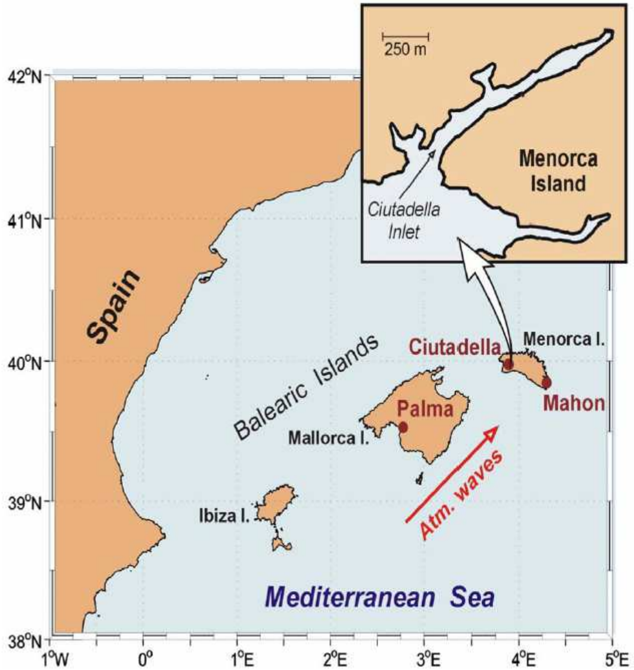
A Computationally Cheap Atmosphere-Ocean Modelling System Aimed At Anticipating METEOTSUNAMI Occurrence in CIUTADELLA Harbour

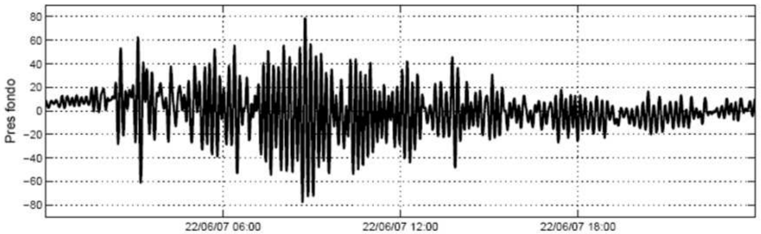
Romu Romero M. Mar Vich C. Ramis

7th METMED Conference

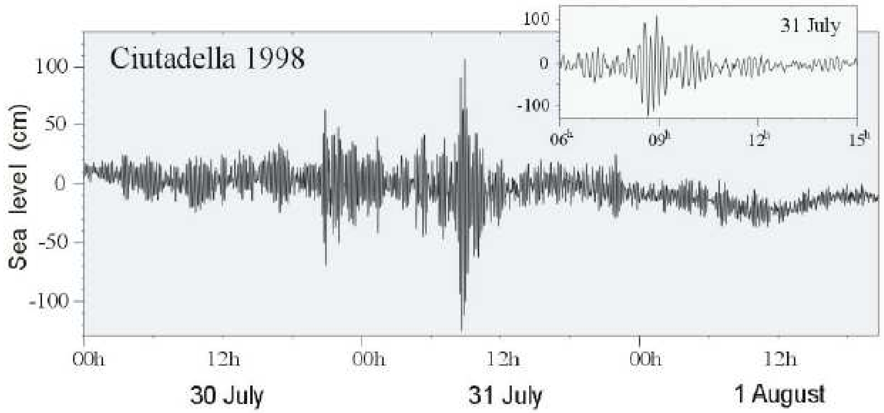
Palma de Mallorca (SPAIN), March 4-6 2019



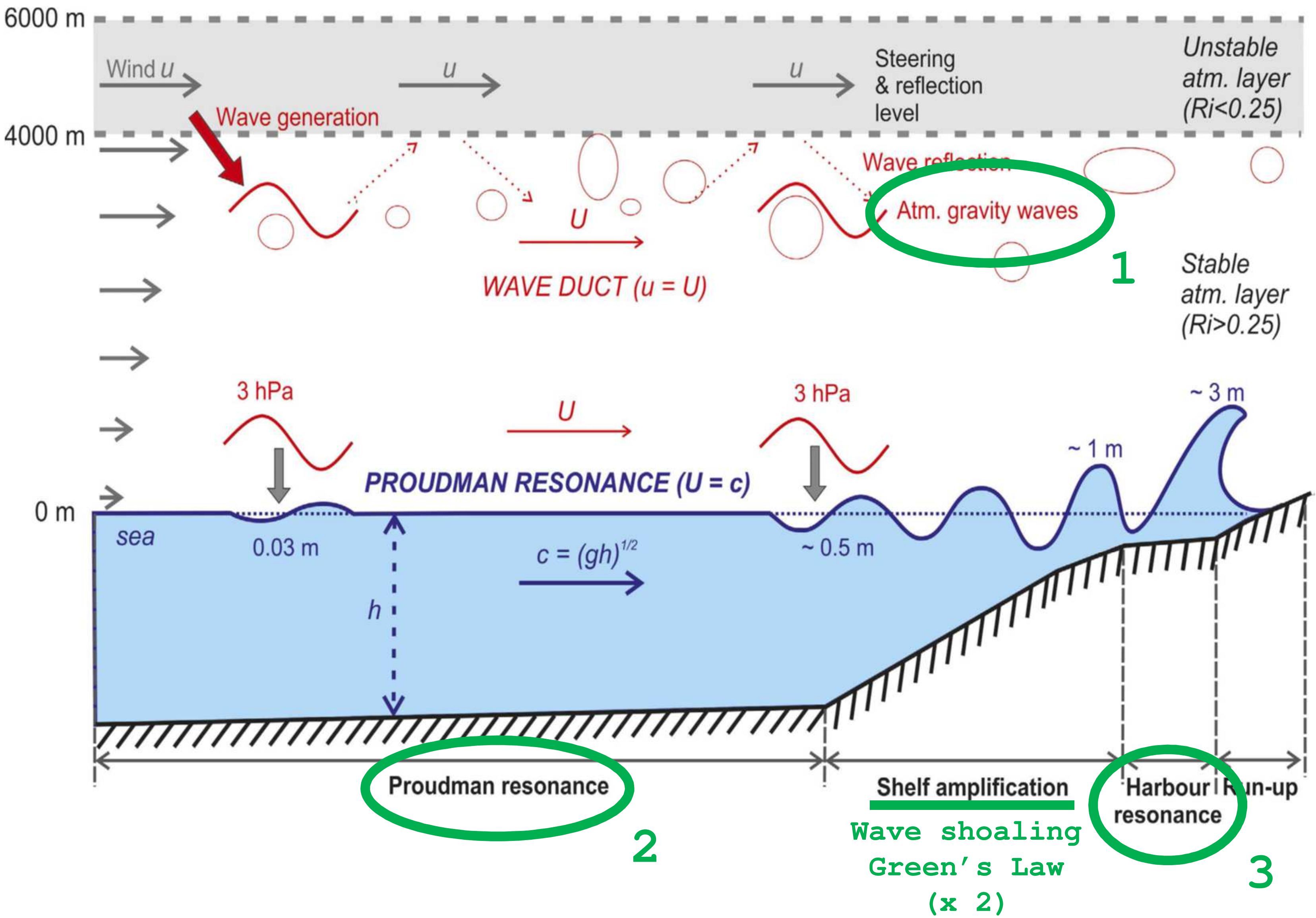
Jansà et al. (2007)



