Pacific Climate Change Science

Regional Climate Science for the Pacific

John Clarke, Tim Erwin, Geoff Gooley & Kevin Hennessy

……on behalf of PACCSAP Science Program (CSIRO & Bureau of Meteorology), incl. collaborative partners in Australia & the Pacific

Pacific-Australia Climate Change Science and Adaptation Planning Program

Australian Government

Presentation Outline

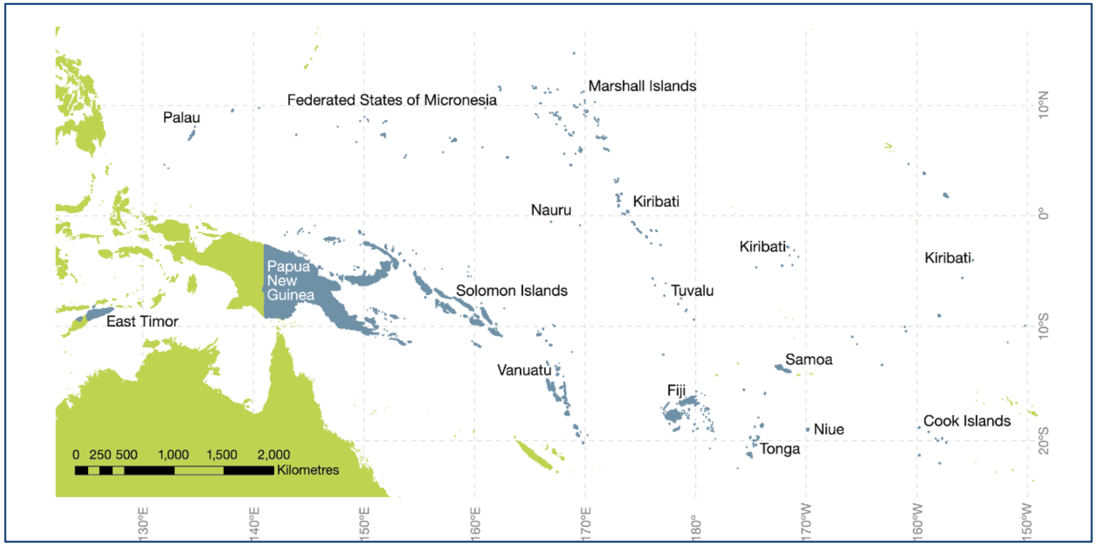
- Overview - PACCSAP Science Program
- Overview - new science, tools, communication & capacity development
- Decision-centred approach to adaptation
- Delivering climate science-based evidence
- Data and information management
- Post-PACCSAP future

PCCSP/PACCSAP Science

- Pacific Climate Change Science Program (PCCSP)
  - ~$20m over ~ 2.5 yrs (2008/09-2010/11)
- Pacific – Australia Climate Change Science & Adaptation Planning (PACCSAP) Science Program
  - ~$20m over ~ 2.5 yrs (2011/12-2013/14)
- Funded & administered by Australian Government:
  - Dept Foreign Affairs & Trade (DFAT) and Dept of Environment (DoE)
- Delivered by Centre for Australian Weather & Climate Research (CAWCR):
  - partnership between CSIRO and Bureau of Meteorology (BOM)
- 15 diverse partner countries & numerous regional organisations and universities incl. SPREP, SPC, USP, Red Cross and GIZ
- Other Australian agencies: Geoscience Australia, ARC Centre of Excellence for Climate System Science

PCCSP/PACCSAP Science

- Regional focus on 14 Pacific Island Countries (PICs) + Timor-Leste
  - key stakeholders - National Met Services
- Response to considerable PIC needs (demand driven, next/end user focus)
- Data/information (knowledge), tools and capacity to facilitate decision-making & associated pathways to adaptation



PACCSAP Science – strategic drivers

- PACCSAP – two components:
  - Adaptation Component (DoE)
  - **Science Component (CSIRO & BOM)**
- PACCSAP goal & objective:
  - PICs developed capacity to monitor & adapt to changing natural environment, & enhanced resilience to impacts of climate change
  - Emphasis on PIC scientists, decision-makers & planners to apply info/tools & develop in-country responses
- **PACCSAP Science component objective:**
  - Primary: Improve scientific understanding of climate change in the Pacific
  - Together with DoE:
    - Increased awareness of climate science, impacts and adaptation options
    - Better adaptation planning to build resilience to climate change impacts

PACCSAP Science Program - Scope

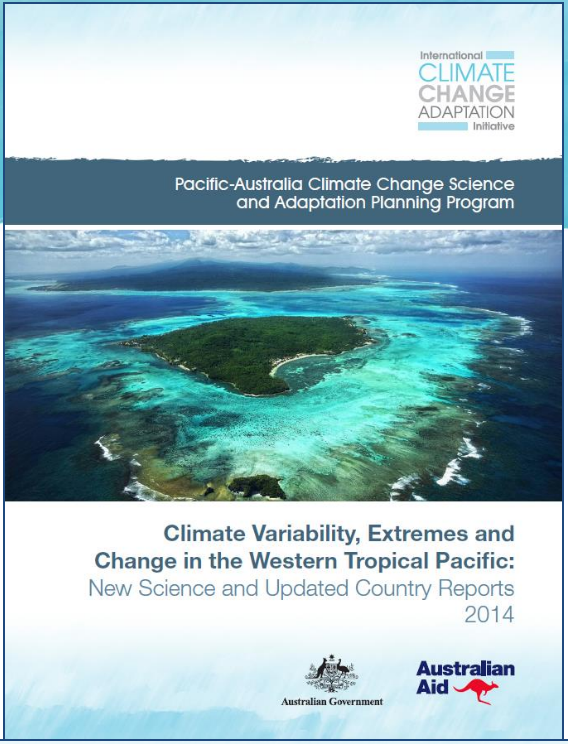
- New science
  - Seasonal predictions & climate data (data rescue, digitisation & management)
  - Large-scale climate features & variability
  - Regionally specific projections & extreme events
  - Ocean processes

- Tools development & technical support
  - Pacific Climate Futures
  - CliDE data management system
  - Data portals
- Communication products
  - Technical Report
  - Synthesis Report
  - Journal papers, animations, fact sheets, training resources, website
- Capacity development
  - Mentoring & attachments
  - Technical training
  - Workshops, conferences, symposia
  - Networking & relationship management

New science/new products

- Climate variability, extremes and change in the western tropical Pacific: new science and updated country reports......(BOM & CSIRO, 2014)
- Technical report, country specific chapters:
  - Climate summary
  - Data availability
  - Seasonal cycles
  - Observed trends
  - Climate projections (CMIP5)
- On-line publication

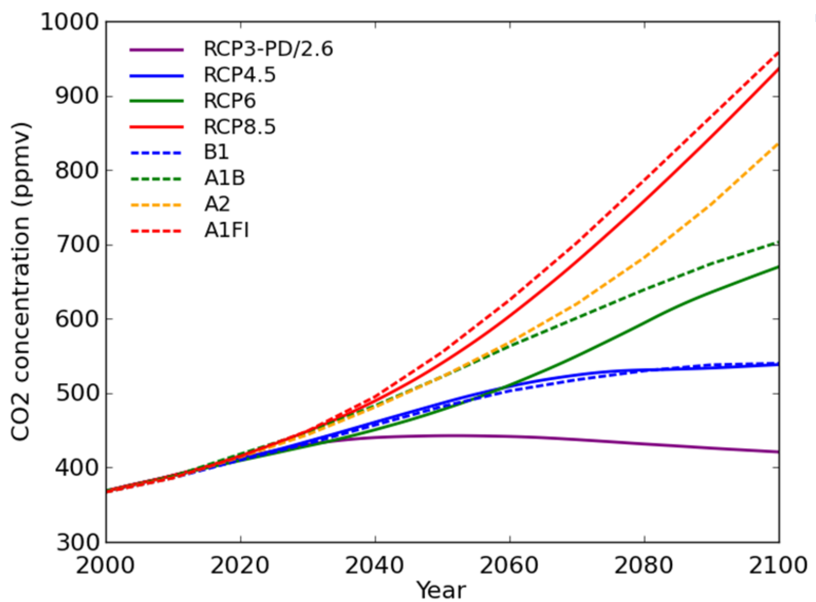
  http://www.pacificclimatechangescience.org



