



Universitat
de les Illes Balears



METEOTSUNAMIS o RISSAGUES.

***Què són i com els podem preveure
amb prou antelació***

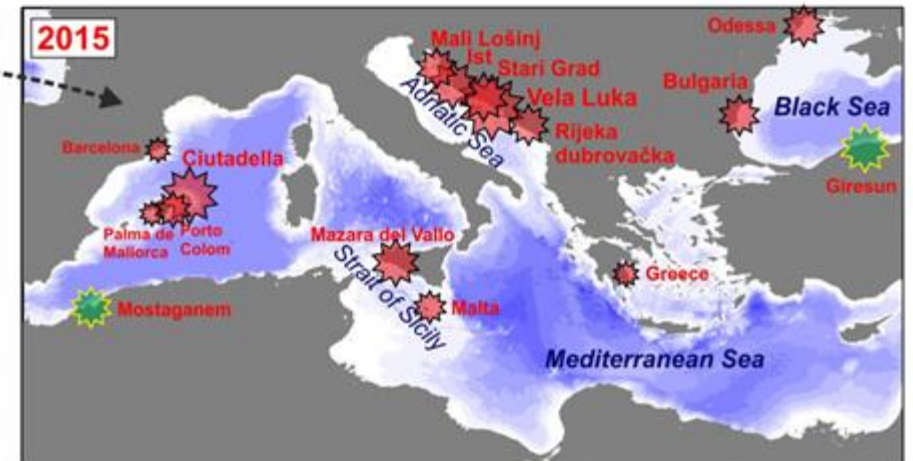
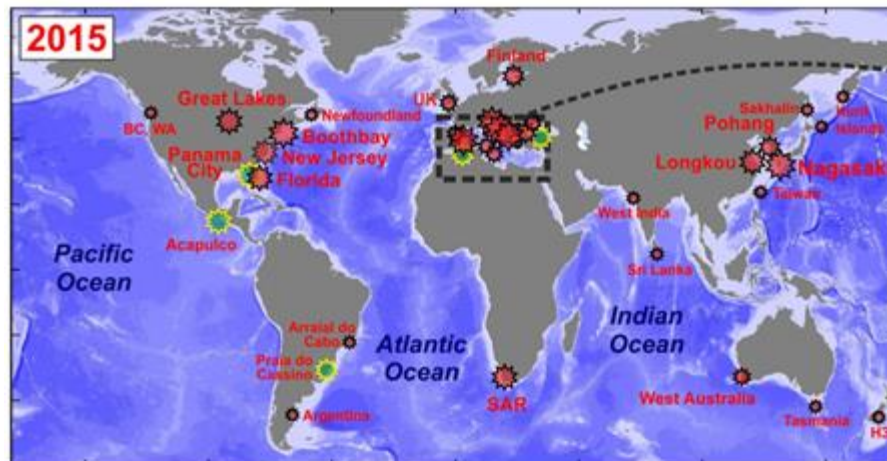
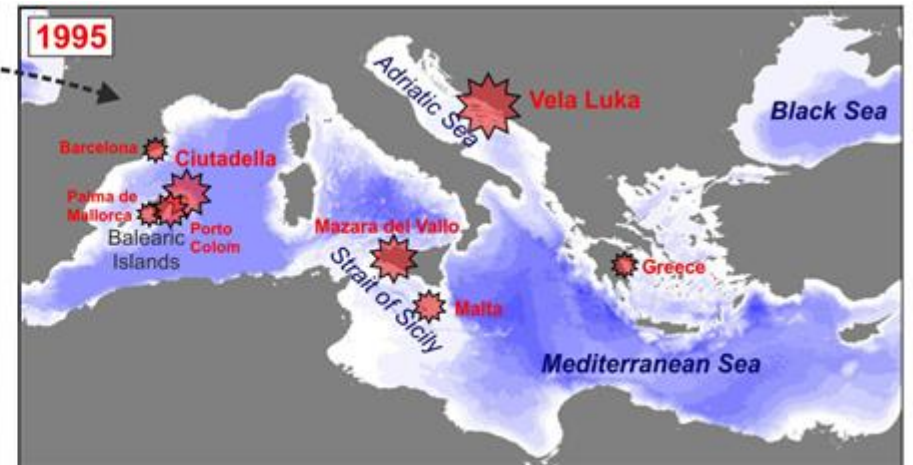
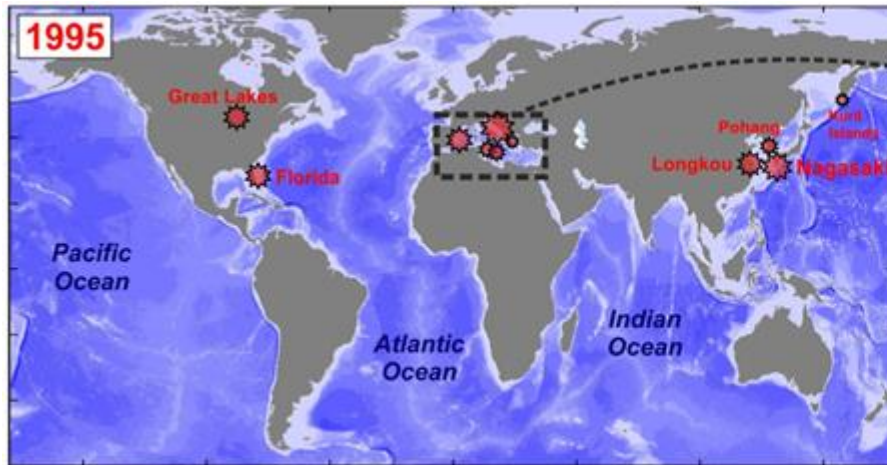
Romualdo Romero

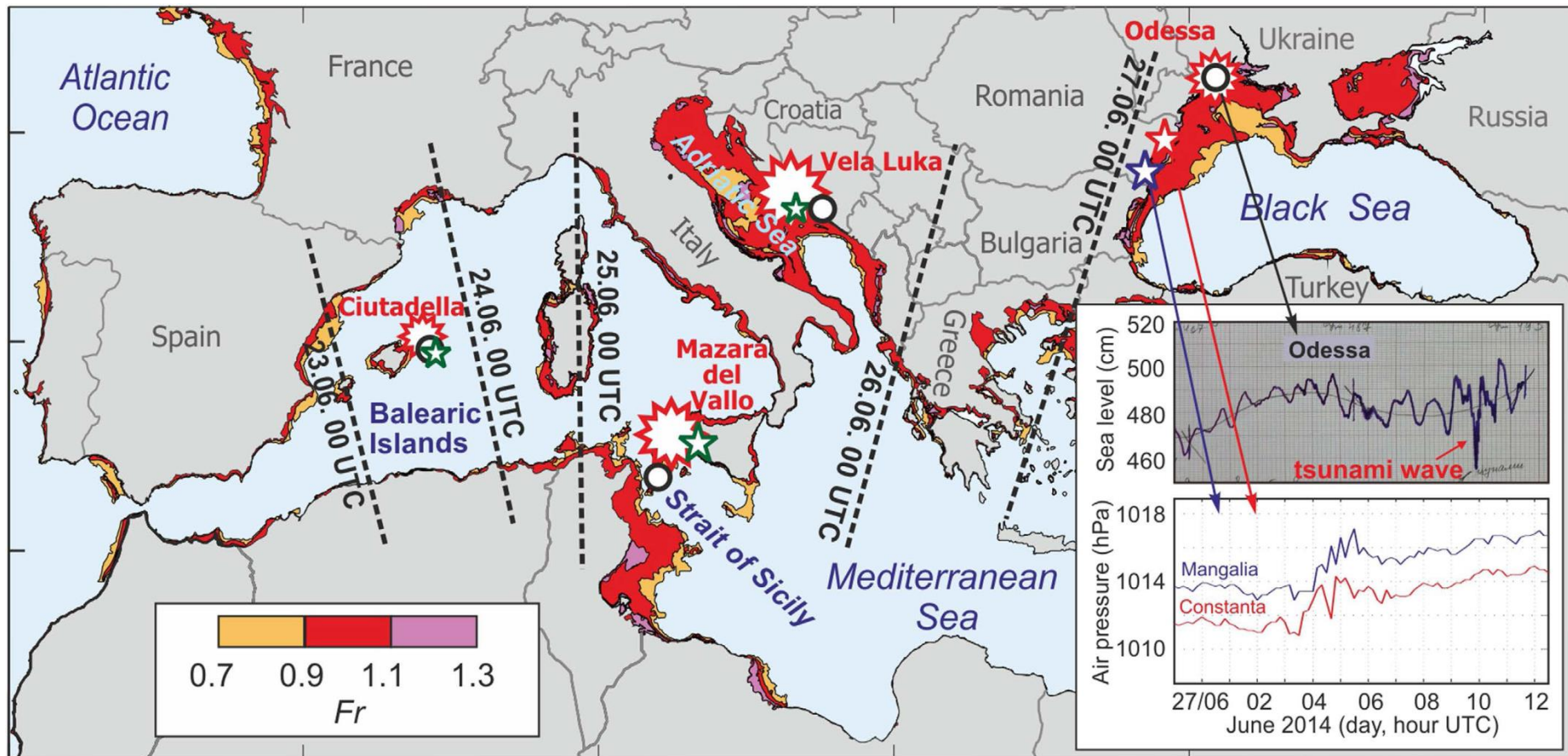
LA UOM A MENORCA "Aprendre no té edat"

Alaior, Ciutadella i Maó (Març 2021)

- 1) *METEOTSUNAMIS* o *RISSAGUES*: *Mecanismes Físics*
- 2) *Mètode "empíric"* de predicció de l'*AEMET*
- 3) *Mètode SOCIB/BRIFS* de modelització *intensiva*
- 4) *Mètode UIB* de modelització *FÍSICA* simplificada
- 5) *Mètode UIB* a partir d'una *XARXA NEURONAL*

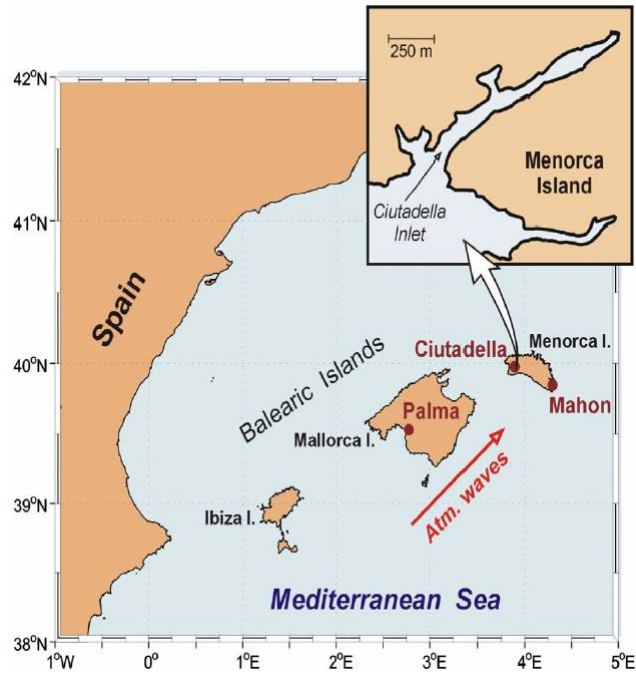
- 1) **METEOTSUNAMIS** o **RISSAGUES**: *Mecanismes Físics*
- 2) *Mètode "empíric" de predicció de l'AEMET*
- 3) *Mètode SOCIB/BRIFS de modelització intensiva*
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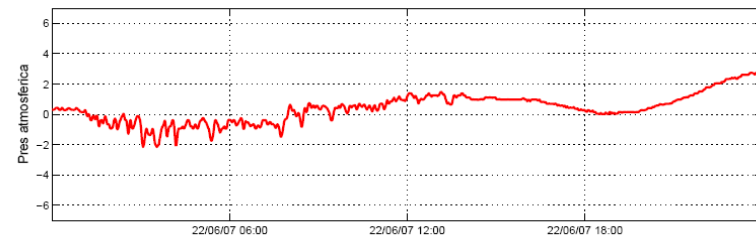
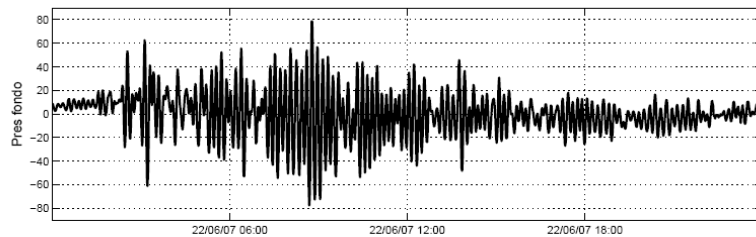


La cadena de meteotsunamis en Junio de 2014

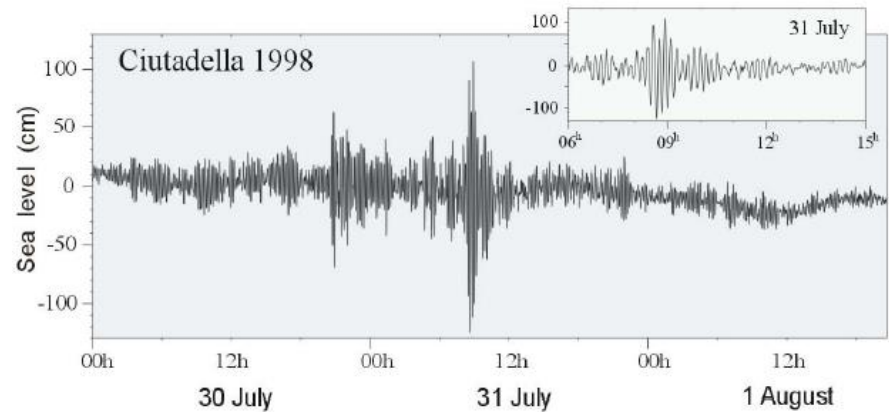
El fenomen de la RISSAGA



Jansà et al. (2007)



15 June 2006

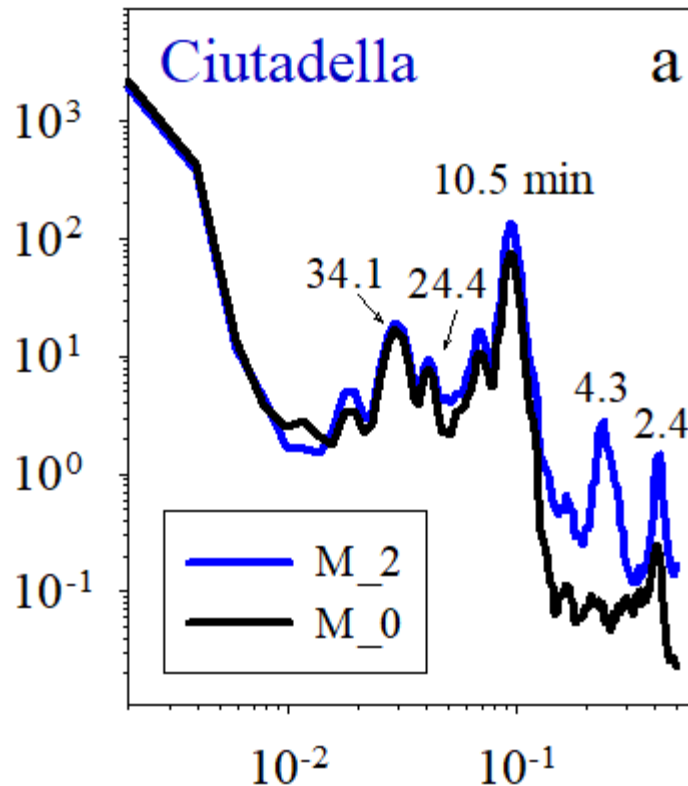


El fenomen de la RISSAGA



Dos minutos y medio!!!

