HISTORICAL DATA

Ce chapitre vise à définir la donnée historique, sa nature et les problématiques associées à sa collection et validation.

Dans ce manuscrit, les données historiques sont des données ponctuelles qui représentent des évènements remarquables survenus pendant des périodes dans lesquelles les instruments de mesure n'ont pas enregistré la variable considérée. Les trois types les plus communs de données historiques seront considérés dans cette étude : la donnée exacte, un intervalle de valeurs et une borne inférieure dépassée par la valeur historique lors de l'événement.

La connaissance d'une ou plusieurs événements historiques est un sujet difficile à traiter. En effet, les données historiques sont liées à différentes types d'informations et de sources qui ne sont pas le plus souvent facilement interprétables et accessibles. Par conséquent, la collecte des données historiques est une procédure compliquée. Toute l'information historique repérée doit être exploitée et, dans la mesure du possible, convertie en données historiques que pourraient être ensuite utilisée pour des applications statistiques d'estimation des événements extrêmes. Pour ces raisons, une approche de collecte et de validation des données historiques suivie d'un exemple d'application est présentée dans ce chapitre. La collecte doit être démarrée à partir des bases des données historiques déjà existantes et étendue à des sources accessibles. Ensuite, une validation de toutes les données collectées doit être réalisée grâce à l'apport essentiel d'un historien compétant sur la période examinée.

2.1 Historical data

Historical data are typically quantitative or qualitative isolated data values representing an exceptional event of the past. In this manuscript, historical data are defined as all quantitative isolated data values representing an extraordinary event which has occurred in a period in which the considered variable was not recorded by a measuring device. For this reason, historical data represent not only events of the past but also exceptional events in which, for whatever reason, the measuring device was not working.

The discovery of historical coastal events that can potentially provoke coastal flooding is a major challenge for an engineer dealing with estimations of extreme coastal events. Finding quantitative data values of historical events is a complex procedure. Information of a particular past event can be used to detect or reconstruct a quantitative data associated to that event. After a wide investigation of different sources, this is also possible by means of a good knowledge of the period of the event that only a qualified historian may have. An approach to collect and validate historical data is proposed in the following chapter.

Over the last twenty years, there have been a number of extraordinary storms such as Xynthia (February 2010) and Lothar and Martin (December 1999) storms, which impacted the European Atlantic coasts. These storms caused several disasters and loss of human life. These have been sometimes defined in the media as exceptional events that have never previously occurred on French coasts until now, however this is incorrect. A wide investigation of all the historical storms which impacted a particular site is required to define the rarity of an extreme event. In particular, Garnier and Surville (2010) identify several catastrophic flood events on the French Atlantic coasts during the last 500 years with a similar vulnerability to the Xynthia storm. For this reason, also if a recent exceptional storm can be perceived by people as the strongest event ever happened in a particular location, it may have previously occurred because history often repeats itself.

Furthermore, Bulteau et al. (2015) conclude that, considering historical traces in La Rochelle, the Xynthia storm is linked to a shorter return period. For this reason, considering all the traces of the past in the statistical analysis of extreme events could help to reduce the impact of natural calamities along the coasts.

Several studies on past coastal floods impacting French coasts (Peret, 2004; Lambert and Garcin, 2013; Lang and Coeur, 2014; Peret and Sauzeau, 2014) show the difficulties faced researching useful information to retrace the history.

Any type of information is useful to retrace the past and to collect, reconstruct or validate a historical data. For example, a painting, a newspaper of the time, a preserved manuscript, a document from municipal archives, an ecclesiastical text, some private letters sent to ask for help from friends and family, a water mark left in an ancient church or building are only a few sources containing useful information of the past which can be used to retrace a historical event. In addition, the vulnerability evaluation of the society of the period is required in order to understand the relevance of a particular past event. This can be used to reply to the ever more frequently asked question regarding the occurrence of a remarkable flood.

Although finding the occurrence of an exceptional past event is challenging, the quantification of a historical event can be considered more complex. In fact, only a small portion of the identified historical events may be expressed with some quantitative data, for instance, the case of water marks or overflows of sea levels in a coastal town. In these and other cases, many attempts have to be performed to retrace and rebuild the numerical value of the considered variable that represents the historical event.

Numerical values of historical events, more simply denominated historical data, can be used in the statistical analysis for extreme events. The use of historical data in the statistical analysis improves significantly the estimations of extreme coastal events (Bulteau et al., 2015; Hamdi et al., 2015). In particular, Hamdi et al. (2015) show as the use of historical data are considered at La Rochelle decreases the uncertainties linked to the estimations of extreme skew surges. For this reason, the use of past events in the extremes' statistical analysis is required to get estimations of extreme events as reliable as possible.

Historical data can be regrouped in three major data types depending on the type of historical information found:

- Type I or exact data;
- Type II or data range;
- Type III or lower limit value of data.

