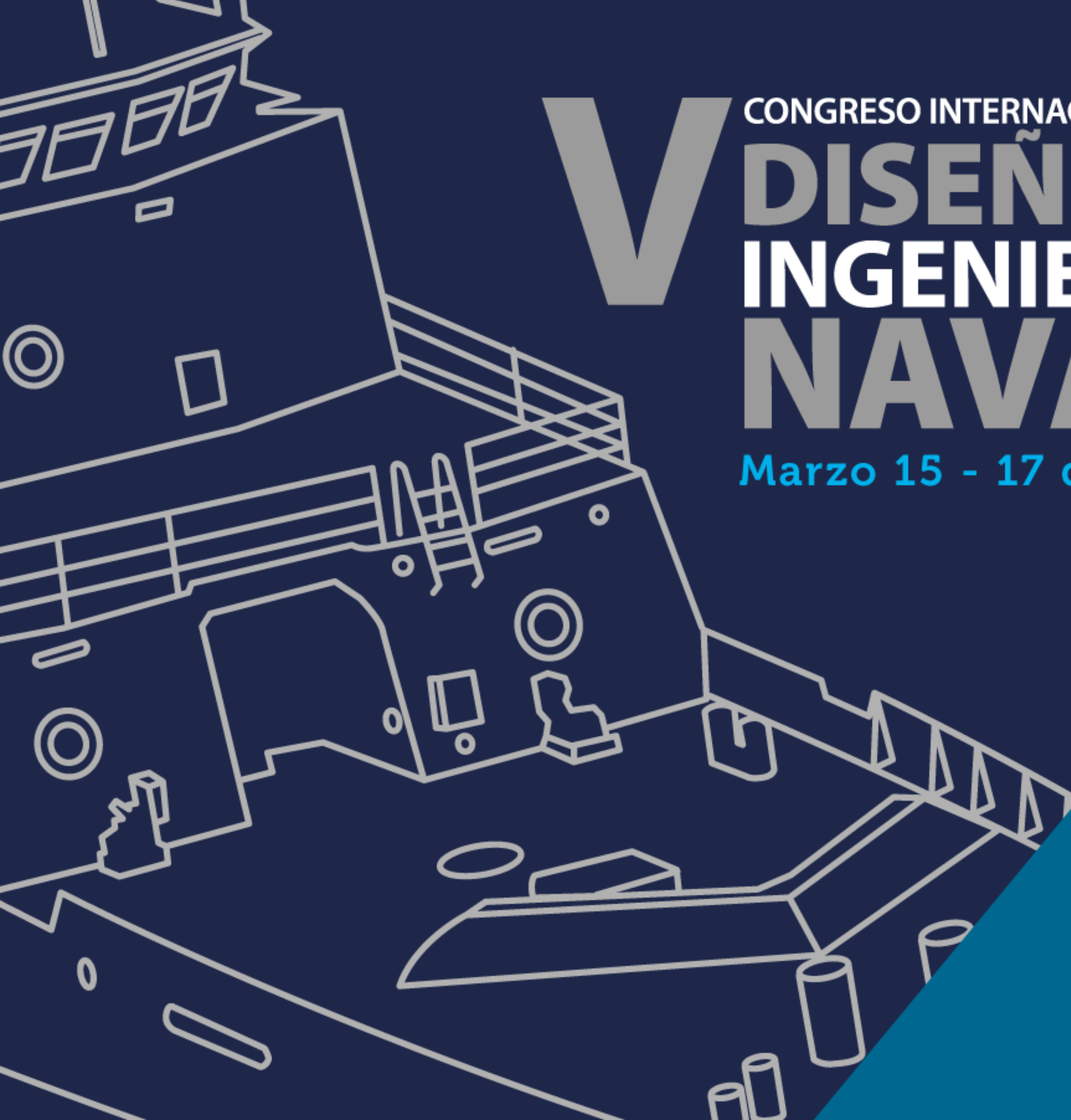
V CONGRESO INTERNACIONAL DE DISEÑO E INGENIERÍA NAVAL

Marzo 15 - 17 de 2017



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WAVELET-BASED PREDICTION OF QUIESCENT PERIODS IN WAVES ENCOUNTERED BY A SHIP

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José M. Riola Rodriguez, Universidad Politécnica de Madrid

The command belongs to the man on the deck (it would be convenient to give him relevant information on next QPP)

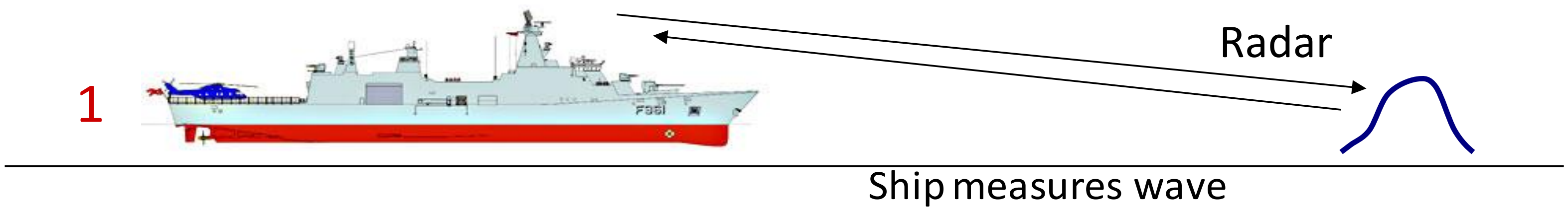
- During *quiescent periods* the ship motions are smoother, corresponding to smaller waves

- In some applications it is convenient to predict, with some time in advance, the advent of quiescent periods

- For example, the landing of helicopters or UAVs on ships

Three aspects are involved:

1



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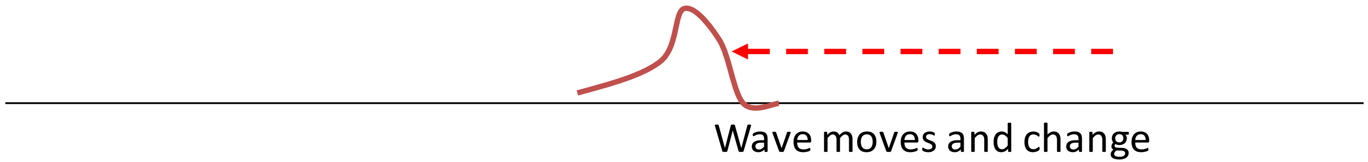

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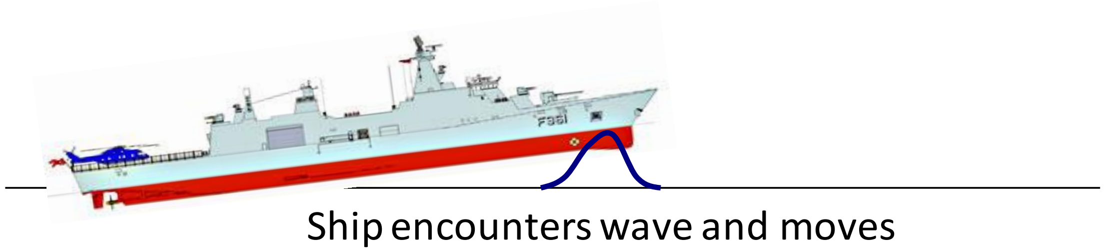


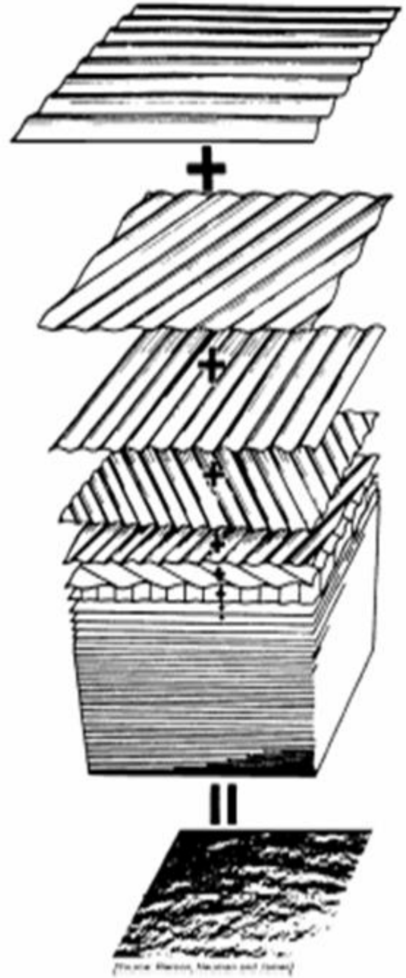
This paper focuses on wave propagation prediction

