Operational climate maps for Vanuatu - 2

Training Workbook and User Guide

Prepared for Vanuatu Meteorology and Geo-Hazards Department

June 2023

Climate, Freshwater & Ocean Science

Prepared by:
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Version 0.1	Draft in preparation/in review with SPREP	8/5/2023
Version 1.0	Updated following SPREP review	12/5/2023
Version 1.1	Added training material and user guide	22/6/2023

Quality Assurance Statement		
	Reviewed by:	
	Formatting checked by:	
	Approved for release by:	

Contents

1 Background to Training Terms of Reference

The Vanuatu Meteorology and Geo-Hazards Department (VMGD) is working to develop new procedures and capability to enhance operational climate monitoring, reporting and services to build weather and climate resilience in Vanuatu.

The Secretariat of the Pacific Regional Environment Programme (SPREP), as the Executing Entity for the Green Climate Fund (GCF) funded Climate Information Services for Resilient Development in Vanuatu project (known locally as *Van-KIRAP – Vanuatu Klaemet Infomesen blong Redy, Adapt mo Protekt*)Van KIRAP) has engaged the services of the NIWA (the New Zealand National Institute of Water and Atmospheric Research) to develop and implement, within the broad scope of *Van KIRAP*, two key outputs:

1. A compendium or atlas of Maps of the Past Climate of Vanuatu (reported in this document): Monthly and seasonal maps showing historical long term average rainfall and air temperature for Vanuatu, including for ENSO phases.

2. A suite of operational climate maps for Vanuatu: operational daily updates of maps showing Vanuatu rainfall and air temperature for the past 30, 60, 90, 180 and 365 days.

These outputs will be developed and delivered in a series of electronic and hard copy formats, rendered maps, User Guides, and training.

This document provides an outline of the Terms of Reference for the training to be delivered as specified in the project Contract. An outline of the content of the proposed 5-day training schedule is appended.

2 Training personnel and schedule

The Contract for Services for this project provides for experienced staff from NIWA's Climate Data and Applications Group to spend one week at the Vanuatu Meteorology and Geo Hazards Department in Port Vila, Vanuatu to deliver the training.

- James Sturman, Spatial Science and GIS Solutions Development Scientist (Principal Consultant)
- Hannah Marley, Scientific Applications Developer
- Juliana Ungaro, Client and sector project management, Climate Services and Risk Analysis Scientist.
- Alan Porteous, Climate Applications Scientist, Project Manager

The training will be delivered during the week of 26th to 30th June, 2023.

3 Expected outcomes

Van KIRAP aims to strengthen the application of Climate Information Services in five targeted development sectors: tourism; agriculture; infrastructure; water and fisheries. More specifically, the project is building the technical capacity in Vanuatu to harness and manage climate data; develop and deliver practical CIS tools and resources; support enhanced coordination and dissemination of tailored information; enhance CIS information and technology infrastructure; and support the application of relevant CIS through real-time development processes, for more resilient outcomes.

The project is addressing information gaps and priority needs of target beneficiaries at national, provincial and local community levels across the five priority sectors through four core components:

1. Strengthening the VMGD platform to provide quality climate data and information for CIS.
2. Demonstrating the value of CIS at the sectoral and community levels.
3. Developing CIS tools and engaging with stakeholders through outreach and communications.
4. Strengthening the institutional capacity for long-term implementation of CIS in decision-making.

3.1 VMGD climate staff

VMGD climate staff will review the CliDEsc user interface and become more familiar with how CliDEsc interacts with CliDE, and the use of product generators to analyse data and create outputs. Staff will gain understanding of how the maps of historical climate were produced, and how they can be interpreted. Staff will gain insights into the production of climate anomaly maps from rainfall and air temperature data, and be able to manage routine or on-demand map generation. A key outcome will be the enhancement of operational product generation and delivery scheduling for both internal use and external sector clients, including email and web services. A road map for future product development will be created.

3.2 Sector representatives

Invited sector representatives will be given an overview of both the historical and operational map generation and outputs. Particular highlights indicating climate variability will be discussed, including ENSO seasonal variations and what can be learned with reference to the coming El Niño. Familiarity with the maps will lead to the opportunity to plan how to use the maps in real time for planning, risk management and decision support.

4 Appendices

1. VMGD Staff consultation and training, Part 1.
   - Schedule Day 1
2. Van KIRAP Sector consultation and training, Part 2.
   - Schedule Day 2
3. Training presentation Part 1.
   - Vanuatu historical and operational climate maps objectives and methods
4. Training presentation Part 2.
   - Operational maps system and user guide

Appendix A Training schedule Part 1.

