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A Truncated Gaussian filter for data assimilation with inequality constraints

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In a variety of data assimilation problems, inequality constraints on state variables often contain valuable information that must be taken into account in the estimation process. Linear estimation methods (like the Kalman filter) cannot incorporate such constraints to optimally combine data with a dynamical model. In this study, it is shown that an optimal filter under inequality constraints can be formulated using the assumption that the probability distributions are truncated Gaussian pdfs. The statistical tools needed to implement this truncated Gaussian filter are presented. As an application, the truncated Gaussian assumption is shown adequate to deal with the condition of hydrostatic stability in ocean analyses. The method is first evaluated using a one-dimensional z-coordinate model of the upper ocean mixed layer. In a second step, the method is applied to a three-dimensional hybrid coordinate model (HYCOM) of the Bay of Biscay, showing that the hydrostatic stability condition can be tackled in isopycnic coordinates (positive layer thicknesses) as well as in z-coordinates (positive downward potential density gradient). These examples demonstrate that the algorithm can be efficiently adapted to real size problems.