ACT Conference 2010
Adapting to Climate Change in time
Ancona
14th december 2010

Communicating what's happening:

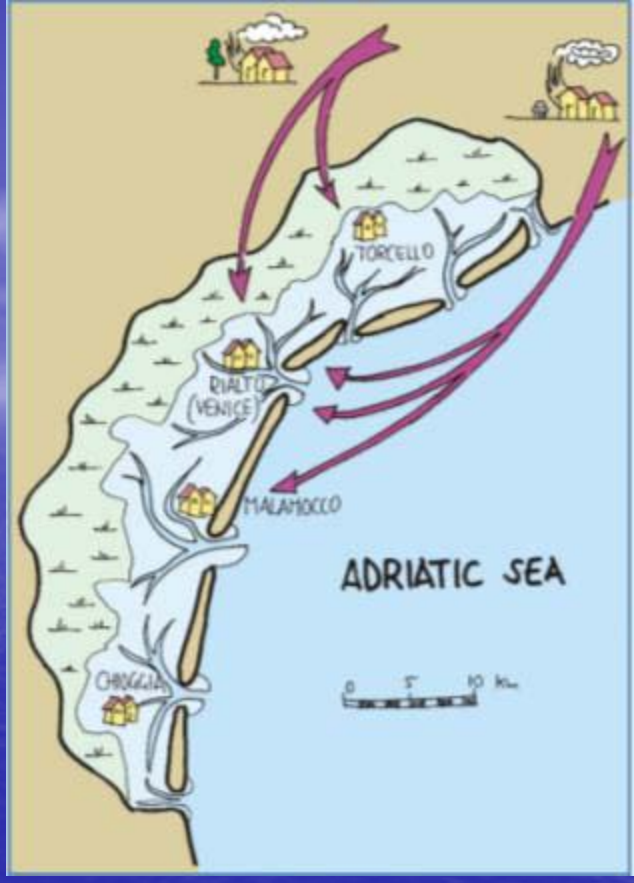
the experiences of the Civil Protection in the City of Venice

Marco Calligaro
Francesco Vascellari
MUNICIPALITY OF VENICE
Civili Protection

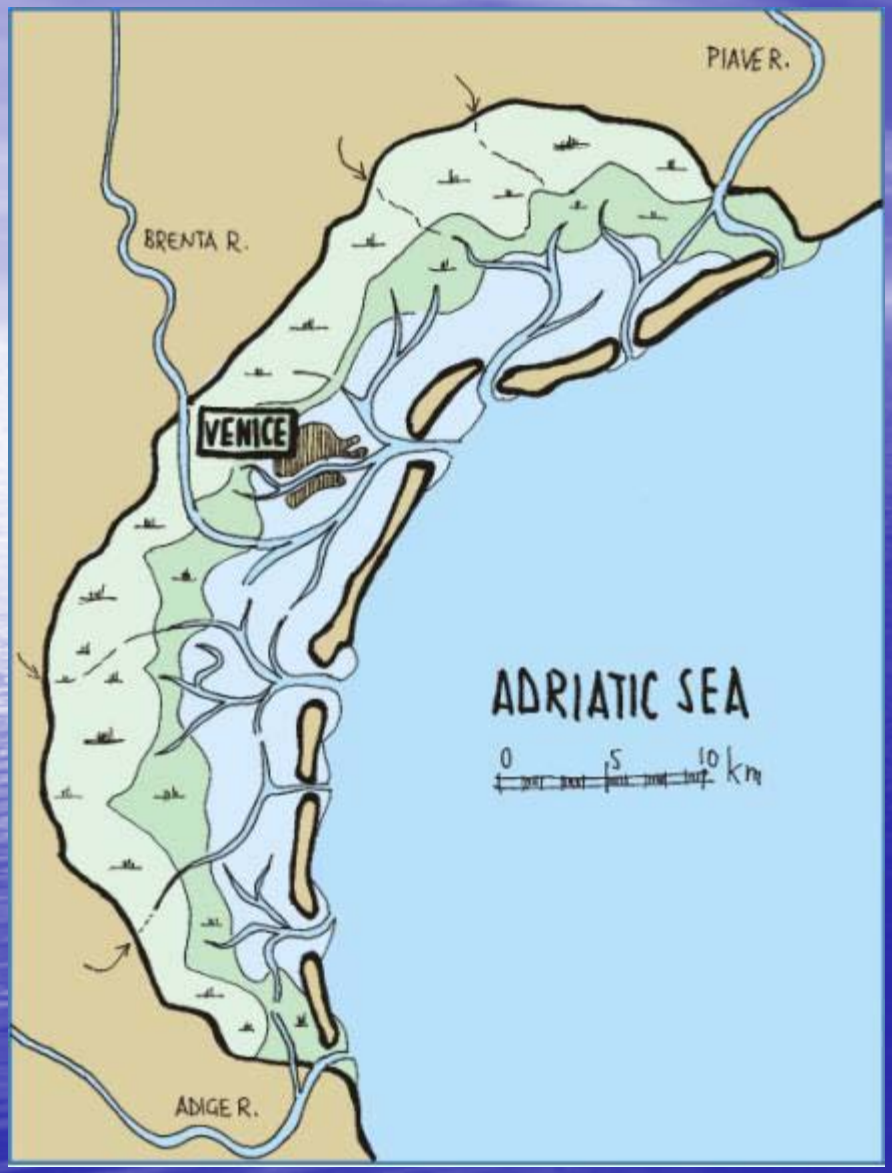
Pierpaolo Campostrini
CORILA, Director
Consortium for Managing Research Activities in the Venice Lagoon

The History

The main reason for building a city in a tidal lagoon of the northern Adriatic sea, was looking for refuge under the pressure of repeated invasions of the V-VI century. Around the 810 AD the Head of these small settlements (the Doge) moved from Malamocco to Rialto (Venice)



Problems were turned into opportunities and in the XIV century Venice was already one of the richest cities of Europe and the *Serenissima Repubblica* a great power of the Mediterranean.



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

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

Location: 45 10' N 12 40' E, Length: ab. 51km. Width: ab. 12 km. Perimeter: 157km.

Total surface: 540km^2, of which 8% land above sea level (littorals, reclaimed areas, islands, embankments) and 92% "water system": channels (11,9%), shallows, mud flats and salt marshes (80,1%).

Channels and open waters (depth >150cm): 66km^2.

Shallows (depth between 150 e 40 cm): 243km^2.

Mud flats (inertial areas between –0.40 and +0.24 on the m.s.l.): 98km^2.

Salt marshes (areas higher than +0.24m, but flooded by high tide): 11km^2.

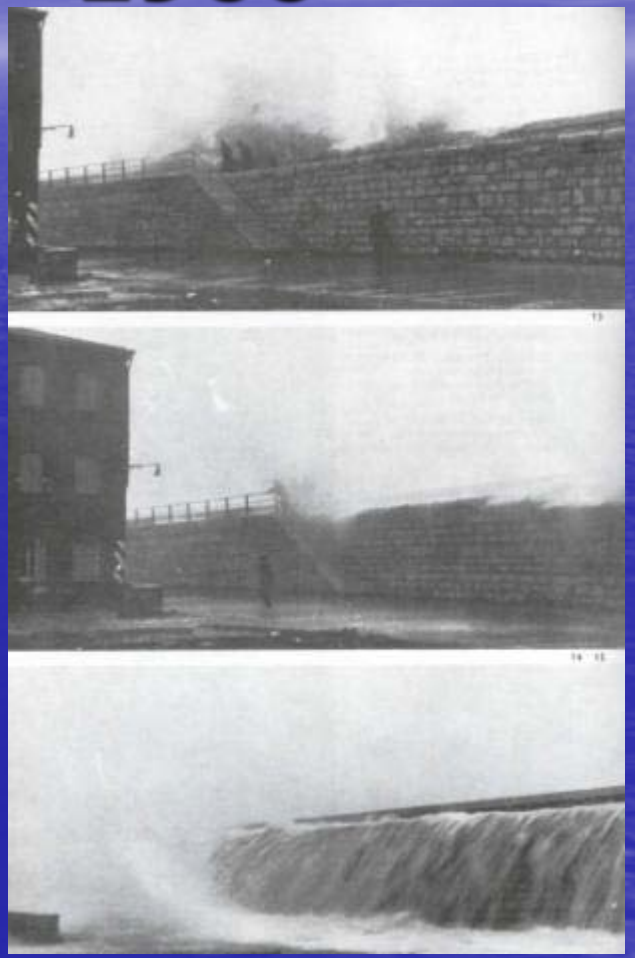
Embanked fish farms: 92km^2.

Islands: 29km^2.

