

**The First World Conference on Meteotsunamis
Split, Croatia, 8-11 May 2019**



Pioneering research on Balearic Islands *rissagues*

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Rissaga is the local name used to refer to large amplitude sea level oscillations in the Port of Ciutadella (Menorca) occurring with periods in the range of tsunami periods.

By 1975 nothing was known about the origin of the *rissaga*, although fishermen in Ciutadella were speaking about “rissaga sky” or “rissaga weather”: a certain type of weather that seemed to be related with the rissaga occurrence.

By that time (on 16 Sept 1975) an intense rissaga of two meters of amplitude occurred at Ciutadella.

The local journals interpellated the scientific community, asking for an interpretation, conducting to some kind of forecasting

A consecuencia de la resaca

EL MAR SUBIO DOS METROS EN EL PUERTO DE CIUDADELA

En Cala'n Porter un yate de 10 toneladas quedó inutilizado

En “Cosas de la Isla” de ayer dábamos cuenta del fenómeno marino que tuvo lugar el pasado martes, día 16, con graves consecuencias para diversas embarcaciones que se hallaban ancladas en zonas normalmente protegidas del azote de los elementos. Una fuerte resaca, que en ocasiones suele durar varios días, se normalizó ayer el día

la'n Porter en cuya rada se hallaba anclado, resultando totalmente inutilizado. Acto seguido se autorizó a sus propietarios el desguace del yate para aprovechar lo que se pueda y se procederá a destruir los restos del barco pues no pueden quedar en el sitio a que han ido a parar. Los desafortunados ocupan

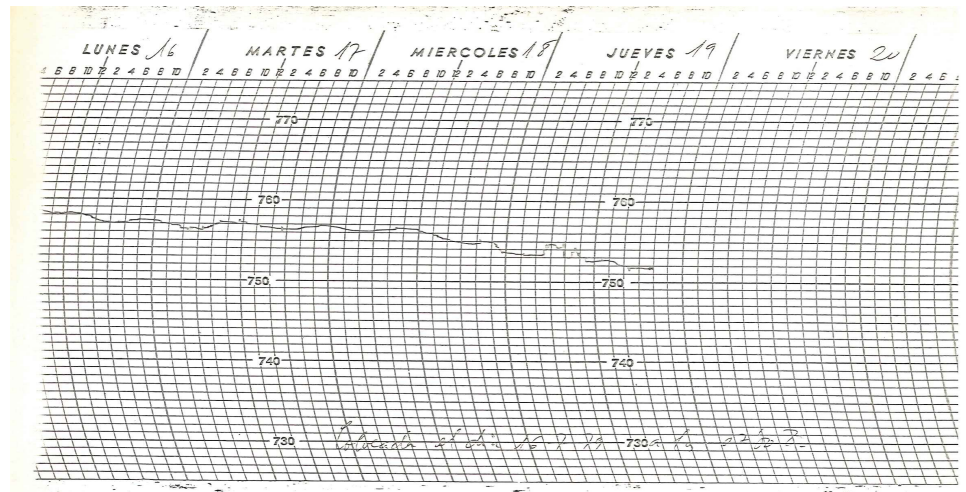
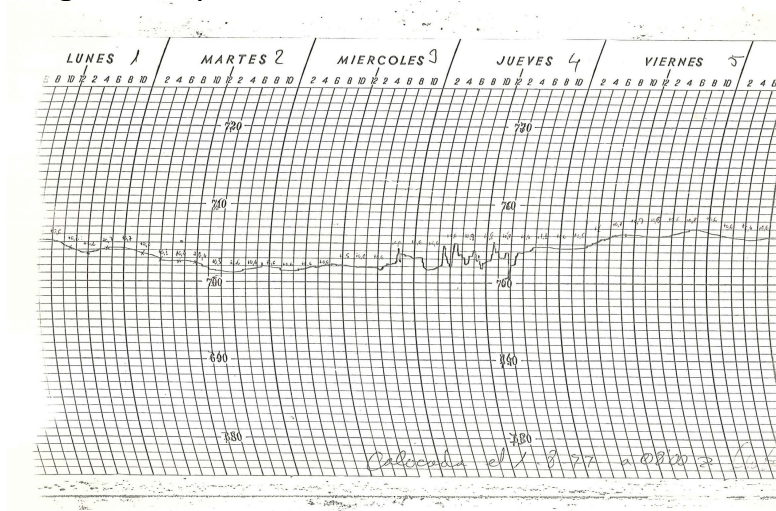
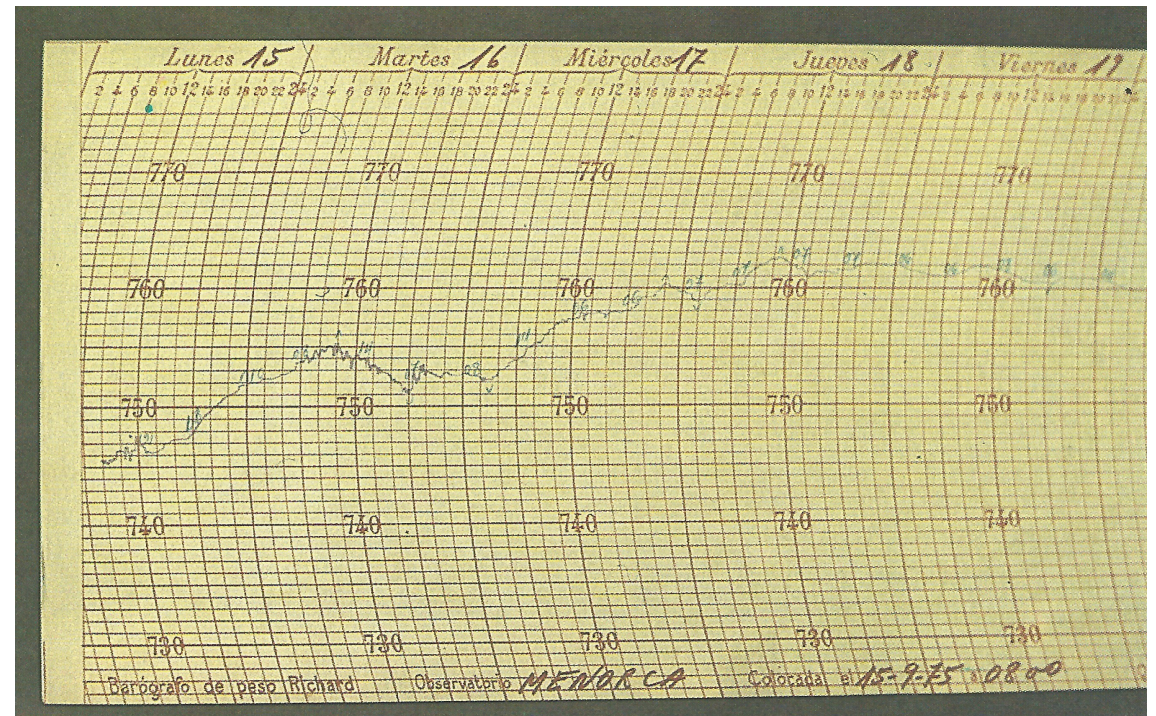
perada.