Vanuatu Meteorology and Geo Hazards Department, Climate Division
Port Vila, Vanuatu 26-28 June, 2023

Programme Schedule for VMGD Climate Staff

Date	Topics	Expectations/Outcomes
Thematic Training Focus: ***Creating informative climate maps from historical and real time data for planning and operational decision making and risk management***		
Mon 26 June	**09:00-10:00 Opening** Formal proceedings, opening, scene setting and training objectives. **10:30-12:00 Introducing the mapping project** Project overview and objectives Map production methods and procedures **13:00-16:00 Creating historical climate maps** a) Making the most of available climate data b) Geography and climate Group work – interpreting the maps. c) Definition of ENSO years d) Guide to understanding historical climate maps Group work – interpreting the maps. Can you find any issues with the maps? Homogeneous regions / gaps in spatial data / interpolation Where to find the maps / how to download / where to store long term	Familiarity with the scope of the project. Familiarity with how the maps were developed, the importance of the data, and any constraints resulting from uncertain data quality. Understanding map making methodology and tools
Tue 27 June	**09:00-10:00** Summary and recap of Day 1. Objectives for Day 2. **10:30-12:00 Rainfall from satellites** a) Rainfall maps from satellite data b) Map production methods and procedures **13:00-16:00 Maps of homogeneous climate regions** a) Making the most of available climate data b) Geography and climate c) Generating maps in real time d) Checking CliDE metadata e) Checking AWS data ingest Future opportunities (THREDDS server etc)	Review the scope of the project. Gain an overview of the sources of satellite data Not all parts of Vanuatu are covered by climate observations, so we can interpolate data using homogeneous climate zones

Date	Topics	Expectations/Outcomes
Wed 28 June	**09:00-10:00** Summary and recap of Day 2. **10:30-12:00** a) CliDE and CliDEsc – joint operations and tools b) Generating map products in CliDEsc **13:00-14:00 Operational climate maps** a) Generating maps each day b) Checking and quality control c) Adding maps to routine products d) Automation of map generation **15:00-16:30 Related services** Extremes dashboard Island Climate Update analysis and forecast maps	Review the objectives of the project. Practice and familiarity using CliDE and CliDEsc to respond to client enquiries and delivering mapped data as a component of climate services. Familiarity with of operational map generation and delivery.

Appendix B Training schedule Part 2.

Vanuatu Meteorology and Geo Hazards Department, climate sensitive sector engagement
Applied climate mapping for climate risk management.
Port Vila, Vanuatu 29-30 June, 2023

Programme Schedule for Vanuatu Climate Sensitive Sectors

Date	Topics	Expectations/Outcomes
Thematic Training Focus: ***Using mapped climate information to make timely decisions and manage climate risk***		
Thu 29 June	**09:00-10:00 Opening** Formal proceedings, opening, scene setting and training objectives. **10:30-12:00 Introducing the mapping project** Project overview and objectives Map production methods and procedures **13:00-13.30 Historical climate maps** a) Making the most of available climate data b) Geography and climate c) Definition of ENSO years d) Guide to understanding historical climate maps **13:30-14.30** How can we use this information – group work discussions and presentations of ideas. **15:00-15:30 Operational climate maps** a) Satellite rainfall data b) Automatic weather station data c) Understanding climate zones and uncertainties **15:30-16:30** How can we use this information – group work and presentations.	Sector representatives will become familiar with the climate maps and how they illustrate the rainfall and air temperature climate of Vanuatu. Distinct characteristics of the climate of Vanuatu illustrated by the maps will be highlighted and discussed. Examples Sector representatives will be introduced to the near real time production of anomaly maps and discuss how these can be distributed and used. ICU outlook maps. Looking at design of information/methods of distribution
Fri 30 June	**09:00-09:30 Recap and Objectives for the day** Sector comments, questions, and current **use cases around risk management** **10:30-12:00 Defining sector needs** How can climate maps contribute to climate resilience Information content, delivery, and communication Compile a use-case table **13:00-15:00 Agreements and commitments to provide services** a) Information formats b) Communication methods and schedules c) Feedback and further development, after implementation	Operational services to use the maps and associated products from the CliDE/CliDEsc platform will be planned, scheduled and put in motion. Set up a reporting system for feedback and further development.

Appendix C Training presentation Part 1.

Vanuatu historical and operational climate maps and mapping services

VMGD introductory workshops and services planning: DAY 1

26-30 June, 2023

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Project overview and objectives

1. Strengthening the VMGD platform to provide quality climate data and information for CIS.
2. Demonstrating the value of CIS at the sectoral and community levels.
3. Developing CIS tools and engaging with stakeholders through outreach and communications.
4. Strengthening the institutional capacity for long-term implementation of CIS in decision-making.

