# Spatially Varying Forecasts of Extreme Total Water Levels in Oregon: Drivers and Impacts

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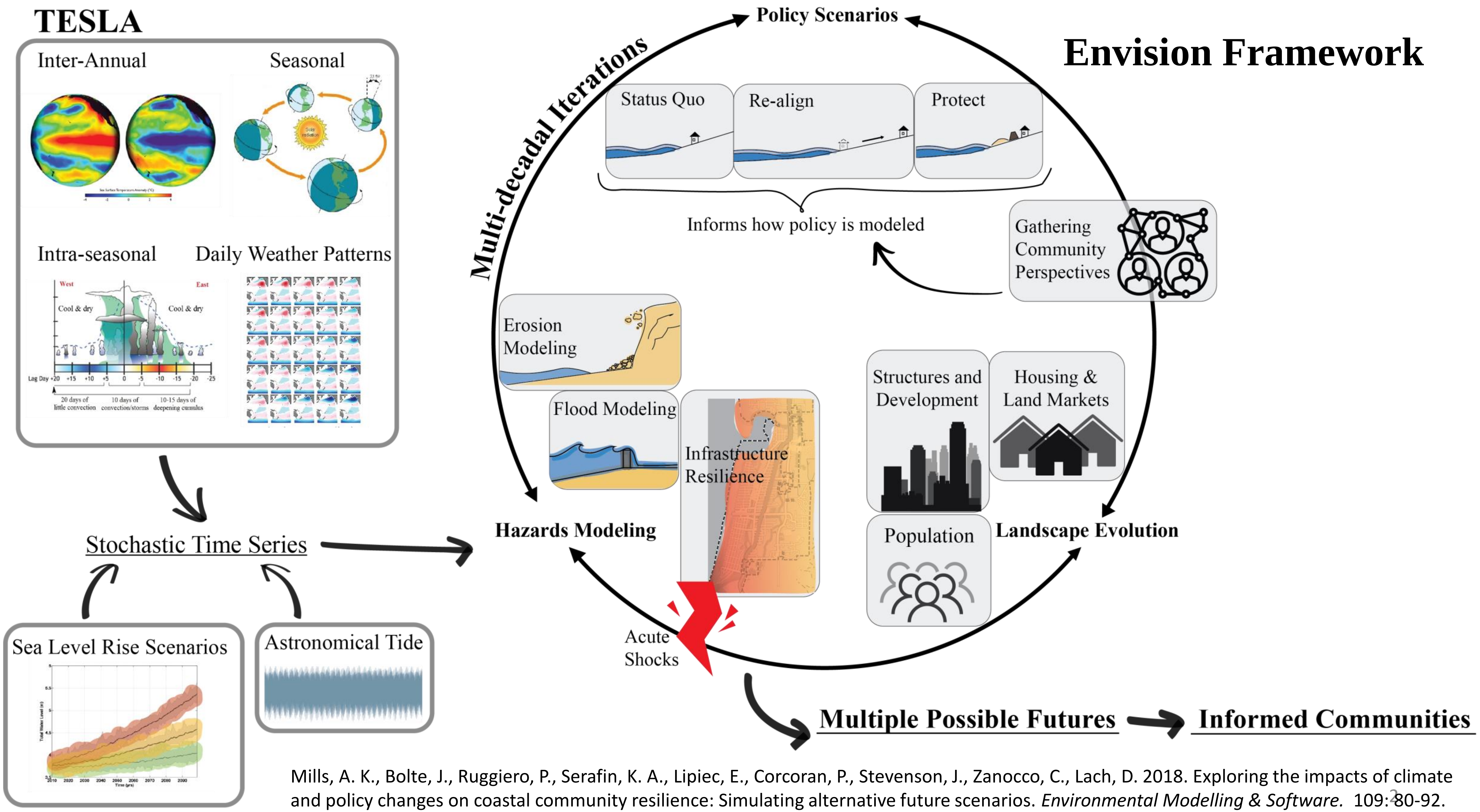
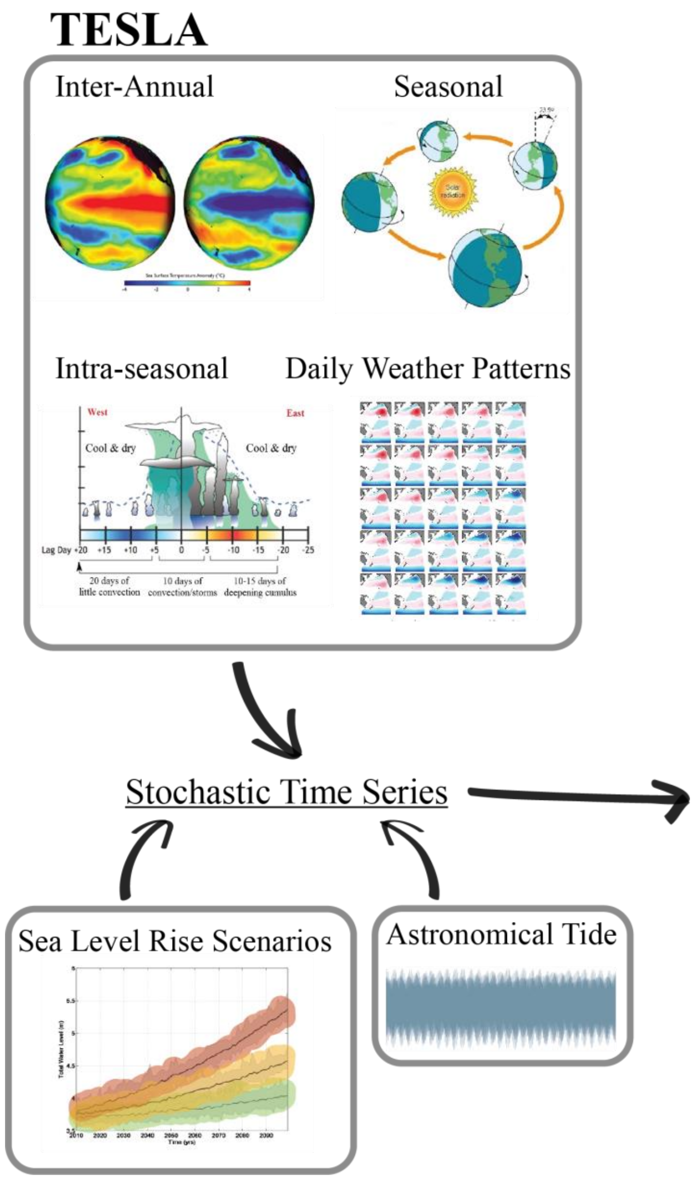



Mills, A. K., Bolte, J., Ruggiero, P., Serafin, K. A., Lipiec, E., Corcoran, P., Stevenson, J., Zanocco, C., Lach, D. 2018. Exploring the impacts of climate and policy changes on coastal community resilience: Simulating alternative future scenarios. *Environmental Modelling & Software.* 109: 80-92.




# TESLA outputs can be used to:

Develop probabilistic input for assessments of extreme coastal flooding and erosion at scales relevant for adaptation and resilience planning and decision making

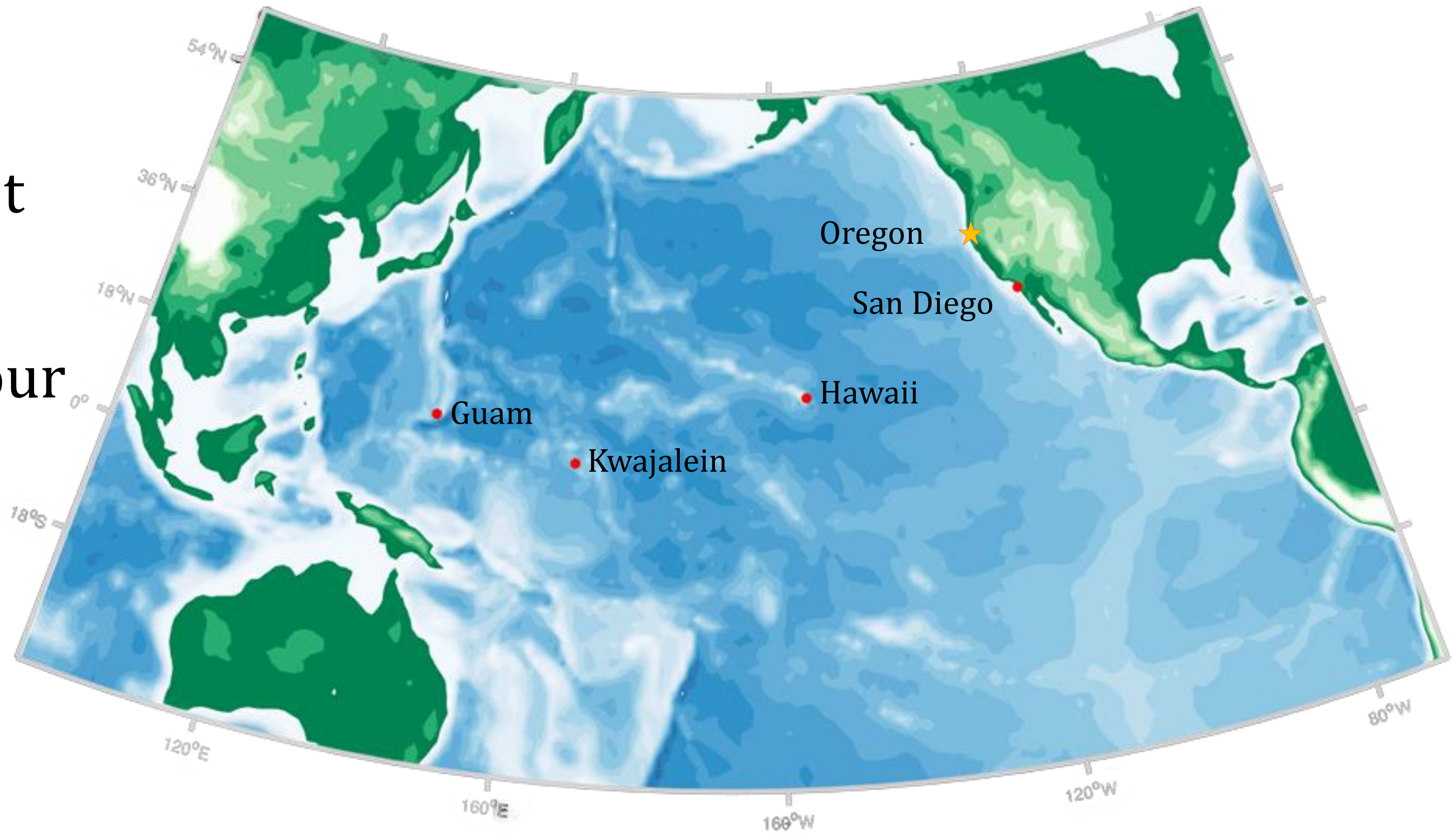
→ Spatially variable probabilistic impact analysis
- → hazards maps

→ Inputs to coastal evolution models
- → Alongshore sediment transport
- → Flooding and erosion

