EnKF brings new flexibilities to data assimilation, both for weather forecasting and climate estimation. Here we focus on the transform type of EnKF where the analysis error covariance is obtained by right-multiplying the background error covariance with a matrix of weights, such as the Ensemble Transform Kalman Filter (ETKF, Bishop et al., 2001) and the Local ETKF (LETKF, Hunt et al., 2007), which have attractive properties.

Among the algorithms easily applied are the No-Cost Smoother, and Running in Place (RIP, Kalnay and Yang, 2010), Quasi-Outer Loop (QOL, Yang and Kalnay, 2011) that deal with nonlinearities and non-Gaussianities, and improve the analysis at the beginning of the assimilation window, important for reanalysis. The ensemble sensitivity without adjoint model (Liu and Kalnay, 2008, Li et al, 2010) allows identifying observations leading to large forecast degradation. The adaptive inflation (Miyoshi, 2010) algorithm has been tested in a number of applications where it was found to significantly improve results.

LETKF assimilates all observations simultaneously within a local region. We have found that serial assimilation of observations used in the Ensemble Square-root Filter (Whitaker and Hamill, 2002) and Ensemble Adjustment Filter (Anderson, 2001), can introduce significant errors, especially for coupled slow-fast systems (Amezcua et al., 2011).

Finally, the ability to estimate unobserved parameters can facilitate the development of models for climate simulation and prediction.