

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

MONTHLY DATA REPORT

NO. 155

MAY 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 May 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

May 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.

May 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 within 10cm of what is normally expected at this time of the year. The absence of any large sea level anomaly is consistent with neutral climate conditions.
- Reasonably large tidal ranges were observed early in the month at many stations due to favourable astronomical positions of the moon and the sun.
- A gradual increase in ocean heat content across the equatorial Pacific continues to be observed in association with a return to neutral climate conditions. Cooler than average sea surface temperatures and the associated reduction of cloudiness in the west-central equatorial Pacific are the only remnants of the recent 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 May, 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	+4.9	+0.2
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	+3.9	0.0
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+4.0	+0.2
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+6.4	+0.2
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+6.1	-0.1
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+4.5	-0.1
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+5.2	-0.1
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+7.7	+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	+22.7	-0.4
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+3.9	-0.1

INTRODUCTION

Welcome to the May 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.

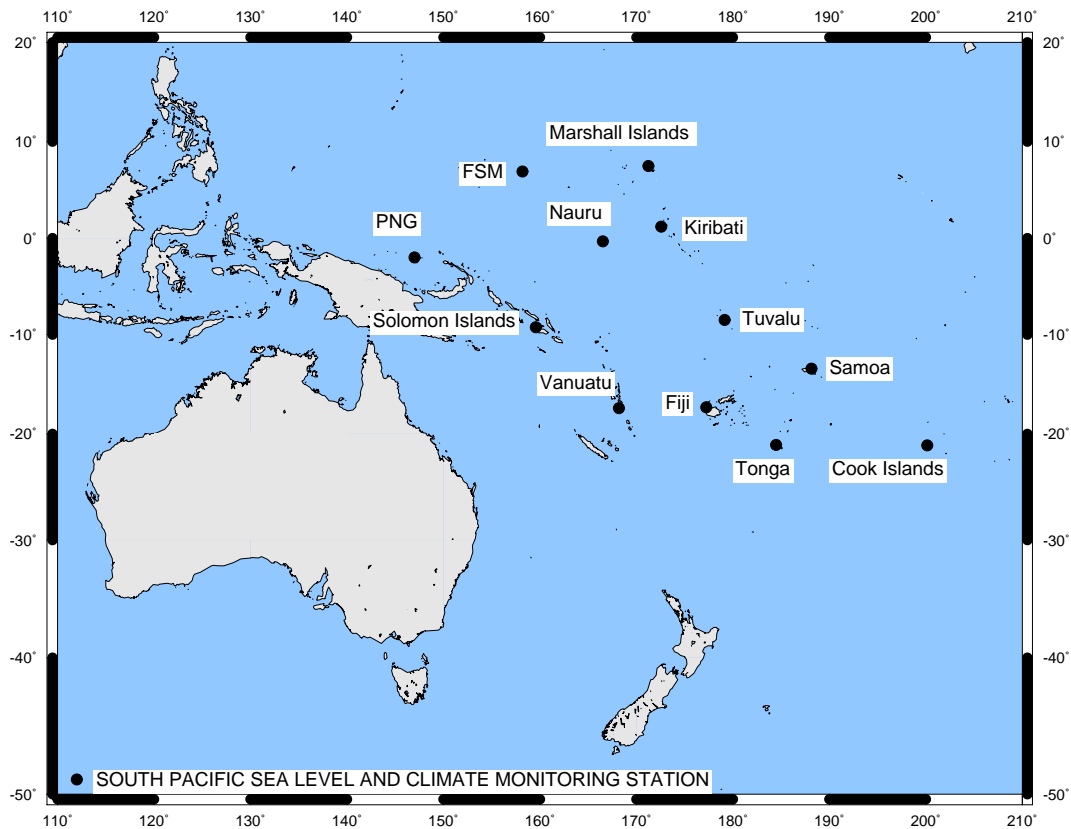


Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

MAY CLIMATOLOGY

Climate conditions in the equatorial Pacific remained neutral through May and a gradual warming of the equatorial Pacific continued to be observed. Remnants of the recent La Niña (cool episode) conditions linger in the western Pacific, including slightly cooler than normal sea surface temperatures and reduced cloudiness near the dateline.

The Southern Oscillation Index (SOI) continued to fall in association with the warming of the equatorial Pacific and a return to neutral conditions. The monthly May value of -4 is the first negative value since mid-2007 (**Figure B**).

The sea-surface temperature (SST) anomalies show cooler than normal conditions in the west-central equatorial Pacific, although this feature continues to decrease in area following the breakdown of La Niña and continued warming across the equatorial Pacific (**Figure C**, **Figure E**). SST anomalies above +1°C continue to be observed near the South American coast and showed some strengthening and westward extension late in the month. Sea surface temperatures in the far western Pacific remain near normal.

Subsurface temperatures across the equatorial Pacific during May showed further weakening of the recent La Niña pattern (**Figure D**). Positive sub-surface temperature anomalies are now being observed across the equatorial Pacific along the thermocline. Warm sub-surface temperature anomalies continue to be observed in the western equatorial Pacific, while cool sub-surface temperature anomalies are now confined to the upper mixed layer in 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 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 across the central to eastern equatorial Pacific were generally weaker than average during May which has contributed to the sea surface warming in that region (**Figure E**). Near average strength Trade Winds were observed across the western Pacific during May. Cloudiness in the equatorial Pacific near the dateline continued to be below average during May in keeping with cooler than 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/>.

Southern Oscillation Index (SOI)

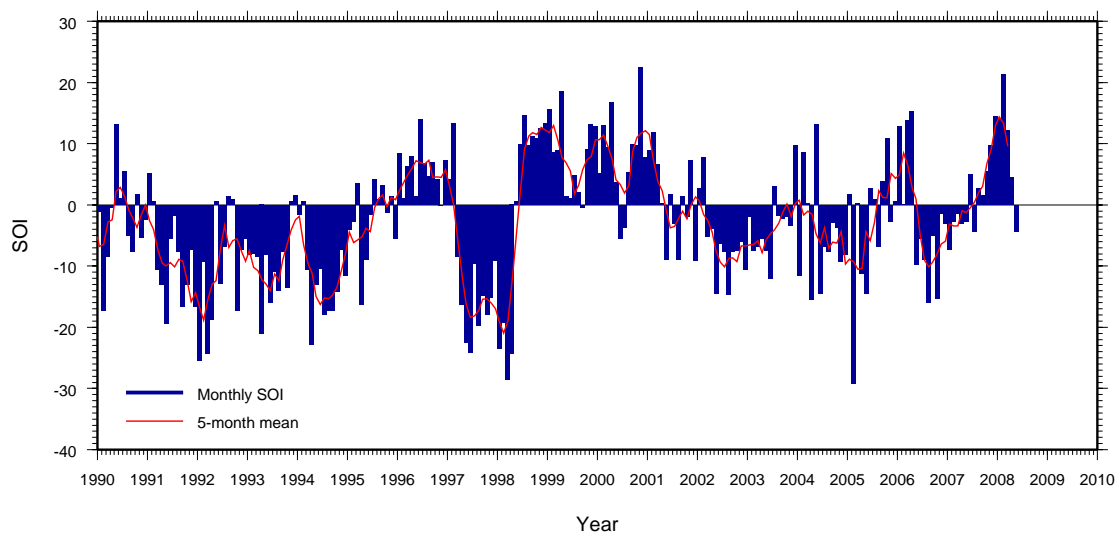


Figure B: The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the long-term standard deviation of that difference for the relevant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

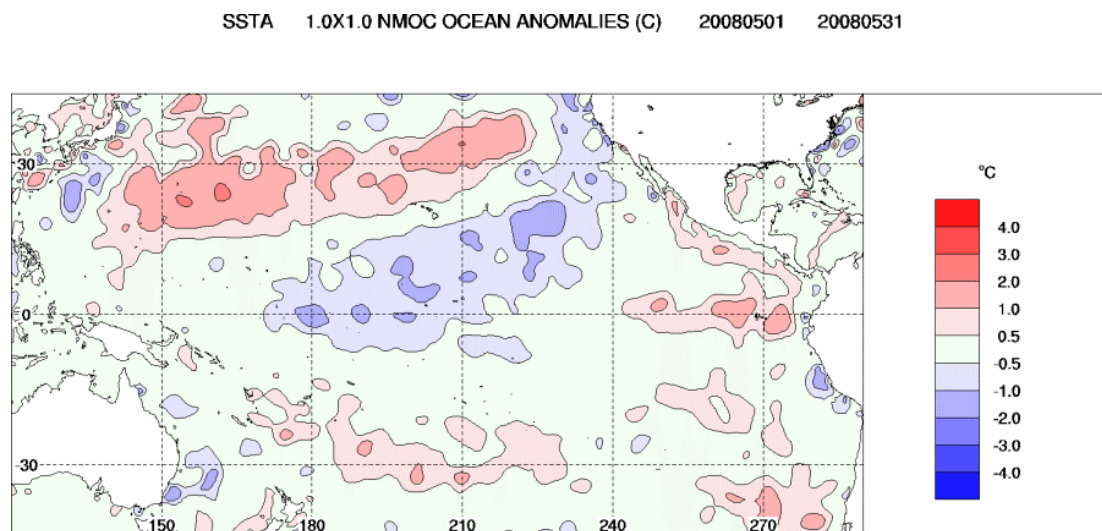


Figure C: Sea surface temperature anomaly (°C) for May 2008.

