



17-19<sup>th</sup> October 2018

Accademia dei Georgofili - Logge Uffizi Corti

Firenze

# Calibration of a coupled flow-wave model for Tuscany coastal areas

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1) CNR-IBIMET Institute of biometeorology, Firenze, Italy

2) Consorzio LaMMA, Sesto Fiorentino, Firenze, Italy



# Objective 1/2



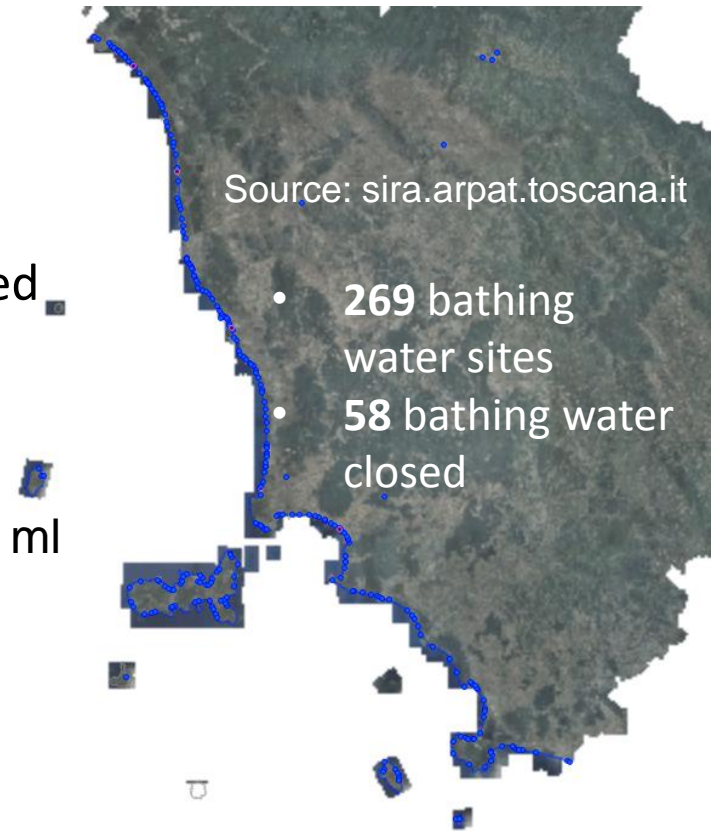
## OBJECTIVE

To implement a forecasting system of short-term pollution events in stretches of Tuscany coast with high tourism, commercial and environmental value



The forecasting system will provide a support for bathing water management and related prohibitions in case of exceed of the limits for the two microbiological parameters

- Intestinal enterococci < 200 MPN/100 ml
- Escherichia coli < 500 MPN/100 ml

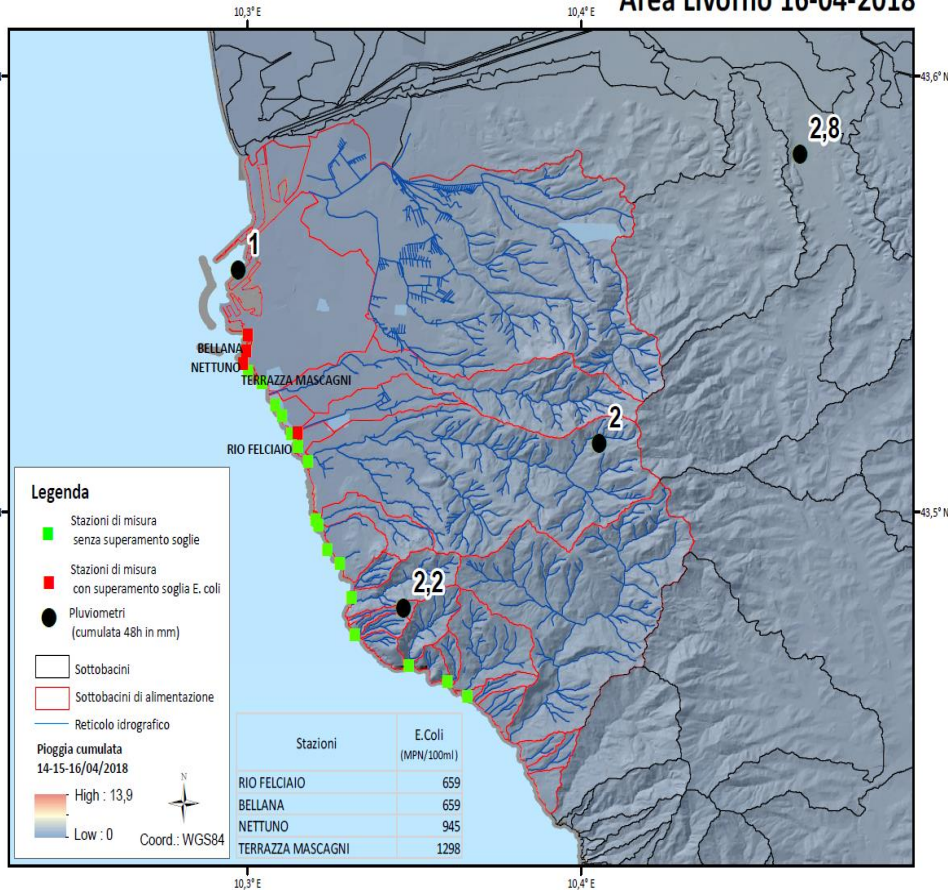




# Objective 2/2

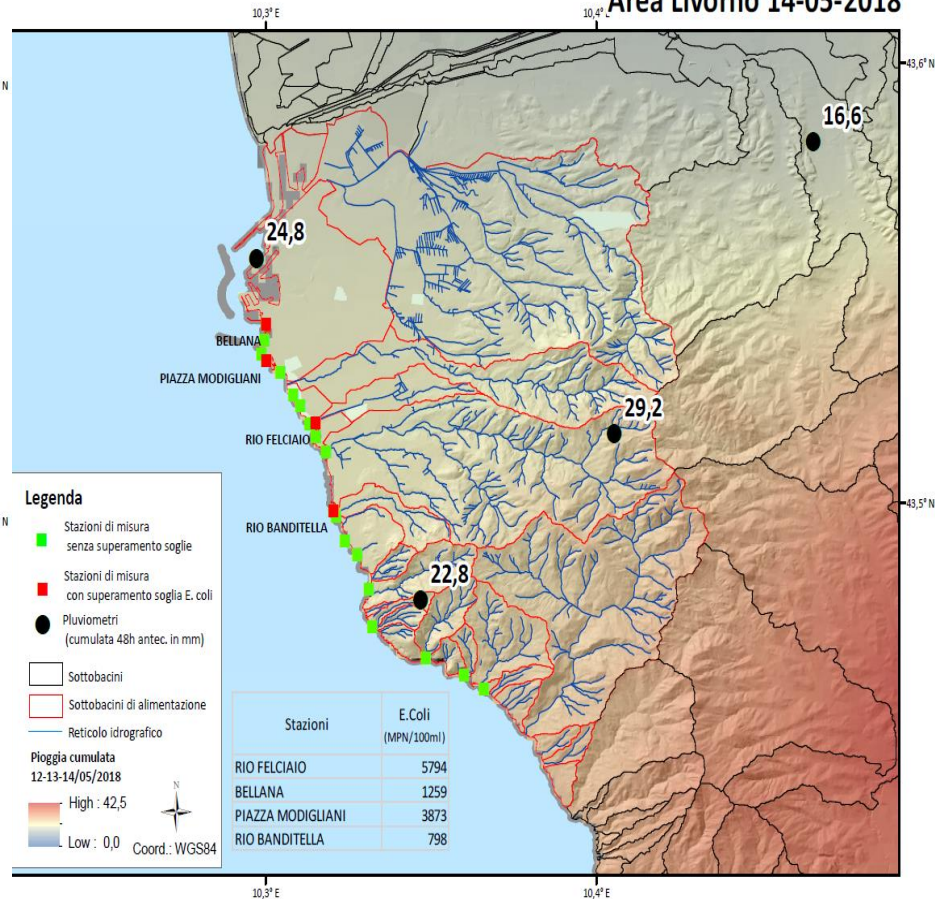
## WITHOUT RAIN

Area Livorno 16-04-2018



## WITH RAIN

Area Livorno 14-05-2018



- How extended are the areas affected by pollution?
- How persistent are pollution events?
- How pollutant sources can be identified and characterized?



# Outline

- Selection of the areas of calibration
  - Pisa san Rossore**  
(2D coupled flow-wave model)
  - Livorno**  
(3D coupled flow-wave model)
- Input data for the Delft3D model
- Description of the computational areas
- Results
- Future works