Type I is a data point, which can be considered as the most precise type of historical data.

Type II is a numerical data range that contains the extreme data representing the historical event. In this case, two numerical values define the past event: the lower bound and the upper bound. This type of data may be considered, for instance, when different historical sources describe the same historical event with different quantitative values (Fig. 2).

Type III represents the minimum value that the extreme data has attained during the historical event. In this case, no more information is provided by the sources. This type of data is used when, for instance, a flooding of a port or a road is widely documented. In this case, the event has at least attained the port/road level. This kind of data, even though it is not very precise, can be used in extreme analysis.

The three different types of historical data can be seen as the result of the wide investigation on a multiplicity of sources. By the definition of this three types of most common historical data, many documentations of the past that may seem worthless are useful to reconstruct historical data exploitable in statistical analysis.

In any case, the analysis of different sources is complex due to their variety and to their degree of reliability. In particular, the reliability of each source depends on many factors. For instance, a historical data found in a newspaper tends to be overestimated in order to permit to the journal editor of the period to sell as many copies as possible.

In addition, all types of historical data are often associated to significant uncertainties related to the data value. These uncertainties can depend on the accuracy of the source and on the period of the event. In fact, when an extreme event of the past is documented, the period of the event must be analysed in order to understand, for instance, which measuring instruments were used, or the vulnerability of the society of that period to that particular event.

For these reasons, only a few quantitative information is currently available for coastal variables (in particular for skew surges).

2.2 Collection and validation approach

In the past, several attempts to collect information on historical floods have been made in France (Roche et al., 2014; Daubord et al., 2015; Lang et al., 2016) and in UK (Haigh et al., 2015; Haigh et al., 2017).

Nevertheless, the creation of a historical database of coastal events is needed in order to use historical data in statistical analyses of extreme events. An approach that enables the collection, the reconstruction and the validation of historical events is proposed.

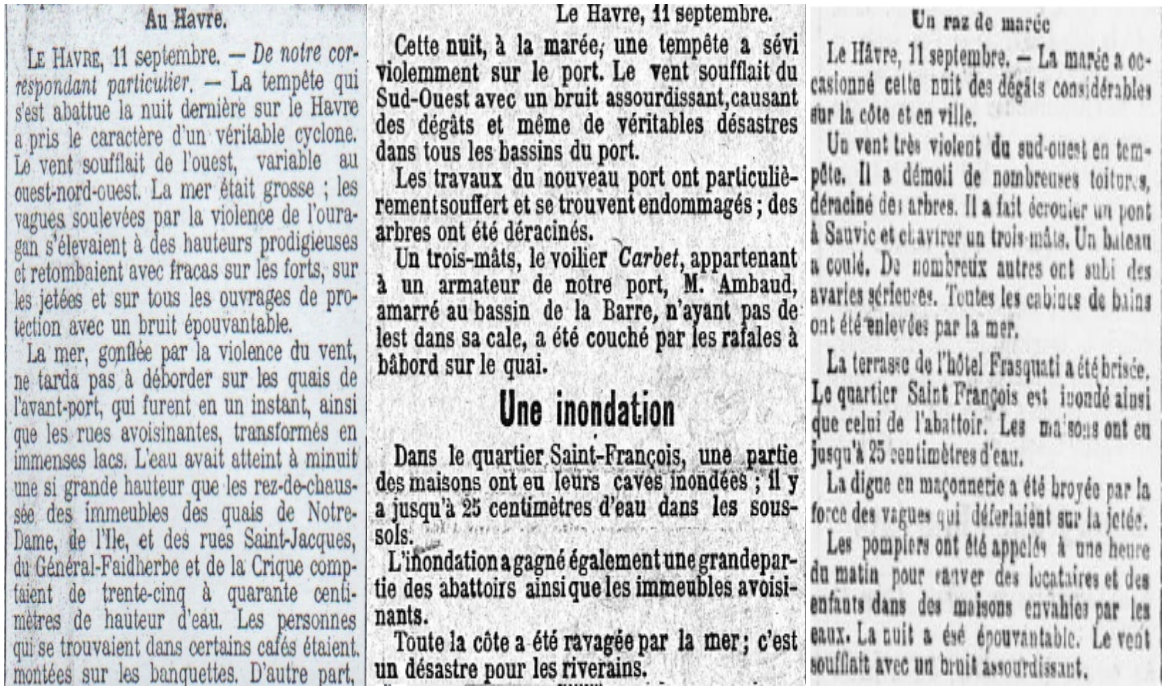
2.2.1 Historical data collection

The collection of historical data is a complex task. Historical data can be available, for instance, in private, ecclesiastical or municipal archives or in many digitalised newspapers of the time and not ever you are aware of the availability of every single source containing important information on a past event. Besides, many sources refer to the original documents that are not readily accessible. If accessible, a supplementary work of reading and interpretation is necessary to extrapolate useful and quantitative data concerning a particular historical event.

