THE SOUTH PACIFIC SEA LEVEL & CLIMATE MONITORING PROJECT

MONTHLY DATA REPORT

NO. 189

MARCH 2011

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 March 2011 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

March 2011

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.

March 2011

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

- The SEAFRAME station at Tonga was successfully upgraded with a modernised data logger, real-time satellite communications and an additional radar-type water level sensor. The remainder of the network will be progressively upgraded over the next two years as part of the AusAID-funded Observation Network Upgrade Project (ONUP).

- A large Pacific-wide tsunami was generated from a magnitude Mw9.1 earthquake off Japan on 11th March 2011, causing devastation throughout Japan. Pacific Island Countries felt the effects of the tsunami, with strong tsunami signals recorded across the SEAFRAME network.

- The La Niña event is in decline, indicated by warming ocean temperatures across the equatorial Pacific during March. However, atmospheric conditions remained typical of a well-developed La Niña, including stronger than normal Trade Winds in the western equatorial Pacific and below average cloudiness on the equator near the dateline.

- The monthly mean sea levels at PNG and Samoa during March were the highest on record. Positive sea level anomalies continued to be observed at PNG, Solomon Islands and Samoa largely due to the influence of La Niña.

- The La Nina event peaked in January and is expected to continue to decline. International climate models predict that neutral atmospheric conditions will return in the coming months and persist into the southern hemisphere spring.

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 March, 2011

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	+4.7	0.0
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+8.4	0.0
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+4.7	0.0
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+4.9	-0.3
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+5.9	+0.1
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+4.1	0.0
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+2.9	+0.1
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+3.7	0.0
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+6.8	+0.2
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+7.5	+0.2
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+16.8	-0.1
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+4.7	0.0

INTRODUCTION

Welcome to the March 2011 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, which 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.

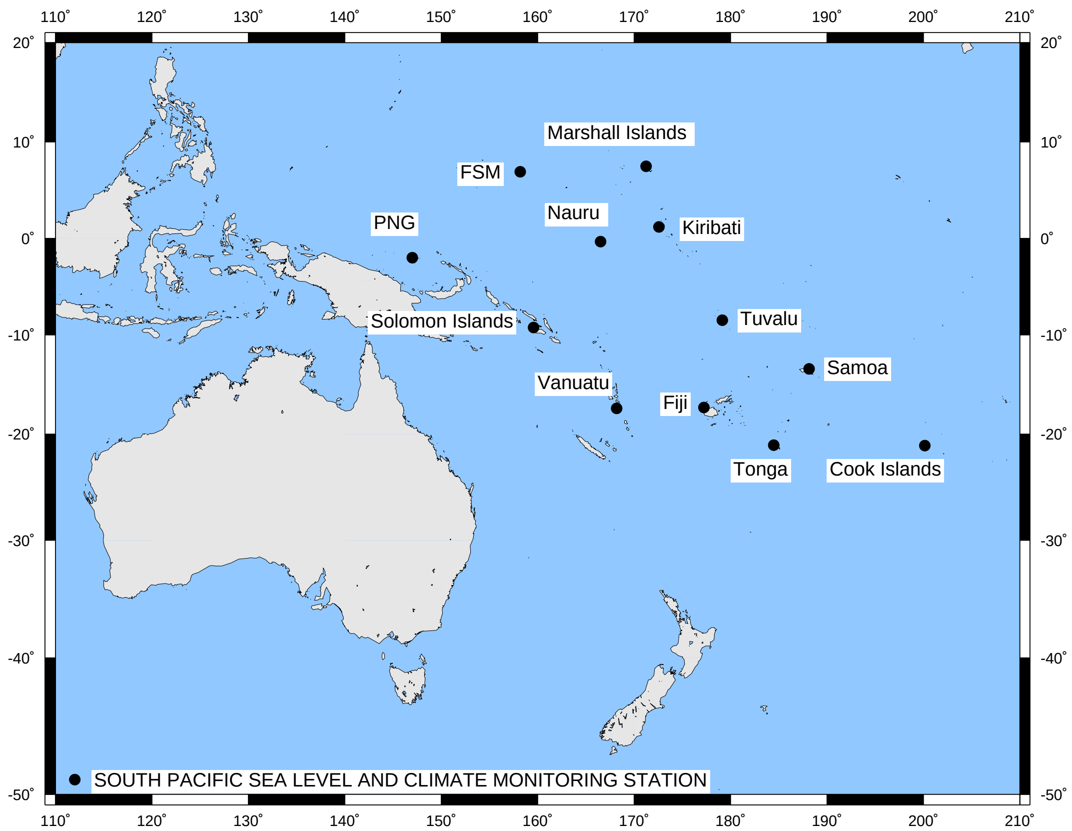


Figure A: *South Pacific Sea Level and Climate Monitoring Stations*

MARCH CLIMATOLOGY

The La Niña event continued to decline during March by way of further warming of ocean temperatures across the equatorial Pacific, although atmospheric conditions remained typical of a strong La Niña. Trade Winds were stronger than normal, cloudiness was suppressed over the central equatorial Pacific and the Southern Oscillation Index (SOI) was at record-high March values. Ocean temperatures across the central and eastern equatorial Pacific remain slightly cooler than normal despite warming during March, while the western equatorial Pacific remained warmer than normal. La Nina conditions have eased from their peak in early January and international climate models predict neutral conditions will return by the southern hemisphere winter and persist into spring.

The Southern Oscillation Index (SOI) has been positive since April 2010 and remained strongly positive during March (**Figure B**). The March 2011 value of +21.4 is the highest March SOI value on record, previously set at +20.3 in 1974. Sustained positive values of the SOI above +8 are typical of La Niña, while sustained negative values below –8 are typical of El Niño.

Sea surface temperatures warmed across the equatorial Pacific during March, but overall remained slightly cooler than is normal for this time of the year (**Figure C**). Anomalies cooler than -1ºC occupy a considerably smaller area than a month ago and are absent along the equator. Warmer than normal sea surface temperatures continue to be observed in the far western equatorial Pacific and in a band extending across the south Pacific centred over latitude 35º S.

Subsurface ocean temperatures have been cooler than normal across the central and eastern equatorial Pacific since April 2010, but a recent warming trend continued during March (**Figure D**). The region remains slightly cooler than normal, while warm subsurface temperature anomalies in the western equatorial Pacific continued to propagate eastward.

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 equatorial 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 remained stronger than normal across the western Pacific during March 2011 (**Figure E**). Cloudiness near the dateline remained below average during March and has generally been suppressed since late April.

The consensus among international computer models surveyed by the Bureau of Meteorology suggests that neutral climate conditions will return in the coming months in response to ocean temperatures and persist into the southern hemisphere spring.

The preceding description of the climatology of the Pacific region, and Figures B, C and D are based on information sourced from the National Climate Centre of the Australian Bureau of Meteorology at http://www.bom.gov.au/climate/. Figure E was generated from the Tropical Atmosphere Ocean project website courtesy of PMEL, NOAA at http://www.pmel.noaa.gov/tao/.

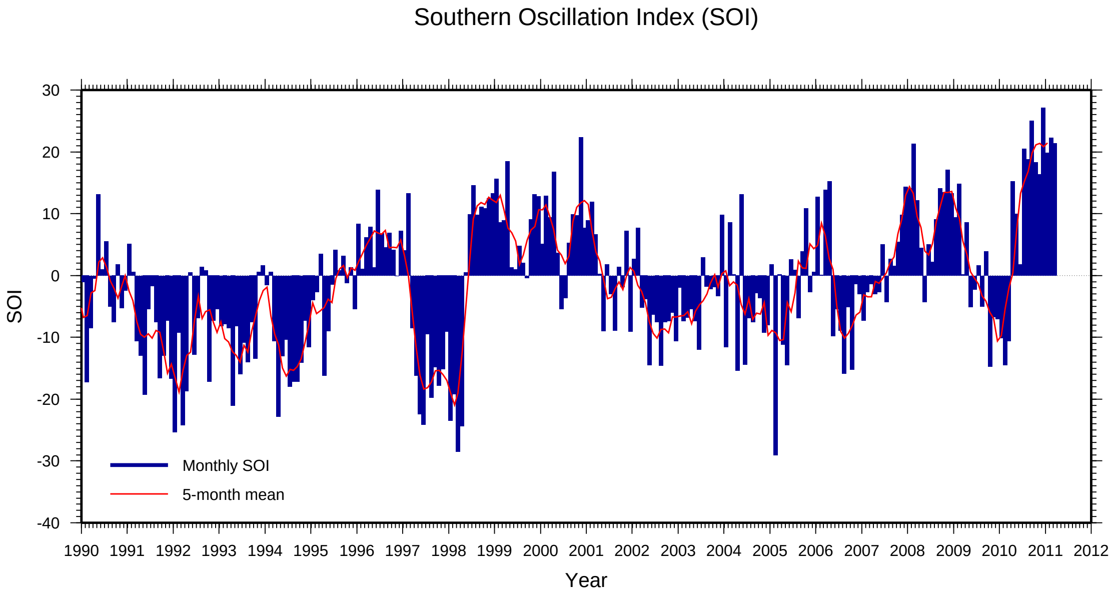


Figure B: *The five-month weighted mean and individual monthly means of the Southern Oscillation Index (SOI). The SOI is ten times the monthly anomaly of the difference in mean sea level pressure between Tahiti and Darwin, divided by the long-term standard deviation of that difference for the relevant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