Bathing prohibited

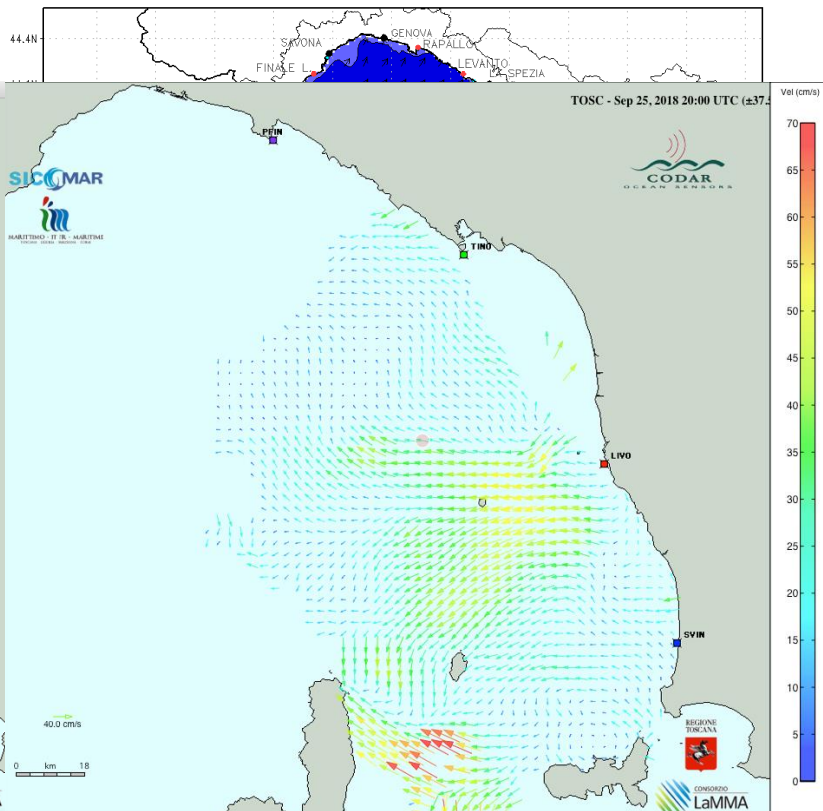
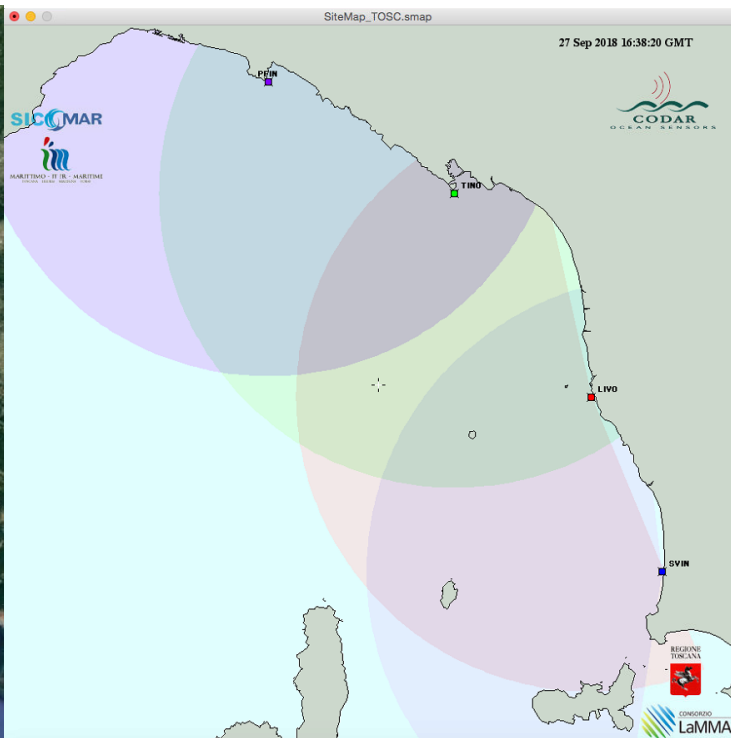
Chiusi	
COMUNE	PISA
PROVINCIA	PISA
AREA	BALN - FIUME MORTO
CODICE	DVB MOR
GB_E	1602683
GB_N	4843184
LON	10.2747114945
LAT	43.734443631
AGGIORNAMENTO	11/09/2018
CLASSE	
STATO	Divieto permanente per motivi igienico-sanitari





# Data used

Consorzio LaMMA WW3 3km – WRF ECM 3km  
Init.: Mon, 16 APR 2012 00 Valid: Mon, 16 APR 2012 00 T=+0h



 Wave and current data (30min) → Wave ADCP Gombo Station (CFR Regione Toscana)

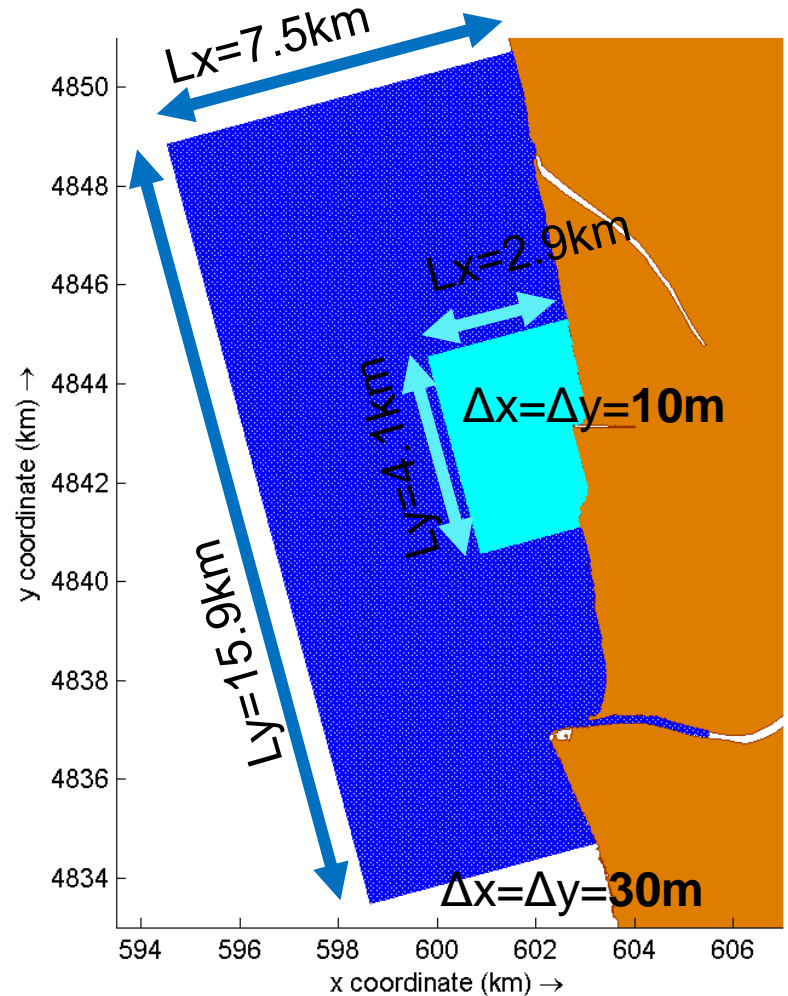
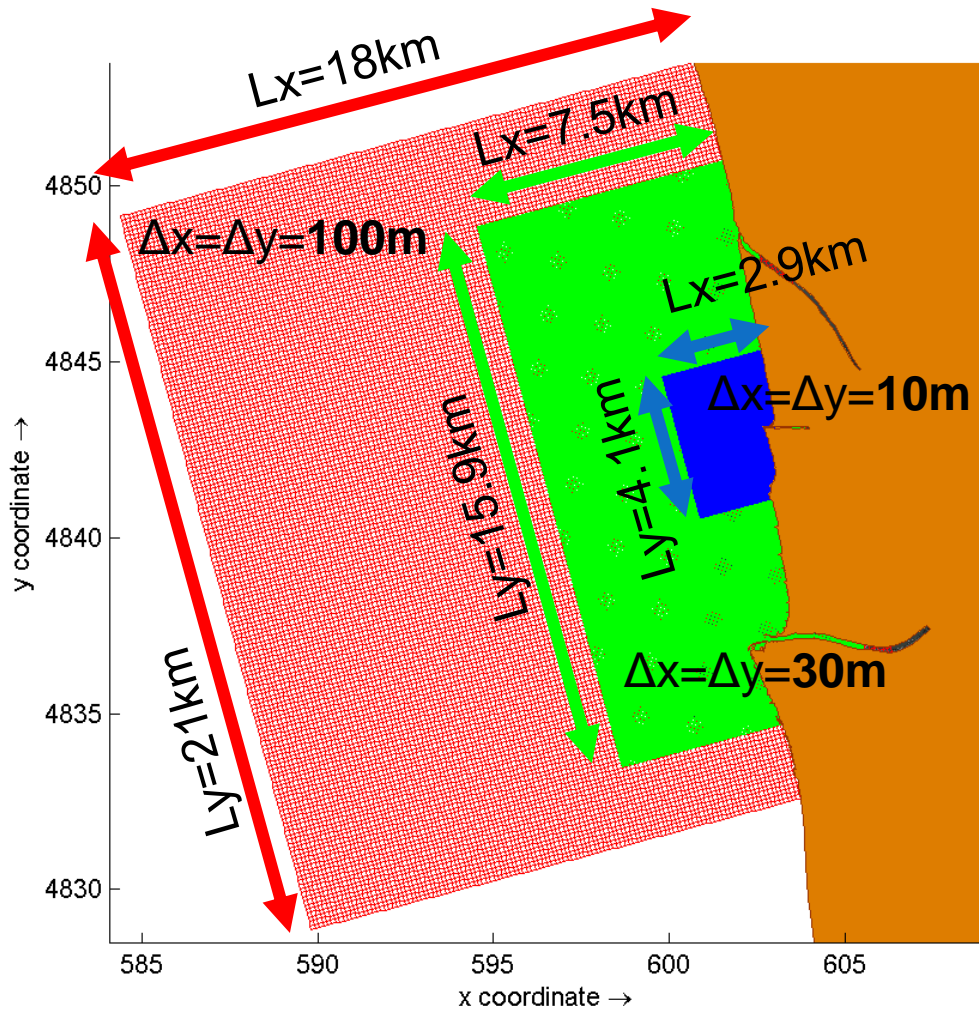
 Current data (1h) → Radar HF (Consorzio LaMMA)



# Pisa 2D Model – computational grids

Wave

Flow





# Pisa San Rossore 2D Model



## CALIBRATION PARAMETERS

- Bottom friction Type JONSWAP

$$S_{ds,b}(\sigma, \theta) = -C_{bottom} \frac{\sigma^2}{g^2 \sinh^2(kd)} E(\sigma, \theta)$$

- Bottom roughness Type Manning
- Horizontal Eddy Viscosity



## TEST

- **1** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0.1\text{m}^2/\text{s}$
- **2** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $1\text{m}^2/\text{s}$
- **3** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0.5\text{m}^2/\text{s}$
- **4** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$
- **5** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.03\text{m}^{-1/3}\text{s}$ , viscosity  $0.5\text{m}^2/\text{s}$
- **6** = friction  $0.067\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0.5\text{m}^2/\text{s}$
- **7** = friction  $0.04\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0.5\text{m}^2/\text{s}$
- **8** = friction  $0.067\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$
- **9** = friction  $0.067\text{m}^2\text{s}^{-3}$ , roughness  $0.03\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$
- **10** = friction  $0.04\text{m}^2\text{s}^{-3}$ , roughness  $0.03\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$
- **11** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.03\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$



