APAT
NATIONAL AGENCY FOR ENVIRONMENTAL PROTECTION AND TECHNICAL SERVICES
DEPARTMENT FOR INNER AND MARINE WATERS
VENICE LAGOON SERVICE

Effects of a "meteorological bomb" inside the Venice Lagoon: the case of the 24th September 2004

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INTRODUCTION

The effect of local wind stress inside the Venice Lagoon was previously studied by various perspectives (Pirazzoli, 1981; Ferla *et al.,* 1994; Melaku Canu, D. *et al.*, 2002). The aim of this poster is to illustrate a particularly strong Bora wind event, that presents some typical features of the "Meteorological bombs" and "Strong winds" events, as defined in (Piervitali et al., 1997). There a "Meteorological bomb" is defined as "a very intense depression during which the rate of pressure-fall is 17 millibar/24h" and "Strong winds" are defined with "intensity ≥ 25 knots and lasting a period of 6 hours or longer". In this case the pression decrease reached 11 millibar/24h. The strong Bora wind had a 7 hour duration over 24 knots. Although the event of the 24th September 2004 didn't cause any relevant flooding in Venice historical centre (maximum: 90 cm at 7pm), it can be taken as an example of local surges within the Lagoon induced by local wind effects.

APAT manages a network of 52 tide gauge stations within the Lagoon of Venice and along the nothern Adriatic sea coastline. We will present the typical hydrodinamic disorder induced by wind stress on the water surface inside the Venice Lagoon. The more relevant tide gauge stations in this case study are highligthed in the fig.1, red coloured those inside the Lagoon, green coloured those outside. The blank circles represent the whole APAT network.

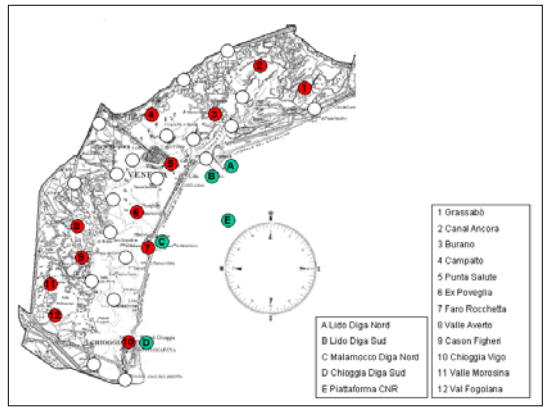


Fig.1- Venice Lagoon: location of the tide gauge stations

CONTEXT OF LOCAL SURGES

The phenomenon of high tides is typical of the Northern Adriatic sea, it is caused basically both by wind stress over the water surface and pressure variations along the Adriatic Sea. It has a scale of hundreds of kilometres. Local surges have a scale of few kilometres within the Venice Lagoon and they are caused by wind stress on the lagoon water. Local surges can produce significant effects especially next to the lagoon borders. Bora wind (from NE sectors), has relevant effects in the southern Lagoon, nearby Chioggia island (# 10 in fig.1), the fishing areas (# 8, 9, 10, 11 in fig.1) and the reclaimed areas, close to the Lagoon borders, all situated below the mean sea level.

BORA WIND RELEVANT CASES

In previous works, an average difference of 50 centimeters had been estimated between the Northern and Southern part of the Lagoon in different cases of Bora wind of 10-13 knots (Pirazzoli, 1981); an absolute difference of 80 centimeters was registered on the 8th December 1992 during a case of an average 20-knots speed Bora wind event (Ferla *et al.,* 1994). A recent analysis classifies the Bora wind effects in term of difference of surge between Chioggia and Venice Punta Salute by wind speed classes (Berrelli *et. al.*, 2006).

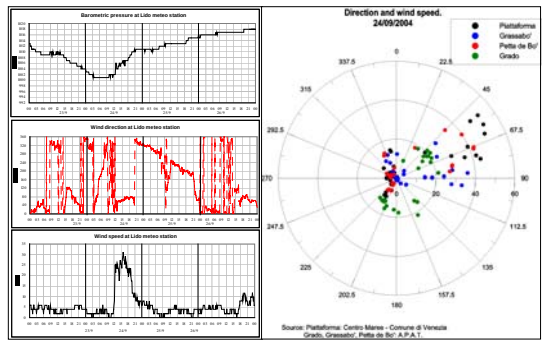
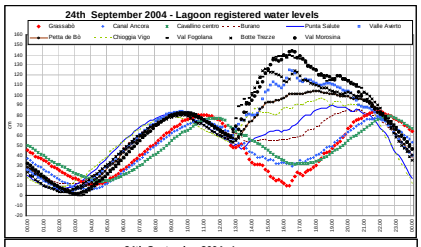


