Improving afternoon thunderstorm prediction over complex terrain with the assimilation of dense ground-based observations: four cases in the Taipei Basin

Yi-Pin Chang[1], Shu-Chih Yang[1,2,3], Hsiang-Wen Cheng[1,4], Kuan-Jen Lin[1], Ya-Ting Tsai[5], Jing-Shan Hong[5], and Yu-Chi Li[5]

[1]Department of Atmospheric Sciences, National Central University, Taoyuan, Taiwan
[2]GPS Science and Research Application Center, National Central University, Taoyuan, Taiwan
[3]RIKEN Center for Computational Science, Kobe, Japan
[4]Taiwan Space Agency, Hsinchu, Taiwan
[5]Central Weather Bureau, Taipei, Taiwan

Abstract

This study investigates the impact of assimilating densely distributed Global Navigation Satellite System (GNSS) zenith total delay (ZTD) and surface station data on very short-term heavy rainfall prediction associated with afternoon thunderstorm events in the Taipei Basin. Under weak synoptic-scale conditions, four intense cases characterized by different development are chosen for investigation.

Data assimilation experiments are conducted with a convective-scale Weather Research and Forecasting-Local Ensemble Transform Kalman Filter (WRF-LETKF) system. The results show that while ZTD assimilation can provide effective moisture correction, assimilating the surface wind and temperature data additionally improves the near-surface convergence and thermal condition, which further brings up the impact of ZTD assimilation. Frequently assimilating the surface data every 10 minutes further improves the rainfall intensity and has the best performance in the 2-hour heavy rainfall prediction. The detailed analysis of Case I reveals that the frequent assimilation provides an initial condition that can lead to the fast expansion of vertical instability and trigger the intense afternoon thunderstorm. Such a benefit can still be identified in the earlier forecast initialized two hours before the event starts.

This study proposes a new metric to use the fraction skill score to construct an informative diagram to evaluate the location and intensity of heavy rainfall forecast and display a clear characteristic of different cases. Issues of how to optimize the assimilation impact of ground-based observations in a convective ensemble data assimilation system are also discussed.

Key word: data assimilation, ground-based observation, zenith total delay, heavy rainfall forecast evaluation