THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 140

FEBRUARY 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

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 February 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

February 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.

February 2007

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

- Monthly mean sea levels remain slightly lower than normal at the majority of SEAFRAME stations due partially to the lingering effects of the recent El Niño. The lowest sea levels were recorded at Solomon Islands and Nauru where they were on average around 10cm below normal.

- The 2006/07 El Niño has officially ended with equatorial Pacific climate indicators falling below El Niño thresholds during February.

- Rapid cooling of equatorial Pacific Ocean temperatures both on and below the sea surface occurred through February. The sea surface temperature pattern is now indicative of neutral climate conditions, as are the strength of the Trade Winds and the degree of cloudiness in the central equatorial Pacific.

- A significant pool of cooler than normal subsurface water has developed across the eastern equatorial Pacific and is beginning to affect surface temperatures in that region.

- The majority of international climate models predict that cool neutral conditions will prevail in the Pacific over the coming months.

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 February, 2007

Location	Lat / Long	Installation Date	Trend (mm/yr)	Change from previous month
Cook Is	21°11'58"S / 159°47'10"W	Feb 1993	+4.0	+0.1
Tonga	21°08'25"S / 175°10'45"W	Jan 1993	+8.2	0.0
Fiji	17°36'19"S / 177°26'17"E	Oct 1992	+2.9	0.0
Vanuatu	17°45'41"S / 168°17'35"E	Jan 1993	+3.2	+0.1
Samoa	13°49'09"S / 171°45'21"W	Feb 1993	+6.2	-0.2
Tuvalu	08°30'10"S / 179°12'33"E	Mar 1993	+5.3	-0.1
Kiribati	01°21'45"N / 172°55'48"E	Dec 1992	+6.3	-0.1
Nauru	00°31'55"S / 166°54'33"E	Jul 1993	+7.3	-0.3
Solomon Is.	09°25'18"S / 159°57'19"E	Jul 1994	+4.9	-0.3
PNG	02°02'10"S / 147°22'31"E	Sep 1994	+6.4	-0.2
FSM	06°58'42"N / 158°11'50"E	Dec 2001	+13.0	-0.8
Marshall Is.	07°06'27"N / 171°22'15"E	May 1993	+3.9	-0.1

INTRODUCTION

Welcome to the February 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.

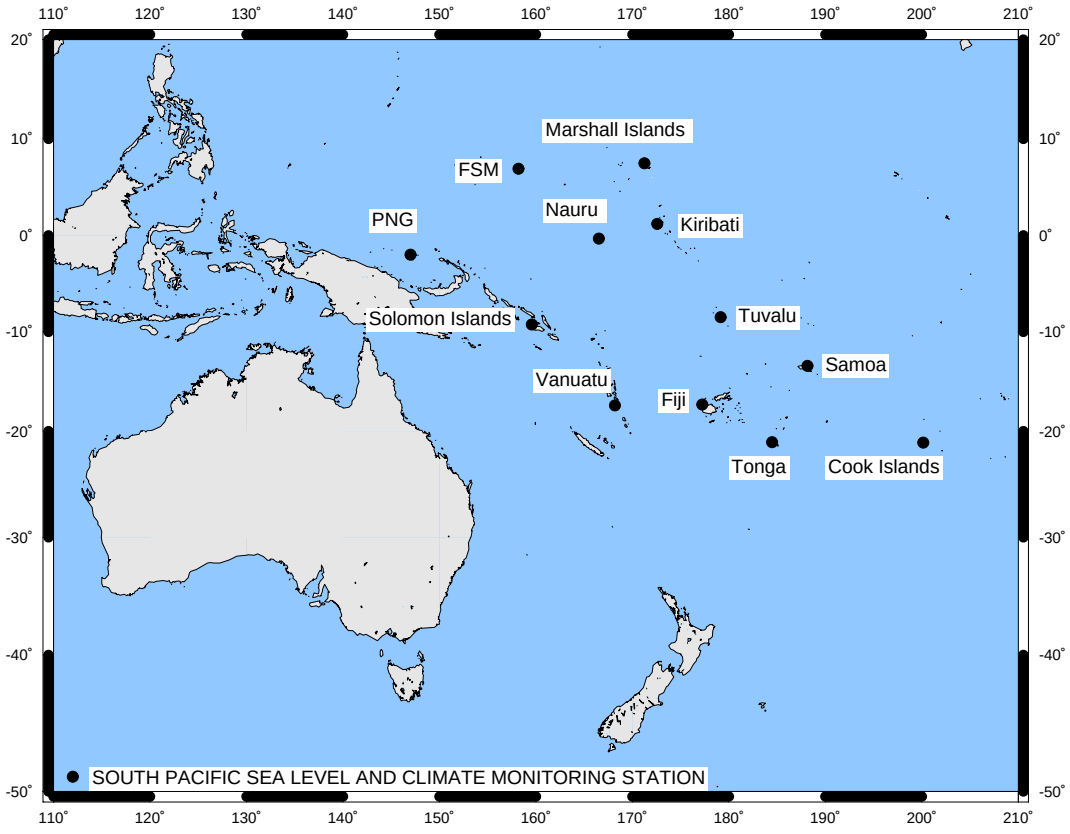


Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

FEBRUARY CLIMATOLOGY

The 2006/07 El Niño has ended and neutral climate conditions are now being observed across the Pacific. Ocean heat content in the equatorial region cooled rapidly during February and the Trade Winds were of near average to slightly above average strength. The consensus amongst international climate models is that cool neutral conditions will develop in the first half of 2007.

The Southern Oscillation Index (SOI) (**Figure B**) had a value of –3 for February, which is indicative of near-neutral atmospheric circulation across the equatorial Pacific. Sea surface temperatures continued to cool along the equatorial Pacific during February. Some residual warmth still exists in the western equatorial Pacific but it is now below El Niño thresholds (**Figure C**).

Substantial cooling of subsurface waters also continued across the equatorial Pacific during February (**Figure D**). Cooler than normal subsurface temperatures are now well established in the eastern Pacific and are beginning to affect surface temperatures in that region. A continuation of this trend could result in the development of basin-wide La Niña conditions across the Pacific.

During El Niño (warm-episode) conditions there is a sustained weakening of the Trade Winds across much of the equatorial Pacific and an increase in cloudiness near the dateline. During La Niña (cold-episode) conditions there is a reversal of this situation, with stronger Trade Winds and decreased cloudiness in the central Pacific. The TAO/TRITON array of moored buoys revealed Trade Winds across the equatorial Pacific were slightly stronger than average in the central equatorial Pacific during February (**Figure E**). Near-average cloudiness was observed in the central equatorial Pacific during February.

The general consensus from twelve international computer models is that warm conditions will continue to decline and cool neutral climate conditions will develop in the coming months.

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/.

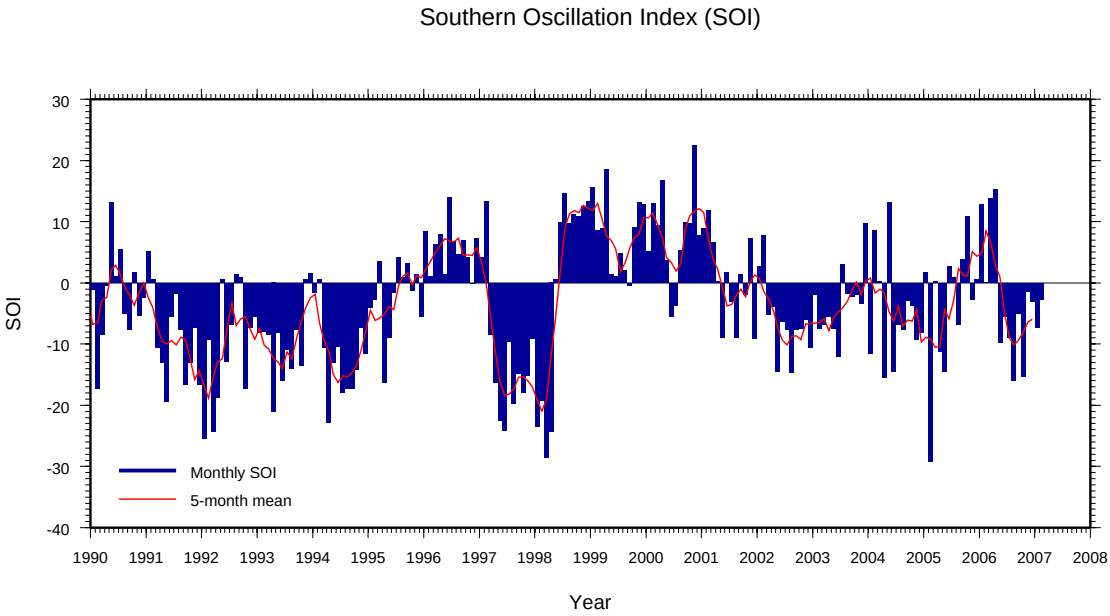


Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the standard deviation of that difference for the relevant month, based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

