

# CAN VENICE SURVIVE POLLUTION AND GLOBAL WARMING? WHAT IS BEING DONE TO SAVE IT

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**water centric  
SUSTAINABLE  
COMMUNITIES**

planning, retrofitting, and building  
the next urban environment

VLADIMIR NOVOTNY JACK AHERN PAUL BROWN



- The city is located on an archipelago of 128 small islands
- Grand canal is in the S in the center



LOCATION

# HISTORY

- Venice is a historical city founded in 750
- For 1000 years it was a great power in southern Europe and its influence extended from Spain to the Byzantine empire





- Grand canal



# Location inside the lagoon



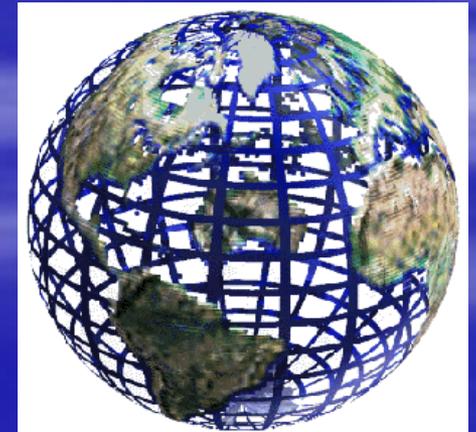
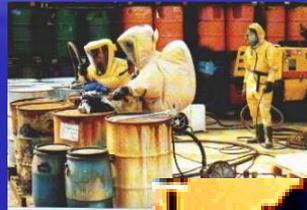
- The 500 km<sup>2</sup> lagoon is separated from the Adriatic Sea by sandy beach islands
- There are three gaps connecting the lagoon with the Sea



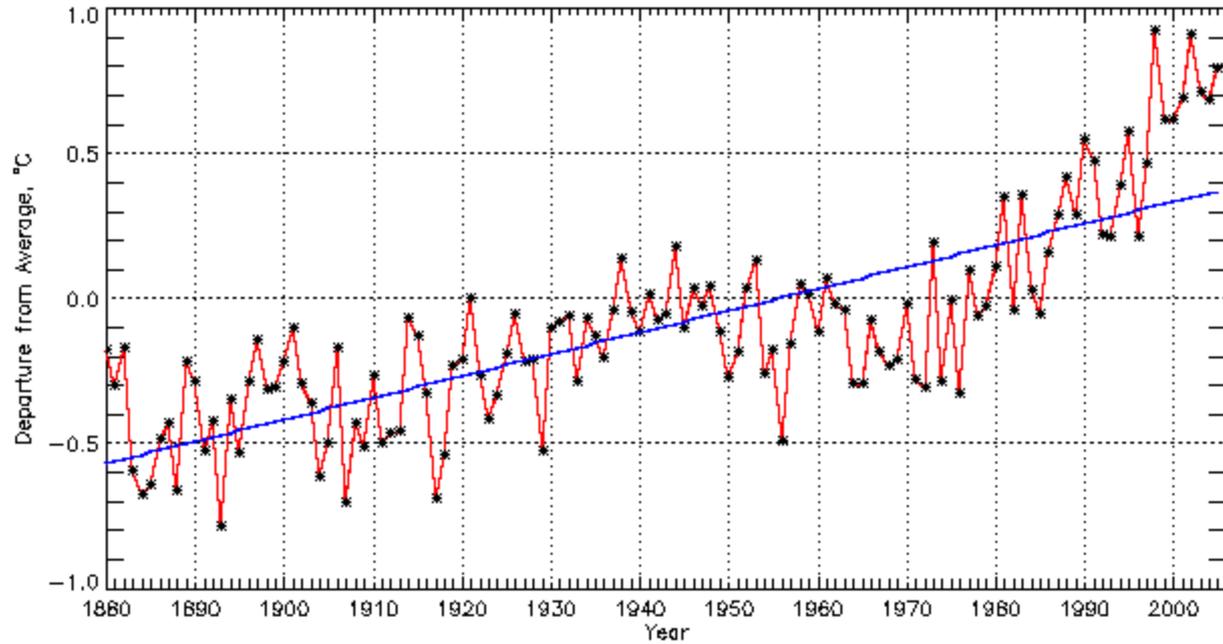
- St. Marco's square is the government and tourist center of the historic city



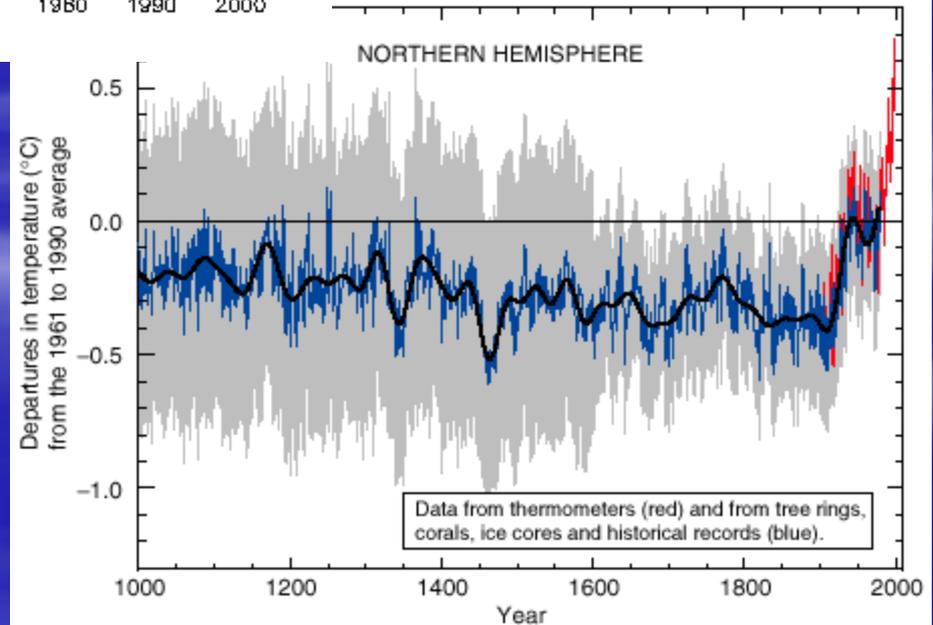
# *Climate Change: it's a matter of degrees...*



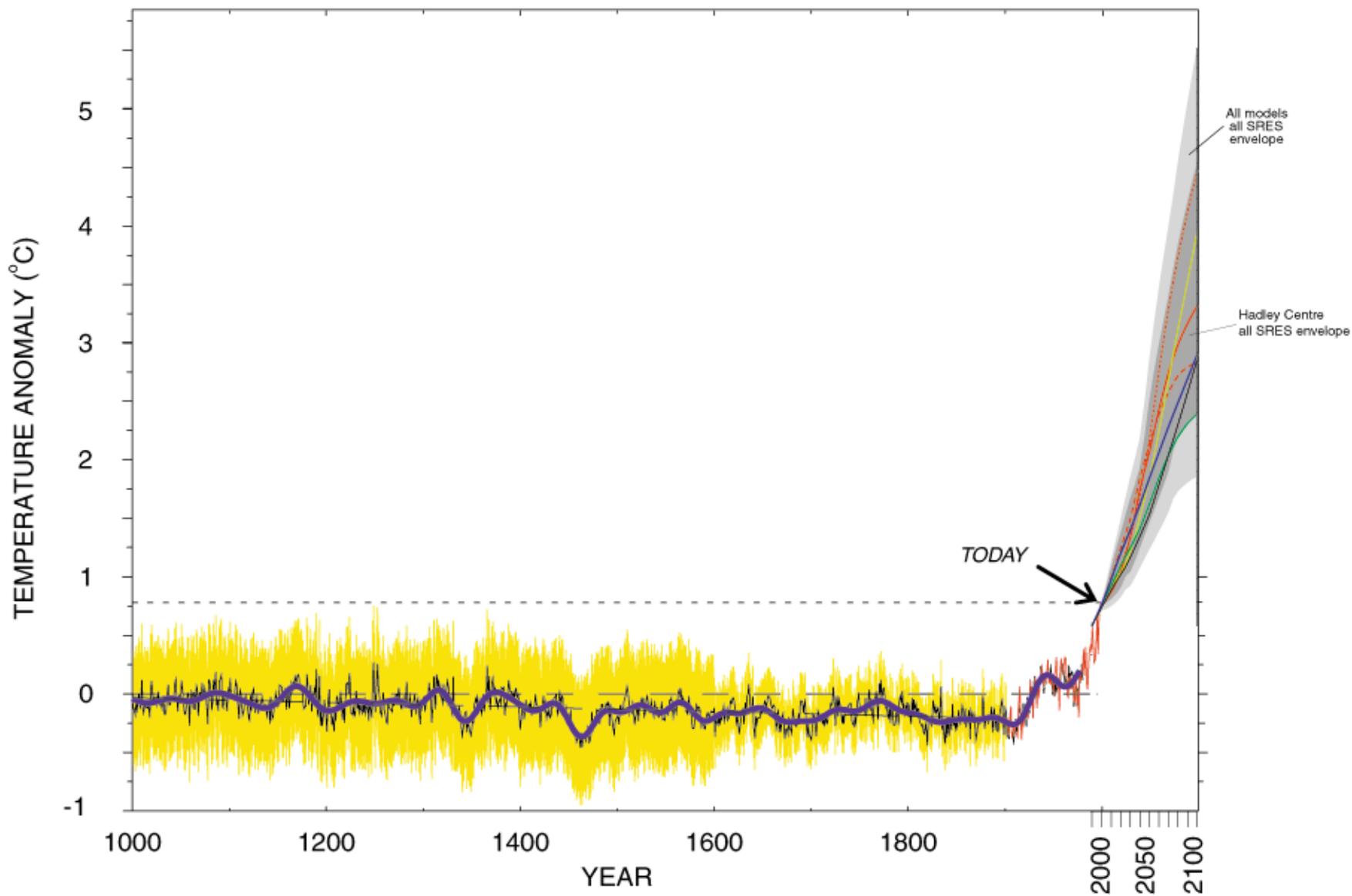
# Variations of the Earth's Surface Temperature for:



