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**COURSE ON CLIMATE VARIABILITY
STUDIES IN THE OCEAN
"Tracing & Modelling the Ocean Variability"
16 - 27 June 2003**

301/1507-21

Venice and Global Changes

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CORILA
Venice, Italy

Please note: These are preliminary notes intended for internal distribution only



Venice and Global Changes

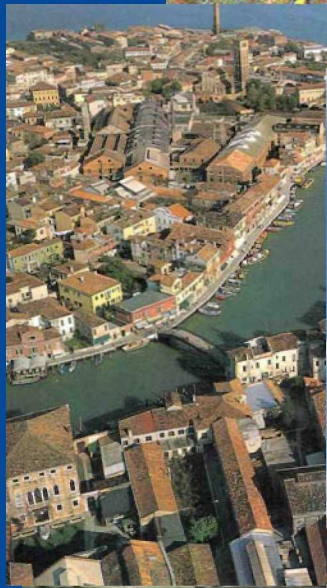
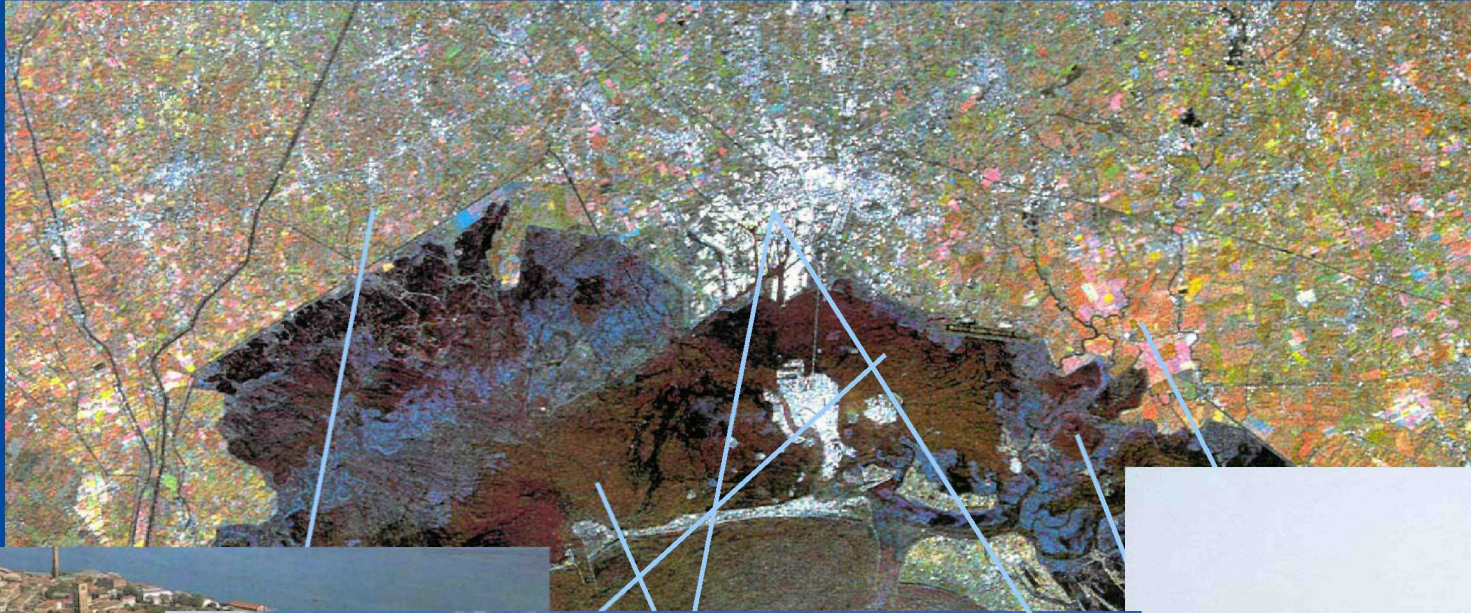
Dr. eng. Pierpaolo Campostrini

*Director of Consortium for Managing
Research Activities in the Venice
Lagoon (CORILA)*

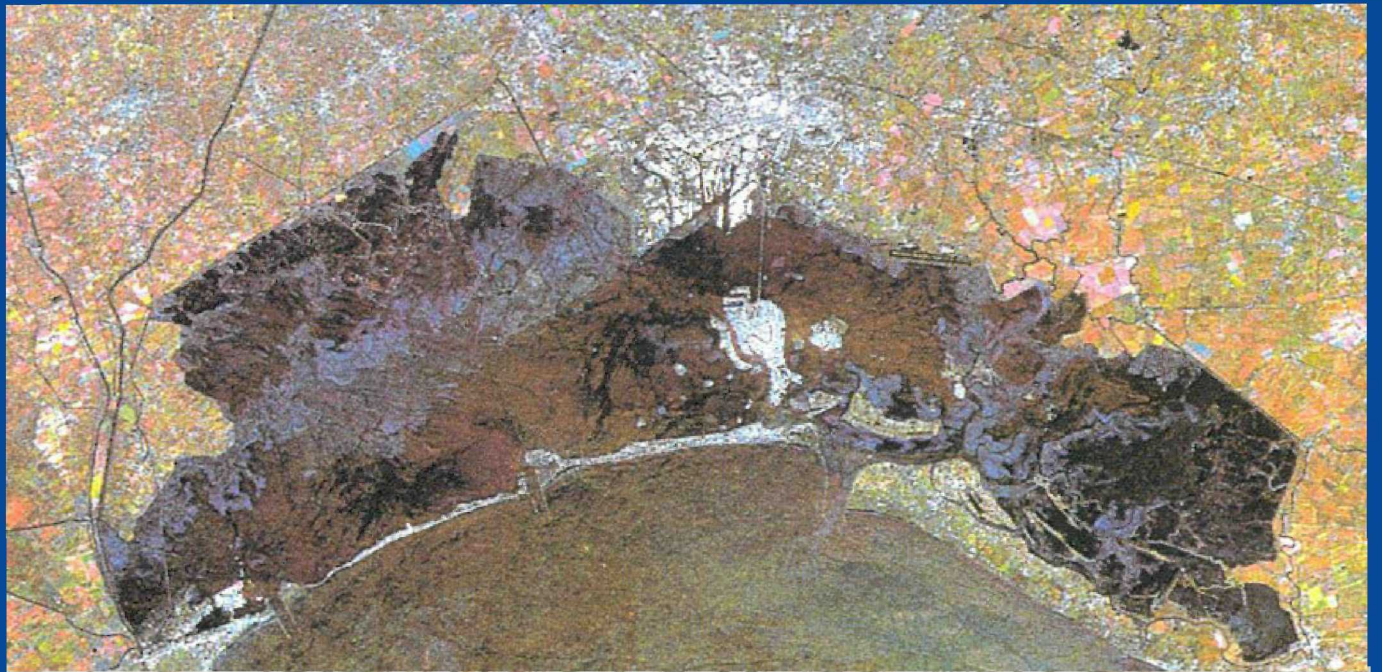
*ICTP Course on Climate
Variability Studies in the
Ocean*

Trieste, 17 June 2003

The city of Venice and its lagoon



The
lagoon:
the
present
and the
past

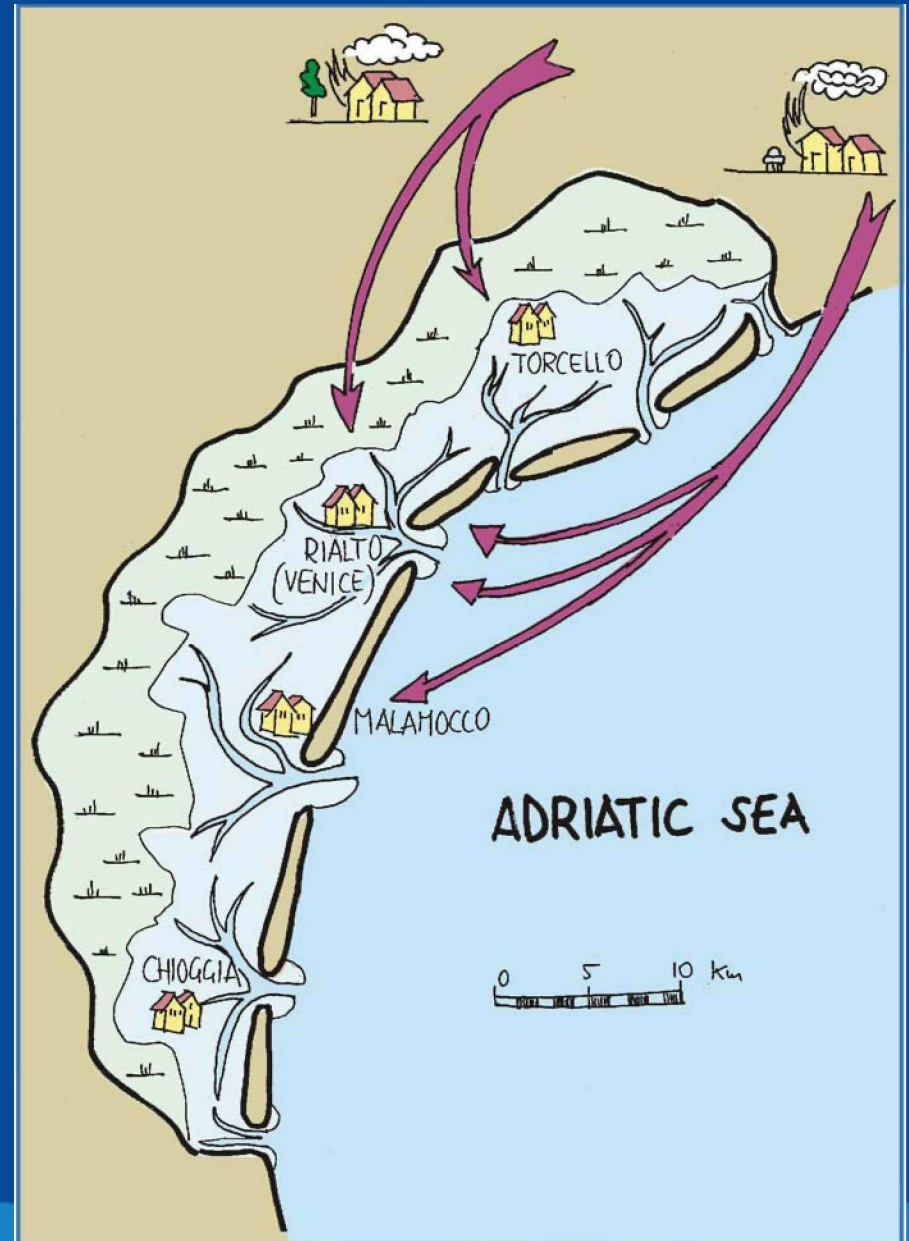


By Italian standards, Venice is a relatively modern city



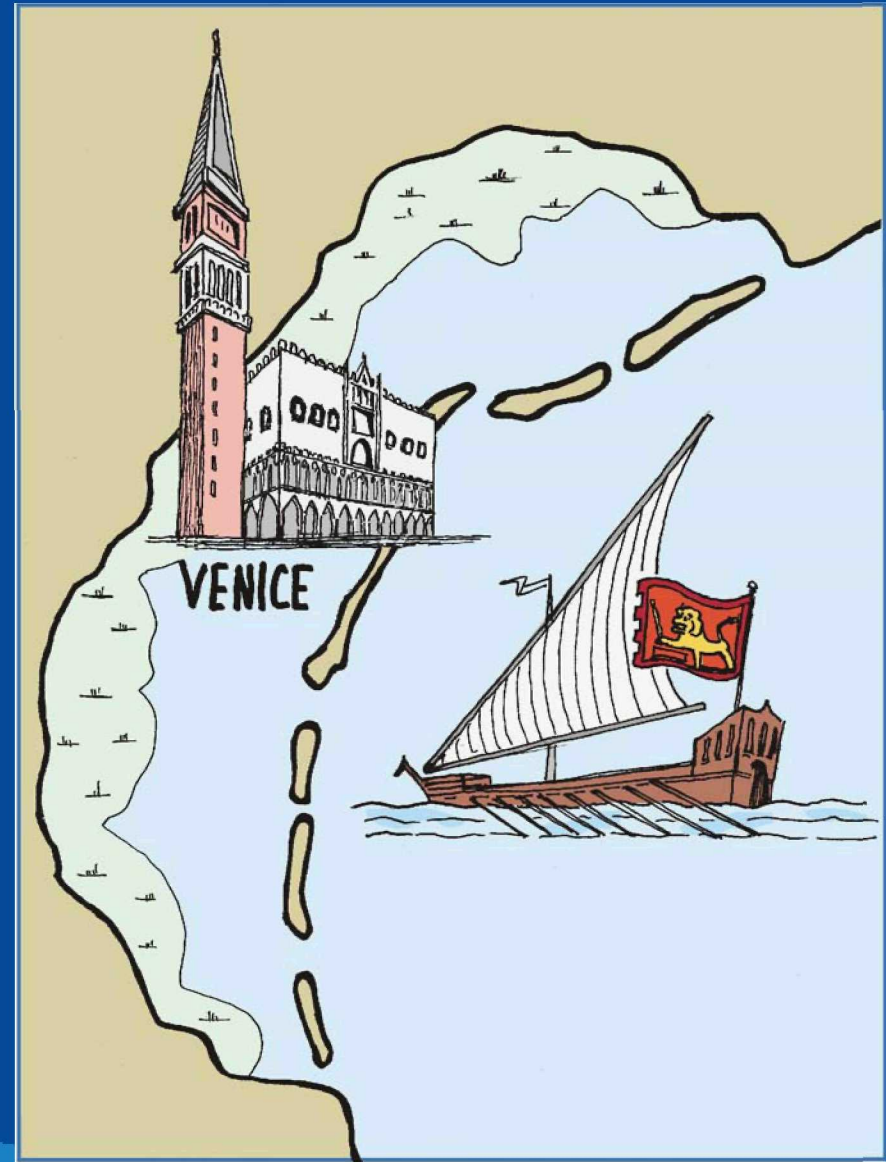
Around the year 1000 A.D. Rialto (Venice) was still one of the many small settlements in a tidal lagoon of the northern Adriatic sea.....

