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The seasonal cycle of the mixing layer height and its impact on black carbon concentrations in the Kathmandu Valley (Nepal)

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The properties and the vertical structure of the mixing layer as part of the planetary boundary layer are of key importance for local air quality. They have a substantial impact on the vertical dispersion of pollutants in the lower atmosphere and thus on their concentrations near the surface. In this study, ceilometer measurements taken within the framework of the SusKat project (Sustainable Atmosphere for the Kathmandu Valley) are used to investigate the mixing layer height in the Kathmandu Valley, Nepal. The applied method is based on the assumption that the aerosol concentration is nearly constant in the vertical and distinctly higher within the mixing layer than in the air above. Thus, the height with the steepest gradient within the ceilometer backscatter profile marks the top of the mixing layer. Ceilometer and black carbon (BC) measurements conducted from March 2013 through February 2014 provide a unique and important dataset for the analysis of the meteorological and air quality conditions in the Kathmandu Valley.

In this study the mean diurnal cycle of the mixing layer height in the Kathmandu Valley for each season (pre-monsoon, monsoon, post-monsoon and winter season) and its dependency on the meteorological situation is investigated. In addition, the impact of the mixing layer height on the BC concentration is analyzed and compared to the relevance of other important processes such as emissions, horizontal advection and deposition.

In all seasons the diurnal cycle is typically characterized by low mixing heights during the night, gradually increasing after sun rise reaching to maximum values in the afternoon before decreasing again. Seasonal differences can be seen particularly in the height of the mixing layer, e.g. from on average 153/1200 m (pre-monsoon) to 241/755 m (monsoon season) during the night/day, and the duration of enhanced mixing layer heights during daytime (around 12 hours (pre-monsoon season) to 8 hours (winter)). During the monsoon season, the observed diurnal cycle typically shows the lowest amplitude and the lowest mixing height during the day and the highest in the night and morning hours of all seasons. These characteristics can mainly be explained with frequently present clouds and the associated lack of incoming solar radiation and outgoing longwave radiation.

In general there is a clear anti-correlation of the BC concentration and the mixing layer height although this relation is less pronounced in the monsoon season. The shape and magnitude of the BC diurnal cycle differs between the seasons (e.g., daily maximum concentration from around 6 to 50 μg/m3 depending on the season). This is partly due to the different meteorological conditions including the mixing layer height but also caused by the different (seasonal and diurnal) time profiles of the main emission sources. From late December to April, for instance, brick kilns are major emitters of black carbon. The brick kilns emit continuously throughout the day whereas in the other months sources with more pronounced diurnal cycles, such as traffic and cooking activities, are dominating the total emissions.