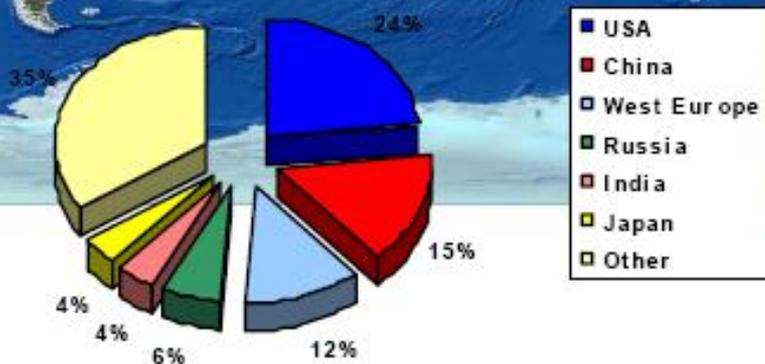
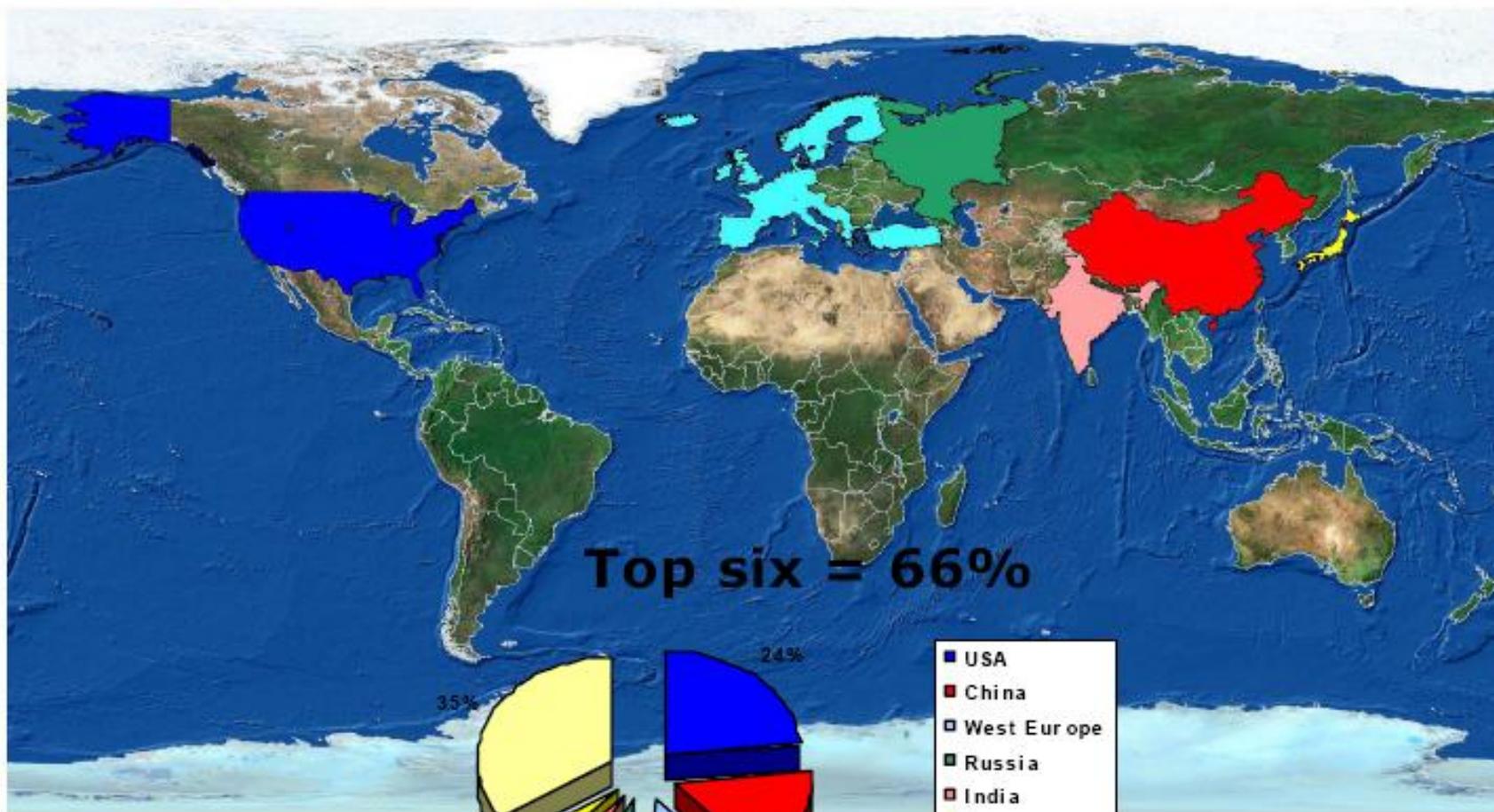
100 years



## Temperature, past and future



# Biggest CO<sub>2</sub> emitters 2000-2025



Cumulative CO<sub>2</sub> Emissions 2000-2025, US EIA, IEO 2004

# CO<sub>2</sub> Emissions in 2002

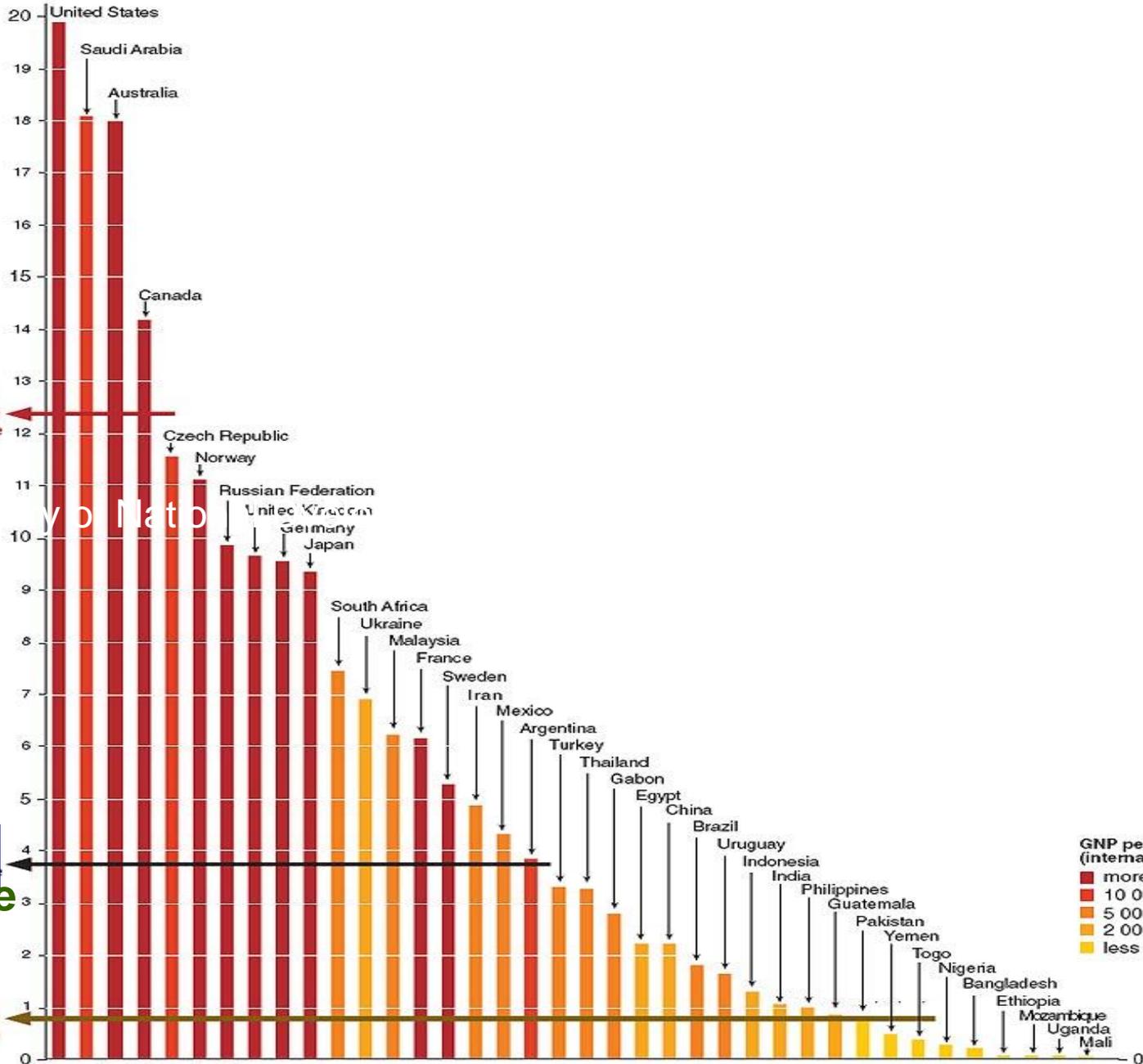
Tonnes per capita

U.S.

