Appendix A: Volumes of the recirculation and ventilation zones

The algorithm used in the heterogeneous version of MUNICH to compute the volumes of the recirculation and ventilation zones is based on the parameterization of OSPM (Berkowicz et al., 1997; Berkowicz, 2000a; Ottosen et al., 2015). This algorithm is applied at the beginning of each time step as the size of the recirculation zone is dependent on wind speed and direction.

Figure A1 presents the shape of the recirculation zone and the associated parameters.

![Recirculation zone diagram]

The first step is to compute the length of the vortex in the direction of the wind:

$$L_{vortex} = 2Hf$$  \hspace{1cm} (A1)

with $H$ the height of the street and

$$f = \begin{cases} 
1 & \text{if } u_{\text{roof}} \geq 2 \text{ ms}^{-1} \\
\sqrt{0.5} u_{\text{roof}} & \text{if } u_{\text{roof}} < 2 \text{ ms}^{-1} 
\end{cases}$$  \hspace{1cm} (A2)

with $u_{\text{roof}}$ the wind speed at roof level.

The width of the trapeze base is the projection of $L_{vortex}$ in the street:

$$W_{\text{base}} = L_{vortex} \sin(\theta)$$  \hspace{1cm} (A3)

with $\theta$ the angle between the wind direction and the street orientation.

The width of the trapeze top is equal to half of the base:

$$W_3 = \frac{L_{vortex} \sin(\theta)}{2}$$  \hspace{1cm} (A4)