.....where local populations fled from the mainland, took refuge under the pressure of repeated barbarian invasions of previous centuries



In the XIV century,
however, Venice was
already one of the richest
cities of Europe while the
Serenissima Repubblica
became a great power of
the Mediterranean

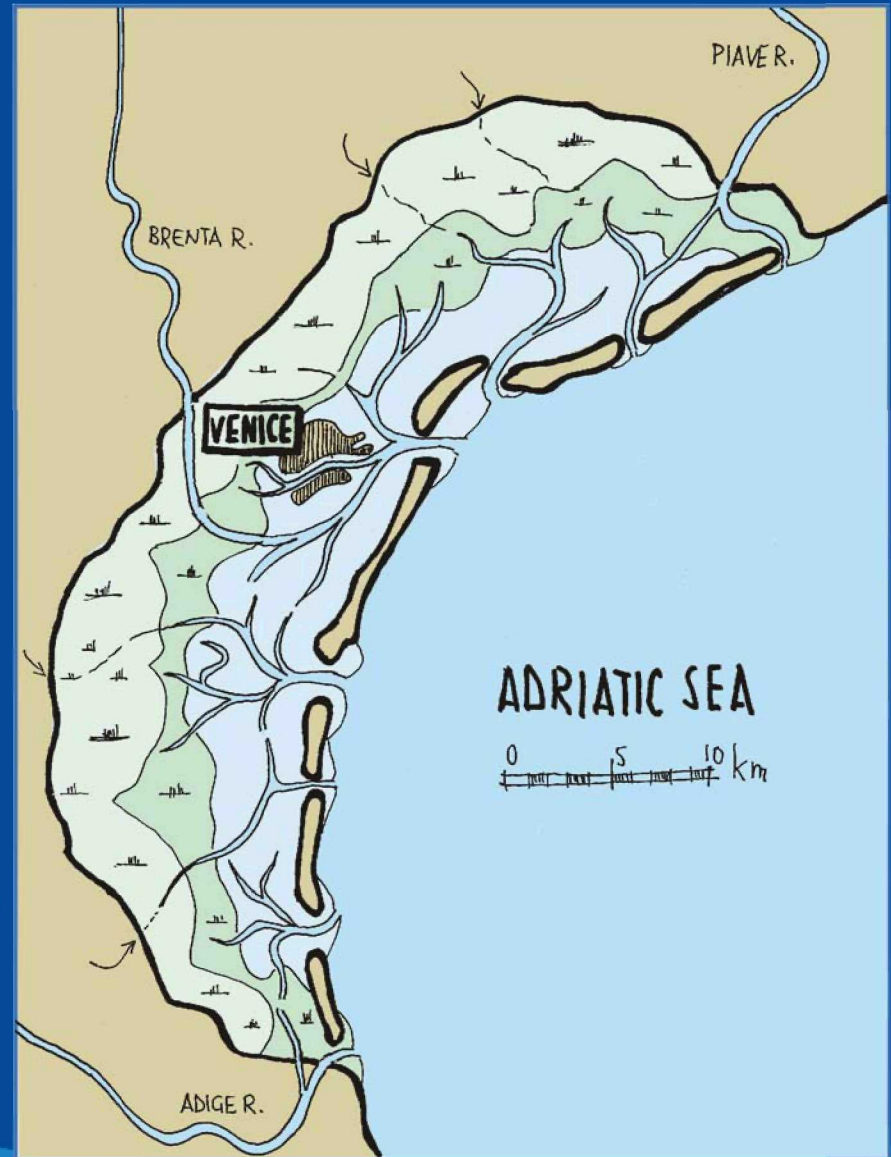
The fortunes of Venice
have always been
connected with its lagoon



In the XIV century, the lagoon of Venice was different from today:

- large rivers flowing into the lagoon
- 5 - 8 unstable inlets
- large extension of marshes
- tendency of tidal flats to become silted

risk of infilling of the lagoon



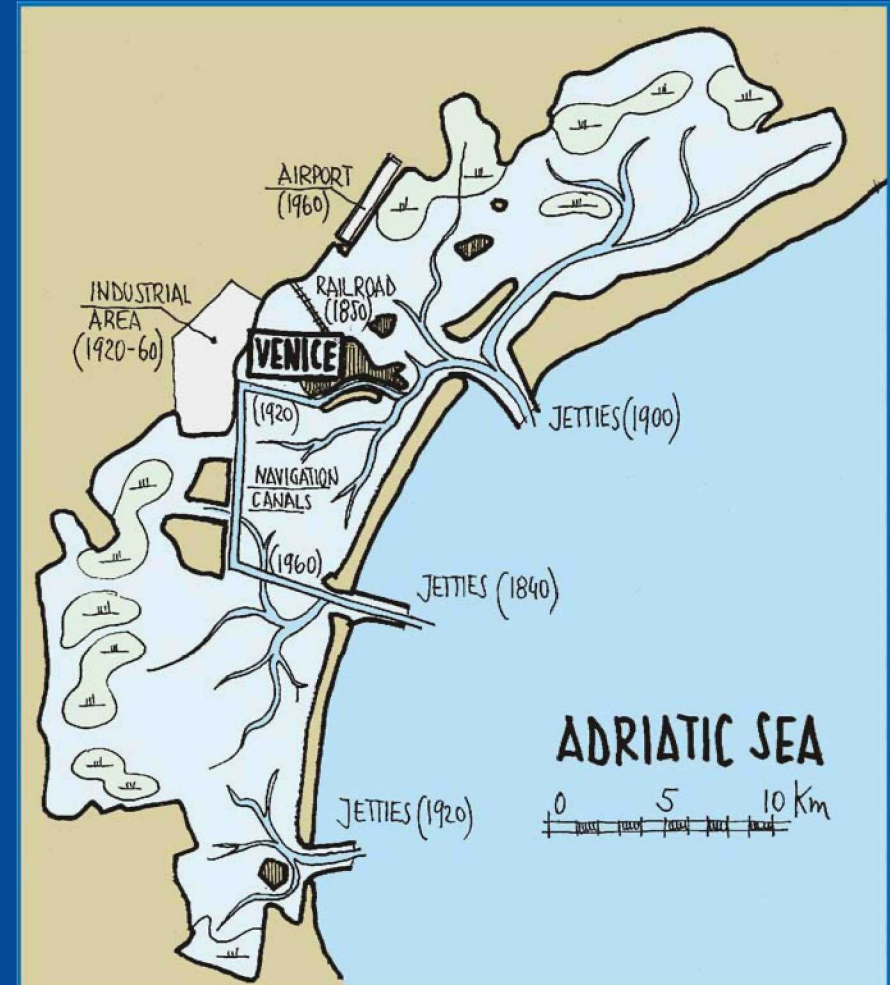
The survival of Venice (commercial, military and even physical) was put in jeopardy by the siltation of the lagoon

From the XIV to the XVII century great care was taken by the *Serenissima Repubblica* to defend its lagoon “against sea, rivers and man”

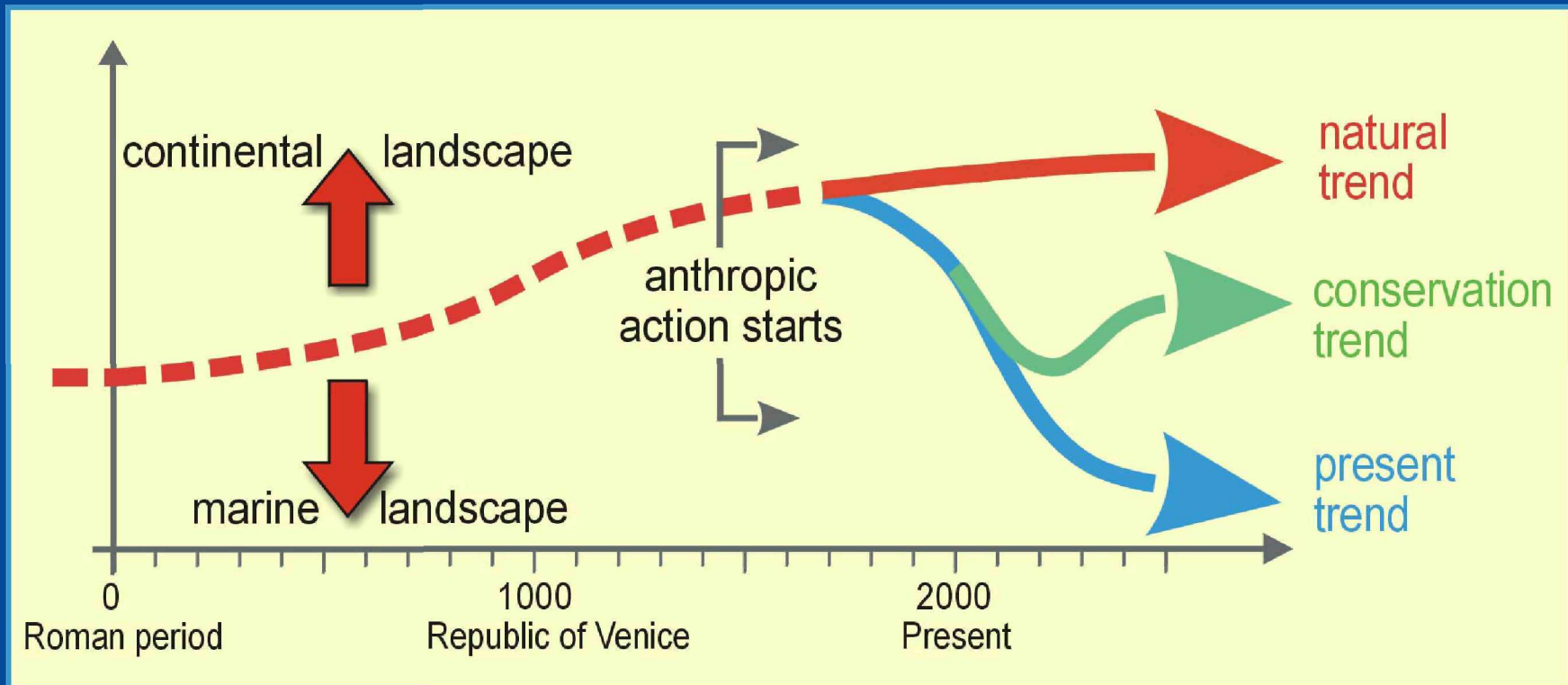


Around the XVIII century the political decadence of Venice brought to a halt the interventions in the lagoon. Over the past 150 years, by contrast, the lagoon was subject again to large modifications.

In 1950-1970, groundwater withdrawal produced 13-14 cm of soil subsidence, pushing the total altimetry loss in last 100 years (including sea level rise) up to 23 cm s.m.l.



Morphological evolution of the Lagoon of Venice



Present conditions are somehow reversed with respect to the XIV century

- No large river flows into the lagoon
- Long jetties prevent sediment input from the sea
- Deep navigation canals trap sediments
- Soil subsidence increases water depth

