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## Luis Angel Espinosa, Maria Manuela Portela

### Perspectives of a climate crisis: higher risks from global to a small island environment

**CERIS** : Investigação e Inovação  
em Engenharia Civil para  
a Sustentabilidade



**DECIVIL**  
DEPARTAMENTO DE ENGENHARIA  
CIVIL, ARQUITECTURA E GEORRECURSOS

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Novi Sad, 23-24 September 2021

## Just to warm up...



"Climate change has been  
called the crisis of our  
time,... and it is."



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2

## Extremes in a changing climate



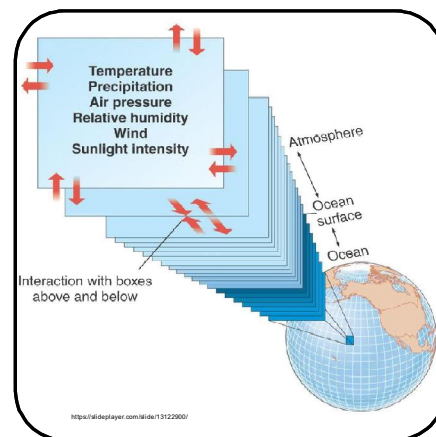
Extreme rainfall and droughts: These extreme hydrological events have increased globally – but not at the same pace



## Motivation of the research



Extreme hydrological events in small areas (e.g. small islands) are often poorly understood or not well reproduced by climate models (e.g. General Circulation Models, GCMs)



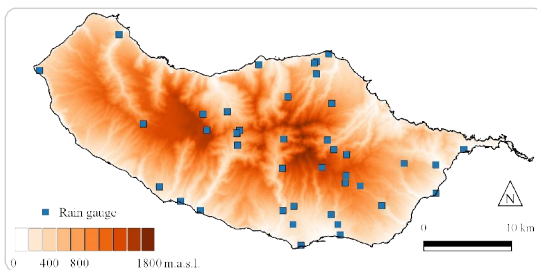
## Selected case study



Madeira Island  
 (741 km<sup>2</sup> ≈ 7.5 times  
 Lisbon county area)  
 located in the North  
 Atlantic Ocean, in the  
 European part of  
 Macaronesia

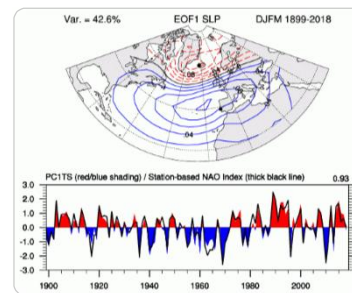


## Primary data used for the analyses



Daily Rainfall

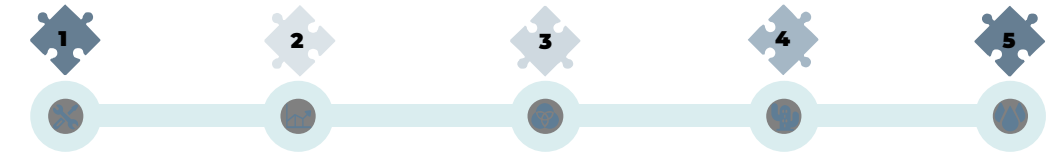
Data from October 1936 to September 2017  
 (80 hydrological years) at 41 raingauges in  
 Madeira Island



Modes of climate variability

Different definitions of the North Atlantic  
 Oscillation (e.g. daily NAO index)

# Main models used



**1**  
Data preparation

- Multivariate imputation by chained equations (MICE) for gap-filling
- Synthetic missing data generation for validation

**2**  
Rainfall trends

- Mann-Kendall (MK) test
- Sen's slope estimator
- Sequential Mann-Kendall (SQMK) test

**3**  
Climate regionalisation

- Principal components analysis (PCA)
- Principal factor analysis (PFA)

**4**  
Droughts

- Standardized Precipitation index (SPI)
- Kernel occurrence rate estimator (KORE)

