Predicting sea and swell energy on the reef-fringed shoreline of Ipan, Guam

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Outline

- Motivation
- Field work
- Spectrum of energy across the reef
- Dissipation on the reef
- Reef transformation model
- Dynamics and prediction
- Summary

Goal: prediction of coastal inundation and erosion along island shorelines due to storm waves

Understanding and quantifying the amount of energy that reaches islands shoreline, in reef dominated environments.

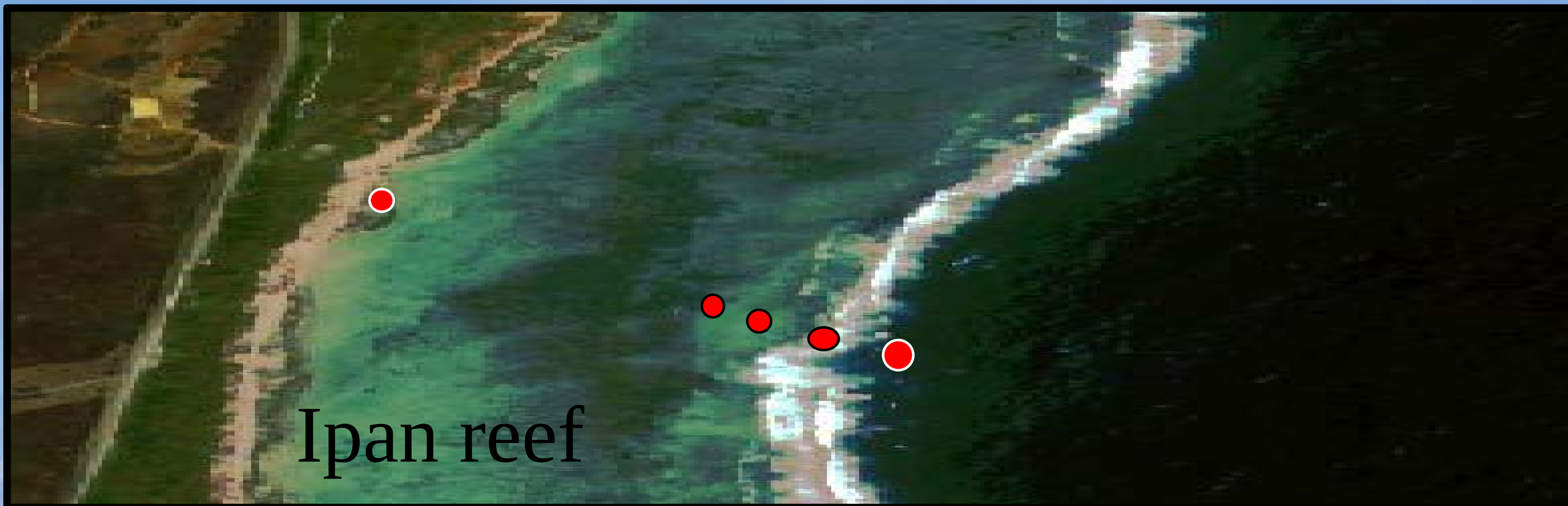
Methodology

- Field data → parametrization of friction, breaking
- Use parametrization in numerical cross-shore model of wave transformation
- Use model for identifying processes and extrapolating predictions

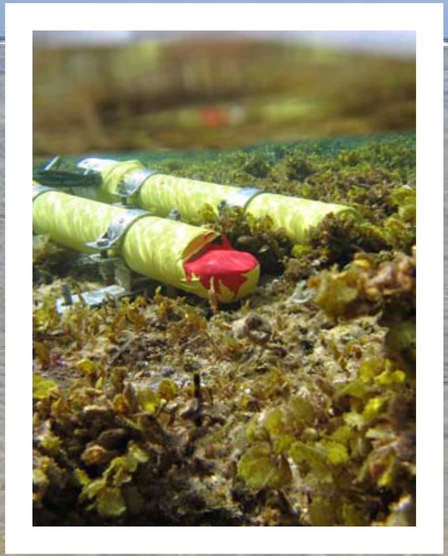
Summary of results

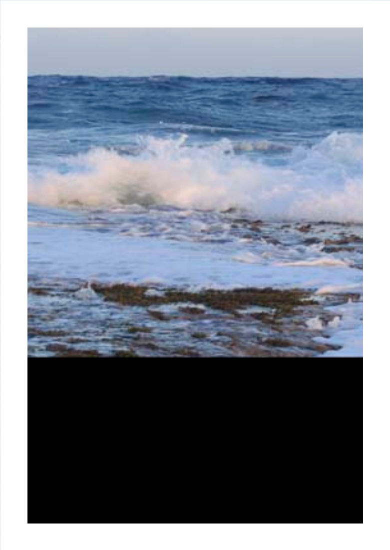
- Breaking and friction (and reflection) on the reef are function of water depth
- Setup decreases with increasing water level
- Sea and swell energy at the shore increases almost linearly with water level
- With increasing sea level, energy at the shore will increase despite the limited decrease of wave setup

