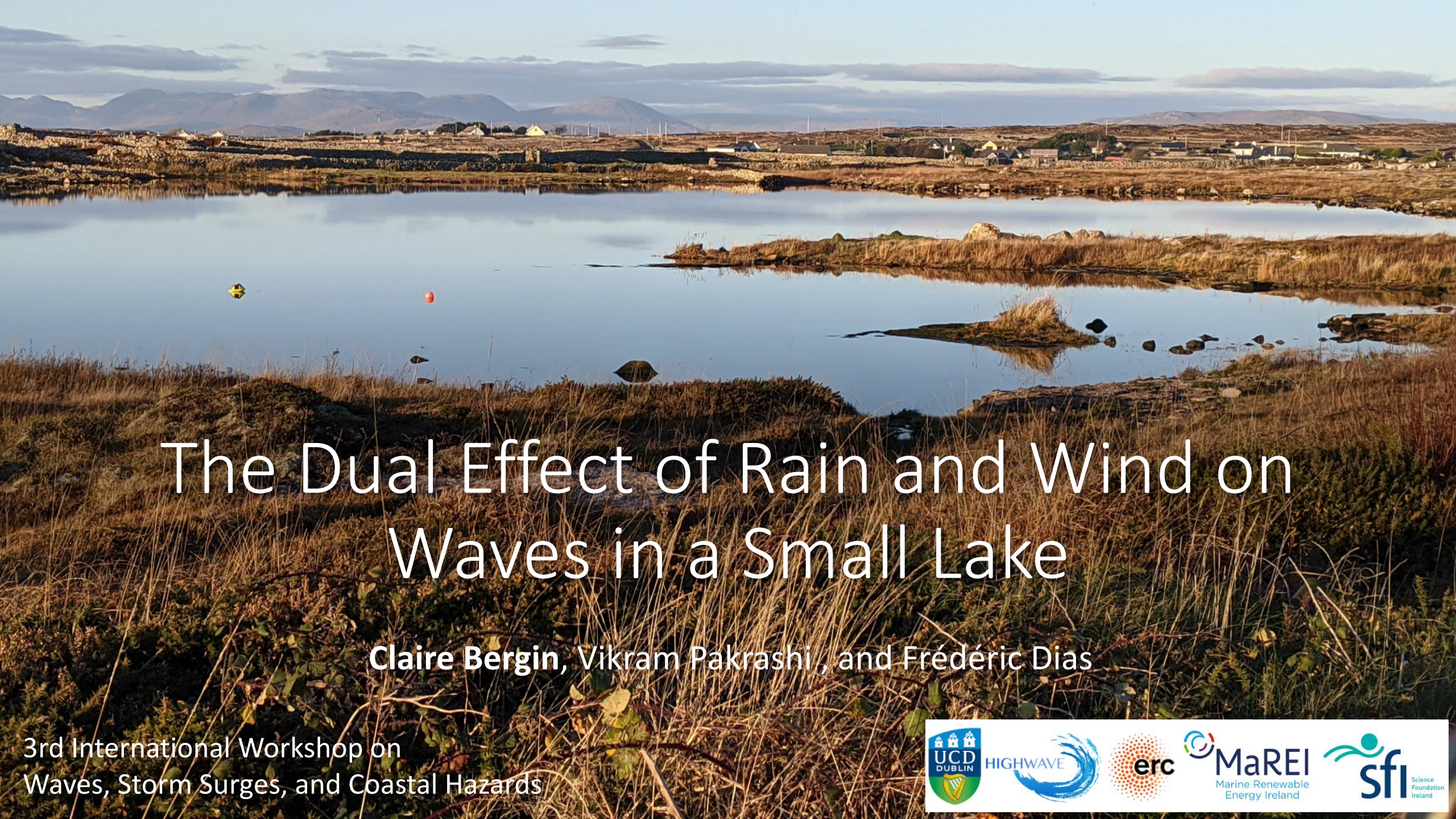


The Dual Effect of Rain and Wind on Waves in a Small Lake

Claire Bergin, Vikram Pakrashi , and Frédéric Dias

3rd International Workshop on
Waves, Storm Surges, and Coastal Hazards

Objectives

- Identify if there are threshold values for both rain intensity and wind speed where damping or amplification of wave height occurs
- Remove inaccuracies from lab experiments
  - Rain drop diameters
  - Instrument location

Hypothesis

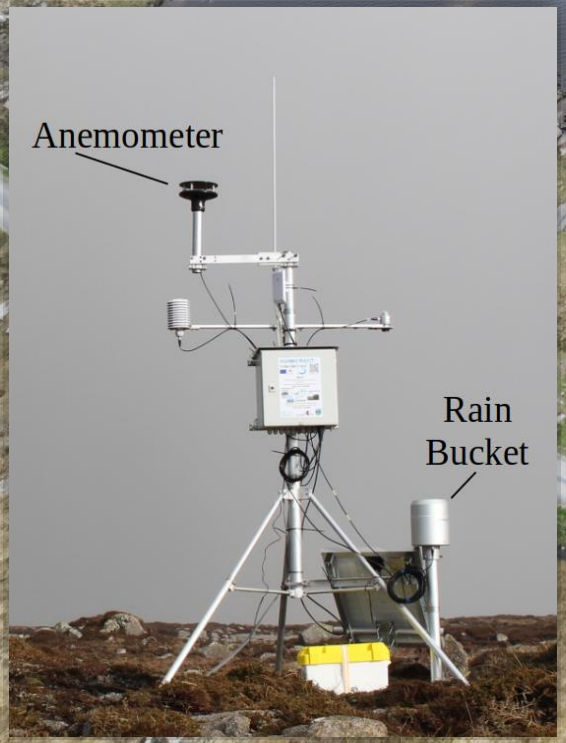
- Based on literature review we expect:
  - For low wind speeds, rain damps significant wave height
  - For higher wind speeds, rain no longer has a damping effect, instead wave height increases with wind speed
  - Observed at sea by Cavaleri et al 2018* and Cavaleri et al 2017**

