INVESTIGATION OF THE SPATIAL CORRELATION STRUCTURE OF 2-D WAVE FIELDS AT THE AEGEAN SEA

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Source: Wall Rogues

Introduction

Ocean energy recourses do have a great **potential** [1].

Besides the **intrinsic uncertainty** of wind [2] and oceanic [3] processes we examine whether **2D** cases exhibit similar dependence.

Aim: to investigate the **spatial variability** without the influence of any structures.

Image courtesy of Green Ocean Energy

Data source

Athos region

- ❑ Data source : **Copernicus Marine Service** [4]
- ❑ Hourly resolution
- ❑ Significant wave height (Hmo) and Period(Tp)

- ▪ Region: Athos, Northern Greece, Pacific Ocean
- ▪ Dataset: Mediterranean Sea Waves Analysis and Forecast [4], Global Ocean Waves Analysis and Forecast [5]

Region of data acquisition : Pacific Ocean

Data source – Copernicus marine service

Mild conditions

0.856	0.883	0.905	0.922	0.941	0.96	0.981	1.001	1.009	1.011	1.017	1.038	1.073	1.113	1.156	1.195
0.852	0.876	0.893	0.906	0.921	0.941	0.962	0.983	0.993	0.995	1	1.019	1.053	1.092	1.138	1.183
0.851	0.872	0.885	0.894	0.906	0.923	0.946	0.968	0.978	0.979	0.983	1	1.031	1.069	1.116	1.168
0.848	0.867	0.878	0.884	0.893	0.909	0.932	0.956	0.964	0.963	0.966	0.98	1.008	1.045	1.092	1.147
0.84	0.859	0.869	0.876	0.884	0.898	0.921	0.945	0.953	0.949	0.949	0.96	0.986	1.021	1.068	1.126
0.824	0.843	0.857	0.866	0.875	0.889	0.912	0.937	0.942	0.936	0.933	0.943	0.965	0.999	1.046	1.106
0.799	0.822	0.84	0.853	0.864	0.879	0.903	0.929	0.932	0.923	0.919	0.926	0.946	0.979	1.027	1.088
0.771	0.796	0.819	0.837	0.851	0.867	0.893	0.921	0.923	0.913	0.907	0.912	0.93	0.962	1.01	1.072
0.742	0.769	0.794	0.816	0.834	0.852	0.879	0.911	0.913	0.902	0.896	0.9	0.916	0.947	0.996	1.058
0.713	0.74	0.767	0.79	0.811	0.83	0.862	0.898	0.9	0.889	0.883	0.886	0.899	0.931	0.98	1.044
0.686	0.712	0.737	0.76	0.781	0.8	0.837	0.881	0.884	0.874	0.868	0.869	0.878	0.909	0.96	1.028
0.662	0.685	0.707	0.726	0.744	0.76	0.803	0.859	0.863	0.855	0.849	0.847	0.85	0.881	0.934	1.006
0.64	0.659	0.675	0.688	0.699	0.707	0.758	0.832	0.838	0.83	0.823	0.816	0.812	0.84	0.898	0.974
0.621	0.635	0.645	0.649	0.649	0.639	0.699	0.806	0.813	0.803	0.792	0.777	0.761	0.784	0.847	0.928
0.606	0.616	0.619	0.611	0.591	0.544	0.619	0.783	0.79	0.777	0.761	0.734	0.697	0.709	0.776	0.864
0.597	0.604	0.602	0.583	0.538	0.403	0.489	0.762	0.769	0.752	0.729	0.686	0.619	0.612	0.688	0.783