Primary outputs

1. A compendium or atlas of Maps of the Past Climate of Vanuatu: Monthly and seasonal maps showing historical long term average rainfall and air temperature for Vanuatu, including for ENSO phases.
2. A suite of operational climate maps for Vanuatu: operational daily updates of maps showing Vanuatu rainfall and air temperature for the past 30, 60, 90, 180 and 365 days.

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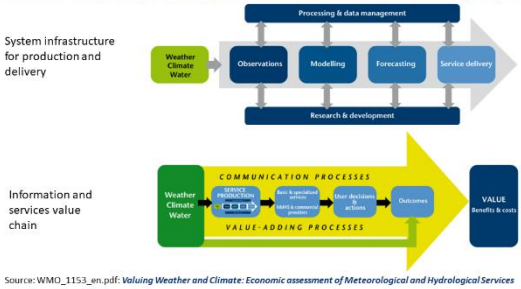
Global context: Global Framework for Climate Services



Source: WMO_1153_en.pdf: *Valuing Weather and Climate: Economic assessment of Meteorological and Hydrological Services*

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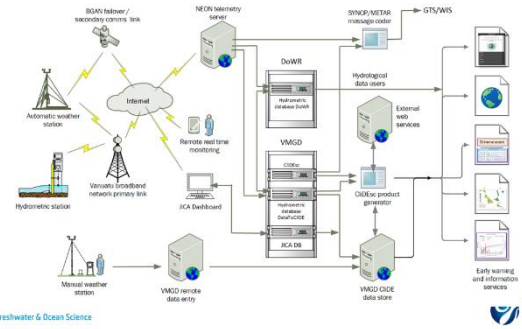
Vanuatu Climate Information and Early Warning System



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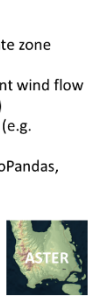
What do we need to create reliable climate maps - 1

- Good long term quality station data
- A representative climate station in each climate zone
  - Spatial - homogeneity
  - Vertical - lapse rate and aspect to dominant wind flow
- Topographic data – (a digital elevation model)
- Data review, analysis, and manipulation tools (e.g. Python, Pandas, xarray)
- Spatial analysis tools (e.g. GDAL, Rasterio, GeoPandas, ANUSplin)
- Mapping software (e.g. Cartopy)
- Satellite data (NASA GPM-IMERG)



python
pandas
GeoPandas
xarray
GDAL
Cartopy

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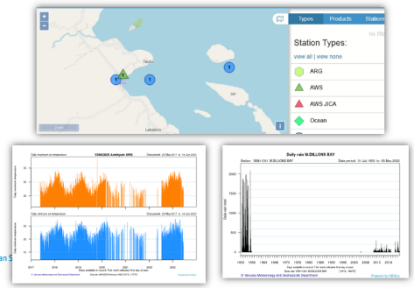
What do we need to create reliable climate maps - 2

- Reliable data: high quality, no gaps, correct location



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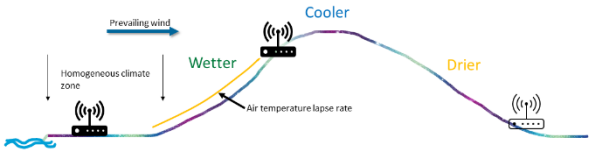
What do we need to create reliable climate maps - 3

- A representative climate station in each climate zone
  - Spatial - homogeneity
  - Vertical - lapse rate and aspect to dominant wind flow



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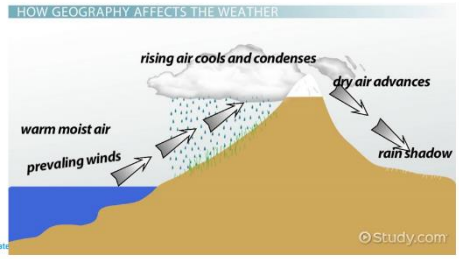
What do we need to create reliable maps - 4

- Topography: height, slope and aspect



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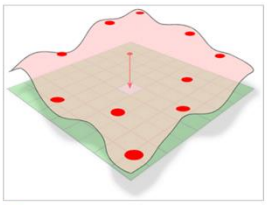
What do we need to create reliable climate maps - 5

- Spatial interpolation – 'getting data everywhere by bending a data surface through known data points'



Definition of ENSO months

- Monthly Southern Oscillation Index (SOI) data provided by NIWA (1950-2023)
- SOI five-month rolling mean centred on each month
- ±0.7 threshold was applied to designate whether a month was in an El Niño, La Niña, or ENSO Neutral phase
- Extended data period 1 January 1951 to 31 December 2020 was used to capture more El Niño or La Niña phases
- Monthly means were then calculated for the respective ENSO phases
- To increase sample size stations with only 2 complete months of data were allowed
- Manual data checking to identify outliers that were removed prior to mapping