El mar subió en el puerto de Ciutadella por encima de los dos metros con lo que rebasó ampliamente la línea del muelle entrando en los bares y casas adyacentes. Ante tal estado de cosas el Sr. Villalonga se vió obligado a no dejar entrar al buque correo en el puerto de Ciutadella

By 1975, until 1979, I was working as a meteorologist in the airport of Menorca.

Analysing the weather situation on 16 September 1975, I could observe the peculiarity of the analogic barogram registered at the airport met office.

In two additional cases (1977 and 1979), a rissaga occurrence was simultaneous with rapid and relatively large amplitude atmospheric pressure oscillations. The connection and therefore, the meteorological origin of the rissaga was quite clear



In addition, by this initial time I had the fortune to examine a paper published in 1934 by a prestigious Catalan meteorologist: Eduard Fontserè

He spoke about large amplitude seiches at the port of Barcelona (named seixes by him) and he related them to quick and large atmospheric pressure oscillations

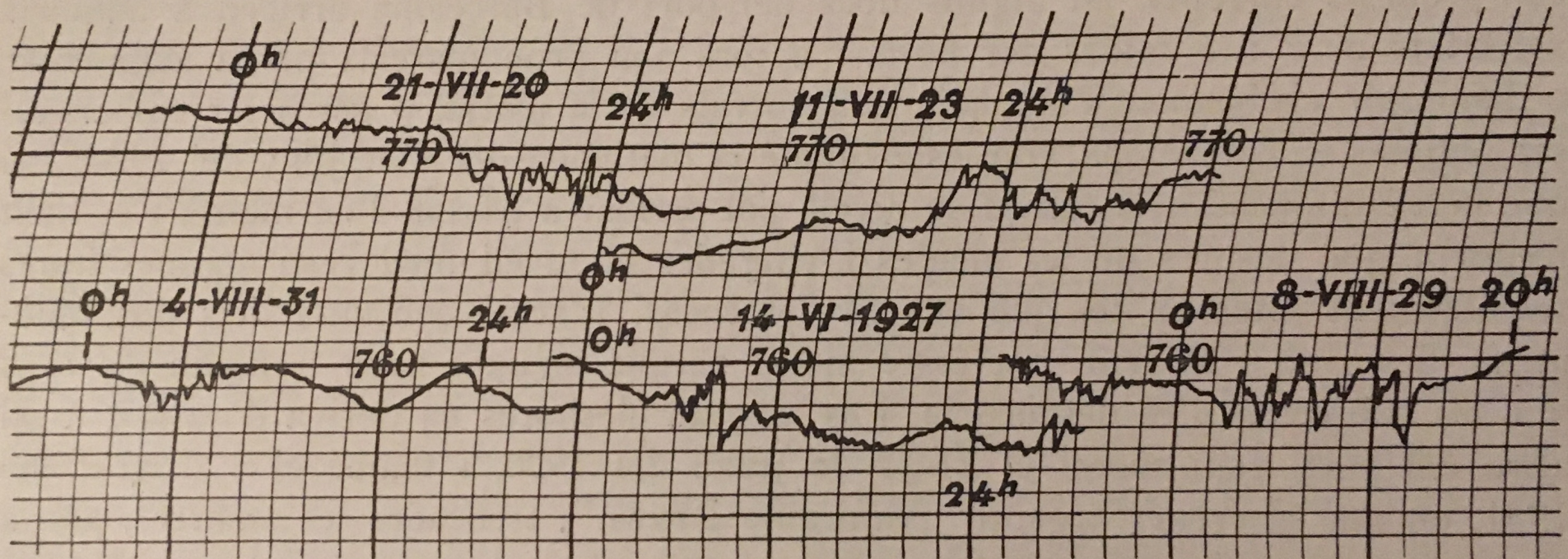
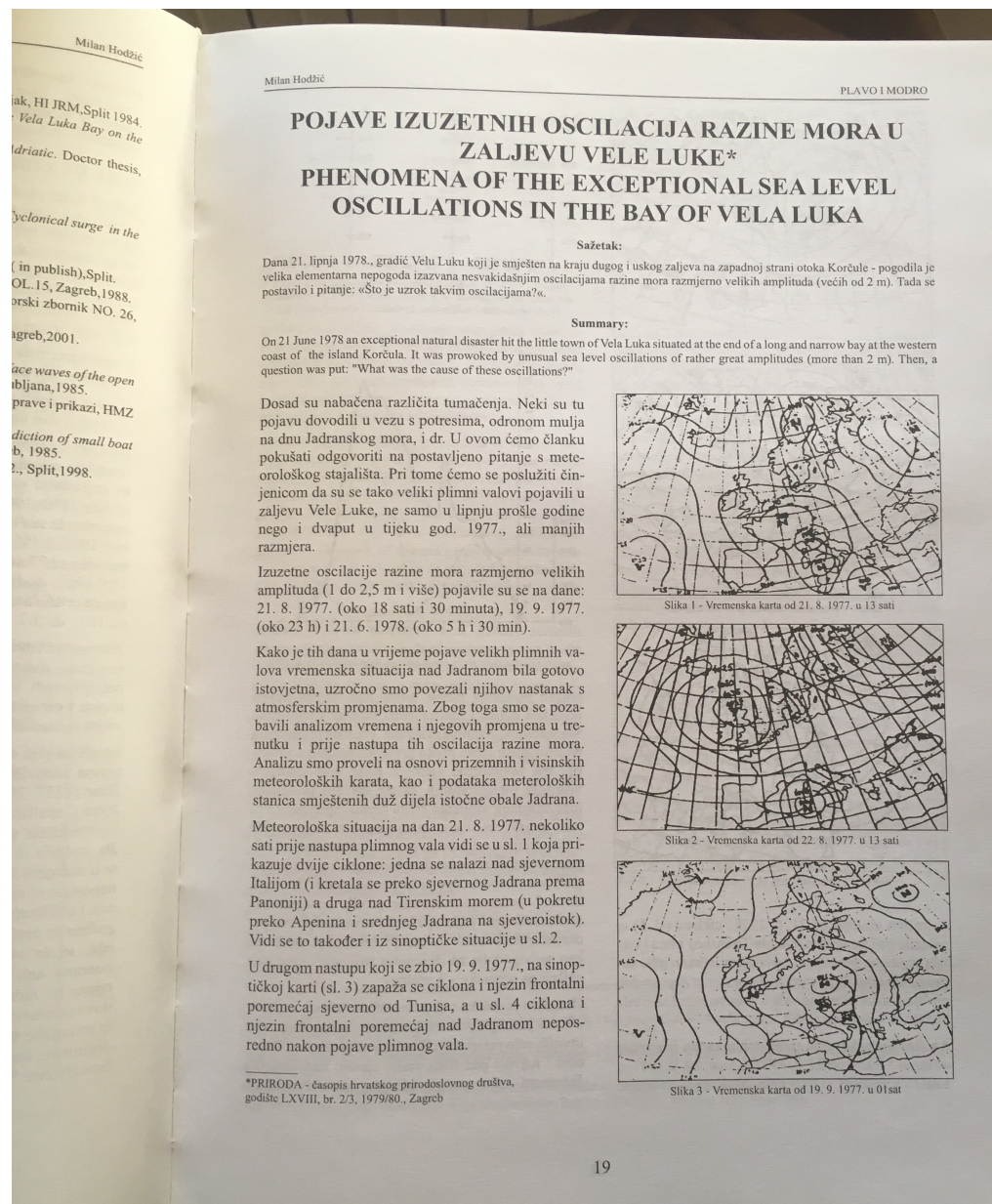


