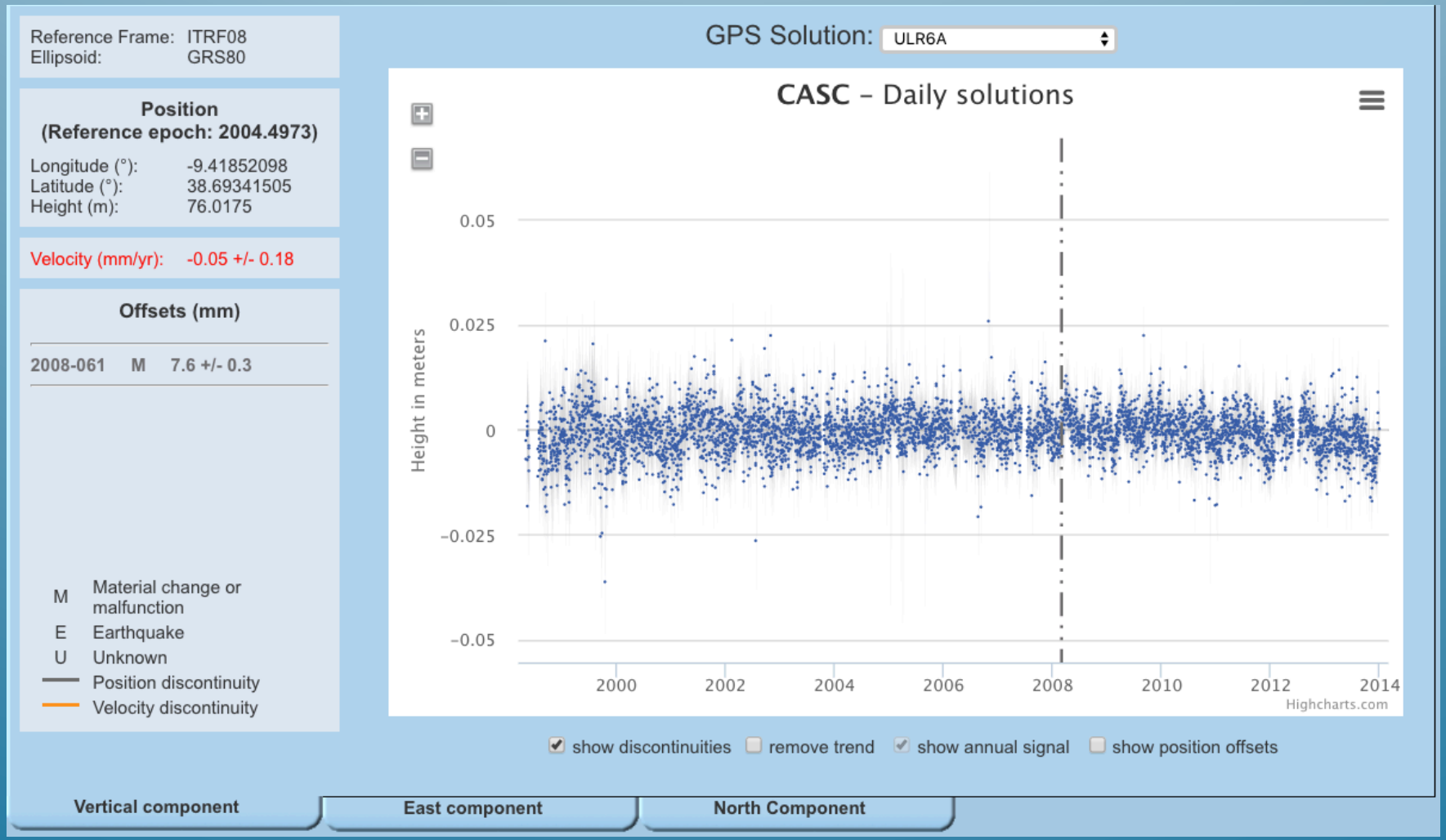
easonal signal removed
nverse barometric correction applied
elative vertical velocity of site corrected

o find this 4 mm It was used an “uplift” of 0,5mm/yr.

But this uplift doesn't exist.

GPS Cascais: vertical velocity=-0,05+/-0,18mm/yr



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sing the 100 year sea level record of Leixões, Portugal

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sea level

S U M M A R Y

A new data set from the tide gauge at Leixões (North–West Portugal) has recently been transferred from its paper format into a digital time series of hourly sea level values. By measuring sea level variations since 1890, this tide gauge station is one of the few in the world with over 100 yr of digitised hourly records and the longest for the South West of Europe and Iberian Peninsula. This paper presents the procedures adopted to recover the Leixões sea level data from paper chart records as well as the data quality control and data editing methodologies. The mean rate of sea level change between 1906 and 2008 is -0.70 ± 0.27 mm yr^{-1}, which does not agree with the global mean sea level rise of 1–2 mm yr^{-1}. No evidence for vertical land movement was found and Global Isostatic Adjustment influence on sea level, at this location, can be neglected. It is likely that prevailing weather systems in the North Atlantic, especially in the winter, and local atmospheric pressure, influence sea levels at Leixões. A further contribution is found from tides and surges. The evolution of the port cannot be ignored when trying to understand sea level change.

