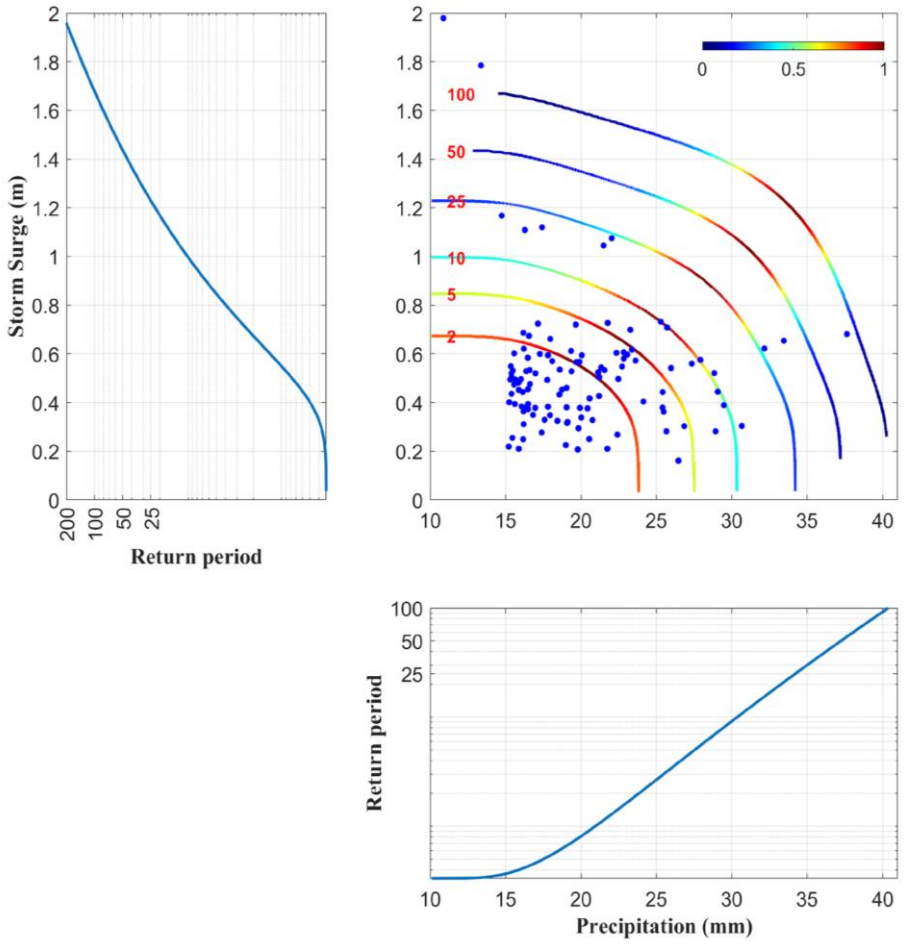
How do we figure out return periods for compound flood events?

We think of flood events in terms of return periods or estimated statistical likelihood of that event (or level of floodwater) happening each year.

Scientists have calculated the return periods for storm surge events and return periods for rainfall events, but what about the combined, or compound flood events? Using the two separate, or univariate, variables, we can determine the return period for the resulting compound flood.

The following are compound flood return period graphs generated in Matlab. The bottom panel shows return periods and corresponding water levels for rainfall events.

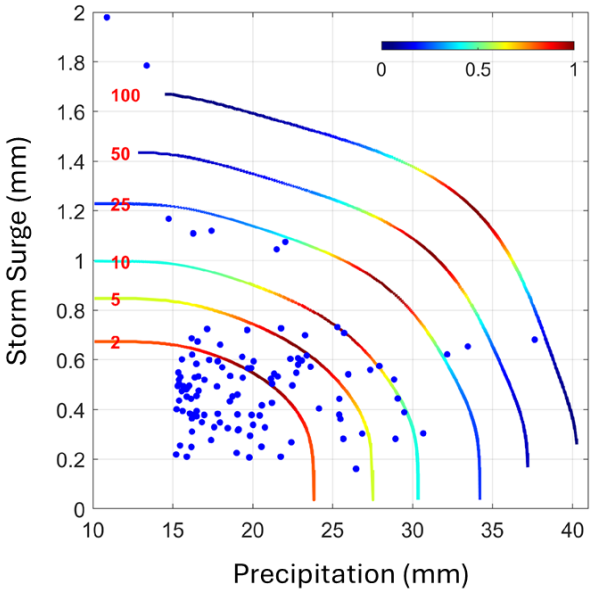


On the top left are the return periods with corresponding water levels for storm surge events.