15 June 2006



Šepić et al. (2015)



1. ATMOSPHERIC Component (Balearic Islands)

> 2D version of Euler equations (dry-adiabatic)

$$\frac{\partial \pi'}{\partial t} = -u\frac{\partial \pi'}{\partial x} - w\frac{\partial \pi'}{\partial z} - w\frac{\partial \bar{\pi}}{\partial z} - \frac{R}{c_v}(\bar{\pi}+\pi')\left[\frac{\partial u}{\partial x} + \underline{\frac{\partial w}{\partial z}}\right]$$

$$\frac{\partial \theta'}{\partial t} = -u\frac{\partial \theta'}{\partial x} - w\frac{\partial \theta'}{\partial z} - w\frac{\partial \bar{\theta}}{\partial z}$$

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - w\frac{\partial u}{\partial z} - c_p(\bar{\theta}+\theta')\frac{\partial \pi'}{\partial x}$$

$$\frac{\partial w}{\partial t} = -u\frac{\partial w}{\partial x} - w\frac{\partial w}{\partial z} - c_p(\bar{\theta}+\theta')\underline{\frac{\partial \pi'}{\partial z}} + g\frac{\theta'}{\bar{\theta}}$$

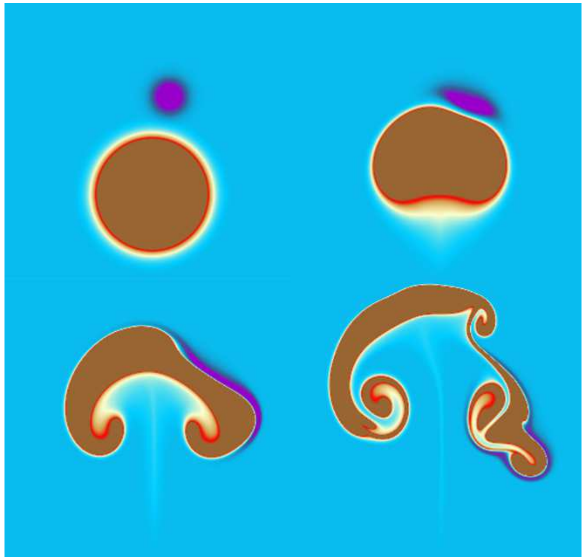
NO rotation

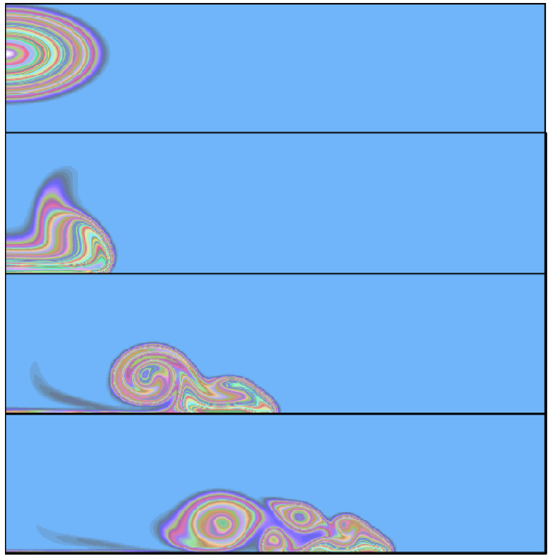
NO physics, etc …

> Numerical implementation [CFL $\xrightarrow{c_s > 300\, m/s}$ $\Delta t \approx 3\ \Delta x(\cancel{\Delta z})$]

* Forward-Backward integration of "forcings" in RK2 cycle
* REA (V and H) integration of advection every 6-10 Nsteps
* Stabilized acoustic vertical modes (Implicit Scheme)