Venice: a dense and fragile city

- The “acqua alta”
- Danger of flooding
- Fire hazard
- Mass tourism
- Environmental weakness and cultural heritage to preserve

4th November 1966



The City altimetry

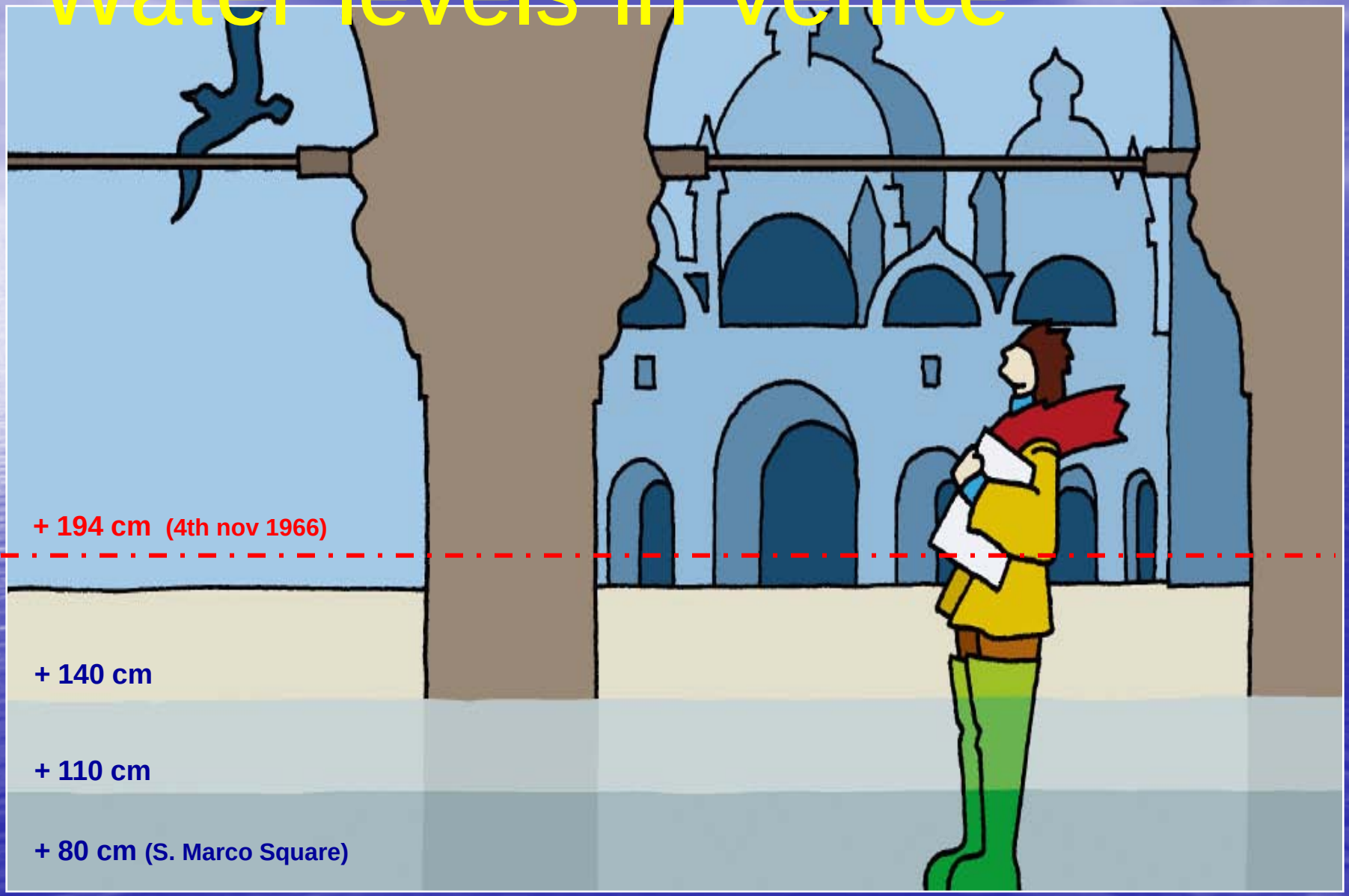
The average height of St. Mark's Square surface is approximately +80 cm

About 70% of the city lies below the height of +160 cm

INTERVAL BETWEEN THE ISOPSES M	PARTIAL SURFACE		PROGRESSIVE SURFACE	
	Area (mq)	Percentage %	Area (mq)	Percentage %
fino a 0.90	17713	1.84	17713	1.84
da 0.91 a 1.00	32159	3.33	49871	5.17
da 1.01 a 1.10	85662	8.88	135534	14.04
da 1.11 a 1.20	141950	14.71	277493	28.75
da 1.21 a 1.30	138936	14.40	416420	43.15
da 1.31 a 1.40	108446	11.24	524866	54.39
da 1.41 a 1.50	82913	8.59	607779	62.98
da 1.51 a 1.60	62207	6.45	669987	69.43
da 1.61 a 1.70				74.20
da 1.71 a 1.80				78.11
da 1.81 a 1.90				82.39
da 1.91 a 2.00				86.40
oltre i 2.00				

In a Δ=80 cm about 70% of the city is flooded

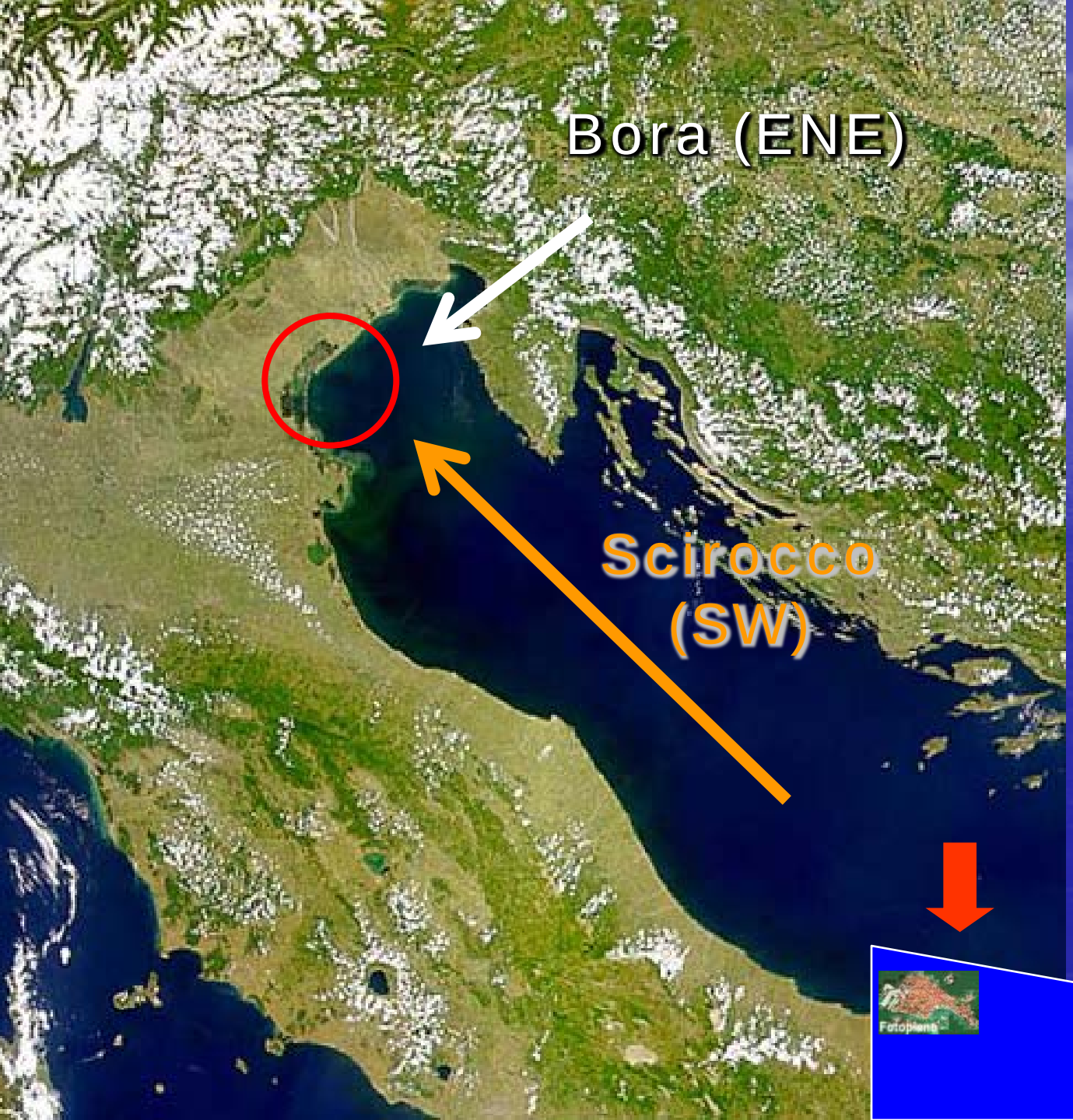
Water levels in Venice



The tide mechanisms

The three weather conditions which play a major role in tide level are:

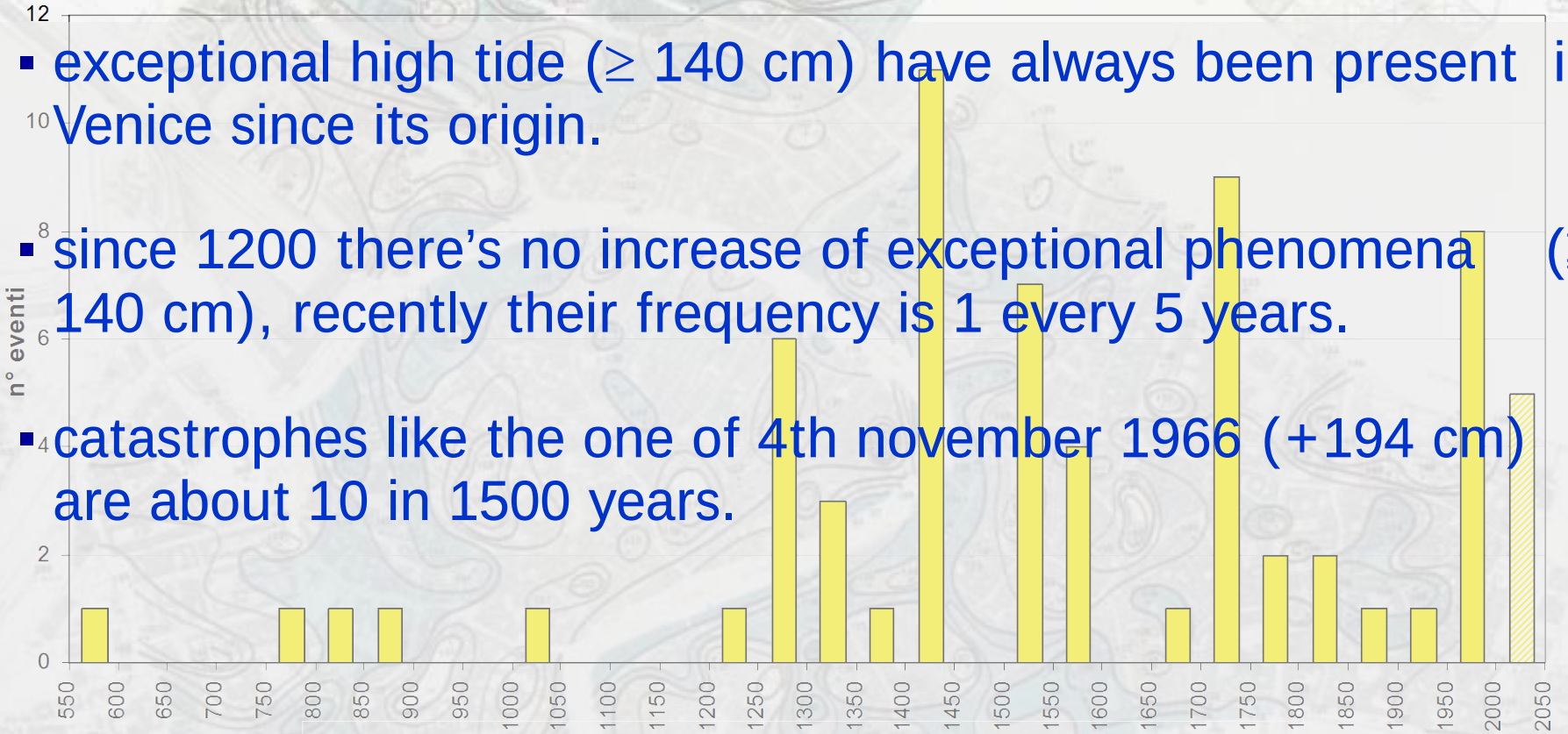
- ***Atmospheric pressure***
- ***Wind***
- ***The “sessa” wave***



A difference in atmospheric pressure of 1 hPA between the two extremities of the Adriatic sea produces a difference in the level of marine surface of approx. 1 cm

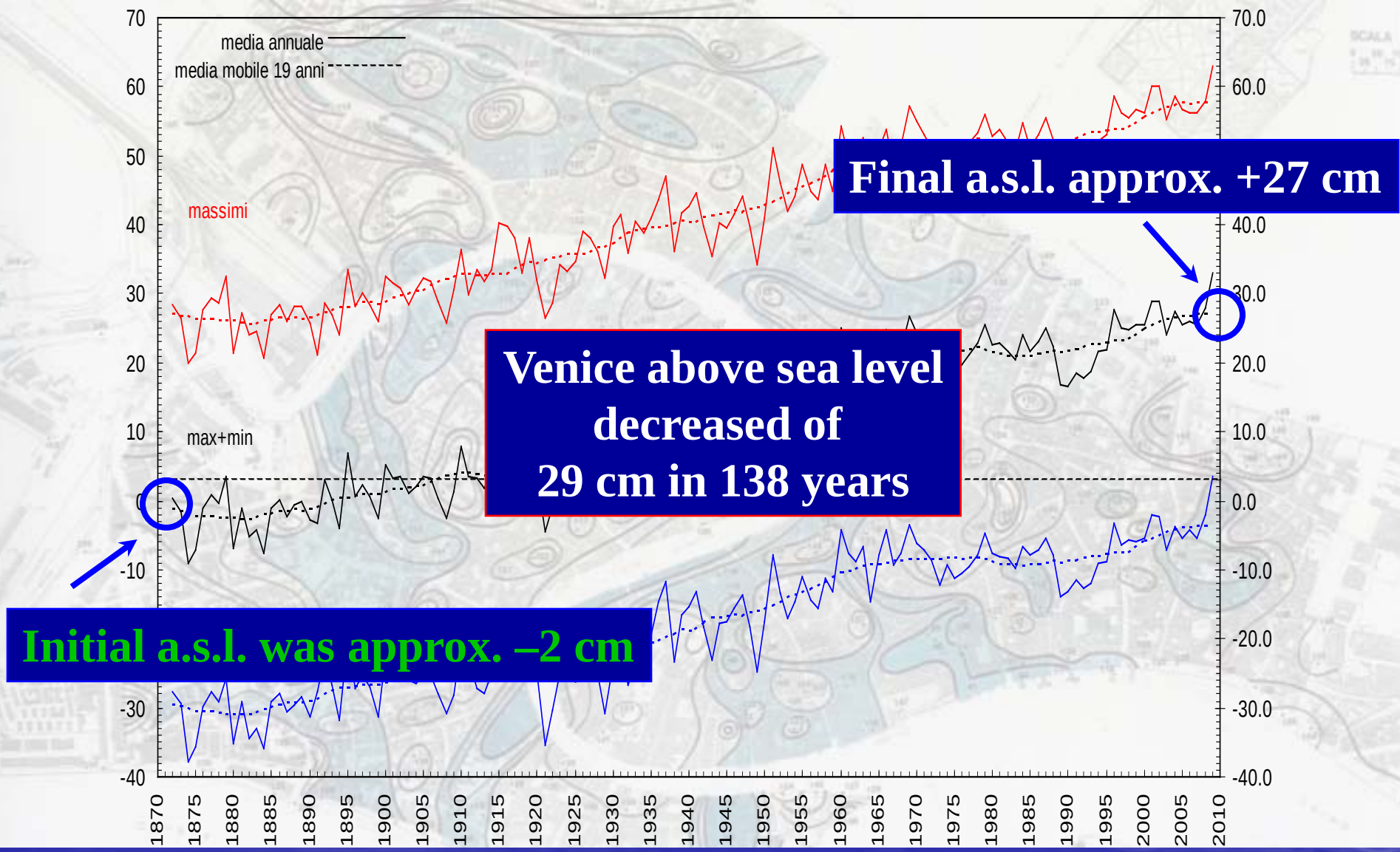
Exceptionally high tides (>140 cm)

- exceptional high tide (≥ 140 cm) have always been present in Venice since its origin.
- since 1200 there's no increase of exceptional phenomena (≥ 140 cm), recently their frequency is 1 every 5 years.
- catastrophes like the one of 4th november 1966 (+194 cm) are about 10 in 1500 years.



Distribuzione delle acque alte eccezionali nella storia di Venezia fino al 2010

Sea level trend in Venice



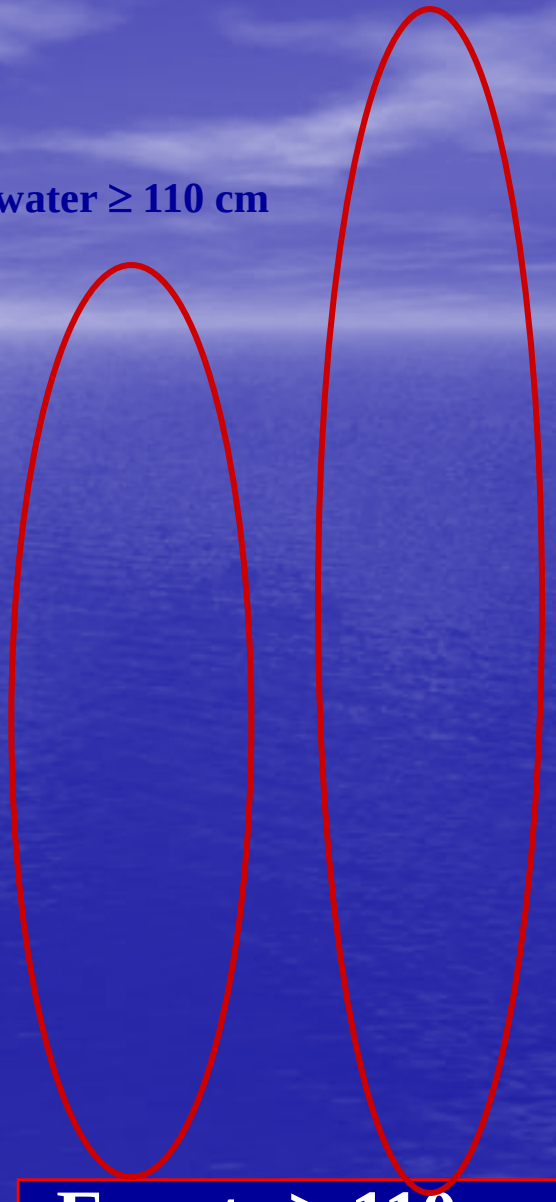
Final a.s.l. approx. +27 cm

Venice above sea level decreased of 29 cm in 138 years

Initial a.s.l. was approx. –2 cm

Decennial frequency high water ≥ 110 cm

Decennial frequency:
events ≥ 110 cm
increased ~ 15 times



Events ≥ 110 cm
Big increase since 1960

CONSEQUENCES OF FUTURE SCENARIOS

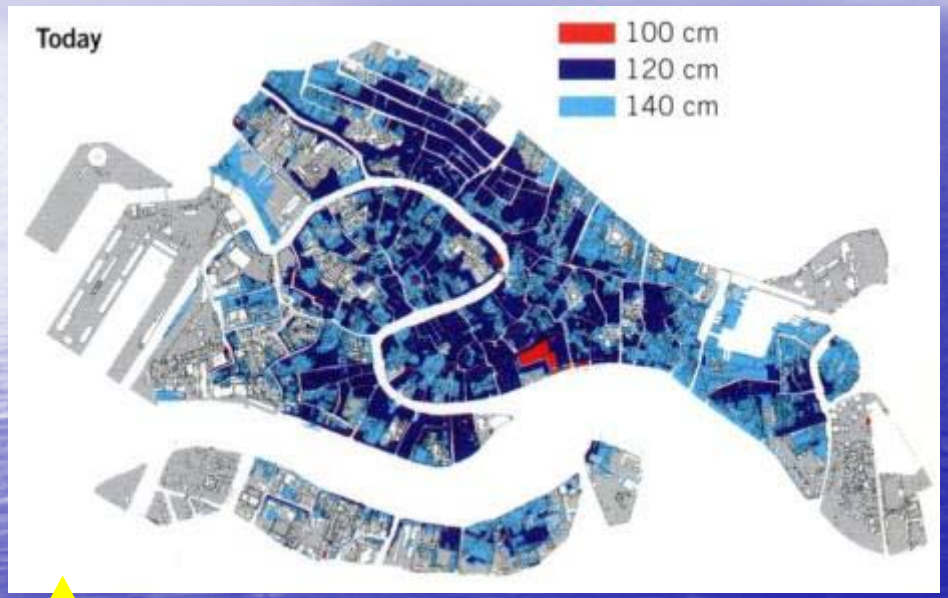
Scenario IPCC most probable (rising of 40 cm):

