THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 181

JULY 2010

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

Bureau of Meteorology

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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 2010 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 2010

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 2010

- The SEAFRAME network continued to collect high quality sea level and associated meteorological information for monitoring climate variability and climate change.

- Climate conditions across the tropical Pacific during July resembled the early stages of a La Niña event. Cooler than normal ocean heat content across the equatorial Pacific, stronger than normal Trade Winds in the western equatorial Pacific and below average cloudiness in the vicinity of the dateline were at levels typical of La Niña.

- Sea levels across the southwest Pacific region during July were generally near normal for this time of the year, although they were depressed across the equatorial region. Sea levels at the equatorial SEAFRAME stations Kiribati and Nauru were 10cm below normal.

- The majority of international climate models predict further cooling of the tropical Pacific and the continuation of La Niña climate conditions in the coming months.

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, 2010				
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	+4.9	0.0
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+9.1	-0.1
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+5.3	-0.1
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+6.4	0.0
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+5.1	0.0
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+3.8	0.0
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+3.6	-0.2
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+4.4	-0.2
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+5.8	0.0
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+6.4	0.0
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+14.2	-0.1
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+3.8	0.0

INTRODUCTION

Welcome to the July 2010 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 stations 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. Support was provided for the installation of SEAFRAME monitoring stations across the South Pacific Forum region.

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, which 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.

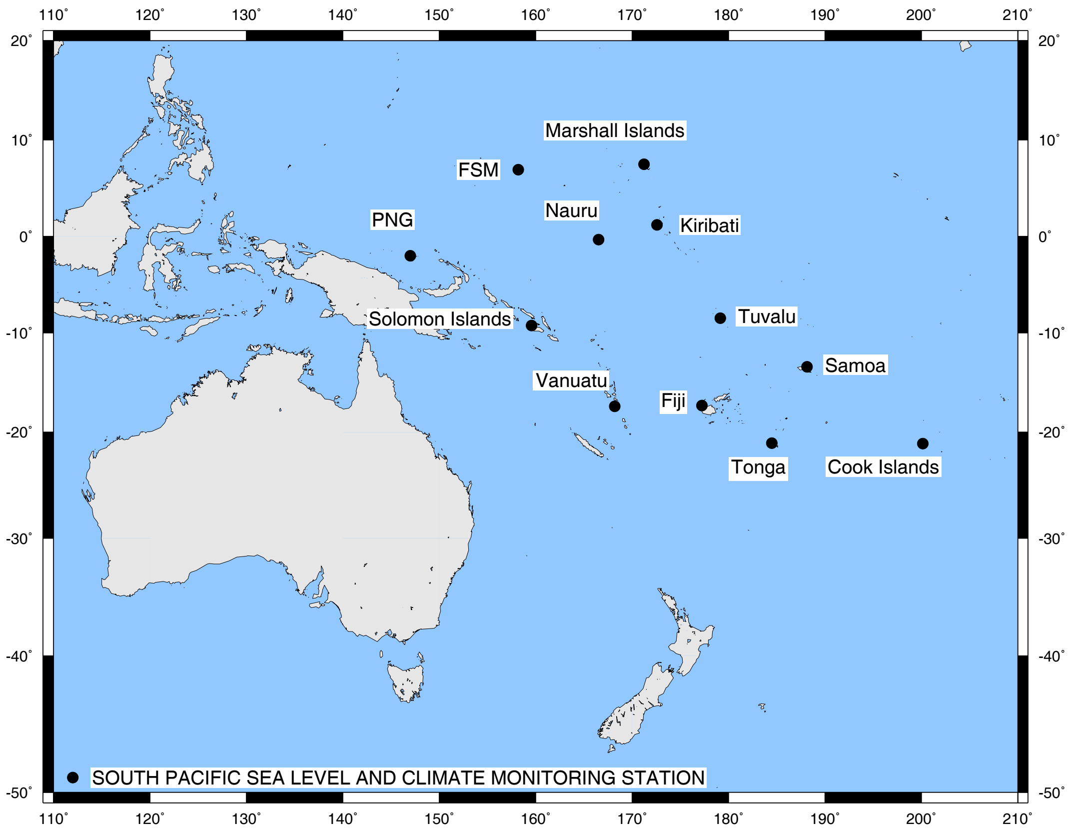

Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

JULY CLIMATOLOGY

Climate conditions across the equatorial Pacific during July resembled the early stages of a La Niña event. Cooler than normal sea surface temperatures across the equatorial Pacific, stronger than normal Trade Winds, enhanced cloudiness in the central equatorial Pacific and positive values of the Southern Oscillation Index (SOI) have been developing over several months and reached La Niña thresholds in July. International climate models predict that Pacific Ocean temperatures will continue to cool in the coming months and La Niña conditions will strengthen.

The Southern Oscillation Index (SOI) has remained positive since April, and increased to +21 in July following the June value of +2 (**Figure B**). Sustained positive values of the SOI above +8 are typical of La Niña, while sustained negative values below –8 are typical of El Niño.

Sea surface temperatures during July continued to cool across the central and eastern equatorial Pacific where they reached more than 1ºC below normal. Warm sea surface temperature anomalies were observed in the far western equatorial Pacific and southwest Pacific region (**Figure C**).

Subsurface ocean temperatures across the central and eastern equatorial Pacific remained considerably cooler than normal through July, with anomalies below -3ºC being observed in some areas. Subsurface ocean temperatures across the equatorial Pacific have been in decline since December and cooler than normal since April 2010 (**Figure D**).

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 in the central equatorial Pacific particularly near the dateline. During La Niña (cold-episode) conditions there is a reversal of this situation, with stronger Trade Winds and a decrease in cloudiness in the central Pacific. During July 2010 Trade Winds were stronger than normal in the western Pacific and of near-average strength in the central and eastern Pacific (**Figure E**). Cloudiness near the dateline was below average during July and has been suppressed since late April.

The consensus among international computer models surveyed by the Bureau of Meteorology predict further cooling of the tropical Pacific over the coming months and La Niña conditions are expected to remain until the latter part of the year.

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/.

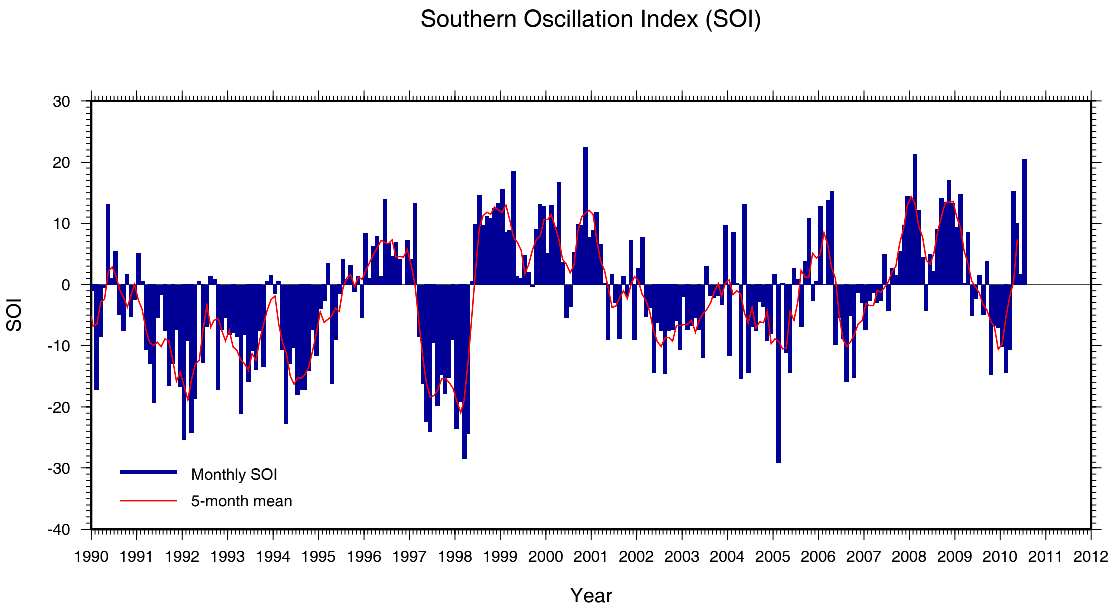

Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the long-term standard deviation of that difference for the relevant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

