THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 148

OCTOBER 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 October 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

October 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.

October 2007

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

- Slightly higher than normal sea levels for this time of the year were observed at most stations. Sea levels at FSM were, on average, 10 cm higher than normal. Sea levels were more than 5cm lower than normal at the equatorial stations of Kiribati and Nauru.

- Air and water temperatures were warmer than normal at many stations. At Fiji and Tonga the air temperature anomalies in recent months have been the highest on record. Cooler than normal water temperatures were observed at equatorial stations Kiribati and Nauru as a result of cool La Niña conditions across the equatorial Pacific.

- La Niña indicators continued to strengthen during October, mostly by way of further cooling of sea surface temperatures across the central and eastern equatorial Pacific. Trade Winds remained stronger than normal across the central equatorial Pacific and upper ocean heat content was cooler than normal across the central and eastern equatorial Pacific. In the far western and southwest Pacific region, sea surface temperatures remain warmer than normal.

- The majority of international climate models predict that La Niña conditions will persist through the remainder of 2007 and into early 2008.

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 October, 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	+4.4	+0.1
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+8.5	+0.1
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+3.3	+0.1
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+3.5	+0.1
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+6.2	+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	+5.4	-0.2
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+6.3	-0.2
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+5.5	+0.1
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+6.6	+0.1
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+19.9	+1.7
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+4.2	+0.2

INTRODUCTION

Welcome to the October 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 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, 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.

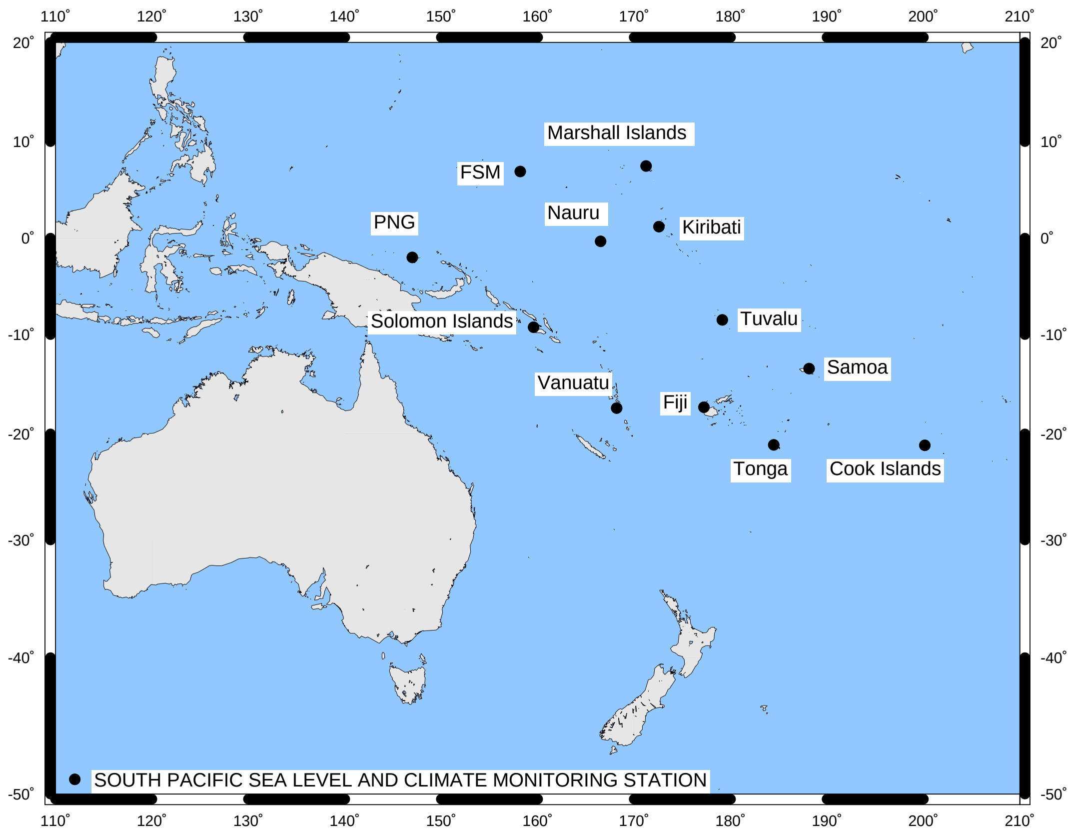

Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

OCTOBER CLIMATOLOGY

La Niña climate conditions intensified across the equatorial Pacific during October, characterised by cooler than average surface and subsurface waters, stronger than normal Trade Winds and reduced cloudiness. A La Niña event is well established and is expected to continue into early 2008.

The Southern Oscillation Index (SOI) is the one indicator that remains near neutral and is slow to show a La Niña signal, although it did rise marginally to a value of +5 for October following a value of +1 in September (**Figure B**).

Cooler than normal sea-surface temperature anomalies further intensified across the central and eastern equatorial Pacific during October (**Figures C and E**). Sea surface temperatures remain warmer than normal in the western equatorial Pacific and in a band extending across the southwest Pacific region (**Figure C**).

Upper ocean heat content across the central and eastern equatorial Pacific remained cooler than normal during October (**Figure D**). Further subsurface cooling occurred in the eastern equatorial Pacific as a result of stronger than normal Trade Winds across the central equatorial Pacific.

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 were stronger than normal across the central equatorial Pacific during October (**Figure E**). Cloudiness in the equatorial Pacific near the dateline was below average during October.

The results from six international computer models predict that cool conditions consistent with a La Niña event will persist for the remainder of 2007 and into early 2008.

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/.

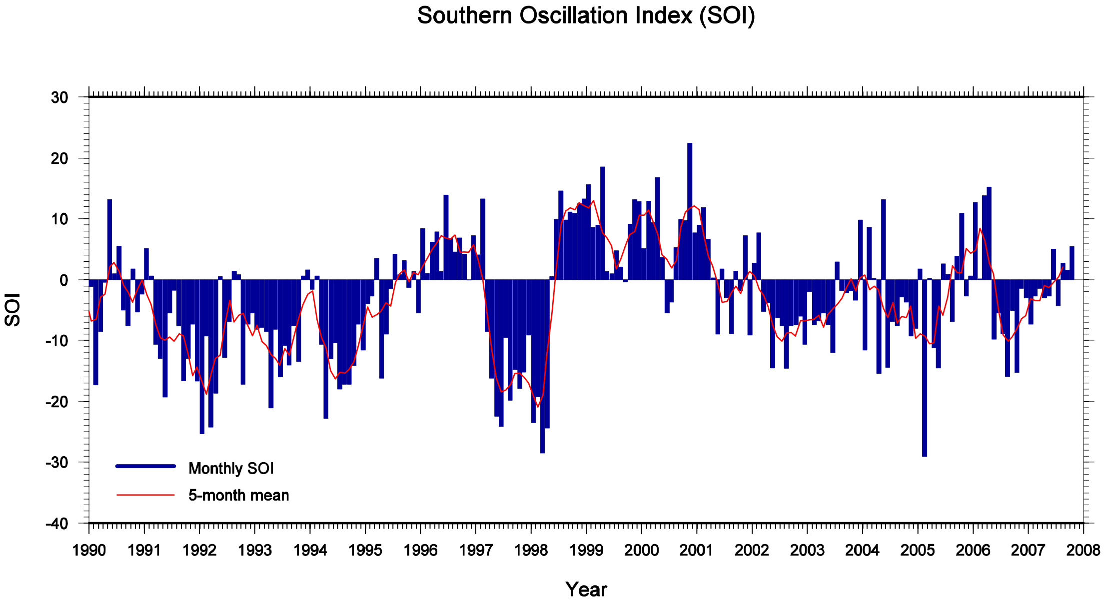

Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the standard deviation of that difference for the relevant month, based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

