Reconstructing Cardiac Voltage Using Data Assimilation: Effects of Observation Distribution

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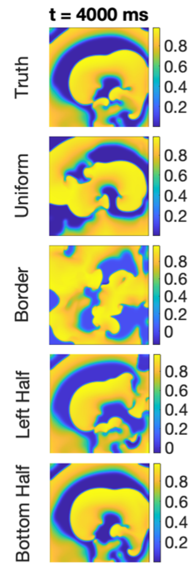
Introduction and Aims: Cardiac electrophysiology data often are recorded with limited spatial resolution or inconsistent spatial distribution. For example, optical-mapping data may exclude portions of the domain due to irregular tissue shape or uneven dye distribution, and clinical data may include a relatively small number of points unevenly distributed in space. Rather than interpolating such data, which neglects constraints imposed by dynamics, data assimilation can be used to mitigate the effects of low-resolution data by providing estimates of voltage in unmapped areas. Here, we investigate the effects of different spatial distributions of observation data on cardiac voltage reconstructions over time using data assimilation. **Methods:** We used an ensemble Kalman filter method to reconstruct complete, uniform voltage data from observational data with different types of spatial distributions. Noisy observational data were combined with model forecasts at regular intervals, weighted by uncertainty in the model forecast. Stable spiral-wave and sustained spiral-wave breakup cases from the Mitchell-Schaeffer model were analyzed. Coarse uniform data, data restricted to tissue edges, and data localized to different halves of the domain were considered. **Results:** For stable spiral waves, accurate estimates were found for all observation distributions tested ($<10\%$ relative error). For spiral-wave breakup, as shown, sparse uniform observations as well as observations restricted to the border of the domain yielded less accurate estimates than cases with observations limited to half of the domain. **Conclusion:** For simple cases with stable spiral-wave behavior, reconstruction accuracy was high for all observation spatial distributions. With more complex spiral-wave breakup, accuracy depended strongly on the observation distribution. Nevertheless, even with limited spatial information, accurate voltage reconstructions could be generated, provided that observations included regions driving breakup.



True and estimated voltage for observation distributions.