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Regionalization of precipitation for the Iberian Peninsula

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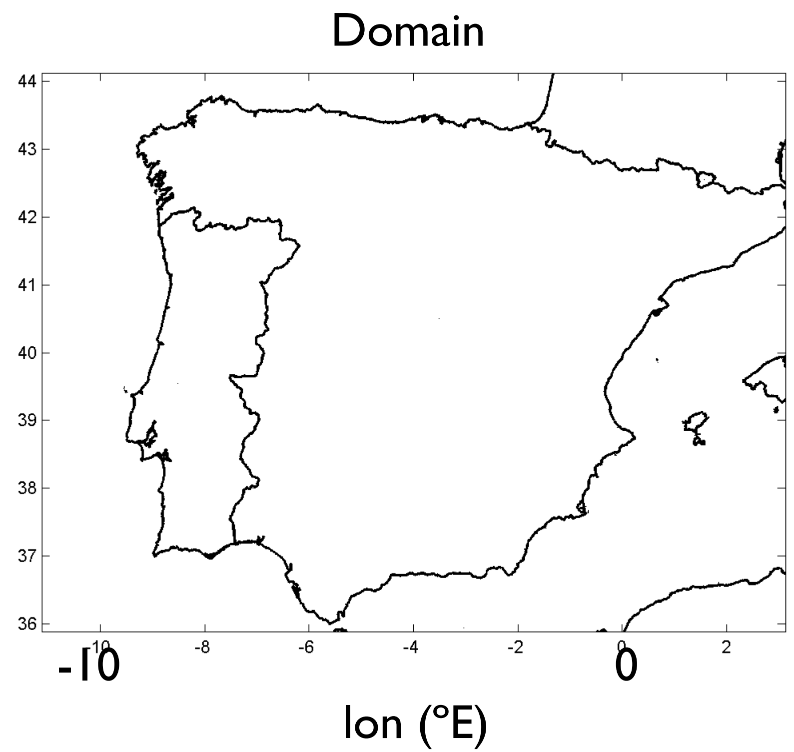
Introduction

- Temporal variability of precipitation over the Iberian Peninsula (IP) has high spatial gradients;
- Some statistics (such as Probability Density Functions), cannot be displayed over a map;
- To overcome this, a reduction of the time series representative of the IP domain is crucial;
- In this work, we propose a **partition of the IP region** into areas of similar precipitation, using cluster analysis.

Data Set & Methods

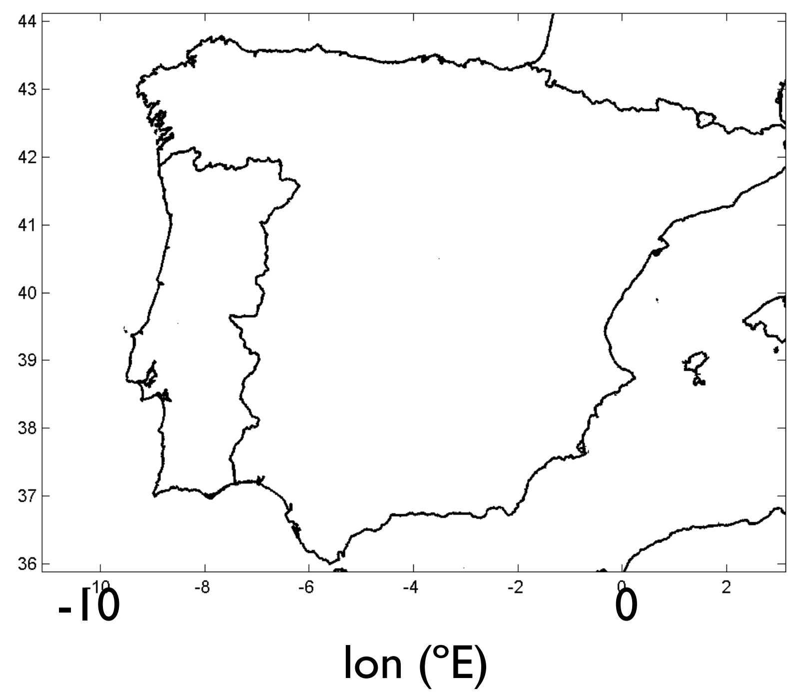
- Data:
  - Daily observed precipitation data (E-OBS):
    - from 1986-2005:
      - land-only;
      - high resolution (0.25°);
      - on a regular grid.
  - Over the Iberian Peninsula region.