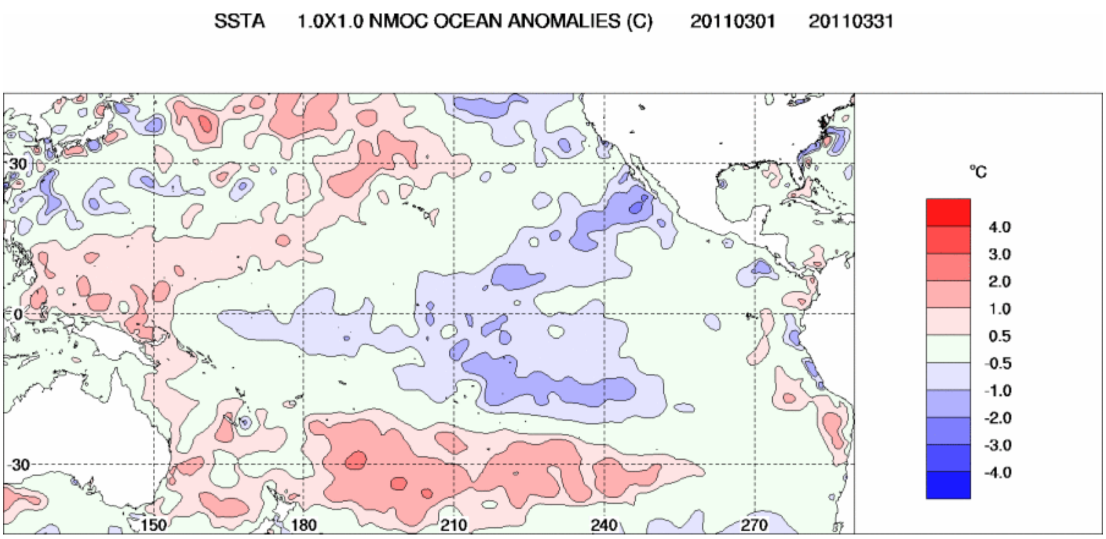


Figure C: *Sea surface temperature anomaly (°C) for March 2011.*

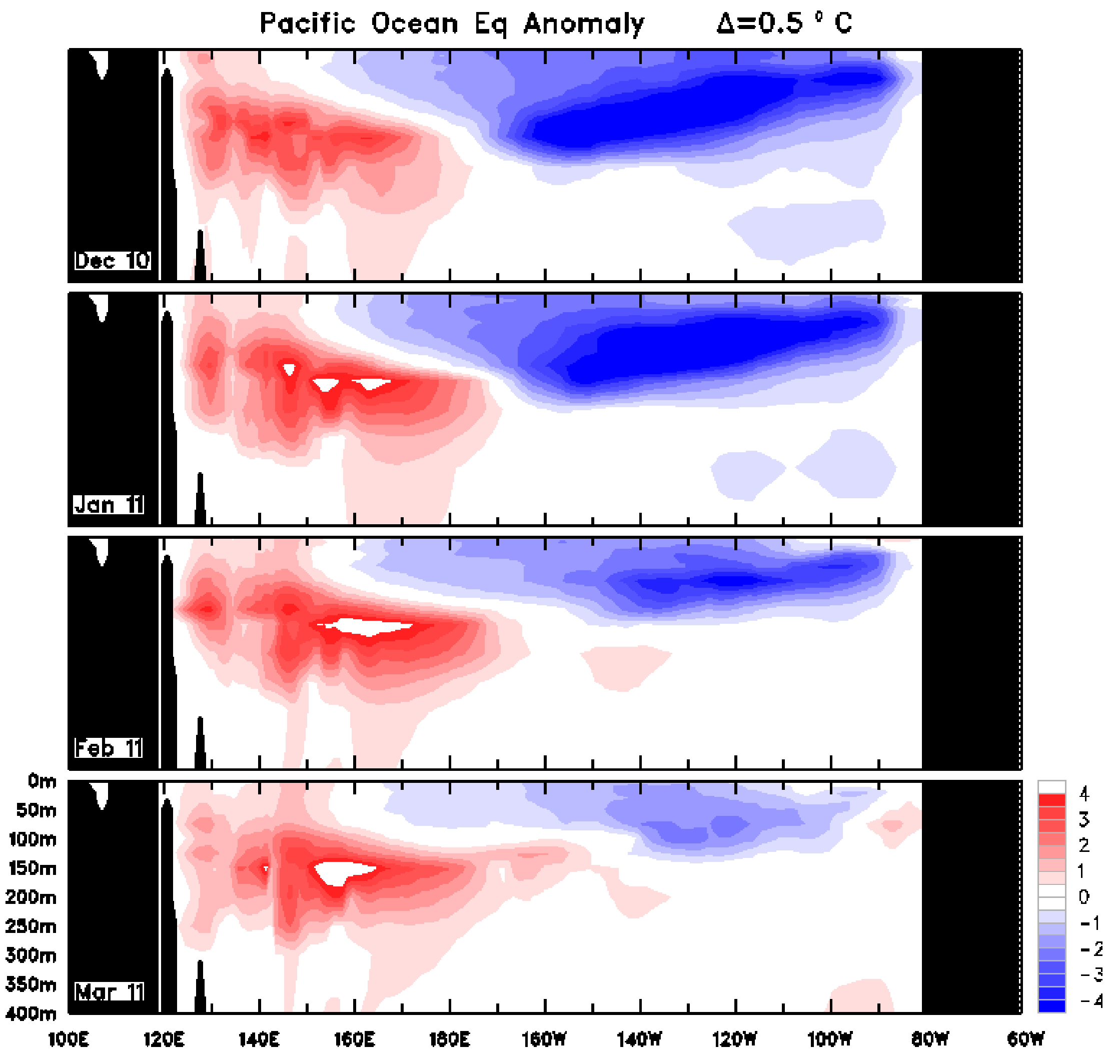


Figure D: *Equatorial depth-longitude section of ocean temperature anomalies for December 2010 through to March 2011. Contour interval is 0.5°C.*

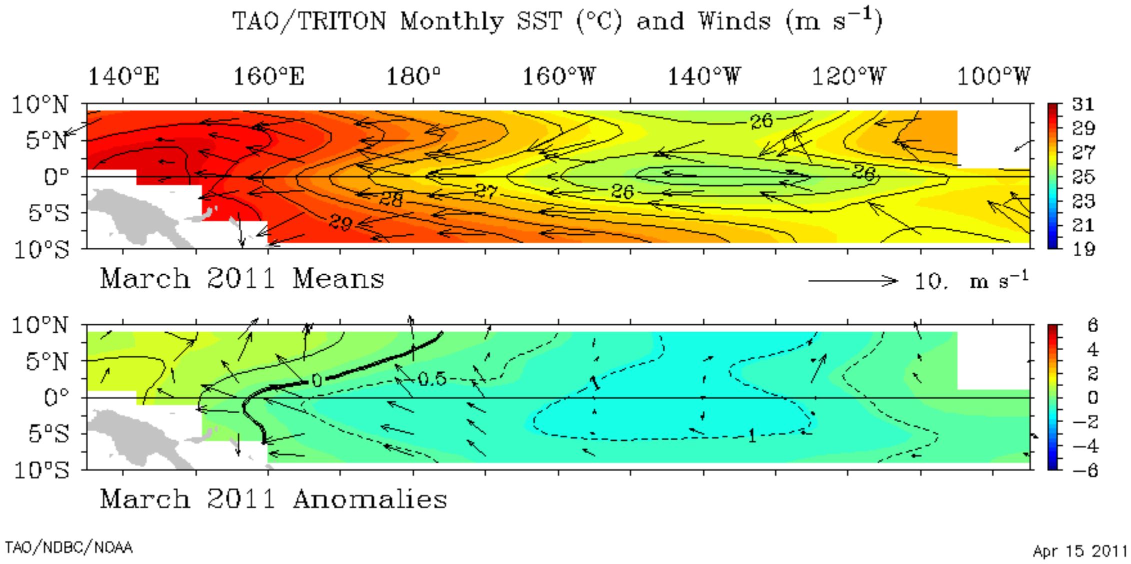


Figure E: *Monthly mean wind vectors (top) and anomalies (bottom) for March 2011. The colour-shaded contours represent the monthly mean sea surface temperatures (top) and anomalies (bottom).*

MARCH 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). Where tides are semi-diurnal the greatest tidal variations are called spring tides and tend to occur close to the full and new moon. There was a new moon on the 4th of March and a full moon on the 19th of March 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 non-tidal sea level fluctuations, such as those due to the effects of weather or tsunamis. Tropical cyclones often produce storm surges where the combination of low barometric pressure and strong winds raise sea levels well above the predicted tides for a period of a day or more.

A large basin-wide tsunami was generated by a magnitude Mw9.1 earthquake off the coast of Japan on 11th March 2011. The earthquake and ensuing tsunami caused severe loss of life and destruction of property across Japan, with waves exceeding 10m and run-up heights exceeding 30m at some locations (IOC/UNESCO bulletin). The Pacific Tsunami Warning Centre issued a tsunami warning for many Pacific Islands Countries and monitored the propagation of the tsunami across the Pacific. The trough-to-peak tsunami signals (based on 1-minute sea level data) recorded by the SEAFRAME stations were 0.9m at Marshall Islands, 0.7m at FSM, 2.3m at PNG, 0.5m at Solomon Islands, 0.4m at Kiribati, 0.4m at Nauru, 0.5m at Tuvalu, 1.7m at Vanuatu, 0.6m at Fiji, 1.1m at Tonga and 0.4m at Cook Islands. Unfortunately the SEAFRAME at Samoa (and a co-located tsunami gauge) were not operational at the time of the tsunami.

If the 11th March 2011 tsunami had occurred during larger spring tides, rather than coinciding with smaller neap tides, the effects of the tsunami may have been exacerbated. Even so, at PNG where the tides are diurnal and do not adhere to the typical spring-neap cycle, both record-low (-0.083m) and record-high (2.079m) sea levels were observed as a result of the tsunami, the latter exceeding the previous maximum of 1.381m observed on 10th January 2009 by 0.7m.

The non-tidal sea level fluctuations can be amplified or sustained by the shape of the harbour in which the gauge is located. Some of the SEAFRAME stations are located in harbours that are favourable to persistent ‘sloshing’ under certain conditions (a phenomenon referred to as a seiche), such as at PNG when the wind suddenly changes strength or direction, at FSM during periods of reduced tidal range and at Nauru during strong westerly winds.

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 Nauru prevailed from the northeast for most of the month.

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 related to interactions between tides and terrestrial (land-based) water discharging into the wharf area. The water temperature fluctuations there are 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 farther 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.* Record March maximum air temperatures were observed at Samoa (32.3 ºC) and Tonga (30.5 ºC). A record March maximum water temperature of 32.7 ºC was observed at PNG and a record March minimum water temperature of 27.2 ºC was observed at Tuvalu. A record March maximum barometric pressure of 1019.3 hPa was observed at Cook Islands.

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 very low sea levels which disrupted the annual sea level cycle at many of the SEAFRAME stations. Recent La Niña conditions contributed to record-high monthly mean sea levels being observed at PNG and Samoa during March.

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.

Sea levels during March 2011 were, on average, more than 10cm higher than normal at Samoa and over 5cm higher than normal at PNG and Solomon Islands. On the other hand sea levels at Vanuatu were, on average, over 10cm lower than normal. Sea levels at the remaining stations of Marshal Islands, FSM, Kiribati, Nauru, Tuvalu, Fiji, Tonga and Cook Islands were close to normal for this time of the year.

Sea Level Trends

The **short-term sea level trends** at individual stations as at March 2011 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 March, 2011

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	+4.7	0.0
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	+8.4	0.0
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	+4.7	0.0
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	+4.9	-0.3
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	+5.9	+0.1
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	+4.1	0.0
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	+2.9	+0.1
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	+3.7	0.0
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	+6.8	+0.2
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	+7.5	+0.2
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	+16.8	-0.1
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	+4.7	0.0

Barometric Pressure, Water Temperature and Air Temperature Anomalies

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

The **barometric pressure anomalies (Figure 14)** show substantially higher than normal barometric pressures were observed at SEAFRAME stations during the 1997-1998 El Niño. During March 2011 barometric pressures were reasonably close to what is normal at this time of the year, at most sites. The largest anomalies were encountered at Cook Islands (+3 hPa) and Tonga (+2 hPa).

The **water temperature anomalies (Figure 15)** show water temperatures during March 2011 were around 1 ºC cooler than normal at Tuvalu and around 1 ºC warmer than normal at PNG. Over the last few months a warming trend has been observed at many of the stations.

The **air temperature anomalies (Figure 16)** during March 2011 were close to normal, with the largest anomalies observed at Tuvalu (-0.5 ºC) and Tonga (+0.5 ºC). A warming trend has been observed at many of the sites in recent months, most notably Kiribati, Nauru 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.

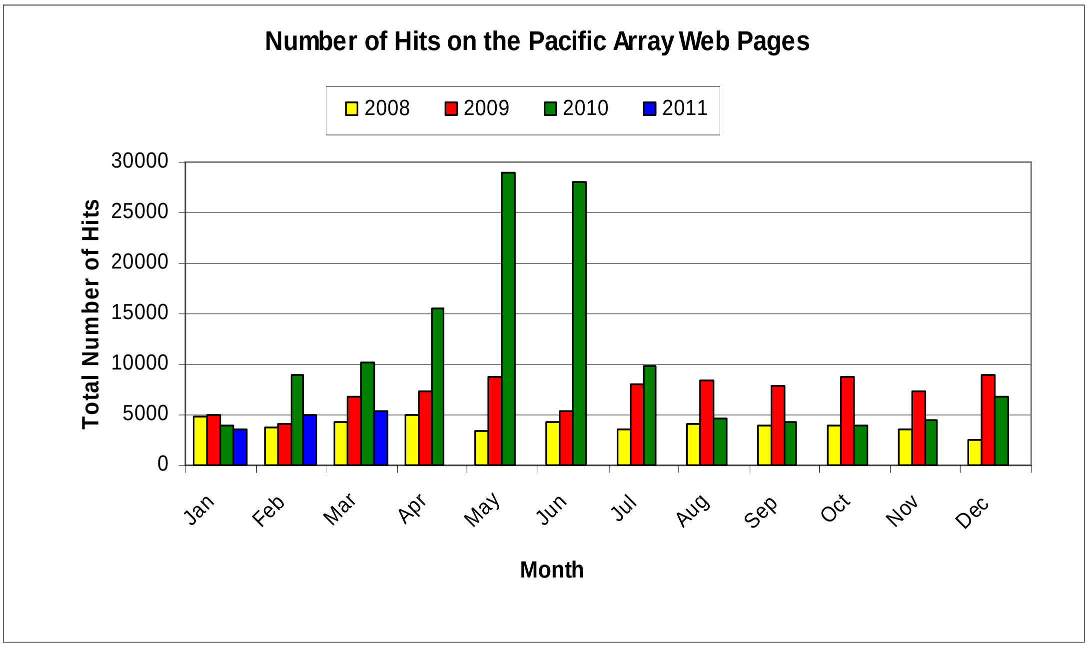
Instrument Performance

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.

