UNIVERSITÀ DEGLI STUDI DI GENOVA

15th International Workshop on Wave Hindcasting and Forecasting & 6th Coastal Hazard Symposium

Storm Clustering in the Mediterranean Sea

Giovanni Besio[1], Riccardo Briganti[2], Alessandro Romano[3], Lorenzo Mentaschi[4], Paolo De Girolamo[3]

1 Department of Civil, Chemical and Environmental Engineering, University of Genoa, Italy – giovanni.besio@unige.it

2 Department of Civil Engineering, University of Nottingham, UK

3 Department of Civil, Architectural and Environmental Engineering, La Sapienza University, Rome, Italy

4 European Commission, Joint Research Centre (JRC), Ispra, Italy

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OUTLINE

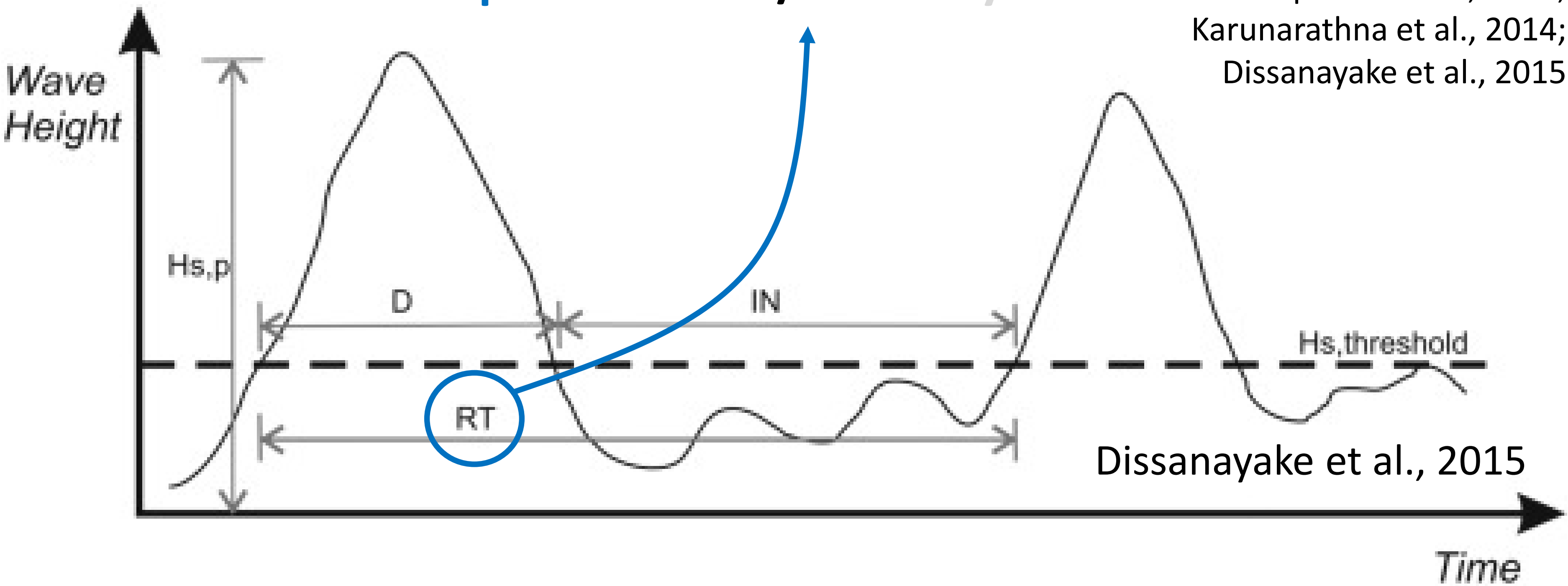
- Motivation for Storm Analysis
- Data Set
- Storm clustering identification technique
- Analysis for single location
- Basin scale trends

MOTIVATION

Occurrence of different coastal storms in a short time has been studied in the context of storm driven erosion of beaches and dunes. Storms occurring in quick succession may result in greater beach erosion than the cumulated erosion induced by single storm of higher return periods

Vousdoukas et al., 2012;
Coco et al., 2014;
Splinter et al., 2014;
Karunarathna et al., 2014;
Dissanayake et al., 2015

Repetition Time/Recovery Time



Dissanayake et al., 2015

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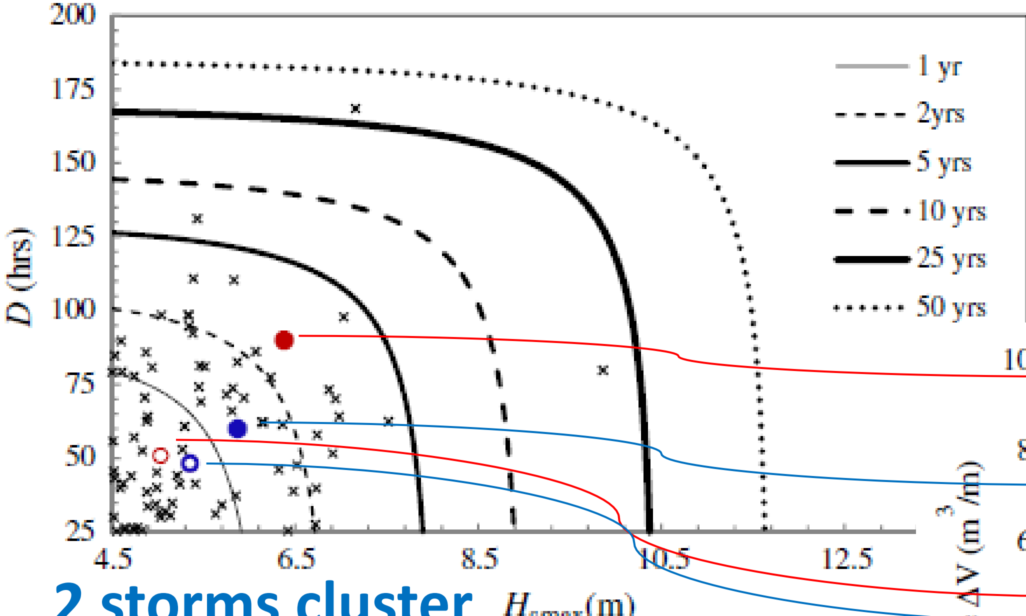

Vousdoukas et al., 2012;
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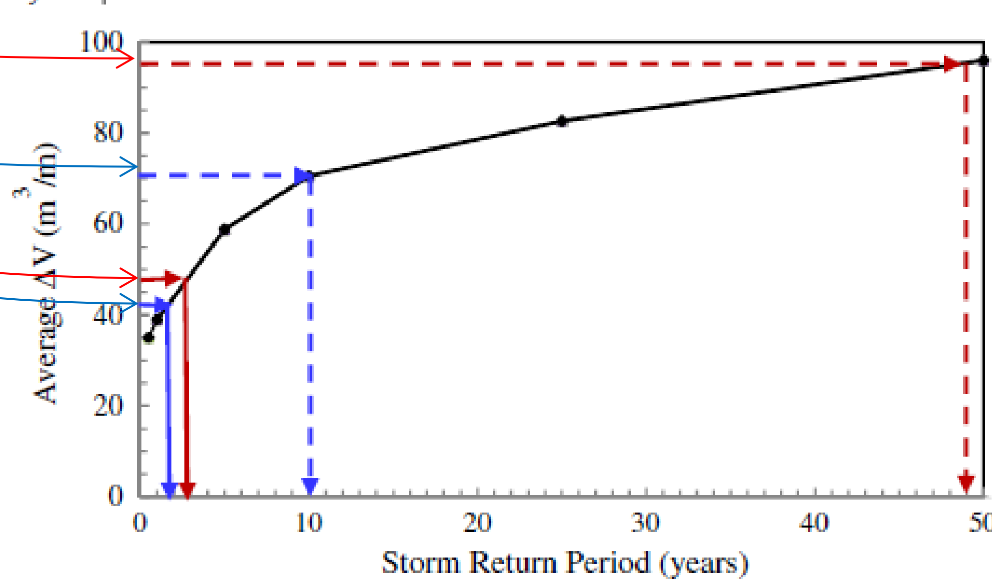
2 storms cluster

