

**THE USE OF SPANISH AND BRITISH DOCUMENTARY SOURCES IN THE
INVESTIGATION OF ATLANTIC HURRICANE INCIDENCE IN HISTORICAL
TIMES**

Ricardo García Herrera^a; Francisco Rubio Durán^a; Dennis Wheeler^b; Emiliano Hernández
Martín^a; María Rosario Prieto^c and Luis Gimeno^d.

- (a) Departamento de Física de la Tierra II. Facultad de CC. Físicas. Universidad Complutense. Madrid. Spain.
- (b) School of Humanities. University of Sunderland. UK.
- (c) IANIGLA. CRYCIT, CONICET. Mendoza. Argentina.
- (d) Departamento de Física Aplicada. Universidad de Vigo. Spain

Abstract:

Official documents from the Caribbean region are a rich source of information on hurricanes for the years following the establishment of the Spanish colonies. Some of these papers are from as early as the sixteenth century. One hundred years later, the growth of British political interest is reflected in the increasing frequency of logbooks from the ships of the Royal Navy deployed in the region. Both the Spanish and the British sources provide different, but detailed, information on hurricane events. Spanish reports are often storm-specific, describing in detail the onset, character and consequences of individual events. British logbooks include references to hurricanes but within a wider body of information relating to day-to-day weather. Preliminary studies indicate that both sources permit the precise dating of hurricanes and, where several accounts of the same event exist, provide information from which a reconstruction of the trajectories can be made. The results cited in this paper are based on a limited sample of the many thousands of documents available in Spanish and British archives. An exhaustive study of these sources is demanding of time and resources but will yield detailed information from the past half millennium that adds to our knowledge of known hurricanes and identifies new events.

KEY WORDS: documentary sources, hurricanes, paleotempestology

'Si el viento te sopla furioso y valiente, enséñale al huracán los dientes'

'If the wind blows strongly and hard, it indicates a hurricane is imminent'¹

Introduction

The use of documentary sources is a well-established high-resolution technique for reconstructing climate during past centuries when no instrumental data are available (Martín Vide and Barriendos Vallvé (1995) and Catchpole (1992)). Documentary material has been used to study a number of important climatic phenomena such as the El Niño-Southern Oscillation (ENSO) (Quinn *et al* (1987) and Ortlieb (2000)) and the North Atlantic Oscillation (NAO) (Jones *et al* (1997) and Luterbacher *et al* (1999)) and used to describe climate variability in a number of regions. Of particular relevance is the work of Lamb (1991) whose chronology of extra-tropical storms was based largely on such sources.

Hurricanes are particularly suitable for study through historical sources because extreme events with serious consequences for the communities that experience them are often recorded in written record . It is to be expected that severe hurricanes of the historical period would provide a legacy of documentary evidence describing their effects and consequences in different societies. Perhaps the oldest documentary records on hurricanes (taken here to include typhoons) are those kept in the Guandong province of south-eastern China in the form of local chronicles of natural disasters. These documents provide information from as long ago as AD 975 (Kam-biu Liu *et al*, 2001). In the Atlantic Basin the first records come from the earliest years of the Spanish Colonies. There is little doubt that Christopher Columbus experienced at least two hurricanes, one in 1495 and the other in 1502 (Millás 1968).

The Spanish were quickly aware of the impact of hurricanes in the Caribbean area and promptly adopted the term *huracán* from the Carib language to describe the phenomenon. In the sixteenth century for example Fernandez de Oviedo wrote: '*Huracán, in the language of this island, is precisely defined as a very excessive storm or tempest but being in reality nothing more than a very great wind with heavy and intense rainfall.* (A.G.I. Indif. Gral. 108 -BIB. L.A. Siglo XVI – 7-). Since then countless documents have been produced containing information on hurricanes in the Atlantic Basin. The studies by Poey (1862), Tannehill (1940), Ludlum (1963), Dunn and Miller (1964), Millás (1968), Salivia (1950), Neumann *et al* (1993), Rappaport and Fernández-Partagás (1997) and Fernández-Partagás and Díaz (1996) provide a comprehensive view of the information that can be obtained from such sources.

The topic continues to attract academic research and there are a number of current projects using old documents to investigate hurricanes; an overview of those pertaining to the United States can be found at the URL: <http://www.ngdc.noaa.gov/paleo/hurricane/>. Not surprisingly most of the previously cited works have made use of documents kept in the American continent. However, a significant number of potentially relevant sources for the study of hurricanes in the past are still unexplored or have not been systematically examined. The majority of these documents are held in those European archives that contain information on the administration of former colonies in the Americas. So vast is the collection of such material that earlier attempts at their study were soon abandoned as too time-consuming an effort. Thus, Marx (1983) wrote in reference to the Spanish *Archivo General de Indias*: '*If a team of one hundred researchers spent their whole lives searching through the more than 250,000 large legajos (bundles) in the Archive of the Indies (at Seville), I doubt that they could locate all the important documents concerning Spanish maritime history in the New World*'. Such warnings notwithstanding, some progress has been made in this direction and in this chapter we present an overview of the Spanish and British archives of potential interest for hurricane reconstructions. Some results are also provided from an exploratory but by no means exhaustive search of these archives.

¹ . This is an old but popular saying amongst the fishermen of the Cuban coast and cited in a recent study by

Spanish Archives: description and previous use for climatic purposes.

