

**THE SOUTH PACIFIC SEA LEVEL & CLIMATE  
MONITORING PROJECT**

**MONTHLY DATA REPORT**

**NO. 154**

**APRIL 2008**



**Australian Government**

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**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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**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 April 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

April 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.

#### *April 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.
- The monthly mean sea level at Solomon Islands was 10cm higher than normal. Monthly mean sea levels at the other stations were within 10cm of what is normally expected at this time of the year.
- The recent La Niña event is officially over and neutral climate conditions have now returned to the equatorial Pacific. Residual La Niña features such as cooler than average sea surface temperatures, stronger than normal Trade Winds and below average cloudiness exist in the west-central equatorial Pacific but not at the levels typical of La Niña.
- The majority of international climate models predict that neutral climate conditions will persist until at least October 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 April, 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	+4.8	+0.1
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+8.7	0.0
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+3.8	+0.1
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+3.9	+0.2
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+6.2	+0.2
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+6.2	-0.1
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+4.6	0.0
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+5.3	-0.1
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+7.6	+0.3
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+7.8	+0.1
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+23.1	-0.9
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+4.1	-0.1

## INTRODUCTION

Welcome to the April 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.

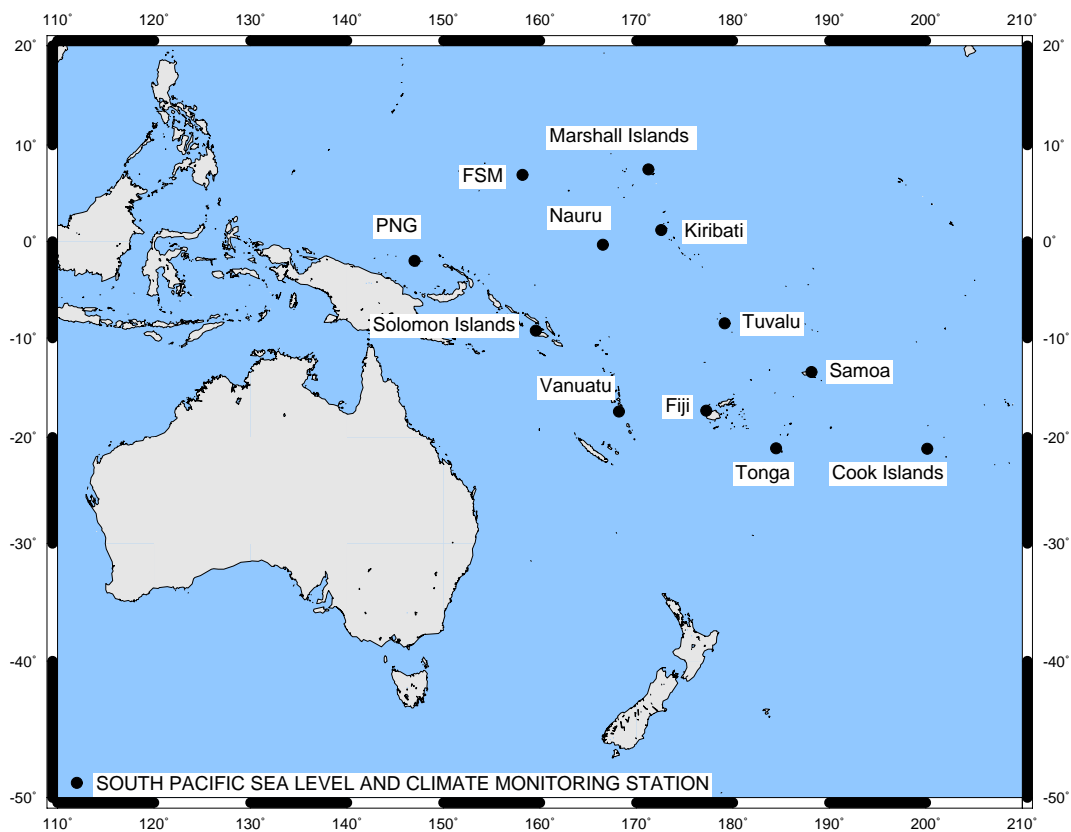
SEAFRAME gauges not only measure sea level by two independent means, but also observe a number of “ancillary” variables - air and water temperatures, wind speed, wind direction and atmospheric pressure. There is an associated programme of levelling to first order, to determine shifts in the vertical 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*

## APRIL CLIMATOLOGY

The La Niña event continued to weaken through April 2008 and equatorial Pacific climate conditions are now generally neutral. La Niña-like conditions such as cooler than normal ocean temperatures, stronger than normal Trade Winds and reduced cloudiness are still being observed in the west-central equatorial Pacific, but elsewhere ocean temperatures have warmed and Trade Winds in the eastern Pacific are weaker than or near average.

The Southern Oscillation Index (SOI) continued to fall during April and is now characteristic of neutral conditions (**Figure B**). The April SOI value remains slightly positive at +5 as a result of sustained higher than normal barometric pressure at Tahiti rather than low barometric pressure at Darwin.

Cool sea-surface temperature (SST) anomalies continue to be observed in the west-central equatorial Pacific but have decreased substantially in area in the last two months (**Figure C**, **Figure E**). Continued surface warming occurred in the eastern equatorial Pacific during April and SST anomalies above +1°C have developed adjacent to the South American coast but at this stage are not considered to be a sign of a developing El Niño. In the far western Pacific sea surface temperatures remain near to slightly warmer than normal.

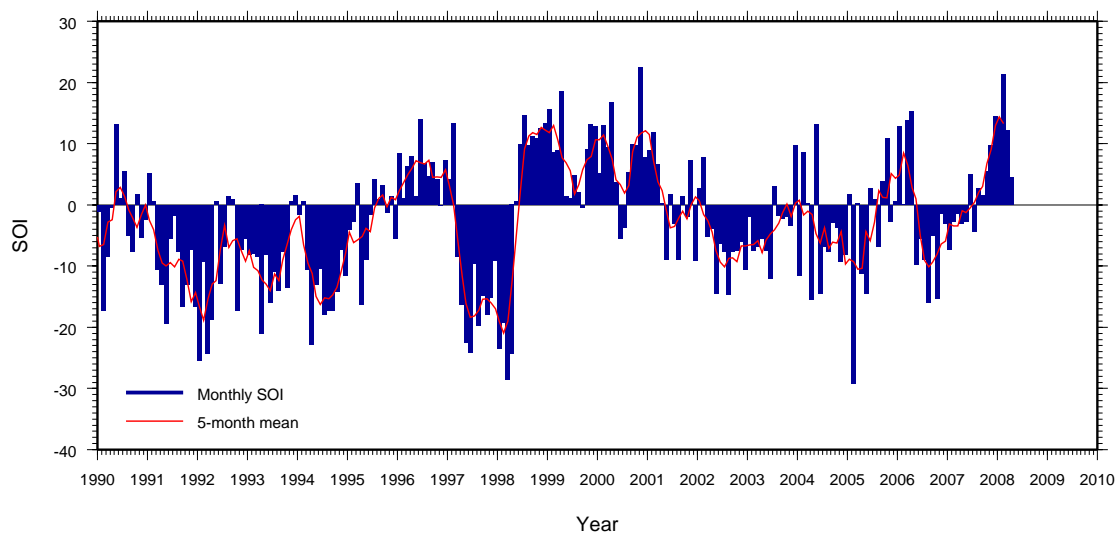
Subsurface temperatures across the equatorial Pacific during April showed a further weakening of the La Niña pattern (**Figure D**). Cool sub-surface temperature anomalies in the eastern equatorial Pacific weakened, while warm sub-surface temperature anomalies in the western equatorial Pacific remained strong.

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 have generally been stronger than normal since August 2007 in keeping with La Niña conditions. However since February 2008, and continuing through April 2008, Trade Winds have been weaker than average across the eastern Pacific which has contributed to the sea surface warming in that region (**Figure E**). Cloudiness in the equatorial Pacific near the dateline continued to be below average during April in keeping with cooler than normal sea surface temperatures in that region.

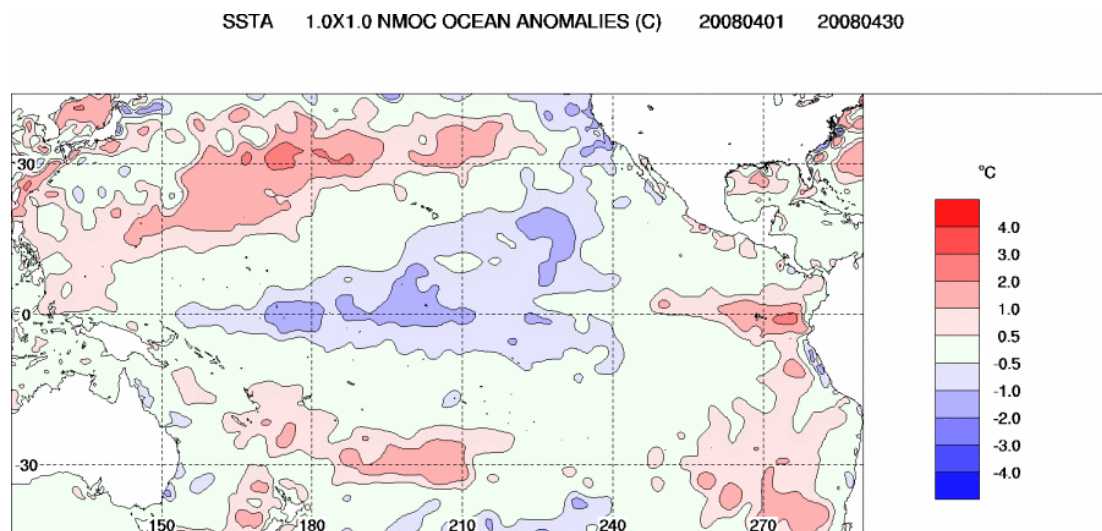
The consensus among six international computer models is that neutral climate conditions will persist across the equatorial Pacific until October.