These events combine in a non-additive way. We cannot use simple addition to add a 5-year rainfall event to a 8-year surge event to give us a 13-year compound flood. The two

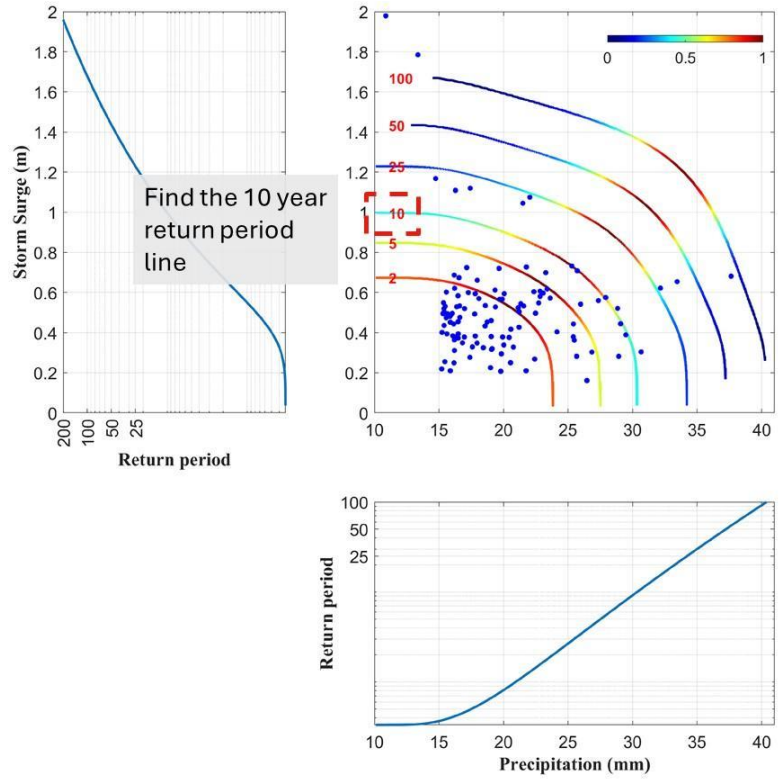
events combine to generate a compound flood which would cause the same floodwater depth and extent as a flood event with a much higher return period.

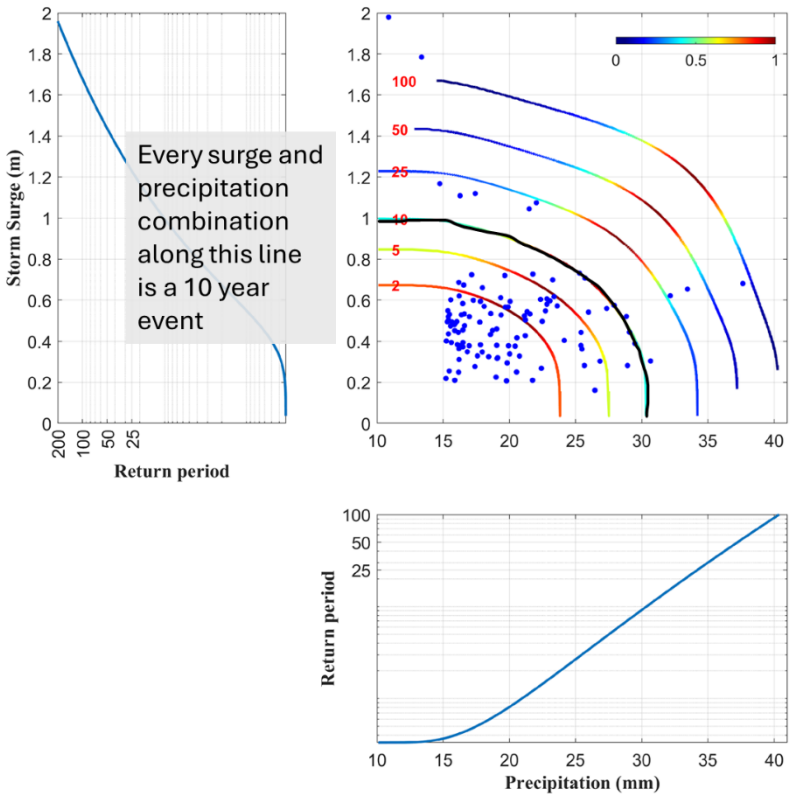
To estimate the return interval of a compound flood, we focus first on the combined graph in the top right.



