



# SPACE CLIMATE

*CLIMATE IN SPACE AND ON EARTH*



## Searching the best data to understand Sun-Climate relationships

**J.M. Vaquero**

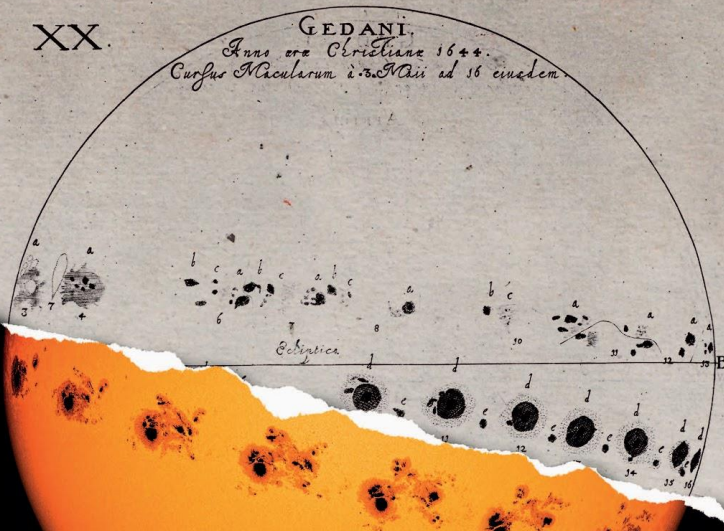
Departamento de Física, Facultad de Ciencias, Universidad de Extremadura, Badajoz, Spain



# nature astronomy

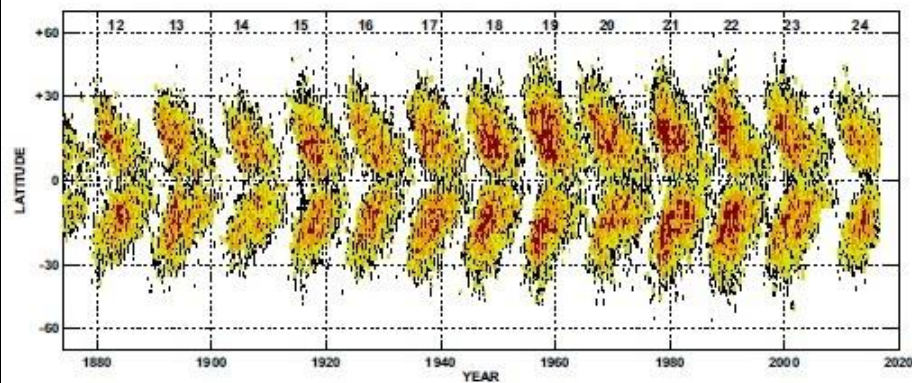
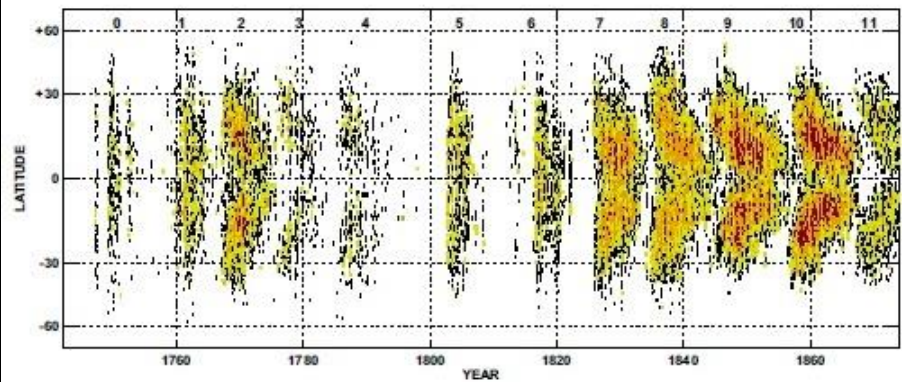
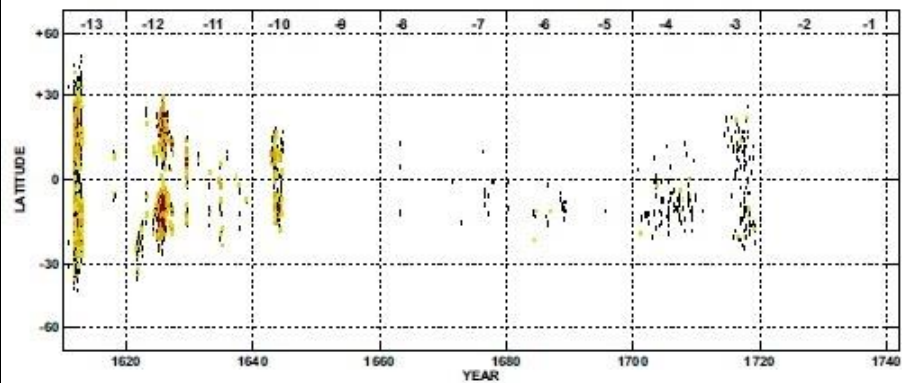
XX.

GEDANI.  
Anno erae Christianae 1644.  
Cognosco Macularum in Sole ad 16 eisdem



Recording solar cycles

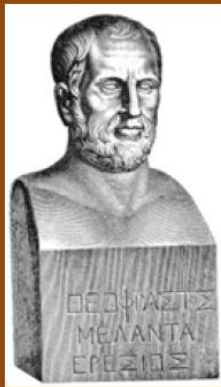
Muñoz-Jaramillo & Vaquero (2019)



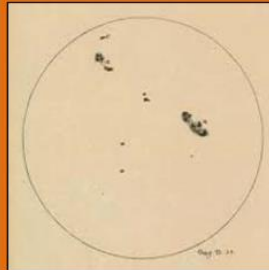
Arlt & Vaquero (2020)

# Motivation

Vaquero & Trigo (2015)



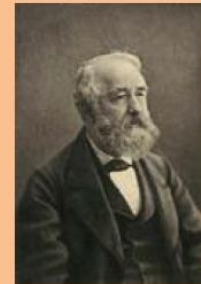
Theophrastus, greek philosopher



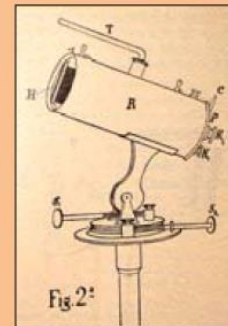
Sunspot drawing by Galileo



Early books on sunspots



R. Wolf



Angstrom Pyrheliometer



SOHO

Telescopic discovery of sunspots

1610

Discovery of 11-year solar cycle

1844

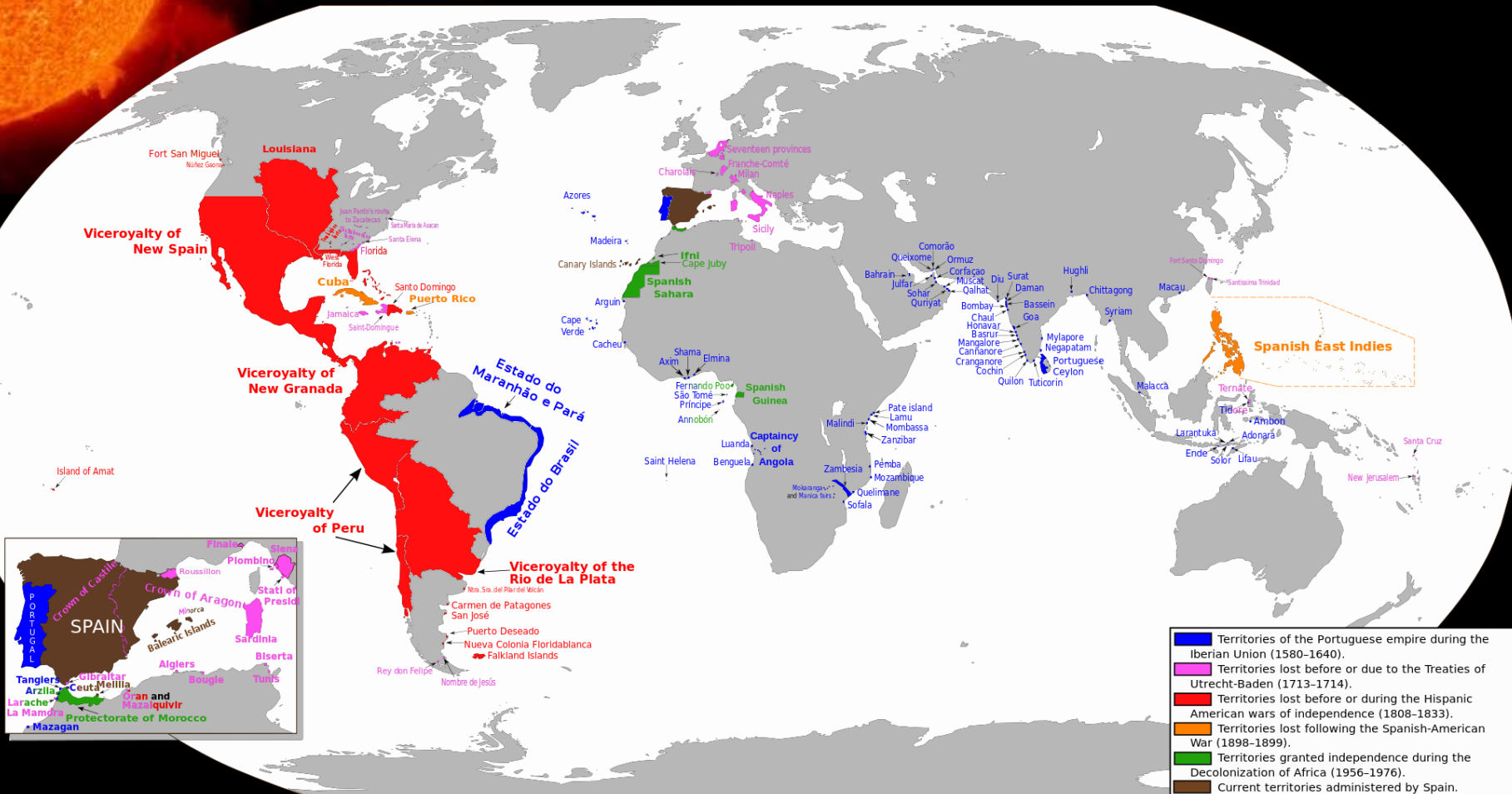
Maunder Minimum confirmed and first measurements of solar irradiance from space

1977

**Theories and hypotheses** about Sun-Climate relationships have been constrained by the **available data**.



# In this talk...



I will review several efforts made in the last years to recover early meteorological (and magnetic) data of Spain, Portugal, and the territories that have been influenced by the Iberian culture.