Global Context– IPCC AR5 WG1

E.1 Atmosphere: Temperature

Global surface temperature change for the end of the 21st century is *likely* to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is *likely* to exceed 2°C for RCP6.0 and RCP8.5, and *more likely than not* to exceed 2°C for RCP4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP2.6. Warming will continue to exhibit interannual-to-decadal variability and will not be regionally uniform (see Figures SPM.7 and SPM.8). {11.3, 12.3, 12.4, 14.8}



New science/new products

- Climate Change in the Pacific: A Regional Summary of New Science and Management Tools (CSIRO, BoM & SPREP, in prep)
  - Plain language report:... "telling the story of the science"...
  - Targeted at non-technical audience in the Pacific, incl:
    - Sectoral policy makers, planners & associated decision-makers
    - National/sub-national to community level
  - Regional context but with PIC perspectives:
    - Understanding changing climate in the Pacific
    - About the science – climate data, modelling, projections & RCPs, uncertainty, confidence, downscaling
    - Large-scale climate features
    - Temperature, rainfall, oceans, tropical cyclones
    - Climate science tools
  - On-line publication (http://www.pacificclimatechangescience.org)

Tools, Communication and Outreach Products

- Existing:
  - Enhanced development of CliDE and data portals
  - >35 peer reviewed journal papers incl. partner country co-authorships (+ PCCSP!!), IPCC AR5 (WG 1 & 2) reporting + misc. other reports and databases
  - Animations:
    - *Climate Crab - regional*
    - *Cloud Nasara - Vanuatu*

- New:
  - Pacific Climate Futures V2.0 (n.b. PVUDP)
  - Technical Report:
    - New Science & updated Country Reports
- Pending:
  - Summary Report (for policy makers; non-Technical)
  - Training materials, Fact Sheets & new country brochures (non-Technical)

Data rescue & digitisation

Table 1 - Number of daily records key-entered during this project (to 31 May 2013)

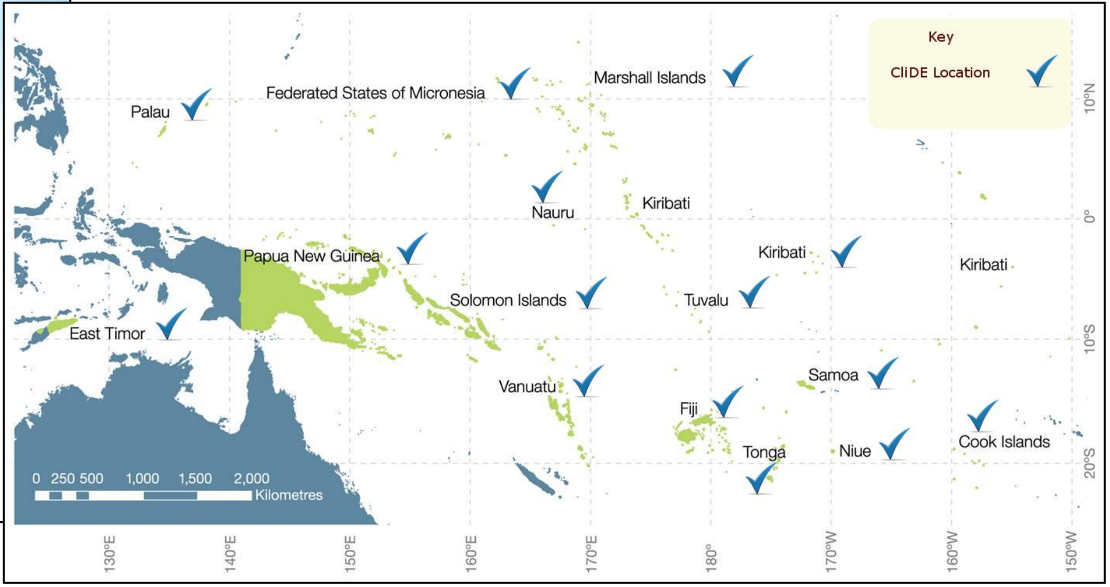
Type	Country	Stations	Work Estimate	Work Done	% Done
daily	Cook Islands	6	27466	7574	28
daily	Kiribati	5	57518	19898	35
daily	Niue	7	19710	4982	25
daily	PNG	158	400040	287454	72
daily	Solomon Islands	7	39777	31503	79
daily	Timor-Leste	15	342370	82711	24
daily	Tonga	6	30052	9720	32
daily	Vanuatu	8	25915	25915	100
daily	Samoa	64	294555	389961	132
subdaily	Niue	3	19710	6218	32
subdaily	PNG	5	400040	25490	6
subdaily	Solomon Islands	7	30660	41353	135
subdaily	Timor-Leste	6	342370	26026	8
subdaily	Tonga	5	11862	11862	100
subdaily	Vanuatu	8	25915	25915	100
subdaily	Samoa	52	294555	142954	49

Table 2 - Partner PIC trainees in digitising data into CliDE in this project

Country	Male	Female	Total
Cook Islands	1	3	4
East Timor	2	4	6
Kiribati	2	4	6
Niue	1	4	5
PNG	2	4	6
Samoa	1	3	4
Solomon Islands	4	3	7
Tonga	2	4	6
Vanuatu	3	3	6
Total	18	32	50

CliDE: Climate Data for the Environment
- climate data management system

Martin et al (2014) *Meteorol. Appl.*
DOI: 10.1002/met.1461



- CliDE is now installed and training provided to met services in 14 Pacific Island Countries plus East Timor
  - now used operationally for data storage and management
  - Visualisation/applications (CLEWS) through CliDEsc (NIWA).

Pacific Climate Futures V2.0

Causes of climate change

The Earth's climate has changed over the centuries and millennia due to a number of different factors (see Figure 9).

These include:

- Natural changes in the Earth's orbit which may occur over time scales of thousands of years
- Natural changes in the sun which affect the amount of incoming solar radiation
- Natural, large-scale volcanic eruptions which eject large amounts of ash into the atmosphere. The ash may remain in the atmosphere for several months or years reflecting sunlight back into space and resulting in a drop of mean global surface temperature
- Changes in atmospheric chemistry (such as the quantity of greenhouse gases) – both natural and caused by human activities. It is almost certain that most of the changes seen in the past century have been caused by human activities such as burning fossil fuels. We will now concentrate on these changes.

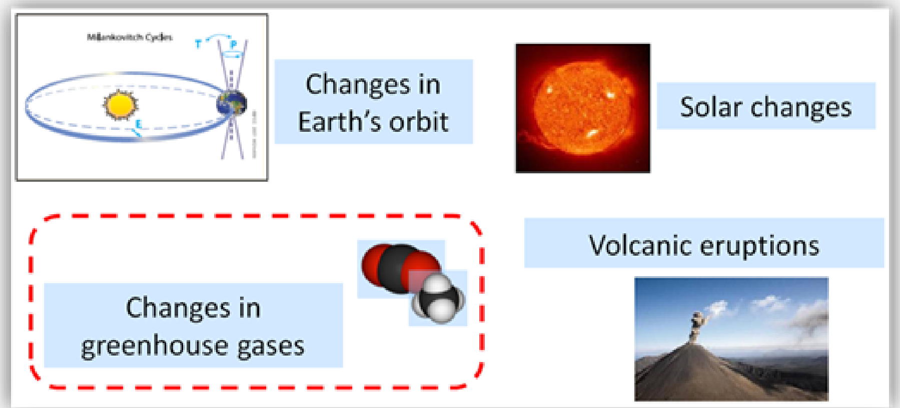


Figure 9: Factors that lead to changes in the Earth's climate.

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Projections Builder: Results

These results were produced using the Pacific Climate Futures Projections Builder, based on the settings selected by the user. It is important to retain a record of those settings.

Representative Models

To identify the representative models, all models were ranked using a multivariate statistical technique (Kokic et al., 2002) to identify the model that is the best fit to the settings selected by the user for the Best and Worst cases.

In addition, where possible, the tool identifies the maximum consensus climate future (i.e. the climate future projected by at least 33% of the models and which comprises at least 10% more models than any other).

Case	Representative Model	Consensus
Best Case	CMIP3 - miroc3_2_hires	Very Low
Worst Case	CMIP3 - gfdl_cm2_1	Low
Maximum Consensus	CMIP3 - gfdl_cm2_0	Moderate

Table 1: Climate Futures description, consensus rating and representative model for each of the three cases: Best, Worst and Maximum Consensus.