Sea level data return during March 2011 was very good for most stations. Power supply problems were experienced at Samoa which caused data loss from 2nd-24th March 2011. A station upgrade at Tonga meant it was offline from 23rd-28th March 2011. Satellite and dial-up communications problems resulted in a number of data gaps for Tuvalu. Calibration and maintenance of the PNG SEAFRAME was performed from 14th-18th March. Problems with the air temperature sensors at Nauru and Manus, the water temperature sensor at Tonga and the wind monitors at Vanuatu and Tuvalu were encountered, which required erroneous data to be removed from the archived records.

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 2008.



SEAFRAME STATIONS

SEAFRAME stations employ either a SUTRON or TELMET (for upgraded stations) 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 SUTRON station is shown in the following figure.

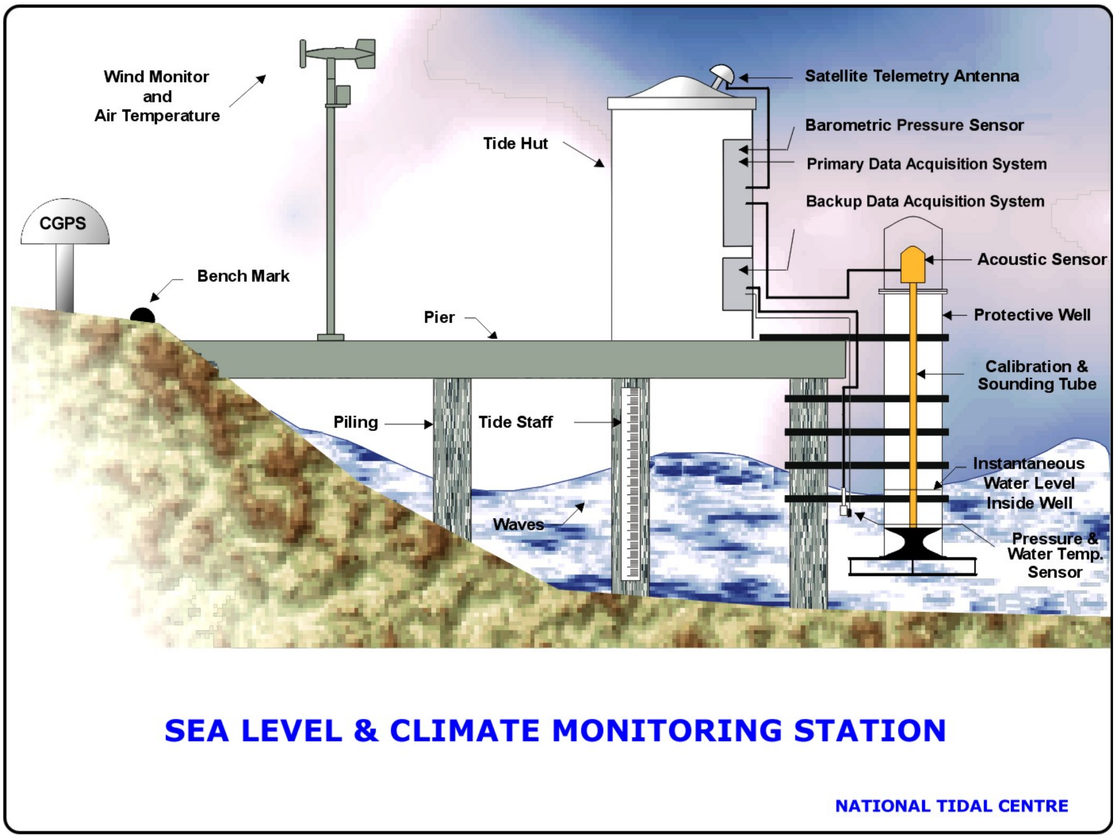
Water level sensors include:

(1) Primary water level using a Bartex 'AQUATRAK' acoustic-in-air sensor,

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

(3) Tertiary water level using a Vega-puls radar sensor mounted above the water (at upgraded sites).

For SUTRON stations, the water level samples are averaged over three minutes and logged every six minutes, while meteorological sensors are logged on an hourly basis. With the upgraded TELMET stations, the water level samples are averaged over one minute and, together with meteorological data, logged every minute. Appropriate weighted-average and time-centred data is computed remotely which conforms to the SUTRON algorithm. Both SUTRON and TELMET data loggers have the memory capacity to store approximately one month of data.



The Observation Network Upgrade Project (ONUP) is scheduled to upgrade all Pacific SEAFRAME stations by mid-2013 with modernised TELMET data loggers, real-time satellite communications and additional radar-type water level sensors. The status of the station upgrades is given in the following table.

Status of Station Equipment Upgrades to March, 2011

Location	Lat / Long	SUTRON Installation Date	TELMET Upgrade Date
Cook Is	21°12'17.1"S / 159°47'5.2"W	Feb 1993	To be upgraded
Tonga	21°8'12.5"S / 175°10'50.5"W	Jan 1993	Mar 2011
Fiji	17°36'17.7"S / 177°26'17.7"E	Oct 1992	To be upgraded
Vanuatu	17°45'19.2"S / 168°18'27.7"E	Jan 1993	To be upgraded
Samoa	13°49'36.4"S / 171°45'40.7"W	Feb 1993	To be upgraded
Tuvalu	8°30'8.9"S / 179°11'42.6"E	Mar 1993	To be upgraded
Kiribati	1°21'54.2"N / 172°55'58.8"E	Dec 1992	To be upgraded
Nauru	0°31'45.9"S / 166°54'36.2"E	Jul 1993	To be upgraded
Solomon Is.	9°25'44.1"S / 159°57'19.3"E	Jul 1994	To be upgraded
PNG	2°2'31.5"S / 147°22'25.6"E	Sep 1994	To be upgraded
FSM	6°58'49.9"N / 158°12'0.8"E	Dec 2001	To be upgraded
Marshall Is.	7°6'21.7"N / 171°22'22.1"E	May 1993	To be upgraded

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/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:

Figure 1

MARCH 2011
SIX MINUTE WATER LEVEL OBSERVATIONS (m)

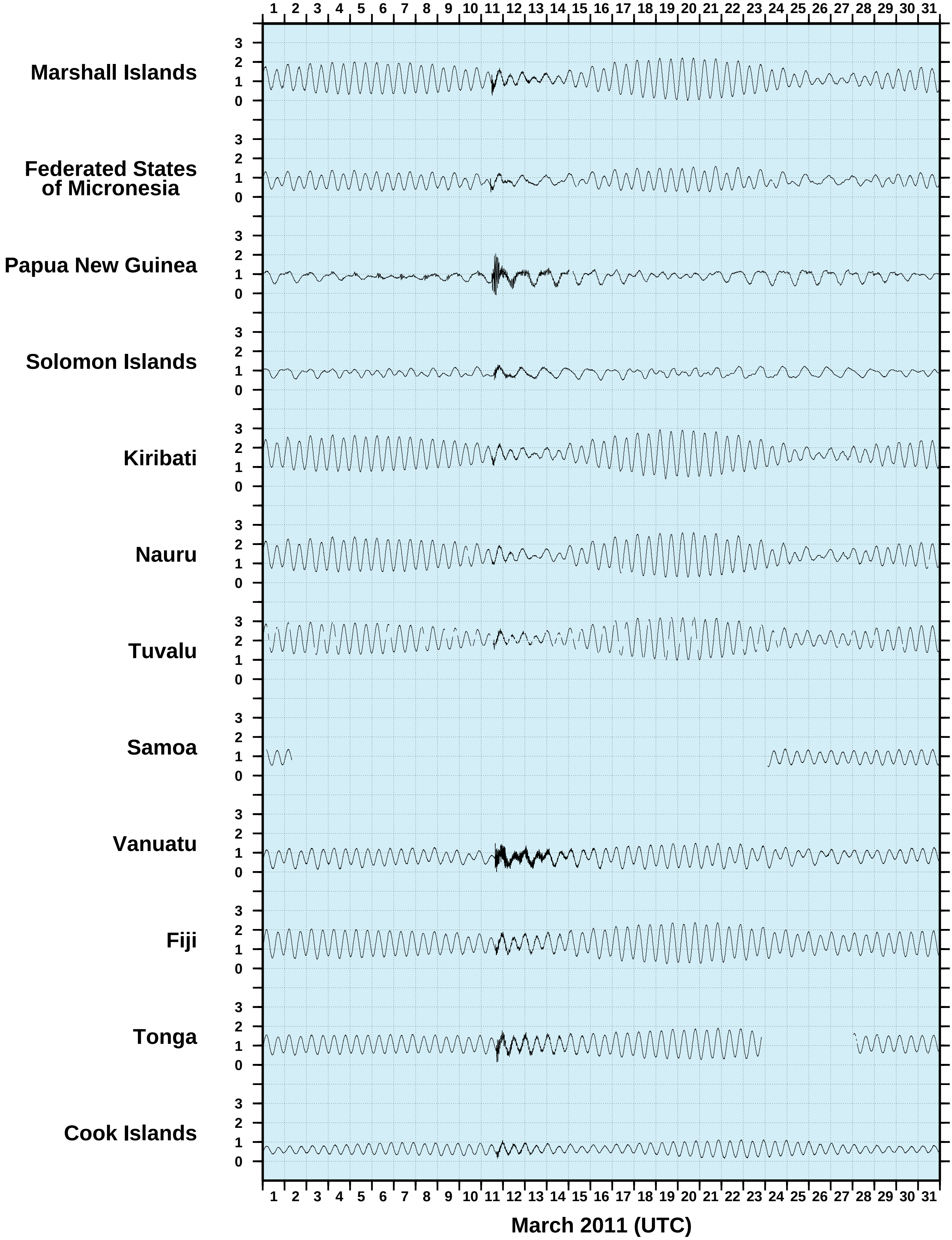


Figure 2

MARCH 2011
SIX MINUTE RESIDUAL WATER LEVELS (m)

