

# Sea-Level Rise, Storms, and Waves on the California Coast

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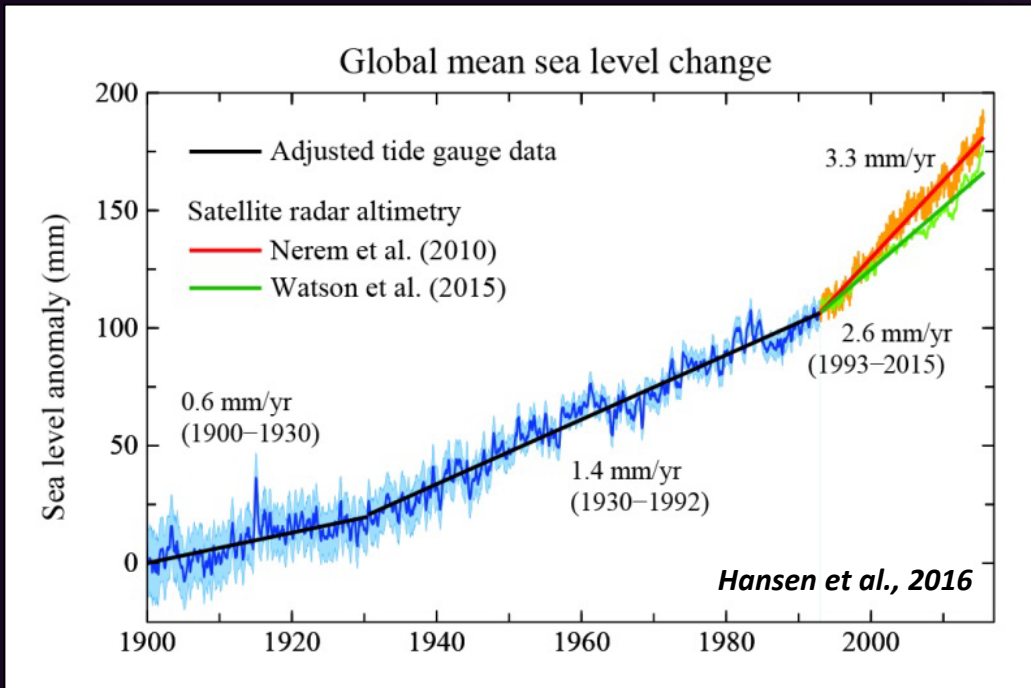
# What is at stake?

- Over 1 billion people are expected to live in the coastal zone by 2050
- 26 million people presently live in CA coastal counties
- Over 3 million people in CA at risk of flooding from SLR and storms by the end of the century, in addition to ~\$150 billion in property
- Impact by 2100 could be ~5% of CA GDP

