High-resolution reconstruction of extreme hydrological events occurred in the Douro River estuary (Portugal, Iberian Northwest) during the 19th century

INÊS AMORIM[1]
LUÍS PEDRO SILVA[2]
JOÃO CARLOS GARCIA[3]

[1] University of Porto/CITCEM/REPORT(H)A
[2] CITCEM/REPORT(H)A
[3] University of Porto/IH, University Carlos III

EGU General Assembly 2020
On-line, 4 to 8 May 2020

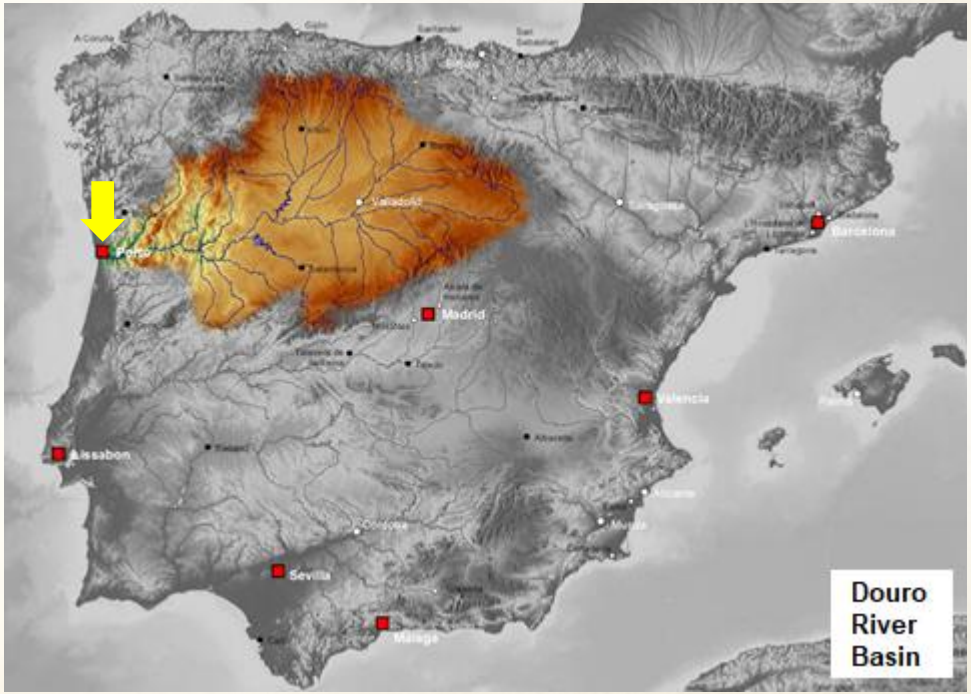
Cofinanciado por:

Introduction

The Douro River flows out of the Urbion Mountains, in the north of Spain, at around 1700 m of altitude, cross northern-central Spain and Portugal to its mouth at Porto city into the Atlantic Ocean.

The Douro River is the third-longest river in the Iberian Peninsula (after the Tagus and The Ebro rivers). It drains an area of 97.600 square kilometers (the most largely in the Iberian Peninsula).

In average, the mean annual rainfall in the Douro River basin accounts for approx. 1000 mm, with almost 70% concentrated in the wet semester, from October to March. The average annual flow at the mouth of the Douro River is 16,907 hm^3, with an average flow of 536 m^3/s at the mouth (in flood situations it can exceed 10,000 m^3/s) (APA, 2012).



Main sources and data

General analysis

In most countries, including Portugal, systematic and continuous instrumental meteorological/hydrological observations began only in the late 19th century. Prior to this date, we use other data sources to obtain information about past floods.

This study presents the results of a historical reconstruction of hydrological series based on pre-instrumental sources.

