

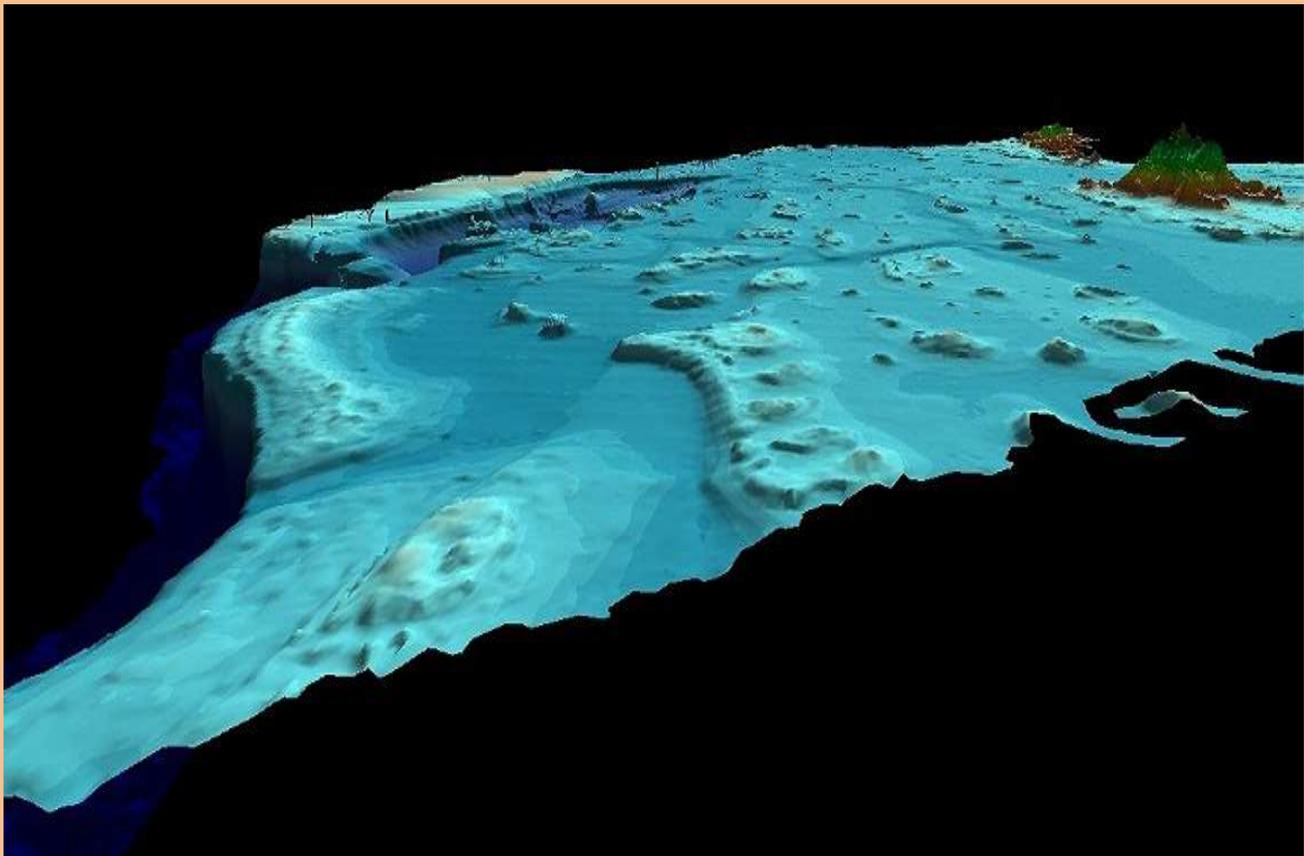


# STAR 2016

## The Pacific Islands Science, Technology and Resources Conference

6 – 8 June 2016  
Tanoa International Hotel, Nadi, FIJI

### ABSTRACT VOLUME & CONFERENCE PROGRAM



[The island motif used here is a reproduction of a portion of a Fijian Festive Masi. Image downloaded from the “Tapa Cloths from the Pacific and Artwork” website: [www.tapapacifica.com](http://www.tapapacifica.com), accessed 13 May 2016. The use of the image is gratefully acknowledged.]





Compiled and Edited by:

**John Collen<sup>1</sup> & Lala Bukarau<sup>2</sup>**

<sup>1</sup>Associate Professor, School of Geography, Environment and Earth Sciences  
Victoria University of Wellington, New Zealand

<sup>2</sup>Consultant to Pacific Community Geoscience Division STAR Steering Committee  
RedIT Office Shop, Nausori, Fiji

The Abstracts Volume is available online at the STAR Website Meetings Page along with the other STAR 2016 Conference documentation and reports:

<http://star.gsd.spc.int/index.php/meetings/106-2016-meeting>

**Cover picture:** 3-D visualization of the Yasawa platform from multibeam and other data collected by SOPAC and the Fiji Hydrographic Department in 2005/2006 for the purpose of producing a new chart of the Yasawa and Mamanuca group of islands. This is the area which will be visited in the STAR 2016 Conference field trip.

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**ABSTRACT VOLUME**  
**&**  
**CONFERENCE PROGRAM**

## PREFACE

The Science, Technology and Resources (STAR) Network was founded in 1984 as a joint initiative between SOPAC<sup>1</sup> and the IOC/UNESCO<sup>2</sup>. The STAR met annually for nearly three decades in conjunction with SOPAC, which provided secretariat support to the network until its suspension in 2010. SOPAC became a new division of the Pacific Community (SPC) and internal policy does not require divisions to hold annual meetings, therefore STAR has not met since 2013. In April 2015 at a Regional Geoscience Steering Group Meeting an agenda item considered the future of STAR.

At that regional geoscience meeting Pacific Island delegates decided:

- to strongly support the re-invigoration of STAR because of its value in refreshing and animating scientific alliances and showcasing useful work, techniques and instrumentation that may be adapted to address development issues of the Pacific;
- to explore how STAR could become more independent in particular with respect to administration and financial matters;
- that for the future of STAR to be sustained, STAR needed to secure ownership by the Pacific islands, hence Malakai Finau, [then] Director of Mineral Development of Fiji, was chosen by Pacific islands representatives to be interim STAR Chair to take forward the independence and reinvigoration causes; and
- requested the Pacific Community Geoscience Division to support interim Chair of STAR with convening a June 2016 STAR Conference as the first STAR Conference where conference fees would be charged as a start to searching for a model for STAR's independence.

An interim STAR Steering Committee has supported the Interim Chair in the work towards the convening of the STAR Conference, which was held from 6 to 8 June 2016 at the Tanoa International Hotel under the overall theme of "*Geosciences, Geo-engineering and the Ocean in the Pacific Islands Region.*"

This booklet is the collection of abstracts of papers presented during the two-day programme of talks. More than 100 participants registered to participate and just under 70 presentations are abstracted in this booklet, of which about 60 are oral presentations in the programme.

The Interim STAR Steering Committee worked for over a year to put together the STAR 2016 Conference programme and field trip. It is hoped the 3 days were professionally fulfilling for each participant. We thank all participants for affirming the self-funding model; and for the splendid rebirth of STAR. We hope to see every one of you again at the next STAR event!

*14 June 2016*

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**Interim STAR Steering Committee Members:**

Permanent Secretary, Fiji Ministry of Lands and Mineral Resources, **Malakai Finau** (Interim Chair)  
Former SOPAC Senior Advisor Technical Editor/Consultant, **Lala Bukarau** (Interim Secretary)  
Director of Geoscience Division, Pacific Community (SPC), **Michael Petterson**  
Manager, Disaster Reduction Programme, Geoscience Division (SPC), **Paul Taylor**  
Technical Adviser (Fiji) & former Director of SOPAC, **Russell Howorth**  
Acting Director of Mineral Development, Fiji Ministry of Lands and Mineral Resources, **Raijeli Taga**  
Team Leader SPC-EU Deep Sea Minerals Project (SPC), **Akuila Tawake**  
Senior Advisor Marine Geophysics, Geoscience Division (SPC), **Robert Smith**  
Junior Geologist, Geoscience Division (SPC), **Christine Prasad**  
Divisional Administrator, Geoscience Division (SPC), **Litia Waradi**

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<sup>1</sup> SOPAC: Pacific Islands Applied Geoscience Commission, now the Geoscience Division of the Pacific Community.

<sup>2</sup> IOC/UNESCO: Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization

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## ABSTRACTS OF PAPERS

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ARTACK

### **Establishing the outer limits of Maritime Zones of Pacific Island Countries**

#### ***Emily Artack***

*Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: emilya@spc.int*

Under the United Nations Convention on the Law of the Sea (UNCLOS), coastal states are entitled to a number of maritime zones and these exclusive claims over areas of ocean space must use sound technical data under the requirements of the Convention.

The Government of Australia has supported the Pacific Islands Maritime Boundaries Project since 2001, and the consortium of partners have been widely recognised as driving a successful collaborative effort to fulfil one of the region's key strategic priorities of formalising maritime boundaries and securing rights over ocean resources.

The presentation will share the experiences and lessons learnt in the past 10 years of the Project and discuss the challenges to complete the remaining maritime boundaries. Establishing the maritime boundaries empowers Pacific island countries states to control activities which make use of the marine resources and contributes to improving ocean governance, such as monitoring, control and surveillance (MCS) and the control of illegal, unreported, and unregulated (IUU) fishing and to manage deep sea minerals exploration and exploitation activities within the area under national jurisdiction, or beyond in "the Area".

In 2010, the Pacific Islands Forum Leaders endorsed the Framework for a Pacific Oceanscape, which identifies strategic priorities to achieve sustainable development, management and conservation of the Pacific Ocean. This Framework identifies (as Strategic Priority 1) to "establish jurisdictional rights and responsibilities" and this goal was reiterated during the 2014 Forum Leaders Meeting in Palau through the Palau Declaration on "The Ocean: Life and Future".

During the World Ocean Day celebrated on Monday 6th June last year, the Pacific Islands Ocean Commissioner, Dame Meg Taylor emphasised, "*We must act now to protect what is rightfully ours and supporting our countries and our partners at SPC to progress this work is one of my key priorities as Pacific Ocean Commissioner.*"



The three major deposits found in the Pacific region that have potential for commercial mining in the future are: i) Seafloor Massive Sulphides (SMS), ii) Manganese Nodules (MN), and iii) Cobalt-rich Crusts (CRC). These mineral deposits exist in various forms, and at different depths and environments on the seafloor. Biological communities of fauna and flora have also been discovered in association with these minerals at depths of about 500 – 6000 m. Although deep sea mining has not happened anywhere in the world, there are concerns over the potential impacts of DSM mining on the marine environment and the fisheries resources. Against this backdrop, developing regional environmental and legal frameworks is essential to regulate and provide guidance for PIC's that decide to engage in deep sea mining in future.

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BARNICOAT

### **Disaster risk reduction challenges in the Pacific: an Australian perspective**

#### ***Andrew C. Barnicoat***

*Community Safety and Earth Monitoring Division, Geoscience Australia, GPO Box 378, Canberra, ACT, Australia  
Email: Andrew.Barnicoat@ga.gov.au*

The Pacific region is prone to damaging natural hazards including cyclones, severe storms, flooding, volcanic eruptions, earthquakes and *tsunami*. While we cannot prevent natural hazards, we can work to prevent these natural hazards become disasters – by improving community resilience through effective preparation, monitoring and response. Building resilient communities helps to strengthen economic security in the region.

Geoscience Australia's Tropical Cyclone Risk Model assesses the wind hazard from tropical cyclones and enables users to generate synthetic tropical cyclone records for many thousands of years of activity, which can be used to derive extreme value distributions of peak wind speed across large geographical regions. The effects of changing climate can also be modelled. Simulation of severe hazard events in the SW Pacific has allowed the potential impact to communities and infrastructure under current and alternative climate conditions to be evaluated; this information can help to inform long-term mitigation and preparedness plans.

Monitoring can identify natural hazards and in some circumstances provide warnings. Geoscience Australia operates national and regional networks of observatories and geophysical monitoring stations, providing real-time information such as for earthquake and *tsunami* events. Time-series satellite imagery has recently been used to monitor drought and has application for other hazards including tropical cyclones and volcanic ash dispersal and could provide useful public safety information into the region.

At Papua New Guinea's most active volcano, Rabaul, in addition to supporting seismic monitoring we have used radar interferometry to measure changing surface heights through time. By modelling these observations the changing flux of magma in and out of the volcano sub-surface magma chamber has been characterised. Radar data can also be applied to landslide and seismic hazards.

A challenge for the future is extending local analyses across larger areas in order to gain a holistic view of all natural hazards and to improve disaster risk management in the region.

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BEAVIS & BECKMANN

### **The Water Ethics Moot: exploring the ethics of water management across the Pacific region (Poster)**

***S. Beavis<sup>1</sup> & E.A. Beckmann<sup>2</sup>***

*<sup>1</sup>Fenner School of Environment and Society, Australian National University, Canberra, ACT, Australia*

*<sup>2</sup>Science Teaching & Learning Centre, Australian National University, Canberra, ACT, Australia*

*Email: sara.beavis@anu.edu.au; Elizabeth.beckmann@anu.edu.au*

Complex issues in natural resources management frequently transcend disciplinary boundaries, so graduates in the geosciences increasingly require much broader skills sets as well as sophisticated disciplinary knowledge. These management issues can involve significant dispute, ambiguity or uncertainty, with key actors having potentially widely divergent worldviews, values and cultural knowledge.

Acknowledging the ethical and moral perspectives of contradictory community needs in water management is difficult even for seasoned professionals. It is critical, within an educational context, therefore, that graduates of courses in geoscience, engineering, and environmental studies understand the role that ethics plays in managing such complexity to the point of decision-making.

The Water Ethics Moot—a component of a Water Resources Management course at the Australian National University—addresses this learning need by engaging students in group-based inquiry into critical facets of water ethics. Case studies are drawn from the Pacific and Pacific Rim region—a geographical area that is the 'canary' of climate change, as well as the growing focus of political strategizing by the US, China, India and Japan as well as Australia and New Zealand. Challenging students to be aware of, and debate, water issues from such a perspective influences their thinking more broadly and builds their capacity to think ethically once they graduate and enter the workforce.

In this paper, we will identify some key features of the Water Ethics Moot, and show how the underlying educational rationale is transferable to a wide range of geoscience teaching contexts, with the capacity to generate educational networks across the Pacific.

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BEGG & OTHERS

### **El Niño coastal impact and recovery monitoring program, Kiritimati, Kiribati**

***Zulfikar Begg, Herve Damlamian, Salesh Kumar, Amrit Raj, Cyprien Bosserelle & Kataebati Bataua***

*<sup>1</sup>Geoscience Division, Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: zulfikarb@spc.int*

El Niño event refers to the extensive warming of the central and eastern tropical Pacific Ocean which leads to a major shift in weather patterns across the Pacific.

Not much data exist on El Niño induced coastal impact on atolls. Kiritimati, Line Group, Kiribati is located in a region where El Niño impact on water level, wave, and in turns sediment transport (erosion/accretion) and inundation is at its peak.

The Geoscience Division of SPC through New Zealand Government's Regional Ocean Sciences Program (NZ-ROSP) and Reef to Ridge funds has initiated a 1-year monitoring program in Kiritimati, Kiribati to investigate coastal impact of El Niño and its potential recovery.

The program is designed around the monitoring of global and local ocean conditions and its impact on inundation hazard, shoreline change and lagoon marine habitat which is the primary source of tourism generated income in Kiritimati.

Local ocean conditions are monitored through the deployment of two pressure sensors (reef slope and reef flat) and one current profiler deployed along the urban centre of Kiritimati.

Shoreline change is quantified through the production of high resolution topography data using unmanned aircraft system (UAS or drones). Three UAS surveys are planned to occur over the 2016 year in Kiritimati. Changes in coastal topography over the 2016 year are assessed based on a Digital Terrain Model (DTM) produced prior El Niño (March 2015 by SPC/GSD).

Finally, the quantification of El Niño impact on the marine habitat is being considered using World View 2 satellite imageries to derive habitat maps before and after El Niño.

With the various development projects potentially occurring in Kiritimati in the short to medium term, the data collected through this initiative will undoubtedly become a great asset to support stakeholder to make informed decision.

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BLACKA & OTHERS

### **Update on UNSW research program for extreme waves and storm surge on fringing reef coastlines**

***Matt Blacka, Kristen Splinter, Ron Cox & Francois Flocard***

*Water Research Laboratory, UNSW Australia*

*Email: m.blacka@wrl.unsw.edu.au*

During extreme events, island nations with fringing reefs have been seen to experience higher water levels and more powerful bore waves than would ordinarily be predicted. When considering coastal processes in fringing reef situations, coastal engineering practice currently applies empirical equations which were derived from laboratory experiments under non-storm conditions and typically monochromatic waves, compared to real world conditions experienced during extreme events such as tropical cyclones. Furthermore, the steep bathymetry that is often associated with volcanic islands can present a challenge with regards to the use of numerical models for analysis of extreme waves, wave setup and infragravity waves across fringing reef platforms.

This presentation will provide an overview and update for the current research program being undertaken at the UNSW Water Research Laboratory. Within this program, several wave tank physical modelling investigations have been undertaken, with the following objectives:

- Assessing the reliability of existing empirical equations for assessing wave heights, wave setup and surf beat across fringing reefs;
- Developing improved simple empirical techniques that can be used for predicting wave and

- storm surge hazards for fringing reef coastlines; and
- Improving available methods for designing coastal protection (armour size, wave runup and overtopping predictions) for fringing reef coastlines.

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**BOSSERELLE & OTHERS**

**Field investigations of coastal inundation and building damages from tropical cyclone Winston**

***Cyprien Bosserelle<sup>1</sup>, Herve Damlamian<sup>1</sup>, Zulfikar Begg<sup>1</sup>, Deepika Lal<sup>1</sup>, Mereoni Ketewai<sup>1,2</sup>, Arieta Navatoga<sup>1</sup>, Joy Papao<sup>1</sup> & Keleni Raqisia<sup>1</sup>***

<sup>1</sup>*Geoscience Division, Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

<sup>2</sup>*Asian Development Bank, 91 Gordon Street, Suva, Fiji*

*Email: cyprienb@spc.int*

Tropical Cyclone Winston was the first category 5 tropical cyclone (Saffir-Simpson scale) to reach the Fiji islands. On the 20<sup>th</sup> February 2016 at around 7pm the cyclone made landfall on the Northeast of Viti Levu in the Rakiraki district. The cyclone caused widespread damage on its path and more than 40 casualties. Severe coastal inundation occurred on the Islands in the path of the cyclone sometimes destroying entire villages. Field investigations were undertaken in the Month following the cyclone to survey the run-up, flow depth and inundation extent and building damages in 45 locations on the islands of Ovalau and Vanua Levu. The survey highest run-up was recorded at 7.72m above the Suva tide gauge zero and the largest inundation extent of 180m inland from the high water mark. The survey also revealed a very high variability in the repartition of the run-up heights along both islands. Further numerical investigation with wave and storm surge models shows that the nearshore and offshore bathymetry can explain most of the run-up repartition.

Information collected during the survey has been delivered to the government of Fiji as baseline information to assess relocation request from communities worst hit by the cyclone. More importantly the findings highlight the vulnerabilities of coastal communities to severe tropical cyclones.