	El Niño	La Niña	Neutral	Total
January	11	16	45	72
February	8	14	50	72
March	8	13	51	72
April	8	17	47	72
May	11	16	45	72
June	11	22	39	72
July	13	24	35	72
August	11	19	42	72
September	13	18	41	72
October	14	17	41	72
November	13	15	44	72
December	14	15	43	72
	135	206	523	864

 Reference: El Niño and La Niña | NIWA

Mapping methodology

- Python mapping script
- Python spatial packages e.g. GDAL, Rasterio, GeoPandas and Cartopy
- Contextual spatial layers e.g. coastlines, DEM and hillshade grids
- Long term average rainfall and air temperature grids
- Climate station locations with long term average rainfall and air temperature statistics

GeoPandas

GDAL cartopy

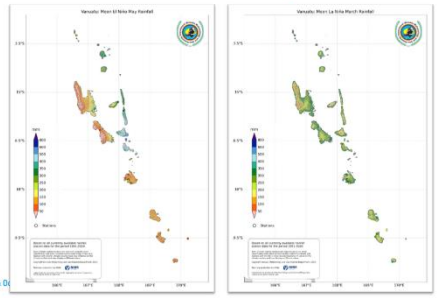
Warning

- A pretty picture doesn't always show the truth

Things to look out for

- Differences between land-based observations and the spatially interpolated data surface
- Something doesn't look right – e.g. spatial relationship between climate parameter and elevation.
- Incorrect metadata – e.g. stations in the wrong place

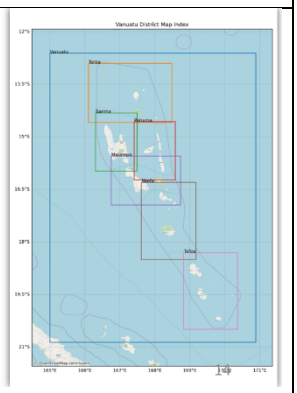
Things to look out for – ENSO Examples



What do the maps tell us?

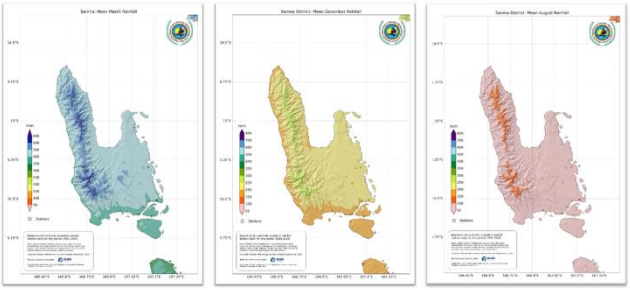
Past (historical climate)

- Average rainfall and air temperature by month
- Distinguish climate of wet and dry seasons
- Distinguish effects of ENSO
- Maps prepared for Vanuatu and 6 Provinces
- Stored in reference map library accessible via CliDEsc



Examples

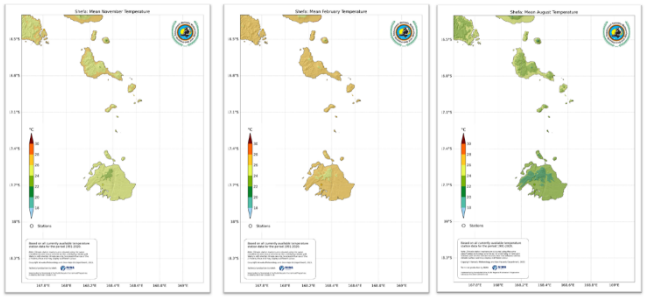
Monthly rainfall



March December August

Examples

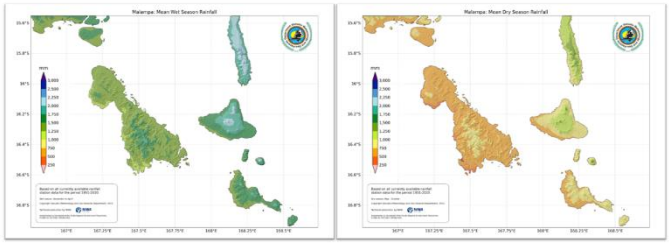
Monthly air temperature



November February August

Examples

Wet and dry seasons rainfall



Wet Dry

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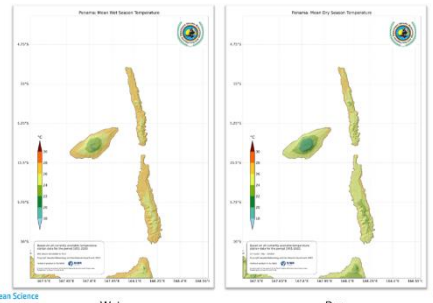
Examples