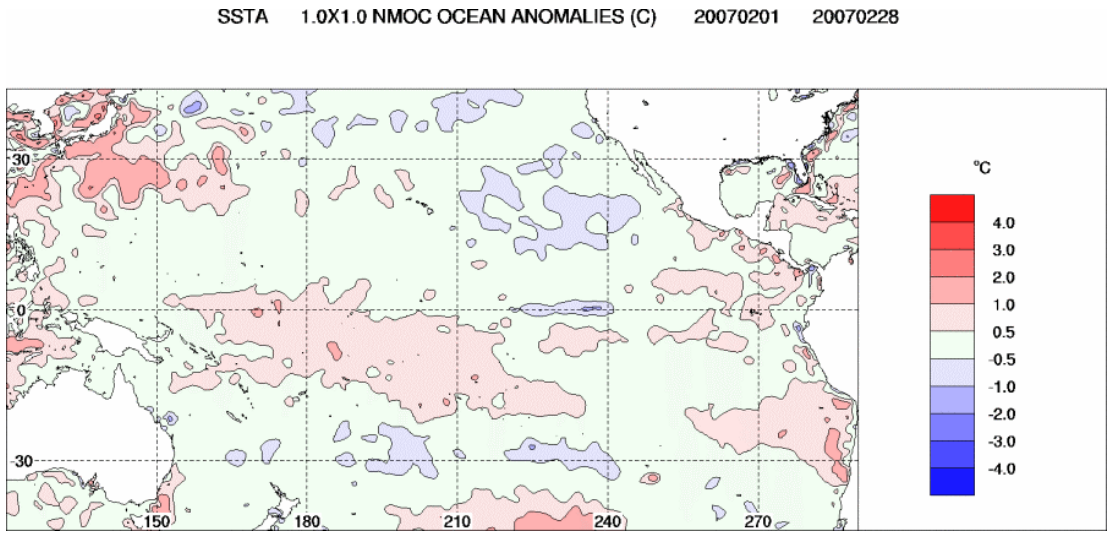


Figure C: *Sea surface temperature anomaly (°C) for February 2007.*

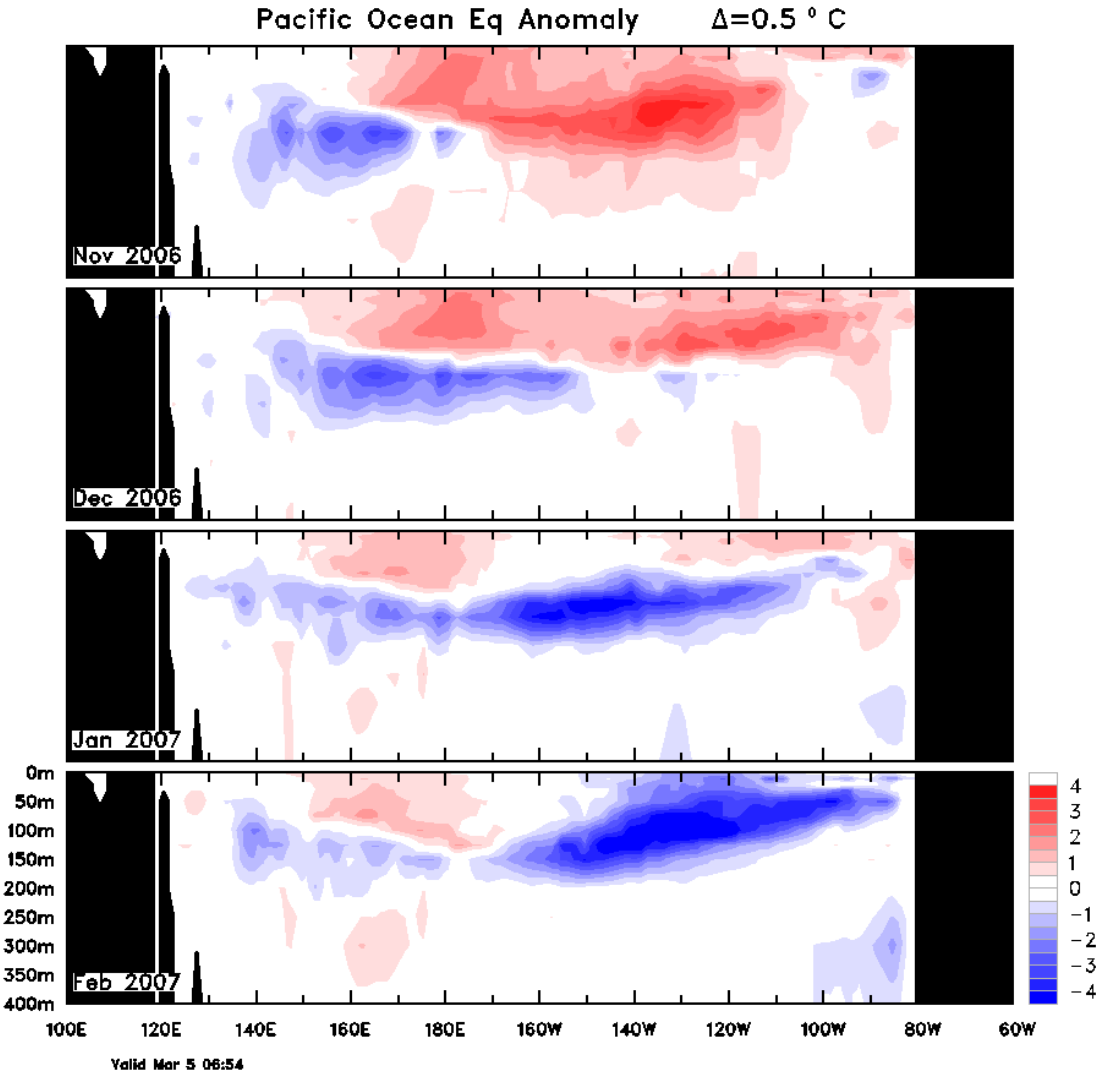


Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for November 2006 through to February 2007. Contour interval is 0.5°C.*

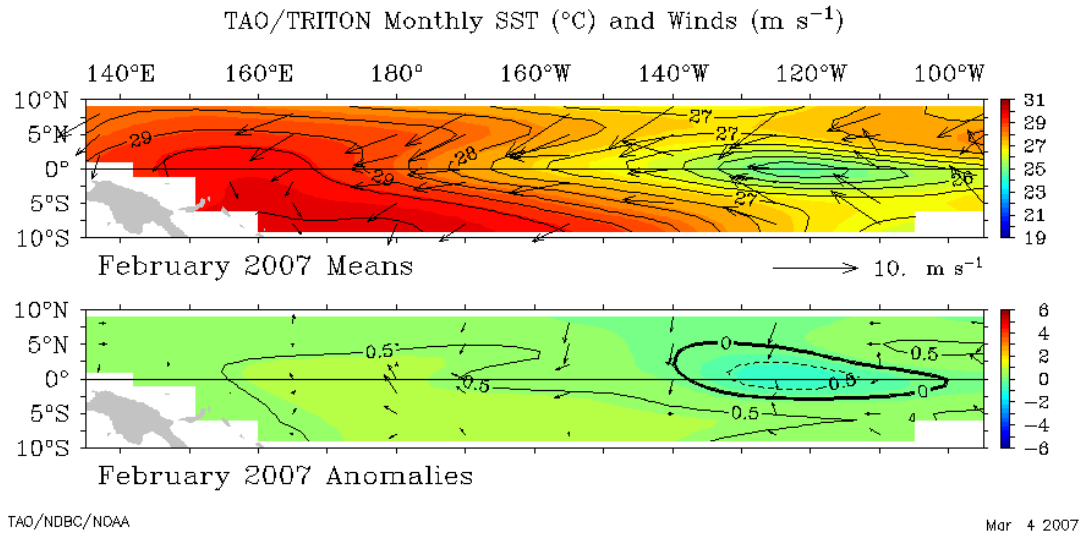


Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for February 2007. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

FEBRUARY 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 February and a new moon on the 17th of February. For sites just east of the dateline, the official dates of full and new moon are normally one day ahead.

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. The residuals are also influenced by the shape of the harbour in which the gauge is located. The sloshing of the sea backward and forward within a harbour is called a seiche. Papua New Guinea (Manus Island), for example, often experiences a seiche within Seeadler Harbour when the wind suddenly changes strength or direction. Residual sea level fluctuations are also often observed at the site of the FSM gauge.

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). Such an effect occurred at Tonga on the 4th of February when a small rise in sea level (Figure 2) occurred with the passage of a low-pressure system (Figure 9).

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 18 m/s (35 knots) were observed at Tuvalu on 23rd of February**.** Strong winds were observed at Tonga on the 4th and 5th of February in association with the low-pressure system. No wind data was collected at Solomon Islands because the wind mast and wind sensor remain 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 3hPa 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. A deep low-pressure system developed near Fiji and passed near Tonga on the 4th of February. Weather-related barometric pressure fluctuations tend to be smallest at equatorial stations and increase with distance away from the equator (eg. at 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 is of less significance because of the short record (since December 2001). Figure 10 shows that new February maximum air temperatures were recorded at Marshall Islands and Tuvalu and a new February minimum air temperature was recorded at FSM. No new February water temperature extremes were recorded. A new February maximum barometric pressure was recorded at FSM and a new February minimum barometric pressure was recorded at PNG.

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.

In February 2007 lower than normal sea levels continue to be observed at 8 of the 12 sea level stations in association with the lingering effects of the 2006/07 El Niño. The lowest sea levels of around 10cm below normal were observed at Solomon Islands and Nauru. Higher than normal sea levels were observed at Vanuatu, Fiji, Tonga and Cook Islands, but the sea level anomalies at these locations have fallen in relation to January.

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 February, 2007

Location	Lat / Long	Installation Date	Trend (mm/yr)	Change from previous month
Cook Is	21°11'58"S / 159°47'10"W	Feb 1993	+4.0	+0.1
Tonga	21°08'25"S / 175°10'45"W	Jan 1993	+8.2	0.0
Fiji	17°36'19"S / 177°26'17"E	Oct 1992	+2.9	0.0
Vanuatu	17°45'41"S / 168°17'35"E	Jan 1993	+3.2	+0.1
Samoa	13°49'09"S / 171°45'21"W	Feb 1993	+6.2	-0.2
Tuvalu	08°30'10"S / 179°12'33"E	Mar 1993	+5.3	-0.1
Kiribati	01°21'45"N / 172°55'48"E	Dec 1992	+6.3	-0.1
Nauru	00°31'55"S / 166°54'33"E	Jul 1993	+7.3	-0.3
Solomon Is.	09°25'18"S / 159°57'19"E	Jul 1994	+4.9	-0.3
PNG	02°02'10"S / 147°22'31"E	Sep 1994	+6.4	-0.2
FSM	06°58'42"N / 158°11'50"E	Dec 2001	+13.0	-0.8
Marshall Is.	07°06'27"N / 171°22'15"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. Barometric pressures during February 2007 were as expected at this time of the year since no significant anomalies were observed.

The **water temperature anomalies (Figure 15)** during February 2007 reveal a mixture of above average and below average water temperatures at SEAFRAME stations with no clear regional trend. The largest anomalies were around –0.5 ˚C at Nauru, Tonga and Cook Islands and +0.5 ˚C at Tuvalu.

The **air temperature anomalies (Figure 16)** show near-average air temperatures were observed at most stations during February 2007, the most notable exceptions being Tonga where an anomaly of around –0.5 ˚C was observed and Tuvalu where the anomaly was +0.5 ˚C. 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.

Calibration and maintenance of the SEAFRAME stations at Fiji and Tuvalu was performed in February and resulted in some small gaps in the data. At Solomon Islands the air temperature sensor and anemometer (wind sensor) remain temporarily dismantled as the wharf continues to be refurbished. Dial-up communications problems were experienced at Nauru and some small data gaps may exist where data were unable to be recovered.