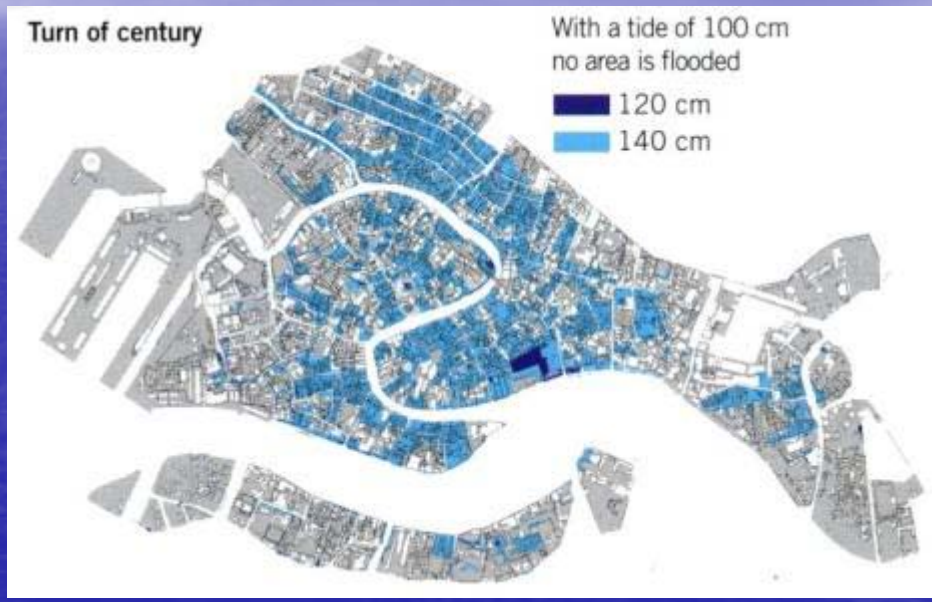
+ 80 cm: from 56 to 553 events

+ 110 cm: from 4 to 133 events

	PERIODO CONSIDERATO 1966-2009					
Livelli di marea	PERMANENZA ore	min	n. casi	DURATA MEDIA ore	min	FREQUENZA n. casi/anno
>= 190 cm	0	10	1	0	10	1/44
>= 180 cm	1	30	1	1	30	1/44
>= 170 cm	5	50	1	5	50	1/44
>= 160 cm	9	20	2	4	40	1/22
>= 150 cm	17	40	4	4	25	1/11
>= 140 cm	33	45	11	3	04	1/4
>= 130 cm	73	35	30	2	27	1/1.5
>= 120 cm	175	15	70	2	30	1.6
>= 110 cm	420	10	170	2	28	3.9
>= 100 cm	995	35	420	2	22	9.5
>= 90 cm	2471	15	985	2	31	22.4
>= 80 cm	6288	45	2452	2	34	55.7
>= 70 cm	15741	55	5847	2	42	132.9
>= 60 cm	33633	00	11470	3	05	260.7
>= 50 cm	63605	00	18327	3	44	416.5
>= 40 cm	112054	15	24310	4	37	552.5
>= 30 cm	162079	40	29203	5	33	663.7
>= 20 cm	212804	25	33424	6	22	759.6
>= 10 cm	259612	20	37745	6	53	857.8
>= 0 cm	299033	55	42495	7	00	965.8
< 0 cm	81024	10	18559	4	22	421.8
< -10 cm	49757	10	13433	3	42	305.3
< -20 cm	27950	30	9194	3	02	209.0
< -30 cm	13268	35	5466	2	26	124.2
< -40 cm	4905	05	2356	2	05	53.5
< -50 cm	1417	50	793	1	47	18.0
< -60 cm	354	00	217	1	38	4.9
< -70 cm	74	10	51	1	27	1.2
< -80 cm	12	30	12	1	02	1/3.6
< -90 cm	1	00	2	0	30	1/22
< -100 cm	0	00	0	0	00	0

Effect of relative mean sea level rise





Larger city areas subjected to flooding

Mobile raised walkways

- the raised walkways
- the alternative pedestrian routes

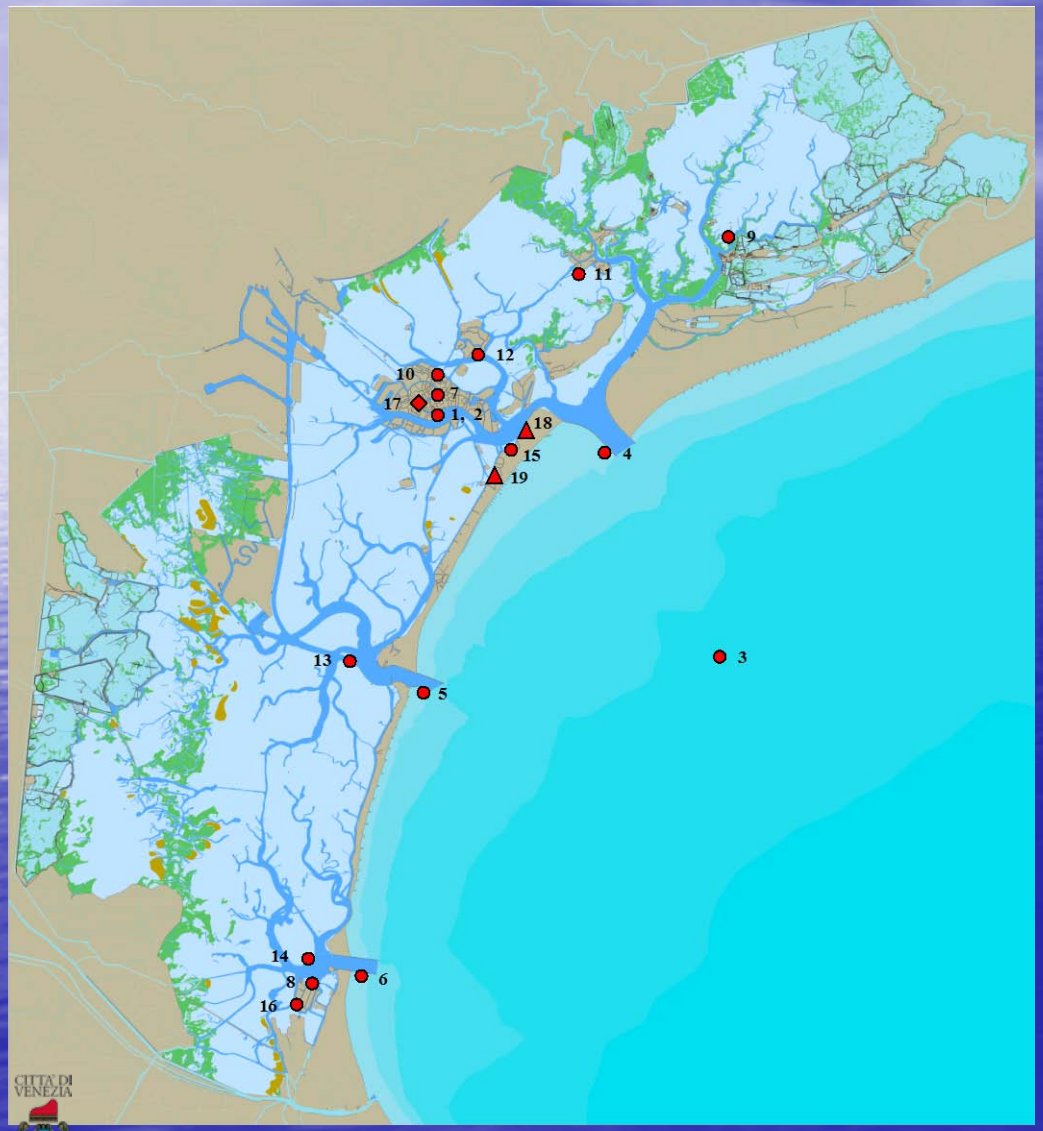
The ICPSM of the Venice Municipality

The ICPSM - Istituzione Centro Previsioni e Segnalazioni Maree (Tidal Forecasting and Early Warning Centre) is an office of the Venice Municipality, founded in 1981 to inform and alert the city in case of high-water events.

