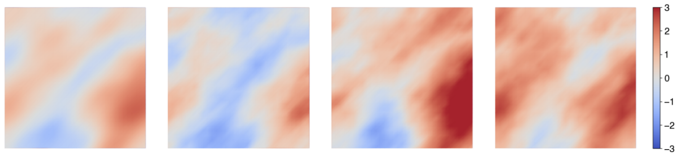
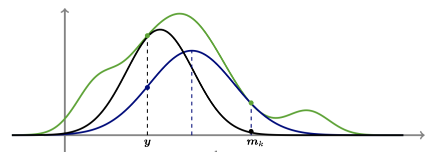
Spring 2022: Advanced Topics in Numerical Analysis: Bayesian Inverse Problems

MATH-GA 2420-011





Lectures: Wednesday 5:10–7:00pm, WWH 517 (half-course; classes Jan 26–March 9)

Instructors: Georg Stadler and Andrew Davis
WWH #929 and #1110
E-mail: stadler@cims.nyu.edu, add8536@cims.nyu.edu

Description: This **half-course** will cover theoretical and computational aspects of Bayesian inverse problems. We discuss how to define probability distributions that model uncertainty given observational data and physical or statistical models. We focus on problems where the likelihood function is expensive to evaluate and on approximations of the posterior distribution such as MAP estimation, Laplace approximation, and sampling methods. While the basics of Markov chain Monte Carlo sampling will be covered, this is not a main focus of the course.

Prerequisites: Prerequisites: Graduate-level Linear Algebra, Basic Probability, Numerical Methods. Having taken the *Inverse Problems* course, which mainly focused on deterministic problems and PDE-constrained optimization in the fall 2021 is an advantage, but not necessary. Contact us if in doubt.

Required work: Two homework assignments involving a mix of theory and computational experiments/implementation, and a final project.

Topics:

- Gaussian random fields, Matern kernels and Karhunen-Loeve expansions
- Prior modeling
- Gaussian process regression
- Bayes' formula in finite and (possibly) infinite dimensions
- Linear and nonlinear Bayesian problems
- MAP estimation and Laplace approximation
- Markov chain Monte Carlo sampling to explore posterior

References

- Jari Kaipio and Erkki Somersalo, *Statistical and Computational Inverse Problems*, Springer, 2005.
- Jonathan Bardsley, *Computational Uncertainty Quantification for Inverse Problems*, SIAM 2018.
- Ralph Smith, *Uncertainty Quantification*, SIAM, 2014.
- Carl Rasmussen and Christopher Williams, Gaussian processes for machine learning, MIT Press, 2006.
- Masoumeh Dashti, Andrew M. Stuart *The Bayesian Approach to Inverse Problems*, https://arxiv.org/abs/1302.6989, 2013.