# America



MEMORIAS  
DA  
ACADEMIA REAL  
DAS SCIENCIAS  
DE LISBOA.

---

*Nisi utile est quod facimus, stulta est gloria.*

---

TOMO I.  
DESDE 1780 ATÉ 1788.



LISBOA:  
NA TYPOGRAFIA DA ACADEMIA,  
1797.  
*Com licença de S. Magestade.*

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OBSERVAÇÕES ASTRONOMICAS

*Feitas junto ao Castello da Cidade do Rio de Janeiro para de  
terminar a Latitudo e Longitude da dita Cidade.*

POR BENTO SANCHES DORTA.

Estas observações forão feitas nos annos de 1781, e 1782 com excellentes instrumentos. As alturas meridianas do Sol, e Estrellas forão tomadas com hum Quadrante Afronomico de hum pé de raio, construido por Mr. *Sisson*, artista de Londres, no anno de 1779: Os Eclipses dos Satellites de Jupiter forão observados com occulos achromaticos de *Dollon*; tendo hum de foco  $3\frac{1}{2}$  pés, e outro 17 pollegadas. O tempo verdadeiro foi

See also [Vaquero et al. 2005, Astron. Nachr.](#)

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OBSERVAÇÕES METEOROLOGICAS

*Feitas na Cidade do Rio de Janeiro.*

POR BENTO SANCHES DORTA.

Sendo o ocio para mim pouco grato, e causando-me hum grande enjôo, resolvi occupar o tempo em cousa que fosse util, e que podesse dar conta delle, quando me visse obrigado a isso: e movido das altas obrigações que inspirão a vassallagem, tributada aos melhores dos Soberanos, e o amor que os interesses da Patria exigem de todos os que constituem o corpo do Es-

## Results of the Rio de Janeiro magnetic observations 1781–1788

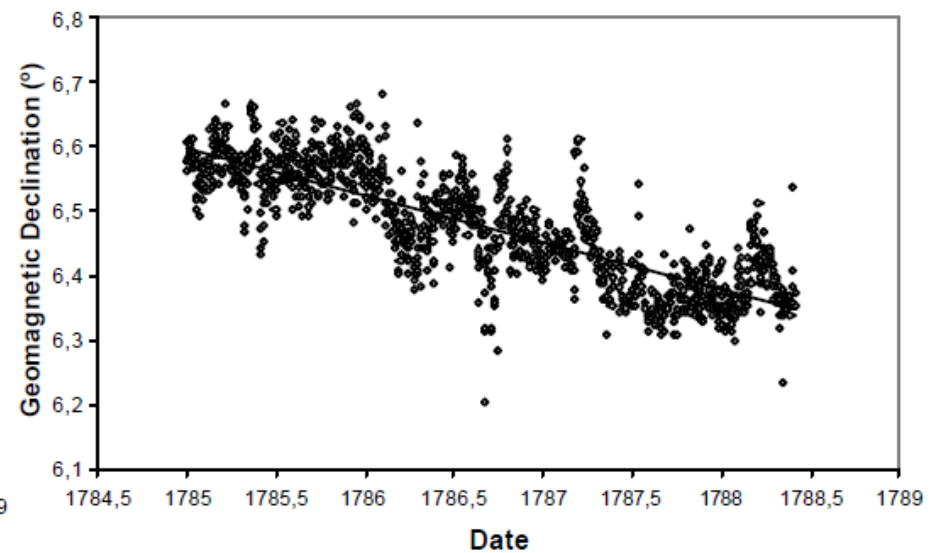
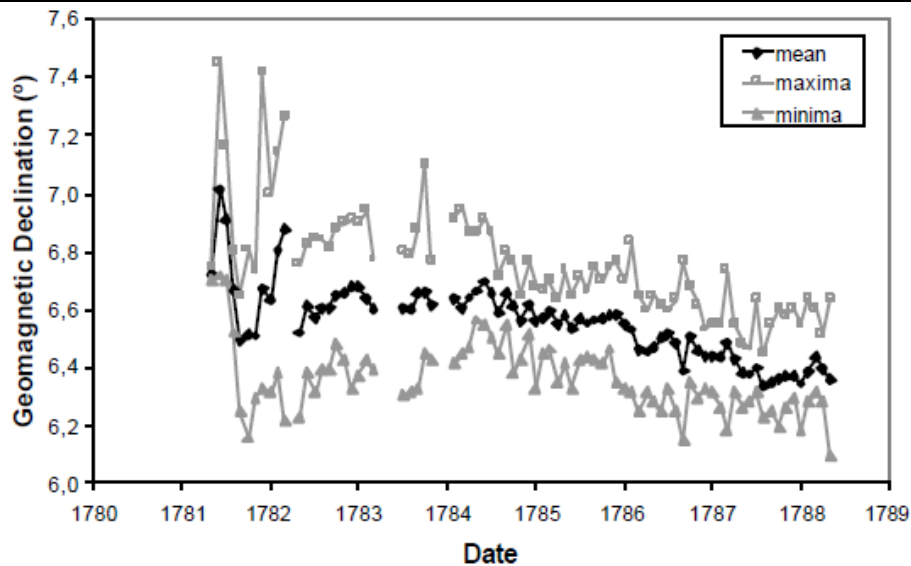
J. M. Vaquero<sup>1</sup> and R. M. Trigo<sup>2,3</sup>

<sup>1</sup>Departamento de Física, Escuela Politécnica, Univ. de Extremadura, Avda. de la Universidad s/n, 10071 Cáceres, Spain

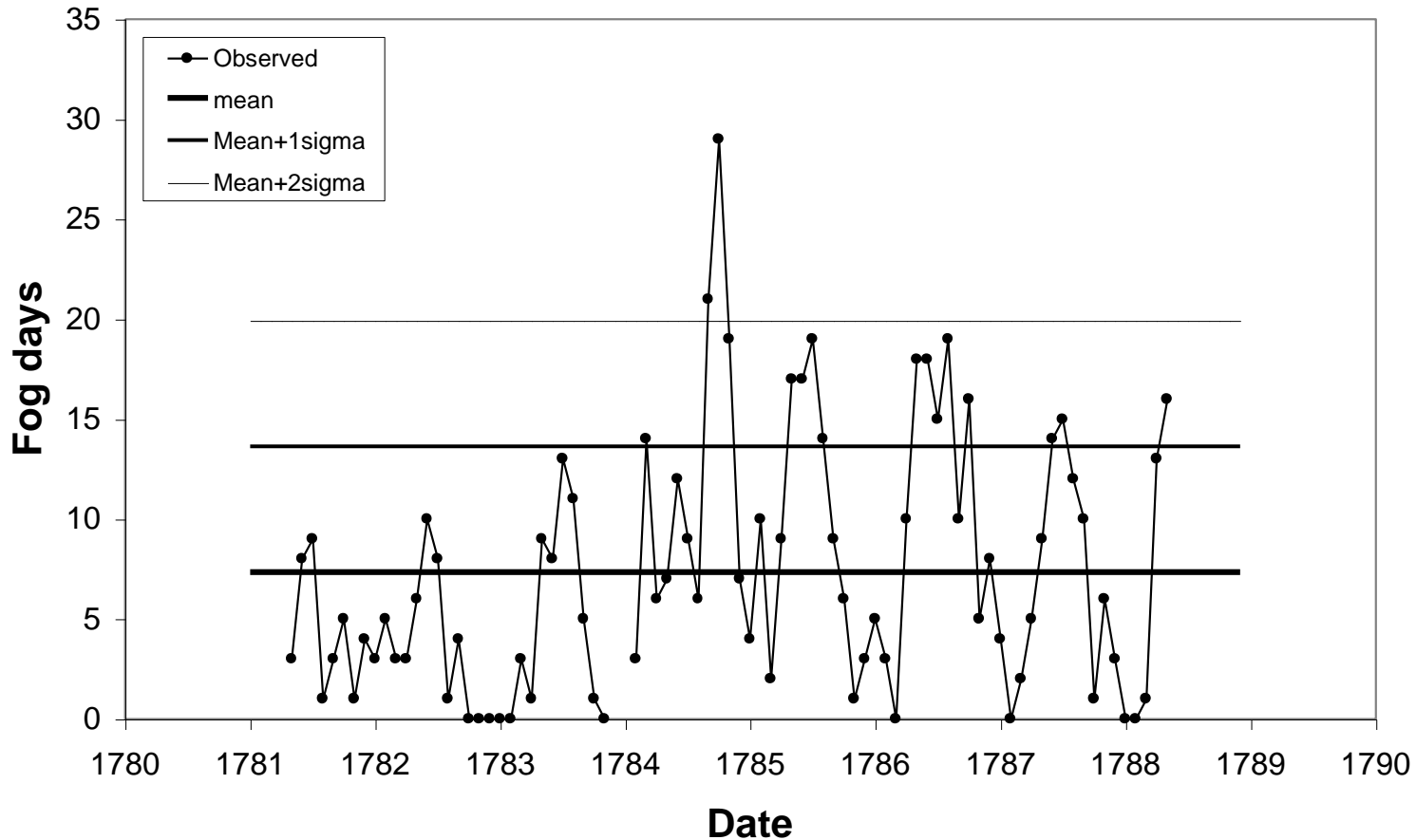
<sup>2</sup>Centro de Geofísica da Universidade de Lisboa, Lisbon, Portugal

<sup>3</sup>Departamento de Eng. Civil da Universidade Lusófona, Lisbon, Portugal

Received: 2 February 2005 – Revised: 11 April 2005 – Accepted: 14 April 2005 – Published: 28 July 2005



# America



Monthly values of number of fog days recorded by BSD between 1781 and 1788.

Trigo, Vaquero and Stothers (2010) "Witnessing the impact of 1783-1784 Laki eruption in the Southern Hemisphere" *Climatic Change* 99, 535-546.

