Physica A 494 (2018) 17–26

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

ρ_{DCCA} applied between air temperature and relative humidity: An hour/hour view

G.F. Zebende [a,d,*], A.A. Brito [b,c], A.M. Silva Filho [d], A.P. Castro [e]

[a] Department of Physics, State University of Feira de Santana, Bahia, Brazil
[b] Federal Institute, Paulo Afonso, Bahia, Brazil
[c] SENAI CIMATEC, Salvador, Bahia, Brazil
[d] Earth Sciences and Environment Modeling Program, State University of Feira de Santana, Bahia, Brazil
[e] Jorge Amado University Center, Salvador, Bahia, Brazil

HIGHLIGHTS

- We quantify cross-correlations between air temperature and relative humidity.
- Our data were available hourly by the Brazilian Institute of Meteorology (INMET).
- We present a new vision about these variables at every scales with a detrended cross-correlation map.

ARTICLE INFO

Article history:
Received 25 August 2017
Received in revised form 13 November 2017
Available online 11 December 2017

Keywords:
Air temperature
Relative humidity
Detrended cross-correlation coefficient
Contour map

ABSTRACT

In this paper we propose to study the cross-correlation between the air temperature and the air relative humidity using the DCCA cross-correlation coefficient ρ_{DCCA}. We choose four cities (meteorological stations) located in the State of Bahia (Brazil), as our case study. Our data were available hourly from the Brazilian Institute of Meteorology. Accordingly, in addition to showing that the variables have a negative cross-correlation, we present a new vision about these variables, producing the detrended cross-correlation contour map. As a result, we can see (or not) islands of cross-correlations, that depend on the local time and also the time scale involved.

1. Introduction

Global warming can be caused by human activities (anthropogenic causes), as well as, by natural phenomena. The climate components are never in equilibrium and are constantly varying, like a complex system, see [1–4]. Thereby, any change in the components may result in a considerable variation in the climate [5]. From the perspective of climatology, mathematical models are important, because they can be applied to study the dynamics of the weather, projections of the future climate, and changes in the air temperature, among others. Meteorological data accumulated over many years, such as records of rainfall, temperature, and atmospheric composition can be analyzed by modern statistical techniques and mathematical models [6–10]. Thus, to study these complex systems we must properly define the fundamental variables, such as: air temperature, pressure, wind direction and speed, relative humidity, and many others, see chapter five of [11]. Most of these models use systems of differential equations based on the laws of physics, fluid motion, and chemistry. But, [12] recently proposed studying the cross-correlation between two time series by applying the DCCA method, designed to investigate

* Corresponding author at: Department of Physics, State University of Feira de Santana, Bahia, Brazil.
E-mail address: gfzebende@pq.cnpq.br (G.F. Zebende).

https://doi.org/10.1016/j.physa.2017.12.023
0378-4371/

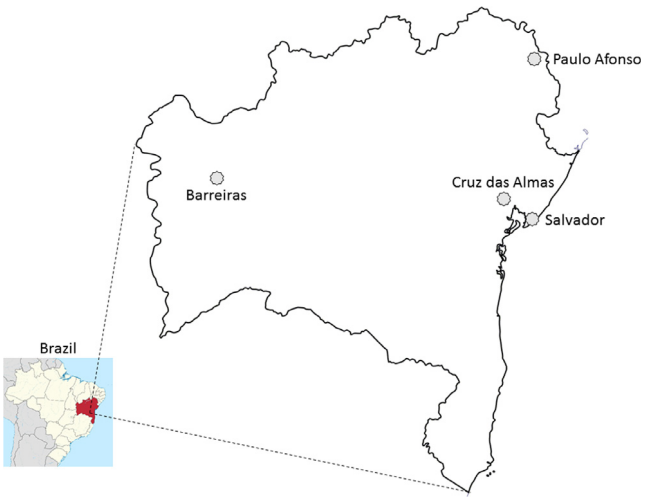

Fig. 1. State of Bahia (BR) and four climatological stations located in cities of: Barreiras, Cruz das Almas, Paulo Afonso, and Salvador.

Table 1
Geographical information for the stations.

Station	Lat.(S)	Long.(E)	Elev.(m)
Barreiras	12°07′29.0″	45°01′37.4″	474
Cruz das Almas	12°40′31.5″	39°05′22.5″	220
Paulo Afonso	09°22′41.2″	38°13′36.4″	255
Salvador	13°00′19.9″	38°30′20.7″	48

Table 2
Data information.

Station	Start	End	points
Barreiras	12/22/2001	09/30/2010	2047
Cruz das Almas	01/26/2003	09/30/2010	1919
Paulo Afonso	06/18/2003	09/30/2010	2065
Salvador	10/07/2000	09/30/2010	2616

power-law cross-correlations between different simultaneously recorded time series in the presence of non-stationarity. However, the DCCA method does not quantify the level of cross-correlation. In order to solve this problem [13] defined the DCCA cross-correlation coefficient, ρ_{DCCA}, which allows the analysis of non-stationary time series, as in climatological variables. To show the efficiency of the DCCA cross-correlation coefficient, we analyze the relationship between the air temperature and the relative humidity. Our database comes from four stations located in Bahia State (BR), with data measured hourly by the Brazilian Institute of Meteorology (INMET).

With an area of 564,733.177 km^2, Bahia is one of the 27 federated Brazilian States, bordering eight other States. On the east it is bathed by the Atlantic Ocean, having the most extensive coast in Brazil. Below, in Fig. 1, we present the location of the meteorological stations, and their description in Table 1.

The importance of these stations (cities) comes from the fact that they are the ones that have the best databases, and because they have the following characteristics (see [14] and Table 2):

- **Barreiras**: This is the most populous city and the most important agricultural center in the western region of Bahia. The city is pierced by the Rio Grande river, the main affluent on the left of the São Francisco river (one of the most important in Brazil and South America). Barreiras stands out in national (international) agribusiness as a great producer of cotton and soybeans.
- **Cruz das Almas**: This is considered an important center in the *Recôncavo*, a geographical region located around the *Todos os Santos* bay, covering not only the coast but also the entire region of the interior surrounding the bay. The city has some agricultural research centers, such as Brazilian Company of Agricultural Research (EMBRAPA), and its industry is known for well made footwear and textiles.
- **Paulo Afonso**: This is the city where the São Francisco Hydroelectric Company (CHESF) plant complex is located. It has four large plants, PA I, PA II, PA III, and PA IV. This makes Paulo Afonso known as the "energy capital". The city has a planned structure, the center is inside an artificial island that was built with the implantation of the channel of the