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Effects of model error on cardiac electrical wave state estimation using data assimilation

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Reentrant electrical scroll waves have been shown to underlie many cardiac arrhythmias, but the inability to observe locations away from the heart surfaces and the restriction of observations to only one or two state variables have made understanding arrhythmia mechanisms challenging. Recently, we showed that data assimilation from sparse surrogate observations could be used to reconstruct reliable time series of state estimates of reentrant cardiac electrical waves in one and three spatial dimensions. However, real cardiac tissue is unlikely to be described accurately by mathematical models because of errors in model formulation and parameterization as well as intrinsic but poorly described spatial heterogeneity of electrophysiological properties in the heart. In this talk, we describe how model error affects the accuracy of cardiac state estimates achieved using data assimilation with the Local Ensemble Transform Kalman Filter. We focus on one-dimensional states of discordant alternans characterized by significant wavelength oscillations. We demonstrate that data assimilation can provide high-quality estimates under a wide range of model error conditions, ranging from varying a single parameter value to using an entirely different model to generate the truth state. We illustrate how multiplicative and additive inflation can be used to reduce error in the state estimates. Even when the truth state contains underlying spatial heterogeneity, we show that using a homogeneous model in the data assimilation algorithm can achieve good results. Finally, we discuss different tools that can be used to help select good model parameters for the algorithm. Overall, we find data assimilation to be a robust approach for reconstructing complex cardiac electrical states corresponding to arrhythmias even in the presence of model error.