Several phases are required to collect historical data. First, a deep analysis of previous studies that have already reviewed some past floods is suggested. This step allows the definition of a first basis of most documented extreme events occurred in the past. Then, all available sources as newspapers of the time or meteorological bulletins must be analysed in order to find past events or other useful quantitative information on events already known. The credibility of sources has to be checked. In fact, not all sources can be considered as accurate and valid.

Fig. 2 shows the difficulties faced on the interpretation and the credibility of sources describing historical sea levels. These three different newspapers (from the left Météo Paris, Le Petit Journal and Ouest-Éclair) provide different quantitative information for the same historical coastal flood occurred the 11th of September 1903 at Le Havre. The first one states that the sea level flooded roads and buildings by 35-40 centimetres, the second one said that the underground

was flooded by 25 centimetres and the last one that the houses was submerged to 25 centimetres of water.



Au Havre.

LE HAVRE, 11 septembre. — *De notre correspondant particulier.* — La tempête qui s'est abattue la nuit dernière sur le Havre a pris le caractère d'un véritable cyclone. Le vent soufflait de l'ouest, variable au ouest-nord-ouest. La mer était grosse ; les vagues soulevées par la violence de l'ouragan s'élevaient à des hauteurs prodigieuses et retombaient avec fracas sur les forts, sur les jetées et sur tous les ouvrages de protection avec un bruit épouvantable.

La mer, gonflée par la violence du vent, ne tarda pas à déborder sur les quais de l'avant-port, qui furent en un instant, ainsi que les rues avoisinantes, transformés en immenses lacs. L'eau avait atteint à minuit une si grande hauteur que les rez-de-chaussée des immeubles des quais de Notre-Dame, de l'Ile, et des rues Saint-Jacques, du Général-Faidherbe et de la Crique comptaient de trente-cinq à quarante centimètres de hauteur d'eau. Les personnes qui se trouvaient dans certains cafés étaient montées sur les banquettes. D'autre part,

Le Havre, 11 septembre.

Cette nuit, à la marée, une tempête a sévi violemment sur le port. Le vent soufflait du Sud-Ouest avec un bruit assourdissant, causant des dégâts et même de véritables désastres dans tous les bassins du port.

Les travaux du nouveau port ont particulièrement souffert et se trouvent endommagés ; des arbres ont été déracinés.

Un trois-mâts, le voilier *Carbet*, appartenant à un armateur de notre port, M. Ambaud, amarré au bassin de la Barre, n'ayant pas de lest dans sa cale, a été couché par les rafales à bâbord sur le quai.

Une inondation

Dans le quartier Saint-François, une partie des maisons ont eu leurs caves inondées ; il y a jusqu'à 25 centimètres d'eau dans les sous-sols.

L'inondation a gagné également une grande partie des abattoirs ainsi que les immeubles avoisinants.

Toute la côte a été ravagée par la mer ; c'est un désastre pour les riverains.

Un raz de marée

Le Hâvre, 11 septembre. — La marée a occasionné cette nuit des dégâts considérables sur la côte et en ville.

Un vent très violent du sud-ouest en tempête. Il a démoli de nombreuses toitures, déraciné des arbres. Il a fait écrouler un pont à Sanvic et chavirer un trois-mâts. Un bateau a coulé. De nombreux autres ont subi des avaries sérieuses. Toutes les cabines de bains ont été enlevées par la mer.

La terrasse de l'hôtel Frasquati a été brisée. Le quartier Saint François est inondé ainsi que celui de l'abattoir. Les maisons ont eu jusqu'à 25 centimètres d'eau.

La digue en maçonnerie a été broyée par la force des vagues qui déferlaient sur la jetée.

Les pompiers ont été appelés à une heure du matin pour sauver des locataires et des enfants dans des maisons envahies par les eaux. La nuit a été épouvantable. Le vent soufflait avec un bruit assourdissant.

Fig. 2 – The flood occurred during the day of 11th September 1903 at Le Havre described by three different newspapers: Météo Paris, Le Petit Journal and Ouest-Éclair

Three different measurements for a same event are available. For this reason, a critical analysis on the source has to be properly performed. This analysis can be achieved by a historian that gives a degree of credibility to all types of sources discovered.

Sources provide not ever a direct quantitative information on the particular event of the past. Sometimes other quantitative data are available. This additional information can enable the reconstruction of a particular variable investigated.

For this reason, an approach to reconstruct historical skew surges is defined thanks to the stage performed by Florian Regnier at EDF R&D LNHE (2017). In particular, sea levels, astronomical tides, street or pier levels of the time are some quantitative data that can be used to reconstruct historical skew surges.

Fig. 3 shows the scheme that enables the retracing of a historical skew surge value neglecting the subsidence. In particular, knowing that the sea level exceeded the dock by the measure of *h* centimetres and we are able to know the dock level of the time *H*, we can compute the skew surge value as the difference between *H*+*h* and the astronomical tide level in the day of the event (for French ports they can be provided by the SHOM).

