THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 156

JUNE 2008

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

National Tidal Centre
Bureau of Meteorology
Australia

GPO Box 421
Kent Town SA 5071
Australia

Tel: (+618) 8366 2730
Fax: (+618) 8366 2651
Website: http://www.bom.gov.au/oceanography/

Quality Certification:

I authorise the issue of this South Pacific Sea Level and Climate Monitoring Project Monthly Data Report for June 2008 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

June 2008

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.

June 2008

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

- No extreme event such as a tropical cyclone or tsunami affected the region.

- Monthly mean sea levels at all stations were near to what is normal for this time of the year.

- Spring tide ranges were reasonably large in early June at many stations due to favourable astronomical positions of the moon and the sun.

- Climate conditions have returned to neutral following the 2007-2008 La Niña event.

- The majority of international climate models predict that neutral climate conditions will persist until the end of 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 June, 2008

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	+5.0	+0.1
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+8.8	+0.1
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+3.9	0.0
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+4.2	+0.1
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+6.5	+0.1
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+6.1	0.0
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+4.4	-0.1
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+5.1	-0.1
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+7.8	+0.1
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+7.8	0.0
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+22.4	-0.3
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+3.9	0.0

INTRODUCTION

Welcome to the June 2008 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.

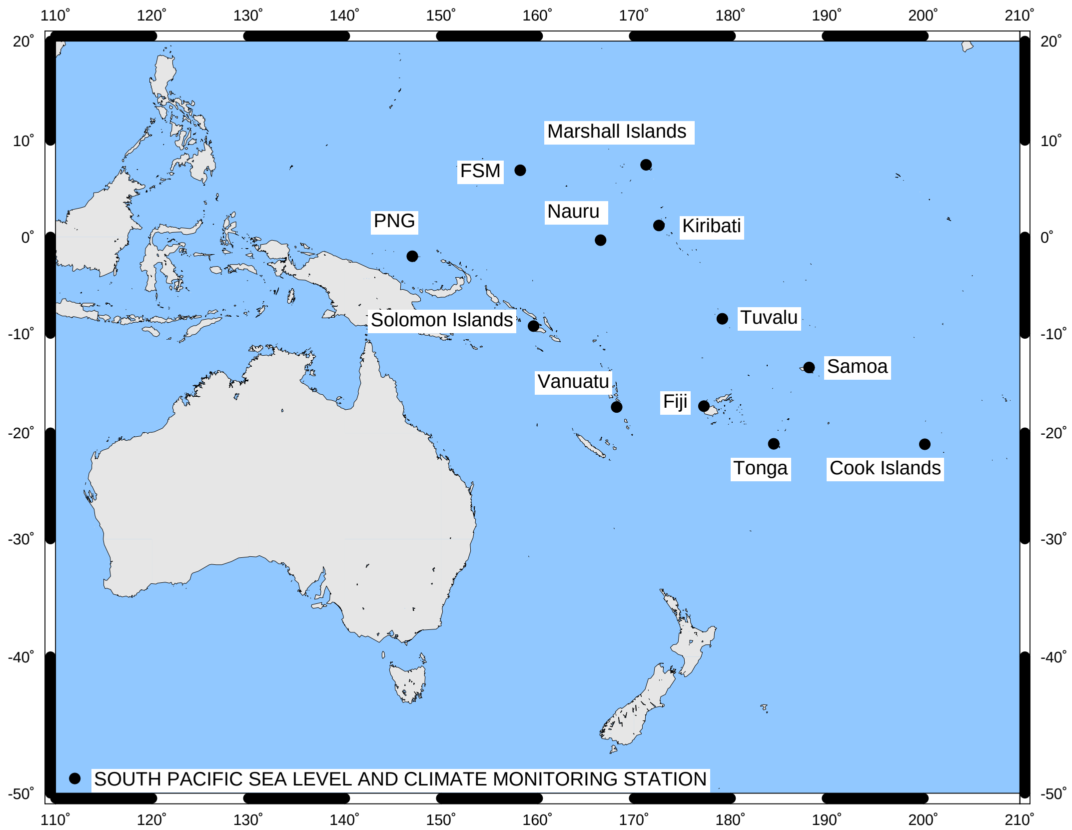


Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

JUNE CLIMATOLOGY

Neutral climate conditions continued to persist in the equatorial Pacific through June. Residual La Niña conditions such as stronger than normal Trade Winds and cooler than normal sea surface temperatures that were observed near the dateline during May weakened even further. Climate conditions are expected to remain neutral in the coming months although there is a small chance of an El Niño developing late in the year.

The Southern Oscillation Index (SOI) monthly June value of +4 showed a small rise in relation to the May value of –4, but remains indicative of neutral conditions (**Figure B**).

The sea-surface temperature (SST) anomalies show near-normal conditions were observed across the entire equatorial Pacific during June (**Figure C, Figure E**). Continued warming during June brought further contraction of cooler than normal surface temperatures in the west-central equatorial Pacific that were a feature of the recent La Niña. SST anomalies above +1˚C continue to be observed near the South American coast. Sea surface temperatures in the far western Pacific remain near normal.

Subsurface temperatures during June reveal a pattern of positive anomalies at thermocline depths extending across the entire equatorial Pacific (**Figure D**). In the past these warm sub-surface temperature anomalies experienced general weakening in the western Pacific and strengthening in the eastern Pacific. Cooler subsurface temperatures were confined to the upper mixed layer in the central equatorial Pacific last month and weakened further during June.

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 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. Trade Winds during June were generally near average across the equatorial Pacific (**Figure E**). Cloudiness in the equatorial Pacific near the dateline has been below average since May 2007 but returned to near normal during June in keeping with near-normal sea surface temperatures in that region.

The consensus among six international computer models is that climate conditions on the warm-side of neutral will persist across the equatorial Pacific until the end 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/.

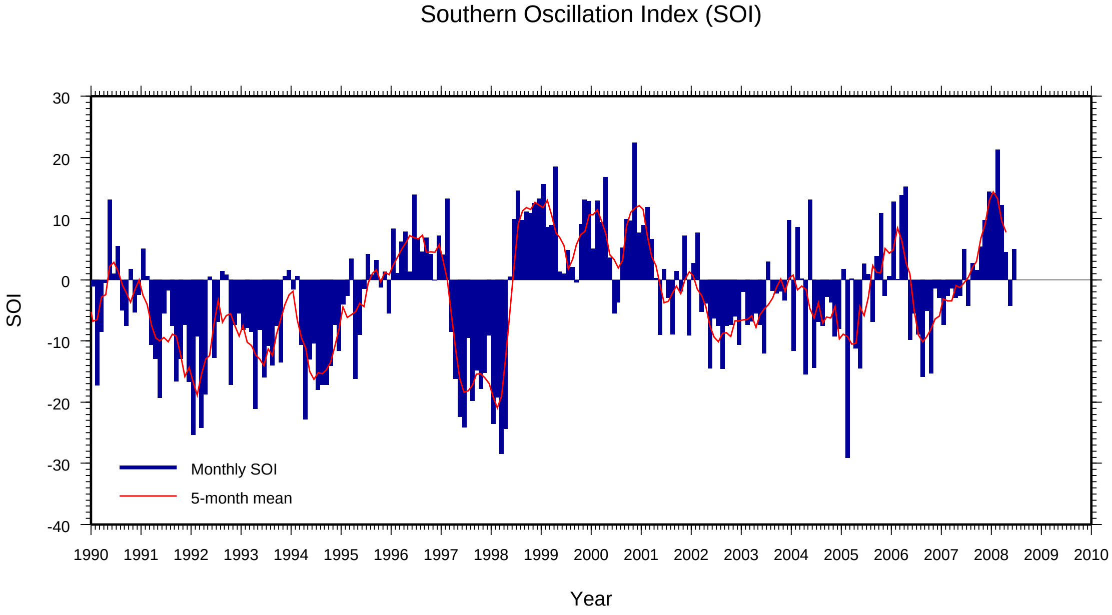


Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the long-term standard deviation of that difference for the relevant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

