Heavy-Rainfall Quantitative Precipitation Forecasts (QPFs) in Taiwan under the Topographic Control
(臺灣地形控制下之豪大雨預報)

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Abstract

During the past several years, high skill of heavy- to extreme-rainfall quantitative precipitation forecasts (QPFs) by the 2.5-km Cloud-Resolving Storm Simulator (CReSS) has been demonstrated for both typhoons and mei-yu events in Taiwan, within the range of 3 days (e.g., Wang 2015, 2016; Wang et al. 2016). For example, for all 29 typhoons during 2010-2015, the overall threat scores (TSs) on day 1 (0-24 h) at rainfall thresholds of 100, 200, 350, 500, and 750 mm (per 24 h) are 0.45, 0.36, 0.28, 0.18, and 0.11. For the most-rainy top 10 periods (roughly top 5% in sample), the TSs at the same set of thresholds are higher, at 0.72, 0.54, 0.39, 0.25, and 0.13 on day 1, at 0.70, 0.52, 0.38, 0.21, and 0.15 on day 2 (24-48 h), and at 0.53, 0.38, 0.25, 0.12, and 0.07 on day 3 (48-72 h), respectively. Similarly, for top mei-yu events (roughly top 4% in rainfall) in May-June, 2012-2014, the overall TSs at 50, 100, 200, 350, and 500 mm are 0.45, 0.31, 0.24, 0.21, and 0.16 on day 1, 0.43, 0.31, 0.20, 0.07, and 0.07 on day 2, and 0.40, 0.25, 0.09, 0.04, and 0.00 on day 3, respectively. These scores at the range of heavy- to extreme-rainfall by this cloud-resolving model are significantly, some dramatically, higher than model QPFs at lower (convective permitting) resolutions. Thus, our results indicate that it is not only possible to significantly improve heavy-rainfall QPFs in Taiwan, but such an improvement is a certainty using the CReSS model.

In this paper, the reason for the above improvement is discussed, and it is demonstrated that the high skills arise from topographic rainfall in the mountains where the model can handle well with the strong, moisture-rich flow impinges on the steep terrain of Taiwan (given a reasonable handling at synoptic scale). Such a scenario of forced uplift has relatively high predictability, and the CReSS model can predict the large amount given its cloud-resolving capability (that also better resolves the topography). On the other hand, localized rainfall over the flat areas (often along the coast and with shorter duration) has relatively low predictability due to the nonlinearity of the atmosphere, and the model cannot capture their occurrence at the correct location in a consistent manner as a result, even when an overall similar scenario is predicted with high resolution.