

CALIFORNIA COASTAL EROSION AND LANDSLIDE EARLY WARNING RESEARCH

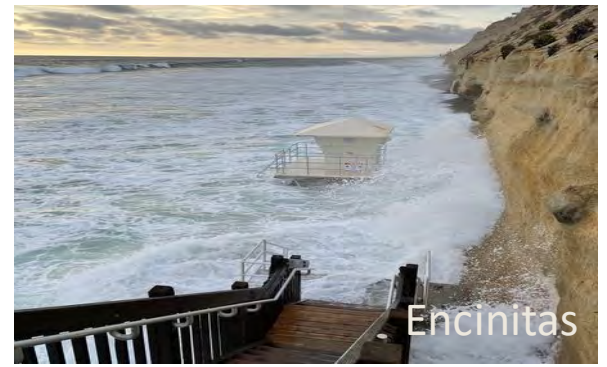
Adam Young, PhD
Beacon | Sep 18, 2026

UC San Diego



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THE PROBLEM





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Two minutes later



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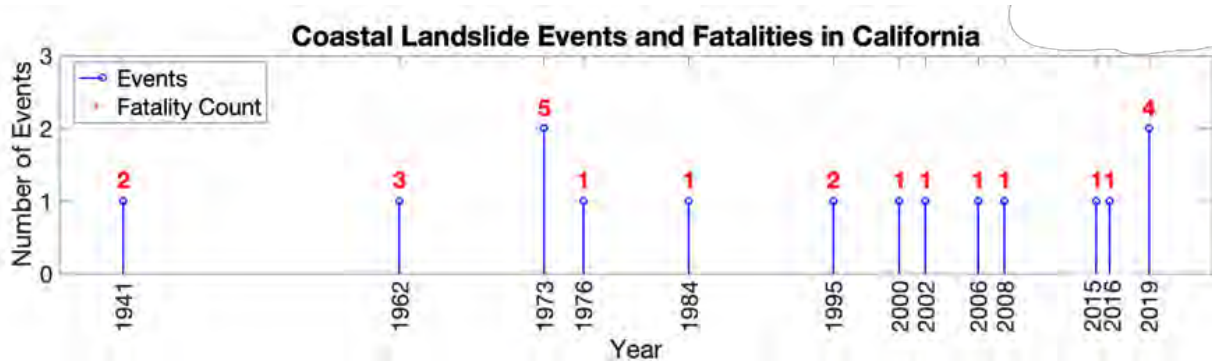