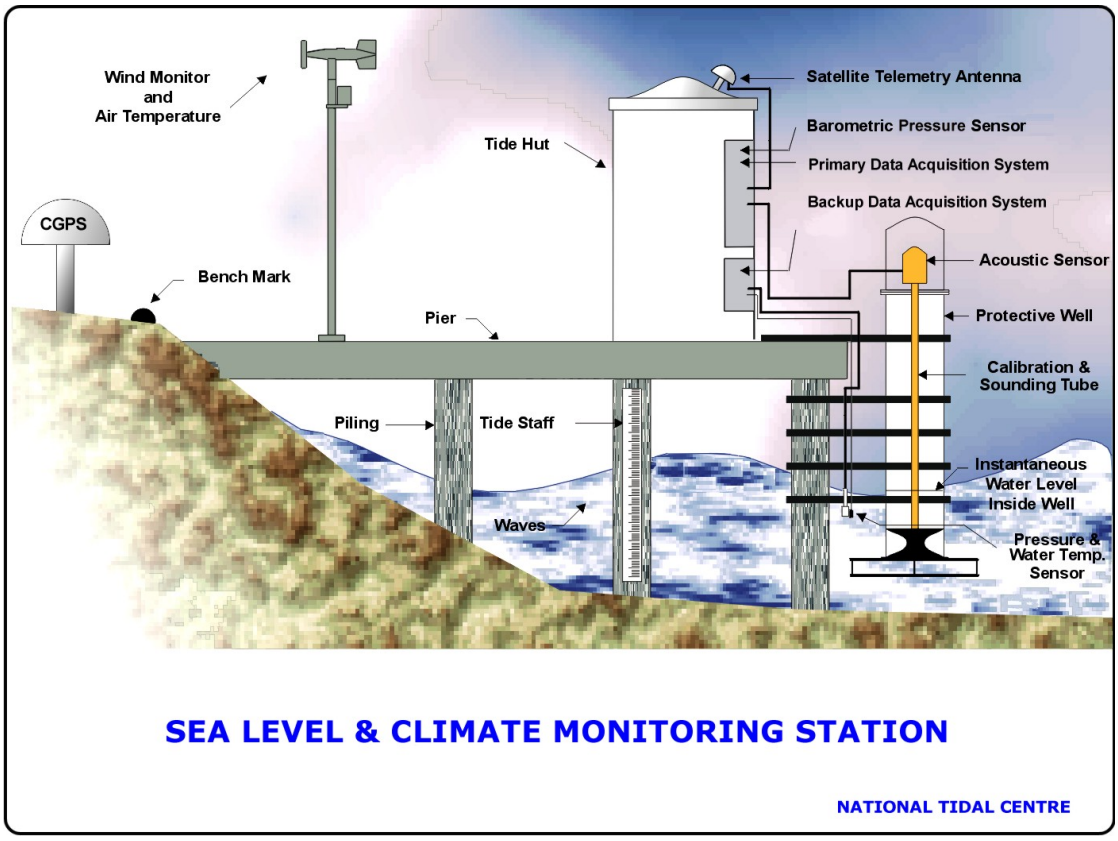
SEAFRAME STATIONS

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

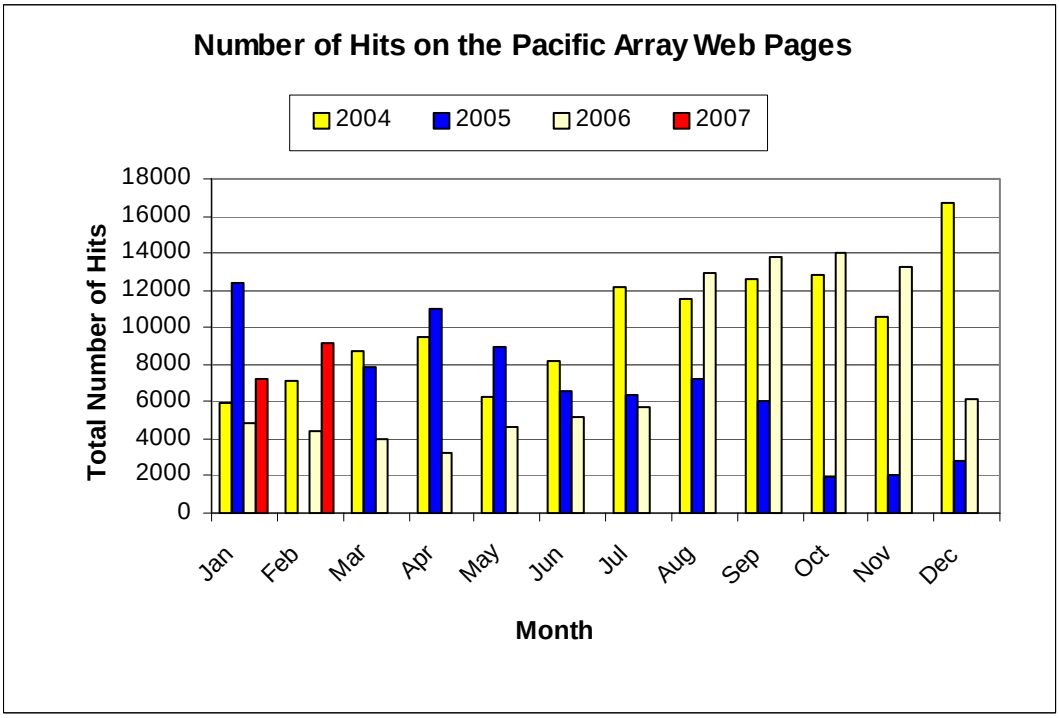
(2) Secondary water level (or backup) using a Druck pressure transducer mounted close to the seabed.

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 2003. 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

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

FEBRUARY 2007
SIX MINUTE WATER LEVEL OBSERVATIONS (m)

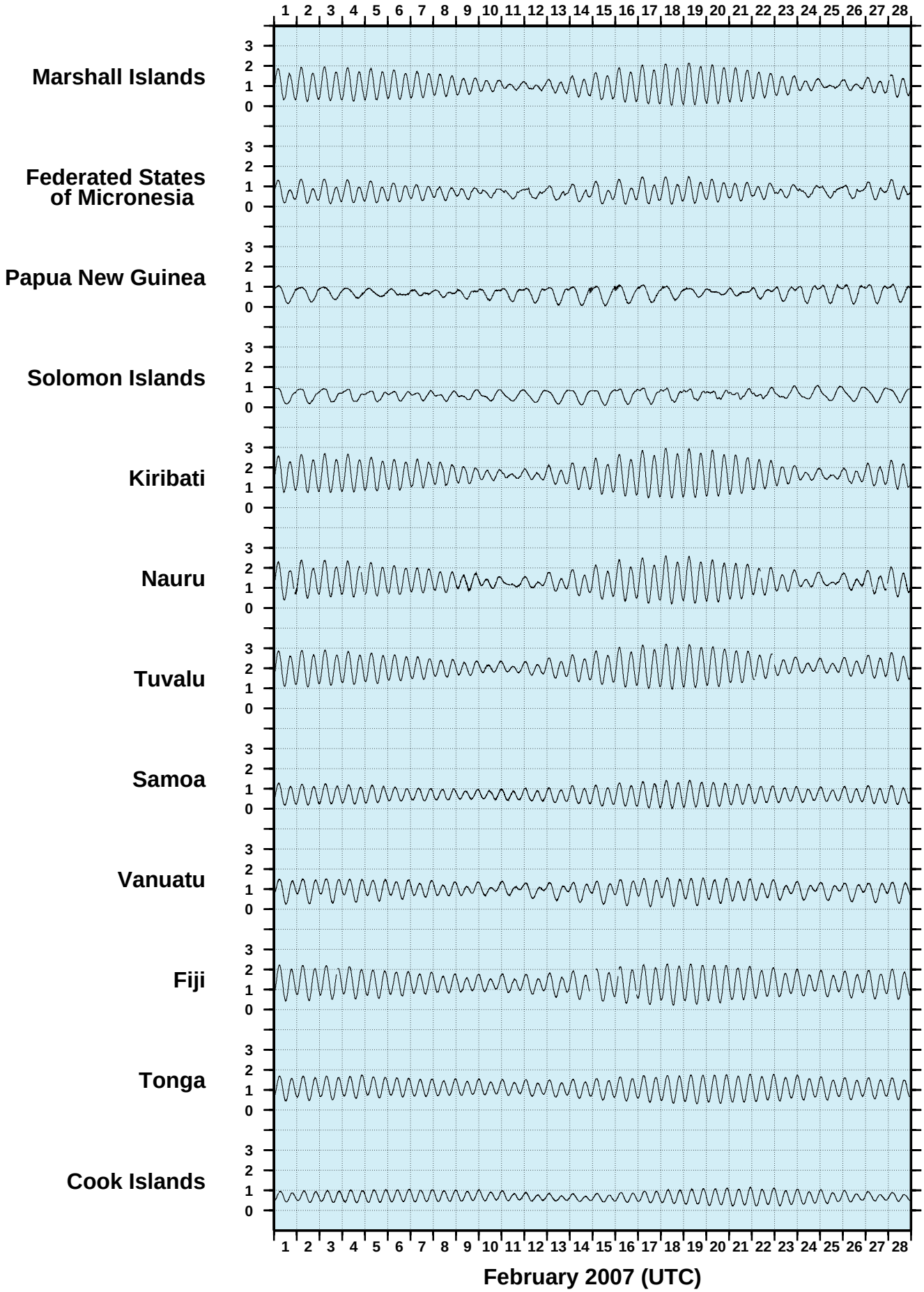


Figure 2

FEBRUARY 2007
SIX MINUTE RESIDUAL WATER LEVELS (m)

