General considerations regarding availability

- Our final report as well as all the data are accessible on Amazon Web Services: https://www.amazon.com/clouddrive/folder/mBhUGphVS72wZBcAaW6qnQ?_encoding=UTF8&mgh=1&ref_=nav_Photos_Files&sf=1
- A link from our website to the data will also be available
- Links to the apps will also be posted

Tailings Dam State Identification & Failure Impact Analysis App

C:/Users/Paulina/Dropbox/Mining/Shinyapp - Shiny

http://127.0.0.1:4095 | Open in Browser | Publish

Overview

This tool serves to estimate the **volume of tailings released in the event of a tailings dam failure** and the corresponding **distance traveled by the tailings (run-out distance).**

The analysis is based on the empirical relationships developed by Rico et al., 2008 using historical tailings dam failures

These equations have great uncertainty around the mean estimation from the regression so the conditional distribution is displayed for risk analysis purposes.

The tool can also be used to estimate a **Hazard Rating Index** that is based on the attributes of the tailings dam and the characteristics of the area downstream from the dam.

For more information about the calculation of the index refer to the documentation section.

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Please select an option from the menu bar

Released volume and Distance | Hazard Rating | Documentation

In this section you can obtain the distribution of the estimated released volume of tailings and the run-out distance of the tailings in case of a dam failure. The inputs needed are the height of the dam and the volume of tailings in the impoundment