*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/>.*

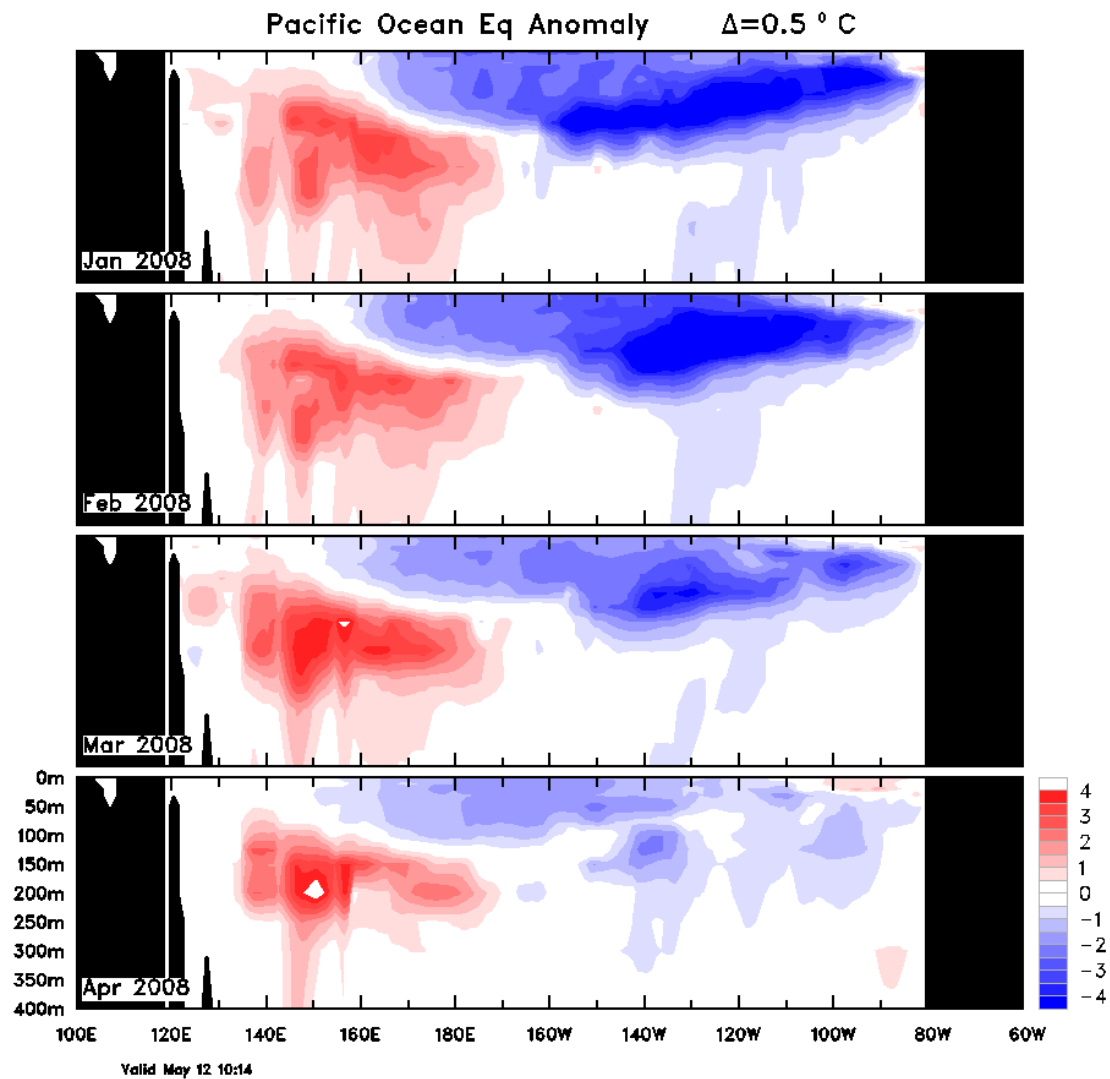
## Southern Oscillation Index (SOI)



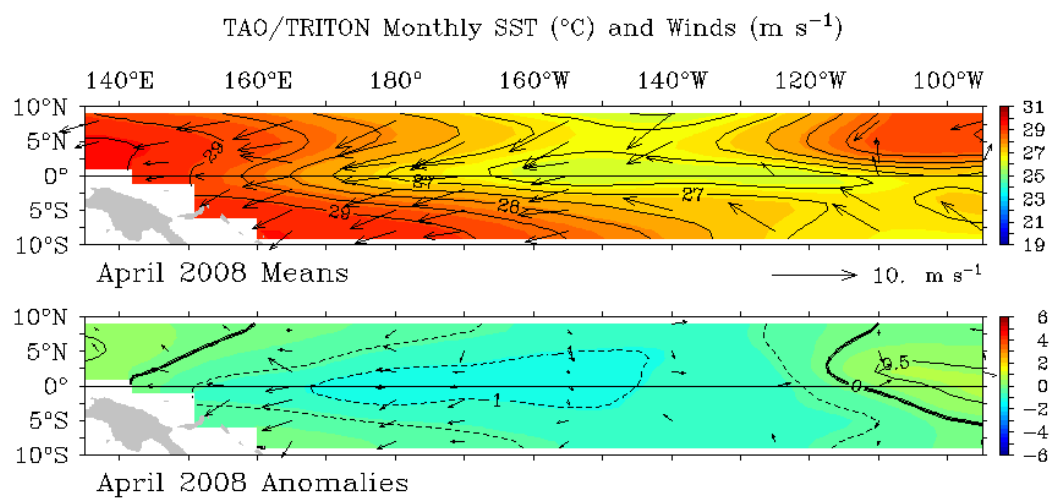
**Figure B:** The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the long-term standard deviation of that difference for the relevant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



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



**Figure D:** Equatorial depth-longitude section of ocean temperature anomalies for January 2008 through to April 2008. Contour interval is  $0.5^{\circ}\text{C}$ .



TAO/NDBC/NOAA

May 13 2008

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



## APRIL 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 6<sup>th</sup> of April and a full moon on the 20<sup>th</sup> of April 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 the non-tidal sea level fluctuations such as those due to the short-term effects of weather or tsunamis. Residual sea level effects can also be amplified or sustained by the shape of the harbour in which the gauge is located. Resonant behaviour such as persistent sloshing of water within a bay or harbour is also 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 April was 20 m/s (39 knots or 72 km/hr) at Fiji on the 6<sup>th</sup> of April (**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 April air temperature was recorded at Marshall Islands and a new minimum April water temperature was recorded at Nauru.

### 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.

In April 2008 positive anomalies (higher than normal sea levels) were observed at PNG, Solomon Islands, Samoa, Vanuatu and Fiji. At Solomon Islands the sea level anomaly was more than +10cm. Conversely negative anomalies (lower than normal sea levels) of around -5cm were observed at Marshall Islands, FSM and Nauru. Sea levels at the remaining sites, namely Kiribati, Tuvalu, Tonga and Cook Islands were near normal through April.

### Sea Level Trends

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

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Location	Lat / Long	Installation Date	Trend (mm/yr)	Change from previous month
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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 April 2008 barometric pressures were near normal across the region following a period of slightly higher than normal barometric pressures at Tuvalu, Samoa, Fiji, Tonga and Cook Islands through February and March.

The **water temperature anomalies** (**Figure 15**) show the recent persistence of cooler than normal conditions at Kiribati and Nauru continued through April 2008. Slightly cooler than normal water temperatures were also observed at Tuvalu, Samoa, Fiji, Tonga and Cook Islands at the start of the year but were near normal in April. At Vanuatu water temperatures have remained warmer than normal for the past 12 months.

The **air temperature anomalies** (**Figure 16**) show near-normal conditions were observed at the majority of stations during April 2008. Cooler than average air temperatures have been experienced at some stations in recent months and continued to persist at Solomon Islands, Kiribati and Samoa. 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.

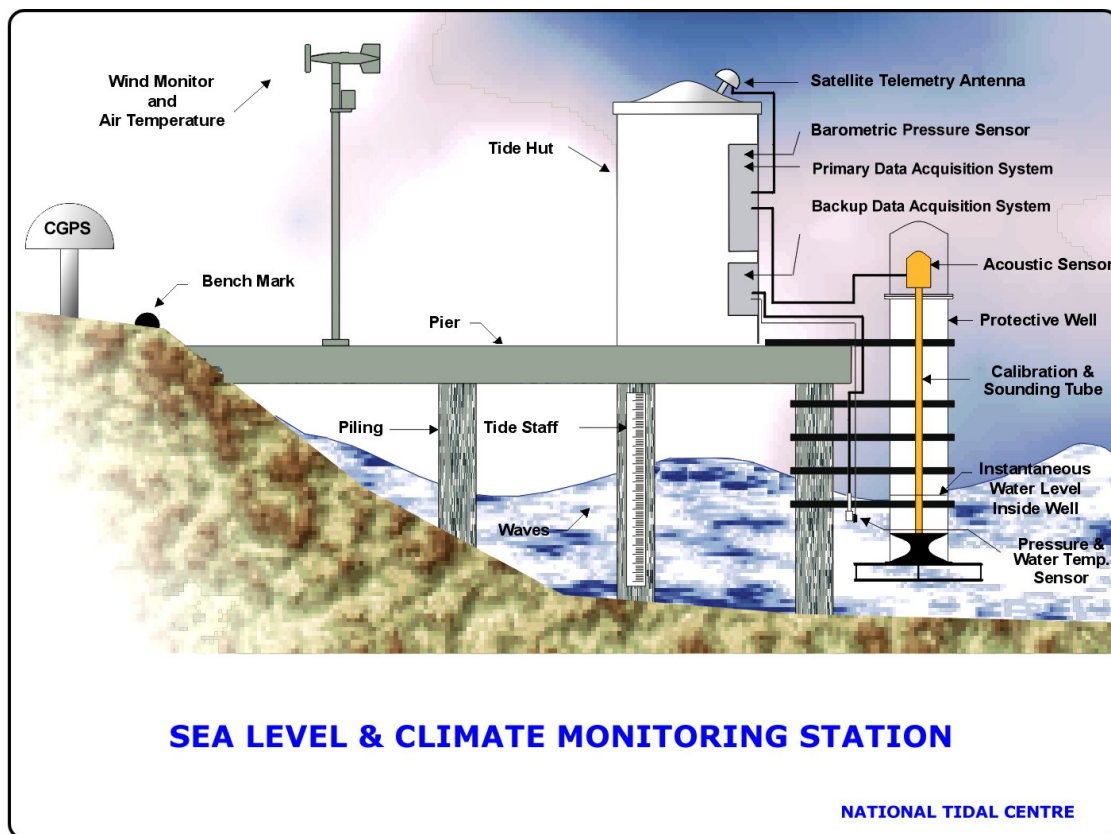
At Tuvalu the air temperature data were removed from the record due to a faulty sensor. At Nauru both the primary sea level sensor and the air temperature sensor produced erroneous readings. Data from the backup sea level sensor were used while the air temperature readings were removed from the record. At Kiribati the air temperature sensor radiation screen was replaced on the 16<sup>th</sup> of April after it had fallen off on the 6<sup>th</sup> of February. The wind sensor at Kiribati was also replaced on the 16<sup>th</sup> of April following the development of a fault on the 10<sup>th</sup> of March. At Solomon Islands the wind sensor was replaced on the 18<sup>th</sup> of April and remedied the problem of erroneous wind directions that had been recorded there since 30<sup>th</sup> July 2007. At Tuvalu, Nauru and PNG phone and satellite communications were intermittent and some small gaps remain in the record where data was 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:

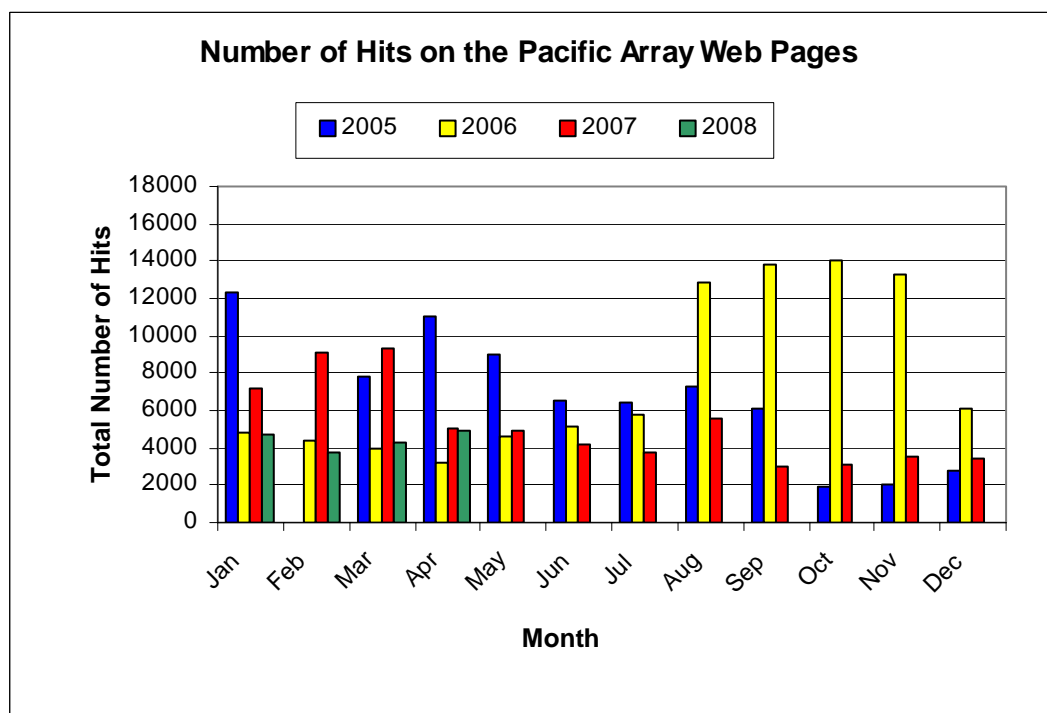
- (1) Primary water level using a Bartex 'AQUATRAK' acoustic-in-air sensor, and
- (2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

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>

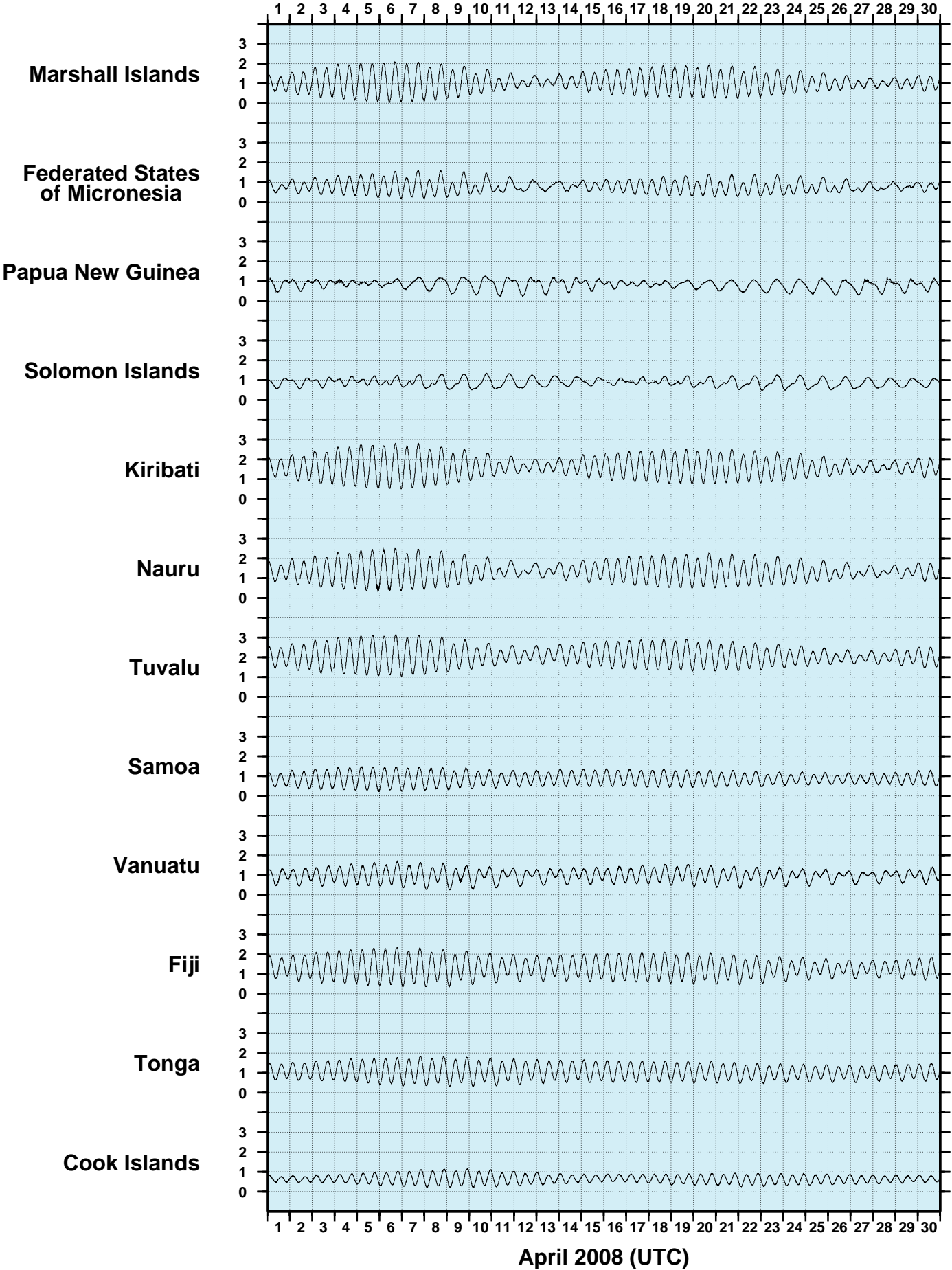
Please refer to: <http://www.bom.gov.au/oceanography/projects/spslcmp/spslcmp.shtml> for details.

Please also note the following:

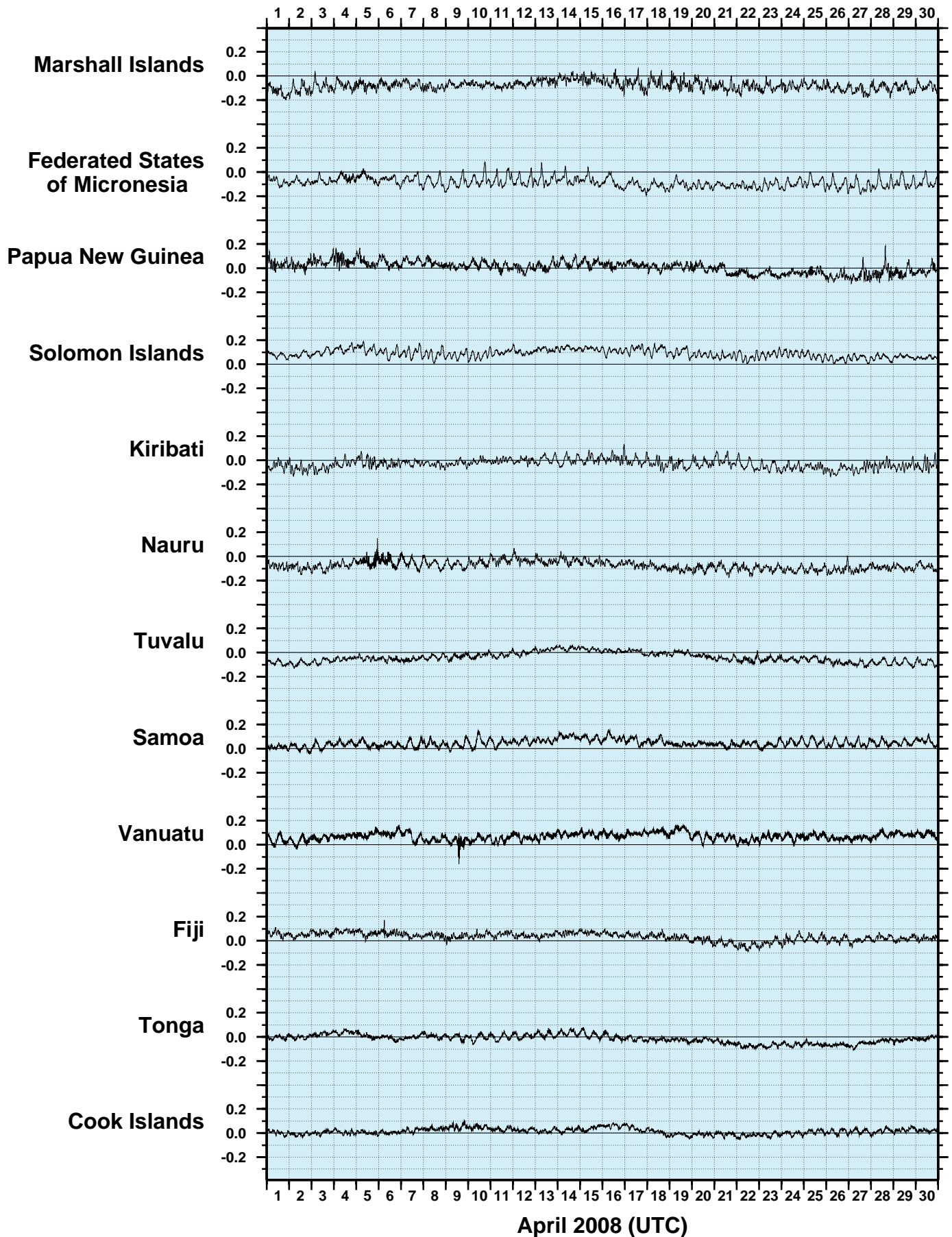
While care has been taken in the collection, analysis, and compilation of the data, it is supplied on the condition that neither the *Commonwealth of Australia* nor *NTC* shall be liable for any loss or injury whatsoever arising from the use of the data. Copyright for material contained in this document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

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**  
**APRIL 2008**  
**SIX MINUTE WATER LEVEL OBSERVATIONS (m)**