Frequent
flooding and
morphological
deterioration

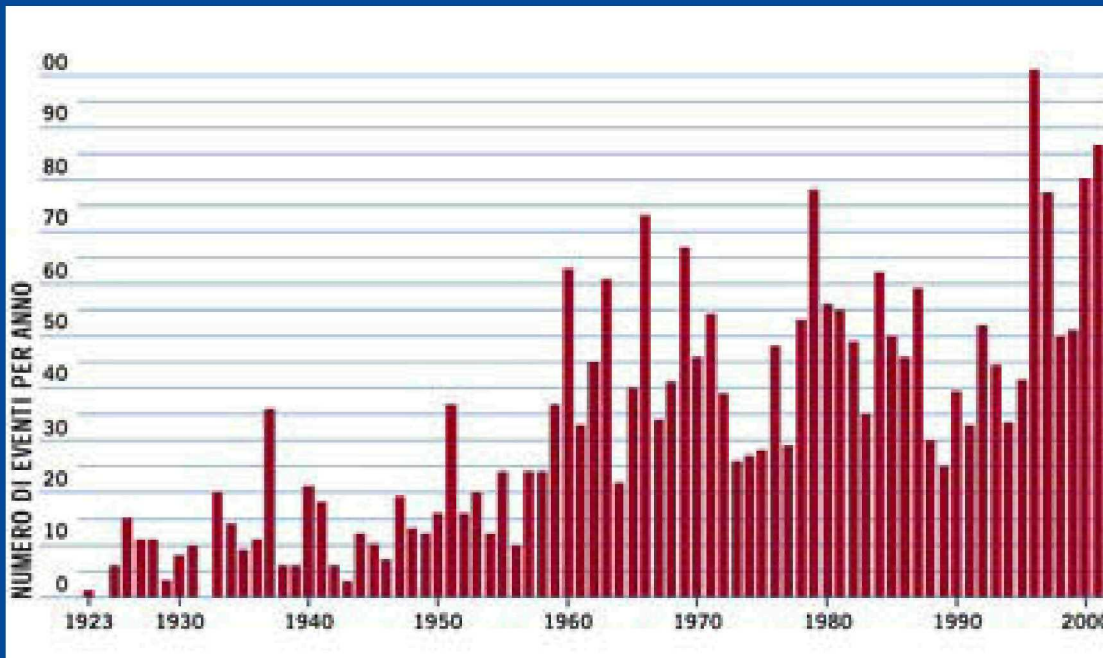


4th
November
1966



4th Nov. '66 :
waves
passing over
the sea
defences in
Pellestrina

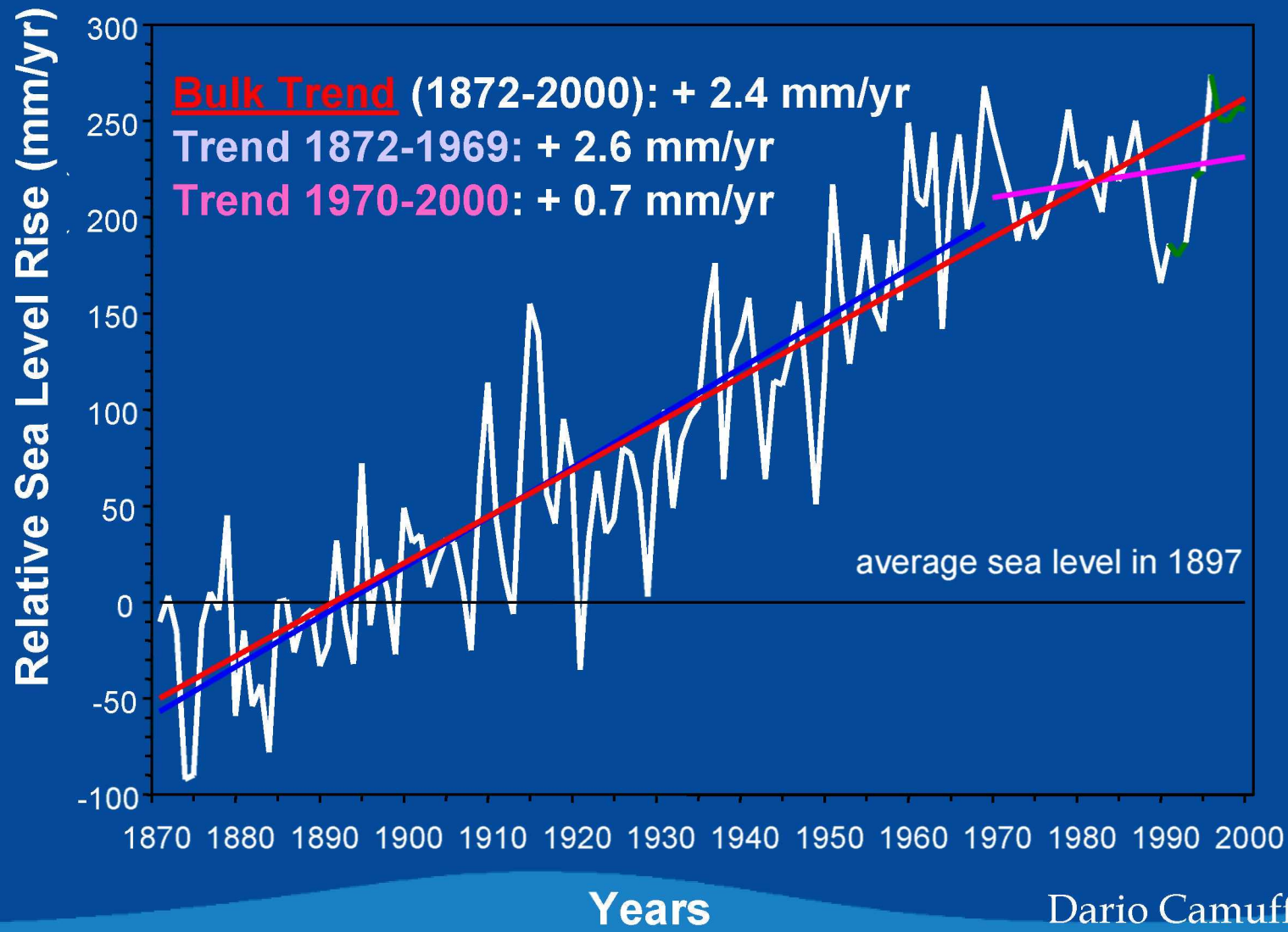
Increased numbers of floodings

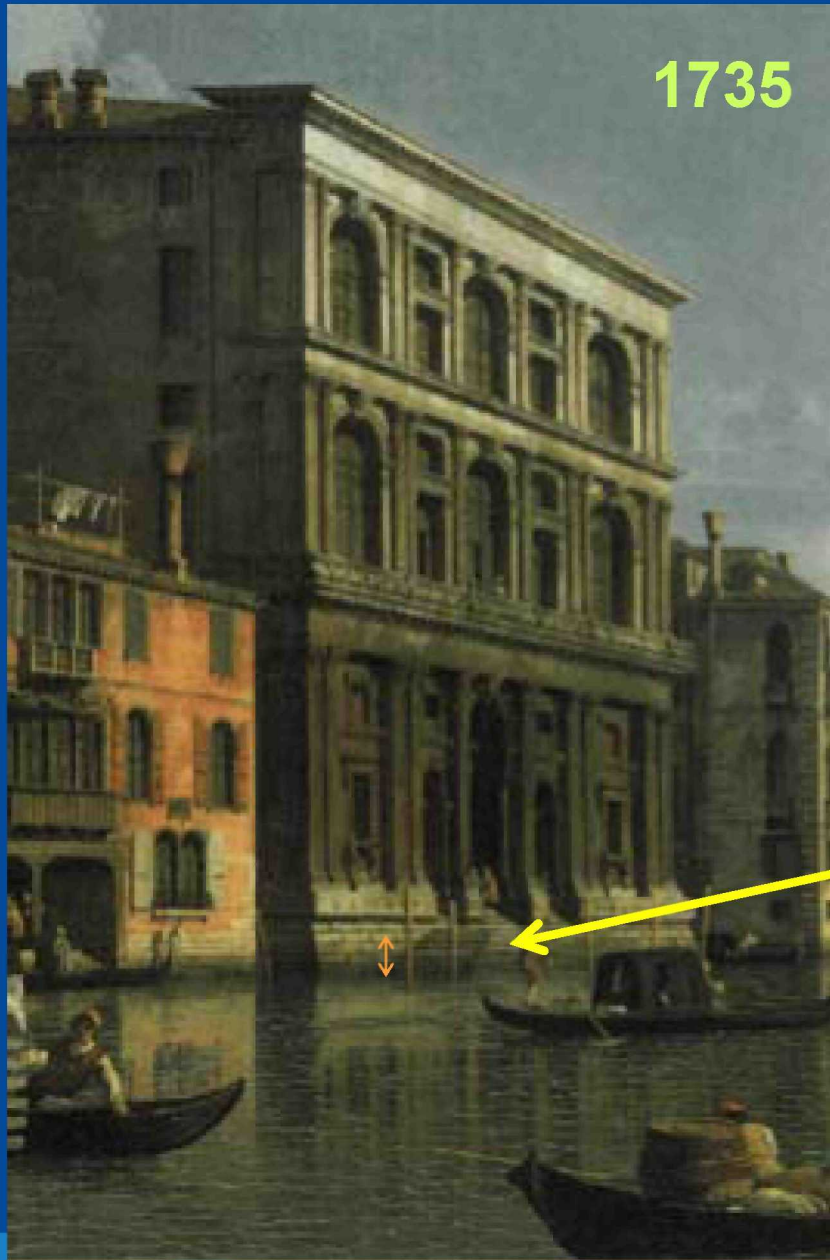


The average yearly occurrence of tide peaks > 80 cm has gone from 10 cases in the first half of the century, to 40 in the second half, reaching almost 60 cases in the last five years.

Occurrences of tides equal or greater than 80 cm

RSL (1872 – today)





1735

Canaletto, 1735: Ca' Grimani
Palace built in 1556-75

Green belt of *laminaria*
alga: a biological indicator
of the average high tide
level