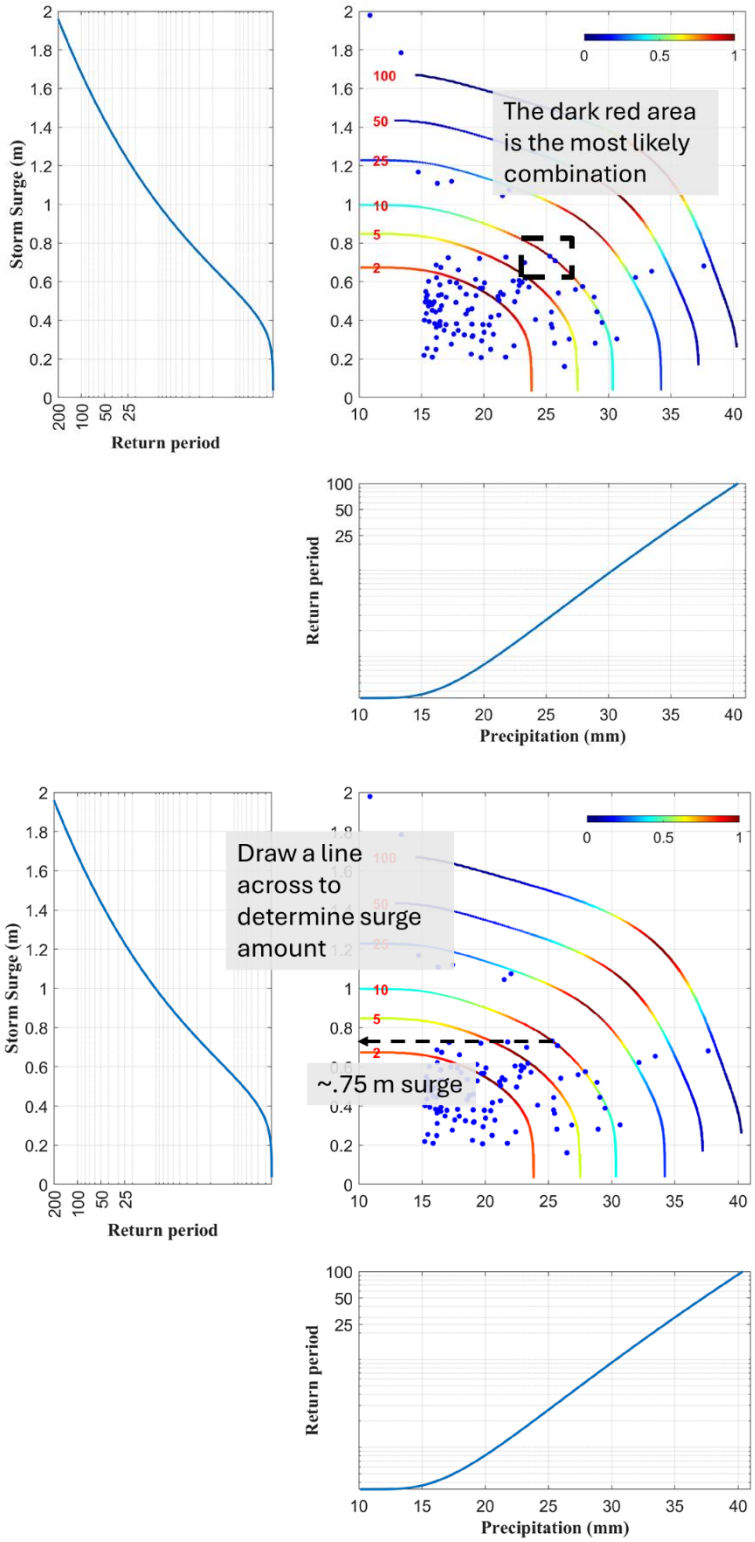
Each multicolored line represents different combinations of rainfall (X axis) and surge (Y axis) with the red areas being the most likely combinations, and the dark blue areas being least likely. Every point, or combination of surge and rainfall, along the same multicolored line has the same return period. These compound return periods are shown in red text near the Y axis.