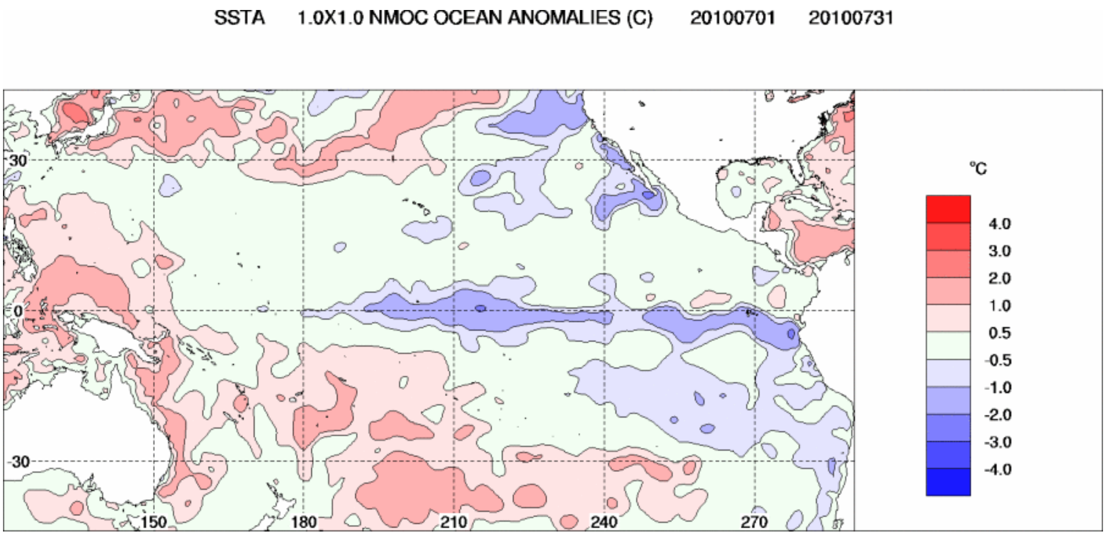

Figure C: *Sea surface temperature anomaly (°C) for July 2010.*

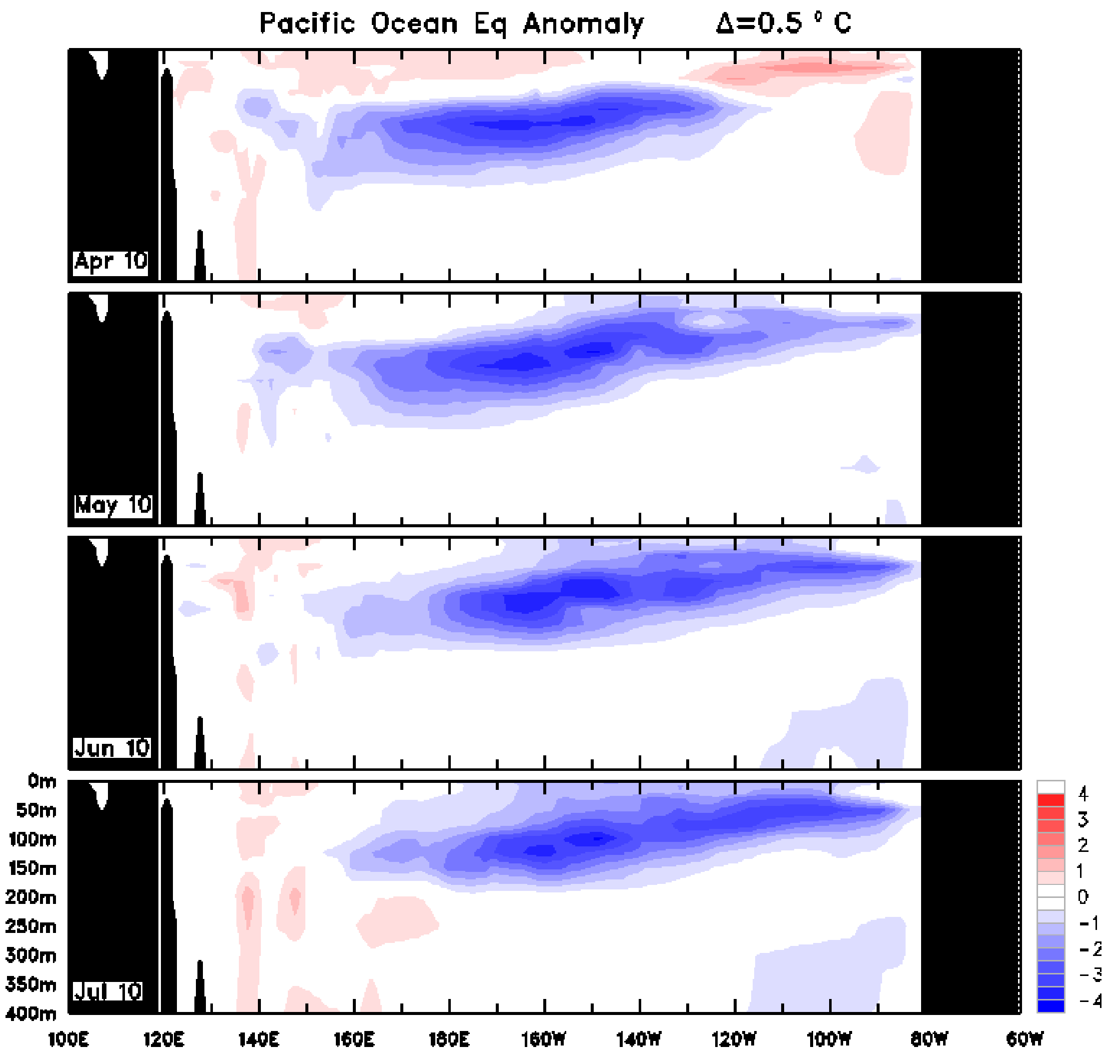

Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for April 2010 through to July 2010. Contour interval is 0.5°C.*

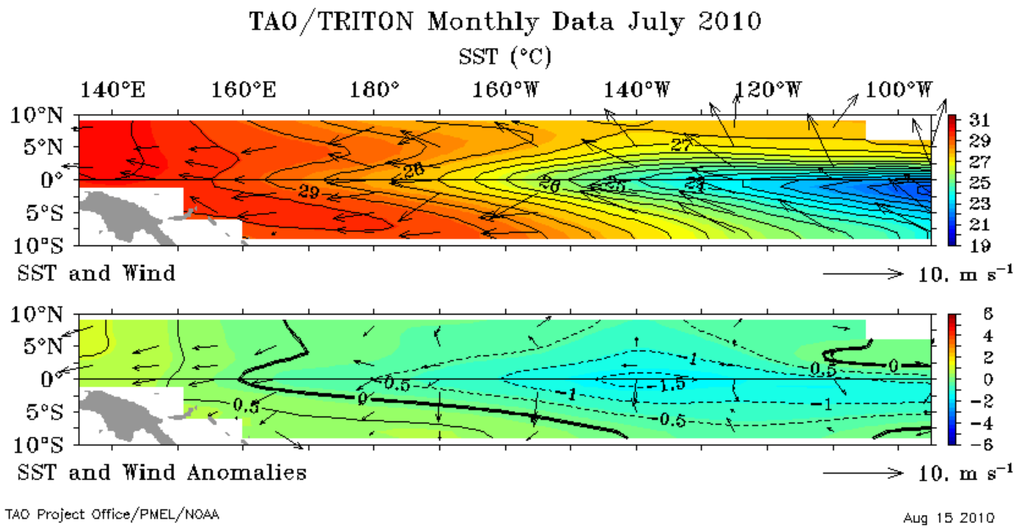

Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for July 2010. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

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 are called spring tides and tend to occur close to the full and new moon. There was a new moon on the 11th of July and a full moon on the 26th 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 highlight non-tidal sea level fluctuations, such as those due to the effects of weather or tsunamis. Tropical cyclones often produce storm surges where the combination of low barometric pressure and strong winds raise sea levels well above the predicted tides for a period of a day or more. The non-tidal sea level fluctuations can be amplified or sustained by the shape of the harbour in which the gauge is located. Some of the SEAFRAME stations are located in harbours that are favourable to persistent ‘sloshing’ under certain conditions (a phenomena referred to as a seiche), such as occurs at PNG when the wind suddenly changes strength or direction, at FSM during periods of reduced tidal range and at Nauru during strong westerly winds.

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 Marshall Islands prevailed from the northeast for most of the month.

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. At Nauru a twice-daily fluctuation in water temperature is related to the tide, as 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 farther 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 data from FSM has only been collected since December 2001.* The maximum air temperatures recorded at Solomon Islands (31.7ºC) and Tuvalu (31.7ºC) during July 2010 are the highest July air temperatures on record for those stations. Likewise the maximum water temperatures at PNG (31.9ºC) and Fiji (28.6ºC) are the highest July water temperatures on record. The maximum barometric pressure of 1014.7hPa recorded at FSM is its highest July barometric pressure on record.

Mean Sea Level and Anomalies (Figures 11-13)

Figure 11 shows the **monthly mean sea levels**, which are simple arithmetic averages 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 monthly mean **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.

Sea levels were near normal at most stations during July 2010. The exceptions were Kiribati and Nauru, where sea levels were around 10cm below normal due to cooler than normal subsurface temperatures and stronger than normal Trade Winds along the equator.

Sea Level Trends

The **short-term sea level trends** at individual stations as at July 2010 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*.

Recent short-term sea level trends in the project area based upon SEAFRAME data through July, 2010

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	+4.9	0.0
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Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+5.3	-0.1
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+6.4	0.0
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+5.1	0.0
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+3.8	0.0
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+3.6	-0.2
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+4.4	-0.2
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+5.8	0.0
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+6.4	0.0
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+14.2	-0.1
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+3.8	0.0

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 2010 barometric pressures were generally near to slightly above average for this time of the year.

The **water temperature anomalies (Figure 15)** show warmer than normal conditions were observed at the majority of stations during July 2010, in agreement with warmer than normal sea surface temperatures across the southwest Pacific region (Figure C). The largest anomalies of around +1.0 °C were observed at Vanuatu, Fiji and Tonga.

The **air temperature anomalies (Figure 16)** show warmer than normal air temperatures were observed at many stations during July 2010, although the anomalies are generally smaller than they were during June. Air temperatures were +1°C warmer than normal at Tonga, 0.8°C warmer than normal at PNG, 0.7°C warmer than normal at Cook Islands and within 0.5°C of what is normally observed at other stations. 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.

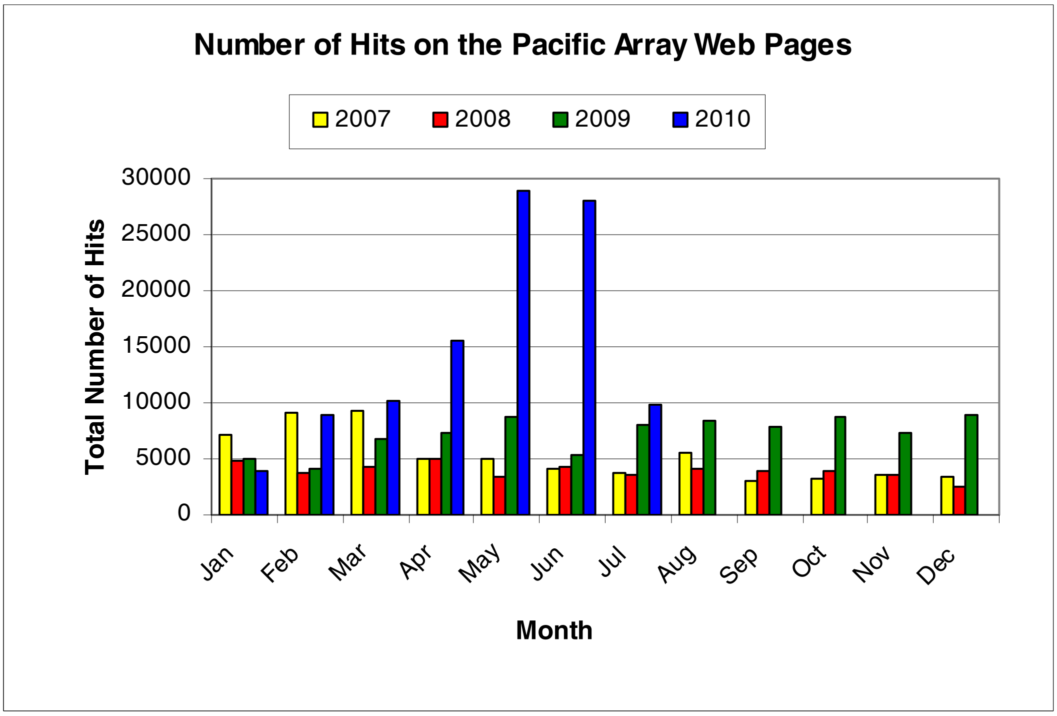
Instrument Performance

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.

Sea level data return was good for some stations during July 2010 but data collection problems were encountered at Samoa, Cook Islands, Tuvalu and Fiji. Power supply problems disrupted operations at Samoa from the 2nd of July and also at Fiji between the 6th and 14th of July. At Cook Islands the primary sea level sensor has been inoperative since the 2nd of June and the secondary sea level sensor has also been unreliable. At Nauru there were continuing problems with the primary sea level sensor but replacement data from the secondary sea level sensor were used. Satellite data transmissions from Tuvalu were only received intermittently, and the missing data was unable to be recovered from the dial-up modem. Data communication problems were also encountered at FSM, Nauru, PNG and Kiribati. Technical difficulties were also encountered with the ancillary sensors, including continued problems with the water temperature sensor at Kiribati and intermittent problems occurred with the wind speed sensor at Vanuatu.

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 2007.



