THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 142

APRIL 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 April 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

April 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.

April 2007

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

- Near-normal monthly mean sea levels were observed at SEAFRAME stations, which is consistent with the near-neutral climate conditions currently prevailing across the Pacific Ocean.

- A destructive tsunami was generated from a magnitude Mw8.1 earthquake near the Solomon Islands on 1st April 2007. Tsunami signals were detected by many of the SEAFRAME stations in the region.

- A significant pool of cooler than normal subsurface water remains in the eastern equatorial Pacific and continues to affect surface temperatures in that region.

- The majority of international climate models predict that cool conditions consistent with a La Niña event will continue to develop across the Pacific in the coming months and persist for the remainder of 2007.

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 , 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**	**+4.1**	**0.0**
Tonga	**21°8'12.5"S / 175°10'50.5"W**	**Jan 1993**	**+8.1**	**-0.1**
Fiji	**17°36'17.7"S / 177°26'17.7"E**	**Oct 1992**	**+2.9**	**0.0**
Vanuatu	**17°45'19.2"S / 168°18'27.7"E**	**Jan 1993**	**+3.2**	**0.0**
Samoa	**13°49'36.4"S / 171°45'40.7"W**	**Feb 1993**	**+5.8**	**-0.1**
Tuvalu	**8°30'8.9"S / 179°11'42.6"E**	**Mar 1993**	**+5.5**	**+0.1**
Kiribati	**1°21'54.2"N / 172°55'58.8"E**	**Dec 1992**	**+6.1**	**0.0**
Nauru	**0°31'45.9"S / 166°54'36.2"E**	**Jul 1993**	**+7.2**	**0.0**
Solomon Is.	**9°25'44.1"S / 159°57'19.3"E**	**Jul 1994**	**+4.7**	**0.0**
PNG	**2°2'31.5"S / 147°22'25.6"E**	**Sep 1994**	**+6.2**	**-0.1**
FSM	**6°58'49.9"N / 158°12'0.8"E**	**Dec 2001**	**+13.5**	**0.0**
Marshall Is.	**7°6'21.7"N / 171°22'22.1"E**	**May 1993**	**+3.9**	**+0.1**

INTRODUCTION

Welcome to the April 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 gauges 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. SEAFRAME gauges were installed in the participating Forum Countries.

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.

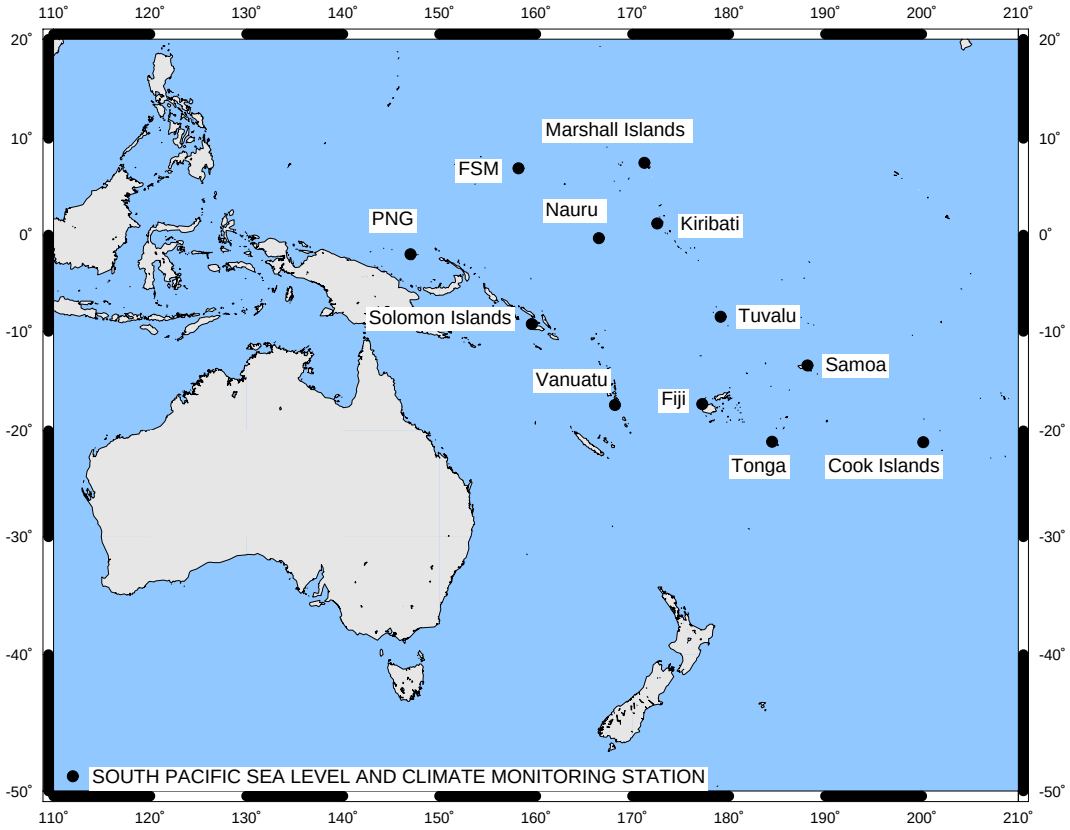

Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

APRIL CLIMATOLOGY

Equatorial Pacific climate conditions remained neutral during April although cooler than normal sub-surface temperatures persisted in the eastern Pacific, which could potentially lead to the development of basin-wide cool La Niña conditions. International climate models suggest the likelihood of a La Niña developing during 2007 has increased.

The Southern Oscillation Index (SOI) (**Figure B**) underwent large variation during April, although such behaviour is not uncommon for this time of the year. The monthly average SOI value for April was –3, which indicates the longer-term climatic situation remains neutral.

Cooler than normal sea surface temperatures were again observed in the far eastern equatorial Pacific, which may be the first signs of an emerging La Niña (**Figure C, Figure E**). Many of the SEAFRAME stations lie within a band of warmer than usual sea surface temperature that stretches from Papua New Guinea southeastward into the south Pacific.

Cooler than normal subsurface temperatures persist along the thermocline across much of the central and eastern equatorial Pacific Ocean (**Figure D**). This cooler subsurface water is the cause of the recent surface cooling in the far-eastern Pacific and its continued presence will likely lead to further surface cooling and potentially the development of basin-wide La Niña conditions.

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 across the equatorial Pacific were of near to slightly above average strength in the central equatorial Pacific during April (**Figure E**). Cloudiness in the equatorial Pacific near the dateline was near to slightly above average during April.

The results from six international dynamic computer models predict that cool conditions will continue to develop across the Pacific in the next few months and persist for the remainder of 2007.

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/.

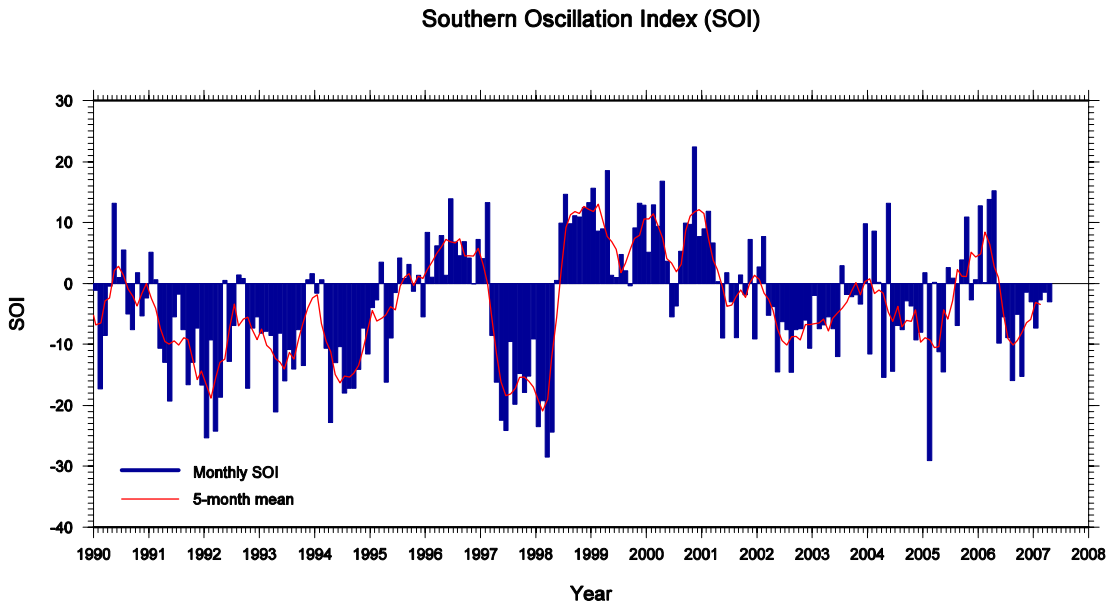

Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the standard deviation of that difference for the relevant month, based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