Tasks of the ICPSM are:

- **observation** of sea level and weather parameters
- sea level **forecast**
- **information** and **alarm** to the city in case of 'high water'

The monitoring network



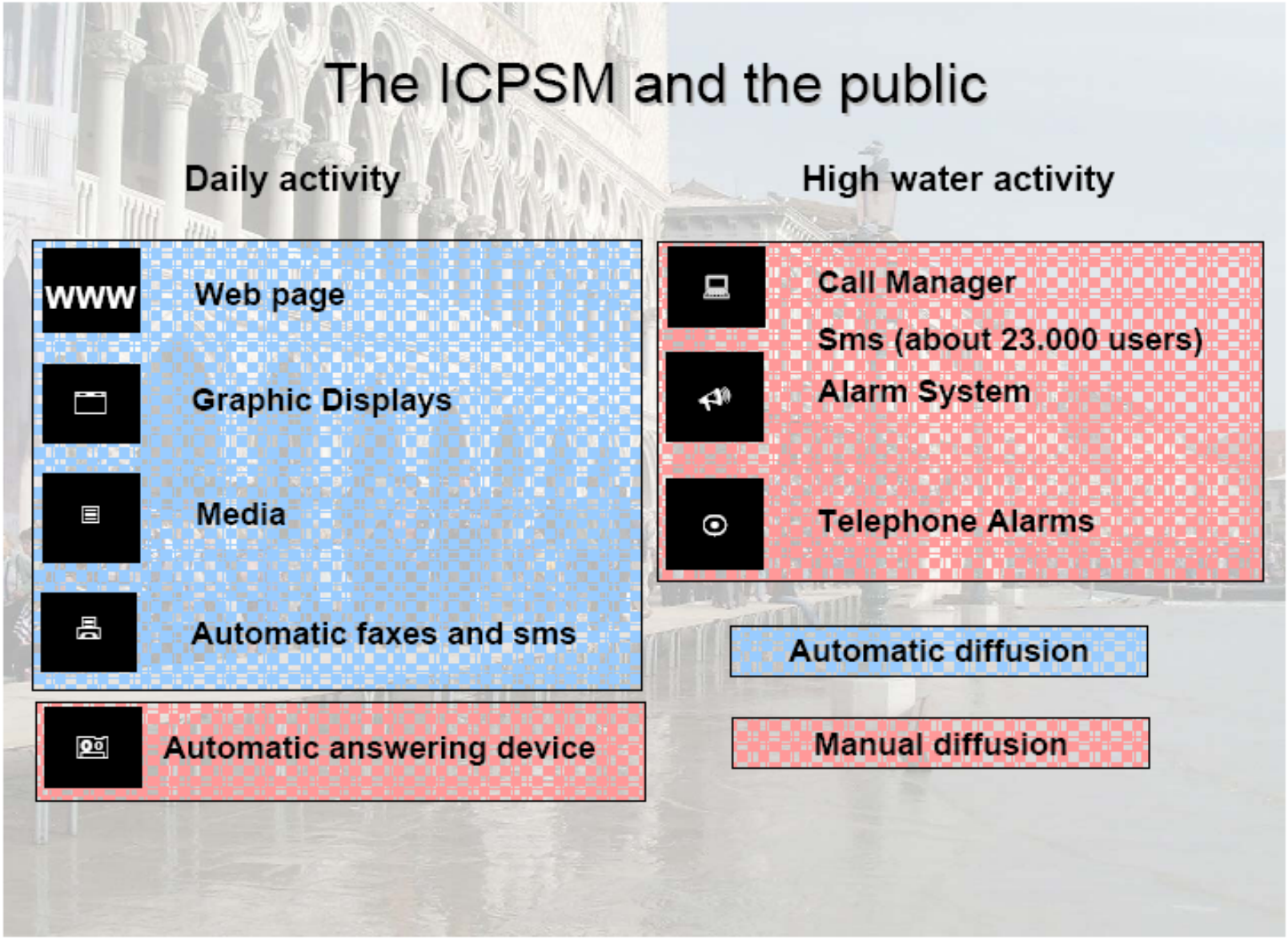
- **Central station**: ICPSM offices
- **Repeaters**: S. Nicolò di Lido, Casinò Lido
- **Measurement stations**:
  10 stations in the inner Lagoon
  5 stations at the inlets
  1 station in the Adriatic Sea

Observed parameters:

- sea level
- meteorological parameters:
  air pressure, wind velocity and direction, humidity, temperature...

Real time acquisition, with frequency of 5 minutes

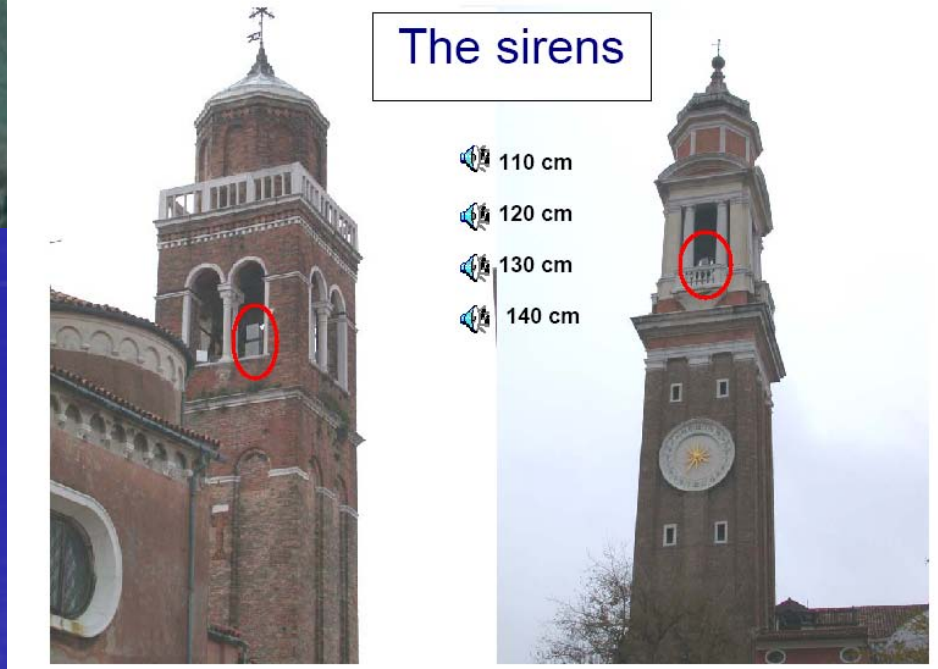
The ICPSM and the public



Alarm System

A net of 23 sirens, placed on the principal Venice islands, alarms the population 3 or 4 hours before a predicted tide of 110 cm or higher

- First alert
- 110 cm
- 120 cm
- 130 cm
- 140 cm



1° Dec 2008

156 cm = 100% of the city flooded

“Adaptation”

“Non-structural measures”

A) passive

B) active

Defence's weakness remediation

Italy's Special Law for Venice (1973)

- Venice: Italy's national interest
- To reach hydraulic equilibrium
- To preserve environment from pollution
- To reinforce socio-economic vitality
- To safeguard the architectural patrimony
- Different levels of administration involved (State, Region, Municipality)

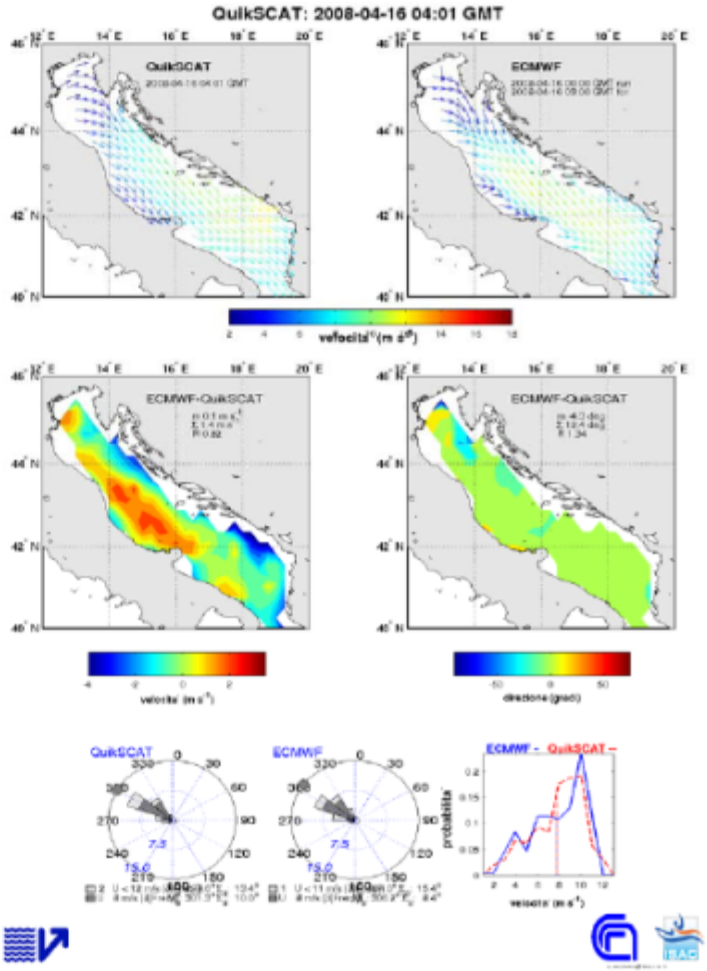
The Oceanographic Platform “Acqua Alta” (ISMAR-CNR)

Data from satellite

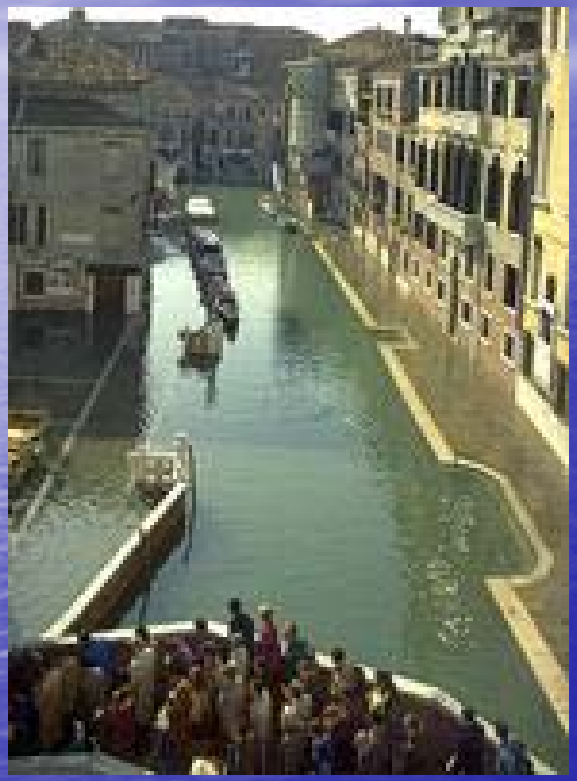
Satellite wind (QuikSCAT and ASCAT)

In collaboration with ISAC-CNR of Padua, ICPSM receives in near-real time satellite wind data from:
- QuikSCAT (NASA)
- ASCAT (EUMETSAT)

A comparison with modelled winds from ECMWF is done. Some statistical analysis are computed.