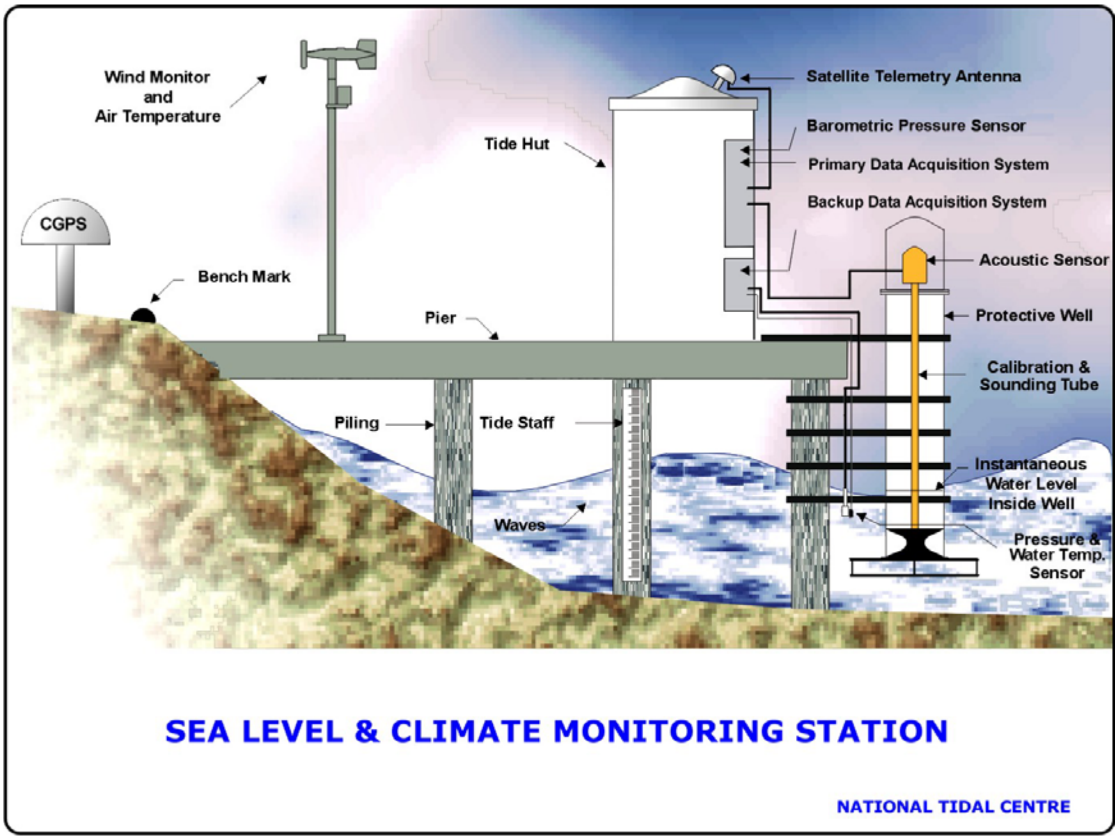
SEAFRAME STATIONS

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.



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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Fax: (+618) (08) 8366 2693
Website: http://www.bom.gov.au/oceanography/tides.shtml

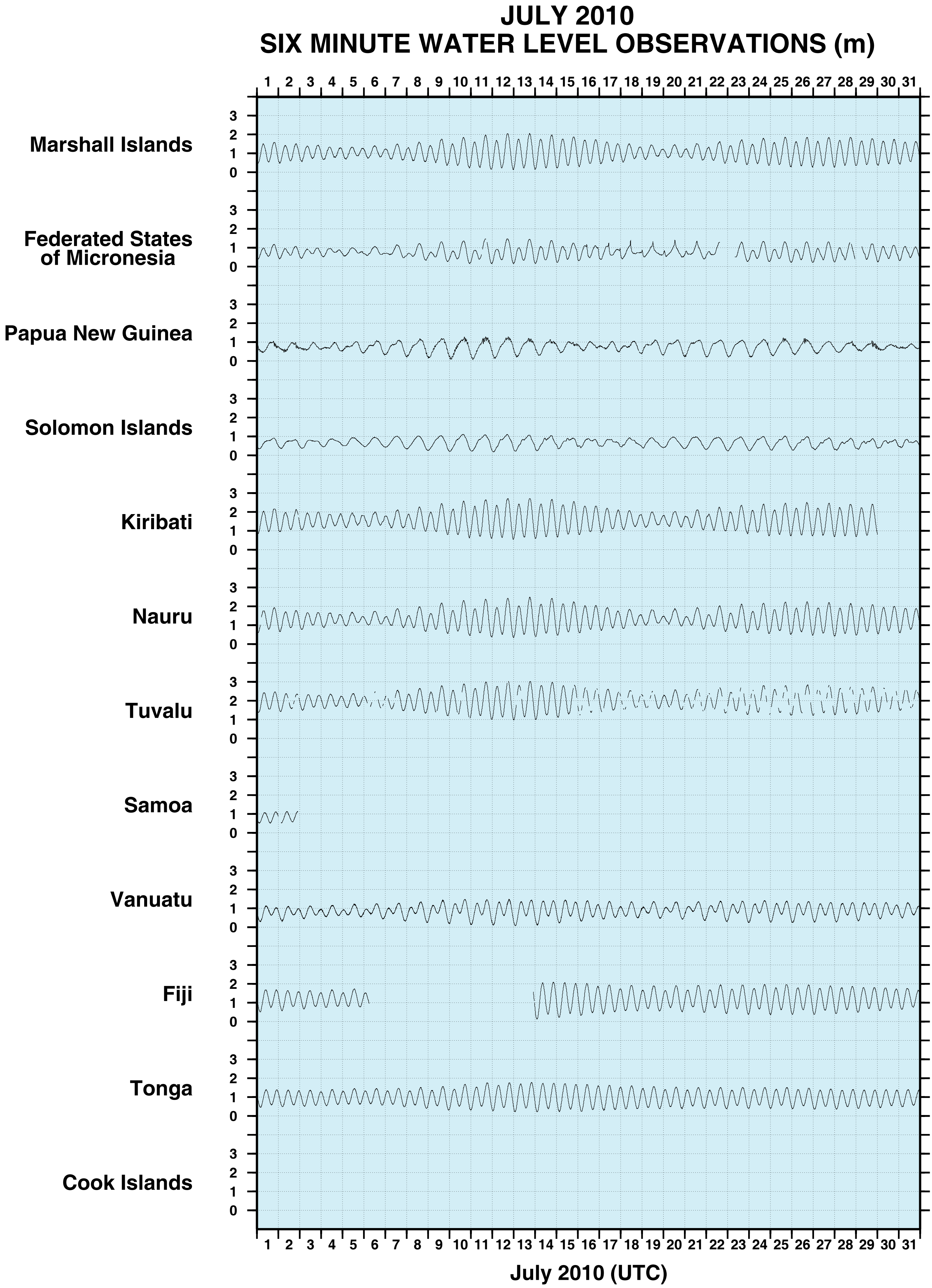
Or visit the project website at http://www.bom.gov.au/pacificsealevel

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

Please also note the following:

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 2010
SIX MINUTE WATER LEVEL OBSERVATIONS (m)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0
1
2
3
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 2010 (UTC)

Figure 2

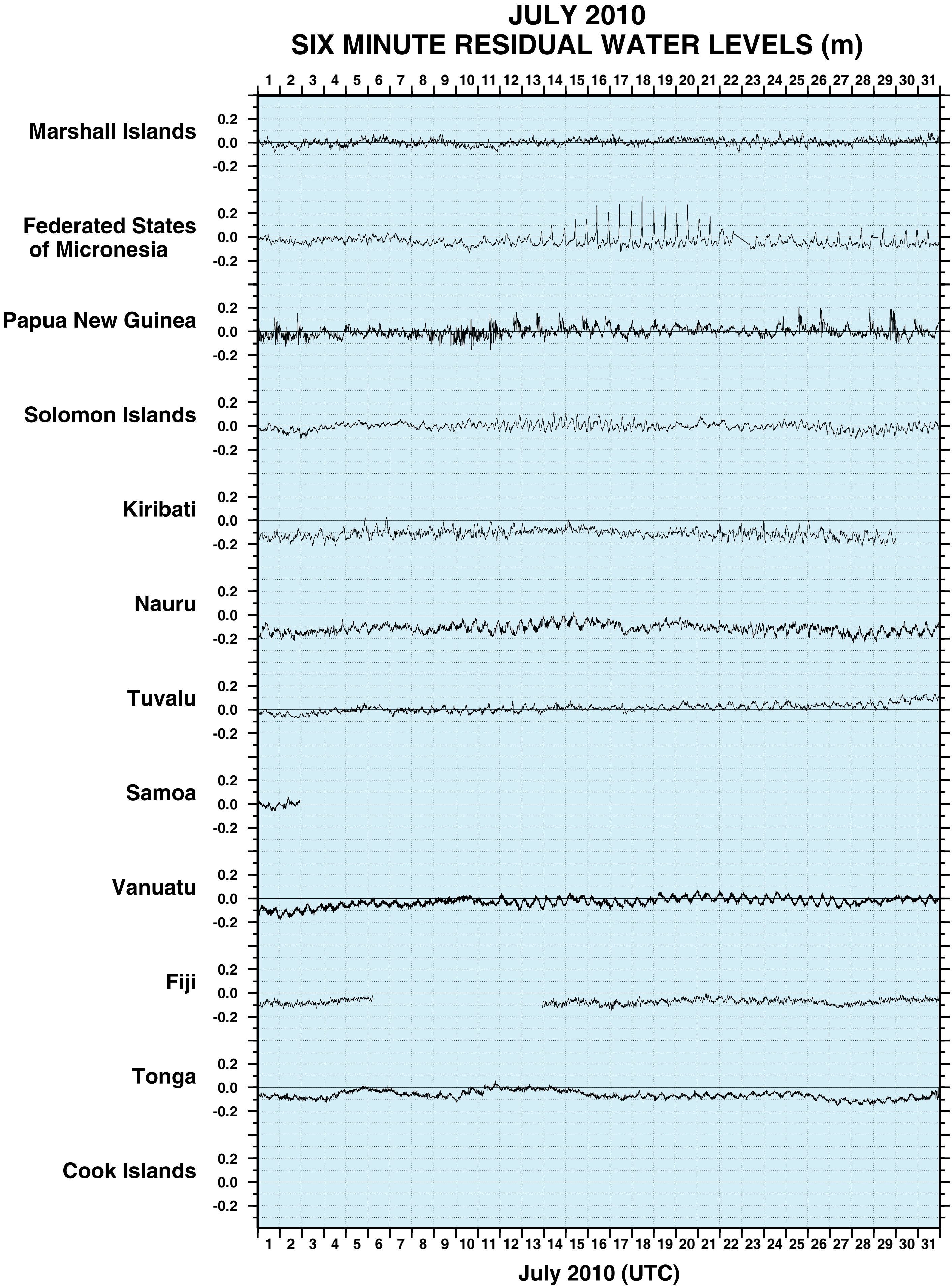

JULY 2010
SIX MINUTE RESIDUAL WATER LEVELS (m)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0.2
0.0
-0.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July 2010 (UTC)

