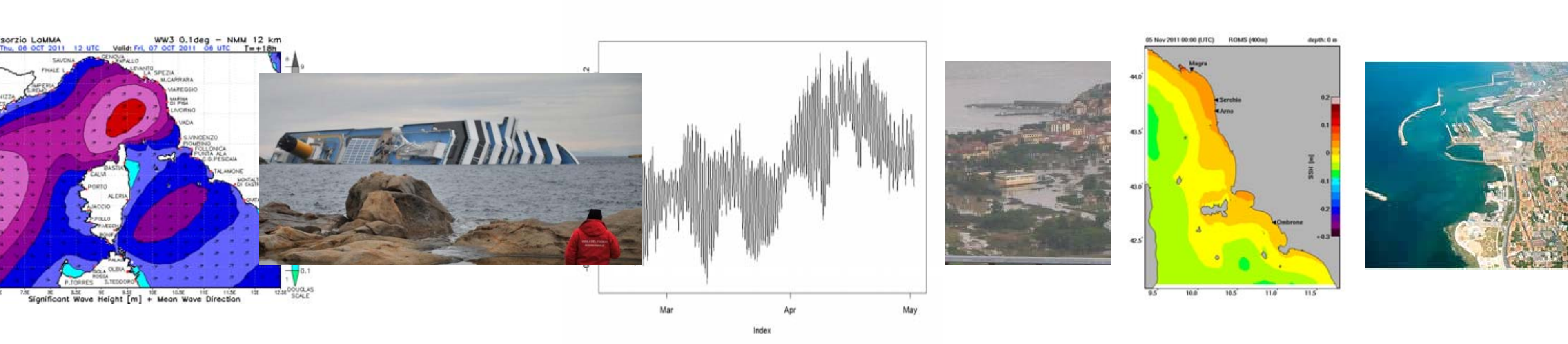
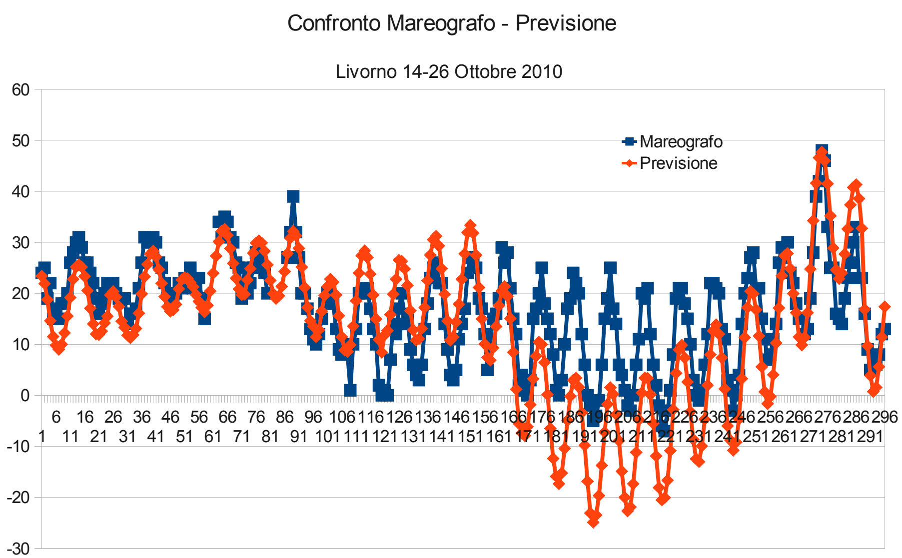
Predictability of nearshore and harbors sea level

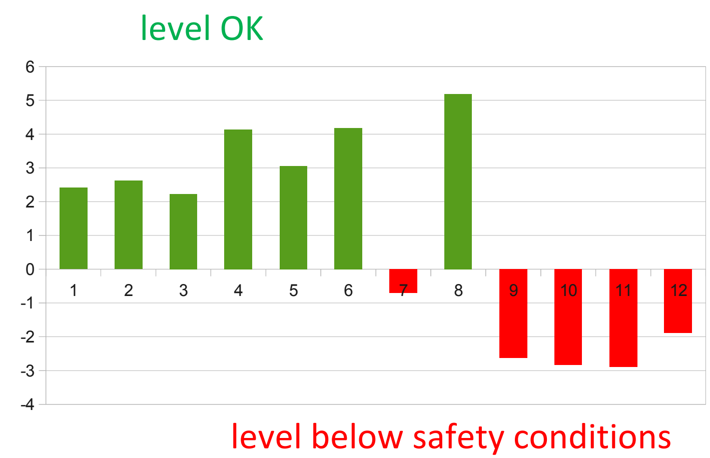


Carlo Brandini, Alfonso Crisci, Francesco Pasi, Stefano Taddei, Maria Fattorini, Alberto Ortolani.

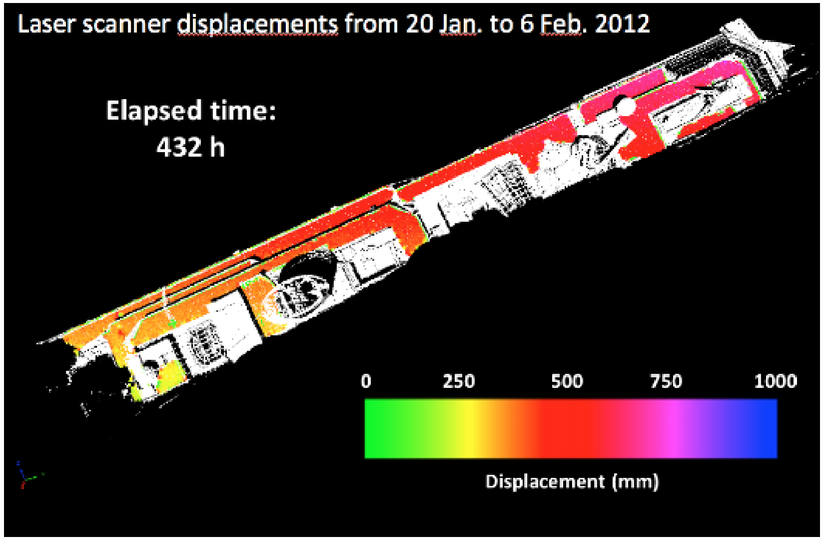
Consiglio Nazionale delle Ricerche
Ibimet ISTITUTO DI BIOMETEOROLOGIA
CONSORZIO LaMMA