See also Guevara-Murua et al. (2014) *Clim. Past* (for 1808/9 volcanic eruption)





## The meteorological observations of Bento Sanches Dorta, Rio de Janeiro, Brazil: 1781–1788

A. M. M. Farrona • R. M. Trigo • M. C. Gallego • J. M. Vaquero

Variable		Years							
		1781	1782	1783	1784	1785	1786	1787	1788
Temperature	Morning								
	Midday								
	Afternoon								
	Maximum								
	Mean								
	Minimum								
	Every 2h								
Pressure	Morning								
	Midday								
	Afternoon								
	Maximum								
	Mean								
	Minimum								
	Every 2h								
State of Sky (Num. days)	Clear								
	Variable								
	Cloudy								
	Thunder								
	Storm								
	Fog								
	Aurora Australis								
	Zodiacal light								
Wind	Morning								
	Afternoon								
Total precipitation									
Total evaporation									

**Fig. 2** Available data from BSD's papers (*white*: unavailable; *yellow*: monthly data; *red*: daily data). There are no data from December 1783 and January 1784. There are pressure data during 1784 after August. There are no data from June 1788



## A PIONEER IN TROPICAL METEOROLOGY

William Sharpe's Barbados Weather Journal, April–August 1680

BY M. CHENOWETH, J. M. VAQUERO, R. GARCIA-HERRERA, AND D. WHEELER

The first barometer in the Western Hemisphere provides new insight into the history of the barometer and the world's first measurement of atmospheric pressure within the circulation of a hurricane.



University of Maryland (College Park) Early English Newspaper Collection

An account of the effects of a hurricane on a ship that put out from Barbados on 29 August 1669 (corrected to the modern calendar) as reported in The London Gazette (see the second paragraph of the first column). This is a typical example of 17th century English newspaper reporting of tropical cyclones.

"I believe, there might be excellent use made of the Barometer for predicting of Hurricanes, and other Tempests, especially at sea; since I am credibly informed, that a person of quality, who lives by the sea-side . . . can by the Barometer almost infallibly foretell any great tempest for several hours before it begins."

This statement, from Bohun (1671) is one of the earliest suggestions in scientific literature, if not the earliest, of using the barometer for

detecting and forecasting tropical cyclones. Interest in the hurricane was partly due to the destruction of an English invasion fleet off of Guadeloupe in 1666 (London Gazette, 3 and 13 December 1666), and a spate of storms from 1666 to 1671 in New England, Virginia, Bermuda, Newfoundland, and the Lesser Antilles [London Gazette, 21 November 1667, 20 September 1669, 21 October 1669, 2 December 1669, 2 February 1670, 19 December 1670, 22 December 1670, 9 January 1671; Ludlum (1963); Teachout (1982)], which led Bohun to write of hurricanes as being ▶

1680	July	Bar	Bar	Wind	Weather in Barbados
25	9	29 $\frac{3}{4}$		E B N	Fair & calm till wind
26	9	29 $\frac{1}{2}$			light and stronger wind
27	9	29 $\frac{1}{2}$			fair & by gale wind
28	9	29 $\frac{1}{2}$		E	fair & by gale wind
29	9	29 $\frac{1}{2}$			Wind
30	9	29 $\frac{1}{2}$			Wind
31	9	29 $\frac{1}{2}$			Wind
4		29 $\frac{1}{2}$			Cloudy
<hr/>					
Aug	Bar	Bar	Wind	Weather	
1	9	29 $\frac{1}{2}$	E N E	Changeable	
2	9	29 $\frac{1}{2}$	N E	cloudy showrs & part of wind	
12	9	29	N	much rain & fair wind	
2	28	28 $\frac{1}{2}$	N W	from westward & moderate	
3	28	28 $\frac{1}{2}$	W	The same	
6	29	29		Wind violent	
8	29	29 $\frac{1}{2}$	S W	The same	
10	29	29 $\frac{1}{2}$		} much violent with lightning thunder and lightning	
1	29	29 $\frac{1}{2}$	S		
6	29	29 $\frac{1}{2}$	S E	most violent rain	
3	9	29 $\frac{1}{2}$		The storm we expect	
4	9	29 $\frac{1}{2}$	E	fair, calm, moderate with	
5	9	29 $\frac{1}{2}$		The same	
6	9	29 $\frac{1}{2}$		The same	
7	9	29 $\frac{1}{2}$		The same	
8	9	29 $\frac{1}{2}$	E B N	The same	
9	9	29 $\frac{1}{2}$	E N E	Hot & dry with wind	
10	9	29 $\frac{1}{2}$		The same	
11	9	29 $\frac{1}{2}$		The same	
12	9	29 $\frac{1}{2}$		light and calm	
13	9	29 $\frac{1}{2}$		The same	
14	9	29 $\frac{1}{2}$	N E	Some showrs with wind	



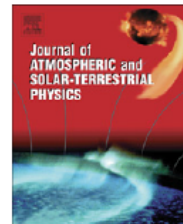


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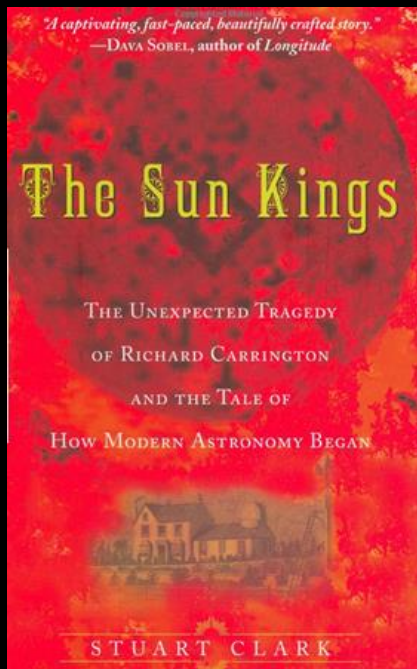
## Journal of Atmospheric and Solar-Terrestrial Physics

journal homepage: [www.elsevier.com/locate/jastp](http://www.elsevier.com/locate/jastp)



### Geomagnetic records of Carrington's storm from Guatemala

P. Ribeiro<sup>a,b,\*</sup>, J.M. Vaquero<sup>c,d</sup>, R.M. Trigo<sup>d,e</sup>



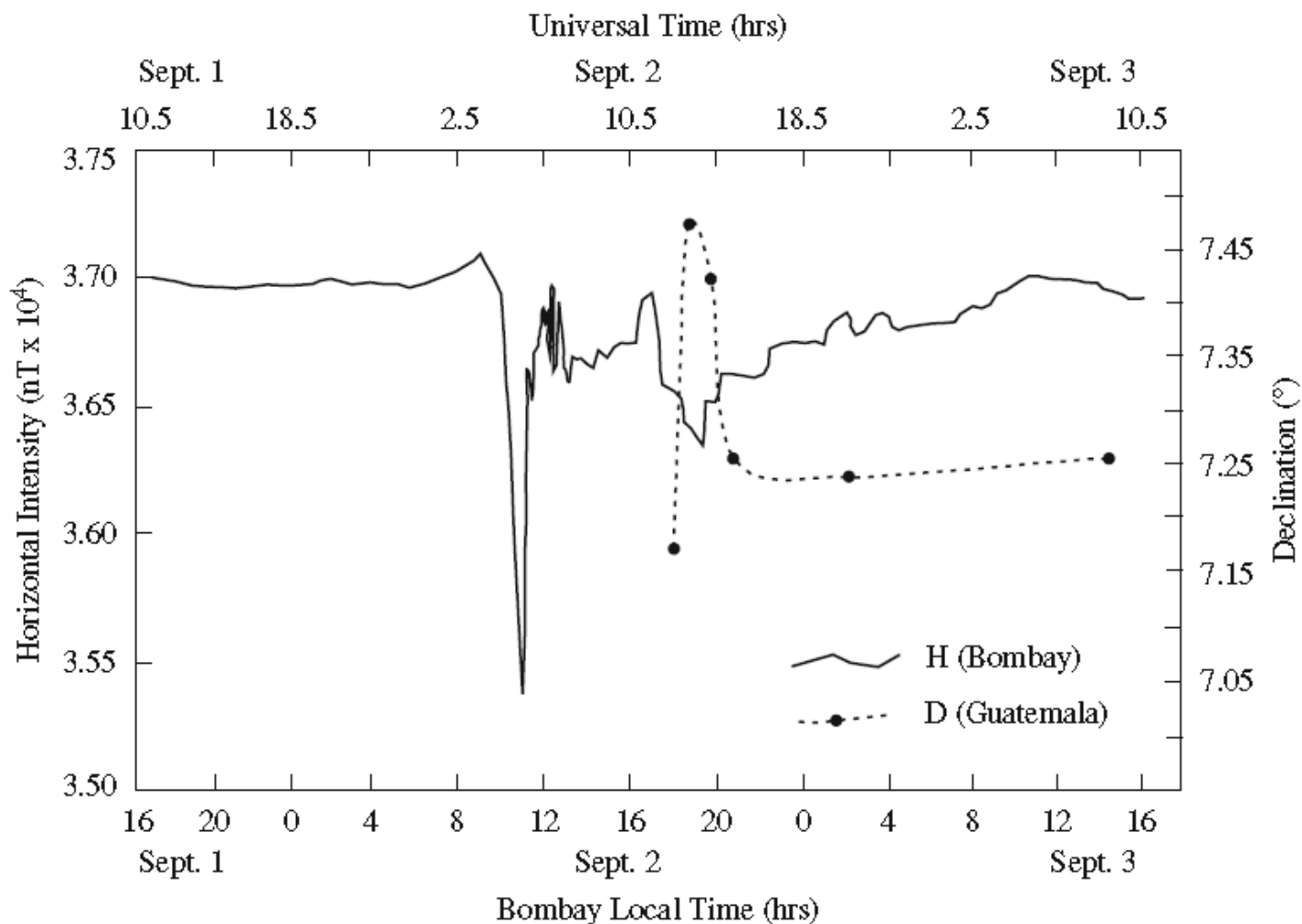
377

meno extraordinario. He aquí algunas posiciones de la aguja magnética en los días 28 de agosto y 2 de setiembre.

Agosto 28.	{	6 <sup>b</sup> mañana	7° 18' 30"	{	6 <sup>b</sup> mañana	7° 10' 6"
		6½	» 7 25 21		6½	» 7 28 47
		12	» 7 8 14		7½	» 7 25 40
		9 noche	7 24 25		8	» 7 15 42
					12	» 7 14 9
		9 noche	7 15 42			




# America





The Bombay magnetogram for the 1–2 September 1859 (adapted from Tsurutani et al., 2003) and the available declination values showing great disturbances during the second phase of Carrington's storm at the Guatemala observatory.