Extreme conditions

2.935	3.002	3.06	3.102	3.131	3.146	3.146	3.141	3.136	3.138	3.144	3.152	3.16	3.169	3.176	3.176
3	3.063	3.116	3.159	3.187	3.199	3.199	3.195	3.195	3.202	3.211	3.22	3.23	3.238	3.244	3.244
3.056	3.113	3.166	3.206	3.232	3.241	3.246	3.247	3.252	3.259	3.274	3.282	3.293	3.303	3.311	3.31
3.085	3.149	3.204	3.242	3.268	3.282	3.292	3.294	3.303	3.316	3.329	3.343	3.356	3.366	3.374	3.378
3.147	3.205	3.255	3.292	3.318	3.332	3.34	3.348	3.359	3.374	3.39	3.406	3.421	3.432	3.441	3.446
3.211	3.261	3.305	3.338	3.363	3.379	3.39	3.4	3.412	3.427	3.444	3.461	3.478	3.49	3.499	3.504
3.276	3.319	3.357	3.388	3.414	3.432	3.445	3.457	3.469	3.485	3.502	3.521	3.538	3.55	3.558	3.563
3.349	3.387	3.421	3.45	3.478	3.498	3.511	3.522	3.533	3.547	3.564	3.583	3.601	3.613	3.621	3.624
3.428	3.462	3.493	3.522	3.55	3.57	3.581	3.59	3.598	3.611	3.627	3.646	3.665	3.678	3.685	3.685
3.514	3.542	3.568	3.595	3.625	3.643	3.65	3.655	3.66	3.67	3.686	3.704	3.725	3.74	3.747	3.743
3.601	3.624	3.646	3.671	3.701	3.714	3.712	3.71	3.711	3.72	3.74	3.767	3.795	3.813	3.819	3.809
3.704	3.722	3.74	3.763	3.794	3.795	3.776	3.764	3.76	3.769	3.794	3.829	3.865	3.884	3.887	3.868
3.815	3.829	3.843	3.862	3.889	3.862	3.814	3.788	3.784	3.802	3.838	3.884	3.926	3.94	3.931	3.899