- The waves height is measured using a X-band radar and a computationally expensive processing

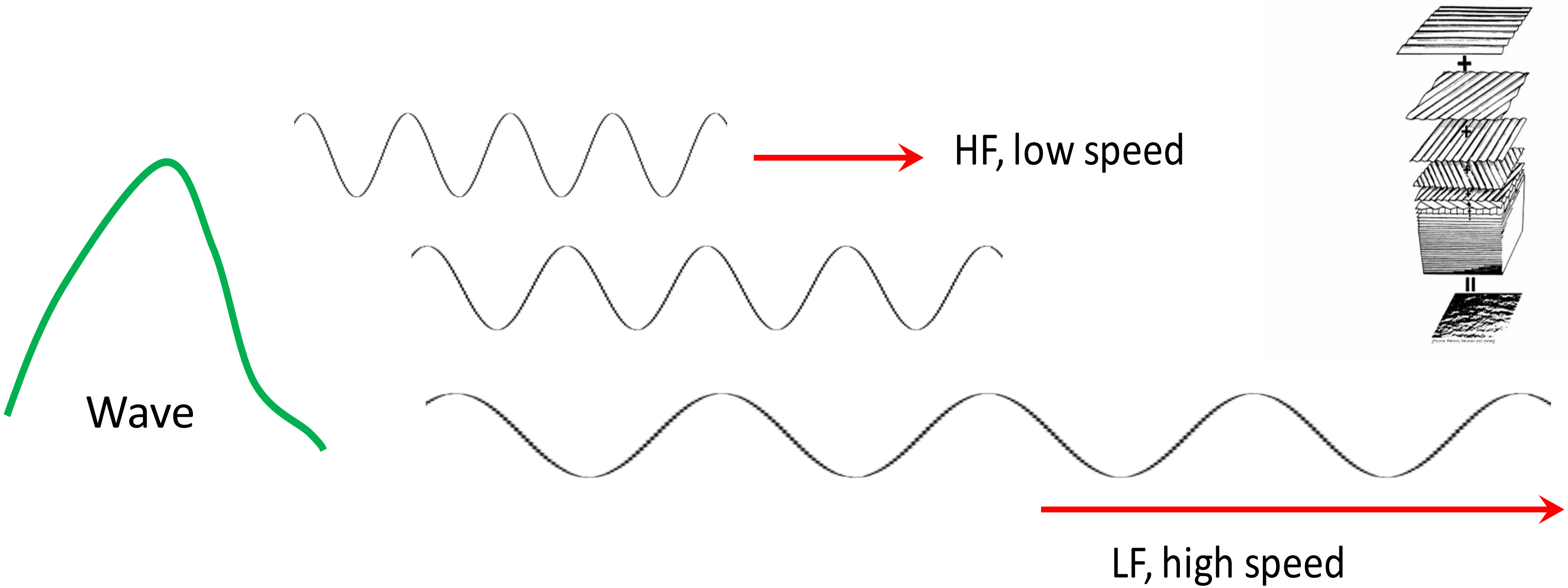
- The prediction concerns waves *one by one*, it is not statistical prediction

To give an idea of dimensions.
If one wants a prediction horizon of 30 seconds,
then waves must be measured at 450 m distance

Wave propagation and wavelets

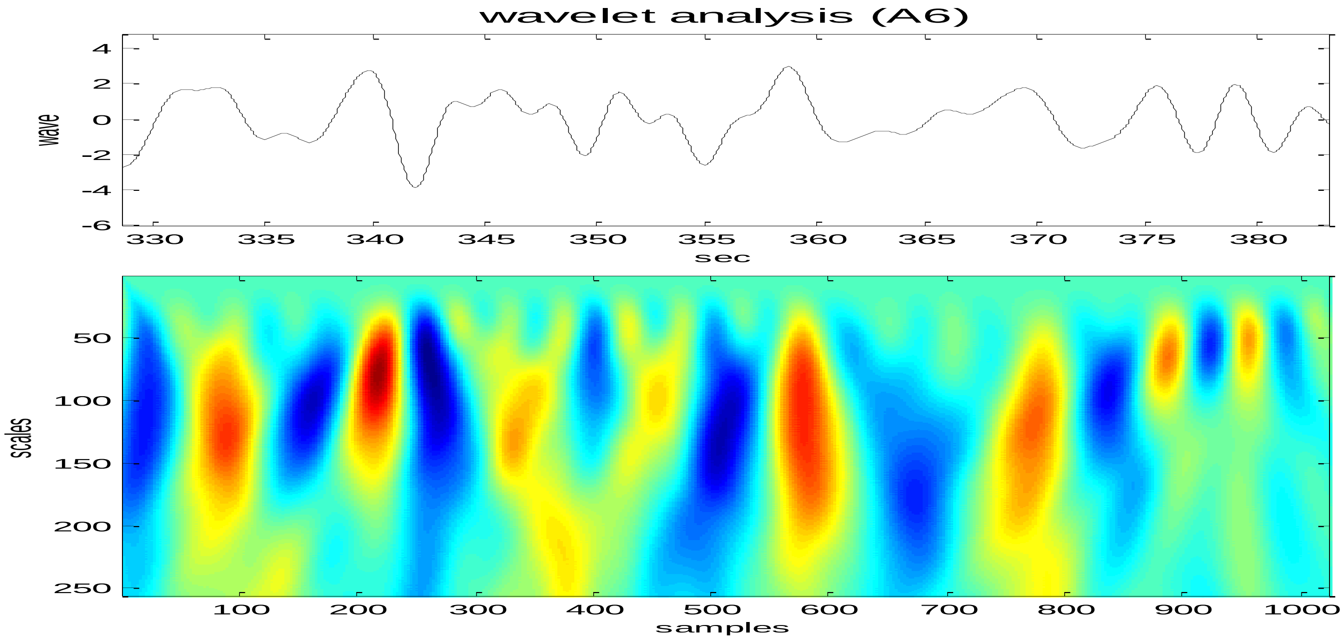


Classical decomposition into Fourier harmonics



While the wave moves, its shape changes since harmonics have different velocities

By design wavelets capture better the instantaneous Time-frequency information of non-stationary signals

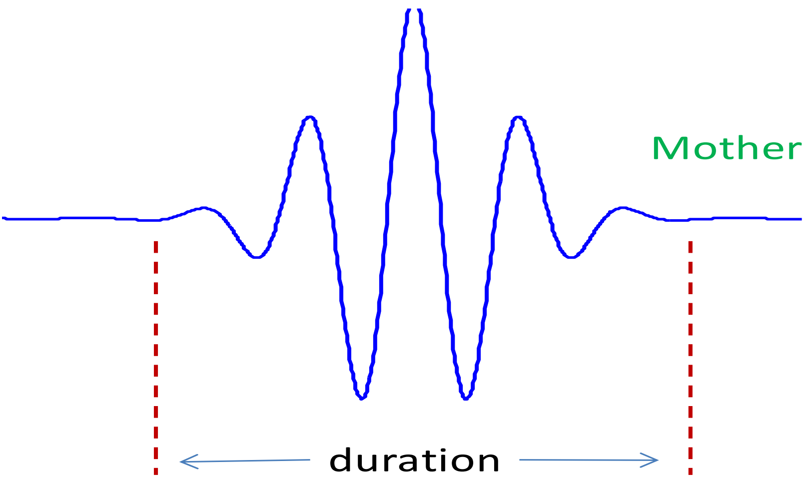


Signal (waves)