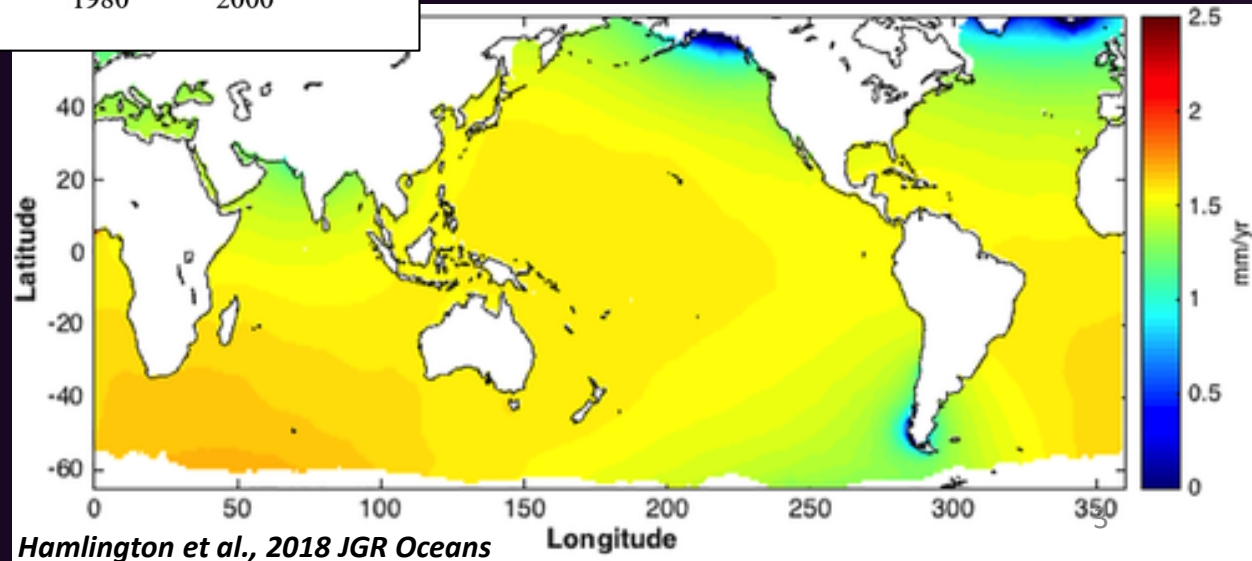




# Historical Sea-Level Rise

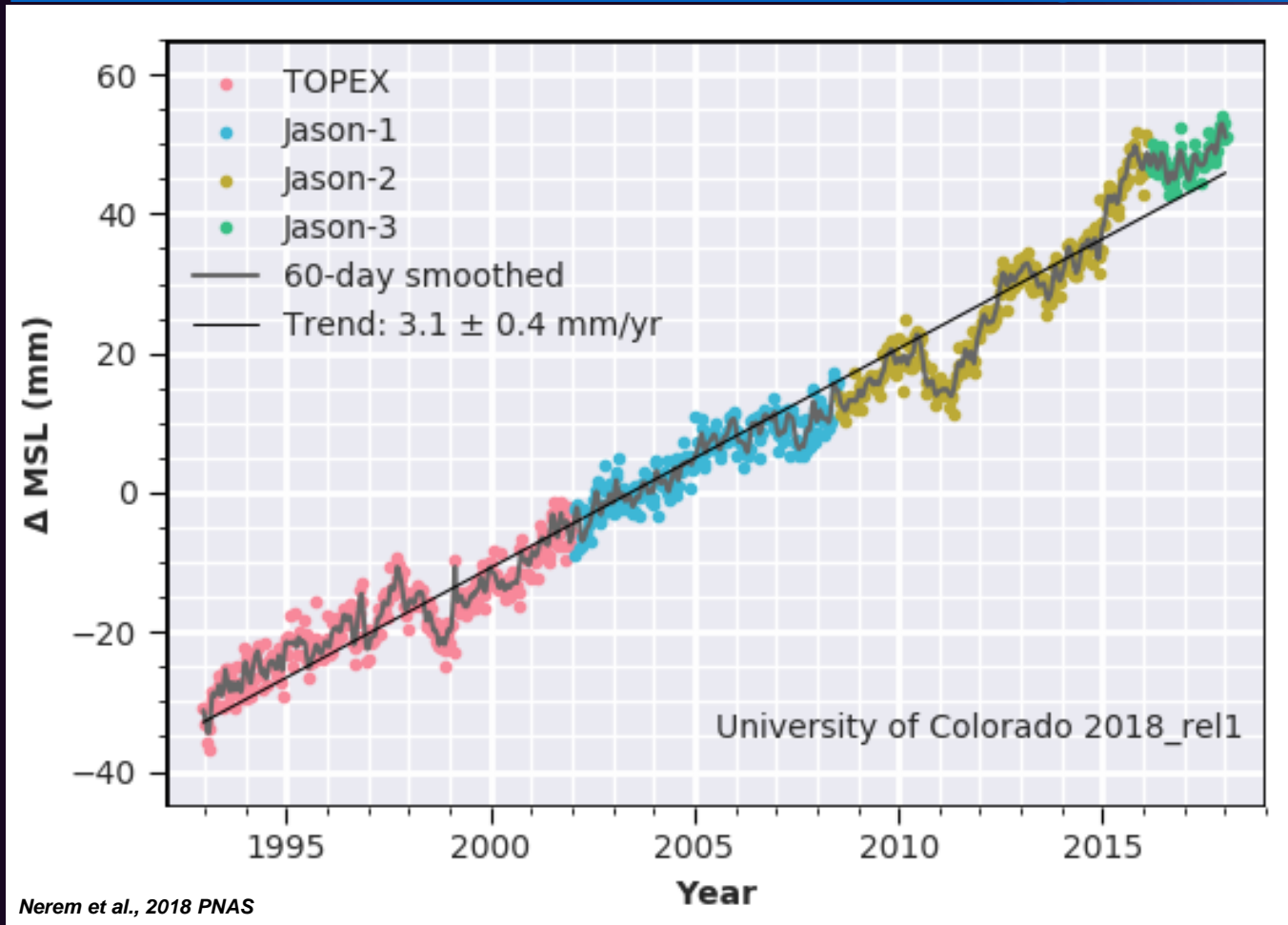


20<sup>th</sup> Century SLR trends from:  
ice melt  
thermal expansion



# Recent Sea-Level Rise

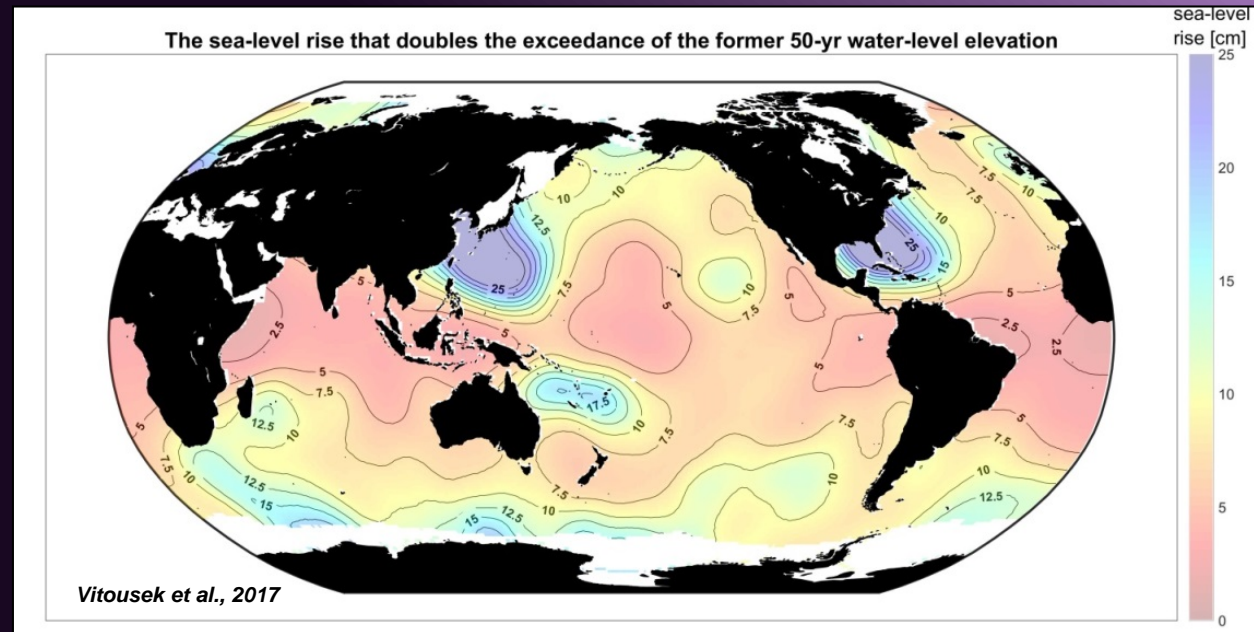
## Global Mean Sea Level Time Series (seasonal signals removed)