Fig.2 – Pressure , wind direction and wind speed 23rd-26th September 2004



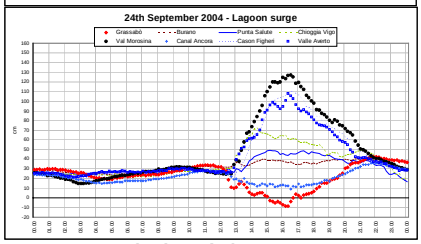
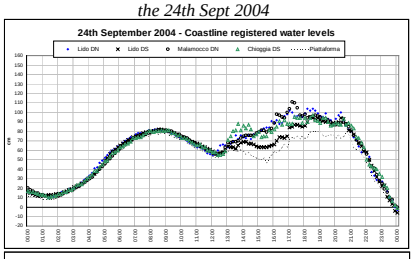


Fig. 3 – Water levels inside the Venice Lagoon on the 24th Sept 2004



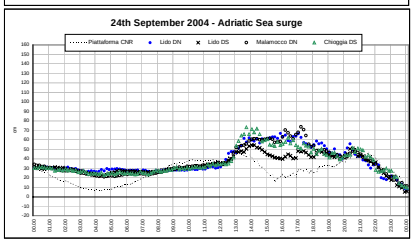


Fig. 4 – Water levels in the Adriatic Sea on the 24th Sept 2004

CASE STUDY: OBSERVED WIND AND PRESSURE VARIATIONS

The pressure decrease observed at Lido meteo station since the 23th September reached its minimum (1001 millibar) on the 24th morning (fig. 2, first row). On the 24th September, at 12.20am the wind speed raised up to 21 knots (with a variation of 13 knots in 10 minutes) (fig. 2 third row), the pressure grew from 1002 up to 1006 millibar at the same time (fig. 2 second row). The wind continued blowing from the NE sector, slowly rotating towards ENE sector. All the stations both within the Lagoon (Grassabò and Petta de Bò) and on the coastline (Grado and Piattaforma) registered similar values (fig.2 - right).

The Bora wind kept blowing from NE sectors for almost 7 hours (from 12.20 to 19.20) at an average speed of 24 knots, with a maximum of 31 knots (4.00pm).

EFFECTS ON THE WATER LEVELS

The effects registered within the Venice Lagoon are macroscopic: an hydrodinamic disorder persisted for almost 9 hours; while the Northern Lagoon registered lower levels than Venice - Punta Salute, the Southern part had an extraordinary surge. Val Morosina tide gauge station during the most intense wind speed reached the maximum absolute level (+144 cm at 4.30pm), whilst at Venice - Punta Salute the water reached just +90 cm at 7.00 at 7pm (fig.3, first row). The astronomical signals calculated in each site had also been filtered out from the observed levels: the resulting storm surges induced by the Bora wind set up depict huge differences within the Lagoon (figure 3, second row). The maximum absolute difference reached +133 centimeters in water levels at 4.20pm (+135 cm in term of storm surge) between Grassabò (station 1 in fig.1) and Val Morosina (station 11 in fig.1): one of the highest ever registered difference in water levels caused by wind effects.

The tide gauge stations located on the coastline (fig.1, A-E stations) registered lower variation in terms both of water levels than surge (fig.4). At Lido inlet it was registered a higher surge during the first gusts, but since 3 pm the surge at lido inlet was up to 7 cm lover than Venice Punta Salute. Indeed, Piattaforma station, located in the Adriatic sea at 7 miles far from Lido inlet, registered a surge lower up to 32 cm than Venice Punta Salute.

CONCLUSION

The event of the 24th September 2007 depicts a new scenario of the Venice Lagoon in case of extreme meteorological events. Such events may represent a good exercise to test via simulations the behaviour of hydrodinamic models. The water levels at the maximum absolute difference of storm surge between the northern and the southern Lagoon are represented in figure 5. The most relevant inhabitated areas are also indicated.

Next steps in the study will consider the behaviour of the Lagoon waters in case of closure of the mobile barriers at the inlets and the impacts of such differences between the water levels inside the Lagoon and the open sea.

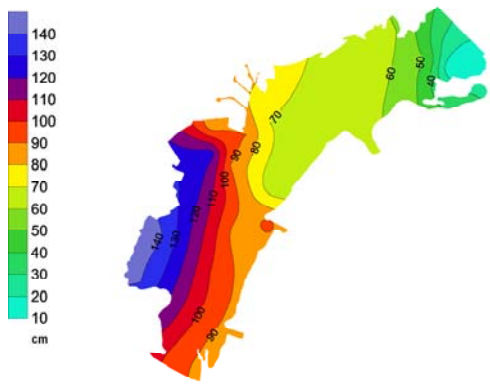


Fig. 5 – Water levels at 4.30pm on the 24th September 2004, at the moment of maximum difference (+135 cm) of surge within the Lagoon. Principal inhabitated areas

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