## SIMULATION PARAMETERS

- Time step 0.1min
- Radiation stresses forces

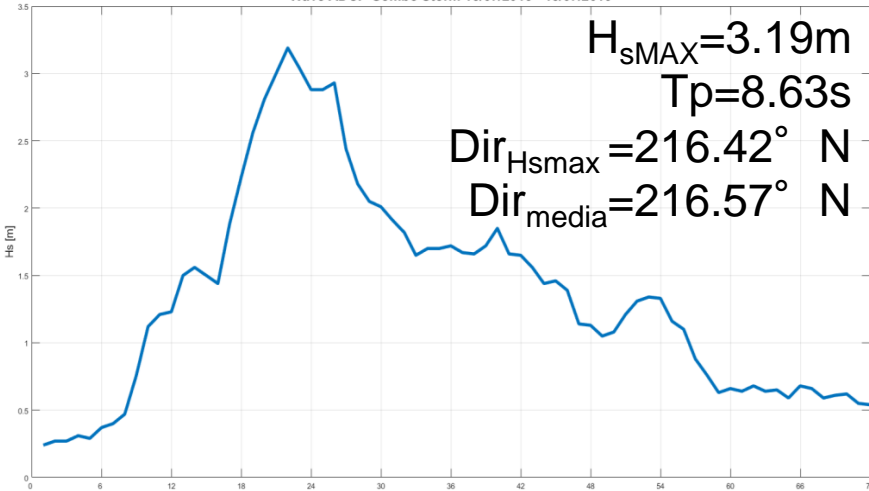


# Pisa 2D Model-storms 1/3

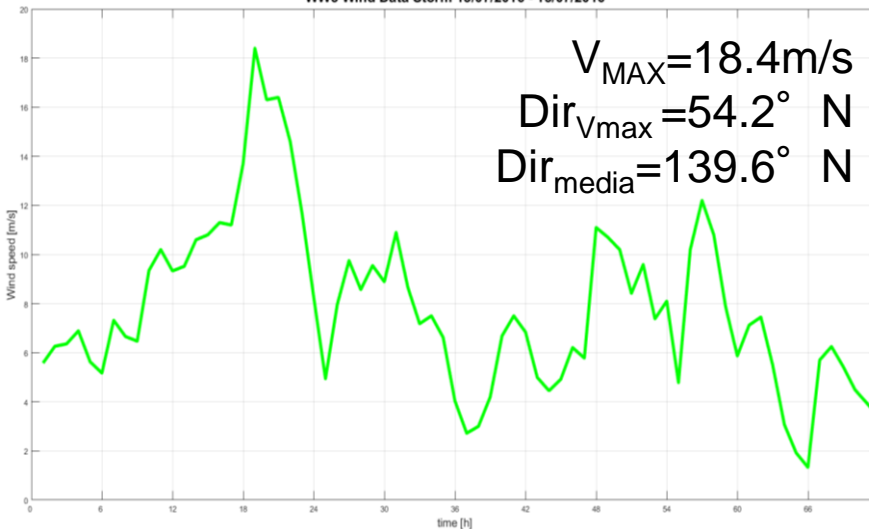


## STORM 13/07/2016 – 15/07/2016

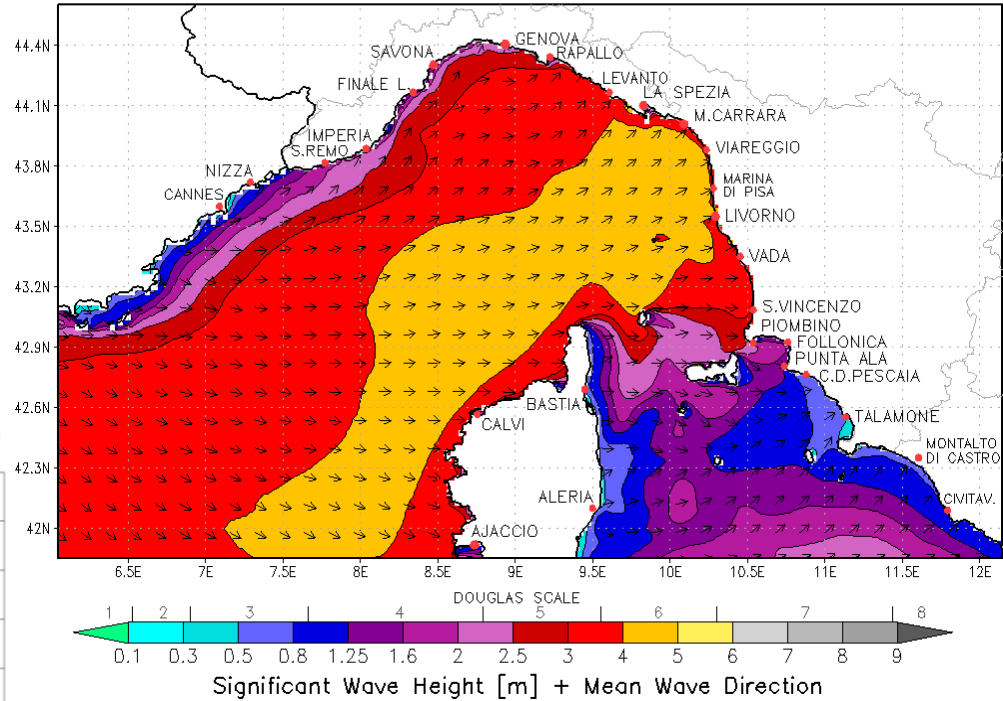
Wave ADCP Gombo Storm 13/07/2016 - 15/07/2016



WW3 Wind Data Storm 13/07/2016 - 15/07/2016



Consorzio LaMMA  
Init.: Wed, 13 JUL 2016 12 UTC Valid: Wed, 13 JUL 2016 19 UTC T=+7h



Duration storm: 3 days





CONSORZIO

LaMMA

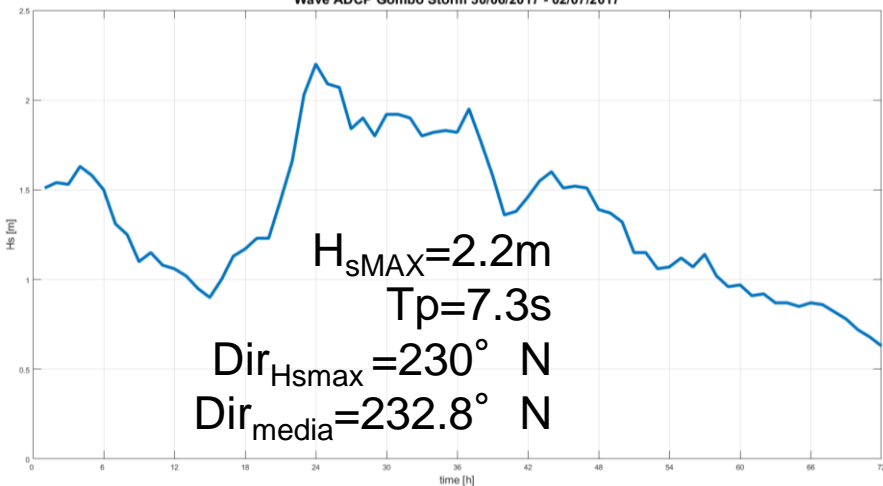
JONSMOD Florence – October 17-19, 2018

# Pisa 2D Model-storms 2/3

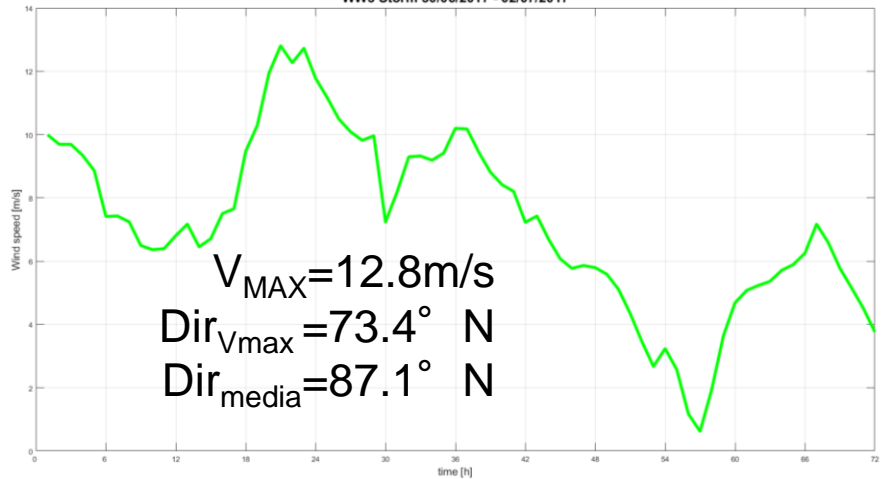


**STORM 30/06/2017 – 02/07/2017**

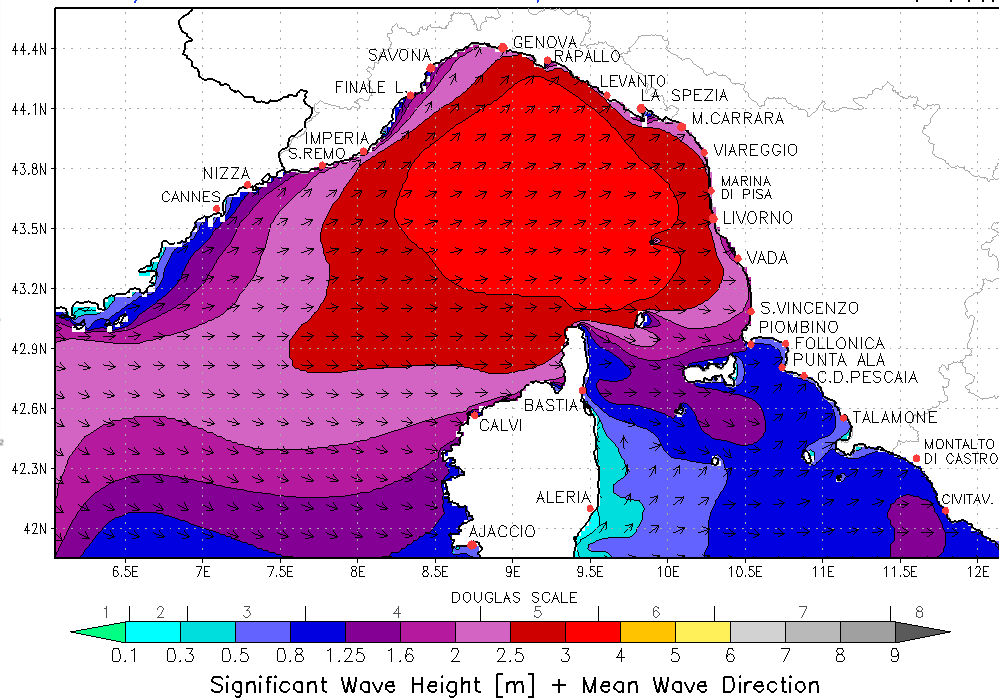
Wave ADCP Gombo Storm 30/06/2017 - 02/07/2017