Figure 3

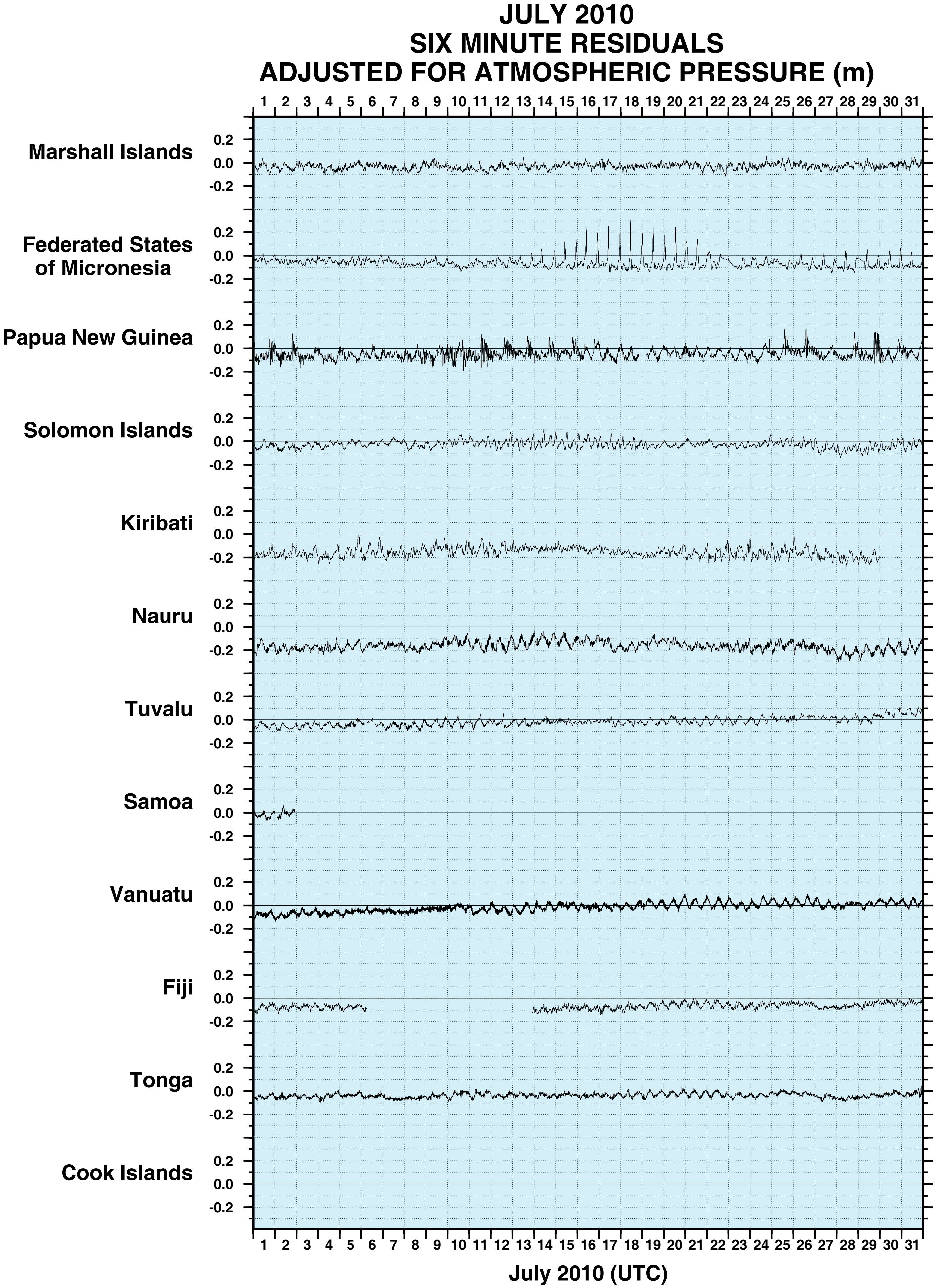
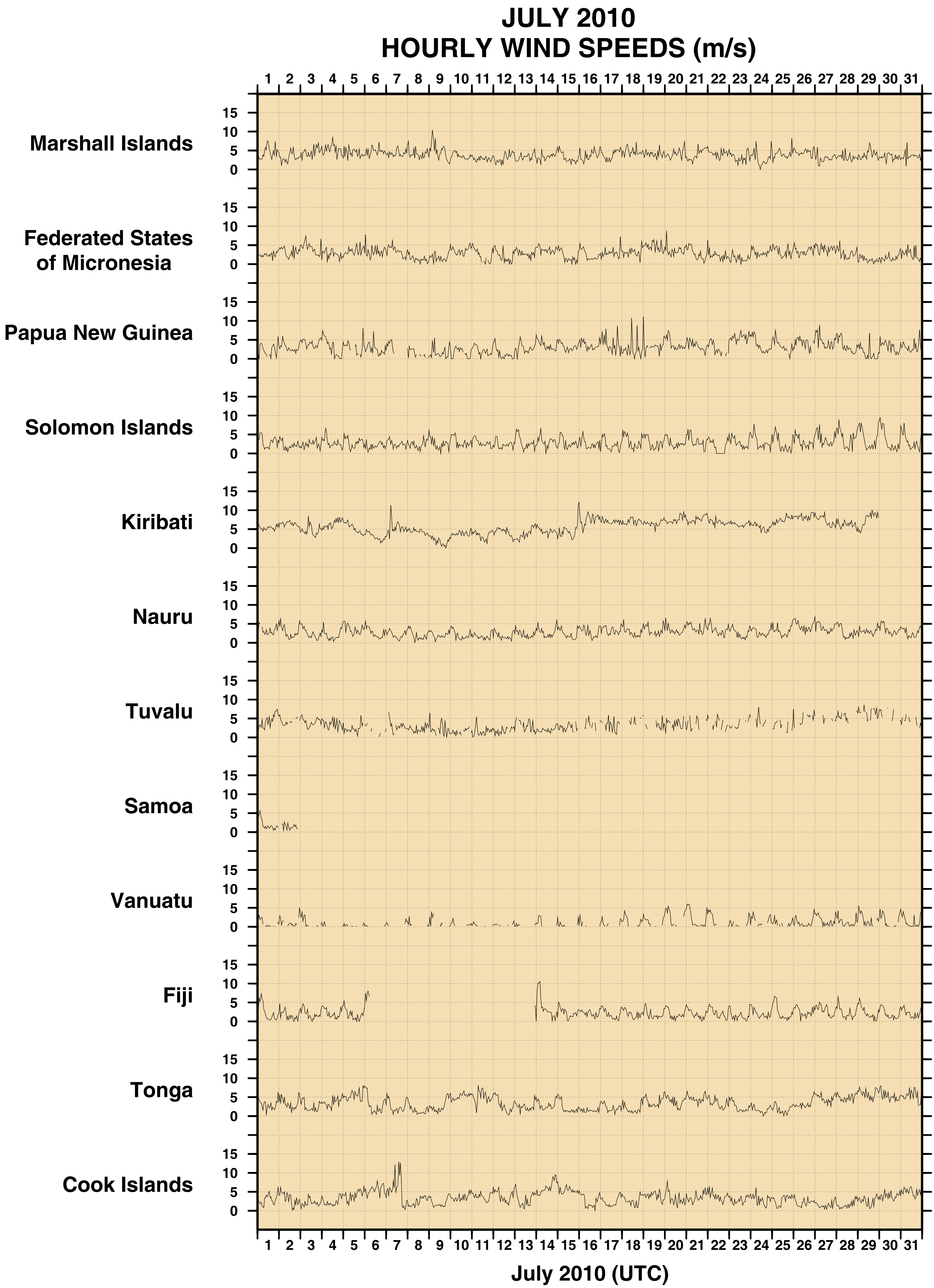

JULY 2010
SIX MINUTE RESIDUALS
ADJUSTED FOR ATMOSPHERIC PRESSURE (m)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0.2
0.0
-0.2
July 2010 (UTC)

Figure 4



JULY 2010
HOURLY WIND SPEEDS (m/s)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0
5
10
15
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 2010 (UTC)

Figure 5

JULY 2010

HOURLY INCIDENT WINDS (m/s, deg True)

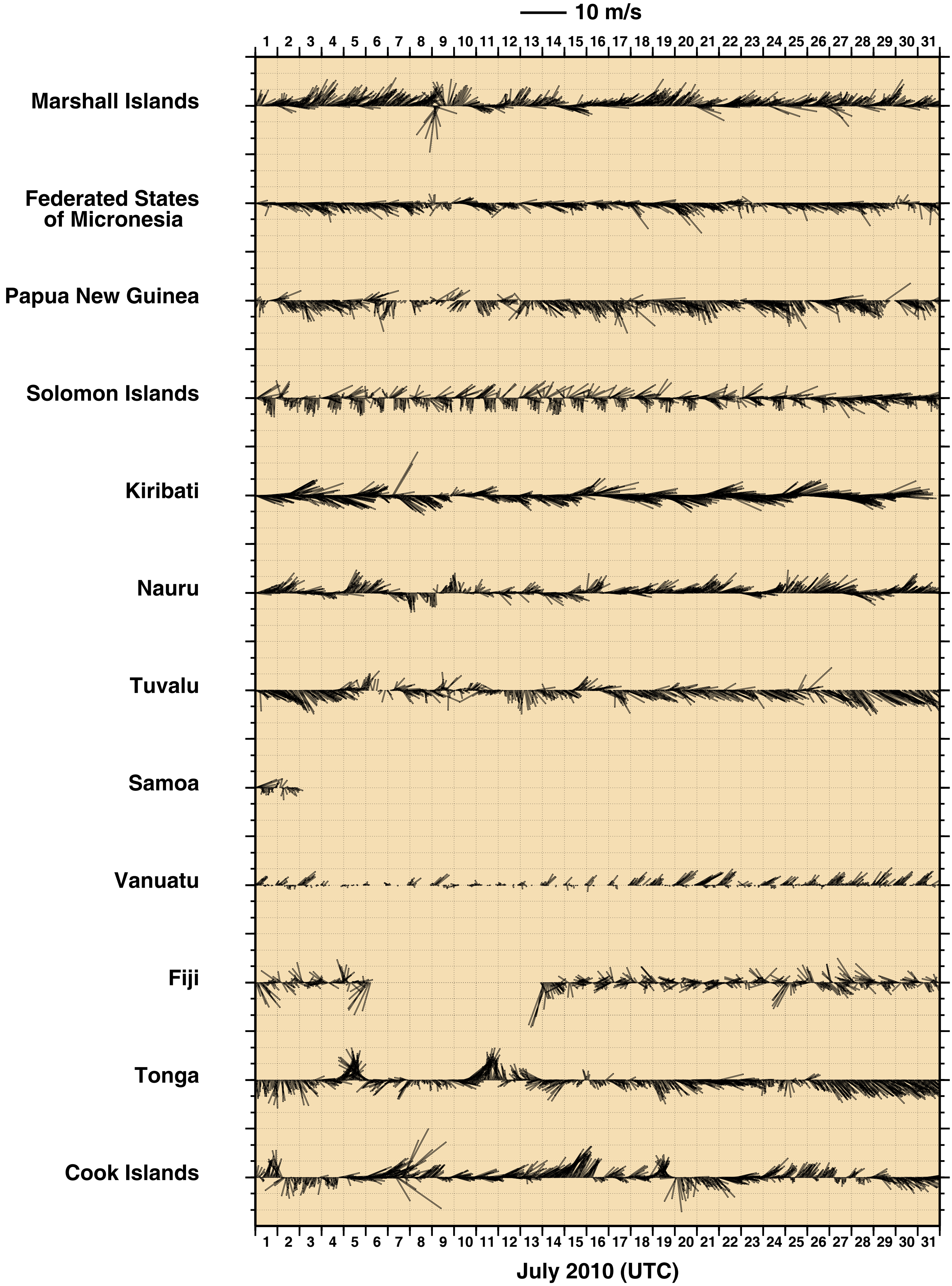


Figure 6

JULY 2010
HOURLY MAXIMUM WIND GUSTS (m/s)