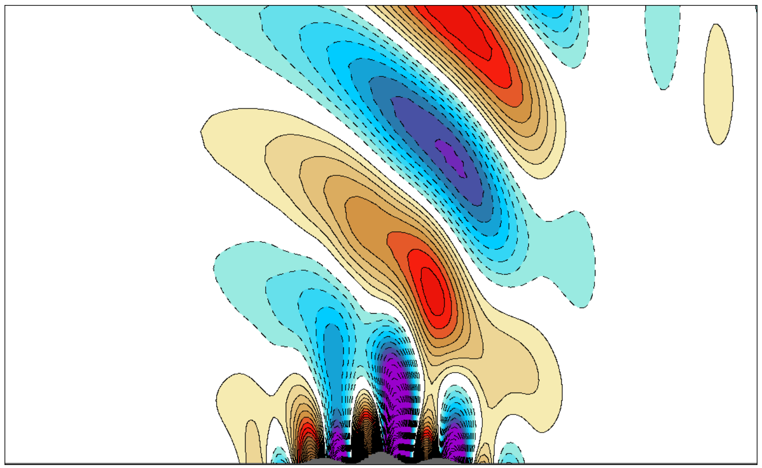
Large Warm & Small Cold Bubble



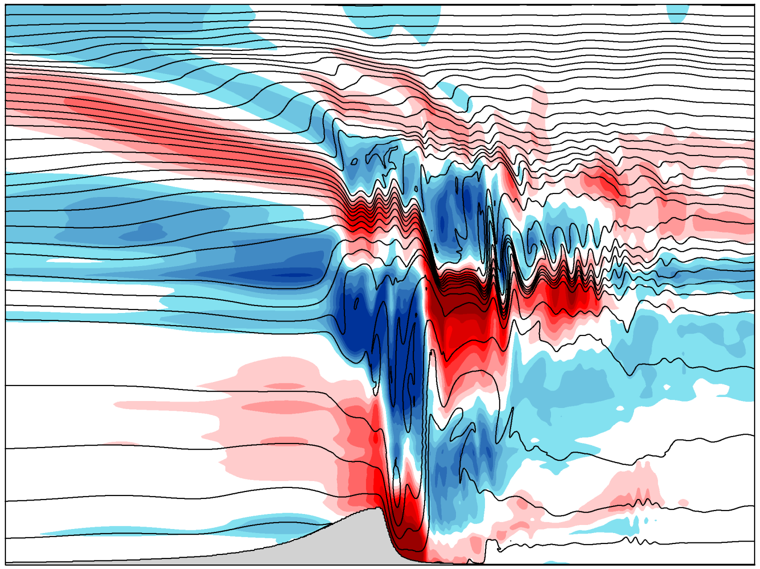


Density Current

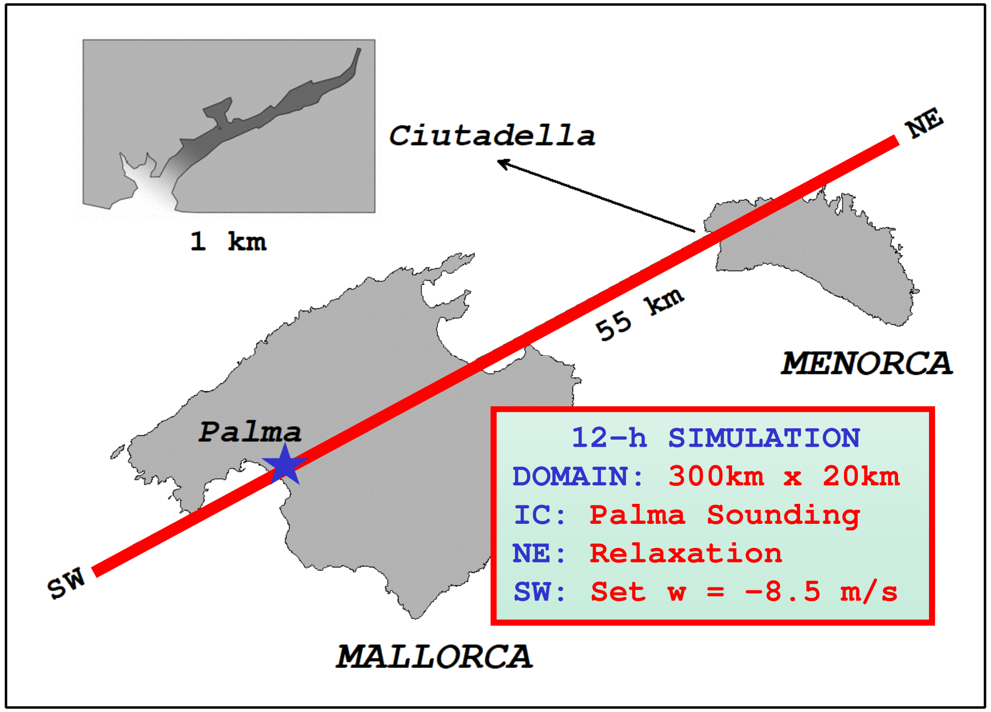
Schär Mountain