3 storms cluster

x single storm



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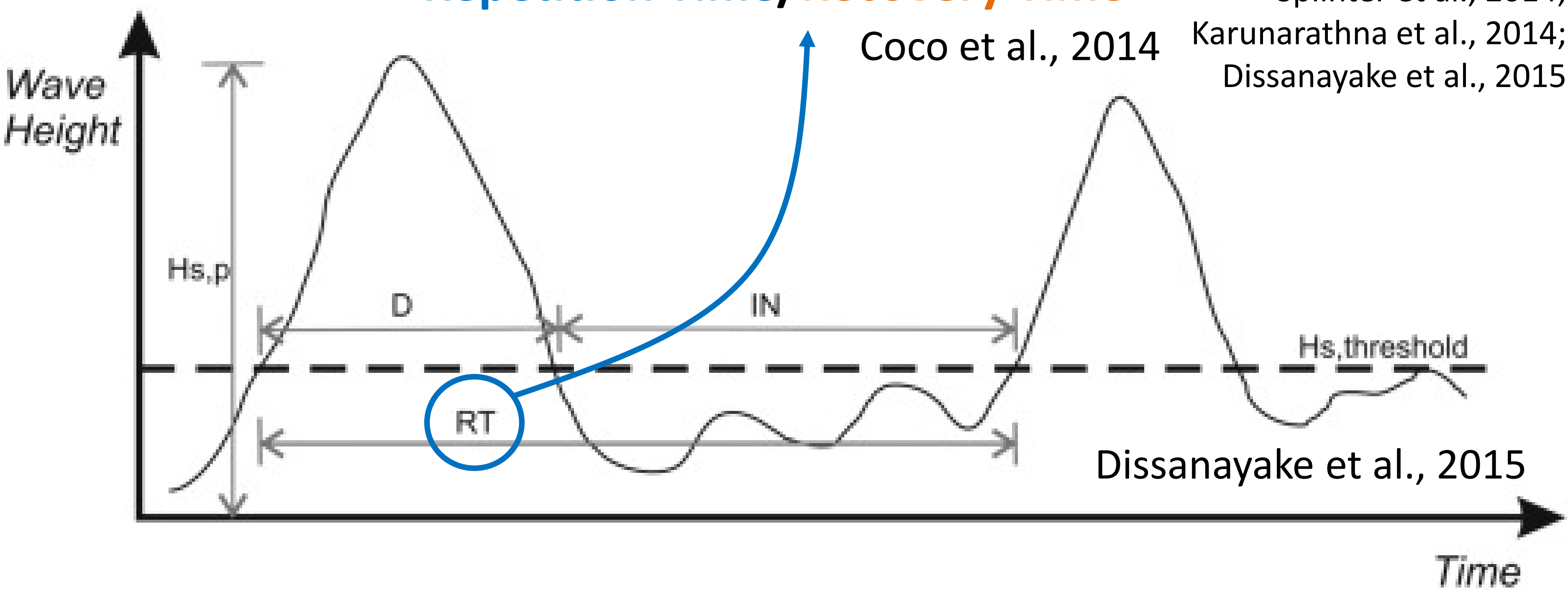

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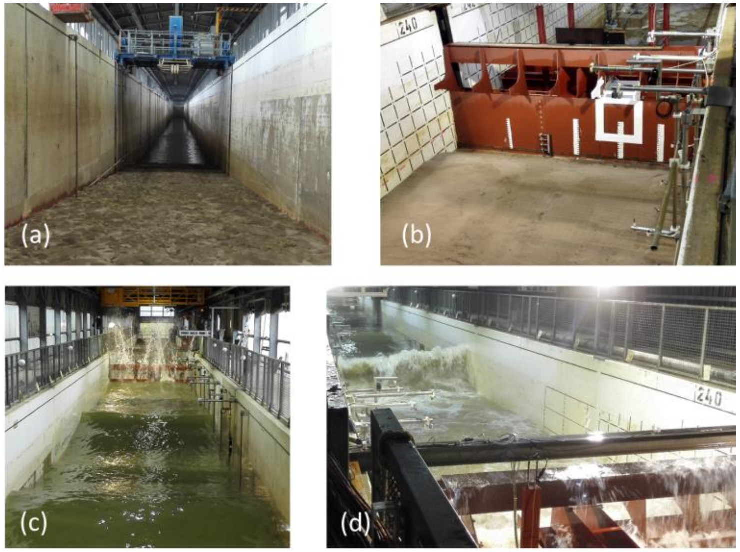
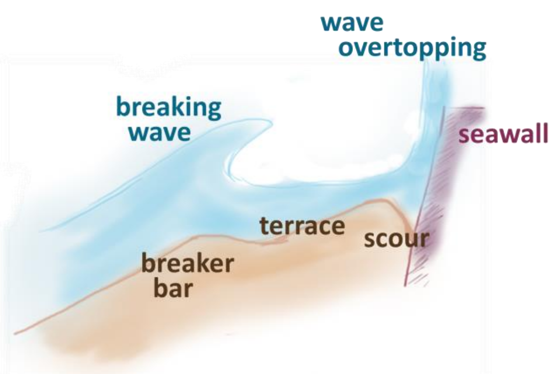
MOTIVATION

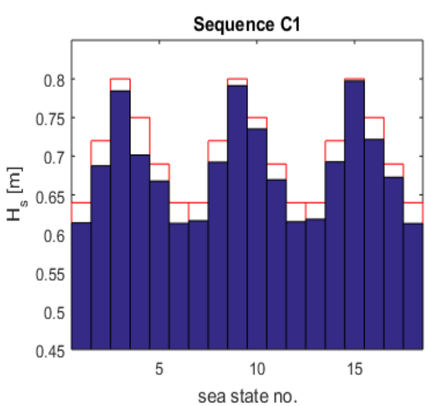


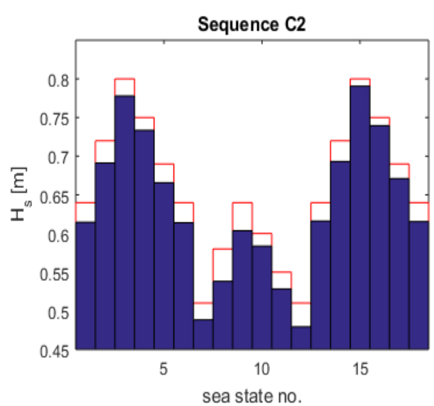
Large Wave Flume, GWK

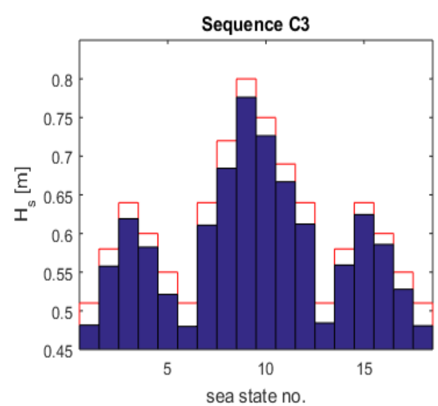
ICODEP - Impact of Changes in the fOreshore on coastal Defence Performance

The overall dynamics of the beach depends both on the energy level of the storm sequence and on the position of individual storm in the group