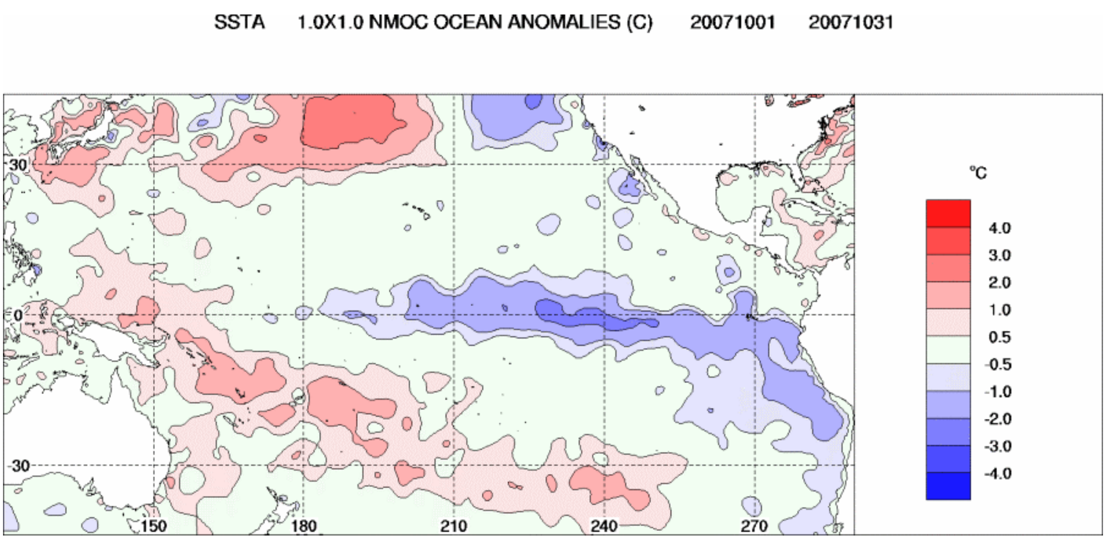

Figure C: *Sea surface temperature anomaly (°C) for October 2007.*

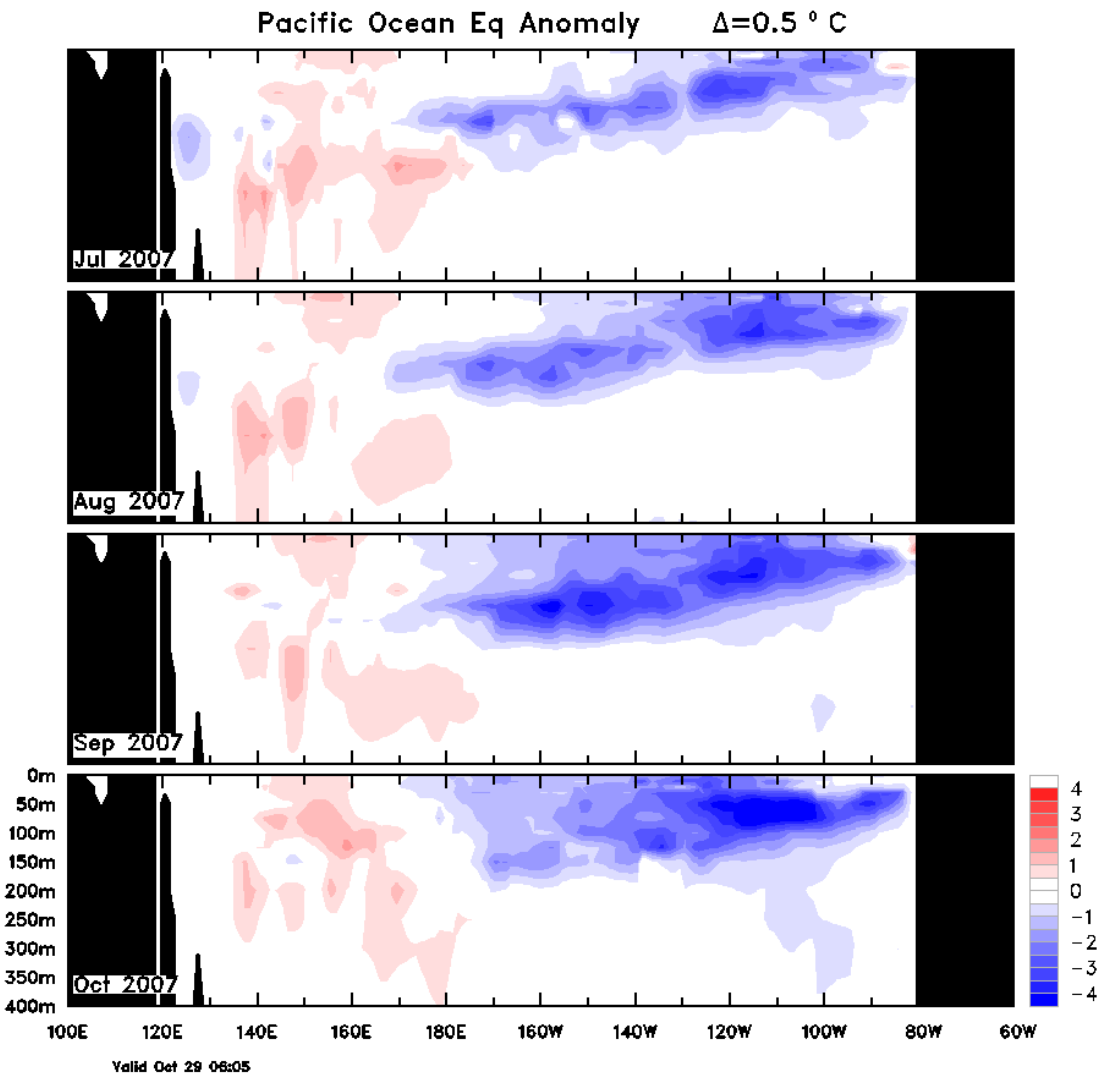

Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for July 2007 through to October 2007. Contour interval is 0.5°C.*

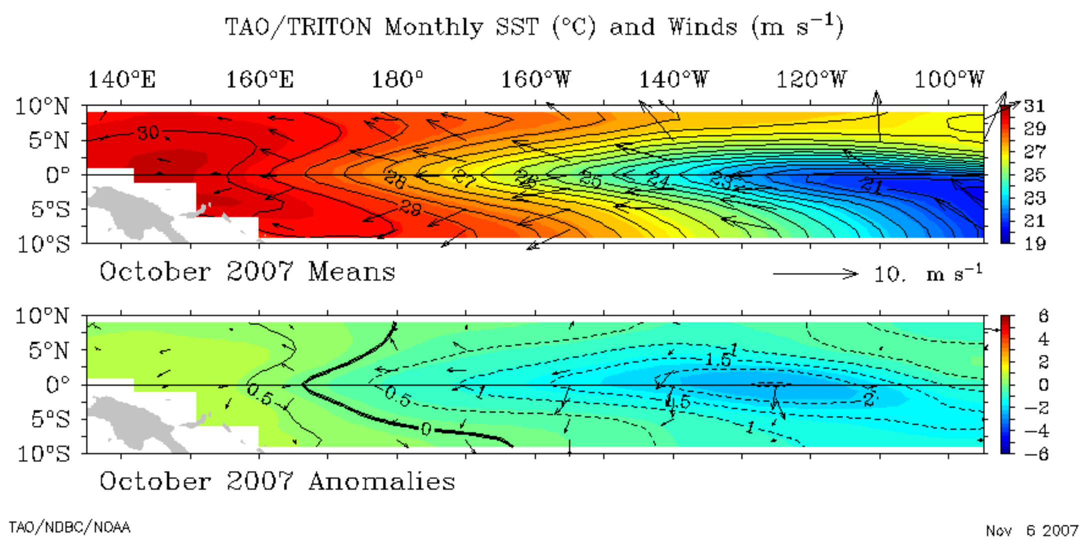

Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for October 2007. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

OCTOBER 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 11th of October and a full moon on the 26th of October 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 the residual sea level fluctuations. 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 Vanuatu prevailed from the northeast for most of the month. The maximum wind gusts observed each hour are plotted in **Figure 6** and show the strongest winds were observed at Marshall Islands where they reached 22 m/s (43 knots) on the 4th of October**.**

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 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 data from FSM has only been collected since December 2001.* A new maximum air temperature for October was set at Vanuatu, and a new minimum air temperature for October was set at FSM. New maximum water temperatures for October were set at PNG, Samoa and Fiji, in accordance with a band of warmer than usual sea surface temperatures extending across the southwest Pacific (Figure C).

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 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.

Figure 12 shows that monthly mean sea levels in October 2007 were higher than normal at 10 of the 12 stations, with lower than normal sea levels observed at the equatorial stations of Kiribati and Nauru. The largest anomaly was observed at FSM where sea levels during October were on average 10cm above normal.

Sea Level Trends

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

Recent short-term sea level trends in the project area based upon SEAFRAME data through October, 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	+4.4	+0.1
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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 October 2007 negative barometric pressure anomalies were observed at PNG, Vanuatu, Fiji, and Tonga. Elsewhere barometric pressures were near normal.

The **water temperature anomalies (Figure 15)** show significantly warmer than normal water temperatures were observed in October 2007 at PNG, Solomon Islands, Samoa, Vanuatu, Fiji, Tonga and Cook Islands. The largest anomalies were observed at Fiji and Tonga where they exceed +1˚C. Cooler than normal water temperatures were observed at equatorial stations Kiribati and Nauru consistent with the development of La Niña conditions across the equatorial Pacific.

The **air temperature anomalies (Figure 16)** show substantially higher than normal air temperatures were also observed at Vanuatu, Fiji, Tonga and Cook Islands in October 2007. The air temperature anomalies at Fiji and Tonga in recent months have been the largest on record. 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 Solomon Islands erroneous wind directions have been recorded since 30th July and have been removed from the record. Problems with the battery power supply were encountered at Samoa and resulted in data loss for 1 day. At Nauru erroneous readings from the air temperature sensor were removed from the record. At Tonga erroneous wind speed data continued to be recorded until 18th October when the problem was rectified.