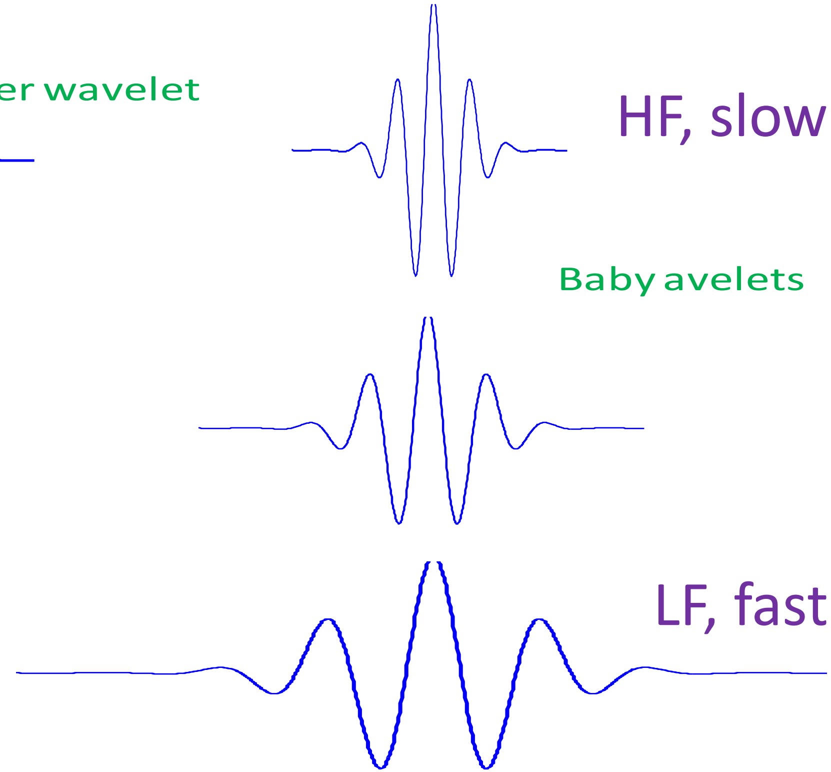
Frequency contents (scalogram)

valleys crests

Large and small wavelets (same family)



Mother wavelet



HF, slow motion

Baby avelets

LF, fast motion

Wavelet type: Morlet

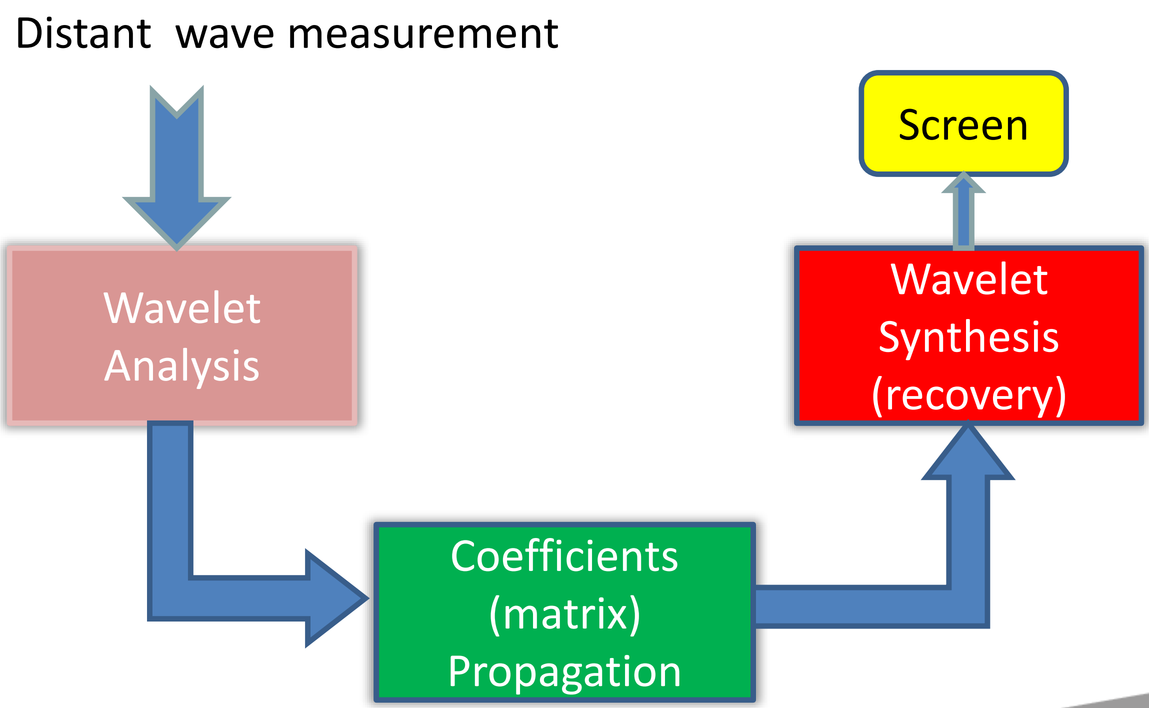
Signals can be decomposed combining small and large wavelets

The proposed method

How to predict the wave deformation along propagation

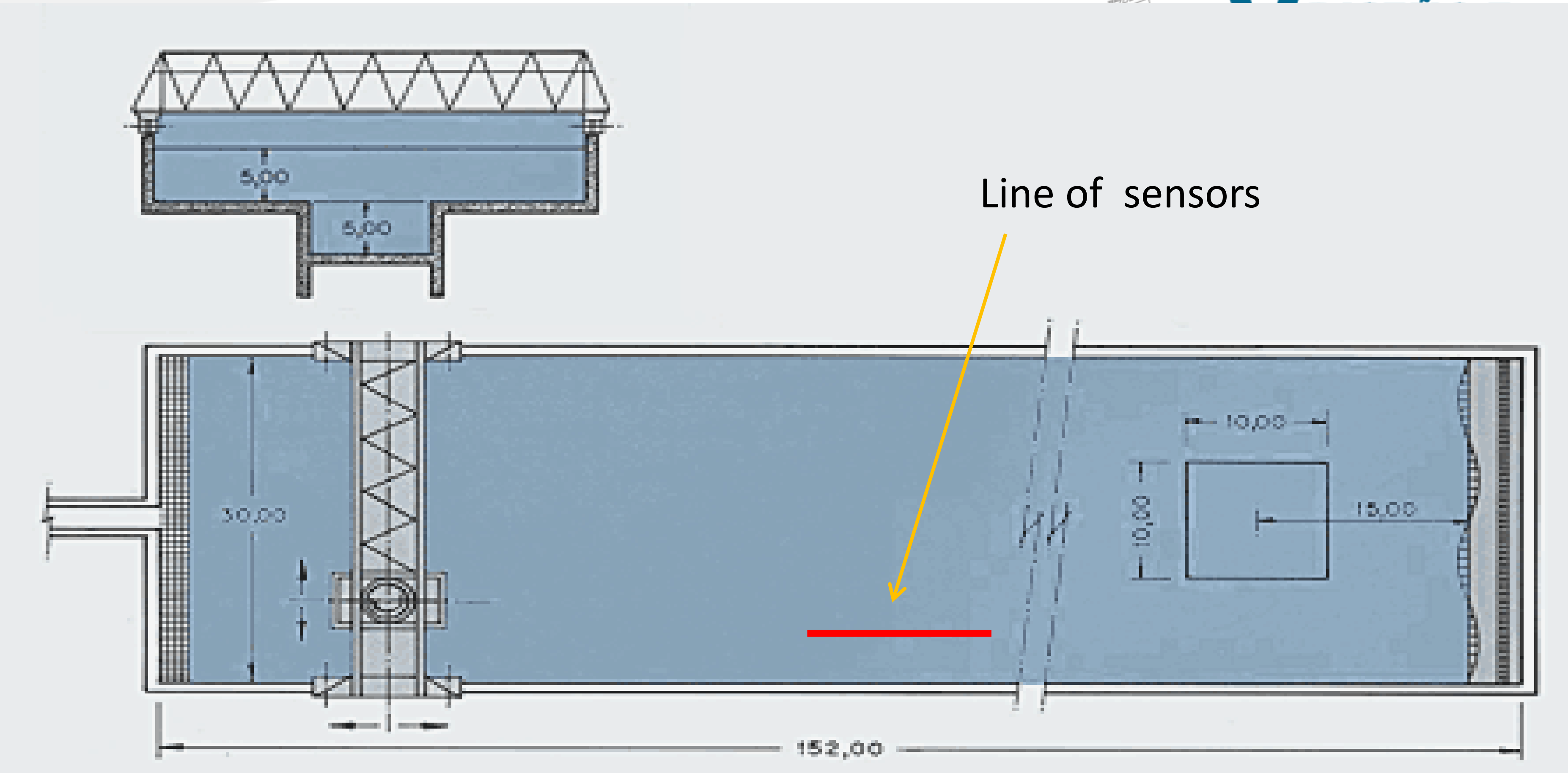
- Decompose into wavelets
- Propagate (move) the wavelets
- Recombine the wavelets