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uction

nderstanding of sea level changes has in the past decade renewed interest in view of climate change research. f historical sea levels to estimate local and global sea level has been invaluable (e.g. Holgate, 2007; Church and 011). As Colosi and Munk (2006) have pointed out, there natural variability in sea level which makes it necessary ery long time-series to detect secular changes.

vel observations have a relatively long history dating back te 17th Century (Woodworth et al., 2011; Wöppelmann 06). Along the European Atlantic coast, examples of such are Brest (Wöppelmann et al., 2006), Amsterdam (van 54), Liverpool (Woodworth, 1999), Stockholm (Ekman, d Cadiz (Marcos et al., 2011), for which datasets date back 1682, 1768, 1774 and 1880, respectively (c.f. Marcos et al. r a summary of long-term records).

of these also have the longest 'continuous' hourly readstered through an automatic recording device composed n attached to a float by a system of wires and counter-The float-gauge system in a stilling well enables a tidal be drawn on a paper chart placed around the drum. It ap- the 1st half of the 19th Century and was still the domi- gauge technology into the 20th Century.

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Until recently, the longest sea level record for South-West Europe has been that of Cascais (Antunes and Taborda, 2009), in Portugal (38° 41′38.8″N; 9°25′5.4″W), for which monthly mean sea levels exist since 1882 and hourly digitized levels only since 1960. Other Spanish and Portuguese hourly sea level data, prior to the 60s, are likely to exist in paper format, nevertheless their digitisation has not been made.

The Leixões Port authority recently brought to our attention that there were additional long-term sea level records that can be added to that of Cascais, namely Cantareira in the Douro River (41°8′47″N; 8°40′0″W) and Leixões (41°11′12″N; 8°42′17″W), approximately 5 km North of Cantareira (Fig. 1). This led to the digitization of the Leixões sea level observations that will be discussed herein. The first records date back to 1890, making this series the longest hourly-digitized record in the country and Iberian Peninsula. The objective of this paper is to present this data set and to investigate if it can be used to study secular sea level changes in the region.

This paper starts by giving an overview of the Port of Leixões, its history and its tide gauges. This is followed by a description of the dataset that was digitized and the methodology used in the recovery of the records, which includes the data quality check (editing). Finally, we present the results and first interpretation of this record.

2. Historical background

2.1. Evolution of the Leixões Port

The Port of Leixões is located on the northern Portuguese coast approximately 5 km north of the Douro River mouth. The port