Predict volume of released tailings

Input volume of tailings in million m^3

12

Predicted released volume in million m^3

Q50	Q25	Q75
3.60	2.10	6.00

Predict run-out distance

Input Height in m

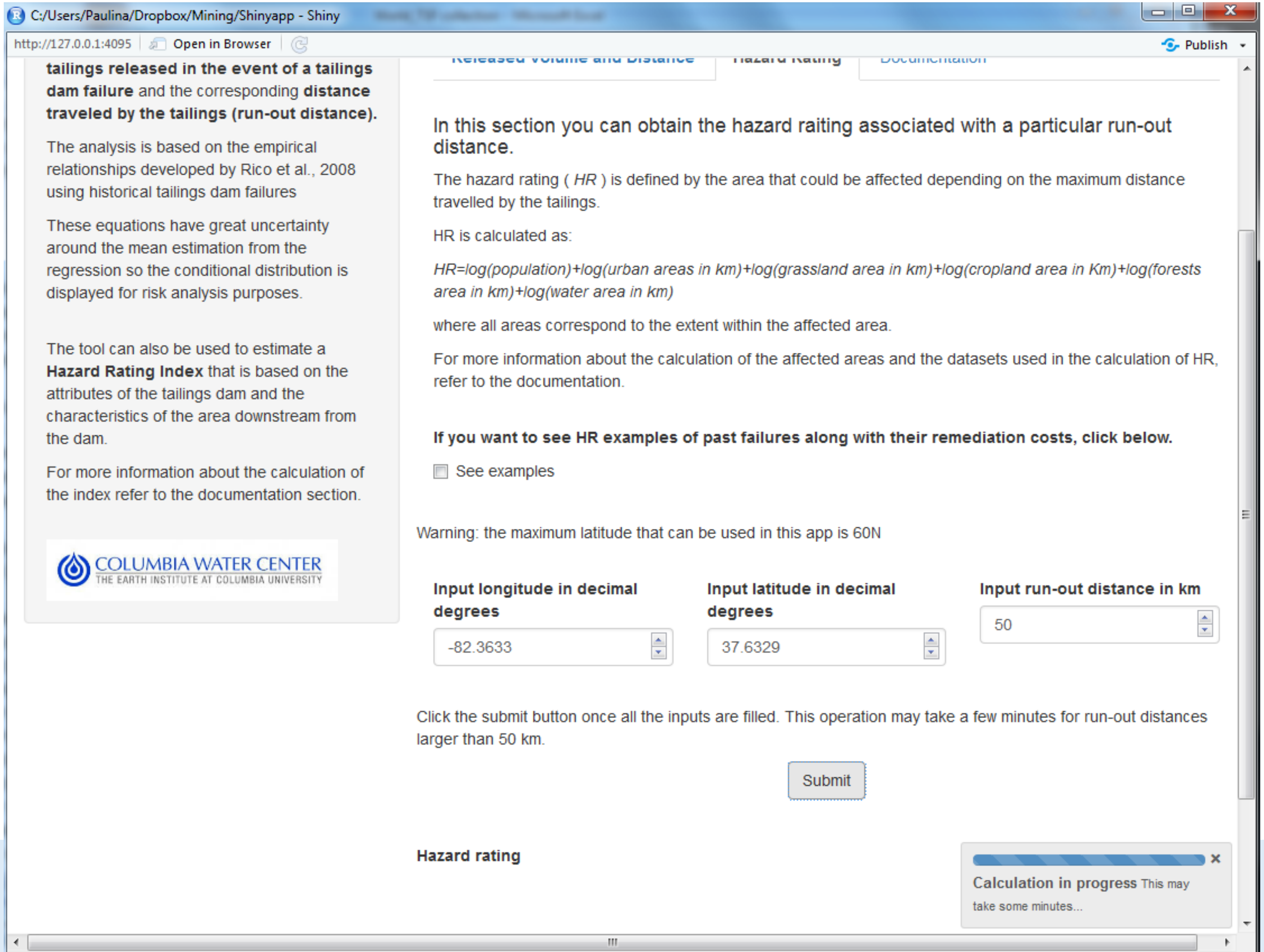
195

Predicted run-out distance in km.This is calculated with the median predicted value of VF

Q50	Q25	Q75
49.10	15.30	157.70

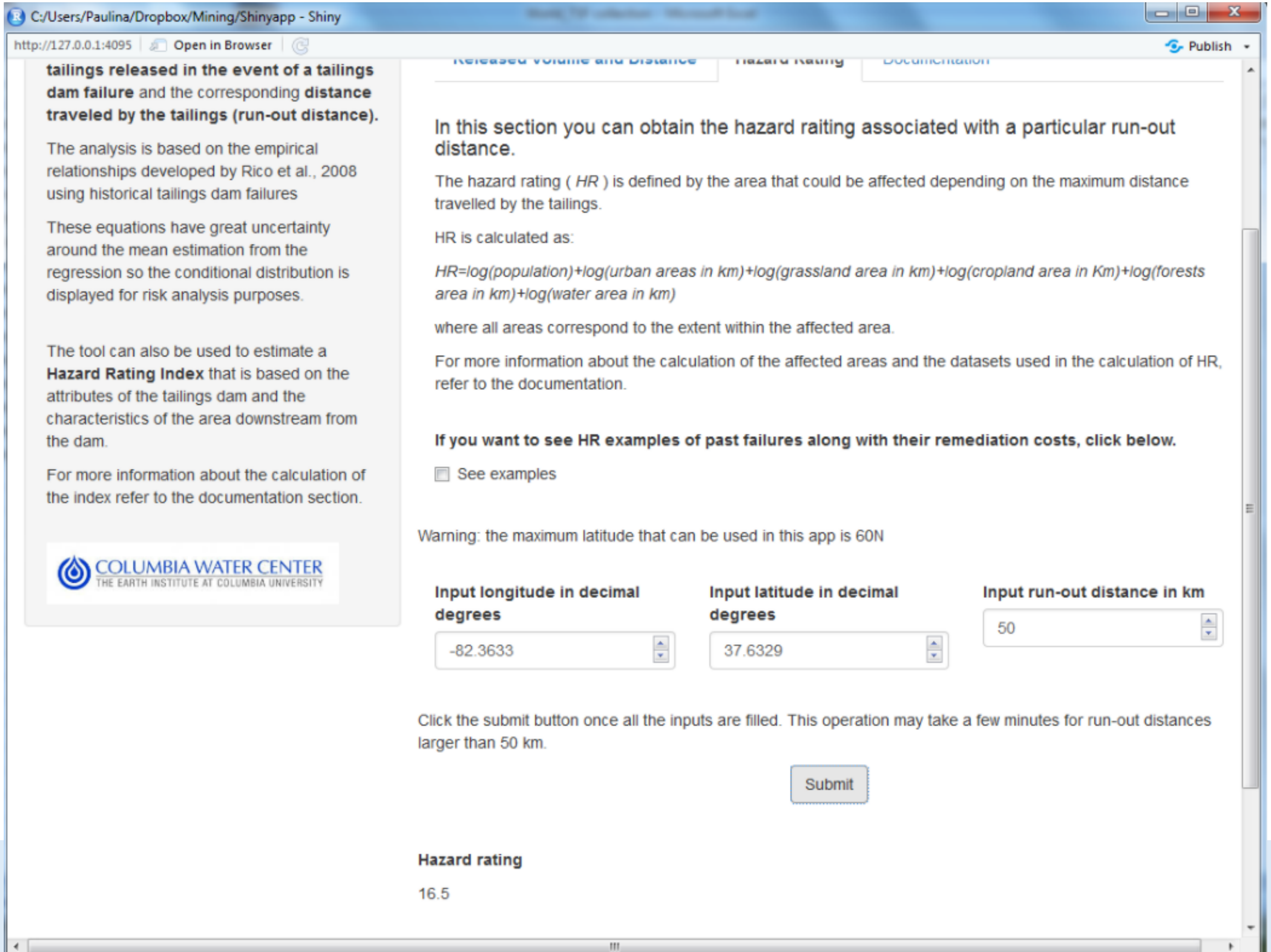
If you want to calculate the run-out distance distribution using another value of released volume of tailings, input it below

