Revista Brasileira de Geofísica
RBGf
Brazilian Journal of Geophysics

Revista Brasileira de Geofísica (2013) 31(Supl. 1)

ISSN 0102-261X
www.scielo.br/rbg

PREFACE

The articles of this supplement resulted from the 5th International Congress of the Brazilian Geophysical Society held in São Paulo city, Brazil, at the Convention Center of the Transamérica Hotel, from 28th September to 2nd of October 1997. The participants of the Round Table Discussions on "Mean Sea Level Changes Along the Brazilian Coast" were Dr. Denizar Blitzkow, Polytechnic School of the University of São Paulo, (POLI-USP), Prof. Dr. Waldenir Veronese Furtado, Institute of Oceanography (IO-USP), Dr. Joseph Harari (IO-USP), Dr. Roberto Teixeira from the Brazilian Institute of Geography and Statistics (IBGE), and the invited coordinator Prof. Dr. Afrânio Rubens de Mesquita (IO-USP).

Soon after the first presentation of the IBGE representative, on the efforts of his Institute regarding sea level matters, it became clear that, apart from a M.Sc. Thesis of Mesquita (1968) and the contributions of Johannenssen (1967), Mesquita et al. (1986) and Mesquita et al. (1994), little was known by the participants, about the history of the primordial sea level measurements along the Brazilian coast, one of the objectives of the meeting. So, following the strong recommendations of the Table participants, a short review on the early Brazilian sea level measurements was planned for a much needed general historical account on the topic.

For this purpose, several researchers such as The Commander Frederico Corner Bentes, Directorate of Hydrography and Navigation (DHN) of the Brazilian Navy, Ms. Maria Helena Severo (DHN) and Eng. Jose Antonio dos Santos, National Institute of Ports and Rivers (INPH), long involved with the national sea level measurements were asked to present their views. Promptly, they all provided useful information on the ports and present difficulties with the Brazilian Law relative to the "Terrenos de Marinha" (Sea/Land Limits). Admiral Max Justo Guedes of the General Documentation Service (SDG) of the Brazilian Navy gave an account of the first "Roteiros" – Safe ways to approach the cities (ports) of that time by the sea –, written by the Portuguese navigators in the XVI Century, on the newly found land of "Terra de Santa Cruz", Brazil's first given name. Admiral Dr. Alberto Dos Santos Franco (IO-USP/DHN) gave information on the first works on sea level analysis published by the National Observatory (ON) Scientists, Belford Vieira (1928) and Lemos (1928).

In a visit to ON, which belongs to the National Council of Scientific and Technological Research (CNPq) and after a thorough discussion on sea level matters in Brazil, Dr. Luiz Muniz Barreto showed the Library Museum, where the Tide Predictor machine, purchased from England, in the beginning of the XX century, is well kept and preserved. Afterwards, Dr. Mauro de Andrade Sousa of ON, sent a photography (Fig. 1) of the Kelvin machine (the same Kelvin of the Absolute Temperature), a tide predictor firstly used in the Country by ON to produce Tide Tables. From 1964 until now, the astronomical prediction of Tides (Tide Tables) for most of the Brazilian ports is produced using computer software and published by the DHN.

Before the 5th International Congress of Geophysics, the Global Observing Sea Level System (GLOSS), a program of the Intergovernmental Oceanographic Commission (IOC) of UNESCO, had already offered a Training Course on sea level matters, in 1993 at IO-USP (IOC. 1999) and, six years later, a Training Workshop was also given at IO-USP in 1999 (IOC. 2000). Several participants of the Portuguese and Spanish speaking countries of the Americas and Africa (Argentina, Brazil, Chile, Mozambique, Uruguay, Peru, São Tome and Principe and Venezuela) were invited to take part in the Course and Workshop, under the auspices of the IOC.

During the Training Course of 1993, Dr. David Pugh, Director of GLOSS, proposed to publish a Newsletter for sea level matters as a FORUM of the involved countries. The Newsletter, after the approval of the IOC Chairman at the time, Dr. Albert Tolkachev, ended up as the Afro America GLOSS News (AAGN).

Figure 1 – Kelvin machine for predicting tides at National Observatory (ON).

The newsletter had its first Edition published by IO-USP and was paper-printed up to its 4th Edition. After that, under the registration Number ISSN: 1983-0319, from the CNPq and the new forum of GLOSS, which the Afro-American Spanish and Portuguese speaking countries already had, started to be disseminated only electronically. Currently on its 15th Edition, the News Letter can be accessed on: www.mares.io.usp.br, Icon Afro America GLOSS News (AAGN), the electronic address of the "Laboratory of Tides and Oceanic Temporal Processes" (MAPTOLAB) of IO-USP, where other contributions on Brazilian sea level, besides the ones given in this Supplement, can also be found.

