



*International Conference on
Ecohydrology, Soil and
Climate Change, 2014*



Regionalization of precipitation for the Iberian Peninsula

A.C. Parracho, P. Melo-Gonçalves, A. Rocha

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

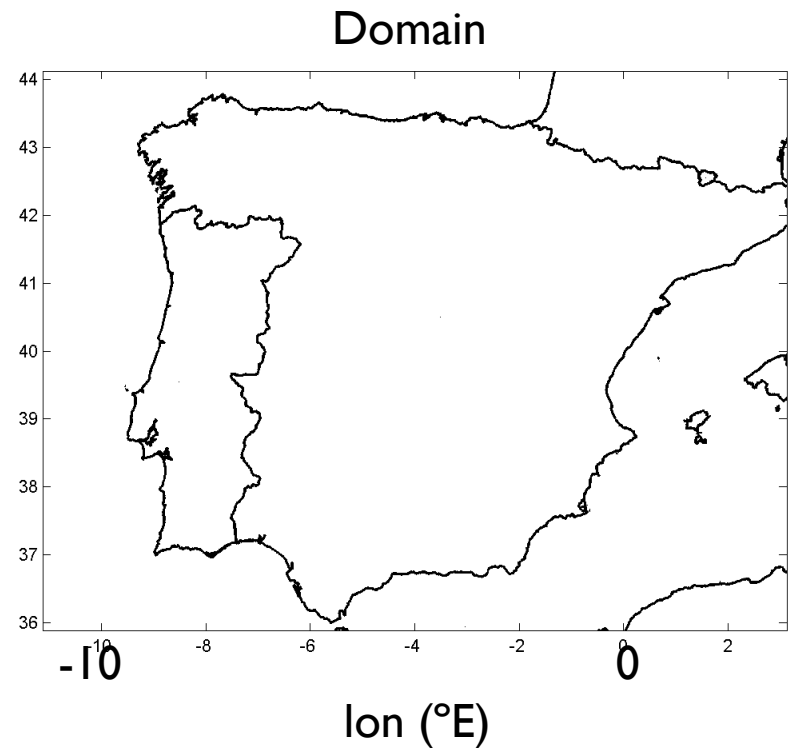
► Data:

► Daily observed precipitation data (E-OBS):

► from 1986-2005:

- land-only;
- high resolution (0.25°);
- on a regular grid.

► Over the Iberian Peninsula region.

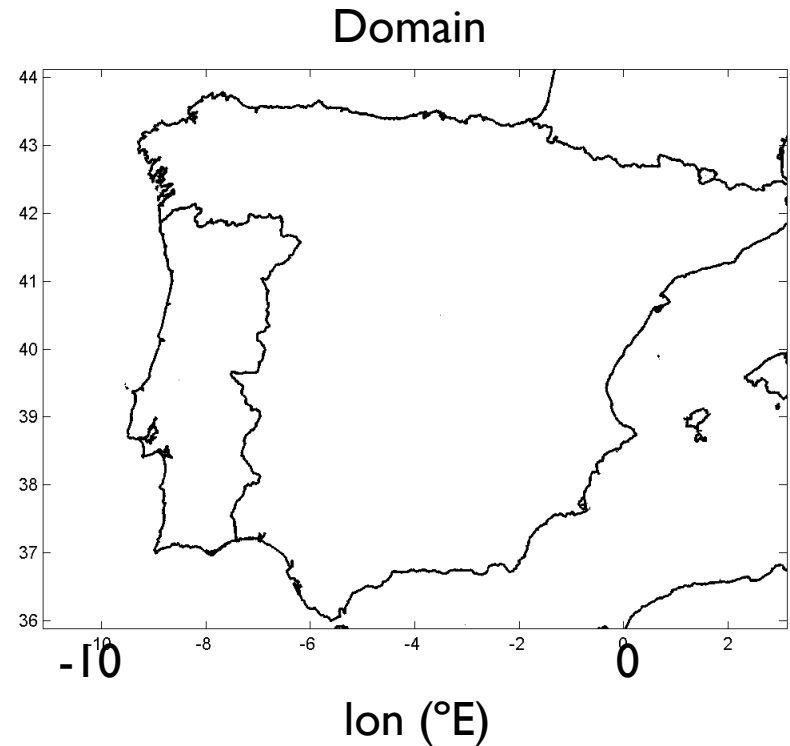


Data Set & Methods

► Methods:

► K-means Cluster Analysis:

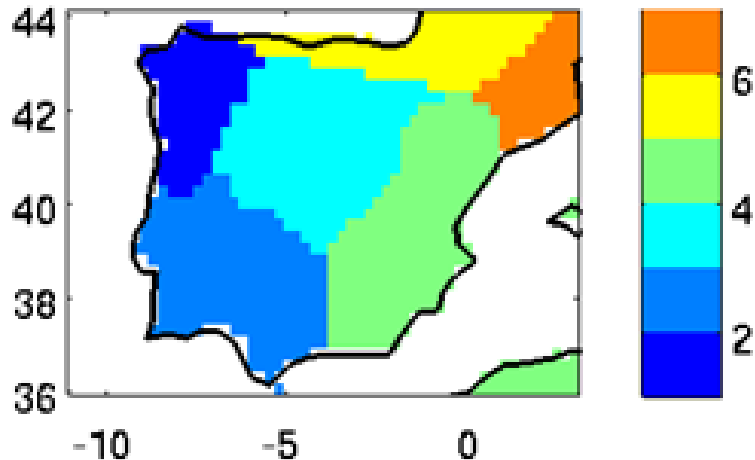
- Iterative partitioning that minimizes the sum, over all clusters, of the within-cluster sums of point-to-cluster-centroid distances;
- Using the squared Euclidean distance - each centroid is the mean of the points in that cluster;
- 6 clusters;
- Results are time series of the centroids for each region.



Results & Discussion

► Regionalization

Reg | E-OBS | ANNUAL | 1986 - 2005

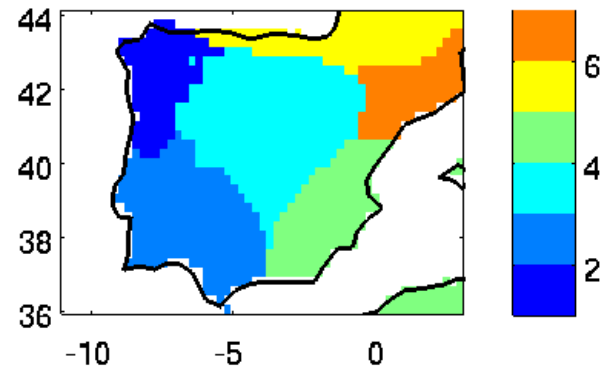


► Regions:

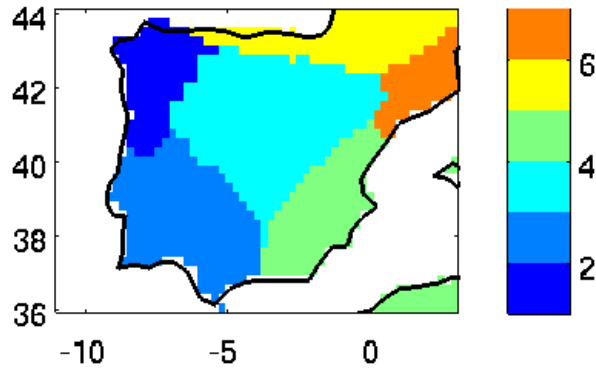
1. Northwest Iberia;
2. Large region from the center to the western and southwestern shores of the IP;
3. Middle of the IP;
4. Large region extending from the center to the eastern and southeastern shores of the IP;
5. North (Asturias) and northeast Spain (Pyrenees);
6. Northeastern Iberia near France.