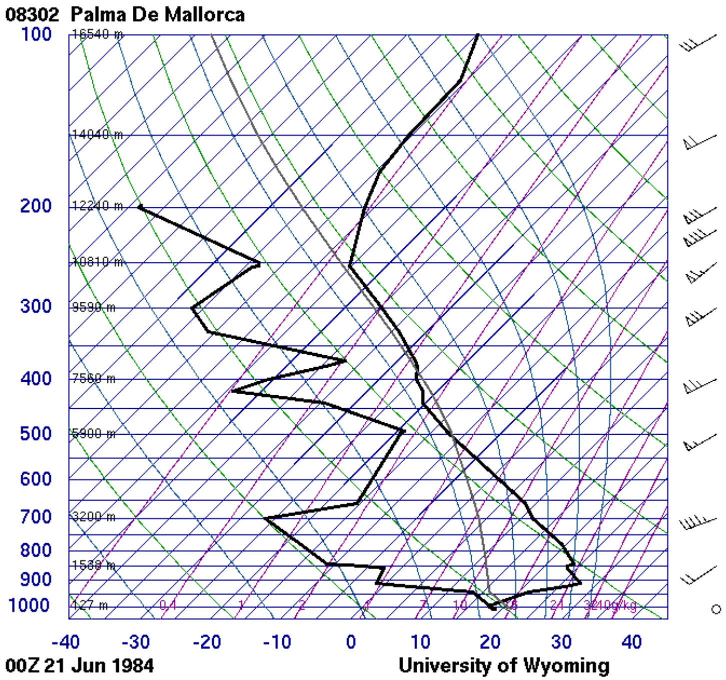


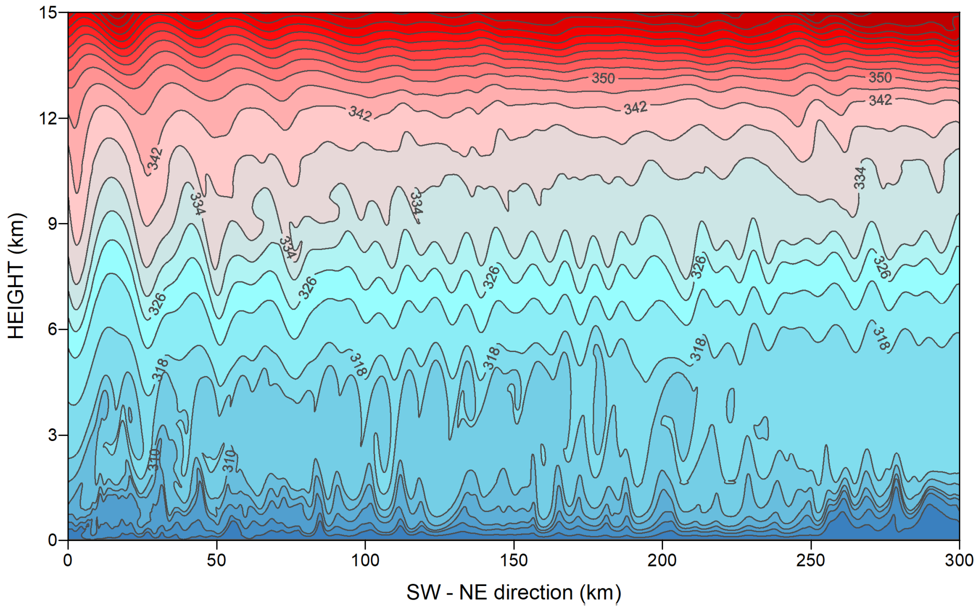
T-REX Intense Mountain-Wave



GRAVITY WAVE Generation & Progagation

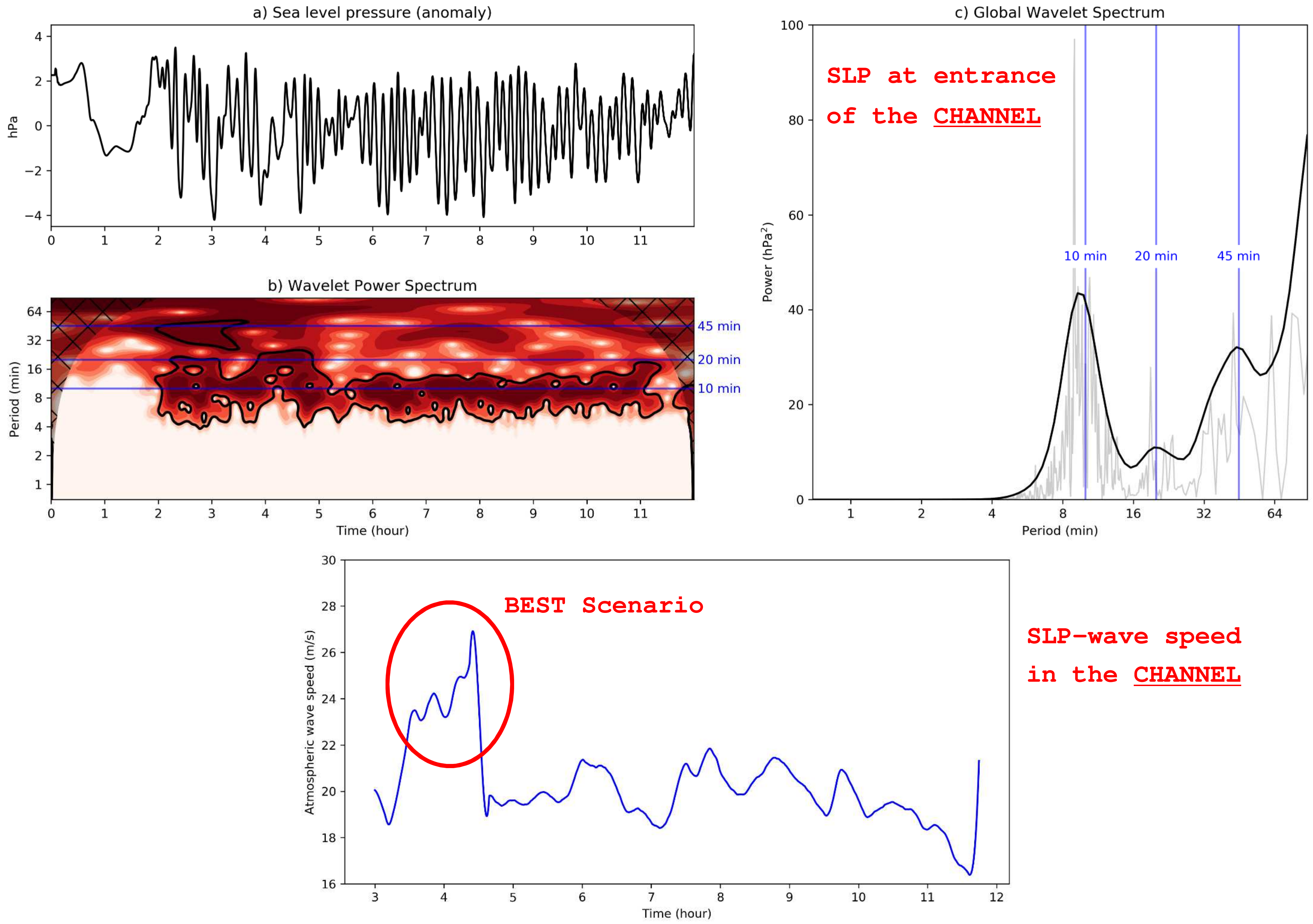






With ORIGINAL (t=5h)