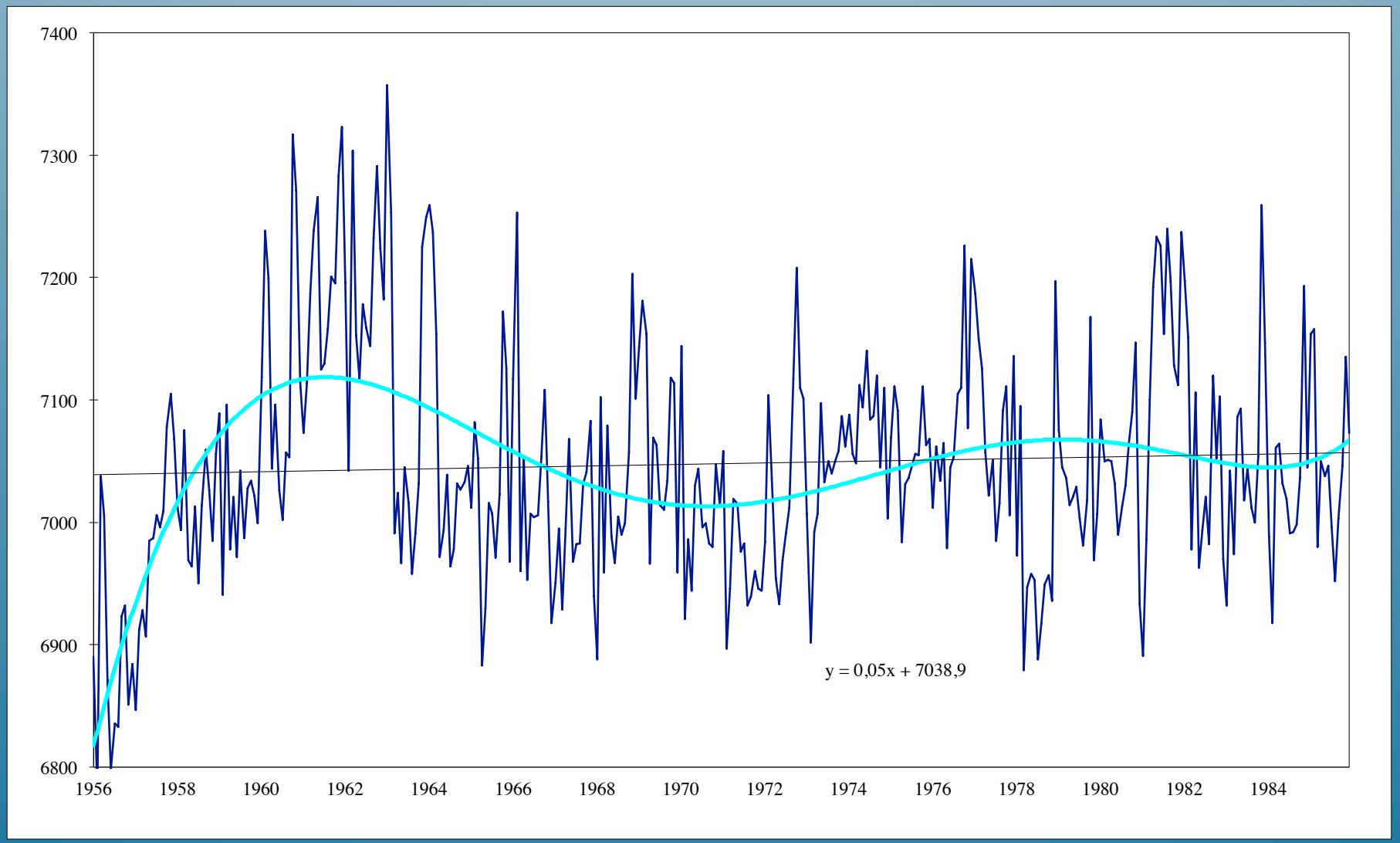
Leixões: one of the longest series

The mean rate of sea level change between 1906 and 2008 is **-0.70 ± 0.27 mm yr.**

Sea level has decreased!

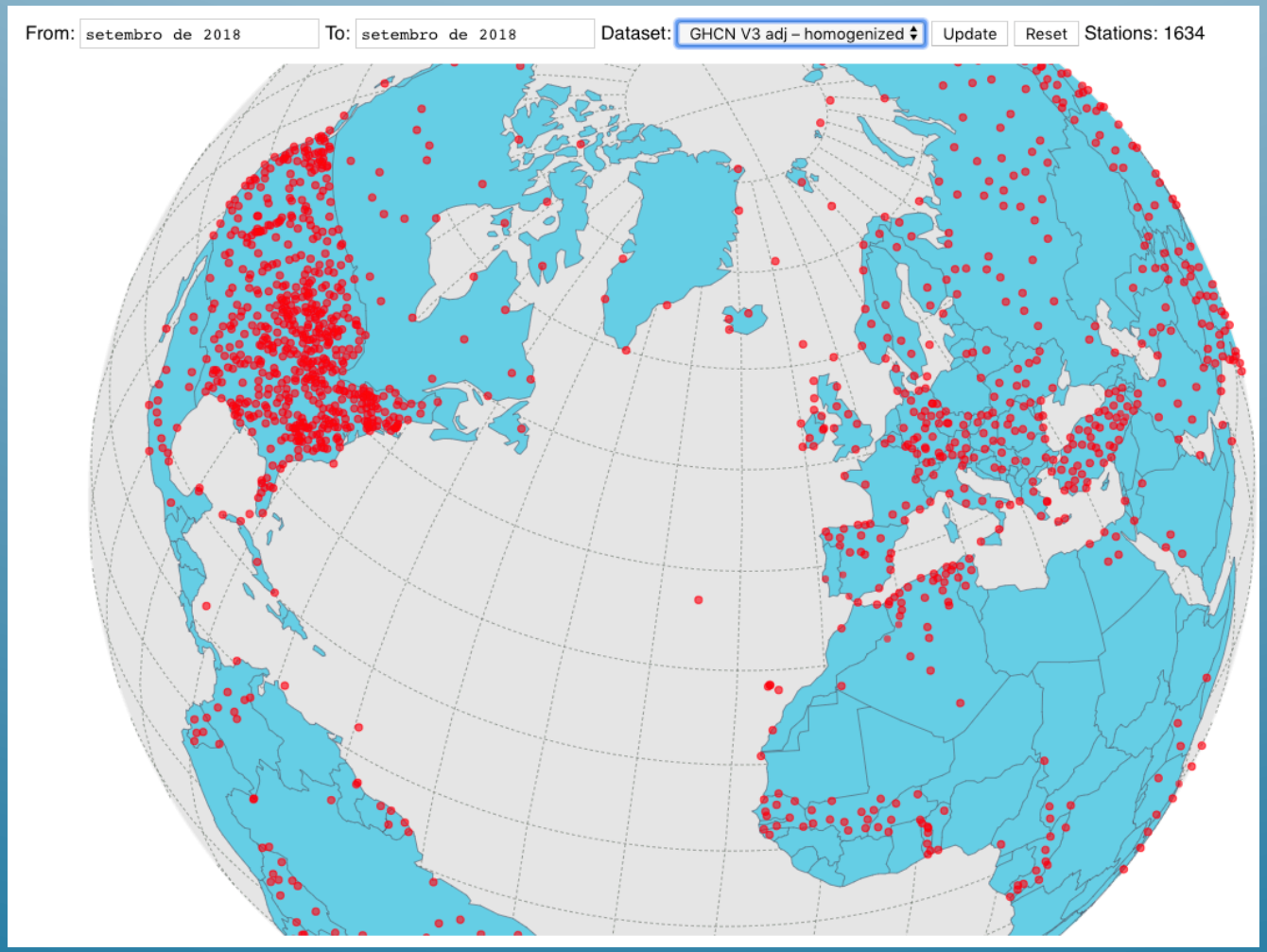
Relative MSL over the period of 1906–2008 has decreased an average rate of 0.70 mm yr^{-1} ±0.27 mm yr^{-1}. This result co tradicts both global and regional MSL estimates. Negative rat in MSL have only been reported in Northern Europe (Scandin via) where Glacial Isotactic Adjustment (GIA) are responsib for the vertical component of land movement which in turn fect MSL.