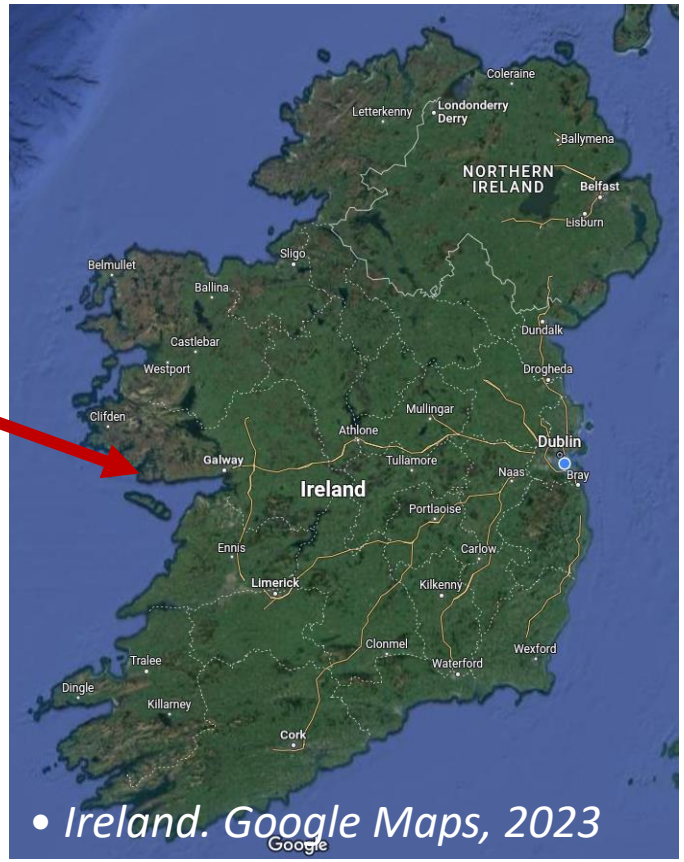
*Cavaleri, Luigi, Tom Baldock, Luciana Bertotti, Sabique Langodan, Mohammad Olfateh, and Paolo Pezzutto (2018). “What a Sudden Downpour Reveals About Wind Wave Generation”. In: Procedia IUTAM 26, pp. 70–80. DOI: https://doi.org/10.1016/j.piutam.2018.03.007.

**Cavaleri, Luigi and Luciana Bertotti (2017). “The Attenuation of Swell Waves by Rain”. In: Geophysical Research Letters 44.20, pp. 10, 504–10, 510. DOI: https://doi.org/10.1002/2017GL075458.

Experiment Setup

- Connemara, Ireland
- Data recorded every minute by wave buoy and weather station

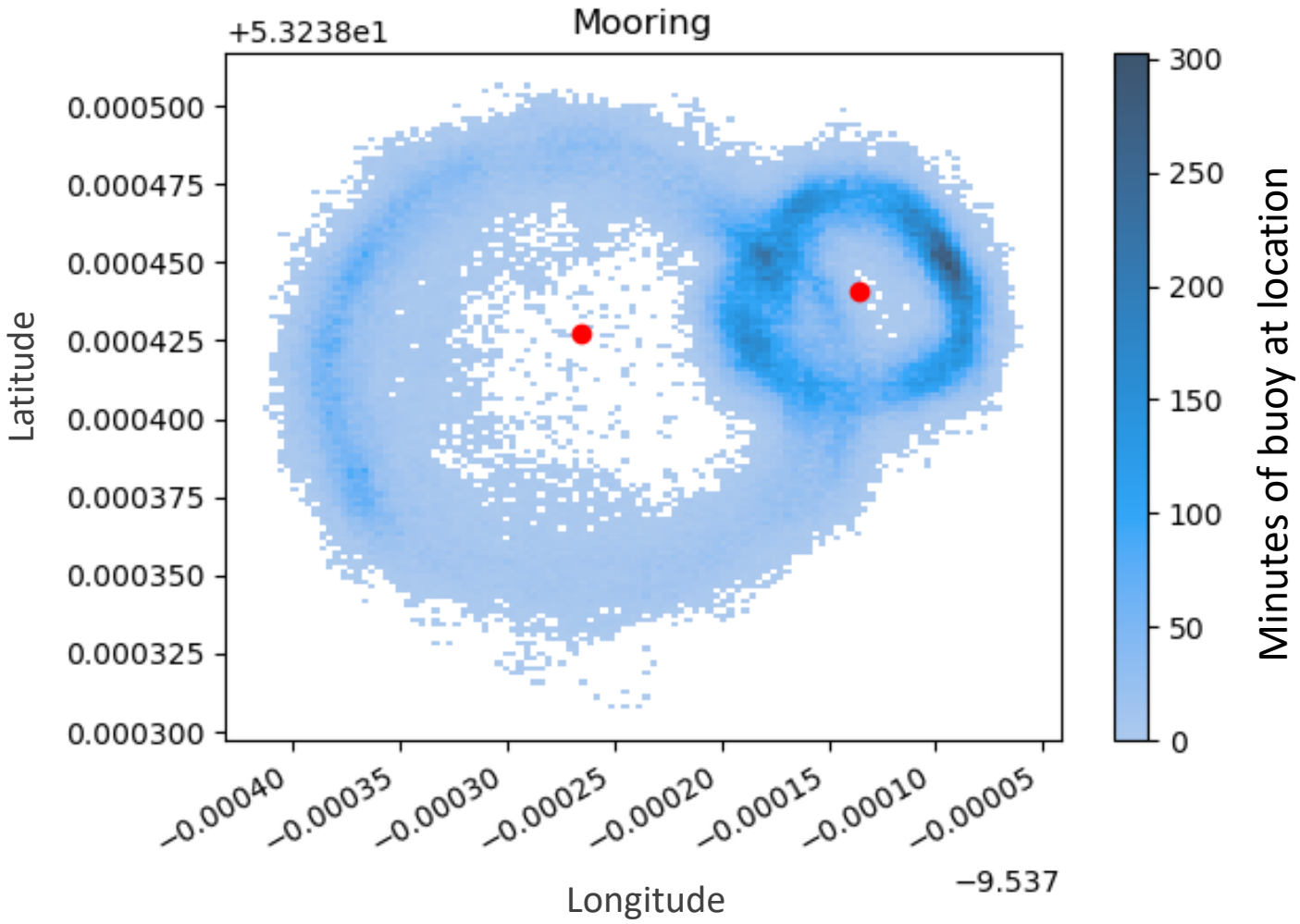




• *Ireland. Google Maps, 2023*

Quality Control

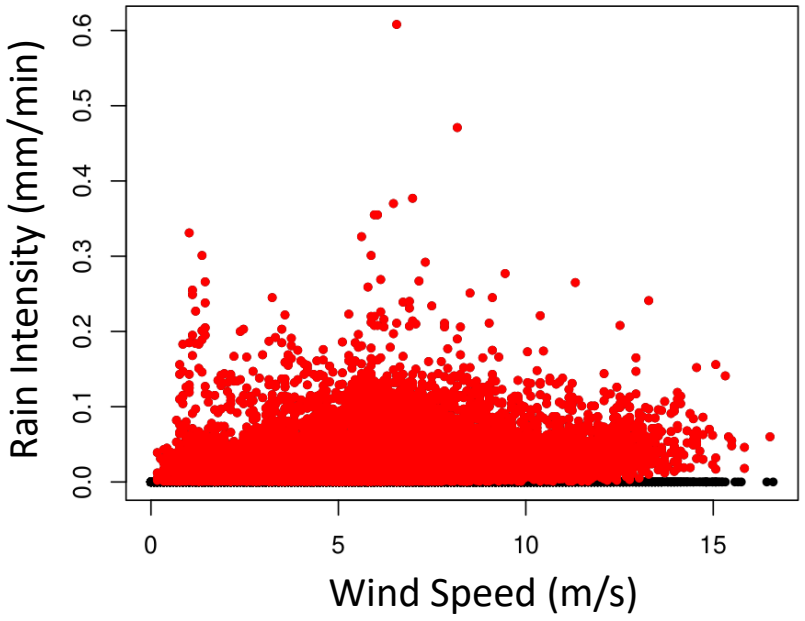
- Data periods
  - 9th to 26th March 2022
  - 1st April to 16th May 2022
  - 14th March to 2nd June 2023
- 205,754 minutes of data
- Visual check of buoy locations in lake

