143 ESP – Soil Physics for Engineers

Inverse modeling

- Optimizing of soil hydraulic parameters

Optimization – Why?

- To obtain the soil hydraulic parameters (SHP)

- It is not possible to measure SHP

- Need for some aggregated information about SHP
  - Measured SHPs are point-base information

Inverse modeling – steps

1. Initial estimation of parameters
2. Run the model
3. Compare modeled and observed data via **objective function**
4. Change parameters based on used algorithm
5. Continue to step 2. until the model does appropriate fit with observations

The goal is to find a minimum of the objective function.

1. Initial estimation of parameters

- It affects the final parameters
- Different strategies to estimate them
  - Based on experience – can be subjective
  - Based on similarity with some other model
  - Based on statistical distribution of parameters
  - Based on direct measurement

2. Run the model

3. Compare modeled and observed data via **objective function**

final parameters: X=14.90, Y=0.50, b=2.18, ks=2.36e-08, s=1.04e-04, ret=-2.08e-04
sum of squares = 4.83E+00
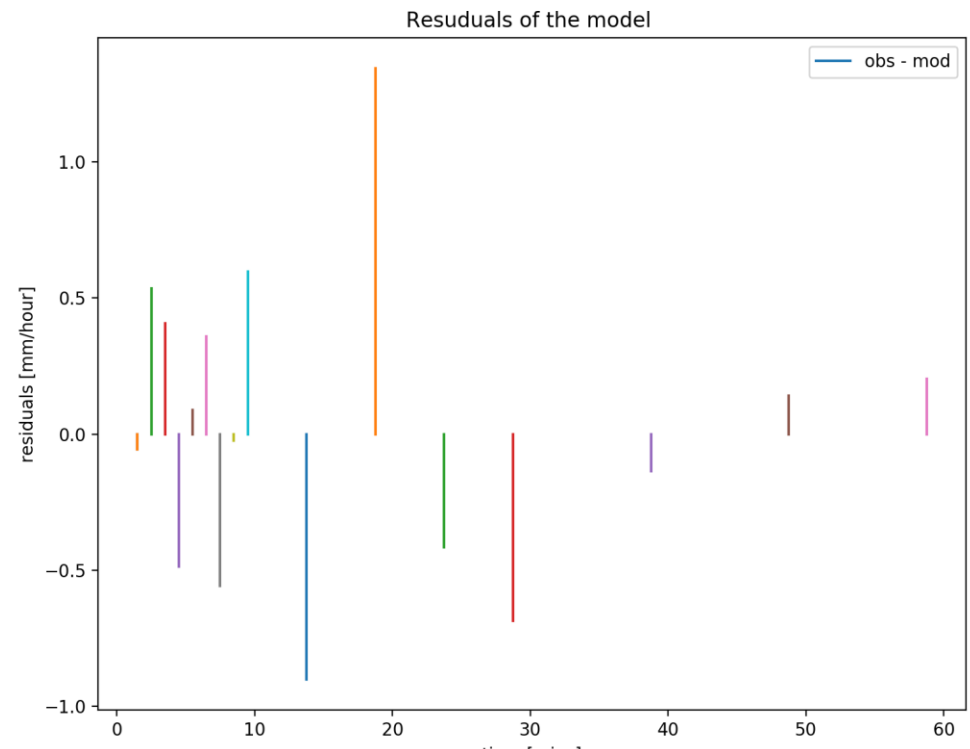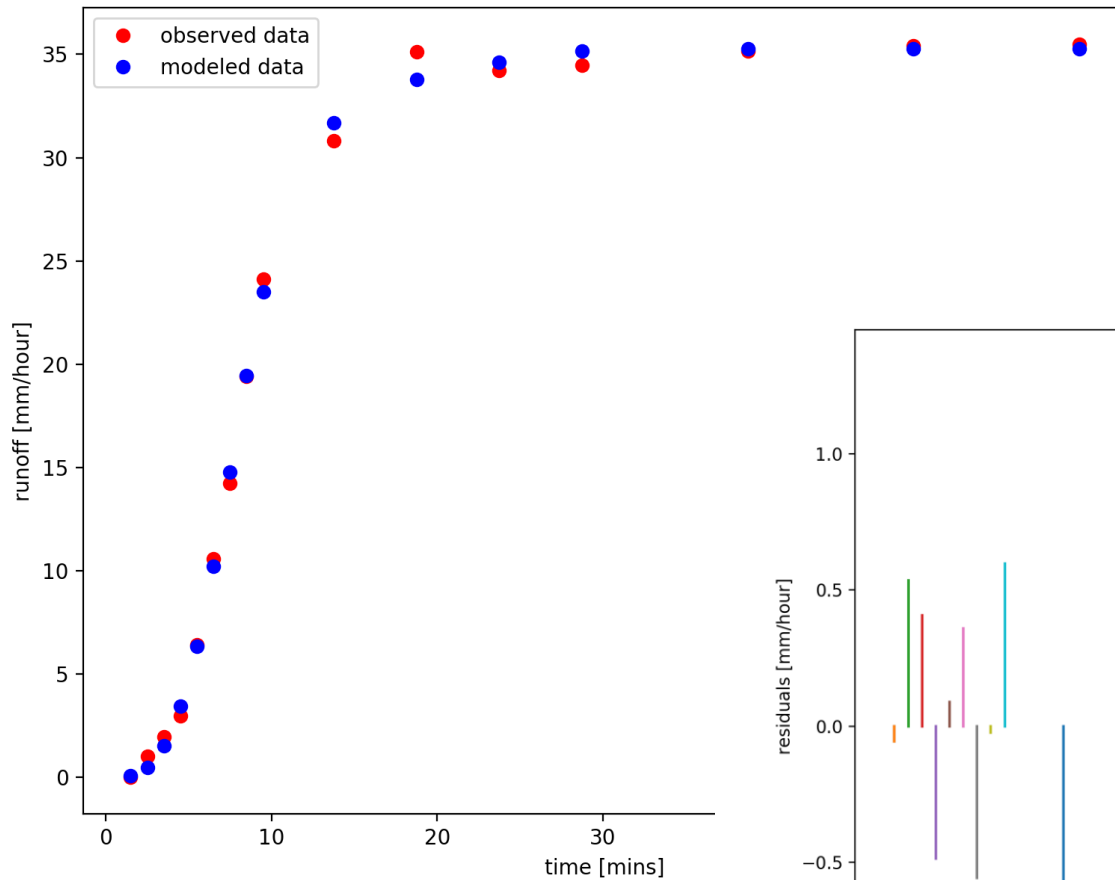
2. Run the model