Les SEIXES del Port de Ciutadella



Puerto rectangular, de fondo plano

$$\eta(x) = A \cos k(x + l)$$

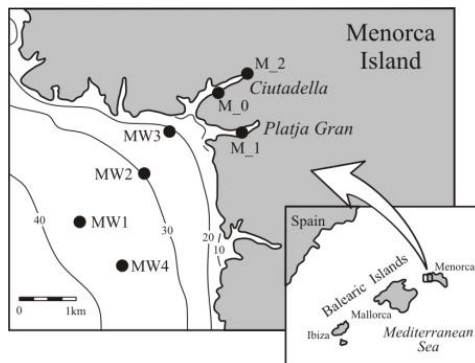
Modos naturales

$$kl = \left(n + \frac{1}{2} \right) \pi$$

$$T = \frac{4l}{(2n + 1)\sqrt{gH}}$$

Fórmula de Merian

L=1100 m, H=5 m



Monserrat et al. (1998)

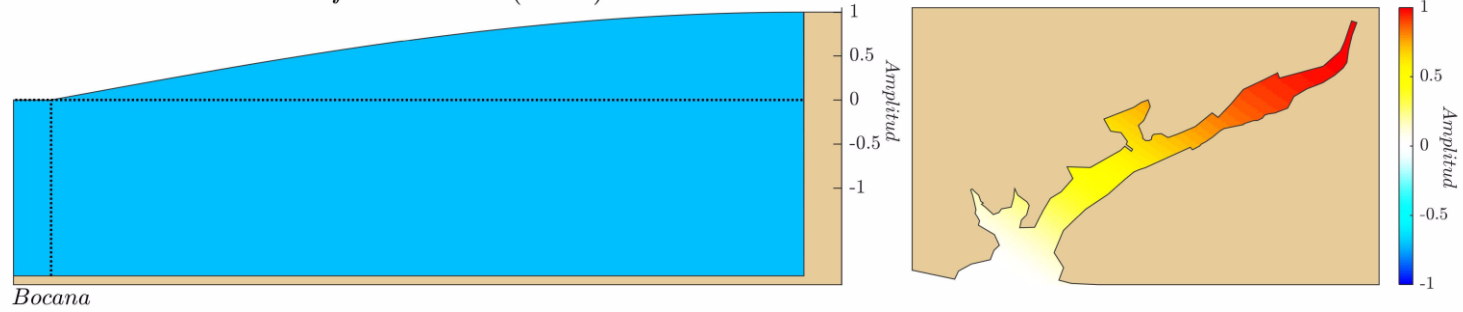
$$T_0 = 10.5 \text{ min}$$

$$T_1 = 3.5 \text{ min}$$

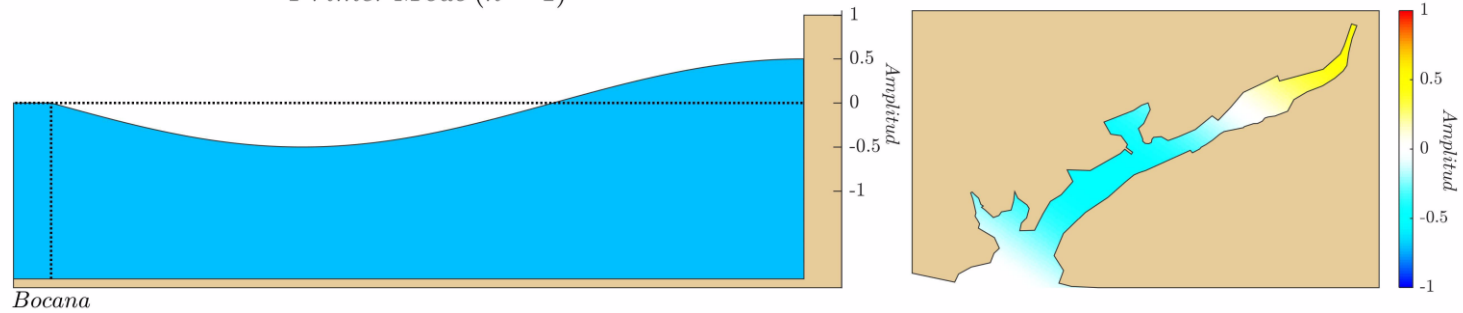
$$T_2 = 2.1 \text{ min}$$

Les SEIXES del Port de Ciutadella

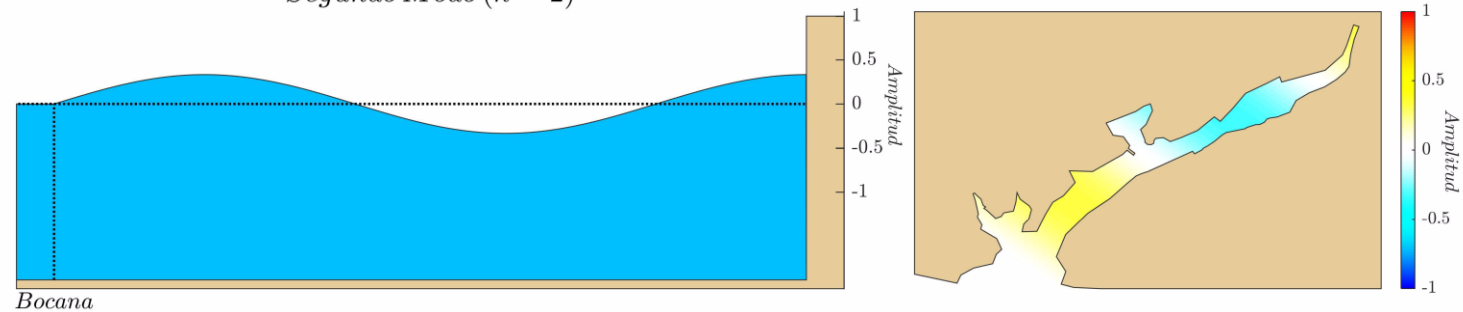
Modo fundamental ($n = 0$)



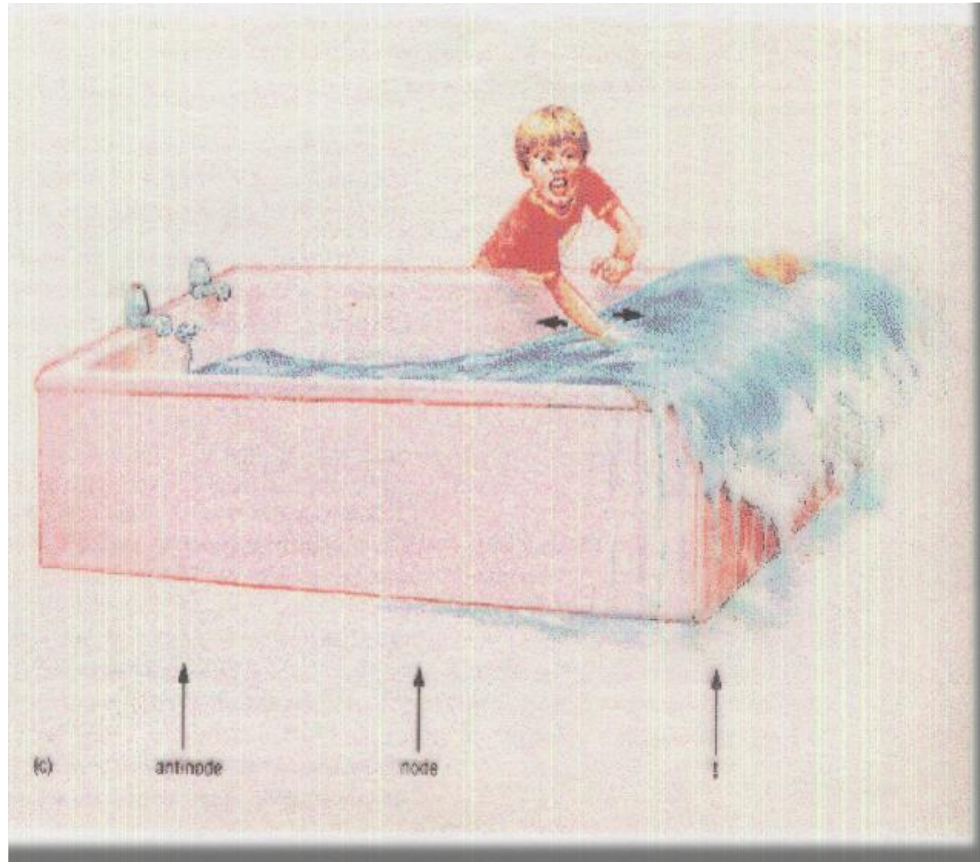
Primer Modo ($n = 1$)



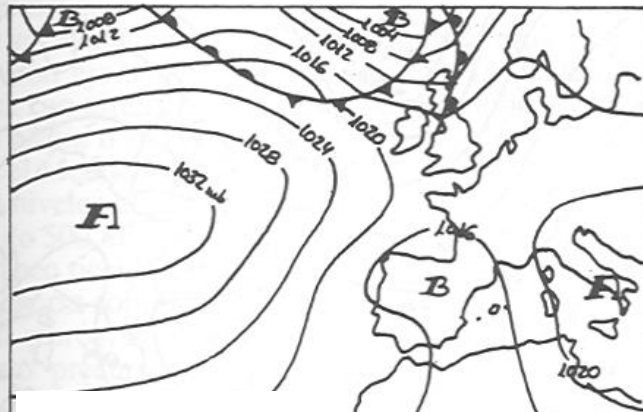
Segundo Modo ($n = 2$)



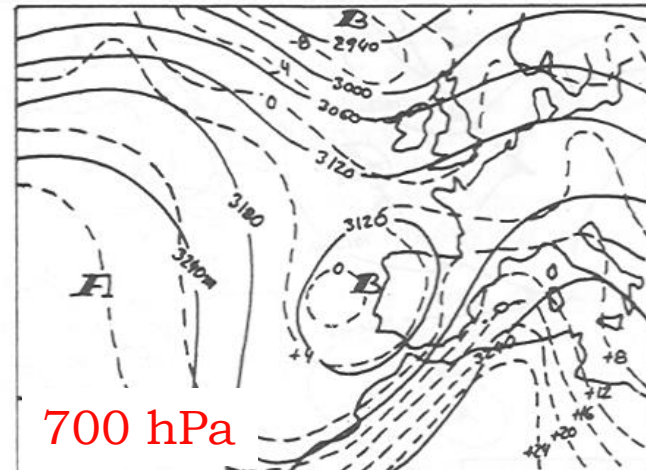
Les SEIXES del Port de Ciutadella



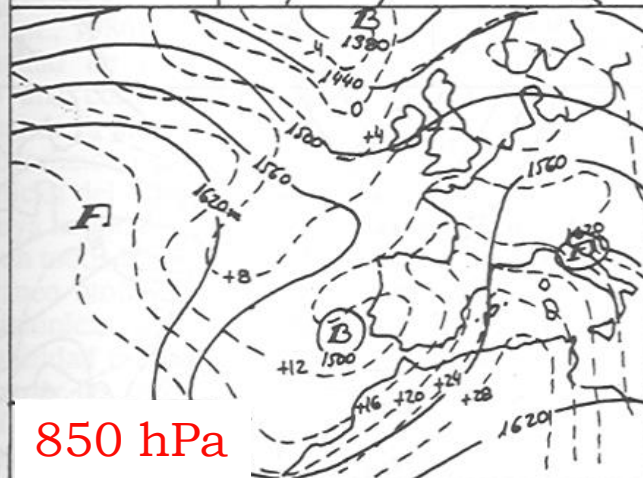
¿Quién tiene la culpa? ¿el niño o la bañera?