**Figure 2**  
**APRIL 2008**  
**SIX MINUTE RESIDUAL WATER LEVELS (m)**





**Figure 3**  
**APRIL 2008**  
**SIX MINUTE RESIDUALS**  
**ADJUSTED FOR ATMOSPHERIC PRESSURE (m)**

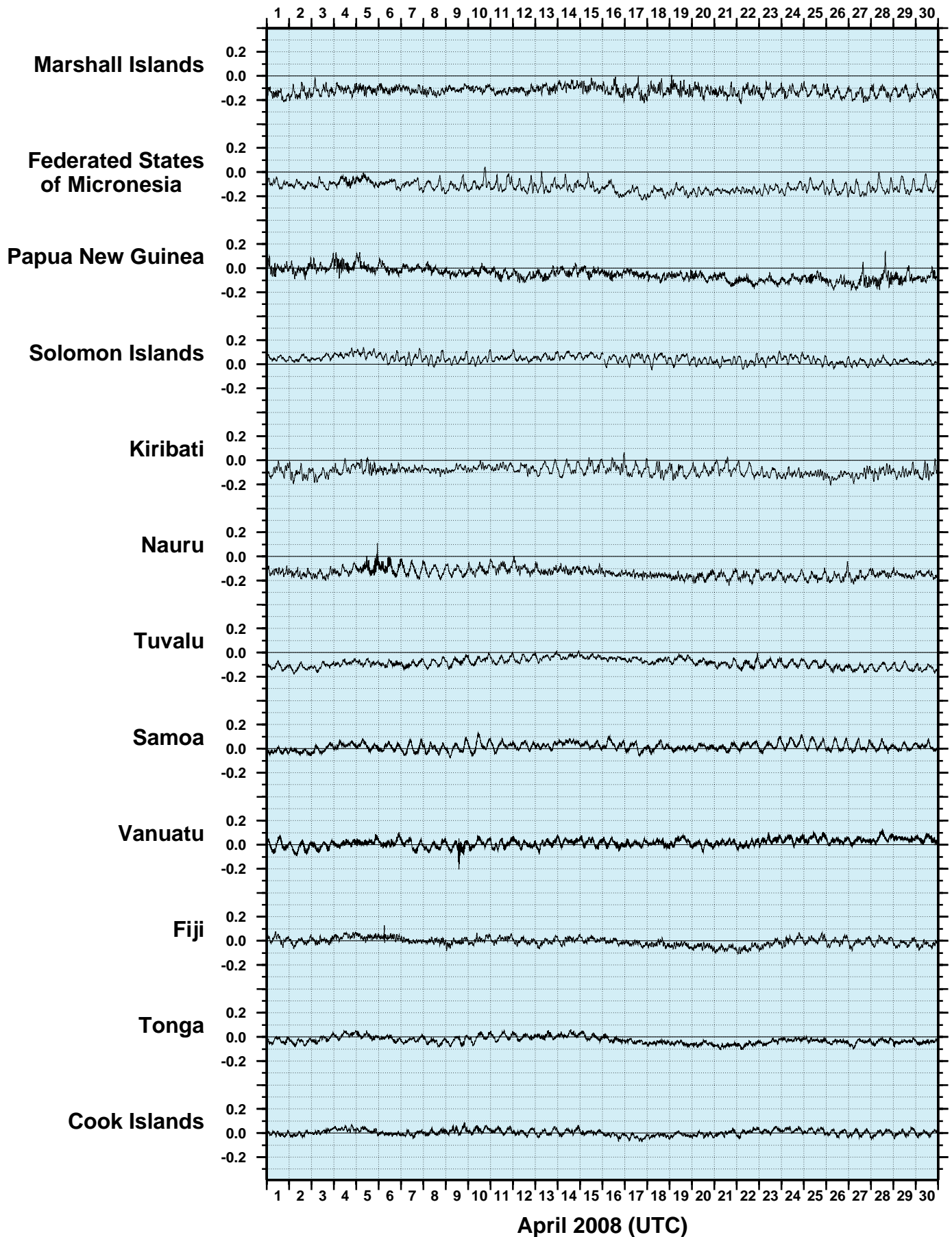


Figure 4

**APRIL 2008**  
**HOURLY WIND SPEEDS (m/s)**

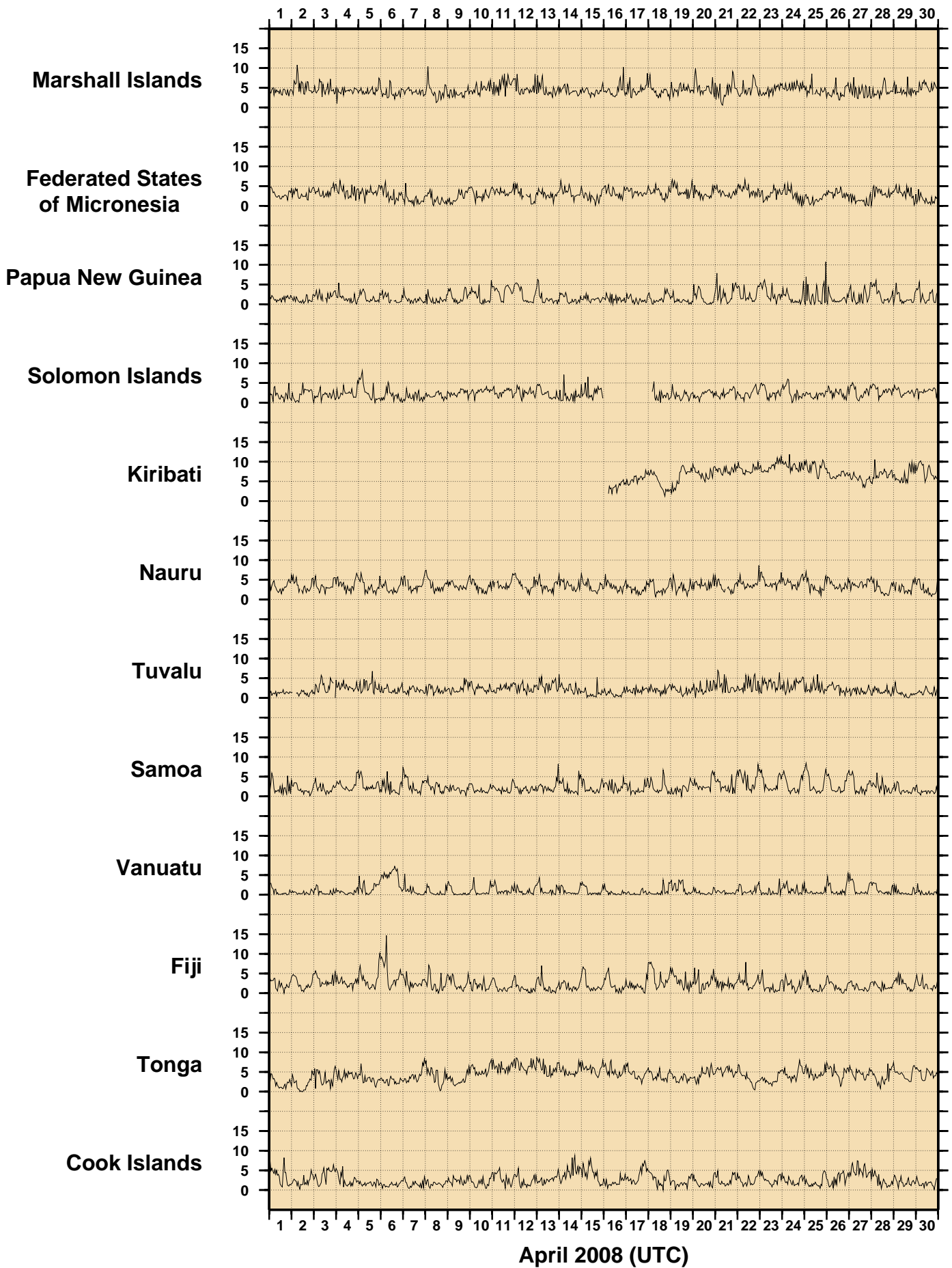


Figure 5  
APRIL 2008  
HOURLY INCIDENT WINDS (m/s, deg True)

— 10 m/s

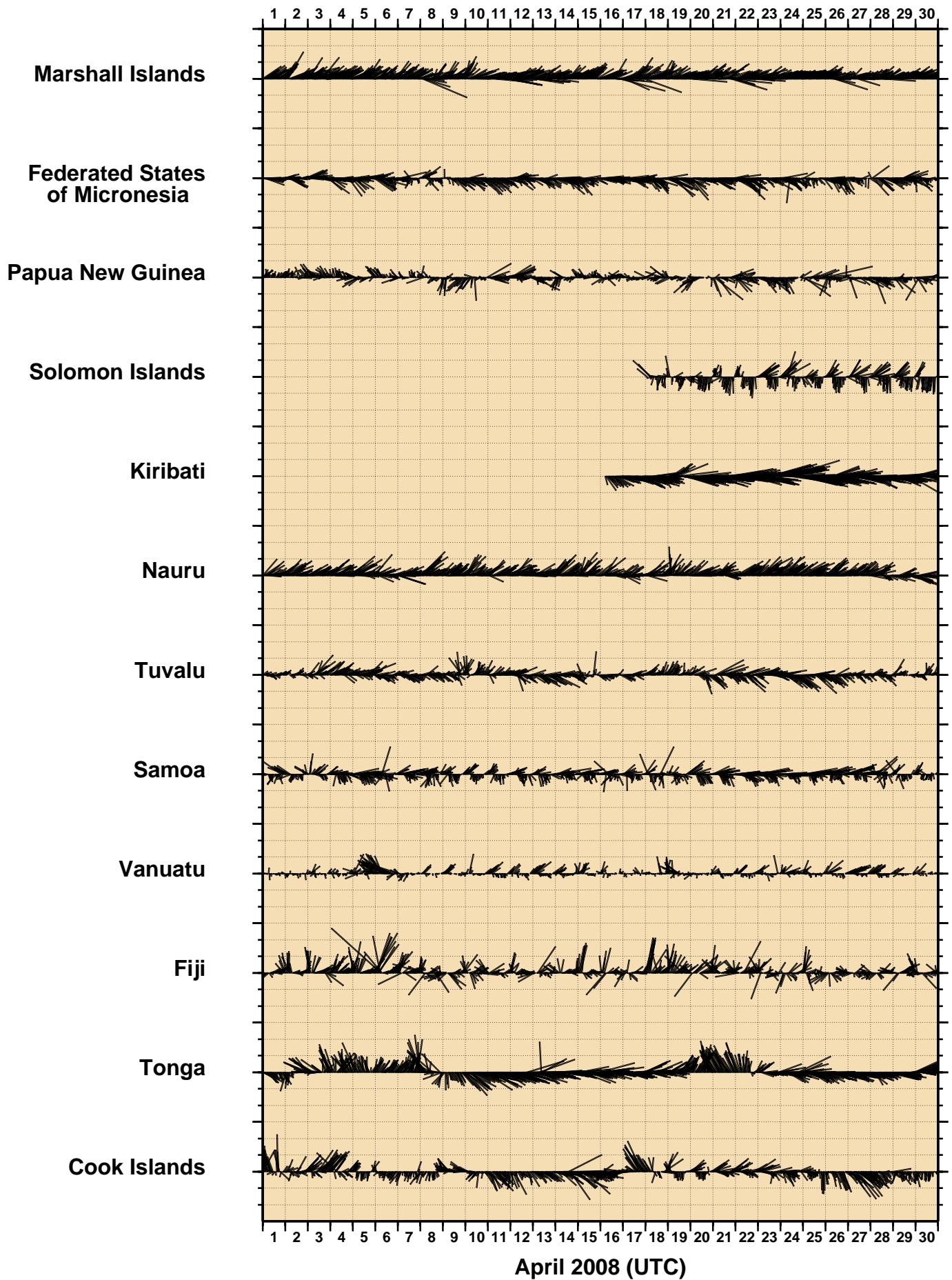
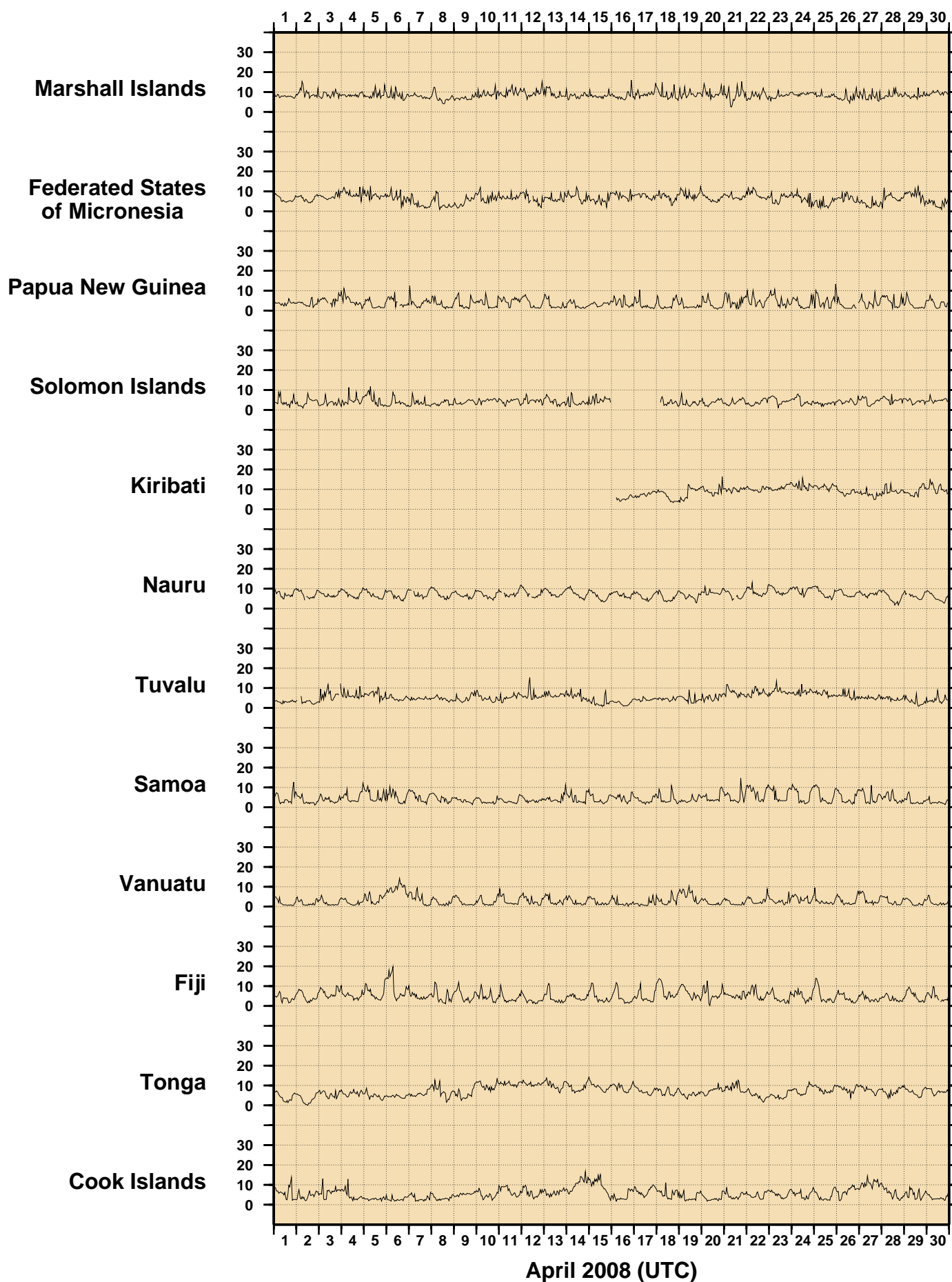