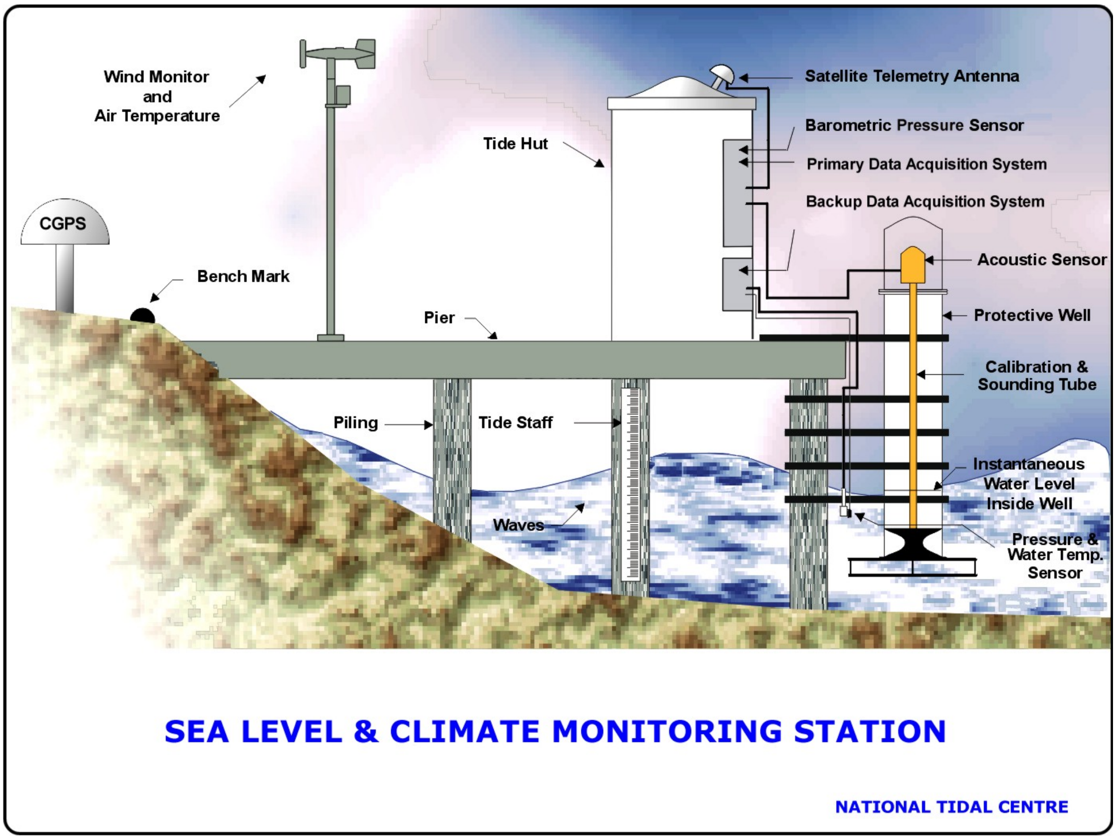
SEAFRAME STATIONS

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

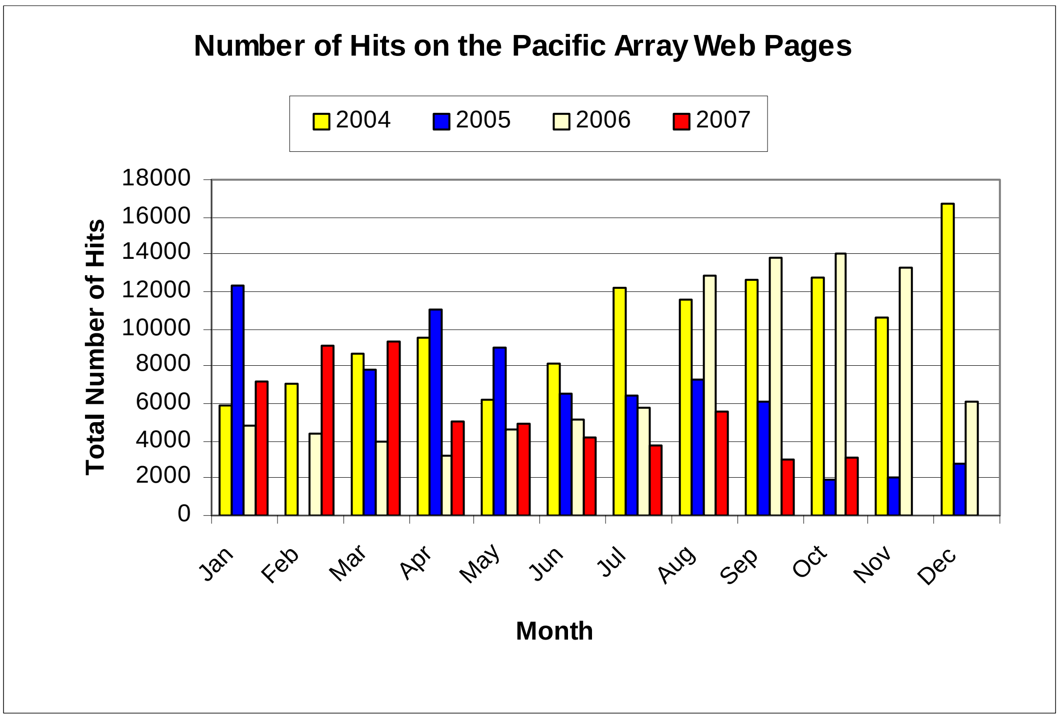
(2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

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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Fax: (+618) (08) 8366 2693
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:

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

OCTOBER 2007
SIX MINUTE WATER LEVEL OBSERVATIONS (m)

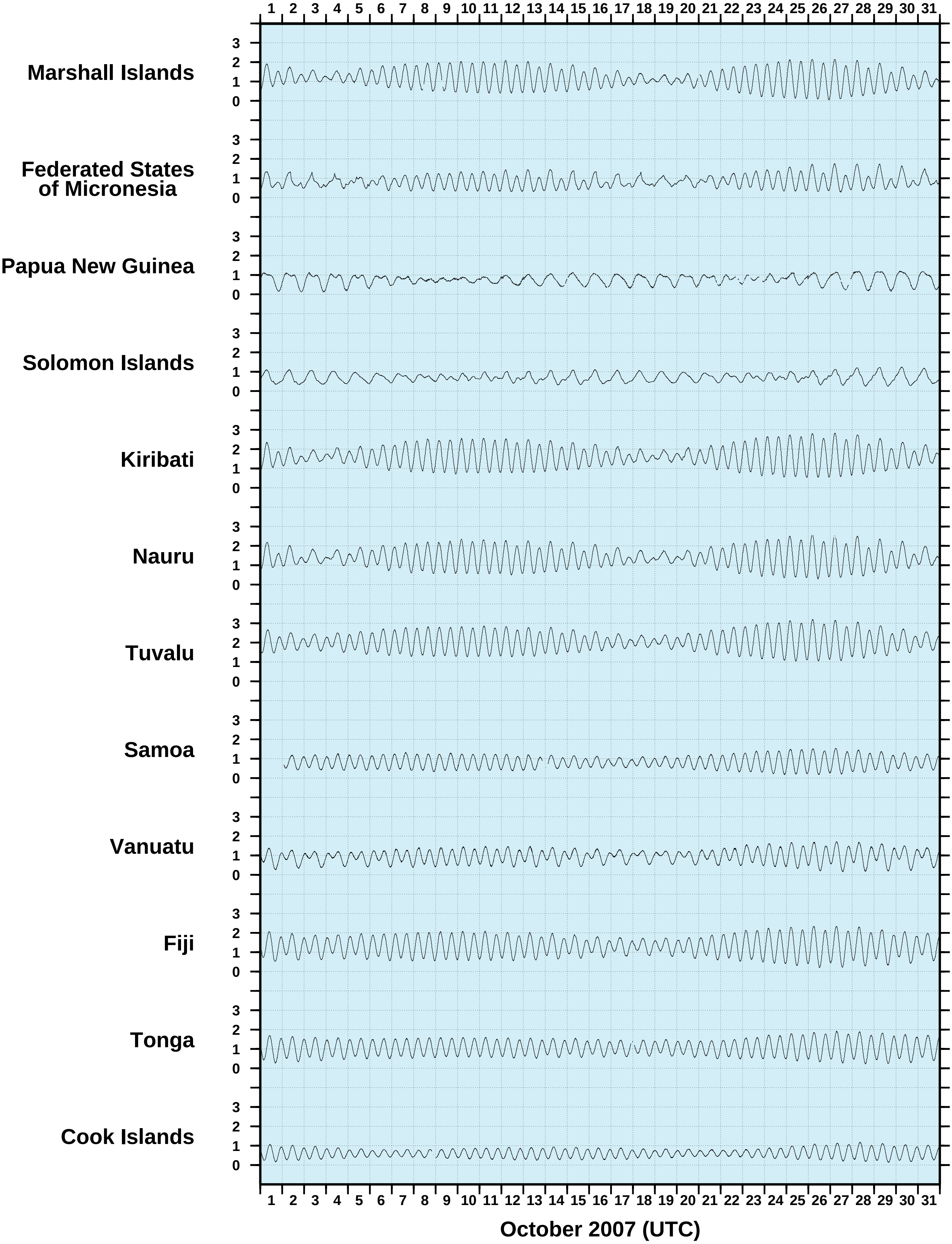

Figure 2

OCTOBER 2007
SIX MINUTE RESIDUAL WATER LEVELS (m)

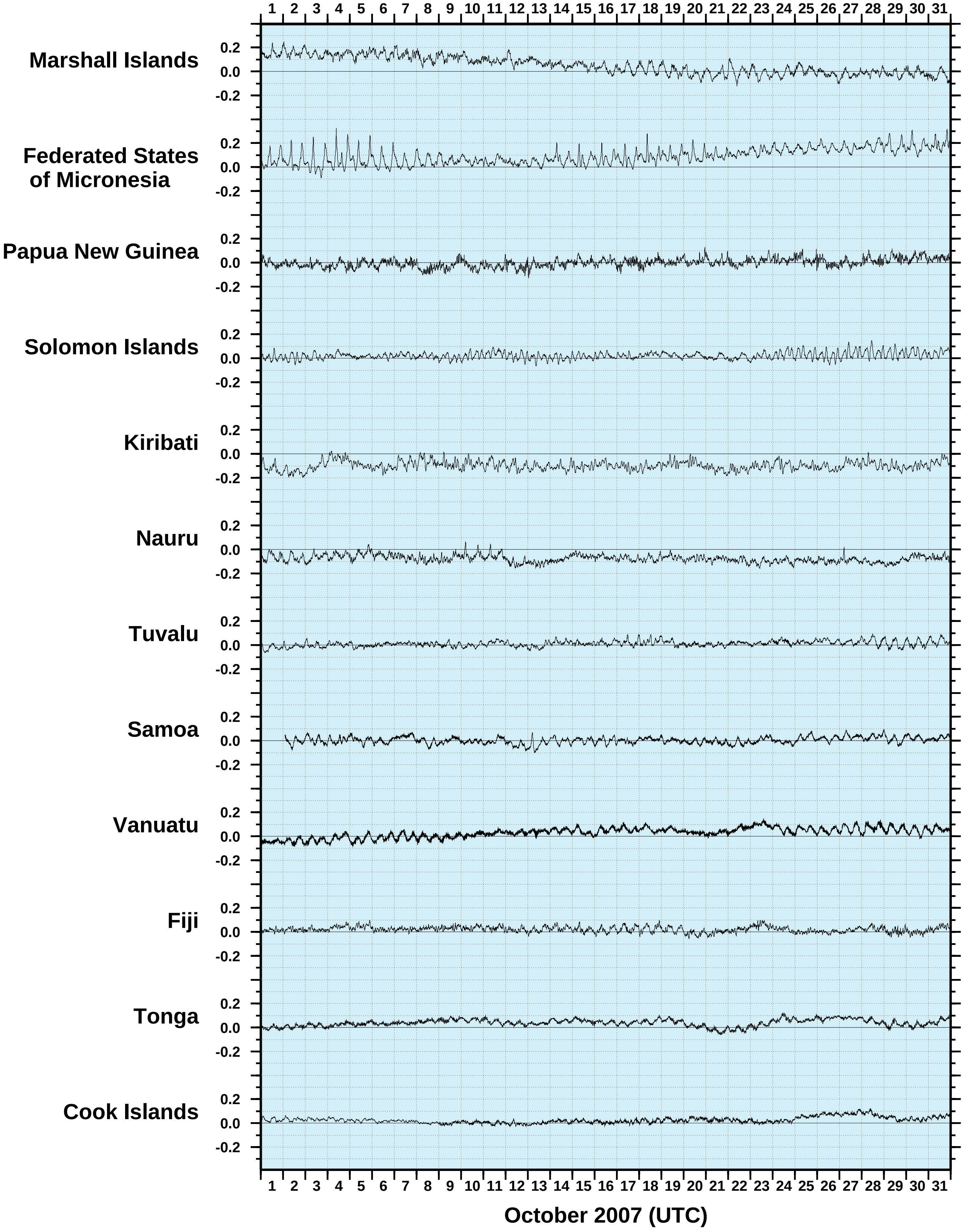

Figure 3

OCTOBER 2007
SIX MINUTE RESIDUALS
ADJUSTED FOR ATMOSPHERIC PRESSURE (m)