Credit: Alexander Sui



FATAL COASTAL LANDSLIDES IN CA

- 15 Fatal Landslides
- 25 Fatalities
- Goleta 1984



Study Sites

San Diego County

Beacons

15 Sensors

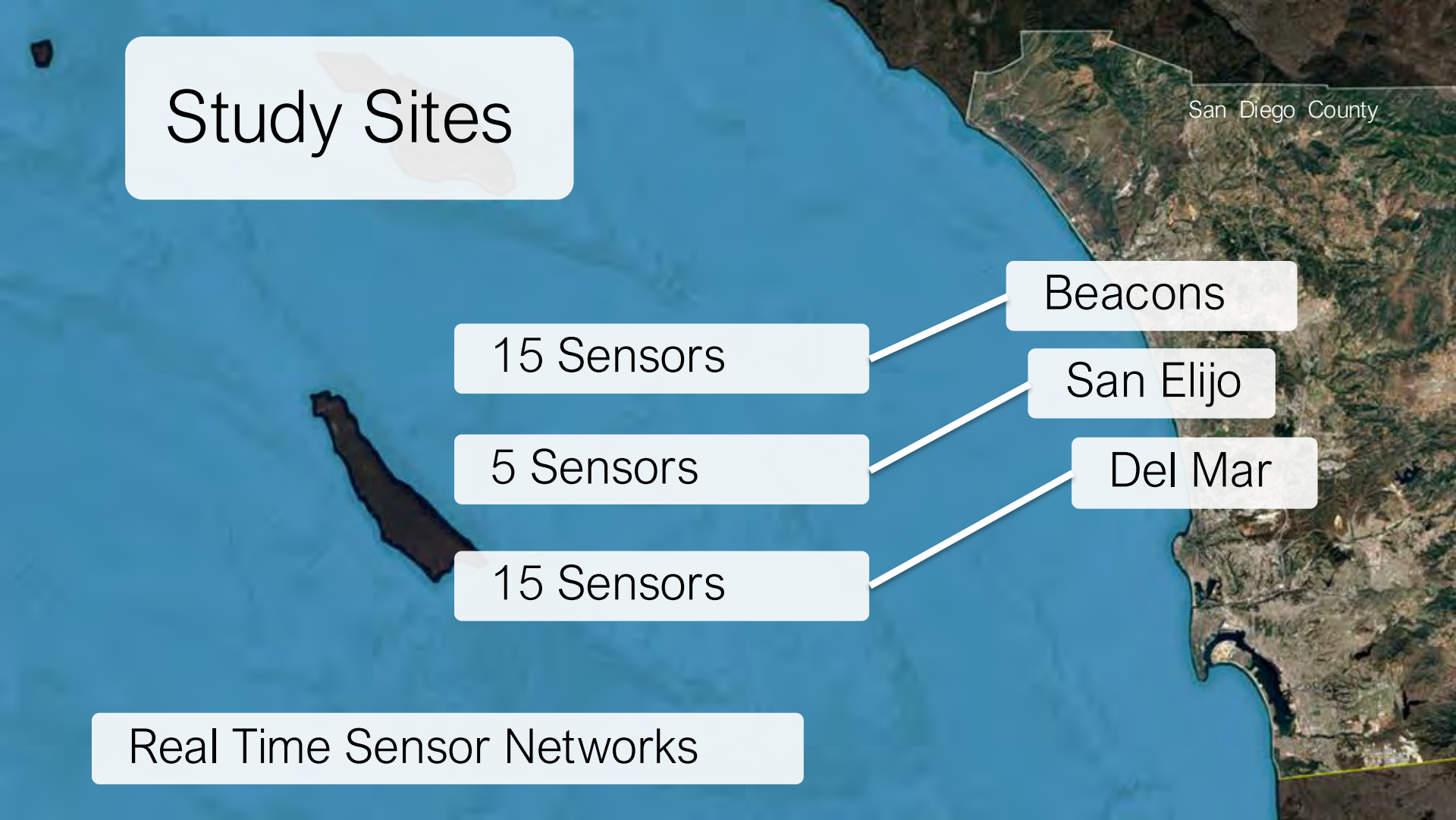
San Elijo

5 Sensors

Del Mar

15 Sensors

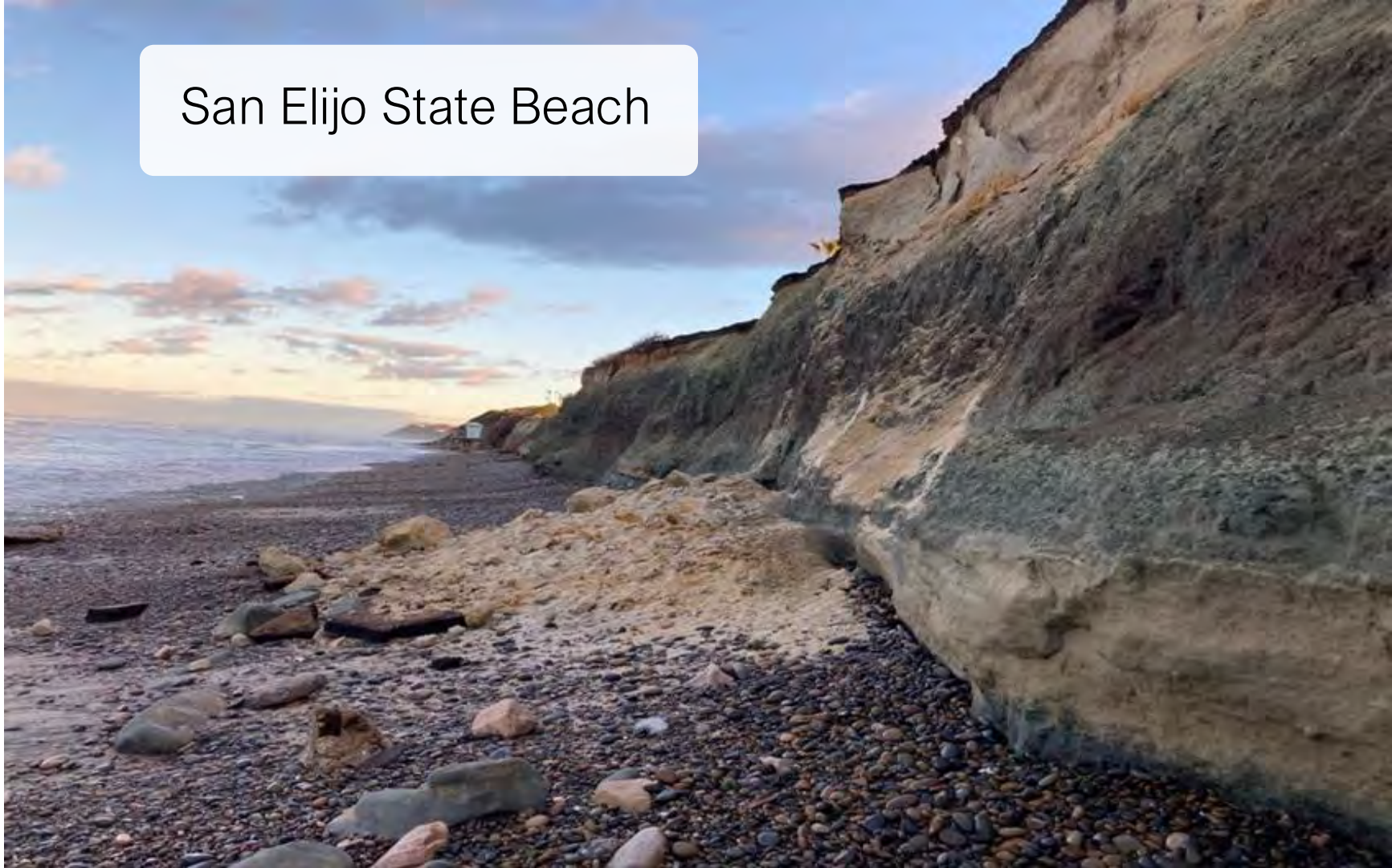
Real Time Sensor Networks



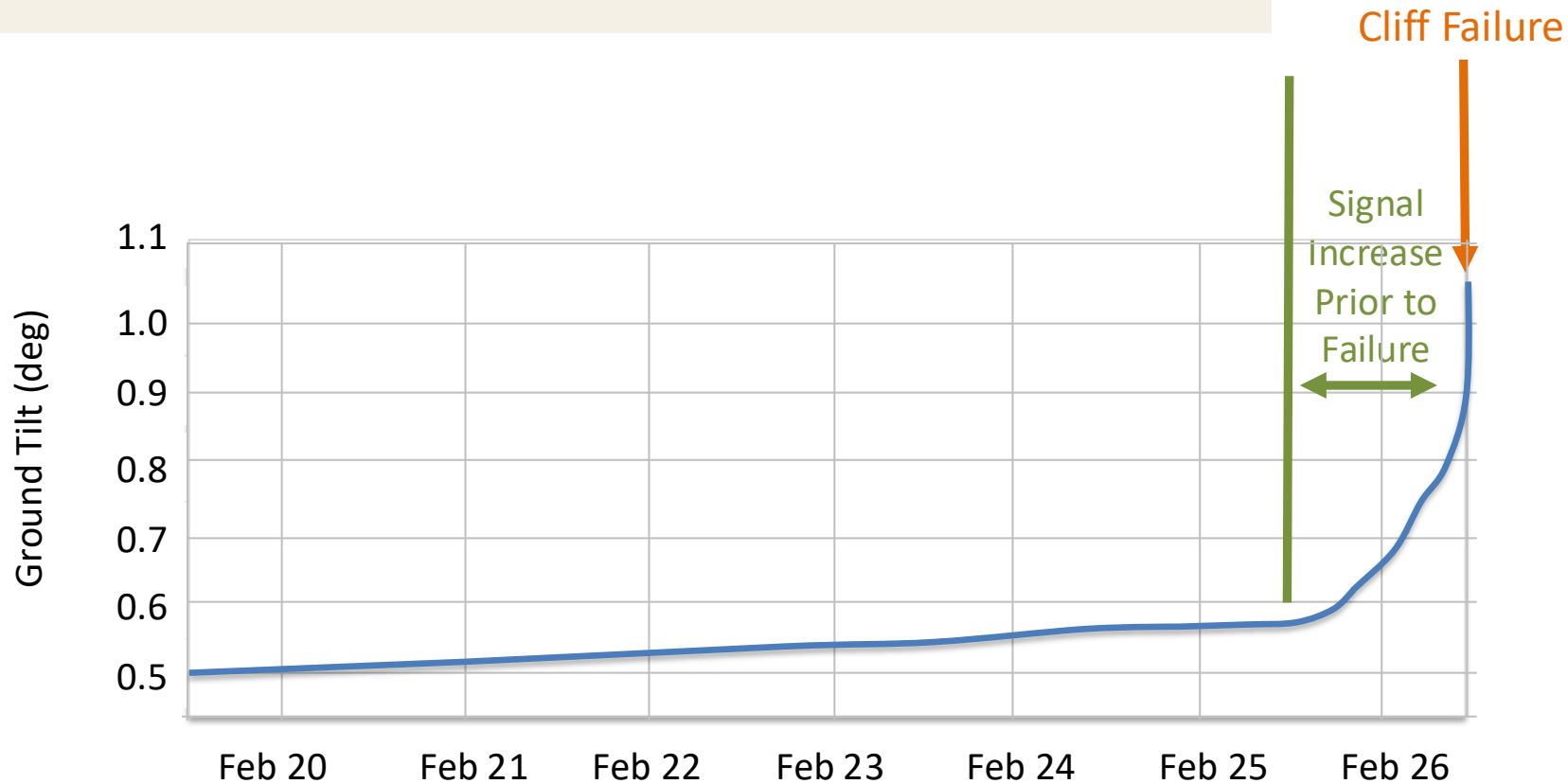
SENSOR INSTALLATION



San Elijo State Beach



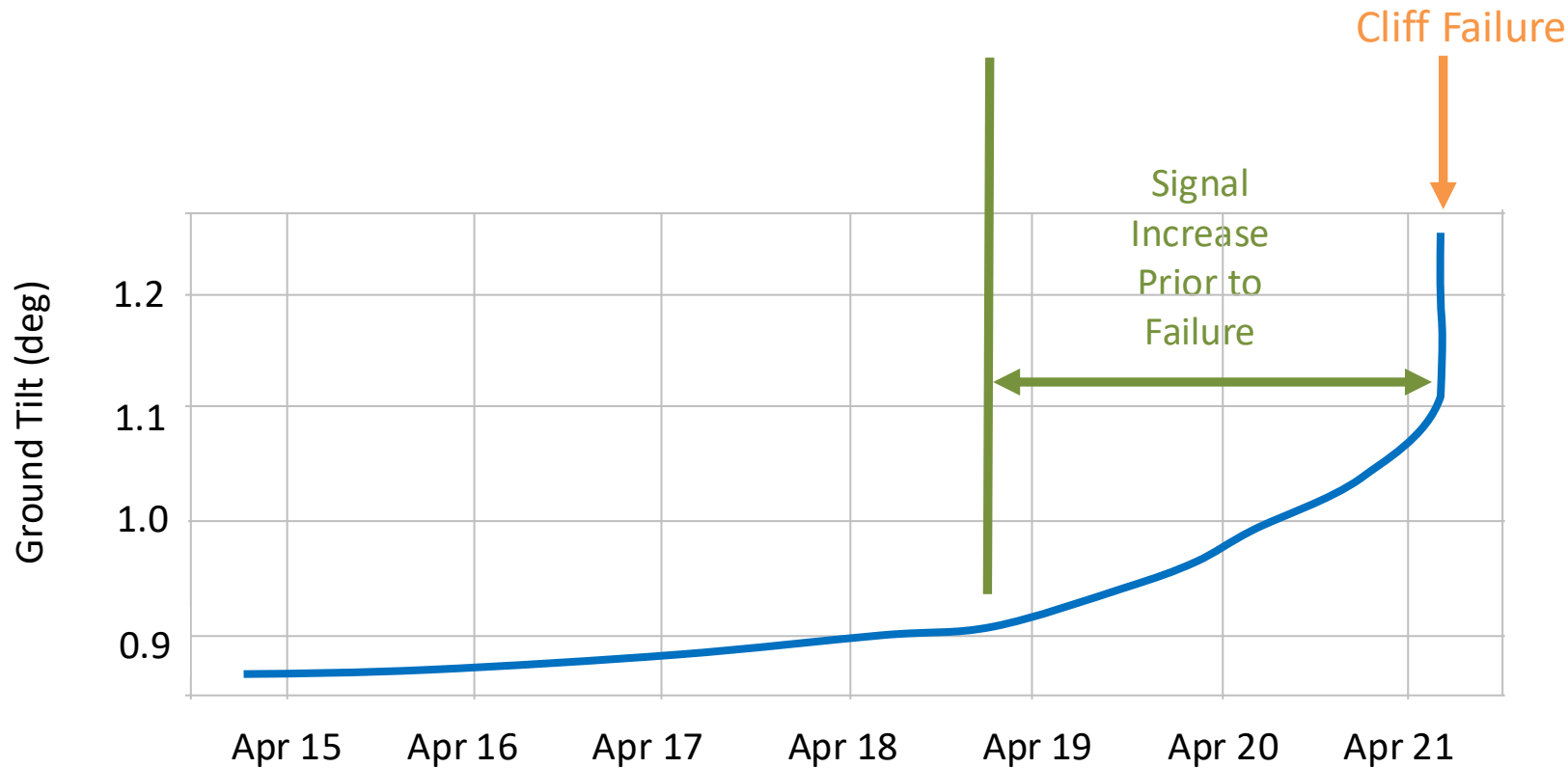
SENSOR READING PRIOR TO FAILURE



Del Mar



SENSOR READING PRIOR TO FAILURE

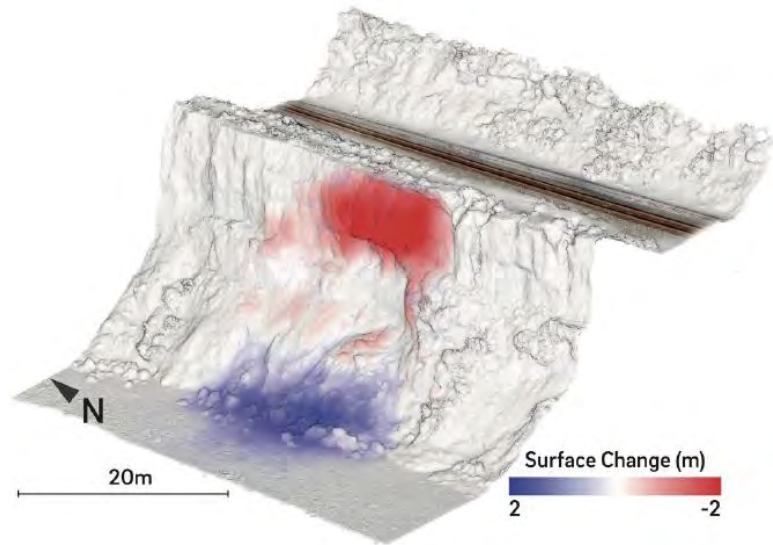
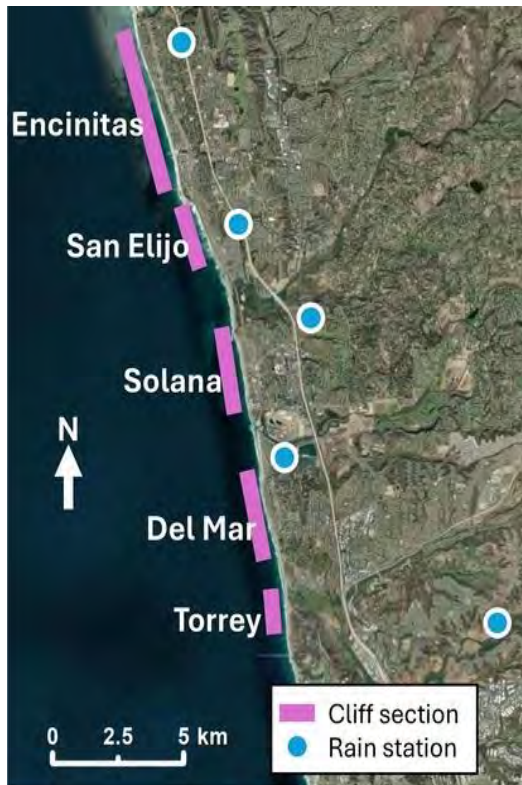
