

Balearic Rissaga Forecasting System: recent progress and study of meteotsunami propagation under synthetic gravity wave forcing

Baptiste Mourre, SOCIB

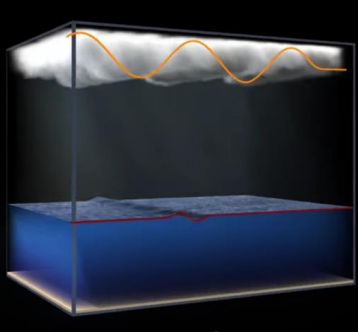
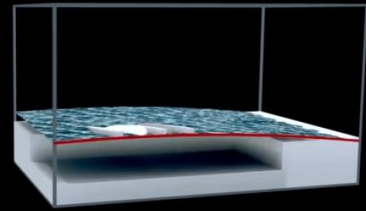
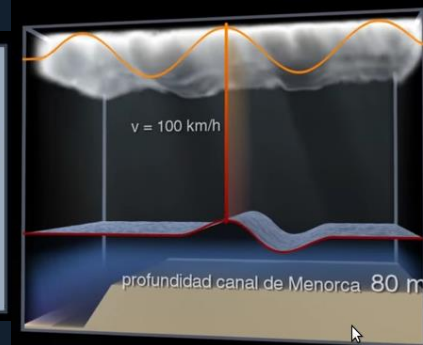
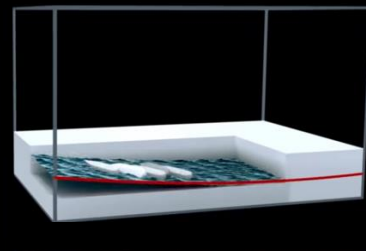
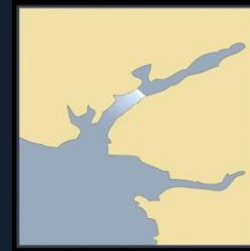
**Matjaž Ličer, Charles Troupin, Andreas
Krietemeyer, Agustí Jansa and Joaquín Tintoré**

MonGOOS modelling workshop, Split, 15 Nov 2016

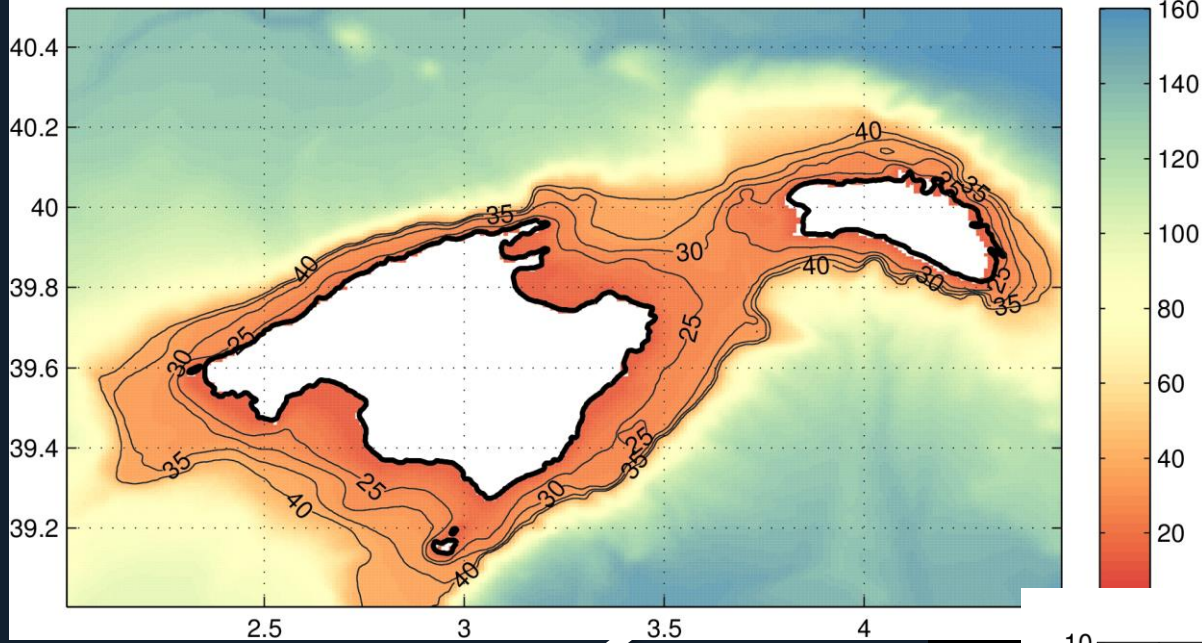
Introduction to the *Rissaga* phenomenon

Rissaga: meteotsunami leading to large (up to 4m) and high-frequency (~ 10 min) sea level oscillations in Ciutadella harbour

Resonant amplification mechanisms over the shelf and in Ciutadella inlet

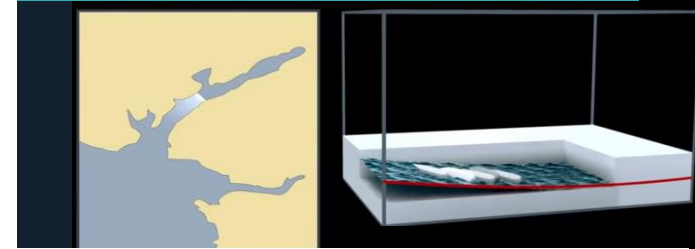


Shallow water wave velocity [m/s]: $c = \sqrt{gH}$

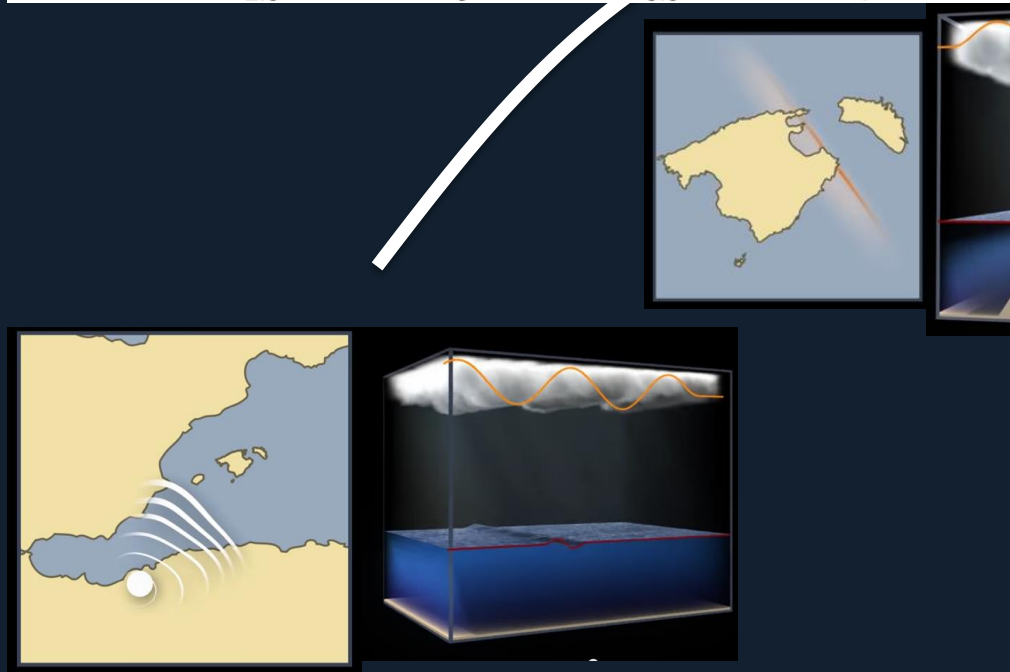
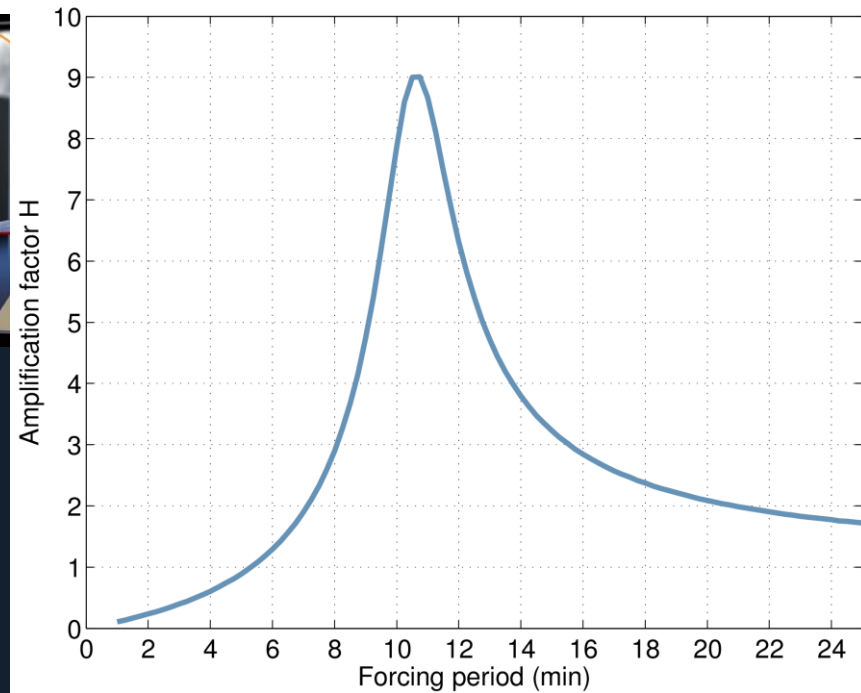