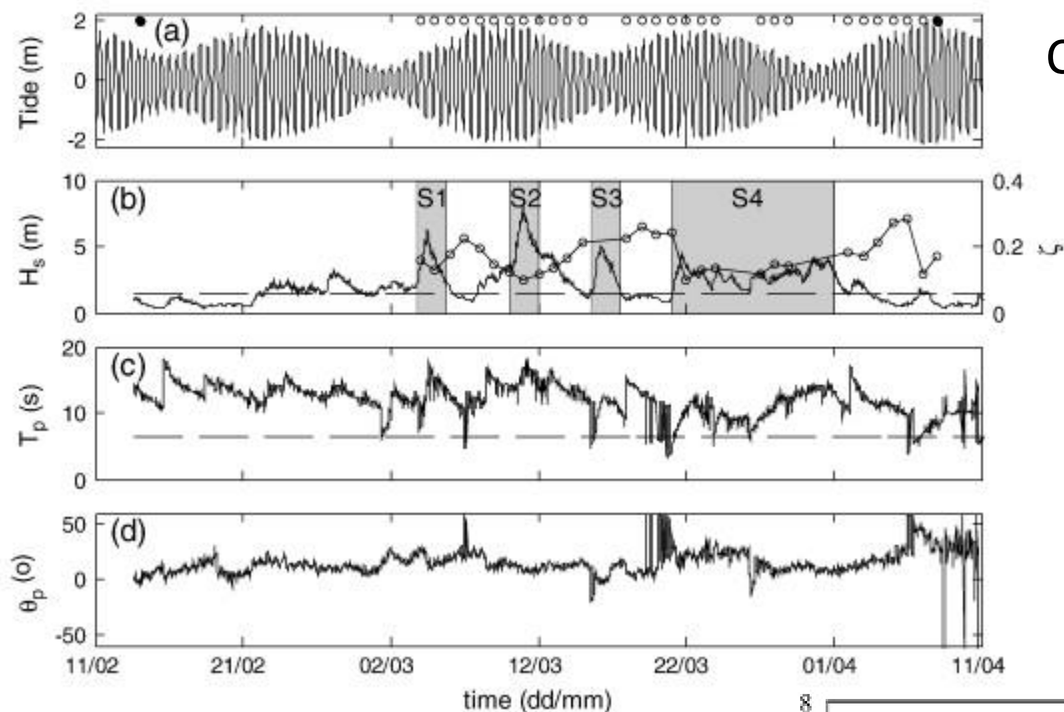






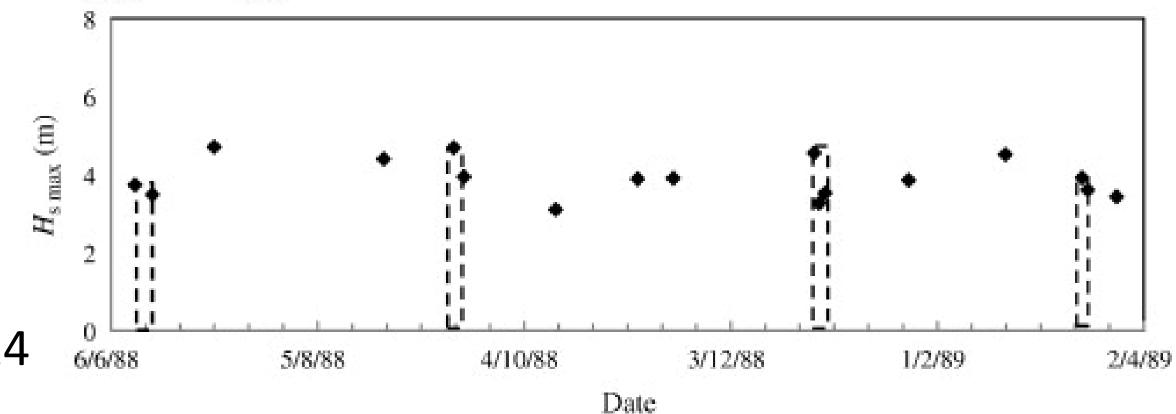
MOTIVATION

There is a fast an automatized procedure to identify storm clusters?



Coco et al., 2014

Analysis of wave storms sequences



Karunarathna et al., 2014

THE MEDITERRANEAN SEA, DATA SET

The analysis has been carried out in the Mediterranean Sea (microtidal)

We employed two data set

- Buoy measures – Rete Ondametrica Nazionale (RON)

Station Name	From	To
La Spezia	01/07/1989 00:00	31/03/2007 00:00
Alghero	01/07/1989 00:00	05/04/2008 00:00
Ortona	01/07/1989 00:00	31/12/2007 13:00
Ponza	01/07/1989 00:00	31/03/2008 16:30
Monopoli	01/07/1989 00:00	05/04/2008 00:00
Crotone	01/07/1989 00:00	15/07/2007 20:30
Catania	01/07/1989 00:00	05/10/2006 11:00
Mazara del Vallo	01/07/1989 00:00	04/04/2008 22:00
Cetraro	01/01/1999 00:00	05/04/2008 00:00
Ancona	01/01/1999 00:00	31/05/2006 12:00
Capo Comino	01/01/2004 00:00	12/09/2005 15:30
Civitavecchia	02/01/2004 11:30	12/09/2006 22:30
Capo Gallo	01/01/2004 00:00	31/03/2008 09:30
P.ta della Maestra	01/01/2004 00:00	24/11/2004 20:30

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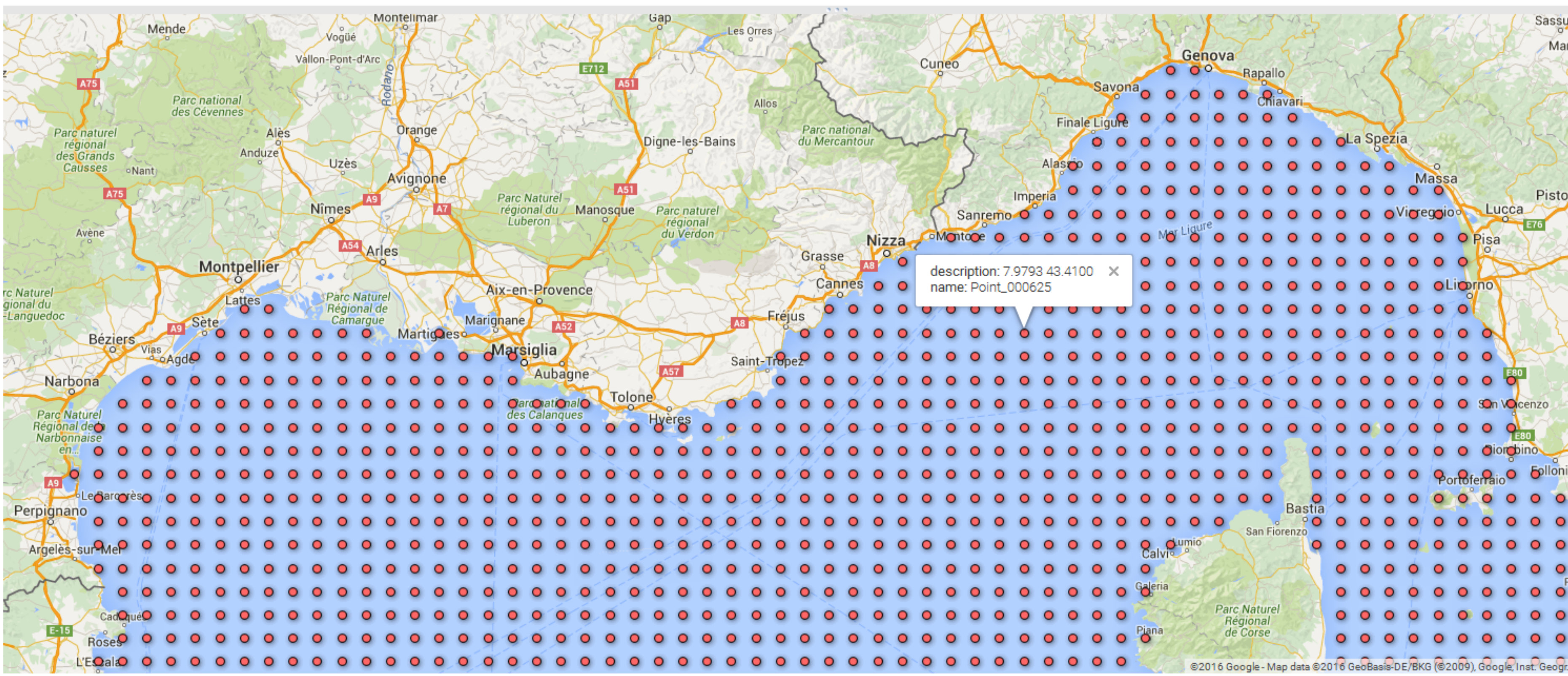
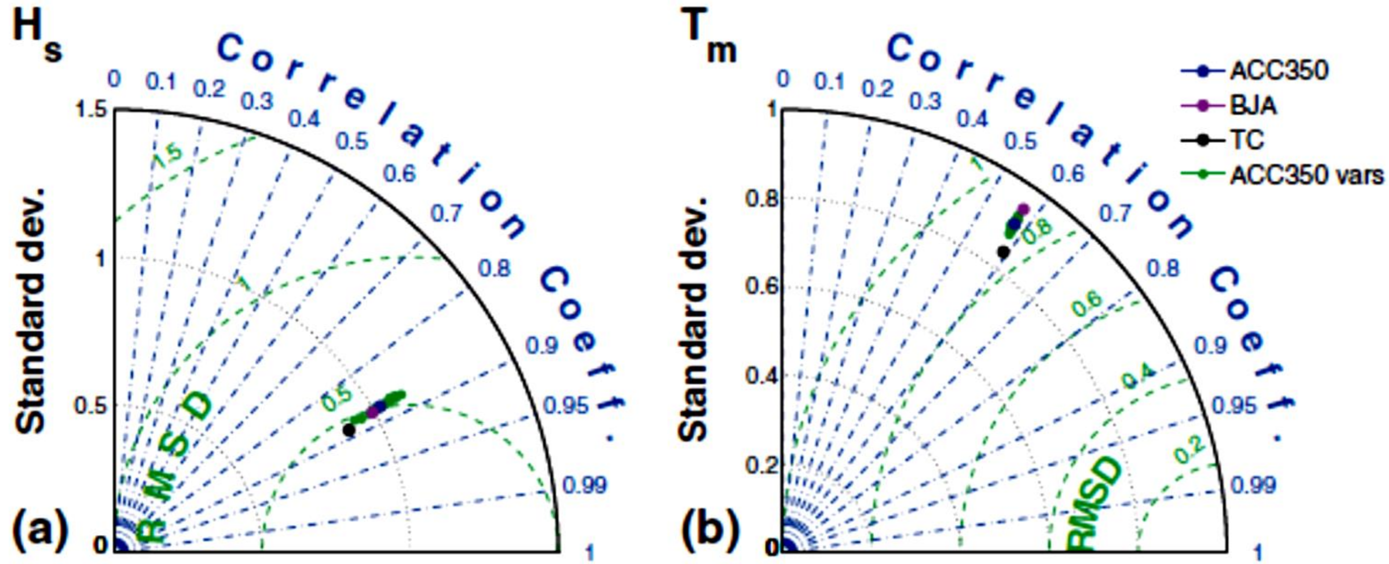
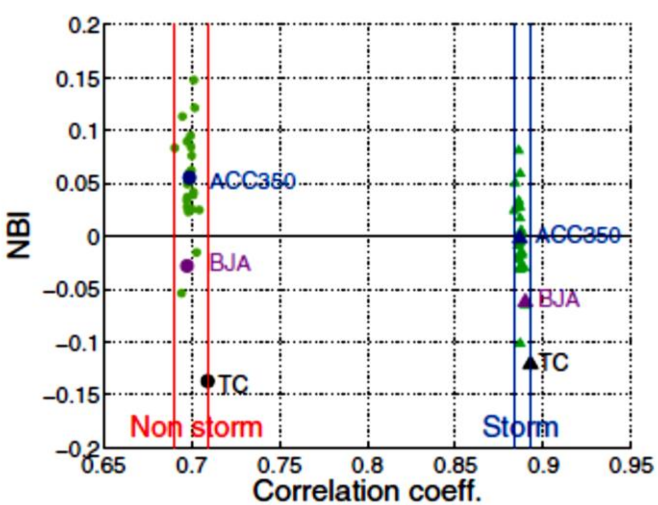
- Wave hindcast 1979-2016 @ 0.1° in lon-lat and 1 hr time res