3.928	3.939	3.95	3.963	3.986	3.906	3.809	3.767	3.773	3.811	3.869	3.93	3.977	3.977	3.944	3.893
4.034	4.042	4.052	4.063	4.084	3.887	3.712	3.676	3.715	3.793	3.879	3.956	4.002	3.959	3.877	3.791
4.126	4.136	4.148	4.158	4.188	3.675	3.418	3.453	3.576	3.713	3.834	3.921	3.955	3.805	3.641	3.511

First set- small scale

- Dataset "Mediterranean Sea Waves Analysis and Forecast "

- 16X16 pixels area of measurements (5km X 5km resolution)

- 24hours of measurements

- Mild weather conditions

Second set- small scale

- Dataset "Mediterranean Sea Waves Analysis and Forecast "

- 16X16 pixels area of measurements (5km X 5km resolution)

- 24hours of measurements

- Extreme weather conditions – storm event

Third set –large scale

- Dataset "Global Ocean Waves Analysis and Forecast"

- 1120X1120 pixels area of measurements (9km X 9km resolution)

- 3 hours of measurements

- Mild weather conditions

Images

… of wave clustering

We also collected sequent close-up frames of ocean waves that show the spatial-dependence in their motion:

Source:https://youtu.be/g2P2ni2yN40
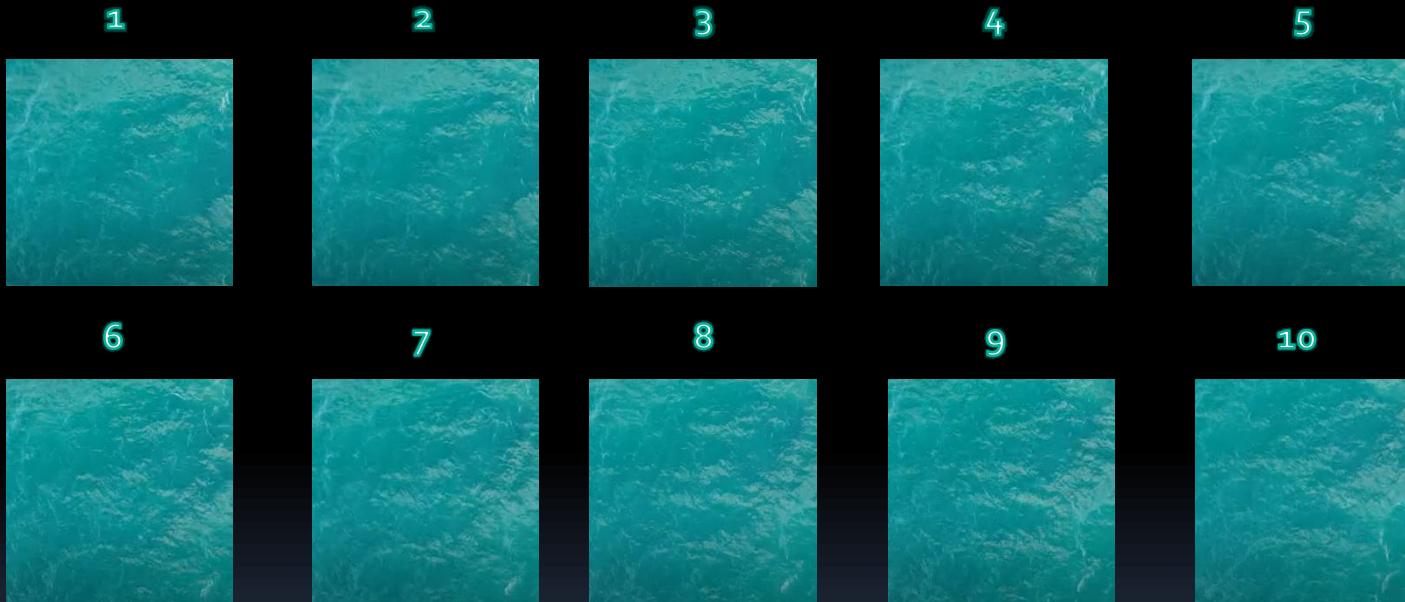
Careful selection of images with spatial information quantify how clustering **alters over area**, characterizing spatial variability.