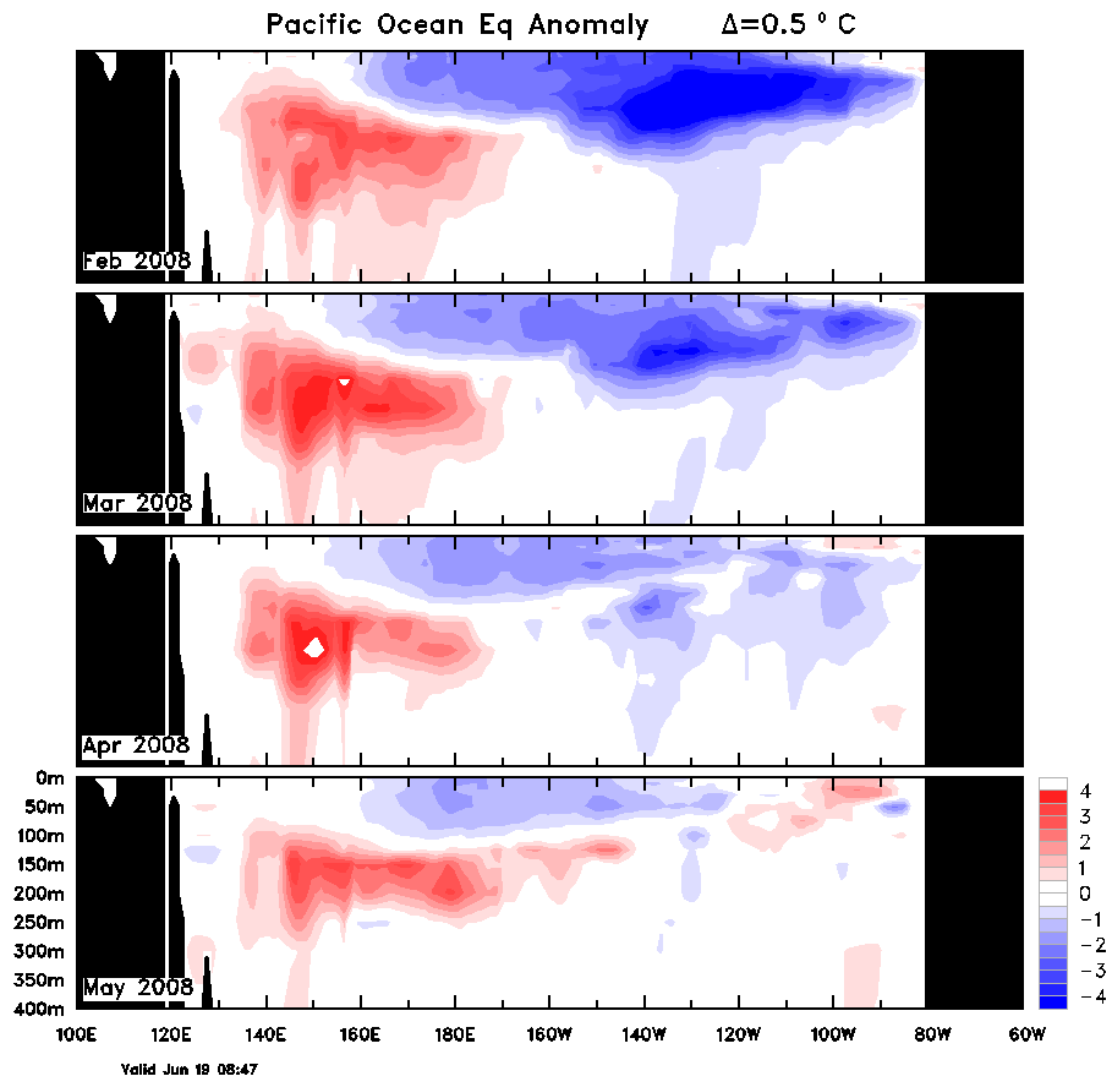
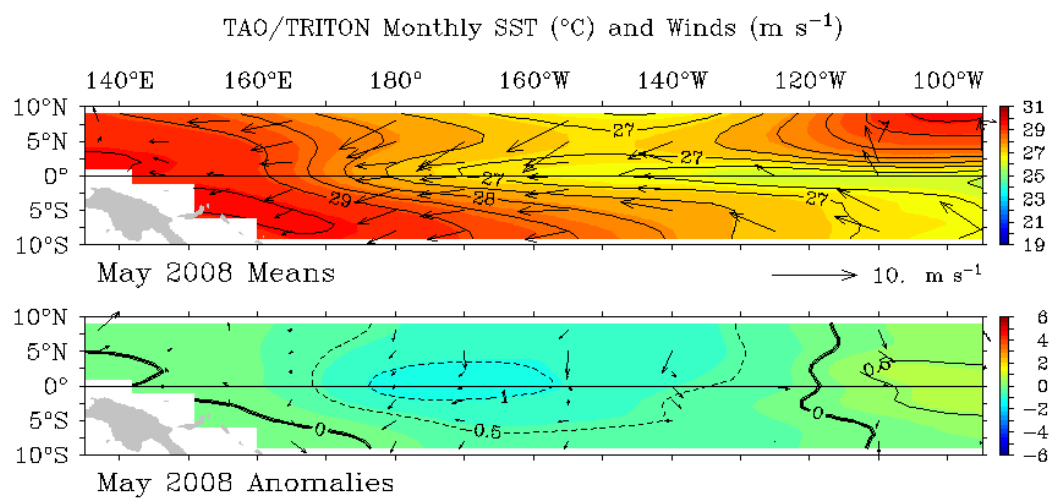


Figure D: Equatorial depth-longitude section of ocean temperature anomalies for February 2008 through to May 2008. Contour interval is 0.5°C .



TAO/NDBC/NOAA

Jun 5 2008

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

MAY 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 5th of May and a full moon on the 20th of May 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 around the same time as the new moon in May, 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 May was 19 m/s (37 knots or 68 km/hr) at Fiji on the 19th of May (**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 May air temperature was recorded at Marshall Islands and new minimum May air temperatures were recorded at Solomon Islands and Cook Islands. A new minimum May water temperature was recorded at Kiribati. A new maximum May barometric pressure was recorded at FSM and a new minimum May barometric pressure was recorded at Tonga.

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 May 2008 small positive anomalies (slightly higher than normal sea levels) were observed at Solomon Islands, Samoa, Vanuatu and Cook Islands. The sea level anomaly at Samoa, Vanuatu and Cook Islands was around +7cm. Lower than normal sea levels of around -5cm were observed at Marshall Islands. Sea levels at the remaining sites, namely FSM, PNG, Kiribati, Nauru, Tuvalu, Fiji and Tonga were near normal through May.

Sea Level Trends

The **short-term sea level trends** at individual stations as at May 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 May, 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	+4.9	+0.2
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	+3.9	0.0
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+4.0	+0.2
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+6.4	+0.2
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+6.1	-0.1
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+4.5	-0.1
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+5.2	-0.1
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+7.7	+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	+22.7	-0.4
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+3.9	-0.1

Barometric Pressure, Water Temperature and Air Temperature Anomalies

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

The **barometric pressure anomalies** (**Figure 14**) show substantially higher than normal barometric pressures were observed at SEAFRAME stations during the 1997-1998 El Niño. In May 2008 slightly below normal barometric pressures were observed at Tonga, a feature also shown in **Figure 10**. Elsewhere barometric pressures were near normal.

The **water temperature anomalies** (**Figure 15**) show Kiribati and Nauru continued to experience cooler than normal water temperatures during May. The water temperature anomalies at these sites can be substantially more pronounced than the other sites due to their position near the equator. At Vanuatu water temperatures have remained warmer than normal for the past 12 months, while slightly warmer than normal temperatures have recently developed at Cook Islands. Elsewhere water temperatures in May were near normal.

The **air temperature anomalies (Figure 16)** show cooler than normal conditions have recently developed in FSM, Solomon Islands, Kiribati, Vanuatu and Fiji, while warmer than normal conditions have developed at Marshall Islands. Elsewhere, aside from Nauru and Tuvalu where problems with the air temperature sensors exist, near-normal air temperatures were observed during May 2008. 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.

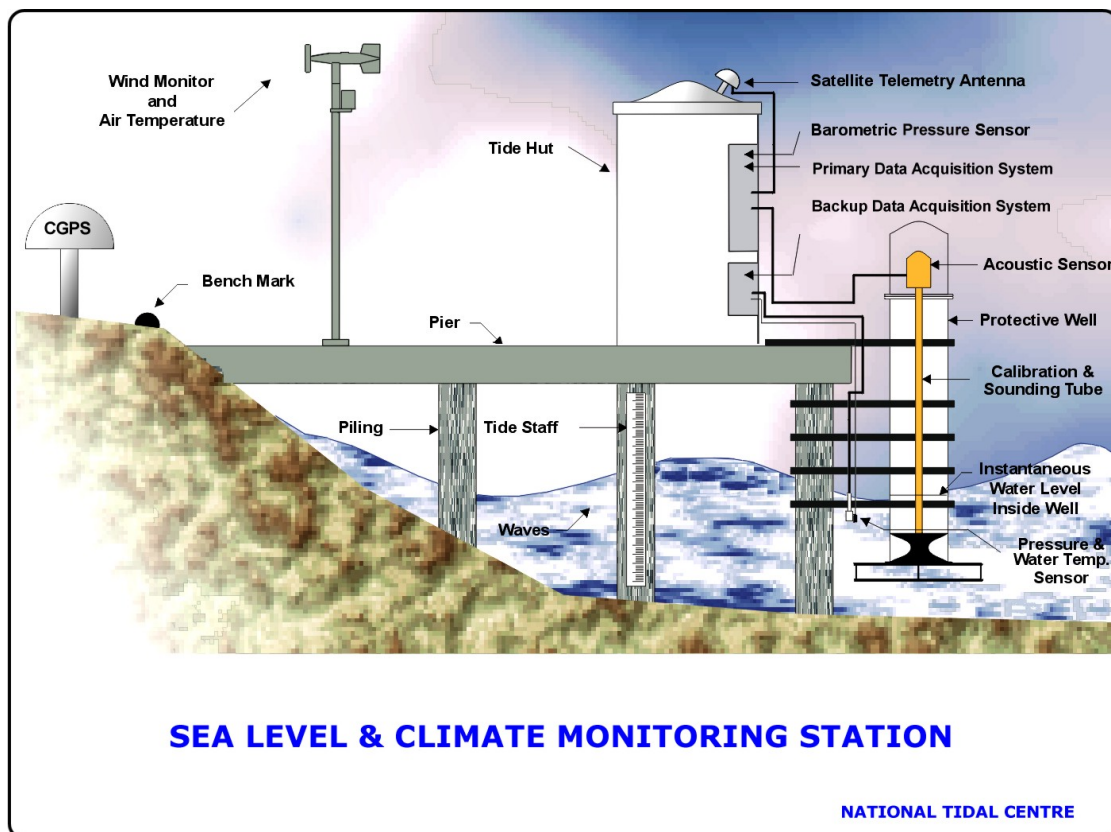
At Tuvalu the air temperature data were removed from the record due to a faulty sensor. Calibration and maintenance work was conducted at FSM and Marshall Islands in late May which resulted in some small data gaps. At Tuvalu, Nauru and PNG phone and satellite communications were intermittent and some 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:

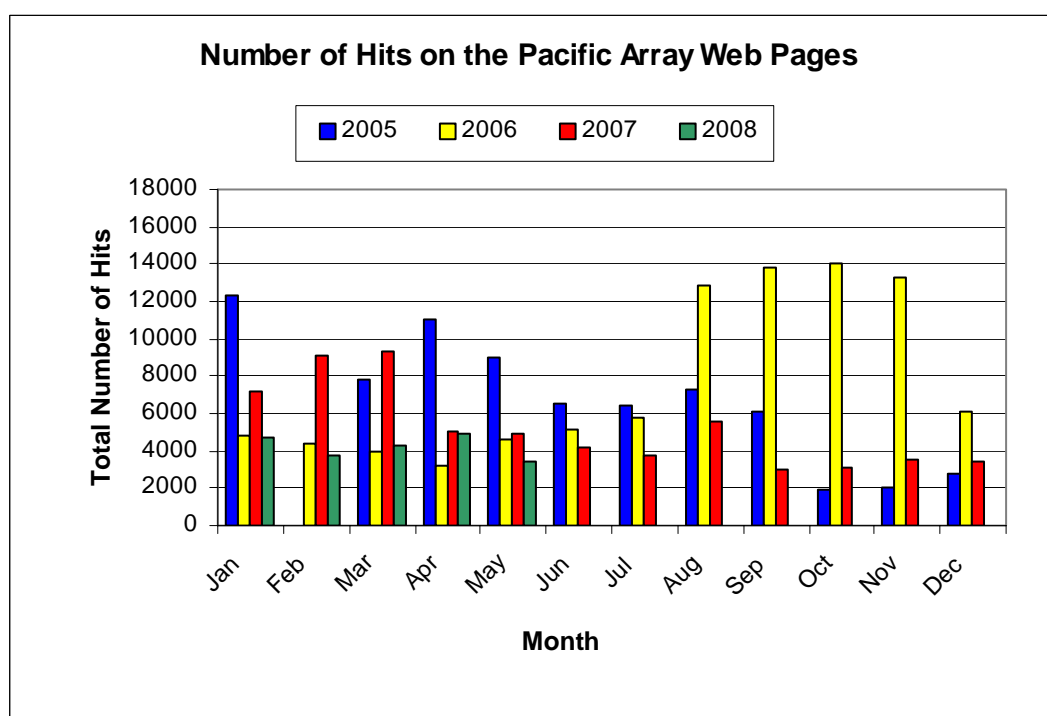
- (1) Primary water level using a Bartex 'AQUATRAK' acoustic-in-air sensor, and
- (2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

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

MAY 2008

SIX MINUTE WATER LEVEL OBSERVATIONS (m)

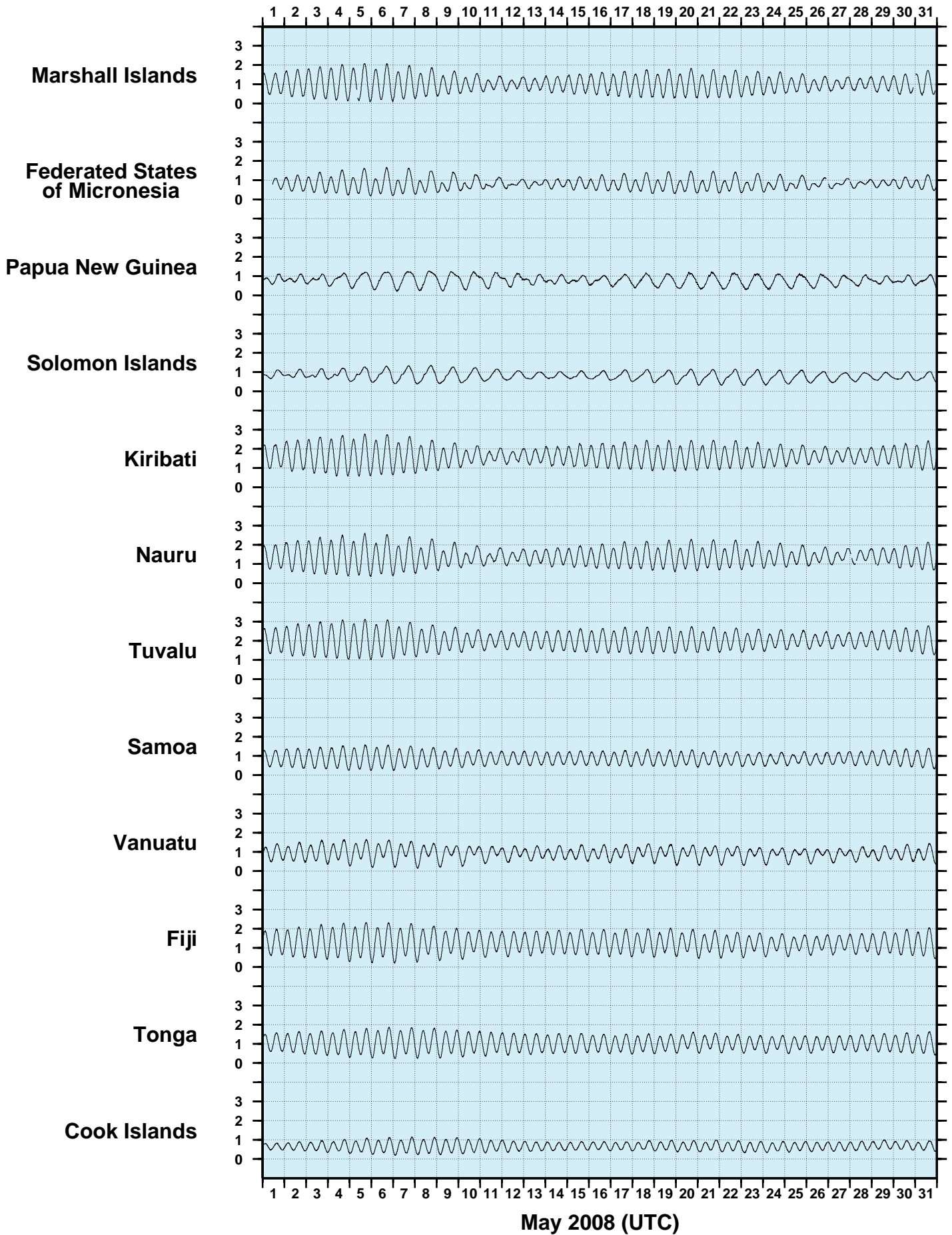


Figure 2

MAY 2008

SIX MINUTE RESIDUAL WATER LEVELS (m)

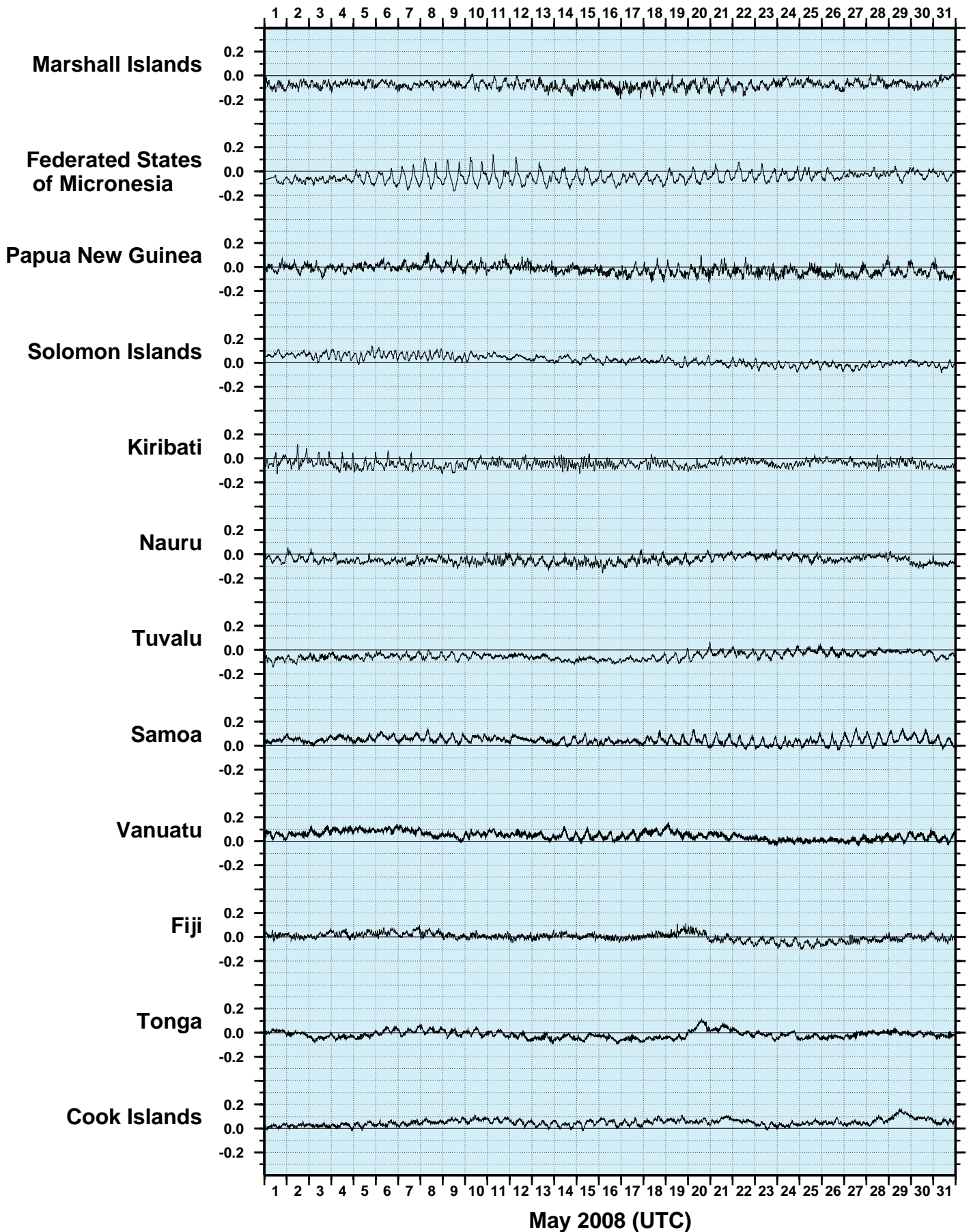


Figure 3

MAY 2008

SIX MINUTE RESIDUALS
ADJUSTED FOR ATMOSPHERIC PRESSURE (m)