→ Inputs to ecosystem models
- → Wetland and estuary health

# TESLA Background

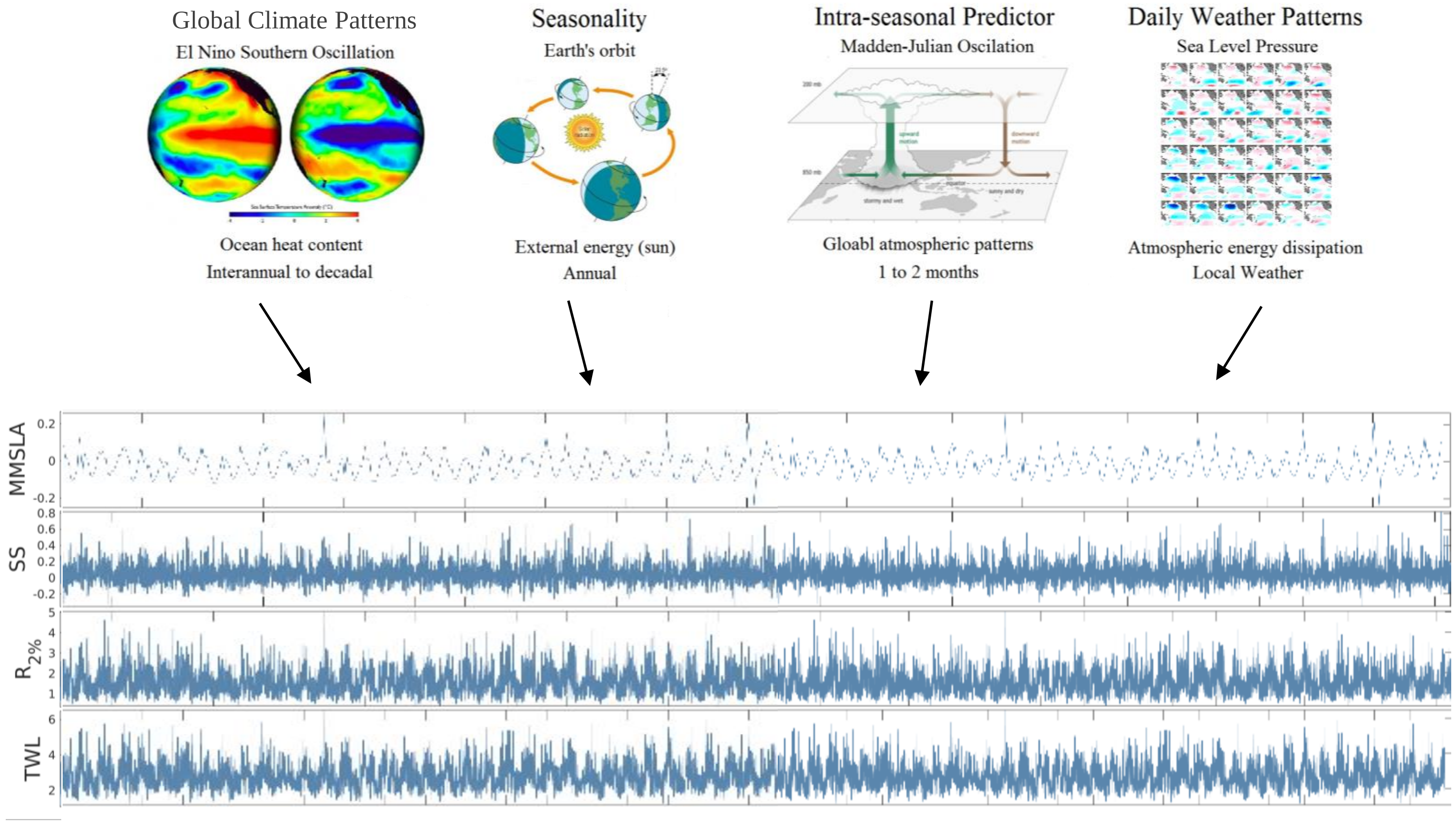
- TESLA – statistical framework to forecast TWLs
- Being developed at four naval sites
- New site: Oregon

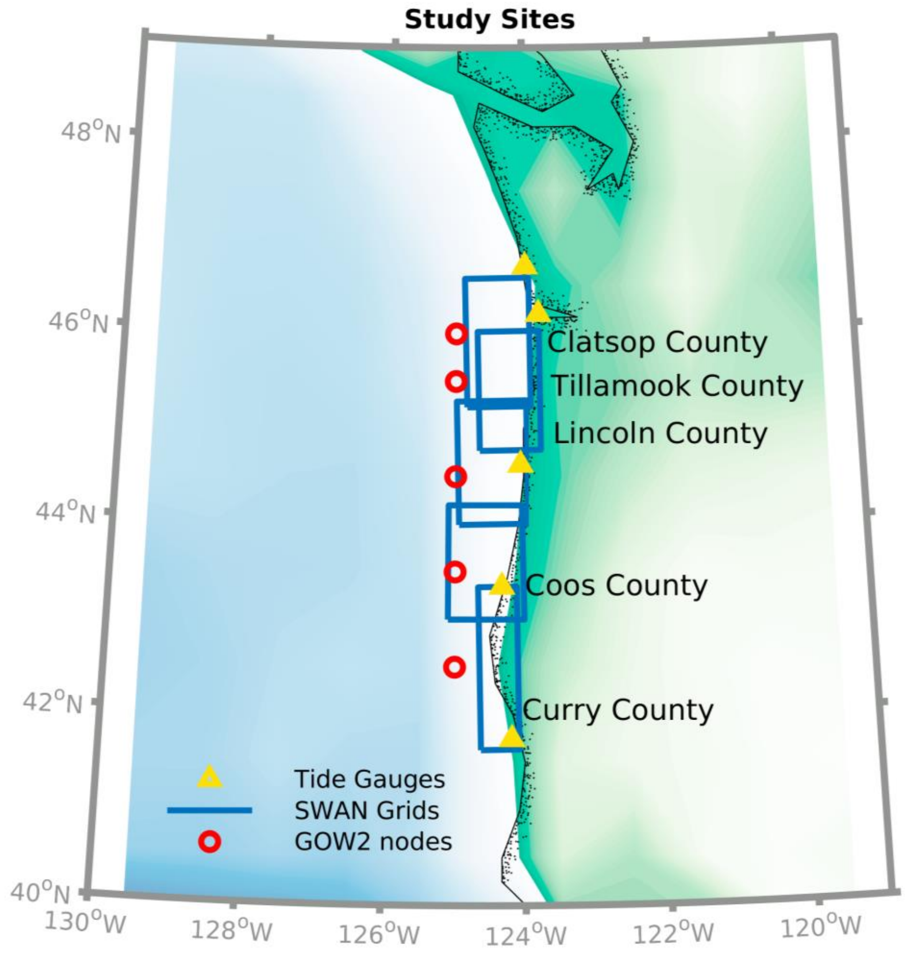



Anderson, D., Rueda, A., Cagigal, L., J. A. A. Antolinez, F.J. Mendez, and Ruggiero, P. ( 2019), Time-varying Emulator for Short and Long-Term Analysis of Coastal Flooding, *J. Geophys. Res. Oceans*.

# **TESLA** – Statistical framework to forecast TWLs

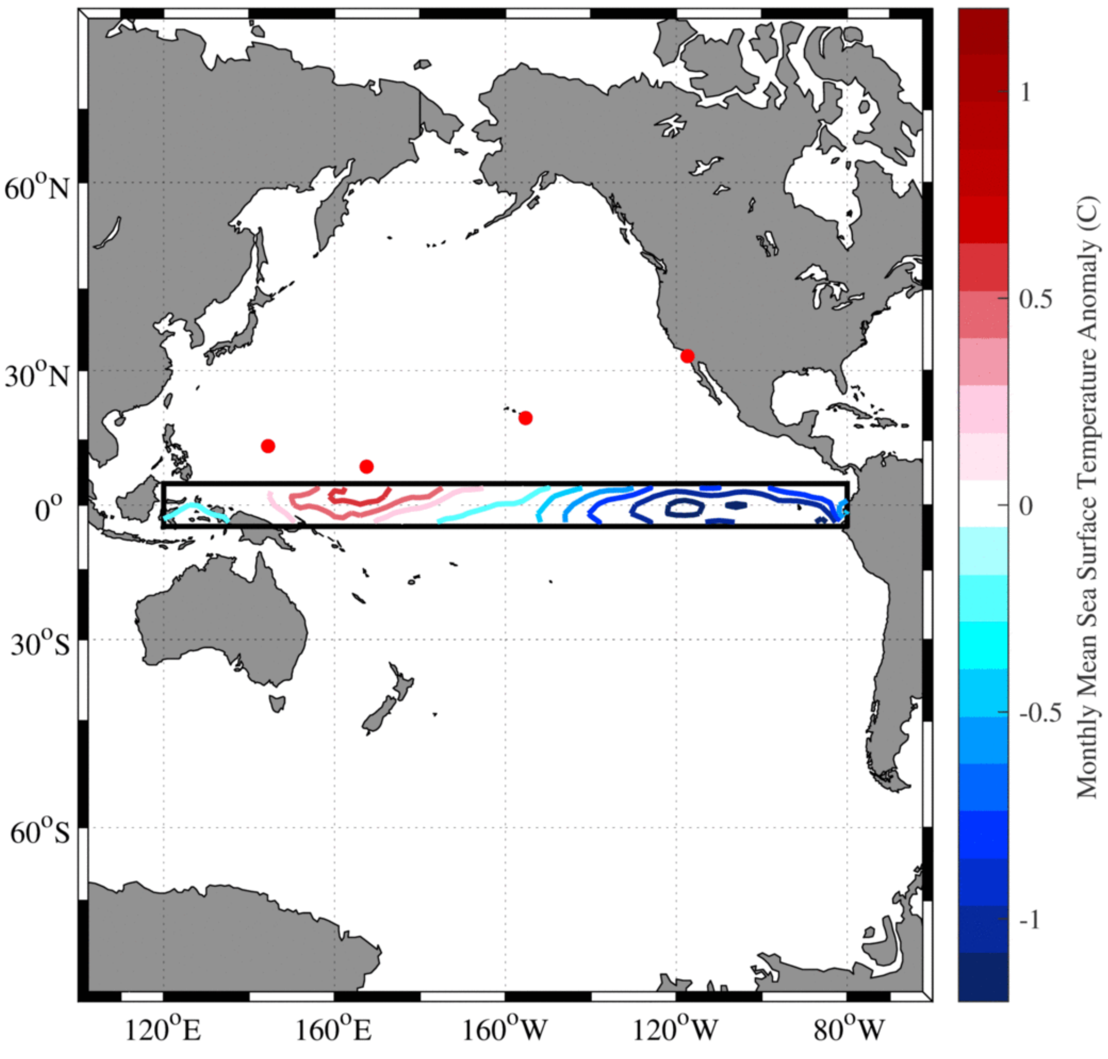
$$\mathbf{TWL = MSL + \eta_A + \eta_{NTR} + R_{2\%}}$$