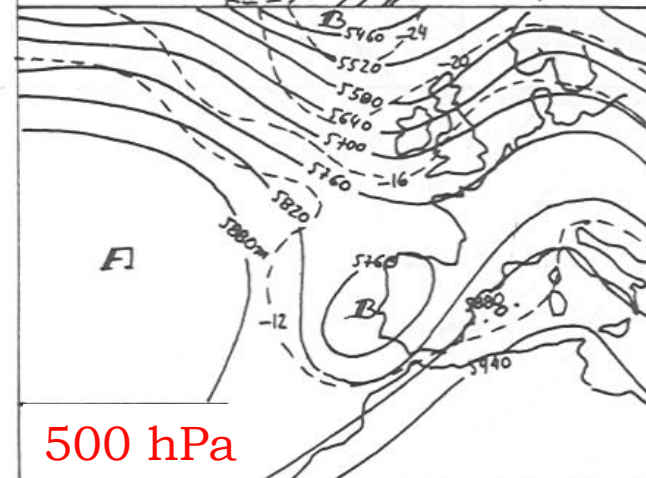
Superficie



700 hPa



850 hPa

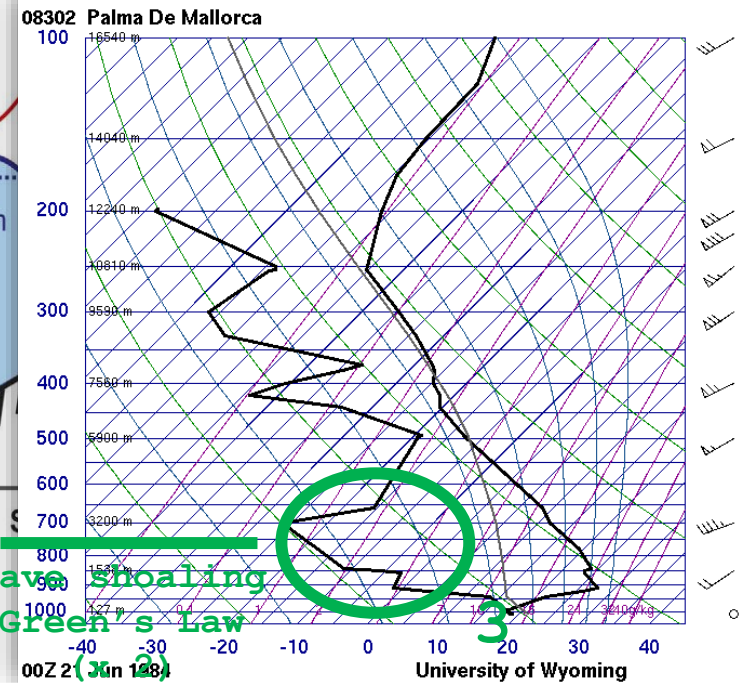
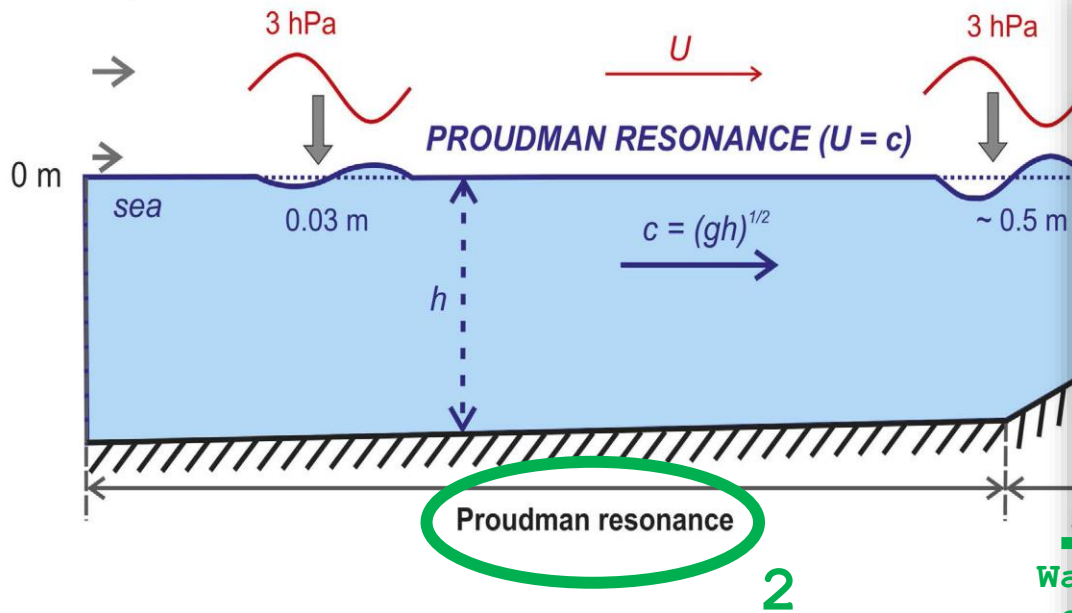
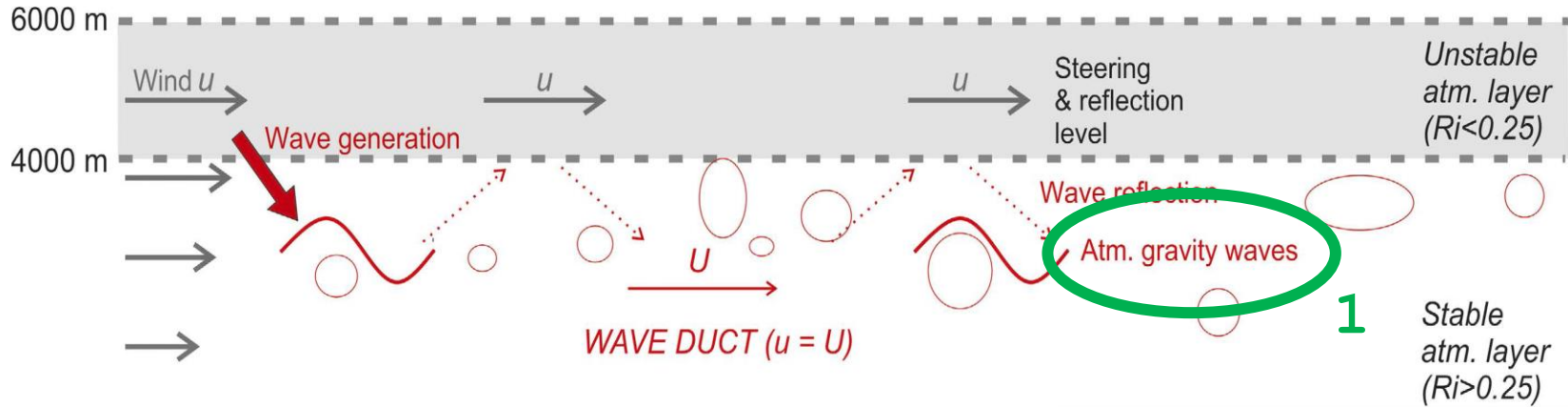


500 hPa

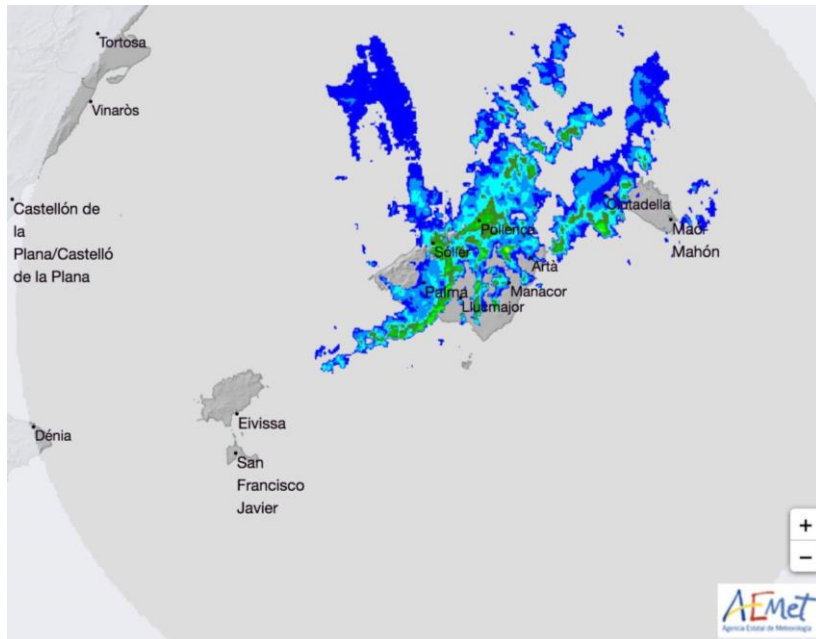
Situación sinóptica 20 Junio 1984, 12.00 GMT

Mecanismes FÍSICS (Ones Gravitatòries)

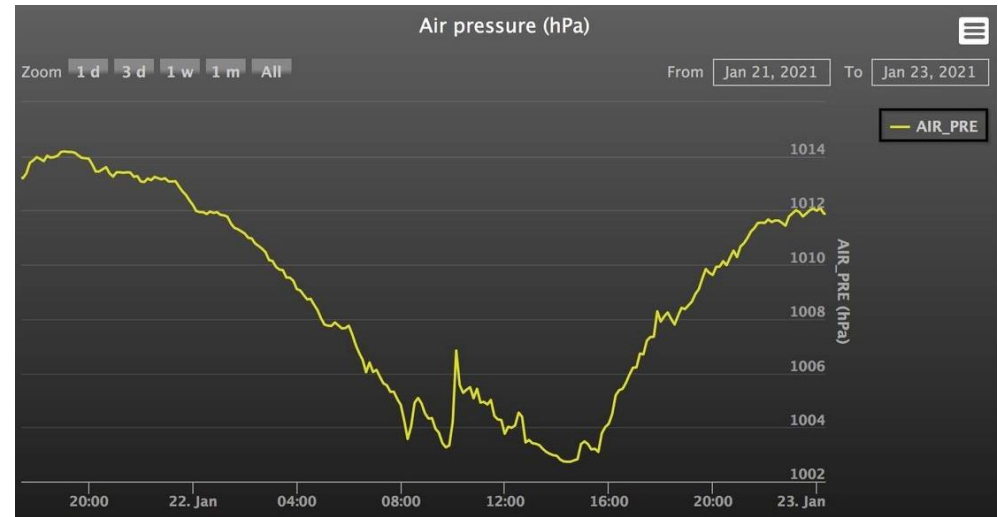
Šepić et al. (2015)



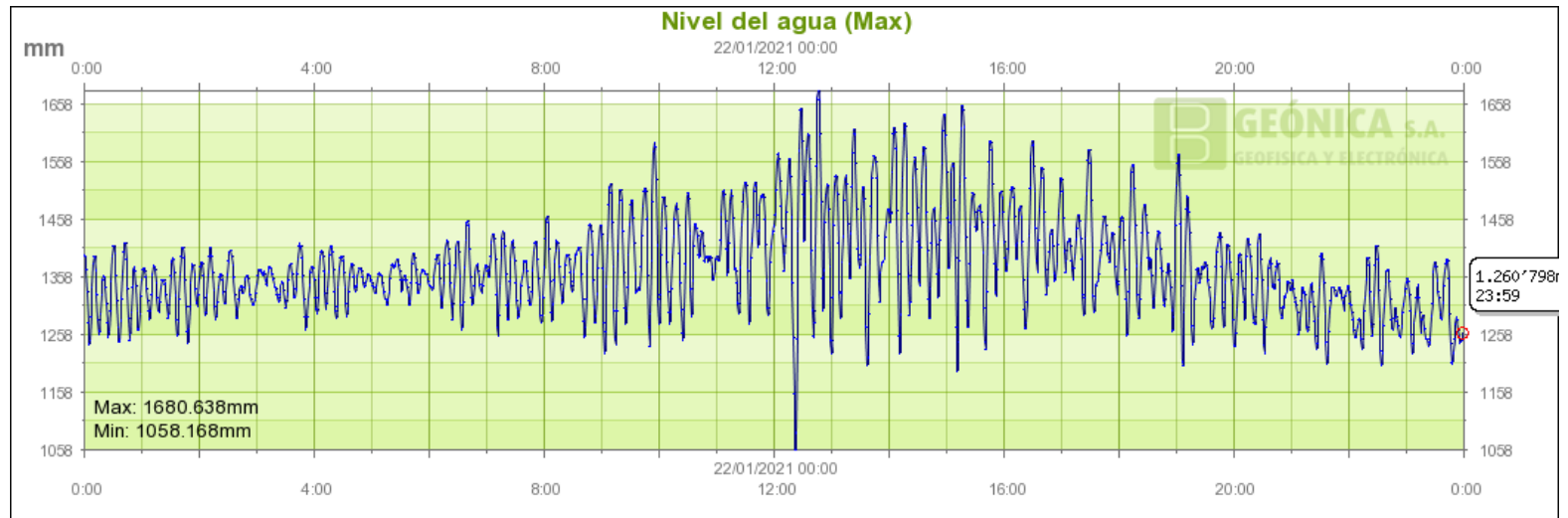
Mecanismes FÍSICS (Tempestes)



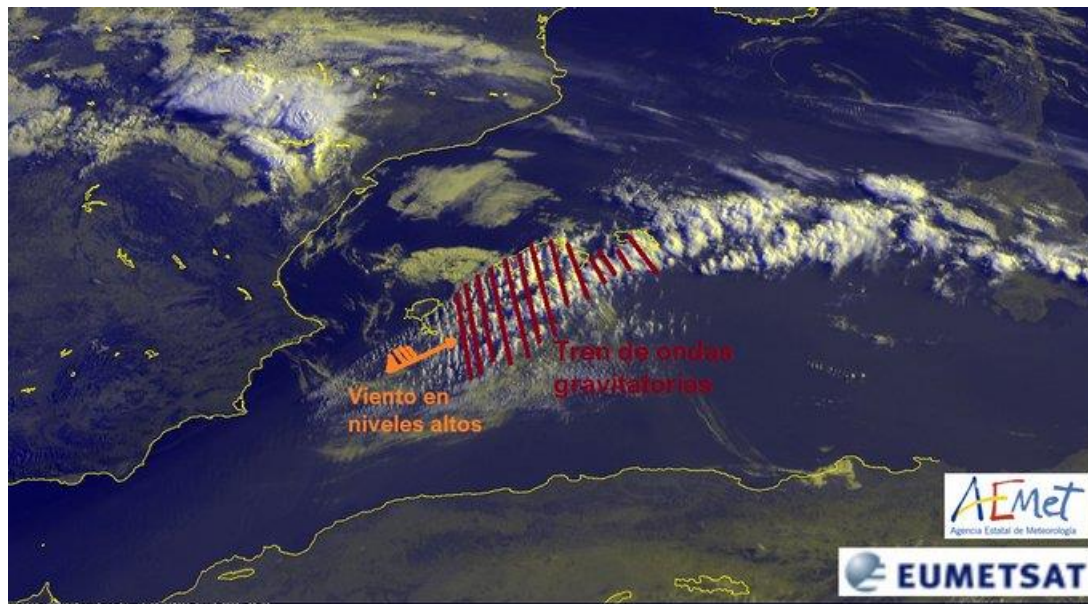
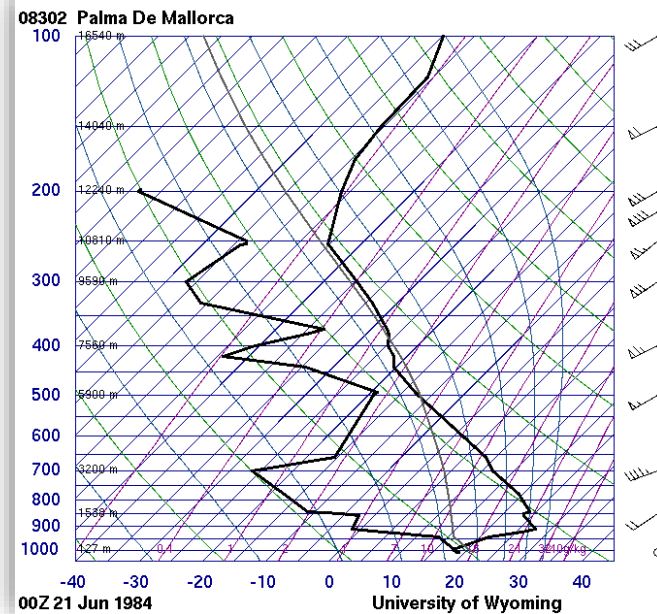
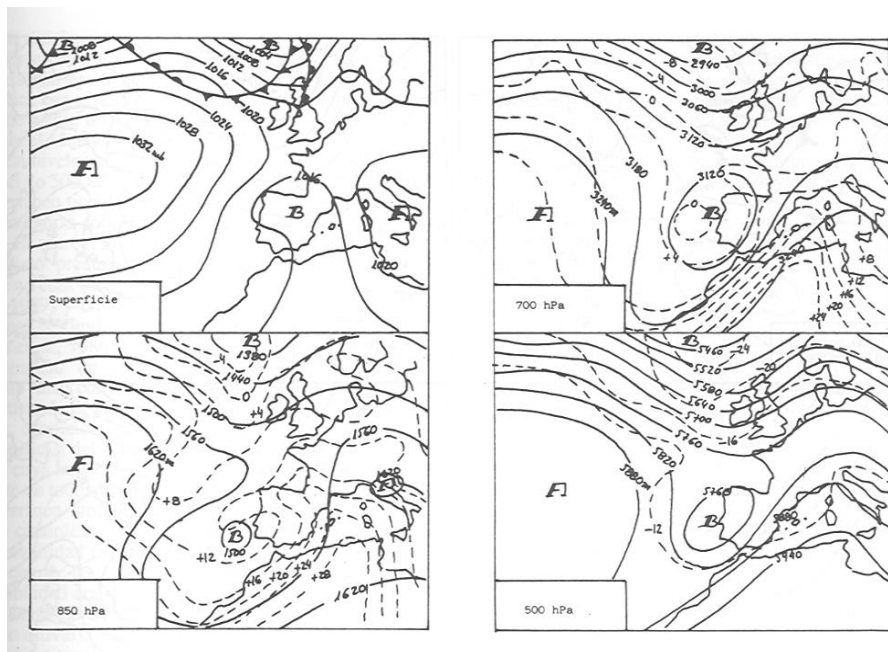
SOCIB-Andratx



