

Case study: estimating height of a dike

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Dikes and flooding



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Dikes and flooding



Flood protection equipment in New Orleans after passage of hurricane Katrina

Dikes and flooding



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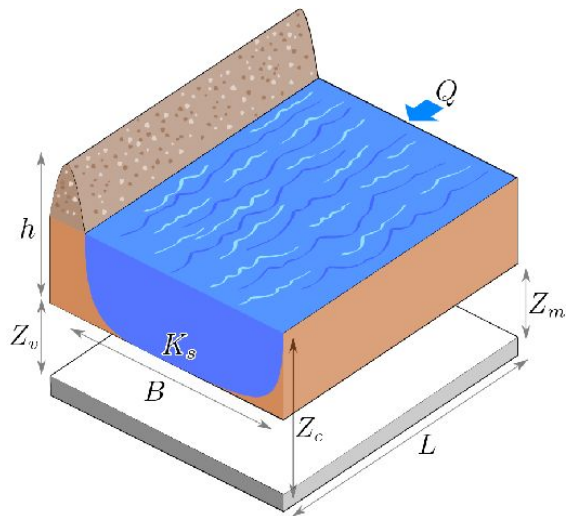
Illustration of dike failure



Modelling flood risk

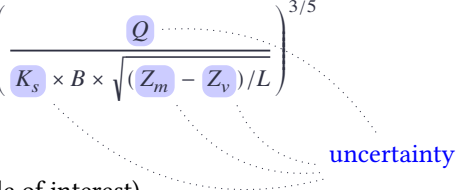
- ▷ In reality, dike design is a function of many parameters:
 - dike geometries and materials
 - hydrological, hydraulic and topographic data
 - wind speed and directions
 - linked wave effects
 - changing roughness due to seasonal vegetation
 - effect of sediment transport on flow resistance
- ▷ In this work, **very simplified equations** are used
 - main aim is to illustrate different risk assessment approaches

Model parameters



The system model

The maximal water level of the river (Z_c) is given as a function of several parameters, some of which are uncertain:

$$Z_c = \left(\frac{Q}{K_s \times B \times \sqrt{(Z_m - Z_v)/L}} \right)^{3/5}$$


where

- ▷ Z_c is flood level (variable of interest)
- ▷ Z_m and Z_v are level of the riverbed, upstream and downstream (uncertain)
- ▷ Q is maximal annual flowrate of the river (uncertain)
- ▷ K_s is Strickler's roughness coefficient (uncertain)
- ▷ B and L are the width and length of the river cross-section (certain)

Input parameters

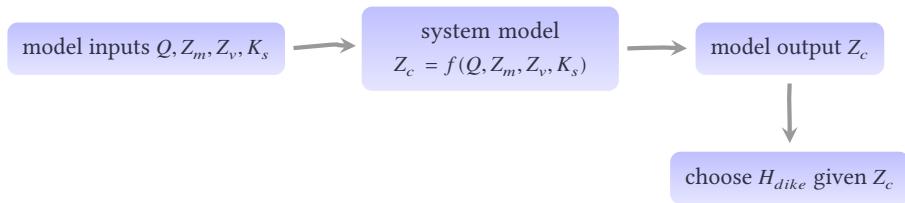
Input	Description	Unit	Probability distribution
Q	Maximal annual flowrate	m^3/s	Fit to observations
K_s	Strickler coefficient	-	Truncated normal $\mathcal{N}(30, 8)$ on $[15, +\infty[$
Z_v	River downstream level	m	Triangular $\mathcal{T}(49, 50, 51)$
Z_m	River upstream level	m	Triangular $\mathcal{T}(54, 55, 56)$
L	Length of the river stretch	m	5000
B	River width	m	300

Flowrate measurements

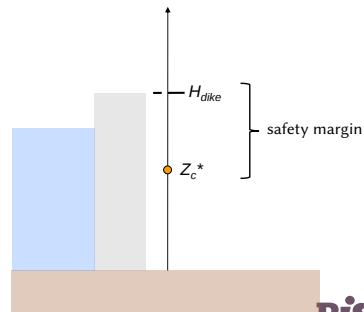
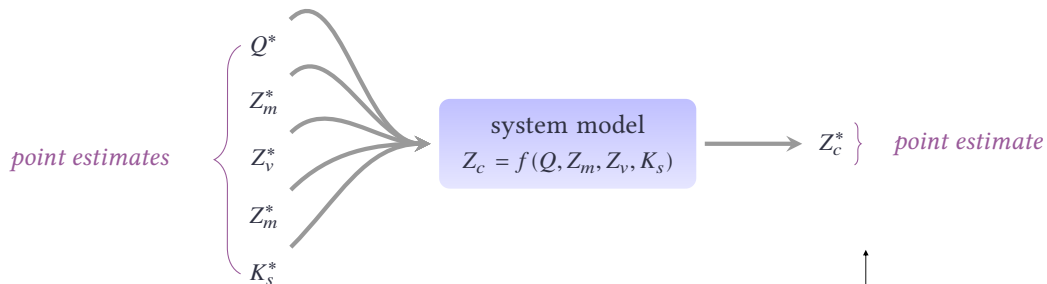
You have the following measurements of the maximum flowrate in the river from the past 20 years (observations are expressed in m^3/s):

