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Methodology to estimate the relative pressure field from noisy experimental velocity data

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Abstract. The determination of intravascular pressure fields is important to the characterization of cardiovascular pathology. We present a two-stage method that solves the inverse problem of estimating the relative pressure field from noisy velocity fields measured by phase contrast magnetic resonance imaging (PC-MRI) on an irregular domain with limited spatial resolution, and includes a filter for the experimental noise. For the pressure calculation, the Poisson pressure equation is solved by embedding the irregular flow domain into a regular domain. To lessen the propagation of the noise inherent to the velocity measurements, three filters – a median filter and two physics-based filters – are evaluated using a 2-D Couette flow. The two physics-based filters outperform the median filter for the estimation of the relative pressure field for realistic signal-to-noise ratios (SNR = 5 to 30). The most accurate pressure field results from a filter that applies in a least-squares sense three constraints simultaneously: consistency between measured and filtered velocity fields, divergence-free and additional smoothness conditions. This filter leads to a 5-fold gain in accuracy for the estimated relative pressure field compared to without noise filtering, in conditions consistent with PC-MRI of the carotid artery: SNR = 5, 20×20 discretized flow domain (25×25 computational domain).