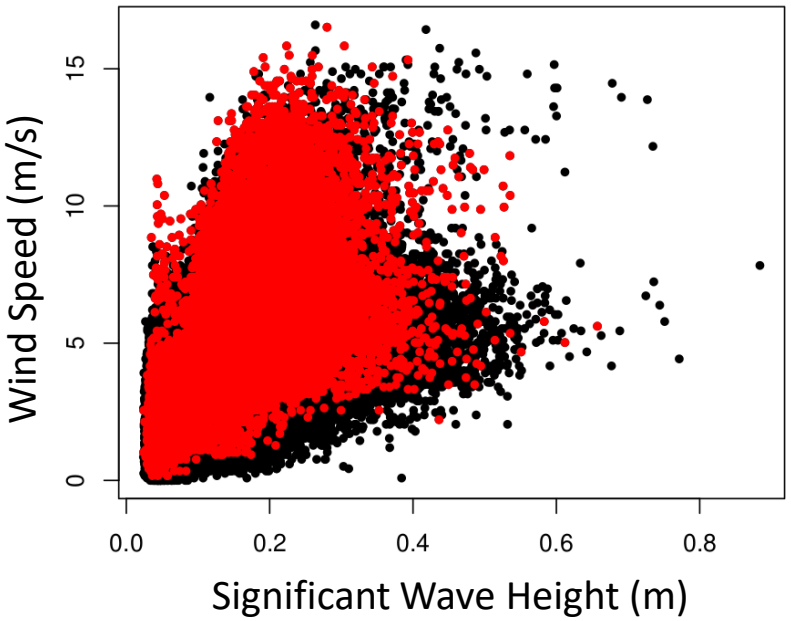


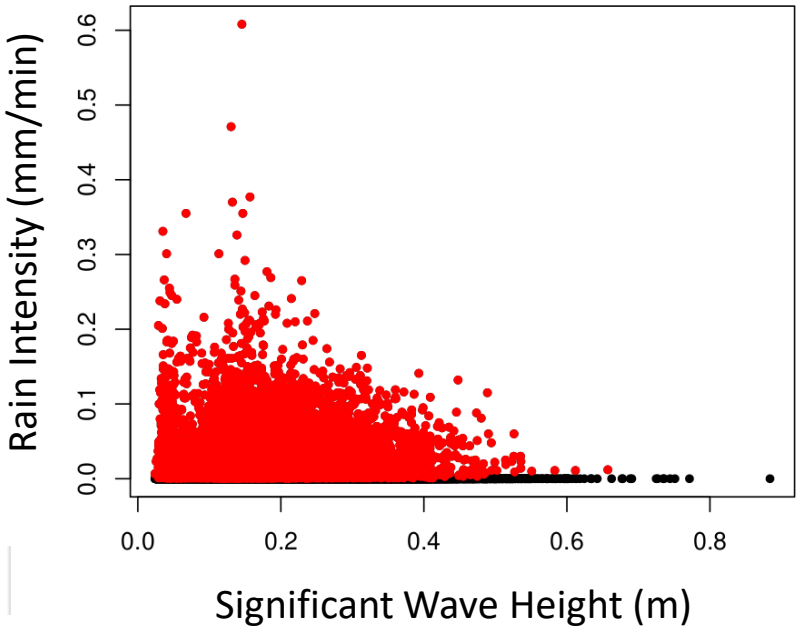
*Red dots indicate mean buoy locations (two separate runs)

Initial Data (Rain and No-Rain)