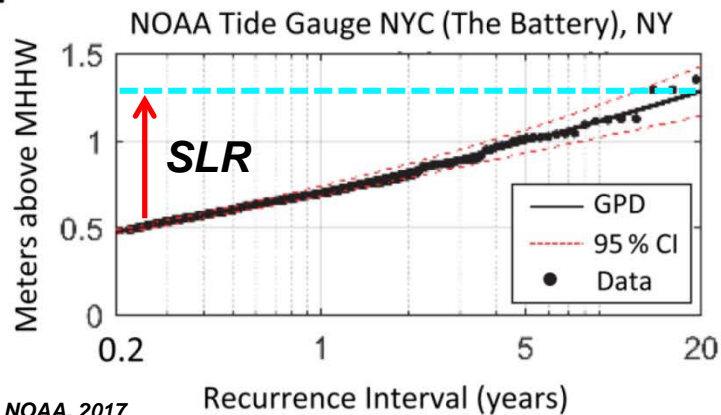
- Global SLR  
~3mm/yr since  
1993 and  
accelerating

# Impacts from Sea-Level Rise

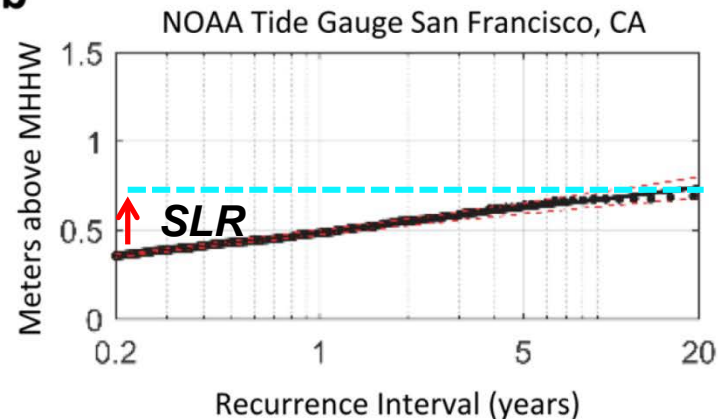
- Areas with limited water-level variability, will experience the largest increases in flooding frequency