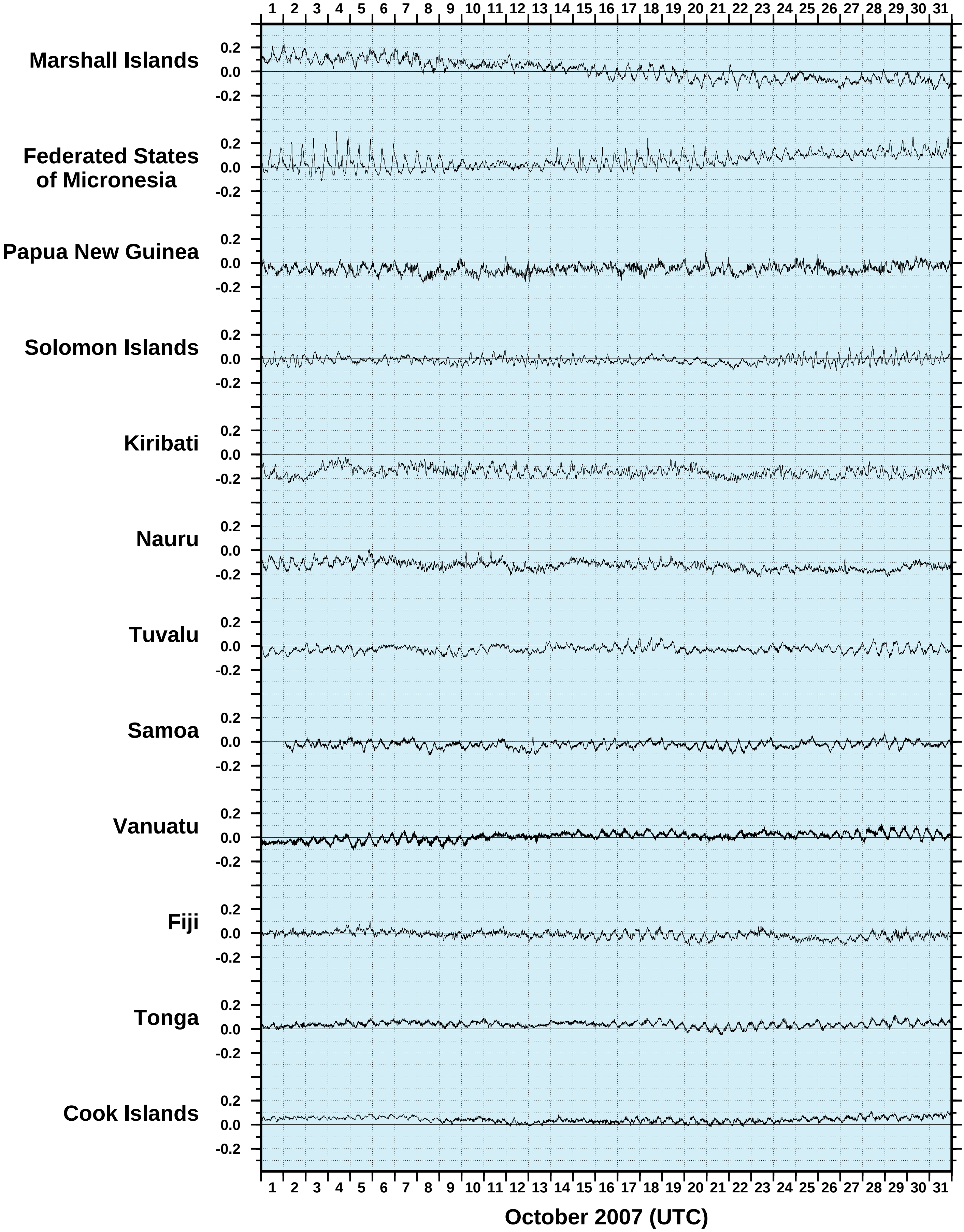

Figure 4

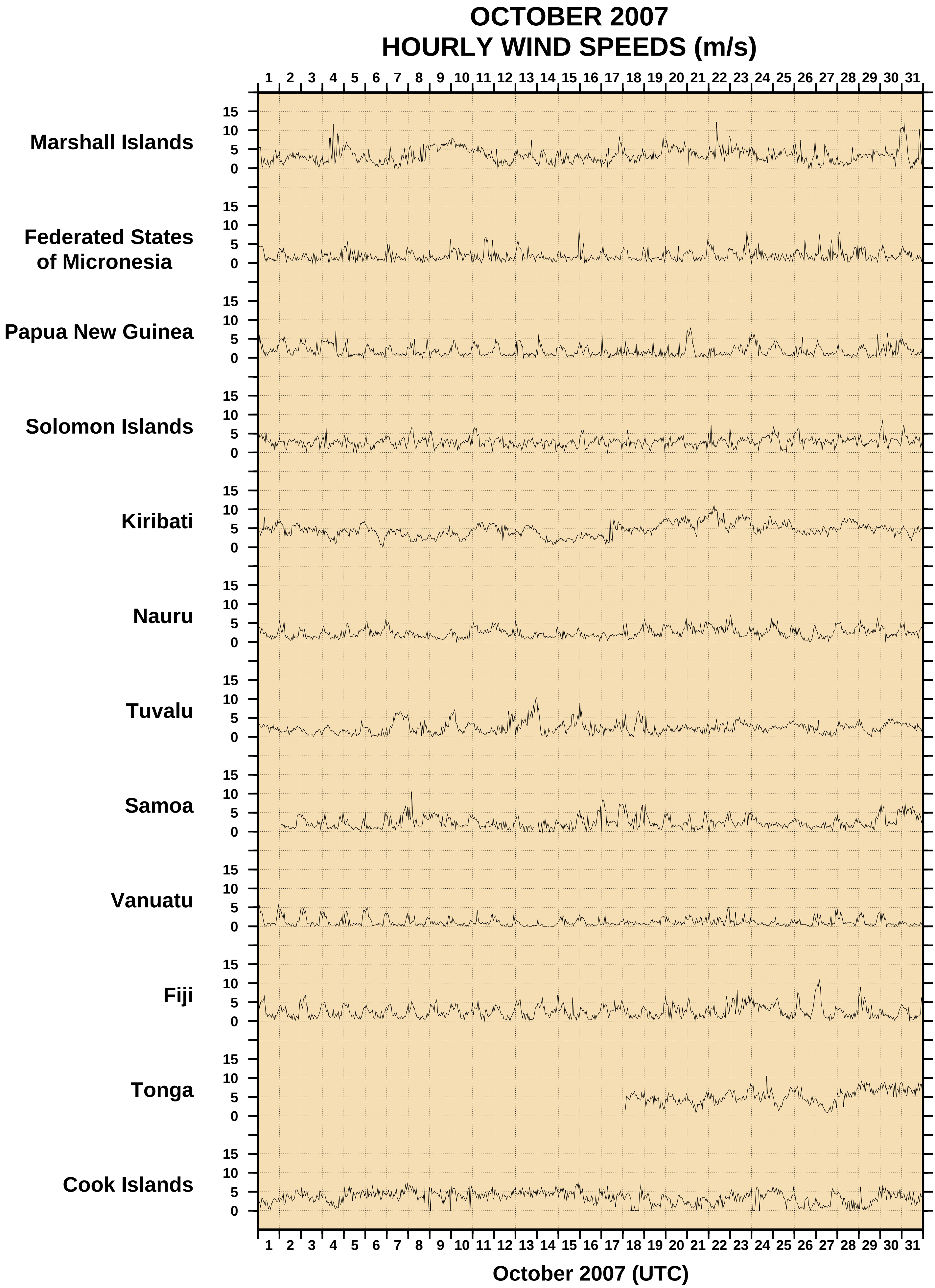
OCTOBER 2007
HOURLY WIND SPEEDS (m/s)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0
5
10
15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
October 2007 (UTC)

Figure 5

OCTOBER 2007

HOURLY INCIDENT WINDS (m/s, deg True)

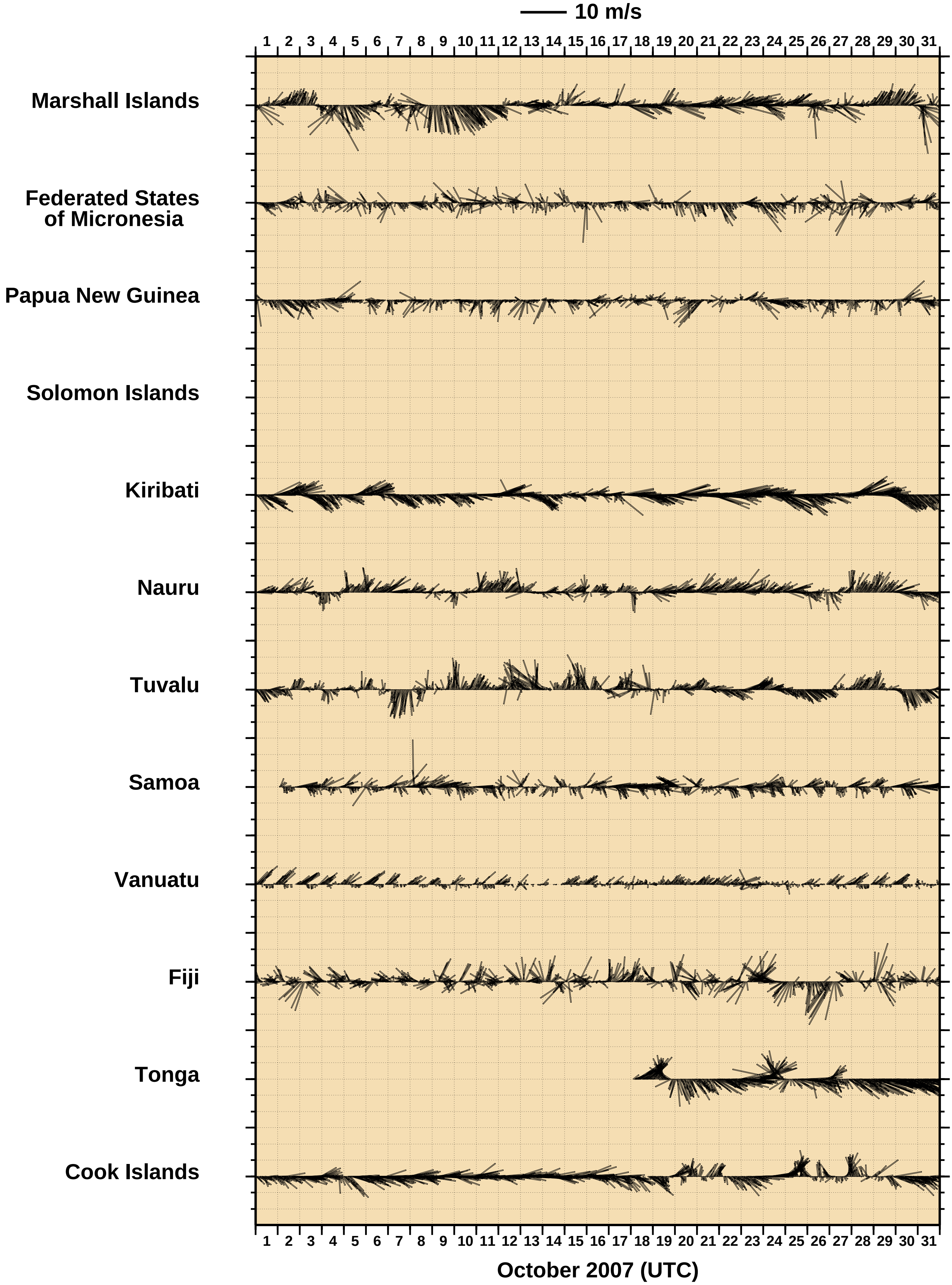

Figure 6

OCTOBER 2007
HOURLY MAXIMUM WIND GUSTS (m/s)