The Spanish organized the settlement of their new American territories through the *Consejo de Indias* (established in 1523 soon after the Columbian discovery). By the mid-sixteenth century, most of the present-day Mexican territory of the Gulf of Mexico and the Antilles were occupied and then followed by settlements in Florida and Louisiana (under Spanish control from the second half of the sixteenth century). By virtue of the bureaucratic nature of the Spanish imperial system and its strictly formal decision-making procedures this colonization resulted in the production of a large volume of information related to everyday life, especially in the coastal cities, and to naval trade. Fortunately, many of the millions of documents have survived and are today available for study. In Spain there are a number of archives that contain information with possible importance for hurricane studies. Of these the most significant are the *Archivo General de Indias* at Seville, the *Archivo Histórico Nacional*, the *Archivo del Museo de la Marina*, the *Biblioteca Nacional* and the *Real Academia de la Historia* at Madrid, and the *Archivo General de Simancas* at Valladolid.

By far the richest source on the Spanish American Colonies is the *Archivo General de Indias* (General Archive of the Indies; hereafter denoted by its initials, AGI). The AGI is the central repository for documents related to the colonial administration of Spanish America. It was founded in the late eighteenth century during the reign of Carlos III to house scattered collections of documents as well as material previously stored in the National Archive at Simancas, in Valladolid. The *Lonja de Mercaderes* (Merchant's Meeting House) of Seville was refurbished to house the new collection; a fitting choice as the *Lonja* served as headquarters for much of the commercial activity between Spain and the New World during the sixteenth, seventeenth and eighteenth centuries. The first papers were received in 1785; since then the collection has since grown to over 80 million pages

of original writings encompassing all aspects of military, commercial and cultural relations between Spain and her American colonies.

The AGI collection

The AGI collection is divided into “Sections”, each one covering a different area of colonial affairs. Table 1 shows the current organization of the AGI, together with the number of legajos, or manuscript bundles, contained in each Section and the range of dates covered. Each legajo consists of a group of related documents and contains some 1500 to 2000 manuscript pages.

Table 1: Organization and Holdings of the Archivo General de Indias

Section	Dates	Number of <i>legajos</i> held
1. Patronato (Patronage)	1480-1790	306
2. Contaduría (Accounting)	1514-1778	2126
3. Contratación (Contracts)	1492-1794	6335
4. Justicia (Justice)	1515-1600	1214
5. Gobierno (Administration)	1492-1858	18,760
6. Escribanía de Cámara (Chamber Clerks)	1525-1760	2864
7. Secretaría Juzgado de Arribadas (Secretary of the Arrival Judge)	1674-1822	648
8. Correos (Mail)	1620-1846	895
9. Estado (State)	1642-1830	110
10. Ultramar (Overseas)	1605-1870	1013
11. Papeles de Cuba (Cuban Papers)	1712-1872	2967
12. Consulados (Consulates)	1520-1870	1903 ¹
13. Títulos de Castilla (Titles from Castilla)	C18 th -19 th	14
14. Tribunal de Cuentas (Accounting Court)	1851-1899	2751
15. Diversos (Miscellaneous)	1492-1898	48
16. Mapas y Planos (Maps and plans)	C16 th -19 th	6457

1) Plus 1255 bound volumes

As noted above, the AGI has not been systematically searched for information on hurricanes, but it has been used to reconstruct climate in South America (Prieto 1998, 2000) and the circulation in the North Pacific (García *et al* 2001). An overview of the potential uses of the AGI for climatological studies can be found in García *et al* (1999). This

preliminary examination has identified, however, those documents and sections most likely to provide information relevant to the study of hurricanes. These can be briefly described:

- *Relaciones Geográficas* (Geographical Accounts) which usually describe the climate of an area or region.
- Logbooks, nautical courses and accounts. These describe the events that occurred on board ship.
- *Actas Capitulares* (Local Acts) periodic reports (usually weekly) from the local government officers.
- Reports from scientific and military missions.
- Accounting books, these are especially important for estimating damage.
- Annals or diaries from priests, military or civil officers and ordinary citizens.
- Public and private correspondence sent by the colonial authorities to Spain.
- Commercial and private correspondence.

As shown in Table 1, the AGI is organized according to administrative criteria; thus, when focusing on a certain geographical area, many different sections need to be investigated. In addition, the miscellaneous nature of the documents makes further demands and adds to an already time consuming task that requires a high level of expertise.

British Archives: description and previous use for climatic purposes

For nearly a century the Spanish enjoyed unchallenged control of the western Atlantic and Caribbean areas that experienced hurricanes and tropical storms. Occasional, usually piratical, intrusions by English mariners left little useful information for climatologists. The picture changes, however, in the latter half of the reign of Queen Elizabeth I (1558-1603) when the first faltering attempts at English colonization were made along the coast of what is today North Carolina and Virginia (Milton, 2000). It was however to be another half century before these colonies became well established. Formal and significant English colonization in the Caribbean began only in 1655 when the forces of Oliver Cromwell's Protectorate captured Jamaica. Even after colonization the nature of

the English government system did not demand the weighty administrative structures that the Spanish had erected. For these reasons English (later British) documentary sources can be thought of as starting only in the mid-seventeenth century and yielding a smaller volume of official papers. There is however one source that is both nearly continuous, voluminous and of particular relevance to climatologists – the logbook collections from vessels engaged in trans-Atlantic voyages or in military activities in the Caribbean. With the notable exception of a few merchant ship survivals (Wheeler, 1995) this source is derived principally from the Masters', Captains' and Lieutenants' logbooks kept on board Royal Navy ships. Admirals' journals also contain climatic information, but this is not set out in any standardized form and is usually presented in a narrative form woven into a more general account of the fleet's proceedings and actions. For this reason they are not to be regarded as logbooks *sensu stricto*, but as diaries. Many logbooks of the voyages of exploration have also survived. These are prepared in standard form but only rarely provide information for the Caribbean region.