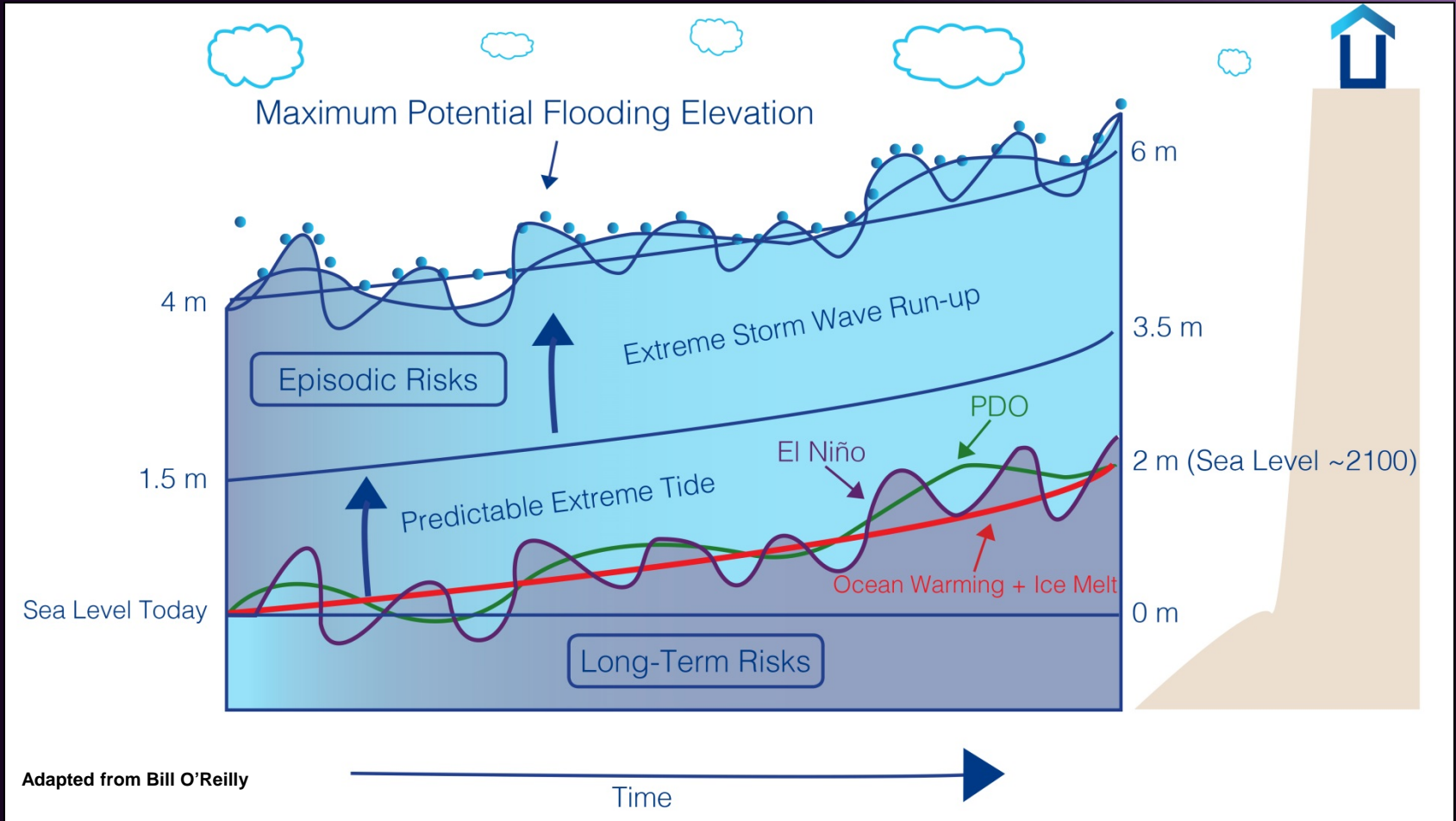
a



b



# Storms and seasonal events





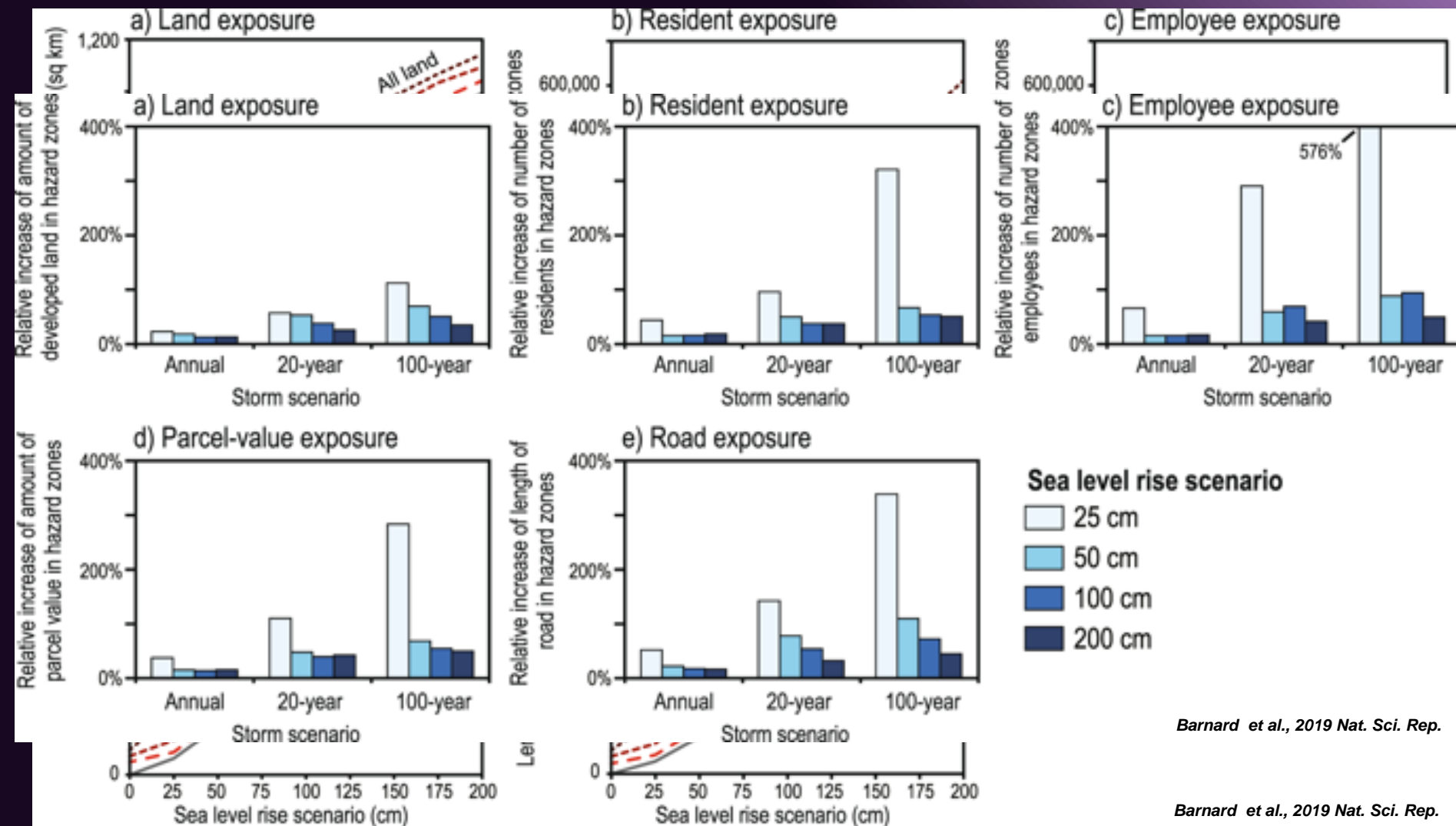
# Storms and seasonal events



- Further changes in water levels: Surge and seasonal
- Waves
- Precipitation and river discharge
- In the future: Frequency and Storm direction?



# Impacts from storm events and SLR

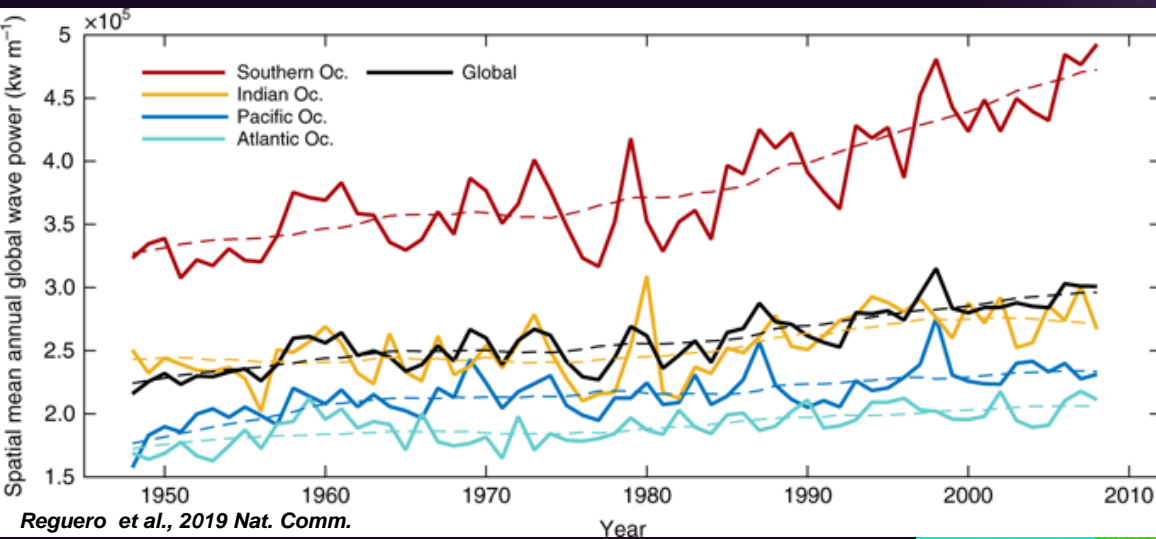


Barnard et al., 2019 Nat. Sci. Rep.

Barnard et al., 2019 Nat. Sci. Rep.

