THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 145

JULY 2007

Australian Government

Bureau of Meteorology

This project is sponsored by the Australian Agency for International Development (AusAID), and is managed by the Bureau of Meteorology with its National Tidal Centre (NTC) providing key technical support.

Australian Government

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Quality Certification:

I authorise the issue of this South Pacific Sea Level and Climate Monitoring Project Monthly Data Report for July 2007 in accordance with National Tidal Centre Quality Assurance procedures.

William Mitchell
Manager - National Tidal Centre

South Pacific Sea Level and Climate Monitoring Project

Monthly Data Report

July 2007

EXECUTIVE SUMMARY

This summary, and the overview that follows, are intended to provide a synopsis of the Monthly Data Report and of the trends observed over the life of the project to date.

July 2007

- The SEAFRAME network continued to collect high quality sea level and associated meteorological information for monitoring climate variability and climate change. Data communications problems were experienced at Kiribati and Samoa during July but have since been resolved.

- Monthly mean sea levels observed from SEAFRAME installations were generally near normal and within 5 cm of what is expected at this time of the year.

- Monthly mean air and water temperatures were warmer than normal at many stations, which is consistent with the warmer than normal sea surface temperatures observed by satellites across the southwest Pacific region.

- Slight strengthening of La Niña indicators occurred during July, including renewed cooling of surface and subsurface temperatures across the central and eastern equatorial Pacific. This cooling primarily occurred as a result of stronger than normal Trade Winds during June.

- The majority of international climate models predict that cool conditions will persist at La Niña thresholds across the Pacific for the remainder of 2007. However fluctuations in climate conditions in recent months has produced uncertainty as to whether a basin-wide La Niña event will develop.

Short-Term Trends

It is important to stress that as the sea level record becomes longer, the short-term trend estimate becomes more stable and reliable. Observed trends in sea level include natural variability, for example, events such as El Niño and effects due to many other atmospheric, oceanographic and geological processes. Longer-term data sets for all stations are required in order to separate the effects of the different signals. ***Please exercise caution in interpreting the short-term trends in the table below*** **–** they will

almost certainly change over the coming years as the data set increases in length. Figure 13 later in this report provides the “time history” of the short-term trend at all project locations.

Recent short-term sea level trends in the project area based upon SEAFRAME data through July, 2007

Location	Lat / Long	Installation Date	Trend (mm/yr)	Change from previous month
Cook Is	21°12'17.1"S / 159°47'5.2"W	Feb 1993	+4.1	-0.1
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+8.2	+0.1
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+3.0	+0.1
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+3.3	0.0
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+6.1	+0.1
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+5.8	+0.1
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+6.0	0.0
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+6.8	-0.2
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+5.0	+0.1
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+6.2	0.0
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+16.6	+1.0
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+4.1	+ 0.1

INTRODUCTION

Welcome to the July 2007 Monthly Data Report for the South Pacific Sea Level and Climate Monitoring Project (SPSLCMP). The report details the month by month operation of the SEAFRAME monitoring gauges in the Pacific, including operational problems with the network or with satellite communications, the occurrence of abnormal sea level or climate events, interpretation of sea level fluctuations in the context of El Niño and the emergence of trends in the data.

The SPSLCMP was developed as an Australian response to concerns raised by the member countries of the South Pacific Forum over the potential impacts of global warming on climate and sea levels in the Pacific. SEAFRAME gauges were installed in the participating Forum Countries.

SEAFRAME gauges not only measure sea level by two independent means, but also observe a number of “ancillary” variables - air and water temperatures, wind speed, wind direction and atmospheric pressure. There is an associated programme of levelling to first order, to determine shifts in the vertical of the sea level sensors due to local land movement. Continuous Global Positioning System (CGPS) measurements are now also being made to determine the vertical movement of the land with respect to the International Terrestrial Reference Frame.

The AusAID funded project has, as its principal objective ***'the provision of an accurate long term record of sea level in the South Pacific for partner countries and the international scientific community, that enables them to respond to and manage related impacts'***.

The project's monitoring network consists of 12 SEAFRAME stations, providing a wide coverage across the Southwest Pacific basin. All of these stations (see Figure A), with the exception of the Pohnpei (FSM) gauge, which was established in December 2001, have been operational since October 1994.

The monthly data report, one of a range of information products produced by the project, is the primary form of SPSLCMP data dissemination. Its content is designed to provide up-to-date access to the project's data products.

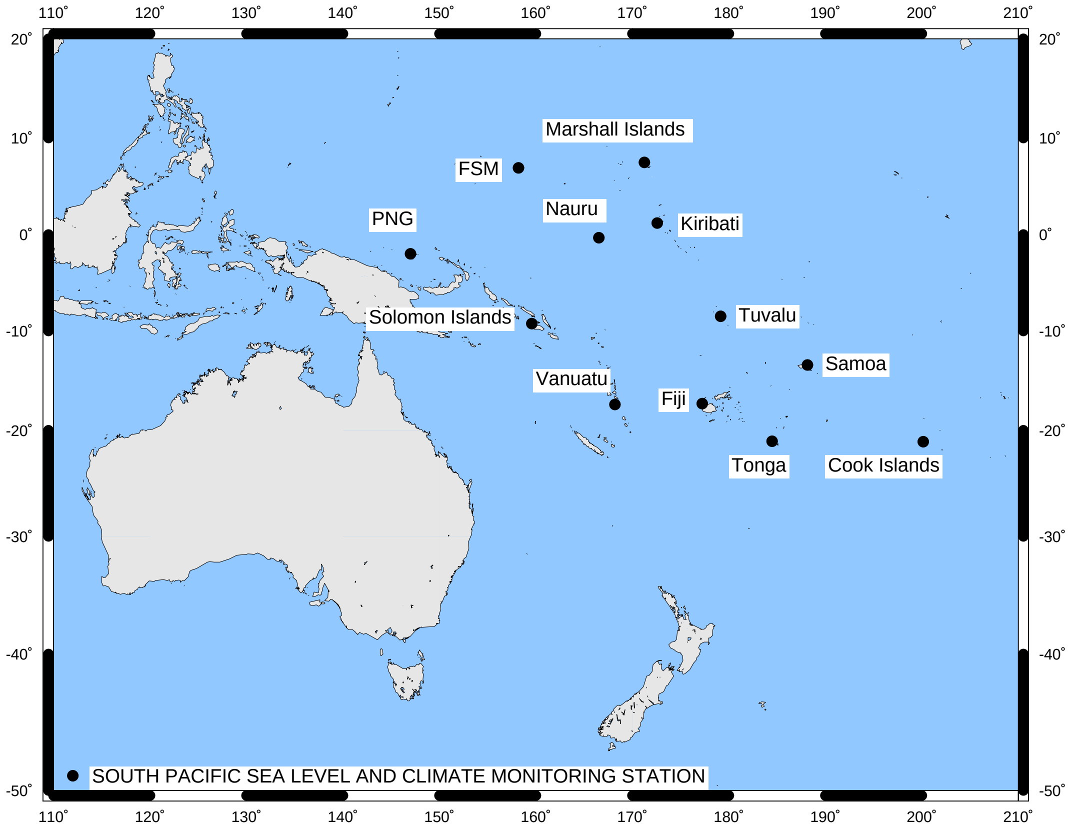

Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

JULY CLIMATOLOGY

Climate conditions across the equatorial Pacific during July showed a slight strengthening of La Niña indicators. These included a cooling of sea surface and subsurface temperatures across the central and eastern equatorial Pacific, stronger then normal Trade Winds, and lower than normal cloudiness across the central equatorial Pacific. However these trends would need to persist for several months before a La Niña event were to develop. The consensus among international climate models is that cool conditions will persist at La Niña thresholds for the remainder of 2007.

The Southern Oscillation Index (SOI) has undergone large fluctuations in recent months with values of –3 for May, +5 for June and –4 for July (**Figure B**). Over the longer term the SOI has been indicative of neutral climate conditions in the Pacific since November 2006.

Sea surface temperatures in the eastern Pacific underwent further cooling during July (**Figures C and E**) in response to stronger than normal Trade Winds experienced in June. Sea surface temperatures remained slightly warmer than normal in the western equatorial Pacific and near average in the central equatorial Pacific. In the southwest Pacific region patches of warmer than normal sea surface temperatures were observed during July (**Figure C**).

Cooler than normal subsurface temperatures continued to be observed at thermocline depths across much of the central and eastern equatorial Pacific Ocean (**Figure D**). A renewed strengthening of this pattern was observed in July due to recent strengthening of the Trade Winds. In the west-central equatorial Pacific slight subsurface warming occurred due to a weakening of the Trade Winds in that region in late June and early July.

During El Niño (warm-episode) conditions there is a sustained weakening of the Trade Winds across much of the equatorial Pacific and an increase in cloudiness near the dateline. During La Niña (cold-episode) conditions there is a reversal of this situation, with stronger Trade Winds and decreased cloudiness in the central Pacific. The TAO/TRITON array of moored buoys revealed Trade Winds across the equatorial Pacific were stronger than average during June, but were weaker than average in the first half of July (**Figure E**). Cloudiness in the equatorial Pacific near the dateline was below average during July.

The results from six international dynamic computer models predict that cool conditions at La Niña thresholds will persist across the Pacific for the remainder of 2007. There is uncertainty regarding the development of a La Niña event in 2007 due to the large fluctuations in Pacific climate indicators experienced between May and July.

The preceding description of the climatology of the Pacific region, and Figures B, C and D are based on information sourced from the National Climate Centre of the Australian Bureau of Meteorology at http://www.bom.gov.au/climate/. Figure E was generated from the Tropical Atmosphere Ocean project website courtesy of PMEL, NOAA at http://www.pmel.noaa.gov/tao/.

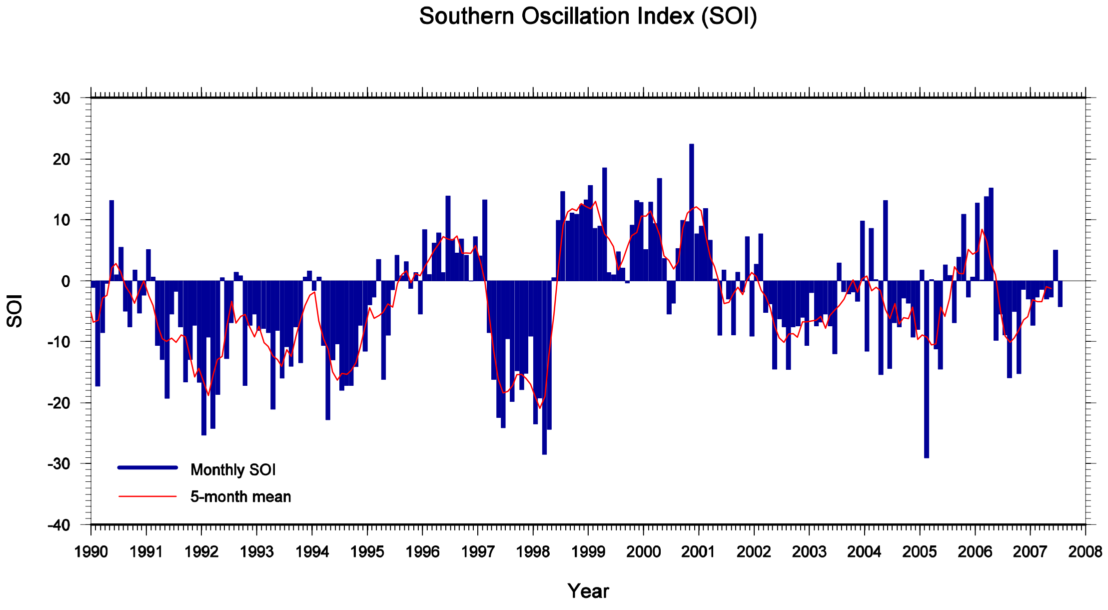

Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the standard deviation of that difference for the relevant month, based on the period 1933-92.*