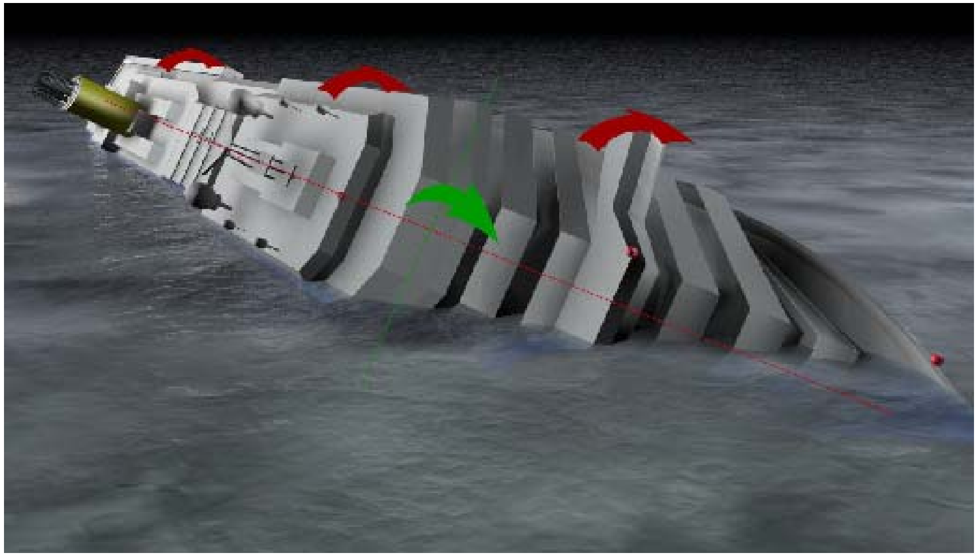
Level forecast for harbor management

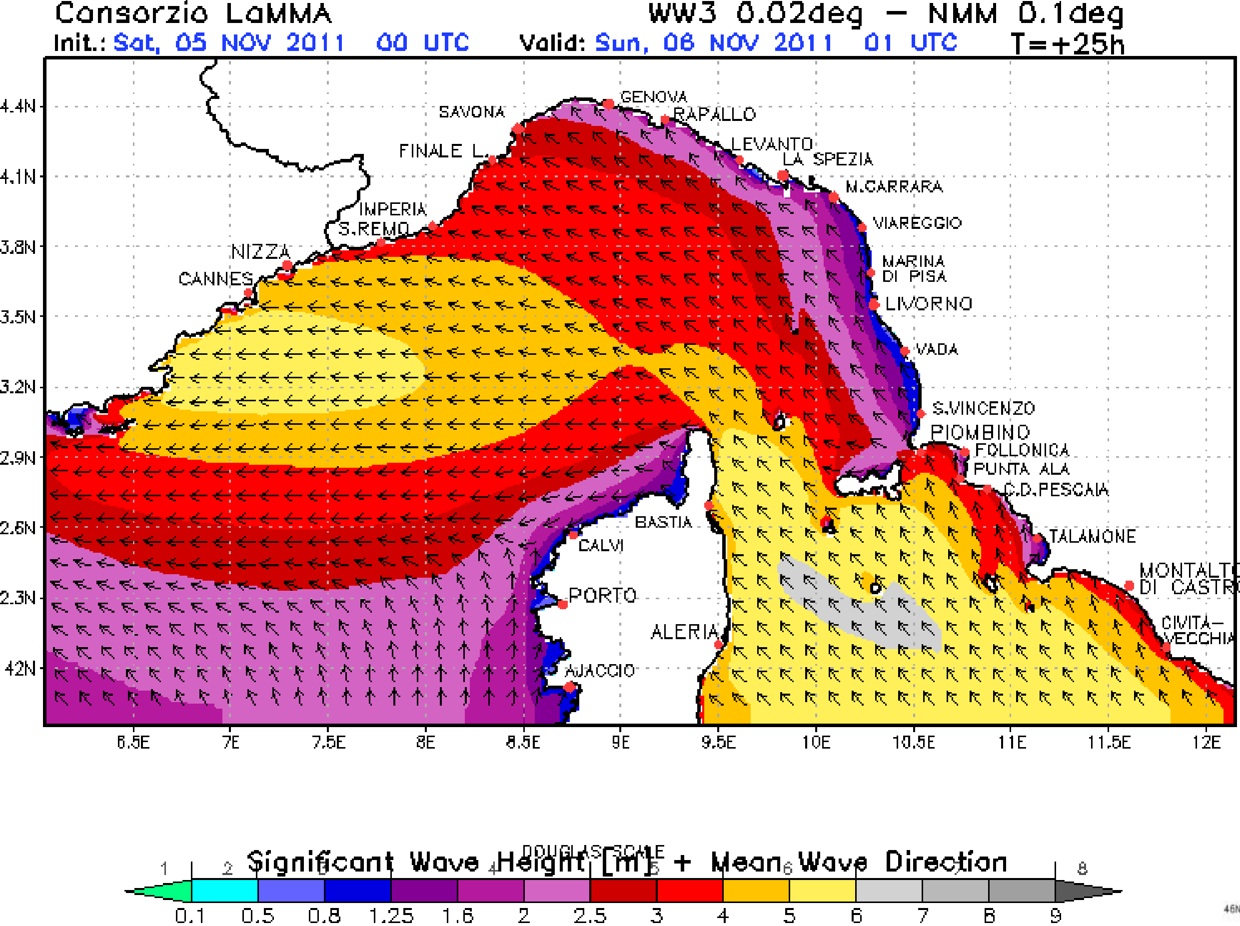




Emergency management







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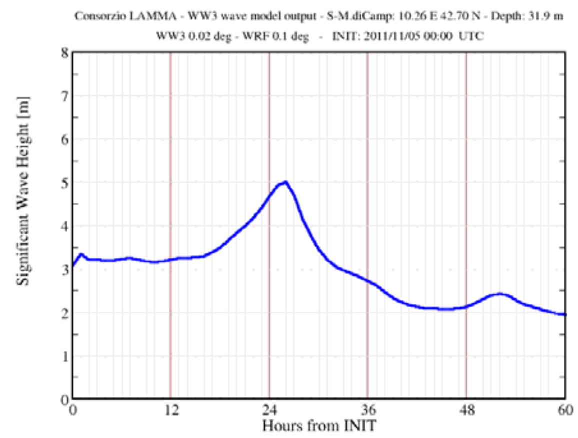
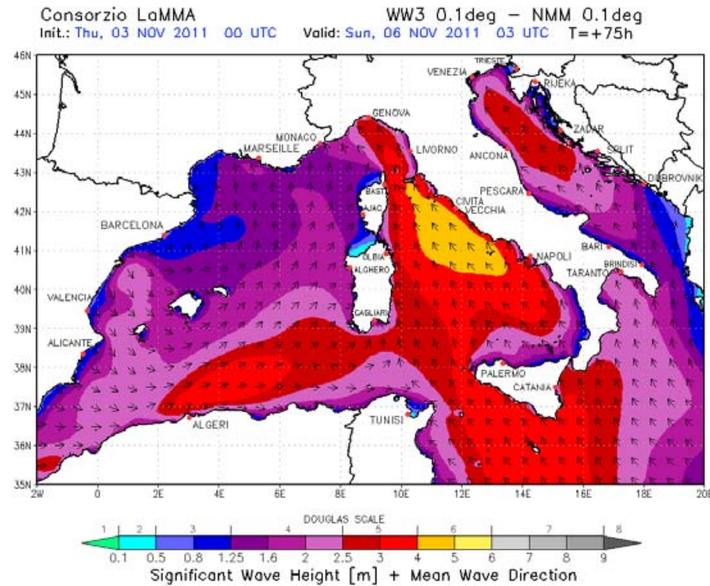


Storm surge of 6th November causing a big flood Southern to the Elba Island also caused by wave set-up



A deterministic picture.