FIG. 1. — Barogrames típics dels dies de seixes al port de Barcelona. (El de l'any 1920 és de l'Observatori Fabra; els altres, del Servei Meteorològic de Catalunya.)

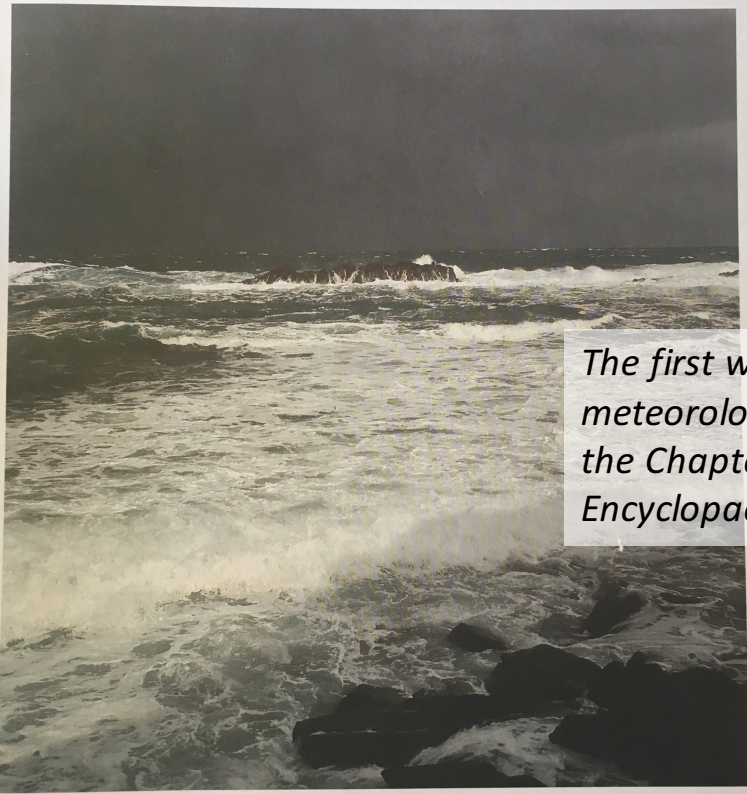
Another significant coincidence to confirm the meteorological origin of the Menorcan rissaga was the analyses made by Milan Hodzic with regard to the extraordinary seiche in Vela Luka (Island of Korcula, Croatia), on 21 June 1978: Hodzic guessed a meteorological origin for the very intense Vela Luka's sea level oscillations.

I had heard about the Hodzic's work through a presentation in a course about Mediterranean Meteorology, in Erice (Sicily), in 1979.



ENCICLOPÈDIA DE MENORCA

OCEANOGRÀFIA (I) per A. Jansà/X. Jansà



The first written mention to the meteorological origin of the rissaga was in the Chapter of Oceanography, in the Encyclopaedia of Menorca, in 1980

obra cultural balear
de MENORCA

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Fig. 7.—Noticia publicada por el diari Menorca del día 19 de setembre de 1975.

les de tipus sinòptic (depressions i anticiclons típics) i els petits remolins de la "micro-meteorologia". En sistemes, se'n diu, peticioniques acompanyant a anticiclons i depressions que haurien de ser de l'ordre de les desenes de kilòmetres de diàmetre.

Un dels autors d'aquesta part va poder comprovar —en ocasió de la "rissagada" excepcional de 1975 a Ciutadella— que aquesta coexistència, denunciada per Fontserè per al cas barceloní, també era aplicable al cas ciutadellenc (posteriorment podríem confirmar el mateix en casos menys espectaculars), registrant-se al barograma de l'observatori de l'Aeroport de Menorca oscil·lacions de pressió ben parel·lades a les publicades per el meteoròleg català el 1934. Per cert, que en aquell cas del 75 comprovàvem també que oscil·lacions de pressió molt parel·lades a les observades a Maó foren detectades a Barcelona i a la Ciutat de Mallorca, i que la "rissagada", la seca excepcional, també es va sentir, almenys, a Barcelona. Fou del 16 al 18 de setembre del 1975.