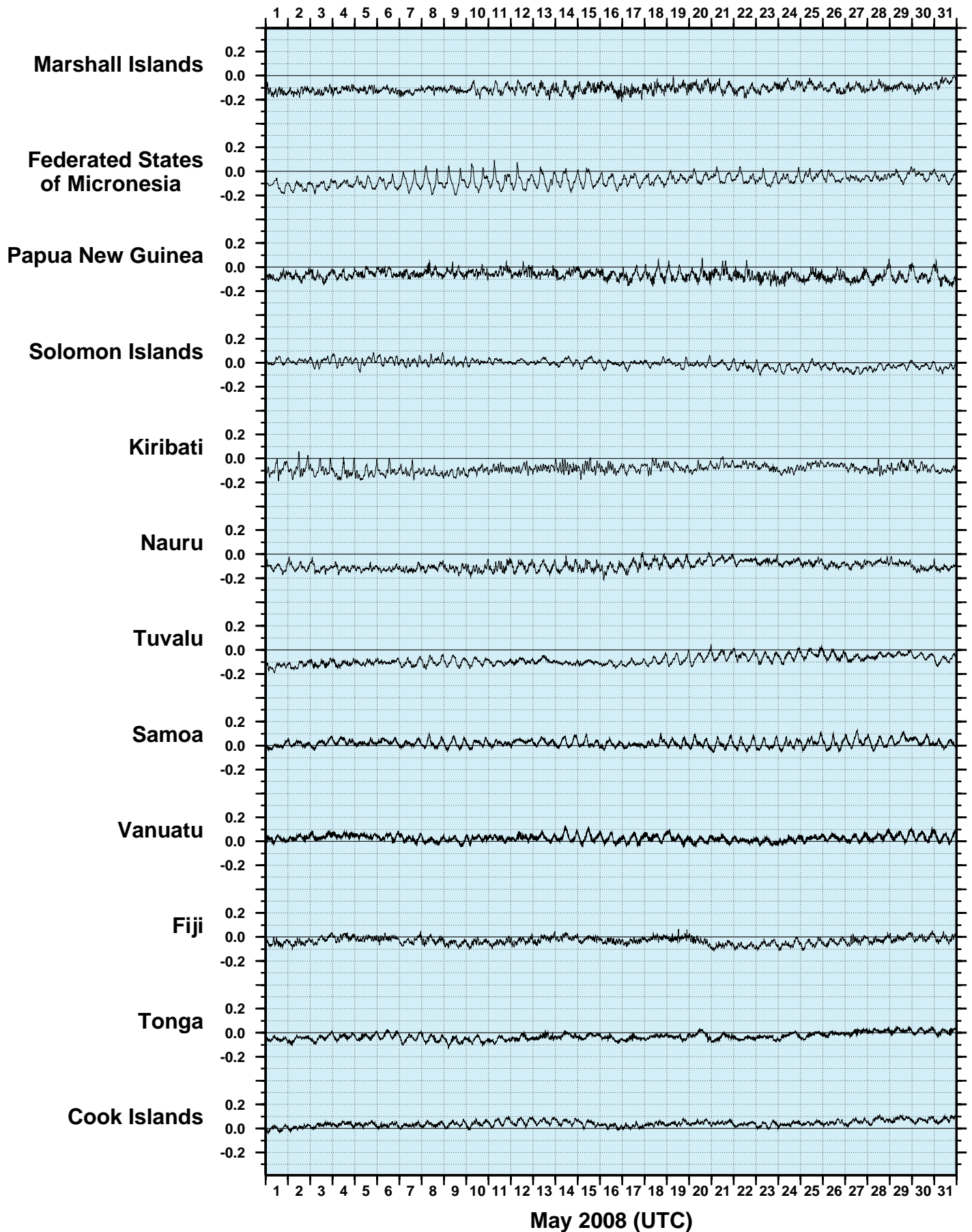


Figure 4

MAY 2008

HOURLY WIND SPEEDS (m/s)

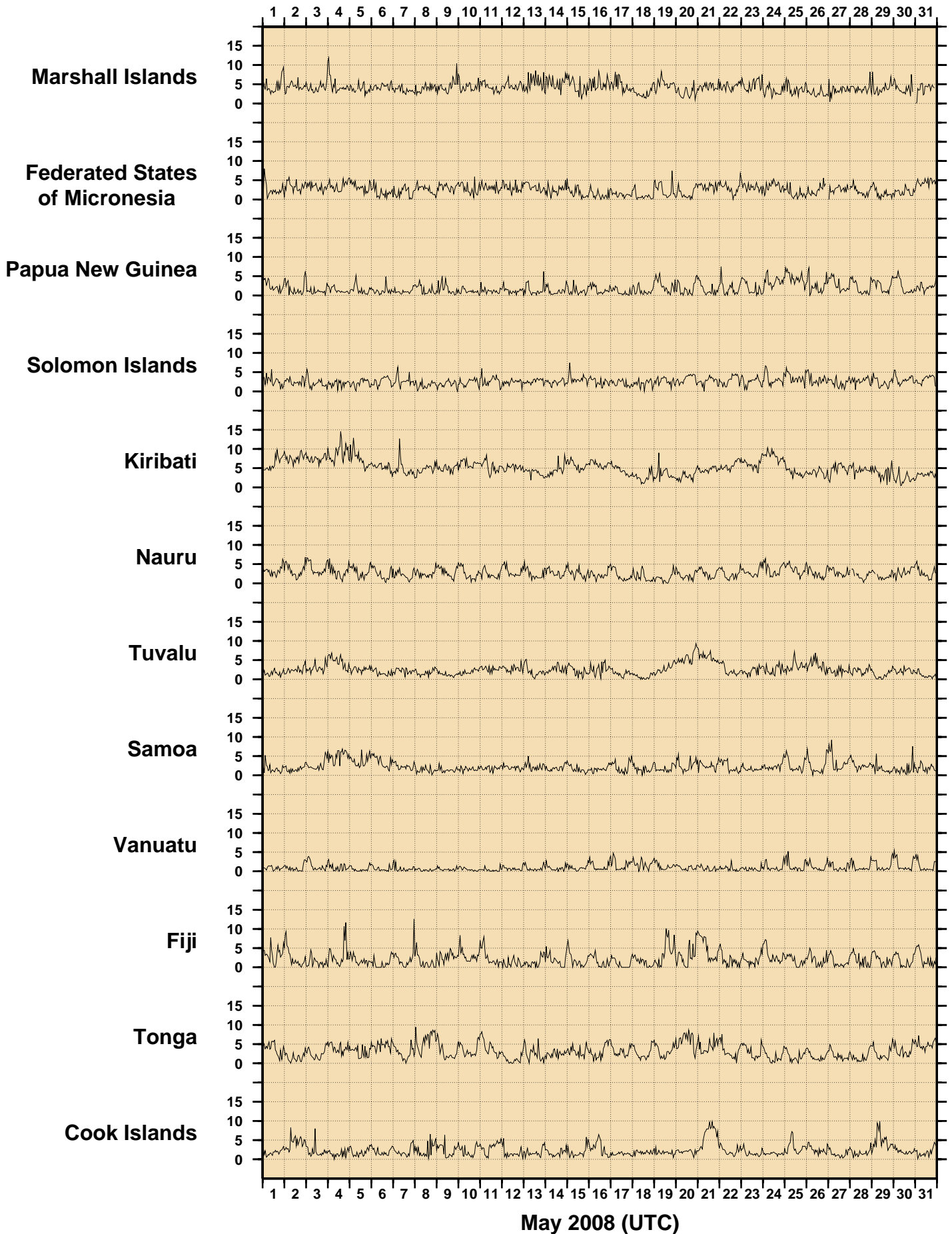


Figure 5
MAY 2008
HOURLY INCIDENT WINDS (m/s, deg True)

— 10 m/s

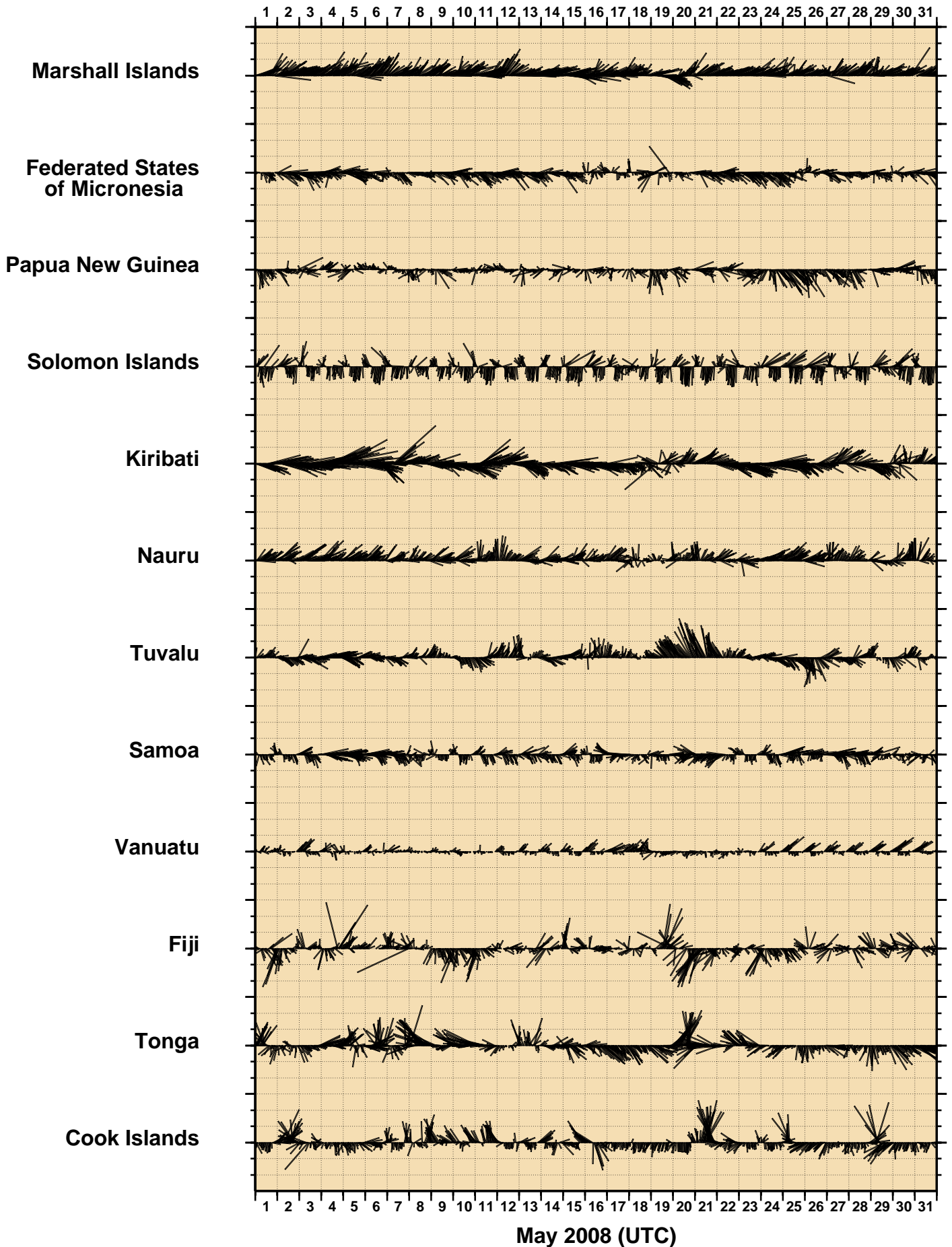


Figure 6
MAY 2008
HOURLY MAXIMUM WIND GUSTS (m/s)