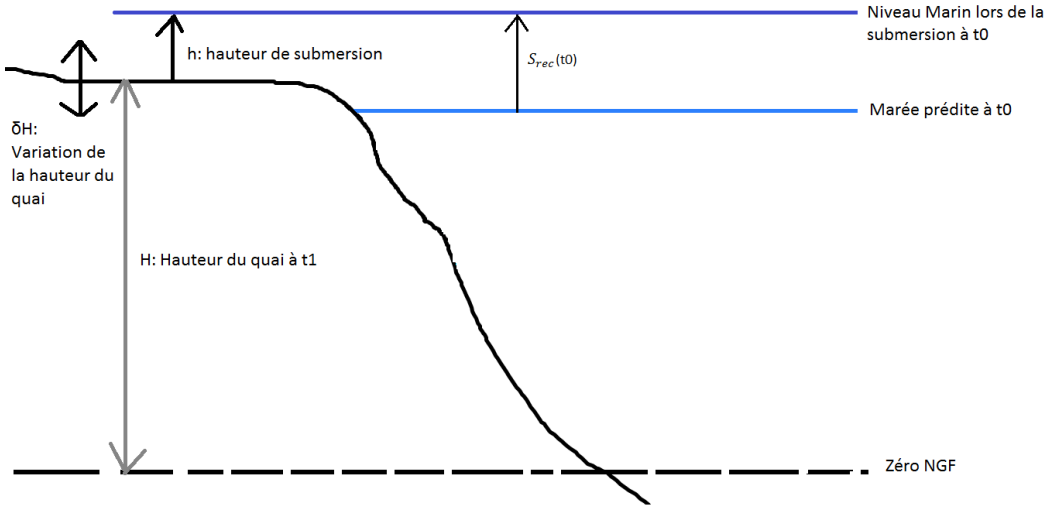


Fig. 3 - Scheme used to reconstruct 11 historical skew surges

Obviously, other factors have to be considered in this reconstruction. For instance, also if it is not difficult to know an actual dock level, it is less easy to know that level in a particular day of the past. Battles, world wars, reconstructions and restorations were made in every location and it is very hard to discover the exact level of a street or a building in the past. In addition, municipal archives are not always easily accessible to find this type of past information. This is a promising way to retrace historical skew surge but it is very challenging to realise. A similar approach can be formulated for other types of coastal variables.

In any case, the collection and reconstruction processes lead to identify some historical events that have to be validated. The use of invalid historical events could provide erroneous statistical estimations of extreme event. For this reason, historical events need a validation.

2.2.2 Historical data validation

The positive feedback of the historical expert on past event concerned allows the validation of historical data. In fact, knowing perfectly the period in which historical event is occurred, the historian can evaluate if that event is effectively happened. In addition, the historical expert can provide the degree of a credibility of a source and, in particular, if exaggerations have been written.

For instance, many deaths recorded in some archives after a storm can be also caused by other factors as plague or other diseases that impacted the society in the same time of the extreme event. These factors linked to the society have to be clearly considered when we validate an extreme event of the past.

The validation of one historical event by the expert is a long process. For this reason, some alternative ways to pre-validate a historical data can be considered.

In particular, for coastal historical events, many meteorological reanalyses and numerical models are currently available. Meteorological analyses help to know if it might be possible that a past event is occurred or not and if an exceptional coastal variable was feasible that day. Meteorological reanalyses contribute then to pre-validate historical events and they cannot replace the historical expert in any way. In particular, wind and pressure data are useful to validate physically the occurrence of a likely historical skew surge. In particular, a surge is principally generated to two factors: a low pressure and a high wind speed (and wind direction) at the sea surface (Heaps, 1983; Cariolet et al., 2011; Regnier et al., 2017). For this reason, if wind and pressure data or reanalyses are available, we can realise if an extreme skew surge can be happened during the day of the past event.

In fact, a validation of historical events based on reanalysis is not enough. Historical elements come from sources and period have to be taken in account in the validation process. Only the historical expert can definitively validate a historical event.

The approach proposed to validate historical events is composed by two phases. The first one is the pre-validation process that must be carried out through the support of physical factors extracted from proper reanalysis. The second and last phase is the final validation of a historical event. This must be performed by an historian after a wide investigation on sources of the period. The historian can focus on some elements (as the society, the epoch, the source etc.) that reanalyses cannot consider but that could be important to validate a historical event.

2.2.3 Numerical models and their role for historical events

Numerical models are another very promising approach that might be used in the future to pre-validate some particular extreme events of the past. In any case, this approach could be used only after a robust validation of the numerical model for well-known recorded extreme events, namely systematic events. The main idea is to compare historical data with the extreme values obtained by a numerical model.