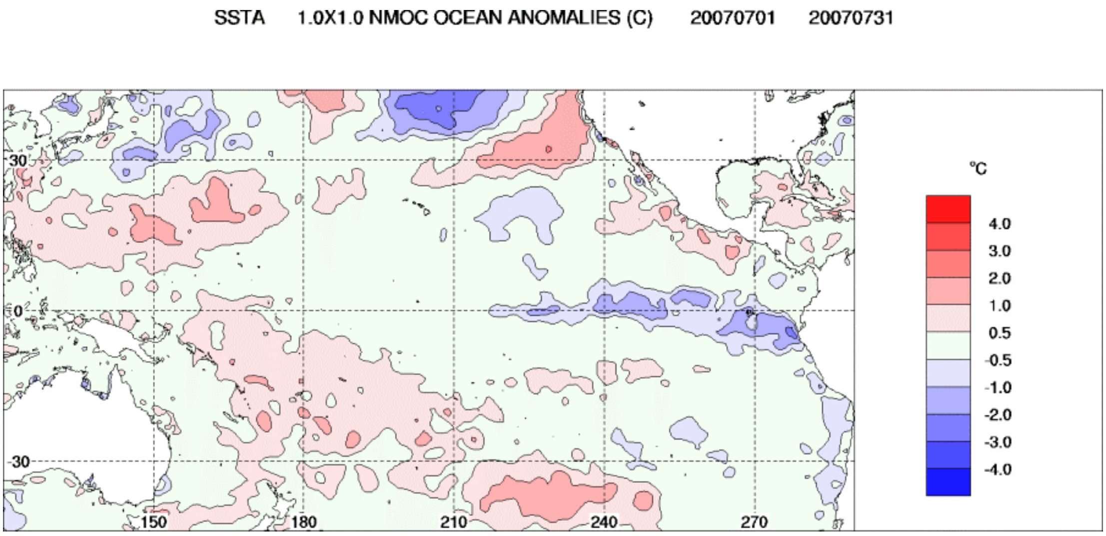

Figure C: *Sea surface temperature anomaly (°C) for July 2007.*

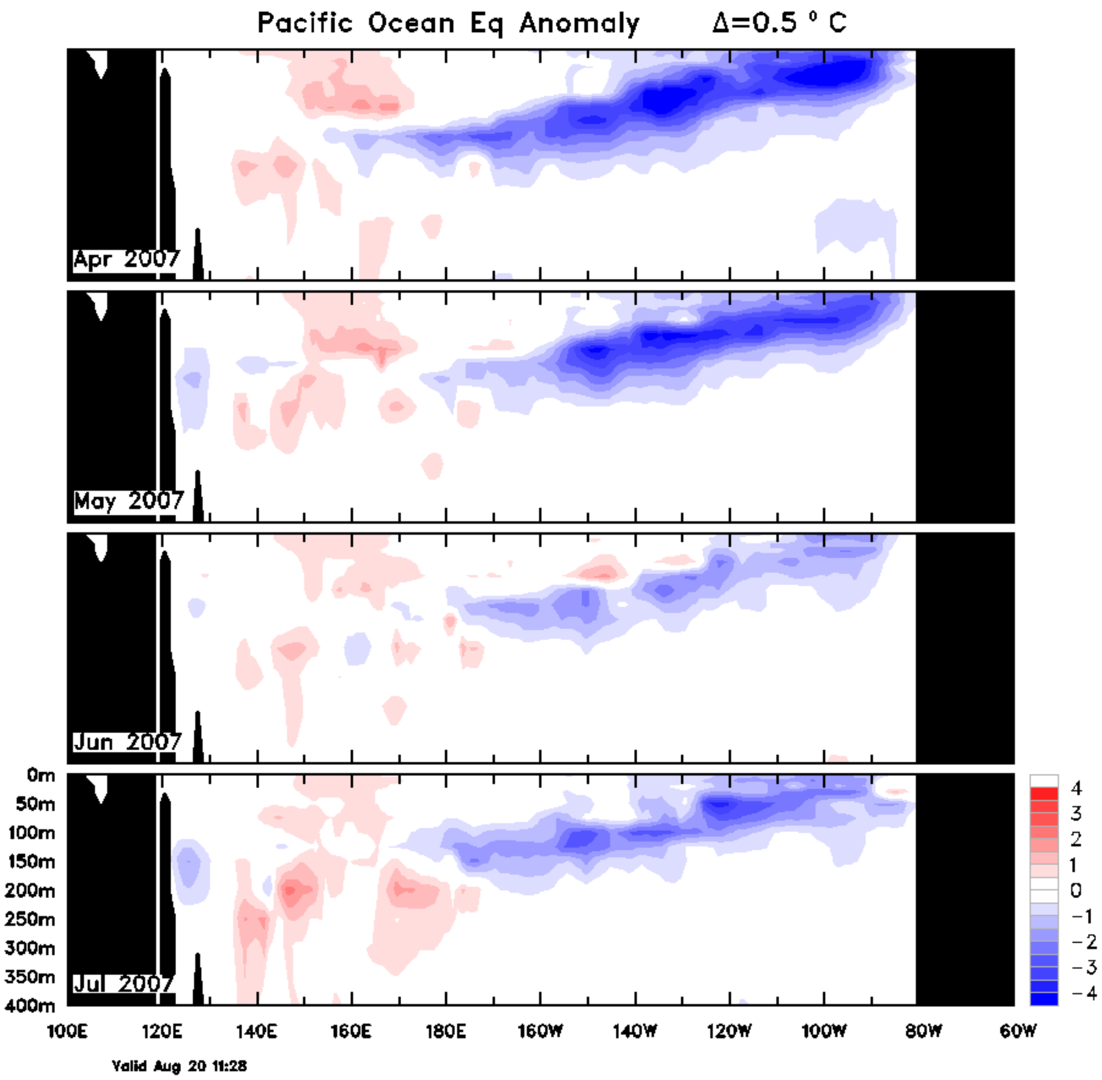

Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for April 2007 through to July 2007. Contour interval is 0.5°C.*

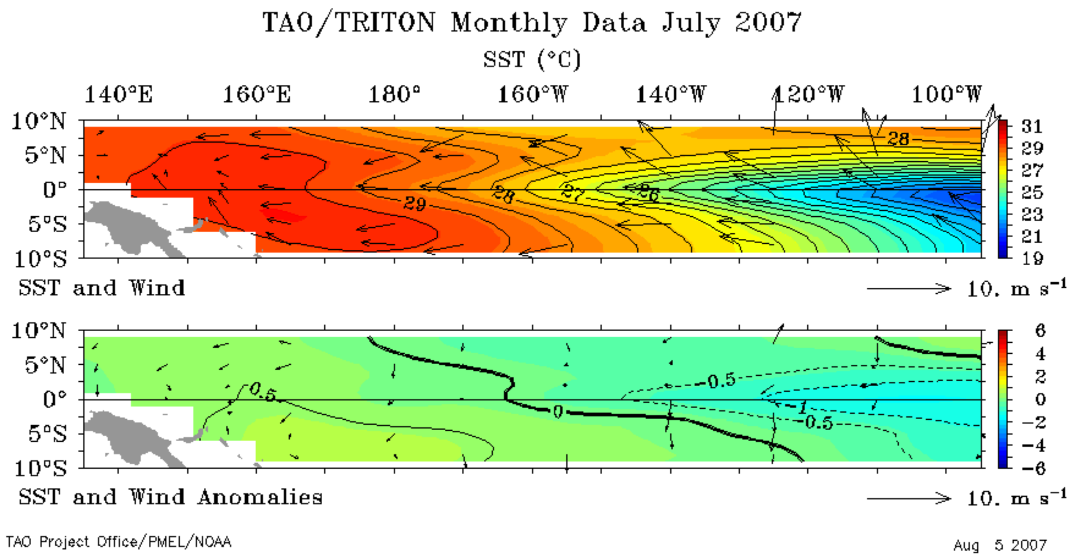

Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for July 2007. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

JULY SEAFRAME DATA

Monthly Sea Level and Environmental Data (Figures 1-10)

The **observed sea levels (Figure 1)** are dominated by the daily oscillations of the tide. In most cases, the tide rises and falls twice per day (semi-diurnal), but at PNG and the Solomon Islands the tide tends to have a single high and low per day (diurnal). The greatest variations tend to occur close to the new and full moon. There was a new moon on the 14th of July and a full moon on the 30th of July UTC.

Gaps in the data are the result of instrumental errors or data retrieval problems and are discussed under **Instrument Performance**.

The **residuals (Figure 2)** are the differences between the observed sea levels and the tidal predictions. They are an indication of the non-tidal fluctuations in the sea level record such as those due to the short-term effects of the weather or tsunamis. The shape of the harbour in which the gauge is located also influences residual sea levels. The gauge at Papua New Guinea (Manus Island), for example, often records residual sea level fluctuations due to a standing wave, or seiche, that arises within Seeadler Harbour when the wind suddenly changes strength or direction.

The sea level residuals at all stations, to some degree, exhibit semi-diurnal or diurnal fluctuations, which last a few days or weeks and then disappear. If these peaks were to persist, rather than appear as occasional “transients”, then the tidal analysis would be able to account for them, and the end result would be virtual eradication from the residuals.

The **barometrically corrected residuals (Figure 3)** have had the effect of atmospheric pressure fluctuations removed from the sea level residuals of Figure 2. The rule of thumb for the ‘inverse barometer effect’ is that a 1-hPa fall in the barometer, if sustained over a day or more, produces a 1 cm rise in the local sea level (within the area beneath the low pressure system).

The **winds**, **temperatures** and **barometric pressures** are plotted in **Figures 4** to **9**. The short lines in **Figure 5** follow the meteorological convention, that is, they point in the direction the wind is coming *from*. For example, the winds at Nauru prevailed from the northeast for most of the month. The maximum wind gusts observed each hour are shown in **Figure 6** and show the strongest winds were observed at PNG where they reached 17 m/s (33 knots) on the 26th of July**.**

Air and water temperatures **(Figures 7** and **8)** are plotted using the same vertical scale for the purpose of comparison. The air temperatures are seen to fluctuate over a much wider range than the water temperatures. At some sites (e.g. FSM) the water temperature shows almost no variation, although the air temperature varies by several degrees between night and day. The SEAFRAME at Nauru records a predominant twice-daily fluctuation in water temperature that is related to the tide, since it is usually more pronounced during the larger spring tides.

Barometric pressures **(Figure 9)** tend to fluctuate by around 3 hPa twice-daily at all stations as a result of atmospheric tides, which are largest in the tropical regions and reduce to near zero toward the poles. The longer-term barometric pressure fluctuations

that occur over periods of days to weeks are due to passing weather systems. These fluctuations tend to be larger at sites further away from the equator such as Cook Islands and Tonga.

The **meteorological data** are put into perspective by **Figure 10**. In this figure, if an open circle falls above (below) a solid dot, a new maximum (minimum) for the particular month has been set. *The data sets only include South Pacific Sea Level and Climate Monitoring Project data, which have been collected since October 1992 when the first station was installed (Fiji).* The FSM data frequently goes outside the range but this is of less significance because the instrumental record is relatively short (commenced December 2001). Figure 10 shows that although air and water temperatures during July 2007 did not exceed any previously recorded extremes, the monthly means were slightly warmer than the long-term averages at many stations. Figure 10 also reveals that new record July minimum barometric pressures were recorded at PNG, Nauru and Tuvalu and a new record July maximum barometric pressure was recorded at FSM.

Mean Sea Level and Anomalies (Figures 11-13)

Figure 11 shows the **monthly mean sea levels**, which is a simple arithmetic average of the sea levels relative to an arbitrary zero. The figure shows that Tuvalu, for example, normally experiences an annual cycle of about 0.2 metres, reaching a peak around February or March. One effect of the El Niño of 1997/1998 was to disrupt the annual sea level cycle at many of the SEAFRAME stations.

Figure 12 shows the **sea level anomalies,** or departures from normal conditions after tides, annual and semi-annual seasonal cycles and the sea level trend have been removed. The annual cycle at Tuvalu (which has the largest consistent annual cycle) is quite notable in **Figure 11** but less apparent in **Figure 12**. By removing the seasonal cycles, the anomalies help to bring out irregular features, such as lower than normal sea levels across the region during the 1997/98 El Niño.

Relatively small sea level anomalies were observed at SEAFRAME stations during July 2007. Monthly mean sea levels were observed to within 5 cm of what is expected at this time of the year at all stations where data was available. Sea level anomalies were positive at all stations aside from the near-equatorial stations of Kiribati and Nauru and the far-eastern station of Cook Islands.