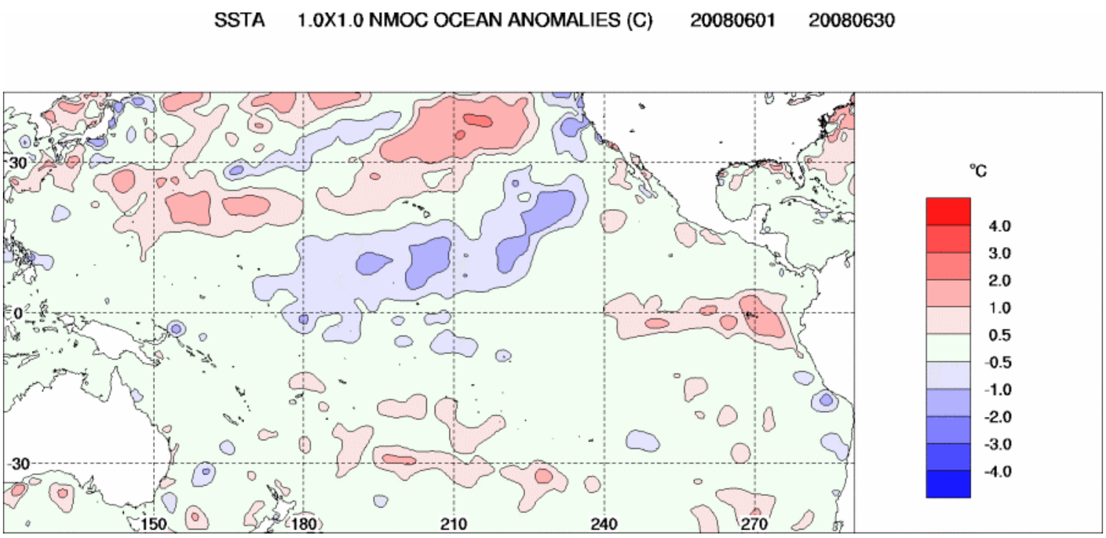


Figure C: *Sea surface temperature anomaly (°C) for June 2008.*

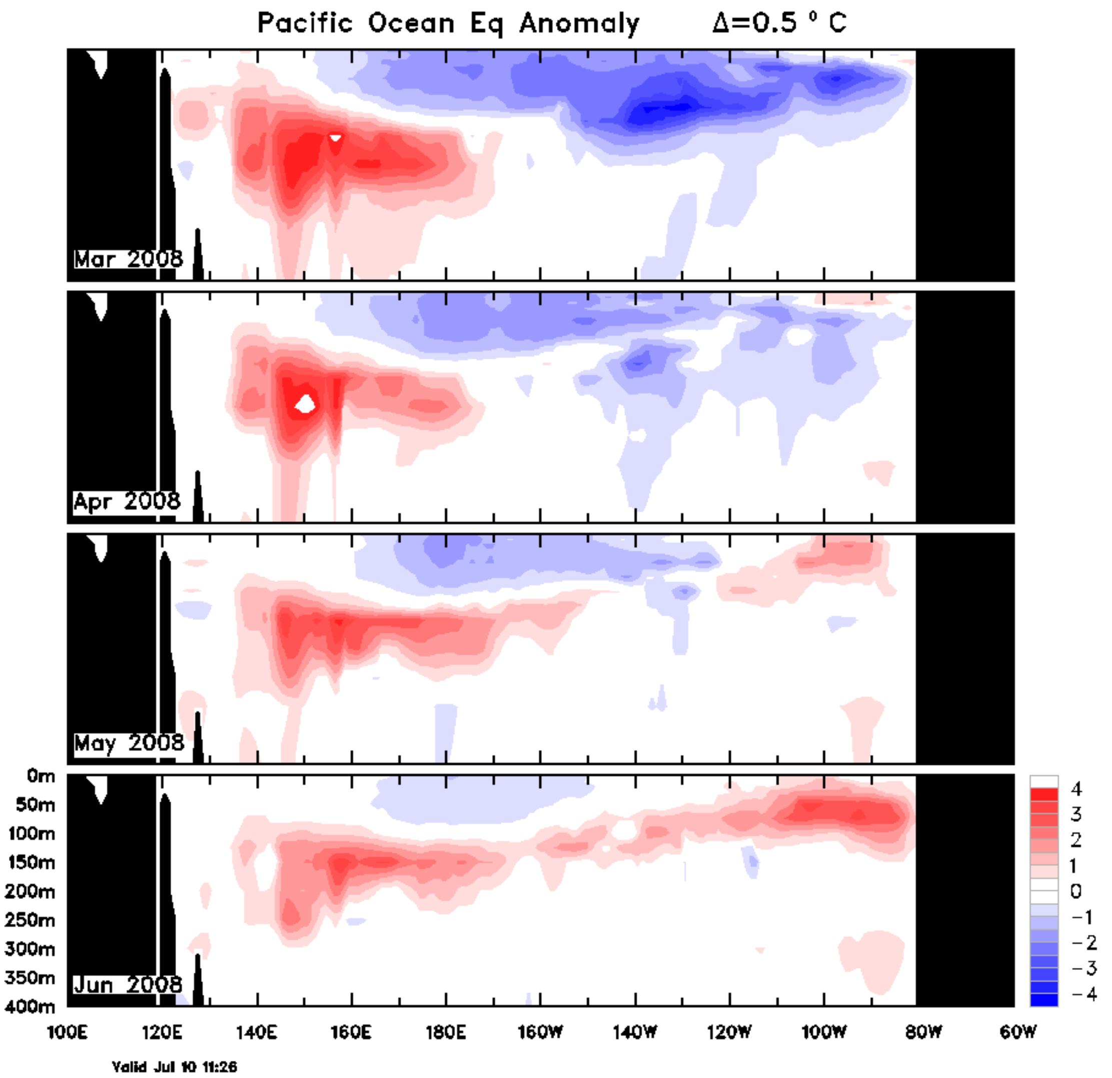


Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for March 2008 through to June 2008. Contour interval is 0.5°C.*

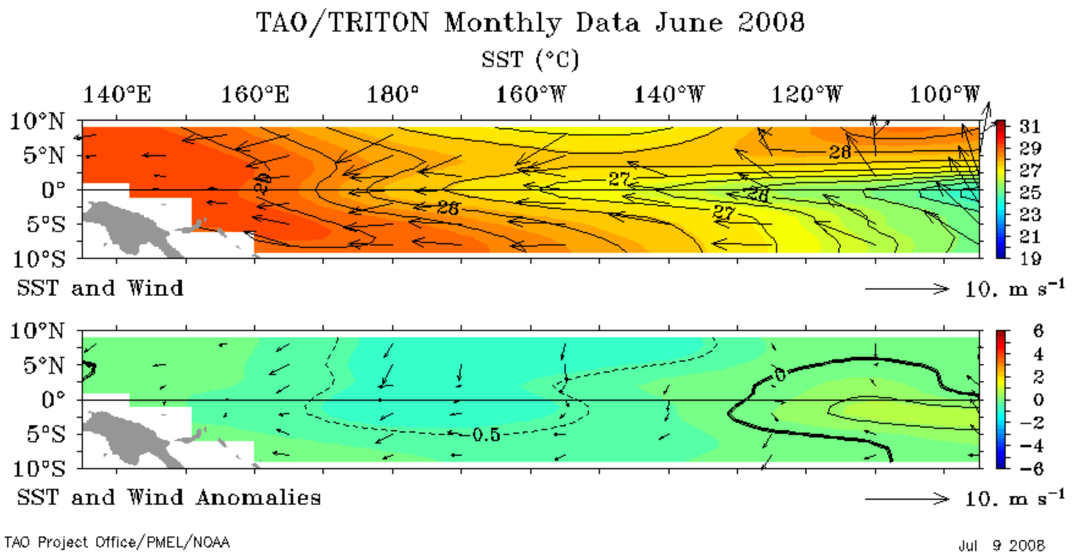


Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for June 2008. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

JUNE 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 new and full moon. There was a new moon on the 3rd of June and a full moon on the 18th of June UTC. The moon orbits the earth on an elliptical path and returns to its closest position, known as lunar perigee, approximately every 28 days. Lunar perigee occurred on the same day as the new moon in June, which is why the spring tides at that time were larger than those around the full moon.

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 the non-tidal sea level fluctuations such as those due to the short-term effects of weather or tsunamis. Residual sea level fluctuations may also be amplified or sustained by the shape of the harbour in which the gauge is located. Persistent sloshing of water within a bay or harbour, for example, is known as a seiche. Seiches are often recorded at PNG when the wind suddenly changes strength or direction and at Vanuatu following the arrival of a tsunami.

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. The maximum wind gust observed by the network during June was 21 m/s (41 knots or 76 km/hr) at Marshall Islands on the 14th of June (**Figure 6**).

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 evident and 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 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 June air temperature of 31.3°C was recorded at Marshall Islands and a new minimum June air temperature of 23.1°C was recorded at Kiribati. A new maximum June barometric pressure of 1014.6hPa was recorded at FSM.

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.

In June 2008 small positive anomalies (slightly higher than normal sea levels) were observed at Solomon Islands, Samoa, Vanuatu, Fiji, Tonga and Cook Islands. The largest of these positive anomalies was +6cm at Vanuatu. Small negative anomalies were observed at FSM, Kiribati, Nauru and Tuvalu, the most significant of these being –5cm at Nauru, while near-normal sea levels were observed at Marshall Islands and PNG. Overall sea levels through June 2008 were consistent with the prevalence of neutral climate conditions across the region.

Sea Level Trends

The **short-term sea level trends** at individual stations as at June 2008 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 June, 2008

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**	**+5.0**	**+0.1**
Tonga	**21°8'12.5"S / 175°10'50.5"W**	**Jan 1993**	**+8.8**	**+0.1**
Fiji	**17°36'17.7"S / 177°26'17.7"E**	**Oct 1992**	**+3.9**	**0.0**
Vanuatu	**17°45'19.2"S / 168°18'27.7"E**	**Jan 1993**	**+4.2**	**+0.1**
Samoa	**13°49'36.4"S / 171°45'40.7"W**	**Feb 1993**	**+6.5**	**+0.1**
Tuvalu	**8°30'8.9"S / 179°11'42.6"E**	**Mar 1993**	**+6.1**	**0.0**
Kiribati	**1°21'54.2"N / 172°55'58.8"E**	**Dec 1992**	**+4.4**	**-0.1**
Nauru	**0°31'45.9"S / 166°54'36.2"E**	**Jul 1993**	**+5.1**	**-0.1**
Solomon Is.	**9°25'44.1"S / 159°57'19.3"E**	**Jul 1994**	**+7.8**	**+0.1**
PNG	**2°2'31.5"S / 147°22'25.6"E**	**Sep 1994**	**+7.8**	**0.0**
FSM	**6°58'49.9"N / 158°12'0.8"E**	**Dec 2001**	**+22.4**	**-0.3**
Marshall Is.	**7°6'21.7"N / 171°22'22.1"E**	**May 1993**	**+3.9**	**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 June 2008 barometric pressures were generally near normal, the largest anomaly being +2hPa at Cook Islands.

The **water temperature anomalies (Figure 15)** show during June 2008 Kiribati and Nauru experienced cooler than normal water temperatures by about –1.0°C. The water temperature anomalies at these sites can be substantially more pronounced than the other sites due to their position near the equator. At Marshall Islands and FSM cooler than normal water temperatures were also observed although only by less than –0.5°C. At Vanuatu water temperatures returned to near normal in June following a period of more than 12 months of warmer than normal conditions. Water temperatures at the remaining sites were generally near normal in June.

The **air temperature anomalies (Figure 16)** show temperatures were +1°C warmer than normal at Marshall Islands and almost -1°C cooler than normal at Kiribati. Elsewhere, aside from Nauru and Tuvalu where problems with the air temperature sensors exist, air temperatures during June 2008 were generally within +/- 0.5°C of what is normally observed at this time of the year. 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 Tuvalu the air temperature data were removed from the record due to a faulty sensor. At Nauru air temperature data were also removed from the record, continuing on from September last year. Data from the backup water temperature sensor was used in both Tonga and Nauru due to problems with the primary water temperature sensors. Spikes in the water temperature data obtained at Kiribati were removed from the record. At Marshall Islands, Nauru and PNG phone and satellite communications were intermittent and some small gaps remain in the record where data were unable to be recovered.