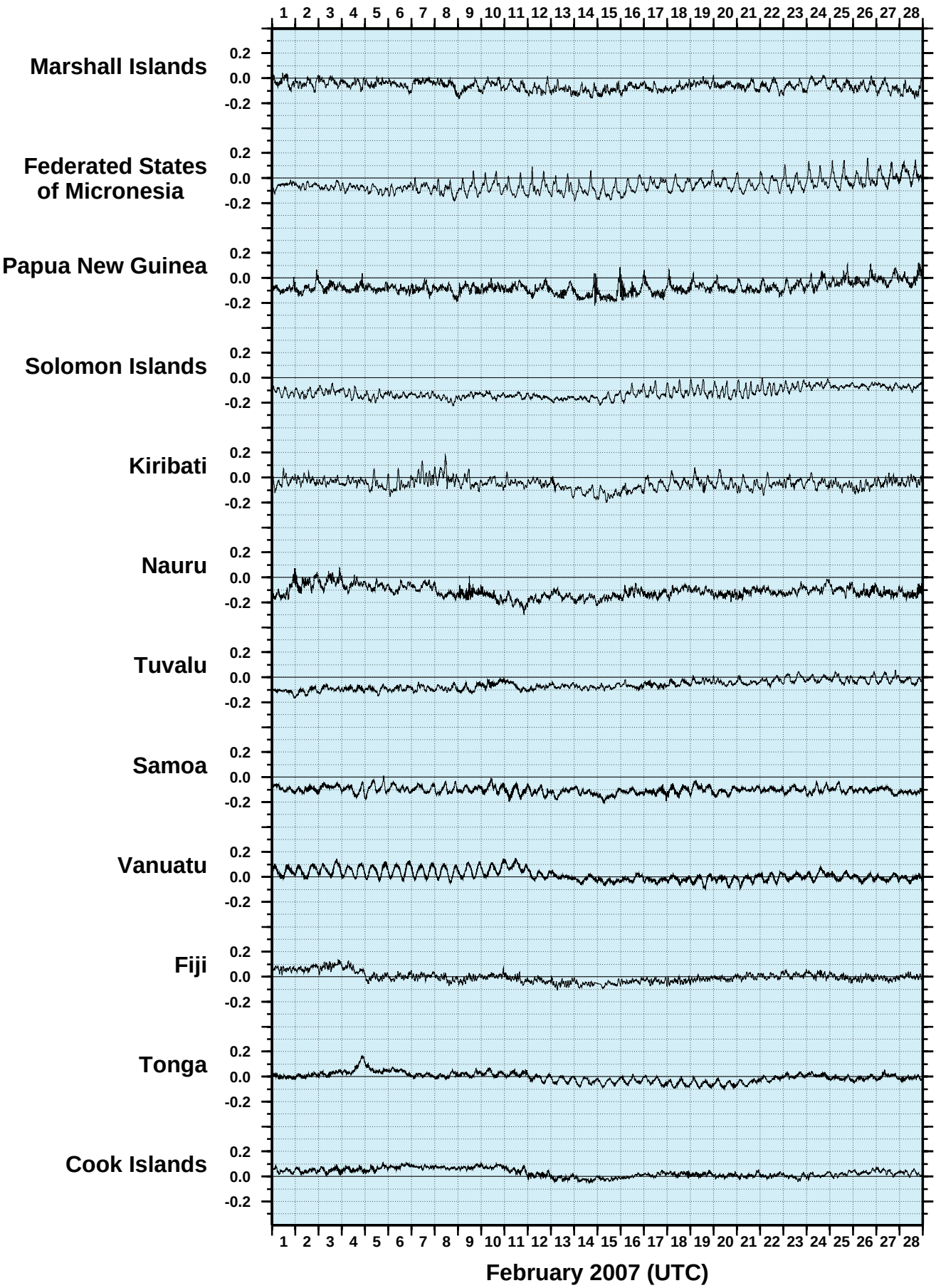


Figure 3

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

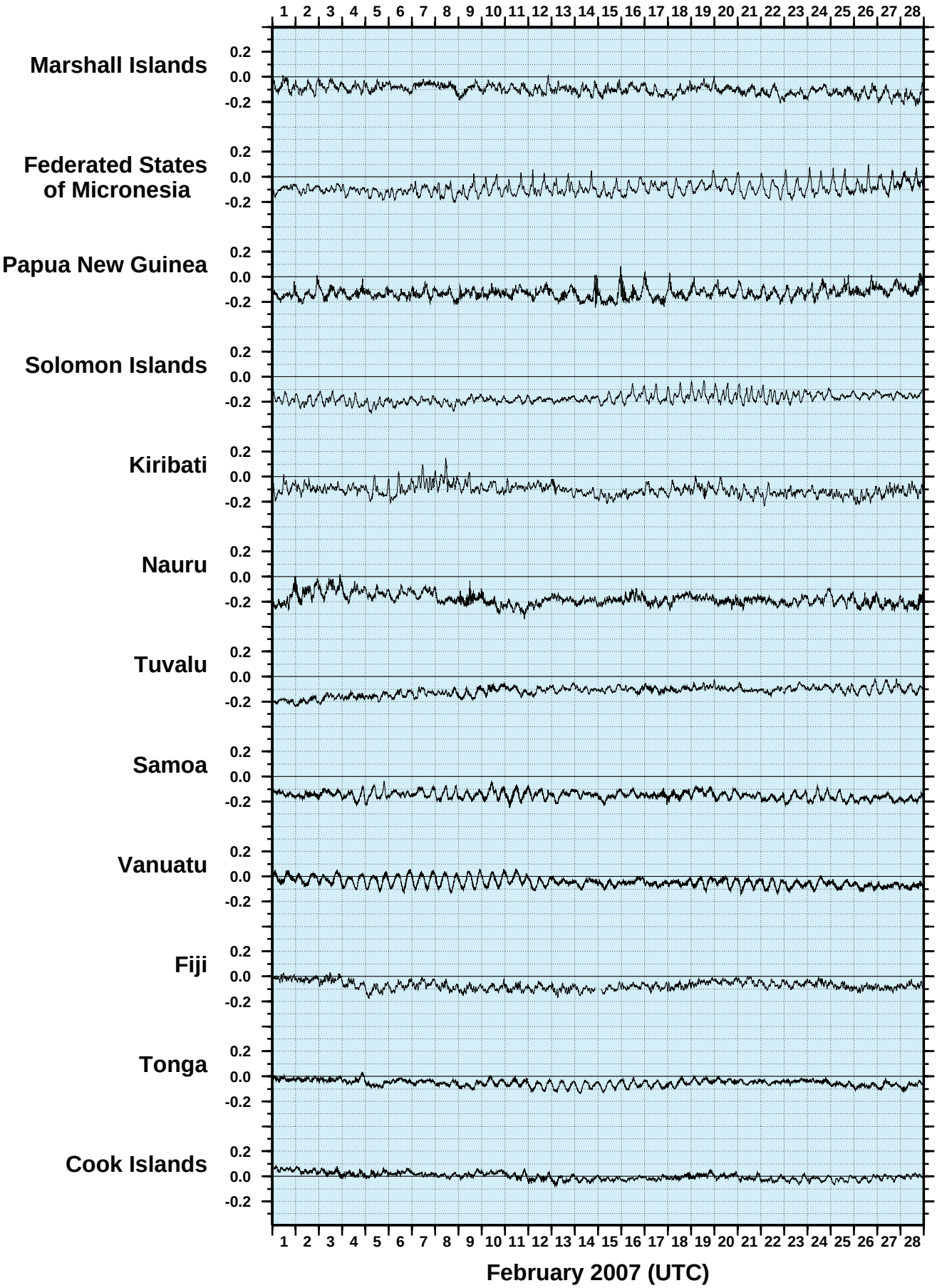


Figure 4

FEBRUARY 2007
HOURLY WIND SPEEDS (m/s)

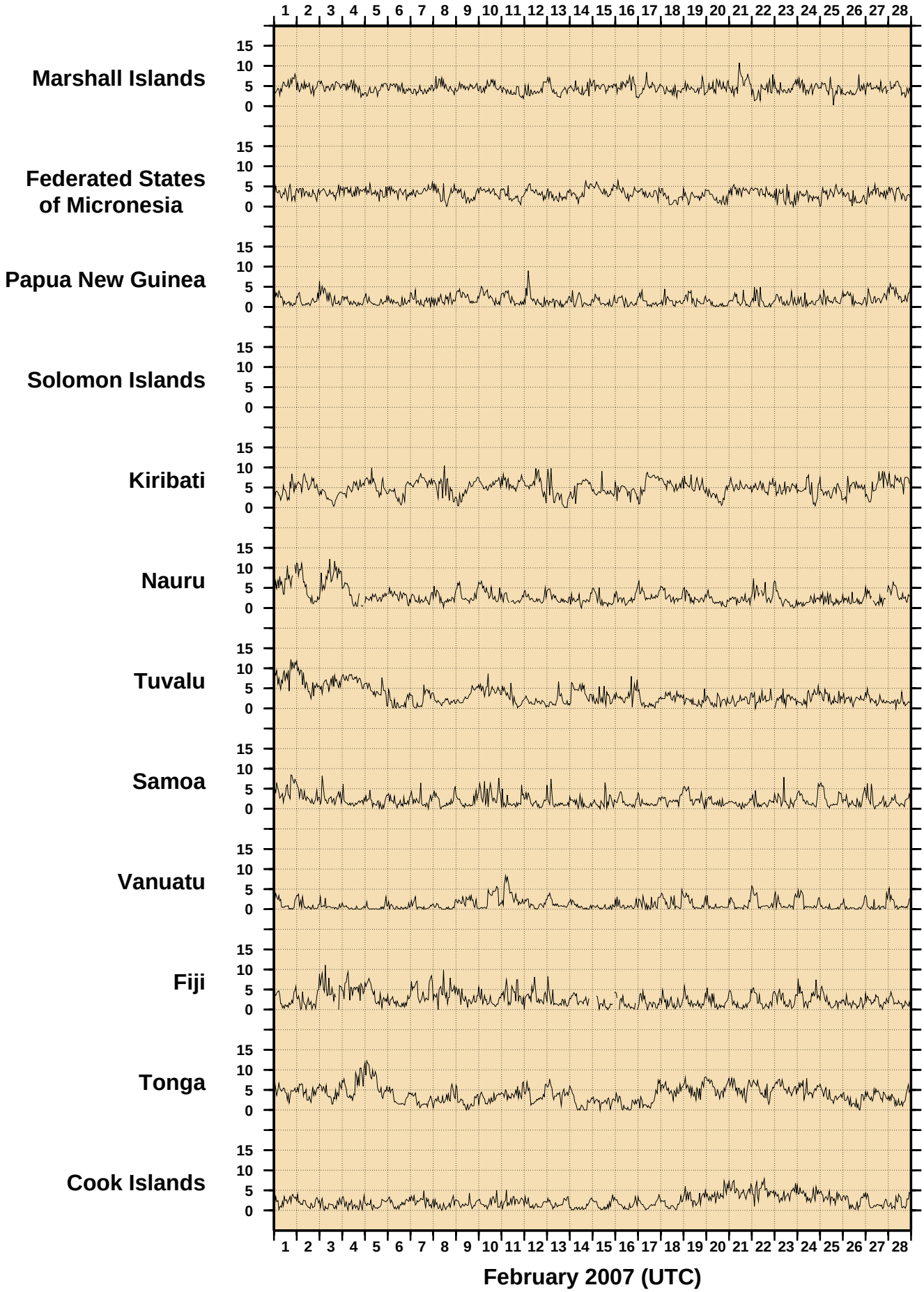


Figure 5

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

—— 10 m/s

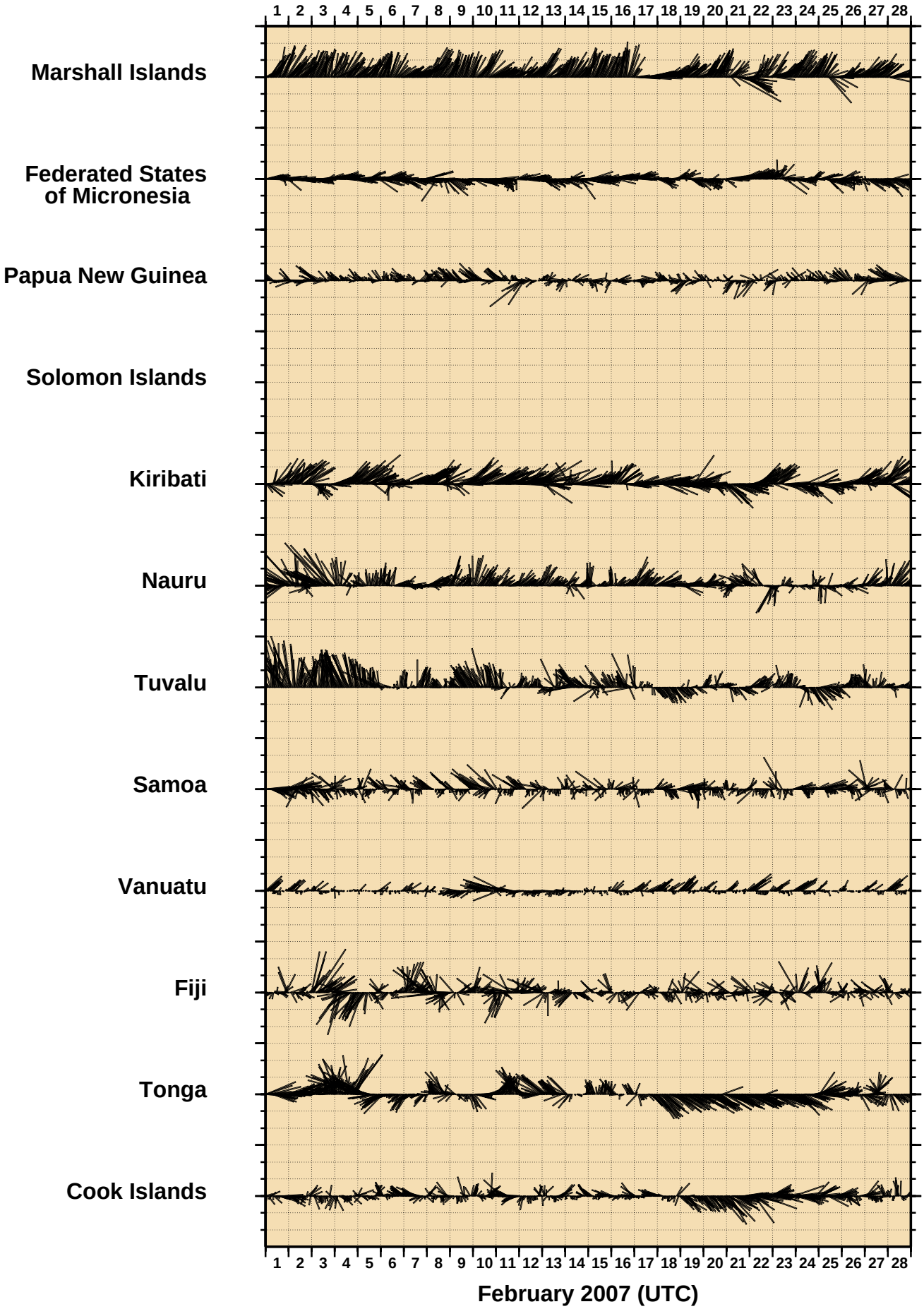


Figure 6

FEBRUARY 2007
HOURLY MAXIMUM WIND GUSTS (m/s)