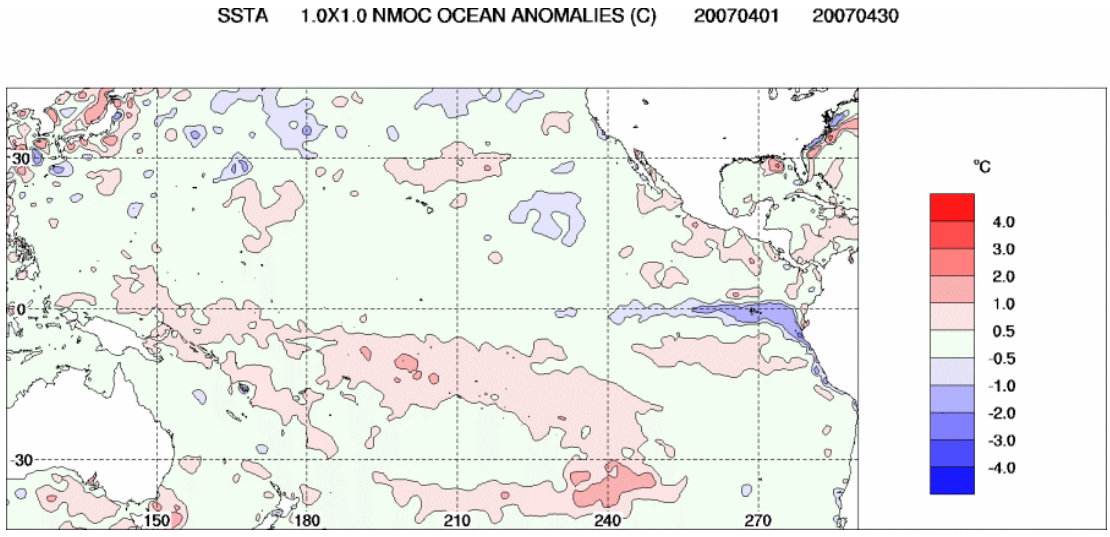

Figure C: *Sea surface temperature anomaly (°C) for April 2007.*

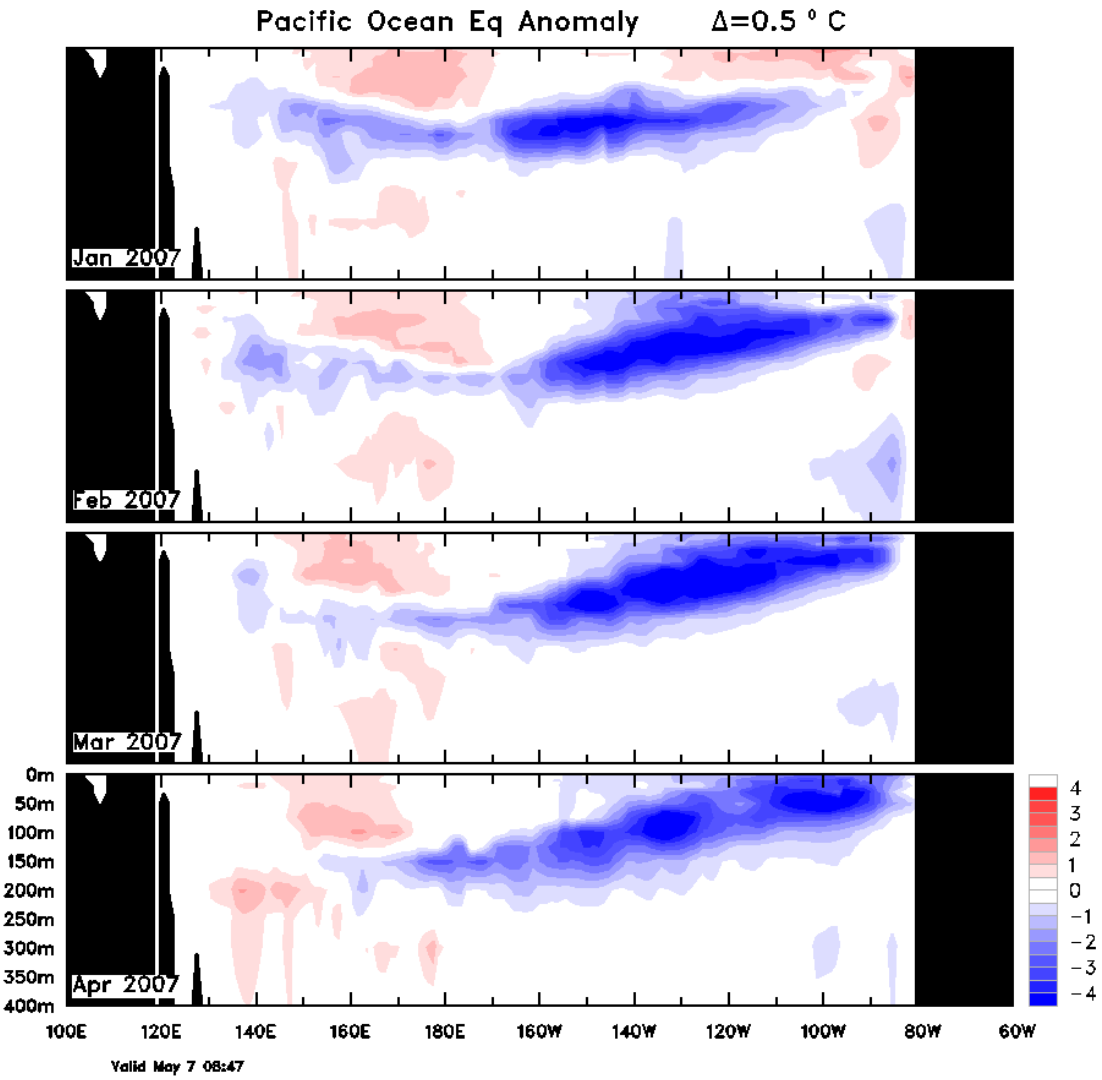

Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for January 2007 through to April 2007. Contour interval is 0.5°C.*

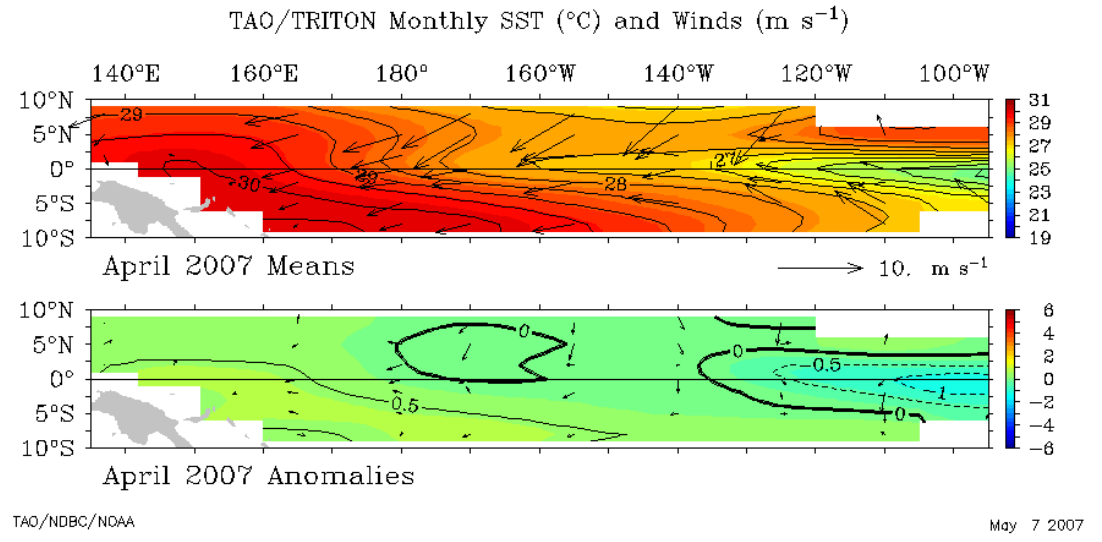

Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for April 2007. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

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 full and new moons. There was a full moon on the 2nd of April and a new moon on the 17th of April UTC.

Gaps in the data are the result of instrumental 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 a tsunami. Residual sea levels are influenced by the shape of the harbour in which the gauge is located. The gauge at Papua New Guinea (Manus Island), for example, often displays 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.

At 20:40 UTC on the 1st of April 2007 a magnitude Mw8.1 earthquake in the vicinity of Solomon Islands generated a tsunami that was detected by SEAFRAME stations in the region. The Pacific Tsunami Warning Centre issued warnings alerting those countries at threat from the tsunami, however extensive damage and numerous deaths were unable to be prevented at localities in the Solomon Islands adjacent the source where the tsunami waves were largest and tsunami arrival was very soon after the earthquake. The SEAFRAME at Honiara in the Solomon Islands, which was 345 km ESE from the epicentre, detected a tsunami of 45cm. The tsunami was also detected by SEAFRAMES at Lombrum, PNG (20cm), Port Vila, Vanuatu (30cm), Nuku'alofa, Tonga (11cm), Lautoka, Fiji (10cm), Apia, Samoa (7cm) and Funafuti, Tuvalu (5cm).

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 gusts observed each hour **(Figure 6)** show the strongest winds of 19 m/s (37 knots) were observed at Tonga on the 5th of April**.** No wind data was collected at Solomon Islands

because the wind mast and wind sensor have been temporarily removed to allow for refurbishment of the wharf.

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 twice-daily fluctuations in water temperature that are related to the tide, since they are usually more pronounced during the larger spring tides.

Barometric pressures **(Figure 9)** tend to fluctuate by around 3 hPa twice per day 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, which 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 FSM data frequently goes outside the range but this is of less significance because the instrumental record is relatively short (since December 2001). Figure 10 shows that new April maximum air temperatures were recorded at Marshall Islands and Tuvalu and a new April minimum air temperature was recorded at Vanuatu. A new April maximum barometric pressure was recorded at Tuvalu and a new April minimum barometric pressure was recorded at FSM.

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 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 **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.

The sea level anomalies for April 2007 indicate near-normal sea levels across the region, which is consistent with the near-neutral climate conditions being observed across the Pacific at this time. Sea levels have recovered from six months ago when they were lower than normal at many stations in association with the 2006/07 El Niño. The largest anomaly was observed at Tuvalu where sea levels during April were on average 5cm lower than what is expected at this time of the year.

Sea Level Trends

Short-term sea level trends (in mm per year), at individual stations, from one year after installation to the present, are depicted in **Figure 13**. The values are calculated by continuously updating the tidal analysis with a short-term trend, based upon all data available at individual stations. Further details are available from the *National Tidal Centre (NTC), Australian Bureau of Meteorology*. It is important to stress that as the sea level record becomes longer, the short-term trend estimate becomes more stable and reliable. It is also to be noted that the observed trends in sea level include natural variability, for example, events such as El Niño and effects due to 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 these data* – they will almost certainly change over the coming years as the data set increases in length. The trend value is highly variable for the above-mentioned reasons.

Recent short-term sea level trends in the project area based upon SEAFRAME data through April , 2007

Location	Lat / Long	Installation Date	Trend (mm/yr)	Change from previous month
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PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+6.2	-0.1
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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 April 2007 barometric pressures were near normal across the region.

The **water temperature anomalies (Figure 15)** during April 2007 were slightly positive at many stations which is consistent with the regional sea surface temperature map that shows slightly warmer than normal conditions across the region (Figure C). Cooler than normal water temperatures were observed at Nauru and Tonga only.

The **air temperature anomalies (Figure 16)** also show near average to marginally warmer conditions across the region during April 2007 in accordance with the water temperatures. 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 the air temperature and wind sensors have been temporarily dismantled as the wharf continues to be refurbished. Satellite data transmissions from the Marshall Islands SEAFRAME have been inoperative since 29th of March. Data is being recovered from the instrument log with the help of on-site assistance provided by staff of the Marshall Islands Weather Service Office. The satellite transmission module will be replaced in the coming months. At PNG water temperature, air temperature and barometric pressure were not logged between the 1st and 3rd of April. Dial-up communications problems were experienced at Nauru, Tuvalu, Marshall Islands, Kiribati and Solomon Islands and some small data gaps may exist where data were unable to be recovered.