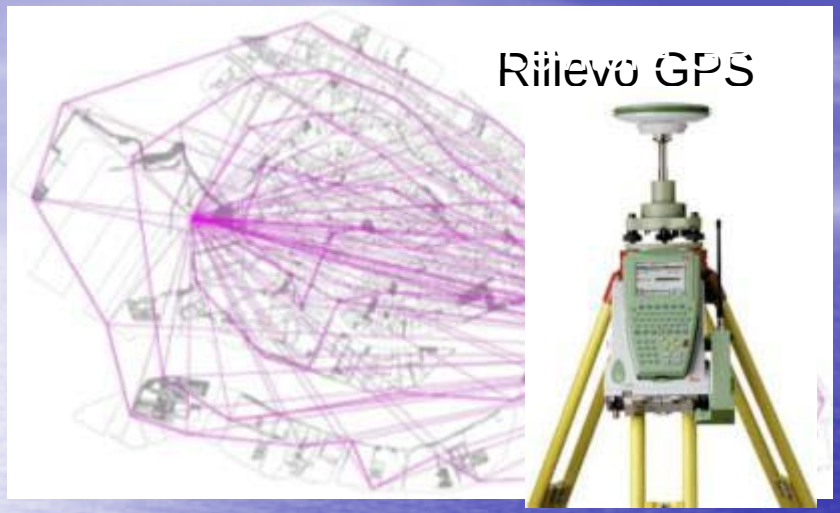
Raising pavements



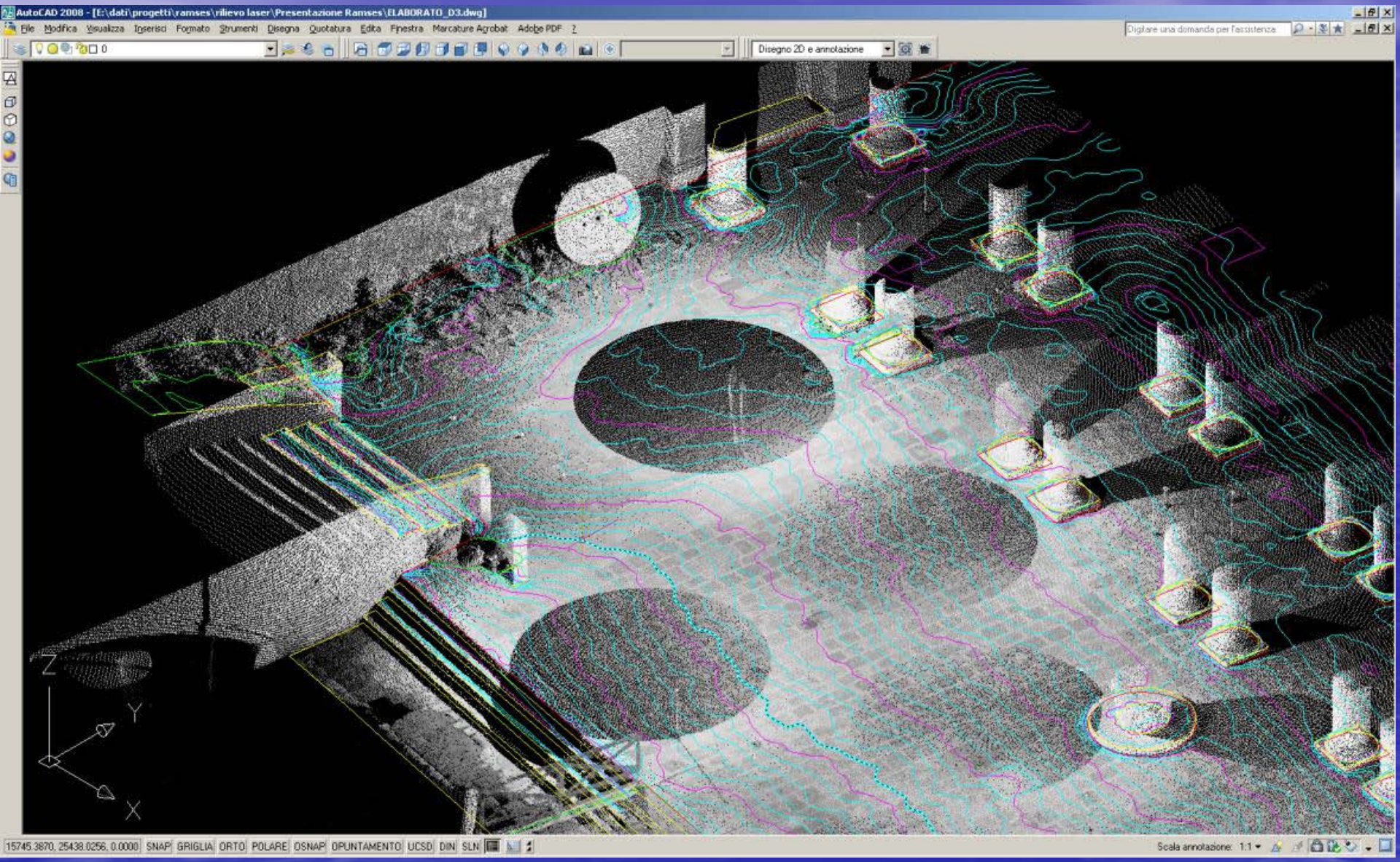
before

after

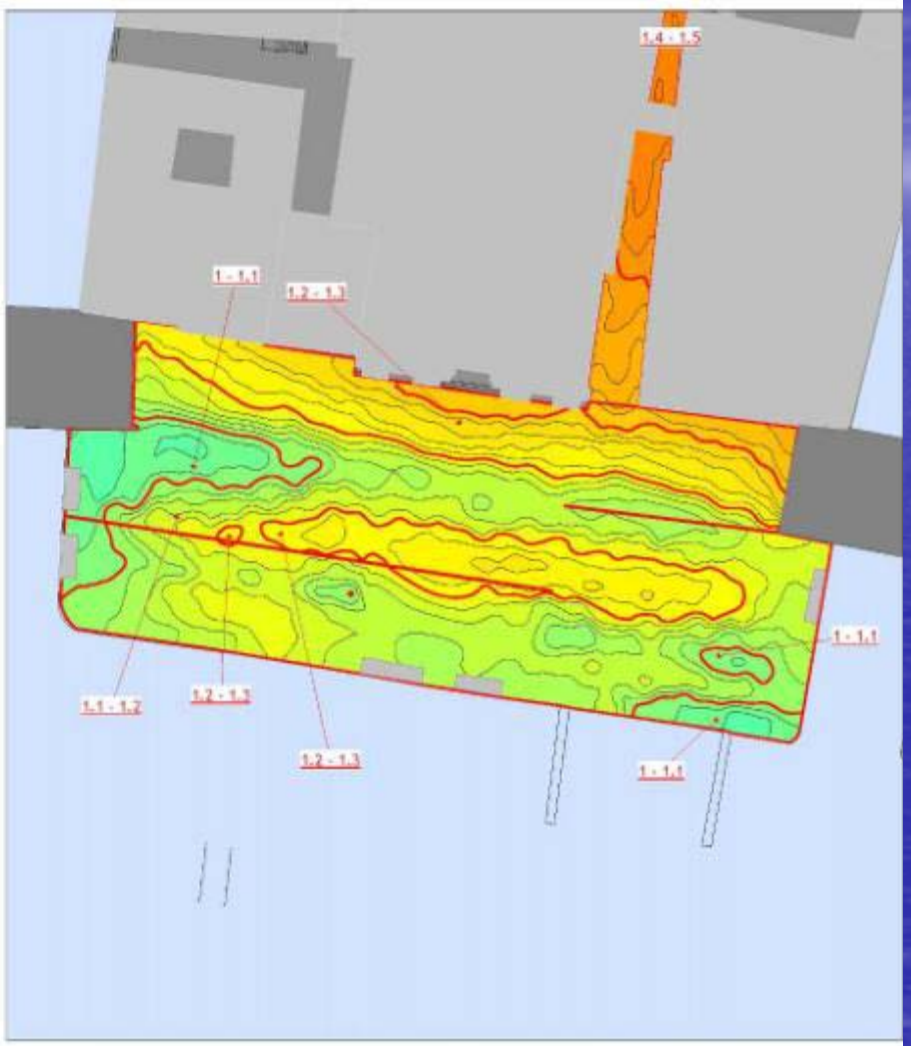
Target: an extensive survey of Venice's pavement with 1 cm precision