GRAVITY WAVE Generation & Progagation

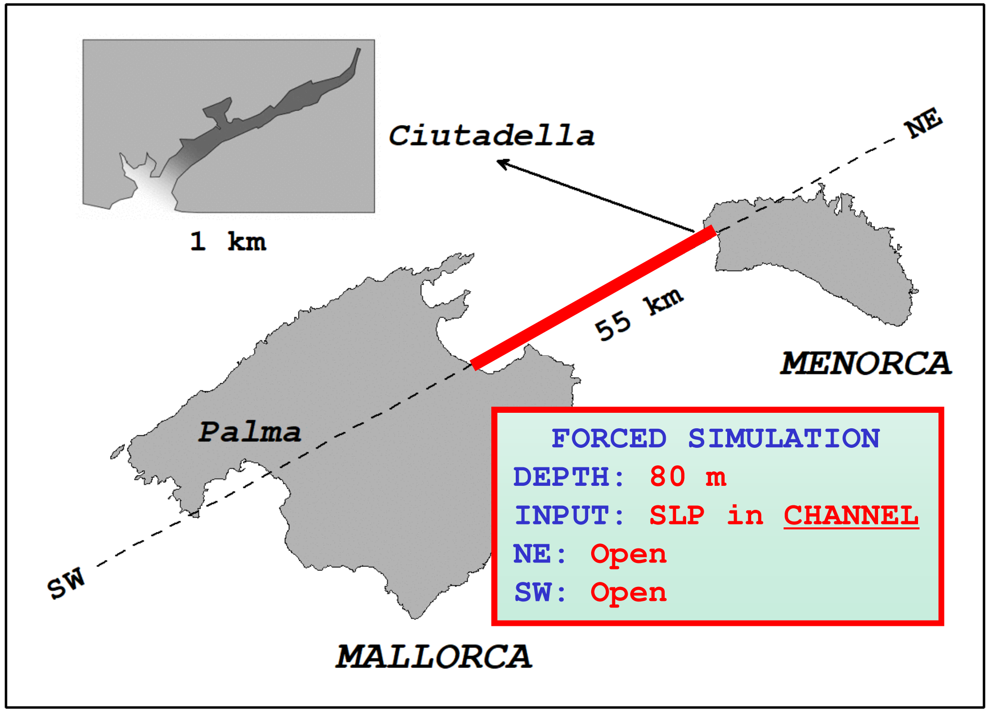


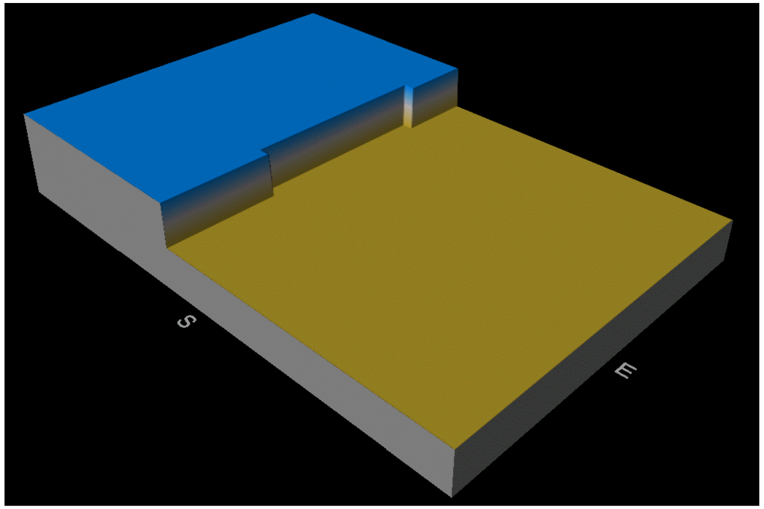
2. OCEANIC Component (MALLORCA-MENORCA Channel)

> **Shallow-Water equations**

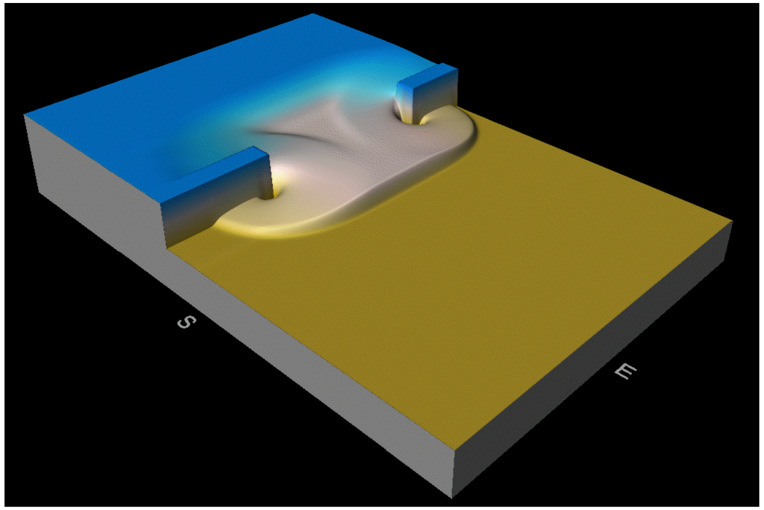
$$\frac{\partial h}{\partial t} = -u\frac{\partial h}{\partial x} - h\frac{\partial u}{\partial x}$$

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - g\frac{\partial h}{\partial x} - \underline{\frac{1}{\rho}\frac{\partial P}{\partial x}} - \frac{gu^2}{hC^2}$$