Sea level variation at Leixões (PSMSL)
The available data could indiciate that...

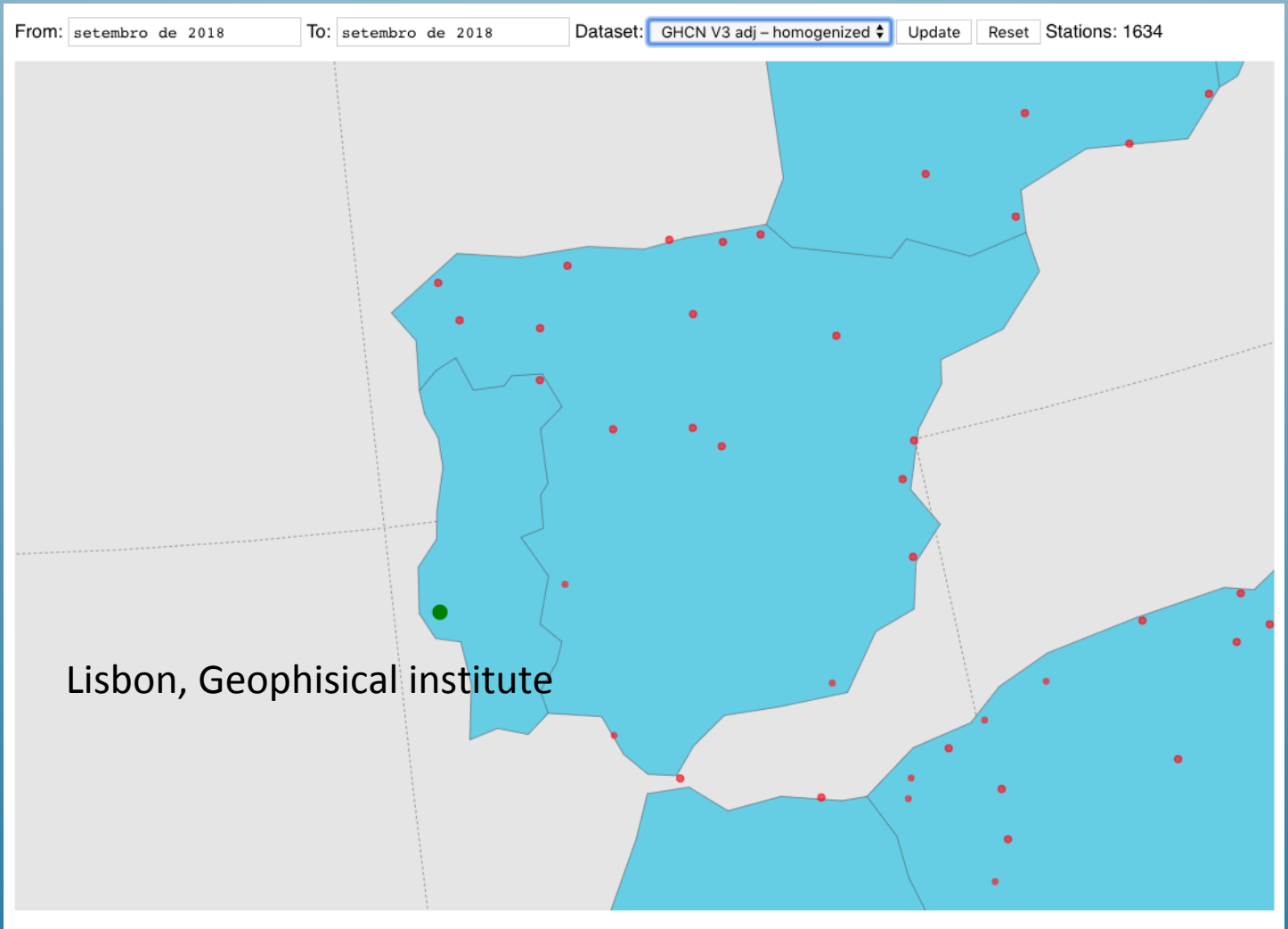


No rising sea level at Porto area! It maybe uplifting!

