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Development and application of an urban climate model with integrated urban vegetation

Gianluca Mussetti (1,2,3), Stephan Henne (1), Dominik Brunner (1), Jonas Allegrini (2,3), Sebastian Schubert (4), Scott Krayenhoff (5), and Jan Carmeliet (3)

(1) Laboratory for Air Pollution/Environmental Technology, Empa, Dübendorf, Switzerland (gianluca.mussetti@empa.ch), (2) Laboratory for Multiscale Studies in Building Physics, Empa, Dübendorf, Switzerland, (3) Chair of Building Physics, ETH Zürich, Zürich, Switzerland, (4) Geography Department, Humbolt-Universität zu Berlin, Berlin, Germany, (5) School of Environmental Science, University of Guelph, Guelph, Canada

Urban vegetation, such as street trees and green roofs, is increasingly recognized as a potentially powerful mitigation measure for urban climate issues. However, current urban climate models do not accurately represent the vegetation in urban street canyons, which limits our ability to predict the effect of urban greening on current and future urban climate. Specifically, urban climate models typically neglect the radiation and flow interactions between trees and buildings. Only a few urban canopy models (UCMs) with a physically-based treatment of urban vegetation have been developed in recent years, but none of these has been used coupled to a larger scale weather and climate model.

Here, we integrated the vegetation representation of the urban canyon model BEP-Tree into the weather and climate model COSMO-CLM (CCLM), building on top of a previous urban parameterisation without trees (DCEP). The CCLM-DCEP-Tree system has been optimised to reduce the computational cost of the UCM (that employs ray tracing) while preserving a high enough accuracy. An advanced leaf stomata model has been implemented in order better represent the daily profile of transpiration through the leaves.

We evaluated the performance of the modelling system against data from a flux tower in Basel, Switzerland and a network of urban stations in Zurich, Switzerland. The distribution of leaf area density in the city is derived using a combination of areal imagery and local datasets. The city-wide impact of urban trees on the urban climate in Zurich was quantified, together with the impact of urban greening scenarios. The results of this study show the importance of representing street trees in urban climate modelling.