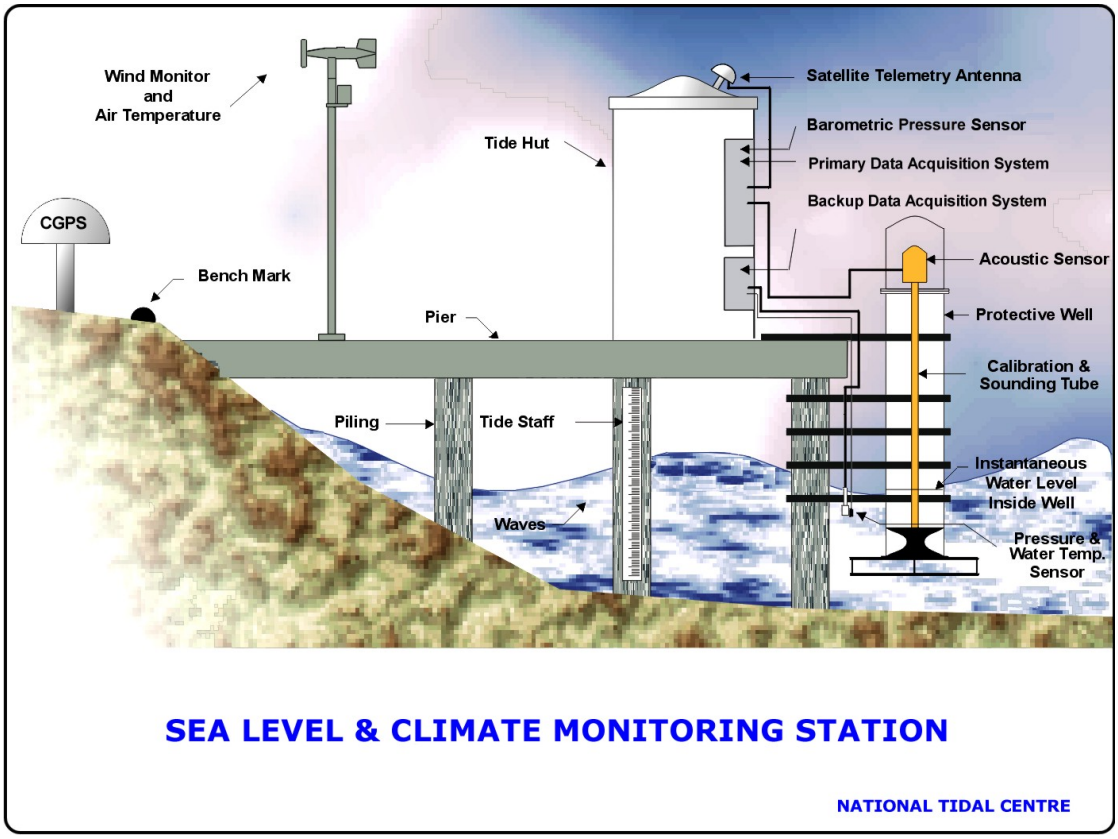
SEAFRAME STATIONS

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

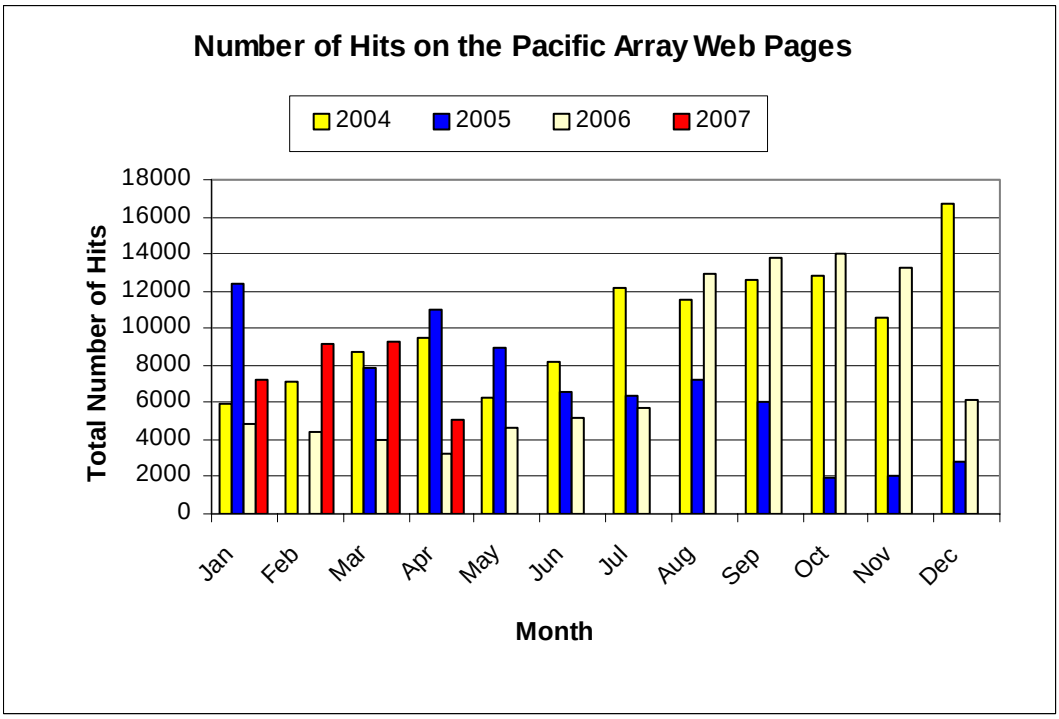
(2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

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 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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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:

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 2007
SIX MINUTE WATER LEVEL OBSERVATIONS (m)

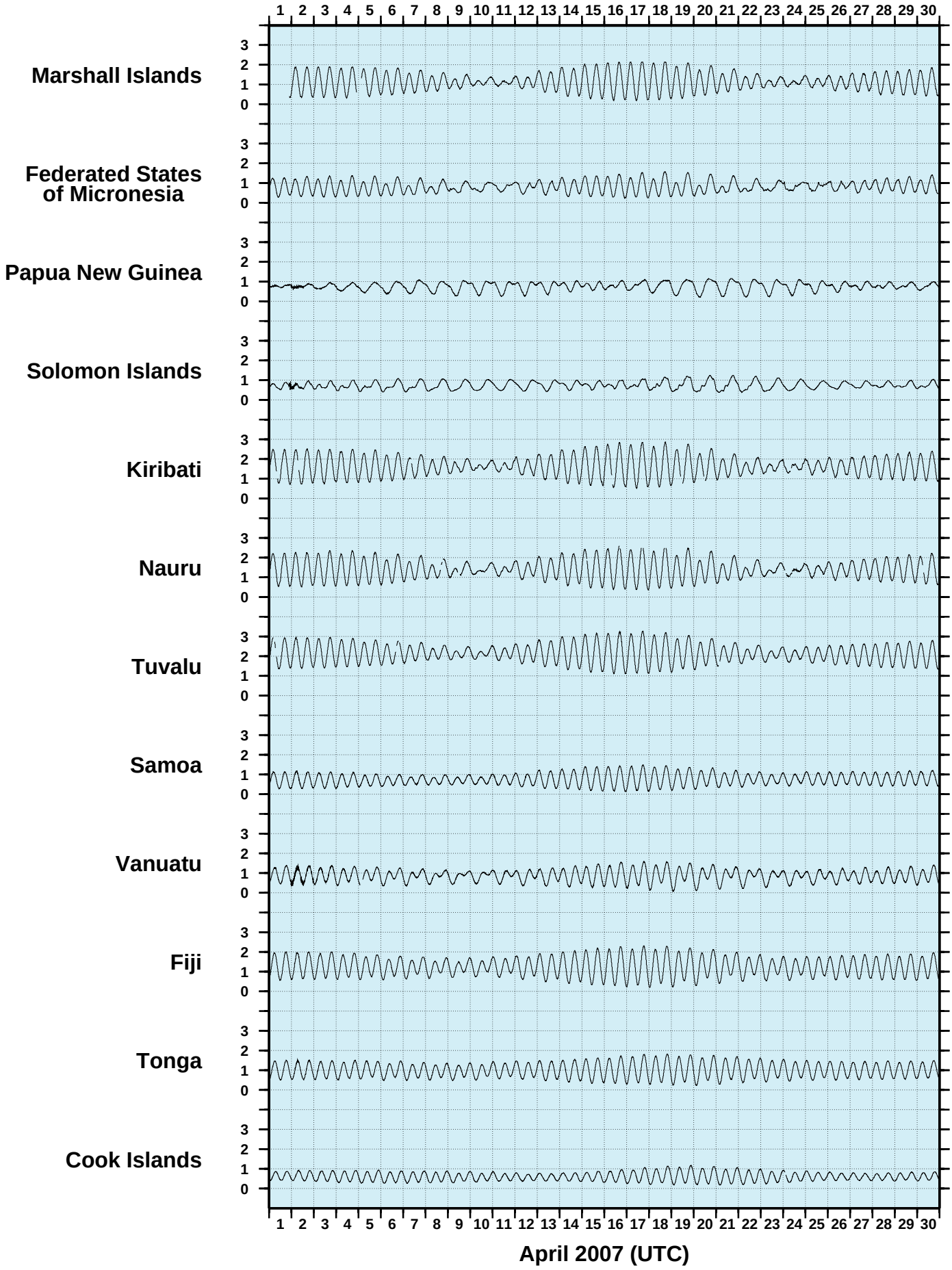


Figure 2

APRIL 2007
SIX MINUTE RESIDUAL WATER LEVELS (m)