**5**  
Extreme rainfall

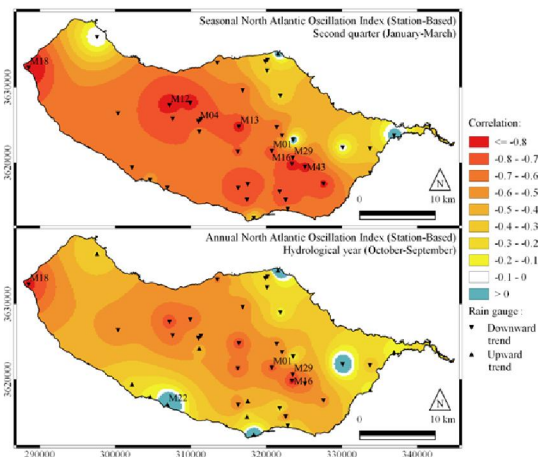
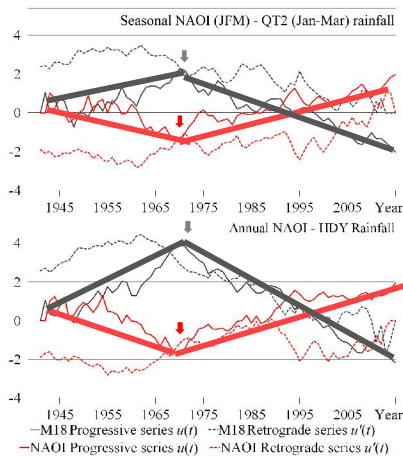
- Bivariate copulas



