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(Research Article)

A statistical study of atmospheric boundary layer evolution using backscatter lidar data for the city of Zanjan

Askari, M.[1] | Bayat, S.[1] | Masoumi, A.[1] ✉ | Moradhaseli, R.[2]

1. Department of Physics, Faculty of Sciences, University of Zanjan, Zanjan, Iran.
2. Department of Physics, Faculty of Science, Zanjan Branch, Islamic Azad University, Zanjan, Iran.

Corresponding Author E-mail: a_masoumi@znu.ac.ir

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Summary

The boundary layer is the lowest part of the Earth's atmosphere and is directly affected by the Earth's surface. Humans live within the boundary layer, and the height of this layer affects air quality and their physical and mental health. It also affects commercial activities such as air and sea transport. Therefore, measuring the height of the boundary layer and knowing how it evolves is very important.

The height of the atmospheric boundary layer is measured in two general ways: in-situ measurements and remote sensing methods. The main disadvantages of in-situ measurements are their cost and the impossibility of continuous measurement. On the other hand, remote sensing methods use the concept of the interaction of sound or electromagnetic waves with the components of the atmosphere. It uses instruments such as Sodar, Radar, and Lidar to continuously study the boundary layer's height at a lower cost.

In this study, the data obtained from the elastic backscatter Lidar measurements have been used to extract the boundary layer's height for the city of Zanjan. The Lidar is located at the Institute for Advanced Studies in Basic Sciences (IASBS), and its 532 nm wavelength channel is used in this study. Also, the method used in this study is the Wavelet Covariance Transform (WCT) method. The attenuated backscatter coefficient or the range-corrected signal is expected to decrease for ground-based Lidars as the height increases. As it exits the boundary layer, the concentration of atmospheric particles decreases sharply, and therefore the backscattered signal is expected to drop significantly. The WCT method uses this sharp reduction of the signal to detect the height of the boundary layer. The wavelet covariance transform function, in simple terms, calculates the difference between the Lidar range-corrected signal for a given height interval and the Lidar range-corrected signal for a higher altitude interval. As a result, the peak height equivalent of this function Corresponds to the height of the boundary layer.

In this study, only the period 2011-2012 was studied because of the significant number of measurements. In total, we had 105 days of data during the mentioned period, the first of which is related to April 13, 2011, and the last of which is related to October 15, 2012. All measurements are taken for days with no active synoptic conditions. In winter, we have the lowest daily average value of the boundary layer height (0.975±0.556 km), and in summer, we have its maximum value (2.597±0.714 km). In the two seasons of spring and autumn, the extracted values of the height of the boundary layer are very close to each other and are about 1.9 km above ground level (AGL). Therefore, there is a direct correlation between air temperature and the height of the boundary layer. Finally, the daily-averaged value of the boundary layer height for the whole 105 days of data was 2,067 km AGL. Also, the hourly-averaged height of the atmospheric boundary layer has been extracted and plotted for all four seasons. For these data, a good relationship is observed between air temperature and the height of the boundary layer, especially in winter, which is expected to improve accuracy if further measurements are made.

Keywords: Atmospheric boundary layer, Remote sensing, Lidar, Wavelet Covariance Transform method, Zanjan.

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E-mail: (1) miladaskari7394@gmail.com | bayatsaeedeh73@gmail.com (2) r.moradhaseli.iauz@gmail.com

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رایانامه نویسنده مسئول: a_masoumi@znu.ac.ir

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رایانامه: r.moradhaseli.iauz@gmail.com bayatsaeedeh73@gmail.com | miladaskari7394@gmail.com

