

A STUDY OF THE SEA LEVEL ELEVATION IN THE TROPICAL ATLANTIC AS OBSERVED IN THE NEIGHBOHOODS OF THE BRAZILIAN NORTHEAST COASTLINE

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Coastal observations

The main cities of the Northeast Brazil (Nordeste) are located in the Atlantic coastal zone. Most of them are partially constructed on the level of the sea, or even a little bit lower (ex. Recife). During the last decades these cities had experienced flooding problems, for account of the discharge of the rivers at the moments of annual highest tides, i.e. in January-February and in August-September. Large sums of money had been spent to create barrages in the rivers and/or areas of escape for the excess of water in the hours of tide peaks.

In the same last decades, despite the carried through efforts, the beach areas of that region hardly had been punished by the tides, and for several cities of Nordeste entire streets had lost to the ocean. That was especially the case for cities of Recife/Olinda and João Pessoa (Figure 1). In the maritime edge of Olinda (close to Recife), traditional bars as the "Bar da agulha frita", the "Palhoça do Zé Pequeno" and the "Bar do Goiámu" had to be transferred to the other side of the "Avenida Senador Marcos Freire" (beach), due to sustainability conditions, a time that the protection wall was knocked down by the waves. In João Pessoa the problem is identical: the "Avenida Arthur Monteiro de Paiva" lost more than a half of its extension and in a similar way that in Recife, some bars of the edge had to be transferred to the "Avenida Governador Argemiro de Figueiredo", in the area of the beach of

"Camboinha", for example. The most oriental point of Americas (07°09'28" South - 34°47'30" West), that it is located in the "Ponta do Seixas" in Tambaú, João Pessoa, also suffered with the strength of the tides. That landmark internationally known already lost part of its "mirante" (see figure 2) and it is not being exactly discarded that, in some years, if nothing it will be made for protection, the lighthouse "Cabo Branco" located in the immediate proximity, will be lost.

It is probable that these damage could be linked to the global change. Many other similar coastal destructions which occurred in the world these last decades were identified as being dramatic responses of the global warming of the oceans, itself responsible for an thermic expansion of the water, and consequently for an elevation of the sea, as seen in the literature, (1 – 3) mm/year [IPCC 2001; Wainer 2003; Janini et al. 2003; Carton et al 2005].

The best candidates of data to evaluate if the regional sea level is dropping all along the time are obviously observations of the mean sea level which are provided by tide gauges, especially if these instruments are geodesical referenced. Unfortunately, such referenced data are not available in the Nordeste region for the last decades. As a preliminary study, our objective here is then to use available meteo-oceanic times series which were recorded in the oceanic region off the coast of Nordeste, and to research to identify some time variations which could be associated to the observed coastal destructions.