High income average

World Average

Low income average



Source : World Bank, online database, 2004.

GNP per capita, PPP (international \$)

- more than 20 000
- 10 000 to 20 000
- 5 000 to 10 000
- 2 000 to 5 000
- less than 2 000

# Grinnell Glacier and Grinnell Lake, Glacier National Park, 1910-1997

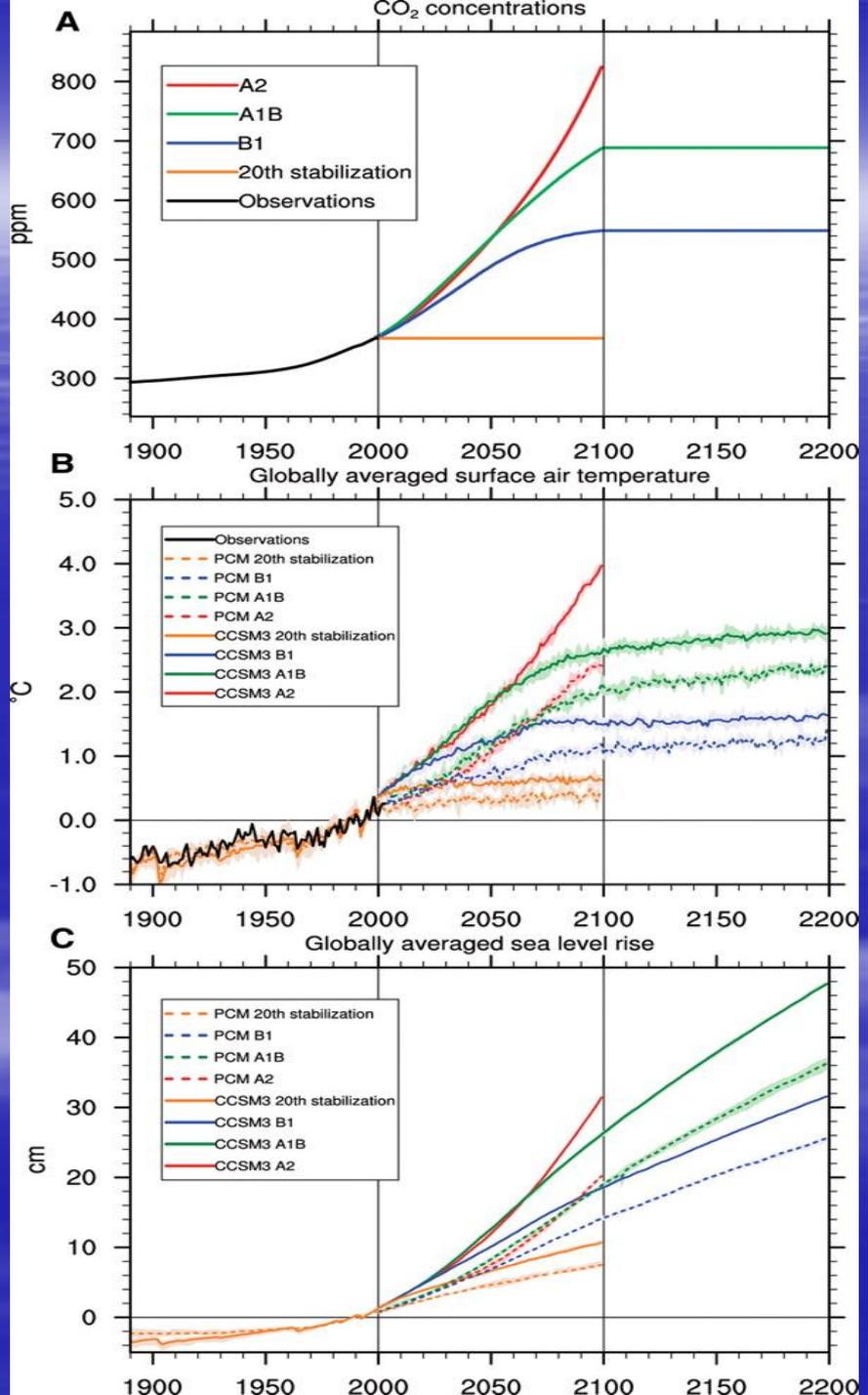


## Shrinking Polar Ice



Extent of Arctic summer ice in 1979 (top satellite image) and in 2003 (lower satellite image).

**Fig. 1. (A) Time series of CO<sub>2</sub> concentrations, temperatures and sea level rises for the various scenarios**



G. A. Meehl et al., *Science*  
307, 1769 -1772 (2005)

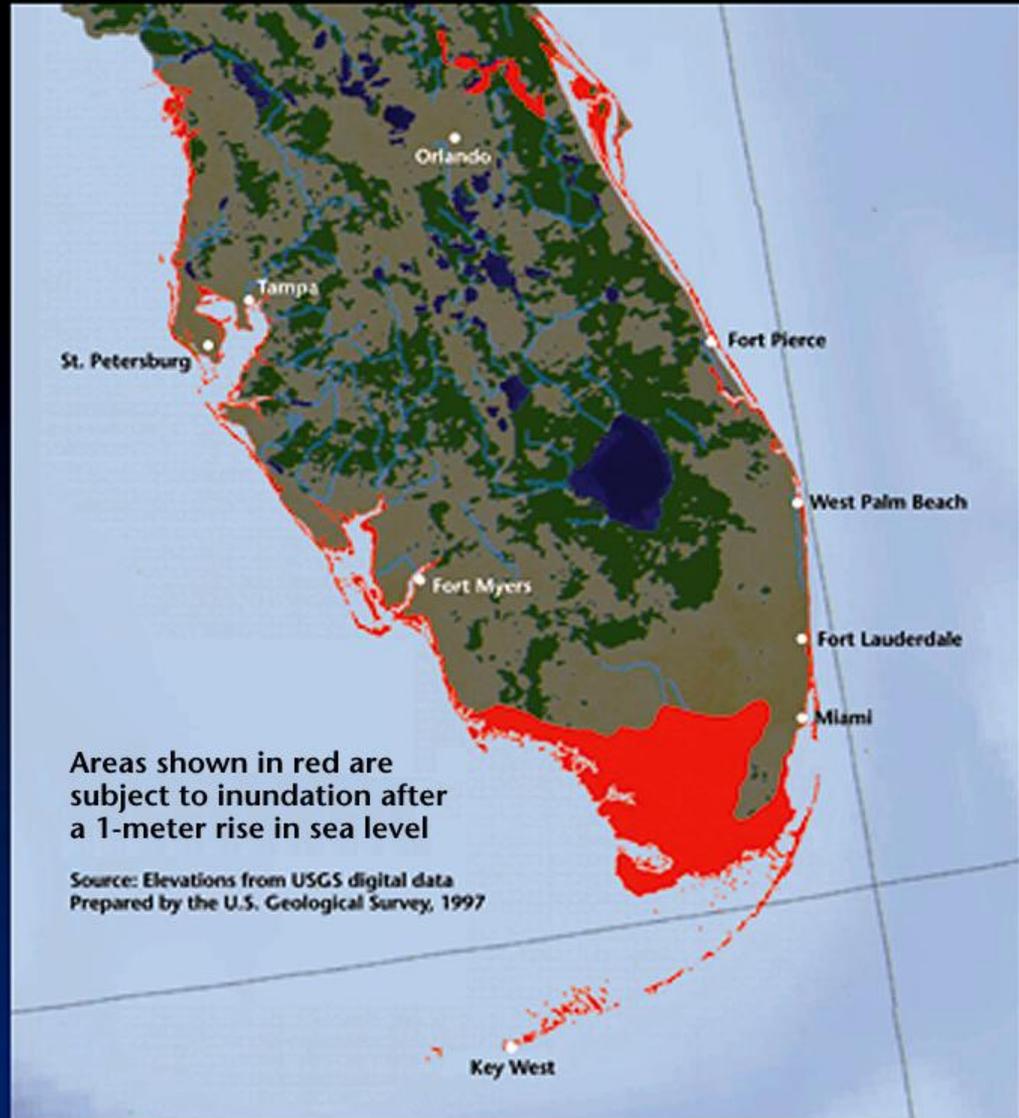
Published by AAAS



# GLACIER MELTING

- Glaciers melting over land in Greenland thermal expansion can rise the ocean level by as much as 0.5 meter by 2200 and continue the increase by about 10 – 30 cm/100 years if nothing is done
- Southern Florida would be affected
- Manhattan Island in New York would be affected
- The doomsday prediction of up to several meters sea level rises would take centuries
- Melting of ice over Antarctica may not occur
- Melting of ice in frozen oceans has no effect on sea levels

# South Florida Shoreline Change after a 1-Meter Rise in Sea Level



# VENICE FLOODING HAS BEEN INCREASING

- First because of subsidence due to groundwater overdraft
- Now because of sea water level rise
- The medium high tide is less than one meter below the elevation of St. Marco's square