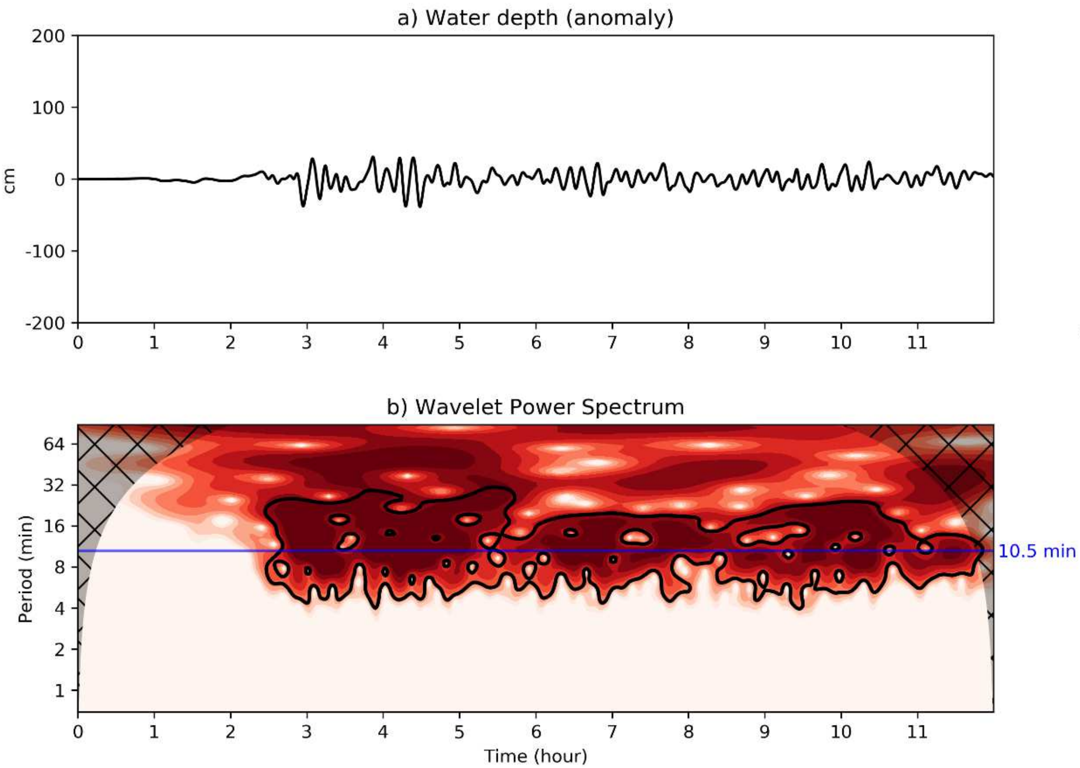


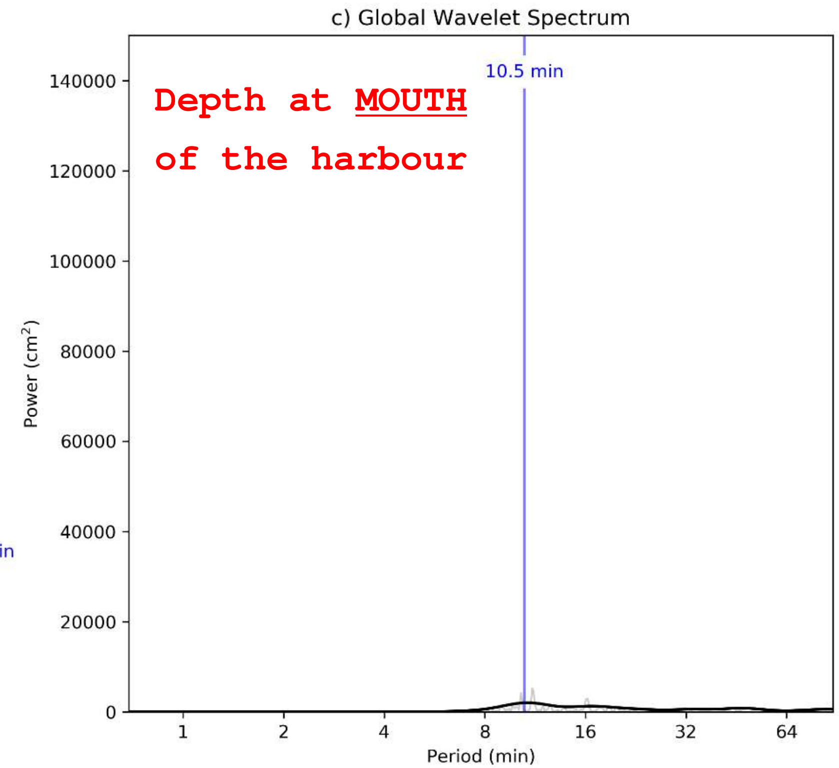


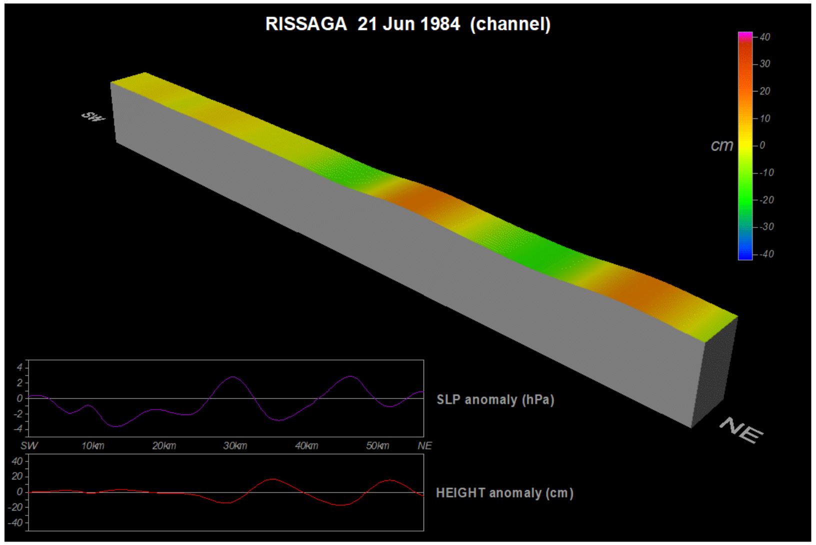
Partial Dam Break 10-5 m



LONG OCEAN WAVES (Proudman Resonance & Wave Shoaling)





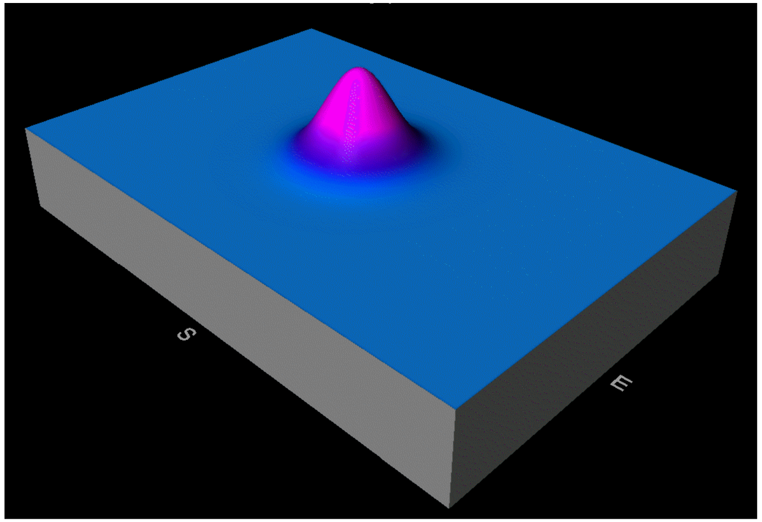


3. COASTAL Component (CIUTADELLA Inlet)

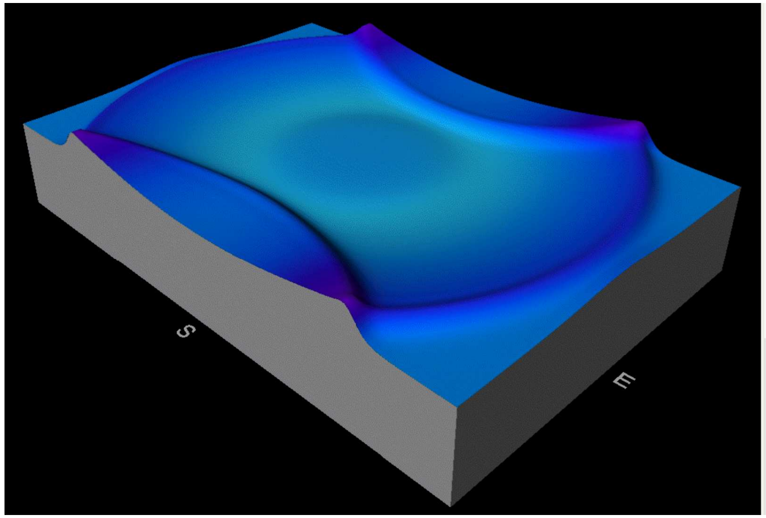
> **Shallow-Water equations**

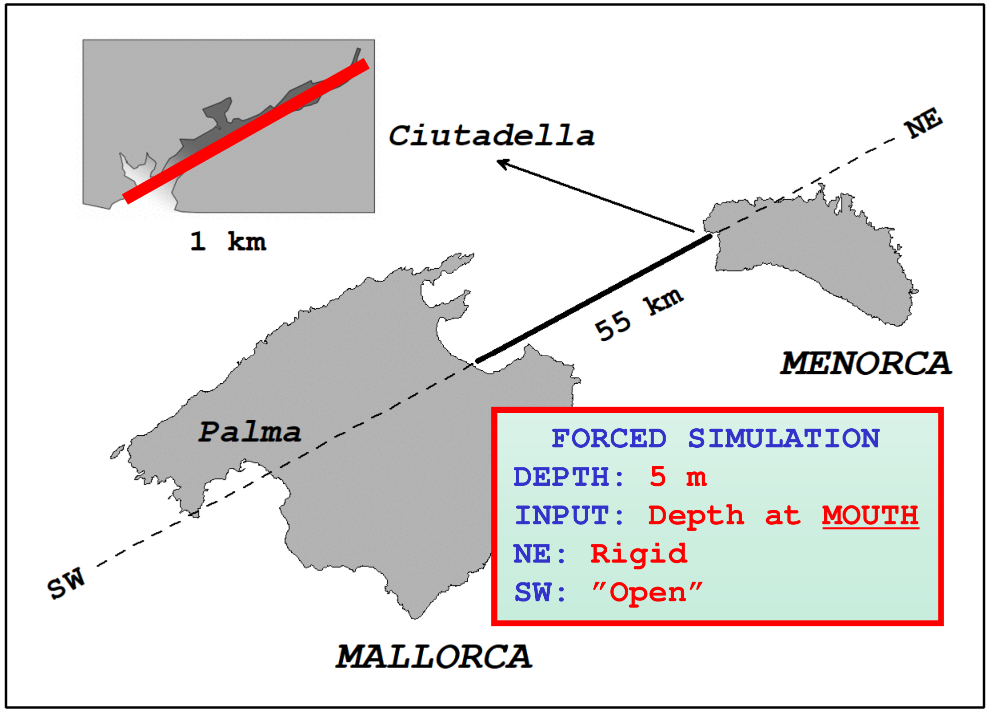
$$\frac{\partial h}{\partial t} = -u\frac{\partial h}{\partial x} - h\frac{\partial u}{\partial x}$$