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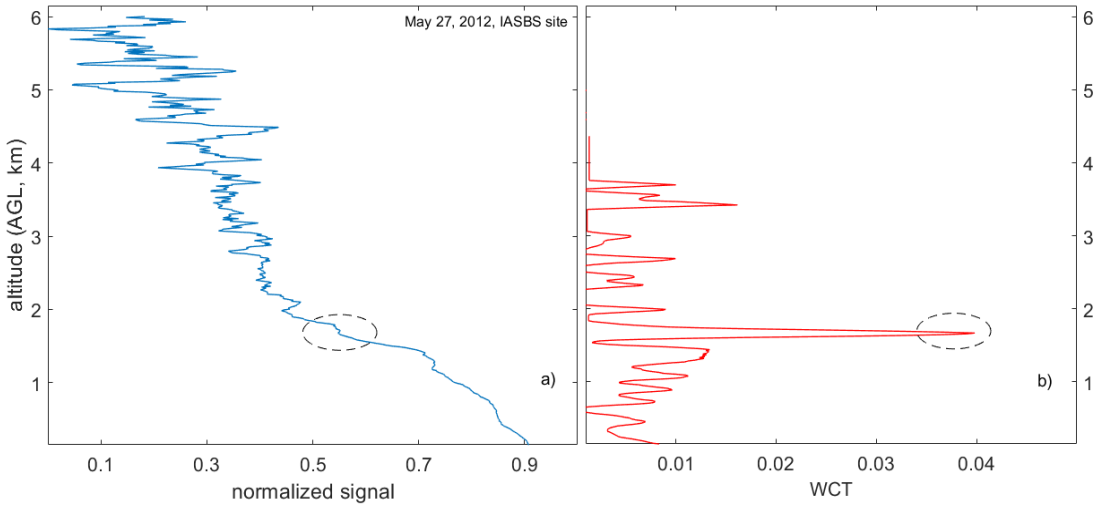