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**BURTON & OTHERS**

**The Pacific Centre for Social Responsibility and Natural Resources – a new research and policy hub (Panel Discussion)**

***John Burton<sup>1</sup>, Akuila Tawake<sup>2</sup>, Glenn Banks<sup>3</sup> & Pierre-Yves Le Meur<sup>4</sup>***

<sup>1</sup>*The Australian National University, Canberra, ACT, Australia*

<sup>2</sup>*Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

<sup>3</sup>*Massey University, Palmerston North, New Zealand*

<sup>4</sup>*IRD, Noumea, New Caledonia*

*Email: john.burton@anu.edu.au*

Pacific Island Countries and Territories (PICTs) collectively need better policy, legislative and implementation tools to ensure good management of natural resources of all kinds (minerals, metals, oil and gas and renewable natural resources such as forestry and fisheries – and all in relation to their customary owners) and to see that development outcomes are sustainable, both in

the sense of being long-lasting and that they do not come at the expense of vulnerable groups and the environments they depend on for their livelihoods.

The idea for a Pacific Centre for Social Responsibility and Natural Resources represents a convergence of national and donor-funded policy processes involving stakeholders in different parts of the Pacific region. It will be temporarily hosted in the Pacific Community's Geoscience Division in Suva. The overall aim is to contribute to the improvement of wellbeing of the Pacific Communities through the responsible and sustainable management of the region's natural resources.

The Centre's specific objectives are: (a) address gaps identified in national policies and capacities, raise awareness, communicate new developments in social responsibility observances (policy and communication); (b) collaboration with governments and the private sector, strengthening existing processes and systems (policy and capacity building); (c) build up monitoring and evaluation capacity (capacity building for technical evaluation); (d) create a platform for social and scientific research, data and information, and policy development (capacity building for science and science policy); (e) promote the involvement of the Pacific Universities and research institutions in policy and development (capacity building for applied science and science education).

The panel will present and discuss the Centre concept and more broadly engage the debate on the issues of knowledge diffusion/access, science/policy interface and policy network in the field of natural resource management in the Pacific.

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CHO & PARK

### **Development of GOCI-II: the next geostationary ocean color imager with potential application for the Pacific Islands** (Poster)

***Seongick Cho & YoungJe Park\****

*Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology, Republic of Korea*

*\*Corresponding author. E-mail: youngjepark@kiost.ac.kr*

After the successful launch and operation of Geostationary Ocean Color Imager (GOCI), the first pathfinder of ocean color remote sensing in geostationary orbit from 2010, necessity of successive GOCI mission regarding expected lifetime of 7.7 years, is remarkably increasing into the international oceanographers and policy/decision makers as well as domestic GOCI users in Korea.

Instrumental development of GOCI-II began in 2013 with a planned launch in 2019. The mission and user requirements of GOCI-II was defined by Korea Institute of Ocean Science & Technology (KIOST) with the collaboration of the international GOCI PIs (Principal Investigators). GOCI-II is being developed for the monitoring of the full Earth disk from 128.2°E longitude in geostationary orbit (35,786km altitude), and for the image acquisition at the local area freely defined by the user with 250m GSD at nadir with 12 VNIR spectral bands (370~885nm). These enhanced features will enable the monitoring of marine disasters such as Harmful Algal Blooms (HABs, incl. red tide), typhoon, *tsunami*, & etc., and research of long-term ocean environmental change with better image quality. Four more spectral bands are added to improve the accuracy of data products such as chlorophyll concentration, total suspended sediments, dissolved organic matters, and etc.

The panchromatic band is newly implemented for more accurate geometric correction with star images especially in the region of the Pacific. Full Disk (FD) and user-defined Local Area (LA)

observation mode of GOCI-II is implemented for the ocean observation over clear sky without clouds and special ocean event area over specific region in anytime and anywhere.

For the moment, GOCI-II is planned to observe the Pacific Islands area once per day, but more frequent observations can be discussed. In this conference, we present the potential application of GOCI-II for the Pacific Islands in the frame of the international cooperation between Korea and the Pacific Islands.

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**CRONIN & OTHERS**

**Hunga Ha'apai-Hunga Tonga – birth of a new volcano and discovery of a new caldera**

***Shane J. Cronin, Marco Brenna, Manuela Tost, Simon Barker, Murray Ford & Ian Smith***

*School of Environment, University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*

*Email: s.cronin@auckland.ac.nz*

***Sisi Tongaonevai & Taaniela Kula***

*Geology Unit, Natural Resources Division, Ministry of Lands and Natural Resources, Nuku'alofa, Tonga*

A month-long eruption from mid-December 2014 built an emergent tuff-cone island, between the existing islets of Hunga Tonga and Hunga Ha'apai, 65 km NW of the capital of Tonga. The "Hunga" volcano is one of several historically active, shallow submarine to emergent volcanoes regularly spaced along the Tonga volcanic arc. Visiting the new subaerial pyroclastic cone provided a rare opportunity to investigate models of emergent volcanism and sample the latest magma of the Tongan arc. It also led to a surprising discovery of a major caldera system on the huge Hunga submarine volcanic edifice. Rapid coastal and surface-runoff erosion redistributed tuff to rapidly reshape the newly formed volcanic cone, and new tombolos to the neighbouring islands of Hunga Ha'apai and Hunga Tonga enabled landing on them. With a multi-beam survey system, we surveyed the shallow submerged summit of the broader Hunga edifice and discovered a 5 km by 3 km caldera, with many submarine cones along its rim. On the older Hunga Ha'apai Island, sequences of partly welded pyroclastic flow deposits testify to an extremely eruptions from the submarine caldera. The youngest ignimbrite mapped contained charcoal newly dated at ~1000 yrs. B.P., correlating in age to a ~10 cm-thick pumice tephra found earlier on Tongatapu Island (pop. ~75,000), 65 km to the SW.

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**CROWLEY & OTHERS**

**Towards the implementation of PARTner: Pacific Risk Tool for Resilience**

***Kate Crowley<sup>1</sup>, Shaun Williams<sup>2</sup>, Litea Biukoto<sup>3</sup>, Nick Horspool<sup>4</sup>, Filomena Nelson<sup>5</sup>, Esline Garaebiti<sup>6</sup>, Peter Korisa<sup>7</sup> & Doug Ramsay<sup>8</sup>***

*<sup>1</sup>National Institute of Water and Atmospheric Research Limited, 301 Evans Bay Parade, Wellington, New Zealand*

*<sup>2</sup>National Institute of Water and Atmospheric Research Limited, 10 Kyle Street, Christchurch, New Zealand*

*<sup>3</sup>Geoscience Division, Pacific Community, 241 Mead Road, Nabua, Fiji*

*<sup>4</sup>GNS Science, 1 Fairway Drive, Avalon, Wellington*

*<sup>5</sup>National Disaster Management Office, Ministry of Natural Resources and Environment, 3<sup>rd</sup> Floor TATTE Building, Apia, Samoa*

*<sup>6</sup>Geohazards Division, Vanuatu Meteorology and Geohazards Department, PMB 9054, Port Vila, Vanuatu*

*<sup>7</sup>National Disaster Management Office, PMB 9107, Port Vila, Vanuatu*

*<sup>8</sup>National Institute of Water and Atmospheric Research Limited, Gate 10 Silverdale Road, Hamilton, New Zealand*

Email: [Kate.Crowley@niwa.co.nz](mailto:Kate.Crowley@niwa.co.nz)

There is increasing acknowledgement and associated goals by planning and disaster risk management agencies in the Pacific to use risk-based information to support hazard/risk related decision-making within the development context. Further, the availability of the multiple hazards impact and loss modelling tool, RiskScape, which was developed in the Pacific by New Zealand Crown Research Institutes' National Institute of Water and Atmospheric Research (NIWA) and GNS Science, provides an opportunity for Pacific Islands' disaster and planning agencies to help achieve these goals. To this end and through a New Zealand Aid Partnerships funded project administered by the New Zealand Ministry of Foreign Affairs and Trade, NIWA in partnership with GNS Science, the Geoscience Division of the Pacific Community, the National Disaster Management Offices of Samoa and Vanuatu, and the Vanuatu Meteorology and Geohazards Department, are piloting the PARTneR project in Samoa and Vanuatu.

PARTneR (Pacific Risk Tool for Resilience) aims to tailor RiskScape to the Samoa and Vanuatu hazard and risk contexts in order to enable relevant agencies and stakeholders to effectively develop and use risk-based information to support development decision-making (e.g. land use and development consent planning). PARTneR is acknowledged by Samoa and Vanuatu as a very useful tool to help analyse local hazard and asset data in order to output risk-based information useful for planning purposes. The planned three year pilot is earmarked for implementation from July 2016 – 2019, with subsequent plans to roll-out PARTneR to the broader Pacific. In this talk we provide an overview of the planned pilot phases of PARTneR in Samoa and Vanuatu over the next three years, including longer-term plans to support risk related decision processes in nations throughout the wider Pacific.

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**DAMLAMIAN & OTHERS**

**The Use of Multicopter and Fixed Wings UAVs to Assess 3D Shoreline Change Patterns Generated by Tropical Cyclone Pam (Category 5) in Vanuatu 2015**

***Herve Damlamian<sup>1</sup>, Cyprien Bosserelle, Amrit Raj<sup>1</sup>, Zulfikar Begg<sup>1</sup>, Teja Kattenborn<sup>2</sup> & Mereoni Ketewai<sup>1</sup>***

<sup>1</sup>Geoscience Division, Pacific Community, GPO Private Mail Bag, Suva, FIJI.

<sup>2</sup>Karlsruher Institut für Technologie (KIT), Institut für Geographie und Geoökologie, Kaiserstr. 12, 76131 Karlsruhe, Germany  
Email: [herveda@spc.int](mailto:herveda@spc.int)

The Pacific region is prone to numerous natural hazards but tropical cyclones have recently caused significant damage in the region. Between 10 – 15 March 2015 tropical cyclone (TC) Pam generated considerable damage in several countries in the South Pacific region. On 12 March, TC Pam reached category 5 with sustained wind speeds peaking at 250km/h as it traversed Vanuatu. Waves generated by TC Pam are believed to have exceeded 10m between the South of Efate to Tanna Island.

The Government of Vanuatu requested support from the Pacific Community (SPC) to undertake a technical assessment of the resulting damage. A team from the Geoscience Division (GSD) of SPC was deployed two weeks after the cyclone. The team carried out two distinctive surveys; an aerial photography survey and a 3D shoreline change analysis survey. The latest was undertaken at sites expected to have experienced large wave impact. Using drones and a RealTime Kinematic (RTK) GPS system, the team produced high resolution topographic model of the coastal zone. A comparison with a previous DTM generated from a LiDAR survey completed in 2012 gave insights on

the impact of severe cyclone wave on reef fronted shoreline. Data shows a range of impact depending on coastal geomorphology features and human activity found along the north east coast of Efate, Vanuatu.

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FAKHRUDDIN

## **Application of science and technology in the Sendai Framework**

### **Bapon Fakhruddin**

*Tonkin+Taylor International, PO Box 5271, Wellesley Street, Auckland 1141  
Email: smfwater@gmail.com*

The Sendai Framework, a landmark international framework adopted in 2015, calls for a shift from managing disasters to managing risks. This requires a more holistic approach to risks and a stronger focus on risk-creation processes, and it presents opportunities to approach disaster risk reduction (DRR) as an integral part of sustainable development. The SFDRR was endorsed last March 2015. There has been much discussion on what the SFDRR encompasses, and it is obviously difficult to cover all aspects of DRR in short documents. There has been discussion what would be the next after the SFDRR. The journey started with the Yokohama Declaration (1994) and moved onto the Hyogo Framework (2005).

Perhaps for the next 15 years it will be the SFDRR. Science has gone through a highly advanced stage but there is still more to go. Unfortunately much of the scientific information is never incorporated into the operational domain for decision making, and very little has been incorporated down to the community level to respond to disaster risks. There is and will be uncertainty in scientific knowledge. Similarly uncertainty exists in all aspects of human decision-making. Thus there is no harm to applying uncertain scientific knowledge for decision-making. If the probability is 60%, the uncertainty is 40%. But by using 60% certainty, many disaster impacts could be avoided. In the law there is a concept of "foreseeability". It refers to actions for which the outcomes could and therefore should have been foreseen. Foreseeability is a qualitative expression of probability.

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FORSTREUTER

## **Mapping village damage with space borne image data**

### **Wolf Forstreuter**

*SPC-GSD, Private Mailbag, GPO, Suva, Fiji Islands  
Email: wolf.forstreuter@gmail.com*

Tropical cyclone Winston damaged villages in Fiji like no other cyclone in the past. DigitalGlobe the worldwide leading company for satellite image data contacted SPC following the cyclone to facilitate the capture of post-cyclone very high resolution (VHR) images. Financial assistance was provided by PCRAFI.

The Australian Defence Force (ADF) as part of the National Disaster Management Office (NDMO)

requested support from the GIS&RS unit of SPC-GSD to estimate the damage per village to direct the assistance. A team comprising 20 GIS officers from SPC (GSD), Department of Lands, and Department of Forestry was set up to conduct the required assessments.

Structures in rural areas have not been mapped in the past which is in contrast to urban centres where the PCRAFI Project mapped and assessed every structure. As an initial step, all structures were mapped in a corridor 30 km either side of the cyclone path. DigitalGlobe had captured and supplied VHR image data during 2015 for this area as part of a food security project. The assessment team placed a dot in the centre of every roof structure visible on the available recent space borne images.

The initial post-disaster image data (WorldView-2) were captured 2 days after the cyclone and delivered within several hours. This allowed the team to overlay the pre-disaster footprints of the villages on post-cyclone data. The team noted which structures were (i) missing, (ii) damaged, (iii) still intact; or (iv) new. Later, cloud cover was increasing; however, the ADF was able to acquire oblique photographs recorded from helicopter sorties. Having the pre-disaster footprints it was then possible to make assessments using oblique image data. Pre- and post-disaster footprints allowed the creation of disaster damage maps. The results were uploaded to a database maintained at GSD. The database, damage maps and footprints were forwarded to the NDMO on a daily basis. A website was also developed at SPC-GSD where all users could view the data and download all three products: (i) the maps showing the damage per village, (ii) the pre-disaster and post-disaster house footprints and (iii) the updated database.

Within the initial six weeks following the cyclone, over three hundred villages were investigated and a clear picture on village damage was provided to users.

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**FORSTREUTER & FAKA'OSI**

**Age estimation and form factor calculation of Pacific coconut palms**

***Wolf Forstreuter<sup>1</sup> & Tevita Faka'osi<sup>2</sup>***

*<sup>1</sup>SPC-GSD, Private Mailbag, GPO, Suva, Fiji Islands*

*<sup>2</sup>Forestry Division, Tonga*

*Email: wolf.forstreuter@gmail.com*

Pacific coconut palms are called "the tree of life" as they produce what villages in outer islands need for income and living. Since soya bean oil was promoted and produced in large farms in US the copra market broke down and the coconut resource was neglected. Today most Pacific coconut stands are overage as replanting programs stopped decades ago; however, the value of coconut is rediscovered and countries started to seek assistance to assess the coconut resource.



**Figure 01:** Felled coconut palms allowed a proper measurement of the trunk form.

The declining coconut production figures are mostly determined from copra processing facilities. The coconut palm area is shrinking in size; however, it is unclear how the age structure contributes too as result of growing senile palms population. The GIS&RS Unit of SPC-GSD was asked to assess the

coconut resource in the Vava'u Group in Tonga to find out the reason for declining coconut production. The inventory provided a clear picture of the available coconut palm area, the palms per hectare, the health condition, the nut production and several other figures. The inventory also provided a picture of the age structure and the timber volume of standing coconut palms. If senile palms have to be removed the trunk has to be transported out of the area otherwise the rotting trunk creates a breeding ground for an important biotic coconut pest, the rhinoceros beetle. For planning the removal of senile palms the timber volume is an important planning figure.

Coconut age is normally calculated from the number of leave scars assuming that after the first five years a coconut palm produces 11 leaves per year. The timber volume was calculated with the input parameter (i) diameter in breast height, (ii) height of the trunk and (iii) form factor of a "normal" tree assuming that a coconut trunk has the form of a tree.

To calibrate form factor and age estimation someone has to climb the trunk and measure the diameter in intervals and count the leave scars. As for a statistical sound figure at least 60 palms have to be measured making it an exhausting exercise. Tonga provided the opportunity that palms were freshly felled as the government enhanced the road network in the agriculture area. 62 palms were measured, age estimation was adjusted and form factor was established. The measurement documented the diameter every for meter and the number of leave scars. At some point holes had to be dug under the trunk to enable the diameter to be measured.

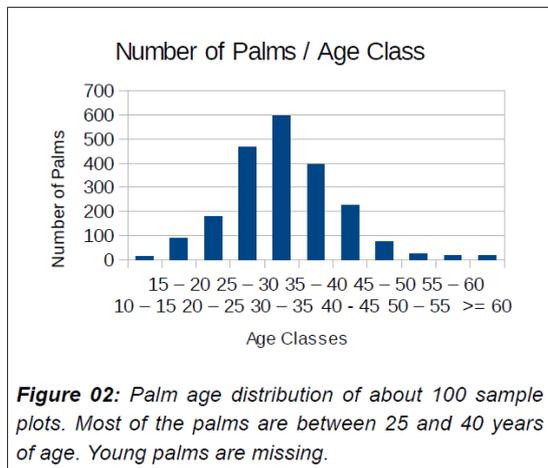
The form factor measurements showed that coconut palm trunks do not have a form like a tree which tapers permanently with the height. The measurement showed that 98% of the coconut trunks had a form where the trunk did not permanently decrease in diameter. Mostly the diameter even increased somewhere at the trunk. The form factor was calculated with 0.74 with very low standard error.

The age estimation was normally calculated as length of trunk divided by the length of 11 leave scars measured from 1.5m upwards. The measurements of the 62 palms showed that this

calculation has to be adjusted as the number of leave scars per meter increases significantly towards the top of the trunk. A new formula was calculated:

$$\text{Age} = (\text{length trunk} / \text{length 11 leave scars} + 5) + ((\text{length trunk} / \text{length 11 leave scars} + 5) / 2.06)$$

Applying this new formula showed that existing senile palms have to be removed. However, it is important to note that there are missing young palms which will soon result in very few productive palms and a serious decline in coconut production.



It is essential to remove the palms above 40 years of age and plant young palms. The volume of the timber to be removed can be calculated and this information used to plan a decent harvesting and removal process.

For further information: [wolff@spc.int](mailto:wolff@spc.int), [wolf.forstreuter@gmail.com](mailto:wolf.forstreuter@gmail.com)

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GALVIS-RODRIGUEZ & SINCLAIR

**Abstraction and climate impacts on the Bonriki freshwater lens, Tarawa, Kiribati: an optimization approach to maximize the resource during droughts**

***Sandra C. Galvis-Rodriguez & Peter Sinclair***

*Geoscience Division, Pacific Community, Private Mail Bag, GPO, Suva, Fiji  
Email: sandrar@spc.int*

In the atoll of Tarawa, in the Republic of Kiribati, availability of freshwater is a major issue, because besides rainfall, which can be irregular, fresh groundwater is the only other source of natural freshwater. In South Tarawa, the urban, political, administrative and commercial centre of the Republic of Kiribati, about half of the population of the country, over 50,000 people, reside in less than 16 km<sup>2</sup>. The growing population of South Tarawa relies on the freshwater lens found under the 0.7 km<sup>2</sup> Bonriki water reserve as their main source of freshwater. Salinisation, driven by an increased abstraction to meet the rising demand, is a key concern.