Data Set & Methods

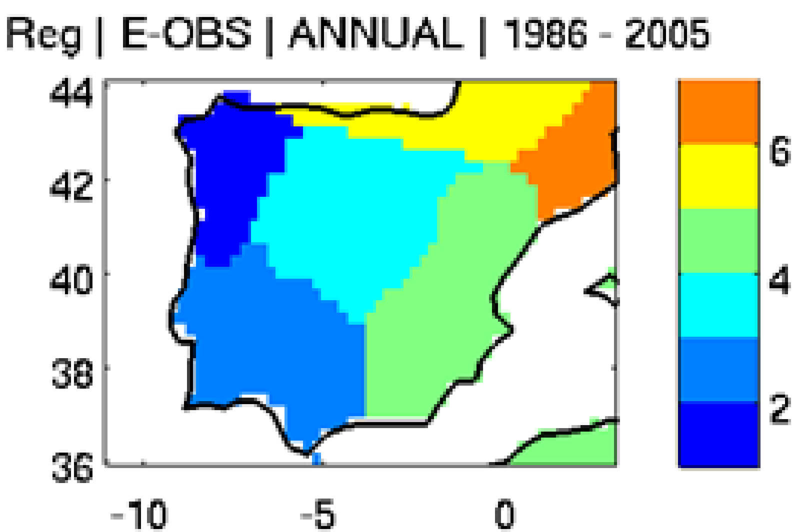
- Methods:
  - K-means Cluster Analysis:
    - Iterative partitioning that minimizes the sum, over all clusters, of the within-cluster sums of point-to-cluster-centroid distances;
    - Using the squared Euclidean distance - each centroid is the mean of the points in that cluster;
    - 6 clusters;
    - Results are time series of the centroids for each region.

