Vanuatu Coastal Adaptation Project (V-CAP)

AWS Installation - Report on project completion

Prepared for Vanuatu Meteorology and Geo-Hazards Department

August 2017, revised November 2017

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Executive summary

The Ministry for Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management, Government of Vanuatu, contracted NIWA (The National Institute of Water & Atmospheric Research Ltd.) for the 'Supply, delivery and installation of Automatic Weather Stations (AWS) in six different locations in Vanuatu' (SC G02).

This work supports the Adaptation to Climate Change in the Coastal Zone in Vanuatu (V-CAP) project, funded by the Global Environment Facility, implemented by UNDP and the Vanuatu Ministry for Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management.

The overall goal of the project was to enable the Government of Vanuatu to develop improved climate information and early warning services for the people of Vanuatu, particularly in vulnerable coastal areas of the country.

The project was implemented during December 2016 to September 2017, in collaboration with the Vanuatu Meteorology and Geo-Hazards Department (VMGD), and achieved the following outcomes:

1. Vanuatu's climate network has been enhanced with the installation and commissioning of six new AWS that provide automated (near real-time) data capture and assimilation to VMGD data management systems. The network enhancement has increased VMGD's capability to monitor and analyse weather and climate risks in near real time, and to issue timely warnings and advisories to mitigate impending risks and improve community and enterprise resilience.

2. The climate network enhancements and allied data transfer processes have strengthened Vanuatu's Climate Early Warning Systems (CLEWS) – which is now a fully operational, 'end-to-end' system that ensures a continuous data lineage from data capture to the issuing of decision support information to users.

3. A new climate analysis and information software suite, CliDEsc, has been installed as part of the CLEWS, to generate products and information to support data quality assurance, climate analysis, and sector-focussed decision-support services.

4. VMGD technical staff have been provided laboratory and field experience and training, and are now capable of installing and maintaining automatic weather stations and associated telemetry and data ingest systems on their own, while occasional back-up support from NIWA can be negotiated if needed.

5. Discussions that were held with key government and enterprise sectors in Vanuatu – Agriculture, Health, Tourism, Marine, Hydrology and Energy – identified climate information needs that can be met by CLEWS operational services, and as a result of this project, VMGD climate staff now have additional capability to develop and deliver this information.

1 Introduction

The Ministry for Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management, Government of Vanuatu, contracted NIWA (The National Institute of Water & Atmospheric Research Ltd.) for the 'Supply, delivery and installation of Automatic Weather Stations in 6 different locations in Vanuatu' (SC G02).

This work supports the Adaptation to Climate Change in the Coastal Zone in Vanuatu (V-CAP) project, funded by the Global Environment Facility, and implemented by UNDP and the Vanuatu Ministry for Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management.

The work aligns with the **Vanuatu Framework for Climate Services** developed in 2016[1], and builds on the data management capability provided through the CliDE (Climate Data for the Environment) database, developed by the Australian Bureau of Meteorology.

The overall goal of the project was to enable the Government of Vanuatu to develop improved climate information and early warning services for the people of Vanuatu, particularly in vulnerable coastal areas of the country.

Specific deliverables of the NIWA Contract focussed on assisting the Vanuatu Meteorology and Geo-Hazards Department (VMGD) to enhance near real-time management of climate and hydrometric data, and improve the functionality of the Vanuatu Climate Early Warning System (CLEWS). Under the Contract, NIWA has introduced several specialist technologies that significantly enhance Vanuatu climate data integration and management, particularly the NEON and DataToCliDE telemetry and data mapping systems, and the CliDEsc (CliDE services client) data analysis and product generator suite, as well as other allied services. An outline of the CliDEsc system is given in Section 5 of this document.

The VCAP project implementation included requirements to:

- Build and install automatic weather stations and provide VMGD staff with relevant training;
- Install telemetry systems to manage real time data transfer and integration with the existing VMGD climate data archive (CliDE) ;
- Assist VMGD to enhance data management and quality assurance processes;
- Develop and install climate data monitoring and analysis tools;
- Work with VMGD staff to develop sector-customised reporting services.

1.1 Previous VCAP-related reports

A series of reports, user guides, and technical documents have been provided separately as part of the implementation of this project. These documents are referenced throughout this report and include:

[1] Vanuatu Framework for Climate Services. Prepared for Government of Vanuatu. Edit: Andrew Tait. SPREP 2016

1. Contract Proposal – a proposal document outlining much of the preparatory technical scope of the project and an outline of equipment specifications, presented in July 2016.
2. VCAP Project Progress Report 1 [Porteous et al., 2017a] – a summary of the project planning meeting between VMGD and NIWA during 29 November to 2 December, 2016. The report contained agreed work plans and timelines, and confirmed technical specifications and the scope and timing of training for VMGD technicians.
3. VCAP Project Progress Report 2 [Porteous et al., 2017b] – a summary of project progress through to March 2017, including equipment preparation and training in New Zealand, hardware and software systems purchasing and installations at VMGD, and planning for the remote field installations in Vanuatu, including full kitting reports.
4. Workbook for the Climate Information and Services Design Workshop, Port Vila, May 2 2017 [Porteous and Ungaro, 2017a] – this Workbook was prepared to facilitate identification of information needs with the VCAP-prescribed sectors, including Agriculture, Health, Hydrology, Energy, Marine, and Tourism.
5. VCAP Sector Workshop Report [Porteous and Ungaro, 2017b] – a summary of information requirements defined by the participants at the Information Services Design Workshop held on May 2, and from follow-up interviews with officials from six sectors.
6. AWS Installation Report, Mission 1 [Flanagan, 2017a] – a summary of the AWS installations at Aneityum, Whitegrass and Lamap in May and June, 2017.
7. AWS Installation Report, Mission 2 [Flanagan, 2017b] – a summary of the AWS installations at Longana and Norsup, July 2017.
8. Automatic weather stations operations manual [Harper and Gorden, 2017] – a core technical reference for the installation, operations, and maintenance of the AWS network, including the telemetry system. The manual includes sensor descriptions and specifications.
9. Synop and METAR coding guide [Miville, 2017] – a guide for managing automatic message coding from the AWS, manual QA, and message preparation for the WIS/GIS.
10. CliDEsc User Guide [Porteous et al., 2017] – the main printed reference document for the CliDEsc product catalogue, and documentation for CliDEsc administration, with similar content to the CliDEsc on-line user guidance.
11. Vanuatu Climate Networks and Operational Services: Workbook for Operational Competencies [Porteous and Harper, 2017] – a reference training guide compiled by NIWA for climate and hydrology early warning system field technicians. The Workbook provides a step by step, task-based, modular training system, backed by WMO guides for technical procedures and competencies, and workflow guidance for CLEWS technologies. The Workbook is in on-going development.
12. DataToCliDE [Hill and Manson, 2017] – document describing the software (called DataToCliDE) which maps the incoming AWS data to the CliDE database. The software supports user access to manage controls over data channels and data range checks.

1.2 Project Implementation timeline

The NIWA VCAP Contract for Services was implemented from November 2016 through to September 2017. A log of key activities during the implementation period is provided in Appendix D of this report.

A summary timeline of project delivery milestones is shown in the table below.

Date	Milestone
July 2016	Presentation of Proposal to Vanuatu Ministry of Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management
October 2016	Contract signed; assembly of equipment commenced
28 November to 2 December 2016	Pre-installation workshop, Port Vila
23 January to 17 February, 2017	Instrument and telemetry training for two VMGD field staff in Christchurch
20-24 March, 2017	Installation of telemetry and CliDEsc product generator servers at VMGD, CliDEsc1
2-3 May 2017	Sector services and information design workshop, VMGD
15 May to 10 June, 2017	AWS installations Aneityum, Whitegrass, Lamap
30 June to 15 July, 2017	AWS installations, Norsup, Longana
31 July to 11 August 2017	CliDEsc upgrade and training, CliDEsc2
12-16 August 2017	Installation of Sola AWS by VMGD team Initialisation of SYNOP and METAR automated messages coding
18-22 September 2017	Final CliDEsc2 and product suite upgrade and training for VCAP climate staff Presentation of draft of Final Implementation Report

The present document is the **Final Implementation Report** for the NIWA VCAP Contract for Services (updated from an earlier Draft Report presented in September 2017). This report provides a complete summary of the project implementation.

Section 2 of this report provides an outline of the Climate Early Warning System structure and main functions.

Section 3 briefly describes the preparation of the AWS equipment, development of the AWS sites in Vanuatu, the data transfer and ingest technology and procedures, and how the observations can be viewed in near real time. A time-log of activities undertaken during the field installations and data integration work is given in Appendix D.

Section 4 covers additional data integration into the VMGD data management processes, and briefly describes work done to integrate data from sources other than the VCAP AWS sites. The Section also outlines the procedure for automatically generating and processing Synoptic and Metar messages– this procedure is covered fully in a separate document [Miville 2017].

Section 5 describes the product generator software suite CliDEsc, and provides example products that support data quality management, and climate analysis, and that can be used to support decision-making to manage climate risk.

The training provided to Government of Vanuatu staff as part of the project is outlined in **Section 6.**

The **Appendices** to this report provide a range of ancillary information covering installation and training activities, and a complete kitting (equipment) list of hardware provided at each AWS site.

2 VCAP 'End-to-end' Climate Early Warning System (CLEWS)

Under the VCAP project, the planned delivery of timely climate information and early warning services to the people of Vanuatu required an 'end-to-end' system of data capture, integration and processing, and the customisation of data products to be delivered by VMGD to meet sector needs. In the Pacific, this end-to-end structure is typically referred to as a Climate Early Warning System, or CLEWS.

A generalised schema for the CLEWS in Vanuatu is shown in Figure 2-1. Successful implementation of the system requires robust and uninterrupted data flow from the AWS (left of figure) through the telemetry system to storage on a secure archive (the CliDE server), and data processing to produce decision support tools and information to be disseminated from an information interface or 'Information Hub'.

Figure 2-1 illustrates in general form the flow of data through the connected processes of capture and final dissemination as products and services. Data are captured at remote stations [1] and are transferred via satellite or government broadband [2] and network services [3] to a central server [4] that maps the data to the **CliDE data archive** [5]. The **CliDEsc product generator** [6] draws data from CliDE and from other web services [13] and creates customised products for a range of user interests and requirements as part of VMGD services provided through its information hub [7,9]. VMGD staff [8] have access to all nodes in the data process and are responsible for successful operation and maintenance of the system.

The NEON telemetry system handles data transfer via the BGAN satellite network as a back-up service in case of loss of service in the Vanuatu Government network. VMGD weather forecasters [15] can monitor near real time weather observations via IP services, and by using the NEON and other customised dashboards (see Section 5).

By agreement with the Water Resources Department in Vanuatu, as an optional service, the Tideda Server [4] can push or exchange data with Vanuatu's remote hydrometric data store [11], in order to develop and provide joint climate and hydrometric information and early warning services for Vanuatu.

At the request of VMGD staff and as a supplement to the VCAP project implementation, NIWA developed and installed a process for automatically coding AWS data into Synoptic and METAR reports [Miville 2017], which is accessible for editing and manual extension of the message code [14] before submitting to the WIS/GTS. This allows manual synoptic observations to be added to the AWS-sourced coded messages, for example cloud height (see also Section 4-4 below).

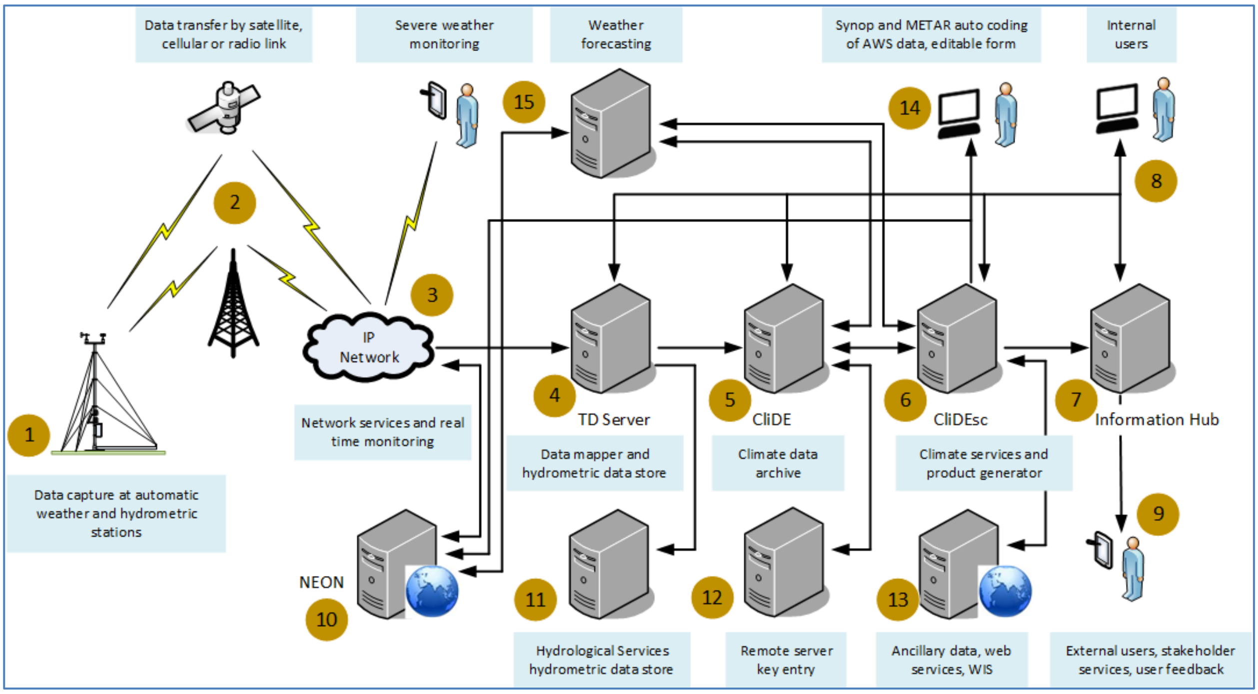


Figure 2-1: CLEWS generalised schema illustrating the flow of data from capture (left) to the dissemination of information services (right).

While the CLEWS in Vanuatu is configured to the particular needs of VMGD, similar systems have been deployed in other Pacific Island nations and elsewhere, thus optimising the opportunity for shared learning and transportable tools for data analysis and information services.

3 Field installations, data capture and display

Automatic Weather Station (AWS) hardware was assembled in Christchurch, New Zealand during December 2016 and January 2017. Two staff from VMGD assisted with instrument assembly, calibration, and station construction, as part of a comprehensive technical training programme [see Activities Log Frame, Appendix D, and VCAP progress reports, Flanigan 2017a, 2017b].

Following training and instrument assembly, the equipment was packed in a container and shipped to Port Vila, departing from Christchurch 22 February and arriving in Port Vila on 19 March 2017.

The NIWA implementation team first arrived in Port Vila on 21 March and worked with VMGD staff for two weeks on preparing for the AWS installations, and carrying out further training for VMGD technical staff (see training activities listed in Appendix C).

Installation at the six sites was conducted during three field missions – (i) 10 May to 15 June, (ii) 30 June to 15 July, and (iii) 12 to 16 August. The first two missions were supported by NIWA technicians, while the installation during the third mission was completed by VMGD staff. Full reports of Missions 1 and 2 are provided in VCAP Installation Reports 1 and 2 respectively [Flanigan 2017a, 2017b].

On commissioning of each station, documentation was completed for each AWS location by NIWA and VMGD staff, ready for uploading to the CliDE station registration, file repository and metadata pages. Example station documentation is shown in the AWS Operations Manual [Harper and Gorden, 2017], and includes the following:

1. Site description including key text descriptions and site plans
2. Photographs showing 360 degree views to record site aspect and exposure, and all equipment installations
3. Siting classification based on WMO guidelines
4. Annual inspection protocols
5. Wiring diagrams

A typical key-directional site photograph showing Whitegrass AWS is shown below (Figure 3-1).

The new AWS were assigned unique WMO numbers to enable the observations to be encoded in Synop and METAR reports and provided to the WMO Information System (WIS). A full description of the automatic coding procedure is given in the Synop and METAR Automatic Coding Document [Miville 2017].

Figure 3-1: Whitegrass Airport AWS looking NNE.

3.1 AWS site locations

The focus of the AWS locations was to supplement meteorological observations, and support community resilience, in low lying coastal communities. The new AWS will enable more systematic analysis of coastal weather risks and provide data for improved planning of risk management, such as drought, extreme rainfall and flooding.

The six automatic weather stations installed under VCAP are indicated by the labelled sites in the map below (left panel). In all cases the stations are co-located with pre-existing manually operated sites in order to provide continuity (or overlap) of data observations. The pre-existing manual (synoptic) sites are shown in the right-hand panel below.

The CliDEsc software, in a process called Station Chaining [see CliDEsc User Guide, Porteous et al. 2017] allows users to link the new AWS to the existing manual sites to provide a continual (integrated but not homogenised) data record using data from the adjacent locations respectively.

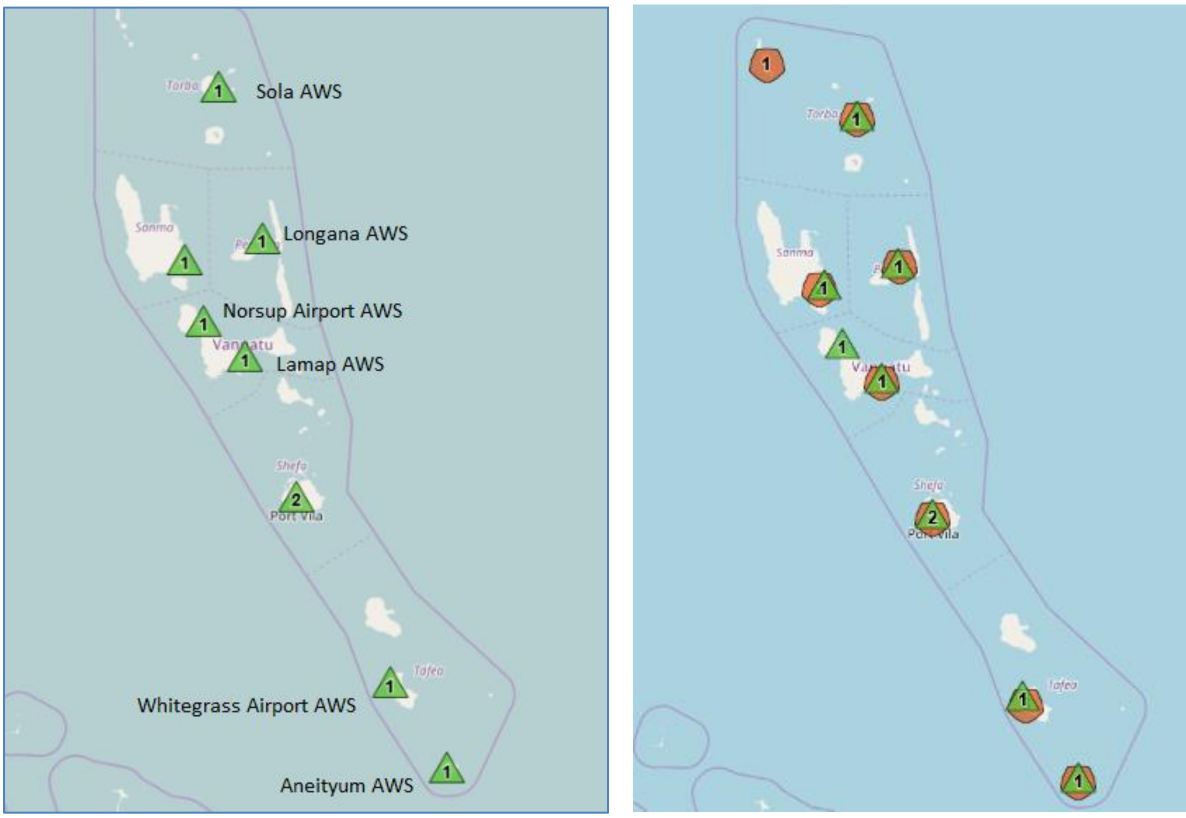


Figure 3-2: Locations of new AWS installed under VCAP (left panel). Orange symbols in the right panel indicate the co-located manual reporting sites.

3.2 AWS data transfer

Data from the AWS network are pushed via the Vanuatu Government Telecom infrastructure as the primary link, and internet protocols to the NEON telemetry server and TDClient server to the CliDE data archive. The NEON Remote Terminal is a small self-contained unit which connects to the automatic weather station sensors, logs readings from them and transmits the data to a central server via satellite or cellular telephone network. For a more detailed description of the data transfer see Harper and Gorden [2017].

The DataToCliDE system is installed on the Tideda server (illustrated below), and translates the AWS data into native CliDE format and pushes the data to the CliDE archive ingest process. DataToCliDE provides initial Quality Assurance checks, such as range checking of the AWS data to eliminate extreme outliers (such as data spikes); the range checking settings can be managed by VMGD staff. See the DataToCliDE documentation for further information [Hill and Manson, 2017].