The **2D Climacogram** [6] quantifies this variability through the variance of the brightness intensity in greyscale.

Methodology

The estimation of the variability of the wave process includes:

- **marginal moments** (mean, standard deviation, skewness, kurtosis)

- **Spatial correlation** structure measured through the 2D-climacogram (i.e., variance of the averaged process vs. spatial scale).

- **periodicity** of the wave processes (more information will be presented in the next presentation '' Investigation of stochastic similarities between wind and waves and their impact on offshore structures by Sofia Efraimia Vrettou et al.)

Results - Marginal characteristics

First set- small scale / ATHOS-Mild & PACIFIC-Mild
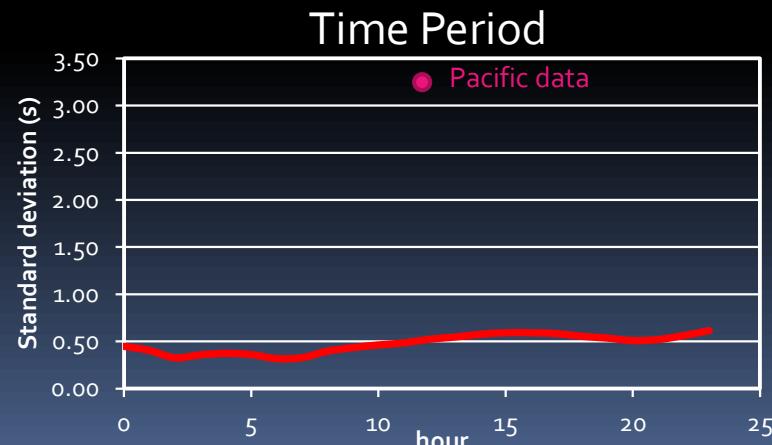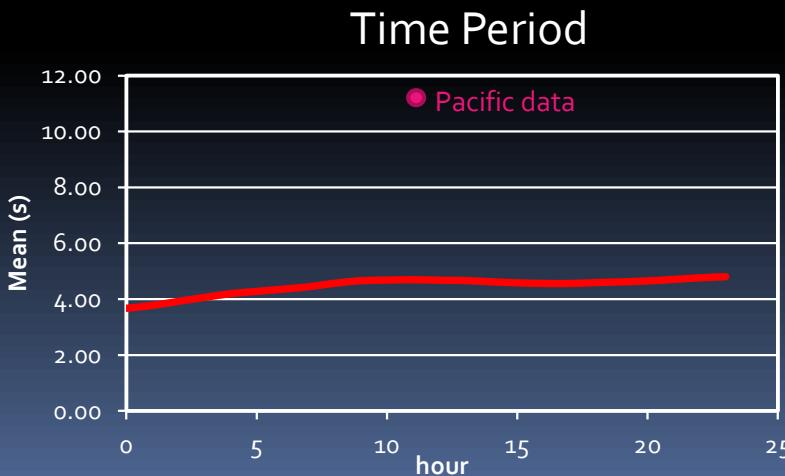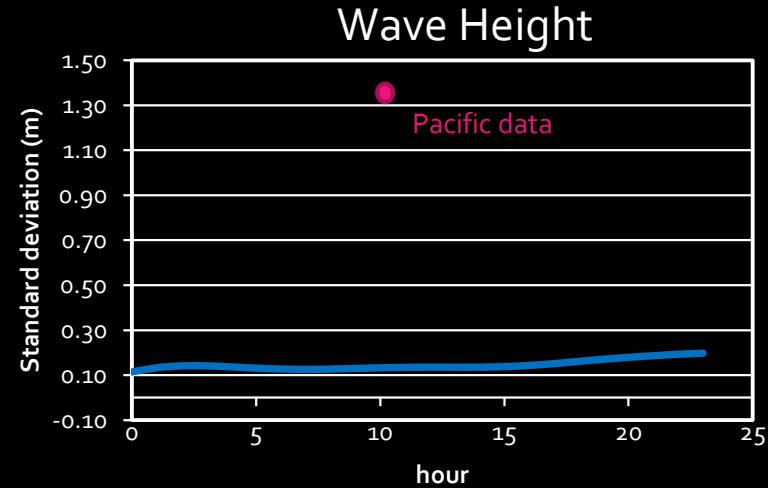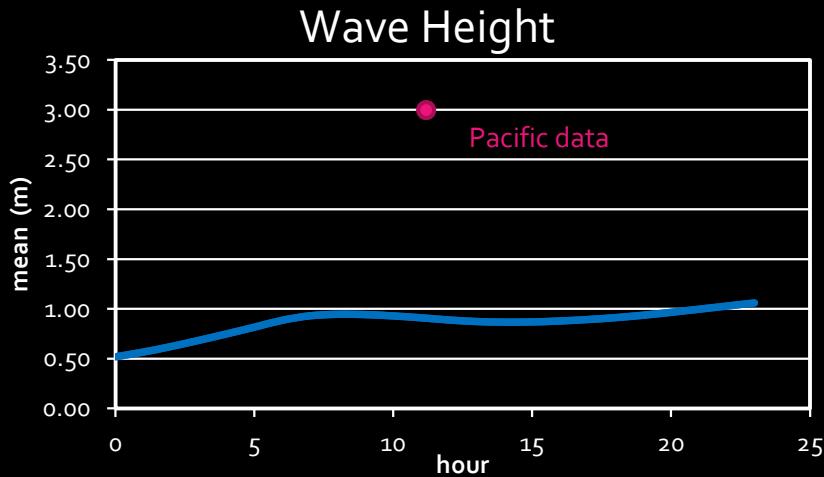
Results - Marginal characteristics