Domain



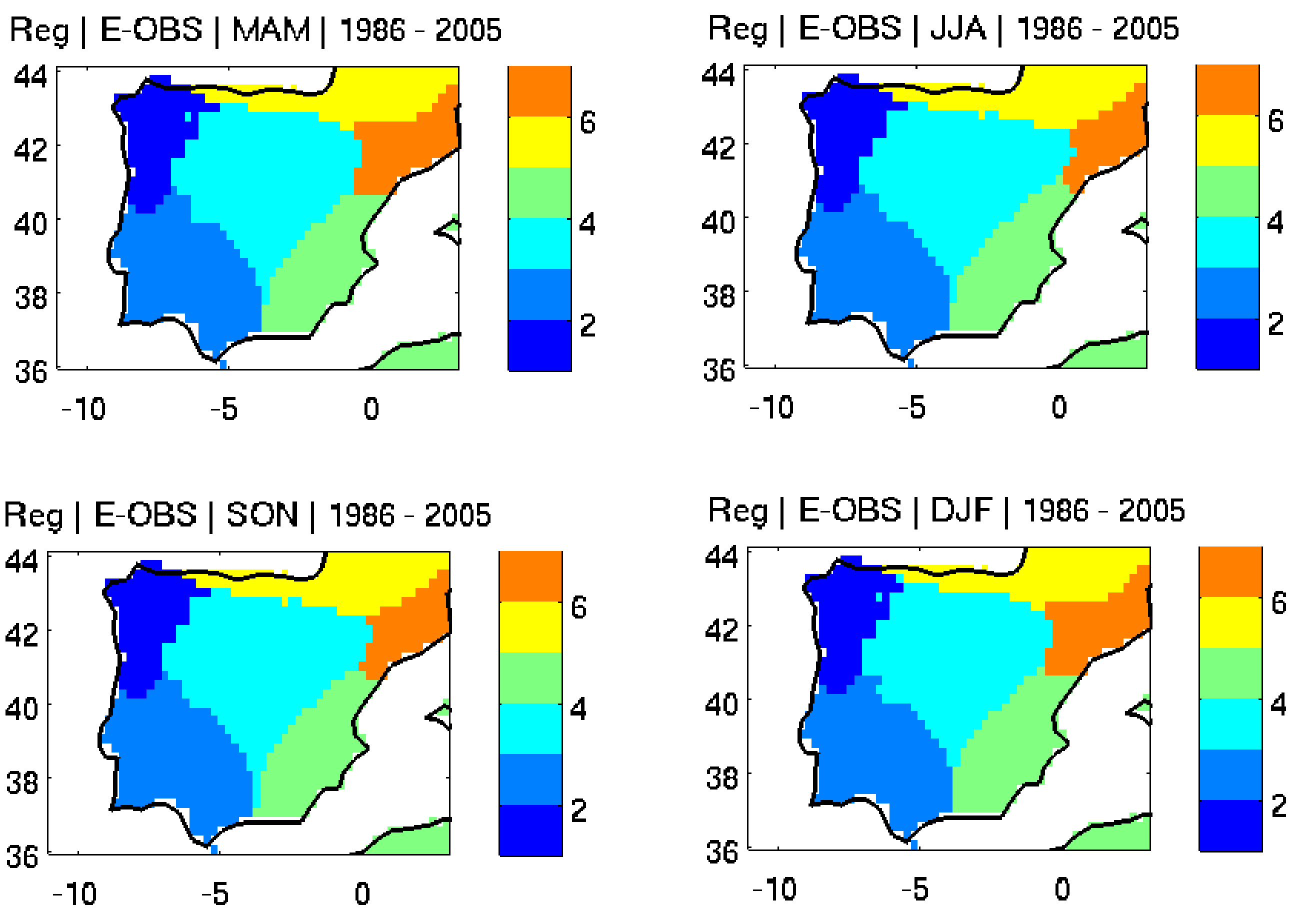
Results & Discussion

- Regionalization



- Regions:
  1. Northwest Iberia;
  2. Large region from the center to the western and southwestern shores of the IP;
  3. Middle of the IP;
  4. Large region extending from the center to the eastern and southeastern shores of the IP;
  5. North (Asturias) and northeast Spain (Pyrenees);
  6. Northeastern Iberia near France.