Δ MSL = Δ Patm + Δ Wind + Δwaves + ΔTide + local effects (Δrivers, …)

Δ Patm

Usually modelled by so-called inverted barometric effect

Can this be adjusted to follow local coastal effects? (e.g. Faggioni et al. 2006)

Δ wind

Simplest model: a (quadratic) function on wind, taking into account of fetch,

Best estimates obtained by a hydrodynamic model

Δ Tide

A number of reliable models today available,

Best estimates if local tidal data are available

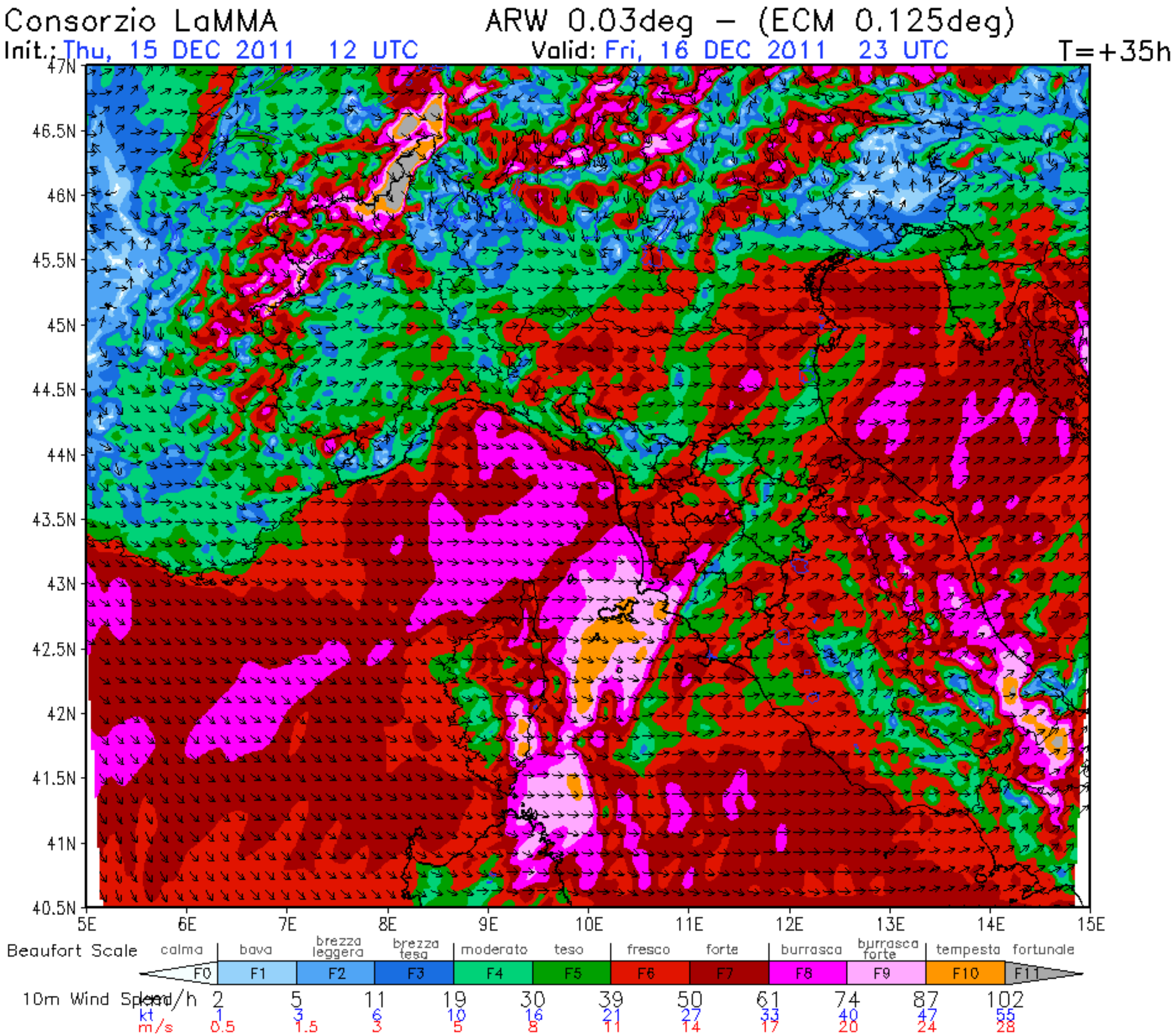
Δ Wave

Expressed with different empirical formulation.

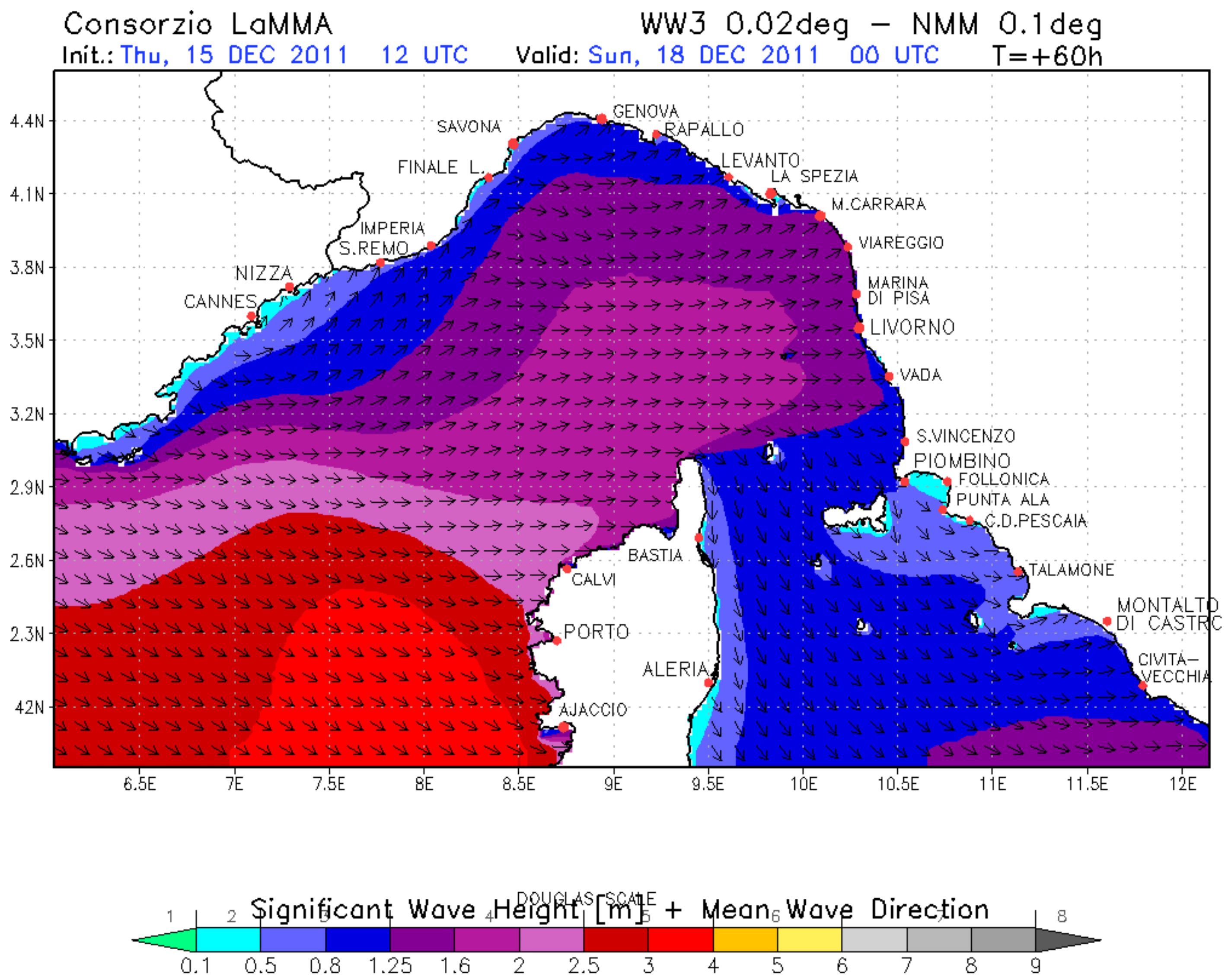
A (linear) function of some wave height parameter (H_b) is often proposed

Aim: is it possible to take into account of all these aspects in a simple economic way?