Results & Discussion

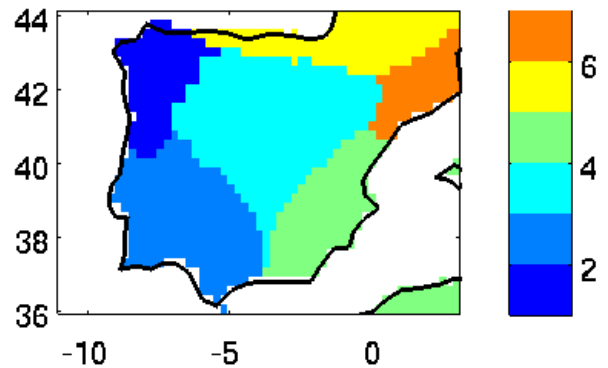
Reg | E-OBS | MAM | 1986 - 2005



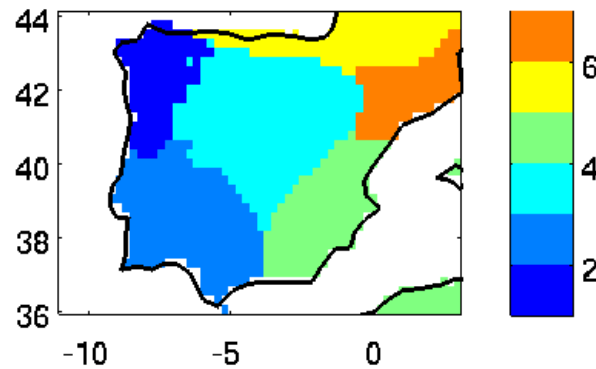
Reg | E-OBS | JJA | 1986 - 2005



Reg | E-OBS | SON | 1986 - 2005



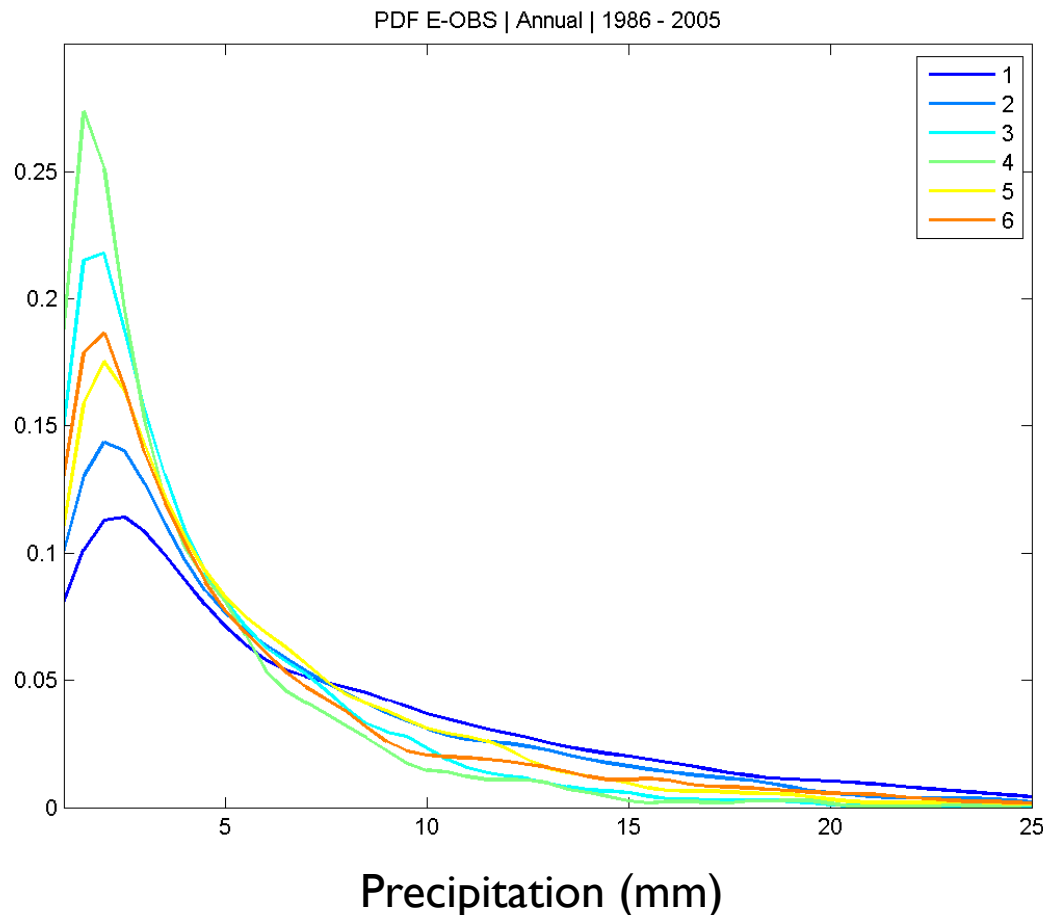
Reg | E-OBS | DJF | 1986 - 2005



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

