

# Lab 3: Depth-Damage Models

## DataFrames and Distributions

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```
1 using CSV
2 using DataFrames
3 using DataFramesMeta
4 using Distributions
5 using Interpolations
6 using Plots
7 using StatsPlots
8 using Unitful
9 using Random
10
11 Plots.default(; margin=6Plots.mm)
```

## 1 Site information

I selected the water gauge at 8771450 Galveston Pier 21, TX, which is located at the coordinates 29.31, -94.626667. The building I selected is the Ocean Star Museum Gift Shop, which is located at the coordinates 29.31046, -94.7917. Based on an estimate from Google Maps, the straight line distance between these points, not accounting for elevation differences, is less than 600 feet. An estimate from the USGS National Map Viewer suggests that this building is at an elevation of approximately 1.01m, or 3.31ft.

## 2 Depth-Damage

```
1 include("depthdamage.jl")
2 haz_fl_dept = CSV.read("data/haz_fl_dept.csv", DataFrame)
```

	Column1	Occupancy	DmgFnId	Source	Description
	Int64	String7	Int64	String31	String?
1	1	RES1	183	USACE - Wilmington	two story, Pile foundation, structure
2	2	RES1	184	USACE - Wilmington	two story, Structure
3	3	RES1	105	FIA	one floor, no basement, Structure, A-Zo
4	4	RES1	106	FIA (MOD.)	one floor, w/ basement, Structure, A-Zo
5	5	RES1	115	FIA	two floors, no basement, Structure, V-Zo
6	6	RES1	185	USACE - Wilmington	two story w/ 1/2 living area below, Struc
7	7	RES1	113	FIA	one floor, no basement, Structure, V-Zo
8	8	RES1	114	FIA (MOD.)	one floor, w/ basement, Structure, V-Zo
9	9	RES1	119	FIA	split level, no basement, Structure, V-Zo
10	10	RES1	116	FIA (MOD.)	two floors, w/ basement, Structure, V-Zo
11	11	RES1	117	FIA	three or more floors, no basement, Structure,
12	12	RES1	118	FIA (MOD.)	three or more floors, w/ basement, Structure,
13	13	RES1	21	FIA	one floor, no basement, Contents, A-Zo
14	14	RES1	111	FIA	split level, no basement, Structure, A-Zo
15	15	RES1	112	FIA (MOD.)	split level, w/ basement, Structure, A-Zo
16	16	RES1	24	FIA (MOD.)	two floors, w/ basement, Contents, A-Zo
17	17	RES1	25	FIA (MOD.)	three or more floors, no basement, Contents,
18	18	RES1	26	FIA (MOD.)	three or more floors, w/ basement, Contents,
19	19	RES1	27	FIA	split level, no basement, Contents, A-Zo
20	20	RES1	28	FIA (MOD.)	split level, w/ basement, Contents, A-Zo
21	21	RES1	29	FIA	one floor, no basement, Contents, V-Zo
22	22	RES1	30	FIA	one floor, w/ basement, Contents, V-Zo
23	23	RES1	31	FIA	two floors, no basement, Contents, V-Zo
24	24	RES1	107	FIA	two floors, no basement, Structure, A-Zo
25	25	RES1	108	FIA (MOD.)	two floors, w/ basement, Structure, A-Zo
26	26	RES1	109	FIA	three or more floors, no basement, Structure,
27	27	RES1	22	FIA	one floor, w/ basement, Contents, A-Zo
28	28	RES1	23	FIA	two floors, no basement, Contents, A-Zo
29	29	RES1	45	USACE - IWR	one story, no basement, Contents
30	30	RES1	46	USACE - IWR	two or more stories, no basement, Conte
...	...	...	...	...	...

Because the selected structure is a museum gift shop, we will use the HAZUS row with the description “Gift Shop, contents (Inventory)”. The building appears to be one story, which is an option for buildings of this class.