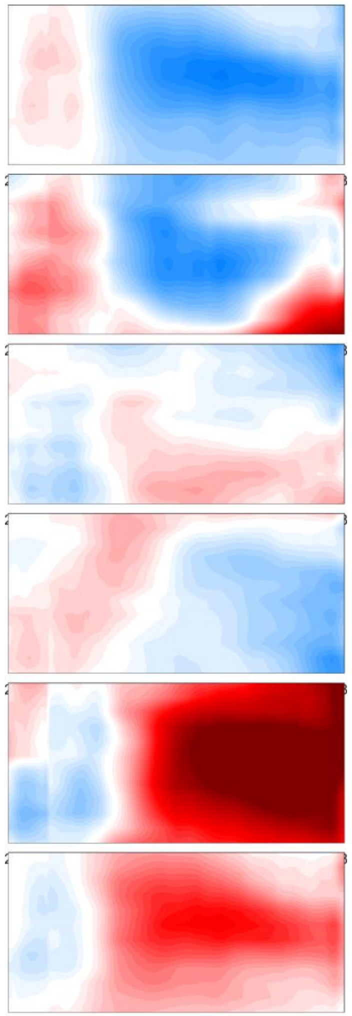


# Modeling the drivers of TWLs- Downscaling from large climate patterns

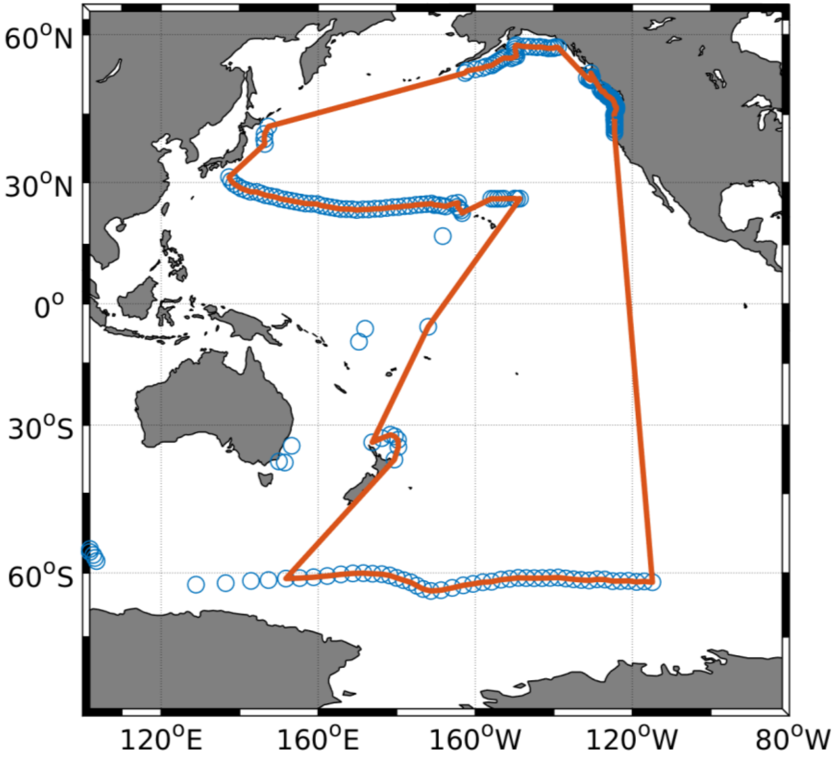
Annual Weather Types (AWTs) from PCs of SST around the equator