Database

(Microsoft Office Excel 2010)

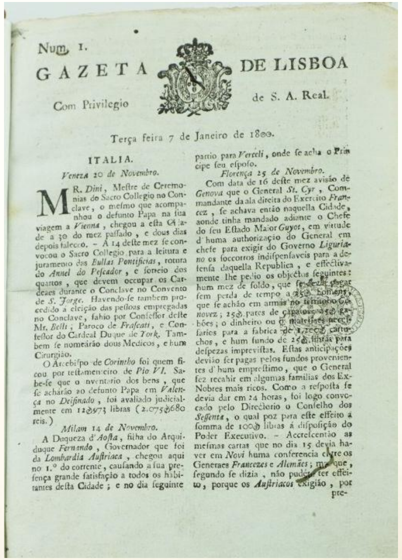
Main sources and data

General analysis

The data used in this research was collected from primary or first-hand sources contemporary to the events, specifically:

- **Newspapers**
  - *Gazeta de Lisboa* (1715-1820)
  - Diário do Governo (1820-1976)
  - *Correio do Porto* (1820-1834)
  - *Periódico dos Pobres no Porto* (1834-1858)
  - *O Correio Português* (1841-1845)
  - *Diário de Notícias* (1864-today)

- **Memories**
  - *Lembranças* by I. A. Henckell (1717-1800)
  - *Apontamentos* by Sousa Reis (-1872)
  - *Apontamentos* by Marcelino Pinto (-1891)
  - *Efemérides* by Marcelino Pinto (-1879)



Num. 1.

GAZETA DE LISBOA

Com Privilegio de S. A. Real.

Terça feira 7 de Janeiro de 1800.

ITALIA.

Veneza 20 de Novembro.

Florença 25 de Novembro.

Milão 14 de Novembro.

Numero 1. Custo 20 Reis. Anno de 1820.

Correio do Porto.

COM PERMISSÃO DO SUPREMO GOVERNO PROVISORIO DO REINO.

Toda a pessoa que tiver assignado para a folha, Regeneração de Portugal, *e não quizer receber em lugar della o* CORREIO DO PORTO, *póde mandar procurar a reposição do preço da assignatura, menos* 140 *reis, pelo que proporcionalmente cabe aos* 8 *numeros impressos e distribuidos.*

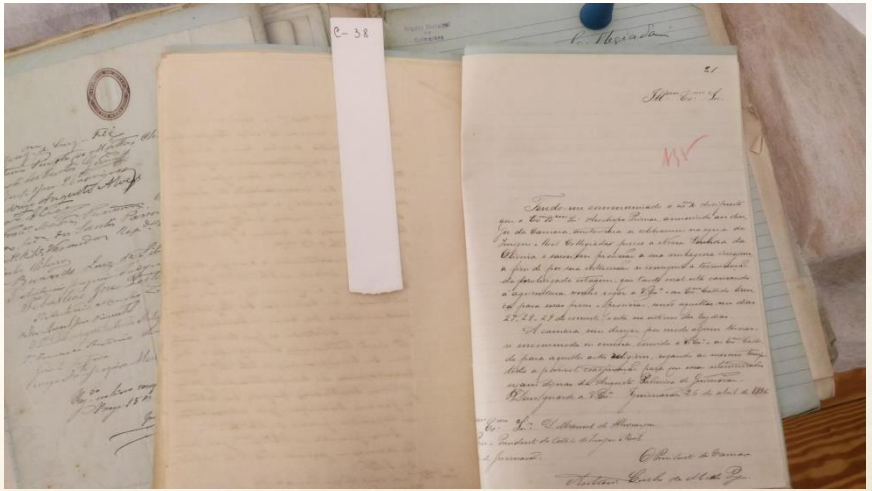
QUARTA FEIRA 27 DE SETEMBRO.