phenomenon

(up to 4m) and high-
s in Ciutadella harbour



Ciutadella harbour resonance

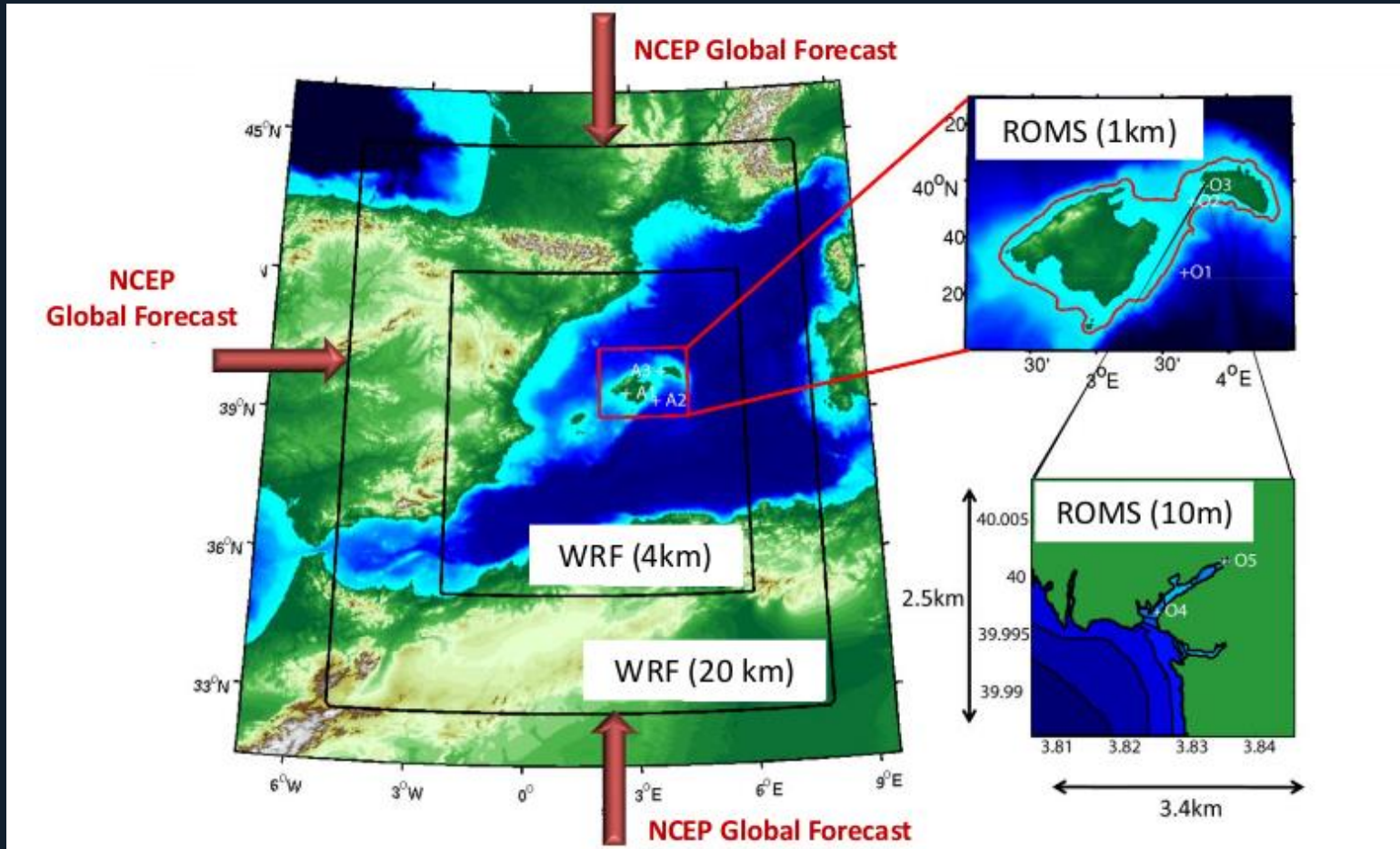


Outline

- 1 BRIFS - *Balearic Rissaga Forecasting System*
- 2 Meteotsunami propagation under synthetic atmospheric gravity wave forcing
- 3 BRIFS evaluation for past *rissagas*

BRIFS - *Balearic Islands* Forecasting System

Ocean-atmosphere modelling prediction system

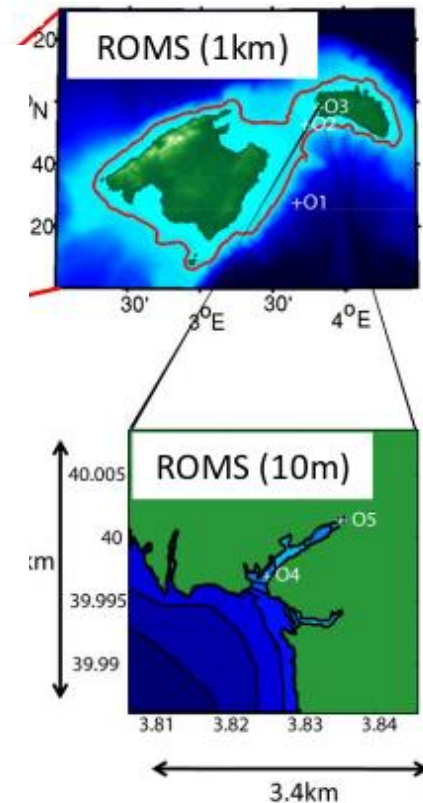
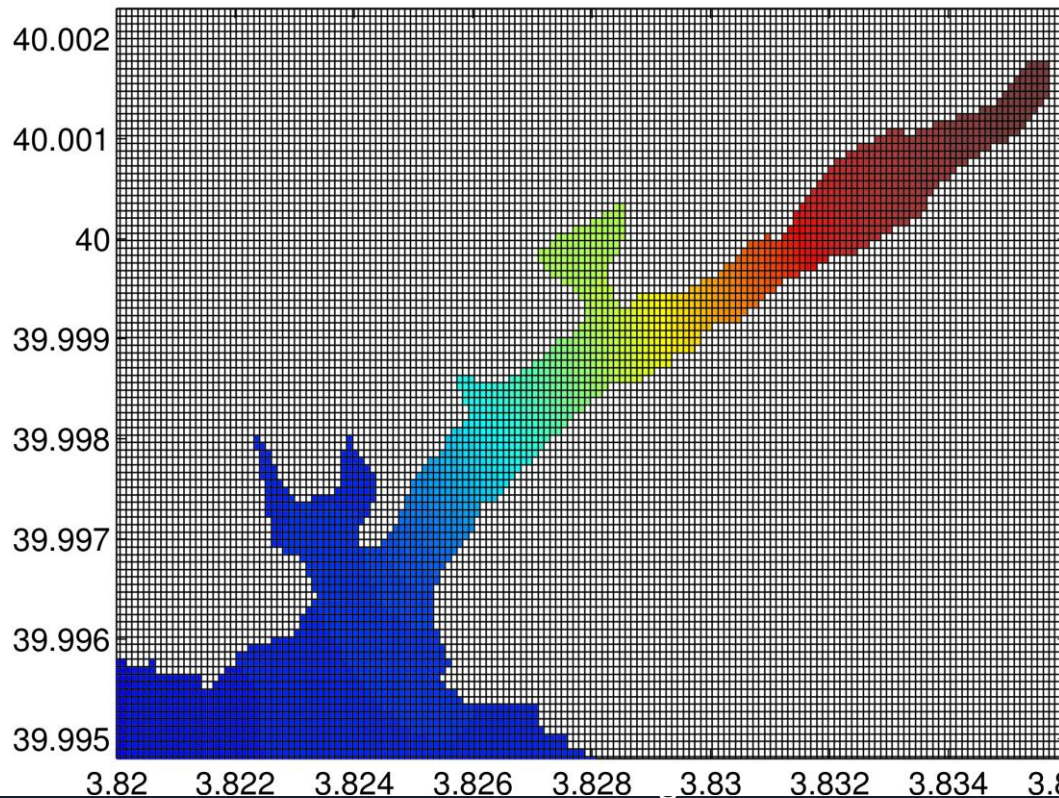
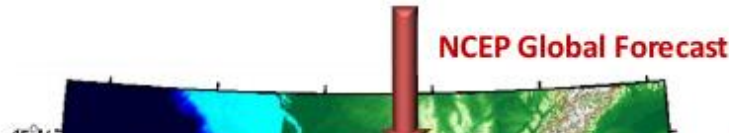


WRF: Weather Research and Forecasting Model
NCEP: National Centers for Environmental Prediction