WW3 Storm 30/06/2017 - 02/07/2017



Consorzio LaMMA  
 Init.: Fri, 30 JUN 2017 12 UTC Valid: Fri, 30 JUN 2017 23 UTC T=+11h



Duration storm: 3 days



CONSORZIO

LaMMA

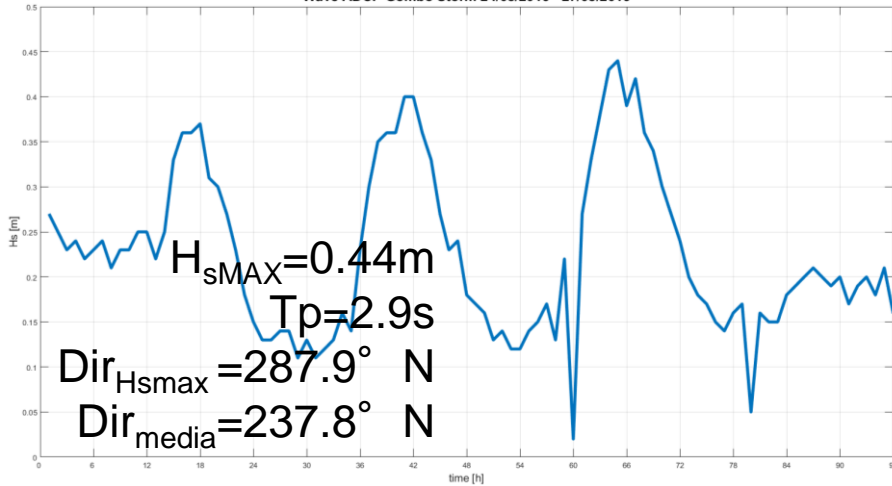
JONSMOD Florence – October 17-19, 2018

# Pisa 2D Model-storms 3/3

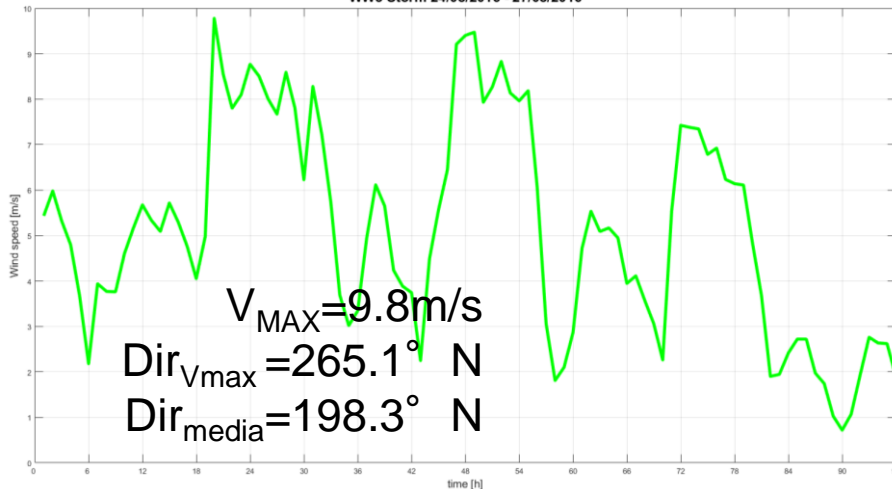


**24/08/2016 – 27/08/2016 – calm event**

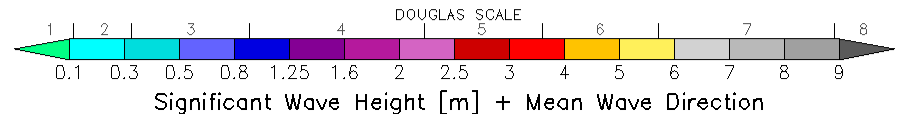
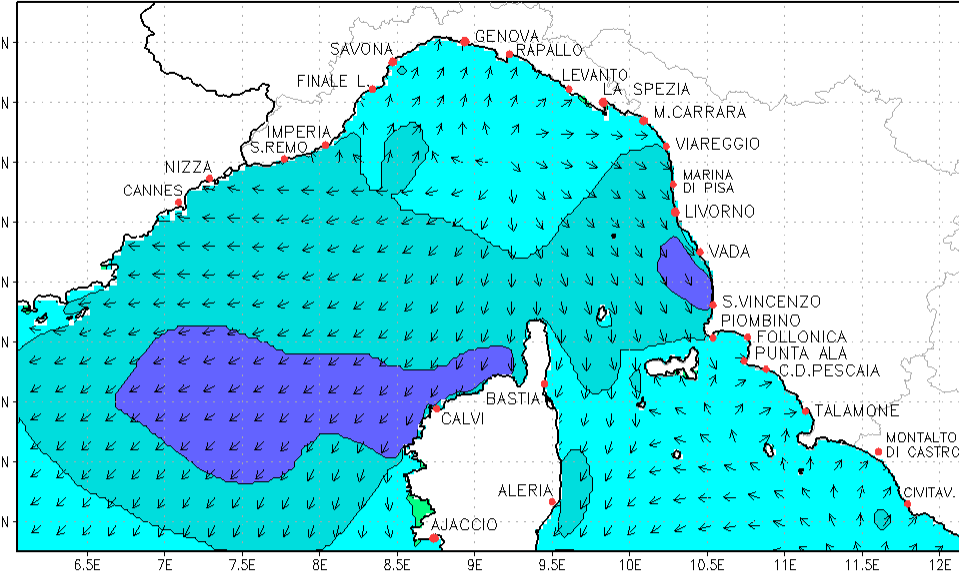
Wave ADCP Gombo Storm 24/08/2016 - 27/08/2016



WW3 Storm 24/08/2016 - 27/08/2016



Consorzio LaMMA  
Init.: Fri, 26 AUG 2016 12 UTC Valid: Fri, 26 AUG 2016 16 UTC T=+4h



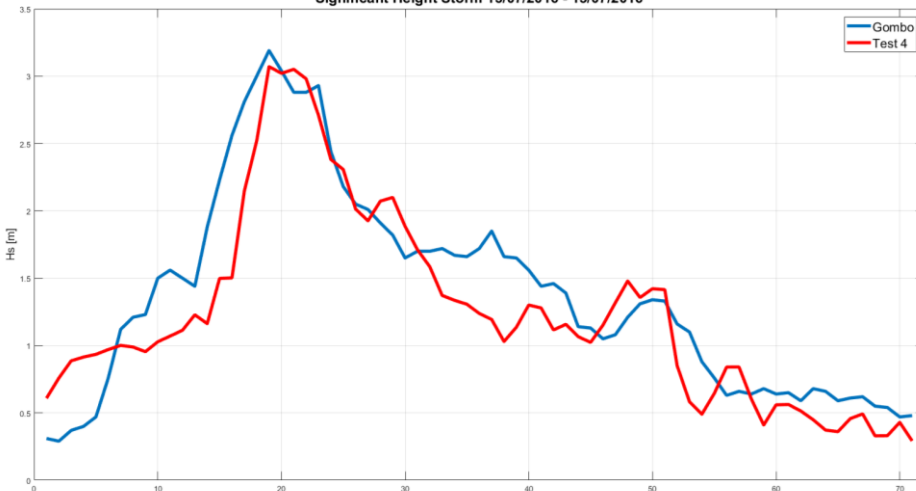


# Pisa San Rossore 2D Model

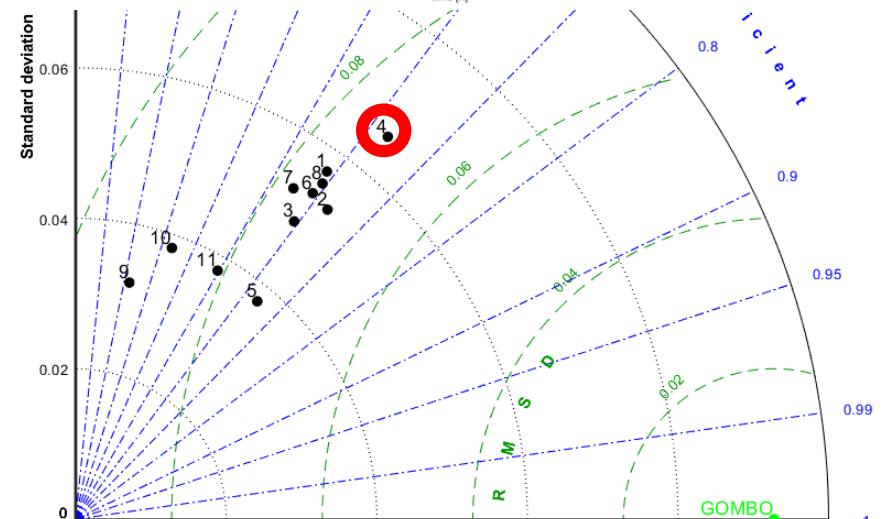
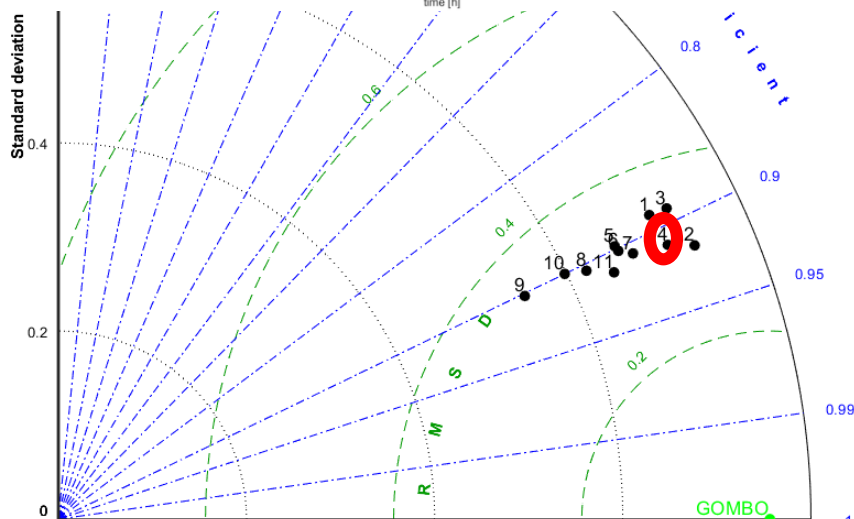