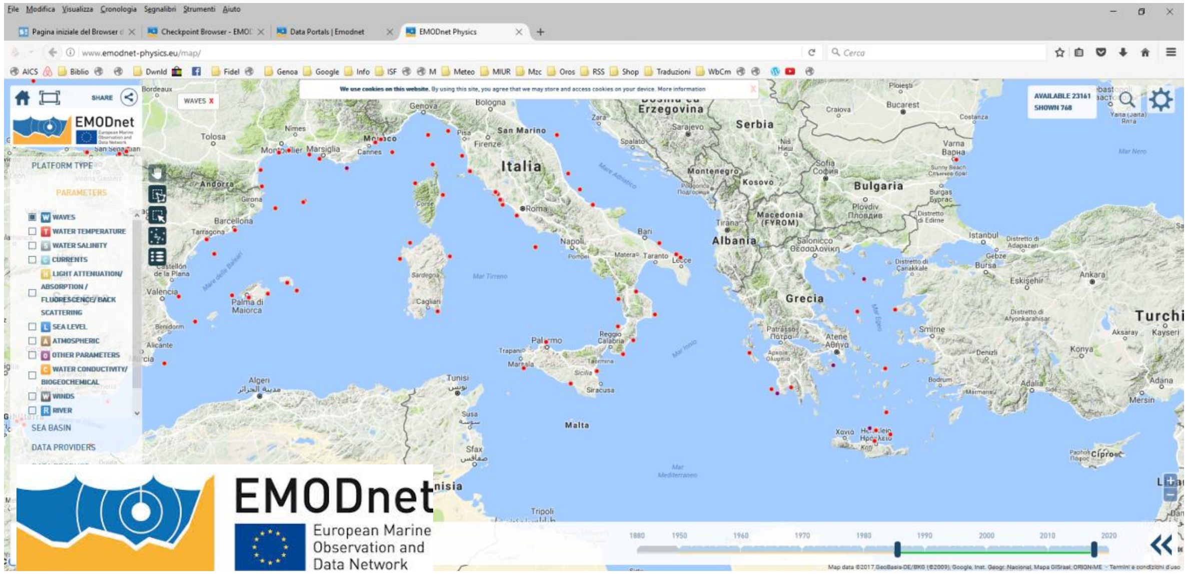


THE MEDITERRANEAN SEA, DATA SET

Hindcast validation vs wave buoys (Mentaschi et al., 2015)







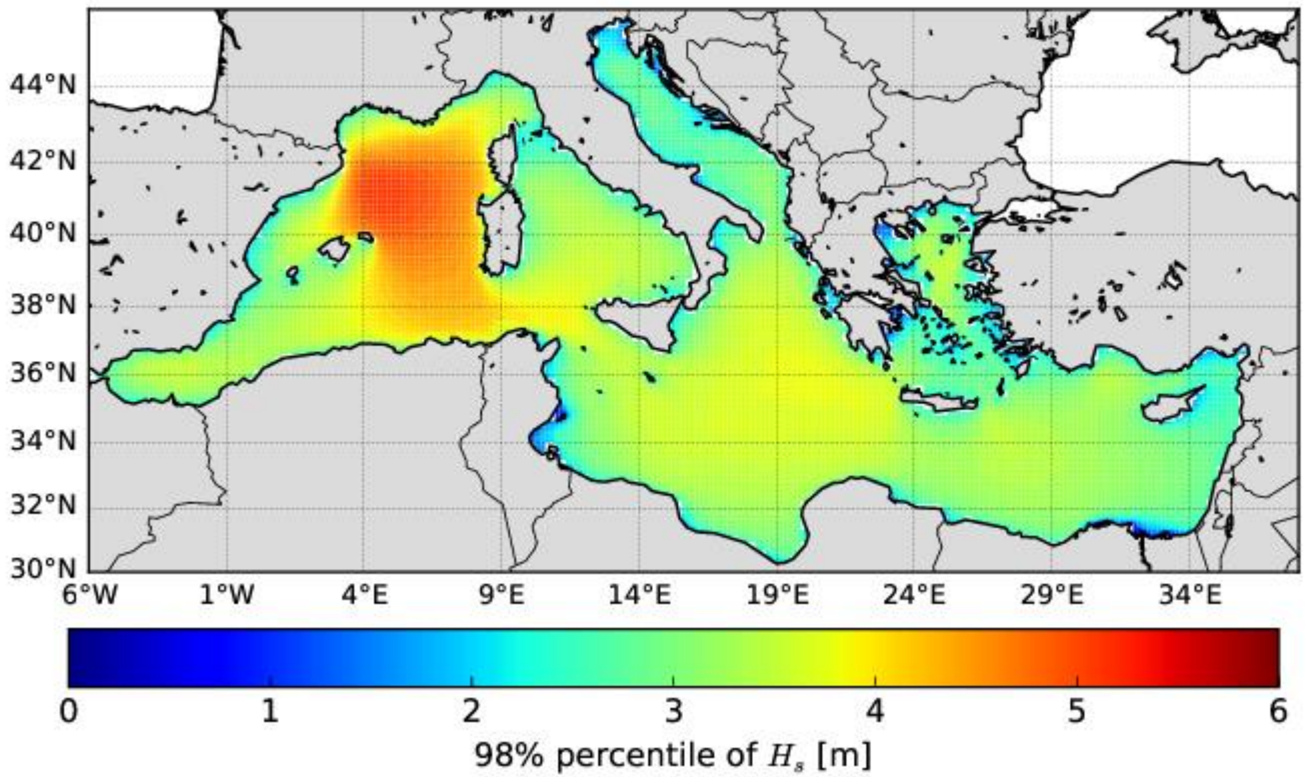
STORM CLUSTERING IDENTIFICATION TECHNIQUE

The occurrence of time clustering of wave storms is carried out through an analysis of wave storms sequences

Sequences of natural events such as earthquakes, rainfall, wildfires, can be seen as realizations of stochastic point processes

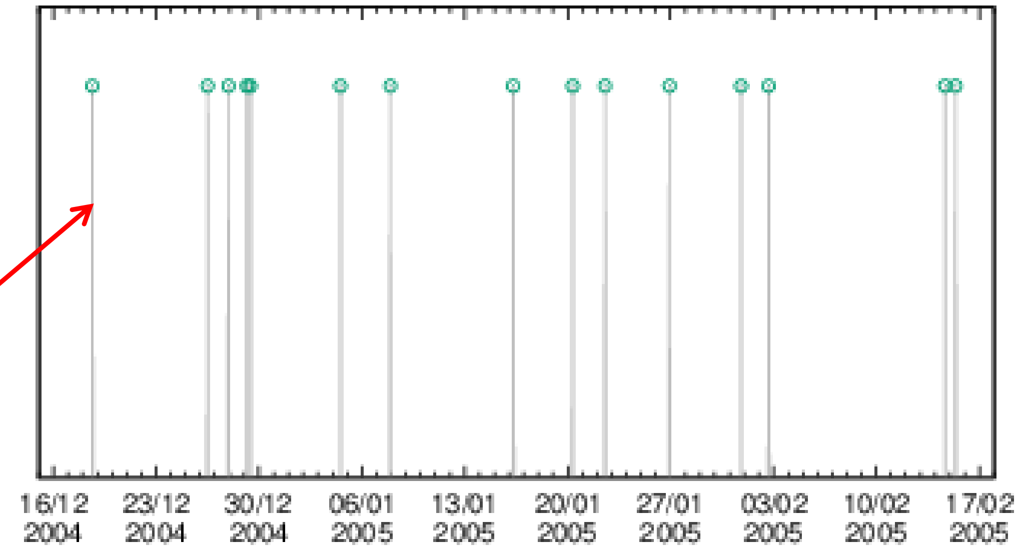
Here time series of sea states are considered