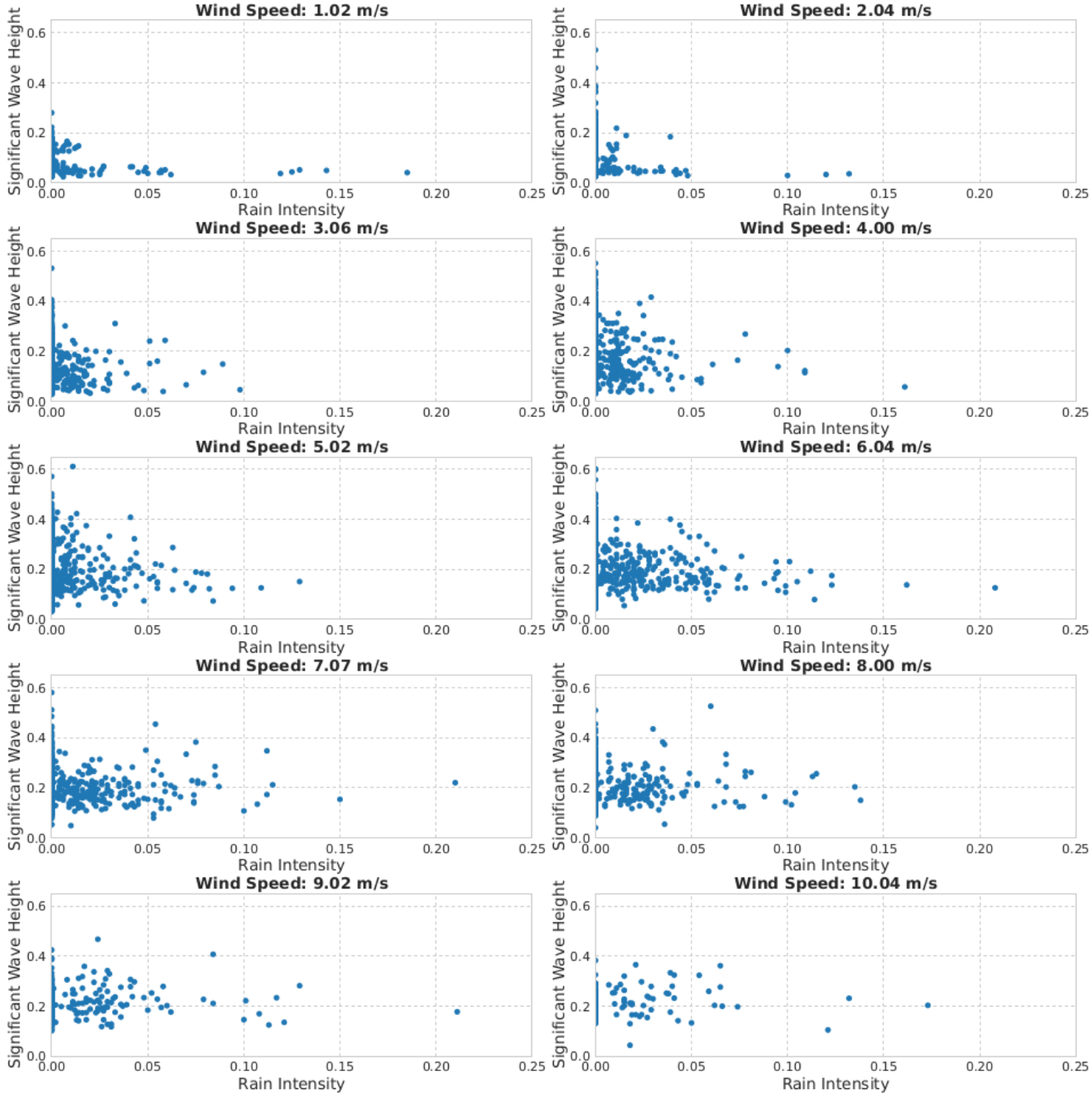
- 8% rainfall data







*Red dots indicate non-zero rainfall


Wind Speed: 1.02 m/s
Wind Speed: 2.04 m/s
Wind Speed: 3.06 m/s
Wind Speed: 4.00 m/s
Wind Speed: 5.02 m/s
Wind Speed: 6.04 m/s
Wind Speed: 7.07 m/s
Wind Speed: 8.00 m/s
Wind Speed: 9.02 m/s
Wind Speed: 10.04 m/s
Significant Wave Height
Rain Intensity
0.0
0.2
0.4
0.6
0.00
0.05
0.10
0.15
0.20
0.25

GAM- Generalized Additive Model

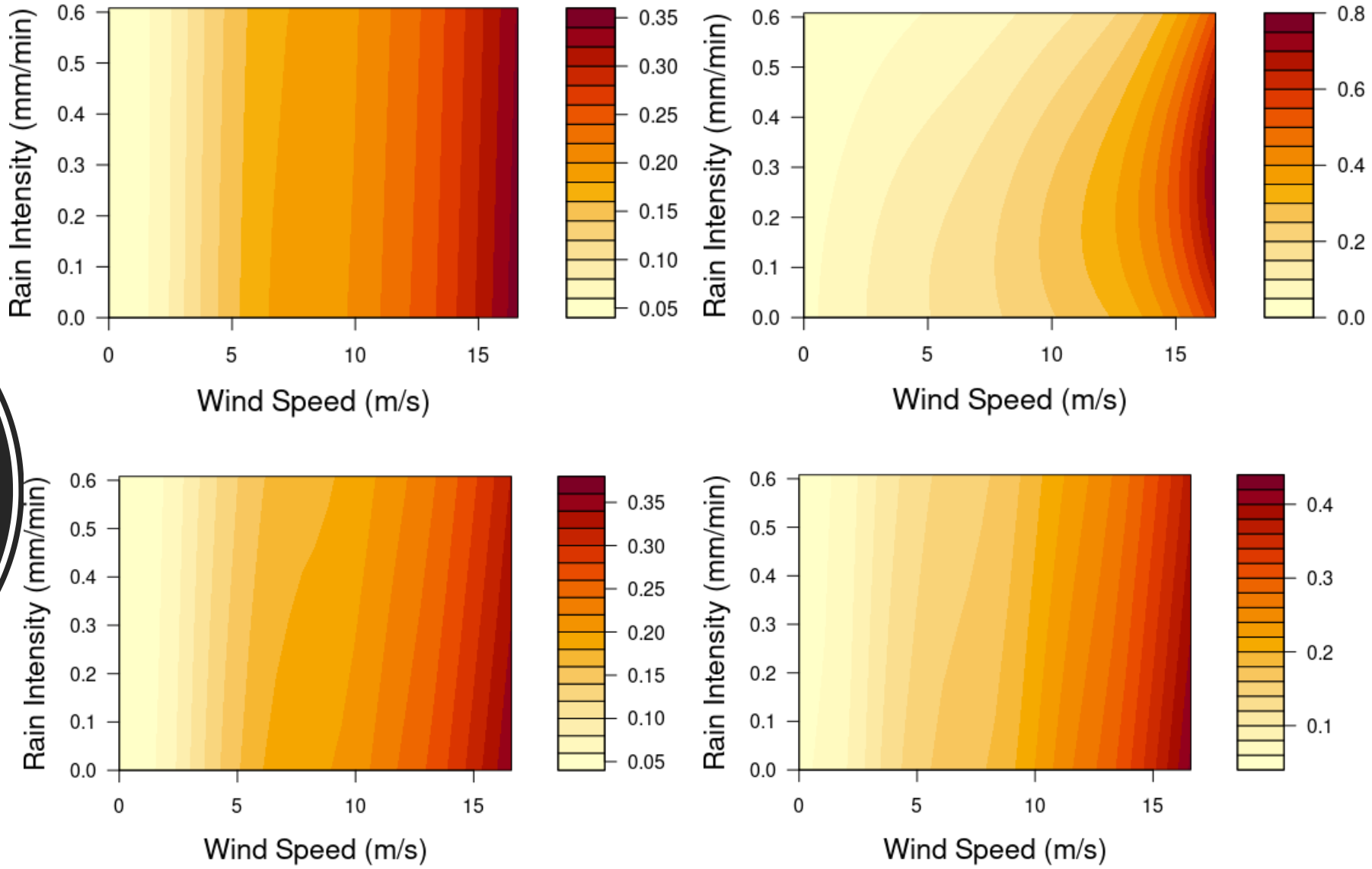
- Adaptation of the Generalized Linear Model for non-linear data