Integration of different tecniques, including 3D laser scanning


AutoCAD 2008 - [E:\dati\progetti\ramses\rilievo laser\Presentazione Ramses\ELABORATO_D3.dwg]
File Modifica Visualizza Inserisci Formato Strumenti Disegna Quotatura Edita Finestra Marcature Acrobat Adobe PDF ?
Disegno 2D e annotazione
Digitare una domanda per l'assistenza
Z
Y
X
15745.3870, 25438.0256, 0.0000
SNAP GRIGLIA ORTO POLARE OSNAP OPUNTAMENTO UCSD DIN SLN
Scala annotazione: 1:1

Flooding maps. Precision 1 cm



Sea walls and beach nourishment

Pellestrina

before

after

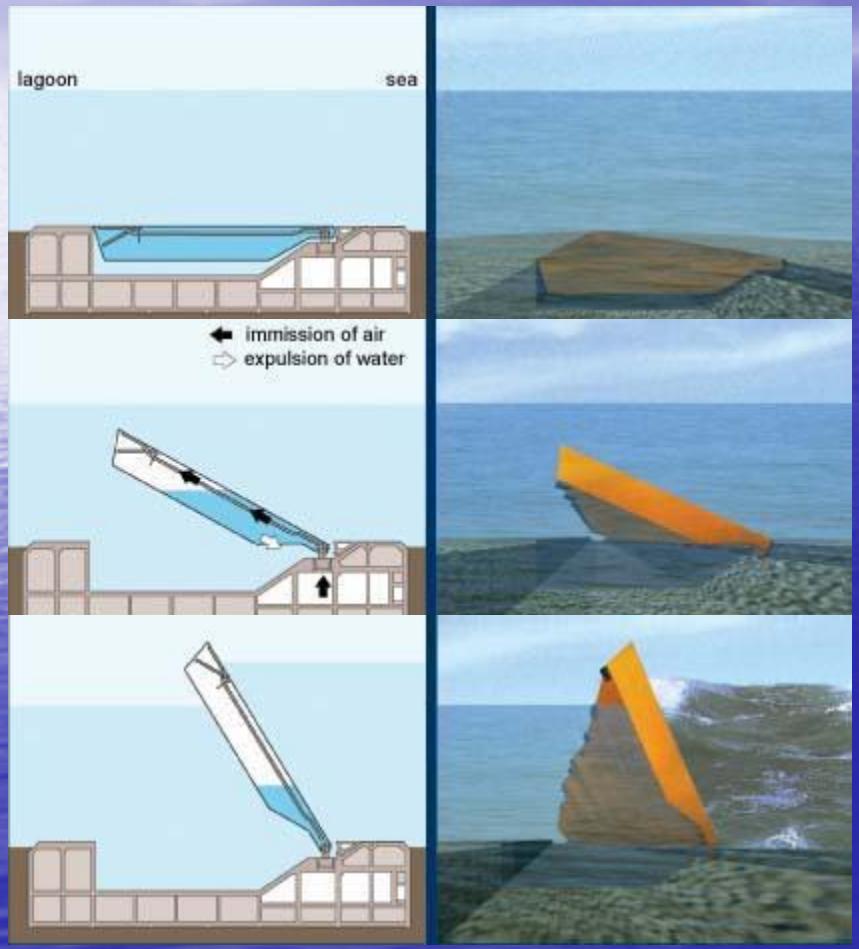
A new beach 9 km - 5,000,000 m^3 of sand.

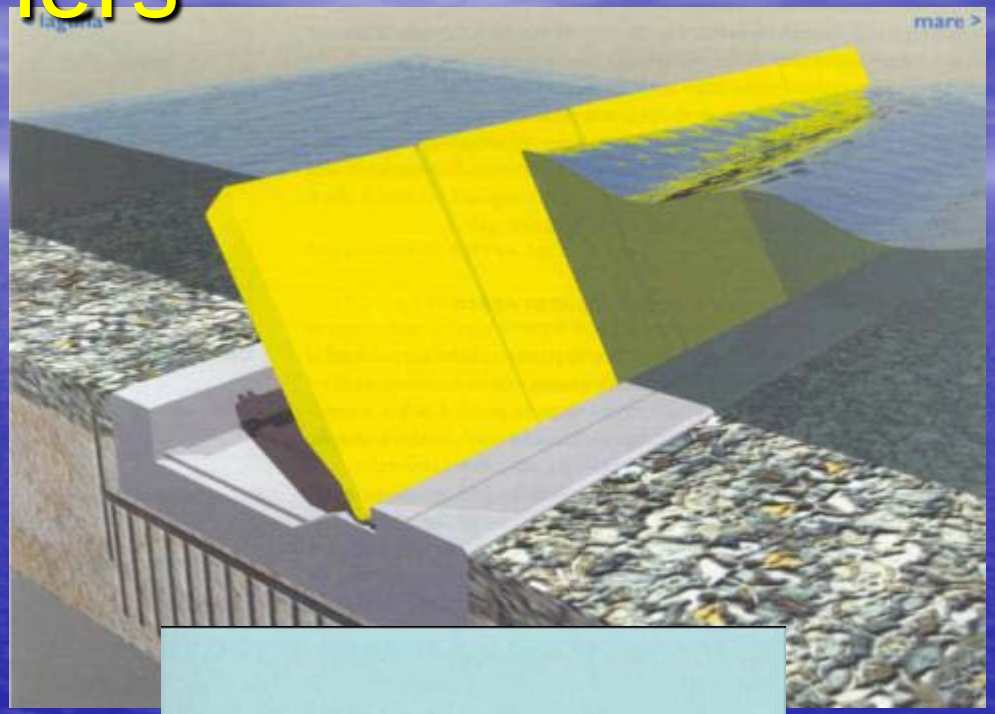
18 containment groynes, connected by a submerged breakwater parallel to the coast, 300 m from the shore along the full lenght of coastline.

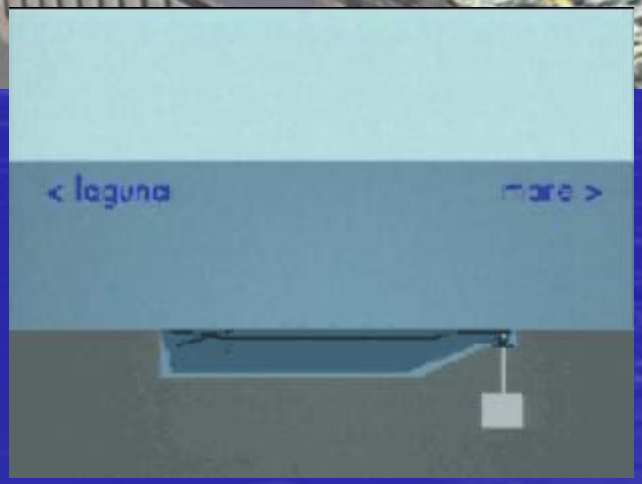
Tidal barriers

- The only way to avoid sea-flooding is to close the inlets
- The adopted solution “saves” the lagoon and the port