All senior British officers were obliged to prepare a daily logbook when at sea. The logbook was also often maintained, albeit in briefer form, when in harbour. Upon return to England the logbooks were deposited with the Admiralty and today many thousands of them are collected in two major archives. The Captains' and Masters' logbooks are to be found in the Public Records Office (PRO), Kew, London, and the Lieutenants' logbooks at the National Maritime Museum (NMM) at Greenwich. Admirals' journals and the logbooks of the voyages of exploration are also archived at the PRO. The logbooks at both archives form part of the Admiralty document collection under the catalogue heading ADM. At the NMM they are catalogued under ADM/L. At the PRO the principal collections of Captains' logbooks are catalogued under ADM/51 and those of the Masters under ADM/52. After the mid-nineteenth century the system of logbooks prepared by specific officers was gradually replaced by one requiring only one, more general, ship's logbook prepared by the succession of officers of each watch. Table 2 lists the quantity of logbooks and volumes under these various headings.

Table 2. Summary of British logbook sources in major collections.

Archive	Source	Catalogue reference	Period covered	Number of logbooks or volumes ¹
NMM	Lieutenants' logbooks	ADM/L/...	1679-1809	5300
PRO	Admirals' journals	ADM/50/...	1702-1916	413
PRO	Captains' logbooks	ADM/51/...	1669-1852	4563
PRO	Masters' logbooks	ADM/52/...	1672-1840	4460
PRO	Ships' logbooks	ADM/53/...	1799-1971	172412
PRO	Supplementary ships' logs	ADM/54/...	1808-1871	337
PRO	Logs and journals of ships on exploration	ADM/55/...	1757-1904	164

1) The PRO collection of Captains' and Masters' logbooks are catalogued by 'volumes'. As each volume may contain up to twenty logbooks, this stated number grossly underestimates the quantity of items that are available. The archive catalogue at NMM can be viewed at <http://www.nmm.ac.uk/>. The full catalogue at PRO, but not the documents themselves, can be examined at the website <http://catalogue.pro.gov.uk/>.

The scientific interest of these logbooks lies in their careful recording of the daily, sometimes hourly, passage of the weather. However interest in the weather was founded not on scientific curiosity but on the need to estimate the ship's 'leeway' or drift as a result of the effect of the wind on the course of the vessel (Taylor, 1956). Such information was vital for safe navigation before methods existed for the accurate determination of longitude. Even when navigational methods were perfected in the nineteenth century, logbooks continued to include climatic information, and they still do to the present day. An example of information from one of the rare merchant vessel logbooks is shown in Figure 1. The logbook has written entries that are typical of the late eighteenth century (this logbook is, however, unusual in its inclusion of pen-and-ink sketches representing conditions on each day at sea). Information on the ship's speed is recorded every two hours and often accompanied by information on wind direction and force. Other, more general, weather information relating to the state of sea or sky, precipitation and visibility was also recorded. The logbook is also typical in that it presents a summary of the navigational calculations for the day by which latitude and longitude were estimated.

Starting from the mid-nineteenth century ships' logbooks of all major maritime nations also compiled instrumental records while at sea. These sources have already provided material for major databases such the COADS (Comprehensive Oceanic and Atmospheric Data Set) described in Woodruff *et al*, (1987) and the Kobe collection

(Manabe, 1999). The earlier English Officer's logbooks, particularly those from before 1800, lack such instrumental data but are nonetheless rich in weather accounts. These accounts focus on three aspects noted above; wind direction, wind force and a general description of the weather for the day (Table 3). Although such items are purely descriptive and not based on any form of instrumental observation, it is important to recall that they were recorded in response to a common requirement for safe navigation. They appear also to have been recorded to consistent standards using a conventional and well-understood vocabulary that, while differing through time, was common to all contemporary records. Wind force was estimated by experience and by reference to the area and type of sail that a vessel could safely carry to secure maximum speed or, at slower speeds, by the effect of the wind on the water. Evidence to date indicates that wind direction was recorded with respect to true and not magnetic north. Methods for determining the variation of the latter were known from the early seventeenth century (Hewson, 1983). The direction itself was probably determined, as it is today when no instruments are available, by reference to streaming flags, wave and spray movement, and disturbances of the sea surface. Regrettably, no text from the periods in question make clear reference to the procedures but the results of a practical, sea-going, experiment where wind force and direction were found to be reliably estimated from the open decks of a sailing vessel are reported in Wheeler (1988).

Table 3. Summary of climatic elements recorded in officers' logbooks.

Recorded element	Description
Wind force	Recorded by non-numerical description. By the early eighteenth century the vocabulary was that later formalised by Francis Beaufort (Fry, 1967). Over the preceding decades the terminology only slowly converged to this standard and work remains to be completed for a reliable definition of the various terms that were used in earlier times.
Wind direction	Recorded from the sixteenth century on the standard 32-point compass still in use today.
Weather conditions	Rain, drizzle, fog, thunder, snow and any other significant weather was recorded using, almost exclusively, terms that are employed today.

Terminology is, however, a major problem in using these sources for climatic studies. In particular the search for the definition of terms such as 'strong gales', 'fresh gales', 'easy gales' or even 'indifferent gales' requires painstaking effort and has yet to be completed. It cannot be assumed that all terms were used in the past with the same meaning

that they now have. The Oxford English Dictionary (OED) provides some guidance on the changing meaning of adjectival qualifiers, as well as of the terms ‘gale’, ‘breezes’ etc. More useful in this context are the various nautical dictionaries. Most recently the great authority is taken to be the *Sailor’s Word Book* (Smyth, 1867). Meanings, however, change over time and one of the most useful of the earlier items is Falconer’s *An Universal Dictionary of the Marine*, published in 1780 and again in 1815. For yet earlier periods recourse can be made to *Boteler’s Dialogues*, edited by Perrin (1929) but covering the final decades of the seventeenth century; the mid-seventeenth century terms are included in Sir Henry Mainwaring’s *Nomenclator Navalis* (published in edited form by Manwaring and Perrin, 1922); while Captain John Smith’s *A Sea Grammar* has been republished (Goell, 1970) but first appeared as long ago as 1627. By these various means some interpretation can be made of the archaic terms employed particularly in the older logbooks.