NASA climate data: a new presentation of https://data.giss.nasa.gov/gistemp/stdata/

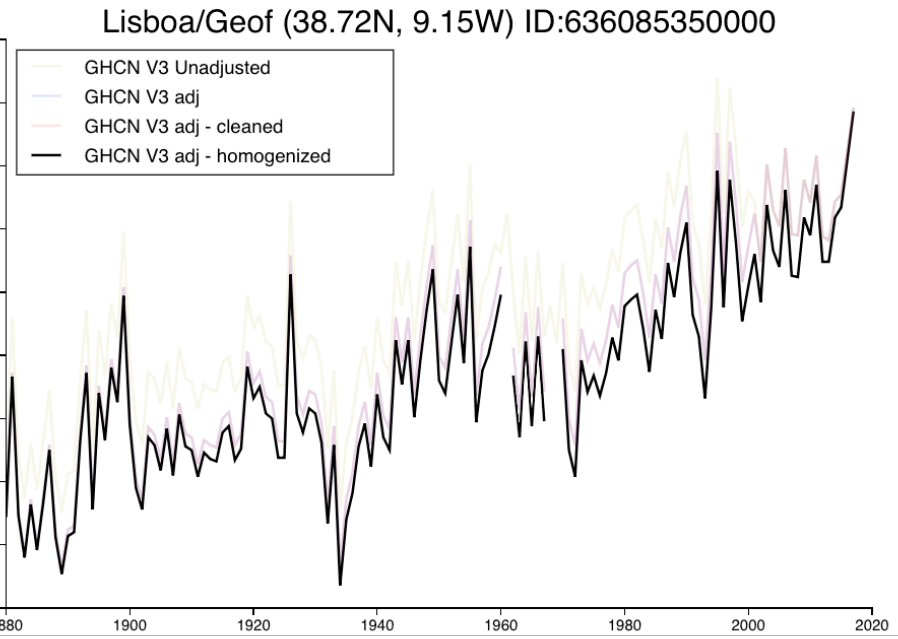


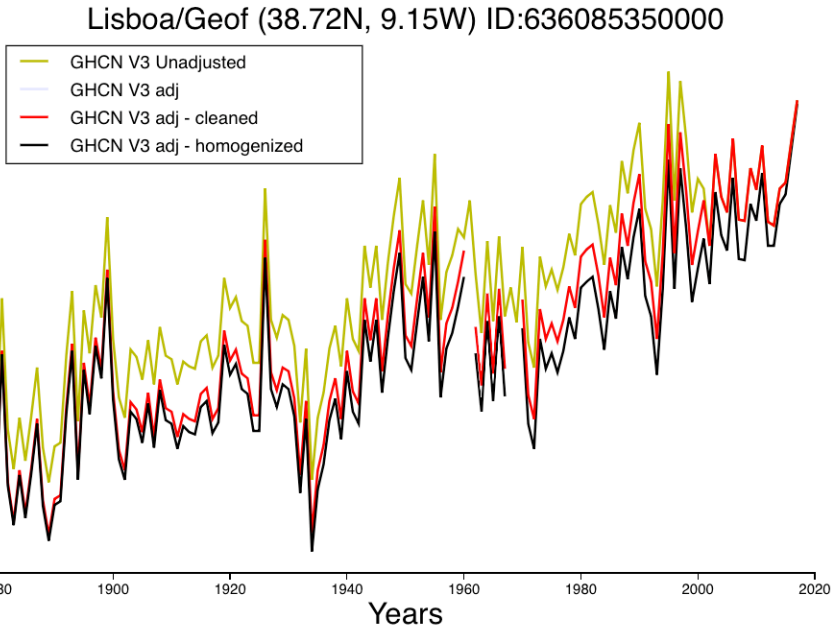
Iberia climate stations



Temperature Analysis

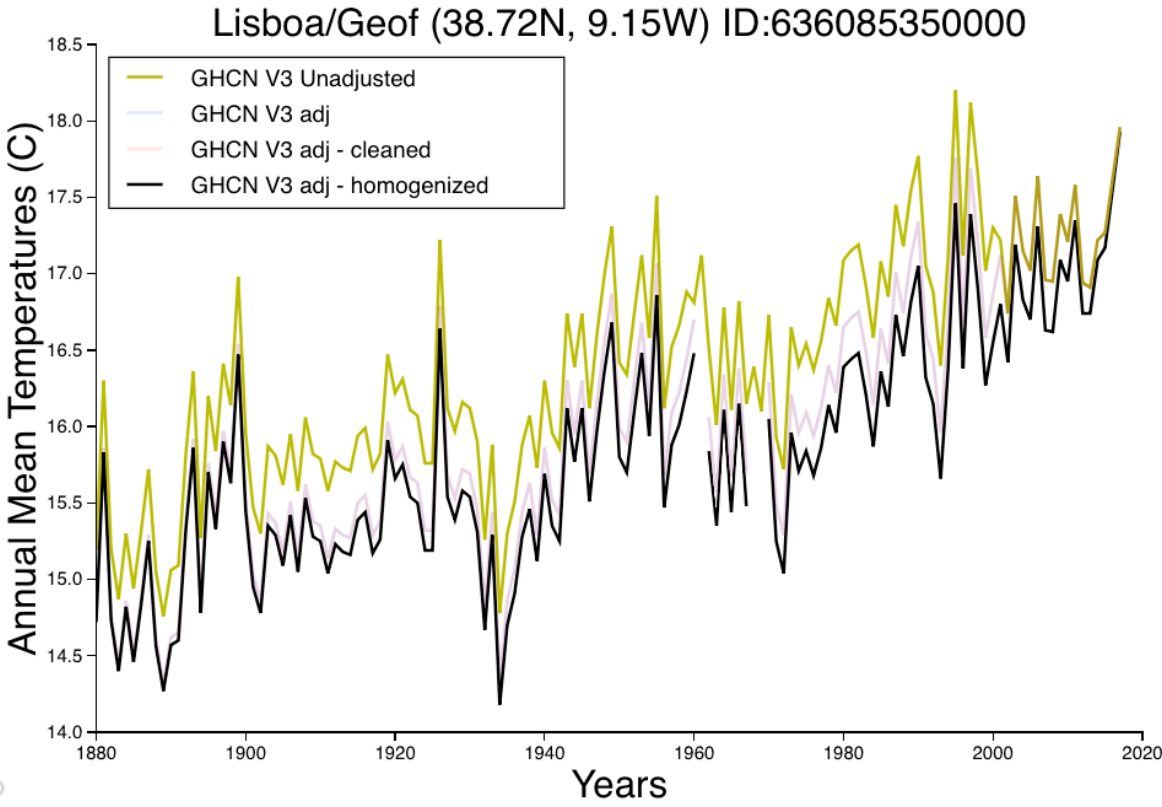