Figure 6  
APRIL 2008  
HOURLY MAXIMUM WIND GUSTS (m/s)



**Figure 7**  
**APRIL 2008**  
**HOURLY AIR TEMPERATURES (°C)**

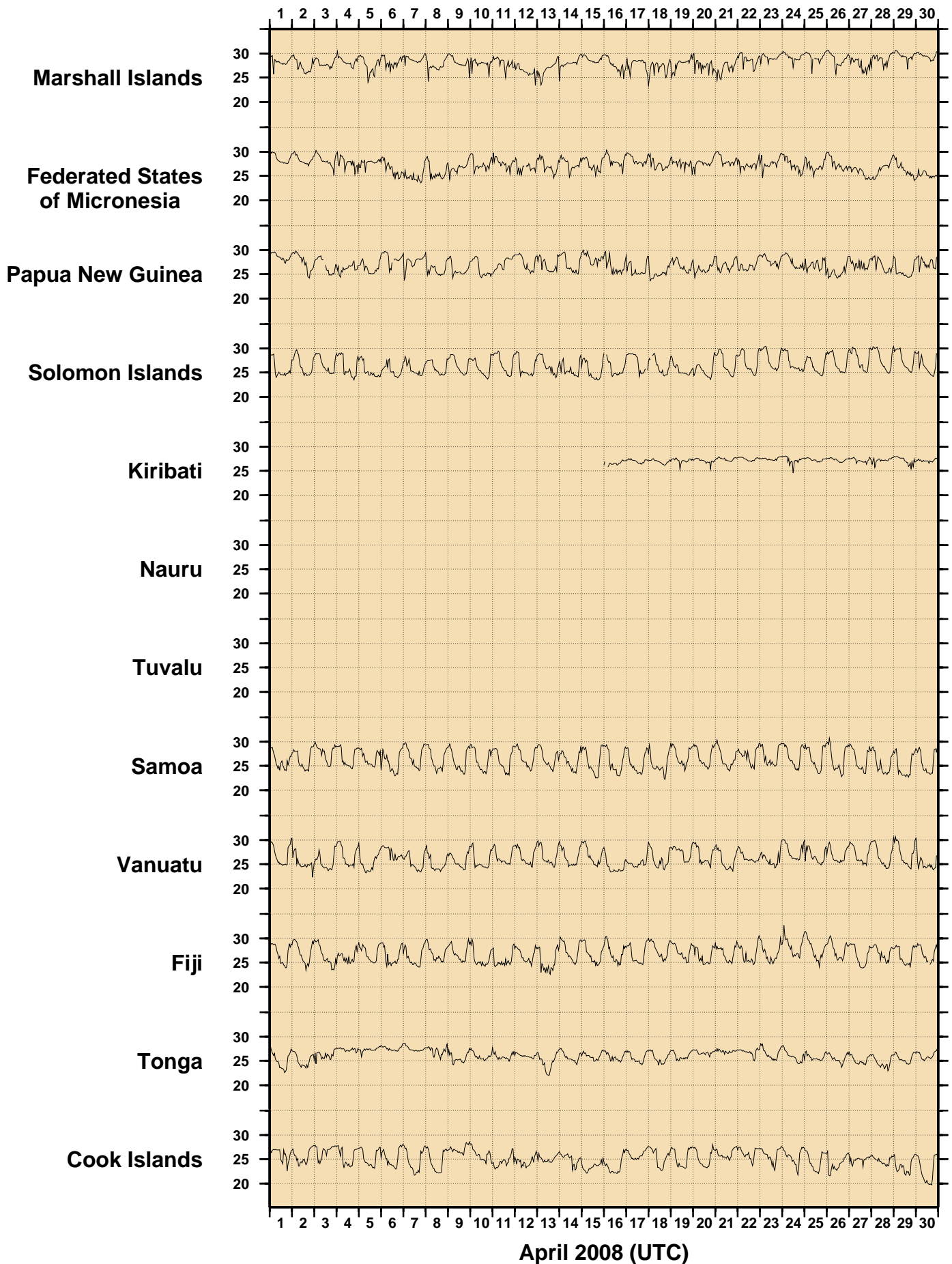
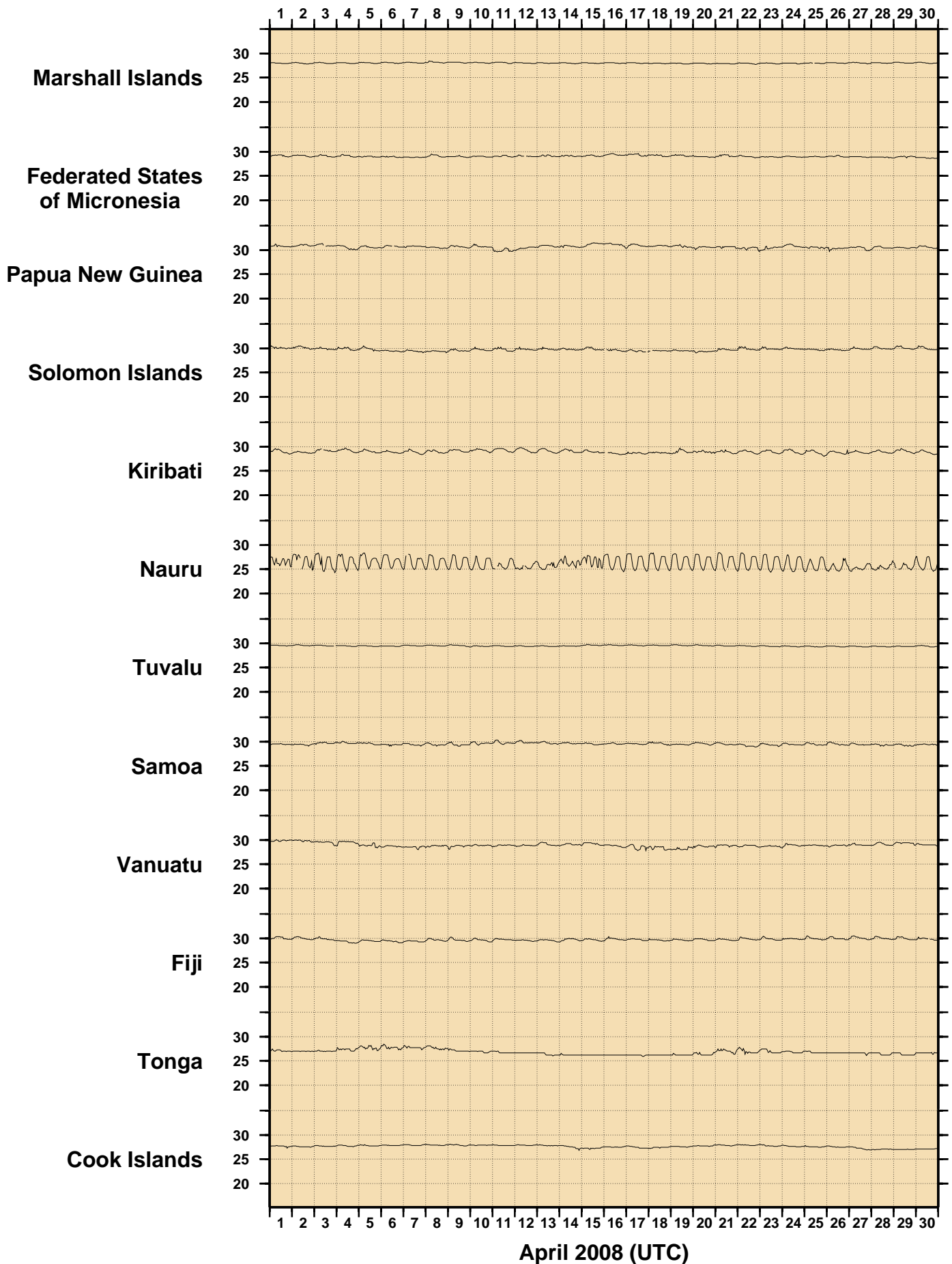