# The first meteorological observations at a tropical high elevation site: Antisana, 1846

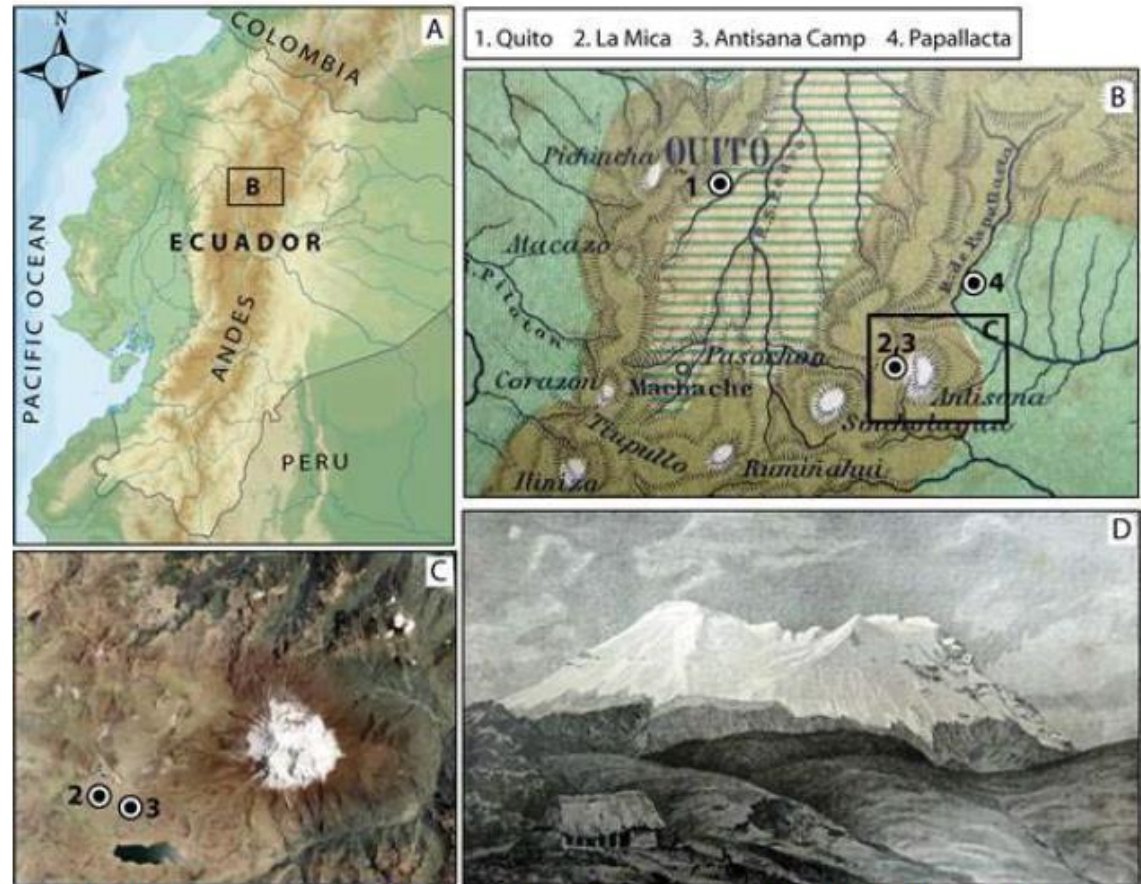
Ana M<sup>a</sup> M. FARRONA<sup>1,2</sup>  <http://orcid.org/>

Fernando DOMÍNGUEZ-CASTRO<sup>3,4</sup>  <http://orcid.org/>  
e-mail: f.dominguez.castro@gmail.com

M<sup>a</sup> Cruz GALLEGO<sup>1,5</sup>  <http://orcid.org/>

José M. VAQUERO<sup>5,6</sup>  <http://orcid.org/>

Observations by Carlos Aguirre Montúfar



**Figure 1** Study area and locations of the meteorological stations used. (A) General map of Ecuador. (B) Detail of the study area with the location of the meteorological stations (modified from Wolf 1892). (C) Aerial photo of Antisana volcano (2011). (D) Engraving of the Antisana volcano with the “Humboldt House” at the end of the 19th century from Wolf (1892).

# SCIENTIFIC DATA



OPEN

## Data Descriptor: Early meteorological records from Latin-America and the Caribbean during the 18th and 19th centuries

Received: 07 February 2017

Accepted: 05 October 2017

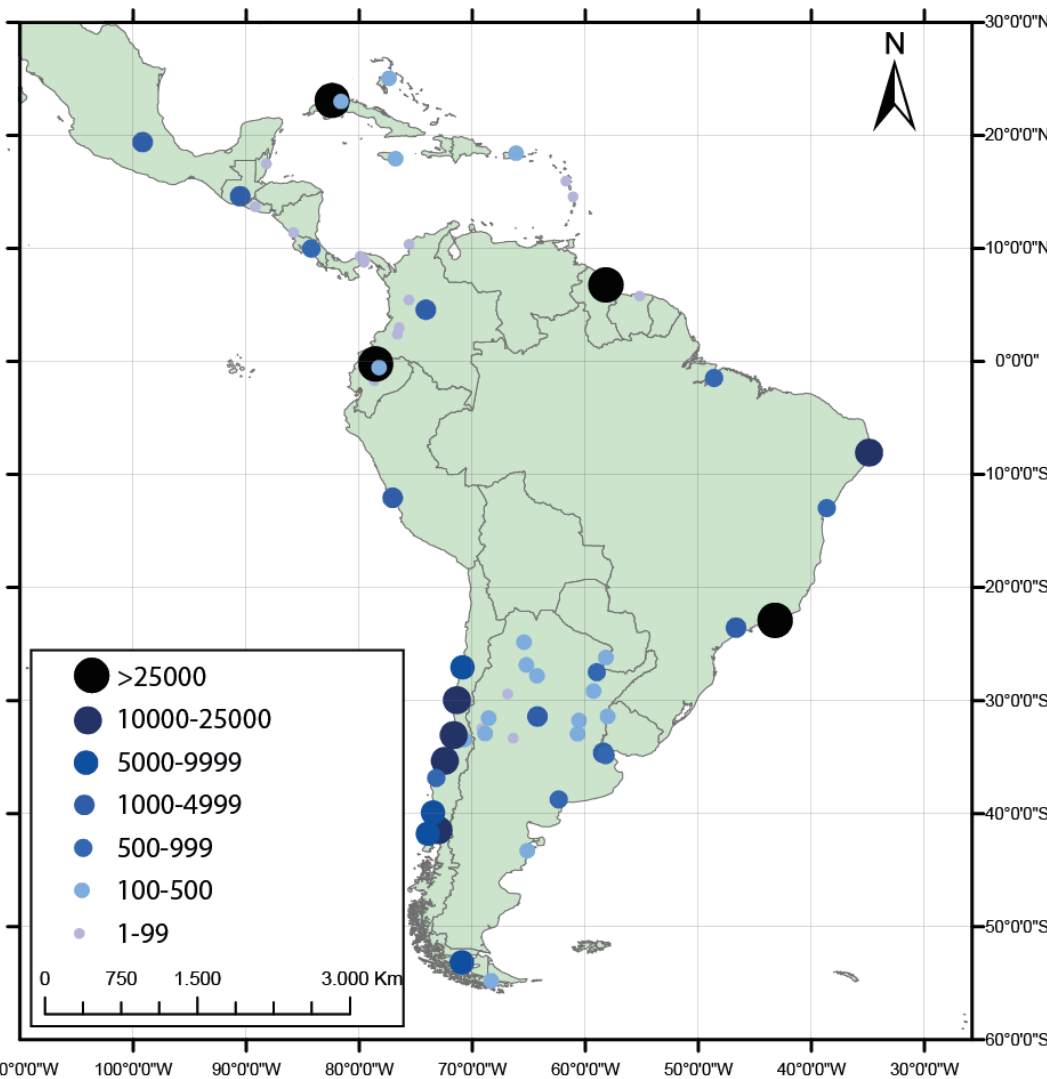
Published: 14 November 2017

Fernando Domínguez-Castro<sup>1,2</sup>, José Manuel Vaquero<sup>3,4</sup>, María Cruz Gallego<sup>3,4</sup>, Ana María Marín Farrona<sup>3</sup>, Juan Carlos Antuña-Marrero<sup>5</sup>, Erika Elizabeth Cevallos<sup>6</sup>, Ricardo García Herrera<sup>7,8</sup>, Cristina de la Guía<sup>9</sup>, Raúl David Mejía<sup>6</sup>, José Manuel Naranjo<sup>3</sup>, María del Rosario Prieto<sup>10</sup>, Luis Enrique Ramos Guadalupe<sup>11</sup>, Lizardo Seiner<sup>12</sup>, Ricardo Machado Trigo<sup>13</sup> & Marcos Villacís<sup>2</sup>

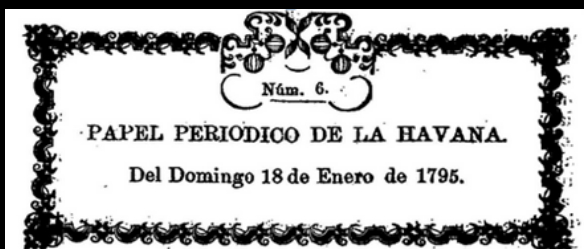
This paper provides early instrumental data recovered for 20 countries of Latin-America and the Caribbean (Argentina, Bahamas, Belize, Brazil, British Guiana, Chile, Colombia, Costa Rica, Cuba, Ecuador, France (Martinique and Guadalupe), Guatemala, Jamaica, Mexico, Nicaragua, Panama, Peru, Puerto Rico, El Salvador and Suriname) during the 18th and 19th centuries. The main meteorological variables retrieved were air temperature, atmospheric pressure, and precipitation, but other variables, such as humidity, wind direction, and state of the sky were retrieved when possible. In total, more than 300,000 early instrumental data were rescued (96% with daily resolution). Especial effort was made to document all the available metadata in order to allow further post-processing. The compilation is far from being exhaustive, but the dataset will contribute to a better understanding of climate variability in the region, and to enlarging the period of overlap between instrumental data and natural/documentary proxies.