Frequency of flooding increased over the years

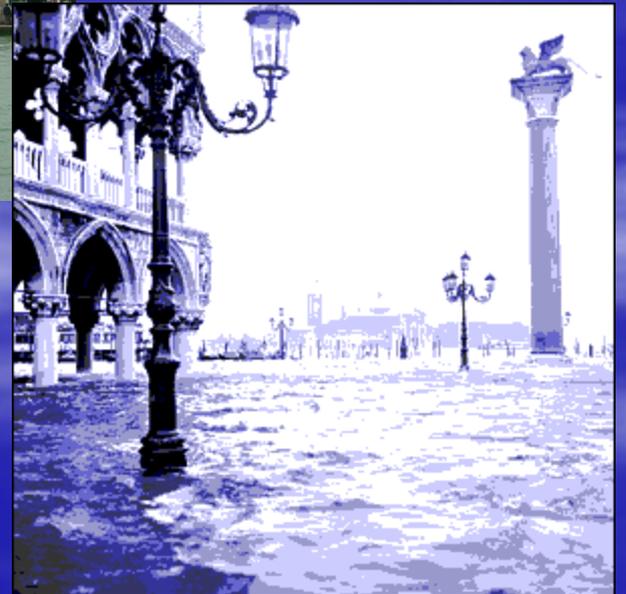
IN 1980 flooding of St. Marco's sq. occurred 10-12 times/year



December 2008



Today, flooding occurs about > 100 times/year





St. Marco's Square during normal high tide

Backwater effect of tide in storm drainage

# Desperate Adaptation

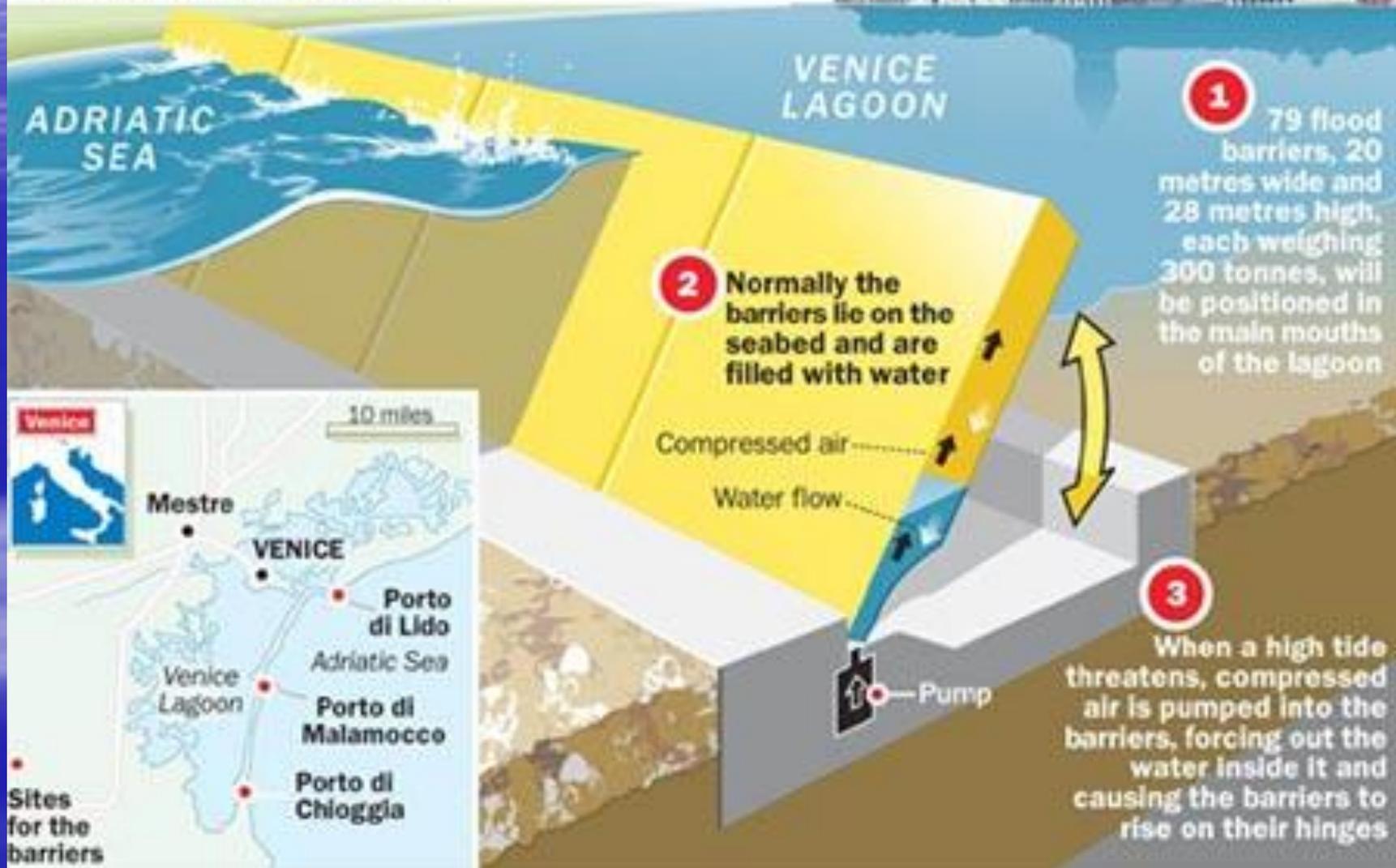
- Coastal cities must adapt to rising water levels
- Become more resilient to increased frequency of catastrophic storms (typhoons, hurricanes)
- In Venice under UNESCO and EC funding
  - City elevation is increased by repaving
  - Tidal barrier

# SAVING VENICE FROM THE TIDE

- Cost of Mose scheme: €4.5bn
- Due for completion: by 2011

## Increased flooding in Venice

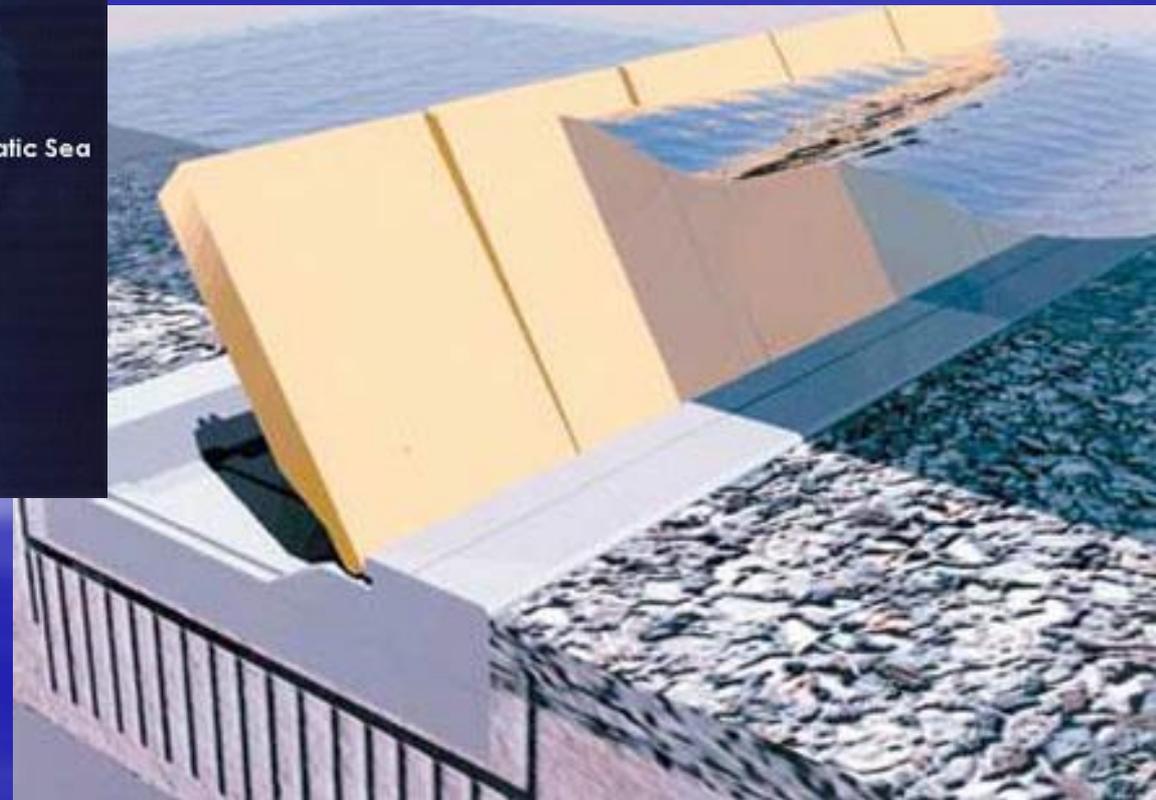
- One century ago: 7 times per year
- 2002: 108 times