Results & Discussion

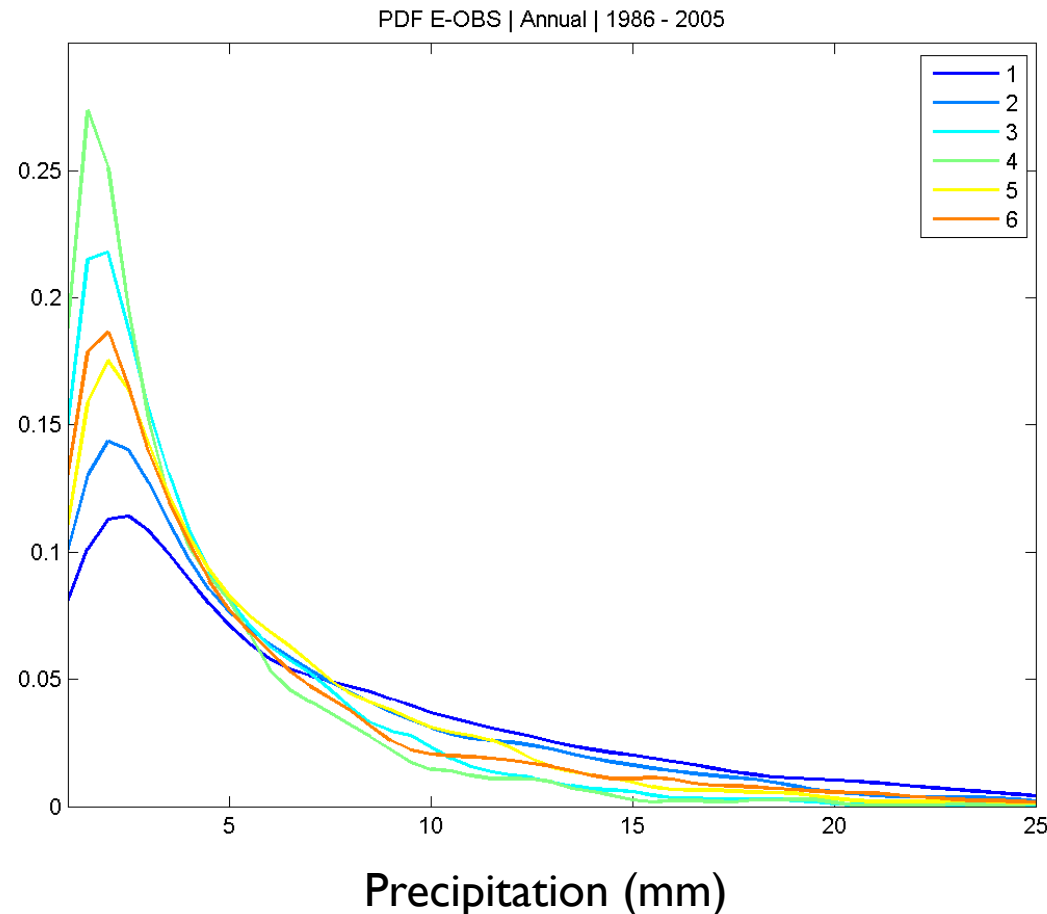
► Probability Density Functions



- 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

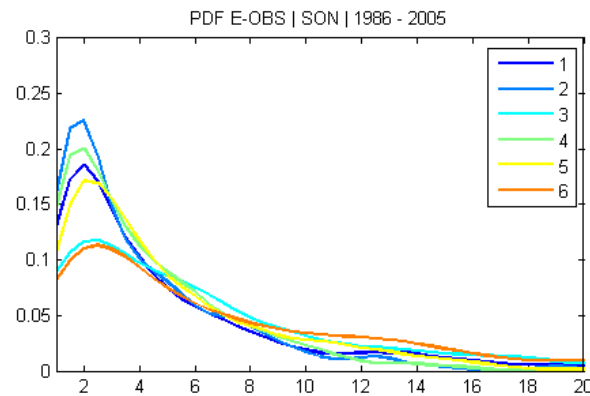
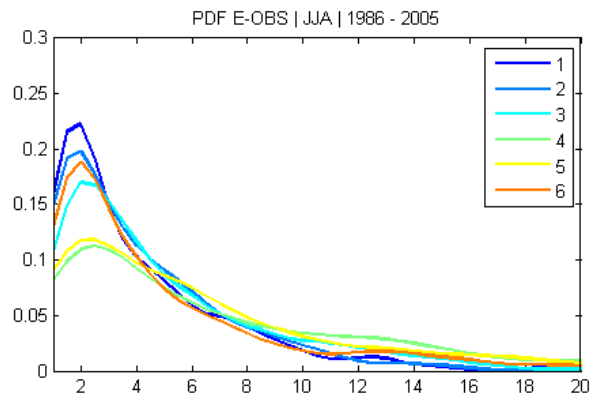
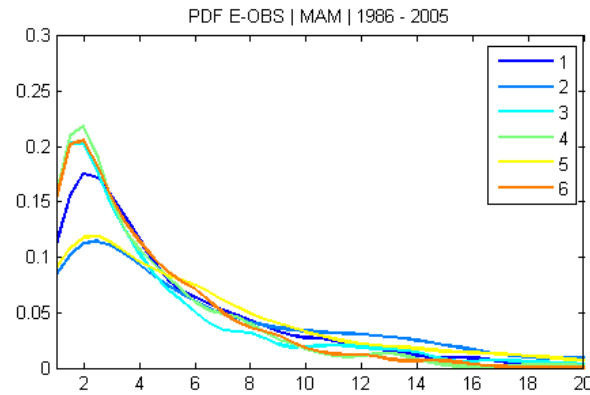
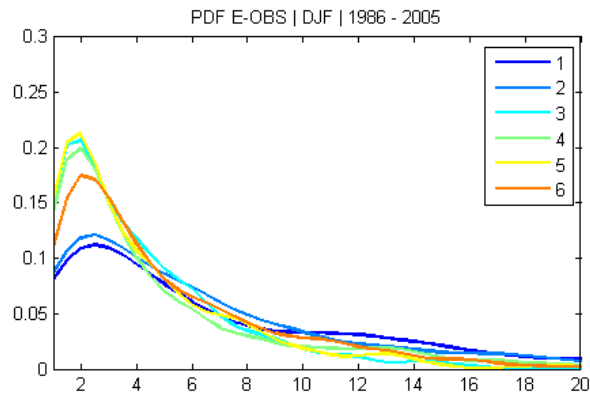