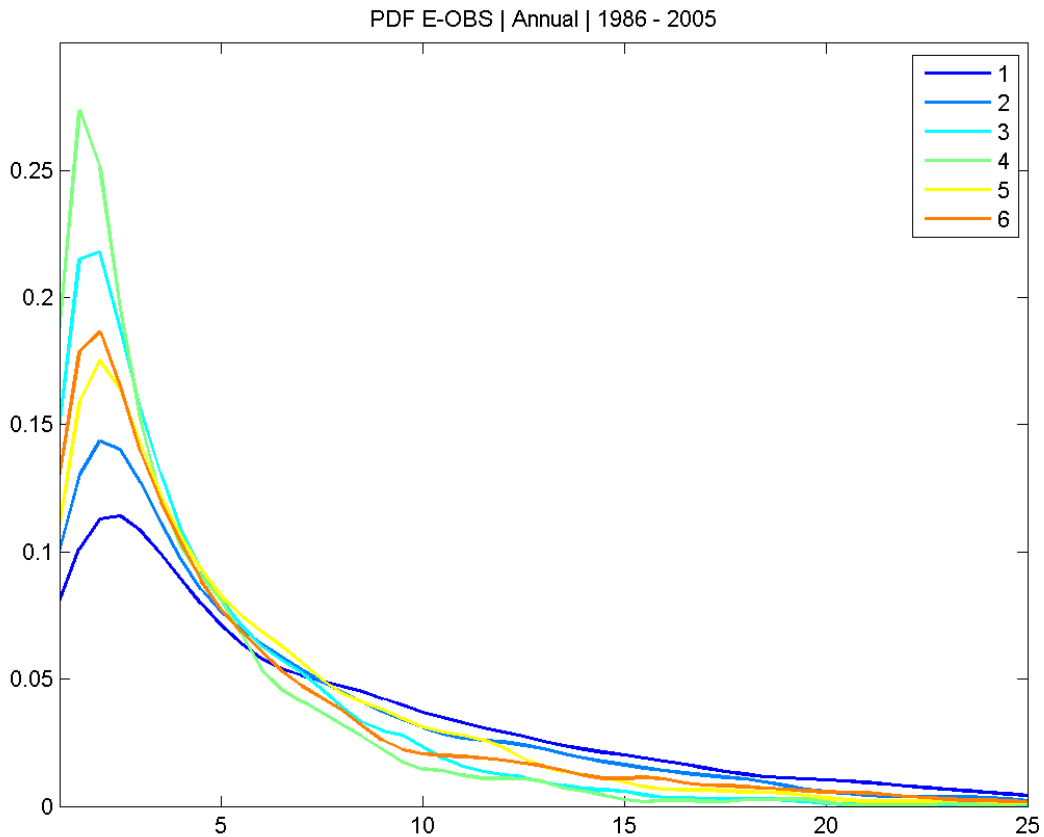
Results & Discussion



- Results are similar for seasonal precipitation;
- Results generally consistent with the thermodynamic characteristics described in literature.

Results & Discussion

- Probability Density Functions

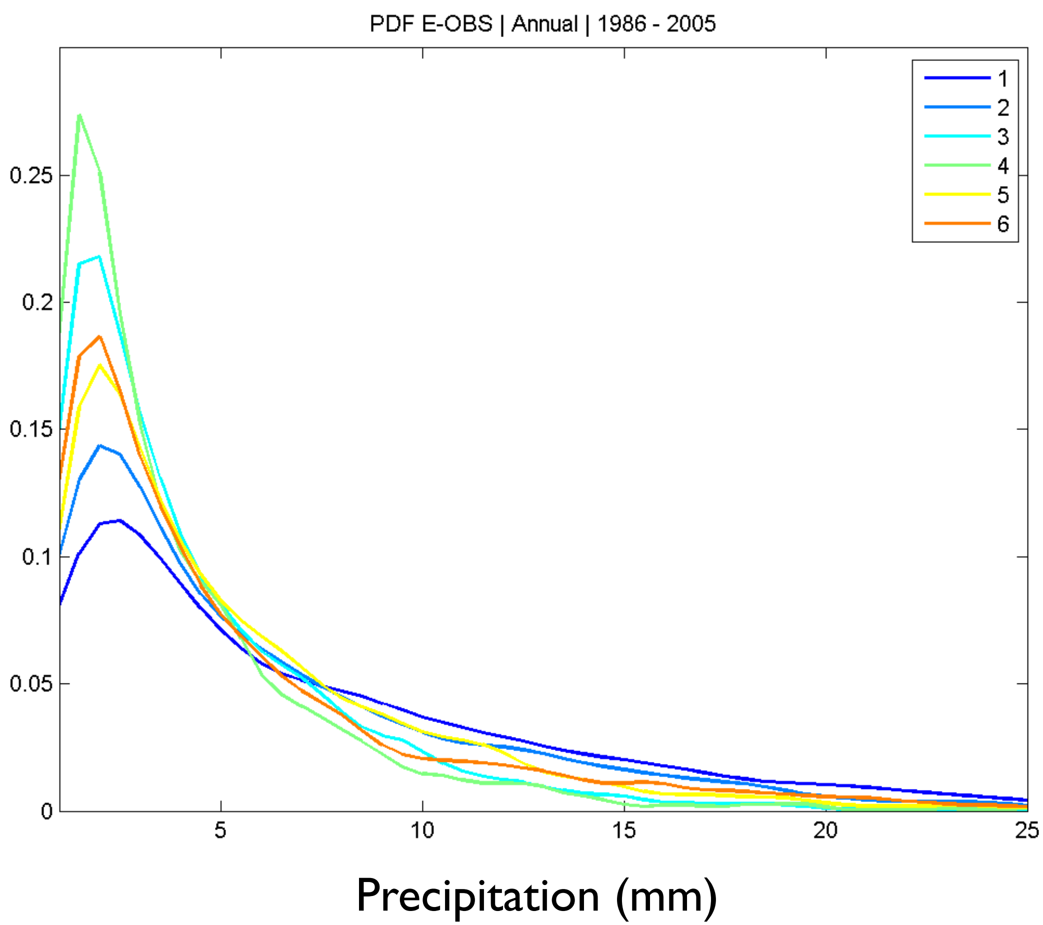


Precipitation (mm)