## STORM 13/07/2016 – 15/07/2016 - RESULTS

Significant Height Storm 13/07/2016 - 15/07/2016



Depth averaged velocity Storm 13/07/2016 - 15/07/2016



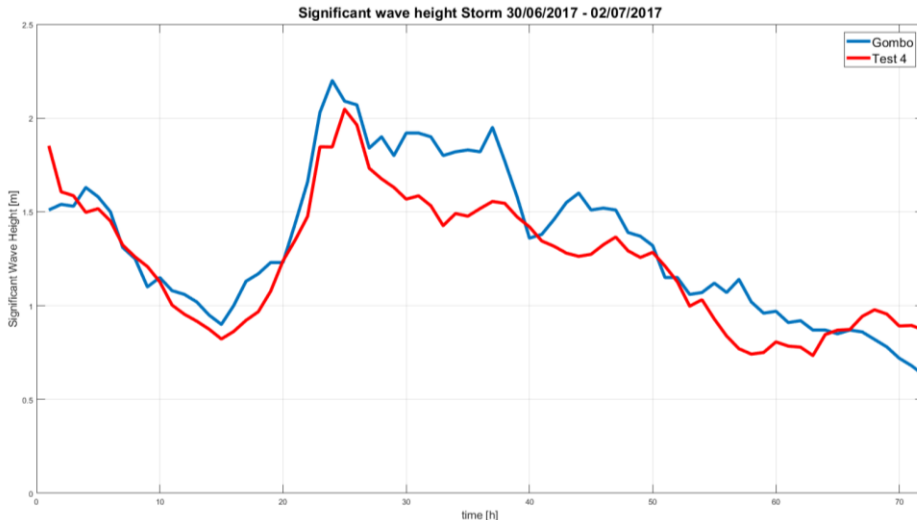
• **4** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$



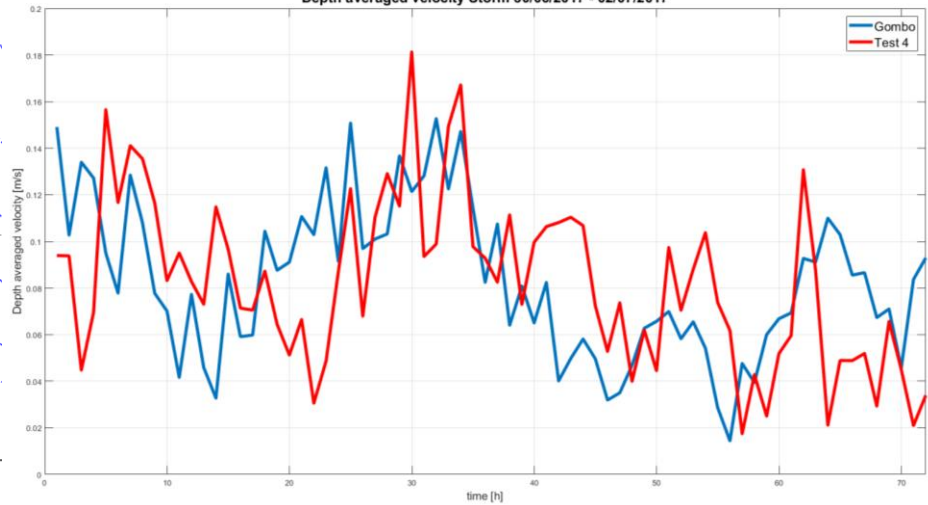
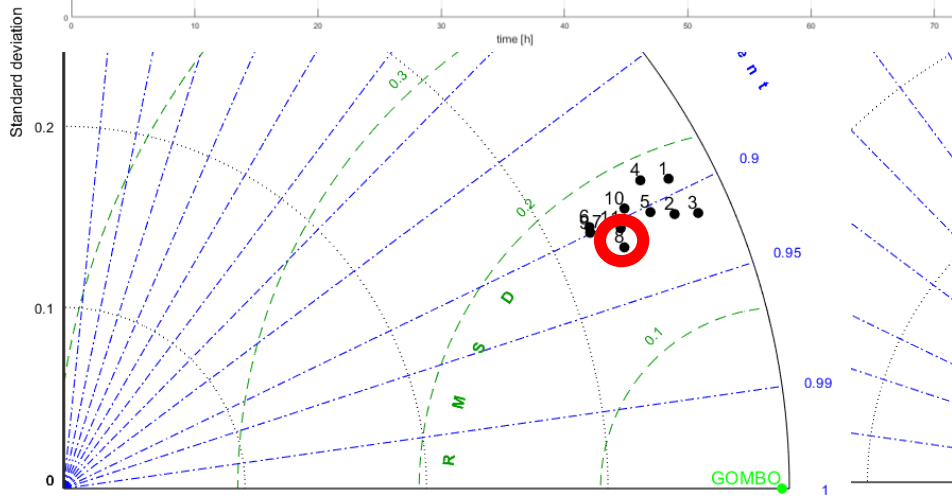
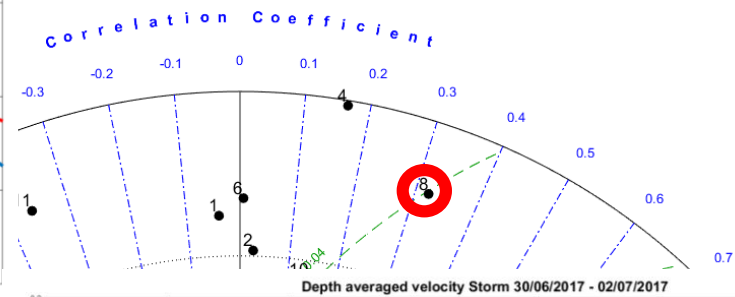
# Pisa San Rossore 2D Model



## STORM 30/06/2017 – 02/07/2017 - RESULTS



### Depth averaged velocity



- **8** = friction  $0.067\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$

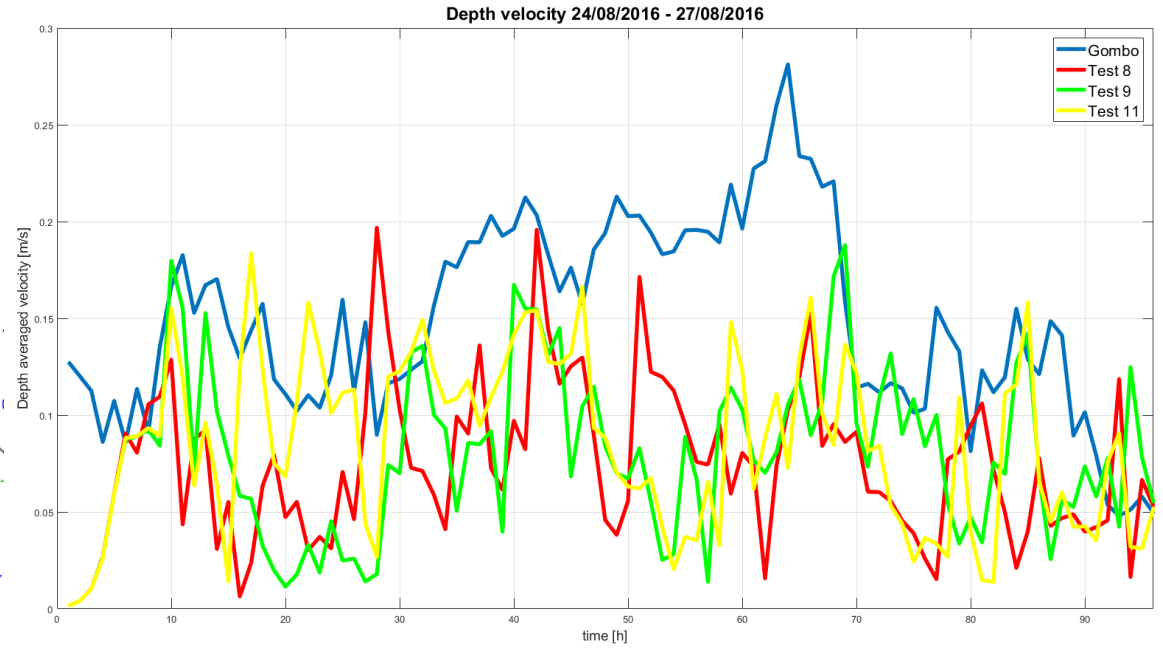
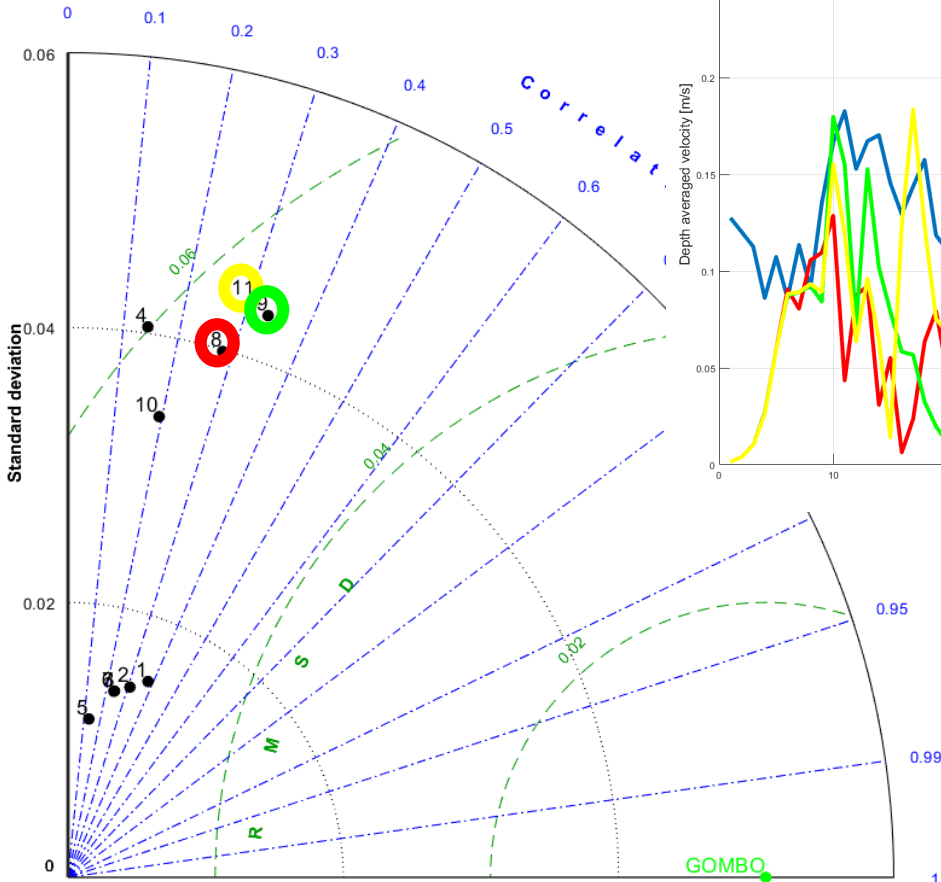