ROMS: Regional Ocean Modeling System

BRIFS - *Balearic Rlssaga Forecasting System*

Ocean-atmosphere modelling prediction system

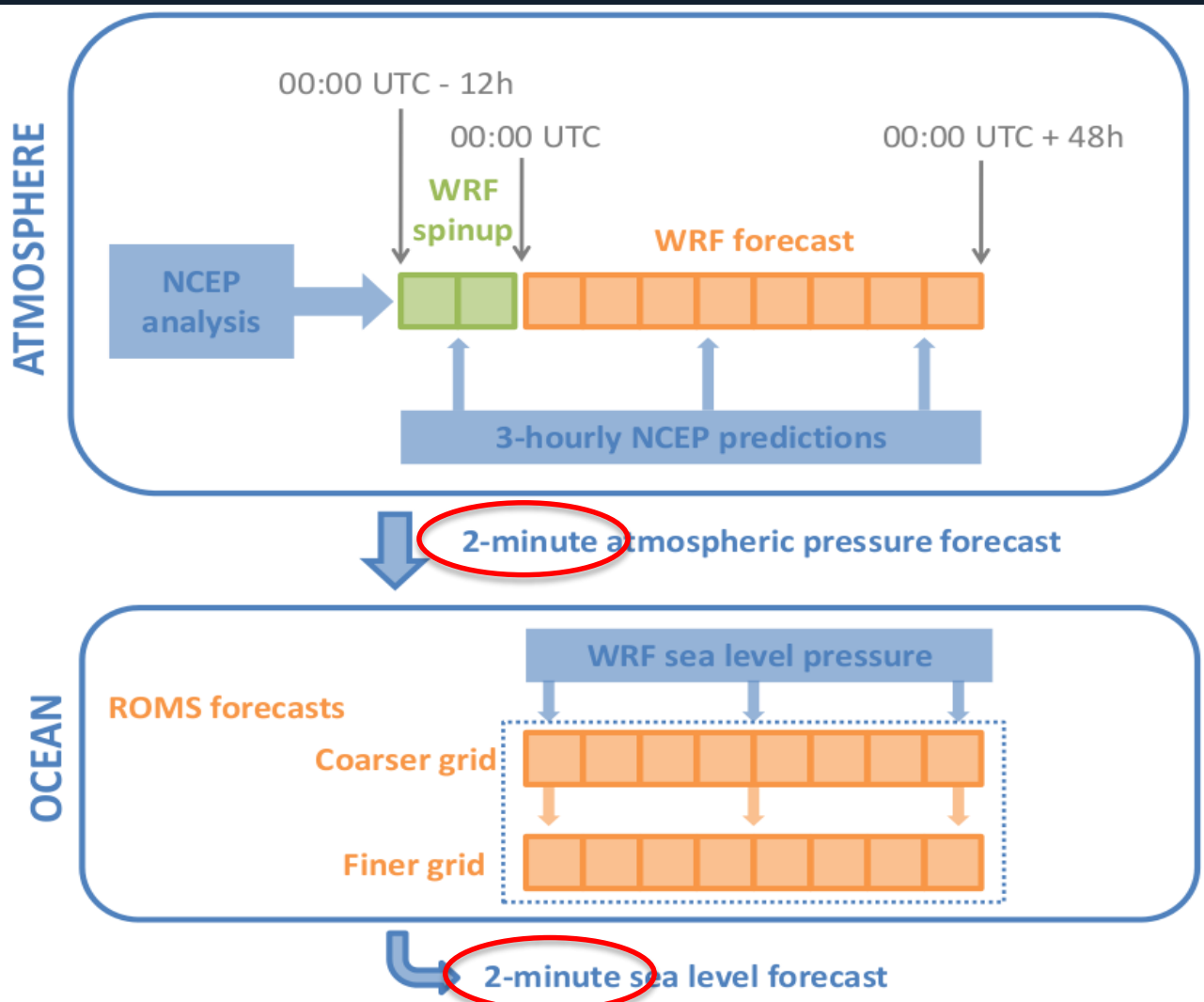


Regional Ocean Modeling System

NCEP: National Centers for Environmental Prediction

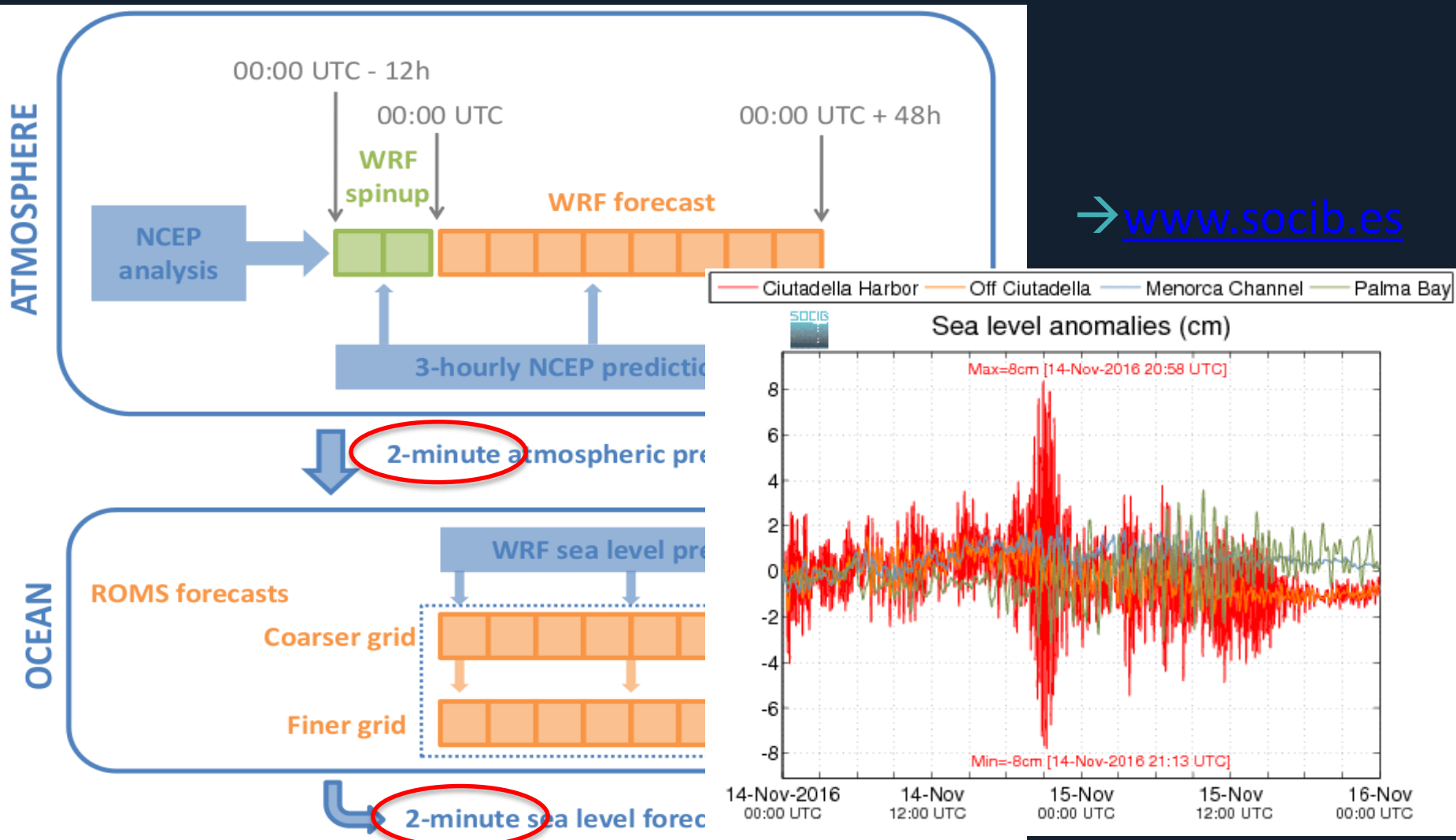
BRIFS - *Balearic Rlssaga Forecasting System*