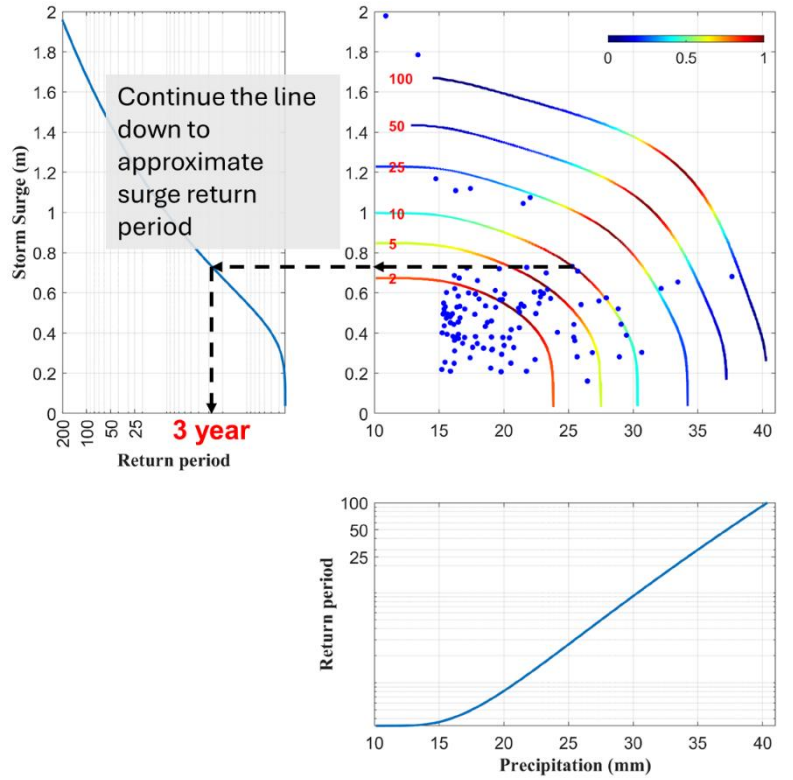
How would we determine how many inches of precipitation and how many inches of surge combine to make a compound flood event with a flood with a 10-year return period? First we look at the 10 line, denoted by the red number 10.