# Pisa San Rossore 2D Model



## CALM EVENT 24/08/2016 – 27/08/2016 - RESULTS

### Depth averaged velocity



- **8** = friction  $0.067\text{m}^2\text{s}^{-3}$ , roughness  $0.02\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$
- **9** = friction  $0.067\text{m}^2\text{s}^{-3}$ , roughness  $0.03\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$
- **11** = friction  $0.02\text{m}^2\text{s}^{-3}$ , roughness  $0.03\text{m}^{-1/3}\text{s}$ , viscosity  $0\text{m}^2/\text{s}$



CONSORZIO

LaMMA

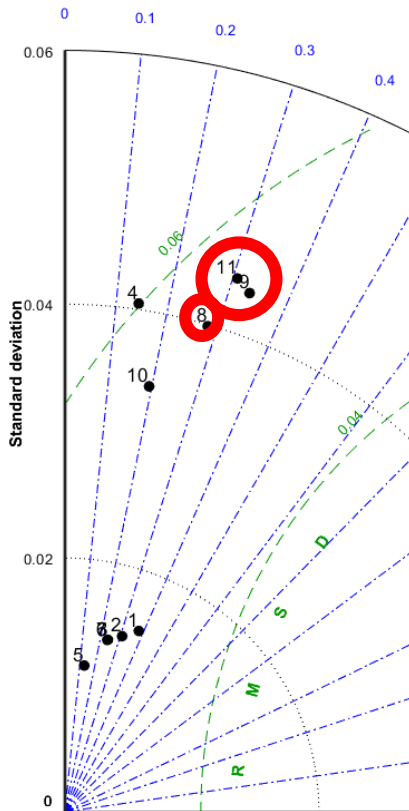
JONSMOD Florence – October 17-19, 2018

# Pisa San Rossore 2D Model

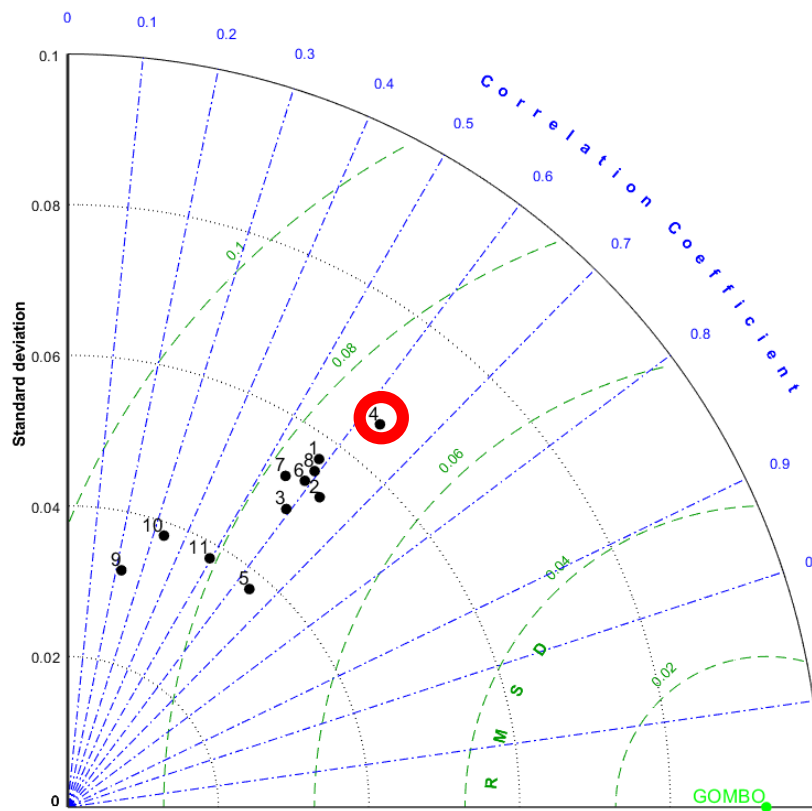


Depth averaged velocity

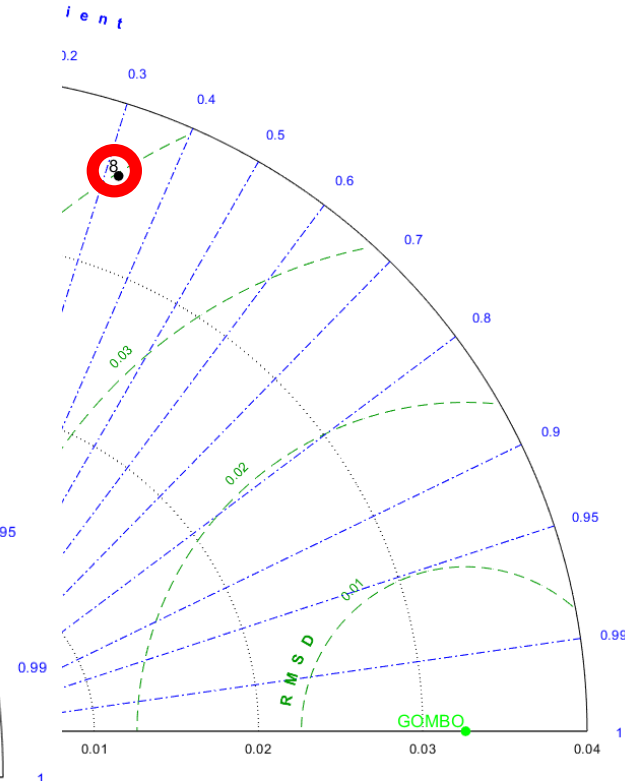
CALM EVENT  
24/08/2016 –  
27/08/2016



STORM 13/07/2016 –  
15/07/2016



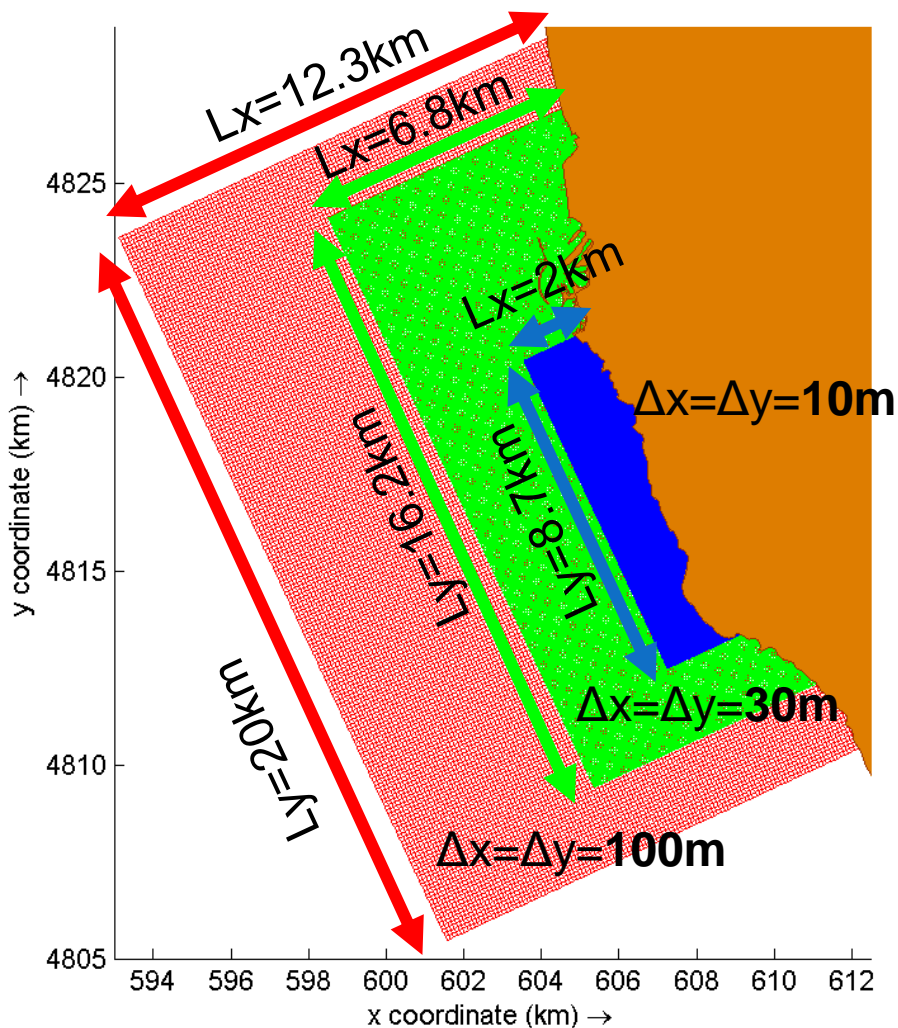