Daily forecast production



BRIFS - Balearic Islands Forecasting System

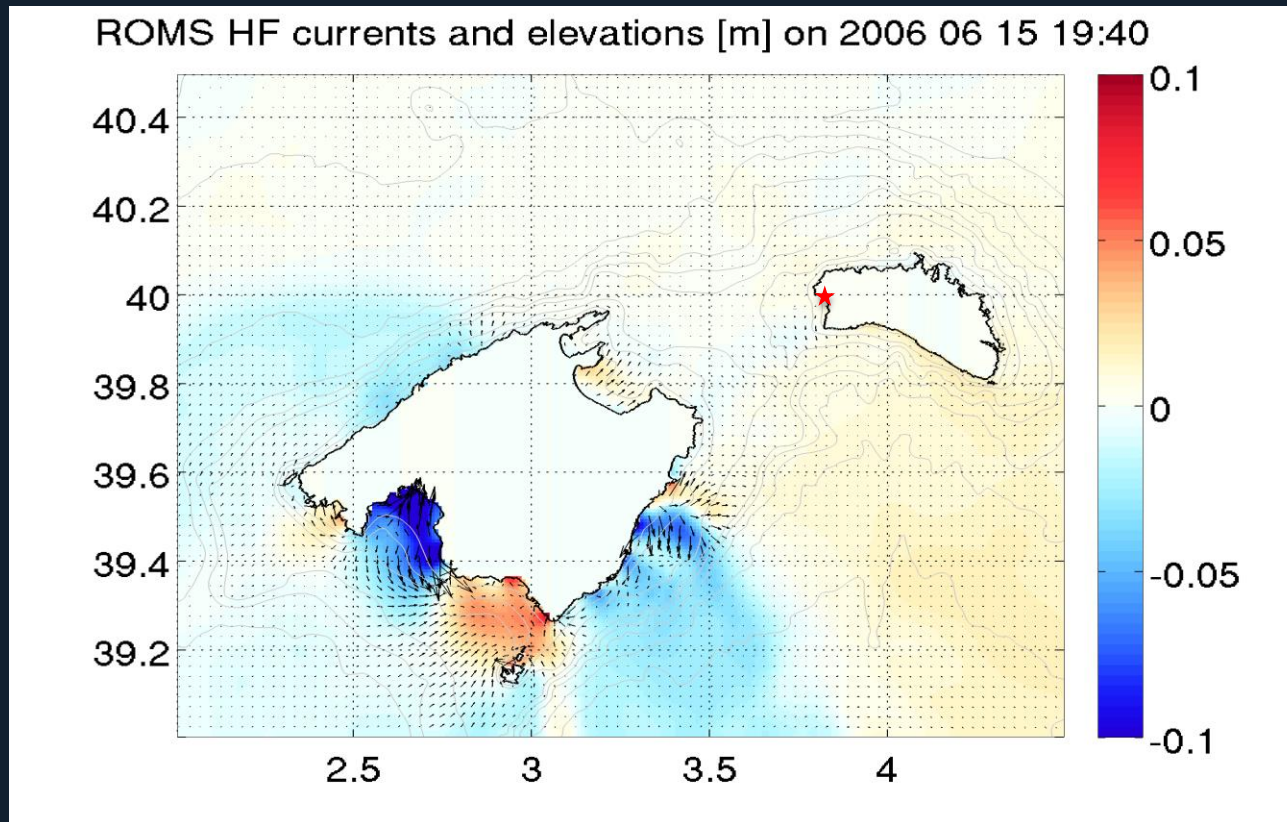
Daily forecast production



Outline

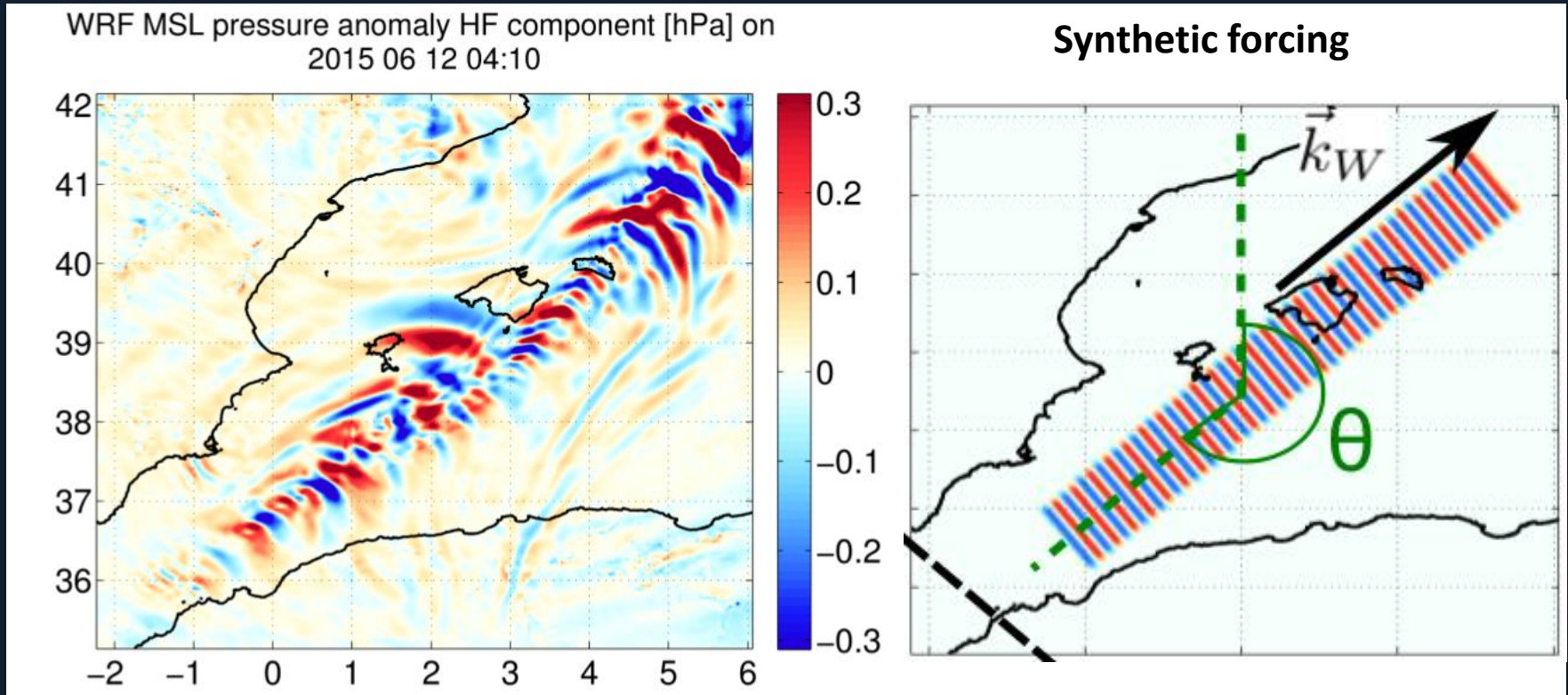
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- 3 BRIFS results for past rissagas

Synthetic gravity wave forcing



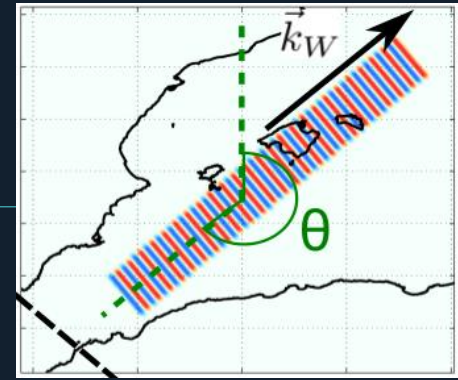
Generation, propagation, amplification according to atmospheric wave speed, direction and extension ?

Synthetic gravity wave forcing

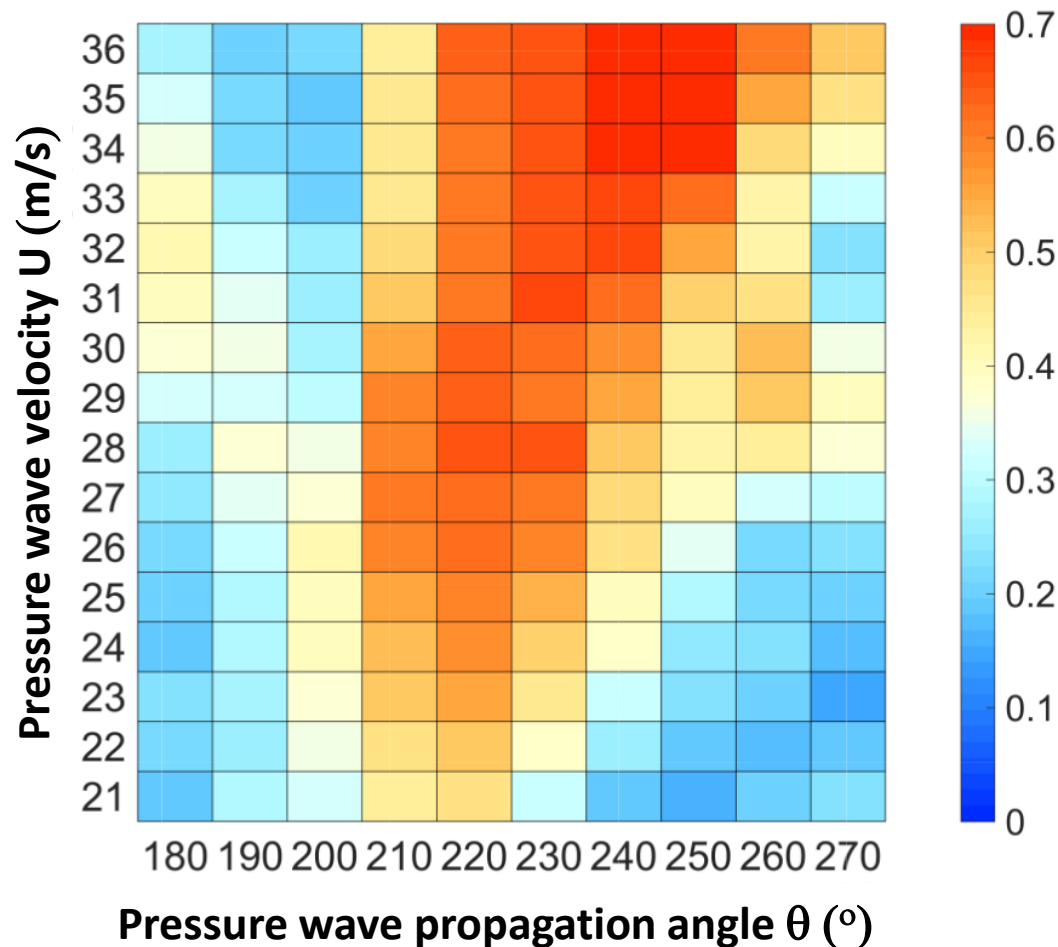


- ✓ 3hPa pressure wave amplitude with a 17-minute period (~0.7hPa change in 1 minute)
- ✓ Varying direction and propagation speed

Synthetic gravity wave forcing



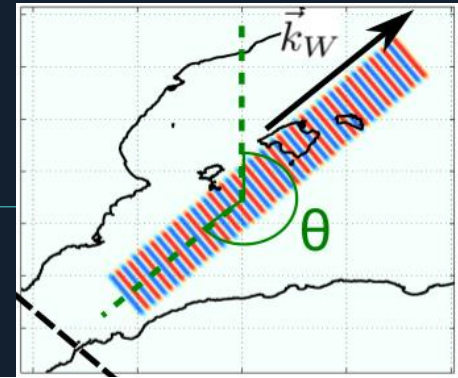
Maximum SSH Off Ciutadella (m)



→ SSH maxima larger than 0.5m occur with wave direction between 210° and 260° and with a large range of wave velocities

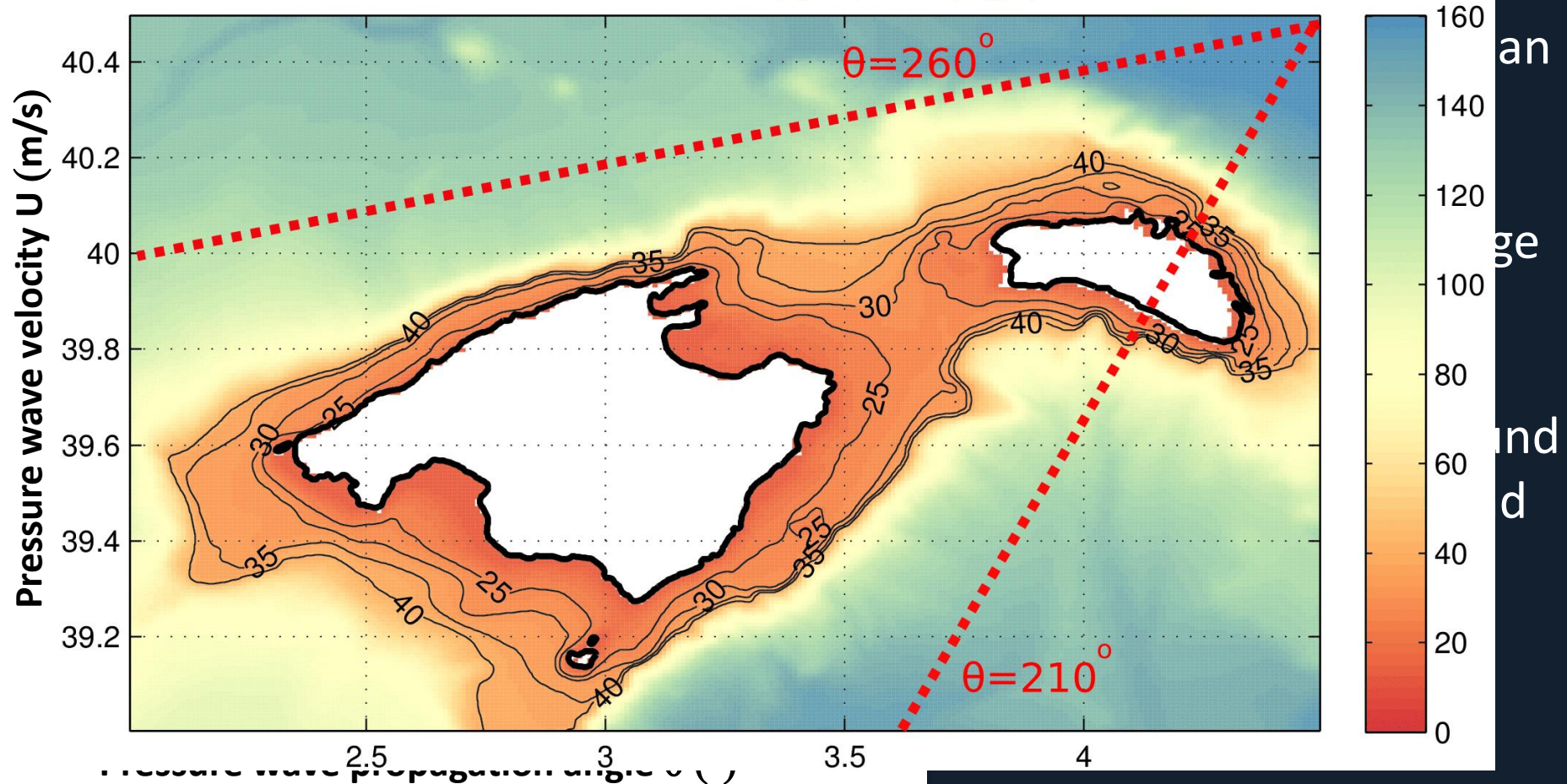
→ Relative maxima around $\theta=230^\circ$ and $U=28\text{m/s}$ and $\theta=250^\circ$ and $U=35\text{m/s}$