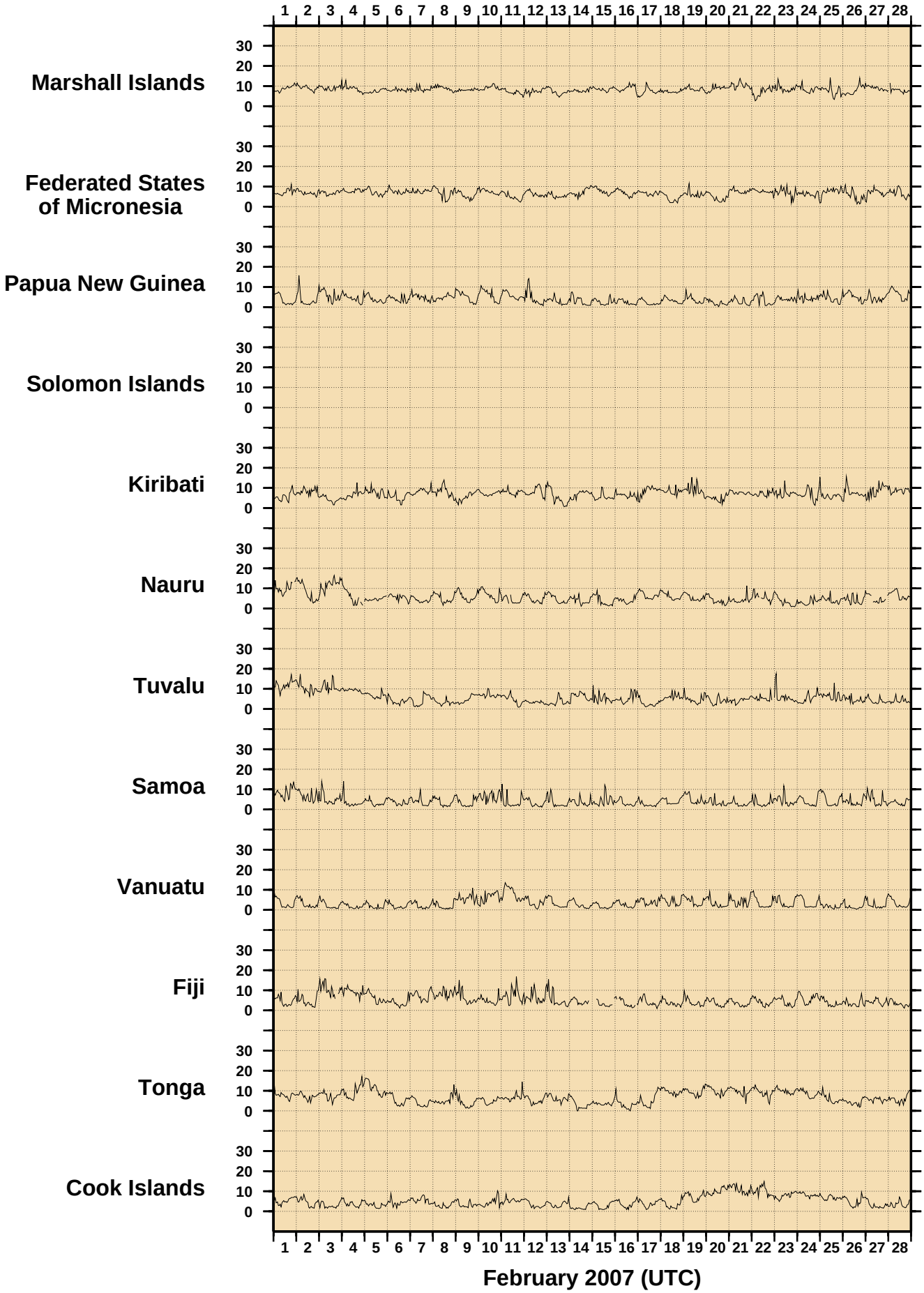


Figure 7

FEBRUARY 2007
HOURLY AIR TEMPERATURES (°C)

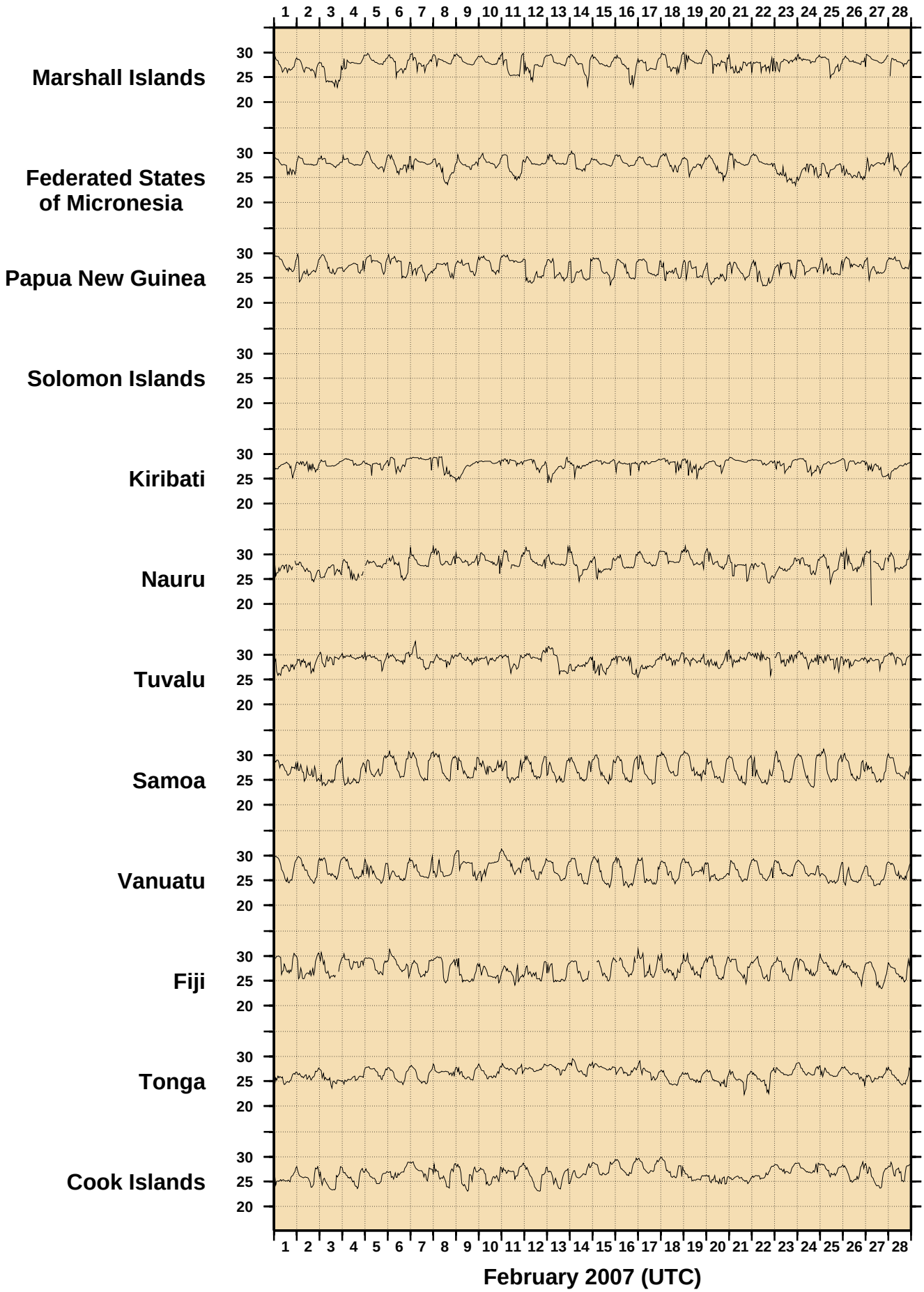


Figure 8

FEBRUARY 2007
HOURLY WATER TEMPERATURES (˚C)

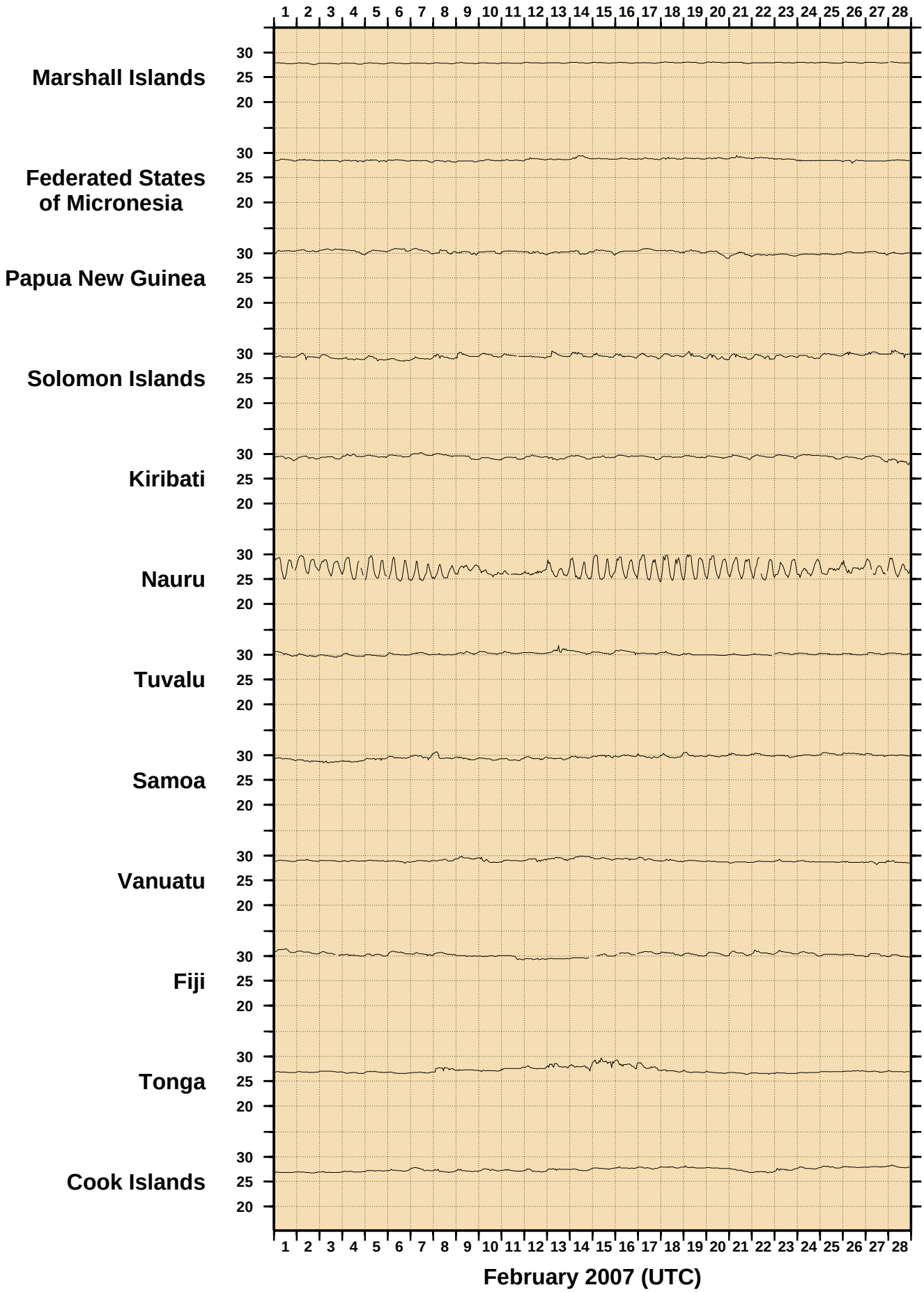


Figure 9

FEBRUARY 2007
HOURLY ATMOSPHERIC PRESSURE (hPa)