Field experiments

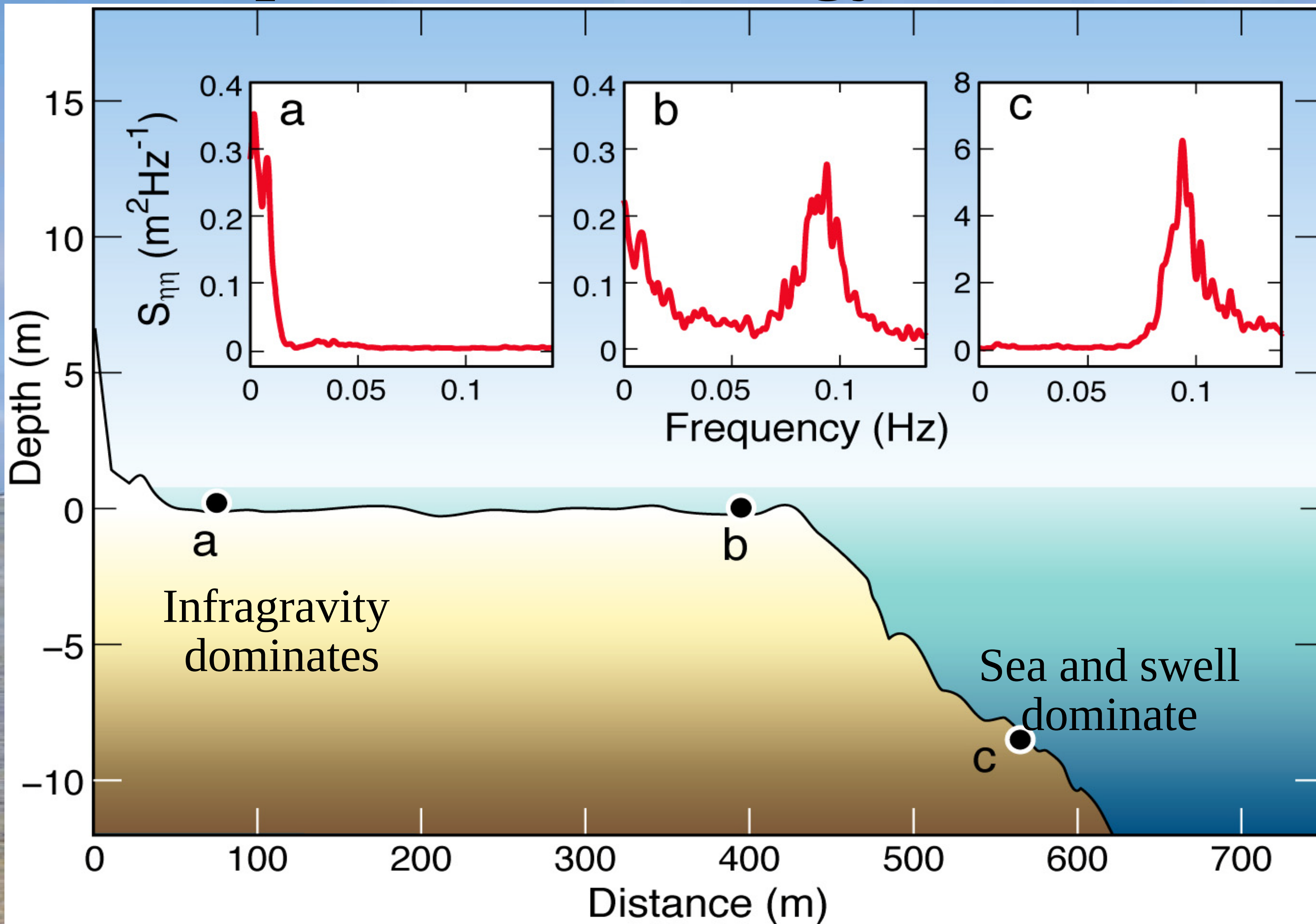


- Deployments:
- At Ipan, Guam
- Aug 05 to now
- Pressure sensors and current-meters
- Offshore buoy