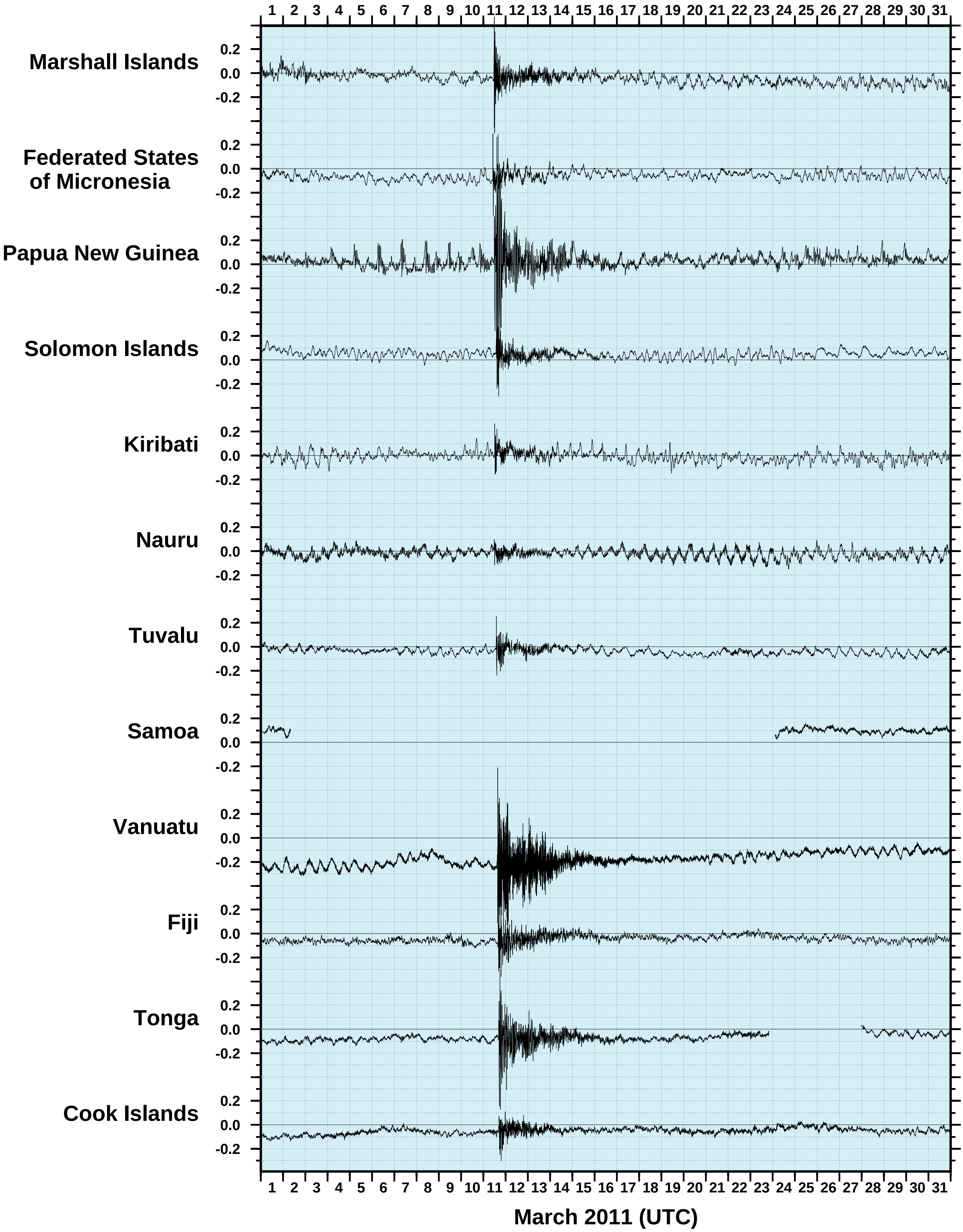
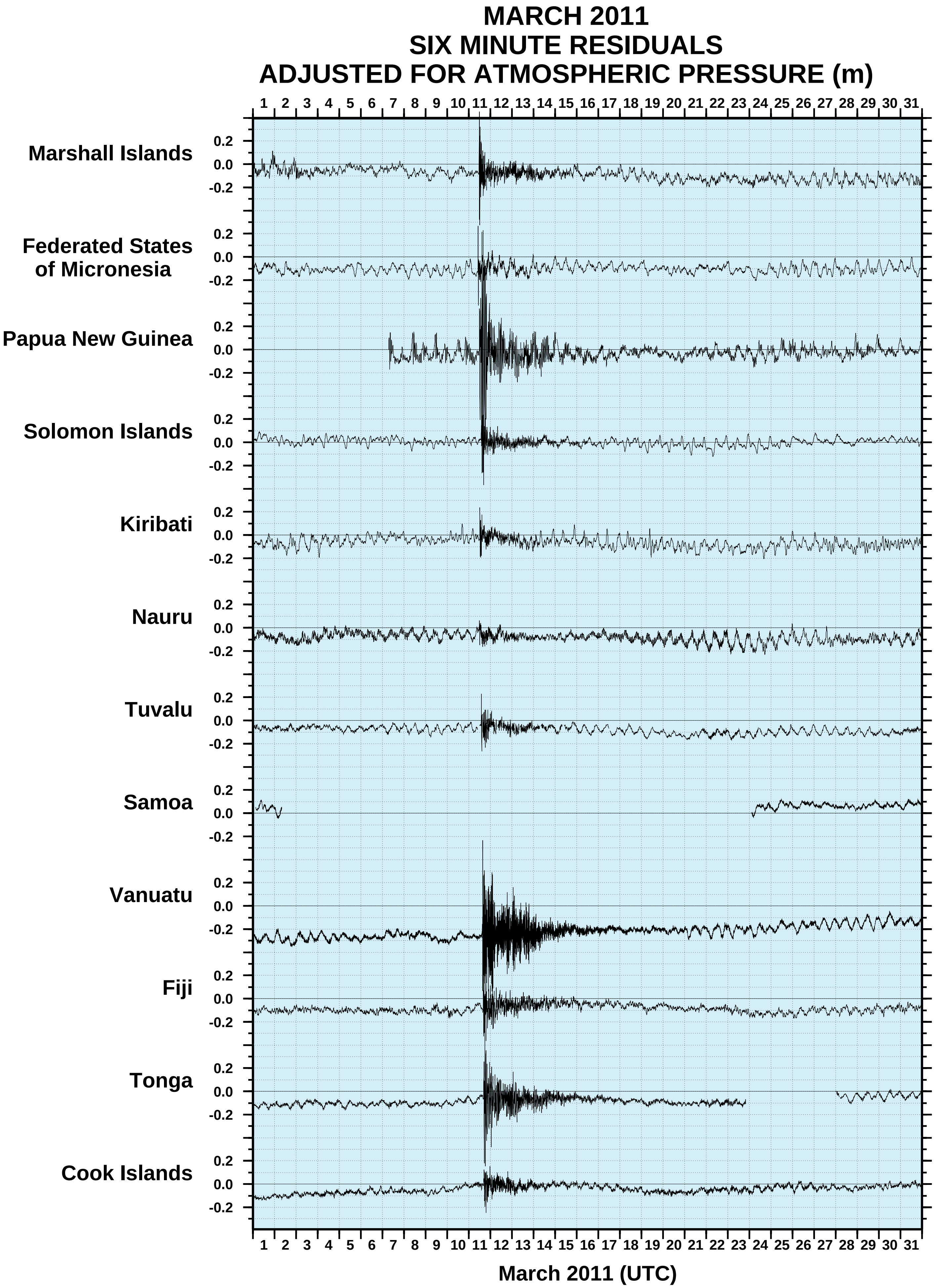


Figure 3



MARCH 2011
SIX MINUTE RESIDUALS
ADJUSTED FOR ATMOSPHERIC PRESSURE (m)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0.2
0.0
-0.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
March 2011 (UTC)

Figure 4

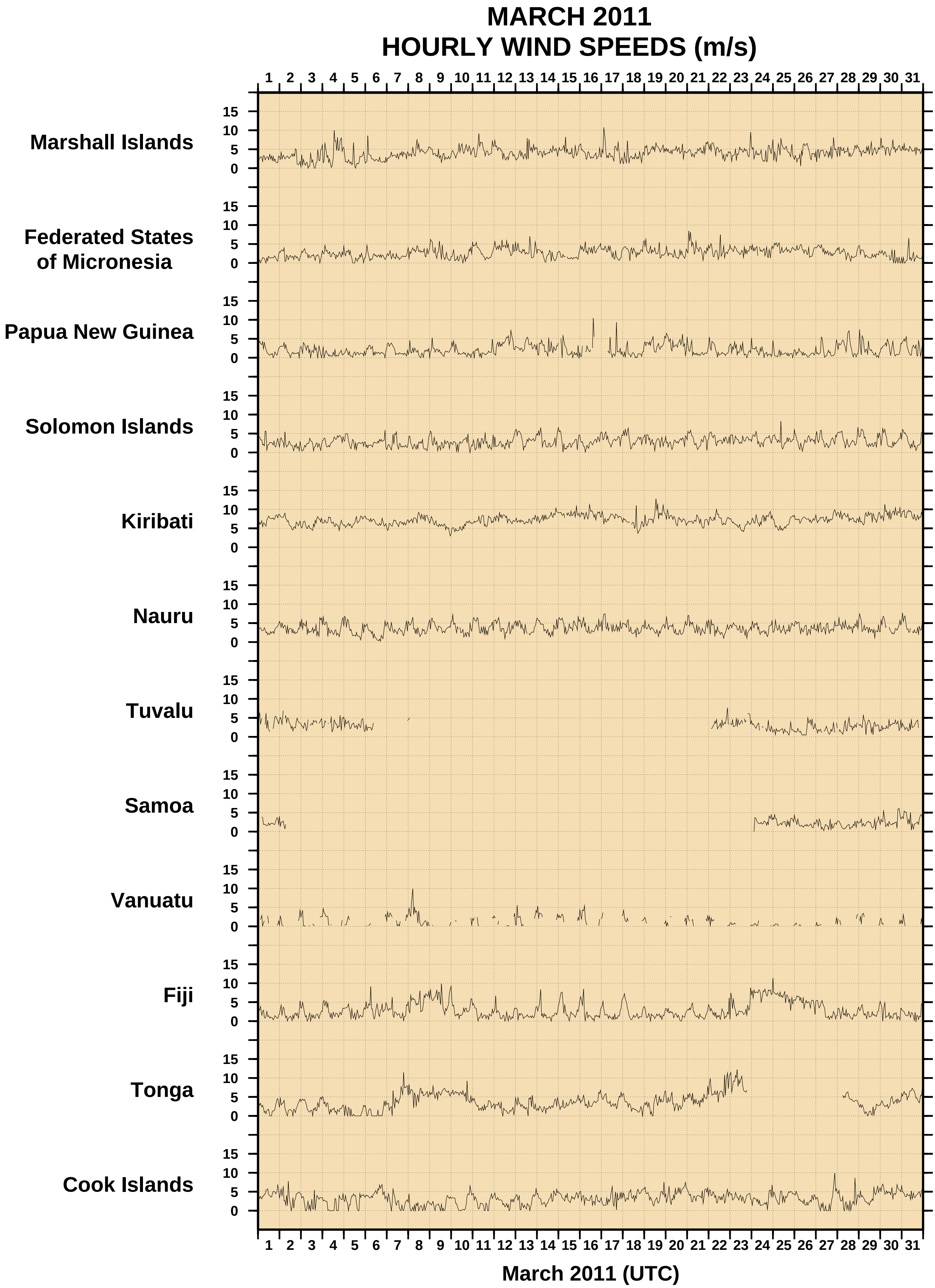

MARCH 2011
HOURLY WIND SPEEDS (m/s)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
0
5
10
15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
March 2011 (UTC)

Figure 5
MARCH 2011
HOURLY INCIDENT WINDS (m/s, deg True)