$$f(x) = \sum_{j=1}^{q} F_j(x) b_j$$

Different Model Inputs Used

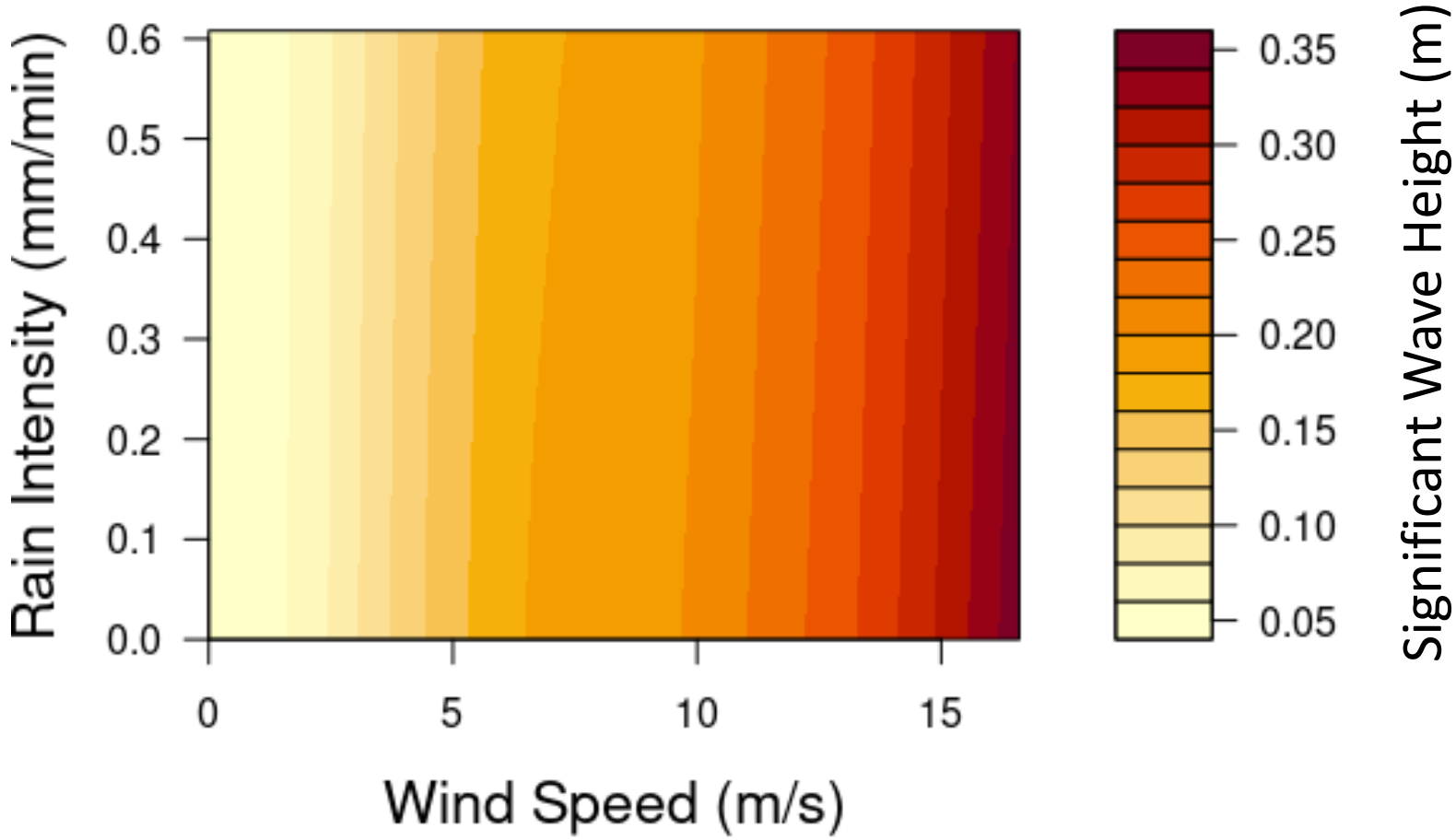
- Log(significant wave height) ~
  s(wind speed, rain intensity)
- Log(significant wave height) ~
  s(wind speed, rain intensity, fetch)
- Log(significant wave height) ~
  s(wind speed, rain intensity) + s(fetch)
- Log(significant wave height) ~
  s(wind speed, rain intensity) + s(wind speed, fetch)

Fetch is 100m

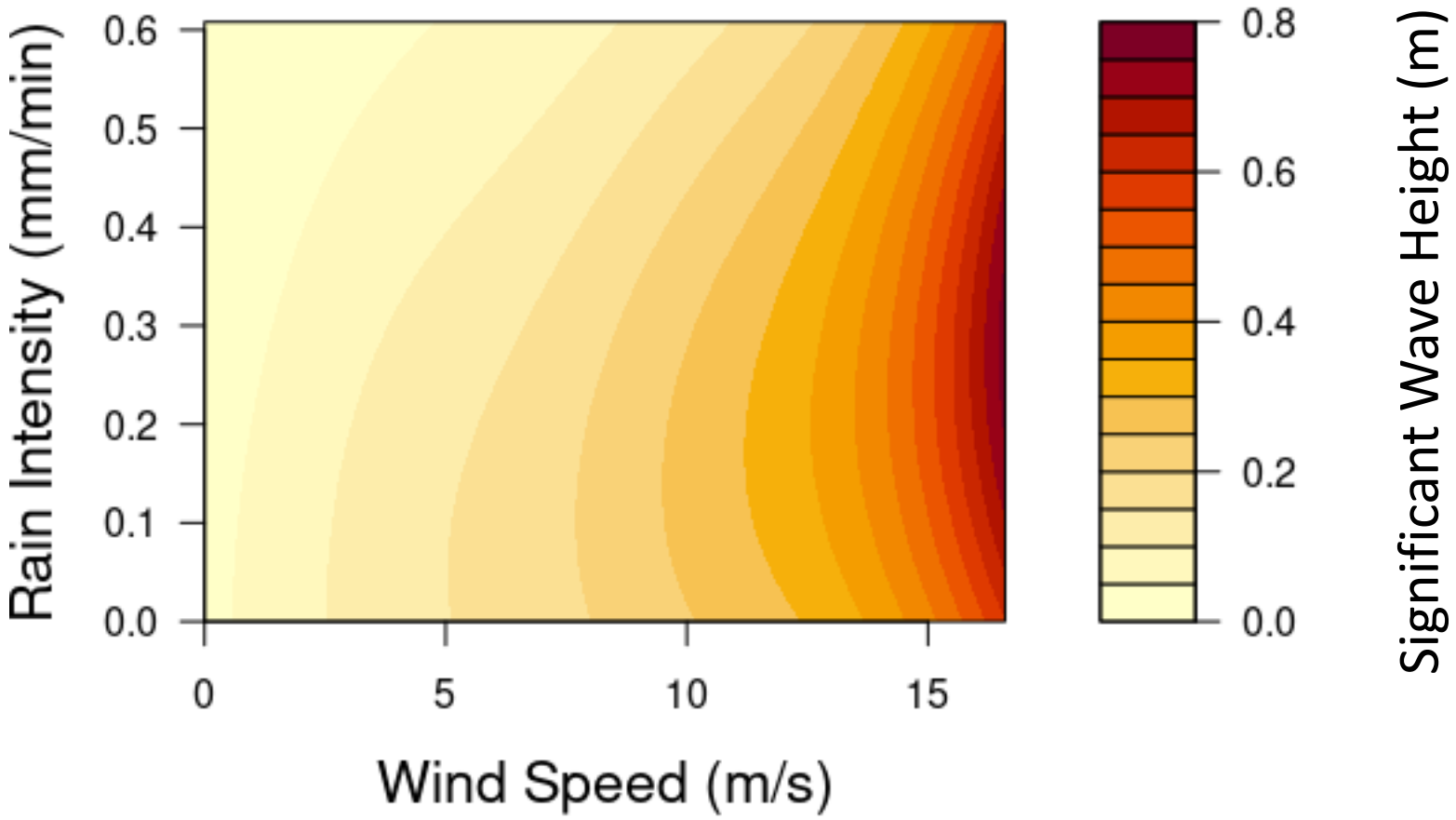


*Heat map: Significant Wave Height (m)