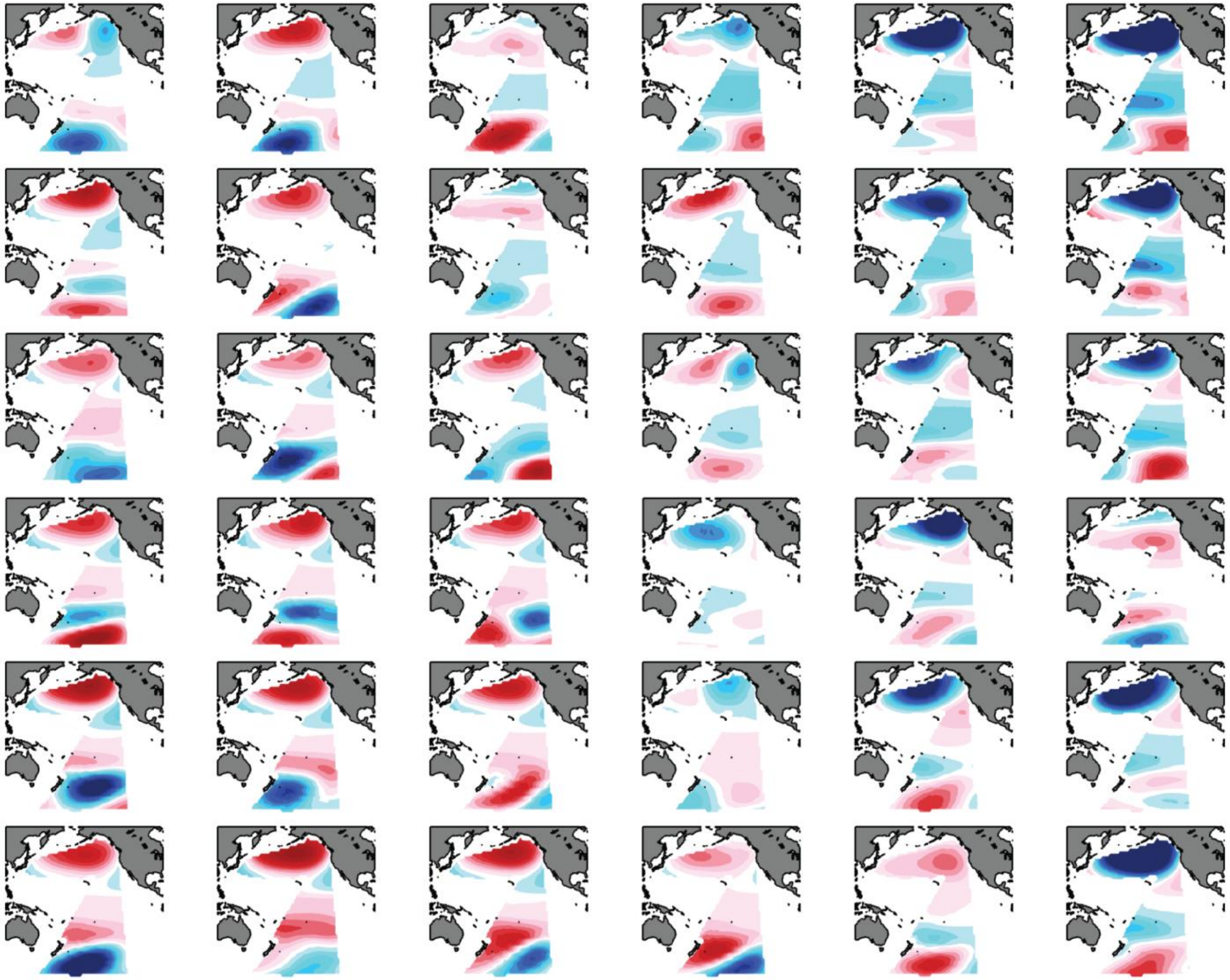


# Modeling the drivers of TWLs- Downscaling from large climate patterns

## Daily Weather Types from PCs of SLP and SLP gradients

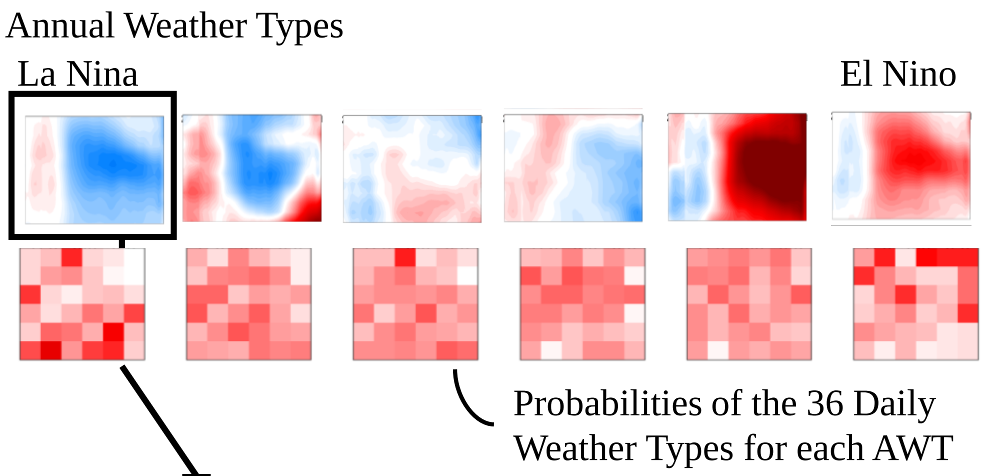


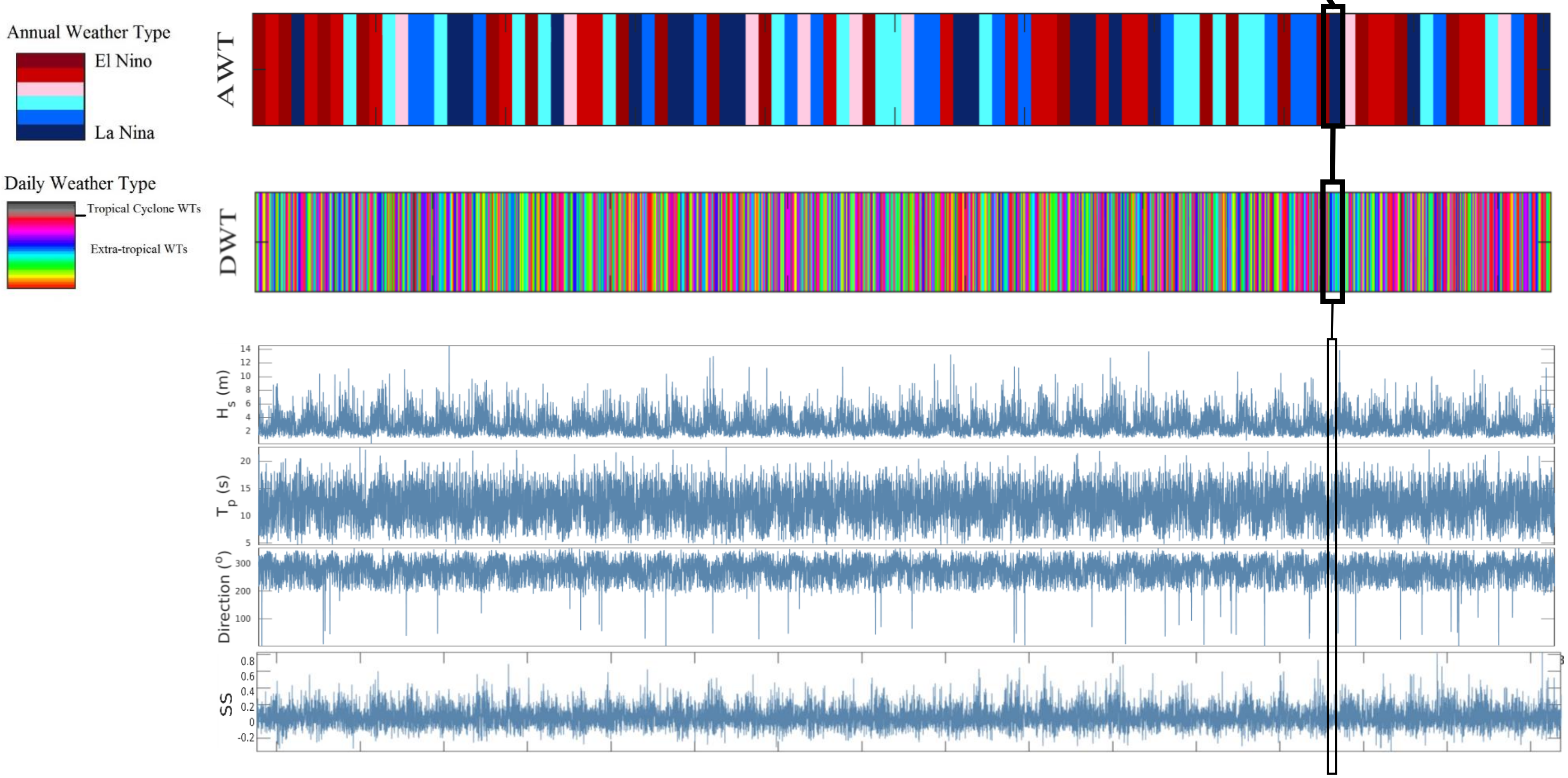



Perez, Jorge & Mendez, Fernando & Menendez, Melisa & Losada, I.J.. (2014). ESTELA: a method for evaluating the source and travel time of the wave energy reaching a local area. Ocean Dynamics.

# Modeling the drivers of TWLs

Fill timeseries of drivers of TWLs by downscaling from Annual Weather Types, to Daily Weather Types, to wave characteristics

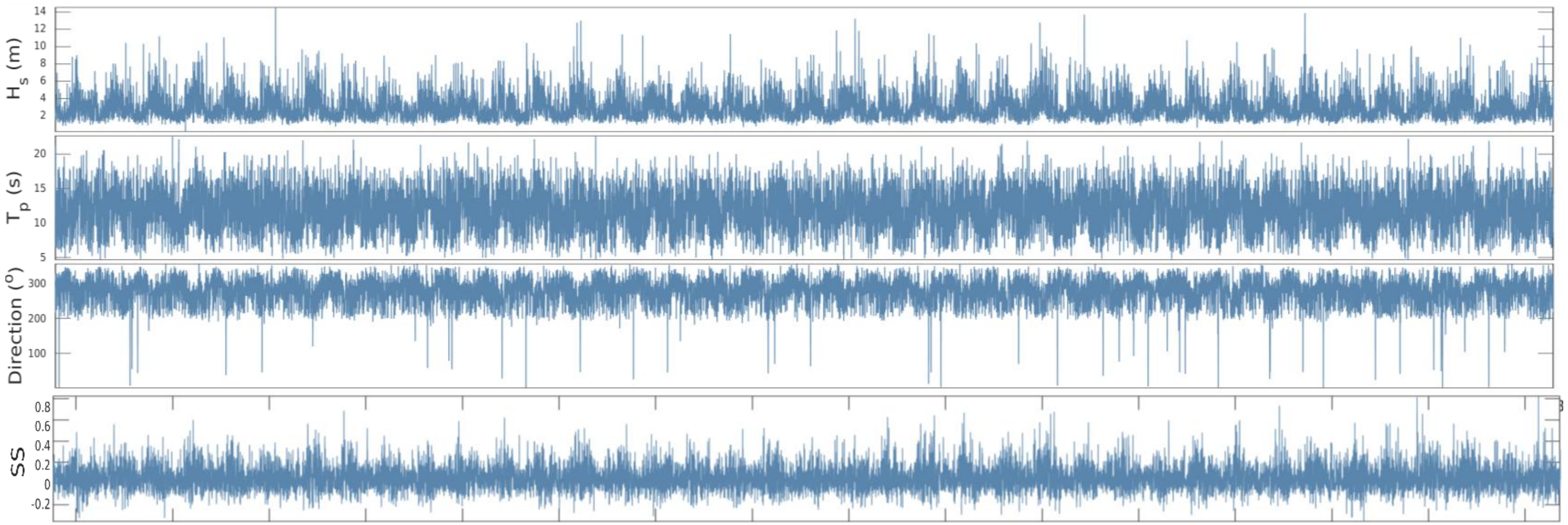



Joint probabilities link AWTs, DWTs, and offshore wave characteristics

# Modeling the drivers of TWLs- Storm Surge and Runup

Populate timeseries of wave characteristics using conditional probabilities based on observed timing and distributions



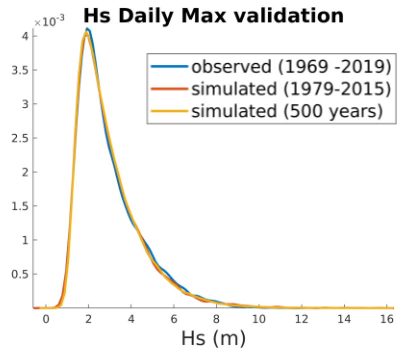

$$TWL = MSL + \eta_A + \eta_{NTR} + R_{2\%}$$

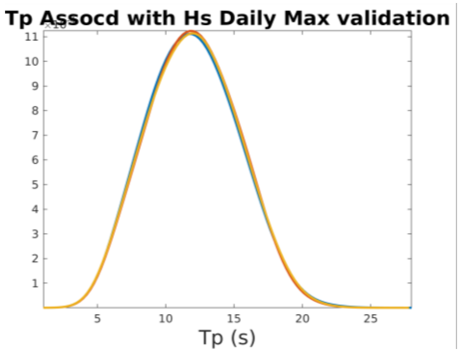
Calculated using Stockdon et al., 2006

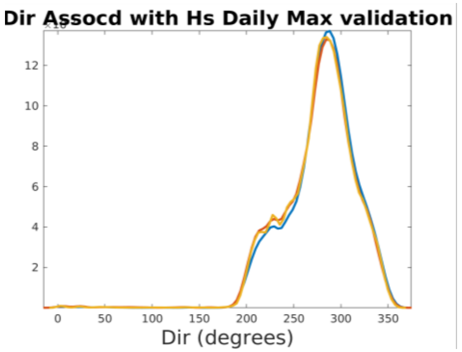
**Storm Surge**

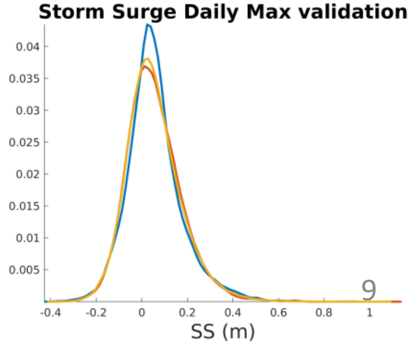
Monthly Mean Sea Level Anomaly (MMSLA)

**Runup**



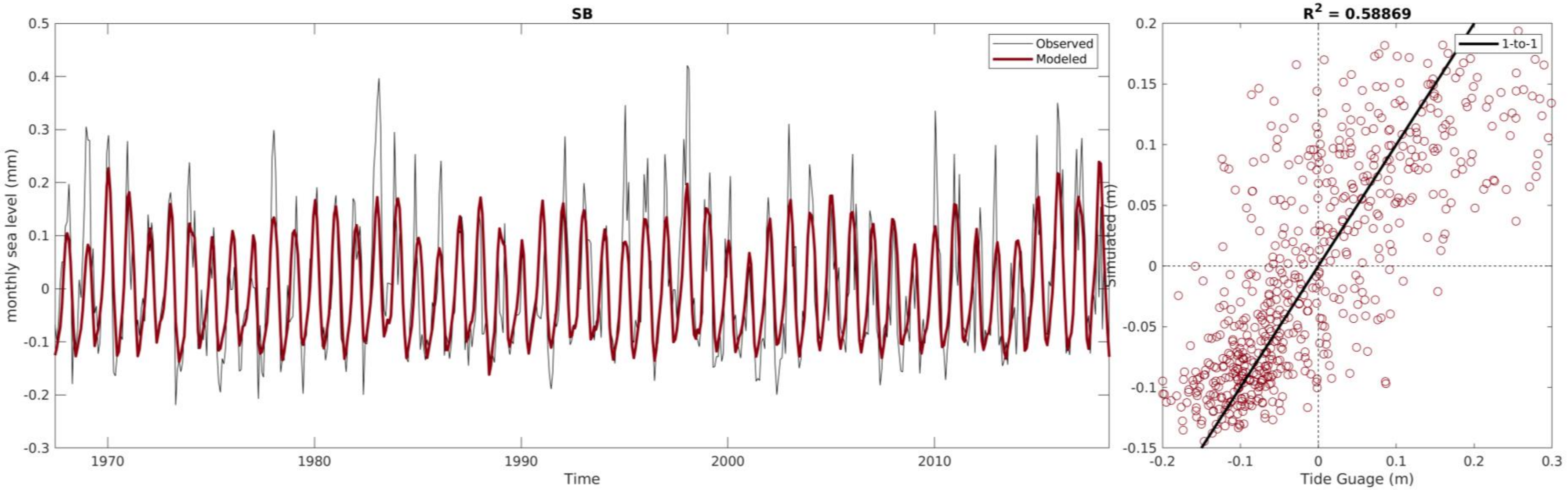



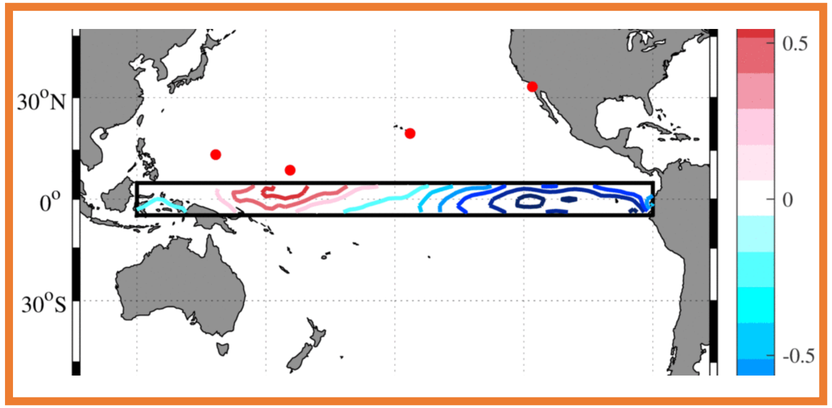



# Modeling the drivers of TWLs- Monthly Mean Sea Level Anomaly

- Multivariate regression of PCs used to generate Annual Weather Types (AWT)