	SURFACE TEMPERATURE	RAINFALL
	ANNUAL	ANNUAL
Best Case	3.23°C	-5.7%
Worst Case	2.46°C	31.3%
Maximum Consensus	2.46°C	2.1%

Table 2: Projected changes for each of the selected variables and seasons for the three cases described in Table 1.

USING THESE PROJECTIONS

In applying these projections to an impact assessment, the results for each case should be used separately, resulting in separate statements of impact for each case.

Important: The projected changes shown in Table 2 are the results from the corresponding climate model as described in Tables 1 and 2. They represent the projected 20-year average change, calculated over the region selected and are calculated relative to the historic reference period 1986 to 2005. The projected changes are influenced concurrently by the long-term climate trend and the decade variability as simulated by the relevant climate model.

Use of these results is subject to the Pacific Climate Futures Terms of Use, as updated from time-to-time, which can be viewed at the website http://pacificclimatefutures.net.

A detailed description of the Climate Futures method can be found in Whetton et al. 2012. The use of the method in an impact assessment is described in detail in Clarke et al. 2011.

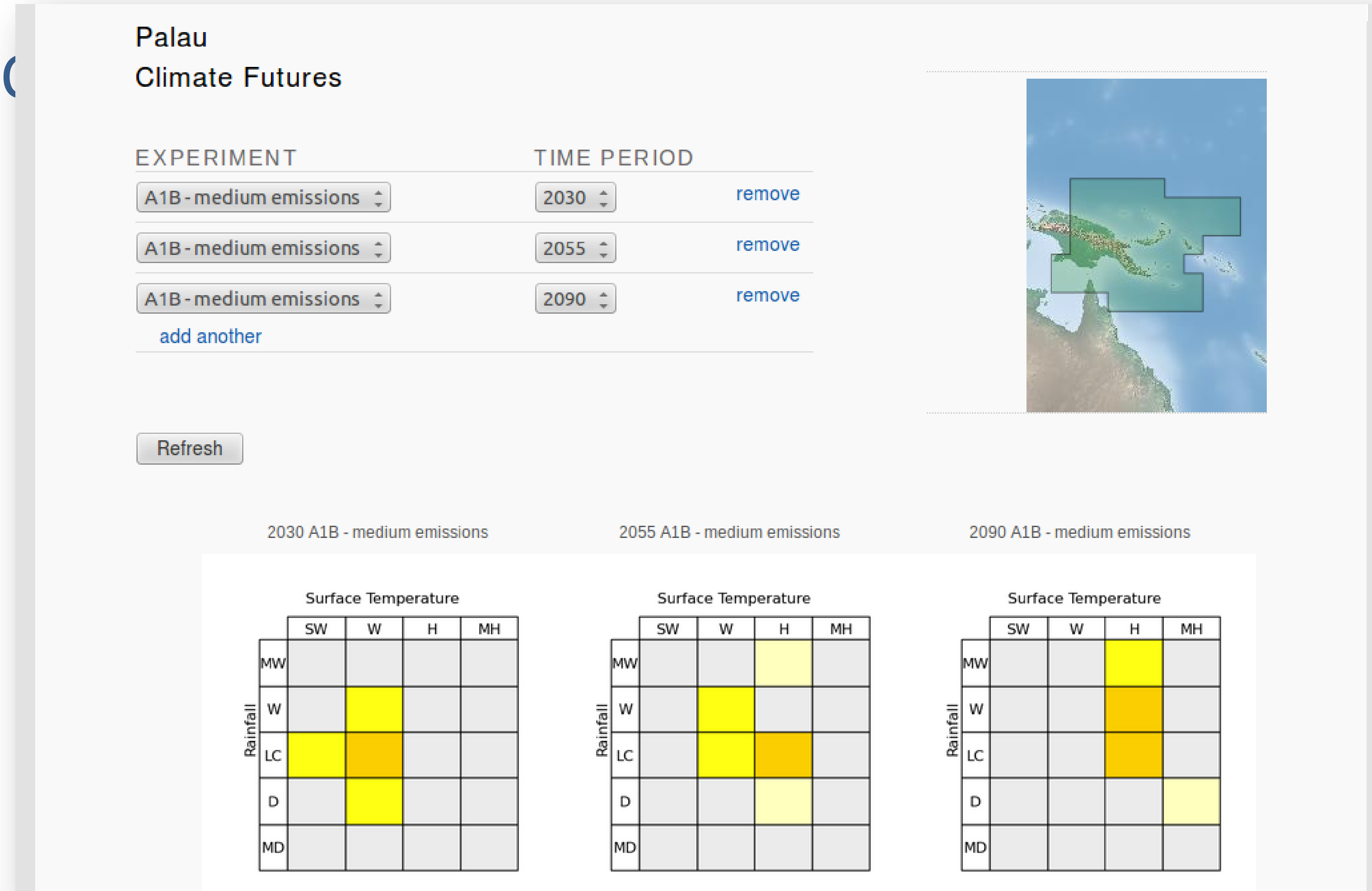
REFERENCES

Clarke JM, Whetton PH, Hennessy KJ (2011) 'Providing Application-specific Climate Projections Datasets: CSIRO's Climate Futures Framework.' Peer-reviewed conference paper. In F Chan, D Marinova and RS Anderssen (eds.) MODSIM2011, 19th International Congress on Modelling and Simulation. Perth, Western Australia. December 2011 pp. 2683-2690. ISBN: 2978-2680-9872143-9872141-9872147. (Modelling and Simulation Society of Australia and New Zealand). http://www.mssanz.org.au/modsim2011/F5/clarke.pdf.

Kokic P, Breckling J, Lübke O (2002) 'A new definition of multivariate M-quantiles.' in Statistical Data Analysis Based on the L1-Norm and Related Methods. (Y Dodge ed.) pp. 15-24. (Birkhäuser Verlag: Basel).

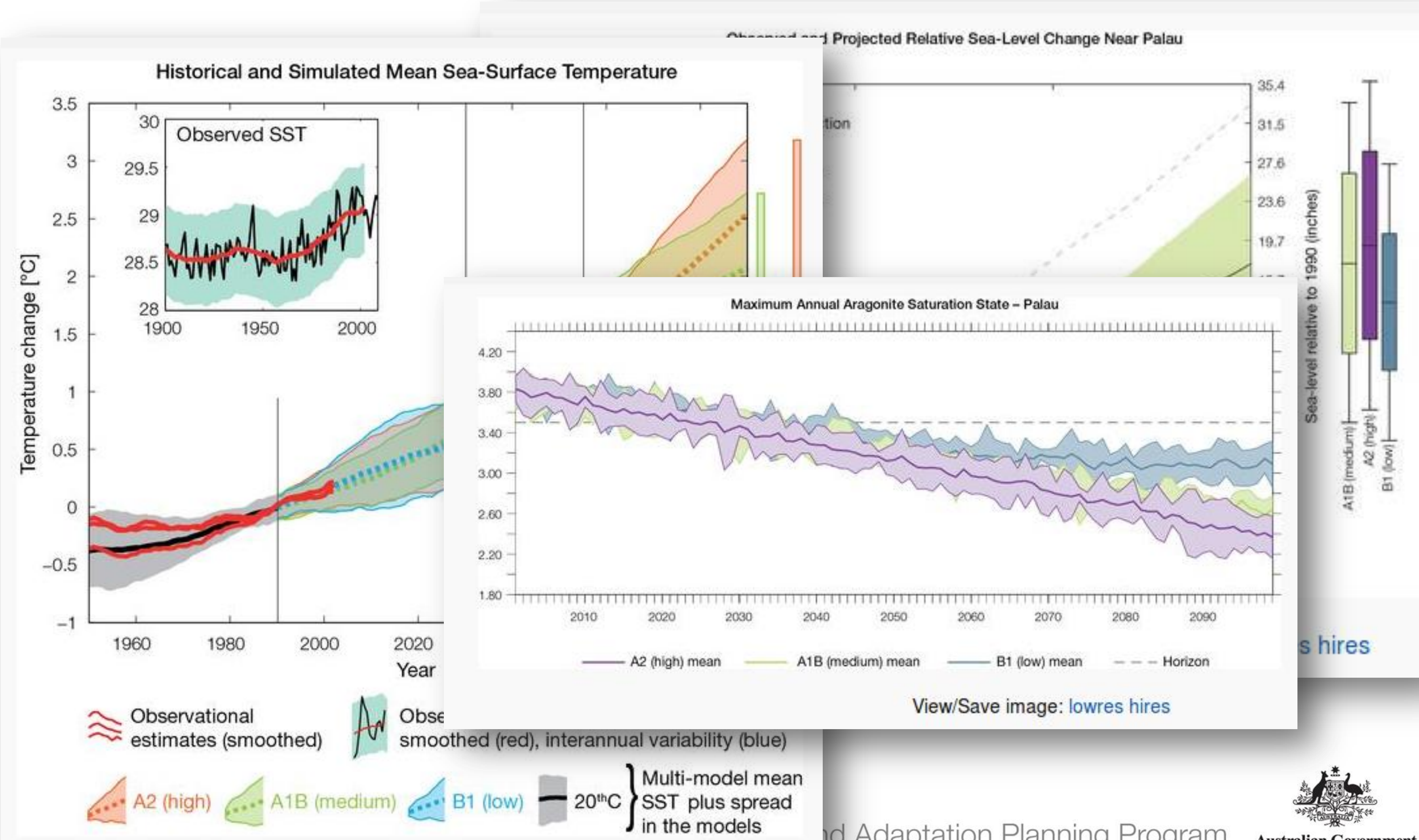
Whetton P, Hennessy K, Clarke J, McInnes K, Kent D (2012) 'Use of Representative Climate Futures in impact and adaptation assessment.' Climatic Change 115, 433-442. 10.1007/s10584-012-0471-z.