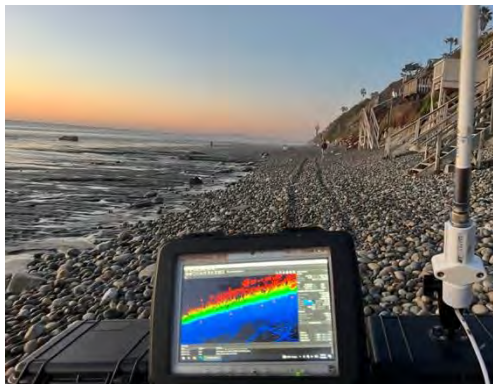


Possible action for imminent failures

- Temporary partial or full beach closure
- Temporary partial or full closure of the cliff top
- Controlled proactive rockfall detachment
- Signage added to specific, at-risk locations
- Continuous monitoring

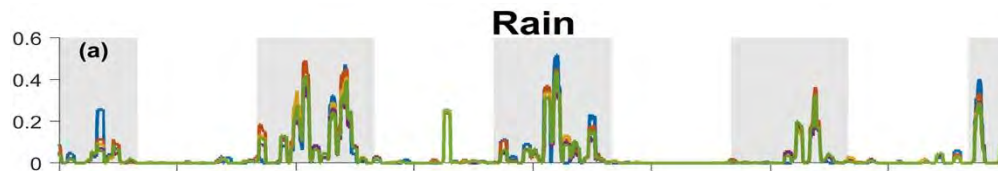


LIDAR MAPPING AND REGIONAL WARNINGS



LANDSLIDE DATABASE

10 Day
Mean Rainfall (in)



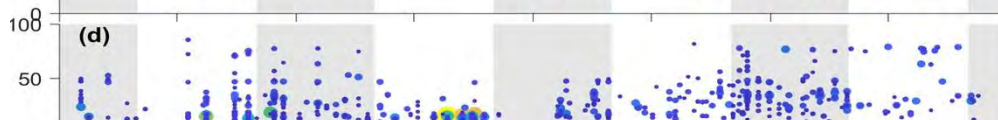
Cliff erosion



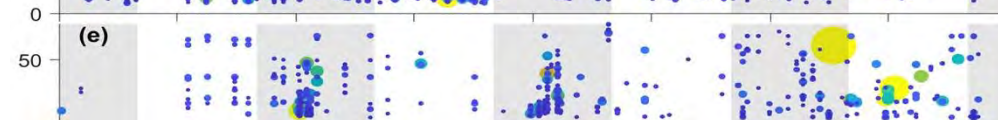
Encinitas



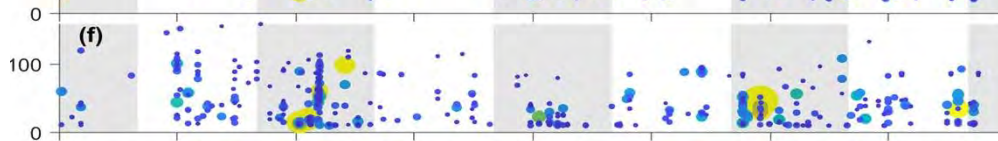
San Elijo



Solana



Del Mar



Torrey Pines

Cliff
Elevation (ft)