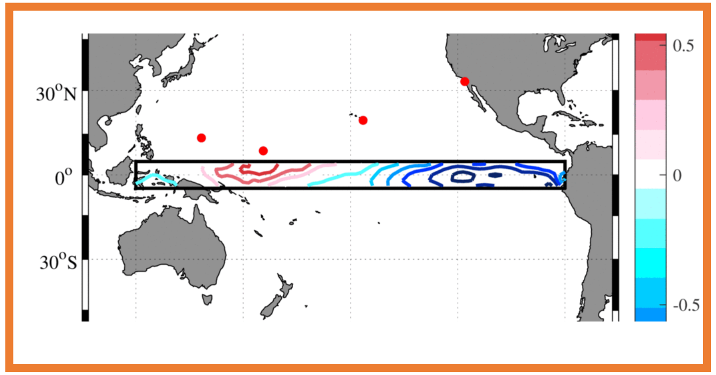


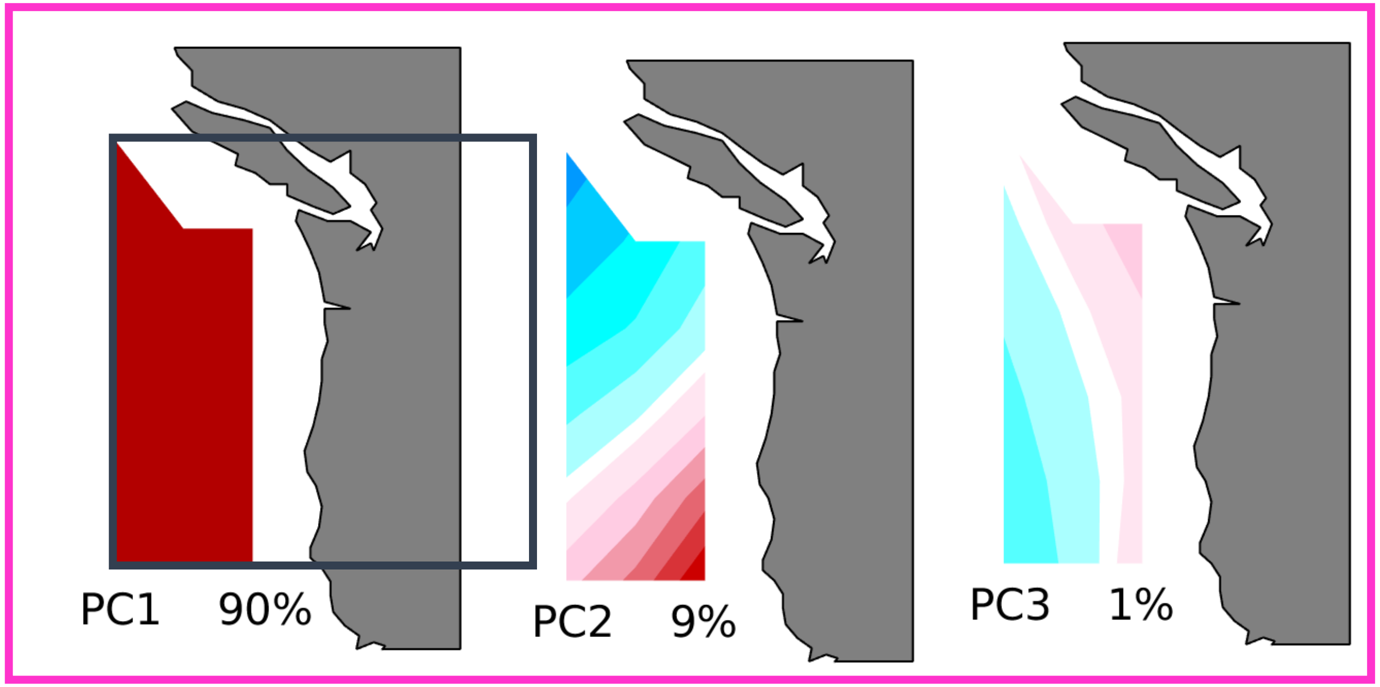




$$\begin{aligned} MMSLA = {} & a_0 + a_1PC_1^a + a_2PC_2^a + a_3PC_3^a \\ & + (b_0 + b_1PC_1^a + b_2PC_2^a + b_3PC_3^a)\cos(2\pi t/T) \\ & + (c_0 + c_1PC_1^a + c_2PC_2^a + c_3PC_3^a)\sin(2\pi t/T) \end{aligned}$$

# Modeling the drivers of TWLs- Monthly Mean Sea Level Anomaly

- Multivariate regression of AWT PCs <u>and</u> PCs of local monthly SLP fields

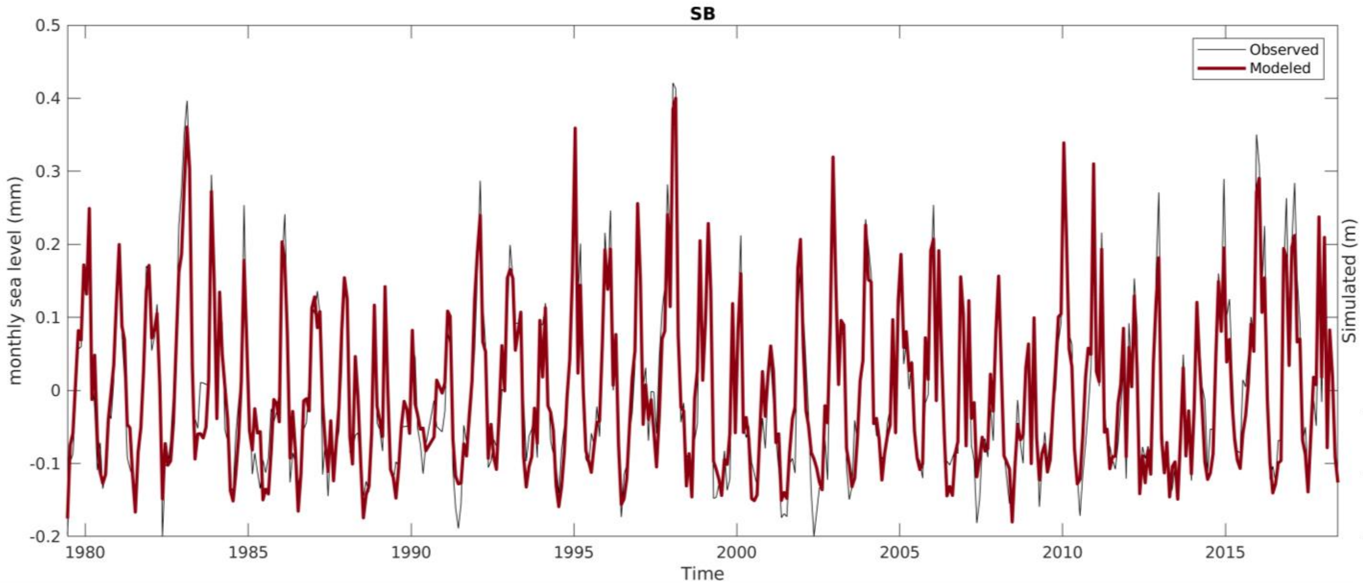


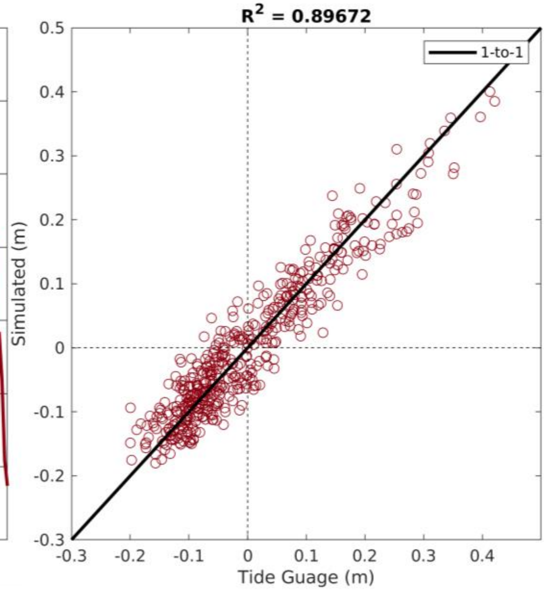




$$
\begin{aligned}
MMSLA = {} & a_0 + a_1 PC_1^{a} + a_2 PC_2^{a} + a_3 PC_3^{a} + a_4 PC_1^{m} + a_3 PC_2^{m} + a_3 PC_3^{m} \\
& + (b_0 + b_1 PC_1^{a} + b_2 PC_2^{a} + b_3 PC_3^{a} + b_4 PC_1^{m} + b_5 PC_2^{m} + b_6 PC_3^{m}) \cos(2\pi t/T) \\
& + (c_0 + c_1 PC_1^{a} + c_2 PC_2^{a} + c_3 PC_3^{a} + c_4 PC_1^{m} + c_5 PC_2^{m} + c_6 PC_3^{m}) \sin(2\pi t/T)
\end{aligned}
$$

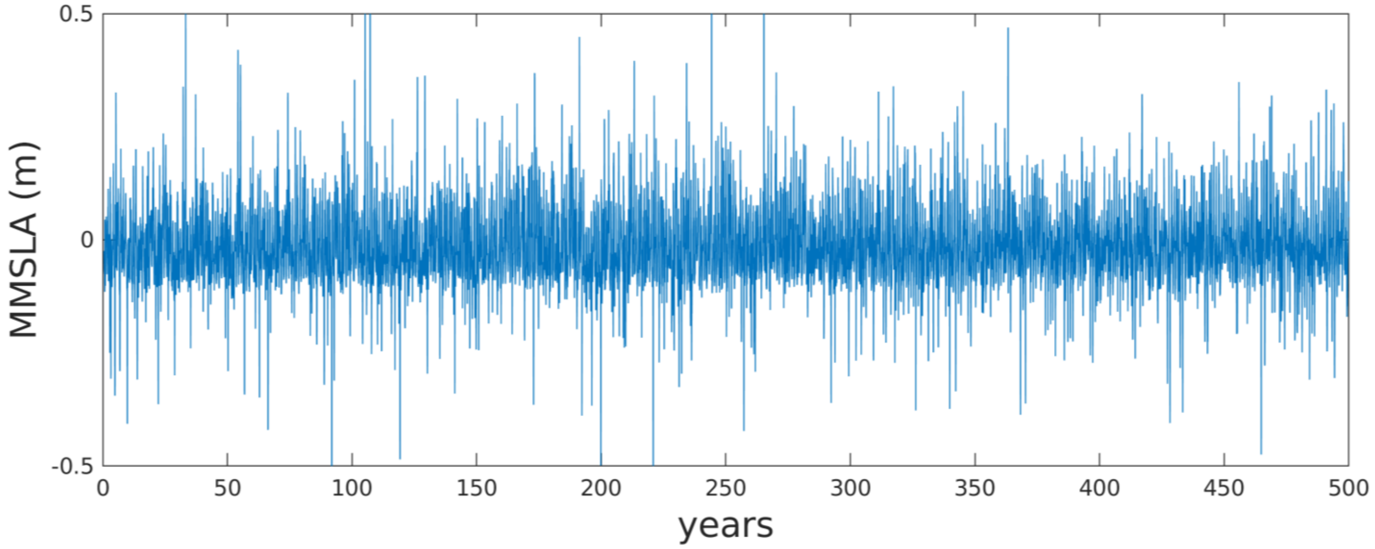
# Modeling the drivers of TWLs- Monthly Mean Sea Level Anomaly