- Marked differences between regions:
 - Region 1: higher precipitation; higher probability for precipitation over about 8 mm.
 - Region 4: lower precipitation; higher probability of precipitation under 5 mm.

Results & Discussion

► Probability Density Functions

- Seasonal PDFs also show some differences between regions.



Precipitation (mm)

Precipitation (mm)

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.

$$D_s = \max (|F1(x_1) - F2(x_2)|)$$

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

- ▶ **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	<u>-5.1889</u>
	2	-1.2503
	3	-0.9344
	4	-0.6935
	5	-5.1820
	6	-4.3402
CDD (N _{days} /year)	1	-0.2250
	2	<u>-0.7735</u>
	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	<u>-5.1889</u>	<u>-5.5623</u>	-1.4657	-0.3421	-0.4339
	2	-1.2503	-0.7010	<u>6.7950</u>	-0.9946	-0.6112
	3	-0.9344	-0.4068	-1.6113	1.8884	4.0068
	4	-0.6935	<u>2.5103</u>	0.8250	<u>-4.4478</u>	-0.1148
	5	-5.1820	0.6606	<u>4.2162</u>	<u>-4.6150</u>	<u>-3.2002</u>
	6	-4.3402	0.2693	1.7450	2.5263	2.0201
CDD (N _{days} /year)	1	-0.2250	0	0	-0.0312	0
	2	<u>-0.7735</u>	-0.0294	0	0.3333	0
	3	0	0.0590	0.1250	-0.1082	<u>0.0955</u>
	4	-0.0651	<u>-0.2500</u>	0	0.1270	0.08712
	5	0.0646	0.2222	0	<u>1.0000</u>	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	<u>-0.2422</u>	0.0547	0.2629
	4	0.0293	0.0901	0.0953	0.0130	0.0616
	5	0.0074	-0.0512	<u>0.2812</u>	-0.1383	-0.1072
	6	-0.0635	0.0092	0.0264	<u>0.1905</u>	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;

References

- ▶ Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones, M. New. 2008: A European daily high-resolution gridded dataset of surface temperature and precipitation. *J. Geophys. Res (Atmospheres)*, 113, D20119, doi:10.1029/2008JD10201
- ▶ Kendall, M. G. (1955). *Rank Correlation Methods*. Griffin, London.
- ▶ Mann, H.B. (1945). Nonparametric tests against trend. *Econometrica*, 13, pp. 245–259
- ▶ Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall's tau. *J. Amer. Statist. Assoc.*, 63, 1379-1389.
- ▶ Silverman B. W. (1986). *Density Estimation for Statistics and Data Analysis*. Chapman and Hall: London, 175 pp.
- ▶ Theil, H. (1950). A rank-invariant method of linear and polynomial regression analysis, I. *Proc. Kon. Ned. Akad. v. Wetensch.* A53, 386-392.
- ▶ Wilks, D. S. (2006). *Statistical Methods In Atmospheric Sciences*. Elsevier, 649 pp.

Acknowledgements

- ▶ We acknowledge the E-OBS dataset from the EU-FP6 project ENSEMBLES (<http://ensembles-eu.metoffice.com>) and the data providers in the ECA&D project (<http://www.ecad.eu>)
- ▶ This study was supported by FEDER funds through the Programa Operacional Factores de Competitividade – COMPETE and by Portuguese national funds through FCT – Fundação para a Ciência e a Tecnologia, within the framework of the project CLIPE, Project Reference PTDC/ AAC-CL/111733/2009

