INTRODUCTION

Recent studies on the global sea level rise are a strong societal concern. The analysis of historical records of water level proves to be an ideal way to provide relevant arguments regarding the observed trends. In France, many systematic sea level observations have taken place since the mid-19th. Despite this rich history, long sea level data sets digitally available are still scarce (Pouvreau, 2008). Currently, only the time series of Brest (Wippelmann et al., 2008), Marseille and recently the composite one of the Port of Antwerp (Gourion et al., 2013) span periods longer than a century and are available to be taken into account in studies dealing with long term sea-level evolution. In this context, an important step of “data archaeology” is undertaken to rescue the numerous existing analog historical data that is part of the French scientific and cultural heritage.

The present study focuses on the measurements carried out at the sea level observatory of Saint-Nazaire.

AIMS

•  Rescue historical sea level data.
•  Improve our knowledge on trends in sea level components on the Atlantic coast on large scale and on the coastal vulnerability at more local scale.
•  Study the influence of the Loire river and of large-scale oceanic circulations on the Atlantic coast on large scale and on the coast vulnerability.

Reconstruction of the Sea Level Time Series

In order to make the inventoried datasets available for studying the sea level evolution, the existing ledgers and tidal charts have to be digitized (Figure 2).

Handwritten ledgers have been manually digitized: about 500,000 hourly values have been processed. During this time-consuming work, verification procedures have been set up to identify errors related to transcription and/or mistakes made by observers (including mostly during the extraction of sea level from tidal chart to ledgers).

Tidal charts are semi-automatically digitized by using the NUMEA software (Ullman et al., 2005). NUMEA is a signal processing tool based on color recognition, developed by the CETE Mediterranée (called noe, CEREMA) and free to access.

DATA CONSISTENCY

A crucial point of this study is to make these data consistent over time in terms of vertical reference and time systems, which were evolved during the studied period.

As reported in Table 1, the used time system is different depending on the considered period: from Apparent Solar Time (AST) for oldest datasets (Vincennes), to the current Universal Time (UT) since 1930. In order to get a time continuity, all the data are converted into the UT system: it consists in the application of the ‘equation of time’ and a correction based on the longitude difference between the current location and Greenwich.

Reducing the reconstructed time series to a common vertical reference level is quite challenging because it implies knowing precisely the different used levels as tide gauge zero and/or chart datum over the time (Figure 4). To get this information, it is necessary to look through lots of diverse and scattered documents (metadata linked to measurements, ledgers, reports, observers’ notes, letters, ...). If it is relatively easy to define recent chart datum, it appears to be more difficult for older periods since much information, sometimes inconherent, have to be analyzed in the present study. The research, information concerning the gauge zero between 1830 and 1914 remain rather uncertain.

STUDY AREA

Saint-Nazaire is located on the French Atlantic coast in the mouth area of the macrotidal Loire estuary. Since the mid-19th century, with the increase of maritime traffic and the harbor development, the city has reclaimed from the sea, and the tide observatory equipped with a tide gauge has been created (Figure 1).

This particular location allows the study of the influence of the Loire River and the anthropogenic effects on sea level since the 19th century. For instance, Winterwerp et al. (2013) showed that the tidal range was strongly modified in upstream areas (Nantes) during the last century because of river deepening, but the impact in downstream locations such as Saint-Nazaire is not yet entirely quantified.

SEAS LEVEL MEASUREMENTS OVER THE HISTORICAL TIME

As a first and preliminary step, this study implies the inventory of existing sea level observations which are scattered in various institutions in France (Figure 3, Table 1).

The first identified measurements took place in 1821 for 4.5 months and correspond to visual observations at a tide staff temporarily located in Saint-Nazaire. The first continuous measurements purpose (background map, Figure 1) started in 1850, 1863 measurements have been automatically performed with the use of a mechanical float tidal gauge. These devices have changed and evolved over the time allowing to measure up to the present time (the observatory relocation (1991, Figure 1)) and some important gaps occurring between 1920 and 1950.

After 2007, the Saint-Nazaire time series has been part of the French RONIM network operated by SHOM, and the old mechanical tidal gauge has been succeeded by a radar tidal gauge (operated by Grand Port Maritime of Nantes-Saint-Nazaire).

The precision analog dataset are handwritten ledgers and/or tidal charts covering periods ranging between 2 weeks and 1 month. Except the older ones (1821), ledgers correspond to transcripts extracted by observers from tidal charts with a 15-minutes to 1-hour time step.

In total, the covered period is up to 190-year-long, including at least 125 years of continuous sea level measurements.

ONGOING WORK / PRELIMINARY RESULTS

By digitizing this huge amount of sea level data (about 60 yrs up to now), the ST Nazaire time series becomes long enough to assess the local long-term sea level evolution and increase the knowledge at the Northern Europe’s scale (Figure 5). However, this is not yet feasible without first rigorously controlling the data quality.

PERSPECTIVES / EXPECTED OUTCOMES

This presentation overviews the current status of the study in progress. Plenty of work is still needed (up to 2013) to get consistent long-term sea level series as complete as possible. Nevertheless, it already noticeable that promising results will be achieved. This type of work highlights how precise historical datasets are essential. Atmospheric pressure data, also available in paper form (1863-1920), could be processed by following the same procedure a probable better long term trend could be reached.

Once the final time-series has been rendered coherent, it will be made available in existing national databases and websites: RFM for high-frequency data (hourly) and BONEL for the corresponding mean sea levels (daily monthly and yearly).

For further information about this study and his progress, please regularly consult: Y.Ferret, G.Voineos, N.Pouvreau, SHOM, 2013.

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