Observed algae shift:
 66 ± 10 cm

Natural subsidence



Costruction 1028
Reconstruction 1590

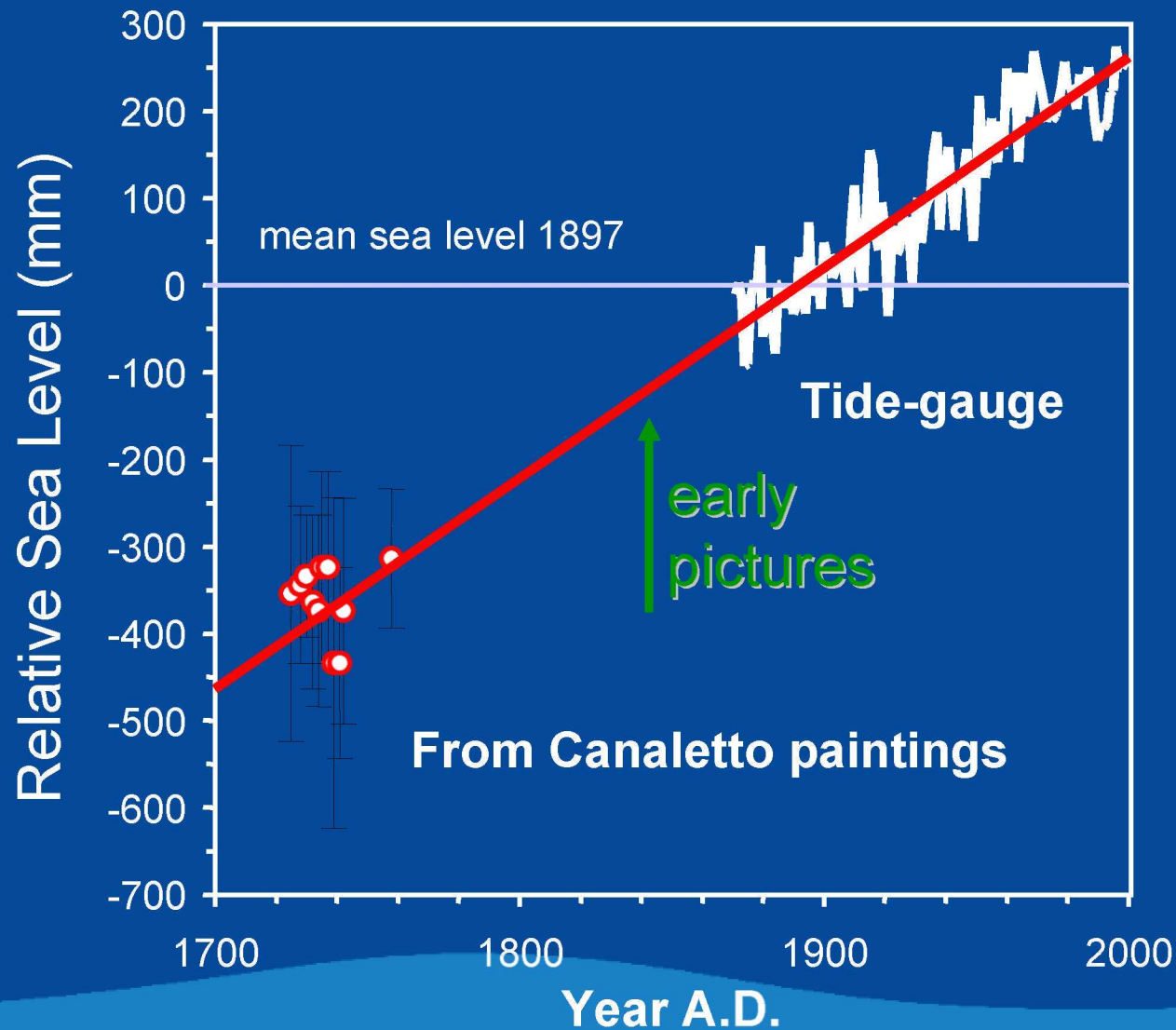


Difference 50 cm



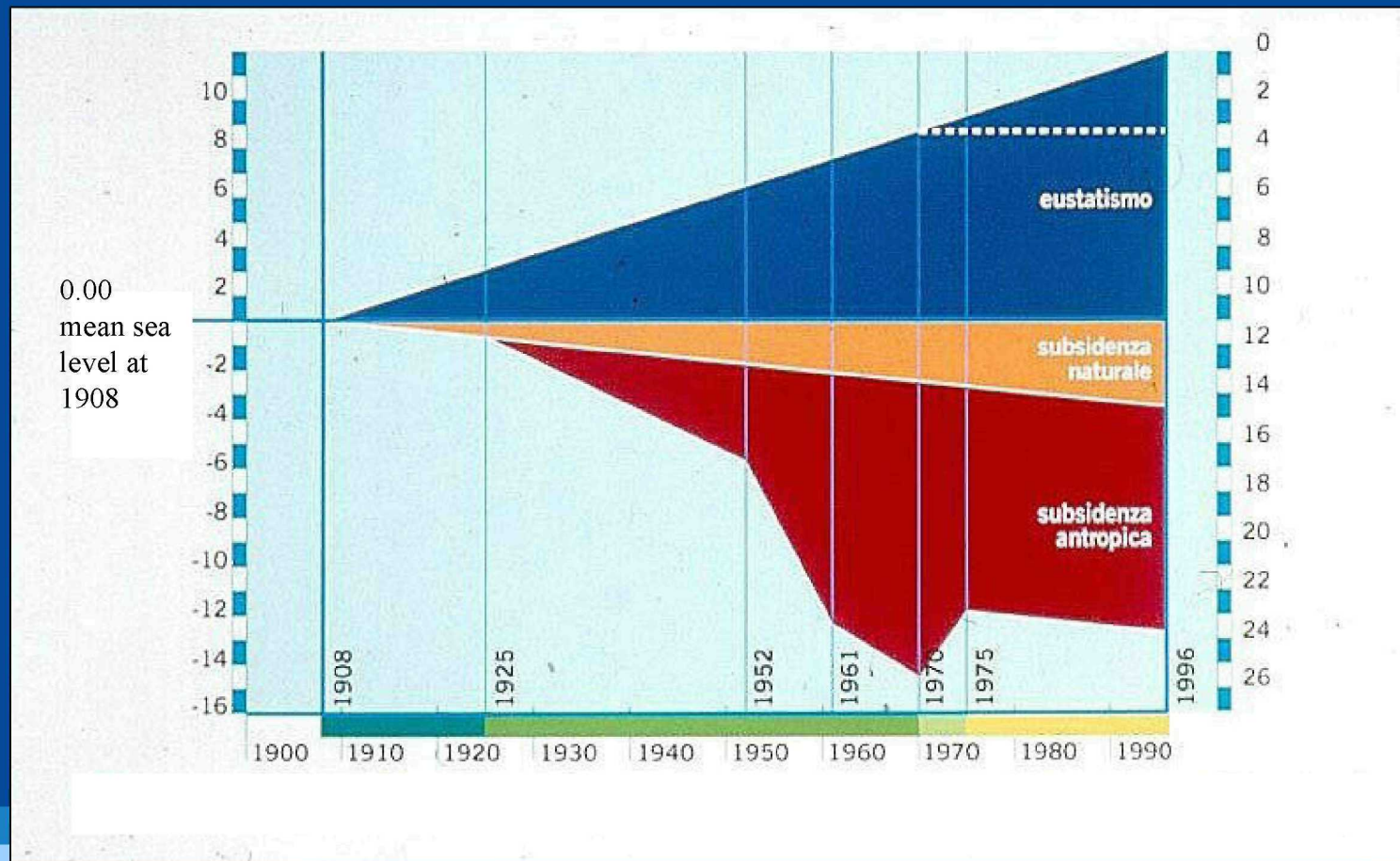
Subsidence
0.9 mm/yr

The RSL rise in the last three centuries

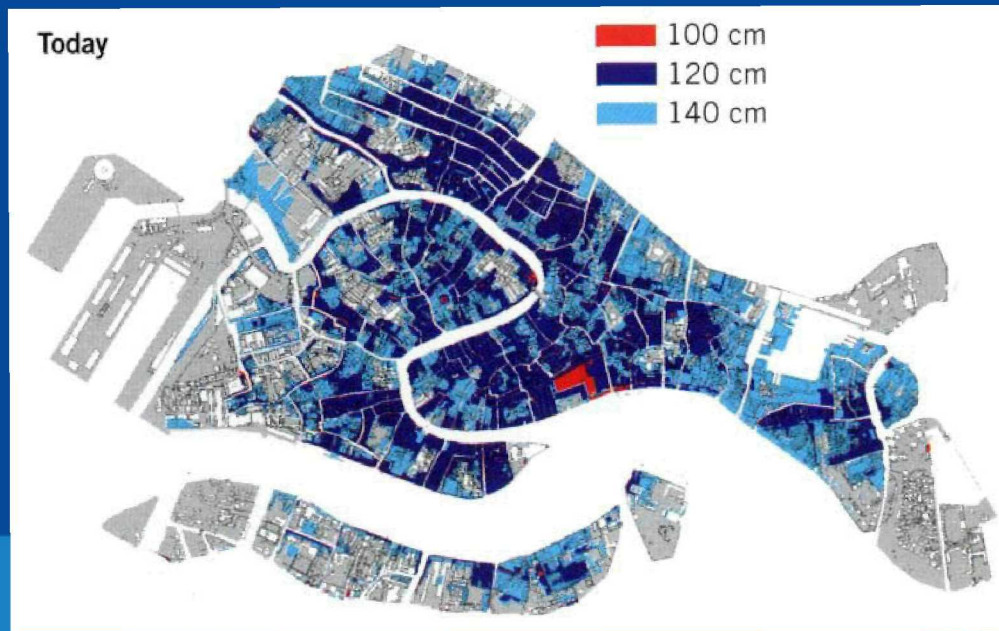
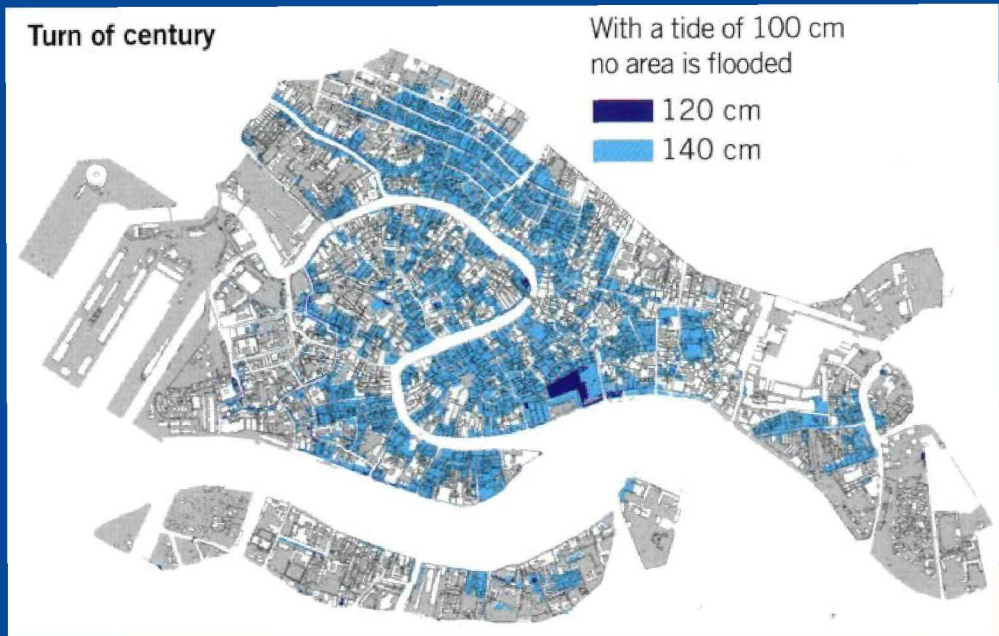


Eustacy and subsidence in Venice

1. Natural subsidence
2. Eustacy
3. Anthropogenic subsidence

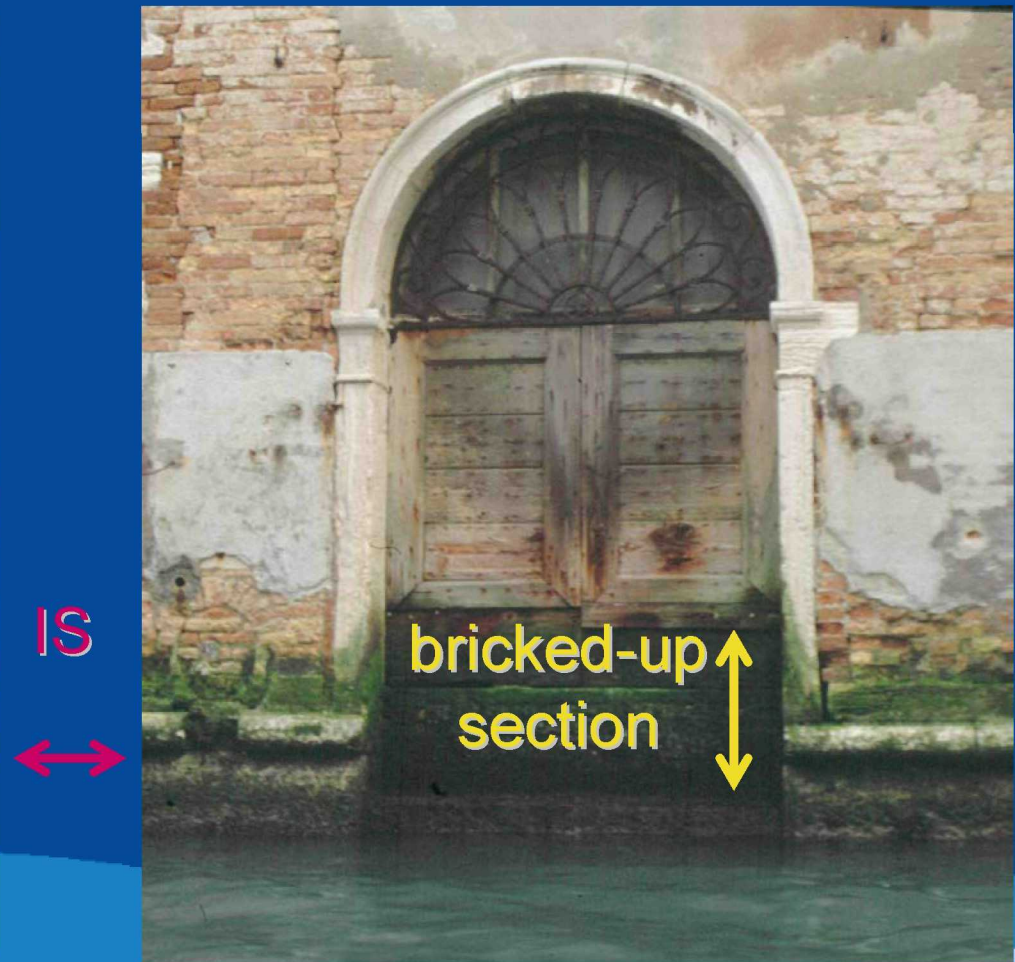
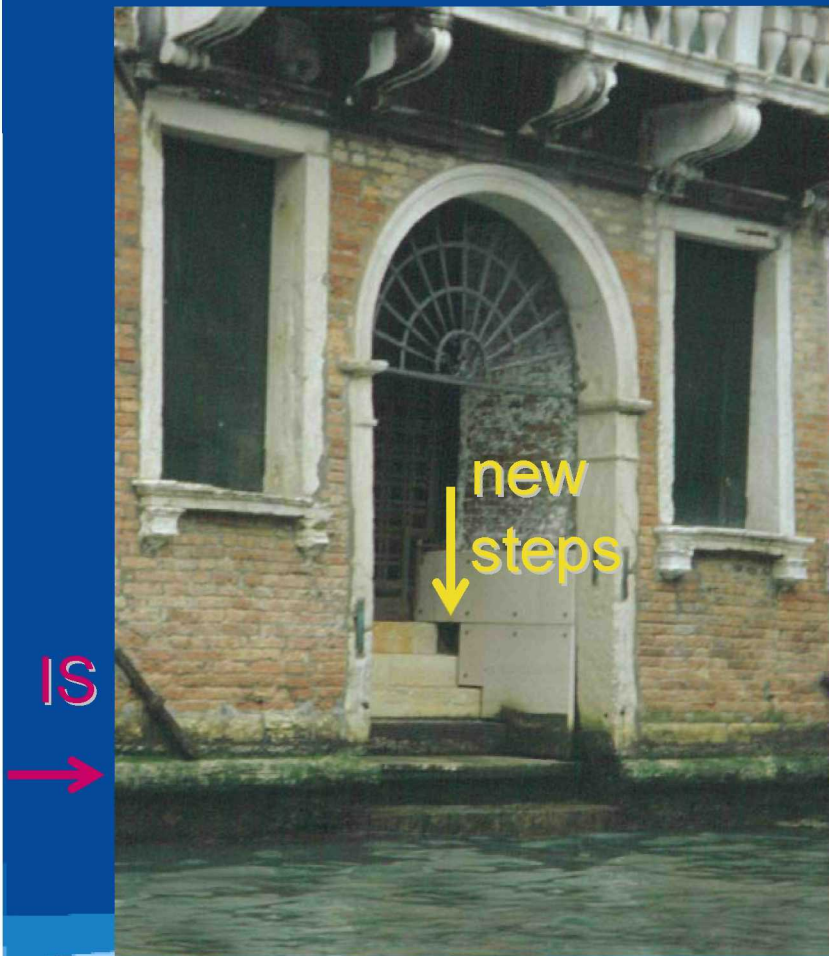


City areas subjected to flooding with same high tide



Consequences for buildings

Most of the Venice buildings have a row of non-permeable Istria stone (IS) to stop capillary rise...



