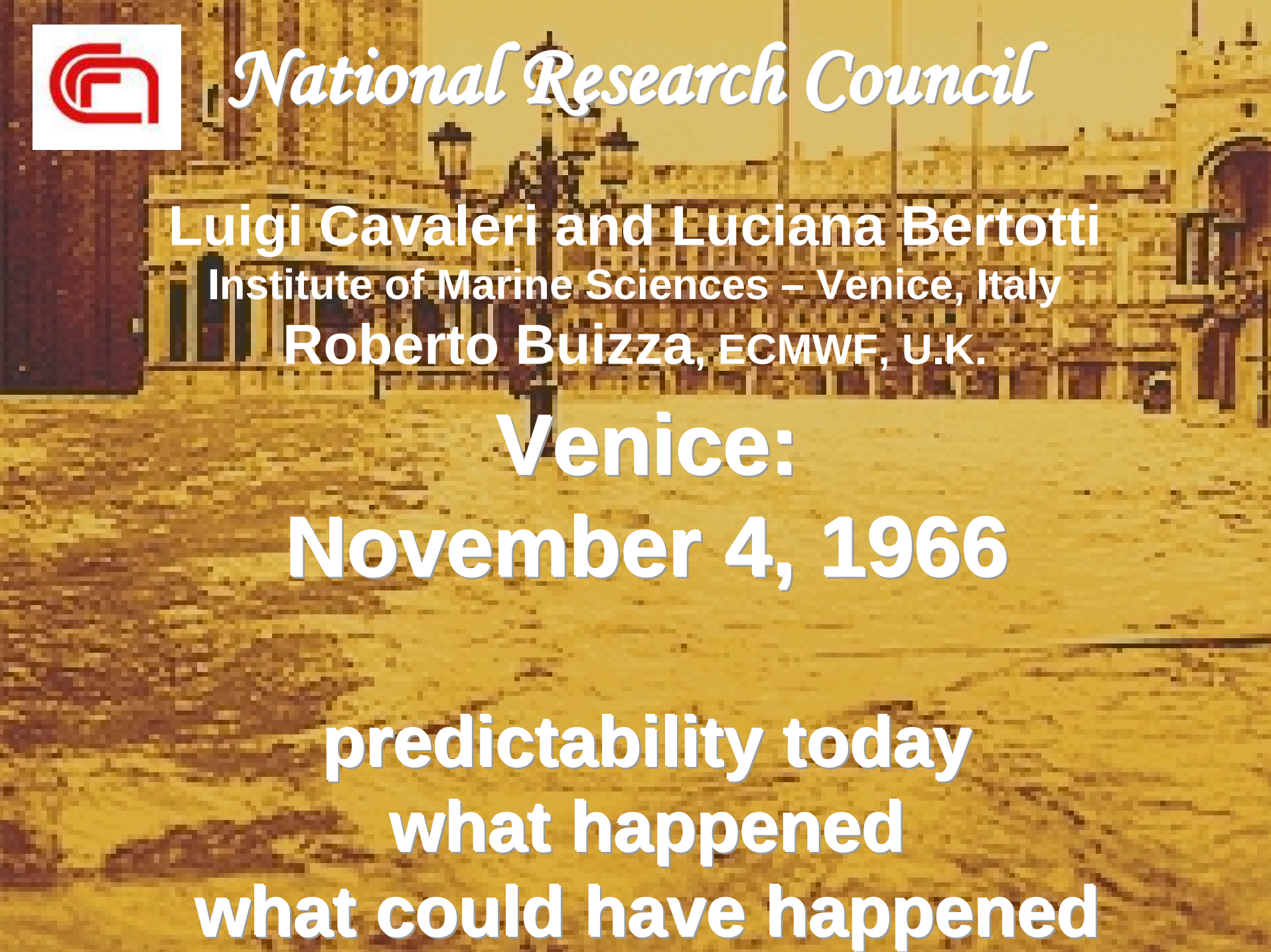

National Research Council

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Institute of Marine Sciences – Venice, Italy
Roberto Buizza, ECMWF, U.K.

Venice: November 4, 1966

predictability today
what happened
what could have happened

summary

- An exceptional event
- The meteorological situation
- If we had had the present forecasting capability
- Analysis of the event of November 4, 1966 and its predictability
- What if the same event happens again in the future? Open problems – future developments

Sequence of actions:

we have considered the meteorological data available at the time of the storm,

we have acted as a 1966 meteorologist,
but with at disposal the present computers and models

we have then issued forecasts based on the data available the days before the storm

the meteorological forecasts have been used to drive circulation and wave models

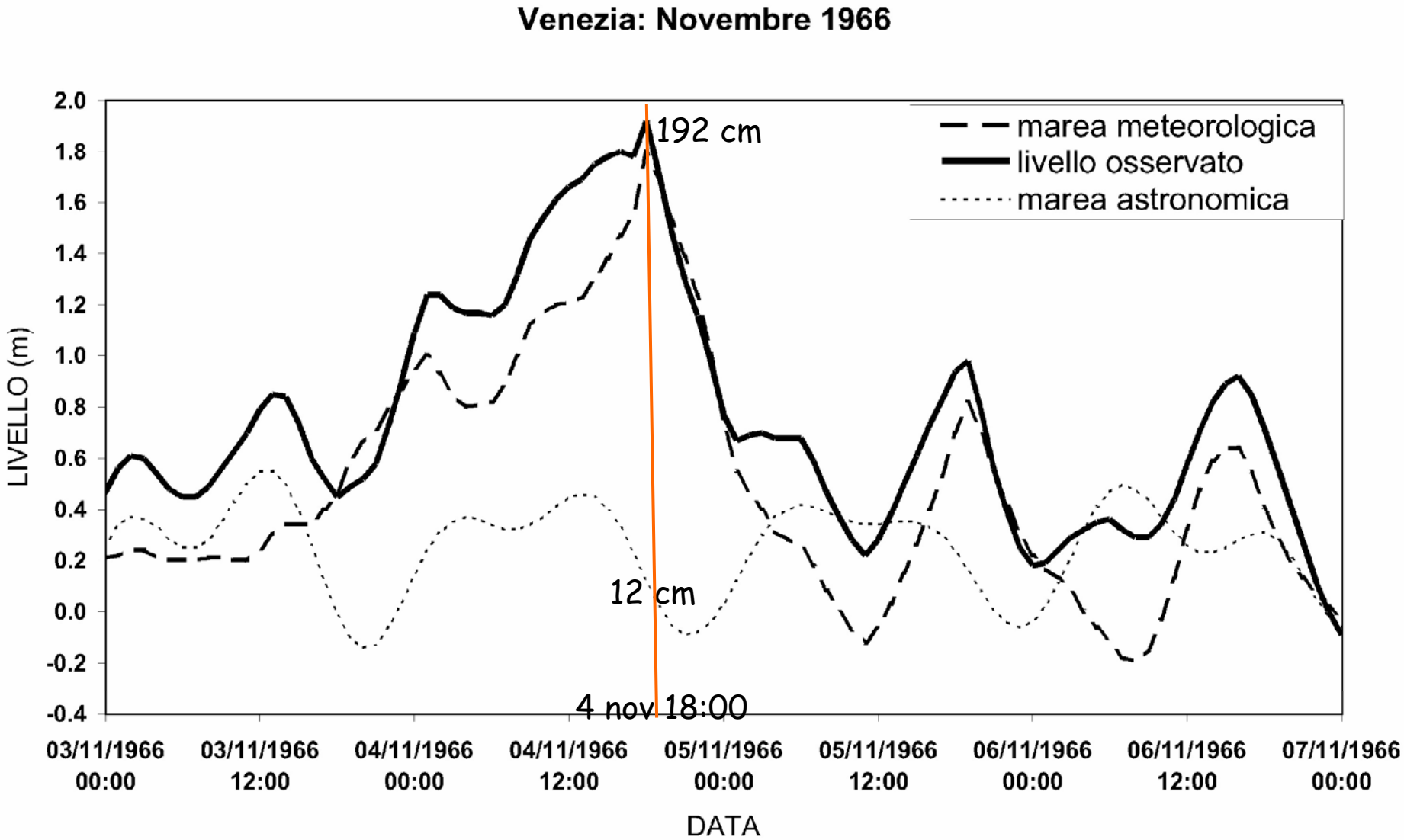
the results have been compared to the available data (tidal only – waves estimated from damages)