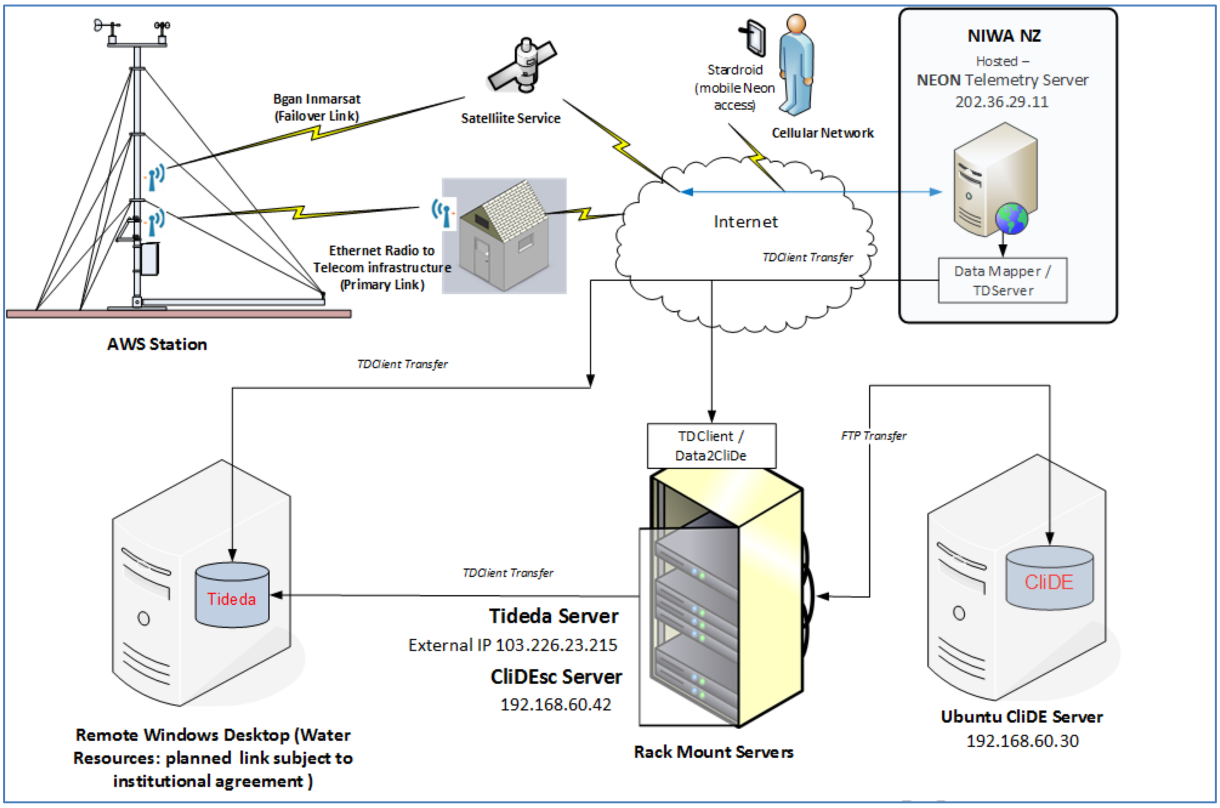


Figure 3-3: Schematic view of CLEWS system hardware data connectivity. The BGAN Inmarsat telemetry system provides back-up data transfer, managed by NEON telemetry, in the absence or failure of the primary telecom link. This service is currently provided from New Zealand. A stand-alone NEON telemetry node in Vanuatu (not shown in this figure) is an option for future development.

3.3 Viewing the AWS data

There are several options for viewing the AWS data in near real time.

3.3.1 NEON dashboard

The NEON system allows the Ethernet NRT to push logged data from the data logger at various user defined intervals, in this case 10-minute, to a web based system which allows the user to view logged data in near real time, as is illustrated below. All data are stored on the NEON web server and the data are accessible using the NEON web interface. Login details for NEON services are approved and provided through VMGD.

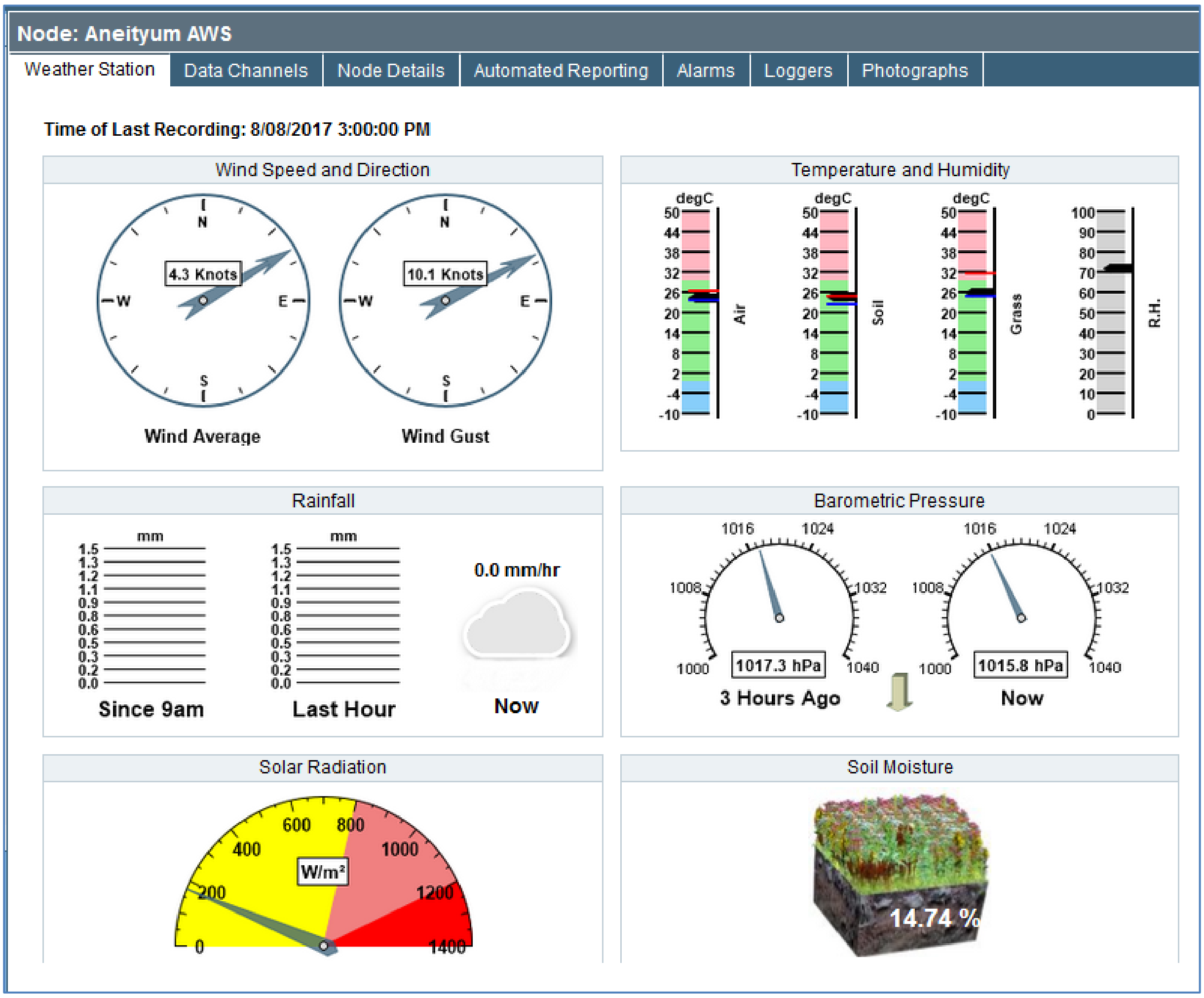


Figure 3-4: NEON dashboard for viewing near real-time data.

3.3.2 Combined AWS site dashboard

A combined dashboard display for the VCAP AWS sites has been set up which draws data from an intermediate data file refreshed regularly by the NEON server. An example display for four sites is shown below, and available at the following *internal* VMGD network link:

http://clidesc.vmgd.gov.vu/clidesc/MetData/gauges_niwa.php

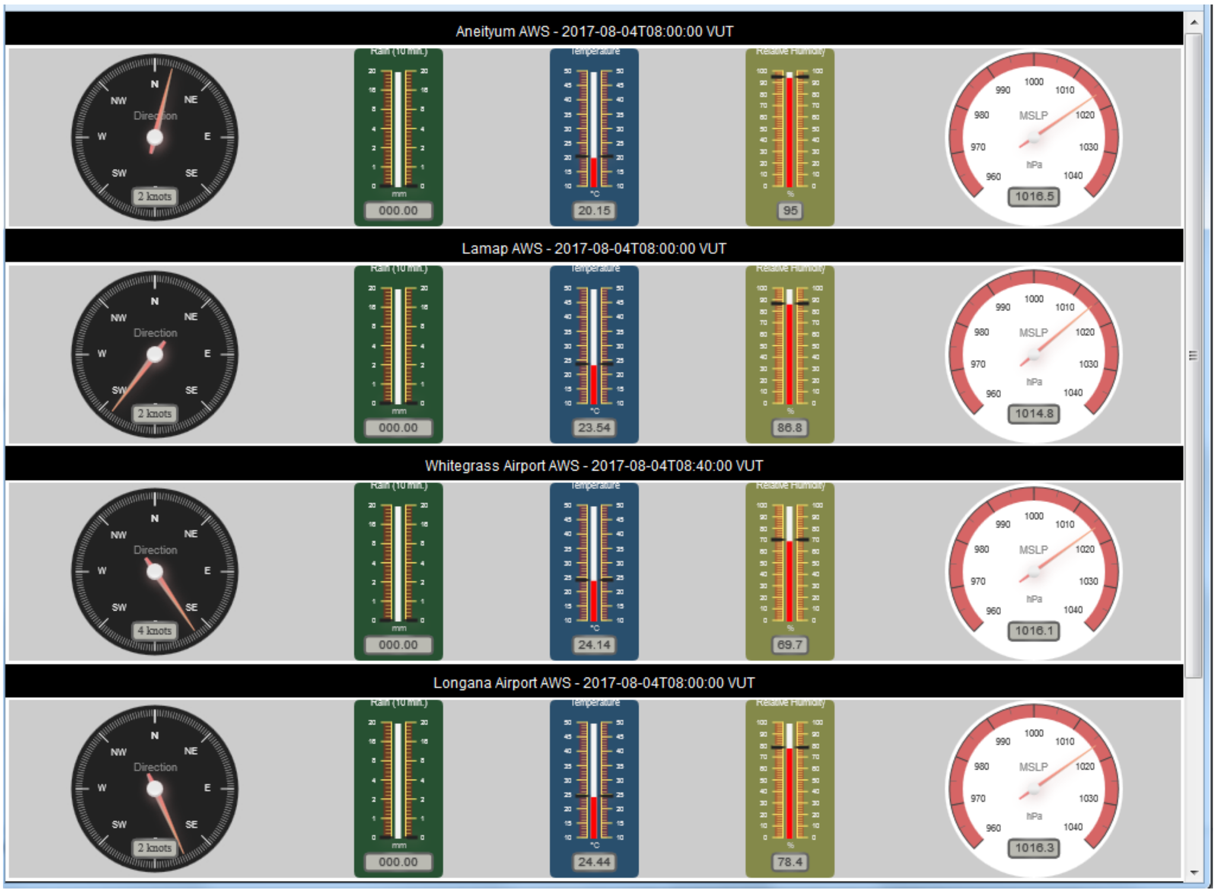
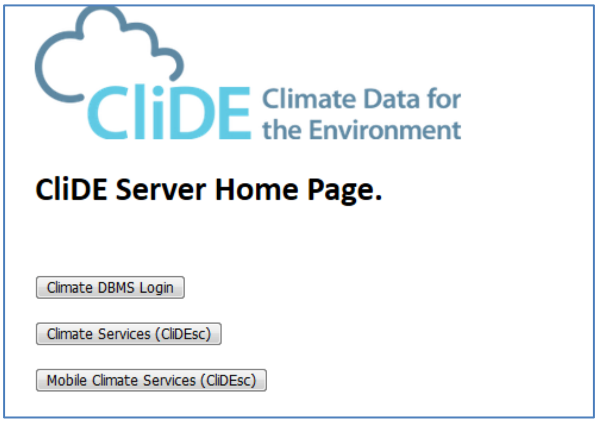


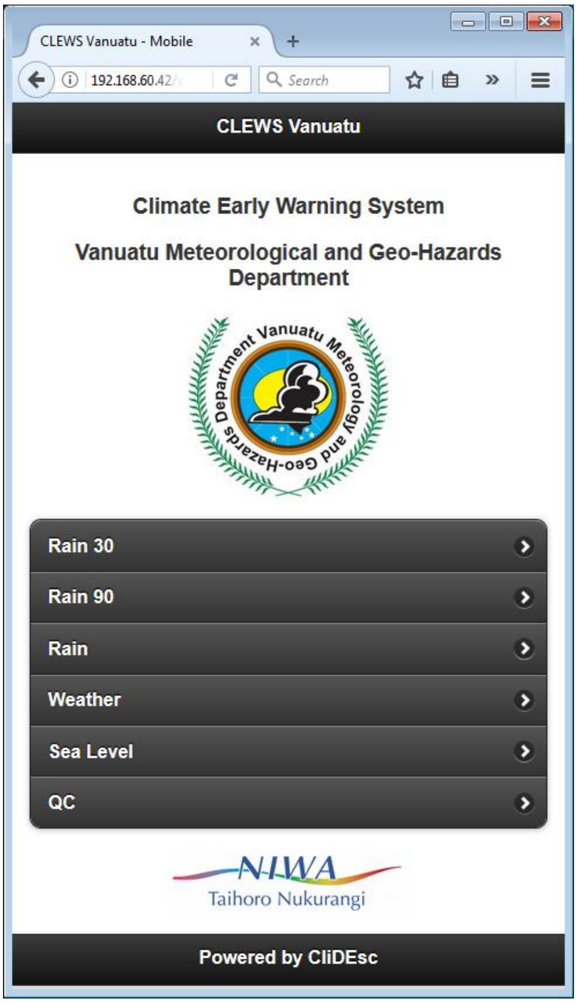
Figure 3-5: A combined dashboard display for the VCAP AWS sites.

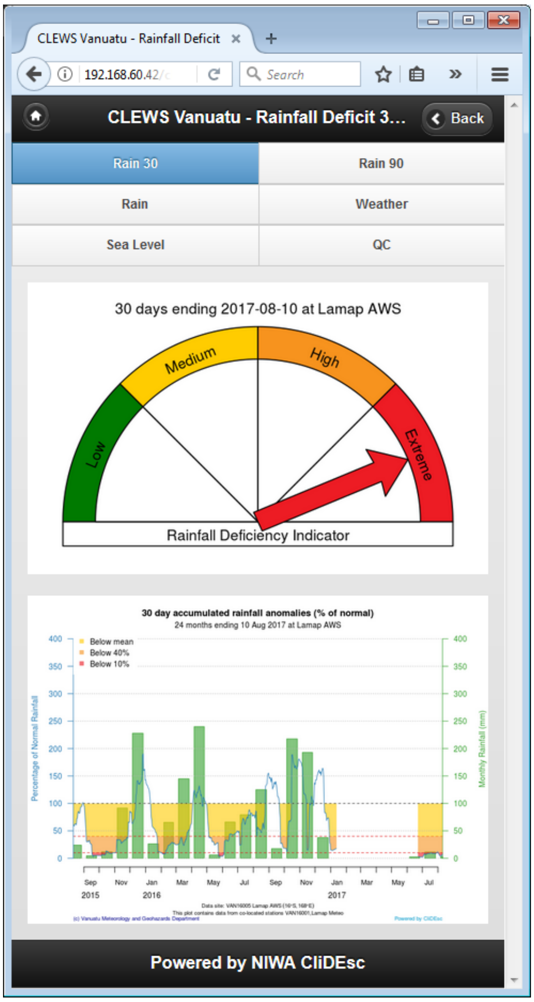
This is a temporary display that has been set up to meet immediate viewing needs. A more purpose-built dashboard can be set up as a follow up to this project, to meet more specific VMGD requirements.

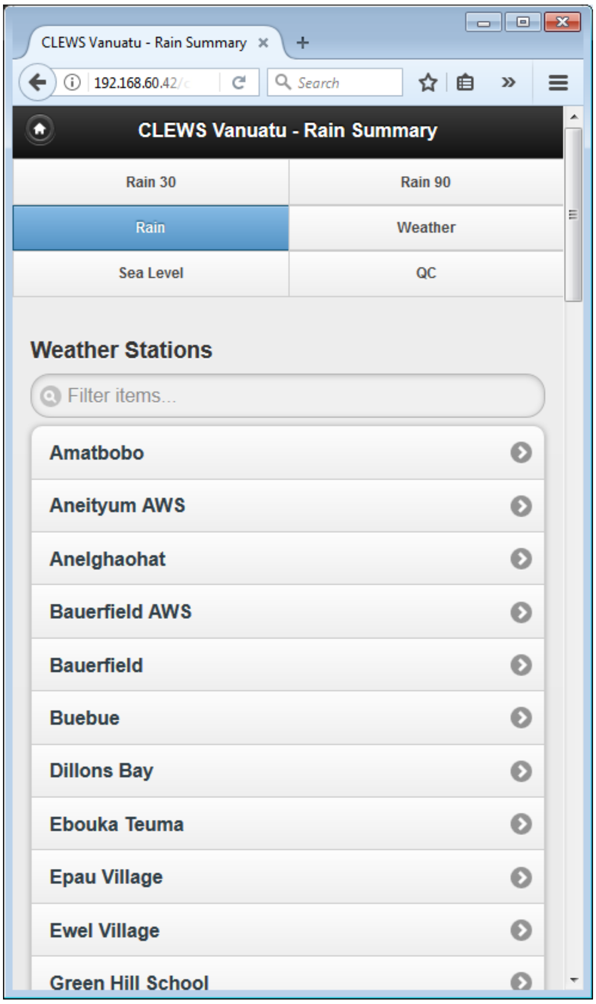
3.4 Mobile device web page

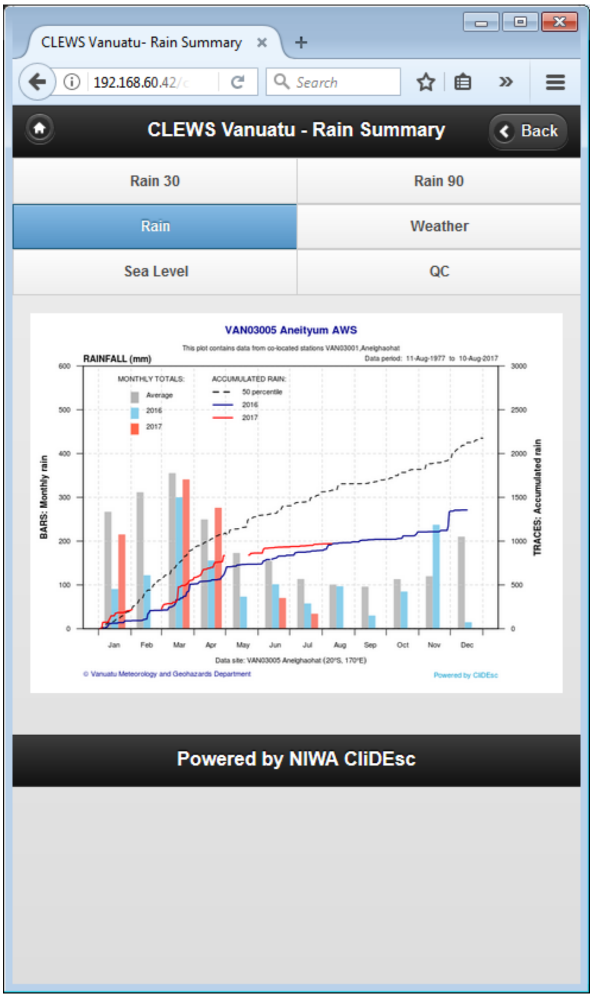
As part of VCAP, a prototype mobile device web site has been set up to display a range of different products coming from CliDEsc in a format suitable for the selected device. This can be viewed at the VMGD internal link http://192.168.60.30/ and selecting 'Mobile Climate Services (CliDEsc). Some screen-shots from the web site are given in the images below.








CLEWS Vanuatu - Rain Summary
192.168.60.42
Search
CLEWS Vanuatu - Rain Summary
Rain 30
Rain 90
Rain
Weather
Sea Level
QC
Weather Stations
Filter items...
Amatbobo
Aneityum AWS
Anelghaohat
Bauerfield AWS
Bauerfield
Buebue
Dillons Bay
Ebouka Teuma
Epau Village
Ewel Village
Green Hill School


CLEWS Vanuatu- Rain Summary
192.168.60.42
Search
CLEWS Vanuatu - Rain Summary
Back
Rain 30
Rain 90
Rain
Weather
Sea Level
QC
VAN03005 Aneityum AWS
RAINFALL (mm)
MONTHLY TOTALS:
ACCUMULATED RAIN:
BARS: Monthly rain
TRACES: Accumulated rain
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Powered by NIWA CliDEsc

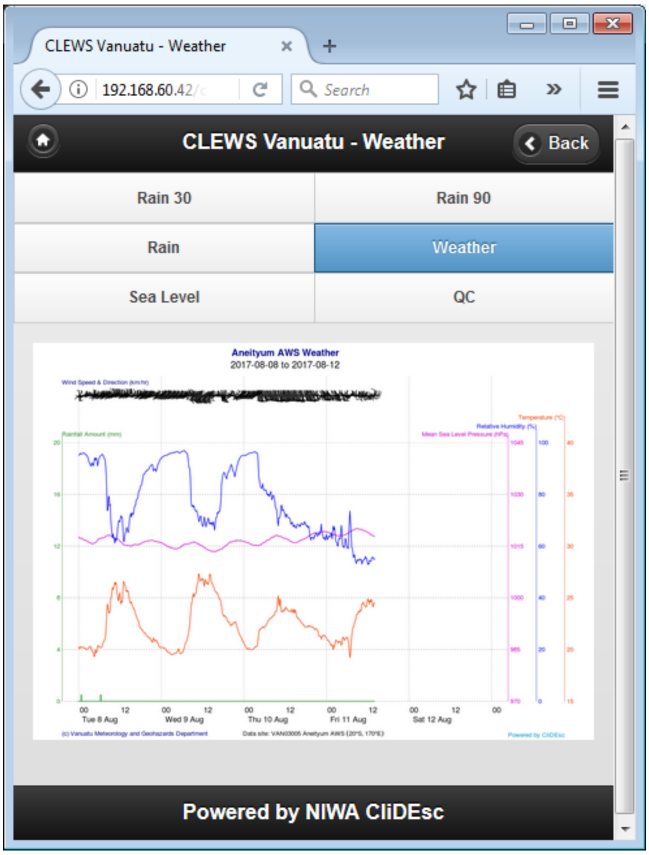


Figure 3-6: Example mobile device access to climate early warning products from the CLEWS.