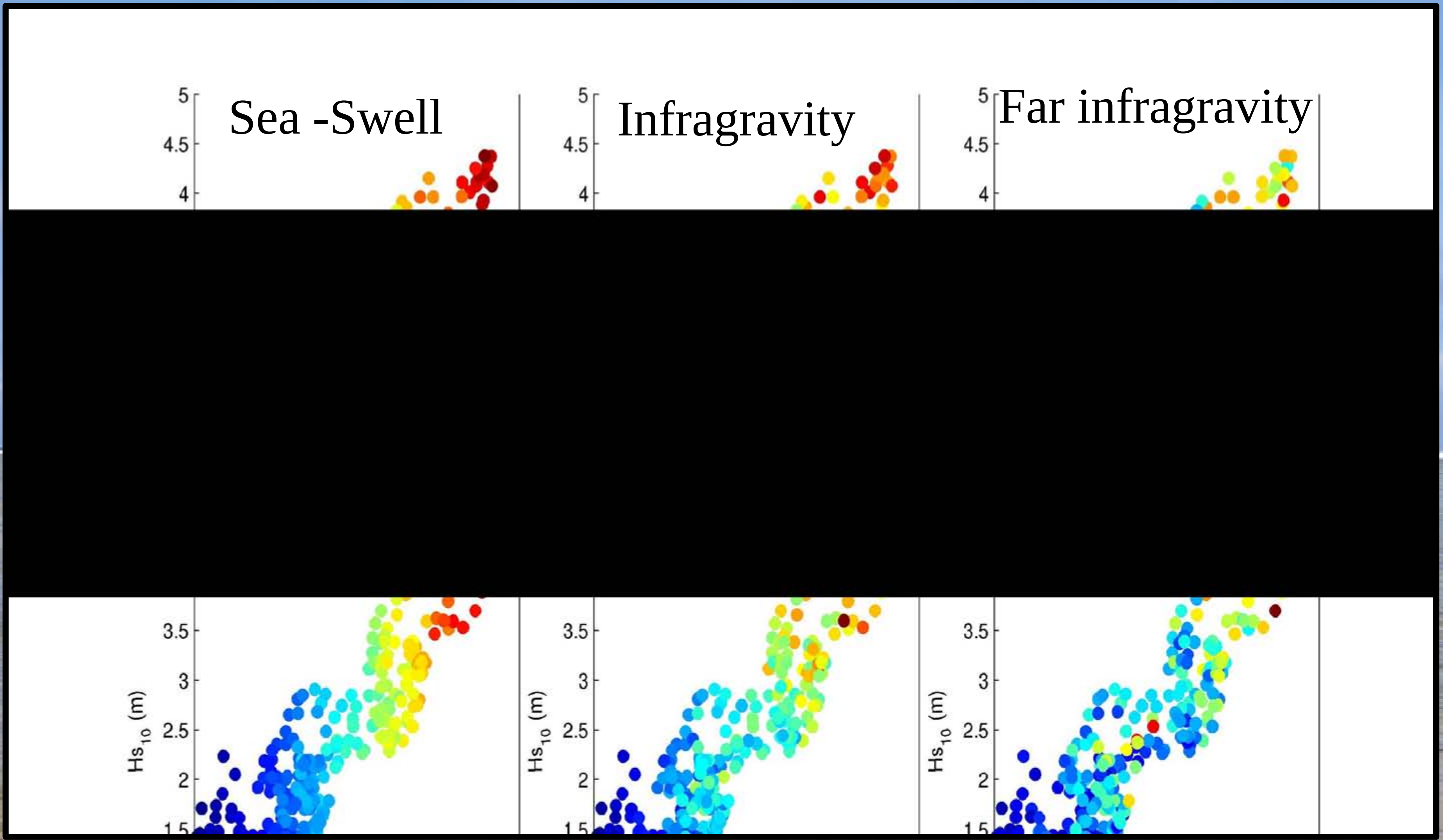




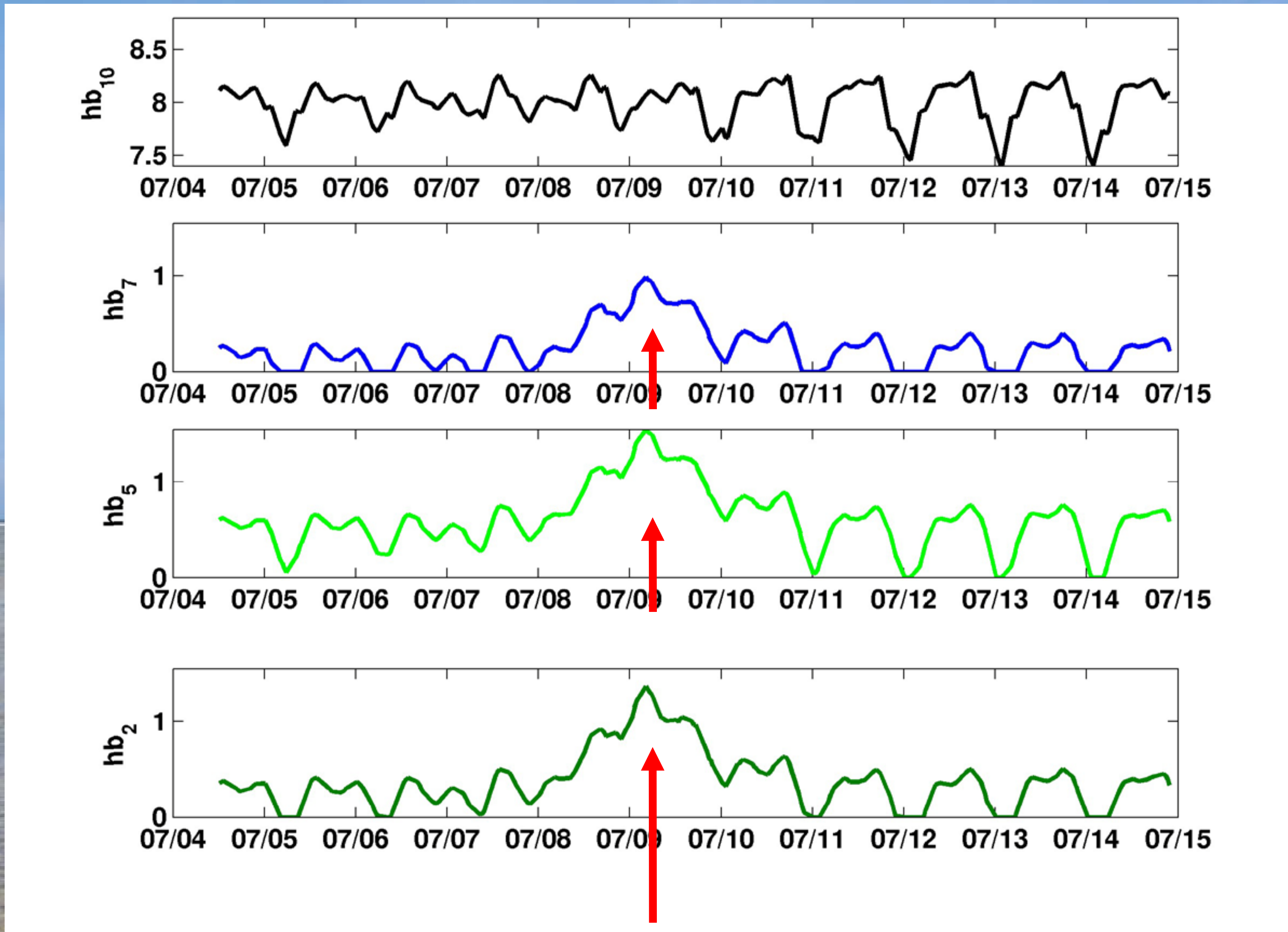
Spectrum of energy on reef



Energy reaching the shore



Setup on the reef



Large setup due to large storm waves
inside of breakpoint

Sea and Swell Energy flux

$$\frac{dF}{dx} \simeq \frac{\Delta F(SS)}{\Delta x_{AB}} = <\epsilon_b> + <\epsilon_f> + <N>$$