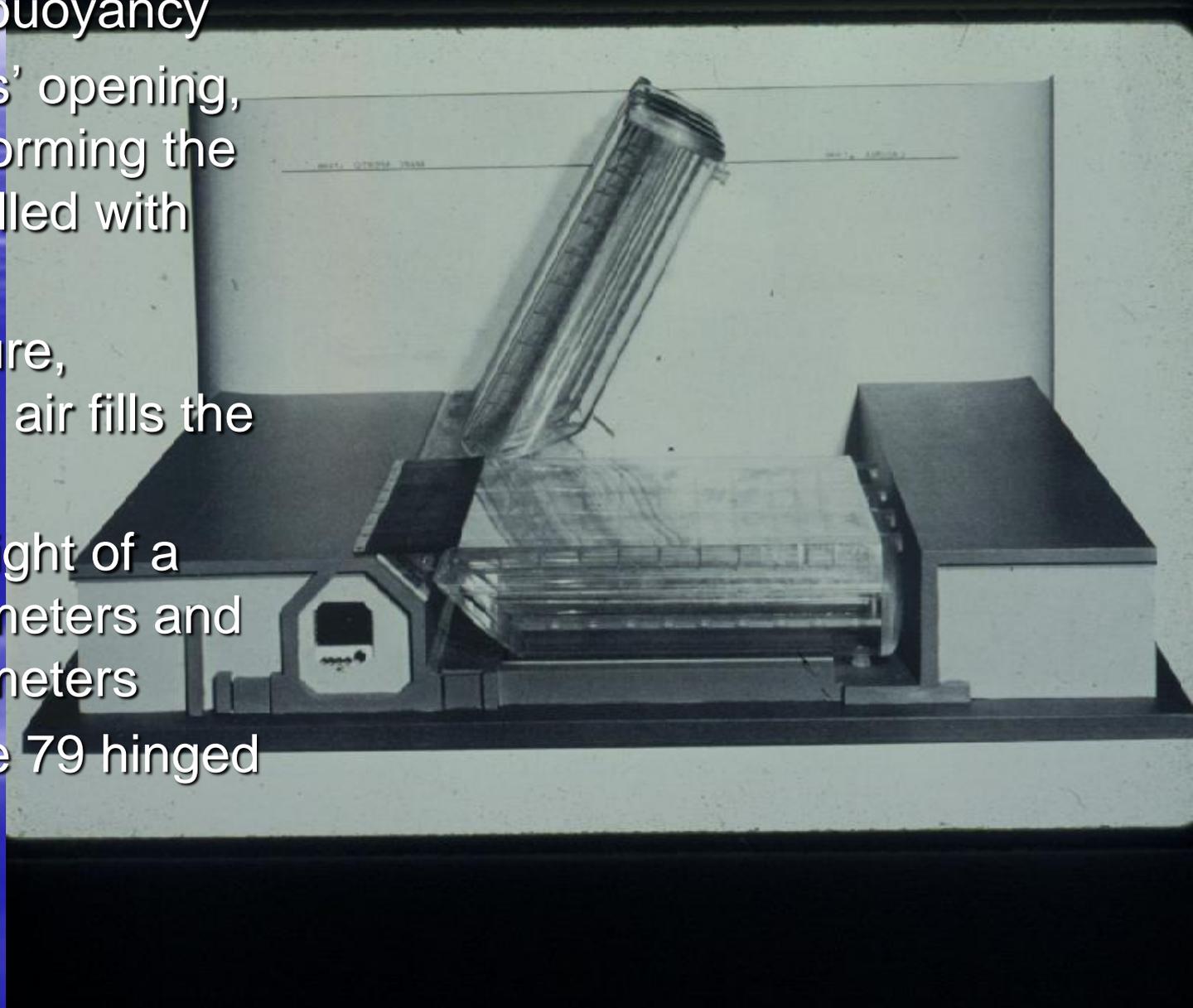
The barrier will close the inlets during the high tides . There are four inlets into the lagoon.

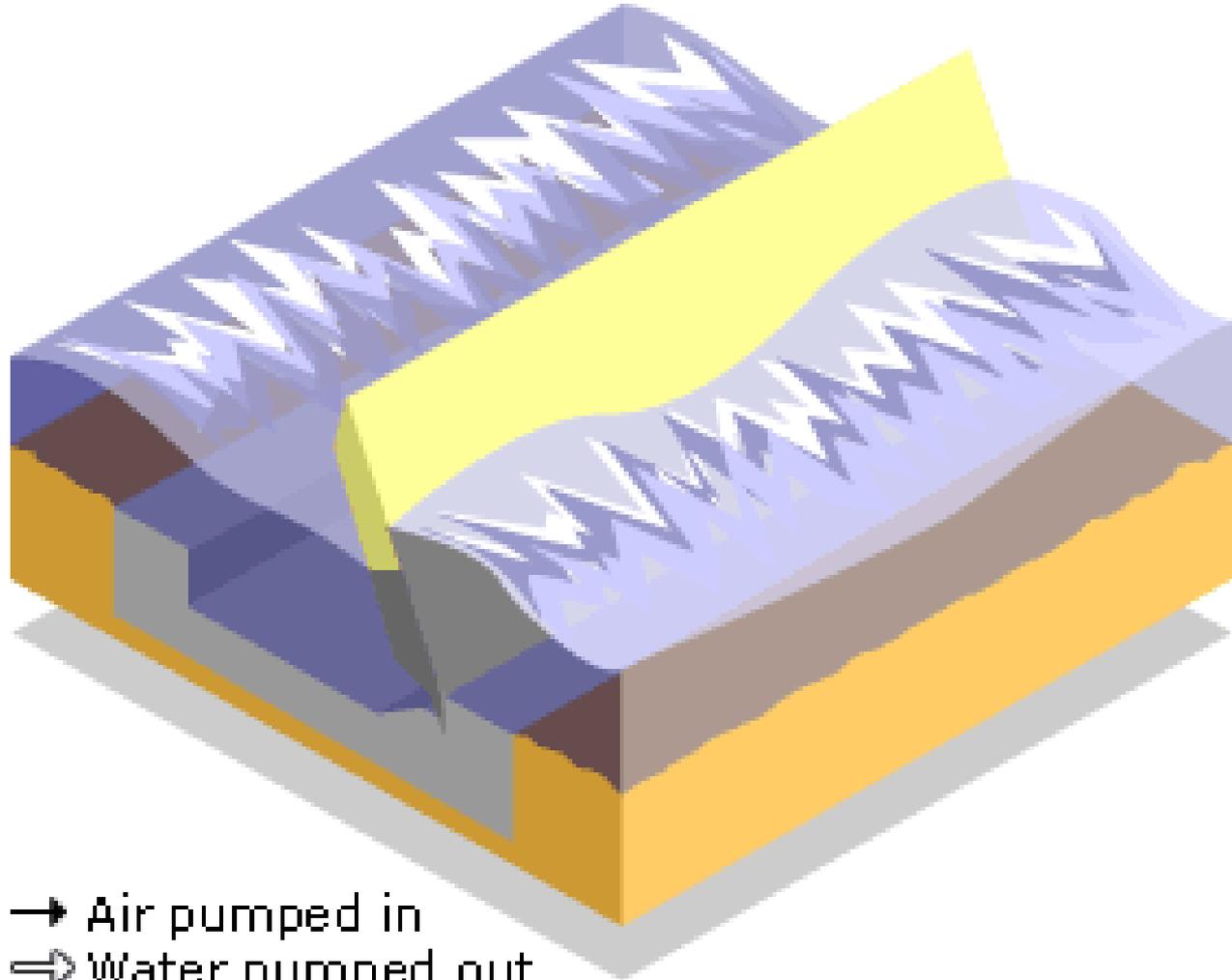
The starting time was 1984 but because of Italian politics not much had been done until the global warming threat. The project was restarted in 2003 and expected to be finished in about 2012



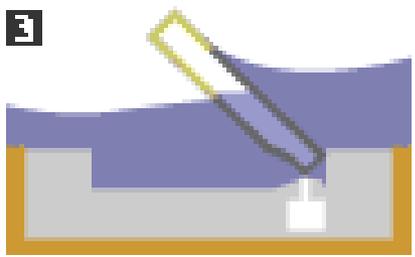
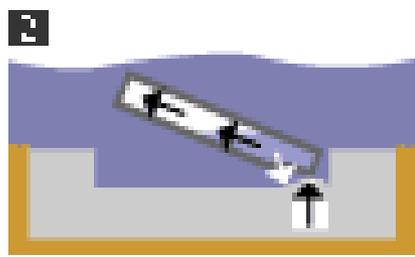
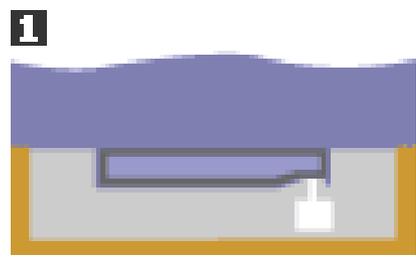
The project is called Mose

- The barrier uses the principle of buoyancy
- During gaps' opening, the panels forming the barrier are filled with water
- During closure, compressed air fills the panels
- The max height of a block is 28 meters and width is 20 meters
- There will be 79 hinged barriers