Sea Level Trends

The **short-term sea level trends** at individual stations as at July 2007 are shown in the following table. Sea level trends are updated every month by allowing for a linear trend term in the tidal analysis of all the data available at individual stations. *Please exercise caution in interpreting the trends* – they will continue to change over the coming years as the data sets increase in length. The evolution of the monthly trend values (in mm per year) at each station from one year after installation to present is depicted in **Figure 13**. This figure illustrates that as the sea level record becomes longer, the relative sea level trend estimates become more stable and reliable. The reason for this is that the trends from short sea level records are affected by the natural sea level variability occurring on inter-annual, El Niño and decadal timescales due to atmospheric, oceanographic and geological processes. Longer-term data sets for all stations are required in order for the underlying trend to emerge from these short-term

variations. Further details are available from the *National Tidal Centre (NTC), Australian Bureau of Meteorology*.

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Location	Lat / Long	Installation Date	Trend (mm/yr)	Change from previous month
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Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+6.8	-0.2
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+5.0	+0.1
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+6.2	0.0
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+16.6	+1.0
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+4.1	+0.1

Barometric Pressure, Water Temperature and Air Temperature Anomalies

The anomalies of barometric pressure, water and air temperature (**Figures 14** to **16**) are determined in the same manner as the sea level anomalies (**Figure 12**), except the trend is not calculated.

The **barometric pressure anomalies (Figure 14)** show substantially higher than normal barometric pressures were observed at SEAFRAME stations during the 1997-1998 El Niño. In July 2007 barometric pressures ranged from near normal to slightly lower than normal across the region.

The **water temperature anomalies (Figure 15)** show water temperatures were warmer than normal at many stations during July 2007. This is consistent with patches of warmer than normal sea surface temperatures across the Pacific Forum region as shown in Figure C. Water temperatures were notably around +1°C warmer than normal at Vanuatu, Fiji and Tonga. At Nauru water temperatures were observed to be around –0.5°C cooler than normal.

The **air temperature anomalies (Figure 16)** show higher than normal air temperatures were observed at all stations where data was available in July 2007, and in particular Marshall Islands, Vanuatu, Fiji, Tonga and Cook Islands. Over the duration of the record the air temperature anomalies generally (although not always)

follow the water temperature anomalies, which is an indication of the large influence the ocean has upon the climate of the Pacific Islands.

Instrument Performance

In **Figure 17,** which shows **sea level data return,** colour is used to distinguish five-year project phases. The number of missing days is noted in gaps in the bars.

At Kiribati no data was retrieved during July 2007 due to both satellite and telephone communications being unavailable. The problems have since been resolved and data is being received. At Samoa a battery failure prevented data retrieval from 23rd July 2007. At Solomon Islands the air temperature sensor, wind mast and wind sensors were reassembled on 27th July 2007 during a calibration and maintenance visit. They had previously been dismantled since 17th November 2006 to allow for the refurbishment of the wharf. Erroneous wind direction data was received from Solomon Islands from the 30th July and have been removed from the record. Calibration and maintenance visits were also performed at PNG and Vanuatu during July 2007. Dial-up communications problems were experienced at Nauru, Kiribati and Solomon Islands and some small data gaps may exist where data were unable to be recovered.

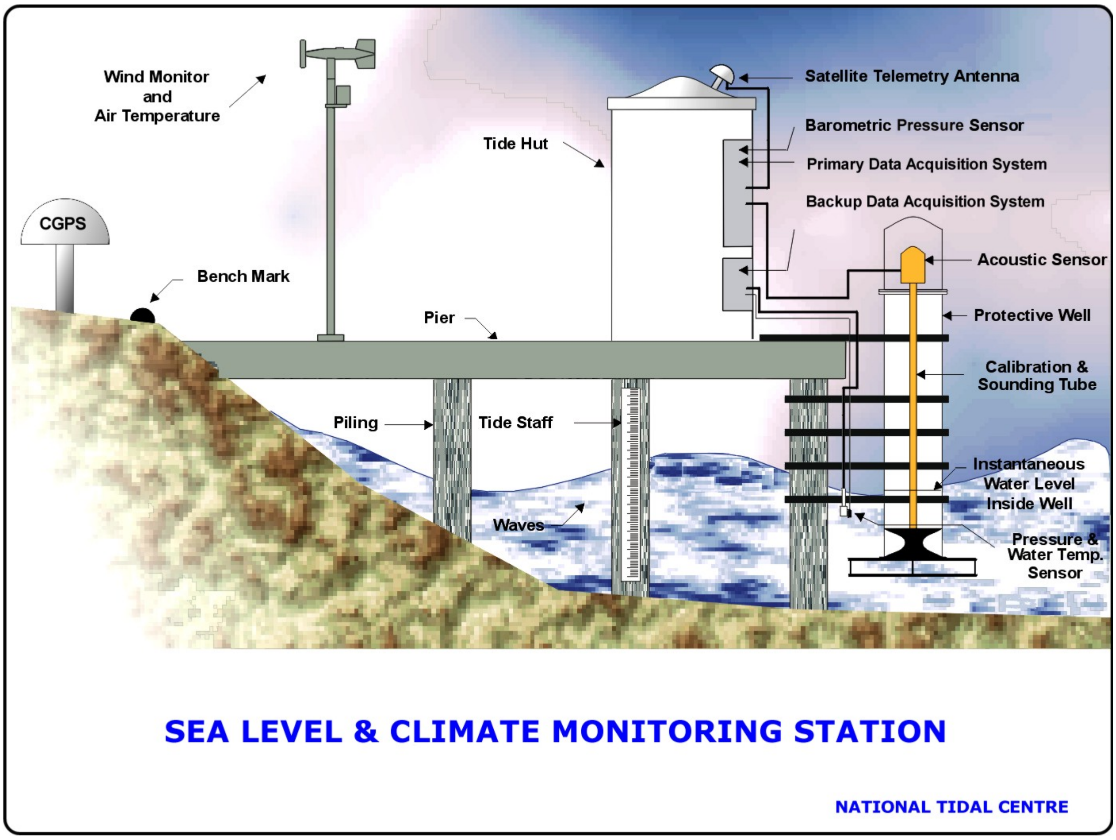
SEAFRAME STATIONS

SEAFRAME stations employ a SUTRON programmable data logger, water level gauges and other sensors. The data logger and associated electronics are normally housed in fibreglass huts. A sketch of a typical station is shown in the following figure. Water level sensors include:

(1) Primary water level using a Bartex 'AQUATRAK' acoustic-in-air sensor, and

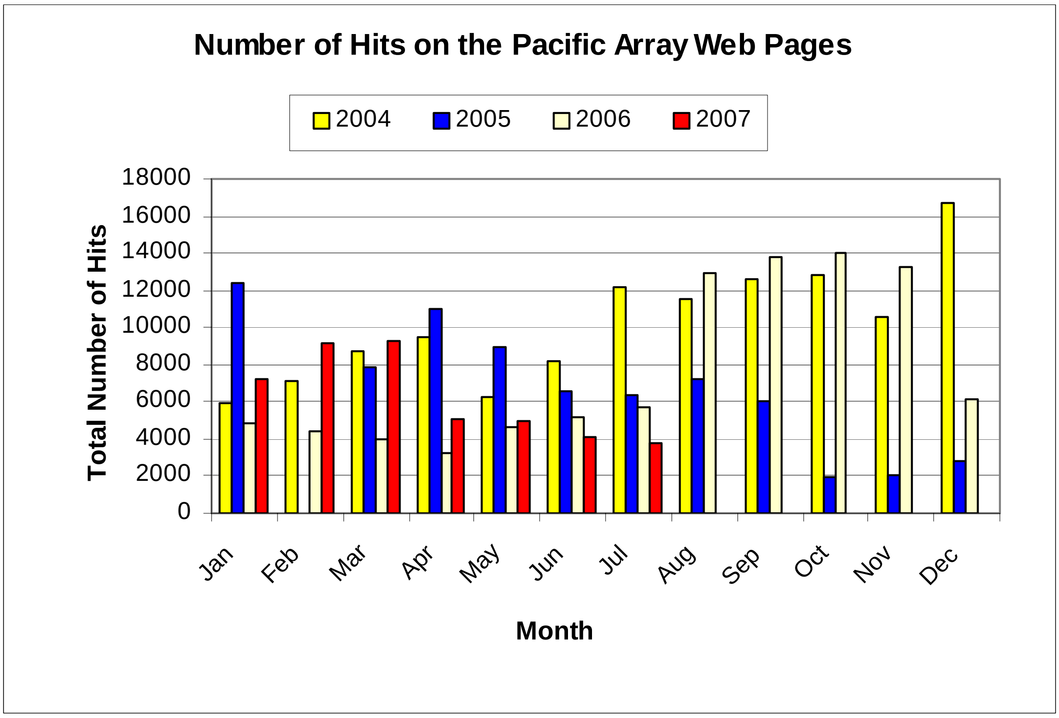
(2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

The primary and backup water level sensors provide water level values, which are averaged over three minutes and are logged every six minutes. The data logger has the memory capacity to store approximately one month of data. The meteorological sensors are logged to the SUTRON data logger on an hourly basis.



Web Hits

The following chart shows the number of times the Pacific pages on the *NTC* web site have been visited, by month since January 2004. Note that the web statistics for February 2005 are not available due to technical difficulties.



The *Monthly Data Report* is prepared by *NTC* for *AusAID*.

NTC would appreciate feedback from readers on the content and presentation of the *Monthly Data Report*.

Please spare a few moments to let us know your constructive opinion.

Further communication on the *Monthly Data Report* may be made to *NTC*. Anyone interested in a more detailed account of the project should contact:

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Website: http://www.bom.gov.au/oceanography

Or visit the project website at http://www.bom.gov.au/pacificsealevel

Please refer to: http://www.bom.gov.au/oceanography/projects/spslcmp/spslcmp.shtml for details.

Please also note the following:

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Individuals and organisations are advised that quality controlled six-minute or hourly data from these stations are available on request from *NTC*. Some handling fees may be charged. For commercial agencies requesting data, some additional costs may be levied.

Figure 1

JULY 2007
SIX MINUTE WATER LEVEL OBSERVATIONS (m)

