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Modelling air temperature via assimilation of satellite derived LST within the Urban Heat Island project

Bino Maiheu (1), Koen De Ridder (1), Benedicte Doucet (2), Paolo Manuta (3), Giulio Ceriola (3), and Iphigenia Keramitsoglou (4)

(1) Flemish Institute for Technological Research (VITO), (2) Hawaii Institute of Geophysics and Planetology, Honolulu (Hawaii), (3) Planetek Italia SRL, Bari (Italy), (4) National Observatory of Athens, NOA-ISARS, Athens (Greece)

One of the goals of the ESA-DUE funded Urban Heat Island project is to produce historic air temperature maps based upon satellite derived land surface temperature data for multiple years and urban agglomerations. As to our knowledge no readily available model exists which is both accurate and fast enough to produce such a historic dataset, a new approach was devised, which on the one hand tries to capture the essential physics behind the urban heat island phenomenon and on the other hand does not require the computing time a full mesoscale meteorological model would need. The model which we propose consists of 2 modules, a surface part and an atmospheric module linked via a data assimilation scheme.

The surface module is constructed around simple prognostic equations for the surface temperature taking urban thermal admittance into account and a simple surface energy balance. The urban storage heat flux is modelled by the objective hysteresis model by Grimmond & Oke, in which the coefficients were gauged upon a simple land cover classification. The data assimilation scheme is built around a sequential Monte Carlo or particle filtering technique : when good LST observations are available, model state ensemble members are compared to the EO LST data and an improved ensemble (analysis) is subsequently constructed. From the net radiation balance and the storage heat flux, the latent and sensible fluxes are generated via the Priestley-Taylor equations.

The atmospheric part of the model encodes the governing equations for horizontal advection and vertical diffusion using boundary conditions defined by the ECMWF ERA Interim data to represent the regional scale temperature variations. The sensible heat fluxes delivered by the surface module are used as lower bounday conditions in the vertical diffusion term. Furthermode, a parametrisation of the anthropogenic heat flux based upon DMSP-OLS radiance calibrated nighttime lights data and a CO2 flux method developed for Marseille is built in the model as well.

Results for the model implementation and performance for the cities of Madrid and Lisbon will be presented at a 4 km and 1 km grid resolution, using land surface temperature obtained within the UHI project from SEVIRI, AVHRR, MODIS and ASTER platforms. Results of the model show a consistent reproduction of the urban heat island effect and agree satisfactory with in-situ air temperature data. We will also show results of a modified atmospheric model where the surface part was replaced by an iterative computation taking into account the aerodynamic resistance for heat transfer to the atmosphere. This modified version enabled us to produce high resolution air temperature fields based upon individual LST images from ASTER and LandSAT.