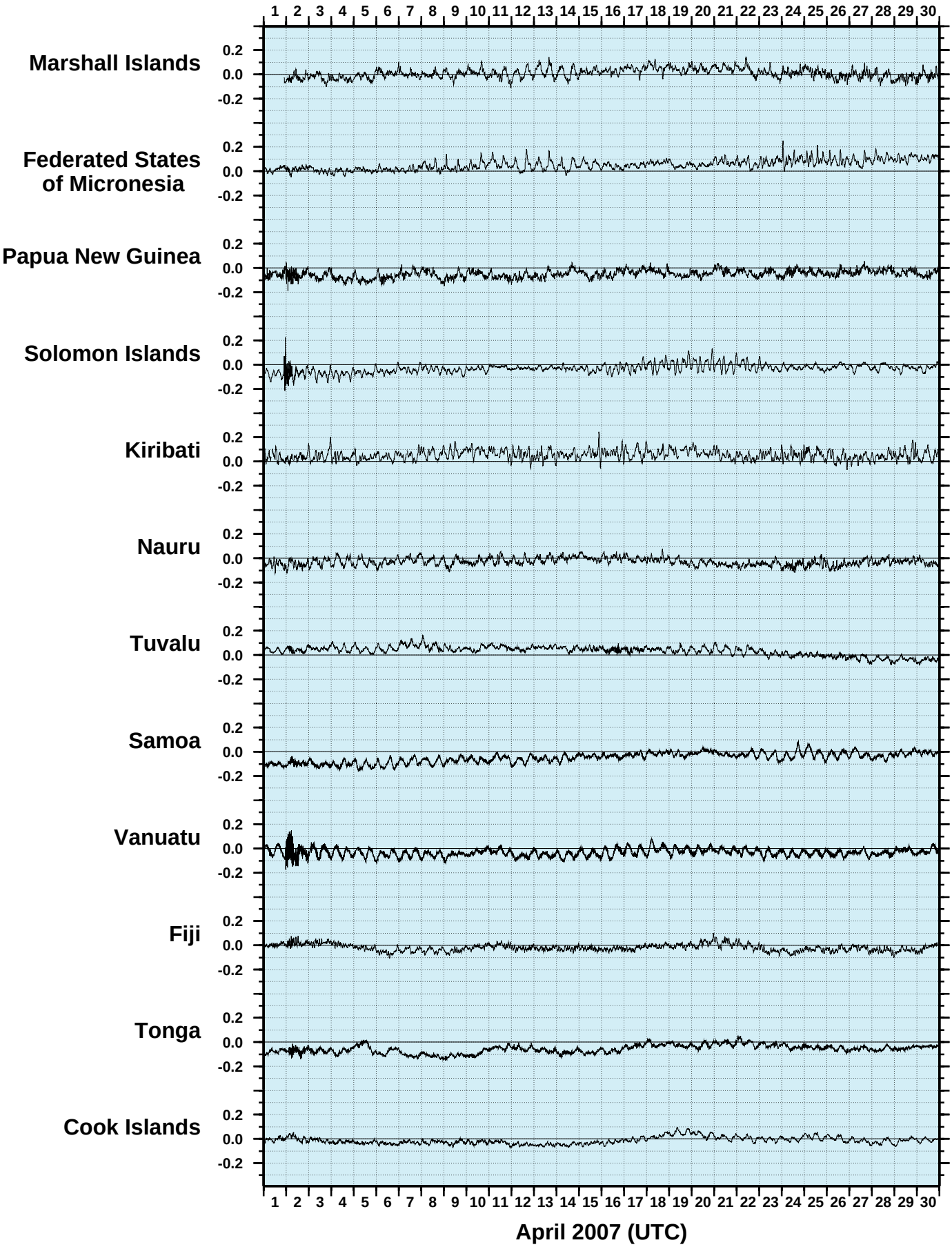


Figure 3

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

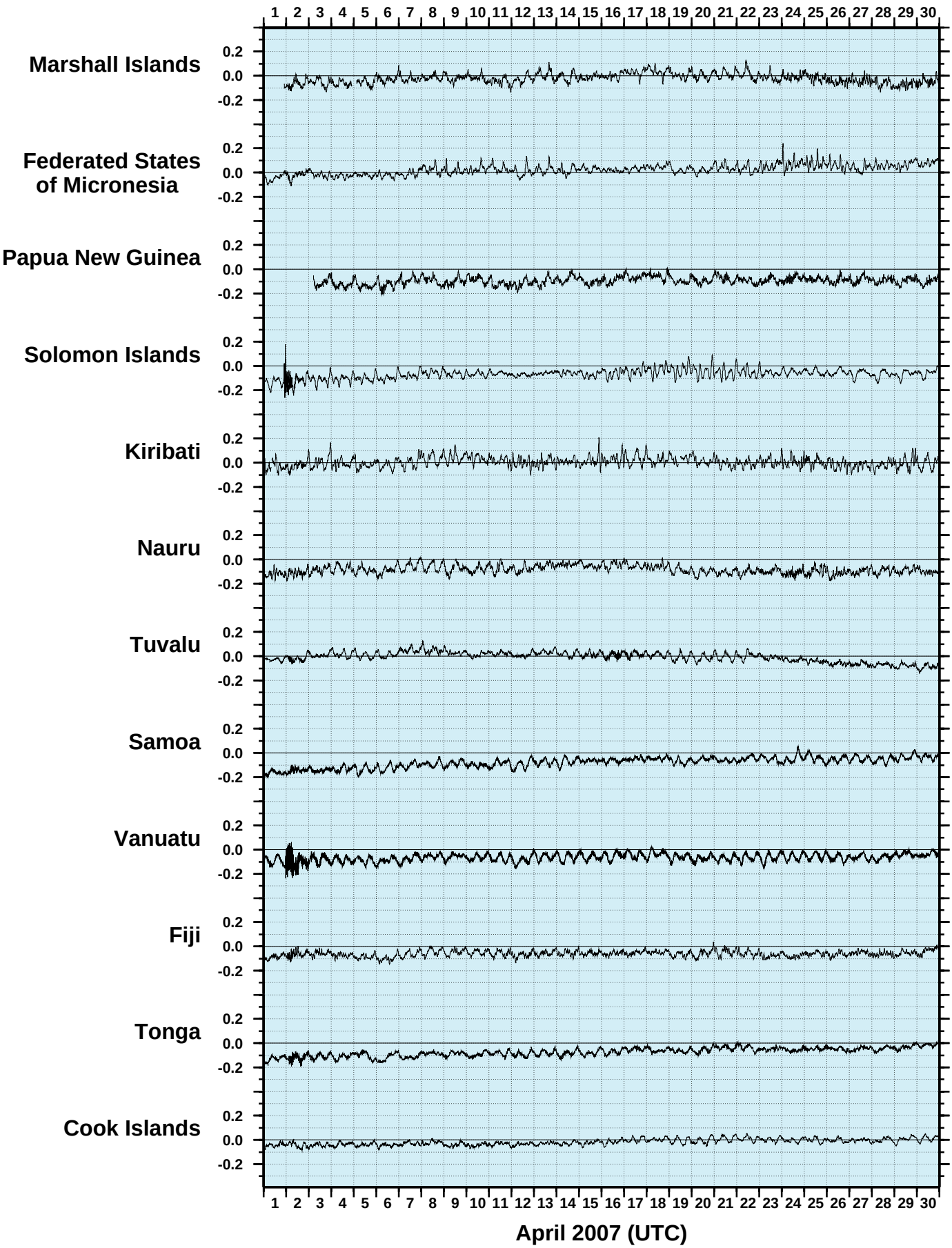


Figure 4

APRIL 2007
HOURLY WIND SPEEDS (m/s)

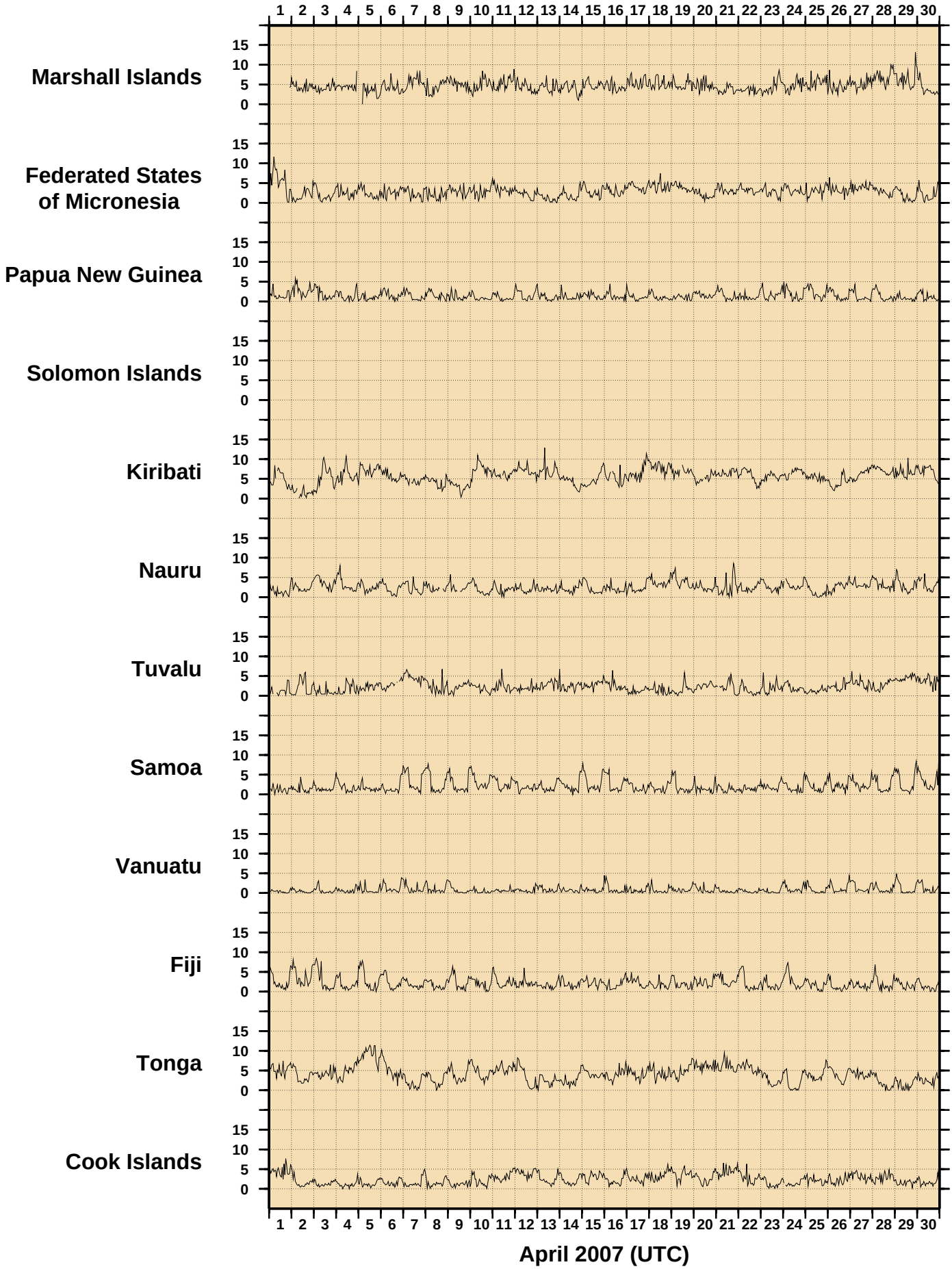


Figure 5

APRIL 2007
HOURLY INCIDENT WINDS (m/s, deg True)

—— 10 m/s

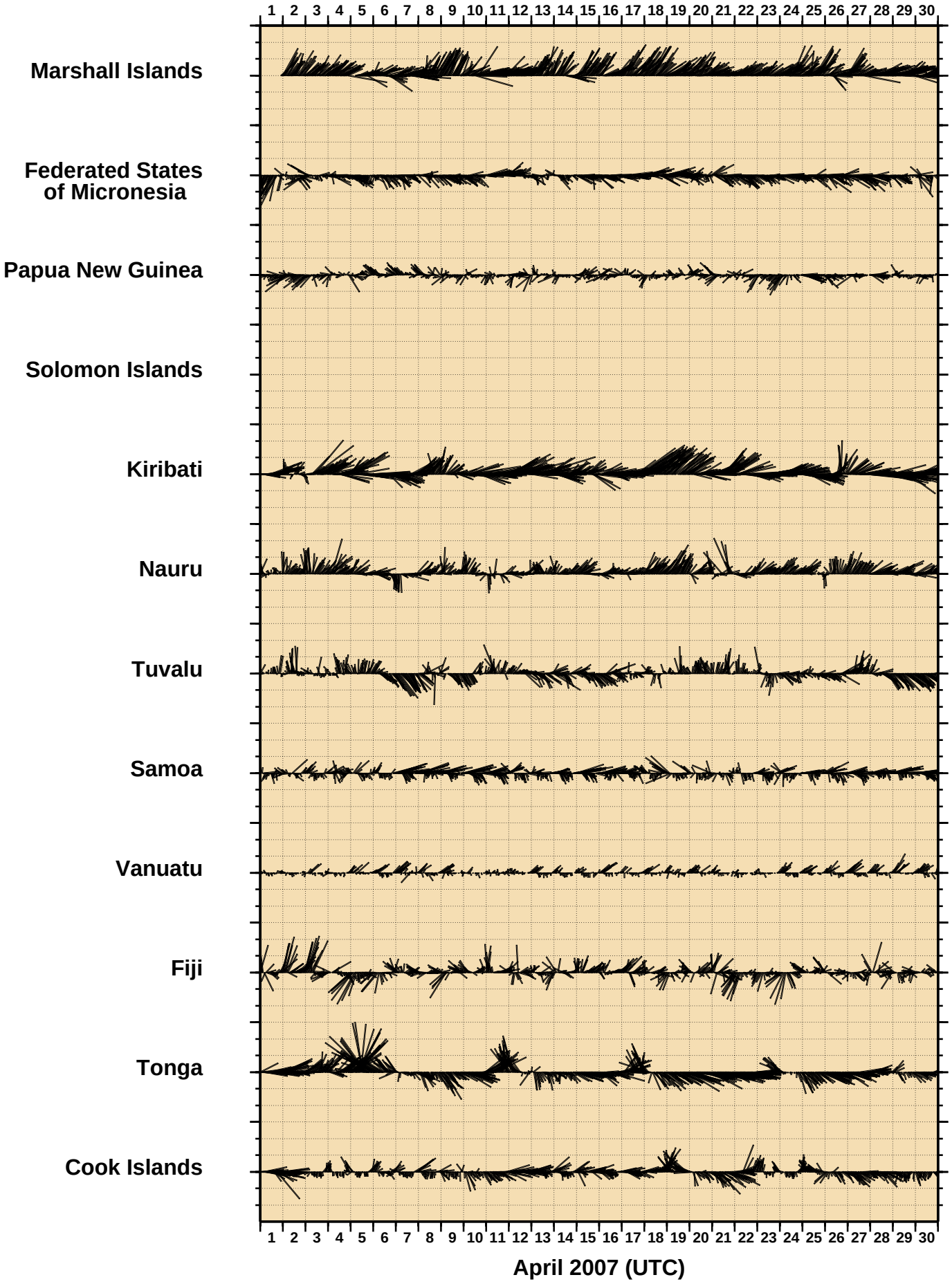


Figure 6

APRIL 2007
HOURLY MAXIMUM WIND GUSTS (m/s)