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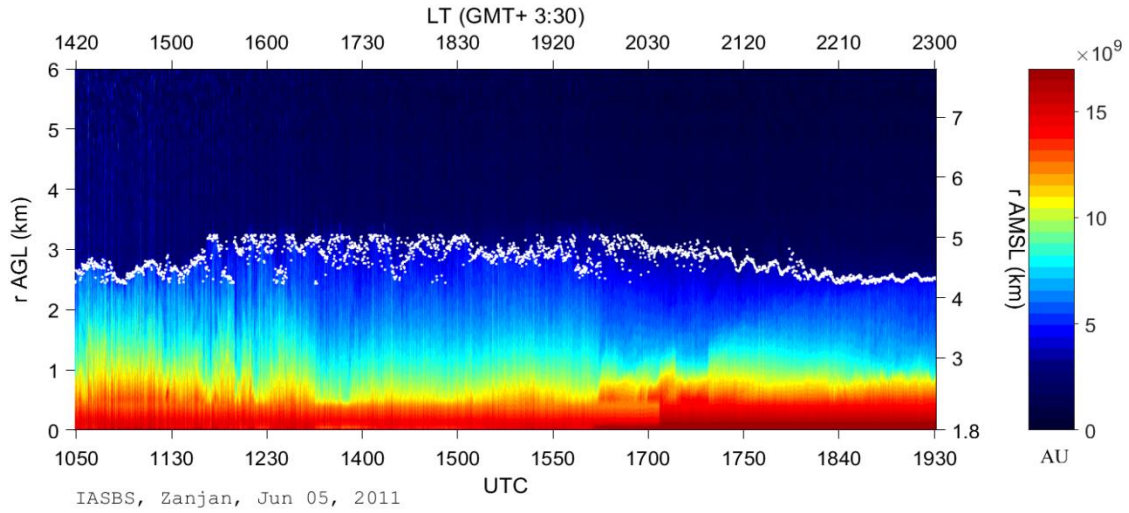
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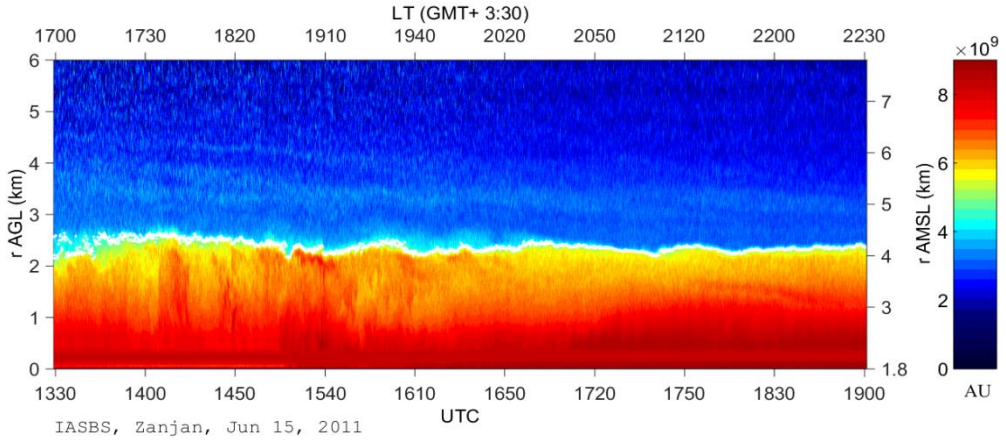
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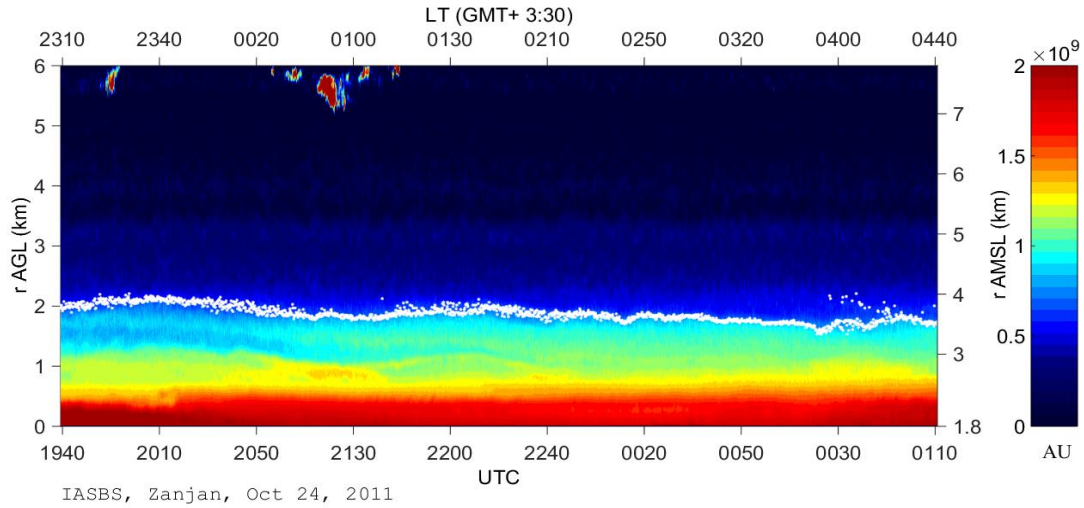
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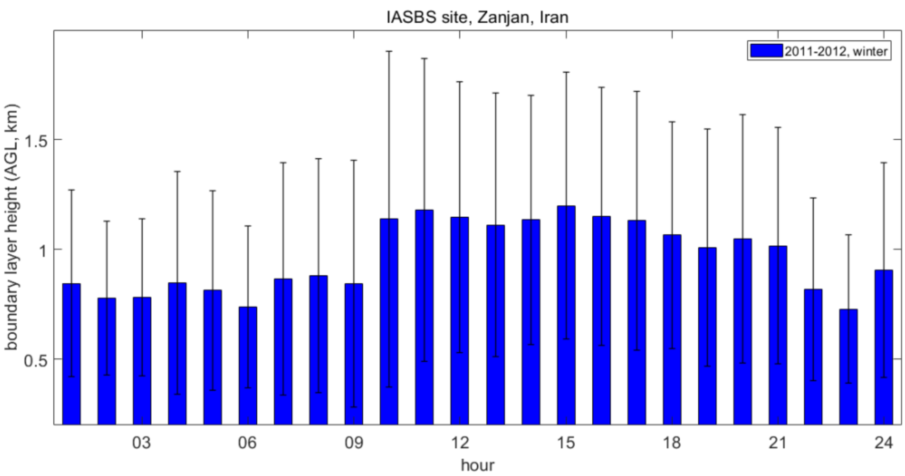
IASBS site, Zanjan, Iran
2011-2012, winter
boundary layer height (AGL, km)
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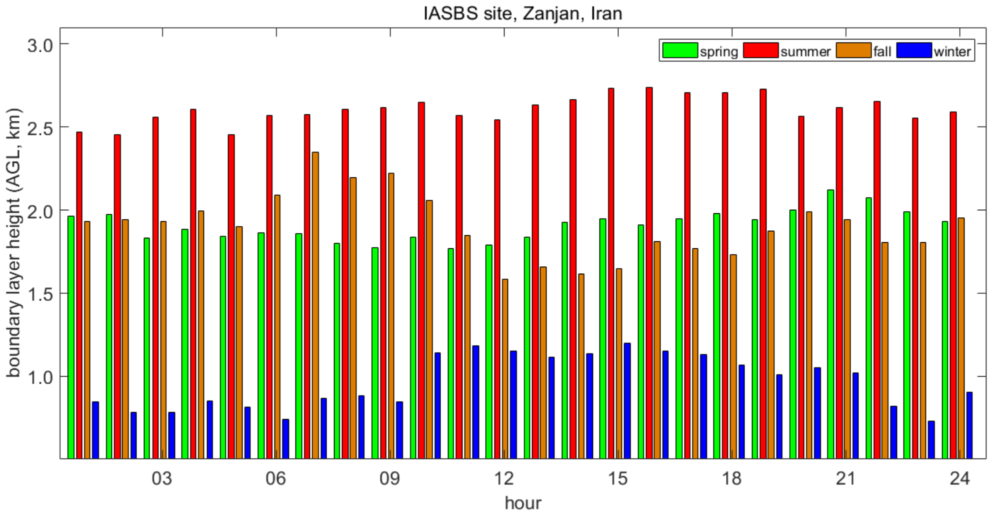
06
09
12
15
18
21
24
hour



