Bayesian inference is a framework of inference that revolves around the application of Bayes' theorem. Although the latter is a simple expression of conditional probability, both the framework of Bayesian inference and its unique interpretation of probability have become an important cornerstone of modern scientific inference. Bayesian methods have seen a rapid rise in statistics, machine learning, physics, decision theory, and engineering. The field of inversion is no exception. In fact, Bayesian inference can be interpreted as the general model of probabilistic inversion. To introduce this idea, this lecture will be divided into two parts.

In the first part, we will look at the concept of Bayesian inference in general. This will include a brief refresher on Bayes' theorem and how its main elements correspond to the various steps of inference in general. We will also talk briefly about the Bayesian interpretation of probability and its implications for interpreting the results of Bayesian inference. Finally, we will see how Bayesian inference is a complete generalization of (probabilistic) inversion.

In the second part, the concept of Bayesian (i.e., probabilistic) inversion is applied to a specific hydrogeologic problem, namely, the inverse estimation of subsurface parameters using data from a pumping test, i.e., drawdown data. This example is used to illustrate the main features of Bayesian inference. In particular, it is shown how Bayes' theorem can be applied in practice, what numerical challenges can arise, how to interpret the results, and how Bayesian inversion differs substantially from classical inversion methods due to its fully probabilistic nature.