Port de Ciutadella



- 1) *METEOTSUNAMIS o RISSAGUES: Mecanismes Físics*
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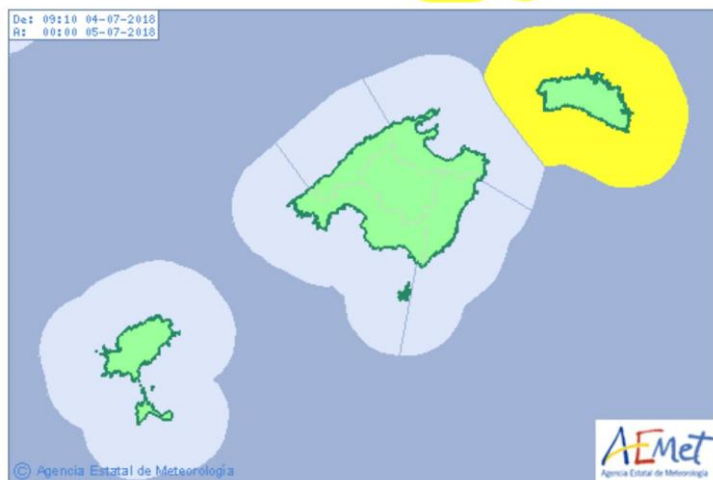


UMBRALES Y NIVELES DE AVISO

1.5. RISSAGUES (RISAGAS)

ZONAS	NIVEL	CARACTERÍSTICAS
ILLES BALEARS	AMARILLO	Oscilaciones en la altura del agua del mar desde 0,7 hasta 1 metro.
	NARANJA	Oscilaciones de la altura del agua del mar desde 1 hasta 2 metros.
	ROJO	Oscilaciones superiores a 2 metros en la altura del agua del mar.

Filtro por fenómenos: **Todos** 



La rissaga que podría llegar hasta los 70 cm

Aviso de rissaga y lluvia en forma de barro para este miércoles

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Balearic Islands
Coastal Observing
and Forecasting
System



GOVERN
ILLES
BALEARS

[inici](#)[sobre SOCIB](#)[infraestructures](#)[notícies](#)[multimedia](#)[ofertes de treball](#)[accés competitiu](#)[sistemes d'observació](#)[sistema de modelat i predicció](#)[centre de dades](#)[Divisió SIAS](#)

SISTEMA DE MODELAT I PREDICCIÓ

[Introducció](#)[Ocean circulation
forecasts](#)[Descripció del sistema](#)[Predicció del oceà](#)[Validació operacional](#)[Indicadors oceànics](#)[Data access](#)[Rissaga forecast](#)[Wave forecast](#)[Publications](#)[Links](#)[Acknowledgements](#)

SOCIB / Balearic Rissaga Forecasting System (BRIFS)



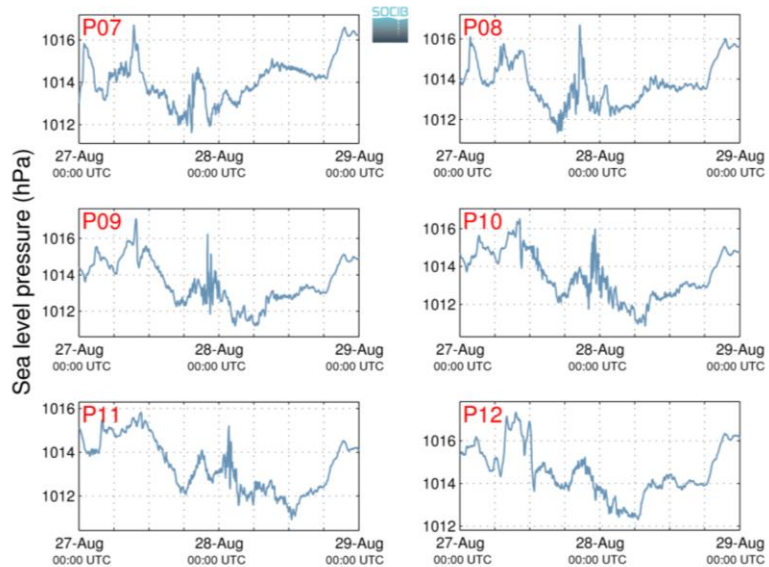
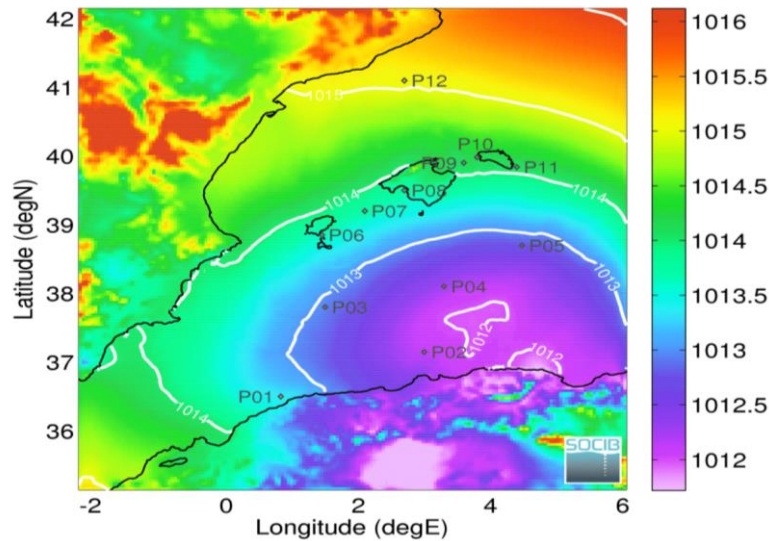
The Balearic Rissaga Forecasting System (BRIFS) aims to quantitatively predict the occurrence of extreme sea level oscillations associated with meteotsunamis in the Menorcan harbour of Ciutadella. Combining both atmospheric and oceanic modelling, the system is run once a day in the morning and provides a 48-hour prediction of air pressure disturbances and associated sea level response over the Balearic shelf and in Ciutadella harbour.



Sea Level Oscillations & Meteo Tsunamis in C...

[Copiar enla...](#)[Ver en](#)[YouTube](#)

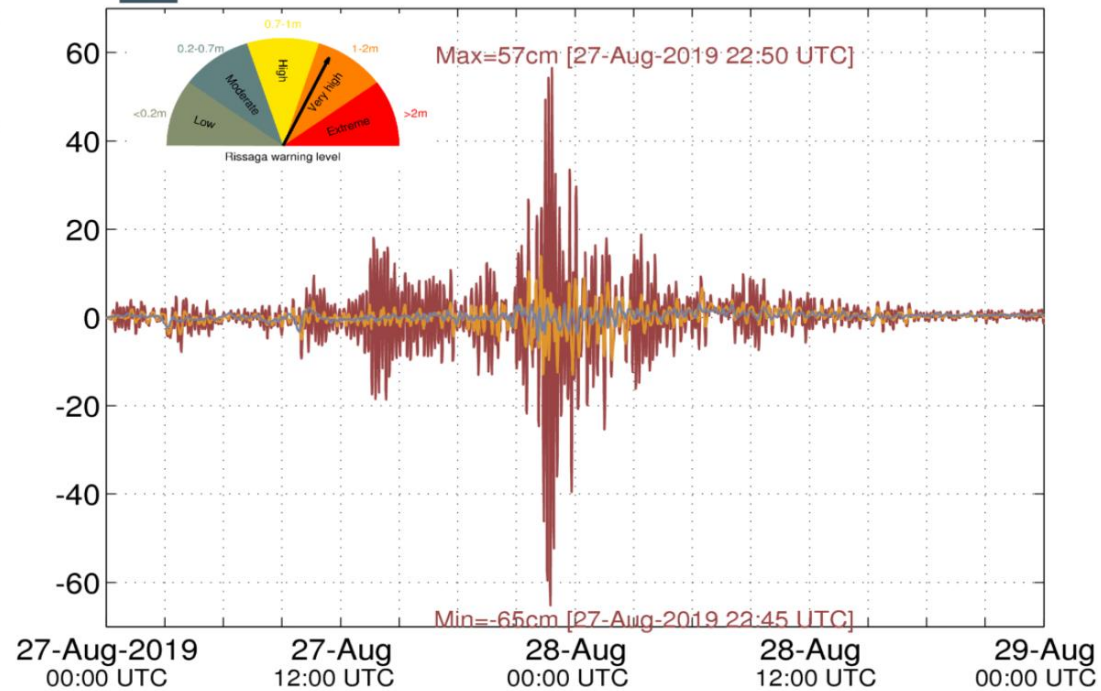
Mean sea level pressure (hPa) for 27-Aug-2019



— Ciutadella Harbour — Off Ciutadella — Menorca Channel



Sea level anomalies (cm)



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> Versió 2D de les equacions d'Euler (sec-adiabàtic)

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

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

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

NO rotació

NO física, etc ...

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

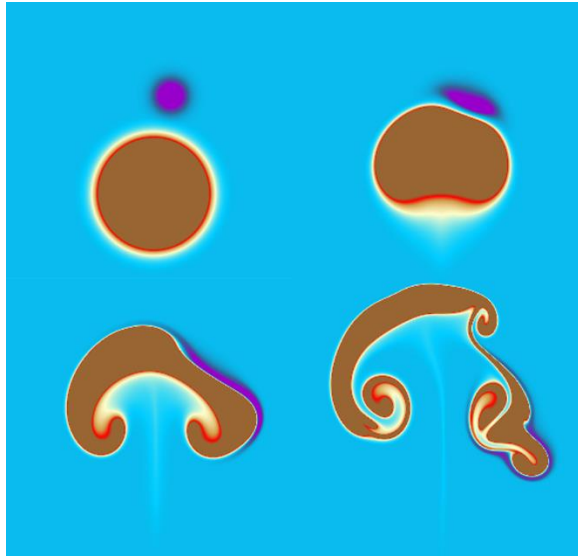
> Implementació numèrica [CFL $\xrightarrow{c_s > 300 \text{ m/s}}$ $\Delta t \approx 3 \Delta x (\Delta z)$]

* Forward-Backward integració "forçaments" en cicle RK2

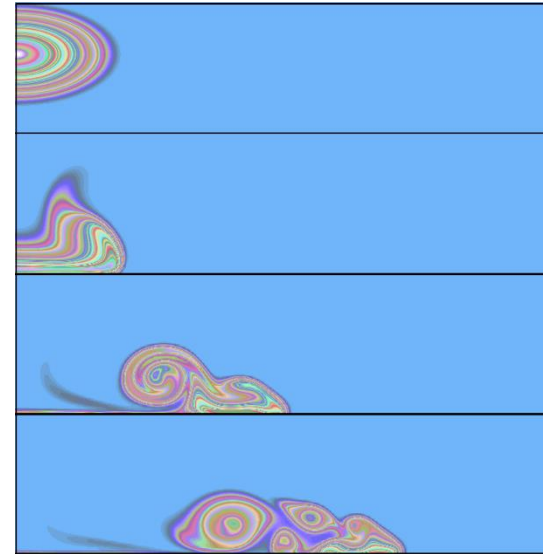
* REA (V and H) integració advecció cada 6-10 Nsteps

* Estabilització modes vertical-acústics (Esquema Implícit)