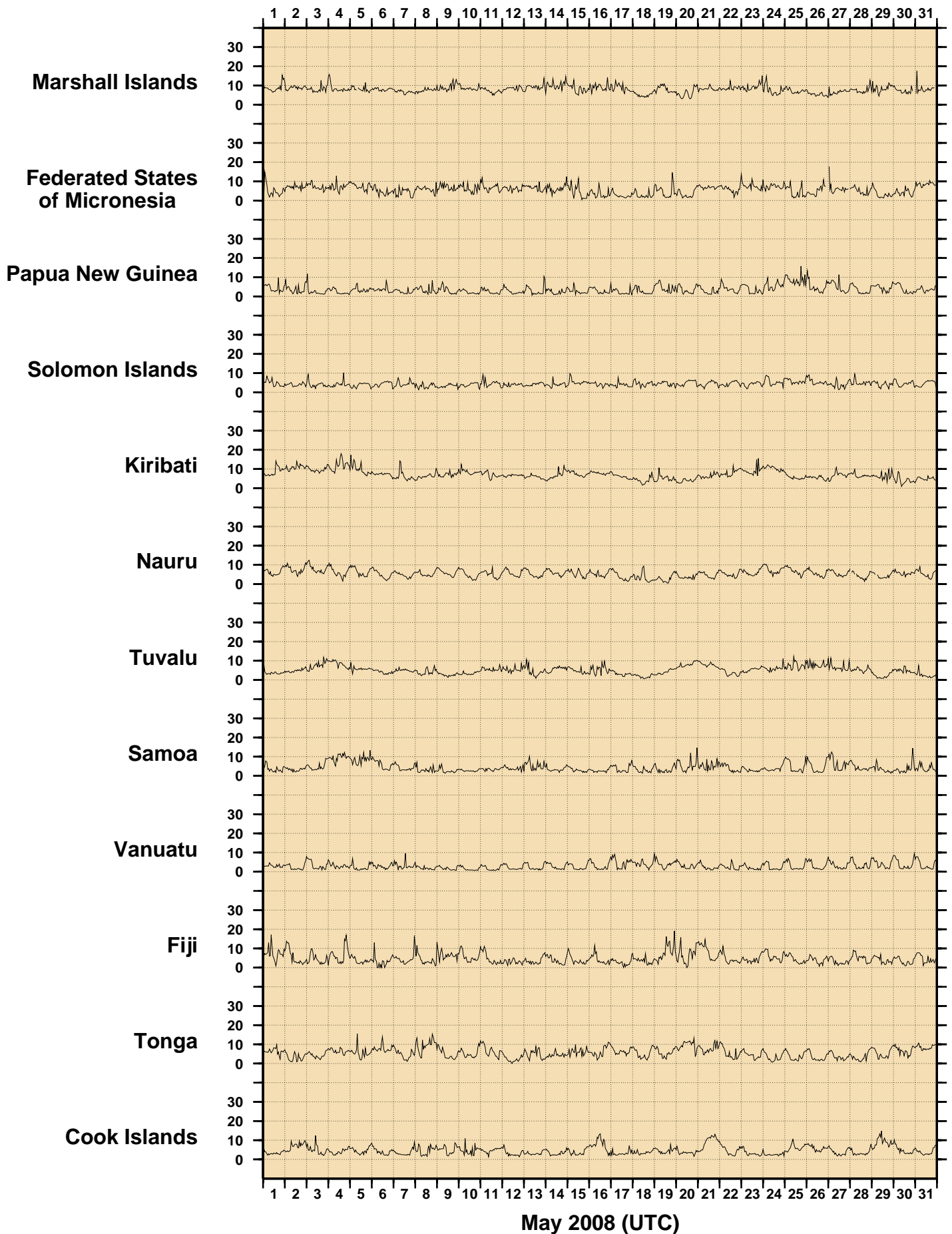


Figure 7

MAY 2008

HOURLY AIR TEMPERATURES (°C)

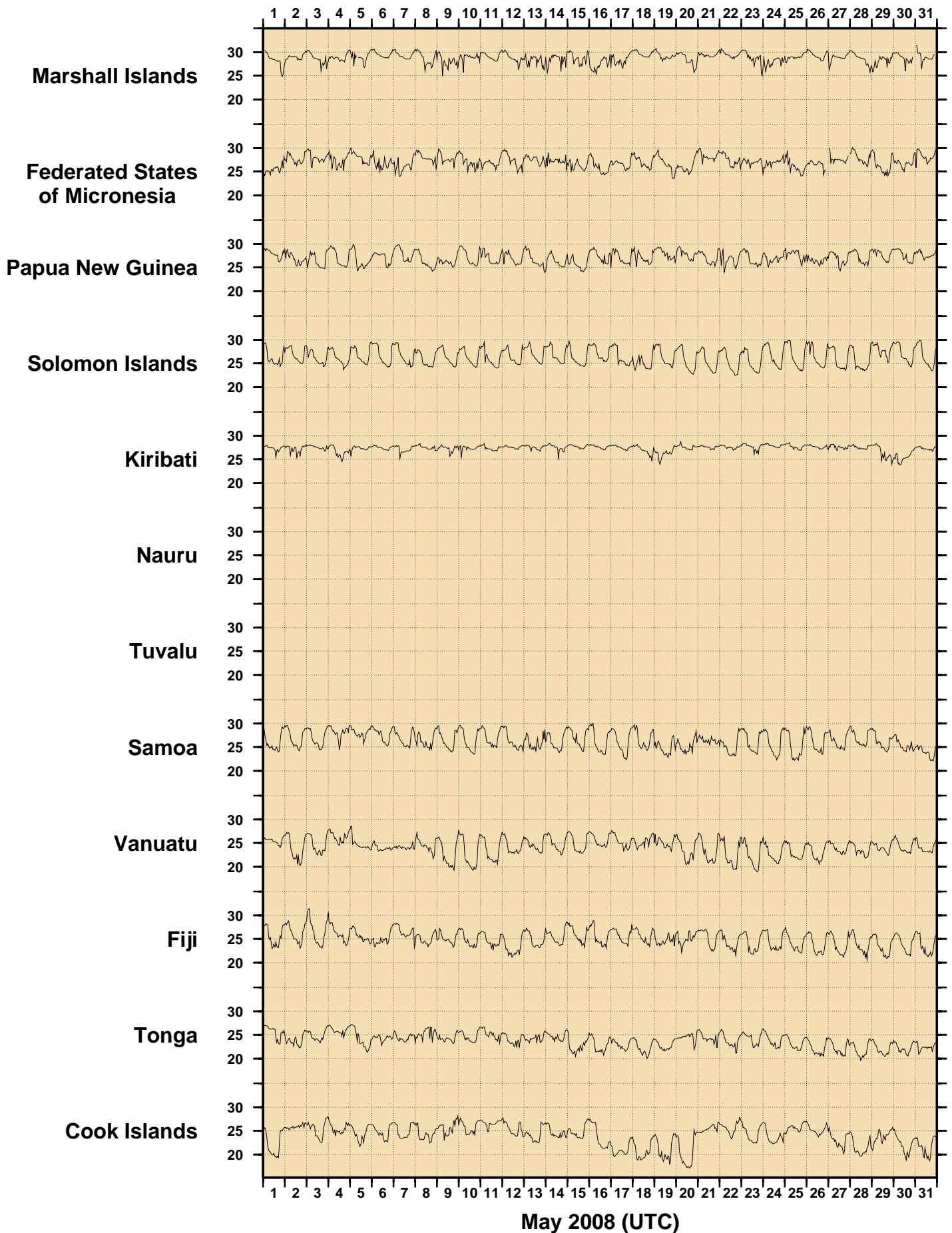


Figure 8

MAY 2008

HOURLY WATER TEMPERATURES (°C)