Tailings Dam State Identification & Failure Impact Analysis App



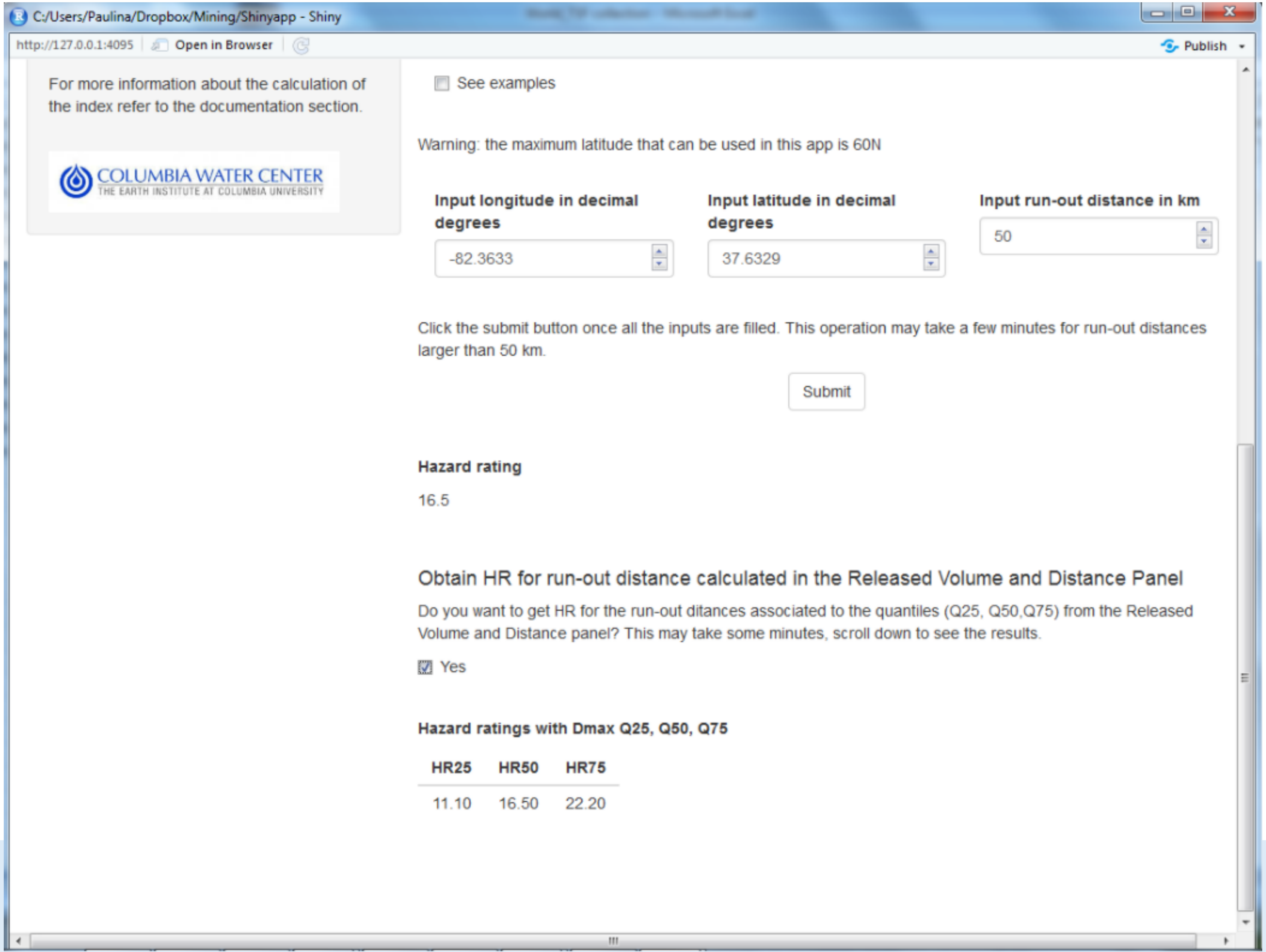
LOW PROBABILITY / HIGH IMPACT EVENTS

Tailings Dam State Identification & Failure Impact Analysis App



LOW PROBABILITY / HIGH IMPACT EVENTS

Tailings Dam State Identification & Failure Impact Analysis App



LOW PROBABILITY / HIGH IMPACT EVENTS

Exposure to Climate Risk - App

Choose:

event of interest : e.g. 30-day precipitation event
return-level of interest: e.g. 10 years, 100 years

Compute the yearly extremum time series at every location
Identify the percentile threshold for the return period of interest

Identify events of interest: all exceedances of the percentile threshold for all days in the record at each location

Weight each event with a damage function
Compute the time series of weighted exceedances at the portfolio level

Compute VaR and CVaR-like measures to rank portfolios

Exposure to Climate Risk - App

For a given event duration d, and return-level p, the process is the following:

- compute local yearly maxima and find the local threshold based on p,
- for each site *i*, obtain

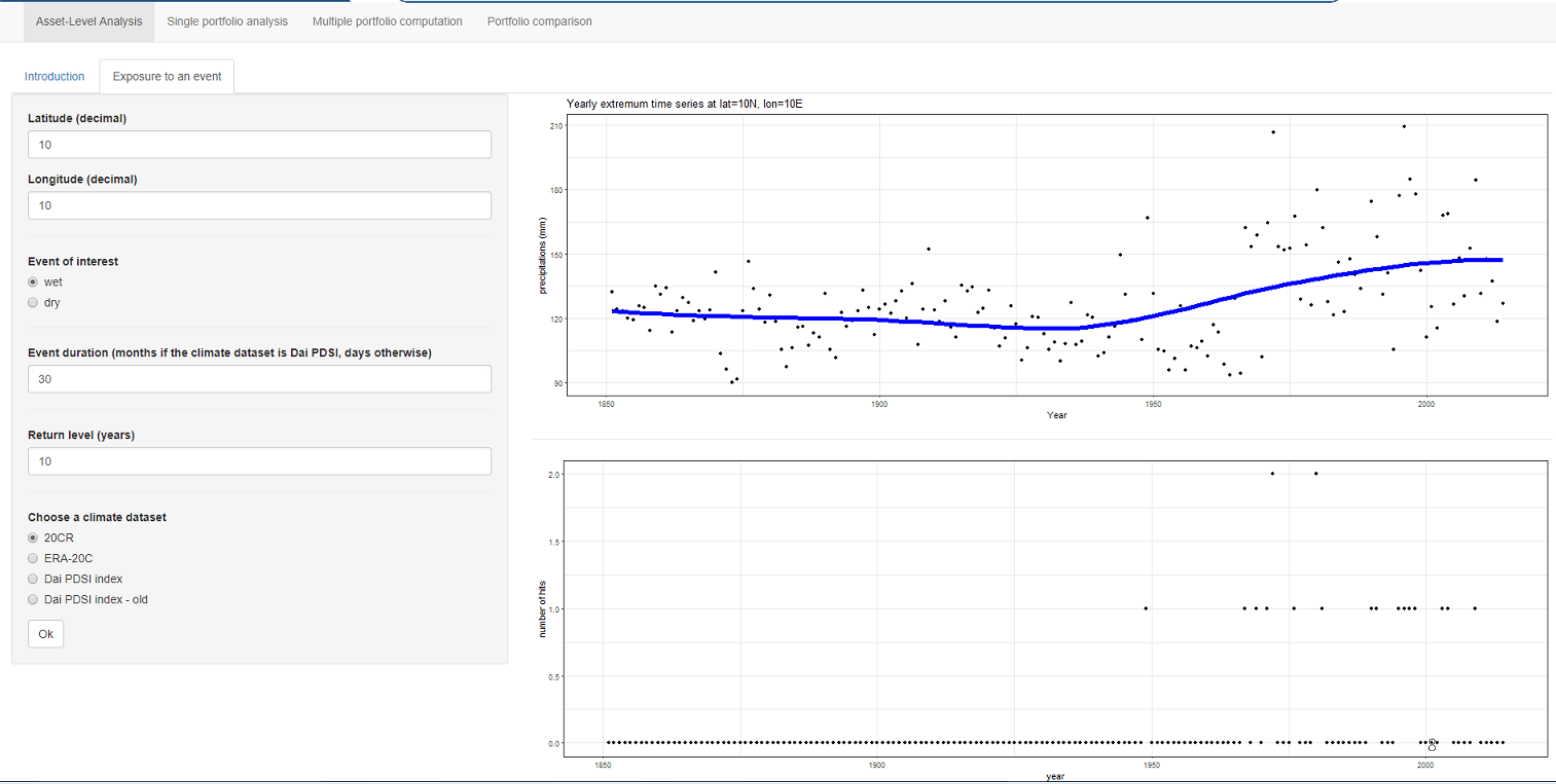
$$n_{i,t}(p,d) \text{ and } L_{\mathrm{i}}(p,d) = C(p,d)V_{\mathrm{i}} + D(p,d)F_{\mathrm{i}},$$

- define portfolio exposure as $S_{\mathrm{t}}(p,d) = \sum_{\mathrm{i}} L_{\mathrm{i}}(p,d)\, n_{\mathrm{i,t}}(p,d)$ or $R_t(p,d) = \frac{S_{\mathrm{t}}(p,d)}{\sum_{\mathrm{i}} V_{\mathrm{i}}}$
- compute VaRq-like measure using quantile($R_t(p,d)$, *q*)
- compute CVaRq-like measure using trapezoidal approximation:

$$CVR_{\mathrm{q}}(p,d) = \frac{1}{(1-q)(m+1)} \left\{ \frac{R_{\mathrm{q}}(p,d) + R_{\mathrm{m}}(p,d)}{2} + \sum_{\mathrm{k=q+1}}^{\mathrm{m-1}} R_{\mathrm{k}}(p,d) \right\}$$