```

1 ocean_star_row = @rsubset(
2   haz_fl_dept, :Description == "Gift Shop, contents (Inventory)"
3 )[
4   1, :,
5 ]
6 ocean_star_dd = DepthDamageData(ocean_star_row)

```

DepthDamageData(Quantity{Float64, , Unitful.FreeUnits{(ft,) , nothing}}[-4.0 ft, -3.0 ft, -2

```

1 scatter(
2   ocean_star_dd.depths,

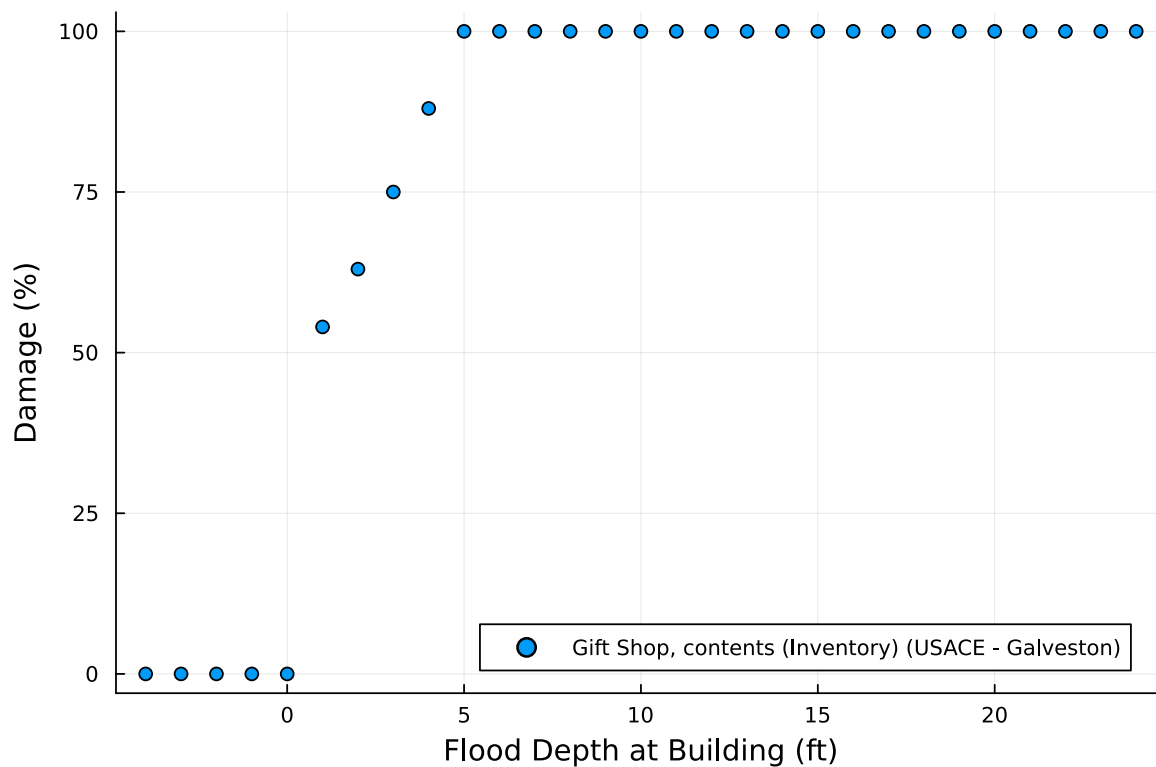
```

```

3 ocean_star_dd.damages;
4 xlabel="Flood Depth at Building",
5 ylabel="Damage (%)",
6 label="$(ocean_star_dd.description) ($(ocean_star_dd.source))",
7 legend=:bottomright,
8 size=(700, 500),
9 title = "Ocean Star Museum Gift Shop HAZUS Damage"
10 )

```

## Ocean Star Museum Gift Shop HAZUS Damage



```

1 damage_fn = get_depth_damage_function(ocean_star_dd.depths, ocean_star_dd.damages)

#79 (generic function with 1 method)