# America



Años	Meses.	Altura del Barómetro.						
		Día	Hora	Maxima	Día	Hora	Minima	Media
1874	Agosto	2	0	762 <sup>mm</sup> 6	17	0	761 <sup>mm</sup> 0	763 <sup>mm</sup> 75
"	Septiembre	28	21	763 <sup>mm</sup> 5	10	3	760 <sup>mm</sup> 0	762 <sup>mm</sup> 87
"	Octubre	20	0	765 <sup>mm</sup> 0	27	0	761 <sup>mm</sup> 0	765 <sup>mm</sup> 29
"	Noviembre	27	0	767 <sup>mm</sup> 0	9	3	761 <sup>mm</sup> 0	764 <sup>mm</sup> 50
"	Diciembre	28	21	767 <sup>mm</sup> 5	21	3	765 <sup>mm</sup> 0	765 <sup>mm</sup> 45
1875	Enero	8	21	768 <sup>mm</sup> 0	29	0	765 <sup>mm</sup> 0	767 <sup>mm</sup> 03
"	Febrero.	5	0	769 <sup>mm</sup> 0	15	0	766 <sup>mm</sup> 0	767 <sup>mm</sup> 68
"	Marzo	3	0	769 <sup>mm</sup> 0	15	0	765 <sup>mm</sup> 0	766 <sup>mm</sup> 77
"	Abril	26	0	768 <sup>mm</sup> 0	22	3	765 <sup>mm</sup> 0	765 <sup>mm</sup> 53
"	Mayo	1	21	768 <sup>mm</sup> 0	31	3	764 <sup>mm</sup> 0	765 <sup>mm</sup> 77
"	Junio	20	0	768 <sup>mm</sup> 0	11	0	764 <sup>mm</sup> 0	766 <sup>mm</sup> 66
"	Julio.	20	0	769 <sup>mm</sup> 0	20.	3	764 <sup>mm</sup> 0	766 <sup>mm</sup> 70



Observaciones meteorológicas.										
Enero 96.	Termómetro.			Barómetro.			Vientos		Meteoros.	
	Mañ. & las 7	Tard. & las 12	Noch. & las 10	Mañ. & las 7	Tard. & las 12	Noch. & las 10	mañ.	tard.		
	Grad.	Grad.	Grad.	Pi. Ls.	Pi. Ls.	Pi. Ls.				
10	20	20	18	27 10	27 10	28	NO	N	D.n.yll.p.l.m	
11	19	20	20	28	27 11	27 11	NE	NE	D.n.l.t.s.dia	
12	20	20	19	28	27 11	27 11	ESE	E	Ll.p.l.m.d.yt	
13	19	20	19	27 11	27 11	27 11	ESE	E	Dia cl. opa n.	
14	19	20	19	27 11	27 10	27 10	S	SE	Dia cl. con v.	
15	19	21	20	27 10	27 10	27 10	S	SE	Dia cl. con n.	
16	20	21	20	27 10	27 9	27 10	S	S	Dia cl. con n.	

## Data Citation

I. Domínguez-Castro, F. et al. PANGAEA <https://doi.org/10.1594/PANGAEA.871480> (2017).

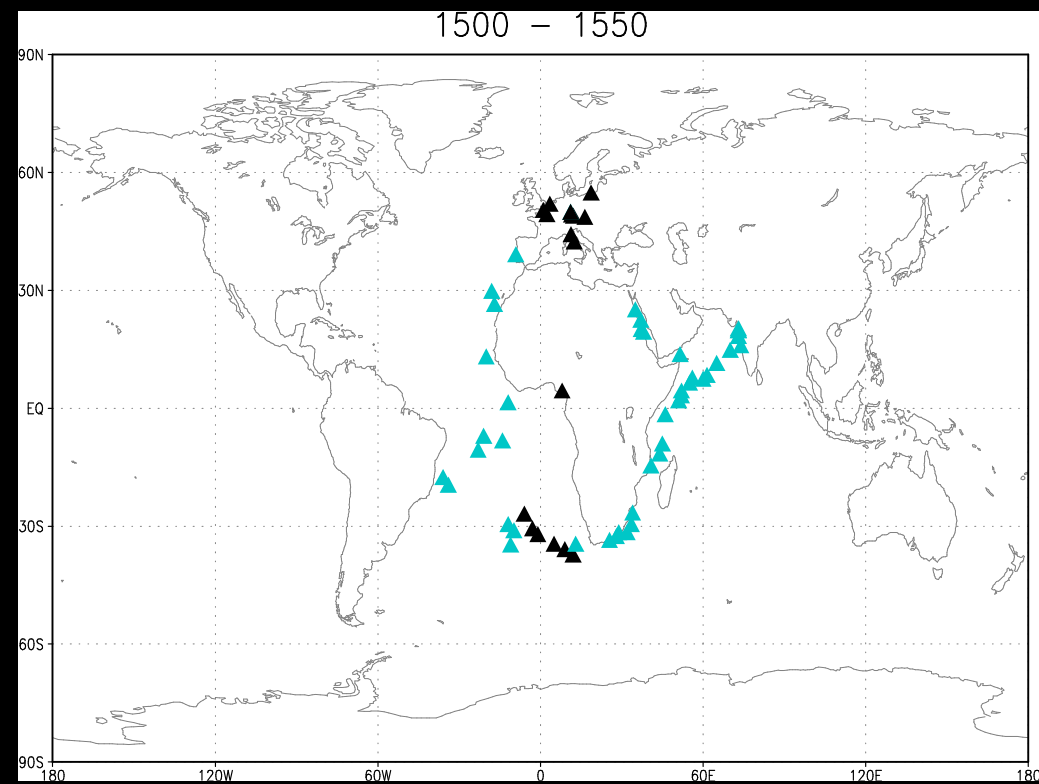


# Africa

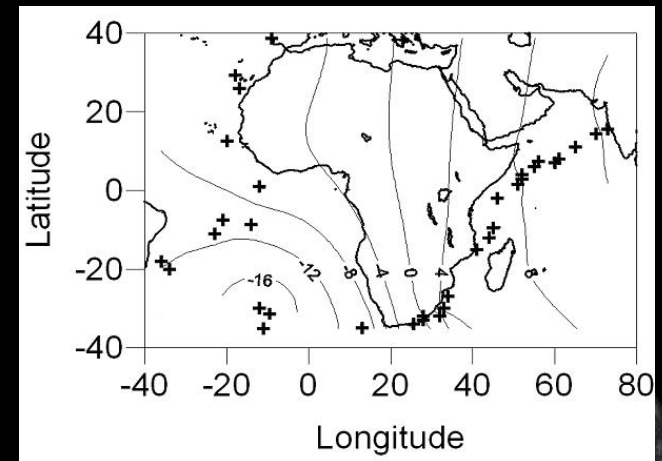




# Africa



Trigo and Vaquero (2008) "D João de Castro: An unsung hero" *Astronomy & Geophysics* 49, 2.14-2.16.