4 Additional data integration

4.1 JICA stations

The JICA (Japan International Cooperation Agency) AWS 10-minute data are available on the MSS server as a csv file. NIWA has installed software to access the data on this server, carry out basic quality control, and push the data every hour to the CliDE obs_aws table. A series of sample files has been captured for further investigation and format testing. A basic dashboard has been set up by NIWA to display the data after archiving to CliDE, see the figure below (Figure 4-1).

JICA stations now auto-ingesting to CliDE are:

VAN07005 Bauerfield AWS, Efate
VAN25005 Pekoa AWS, Santo
VAN55301 Litzlitz Sea Level, Malekula
VAN55601 Lenakel Sea Level, Tanna

The real-time data display of JICA automatic weather station data can be found at the following VMGD internal network link:

http://192.168.60.30/clidesc/MetData/gauges_jica.php

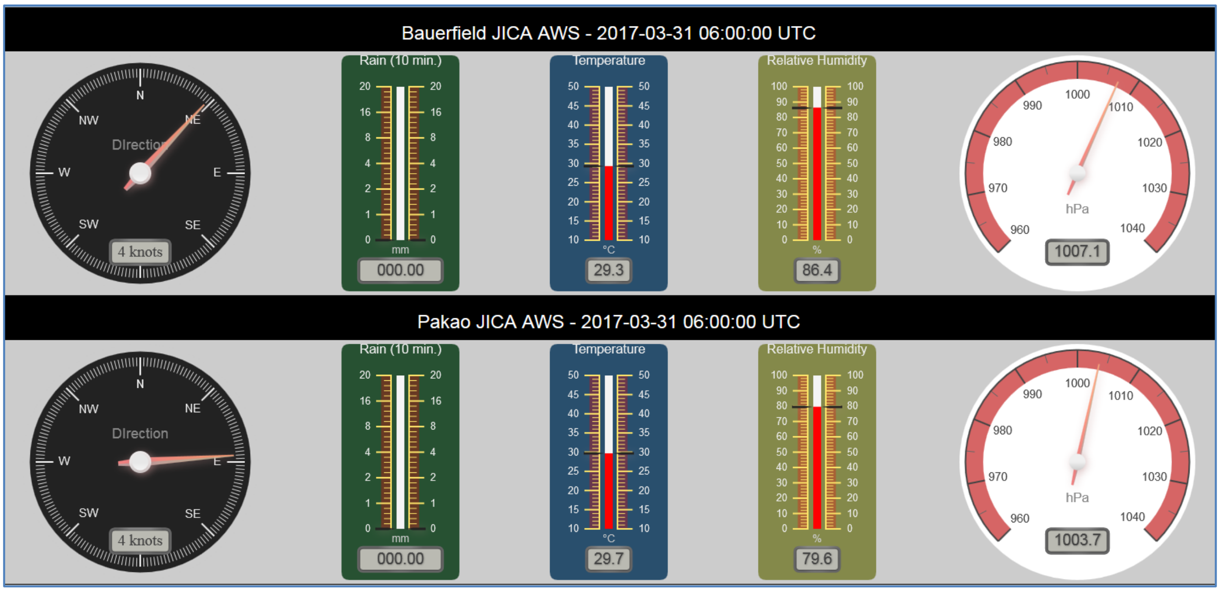


Figure 4-1: Near real-time weather dashboard display under development. This set is connected to the JICA server and will automatically refresh the display each time new data become available on the server (currently every five minutes).

The JICA station data can also now be displayed within CliDEsc using product generators that access sub-daily data, for example the Meteogram AWS product. An example of this product is shown below (Figure 4-2)

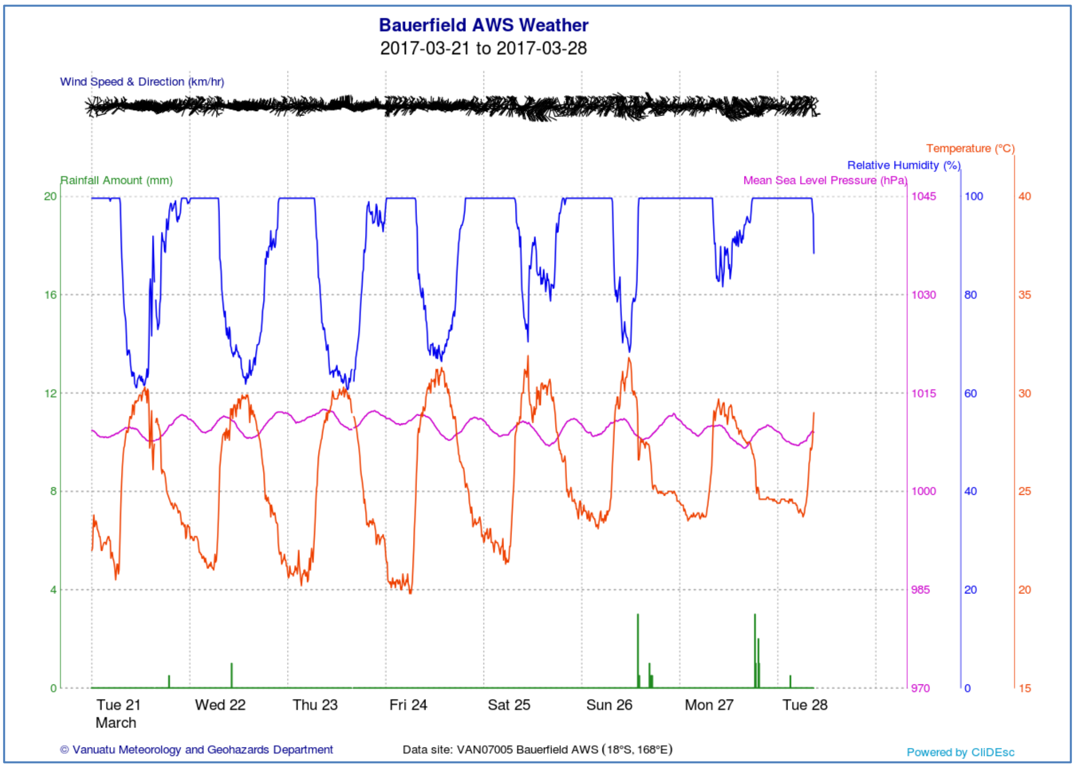


Figure 4-2: CliDEsc product showing 10-minute data from Bauerfield AWS.

4.2 National Oceanic and Atmospheric Administration (NOAA) Marine Data

The current version of CliDEsc includes a product to source sea surface temperature (SST) data from NOAA and visualise data for the Vanuatu region. Currently three maps are produced – average SST for the past day, 7 days, and 30 days. An example is shown in Figure 4-3 below.

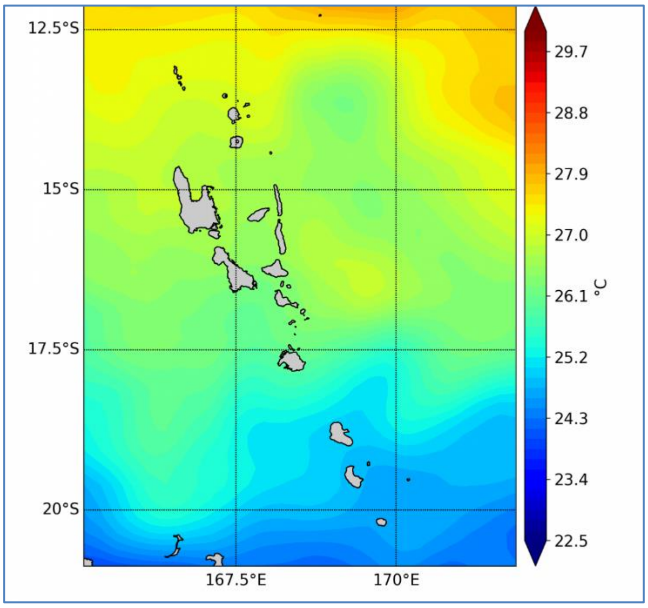


Figure 4-3: Sea surface temperature visualisation product for Vanuatu.

4.3 Bureau of Meteorology (BOM) Sea Frame station

At the request of VMGD staff, NIWA downloaded data for the Port Vila BOM sea-level station (station VAN07003) for 1993-2017 and ingested the data into CliDE. This process could be automated, allowing data to be automatically ingested in to CliDE in near real time in a similar manner to the above AWSs, subject to agreement between VMGD and the BOM.

A CliDEsc-generated display of a sample of the data is shown below (Figure 4-4).

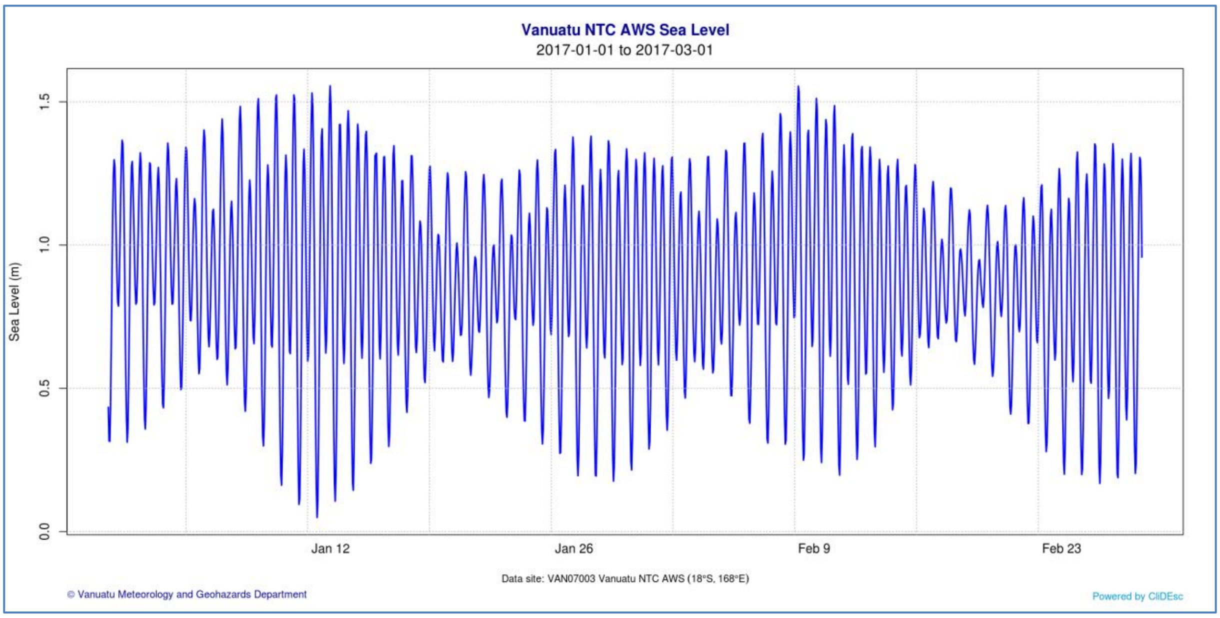


Figure 4-4: Sample sea level data for Vanuatu NTC sea-level station.

A quality plot of a sample of the data is shown in Figure 4-5. The figure shows wind and pressure changes during Cyclone Pam, March 2015.

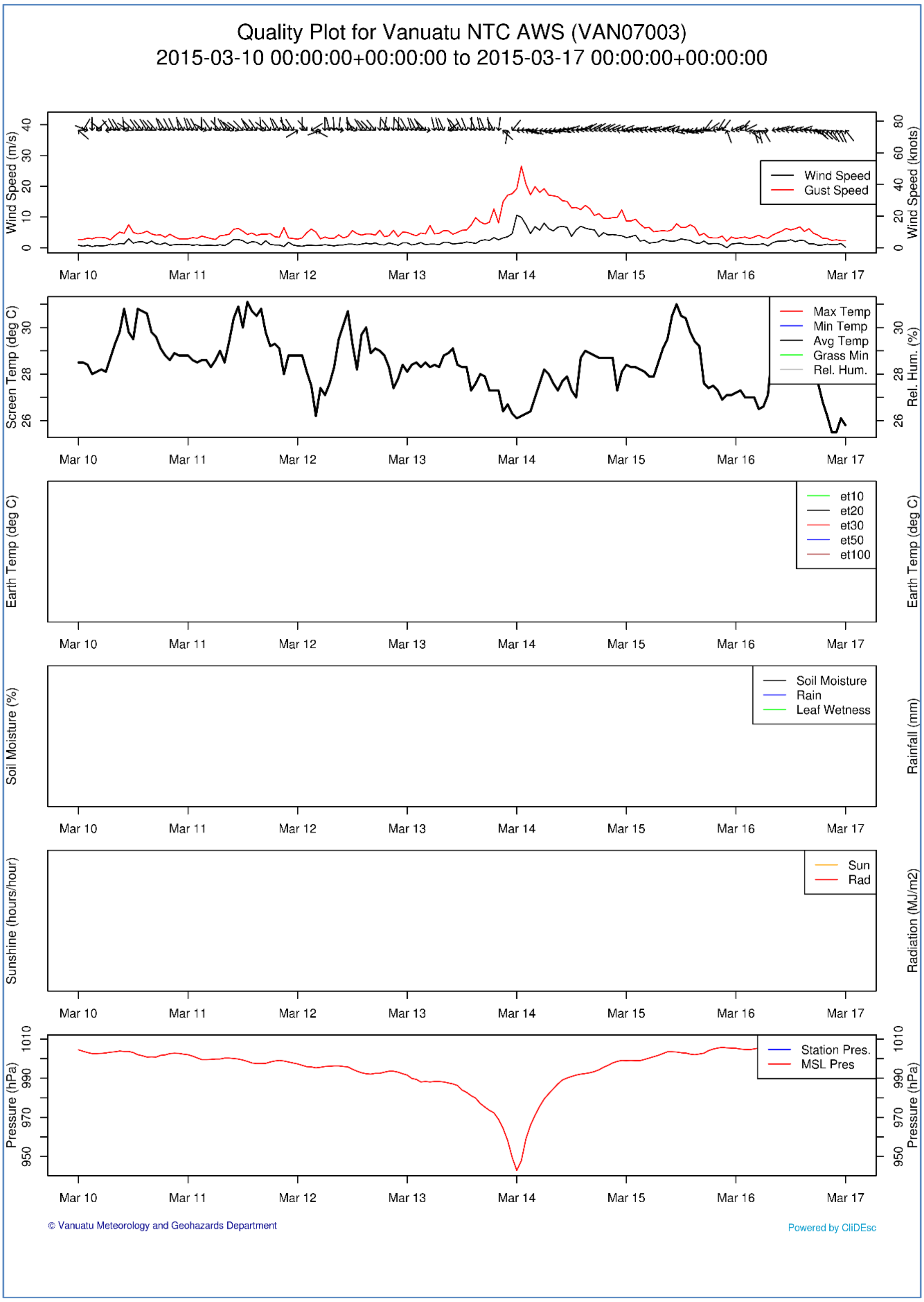


Figure 4-5: Plot showing sample time series of data from the NTC AWS. The bottom panel shows the impact of Cyclone Pam when the pressure dropped to 942.9 hP at midnight.

4.4 Synop and METAR automatic coding system

VMGD requested a web form to provide automatic pre-coded Synop and METAR messages for the newly installed NIWA stations. A web form was developed and installed at VMGD and training was provided.

The system will remove the need for staff in the field to call in their observations, saving time and potentially reducing the number of errors.

The web form is designed to pre-code the following messages:

- SYNOP both MANUAL and AWS
- METAR
- CLIMAT

It is expected that the system will be used by observers in the field and the quality control person at Bauerfield airport.

A technical document [Miville 2017] was prepared to describe how the system works and serve as a user guide for both the field staff and quality control person.

4.5 Rainfall data entry form

The VCAP implementation plan included support for the development of a data entry form to allow volunteer observers of daily rain gauge data to submit data via a mobile web form which will directly upload to CliDE. The data would be automatically quality assured by processes within the data entry form. Use of the form will require the observer to have access to the internet.

This remote entry procedure would overcome the delay in receiving rainfall data via field books, and eliminate the need for manual key entry of data from these sites.

The development of this form was delayed due to the above work (the automatic Synop and METAR coding development) taking priority. The form is currently under test and will be available for installation in a subsequent visit to Port Vila by NIWA technical staff. Additional training for VMGD personnel will be needed to implement the rainfall entry form.

4.6 Data sourced from web services

Data published in public web services in Vanuatu or elsewhere after often important sources of information that are useful to support monitoring of climate risk in Vanuatu. These sources include satellite imagery, available by agreement with image providers, and other internationally published data sets relevant to the Pacific region, such as sea surface temperatures.

An example data set, the El Niño-Southern Oscillation Index (SOI), is shown in Figure 4.6 below.

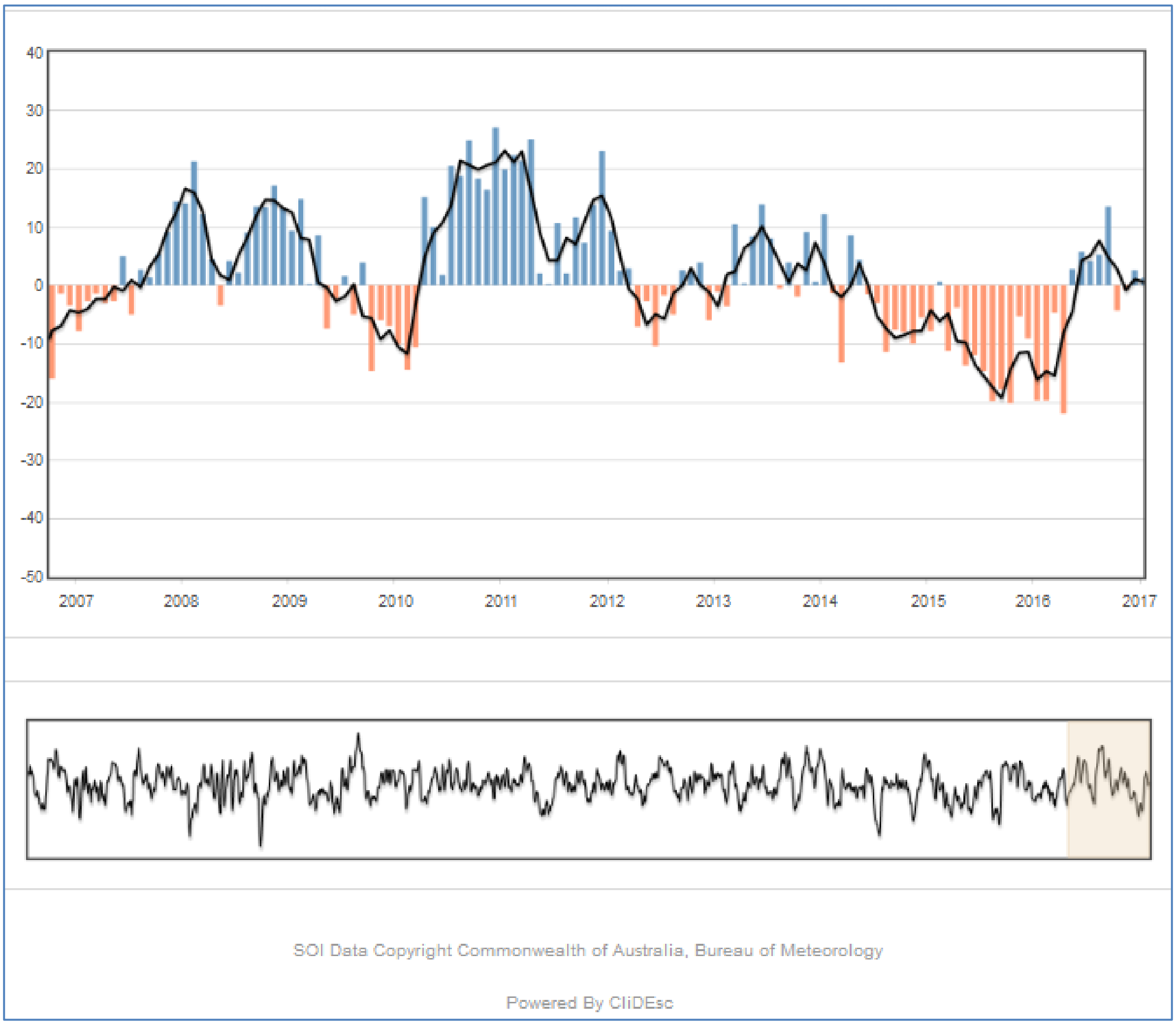


Figure 4-6: CliDEsc rendering of the Southern Oscillation Index time series, sourced from http://www.bom.gov.au/climate/current/SOIValues.txt. By dragging the mouse across the lower panel (in the CliDEsc user interface), any period of interest during the SOI time series can be selected.

A CliDEsc product can calculate the relationship between the three-month mean SOI and seasonal (3-month), as shown in the example in Figure 4-7 below. This calculation helps to indicate the reliability or '*weighting'* that can be applied to variations in SOI values, when estimating likely total rainfall for the next three months, given the projected value of the SOI.