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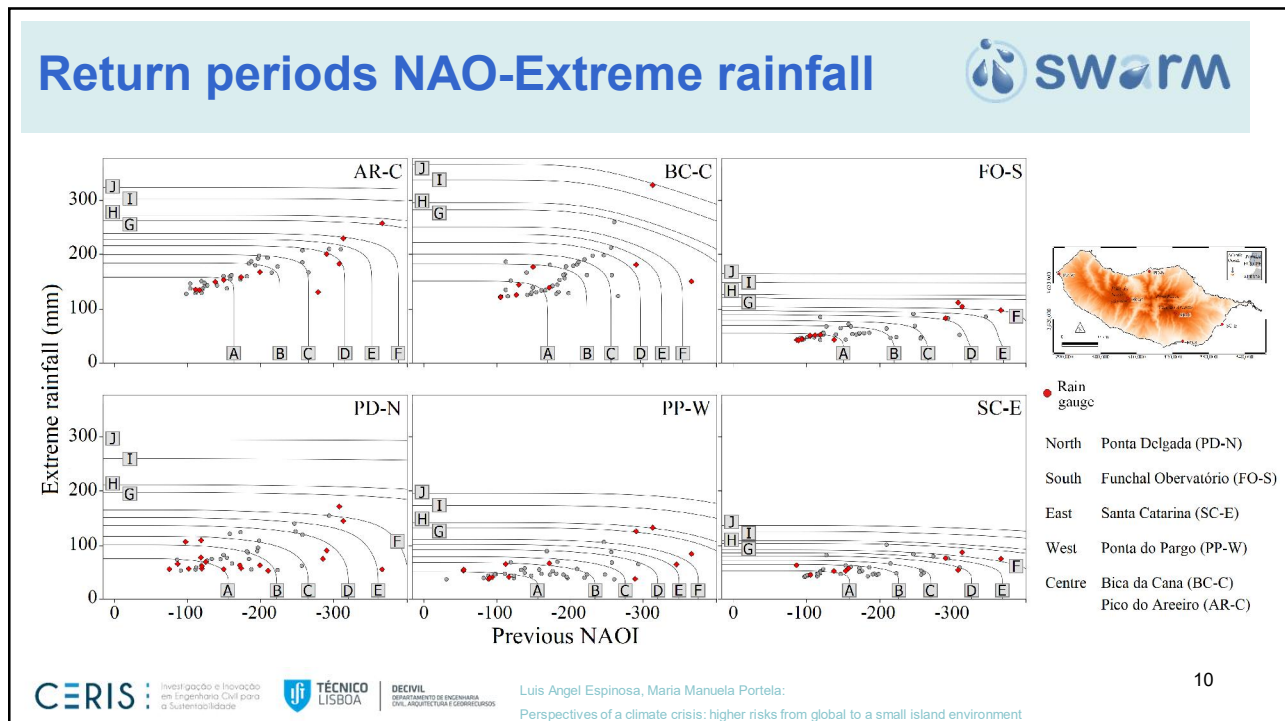
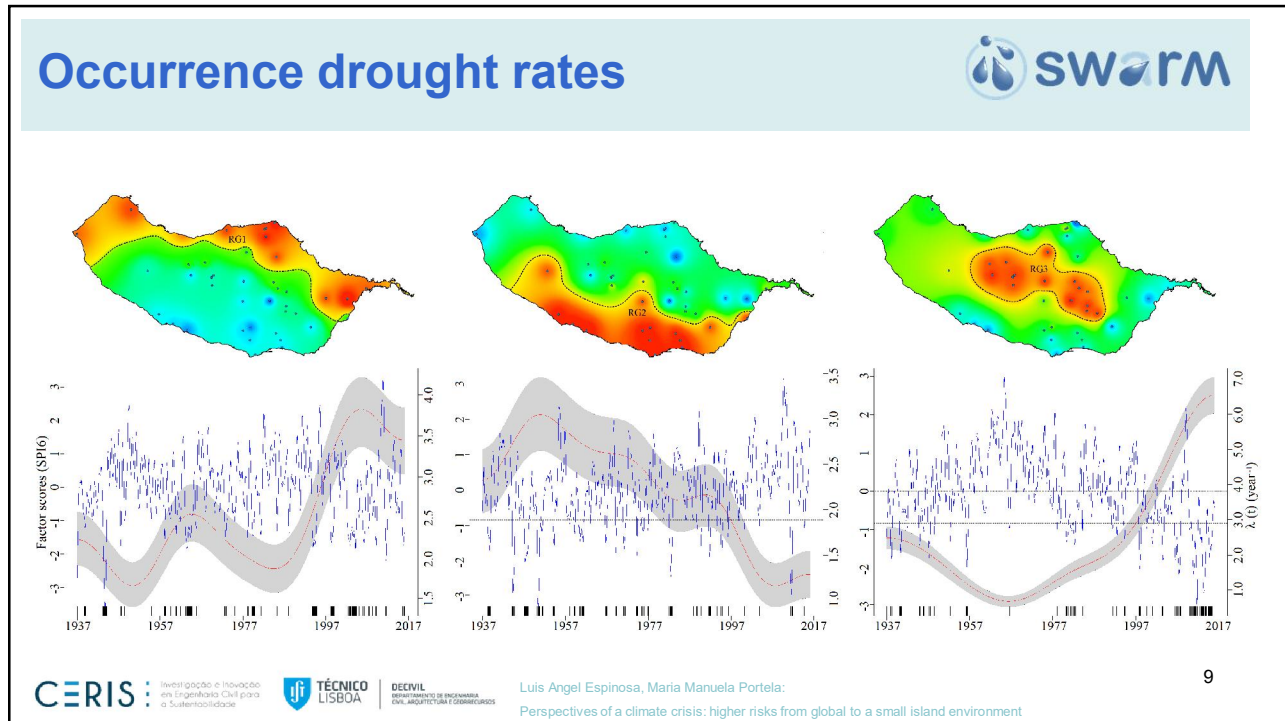
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# NAO and rainfall trends (1937-2017)



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## Summary



The coupling of the results from the research with other published studies over the past sixty years provides evidences that in Madeira Island:

- (1) seasonal and annual rainfall has shown a gradual decrease since the late 1960's with the uncertainty regarding to whether rainfall will continue to decrease or it will counterbalance the already experienced rainfall deficits;
- (2) the variability of seasonal and annual rainfall is highly correlated with the large scale atmospheric circulation pattern of NAO;
- (3) droughts in the island have become worse (higher magnitude and longer duration in recent years); and that
- (4) extreme rainfall is clearly intensified by the persistent changes in the NAO mainly during negative NAO phases (recently more recurrent and "extreme")



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