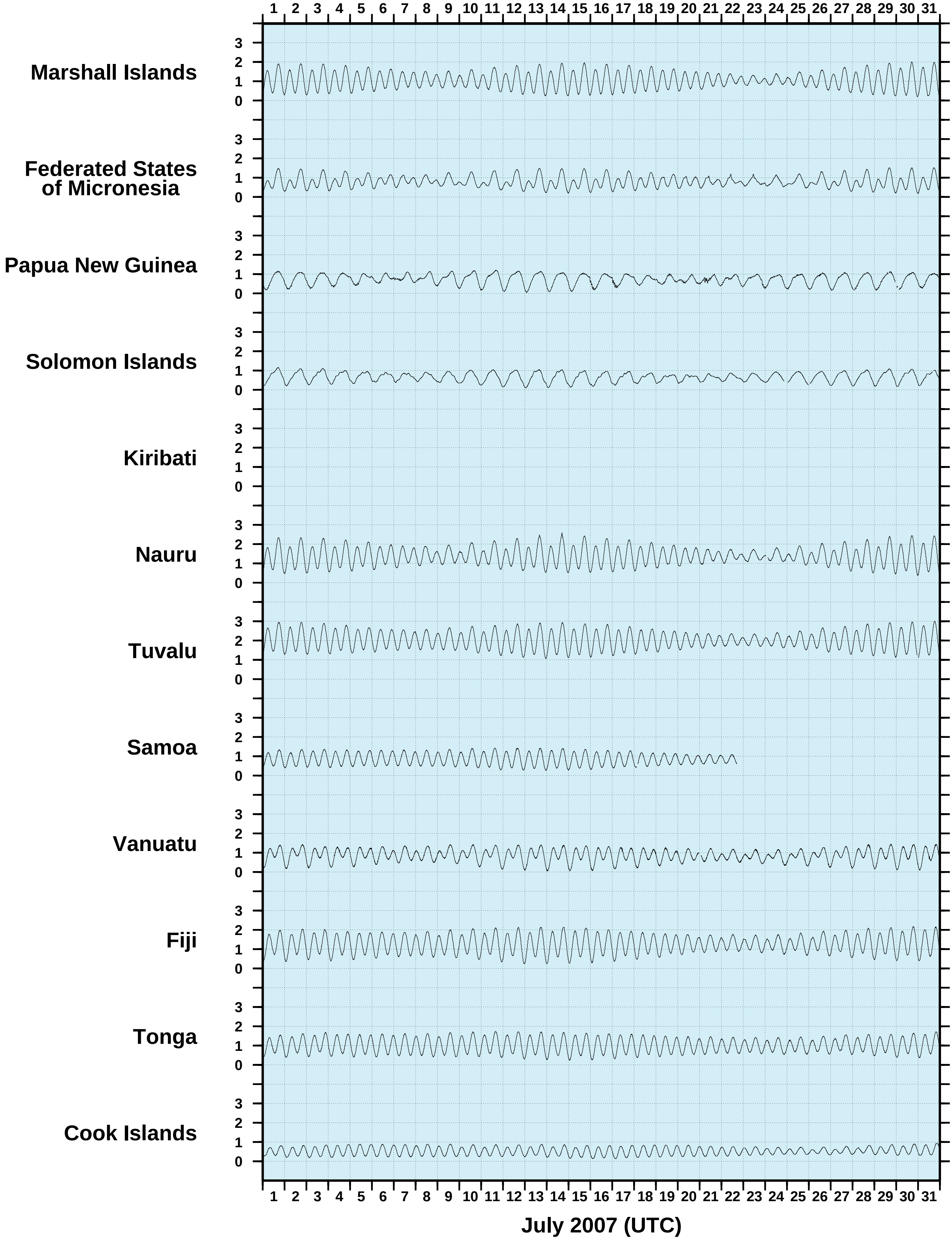

Figure 2

JULY 2007
SIX MINUTE RESIDUAL WATER LEVELS (m)

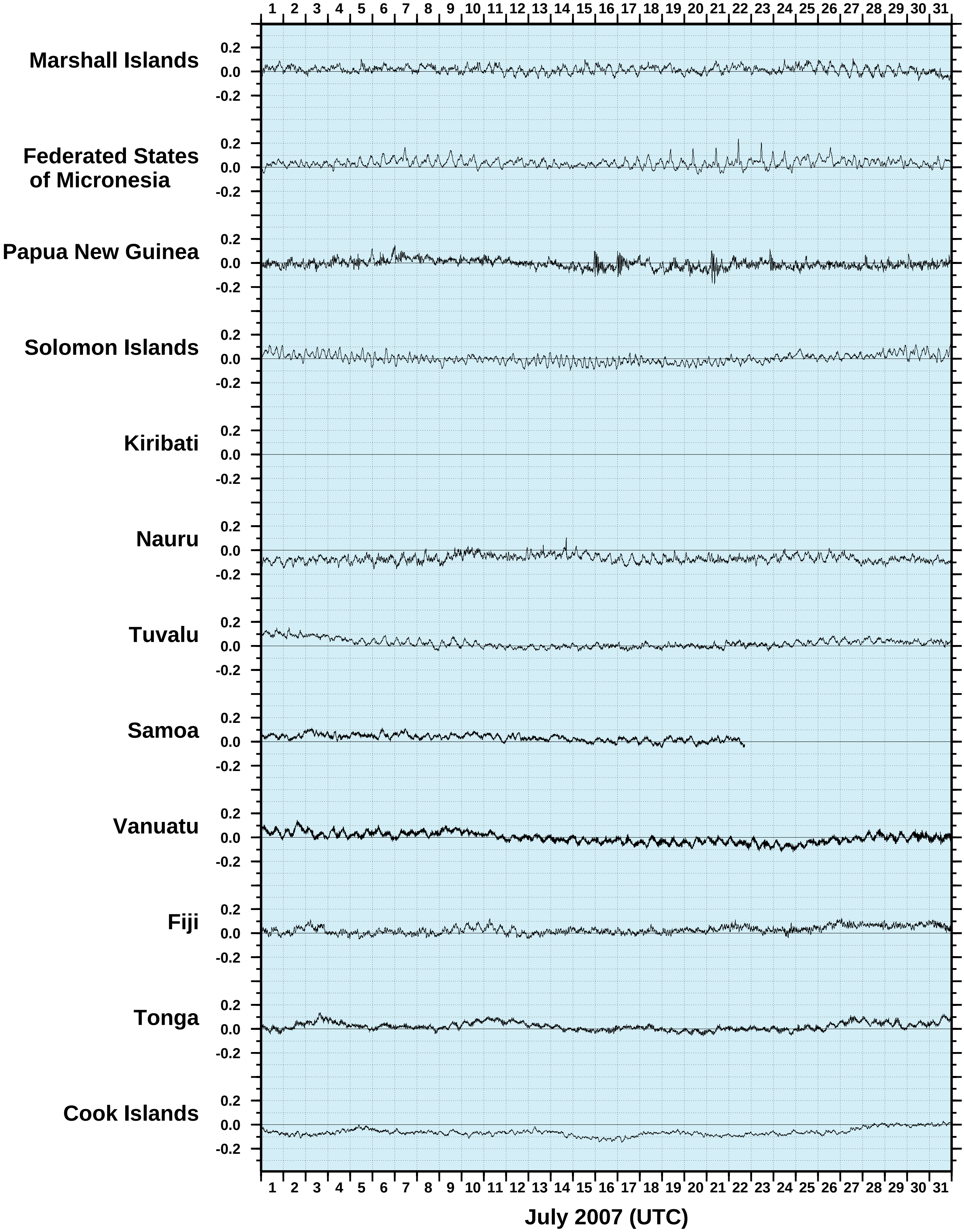

Figure 3

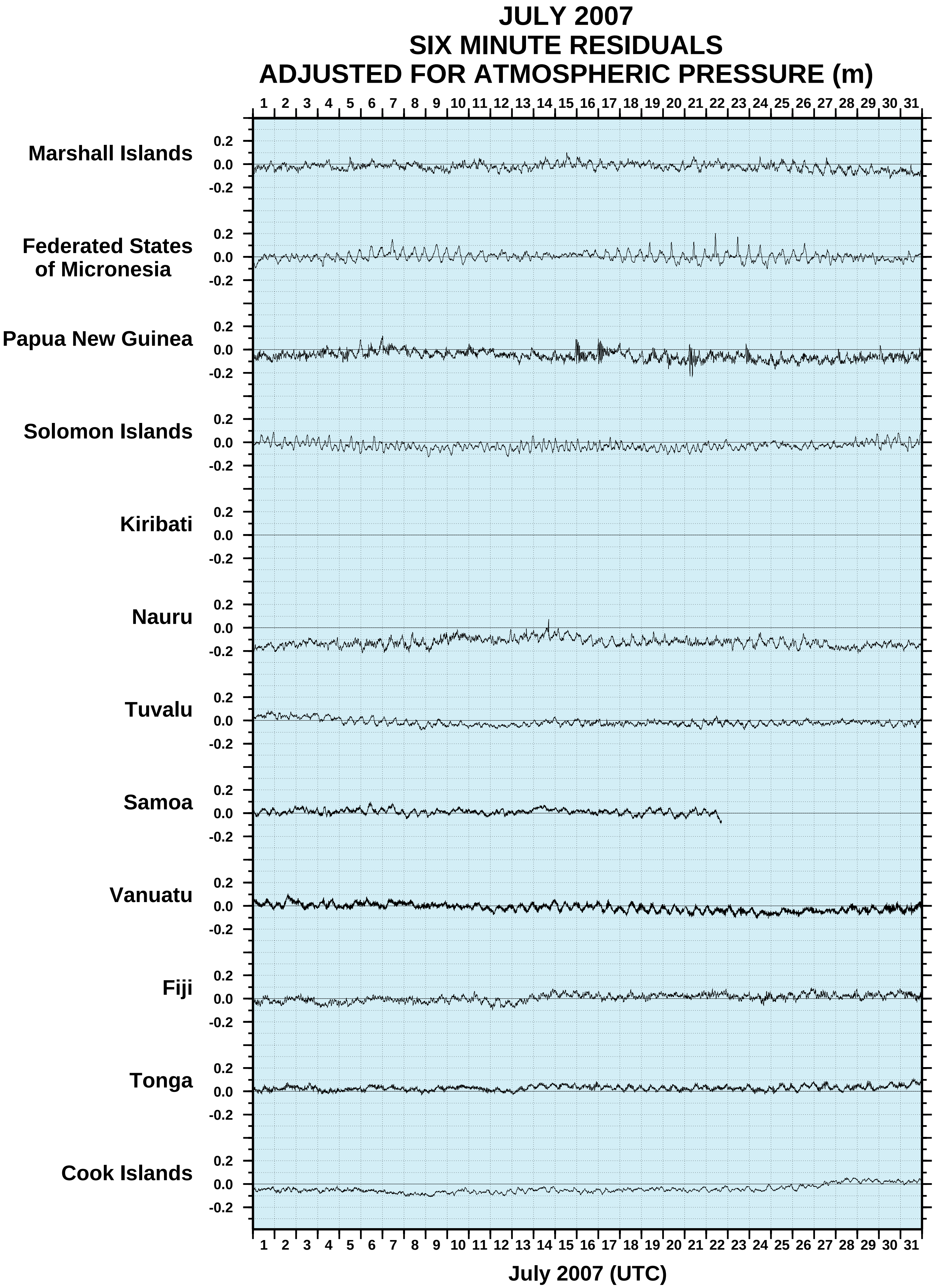
JULY 2007
SIX MINUTE RESIDUALS
ADJUSTED FOR ATMOSPHERIC PRESSURE (m)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0.2
0.0
-0.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July 2007 (UTC)

Figure 4

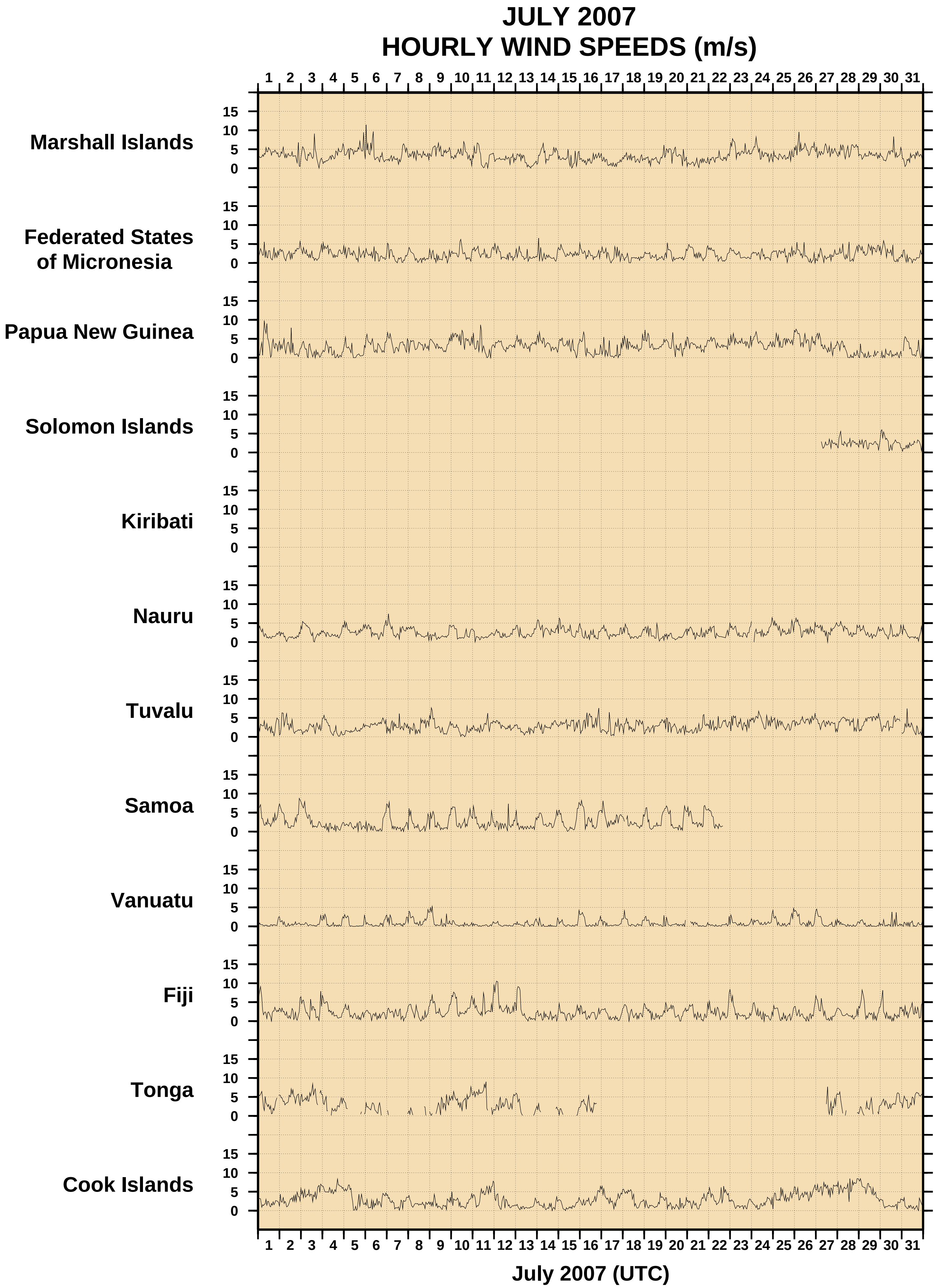
JULY 2007
HOURLY WIND SPEEDS (m/s)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
15
10
5
0
July 2007 (UTC)