The acronym GLOSS identifies the IOC program, which aims to produce an overall global long-term sea level data set from permanent measuring stations, distributed in ocean islands and all over the continental borders about 500 Km on average apart from each other,

covering evenly both Earth hemispheres. The program follows the lines of the Permanent Service for the Mean Sea Level (PSMSL), a Service established in 1933 by the International Association for the Physical Sciences of the Ocean (IAPSO), which, however, has a much stronger and denser sea level data contribution from countries of the Northern Hemisphere. The Service receives and organizes sea level data sent by all countries with maritime borders, members of the United Nations (UN) and freely distributes the data to interested people, on the site http://www.pol.ac.uk/psmsl.

The Permanent Station of Cananeia, Brazil, which has the GLOSS number 194 together with several other permanent stations (San Francisco, USA, Brest, France and many others), belongs to a chosen group of stations (Brazil has 9 GLOSS Stations) prepared to produce real time sea level, accompanied by gravity, GPS and meteorological high quality data measurements, aiming to contribute for a strictly reliable "in situ" data knowledge regarding the Global Earth sea level variability.

Following the recommendations of the Round Table for a search of the first historical events, it was found that sea level measurements started in the Brazilian coast in 1781. The year when the Portuguese astronomer Sanches Dorta came to the Southern oceans, interested in studying the attraction between masses, applied to the oceanic tides a fundamental global law discovered by Isaak Newton in the seventeenth century. Nearly a hundred years later the Law was confirmed by Henry Cavendish. Another nearly hundred years passed and a few years after the transfer of the Portuguese Crown from Europe to Brazil, in 1808, the Port of Rio de Janeiro was occupied, in 1831, for the first systematic sea level measurements ever performed on the Brazilian coast. The one year recorded tidal signal, showing a clear semidiurnal tide is kept nowadays in the Library of the Directory of Hydrography and Navigation (DHN) of the Brazilian Navy. After the proclamation of the Brazilian Republic in 1889, systematic sea level measurements at several ports along the coast were organized and established by the Port Authorities precursors of INPH. Sea level analyses based on these measurements were made by Belford Vieira (op. cit.) and Lemos (op. cit.) of the aforementioned National Observatory (ON), and the Institute of the National Council of Research and Technology (CNPq), which gave the knowledge of tides and tidal analysis a valuable boost at that time.

For some reason, the measurements of 1831 were included into the Brazilian Federal law No. 9760 of 1946, to serve as the National Reference (NR) for determining the sea/land limits of the "Terrenos de Marinha", and inadvertently took it as if it were a fixed and permanent level along the years, which is known today to be untrue.

Not only for this reason, but also for the fact that the datum, the reference level (RL) in the Port of Rio de Janeiro, to which the measurements of 1831 were referred to, was lost, making the 1946 Law inapplicable nowadays. The recommendations of the Round Table participants seemed to have been providential for the action which was taken, in order to solve these unexpected events. A method for recovering the 1831 limits of high waters, referred by Law 9760, was produced recently and is shown in this supplement.

It is also shown the first attempt to identify, on the coast of São Paulo State, from the bathymetry of the marine charts produced by DHN, several details of the bottom of the shelf area. The Paleo Rivers and terraces covered by the most recent de-glaciation period, which started about 20,000 years ago, were computationally uncovered from the charts, showing several paleo entrances of rivers and other sediment features of the shelf around "Ilha Bela", an island off the coast of São Sebastião.

Another tidal analysis contribution, following the first studies of ON scientists, but now using computer facilities and the Fast Fourier Transform for tidal analysis, developed by Franco and Rock (1971), is also shown in this Supplement. Estimates of Constituents amplitudes as M2 and S2 seem to be decreasing along the years. In two ports of the coast this was effective, as a consequence of tidal energy being transferred from the astronomical Tide Generator Potential (PGM), created basically by the Sun and the Moon, to nonlinear components generated by tidal currents in a process of continuously modifying the beaches, estuarine borders and the shelf area. A study on the generation of nonlinear tidal components, also envisaged by Franco (2009) in his book on tides, seems to be the answer to some basic questions of this field of knowledge. Harari & Camargo (1994) worked along the same lines covering the entire South Eastern Shelf.