Analysis of hydrogeological information and historical records of salinity and water level measurements were used to develop a conceptual model of the Bonriki freshwater lens. This was used to underpin a 3D variable-density numerical groundwater model to assess the impacts from groundwater abstraction and climate variability on the freshwater lens.

The model results indicated that rainfall variability and pumping have a strong control on the temporal dynamics of the freshwater lens that are apparent in field observations. The model scenarios further showed that the rate and distribution of abstraction is a key factor in the historical variability of salinity, which is recorded at the island's water treatment plant. A range of sustainable abstractions, i.e. abstractions volumes that ensure that salinities at the groundwater infiltration galleries do not exceed a threshold value of 1500 µS/cm, were identified under different rainfall scenarios. Optimization scenarios were used to identify and rank the galleries that cause an increment above the threshold value in the salinity at the treatment plan during drought periods. The effect of reducing abstraction on these galleries during droughts was assessed and used to develop a more reliable management strategy for protecting their long-term extraction of freshwater from the Bonriki lens.

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GARAEBITI & OTHERS

**Development and progress of the Oceania Regional Seismic Network (ORSNET) for *tsunami* early warning**

***Esline Garaebiti<sup>1</sup>, Sylvain Todman<sup>1</sup> & Pierre Lebellegard<sup>2</sup>***

*<sup>1</sup>Geohazards Section, Vanuatu Meteorology and Geohazards Department, Port-Vila, Vanuatu*

*<sup>2</sup>Institut de Recherche pour le Développement, Nouméa, New Caledonia*

*Email: gesline@vanuatu.gov.vu; stodman@vanuatu.gov.vu*

Thirty percent of worldwide earthquakes occur in the southwest Pacific area but the average detection time for local and regional seismic events is one of the lowest times locally. Eighty one percent of the Pacific *tsunami* are generated by earthquakes, and 90 percent of *tsunami* occur in the Pacific Ocean, improving the seismic detection and response time to help enhance *tsunami* early warning system.

In 2009, the Intergovernmental Oceanography Commission Coordination Group for the Pacific Tsunami Warning System (IOC/ICG/PTWS) began to discuss the need for sharing seismic data in the region to enhance earthquake detection for *tsunami* warning. Until January 2011, New Caledonia and Vanuatu successfully implemented a joint project to address data sharing between the two countries for earthquakes occurring in the Vanuatu trench. This became a pattern approved and encouraged by the IOC since July 2012 to extend to other national seismic observatories in the region as the Oceania Regional Seismic Network.

The national seismic network observatories officially agreed to share their respective seismic data, and the ORSNET server has been installed in New Caledonia since March 2014. The ORSNET countries include Papua New Guinea, Solomon Islands, New Caledonia, Vanuatu, Fiji, Tonga and Samoa.

These Pacific Island Countries share not only their data through the ORSNET server but also their skills, experiences, and resources, they are expanding to share common earthquake and *tsunami* products. Funded by the Pacific Fund through the French Embassy in Vanuatu, the ORSNET is the best solution so far to improve *tsunami* warning systems in the southwest Pacific region.

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GREENE & MAHER

## **Using a UAV to map and monitor environmental changes in lagoons, Bays and sounds of the San Juan Archipelago for management purposes**

***H. Gary Greene<sup>1</sup> & Norman Maher<sup>2</sup>***

<sup>1</sup>*Moss Landing Marine Labs, Center for Habitat Studies & SeaDoc Tomolo Mapping Lab, Orcas Island, WA, USA*  
Email: [greenem@mlml.calstate.edu](mailto:greenem@mlml.calstate.edu)

<sup>2</sup>*Tahoe Maps & Moss Landing Marine Labs, Center for Habitat Studies*

The use of a lightweight, fixed-wing, inexpensive Unmanned Aerial Vehicle (UAV) to map very shallow water and tidally exposed lagoons, bays and sounds, and their terrestrial associates within the San Juan Archipelago and vicinity has led to a rapid and very accurate method to survey hard to reach coastal areas. We have used UAVs to map critical habitats such as eelgrass beds, clam banks, streams, and deltas/fans where anthropogenic impacts have taken, or are to take, place. The data collected by the UAV we used are high density, closely spaced photographic images that overlap enough to produce stereo-pairs used in the generation of Digital Elevation Models (DEMs). The DEMs produce a base map that then can be overlaid at a later date with newly collected data and constructed DEMs to determine changes in elevation and shifting of geomorphic features.

The UAV technology is rapidly expanding and in need of oversight and regulation. In the US much regulation is in place that constrains effective use of the technology, as the majority use of UAVs has been by hobbyists with the scientific community not being adequately listened to. We have found that the regulatory aspects for UAV use is rapidly evolving and that the best approach has been to continue to fly and collect data in keeping with the flight restrictions produced to date by the government. We feel that the best proof of responsible use of UAVs is having a flawless and extensive flight record. Also, with the ability to collect data with little preparation time and good mobility, many land, environmental, and infrastructure management agencies are looking to the technology to assist them in their regulatory tasks. We will present several case histories that show the value of the UAV technology as a tool, but most of all we will show how added value to the data becomes the critical component in the use of a UAV.

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GREENE & OTHERS

**Assessing the seismic and tsunami hazards along a major transform plate boundary – the Queen Charlotte-Fairweather leaky transform fault system of Canada and Alaska**

***H. Gary Greene<sup>1</sup>, J. Vaughn Barrie<sup>2</sup>, Kim Conway<sup>2</sup>, Daniel S. Brothers<sup>3</sup>, James E. Conrad<sup>3</sup>, Katherine L. Maier<sup>3</sup> & Stu Nishenko<sup>4</sup>***

<sup>1</sup>Moss Landing Marine Labs, Center for Habitat Studies & SeaDoc Tombolo Mapping Lab, Orcas Island, WA, USA  
Email: [greenem@mlml.calstate.edu](mailto:greenem@mlml.calstate.edu)

<sup>2</sup>Geological Survey of Canada, Pacific, Sidney, B.C., Canada

<sup>3</sup>U.S. Geological Survey, Pacific Coastal and Marine Science Center, Santa Cruz, CA, USA

<sup>4</sup>Pacific Gas & Electric Co., San Francisco, CA, USA

A recent geophysical and geological investigation in the NE Pacific found that the Queen Charlotte-Fairweather fault system located offshore of Southern Alaska and western B.C. Canada is a unique tectonic transform plate boundary that appears to accommodate the entire relative plate motion between the Pacific and North American plates along a single fault trace. The investigation utilized previously collected multibeam echosounder bathymetry and newly collected 3.5-kHz Chirp sub-bottom profiles, piston cores, and seafloor towed camera photos to image the seafloor and determine offset along the fault zone. We found that the southern part of the fault zone leaks gas and fluids that produced substantial mud volcanoes and which are associated with gully and canyon formation. Offsets of the canyons along a single trace of the fault are consistent and indicate that the plate boundary as expressed in the seafloor is a very linear feature. This leaky transform fault system exhibits areas of instability along the steep continental slope where high pore pressures associated with gas venting may facilitate mass wasting events that could trigger major submarine landslides and produce damaging *tsunami*, adversely impacting population centers such as those located in Ketchikan, Alaska and Prince Rupert, B.C. Canada.

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HERON & OTHERS

**New approaches to hazard and risk mapping, Vanuatu – developing safer communities**

***David Heron<sup>1</sup>, Biljana Lukovic<sup>1</sup>, Graeme Smart<sup>2</sup>, Doug Ramsay<sup>2</sup>, Graeme Roberts<sup>3</sup>, Lesley Hopkins<sup>3</sup> & Sylvain Todman<sup>4</sup>***

<sup>1</sup>GNS Science, PO Box 30-368, Lower Hutt, New Zealand

Email: [d.heron@gns.cri.nz](mailto:d.heron@gns.cri.nz)

<sup>2</sup>National Institute of Water and Atmospheric Research Limited, Gate 10 Silverdale Road, Hamilton, New Zealand

<sup>3</sup>Beca, PO Box 6345, Auckland, New Zealand

<sup>4</sup>Meteorology and Geo-Hazards Department, Vanuatu

The Republic of Vanuatu, like many other Pacific Island states, has experienced many significant natural hazard events that have killed people and destroyed housing and infrastructure. Previous studies of hazard and risk in Vanuatu were aggregated to a level not useful for informing local decision making. To help address this, the Mainstreaming Disaster Risk Reduction Project, funded by the World Bank and implemented by the Vanuatu Meteorology and Geo-hazards Department, included the Risk Mapping and Planning for Urban Preparedness (RMPUP) Project. GNS Science, NIWA and Beca undertook the RMPUP project to take the existing science and make it useable for

future planning and risk reduction purposes. The project focus was the greater Port Villa and Luganville areas.

The RMPUP project focused on five natural hazards: earthquake, flood, wind, coastal inundation and *tsunami*. A key component of the project was the development and application of “realistic” “science-based” hazard models. A probabilistic earthquake model was available for one return period and was extended. Models for susceptibility to ground shaking amplification, liquefaction and land sliding were developed. Numerical modelling of flood and *tsunami* hazard was undertaken and an assessment of the exposure to coastal inundation made. Existing hazard information for wind was used as is.

Based on this modelling, risk maps were created for use by planners and other key stakeholders. As risk is deemed to occur only where a hazard is present at a location occupied by people or property that are vulnerable to that hazard, conventional risk maps show unsettled areas as having no risk. Such maps have little use for informing planners who want to assess land that could be potentially settled with the minimum of risk. For this reason risk was assessed using an equal spread of people and buildings across the entire landscape and Potential Risk Maps produced.

As a separate exercise an Urban Risk Assessment was undertaken using the actual spread of people and buildings. The exercise confirmed previous studies that the majority of the population of Port Vila and Luganville live with moderate or higher levels of risk from natural hazards.

The study concluded that the risk associated with each identified hazard could be significantly reduced using one or more of a number of available options, including risk-sensitive land use planning, development controls (e.g. building codes), community education, and the use of early warning systems to trigger evacuations.

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**HOEKE & OTHERS**

**Multi-variate coastal inundation forecasting and risk analysis for the Pacific**

***Ron K. Hoeke, Kathy L. McInnes & Julian G. O’Grady***

*CSIRO Oceans and Atmosphere, Aspendale, Victoria, NSW, Australia*

*Email: Ron.Hoeke@csiro.au*

Many Pacific Island countries (PICs) will experience an increase in the number and severity of coastal inundation events as a consequence of sea level rise. In this study, we show how a multivariate approach, incorporating data on regional sea level, tides and storm waves (swell), can improve both short-term forecasting and longer-term estimates of how inundation risk may change in a future climate. Additionally, an ongoing reef hydrodynamics model inter-comparison project, validated by measurements at 5 different PIC locations, will be discussed. This project, along with information from other current or planned storm-surge-type modelling projects, may ultimately better inform and quantify such multi-variate approaches to inundation forecasting and risk assessment across the region.

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JOLLIFFE

## **The economic dimensions of relocation as an adaptation to climate change in Fiji**

***W. James Jolliffe***

*Geoscience Division, Pacific Community (SPC), Private Mail Bag, GPO, Suva, Fiji*

*Email: williamj@spc.int*

Relocation has been identified as an adaptation strategy for low-lying coastal communities that are vulnerable to the impacts of climate change in Fiji. The National Climate Change Policy was signed in 2012, but relocation was not considered and no formal strategy exists to guide the relocation process. Whether relocation should be pursued depends on a number of factors but, crucially, the costs and benefits of doing so are poorly understood. To address this, the Climate Change Division of the Fiji Government commissioned the Pacific Community (SPC) to assist with a cost-benefit analysis (CBA) of relocation efforts already underway in a remote rural village in Kadavu Province. The findings will inform the development of climate change relocation guidelines which are currently being drafted.

The analysis took into account a wide range of the impacts associated with relocation. The results of the case study suggest the costs of relocating the community outweigh the benefits by considerable amounts, a situation exacerbated by the generation of intangible relocation costs. The benefits of relocation are determined almost entirely by the magnitude of the threat faced by the community. This would suggest that relocation guidelines for Fiji could be strengthened by ensuring that, prior to a decision being made, (i) community specific risks are identified, assessed and understood properly; and (ii) the nature of the costs and benefits are specified. Further implications for future relocation policy include the importance of synchronising expertise in land affairs, rural development and the sciences. A multi-disciplinary approach will ensure a holistic understanding of risks faced by vulnerable communities and ensure that relocation is only considered where it is the most beneficial adaptation strategy available.

The CBA has received financial support from the SPC/United States Agency for International Development project 'Vegetation and land cover mapping and improving food security for building resilience to a changing climate in Pacific Island communities'.

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KAITU'U

## **Building GIS capacity from the ground up**

***John Kaitu'u***

*IUCN MACBIO Project, 5 Ma'afu Street, Suva*

*Email: sionelaglelei@gmail.com*

As part of its objective to support the sustainable management of marine and coastal biodiversity in Fiji, Kiribati, the Solomon Islands, Tonga, and Vanuatu, the regional MACBIO project assists partner governments in their efforts to strengthen GIS capacity and address the demand for license-free spatial data tools in the region.

Based on the open-source application QGIS, the "Qbook" training hub is a free, dynamic, MOODLE-based, on and offline learning platform, that provides easy access to training materials for GIS

beginners and practitioners that are interested to increase their capacities and share their experience.

Through close collaboration with SPC-GSD, USP and a growing range of partner organisations the QBook Moodle aims to provide a conduit for a range of spatial data applications, such as mapping and monitoring the status of natural resources and their uses, e.g. as part of marine and terrestrial spatial planning.

The presentation aims to introduce and explain the core functions of the QBOOK, its goals and progress. The team involved in the development of the platform hopes to gain valuable feedback and build further collaboration with practitioners and stakeholders in the region.

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KILAMANU

## **Surface and drill-hole geological and geochemical data capture, analysis, input and visualisation**

### **Willie Kilamanu**

*Geological Survey Division, Mineral Resources Authority, PO Box 1906, Port Moresby, Papua New Guinea  
Email: [wkilamanu@mra.gov.pg](mailto:wkilamanu@mra.gov.pg)*

The effective management of data, in any form or shape, is vital for any organisation whose roles and functions are interwoven and centred on data collection, analysis, storage, archival and dissemination. The data digitization project of the Mineral Resources Authority extracted geological and geochemical data from the archived exploration reports. The process of extraction involves digitising surface sample points using an application called RastReg in MapInfo. The points are captured and the coordinates are populated using Discover's Data Utilities tools. The sample locations together with other attribute data are then exported as a *DBF* file to MS Excel and saved as a spreadsheet once opened. Excel template for each data type such as Rock Chip, Stream Sediment (Pan Concentrate and Sieved samples) and Soil are populated from assay results published in the reports with the necessary conversions of units of measurement carried out where required. The location data exported from MapInfo is used to populate the coordinate fields in the template. Once all fields in the templates are filled, validation is run using *valdata*, an Excel extension that checks and verifies that all primary fields are correctly populated with the required data type as well as format. The validated file which includes assay information is then loaded into Explorer3, a database management system (DBMS) based on Sequential Query Language (SQL). A series of validation in Explorer3 ensures any issue is addressed and corrected. Final outcome of the validated data in Explorer3 is that spatial queries can be run based on sampling method, assay technique, detection limits or by analysis laboratory, among others. Reports and spatial maps can be generated by Explorer3 from which further GIS analysis can be undertaken.

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KIM & OTHERS

**Pilot study: remediation of contaminated marine sediments for beneficial use**  
(Poster)

**Kyoungrean Kim<sup>\*1,2</sup>, Eun-Ji Won<sup>1</sup>, Jin Young Choi<sup>1</sup> and Chang Soo Chung<sup>1</sup>**

<sup>1</sup>Korea Institute of Ocean Science and Technology, Ansan, Republic of Korea

<sup>2</sup>Dept. of Integrated Ocean Science, University of Science and Technology, 787 Haeanro, Ansan 426-744, Republic of Korea  
Email: kyoungrean@kiost.ac.kr

Although the remediation mechanism of contaminated marine sediments is similar to that of soil, particle size distribution, high contents of organic matters and the presence of chlorine ions might be also limiting factors comparing to the remediation of contaminated soil. If remediation process could be conducted on-site (or immediate area) of target area and if treated sediments might be used beneficially followed by environmental dredging, Korea's dilemma such as the mass transportation hardship of dredged materials, the lack of treatment area (upland/near shore) and et cetera will not take place.

Based on experimental results, the use of oxidant (H<sub>2</sub>O<sub>2</sub>) and non-ionic surfactant (Tween 80) was very effective and adequate in the viewpoint of environmental safety, cost and second pollution. Lots of treated sediments under various conditions were to meet domestic environmental standards for disposal such as near shore confined disposal facility (NS-CDF) as well as beneficial use at upland landfill. Thus washing technology by using H<sub>2</sub>O<sub>2</sub> and Tween 80 combined with particle separation (higher than 125 µm, 125~ 63 µm, 63~ 32 µm, lower than 32 µm) might be successfully applied in the remediation of contaminated marine sediments.

Besides washing and particle separation technologies which were selectively used on the basis of their contamination degree, were applied repeatedly and then treated sediments of all particle size distribution including lower than 32 µm could be used as various purposes.

Fine particles of contaminated marine sediments could be treated by particle separation of specific range with washing technologies under suitable conditions. And fine particles of contaminated marine sediments could be treated by particle separation of specific range with washing technologies under suitable conditions (sample (30 g, dry weight) with H<sub>2</sub>O<sub>2</sub> (5M, 100 ml) and surfactant (Tween 80, 100 ml) for 1 h).

\*: Corresponding author

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LAHAN

**An overview of surface geothermal exploration in Papua New Guinea**

**Maxine Lahan**

Mineral Resources Authority, Geological Survey Division, P O Box 1906, Port Moresby  
Email: mlahan@mra.gov.pg

Papua New Guinea's ideal location on the "Pacific Ring of Fire" has enabled its rich untapped geothermal resource. This resource sector has not been given much thought by the policy makers to enable exploration and development until recently after the COP21 conference where the

importance of policy was highlighted. But despite the lack of policy, the Geological Survey Division of the Mineral Resources Authority, sighting the importance of clean sustainable energy which would be derived from this rich resource in the country, began conducting surface geothermal exploration in 2010.

There are more than 50 known geothermal sites in the country; most of these sites are located on smaller islands. Four Provinces with geothermal areas have been visited and their geothermal resource mapped, samples (water and gas samples) collected and analyzed. The chemical results from solute geothermometry analysis have been very encouraging with an estimated reservoir temperature of more than 250 °C for prospects in West New Britain and Milne Bay Provinces. More surface and sub-surface studies must be conducted on these prospects as well as others not mapped yet, to fully understand the geothermal systems and to prove their potentials for development.

