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Improving Visibility Forecasting during Haze-fog Processes in Shanghai and Eastern China: the Significance of Aerosol and Hydrometeor

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Aerosols and droplets are the main factors of visibility reduction by scattering and absorbing light. For visibility predictions in operational NWP models, hydrometeors are often considered to be the dominant factor in the total extinction, whereas aerosol effects are usually simplified or omitted in models developed for relatively clean regions. In China, also many NWP studies related to visibility forecasting during haze-fog processes have been conducted, primarily focusing on severely polluted periods before 2018. These studies often employed visibility parameterizations that considered either aerosol extinction alone or hydrometeor extinction alone. Therefore, the significance of incorporating both aerosol and hydrometeor extinction into visibility forecasting during haze-fog processes remains uncertain, particularly under recent rapid changes in aerosol concentration, composition, and hygroscopicity in China.

In this study, we first use the 3-D meteorology fields from the Shanghai Meteorological Service WRF-ADAS Real-Time Modeling System (WARMS) to drive the Community Multiscale Air Quality (CMAQ) model. In this version, CMAQ is used in an off-line mode and visibility is diagnosed by combining extinctions due to hydrometeors and aerosols. Satellited derived NOx emissions using the Daily Emissions Constrained by Satellite Observations (DECSO) algorithm have been incorporated to give more up-to-date emissions. We analyze the results of a one-month forecasting period during the winter of 2021-2022 to assess the model's performance and understand the impact of hydrometeor and aerosol extinction on operational visibility forecasting. We find that for the city of Shanghai, aerosol extinction has a minor impact on the model's performance when forecasting visibility below 1 km but becomes crucial for predictions spanning 1-10 km. Comparison against observations shows that the model well captures the general contributions from various chemical constituents with nitrate as the most important factor in aerosol extinction (~60%). Furthermore, our assessment of the North China Plain (NCP) highlights that in highly polluted areas aerosols could be significant for visibility below 1 km. Finally, we

conduct case studies with the fully coupled WRF-Chem model and compare results with the offline WARMS-CMAQ system. Aerosol effects on fog and visibility forecasting due to feedbacks between aerosols, radiation, and cloud physics will be discussed.