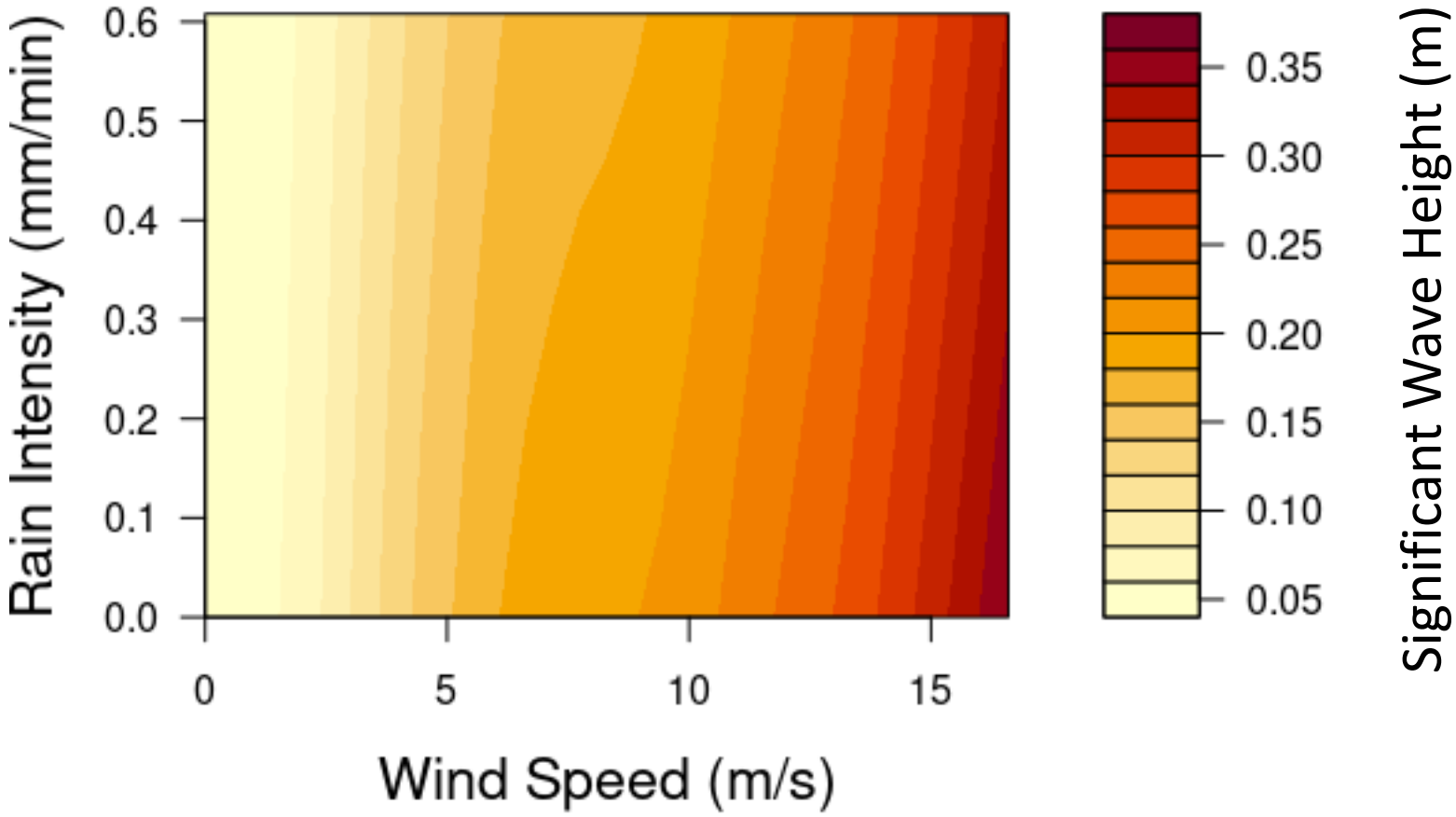
Log(significant wave height) ~ s(wind speed, rain intensity)



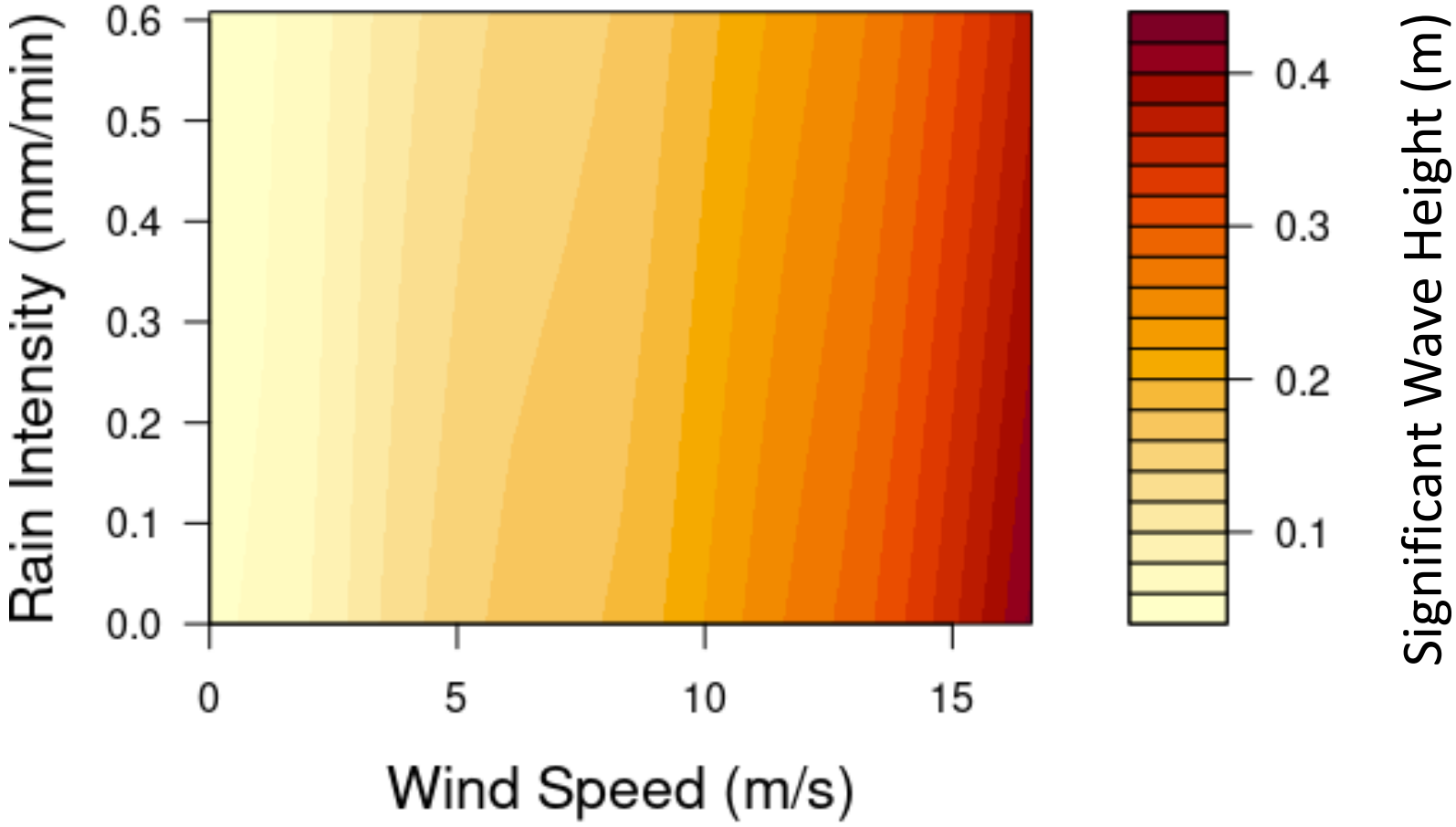
Log(significant wave height) ~ s(wind speed, rain intensity, fetch)



