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The Samoa Hurricane, 15-16 March 1889

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Abstract

Analysing historical weather extremes such as the tropical cyclone in Samoa in March 1889 could add to our understanding of extreme events. However, up to now the availability of suitable data was limiting the analysis of historical extremes, particularly in remote regions. The new "Twentieth Century Reanalysis" (20CR), which provides six-hourly, three-dimensional data for the entire globe back to 1871, might provide the means to study this and other early events. While its suitability for studying historical extremes has been analysed for events in the northern extratropics (see other papers in this volume), the representation of tropical cyclones, especially in early times, remains unknown. The aim of this paper is to study to the hurricane that struck Samoa on 15-16 March 1889. We analyse the event in 20CR as well as in contemporary observations. We find that the event is not reproduced in the ensemble mean of 20CR, nor is it within the ensemble spread. We argue that this is due to the paucity of data assimilated into 20CR. A preliminary compilation of historical observations from ships for that period, in contrast, provides a relatively consistent picture of the event. This shows that more observations would be available and implies that future versions of surface-based reanalyses might profit from digitizing further observations in the tropical region.

1. Introduction

Tropical cyclones are among the most devastating natural disasters. Each year, tropical cyclones cause the loss of life of thousands and tremendous damage, often in countries with limited economic capacities. Better understanding the development and tracks of tropical cyclones as well as changes therein thus is a relevant aspect of climate change science. Extreme events are rare, however, and long time series are required to establish changes in

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extremes. As a consequence, studying historical extremes is considered a valuable addition to the analysis of well-observed, present-day cases. However, detailed three-dimensional data sets are required for this purpose, which until recently have not been available further back than the mid-twentieth century. Since 2011, the "Twentieth Century Reanalysis" is available and provides six-hourly three-dimensional fields of the global atmosphere back to 1871 (Compo et al., 2011). However, it is unclear to what extent tropical cyclones are depicted. Emanuel (2010) analysed whether downscaling of 20CR can be used to study hurricanes. Neff et al. (this issue) found that the Galveston hurricane of 1900 is relatively well depicted, but it concerned a region well covered with observations, and the track of the hurricane was assimilated. Here we analyse an even earlier event in the tropical Pacific, a region not well covered with observations.

In February and March 1889 at least three tropical cyclones struck the area around Samoa (Kane, 1889 [2006]; Hayden, 1889; Knipping, 1892). The third cyclone caused considerable damage in the harbour of Apia (Fig. 1). The hurricane struck during a political crisis, which had brought battleships from three colonial powers to Apia. Because none of the competing maritime powers wanted to leave first, the cyclone caught the ships in the harbour and sank two German and US-American warships (Stevenson, 1892) and stranded further two ships. The British navy ship could escape scarcely (Kane, 1889). The loss of war material and human life brought the colonial powers back to the negotiation table (Wehler, 1965). Shortly after the storm, American as well as German meteorologists analysed the most devastating storm as well as the preceding storm based on observations on land (above all Apia, Samoa) and at Sea (Hayden, 1891; Blanford, 1891; Knipping, 1892).

Figure 1. Wrecked ships in Apia harbour soon after the storm. The view looks northwestward, with the shattered bow of the German gunboat Eber on the beach in the foreground. The stern of USS Trenton is at right, with the sunken USS Vandalia alongside. U.S. Naval Historical Center Photograph.

The aim of this paper is to study to the Samoa hurricane of 15-16 March 1889 in 20CR and in contemporary observations. We analyse whether the event is represented at all in the ensemble mean or whether it is consistent with the ensemble spread. For this purpose, we present a compilation of historical observations. As we will show, the event is not represented in 20CR, and hypotheses are raised as to why it is not represented.

The paper is organized as follows. Section 2 describes the data used, *i.e.,* 20CR and the historical observations. We also demonstrate which additional data, not available to us for the moment, could be consulted for a future study. In Section 3 we present our analysis of the event. Section 4 discusses the results. Conclusions are drawn in Section 5.

2. Data and Methods

2.1. The Twentieth Century Reanalysis and present repositories

The "Twentieth Century Reanalysis" (20CR) is an atmospheric data set that is based on the assimilation of only surface and sea-level pressure observations (Compo et al., 2011). The NCEP/CFS Model is used to generate background fields, with monthly sea-surface temperature and sea ice (Rayner et al., 2003) as boundary conditions. A variant of the Ensemble Kalman Filter is used for assimilation. 20CR consists of 56 equally likely members. Here we analyse both the ensemble mean and the individual members.