Synthetic gravity wave forcing

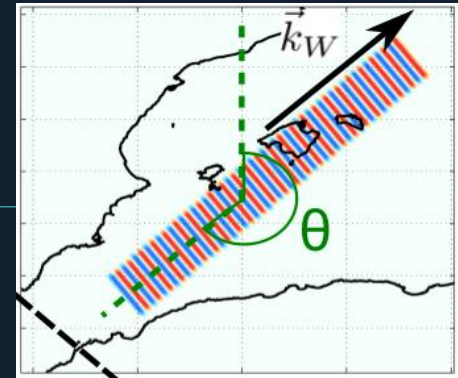


Maximum SSH Off Ciutadella (m)

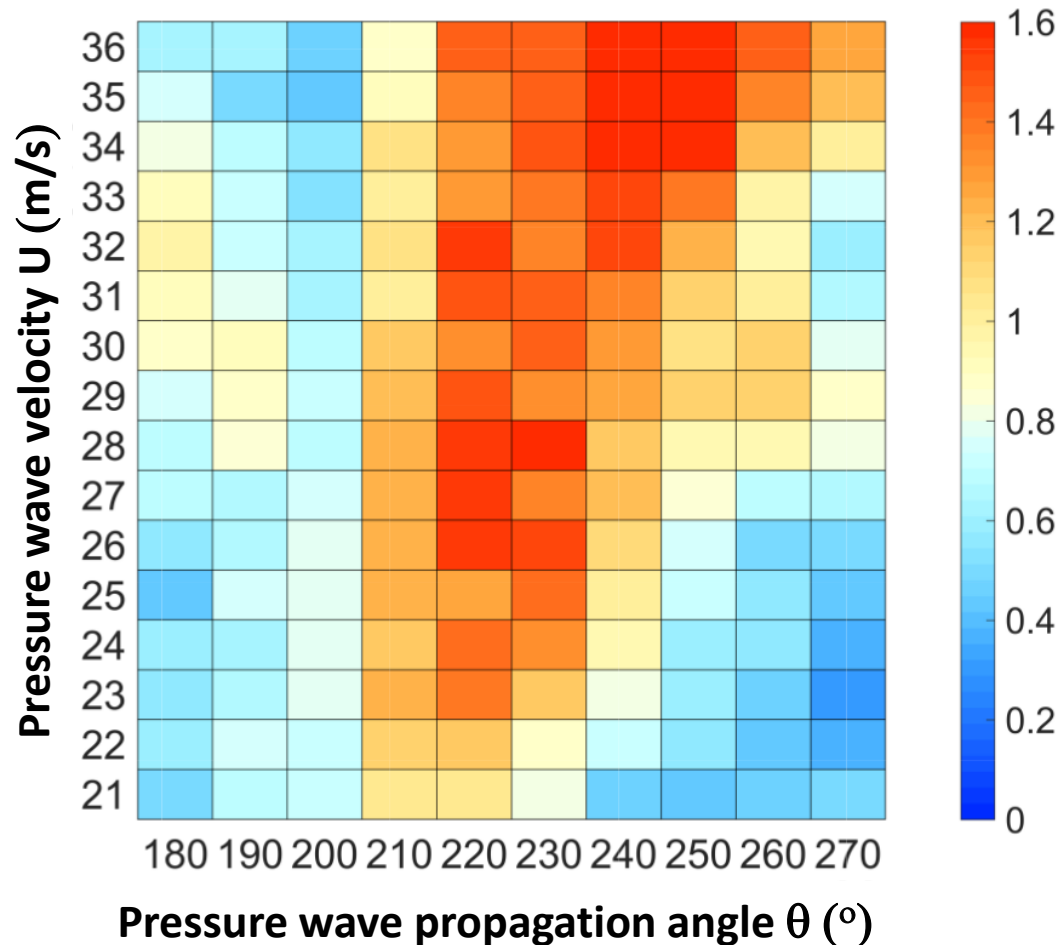
Shallow water wave velocity [m/s]: $c = \sqrt{gH}$



Synthetic gravity wave forcing

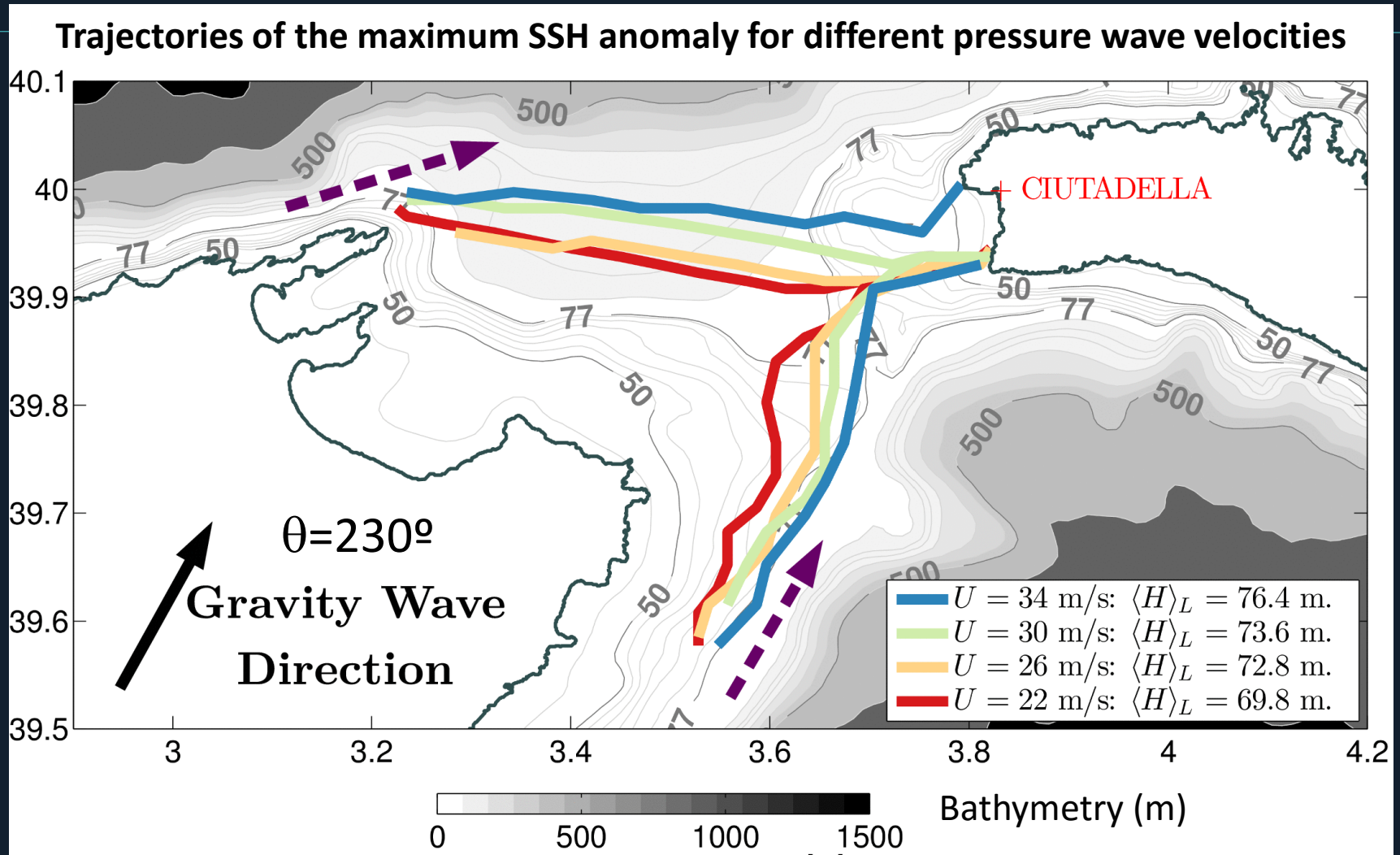


Maximum SSH at Ciutadella (m)