$$\frac{\partial u}{\partial t} = -u\frac{\partial u}{\partial x} - g\frac{\partial h}{\partial x} - \frac{gu^2}{hC^2}$$

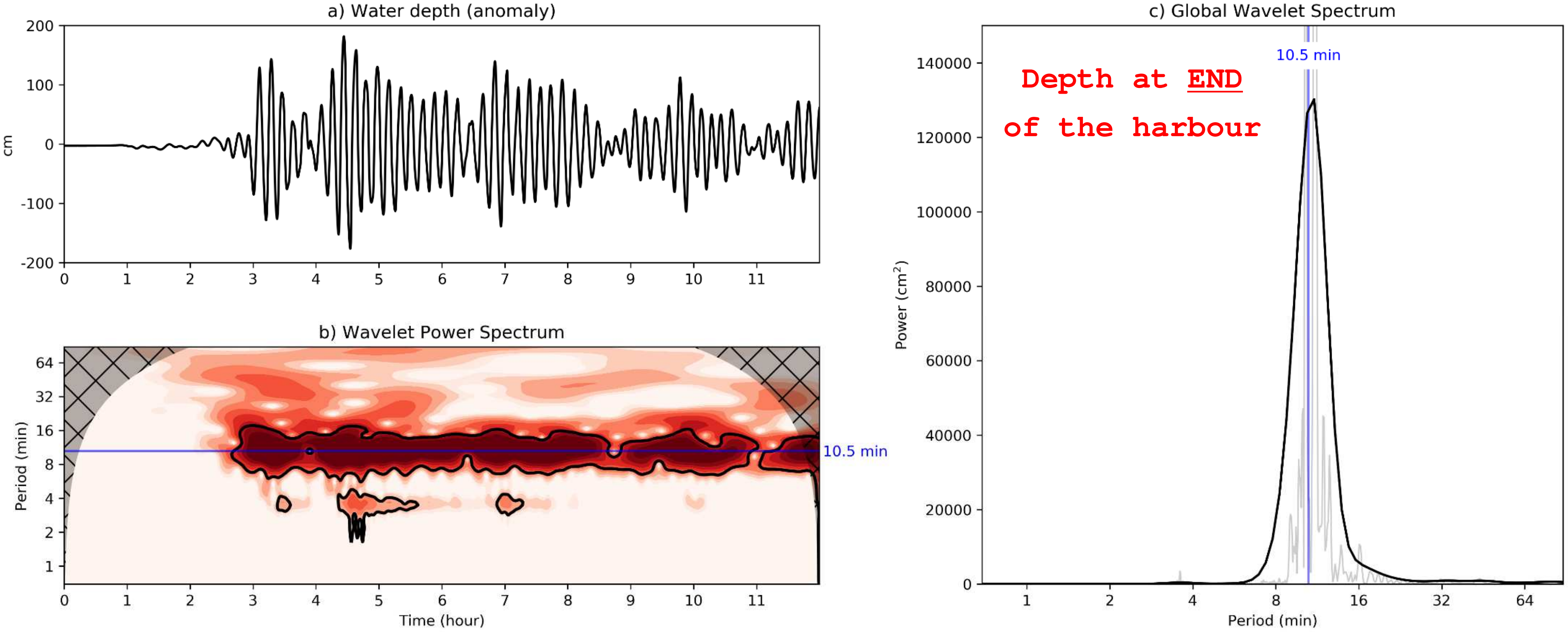


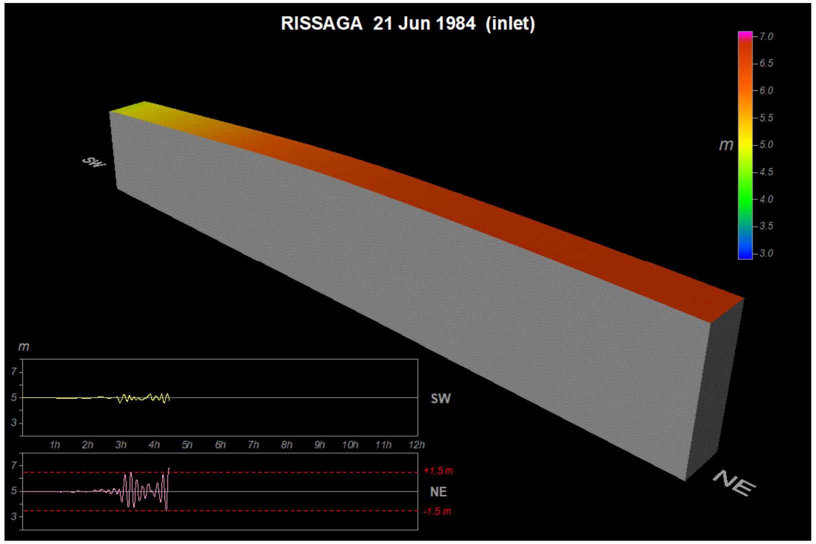
Gaussian Bump in 10 m

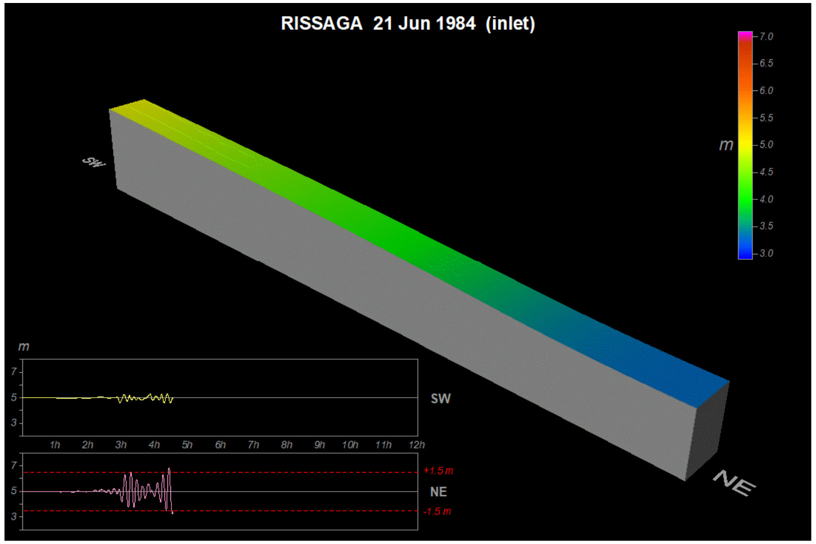




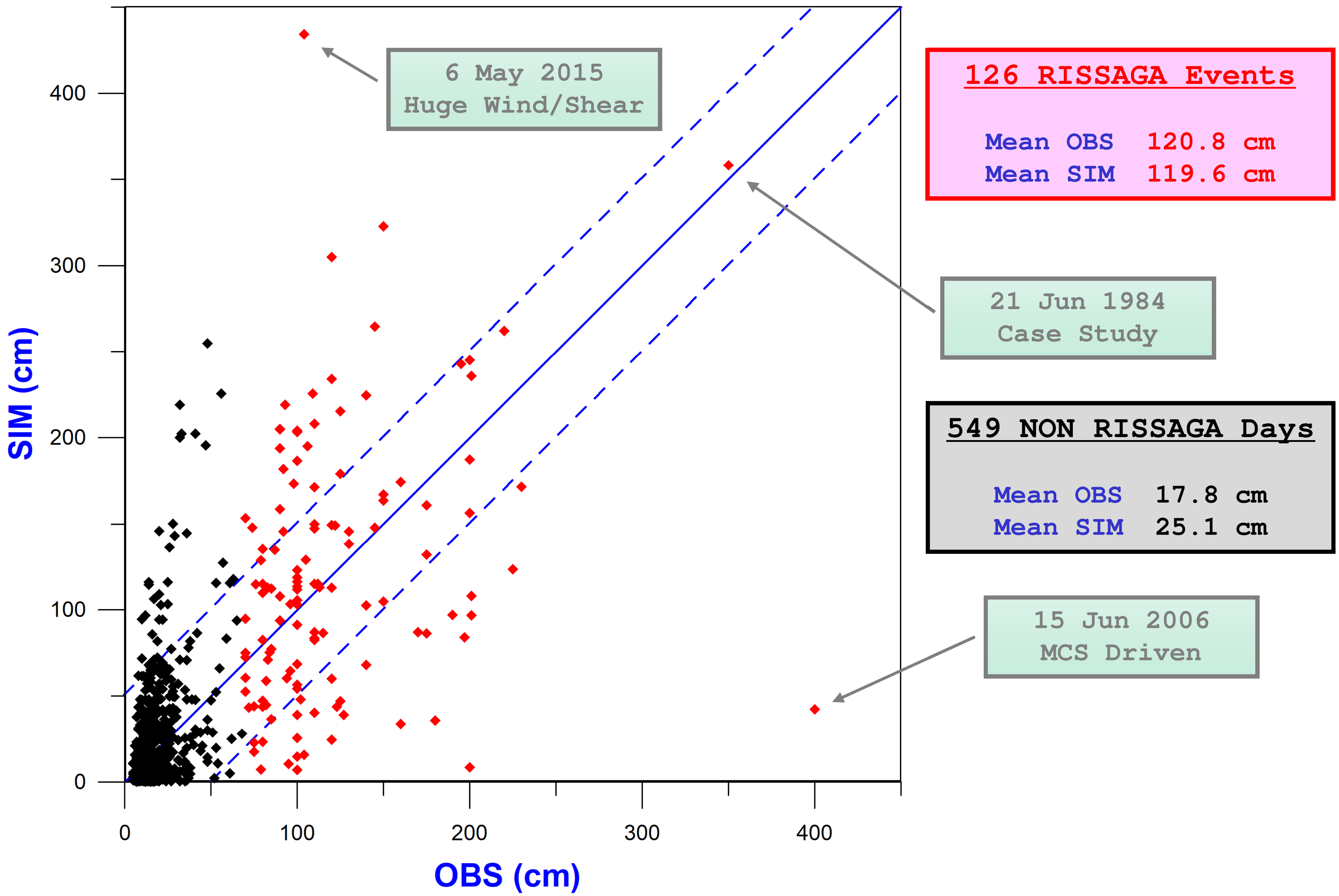
RISSAGA (Harbour Resonance)







RISSAGA (GLOBAL Results)



RISSAGA (CATEGORIES of Practical Interest)

Petites Oscil·lacions (H < 20 cm)	Oscil·lacions Moderades (20 - 70 cm)
Rissaga (70 - 100 cm)	Rissaga Forta (100 - 200 cm)
Rissaga Extrema (H > 200 cm)	

F O R E C A S T (%)

O B S E R V E D

	71.2	25.9	1.8	1.0	0.0
	43.1	38.9	6.0	8.4	3.6
	6.8	29.5	18.2	38.6	6.8
	4.3	21.4	14.3	42.9	17.1
	8.3	8.3	8.3	41.7	33.3

What fraction of the events are (are not) correctly forecast ???

O B S E R V E D (%)

F O R E C A S T

	77.5	20.5	0.9	0.9	0.3
	51.3	33.7	6.7	7.8	0.5
	19.4	27.8	22.2	27.8	2.8
	5.7	20.0	24.3	42.9	7.1
	0.0	24.0	12.0	48.0	16.0

What fraction of the forecasts are (are not) correct ???

> A PRAGMATIC (and computationally CHEAP) numerical APPROACH aimed at PREDICTING the occurrence and magnitude of meteotsunamis in Ciutadella (RISSAGAS): SKILL for the recognition of RISK situations and for a categorization among WEAK, MODERATE and INTENSE

> SOME ISSUES to explore: Sounding representativity; Type and amount of GW triggering; Inclusion of moist physics (MCS); Second-order oceanic influences...

> The system could be applied as a DOWNSCALING METHOD to assess quantitatively the future risk of rissagas

> It is now in operation, running daily driven by GFS forecast soundings for the next 3 days and providing PROBABILISTIC PREDICTIONS: http://meteo.uib.es/rissaga

THANK YOU

for

your attention