  after propagation



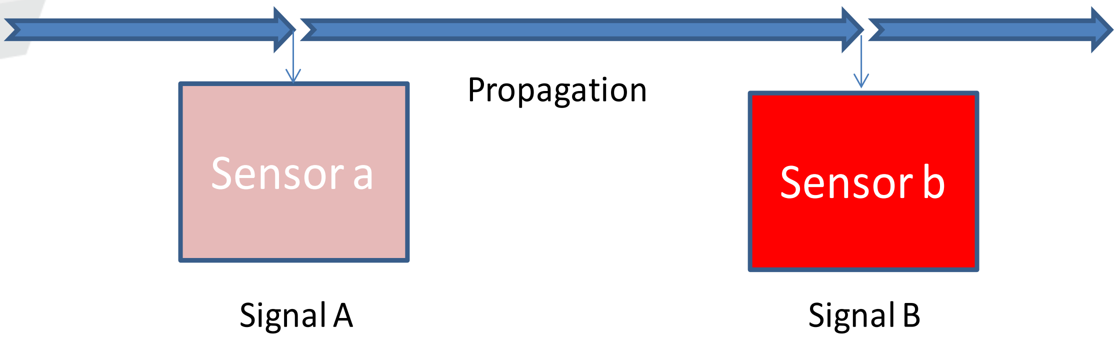
CEHIPAR, ship dynamics laboratory

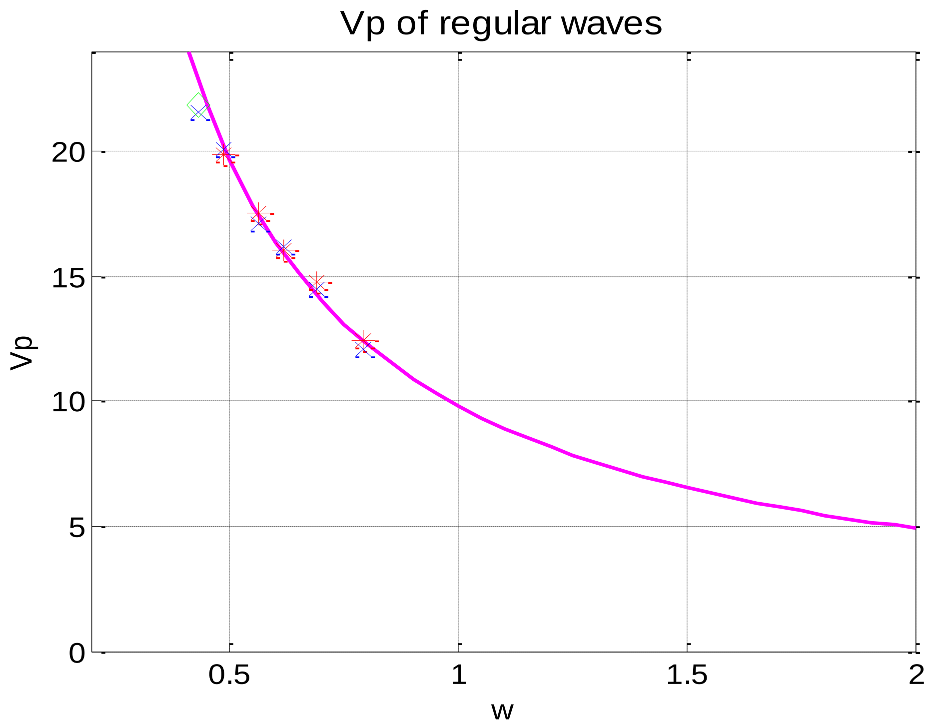
Arrangement for wave propagation measurements



12 regular waves and 3 irregular seas (JONSWAP) were generated

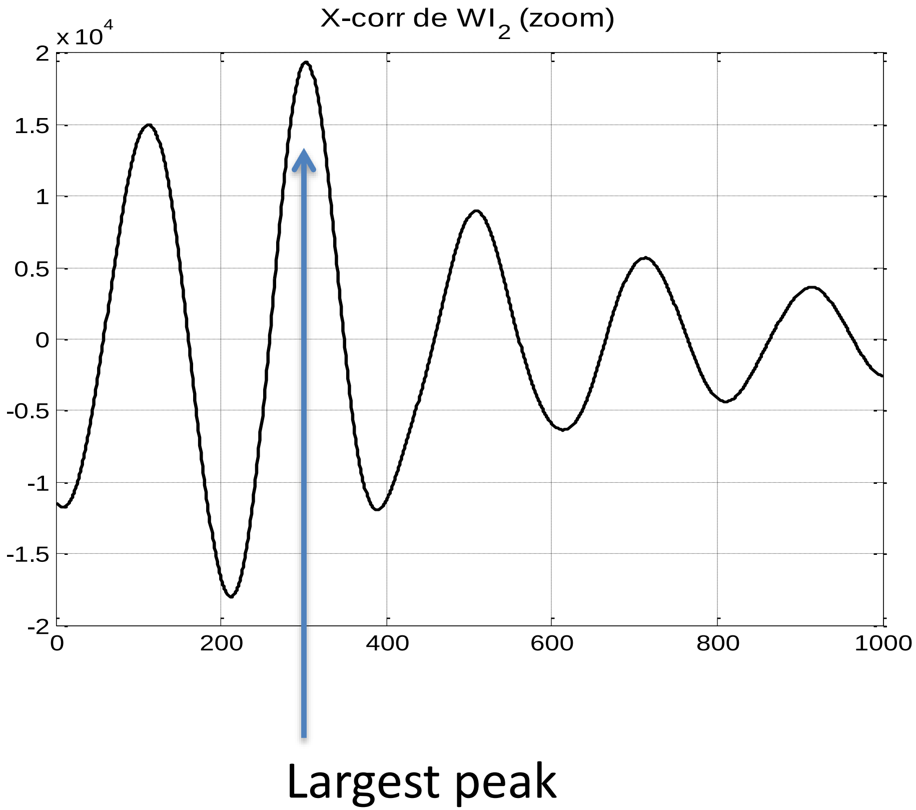
Propagation velocities





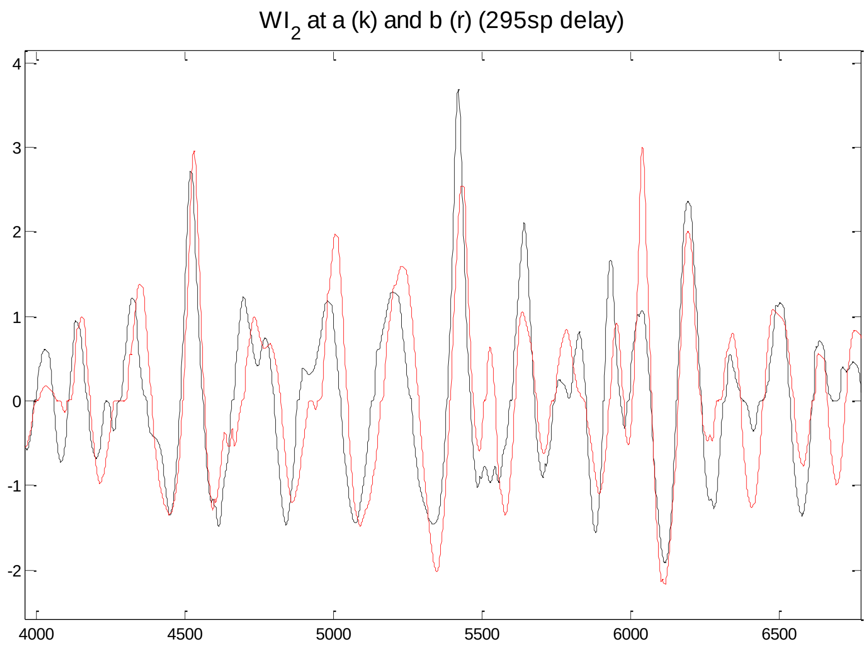
Regular waves propagate according with theory