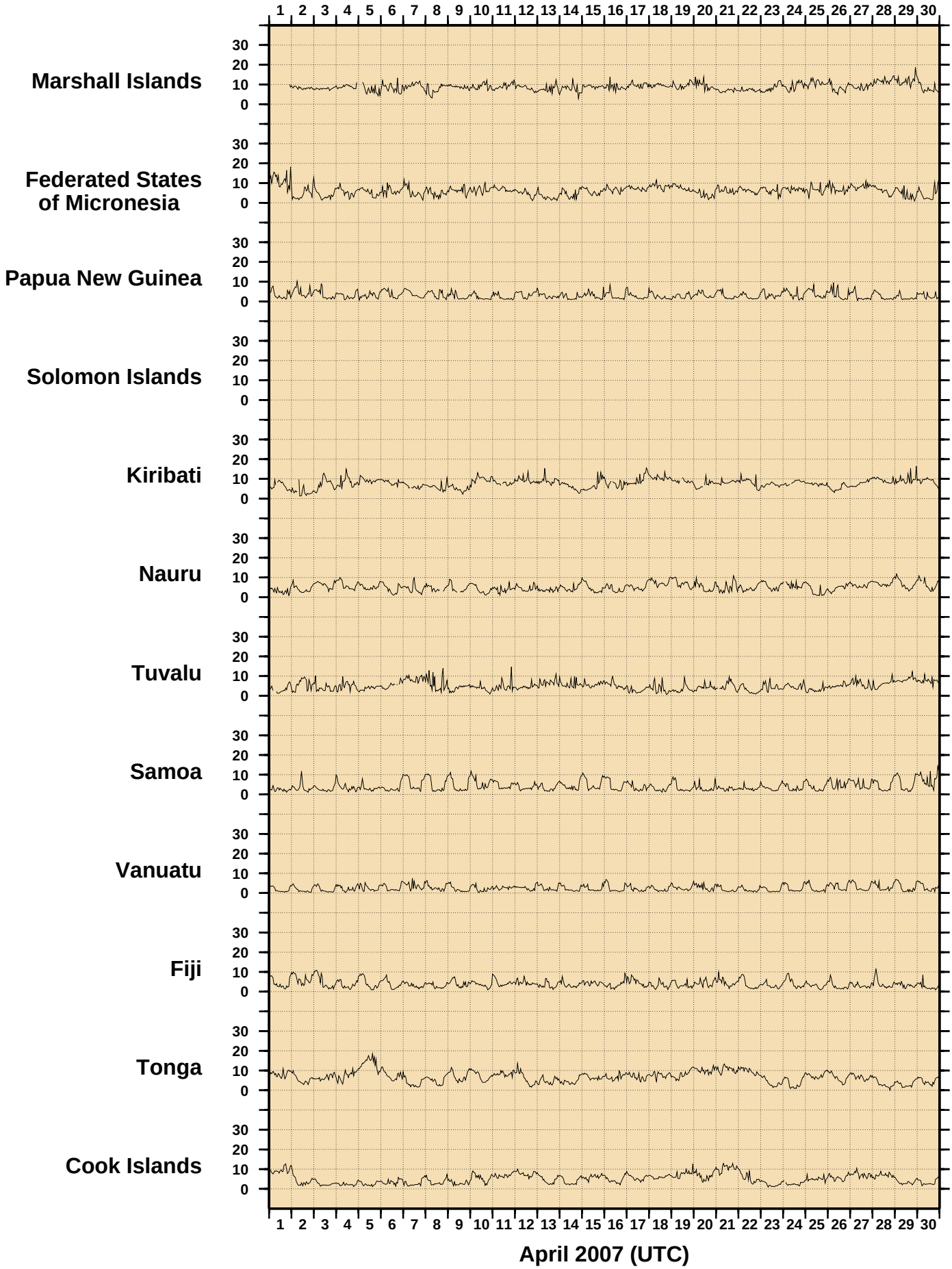


Figure 7

APRIL 2007
HOURLY AIR TEMPERATURES (°C)

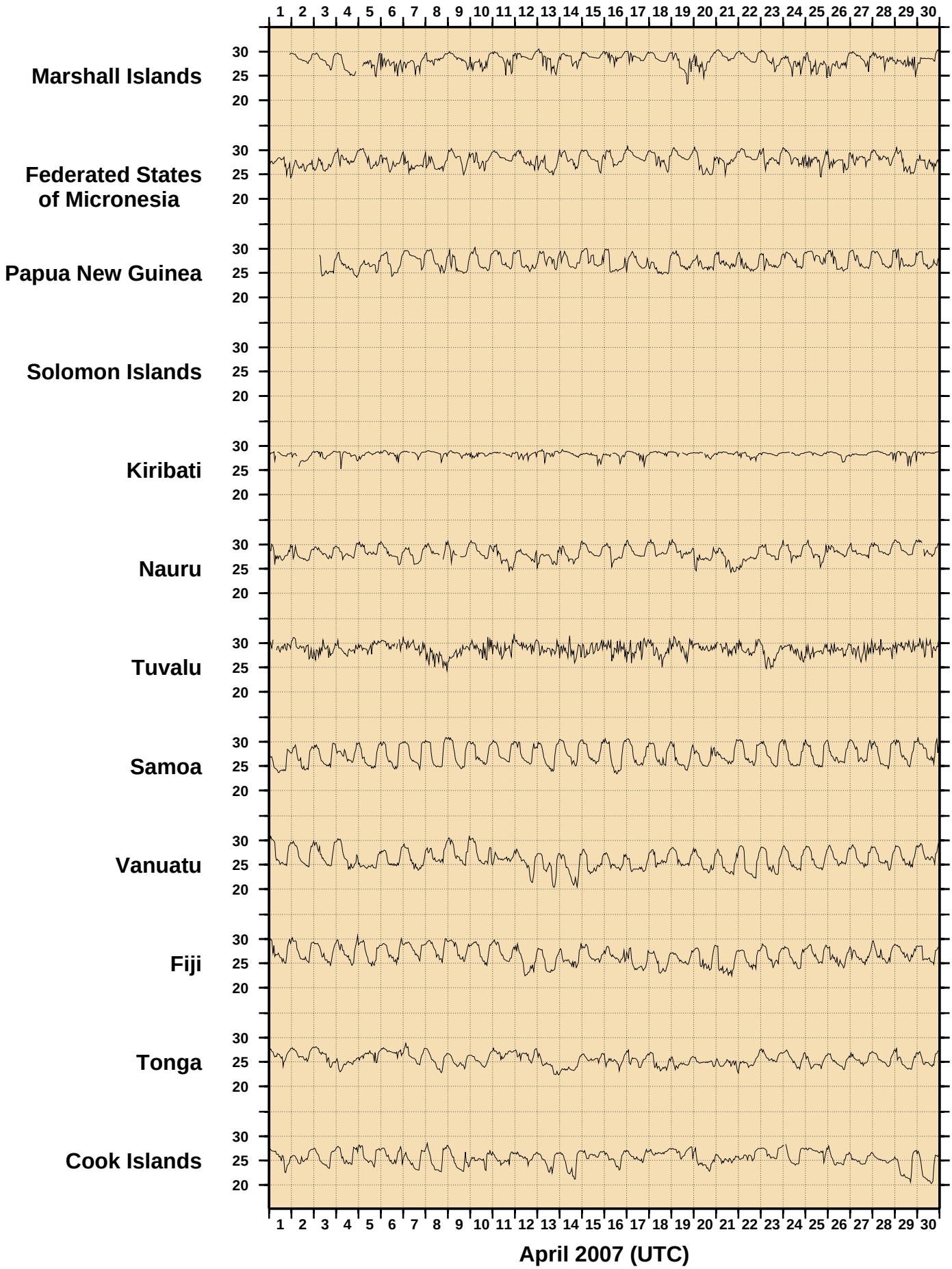


Figure 8

APRIL 2007
HOURLY WATER TEMPERATURES (˚C)

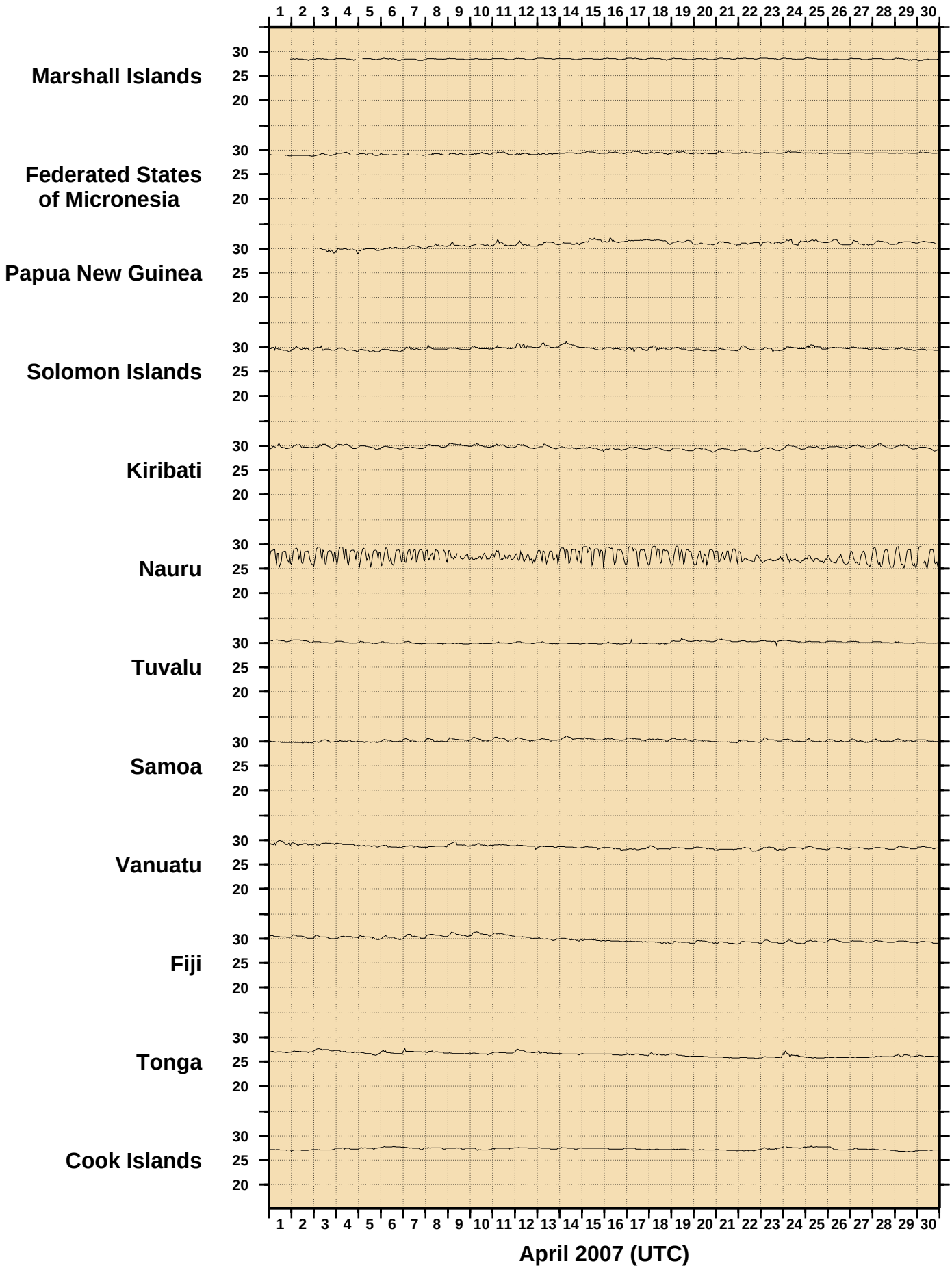


Figure 9

APRIL 2007
HOURLY ATMOSPHERIC PRESSURE (hPa)