- Estimated by the Kernel method (Silverman, 1986) with a normalized Kernel function.
- The density was evaluated in 100 equally spaced points that cover the range of values in each data set.

Results & Discussion

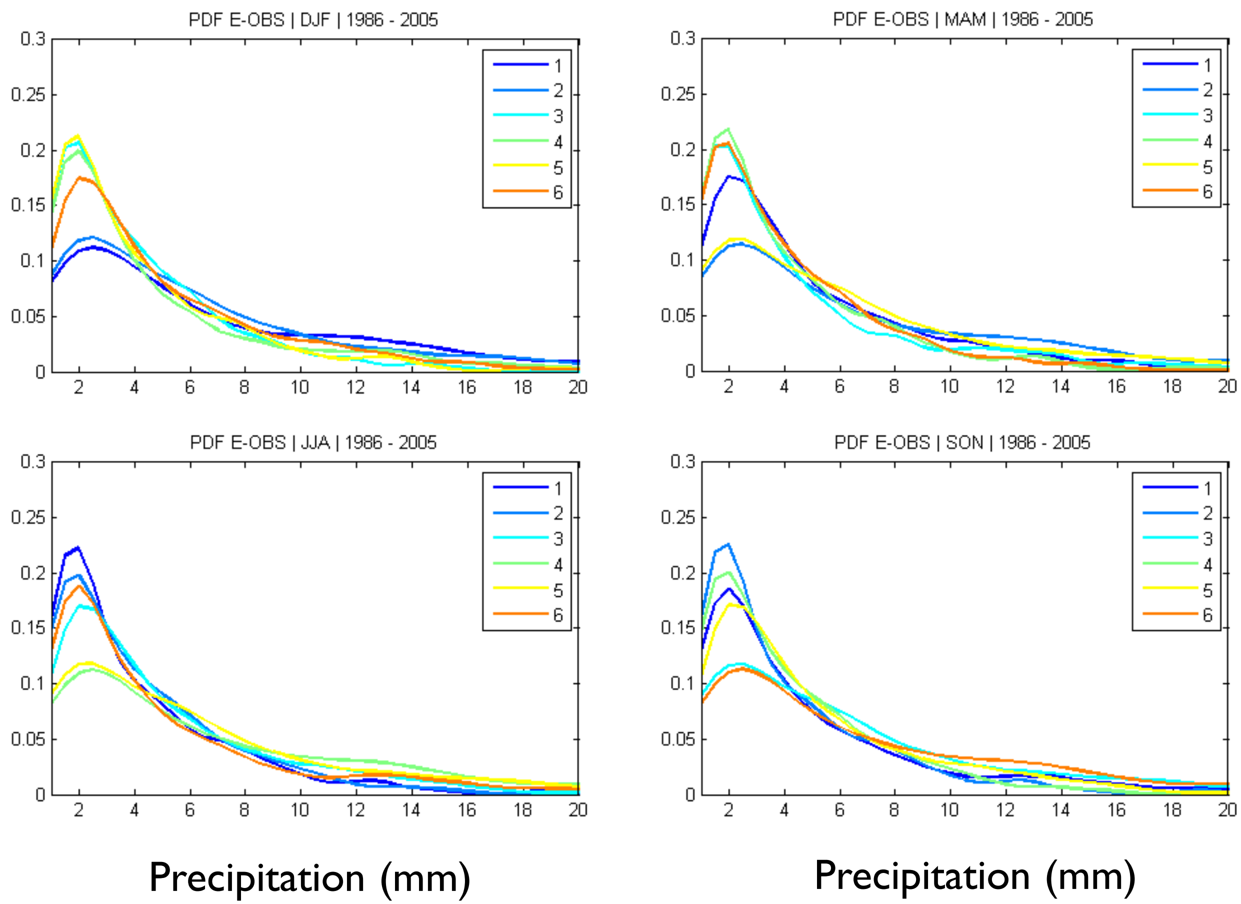
- Probability Density Functions



- Marked differences between regions:
  - Region 1: higher precipitation; higher probability for precipitation over about 8 mm.
  - Region 4: lower precipitation; higher probability of precipitation under 5 mm.