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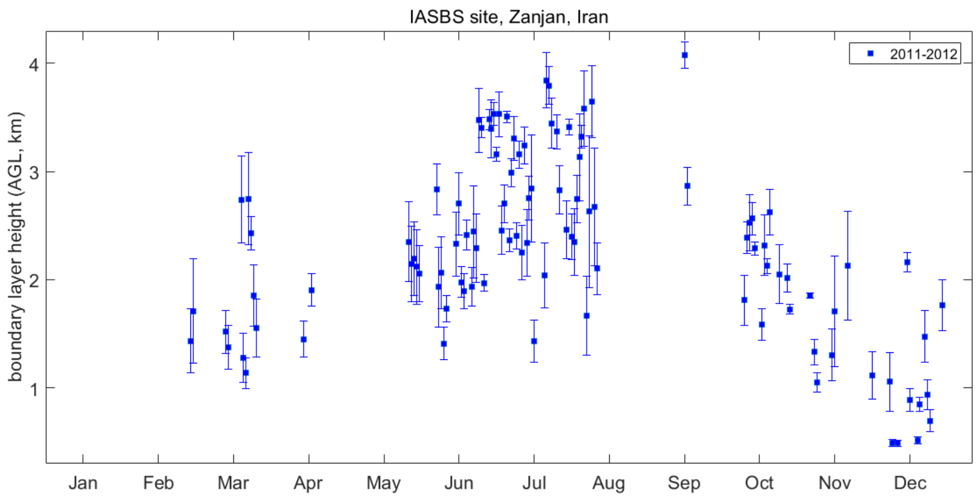

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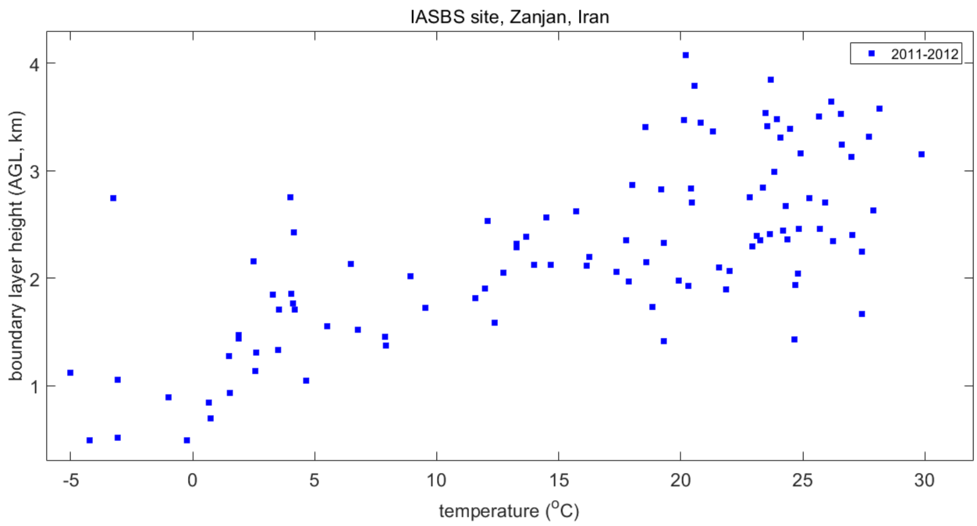

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