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LAL

## **Positioning in the Pacific Islands**

### ***Andrick Lal***

*Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands  
Email: andrickl@spc.int*

Most of the islands and atolls in the Pacific are low lying (some are 2 to 3 m above mean sea level) and therefore it is very important to have a vertical reference system established, so that the Pacific islanders are able to accurately know how high or above are their islands above sea level, whether it is chart datum or mean sea level datum. Since these islands are fairly remote and the tides are different in each location, it is very important to have an accurate vertical reference system recognised regionally and globally and above all it is quite a challenging task. One good example is the Hydrographic Project in the islands of Vanuatu funded by the Government of New Zealand and Vanuatu where by geodetic and bathymetry surveys were carried out to map the anchorage points for the cruise vessels (nearly 250 cruise ships enter into the islands of Vanuatu).

The Geoscience for Development Programme of SPC has been actively involved in regional projects such as the Pacific Sea Level Monitoring Project and Regional Maritime Boundaries project funded by the Government of Australia.

The Pacific Sea Level Monitoring Project is a longstanding regional project and we have been closely working with the Geodesy Division of Geoscience Australia. The project has established a network of Continuous Global Positioning System Stations and Tide Gauge Stations in the thirteen participating countries.

The Regional Maritime Boundaries Project includes fourteen participating countries. As for the definition of the maritime boundaries, with good horizontal location information, vertical location information is also very important as due to sea level implications, the tides are shifting the low water mark and thus it affects the defined territorial seas baseline; that is the reference for establishment of exclusive economic zone.

In December 2014, the Pacific Geospatial & Surveying Council was established for the region, specialist from the Pacific attended and a desk was formalised at the Geoscience Division of SPC.

This council will be a platform for the development of the international reference frame for the region and will lead the way forward to develop 'one' unified reference system.

With the modern techniques available, the Pacific island countries would need financial assistance from aid agencies and expertise from the organisations such as UN-GGIM, FIG, IAG and ICG not only to develop their geodetic survey infrastructure (CORS Network) but also to establish their vertical and horizontal reference frame in terms of international standards and specifications. Development of geodetic survey capacity is a need in the region is also necessary.

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## LAMARCHE & BONNIFAIT

### **From hazard assessment to village adaptation: the village of Sa'anapu, Samoa**

***Geoffroy Lamarche<sup>1</sup> & Cécile Bonnifait<sup>2</sup>***

<sup>1</sup>*National Institute of Water and Atmospheric (NIWA), Wellington, New Zealand*

<sup>2</sup>*Atelierworkshop Architects, Wellington, New Zealand*

*Email: geoffroy.lamarche@niwa.co.nz*

On 29 September 2009 the Southwest Pacific *tsunami* resulted in severe infrastructure damage and the loss of 115 lives in Samoa. Subsequently, UNESCO issued recommendations which our project addresses through a multidisciplinary initiative that recognises the inter-relationship between the natural environment and the spatial, social and architectural environments. We worked very closely with the village of Sa'anapu on the South coast of Upolu, Samoa. The village represents a structured community, characterised by a distinct, limited geomorphology which has been affected by the *tsunami*. The project aims to characterise the natural hazard and risk, and propose adapted architectural solutions in respecting the Samoa cultural identity and local economical specificities. It is unique in that it aspires to federate teams and expertise that rarely work together.

We collected and integrated data on (1) the physical characteristics of the land, including information on geological and climatic natural hazard impact and recurrence, including *tsunami* numerical models; (2) the patterns of local habitation and the socio-cultural characteristics of the village; and (3) the space and structures of construction including traditional and contemporary typologies, including oral accounts of climatic events that impacted the community, information about the land physical characteristics, its changed through time, and the types of land-use practices.

The intertwining of scientific data, anthropological notes, sociological surveys, and architectural appraisal has enabled us to propose, in close partnership with the community, technical and operational responses adapted to the geological, climatic, economic and cultural particularities of Samoa. We produced maps (zoning, circulation, habitation), plans, and drawings of construction methods, which help formulating a credible and feasible architectural typology adapted to the specific natural environment and construction method. The project addresses the natural hazard while respecting Samoa cultural identity, working from vernacular architecture towards a contemporary adaptation, and establishing a safer community, through informed coastal management and community development.

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## LAMARCHE & OTHERS

### **Combining scenario-based numerical modelling, post-disaster surveys, palaeo/historic investigations and traditional environmental knowledge to increase community resilience to tsunami hazard in the Southwest Pacific**

***Geoffroy Lamarche<sup>1</sup>, Alan Orpin<sup>1</sup>, Graham Rickard<sup>1</sup>, Emily Lane<sup>2</sup>, James Goff<sup>3</sup>, Bernard Pelletier<sup>4</sup>, Stéphane Popinet<sup>5</sup> & Shaun Williams<sup>2</sup>***

<sup>1</sup>NIWA, 301 Evans Bay Parade, Wellington, New Zealand

Email: geoffroy.lamarche@niwa.co.nz

<sup>2</sup>NIWA, 10 Kyle Street, Christchurch, New Zealand

<sup>3</sup>University New South Wales, Australia

<sup>4</sup>IRD, Nouméa, New Caledonia.

<sup>5</sup>Université Pierre et Marie Curie, Paris, France

Devastating *tsunami* over the past decade have significantly heightened awareness about the vulnerability of atolls, low-lying islands, barrier reefs, and volcanic islands with fringing reefs in the Southwest Pacific. However, there are still few comprehensive assessments for the region. Here we present four independent approaches to tsunami hazard assessment:

- (1) Palaeo- and historical *tsunami* studies undertaken for geological evidence of rapid/catastrophic marine inundation of the coast, in Futuna, Wallis and Samoa;
- (2) post-*tsunami* surveys from the 2009 South Pacific *tsunami* for Futuna and Samoa;
- (3) source-propagation-inundation models, for which maximum wave elevation, inundation distance, and expected time of arrival are calculated using a number of circum-Pacific earthquake-generating *tsunami* sources, for Futuna, Wallis, Tokelau and Samoa; and
- (4) gathering traditional environmental knowledge of past events for Futuna and Samoa.

Combining these approaches enables us to develop better *tsunami* hazard/risk assessments that are currently available in a variety of geomorphological environments. The results provide useful insights into the potential *tsunami* inundation of coastal settlements and agricultural land, yielding important data for community empowerment and resilience as opposed to being deterministic.

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## LEE

### **Role of ocean energy in the stand-alone microgrid system for green energy-independent islands**

***Kwang Soo Lee***

Korea Institute of Ocean Science and Technology (KIOST), 787, Haeanro, Ansan 15627, Korea

Email: kslee@kiost.ac.kr

Ocean energy has considerable long-term potential for economic growth, energy security and job creation. In order to develop ocean energy, a critical technology and successful cases of practical applications should be provided and proved. Generally ocean energy Technology Readiness Level

(TRL) has reached the stage of demonstration and verification of machine performance and pre-commercialization.

From 2000, Korea has operated the national R&D program for the development of ocean renewable energy technologies on tidal power (barrage), tidal current, wave, offshore wind and ocean thermal energy conversion (OTEC). Based on the R&D results, Uldolmok Tidal Current Power Pilot Plant (1MW), Sihwa Tidal Power Plant (254MW) and hybrid-OTEC power plant using multiple heat sources (200kW) had been built in 2009, 2011 and 2014, respectively. And Jeju Wave Power Pilot Plant will be completed in 2016. In the national mid- and long-term strategic roadmap of R&D&BD to facilitating early commercialization of ocean energy established in 2015, the development of wave and wind power combined with breakwater for support to green energy-independent island program of Korea including ESS (Energy Storage System) and EMS (Energy Management System). As ESS from ocean side, CAES (Compressed Air Energy Storage) combined with breakwater and seawater pumped storage generation using wind and current energy are included.

Ocean energy resources, environmental and economic conditions are different from country to country and site to site. For the economically feasible and environmentally sound development of ocean energy, the exchange of information, technology and knowledge is recommended, especially for the assessment and mitigation of environmental impact and the risk-sharing business model, to overcome some barriers such as financial risk and technological uncertainties.

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**LEEVES & OTHERS**

**Rapid damage mapping – Tropical Cyclone Winston, Fiji**

***John Leeves, Peter Quilter & Bapon Fakhruddin***

*Tonkin + Taylor International Limited, PO Box 5271, Auckland, New Zealand*

*Email: [pquilter@tonkintaylor.co.nz](mailto:pquilter@tonkintaylor.co.nz); [Bfakhruddin@tonkintaylor.co.nz](mailto:Bfakhruddin@tonkintaylor.co.nz)*

Fiji's location in the tropical southwest Pacific Ocean makes it vulnerable to tropical cyclones. Since 1980 a total of 42 TCs have hit the country with more than 300 deaths. The recent TC Winston caused 44 deaths, more than 44 percent population highly impacted and estimated damages of around USD 250 million. The days immediately following a natural disaster are particularly challenging for authorities and aid organisations that need to make decisions relating to deployment and distribution of resources. Rapid Damage Mapping (RDM) is a tool developed by Tonkin + Taylor International Limited (T+TI) whereby integrated disaster mapping information is assembled within the first 24 to 72 hrs of an event. Rapid advances in technology leading to substantially higher resolution data-sets arguably hamper regional scale damage assessment, particularly in counties that lack specialist services to manage this information. The primary objective of RDM is to empower organisations with regional scale mapping information of a resolution appropriate for early coordination and management for disaster response. Key information added to this platform comprised high resolution oblique aerial imagery taken by the New Zealand Defence Force in the days following the cyclone. Regional scale building damage assessment in these photographs was undertaken by data analysts in New Zealand within 7 days of these photographs becoming available. Evacuation centre locations and aid deployment information was also added at the request of aid organisations who were utilising this information. Other information relating to cyclone path, storm tide levels and road closure information were also provided. While the recent RDM response work was largely reactive in nature, the data set compiled during this work provides a valuable resource, presenting opportunities to apply a more proactive and refined approach to similar RDM work in the

future. The recent RDM work provides valuable insight into key vulnerabilities to Tropical Cyclones (TC) for Pacific Island Countries (PICs) throughout the Pacific.

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**LEODORO & BLOOMBERG**

**Preliminary geothermal survey – Vanuatu: Tanna and Ambrym**

***Michel Leodoro & Simon Bloomberg***

*Geology and Mines Unit, Ministry of Lands and Natural Resources, Port Vila, Vanuatu*

*Email: mleodoro@vanuatu.gov.vu*

The high cost and carbon emission of burning imported fossil fuels has inspired Vanuatu to conduct research into its potential alternative energy resources. In this study we describe the results of a preliminary geothermal survey undertaken on the islands of Ambrym and Tanna to classify existing geothermal systems to deduce the potential of geothermal development in Vanuatu. The key question for the survey was to identify whether the existing geological features (particularly hot springs) could confirm the presence of an underground reservoir.

A mixture of quantitative and qualitative observations were undertaken to record and sample the geological features i.e. geological mapping, geothermal water sampling and analysis by the New Zealand Geothermal Analysis Laboratory. Sample waters were analysed for major cations, anions and isotopes. Laboratory analysis of the waters from Ambrym showed the SW springs were closely related to mixed seawaters while the NW springs being more closely related to a mixed bicarbonate water. The results also indicated that no water on Ambrym had boiled during ascent. Laboratory analysis of the waters from SE Tanna indicated that they are either steam fed condensates in acid-sulphate systems or neutral-chloride waters from deep reservoirs. Silica geothermometry indicated that most water boiled at some point while one spring is discharging from a very hot (200°C) aquifer.

The information from the survey illustrates that the hot springs from Ambrym are peripherally heated and that there is not an exploitable hydrothermal reservoir present on Ambrym despite the presence of geothermal activity. On Tanna we find that a high-temperature reservoir is present but a more comprehensive assessment is required to understand the Siwi caldera geothermal system.

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**LEONARD & OTHERS**

**Development of a collaborative consistent volcano communication framework in Vanuatu: hazard maps, education, alert levels, bulletins, signs and procedures**

***Graham Leonard<sup>1</sup>, Esline Garaebiti<sup>2</sup>, Sylvain Todman<sup>2</sup>, Sandrine Cevuard<sup>2</sup>, Shadrack Welegtabit<sup>3</sup>, Gill Jolly<sup>1</sup> & Steve Sherburn<sup>1</sup>***

<sup>1</sup>*GNS Science, Lower Hutt, New Zealand*

<sup>2</sup>*Vanuatu Meteorological and Geo-hazards Department, Port Vila, Vanuatu*

<sup>3</sup>*National Disaster Management Office, Port Vila, Vanuatu*

*Email: g.leonard@gns.cri.nz*

A consistent framework for volcanic hazards communication has been in development since 2012 across the active volcanoes of Vanuatu. This is a collaboration with Vanuatu Meteorological and Geo-hazards Department (VMGD), GNS Science and the National Disaster Management Office (NDMO) and supported by the New Zealand Aid Programme.

A significant part of this is background and safety hazard maps. Background hazard maps cover the myriad of volcanic hazards across each island from a long-term probabilistic perspective. These include safety messages in case an eruption were to suddenly occur, but such maps are intended to be applied in periods without significant new unrest or eruption. Safety maps are scenario-specific and include life-safety messages and access restrictions particular to an imminent or ongoing eruption situation. Safety maps have been developed for ongoing use at the currently active volcanoes on Tanna and Anbrym. Safety maps include danger zones, linked to signage on the ground at the volcanoes. The graphic design of maps, signage and information boards are in development with collaboration from the Vanuatu Red Cross Society.

A new Vanuatu Volcanic Alert Level (VVAL) system has been put in place that includes two unrest levels, three eruption levels, and statements about hazard distance. Volcanic Alert Bulletin (VAB) templates have been developed to link to the mapped danger zones, key safety messages, and new VVAL. Danger zones can be set as 'off-limits' and evacuated in NDMO messages within VABs. New harmonised Standard Operating Procedures are being written at NDMO and VMGD to trigger all of these activities in an event. Tourist safety sheets have been developed incorporating volcano facts, danger zones, signage, VVAL, and where to get the current alerts and danger zone exclusions. Messages need to be consistent with the other hazards too and for Port Vila and Luganville such additional work has recently been conducted (see Heron et al., this volume).

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**LOCO & OTHERS**

**Assessment of water resources in atoll islands**

***Amini Loco<sup>1</sup>, Peter Sinclair<sup>1</sup>, Amit Singh<sup>1</sup> & Martin Mataio<sup>2</sup>***

*<sup>1</sup>Secretariat of the Pacific Community - Geoscience Division, Private Mail Bag, GPO, Suva, Fiji*

*<sup>2</sup>Government of Kiribati*

*Email: aminisital@spc.int*

Water is a scarce resource in atoll islands. Limited rainwater harvesting and small fragile freshwater lenses can result in a shortage of freshwater for communities domestic water needs during extended dry periods. Coupled with these water resources issues is the high prevalence of WASH diseases in these communities. Water resource assessment techniques including geophysics were used for groundwater resource mapping in outer islands providing important information on the development of appropriate options for improved water supply and sanitation in keeping with the socio economic and cultural constraints and preferences of the island communities.

Groundwater is relied upon for the domestic water supply needs of over 90% of all households in Kiribati. The location and extents of freshwater lenses determined using geophysics and other survey techniques allowed for an estimation of the available groundwater resources for development, and an assessment of their potential as a drought-resilient resource.

Recent work in Kiribati indicates that long-term success to implement improved water supply systems in isolated and self-sufficient communities requires a customised approach to engaging the

community to institutionalise water management, operation and maintenance needs. Experience from previous practitioners and recent actions suggests that this should be formalised using existing village social structures and by laws with an appreciation of the socio-economic settings in which the development is to be undertaken.

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LUKOVIC & OTHERS

**Development of *tsunami* evacuation maps, Port Vila and Luganville, Vanuatu**  
(Poster)

***Biljana Lukovic<sup>1</sup>, William Power<sup>1</sup>, Xiaoming Wang<sup>1</sup>, Graham Leonard<sup>1</sup>, David Heron<sup>1</sup>, Esline Garaebiti<sup>2</sup>, Florence Iautu<sup>2</sup>, Morris Harrison<sup>2</sup>, Sandrine Cevuard<sup>2</sup> & Sylvain Todman<sup>2</sup>***

<sup>1</sup>GNS Science, PO Box 30-368, Lower Hutt 5040, New Zealand

<sup>2</sup>Meteorology and Geo-Hazards Department, Vanuatu

Email: b.lukovic@gns.cri.nz

An assessment of the *tsunami* hazard faced by 19 Pacific Island states ranked Vanuatu 6<sup>th</sup> worst (Thomas and Burbridge, 2009). Recent experience in the Indian Ocean (2004) and Japan (2011) has shown the devastating impact of *tsunami* on coastal communities. Early warning systems have proven to be an effective method of reducing risk for distant source *tsunami*, however, local source *tsunami* often have short travel times and arrive before warning systems can be triggered. Community education in self-evacuation, evacuation routes and safe areas is therefore an essential part of a risk reduction strategy.

The Mainstreaming Disaster Risk Reduction Project, funded by the World Bank and being implemented by the Vanuatu Meteorology and Geo- Hazards Department (VMGD) includes the Risk Mapping and Planning for Urban Preparedness Project. The development of *tsunami* evacuation maps is a vital part of the project.

GNS Science undertook numerical modelling of 15 *tsunami*-generating earthquake scenarios for use in hazard assessment and to assist in the development of *tsunami* evacuation zones for Port Vila and Luganville. The zones were developed to match as closely as possible the warnings issued by the Pacific Tsunami Warning Centre (PTWC).

Three zones were developed within a GIS using a rule-based methodology. The Red Zone is based on a 'less than 1 metre' threat level and should be evacuated in a case of such a warning issued by PTWC. The Orange Zone is developed for a '1–3 metre' threat level warning issued by PTWC. The Yellow Zone matches the maximum credible *tsunami* wave amplitude and is designed primarily for use as a self-evacuation zone in the event of a strong or long duration earthquake but should also be evacuated in the case of an official warning by PTWC for an approaching *tsunami* 'greater than 3 metres'.

The developed *tsunami* evacuation zones are being used by the VMGD to produce community evacuation maps. Community consultations are being conducted to share the new hazard information and to use local knowledge for the selection of evacuation routes and sign locations. Sirens and notices will be installed before live exercises are conducted.

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LUNGE & ESPI

### **Trace element geochemistry of chalcopyrites and pyrites from Golpuand Nambonga North porphyry Cu-Au deposits, Wafi-Golpu Mineral District , Papua New Guinea**

***Moira Lunge<sup>1</sup> & Joseph O. Espi<sup>2</sup>***

<sup>1</sup>*Geological Survey Division, Mineral Resources Authority, P O Box 1906, Port Moresby 121, NCD, Papua New Guinea*

<sup>2</sup>*Geoexmin Services, P O Box 412, University 134, NCD, Papua New Guinea*

*Email: mlunge@mra.gov.pg*

Miocene-Pliocene Golpu and Nambonga North porphyry Cu-Au deposits are located 2.5km apart in the Wafi-Golpu mineral district, Papua New Guinea; Golpu has a spatially, temporally and genetically related high sulfidation epithermal Au deposit. Trace element composition of chalcopyrites (Pd, Pt, Au, Zn, As, Se, Mo, Ag, Sb, Te, Pb, Bi) and pyrites (Pd, Pt, Au, Cu, Zn, As, Se, Mo, Ag, Sb, Te, Pb, Bi) from these deposits obtained using laser ablation-inductively plasma mass spectrometry are presented here.