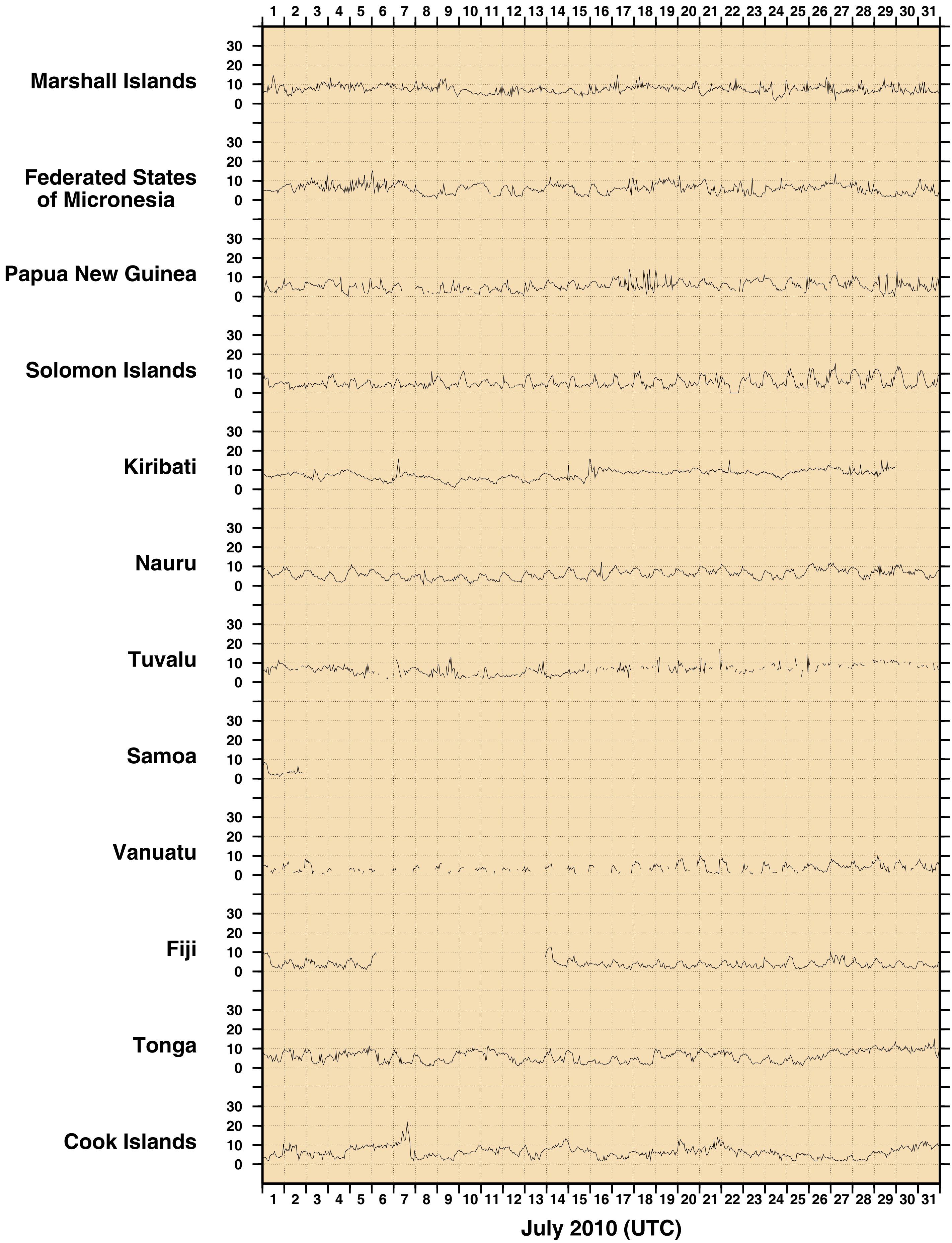


Figure 7

JULY 2010
HOURLY AIR TEMPERATURES (˚C)

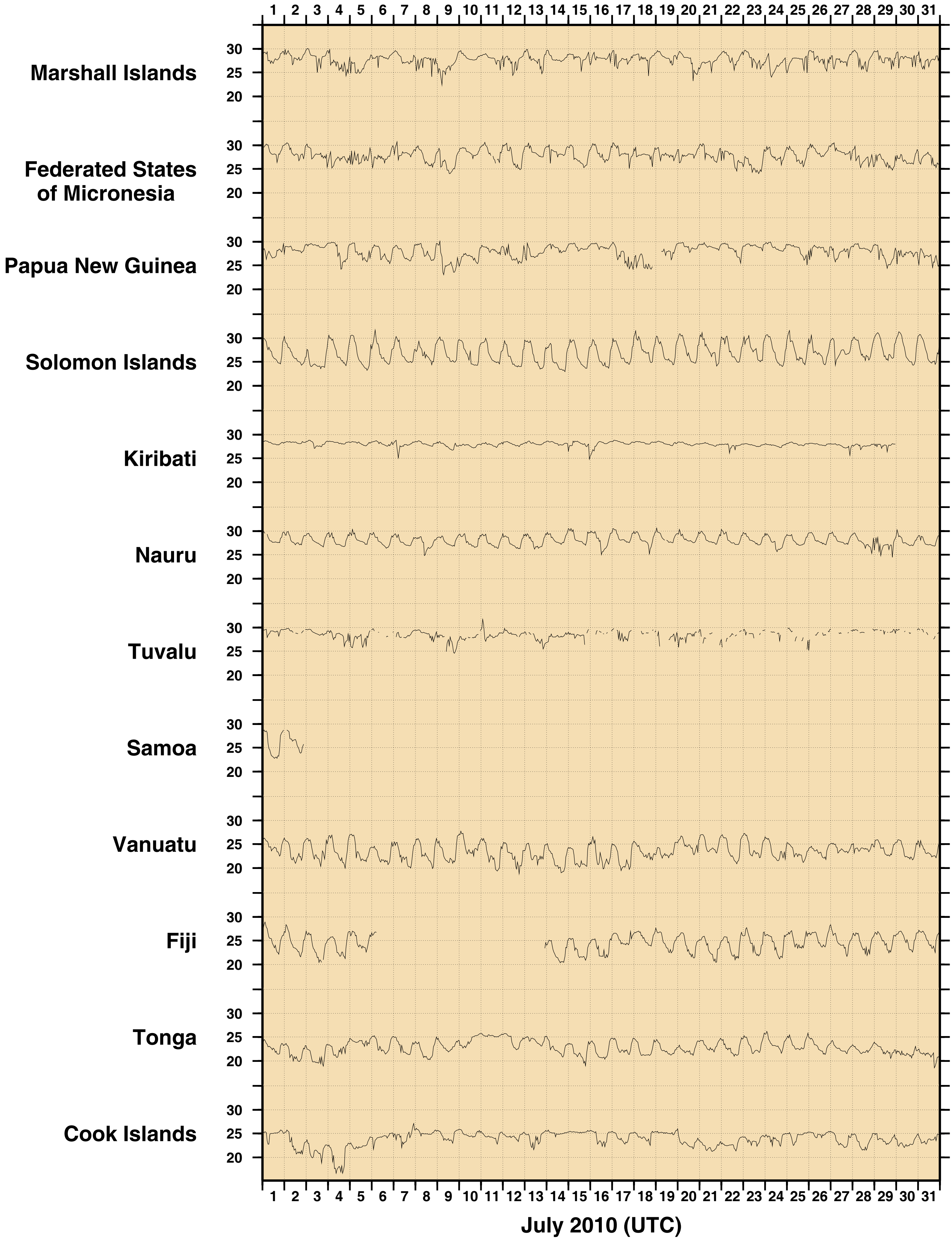


Figure 8

JULY 2010
HOURLY WATER TEMPERATURES (˚C)