Pensem que pot haver-hi una resonància del sistema hidrogràfic

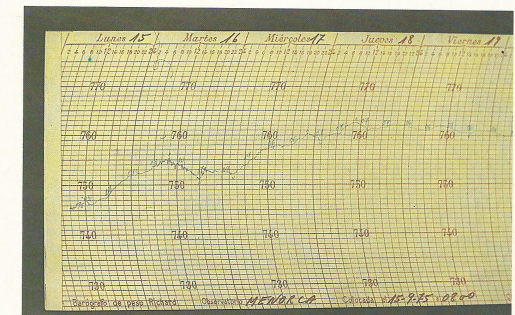


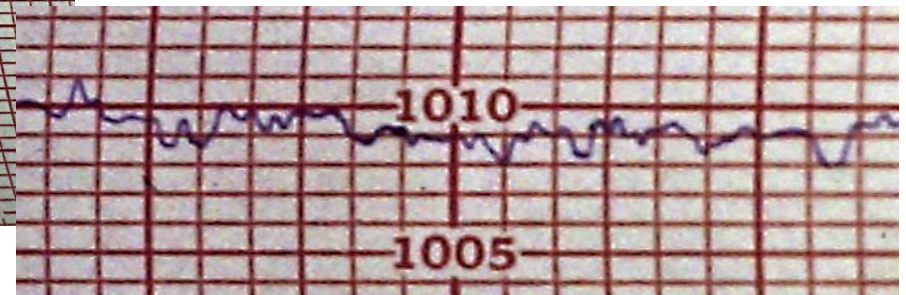
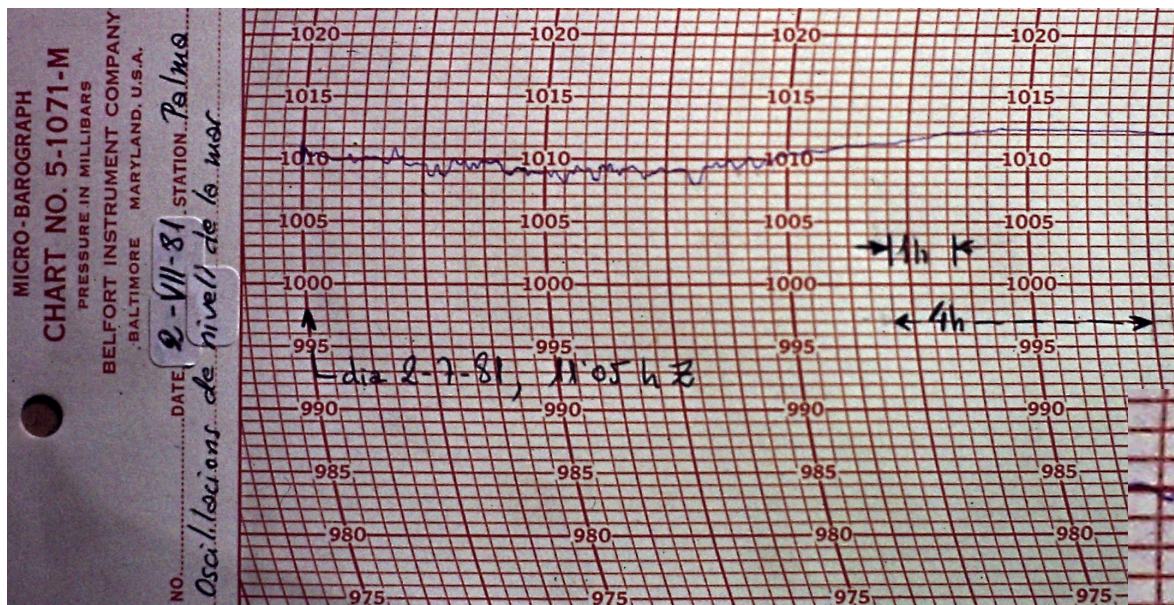
Fig. 8.—Barograma obtingut a l'observatori de l'aeroport de Menorca els dies 16-18 de setembre de 1975 (Rissaga extraordinària a Ciutadella).

majorment responsable de les seques normals a Ciutadella —insensibles— per efecte d'oscil·lacions de la pressió i el vent de període igual al propi de dit sistema. Aquest període comú seria de l'ordre dels deu-vint minuts. La primera baixada de pressió suposaria una petita pujada local del nivell de la mar i la causa del co-

mençament de seques lliures en desaparèixer la causa sense temps per a desaparèixer l'efecte. Però si amb la primera davallada de la mar hi coincidís un augment de pressió, encara que petit, aquesta davallada es multiplicaria. Mentre el ritme natural de pujades i davallades propi de la seca lliure s'avingués amb el de les compres-

In the following step Climent Ramis and me, working together tried to characterise the pressure perturbation associated with the rissaga as well as the meteorological large scale framework in which this kind of perturbation, and so the rissaga, occurs.

A useful working instrument was a modified barograph, with increased time resolution. Taking profit of a barogram obtained in Palma during an important event occurred in Ciutadella and in several other points of the Balearic coasts (2 July 1981), an spectral analysis of the pressure oscillations revealed periods of around ten minutes, compatible with gravity waves and suggesting harbour resonance (the free seiche of the Ciutadella Port is also around 10 minutes period).



The former results, as well as the description of the meteorological large scale framework, including the vertical profile, simultaneous to rissaga occurrence were included in a key paper, Ramis & Jansà, 1983, almost unknown by the international scientific community, because it was only published in Spanish, in a Spanish journal.