2022

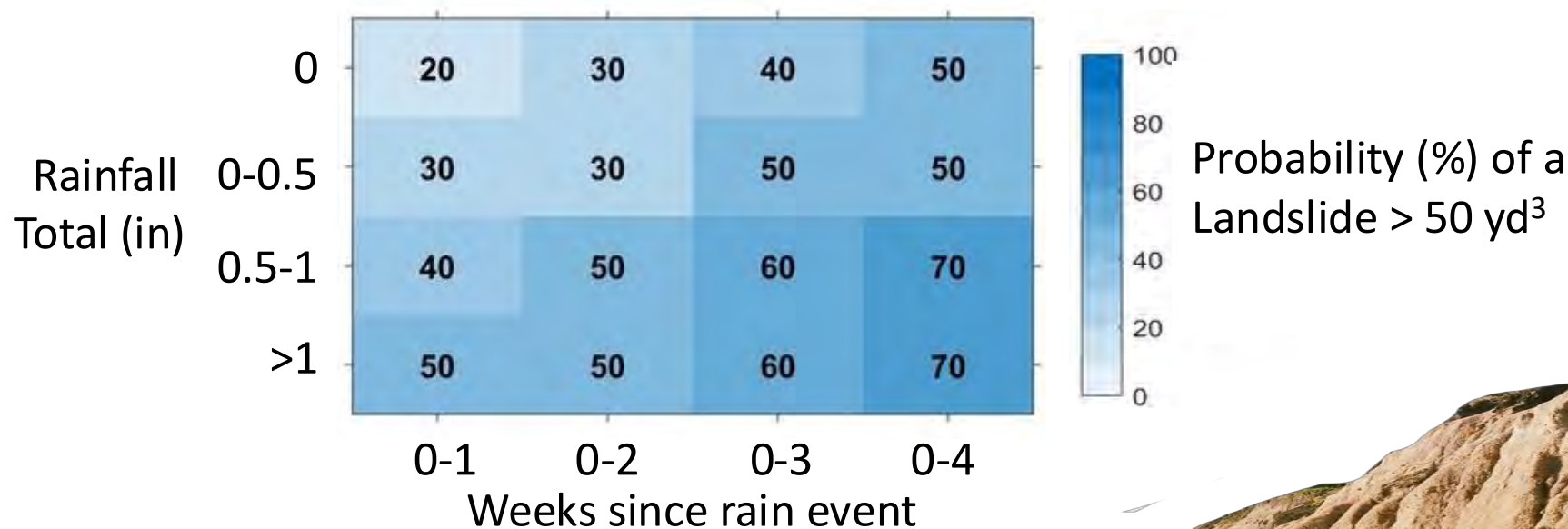
2023

2024

2025

2026

REGIONAL PROBABILISTIC WARNING



RECOMMENDATIONS

(1) Monitoring

In-ground sensors: Initial results indicate that real-time tiltmeters can provide an alert of impending collapse at a specific location.

Remote sensing monitoring: Continued topographic mapping can expand our landslide database leading to improved forecasting.

Routine field inspection: In several of our successful predictions, physical features (e.g. cliff top cracks) appeared preceding collapse and alerted us where to focus attention.

(2) Warnings

Regional Warnings: Forecasts of impending intense rain storms, coupled with surf and tide models, can enhance our capability to identify areas of risk.

Establish warning protocols: If and when a prediction can be made, a plan of action for coastal managers, marine safety, rail operators, and other stakeholders needs to be developed to respond effectively.

(3) Education

Outreach programs: Reducing the likelihood of injury from landslides can be accomplished by better informing beachgoers of where and when the risk is heightened.

Continued research: While much has been learned in our four-year project, continued data collection and expansion to other regions is necessary to better learn how to make predictions reliably.



San Diego Coastal Mapping Program

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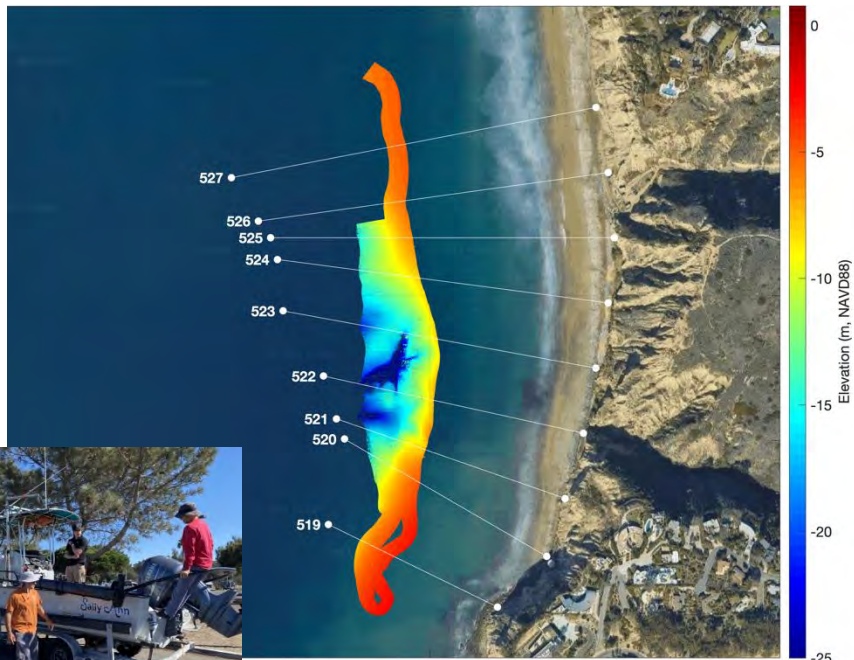
GPS Survey Tools



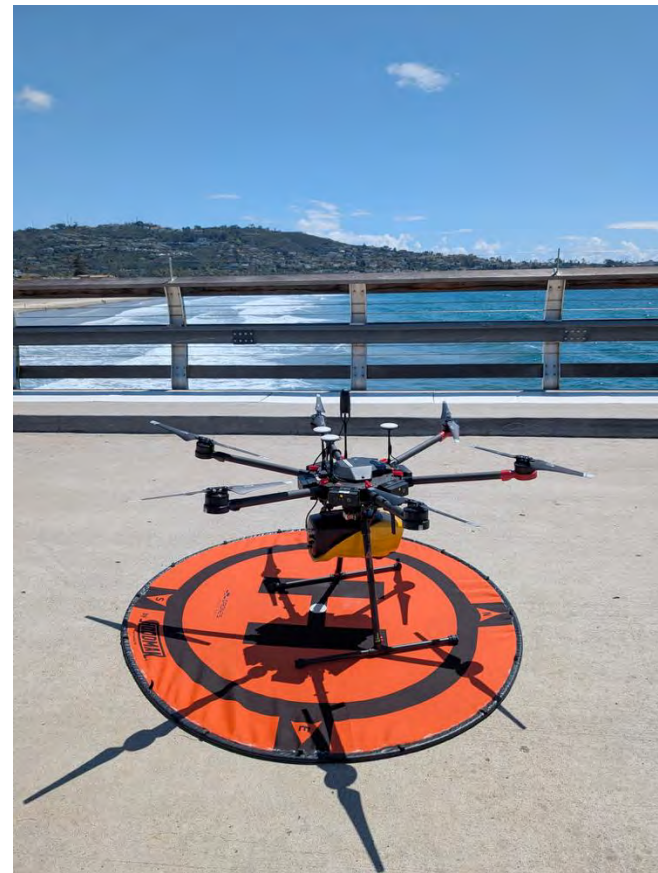
Lidar Photos Drones



Shallow Water Multibeam



Bathymetric Drone



Coastal Monitoring



South County – 20 km

Coronado

San Diego

Monthly
Beach

Monthly
Beach

Monthly
Beach

Monthly

Monthly Beach
Quarterly Bathymetry

Imperial
Beach

2008

2015

NOW

North County – 40 km

Oceanside

2-3x Yearly

Weekly

Monthly Beach
Quarterly Bathymetry

Monthly Beach / Quarterly Bathymetry		
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Monthly Beach / Quarterly Bathymetry