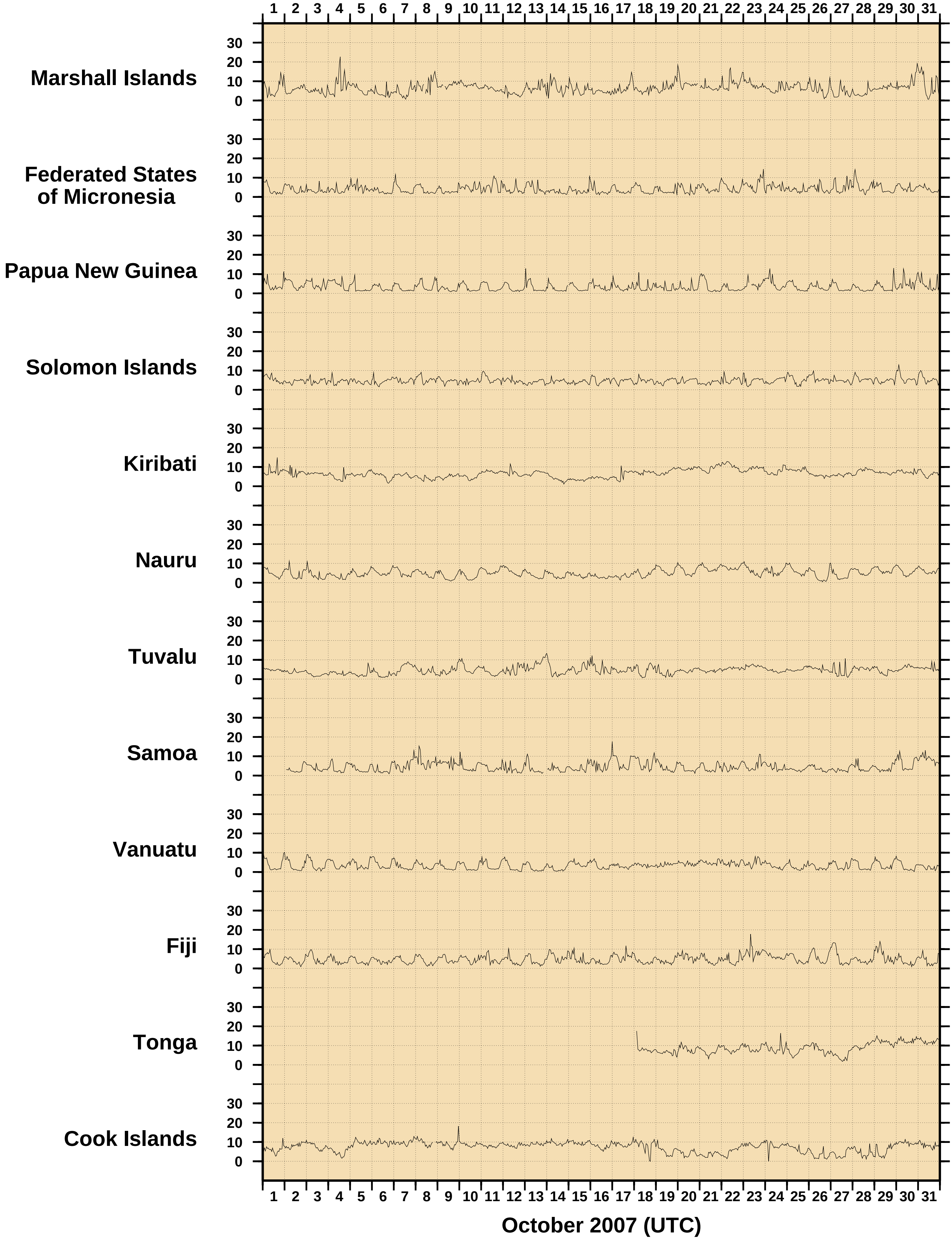

Figure 7

OCTOBER 2007
HOURLY AIR TEMPERATURES (°C)

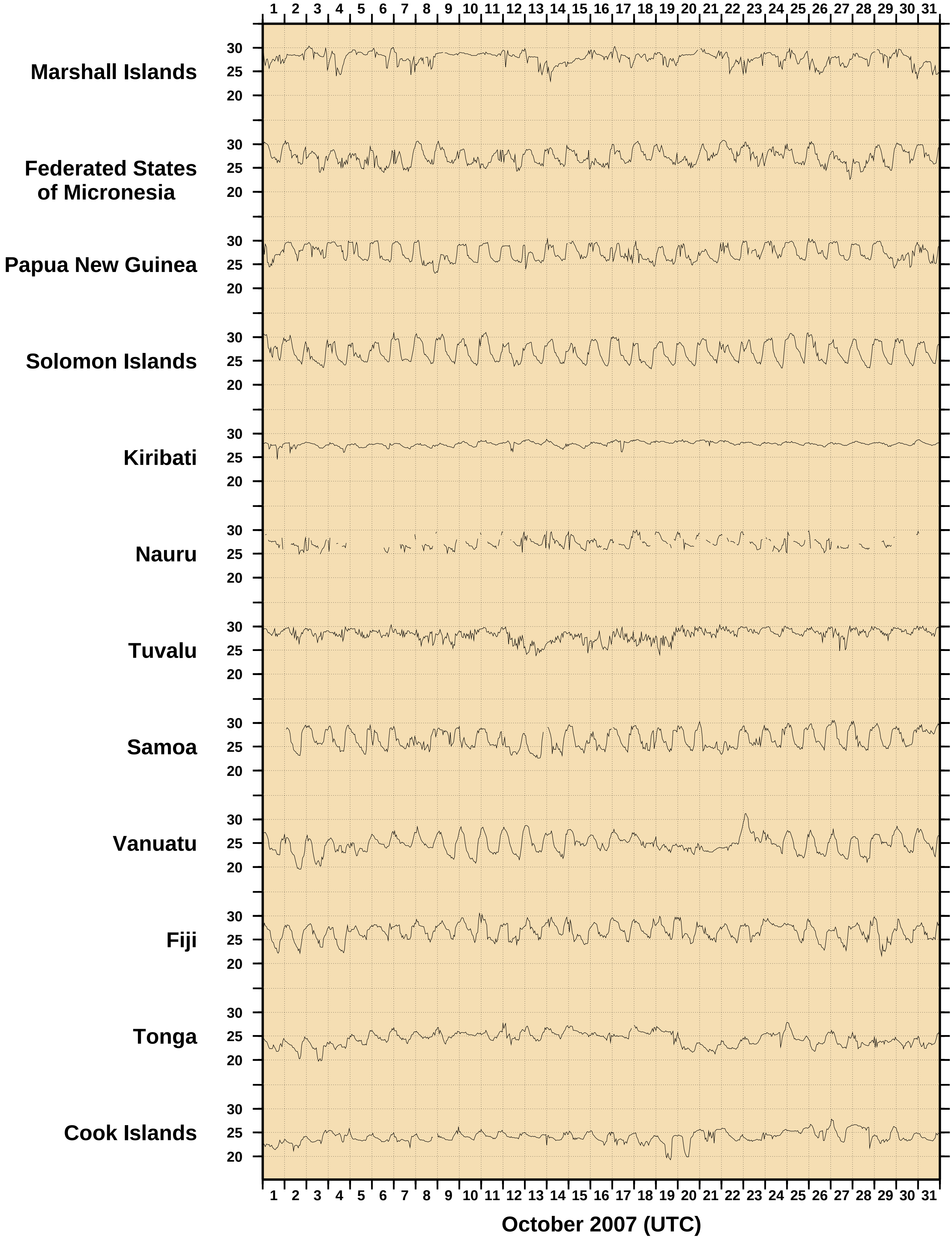

Figure 8

OCTOBER 2007
HOURLY WATER TEMPERATURES (°C)

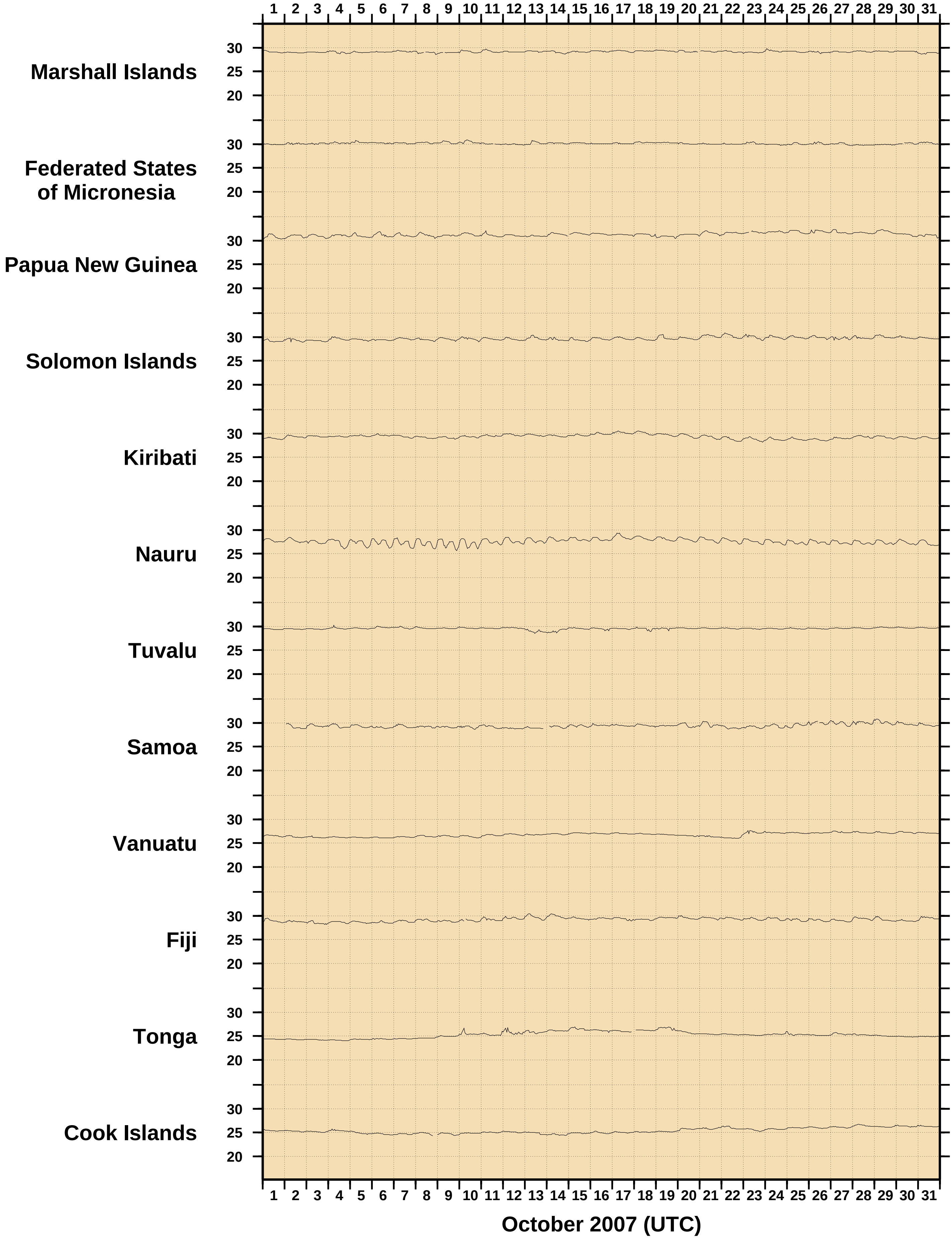

Figure 9

OCTOBER 2007
HOURLY ATMOSPHERIC PRESSURE (hPa)