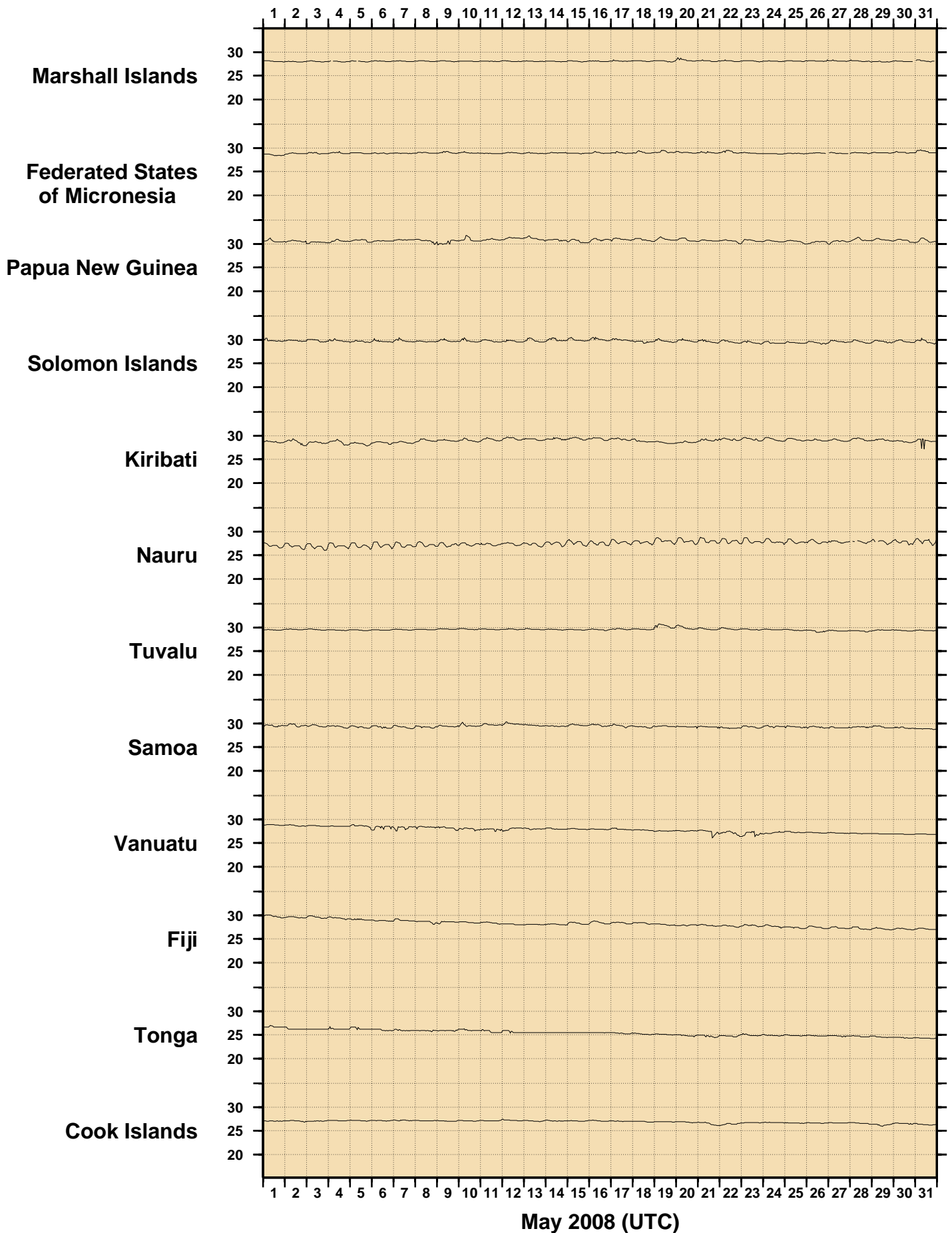


Figure 9
MAY 2008
HOURLY ATMOSPHERIC PRESSURE (hPa)

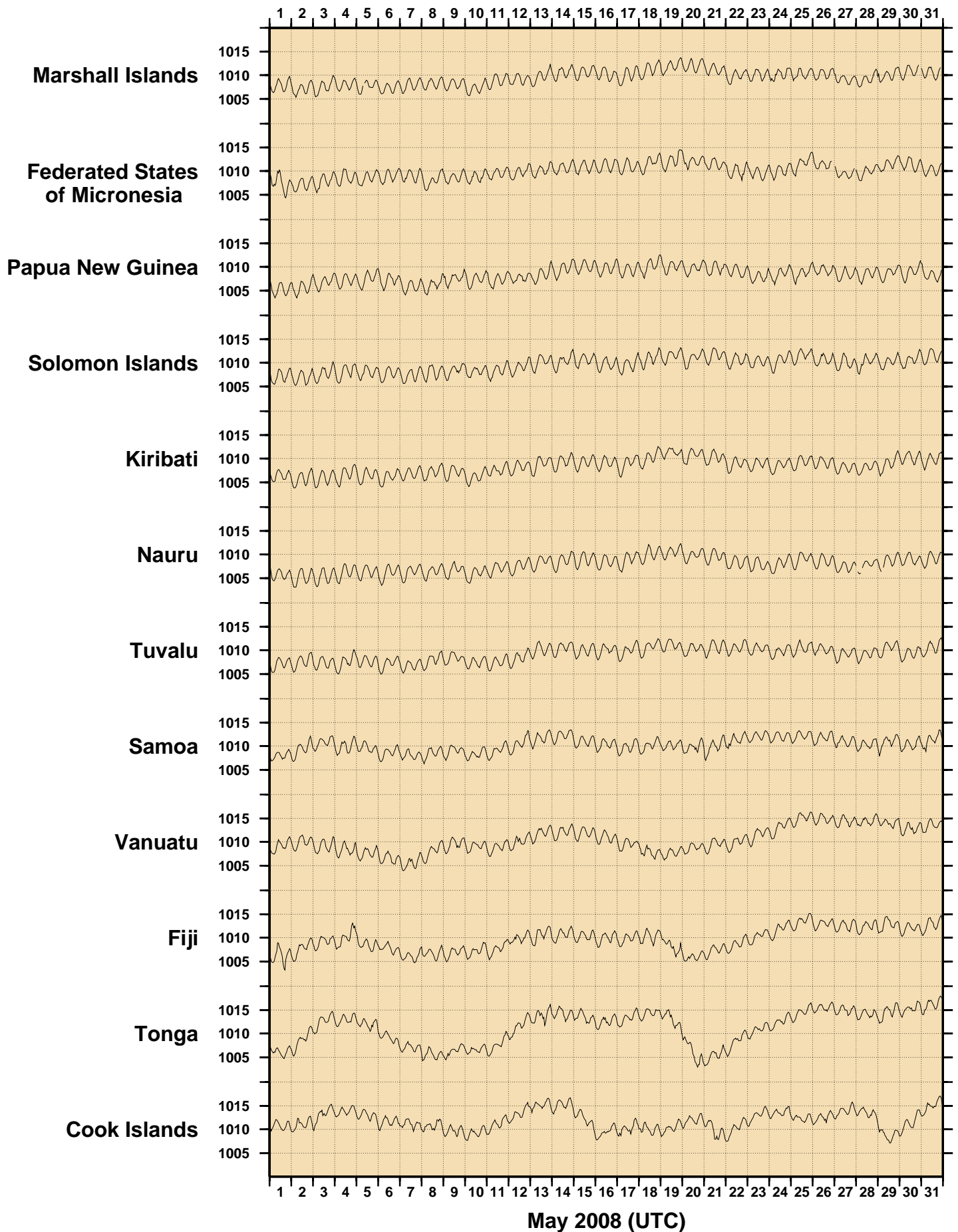
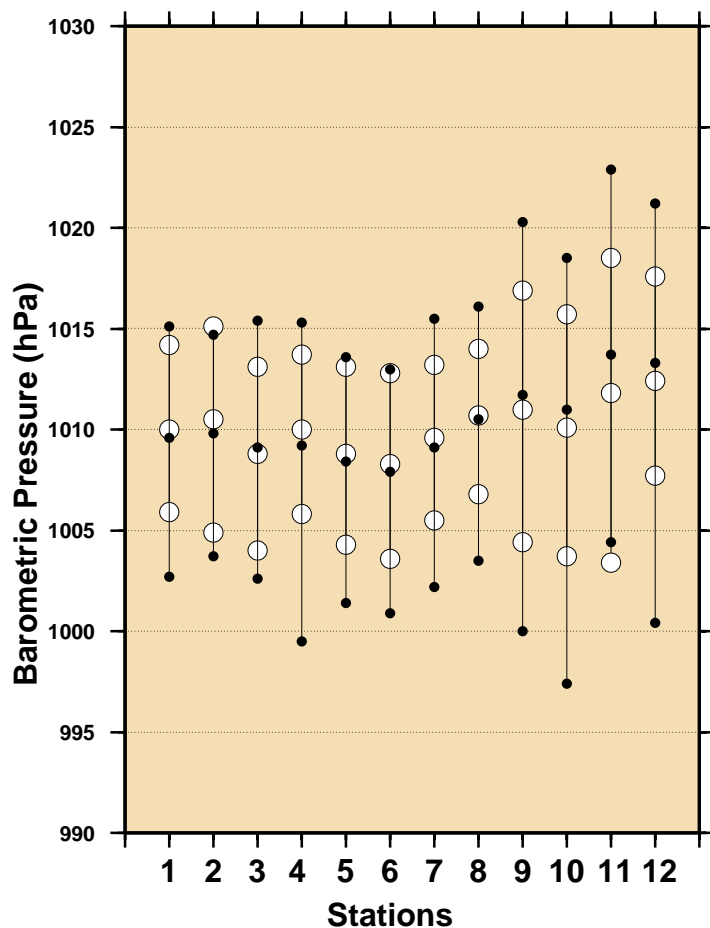
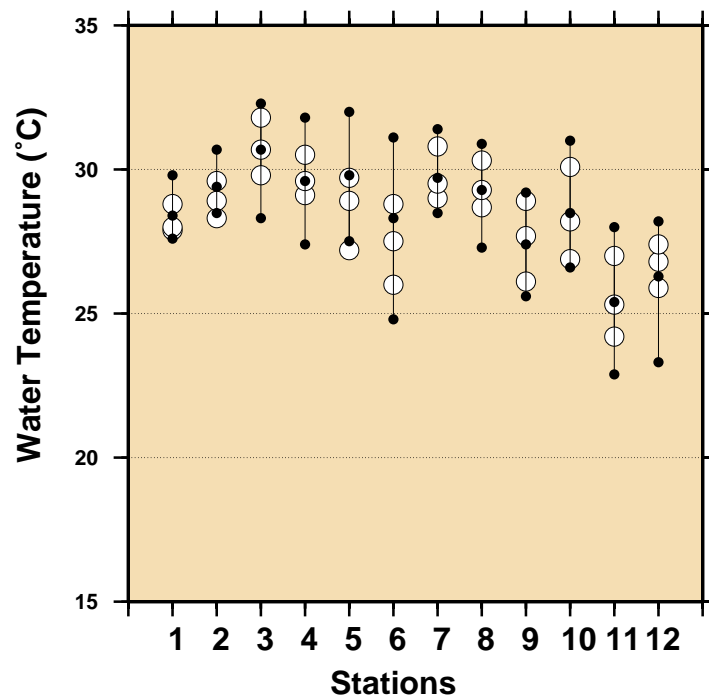
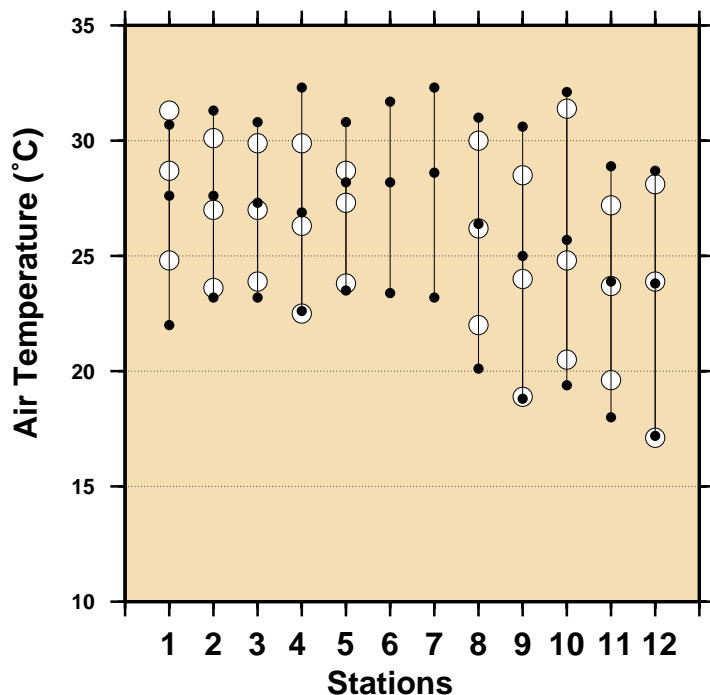