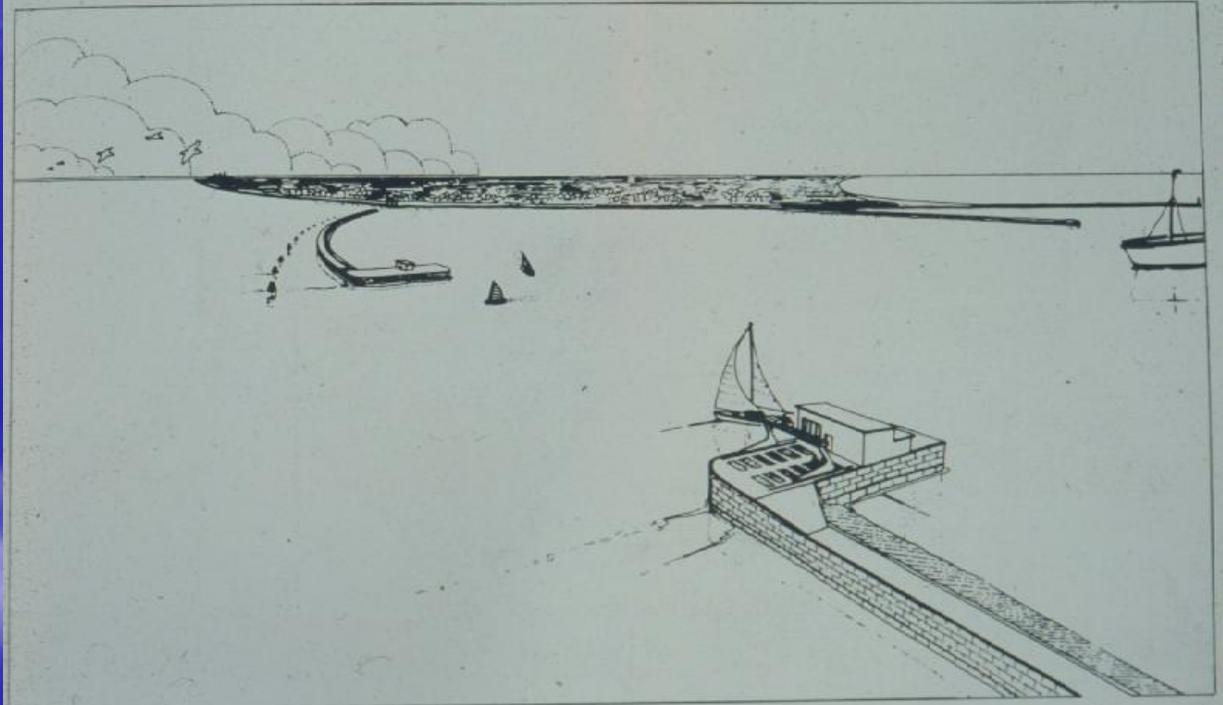


→ Air pumped in  
⇨ Water pumped out



# Tide barrier

- Barrier open



- Barrier closed

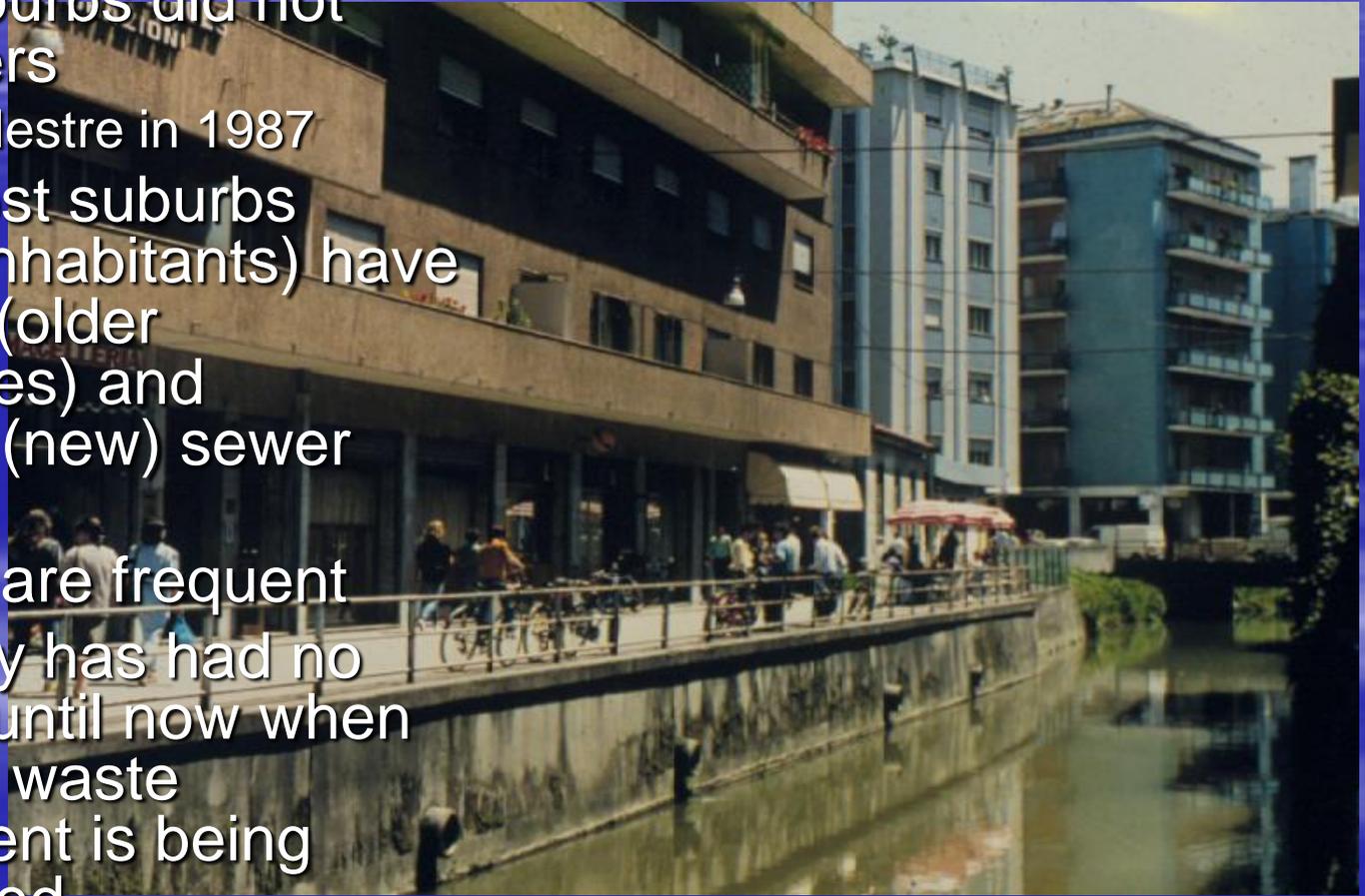


# Environmental Concerns and Opposition to MOSE

- Without the barrier the flushing time of the lagoon by the tide is less than 7 days.
- With the barrier the flushing will be reduced and there is a danger of increasing nutrient and pollution levels and accumulation in the lagoon that would lead to pollution catastrophes similar to those of 1980s
- The tides are also the only cleansing mechanisms for removing pollution from the canals in the historic city. The pollution within the historic city will increase

# SEWERS IN VENICE

- Prior 1990 the historic city and its suburbs did not have sewers
  - Venice Mestre in 1987
- Today, most suburbs (900,000 inhabitants) have combined (older communities) and separated (new) sewer systems
- Overflows are frequent
- Historic city has had no treatment until now when distributed waste management is being implemented.



# URBAN DRAINAGE SYSTEMS

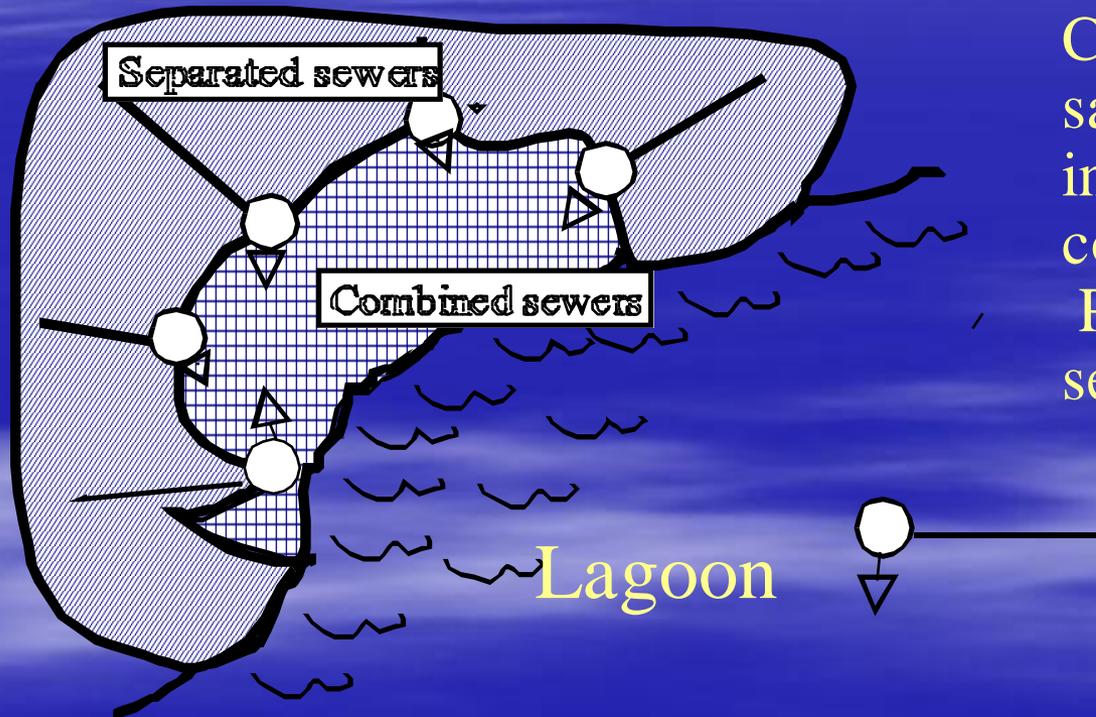
## SOURCES OF POLLUTION

- Wastewater (sewage) flow
- Urban Runoff Inputs
- Infiltration/inflow(I-I)

Main problem in Venice :

Infiltration-Inflow cause overflows from combined and sanitary sewers

# Poor connection of suburban separate sewers to combined sewers in Mestre



Connection of a sanitary interceptor to a combined system. Possible sanitary sewer overflow

Today mainland Venice has two regional treatment plants, one in Porto Marghera , the other, smaller in Campalto.