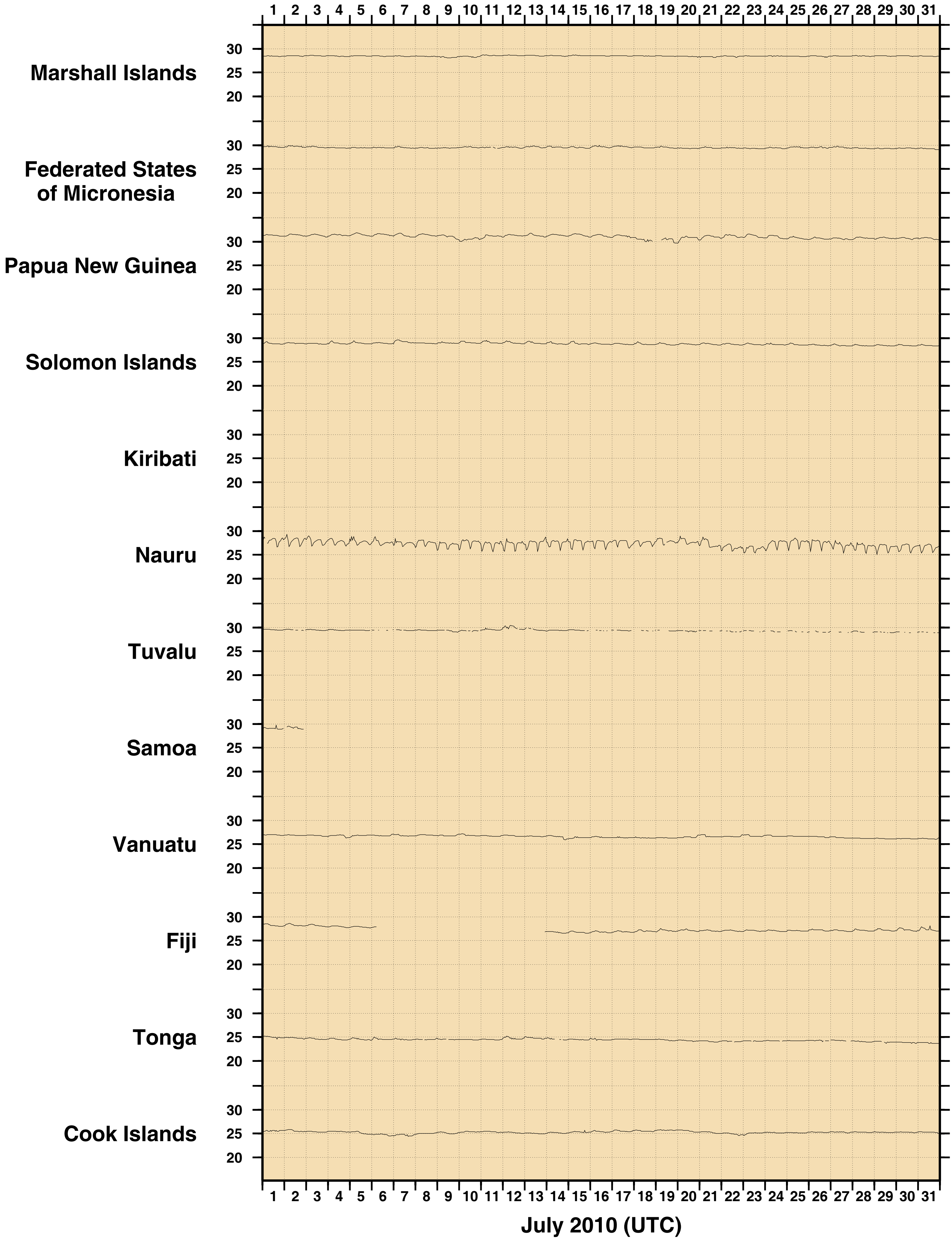


Figure 9

JULY 2010
HOURLY ATMOSPHERIC PRESSURE (hPa)

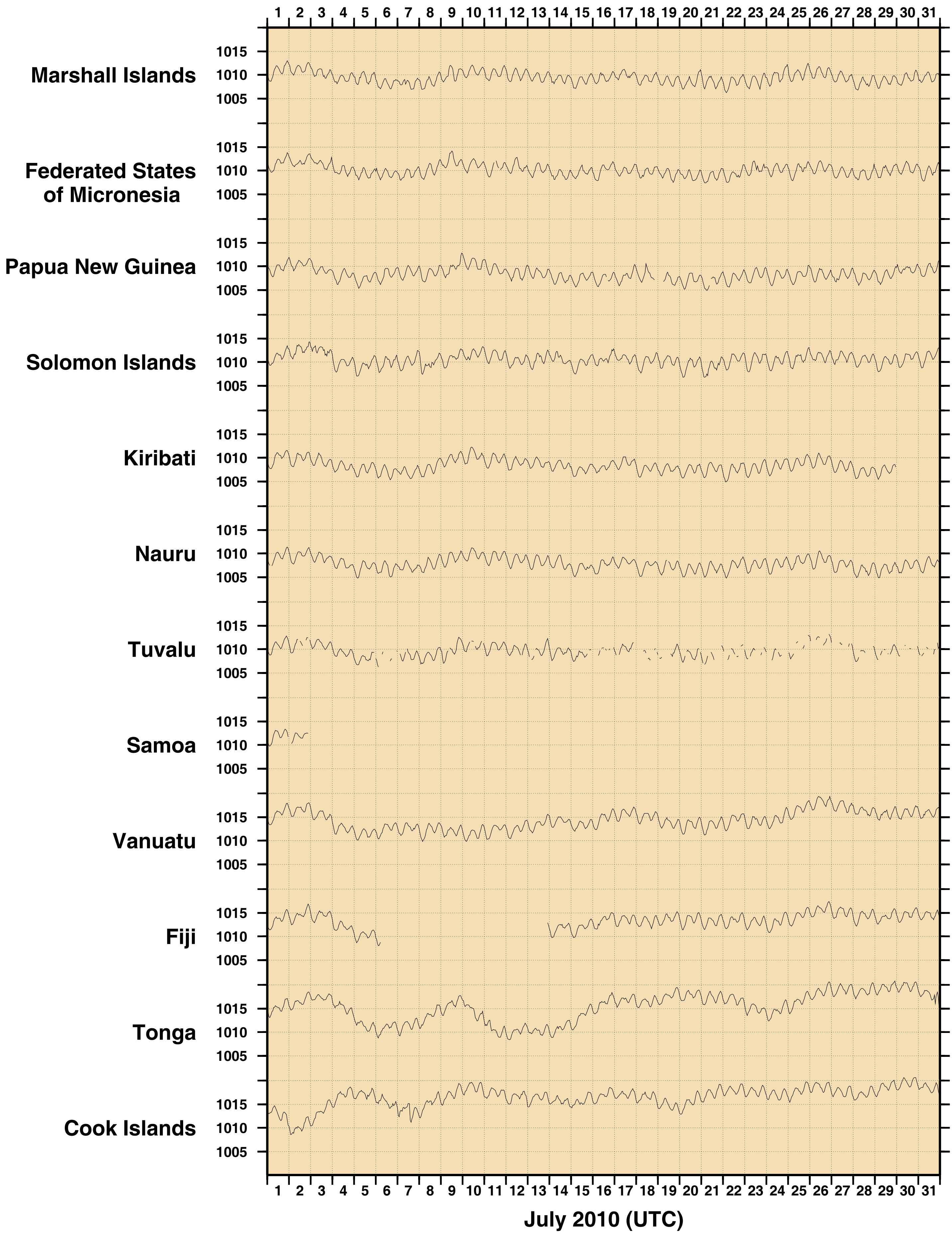


Figure 10

Comparison of July 2010 Max, Min & Mean with Long Term July Values

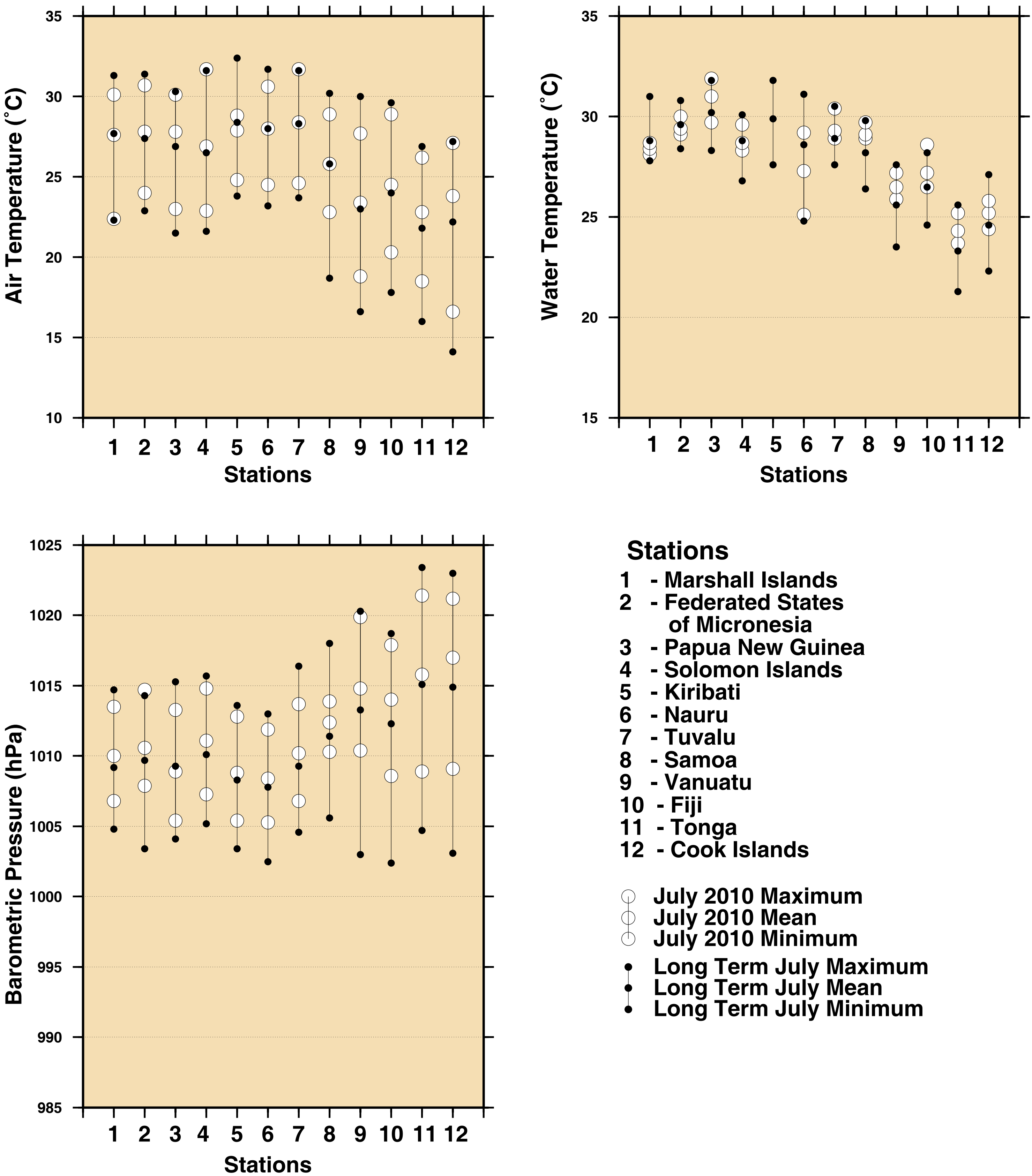


Figure 11

MONTHLY MEAN SEA LEVELS TO JULY 2010 (m)