sboa/Geof (38.72N, 9.15W)





GISS Surface Temperature Analysis

Station Data: Lisboa/Geof (38.72N, 9.15W)



The “adjustments”: the hig
temperatures in the recen
past (1998) were discarde

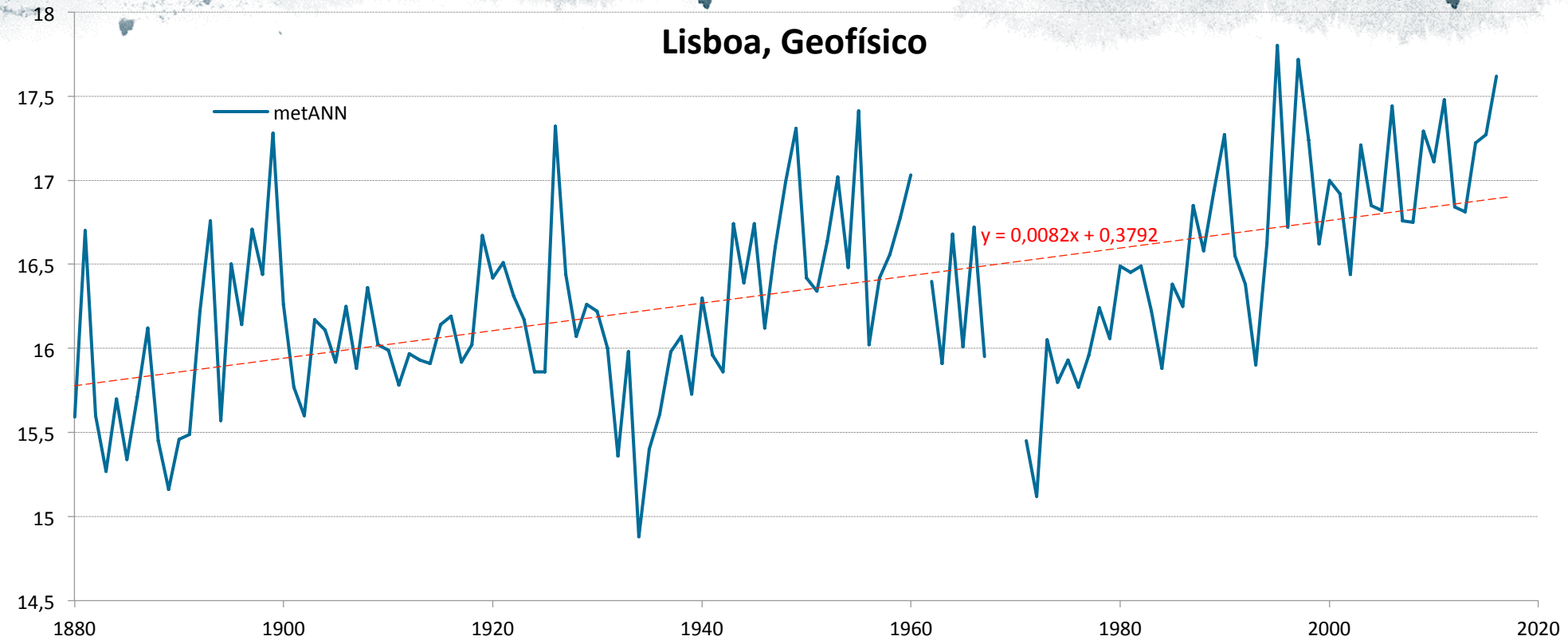
No more uncorrected data!!!
They are homogenized!