Pacific Climate Futures V2.0



Pacific Climate Futures V2.0

- Marine Projections



Australian Government

New products – Pacific Climate Futures V2.0

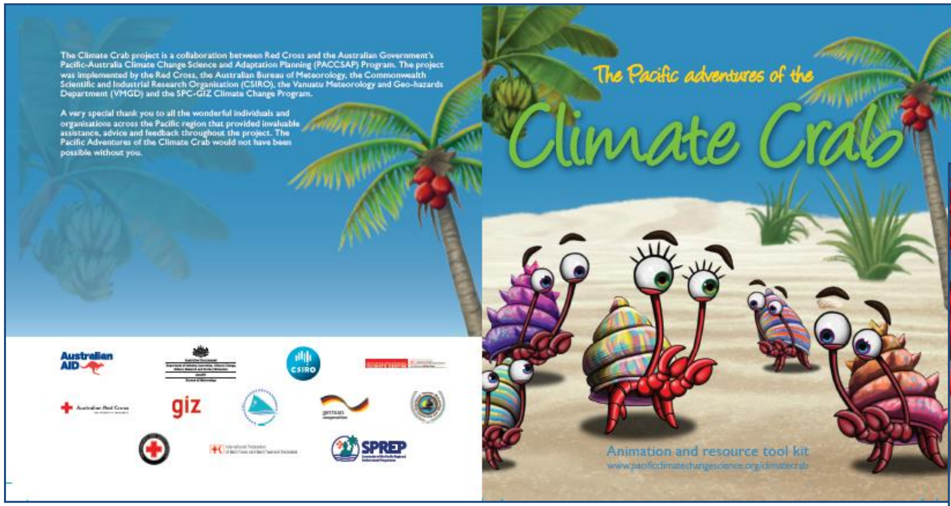
What's new:

- CMIP5 Data
- Downscaled data for all countries (50km resolution)
- Online training: access to Projections Builder (Intermediate capability)
- Projections Builder: guided generation of internally consistent projections data (Best, Worst and Max. Consensus cases) tailored to suit non-complex impact assessments
- Compare Projection module: contextualise results from multiple sources (e.g. Downscaling, CMIP3, CMIP5); display changes over time
- Online access to pre-calculated, high quality sea level, SST and ocean acidification data
- Outputs applied to observed data sets (CliDE/portal) to generate application-ready climate change data (Advanced capability)

www.pacificclimatechangescience.org
www.pacificclimatefutures.net

Climate animations

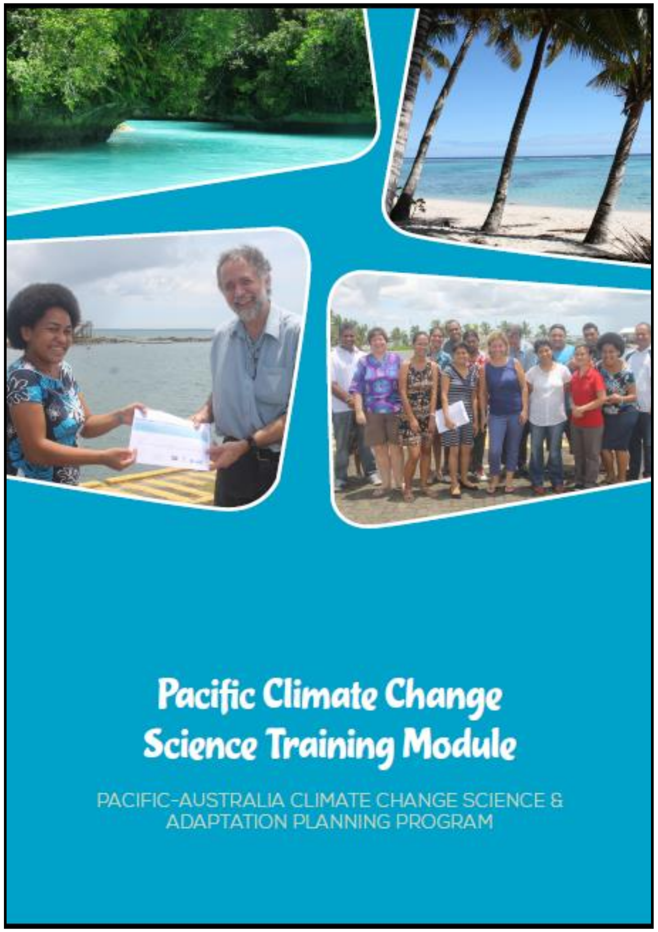
- Climate Crab (regional) & Klaod Nasara



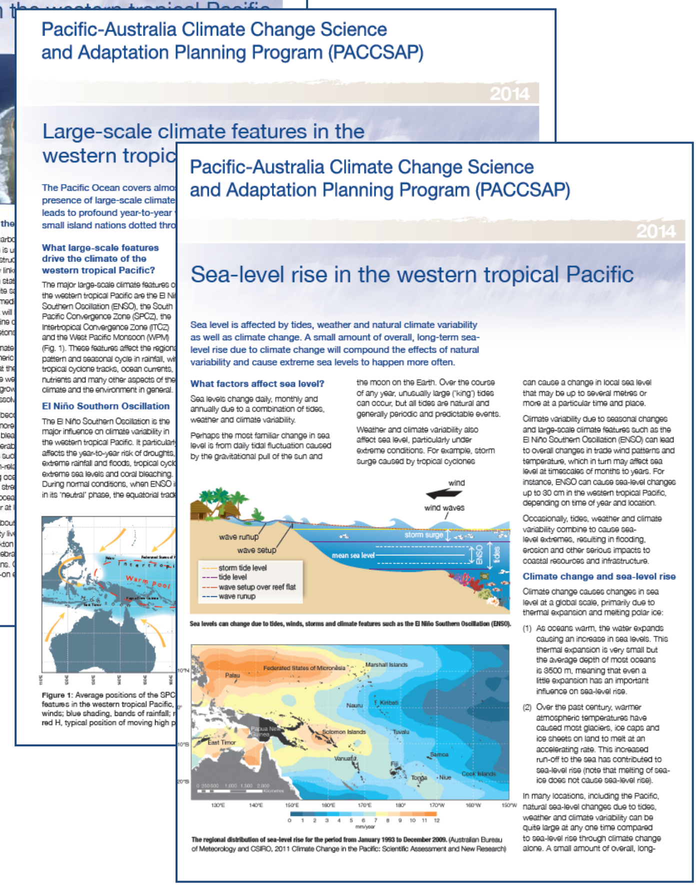
- Resource kits

New science/new products

- Climate science-based training module & associated materials, including documented 'manual' & ppt presentations:
  - Country specific presentations (14 x PICs + Timor-Leste)
    - Tailored for NMSs
  - Regional Pacific current/future climate
  - Understanding climate projections
  - Understanding climate variability and change
    - Tailored for more general use
  - ppt presentation templates to facilitate 'small group' discussions
    - Tailored for more general use