$$<\epsilon_b> \sim B_r \rho g \bar{f} H_b^2$$

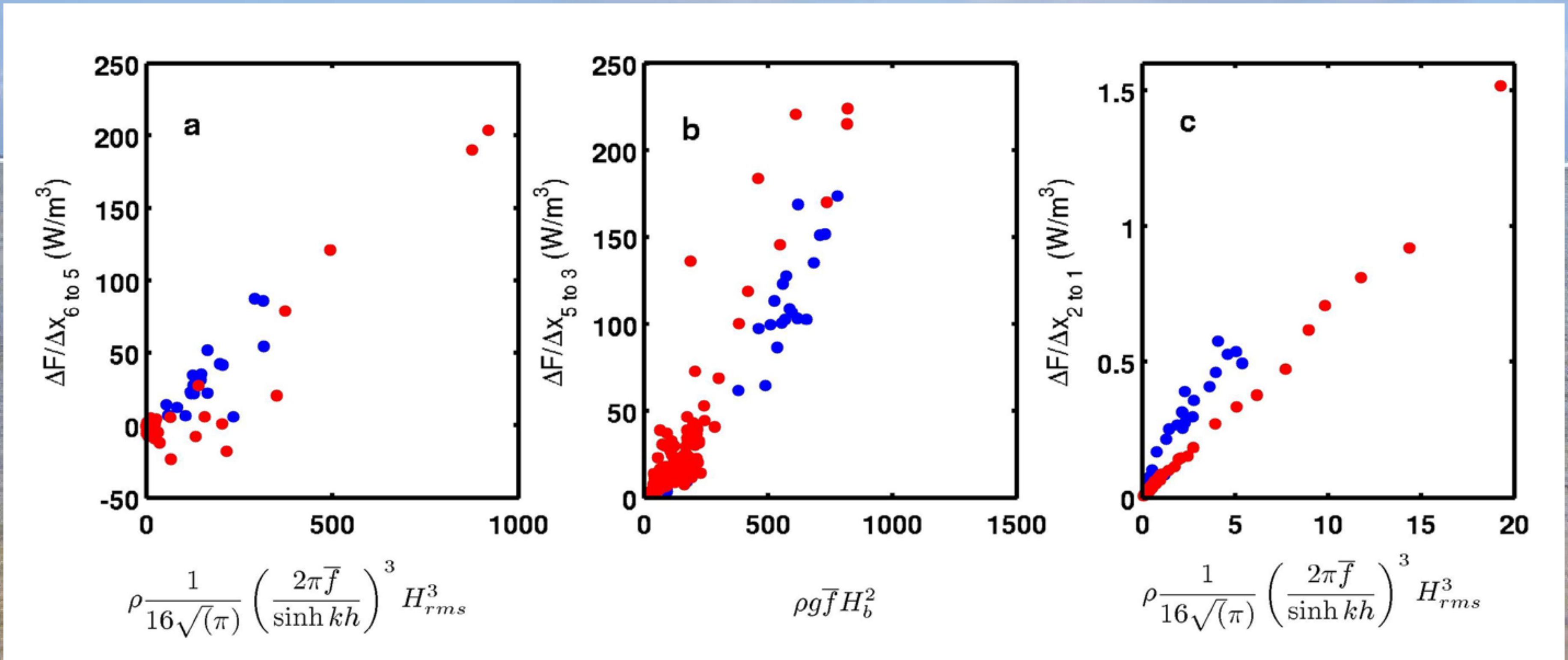
$$H/h = \gamma$$

$$<\epsilon_f> = \rho C_f \frac{1}{16\sqrt{\pi}} \left(\frac{2\pi f}{\sinh kh} \right)^3 H_{rms}^3$$