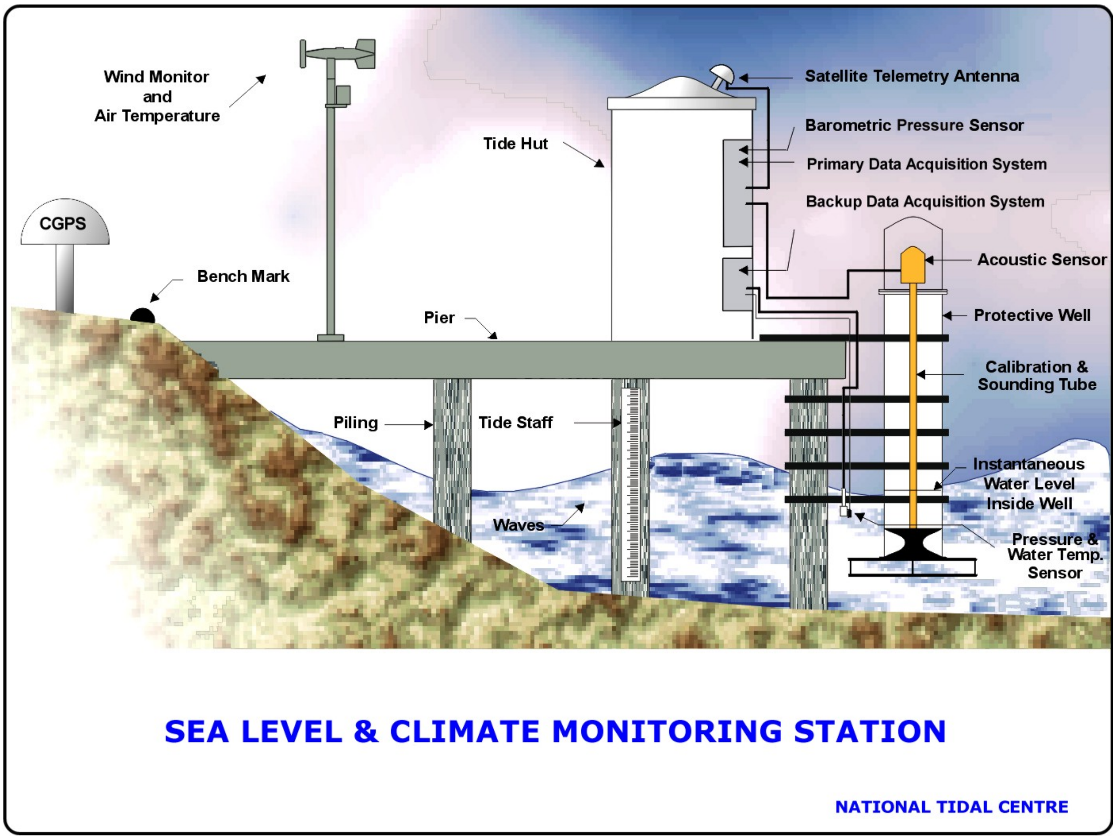
SEAFRAME STATIONS

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

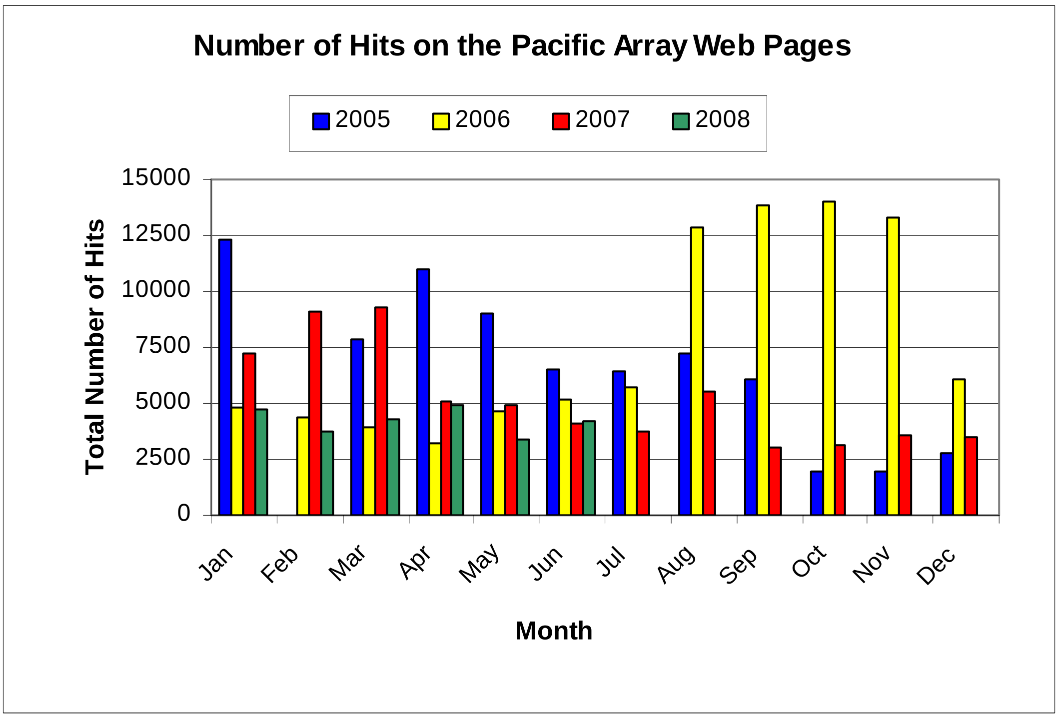
(2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

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 2005. 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:

National Tidal Centre
Bureau of Meteorology
PO Box 421
Kent Town SA 5067
Tel: (+618) (08) 8366 2600
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:

While care has been taken in the collection, analysis, and compilation of the data, it is supplied on the condition that neither the *Commonwealth of Australia* nor *NTC* shall be liable for any loss or injury whatsoever arising from the use of the data.

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

JUNE 2008
SIX MINUTE WATER LEVEL OBSERVATIONS (m)

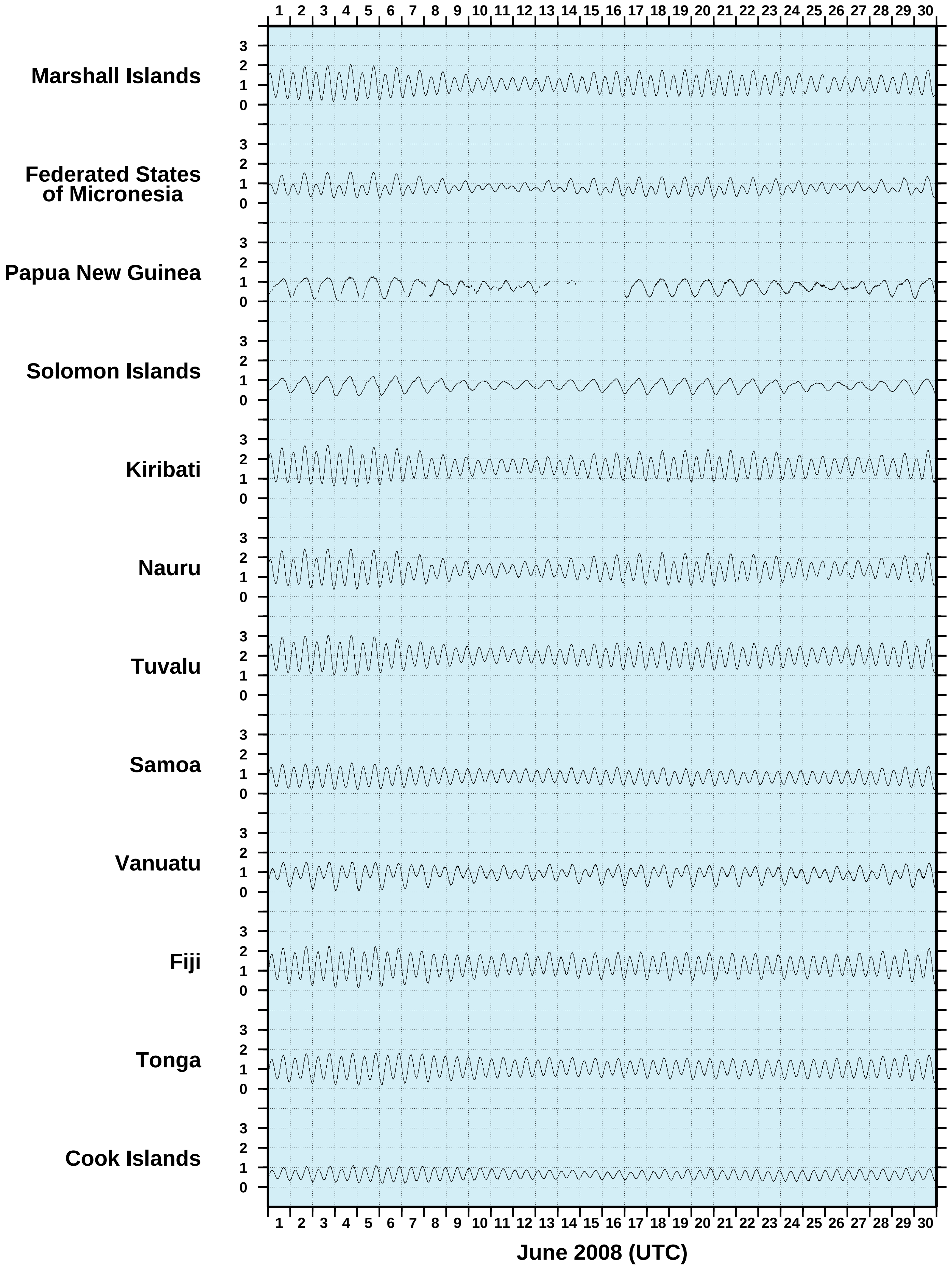


Figure 2

JUNE 2008
SIX MINUTE RESIDUAL WATER LEVELS (m)

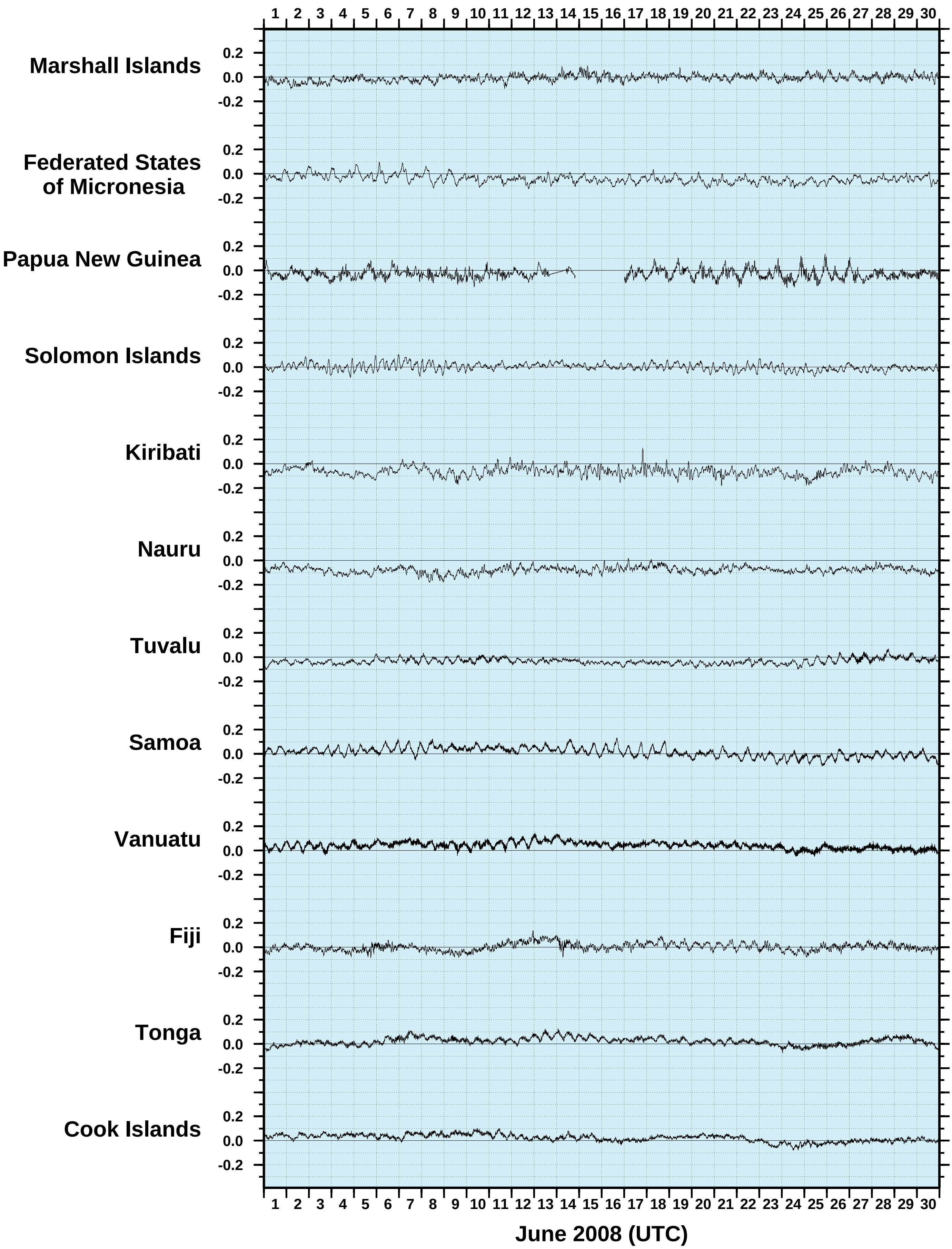


Figure 3

JUNE 2008
SIX MINUTE RESIDUALS
ADJUSTED FOR ATMOSPHERIC PRESSURE (m)