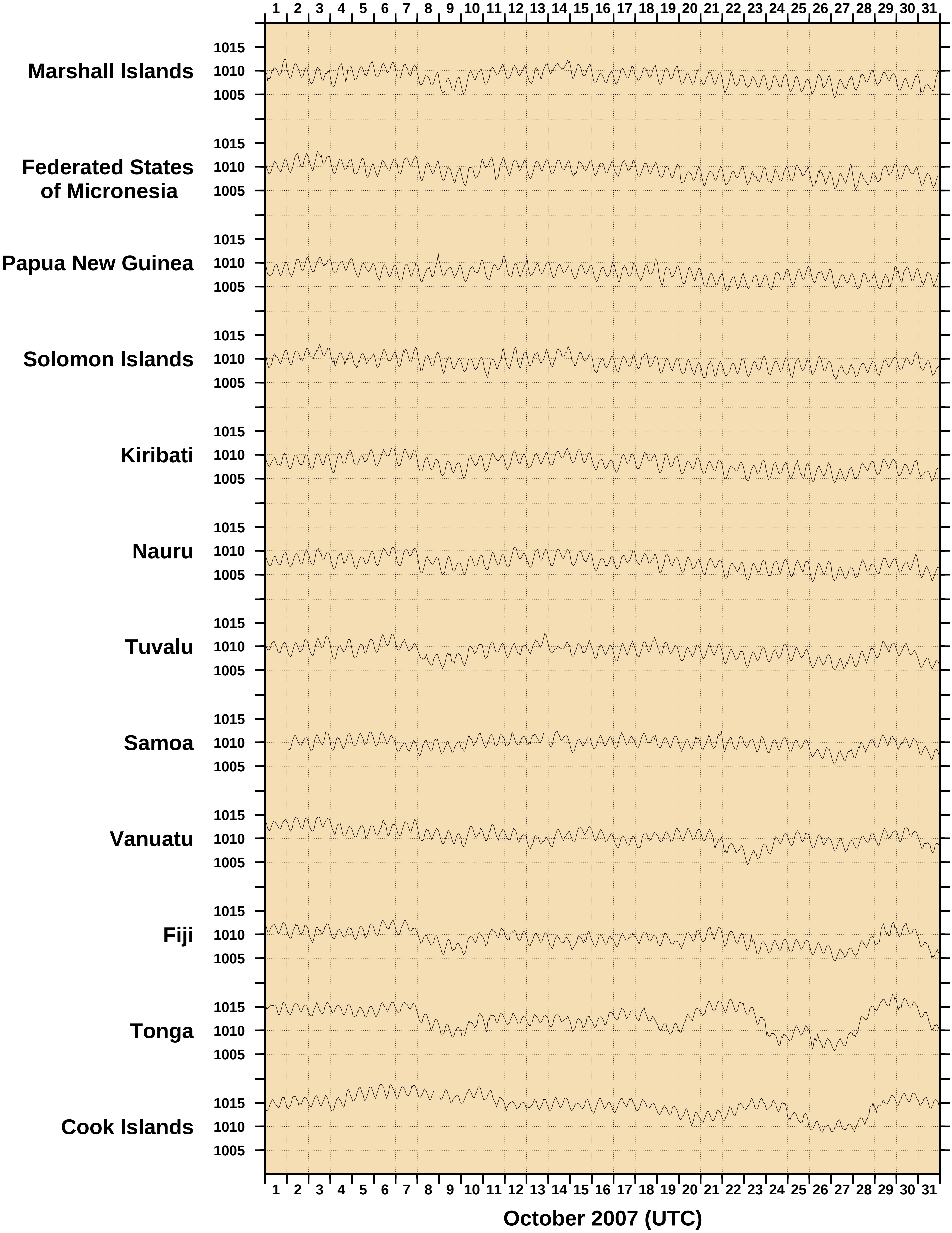

Figure 10

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

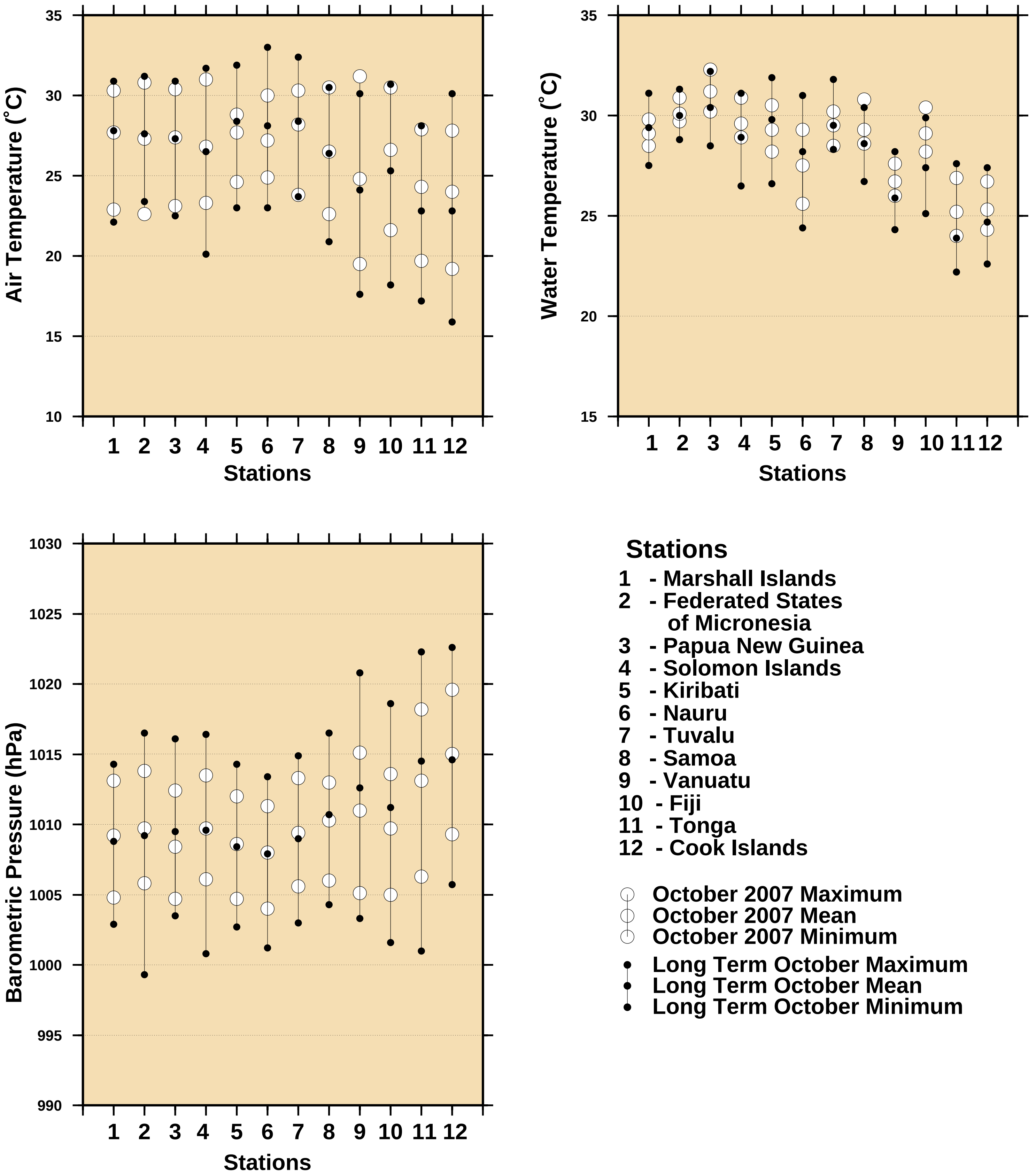

Figure 11

MONTHLY MEAN SEA LEVELS TO OCTOBER 2007 (m)