→ Additional modulation due to Ciutadella harbour resonance

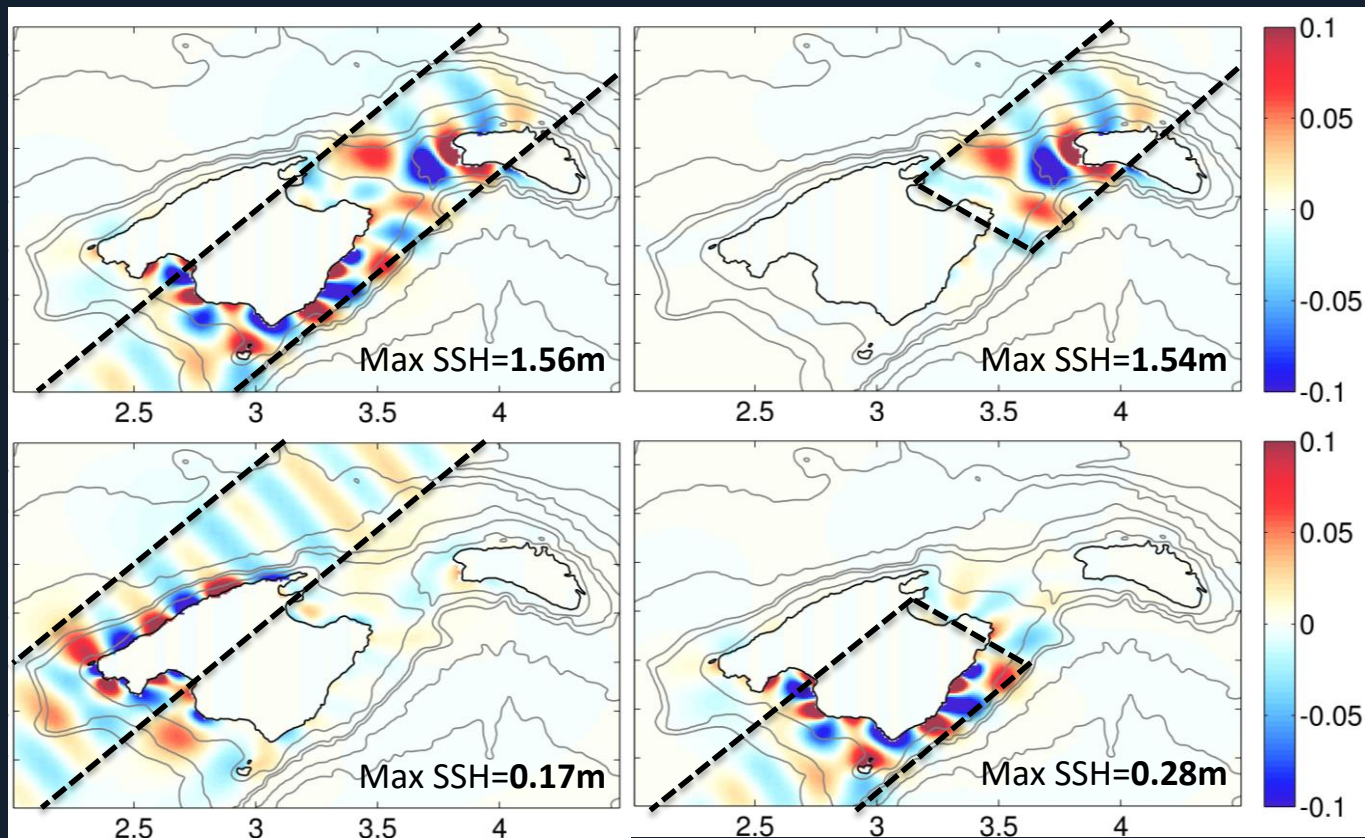
Synthetic gravity wave forcing



→ Amplification associated with Proudman resonance occurs in deeper water as the atmospheric wave goes faster

Synthetic gravity wave forcing

Contribution of Menorca Channel and Mallorca shelves to the amplification off the rissaga



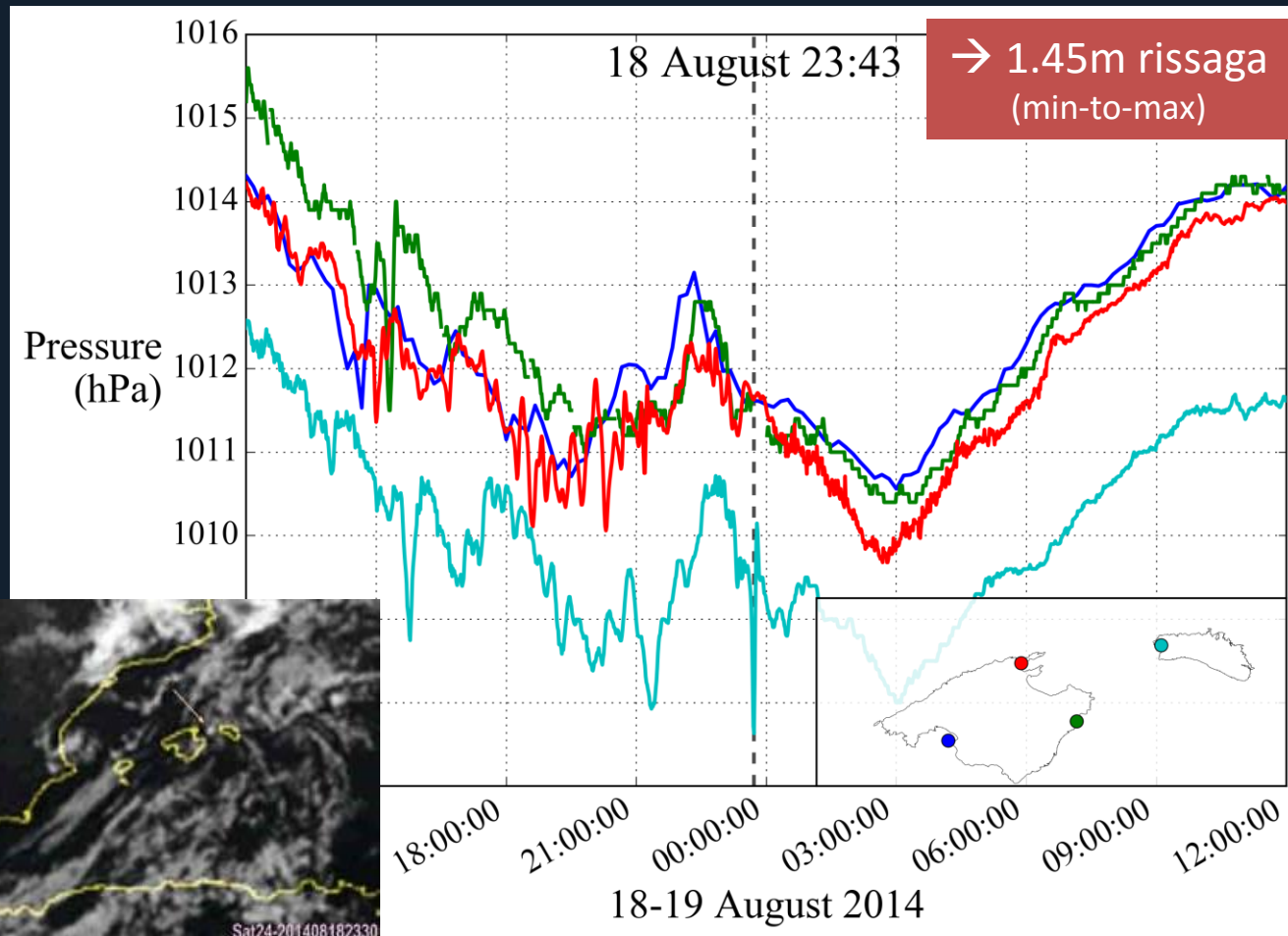
→ Menorca Channel is found to be the key build-up region

Synthetic gravity wave forcing

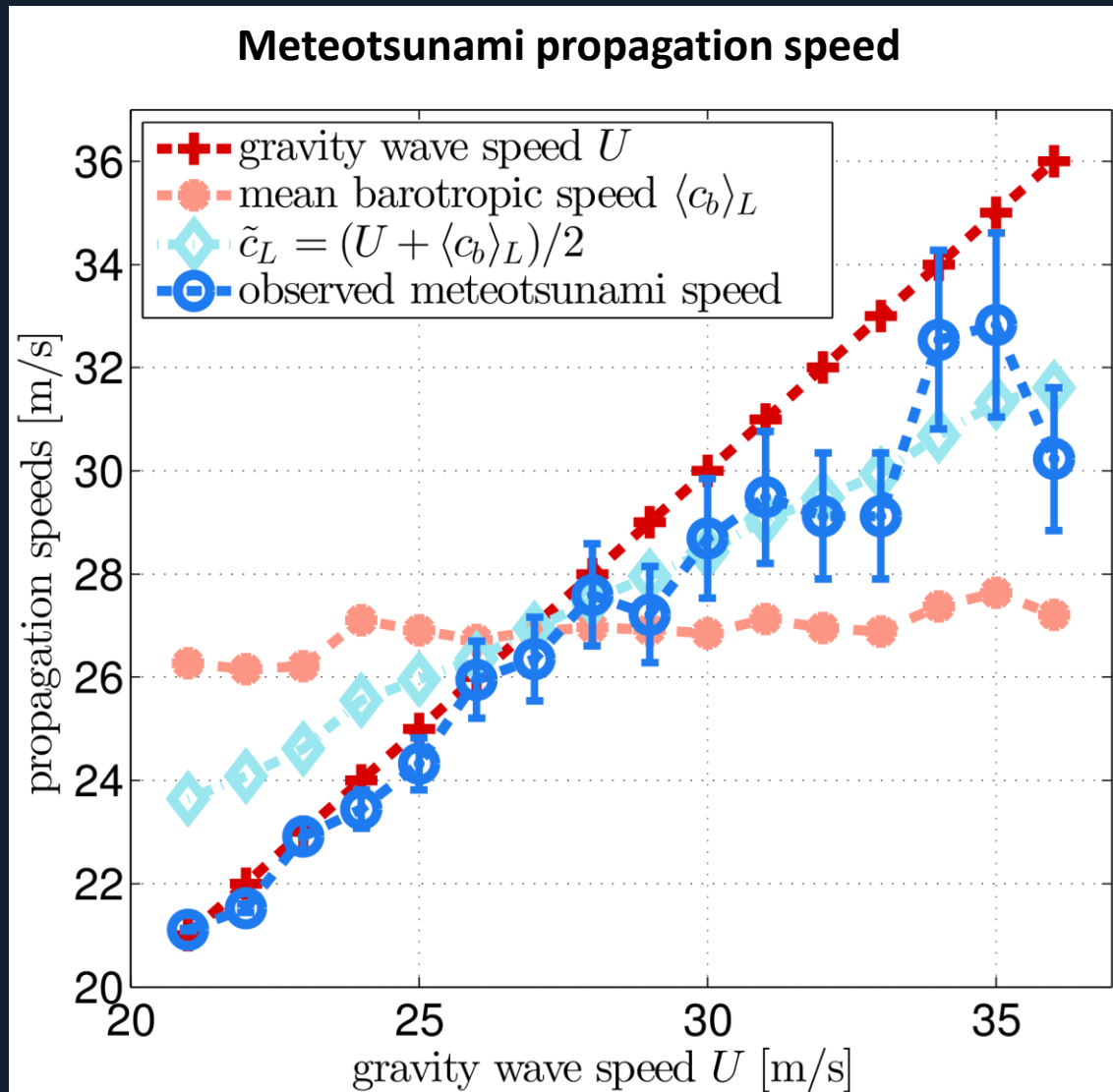
Contribution of Menorca Channel and Mallorca shelves to the amplification off the rissaga

Menorca Channel is found to be the key build-up region

→ Very short early warning alert time in case of locally generated pressure perturbations



Synthetic gravity wave forcing



- Subcritical regime ($U < c$): meteotsunami propagates at the same speed as forcing wave
- Supercritical regime ($U > c$): meteotsunami propagate at a speed below the forcing speed and above the ocean barotropic speed