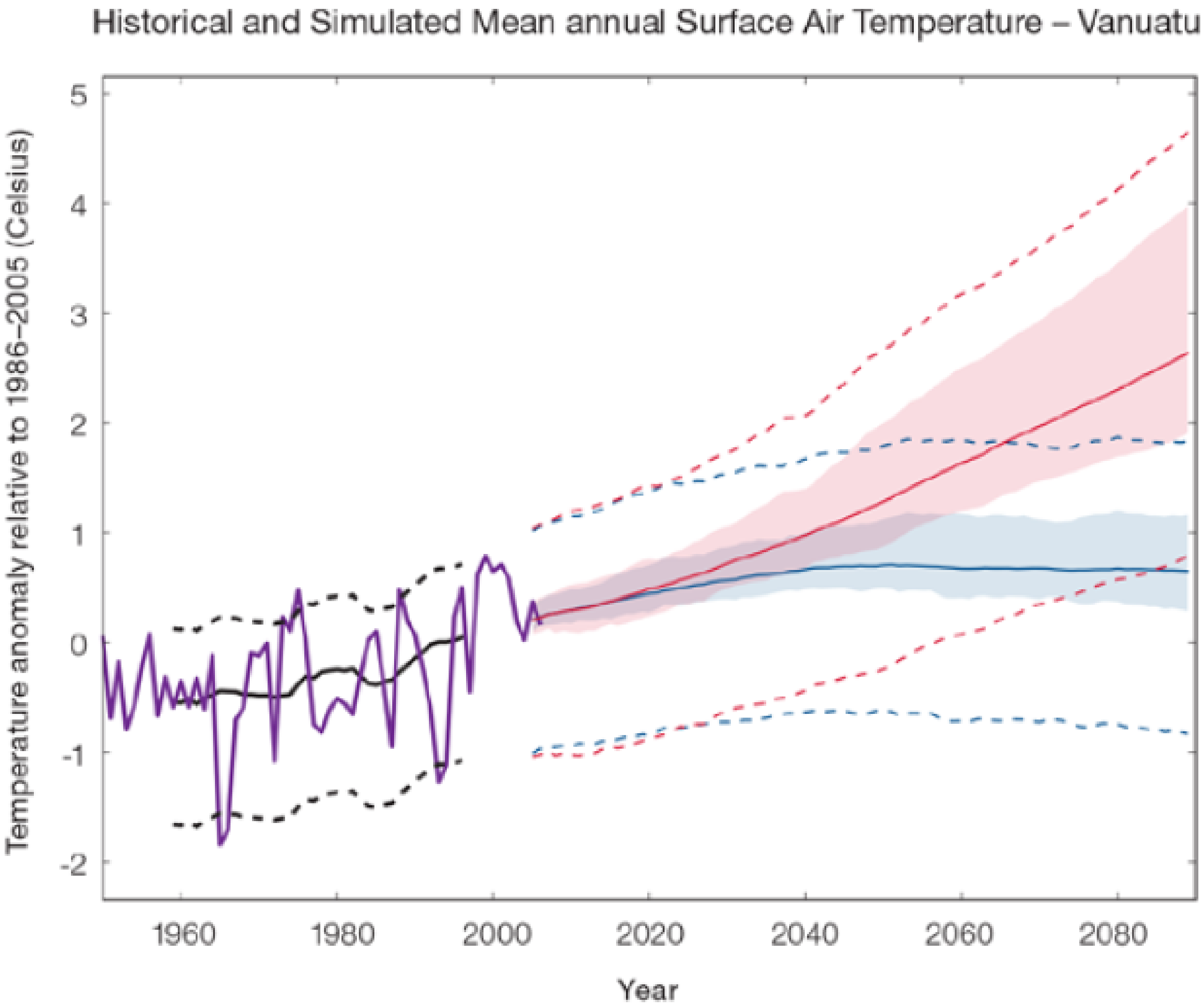
Fact Sheets



Fact Sheets (http://www.pacificclimatechangescience.org):

- Climate variability & change
- Large-scale climate processes
- Climate extremes
- Sea-level rise
- Ocean acidification

Vanuatu: Temperature Projections



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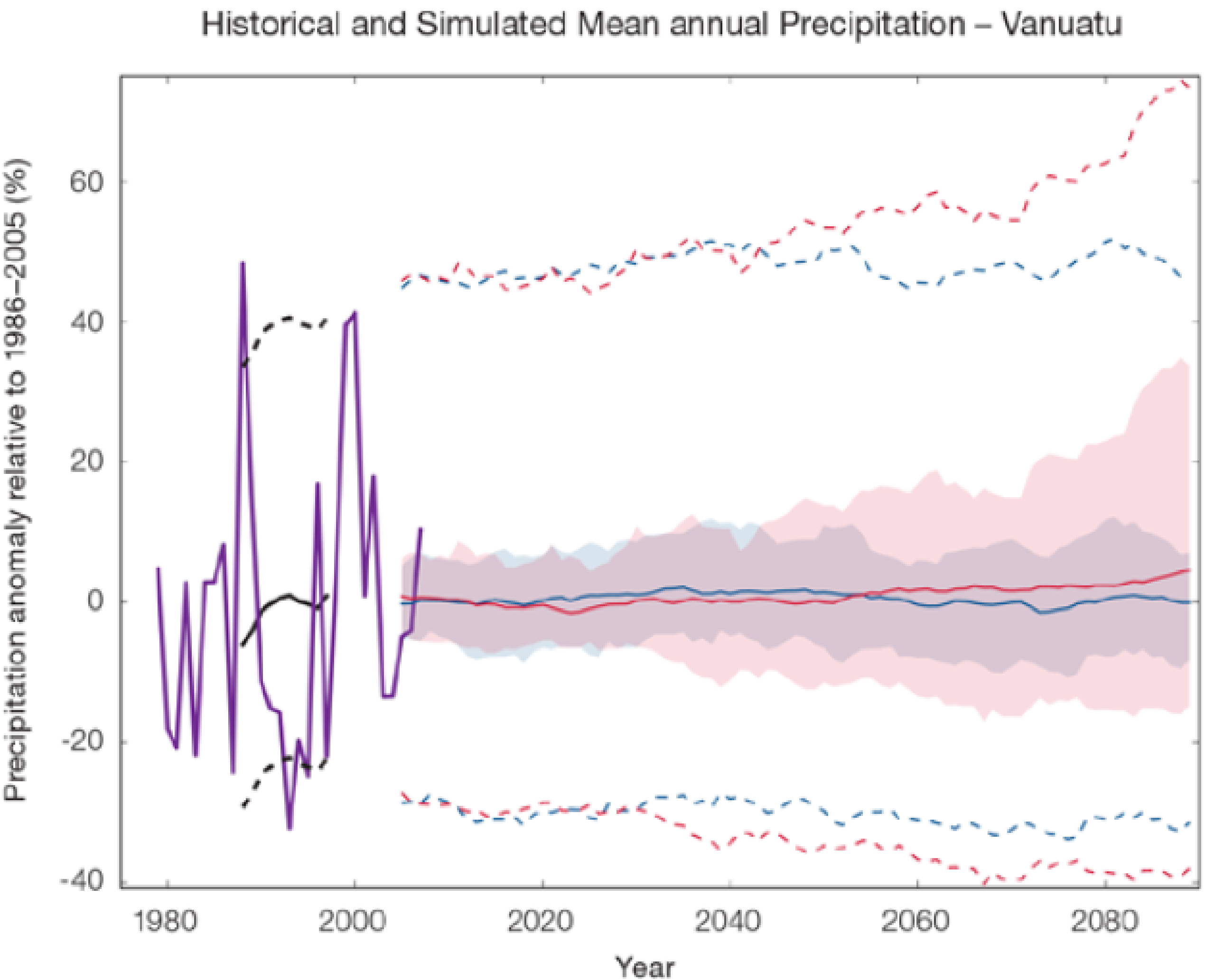
Vanuatu: Rainfall Projections