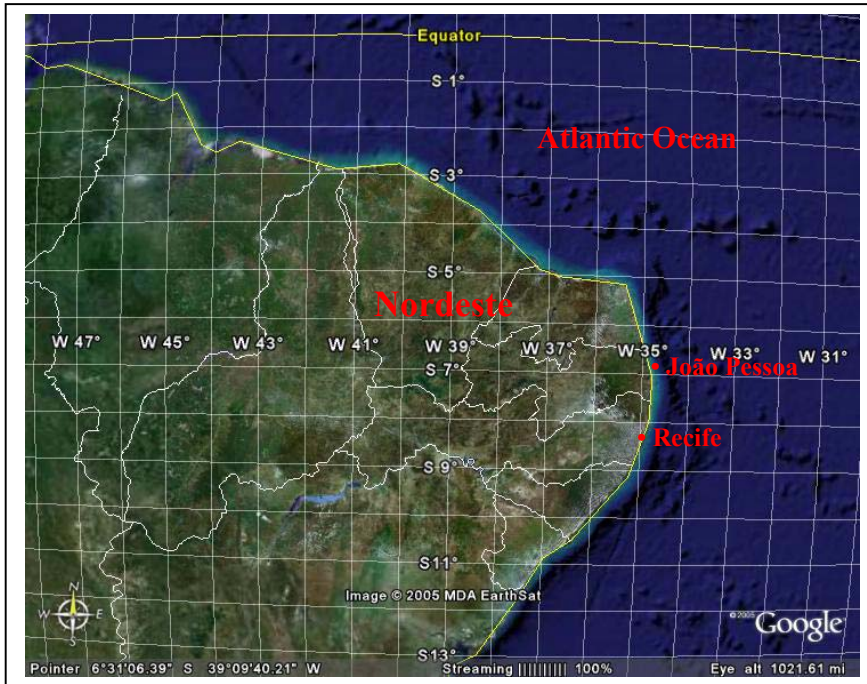


Figure 1 – Northeast Brazil Region (Nordeste) location and the cities considered in this paper as seen in the Google Earth. Olinda is considered here as urban part of Recife (Grande Recife) once they are very closely.

The sequence of figures shown as follow (figure 2 – 5), it suggests that in last fifteen or twenty years, the ocean advanced over the beach regions of the main cities of eastern Nordeste, provoking landslides of support walls, parts of situated houses to the side sea and until making entire streets or parts of them to disappear.

As it has not more than ten years behind, if somebody consulted the boards of the tides in the port of “Cabedelo”, it could evidence a variation between the low tide and the high water of the order of 0.50m to 1.50m. Today this variation is of 0.10m - 2.50m observed in January of this year of 2005. In 2005 August, it was observed maximum value of 2.80m at Cabedelo port. An initial analysis of the daily data of the mean sea level in that port,

in João Pessoa and the port of Recife, supplied for the “DHN” for the last five years, from March of 2001 to March of 2005, which shows that in January, this level passed from 1.18 m, to 1.34 m with an increase of 0.16 m, as shown in the DHN web page (see for reference www.dhn.mar.mil.br). However, it need’s a more extensive analysis of secular time series so that if they can take off more concise conclusions on this variation, that it is not small, therefore if this increase will be linear, 16 centimeters in five years, it does mean that this level could arrive the 160 centimeters in year 2050, a very bigger increase than one predicted in all the works divulged on the subject until the present moment, 1 – 3 millimeter per year.



Figure 2 - Destruction of the “mirante” of the “Farol do Cabo Branco” at “Ponta do Seixas”, more eastern point of Americas, in João Pessoa - PB. Left picture (A) was taken on 2005 January and right one (B) on 2006 January. We can see the increasing destruction of the wall where the people using to see the sea.



Figure 3 - Map of part of the City of João Pessoa, quarter and beach of “Bessa” as seen ten years ago. - The “Arthur Monteiro de Paiva” Avenue (the area in detach), in this stretch - the first one from coastline to the west - it does not exist more; it was swallowed by the tide.



Figure 4 - Edge of Olinda, “Senator Marcos Freire” Avenue, where if they can notice the workmanships of containment of the advance of the sea where long ago the Bar’s existed that had been transferred to the left side of the avenue.