Results & Discussion

- Probability Density Functions



- Seasonal PDFs also show some differences between regions.

Results & Discussion

- K-S Test
  - Used to determine if the regions are statistically different from each other.
  - The K-S test (Wilks, 2006) establishes a null-hypothesis that the datasets belong to the same continuous distribution.
  - This hypothesis is rejected if the discrepancy, D, is high enough.

$$D_s = \max\left(|\mathrm{F1}(\mathrm{x}_1) - \mathrm{F2}(\mathrm{x}_2)|\right)$$

$$D_S > \sqrt{-\frac{1}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)\ln\left(\frac{\alpha}{2}\right)}$$

  - **Result: annual & seasonal precipitation at the centroids of the six regions are statistically different from each other.**

Application: trends in precipitation indices

Index	Reg	Annual
PRCPTOT (mm/year)	1	**-5.1889**
	2	-1.2503
	3	-0.9344
	4	-0.6935
	5	-5.1820
	6	-4.3402
CDD (N_{days}/year)	1	-0.2250
	2	**-0.7735**
	3	0
	4	-0.0651
	5	0.0646
	6	-0.1667
R90p (mm/day/year)	1	0.0213
	2	-0.0014
	3	-0.0046
	4	0.0293
	5	0.0074
	6	-0.0635

- **Precipitation Indices**
  - PRCPTOT – annual total precipitation
  - CDD – Maximum number of consecutive dry days
  - R90p – 90th percentile in distribution at wet days
- Trends were computed using the **Theil-Sen Regression** (Theil, 1950 & Sen, 1968)
- Their statistical significance was tested using the **Mann-Kendall Test** (Mann, 1945 & Kendall,1955), at a 95% significance level.

Application: trends in precipitation indices

Index	Reg	Annual	DJF	MAM	JJA	SON
PRCPTOT (mm/year)	1	**-5.1889**	**-5.5623**	-1.4657	-0.3421	-0.4339
	2	-1.2503	-0.7010	**6.7950**	-0.9946	-0.6112
	3	-0.9344	-0.4068	-1.6113	1.8884	4.0068
	4	-0.6935	**2.5103**	0.8250	**-4.4478**	-0.1148
	5	-5.1820	0.6606	**4.2162**	**-4.6150**	**-3.2002**
	6	-4.3402	0.2693	1.7450	2.5263	2.0201
CDD (N_{days}/year)	1	-0.2250	0	0	-0.0312	0
	2	**-0.7735**	-0.0294	0	0.3333	0
	3	0	0.0590	0.1250	-0.1082	**0.0955**
	4	-0.0651	**-0.2500**	0	0.1270	0.08712
	5	0.0646	0.2222	0	**1.0000**	0.1082
	6	-0.1667	-0.0667	0	0	-0.1000
R90p (mm/day/year)	1	0.0213	-0.1091	-0.0381	-0.0411	0.0417
	2	-0.0014	-0.0024	0.2757	0.0207	-0.0082
	3	-0.0046	0.0243	**-0.2422**	0.0547	0.2629
	4	0.0293	0.0901	0.0953	0.0130	0.0616
	5	0.0074	-0.0512	**0.2812**	-0.1383	-0.1072
	6	-0.0635	0.0092	0.0264	**0.1905**	0.0668

Conclusions

- We conclude that:
  - The identified regions of the IP can be used to represent the Iberian precipitation by six time series;
  - These series can be subjected to further analysis with results that can be presented in a concise manner, which would otherwise be impossible.
  - The methodology used here, based on Cluster Analysis, can be used to regionalize other areas of the world;

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