Differently from meteorological models, this approach might also allow the pre-validation of a historical quantitative value in some special cases. In particular, an event of the past impacted the site A and the site B. The site A is provided by systematic data and the site B by historical data. Assuming that the site A is well modelled and, for another more recent event in which systematic data are available for the sites A and B, the numerical model provides good estimations, the historical data founded in the site B can be pre-validate by the numerical model.

This possible type of pre-validation of historical events can be allowed only after a robust validation of the numerical model for systematic extreme events. When the model is considered valid for extremes, the pre-validation of historical skew surge values by the numerical model can be achieved. An application for skew surges has been performed by Cécile Lalanne during her stage at EDF R&D LNHE (2018).

In particular, a numerical model of skew surges based on TELEMAC-2D is used. The validation of this model for extremes and some implementations to make it utilisable for extreme comparison is carried out. This work will be object to a talk that it will held during the XXVth TELEMAC-MASCARET User Conference (TUC) 2018 from 9th to 11th October in Norwich (UK). For more details, the conference paper is shown in Annexe D.

2.2.4 An example of historical skew surge collection

A preliminary collection of historical skew surges was performed through an event-by-event approach, gathering together skew surges of a same past event recorded in different locations.

Fourteen extreme events associated to 14 historical skew surges (further details on these historical data are available in Chapter 4) were collected during the first part of this PhD study for 3 French sites (La Rochelle, Dieppe and Dunkirk).

This collection was successively completed by Florian Regnier during his internship at EDF R&D LNHE in 2017. His work has contributed to review a total of 74 additional historical events occurred between 1705 and 1953 located in French side of English Channel and in French Atlantic coasts. Depending on types of numerical elements available, we focused especially on 5 of these 74 reviewed historical events that allowed the reconstruction of 11 skew surges: the event of the 1st January 1877 that impacted especially the Brittany and the Pays de la Loire regions, the event happened between the 4th and the 6th of December 1896 in Brittany and in the south of England, the storms occurred during the 11th September 1903 and during the 3rd February 1904 in the English Channel and the event of the 13th-14th March 1937 that impacted the French Atlantic coasts. In addition, other 6 historical skew surges were identified during this internship, for a total of 17 historical skew surges. All of these data collected must be after validated and, for this reason, an example of the pre-validation of historical events by meteorological reanalysis is shown in the following.

The collection and reconstruction performed have been the subject of an oral talk at the Conference EVAN 2017 (Advances in Extreme Value Analysis and application to Natural Hazard) held in Southampton (UK) between 5th and 7th September 2017 (Annexe D).

However, the collection of historical data, and in particular historical skew surges, is a common need for the scientific community dealing with the statistical estimations of extreme coastal events. For this reason, a Working Group is formed in France. The main aim of this group is to create a database of all historical events that are susceptible to cause a coastal flood (Giloy et al., 2018). For the moment, this French Working Group leaded by the IRSN is composed of EDF R&D, SHOM, Artelia, BRGM and the University of Poitiers. Each partner provides its knowledge on past events. Every historical event and their numerical values associated (as skew surges or sea levels) must be checked and validated by all members of the group including the historian.

The pre-validation approach is detailed in the following of this section with a practical example on the historical skew surges.

2.2.4.1 Pre-validation of historical skew surges by reanalysis

An application of pre-validation is performed for skew surges. Based on wind and pressure reanalysis of the 20th century, this analysis checks if an important skew surge is physically possible the day of the past event.

Many daily weather reports of the 20th century are available in France (Météo France) and in UK (Met Office). Fig. 4 shows the pressure chart and the daily weather report of Météo France for the 1st January 1877. French daily weather reports are available since 1857 and they contain pressure and wind data of the time.

Historical reports are sometimes inaccurate and wind intensities, that not always refer to the right phenomenon, are computed by the Beaufort scale. Beaufort wind force scale is an empirical measure that relates wind speed to observed conditions inshore and offshore. Accurate wind speeds and detailed wind directions is hardly interpretable from this scale.

