BAYESIAN ESTIMATION OF SOIL PARAMETERS FROM REMOTE SENSING DATA

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We consider the problem of finding a mathematically optimal algorithm to estimate soil parameters based on radar measurements. Specifically, given measurements $m_1, m_2, \ldots, m_J$ representing radar cross-sections of a given resolution element at different polarizations and/or different frequency bands, and given an approximate model expressing the dependence of these measurements on the dielectric constant ϵ and the r.m.s. surface height h of the corresponding resolution element, we would like to make an "optimal" estimate of the actual ϵ and h that gave rise to the particular $\{m_j\}$ observed. By "optimal" we mean that our algorithm should produce estimates that are, on average, as close as possible to the actual values. To obtain such an algorithm, we assume that we have at our disposal a data catalogue consisting of careful measurements of the soil parameters ϵ and h, on one hand, and the corresponding remote sensing data $\{m_j\}$ on the other. We also assume that we have used these data to write down, for each j, an approximate formula which computes an average value of m_j associate to the corresponding ϵ, h. Rather than throw away the data catalogue at this stage and use the average formulas in a deterministic fashion to solve the inverse problem, we propose to use the data catalogue more fully and quantify the spread of the measurements about the average formula, then incorporate this information into the inversion algorithm. In this study, we show how a Bayesian approach allows one to

1) make an optimal estimate of ϵ and h
2) place a quantitative error bar on each estimate, as a function of the actual measurements
3) fine-tune the inital formulas expressing the dependence of the remote sensing data on the soil parameters
4) take into account as many (or as few) remote sensing measurements as we like in making our estimates of ϵ and h, in each case quantifying the benefits of using a particular combination of measurements.