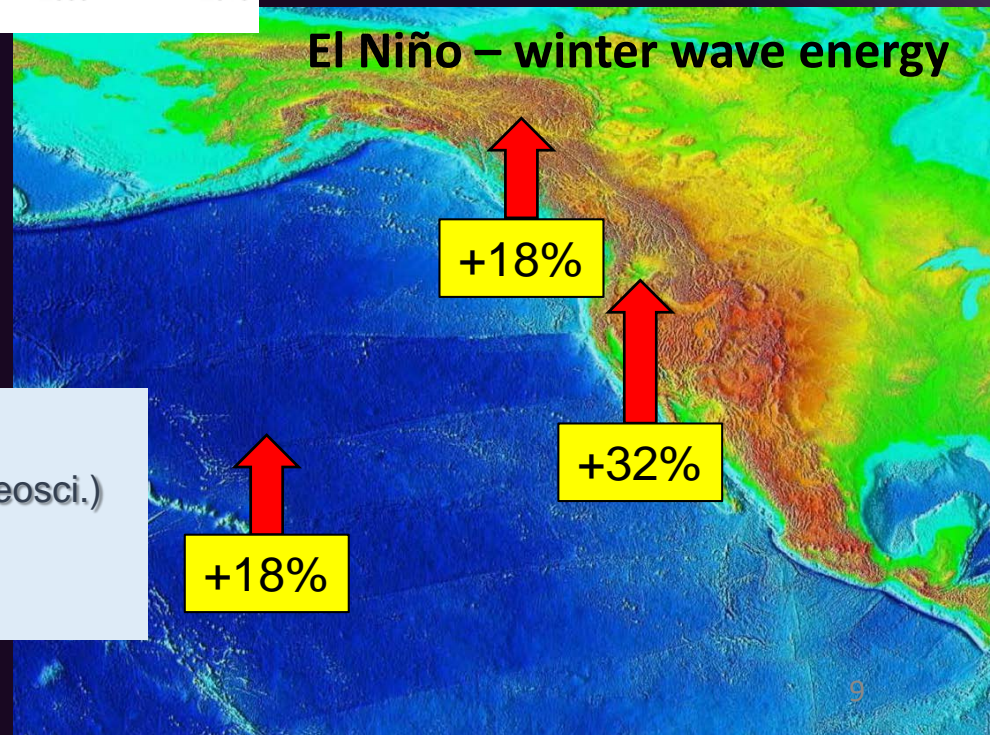


# Storms - waves

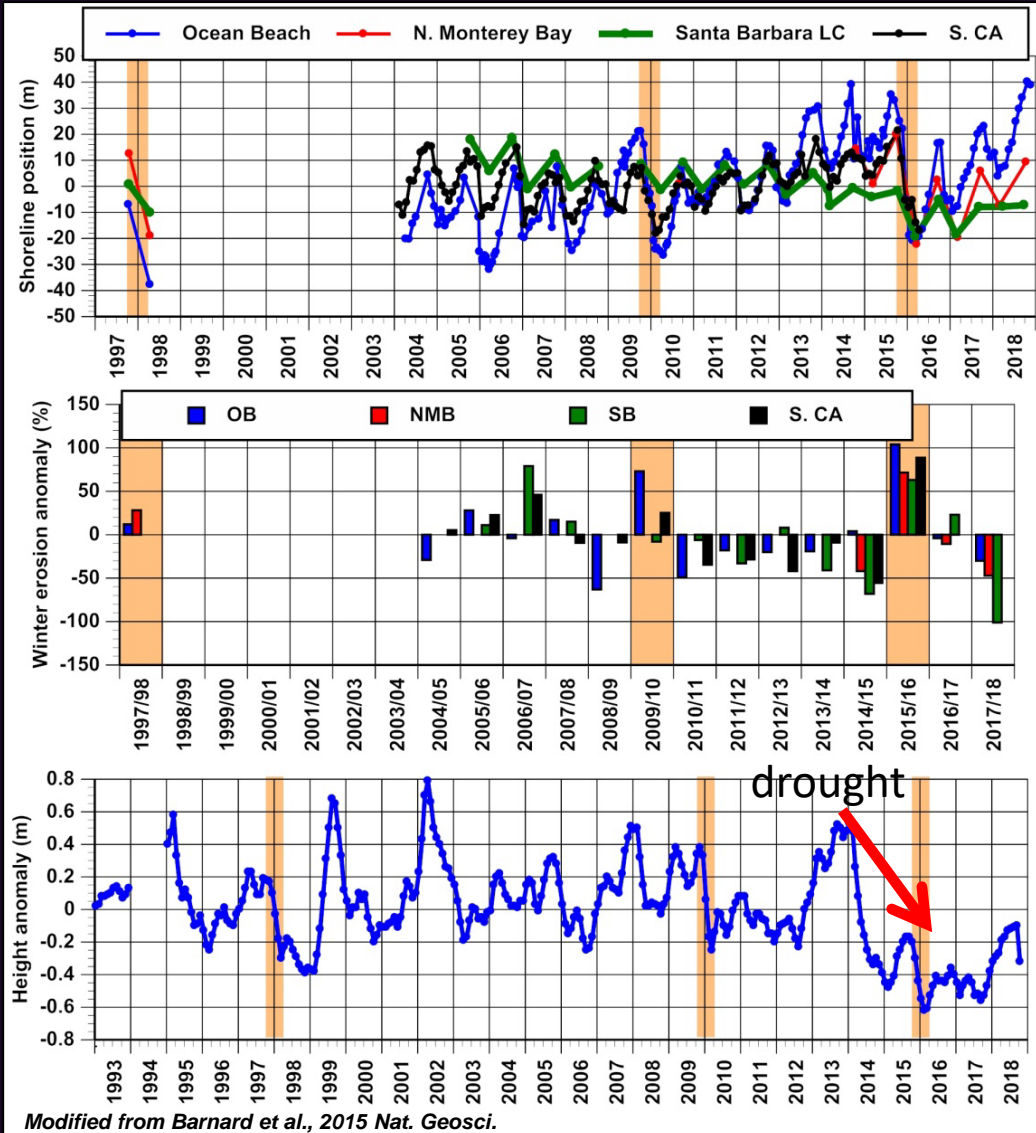


- Storm direction
- Storm intensity
- Storm frequency

- ENSO forcing and coastal response across Pacific (Barnard et al., 2015 Nat. Geosci.)
  - regional wave and water level conditions