Main sources and data

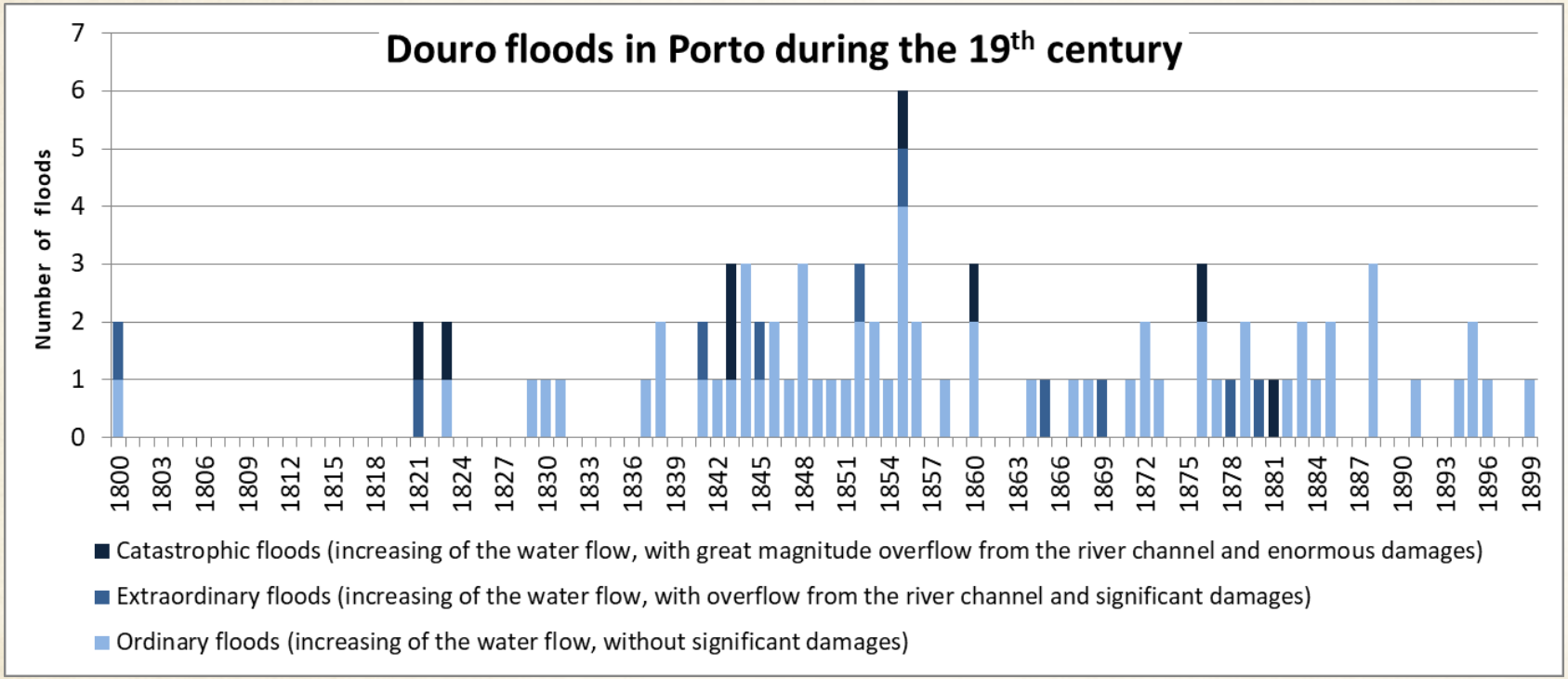
General analysis

The data used in this research was collected from primary or first-hand sources contemporary to the events, specifically:

- **Studies**
  - *As cheias do rio Douro* by J. F. Tato (1966)
  - *As grandes cheias do Douro* by Alberto Bessa (1910)
  - *Os portos marítimos de Portugal* by A. Loureiro (1904)
- **Institutional sources**
  - Council minutes and cathedral chapter books
  - Official correspondence
- **Others**
  - Pictures
  - Marks on buildings and bridges
  - Etc.