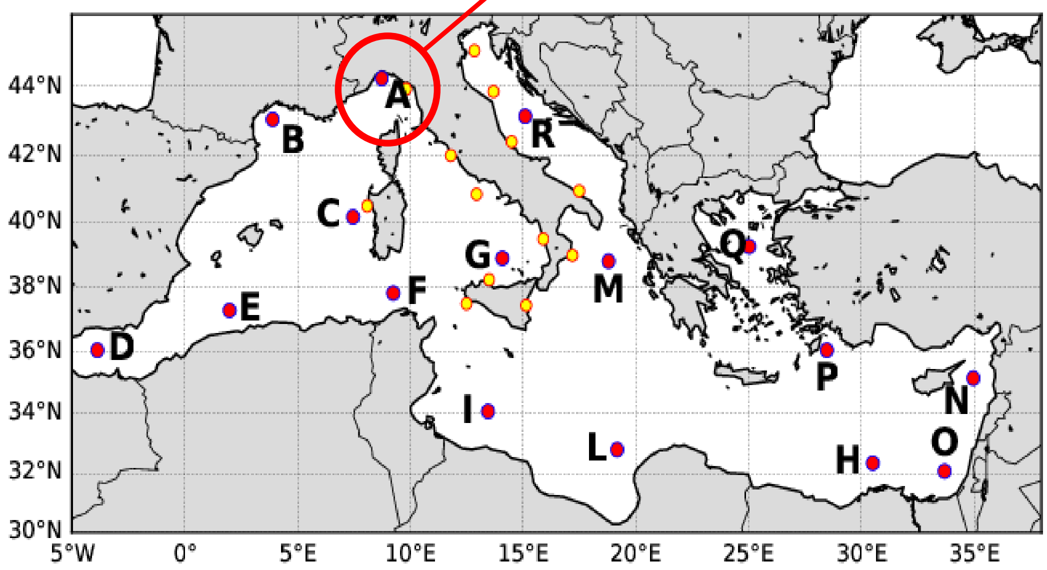
Sequence of storms are be extracted from a time series of sea states (POT, different percentiles)

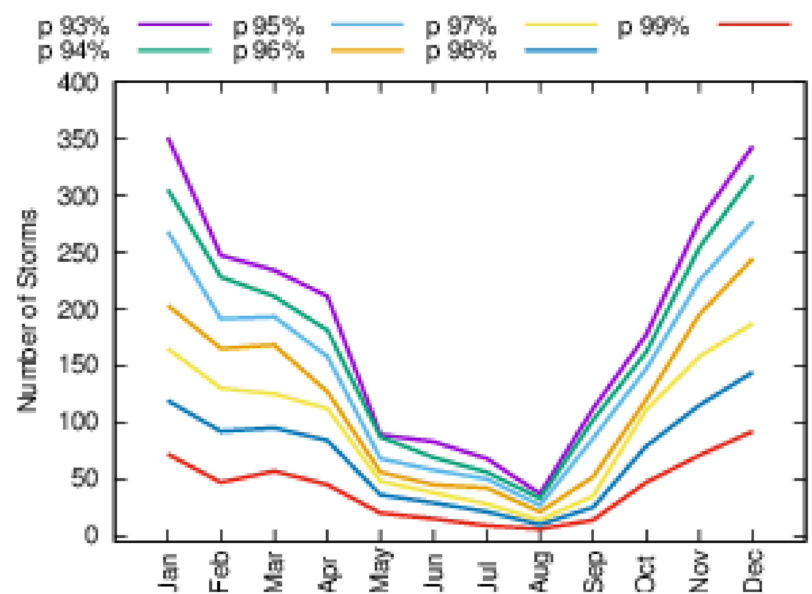


STORM CLUSTERING IDENTIFICATION TECHNIQUE

Sequence of storms are be extracted from a time series of sea states (POT, different percentiles) – Point Process







STORM CLUSTERING IDENTIFICATION TECHNIQUE

Point processes are studied by defining equally spaced time windows of duration τ and counting the events in each window

The result is a sequence of counts N_k ($k = 1,...,M$, where M is the number of time windows)

$$\mathrm{AF}(\tau) = \frac{\left\langle \left[N_{k+1}(\tau) - N_k(\tau)\right]^2 \right\rangle}{2\left\langle N_k(\tau)\right\rangle}$$

Allan Factor

$$\mathrm{AF}(\tau) = 1 + \left(\frac{\tau}{\tau_1}\right)^{\alpha}$$

A point process is called fractal when a number of the relevant statistics shows scaling with related scaling exponent

$$\alpha \sim 0 \rightarrow \mathrm{AF} \sim 1$$

Poissonian Process

$$\alpha > 0 \rightarrow \mathrm{AF} > 1$$

Non-Poissonian Process
(Non-Homogeneous Poisson Process)

STORM CLUSTERING IDENTIFICATION TECHNIQUE

$$\mathrm{AF}(\tau) = 1 + \left(\frac{\tau}{\tau_1}\right)^{\alpha}$$

τ_1 fractal onset time that marks the lower limit for significant scaling

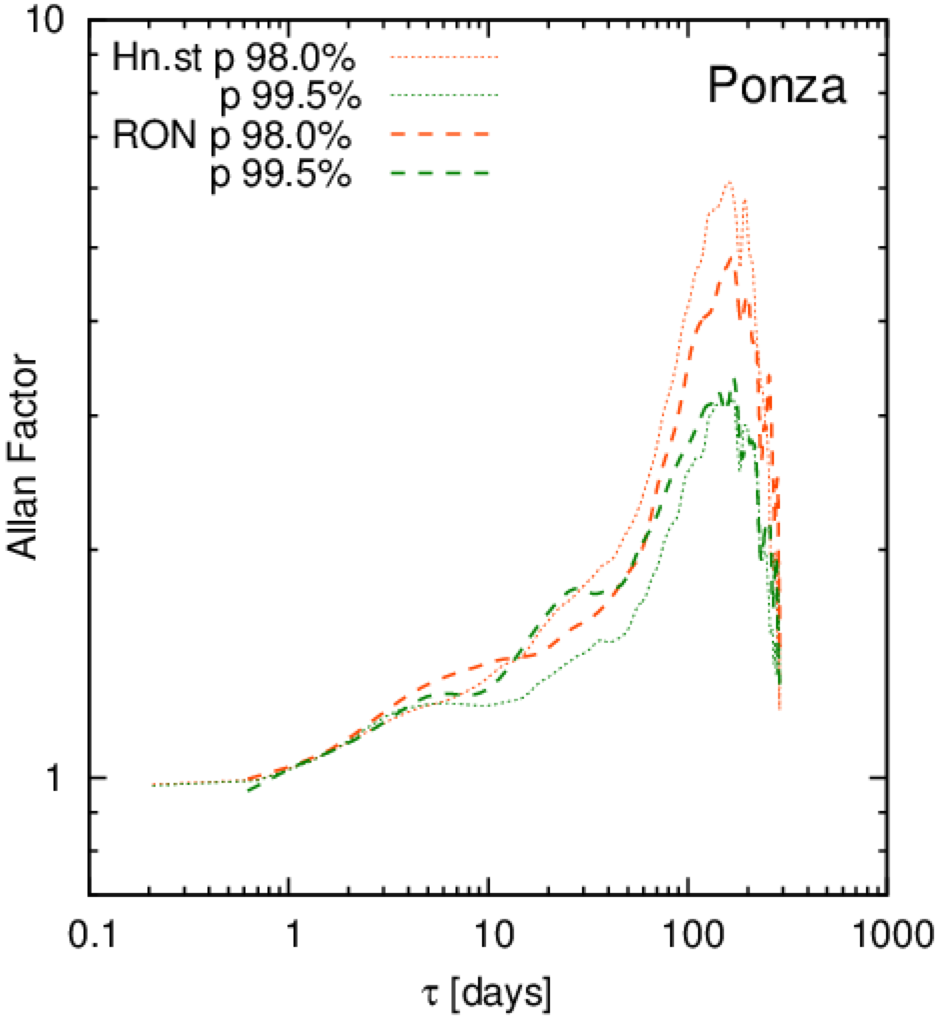
Different ranges of τ can reveal different time scaling (clustering) of the same process through different slopes of *AF* due to different kind of forcing

