BIG DATA COLOMBIA

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RADA

# Python for Data Science

## Parameter Estimation

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Science & Technology
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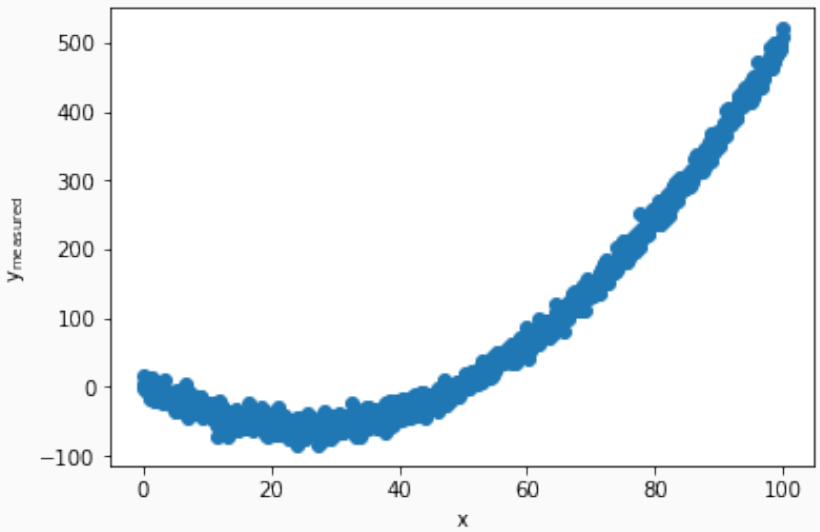
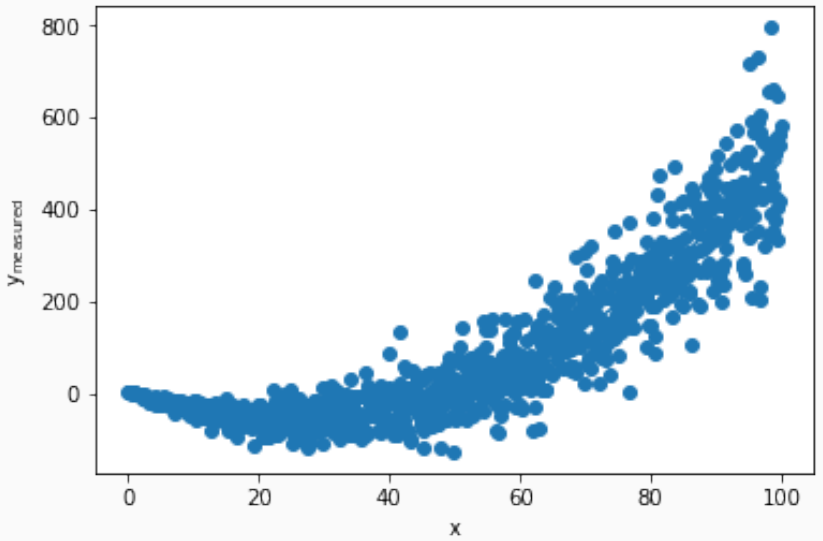
# Parameter Estimation

Parameter estimation is one of the most common applications in numerical data science.

# Parameter Estimation



# Parameter Estimation

We think that the model which describes the data has this form:

$$y = ax^2 - mx + c$$

and we know the value of the measurement noise for each data point, $\sigma_i$.

What we don't know is the value of the parameters $a$, $m$ and $c$.

# Cost Function

To fit the model to our data we need to specify a *cost function*. This is a function that evaluates the deviation of the model from the measurements.

The most commonly used cost function is chi-squared:

$$\chi^2 = \sum_i \frac{(d_i - m_i)^2}{\sigma_i^2}$$

The cost function that we specify expresses our *a priori* knowledge of the data.

# Direct Optimisation

Import the library:

```
import scipy.optimize as op
```

Define the function you want to fit:

```
def model(p,x):

    a,m,c = p
    y = a*x**2 - m*x + c

    return y
```

# Direct Optimisation

Define the cost function. Here it is the Gaussian loglikelihood:

```
def ll(p,x,y,sigma):

    y_try = model(p,x)
    diff = y_try - y

    ll = -0.5*np.sum(diff**2/sigma**2)

    return ll
```

`scipy` optimisation requires the negative loglikelihood:

```
nll = lambda *args: -ll(*args)
```