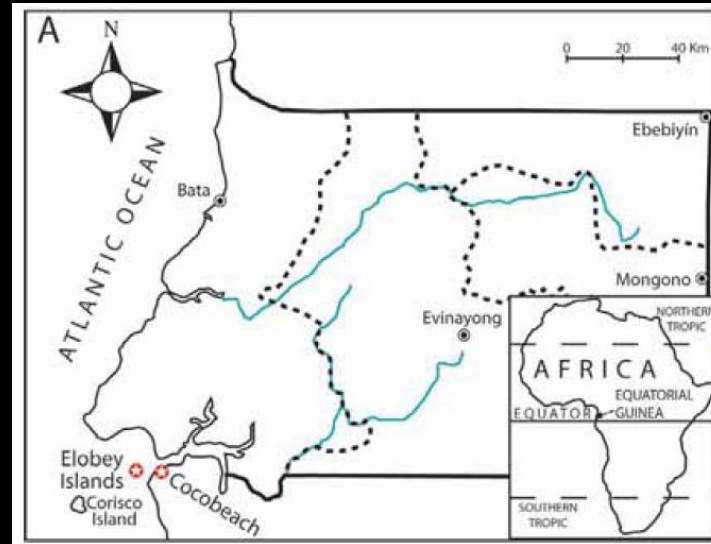


# THE HIDDEN ROLE OF WOMEN IN MONITORING NINETEENTH- CENTURY AFRICAN WEATHER

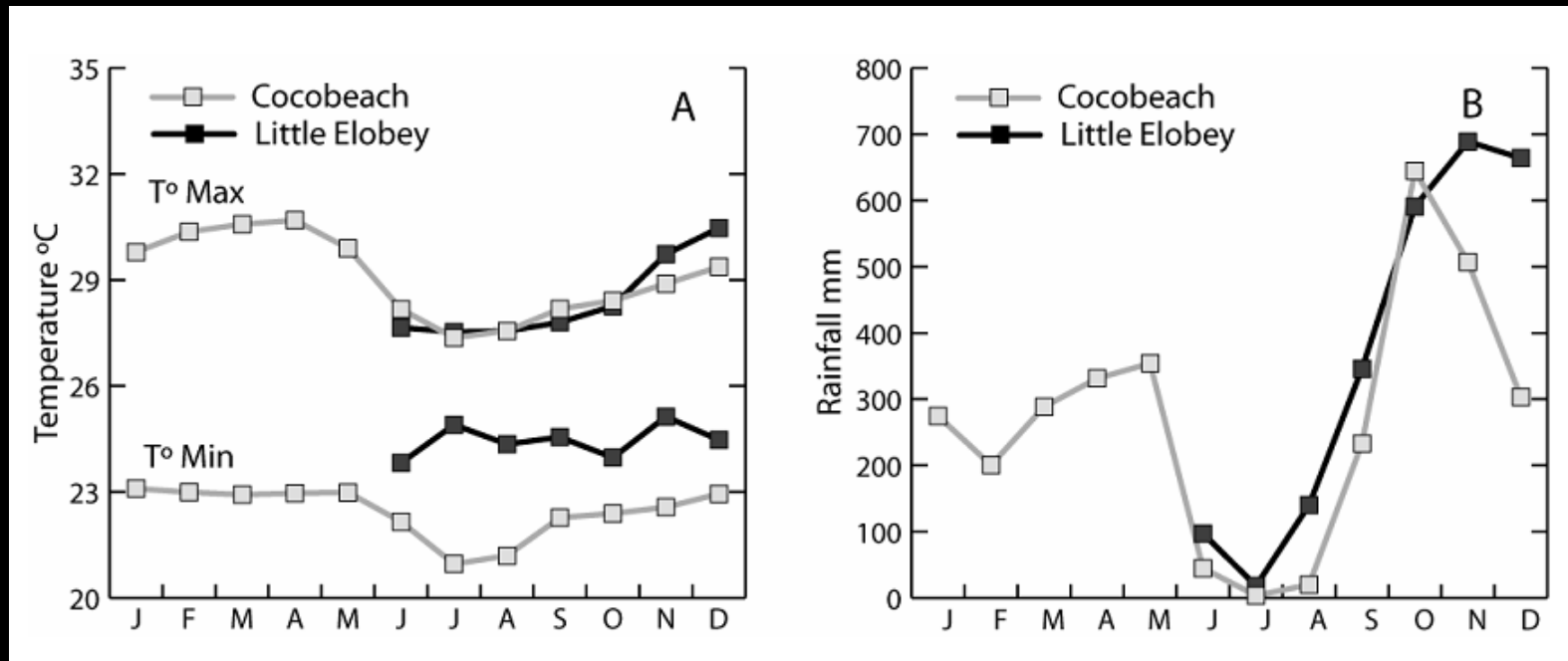
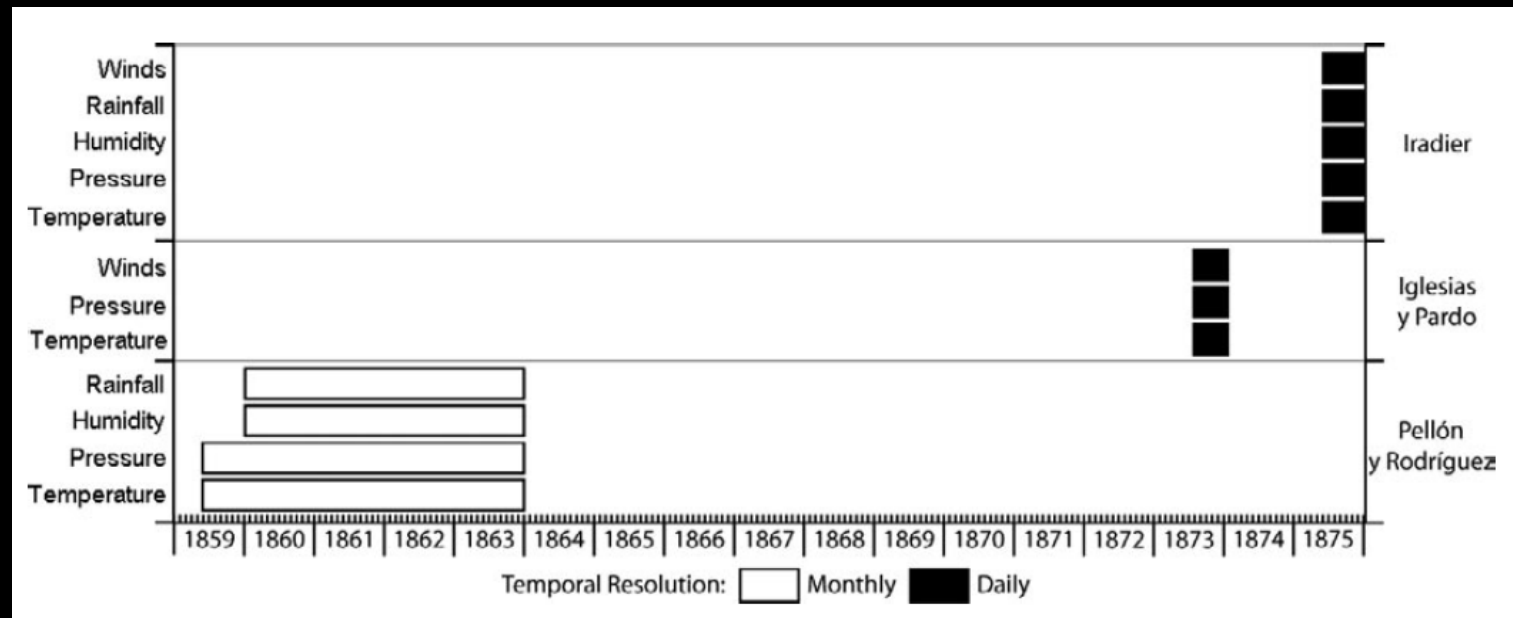
Instrumental Observations in Equatorial Guinea

BY M. CRUZ GALLEGO, FERNANDO DOMÍNGUEZ-CASTRO, JOSÉ M. VAQUERO, AND RICARDO GARCÍA-HERRERA

Bull. Am.  
Met. Soc  
(2011)



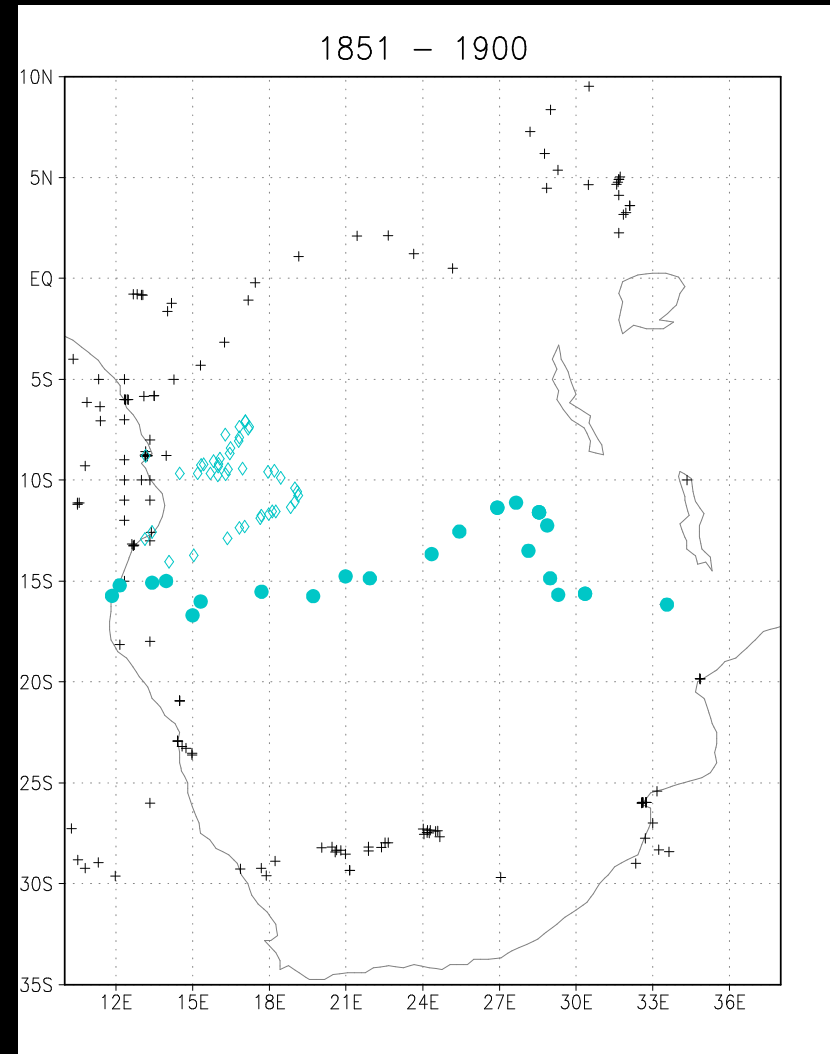
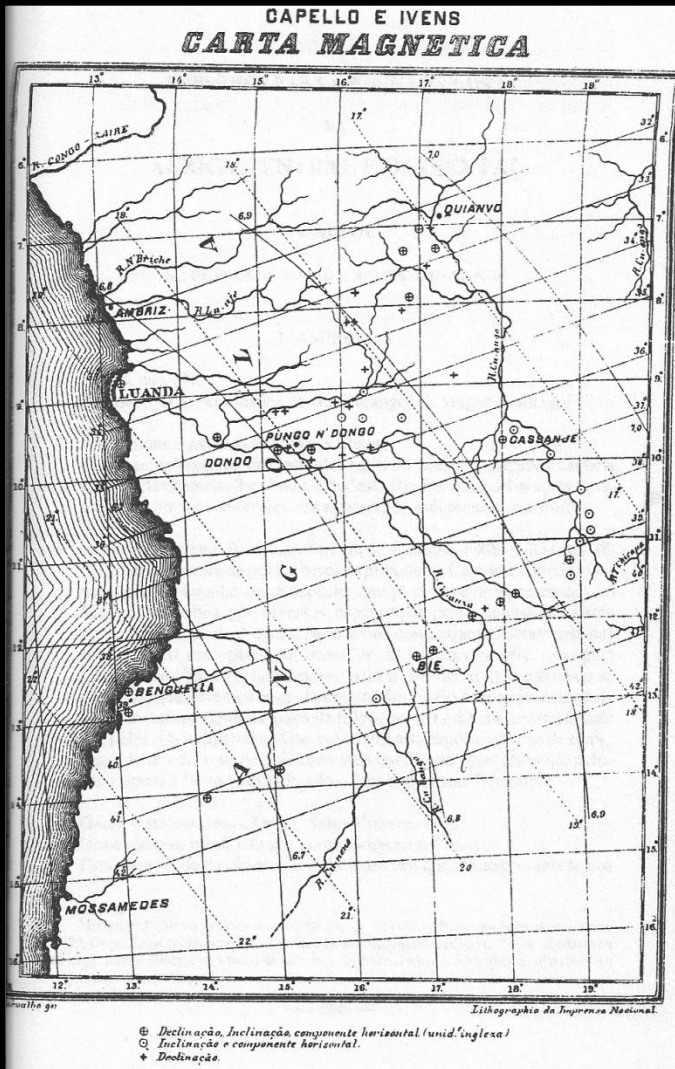
# Africa



(a) Maximum and minimum monthly mean temperature from Cocobeach (1950-1980) and Little Elobey (June to December 1875). (b) Monthly rainfall for the same periods and stations.



# Africa



Vaquero and Trigo (2006) "Results of Geomagnetic Observations in Central Africa by Portuguese Explorers during 1877-1885" *Physics of the Earth and Planetary Interiors* **157**, 8-15.



# Asia



# Early meteorological records of Manila: El Niño episode of 1864

J. M. VAQUERO

*Departamento de Física, Escuela Politécnica, Universidad de Extremadura,  
Cáceres, España*

Corresponding author's e-mail: [jvaquero@unex.es](mailto:jvaquero@unex.es)

M. C. GALLEGO and J. A. GARCÍA

*Departamento de Física, Universidad de Extremadura,  
Badajoz, España*

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demia sabe que Mr. de Verguetle-Lumotte habia ya empleado con mucho éxito el frio y la congelacion para la mejora de los vinos, y me felicito en ver que su comunicacion de hoy asegura en cierto modo las esperanzas que fundo en el procedimiento que he tenido el honor de comunicar con esta ocasion à la Academia.