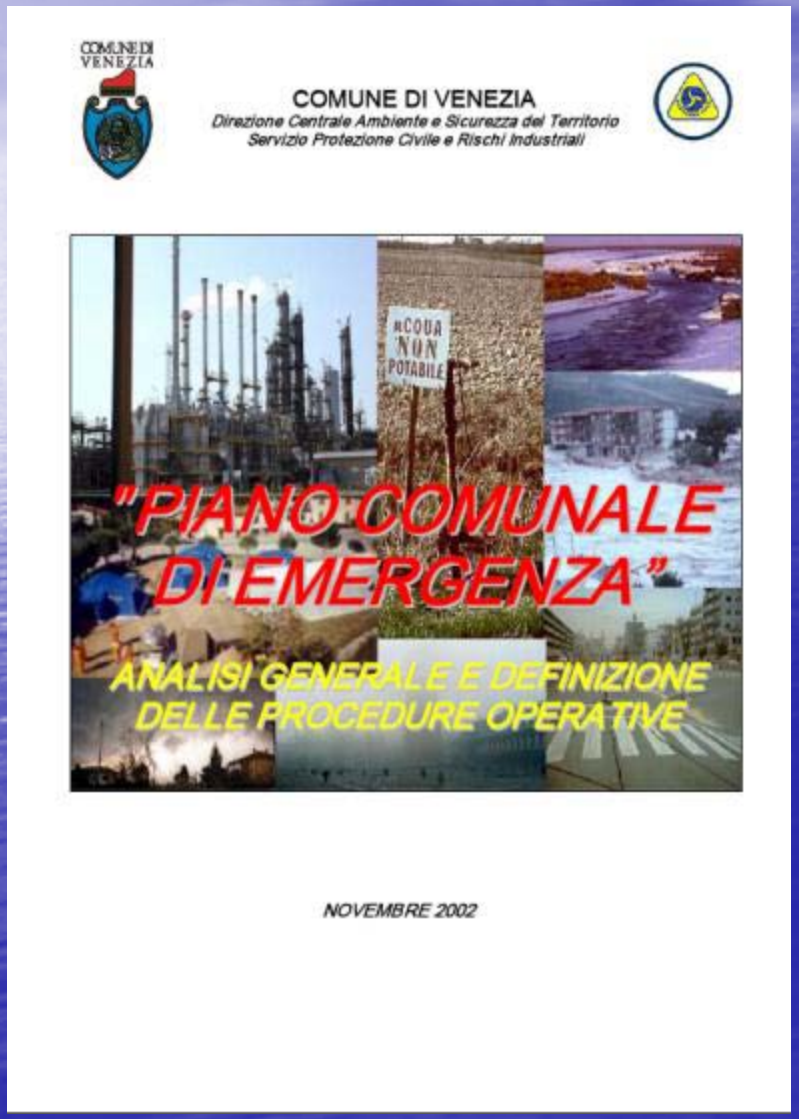
MOSE
Mobile flood barriers







Municipal Emergency Plan



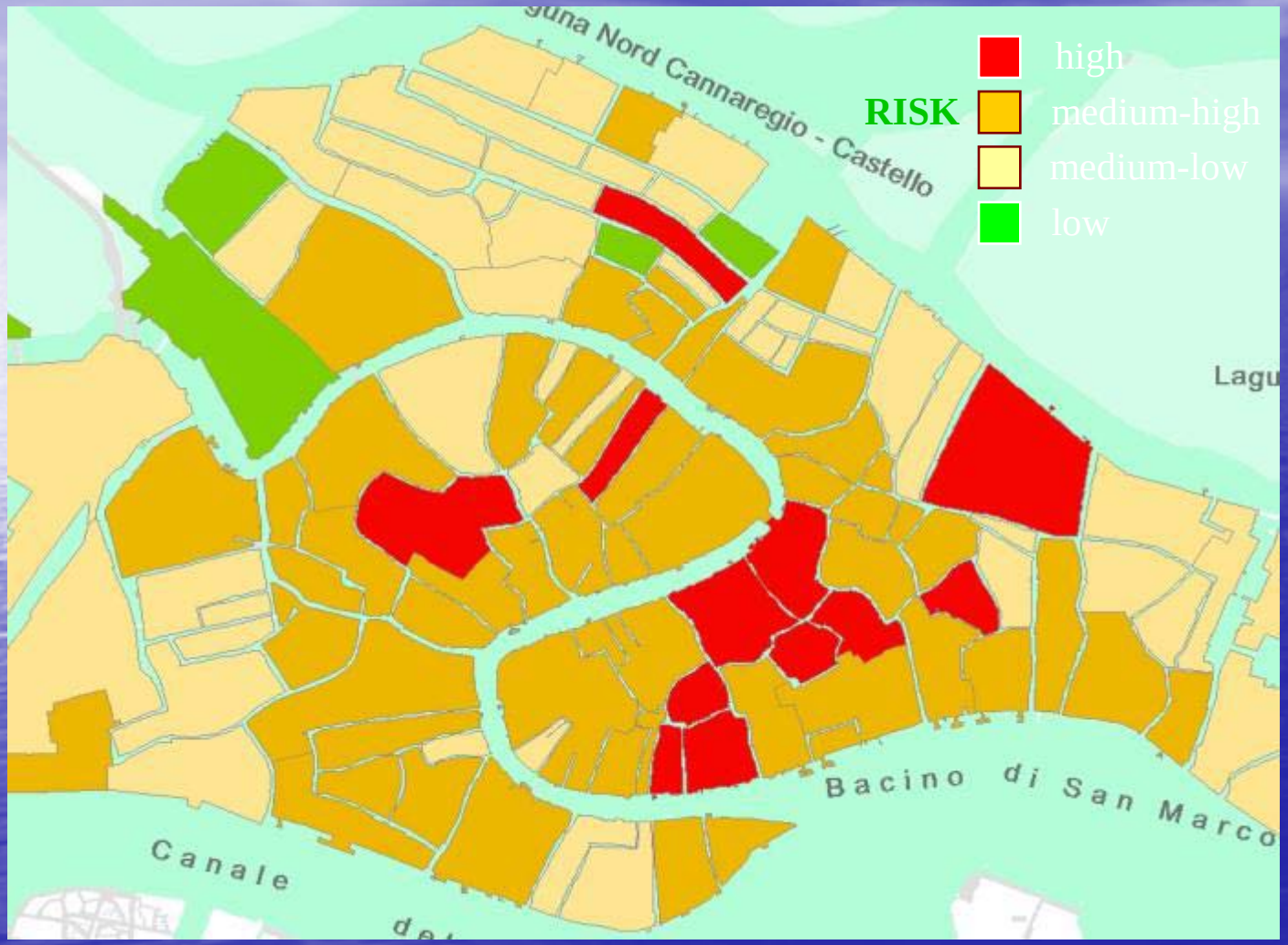
The Civil Protection adopted in 2002 the Municipal Emergency Plan. The Plan reppresents the main instrument to manage the emergencies according to the prevention principle.

The Plan has three main objectives:

- to organize the emergency procedures
- to implement monitoring activities
- to define the activities of assistance to the population

FIRE RISK

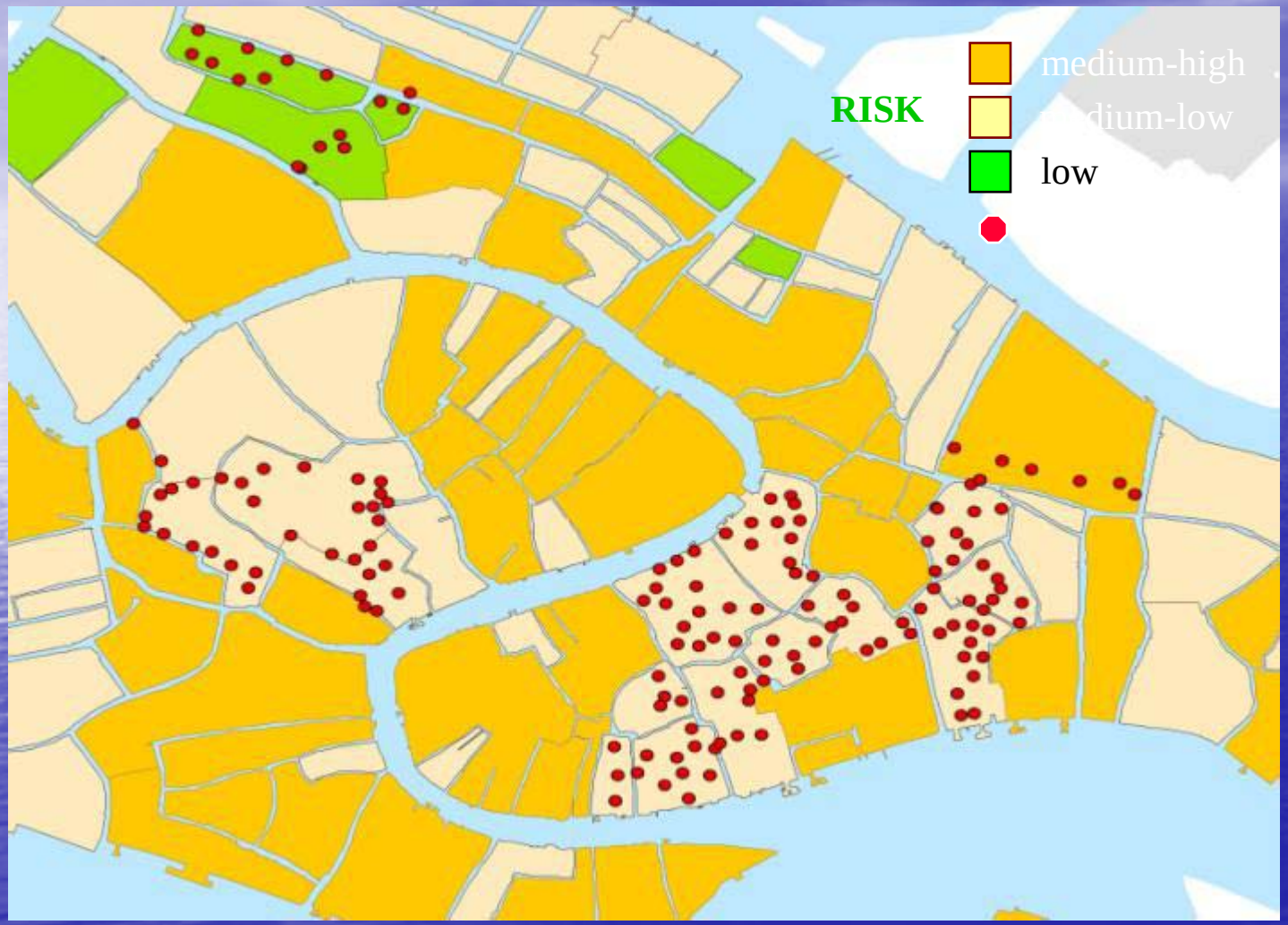
Fire Risk Map 1998



8 factors has been determined:

1. Fire probability
2. Fire level
3. Number of people on the buildings
4. Buildings' height
5. Distance between buildings and their dimension
6. Accessibility
7. Buildings' fire resistance and reaction
8. Buildings' economic value

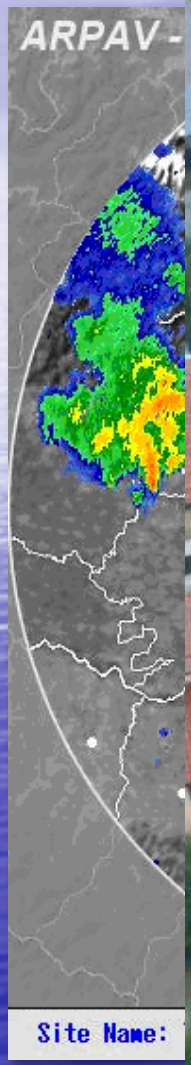
Fire Risk Map 2006



The hydrants' position ameliorates the accessibility to the fire place and diminishes the intervention time.

The "high risk" has been eliminated in the city centre. Most of the areas have shifted from "high risk" to "medium-low risk" and, in some cases, to "low risk".

Danger of flooding 26° september 2007



www

Web page

A web site with the wheader forecast for the next 48-72 hours (www.comune.venezia.it/protezionecivile)

Call Manager

SMS

When the forecast is equal or higher than 70 mm/24h of precipitation, the CRM system sends forecast sms to about 2500 numbers.

Acknowledgments

- Magistrato alle Acque di Venezia
- Prof. Giampaolo Di Silvio, University of Padua
- Ing. Paolo Canestrelli, Director ICPSM
- Ing. Rudy Todaro, INSULA SpA

Thank you for your attention