Second set- small scale / ATHOS-Extreme Event
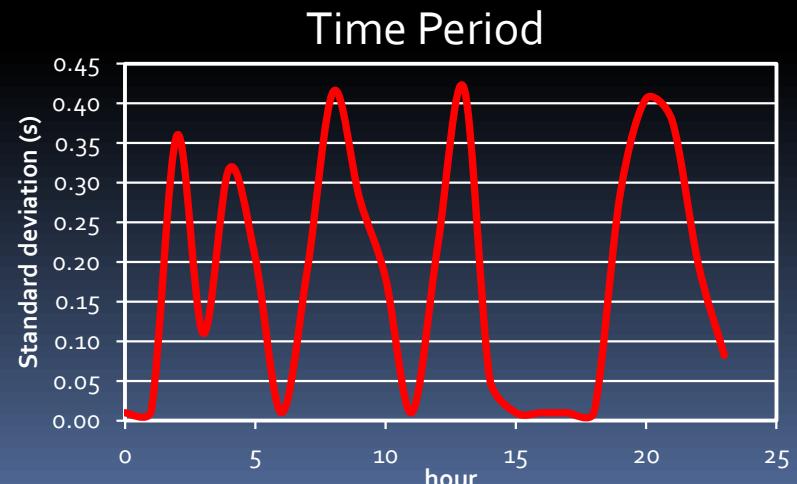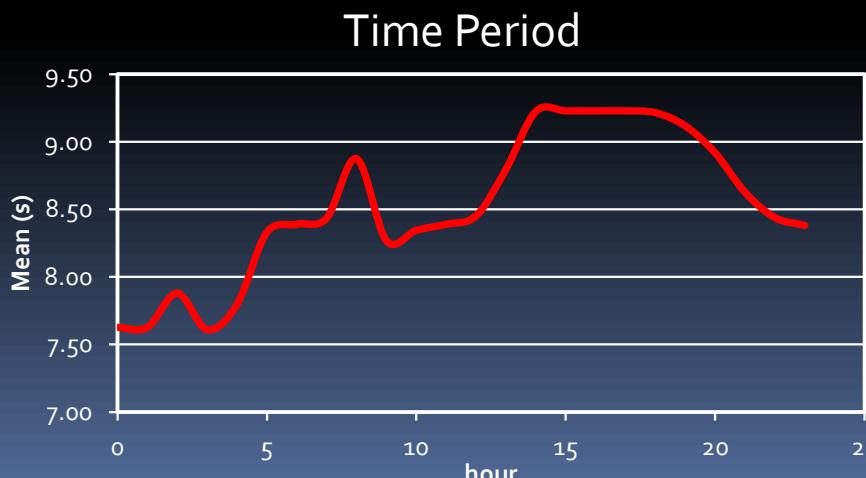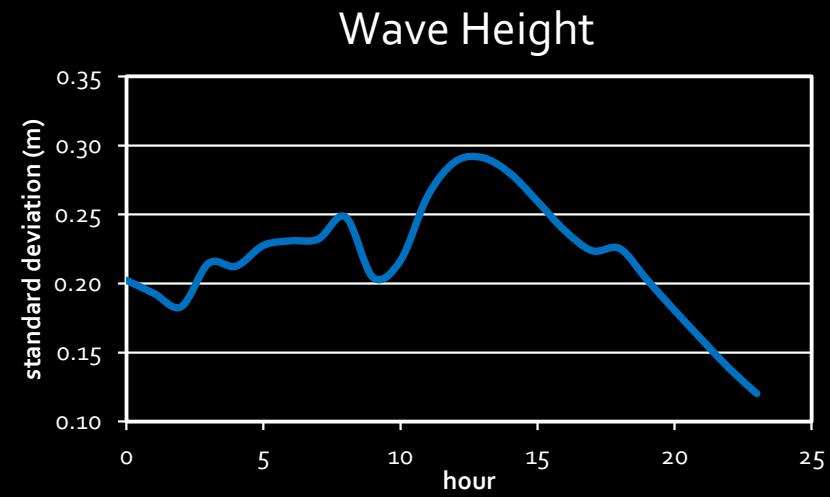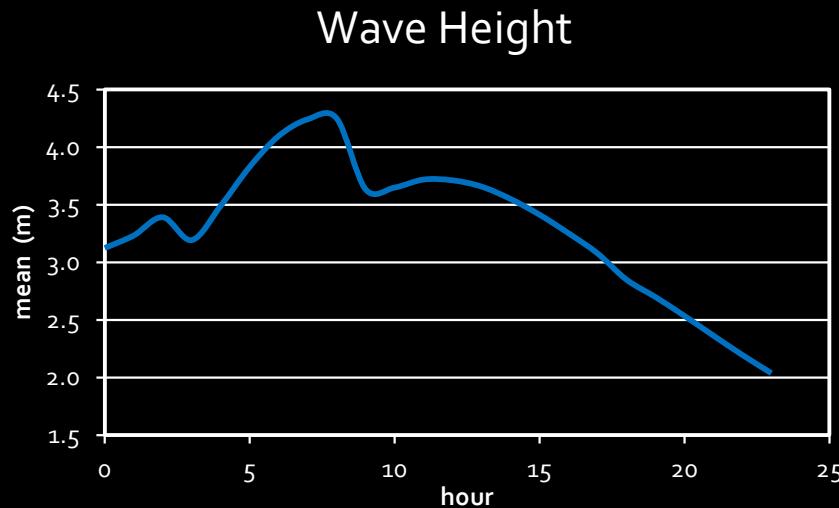
Coefficient of Variability

Data		wave height (m)	time period (s)
mild conditions - ATHOS	min	0.82	3.67
	max	1.06	4.80
extrene conditions -	min	0.12	7.61
	max	0.29	9.23
mild conditions - PACIFIC	min	0.04	2.99
	max	11.30	20.67
mild conditions- ATHOS	cv	0.17	0.11
extrene conditions -	cv	0.07	0.02
mild conditions - PACIFIC	cv	0.44	0.28
images	cv	0.16	-

