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Precipitation Analysis using Test of Hypothesis and Energy Flux Simulation for the São Francisco River Transposition Project

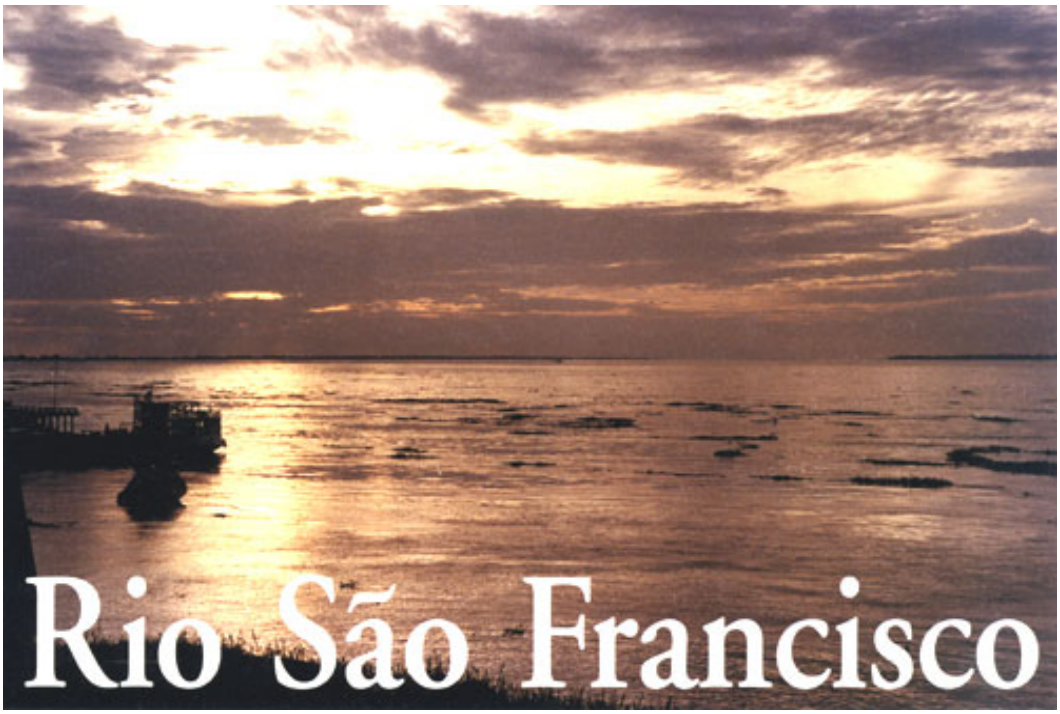

Foto: Roberto Malvezzi.

Climate adversities have frequently generated hydrological extreme events, as precipitation, floods and droughts, being able to influence negatively the social-economic development of a given region. The hydric developmental interest has been concentrated in the northeast region of Brazil. In turn, since long date the project of transposition of the waters of the São Francisco river has deserved the attention of Brazilian society as a possible solution for such challenge.

INTRODUCTION

The study of the hydrological cycle is very important, given that although not always explicit, water is an essential element to the development of the civilizations. Brazil is privileged when the subject is hydric resources. It is estimated that approximately 12% of all fresh water available for human use in the world is in Brazil. However, it suffers with the imbalance between supply and demand, wastefulness and environmental pollution.

In the Northeastern region particularly, the irregular pluviometry in time and in space has led to no significant evolution of the Human Development Index (HDI - United Nations) of the region throughout the last decades. In this context, the discussion of the project for the transposition of the waters of the São Francisco river basin gains relevance under the meteorological perspective, little studied until now.

The identification of the energy balance components at the surface from the available solar radiation is fundamental for studies of the nature of the transposition project proposed. In this direction, the objective of this study was to analyze the latent and sensible heat fluxes at the donors and recipients regions of the São Francisco River basin water transposition project by using the regional atmospheric model RAMS (*Regional Atmospheric Modeling System*) during an El Niño period[1], as well analyze the stationarity hypothesis[2] for the precipitation time series.

