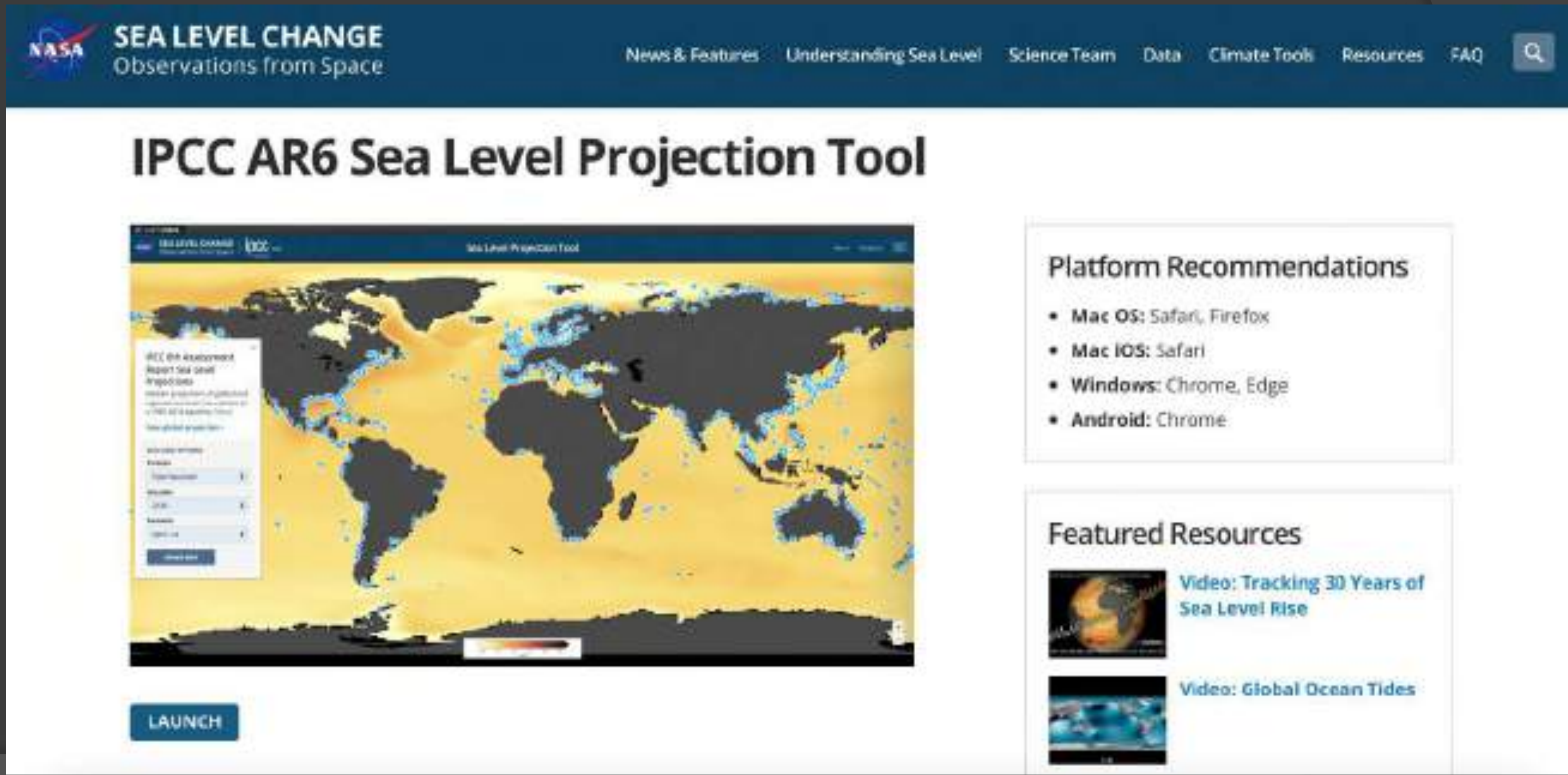
Images from http://www.salve.it/it/soluzioni/ambiente/recupero_life.htm

Adaptation option: lagoon espansion ?