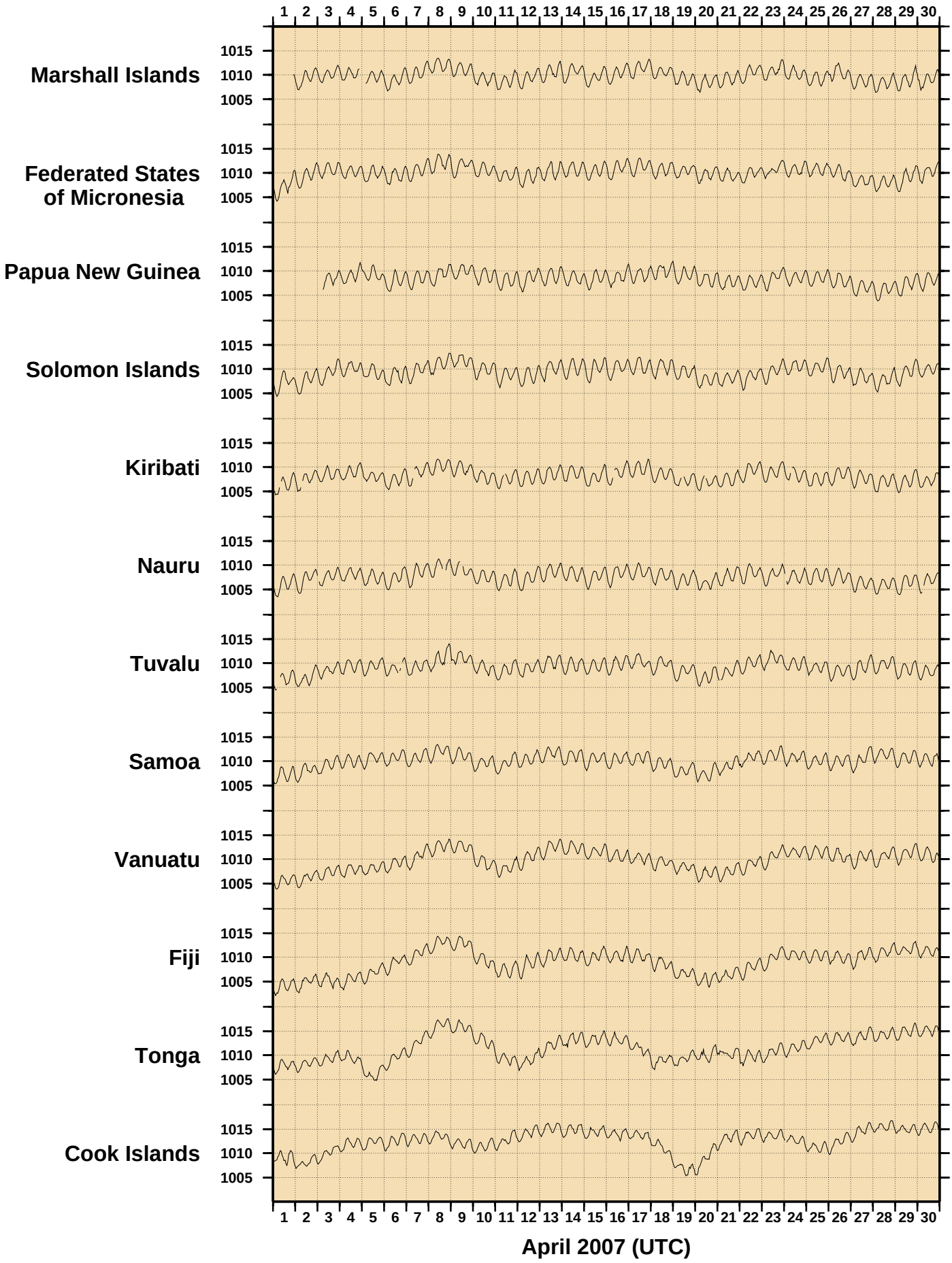
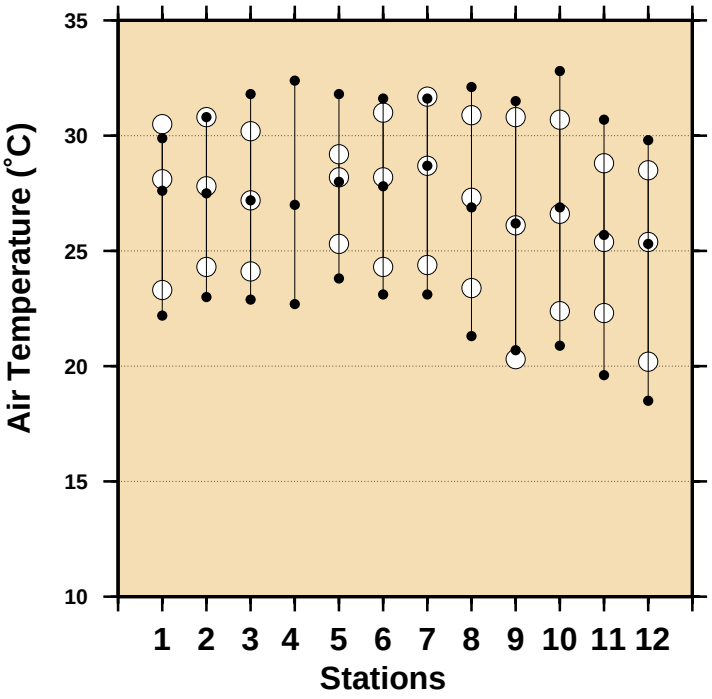
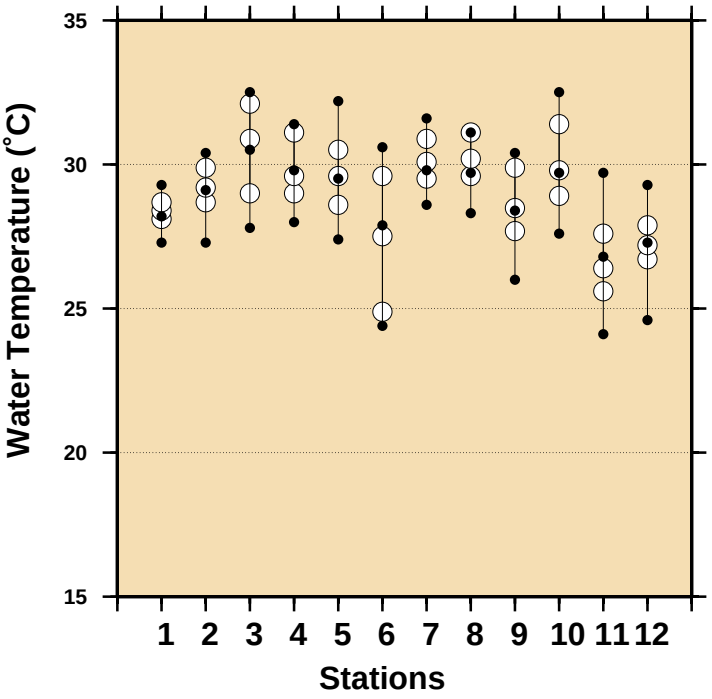
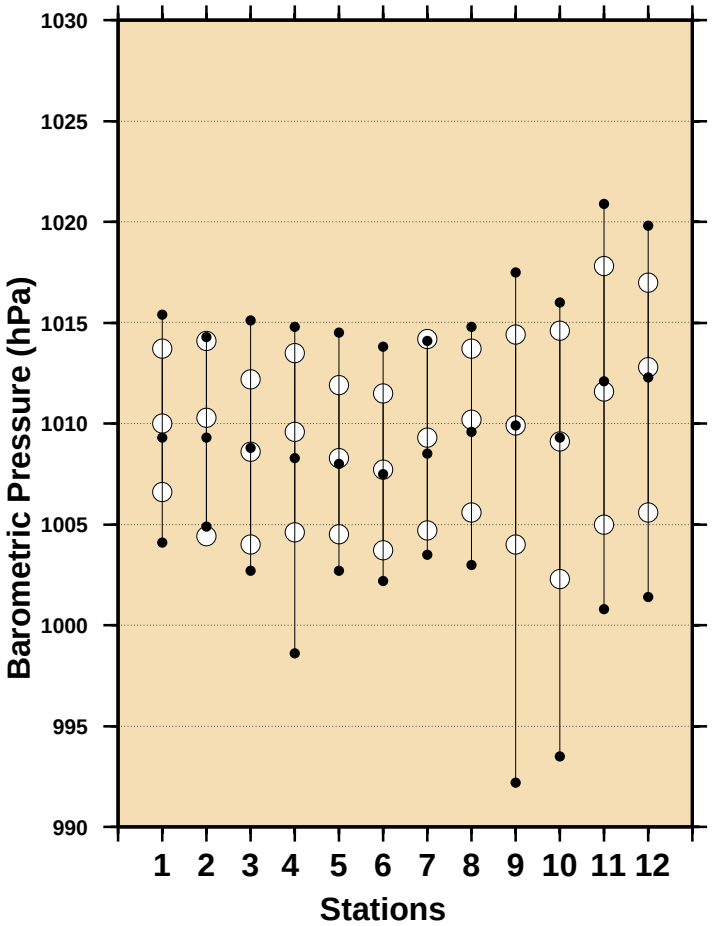


Figure 10

Comparison of April 2007 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 2007 Maximum
April 2007 Mean
April 2007 Minimum
Long Term April Maximum
Long Term April Mean
Long Term April Minimum

Figure 11

MONTHLY MEAN SEA LEVELS TO APRIL 2007 (m)