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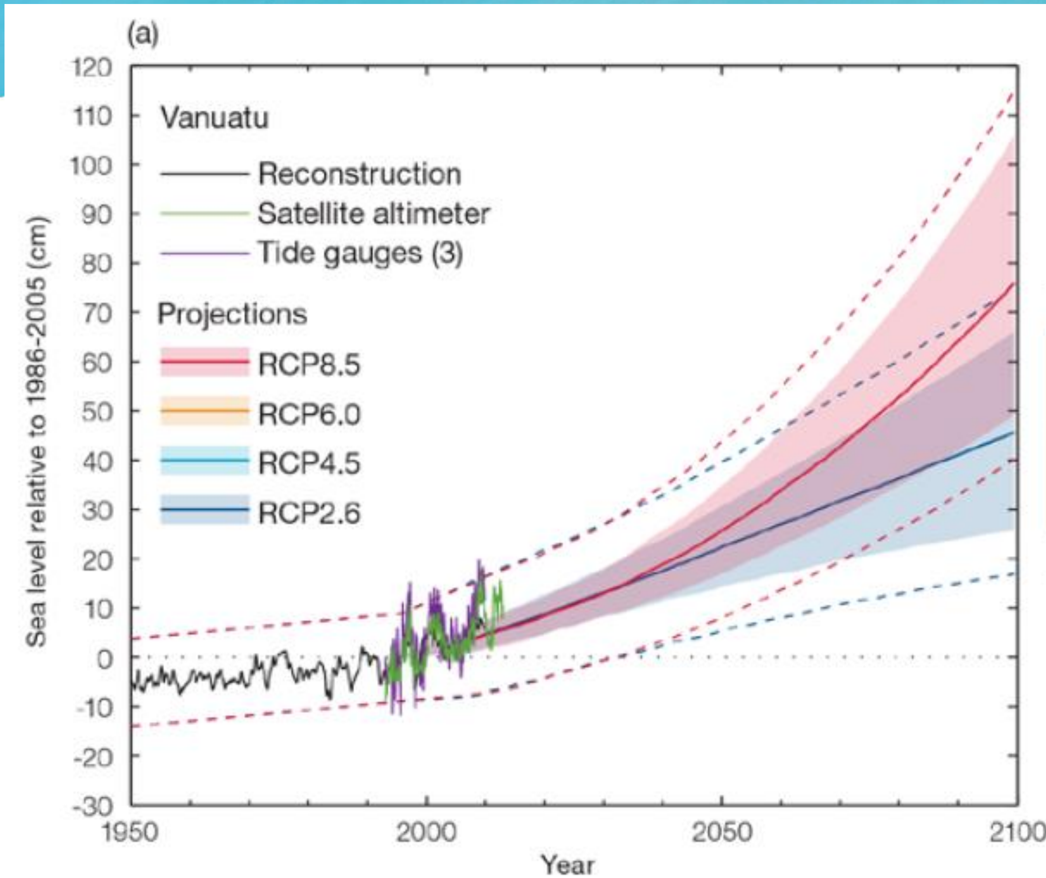
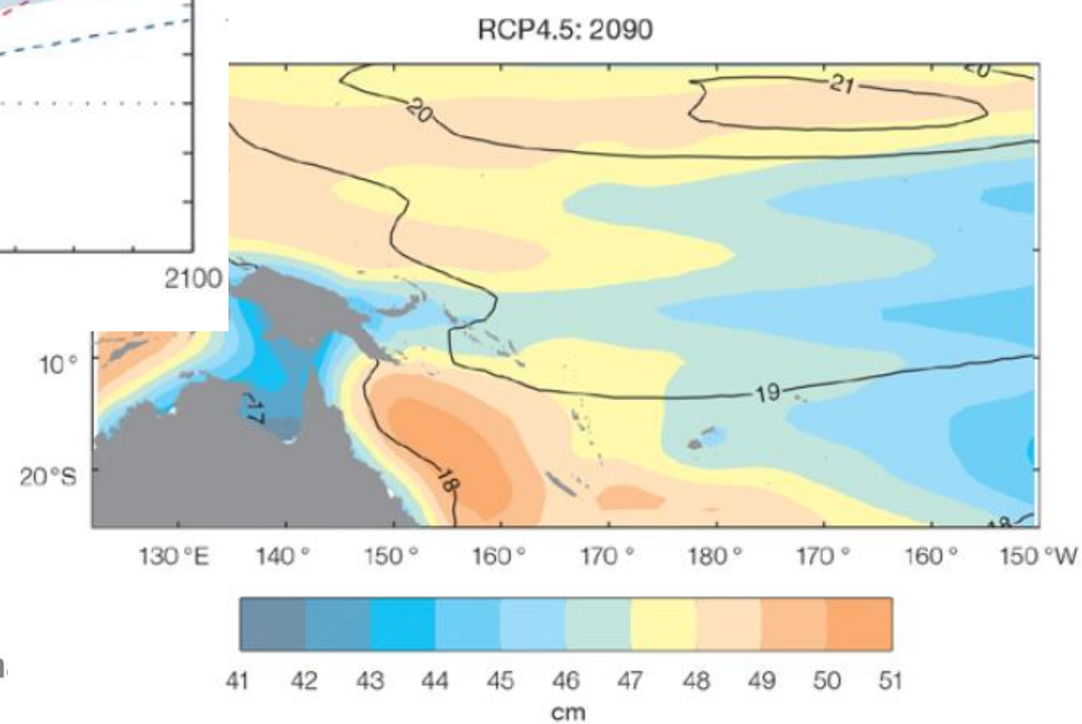
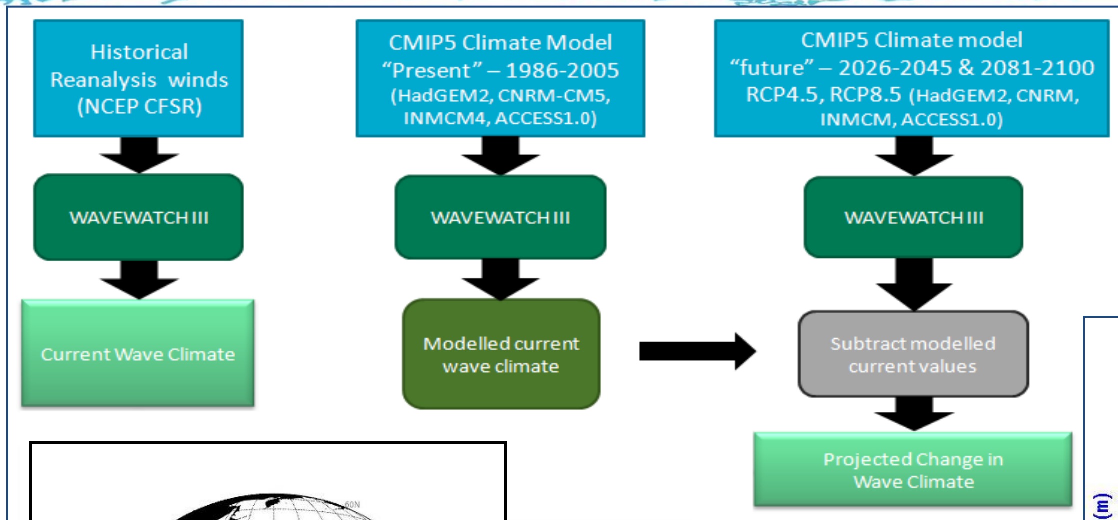
Vanuatu: Sea Level Projections



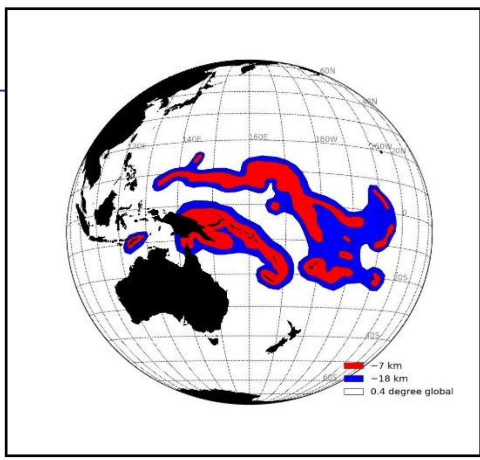


Pacific-Australia **Climate Ch**

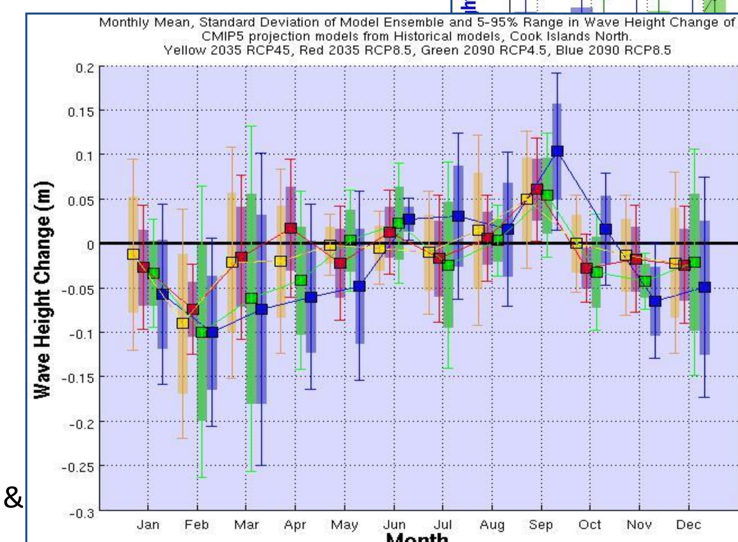
Technical Report – observed & projected wave climate