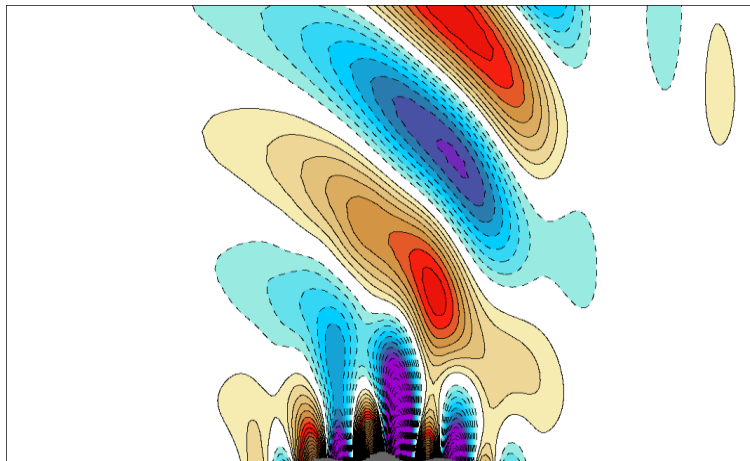
Bombolles Càlida-Gran & Freda-Petita



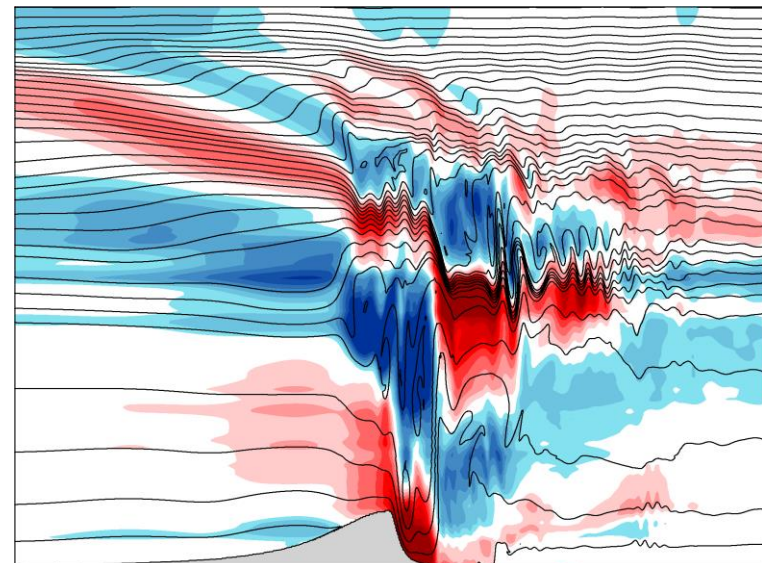
Corrent de
Densitat



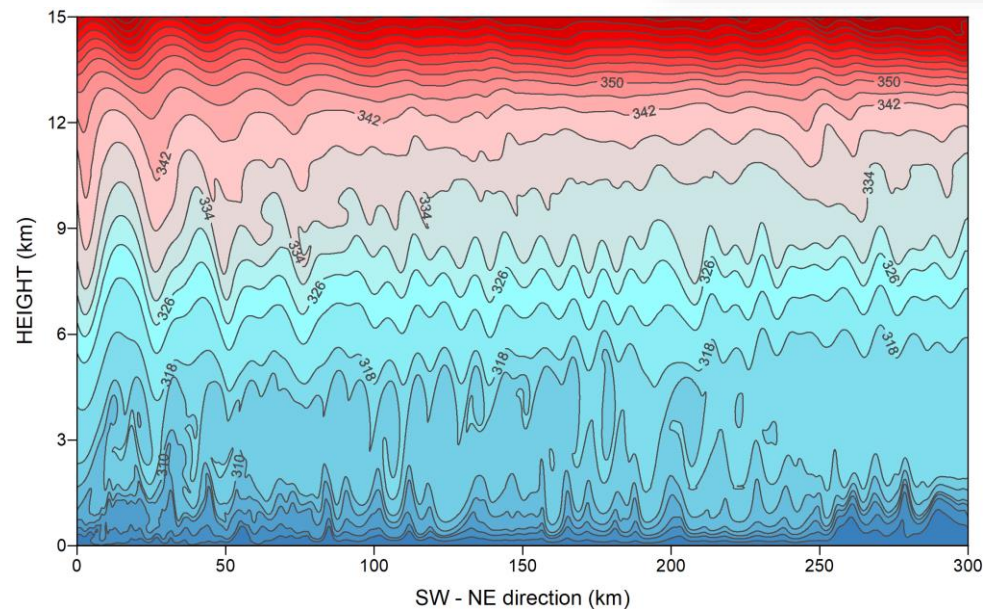
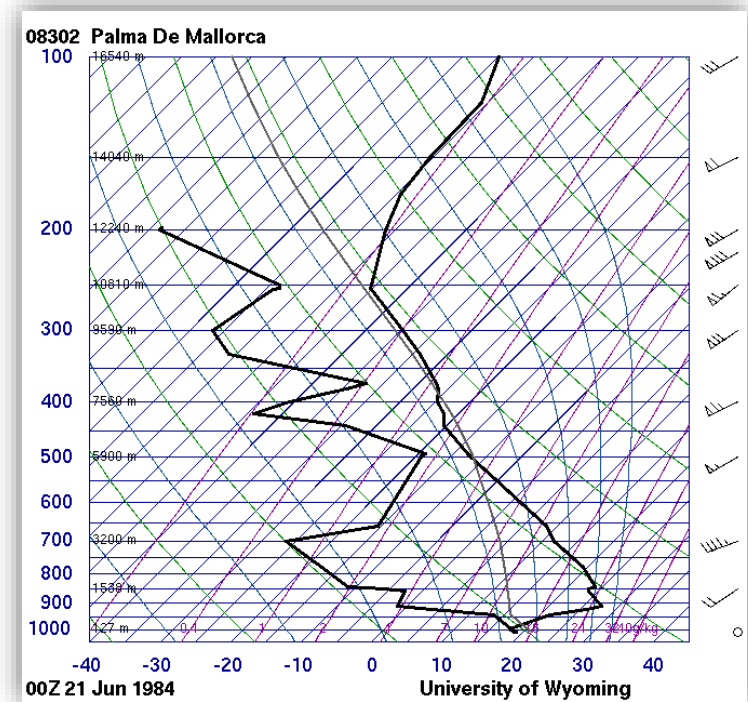
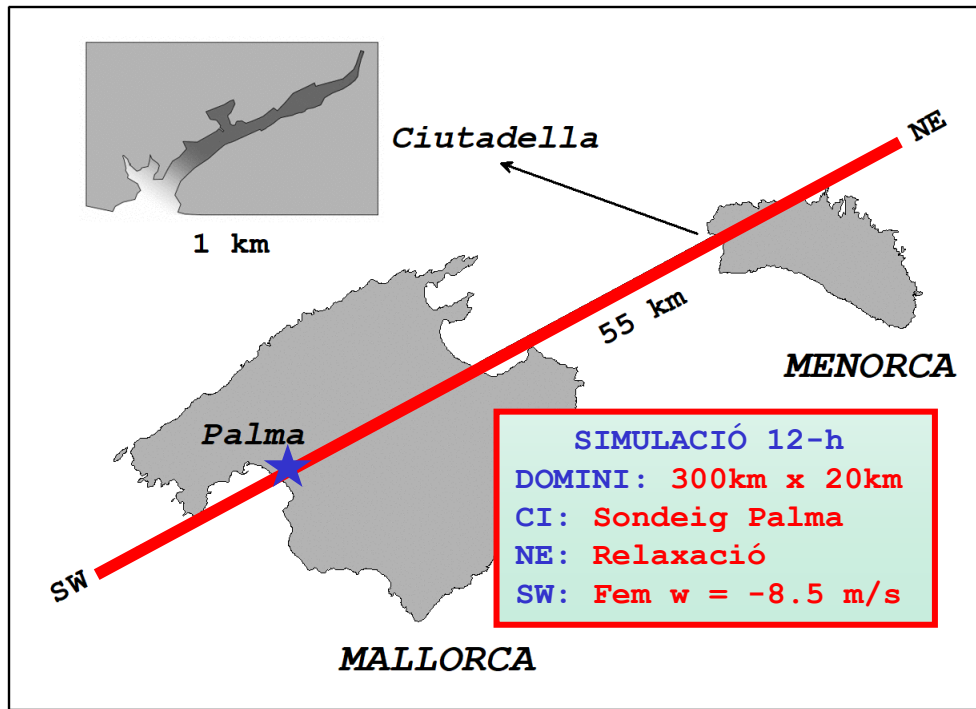
Ona-Muntanya SCHÄR



Ona-Muntanya Intensa T-REX



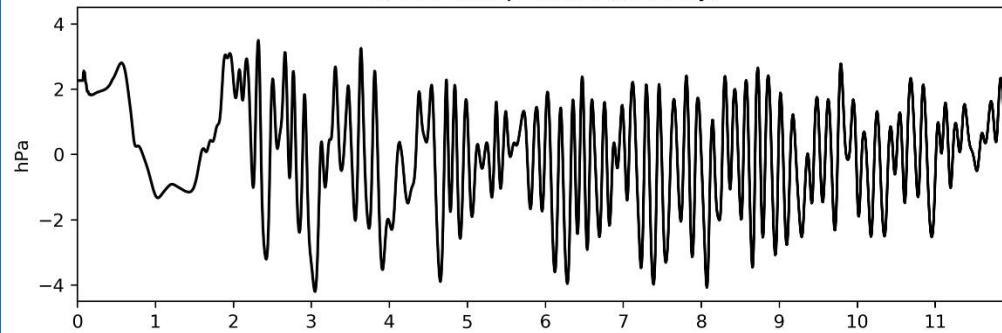
Generació & Propagació ONES GRAVITATÒRIES



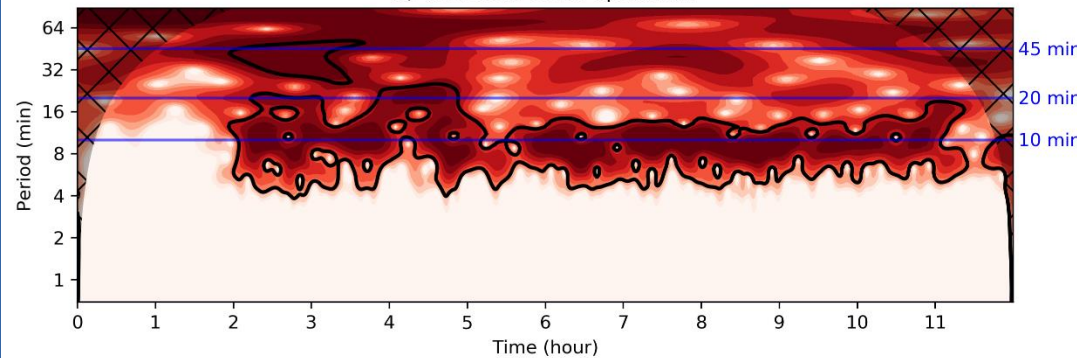
Amb ORIGINAL
(t=5h)

Generació & Propagació ONES GRAVITATÒRIES

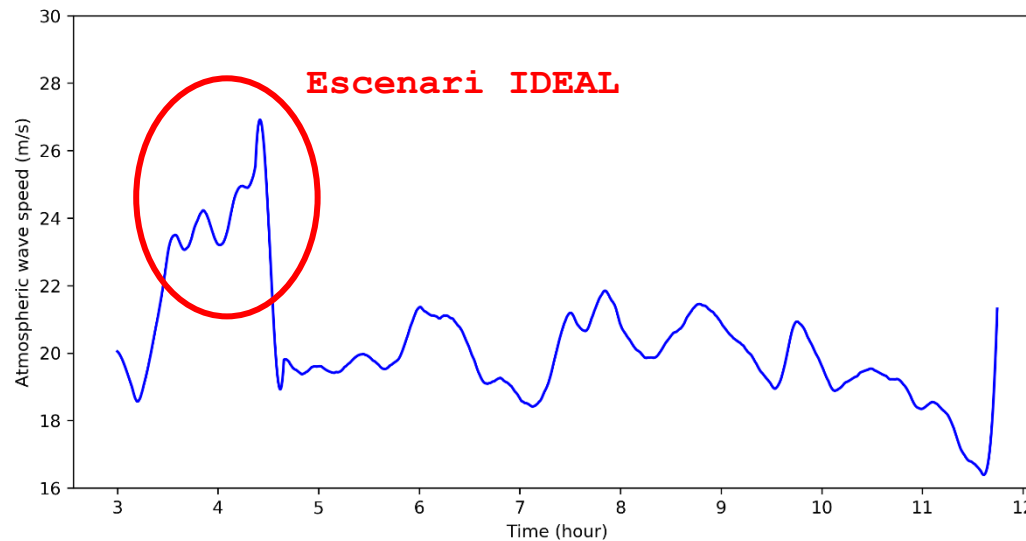
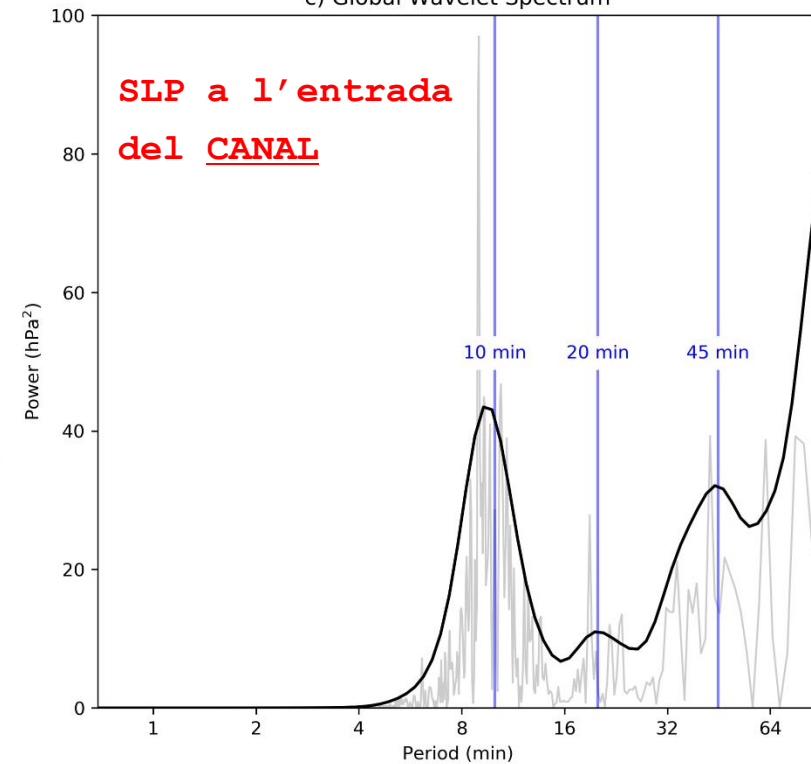
a) Sea level pressure (anomaly)



b) Wavelet Power Spectrum



c) Global Wavelet Spectrum



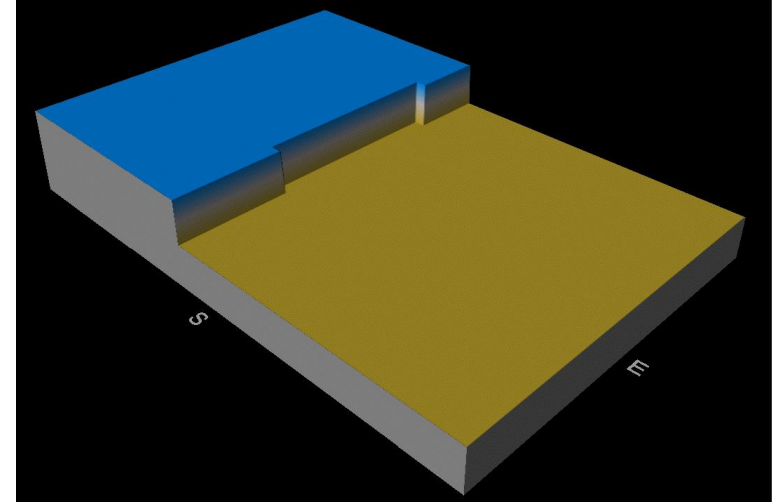
Velocitat ona-SLP
en el CANAL

Component OCEÀNICA (Canal MALLORCA-MENORCA)

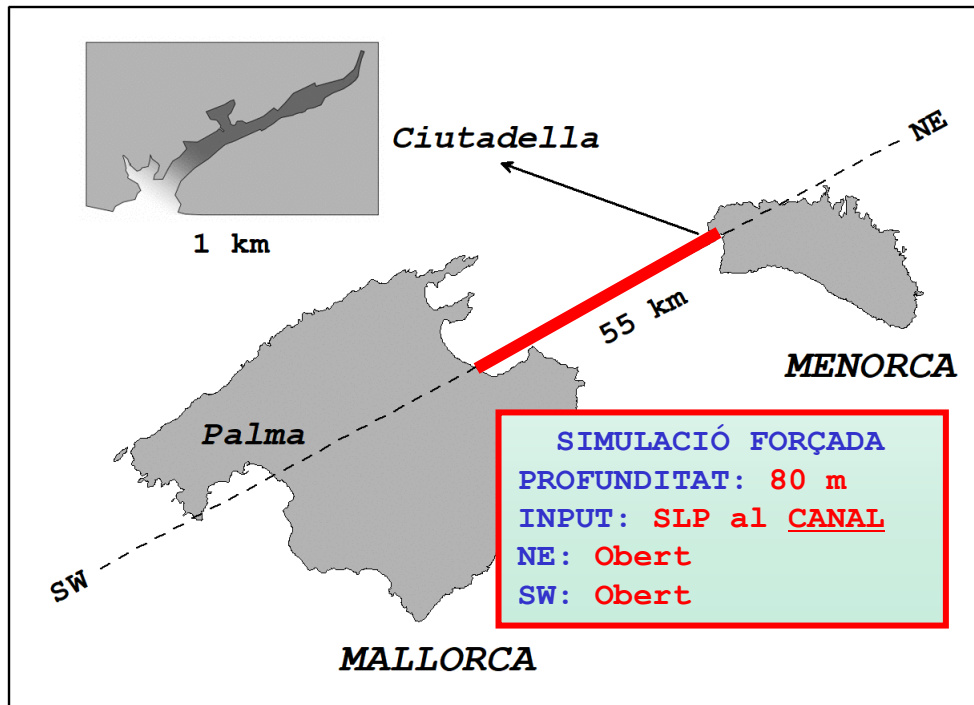
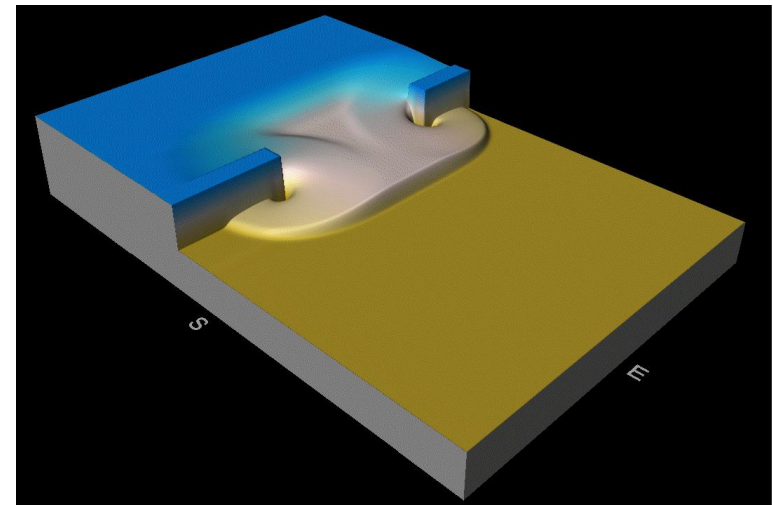
> Equacions "Shallow-Water"

