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Application of the ACASA model for urban development studies

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Since urban population is growing fast and urban areas are recognized as the major source of CO_2 emissions, more attention has being dedicated to the topic of urban sustainability and its connection with the climate. Urban flows of energy, water and carbon have an important impact on climate change and their quantification is pivotal in the city design and management. Large effort has been devoted to quantitative estimates of the urban metabolism components, and several advanced models have been developed and used at different spatial and temporal scales for this purpose. However, it is necessary to develop suitable tools and indicators to effectively support urban planning and management with the goal of achieving a more sustainable metabolism in the urban environment.
In this study, the multilayer model ACASA (Advanced Canopy-Atmosphere-Soil Algorithm) was chosen to simulate the exchanges of heat, water vapour and CO_2 within and above urban canopy. After several calibration and evaluation tests over natural and agricultural ecosystems, the model was recently modified for application in urban and peri-urban areas. New equations to account for the anthropogenic contribution to heat exchange and carbon production, as well as key parameterizations of leaf-facet scale interactions to separate both biogenic and anthropogenic flux sources and sinks, were added to test changes in land use or urban planning strategies.
The analysis was based on the evaluation of the ACASA model performance in estimating urban metabolism components at local scale. Simulated sensible heat, latent heat, and carbon fluxes were compared with in situ Eddy Covariance measurements collected in the city centre of Florence (Italy). Statistical analysis was performed to test the model accuracy and reliability. Model sensitivity to soil types and increased population density values was conducted to investigate the potential use of ACASA for evaluating the impact of planning alternative scenarios.
In this contest, an in progress application of ACASA for estimating carbon exchanges alternative scenarios is represented by its integration in a software framework composed by: (i) a Cellular Automata model to simulate the urban land-use dynamics; (ii) a transportation model, able to estimate the variation of the transportation network load; (iii) the ACASA model, and (iv) the mesoscale weather model WRF for the estimation of the relevant urban metabolism components at regional scale.
The CA module is able to produce future land use maps, which represent a spatial distribution of the aggregate land-use demand consistent with the main rules governing the functioning of an urban system. Such future land use maps, together with the street network including the current traffic data, are used by the transportation module for estimating future traffic data coherent with the assumed land uses trends. All these information are then used by the coupled model WRF-ACASA for estimating future maps of CO_2 fluxes in the urban area under consideration, allowing to estimate the impact of future planning strategies in reducing C emissions. The in-progress application of this system to the city of Florence is presented here.