The Golpu pyrite (WR331, 1214.20m) associated with potassic alteration have high Au (23,700 ppb) and Cu (1216 ppm). Similarly, the phyllic alteration pyrites (WR327A, 756.40 m) have high Au (4,910 ppb) associated with high Cu (7,625 ppm) and As (1,281 ppm). The Golpu pyrites deposited by high sulfidation fluids (WR351, 957.00 m) localizes high Au (1,020 ppb) and As (1325 ppm). High Au (143,000 ppb) from Nambonga North pyrites (WR272, 294.00 m) is associated with the phyllic alteration. A negative correlation of As, Bi and Zn with high Au is displayed by the pyrites (WR272, 396.00 m).

The Golpu chalcopyrites (WR331, 1214.20 m) deposited during potassic alteration have low Au. High Au (up to 1,400 ppb) deposited by pyrite (WR342, 710 m) during the phyllic alteration and is associated with slightly elevated As, Ag, Sb, Te and Bi. No clear relationship of the trace elements is shown in chalcopyrites analyzed from Nambonga North.

Potassic alteration pyrites at Golpu host high contents of Cu and Au. At both deposits, Cu and Au deposited during potassic alteration were remobilised and redeposited as part of the phyllic (and chlorite-sericite) alteration stages. At Golpu, a second event of remobilization and redeposition was implemented by high sulphidation epithermal mineralization.

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MARTIN & OTHERS

### **Assessing soil quality with a systematic geochemical baseline survey: a New Zealand example applicable to the Pacific Islands**

***Martin, A. P.<sup>1</sup>, Heron, D. W.<sup>2</sup>, Turnbull, R.E.<sup>1</sup> & Mortimer, N.<sup>1</sup>***

<sup>1</sup>*GNS Science, Private Bag 1930, Dunedin, New Zealand*

<sup>2</sup>*GNS Science, PO Box 30368, Lower Hutt, New Zealand*

*Email: n.mortimer@gns.cri.nz*

Soil records natural and anthropogenic inputs from proximal and distal sources. Geochemical analysis of soils is a straightforward and low cost method of assessing soil composition and quality. Systematic, grid-based geochemical baseline surveys are now the gold standard method to measure

the background state of soil quality, at local to continental-scales, and provide an essential dataset for informing governmental, environmental, human health, agricultural, forestry and mineral exploration sectors. New Zealand has completed its first regional study over the south of its South Island, collecting soil from two depths (0-30 cm and 50-70 cm) on an 8 km grid at 348 sites, and analysing them for a variety of chemical, isotopic and physical properties. Significant chemical (e.g. Si, La, Fe) and isotopic (Sr, C, N, S) variation in the soil samples can be linked to variations in source geology, soil type, climate and topography. Some relatively high element concentrations (e.g. S, P, Pb, Hg, Cd) are attributed to anthropogenic sources such as fertilizers, paints, vehicle emissions or industrial emissions. Other elevated element concentrations are natural, with high As, Bi, Sb and W reflecting proximity to gold mineralisation, and elevated Platinum and Rhenium near inferred platinum-related mineralisation. In the Pacific, systematic soil surveying would provide soil quality baselines to inform environmental regulatory decisions and government planning. The surveys also provide source region information that is vital in 'source-to-sink' models for groundwater and tracing agricultural runoff. Regional and national-scale systematic soil surveys can also encourage mineral exploration investment. We suggest that the regional geochemical survey model used in New Zealand is also suitable for the Pacific Islands and will yield valuable information for a variety of purposes.

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McCONNELL & OTHERS

### **Seafloor mapping for seafloor mineral exploration – technical overlap with approaches used in wide area high resolution search and large area cold seep mapping**

***Dan McConnell, Jamshid (Jim) Gharib & Paul Kennedy***

*Fugro GeoConsulting, Inc., 6100 Hillcroft Ave., Houston, TX, USA*

*Email: dmccconnell@fugro.com*

Identification of potential economic mineral deposits and investment in offshore mining concepts and processes is currently active and developing. As feasibility continues to improve, the exploration for economic deposits of abyssal metallic precipitates and massive sulfides associated with the earth's plate boundaries and will rapidly accelerate.

Techniques employed in searches for man-made objects, shipwrecks, aircraft, etc, across wide areas in abyssal depths have critical common elements applicable to seafloor mineral explorations including:

- Daily integrated missions of coordinated Autonomous Underwater Vehicle (AUV) and deep-tow operations
- Daily transfer of large volumes of raw seafloor mapping data for shore-based processing, analysis centers and client QC
- Accurate subsea navigation
- Efficient contact re-acquisition for cm resolution mapping

Also complementary and directly applicable to marine mineral exploration are the techniques used to identify deep water cold seeps for oil and gas exploration, including several projects covering areas over 500,000 sq. km. These techniques include:

- Detection, sampling, and analysis of water column anomalies, both physical and chemical

- Identification of seafloor geomorphology from multibeam echosounders, deep imaging seismic, high resolution seismic, and AUV/ROV visual and photomosaic
- Calibration and interpretation of high-quality quantitative backscatter to interpret seabed character (hardness, rugosity, etc.)
- Sampling and real-time analysis through using geochemical laboratories on the vessels

Survey design elements and geochemical sampling protocols are adapted for scientific characterization, fine scale detection, and calibration of hydrothermal systems for seafloor mineral exploration and delineation. Efficient scientific exploration will be critical to the establishment of a seafloor mineral exploration industry in the first half of the 21<sup>st</sup> century.

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**McMURTRY & OTHERS**

**Development of a field-portable helium isotope detector for continuous monitoring of large earthquakes and volcanic unrest (Poster)**

**Gary M. McMurtry<sup>1</sup>, James R. Deluze<sup>2</sup>, David R. Hilton<sup>3</sup> & James E. Blessing<sup>4</sup>**

<sup>1</sup>SOEST, University of Hawaii, Honolulu, Hawaii 96822 USA

<sup>2</sup>Fusion Energy Solutions of Hawaii, 611 University Avenue, Apt. 301, Honolulu, HI 96826 USA

<sup>3</sup>Scripps Institution of Oceanography, Univ. of California, San Diego, California 92037 USA

<sup>4</sup>MKS Instruments, Inc., San Jose, California 95134 USA

Emails: mcmurtry@hawaii.edu; jrdeluze@icloud.com; drhilton@ucsd.edu; James\_Blessing@mksinst.com

The <sup>3</sup>He/<sup>4</sup>He ratio in volcanic emissions and dissolved gas in groundwater is often co-seismic with, and sometimes precursory to, volcanic unrest and earthquake activity. Because of the extremely low abundance of primordial <sup>3</sup>He to radiogenic <sup>4</sup>He, and difficulties in resolving <sup>3</sup>He in the presence of hydrogen isobars such as HD, the measurement of this ratio has so far been confined to the laboratory. A field-portable He isotope instrument must overcome these analytical hurdles and be small, compact, lightweight and low enough in power consumption to deploy in critical locations. We use two compact mass spectrometers, an MKS ion trap and a frequency-modified quadrupole MS, with a full-range pressure gauge and waste pumps based upon noble diode ion or turbo-rough pumping. These are coupled to a high-purity quartz glass port that is heated under high vacuum. Gas samples can be separated from waters or directly analyzed by pumped circulation through a sample chamber. We monitor vacuum quality with the ion trap and use the quadrupole MS to obtain sensitive determination of hydrogen and helium isotopes. Two methods of isobaric separation are utilized: a statistical mass-2 vs. mass-3 regression intercept, and an adjusted (threshold) ionization mass spectrometry (AIMS) technique. Comparison of these two independent methods for 44 data pairs in a "blind collection" after heat ramps to a predetermined maximum temperature are complete yields a significant correlation ( $r = 0.89$ ). Results on laboratory air are within a factor of 2 of the accepted ratio of  $1.40 \times 10^{-6}$  (R<sub>a</sub>). We can obtain the exact air ratio ( $R/R_a = 1.0$ ) if we continuously monitor the MS scans during the heat ramps, allowing for differences in the diffusion rates of <sup>3</sup>He and <sup>4</sup>He. With an established power level, keeping to a constant scan time allows air <sup>3</sup>He/<sup>4</sup>He ratios to be obtained to within 0.1 R/R<sub>a</sub>.

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**Towards *in situ* monitoring of submarine gas hydrate fields with the Deep-Ocean Mass Spectrometer (DOMS)**

***Gary M. McMurtry<sup>1</sup>, Luis A. DaSilveira<sup>2</sup>, James A. Jolly<sup>1</sup> & Jong-Hwa Chun<sup>3</sup>***

<sup>1</sup>*School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, Hawaii USA*

<sup>2</sup>*Microbiology Department, University of Hawaii, Honolulu, Hawaii USA*

<sup>3</sup>*Petroleum and Marine Resources Division, KIGAM, Daejeon, Republic of Korea*

*Email: mcmurtry@hawaii.edu*

In an ongoing collaboration with KIGAM to monitor effluent in potential seafloor mining areas within the Ulleung Basin, we are calibrating and test-deploying the Deep-Ocean Mass Spectrometer developed by Pacific Environmental Technologies, LLC (PTH). DOMS is a compact mass spectrometer-based instrument for multi-species determination of dissolved gases and volatile organic compounds which can operate autonomously, semi-autonomously or manually in water depths ranging to >4000 m. Detectable dissolved gases include: H<sub>2</sub>, He, N<sub>2</sub>, O<sub>2</sub>, Ar, NO, N<sub>2</sub>O, CO, CO<sub>2</sub>, H<sub>2</sub>S, and CH<sub>4</sub>; detectable volatile organic compounds include chloroform, toluene, benzene, chlorobenzene, dimethyl sulfide, etc. DOMS uses polydimethylsiloxane (PDMS)-based membrane inlet mass spectrometry (MIMS) technology proven to 6500 m water depth equivalent pressure and patented by PTH. A laboratory-based dissolved gas calibration apparatus for the DOMS was designed. We tested two-component dissolved gas mixtures, using CH<sub>4</sub> or CO<sub>2</sub> as the target gas and nitrogen as the diluent gas, and up to four more pure gases can be simultaneously mixed in this manner, each with an independent mass flow controller.

Alternatively, a premixed multiple-gas standard can be used. Results at lab temperature and pressure were highly linear and suggested a minimum detection limit of 5 ppb for dissolved CH<sub>4</sub>; and of 2 ppm for dissolved CO<sub>2</sub>. Dives in 2014 with the KIGAM KISOS sled were cut short by an electrical fault, but we obtained a surface time series of dissolved CH<sub>4</sub> that suggested the water flow rate over the MIMS as well as water temperature were important to the detection sensitivity of the instrument, with higher flow rates and colder temperature increasing sensitivity. These results and plans for future instrument improvements, calibrations and deployments will be presented, including new post-processing software developed for the data torrent recorded from the MKS ART mass spectrometer and associated temperature, vacuum pressure and flow rate sensors.

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**MORTIMER**

**Zealandia: the SW Pacific's hidden continent**

***Nick Mortimer***

*GNS Science, Private Bag 1930, Dunedin, New Zealand*

*Email: n.mortimer@gns.cri.nz*

Continents are Earth's largest and most visible solid objects. Geologically they number six: Africa, Eurasia, North America, South America, Antarctica and Australia. It may seem unusual or impossible that a seventh geological continent can be discovered or proposed. But a large body of marine geoscientific evidence points to just that – the presence of the 4.9 Mkm<sup>2</sup> continent of Zealandia in the SW Pacific Ocean. The continental nature of the crust in the New Zealand-New Caledonia region has been known for some decades. But in the last 20 years, the case has been building that Zealandia meets the geological criteria of a true continent, not a continental ribbon, fragment or microcontinent. The defining elements of Zealandia are its large area, elevated bathymetry relative to oceanic crust, diverse geology, appropriate continental crustal structure, and tectonic separation

from Australia. Formerly Zealandia was part of the Gondwana supercontinent. Today it is 94% submerged. It is the broad submerged continental shelves around New Zealand and New Caledonia that have, until recently, literally kept Zealandia hidden from the geological and wider scientific community.

Identifying Zealandia as a continent rather than a collection of continental fragments and ribbons more correctly represents the geology of this part of the SW Pacific Ocean. It is possible (but yet unproven) that a piece of Zealandia may underlie Fiji. Zealandia provides a fresh context for understanding and explaining many aspects of SW Pacific natural science, including biogeography, tectonics, natural hazards and onland and offshore sedimentary basins and resources.

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PARK & HEO

### **Development of an operational oceanographic system for coastal disaster reduction**

***Kwang-Soon Park & Ki-Young Heo***

*Korea Institute of Ocean Science and Technology, Ansan, 1562, Republic of Korea*

*Email: kspark@kiost.ac; kyheo21@kiost.ac*

The operational ocean forecasting system is necessary to reduce ocean related disasters such as storm surges, abnormal waves, search and rescue, and oil spill which cause tremendous damages by timely providing useful ocean information, for initial countermeasures. It is also a powerful tool to manage the ocean territory and to understand ocean for protection and preservation for ocean environment as well as it will provide social-economic benefits.

KIOST(Korea Institute of Ocean Science and Technology) has been developing the Operational Ocean/Coastal Forecasting System in Korea (KOOS) since August 2009. KOOS is sustained, routine, user-driven and end-to-end system. The main purpose of KOOS program is developing and operating operational forecasting system for the Korean waters to solve various problems, coastal disasters, marine pollution, safe navigation and to provide necessary information of sea states and prediction for governments, industries and the public.

There are an operational high-resolution ocean weather forecasting system and ocean model input data production systems, operational coastal sea state forecasting systems (wave, tide, tidal current, storm surge, wind-driven current), operational 3D regional ocean circulation forecasting systems, operational application systems (SAR, oil spill, Integrated maritime prediction system), Operational Ocean Data Management System based on GIS in KOOS

With observing networks, various atmospheric models and ocean models have been set up and tested. Operational oceanographic system enables us to forecast tides, waves, storm surges, 3D-currents as well as temperature and salinity for 72-hour time period in two times a day. The performance of numerical models is evaluated by the skill assessment system. All ocean information in KOOS is controlled by data management system and is presented via web-based GIS. We expect KOOS will be able to contribute to developing the operational forecasting system in the SPC area.

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## PARK & OTHERS

### Ocean prediction and marine resources

***Young-Gyu Park, Young Ho Kim & Hanna Na***

*Korea Institute of Ocean Science and Technology, Ansan, Republic of Korea*

*Email: ypark@kiost.ac.kr*

Upper sea water temperature is one of the important parameters governing ocean eco system and prediction on ocean temperature could be used in managing diverse ocean resources. One of such would be the coral beach warning made by NOAA (<http://coralreefwatch.noaa.gov/satellite/baa.php>). Another example would be salmon forecast made by the Northwest Fisheries Science Center, NOAA. The dominant phenomena governing upper sea water temperature in North and equatorial Pacific are the PDO (Pacific Decadal Oscillation), which was discovered while investigating changes in salmon production, and El Nino. There are quite a few organizations that have been forecasting the ocean globally or regionally using numerical models and observations, and predicting PDO or El Nino. These forecast and hindcast (reconstruction of past state) data are freely available to the public. Although marine resources would not solely depend on water temperature, one could try to relate them to temperature in spatial or temporal domain. Ocean color from satellites is another data set one could utilize. Here we review various ocean data products and then demonstrate how oceanographic data could be used in evaluating fishery statistics. Our research for global ocean prediction and El Nino will be also introduced.

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## PEARSON & SMILLIE

### Datum modernization in the Pacific Island developing states: key infrastructure for sustainable development and disaster risk reduction (Poster)

***Chris Pearson<sup>1</sup> & Robert Smillie<sup>2</sup>***

<sup>1</sup> *School of Surveying, University of Otago, Dunedin*

<sup>2</sup> *GNS Science, PO Box 30-368, Lower Hutt, New Zealand*

*Email: R.Smillie@gns.cri.nz*

A national geodetic datum defines the official coordinate system used within a country and it provides the framework so that critically important data sets such as land ownership, land use, elevation and infrastructure to be combined. Most of the Small Island Developing States still use colonial era datums developed before advent of GPS. These datums have three key deficiencies that make it hard to use modern GNSS technology to its full potential. First the datums are static which means that plate motion and tectonic deformation are ignored which over time produce distortions (of up to several m) in the coordinate system. Secondly the relationship between the local datum and international datums used by GPS (ITRF and WGS84) may not be well defined. Thirdly the relationship between the ellipsoid (which is the basis of GPS heights) and the geoid (which is the basis of sea level heights) is usually not known to any precision. In contrast modern datums are defined relative to global coordinate systems, they minimize distortions associated with plate tectonics by containing an explicit model of deformation and increasingly they contain a highly precise model of the difference between the ellipsoid and the geoid.

Modern geodetic datums represent critical infrastructure which allow countries to mitigate and recover from natural disasters. For example developing disaster preparedness and management

plans for flooding storm surges or *tsunami* requires that emergency responders have accurate inundation maps to identify areas at risk and allow emergency responders to direct vulnerable populations to safety. This, in turn, requires highly accurate elevation models be combined with GPS surveys of road and levy elevations. Geodetic datums provide the essential framework that allows these surveys to be conducted and combined.

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PRASAD

## **SPC-EU Environmentally Safe Aggregate for Tarawa (ESAT) Project overview** (Poster)

### ***Christine Prasad***

*Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*  
Email: [christinep@spc.int](mailto:christinep@spc.int)

The Environmentally Safe Aggregate for Tarawa (ESAT) Project is designed to protect the fragile beaches of South Tarawa in Kiribati from damage caused by unsustainable sand and gravel (aggregate) mining. Coastal erosion increases the risk of flooding, wave over topping that compromise communities and infrastructure in an environment already under threat from climate change impacts which compound the development and economic issues faced by Tarawa local council and government entities. The Project is funded by the European Union and jointly implemented by the Pacific Community (SPC) Geoscience Division and the Government of Kiribati. It aims to provide an alternative supply of construction aggregate from the lagoon basin to meet South Tarawa's rapidly growing demand for aggregates while also reducing pressure on traditional source, the beach.

The Key Achievements of this Project are:

- The dredge ship, MV Tekimarawa: 40-m steel, open-water vessel with a shallow draft for lagoon work and a total payload of 300 tonnes.
- Te Atinimarawa Co. Ltd (TACL), a state-owned enterprise established in 2013 whereby the Government of Kiribati assists and oversees the monitoring of the dredging of sand and gravel.
- The implementation of the Environmental Management Plan.
- Capacity building within relevant Government Ministries and TACL personnel.
- Implementation of educational awareness and behavior change programmes ( for instance the Sand Watch Programme in schools)

The EU-supported ESAT Project ends in December 2016 but will continue as a state owned enterprise under the trading name of TACL who will be responsible for the activities of dredging through the assistance of Government of Kiribati.