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

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

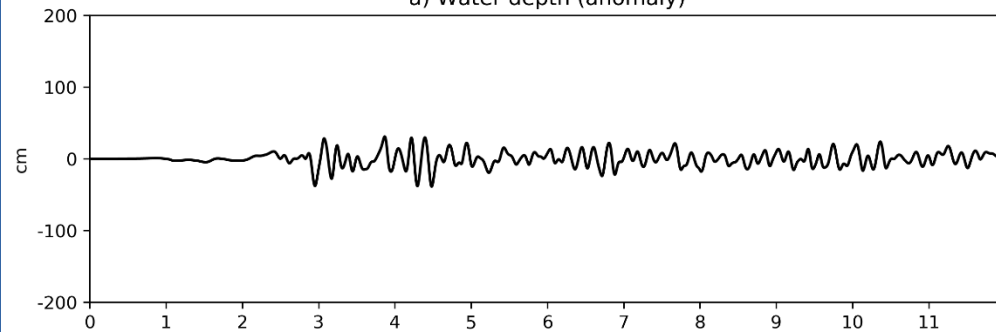


Trencament Parcial Presa 10-5 m

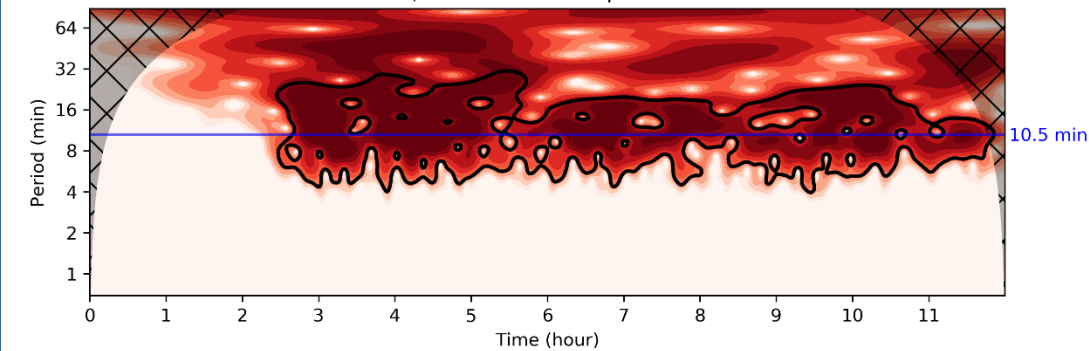


ONES OCEÀNIQUES (Ressonància de Proudman & Plataforma)

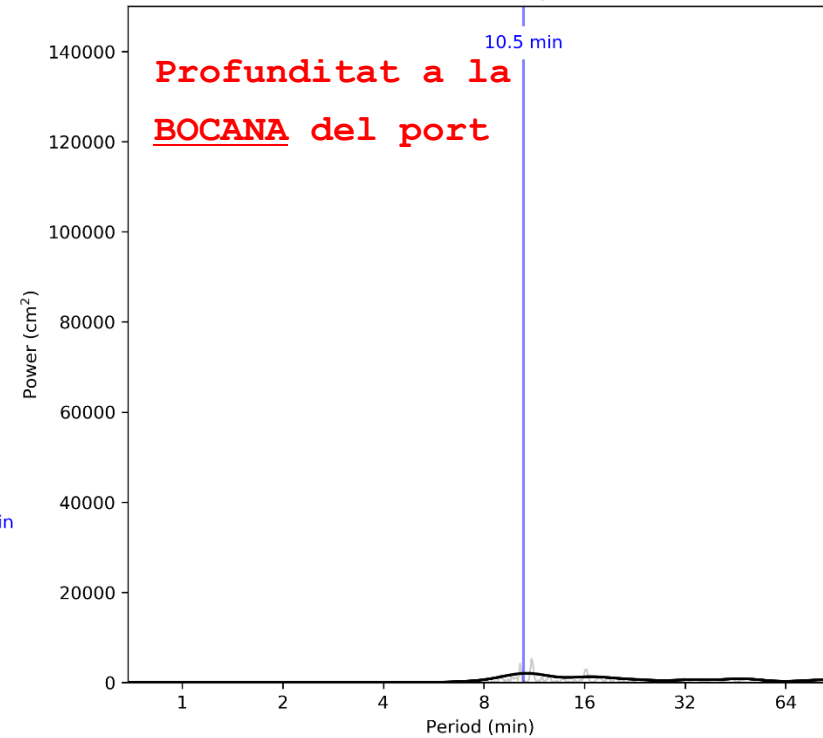
a) Water depth (anomaly)



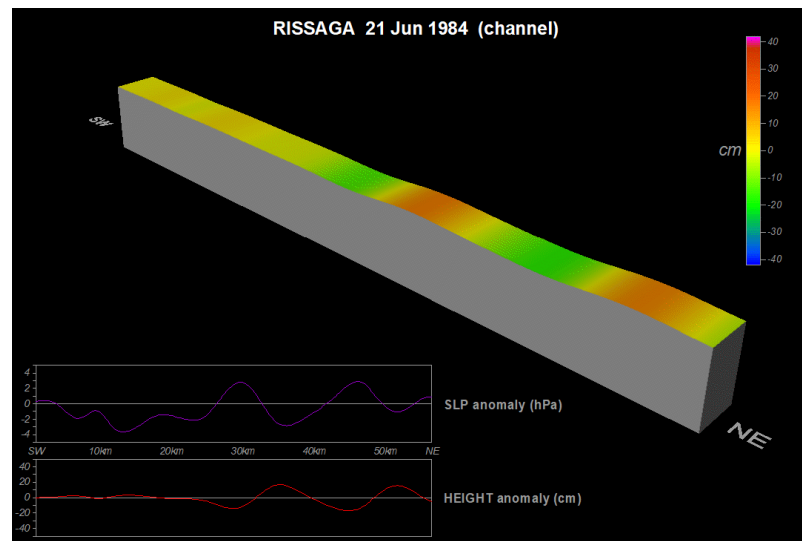
b) Wavelet Power Spectrum



c) Global Wavelet Spectrum



RISSAGA 21 Jun 1984 (channel)

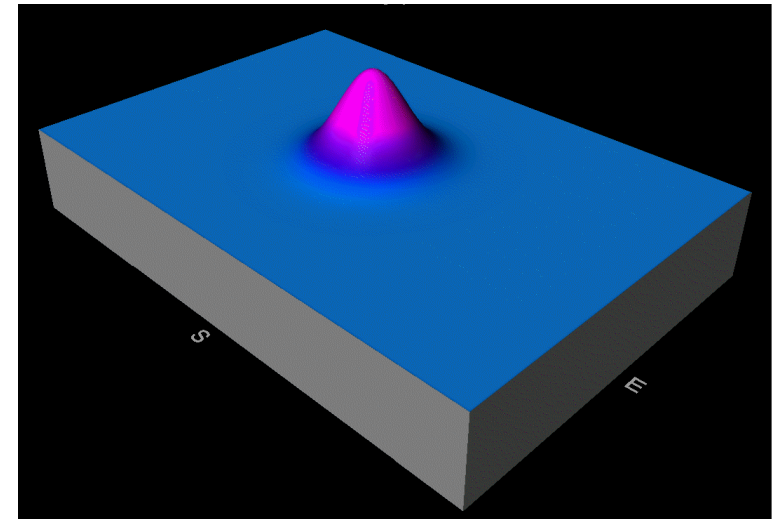


Component COSTANERA (Port de CIUTADELLA)

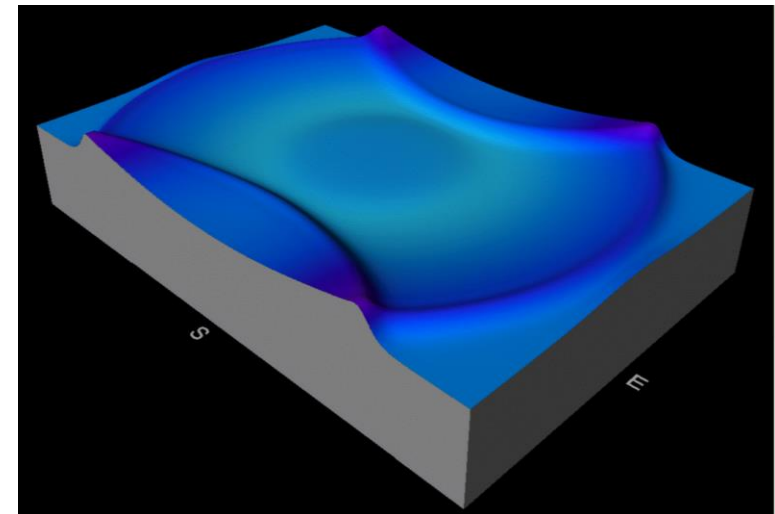
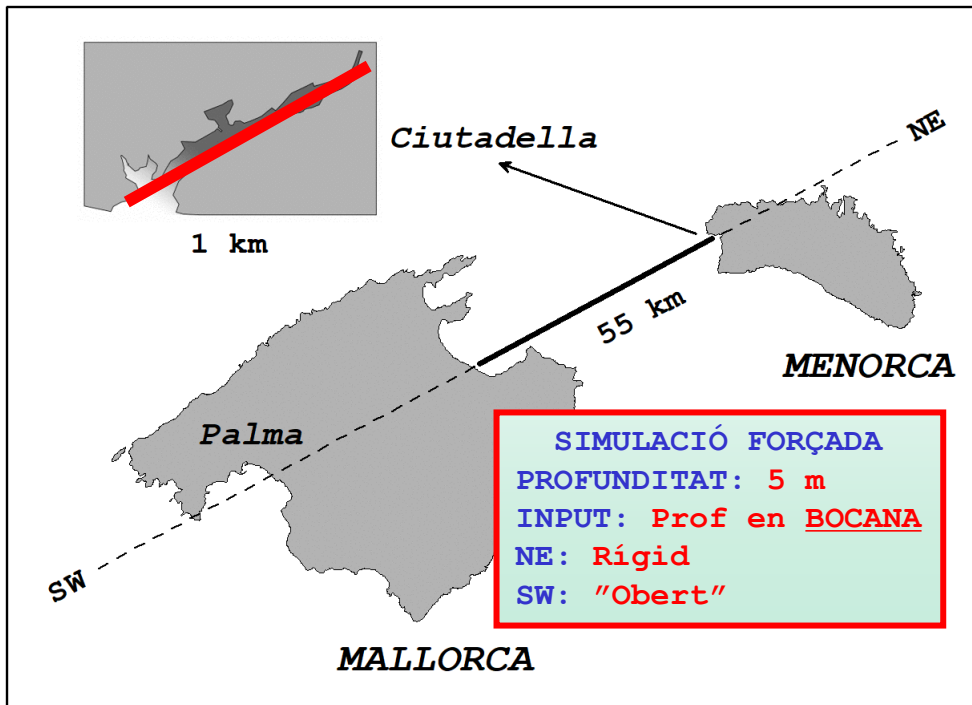
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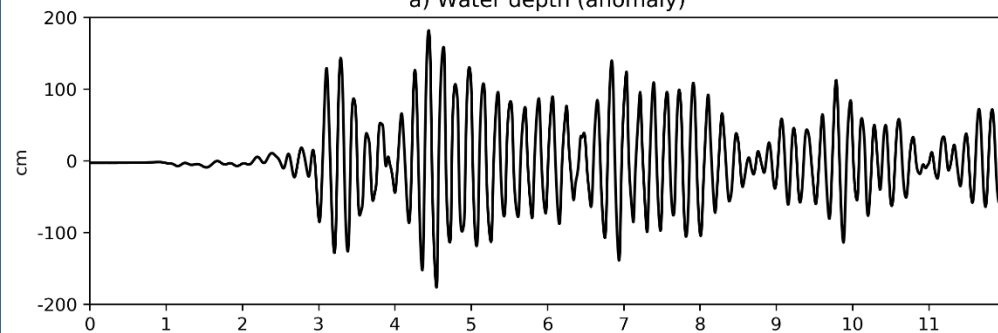


Protuberància Gaussiana en 10 m

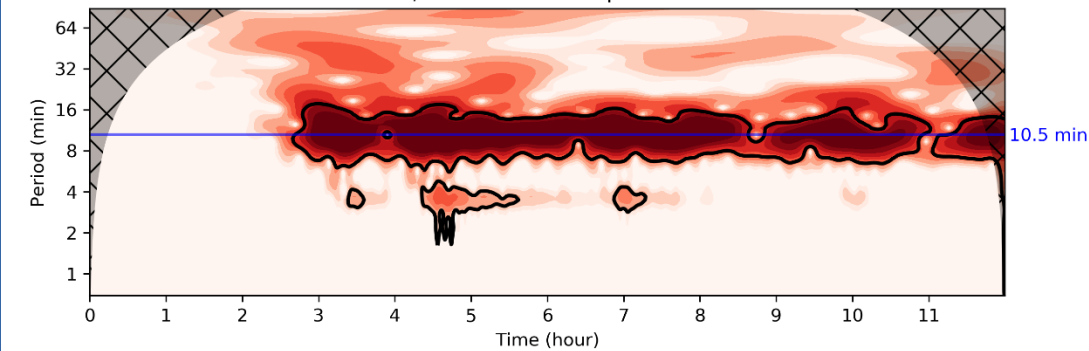


RISSAGA (Ressonància en el Port)