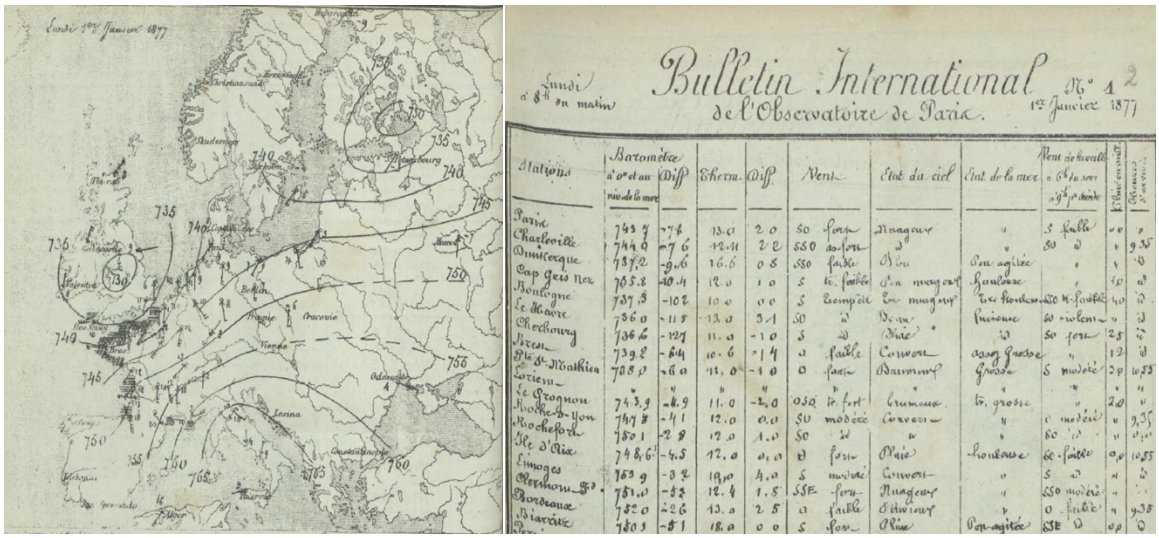


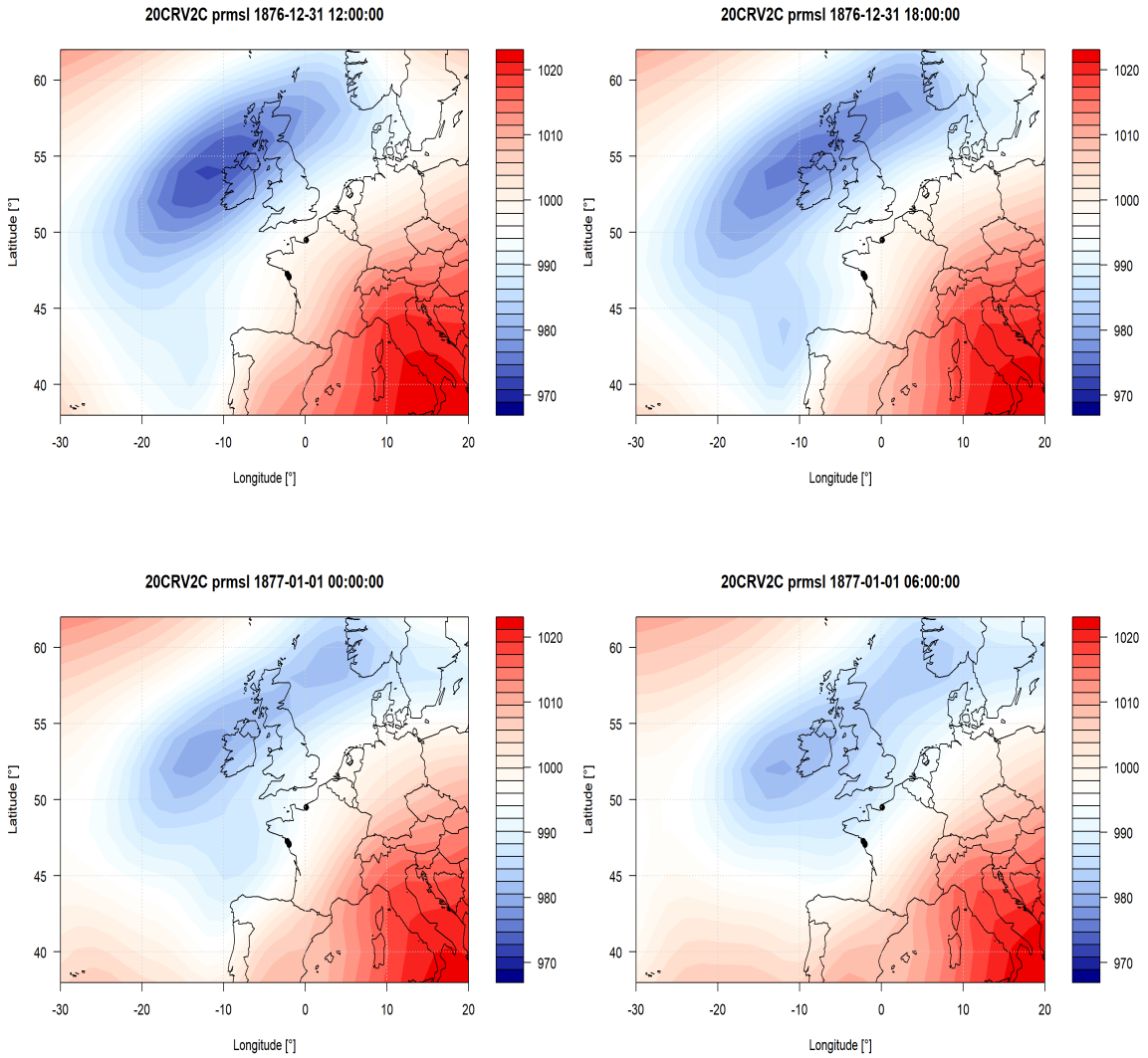
Fig. 4 – Daily weather report on the left and Pressure chart on the right for the 1st January 1877 (source Météo France)