Result:

even with only the data available at the time

warning could have been issued well before the storm

An exceptional event



Characteristics of the event

- 192 cm maximum level at 18 (local time)
- Decreasing astronomical tide towards the minimum at 21
- Flood (above 110 cm) from 18 of Nov 3 till 01 of Nov 5 = 31 consecutive hours
- Wind up to 26 m/s (above 90 km/h)
- 8 metre wave heights at the harbour entrances

The event of November 4 was the worst flood in Venice during the last 130 years :

1	4 Nov 1966	192 cm	14	6 Oct 1982	132 cm
2	22 Dec 1979	166 cm	15	18 Dec 1981	128 cm
3	1 Feb 1986	158 cm	16	10 Dec 1990	128 cm
4	12 N				125 cm
9					
10	8 Dec 1992			1993	112 cm
11	17 Feb 1979	140 cm	24	17 Feb 1967	107 cm
12	26 Nov 1969	138 cm	25	24 Nov 1991	107 cm
13	18 Nov 1996	134 cm	26	13 Dec 1957	98 cm

Tidal data from 1872 -
2 events comparable with 1966,
in 1822 and in 1867,
but no measured data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The meteorological situation

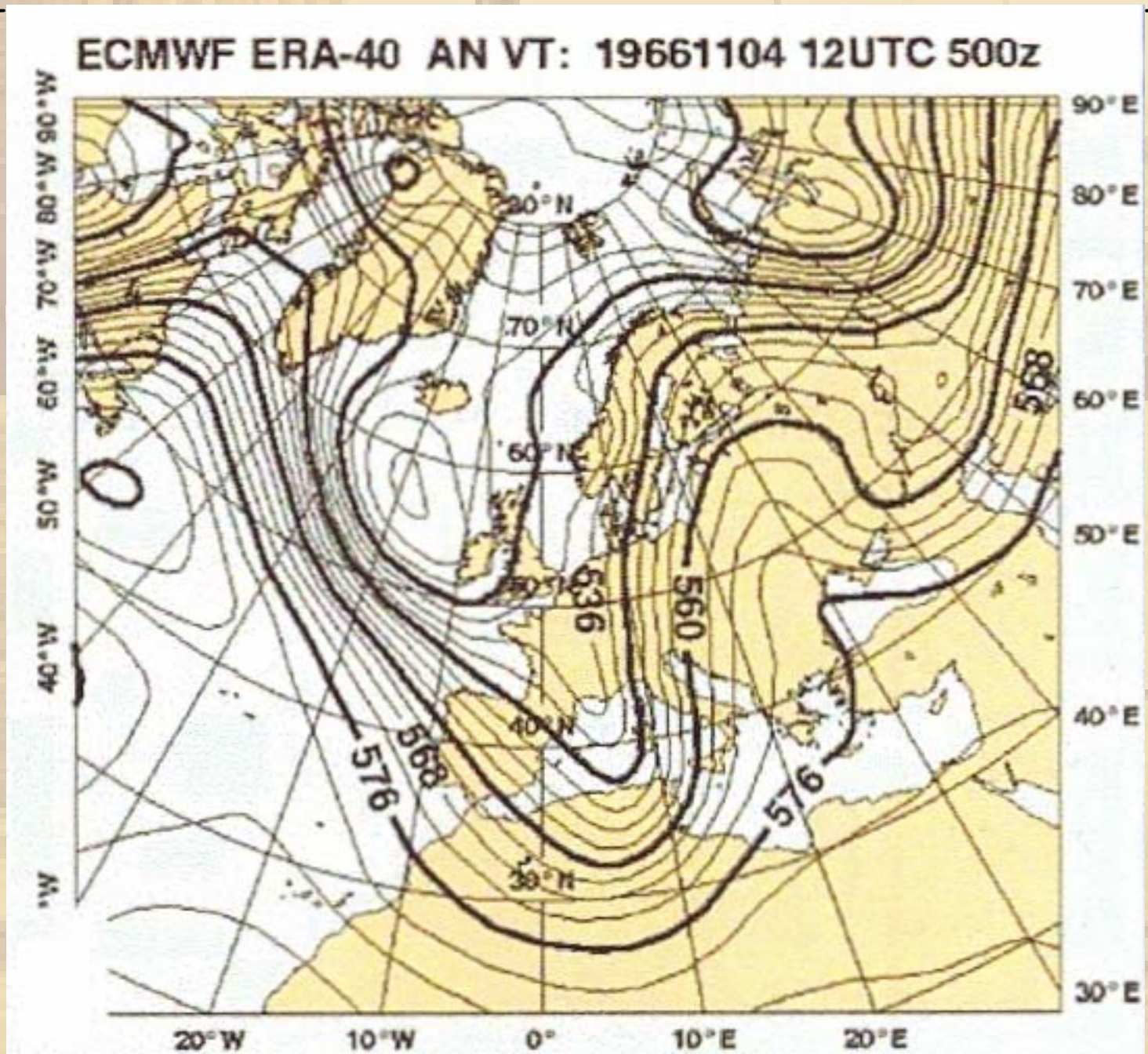
The event of November 1966 affected not only Venice, but the whole central and northern Italy

flooding in **Venice**;
flooding in **Florence**;
flooding of **Polesine** (lowest Po river valley);
overflow of Brenta, Bacchiglione, Adige rivers;
creek floods and landslides in the **Dolomites**.

1119 areas e 34 counties were flooded, 118 casualties

www.Meteomagazine.meteonetwork.it/modules/news/articles.php
www.meteogiornale.it/reportages/read.php
www.3bmeteo.com/giornale_stampa.php

the meteorological situation



In November 1966
the forecast did not anticipate
the intensity of the storm

Had we had the present forecasting capability

40 years ago → poor reliability of the forecasts

- few meteorological data
- no sophisticated meteorological model

↓

Today:

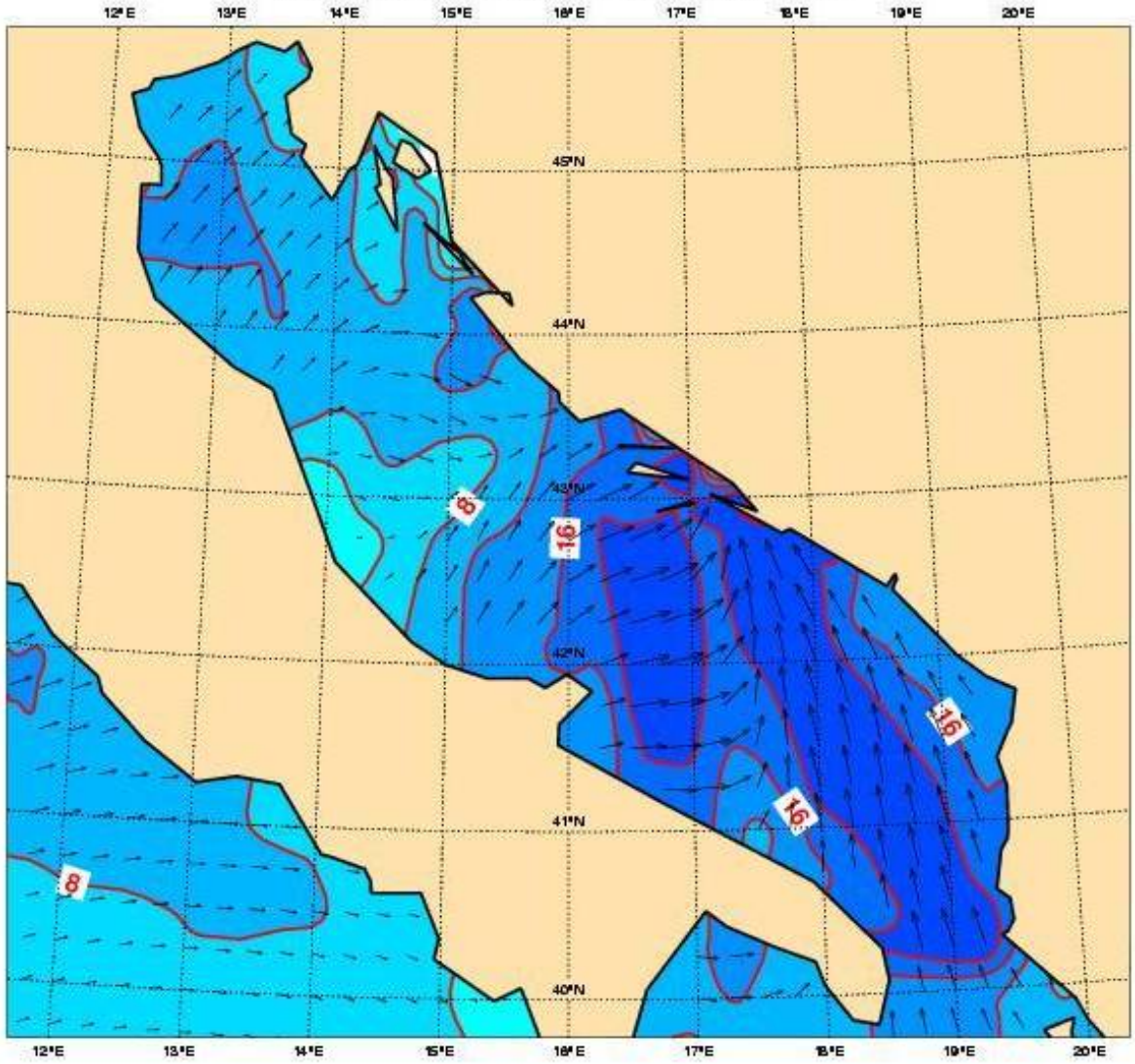
- plenty of data (satellites, ships, planes, meteorological stations)
- powerful computers
- sophisticated numerical models