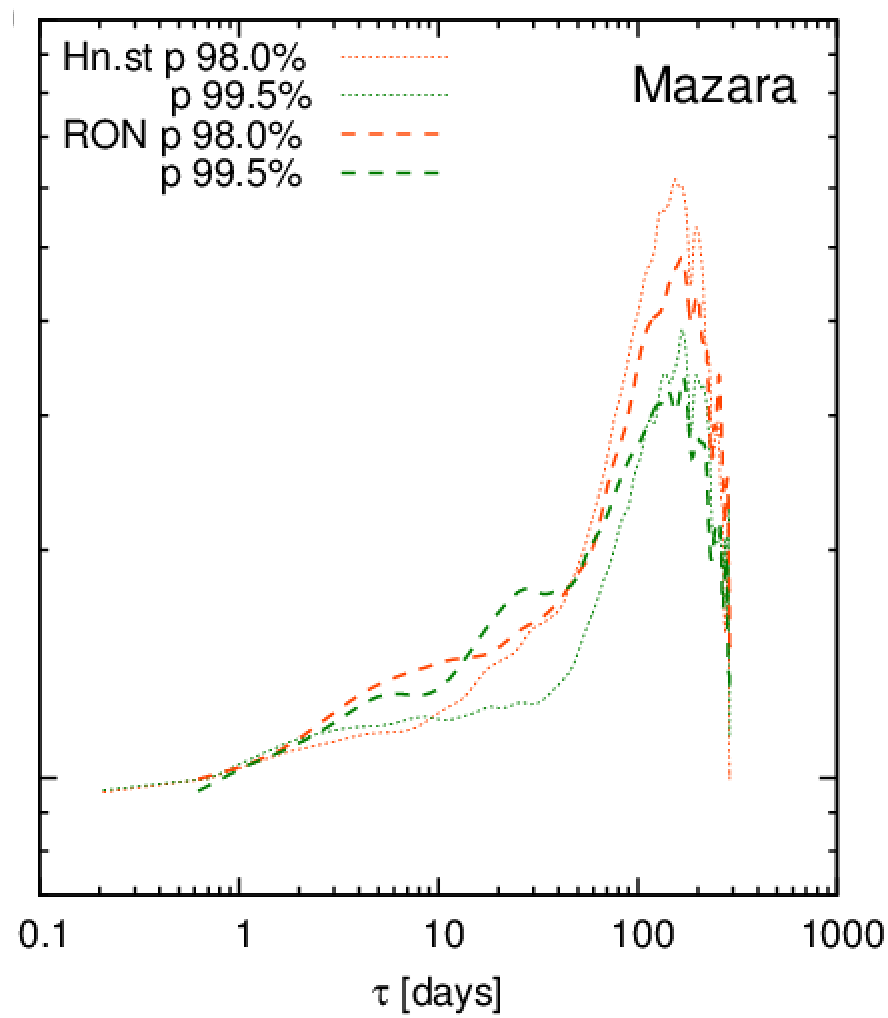
Cyclic (Non-Homogeneous) Poisson processes can show *AF*>1 for time scale associated to cyclic components (Serinaldi & Kilsby, 2013)

It is necessary to identify and separate the timescales at which clustering occurs from those at which the point process is Poissonian

To this end it is necessary to compare the *AF* pattern found in the wave time series with that of a process of known properties

STORM CLUSTERING, BUOYS VS HINDCAST



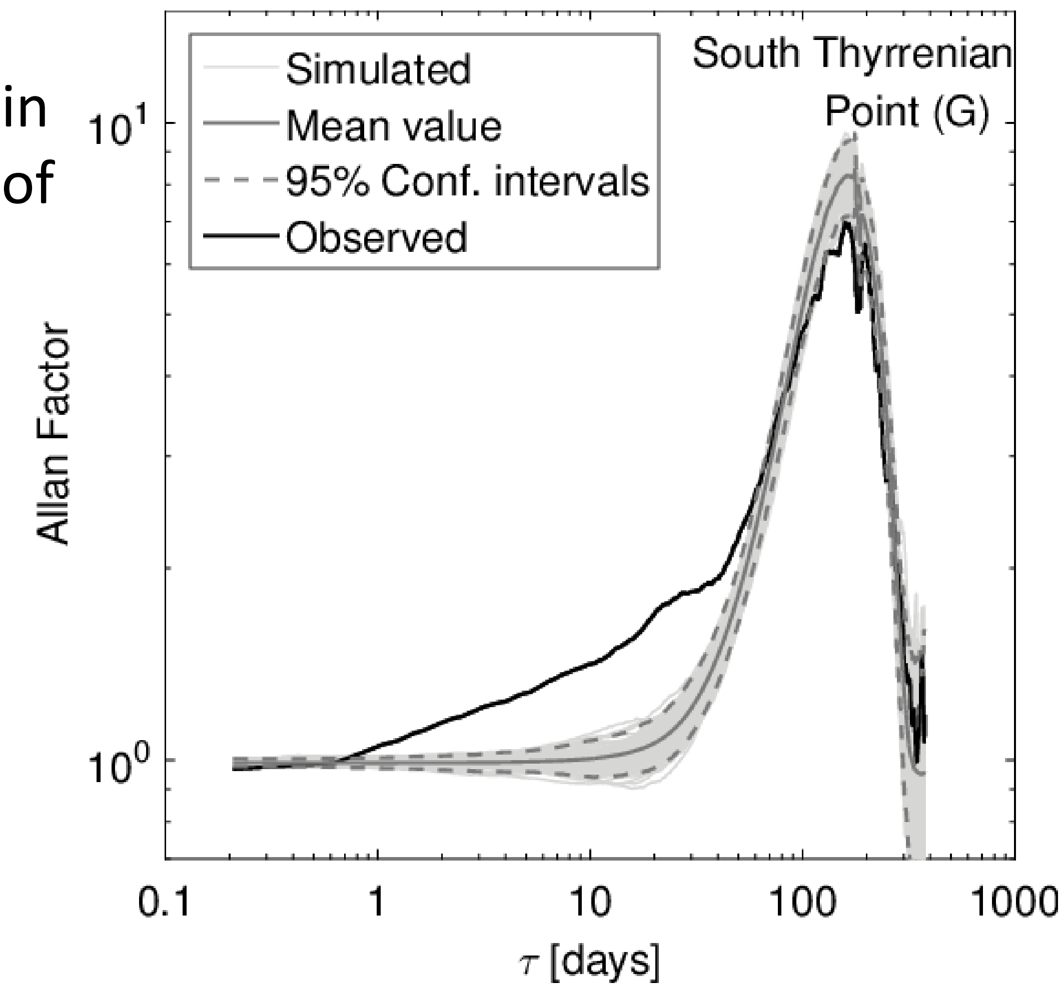


STORM CLUSTERING VS SIMULATED N-H POINT PROCESS

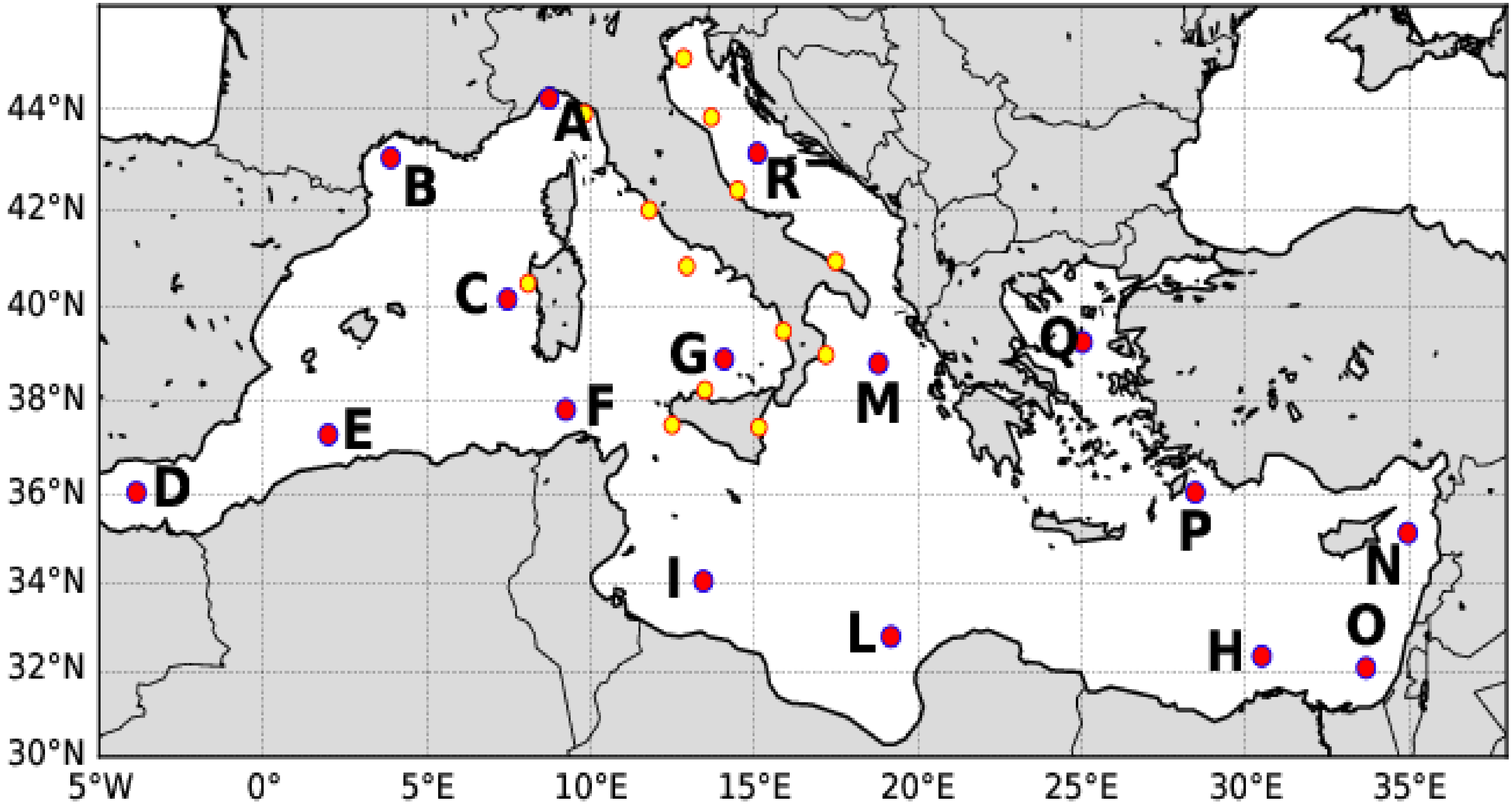
It is necessary to identify and separate the timescales at which clustering occurs from those at which the point process is Poissonian