Fortunately, when seeking information specifically relating to hurricanes this lexicographic problem is less acute for, as noted above in the discussion of Spanish sources, mariners were quickly made aware of the character of these destructive weather elements and the specific term hurricane (precise spellings differ over time) was universally adopted to describe them. One of the earliest definitions in English is found in John Smith’s *A Sea Grammer* of 1627 but a more interesting definition dates from the 1680s in *Boteler’s Dialogues*. This book takes the form of an imaginary discussion between an uninformed ‘Admiral’ and a knowledgeable ‘Captain’. At one point the Admiral inquires:

“*Since we have here made mention of storms and tempests; tell me what your hurricanoes are, which are found so common in the West Indies.*”

The Captain’s response is informative:

“*I shall, my Lord, and that in regard that this hurricanoe may be said to be the most enraged prince amongst them, and the lion of tempests... true it is that these whirlwinds [sic] in the West Indies and those parts, are exceeding extraordinary, as well in regard of their violence as lasting. And it is very observable that in some places these devastating winds are found very frequent, and so extreme outrageous that, if reports misreport not, some ships that have been taken with them, near*

some of those coasts, have been rather thrown than driven, even far into the land..." (Perrin, 1929, p.164)

The Captain goes on to describe how such hurricanes may endure at one place for two or three days and how they are to be found in the tropical latitudes rather than "...*in other parts where the sun looks not down so perpendicularly.*" The same items make it clear that the term 'storm' was used and understood in very much the same way as it is today. The arbitrary distinction currently made between 'tropical storms' and 'hurricanes' was, on the other hand, unknown and unnecessary to the mariners of those distant times. In this sense, the present-day researcher must recognize that the precise definition employed today enjoyed a wider, but not necessarily imprecise, currency in the past.

Other, more practical, difficulties are encountered when using the British logbooks. The very large number of such items in the PRO and NMM are not all from vessels in the Caribbean and nearby waters. In order to render the task of data abstraction more efficient, some means is needed to identify those vessels in the Caribbean at any given time. Fortunately, documents exist to allow this. For dates from the mid-seventeenth century recourse can be made to the Admiralty List Books (PRO series ADM/8/.... with a smaller collection of 'station of ship' records under ADM/7/...) in which the various stations are listed to which all Royal Navy vessels large and small were attached. These documents were prepared monthly, often give the sailing and arrival dates of individual vessels and although not always absolutely reliable, they provide great assistance in identifying those ships allocated to the hurricane-prone areas of which the Leeward Islands fleet and the Jamaica squadron are the most important. The quantity of logbooks is, however, variable from year to year and is determined largely by the political conditions of the day. The numbers of warships constructed and, to an even greater degree, the number in commission were much higher in wartime. Thus, for example, the Leeward Islands fleet of 1780 numbered twenty-five ships of the line with a commensurate number of frigates, sloops, brigs and support vessels perhaps doubling this number, but this was a time of conflict with France for possession of valuable territory in the Caribbean. During the Seven Years War the same fleet numbered just six with activity concentrated in Canadian waters (Lavery, 1983). This lower figure would also be typical of times of peace but, most importantly, the

overall number of logbooks is sufficient to ensure a continuity of record from the early eighteenth century onwards.

It is therefore possible, using supplementary documents, to narrow the range of potentially useful logbooks by reference to the region or area and to a specific period of time. The selected logbooks will then provide the precise dates for each set of observations. However, the accuracy with which the daily latitude and longitude were observed is another matter. The nature of navigation before approximately 1800 means that the day-to-day location of the ships is subject to error. This is marginal in relation to latitude which, by the eighteenth century, could be determined with reasonable accuracy using octants or sextants. The reliable determination of longitude, on the other hand, excited much intellectual debate and might fairly be described as one of the great scientific challenges of the age. A review of the 'longitude problem' can be found in Hewson (1983) while some of its more dramatic aspects were popularized by Sobel (1996). Error terms of tens of miles would not be uncommon in those days of 'dead (deduced) reckoning' before the various solutions to the longitude problem were found, and then widely adopted, in the early nineteenth century. This possible source of error needs always to be borne in mind when using this data source in reconstruction exercises and when 'mapping out' data. These characteristics, described for the British logbooks, apply equally to Spanish sources during the eighteenth and nineteenth centuries, a period during which most of the European logbooks exhibit a broadly common structure derived from identical observational procedures. Recent studies by Jackson *et al.* (2000) have, however, shown that reliable corrections using statistical methods can be made to latitude and longitude data from logbooks.

Even allowing for the vagaries of terminology and location, case studies using logbooks allied to other data have already demonstrated that such material can provide for the reconstruction of synoptic maps at a daily scale of temporal resolution. Whilst not focusing on hurricanes, at least one of these studies takes the case of a very severe storm as its theme (Wheeler, 2000) and illustrates the potential of this source when a long series of data are available.

Some examples of hurricane records

In this section examples of the different forms of information obtained during some exploratory work, mostly at the *Archivo General de Indias*, is provided. A preliminary identification of hurricanes from Spanish historical documents can be found in García Herrera *et al* (2000), where twelve hurricanes were identified from Spanish fleet reports. However, only secondary sources were used and not primary ones, as is the case here. The range of examples below includes the more abundant and relevant categories of documents that can be used for hurricane reconstructions.