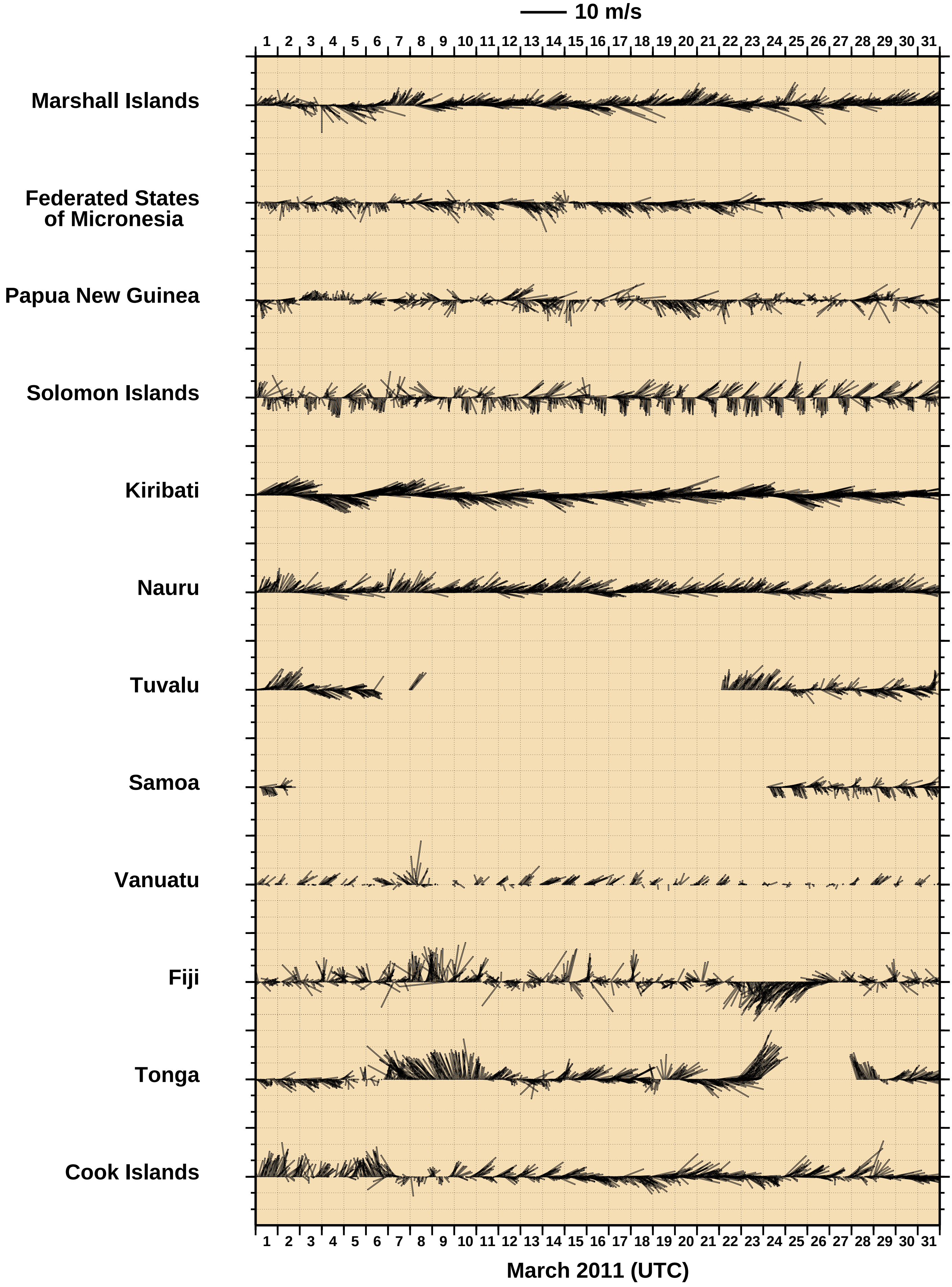


Figure 6

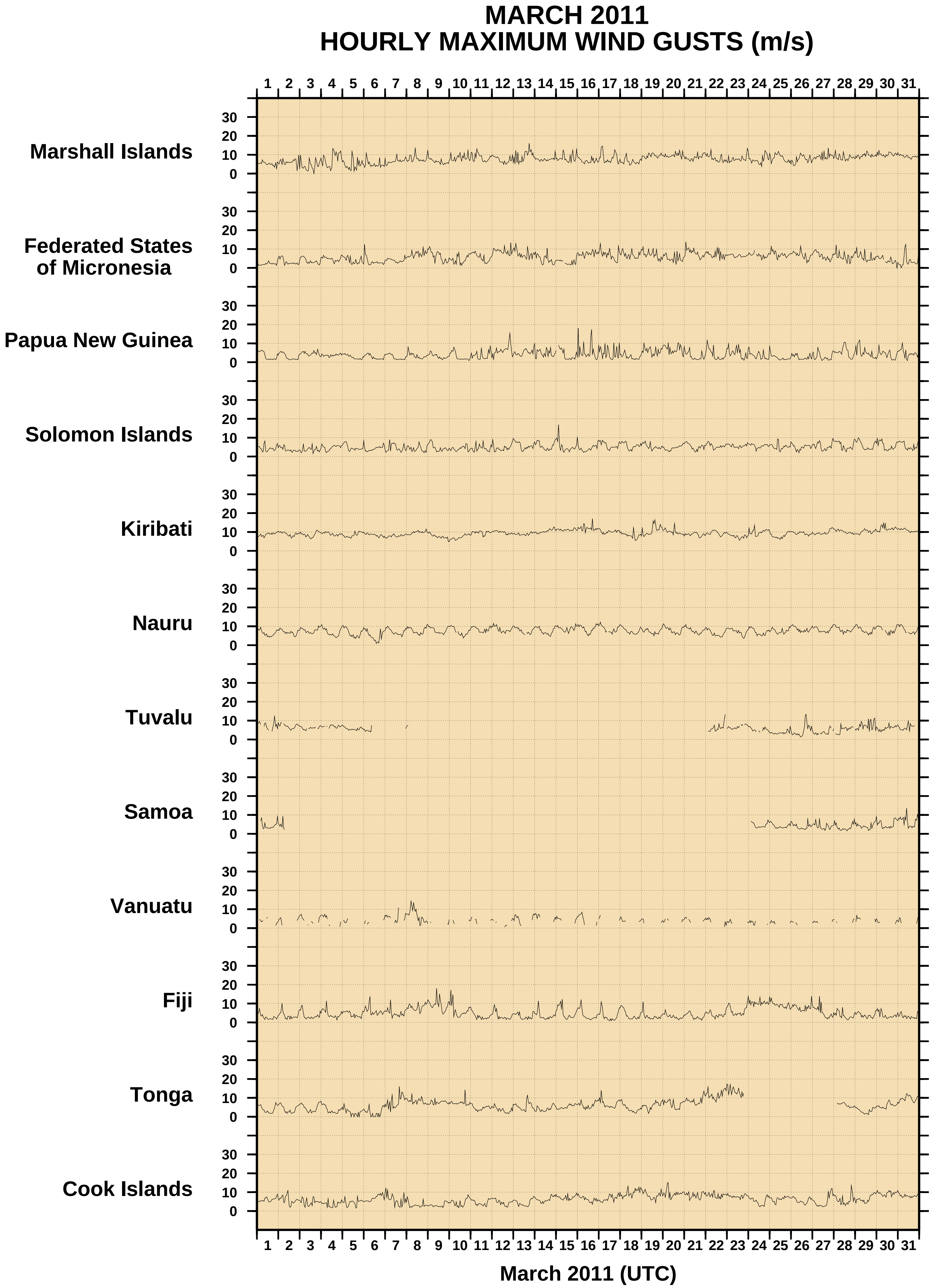

MARCH 2011
HOURLY MAXIMUM WIND GUSTS (m/s)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
March 2011 (UTC)

Figure 7

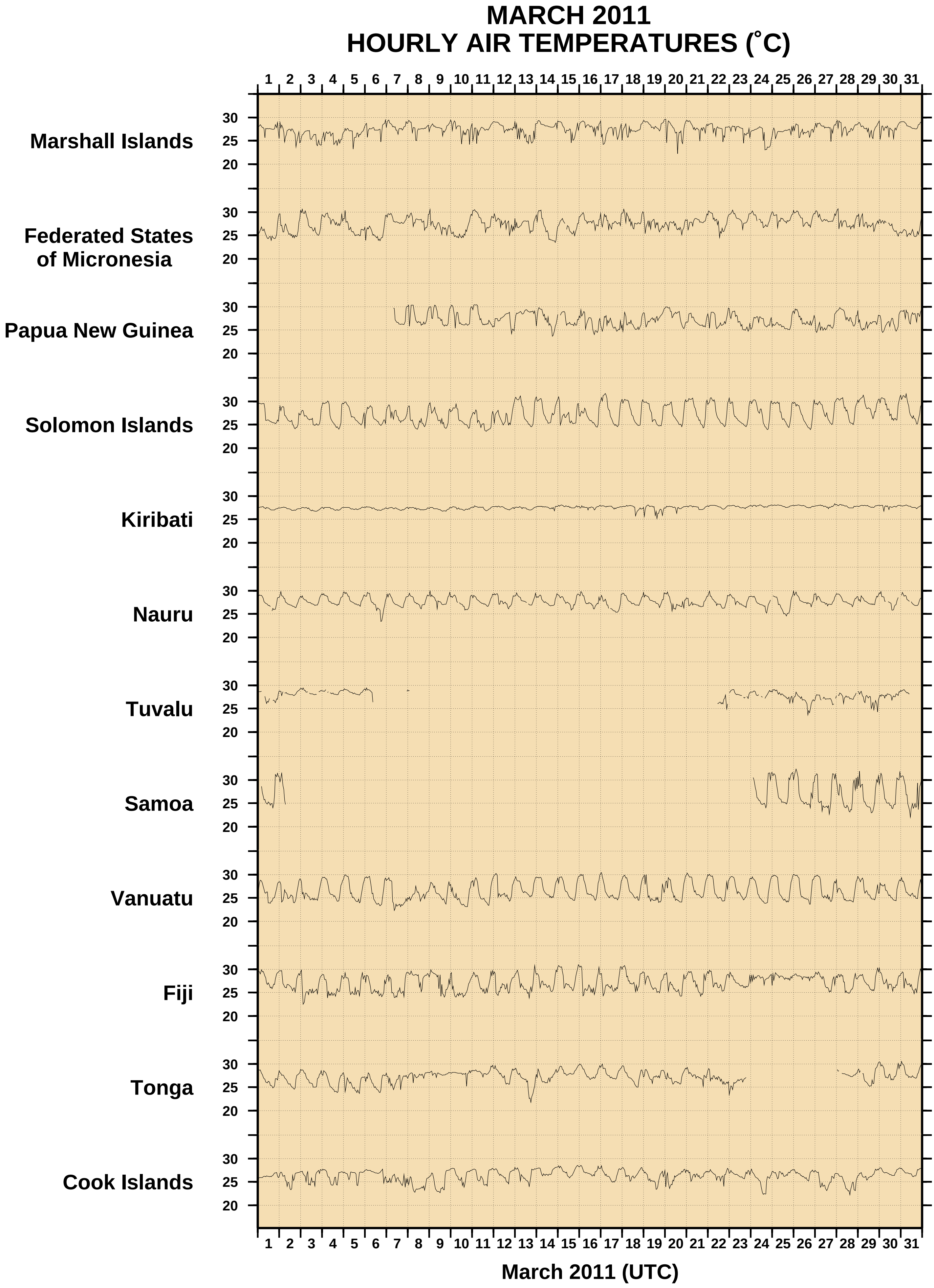

MARCH 2011
HOURLY AIR TEMPERATURES (˚C)
Marshall Islands
Federated States of Micronesia
Papua New Guinea
Solomon Islands
Kiribati
Nauru
Tuvalu
Samoa
Vanuatu
Fiji
Tonga
Cook Islands
30
25
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
March 2011 (UTC)

Figure 8

MARCH 2011
HOURLY WATER TEMPERATURES (°C)

