DEVELOPING TAILORED COASTAL INUNDATION FORECAST SYSTEM IN PACIFIC ISLAND COUNTRIES
SPC’S GOAL

“To help Pacific island people to position themselves to respond effectively to the challenges they face and make informed decision about their future and the future they wish to leave for the generations to follow.”
Bridging the gap between science and decision making

Cultural aspect
Political strategy

Finance

Land Ownership

Scientific/technical information

Prioritize
Compromise
SCIENCE AND TECHNOLOGY: RISE TO THE CHALLENGE

. Provide information with acceptable uncertainties
. Provide timely and actionable information
CHALLENGE OF MAPPING INUNDATION ON REEF FRONTED ISLANDS

• Inundation driven processes:
  Continental shelf vs. reef fronted Island

• 1m SLR -> 200% increased wave energy (Hoeke et al, 2015)

• Highly sensitive to nearshore bathymetry
FIRST STEP: INVEST IN HIGH QUALITY BASELINE DATA
SWELL DRIVEN INUNDATION
COASTAL INUNDATION EVENTS IN THE REGION

December 2008
Wave Climate In The Pacific

Mean annual wave height and direction

Source Tom Durant, BOM
FIJI CORAL COAST – HIGHLY VULNERABLE TO SWELL INUNDATION
Coast swamped
Why is coastal inundation difficult to forecast on reef fronted shoreline?

Swell driven inundation

Wave (Hs, Tp, Dp)

Water level (Tides + SLA+ Storm Surge)

Coastal topography

Local beach morphology and geology

Each element is easy to predict on its own but the interaction between swell, tide and topography is highly non-linear and complex to understand.
GLOBAL FORECAST

Global Wave Forecast, ~40km resolution

Daily Sea Level Anomalies

Tide prediction, Suva
GLOBAL TO LOCAL INFORMATION
DOWNSCALED WAVE FORECAST MODEL

- Run 4 times daily 00z 06z 12z 18z
- Provide 7 day forecast
- Bash and Python script

Fiji’s downscaled wave forecast

~300m
GLOBAL TO LOCAL INFORMATION
DOWNSCALED WAVE FORECAST MODEL

- Run 2 times daily 00z 06z 12z 18z
- Provide 7 day forecast
- Bash and Python script

Tuvalu’s downscaled wave forecast

[Diagram showing global and regional wave models with locations Nukufetau, Vaitupu, and Funafuti]
RUN-UP FORECAST USING META-MODELLING
Extended methodology from Camus et al. 2011 and Rueda et al. 2014

1) Multivariate Extreme Value Analysis
Generate large number of possible scenarios (Hs, Tp, Dp, WL)

2) Meta-Modelling

Maximum Dissimilarity Algorithm
Select 300 representative cases (from 800,000 offshore scenarios (Hs, Tp, Dp, WL)

Dynamic Modelling (Xbeach-GPU)
Simulate each selected cases with Inundation model

Radial Basis Functions (RBF)
Reconstruct Max Water Level and inundation depth forecast ensembles based on simulations

Too slow to run operationally

Trained RBF are used operationally to forecast Max Water Level at the shore and Max Inundation depth every 10m on land
WATER LEVEL FORECAST AT THE SHORE

Dashed line: Offshore water level (tide + SL anomaly)

Black line: mean water level inside the reef (tide, sea level anomaly and wave setup)

Blue shaded area: max. water level at the beach (tide, SL anomaly, wave setup, infragravity wave and swell)

Automatically generated inundation map based on machine learning

http://phpstack-15188-38272-117120.cloudwaysapps.com/Forecast/Maui_Bay-WL.pdf
REAL-TIME OBSERVATION
Near-Real Time Wave Data

REGION: 20% of EEZ and <1% of buoys
MONITORING SYSTEM

• SPOONDRIFT

✓ Light
✓ Small
✓ Cheap (~5 000 euros)

Building mooring system at SPC

Wave buoy deployment

Community consultation and awareness
UPCOMING IN-SITU AND REAL-TIME WAVE OBSERVATION SYSTEM.
OUTCOME: INUNDATION IMPACT FORECAST
28TH MAY 2018

Long period swell with a height exceeding 4m from a SSW direction

Maui Bay forecast:
Wave period 18s
Wave height 4m
OUTCOME: INUNDATION IMPACT FORECAST
28TH MAY 2018

Dashed line: Offshore water level
Black line: mean water level inside the reef (incl. wave setup)
Blue shaded area: maximum water level at the beach (incl. wave runup)

Water Level [m above msl]

(red) 99th percentile
(orange) 95th percentile
(yellow) 90th percentile