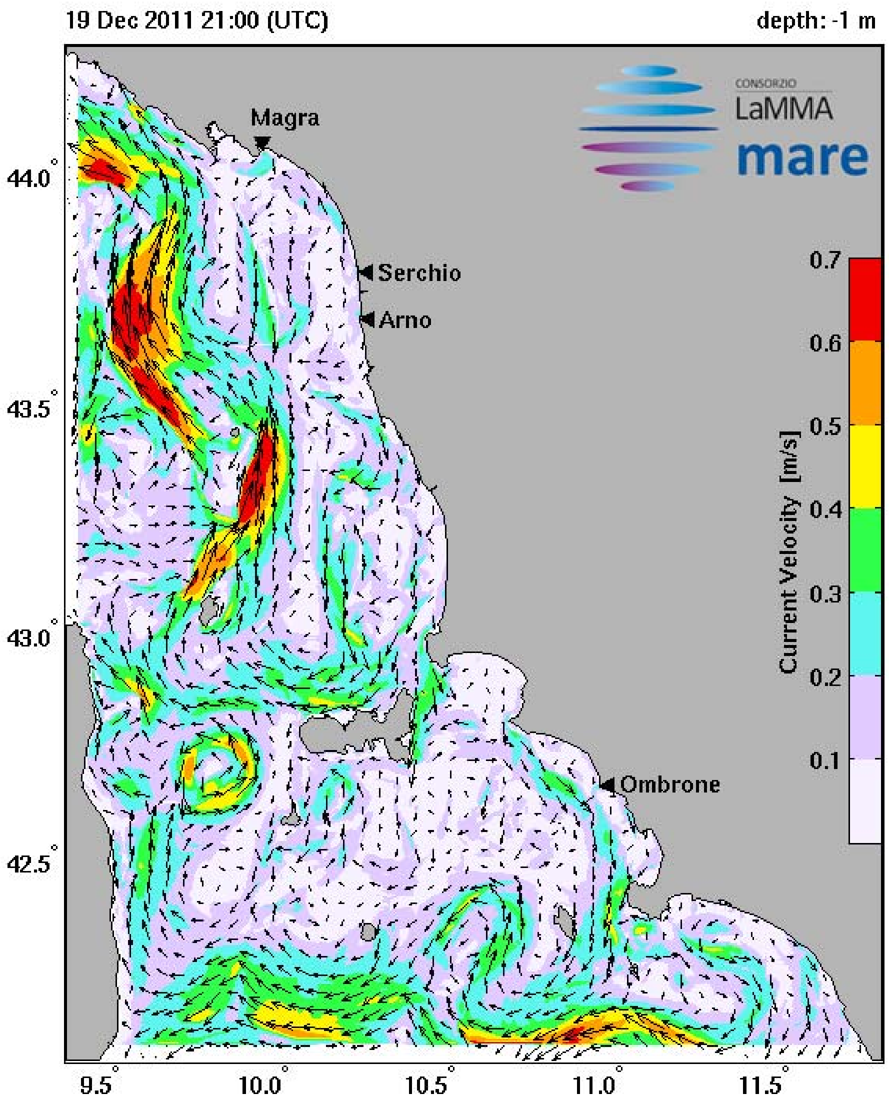
WRF – Meteo model.

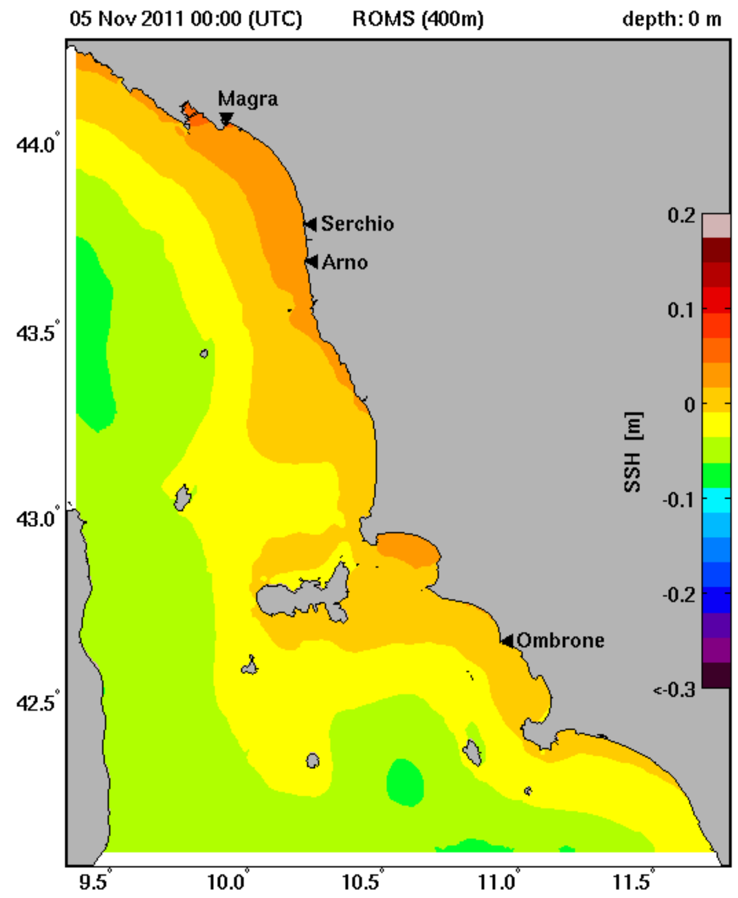


Wave forecast: Wavewatch III



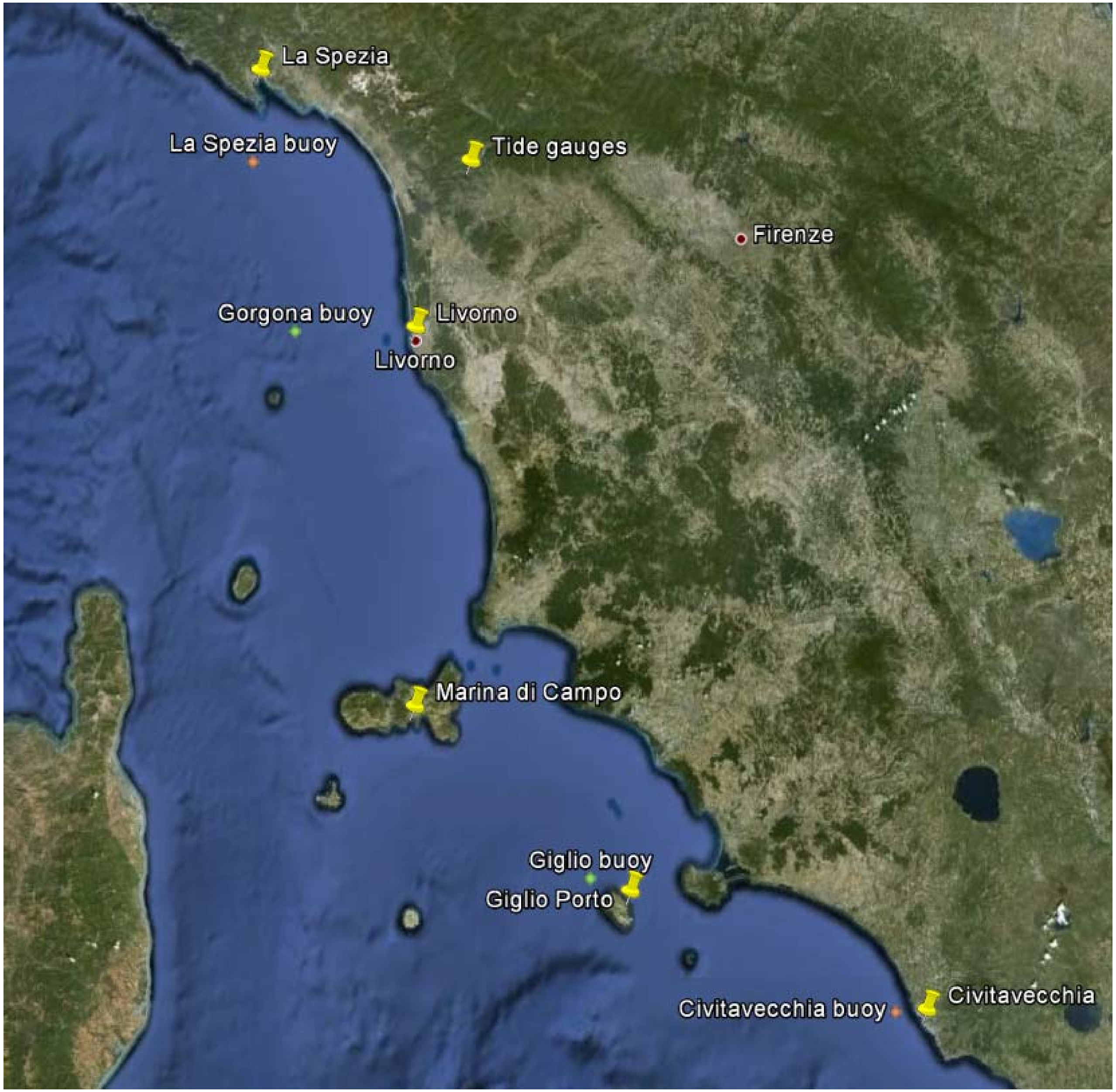
Hydrodynamic forecast: ROMS.