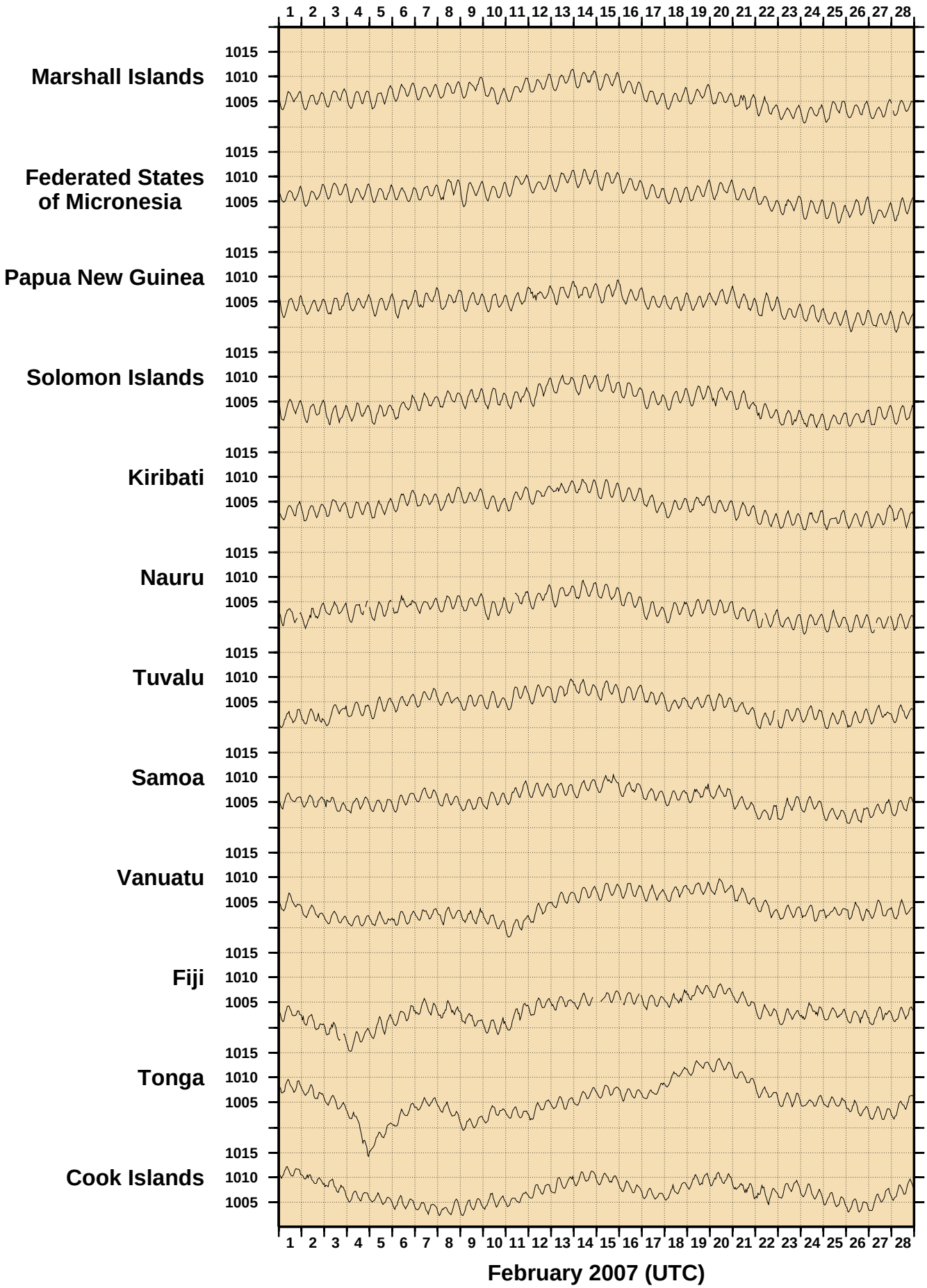
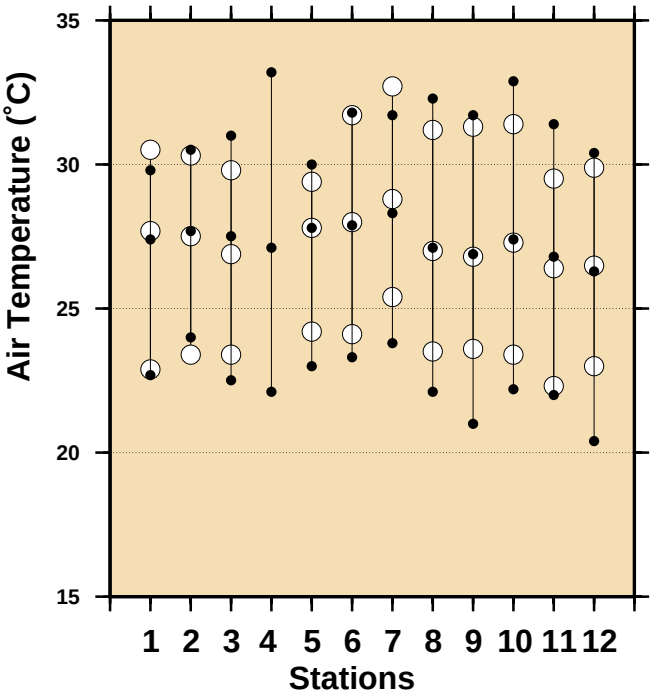
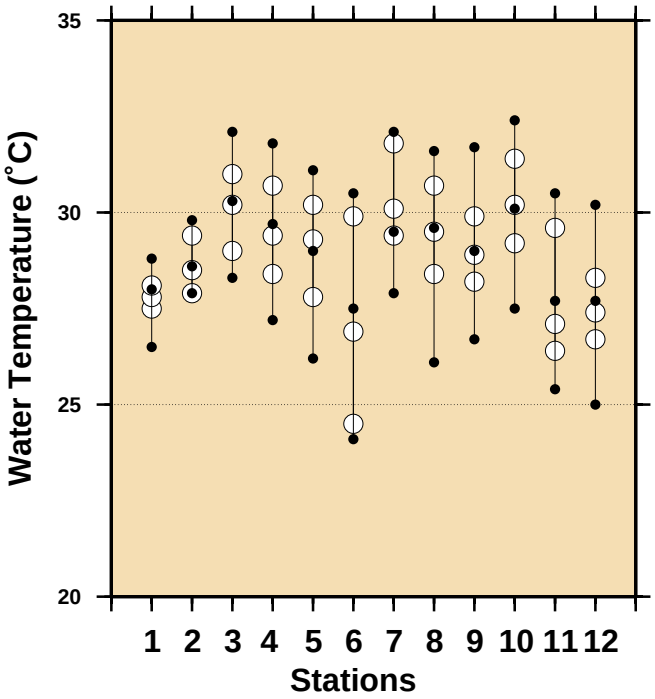
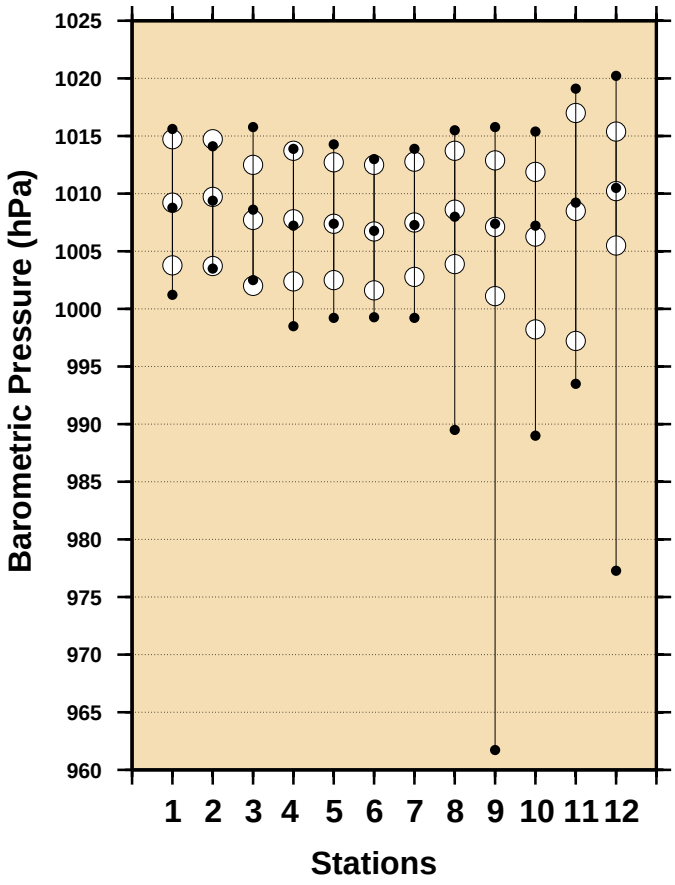


Figure 10

Comparison of February 2007 Max, Min & Mean with Long Term February 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

February 2007 Maximum
February 2007 Mean
February 2007 Minimum

Long Term February Maximum
Long Term February Mean
Long Term February Minimum

Figure 11

MONTHLY MEAN SEA LEVELS TO FEBRUARY 2007 (m)