Wind and pressure reanalysis of 20th century are available and more easily exploitable. The reanalysis 20CRV2C of the pressure at the sea surface (hPa) and of wind direction and wind speed (m/s) have been used to pre-validate some historical skew surges recovered. An example of pre-validation by reanalysis of the historical event of 1st January 1877 impacted Le Havre, Saint Nazaire and Les Moutiers-en-Retz is showed above.

Meteorological reanalysis 20CRV2C are available every 6 hours and the pressure sea surface, direction and speed of the wind for the areas affected are analysed before, during and after the storm.

In this way, synoptic charts of sea surface pressure and wind speed/direction are generated (Fig. 5 and Fig. 6). As you can see in Fig. 5, a strong depression impacted the Europe during the 1st January 1877. In the same moment, very fast winds impacted French coasts (Fig. 6) and, in particular, the black points (Le Havre, Saint Nazaire and Les Moutiers-en-Retz). Focusing on Fig. 5 and Fig. 6, an extreme skew surge was physically possible that day.

Finally, meteorological reanalysis can be a useful tool to better assess and know if a remarkable skew surge could be happened. In any case, in order to fully validate a past skew surge, the opinion of the expert on that period is needed.



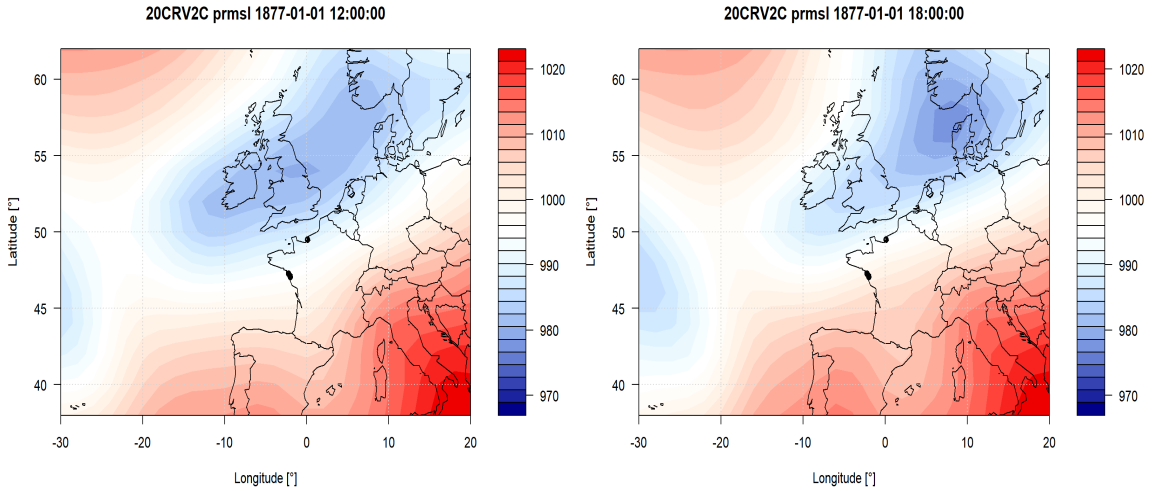
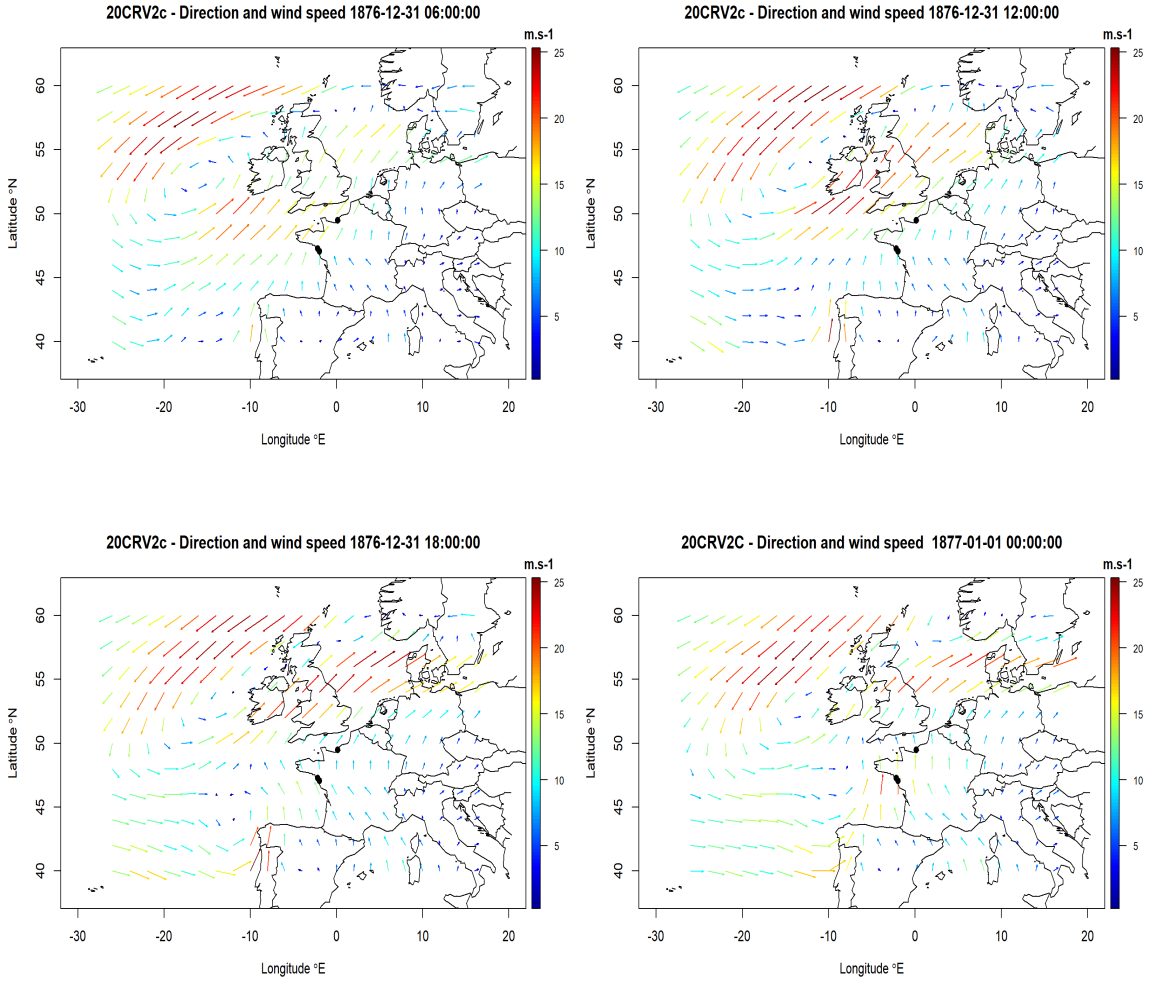