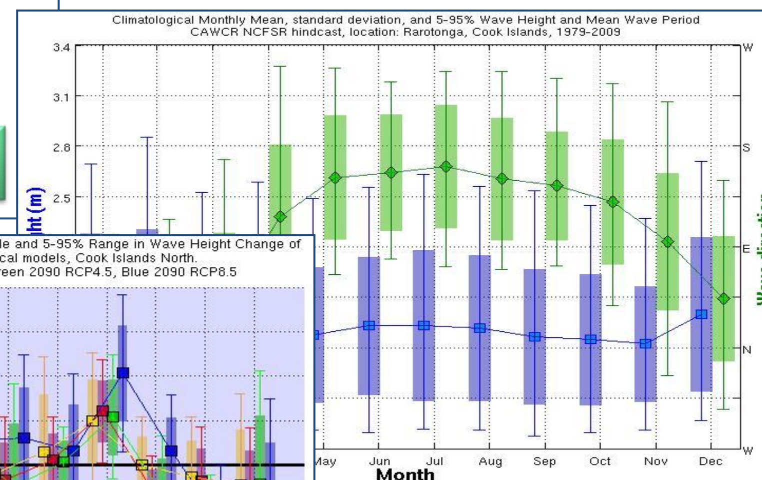


Wave climate description in the historical-current context is developed from a hindcast made by forcing a wave model with reanalysis winds (left), while projected changes are made by forcing the wave model with CMIP5 model winds and looking at the change in wave properties between historical and future time slices (right).



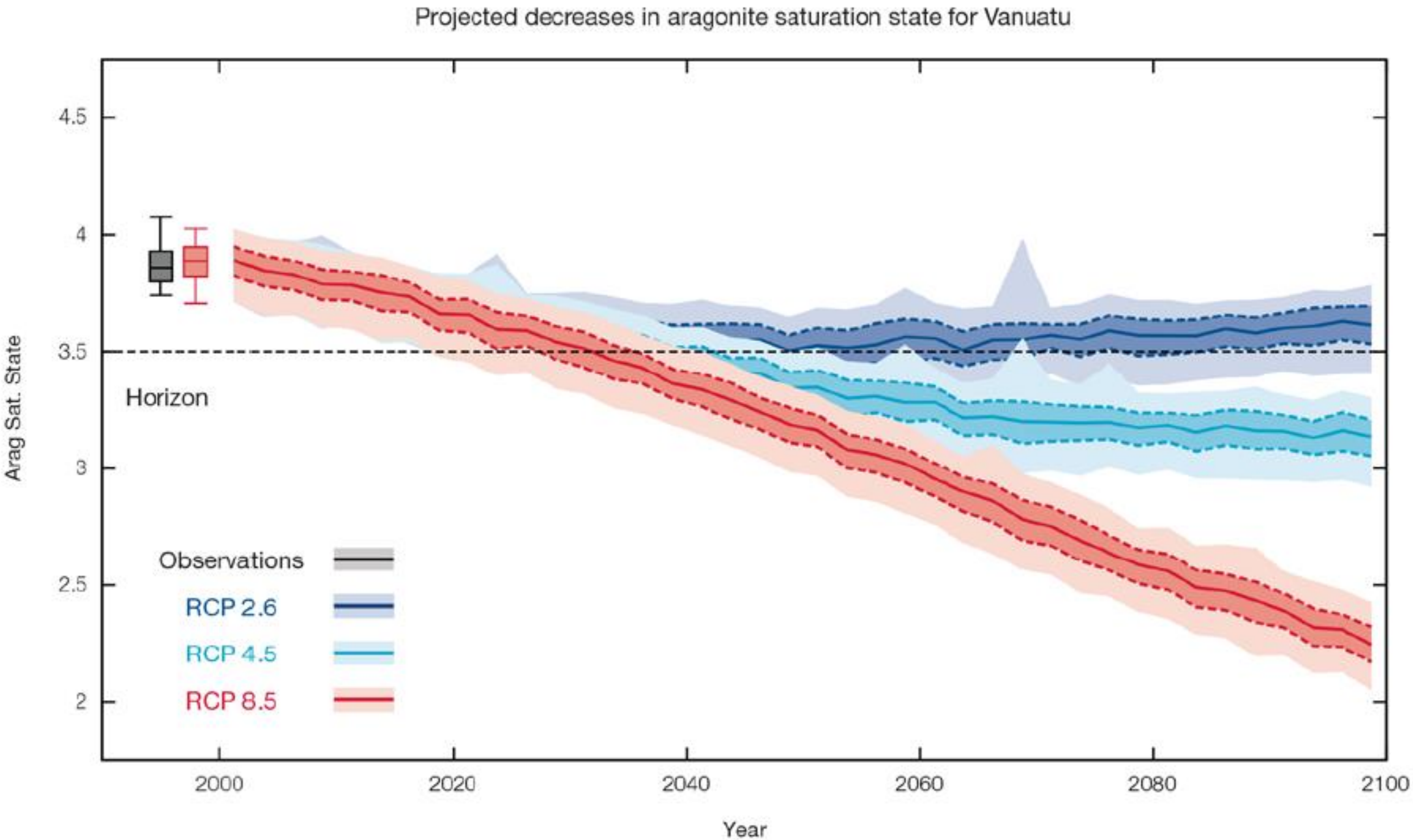
Region of validated high-resolution 30-year wave hindcast, showing a global 0.4 degree grid, with a series of nested grids of 10 and 4 arcminutes (~18 & 7 km respectively) in the western tropical Pacific.





Mean annual cycle of wave height (blue) and mean wave direction (green) at Rarotonga in hindcast data.

Vanuatu: Marine Projections



Vanuatu: Marine Projections

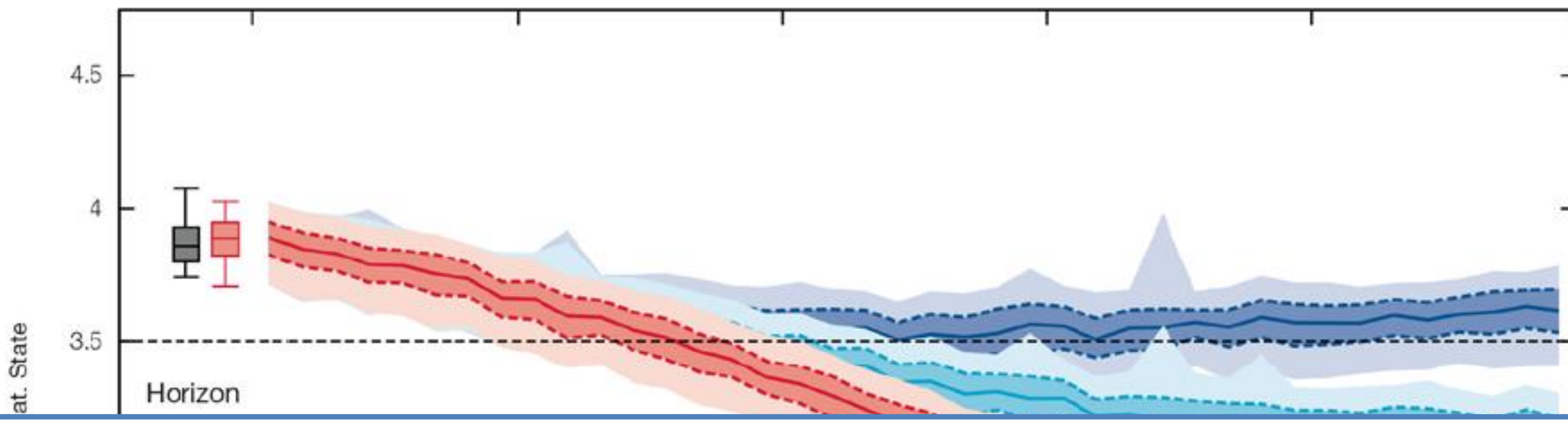


Table 16.5: Projected changes in severe coral bleaching risk for the Vanuatu EEZ for increases in SST relative to 1982–1999.