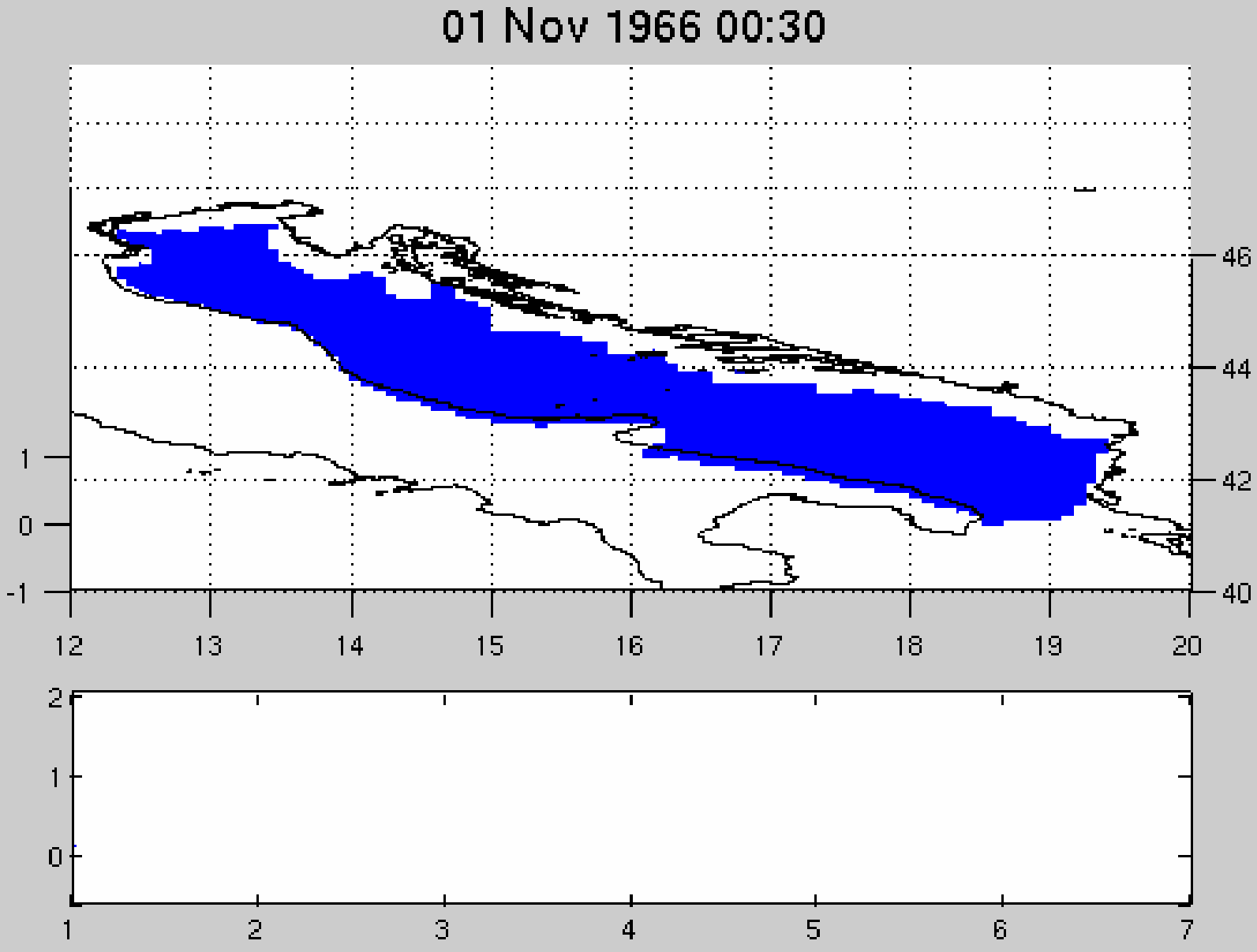
Analysis of the November 4, 1966 event and its predictability

The ECMWF reanalysis has focused on the last 45 years, using all the available data (resolution = 125 km)

Starting from these data we have analysed the event on the Mediterranean area with the resolution operational in 2005

wind fields (analysis)



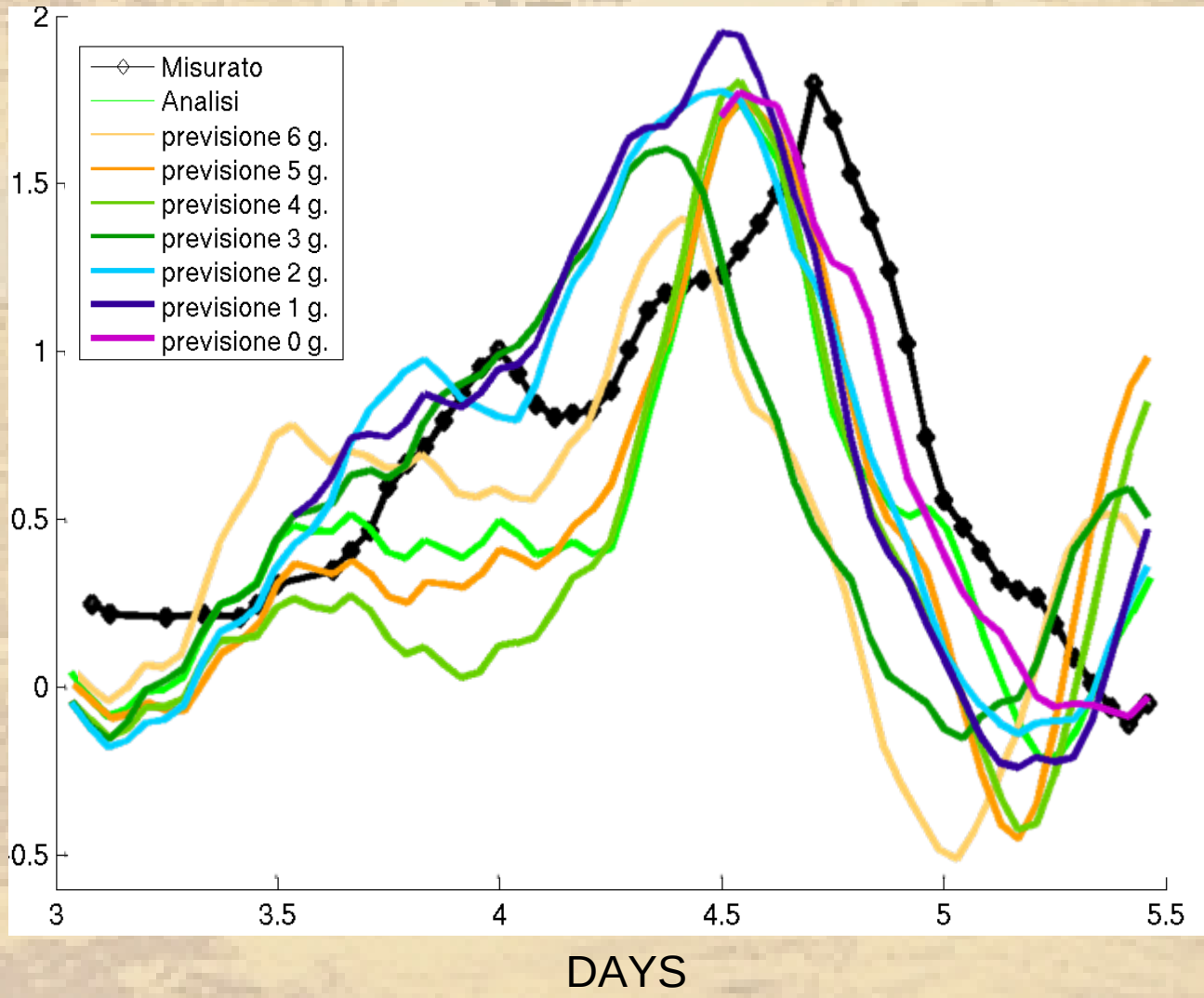

01 Nov 1966 00:30
46
44
42
40
1
0
-1
12
13
14
15
16
17
18
19
20
2
1
0
1
2
3
4
5
6
7

ECMWF has reanalysed the last 45 years, collecting all the available data (resolution = 125 km)