3. Compare modeled and observed data via **objective function**

- Mean absolute error: $MAE = \dfrac{1}{n}\sum\limits_{i=1}^{n}|y_i - x_i|$

- Mean square error: $MSE = \dfrac{1}{n}\sum\limits_{i=1}^{n}(y_i - x_i)^2$

- Mean squared logaritmic error: $MSLE = \dfrac{1}{n}\sum\limits_{i=1}^{n}(\log_{10}(y_i) - \log_{10}(x_i))^2$

- Root mean square error: $RMSE = \sqrt{\dfrac{1}{n}\sum\limits_{i=1}^{n}(y_i - x_i)^2}$

- Sum of squares: $SS = (y_i - x_i)^2$

2. Run the model

3. Compare modeled and observed data via **objective function**

- V H1D:

$$\Phi(b, q, p) = \sum_{j=1}^{m_q} v_j \sum_{i=1}^{n_{qj}} w_{i,j} [q^*_j(x, t_i) - q_j(x, t_i, b)]^2 +$$

$$\sum_{j=1}^{m_p} \overline{v_j} \sum_{i=1}^{n_{pj}} \overline{w_{i,j}} [p^*_j(\theta_i) - p_j(\theta_i, b)]^2 +$$
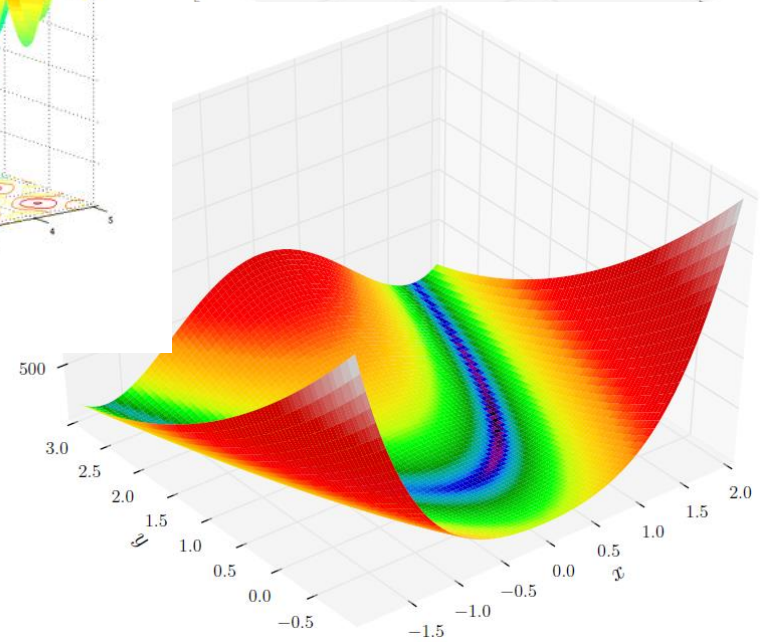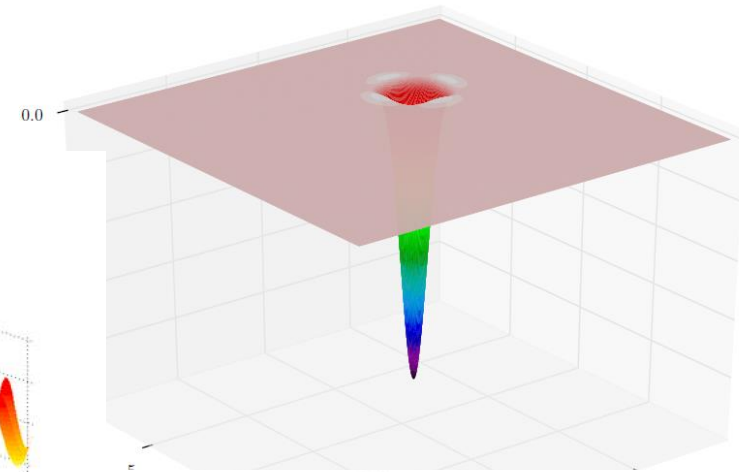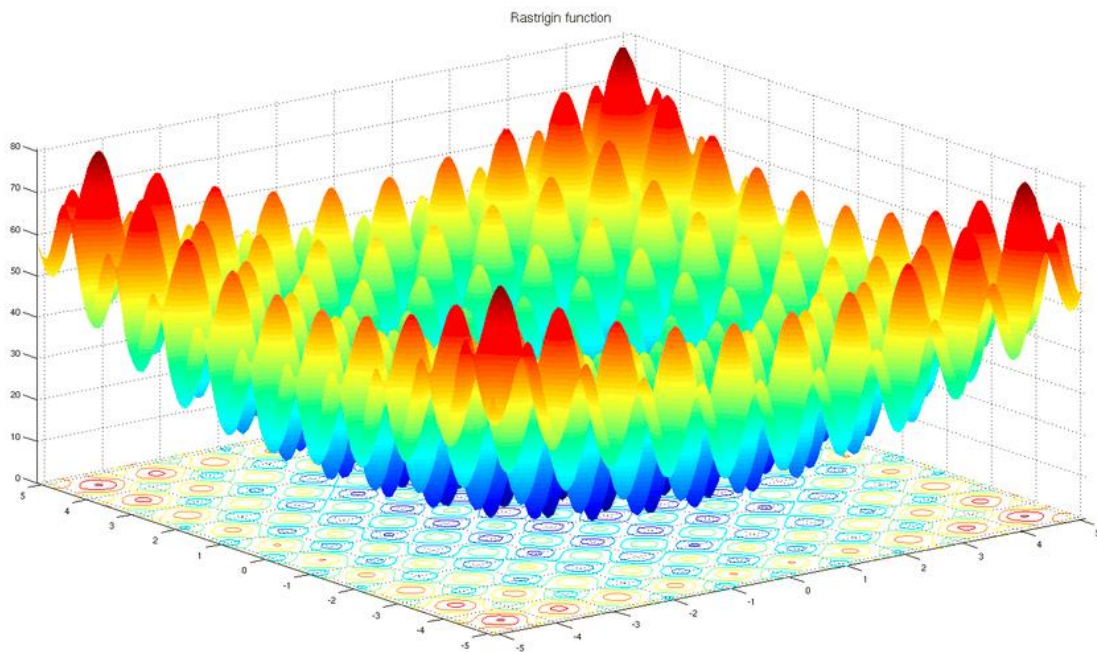
$$\sum_{j=1}^{n_b} \hat{v}_j [b^*_j - b_j]^2$$