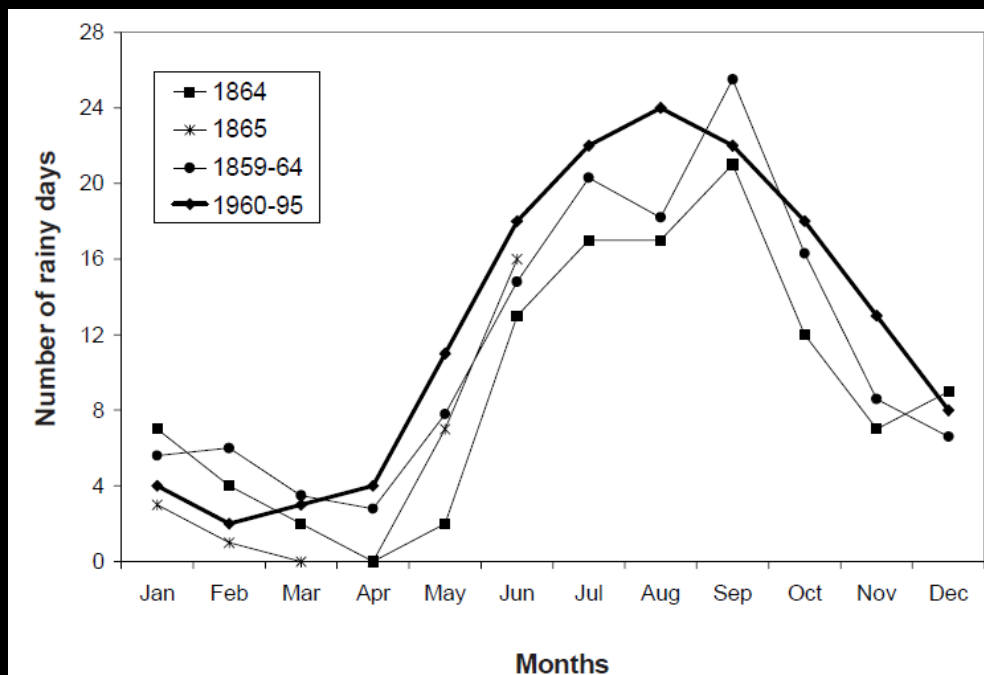
## METEOROLOGIA.

Nuestro ilustrado corresponsal de Manila el P. Fr. Antonio Llanos ha remitido las observaciones que insertamos à continuacion.

*Observaciones meteorológicas verificadas en la torre del telégrafo de Manila en todo el año 1864.*

## PLUVIÓMETRO.

MESES.	Número de días en que ha llovido.	Cantidad de agua recogida.
Enero.....	7	0,081
Febrero.....	4	0,009
Marzo.....	2	0,004
Abril.....	0	0,000
Mayo.....	2	0,016
Junio.....	13	0,151
Julio.....	17	0,347
Agosto.....	17	0,280



# Europe





## Early Portuguese meteorological measurements (18th century)

M. J. Alcoforado<sup>1</sup>, J. M. Vaquero<sup>2,3</sup>, R. M. Trigo<sup>3,4</sup>, and J. P. Taborda<sup>5</sup>

INTERNATIONAL JOURNAL OF CLIMATOLOGY  
*Int. J. Climatol.* (2013)  
Published online in Wiley Online Library  
(wileyonlinelibrary.com) DOI: 10.1002/joc.3709



## Early Spanish meteorological records (1780–1850)

F. Domínguez-Castro,<sup>a\*</sup> J. M. Vaquero,<sup>a</sup> F. S. Rodrigo,<sup>b</sup> A. M. M. Farrona,<sup>c</sup> M. C. Gallego,<sup>a</sup>  
R. García-Herrera,<sup>c,d</sup> M. Barriendos<sup>e,f</sup> and A. Sanchez-Lorenzo<sup>g,h</sup>


Geoscience Data Journal

Open Access



DATA PAPER |  Open Access |  

## Recovery of early meteorological records from Extremadura region (SW Iberia): The ‘CliPastExtrem’ (v1.0) database

José M. Vaquero , Nieves Bravo-Paredes, María Angeles Obregón, Víctor M. S. Carrasco, María Antonia Valente, Ricardo M. Trigo, Fernando Domínguez-Castro ... [See all authors](#) ▾





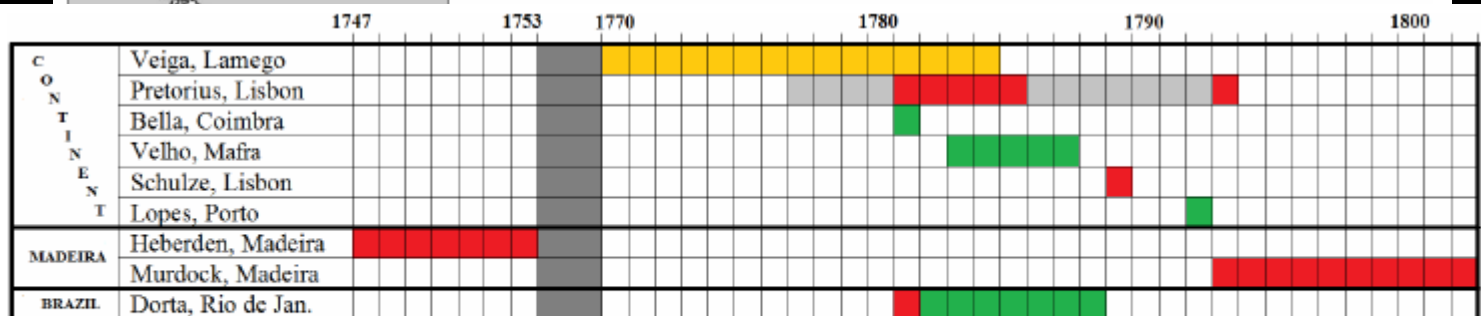
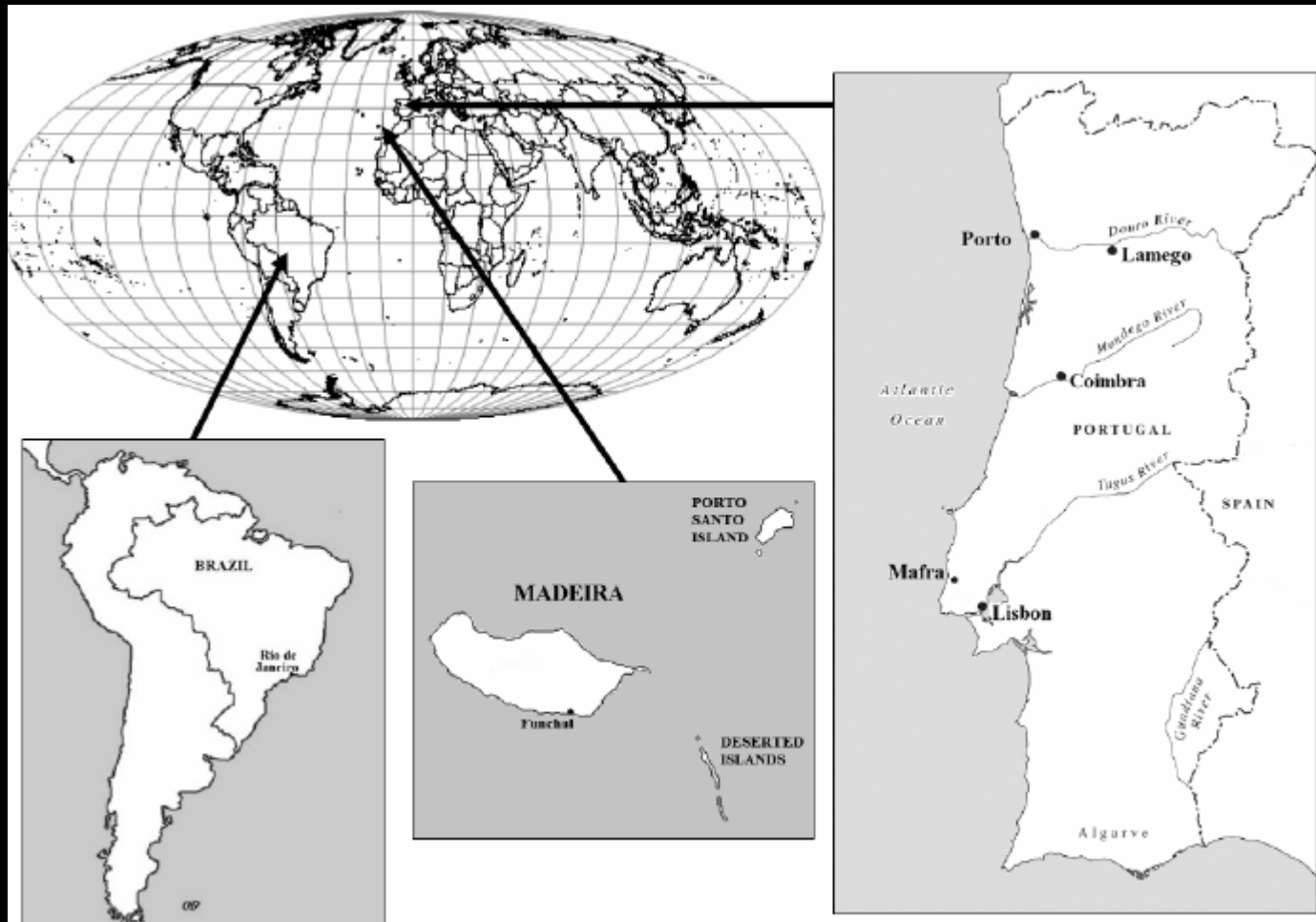
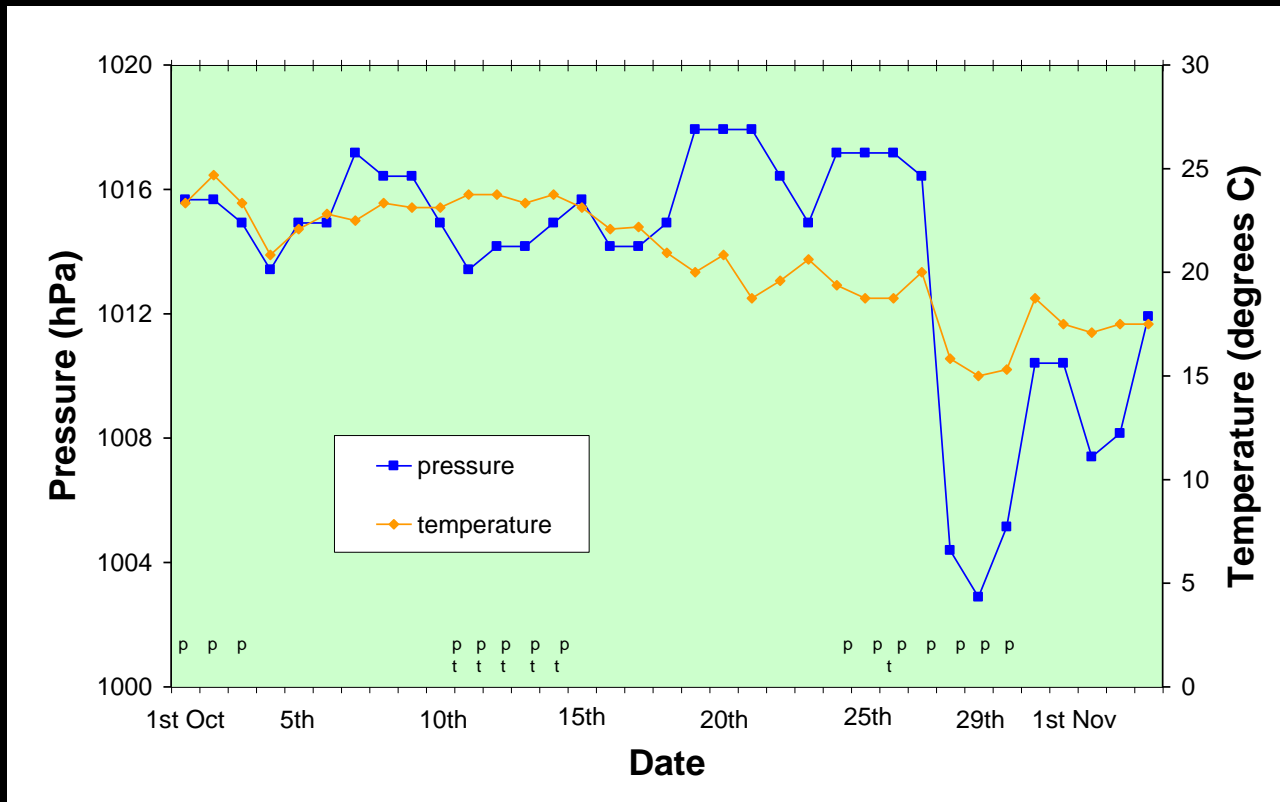