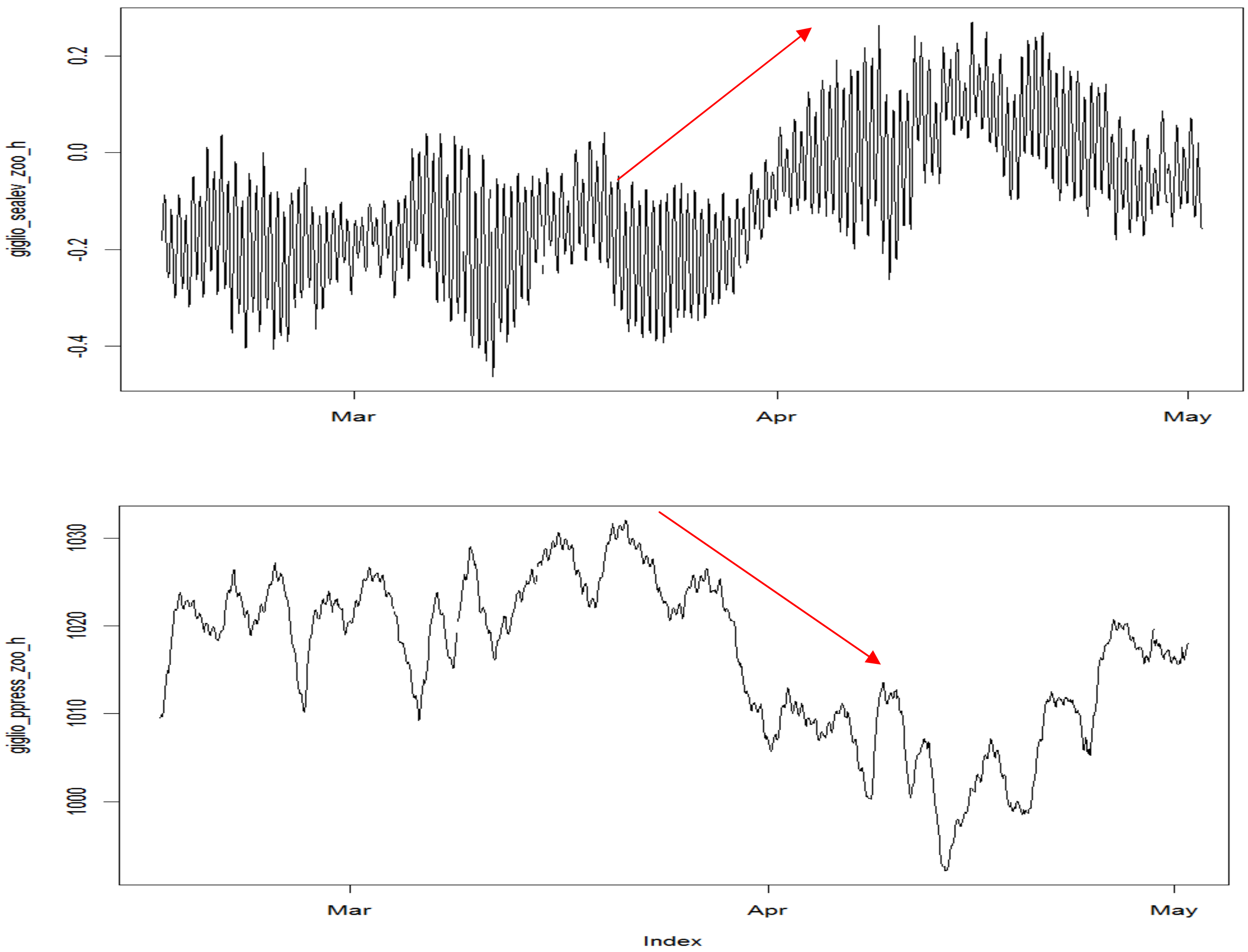


Sea surface height

The study area

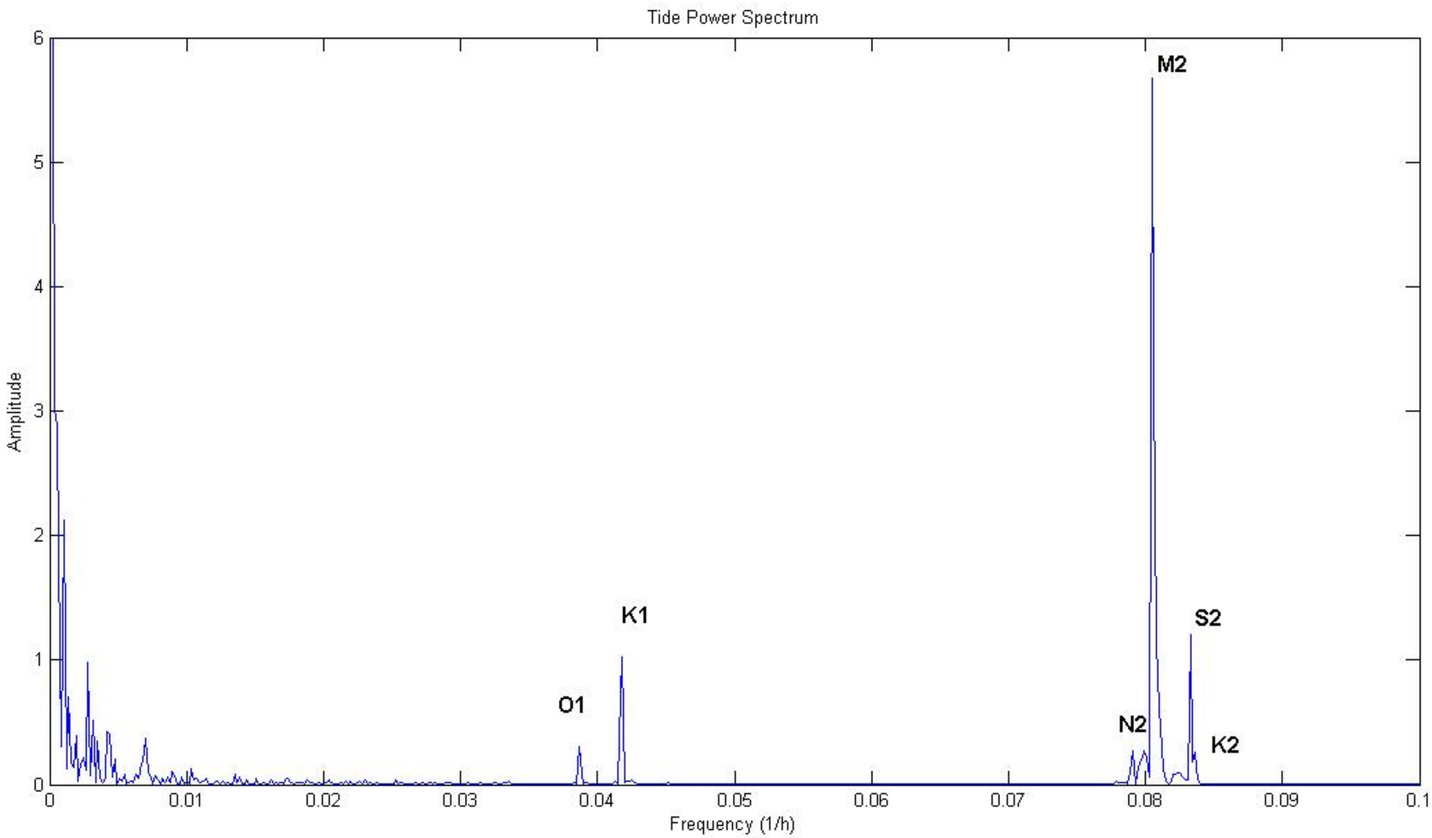


Sea level excursion and pressure variation



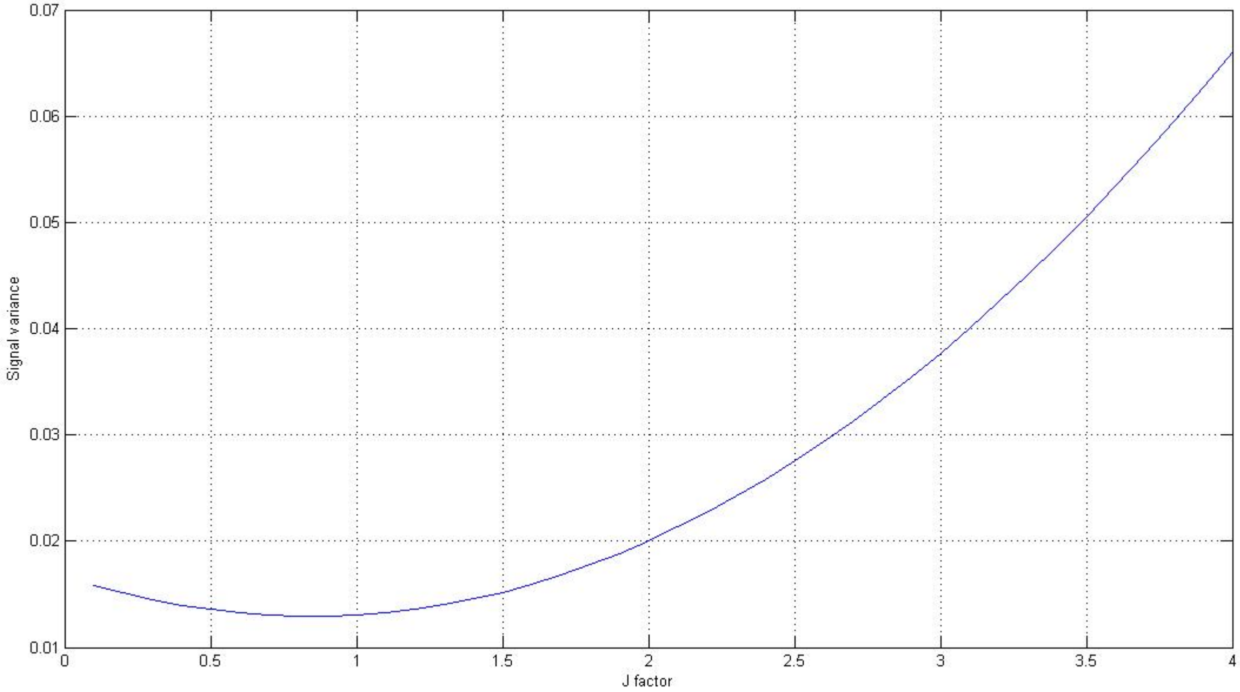
Tidal components

Giglio tide gauge