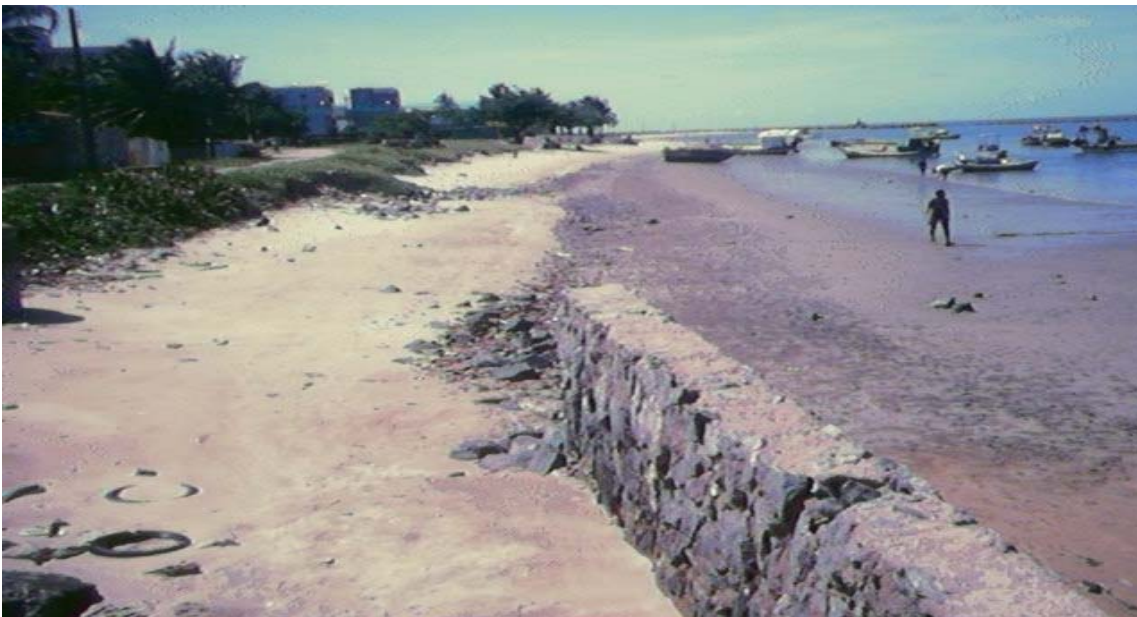


Figure 5- Sight of the beach of “Janga” at Olinda, with it remained of a street after the sea to have been destroyed the containment wall and taken the stone pavement. In it we see, left inferior, a "mouth of wolf" of the sewer system. To the deep one, right side in the superior part, natural “Arrecifes” had received reinforcement from rocks.

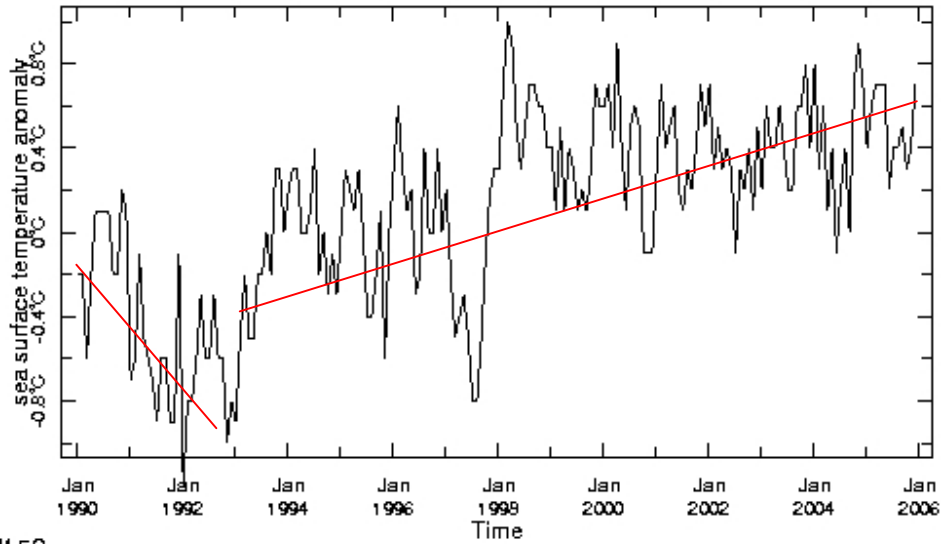
Analysis of ocean-atmosphere observations

In that preliminary study we would like to check about an eventual variation of the sea temperature in the region off Nordeste Brazilian coast, as well as about an eventual variation in the intensity of the trades in the same region. For that purpose we used historical time series of observed sea surface temperature (SST) and pseudo wind-stress (PWS). This data base (Servain et al., 1987; Smith et al., 2004) is now currently performed at FUNCEME from meteo-oceanic observations provided by the Volunteer Observing System (VOS), i.e., mainly, from the merchant ships which are routinely crossing the open ocean. SST and PWS are monthly computed using a complex processing combining both subjective and objective routines (Servain et al., 1987), according a regular grid ($2^\circ \times 2^\circ$) spaced in the tropical Atlantic basin from 15°N to 10°S . This data base is available at the FUNCEME Home Page (<http://www2.funceme.br/DEMETS/index.htm>). Monthly anomalies are obtained by retrieving the monthly climatology computed during the period 1964-2005. We are only using here the period 1990-2005 over the oceanic region limited by 5°S and 15°S in latitude and by 37°W and 30°W in longitude (see Figure 1).