Reports from Spanish ships

These reports can be found mostly, but not exclusively, in logbooks. A Royal Order issued in 1575 committed the masters and pilots of Spanish ships in the *Carrera de Indias* to produce accounts of each trans-Atlantic journey including, importantly, a detailed description of the voyage and of any geographical events, winds, currents and hurricanes. The completed logbooks had then to be delivered to the Professor of Cosmology in the *Casa de Contratación*. (AGI Indif. Gral 1956, L.1, f266r-266v). A careful examination of even earlier documents, not specifically designed for the description of hurricanes, suggests that some years were particularly bad for navigation in the Caribbean (Fernández Duro, 1903; Navarrete, 1901; Marx, 1983). For example, in 1553 sixteen ships were lost in a hurricane; in 1554 a number of shipwrecks were reported in Florida, Cuba and the Gulf of Mexico coast; in 1557 a fleet was dispersed by a hurricane in the Bahamas; and in 1563 seven ships were lost in Nombre de Dios Bay, five in Campeche and five more in Bermuda. In 1571 eleven ships were lost and two fleets were struck by hurricanes in the Bahamas Strait in 1589. The next year fifteen ships were lost in Veracruz. In 1622 the New Spain Fleet was dispersed by a hurricane in the Bahamas Strait; the Tierra Firme Fleet lost 1000 men and dozens of ships. On July 31st 1715 a fleet was devastated by a hurricane and

grounded on the reefs between Cape Canaveral and Fort Pierce in Florida and eleven ships were lost and 2500 persons died.

The document AGI, Mexico 360, describes a shipwreck on Oct 20th 1620 close to the Campeche coast. *‘On October 20th a gale entered from the Southeast at nine in the night which seemed more than a hurricane. The night was so dark and full of thunder and lightning from the four quarters that we had to offer prayers to Our Lady Virgin of Carmen... Later the hurricane veered to the north and a quarter, at dawn it blew away the foremast and jibsail...’*. These words were sent to ‘His Majesty’ by the Governor of Yucatan and formed part of a report that was originally produced in the diary of Andrés de Aristizábal, Chief of the Tierra Firme, on board on *Nuestra Señora del Juncal* off shore of the Campeche Coast.

Information is also found in the claims for compensations for losses of merchandise in shipwrecks. An example is provided in AGI Contratación, 730. Juan Ferrer, a ship’s master, begged the Casa de Contratación to be exonerated from any possible responsibility for the damage incurred by the *Santa Inés* sailing in the Nueva España Fleet in 1689:

‘being dismasted in the Bahamas channel between Cape Cañaveral and Saint Helena we survived a violent sea hurricane [sic] with north-east and east-north-east winds of such ferocity that they lasted six days during which time we thought ourselves lost together with the naos² of the fleet

AGI Contratación 5108 provides yet another description of hurricanes. In this case it occurred on 1589 close to the Florida coast and the account is contained in a letter from General Martín Pérez de Olázabal, issued at Sanlúcar de Barrameda. It informs His Majesty of the strong hurricane which affected the Nueva España and Tierra Firme fleets on their way to Spain: *‘sailing out of the channel with the wind large on our quarter we encountered a great storm of wind from the east-north-east that, finding us in the narrows*

between Florida and the Bahamas, we were battered for five days during which we lost contact with the large naos'

Examples of reports from English logbooks

The logbooks of Royal Navy vessels were, in contrast, highly formalized documents, set out in a standard fashion with little latitude for personal embellishment or literary style. Given that seasoned officers that had experienced the worst the elements could hurl at them produced the logbooks, the rather matter-of-fact and laconic style with which they describe most storms, and even many hurricanes, should come as no surprise. Some of the following few examples make this point very clearly. They were abstracted from logbooks of vessels known to be in the Caribbean region during October 1780, a month of notable hurricane activity. The true value of such information lies not so much in the individual detail, which is routine, but in the collective picture and continuity of account that several such documents create. The mapping of the daily winds, their strengths and the direction of sea (swell) can also be used to help define the reconstructed path of the hurricane(s), to identify previously unknown events, and to confirm, or otherwise, independent reconstructions from other sources.

1. HMS *Hector* (74 gun battleship) was cruising off the east end of Hispaniola in early October 1780. On 6th the logbook entry was:

Winds: EbN (east-by-north), strong gales and squally, at 7 (pm) the gale increasing, at 12 (midnight) increasing to a hurricane. The sea running high.

On 7th the situation had moderated and the winds veered

Winds: W, hard gales. Heavy sea from the west

² A nao was an ancient, high-sided sailing vessel. Saint Helena refers to St. Helena Sound, between Charleston and Savannah

The most severe of the month's hurricanes is thought to have approached Florida between 11th and 18th October. On 16th the entry was:

Winds: EbN, strong gales. Heavy swell from the east

And on 19th:

Winds: NbE, fresh breezes. Heavy swell from the north.

2. HMS *Ajax* (74 guns) was nearby off (British) Dominica. Here the entry for 12th reads:

Winds: all around the compass. Strong gales and heavy squalls. At 6 (am) violent squalls of wind. At noon less wind. Very heavy sea. At noon the sea very high and confused. Lightning.

At the same time HMS *Charon* (44 guns) was off Charleston. Here the worst of the weather, and by no means a hurricane, was recorded on 17th:

Winds: NNE and NbE. Strong gales and heavy seas.

These examples show how fragments of evidence might be put together to provide a fuller picture. Such information from sea-going vessels provides also a valuable complement to land-based information. The problem of vocabulary is however evident and the issue surrounding the precise meaning of terms such as 'strong gales' for example has yet to be fully addressed.