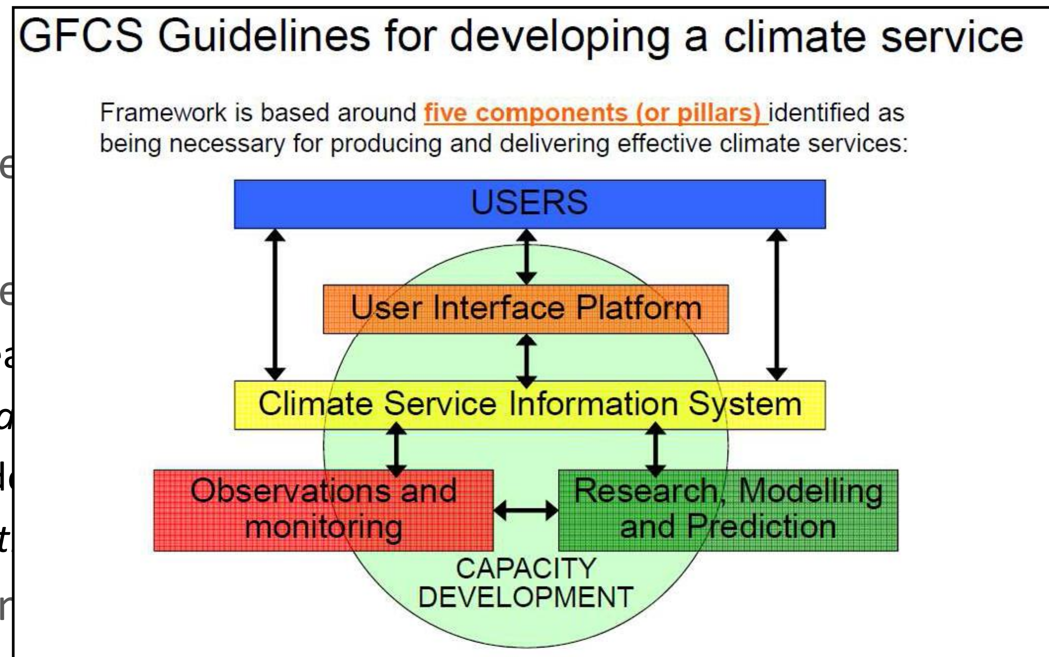
Temperature change [1]	Recurrence interval [2]	Duration of the risk event [3]
Change in observed mean	30 years	4.1 weeks
+0.25°C	26.1 years (24.8 years – 27.4 years)	5.6 weeks (5.1 weeks – 6.0 weeks)
+0.5°C	20.3 years (15.8 years – 24.4 years)	5.3 weeks (4.2 weeks – 6.5 weeks)
+0.75°C	9.5 years (3.2 years – 18.0 years)	6.9 weeks (3.3 weeks – 2.3 months)
+1°C	3.1 years (7.4 months – 8.7 years)	8.0 weeks (2.2 weeks – 3.5 months)
+1.5°C	11.8 months (4.9 months – 3.2 years)	3.1 months (2.8 weeks – 5.3 months)
+2°C	8.0 months (5.0 months – 1.6 years)	4.8 months (1.7 months – 6.5 months)

Vanuatu: Projections Summary

Variable	Season	2030	2050	2070	2090	Confidence (magnitude of change)
Surface air temperature (°C)	Annual	0.6 (0.4–0.9)	0.7 (0.5–1.1)	0.7 (0.4–1.1)	0.7 (0.3–1.2)	*Medium*
		0.6 (0.3–1)	0.9 (0.6–1.5)	1.2 (0.7–1.8)	1.3 (0.8–2)	
		0.6 (0.4–1)	0.9 (0.6–1.3)	1.2 (1–1.9)	1.6 (1.2–2.5)	
		0.7 (0.5–1)	1.3 (0.8–2)	2 (1.5–2.9)	2.7 (1.9–4)	
Maximum temperature (°C)	1-in-20 year event	0.6 (0.4–0.9)	0.7 (0.2–0.9)	0.7 (0.3–1)	0.7 (0.3–0.9)	*Medium*
		0.6 (0.2–0.9)	0.9 (0.5–1.2)	1.2 (0.6–1.6)	1.3 (0.7–2)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		0.7 (0.3–1.1)	1.4 (0.7–2)	2.1 (1.4–3.1)	2.9 (1.9–4.2)	
Minimum temperature (°C)	1-in-20 year event	0.5 (0.2–0.9)	0.6 (0.2–1)	0.7 (0.1–1)	0.6 (0.1–0.9)	*Medium*
		0.6 (0.1–0.8)	1 (0.3–1.2)	1.1 (0.5–1.6)	1.3 (0.7–1.8)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		0.8 (0.3–1)	1.4 (0.9–1.8)	2.2 (1.6–2.7)	3 (2.1–3.9)	
Total rainfall (%)	Annual	1 (-7–9)	1 (-6–9)	0 (-10–9)	0 (-8–7)	*Low*
		0 (-9–13)	0 (-9–6)	1 (-9–9)	0 (-14–10)	
		2 (-4–13)	2 (-8–12)	3 (-6–16)	4 (-11–19)	
		0 (-6–8)	0 (-12–14)	2 (-16–15)	5 (-15–34)	
Total rainfall (%)	Nov-Apr	2 (-5–13)	2 (-6–9)	0 (-9–14)	1 (-7–13)	*Low*
		0 (-8–15)	1 (-9–9)	2 (-8–18)	1 (-13–13)	
		3 (-5–15)	2 (-7–11)	3 (-5–16)	3 (-11–22)	
		1 (-6–12)	1 (-9–13)	3 (-14–17)	5 (-13–30)	
Total rainfall (%)	May-Oct	0 (-11–12)	1 (-8–13)	-1 (-17–9)	-2 (-15–10)	*Low*
		0 (-12–15)	-1 (-13–11)	-2 (-14–12)	-1 (-25–14)	
		2 (-6–13)	2 (-11–16)	2 (-11–18)	5 (-9–21)	
		-2 (-10–8)	-1 (-19–16)	-1 (-21–17)	3 (-26–34)	
Aragonite saturation state (Ωar)	Annual	-0.3 (-0.7–0.0)	-0.4 (-0.7–-0.1)	-0.4 (-0.7–0.0)	-0.3 (-0.7–0.0)	*Medium*
		-0.4 (-0.7–0.0)	-0.6 (-0.9–-0.3)	-0.7 (-1.0–-0.4)	-0.8 (-1.1–-0.5)	
		NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	NA (NA–NA)	
		-0.4 (-0.7–-0.1)	-0.8 (-1.1–-0.5)	-1.2 (-1.4–-0.9)	-1.5 (-1.8–-1.3)	
Mean sea level (cm)	Annual	13 (8–19)	23 (15–31)	32 (20–45)	42 (25–59)	*Medium*
		13 (8–18)	23 (15–32)	36 (23–49)	48 (30–67)	
		13 (8–18)	23 (15–31)	35 (23–48)	50 (32–69)	
		13 (8–18)	26 (17–35)	43 (29–59)	64 (42–89)	

Post-PACCSAP future

- PACCSAP Science Program finishes in 2014
  - New strategic benchmark in fundamental climate science for the western tropical Pacific (n.b. alignment with IPCC AR5)
  - Evaluation & final reporting: leverage off new knowledge, capacity & key learnings on regional/inter-regional basis
- Strategic considerations:
  - Manage/action existing knowle sustainable legacy!!
  - Plan for sustainable resilient de M:
    - Role of climate science/outrea
      - *GFCS innovation pathwa*
    - Support in-country capacity d
      - *Coordination, collaborat*
  - What are the new and emergir
    - tailored/application-ready, multiple sectors, multiple risks, multiple time-frame, finer spatial scale, seamlessly interfaced to DSS!!??



Thank you

For further information

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Australian Government

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CSIRO

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