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Long-term Study of Urban Mixing Layer Height over Sofia, Bulgaria

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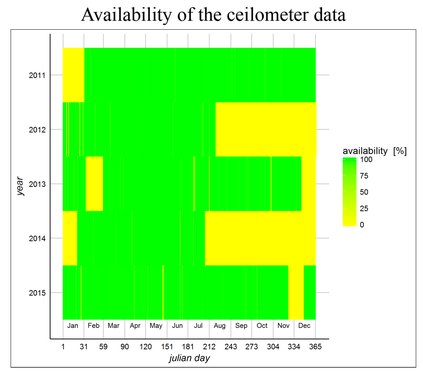
Abstract: Knowledge of the mixing layer (ML) is vitally important as it controls vertical diffusion of near surface pollutants and thus mixing layer height (MLH) regulates their surface concentration. Regardless of having important significance in cities, urban MLH is seldom monitored and reported. Recently ground based remote sensing instruments are utilized for continuous observation of MLH evolution as they provide vertical profiles of atmospheric parameters that can serve as tracers for the process of mixing. A Jenoptik's ceilometer CHM15k has been continuously operated for several years in Sofia, Bulgaria, reporting vertical distribution of backscatter signal. Estimated from the ceilometer data MLHs are verified against determined ones from radiosonde profiles around time of balloon launching. We investigate the diurnal, seasonal and annual variations of urban MLH over Sofia. The importance of synoptic-scale processes on MLH and its evolution is also studied. Significant agreement between MLHs determined by both instruments is registered in summer months. In cold part of the year MLHs retrieved from the ceilometer has tendency to outreach retrieved ones from the radiosonde. We attribute the lack of agreement between MLHs derived from both instruments to different tracers that are used. The poor consistency between MLHs determined from the ceilometer and radiosonde in winter is imputed to incomplete overlapping of the ceilometer, which deteriorates its ability to detect low MLH in winter.

Instruments and Data:

Continuously operating CHM15k in the period 2011 – 2015 (the data are archived at the Sofia University)

Radiosonde (launched at 12UTC (12LT)) data for a year (2015) (IGRA—Durre et al. 2006)

Availability of the ceilometer data



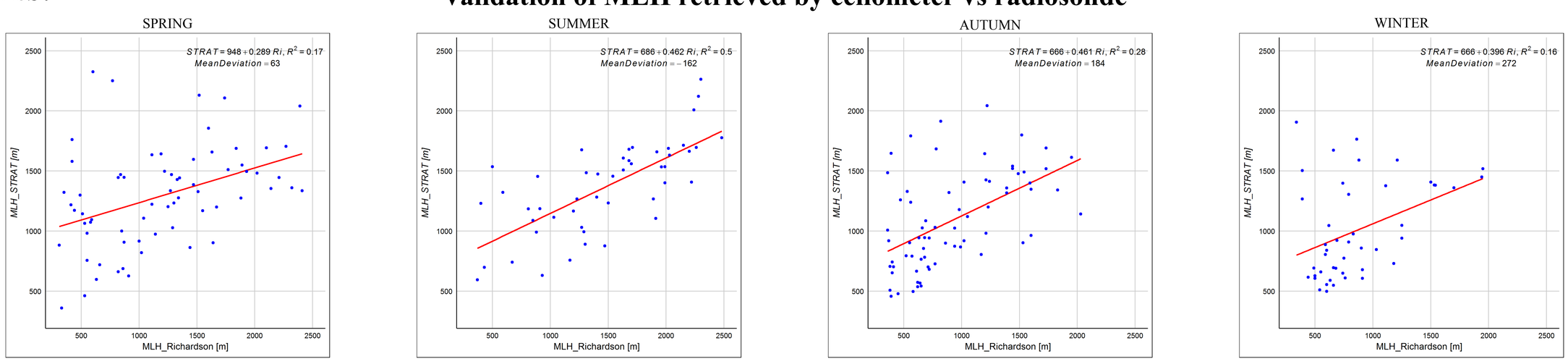
MLH determination:

By the radiosonde: Critical Richardson number (Ri_c=0.21) (Vogelezang and Holtslag 1996)

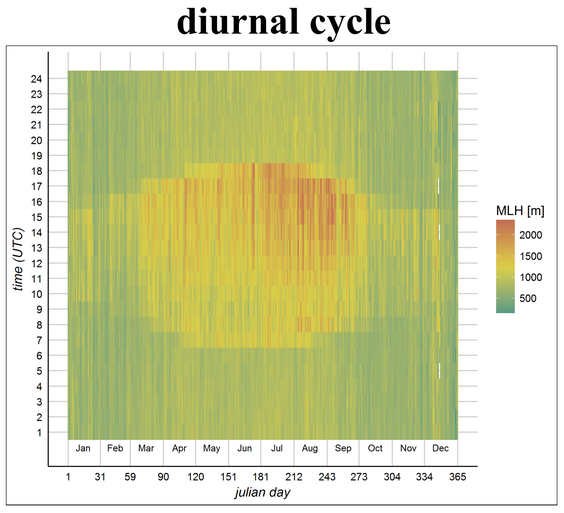
By the ceilometer: STRAT2D (Morille et al. 2007)