The position of Venice and meteo forces



The Flooding Problem

Relative Sea Level Rise

- 1) Land Subsidence
(natural + anthropic)
- 2) Sea Level Rise
(climate change)

+

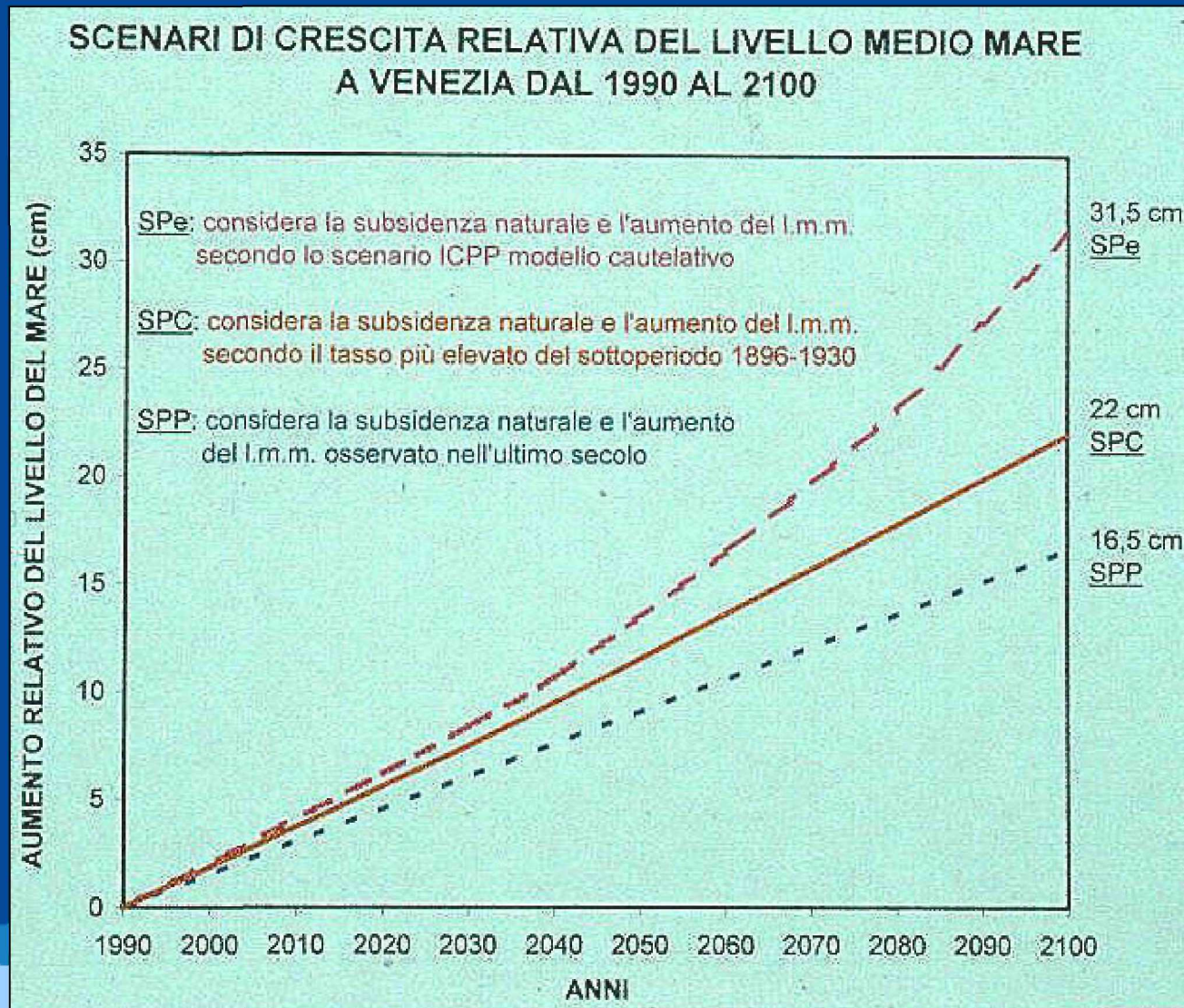
Fluctuations in Sea Level

- 1) Storm Surges (Sirocco + Bora Wind, air pressure field)
- 2) Sea Surface Oscillations
(seiches)
- 3) Tides (max at syzygy)
- 4) Dynamic Factor
(sea-lagoon exchanges)



Flooding tide = *Acqua Alta*

Relative sea-level rise scenarios



Morphology and erosion

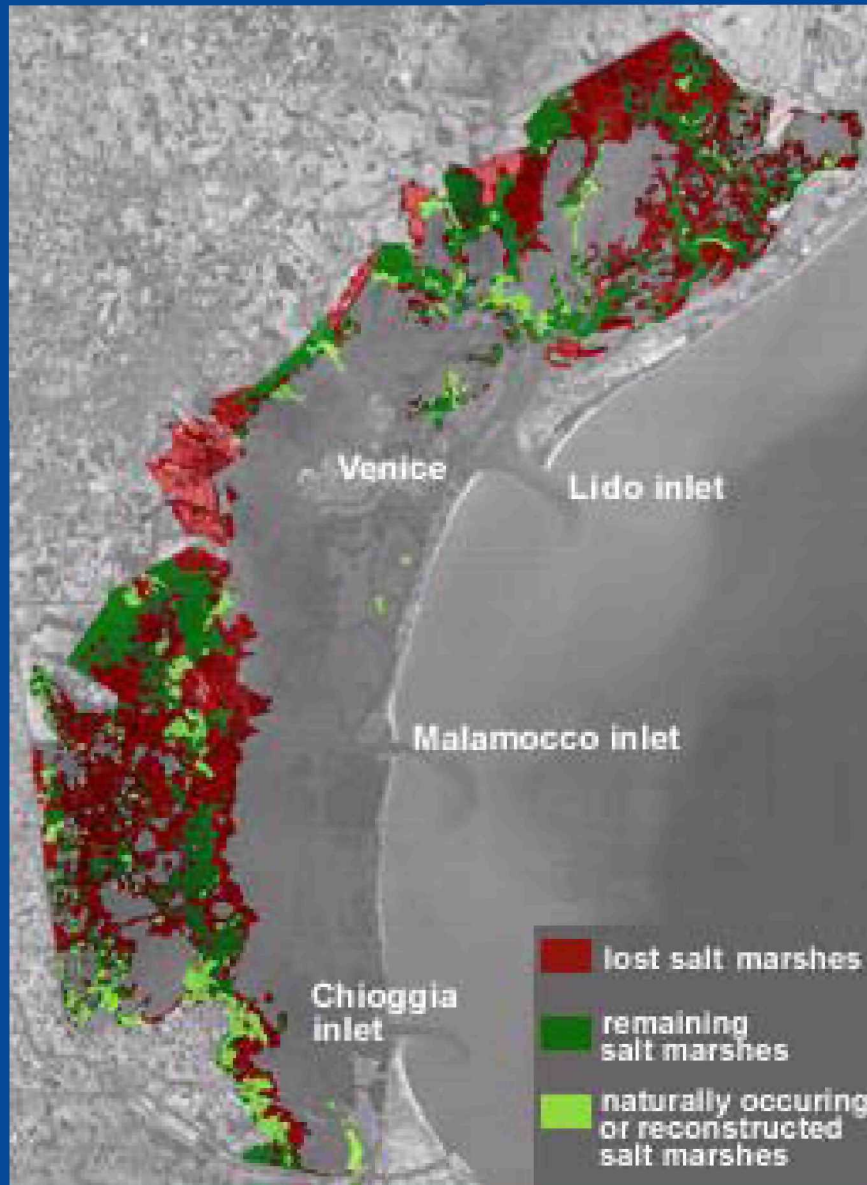


The lagoon morphology

- The lagoon is a wetland coastal area in a continual state of instability and movement of water inside it is governed by the tide.
- The lagoon morphology depends on the relationship between the amounts of solid material brought by the sea or the rivers and the erosive forces of waves and seas.
- The physical shape of the lagoon is modified and formed through the daily entrance and exit of the sea through the lagoon inlets. The sea can also be considered one of the main risk factors involved in the evolution of the lagoon basin, especially if the erosive actions of wave motion and coastal currents predominate over the build up of sediment accumulation.

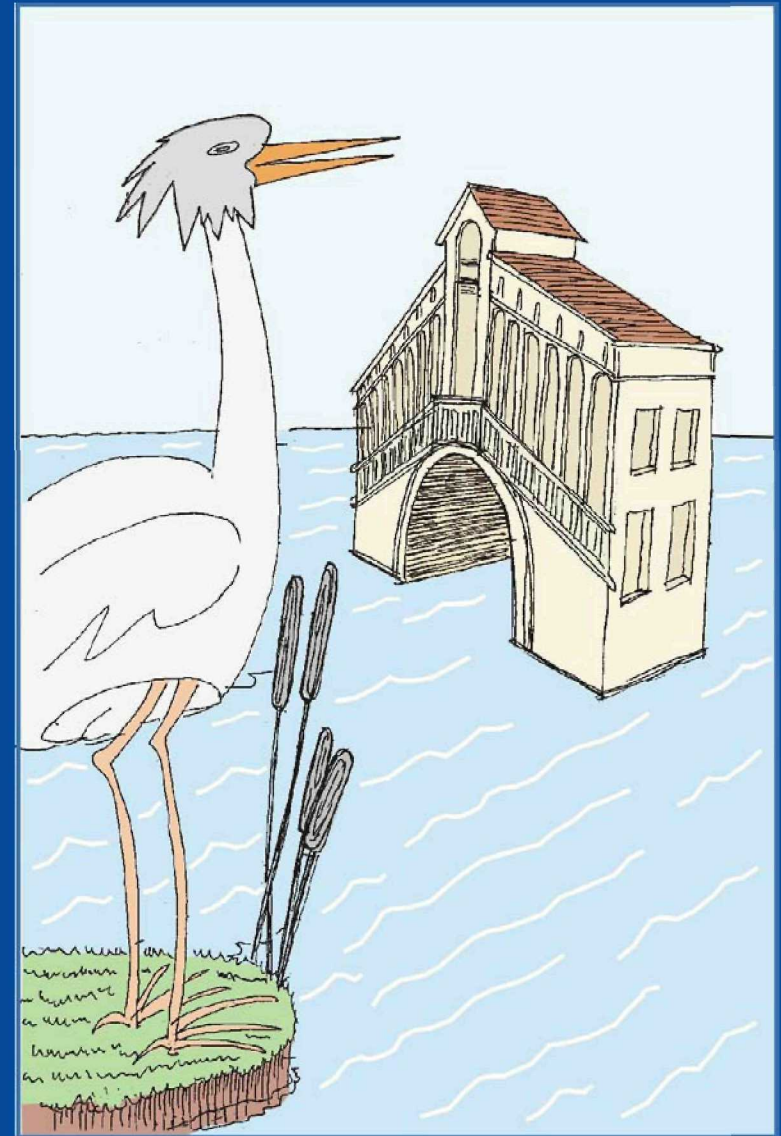
The erosion

The current evolutionary tendency of the lagoon towards erosion is clearly shown by the progressive disappearance of salt marshes (the red areas).

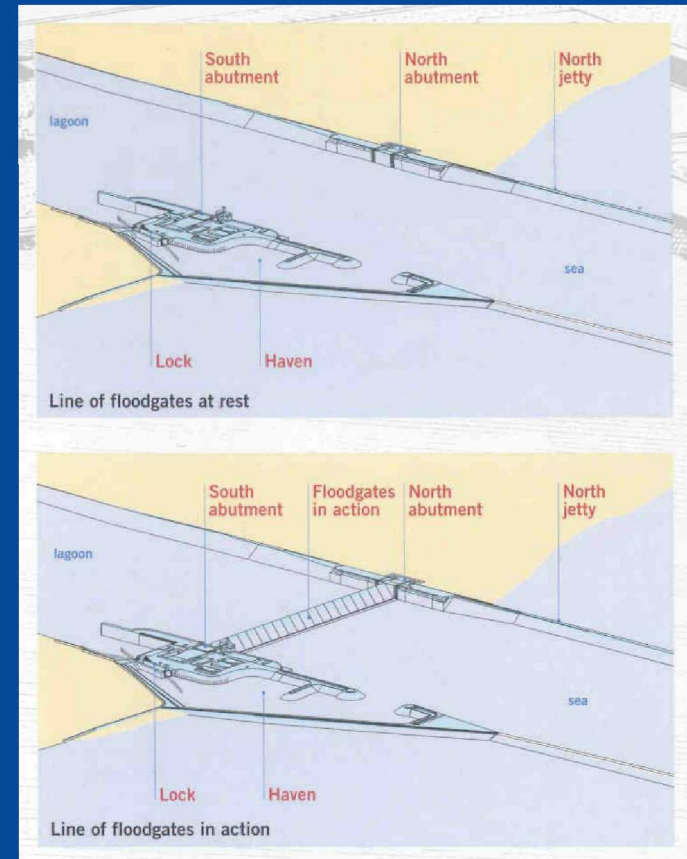
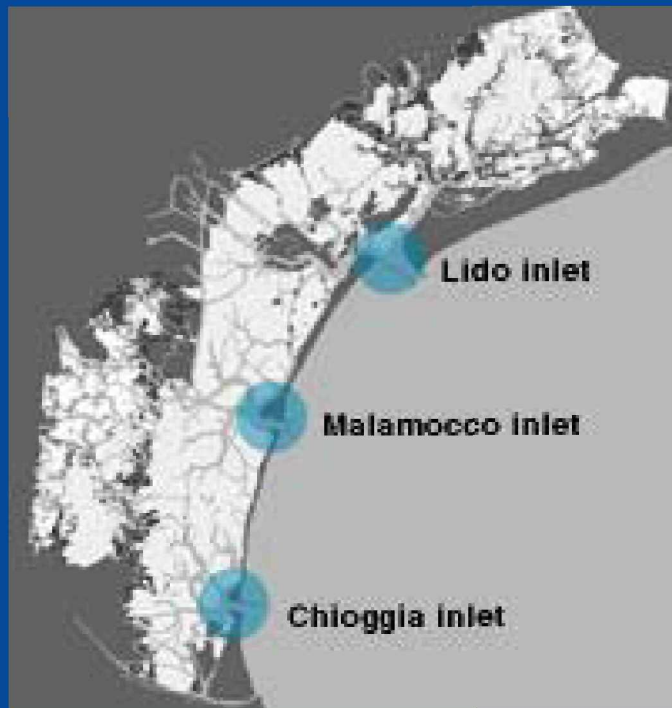