Figure 10
Comparison of May 2008 Max, Min & Mean with
Long Term May Values



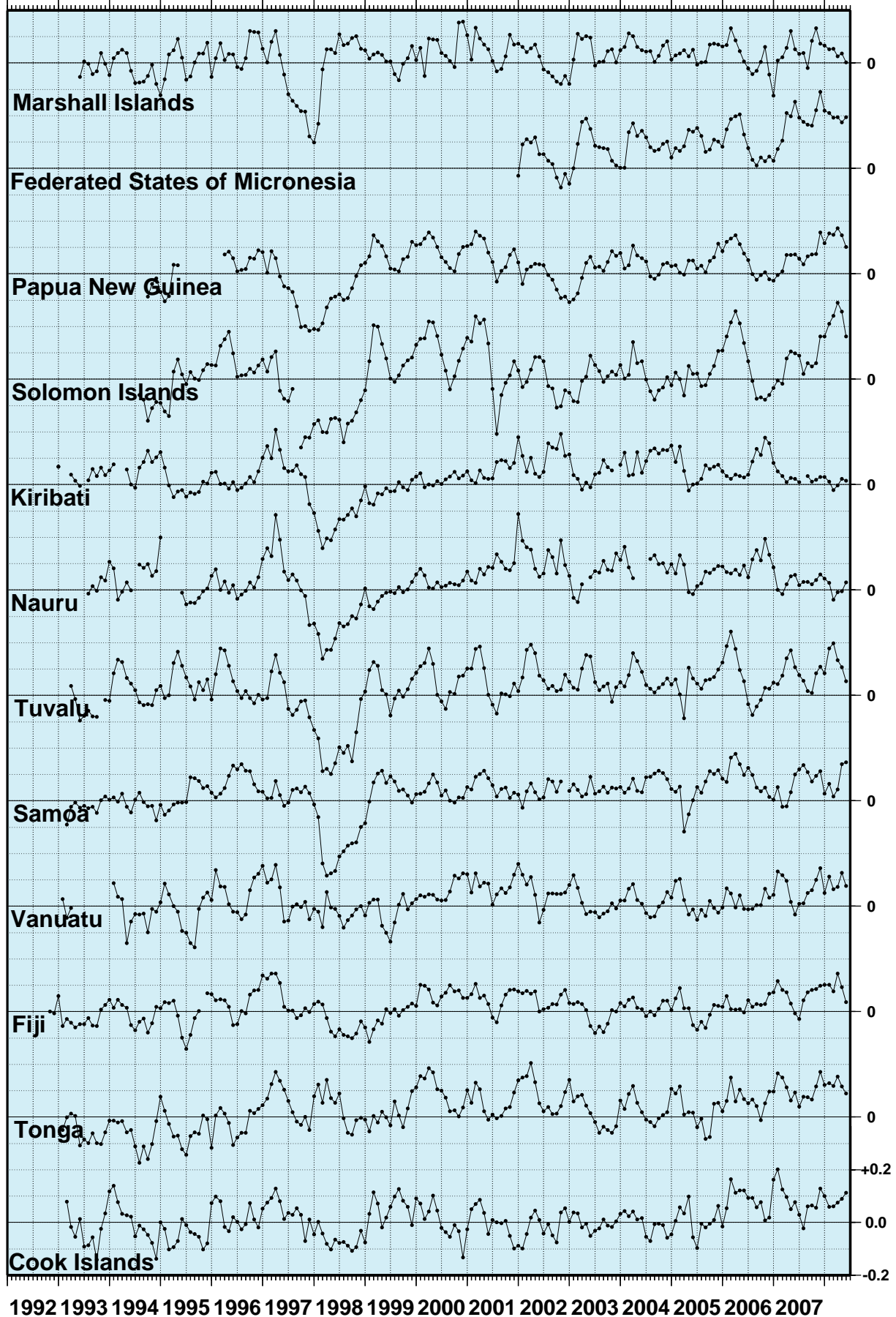
Stations

- 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

- May 2008 Maximum
- May 2008 Mean
- May 2008 Minimum
- Long Term May Maximum
- Long Term May Mean
- Long Term May Minimum

MONTHLY MEAN SEA LEVELS TO MAY 2008 (m)

1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007



1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

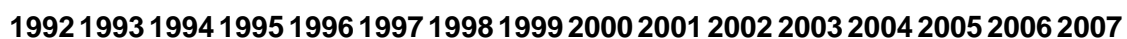


Figure 13

SEA LEVEL TRENDS THROUGH MAY 2008 (mm/year)

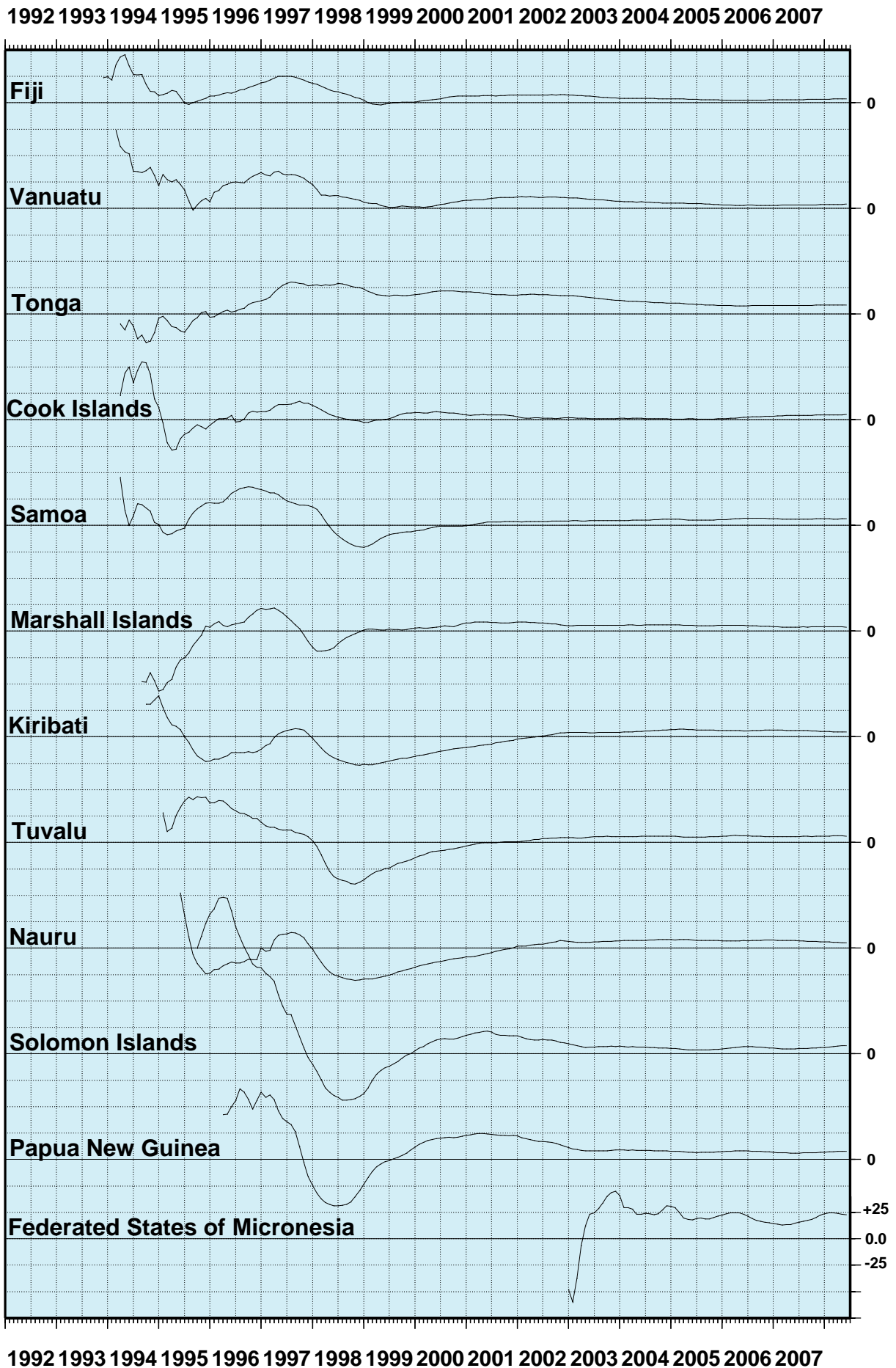


Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH MAY 2008 (hPa)