# Coastal change in response to storms and climate variability



2015/16

- Extreme EN erosion
- Below average rainfall

2016/17

- ~Average erosion –good summer recovery
- Lots of AR rain in N/C CA, less in So CA

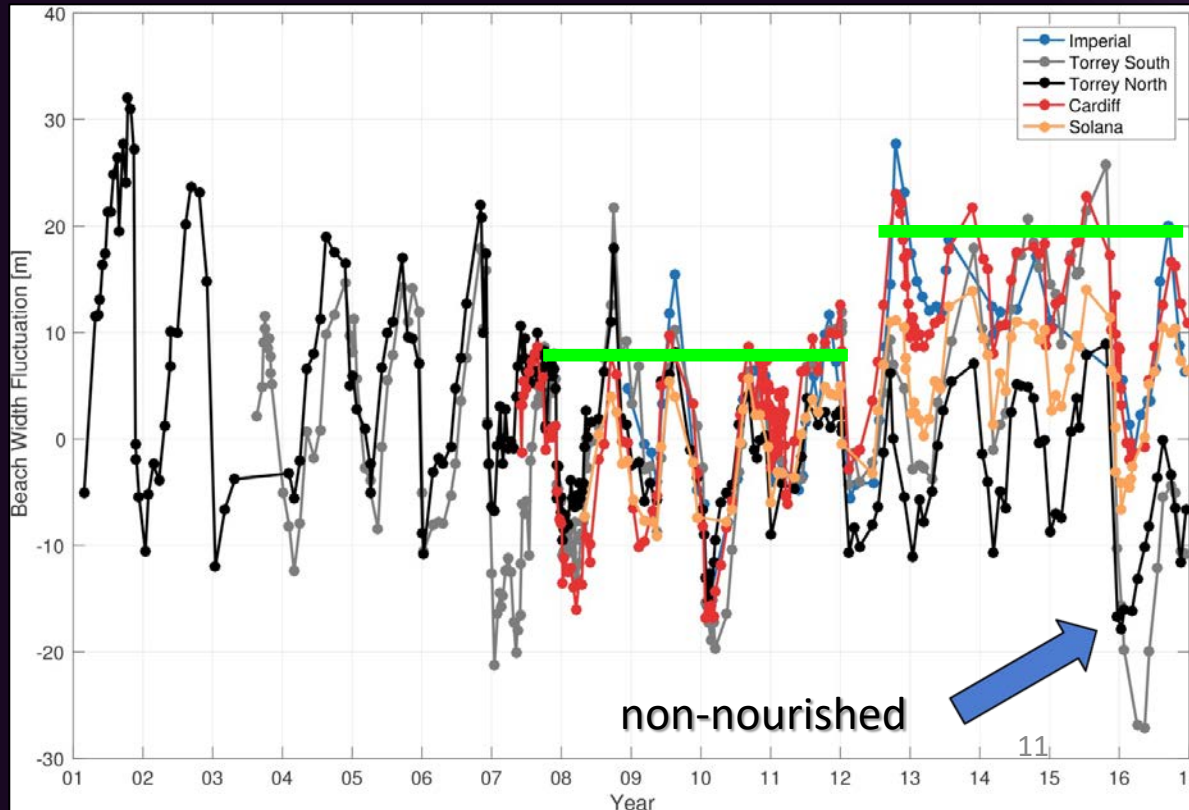
2017/18

- Way below average erosion
- Record fires and AR rain

Winter 2016



# Coastal change and coastal management



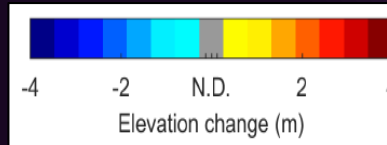
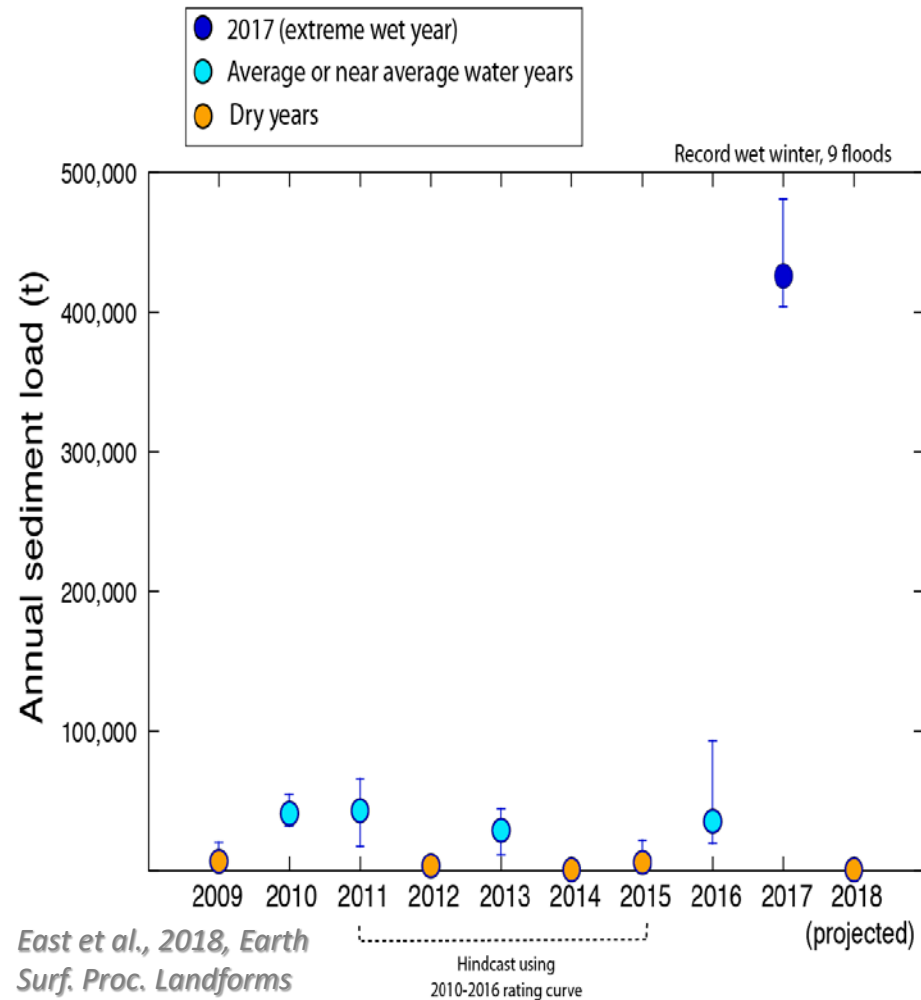
Young et al., 2018, JGR Earth Surface