2001

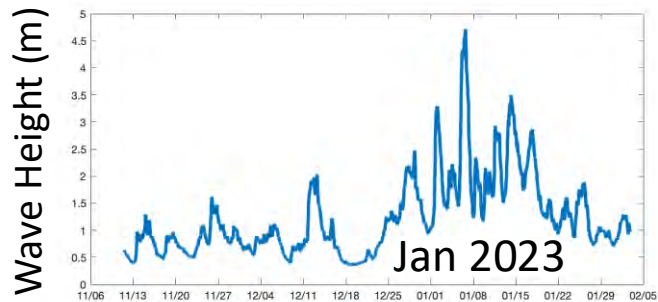
2005

2010

NOW

La Jolla

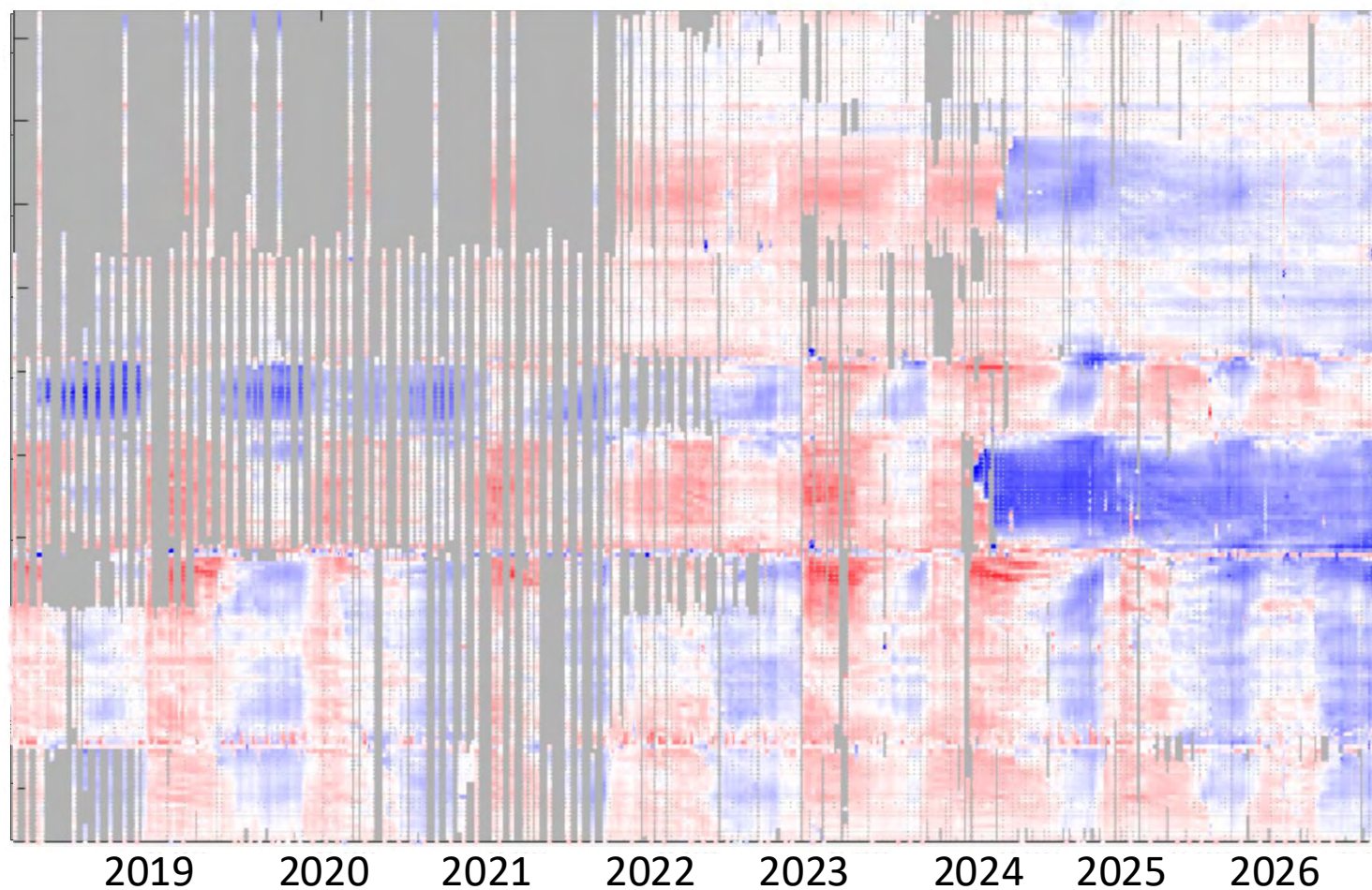
Rapid Response Surveys



Carlsbad

20 km

Torrey Pines



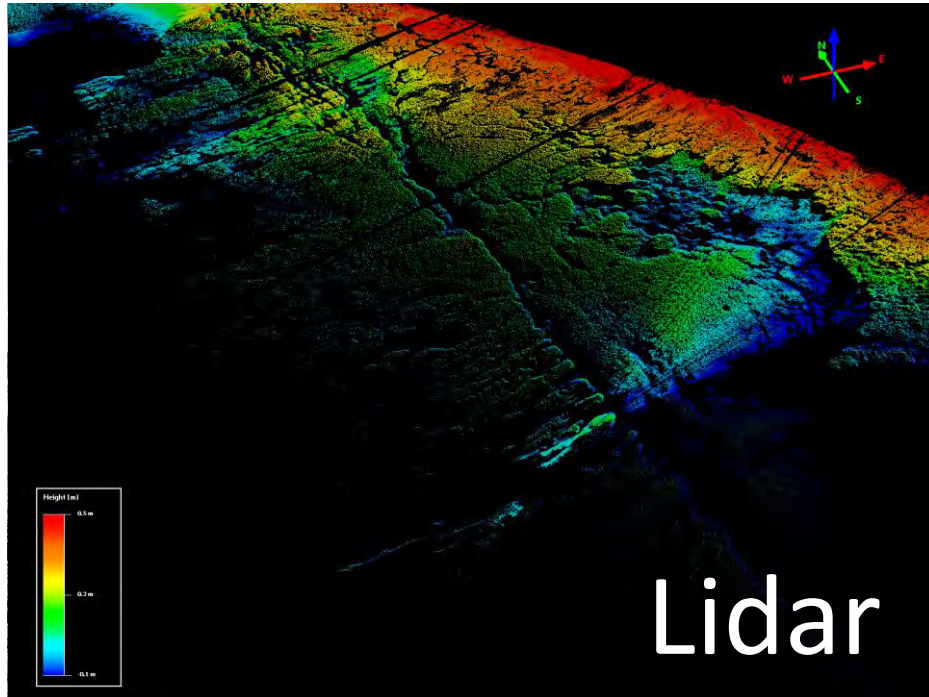
Beach Change (m)