# Effect of overflows on Inland canals

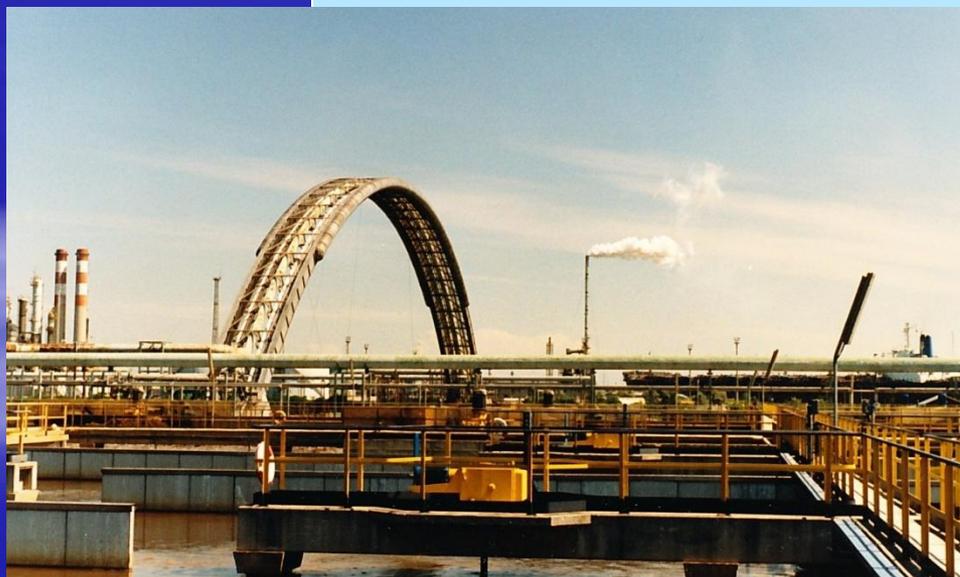
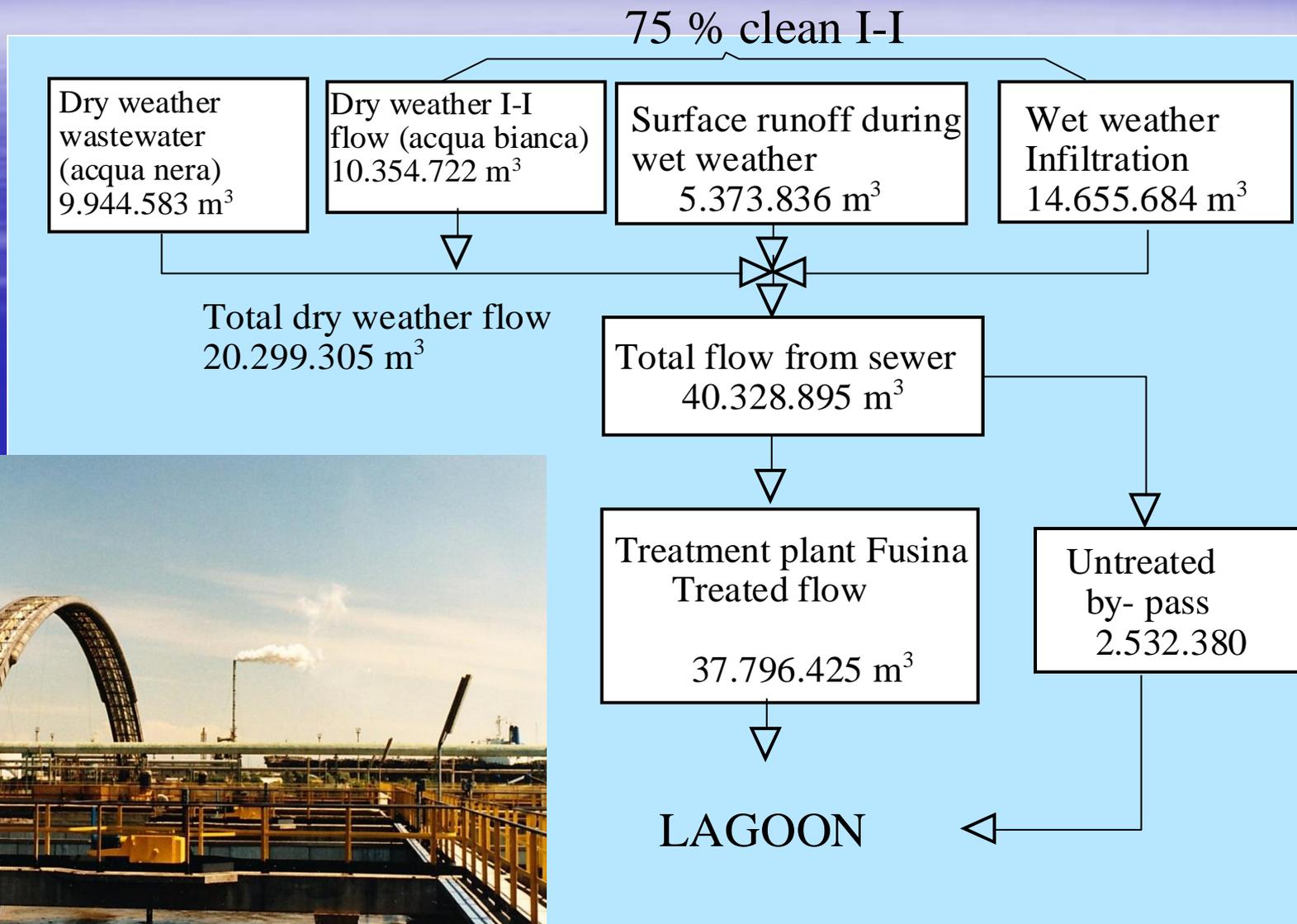


Many inland canals are overloaded with untreated sewage from "terra firma communities" than have either poor sewer system impacted by I-I or no sewers at all.

Black color of anoxia of the River Draganziolo

# Flow balance in the main treatment plant in Fusina

2002

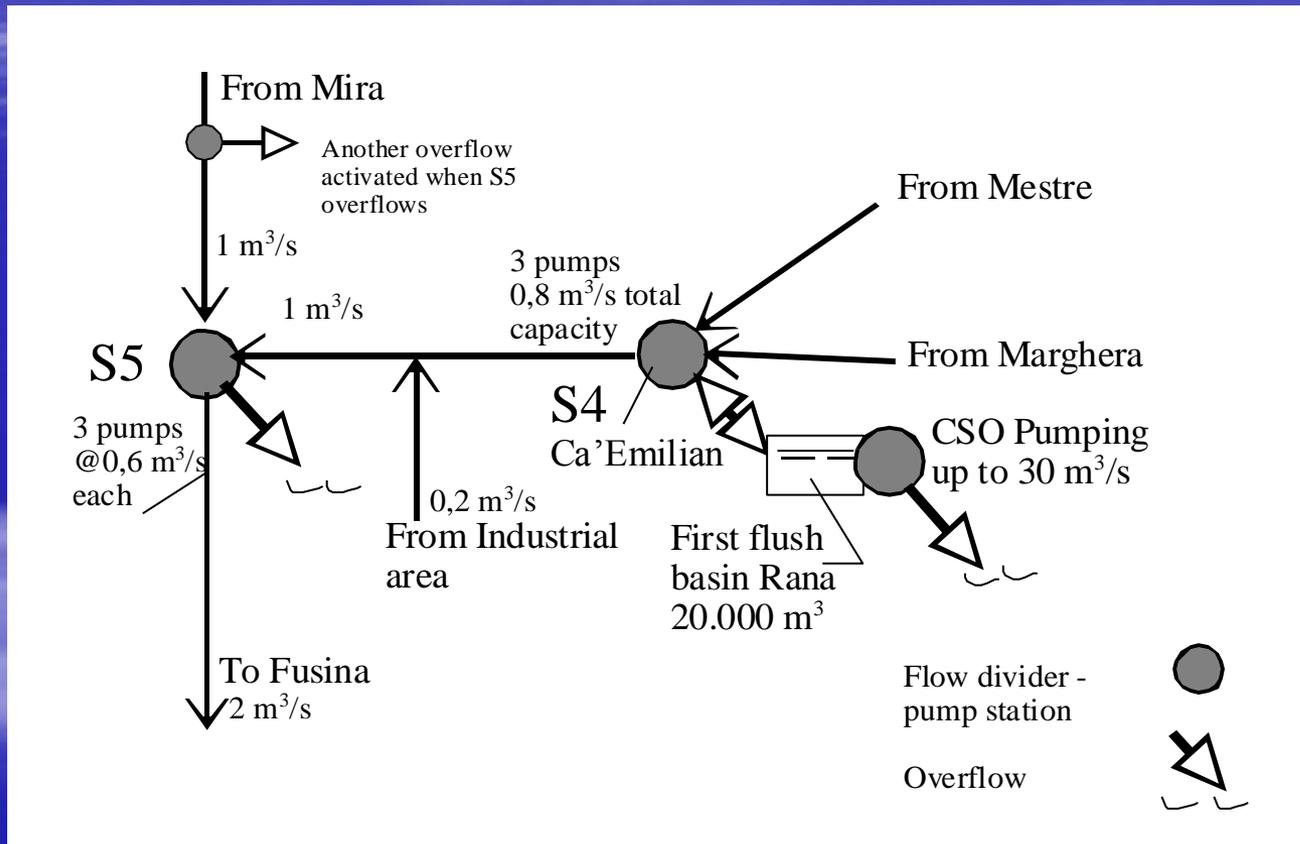


# PROBLEMS IN THE BASIN OF THE LAGOON OF VENICE (2003)

- PREDOMINANTLY FAST CONVEYANCE
- HIGH I-I (Acqua falda and parasita) INPUTS IN SEWERS
  - treatment plant of Fusina is treating 75 percent clean water flows
  - treatment plant in Campalto is overloaded
  - frequent overflows from combined sewers during wet weather and dry weather (in Campalto basin)
  - little or no management of urban stormwater pollution
- WATER QUALITY IN CANALS DOES NOT MEET STANDARDS