LOW PROBABILITY / HIGH IMPACT EVENTS

Exposure to Climate Risk - App



Exposure to Climate Risk - App

Asset-Level Analysis | Single portfolio analysis | Multiple portfolio computation | Portfolio comparison

Analysis type

compute

Portfolio Information

Browse... Barrick_production_2015_wet_10-yr_30days.csv

Upload complete

- [x] Header

Separator

- (•) Comma
- ( ) Semicolon
- ( ) Tab

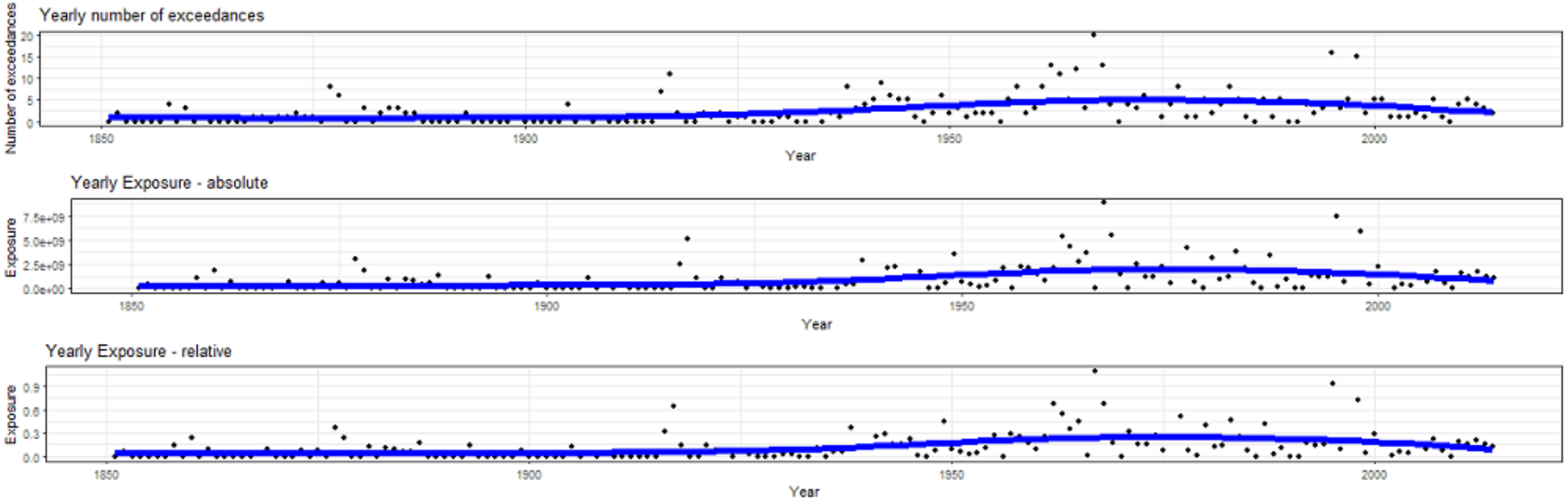
Quote

- ( ) None
- (•) Double Quote
- ( ) Single Quote

Choose a climate dataset

- (•) 20CR
- ( ) ERA-20C
- ( ) Dai PDSI index
- ( ) Dai PDSI index - old

Ok



Exposure to Climate Risk - App

Asset-Level Analysis | Single portfolio analysis | Multiple portfolio computation | Portfolio comparison

Simulation list

Browse... mother_file3.csv

Upload complete

- [x] Header

Separator

- (•) Comma
- ( ) Semicolon
- ( ) Tab

Quote

- ( ) None
- (•) Double Quote
- ( ) Single Quote

Risk level

0.1

Ok

Show 25 entries

Search:

portfolio	scoreMean	rankMean	scoreStd	rankStd	scoreV	rankV	scoreCV	rankCV
Barrick production 2015	740916923	1.5	974422613	2	0.2702016	1	0.2878233	2
Barrick production 2015	740916923	1.5	986346740	1	0.2666559	2	0.2938251	1
portfolio	scoreMean	rankMean	scoreStd	rankStd	scoreV	rankV	scoreCV	rankCV