50

0

-50

Bedrock Mapping

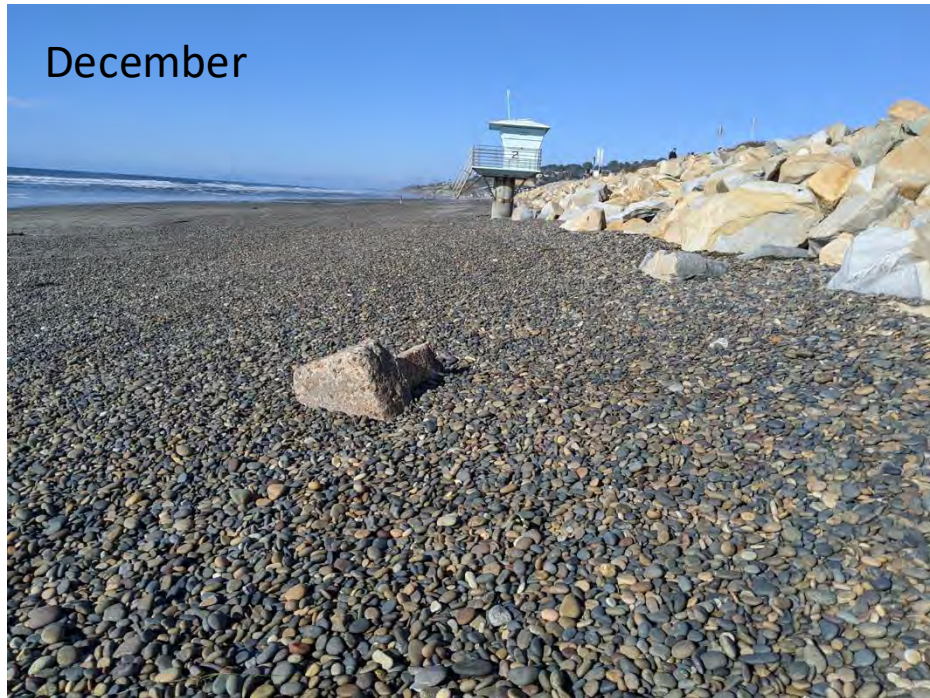


Sand and Cobble

November



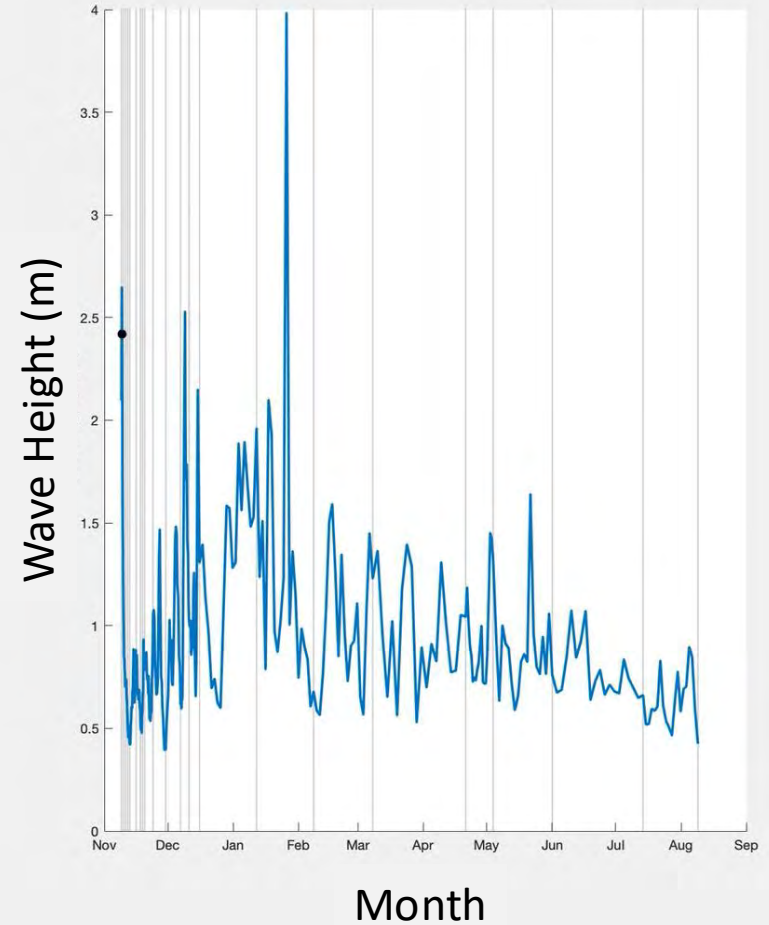
December



RFID Cobble Tracking



RFID Cobble Tracking



Subsurface Cobble Monitoring

Excavations
GPR
In situ Sensors

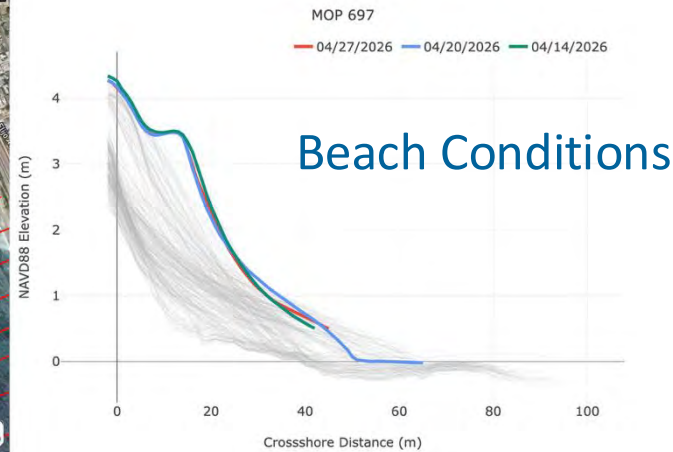
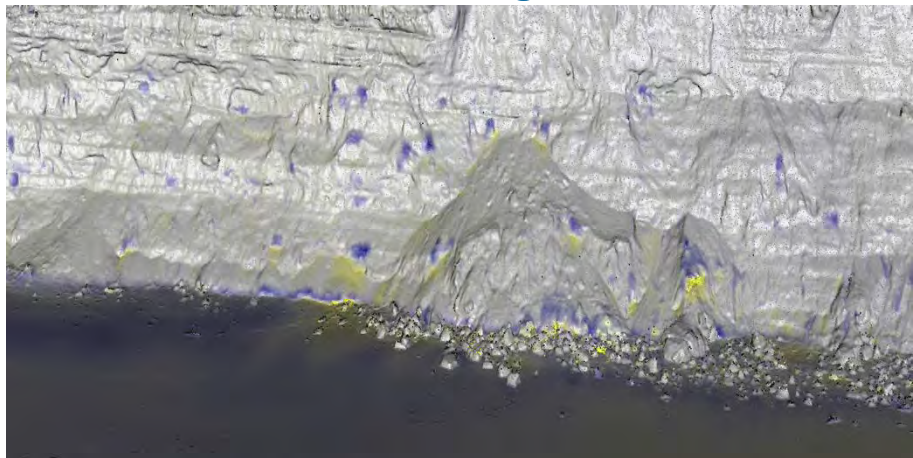


**Advanced Monitoring of Subsurface Sediment Structures
Within Gravel Berms**

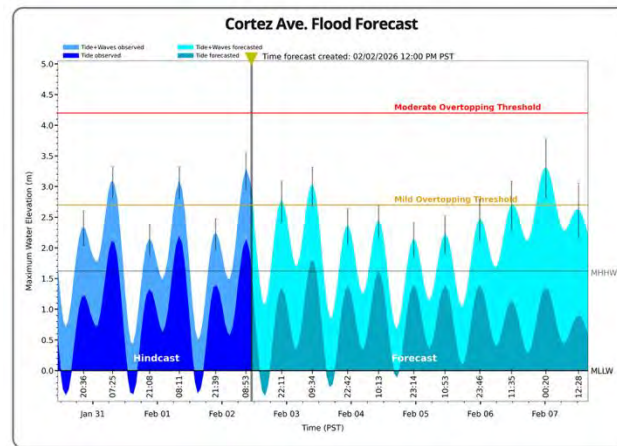
H. Matsumoto¹, G. Shtienberg², and A. P. Young¹

Rapid Management Products

Cliff Changes



Flood Forecast



Statewide Coastal Mapping

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STATEWIDE AIRBORNE SURVEYS

Adam Young and Luc Lenain

Consistent Systematic Surveys
Routine Updated Baseline Data

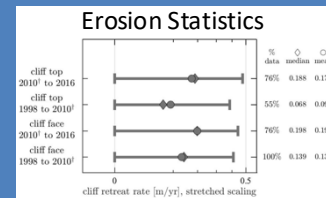
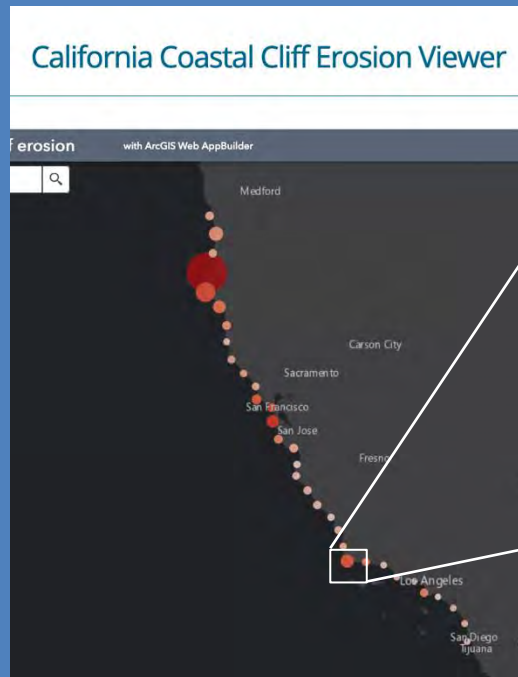
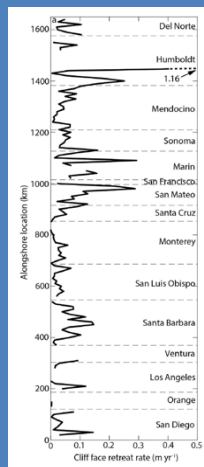
Lidar
Imagery
Hyper Spectral
Video