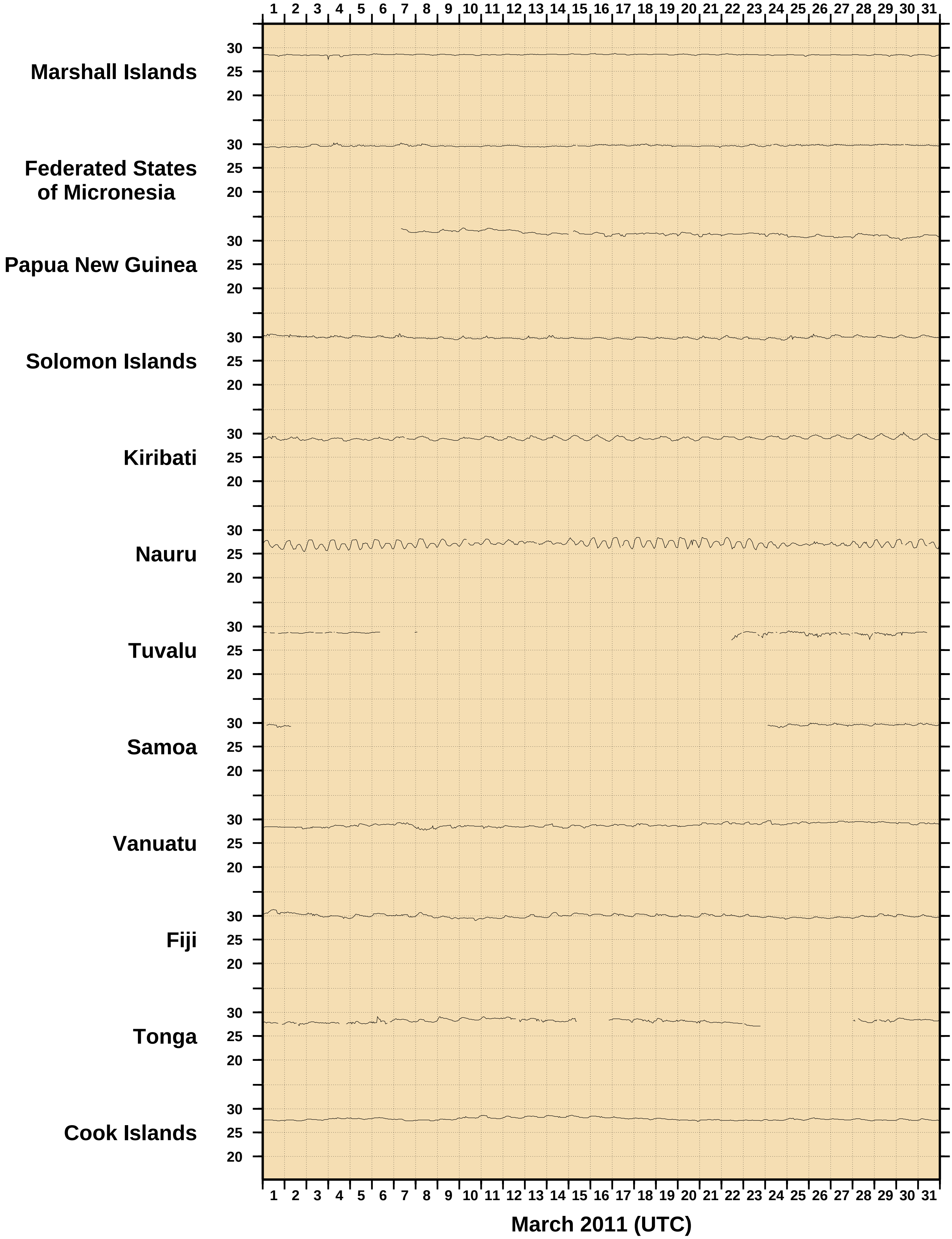


Figure 9

MARCH 2011
HOURLY ATMOSPHERIC PRESSURE (hPa)

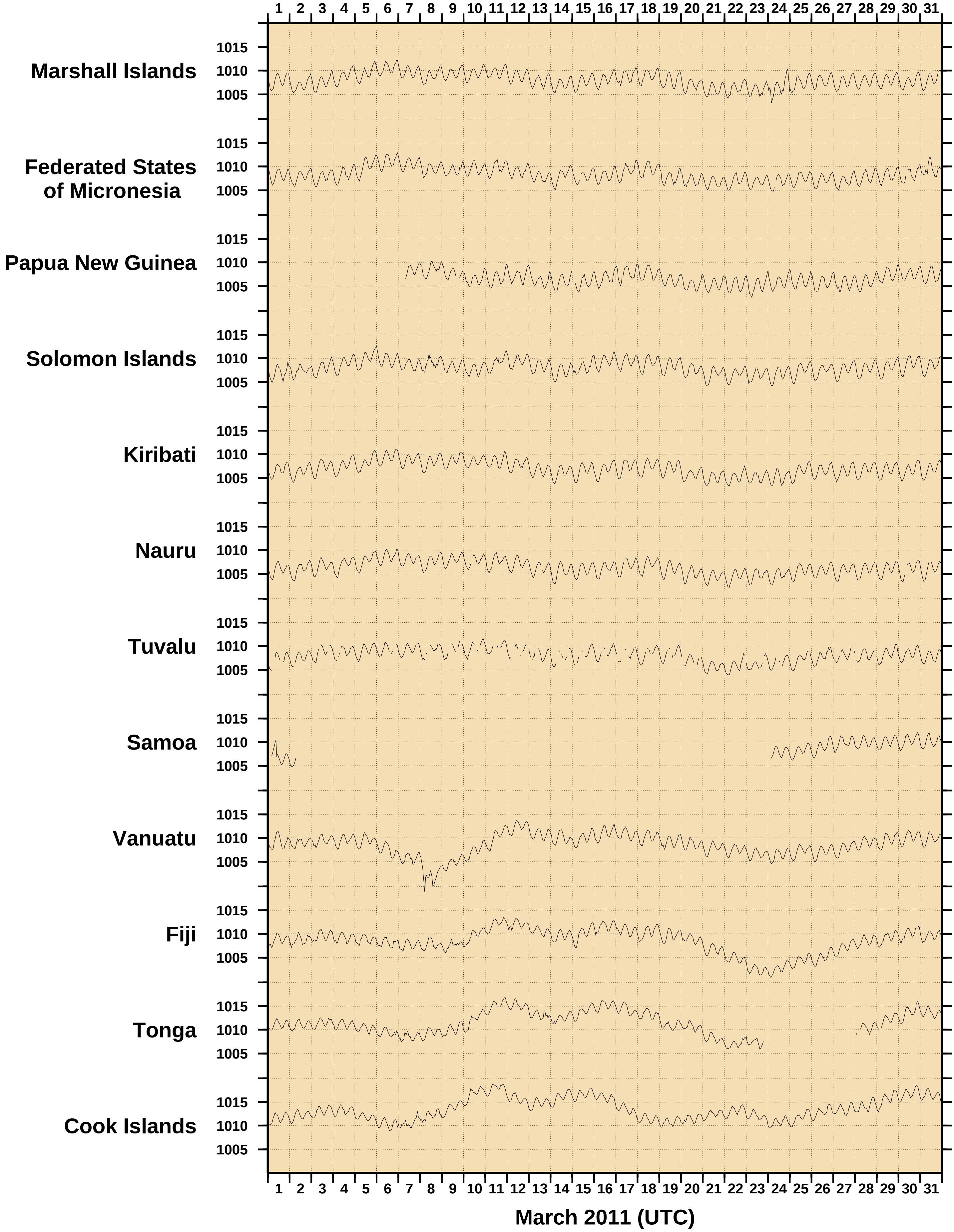


Figure 10

Comparison of March 2011 Max, Min & Mean with Long Term March Values.

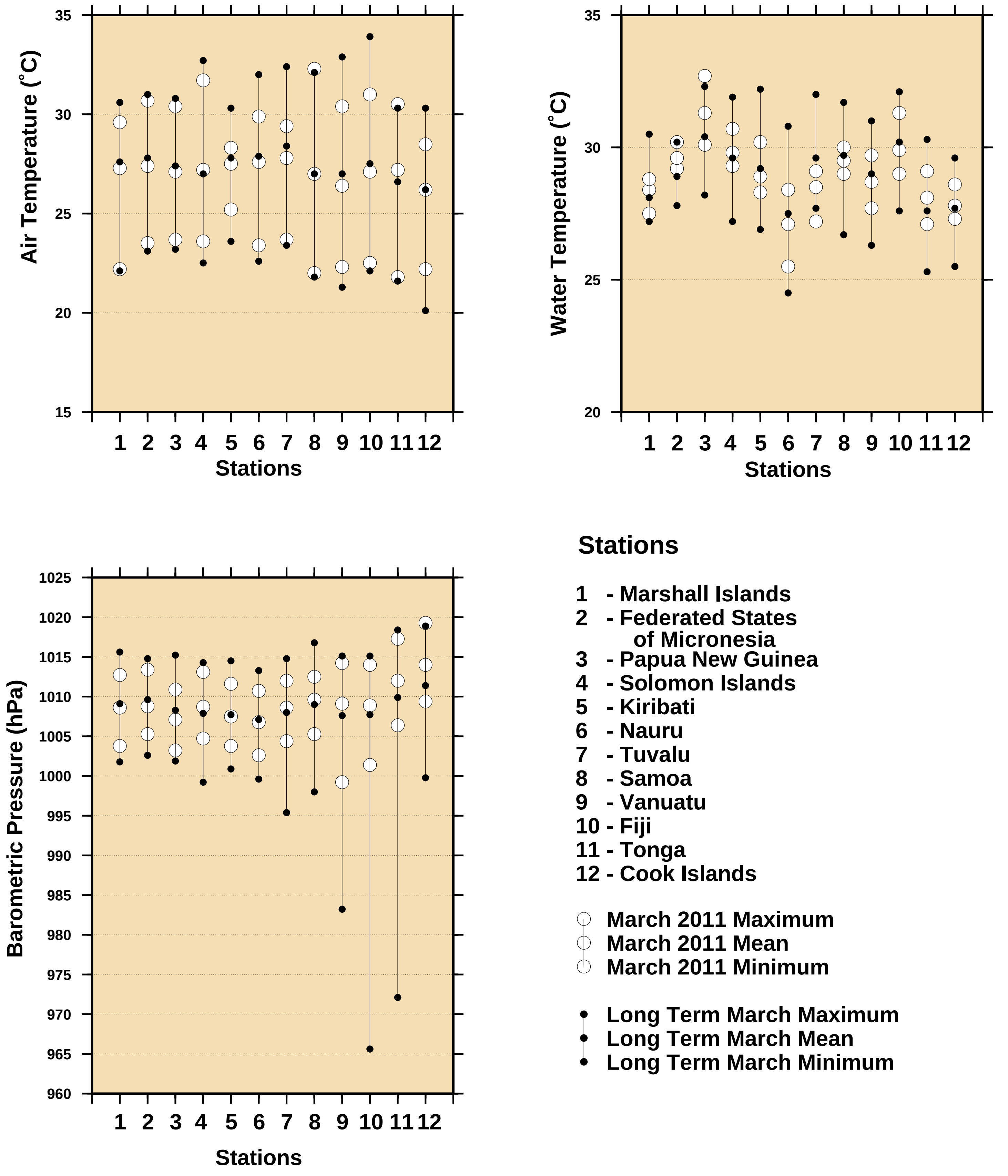


Figure 11

MONTHLY MEAN SEA LEVELS TO MARCH 2011 (m)