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

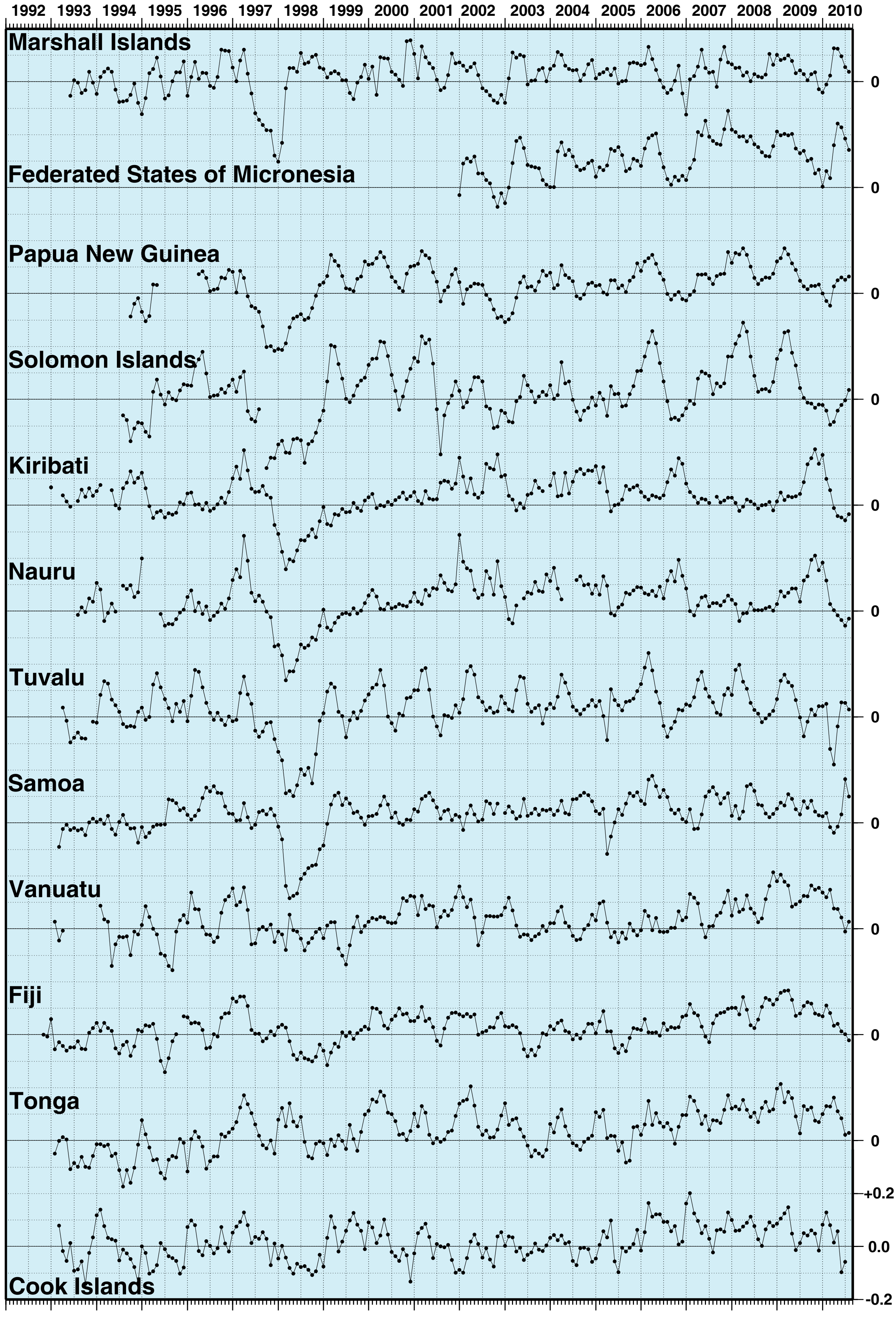


Figure 12

SEA LEVEL ANOMALIES THROUGH JULY 2010 (m)

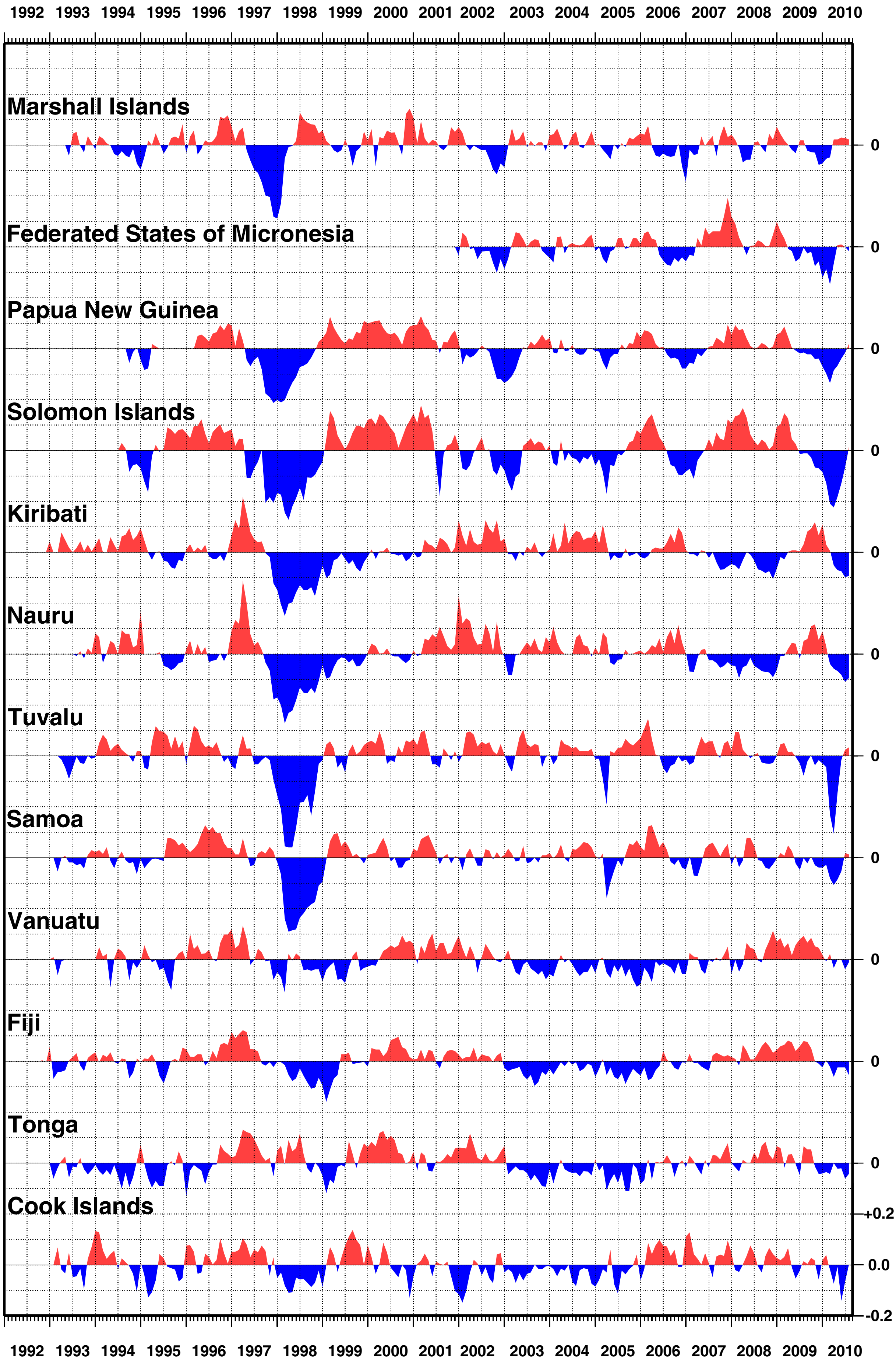


Figure 13

SEA LEVEL TRENDS THROUGH JULY 2010 (mm/year)

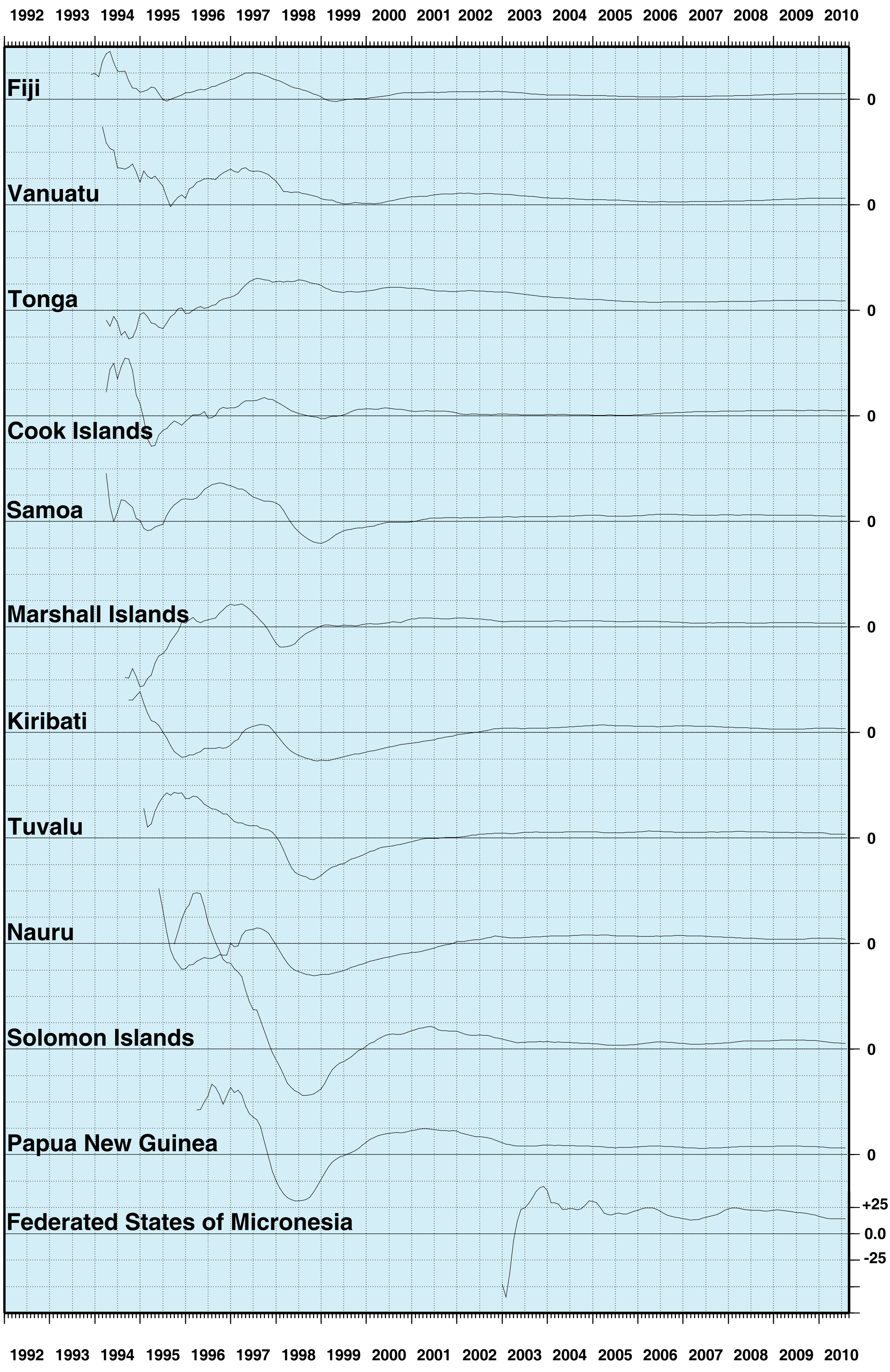


Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH JULY 2010 (hPa)