STUDY AREA

The study region is defined at the domain: 35ºW to 46ºW and 2ºS to 15ºS, and have the Northeast and part of the Atlantic Ocean as domain. These simulations were performed for the 9°S latitude, water catchment region, and 5°S, water recipient region (Figure 1).

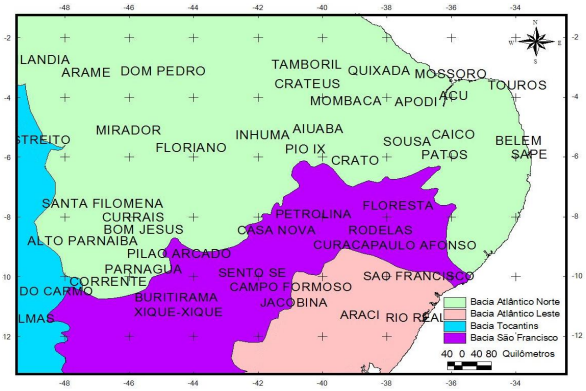

Figure 1 - Municipalities located at the latitudes 11ºS, 9ºS, 7ºS and 5ºS.

CLIMATIC CHARACTERISTICS

According to Wladimir Köppen (1948) classification, the study region have three climatic types: (a) Cwb - mild temperate climate with warm summer (mean temperature of the hottest month below 22°C) and mild winter (mean temperature of the coldest month below 18°C); dry season coincides with winter; (b) Cwa - mild temperate climate with hot summer (mean temperature of the hottest month above 22°C) and - mild winter (mean temperature of the coldest month below 18°C); (c) Aw - tropical climate, rainy, hot and humid, with dry winter and rainy summer (mean temperature of the coldest month always above 18°C); this climatic type occurs at the other areas of the sub-basin.

ATMOSPHERIC MODELING

In this study, the model RAMS version 3.b was chosen objecting a better understanding of the sensible and latent heat fluxes for the month of April during an El Niño (1983) period. The month choice was due to the fact that this month is part of the rainy season when the El Niño phenomenon interference is more severe on the volume of water available at the sub-medium and lower São Francisco.

The soil cover used is classified as semi-desertic type, with volumetric humidity of 25% and sandy-clay texture. The adopted formulation was the non-hydrostatic. The following parameterizations were activated[3]: short-wave and long-wave radiation; cumulus; soil and vegetation; turbulent diffusion and cloud microphysics.

Table 1 shows the simulations spatial and temporal configurations, while Table 2 presents the simulations vertical grid dimension.

Table 1 – Simulation spatial and temporal configuration.

Grid	Δx (m)	Δx (m)	Δt (s)	Points in x	Points in y	Domain
1	40000	40000	60	36	36	NE and part of Atlantic Ocean

Table 2 – Vertical simulation configuration.

Number of levels in z	28
Δz (min.)	60
Δz (Max.)	1,200
Increase factor	1.2

TEST OF HYPOTHESIS

The hypothesis was evaluated using Wilcoxon or Mann Whitney or u-test (BRADLEY, 1968), at 95% confidence level. Regional stationarity of the basin was evaluated.

[1] Atmospheric-oceanic phenomenon characterized by an abnormal heating of the superficial waters of the Pacific Ocean that can affect the regional and global climate.
[2] It is a decision taken by the analyst, to verify the model adjustment to the reality being investigated.
[3] Process which defines the parameters - usually a model - that are evident to the question asked from this model.

Under the null hypothesis of stationarity of the whole basin, and assuming the independence between the pluviometric stations series, the number of rejected series in a test with significance level α is an aleatory variable with binomial probability distribution with mean $np\ \alpha$, where np is the total number of stations. The probability of rejection of many stations in the tests increases when there are significant non-stationary effects at some or all sub-regions of the basin. The conduction of the test is presented next:

- Null hypothesis: there is regional stationarity;
- Alternative hypothesis: there is no regional stationarity;
- Significance level: α=0.05;
- Criteria: accept null hypothesis if A >0.05.

$$A = \sum_{i=nr}^{i=np} \left[\binom{np}{i} (\alpha)^i (1-\alpha)^{np-i} \right]$$

where A - probability rejection of nf or more stations; nr - number of stations rejected in the stationarity test; np - total number of stations; α - significance level.

