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Wintertime Local Circulations in and around the Ulaanbaatar Metropolitan Area in the Presence of Temperature Inversion

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Temperature inversions are frequently observed in mountainous urban areas and can cause severe air pollution problems especially in wintertime. This study investigates wintertime local circulations in and around the Ulaanbaatar, the capital of Mongolia, metropolitan area in the presence of temperature inversion using the Weather Research and Forecasting (WRF) model coupled with the Seoul National University Urban Canopy Model (SNU-UCM). Ulaanbaatar is located in complex terrain and in a nearly east-west oriented valley. A wintertime scenario with clear skies, weak synoptic winds, and temperature inversion under the influence of a Siberian high-pressure system is selected. It is found that the thickness and strength of temperature inversion layer are associated with the terrain. The temperature inversion layer is deeper and stronger in the valleys than the mountain slopes, and its top height is typically lower than the maximum ridge top height of the surrounding mountains but higher than the boundary layer height. Weak local circulations develop in the presence of temperature inversion. In the daytime, weak mountain upslope winds develop, up-valley winds appear to be stronger in the urban area, and channeling winds are produced in the narrow valleys. The bottom of temperature inversion layer rises up in the urban area, and winds below the bottom of temperature inversion layer strengthen. In the nighttime, mountain downslope winds and down-valley winds develop with a lifted daytime residual layer. Urban effects in the presence of temperature inversion are examined by comparing simulation cases with and without the city. It is shown that in the daytime the urban area acts to elevate the bottom of temperature inversion layer and weaken the strength of temperature inversion layer. Compared to the simulation case without the city, the simulation case with the city shows that winds east of the city weaken in the afternoon and that down-valley winds develop later. These result from the interactions of urban breezes with valley winds.