Wet and dry seasons temperature



Wet Dry

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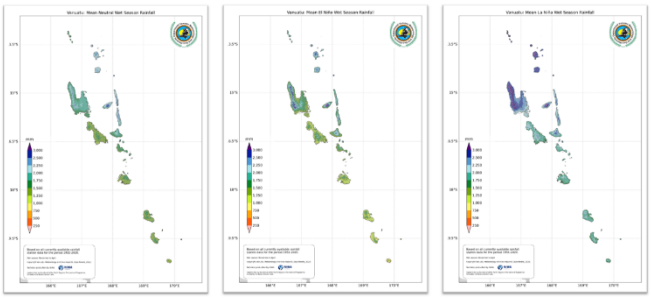
Examples

ENSO wet season rainfall



Neutral El Niño La Niña

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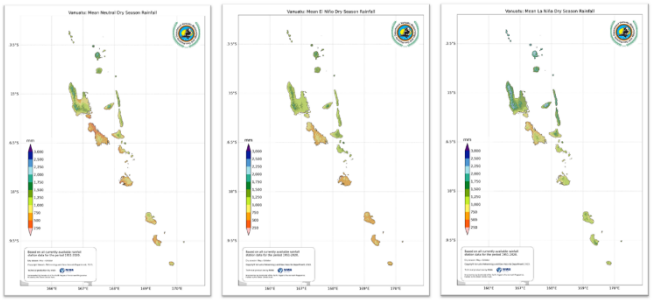
Examples

ENSO dry season rainfall



Neutral El Niño La Niña

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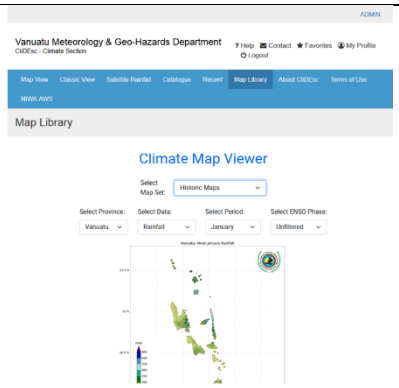
Where to find the maps

- CliDEsc Demonstration
- Where to store long term?
- Other locations e.g. external websites



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Steps for accessing CliDEsc Map Library

1. Open browser and navigate to CliDEsc log in page http://clidesc.vmgd.gov.vu/clidesc/

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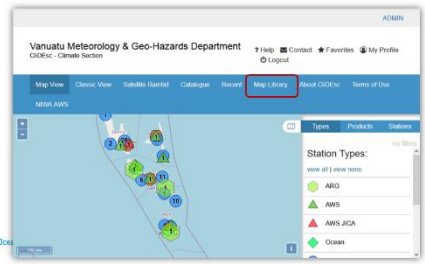
Steps for accessing CliDEsc Map Library

2. Select Map Library tab



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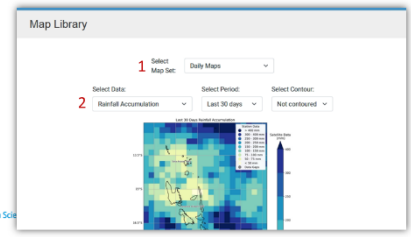
Steps for accessing CliDEsc Map Library

3. Use the first selector to choose the Map Set
4. Use the second set of selectors to choose a map to view



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Appendix D Training presentation Part 2

Vanuatu historical and operational climate maps and mapping services

VMGD introductory workshops and services planning: DAY 2

26-30 June, 2023

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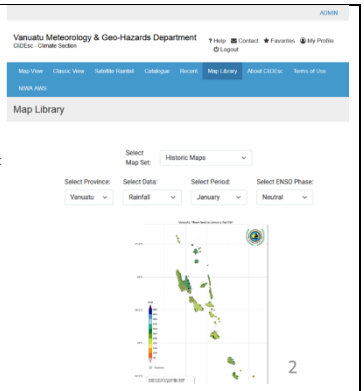
Summary of Day 1

- Monthly and seasonal maps showing historical long term average rainfall and air temperature for Vanuatu, including for ENSO phases.
- A suite of operational climate maps for Vanuatu showing rainfall and air temperature for the past 30, 60, 90, 180 and 365 days.
- All maps accessible via CliDEsc.
- Importance of good quality long term climate station data and representative stations in specific climate zones.
- Understanding what the historical climate maps tell us.