MAV picture

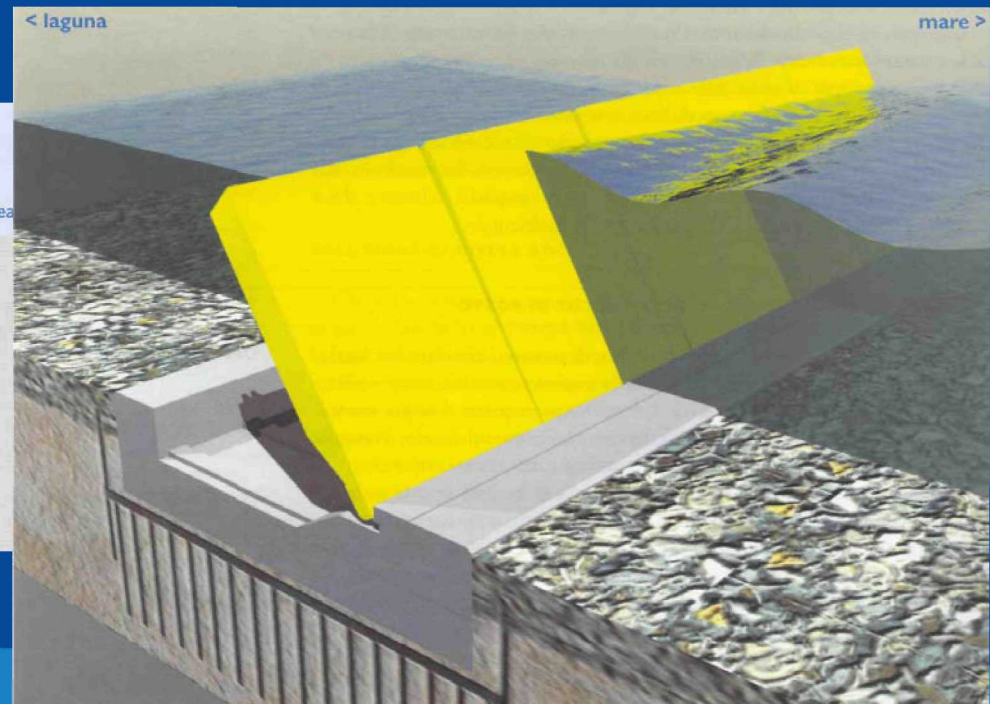
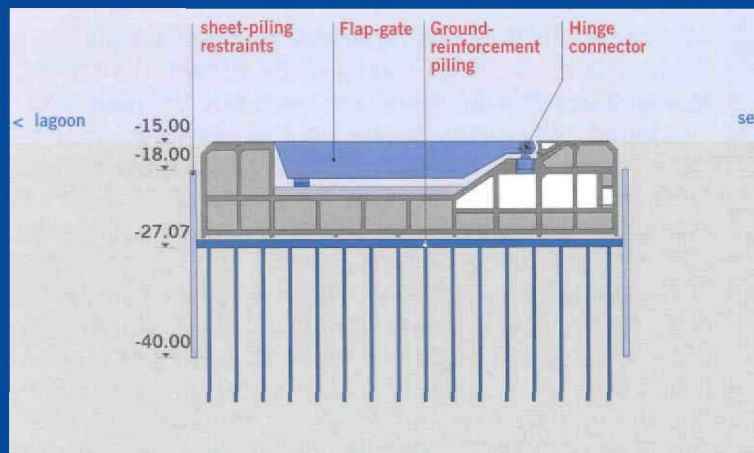
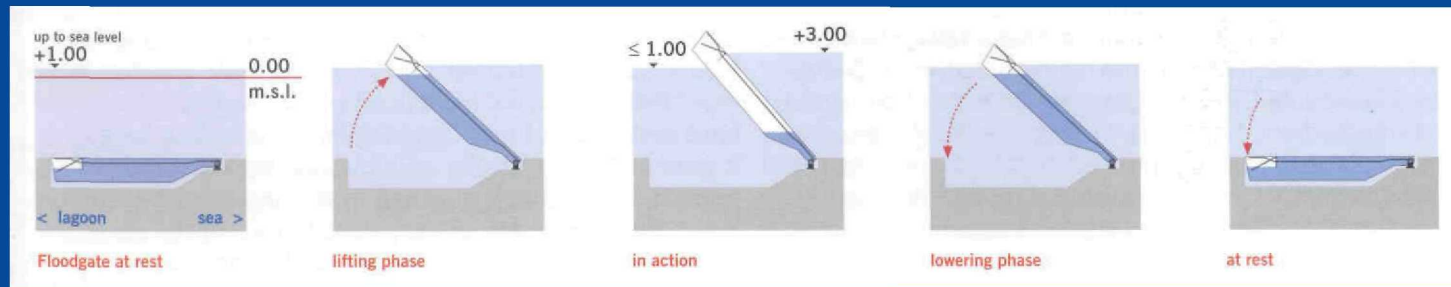
The Venice Lagoon is a delicate environment, very sensible to global and local changes. Sophisticated research and technology are required to protect both the city and its lagoon



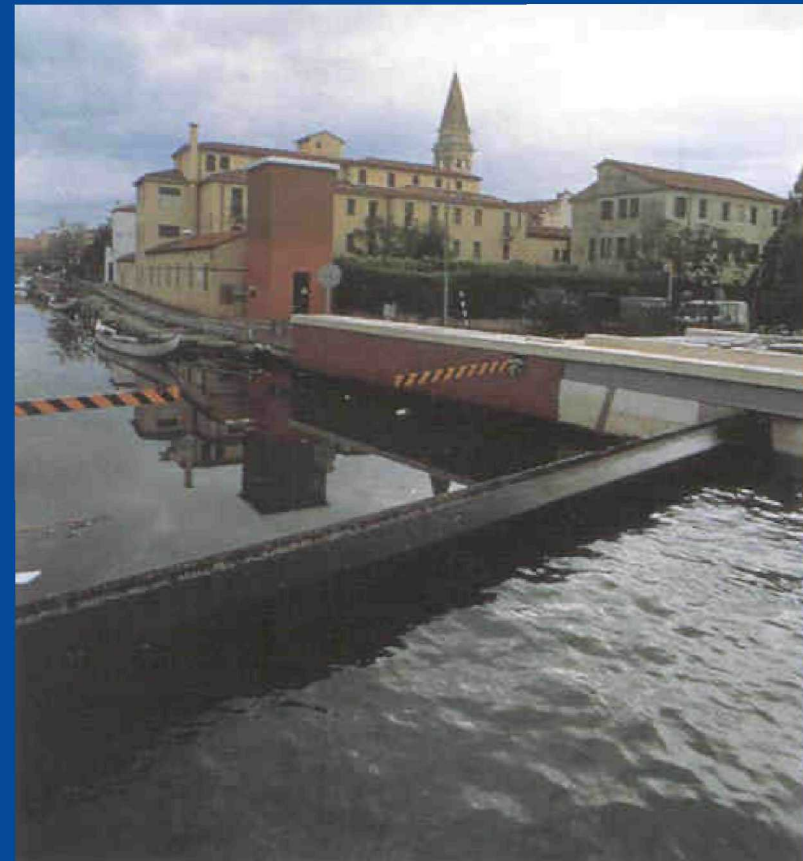
Mobile flood barriers



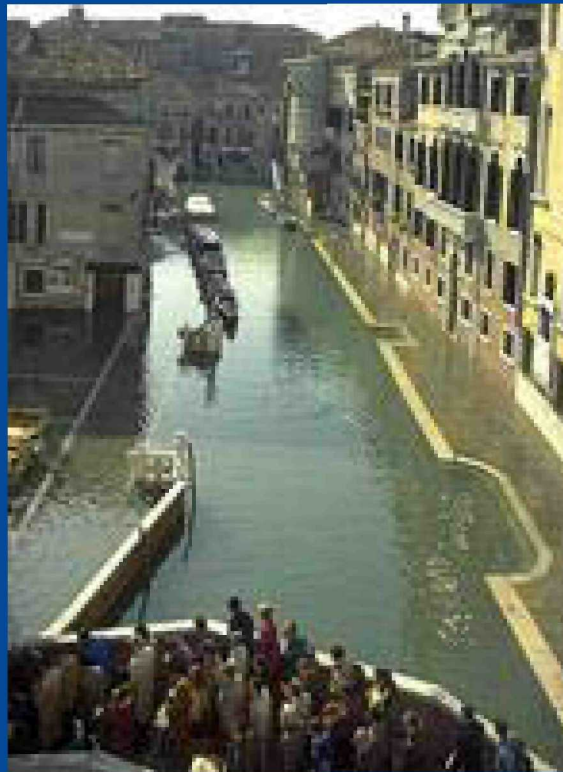
Mobile flood barriers



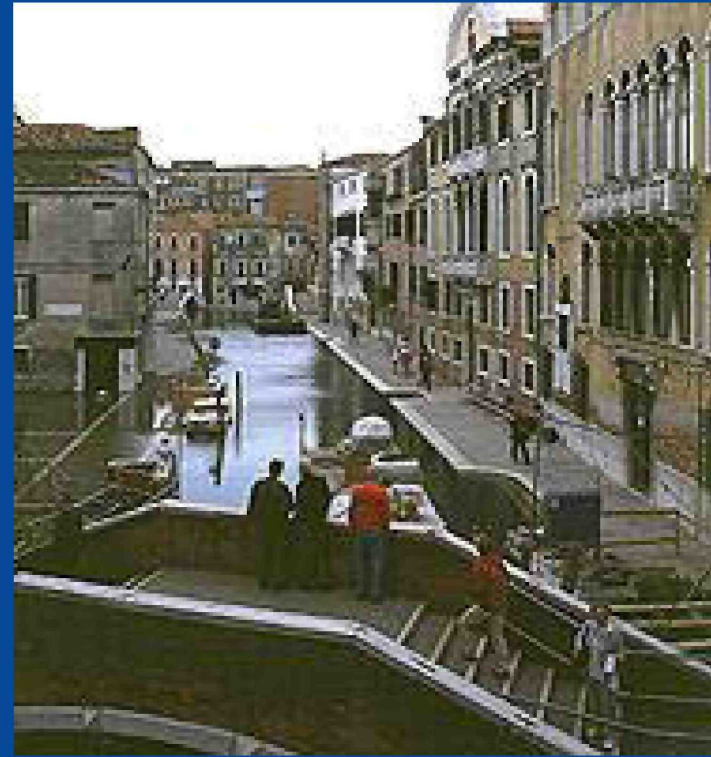
Local defences : Malamocco



RAISING PAVEMENTS : Tolentini



before

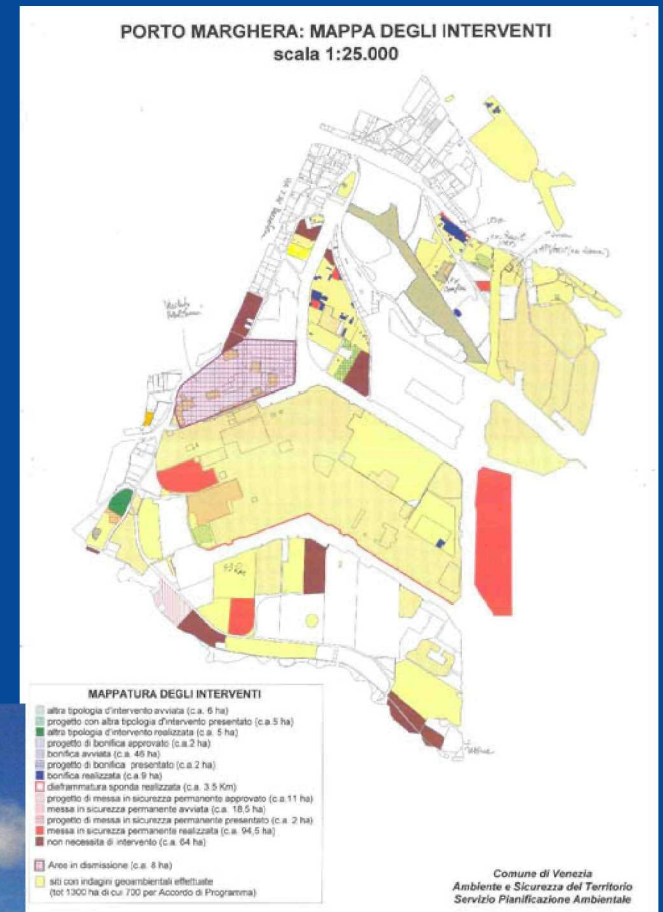
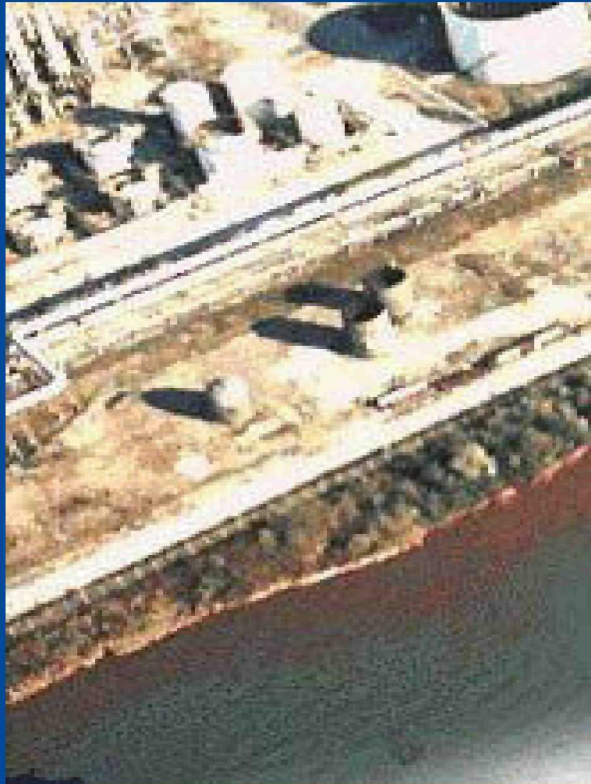