STORM 30/06/2017 –  
02/07/2017



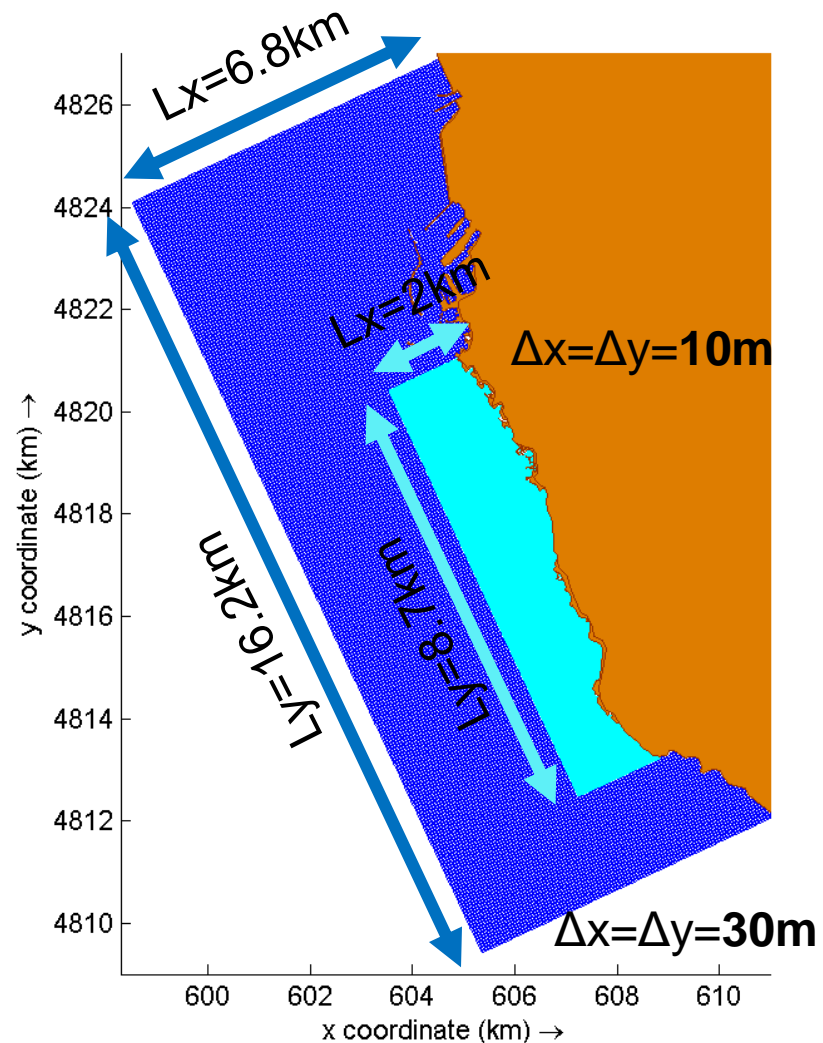


# Livorno 3D Model

Wave



Flow



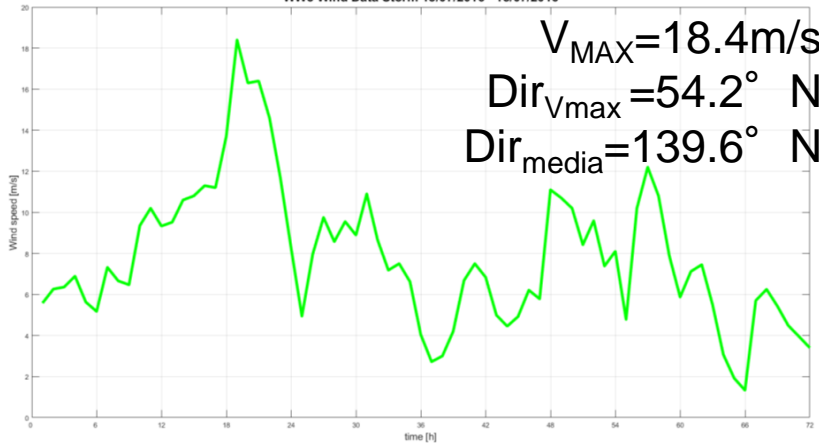


# Livorno 3D Model

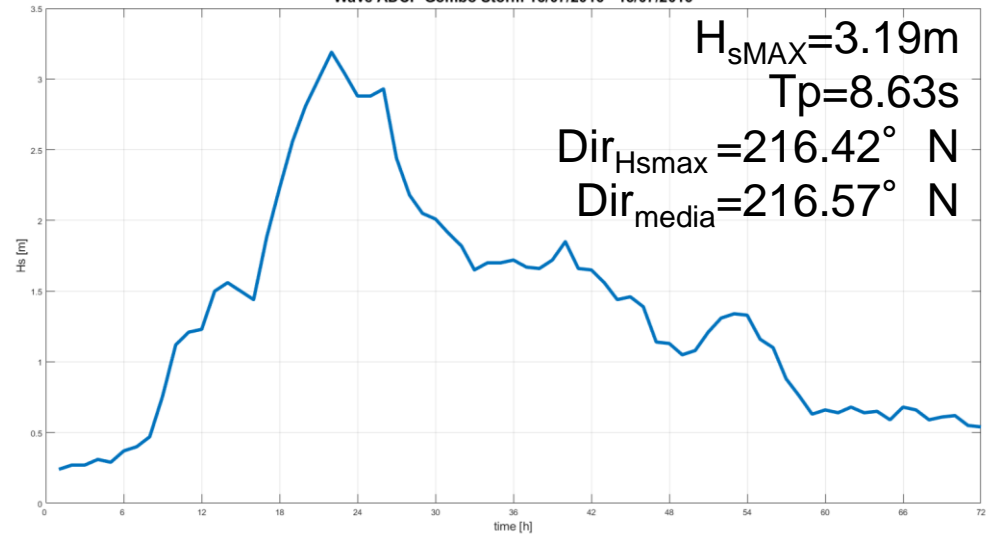


## STORM 13/07/2016 – 15/07/2016

WW3 Wind Data Storm 13/07/2016 - 15/07/2016



Wave ADCP Gombo Storm 13/07/2016 - 15/07/2016



### CALIBRATION PARAMETER

- Horizontal Eddy Viscosity



### TEST

- **1** = viscosity  $2\text{m}^2/\text{s}$
- **2** = viscosity  $1\text{m}^2/\text{s}$
- **3** = viscosity  $1.5\text{m}^2/\text{s}$
- **4** = viscosity  $1.25\text{m}^2/\text{s}$



### SIMULATION PARAMETERS

- Time step 0.1min
- 5 layers (8%, 12%, 15%, 25%, 40%)
- Vertical eddy viscosity  $10^{-6} \text{m}^2/\text{s}$
- Bottom friction JONSWAP  $0.02\text{m}^2\text{s}^{-3}$
- Bottom roughness Manning  $0.05\text{m}^{-1/3}\text{s}$