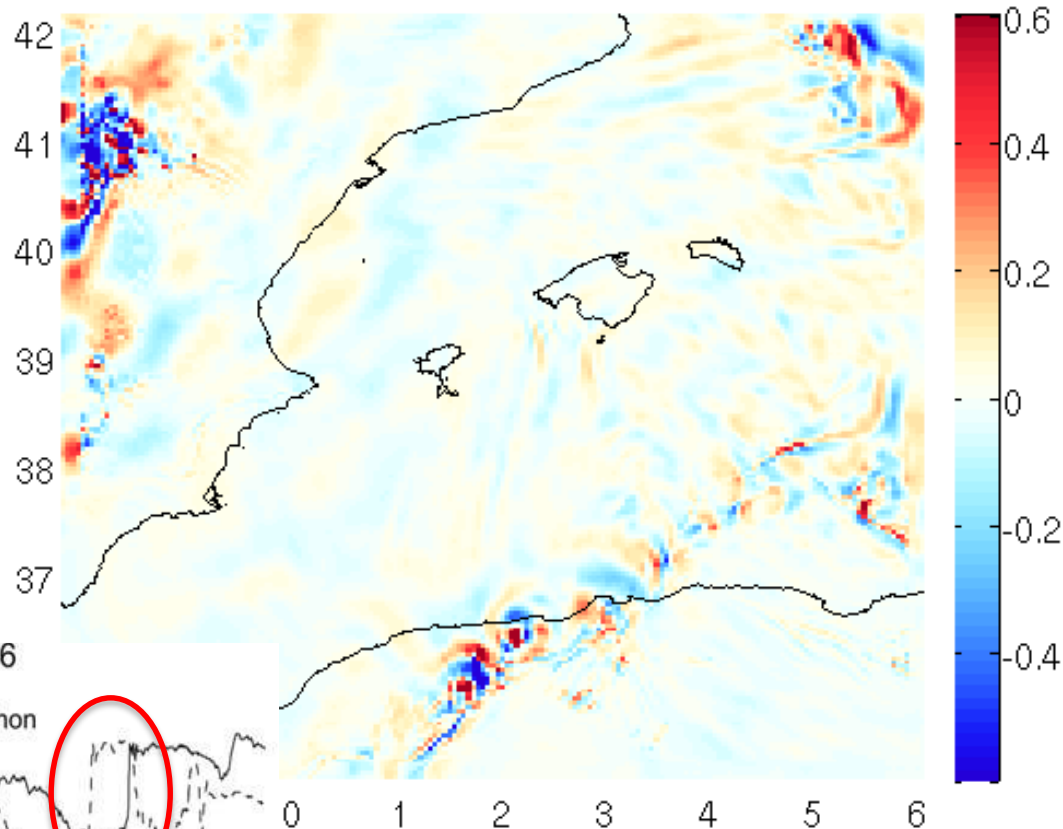
Outline

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- 3 BRIFS results for past rissagas
 - 15 June 2006 event
 - 2014-2015-2016 events

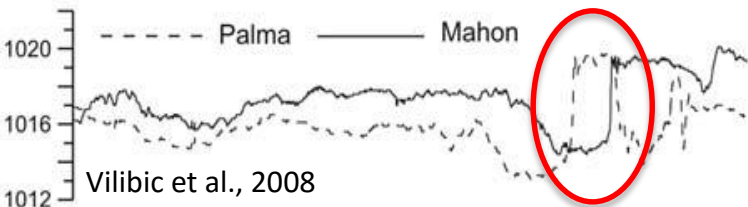
BRIFS representation of the 15 June 2006 rissaga

WRF

WRF MSL pressure anomaly HF component [hPa] on 2006 06 15 14:00



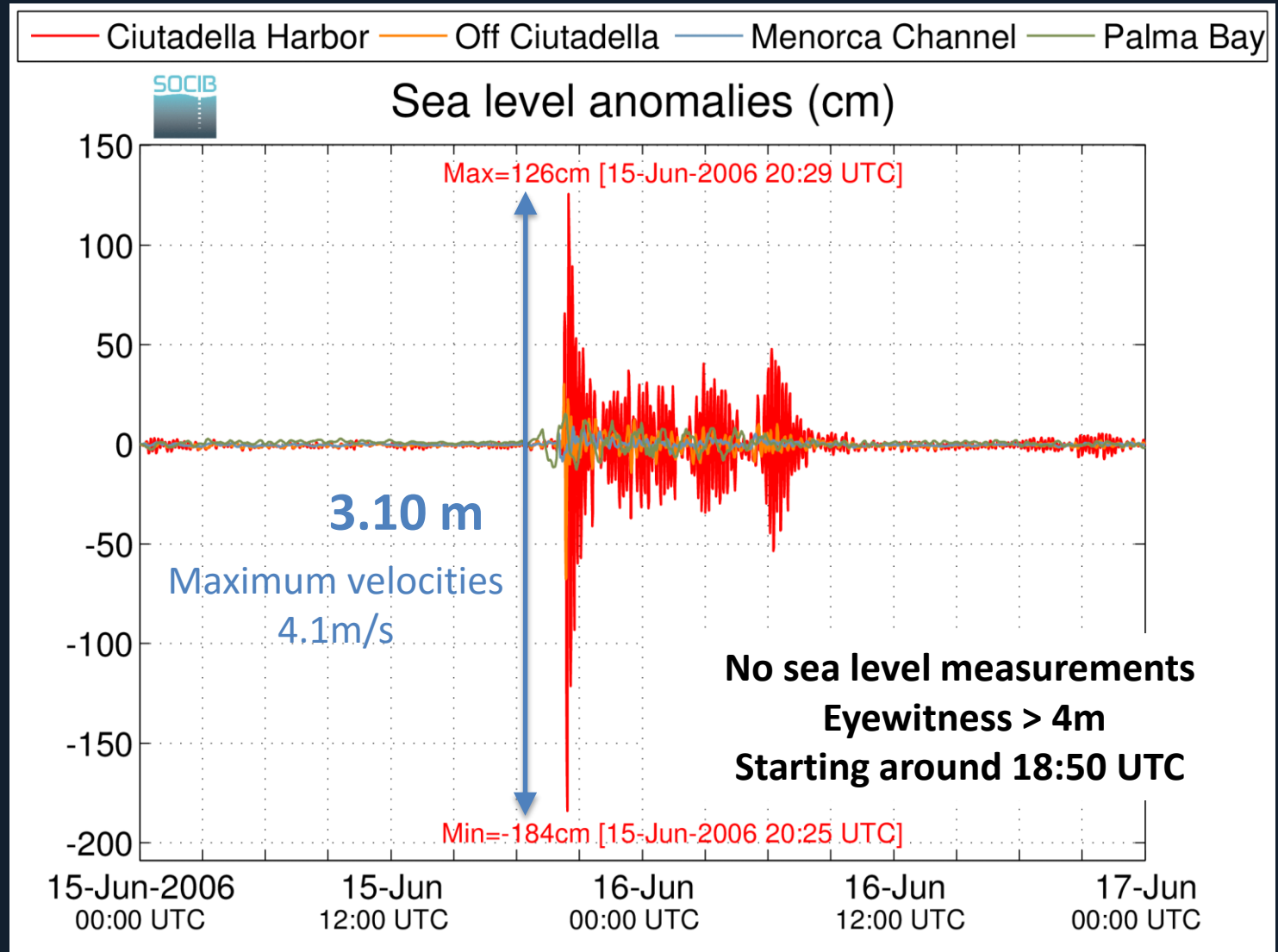
15 June 2006



→ Squall line with a ~ 4 hPa pressure jump, as registered in Mahon and Palma airports

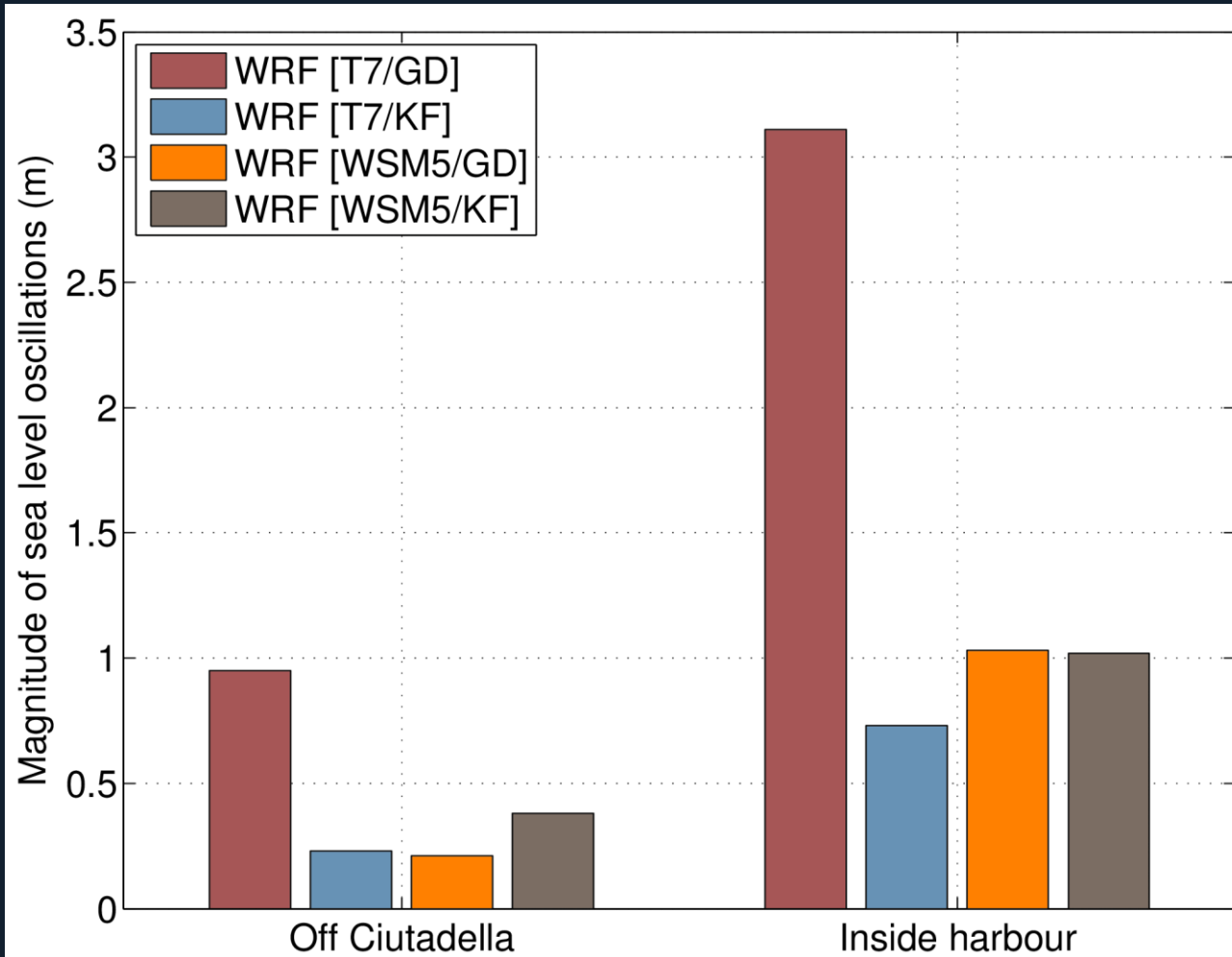
BRIFS representation of the 15 June 2006 rissaga