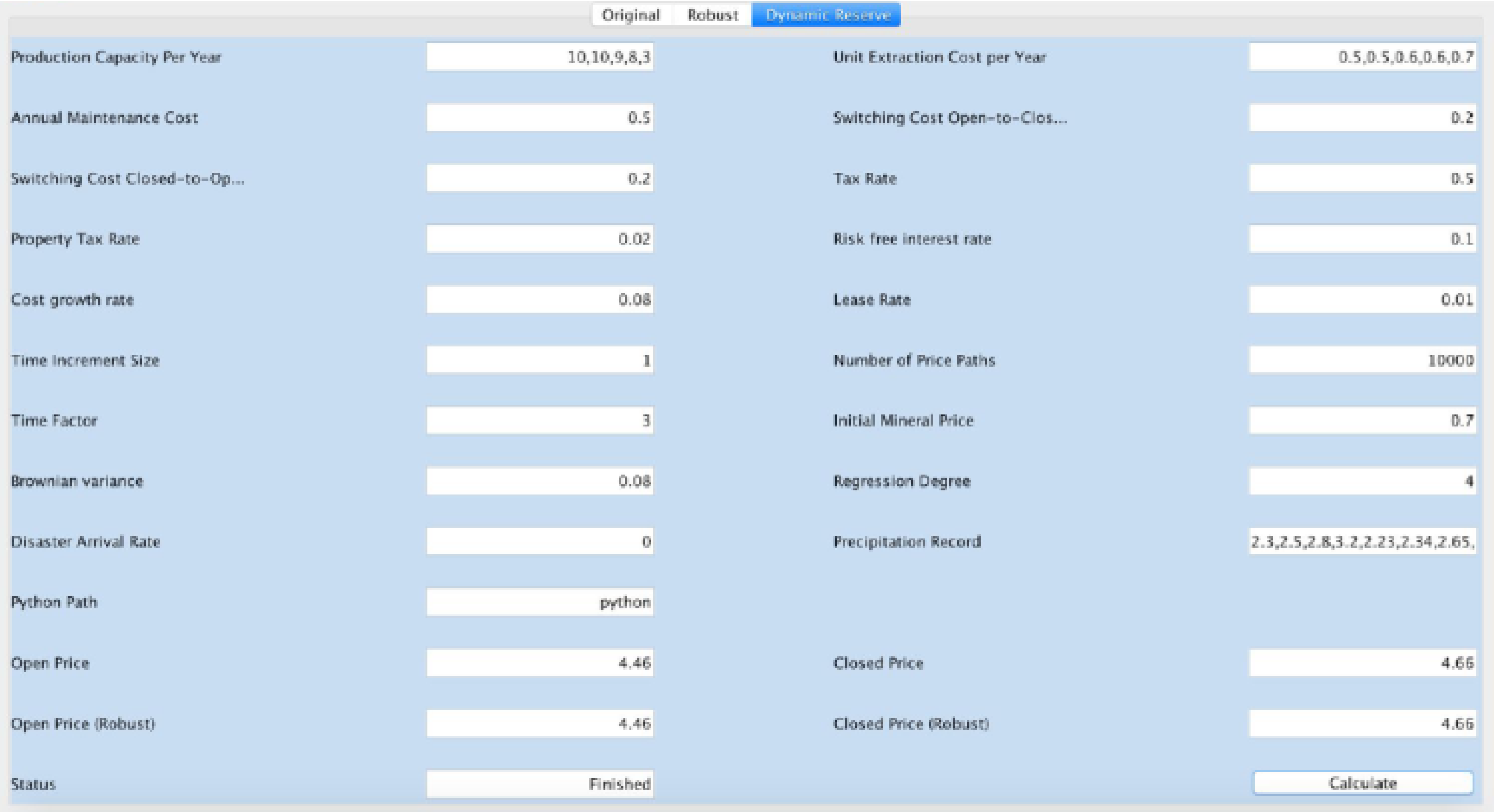
Showing 1 to 2 of 2 entries

Previous 1 Next

Datasets Compiled and Available

- Mine level water use in Cu and Au, Water development & water/ wastewater treatment costs for mines
- Global gridded climate data =100+ years
- Tailing dam attributes, satellite imagery, dam failure attributes
- Social conflict and related covariates for Peru & Mexico
- Mining production, ambient water quality time series for Peru, USA
- Remediation cost estimate reports over time for mines
- Financial reporting and valuation data for mines from market research
- “Water Risk” indices from Aqueduct
- Water related mining regulations for comparative analysis across countries