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Objectives for Day 2

- Rainfall maps from satellite data
- Importance of climate station data reliability
- Operational climate mapping data sources, methods and procedures
- Scheduling climate map production
- Interpreting the operational climate maps
- Future opportunities

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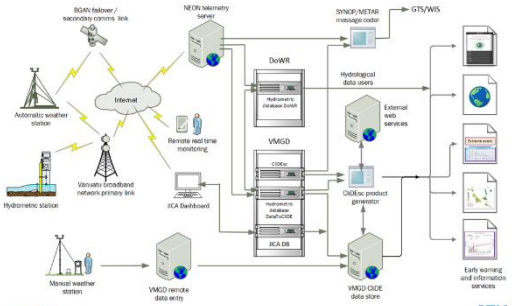
Vanuatu Climate Information and Early Warning System



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What do we need to create reliable climate maps - 1

- Access to satellite precipitation data products (NASA GPM-IMERG & NIWA)
- Near real time good quality station data
- Data review, analysis, and manipulation tools (e.g. Python, Pandas, xarray)
- Historical long term monthly average rainfall and air temperature data grids for Vanuatu
- Spatial analysis tools (e.g. Gdal, Rasterio, GeoPandas)
- Mapping software (e.g. Cartopy)

python
pandas
GeoPandas
xarray
GDAL
Cartopy

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What do we need to create reliable climate maps - 2

- Reliable data: high quality, no gaps, correct location, near real time

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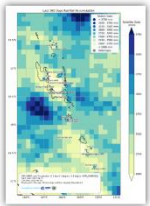
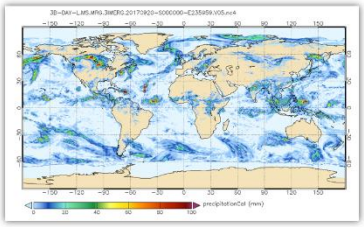
What do we need to create reliable climate maps - 3

- Satellite data
- Inherent uncertainty and error





https://disc.gsfc.nasa.gov/datasets/GPM_3IMERGDL_06/summary

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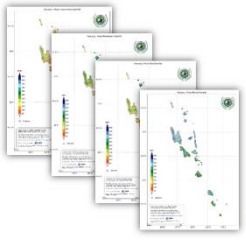
What do we need to create reliable climate maps - 4

- AWS station locations
- Historical long term monthly average rainfall and air temperature data grids



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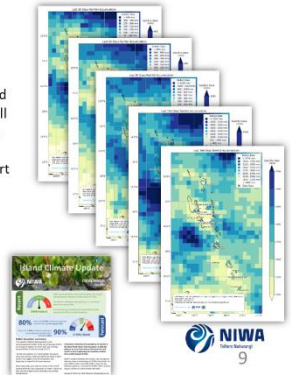
Operational rainfall maps

- GPM-IMERG satellite data provided by NASA and used by NIWA to generate rainfall accumulation and rainfall anomaly data products for the Island Climate Update https://niwa.co.nz/climate/island-climate-update
- AWS daily rainfall data extracted from CliDE using start and end dates that match the satellite data
- Subsets of data were created for the past 30, 60, 90, 180 and 365 day periods
- Python and Pandas used to calculate the mean total rainfall (*Rptot*) (mm) for each period
- Missing daily station data allowed, but no more than 20%



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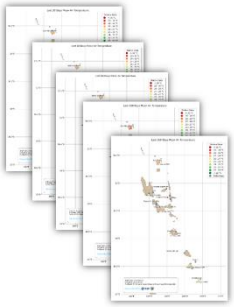
Operational temperature maps

- NASA/NIWA temperature satellite data products unavailable
- AWS daily minimum and maximum temperature data extracted from CliDE using start and end dates that match the rainfall maps
- Subsets of data were created for the past 30, 60, 90, 180 and 365 day periods
- Python and Pandas used to calculate the mean daily temperature (°C)

$$Tdave = \frac{(Tdmax + Tdmin)}{2}$$

- Mean temperature (*Tpave*) (°C) then calculated for the past 30, 60, 90, 180 and 365 day periods
- Missing daily station data allowed, but no more than 20%



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Rainfall and Temperature Anomaly Calculation

- Monthly historical average temperature and rainfall values assigned to AWS station locations using an Extract Grid Values to Points operation
- Each day was assigned a historical monthly mean temperature ($HTmave$) and monthly mean total rainfall ($HRmavetot$)
- Daily historical rainfall values determined:

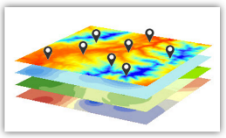
$$HRdavetot = \frac{HRmavetot}{Mndays}$$

- Historical total rainfall for each period ($HRpavetot$) was calculated by summing the daily rainfall ($HRdavetot$) values for each AWS station
- Historical mean temperature for the period ($HTpave$) was calculated by averaging the mean temperature values ($HTmave$) for each AWS station
- Rainfall anomaly calculated as:

$$Rpanom = Rptot - HRpavetot$$

- Temperature anomaly calculated as:

$$Tpanom = Tpave - HTpave$$



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Things to look out for

- Large differences between land-based observations and satellite data
- Incorrect metadata – e.g. stations in the wrong place
- Stations not updating

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What do the maps tell us?