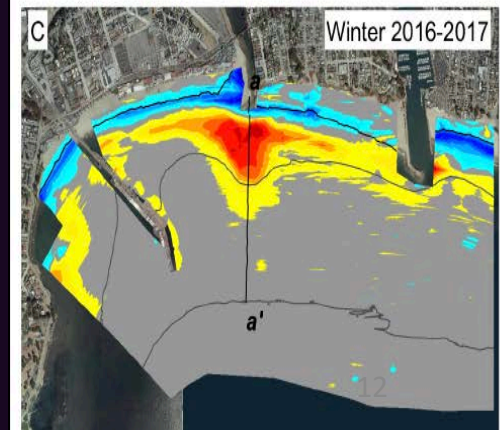
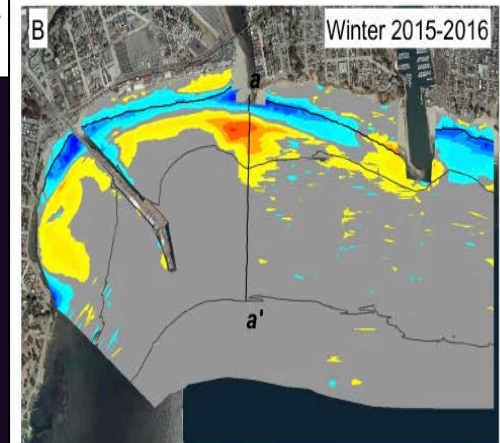
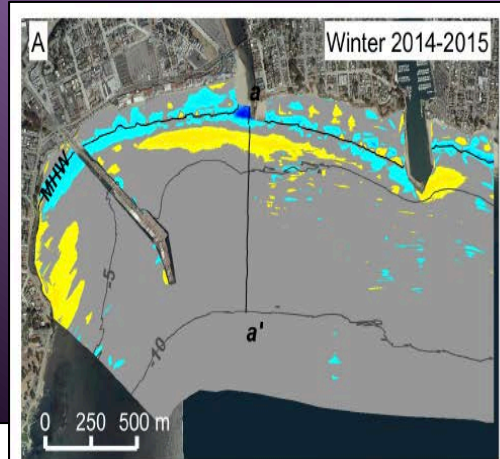


# Coastal effects of extreme precipitation

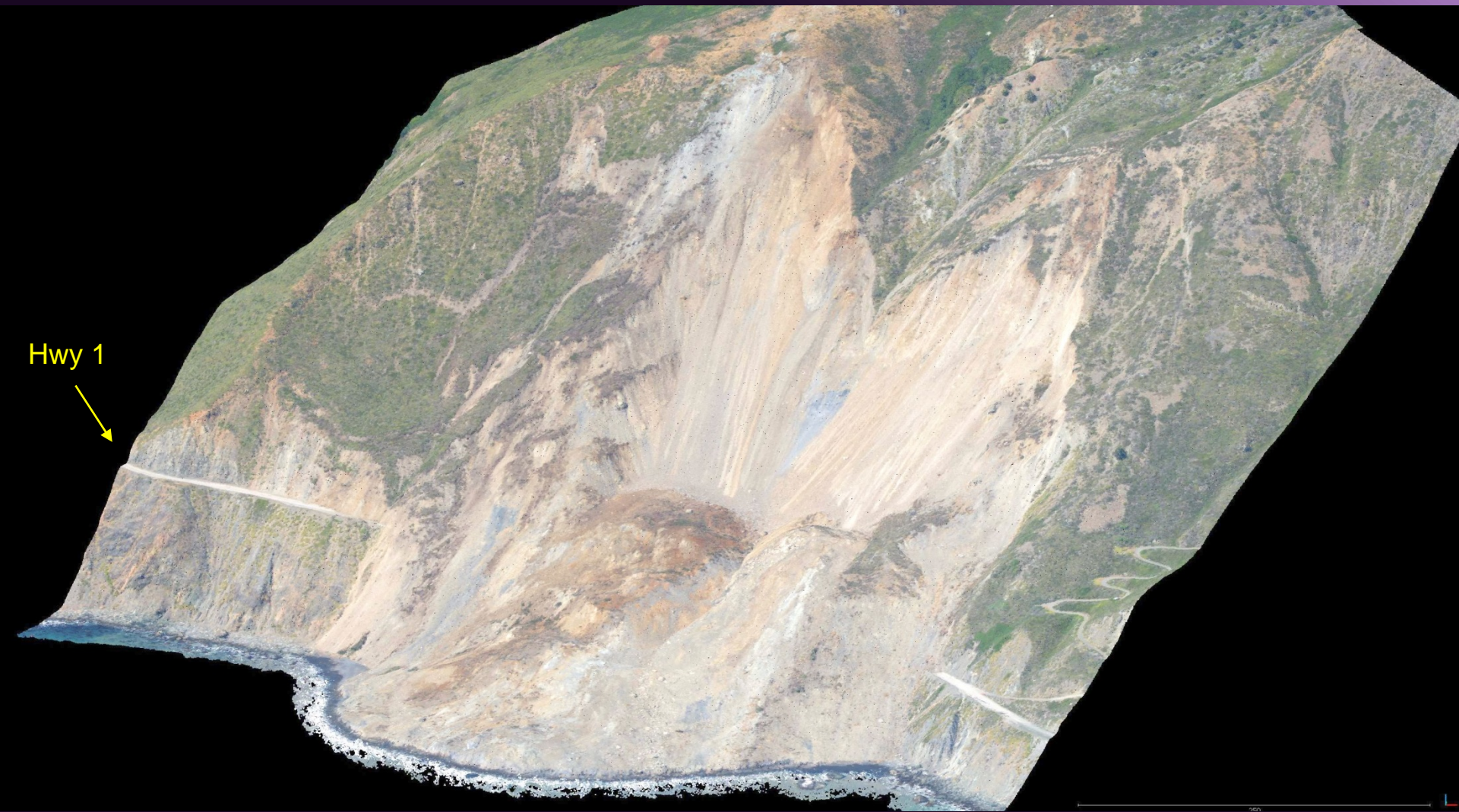
## San Lorenzo River annual sediment export



