An analysis of urban heat sink in Beijing using ASTER data

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More and more problems were emerged with the development of Beijing's urbanization. One of them is urban heat island (UHI) effect. UHI refers to the phenomenon of the higher atmospheric temperature difference between central urban area and the surrounding rural area, which makes the urban like a warm island compared with the rural area. During our monitoring of the UHI effect using Advance Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data, an urban heat sink which means that the temperature in the central urban area is lower than that of the surrounding rural area was found. Our study area is located in the central urban area of Beijing which mainly the area surrounded by the fifth ring road. This paper focuses on the analysis of this urban heat sink developed in the winter morning of Beijing by detailedly analyzing the subsurface's thermal characteristics. Thermal inertia and heat energy exchange between land and air were used in this paper to identify the subsurface's thermal characteristics. Thermal inertia is a physical parameter representing the ability of a material to conduct and store heat, and in the context of planetary science, it is a measure of the subsurface's ability to store heat during the day and reradiate it during the night. It can be expressed as the function of the surface albedo and the diurnal temperature difference. The surface albedo can be obtained through weighting the spectral reflectance which can be acquired after performing the calibration using software ENVI and atmospheric correction using 6S Model. And the weight indexes we adopted are the simulated values for ASTER data given by Liang (2000). The calculation of the diurnal land surface temperature laid on the determination of land surface temperature at day and night time. The iterative self-consistent split window algorithm which is based on the fact that the actual land surface temperatures should be the same for all 5 thermal bands of ASTER data was used in our paper to retrieve the land surface temperature to constitute two groups of the split windows. The final land surface temperature was obtained by the maximum correlation and minimum least square of those two groups of land surface temperature calculated from those two split windows respectively. The diurnal land surface temperature could be computed after getting the land surface temperature at day and night respectively. After acquiring the surface albedo and the diurnal land surface temperatures, the thermal inertia was calculated using a real thermal inertia model. The result shows that the urban area has a bigger thermal inertia than that of the rural area. Which makes the materials in rural area have a rapidly increase in surface temperature then those in the urban area in winter morning which mainly caused the formation of the urban heat sink. Besides, the heat energy exchange at the boundary of the air and land was taken into consideration of the formation of this urban heat sink. In this paper, the heat energy exchange including the net radiation, latent heat flux and sensible heat flux were calculated using the models proposed by Xue et. al., (2000) and Cai et. al., (2007). The results show that the rural area has a bigger net radiation, sensible heat flux and smaller latent heat flux than that of the urban area, and the remained heat flux in the rural area is bigger than that of the urban area which is another main reason resulted in the formation of the urban heat sink.