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

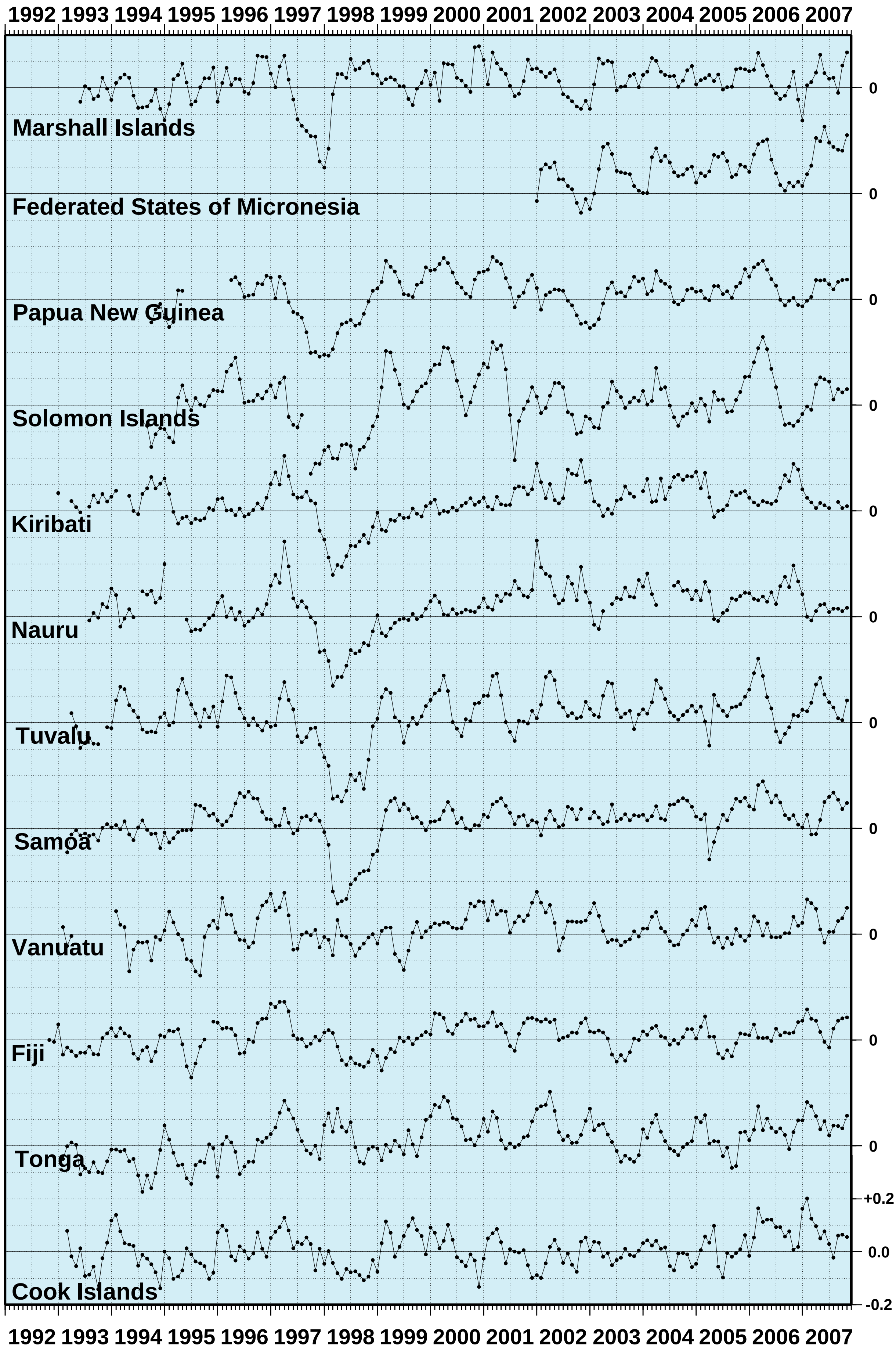

Figure 12

SEA LEVEL ANOMALIES THROUGH OCTOBER 2007 (m)

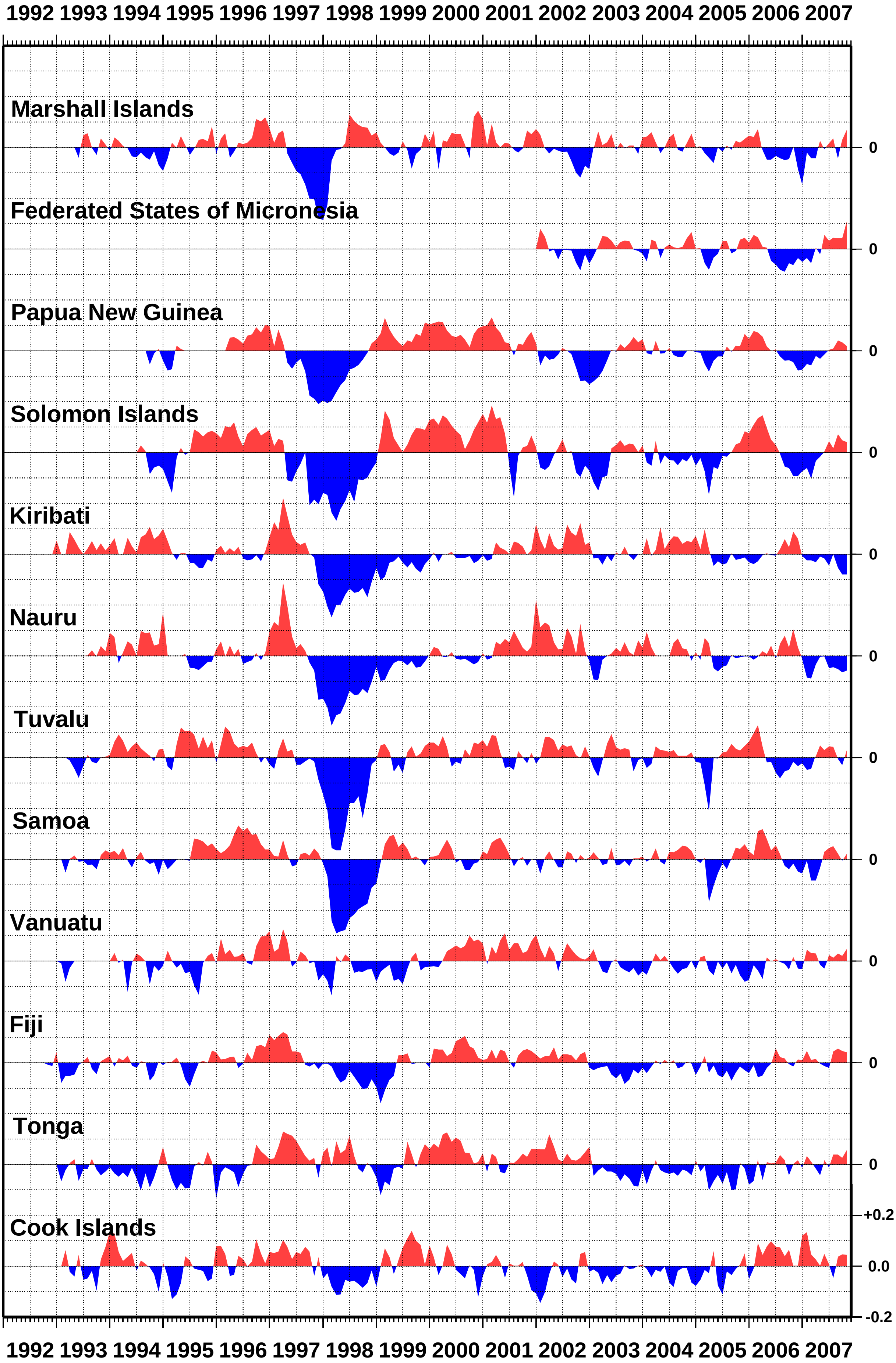

Figure 13

SEA LEVEL TRENDS THROUGH OCTOBER 2007 (mm/year)

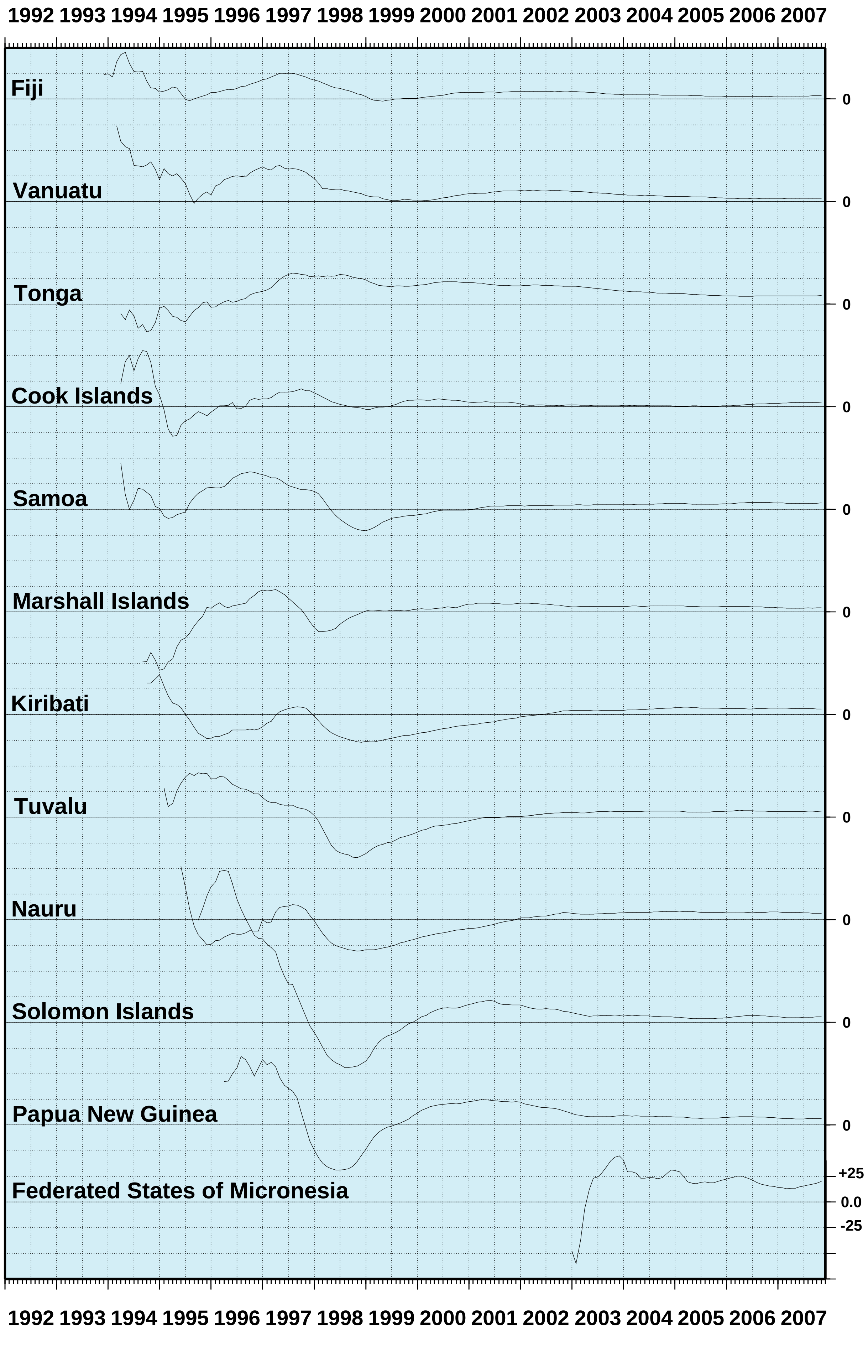

Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH OCTOBER 2007 (hPa)