1 function get_depth_damage_function(
2     depth_train::Vector{<:T}, dmg_train::Vector{<:AbstractFloat}
3 ) where {T<:Unitful.Length}
4
5     # interpolate
6     depth_ft = ustrip(u"ft", depth_train)
7     interp_fn = Interpolations.LinearInterpolation(
8         depth_ft,                                     ①
9         dmg_train;
10        extrapolation_bc=Interpolations.Flat(),       ②

```

```

11 )
12
13 damage_fn = function (depth::T2) where {T2<:Unitful.Length}
14     return interp_fn(ustrip.(u"ft", depth)) ③
15 end
16 return damage_fn ④
17 end

```

get\_depth\_damage\_function (generic function with 1 method)

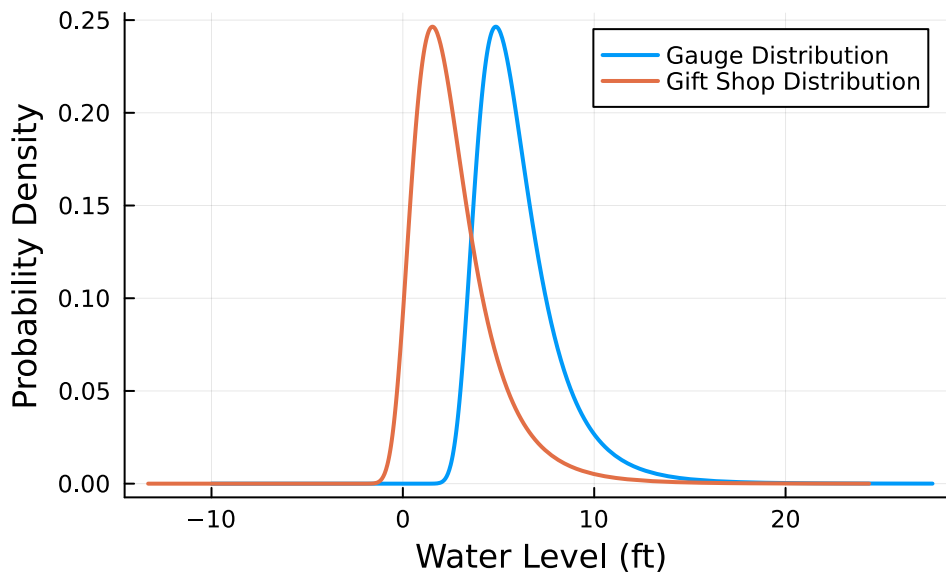
### 3 Expected annual damages

The following plot shows the generalized extreme value distribution that we are assuming captures flood risk at the Galveston Pier 21 Water Gauge and at the Ocean Star Museum Gift Shop.

```

1 gauge_dist = GeneralizedExtremeValue(5, 1.5, 0.1)
2 p1 = plot(
3     gauge_dist;
4     label="Gauge Distribution",
5     xlabel="Water Level (ft)",
6     ylabel="Probability Density",
7     legend=:topright,
8     linewidth=2,
9 )
10
11 offset = 3.31 # house is 2.5 feet above gauge
12 building_dist = GeneralizedExtremeValue(gauge_dist. - offset, gauge_dist., gauge_dist.)
13
14 plot!(p1, building_dist; label="Gift Shop Distribution", linewidth=2)

```



I next draw 1,000,000 samples from the generalized extreme value distribution and calculate the sample mean.

```

1 Random.seed!(123)
2 samp = 1u"km".* rand(building_dist, 1000000)

1 dmg_fn(samp) = itp(ustrip.(u"ft", samp))
2 year_vec = dmg_fn.(samp)
3 mc_est = mean(year_vec)

```

①  
②

96.3362792558495

## 4 Discussion

The estimate of annual damages based on 1,000,000 random samples from a generalized extreme value distribution with a mean of 5ft, a standard deviation of 1.5 ft, and error 0.1ft is 96.3362792558495 percent. This means that if we assume that flooding at the Galveston Pier 1 Water Gauge follows this distribution, the HAZUS depth damage curve predicts that, on average, the Ocean Star Museum Gift Shop will experience flood damage to 96.3362792558495 percent of its content, meaning its inventory in the case of a gift shop.