after

Sea Defences



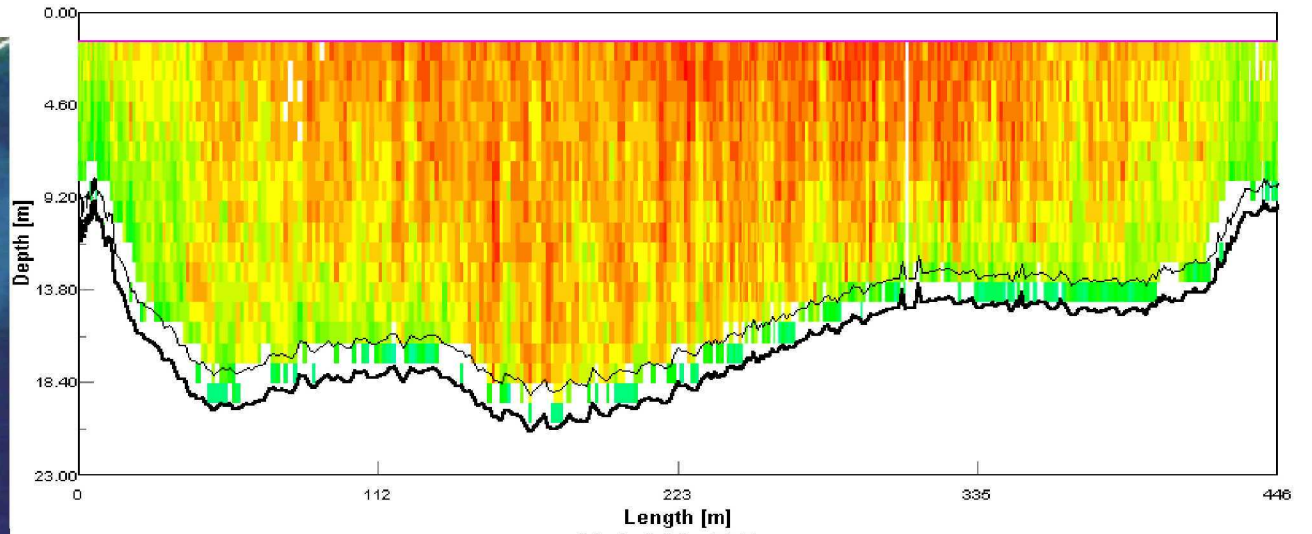
Reclamation of polluted sites





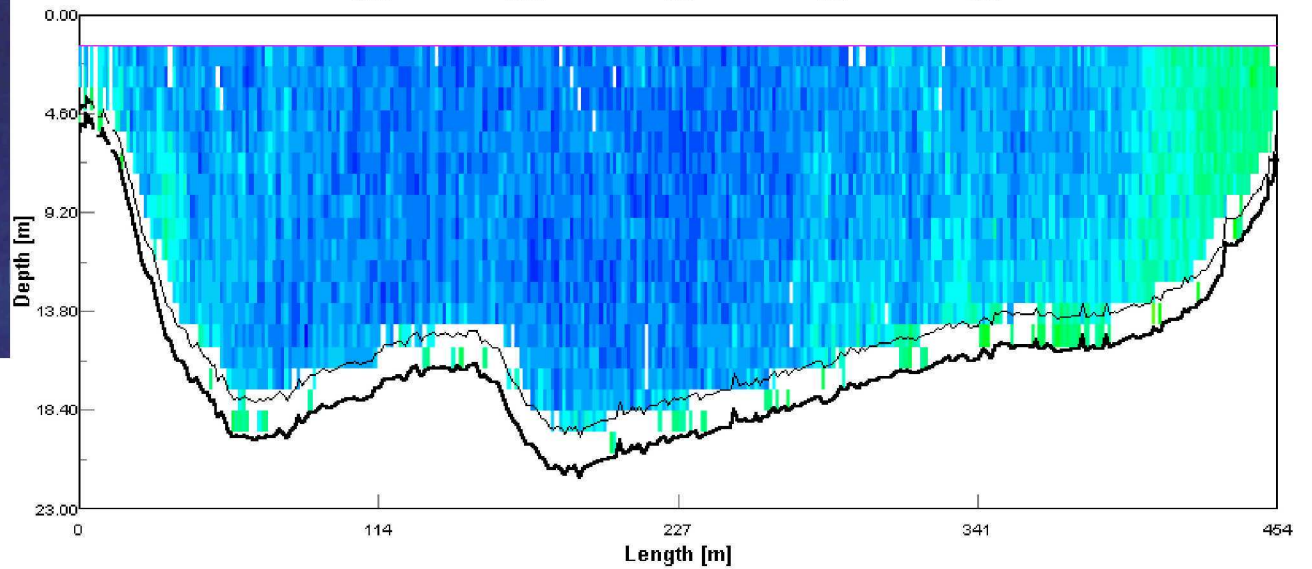
Mala1001r.000
01-03-09

110.0° Projected Velocity [m/s] (Ref: Btm)

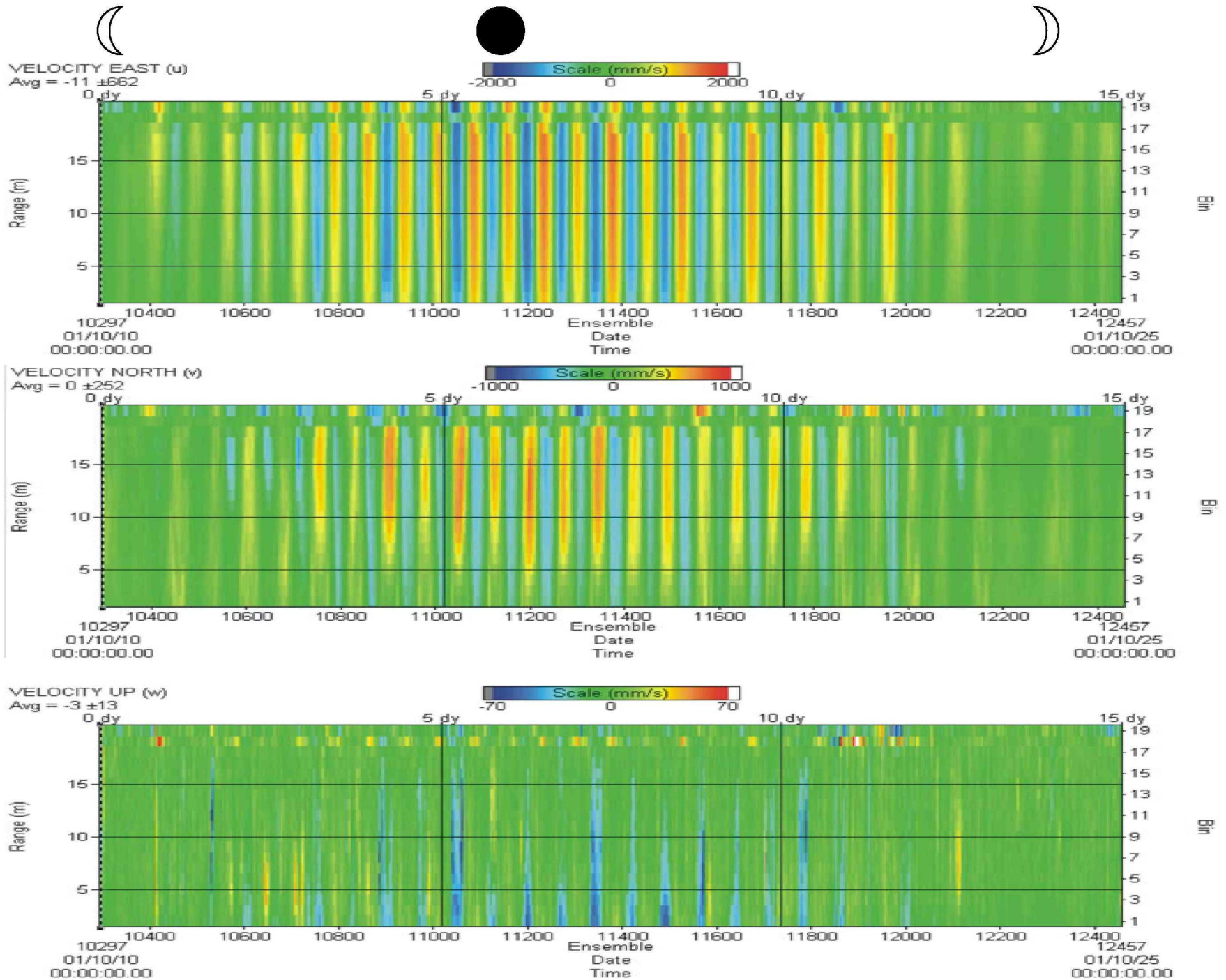


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110.0° Projected Velocity [m/s] (Ref: Btm)

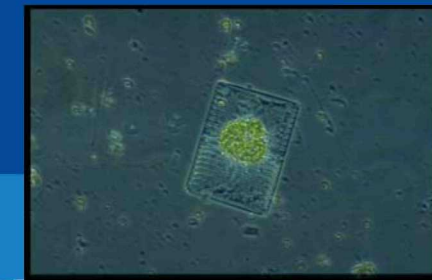


Malamocco East

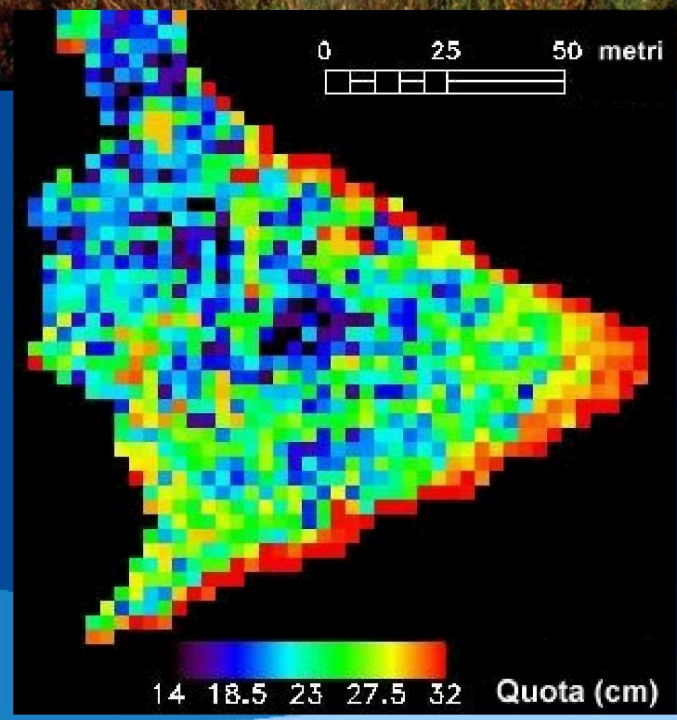
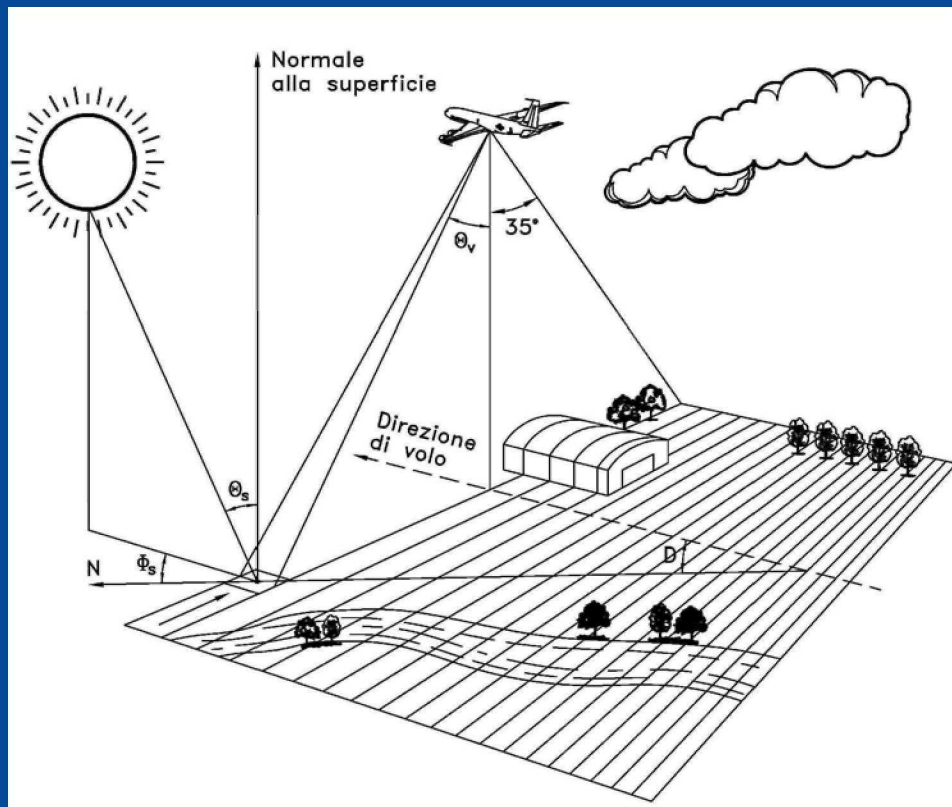