The figure 6 presents a monthly SST anomaly averaged for the area nearest the Nordeste coast ($5^\circ - 15^\circ \text{S}$ and $30^\circ - 37^\circ$

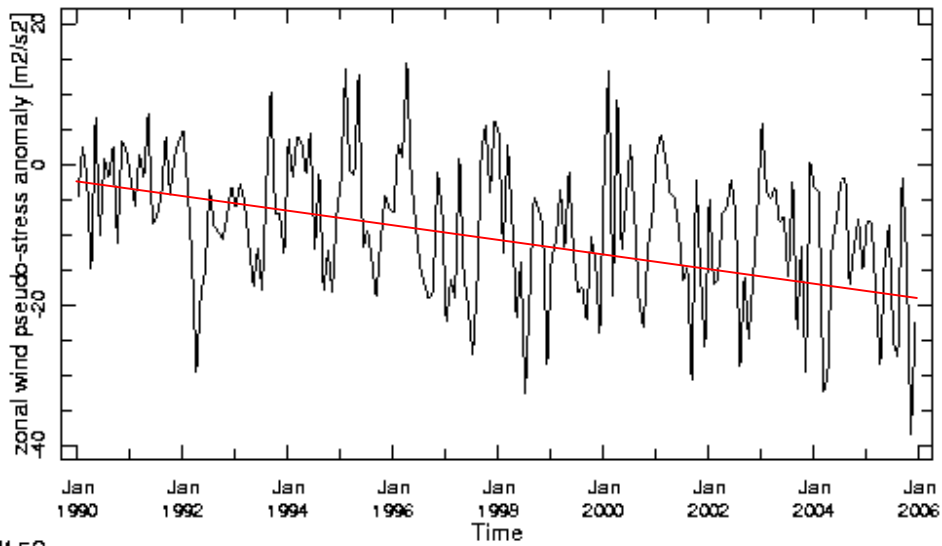
W). As seen through the same figure, in the early ninety (1991 – 1993) the SST was presenting a sharply descend and from this period, it has a monotonic increasing until the present days. To try to understanding what was happening over that area, we have plotted, for the same area and the same period, the time series of the monthly zonal pseudo stress anomaly of the wind, as seen in the figure 7. The pattern presented by this variable, an increasing easterly, is compatible with mass accumulation in the Atlantic West boundary for the area focused here. In a similar way, one can explain the rise observed in the last five years of the tides of the sea which damages is registered through the figures 2 – 5. This pattern partially explains the rise in the sea level but not the increasingly SST. Otherwise one could speculate if this SST pattern could be explained through the global change of climate and the related global warming of the worldwide oceans. There is no proof yet that it's really is happen.

Through the figure 8 we see that the observed warming in the SST anomaly in the Tropical Atlantic it's spreading over the entire area but it has its bigger values in the coast of Nordeste, especially in its Southern part. At the same time, the zonal pseudo stress anomaly presents a sharply increase to the West direction as we seen in the figure 9, which is in accordance to the pattern observed through the time series of the former figure 7.



37W 5S

Figure 6 - 1990-2005 monthly time series of SST anomaly averaged in the region 5°S-15°S, 37°W-30°W.



37W 5S

Figure 7 - 1990-2005 monthly time series of zonal pseudo stress anomaly averaged in the region 5°S-15°S, 37°W-30°W.