Fluvial sediment  
backfilling El  
Niño losses



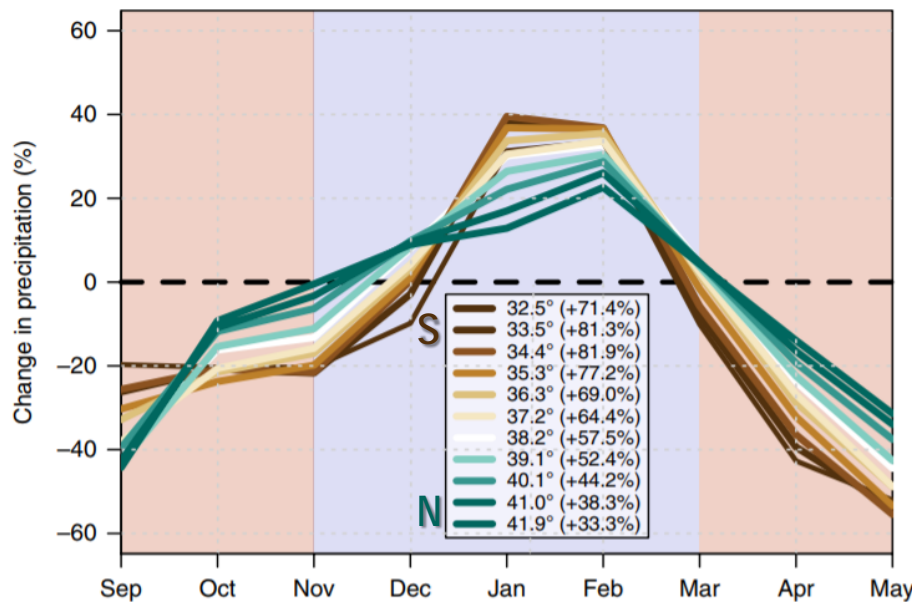
# Mud Creek landslide



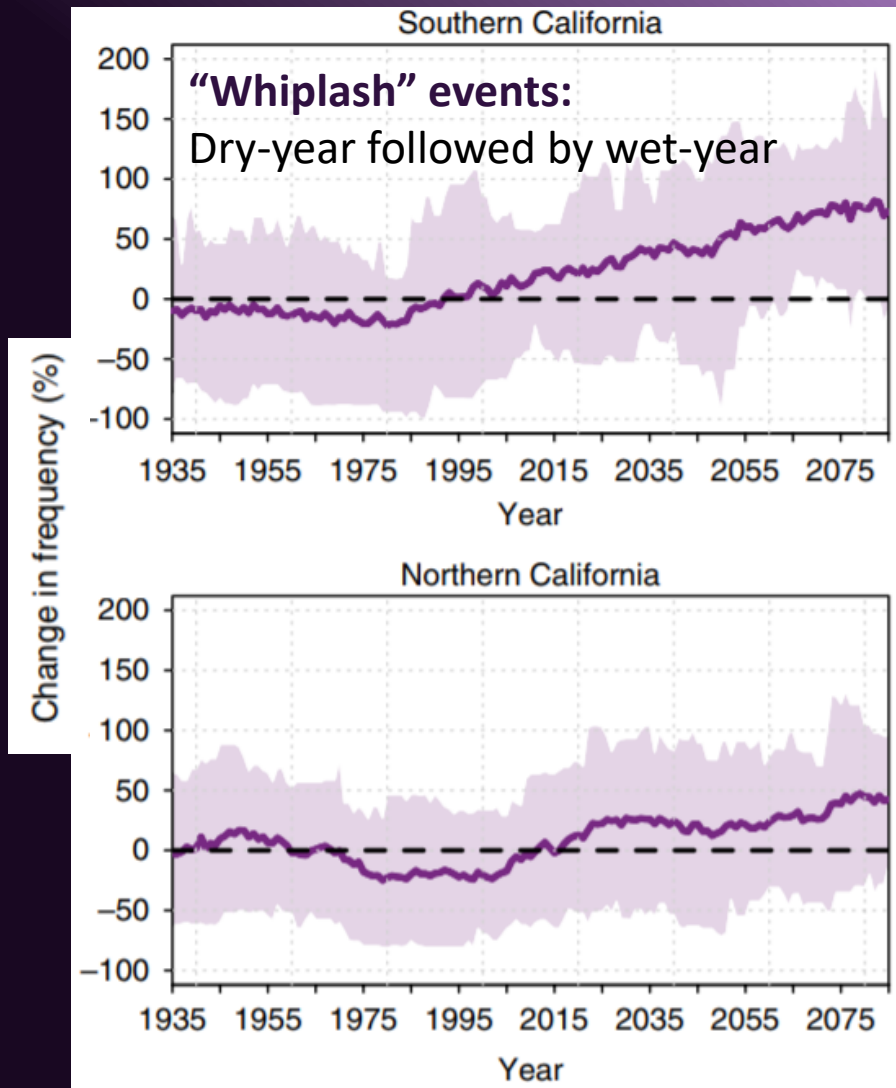


# Future precipitation

## Shifts in seasonality



Swain et al., 2018, Nat. Cli. Change





# Questions

- **What will the 21<sup>st</sup> century SLR curve actually look like?**
  - Emissions currently tracking along RCP 8.5
- **How will storm patterns change?**
  - Frequency of extreme events, northerly shift, ENSO, ARs and precipitation
- **How will the shoreline evolve?**
  - Erosion with waves/SLR; sediment fluxes with precipitation extremes
- **How will coastal management decisions (e.g., beach nourishment, hard structures, levees, tidal marsh restoration) affect the dynamics of flooding and coastal change?**