Figure 2 shows the land-sea mask as well as the station data assimilated into 20CR on 15 March 1889. 20CR does not have any land within the shown perimeter. Only two observations were assimilated, one from a station in Suva (Fiji) and a ship that was south of the Solomon Islands during these days.

The data assimilated into 20CR (V2) originate from the International Surface Pressure Databank (version ISPD 2, http://reanalyses.org/observations/international-surface-pressure-databank) and the International Comprehensive Ocean-Atmosphere Data set (version ICOADS 2.5, Woodruff et al., 2011) for land and maritime data, respectively. Furthermore,

Figure 2. Map showing the surface and sea-level pressure measurements assimilated into 20CR on 15 March 1889. The land-sea mask of 20CR as depicted in the Gaussian grid (192x94 cells) shows no land.

cyclone tracks from the Best-Track archive (IBTrACS, http://www.ncdc.noaa.gov/oa/ibtracs/) were assimilated. No track was available, however, for the tropical cyclones considered here. We have studied the pressure data assimilated into 20CR from these sources.

2.2. Additional historical sources

In addition to the electronically available data, historical observations were also digitized from documentary sources, which are summarized in Table 1. We used pressure data from the ship "Uvea" given in Knipping (1892) and digitized pressure data from other ships and from the station in Apia from a figure in Knipping (1892). Furthermore, we used pressure and wind information from a figure in Hayden (1891).

Hayden (1891), for his paper "The Samoan Hurricane of March 1889", used reports of the Navy (*e.g.,* a report of the admiral on U.S.S. Trenton, L. A. Kimberley), as well as different weather diaries (including logbooks and nearby weather stations). Knipping (1892) used Hayden's information and complemented it with data from the German Naval Office (Deutsche Seewarte; mainly reports from the German navy) as well as recordings from Dr. Funke who operated a weather station in Apia. Maps and diagrams including possible tracks of the hurricanes as well as the positions of the ships are added to both reports (Hayden, 1891, Knipping, 1892). The data underlying the two reports are at least partly available from different meteorological archive.

Table 1. Manuscript sources for pressure and wind for the Samoan hurricanes of March 1889 used in this study.

Series	Type	Coordinates	Pressure	Source	Wind	Source
S.M.S. Olga	Ship	Harbour of Apia	Yes	Knipping (1892)	Yes	Knipping (1892)
U.S.S. Trenton	Ship	Harbour of Apia	Yes	Knipping (1892)	Yes	Hayden (1891)
Hagarstown	Ship	South of Samoa, position only approximately known	Yes	Knipping (1892)	No	
Calliope	Ship	Harbour of Apia, then north after the storm; one position is given in Hayden (1891)	Yes	Knipping (1892)[1]	Yes	Hayden (1891)
Uvea	Ship	Coastal waters of Samoa, exact positions unknown	Yes	Hayden (1891)	Yes	Hayden (1891)
Equator	Ship	North of Samoa, positions given in Hayden (1891)	No		Yes	Hayden (1891)
Nukualofa	Station	21.13° S, 175.20° W	Yes	CORRAL[2]	No	
Apia	Station	13.83° S, 171.75° W[3]	Yes	Knipping (1892)[4]	Yes	Knipping (1892) Hayden (1891)
Suva	Station	18.13° S, 178.43° E	Yes	CORRAL/ISPD[5]	No	

[1] Two observations are also given in Scott (1889)

[2] Digitized by the authors from manuscripts retrieved from CORRAL. Observations compiled by Edward John March (1889)

[3] Exact location is unknown

[4] One observation is also given in Hayden (1891)

[5] Cross-checked with original data (Anonymous 1889)