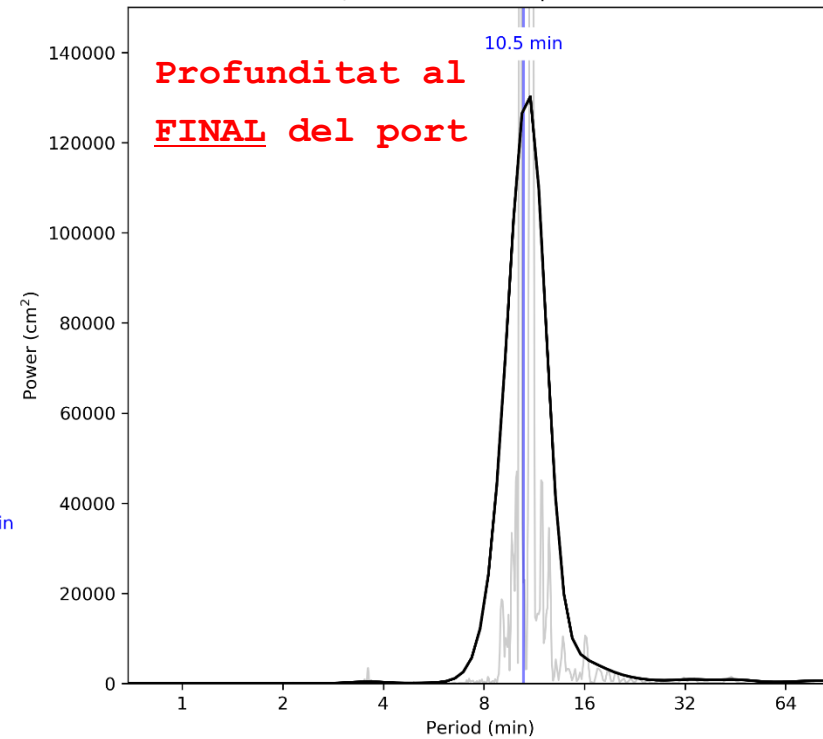
a) Water depth (anomaly)



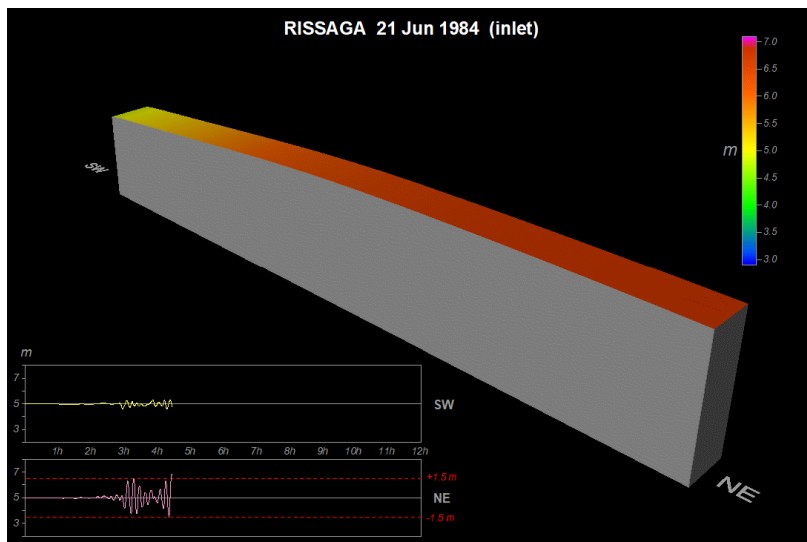
b) Wavelet Power Spectrum



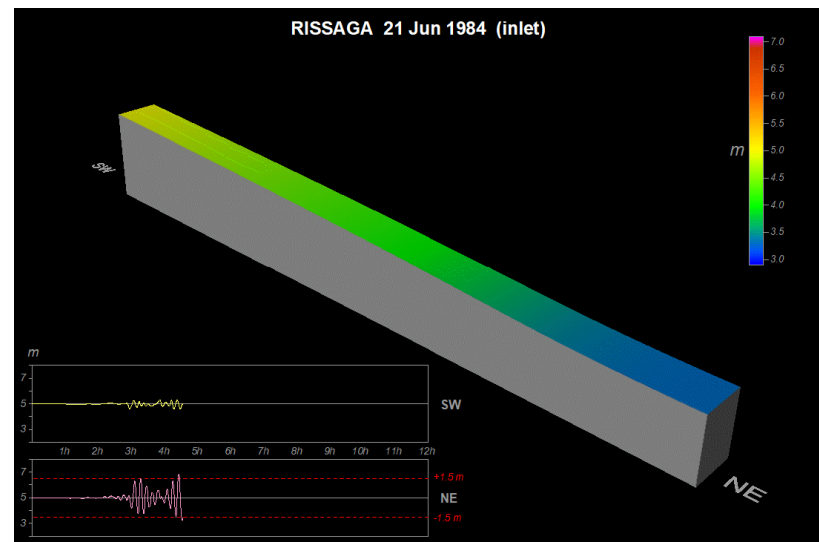
c) Global Wavelet Spectrum

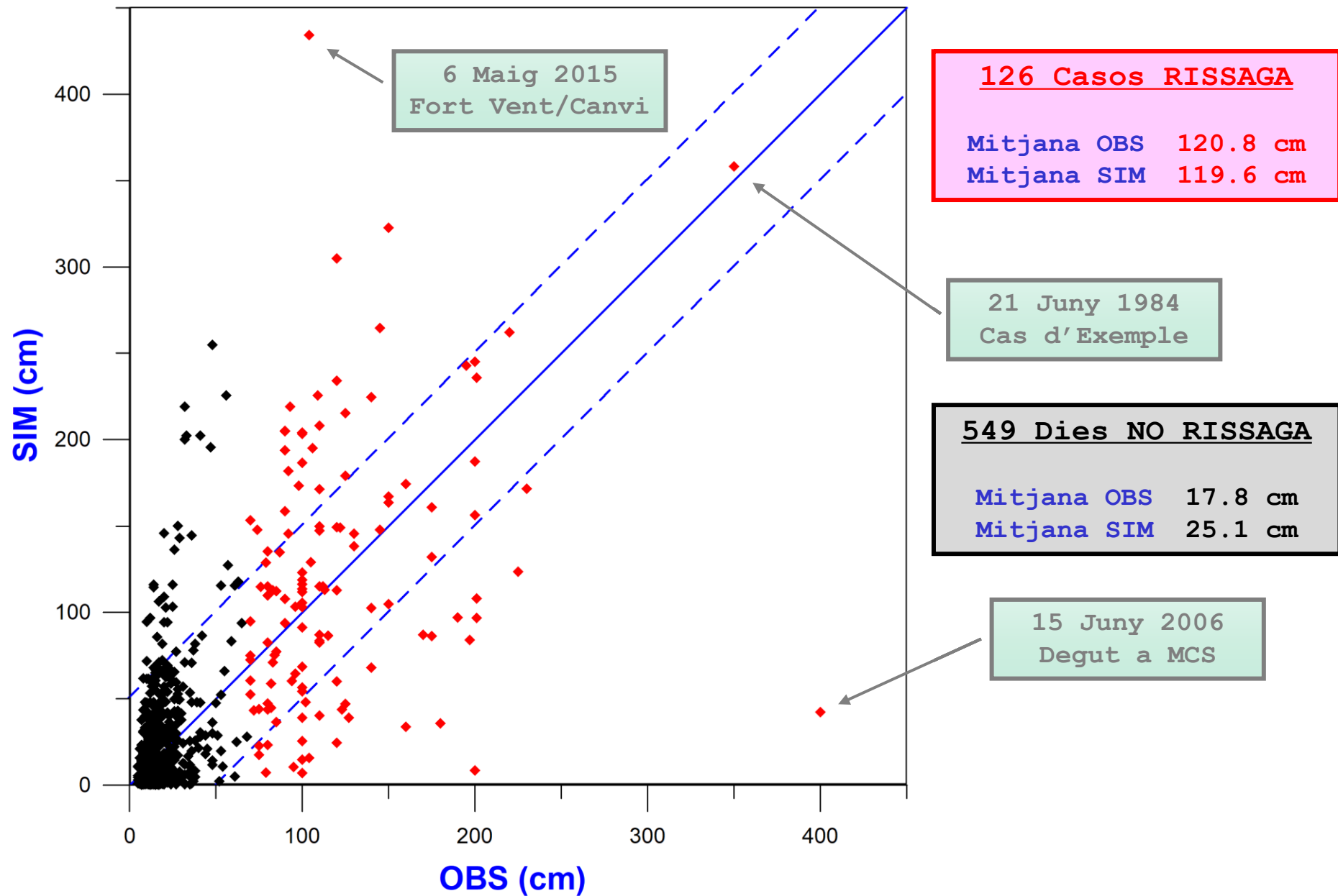


RISSAGA 21 Jun 1984 (inlet)



RISSAGA 21 Jun 1984 (inlet)





RISSAGA (CATEGORIES d'Interès Pràctic)

 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)
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P R E V I S T (%)



O
B
S
E
R
V
A
T



	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

Quina proporció dels casos
són (no són) prevists ???

O B S E R V A T (%)



P
R
E
V
I
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

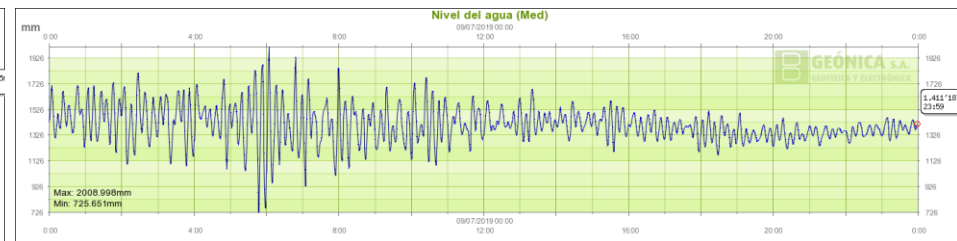
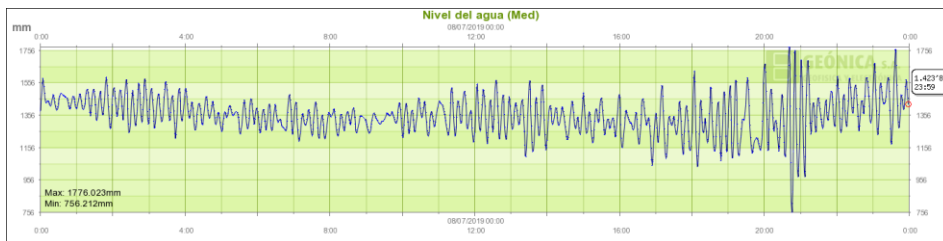
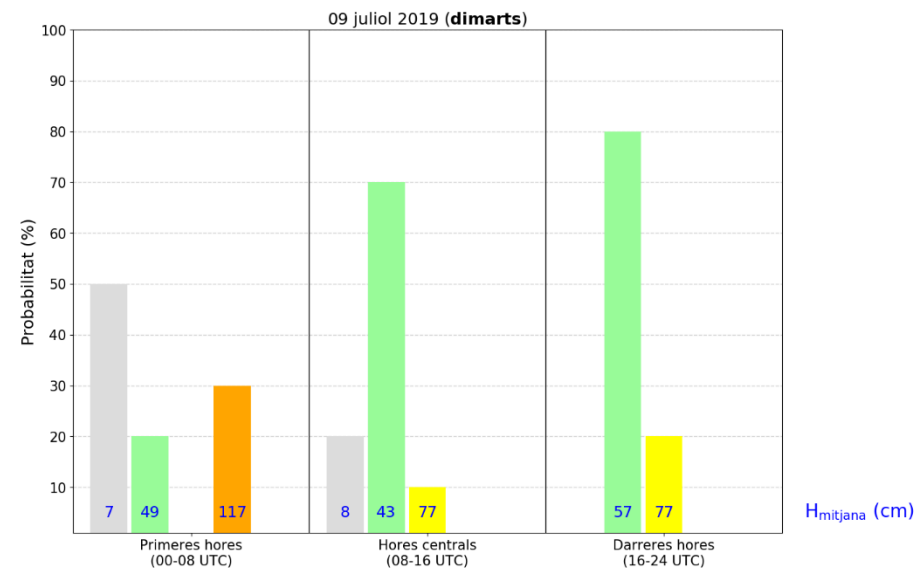
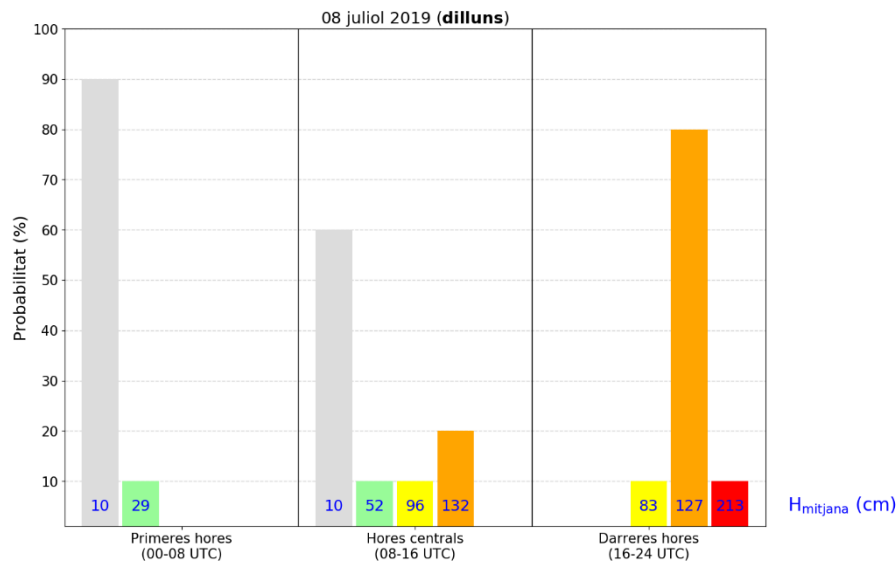
Quina proporció de les previsions
són (no són) correctes ???