To this end it is necessary to compare the *AF* pattern found in the wave time series with that of a process of known properties

The rate function of the simulated Non-Homogeneous Poisson process is generated as a sum of sinusoidal components with amplitudes, periods and phases obtained from the Fourier analysis of the reference signal



STORM CLUSTERING IN THE MED SEA



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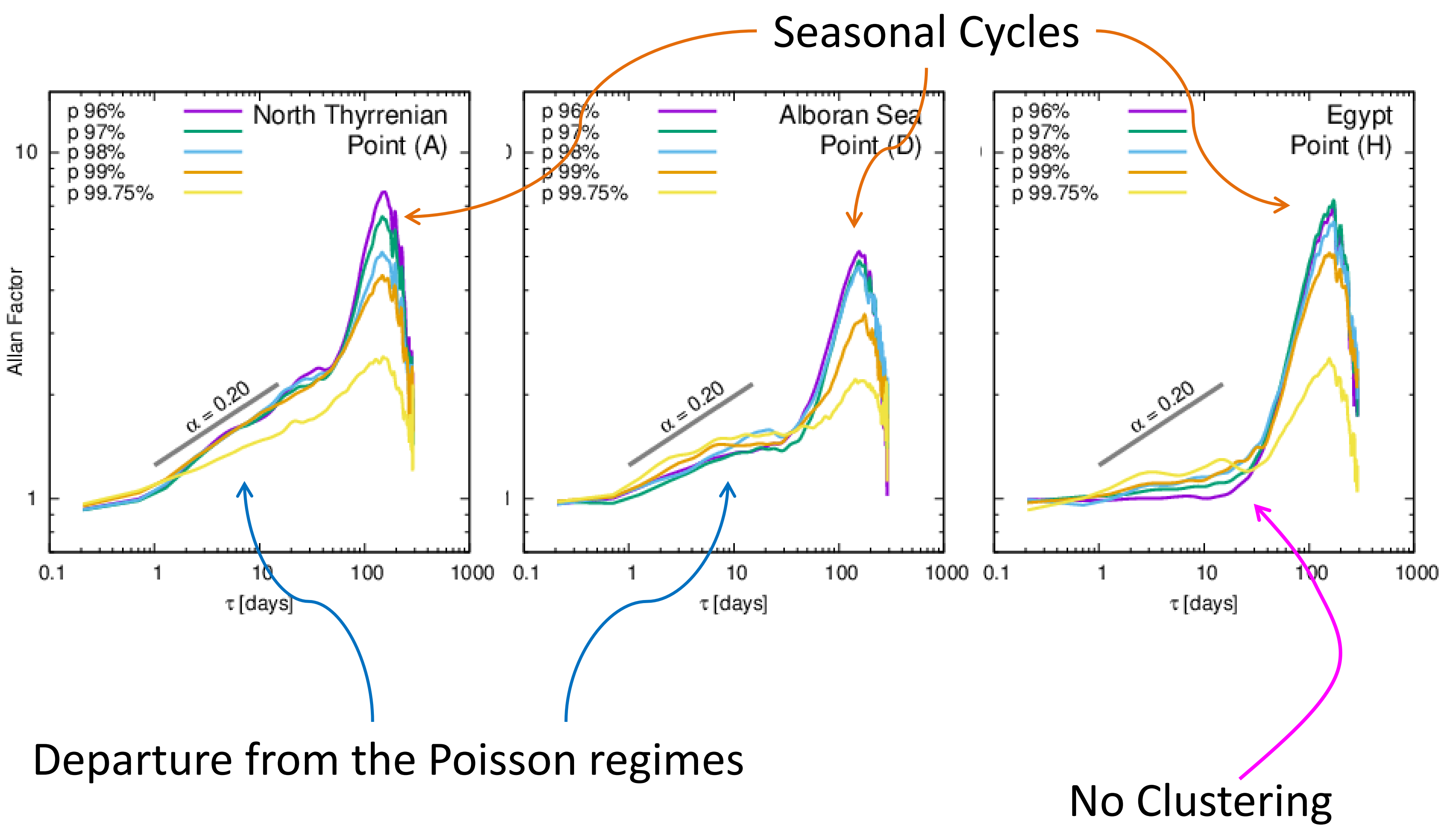

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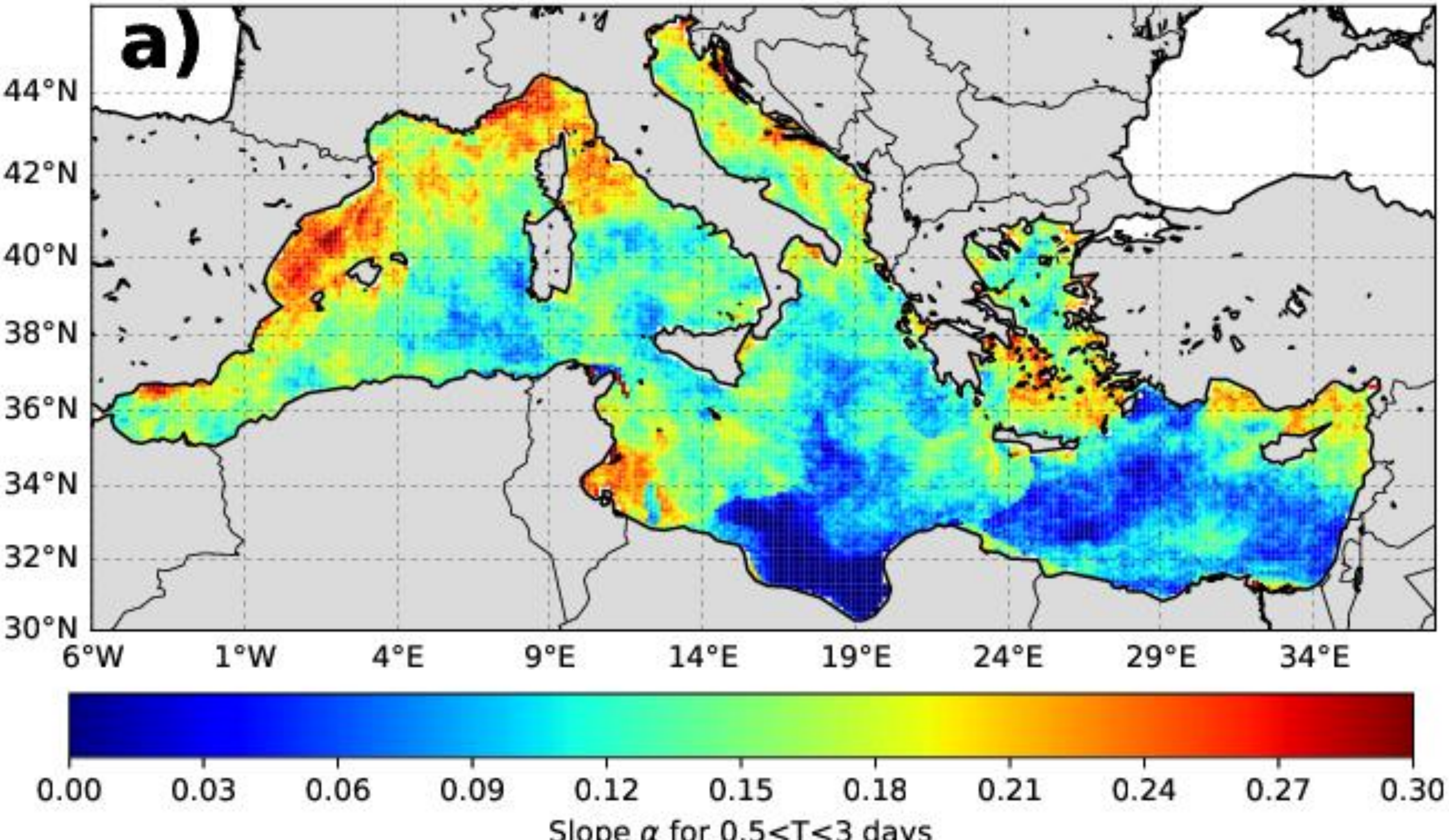