Analysis of differerent (measured) effects

LIVORNO HARBOR

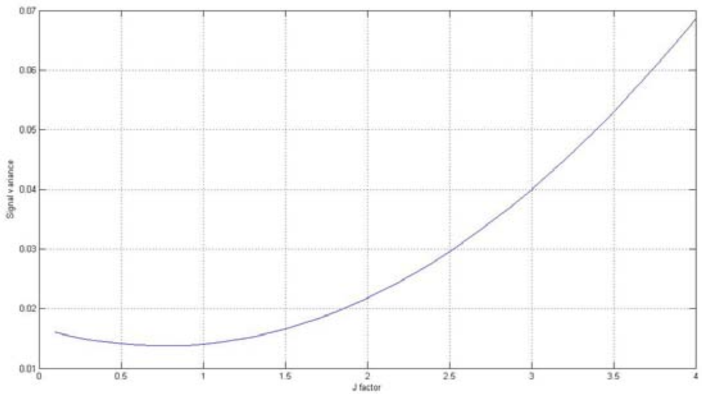


No evidence for a modified level-pressure relationship within the harbor

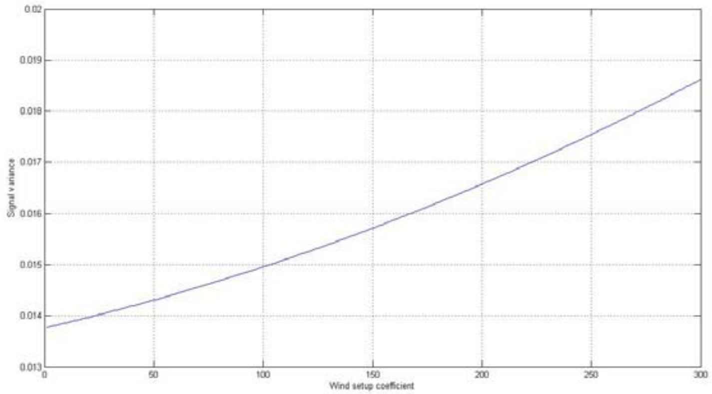
Analysis of differerent (measured and simulated) effects