REV. DE GEOFISICA (1983) 39, 35-42

(RAMIS y JANSÀ 1983)

Condiciones meteorológicas simultáneas a la aparición de oscilaciones del nivel del mar de amplitud extraordinaria en el Mediterráneo occidental

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RESUMEN

Se presenta un mapa con las oscilaciones del nivel del mar del 2 de julio de 1981, así como su período en diversos puertos y calas de las Islas Baleares. Se ha comprobado simultaneidad con las costas catalanas. Se presenta el registro obtenido con un microbarógrafo de alta resolución, observándose oscilaciones rápidas de presión. En los casos estudiados se han observado asociados al fenómeno unas condiciones meteorológicas generales en el Mediterráneo occidental caracterizadas por: a) en superficie, circulación ciclónica muy débil; b) baroclinidad acusada con aire cálido sobre el Mediterráneo y aire frío sobre la Península Ibérica, y c) superposición de una capa de aire frío y húmedo y otra de aire seco y cálido, separadas por una fuerte inversión térmica, asociada a un cambio brusco de dirección y velocidad del viento. Se introduce la hipótesis de que las condiciones meteorológicas son suficientes para producir ondas gravitatorias internas en la superficie de discontinuidad, que explicarían las oscilaciones de presión y que con algún mecanismo de acoplamiento provocaría las oscilaciones de la superficie del mar.