Examined parameters

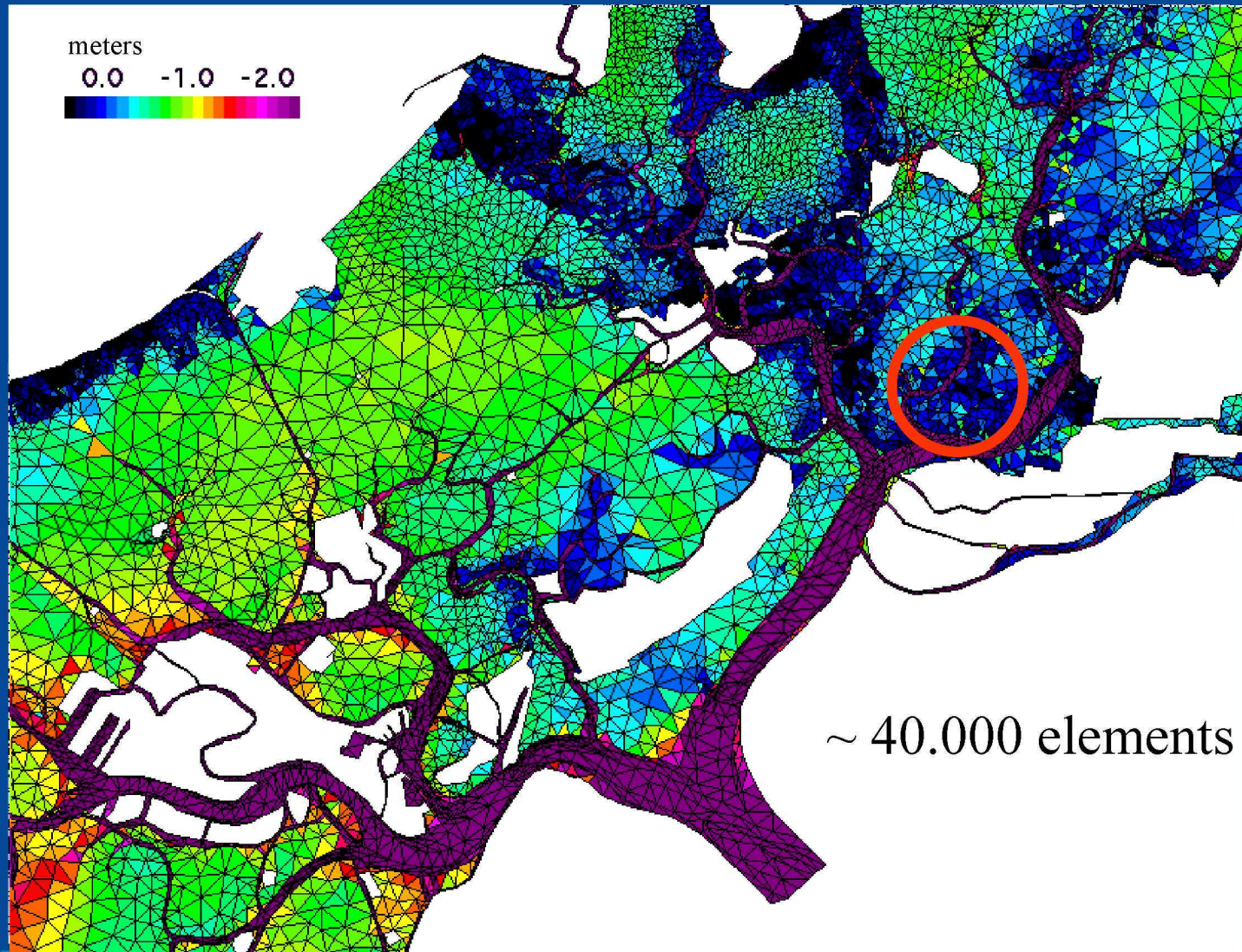
- Temperature
- Salinity
- Dissolved oxygen
- pH
- In-situ transmittance and fluorescence
- Dissolved macronutrients (ammonia, nitrous, nitric nitrogen, orthosilicate, orthophosphate)
- a chlorophyll
- Particulate organic carbon and nitrogen
- Organic dissolved carbon
- Suspended matter
- Dimensional spectrum of the particles
- Fito- and zooplankton abundances, with their relative taxonomic distribution



Study of tidal forms and vegetation using remote sensing techniques

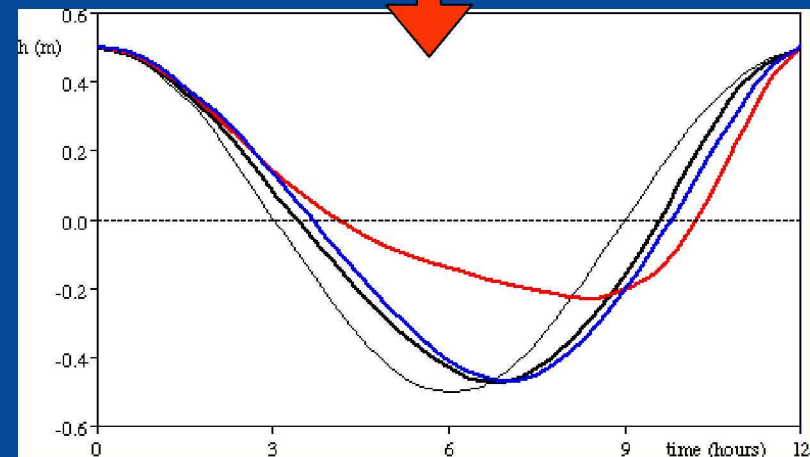
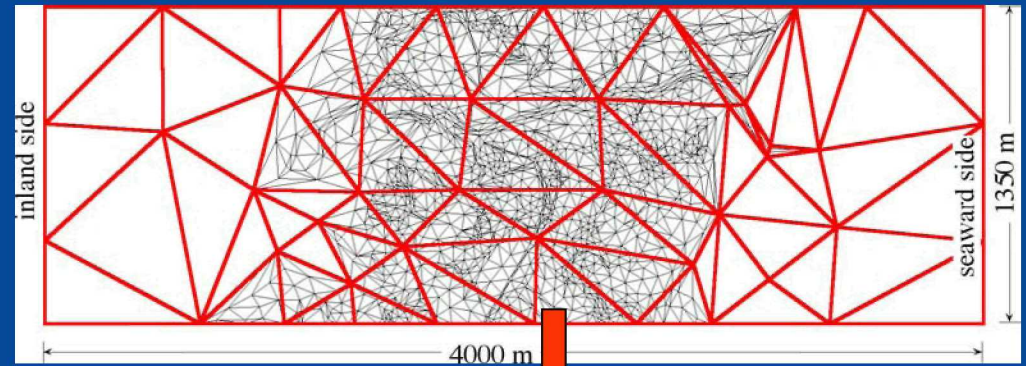
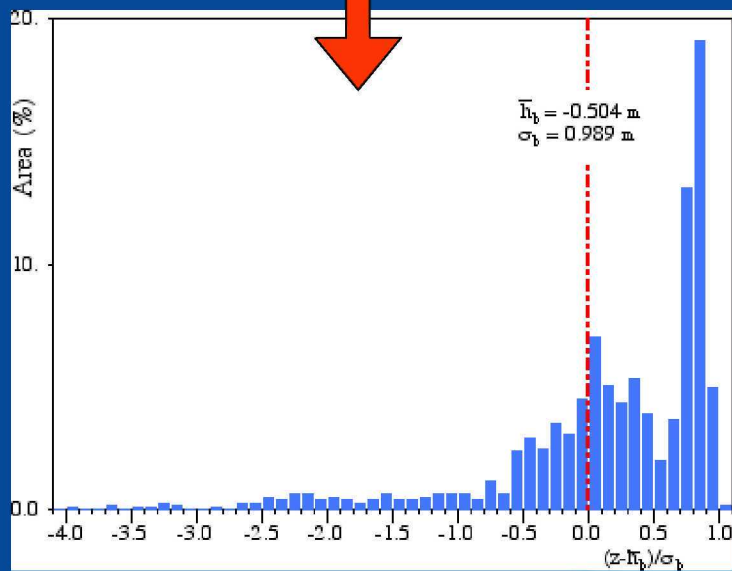
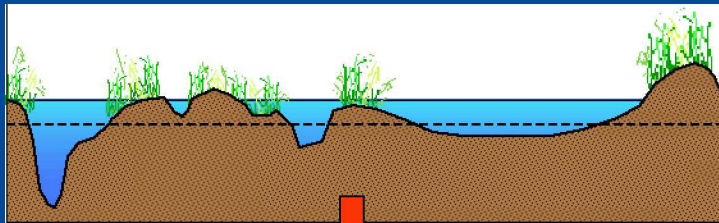


Models



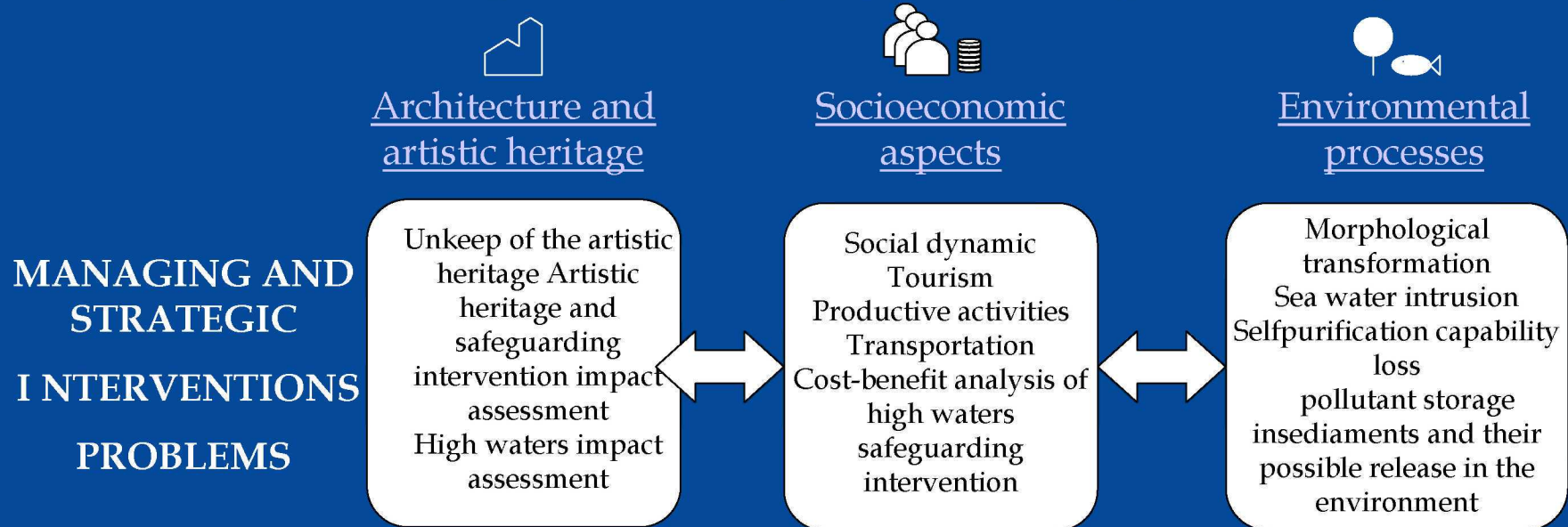


Subgrid schemes for models





Knowledge and safeguarding strategies



**CORILA
RESEARCH
PROGRAMME**

Lagoon of Venice



Research lines

Economy

Architecture
and
cultural
heritage

Environmental
Processes

Data
management



Socioeconomical evaluation of environmental interventions

The defence from waters and the conservation of architectural heritage

Climatic trends, global changes and local effects

Hydrodynamic and morphology

Efficiency of the lagoon metabolism

Chemical contamination

Quality and quantity of the exchanges between the lagoon and the sea

Biodiversity in the Venice lagoon

Predictive and management models

Data acquisition and diffusion

Conclusions

- The morphology and the biodiversity of the lagoon, as well as the artefacts and the social system, are adapting to “new” forces (anthropogenic and natural), but the process description is not still completed: more inter-disciplinary research is needed.
- Venice and its lagoon represent a “case study” very sensible to global changes
- Long data series, wide and deep analyses, sophisticated instruments are already available for promoting of a better understanding and a more efficient management of this unique environment, and the knowledge may be useful in many other parts of the world

What next

- 15-17 September 03, Cambridge UK, International meeting Venice flooding protection and ecosystem
- Spring 2004, Venice I, International Conference on Lagoons and Global Changes (*Unesco support*)

www.corila.it

www.coastwet.net