**Homework #5**

**Non-linear inverse problems**

**A. Gauss-Newton gradient methods.** Git clone the gravity inversion example below. This notebook creates synthetic gravity data for a sedimentary basin. The model parameters are the basin depths along a profile. Noise is added and the inversion for the basin depth using the Gauss-Newton approach is demonstrated. Go through the steps of the notebook. Identify how the Jacobian matrix is generated and comment on the

[git@github.com:GeophysicsLibrary/non-linear-gravity-inversion.git](mailto:git@github.com:GeophysicsLibrary/non-linear-gravity-inversion.git)

<https://github.com/GeophysicsLibrary/non-linear-gravity-inversion.git>

**B. Monte Carlo methods**. Develop code to solve non-linear inverse problems using the Gibbs Sampling and Markov Chain Monte Carlo algorithms. For the latter use the pymc python package. Start with a 2D function with 4 model parameters

y = m0 / (1 + exp(-m1\*(x - m2))) + m3\*sin(x)

Plot the function. Create noisy synthetic data by adding gaussian noise. Invert for the 4 model parameters using the two inversion approaches. Plot the 2-D covariance matrixes and the marginal probability distributions in a lower triangular matrix plot with the marginal probabilities in the diagonals. With how much noise can you reliably retrieve the model parameters using the two algorithms?

**C.** **Magma source model.**  (InSAR students). Generate synthetic data for a model of a magmatic system with two Mogi sources. Add power-law noise which is representative for noise from tropospheric delays. Invert the data using (1) a grid search, (2) undirected Monte Carlo approach and (3) directed Monte Carlo using a Gibbs Sampling approach.

**D.** **Simulated annealing.**  (InSAR students). Find the minimum of the Rosenbrock function (also known as the banana function using the simulated annealing algorithm. (My experience is that simulated annealing is the most effective non-linear algorithm to find the global minimum, but it does not generate the a-posteriori probability density function).

**Solutions:**

There are in

https://github.com/geodesymiami/InverseTheory/tree/main/notebooks