Reports on landfalling hurricanes

There are abundant references to disasters on the coasts, mostly contained in *Gobierno, Patronato, Ultramar, Secretaría de Guerra, Diversos and Papeles de Cuba* sections from the AGI. The *Actas de Cabildo* (Mayorality Acts) are the written notes produced by the members of the Mayoralties (Councils) during their weekly meetings. They are an excellent source of information on any event interrupting the daily life of the city. Climate related incidents, especially extreme events such as floods, droughts and

hurricanes affecting the city and its surroundings were always noted in these documents. For Cuba and Puerto Rico the AGI keeps records for a period of more than four hundred years and they constitute a major source of environmental information for the study of hurricanes and their impacts. Of particular interest are the *Reports of the General Navy Command of the Antilles*, the *Gazetas* and other periodic publications such as the *Partes de tranquilidad*, the monthly papers produced by the authorities, or the reports from the Meteorological Services established in the area during the nineteenth century. These reports can be found in different AGI sections. AGI Patronato 181, R.25 for example provides an account of the damage caused by a hurricane on November 2nd 1552 in S. Juan de Ulúa (close to Veracruz) in which the mayor of the city describes the storm damage and the actions taken to alleviate its consequences.

A copy of an informative document (AGI Secretaría de Guerra 7241, exp 26) shows the certificate of a Lieutenant Colonel supporting the claim of the repairs to a partially-completed fort in Placaminas (Plaquemines) close to New Orleans (Figure 2). The works were badly damaged by a hurricane on August 18th 1793. The contractor claimed against the Spanish Government for additional funding to complete the fort. A copy of a report produced by the Governor of Puerto Rico (AHN/ Ultramar 2007, exp.2) on the damages caused by a hurricane that struck the island on July 26-27th 1825 is shown in Figure 3. The report itemized for the different villages on the island the loss of lives, number of injured persons, and damage to houses, farming and livestock. AHN/ Ultramar 5066, Exp 14 and 15 contains a report on the simultaneous occurrence of a hurricane and earthquake affecting Puerto Rico and La Española on September 12th 1846.

The archival information is not limited to the Gulf area, there is also evidence of hurricanes affecting Venezuela and Panamá. AGI/ Secretaría de Guerra 7171, Exp22 contains a report of the General Captain based in Caracas on the 'furious hurricane' in Margarita Island on August 11th 1790.

Some detailed descriptions

The combination of documents of a varied nature, such as those described previously, can provide detailed information on location, intensity and even trajectory of the hurricanes. Some examples are provided below.

a) The hurricane of mid-October 1768 in Cuba.

This hurricane can be traced in two different documents. Firstly the logbook of *El Quirós* (AGI Correos 271B R11) which describes how the mail ship encountered a frigate coming from Boston which had been affected by the hurricane on October 7th. The logbook continues by referring to events on the 21st ‘*at seven in the morning on passing through the Royal Passage I encountered much flotsam of wood from ships, boxes, windows and general stores*’

At the same time, a report was produced on the damage that occurred in Cuba on October 15th as the hurricane passed the island. An analysis of the damage to houses and persons in different cities and villages (Table 4) can give additional evidence about the hurricane's intensity.

Table 4. Summary of damage in Cuba due to the hurricane on October 15th, 1768.

Places in which occurred	Tile houses destroyed	Guano houses destroyed	Damaged tile houses	Damaged guano houses	Died	Injured
La Habana	34	488		125	11	31
Horcón, Jesús M ^a y Guadalupe	15	289		70	1	
Guanabacoa y arrabales	7	983	19	16	3	35
Partido de Buena Vista	1	411				
Bucaranao		193				
Cruz del Padre		421			1	10
Las Vegas		317				
Santa M ^a del Rosario y Guaraco		456				3
Santuario de Regla		46		25	1	2
Santiago	28	254		69	4	4
Vejucal	6	225		68	1	
San Miguel	5	179		16	4	6
Guines		87		104	5	9
Managuana y Canoa		351		160	6	16

b) *The Hurricane of September 13th 1876 in Puerto Rico*

This hurricane is carefully described in AGI AHN/Ultramar 374, Exp2. The document, written by Leonardo de Tejada, Chief Engineer of Public Works, contains a theoretical introduction to the occurrence of hurricanes and a map with the trajectories of the strongest hurricanes that occurred in the nineteenth century (reproduced in Figure 4). A complete set of data for this storm is included with hourly resolution for pressure, temperature and wind in Figure 5. It can be seen that a maximum wind speed occurred at 8:30 am. (28 m/s), while the minimum pressure was 976.6 hPa at 6:00 am. The trajectory can be seen in Figure 6 and additional references to hurricane parameters are summarized in Table 5.

Table 5. Characteristics of the hurricane of September 13th 1876 in Puerto Rico

Direction	ESE to WNW from St. Kitts to Puerto Rico
Speed	35 km/h
Diameter	280 km
Eye diameter	15 km
Max. Speed at S. Juan	100-130 Km/h
Temperature decrease	28° to 24°
Increase in relative humidity	71% to 94%
Minimum pressure	734.65 mm

This information was described by Tejada in AGI AHN/Ultramar 374, Exp2.

Perspectives and future development.

The cases described in the above paragraphs represent only a small fraction of those that have been identified in preliminary searches of the Spanish and British archives. They have been checked against the information contained in: Evans (1848), Millás (1968), Salivia (1950), Tannehill (1940), Viñes (1877), Tuero (1860) and Ludlum (1963). It has been found that the above examples corresponding to the years 1552, 1589, 1620 and 1790 have not been identified in any of these previous works. Others, such as those in 1772 or 1876, are well-known, but these AGI sources provide complementary information. About 30% of the total storms identified in our preliminary searches can be considered as previously unreported. This confirms that there is significant potential for adding new hurricanes to present day chronologies.

The total sample obtained in the preliminary exploration contains 127 references from Spanish sources. The temporal and spatial distribution of these hurricanes concentrates in the second half of the eighteenth century (Figure 7). It is still unclear if this concentration is the result of a higher frequency of hurricanes or greater availability of sources. Regarding the spatial coverage, Cuba, Puerto Rico, the open sea, and Florida and Louisiana are the areas providing more information. The information for the whole sample is currently being collated and will be included in a database to allow its free use for the scientific community.

