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A neural network approach to estimate posterior distributions of Bayesian remote sensing retrievals

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This research concerns the estimation of Bayesian a posteriori distributions of remote sensing data. Deep quantile regression neural networks (QRNNs) are proposed as a method to estimate quantiles of the a posteriori distribution of scalar retrieval quantities. This application of neural networks is new to atmospheric remote sensing and aims to combine the theoretically sound Bayesian treatment of inverse problems with the flexibility and computational efficiency of neural network based retrievals.

The predictive skill of QRNNs is carefully evaluated on a synthetic retrieval case against a baseline obtained from Markov chain Monte Carlo simulations, as well as another state-of-the-art Bayesian retrieval method, based on Monte Carlo integration (BMCI) and importance weighting of entries in a retrieval database. QRNNs and BMCI are both shown to yield good estimates of the posterior distribution obtained using MCMC, but QRNNs outperform BMCI for smaller training databases.

Finally, QRNNs are applied to estimate cloud top pressures from MODIS, using a training set generated from collocations with Calipso. It is shown that QRNNs can provide statistically consistent uncertainty estimates on a per-retrieval basis. Furthermore, they provide a better description of the error statistics than the standard approach of providing only a mean error that is assumed valid for all retrievals.