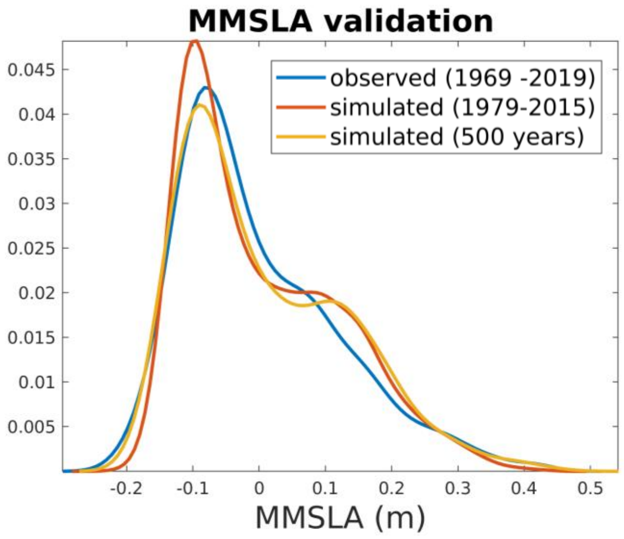
Regressed



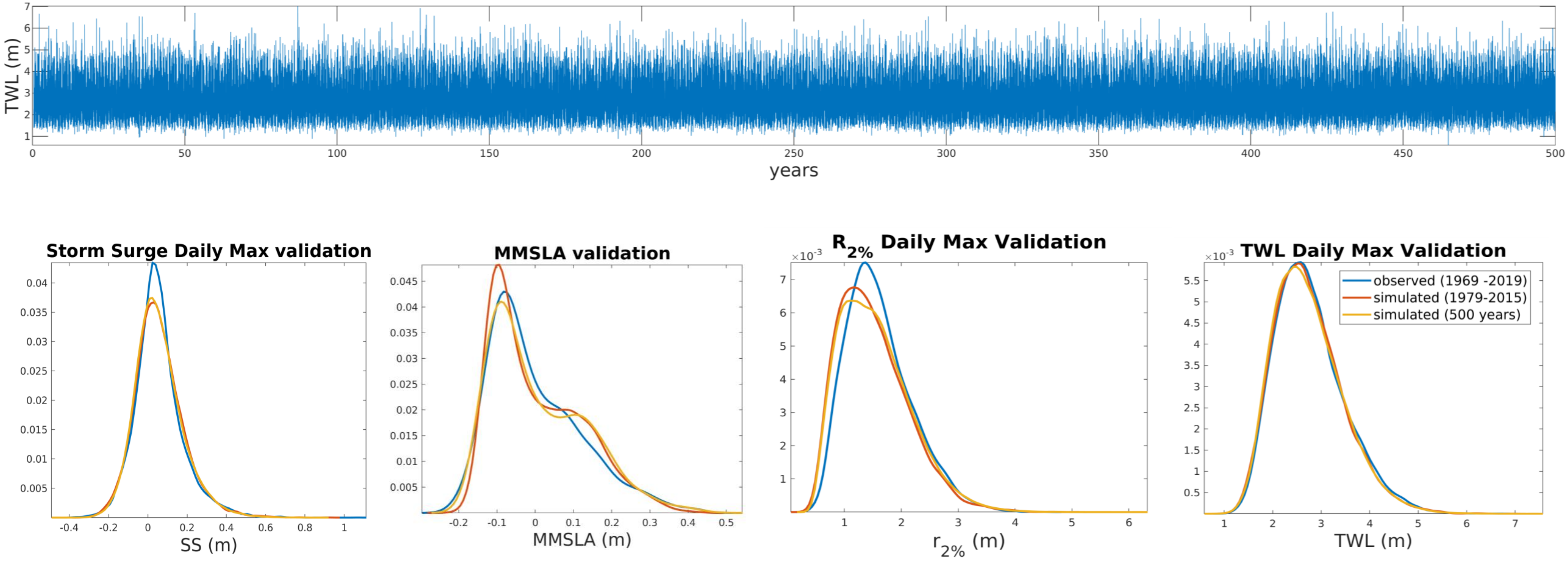

Simulated



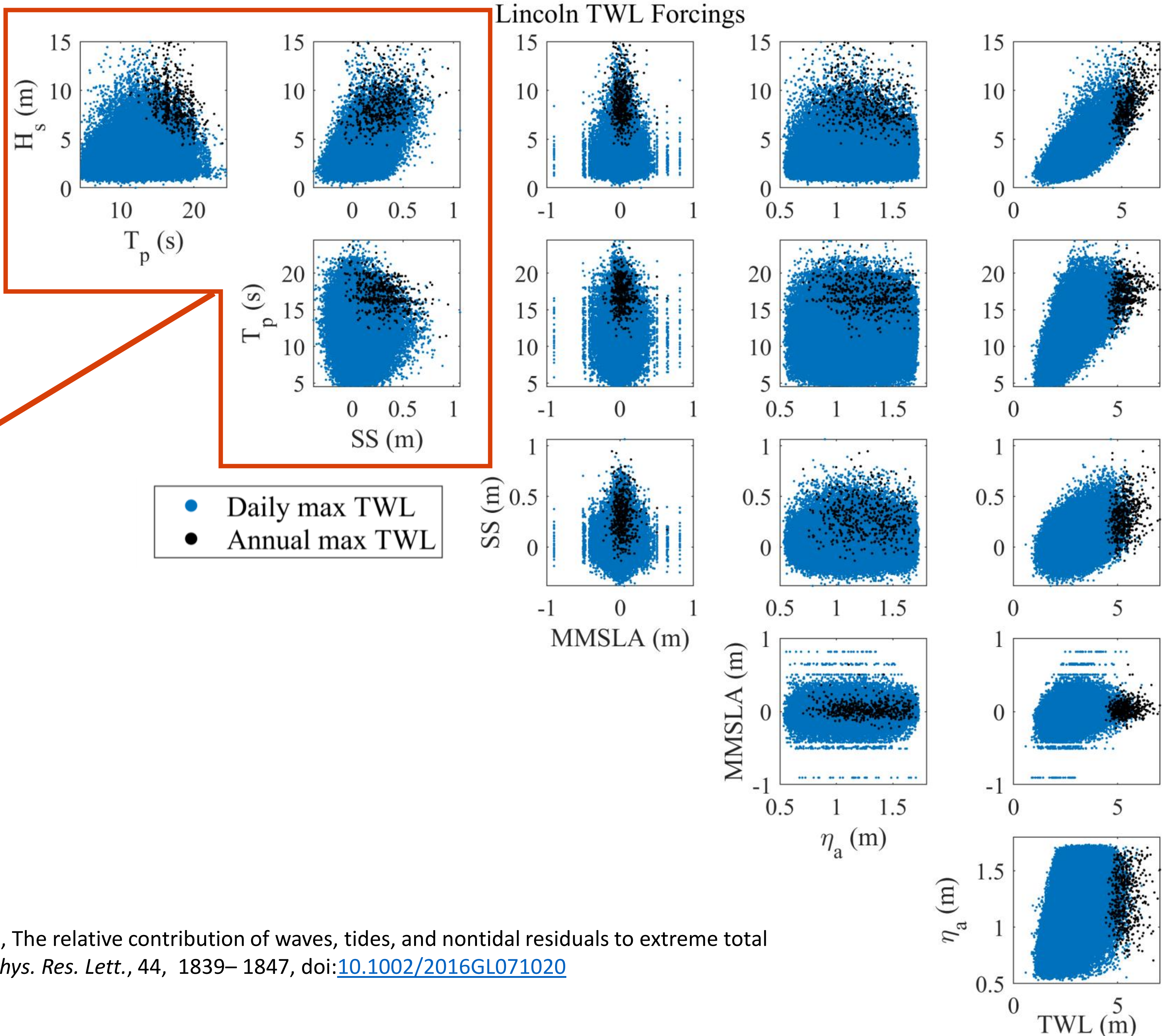
# Modeling the drivers of TWLs

$$TWL = MSL + \eta_A + \eta_{NTR} + R_{2\%}$$



# Drivers of Extreme TWLs

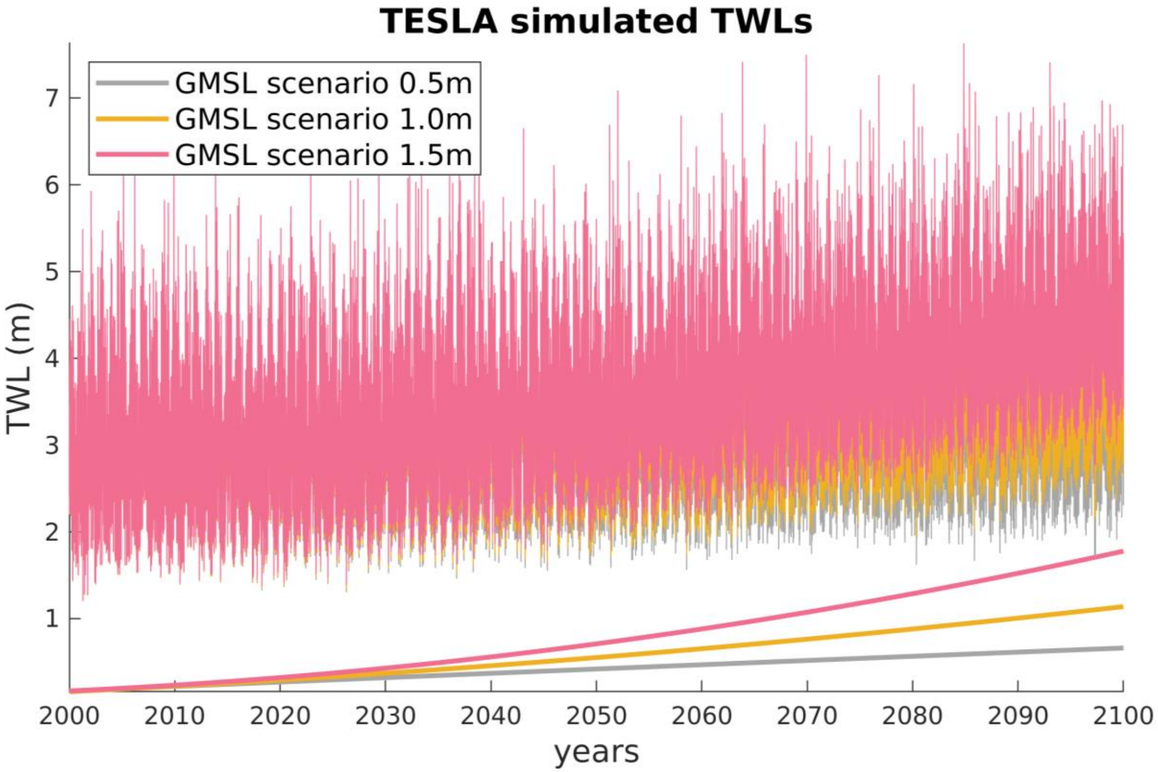
Tight clusters of large $H_s$ and $T_p$ for extreme TWLs indicate **runup is a major driver of hazardous events in Lincoln County**