This first analysis illustrates the potential of these sources, some of the problems associated with assembling these sources, and allows some conclusions to be drawn that have a bearing on future studies in this field.

- 1) The Spanish and British archives contain significant volumes of information that are relevant for hurricane reconstructions and/ or reanalysis. This information is especially valuable for the identification of 'new' hurricanes, particularly from the sixteenth to eighteenth centuries, an era when the information is more scarce in other local sources, and

for the reduction of uncertainties related to the timing, trajectory, and/or intensity of already-known hurricanes.

2) These sources are especially rich for the Caribbean area and in particular for Cuba, Puerto Rico and the Gulf coast. These areas have been the most densely populated regions of the Caribbean since the beginning of the sixteenth century. Additional information can be obtained for other areas such as Panama, Colombia, Venezuela and the open sea. British records are abundant not only for the Caribbean region from the mid-seventeenth century, but also for the American seaboard (the present-day states of North and South Carolina, Georgia, Virginia and lands to the north) at least until the War of Independence.

3) The need to agree upon a strategy for future research presents a number of challenges. Logbooks provide the greatest geographical coverage, collectively cover a long time span, and pay particular attention to weather conditions. They do, however, have some limitations; most importantly, unless close to shore a ship's logbook can provide little information on the landfall location of hurricanes. In addition many ships sought the refuge of harbors and anchorages during the hurricane season, and in these situations logbook entries are scarce or may even cease altogether. The logbooks may therefore yield only a partial view of individual events.

4) Searches for hurricane landfall sites are circumscribed by the nature of the archive sources. In particular shifting political boundaries often caused documents to be cataloged under different headings. Even with greater experience and knowledge of these sources, future workers will require significant amounts of time to undertake the unavoidably lengthy task of sifting through the vast volume of documents that have survived from earlier centuries.

References

- Catchpole, A.J.W. (1992). Hudson's Bay Company ships' log-books as sources of sea ice data, 1751-1870. In P.D. Jones and R.S. Bradley, eds., *Climate Since A.D.1500*, London: Routledge.
- Dunn, G.E. and B.I. Miller. (1964). *Atlantic Hurricanes*. Baton Rouge: Louisiana State University Press.
- Evans, J. (1848). Hurricanes 1493-1848. *Nautical Magazine*. London.
- Falconer, W. (1780) *An Universal Dictionary of the Marine*. London: T. Cadell.
- Fernández Duro, C. (1903). *La Armada española desde la unión de los reinos de Castilla y Aragón*. Estudios Tipográficos G. de Rivadeneyra. Madrid.
- Fernández-Partagás, J. and Díaz, H.F. (1996). *A Historically Significant Revision of Atlantic Tropical Cyclone Frequency 1851 to 1890*. Final Report Supplement, ERL-NOAA Report 40 RANR 503516.
- Fry, H.T. (1967) The emergence of the Beaufort scale. *Mariner's Mirror*, 53, 311-313.
- García R., Prieto M.R., Gimeno L., Hernández E., López E. and Herrera, R (1999). The Archivo General de Indias as a source of climatic marine surface information. *Proc. International Workshop on Digitization and Preparation of Historical Surface Marine Data and Metadata*. 15-17 September. Toledo.
- García Herrera, R. Gimeno, L., Hernández, E., Prieto, M.R. and Ribera, P. (2000). Reconstructing the North Atlantic Atmospheric Circulation in the 16th, 17th and 18th centuries from Historical Sources. *Climate Research*, 14: 147-151.
- García R. R., Díaz, H.F., García Herrera, R, Eischeid, J., Prieto, M.R., Hernández, E.,L. Gimeno, E.L., Rubio, F. and Bascary, A.M. (2001). Atmospheric Circulation Changes in the Tropical Pacific Inferred from the Voyages of the Manila Galleon in the 16th–18th Centuries. *Bulletin of the American Meterological Society*. **82**, 2435-2455.
- Goell, K. ed (1970). *A Sea Grammar: with the plaine exposition of Smiths accidence for young seamen, enlarged*. London:Michael Joseph.
- Haensch, Günther; *Diccionario del español de Cuba; español de Cuba – español de España*. Gredos S.L. Madrid, 2000.
- Hewson, J.B. (1983). *A History of the Practice of Navigation*. Glasgow: Brown, Son and Ferguson.

- Jackson, A., Jonkers, A.R.T. and Walker, M.R. (2000). Four centuries of geomagnetic secular variation from historical records. *Phil. Trans. R. Soc. Lond. A*, 358: 957-990.
- Jones, P. D., T. Jonsson, and D. Wheeler (1997). Extension of the North Atlantic Oscillation using early instrumental pressure observations from Gibraltar and south-west Iceland. *International Journal of Climatology*, 17: 1433-1450.
- Lamb, H.H. (1991). *Historic Storms of the North Sea, British Isles and Northwest Europe*. Cambridge (UK): Cambridge University Press.
- Lavery, B. (1983). *The Ship of the Line: volume 1 – the development of the battlefleet 1650-1850*. London: Conway Maritime Press.
- Liu, K-B., Shen, C., and Louise K.S. (2001). A 1000-year history of typhoon landfalls in Guangdong, southern China, reconstructed from Chinese historical documentary records, *Annals of the Association of American Geographers*, 91: 453-464.
- Ludlum, D.M. (1963). *Early American Hurricanes, 1492-1870*. Boston: American Meteorological Society.
- Luterbacher, J., Schmutz, C., Gyalistras, D., Xoplaki, E. and Wanner, H. (1999). Reconstruction of monthly NAO and EU indices back to AD 1675, *Geophysical Research Letters*, 26(17): 2745-2748.
- Manabe, T. (1999): The digitized Kobe collection, phase I: historical surface marine meteorological observations in the archive of the Japan Meteorological Agency. *Bull. Am. Met. Soc.*, 80: 2703-2715.
- Manwaring, G.E. and Perrin, W.G. eds (1922). *The Life and Works of Sir Henry Mainwaring, vol.II*. London: Navy Records Society.
- Martín Vide, J. and Barriendos Vallvé, M. (1995) The use of rogation ceremony records in climatic reconstruction: a case study from Catalonia (Spain). *Climatic Change*, 30: 201-221.
- Marx, R. F. (1983). *Shipwrecks in the Americas*. Bonanza Books.
- Millas, J.C. (1968). *Hurricanes of the Caribbean and Adjacent Regions, 1492-1800*. Miami: Academy of the Arts and Sciences of the Americas.
- Milton, G. (2000). *Big Chief Elizabeth: how England's adventurers gambled and won the New World*. London: Hodder and Stoughton.

