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The Relationship Between Atmospheric Boundary Layer Structure, Brown Haze, and Air Pollution in Auckland, New Zealand

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A brown air pollution haze that forms over some international cities during the winter has been found to be associated with negative health outcomes and high surface air pollution levels. Previous research has demonstrated a well-established link between the structure of the atmospheric boundary layer (ABL) and surface air quality; however, the degree to which the structure of the ABL influences for formation of local-scale brown haze is unknown. Using continuous ceilometer data covering seven consecutive winters, we investigate the influence of the structure of the ABL in relation to surface air pollution and brown haze formation over an urban area of complex coastal terrain in the Southern Hemisphere city of Auckland, New Zealand. Our results suggest the depth and evolution of the ABL has a strong influence on severe brown haze formation. When days with severe brown haze are compared with those when brown haze is expected but not observed (based on favorable meteorology and high surface air pollution levels), days with severe brown haze are found to coincide with significantly shallower daytime convective boundary layers (~ 48% lower), and the nights preceding brown haze formation are found to have significantly shallower nocturnal boundary layers (~ 28% lower). On severe brown haze days the growth rate during the morning transition phase from a nocturnal boundary layer to a convective daytime boundary layer is found to be significantly reduced (70 m h^{-1}) compared to days on which brown haze is expected but not observed (170 m h^{-1}). Compared with moderate brown haze, severe brown haze conditions are found to be associated with a significantly higher proportion of days with a distinct residual layer present in the ceilometer profiles, suggesting the entrainment of residual layer pollutants may contribute to the severity of the haze. This study illustrates the complex interaction between the ABL structure, air pollution, and the presence of brown haze, and demonstrates the utility of a ceilometer instrument in understanding and predicting the occurrence of brown haze events.