1. Change parameters based on used algorithm

- Simplex method
- Gradient methods
  - Conjugation gradient method
- Heuristics methods
  - Differentil evolution
  - Particle swarm optimization
- In H1D: Marquardt-Levenberg method
  - Nonlinear least-squares method
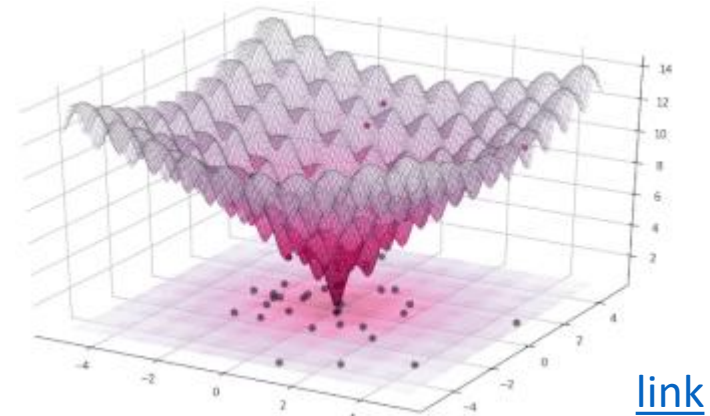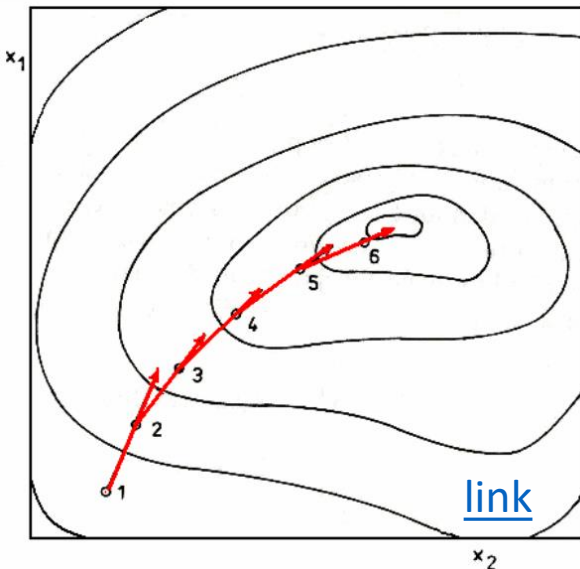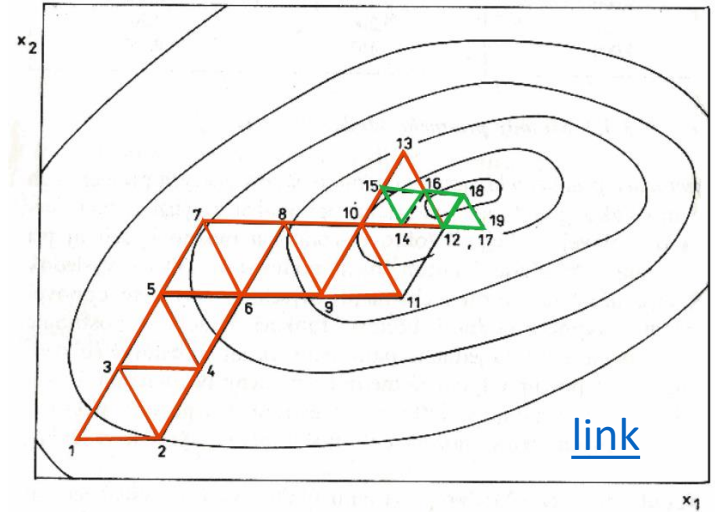
5. Continue to step 2. until the model does appropriate fit with observations

- Examples of test objective function

Rastrigin function

link