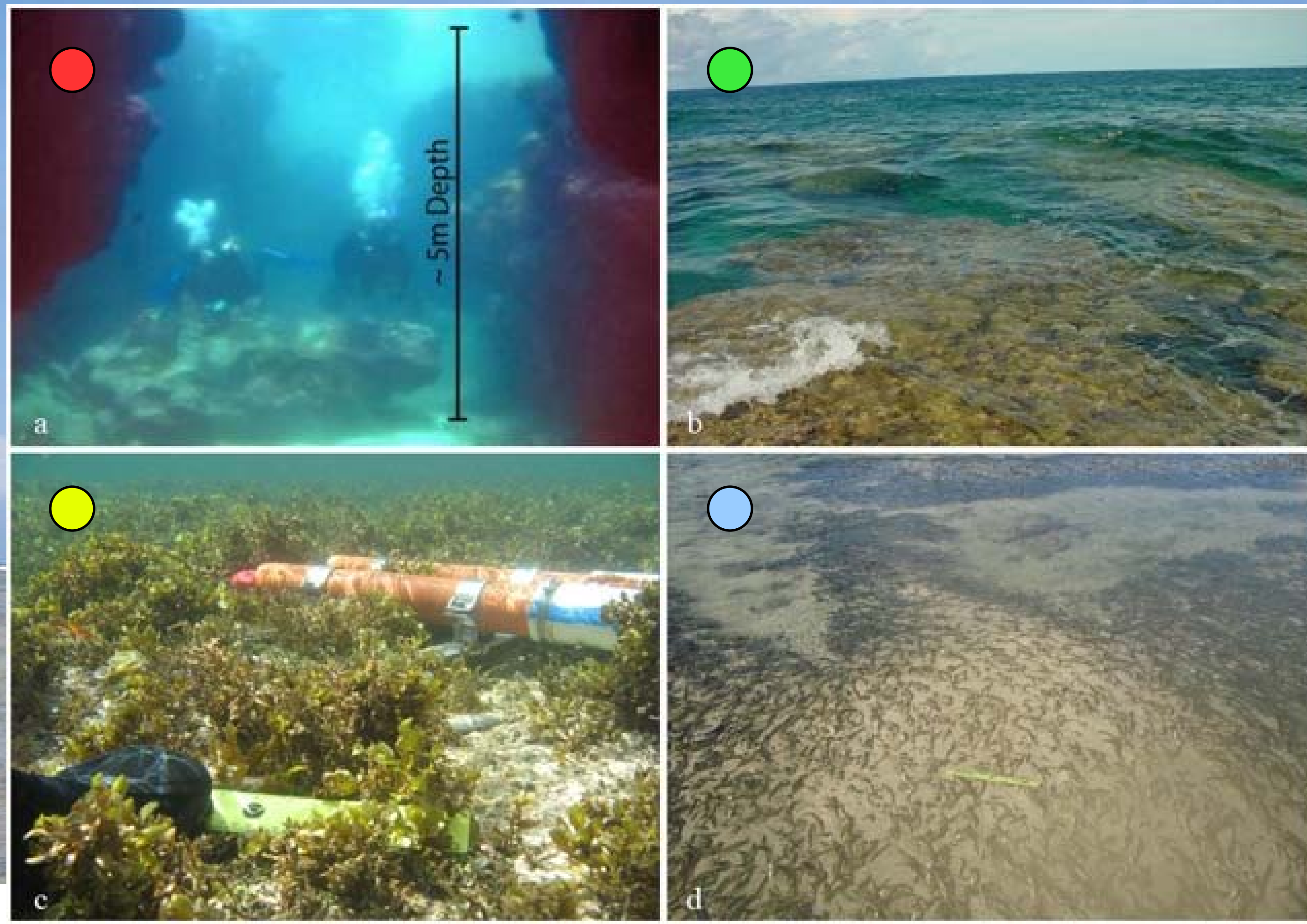
Breaking and friction

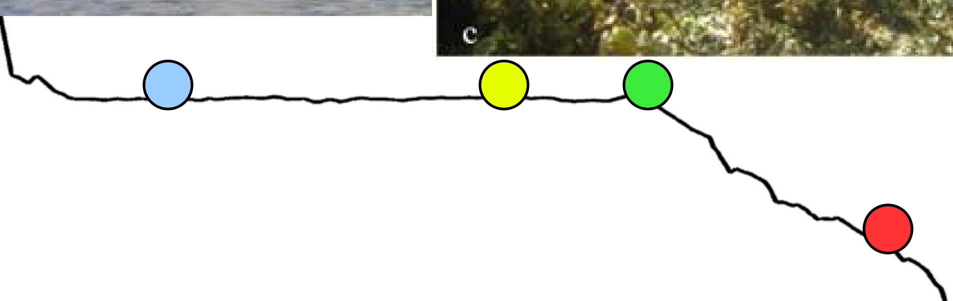
- Wave breaking
- Based on bore propagation
- **B_r=0.57**

- Bottom friction
- quadratic formulation of bottom shear stress
- **C_f=0.06 - 0.2**



