Spatial variability, horizontal anisotropy and diurnal evolution of measured infra-red fluxes in a city neighborhood of Toulouse

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In flat and uniform terrain, the infra-red (IR) fluxes are horizontally homogeneous and isotropic, depending only on the vertical direction. The diurnal evolution, with ground cooling at night and heating during the day is very uniform. This can be modeled with the "plane-parallel" approximation where the fluxes depend only locally on the vertical coordinate and that is the basis of a number of radiative models.

In urban area, however, local variations of the urban fabric, such as big buildings, little houses, parks …, lead to both a horizontal variation of the upward IR fluxes and to an anisotropy of their horizontal component. For example in a northern hemisphere mid-latitude city, a southward facing wall receiving the sunlight will radiate more than its north facing counter part and this will evolve throughout the day and will depend on the local building layout. At night this will tend to equilibrate with the neighboring buildings. To take these effects into account the radiative model needs to be three dimensional.

In order to document and quantify these effects experimentally and in the framework of the EUREQUA project (Environmental improvement of neighborhood, sponsored by French ANR), we have deployed an IR imager accompanying a mobile meteorological measurement system and sound recordings. These mobile systems were walked in the neighborhood of Toulouse approximately every three hours during three days. At each of the 9 stop points for each hourly walk, we took one ground picture and eight horizontal pictures one for each direction. The imager records simultaneously a visible picture, an IR picture and a text file containing the IR measurements that can be later reprocessed. The images then needs to be manually tagged to each stop point and direction. These two parts have been the most labor intensive of the data collection. For image processing, we have then developed a python script to plot histograms, group images and compute simple statistics, such as the mean for each image that we will discuss here.

For each hourly walk we have collected around 100 images (x2 with the visible ones) that amounts to 2500-3000 for one Intensive Observing Period (IOP) of 3 days, which has been repeated in January, April and June in Toulouse (the project also did 2 IOP in Paris and Marseilles but they will not be discussed here).

If we first look at spatial variability of the ground IR fluxes, we notice that the variability is very small in early morning (6h UTC; all stop points around 400 W/m2 for June) but that it is maximal at 15h UTC (3h time resolution). At this time, some stop points can be around 500 W/m2 whereas as others can be close to 700 W/m2. To characterize anisotropy, based on each set of 8 horizontal pictures, we have computed the mean, minimum and maximum. Again in early morning, when the mean horizontal fluxes are minimal, all three values are very close (+- 20 W/m2). At its maximum, the anisotropy measured can reach above 100 W/m2. These measurements will be used in the future for the validation of our 3D IR radiative scheme.