Figure 5

JULY 2007

HOURLY INCIDENT WINDS (m/s, deg True)

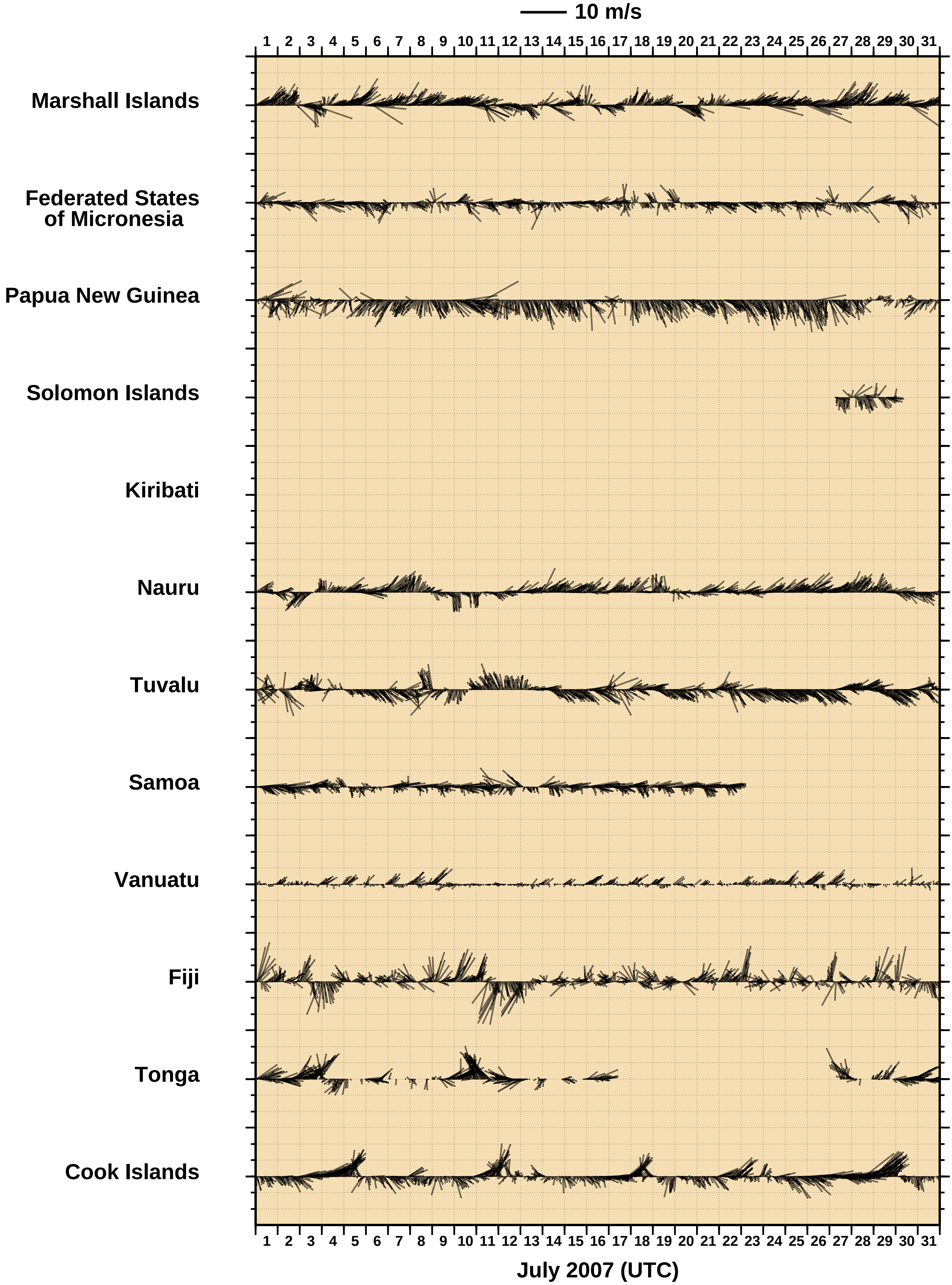

Figure 6

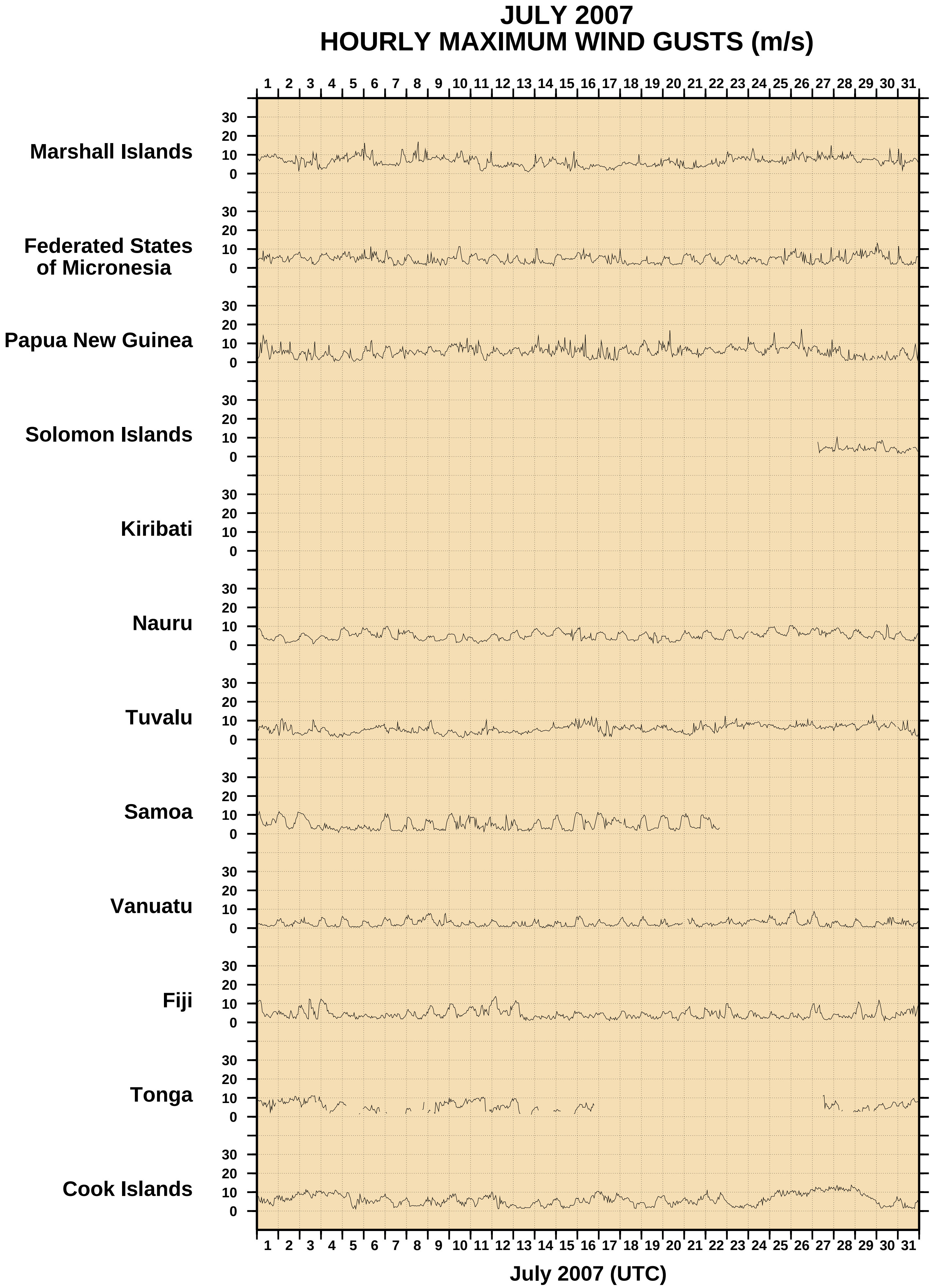
JULY 2007
HOURLY MAXIMUM WIND GUSTS (m/s)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0
10
20
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July 2007 (UTC)

Figure 7

JULY 2007
HOURLY AIR TEMPERATURES (°C)

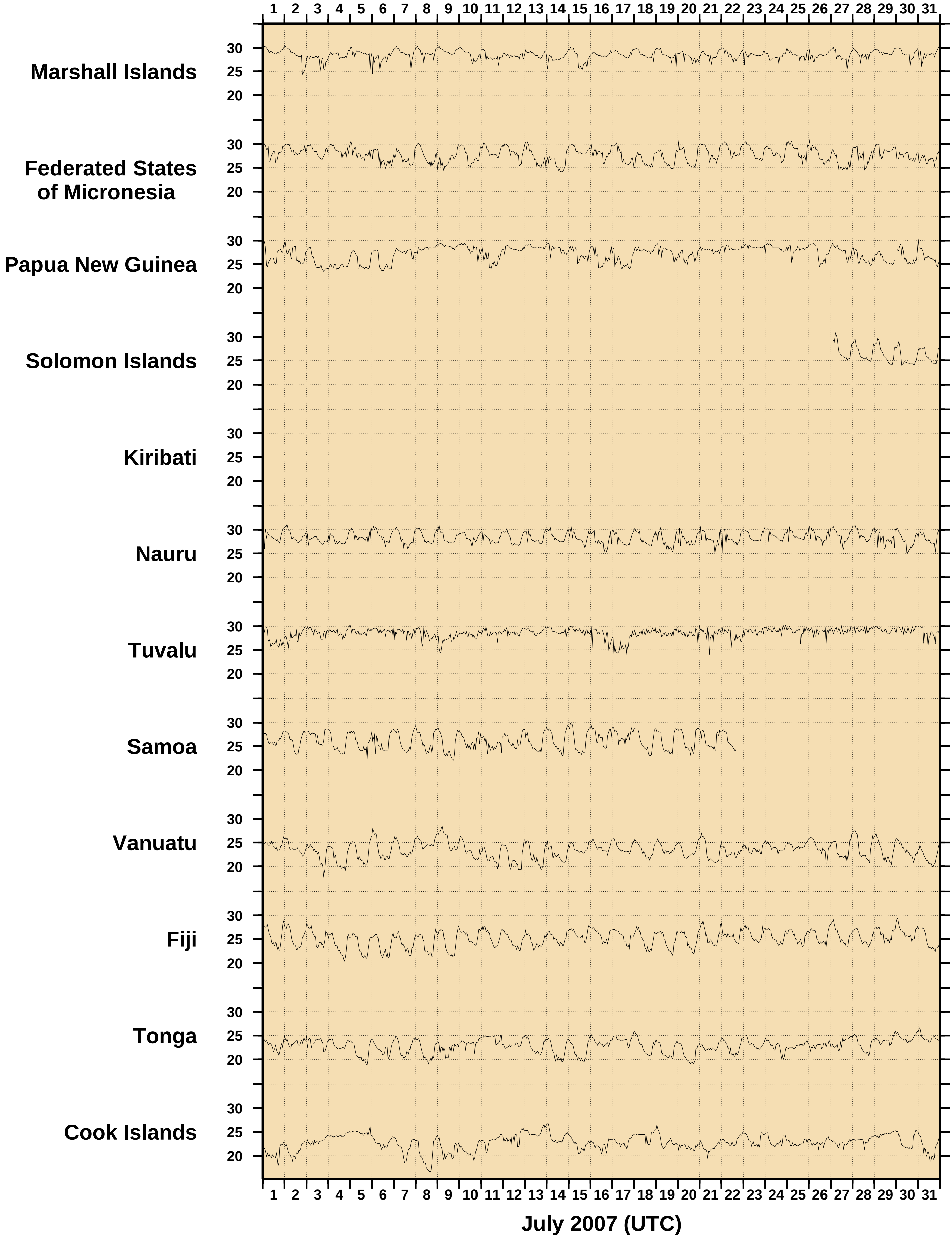

Figure 8

JULY 2007
HOURLY WATER TEMPERATURES (˚C)