RESULTS AND DISCUSSION

The energy fluxes behavior is an important boundary condition in the distribution of the radiative energy absorbed at the soil surface as sensible heat (H) and latent heat (LE).

Atmospheric thermodynamic characteristics influence the surface fluxes distribution.

Figures 2 and 3 are related to the sensible heat flux, while Figures 4 and 5 illustrate the latent heat flux behavior. The sensible and latent heat fluxes configurations were determined for the donor and recipient regions respectively.

Possibly there is a significant difference in the sensible heat fluxes between the plateaus and the flat areas, directly related to the solar radiation rate at the soil surface. There is a noticeable increase at the region between 36°W and 43°W during most of period (Figure 2). At the latitude 5°S (Figure 3) there was a small reduction, with the highest values registered between 38°W and 43°W.

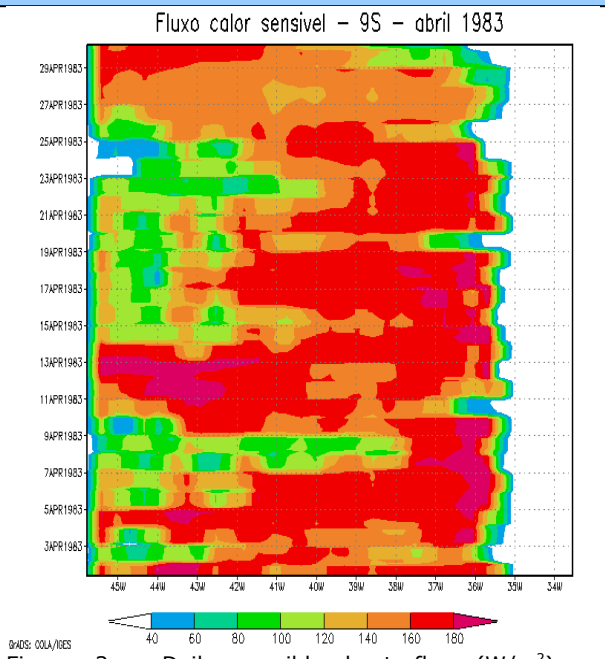

Figure 2 - Daily sensible heat flux (W/m^2) simulated for the latitude 9°S in April 1983.

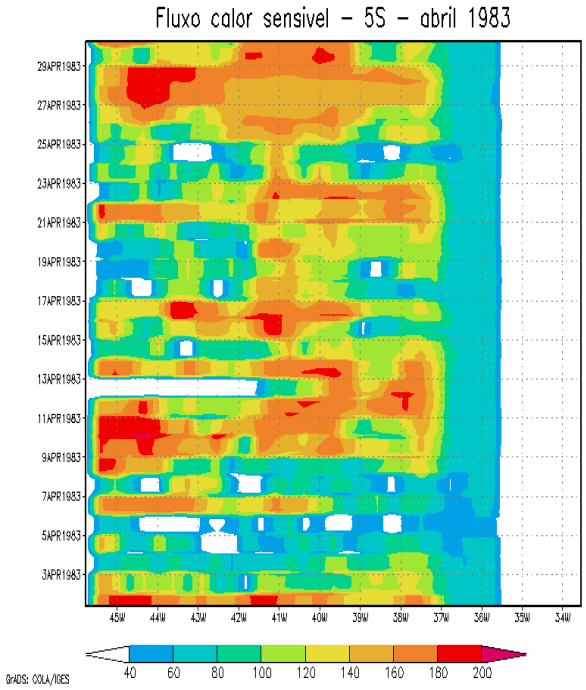

Figure 3 - Daily sensible heat flux (W/m^2) simulated for the latitude 5°S in April 1983.

For these simulated scenarios, it is noticeable the importance and the influence of the climatological phenomenon El Niño of 1983. Although soil humidity is an important variable of the energy balance at the surface, in this evaluation it was considered constant at the donors and recipient regions of the project.