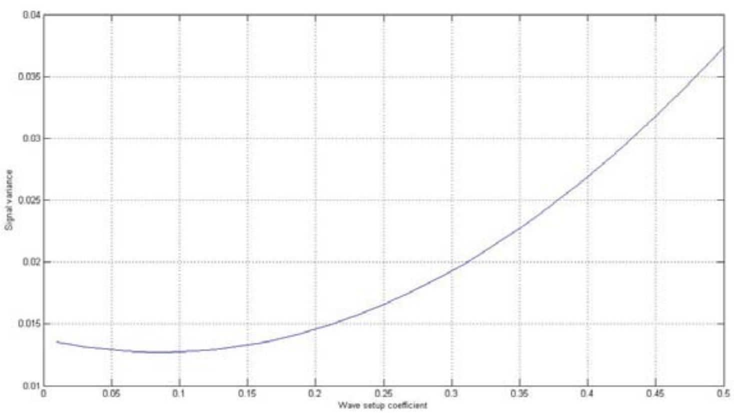
MARINA DI CAMPO HARBOR

PRESSURE

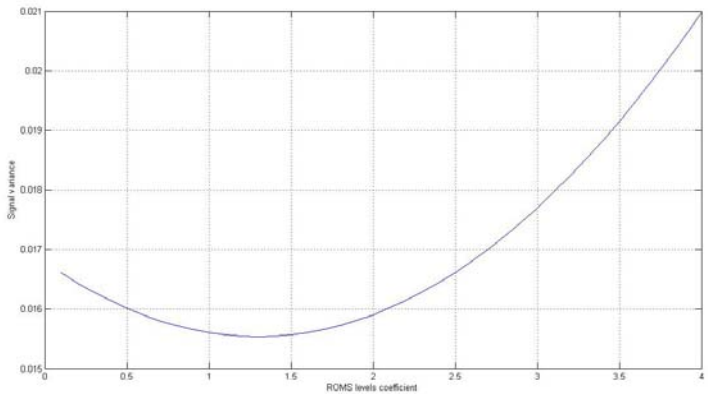


WIND SETUP





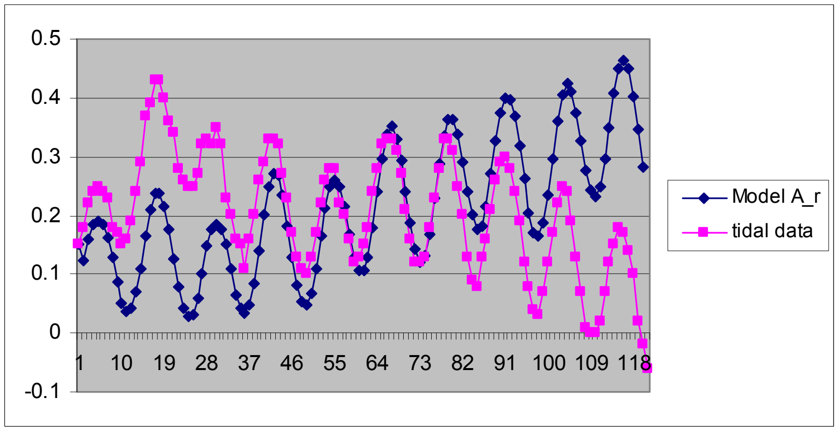
WAVE SETUP



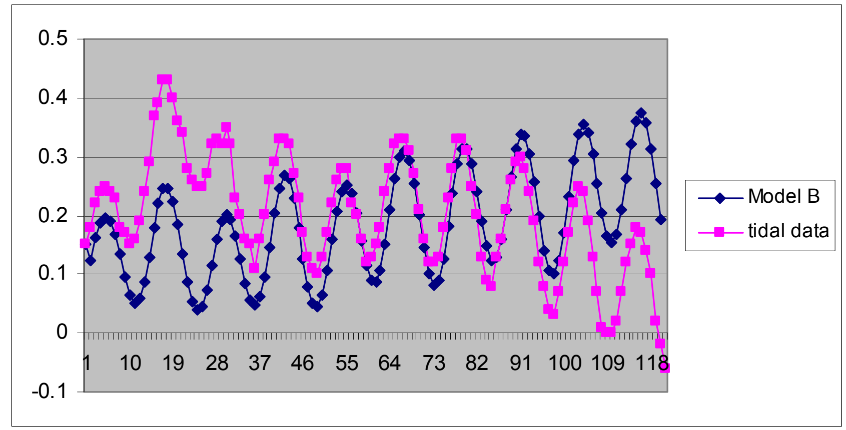
ROMS

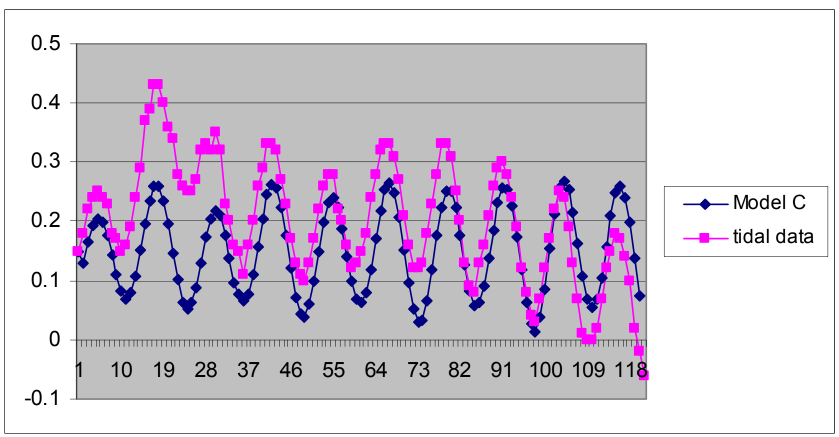
Simulation

Modified “J” simulation

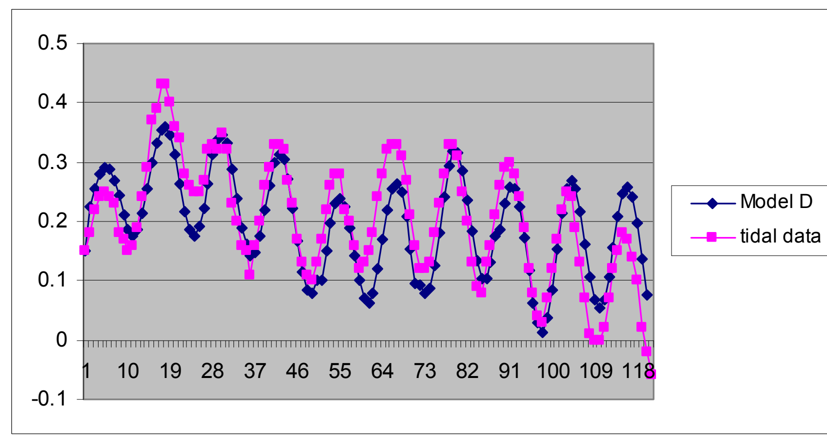


Standard “J” simulation





Tide + ROMS level



Tide + ROMS level + wave set-up

Stochastic forecast

- Build a mixed tool chain to help forecast hourly sea level profile with a 5 day horizont.
- The method is based on ARIMA model deterministically drived using local WRF ARW hourly outcomes relative to sea level pressure and mean wind velocity.
- Coregressors are needed in order to make the best possible use of observed and forecasted data
- Several techniques were used to extract the (local) structure of the system, such as standard Fourier analysis, and the EMD – EMpirical Mode Decomposition (Huang,1996)