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

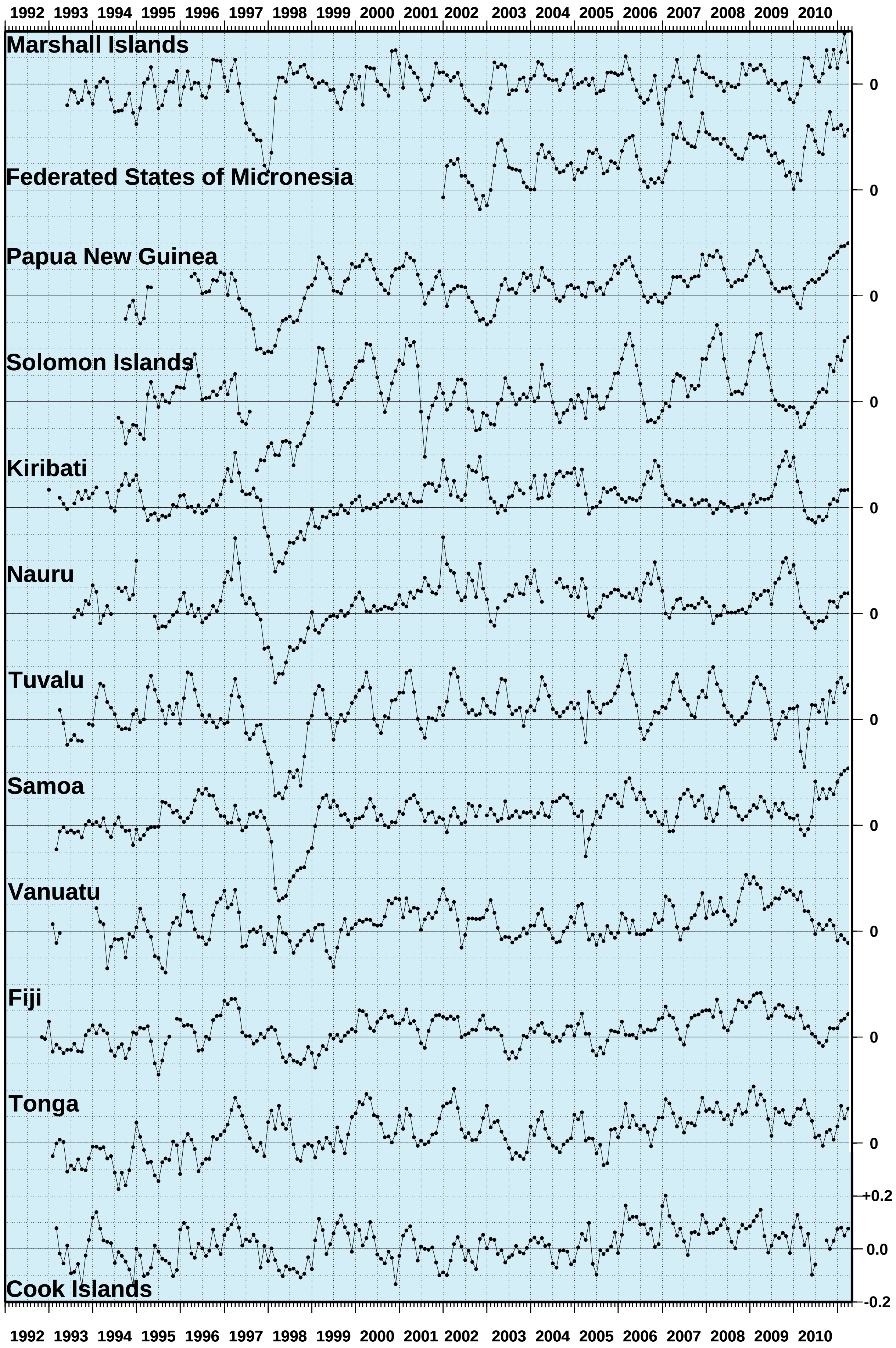


Figure 12

SEA LEVEL ANOMALIES THROUGH MARCH 2011 (m)

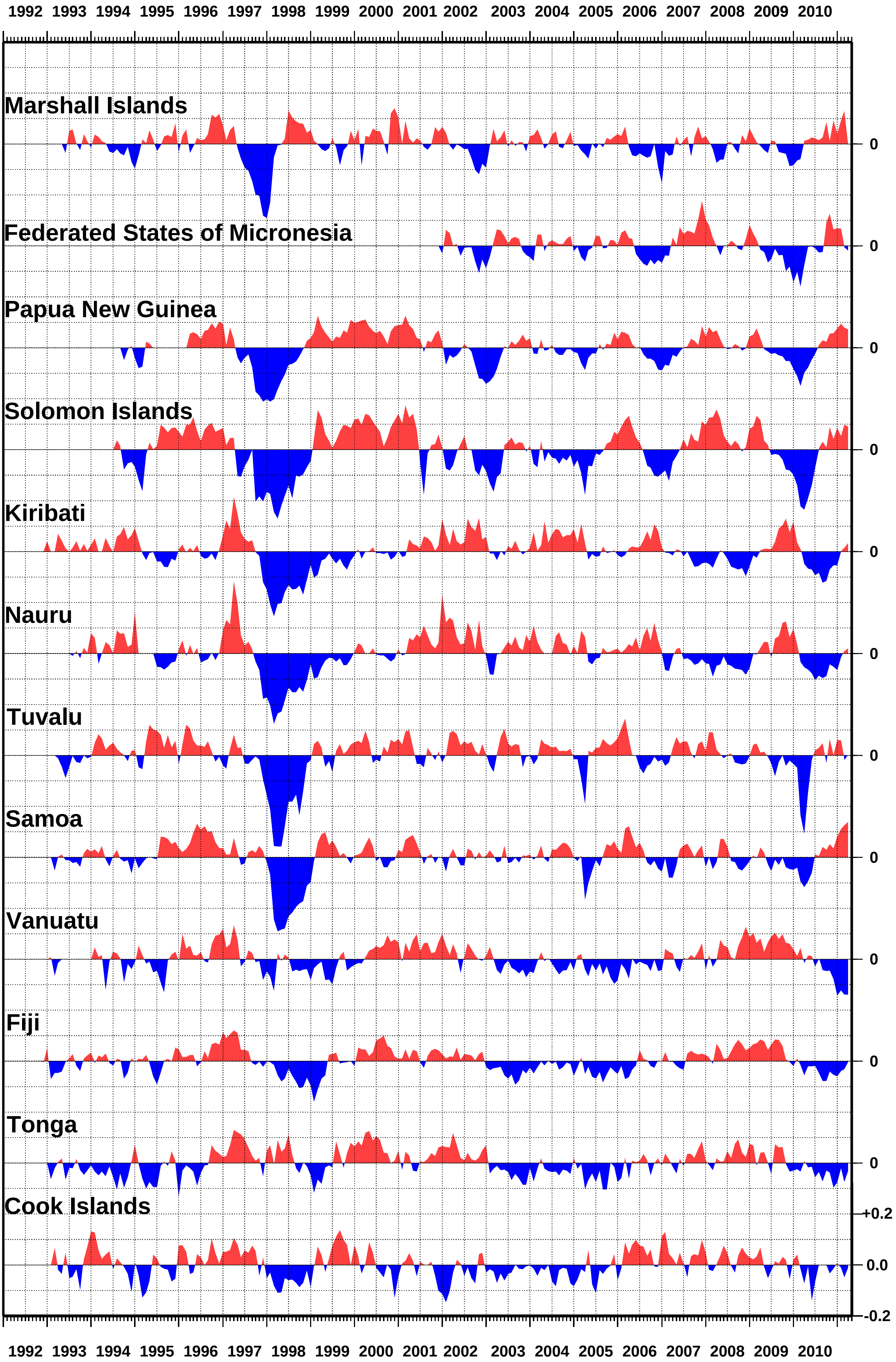


Figure 13

SEA LEVEL TRENDS THROUGH MARCH 2011 (mm/year)

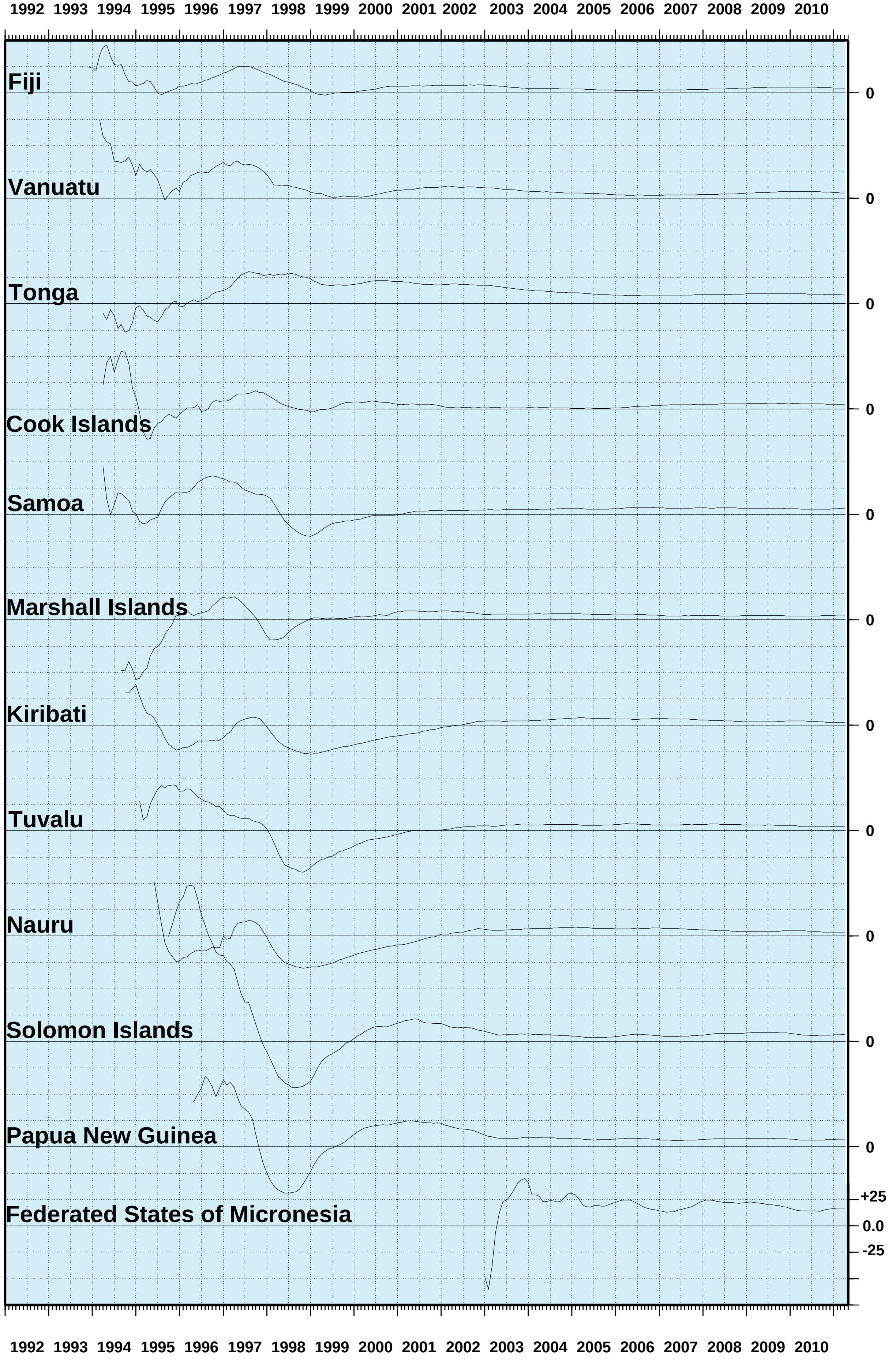


Figure 14

BAROMETRIC PRESSURE ANOMALIES THROUGH MARCH 2011 (hPa)

