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Bayesian calibration of dense gas flow models using Kalman filters

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Numerical simulations of dense gas flows, when operating conditions are closed to the saturation conditions, can be extremely sensitive to the model used to describe the fluid thermodynamic behaviour [1]. To confidently predict such dense gas flows, it is thus necessary to quantify *i*: the uncertainty due to the lack of knowledge of the models parameters, and *ii*: the uncertainty related to the mathematical form of the models. The Bayesian framework allows to achieve both objectives by providing posteriors distributions of both uncertainties if prior distributions and high-fidelity date are given.

Classical implementations of the Bayesian framework for complex models are based on the famous Metropolis-Hastings algorithm (MCMC) for sampling the posterior parameter distribution. This allows to recover the full distributions of parameters and model-form uncertainties but requires large samples, which is especially painful to achieve in a CFD context, and is thus very time consuming. As an alternative, Kalman filters have been increasingly employed for data assimilation. Specifically, the ensemble Kalman filter (EnKF) of Evensen[2] showed good results at approximating the MCMC with lower computational requirements.

In this work, we apply both approach to the calibration of the parameters of the Peng-Robinson and the Martin-Hou EOS using aerodynamic data available for a dense gas flow past an airfoil, a configuration already considered for Bayesian calibration using MCMC along with a surrogate model [3]. For this purpose, the flow field is modeled using a dense gas flow solver supplemented with the above mentioned EOS, and syntetic data for the pressure measured at 17 locations along the profile are used for the calibration.

At the conference, we will provide a full description of both the numerical and statistical models. Calibration results for the Kalman approach will be compared with the MCMC ones both in terms of efficiency and accuracy. .

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