Results - Climacograms

Averaged 2-d Climacogram of the Wave Height in each case
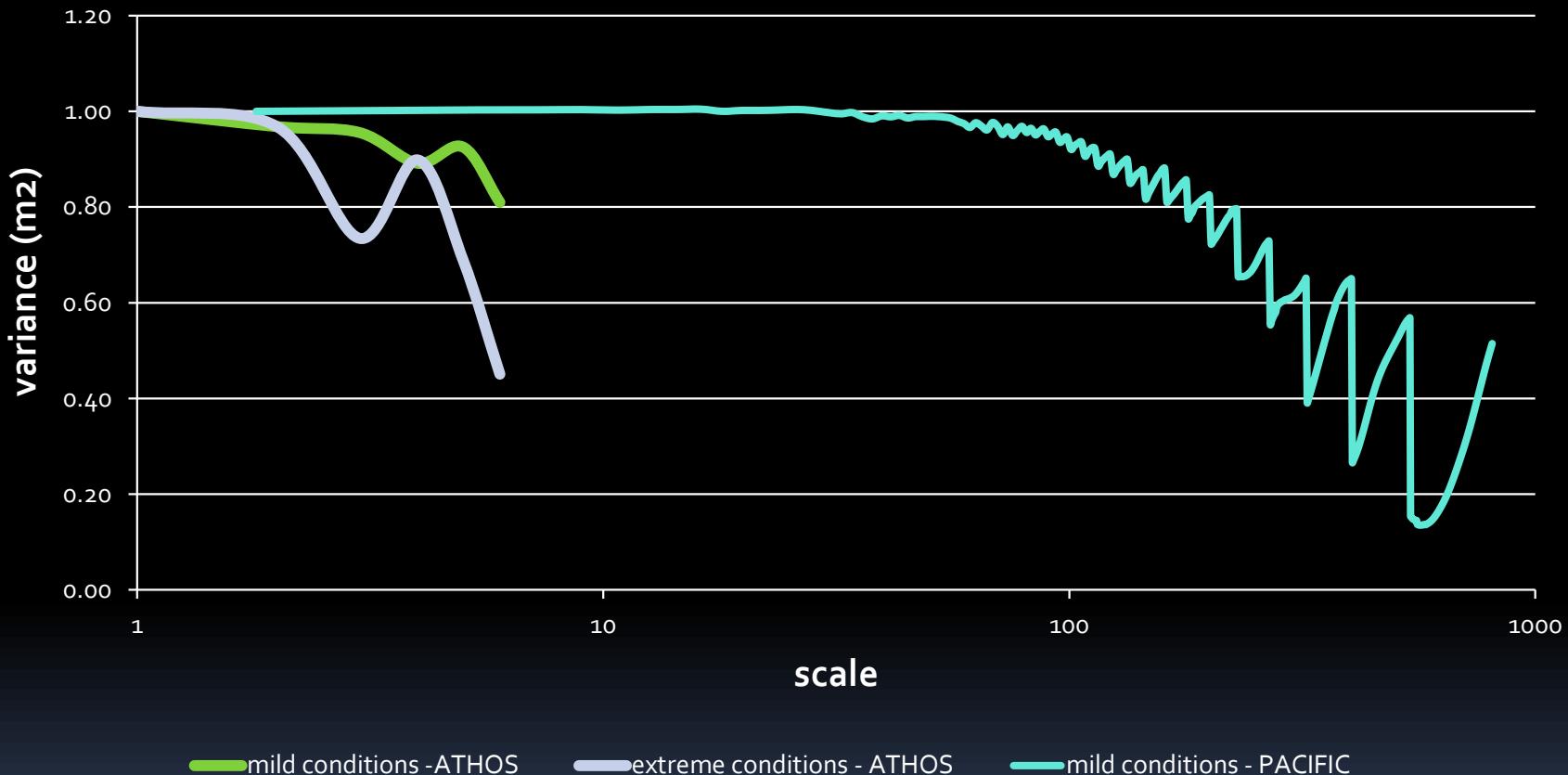
	Hurst Factor
mild - ATHOS	0.83
extreme - ATHOS	0.95
mild- PACIFIC	0.79