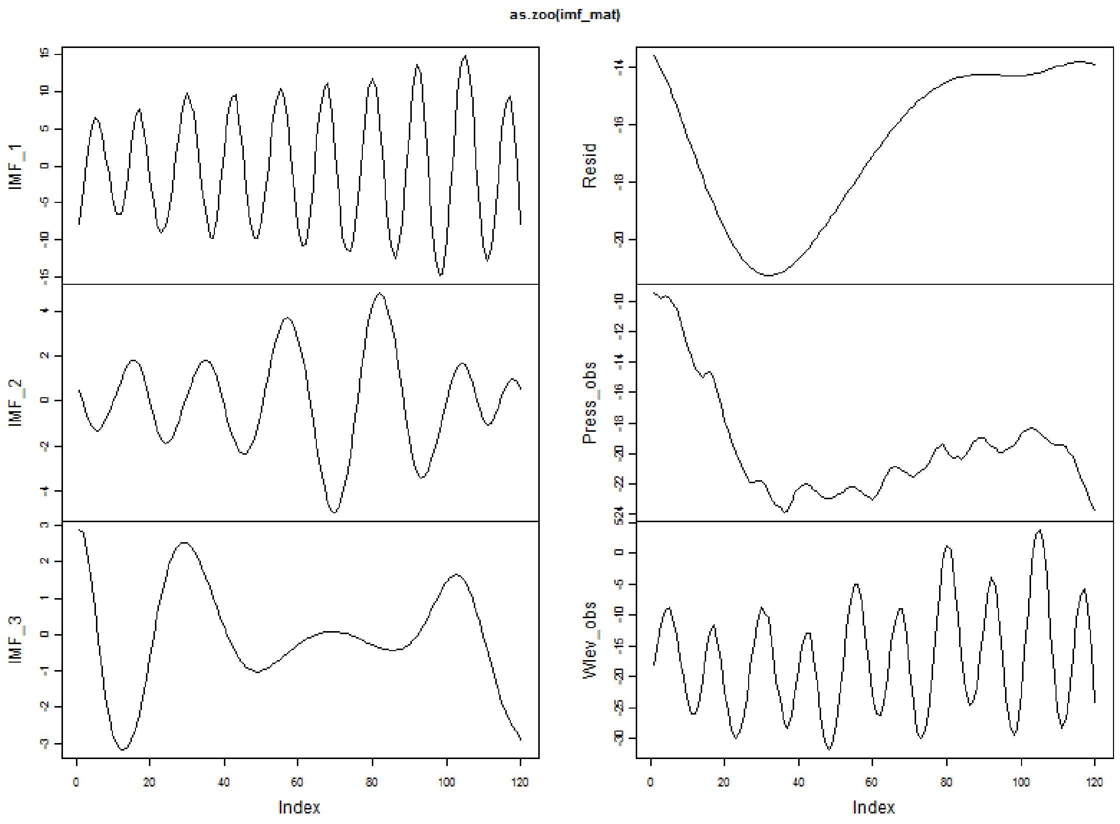
Training set-up are carried out on 5 day lagged observed data.

TRAINING STAGE: five days before hourly data (observed data up to five days before, to determine ARIMA models parameters)

TEST STAGE: level forecasts using homologue time series

EMD – Empirical Mode Decomposition

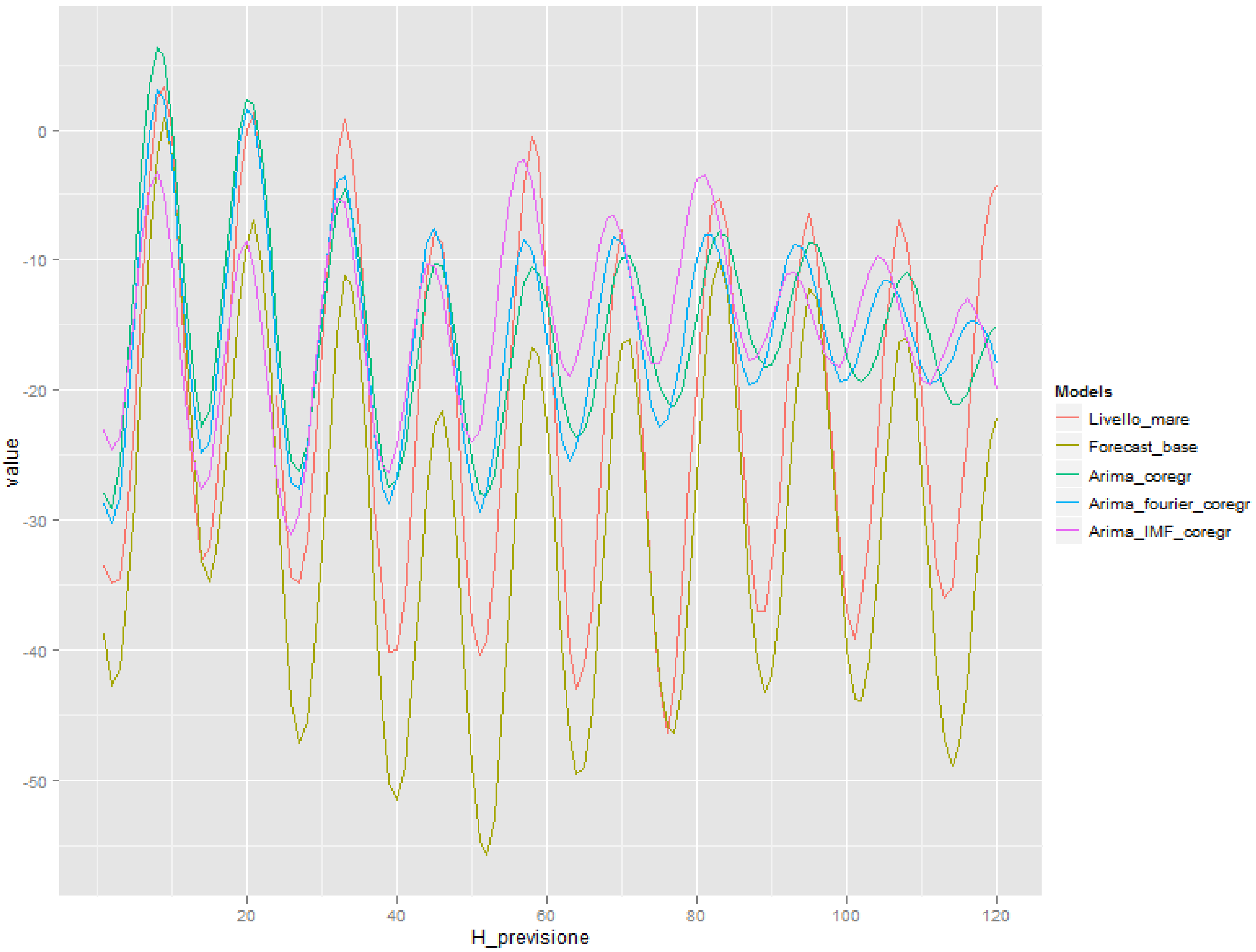
Huang (1996)



IMF functions and corresponding residual are represented. The latter well describes the signal related to pressure variation (or to other external signals) →

IMF represent mutually ortogonal (similar to EOFs) and not stationary signals.

Stochastic forecasts comparison



Error analysis

	error "B"	error "A_r"	error B_o	error C	error D	Arima coregr	Arima_emd coregr	Arima_fou coregr
1st	0.13	0.14	0.09	0.12	0.05	0.06	0.08	0.06
2nd	0.09	0.10	0.07	0.09	0.02	0.07	0.09	0.09
3rd	0.04	0.03	0.11	0.06	0.06	0.09	0.10	0.11
4th	0.04	0.08	0.12	0.05	0.03	0.10	0.12	0.12
5th	0.14	0.22	0.05	0.06	0.06	0.10	0.12	0.13

ROMS sea level corrections to tidal prediction give always the best results, but short-term (1-2 days) stochastic forecast may be better than oversimplified deterministic models

Conclusions.

• Several deterministic and stochastic approaches to the problem of sea level forecast in nearshore and harbor areas were compared in order to find the best “cheap” method

• Stochastic models usually give good results in the first forecasting period, but after that soon loose information on phase and amplitude, expecially when atmosperic conditions change rapidily

• Deterministic hydrodynamic problems are good only when they are able to take into account all main influencing factors in a physically-based modelling approach

• Results also represent an indirirect validation of existing hydrodynamic models (ROMS). Existing network of tidal gauge data could hence be used for validation/purposes and even more …

• Any suggestion is welcome …!