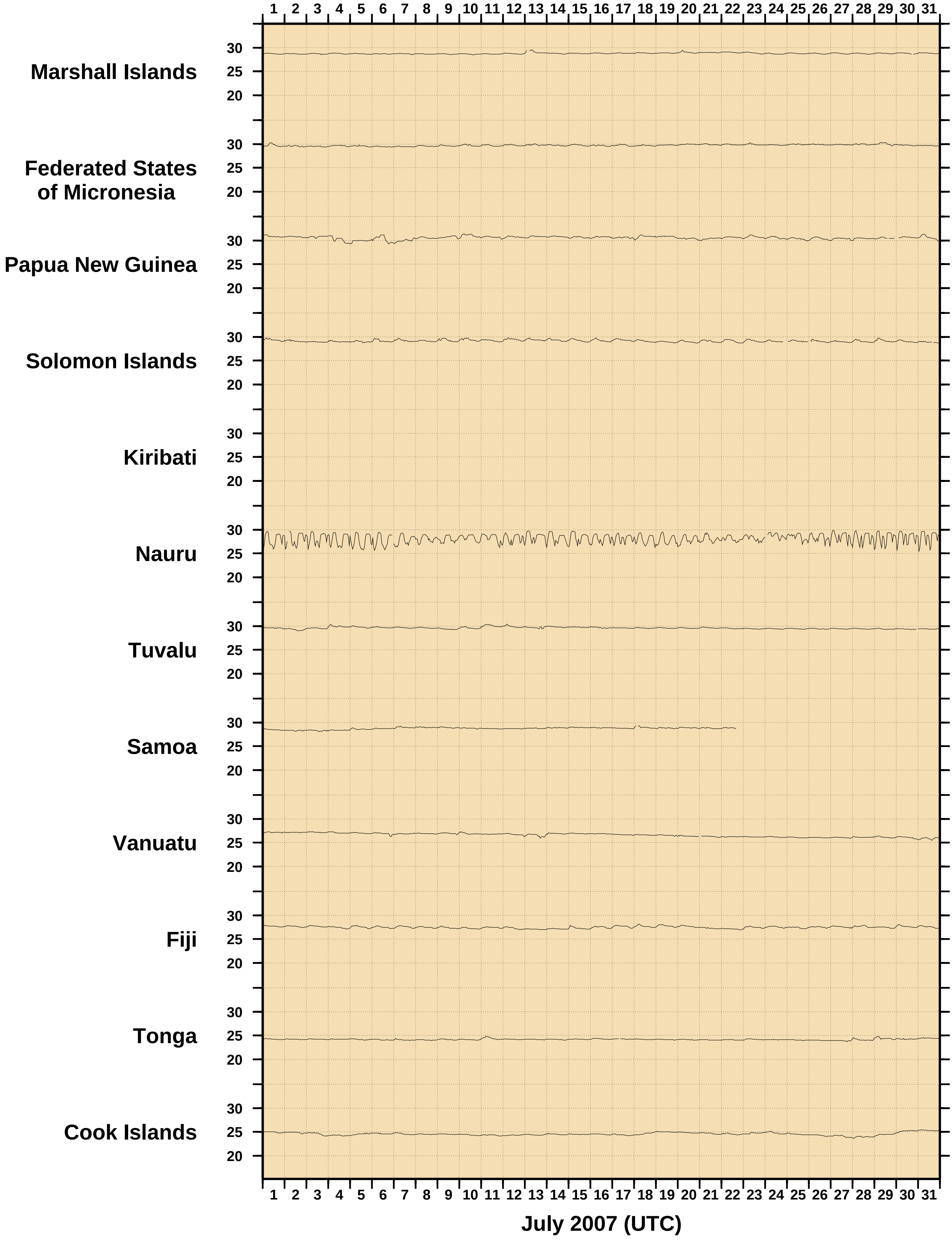

Figure 9

JULY 2007
HOURLY ATMOSPHERIC PRESSURE (hPa)

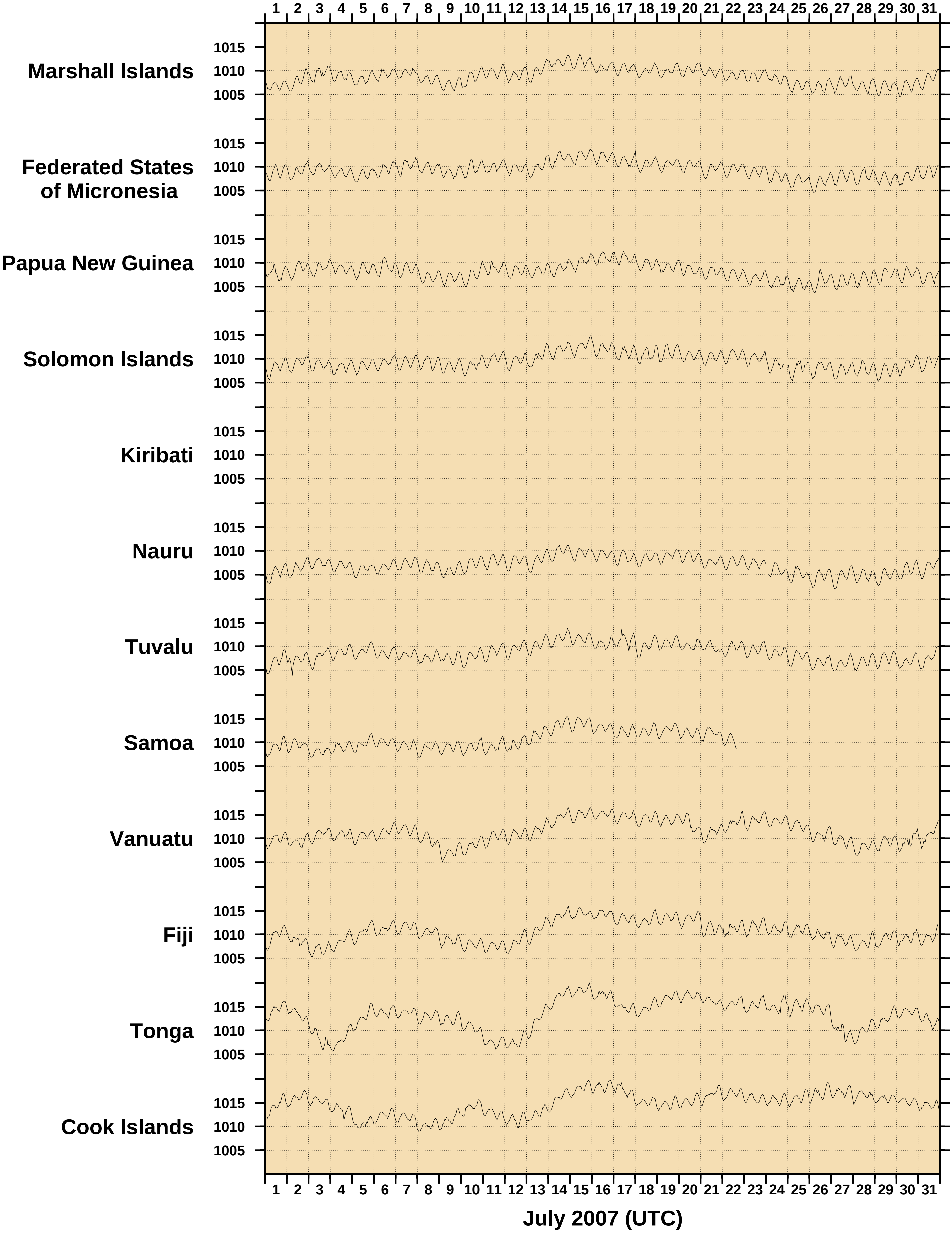

Figure 10

Comparison of July 2007 Max, Min & Mean with Long Term July Values

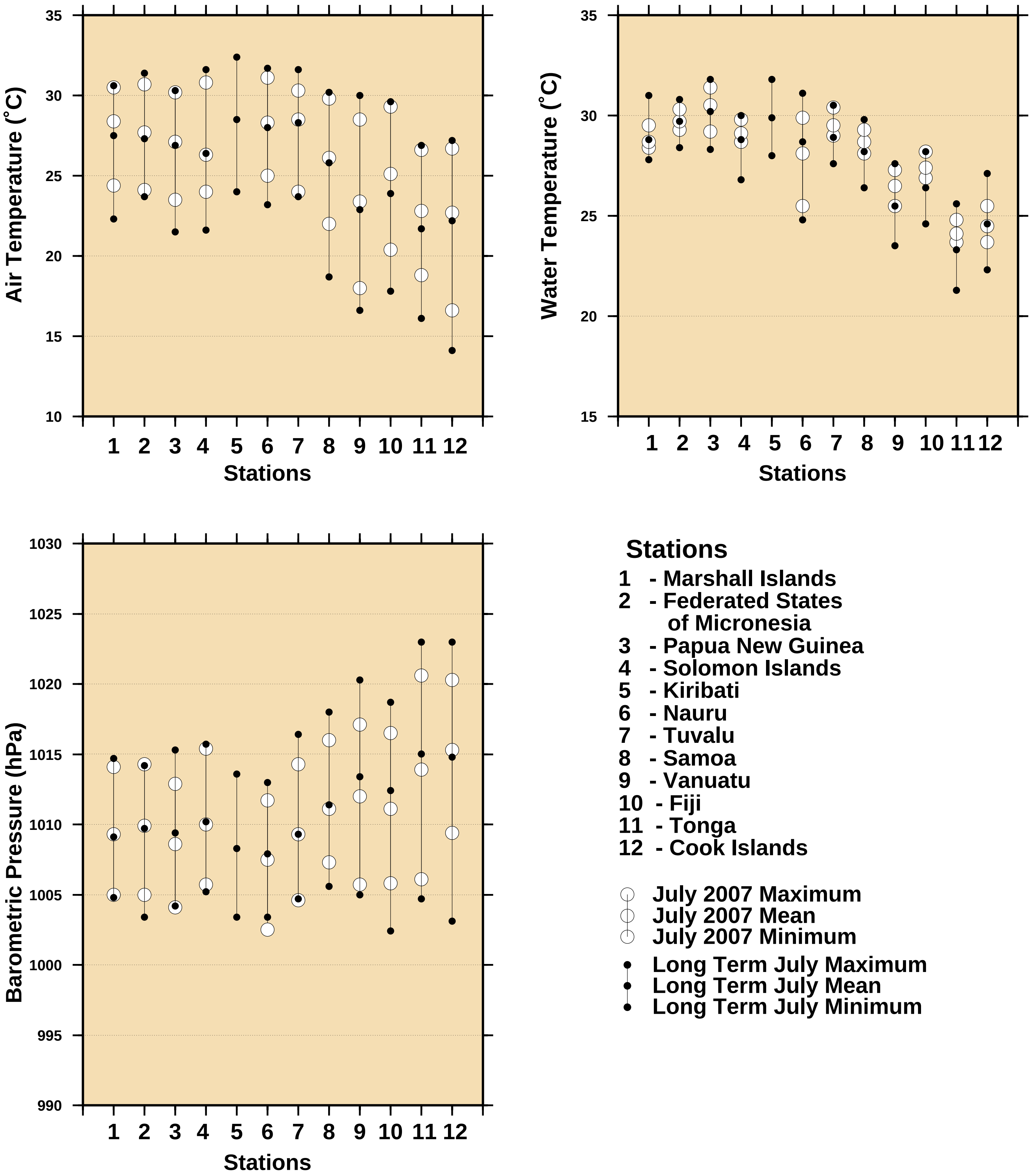

Figure 11

MONTHLY MEAN SEA LEVELS TO JULY 2007 (m)

The zero line represents an arbitrary fixed offset from the zero of the tide gauge.