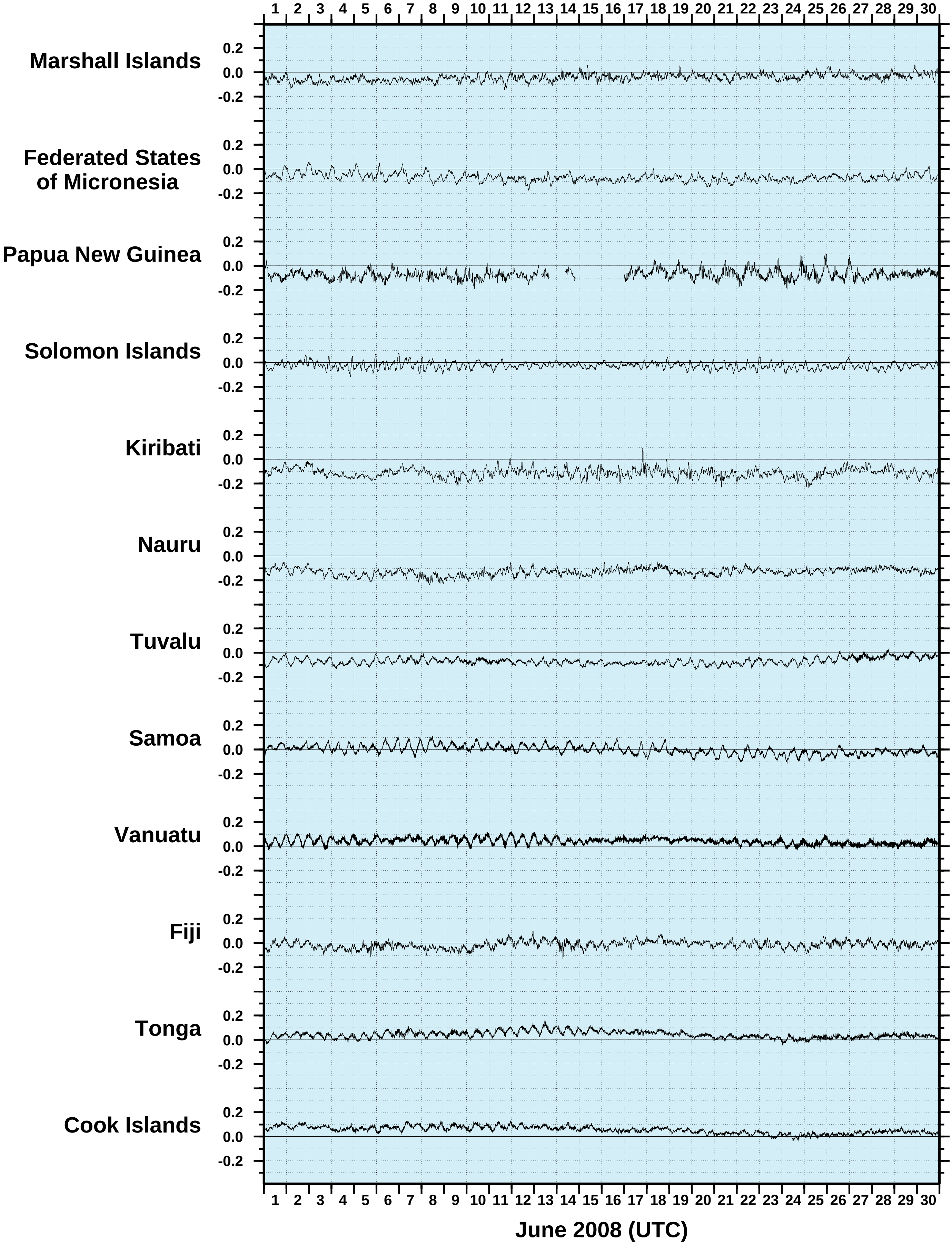


Figure 4

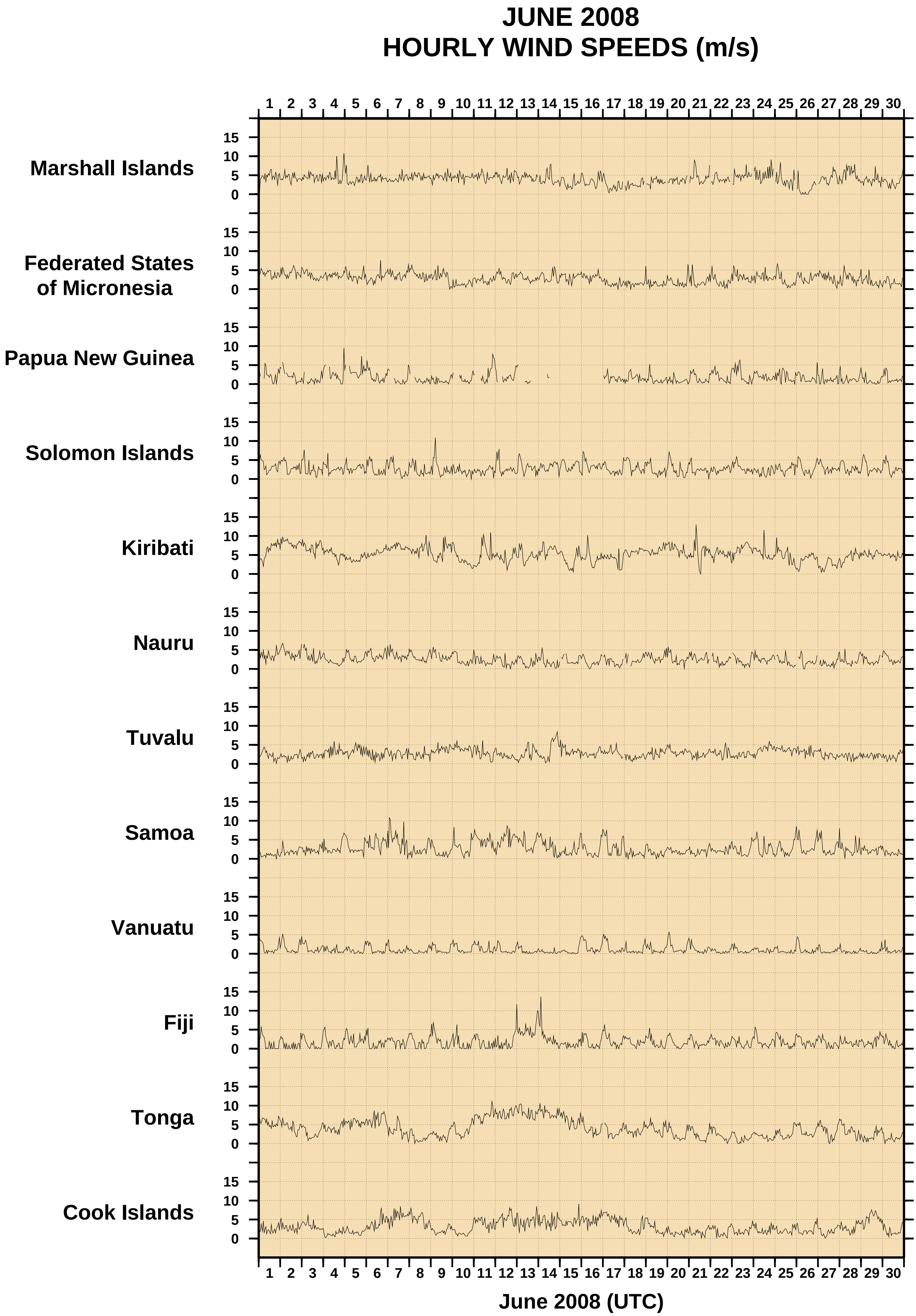

JUNE 2008
HOURLY WIND SPEEDS (m/s)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0
5
10
15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
June 2008 (UTC)

Figure 5

JUNE 2008

HOURLY INCIDENT WINDS (m/s, deg True)

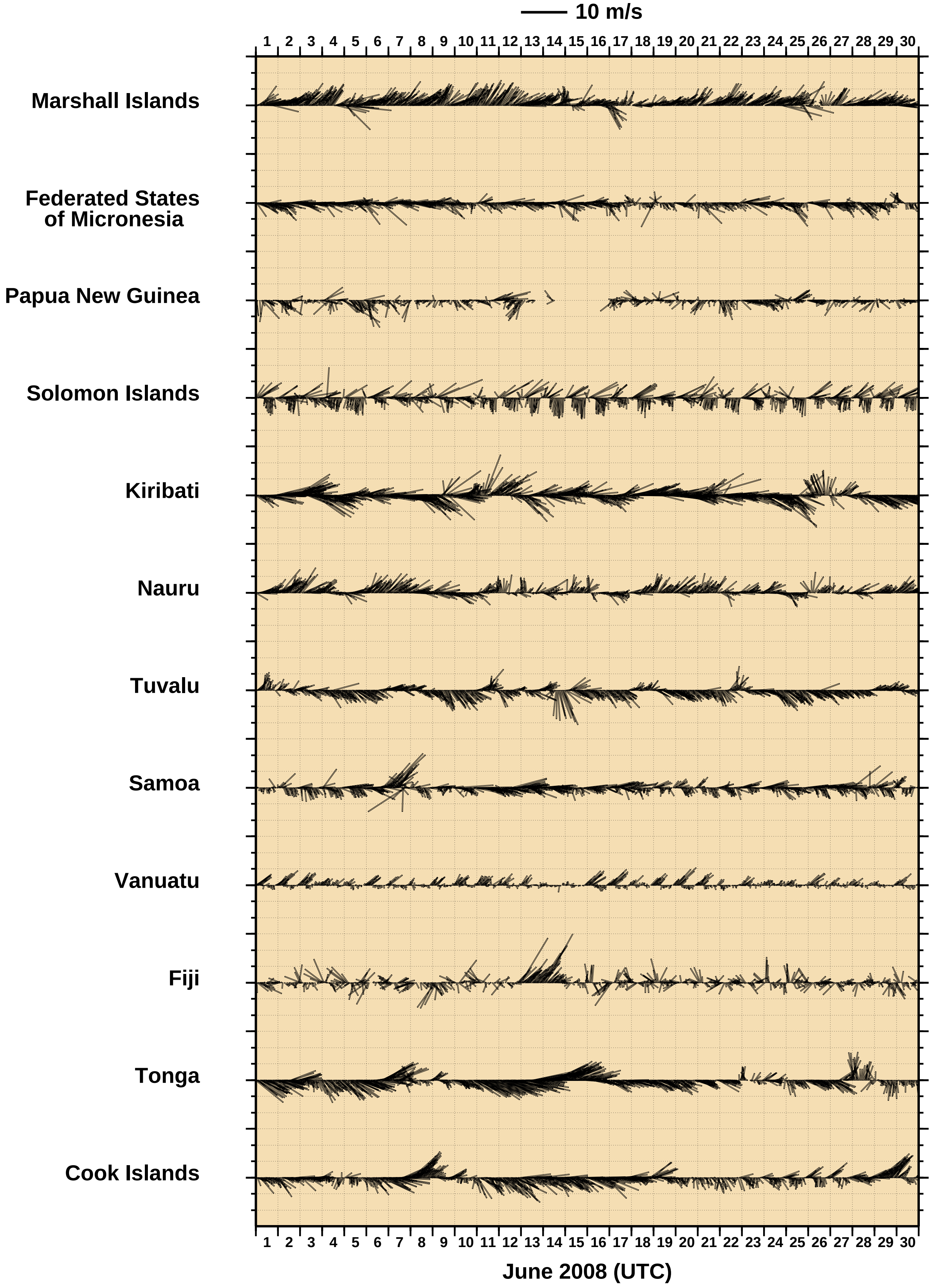


Figure 6

JUNE 2008
HOURLY MAXIMUM WIND GUSTS (m/s)