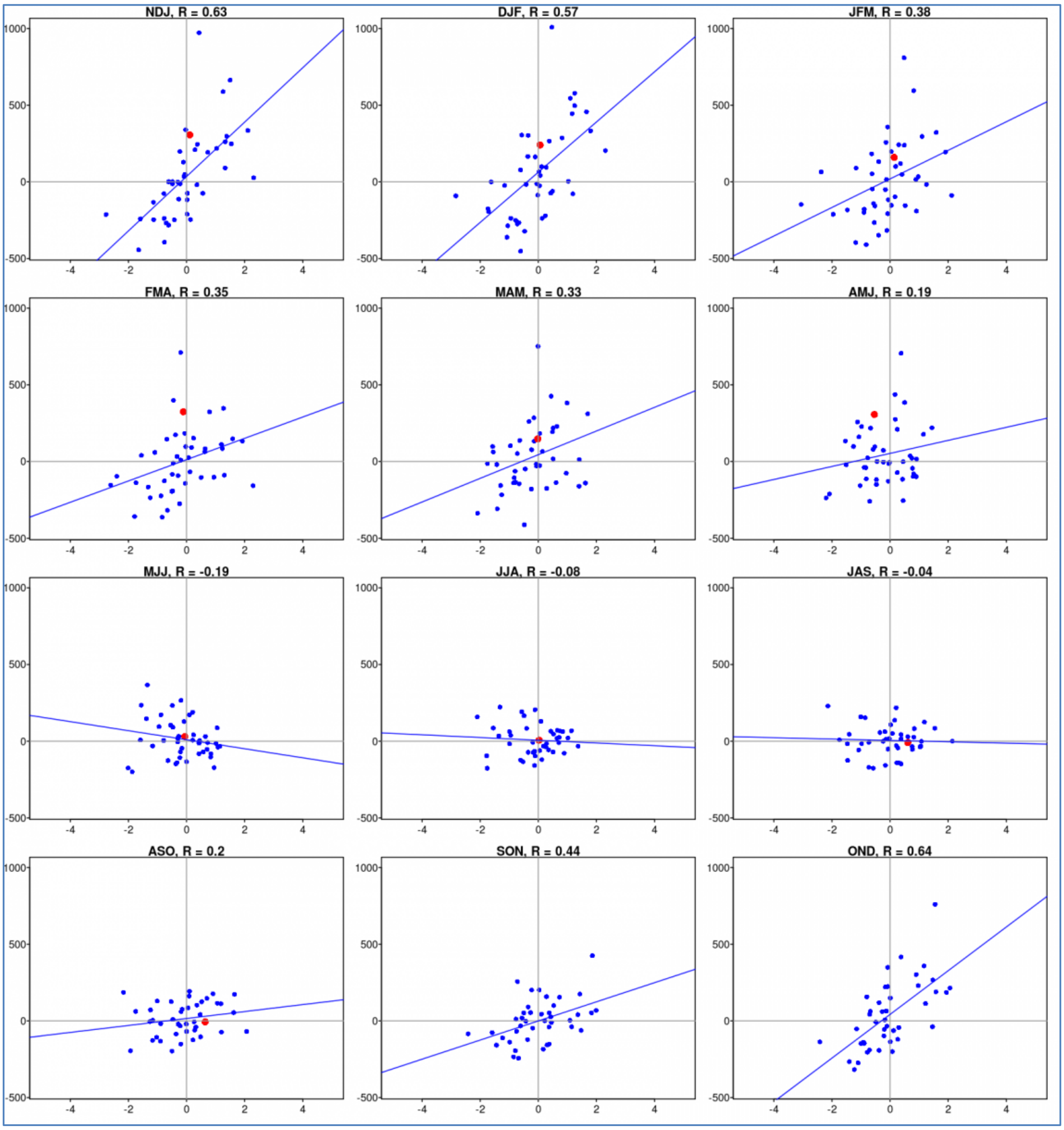


Figure 4-7: Correlation between 3-month rainfall total and the Southern Oscillation Index. The data show that the relationship is more closely correlated during the wetter months. Data for the current year are indicated by red dots.

5 Products and services generation with CliDEsc

During August 2017, an upgraded CliDEsc software suite was installed on a new rack-mounted, HP DL360 server located in the VMGD server room.

CliDEsc was originally developed in consultation with National Meteorological Services in Samoa, Fiji and Solomon Islands, and adapted for Vanuatu in consultation with VMGD climate services staff to meet the specific requirements of VCAP.

CliDEsc is a web based tool that allows end users to request data and products to be generated from a range of environmental observations and variables. CliDEsc provides systematic connectivity to the Vanuatu's national climate database CLIDE, developed by the Australian Bureau of Meteorology. It can also connect to other structured database management systems (for example the hydrometric database Tideda which is widely used in the Pacific), and to published web pages and other ancillary data repositories.

With the implementation of VCAP now completed, CliDEsc is now an integral part of Vanuatu's Climate Information and Early Warning System (CLEWS), and provides a User Interface to manage the 'many-to-many' connections required to:

- query data from multiple sources (CliDE and other databases, internal files and data structures, and data available through external web services)
- analyse and visualise data in time series, tables, and maps
- create customised, data-derived products to support specific decision-support needs
- disseminate outputs via a range of communication channels and web services

CliDEsc provides a logical platform for integrating data processing with data sources, thus avoiding the need to extract and manage work files in unconnected product processes.

In addition to the products that are already installed, the CliDEsc platform is designed for easy access by advanced users who are able to develop scripts for new product generators, and register them in the CliDEsc product generator system. Admin access is required – Admin level CliDEsc Documentation is provided for Admin users.

CliDEsc in Vanuatu is a stand-alone system, with its own authentication, user administration, and rack-mounted server. The content management system underlying CliDEsc was built by Catalyst IT, New Zealand, using the Silverstripe open source CMS.

The CliDEsc product generator application login page is internal to the VMGD local area network and is found at:

http://clidesc.vmgd.gov.vu/clidesc/

User authorisation is managed at the CliDEsc Admin level by the Manager of the VMGD Climate Section.

CliDEsc products are generated using data from CliDE, by sourcing data from public web-based data services, and from special data sets stored in CliDEsc internal files. Approximately 50 CliDEsc generator products are now installed, as listed in Table 5.1 below.

The generation of CliDEsc products is menu-driven at the User Interface. Users combine station and product selection to create time series and summaries of a range of data. Various products, including maps, use data from several or many stations.

5.1 Product categories

In discussion with Pacific Island climate staff, current CliDEsc products have been designed to meet a number of specific purposes that can be generally categorised as:

- Data quality assurance
- Seasonal climate monitoring
- Climate averages and characterisation
- Sector focussed product services
- Trial products under development

A list of the current products is provided in Table 5-1 below. Entries under 'Sector focus' indicate information identified by as important by representatives at the Sector Workshop held in Port Vila on 2 May, 2017.

Table 5-1: Current CliDEsc products listed by category of design purpose.

Category	CliDEsc product name	Sector focus
Quality assurance These products are designed to assist climate staff to identify incorrect or suspect data that may need correction.	Air temperature, raw maximum and minimum and XY plot	
	Meteogram AWS	
	Meteogram Synoptic	
	Quality plots, AWS	
	Rainfall, raw daily time series, and cumulative frequency tables	Utilities and infrastructure
	Rainfall, two station raw daily data	
	Station data range	
	Station location maps	
	Station type maps	
Seasonal climate monitoring These products monitor the daily and monthly climate of the current season compared to last year and the long-term average.	Air temperature, monthly average	
	Climate normals versus the current year	Agriculture
	El Nino-Southern Oscillation Index	Agriculture
	Radiation, daily	
	Rainfall, monthly	Agriculture
Sector focussed products These products were developed to inform sector users of observed climate parameters and summary data. They are examples of reporting the status of the current climate as the background and context for seasonal climate outlooks.	Climate guide, multi-site	Tourism
	Daily Summary of weather observations	Health, Agriculture (eg DSSAT model input)
	Interactive climate map – identified by	
	Map Days without rain (AWS and satellite observations)	Hydrology
	Radiation, daily	Agriculture
	Rainfall, daily accumulation	Agriculture, Hydrology, Energy, Marine
	Rainfall deficiency monitor – 30, 90, 180,365 days	Hydrology, Agriculture
	Rainfall deficit map – 30, 90 days	Hydrology, Agriculture
	Rainfall, 3-mth summary	Hydrology
	Sea level plot	Marine
	Sea surface temperature	Marine
	Soil water balance	Agriculture
	Wind rose analysis, AWS	Energy
	Wind rose analysis, Synoptic	Energy
Products under development Product ideas and prototypes that are used to explore formats to present information that is easy to understand and act upon – these	Drought summary	Agriculture
	Rainfall, percentage of normal, all sites, current and past year	Agriculture
	Report, Agricultural drought risk	Agriculture

Category	CliDEsc product name	Sector focus
product ideas need to be tested with users and refined based on user-feedback. These products are not complete and require further development before being used as part of sector services.	Rainfall outlook (product to combine climate observations and seasonal climate outlook	Agriculture, Health, Hydrology, Tourism, Marine
	House hold water consumption model	Hydrology
	Wind between thresholds eg 6 m/s to 25 m/s for efficient turbine generation	Energy
Climate averages and characterisation These products present long term averages, trends, and typical variability that characterise Vanuatu's climate at the observation sites.	Climate, long term averages	Tourism
	Climate normal graph	
	Climatology, probability tables	Agriculture, Hydrology
	Drought, monthly severity index	Hydrology
	Rainfall, annual anomaly	Energy
	Rainfall, Max 1,2,3-day falls	Utilities and infrastructure
	Water balance – potential evapotranspiration deficit	Agriculture, Hydrology

5.1.1 Quality assurance products

VMGD Climate Services staff are responsible for maintaining the quality of the climate data stored in CliDE. Both CliDE and CliDEsc have services to detect data issues and manage data quality. See the CliDE and CliDEsc documentation respectively for further information that can help with managing data quality.

A typical work flow to maintain data quality includes:

- Site and instrument maintenance and instrument calibration
- Managing the continuity of data communications, telemetry and transfer
- Managing the DataToCliDE extreme value range checking
- Implementing routine procedures to identify spurious data including quick data views
- Editing data in CliDE and completing associated quality flag fields
- Systematic data auditing of archived data

Many of these procedures are discussed in the Vanuatu Workbook for Operational Competencies [Porteous and Harper, 2017], and in the associated WMO guidance material.

CliDEsc provides a range of data time series and views to support discovery of potential data issues, such as the examples that follow. Their purpose is to ensure the archived data are of high quality so that products derived from the data can be used with confidence.

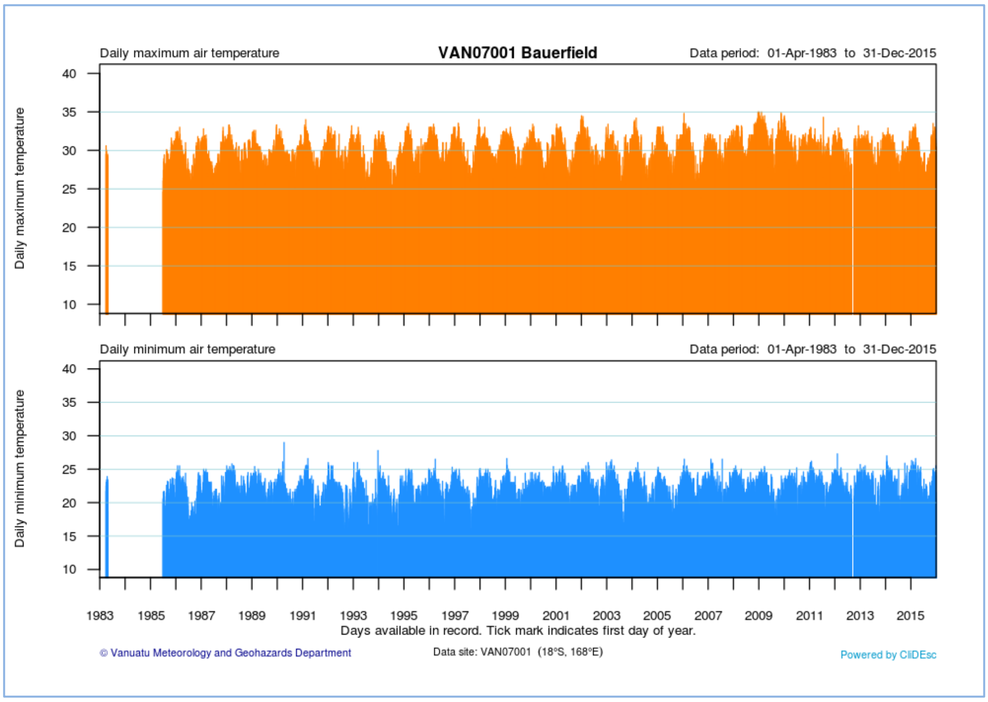


Figure 5-1: Example time series to display maximum and minimum air temperatures. The view makes it easy to identify outliers or obvious trends in the data, as a starting point for further investigation.

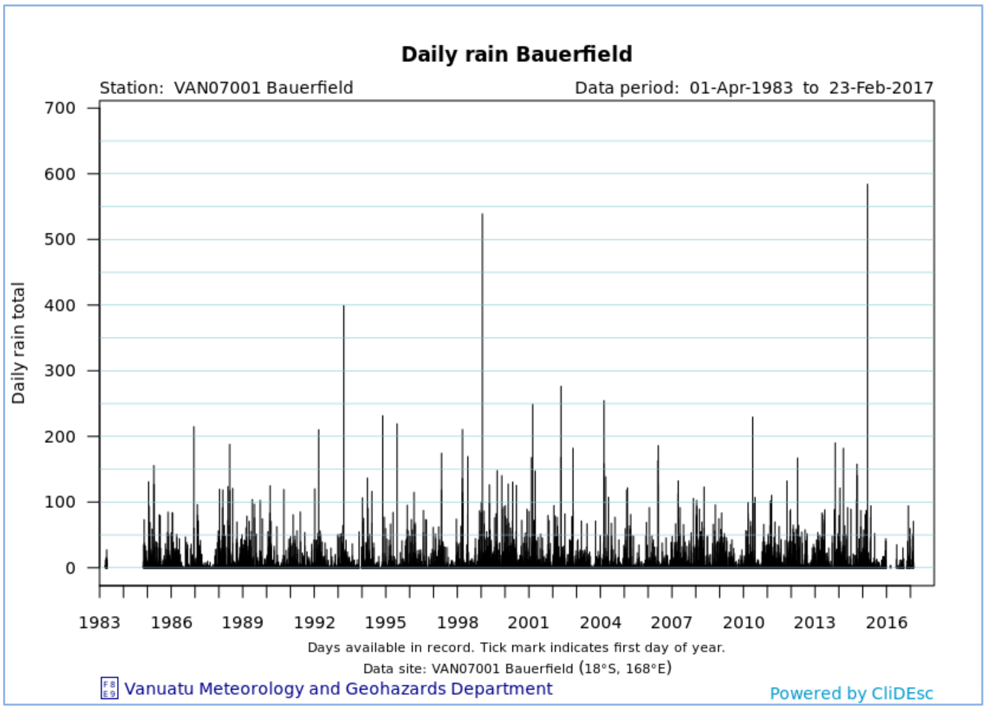


Figure 5-2: Example plot of daily rainfall totals for Bauerfield. The figure shows rainfalls that are unusually high, but may indicate accumulated totals that should be given a multi-day quality flag in the appropriate CliDE metadata field.

A further example product to assist with Quality Assurance is shown below. This product provides a weekly time series of data from all AWS sensors at a station, showing typical daily patterns across the week, and enabling easy recognition of potential data errors or other issues.

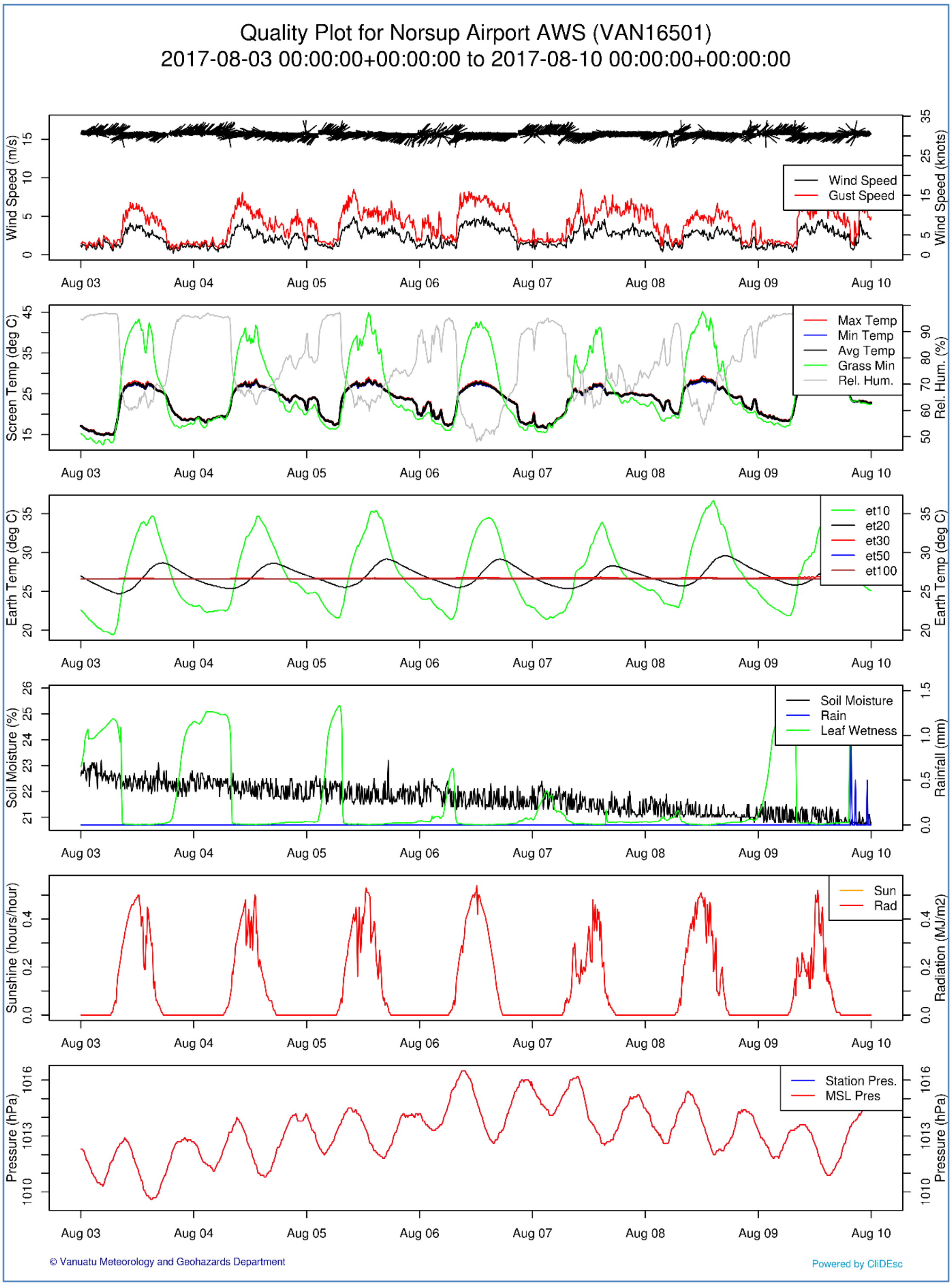


Figure 5-3: Quality assurance plot for Longana Airport AWS. The generation of this image can be on demand, or automated as needed to assist routine quality assurance activities.

5.1.2 Products to monitor seasonal climate

Daily monitoring on seasonal and annual time scales enables early detection of significant seasonal anomalies, such as differences from long term a, and from the same time in the previous year.

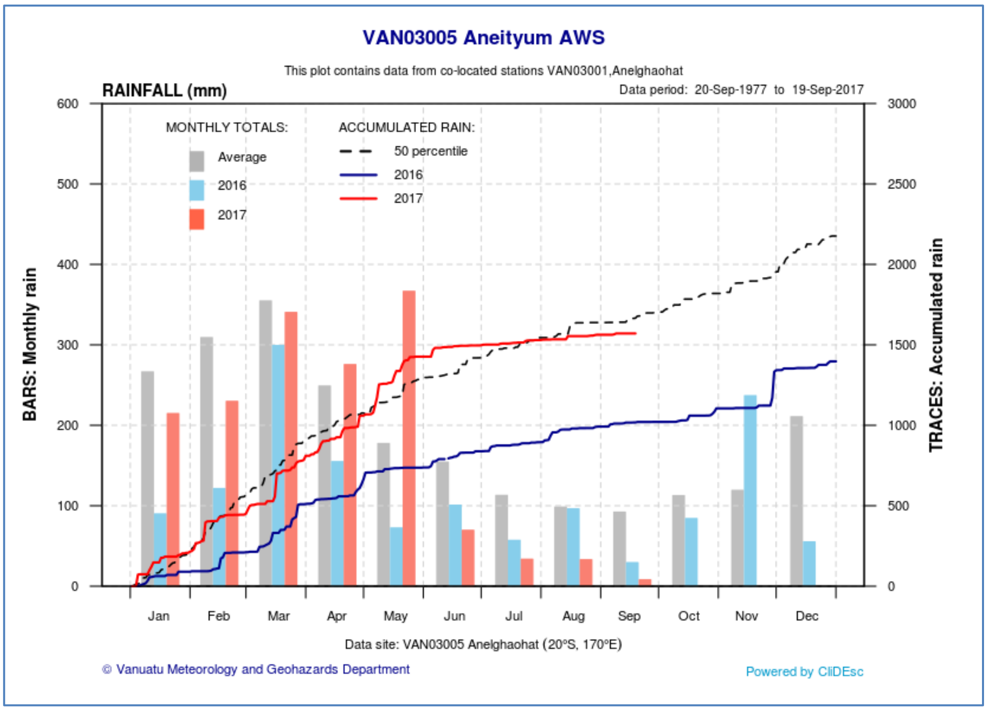


Figure 5-4: Plot of daily rainfall data showing the daily accumulated total during the year (traces) and monthly totals (bars). This product uses the station chain option to link the new AWS to a co-located manual site, thus providing a continual (although not homogenised) time series.