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	D-J-F	M-A-M	J-J-A	S-O-N	metANN
1880	9,6	12,4	14	13,5	16,1	17,4	19,5	21	21,1	18,3	12,9	11,5	11,1	14,5	19,3	17,4	15,59
1881	11,8	12,2	14,5	14,8	17,7	19,6	22,2	23,9	20,4	16,7	15,1	10,4	11,8	15,7	21,9	17,4	16,7
1882	10,5	12,3	13,9	14,4	16	18,3	20,7	21,4	18,4	16,8	14,1	11,1	11,1	14,8	20,1	16,4	15,6
1883	11,3	11,9	10,9	14,2	15	17,6	19,9	22	19,2	16,2	13,9	9,9	11,4	13,4	19,8	16,4	15,27
1884	11,6	11	12,8	12,6	16,8	19,5	21,8	22,8	19,9	16,8	12,9	10,7	10,8	14,1	21,4	16,5	15,7
1885	9,8	13,4	12,3	12,7	16,4	19,1	19,9	20,8	20,5	15,1	13,4	10,7	11,3	13,8	19,9	16,3	15,34
1886	10,1	10,8	14,1	14,5	15,9	19,4	22	22,4	20,1	16,1	12,4	11,9	10,5	14,8	21,3	16,2	15,71
1887	10,5	10,2	13,6	13,7	17	22,4	22,6	22,5	19,6	15,8	13,7	10,4	10,9	14,8	22,5	16,4	16,12
1888	10,2	8,6	11,5	13,1	18	19	20,1	21,9	21	17,6	14	12	9,7	14,2	20,3	17,5	15,45
1889	9,7	11,2	12	12,7	14,7	17,8	20,4	21	20,5	15,9	14	9,6	11	13,1	19,7	16,8	15,16
1890	11,3	10,2	11,5	13,7	14,7	21,1	20,9	20,3	20,5	18,4	13,3	10,1	10,4	13,3	20,8	17,4	15,46
1891	8,8	11,4	12,1	14,5	15,5	20	21,5	21,1	20,1	16,9	13,9	11,5	10,1	14	20,9	17	15,49
1892	10,5	11,6	13	14,6	18	20	21,3	22,6	21,1	16	14,5	10,9	11,2	15,2	21,3	17,2	16,22
1893	10,3	11,6	15,2	15,6	18,3	20,6	23,1	22,9	20,3	18,5	13,8	10,8	10,9	16,4	22,2	17,5	16,76
1894	10,3	10,9	12,5	13,3	15,4	19,7	21,1	21,2	19,8	18	13,9	11,4	10,7	13,7	20,7	17,2	15,57
1895	10	13	11,7	14,6	17,8	20,2	21,3	22,4	21	18,4	16,2	12,8	11,5	14,7	21,3	18,5	16,5
1896	10,2	11,6	13,8	17,3	18	19,7	21,8	21,8	20,3	14,6	11,8	11,7	11,5	16,4	21,1	15,6	16,14