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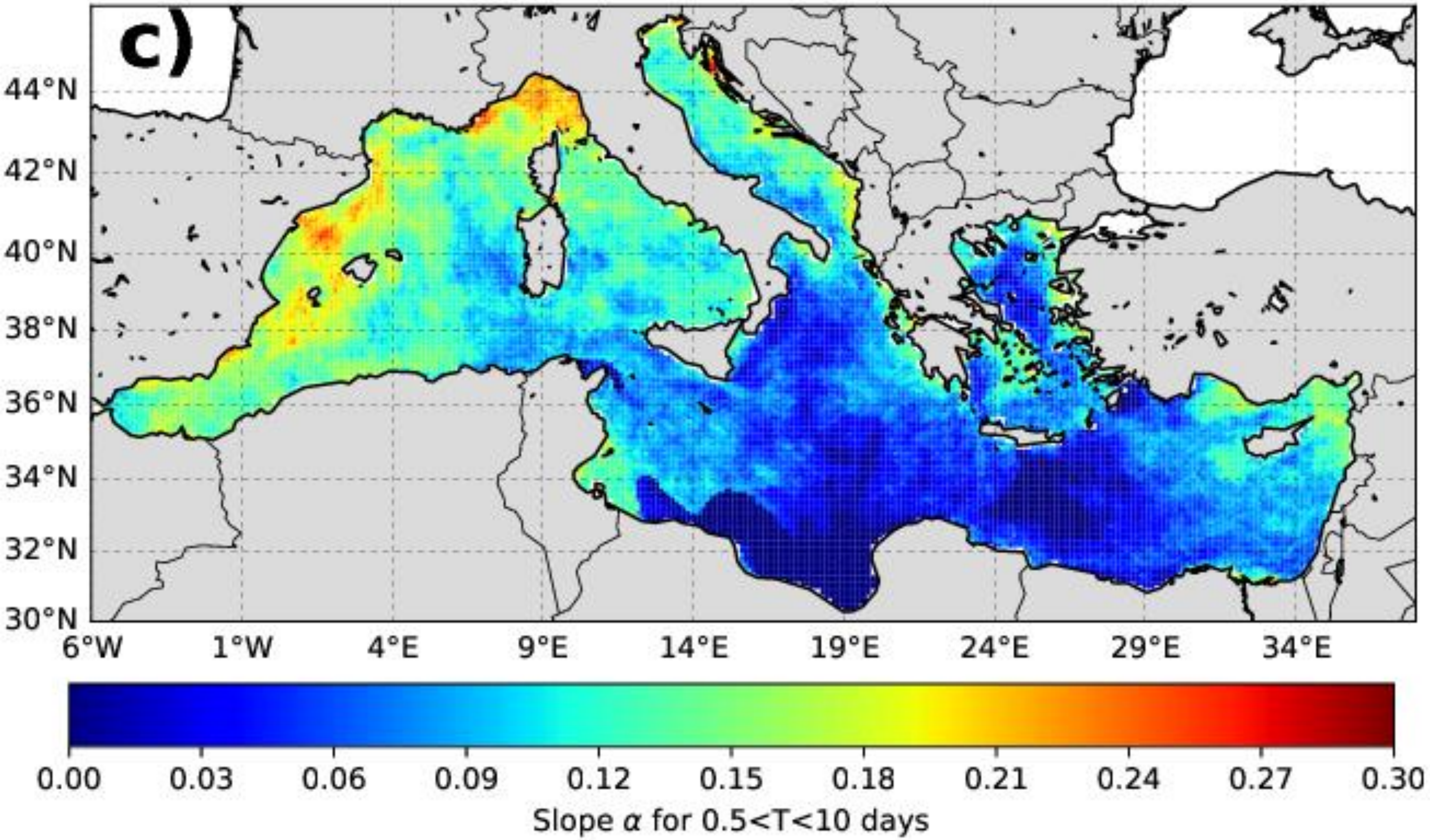

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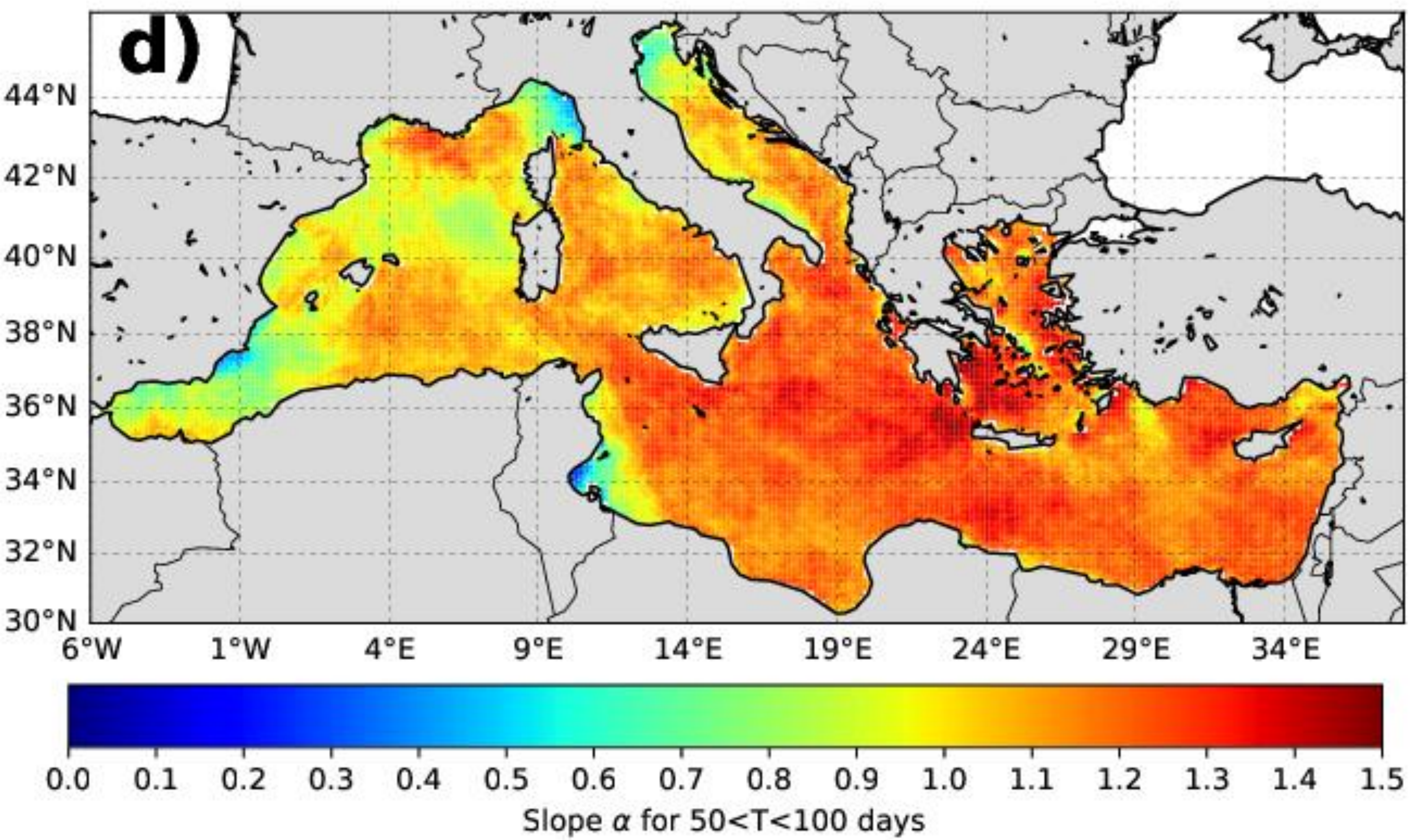

CONCLUSIONS

Presence of a departure from the Poisson distribution for time scales shorter than τ<1200 hours (50 days)

For τ >50 days the arrival of storms is dominated by seasonal and inter-seasonal oscillations (cyclic Poisson process)

Persistence of cyclonic events explains the behavior at smaller scales. Clustering at scales of days indicates that meteorological conditions favor the occurrence of multiple events in few days

Where these persistent conditions do not occur, the arrival of storms is well described as a cyclic-Poisson process

AF values do not allow to draw conclusions on whether this deviation from a Poisson distribution is large or small for the phenomenon at hand, as there is no comparison with other basins

THANK YOU FOR YOU ATTENTION!