Serafin, K. A., Ruggiero, P., and Stockdon, H. F. ( 2017), The relative contribution of waves, tides, and nontidal residuals to extreme total water levels on U.S. West Coast sandy beaches, *Geophys. Res. Lett.*, 44, 1839– 1847, doi:10.1002/2016GL071020

# Impacts of Extreme TWLs

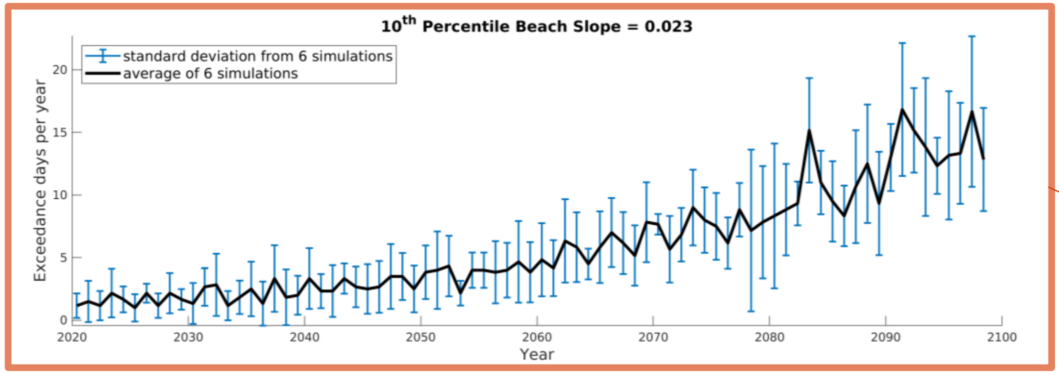
Video courtesy of Jay Sennewald, Oregon State Parks & Rec
Neskowin, OR December 2018

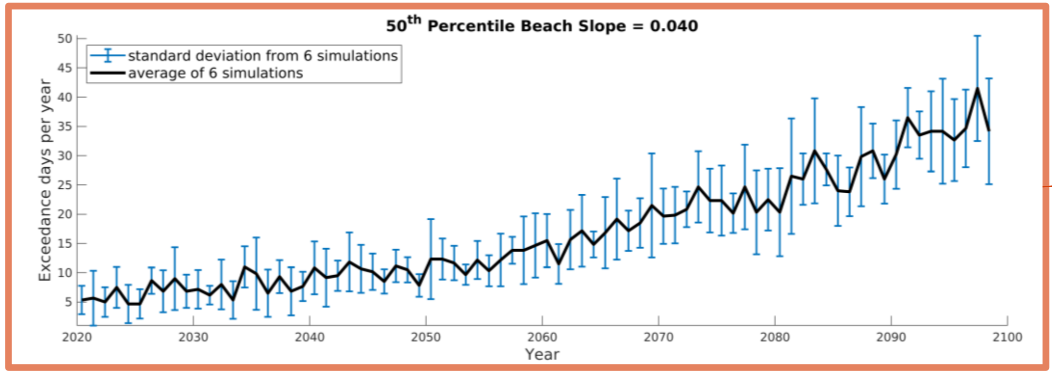


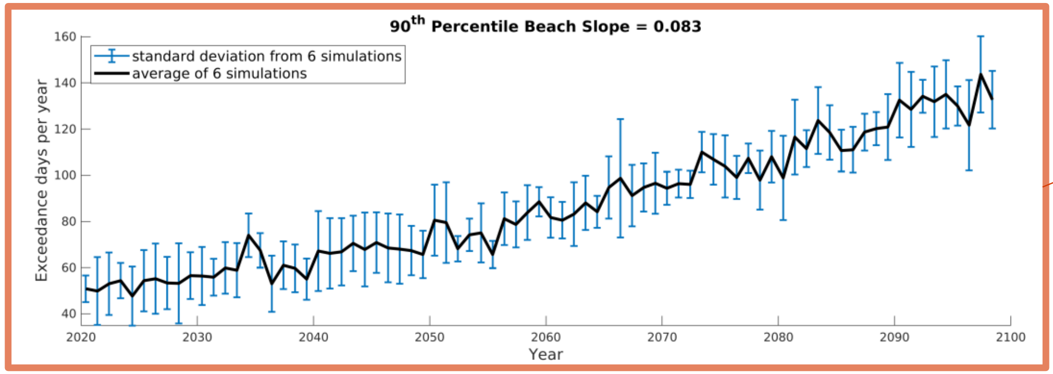

Sweet, W.V., R.E. Kopp, C.P. Weaver, J. Obeysekera, R.M. Horton, E.R. Thieler, and C. Zervas, 2017: *Global and Regional Sea Level Rise Scenarios for the United States*. NOAA Technical Report NOS CO-OPS 083. NOAA/NOS Center for Operational Oceanographic Products and Services.