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

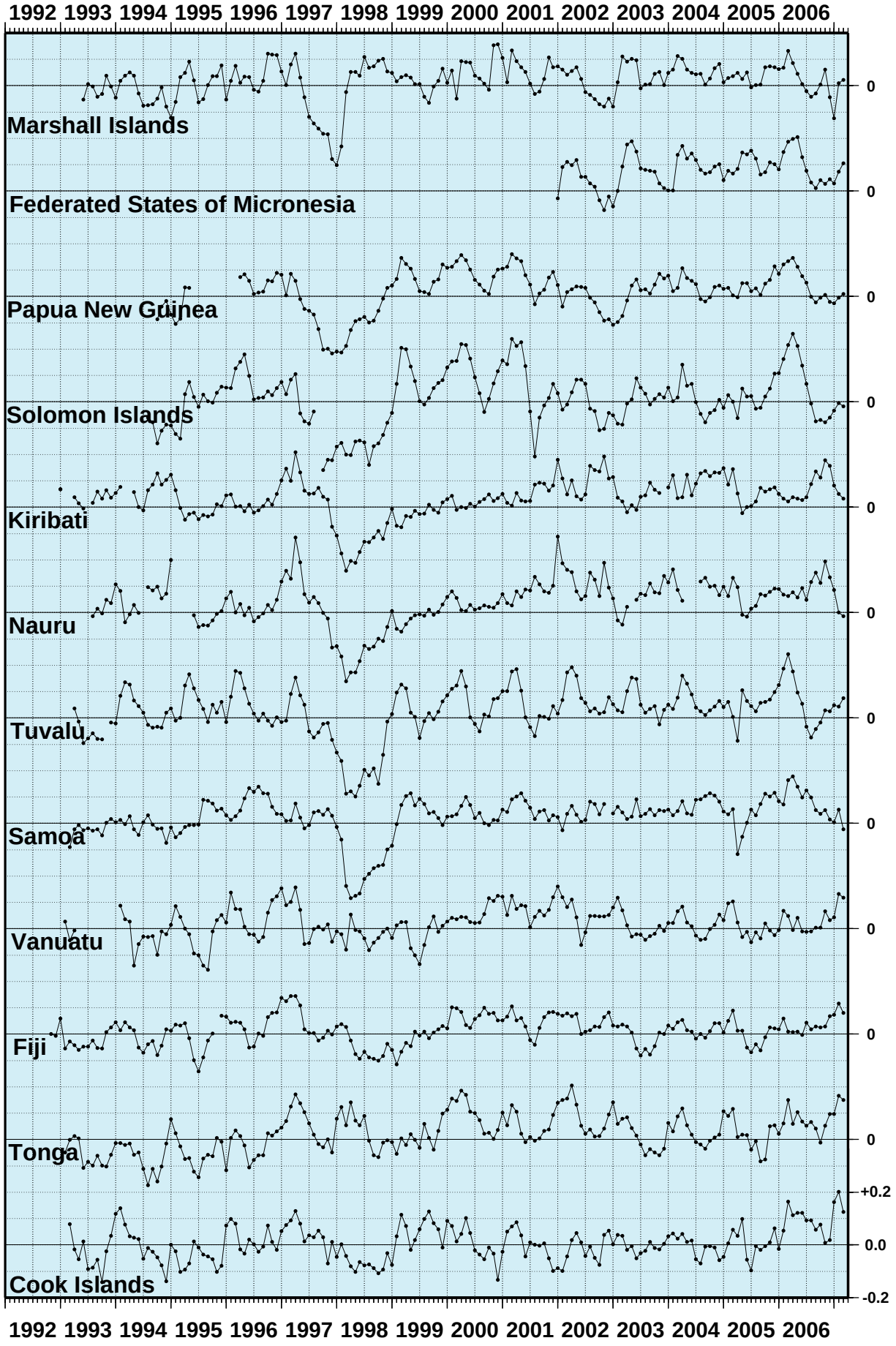


Figure 12

SEA LEVEL ANOMALIES THROUGH FEBRUARY 2007 (m)

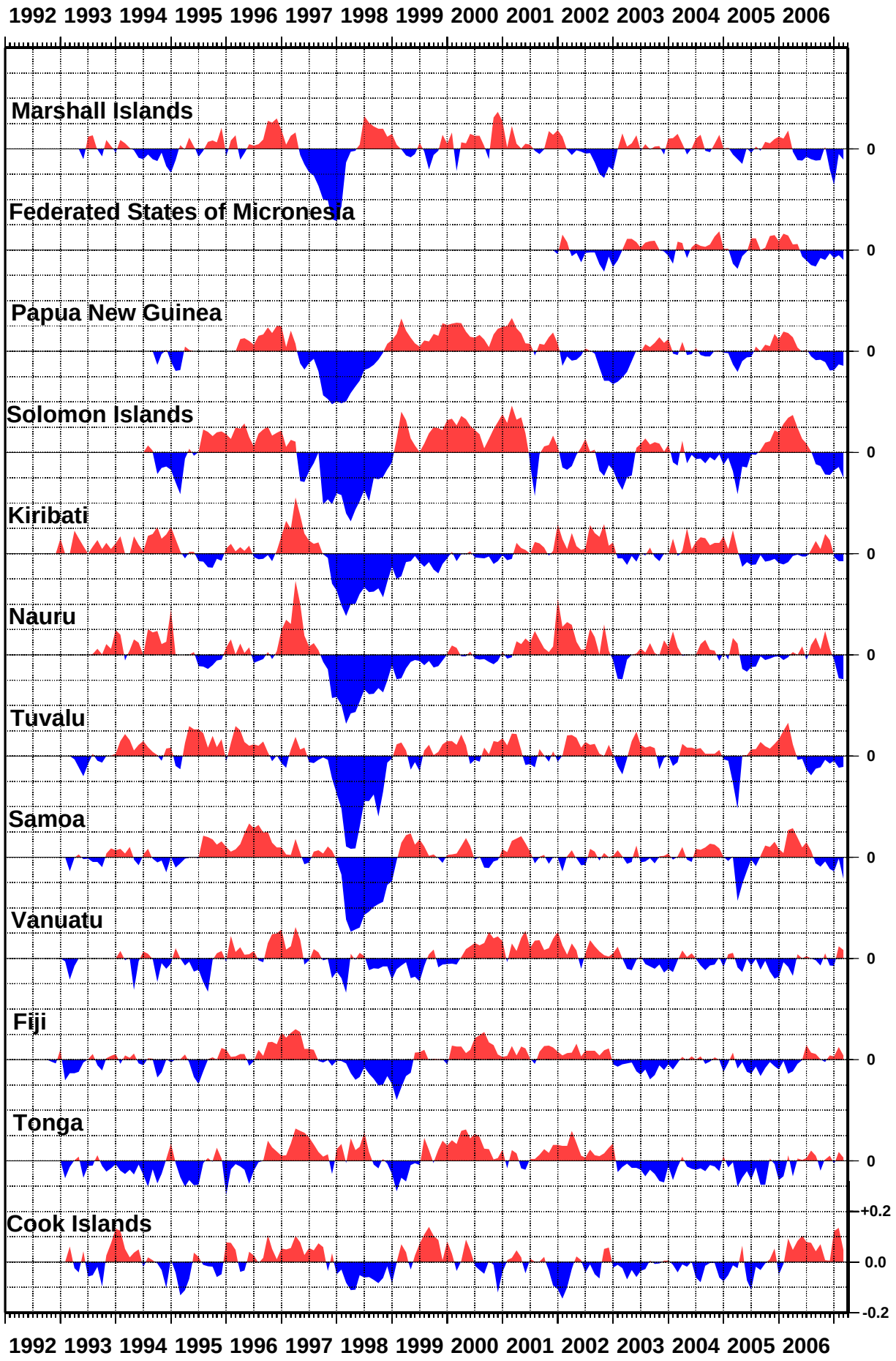


Figure 13

SEA LEVEL TRENDS THROUGH FEBRUARY 2007 (mm/year)

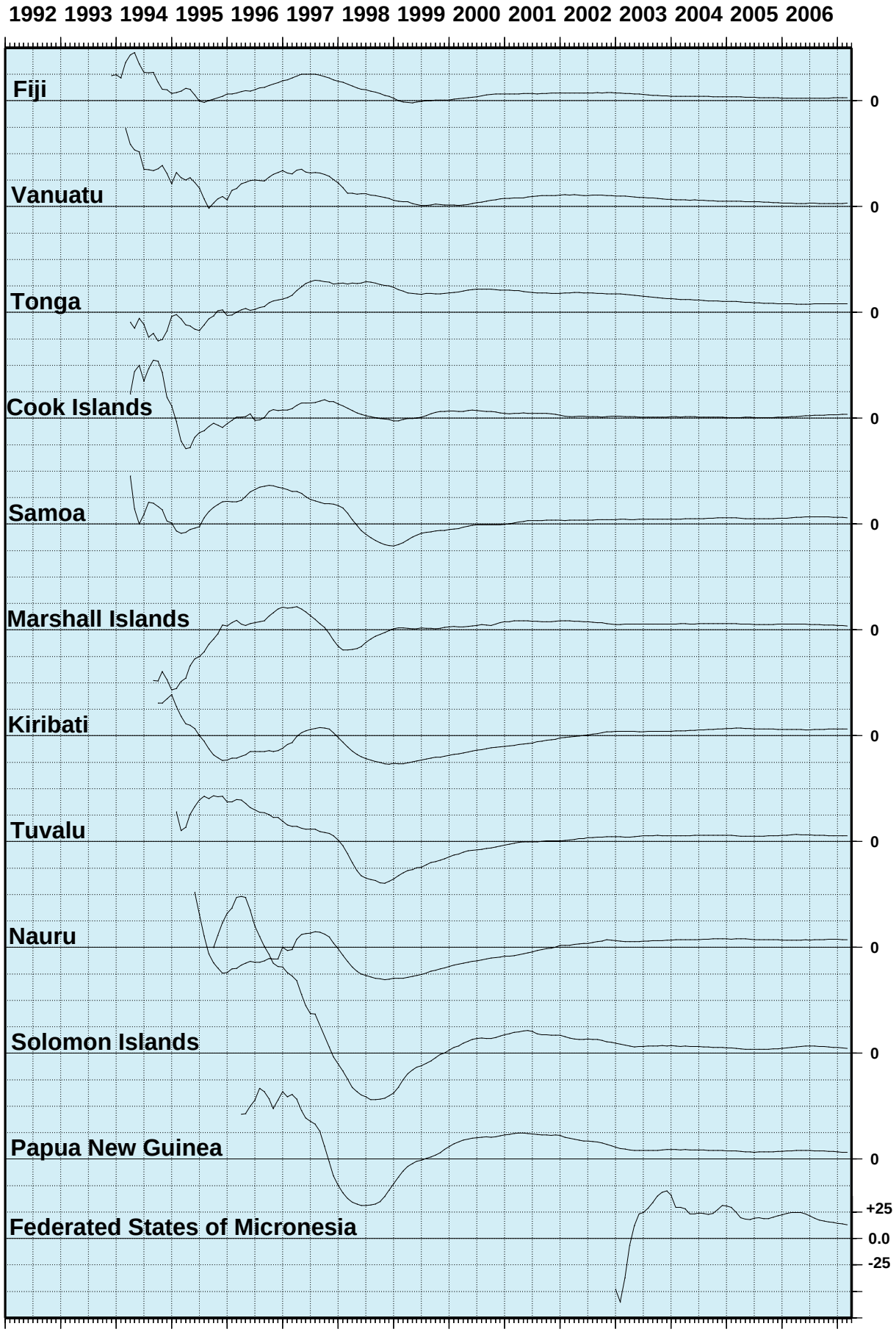


Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH FEBRUARY 2007 (hPa)