Results - Climacograms

Averaged 2-d Climacogram of the Time Period in each case
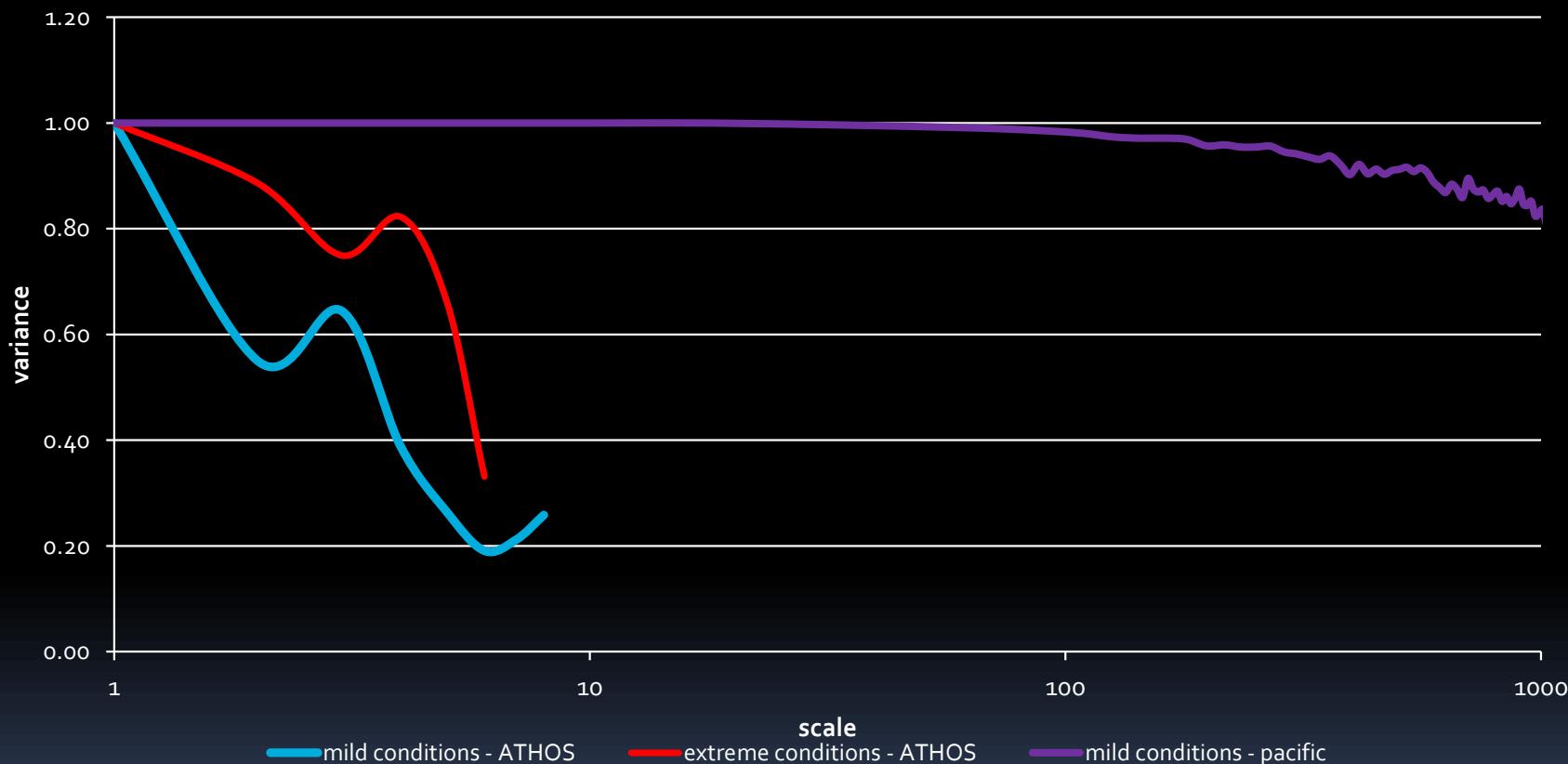
	Hurst Factor
mild - ATHOS	0.57
extreme - ATHOS	0.78
mild- PACIFIC	0.92