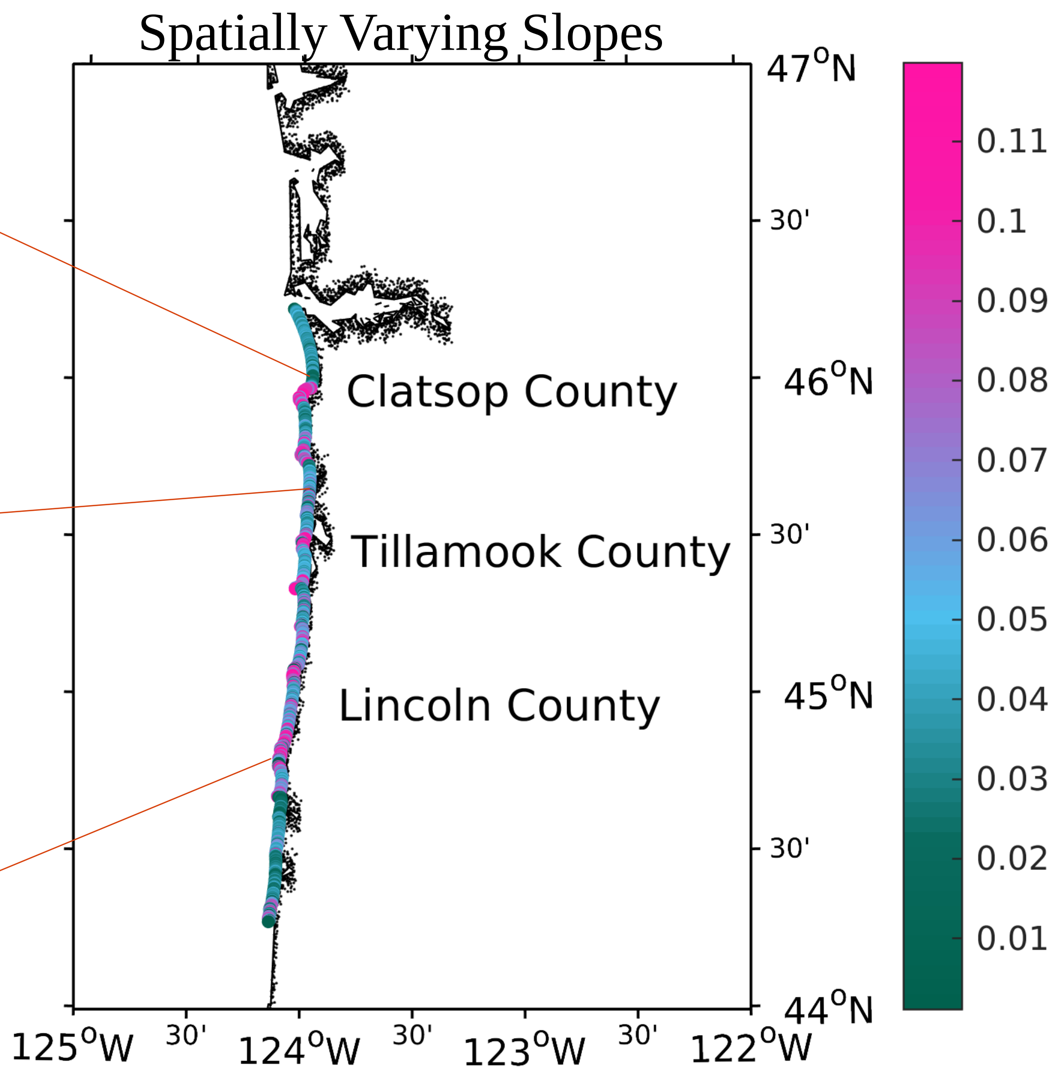
# Impacts of Extreme TWLs

## Number of days impacting present day average dune toe (4.52m)-1m of SLR scenario



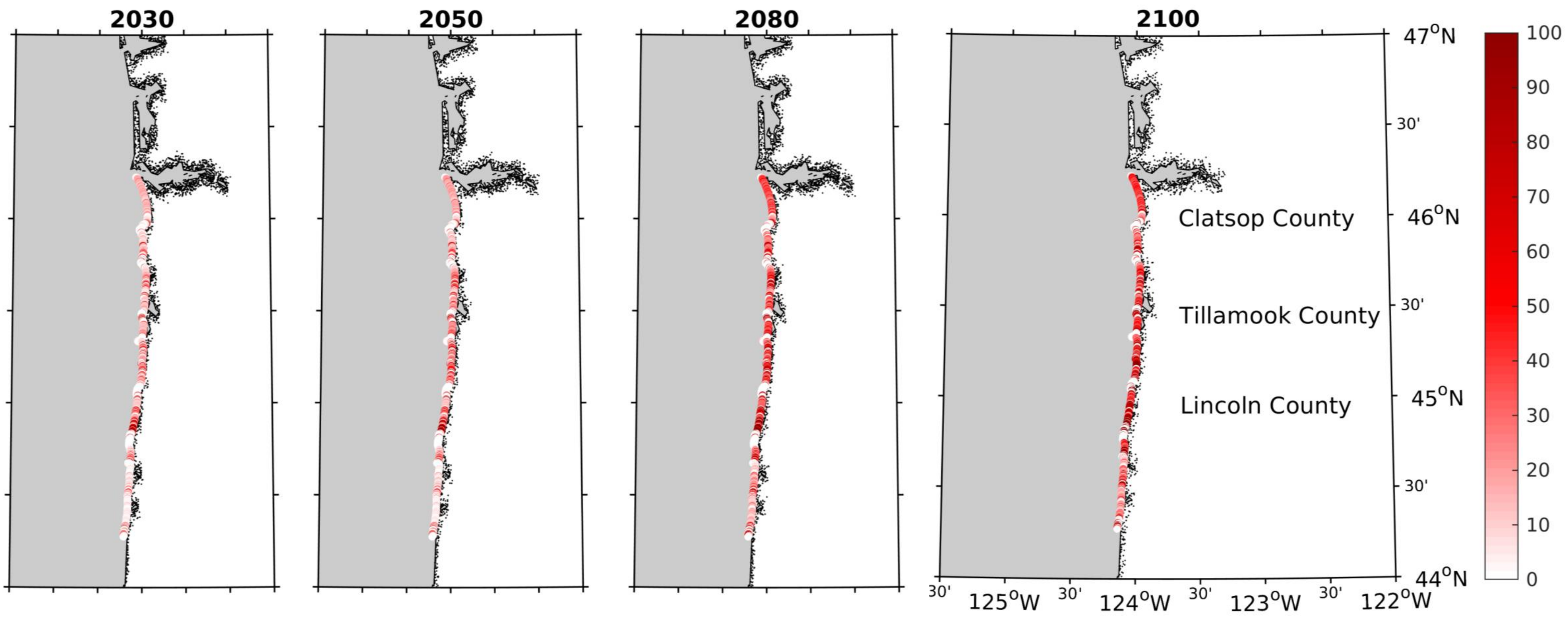



# Impacts of Extreme TWLs

## Number of days when daily max TWL exceeds average dune toe elevation

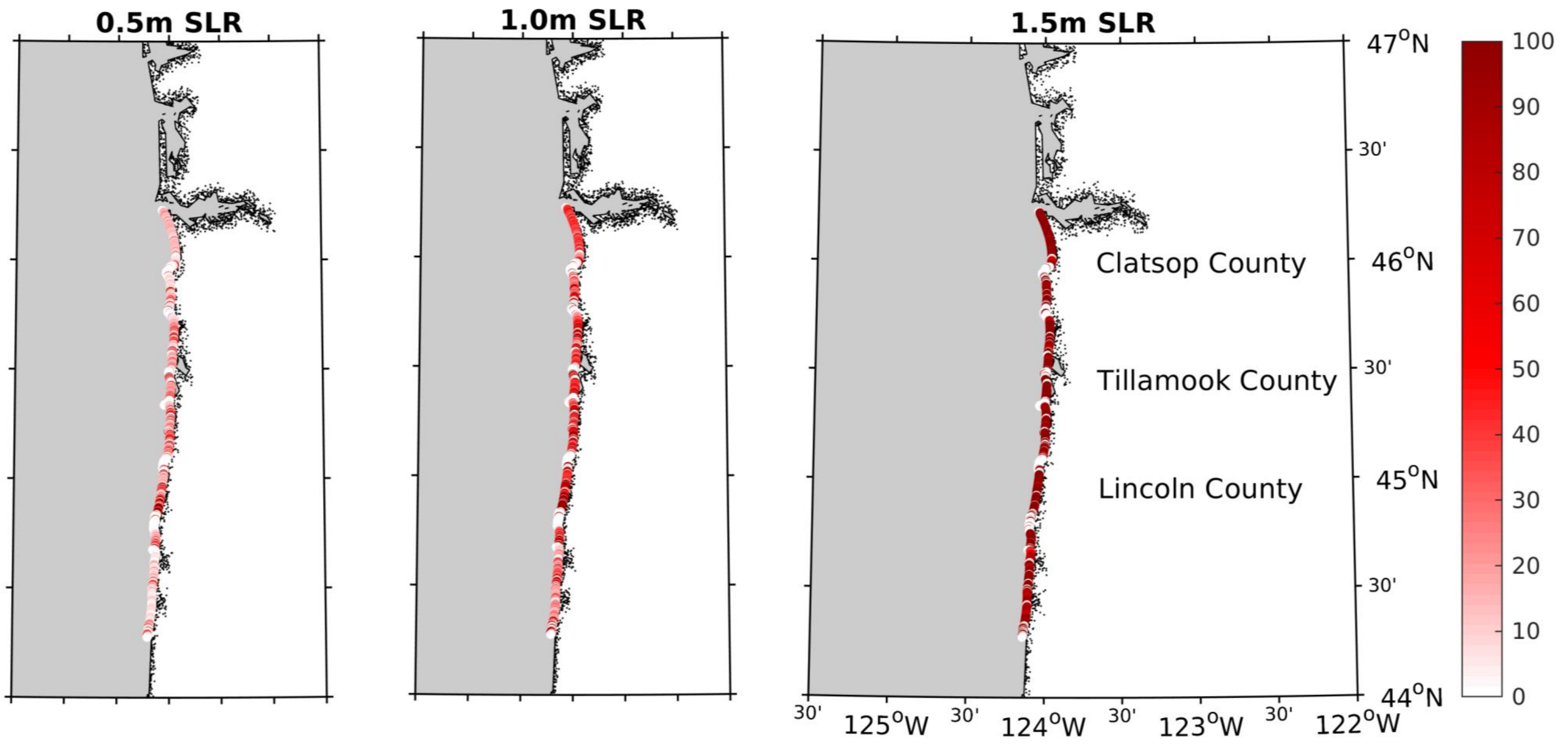
1m GMSL rise by 2100



# Impacts of Extreme TWLs

## Number of days when daily max TWL exceeds average dune toe elevation

2100 - Under different SLR scenarios

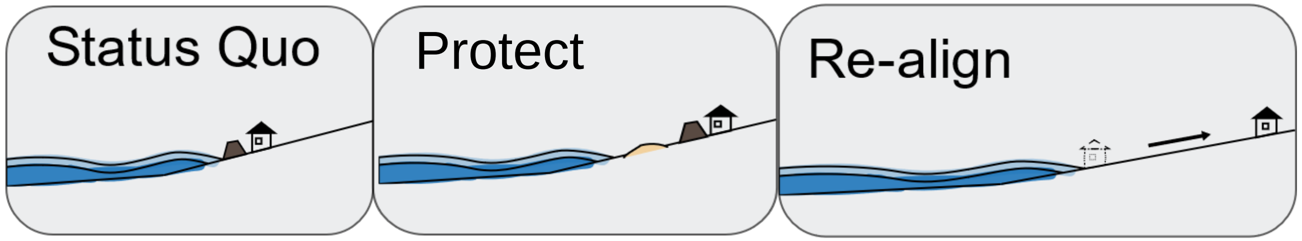


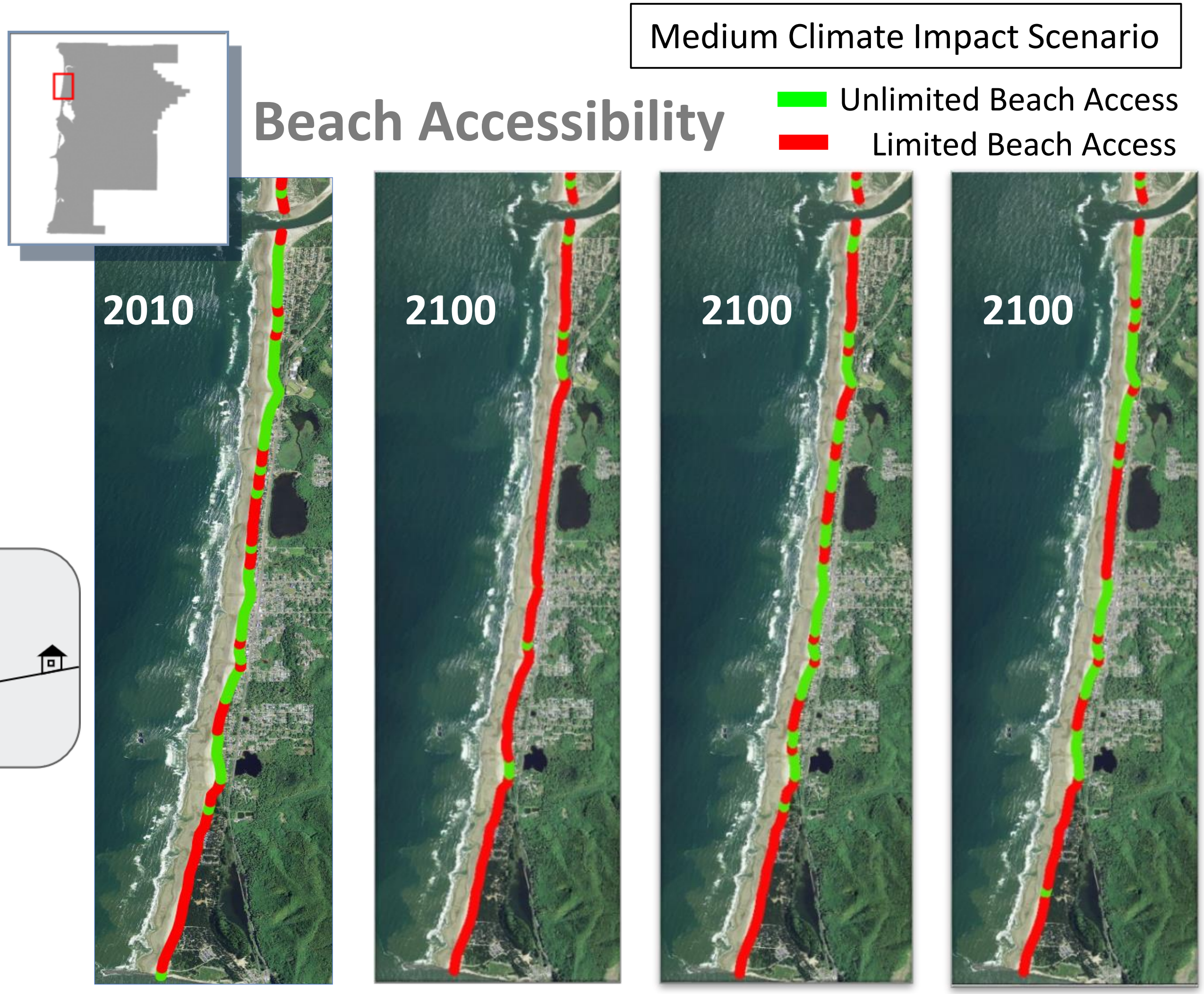
# Impacts of Extreme TWLs

**<u>TESLA in Envision:</u>**

**Trigger**: Erosion / Flood Frequency

**Policy Response:**




Present Day | Status Quo | Protect | Realign

Mills, A. K., Bolte, J., Ruggiero, P., Serafin, K. A., Lipiec, E., Corcoran, P., Stevenson, J., Zanocco, C., Lach, D. 2018. Exploring the impacts of climate and policy changes on coastal community resilience: Simulating alternative future scenarios. Environmental Modelling & Software.

# Questions?

## Acknowledgements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- USGS – Coastwide Oregon beach slopes
- ARCS Foundation
- Researchers at OSU and IH Cantabria
- Funding from Oregon Sea Grant and SERDP