# SOLUTIONS

Smaller basins (5 mm storage) are used or proposed in Venice, residual pollution is controlled by wetland (phytoepuration)



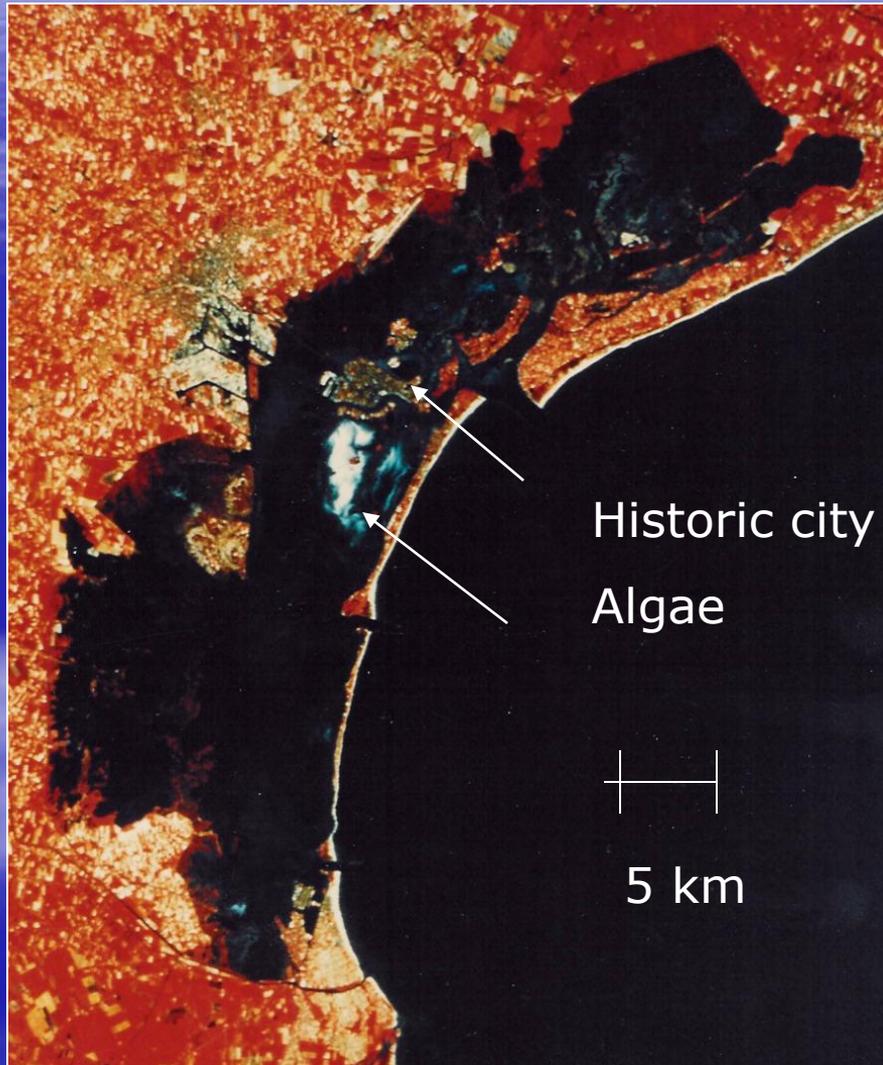
Sewer rehabilitation ??? to minimize I-Is

# Watershed of the Lagoon

- The watershed contained originally the historic urban areas and wetlands that were drained about 100 years ago by canals with giant pumping stations.
- The drainage brings significant amounts of pollutants (10,000 tons of nitrogen and 5,000 tons of phosphorus into the lagoon



# EUTROPHICATION IN VENICE LAGOON



Algal bloom of *Ulva* sp. in Venice in late 1980's

# Eutrophication in the Lagoon in 1987



The lagoon eutrophication is nitrogen limited

# VENICE LAGOON

- A tidal lagoon 500 km<sup>2</sup>; Watershed area 2000 km<sup>2</sup>
- Before 1900s the watershed had significant wetland percentage. In 1900s wetlands were drained and converted to intensive agriculture



# Eutrophication in the canals



# Nutrient Loading of the Lagoon

Sources 1995	Annual loads, tons	
	N	P
Municipal Point	2298	359
Industrial Point	849	79
Urban Diffuse (CSO + Urban Runoff)	468	114
Agricultural	3421	102
Animal operations	2293	464
Atmospheric	773	57
Total	10102	741
Loading Capacity of the Lagoon	3000	300

**Loading capacity will be reduced by MOSE**

# IMPACTS OF WETLAND DRAINAGE



- Nitrification of stored organic nitrogen and release of nitrate
- Release of metals stored as metal sulfides
- Loss of pollutant retention capacity  
“Wetlands are kidneys of nature”
  - BOD and SS removal > 90%
  - Significant removals (immobilization) of toxics
  - pH control
- Wetlands are naturally dystrophic (low dissolved oxygen)

Ca'di Mezzo recreated wetland – Venice Lagoon

Today the job of reducing nutrients is more than half done. Ulva disappeared and was replaced by phytoplankton that reduced the transmissibility



It is a great place to visit at least  
once in a life time and before it may  
be gone

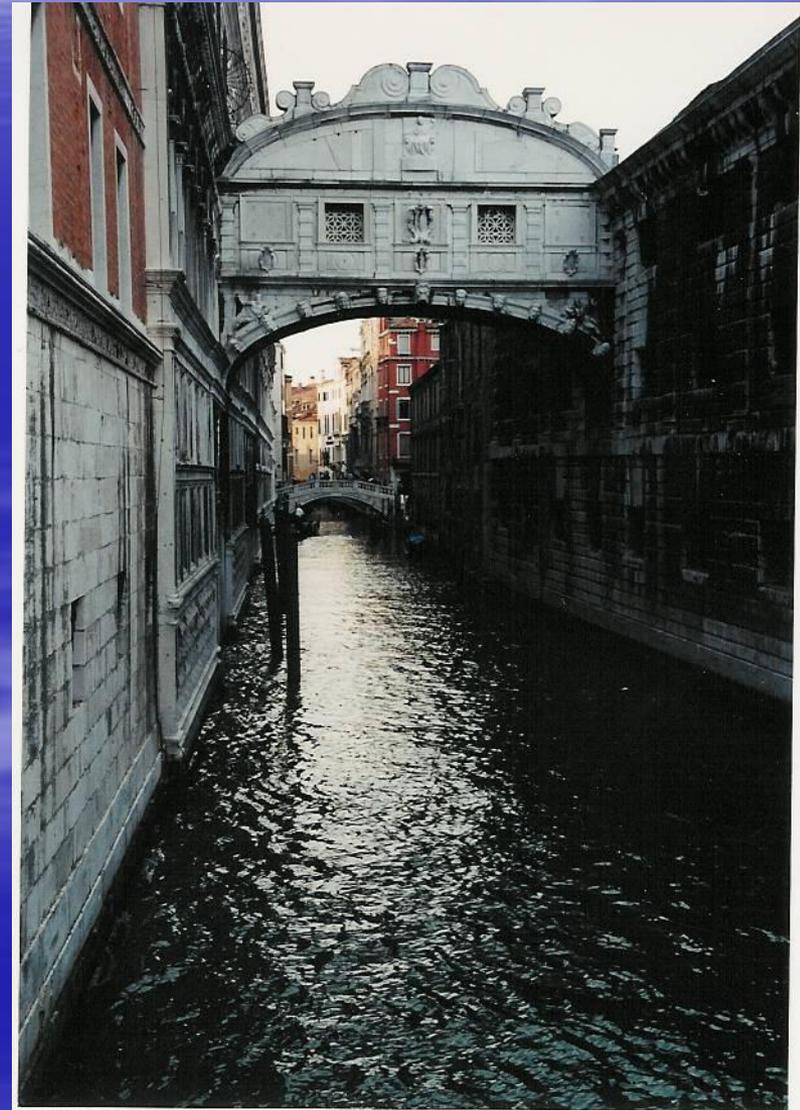




# Visit and enjoy this wonderful city



Grand canal



Jail bridge and canal

# IN MEMORY OF

Professor Giuseppe  
Bendoricchio (+2002)

University of Padova

A good friend, fighter for saving  
his beloved city and lagoon and  
pioneer of diffuse (nonpoint)

pollution abatement