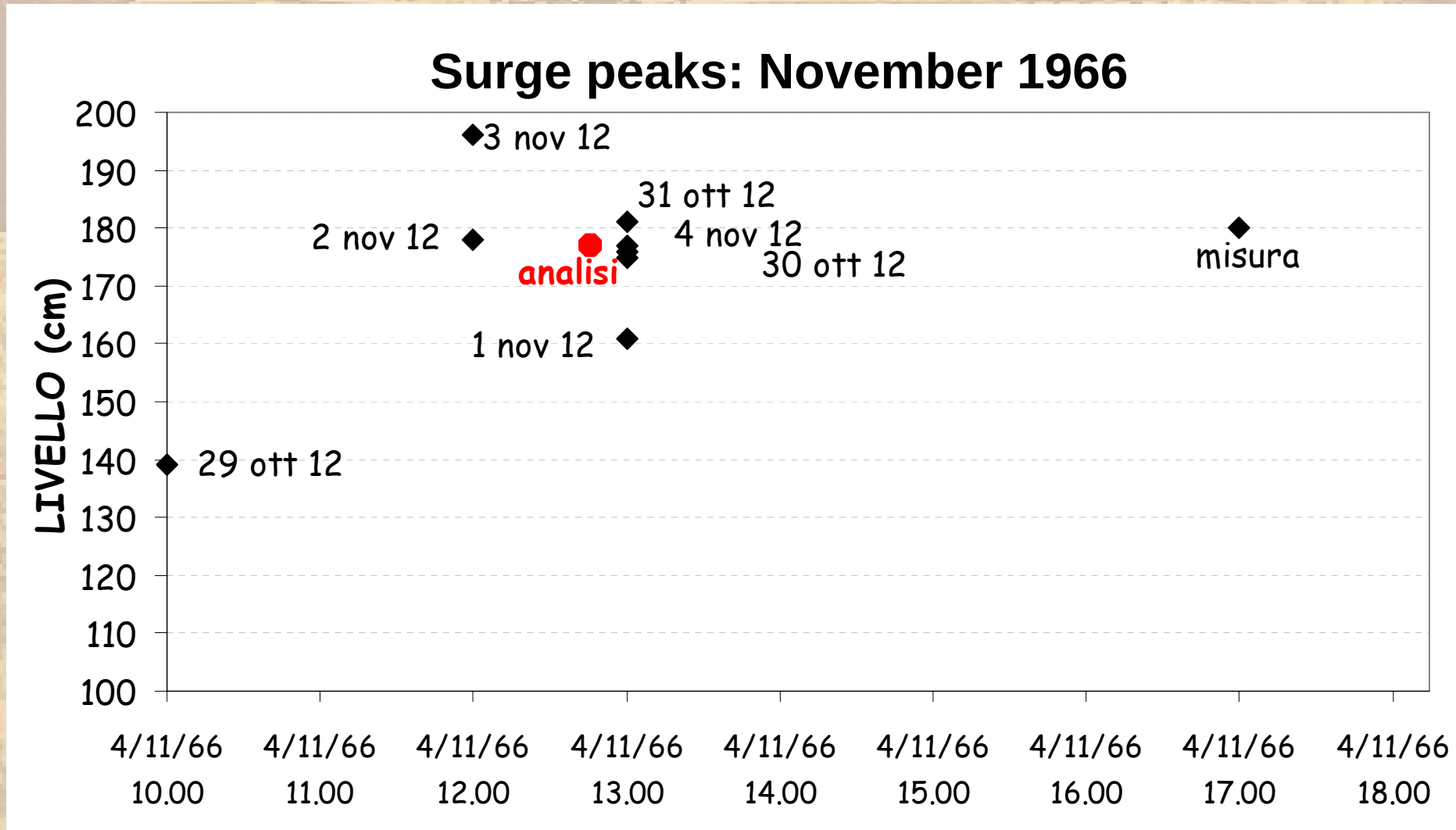
From these data we have analysed the event on the Mediterranean area with the resolution operational in 2005 (40 km)

Using these analyses, we have forecast the storm starting from each one of the various days before November 4, 1966

Modelled surge at Venice – November 1966



WAS THE EVENT PREDICTABLE?


Surge peaks: November 1966
LIVELLO (cm)
200
190
180
170
160
150
140
130
120
110
100
3 nov 12
31 ott 12
2 nov 12
4 nov 12
analisi
30 ott 12
misura
1 nov 12
29 ott 12
4/11/66 10.00
4/11/66 11.00
4/11/66 12.00
4/11/66 13.00
4/11/66 14.00
4/11/66 15.00
4/11/66 16.00
4/11/66 17.00
4/11/66 18.00

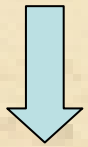
We would have known six days in advance that an exceptional storm would come along

How heavy was the storm?

WAS THE EVENT PREDICTABLE?

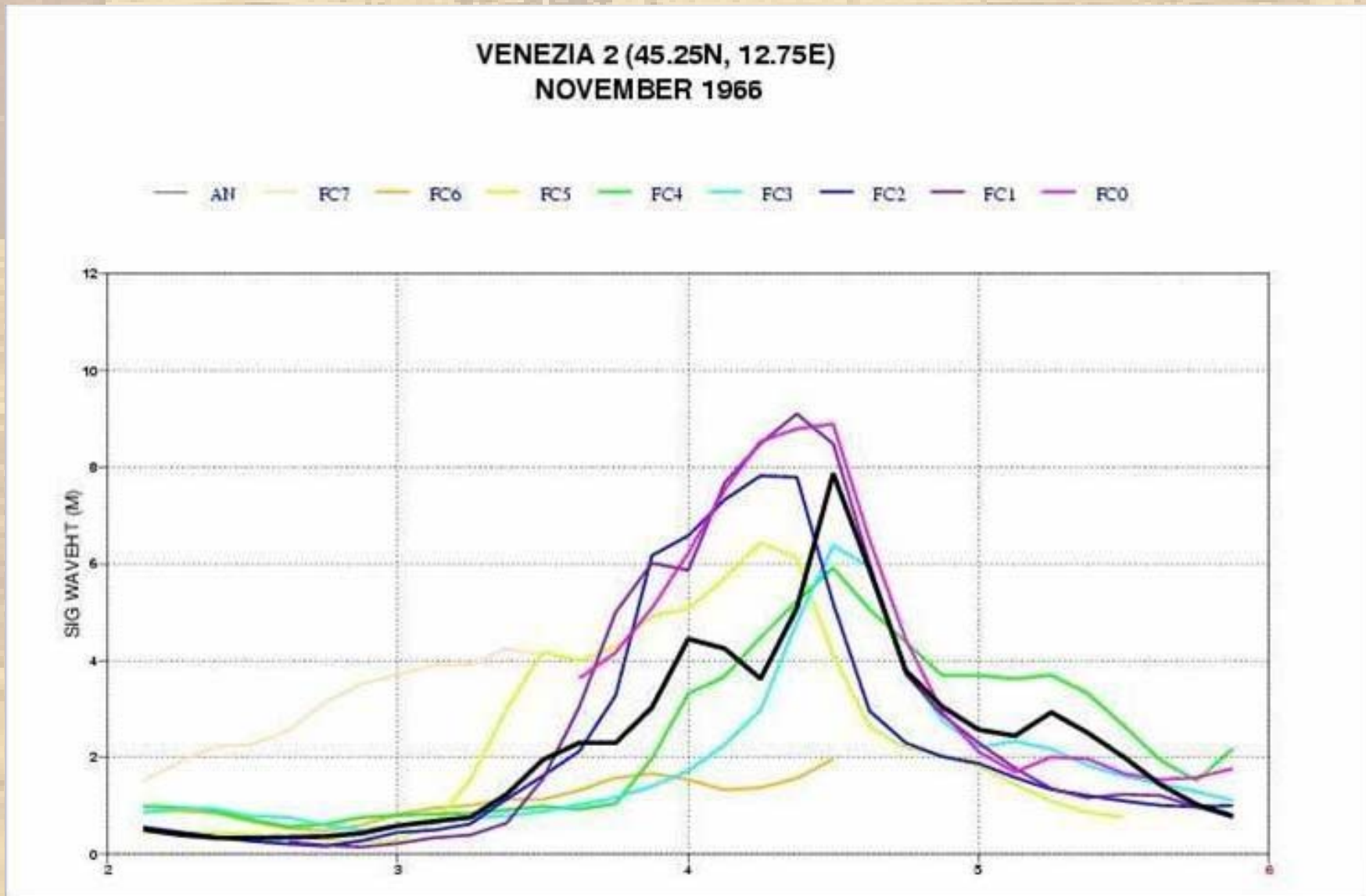
How heavy was the storm?