Irregular seas



Propagation delay can be measured using cross-correlation

Irregular seas



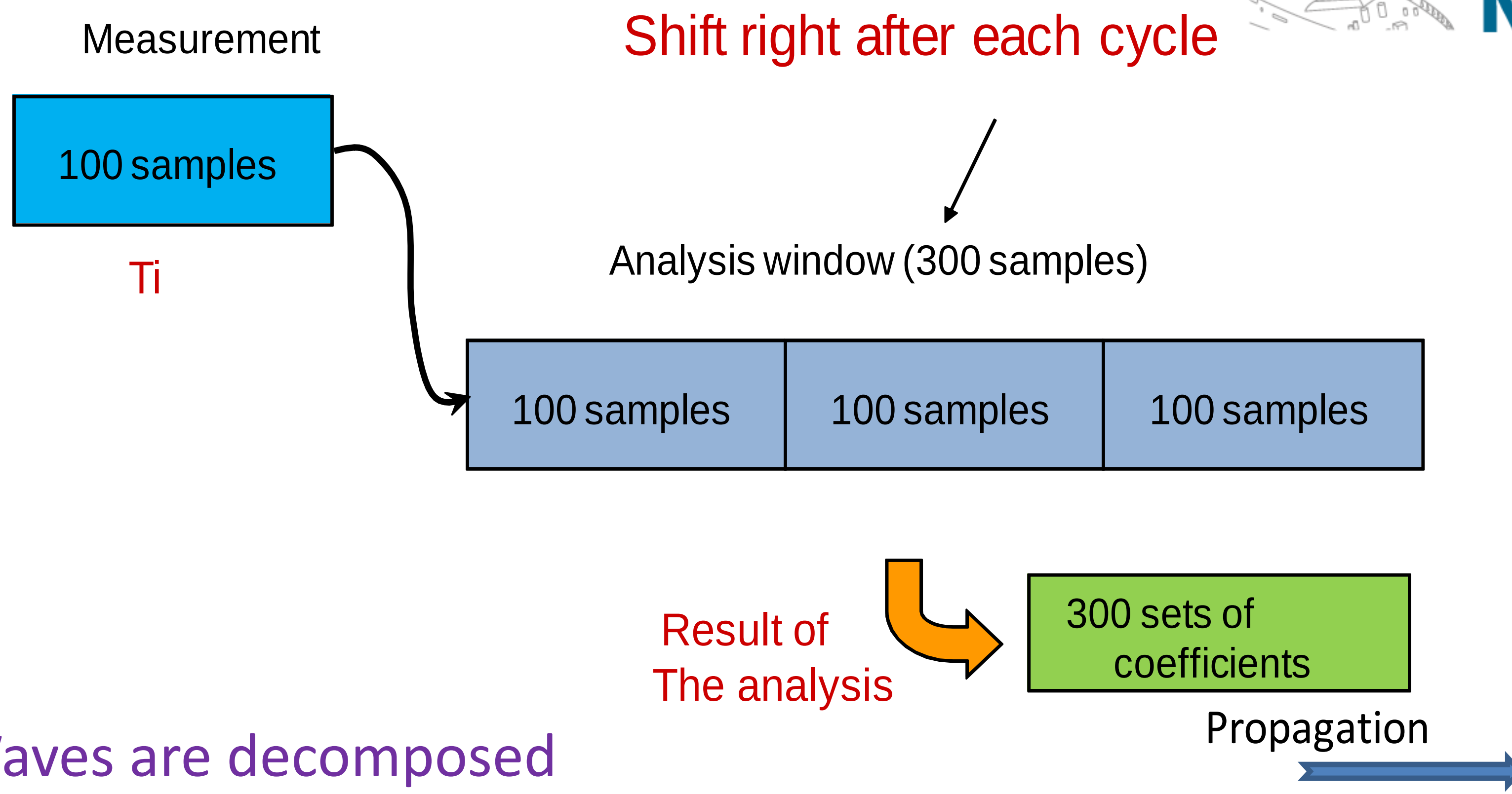
Once delay is determined,
the propagated wave is shifted
In order to compare with the
original wave