Real Options Valuation App

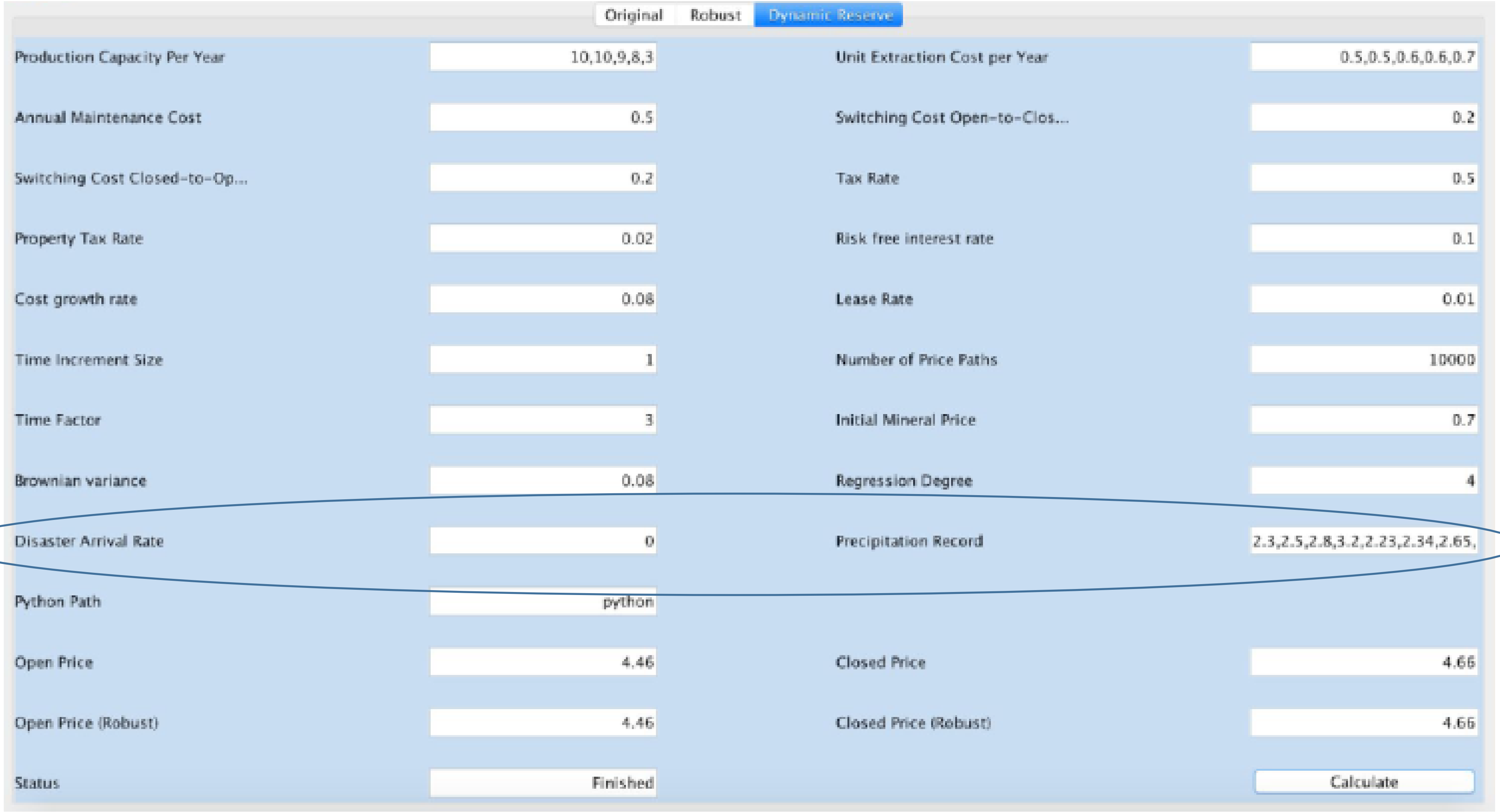


Real Options Valuation App

Original | Robust | Dynamic Reserve

Production Capacity Per Year	10,10,9,8,3	Unit Extraction Cost per Year	0.5,0.5,0.6,0.6,0.7
Annual Maintenance Cost	0.5	Switching Cost Open-to-Clos...	0.2
Switching Cost Closed-to-Op...	0.2	Tax Rate	0.5
Property Tax Rate	0.02	Risk free interest rate	0.1
Cost growth rate	0.08	Lease Rate	0.01
Time Increment Size	1	Number of Price Paths	10000
Time Factor	3	Initial Mineral Price	0.7
Brownian variance	0.08	Regression Degree	4
Disaster Arrival Rate	0	Precipitation Record	2.3,2.5,2.8,3.2,2.23,2.34,2.65,
Python Path	python		
Open Price	4.46	Closed Price	4.66
Open Price (Robust)	4.46	Closed Price (Robust)	4.66
Status	Finished		Calculate

Real Options Valuation App



An Example: Antamina

- Large open pit copper mines in Peru
- Owned by a consortium of major companies
- About 400 kt of copper per yr
- Tailings dam is 230m tall (one of the highest rock-filled dams)
- Highly acidic due to high concentration of sulfites

Additional Parameters

- An initial cost of extraction C per unit
- An initial level of reserves Q
- A fixed rate of extraction q
- The maintenance cost for a closed mine M
- The costs of switching between open and closed states K_1 and K_2
- A rate of cost growth π
- A tax rate t_r

- The cost of the underlying asset S
- The risk-free interest rate r
- The borrowing cost for the underlying asset d
- The volatility of the underlying asset σ