# Direct Optimisation

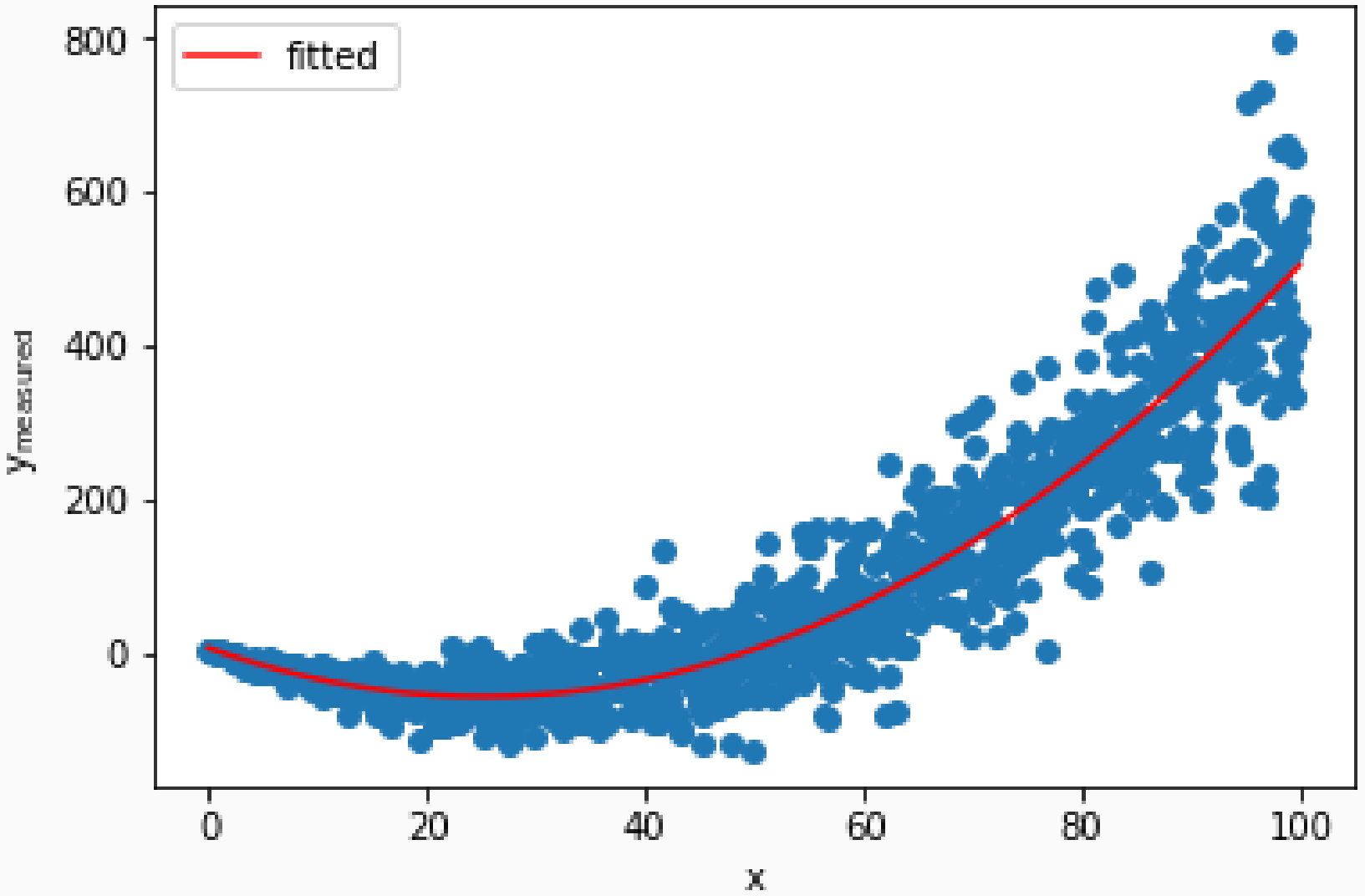
```
initial = np.array([1.,1.,1.])
```

```
result = op.minimize(nll, initial, args=(x, y_meas, sigma))
a, m, c = result["x"]
```

```
In [12]: print result
```

```
      fun: 482.94548559080283
 hess_inv: array([[1.80041525e-07, 1.79870092e-05, 2.99227436e-04],
       [1.79870092e-05, 1.91700675e-03, 3.58894926e-02],
       [2.99227436e-04, 3.58894926e-02, 8.96796830e-01]])
      jac: array([-7.62939453e-06,  0.00000000e+00, -3.81469727e-06])
  message: 'Optimization terminated successfully.'
     nfev: 50
      nit: 7
     njev: 10
   status: 0
  success: True
        x: array([0.10051117, 5.05231612, 5.89715686])
```

# Direct Optimisation



# Markov Chain Monte Carlo

Import the library:

```
import emcee
```

Set up the MCMC sampler:

```
ndim, nwalkers = len(initial), 10
p0 = initial + 1e-8 * np.random.randn(nwalkers, ndim)
sampler = emcee.EnsembleSampler(nwalkers, ndim, ll,
                                args=(x,y_meas,sigma))
```

# Markov Chain Monte Carlo

```
print("Running burn-in...")
p0,_,_ = sampler.run_mcmc(p0, 1000)
sampler.reset()
```

```
print("Running production...")
sampler.run_mcmc(p0, 3000)
```

# Markov Chain Monte Carlo

```
import corner

tri_labels = [r"a", r"m", r"c"]
tri_truths = [0.1,5.,5.]
tri_range = [(0, 1.), (0, 10), (0, 10)]
inds = np.array([0,1,2])
corner.corner(sampler.flatchain[:, inds], truths=tri_truths,
                                          labels=tri_labels)
```

# Markov Chain Monte Carlo