Notice the deformation after 67 m of propagation

Implementation of the prediction method

- We take succesive segments of wave trains
- Computation speed is required

The analysis part

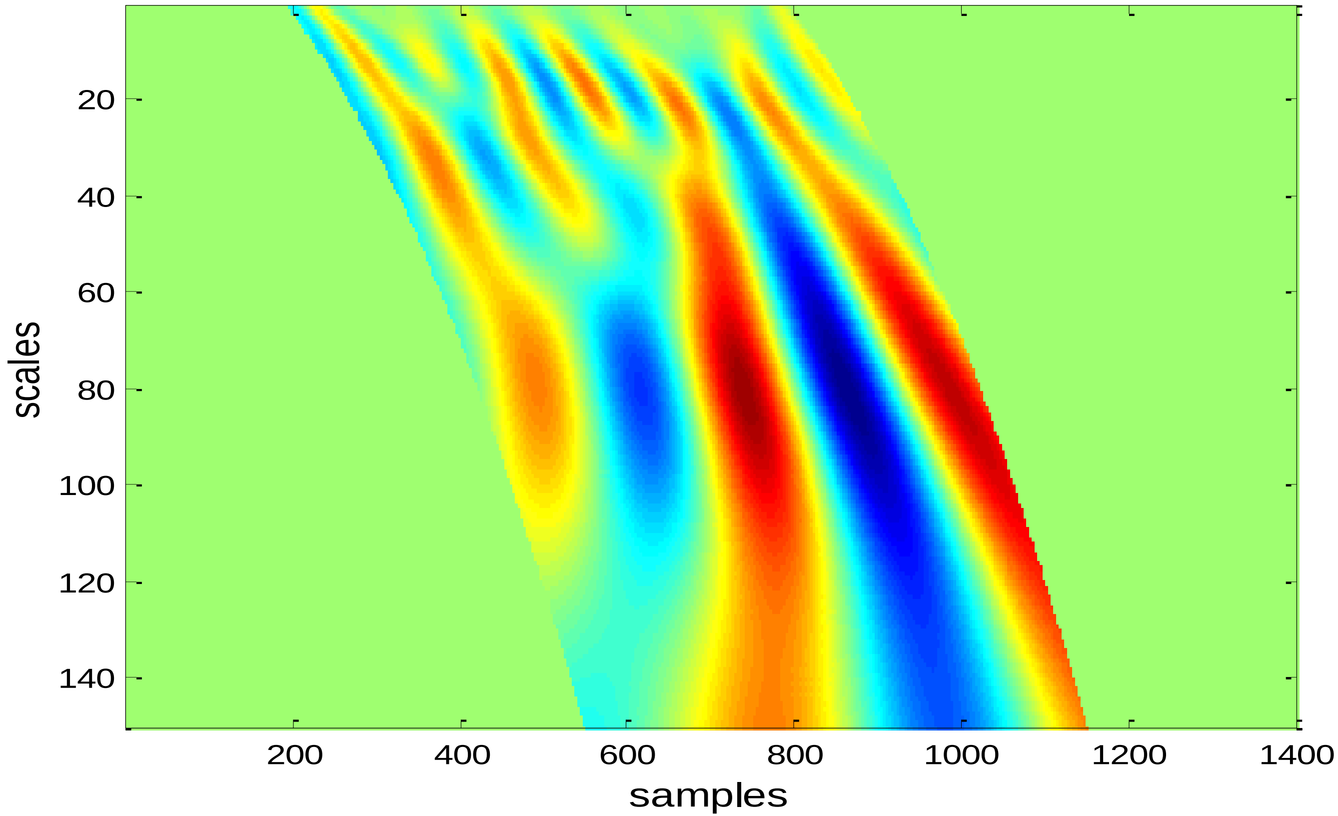


Waves are decomposed into wavelet coefficients

The propagation matrix

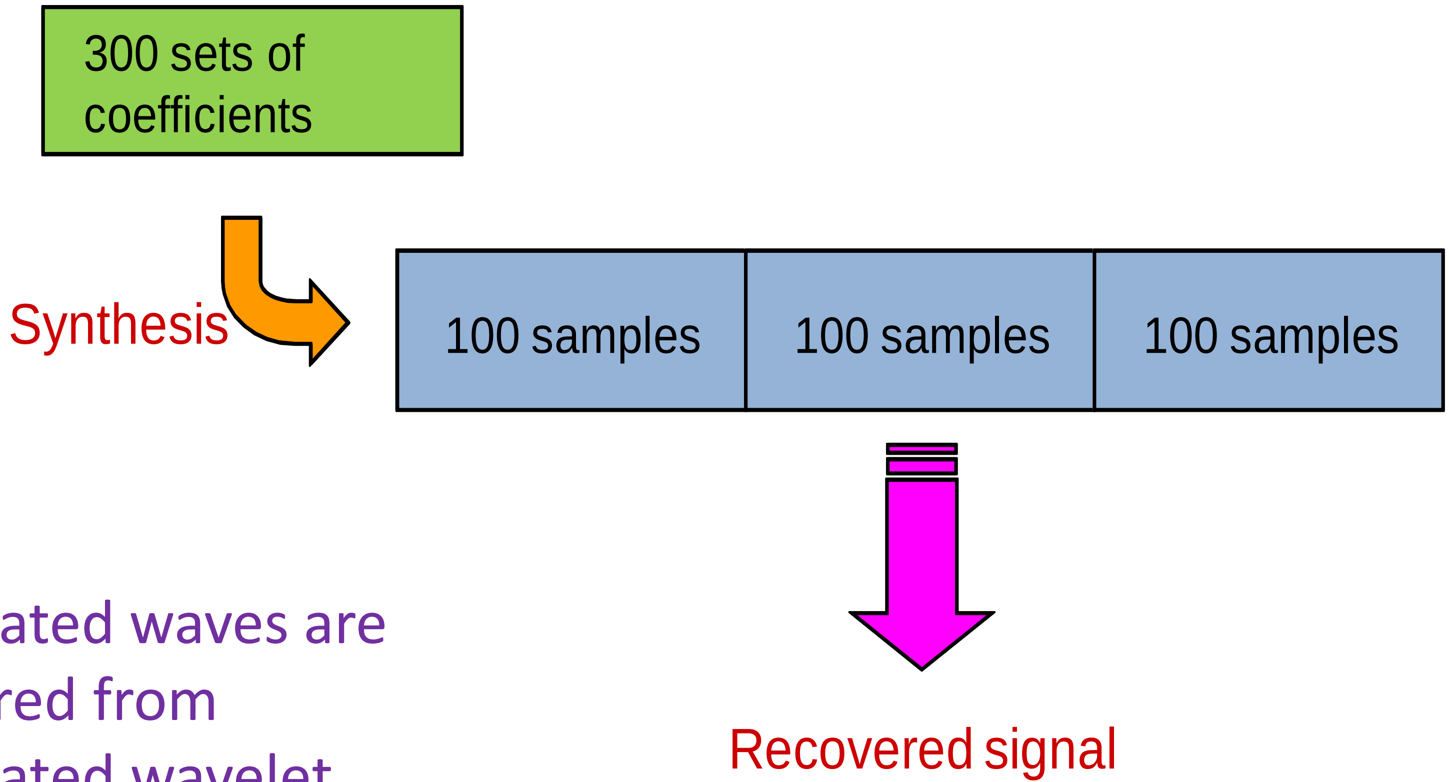
High frequency
Slow prop

Low frequency
Fast prop



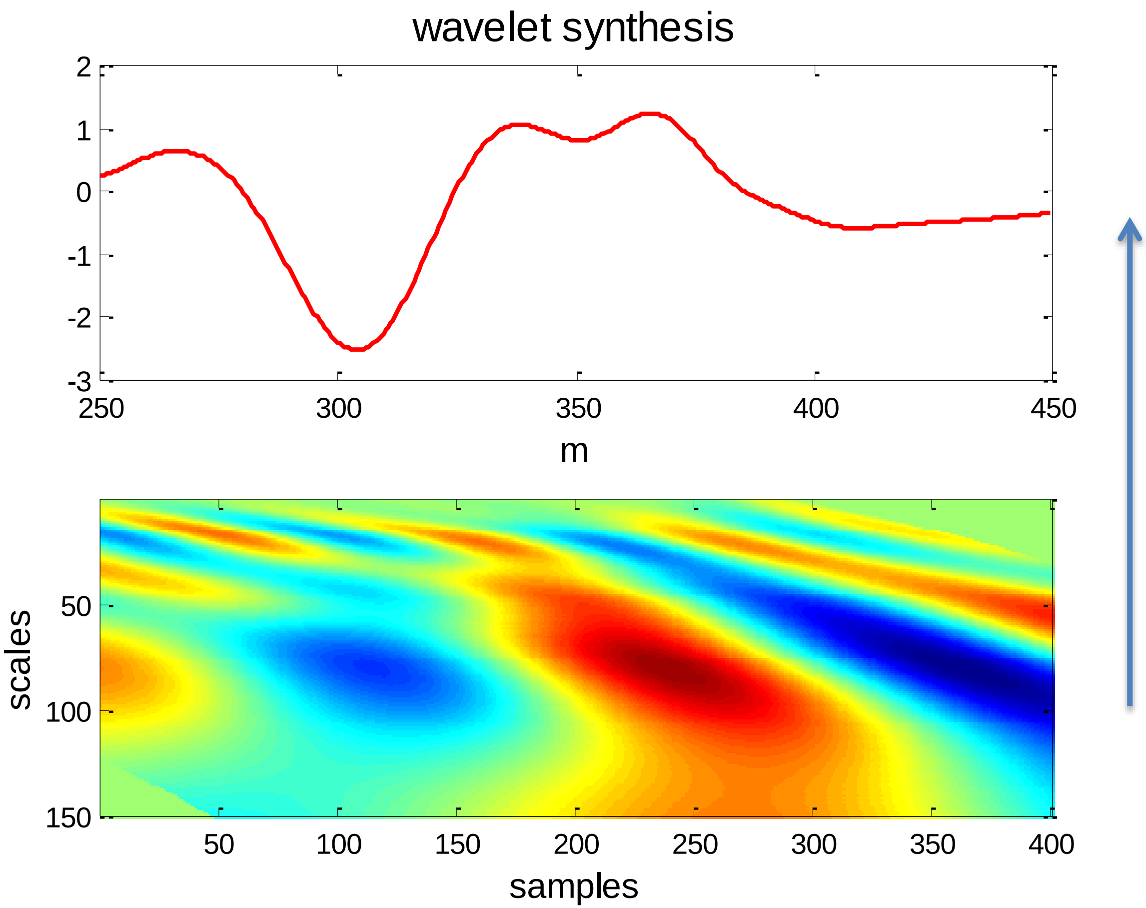
Here we propagate the Wavelet coefficients

The synthesis part



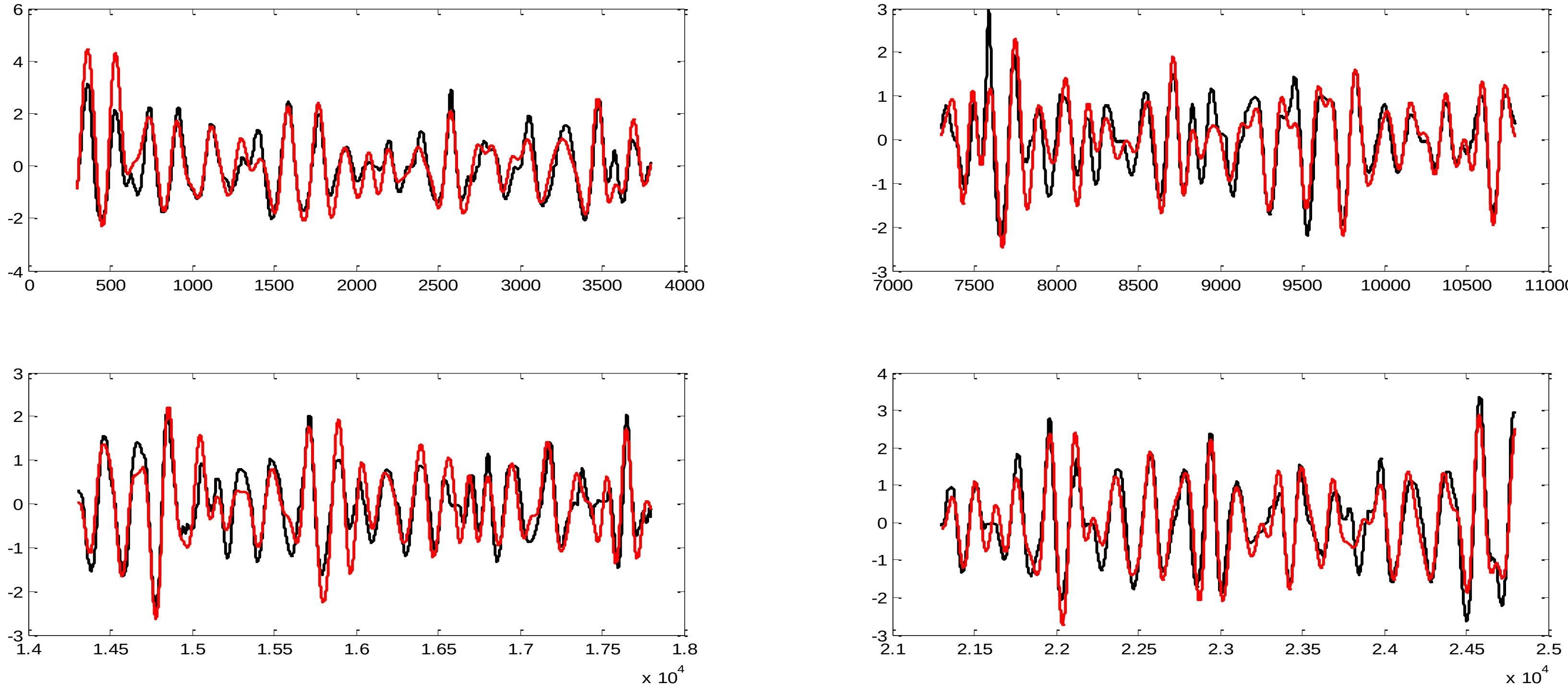
Propagated waves are recovered from propagated wavelet coefficients

