Timing and coincidence of atmospheric nucleation events in a region

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Particle number size distributions were measured in urban (Budapest, BP, Salma *et al.*, 2014) and rural background sites (K-puszta, KP) in the Carpathian Basin. The measurements were performed by Differential Mobility Particle Sizer (DMPS) for two 1-year long time intervals in 2008–09 and 2012–13. The measurement days for both sites were classified into nucleation event, non-nucleation and undefined days according to Dal Maso *et al.* (2005). The beginning (t_1) and end (t_{end}) time of nucleation events were set as described earlier in Németh and Salma (2014). Backward air mass trajectories were calculated by HYSPLIT code (Draxler and Rolph, 2013) for each event (from t_{end} to t_1) and non-event (from mean t_{end} to mean t_1) day. Meteorological parameters and SO_2 concentration were also investigated.

In total, 64 days with class-1 nucleation event at both sites, and 270 non-nucleation days at both sites were identified. On 58 days, there was nucleation at the rural background site and there was no nucleation in the city, while on 15 days, it was vica versa. Meteorological conditions and SO_2 concentration were averaged between t_1 and t_{end} time parameters. Direct solar radiation was 29 (BP) and 28 W m^{-2} (KP), and 143 (BP) 147 (KP) W m^{-2} for non-nucleation and nucleation events, respectively. Cloudiness and relative humidity have an opposite tendency.

Backward trajectories were evaluated for all nucleation and non-nucleation days for an arriving height of 200 m above ground level. Trajectories were classified into 4 groups (NW, NE, SE and SW) depending on their arriving direction. It is noted that the prevailing wind direction in the central part of the Carpathian Basin is NW, which is in parallel with the line of the Budapest–K-puszta site. The parallel direction became more frequent on nucleation days (67%) than on non-nucleation days (48%). Parameter τ was introduced to investigate whether the nucleating air mass is able to reach the other measurement on time:

$$\tau = \frac{\Delta t_1}{t_{WS}}, \qquad (1)$$

where Δt_1 is the time difference between the start time of nucleation events at the two measurement sites, and t_{WS} represents the time that takes the air mass with the mean wind speed to reach from one site to the other site in case of parallel directions. If the τ parameter is greater than 1.00, then the nucleating air mass is able to reach the other measurement site. If it is smaller than 1.00, there is not enough time for the nucleating air masses to be convected from one of the sites to the other site. In 79% of the cases, parameter τ was smaller than 1.00 (Table 1). If the nucleating air masses arrive from the perpendicular directions, Δt_1 is only investigated. This all implies that an air mass arriving from one of the sites to the other site only reaches approximately half of the distance in general when the nucleation event already starts at the other site. Hence, nucleation events observed at the sites are realisations of a common phenomenon occurring in the Carpathian Basin. At present knowledge, convection of nucleating air masses within the basin cannot be excluded in some cases. The local realisation also depends on triggering or suppressing processes.

Table 1. Parameters τ for parallel arrival directions, and Δt_1 in units h:mm for perpendicular arrival directions.

	τ	Δt_1
Minimum	0.05	0:02
Median	0.45	3:33
Maximum	1.66	6:16
Mean	0.61	3:08
St. dev.	0.41	1:47

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