Friction and roughness





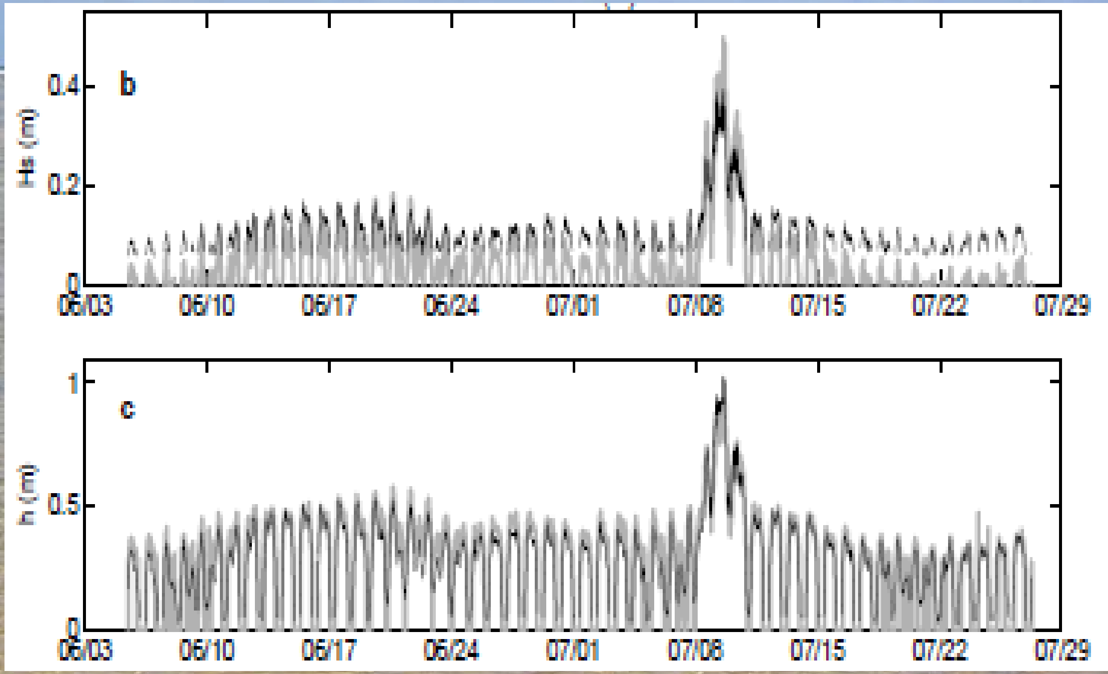
Modelling SS transformation

- Solving the energy flux and setup momentum equation across the reef

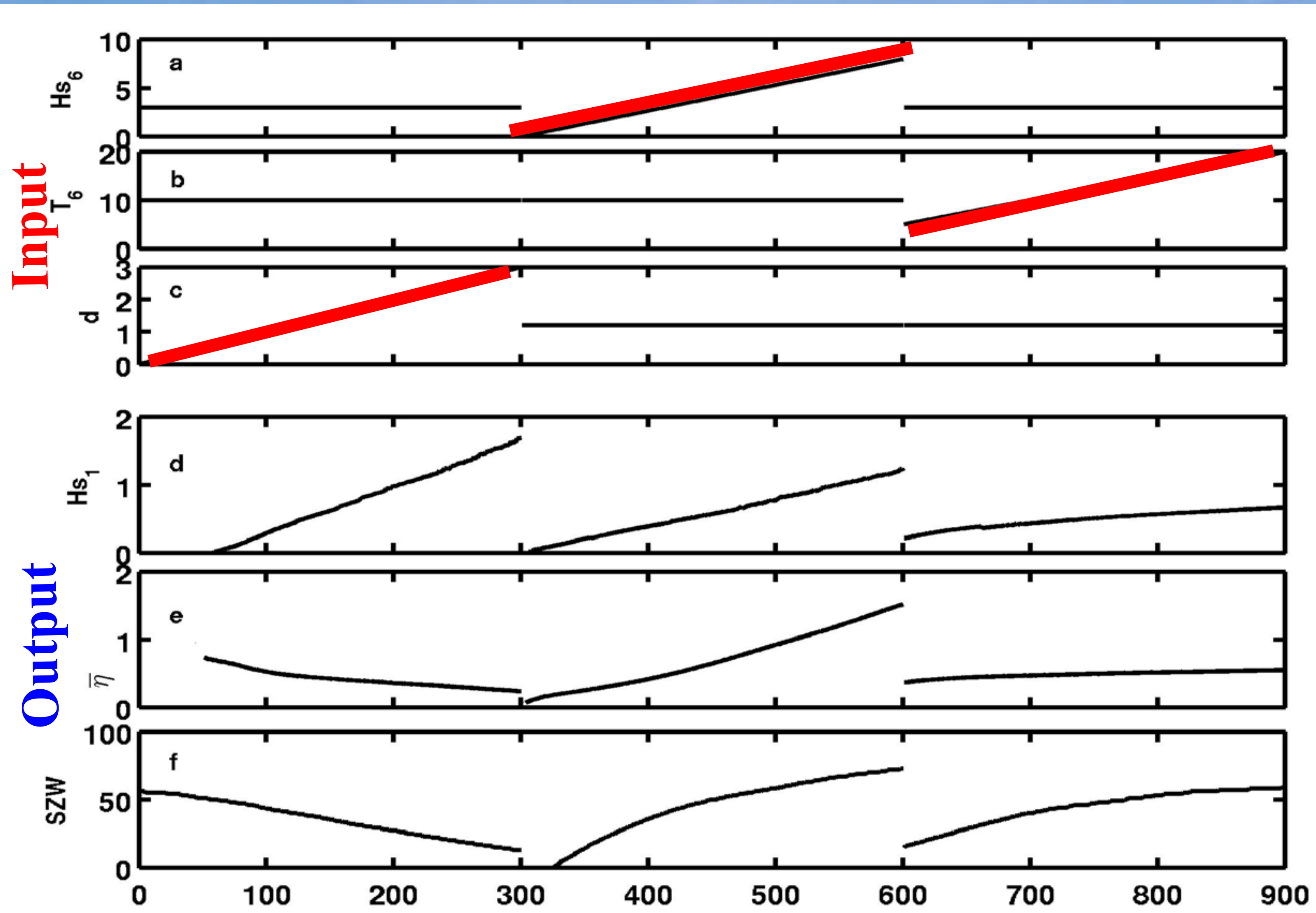
$$\boxed{\frac{dF_{SS}}{dx} = <\epsilon_b> + <\epsilon_f>}$$

