# Calibration of DART Radiative Transfer Model with Satellite Images for Simulating Albedo and Thermal Irradiance Images and 3D Radiative Budget of Urban Environment

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Remote sensing is increasingly used for managing urban environment. In this context, the H2020 project URBANFLUXES aims to improve our knowledge on urban anthropogenic heat fluxes, with the specific study of three cities: London, Basel and Heraklion. Usually, one expects to derive directly 2 major urban parameters from remote sensing: the albedo and thermal irradiance. However, the determination of these two parameters is seriously hampered by complexity of urban architecture. For example, urban reflectance and brightness temperature are far from isotropic and are spatially heterogeneous. Hence, radiative transfer models that consider the complexity of urban architecture when simulating remote sensing signals are essential tools. Even for these sophisticated models, there is a major constraint for an operational use of remote sensing: the complex 3D distribution of optical properties and temperatures in urban environments. Here, the work is conducted with the DART (Discrete Anisotropic Radiative Transfer) model. It is a comprehensive physically based 3D radiative transfer model that simulates optical signals at the entrance of imaging spectro-radiometers and LiDAR scanners on board of satellites and airplanes, as well as the 3D radiative budget, of urban and natural landscapes for any experimental (atmosphere, topography,…) and instrumental (sensor altitude, spatial resolution, UV to thermal infrared,…) configuration. Paul Sabatier University distributes free licenses for research activities.

This paper presents the calibration of DART model with high spatial resolution satellite images (Landsat 8, Sentinel 2, etc.) that are acquired in the visible (VIS) / near infrared (NIR) domain and in the thermal infrared (TIR) domain. Here, the work is conducted with an atmospherically corrected Landsat 8 image and Bale city, with its urban database. The calibration approach in the VIS/IR domain encompasses 5 steps for computing the 2D distribution (image) of urban albedo at satellite spatial resolution. (1) DART simulation of satellite image at very high spatial resolution (e.g., 50cm) per satellite spectral band. Atmosphere conditions are specific to the satellite image acquisition. (2) Spatial resampling of DART image at the coarser spatial resolution of the available satellite image, per spectral band. (3) Iterative derivation of the urban surfaces (roofs, walls, streets, vegetation,…) optical properties as derived from pixel-wise comparison of DART and satellite images, independently per spectral band. (4) Computation of the band albedo image of the city, per spectral band. (5) Computation of the image of the city albedo and VIS/NIR exitance, as an integral over all satellite

spectral bands. In order to get a time series of albedo and VIS/NIR exitance, even in the absence of satellite images, ECMWF information about local irradiance and atmosphere conditions are used. A similar approach is used for calculating the city thermal exitance using satellite images acquired in the thermal infrared domain. Finally, DART simulations that are conducted with the optical properties derived from remote sensing images give also the 3D radiative budget of the city at any date including the date of the satellite image acquisition.