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Title: Some Challenges in Spatial Functional Data Analysis of West Antarctic Snow Density

Abstract:

Snow density estimates below the surface, used with airplane-acquired ice-penetrating radar measurements, give a site-specific history of snow water accumulation. Because it is infeasible to drill snow cores across all of Antarctica to measure snow density and because it is critical to understand how climatic changes are affecting the world's largest freshwater reservoir, we develop methods that enable snow density estimation with uncertainty in regions where snow cores have not been drilled. In inland West Antarctica, snow density increases monotonically as a function of depth, except for possible microscale variability or measurement error, and it cannot exceed the density of ice. We present a novel class of integrated spatial process models that build upon physically-derived differential equation models and allow interpolation of monotone snow density curves. For computational feasibility, we construct the space-depth process through kernel convolutions of log-Gaussian spatial processes. We discuss model comparison, model fitting, and prediction. Using this model, we extend estimates of snow density beyond the depth of the original core and estimate snow density curves where snow cores have not been drilled. Along flight lines with ice-penetrating radar, we use interpolated snow density curves to estimate recent water accumulation and find predominantly decreasing water accumulation over recent decades. Lastly, we briefly discuss how climatological variables can be incorporated into this modelling framework to improve interpolation.