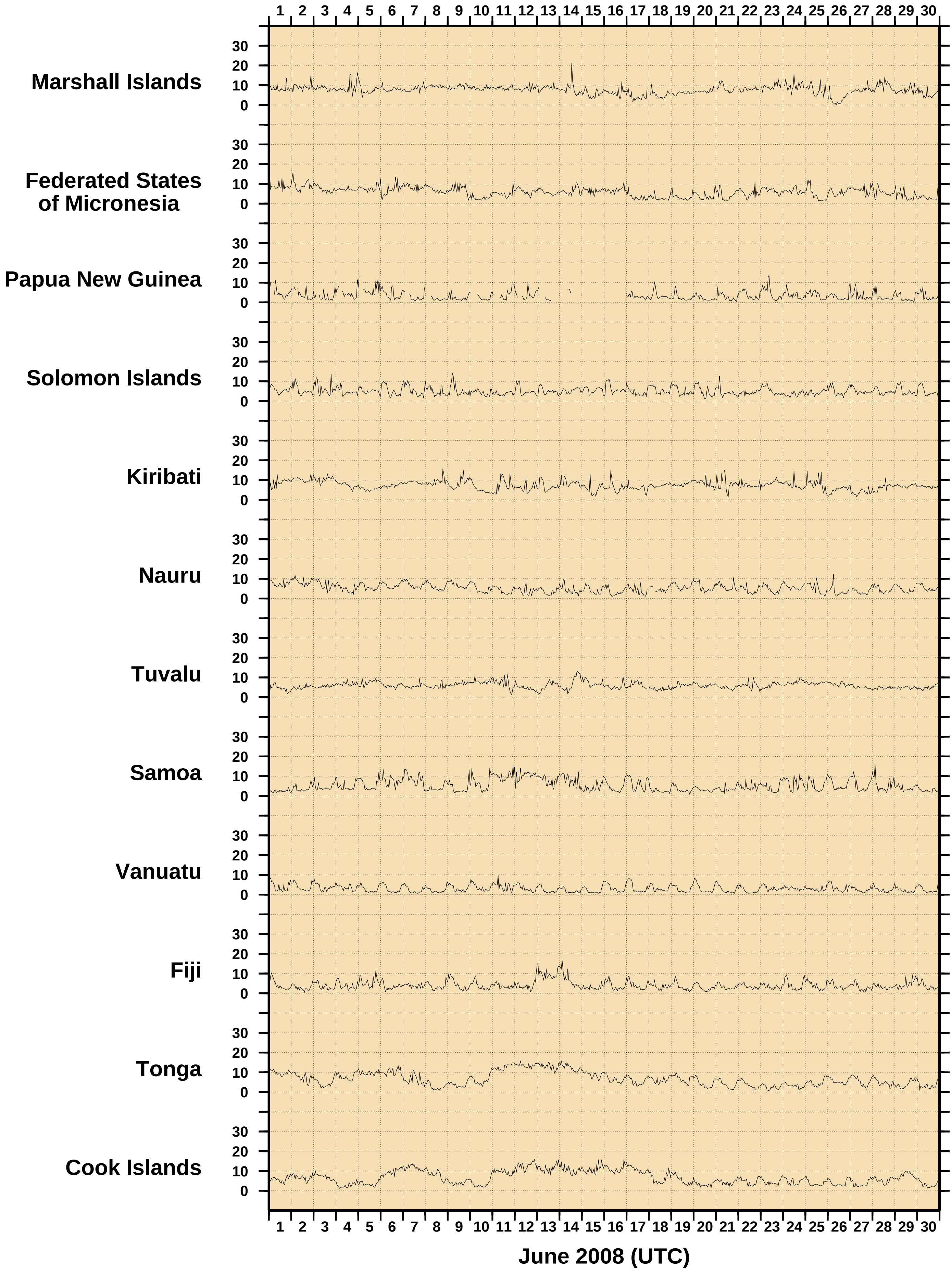


Figure 7

JUNE 2008
HOURLY AIR TEMPERATURES (°C)

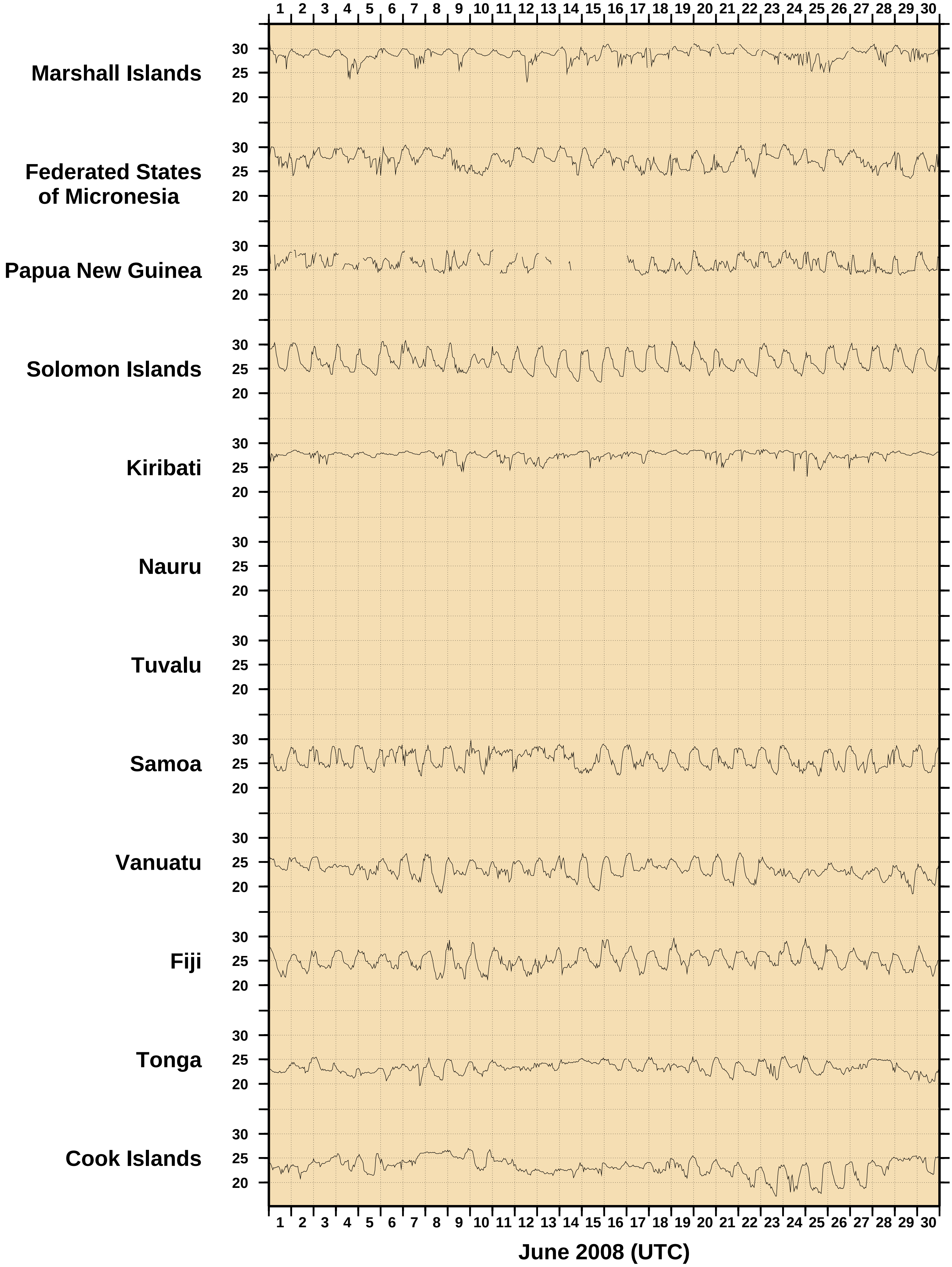


Figure 8

JUNE 2008
HOURLY WATER TEMPERATURES (˚C)

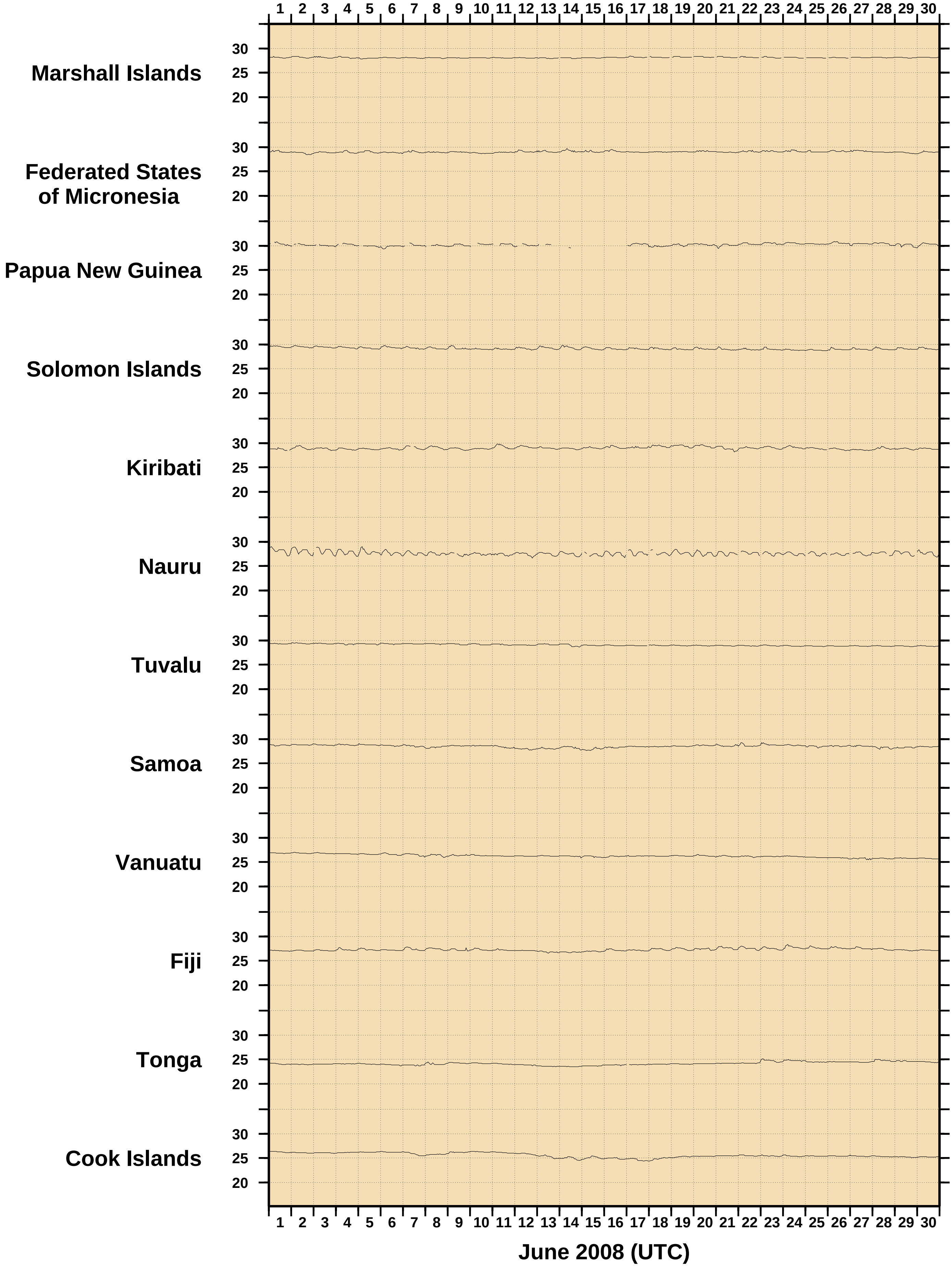


Figure 9

JUNE 2008
HOURLY ATMOSPHERIC PRESSURE (hPa)