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

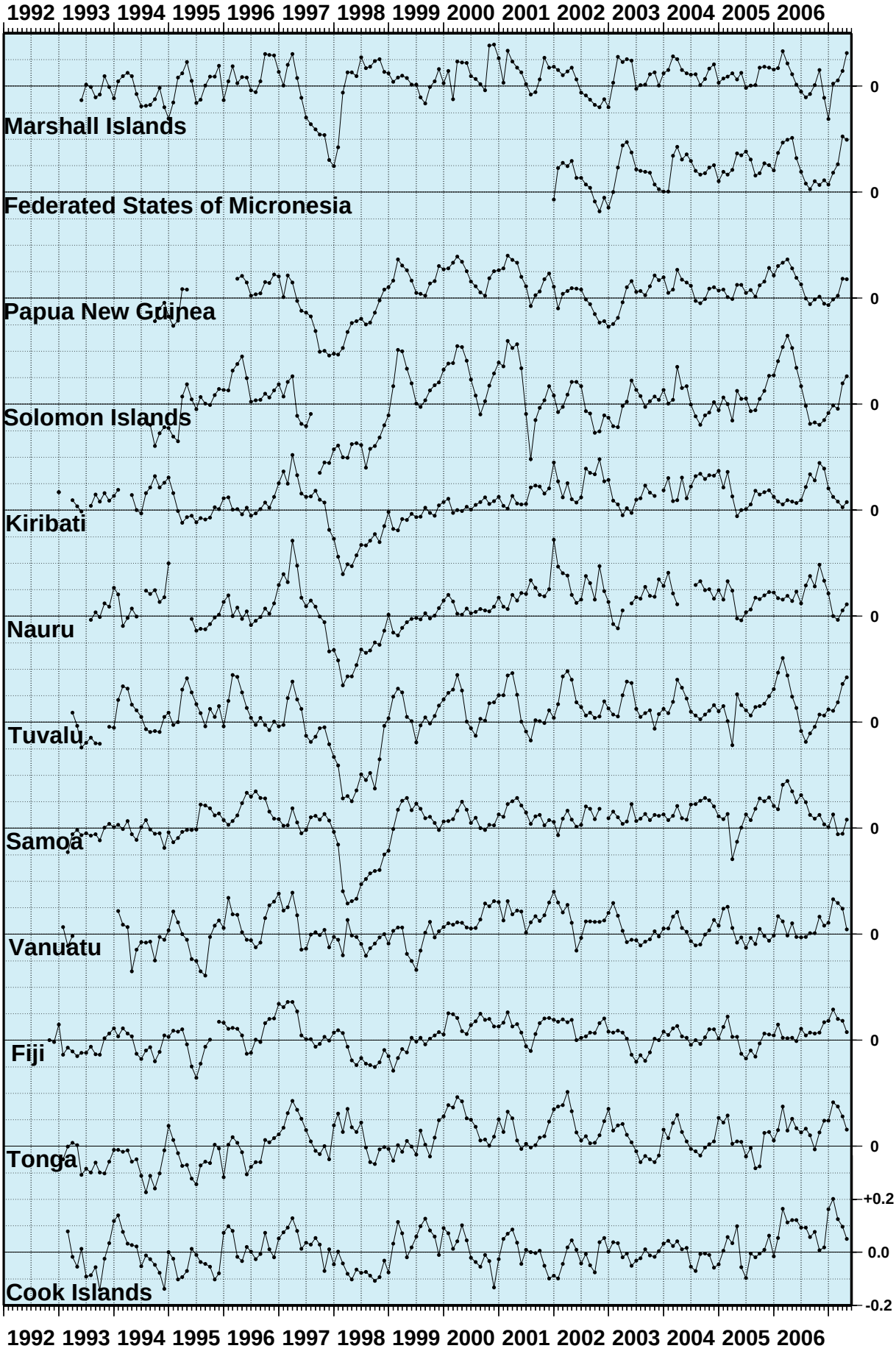


Figure 12

SEA LEVEL ANOMALIES THROUGH APRIL 2007 (m)

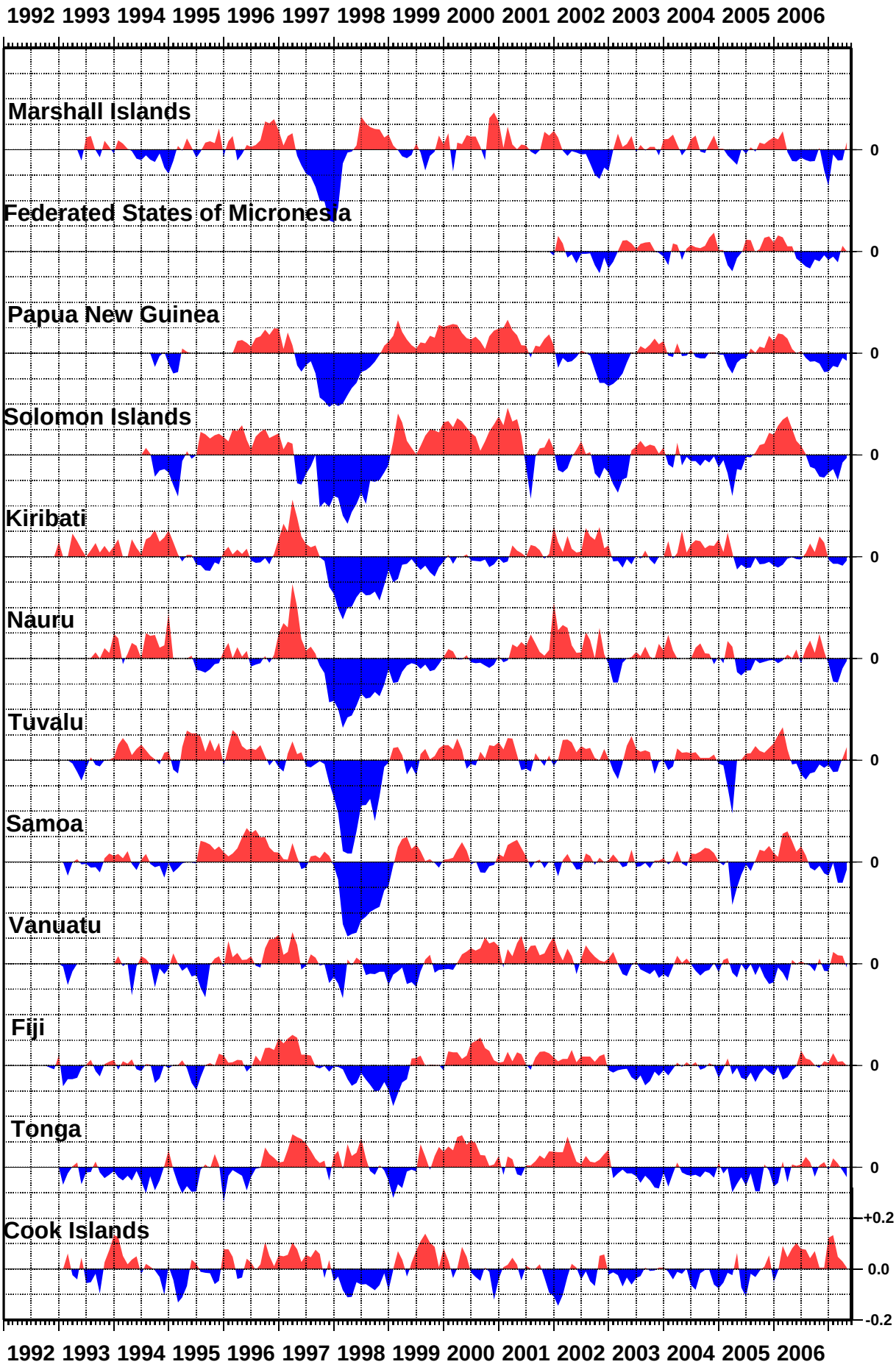


Figure 13

SEA LEVEL TRENDS THROUGH APRIL 2007 (mm/year)

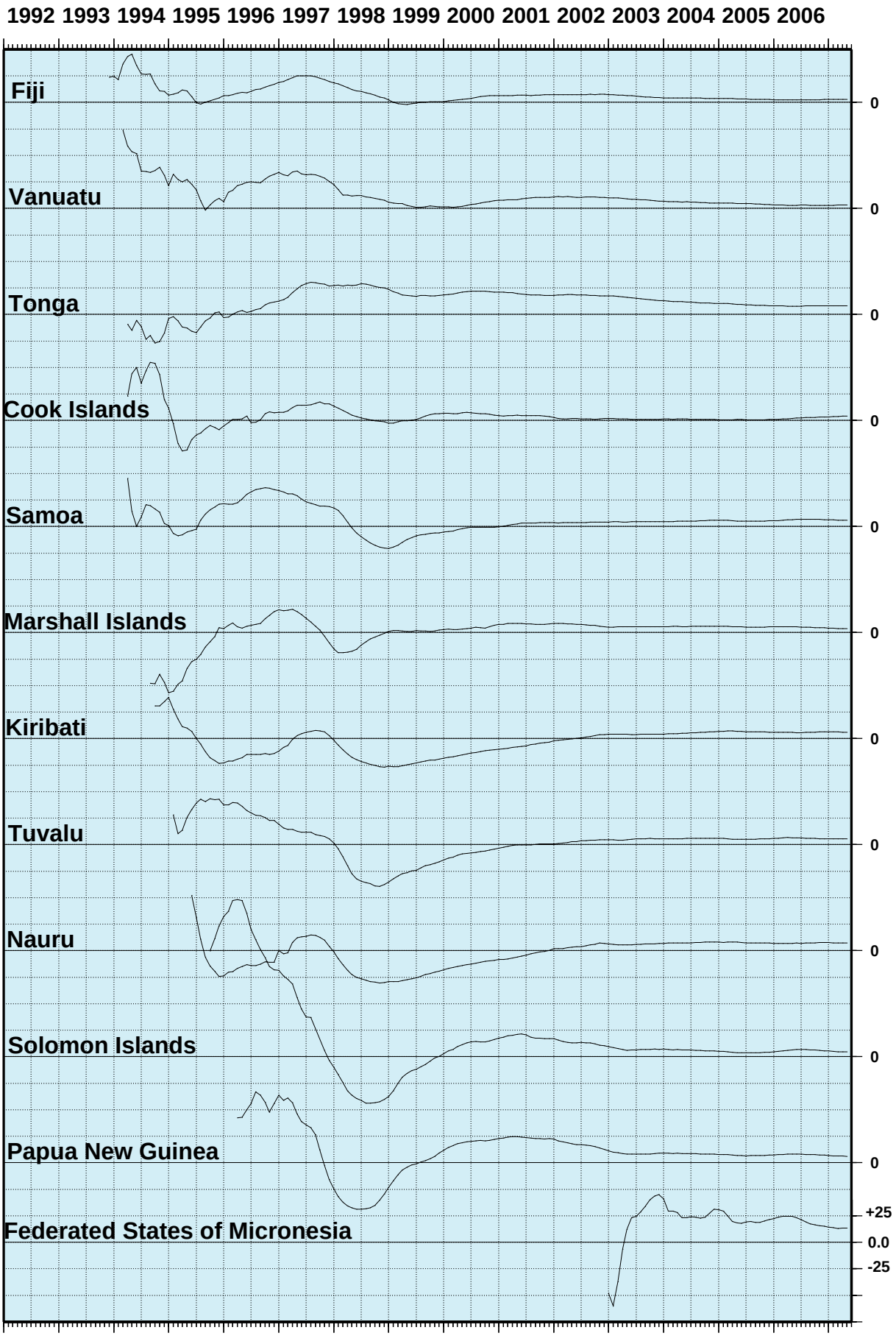


Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH APRIL 2007 (hPa)