We have the wind data out of the ECMWF a posteriori analysis

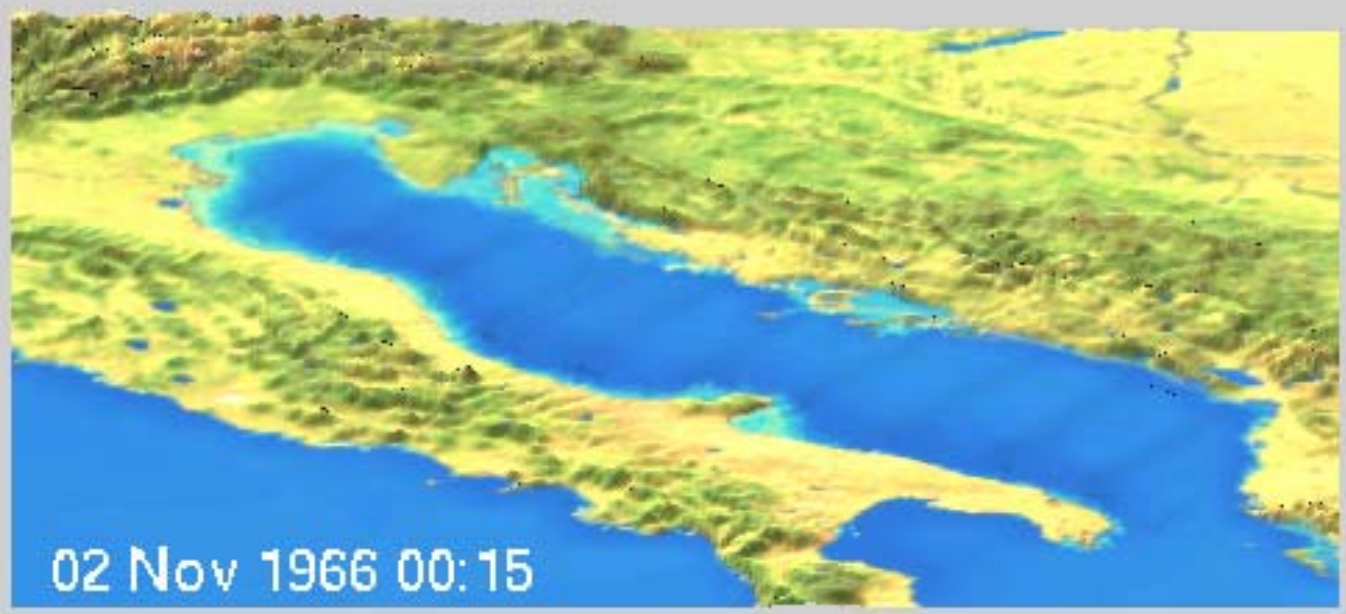


We can hindcast the wave fields

Time series of the significant wave height



WAS THE EVENT PREDICTABLE?

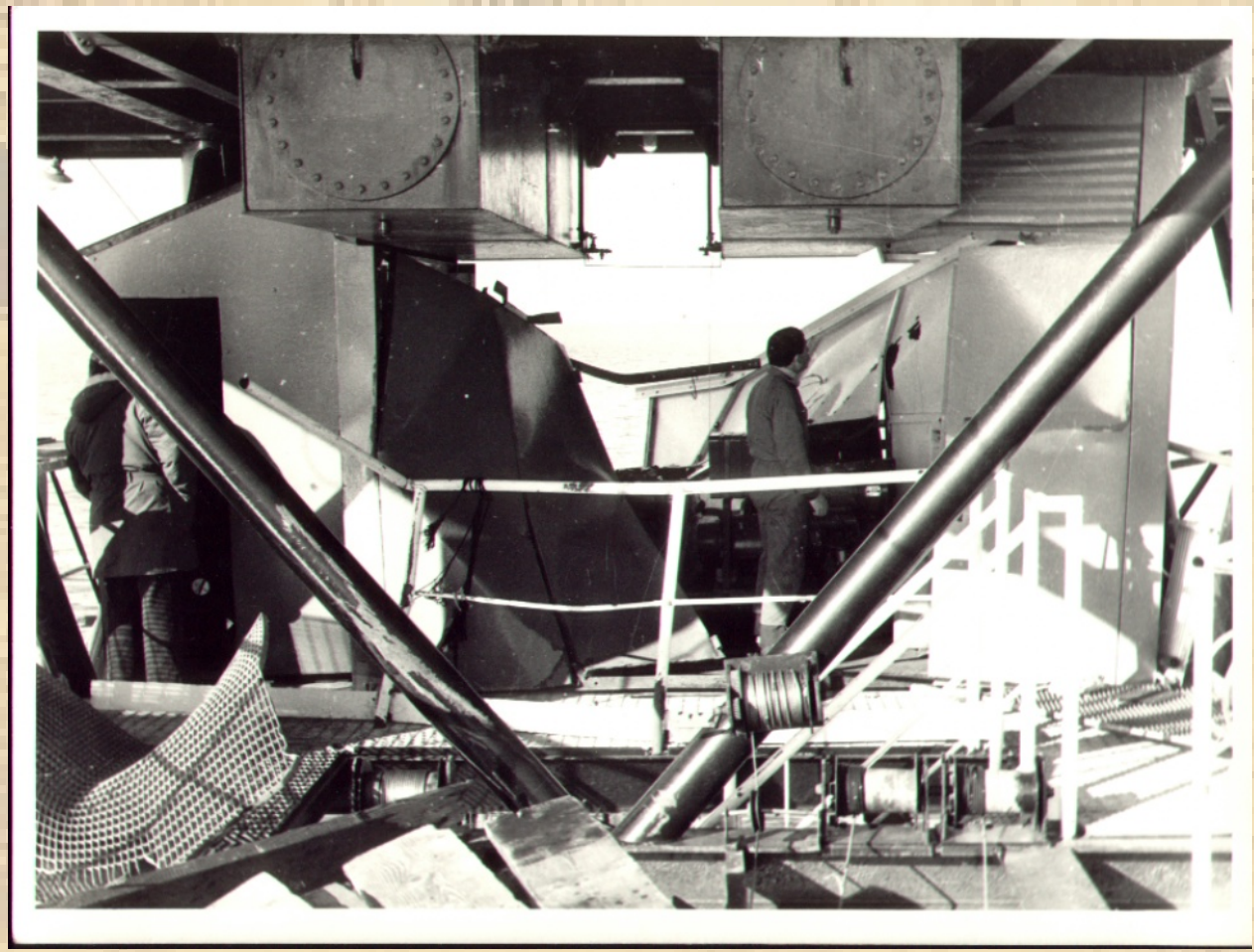


- **Had the ISMAR tower been there, how much damage would have it suffered?**

- **The tower has been built just because of the 1966 storm to collect data and observations in the open sea and to carry out specific experiments**