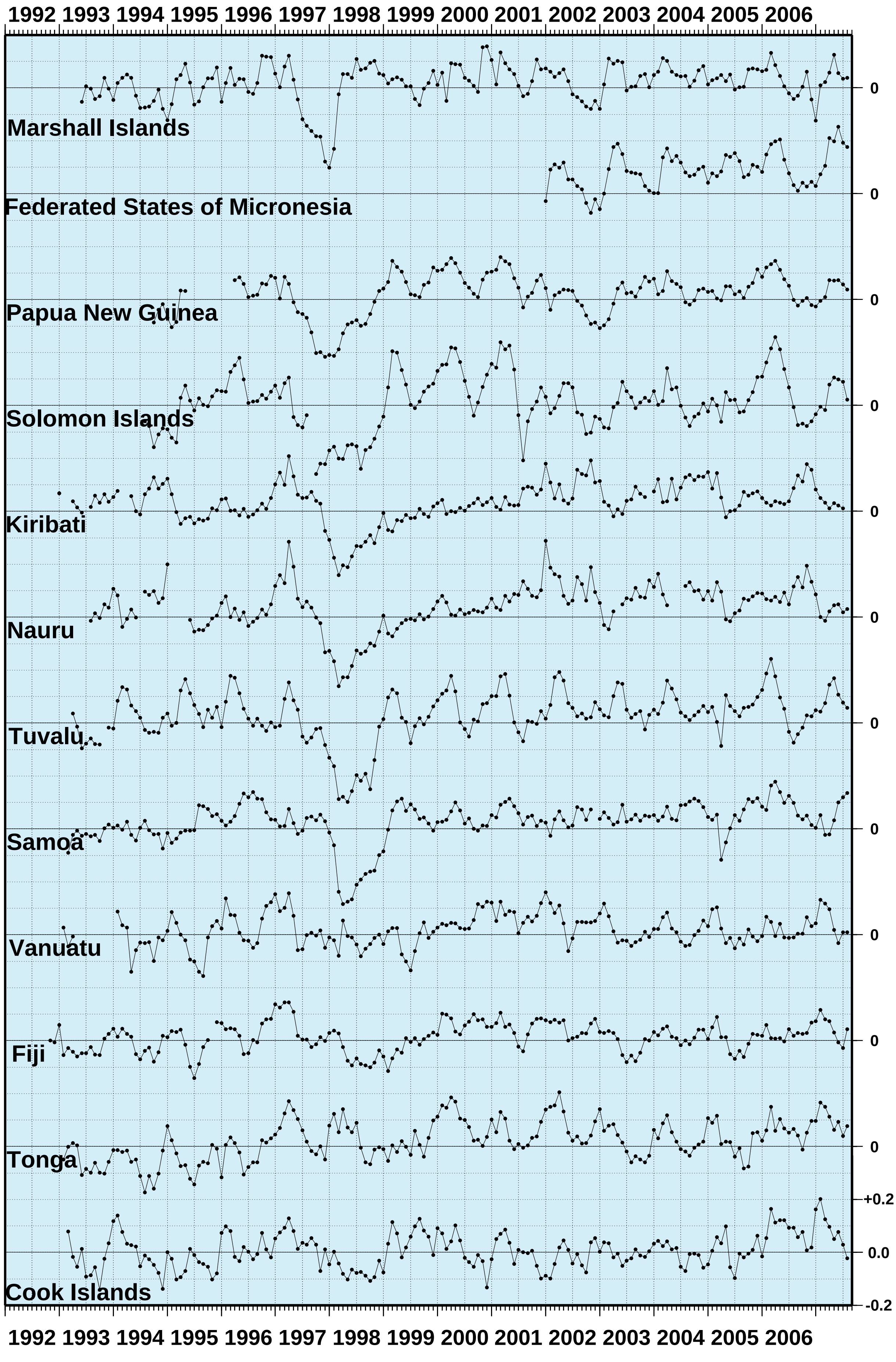

Figure 12

SEA LEVEL ANOMALIES THROUGH JULY 2007 (m)

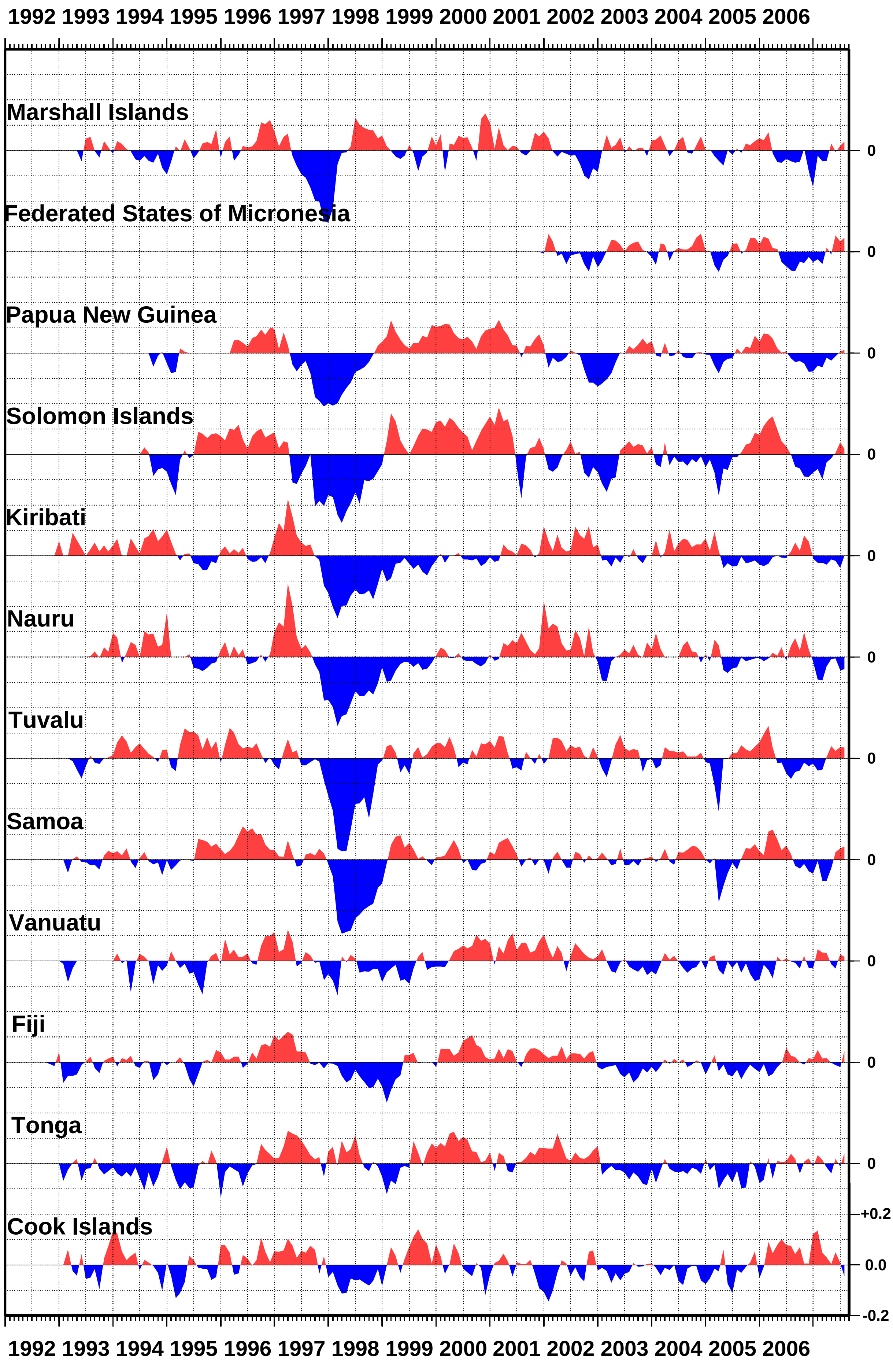

Figure 13

SEA LEVEL TRENDS THROUGH JULY 2007 (mm/year)

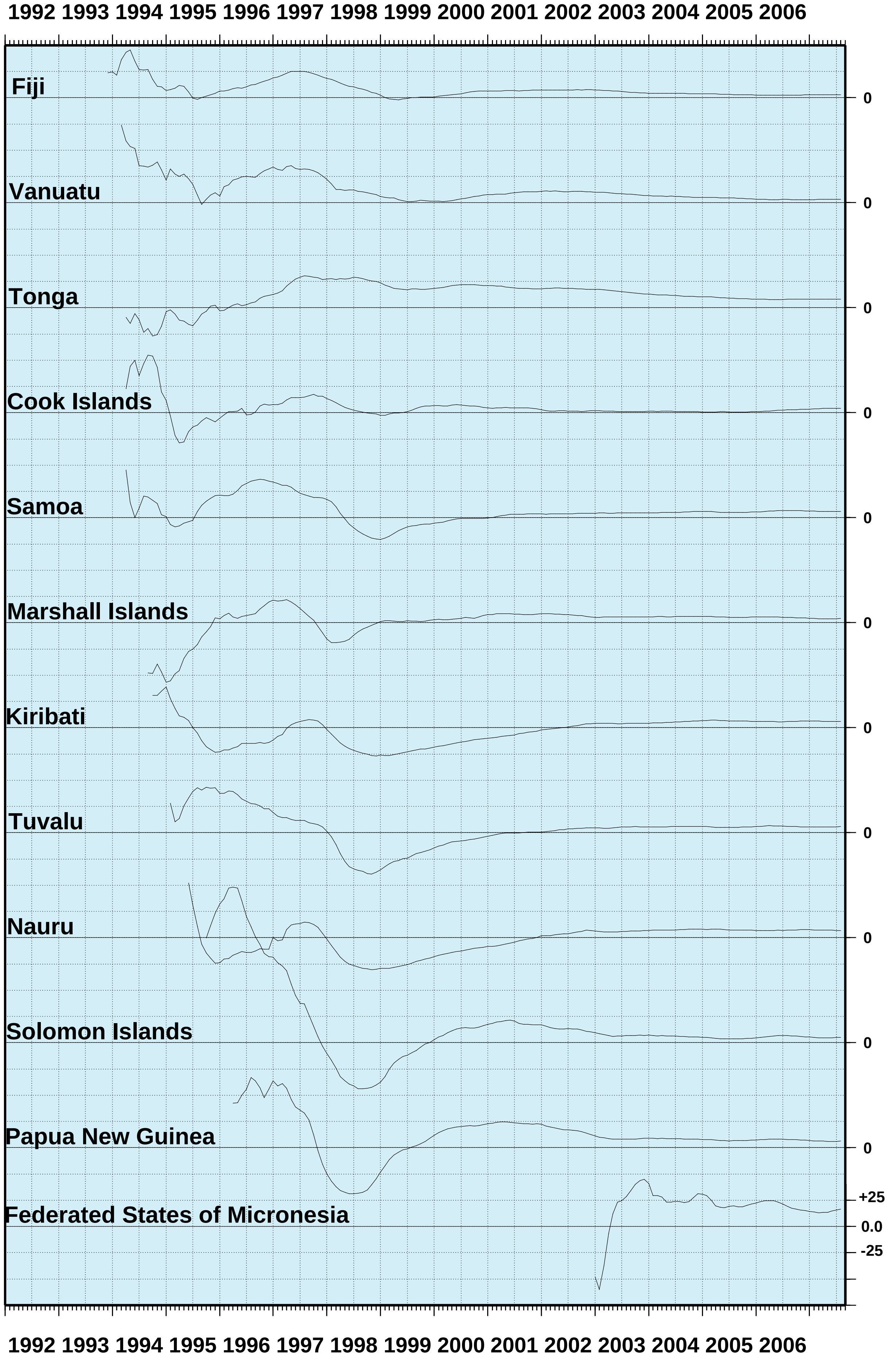

Figure 14

BARAMETRIC PRESSURE ANOMALIES THROUGH JULY 2007 (hPa)