1114, 773, 570, 1069, 1340, 2653, 2956, 892, 701, 1169,
525, 683, 2102, 1060, 296, 2107, 1720, 849, 1361, 2024

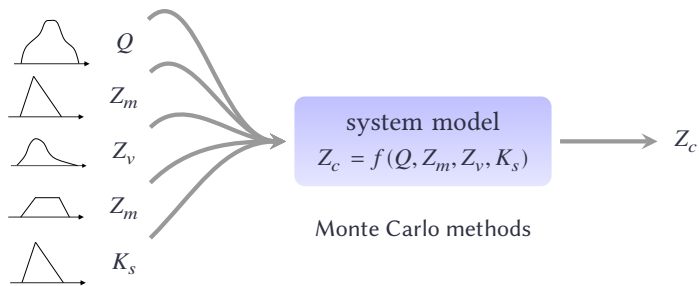
System model and risk



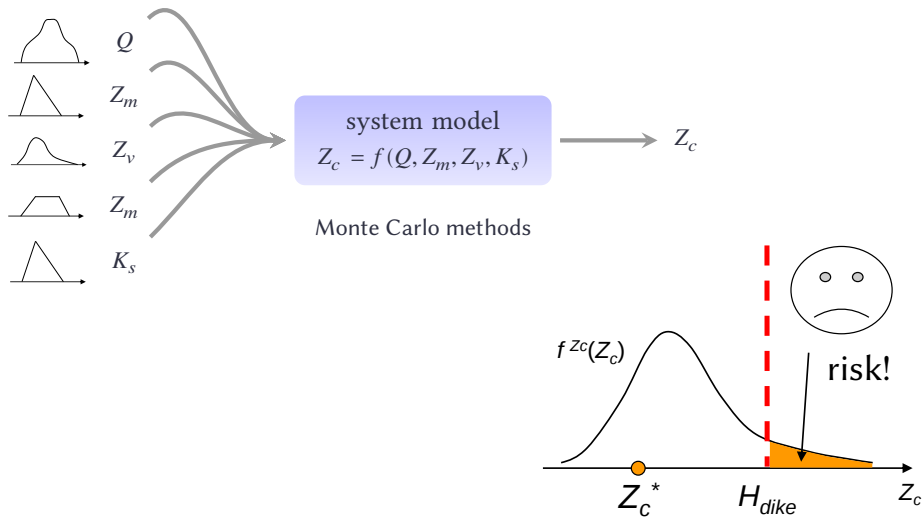
Deterministic approach to risk assessment



Probabilistic approach to risk assessment



Probabilistic approach to risk assessment



Task

- ▷ Fit a lognormal distribution to the measurements of maximal flowrate
 - check that a lognormal distribution fits this data well, using a probability plot
- ▷ Calculate the average height of the river by making a deterministic calculation
 - use median values for each uncertain parameter
- ▷ Calculate the maximum (“worst case”) height of the river using a deterministic approach
- ▷ Produce a histogram of possible water levels, given the input uncertainty, using a Monte Carlo approach
- ▷ Estimate the 100-year flood level for this river
 - note: specialists use the term “0.01 annual exceedance probability” flood, meaning a flood that has a 1% chance of happening in any given year

Hints

- ▷ To fit a lognormal distribution to data, use
`shape, loc, scale = scipy.stats.lognorm.fit(obs)`
- ▷ A probability plot can be drawn with
`scipy.stats.probplot(obs, dist=scipy.stats.lognorm(shape, loc, scale), plot=plt.figure().add_subplot(111))`
- ▷ To obtain a random variate from a probability distribution, use method `rvs()`
- ▷ To obtain a random number from a triangular probability distribution, use
`numpy.random.triangular(min, centre, max)`
- ▷ A left-truncated probability distribution can be obtained using (left truncation at 15)
`max(15, random_variate)`
- ▷ The square root of x is given by `numpy.sqrt(x)`
- ▷ Plot a histogram with `plt.hist(obs)` (first say `import matplotlib.pyplot as plt`)