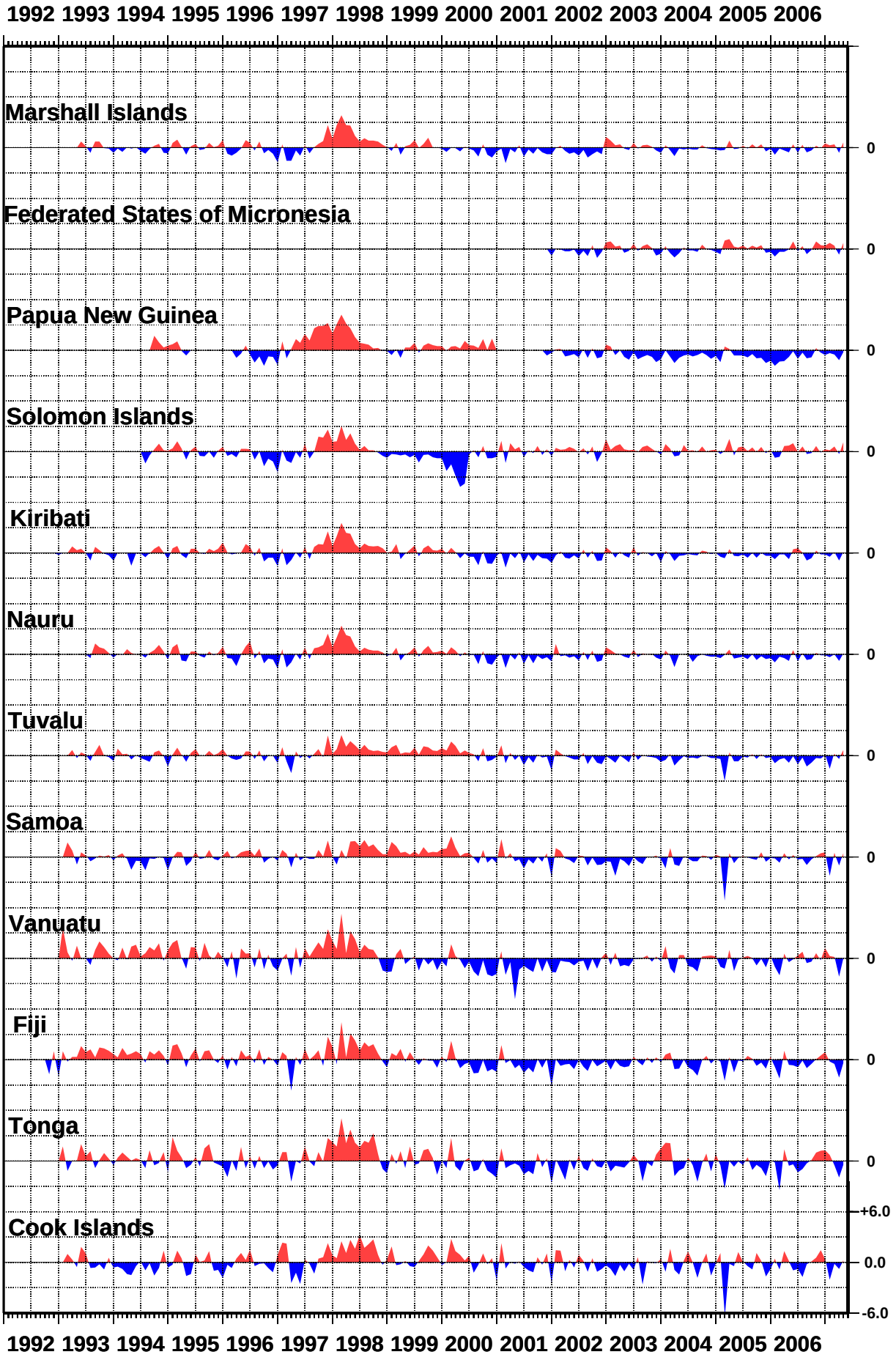


Figure 15

WATER TEMPERATURE ANOMALIES THROUGH APRIL 2007 (°C)

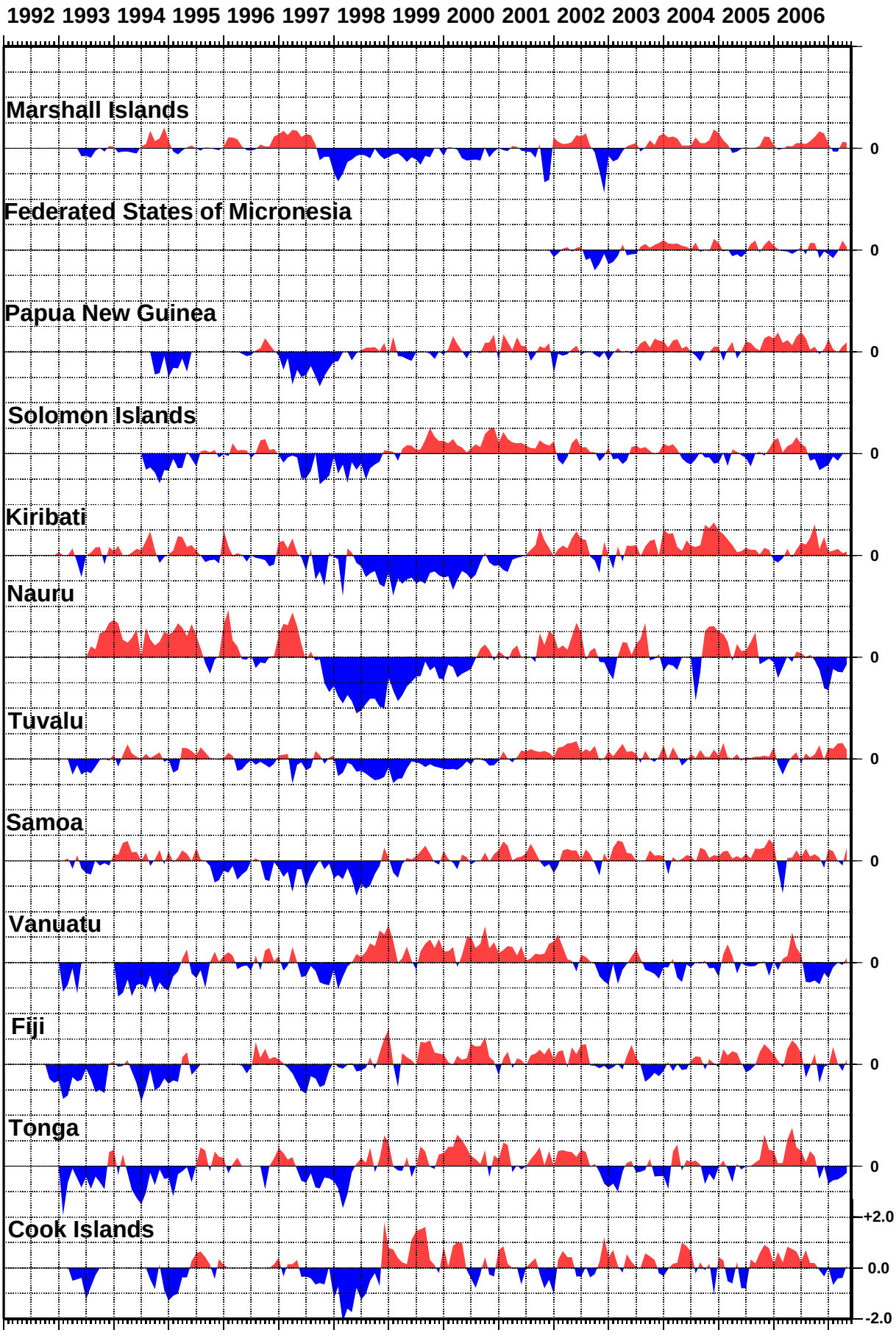


Figure 16

AIR TEMPERATURE ANOMALIES THROUGH APRIL 2007 (°C)

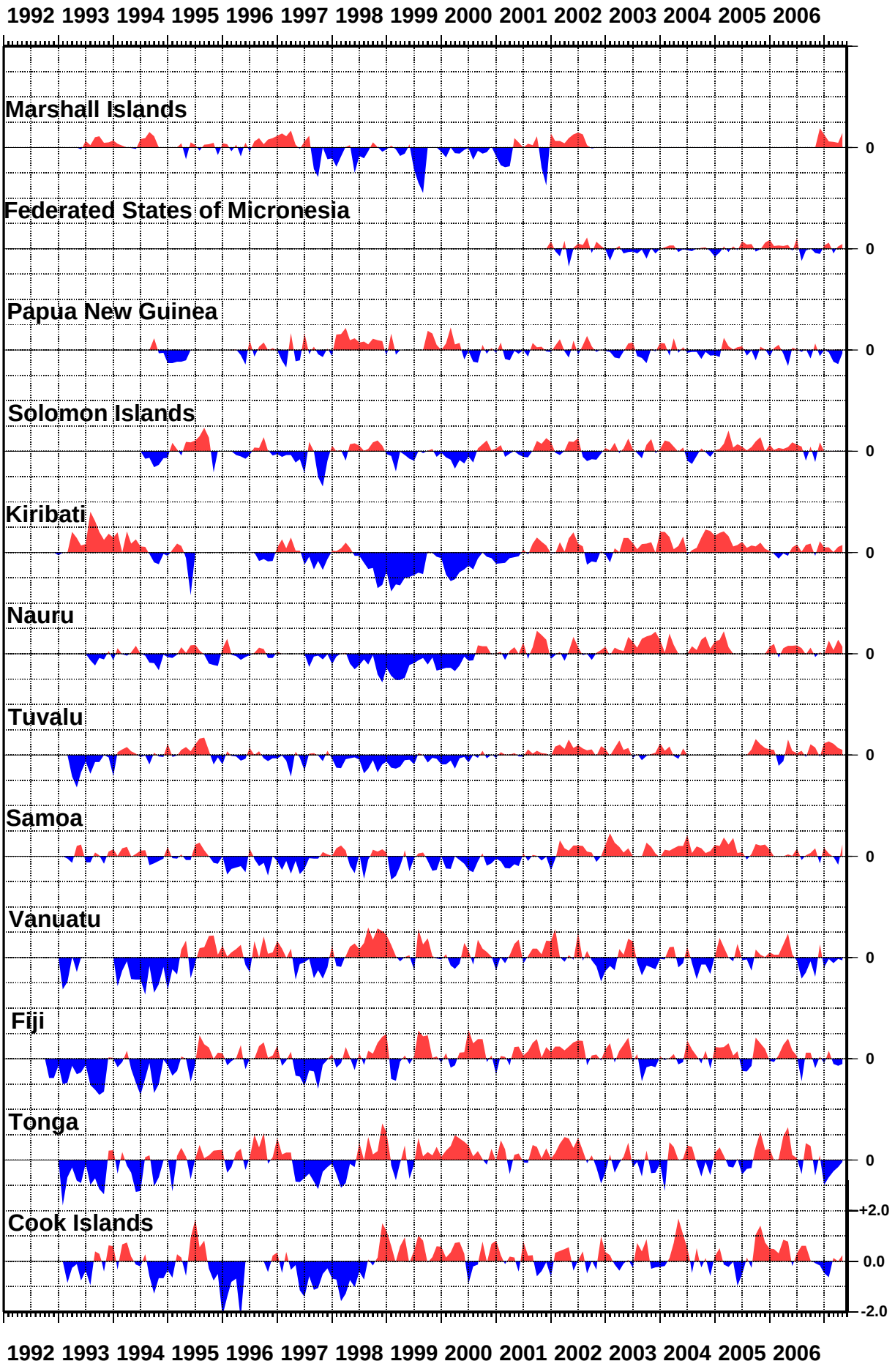


Figure 17

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED

GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE

* Patchy record