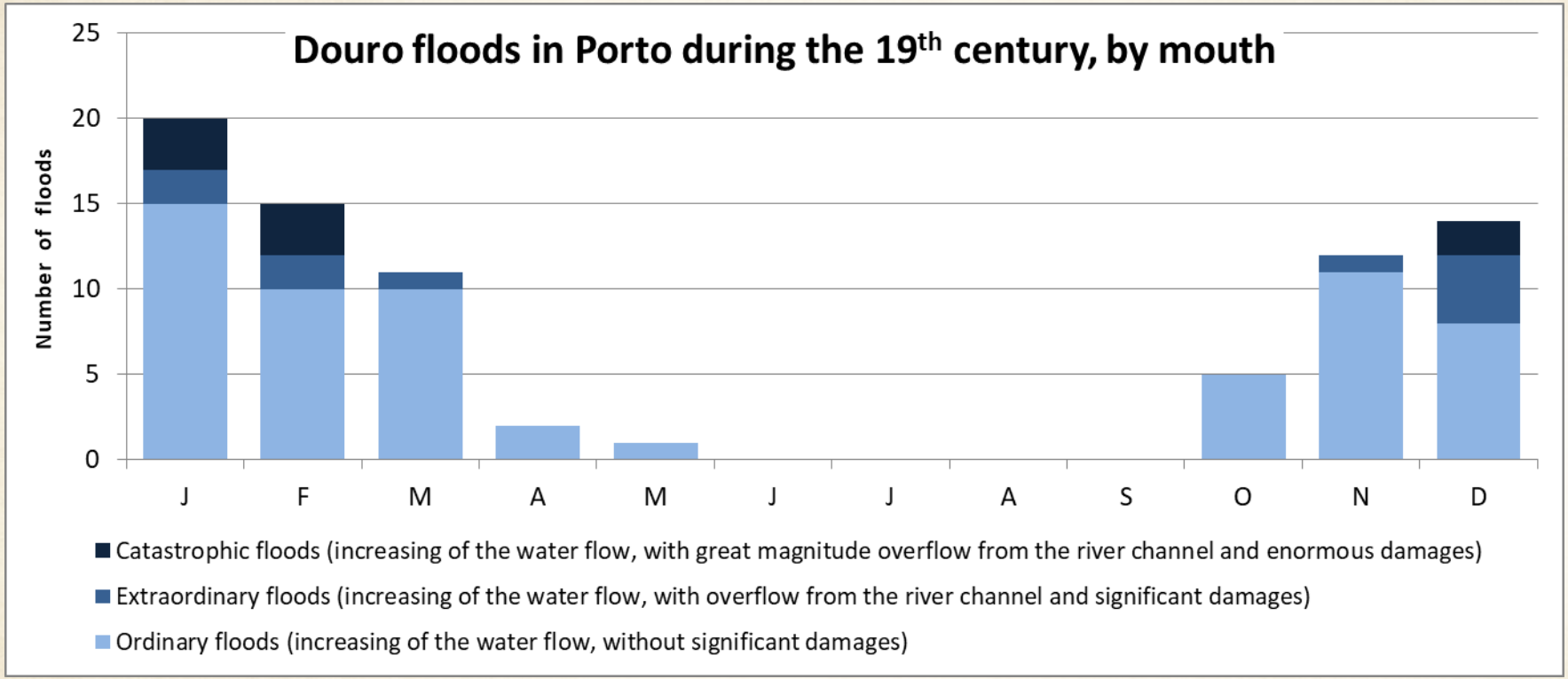


Results



The data registered 83 floods. There was great inter-annual variability among the Douro floods during the 19th century. Flooding events were by far more frequent in the 40's and 50's. A smaller record of floods in the first two decades of the studied period was probably due to a lesser amount of available documentary evidence within the scope of Napoleonic Wars and the Portuguese Civil War.

