Boundary layer characteristics on cloudless days in Beijing based on UHF wind-profiler and related meteorological observations

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Based on 1290 MHz boundary layer wind-profiler observations, this study revealed important characteristics of the diurnal variation of atmospheric refractive index structure parameter (C_n^2) on cloudless days in Beijing and made explanations from related meteorological environment fields and radar echoing mechanism. By investigating the vertical distribution of C_n^2 on a total of 114 completely cloudless days over a two-year period (March 2011 to March 2013), three patterns of C_n^2 diurnal variation were found. Pattern 1 showed weak diurnal variation, happening in winter months and with low humidity. Pattern 3 showed obvious diurnal variation, with larger C_n^2 at nighttime and smaller values during daytime, detected in high humidity months. In the transition months, with transitional characteristics between patterns 1 and 3, there was Pattern 2. Patterns 1, 2 and 3 accounted for 40.3%, 12.3% and 47.4% of cloudless days, respectively.

The variation in the C_n^2 characteristics among the three patterns was related to the variation of the dominant air flow, terrain effects – both dynamic (terrain blocking and air flow ascent) and thermodynamic (mountain and valley breezes) – and also the echoing mechanism.

As for echoing mechanism, the present study puts forward that isotropic turbulence scatter worked during the daytime, while at nighttime for Pattern 3 echoes were produced by scattering from anisotropic structures of the refractive index. In Pattern 3, the effective detection height at nighttime was higher than that during daytime, suggesting that the anisotropic echo at night may have been related to specular reflection (Fresnel reflection/scattering). The alternating of the echoing mechanisms between day and night has a good corresponding in time with the transformation of the day and night distribution characteristics of C_n^2. The production of echoes scattering from anisotropic structures at nighttime in Pattern 2, and especially in Pattern 3, were closely related to the stable atmospheric structures, making it easy for stratifications to form with a scale of radar half-wavelength to several wavelengths.

Higher humidity and echoes scattering from anisotropic structures in the refractive index resulted in higher C_n^2 values at nighttime.