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Development of a Three-Source Remote Sensing Model for Estimation of Urban Evapotranspiration (TRU)

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Evapotranspiration (ET) from an urban area and its components are important when estimating the urban 'heat island' effect and the urban hydrological cycle. Multi-source satellite-based ET models for ecosystems (e.g. farmland, forest, and wetland) have been developed and applied, but satellite-based ET model dimensions for urban areas are lacking, especially since all currently available models are designed for single-source schemes. This paper proposes the first Three-source Remote sensing model for Urban areas (TRU) to discriminate between soil evaporation, vegetation transpiration, and impervious surface evaporation. TRU uses a new parameterization scheme, based on the use of a complementary relationship integrating soil surface temperature to estimate soil evaporation. An iterative procedure was developed for decomposing land surface temperature (LST) into component temperatures. Also, the ET for impervious areas was independently delineated using the "patch" approach. The model was tested for 45 cloudless days in Tianjin for 2017-2020 based on 30 m Operational Land Imager (OLI)/Enhanced Thematic Mapper Plus (ETM^+) images. Results indicated the root mean square error (RMSE) of 38.8 W/m^2 and Bias of 9.9 W/m^2 compared with two Eddy Correlation (EC) observations for instantaneous latent heat (LE) simulation and RMSE was 0.087 and Bias was -0.012, compared with stable water isotope measurements for the estimation of the ratio of vegetation latent heat flux to latent heat flux (LE_v/LE).Comparison with urban single-source models and two-source models for ecosystem suggest TRU provide best accuracy for ET and its components simulation. The spatial pattern suggested impervious surface evaporation exhibited minimal seasonal variation and maintained a very lower level due to limited availability of water. The results emphasized the importance of using land use and land cover (LULC) in urban ET modeling and the necessity to calculate ET as independent of impervious areas. TRU represents a groundbreaking development of multi-source urban satellite-based ET models and facilitates the mapping of urban ET components.