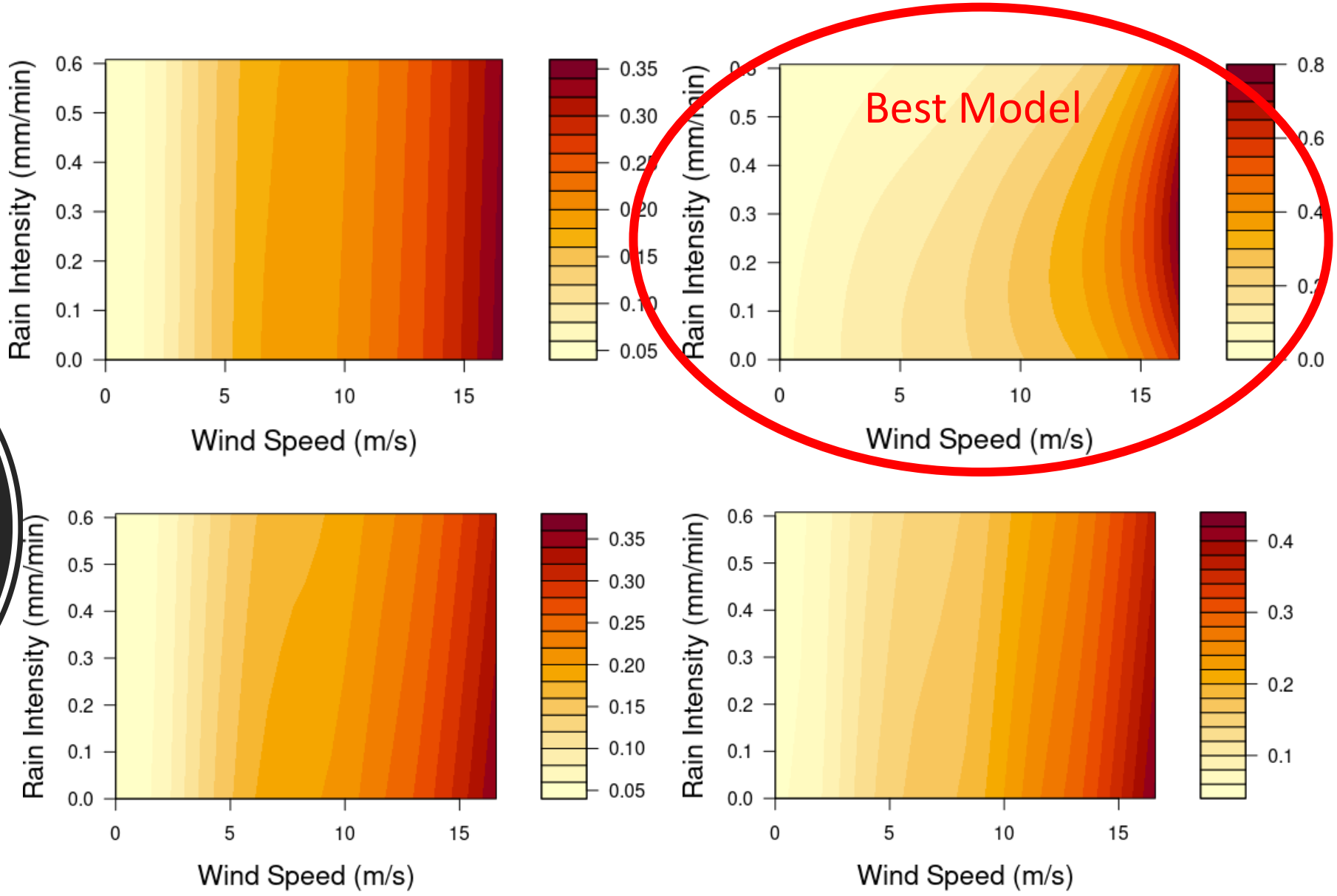
Log(significant wave height) ~ s(wind speed, rain intensity) + s(fetch)



Log(significant wave height) ~ s(wind speed, rain intensity) + s(wind speed, fetch)

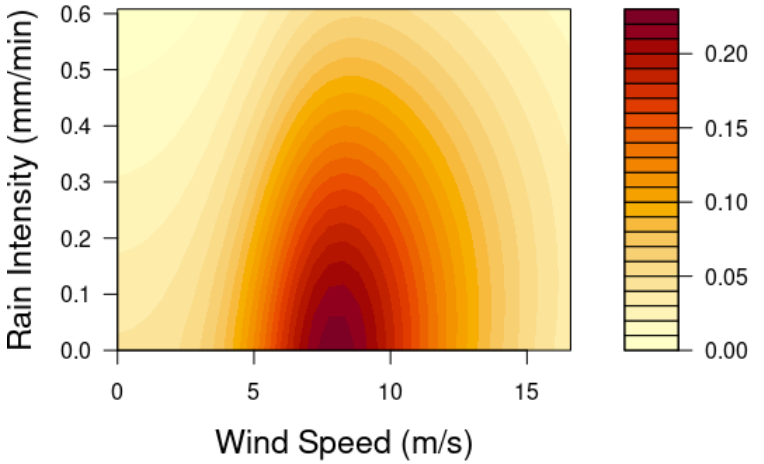


Fetch is 100m

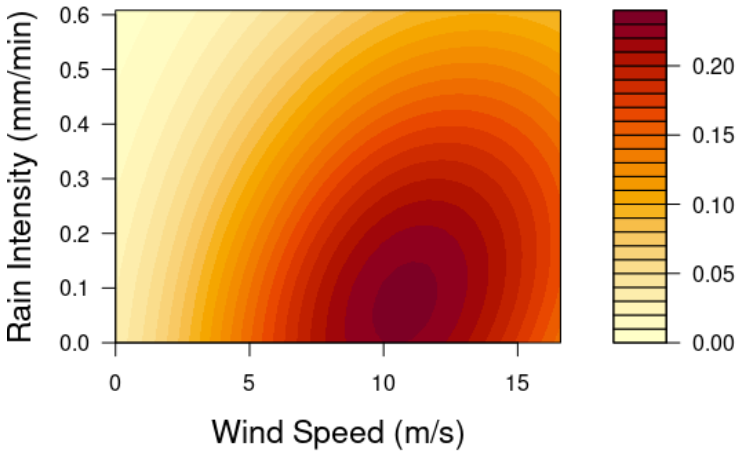


*Heat map: Significant Wave Height (m)