Flights Conducted:
2023-current
Spring and Fall
El Nino



STATEWIDE EROSION ANALYSIS

1998-2009-2016-2023
Online viewer



Coastal Hazard Stations

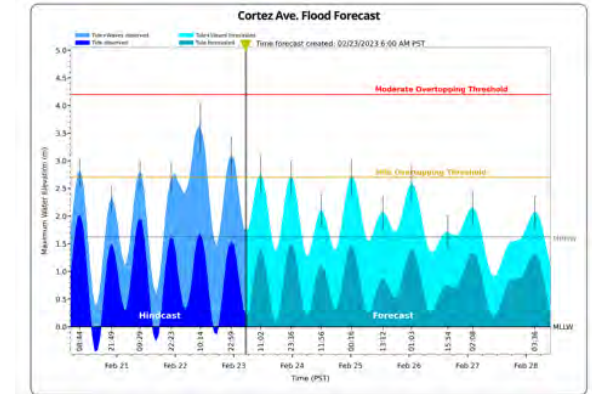
Autonomous Remote Coastal Hazard Monitoring Stations

Automated Hazard Monitoring
Continuous Data
Online Dashboards

Offshore



Onshore



Autonomous Remote Coastal Hazard Monitoring Stations

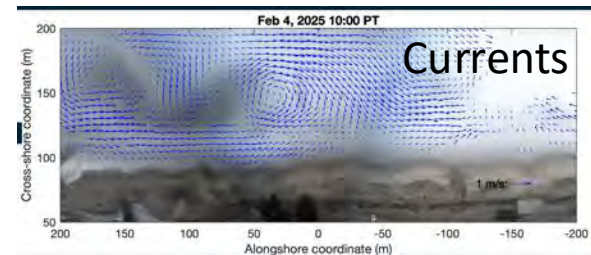
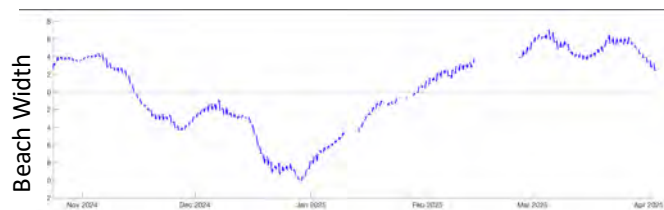
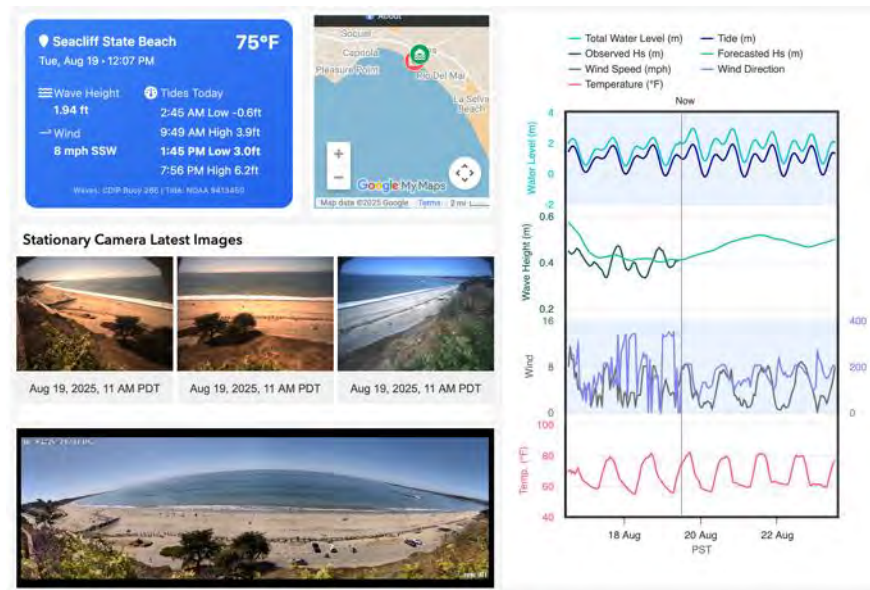
Torrey Pines
South Carlsbad
Solana Beach
Del Mar
Scripps
Seacliff State Beach
Doheny



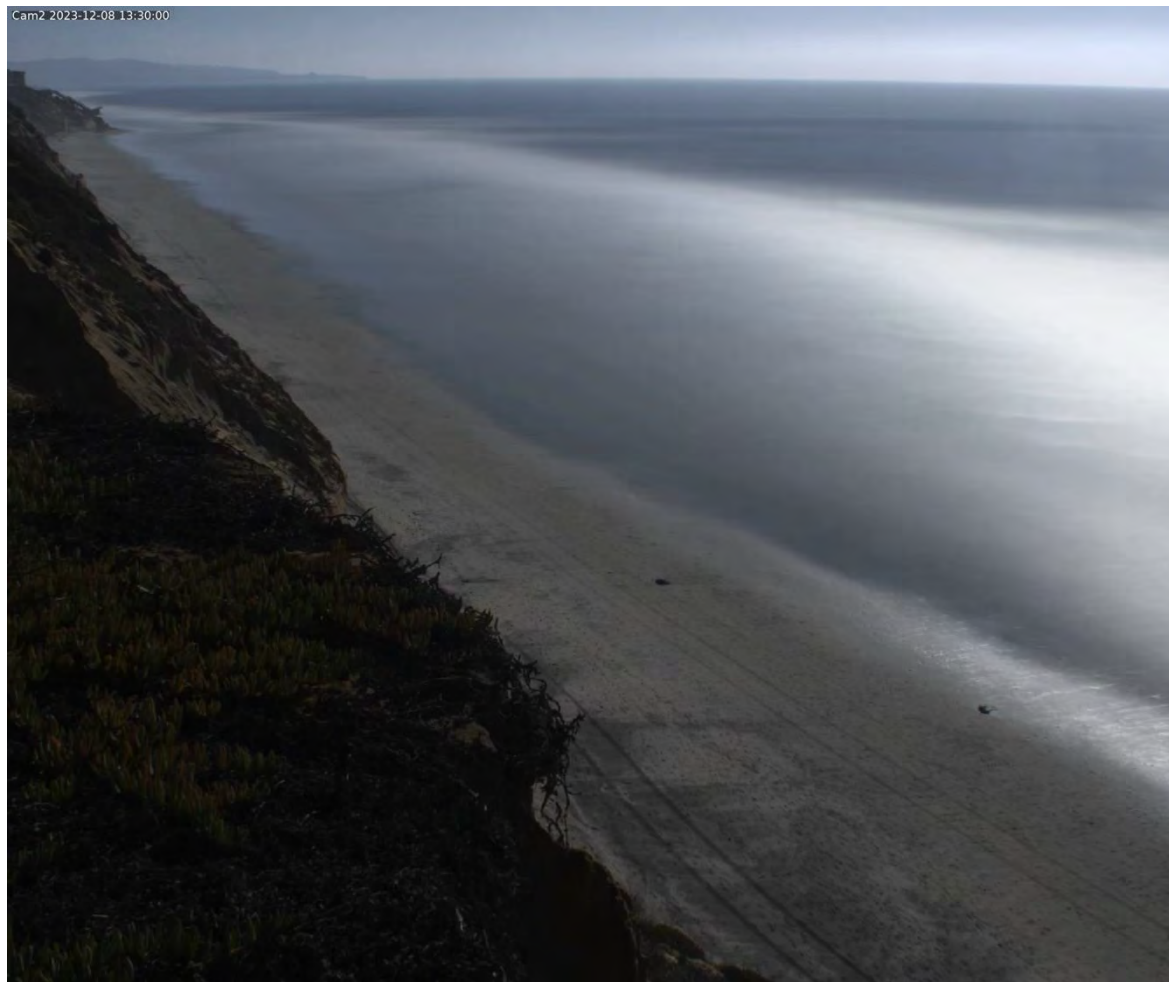
Applications

Shoreline Change
Beach Slope
Wave Runup
Flooding
Estuary Closures
Bathymetry
Currents
Nourishments
Landslides
Cobble Berms