The tower today

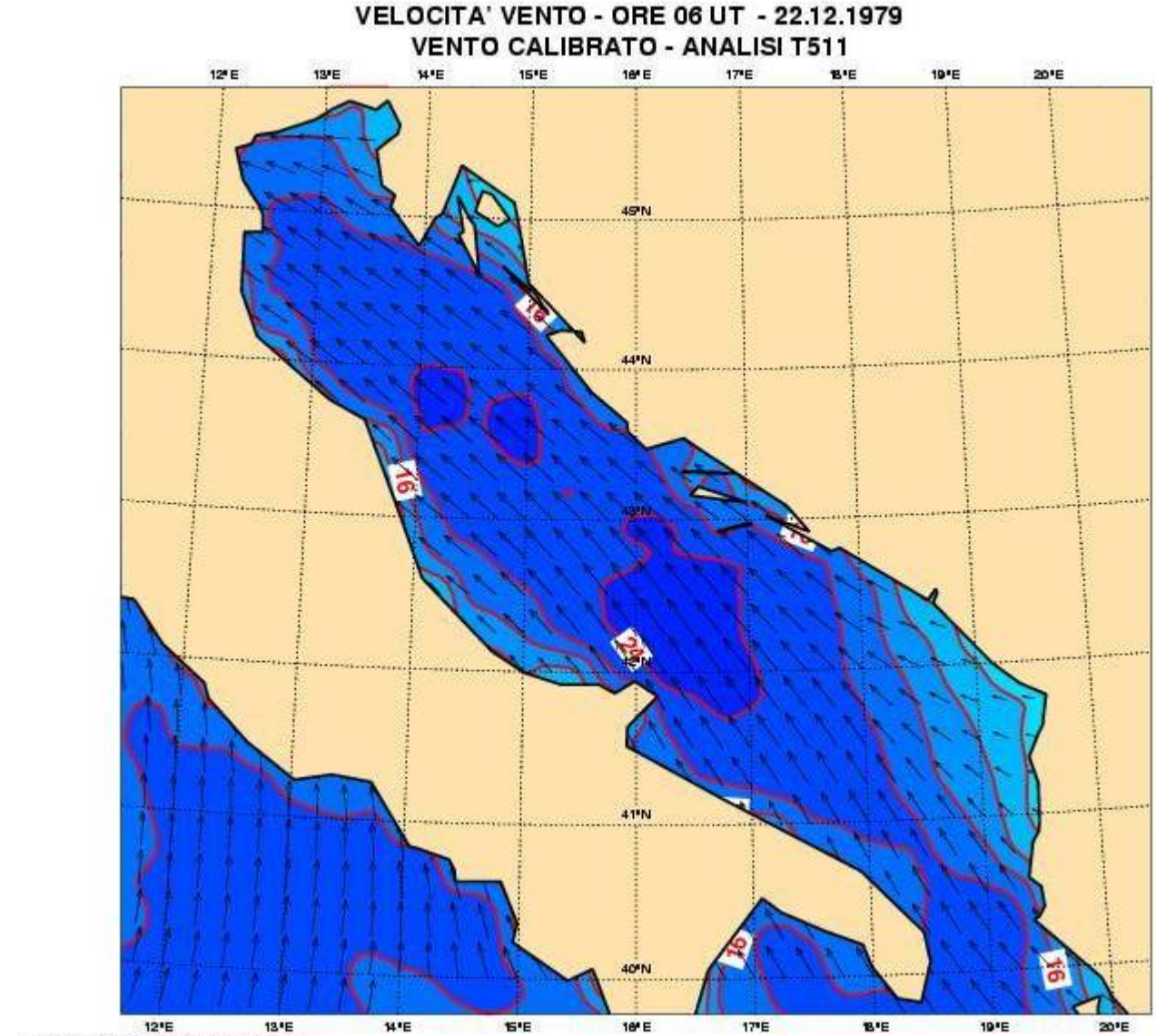
After the storm of December 22, 1979



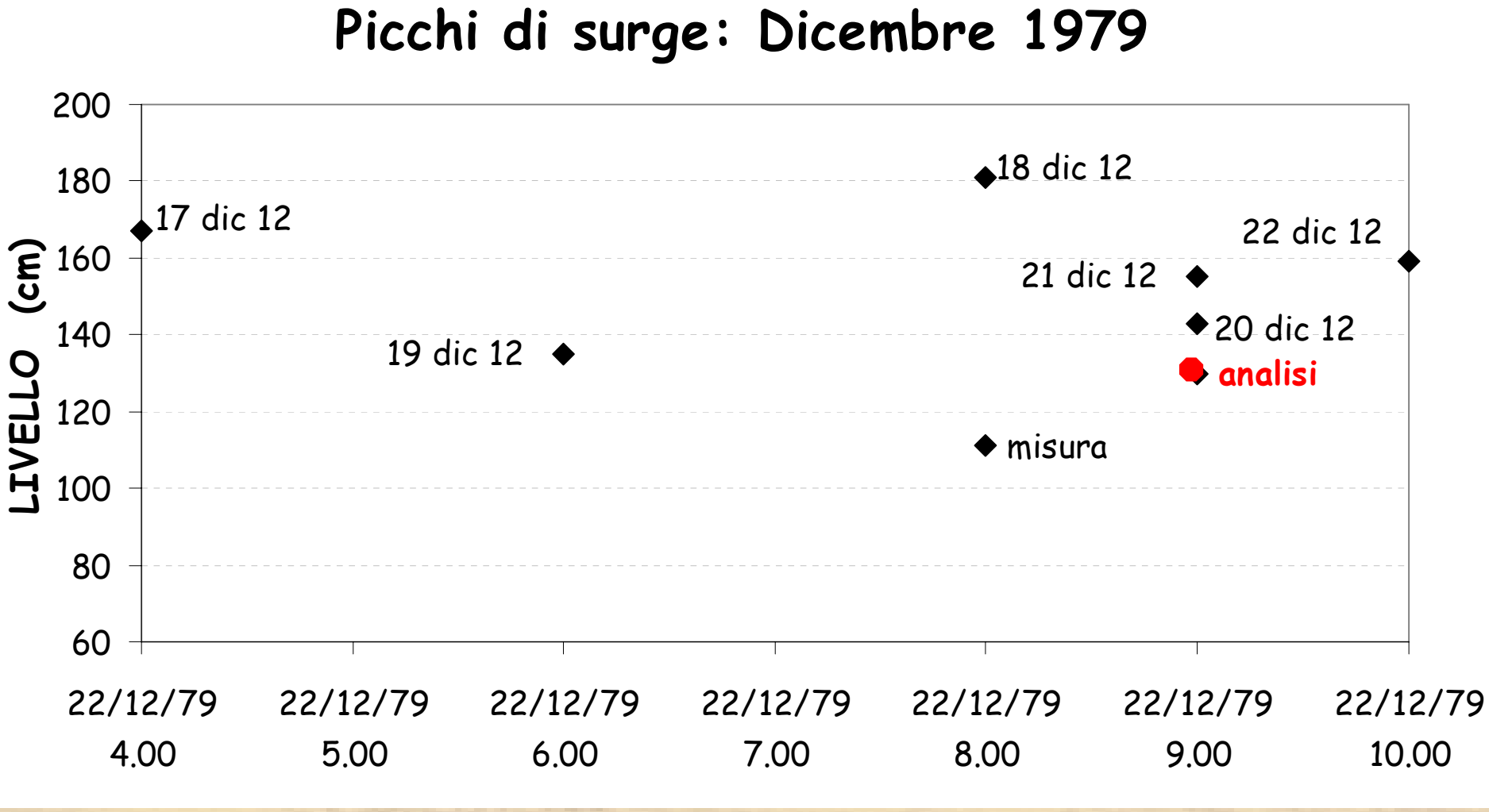
With the same method used for 1966

we have studied also the event of December 22, 1979.