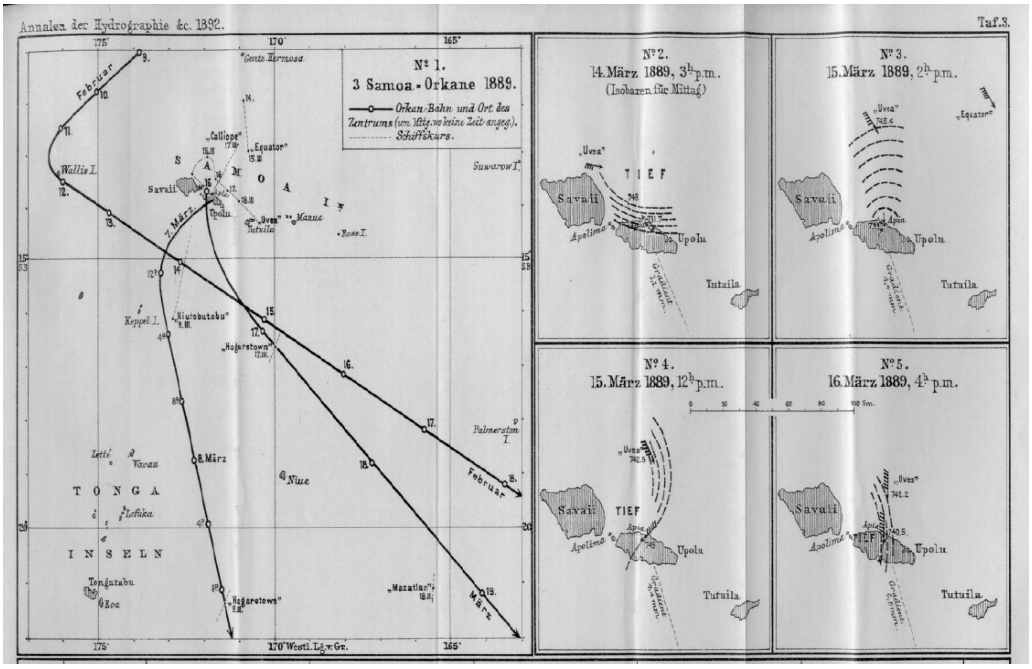

Figure 3: Map from Knipping (1892) showing the tracks of three Samoa hurricanes in February and March 1889 (left) and pressure observations for different times. Locations and dates of ship observations (including in some cases the ship tracks) are indicated, including the Equator (US) and the Niutobutabu which were not used for Figure 5.

In addition to these historical observations, we used observations from Nukualofa (Tonga) published in March (1889) and from Suva (Fiji) published in 1889 (Anonymous, 1889) (see Table 1). The Nukualofa and Suva data were retrieved from the CORRAL (UK Colonial Registers and Royal Navy Logbooks) collection of images of marine data (UK Met Office). Only the Suva data were assimilated into 20CR.

Together with the scientific reports of Hayden (1891) and Knipping (1892), a wide journalistic and literary reporting is found in newspapers and journals. However, these sources are often imprecise, some were written many years later, and in the context of our study they merely served to track data sources, identify names of observers etc. (*e.g.,* Brown, 1903; Stevenson, 1892).

The historical data sources were incomplete in many respects. Some data were only available in graphical form, the ship data in Knipping (1892) lack essential information such as coordinates. For this purpose, information on ship names, date and time, wind speed and direction, air pressure, and position of the ships were collected. Some of the original data could not be found but had to be digitized from the figures in Hayden (1891) and Knipping (1892).

3. Results

3.1. The Twentieth Century Reanalysis

An analysis of sea-level pressure and wind in 20CR suggests that the event is not captured in the data set. Figure 4 shows sea-level pressure and wind for 14, 15, and 16 March 1889. No appreciable pressure drops or pressure minima can be seen. The ensemble spread (not shown)

is ca. 2.75 hPa near Samoa. The ensemble mean sea-level pressure near Samoa is 1008 hPa, the lowest pressure found in any member is around 1005 hPa. A low pressure system is however found south of the Solomon Islands. An analysis of wind speed (right) gives a similar result, with low wind speeds near Samoa even in the ensemble member with highest wind speeds, while higher speeds are simulated in the cyclone near the Solomon Islands. In all, the analysis clearly shows that the hurricane from 15-16 March does not appear in the ensemble mean, nor in the ensemble members.