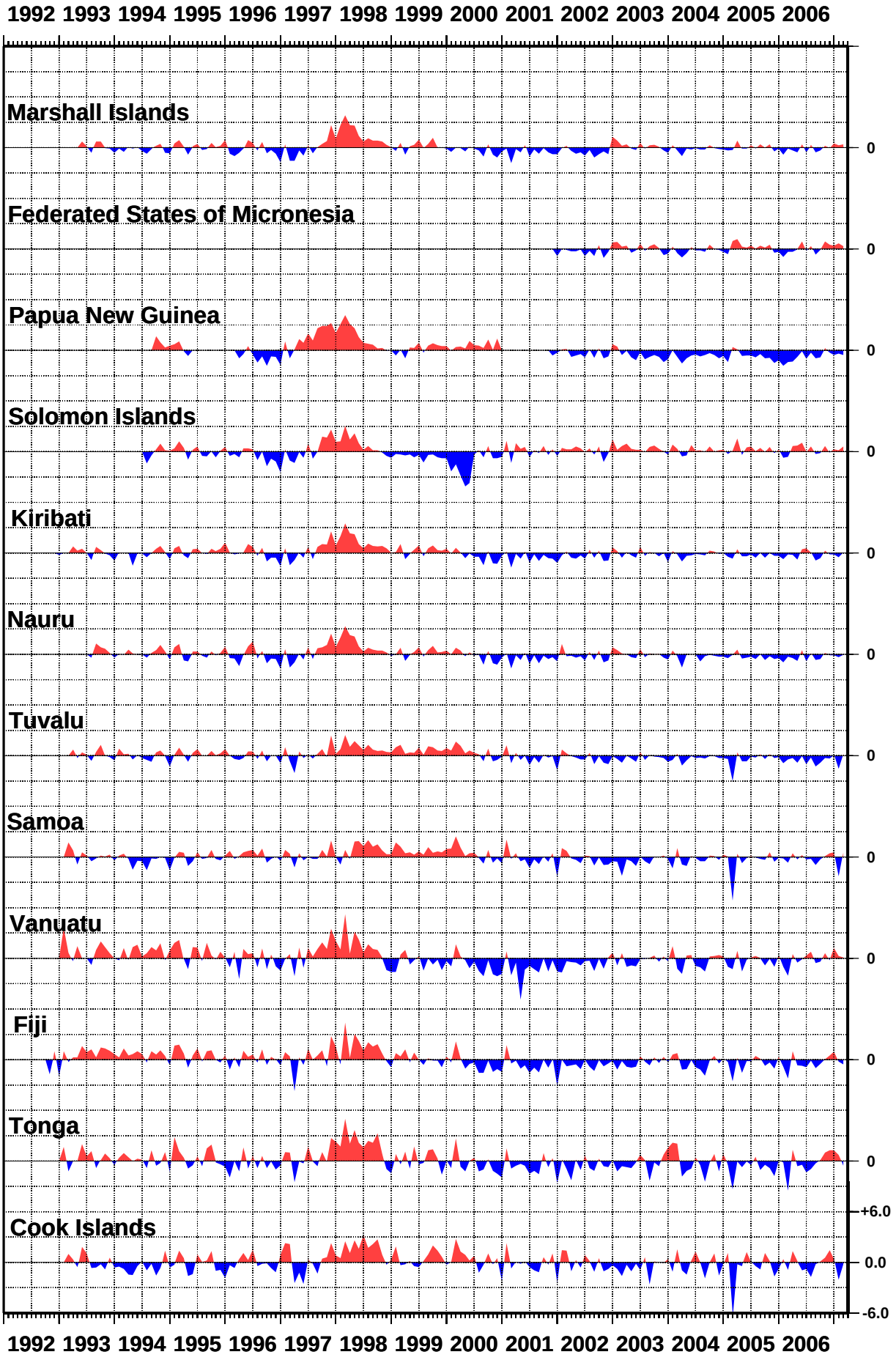


Figure 15

WATER TEMPERATURE ANOMALIES THROUGH FEBRUARY 2007 (°C)

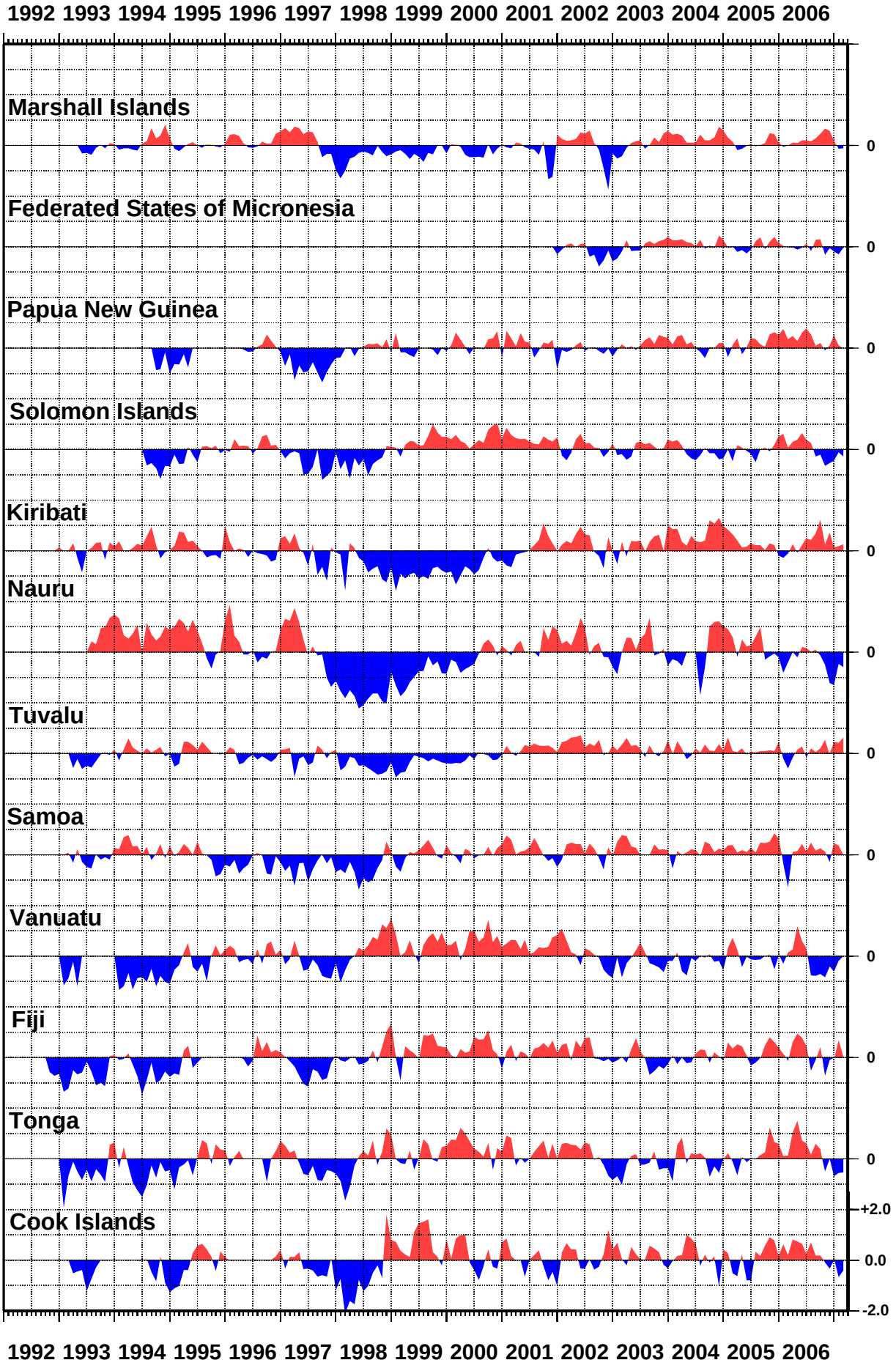


Figure 16

AIR TEMPERATURE ANOMALIES THROUGH FEBRUARY 2007 (°C)

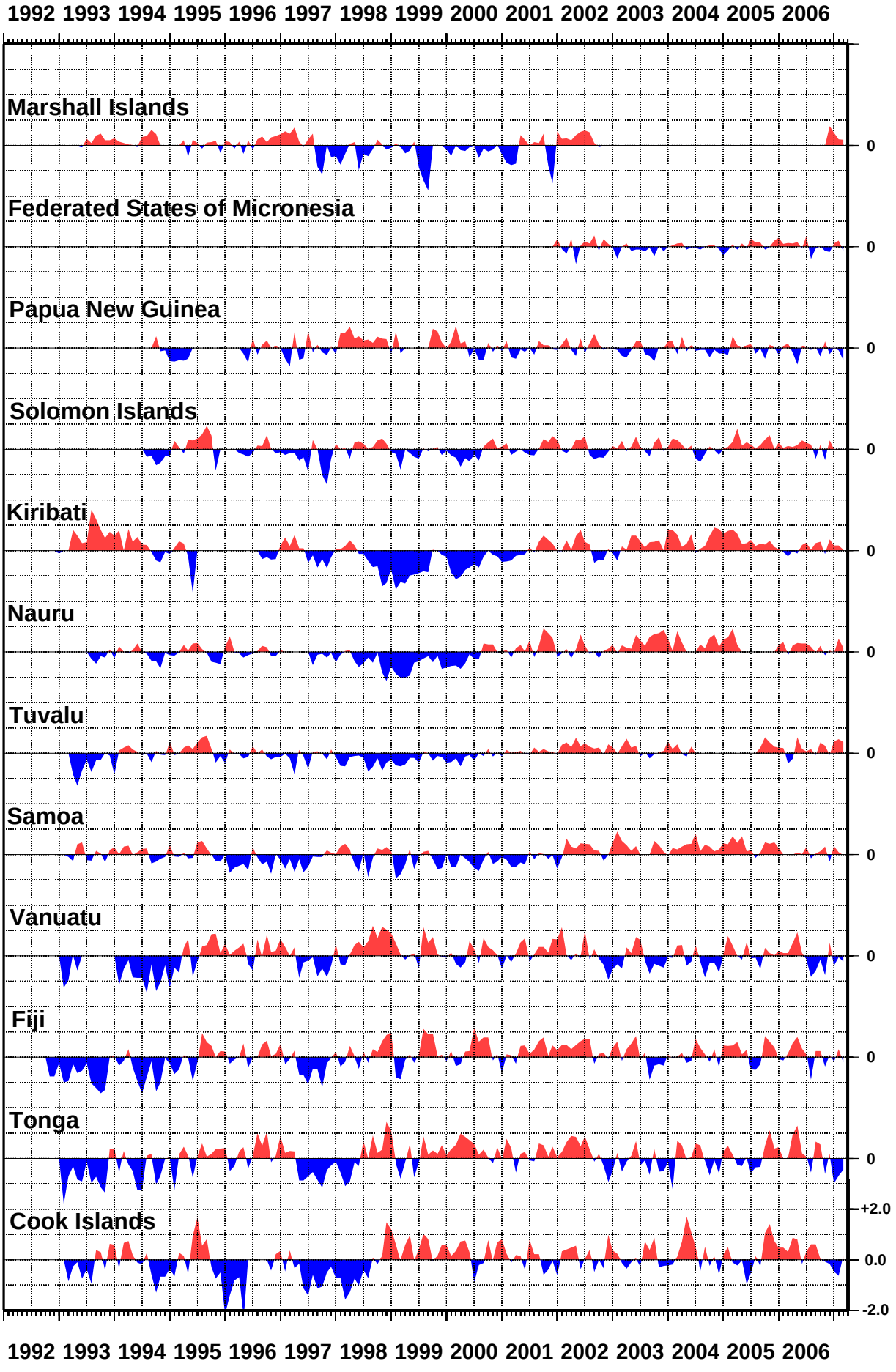


Figure 17

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED

GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE

* Patchy record