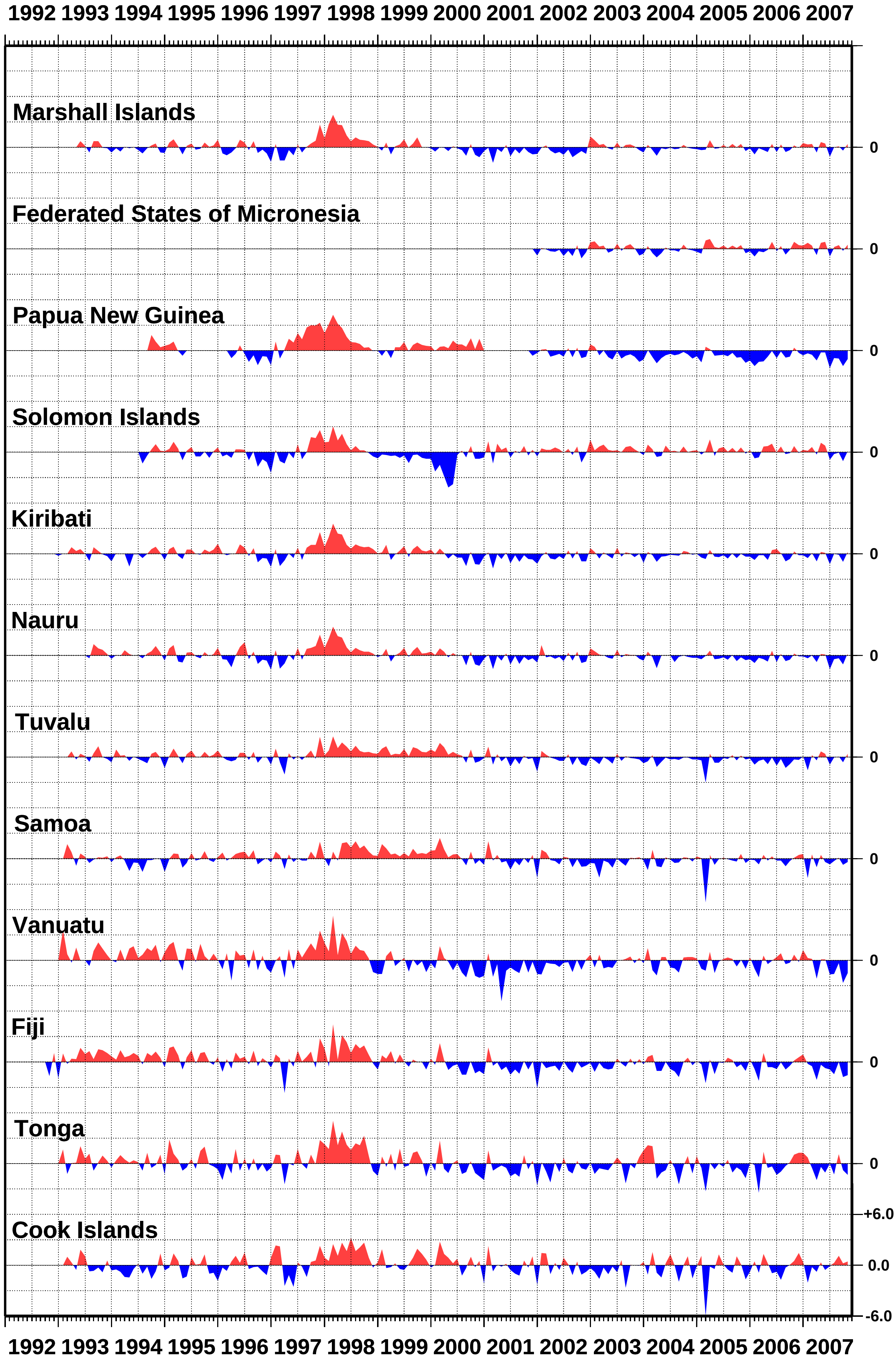

Figure 15

WATER TEMPERATURE ANOMALIES THROUGH OCTOBER 2007 (°C)

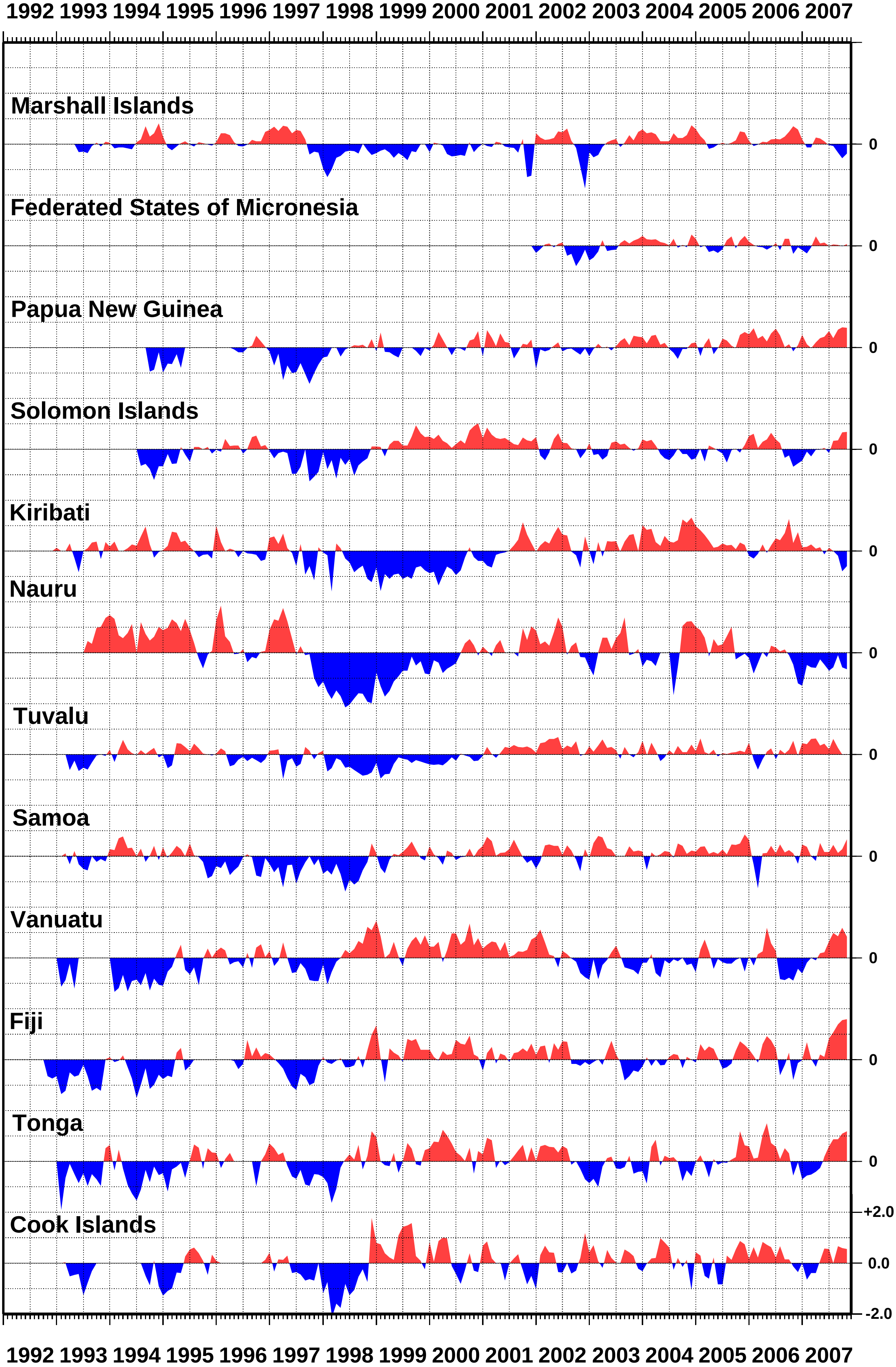

Figure 16

AIR TEMPERATURE ANOMALIES THROUGH OCTOBER 2007 (°C)

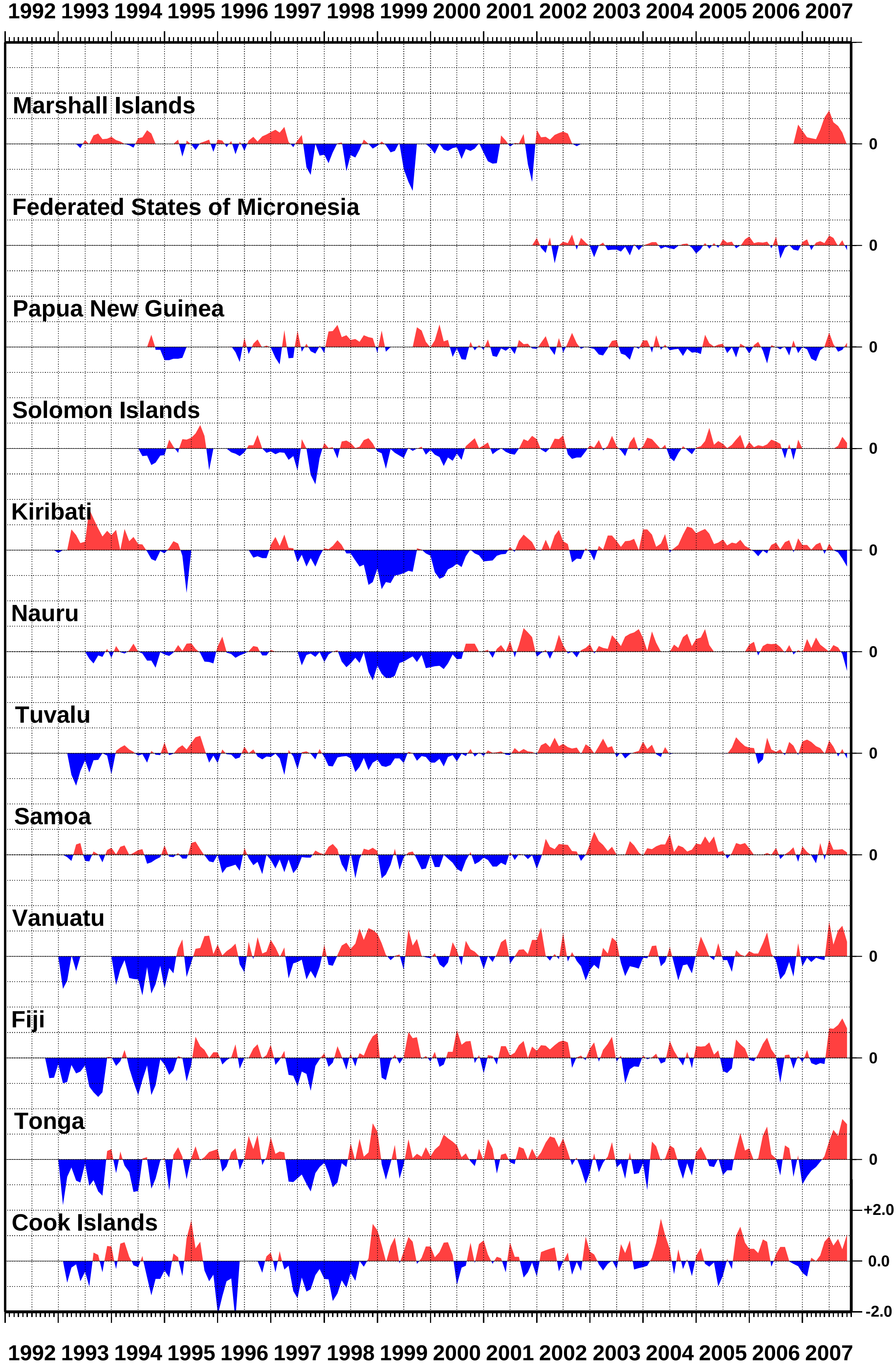

Figure 17

SEA LEVEL DATA RETURN

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