Results

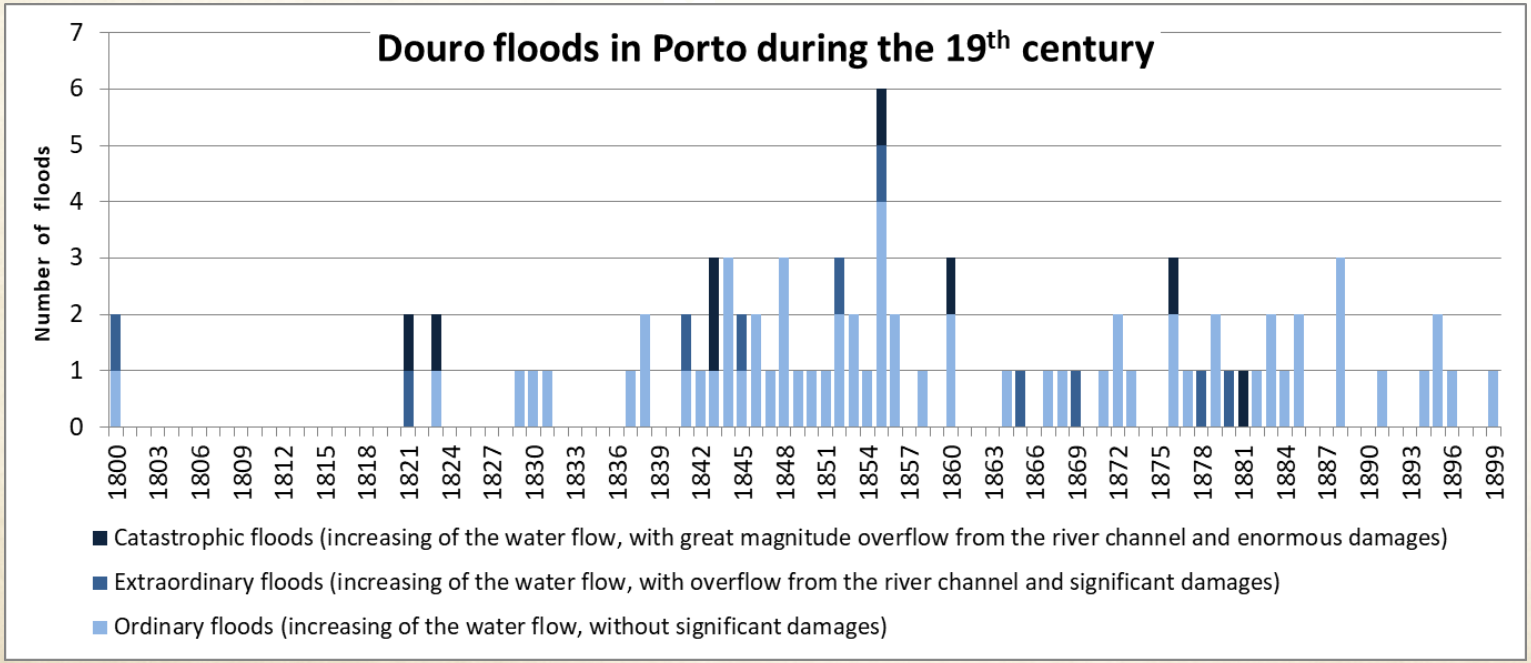


All events took place between October and May, focusing mainly from November to March, according to Douro's hydrographic regime.

Results

In addition to variations in the frequency and seasonality of such extreme phenomena, sources reveal clear differences in flood intensity/magnitude. Therefore, the Douro river floods were classified into three categories, according to the **level reached by the river water** and the **severity of the damages**.

Catastrophic floods: 9,6%; Extraordinary floods: 12,1%; Ordinary floods: 78,3%



Results

Source: Partial view of the city of Porto in 19th century, by Isidore Laurent Deroy

The “catastrophic” floods were recorded in:

- January 1821
- January 1823
- February 1843 (2)
- February 1855
- December 1860
- December 1876
- January 1881

Case study:
The December 1860 flood

On the night of December 24th 1860, after a few days of intense rain, the flow of the Douro River began to increase suddenly. The river continued to grow in the following days and its greatest height was on the 28th; it rose "**one span above the 1788 flood and three spans above the 1823 flood**". The Pênsil bridge [in the image] was in danger; «There was only one meter left to be carried by the river water».

The flow was so fast that it dragged everything it found in its way: boats, furniture, houses, trees, cattle, kites, wood, "everything the water could reach - such was its violence!". Four Portuguese, as well as one foreign vessels, sank. Many ships were stranded. All ships suffered damage. The damages were uncounted for the river and inland.

Since midnight on the 28th, the water began to fall steadily. On the last day of December 1860, the river returned to its normal state.

Porto, Ribeira: aspect of the 1860 flood. Porto : [s.n.], [186-?]
https://repositorio-tematico.up.pt/handle/10405/1107?locale=pt

Conclusions

Ongoing work

The research carried out revealed an extraordinary wealth of hydrological information, dispersed among the Portuguese historical documental sources, and contributed to a better understanding of the temporal variability of floods in the Douro river estuary during the 19th century.

In order to increase and deepen the knowledge of the past floods in Portugal it is extremely important to continue the research and the systematization of the records and historic documental sources. This research should assess more records (in particular local journals and reports).

Furthermore, the study and the systematic analysis should be undertaken under a joint strategy: enlarged information about rainfall records, number of flood days and impacts.