$$\boxed{\frac{\partial\bar{\eta}}{\partial x} = -\frac{1}{\rho g(\bar{\eta}+d)}\frac{\partial S_{xx}}{\partial x}}$$

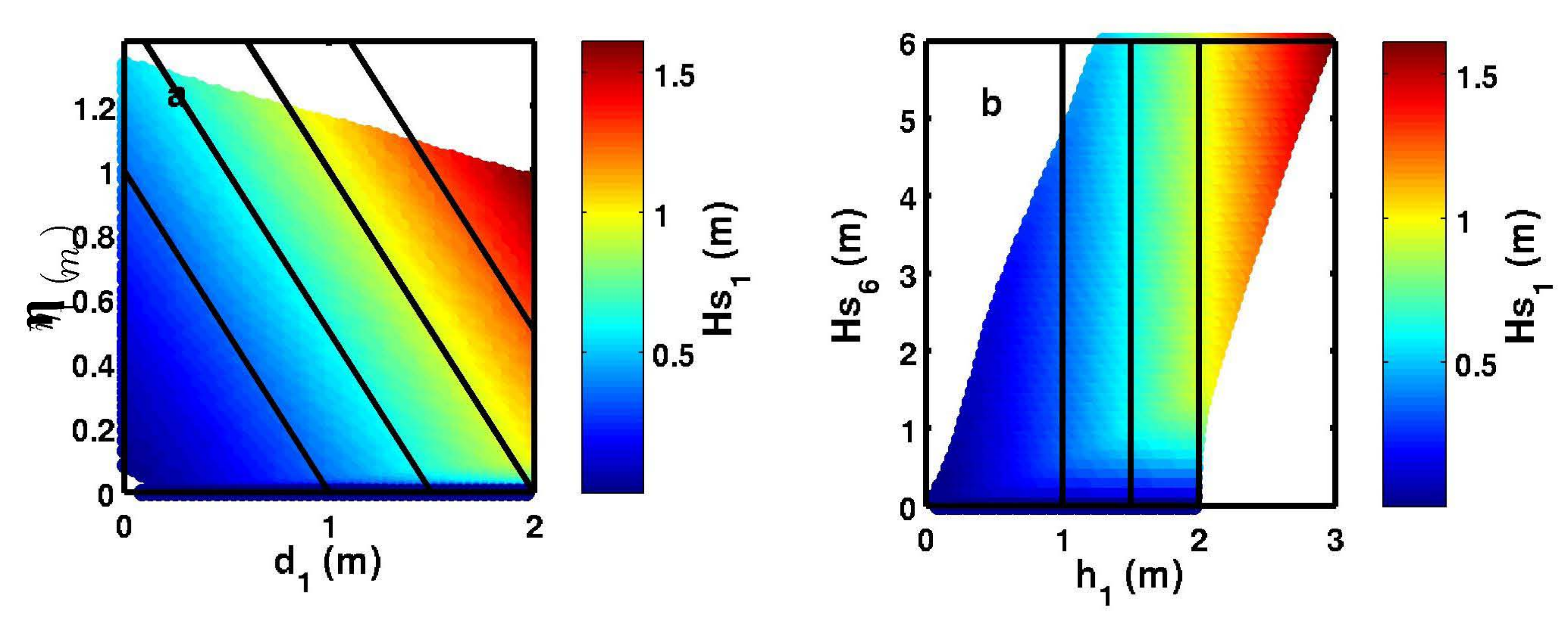
- Using C_f and B_r from Guam data
- Applied to Saipan
- Run tests



Effect of Hs, Tp, d



Prediction of wave energy



$$\eta = aH_6 + b$$

$$H_1 = c(C_f)[d_1 + aH_6 + b(d_1)]^{m(Cf)}$$

Summary

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- Setup decreases with increasing water level
- Sea and swell energy at the shore increases almost linearly with water level
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(eg. For +0.5m SLR, wave height increases by 25cm (for 1-4m incident wave) and setup decreases by 6cm