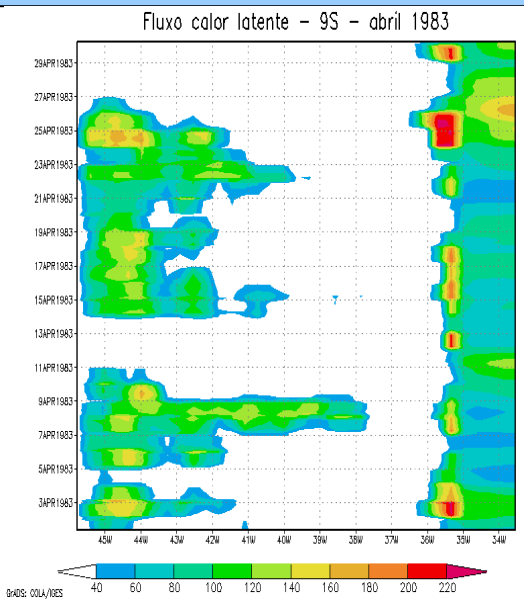

Figure 4 - Daily latent heat flux (W/m^2) simulated for the latitude 9°S in April 1983.

The important of soil humidity in the simulated scenarios is observed in Figures 4 and 5, given that a higher concentration of daily latent heat flux was found at the northeastern Brazilian coast (36°W) and part of the Atlantic Ocean (33ºW to 36ºW), at the time of El Niño.

On the other hand, it is observed that at the recipient region (Figure 5) there were higher concentrations of latent heat flux throughout the entire area, when compared to the results for the donor region (Figure 4). Notice that simulations results indicate higher atmospheric humidity at the recipient region.

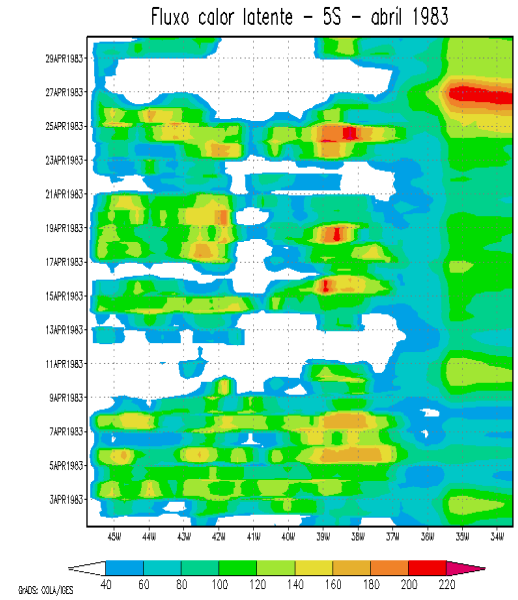

Figure 5 - Daily latent heat flux (W/m^2) simulated for the latitude 5°S in April 1983.

Initially it was expected that the northern semi-arid, which contains the recipient region, would have lower humidity availability. This expectation was refuted by the simulation results. The results had shown the acceptability of the null hypothesis of stationarity of the pluviometric data as well as the hypothesis of regional stationarity at the 95% confidence level.

CONCLUSION AND FINAL CONSIDERATIONS

As previously mentioned, the objective of this study was to simulate the energy fluxes at the water donors and recipients regions at the São Francisco river basin during an El Niño climatic event period, and verify the stationarity of the basin. An important result to be highlighted is that the low humidity found in the Brazilian northeastern soils is not necessarily connected to the low atmospheric humidity contents but to the controlling atmospheric mechanisms.

The study try to demonstrate that it is necessary to adopt a greater scientific rigor in the versions divulged by different media about the water availability at the donor and recipient regions of the project of transposition of the waters at the São Francisco river basin. This affirmation is supported by the fact that the discussion did not incorporate adequately the meteorological study of the donors and recipients regions.

REFERENCES:

BRADLEY, 1968. **Distribution-Free Statistical Tests**. Prentice Hall, Chapter 12.

To Learn More:

MARQUES DA SILVA, A. P. L., 2004. **Avaliação Hidrológica e Meteorológica para a Transposição de Águas da Bacia do Rio São Francisco**. Tese de Doutorado, Curso Interdisciplinar de Ciências Atmosféricas, Programa de Engenharia Civil/COPPE/UFRJ, 268 p. Avalaible at http://www.coc.ufrj.br/index.php?option=com_content&task=view&id=1269&Itemid=31.

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