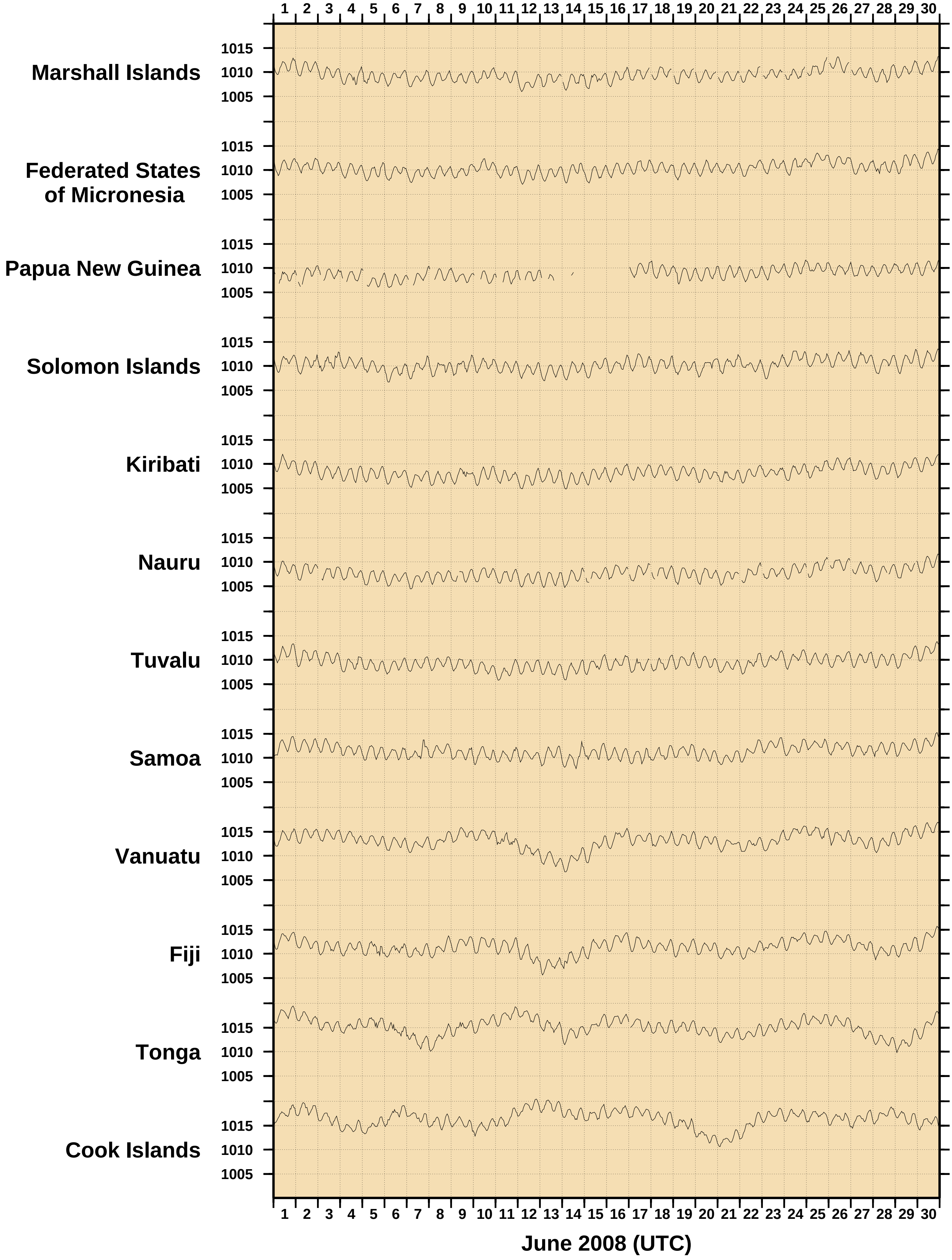
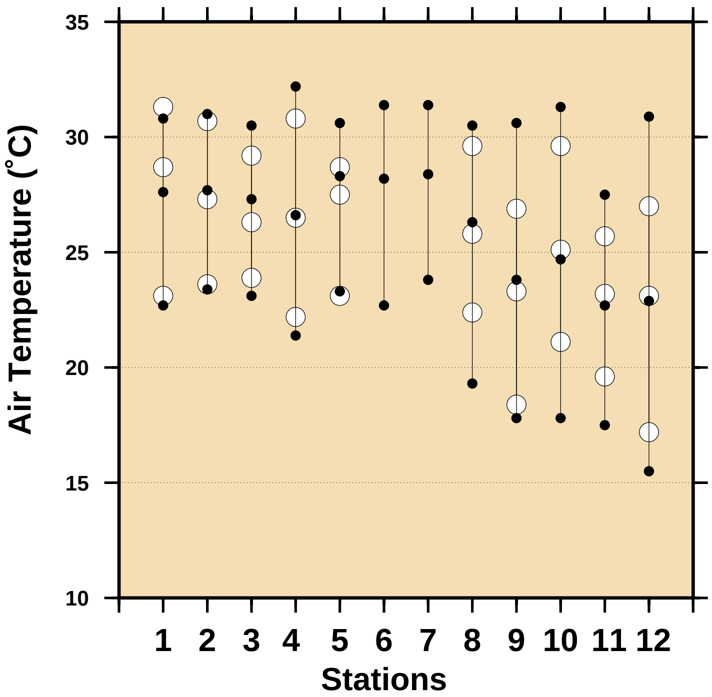
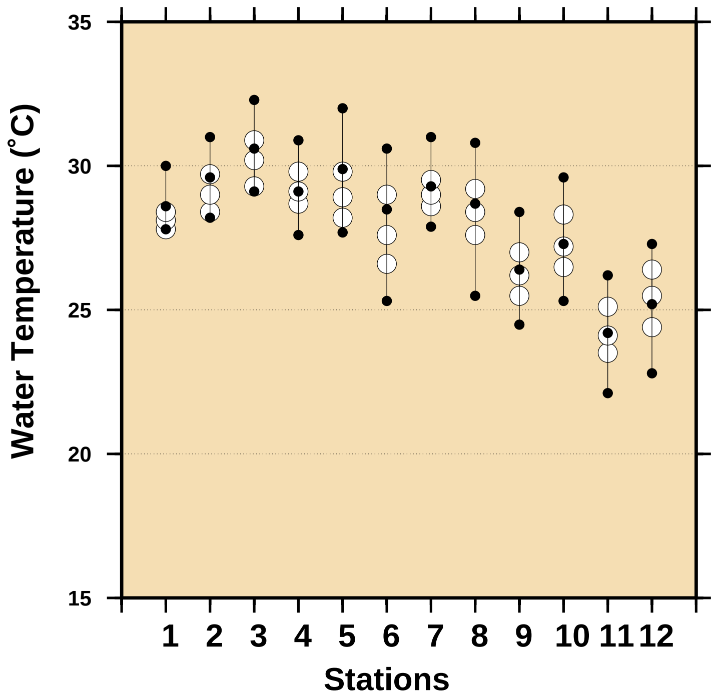
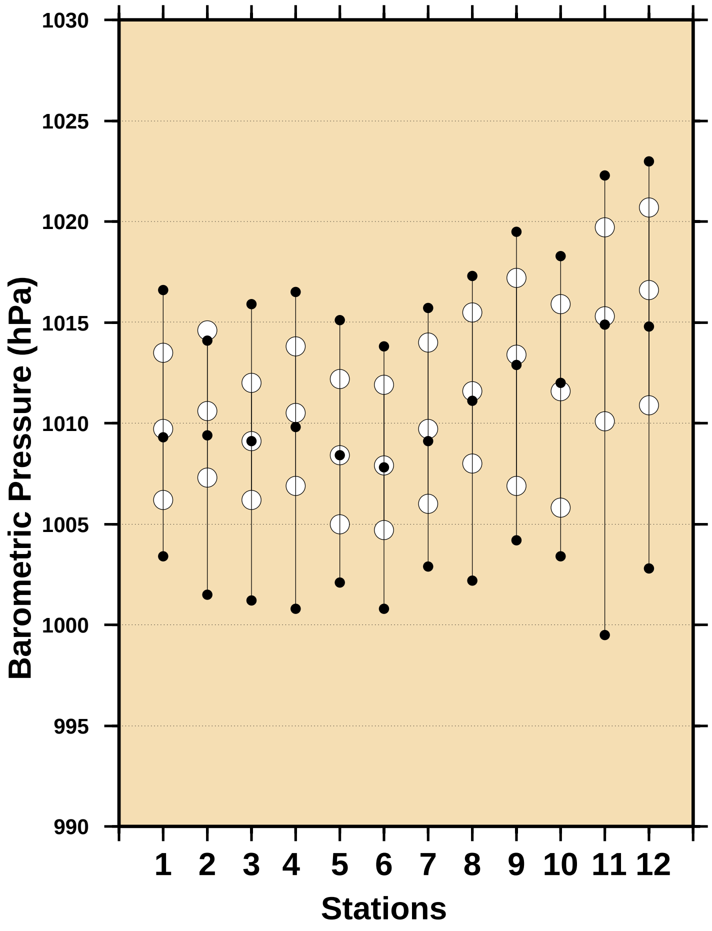


Figure 10

Comparison of June 2008 Max, Min & Mean with Long Term June Values







Stations

1 - Marshall Islands
2 - Federated States of Micronesia
3 - Papua New Guinea
4 - Solomon Islands
5 - Kiribati
6 - Nauru
7 - Tuvalu
8 - Samoa
9 - Vanuatu
10 - Fiji
11 - Tonga
12 - Cook Islands

○ June 2008 Maximum
○ June 2008 Mean
○ June 2008 Minimum

• Long Term June Maximum
• Long Term June Mean
• Long Term June Minimum

Figure 11

MONTHLY MEAN SEA LEVELS TO JUNE 2008 (m)

