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The Daily Evolution of Black Carbon Profiles over Shanghai during Winter

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Introduction

For China, this was the first vertical observation of multi-pollutants within a 1000 m atmospheric boundary layer over a metropolitan area using a tethered balloon filled with 1600 m^3 Helium. Ultimately, this campaign not only stirred up our appreciation of observational technology, but also deepened our understanding of the causes of heavy air pollution and its various transport patterns, and improved the performance and forecast accuracy of air quality models.

Field Measurement

The field (N30°49'47", E121°30'04") was located in southern Shanghai, which borders the East China Sea(Fig.1). The surrounding area was by the campuses of a couple of universities.

The platform for the vertical observation consisted of two components (Fig.2,3). One was the tethered balloon filled with 1600 m^3 Helium; the other component was an on-line monitoring instrument assembly. The platform ascended at a rate of 0.5m/s taking measurements from 150 m through 1000 m; it was defined as one vertical profile. Meanwhile, ground pollutants, mixing height layer and wind profiles were observed synchronously in the field.

Fig. 1 Map of the field

Fig. 2 Tethered balloon

Fig. 3 Instruments assembly

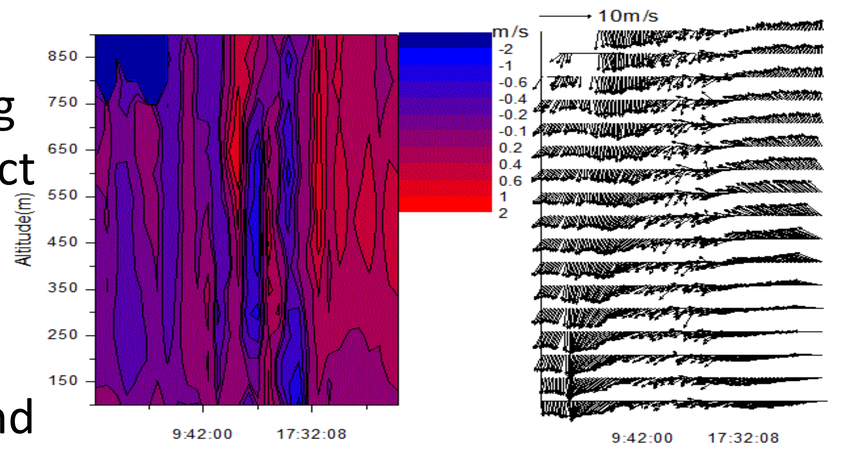
Results and Discussions

1.Daily variation of atmosphere within 1000 m

Daily variation of the atmospheric boundary layer resulted from solar radiation. In the field measurement, MHL could reach to over more than 1500 m at noon, while it dropped to around 150 m at midnight. For wind profiles (Fig.4), the upward wind was dominant in sunrise; at noon, upward wind strengthened with the maximum speed reaching 1.6 m/s. The upward and downward wind shifted with high frequently at all layers. After sunset, the downward winds were predominant, weakening with time.

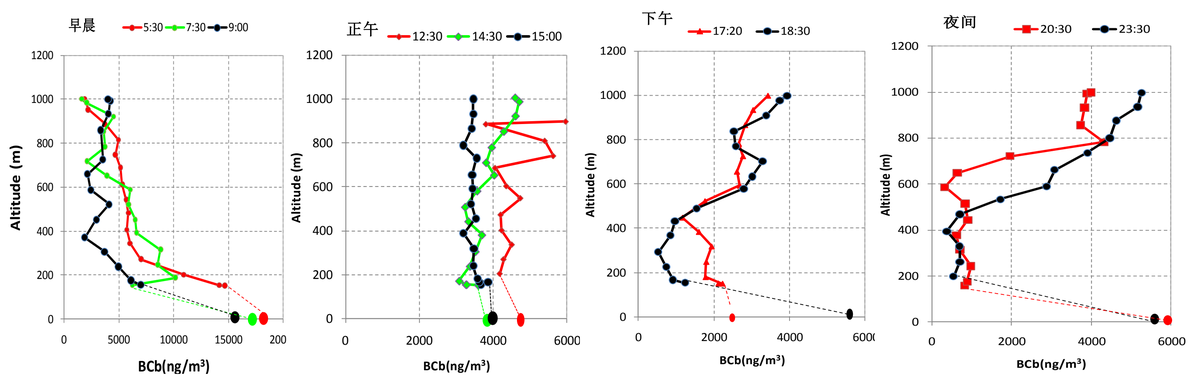
2. Daily evolution of BC profiles

Daily evolution of BC profiles were strongly influenced by the air motion. At sunrise the BC at the same altitude gradually became lower. Also, the fluctuation of BC profiles rose rapidly, suggesting that BC was subject to transport upward and downward with turbulence. Around noon, BC concentrations tended to be constant at all levels. Around sunset, BC concentrations near the ground continuously decreased to 1.2 μg/m^3, while at the upper layer (i. e. at the altitude of 1000 m), BC concentrations were persistent up to 4.0 μg/m^3. At midnight, the difference of BC profile both near the ground and at the upper layer were very slight (see Fig.5).



(a):Vertical wind (b): Horizontal wind

Fig. 4 Daily variation of wind profiles on Dec. 13, 2014



(a): Sunrise (b): Noon (c): Sunset (d): Midnight

Fig.5 Daily BC profiles on Dec. 13, 2013

These results demonstrated pollutant BC was not only transported from the surface to the upper air, but also be transported downward. It would be very useful to quantitatively evaluate the contribution of vertical transport of pollutants in air pollution episodes at regional level.

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