Results - Climacograms

From the analysis of the **images** taken, we formed the 2D- Climacogram of the average wave height:
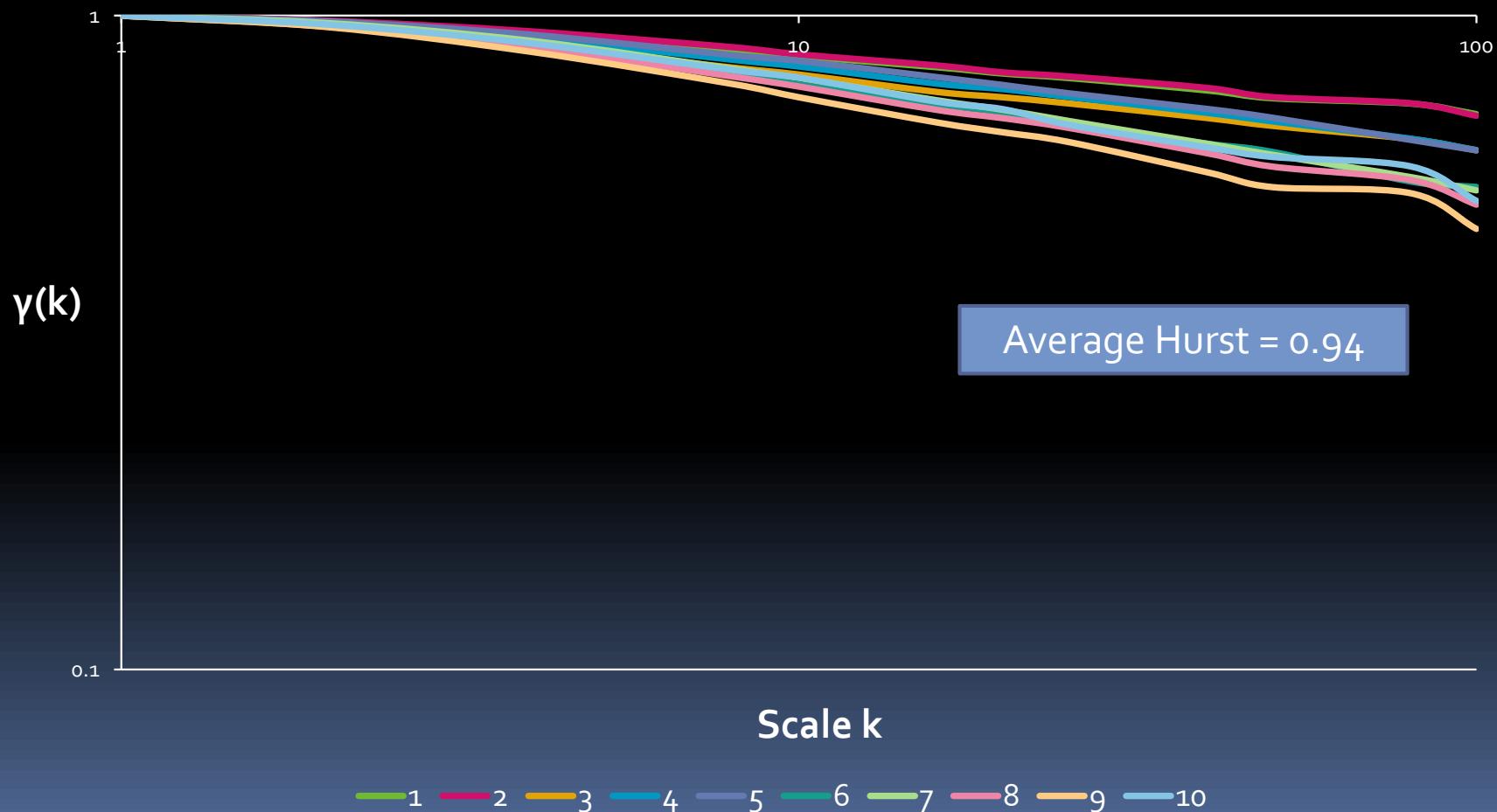
Conclusions

1. In all data sets used its obvious that exist **strong correlation** in smaller scales and **long – range dependence** on larger ones.
2. There are similarities between significant height's and time period's marginal characteristics. The height's **Coefficient of Variability (Cv)** is almost double the time period's Cv in each case.
3. On larger scale both images and data retrieved from the Pacific region maintain a high **Hurst – Kolmogorov** indicator, showing the existing long-range correlation.
4. There is **no similarity to the white noise** behavior. In all cases it is established that spatial correlation exists.

Thank you for your attention!

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