Recent climate

- Rainfall accumulation and anomaly
- Air temperature average and anomaly
- Combine satellite and land-based observations (rainfall only)
- New maps generated each day via CliDEsc job schedule
- Stored in reference map library accessible via CliDEsc

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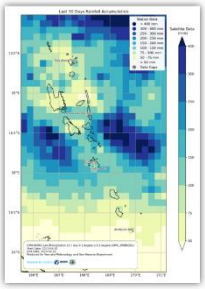
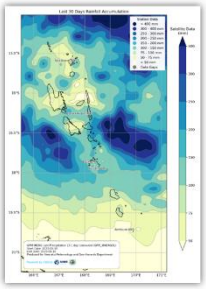
Examples

Rainfall accumulation last 30 days



Raw satellite data



Contoured satellite data

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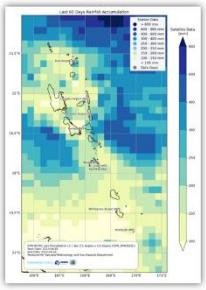
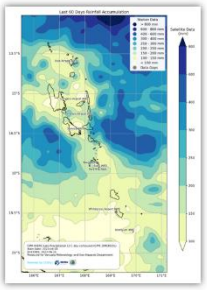
Examples

Rainfall accumulation last 60 days



Raw satellite data



Contoured satellite data

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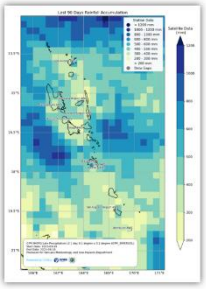
Examples

Rainfall accumulation last 90 days



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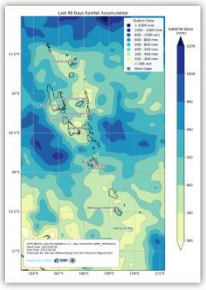

Contoured satellite data

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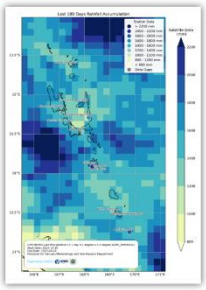
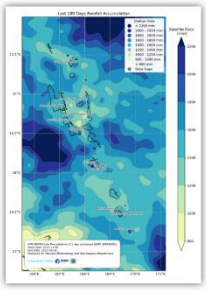
Examples — Rainfall accumulation last 180 days



Raw satellite data



Contoured satellite data

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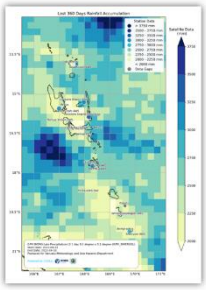
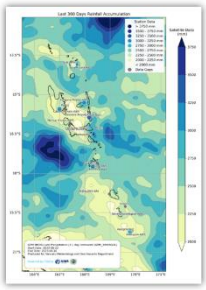
Examples — Rainfall accumulation last 360 days



Raw satellite data



Contoured satellite data

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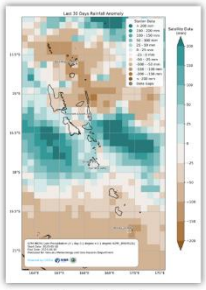
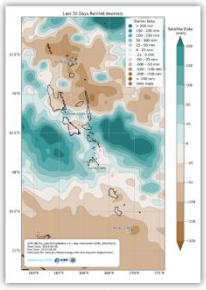
Examples — Rainfall anomaly last 30 days



Raw satellite data



Contoured satellite data

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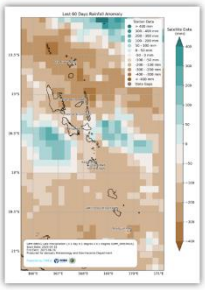
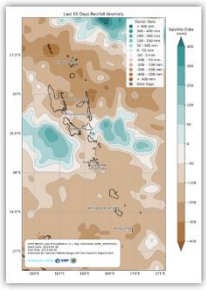
Examples — Rainfall anomaly last 60 days



Raw satellite data



Contoured satellite data

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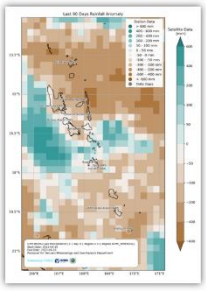
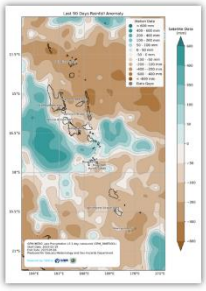
Examples — Rainfall anomaly last 90 days