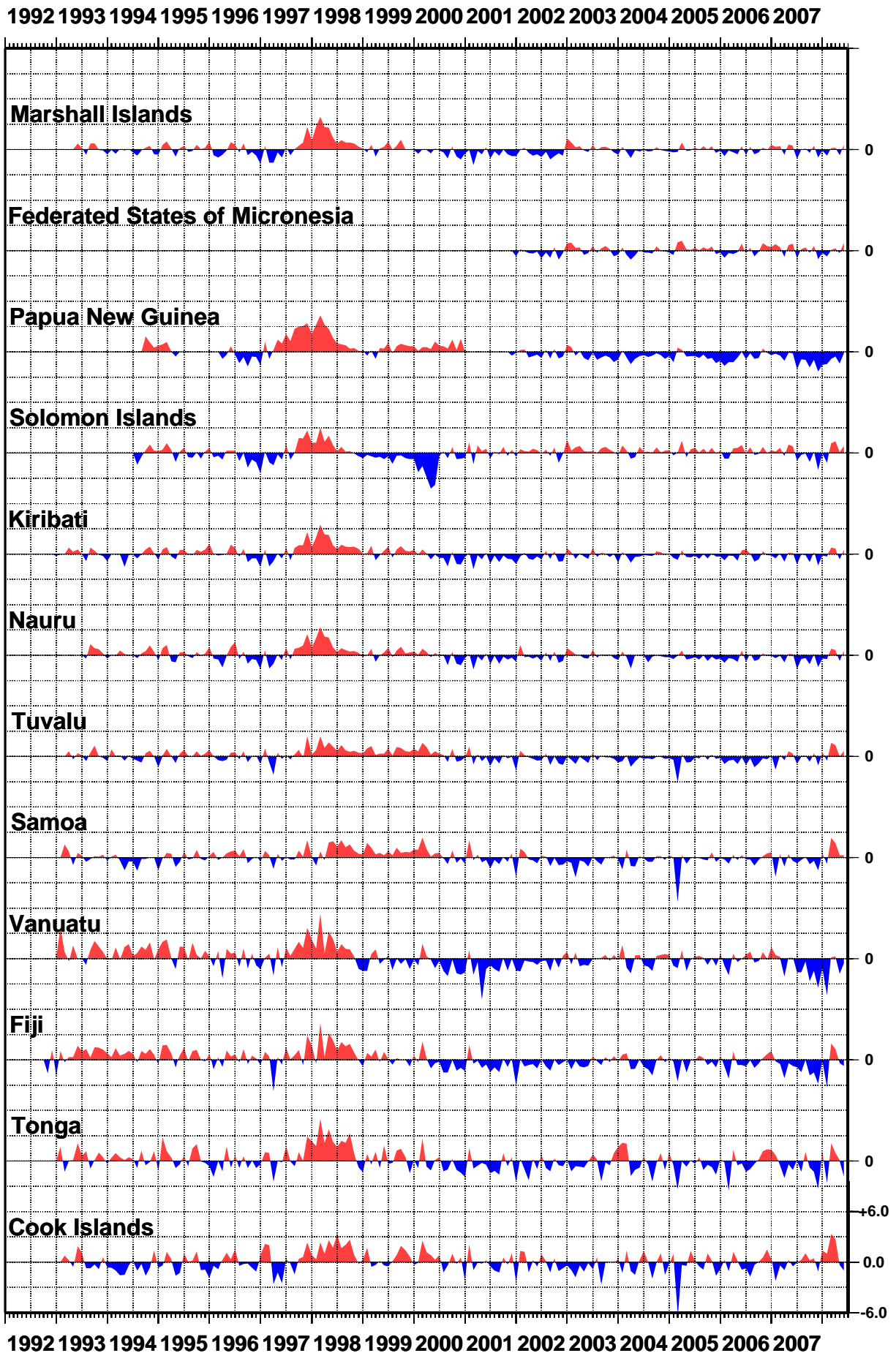


Figure 15
**WATER TEMPERATURE ANOMALIES
 THROUGH MAY 2008 (°C)**

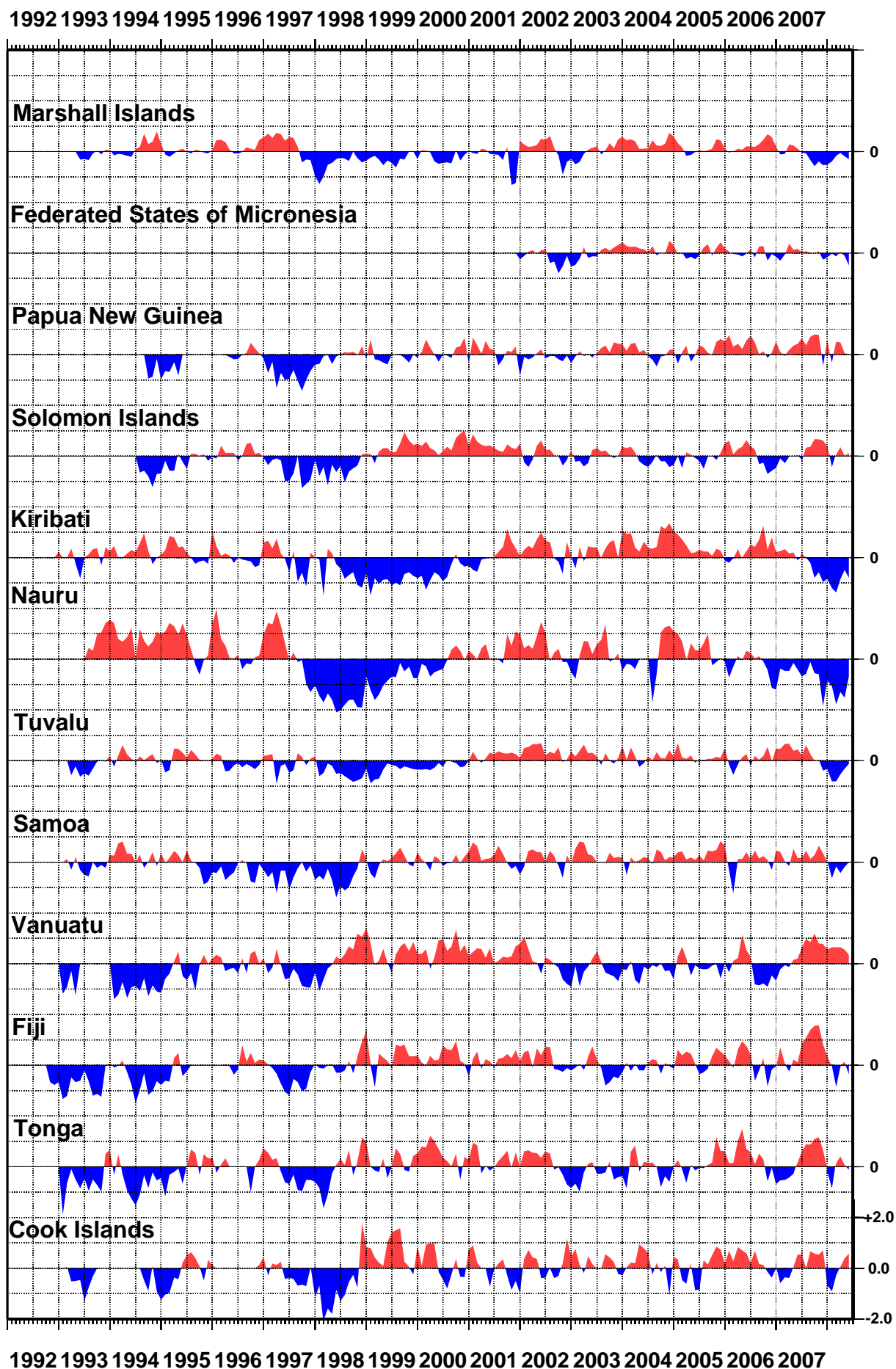


Figure 16
**AIR TEMPERATURE ANOMALIES
THROUGH MAY 2008 (°C)**

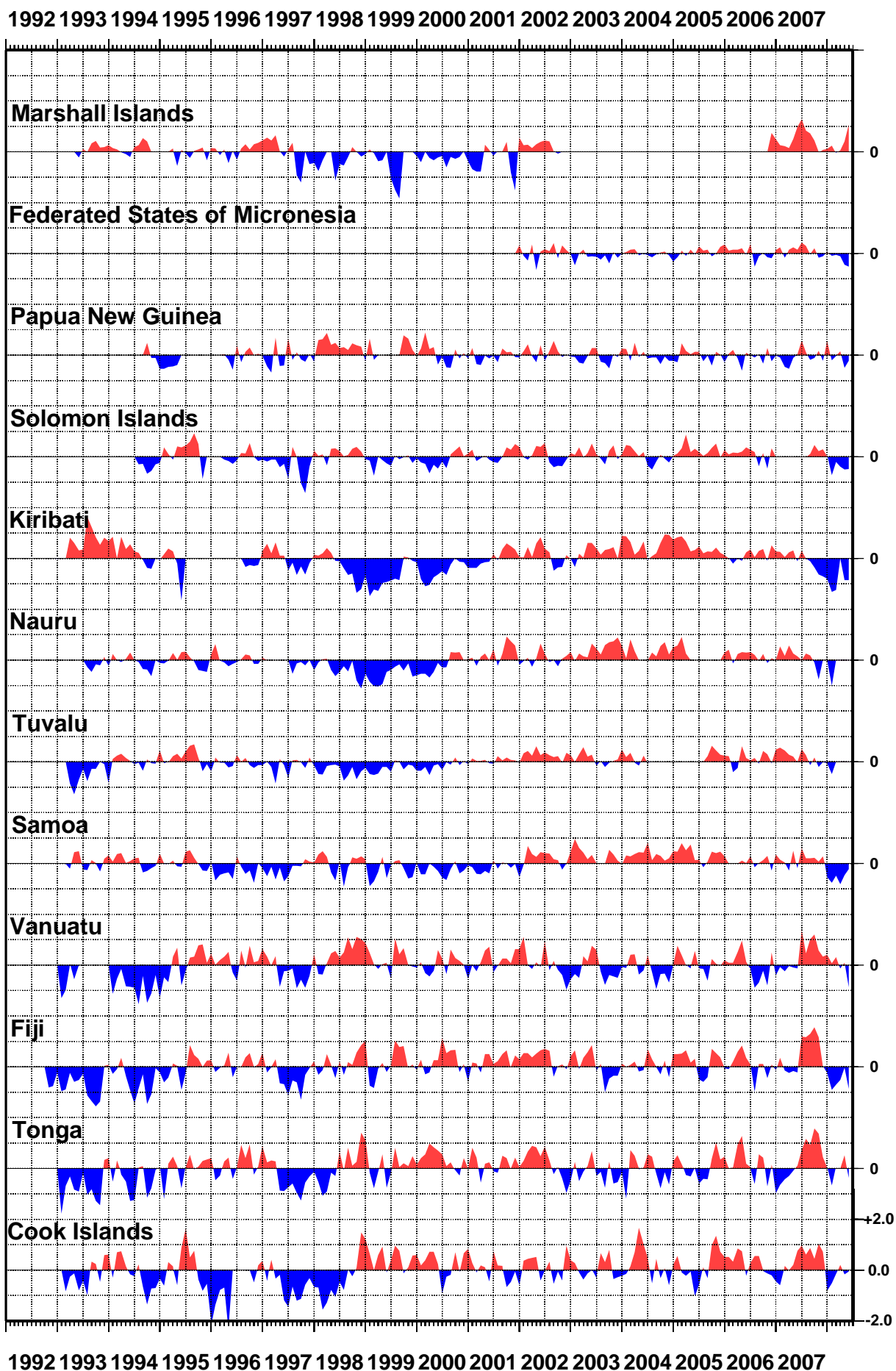


Figure 17

SEA LEVEL DATA RETURN

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