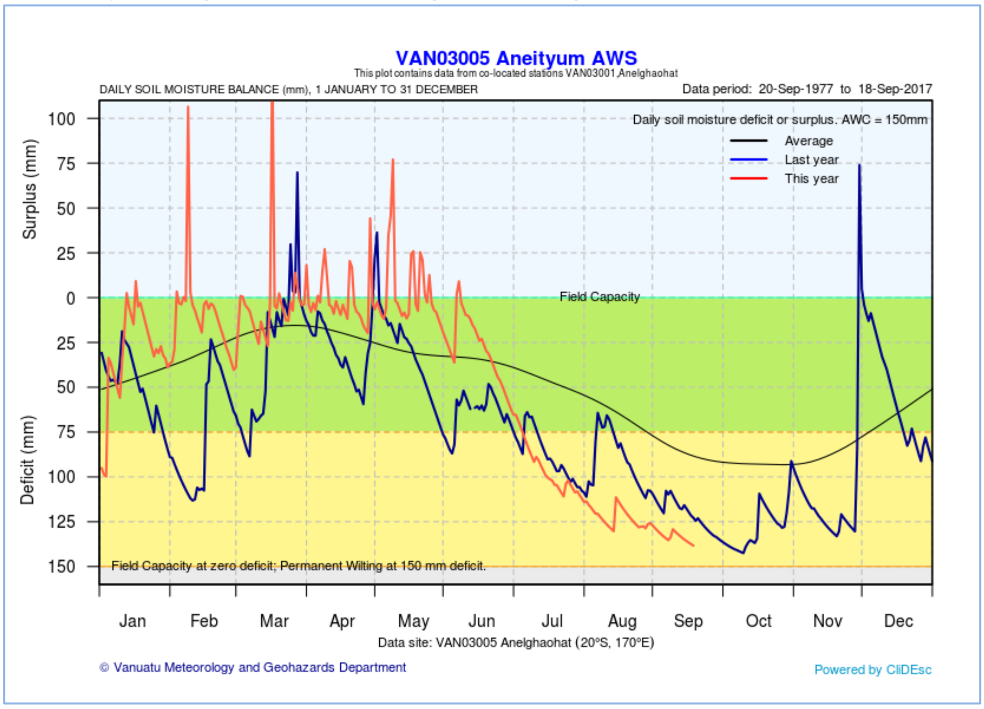


Figure 5-5: Simple soil water balance model indicating drier than normal conditions in the current season (red curve) since late June. The figure is an effective early indicator of the onset of soil dryness (drought), and provides a useful comparison of moisture deficit in a typical seasonal and for the previous year (blue curve).

5.1.3 Sector-based products to assist climate early warning information

Discussions with economic and enterprise sector representatives in Vanuatu identified a wide range of climate services and information that would be useful for managing climate as both a resource (eg the potential for energy generation from wind and solar radiation) and risk – such as the probabilities of extreme weather and adverse seasonal climate developments. Many of the current CliDEsc products that can assist with information like this have been developed and are listed in Table 5-1 above.

The figure below was developed in response to a request for information on the 'difference from normal rainfall for the past 90 days', as a measure of the risk of low water supplies in some parts of Vanuatu.

In the figure, the **green bars** indicate monthly rainfall totals, with amounts shown in the right-hand (green) scale. The **blue curve** represents a series of 90-day rainfall totals (as a percentage of the average) ending on each day of the two-year series eg., the point of the curve on the last date, 31 December 2015, indicates the 90 day total ending on that date as a percentage of the average total for that period for all other years of available data.

The areas of the curve below 100% of normal, and 40% of normal, as indicated on the left-hand scale, are shaded yellow and orange, respectively, and would show red below 10%. The three categories can be taken to mean 'drought watch', 'drought alert, and 'drought warning' or similar terminology respectively, and the anomaly thresholds can be adjusted as needed to meet drought planning and response requirements.

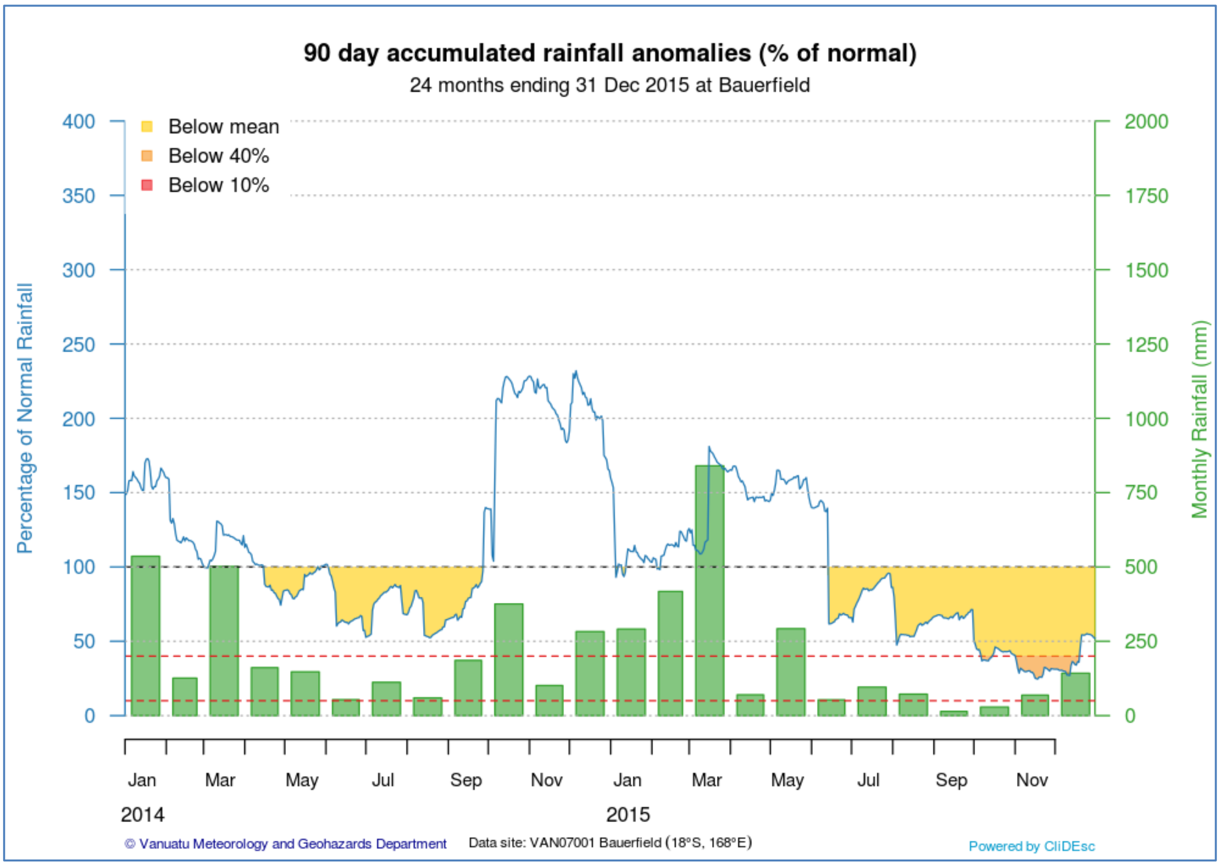


Figure 5-6: Example figure showing a daily time series of the 90-day rainfall anomaly from the long-term average. The figure shows that rainfall totals for 90 days ending during November and December 2015 were less than 40% of normal.

Figure 5-6 above is an example of a product that was developed to meet a request for early drought warnings, but which needs further testing with users to make sure it is easily understood, and refinement to ensure reasonable representation of what is happening in Vanuatu observing locations.

For example, are the thresholds for trigger warnings (40% and 10% of normal) appropriate and timely enough to enable effective response measures to be initialised? Is the 90-day rainfall accumulation period well matched to deteriorating water security for urban supplies, households, or large enterprises such as agriculture?

It is important that this type of information is fully tested with, for example, drought response managers, and tuned or calibrated as needed to improve accuracy and reliability.

5.1.4 Climate averages and characterisation

CliDEsc includes products to describe the range of conditions experienced at climate observing sites, such as wind speed and direction, and monthly rainfall, as shown in the examples below. A key benefit of these products is to determine the likelihood of occurrence of specific events, based on what has been recorded in the past. For example, how often are selected wind speeds or rainfall depths over critical periods likely to be exceeded?

This information can help with design planning for structures like buildings and drainage infrastructure.

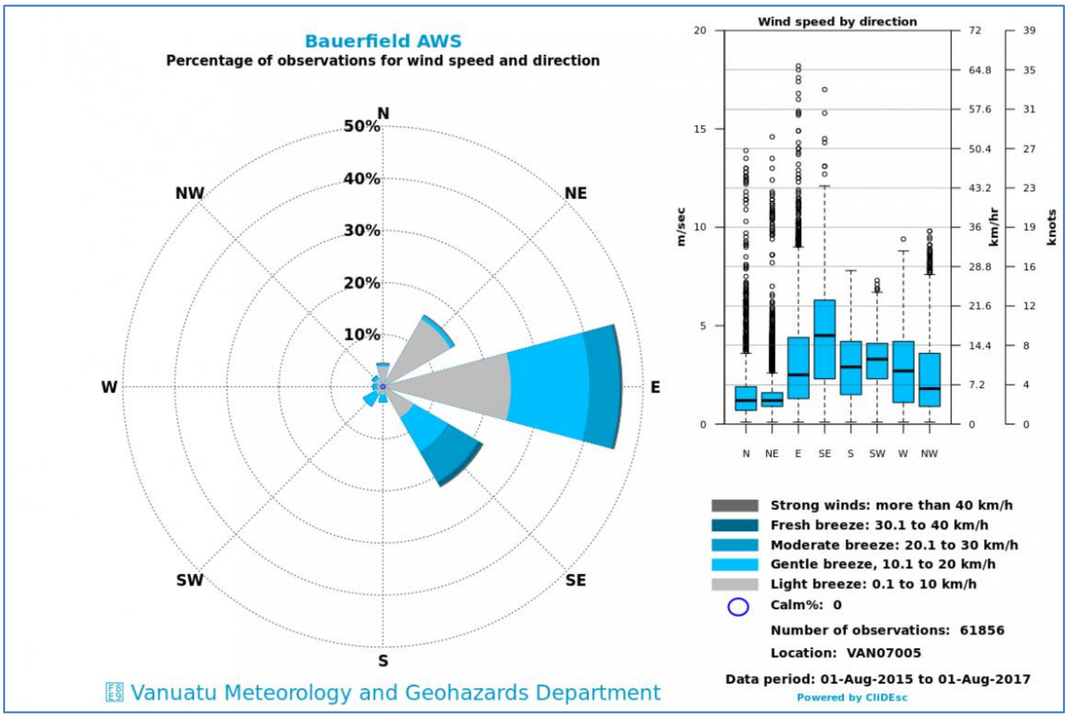


Figure 5-7: A standard wind rose display for AWS data. The right-hand panel shows the distribution of wind speeds in m/sec, km/hr and knots. As shown in the right-hand panel, of the 61856 observations in this example, only a few exceeded 30 knots – near gale force winds on the Beaufort scale.

Climatology for Bauerfield

RAINFALL TOTALS - millimetres(1987-03-22 - 2017-02-23)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Total Rainfall	291	315	340	262	202	175	95	81	89	115	153	170	2352
Highest Recorded	944	664	839	618	621	560	247	276	268	376	430	367	4050
Lowest Recorded	0	91	6	70	37	25	18	8	3	3	19	30	1520
Highest 1-Day	538.8	254.4	584	167.1	276.3	219.1	89.1	120.8	147.8	157.7	231.5	92.6	584
Date of Highest	20/01/99	26/02/04	16/03/15	08/04/12	08/05/02	23/06/95	06/07/14	01/08/88	03/09/99	06/10/14	15/11/94	16/12/99	16/03/15
Percentiles("P"percent of the years have rainfall equal to or less than R(p) mm) (1987 - 2017)													
P=5	44	117	101	90	43	43	21	23	8	15	20	37	1597
P=10	74	138	167	118	49	53	27	24	13	17	31	71	1721
P=20	163	164	223	147	72	85	51	31	23	34	59	88	1829
P=30	209	181	264	161	98	103	59	47	37	53	72	113	1873
P=40	233	256	289	185	140	120	68	61	54	66	91	137	2160
P=50	257	276	312	212	180	136	77	67	67	94	120	160	2305
P=60	287	324	333	265	218	163	94	86	95	130	140	187	2401
P=70	341	374	359	318	237	210	118	103	114	149	199	207	2583
P=80	417	437	451	409	281	253	133	108	162	174	246	259	2862
P=90	487	577	582	462	389	350	183	141	184	239	331	291	3104
P=95	592	627	673	518	527	352	212	169	205	294	356	310	3226

Figure 5-8: Example monthly rainfall climatology that can help with water resource planning. As an example, P=5 can be read as '5 times in every 100 years'. Following such an analysis, extreme values should always be verified (eg. in some cases, archived rainfall totals may be accumulations over more than one day.)

5.1.5 Products under development and future product innovation

In discussion with potential users of climate information in Vanuatu, a number of CliDEsc products have been devised to test ideas and learn how best to communicate key messages that are easy to interpret, timely, and actionable in mitigating climate risk. An example is shown below.

The figure was developed in response to evidence that the number of consecutive days with little or no rainfall is a useful indicator of shortages of drinking water for village households. In this example satellite data are used to help interpret risk where on-the-ground AWS data are not available. For example, there are no AWS data shown here in Espirito Santo, while the lower satellite panel indicates that conditions may be particularly dry in the west of the island.

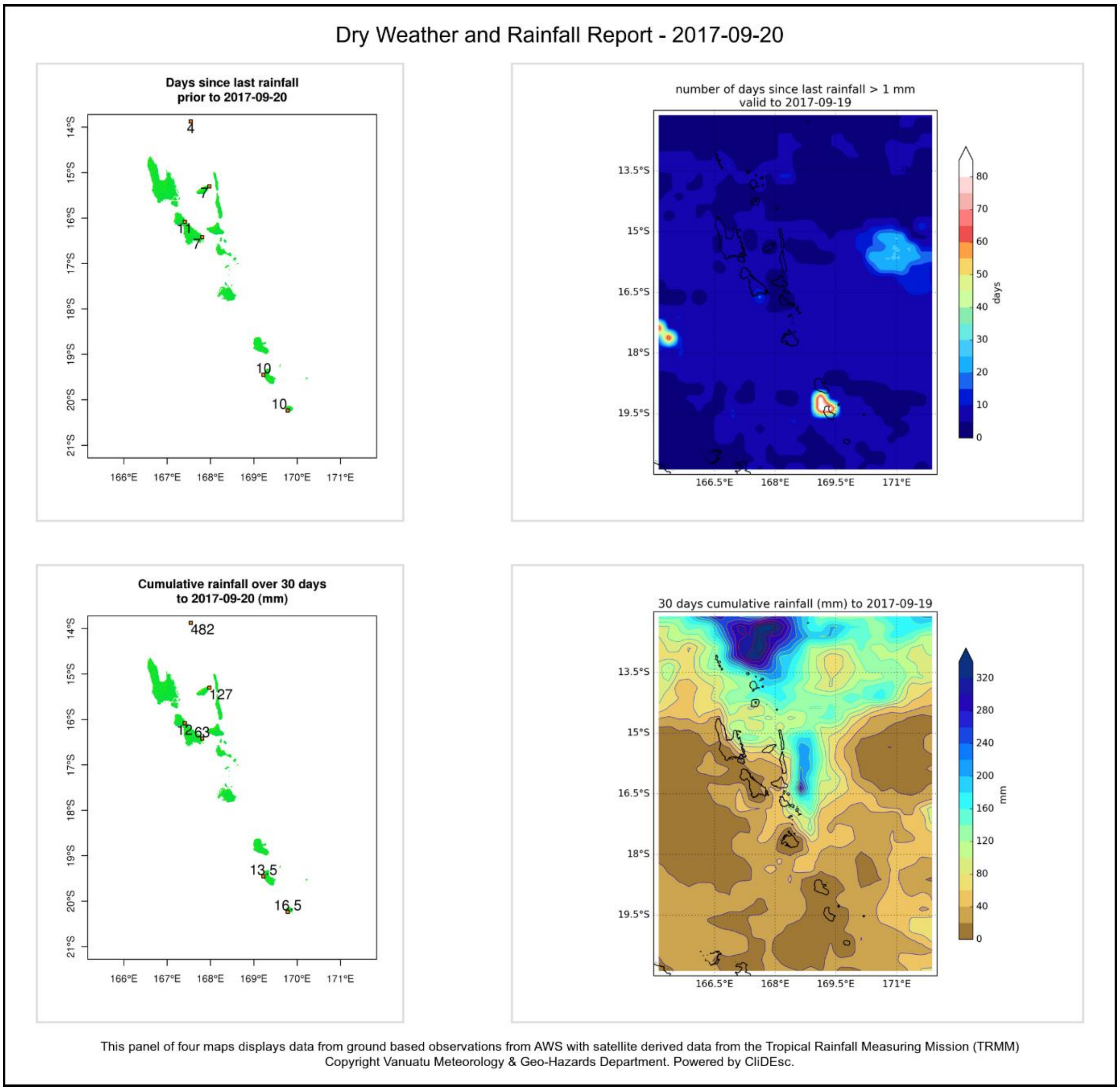


Figure 5-9: Continuous days recorded with rainfall less than 1 mm prior to the run date, and total rainfall for the past 30 days, recorded at automatic weather stations, are shown in the upper and lower left-hand panels respectively. The right-hand panels show the same information, derived from Tropical Rainfall Monitoring Mission (TRMM) data. Both sources of data provide similar results, indicating that the satellite data may provide useful spatial coverage where ground based observations are lacking.

The development of new products requires creativity and consultations with potential clients about their needs for information to manage climate risks, including means of communication and possible timeframes within which information is most valuable and effective.

Through VCAP, the needs of six government sectors were mapped at the VCAP Sector Workshop and corresponding sector interviews [Porteous and Ungaro, 2017b]. The time series below of a prototype product is an example that was proposed, and could be developed as a potential product for the Energy Sector, focussing on wind as a resource for turbine-driven energy production.

The stratified data could be used, for example, to calculate the probability of effective wind speeds for wind turbine energy generation, derived from the period of time wind speeds are measured between design maximum and minimum speeds for generation.

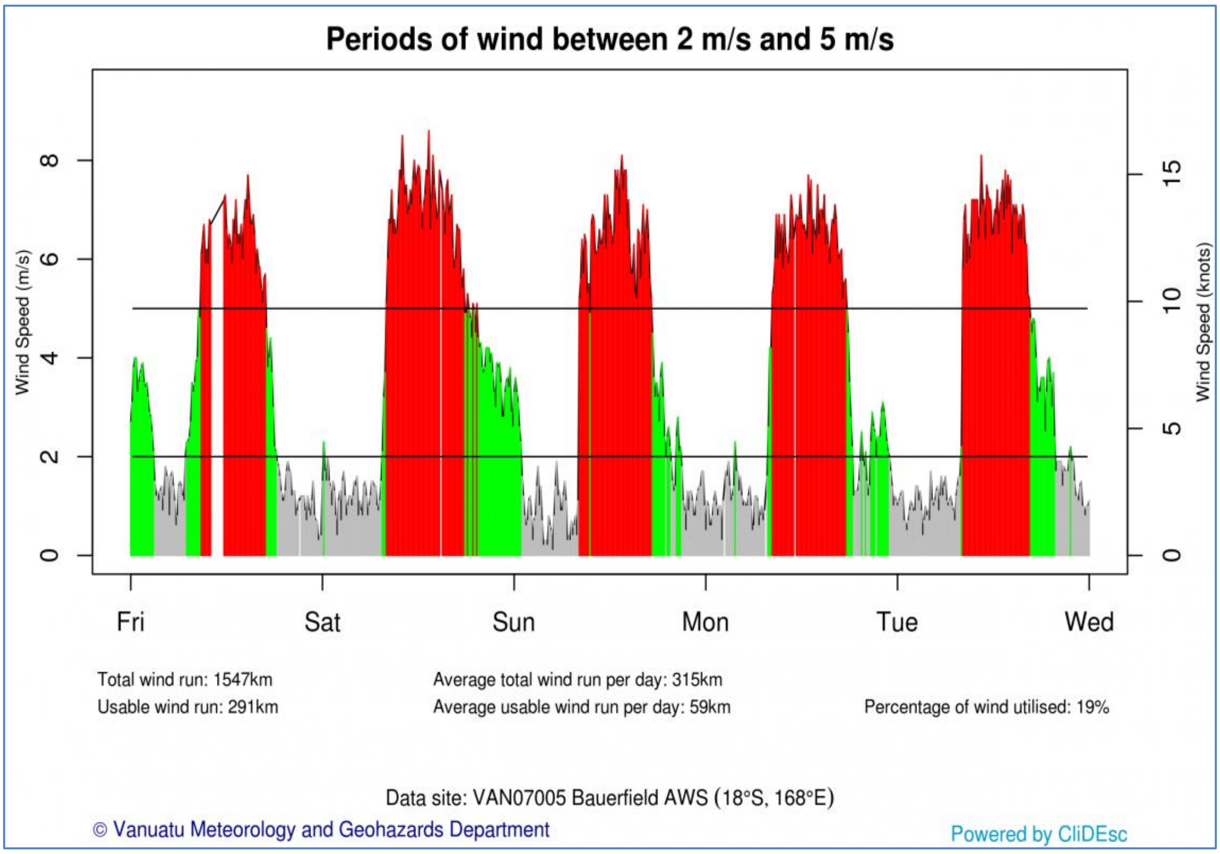


Figure 5-10: Example of a product generator that has been set up to determine the percentage of observations of wind speed fall between selected speed thresholds, illustrated here by the green curve. Wind speeds of 2 and 5 knots are used here for illustration; for practical application, speed thresholds can be adjusted by the user to suit specific use cases.