Figure 8  
APRIL 2008  
HOURLY WATER TEMPERATURES (°C)



**Figure 9**  
**APRIL 2008**  
**HOURLY ATMOSPHERIC PRESSURE (hPa)**

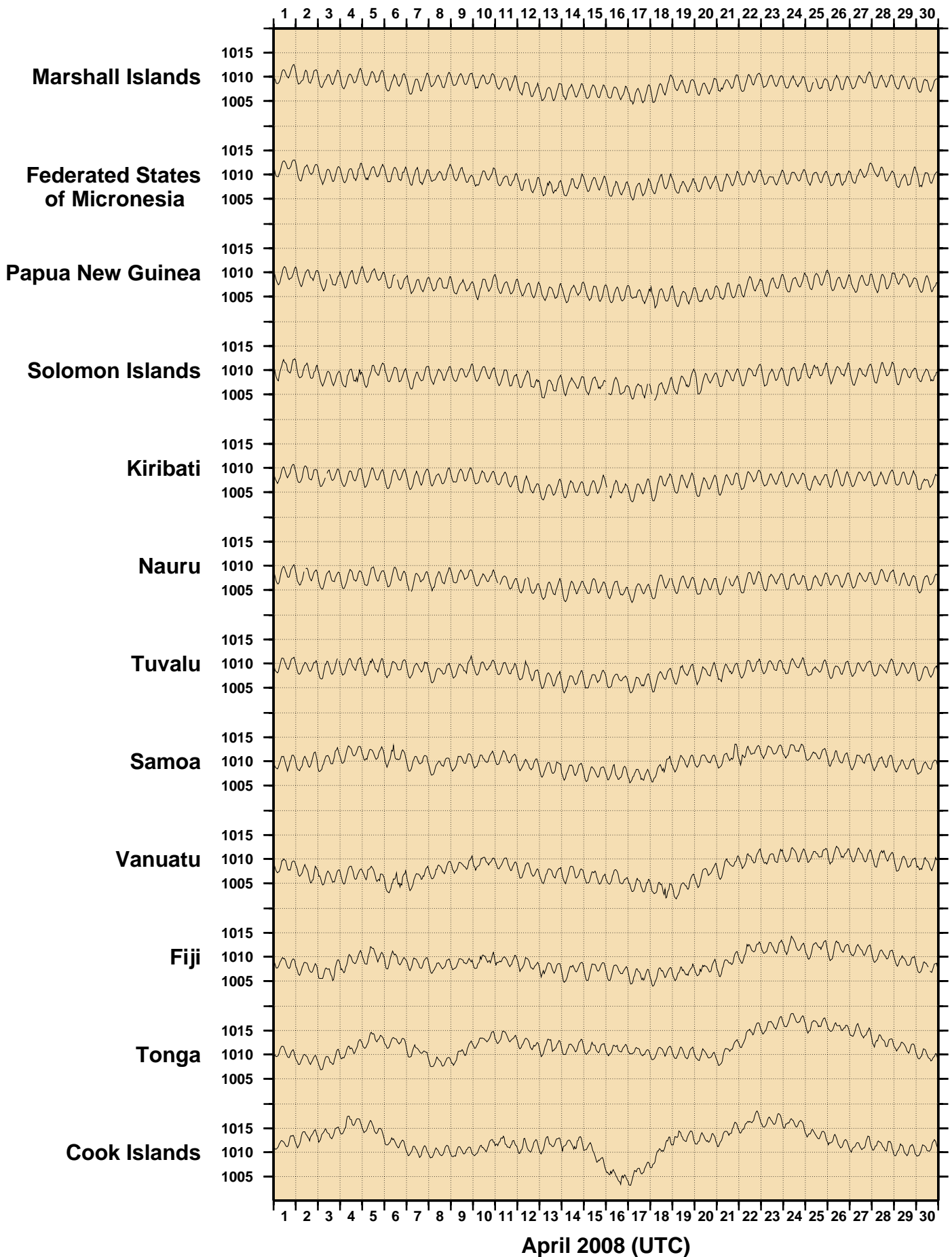
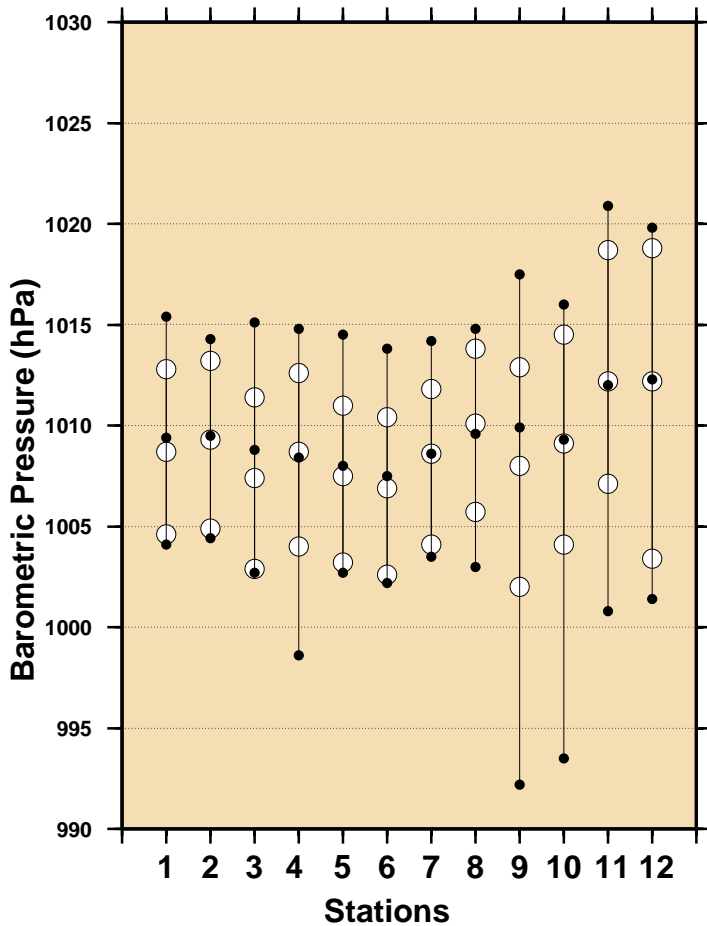
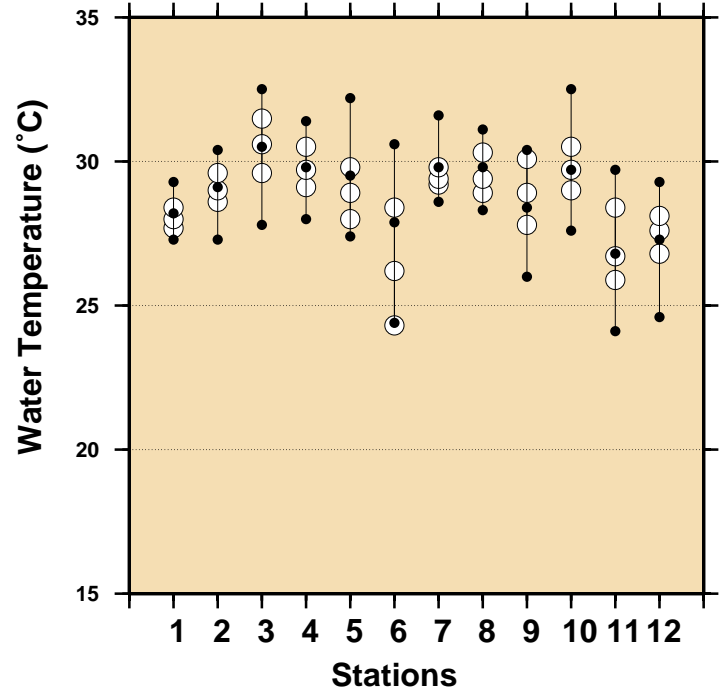
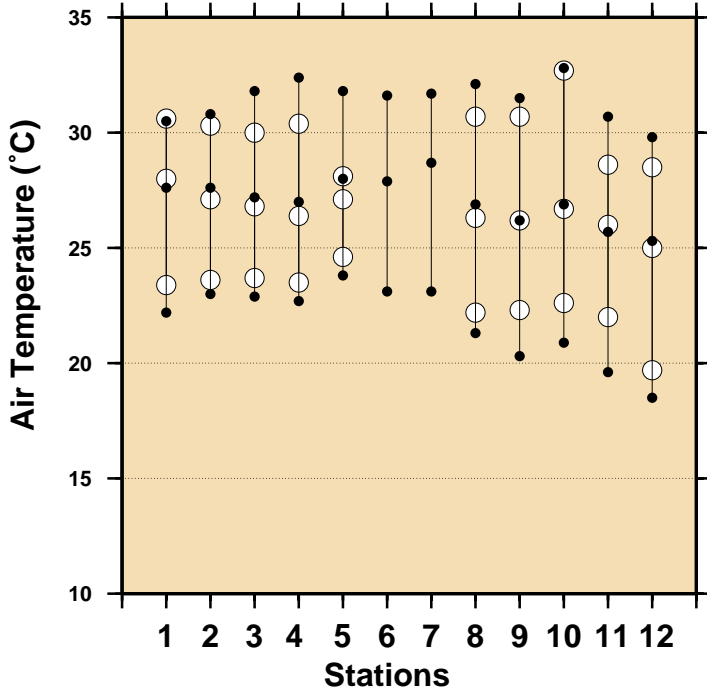


Figure 10

## Comparison of April 2008 Max, Min & Mean with Long Term April 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

- April 2008 Maximum
- April 2008 Mean
- April 2008 Minimum
- Long Term April Maximum
- Long Term April Mean
- Long Term April Minimum