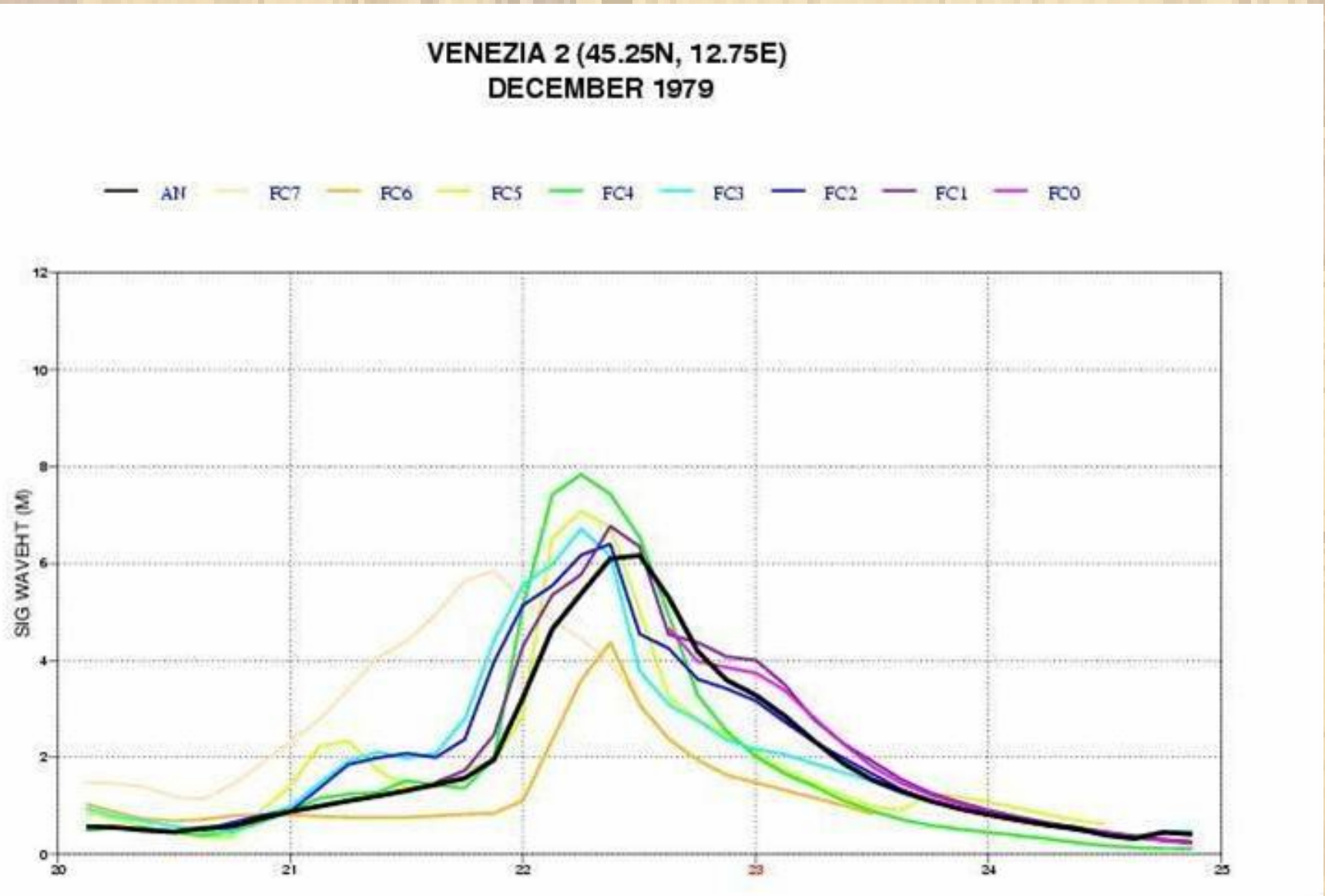
Analysed wind field - ECMWF



Surge using ECMWF forecasts

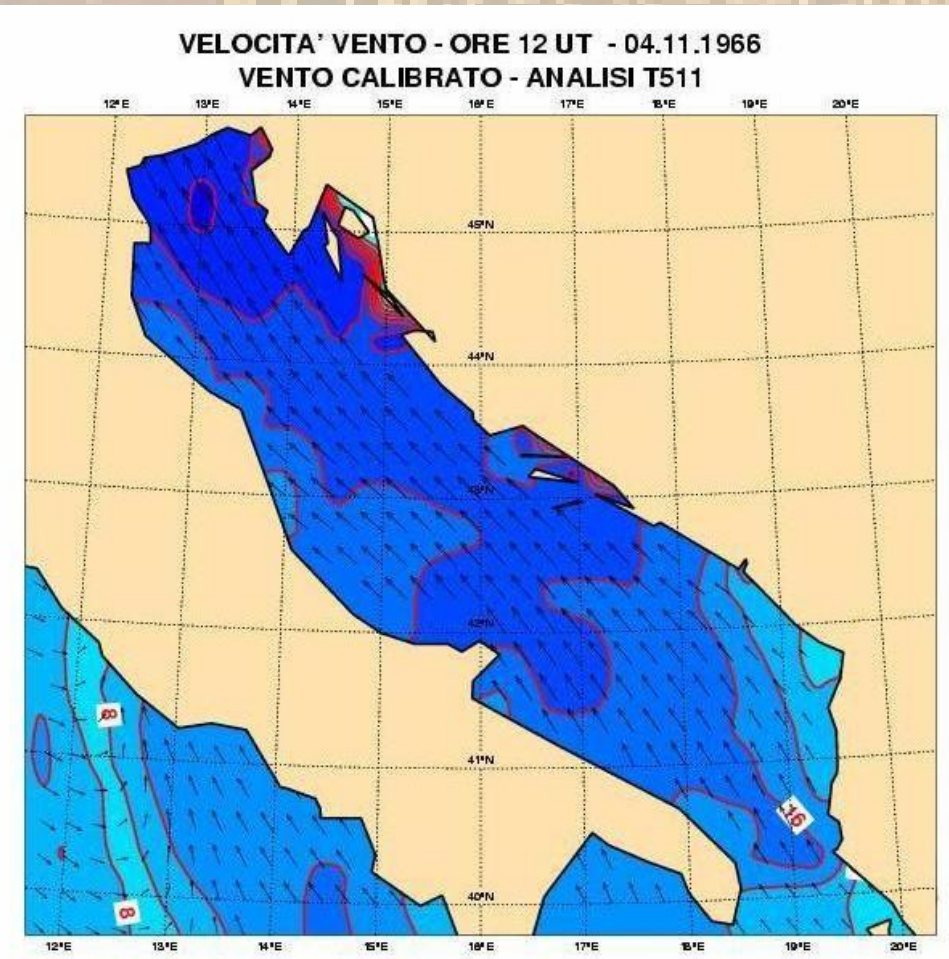


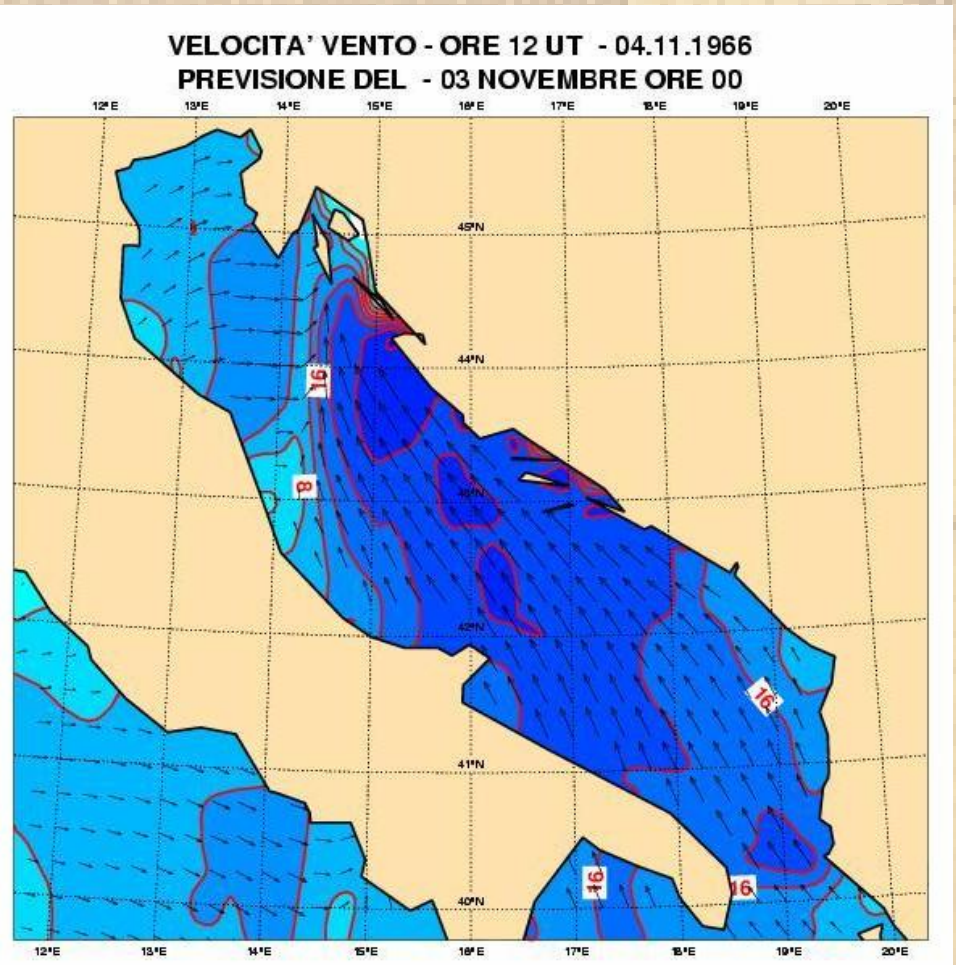
Time series of significant wave heights offshore Venice – December 1979

