**Adaptive emissions estimation over China with an Ensemble Kalman Filter and hourly surface PM2.5 observations**

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An ensemble Kalman filter (EnKF) was expanded to estimate source emissions over China by assimilating the hourly surface PM2.5 observations into the WRF/Chem model. The system allows simultaneously analyzing the chemical initial conditions (ICs) and source emissions. A time smoothing operator is used as the forecast model of emission scaling factors, which are actual variables to be estimated via EnKF. The appropriate ensemble covariance localization and inflation were also implemented. The system was first applied for a heavy polluted period in October 2014. The results showed that the forecasts with the optimized initial conditions and emissions typically outperformed those from the control experiment without data assimilation. In the Yangtze River delta (YRD) and the Pearl River delta (PRD) regions, large reduction of the RMSEs was obtained for almost the entire 48 h forecast range, especially at nighttime when the forecast performance is worse. Moreover, the experiment with the joint analysis of emissions and ICs performed much better than that of solely analyzing the ICs. In the Beijing-Tianjing-Heibe region, the impact of emission estimation on the forecast is less pronounced than that over YRD and PRD. The system was also applied for a period from late August to early September 2015, when strict emission control was applied to ensure good air quality for the 15th International Association of Athletics Federations World Championships (22–30 August) and the China Victory Day parade (3 September) in Beijing. The system was able to quantify the emission reduction due to the emission control throughout the period.