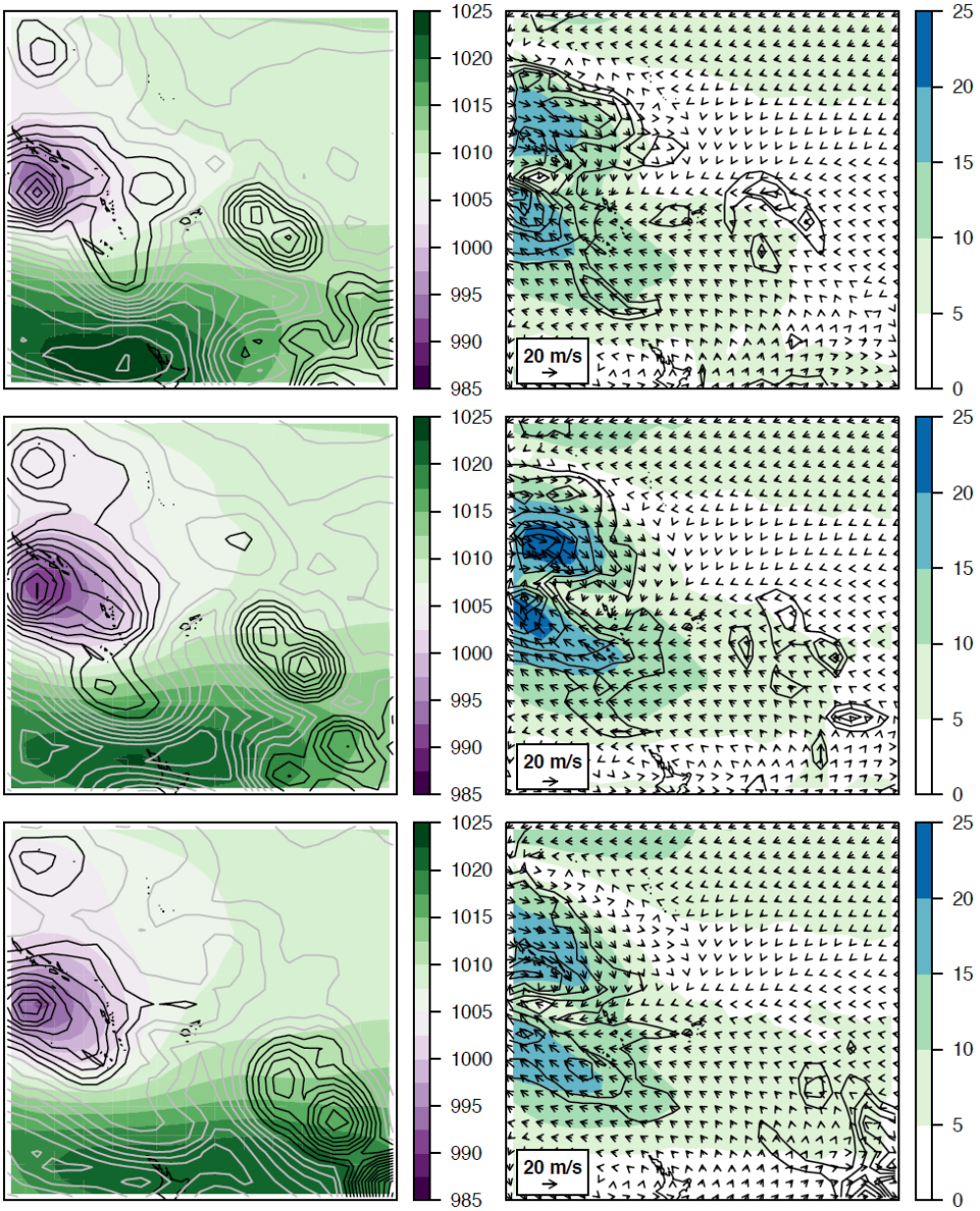

Figure 4. Sea-level pressure (left) and wind (right) and on 14 (top), 15 (middle) and 16 March 1889 (bottom), 0 UTC from the 20CR reanalysis. Shading indicates the ensemble mean, contours give the ensemble minimum (SLP, spacing 2 hPa, <1000 hPa in black) and maximum (wind speed, spacing 2 m/s, only ≥20 m/s shown). Wind vectors refer to the ensemble mean.