**Figure 1:** The single largest budget item in ESAT Project is the MV Tekimarawa

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**RAM & OTHERS**

**Characteristics of slope failures induced by Tropical Cyclone Winston (20-21 Feb, 2016) along King's Road, northern Viti Levu, Fiji Islands (Poster)**

**Arishma R. Ram, Shane J. Cronin & Martin Brook**

*School of Environment, University of Auckland, Auckland, New Zealand*

*Email: aram836@aucklanduni.ac.nz*

Slope failures and soil slips are caused by a number of natural and anthropogenic factors, but the main factors predisposing the stability of a slope are its geology, geometry (aspect and slope), (pore)-water conditions and drainage properties, vegetation cover along with any human modification. Many Pacific region countries in humid tropical environments are highly susceptible to slope failures due to their young geological age, steep terrain, high earthquake and volcanic potential. These factors are compounded by high rainfall magnitudes and intensities, especially during tropical cyclones, often in areas of continual and often unregulated urban and rural development.

Although tectonically and volcanically relatively stable compared to many of its neighbours, Fiji is particularly susceptible to numerous and damaging landslides exacerbated by loss of forest vegetation and rapid rates of road and other urban development. Slope failures resulting from tropical cyclones have caused a high number of fatalities and great damage on or near Fiji's roads in the past, particularly for the King's Road, one of the two major highway's spanning Fiji's largest island, Viti Levu. Tropical Cyclone (TC) Winston was one of the strongest cyclones to ever cross the southern hemisphere, battering the Fiji group from the early hours of 20 February until 3 am, 21 February, 2016, with wind gusts of up to 306 km/hr. Fiji's National Disaster Management Office estimated damage at \$476.3M (a preliminary estimate), with the highest individual figure of \$13M reported by the Fiji Roads Authority. Of the road-related costs approximately 30% relates to restoration related to slope failures.

A rapid field reconnaissance study examined the characteristics and possible failure mechanisms of selected slope failures induced by TC Winston along a 30 km stretch of the King's Road between Barotu and Wailevu villages in northeast Viti Levu. Approximately 30 distinctive shallow, small-scale

failures were identified most of which were debris-slides (both rotational and translational). Some of these were deep enough to entrain bedrock, while other failures included a minor flow component. Evidence of recurring slips along Fiji's King's Road indicates a need for new engineering solutions to resolve slope failure issues close to infrastructure. It is hoped that further research developing from this preliminary study will be able aid Fiji authorities to identify areas of greatest vulnerability for slope failure and recommend long-term solutions managing slope stability hazard.

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RONGO

**Using local knowledge to understand climate variability and climate change in the Cook Islands**

***Teina Rongo***

*Office of the Prime Minister, PO Box 881, Avarua, Rarotonga, Cook Islands  
Email: teina.rongo@cookislands.gov.ck*

Climate change has been the topic of much research in the last few decades, however information on its impacts — particularly on remote small island nations — remain scant. Yet, through centuries of observation of their natural environment, Pacific islanders hold a wealth of knowledge of the sky, land, and sea. Sadly, with a shift towards a more western lifestyle on some of these islands in recent decades, this local knowledge is at risk of being lost because it is not passed down to younger generations. The aim of this study was to collect information on changes in various biological and physical systems over people's lifetimes to understand the impact of climate variability and human induced climate change in the Cook Islands.

While causal factors for some changes recorded seem complex and difficult to explain, a large number of changes seemingly coincided with hydroclimatic shifts associated with the well-documented phase shift of the Inter-decadal Pacific Oscillation/Pacific Decadal Oscillation (IPO/PDO) in 1976/77. This shift coincided largely with the loss or the decline of many important floral and faunal species on the islands. Some changes recorded may support the well-documented global sea level rise, such as the loss of salt crystals on reef flats and shorter low tide durations. The decline in pelagic fish stocks noted throughout the Cook Islands is also concerning, and managers need to take these observations seriously considering the lack of historical information on these fisheries in the Cook Islands, and offshore commercial pelagic fishing activities are expected to increase in the future. We note that the information collected in this survey will be useful in developing strategies for infrastructure and resource management, and could provide the basis for future research in the Cook Islands.

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ROSSER & DELLOW

## **Landslide mapping and hazard assessment in New Zealand**

***Brenda Rosser & Sally Dellow***

*GNS Science, PO Box 30368, Lower Hutt 2014, New Zealand*

*Email: [b.rosser@gns.cri.nz](mailto:b.rosser@gns.cri.nz)*

In New Zealand, landslides occur frequently, but because of the relatively low population density, especially in the hilly and mountainous terrain where landslides occur, there are relatively few deaths. However, the national annual cost associated with landslides is estimated to be at least \$250 – \$300 M/yr. To understand the hazard and risk posed by landslides to society, knowledge of where, when and why landslides occur is vital.

Landslide inventories provide the basis for predictive landslide hazard and susceptibility assessments, which then form the basis for risk based assessments. The quality and accuracy of assessments are directly related to the quality of the underpinning data, including length, quality and nature of the record. In New Zealand, landslide datasets and their analysis has improved as the scale of the problem of rainfall-induced landslides, including both the magnitude and the frequency has become better understood. Information on landslides is collected after major storm or earthquake events as part of geohazards monitoring through the GeoNet project, and stored in a National Landslide Database. Data are collected by a variety of techniques, depending on the event scale, and resources available.

We discuss the importance of capturing timely data on landslide events (and their associated triggers), some of the emerging techniques used to capture and analyse data, and provide recent examples of how data are used.

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SEO

## **Reclamation and channel dredging of the Korea South Pacific Ocean Research Center, Chuuk**

***Seung-Nam Seo***

*Coastal Engineering Division, Korea Institute of Ocean Science and Technology, Ansan, 426-744, Seoul, South Korea*

*Email: [snseo@kiost.ac.kr](mailto:snseo@kiost.ac.kr)*

To enhance the research capabilities of the Korea South Pacific Ocean Research Center (KSORC) in the South Pacific region, the Korea Institute of Ocean Science and Technology (KIOST) completed a land reclamation project last year covering an area of 9,900 m<sup>2</sup> and using coral sands dredged from a nearby navigation channel. The landfill materials were protected by a 350-m-long interlocking concrete-block revetment. As toe scouring of the revetment has progressed, this year KIOST has begun to investigate the problem - including wave forces, tidal and wave-induced currents, and stability of the toe protection - and reinforce the toe protection. To achieve the overall goal of integrated coastal management adopted by Pacific Island countries, we also consider the detrimental effects of shore protection structures on adjacent areas in the light of local physical and biological processes.

KIOST wants to share our experiences and ideas with Pacific Island Country for ecologically sustainable development and conservation of coastal areas. We also extend our responsibilities to provide coastal environmental information for the South Pacific and conduct bathymetric and geophysical surveys of the coastal area around KSORC. To obtain wave and current profile data, a Nortec AWAC will be deployed this spring. For navigation channel dredging, we plan to use the remotely controlled underwater Poclair excavator recently developed by the KIOST.

For re-examination of the revetment structure design criteria, various numerical models are applied: the WRF model for wind data, SWAN model for design wave computation, MOHID model for tide and coastal circulation and FUNWAVE model for nonlinear wave and wave-induced currents. Our effort will be ongoing to enhance our understanding of the physical processes in the South Pacific Islands and strengthen cooperation with regional officials and experts.

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SHERBURN & OTHERS

**Managing a volcanic eruption in a small island country: lessons from the 2014-15 eruption of Hunga Tonga – Hunga Ha'apai in the Kingdom of Tonga**

***Steven Sherburn<sup>1</sup>, Taaniela Kula<sup>2</sup>, Leveni Aho<sup>3</sup>, Moleni Tu'uholoaki<sup>4</sup> & Kyle Lee<sup>5</sup>***

*<sup>1</sup>GNS Science, Private Bag 2000, Taupo 3352, New Zealand*

*Email: s.sherburn@gns.cri.nz*

*<sup>2</sup>Ministry of Lands & Natural Resources, Tonga*

*<sup>3</sup>National Emergency Management Office, Tonga*

*<sup>4</sup>Metoffice, Tonga*

*<sup>5</sup>Metservice, New Zealand*

A submarine volcanic eruption near the islands of Hunga-Tonga and Hunga Ha'apai, in the Kingdom of Tonga, emerged from the sea in late-December 2014. During a month-long eruption, an island was built approximately 2 km x 1 km in area and 120 – 140 m in height.

Based on the distance from Hunga-Tonga and Hunga Ha'apai to inhabited islands, Tongan authorities correctly forecast minimal direct impact on people. However, in the second half of the eruption, information on the height of eruption plumes and the ash content received by the Wellington Volcanic Ash Advisory Centre (VAAC) gave models that predicted ash over Fua'amotu International Airport in Tonga. This caused the cancellation of some domestic and international flights. The information provided to the VAAC was not always accurate, and, in hindsight, the cancellation of these flights may have been prevented if better observations had been available.

We will discuss what worked well in the eruption response, and what did not work so well, and we will describe specific actions taken to address shortcomings that were identified. We will also discuss lessons that were learned from the eruption response that may be able to be applied to other small island and developing countries in a similar situation.

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SIMONS & OTHERS

**Drivers of variation in hazards at a persistently active volcano, Yasur, Vanuatu**  
(Poster)

***Benjamin Simons<sup>1</sup>, Shane Cronin<sup>1</sup>, Jennifer Eccles<sup>1</sup>, Esline Garaebiti<sup>2</sup> & Morris Harrison<sup>2</sup>***

*<sup>1</sup>School of Environment, University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*

*<sup>2</sup>Vanuatu Meteorology and Geohazards Department, PMB 9054, Port Vila, Vanuatu*

*Email: s.cronin@auckland.ac.nz*

Yasur volcano has existed for at least 800 years and is remarkable in producing ongoing, regular small Strombolian-Vulcanian explosions from several summit vents. Whilst small on a global scale, the spectacular explosions can change suddenly to endanger lives of tourists and guides that visit its crater rim on a daily basis. Yasur is globally rare in being a persistently active volcano, with sustained eruptions over centuries and millennia, and displaying uniform geochemistry over time.

The processes that sustain such regular scales, types and compositions of volcanism over such long timescales are poorly understood. Furthermore, the regularity of Yasur's eruptions is often mistaken to provide a false degree of safety for visitors. Sudden changes, even minor ones, may send explosive ballistics at low angles or farther than their normal range. It is these small-scale variations from the regular eruption processes that are deadly, and understanding the processes that precede them is the focus of our research. The deep internal dynamics of volcanoes like Yasur are typically investigated using geochemistry of eruption products, while shallow-level processes are examined using geophysical techniques along with gas measurements. In this work, we will bring together these diverse sets of information to build a unified model of the factors that control eruptive/explosive vigor and consequent hazard. Many researchers at Yasur have applied a range of techniques to measure volcanism over short periods (hours to days), but few have spent longer times, attempting to understand the variability of activity and the consequences this has for hazard. Understanding this variability may also provide us new insights into how persistently active volcanic systems function. After our preliminary 2-week study, we plan to gather observations over a 3-month period with the aim of quantifying the short (seconds to hours) and longer (days to months) term variability in explosivity, gas and magma output at Yasur.

Results will be used to identify both internal (magma-driven) as well as external (e.g. environmental) processes that affect eruption behaviour. Successful outcomes of this research will lead to a better understanding of time-varying hazard at Yasur as well as new hazard-monitoring strategies that could be applicable to steady-state volcanoes worldwide.

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SINCLAIR & GALVIS-RODRIGUEZ

**Sustainability of freshwater lenses in atoll environments**

***Peter Sinclair & Sandra C. Galvis-Rodriguez***

*Geoscience Division, Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: peters2@spc.int*

Groundwater is often the most reliable and important source of freshwater found in atolls. The characteristically low lying and narrow ribbon like atoll islands found within the Pacific are often

classified as Small Island Developing States, where the average Gross Domestic Product per capita is less than 3,000 USD.

Traditional operation and management of a groundwater resource in atolls, is based on a constant abstraction within a calculated sustainable yield. This approach may require reconsideration, as it can be too conservative and restrictive in cases where the demands on the freshwater lens are intensifying from increasing population pressures, and more frequent extremes in rainfall.

In a recent study of the Bonriki freshwater lens (Kiribati), 3D numerical modeling has been successfully used to provide insight on specific threats to the lens, such as the impact of sea-level rise, land use, and optimized abstraction. The results from this modeling also allow greater insight into management options available to maximize the access to the limited freshwater for the more than 50,000 residents of South Tarawa. Other island communities rely on far more rudimentary approaches in the management of their freshwater resources.

It is suggested that operation and management of freshwater lenses in atolls would benefit by considering the use of a dynamic abstraction approach to better reflect the temporal variations in the freshwater lens thickness and extent, rather than relying on an annual and constant abstraction based on a calculated long-term sustainable yield for the aquifer.

A dynamic abstraction approach for freshwater lenses concerns itself with the available freshwater being provided to the community at any specific point in time rather than managing abstraction based on a long term sustainable yield and the thickness of the freshwater lens alone. During dry periods, the freshwater lens will thin and salinity may increase at some wells or galleries with the resulting need to reduce abstraction. Returning rains and recharge will result in recovery of the lens, allowing a quicker return to optimal abstraction than what may be suggested by monitoring bores alone or other surrogate indicators such as calculated residence time.

This approach focuses on determining an available abstraction based on the water quality at the galleries to maximize abstraction which is more in keeping with the dynamic nature of the freshwater lens. Variable pump scheduling and daily salinity monitoring at abstraction points is required to operate a groundwater lens in such a way, and its operation is likely to be improved through a combination of numerical modeling rainfall trends, and regular observations of salinities from both galleries and monitoring boreholes.

A dynamic abstraction approach is necessarily prescriptive, and utilises information sources which are currently available and regularly monitored. Furthermore, the concept of "sustainability" is developed through operational practices that are already in use and accepted by government and community alike, thereby strengthening the ability of local managers to understand and control the risks associated with failure of key freshwater supplies. The approach prescribes specific actions for reducing or increasing abstraction based on monitoring information, which is compared to trigger levels (e.g. water levels, salinities, changes in recharge, and the occurrence of overtopping events) that signify critical changes in the lens condition. In this way, the approach assists resource operators and managers alike to realize their responsibilities for achieving sustainable groundwater extraction, and establishing protocols to maintain vigilance in the assessment of groundwater conditions in trends to avoid detrimental impacts to the resource and the communities that rely upon it.

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SINGH

## **Provisioning spatial data infrastructure within Pacific island countries**

### ***Sachindra Singh***

*Geoscience Division, Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: sachindras@spc.int*

The term "Spatial Data Infrastructure" (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of, and access to, spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general. In short it is any inter-connected set of systems, tools and processes that enables easy management, exposure and analysis of information across all spatial data themes.

Pacific SDI has the potential to be a suitable driver to derive economic benefits for member countries by leveraging collective intelligence and data across ministries and regional agencies, and additionally empowers stakeholders to make sound decision within a spatial context.

Geoscience Division of SPC has implemented and provides ongoing technical support, enhancements and capacity building to large-scale regional SDI deployments such as PacGeo and Pacific Risk Information System. They are built to act as the authoritative open access geospatial data repository for the Pacific Region – providing premier geophysical, geohazard, geodetic, baseline infrastructure and marine spatial data.

The regional deployments are hosted in the cloud to counter redundancy, backup and disaster recovery issues, as well as countering sub-optimal hosting bandwidth in SPC. Additionally cloud-hosting enables multiple stakeholders' remote management, and thereby promotes data ownership.

Many member countries do not have optimal bandwidth and technical capacity to utilise and maintain the services provided by the regional SDIs, in particular consuming datasets using OGC web services. Hence, it is imperative that localised instances be deployed within member countries as a government-side service facilitates faster and easier access to their country's data holdings and information products.

Geoscience division has implemented such services, and provided relevant capacity building via workshops and trainings to a number of countries, and will eventually target additional countries, depending on funding availability.

Geoscience Division undertakes the deployment of the SDI services with the assistance (in terms of funding, human resources and technical support) of a wide range of partner agencies. This working arrangement has been formalised as the Pacific Spatial Data Information Working Group (Pacific SDI WG) and currently comprises SPC, Geoscience Australia, CSIRO, SPREP, GIZ, IUCN, and the Pacific Islands Forum Secretariat.

The SDI working group actively contributes to:

- Deployment and support of country-specific SDI, along with contributing developers and resources to enhance and evolve SDI platforms in the region.
- Formalize regional capacity building in the way of collaborating on online course materials for QGIS and PacGeo, and generating specialised manuals.

- Work towards a CROP-wide data sharing agreement, and provide advocacy to country leaders to adopt it across the region.
- Work towards adopting and fine-tuning international spatial data standards and protocols suitable for a large geographically dispersed, ocean surrounded region such as the Pacific.

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SMILLIE & OTHERS

**The role of geological mapping and innovative GIS applications for identifying natural resources potential: the New Zealand QMAP experience**

***Robert Smillie, Simon Cox, David Heron & Mark Rattenbury***

*GNS Science, PO Box 30-368, Lower Hutt, New Zealand*

*Email: r.smillie@gns.cri.nz*

The Pacific region is host to many on-shore world-class mineral deposits which contribute significantly to the economic prosperity in the region. While deep-sea exploration is on the rise, responsible development of on-shore mineral deposits will continue to be an important driver of economic growth for years to come.

In an increasingly global and data-rich world, companies have many countries from which to choose from when deciding where to spend their limited exploration dollar. Jurisdictions wishing to promote investment in mineral exploration have many mechanisms at hand, including regulatory and policy frameworks. However, enhancing perceptions of mineral prospectivity through the provision and marketing of pre-competitive geoscientific information is one of the best strategies for attracting new mineral investment. A key component of this information is high-quality geological mapping in a geographic information system (GIS) format. Exploration companies consider availability of geological maps to be a key aspect when evaluating countries for mineral investment.

The 1:250,000 QMAP Geological Map of New Zealand built by GNS Science (formerly the New Zealand Geological Survey) utilised an ArcInfo® GIS. Mapping undertaken at 1:50,000 scale involved fieldwork in some of the most rugged and harsh conditions found anywhere in the Pacific. Digital versions of the individual QMAPs have been stitched into a single "seamless" national GIS dataset, the 2014 Geological Map of New Zealand 1:250,000.

There is increasing demand to use and improve the QMAP data for resources and natural hazards applications in New Zealand. To meet these challenges, innovative, derivative GIS spatial products including predictive mineral, groundwater, & natural hazard maps have been developed by GNS Science. The predictive mineral maps were highly successful in attracting international investment, as well as assisting regulators in minerals policy development. By 2017 New Zealand will have a third of its land area covered by high quality, publicly available aeromagnetic datasets, also highly valued by resources exploration companies. GIS-based geological QMAP map data will be essential for thorough informed analysis of the geophysical data.

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SMITH

## **Atoll reclamation a solution to pressing problems of land scarcity, water lens vulnerability sea level rise and climate change**

***Robert Smith***

*Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: roberts@spc.int*

Atolls and their vulnerability to climate change and sea level rise have been and continue to command global attention. Much has been published in scientific circles on whether or not atolls will be still habitable by the end of the 21<sup>st</sup> century. There appears to be differences of opinion on sea level rise and its impacts on atolls within these circles yet there is no one consensus and there remains considerable uncertainty in sea level projections. However, with these ongoing scientific discussions, atoll communities continue to face social and health problems from overcrowding, pollution, waste management issues, low incomes, substandard housing, inadequate supply of safe water and a lack of basic sanitation facilities, flooding and drought due to the oscillations of ENSO events and from sea-level rise, inundation and coastal erosion all serious problems in varying degrees faced by developing atoll nations.