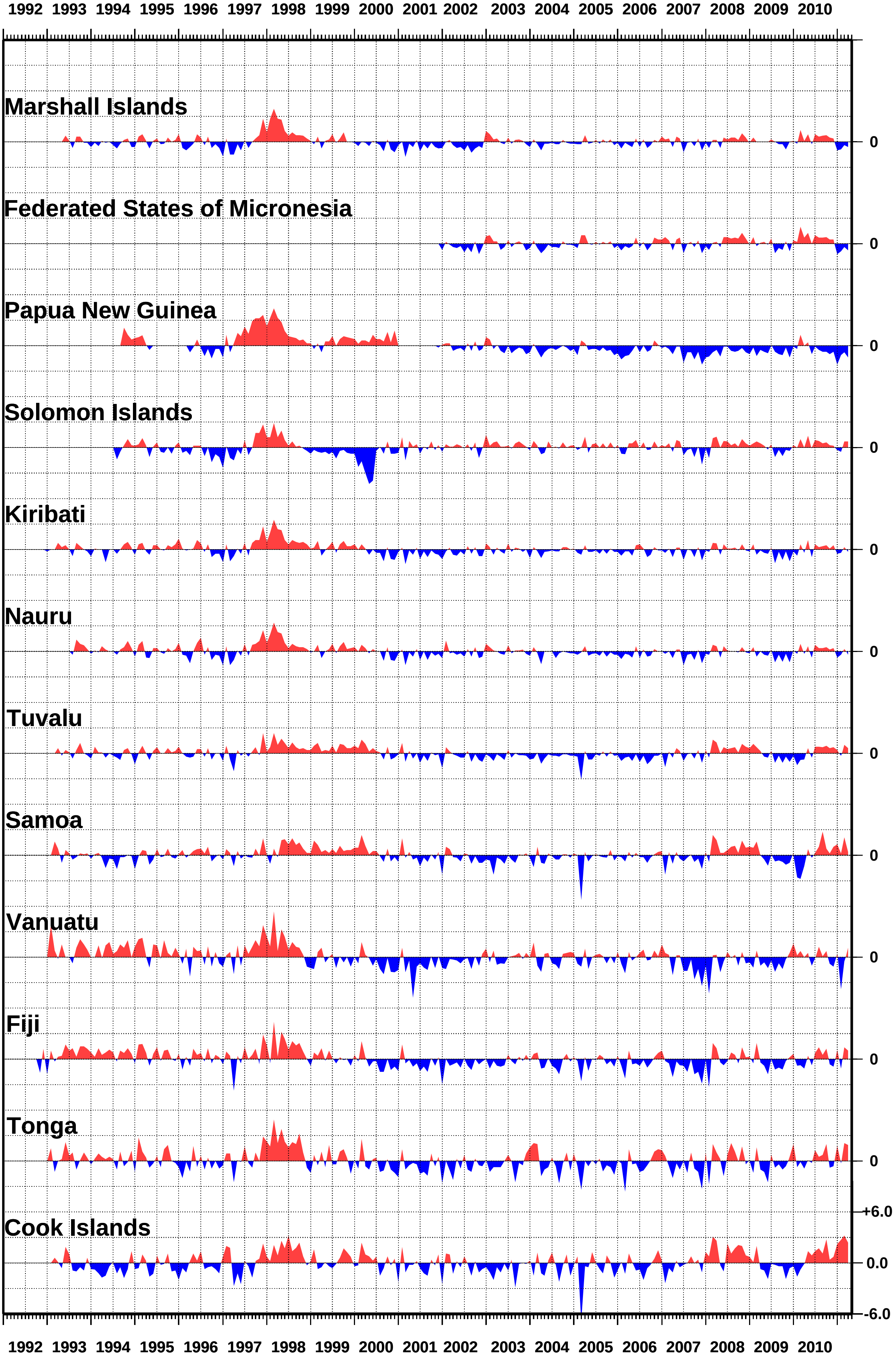


Figure 15

WATER TEMPERATURE ANOMALIES THROUGH MARCH 2011 (˚C)

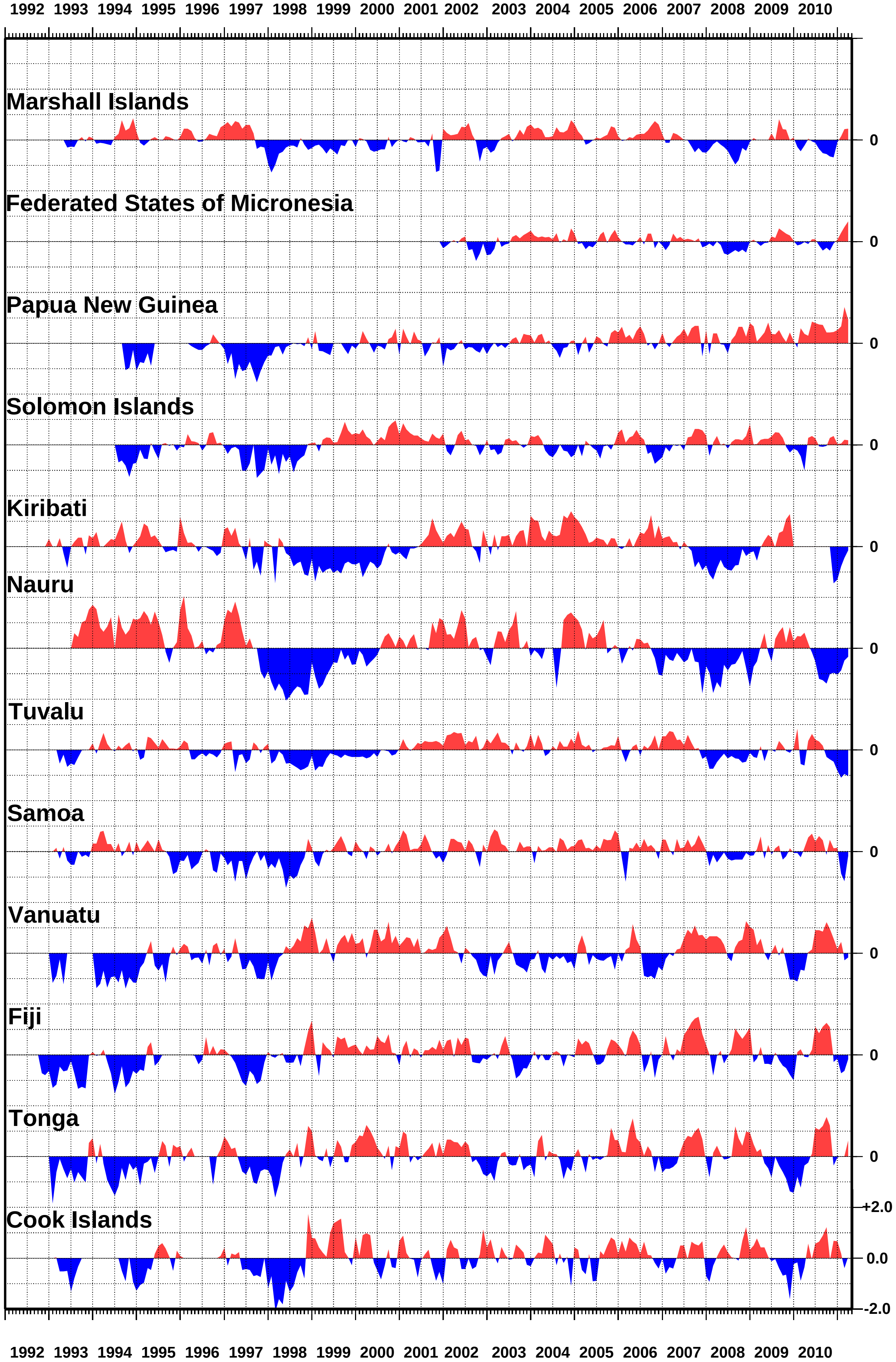


Figure 16

AIR TEMPERATURE ANOMALIES THROUGH MARCH 2011 (˚C)

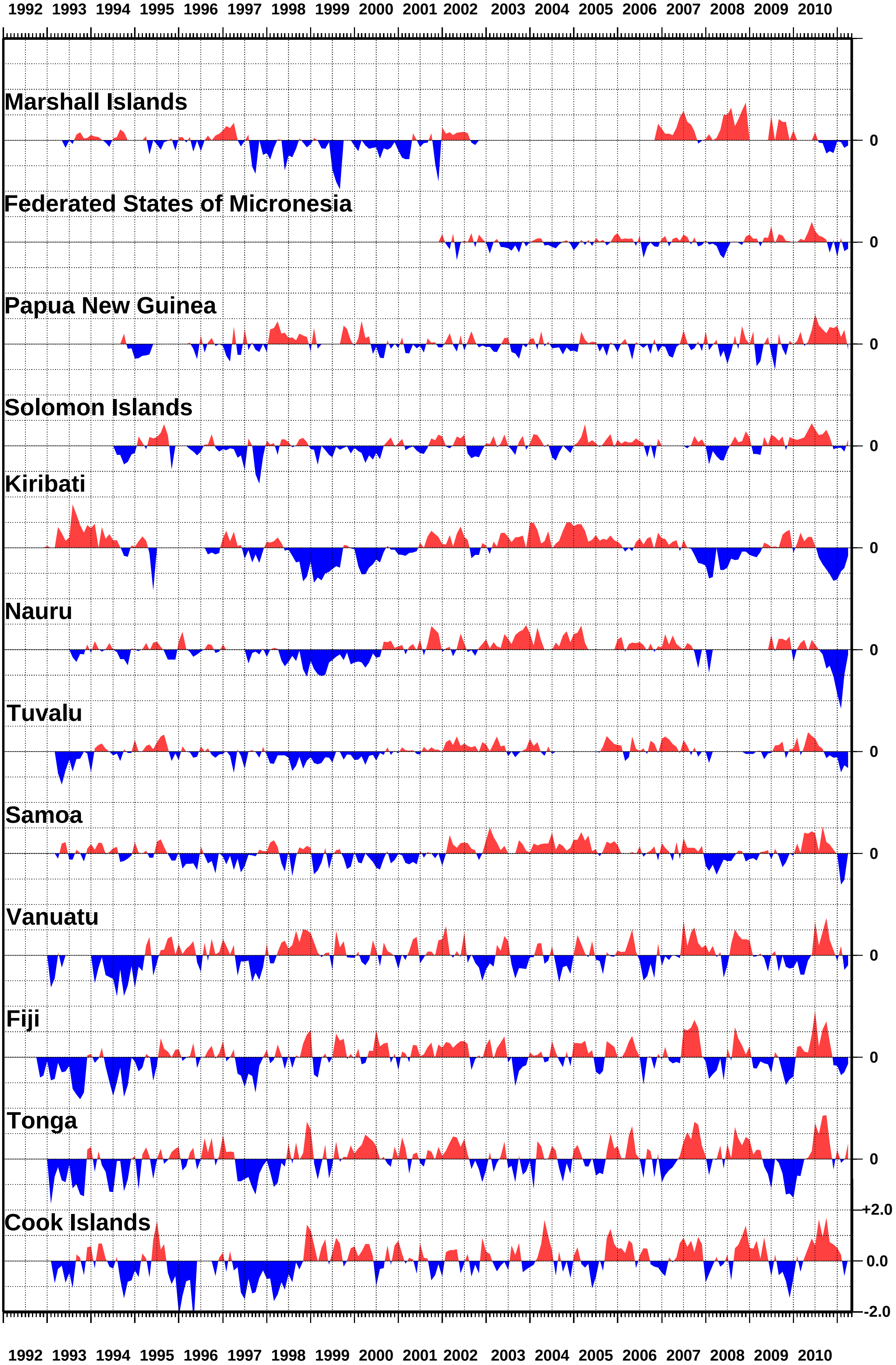


Figure 17

SEA LEVEL DATA RETURN

THE NUMBER OF DAYS OF GAP ARE INDICATED

GAPS INCLUDE TRANSMISSION, POWER AND LOGGER FAILURE

* Patchy record