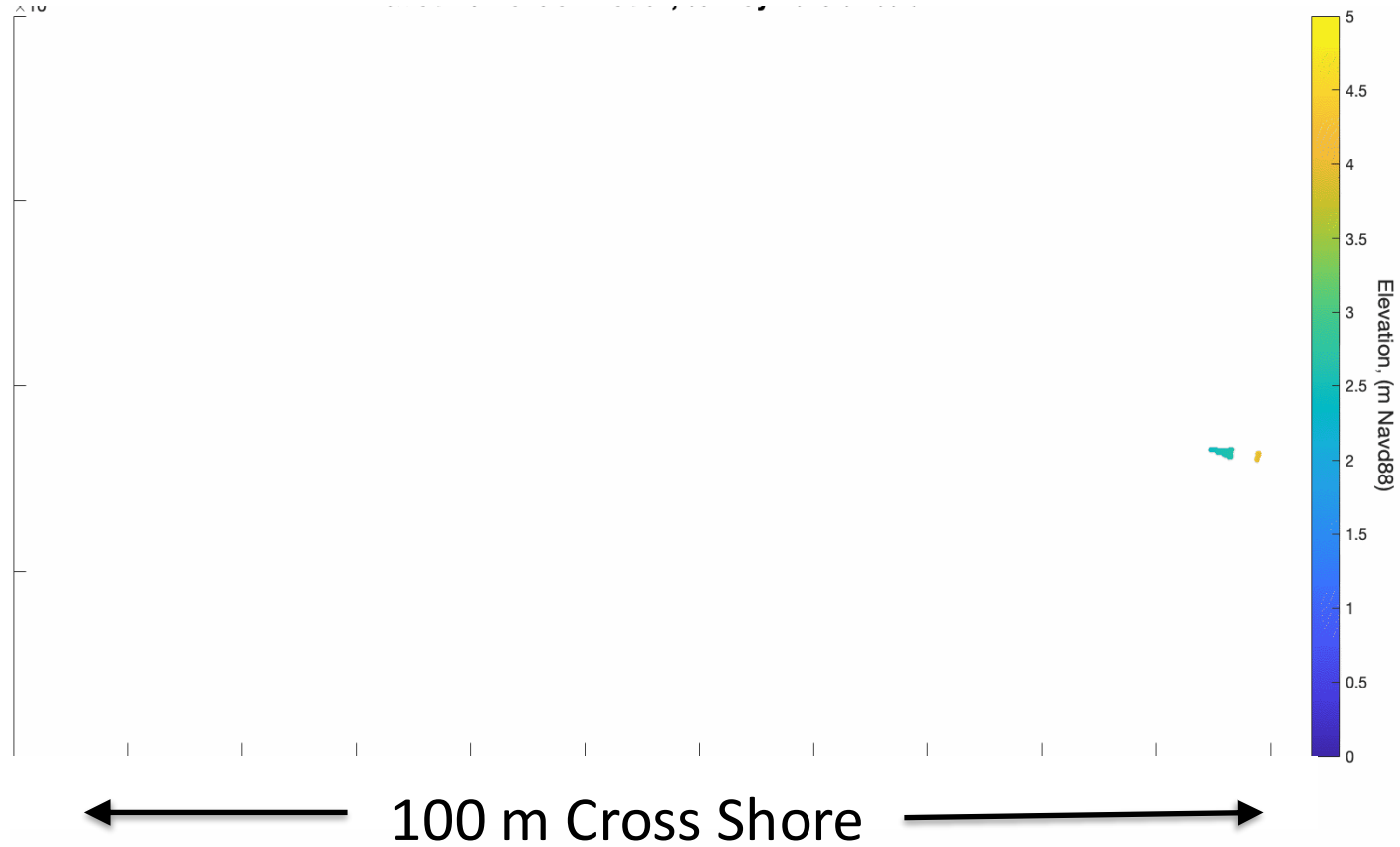
Online Dashboards



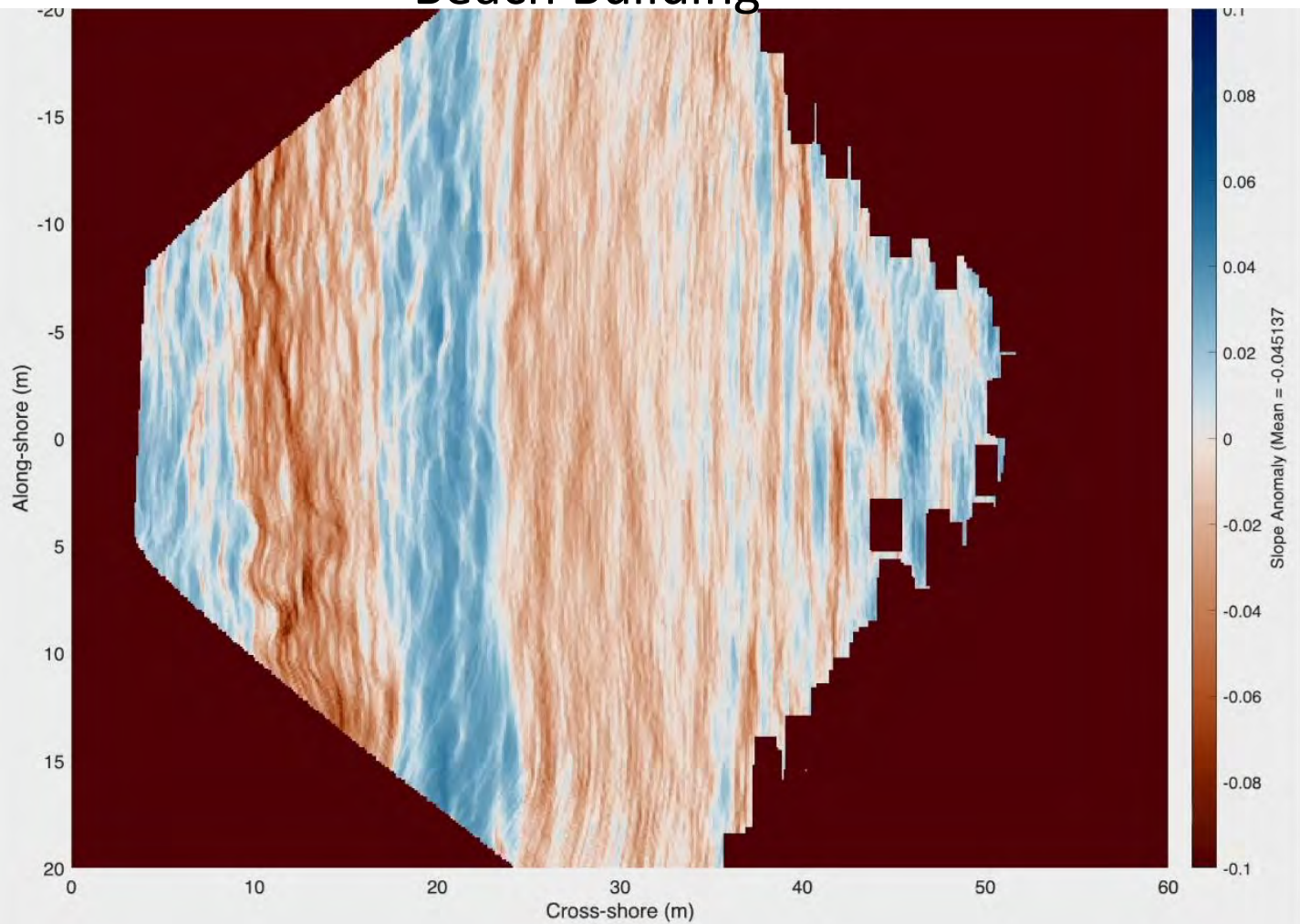
Solana Beach



Waves
Runup
Overtopping
Beaches



Beach Building



Summary

- Coastal Mapping Program
- Continuous Monitoring Stations
- Landslide Warning System
- Research Applications

Scripps 1910



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