Results:

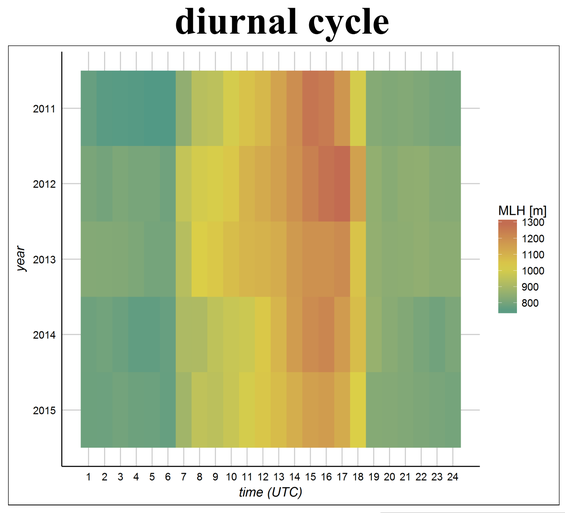
Validation of MLH retrieved by ceilometer vs radiosonde



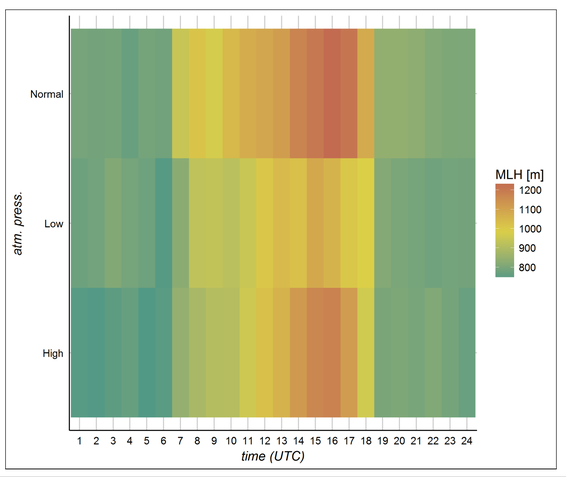
Intraanual variability of MLH diurnal cycle



Interanual variability of MLH diurnal cycle

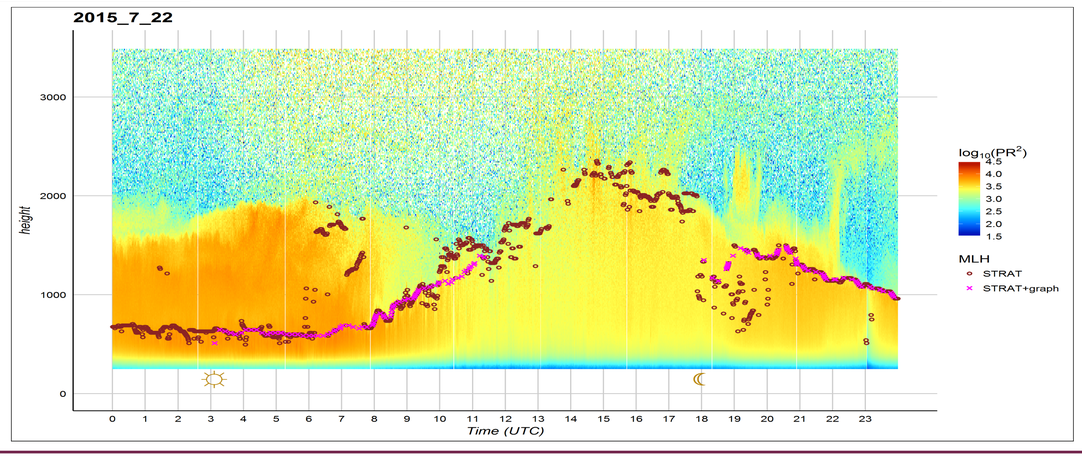


MLH diurnal cycle dependency on atmospheric pressure



Improvement of layer attribution during transition periods by graph theory:

- Individual graphs for morning and evening transitions ($MLH_{sunrise} \rightarrow MLH_{noon}$ & $MLH_{sunset} \rightarrow MLH_{midnight}$)
- STRATs candidates (the strongest, the 2nd strongest and the lowest gradient) are vertices
- Edges from current vertex to all available vertices in next ***n=15*** minutes
- The shortest path for each graph



Conclusions: Determined by the ceilometer MLHs corresponds passably to radiosonde only in summer (underestimation of ~160m). In the rest of the seasons correlation is too low (<0.5). Diurnal cycle of MLH evolves within the year, the maximum MLH is prolonged and observed later in summer mounts. In cold part of the year diurnal variations are smaller. MLH daily maximum was found from 17 to 19LT over the years. At High and Normal atmospheric pressure MLH is higher and faster growing than at Low. The observed MLH values at night are too high that can be result of uncomplete overlapping and misattribution of STRATs MLH candidates. The shortest path approach might overcome misattribution in transition periods but graphs number and their construction should be carefully selected.

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