- Navarrete, A. (1901): Historia marítima militar de España. Armadas españolas y marinas que le antecedieron en la Península Ibérica. *Sucesores de Rivadeneyra*. 11. Madrid.
- Neumann, C.J., Jarvinen, B.R., McAdie, C.J. and Elms, J.D. (1993). *Tropical Cyclones of the North Atlantic Ocean, 1871-1992*. Asheville, N.C.: NOAA Historical Climatology Series 6-2.
- Ortlieb, L. (2000). The Documented Historical Record of El Niño Events in Perú: An Update of the Quinn Record (Sixteen through Nineteen Centuries). In H.F. Díaz and V. Markgraf eds., *El Niño and the Southern Oscillation*, Cambridge (UK): Cambridge University Press.
- Perrin, W.G. ed (1929). *Boteler's Dialogues*. London: Navy Records Society.
- Poey, A. (1862). *Table chronologique de quatre cents cyclones*. Paris. 66 pp
- Prieto, M.R. (1998). Austral climate and glaciers in the 16th century through the observations of the Spanish navigators. *Quatern. South Amer. Antarct. Penins.* 11: 227-236.
- Prieto, M.R. (2000). Archival evidence for some aspects of historical climate variability in Argentina and Bolivia during the 17th and 18th centuries. In W. Volkheimer and P. Smolka eds., *Southern Hemisphere Paleo- and Neoclimates*. Berlin-Heidelberg: Springer-Verlag..
- Quinn, W.H., Neal, V.T. and Antúnnez de Mayolo, S.E. (1987). El Niño Occurrences over the past four and a half centuries. *Journal of Geophysical Research*, 92 C13: 14449-14461.
- Rappaport, E.N. and Fernández-Partagas, J. (1997). History of the Deadliest Atlantic Tropical Cyclones since the Discovery of the New World in Hurricanes: In H.F. Díaz and R.S. Pulwarty eds. *Climate and Socioeconomic Impacts*. Berlin: Springer.
- Salivia L.A. (1950) Historia de los temporales de Puerto Rico. S. Juan. .
- Sobel, D. (1996) *Longitude: the true story of a lone genius who solved the greatest scientific problem of his time*. London: Fourth Estate.
- Smyth, W.H. (1867). *A Sailor's Word Book*. London: Blackie and Son.
- Tannehill, I.R. (1940). *Hurricanes: Their Nature and History*. Princeton, NJ: Princeton University Press.

- Taylor, E.G.R. (1956). *The Haven-finding Art: a history of navigation from Odysseus to Captain Cook*. London: Hollis & Carter.
- Tuero, J. M. (1860). *Huracanes. Vda. de Calero*, Madrid.
- Viñes B. (1877). *Huracanes de la Antillas*. La Habana: Iris.
- Wheeler, D.A. (1988) Sailing ships logs as weather records: a test case . *J. Meteorology*, (UK), 13: 122-126.
- Wheeler, D.A. (1995): The weather vocabulary of an eighteenth century mariner: the logbooks of Nicholas Pocock. *Weather*, 50: 298-304. reprinted in *The Marine Observer*, 67: 22-28. (1997).
- Wheeler, D.A. (2000): The weather of the European Atlantic Seaboard during October 1805: an exercise in historical climatology: *Climatic Change*, 45: 361-385.
- Woodruff, S.D., Slutz, R.J., Jenne, R.L. and Steurer, P.M. (1987). A comprehensive ocean-atmosphere data set. *Bull. Am. Met. Soc.*, 68: 1239-1250.

Figure captions:

Figure 1: Pages from the logbook of the merchant vessel *Lloyd* for August 1771. This merchant vessel sailed regularly between England and the Caribbean region. The layout of the pages is typical of the time (see text) and differs only in the inclusion of pen-and-ink sketches by her master Nicholas Pocock who later became a famous marine painter. By courtesy of Bristol Records Office

Figure 2: Report of an army officer supporting the claims of the builder of the fort in Plaquemines (close to New Orleans) to be reimbursed for the damages of a hurricane.

Figure 3: Report of the Governor of Puerto Rico describing the damages in the Island due to the hurricane on July 26-27th 1825.

Figure 4: Trajectories of the strongest hurricanes affecting the Antilles during the 19th century according to a report by Leonardo de Tejada, Chief Engineer of Public Works at Puerto Rico.

Figure 5: Hourly data for the hurricane of September 13th 1876 in Puerto Rico according to the report by Leonardo de Tejada, Chief Engineer of Public Works at Puerto Rico (AGI AHN/Ultramar 374, Exp2).

Figure 6: Trajectory of the hurricane of September 13th 1876 in Puerto Rico according to the report by Leonardo de Tejada, Chief Engineer of Public Works at Puerto Rico (AGI AHN/Ultramar 374, Exp2).

Figure 7: a) Time distribution of the hurricanes identified by exploratory research in the Spanish Archives. b) Spatial distribution of the hurricanes identified by exploratory research in the Spanish Archives.