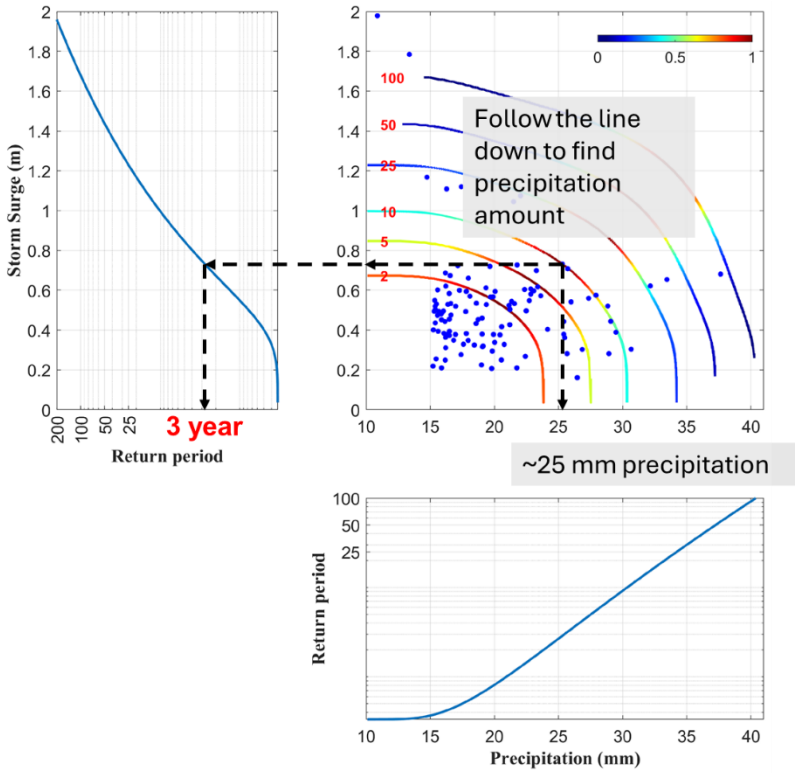

Storm Surge (m)
Return period
200
100
50
25
Find the 10 year return period line
100
50
25
10
5
2
0
0.5
1
Return period
Precipitation (mm)

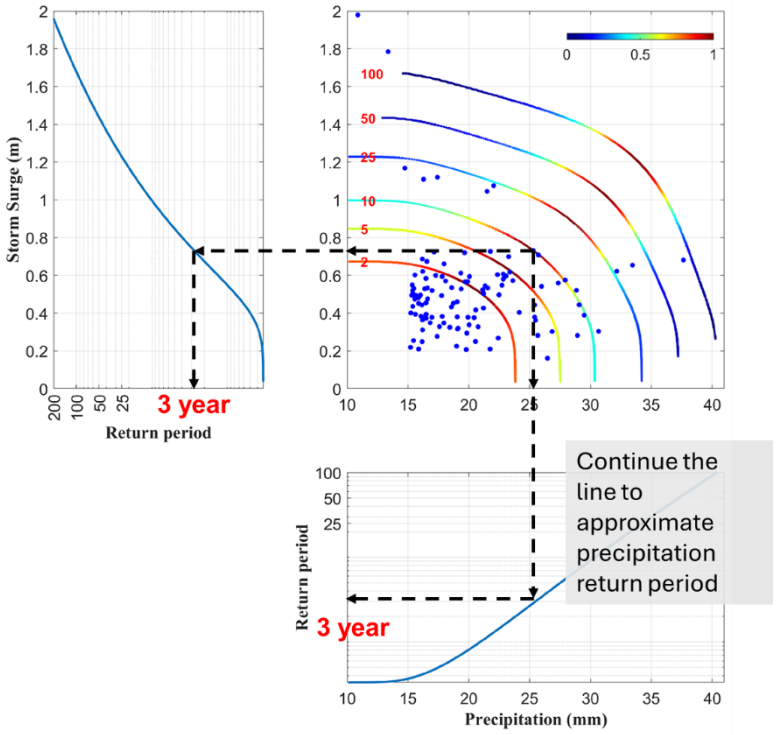

Storm Surge (m)
Return period
200
100
50
25
Every surge and precipitation combination along this line is a 10 year event
100
50
25
10
5
2
0
0.5
1
Return period
Precipitation (mm)

The most likely combination is the dark red section of the line. Now we uncouple the two factors to find what return period of surge and rainfall will combine to make this compound flood.




Continue the line down to approximate surge return period
Storm Surge (m)
Return period
3 year
100
50
25
10
5
2
Return period
Precipitation (mm)


Follow the line down to find precipitation amount
~25 mm precipitation
Storm Surge (m)
Return period
3 year
100
50
25
10
5
2
Return period
Precipitation (mm)



A 3-year rainfall (approx. 25 mm) and 3-year surge event (approx. .75 m) combine to make a compound flood that would be equivalent depth and extent as a typical 10-year flood event.