A further example advisory product is shown below. The map panel and comments provide an outline of the current rainfall status, described in this example as ‘Potential drought risk’. The seasonal Rainfall Outlook, shown to the left of the map, is obtained from published sources, such as the Island Climate Update. The key message of the bulletin is to gauge how present conditions, on a regional scale, might change—improve or deteriorate—over the next three months, based on the seasonal climate outlook.

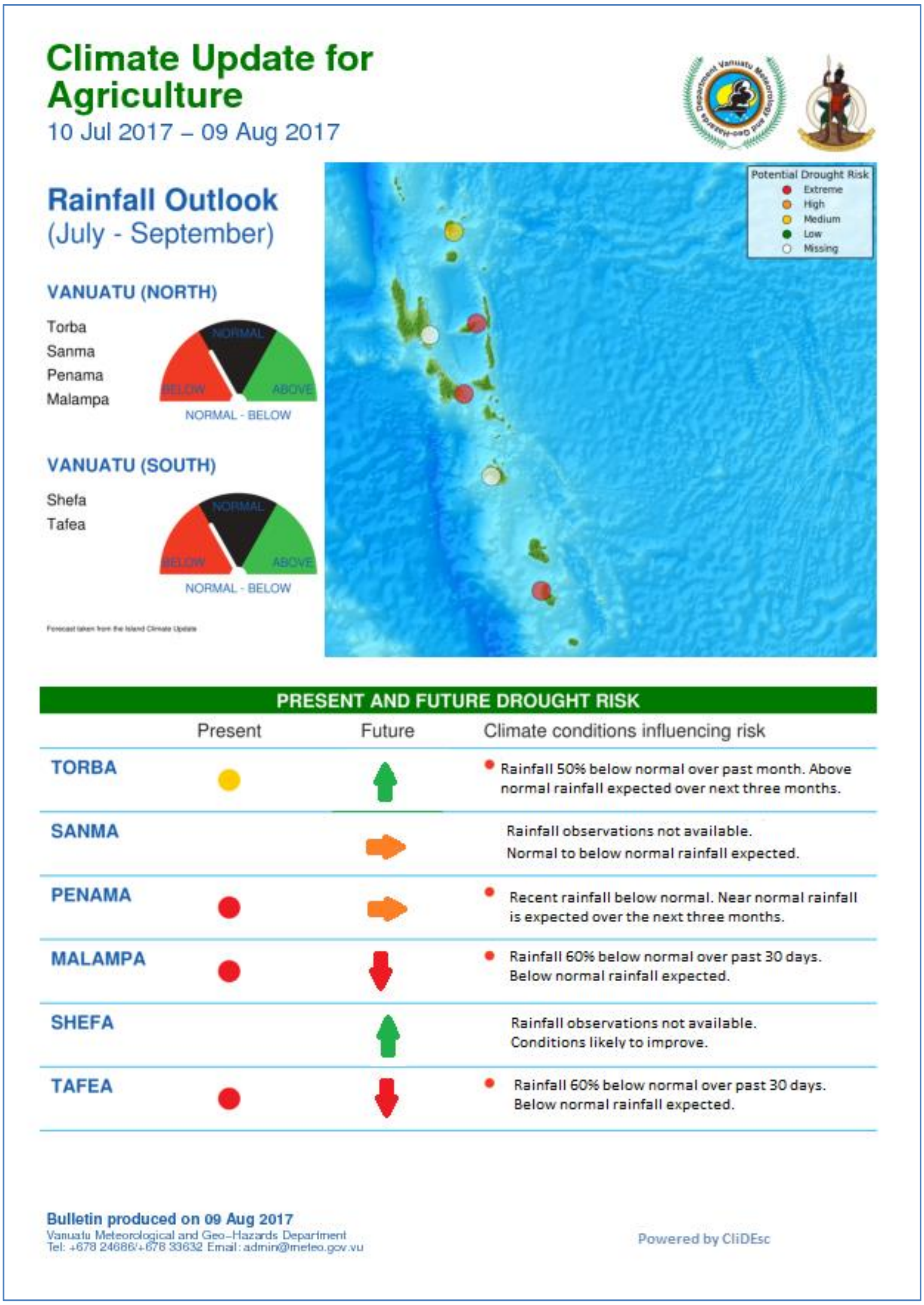


Figure 5-11: Mock-up and example content for a bulletin to provide seasonal advice to the agriculture sector, designed for easy reading and interpretation. The product could provide a brief summary of past and current conditions, and the rainfall outlook for the next three months. The bulletin can be compiled from various sources of information and converted to suitable formats for electronic dissemination.

These and other trial products can evolve according to user requirements, but can in the meantime be used for demonstration to potential clients and stakeholders to seek feedback on how to develop improved climate risk-management and decision-support tools and advisory bulletins.

Users of CliDEsc are encouraged to use their climate knowledge and communication skills to engage with end-users of climate information and services, in order to develop collaborative customised products and services.

6 Technical training – requirements under VCAP

Under the VCAP programme, NIWA was asked to provide training for VMGD technical staff across the complete CLEWS system, to ensure that all system operational and maintenance tasks were sustainable into the future by trained staff. Components of training included:

i. Instrument calibration and maintenance, climate station configuration and assembly, climate site layout, construction and commissioning.

ii. Digital and analogue data capture, scaling and integration, telemetry, formatting and ingesting to archive.

iii. AWS metadata design, commissioning and record keeping.

iv. Data quality assurance, and database management.

v. Generation of climate products for quality assurance, climate monitoring and risk analysis, and sector-focussed products for climate risk decision support.

vi. Integration of data into VMGD real time monitoring and forecasting systems, including automatic synoptic and METAR reporting from the AWS.

Preparation and delivery of these training components was guided by training standards and core competencies developed under World Meteorological guidelines, and using technical guidance developed by NIWA Instrument Systems to support equipment provided under VCAP.

A breakdown of the training components and hours provided is given in Appendix C, and summarized in the table below. (Note that some staff were trained across several task categories.)

	Tasks as outlined above	No of staff trained
i	Instrument systems and site installations	12
ii	Data capture, transfer and archiving	5
iii	Metadata and records	4
iv	Data quality assurance	6
v	Climate products	8
vi	Integration to VMGD systems	8

To assist with the training, and help provide structure around the topics covered, NIWA developed a **'Workbook for Operational Competencies'** – a practical guide to assist staff who are managing climate and hydrological networks to accomplish a range of operational tasks that constitute, in a logical framework and order, the connected components of Vanuatu's national climate and hydrological monitoring infrastructure and services [Porteous and Harper, 2017].

The current content of the Workbook for Operational Competencies is outlined in Appendix A of this report.

6.1 Examples of training activities provided under VCAP

6.1.1 Instrument systems

Instrument systems training was provided during a technical training visit by two VMGD staff to NIWA laboratories in Christchurch, for four weeks during January and February 2017 (Figure 6-1). A summary of the hours of training provided is given in Appendix C of this report. The complete schedule of training exercises is listed in Appendix E.

An objective of the training was to provide VMGD staff with adequate skills to enable them to competently manage and maintain the enhanced climate network in Vanuatu. This training was put to the test during the subsequent installation of the AWS network, when VMGD staff successfully installed the new AWS at Sola Airport.

Figure 6-1: Technical training undertaken by VMGD staff in New Zealand during the preparation of the VCAP climate station equipment.

Where new AWS have been installed at existing meteorological observing stations, local observers are required to help maintain the new equipment. To assist trained VMGD technical staff to help local observing staff gain knowledge to assist with these new duties, an AWS maintenance Local Observer Check Sheet was provided by NIWA. A copy is appended to this report (Appendix B).

6.1.2 Data quality assurance and climate services

VMGD climate staff are responsible for quality assurance of the climate data and for developing and providing data analysis and information products to a range of Ministries, sector clients and the public.

NIWA provided several training sessions encompassing

- Metadata management in CliDE
- Data quality assurance and identifying spurious data and outliers
- CliDEsc quality assurance products including quality plots
- Developing customised products and advisory bulletins in CliDEsc.

Figure 6-2: Above: VMGD climate staff during CliDE/CliDEsc training.

VMGD staff took part in a one-day workshop of planning and interaction with sector representatives and other users of climate information [Porteous and Ungaro, 2017a]. The challenge is now for climate staff to continue the development of customised products and services to support climate risk management and resilience in Vanuatu.

6.1.3 Coding of World Meteorological Organisation data formats

VMGD requested a web-based procedure to enable pre-coding of Synop and METAR messages from the newly installed automatic weather stations. A web form was developed and installed at VMGD and training was provided.

The system removes the need for staff in the field to telephone in their observations, thus saving time and potentially reducing the number of errors.

The web form is designed to pre-code the following messages:

- SYNOP both MANUAL and AWS
- METAR
- CLIMAT

This document providing technical information and user guidance on how the system works has been provide [Miville 2017].

The system will be used by observers in the field and a quality control person at Bauerfield Airport.

Figure 6-3: Bernard Miville from NIWA demonstrates the AWS automatic synop and metar message encoder to VMGD staff.

7 Summary and Recommendations

VCAP project has successfully enhanced the VMGD weather and climate monitoring, data reporting and archiving, and ability to deliver climate services and early warnings to support the development of climate risk resilience in communities in Vanuatu. This work provides a platform from which VMGD can grow and develop their climate services to meet sector needs for climate risk management and building climate-resilient communities.

The following recommendations are offered to help maximise the outcomes of the VCAP project.

Ensuring reliable data capture

Station maintenance is key to recording reliable weather and climate data, and it is recommended that a systematic station and instrument maintenance programme be initiated to ensure AWS sites and installations are well looked after. It will be important to ensure that all station operations staff are aware of the need for uninterrupted capture and delivery of high quality data, and to implement corrective procedures as soon as possible when instrument damage or failure, or data quality issues, are found. Key components of climate network maintenance procedures are good management of station records (metadata), and implementing planned life-cycle instrument maintenance.

VMGD climate data capture can be further enhanced by automating, where possible, the integration of manual rainfall observations into the CliDE database. To assist this development, a rainfall data entry form has been developed by NIWA and will optionally be available for Vanuatu as part of a subsequent project.

Maintaining robust telemetry and archiving procedures

It is recommended that VMGD IT staff gain advanced familiarity with the Vanuatu Government Broadband Service (iGov), NEON, DataToCliDE and other telemetry and data transfer procedures so that any changes or maintenance of the system can be managed efficiently. NIWA is available to advise and provide further training on this as part of subsequent projects.

Improving procedures for data quality assurance

The VMGD Climate Group manage routine procedures that provide early detection of data issues, and systematic correction and flagging. However, following the introduction of AWS and sub-hourly reporting intervals, the volume of data being ingested into CliDE has significantly increased. For example, a station measuring 12 parameters every 10 minutes reports 1728 data per day.) This increased data volume makes manual data checking less practical. It is recommended that additional auditing software be developed, to run on CliDE or CliDEsc, that systematically identifies potential problems with the data, for example outliers and repeated data, and provides daily quality assurance reports on data that need to be checked. This software should recognise all data types and observation periods, and can be used in conjunction with existing procedures in CliDE and CliDEsc.

Extend the range of climate analysis and reporting tools in CliDEsc

There is potential for the development of many more climate analysis and reporting products in CliDEsc, such as the examples noted in Section 5.1.4 above.

Where climate services staff are currently preparing manual reports each month for operational purposes, this work in most cases can be assisted (or replaced) by automating the data analysis and formatting required, through developing additional reporting tools in CliDEsc. This could free up staff time, for example for developing new services, and for engaging more with the user community to process feedback and additional requests for information.

Developing decision-support products and services

Effective decision-support and hence achieving climate-resilience through the CLEWS system can only be achieved by direct and constant interaction with climate risk managers across all sectors. Each sector, enterprise, or community will have different needs, and the challenge for climate services staff is to develop a clear pathway of what is required in each case, and then systematically start to address those needs by compiling relevant and timely information in each case.

New climate information products will be needed, requiring both consultation and careful planning, and then developing how these products will work and be supplied operationally.

Some services will require the addition of weather forecasts and seasonal outlooks to products that are derived primarily from observations.

Many government staff who are managing climate risk may not be familiar with climate data or the kind of products and services that can be obtained through VMGD climate services. In order to determine user needs and customise climate services, the following actions are recommended:

- Conduct meetings with key users of information to find out their information needs, and capabilities to understand and apply climate monitoring and risk data.
- Work with key users to customise climate products, bulletins and advisories, and improve the uptake and use of these through regular updates and feedback consultations.
- As part of the service customisations, consider ‘trigger levels for response’, for example, the number of days without rainfall that may put communities at risk, and who should be advised when risk thresholds are met or exceeded.
- Consider further training for climate services staff in participatory practices and consultation skills, thereby enabling them to engage more closely with sector users and other clients.
- Explore options for communication pathways for climate information – some processes can be automated to enable key users to receive regular updates of climate risk information.
- Further training for the CliDEsc administrator(s) are highly recommended, to enhance the capability of key climate staff to further develop the information in the CliDEsc Content Management System, and the range and capability of product generators.

8 References

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Appendix A Workbook for Operational Competencies: Background to Training Content

The *Workbook for Operational Competencies* is set out in a sequence of objectives, tasks and check lists, from the planning and development of a robust climate network and high quality observational record, through to the delivery of information to aid decision making and mitigate climate risk.

Each set of tasks is referenced to sources of relevant training and technical guidance for further information. Where relevant, references are given to the appropriate World Meteorological Organisation (WMO) technical guides, to ensure alignment with WMO recommended methods and competencies, and as a resource to provide supplementary training material where it is needed.

Also referenced are operational guides and manuals specific to Vanuatu's climate network infrastructure and systems – including automatic weather stations (AWS), telemetry (NEON or other systems), data ingest (e.g. DataToCliDE), data management (CliDE) and product generators (CliDEsc).

The Workbook is designed to expand technical knowledge and achieve improved competencies in the context of day-to-day responsibilities and operational tasks, in order to strengthen both individual and institutional capability to deliver sustainable and improving information services.

This Workbook aims to assist the Government of Vanuatu's endeavour to improve national infrastructure and capability for enhanced weather and climate services. It is specifically aimed at strengthening climate services and early warning systems (CLEWS) which encompass improved understanding of past climates and underlying risk, real time monitoring of present weather and climate, and operational advice and services on future climate risk and opportunity on all time scales, from hours and days, to seasons and decades ahead.

Workbook modules

The scope of the topics covered in the *Workbook for Operational Competencies* are set out in six Training Modules. Module 1 explores the strategic and technical issues as background to the infrastructure and services needed to build climate resilience in Vanuatu. Modules 2 - 6 aim to provide the technical and hands-on training relevant to the operation of each component of the climate data and services system. Specifically, Modules 2-5 break down the technical training into specialist operational requirements and component tasks. Module 6 then aims to bring the whole system together to deliver information and customised outputs for day to day climate risk management.

The focus of the training is on technical understanding and operational competencies. The training does not distinguish between staff with different specialist academic or technical qualifications, but aims to provide hands-on participatory experience for all operational staff.

Key outcomes are:

1. All staff involved in climate data information, services and early warning systems in Fiji have a general understanding of all aspects of the system and its national and international relevance.
2. Improved staff knowledge, skills and competencies related to key operations of climate services, including climate instruments, telemetry systems, data integration, product development, and sector engagement.

3. Increased opportunities for staff who have demonstrated competencies in carrying out key operational tasks to obtain accreditation.
4. Improved institutional capacity to sustain, maintain and operate national climate services and build climate resilience within vulnerable communities and economic sectors.
5. Each trainee is provided with a copy of this Workbook for Operational Competencies to support and record their own achievements in institutional and self-motivated training and competencies.

A summary of the module content is given in the table below.

Module 1 Climate services – strategic and technical overview (and how to use the Workbook)	Module 1 is expected to set the scene for the training, based on having a good understanding of the strategic objectives of developing a climate early warning system. The Module will encompass a working awareness of national adaptation plans, sector science and information needs, and institutional operational objectives. Participants will become familiar with the basic operational elements of a robust and effective climate information and early warning system (CLEWS).
Module 2 Instruments and measurements	Module 2 will cover basic aspects of network design but focus mainly on climate instruments and measurements, and building and maintaining climate stations. Training will include laboratory and field work. Exercises will include configuration of climate stations, and setting up and calibrating instruments for climate observations, installation requirements, trouble shooting, maintenance and metadata.
Module 3 Data transfer, telemetry and integration	Module 3 will be carried out in parallel with Module 2 and will focus on telemetry systems, data transfer and ingest of data. The aim of this module is to ensure understanding and implementation of the full scope of data integration, including real time data ingest and display, quality assurance procedures on ingest to the data archive, management of multiple data sources and outputs including the GTS/WIS, and data transmission to the FMS Weather Forecasting System.
Module 4 Data storage and quality management	Module 4 will focus on managing the data in the CliDE database management system, with a particular focus on quality assurance. Topics will include station numbering and registration, data parameters and tables, ingest procedures, quality assurance and management, data rescue, data reporting and the storage and upkeep of metadata and station maintenance records.
Module 5 Climate monitoring, products and client services	Modules 5 will aim to improve climate staff capability to monitor and report the climate using CliDE and CliDEsc data analysis and reporting tools. The module will include using the CliDE/CliDEsc platform to illustrate climate variability and extreme events, and to develop and generate routine climate reports. Staff will develop improved tools and services to help respond to stakeholder and public requests for climate products and advice.
Module 6 Sector engagement, decision support and risk management	Module 6 will encourage climate services staff to actively engage with sectors of government and business, civil societies and communities to determine climate vulnerabilities and needs for information. Staff working with these sectors will help develop the information content, format and communication needs to support vulnerability assessment and decision-making to strengthen climate resilience. Staff will work on the design of climate products and services, which may include the development and installation of new CliDEsc product generators. Skills in product coding and data analysis will be encouraged.

Appendix B Automatic Weather Station Local Observer Check Sheet

Important: Ensure AWS enclosure gate remains closed at all times station is unattended!

Weekly Check and after storm events.

Are there any signs of wear or physical damage to equipment and structures?

- All instruments appear operational and in correct position? (no loose cables or instruments dangling from mast after storms).
- Any sign of lightning strike after thunder storms? (Burn marks on instrument boxes, melted wires or conduit).
- Cables and conduits OK and not damaged? Dog (or other animal) bites or damage?
- Mast and anchor blocks all ok?
- Guy wires are secure? (not too loose or not too tight?). Not damaged or cuts in plastic skin.
- Any Insect, lizard or rodent infestation (in housings, junction boxes) ? Remove any nests.
- Grounds inside compound is kept tidy and maintained.
- Grass around instruments is cut short (5 - 10-centimeter length) especially under Stevenson screen, rain gauge, grass minimum and earth temperatures.
- Compound fence is secure and gate is kept locked.

Fault Checking

If site is not sending data to NEON

Power Supply

Battery Volts should be 12 – 14 volts, Green LED on solar regulator and solar panel intact.

NRT NEON data logger

Is the NEON logger operational? What is the LED status?

- The Red light should be blinking once every 3 – 5 seconds.
- Rapid blinking means logger is transmitting. Should last less than one minute
- A solid red LED means the logger is locked up
- No LED light means the logger has a power supply fault

BGAN

Is antenna pointing to 305 degrees (True) and at an angle of 55 degrees?

What is the Green LED status of the BGan modem?

- After a soft touch on the black button all LEDs should light up. They will turn off (go to sleep mode) after about 1 minute.

Wind

- Are the cups rotating freely and smoothly? Even in light winds they should rotate easily.
- Is the fin moving freely and pointing into the wind?
- Is the direction output in NEON displayed correctly with your observations?

Rainfall

- Is the rain gauge blocked? Is there water sitting in the top of the funnel?
- Is Rain gauge clear of debris?
- After removing the cover are there any obvious blockages? Are there any cobwebs preventing the buckets from tipping?
- Does the siphon run freely?
- If all the above are OK, then try rewiring the gauge to the other side of the reed switch.

Air Temp / Relative Humidity

- Is sensor filter clean? Not damaged or covered in dirt/salt.
- Check for any loose connections.

Earth Temperatures & Grass minimum temperature

- Are conduit and plastic covers secure and intact?
- No exposed cabling visible?

Leaf Wetness Sensor

- Sensor is securely intact and located on the roof of the Stevenson's screen

Licor Solar Radiation

- Licor plastic sensor is clean and unobstructed.
- Sensor is level and pole is vertically straight. Check bubble level indicator.

Appendix C V-CAP Training Completed

Date and Training event	No of staff (Male/Female)	M1	M2	M3	M4	M5	M6	Hours completed under V-CAP
Technical staff training in Christchurch, Jan-Feb 2017	2 (2M)	■						1
Technical staff training in Christchurch	2 (2M)		■					80
Technical staff training in Christchurch	2 (2M)			■				30
Technical staff training in Christchurch	2 (2M)				■			10
28 March, CLEWS Training	12 (4F,8M)	■						1
28 March, CliDE, CliDEsc training	6 (2F,4M)				■	■	■	3
27 March, station planning and installation	6 (6M)	■	■					3
28 March, AWS equipment testing	1 (1M)		■	■				4
29 March, AWS testing; spare station set up	1 (1M)		■	■				4
30 March, telemetry	3 (3M)		■	■				3
31 March, NEON, Dishpointer	3 (3M)			■				3
29 March, CliDEsc training	6 (2F,4M)				■	■		2
30 March, CliDEsc software training	1 (1F)					■		1
14 May-10 June AWS Installation Aneityum, Whitegrass and Lamap	4+ (M)	■	■	■	■			33
30 June to 15 July AWS installations Longana and Norsup	4+ (M)	■	■	■	■			12
3-8 August, Data management and reporting (climate)	6+ (2F,4M				■	■		6
3-8 August, Synoptic and METAR reporting, automatic coding	8 (3F,5M)	■	■		■	■	■	4
3-8 August, Sector engagement and customisation	2 (2F)					■	■	2
18 September, Data management and report; correction of site locations	2 (2M)	■						1
19 September, CliDEsc products (climate and NDMO staff)	5 (1F,4M)					■	■	3
21 September, CliDEsc products and system training	7 (3F,4M)					■	■	3

Appendix D Implementation Log Frame

The following table is a record of all implementation activities for the V-CAP project.