Implementació OPERACIONAL (Probabilística)



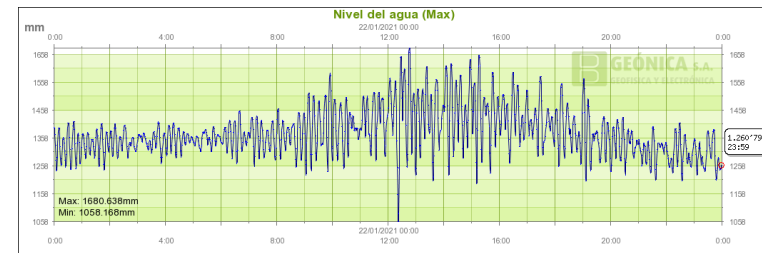
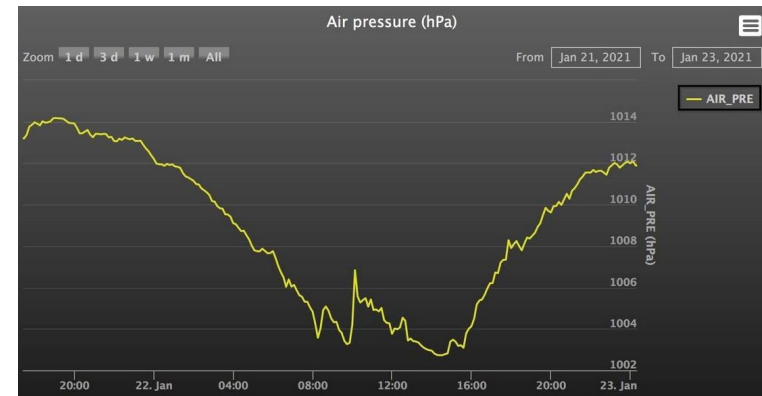
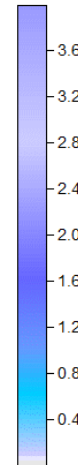
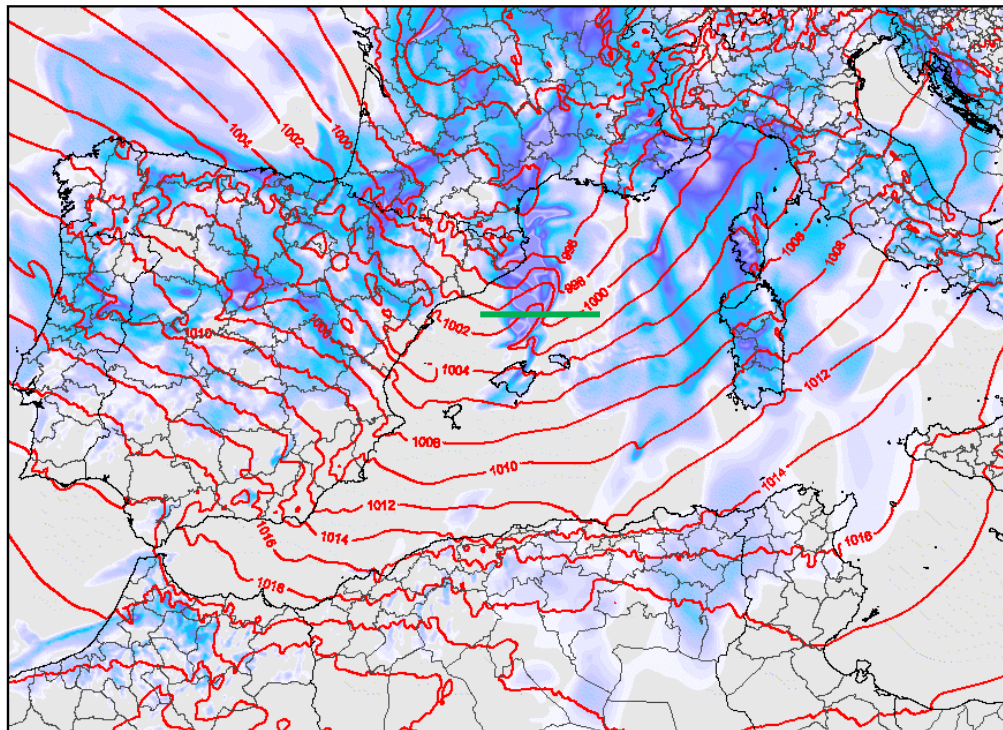
> <http://meteo.uib.es/rissaga>

Exemple

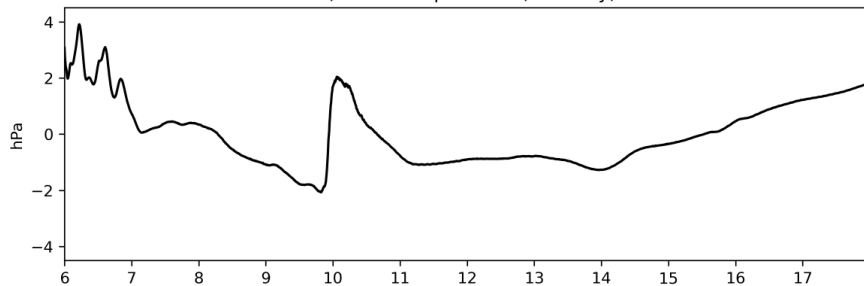


Implementació per a CASOS D'ESTUDI (via TRAM 3D)

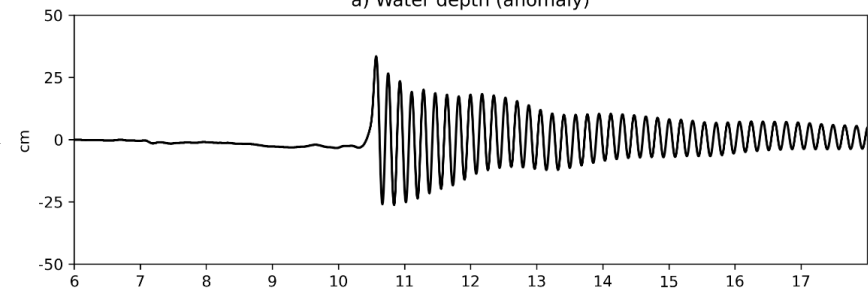
MSL PRESSURE (hPa) & CONDENSATE (kg/m³) Forecast: 04:30h / Valid: 10:30z Fri, 22 Jan 2021



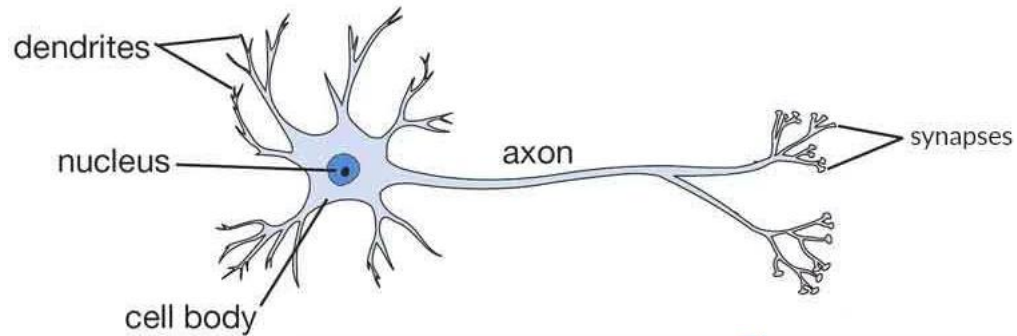
a) Sea level pressure (anomaly)



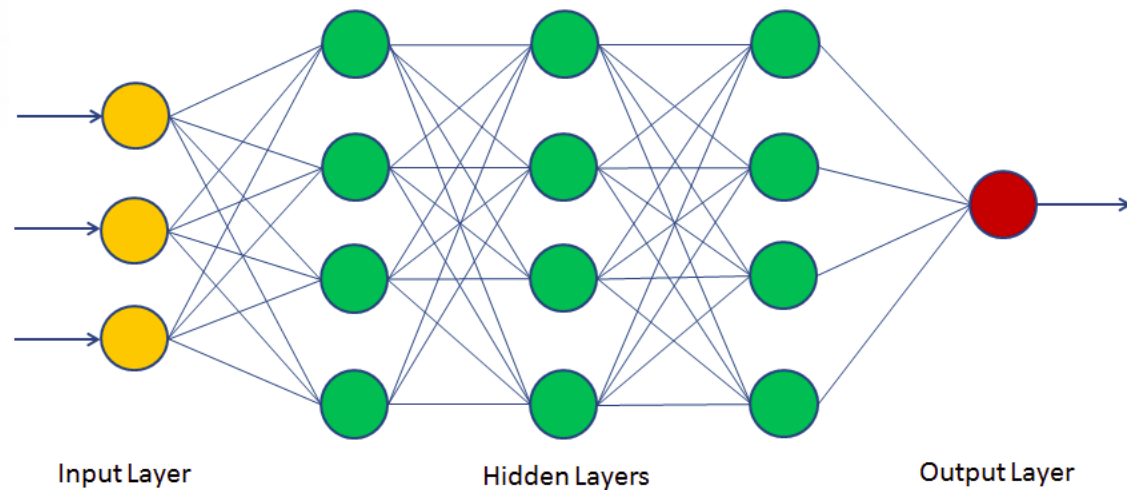
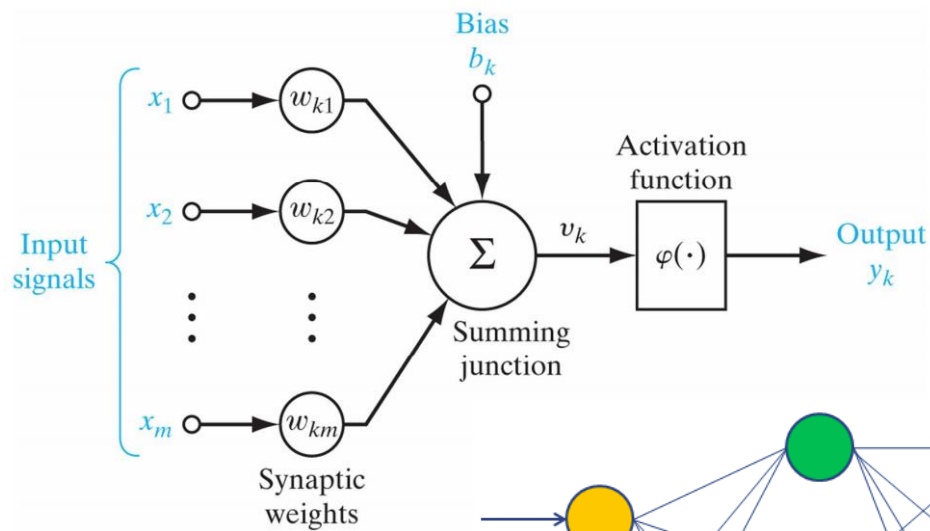
a) Water depth (anomaly)



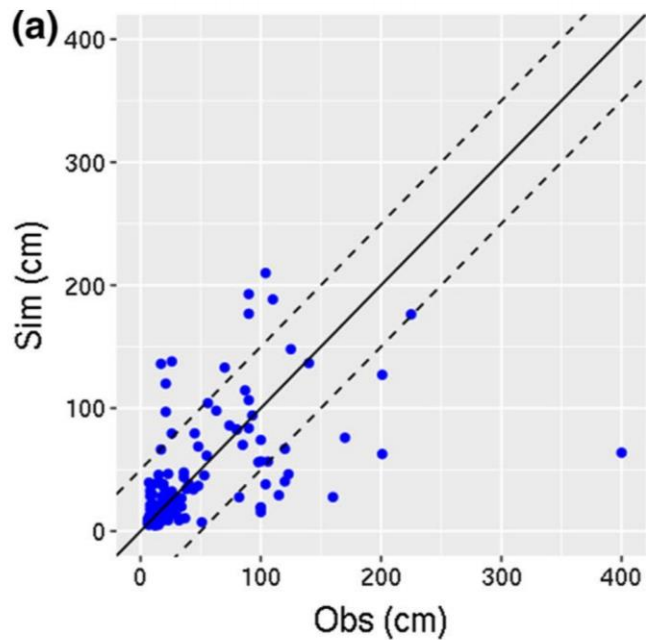
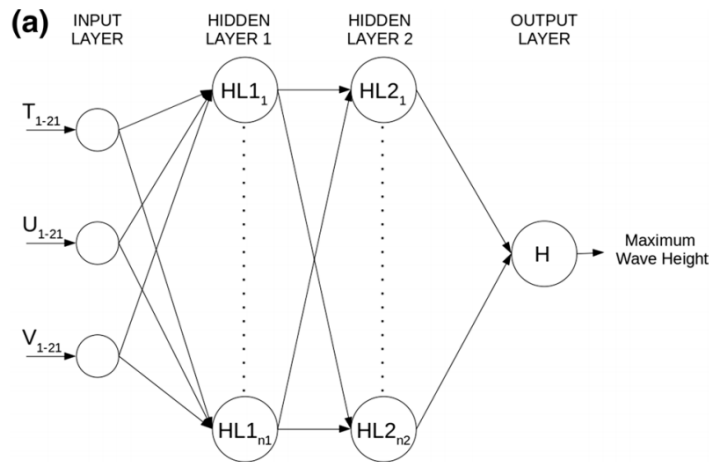
- 1) *METEOTSUNAMIS o RISSAGUES: Mecanismes Físics*
- 2) *Mètode "empíric" de predicció de l'AEMET*
- 3) *Mètode SOCIB/BRIFS de modelització intensiva*
- 4) *Mètode UIB de modelització FÍSICA simplificada*
- 5) *Mètode **UIB** a partir d'una **XARXA NEURONAL***



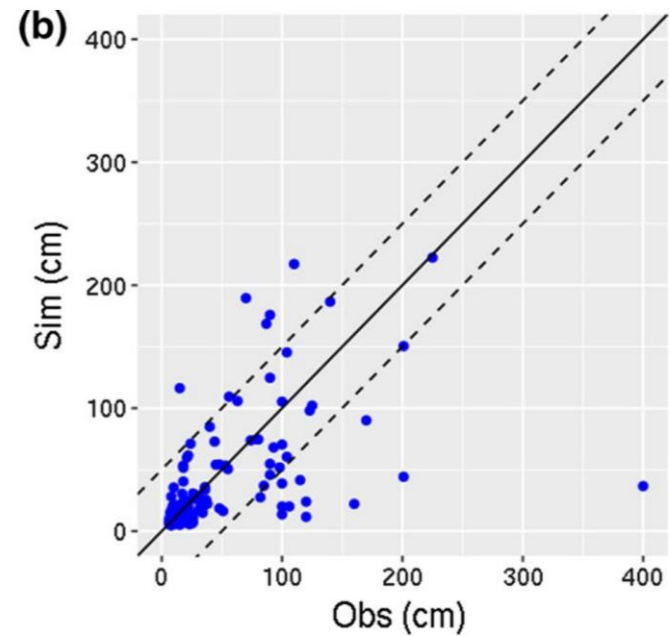
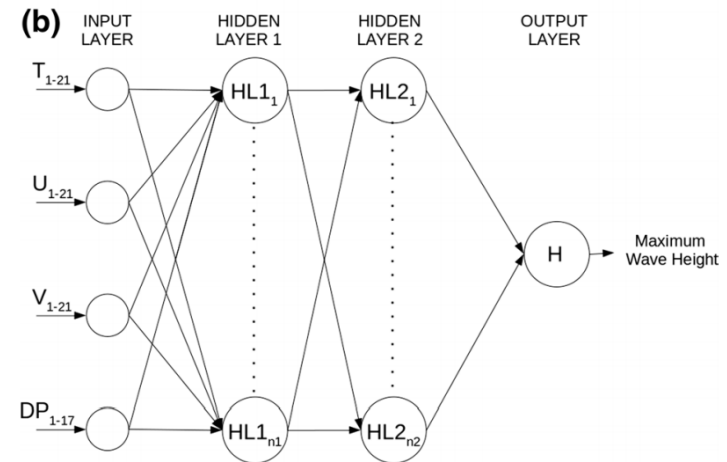
Principi de FUNCIONAMENT



Esquema SEC



Esquema HUMIT



 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)
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> XARXA NEURONAL (Esquema SEC)

<http://mm5forecasts.uib.es/nn/nnndry>

> XARXA NEURONAL (Esquema HUMIT)

<http://mm5forecasts.uib.es/nn/nnwet>

MOLTES GRÀCIES
per
la vostra atenció