Scenarios on offer include but are not limited to: migration, do nothing, opt to go with hard engineering for coastal protection and decentralisation in atoll communities. It is suggested for a more long term solution to problems of land and water resources and mitigating against vulnerability associated with climate change there is an additional option worthy of consideration –

**RECLAMATION**. Engineered reclamation is not new and has been practised in many places in the world. In atolls the Maldives have been doing this for a number of decades.

Within the range of future scenarios of climate variability and sea level change atoll dwellers cannot wait for consensus among the scientific community but need to act now and need to make choices but choices based on the best available advice. Highlighting our recent experience and lessons learnt being part of what may be the largest single reclamation project in recent years for a Pacific atoll country the Geoscience Division of SPC can demonstrate we have in house the scientific and technical capability to help our member atoll nations facilitate the process that could lead to reclamation as one potential mitigation strategy. In this light we present some scenarios for land reclamation in Kiribati, Marshall Islands and Tuvalu.

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SMITH & PRASAD

## **A geophysical and geological interpretation of northeast Tongatapu, the importance of it to understanding how climate variability drives social adaption**

***Robert Smith & Christine Prasad***

*Geoscience Division, Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: roberts@spc.int; christinep@spc.int*

Practical solutions for mitigating or adapting to climate change impacts when dealing with coastal communities where the threats of sea level rise, inundation from storms and cyclones, the cause and effects of coastline erosion that impinge on humanity can only be realised if there is detail in the science to understand the past, present and the future. Understanding coastline behaviour that

responds to a complex set of variables that govern how the coastal zone acts over logarithmic time scales cannot be looked at from any one perspective but requires an interdisciplinary approach. In northeast Tongatapu the vulnerability of the coastal communities from Nukuleka through Manuka to Kolonga to coastal erosion is visibly apparent. Here we present results of a survey that began with simple mapping exercise of the lagoon with a goal to locate suitable sediment in volume of a preferred composition that could be extracted as a sustainable and environmentally considerate supply for the construction industry to understanding the strength in connectivity between early habitation, sediment supply, shoreline erosion and accretion, tectonics and the roll sea level variability which has led to the product we see on the ground today. Such connectivity must be understood if adaptable climate change solutions are to be realised. The results of the study are based on an extensive drilling and sampling program, seismic reflection and sidescan data and composition analysis of a 108 samples from 105 holes drilled offshore in the lagoon area. Lidar and image analysis provide an excellent backdrop to the interpretation presented.

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SON & OTHERS

**Searching active hydrothermal vent sites in the EEZ of the Republic of the Fiji Islands using biogeochemical tracers** (Poster)

***Seung-Kyu Son, Ju-Won Son, Kyeong-Hong Kim, Sang-Bum Chi, Jai-Woon Moon & Se-Jong Ju***

*Korea Institute of Ocean Sciences & Technology (KIOST)*

*Email: [skson@kiost.ac.kr](mailto:skson@kiost.ac.kr)*

In the last few decades, hydrothermal vents have earned attention for the purpose of resource development because those created by volcanic activity not only form diverse and unique biological communities, but also deposit very valuable and rare mineral resources called SMS deposits. Therefore, Korean government has applied and issued an exploration license in the national jurisdiction waters (EEZ) of the Republic of the Fiji Islands from 2011.

Then, we have conducted and are will carry out environmental studies including environmental baseline studies in our exploration-contracted regions to better manage, mitigate, and minimize the mining impact on marine environments. Among environmental studies, finding active vent sites is very critical to select target sites for development and environmental management. Some of the biogeochemical components in seawater show dramatic changes with hydrothermal activities. According to the gradient characteristics between plumes and ambient seawater, these biogeochemical components are generally divided into two groups, such as the anomaly-increase and the anomaly-decrease tracers. The first group of the components includes temperature, sulfide, ammonia, methane, manganese, iron, and helium, which shows the anomaly-increase (high to low gradients from plumes to ambient seawater) property. In contrast, the second group, such as oxygen, nitrate, and pH, shows the anomaly-decrease (low to high gradients) property.

In order to determine active vent sites, we measured these tracers (such as Transparency, CH<sub>4</sub>, ATP, trace metal, etc.) using CTD and selected depth water casting during the environmental baseline survey. We detected through the spatial distribution of the biogeochemical tracers indicate not only the existence of potential hydrothermal vent activities but also pin-point active vent sites with their strength of activity in our contracted area. Based on this result, we could select intense-survey vent sites for the upcoming field survey, which will be carried out with a remotely operated vehicle (ROV) for imaging and direct sampling of vent fauna and ore.

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SULLIVAN

## High-resolution biogeographic classification of regional oceans

**Jonah Sullivan**

*MACBIO Project, IUCN – Oceania Regional Office, 5 Ma'afu Street, Suva, Fiji*

*Email: [Jonah.Sullivan@iucn.org](mailto:Jonah.Sullivan@iucn.org)*

The MACBIO Project has endeavoured to create a high-resolution biogeographic classification of Oceania's marine areas. These works are building upon and improving the concepts behind Marine Ecoregions of the World (MEOW), and the Global Open Ocean and Deep Sea (GOODS) classification schemes. The disparity of accessibility to high resolution comprehensive biological data in the inshore areas versus offshore areas has led to two diverging classification methodologies using species occurrence data and biophysical proxies for the former, and only biophysical proxies in the latter.

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TAWAKE & OTHERS

## Cost benefit analysis for deep sea minerals mining in the Pacific

***Akuila K. Tawake<sup>1</sup>, Jeffrey R. Wakefield<sup>2</sup> & Kelley Myers<sup>2</sup>***

*<sup>1</sup>Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*<sup>2</sup>Cardno, 121 Continental Drive, Suite 308, Newark, DE 19713, USA*

*Email: [akuilat@spc.int](mailto:akuilat@spc.int)*

Many countries in the Pacific Island Region have significant mineral deposits on the seafloor within their national jurisdiction. Emerging technology has considerably increased the probability that these deposits could be mined profitably. However, to date no one has attempted to determine if such activity is likely to improve the well-being of host country citizens.

This paper uses a cost-benefit analysis framework to formally assess the social costs and benefits of mining deep-sea minerals in the Pacific Island Region. Since this type of mining has yet to occur anywhere in the world, the analyses are based on realistic yet hypothetical mining scenarios developed for three mineral deposits thought to have a high potential for economic viability: seafloor massive sulphides deposits in Papua New Guinea, manganese Nodules in the Cook Islands, and cobalt-rich Crusts in the Republic of Marshall Islands.

In each country, costs and benefits are assessed from the perspective of citizens of the host country based on the operation of a single mine site. To the extent possible, costs and benefits are quantified and monetised in order to estimate the net social benefit (NSB) to the people of the host country. Where costs and benefits could not be monetised, they are identified and discussed qualitatively.

Table 1 summarises the preliminary estimates of the total social costs, total social benefits and net social benefits (total social benefits minus total social costs) in each of the case study countries.

Table 1 – Summary of Total Net Benefits by Case Study Country (in millions USD, 2015).

Country	Resource	Total Costs	Total Benefits	Net Benefits	Benefit-Cost Ratio
<b>Papua New Guinea</b>	Seafloor-massive Sulphides	\$0.64	\$83.3	\$82.7	124
<b>Cook Islands</b>	Manganese Nodules	\$27.4	\$494	\$467	18
<b>Republic of Marshall Islands</b>	Cobalt-rich Crusts	\$29.3	\$39 <sup>1</sup>	\$0	0

Note 1: This amount is received from royalty payments, however, since neither of the RMI scenarios were economically feasible from the perspective of the miner, the country would not incur any costs nor receive any benefits; therefore, the net benefits and benefit cost ratio are both zero.

The results indicate that deep-sea mining has the potential to make the people of Papua New Guinea and the Cook Islands better off. In contrast, given current technology and commodity prices, the mining of cobalt-rich crusts is unlikely to improve the well-being of Republic of Marshall Islands residents.

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TAYLOR

### **The 1946 Eruption of Niuafu'ou Island, Kingdom of Tonga: was an evacuation really warranted?**

***Paul W. Taylor***

*Pacific Community, Private Mail Bag, GPO, Suva, Fiji Islands*

*Email: pault@spc.int*

Niuafu'ou is Tonga's remotest island, being located some 450 km north of the main island of Tongatapu at latitude 15.60°S, longitude 175.63°W and is home to about 800 Niuafu'ouans who live in 8 villages located on the eastern and northern flanks of the island. Niuafu'ou is the most active volcano in the Kingdom and its history has been dominated by periods of both lava-producing (effusive) and ash-producing (explosive) activity. Since the early-1800s, at least 10 periods of activity have reported. Although the majority of these eruptions have only resulted in damage to dwellings and crops, during the 1853 eruption at least 25 Niuafu'ouans may have perished. The most recent eruption occurred during September 1946. Since the 1946 eruption, the volcano has remained dormant, except for an earthquake swarm on 21 - 22 March 1985. A volcanic hazard assessment completed during the mid-1990s suggested that based on the numerous periods of activity and the development of a number of new hot springs, Niuafu'ou must still be considered as a potentially dangerous volcanic system.

The 1946 eruption occurred during the period 09-18 September producing a small lava field that covered 0.3 km<sup>2</sup> of land along the north coast. A series of four en-echelon fissures opened propagating in an eastward direction with the eastern-most fissure opening directly under Angaha village. There were no known fatalities that were directly attributed to eruption. Other than the partial destruction of structures in Angaha there was no effect on the other villages or farmlands in other parts in the island. However, as a result of the eruption the Government directed that a

complete evacuation of all inhabitants be undertaken at the best possible time. The evacuation was completed by early December 1946. Following the evacuation although several small groups of copra cutters were permitted the island during the intervening period, resettlement was only permitted by the Government in 1958. However, it was under the condition that residents returned without direct Government support. Since the evacuation the inhabitants of Niufo'ou have endured a considerable degree of cultural and economic hardship and even today still harbor some considerable degree of resentment toward the Government.

Was this evacuation really warranted? In volcanological terms the eruption was a relatively minor event; however, it did result in the destruction of the main Government village of Angaha, on the north coast. There are no known records that indicate that a volcanic hazard assessment of any kind was conducted following the eruption and whilst a recent assessment conducted by the author indicated that Niufo'ou should be considered a dangerous volcano, the evacuation was not necessary. Although a plebiscite (referendum) was conducted on the island, it appears that the final decision to evacuate may have been made purely for political reasons.

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TODMAN & OTHERS

### **Warning information and dissemination platform in Vanuatu: a new approach supported by the Common Alerting Protocol (CAP)**

***Sylvain Todman, Patricia Mawa & Eslie Garaebiti***

*Vanuatu Meteorology and Geohazards Department, P.M.B 9054, Port Vila, Vanuatu  
Email: [stodman@vanuatu.gov.vu](mailto:stodman@vanuatu.gov.vu); [pmawa@vanuatu.gov.vu](mailto:pmawa@vanuatu.gov.vu); [gesline@vanuatu.gov.vu](mailto:gesline@vanuatu.gov.vu)*

According to the Global Facility for Disaster Risk Reduction's Natural Disaster Hotspot study, Vanuatu ranks as one of the countries with the highest exposure to multiple hazards. Almost 81 percent of its landmass and 76 percent of its population is vulnerable to two or more hazards including volcanic eruptions, cyclones, earthquakes, droughts, *tsunami*, storm surge, coastal and river flooding and landslides. Vanuatu has over the past decade continuously improved its hazard monitoring and warning services and has taken the lead within the region in creating a National Hazard Observatory housing a newly established Vanuatu Meteorological and Geohazard Department (VGMD), as well as the National Disaster Management Office (NDMO) in a state-of-the-art purpose built Warning Center. However lack of appropriate warning procedures and limited capacity to provide end-to-end warning services, in particular for *tsunami*, became apparent. To this end, VMGD and NDMO with the support of the World Bank Group have successfully secured funding from the Japanese Government through the Japan Policy and Human Resource Development (PHRD) Technical Assistance Program to address these needs.

The main goal of developing a National Warning Information and Dissemination Platform (WIDS), under this project, was to warn people of Vanuatu in a timely manner. Following recent research that has proven the wide spread of instant information on several platforms and devices (such as Internet and Social Media Network), the architecture of this WIDS was designed to address these new roads of information with the objective to keep the information as consistent as possible. Platform as TV, Radio, Website, Mobile Application, Social Network Application, Email and Mobile Phone Messaging Services were then considered as a potential way of warning people of Vanuatu alongside the installation of a dedicated *Tsunami* Siren System for the two most important urban areas of Vanuatu.

The Common Alerting Protocol (CAP) is an international standard format for emergency alerting and

public warning. It is designed for "all-hazards", related to weather events, earthquakes, *tsunami*, volcanoes, public health, power outages, and many other emergencies. CAP is also designed for "all-media", including communications media ranging from sirens to cell phones, faxes, radio, television, and various digital communication networks based on the Internet. The World Meteorological Organization (WMO), through the Public Weather Services (PWS) Program offered expertise assistance to VMGD on how to implement the Common Alerting Protocol (CAP) Standard in its WIDS.

Multi Hazards Early Warning Systems are actively under development in several Pacific Islands Countries, we believe that the Vanuatu example shows a new and interesting approach that might be followed by others in national warning centers in the region.

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VAN DE POLL

### **Asia Pacific: 25 coastal states' Law of the Sea summary update (securing the seabed resources of the EEZ and ECS)**

#### ***Robert van de Poll***

*Fugro N.V., Leidschendam, The Netherlands*

*Email: rvandepoll@fugro.com*

Present day United Nations "Law of the Sea Applications" now manages 162 Coastal States' Exclusive Economic Zone (EEZ) Waters (approx. 169,000,000 km<sup>2</sup> (Geodetic), and up to 88 Coastal States Extended Continental Shelf (ECS) claims Waters (approx. 35,000,000 km<sup>2</sup> (Geodetic).

Regional Asia Pacific has some 25 individual States all following the Rules of Procedure outline in the Law of the Sea Technical Guidelines.

This presentation will offer the latest updates on status of all Asia Pacific States' Law of the Sea applications (i) LOS Territorial Sea Baselines (ii) LOS Legal Maritime Limits (iii) LOS Maritime Boundaries (iv) LOS ECS Submission to the United Nations with specific emphasis and analysis on current Seabed Mining and Gas Hydrates and/or new (future) potential areas of Interest.

All of the World's Coastal States have some Exclusive Economic Zone Maritime Frontiers. About half of the world's coastal States have moved to secure jurisdictional rights over broad areas of continental shelf seawards of their 200 nautical mile limits. These extensive areas of what are often termed extended continental shelf (ECS) offer considerable potential resource opportunities, notably with respect to various types of seabed energy resources, seabed minerals and marine genetic resources. This presentation will provide an updated Law of the Sea overview (EEZ & ECS) of progress towards Maritime Boundary dispute resolution (EEZ) and also the establishment of outer continental shelf limits (ECS) as well as with respect to seabed resource exploration within the Asia-Pacific region in particular.

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WICHMAN

## **Development of the database for seabed minerals activities by the Cook Islands Seabed Minerals Authority**

### ***Marino Wichman***

*Seabed Minerals Authority, P.O. Box 733, Rarotonga, Cook Islands  
Email: marino.wichman@cookislands.gov.ck*

The Cook Islands contain one of the largest Manganese Nodule resource of any national EEZ in the world. This Deep Sea Mineral (DSM) resource has been estimated to be in excess of 10 billion tonnes<sup>1</sup> with nodule abundances reaching over 30kg per square metre with elevated levels of cobalt, nickel, copper, titanium and rare earth elements.

This expansive Cook Islands resource has now been clearly defined as a potential for sustainable economic resource development, to not only meet the demand of global minerals market but also to provide potential new economic diversification, stimulus and input into the small Cook Islands economy.

Since its inception, the Cook Islands Seabed Minerals Authority (SBMA) has been actively searching for DSM information related to our EEZ, with the goal of establishing a comprehensive digital database compilation. This search has involved a long and complicated process in locating the legacy data acquired by research programs from the 1970's to 2000. This detailed technical work has enabled the SBMA to perform extensive analysis on the data, thus providing a better understanding to the geological parameters of the nodule resource.

Improved understanding to the seabed data is critical for the Cook Islands. This new and exciting sector has the potential to significantly contribute to the sustainable economic development of the Cook Islands as a developing nation, and pave the way to provide for and enhance the livelihoods of all Cook Islanders for current and future generations.

In this paper, the historic technical process of recovering the vast and scattered DSM legacy data and converting into a form suitable for geological modelling of the vast seabed resource will be discussed.

*<sup>1</sup>Cronan, D.S. (2013). The Distribution, Abundance, Composition and Resource Potential of the Manganese Nodules in the Cook Islands Exclusive Economic Zone. Unpublished report, Cook Islands Seabed Minerals Authority*

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WILLIAMS

## **Preliminary 3,000 year-long *tsunami* and cyclone history for the Samoan Islands based on sedimentary records**

### ***Shaun Williams<sup>1,\*</sup>***

*<sup>1</sup>Geological Sciences Department, University of Canterbury, PB 4800, Christchurch, New Zealand*

*\*Present affiliation: National Institute of Water and Atmospheric Research Limited, 10 Kyle Street, Christchurch, New Zealand  
Email: Shaun.Williams@niwa.co.nz*

This talk provides a follow-up to the associated work reported at the 2012 STAR conference in Noumea, New Caledonia, entitled "*Towards the development of a palaeotsunami database in*

*Samoa*". Subsequent findings from 2012 – 2014 have resulted in the development of a preliminary 3,000 year-long baseline *tsunami* and cyclone chronology for the Samoan Islands region. Emphasis in this talk is made on the underlying assumptions as well as field, laboratory (e.g. geochemical, sedimentary, geochronology), and literary techniques used to develop the *tsunami* and cyclone chronology. Applications of this type of underpinning information to support *tsunami* and cyclone hazards knowledge and management in the wider Pacific is discussed.

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YAKUB

## **MACBIO – Assisting Pacific governments to manage marine resources**

### **Naushad Yakub**

*MACBIO Project, IUCN – Oceania Regional Office, 5 Ma'afu Street, Suva, Fiji*  
Email: [Naushad.Yakub@iucn.org](mailto:Naushad.Yakub@iucn.org)

MACBIO (Marine and Coastal Biodiversity Management in Pacific Island Countries) Project funded by the German Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU) is assisting the governments of Fiji, Solomon Islands, Vanuatu, Tonga and Kiribati by "strengthening the sustainable management of marine and coastal biodiversity in selected Pacific island states by conducting ecosystem service valuation, marine spatial planning (MSP) and advice on protected areas."

Conserving and using marine resources sustainably are not always reflected in national planning processes, due in part to a lack of information regarding their economic value. Existing marine protected areas (MPAs) have often been developed opportunistically, lacking a clear design and spatial planning process and are sometimes not managed in a way to secure associated ecosystem services and biodiversity.

MACBIO is helping countries to address these issues by supporting MSP, mainstreaming and extending MPA networks using seascape-level planning and to demonstrate effective approaches to site management, including payment for ecosystem services.

Some examples of MACBIO working to build ecologically representative networks of MPAs include: planning Special Managed Areas (Tonga); assisting Fiji with achieving a 30% MPA network commitment, supporting Oceans Policy (Vanuatu) and Ocean's Summit (Solomon Islands).