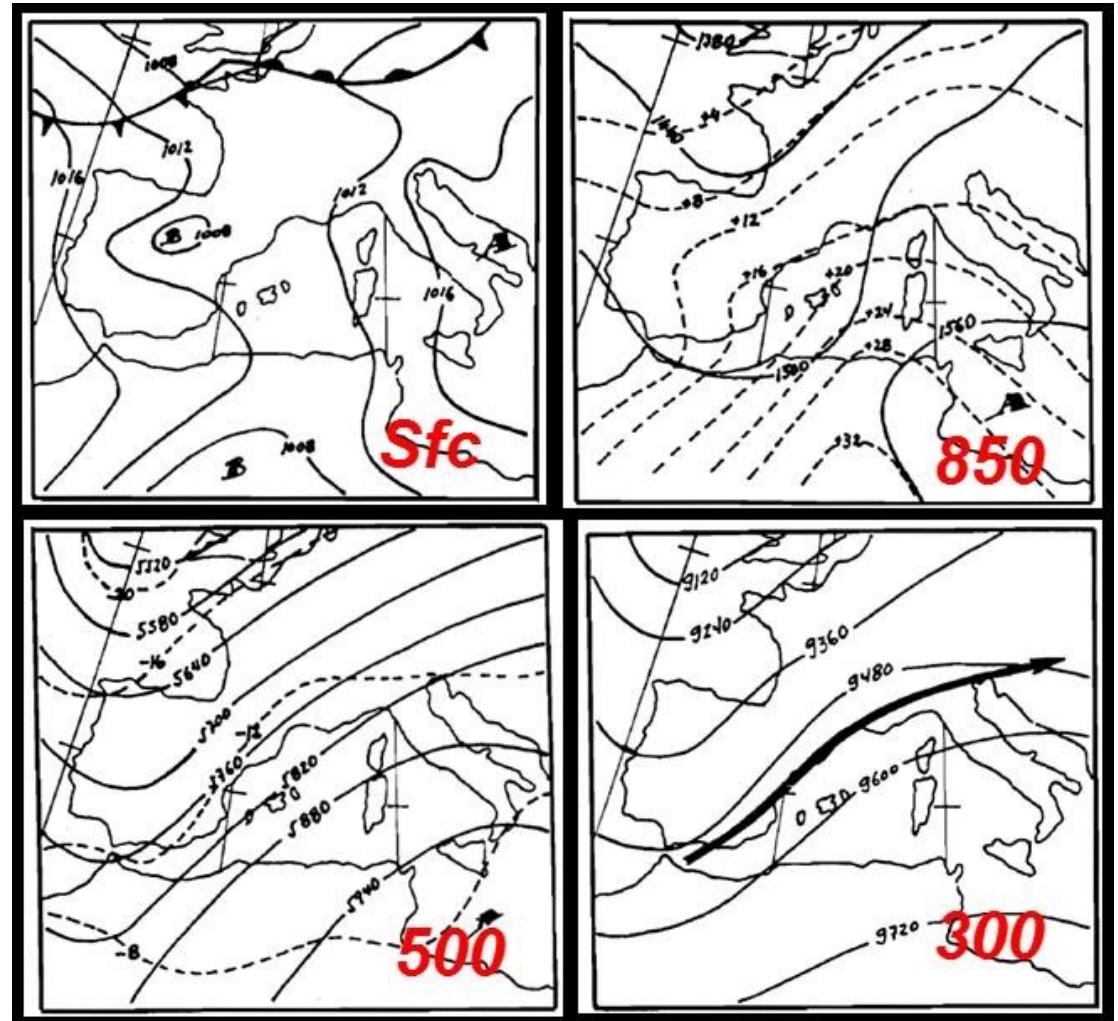
ABSTRACT

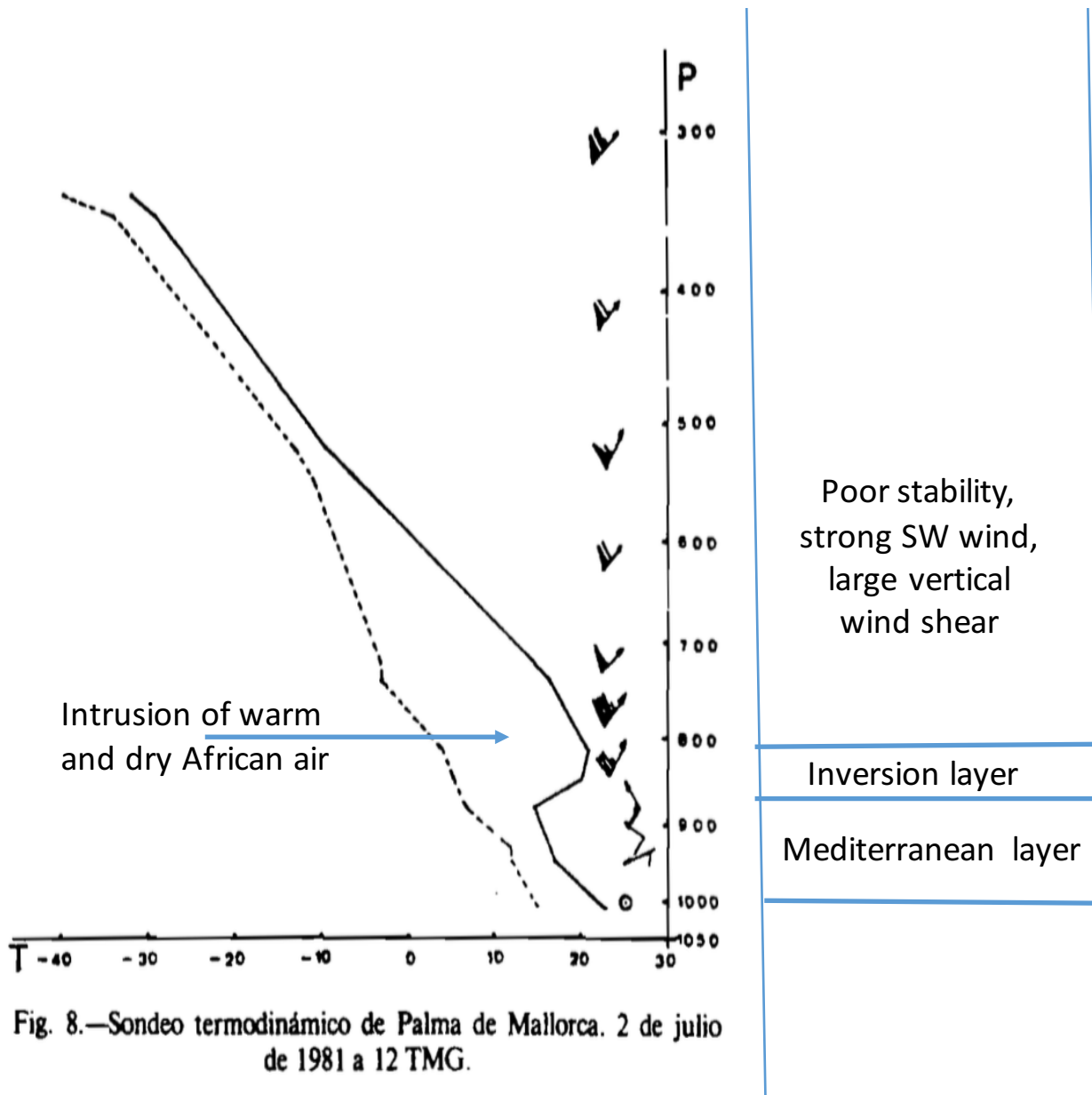
A map of the sea level oscillations and their periods at the Balearic Island the 2nd July 1981 is presented. The simultaneity with the values observed at the Catalanian coast is discussed. The pressure record obtained for this day with a microbarograph is included; short pressure oscillations have been observed. It is reported that exceptional oscillations in the area considered occur when following meteorological conditions happen: a) flow from the East, with cyclonic circulation at lower levels, surface and 850 mb; b) strong flow from the Southwest at 700 mb and upper levels, with cut-off on the southwest of Iberian Peninsula with jet stream on the eastern coast, and c) two imposed air masses, the lower one cold and humid and the upper warm and dry, with strong stress between them. It is supposed that those conditions can justify the existence of internal gravity waves, which would explain the pressure oscillations. Eventually these pressure waves would, in turn, result into the oscillations of the sea level.

1. INTRODUCCION

Con una frecuencia anual, aunque algunos años pueden darse varios episodios o no presentarse, y según los datos disponibles siempre entre junio y sep-

tiembre, aparecen en las costas de las Islas Baleares oscilaciones del nivel del mar de una amplitud extraordinaria y período de algunos minutos que se mantienen durante horas. Estas oscilaciones conllevan en puertos y calas una entrada y salida de masa de agua





The Ramis & Jansa 1983 thinking

Gravity waves generation and amplification

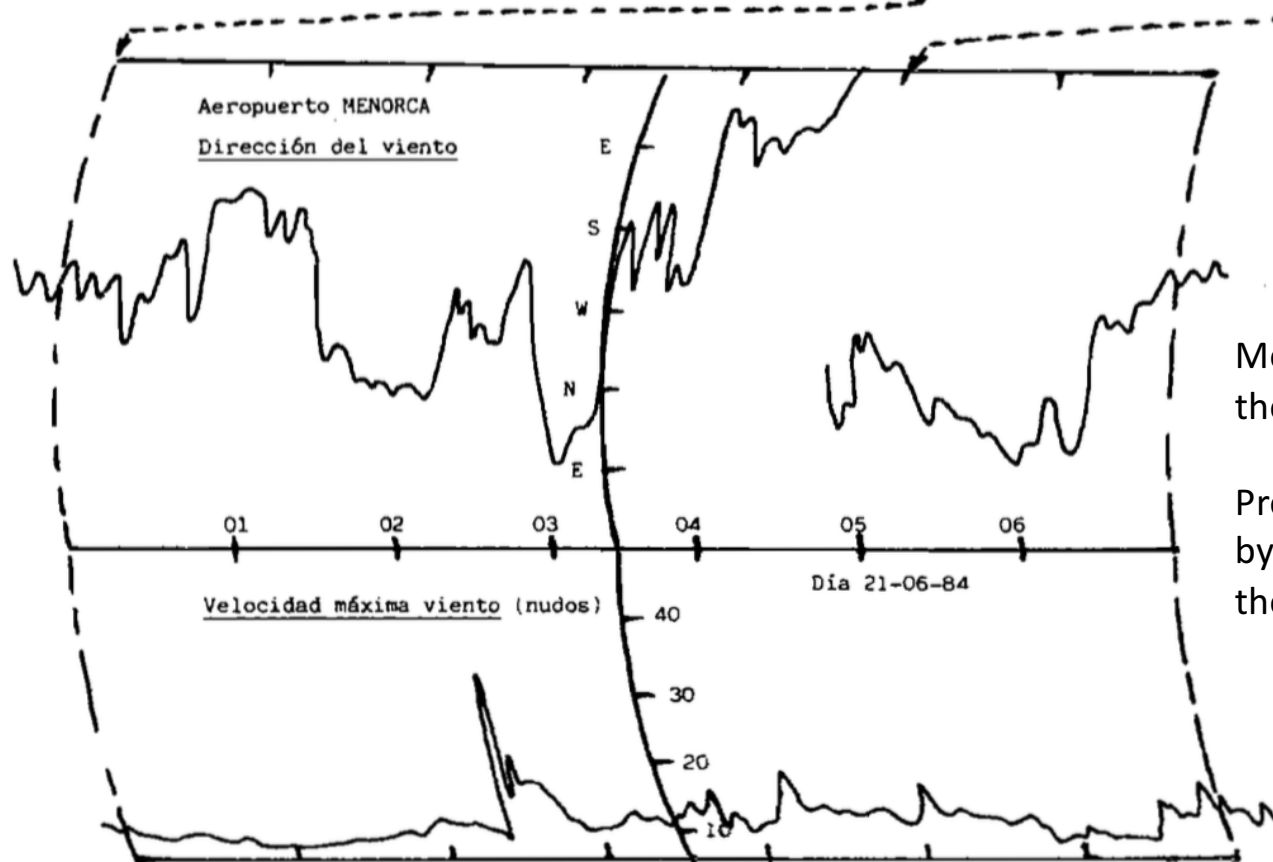
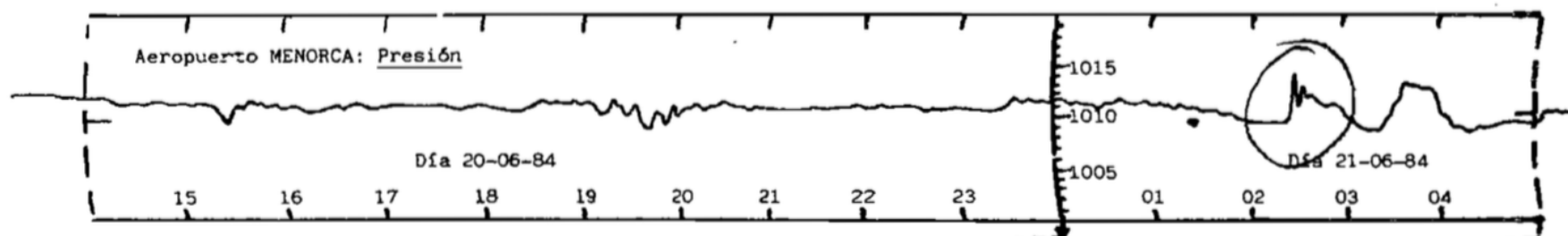
The oscillation of the inversion layer produces surface atmospheric pressure oscillations

