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Modeling Posterior Uncertainty of Petrophysical and Gravity Data

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The information and uncertainty of the Earth's physical parameters can be treated in a Bayesian framework for inverse problems. Within this framework, uncertainty quantification is carried out by analyzing the posterior probability model that updates the prior model based on measurements. We formulate the posterior model in the context of multiple measurement modalities. We consider the problem of estimating subsurface (mass) density from different scales of data, i.e. surface gravity measurements and petrophysical observations (sample data). Petrophysics plays the crucial role of linking physical properties to a geological characterization of the subsurface. Both gravity and sample data have their associated uncertainties and they map different scales within the survey area. The rock sample scale uncertainty can be treated as a modeling error within the gravity resolution grid and can be incorporated in the observation model as additive (Gaussian approximation for) noise. We assess the mutual complementarity of the posterior uncertainty carried by the different measurement modalities.