The gustiness of wind downstream of a forest edge

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Assuming a spatially uniform vegetation density within the entire forest volume, a transition from open land to forest may be regarded as a porous forward facing step submerged in a turbulent boundary layer. According to this simplification, the flow across a forest edge was modeled in an atmospheric wind tunnel using a layer of an open-pored permeable polyurethane foam as vegetation model.

Single- and two-point measurements were carried out using both laser Doppler velocimetry and hot wire technique. Particular attention was paid to the dynamics of the shear layer which is formed immediately behind the edge and separates the decelerated air which has penetrated the forest edge from the free flow above. Turbulent diffusion and, thus, the vertical growth of this layer is mainly driven by the oncoming boundary layer turbulence. Very close to the edge, in the early stadium of development of the shear layer, it could be observed that the actual mixing layer is formed by a thin vertically flapping mixing layer. Time series of two point measurements, taken simultaneously at a detection point and at several points in the remainder of the flow field, were examined using a variable interval time averaging method (VITA). It could be shown that oncoming eddies of the same size as the forest height are mainly responsible for the flapping movement. The flapping implies a highly anisotropic turbulence with fluctuations much stronger in the horizontal than in the vertical. As already stated in previous works, further downstream energy is fed into the vertical motions by the return-to-isotropy mechanism.

For the case of real forests it is suggested that extreme loads on trees at a certain distance from the edge could be the consequence of discrete eddies which are contained in the upstream boundary layer and which might result in a violent downburst of air into the forest as they are distorted by the presence of the forest edge. It will be discussed in how far the density of the forest, the roughness conditions of the upstream boundary layer and the shape of the forest edge might have an influence on the position and magnitude of the extreme wind loads.

Keywords: forest edge, permeability, surface mounted obstacle, windthrow, variable interval time averaging