ROMS



BRIFS representation of the 15 June 2006 rissaga

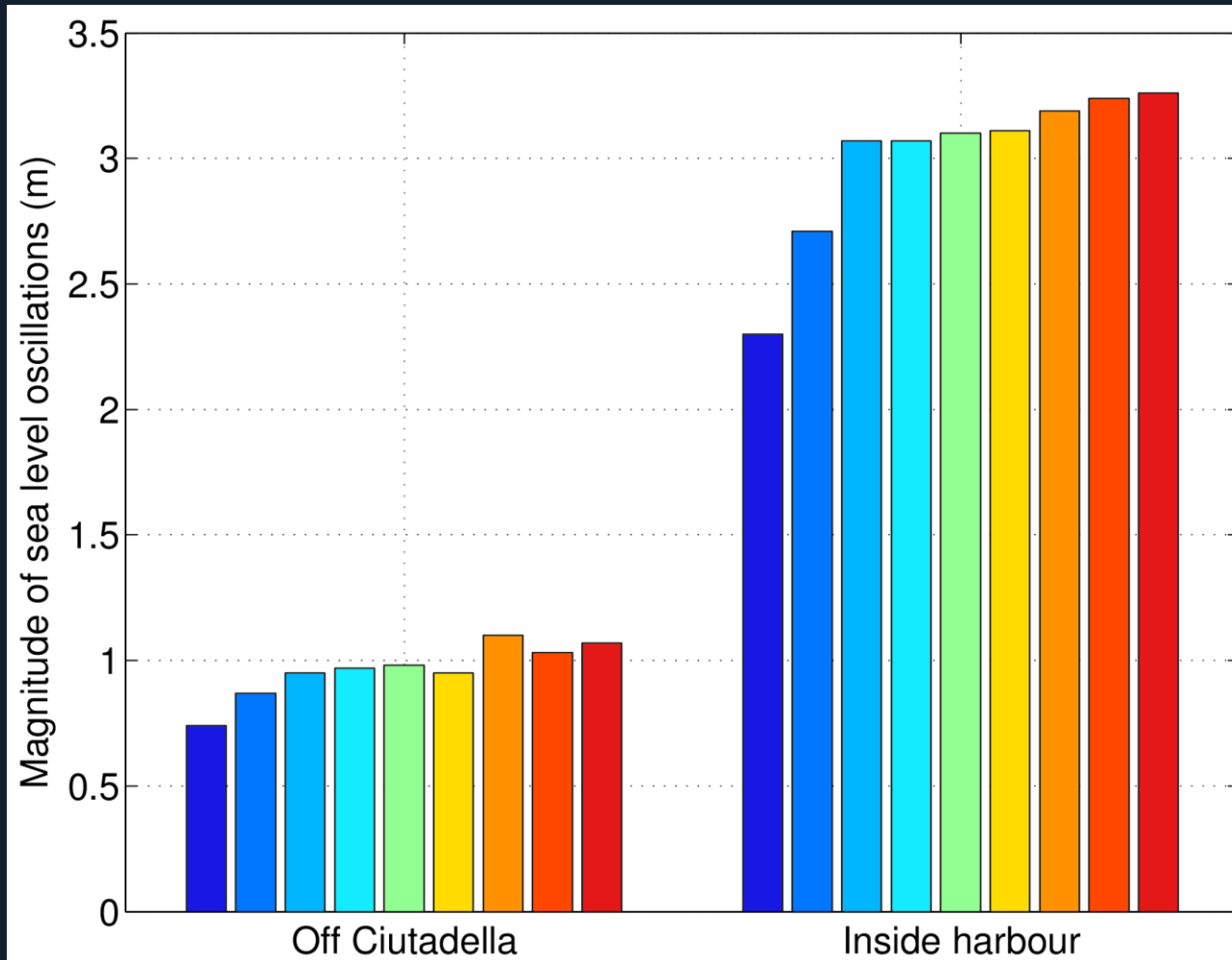
Impact of WRF parameterizations



→ Fine-tuning
of WRF setup
is essential

BRIFS representation of the 15 June 2006 rissaga

Stochasticity of small scale processes affecting the rissaga



9 WRF
simulations using
the same setup:
rissagues from
2.30m to 3.26m,
average 3.00m

→ need for
ensembles ?

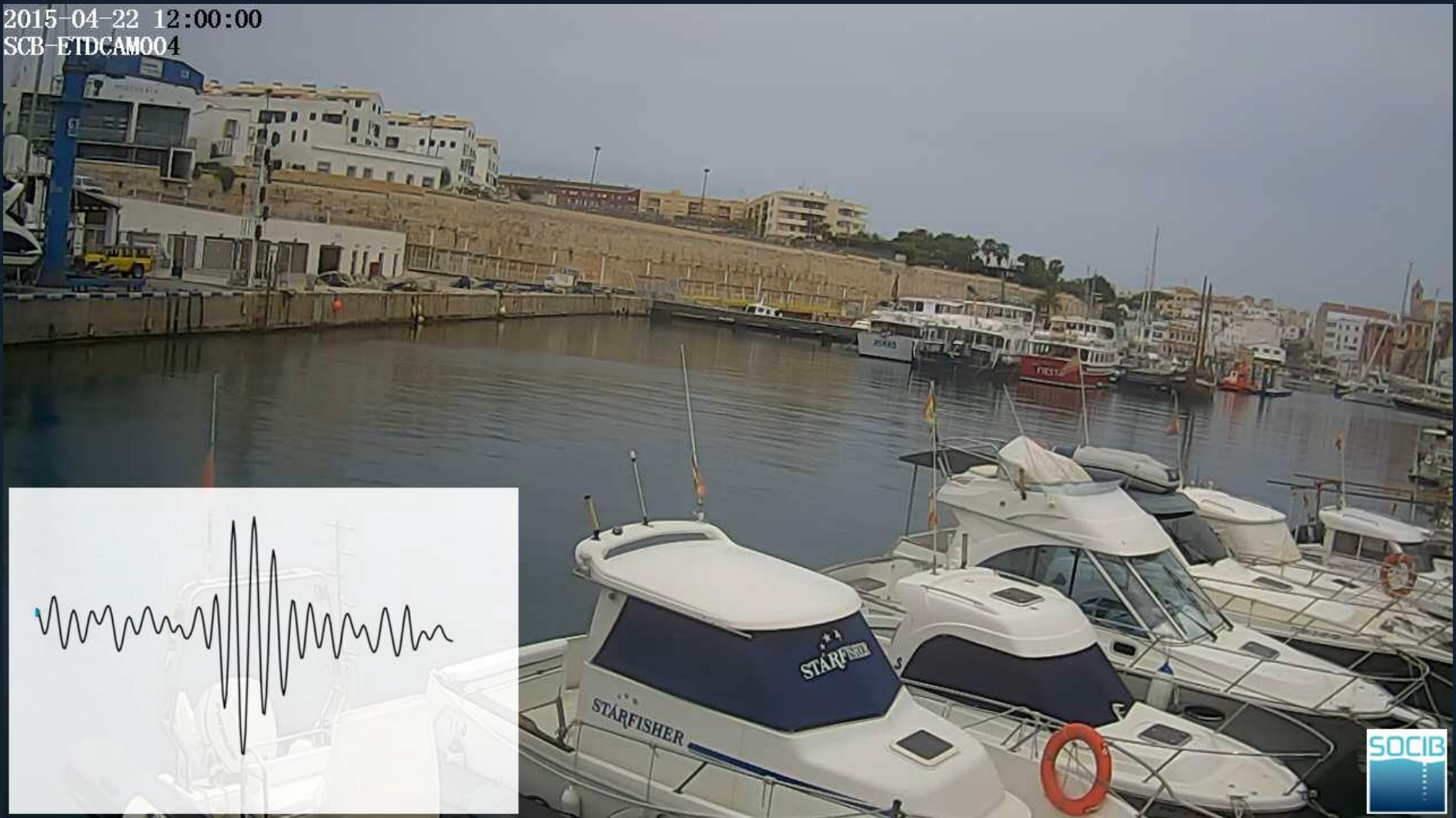
BRIFS representation of 2014-2015-2016 events

Date	Measured sea level oscillation (min-to-max)	AEMET warning	BRIFS prediction (sea level oscillation)	Time (CET) of the rissaga	BRIFS prediction (rissaga time CET)
15-Jun-2006	(> 4m)	?	3.10m	20:50	22:25
26-May-2008	2.25m	?	1.16m	?	01:00
19-Aug-2014	1.45m	Amarillo	1.04m	01:40	00:30
22-Apr-2015	1.40m	—	0.30m	15:00	16:15
01-Aug-2015	1.30m	Naranja	1.00m	06:40	07:20
01-Apr-2016	1.23m	—	0.51m	07:00	12:40
31-Jul-2015	0.92m	Amarillo	0.40m	20:10 / 23:00	23:00
07-Feb-2016	0.80m	—	0.11m	12:20	11:00
29-Jun-2016	0.22m	Amarillo	0.07m	11:15	09:00

Conclusions

- ✓ BRIFS: operational daily 48-hour rissaga prediction system
 - Quantification of sea level oscillations in Ciutadella
- Plots and videos available at www.socib.es
- ✓ Synthetic atmospheric forcing has allowed to evaluate the physical soundness of the ocean modelling system and to investigate the amplification and propagation of meteotsunamis
- ✓ Realistic high-frequency and high-resolution atmospheric forcing is essential.
 - This is the challenge ! Small scales are crucial !
- ✓ Reasonably realistic results for the destructive June 2006 rissaga. Some significant events have been missed over the last 3 years. Overall underestimation of the measured sea level oscillations.

2015-04-22 12:00:00
SCB-ETDCAM004



Thank you for your attention