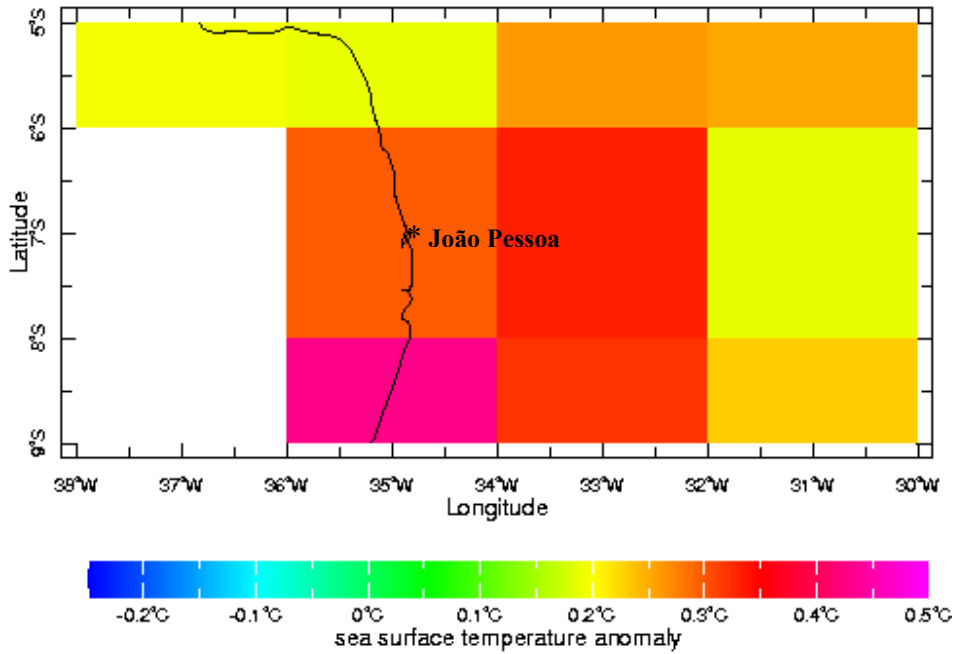


Figure 8 - SST anomaly averaged during the period 1992-2005 according the 2° x 2° grid

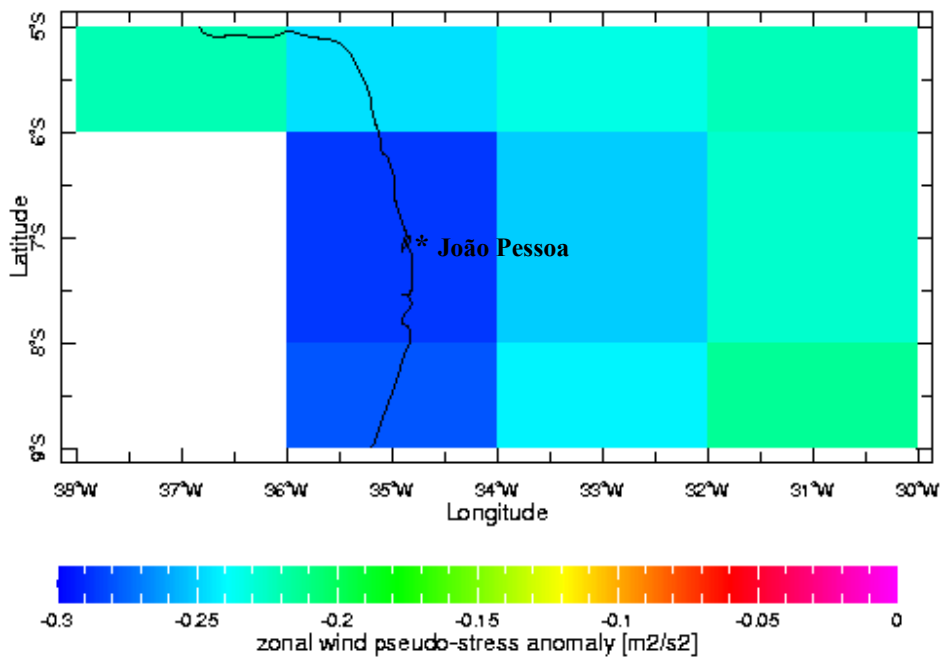


Figure 9 – Zonal pseudo stress anomaly averaged during the period 1992 - 2005 according the 2° x 2° grid.

Conclusion

In the context of climate change and worldwide oceans warming and rising, this paper represents a tentative to provide one observational contribution to the problem. Otherwise one alert to the lack of confident information in relation to the sea level rising along the Nordeste east coast. Once the tide sea forecasting it is carried out based only in astronomical variables, the authors call the attention for the necessity of one have a network of geodesic referenced tide gauges along the coast to confirm these results.

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