The synthesis part



The propagated wave
Is obtained from the
Propagation matrix

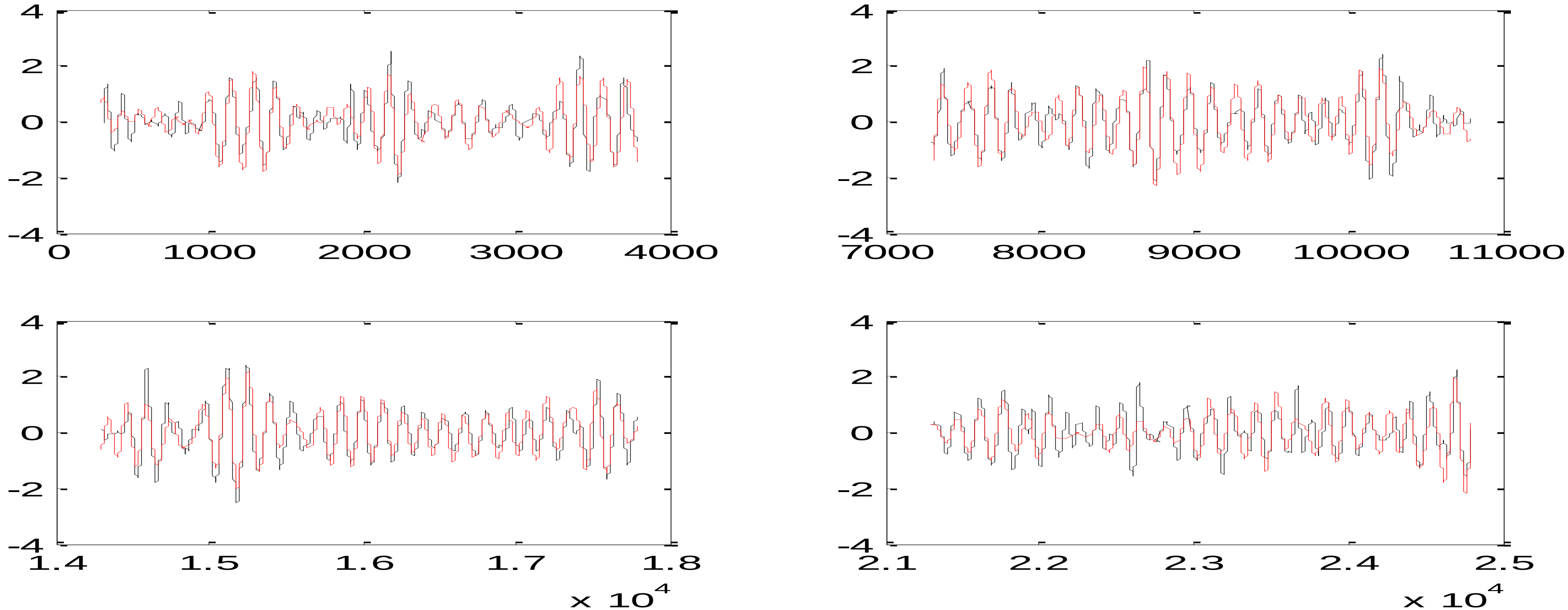
Irregular JONSWAP sea



Black- measured

Red- predicted

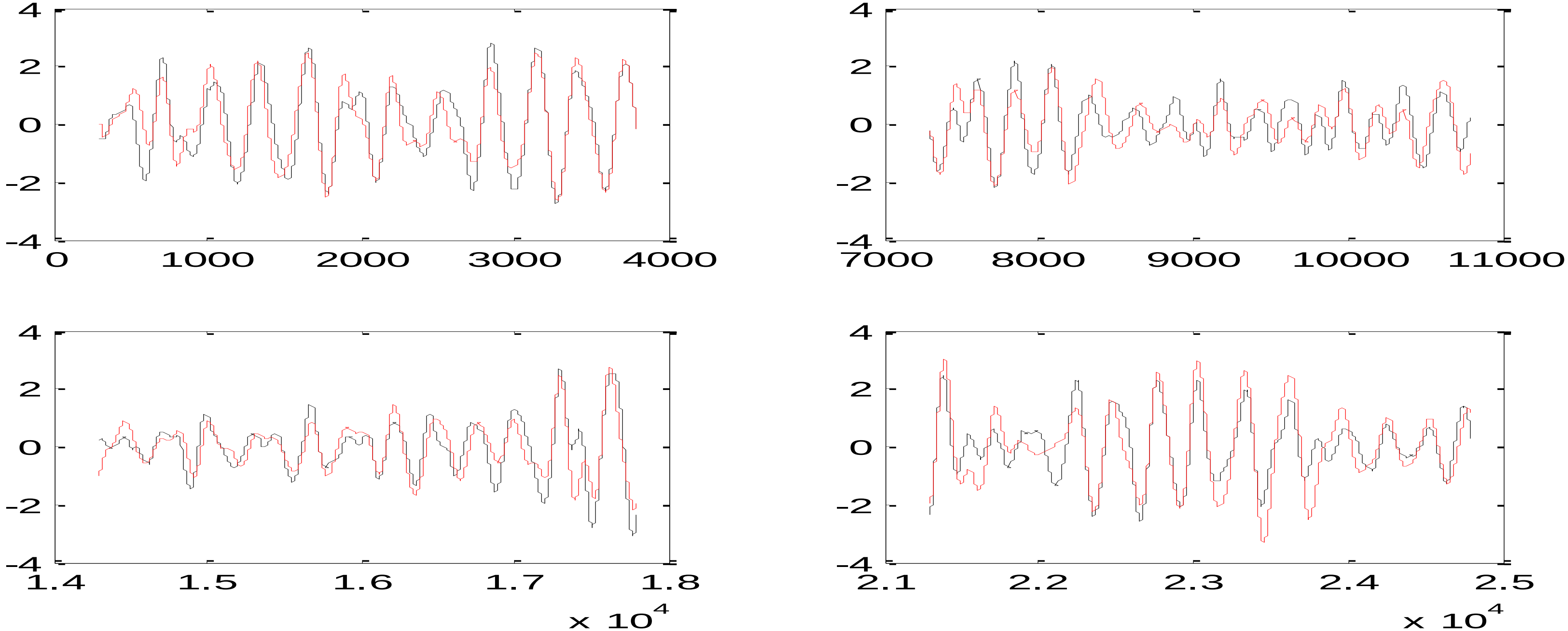
Irregular JONSWAP biased towards High Frequency