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
22 June 2016	Tender submitted for Supply, Delivery and Installation of Automatic Weather Stations throughout Vanuatu and Integrated Forecasting System for Vanuatu Meteorological And Geo-Hazard Department.		RFT G01/03
6 July 2016	Submitted amended Tender, excluding taxes and duties in tendered prices (at request of Tenders Board)		
13 October 2016	Supply Contract final draft signed by NIWA		
14 October 2016	Supply Contract SCG02 agreed and signed by Minister of Climate Change, Government of Vanuatu		
29 November to 2 December, 2016	NIWA project staff visit to VMGD, Port Vila. Review of itemised Scope of Work.	Progress Report 1 ▪ Work plan and implementation timeline ▪ Field installations and materials ▪ Data integration, IT hardware and operations ▪ Training scope and schedule	TRS 9-1
7 December 2016	NIWA team technical meeting, Christchurch	Implementation work plan update and allocation of resources, technical personnel, equipment orders, training schedule, project phasing.	TRS 3, 4, 5, 8, 9

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
23 January to 17 February, 2017 VMGD tech training in New Zealand	Two VMGD technical staff attended NIWA Instrument Systems Training, Christchurch, New Zealand (Jeremy, Pattison) Week 1 of training. J Bani and P Naut arrive Christchurch for training. Installation of software on laptop and the NIWA Stardroid and SDI-12 phone apps. Instrument basics, wiring, configuring and testing. Troubleshooting and repairing wind instruments. WMO siting classification.	Technical training for 2 staff M1 (Strategic settings) 4 hours M2 (Instruments and Measurements) 80 hours M3 (Data transfer, telemetry and integration) 30 hours M4 (Data storage and quality management) 10 hours Module 2 – Topics 2, 3, 4, 5, 6, 7 and 8 Module 3 – Topic 2	TRS 4-6
	Week 2 of training Networks and planning. Neon - Communications and data logger setup. Starlog V4 - Data logger programming. SDI-12 Device configuration. Connecting sensors to logger and comms for end to end bench testing.	Module 1 – Topics 1, 2, 3, 4, 5, 6 and 7 Module 2 – Topics 2, 3, 4, 5, 6, 7 and 8 Module 3 – Topics 1, 2, 3 and 4	
	Week 3 of training AWS assembly and bench testing. - Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting Visit to Arthurs Pass EWS - Inspection and site maintenance, including field testing of instruments, sensor exchange, checking and updating station documentation (MetaData) and WMO siting classification. CliDE - overview (administration, station setup and registration, metadata, data tables and types, data entry, data QA, data reports)	Module 2 – Topics 2, 3, 4, 5, 6, 7 and 8 Module 3 – Topics 1, 2, 3 and 4 Module 4 – Topics 1, 2, 3, 4, 5 and 6	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
	Week 4 of training AWS assembly and bench testing. - Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting Dishpointer - Used to find locations of new AWS and to determine antenna angles.	Module 2 – Topics 2, 3, 4, 5, 6, 7 and 8 Module 3 – Topics 1, 2, 3 and 4	
18 February 2017	J Bani and P Naut depart Christchurch.		
22 February 2017	Container packing completed. Climate station equipment picked up from Christchurch by DHL	Shipping ex New Zealand	
3 March 2017	Equipment/container shipped from Auckland by Southern Moana, Voyage 299		
19 March 2017	Vessel arrival Port Vila		
19-31 March 2017	NIWA implementation team working at VMGD Alan Porteous, John Powell, Bernard Miville, Andrew Harper (from 23 March)		
20 March 2017	CliDEsc installation	CliDEsc software suite installed in CliDE server. (Note this is fully operational, but remains a temporary option until the dedicated new HP server becomes available.)	
23-31 March 2017 Pre-installation technical mission	23 March Afternoon meeting with P Mawa and J Mala re-installations. Brief overview of system and Neon demonstration. Scouting on roof for GIZ? Site.		

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
	24 March Meeting with Sam. Visit to suppliers for hardware and fencing supplies. PTH quote for materials is best. Meeting at PTH to confirm quantities and cutting of pipe to length for fences. Vate Industries to supply and thread pipe for masts. Visit to DHL and Wharf to follow-up on air freight and container. Assured container to be delivered today.		
	27 March Afternoon training (Module 2 – planning) on logistics to work through for installations. Patterson, Peter, Sam, Patricia, Grace and Esther attended. Quote from PTH arrived. Arranged urgent payment by NIWA Corporate. PTH unable to supply gates. Arranged with Vate Industries to manufacture gates. Contained still retained at Port Vila port.	Module 1 – Topic 4 Module 2 – Topic 4	
	28 March Container arrived last night. Verified contents arrived in good condition with Patterson. Also confirmed tools supplied as per contract. Patterson tested the spare and three AWS loggers and communications. Pipe for masts arrived from Vate Industries.	Module 2 – Topics 4 and 8 Module 3 – Topics 1, 3 and 4	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
	29 March Patterson completes testing of the remaining AWS. Patterson then sets up the spare AWS in the office for familiarization. Spent time with Patricia entering new stations in CliDE and working through the equipment lists to be entered into CliDE. Demonstrated the examples and the types of MetaData required. Also worked through and left electronic copies of various manuals and guidance material from WMO, PMC, NIWA and instrument manufacturers. Joe, Patricia and Grace on SYNOP codes and data integration into national and global systems.	Module 2 – Topics 4 and 8 Module 3 – Topics 1, 3 and 4 Modules 1 – Topics 4 and 7 Module 2 - Topics 1, 2, 3,4,5,6 and 8 Module 3 – Topics 1, 3, 4, 5 and 6	
	30 March Patt in morning – instrument familiarisation, NEON setting up weather station tabs, derived channels. Also recompiled and edited scheme. Demonstration to RESPAC Sam, Joe Patricia in afternoon for planning, budgets and logistics Labelling everything in container for shipping	Module 2 – Topics 4 and 8	
	31 March Completed container work Demonstration of end to end system to Patricia Patt – working on WIFI connections. Patricia, Patt and Severine – adding NEON users and user rights Dishpointer - Used to find locations of new AWS and to determine antenna angles. PTH gear arrived – delivered to Bauerfield Some materials still to come. Shipping lists to Joe, Patricia ad Sam	Module 2 – Topics 3, 4 and 8 Module 3 – Topics 1, 3 and 4.	
27 March 2017	Container cleared from Port and transported to VMGD	Container available for opening and equipment checking, 28 March, 2017.	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
28-30 March 2017	Equipment checking, hardware purchases, Port Vila and VMGD	Hardware and materials purchases. AWS unit checking, comms testing Spare station set up for telemetry channel testing and training	
28 March 2017	Technical training, CLEWS	Technical training for 14 VMGD staff Overview of CLEWS system Technical training for Climate Division 9 staff M1 (Strategic settings) 1 hour M4 (Data storage and quality management) 1 hour M5 (Climate monitoring, products and client services) 1 hour M6 (Sector engagement, decision support and risk management) 1 hour	
29 March 2017	Technical training, CliDEsc	Technical training for Climate Division 9 staff M4, M5 (CliDE and CliDEsc) 2 hour M6 (Sector engagement, decision support and risk management) 1 hour	
29 March 2017	Server installation	Dedicated CliDEsc server installed on VMGD server rack	
30 March 2017	Technical training	One-one CliDE/CliDEsc training, 2 hours.	
31 March 2017	Technical training	One-on-one product development training (using R code), 1 hour.	
1 April 2017	NIWA team departs Port Vila for NZ.		
2-3 May 2017	Information Design Workshop. NIWA Team: Alan Porteous, Juli Ungaro, John Powell, Seema Singh	Report: Vanuatu Coastal Adaptation Project – climate information and services workshop report	TRS-4, Item 6
14 May 2017	Andrew Harper arrives Vanuatu		

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
15 May to 10 June 2017 AWS Installation Mission 1	Briefing with Sam, Jeremy and Patricia Account for payments. Visit shipping company for pay for Whitegrass shipment- MV Touaraken. This still has not left.	Setting up AWS installation, Mission 1 Training Module 2- Topic 4	TRS-4, Item 2
16 May	Visit airline to confirm and pay for flights to Whitegrass and Aneityum. Find out that we are now not leaving Thursday but on Sunday. Still having difficulty with return flight and four of team are currently waitlisted. Enquiries made on chartering flights. Very expensive option. Visit Vanuatu Shipping Company to get quotes for shipping to Lamap, Longana and Norsup.		
17 May	There is an ICT conference in town. VMGD have display. Jeremy sets up the spare AWS with BGAN communications and explains system to general public. Make cash payment for Lamap and arrange direct payment for Longana and Norsup shipping. Marty Flanagan arrived in Port Vila. Passport was confiscated by Airport customs immigration reportedly due to not having a 'business visa' approval for entry. This was disputed at the time but passport retained by Vanuatu Immigration for two weeks until resolved by VMGD Director.	Module 2 – Topic 4 Module 3 – Topics 3 and 4	
18 May	Collect fencing materials from Bauerfield and pack gear for Lamap. We hear that the PVC pipe was not delivered to Aneityum. We arranged for a barge to deliver some more and purchase this. At same time we are advised the remaining fencing netting (9 rolls) is still 2 weeks away.	Module 2 – Topic 4	
19 May	Deliver gear for Lamap. Collect fencing materials for Sola and pack gear in preparation for remaining sites. It is possible Sola may be sent next week. Visit airline to pay for Aneityum and Whitegrass flights. Jeremy is now confirmed for return to Whitegrass. Booking made for Loic Jimmy to Whitegrass. Confirm PVC pipe is on barge and make payments. ETD is tonight. Make DSA payments to installation team.	Module 2 – Topic 4	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
20 May	Make payments for Lamap flights and final arrangements for trip.		
21-24 May **Aneityum AWS installation**	21 May Installation team departs. Andrew Harper and Marty Flanagan (NIWA), Sam Tapo (V-CAP), Joe Mala (VMGD Observations), Jeremy Bani, Patterson Naut (VMGD ICT) and Kalsuak Gorden (VMGD Climate) Arrive Aneityum early afternoon. Meet with local observers Tom Kaio and Joseph Feke. Unable to work but discuss layout and work through logistics for installation with team.	Module 2 – Topic 2	
22 May	Begin AWS installation. Barge has not yet departed so still missing PVC pipe and some fencing materials. Make local arrangements for use of some alcathene tubing. Dismantled and moved HF radio antenna to make way for AWS mast. Weather was very wet, but installation team along with some local help make an excellent start and AWS foundations all completed.	Module 2 – Topic 4 and 8	
23 May	Joe departs for Whitegrass to begin preparations to get site cleared as we noticed when in transit the site was not clear and start get sand and coral to the site for foundations. Team assemble mast and install sensors, complete cabling. AWS first initialized at 1610hrs Spent some time with Kalsuak working through station documentation requirements after observing him taking notes during the day as each sensor was installed.	Module 2 – Topics 4, 5, 6, 7 and 8 <u>Aneityum AWS Commissioned</u>	TRS-4, Item 2
24 May	Final tidy up of site works, sensor verification and station commissioning. Station documentation preparation. Patterson installed Wifi transmitter aerial on AWS mast. ICT still need to install receiver and internet link with communications site on Mystery Island. Provided further training, including VMGD station observers on maintenance and fault finding. Left materials and instructions with Joseph on how to erect the mesh fencing material for completion.	<u>Training</u> Module 2 – Topics 4, 5, 6, 7 and 8	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
25-28 May Whitegrass Airport AWS installation	25 May Travel from Aneityum to Whitegrass. Had to charter a plane for four of the team as they were wait-listed until 28th. Also had to send all tool on the charter as we almost had to leave our personal bags behind to.	Module 2 – Topic 4	
	Visit wharf to check on boat unloading – still no progress. Visit proposed site with Airport Manager. Used second of the sites as the first location was borderline for aviation requirements for distance from runway and glide-paths. 1:7 from glide-path markers i.e., for every 1m in height, must be 7m distant. Joe turns up late in the afternoon with the timber and pipework for the AWS and fencing materials. At least we can make a start Met up with Dave Allen walking down the road.		
26 May	Andrew, Marty, Dave, Loic, Kalsuak and Patterson go to site to begin preparations and laying out of station. The remainder of team head to wharf to get cargo off ship. They were only able to get some of the remaining gear. Sam makes alternative arrangements for cement as this is still to be unloaded. Sam also arranges for the use of a vehicle. The foundations for the mast are completed just on dark.	Module 2 – Topic 4	
27 May	The team, excluding Joe, head out to site. Have a delay getting to the site due to aircraft movements. Once we get there, complete foundations (logger housing and rain gauge) and begin installing sensors. Kalsuak runs the 4 boys preparing the fence. Mast is raised late in the afternoon.	Module 2 – Topics 4 and 5	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
28 May	Completed AWS, verification checks and commissioned station. Noticed starlog scheme issue with wind direction data value. Kalsuak and local observer Bradley Bani created site plans and Bradley went through station checklist. Remainder of fencing material arrived and made start on fencing. Internet connection was down, but were able to verify Wifi ping tests. On reviewing Aneityum data, noticed some issues with soil moisture not working and 10 and 100cm swapped. Sam Tapo returned to Port Vila. Dave Allen sick.	Module 2 – Topics 4 and 5 Whitegrass Airport AWS commissioned	
29 May	We are having cash-flow problems with transport and accommodation being more expensive than expected. Our NZ cards do not work in the local ATM and are not accepted by the bank. Arranged with NIWA Corporate to transfer funds via Western Union. Made arrangement for Marty and Jeremy to get back to Aneityum. Remainder of team to return to Port Vila next day. Final checks of AWS. New starlog scheme loaded to correct issue with wind direction parameter. Patterson set up the observing staff for access to Whitegrass on Neon and time spent with Bradley on using Neon. Also, gave a brief demonstration to the Airport Manager. Wifi link to internet not operating due to suspected firewall issue with ICT. Patterson and Loic are to determine fix.	Module 2 – Topics 4 and 5 Module 3 – Topic 4	
30 May	Andrew, Patterson and Kalsuak return to Port Vila		
31 May	Andrew and Sam arranging finances for charter flights and preparation for Lamap. Settle accounts for Longana shipment of gear (Vehicles, DSA, Ship passage)		

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
1 June	Jeremy Bani and Marty return to Aneityum. Corrected wiring issue in earth temperature sensors (10 & 100cm). Also corrected soil moisture sensor and leaf wetness sensor as wiring was mismatched. AWS fencing bracing and mesh installation started with Joseph and two labourers. Repositioned HF radio antenna in a NW – SE orientation for correct alignment for transmissions. Jerry also installed Meteo office computer. No internet connection available yet.	Module 2 – Topics 4	
2 June	Andrew and Sam arranging finances for charter flights and preparation for Lamap. Settle accounts for Longana shipment of gear (Vehicles, DSA, Ship passage). Marty and Jerry completed Aneityum AWS fencing. Flew back to Tanna via charter flight. Arrived back in Vila at 1700h.		
3 June	Andrew returned home to New Zealand. Marty sick.		
4 June	Marty sick. Prepared some materials for flight to Lamap.		
5 June Lamap AWS Installation commenced	Sam, Loic, Igor, Jerry, Nelson (Ian) on morning flight to Lamap, delayed 4 hours. Finally arrived Lamap at 12pm. Excess baggage (40kg tools) had to be sent to Lamap by overnight ship. Met local observers at Lamap Meteo office, Paul (semi retired) and Arno. Discussed layout and worked through logistics for installation with team at proposed location. Proceeded with installation, achieving completion of main anchor blocks concreted and majority of site laid out. 4x local labourers employed to mix concrete and dig fence holes. Finished late in the evening but made a very good start.	Module 2 – Topics 2 and 4	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
6 June	Complete concreting foundations (logger housing, anchors and rain gauge) and begin installing sensors. Sam runs the 4 boys preparing the fence. Mast is raised late in the afternoon. Neon logger was powered and initialised by Jerry. Fencing is erected and enclosure made animal proof overnight.	Module 2 – Topics 2 and 4 Module 3 – Topics 3 and 4	
7 June	Completed instrument calibration checks, fencing completed, site enclosure tidied up. Final checks and confirmation with viewing data on NEON. Instructed Arno regarding site maintenance and Observer's weekly checklist.	Module 2 – Topics 2 and 4 Module 3 – Topics 2, 3 and 4 Module 2 – Topics 3 **Lamap AWS commissioned**	
8 June	Packed equipment and cleaned office. Truck transport to Lamap airport for return flight to Vila. Again, excess baggage (90kg tools and equipment) had to be left behind at Lamap (with Arno) due to plane being overloaded. This will be sent to Baufield on a flight next week.		
9 June	Marty met briefly with Sam. Discussed plans and time frame for mission 2. Proposed to start on 3 July for next three AWS installations. Left Sam with $150,000 vatu cash to make payment for shipment of remaining equipment.		
10 June	Marty returned home to New Zealand.		
AWS Installation Mission 2 **30 June to 15 July 2017**	Marty arrived in Port Vila on 30 June, in time to pay for pre-booked flights to the northern island locations. Christian arrived on 1 July. No entry issues with immigration were encountered this time on arrival at airport customs. Building materials (pipework, timber and fencing) and the AWS equipment had been already delivered to the locations, except for the Sola AWS material (Figure 2-1). The Sola equipment had been transported as far as Espirito Santo port in late June, then placed in storage at Luganville due to limited shipping options to Sola. This delay resulted in the equipment not being available in Sola for installation as originally scheduled, and NIWA staff had to leave Vanuatu before this installation could be completed.	Mission 1 installation report	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
Sunday 2 July	Due to a booking mistake with the Air Vanuatu flights, two VMGD staff were asked to depart for Longana on Sunday. This proved advantageous as it enabled Kalsuak Gordon, Loic Jimmy and local Meteo observer (Hilton Henry) to make excellent preparations on-site for labour resources, chainsaw hire and landowner's permissions, to undertake the clearance work required to remove mature trees and large vegetation at the chosen AWS location.		
Monday 3 July	The remainder of the installation team (Jeremy Bani, Christian Hyde and Marty Flanagan) departed for Longana. The team packed a truck for the first load transported to site. It was confirmed a 3m solar support pipe was indeed missing from shipped equipment delivered to site. The proposed AWS site was very overgrown (Figures 2-2, 2-3) with mature trees standing. We spent all of the morning (10am- 2pm) clearing enough area to plan and layout design of AWS station. Two men with chainsaws were hired to fell large trees. Hilton arranged additional labour boys to assist with clearing work. We started mixing concrete for foundations at 3.30pm. We finished at 7pm with all main anchor foundations poured. Very good work by all.		
Tuesday 4 July	We were onsite at 8.15am. We finished off concreting rain gauge base and trenched conduit and laid cabling for main junction runs. Loic installed the Stevenson screen stand then installed wifi aerial and cabling on mast. Jerry wired in junction cabling (Figure 2-4). Hilton arranged labourers and more concreting materials (sand, coral and water). Kalsuak recorded instrument serial numbers then directed fence installation. More trees felled and site clearance continued. Fence posts cemented in. Top mast assembled by Jerry and Loic, sensors installed and conduit. Mast erected at 2pm. Wiring and sensor installation continued. Loic installed power supply and started site. Jerry completed NEON logger initialization. Site active 5pm. Fence posts, bracing and two strands of wire completed to keep cattle out of enclosure for the night.	Training Module 2,3, equivalent 2 hours	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
Wednesday 5 July	We arrived down at AWS site at 0815am. A cow had got into the enclosure early morning but caused no damage. Jerry, Loic and Christian completed AWS sensor calibrations. Offset corrections for grass minimum (+0.9) and all earth temperatures (+0.3) applied by calling NIWA to update NEON scheme. All other sensors within specification. Kalsuak and Hilton completed AWS site classification and site diagram /plans. Remaining tall trees felled and mesh fencing completed around compound. Photos taken (Figures 2-5, 2-6). Left completed AWS site at 2pm. Packed and wrapped equipment for transport to Norsup on Thursday.	Training Module 2,3, equivalent 2 hours	
Thursday 6 July	Longana AWS site completed and commissioned. All team travel from Longana to Norsup, via Santo stop-over. Half of the installation tools were left behind in Longana, due to the plane being already overweight.	**Longana Airport AWS commissioned**	
Friday 7 July Norsup AWS installation commenced	Hired truck for morning to travel as a team of five. Located a potentially good AWS location in plantation land at NE end of Norsup airport runway, with minimal trees to clear (Figure 2-7). Met with land owner's (David Russet) representative (Pietelo). Drove back with him to potential location and received final approval to build station. Agreed to cutting down of 12 – 15 coconut palms. Pietelo also offered hire of tractor mower to clear area. Drove to Norsup hospital and found stored AWS equipment and materials (at Dr Mackenzie's house). All accounted for (plus missing Longana solar pole). After lunch, returned to AWS location. Tractor mower already clearing area. Measured out and planned AWS layout and enclosure area. Kalsuak, Loic and Jeremy all involved in this process. Transported some building materials to location. Built boxing and dug foundation holes. Very dense, compact soil made difficult digging.	Training Module 2,3, equivalent 2 hours	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
Saturday 8 July	Plantation staff cut down 14 coconut palms as required, within 30m from AWS enclosure fence line (Figure 2-8). Hired two trucks for the day. Another 3x trips to transport all equipment stored at Norsup hospital. Other truck made 5x trips to bring coral / sand / water to site. 5 boys hired for labouring. Started mixing concrete after lunch for foundations and fence posts, taking all afternoon to complete this job. Loic and Jeremy laid out site equipment, prepared conduit, installed junction box wiring. Kalsuak managed concrete mix and fence post installation overseeing hired labourers. All concreting completed by day's end, except 6x fence posts. Very dense soil to dig holes. Finished at 6pm.	Training Module 2,3, equivalent 2 hours	
Sunday 9 July	Hired truck for day plus three boys for labour. Jeremy unwell so had morning off. Kalsuak continued managing enclosure fence construction and directing labour boys. Loic, Christian and Marty completed AWS assembly, wiring in sensors and communications. Mast raised at 1pm. Power supply installed and NEON logger initialised at 2pm. All sensors calibrated and site commissioned at 4pm (Figures 2-9, 2-10).	Training Module 2,3, equivalent 2 hours Airport AWS commissioned	
Monday 10 July	Marty and Jerry departed early for reconnaissance trip to Sola AWS location. Got to Santo only as Sola flight was cancelled. Loic, Kalsuak and Christian completed Norsup AWS site fencing and site meta data, site diagrams and tidying up. Loic injured his head on the corner of solar panel whilst removing concrete boxing timber. Made hospital visit for attention. Calibration offset for Grass minimum sensor uploaded to NEON scheme. As mentioned, the Sola AWS was not installed as planned due to shipping delays in delivering the equipment to the Torba province location in the expected timeframe. Marty made the decision to cancel flights for all the team travelling to Sola. Three of the team remained in Norsup to complete commissioning the AWS. Marty and Jeremy flew to Sola to inspect the proposed AWS site location and determine logistics on-site.	Training Module 2,3, equivalent 2 hours	

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
Tuesday 11 July	Flight for Loic, Kalsuak and Christian was cancelled due to non-availability of an aircraft. Had to stay another day in Norsup. Sam Tapo also arrived in Norsup for preparations of the official AWS openings. Marty and Jerry inspected Sola AWS location. Met with Torba Provincial Secretary General Mr Reynold. He was aware of the project and confirmed his support for the AWS installation. Proposed AWS location NE of runway is in very dense bush. It will be a big job to clear area before installation can proceed. Landowners' agreements have been settled verbally.		
Wednesday 12 July	Loic, Kalsuak and Christian returned to Vila. Excess tools and equipment too much to fit on small plane. Sent back to Port Vila via sea freight by Sam Tapo. Returned to Sola AWS location with Ali Eldads (husband of Alvine – Sola Meteo Officer) and scoped out a suitable area for site installation. Found an area of higher, dry ground 50m in from fence line (Figures 2-11, 2-12, 2-13). A large area of thick bush will need to be cleared before installation can commence. Ali agreed to help arrange community involvement with labour resources and sand / coral supply. Source of fresh water for concreting at stream near airport terminal. Marty and Jerry's return Air Vanuatu flight from Sola cancelled. Uncertainty of flight reliability which was rescheduled for Saturday 15 July, so NIWA hired an air charter next day from Sola to Santo.		
Thursday 13 July	Christian met with Patrica Mawa. Travelled to proposed GIZ AWS location at Takara (old airfield site, NE Efate) to assess site suitability. Then departed home for NZ in afternoon. Marty and Jerry returned to Santo via Air Taxi charter flight. Returned to Port Vila at 5pm.		