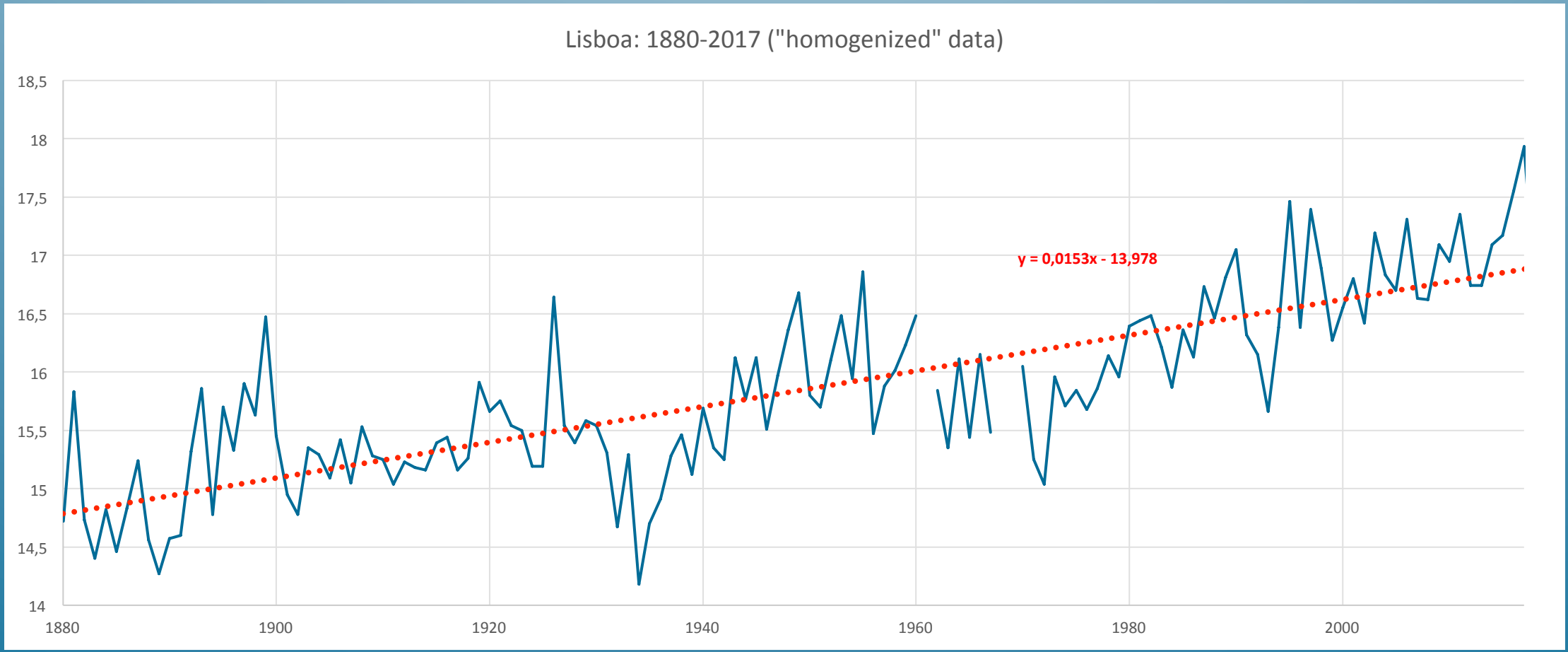
Lisboa/Geof (38.72N, 9.15W) 636085350000 GHCN V3 adj - homogenized

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	D-J-F	M-A-M	J-J-A	S-O-N	metANN
1880	8.73	11.53	13.13	12.63	15.23	16.53	18.63	20.13	20.23	17.43	12.03	10.63	10.22	13.66	18.43	16.56	14.72
1881	10.93	11.33	13.63	13.93	16.83	18.73	21.33	23.03	19.53	15.83	14.23	9.53	10.96	14.80	21.03	16.53	15.83
1882	9.63	11.43	13.03	13.53	15.13	17.43	19.83	20.53	17.53	15.93	13.23	10.23	10.20	13.90	19.26	15.56	14.73
1883	10.43	11.03	10.03	13.33	14.13	16.73	19.03	21.13	18.33	15.33	13.03	9.02	10.56	12.50	18.96	15.56	14.40
1884	10.72	10.12	11.92	11.72	15.92	18.62	20.92	21.92	19.02	15.92	12.02	9.82	9.95	13.19	20.49	15.65	14.82
1885	8.92	12.52	11.42	11.82	15.52	18.22	19.02	19.92	19.62	14.22	12.52	9.82	10.42	12.92	19.05	15.45	14.46
1886	9.22	9.92	13.22	13.62	15.02	18.52	21.12	21.52	19.22	15.22	11.52	11.02	9.65	13.95	20.39	15.32	14.83
1887	9.62	9.32	12.72	12.82	16.12	21.52	21.72	21.62	18.72	14.92	12.82	9.51	9.99	13.89	21.62	15.49	15.24
1888	9.31	7.71	10.61	12.21	17.11	18.11	19.21	21.01	20.11	16.71	13.11	11.11	8.84	13.31	19.44	16.64	14.56
1889	8.81	10.31	11.11	11.81	13.81	16.91	19.51	20.11	19.61	15.01	13.11	8.71	10.08	12.24	18.84	15.91	14.27
1890	10.41	9.31	10.61	12.81	13.81	20.21	20.01	19.41	19.61	17.51	12.41	9.21	9.48	12.41	19.88	16.51	14.57
1891	7.91	10.51	11.21	13.61	14.61	19.11	20.61	20.21	19.21	16.01	13.01	10.60	9.21	13.14	19.98	16.08	14.60
1892	9.60	10.70	12.10	13.70	17.10	19.10	20.40	21.70	20.20	15.10	13.60	10.00	10.30	14.30	20.40	16.30	15.32
1893	9.40	10.70	14.30	14.70	17.40	19.70	22.20	22.00	19.40	17.60	12.90	10.00	10.03	15.47	21.30	16.63	15.86
1894	9.50	10.10	11.70	12.50	14.60	18.90	20.30	20.40	19.00	17.20	13.10	10.60	9.87	12.93	19.87	16.43	14.78
1895	9.20	12.20	10.90	13.80	17.00	19.40	20.50	21.60	20.20	17.60	15.40	11.99	10.67	13.90	20.50	17.73	15.70

The “uncorrected” data: trend=0,0082



Lisboa: 1880-2017, "homogenized" data; trend=0,0153: almost the double!



An hidden cat with this tail off ;-)

Thanks for your attention!