Black- measured

Red- predicted

Irregular JONSWAP biased towards Low Frequency



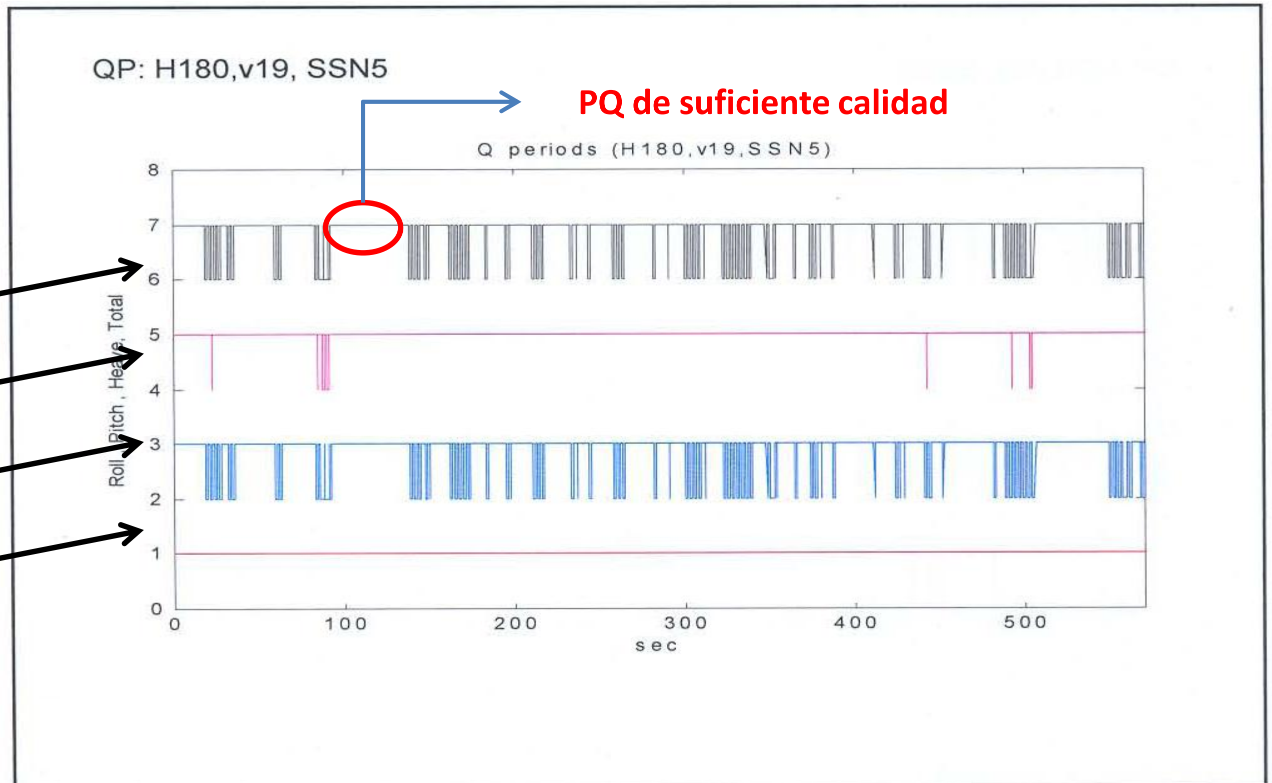
Black- measured

Red- predicted

RESULTADOS PROGRAMA QPP

Datos:

- Composición
- Arfada
- Cabeceo
- Balance



Criterios establecidos en el STANAG 4154

Conclusions

- Good results, and some improvements are under way, close to 90% goals

- 30 s, of prediction horizon can be obtained with 6 s of computation

- First coupling with a ship motions model show satisfactory prediction of QPP on ship

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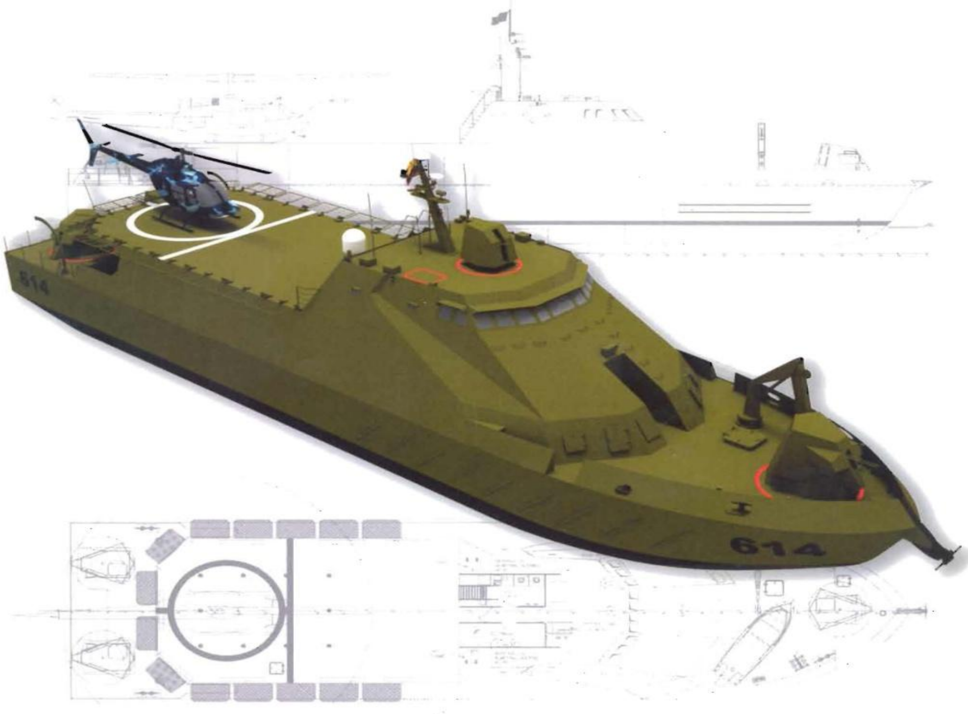

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Smoothing warships movements based on wavelets

Reducción de los movimientos del buque de guerra basándose en wavelets

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J.J. Díaz [3]

Abstract

In seakeeping terminology, the Quiescent Period is known as the period of calm in rough waters to allow the ship to perform operations such as landing aircrafts and unmanned aerial vehicles (UAVs), aswell as the entry of landing crafts in the basin. Quiescence refers to the interval of time where all ship motions are within acceptable limits to perform a desired activity. Among the key issues for Quiescent Period Prediction is to be able to measure waves from a suitable distance and predict ship motions in response to waves encountered; both aspects are crucial and must be taken into account. Many of the opearations performed at sea are carried under severe weather conditions, as a result of this situation there is a need to determine this called "window of opportunity" that allows carrying them out. The paper aims to explain from the point of view of Quiescent Period Prediction, the most promising wave measurement systems, which are currently based on radar, but the main question is that if we want predictions a few seconds ahead, it will be appropriate to measure waves at a distance of some hundreds of meters, describing the new mathematical model based on wavelets in determining the spread of the waves from their initial measurement until they reach the vessel.

Key words: Quiescent Period, Wavelet, Ship Motions, Seakeeping, Control, Hydrodinamics

Resumen

Dentro del ámbito del comportamiento en la mar, se denomina Periodo Quiescente a aquellos periodos de calma que se producen en un estado de mala mar que permiten al buque llevar a cabo operaciones como pueden ser el aterrizaje de plataformas aéreas, vehículos aéreos no tripulados (UAVs) o la entrada de lanchas en el dique. El término quiescente hace referencia al intervalo de tiempo durante el cual los movimientos del buque se encuentran dentro de los límites aceptables para llevar a cabo una actividad determinada. Las claves para llegar a predecir los Periodos Quiescentes están en ser capaz de llegar a medir las olas desde una distancia adecuada, y ser capaz de llegar a predecir los movimientos que dichas olas inducirán en el buque una vez le alcance; ambos aspectos son cruciales y deberán ser tenidos en cuenta. Muchas de las operaciones que se realizan en la mar se llevan a cabo bajo condiciones climatológicas adversas, y es en estos casos donde surge la necesidad de determinar una "ventana de oportunidad" que nos permita llevarlas a cabo. El artículo trata de explicar desde el punto de vista de la predicción de periodos quiescentes los sistemas de medida de oleaje más prometedores, actualmente basados en radar, pero la inquietud principal es que si queremos una predicción de varios segundos en adelanto es necesario medir las olas a una distancia de cientos de metros, para ello se describirá el nuevo desarrollo matemático basado en "wavelets" que se ha empleado para determinar la deformación que sufren las olas desde su medida inicial hasta que alcanzan la plataforma.

Palabras claves: Periodos Quiescentes, Wavelet, Movimientos del Buque, Comportamiento en la Mar, Control, Hidrodinámica

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