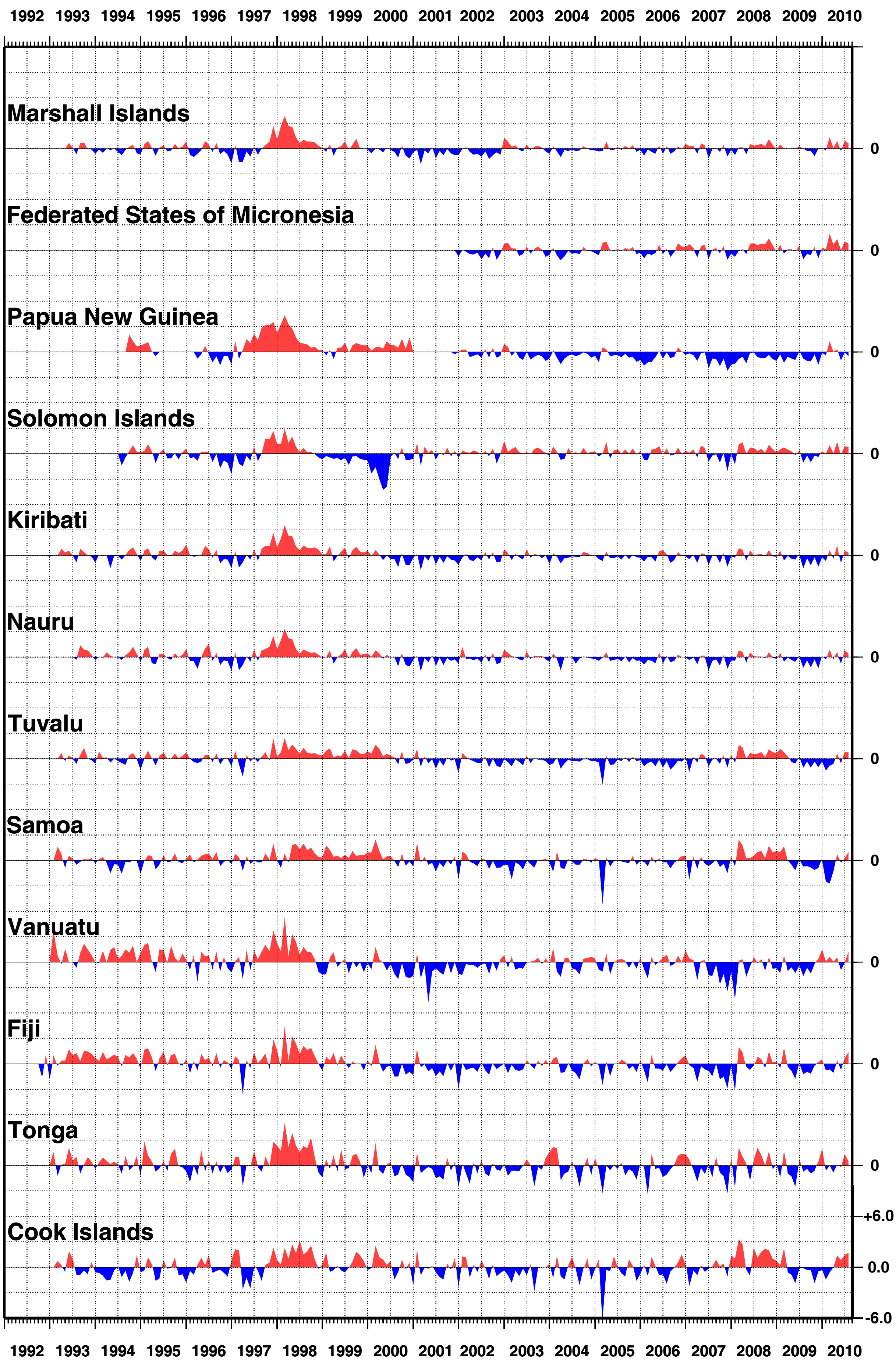


Figure 15

WATER TEMPERATURE ANOMALIES THROUGH JULY 2010 (˚C)

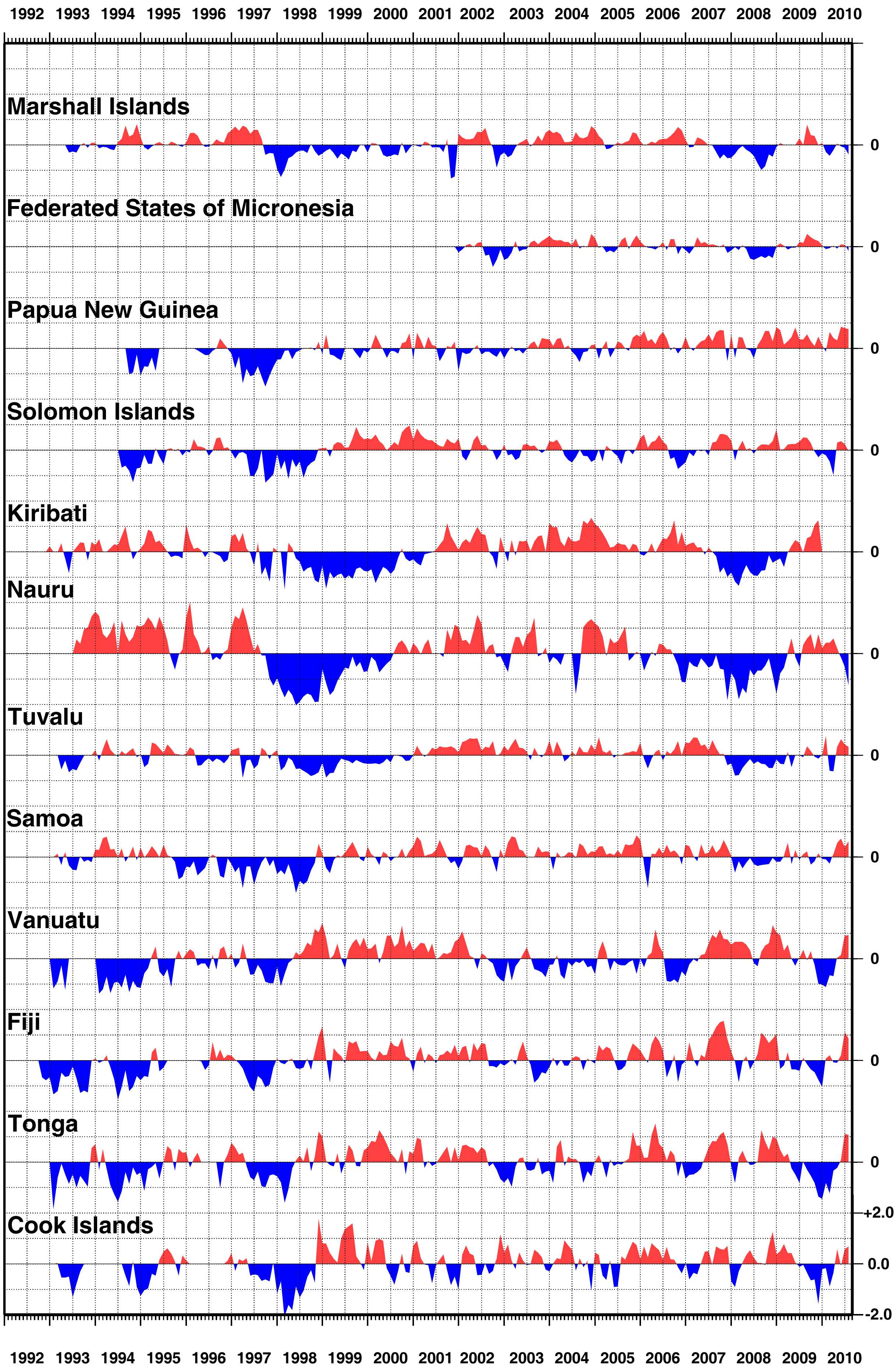


Figure 16

AIR TEMPERATURE ANOMALIES THROUGH JULY 2010 (˚C)

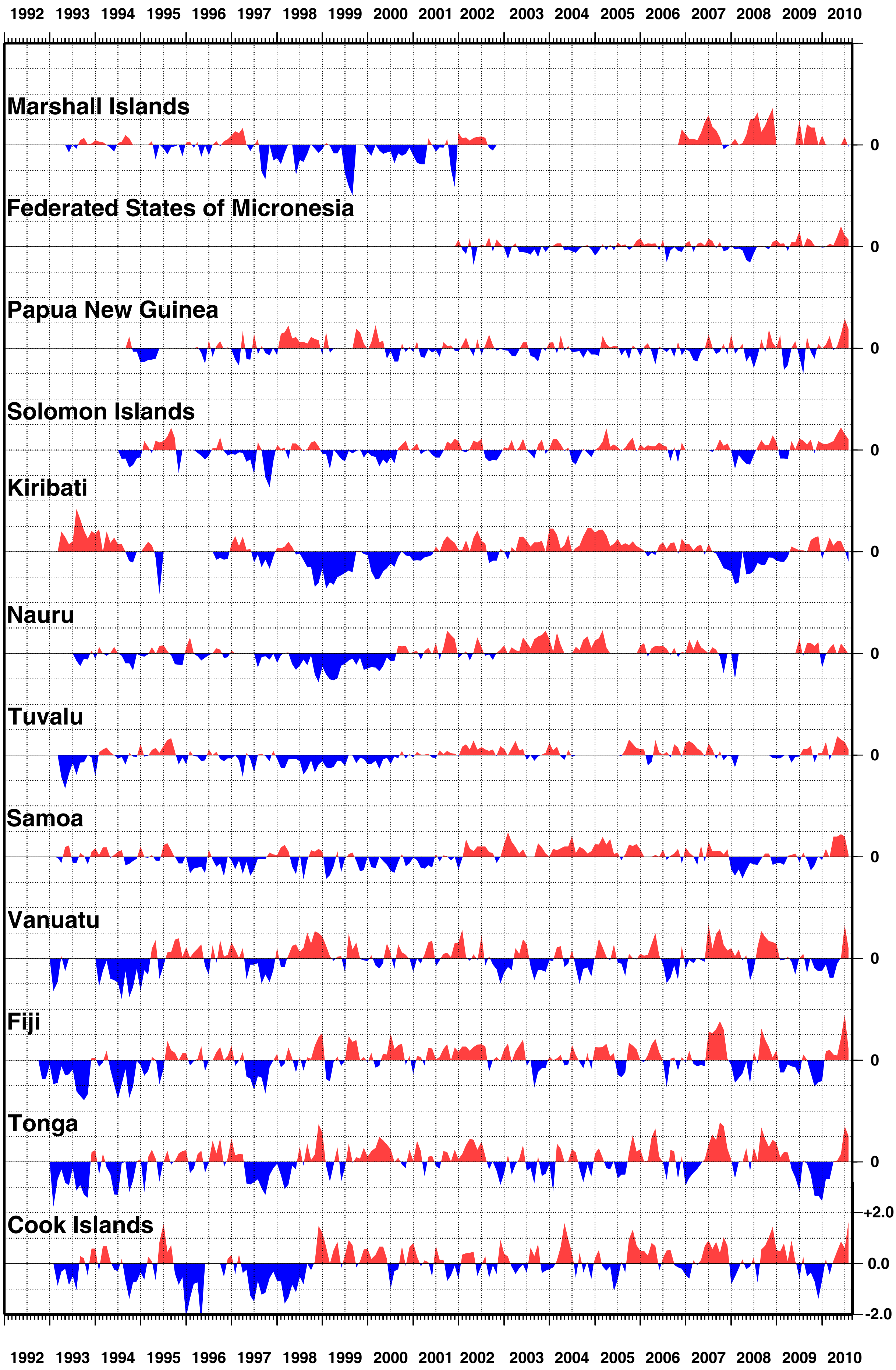


Figure 17

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED
GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE
* Patchy record