Figure 11

## MONTHLY MEAN SEA LEVELS TO APRIL 2008 (m)

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

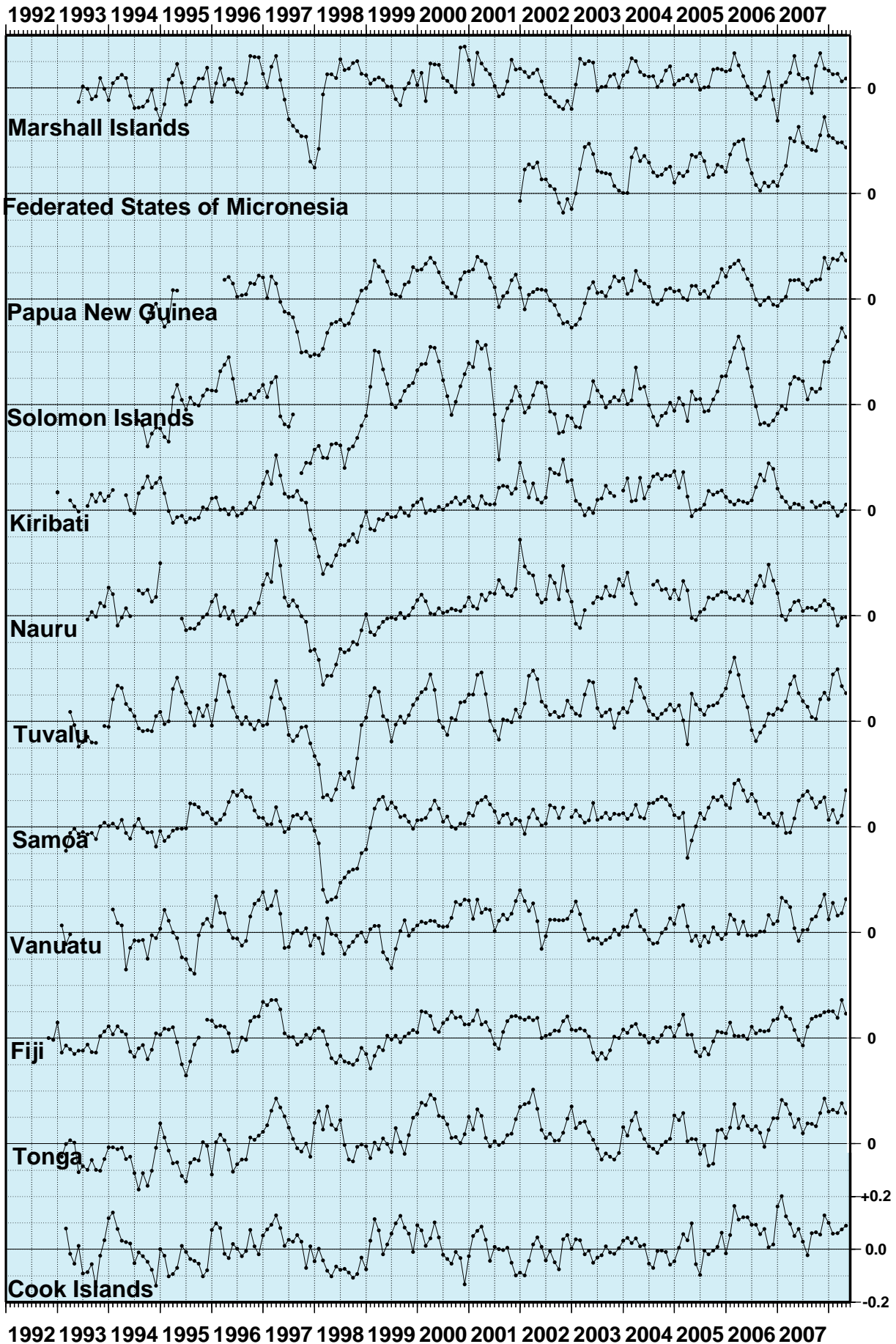


Figure 12  
SEA LEVEL ANOMALIES THROUGH APRIL 2008 (m)