(1) Open, in which the owner receives cashflow $q(S - c)dt$

(2) Closed, in which the owner pays $-M dt$

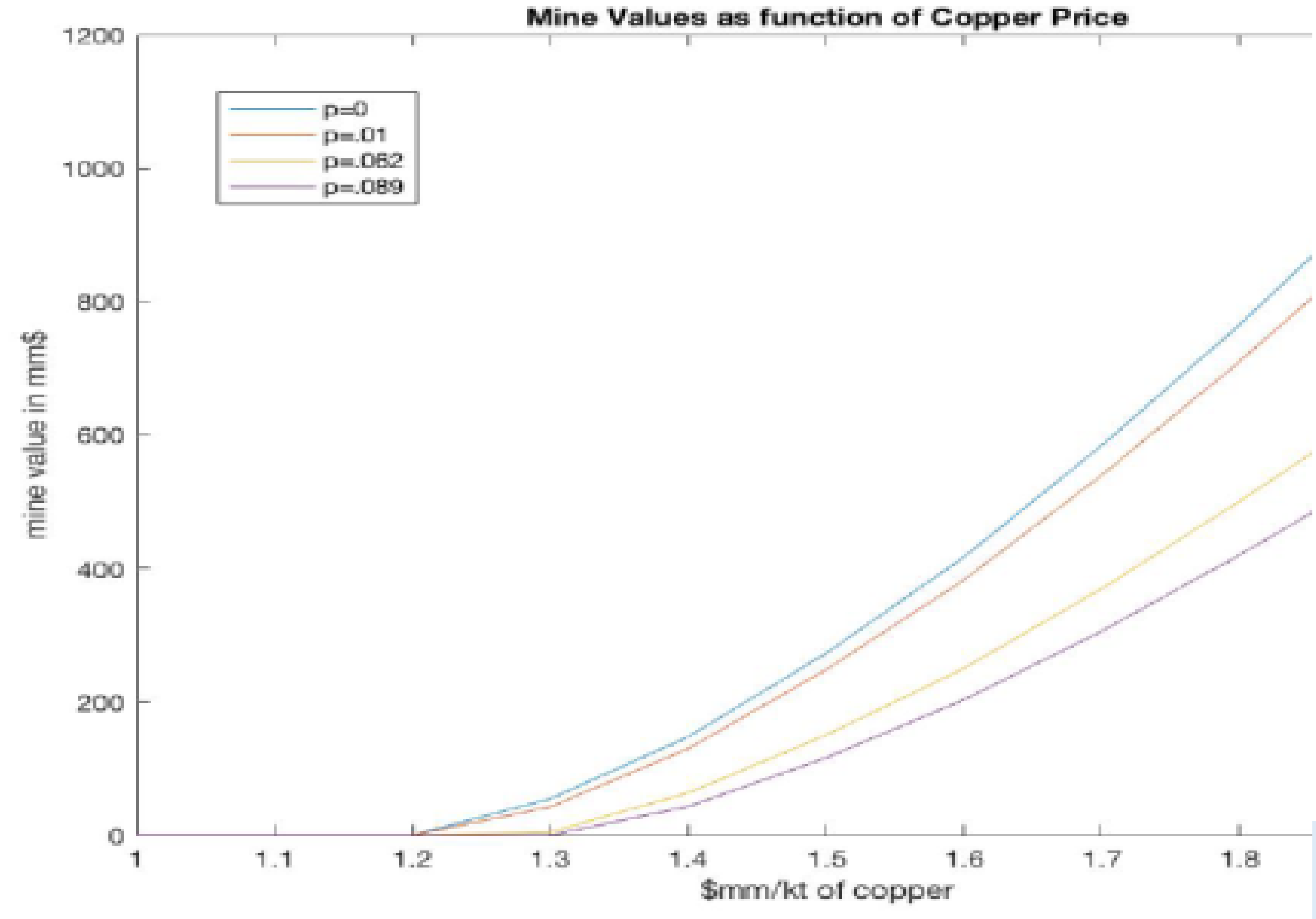
(3) Abandoned, where the value of the mine goes to zero but cannot be re-opened.

An Example: Antamina

Parameter	Value
C	\$1.66mm/kt
Q	5600(kt)
q	400(kt/yr)
M	\$135mm/yr
π	3%
t_r	40%
r	2.2%
d	1.5%

	1977-1997
α	1.38
δ	.21
worst case for 1 in 100 year event	.089

Real Options Valuation App



Another Approach for Using the App

- Input:
  - A) basic characteristics of the mine (such as its location, type of mine, age, production cost, etc.)
  - B) market information such as spot price, interest rates
  - C) a few representatives examples of “accurate” valuations of mines
- Outputs an interval [V_min, NO_Shocks]:
  - If market price is smaller than V_min. Then, market is underpricing shocks.
  - If market price is larger than NO_Shocks. Then, market is overpricing shocks.