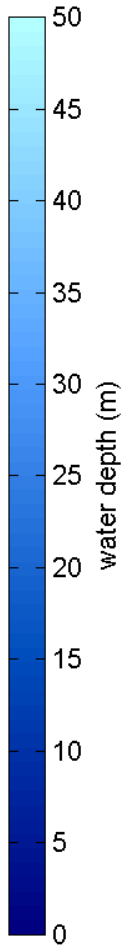
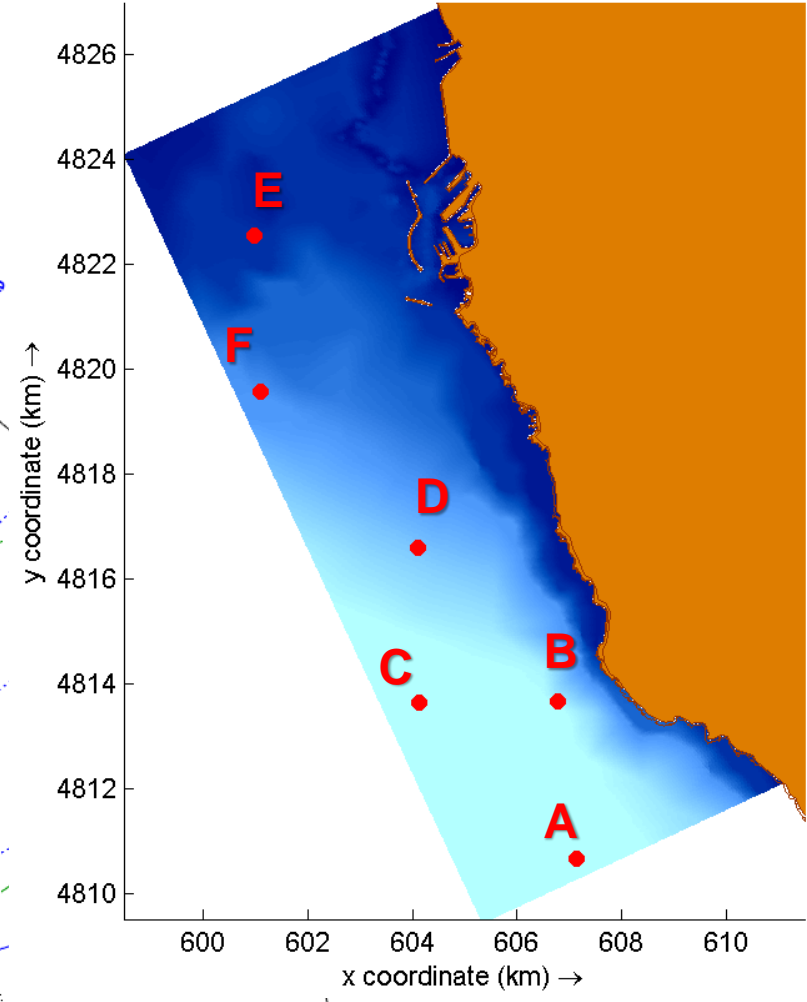
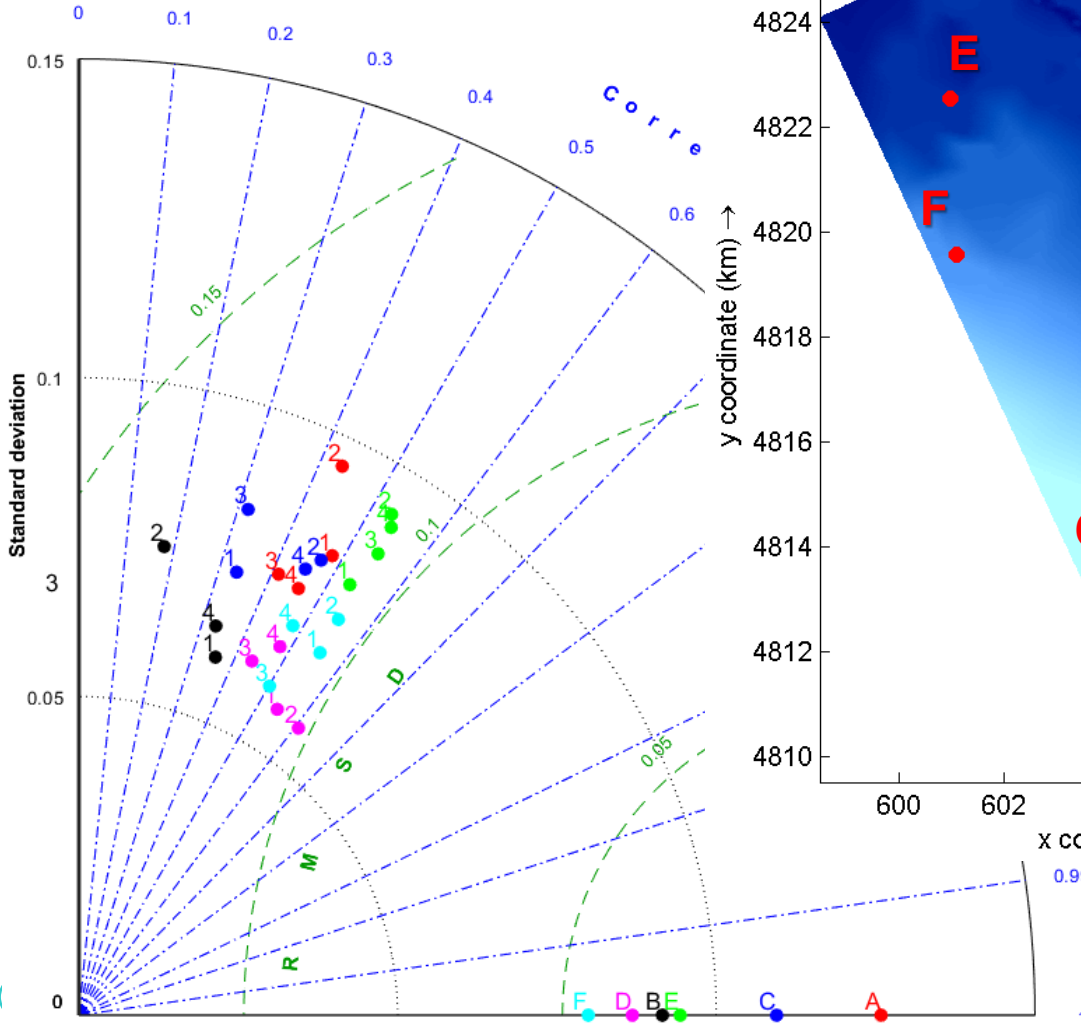




# Livorno 3D Model



## VELOCITY RESULTS

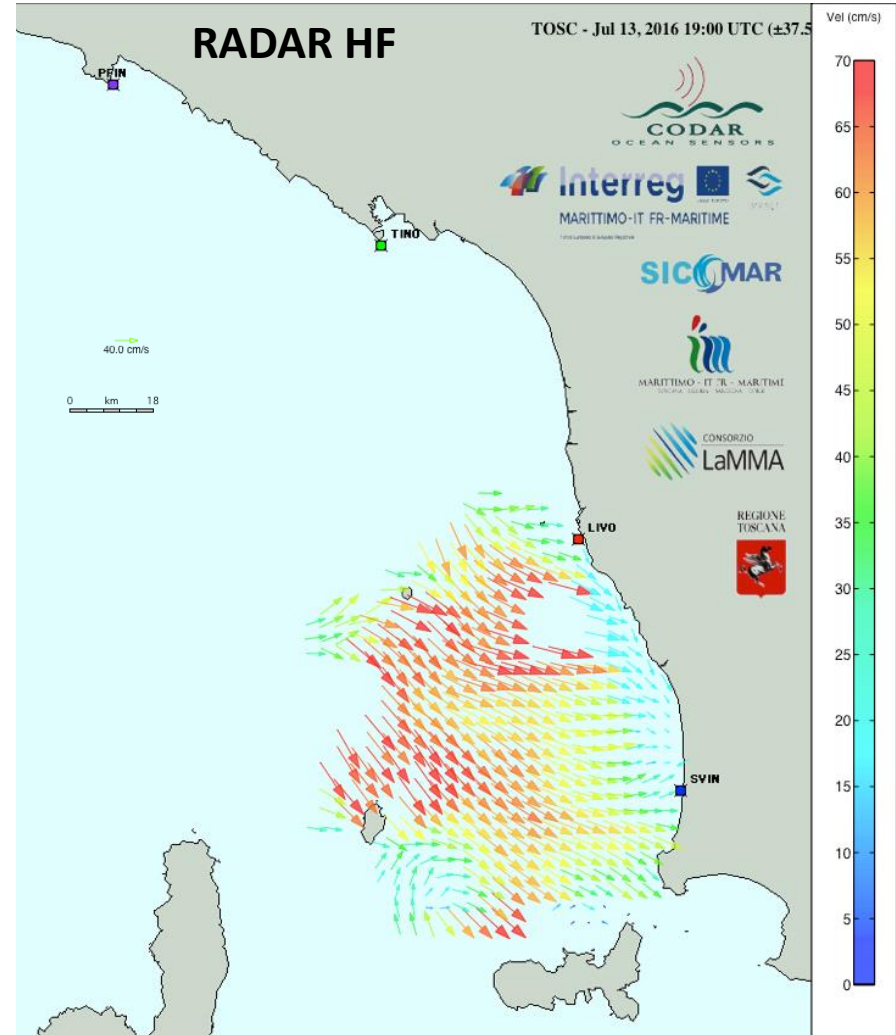
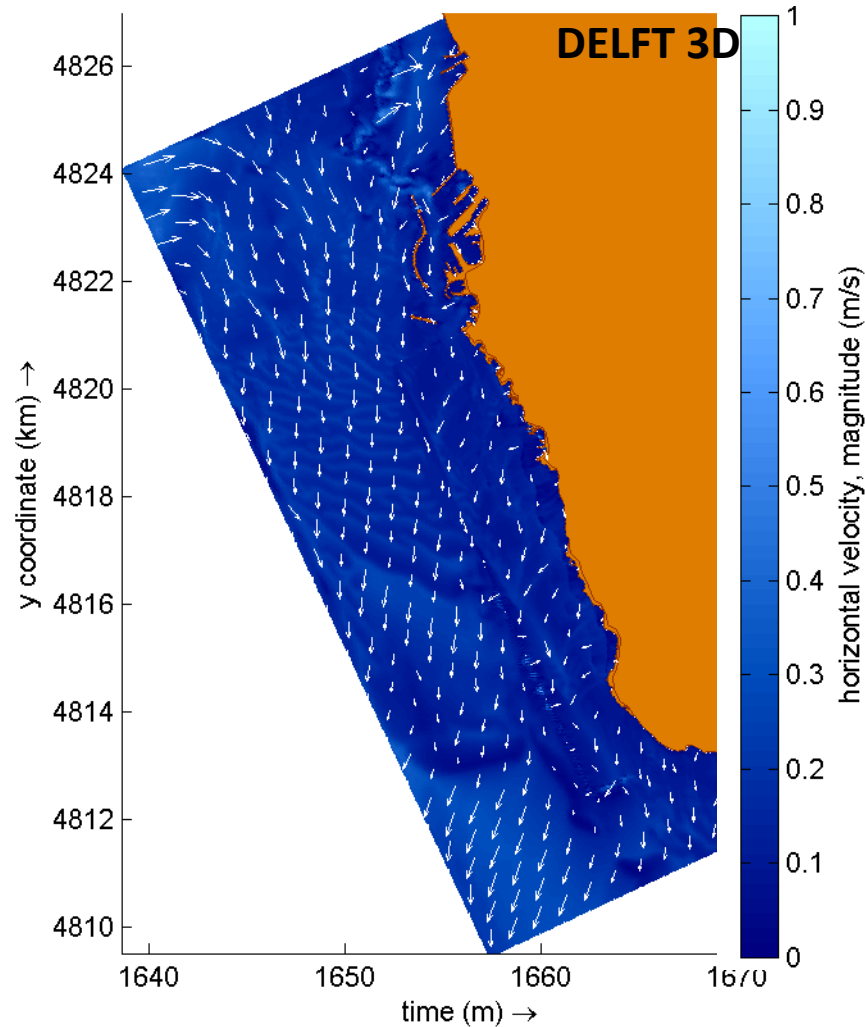




# Livorno 3D Model



## VELOCITY RESULTS





# Future works



Goodness of the water quality forecasting system → goodness of the hydrodynamic model

- Calibration results of the significant wave height are very good
- Calibration results of the velocity have a greater degree of uncertainty



Improve the calibration of the hydrodynamic model

- Longer periods
- More parameters
- Open DA
- Delft FM Suite



**17-19<sup>th</sup> October 2018**

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Firenze**

**THANKS FOR YOUR ATTENTION**

**V. Vannucchi<sup>2</sup>, B. Doronzo<sup>12</sup>, S. Taddei<sup>2</sup>, L. Costanza<sup>12</sup> and Carlo Brandini<sup>12</sup>**

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