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
Friday 14 July **End of Mission 2**	Marty met with Osborne and Patrica. Secured flight refunds from Air Vanuatu for cancelled flights. V-CAP arranging ship to pick up AWS equipment and materials from Santo storage and deliver to Sola. Once delivered and the site has been cleared of vegetation, a team of VMGD staff will travel to Sola for the installation work. It is anticipated these staff are now suitably trained to fully undertake and complete an AWS installation. Phone support from NIWA will be provided during this phase of installation and commissioning.		
Post Mission 2 NOTES	At the end of Mission 2, all the five installed AWS stations were operating on the backup satellite (BGan) telemetry system at a 60-minute polling frequency. Currently satellite telemetry is being used until the planned primary communications pathway (wifi links and internet communication) is in place at each location. Over the months of July and August 2017, the ICT group of VMGD will be completing the necessary work schedule to enable internet communication to each location Meteo office and configuring the wifi linkages to transmit AWS data via the primary communications pathway, as proposed under V-CAP. Once the primary internet wifi links are operational, the NEON polling frequency can be returned to 10 minute periods. It is expect the Sola AWS installation will be completed by mid-August, once equipment has been delivered to the location and the VMGD Team are able to travel for this work.	Mission 2 Installation Report	
Date to be confirmed	VMGD team Loic, Kalsuak, Sam, installed Sola Airport AWS	Sola Airport AWS commissioned	
31 July to 12 August 2017 **CliDEsc upgrade mission**	NIWA team Alan Porteous, Bernard Miville, John Powell upgraded to CliDEsc 2 on the CliDEsc server.		
Thursday 3 August	CliDEsc training with Climate Group, 1.5 hours. Introducing CliDEsc2		

Date	Activity	Outputs	Item Project Deliverable (Tender Response Schedule TRS)
Friday 4 August	CliDEsc training with Forecasting Group, 1.5 hours. Synoptic and METAR automatic coding and quality assurance	Operations Guide: Synop and METAR automated messages coding for Vanuatu Meteorology and Geo-Hazards Department	
Monday 7 August	CliDEsc training with Forecasting Group, 1.5 hours. Synoptic and METAR automatic coding and quality assurance, Session 2		
Tuesday 8 August	CliDEsc training with Climate Group, 1.5 hours. Station chains and monthly reports.		

Appendix E Daily schedule for technical training programme, Christchurch

Week one: 23 January to 27 January

	Monday	Tuesday	Wednesday	Thursday	Friday
0830 - 1000	Welcome and introductions. In briefing discussion on expectations.	Wind direction introduction. - cable termination and connection fitting.	Wind speed introduction. - cable termination and connection fitting	Lincoln EWS – siting classification and discussion (JB) Wifi modem (PN)	Wind speed - servicing, repairing and testing used sensors
1000 - 1015	Morning tea	Morning tea	Morning tea	Morning tea	Morning tea
1015 - 1200	Continuation of introductions and workshop orientation. Campus health and safety induction.	Wind direction continued. - connection fitting continued - sensor operating principles - testing sensor output using DMM and W200P test lead.	Wind speed introduction. - cable termination and connection fitting	Lincoln EWS – siting classification and discussion (JB) Wifi modem (PN)	Wind speed - servicing, repairing and testing used sensors
1200 – 1245	Lunch	Lunch	Lunch	Lunch	Lunch
1245 - 1500	Vaisala HMP155A Temp/RH introduction. - sensor cable termination - sensor operating principles - testing output with digital multi-meter (DMM) Installed NIWA Stardroid and NIWA SDI-12 apps on technicians' Android smartphones and introduction. Bluetooth serial extender introduction. Acclima soil moisture introduction. - sensor cable termination - sensor operating principles - testing output using Bluetooth serial extender and smartphone - changing SDI-12 address on sensor using smartphone.	Wind direction continued. - completion of testing using DMM - begin sealing of connectors	Wind direction - servicing, repairing and testing used sensors	Botanic Gardens – siting classification and discussion (JB) Wifi modem (PN)	Wind speed - servicing, repairing and testing used sensors
1500 - 1515	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea
1515 - 1700	LiCor Li-200 sol radiation sensor introduction. -cable termination. Leaf wetness sensor introduction. -cable termination.	Wind speed introduction. - cable termination and connection fitting	Wind direction - servicing, repairing and testing used sensors	Wind speed - servicing, repairing and testing used sensors	Wind speed - servicing, repairing and testing used sensors

Week two: 30 January to 3 February

	Monday	Tuesday	Wednesday	Thursday	Friday
0830 - 1000	Wind speed - servicing, repairing and testing used sensors	Module 1 – networks and planning	Hughes 9502 modem setup and testing.	NRT communication configuration	Completed sensor wiring. Fine tuning and completion of all cable terminations quality checking of connections.
1000 - 1015	Morning tea	Morning tea	Morning tea	Morning tea	Morning tea
1015 - 1200	Wind speed - servicing, repairing and testing used sensors	Module 1 – networks and planning	Hughes 9502 modem setup and testing. Wifi setup and testing.	NRT communication configuration	Initial sensor checks to confirm all operating. Troubleshooting for sensors not working.
1200 – 1245	Lunch	Lunch	Lunch	Lunch	Lunch
1245 - 1500	Module 1 – networks and planning	Module 1 – networks and planning	NEON setup and configuration. All stations added to NEON, schemes loaded and metadata all updated and checked.	NRT communication configuration	Smarti configuration using Bluetooth serial extender. Wifi current consumption testing and reseting.
1500 - 1515	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea
1515 - 1700	Module 1 – networks and planning	Module 1 – networks and planning	NEON, NRT configuration and intro to StarLog	Junction box and sensor connections to NRT end to end for Aneityum AWS. Wiring diagram interpretation.	Completed Smarti setup and confirmation all sensors working. Started hook up of second station.

Week three: 6 February to 10 February

	Monday	Tuesday	Wednesday	Thursday	Friday
0830 - 1000	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)
1000 - 1015	Morning tea	Morning tea	Morning tea	Morning tea	Morning tea
1015 - 1200	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)
1200 – 1245	Lunch	Lunch	Lunch	Lunch	Lunch
1245 - 1500	Public Holiday	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)
1500 - 1515	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea
1515 - 1700	Public Holiday	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)

Week four: 13 February to 17 February

	Monday	Tuesday	Wednesday	Thursday	Friday
0830 - 1000	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	Wrap up meeting.
1000 - 1015	Morning tea	Morning tea	Morning tea	Morning tea	Morning tea
1015 - 1200	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	Wrap up meeting.
1200 – 1245	Lunch	Lunch	Lunch	Lunch	Lunch
1245 - 1500	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	Free time
1500 - 1515	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea	Afternoon tea
1515 - 1700	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	AWS assembly and bench testing. (Includes Smarti configuration, instrument calibration, NEON setup, logger programming and reprogramming, communications setup and any trouble shooting)	Free time

Appendix F Site shipping lists

The following items comprise the shipping list for each site, including items imported from New Zealand, and items purchased in Port Vila.

Aneityum AWS

1	Large stainless steel housing labeled with station name (complete with logger)
1	Square galvanised mounting stand for solar panel and housing with plate on top
2	65 Ah batteries
1	100W solar panel
1	Small Stevenson screen
1	Stand for Stevenson screen
1	Braces stand Stevenson screen
1	PVC probe for earth temperature sensors
1	Copper coated earth rod
1	Aneityum Box 1 - buckets with Iplex fittings, misc fittings, rg mount, sat antenna and mount)
1	Aneityum Box 2 - sensors and wifi units
1	80mm x 3.25m pipe with pivot fitted one end, 80-50mm reducer other end
1	40mm x 3.25m pipe with protection socket one end.
2	50mm x 6m pipe with socket each end
3	Anchors
1	Cradle
1	Winch mount
1 pair	Wifi mount (2 x 2m x 40mm pipe)
11	6m 25mm pvc pipe
1	1kg nails
1	Boxing timber (full set)
10	40kg bags cement

Fencing

6	2.8m x 50mmNB post with caps
22	2.6m x 40mm NB post with caps
10	2.8m x 32mmNB post
6	Green PVC chain link mesh 1800 x 2.8 x 50
6 roll	High tensil wire 1.6mm 1kg
10	M8 turnbuckle
1 roll	3.15mm tie wire
1	Gate
2	Elgate Tee, Thru 50NB x Butt 32NB
10	Elgate Tee, Thru 40NB x Butt 32NB
4	Elgates Corner, Thru 50NB x Butt 32NB x Butt 32NB

Sola Airport AWS

1	Large stainless steel housing labeled with station name (complete with logger)
1	Square galvanised mounting stand for solar panel and housing with plate on top
2	65 Ah batteries
1	100W solar panel
1	Small Stevenson screen
1	Stand for Stevenson screen
1	Braces stand Stevenson screen
1	PVC probe for earth temperature sensors
1	Copper coated earth rod
1	Sola Box 1 - buckets with Iplex fittings, misc fittings, rg mount, sat antenna and mount)
1	Sola Box 2 - sensors and wifi units
1	80mm x 3.25m pipe with pivot fitted one end, 80-50mm reducer other end
1	40mm x 3.25m pipe with protection socket one end.
2	50mm x 6m pipe with socket each end
3	Anchors
1	Cradle
1	Winch mount
1 pair	Wifi mount (2 x 2m x 40mm pipe)
11	6m 25mm pvc pipe
1	1kg nails
1	Boxing timber (full set)
10	40kg bags cement

Fencing

6	2.8m x 50mmNB post with caps
22	2.6m x 40mm NB post with caps
10	2.8m x 32mmNB post
6	Green PVC chain link mesh 1800 x 2.8 x 50
6 roll	High tensil wire 1.6mm 1kg
10	M8 turnbuckle
1 roll	3.15mm tie wire
1	Gate
2	Elgate Tee, Thru 50NB x Butt 32NB
10	Elgate Tee, Thru 40NB x Butt 32NB
4	Elgates Corner, Thru 50NB x Butt 32NB x Butt 32NB

Longana Airport AWS

1	Large stainless steel housing labeled with station name (complete with logger)
1	Square galvanised mounting stand for solar panel and housing with plate on top
2	65 Ah batteries
1	100W solar panel
1	Small Stevenson screen
1	Stand for Stevenson screen
1	Braces stand Stevenson screen
1	PVC probe for earth temperature sensors
1	Copper coated earth rod
1	Longana Box 1 - buckets with Iplex fittings, misc fittings, rg mount, sat antenna and mount)
1	Longana Box 2 - sensors and wifi units
1	80mm x 3.25m pipe with pivot fitted one end, 80-50mm reducer other end
1	40mm x 3.25m pipe with protection socket one end.
2	50mm x 6m pipe with socket each end
3	Anchors
1	Cradle
1	Winch mount
1 pair	Wifi mount (2 x 2m x 40mm pipe)
11	6m 25mm pvc pipe
1	1kg nails
1	Boxing timber (full set)
10	40kg bags cement

Fencing

6	2.8m x 50mmNB post with caps
22	2.6m x 40mm NB post with caps
10	2.8m x 32mmNB post
6	Green PVC chain link mesh 1800 x 2.8 x 50
6 roll	High tensil wire 1.6mm 1kg
10	M8 turnbuckle
1 roll	3.15mm tie wire
1	Gate
2	Elgate Tee, Thru 50NB x Butt 32NB
10	Elgate Tee, Thru 40NB x Butt 32NB
4	Elgates Corner, Thru 50NB x Butt 32NB x Butt 32NB

Whitegrass Airport AWS

1	Large stainless steel housing labeled with station name (complete with logger)
1	Square galvanised mounting stand for solar panel and housing with plate on top
2	65 Ah batteries
1	100W solar panel
1	Small Stevenson screen
1	Stand for Stevenson screen
1	Braces stand Stevenson screen
1	PVC probe for earth temperature sensors
1	Copper coated earth rod
1	Whitegrass Box 1 - buckets with Iplex fittings, misc fittings, rg mount, sat antenna and mount)
1	Whitegrass Box 2 - sensors, wifi units, 7Ah batt
1	Whitegrass Box 3 - junction boxes, rad mount
1	80mm x 3.25m pipe with pivot fitted one end, 80-50mm reducer other end
1	40mm x 3.25m pipe with protection socket one end.
2	50mm x 6m pipe with socket each end
3	Anchors
1	Cradle
1	Winch mount
1 pair	Wifi mount (2 x 2m x 40mm pipe)
11	6m 25mm pvc pipe
1	1kg nails
1	Boxing timber (full set)
10	40kg bags cement

Fencing

6	2.8m x 50mmNB post with caps
22	2.6m x 40mm NB post with caps
10	2.8m x 32mmNB post
6	Green PVC chain link mesh 1800 x 2.8 x 50
6 roll	High tensil wire 1.6mm 1kg
10	M8 turnbuckle
1 roll	3.15mm tie wire
1	Gate
2	Elgate Tee, Thru 50NB x Butt 32NB
10	Elgate Tee, Thru 40NB x Butt 32NB

Lamap AWS

1	Large stainless steel housing labeled with station name (complete with logger)
1	Square galvanised mounting stand for solar panel and housing with plate on top
2	65 Ah batteries
1	100W solar panel
1	Small Stevenson screen
1	Stand for Stevenson screen
1	Braces stand Stevenson screen
1	PVC probe for earth temperature sensors
1	Copper coated earth rod
1	Lamap Box 1 - buckets with Iplex fittings, misc fittings, rg mount, sat antenna and mount)
1	Lamap Box 2 - sensors
1	Lamap Box 3 - cross arm, wifi units
1	80mm x 3.25m pipe with pivot fitted one end, 80-50mm reducer other end
1	40mm x 3.25m pipe with protection socket one end.
2	50mm x 6m pipe with socket each end
3	Anchors
1	Cradle
1	Winch mount
1 pair	Wifi mount (2 x 2m x 40mm pipe)
11	6m 25mm pvc pipe
1	1kg nails
1	Boxing timber (full set)
10	40kg bags cement

Fencing

6	2.8m x 50mmNB post with caps
22	2.6m x 40mm NB post with caps
10	2.8m x 32mmNB post
6	Green PVC chain link mesh 1800 x 2.8 x 50
6 roll	High tensil wire 1.6mm 1kg
10	M8 turnbuckle
1 roll	3.15mm tie wire
1	Gate
2	Elgate Tee, Thru 50NB x Butt 32NB
10	Elgate Tee, Thru 40NB x Butt 32NB
4	Elgates Corner, Thru 50NB x Butt 32NB x Butt 32NB

Norsup Airport AWS

1	Large stainless steel housing labeled with station name (complete with logger)
1	Square galvanised mounting stand for solar panel and housing with plate on top
2	65 Ah batteries
1	100W solar panel
1	Small Stevenson screen
1	Stand for Stevenson screen
1	Braces stand Stevenson screen
1	PVC probe for earth temperature sensors
1	Copper coated earth rod
1	Norsup Box 1 - buckets with Iplex fittings, misc fittings, rg mount, sat antenna and mount)
1	Norsup Box 2 - crossarm, wind sensors, wifi units
1	Norsup Box 3 - sensors, junction boxes
1	80mm x 3.25m pipe with pivot fitted one end, 80-50mm reducer other end
1	40mm x 3.25m pipe with protection socket one end.
2	50mm x 6m pipe with socket each end
3	Anchors
1	Cradle
1	Winch mount
1 pair	Wifi mount (2 x 2m x 40mm pipe)
11	6m 25mm pvc pipe
1	1kg nails
1	Boxing timber (full set)
10	40kg bags cement

Fencing

6	2.8m x 50mmNB post with caps
22	2.6m x 40mm NB post with caps
10	2.8m x 32mmNB post
6	Green PVC chain link mesh 1800 x 2.8 x 50
6 roll	High tensil wire 1.6mm 1kg
10	M8 turnbuckle
1 roll	3.15mm tie wire
1	Gate
2	Elgate Tee, Thru 50NB x Butt 32NB
10	Elgate Tee, Thru 40NB x Butt 32NB
4	Elgates Corner, Thru 50NB x Butt 32NB x Butt 32NB

Common to all sites

Note this list is not to be shipped in advnce but to be taken on flights at time of vist

1	100m roll data cable with crimps (for Wifi)
1	25m roll 32mm flex conduit
1	100m roll of auto cable (for wifi power supply)

See Checklist of gear to take into field.doc
Also copied below

Field references (Travelling standards)

Vaisala PTB330TS air temp/humidity and pressure
Hydrological Services rain gauge calibrator
- NIWA rain gauge counter for use with HS calibrator
- Charged 12V 1.9Ah battery
- Water for rain gauge calibrations

Center 375 RTD Inspector's or reference thermometer for water or ice point checks
- Flask for water/ice

LI250A – Licor hand held solar radiation field reference

Field kit

Padlock
Keys (gate, logger box)
Laptop (fully charged)
- Correct software and logger programs loaded
- Correct cables to connect to data loggers
- Power adaptor/invertor

SDI-12 to USB device (Bluetooth serial adaptor)
Multimeter (with Frequency output)
GPS unit
Protractor and angle finder
Compass
Range finder
Camera
Mast Winch (I-trans safety winch)

Field Tools

225mm Torpedo Level
13mm spanner (x2)
Screw Driver set (Small - 3mm flat head and Phillips)
Screw Driver set (larger screw drivers)
Weidmuller 4.0 x 100 (for klippon terminals)
Fuller square drive screw driver
Kokon 167m 5mm socket driver
Kokon 167m 5.5mm socket driver
10mm, 13mm socket with driver and 250mm extension
Spanners/Cresents (assorted sizes) 4mm to 250mm
5m tape measure
30m tape measure
Post Level

6” pliers
10” pliers
Hex Key set
PVC pipe cutter
Side cutters
Craft knife
Pull through string
6.5mm, 10mm, 13mm drill bits
32mm and 35mm hole saws
Hammer
Saw
Hacksaw
12V soldering iron
RJ45 crimp tool
PZ4 crimp tool
Hex crimp tool

Field Maintenance misc items

PVC tape
Zinc-it cold galv spray can
Lubricant (WD40 or CRC)
Cable ties
20mm flex conduit (grass min)
32mm flex conduit
RTV (gap filler) and caulking gun
Paint brushes
White paint (for thermometer screen)
White paint (for mast)
Red paint (for mast)
Water container
Cleaning materials – cloth, cleaning liquid, cleaning brush
Insect spray (Mortein) – for ants etc.
Grass/Hedge cutters
Kit containing assorted bits (ferrules, fuses, diodes, connecters, M4, M6 and M8 screws etc.)
Band-it tape, tool and crimps
Grease
Denso tape

Misc tools

14 or 18V Cordless Drill
600mm Pipe Wrench (x2)
Sledge hammer
Long bar (Crow bar)
Pick
Spade
Edging Trowel
Flat Trowel
Bolt cutters
Band-it tool, tape and clips
4” flat head nails

Boxing timber
Rope

Personal gear

Wet weather gear
Sunscreen
Insect repellent

Other

Battery
Solar regulator
Umbrellas
Ground sheets