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YEO & OTHERS

## **Flood risk management in the Pacific**

### **Stephen Yeo, Michael Bonte-Graptin, Denis Jody & Simone Esler**

*The World Bank*  
Email: [syeo.flood@gmail.com](mailto:syeo.flood@gmail.com)

The World Bank is preparing a knowledge note on flood risk management (FRM) in the Pacific. This draws upon many years' practice and research from Fiji, Samoa and the Solomon Islands. A template to benchmark current FRM practices is presented as a means of identifying successes and gaps. Barriers to improving FRM practice in the Pacific, and ways of overcoming those barriers to

enhance resilience to flooding hazards are discussed. Current FRM investigations offer the promise of significant advances, but achieving and sustaining reductions in risk will require continuing, concerted efforts.

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YOO & OTHERS

## **Resources estimation of polymetallic nodule deposits in the Clarion-Clipperton Fracture Zone, northeast Pacific**

***Chanmin Yoo<sup>1</sup>, Sang-Bum Chi<sup>1</sup>, Kiseong Hyeong<sup>1</sup> & Seong-hyeon Min<sup>2</sup>***

<sup>1</sup>*Korea Institute of Ocean Science and Technology, Ansan, 1562, Republic of Korea*

<sup>2</sup>*NEXGEO Inc., Seoul, Republic of Korea*

*Email: cmyoo@kiost.ac.kr*

Since the early 1990s, Korea has been carrying out researches on the development of deep seabed mineral resources to achieve two national strategic goals: 1) to secure the stable long-term supply source of strategic metals such as Cu, Ni and Co and 2) to create new marine industries related to seabed mining. We acquired an Exploration Area for 75,000 km<sup>2</sup> on polymetallic nodules by contract with the International Seabed Authority in 2002 at the Clarion-Clipperton Fracture Zone, northeast Pacific.

Estimation of polymetallic nodule abundance is one of key factors prerequisite for economic feasibility study and is of great importance on preparation of nodule development strategy. To increase the accuracy of nodule abundance estimated from traditional direct sampling techniques, we used seafloor photographs acquired from a deep tow camera system on 4 selected blocks which represent different nodule abundance and topographic characteristics of the Korean Contract Area. Each block of approximately 100 km<sup>2</sup> was surveyed along 4 deep tow survey lines.

Areas of nodule coverage in sea floor photographs were obtained from an image analysis program and converted to abundance using an equation established from FFG (Free Fall Grab) sampling and photographic data. Two conversion equations were established for the southern and northern blocks separately: abundance (kg/m<sup>2</sup>) in the southern blocks =  $0.4558 \times \text{nodule coverage (\%)} + 1.6658$  ( $R^2=0.4225$ ,  $n=536$ ); abundance (kg/m<sup>2</sup>) in the northern blocks =  $0.3979 \times \text{nodule coverage (\%)} - 0.9692$  ( $R^2=0.626$ ,  $n=248$ ).

Hundreds of photographs were taken on a track line at a 1 minute interval which corresponds to 30 to 50 m resolution in distance and converted to abundance data using the equation. We produced variograms on four different blocks for resource estimation. The variogram ranges of each block are 3250 m, 3285 m, 639 m, and 1188 m from block 1 to block 4 in numerical order. The average abundances of each block are 5.88 kg/m<sup>2</sup>, 5.07 kg/m<sup>2</sup>, 8.67 kg/m<sup>2</sup>, and 8.78 kg/m<sup>2</sup>. Abundances from deep tow camera data show similar patterns on distribution and tendency compared with those from FFG data, although average values between two data sets are somewhat different. QQ-plot also represent linear and close to the tie line.

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ATTACHMENT

**FINAL PROGRAMME (8<sup>th</sup> June 2016)**

**Programme for 31<sup>st</sup> STAR Conference, Nadi, Fiji**  
**6-8 June 2016**  
**Tanoa International Hotel, Nadi**

**“GEOSCIENCES, GEO-ENGINEERING AND THE OCEAN IN THE PACIFIC ISLANDS REGION”**

*Preceded by:*

- 1) SPC-EU Deep Sea Minerals Project Final Steering Committee Meeting, 3<sup>rd</sup> June
- 2) CPC/NIWA/STAR Deep Sea Mining Workshop, 4<sup>th</sup> June

Time	Theme	Authors & Presenter	Title	Chair
<b>Sunday, June 5<sup>th</sup> – Conference registration from 3:30 pm at Tanoa International Conference Centre</b>				
<b>Monday, June 6<sup>th</sup></b>				
<i>Conference registration continues from 07:00 at Tanoa International Conference Centre</i>				
09:00-10:00	<b>OPENING OF STAR</b> (see separate opening session programme – Attachment 1)			
<b>10:00-10:30</b>	<b>MORNING TEA [GROUP PHOTO]</b>			
10:30-10:45	<b>Ocean Science &amp; Governance</b>	<u>Marino Wichman</u>	Development of the database for seabed minerals activities by the Cook Islands Seabed Minerals Authority	<b>Malakai Finau</b>
10:45-11:00		<u>Robert Smith</u> & Christine Prasad	A geophysical and geological interpretation of northeast Tongatapu, the importance of it to understanding how climate variability drives social adaption	
11:00-11:15		<u>Bapon Fakhruddin</u>	Application of science and technology in the Sendai Framework	
11:15-11:30		<u>Teina Rongo</u>	Using local knowledge to understand climate variability and climate change in the Cook Islands	
11:30-11:45		<u>Matt Blacka</u> , Kristen Splinter, Ron Cox & Francois Flocard	Update on UNSW research program for extreme waves and storm surge on fringing reef coastlines	
11:45-12:10		<u>Robert Van de Poll</u>	Asia Pacific: 25 Coastal States' Law of the Sea Summary Update (Securing the Seabed Resources of the EEZ and ECS)	
12:10-12:25				
<b>12:30-13:30</b>	<b>EARLY LUNCH BREAK</b>			
<b>PARALLEL SESSION A – MAIN CONFERENCE ROOM</b>				
13:30-13:45	<b>Pacific Volcanoes: science, hazard &amp; impacts</b>	<u>Shane J. Cronin</u> , Marco Brenna, Manuela Tost & others	Hunga Ha'apai-Hunga Tonga – birth of a new volcano and discovery of a new caldera	<b>Russell Howorth</b>
13:45-14:00		<u>Graham Leonard</u> , Esline Garaebiti, Sylvain Todman & others	Development of a collaborative consistent volcano communication framework in Vanuatu: hazard maps, education, alert levels, bulletins, signs and procedures	
14:00-14:15		<u>Nick Mortimer</u>	Zealandia: the Southwest Pacific's hidden continent	
14:15-14:30		<u>Esline Garaebiti</u> , Sylvain Todman & Pierre Lebellegard	Development and progress of the Oceania Regional Seismic Network (ORSNET) for tsunami early warning	
14:30-14:45		<u>Steven Sherburn</u> , Taaniela Kula, Leveni Aho & others	Managing a volcanic eruption in a small island country: Lessons from the 2014-15 eruption of Hunga Tonga – Hunga Ha'apai in the Kingdom of Tonga	
14:45-15:00		<u>Paul Taylor</u>	The 1946 eruption of Niuafou'ou Island, Tonga: was an evacuation really warranted?	



## PARALLEL SESSION B – TALEI ROOM

13:30-13:45	<b>Ocean Management &amp; Governance</b>	<u>Akuila K. Tawake</u> , Jeffrey R. Wakefield & Kelley Myers	Cost benefit analysis for deep sea minerals mining in the Pacific	<b>Peter Sinclair</b>
13:45-14:00		<u>John Kaitu'u</u>	Building GIS capacity from the ground up	
14:00-14:15		<u>Andrick Lal</u>	Positioning in the Pacific Islands	
14:15-14:30		<u>Emily Artack</u>	Establishing the outer limits of maritime zones of Pacific island countries	
14:30-14:45		<u>Naushad Yakub</u>	MACBIO – Assisting Pacific Governments to manage marine resources	
14:45-15:00				
15:00-15:30	<b>REFRESHMENT BREAK</b>			
15:30-15:45	<b>GSD Science &amp; Policy</b>	<u>Zulfikar Begg</u> , Herve Damlamian, Salesh Kumar & others	El Niño coastal impact and recovery monitoring program, Kiritimati, Kiribati	<b>Paul Lynch</b>
15:45-16:00		<u>Amini Loco</u> , Peter Sinclair, Amit Singh & Martin Mataio	Assessment of water resources in atoll islands	
16:00-16:15		<u>Sandra C. Galvis</u> & Peter Sinclair	Abstraction and climate impacts on the Bonriki freshwater lens, Tarawa, Kiribati: An optimization approach to maximize the resource during droughts	
16:15-16:30		<u>Peter Sinclair</u> & Sandra C. Galvis	Sustainability of freshwater lenses in atoll environments	
16:30-16:45		<u>Wolf Forstreuter</u> & Tevita Faka'osi	Age estimation and form factor calculation of Pacific coconut palms	
16:45-17:00		<u>Sachindra Singh</u>	Provisioning spatial data infrastructure within Pacific island countries	
17:00-17:15		<u>James Jolliffe</u>	The economic dimensions of relocation as an adaptation to climate change in Fiji	
17:15-17:30		<u>Wolf Forstreuter</u>	Mapping village damage with space borne image data	
17:30-17:45	John Burton, <u>Akuila Tawake</u> , Glenn Banks & Pierre-Yves Le Meur	The Pacific Centre for Social Responsibility and Natural Resources – a new research and policy hub		
18:00	<b>CONFERENCE COCKTAIL HOSTED BY CHAIR/FIJI GOVERNMENT</b>			

Tuesday, June 7<sup>th</sup>

## One-day field trip to the Yasawa islands

Wednesday, June 8<sup>th</sup>

08:00-08:15	<b>Pacific Cyclones &amp; their impacts</b>	Herve Damlamian, Cyprien Bosserelle, Amrit Raj & others	The use of multirotor and fixed wings UAVs to assess 3D shoreline change patterns generated by Tropical Cyclone Pam (Category 5) in Vanuatu 2015	<b>Rajjeli Taga</b>
08:15-08:30		<u>Terry Atalifo</u>	Tropical Cyclone Winston talk by Fiji Meteorological Services	
08:30-08:45		John Leeves, <u>Peter Quilter</u> & Bapon Fakhruddin	Rapid damage mapping – Tropical Cyclone Winston, Fiji	
08:45-09:00		<u>Cyprien Bosserelle</u> , Herve Damlamian, Zulfikar Begg & others	Field investigations of coastal inundation and building damages from tropical cyclone Winston	
09:00-09:15		<u>Geoffroy Lamarche</u> & Cécile Bonnifait	From hazard assessment to village adaptation: the village of Sa'anapu, Samoa	
09:15-09:30		<u>Shaun Williams</u>	Preliminary 3,000 year-long tsunami and cyclone history for the Samoan Islands based on sedimentary records	
09:30-09:45		<u>Seung-Nam Seo</u>	Reclamation and channel dredging of the Korea South Pacific Ocean Research Center, Chuuk	



09:45-10:00	<b>Dredging &amp; Reclamation</b>	<u>Robert B. Smith</u>	Atoll reclamation a solution to pressing problems of land scarcity, water lens vulnerability, sea level rise and climate change	
10:00-10:30	<b>REFRESHMENT BREAK – WORLD OCEANS DAY SIDE EVENT (organised by Molly Powers, SPC)</b>			
10:30-10:45	<b>Ocean technology &amp; marine management</b>	<u>Gary M. McMurtry</u> , Luis A. Dasilveira, James A. Jolly & Jong-Hwa Chun	Towards <i>in situ</i> monitoring of submarine gas hydrate fields with the Deep-ocean Mass Spectrometer (DOMS)	<b>Paul Taylor</b>
10:45-11:00		<u>Kwang-Soon Park</u> & Ki-Young Heo	Development of operational oceanographic system for coastal disaster reduction	
11:00-11:15		<u>Kwang Soo Lee</u>	Role of ocean energy in the stand-alone microgrid system for green energy-independent island	
11:15-11:30		<u>H. Gary Greene</u> & Norman Maher	Mapping and monitoring environmental changes in lagoons, bays and sounds of the San Juan Archipelago using a UAV for management purposes	
11:30-11:45		<u>Jonah Sullivan</u>	High resolution biogeographic classification of regional oceans	
11:45-12:00		<u>Dan McConnell</u> , Jamshid (Jim) Gharib & Paul Kennedy	Seafloor mapping for seafloor mineral exploration – technical overlap with approaches used in wide area high resolution search and large area cold seep mapping	
12:00-12:15	<b>Geothermal</b>	<u>Maxine Lahan</u>	An overview of surface geothermal exploration in Papua New Guinea	
12:15-12:30		<u>Michel Leodoro</u> & Simon Bloomberg	Preliminary geothermal survey – Vanuatu: Tanna and Ambrym	
12:30-13:30	<b>LUNCH BREAK</b>			
13:30-13:45	<b>Geothermal</b>	<u>Willie Kilamanu</u>	Surface and drill-hole geological and geochemical data capture, analysis, input and visualisation	<b>Robert Smith</b>
13:45-14:00	<b>Georesources</b>	<u>Young-Gyu Park</u> , Young Ho Kim & Hanna Na	Could we predict tuna catch using ocean circulation data?	
14:00-14:15		<u>Robert Smillie</u> , Simon Cox, David Heron & Mark Rattenbury	The role of geological mapping and innovative GIS applications for identifying natural resources potential: The New Zealand QMAP Experience	
14:15-14:30		<u>Maira Lunge</u> & Joseph O. Espi	Trace element geochemistry of chalcopyrites and pyrites from Golpuand Nambonga North porphyry Cu-Au deposits, Wafi-Golpu mineral district, Papua New Guinea	
14:30-14:45		<u>Chanmin Yoo</u> , Sang-Bum Chi, Kiseong Hyeong & Seong-hyeon Min	Resources estimation of polymetallic nodule deposits in the Korean Contract area of the Clarion-Clipperton Fracture Zone, northeast Pacific	
14:45-15:00				
15:00-15:30	<b>REFRESHMENT BREAK</b>			
15:30-15:45	<b>Hazards – Science &amp; Management</b>	<u>Andrew C. Barnicoat</u>	Disaster risk reduction challenges in the Pacific: an Australian perspective	<b>Taniela Kula</b>
15:45-16:00		<u>David Heron</u> , Biljana Lukovic, Graeme Smart & others	New approaches to hazard and risk mapping, Vanuatu – developing safer communities	
16:00-16:15		Kate Crowley, <u>Shaun Williams</u> , Litea Biukoto & others	Towards the implementation of PARTneR: Pacific Risk Tool for Resilience	
16:15-16:30		<u>Sylvain Todman</u> , Patricia Mawa & Esline Garaebiti	Warning information and dissemination platform in Vanuatu: A new approach supported by the Common Alerting Protocol (CAP)	
16:30-16:45		<u>Brenda Rosser</u> & Sally Dellow	Landslide mapping and hazard assessment in New Zealand	
16:45-17:00		Ron K. Hoeke, <u>Kathy L. McInnes</u> & Julian G. O’Grady	Multi-variate coastal inundation forecasting and risk analysis for the Pacific	
17:00-17:15		<u>H. Gary Greene</u> , J. Vaughn Barrie, Kim Conway & others	Assessing the seismic and tsunami hazards along a major transform plate boundary – the Queen Charlotte-Fairweather leaky transform fault system of Canada and Alaska	
17:15-17:30		<u>Stephen Yeo</u> , Michael Bonte-Grapentin, Denis Jody & Simone Esler	Flood risk management in the Pacific	
17:40-18:00		<b>STAR BUSINESS MEETING</b>		



## STAR 2016 POSTER PAPERS

{Poster paper authors please come prepared to leave posters behind, as these will be scanned and thumbnails published on the STAR Website; or better still prepare digital copy of the poster which you can hand in to Secretariat so we can publish on the STAR Website}

1	A.P. Martin, D.W. Heron, R.E. Turnbull & N. Mortimer	Assessing soil quality with a systematic geochemical baseline survey: a New Zealand example applicable to the Pacific islands
2	Biljana Lukovic, William Power, Xiaoming Wang & others	Development of tsunami evacuation maps, Port Vila and Luganville, Vanuatu
3	Kyoungrean Kim, Eun-Ji Won, Jin Young Choi & Chang Soo Chung	Pilot study: Remediation of contaminated marine sediments for beneficial use
4	Seongick Cho & Young Je Park	Development of GOCI-II: the next geostationary ocean color imager with potential application for the Pacific islands
5	Gary M. McMurtry, James R. Deluze, David R. Hilton & James E. Blessing	Development of a field-portable Helium Isotope Detector for continuous monitoring of large earthquakes and volcanic unrest
6	Seung-Kyu Son, Ju-Won Son, Kyeong-Hong Kim & others	Searching active hydrothermal vent sites in the EEZ of the Republic of the Fiji Islands using biogeochemical tracers
7	Chris Pearson & Robert Smillie	Datum modernization in the Pacific island developing states: Key infrastructure for sustainable development and disaster risk reduction
8	Arishma R. Ram, Shane J. Cronin & Martin Brook	Characteristics of slope failures induced by Tropical Cyclone Winston (20-21 Feb, 2016) along King's Road, northern Viti Levu, Fiji Islands
9	Christine Prasad	SPC-EU Environmentally Safe Aggregate for Tarawa (ESAT) Project Overview
10	Vira Atalifo	Deep sea minerals in the Pacific region and the potential mining impacts
11	Benjamin Simons, Shane Cronin, Jennifer Eccles & others	Drivers of variation in hazards at a persistently active volcano, Yasur, Vanuatu
12	Sara Beavis & E.A. Beckmann	The Water Ethics Moot: exploring the ethics of water management across the Pacific region
13	Emma Newland	GEF Pacific Ridge to Reef programme poster

STAR 2016 Conference book of abstracts – see online at address below. A revised version will replace the pre-session version, to reflect the actuals of the STAR 2016 Conference.

<http://star.gsd.spc.int/>



ATTACHMENT

# Official Opening Programme





# STAR 2016

## The Pacific Islands Science, Technology and Resources Conference

*Hosted by the Government of Fiji*

### OFFICIAL OPENING – PROGRAM of EVENTS

#### TRADITIONAL FIJI WELCOME

*(Bure outside Conference Centre)*

#### GROUP PHOTOGRAPH

#### Master of Ceremony

**Mr Apete Soro**

*Manager Geological Services  
Mineral Resources Department  
Government of Fiji*

#### OPENING PRAYER

#### WELCOME TO PARTICIPANTS

**Ms Raijeli Taga**

*Acting Director Mineral Development  
Government of Fiji*

#### OFFICIAL OPENING

#### Guest of Honour

*Chair of STAR*

**Mr Malakai Finau**

*Permanent Secretary of Lands and Mineral Resources  
Government of Fiji*

#### Introductory Comments

*Director Geoscience Division of the Pacific Community*

**Professor Michael Petterson**

#### Introductory Comments

*President of the Circum-Pacific Council*

**Professor Gary Greene**

#### Invited Address

*Director of the Coordinating Committee for Geoscience Programmes in East and Southeast Asia Technical Secretariat*

**Dr Adichat Surinkum**

*Morning Tea will be served at the conclusion of the ceremony*