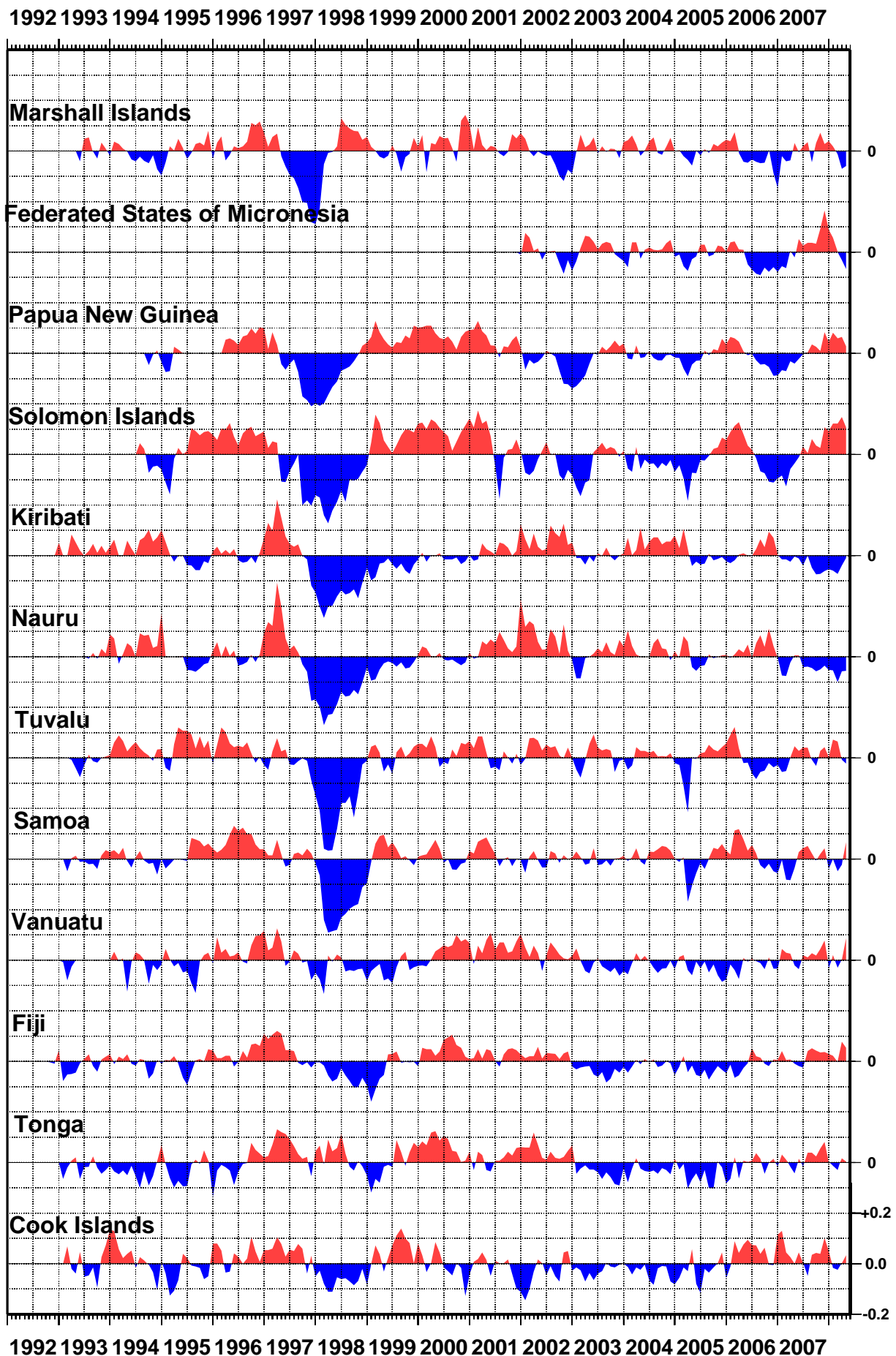


Figure 13

## SEA LEVEL TRENDS THROUGH APRIL 2008 (mm/year)

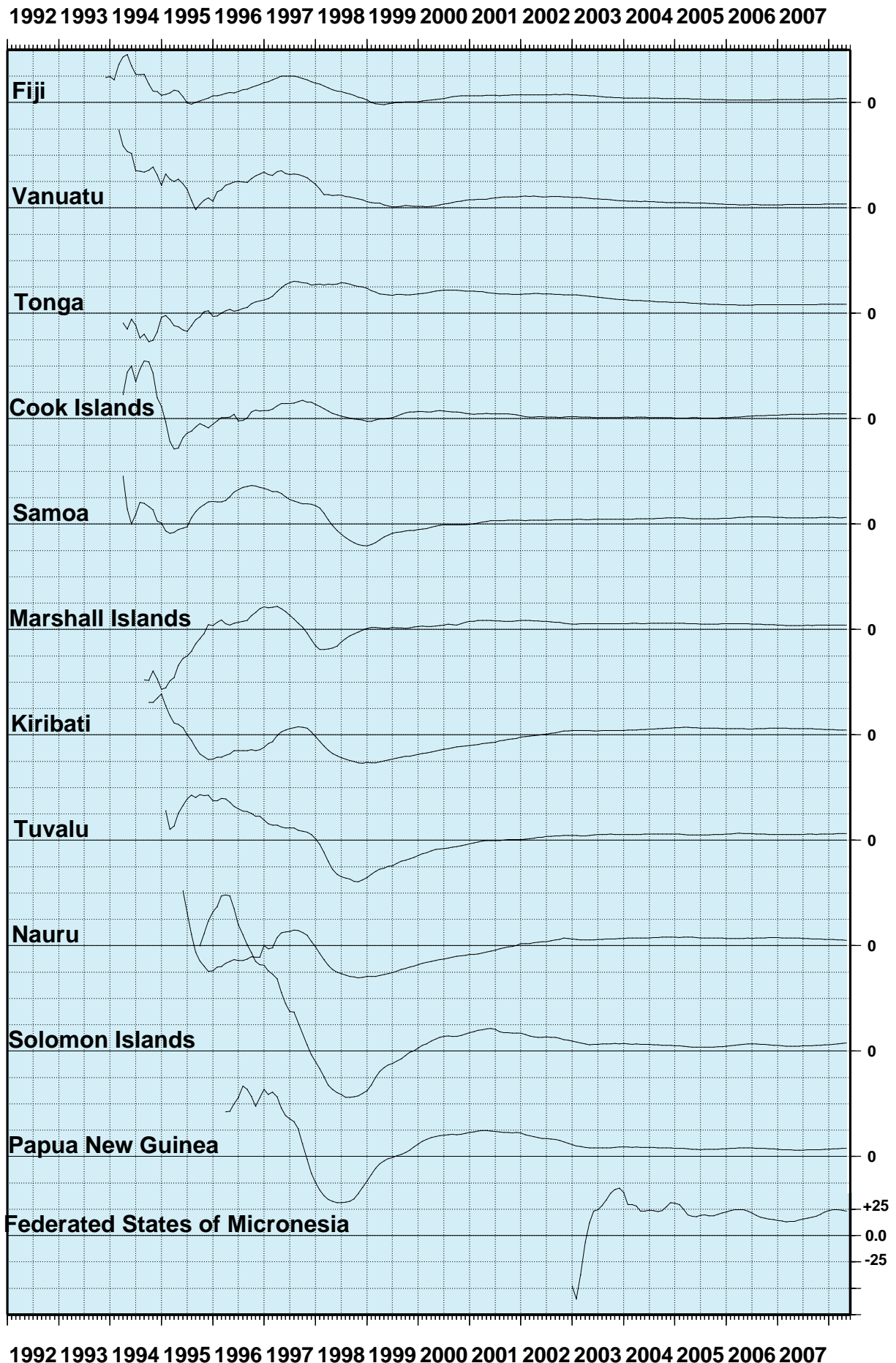


Figure 14

## BAROMETRIC PRESSURE ANOMALIES THROUGH APRIL 2008 (hPa)

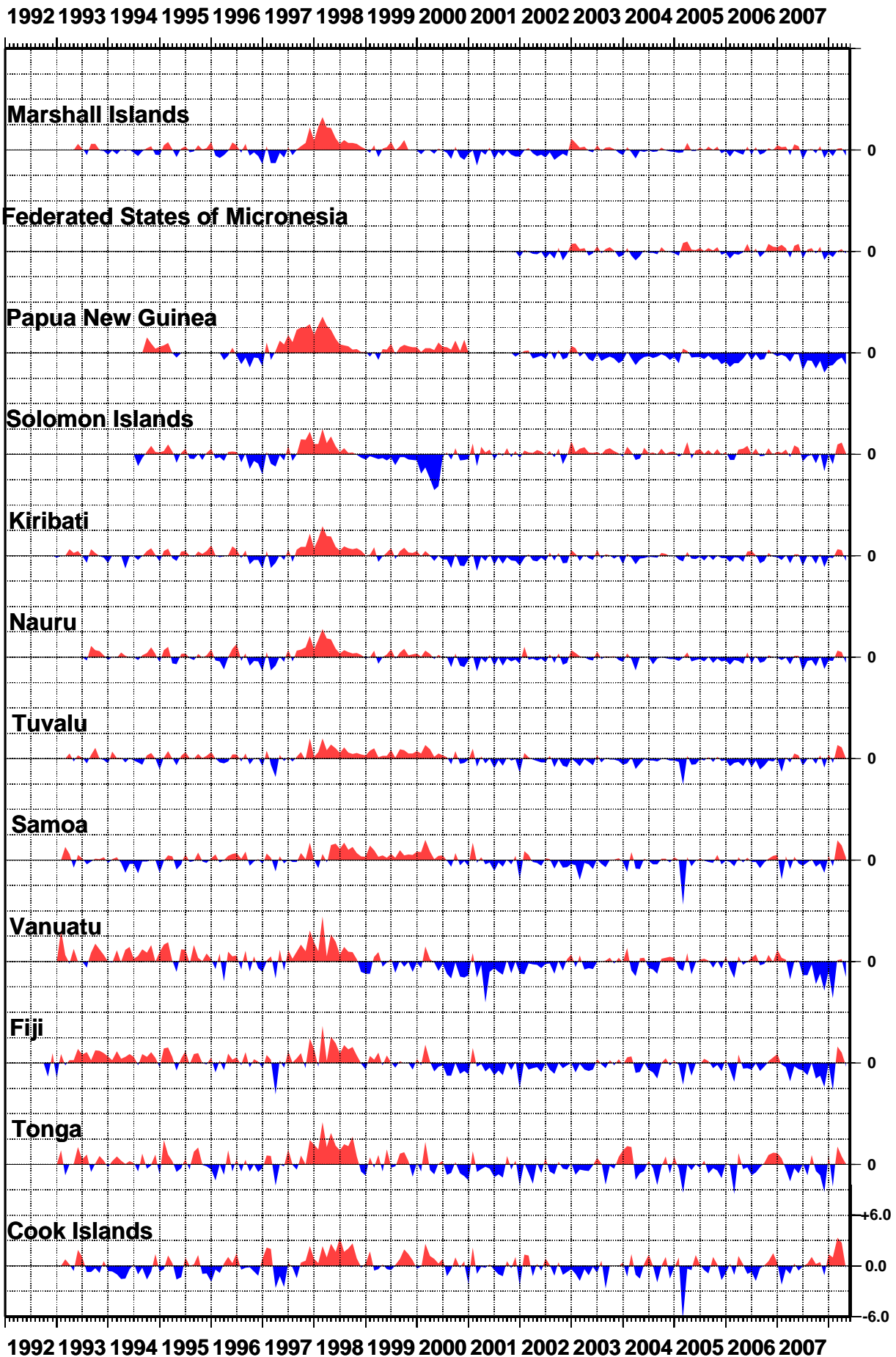


Figure 15

# **WATER TEMPERATURE ANOMALIES THROUGH APRIL 2008 (°C)**

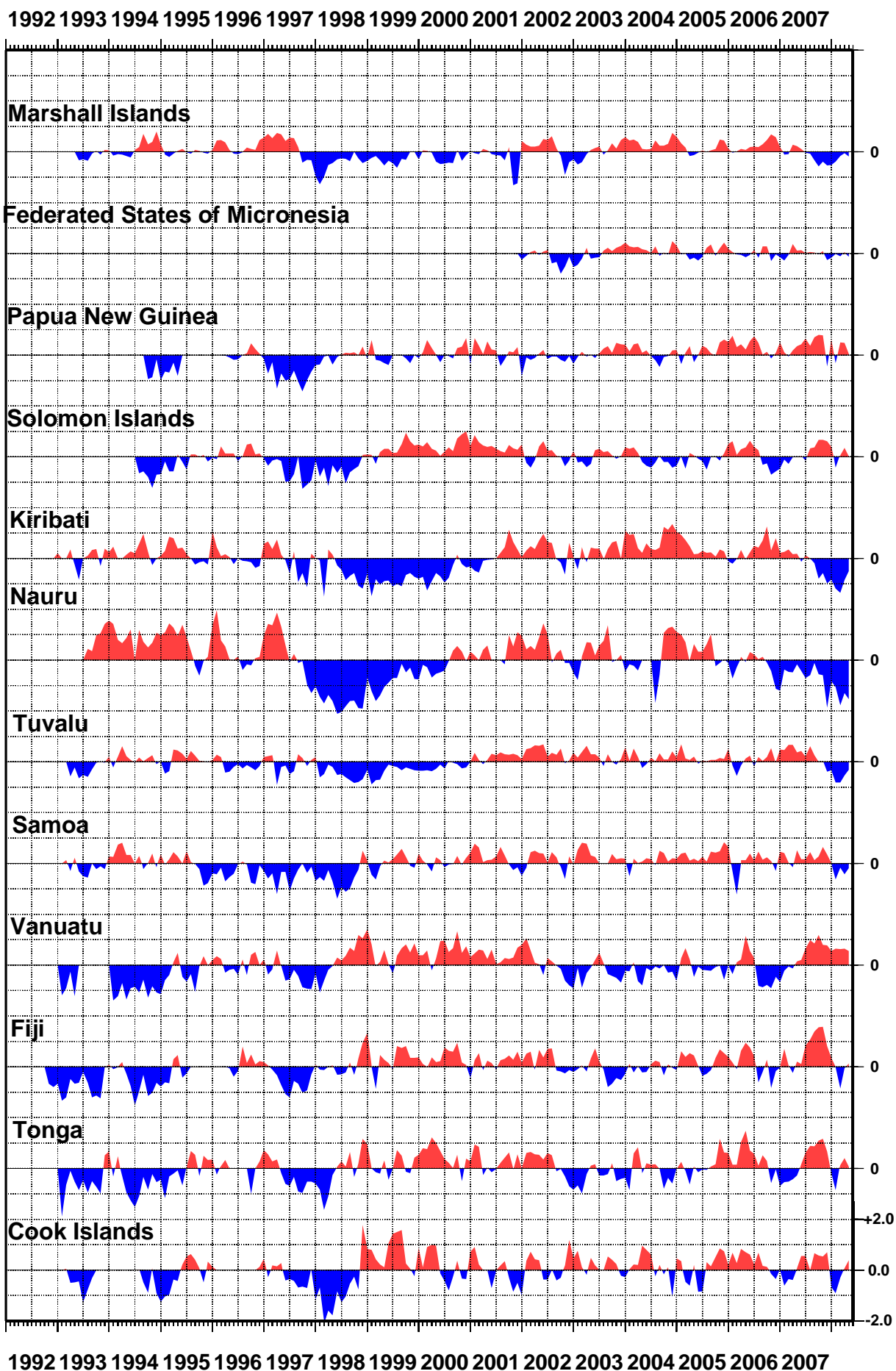


Figure 16  
**AIR TEMPERATURE ANOMALIES  
THROUGH APRIL 2008 (°C)**

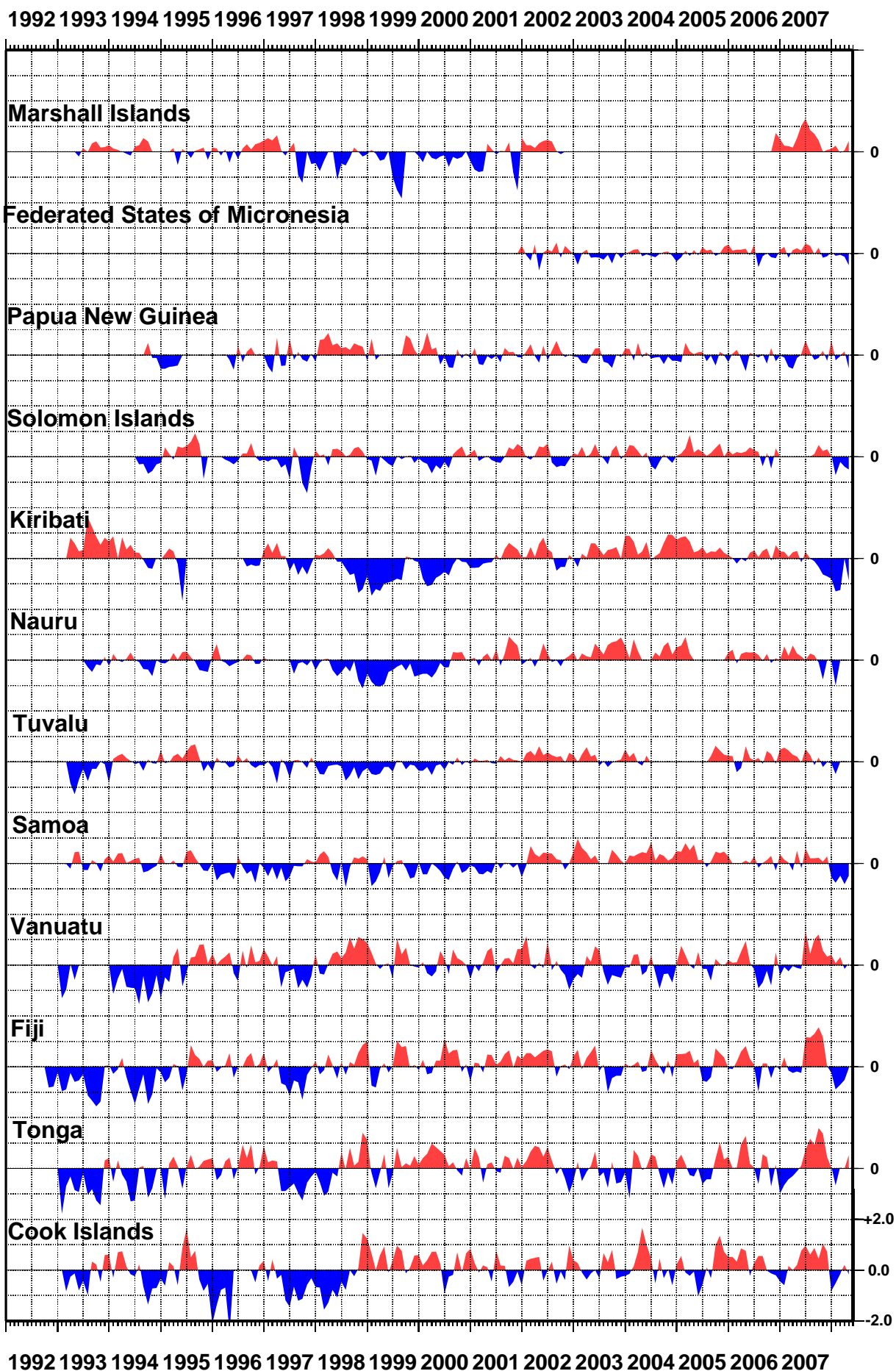


Figure 17

# SEA LEVEL DATA RETURN

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

\* Patchy record

