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Smoothing problems in a Bayesian framework and their linear Gaussian solutions

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Smoothers are increasingly used in geophysics. Several linear Gaussian algorithms have been presented in the past literature: The sequential smoothers (fixed-interval or fixed-lag), the ensemble smoother, the forward-backward smoother, also called Rauch-Tung-Striebel smoother, and the two-filter smoother. Even if they are all equivalent in the linear Gaussian framework, their prior Bayesian formulations are different, both in the nature and the resolution strategies of the smoothing problem. In particular, the first two solve a joint estimation problem. The typical joint smoothing problem is reanalysis, that is, the estimation of a time sequence of system states based on the observations available in the same time interval. The last two solve a marginal smoothing problem. This problem is met, for example, when one aims to estimate the initial state of an observed process.

In this presentation, we propose a revisit of the different smoothing algorithms, with the following goals: (i) present a clear description of the Bayesian formulation of each smoothers mentioned above (what they really solve, and how); (ii) exhibit the assets and drawbacks, in particular for implementations based on the Ensemble Kalman Filter; (iii) present a few examples of application.