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

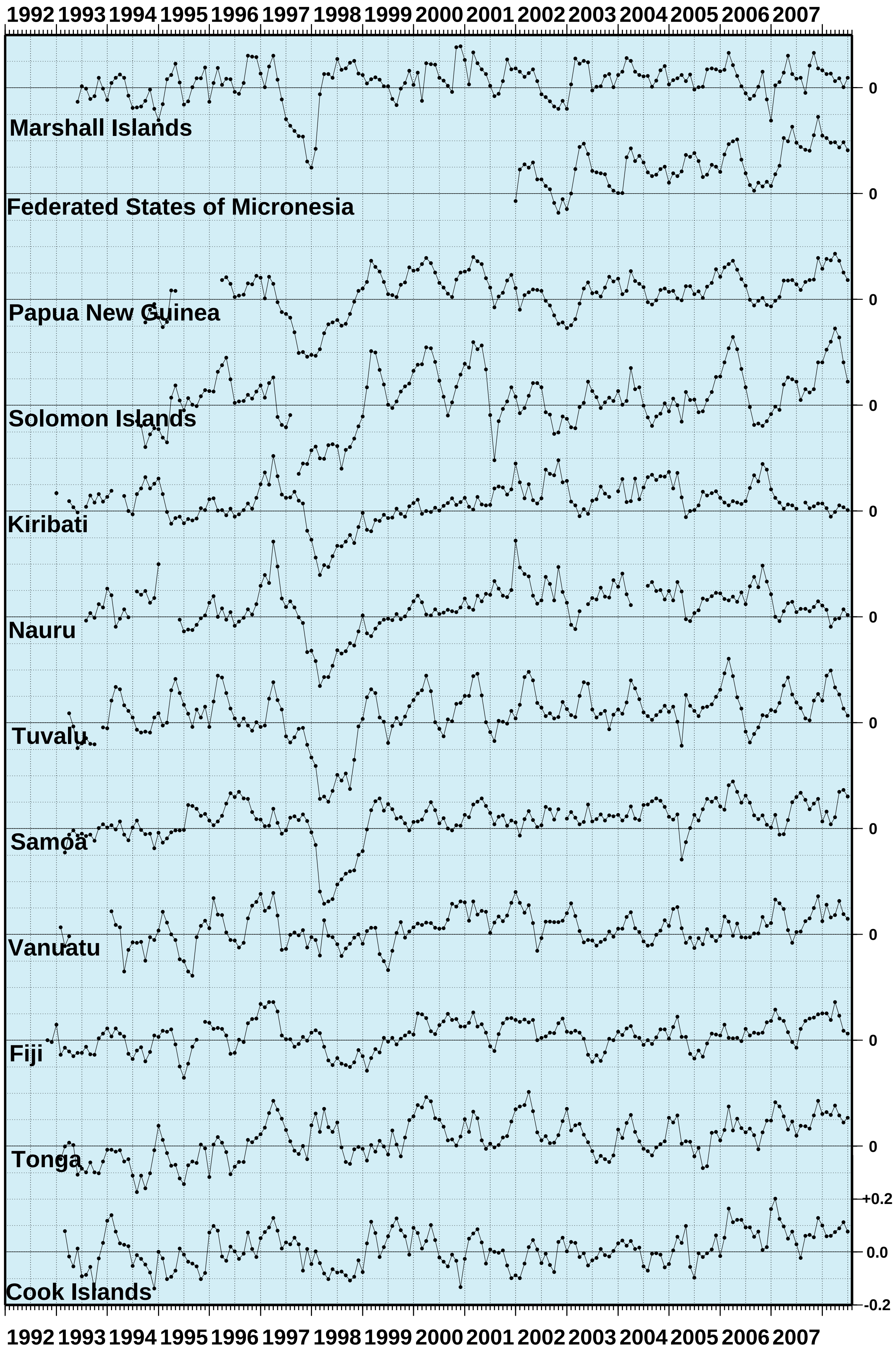


Figure 12

SEA LEVEL ANOMALIES THROUGH JUNE 2008 (m)

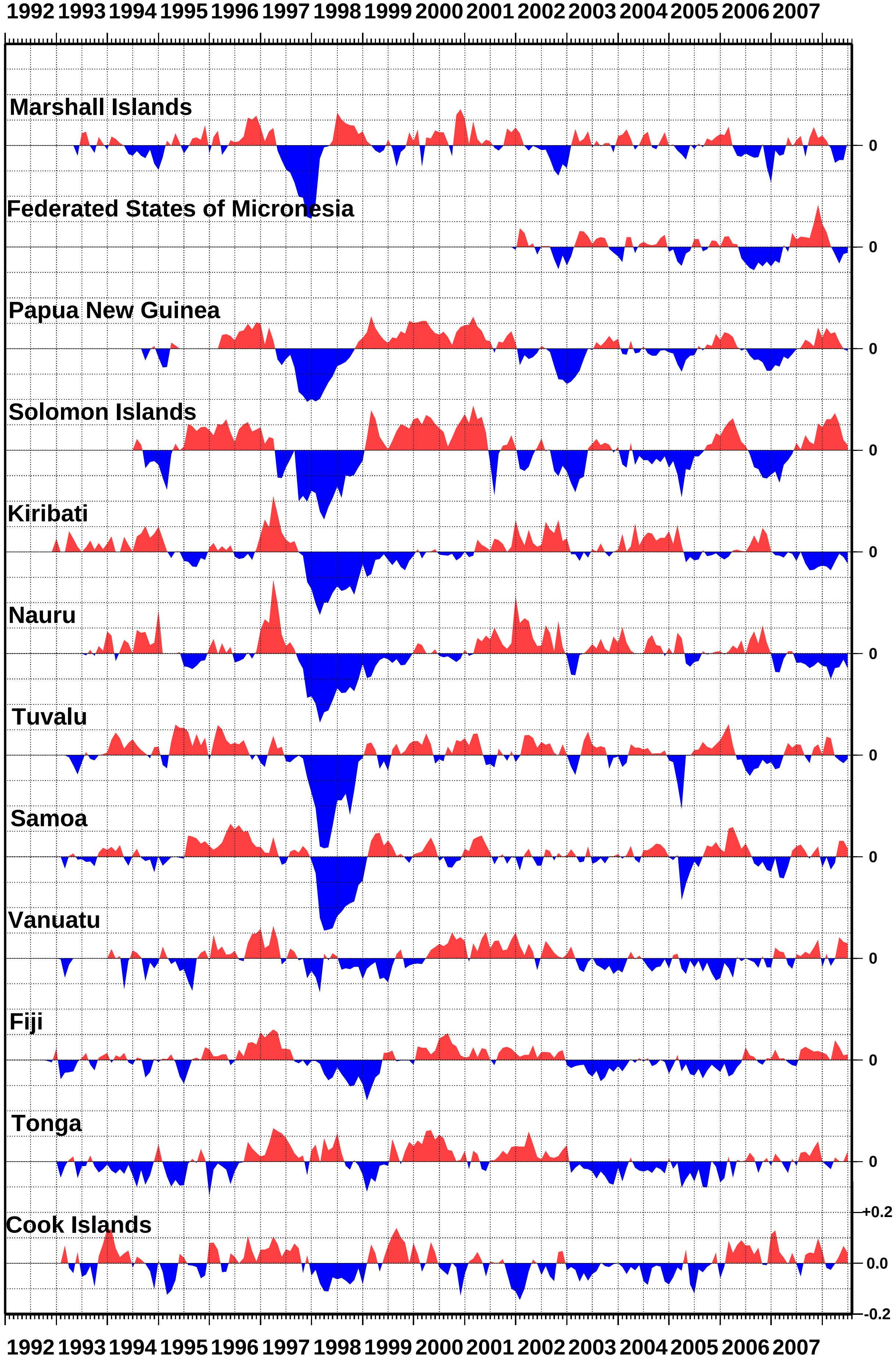


Figure 13

SEA LEVEL TRENDS THROUGH JUNE 2008 (mm/year)

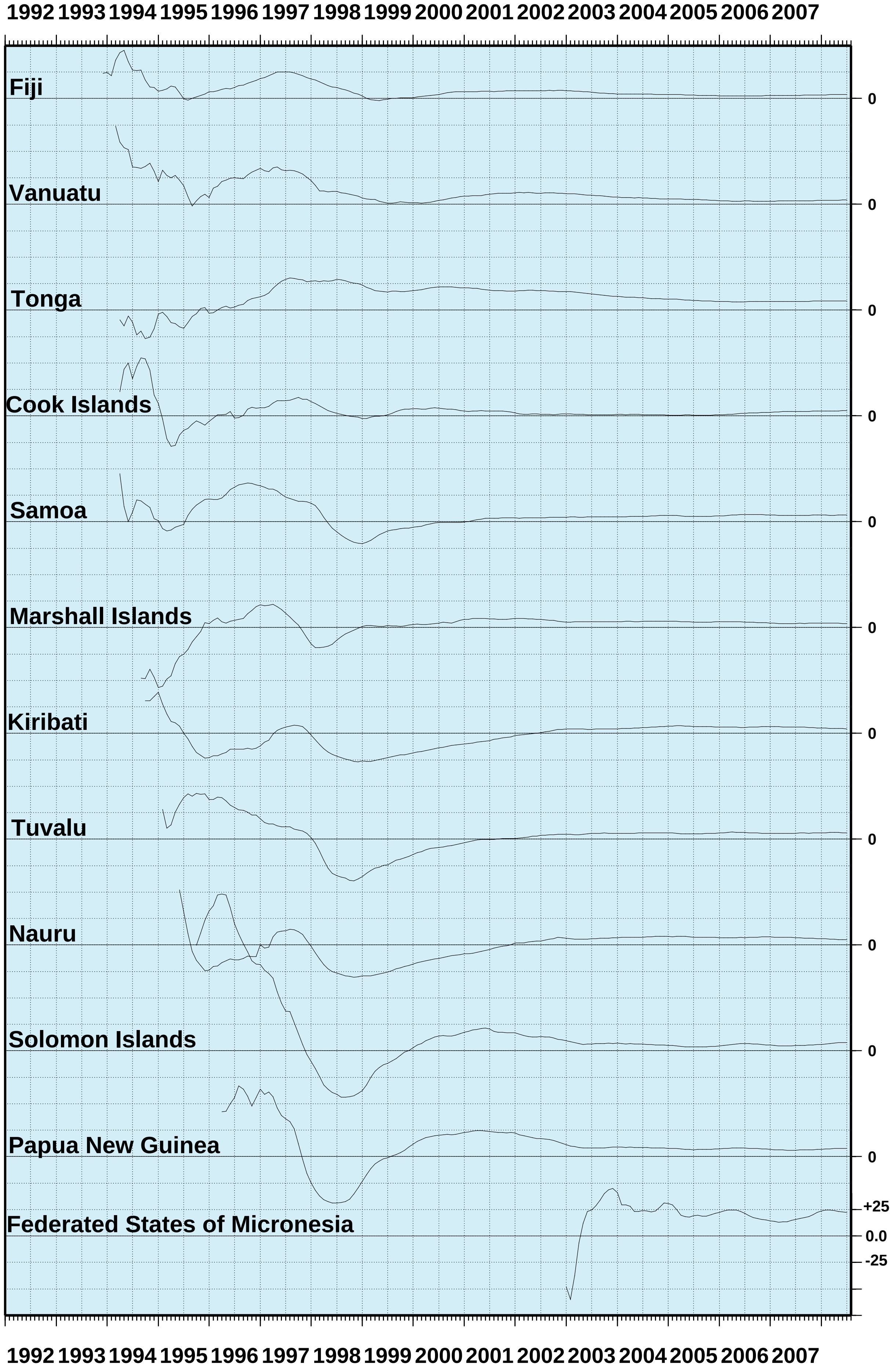


Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH JUNE 2008 (hPa)