Raw satellite data



Contoured satellite data

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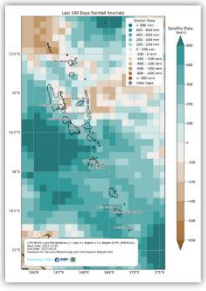
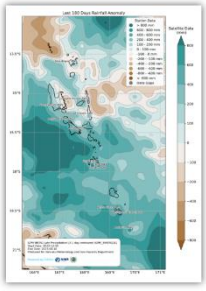
Examples — Rainfall accumulation last 180 days



Raw satellite data



Contoured satellite data

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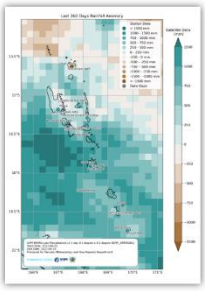
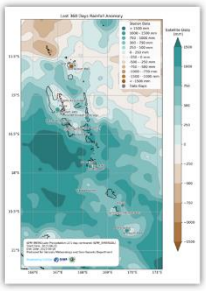
Examples — Rainfall anomaly last 360 days



Raw satellite data



Contoured satellite data

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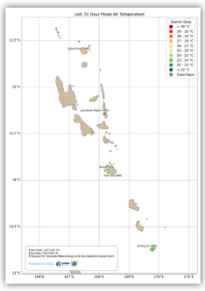
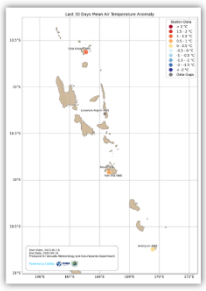
Examples — Temperature last 30 days



Mean



Anomaly

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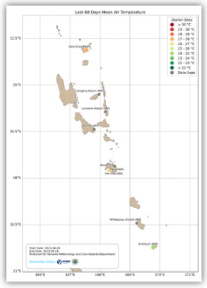
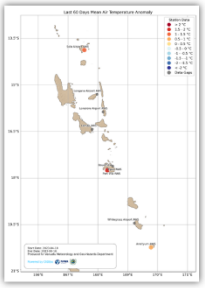
Examples

Temperature last 60 days



Mean



Anomaly

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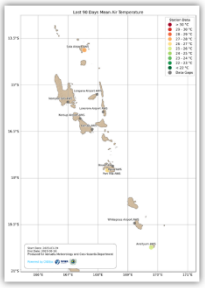
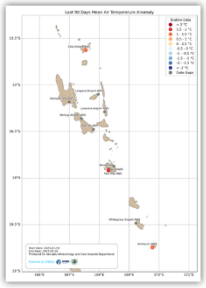
Examples

Temperature last 90 days



Mean



Anomaly

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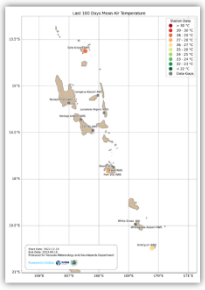
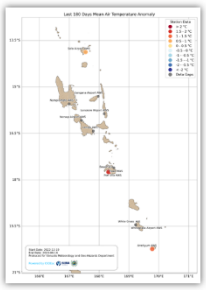
Examples

Temperature last 180 days



Mean



Anomaly

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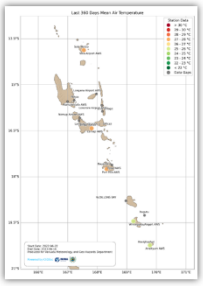
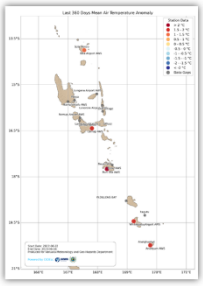
Examples

Temperature last 360 days



Mean



Anomaly

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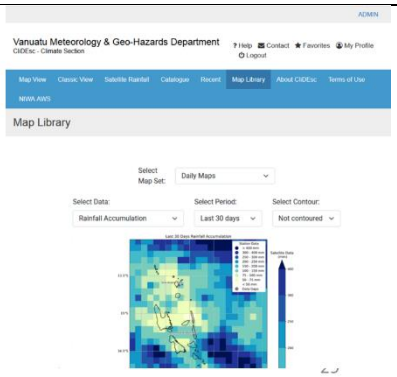
Where to find the maps

- CliDEsc Demonstration
- Where to store long term?
- Other locations e.g. external websites



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Future opportunities

- Interactive Dashboard style data presentation
- Mapping other climate parameters e.g. maximum and minimum temperature
- Tailored data products for specific sectors
- Sharing the climate maps with other users or publicly

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Whakawhetai mo te whakarongo

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