Marine response –long waves– amplified by port resonance



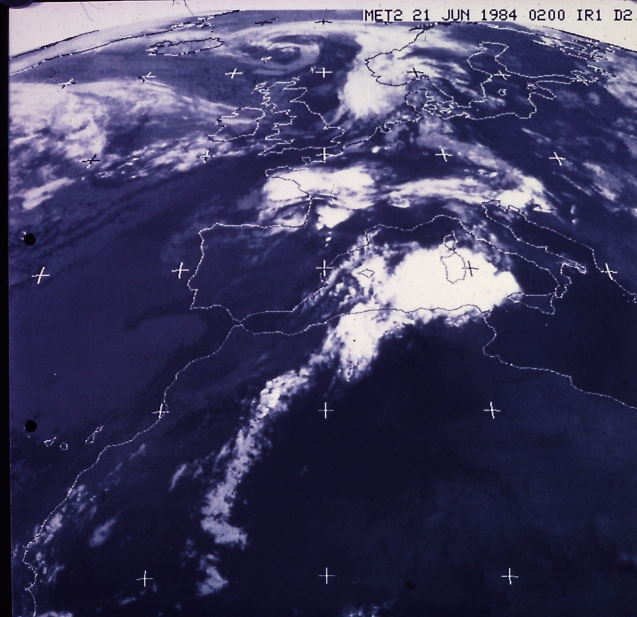
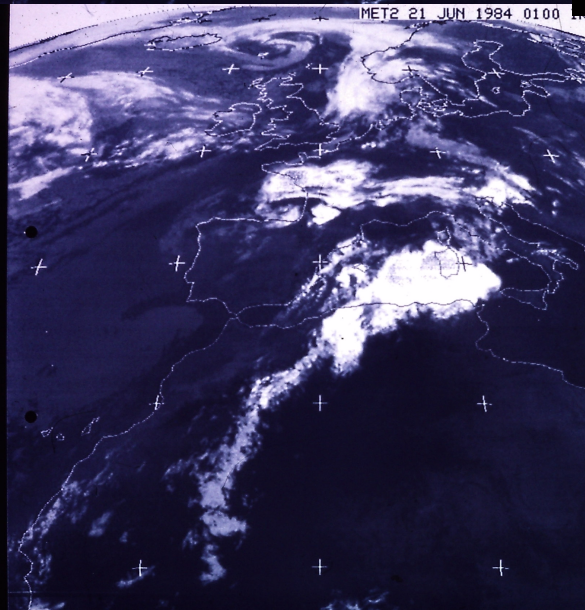
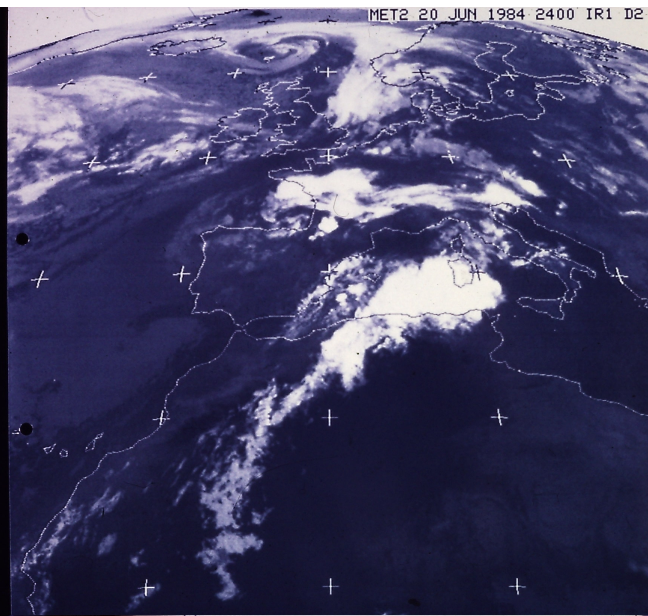
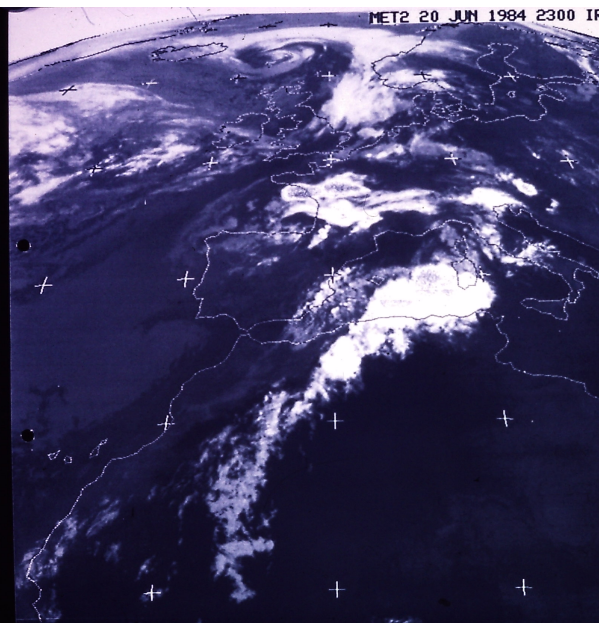
On 21 June 1984 an extraordinary (3 m high?) and destructive rissaga occurred at Ciutadella ... And obliged us to complement some aspects of the previous thinking:

- In extreme rissaga events, a **singular pressure jump**, associated with a **convective discharge** and accompanied by a strong wind gust, can appear together with pressure oscillations associated with gravity waves
- Convective activity associated with rissaga can come from breaking gravity waves
- The **large scale meteorological framework** favourable to convective pressure jumps or to gravity waves can be **almost the same**, as described in Ramis&Jansa (1983)
- The simultaneous arrival at Ciutadella of the convective discharge and the rissaga occurrence suggests that the **meteorological disturbance and the marine response have travelled together** during a time, what makes an intermediate amplification (**Proudman resonance**) not only possible, but probably necessary



Meteorological registers at
the airport of Menorca:

Pressure jump and wind gust
by 02:30, about the time of
the rissaga at Cutadella



Gravity waves and
convective nucleus
From 20 June at 23 UTC, to
21 June at 02 UTC

(JANSA 1986)

RESPUESTA MARINA A PERTURBACIONES MESOMETEOROLÓGICAS: LA "RISSAGA"
DE 21 DE JUNIO DE 1984 EN CIUTADELLA (MENORCA)

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Instituto Nacional de Meteorología
Centro Zonal en Palma de Mallorca

After the 1984 extraordinary rissaga:

- A paper (Jansa, 1986) was prepared, to include the new data and appreciations (again only published in Spanish, in a Spanish journal)
- An experimental forecasting service was established (since 1985) at the Regional Met Centre in the Balearics of the Spanish National Meteorological Service (INM, at that time): the service provided an estimate of the rissaga amplitude, based in identifying the meteorological framework described in Ramis&Jansa (1983) in the forecast meteorological charts, with additional details (satellite images, barograms, ...). The service is still live nowadays, more thirty four years later

Abstract

On June 21st, 1984, a violent marine surge penetrated into the Port of Ciutadella, Minorca (Balearic Is.) and destroyed the most of the fleet present there. Great sea level oscillations are an infrequent but known phenomenon in that Port. They are locally named "rissaga" and were described in previous papers as resonant "seiches", excited by mesoscale atmospheric disturbances, mainly tropospheric gravity waves.

From barographic and anemographic traces, satellite pictures and an upper air sounding two kind of mesoscale atmospheric perturbation are identified and analysed, the one being gravity waves and the other, a gust front of convective origin. The vertical structure of the atmosphere was characterized by a low and strong inversion and a nearly unstable, strongly sheared and very dry layer above it and it allowed gravity waves to exist and to produce significant pressure oscillations at the ground level. An increasing of waves or a decreasing of static stability in the upper layers might provide a trigger mechanism for breaking the wave situation into a convective one. The tropospheric structure (shear wind and dry layer) would allow the convection to be severe (well organized), with intense downdrafts and gust fronts.

Pressure oscillations related to gravity waves would generate a weak marine response on open sea. But when their period (8-10 min. in our case) was close to the free oscillation ("seiche") period of a port (8,6 min. for the Ciutadella Port)

a resonance would appear and the response into the port would be greatly amplified.

Although the gravity wave phase might "prepare" the Ciutadella Port, it seems that the gust microfront was the main factor in the "rissaga" case studied here. The oceanic response to an individual mesoscale atmospheric forcing depends on the relation between the speed of propagation of both, response and forcing. A coupling may amplify the response and when the atmospheric perturbation advances the marine response, the last may consist of big "lee" waves.

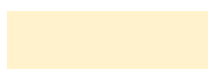
The bathymetry of the sea surrounding Ciutadella favours the evolution to be as described just now, when taking into account the characteristics of the actual gust front. In fact, the succession of phenomenon observed in Ciutadella is congruent with it: a wind gust, with little movement in the Port, followed by a great descend of sea water and the irruption of a water wall, all this succession in a few minutes, perhaps ten minutes.

Resumen

El 21 de julio de 1984 una súbita elevación del nivel del mar afectó al Puerto de Ciutadella (Menorca), destruyendo la mayor parte de la flota presente. Es un hecho conocido que en dicho Puerto hay ocasionalmente grandes oscilaciones del nivel del mar, denominadas localmente "rissagues" y que en anteriores trabajos han sido descritas como "seiches" resonantes, excitadas por perturbaciones atmosféricas mesoscales, principalmente ondas gravitatorias troposféricas.

Verification –through a contingency table- of a sample (2003-2006) of the analogical rissaga prediction service established in 1985 at the Spanish National Meteorological Service

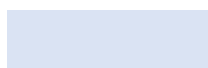
Rissaga	Observed amplitude (when amplitude >= 30 cm)			
Forecast amplitude	30-75 cm	75-150 cm	> 150 cm	total
No forecast (< 30 cm)	4	1	1	6
30-75 cm	2	1	1	4
75-150 cm	9	11	4	24
> 150 cm	1	2	1	4
Total	16	15	7	38



Under-prediction



Correct prediction



Over-prediction

When rissaga (>30 cm) is observed:
Rissaga was not forecast: 16%
Rissaga was forecast: 84%

Thank you for your attention