Fig. 2. Meteorological data availability in Portugal and overseas during the 18th century (yellow: annual data; red: monthly data; green: daily data; grey: lost data).

## A HISTORICAL ANALOG OF 2005 HURRICANE VINCE

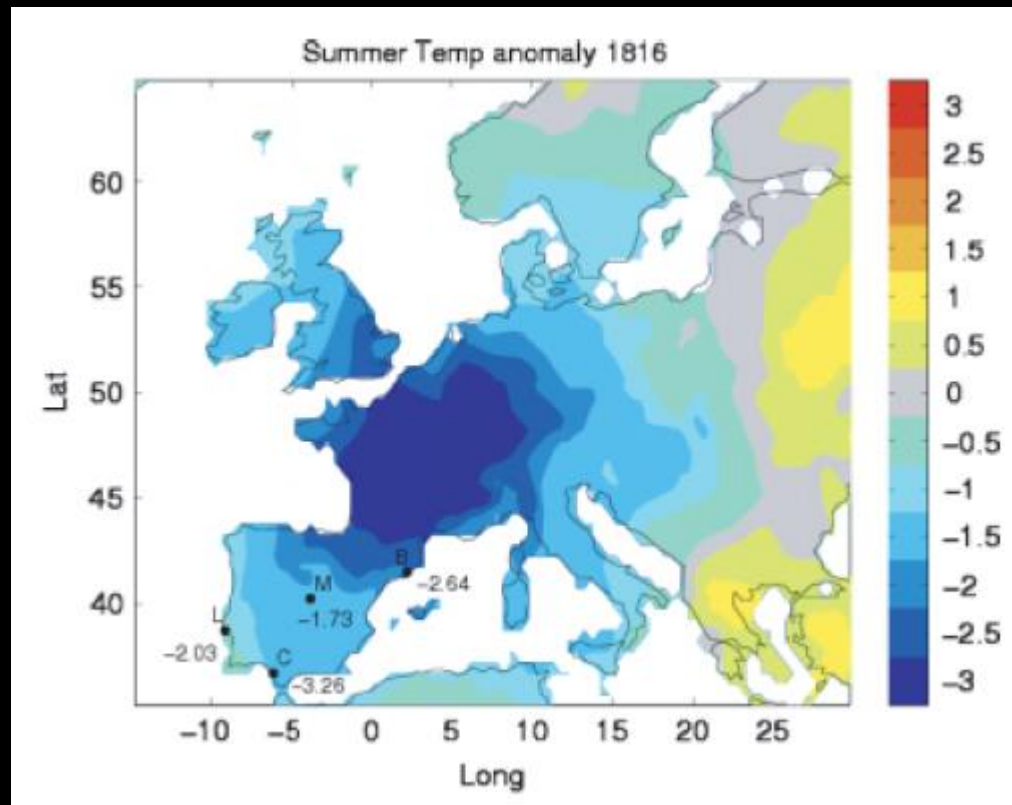
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## Iberia in 1816, the year without a summer

Ricardo M. Trigo,<sup>a,b\*</sup> José M. Vaquero,<sup>c</sup> Maria-João Alcoforado,<sup>d</sup> Mariano Barriendos,<sup>e</sup>  
João Taborda,<sup>f</sup> Ricardo García-Herrera<sup>g</sup> and Juerg Luterbacher<sup>h,i</sup>



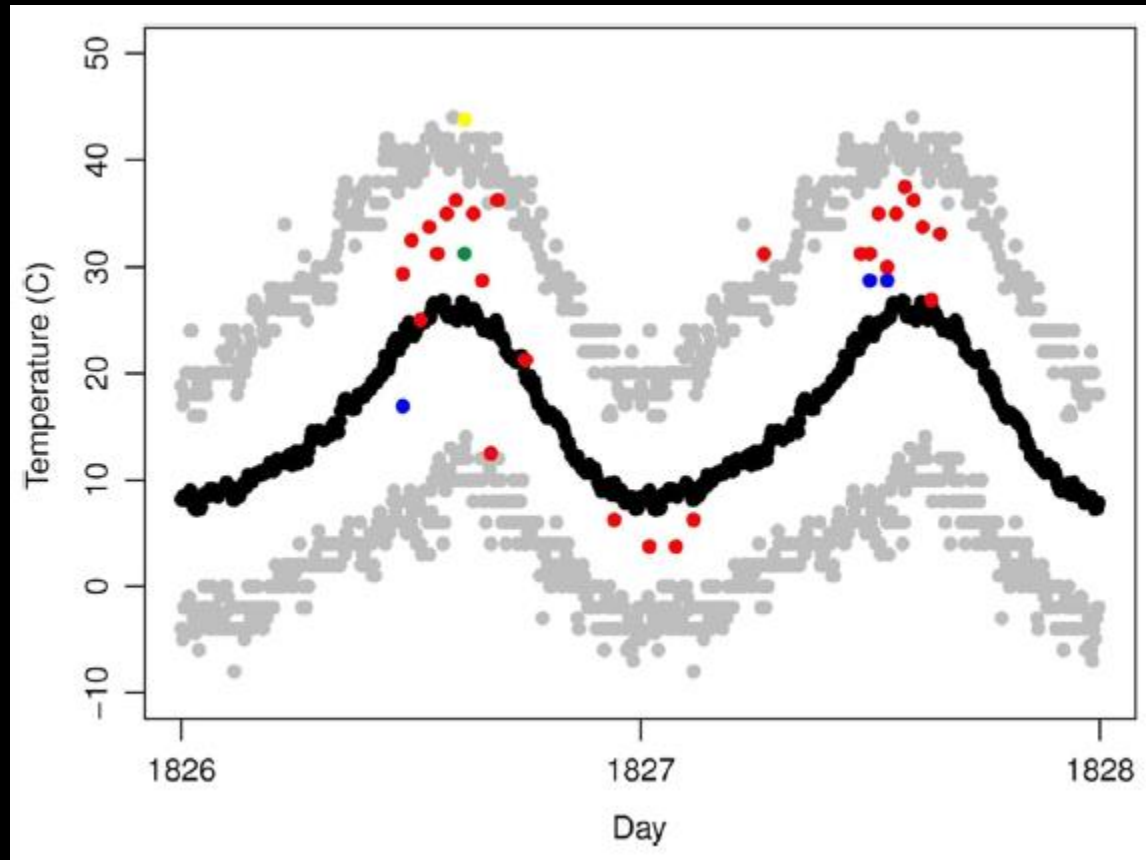
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Not only pressure and temperature...

## An early clear sky record from Eastern Spain: 1837–1879

Benjamin A. Laken<sup>a,b\*</sup> and José M. Vaquero<sup>c</sup>

Global and Planetary Change 115 (2014) 71–75

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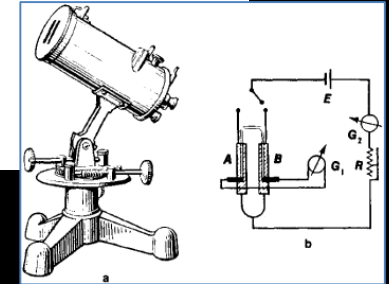
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Short communication

The controversial early brightening in the first half of 20th century: A contribution from pyrheliometer measurements in Madrid (Spain)

M. Antón\*, J.M. Vaquero, A.J.P. Aparicio



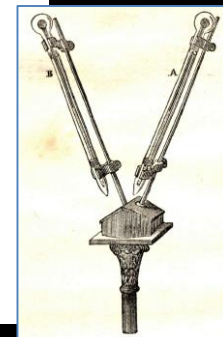
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SERIES B  
CHEMICAL  
AND PHYSICAL  
METEOROLOGY

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## Analysis of actinometric measurements under all-sky and cloud-free conditions in Cáceres (Spain) for the period 1913–1920

By NIEVES BRAVO-PAREDES<sup>1</sup>, MARÍA CRUZ GALLEG<sup>1</sup>, MANUEL ANTÓN<sup>1</sup>, MARCELINO NÚÑEZ<sup>1,2</sup>, and JOSÉ MANUEL VAQUERO<sup>3\*</sup>, <sup>1</sup>Departamento de Física, Facultad de Ciencias, Universidad de Extremadura, Badajoz, Spain; <sup>2</sup>Agencia Estatal de Meteorología, Badajoz, Spain; <sup>3</sup>Departamento de Física, Centro Universitario de Mérida, Universidad de Extremadura, Mérida, Spain





## Main conclusions

*Theories and hypotheses* about Sun-Climate relationships have been constrained by the *available data* and, therefore, the data recovery is a critical task for our community.

Surprisingly, *my personal experience* indicates that you always find data of great interest when you visit a *historical library or archive*.



***Thank you  
very much!***

**Comments,  
suggestions, etc.:**

**[jvaquero@unex.es](mailto:jvaquero@unex.es)**