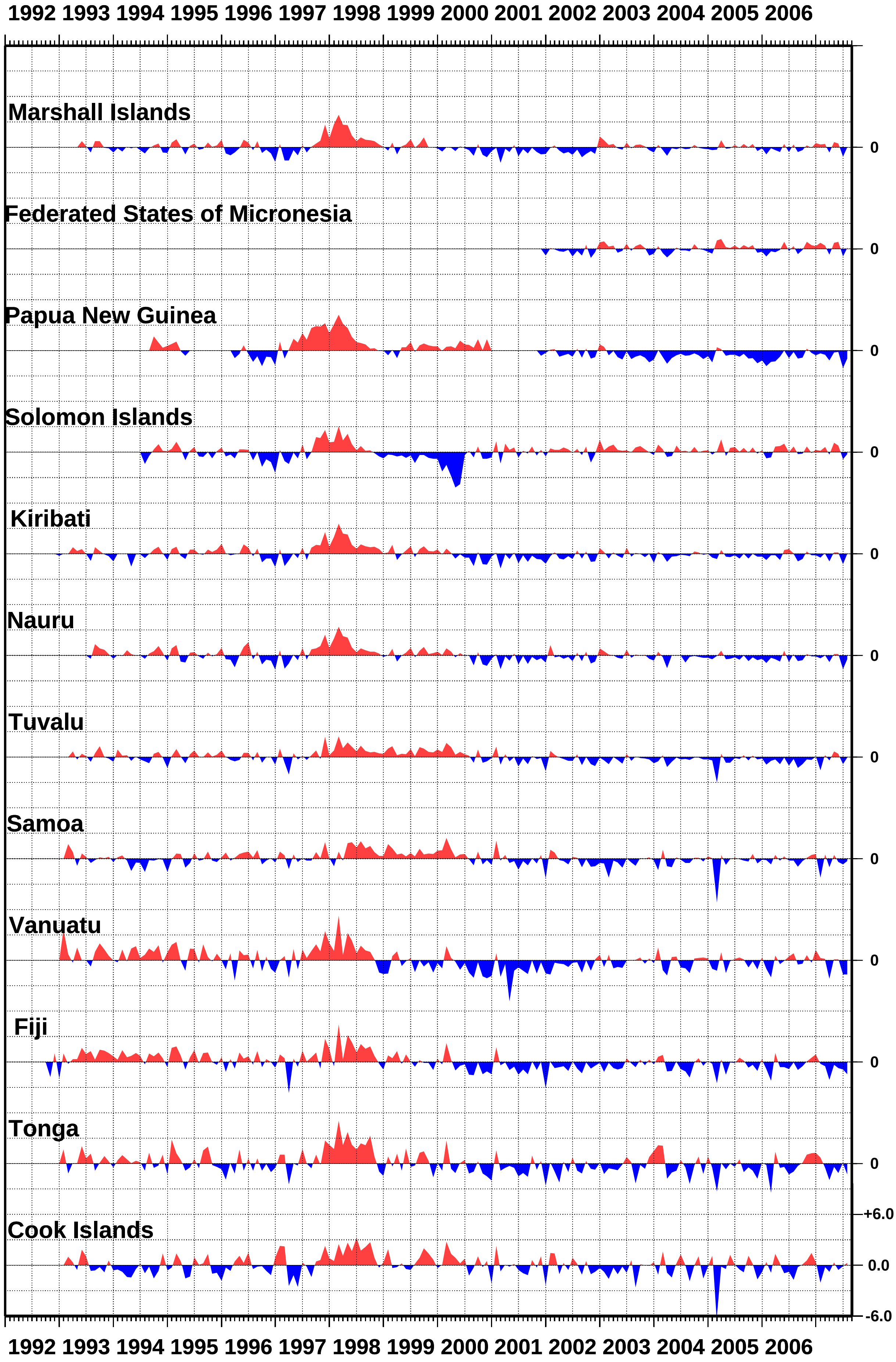

Figure 15

WATER TEMPERATURE ANOMALIES THROUGH JULY 2007 (°C)

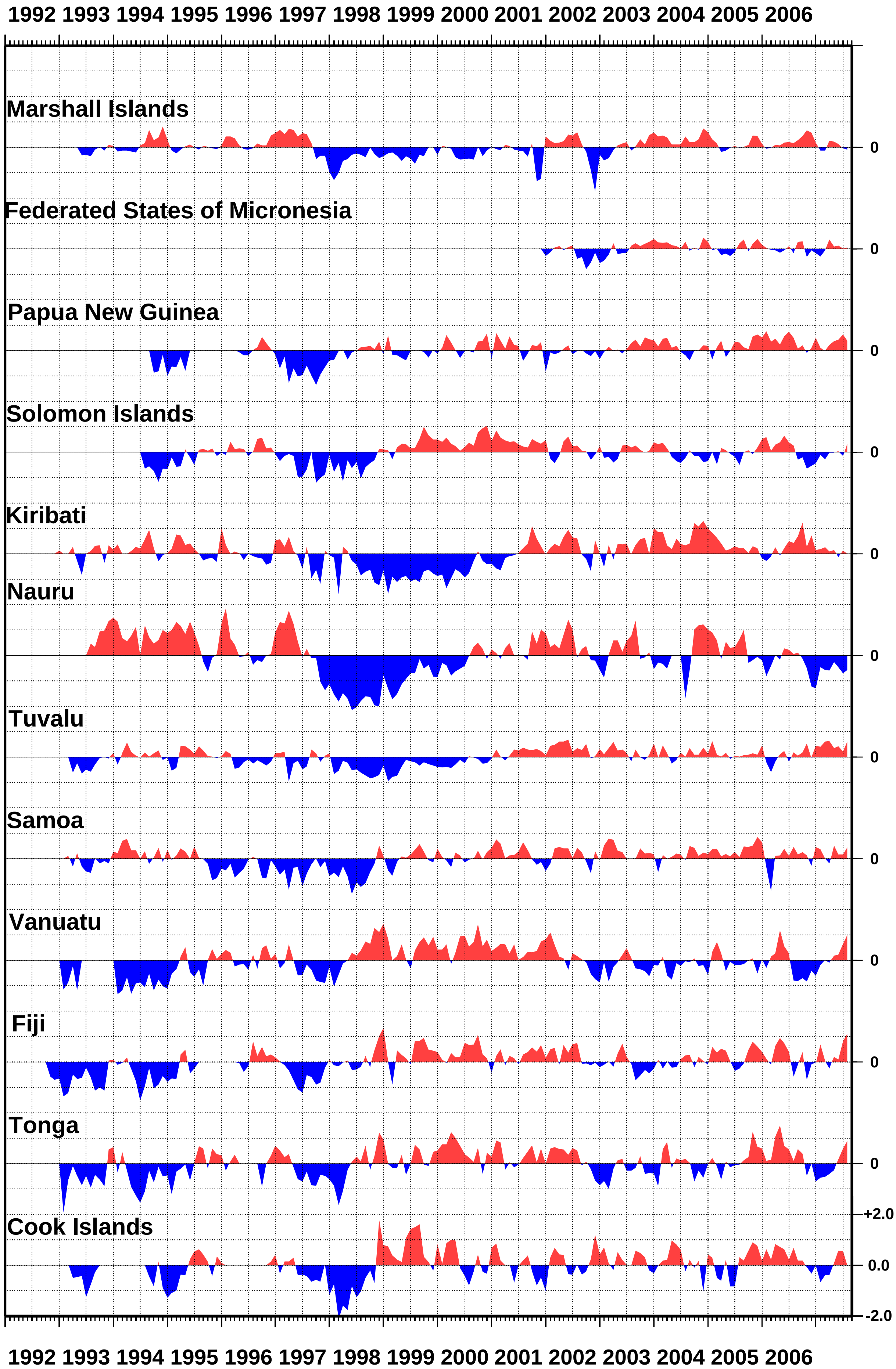

Figure 16

AIR TEMPERATURE ANOMALIES THROUGH JULY 2007 (°C)

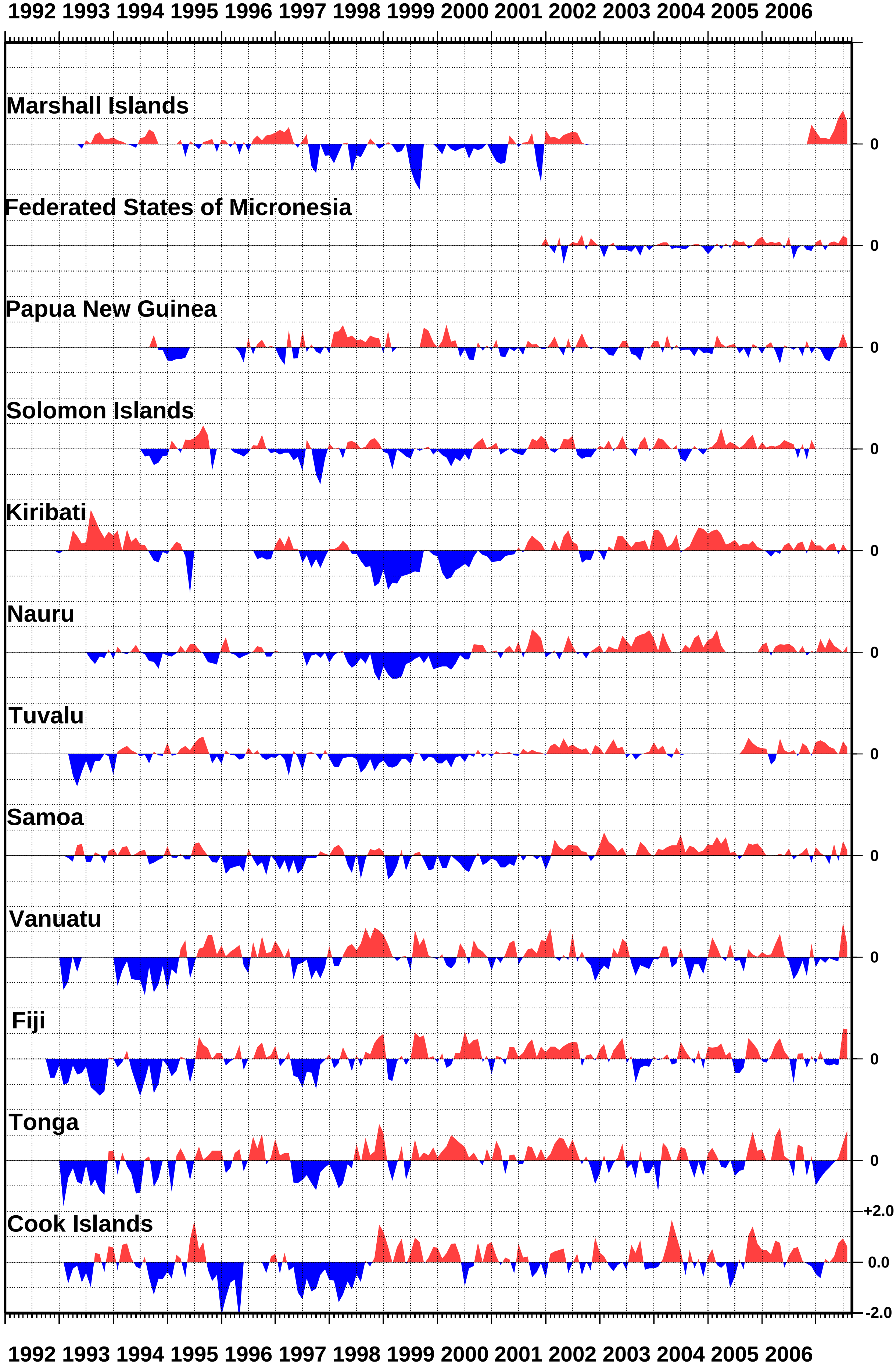

Figure 17

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED

GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE

* Patchy record