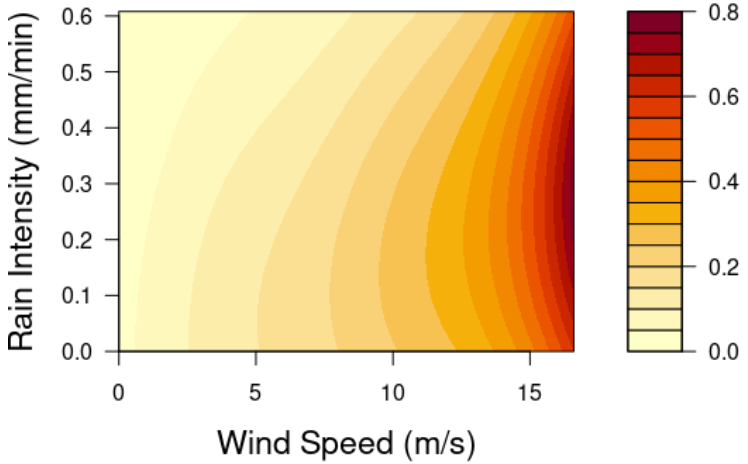
Best model - Log(significant wave height) ~ s(wind speed, rain intensity, fetch)



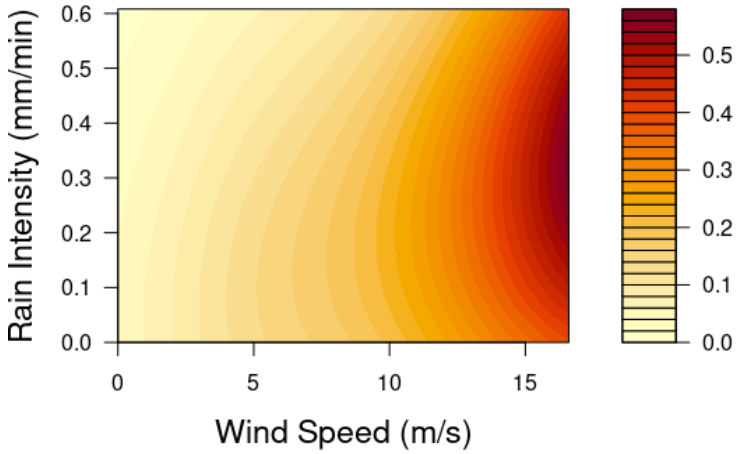
20m Fetch



50m Fetch



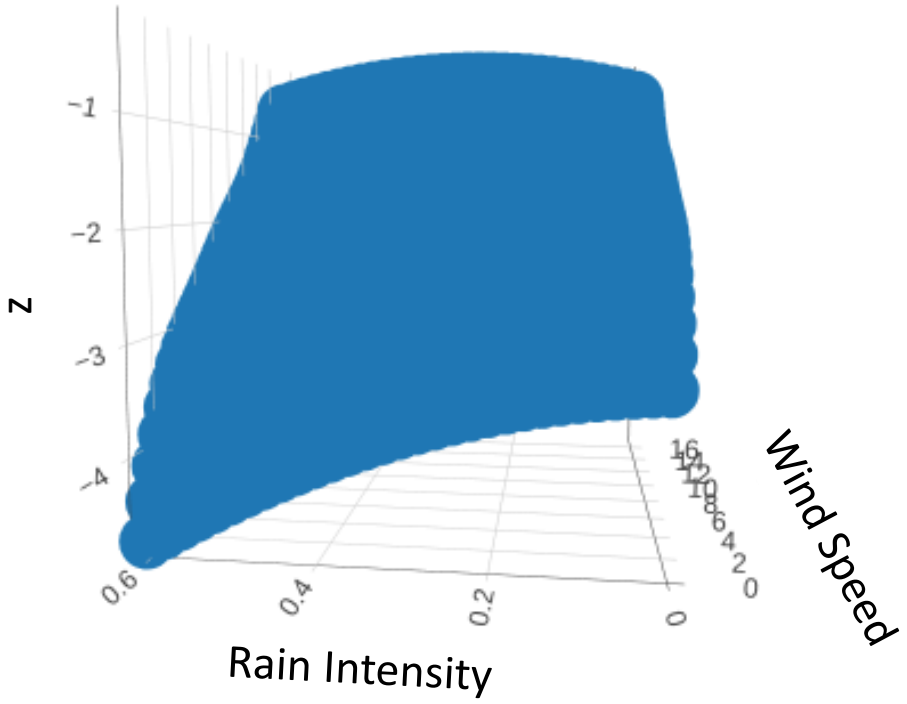
100m Fetch

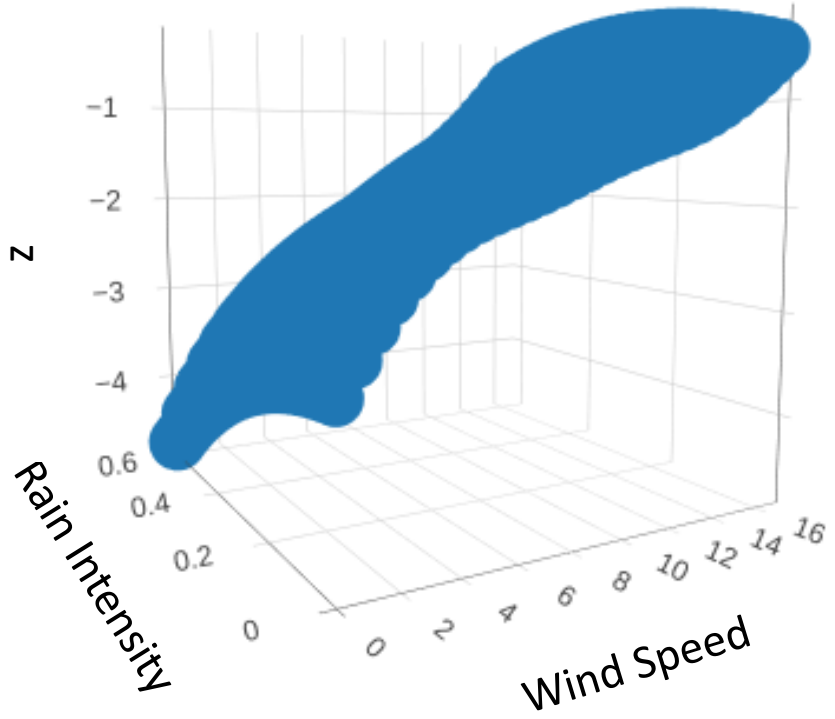


130m Fetch

*Heat map: Significant Wave Height (m)

3D plots – 100m Fetch





Future Plans

- Running the experiment at sea
- Including effects of swell
- Including higher wind speeds
- Comparing with the lake results

Conclusions

- Interaction between rain, wind, and wave height is well described by GAM models
- More data needed
- Experiment needs to be expanded again to the sea

Thank you for listening… Any questions?

Many thanks to Prof. Brendan Murphy for his statistics help and expertise, and Arnaud Disant for his help with the experiment design and deployment.