As for Long Term Sea Level Trends, the sea level series produced by the National Institute of Research for Ports and Rivers (INPH), with the 10 years series obtained by the Geodetic Survey of USA, in various Brazilian ports, together with the sea level series of Cananeia of IO-USP, allowed the first estimation of Brazil's long term trend, as about 30 cm/cty. A study comparing this value with

the global value of sea level variation obtained from the PSMSL data series, shows that among the positively and negatively trended global tidal series, the Brazilian series are well above the mean global trend value of about 18 cm/cty. This result was communicated to IAPSO in the 1987 meeting in Honolulu, Hawaii, USA.

In another attempt to decipher the long term sea level contents of these series, the correlation values, as a measure of collinearity and proximity values, as well as the distance of the yearly mean data values of sea level to the calculated regression line, are shown to be invariant with rotation of the Cartesian axes in this Supplement.

Not following the recommendations of the Round Table but for the completeness of this Preface, these values, estimated from the Permanent Service for the Mean Sea Level data, with the Brazilian series included, allowed the definition of a function F, which, being also invariant with axis rotation, seems to measure the sort of characteristic state of variability of each sea level series. The plot of F values against the corresponding trend values of the 60 to 100 year-long PSMSL series is shown in Figure 2. This plot shows positive values of F reaching the 18 cm/cty, in good agreement with the recent International Panel for Climate Changes (IPCC) estimated global value. However, the negative side of the Figure also shows other values of F giving other information, which is enigmatic and is discussed in Mesquita (2004).

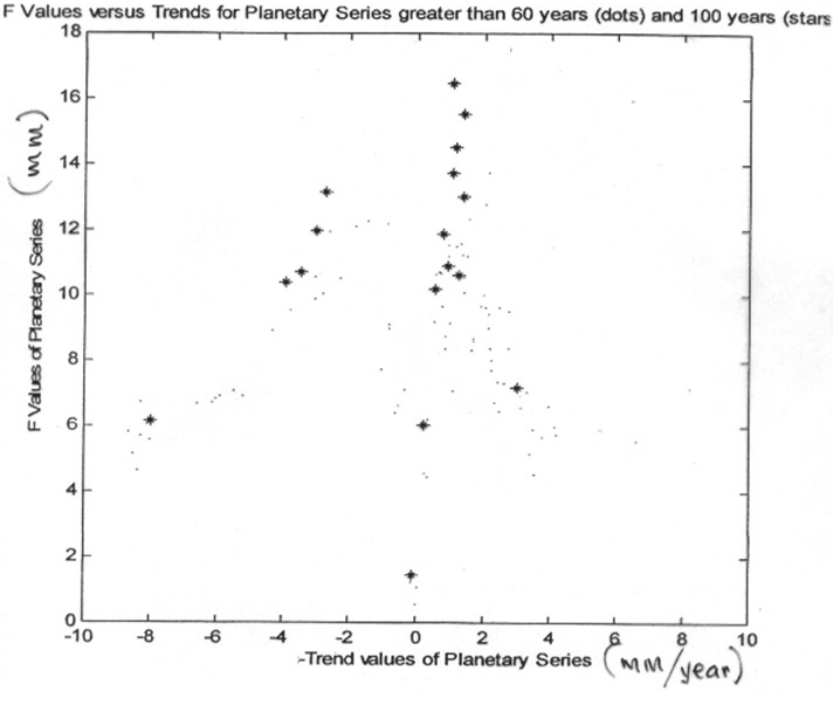

Figure 2 – Plot of F values (mm), (F= proximity x collinearity coefficients), see text, against the trend values (mm/year) of PSMSL mean annual sea level series with 60 (dots) and more than 100 (stars) years long.

For the comprehensiveness of this Preface and continuation of the subjects, although not exactly following the discussions of the Round Table, other related topics were developed since the 5th Symposium in 1997, for the extreme sea level events. They were estimated for the port of Cananeia, indicating average values of 2.80 m above mean sea level, which appears to be representative of the entire Brazilian coast and probable to occur within the next hundred years, as shown by Franco et al. (2007).

Again for completeness, the topic on the steric and halosteric sea levels has also been talked about a lot after the 1997 reunion. Prospects of further studies on the topic rely on proposed oceanographic annual section measurements on the Southeastern coast, "The Capricorn Section," aimed at estimating the variability and the long term steric and halosteric sea levels contributions, as expressed in Mesquita (2009). These data and the time series measurements (sea level, GPS, meteorology and gravity), already taken at Cananeia and Ubatuba research Stations, both near the Tropic of Capricorn, should allow to locally estimate the values of almost all basic components of the

sea level over the Brazilian Southeastern area and perhaps also of the whole South Atlantic, allowing for quantitative studies on their composition, long term variability and their climatic influence.

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June 2014