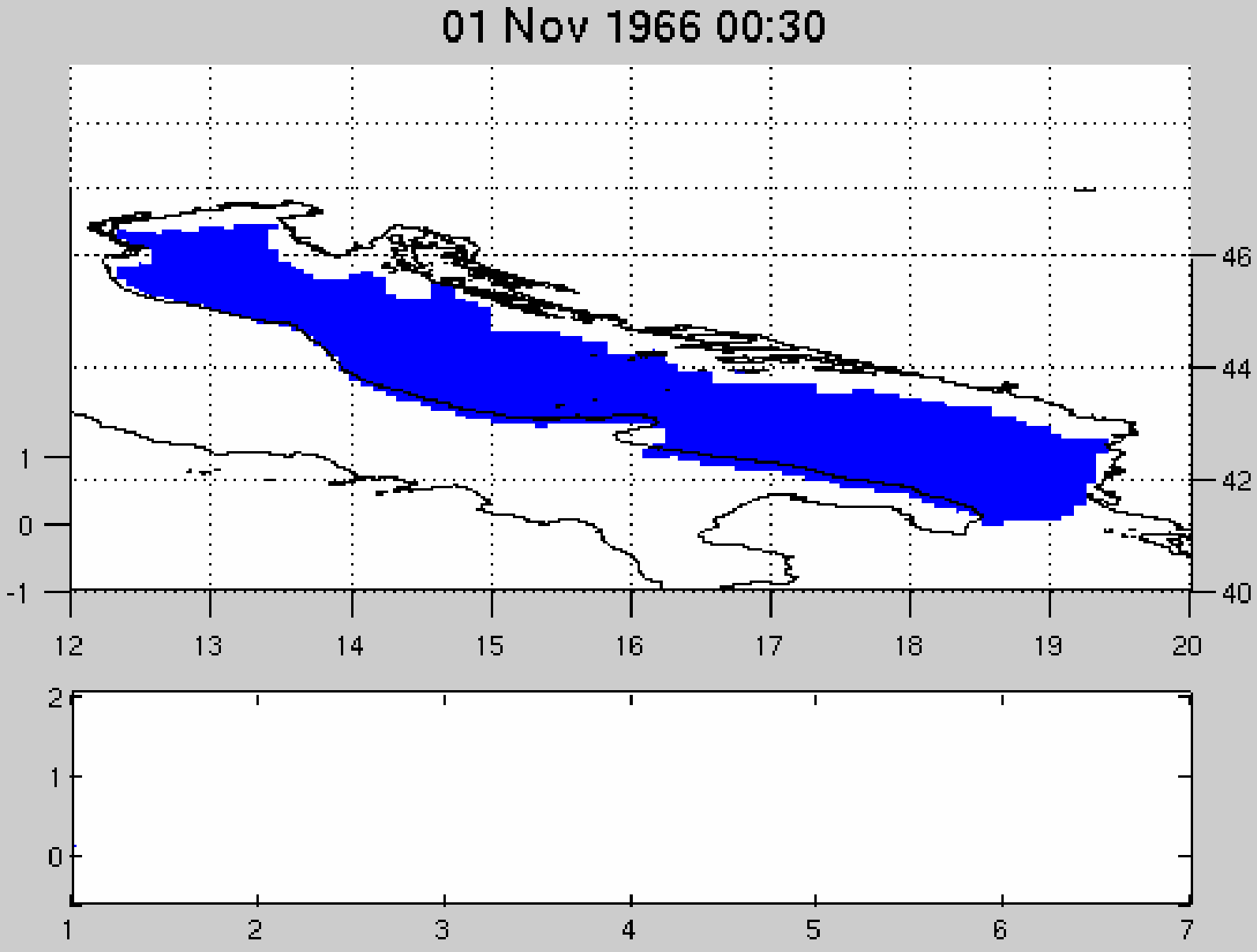


Open problems: future developments

Forecast issued at Nov 03:00 UTC






01 Nov 1966 00:30
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12
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14
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16
17
18
19
20
2
1
0
1
2
3
4
5
6
7

Open problems: future developments

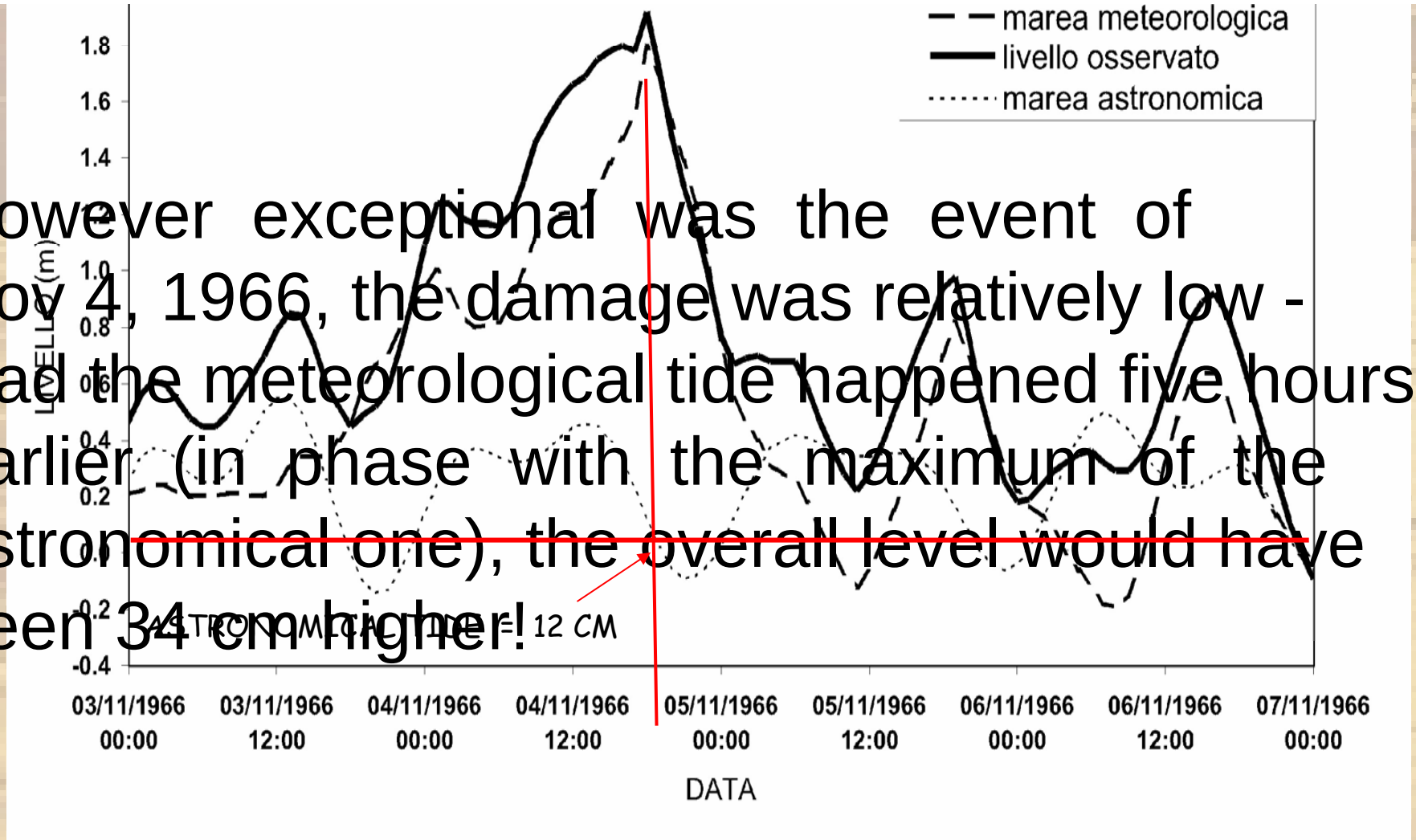
forecast issued at Nov 03:00 UTC

wrong forecast – the early advance of the cold front has completely cancelled the flood

Open problems: future developments

How lucky-unlucky we were during the flood of Nov 4, 1966 ?

The maximum level was reached when the astronomical tide was below the mean sea level



However exceptional was the event of Nov 4, 1966, the damage was relatively low - Had the meteorological tide happened five hours earlier (in phase with the maximum of the astronomical one), the overall level would have been 34 cm higher!


Luisa Spagnoli
FARMA


Luisa Spagnoli
FARMA


Luisa Spagnoli

Arguing about a possible repetition of the Nov 4, 1966 event

What is the probability of a repetition ?
Nov 4, 1966 – estimated as the 100-150 year meteorological event

What is the probability for the meteorological tide to coincide with the astronomical one ?
< 1:10 - 1:20 >

The combination (194+34=228 cm) becomes the (1-2 thousands?) year event

However, 194 cm are possible also with storms less intense, but with higher astronomical tides - This brings the 1966 event within the 100-150 year range

If we consider also the raising sea level (present rate estimated at 3 mm/year), the 194 cm will be less and less a unique phenomenon


Questions?