A useful tip for discovering SLR impacts worldwide

https://sealevel.nasa.gov/data_tools/17



THANKS

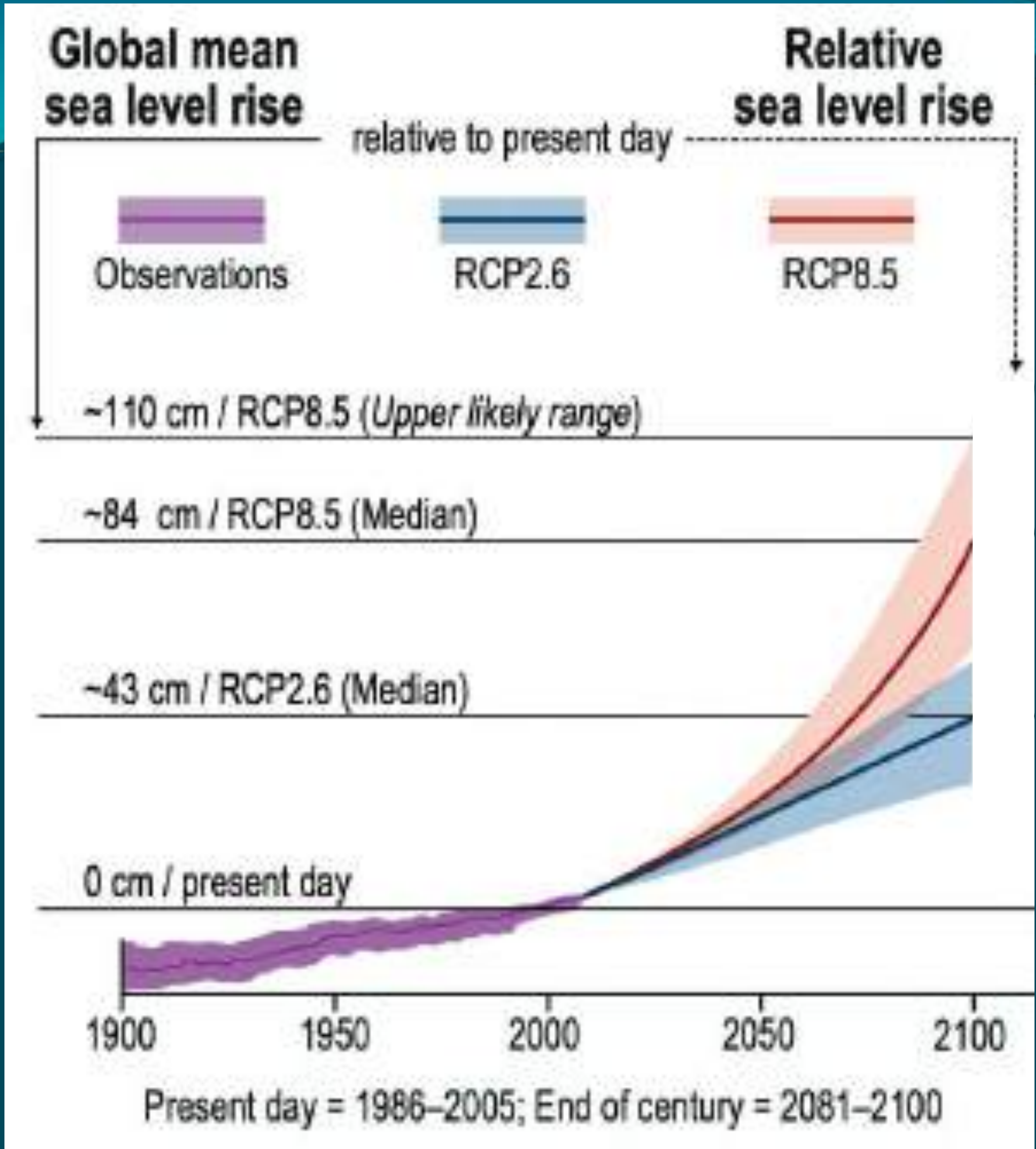
Giorgio Fontolan
Dipartimento di Matematica e Geoscienze
Università degli Studi di Trieste
via Edoardo Weiss, 1 - 34128 Trieste (Italy)
fontolan@units.it
Tel. | Ph. +39 0405582260
Cell. | Mob. +39 3346334342
Skype: jure.fontolan

UNIVERSITÀ DEGLI STUDI DI TRIESTE

dipartimento di matematica e geoscienze

https://youtu.be/ul4SwElLeo8

SEA LEVEL – the projections



Projections for TS and VE *

year	RCP 2.6 (SSP1)	RCP 4.5 (SSP2)	RCP 8.5 (SSP5)
2050	0.17-0.22 (0.09, 0.31)	0.18-0.23 (0.11, 0.32)	0.21-0.26 (0.13, 0.34)
2100	0.39-0.49 (0.22, 0.70)	0.48-0.59 (0.32, 0.82)	0.67-0.77 (0.46, 1.06)

* Reported in *Sea Level Projection Tool*, using the IPCC Sixth Assessment Report