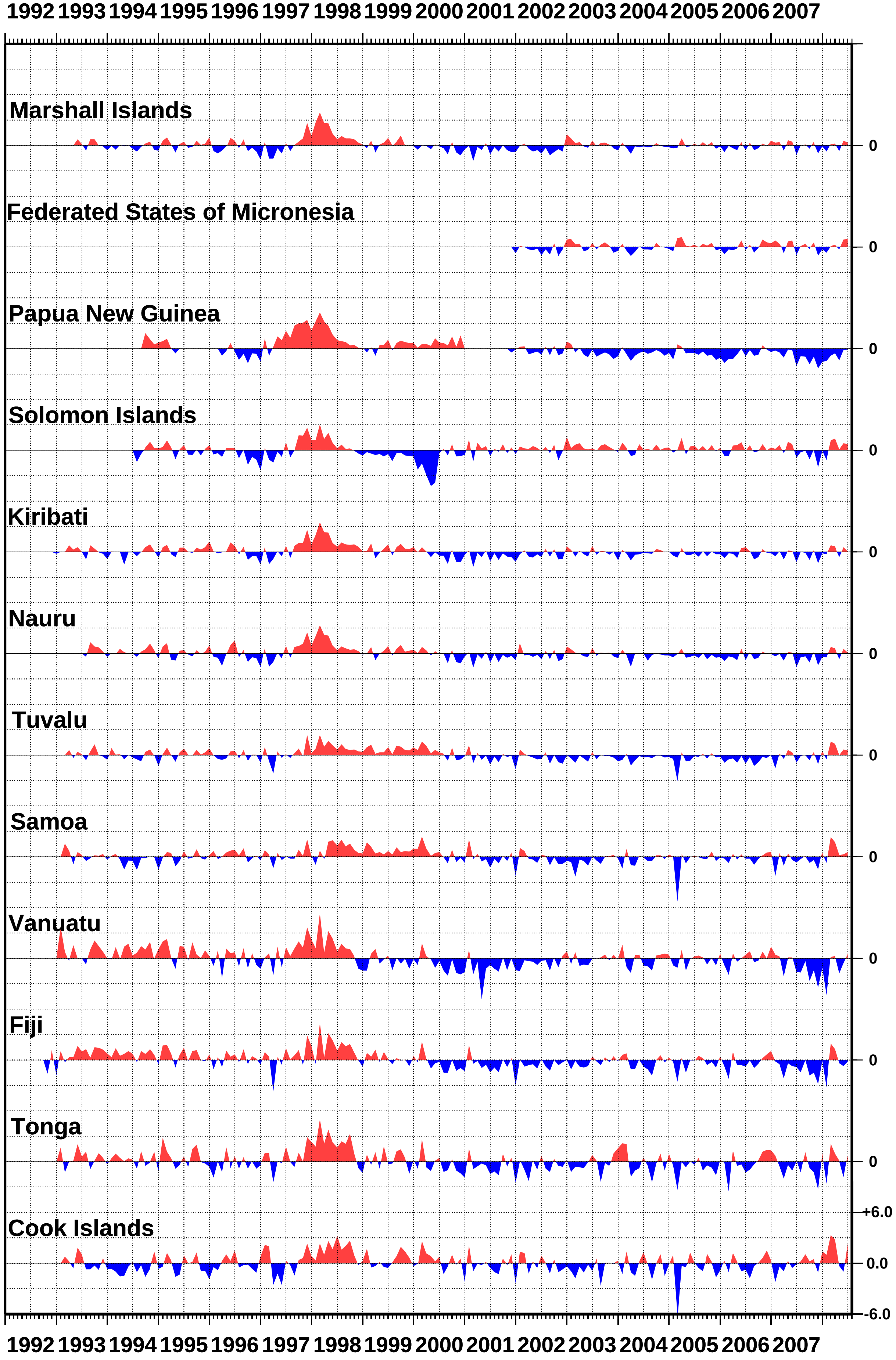


Figure 15

WATER TEMPERATURE ANOMALIES THROUGH JUNE 2008 (°C)

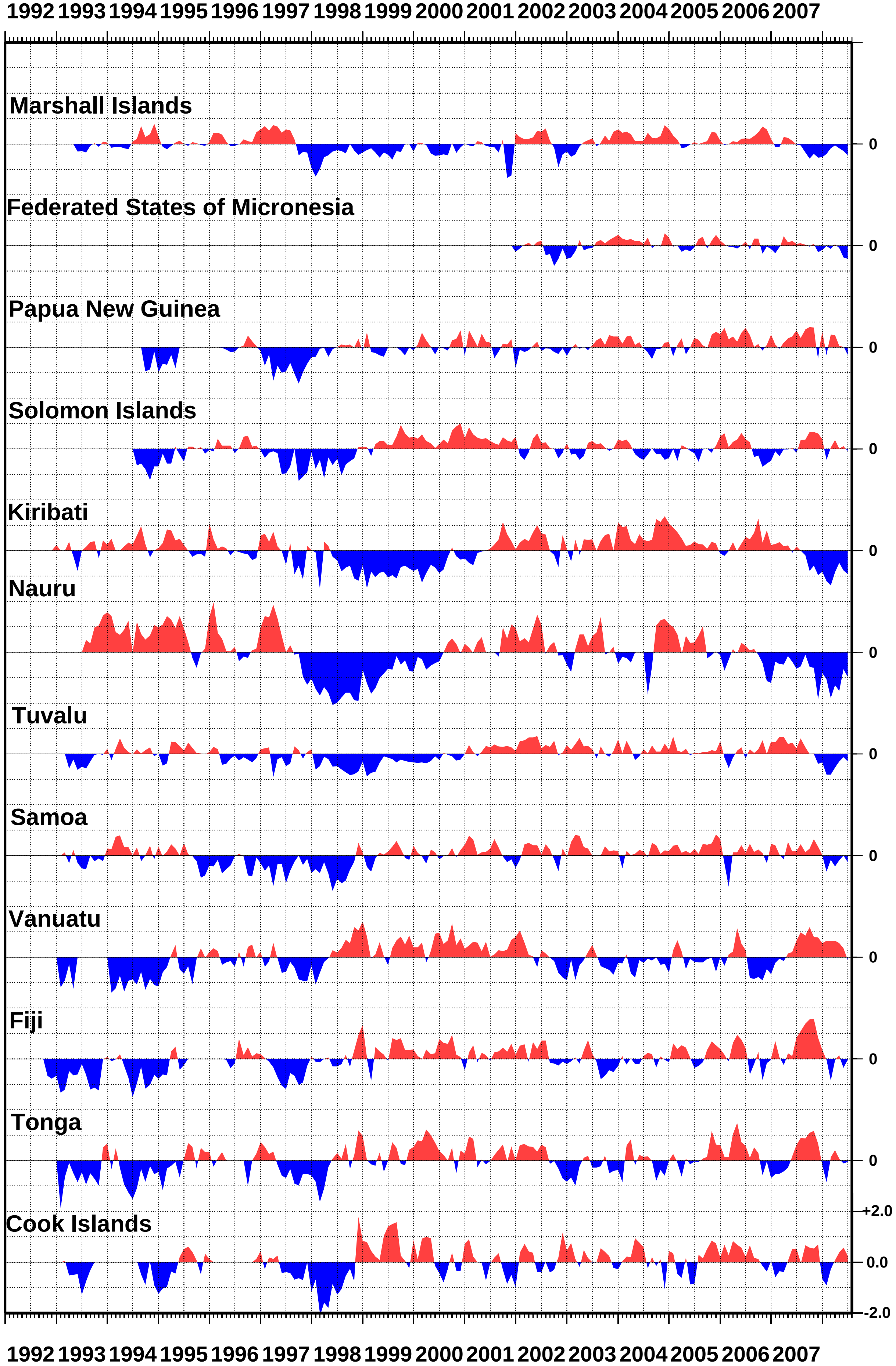


Figure 16

AIR TEMPERATURE ANOMALIES THROUGH JUNE 2008 (°C)

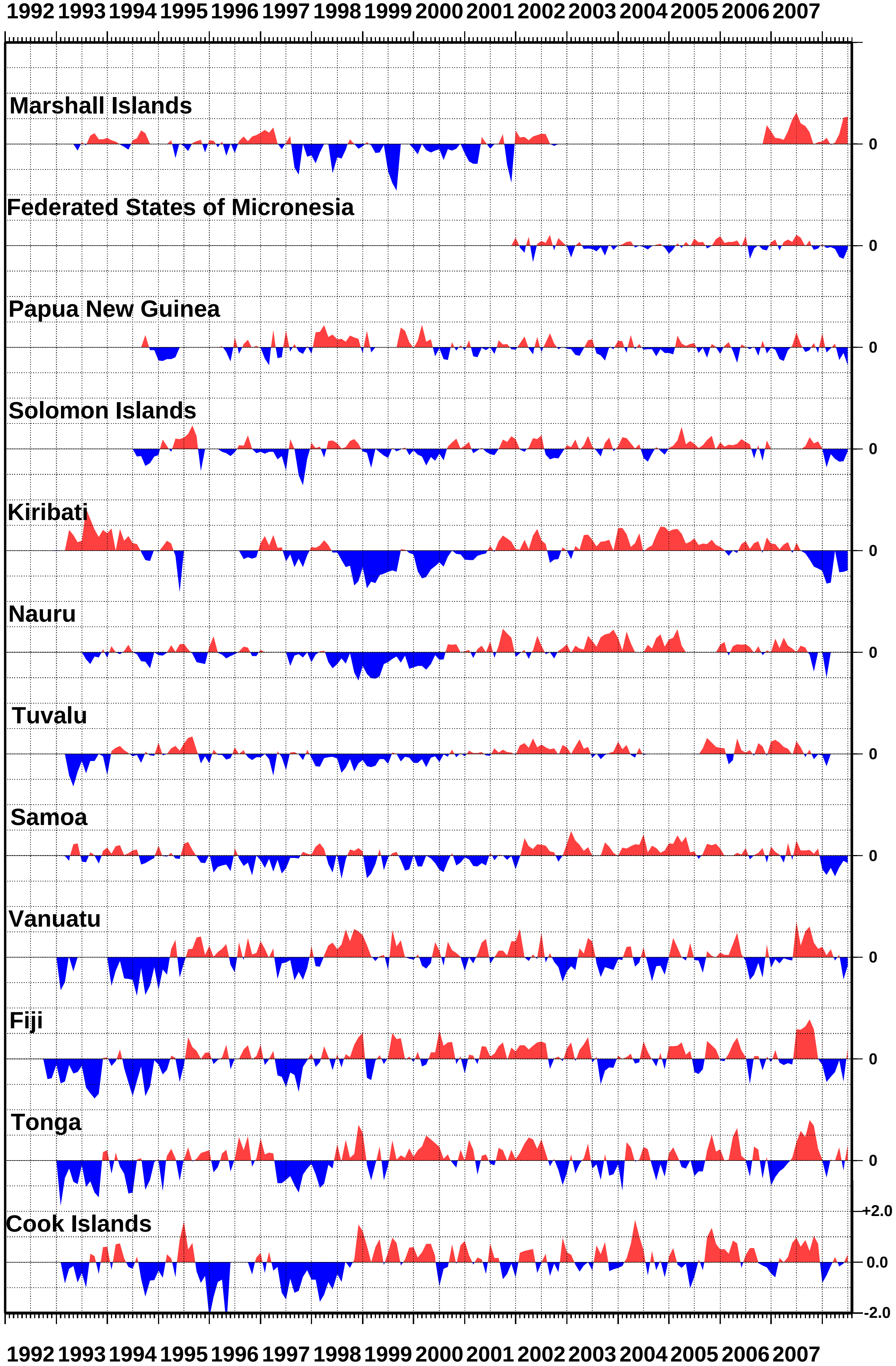


Figure 17

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED

GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE

* Patchy record