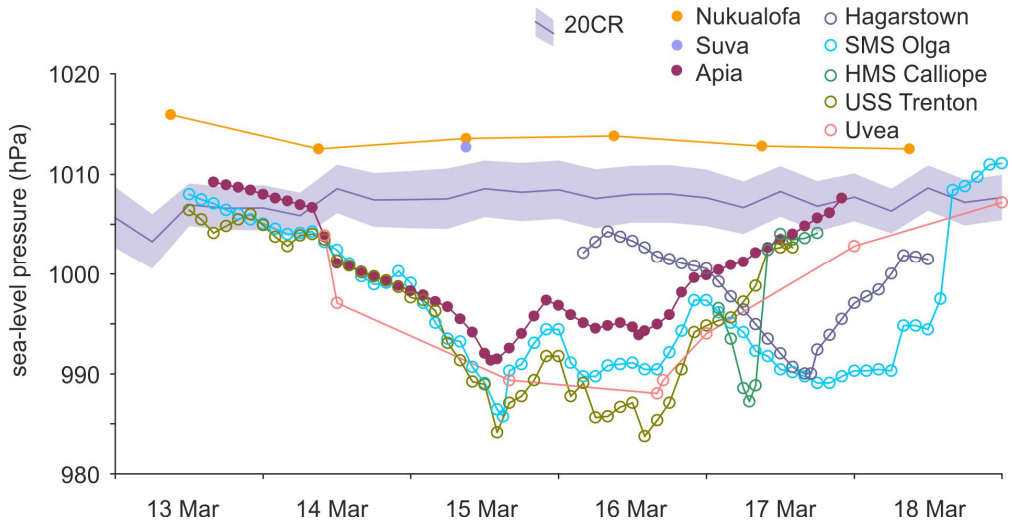

Figure 5: Sea-level pressure in the vicinity of Samoa in March 1889 based on data from Knipping (1892; digitized from the diagram in 2 hourly resolution), and Hayden (1891). Six-hourly values from the 20CR ensemble mean (shading denotes the ensemble standard deviation) are also given. The ships Olga and Trenton were in the harbour of Apia during the entire time, Hagarstown and the Uvea were in the open sea, and H.M.S Calliope escaped during the storm. "Apia" refers to a local weather station (arguably operated by Dr. Funke). Data for Suva and Nukualofa are taken from ISPD and CORRAL, respectively.

3.2. Historical observations

A first overview of the historical observations can be gained from the figures in Hayden (1891) and Knipping (1892). The tracks of the three cyclones were reconstructed by Knipping (1892) and are shown in Figure 3. All tracks originate from the northeast and curve southward and then southeastward after passing Samoa or the waters nearby.

Our digitized historical pressure data are shown in Figure 5. The observations in Fiji (Suva) and Tonga (Nukualofa) show no pressure drop. Most of the ships were very near or slightly north of Samoa and show a pressure drop starting on 14 March, minimum values were reached on 15 and 16 March. All observations in the region of Samoa consistently show low pressures down to 985 hPa on 16 March 1889. Pressure at the station in Apia dropped to 991 hPa according to Knipping (1892) but to 985 hPa according to Hayden (1991). The ship Hagarstown, which was ca. 350 km southeast of Samoa observed pressures down to 990 hPa one day later, on 17 March.

Historical observations provide not only pressure, but also wind. The logs of the German ships Uvea and Olga indicate maximum wind speeds between 9 to 12 Beaufort between 15 and 17 March 1889 (Knipping, 1892). This corresponds to wind speeds between 20 and 25 m/s (Beaufort 9) and above 33 m/s (Beaufort 12, Aller et al., 2009). Following World Meteorological Organization (WMO) terminology, the event thus was a hurricane or a severe tropical cyclone (WMO 2012).

4. Discussion

The severe tropical cyclone of Samoa, 15-16 March 1889 could be clearly tracked in pressure observations from five ships and one weather station (Apia) as well as additional wind information from ships. All sources clearly confirm the passage of a deep low with minimum values around 990 or 985 hPa and winds of hurricane strength, moving to the southeast after passing Samoa. 20CR, in contrast, does not show the event at all.

For 15-16 March 1889, there are hardly any observations in ISPD and ICOADS. In the region from 10° S to 20° S and 165° W to180° W, only one observation was thus assimilated into 20CR, namely that of Suva (plus one ship further to the west, see Fig. 2). The value for Suva in ISPD (1012.7 hPa) corresponds well with that reported in Hayden (1891) and that found in the Suva observations (1011.3 hPa; Anonymous, 1889). It also corresponds well with the measurements from Tonga. These values are far above the threshold for tropical storms and thus we assume that the two locations were outside the paths of the storms. As Suva was the only pressure observation entering 20CR during the period of the storm, 20CR could not see the storm. The low pressure system south of the Solomon Islands was due to the low pressure values reported by a ship in that region.

ICOADS (version 2.5) has slightly more entries for the time period. During the period of the storm (13 to 19 March), there are three entries, none of which however, concerns pressure. It is interesting to note that much more observations would be available than there are currently in ICOADS and ISPD.

Assimilating these observations in future approaches might be beneficial. It might also be possible, from these observations and additional observations of other variables, to construct tracks for the three cyclones that might be added to IBTrACS. This case study shows that much more data could potentially be made available for reanalyses. For a full analysis of the event, more data must also be searched from neighbouring regions that were unaffected by the storm, which we could not do for this study.

5. Conclusions

In this paper we have studied the Samoa hurricane from 15 March 1889 in 20CR and in contemporary observations recovered from various sources. We find that the event is not reproduced in the 20CR ensemble mean and inconsistent with the 20CR ensemble spread. This is not surprising given the fact that only one observation from the region that was clearly outside the path of the storm was assimilated into 20CR. Consulting additional data – pressure observations from five ships and a weather station on Samoa – we find a clear imprint of the storm and conclude that using these data, the storm might have been captured.

We have digitized several of the series from a published diagram. The log book of S.M.S Olga could be located in the meantime and will be digitized for future studies. The observations on-board the ships Trenton and Calliope are arguably well accessible. The vast amount of literary and journalistic sources, however, seems less reliable.

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