Fig. 5 – Synoptic charts generated by reanalysis 20CRV2C of the pressure on sea surface (hPa) every 6 hours between the 31st December 1876 and the 1st January 1877



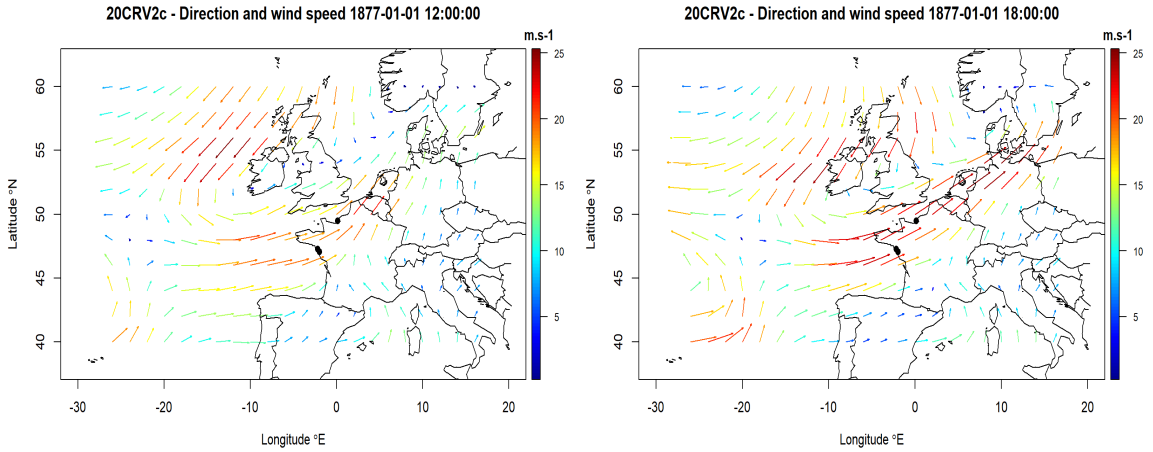


Fig. 6 - Synoptic charts generated by reanalysis 20CRV2C of wind direction and wind speed (m/s) every 6 hours between the 31st December 1876 and the 1st January 1877

2.2.4.2 Final validation by the historical expert

Even though the pre-validation based on physical considerations could provide good results, the historical data need a final validation of the historical expert. These validation is a long process and actually it has not been yet performed. For this reason, these collected and pre-validated historical skew surges cannot be still used for statistical applications of extreme events' estimations.