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Atmospheric effects on infrared measurements at ground level: Application to monitoring of transport infrastructures

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Being able to perform easily non-invasive diagnostics for surveillance and monitoring of critical transport infrastructures is a major preoccupation of many technical offices. Among all the existing electromagnetic methods [1], long term thermal monitoring by uncooled infrared camera [2] is a promising technique due to its dissemination potential according to its low cost on the market. Nevertheless, Knowledge of environmental parameters during measurement in outdoor applications is required to carry out accurate measurement corrections induced by atmospheric effects at ground level. Particularly considering atmospheric effects and measurements in foggy conditions close as possible to those that can be encountered around transport infrastructures, both in visible and infrared spectra.

In the present study, atmospheric effects are first addressed by using data base available in literature and modelling. Atmospheric attenuation by particles depends greatly of aerosols density, but when relative humidity increases, water vapor condenses onto the particulates suspended in the atmosphere. This condensed water increases the size of the aerosols and changes their composition and their effective refractive index. The resulting effect of the aerosols on the absorption and scattering of radiation will correspondingly be modified. In a first approach, we used aerosols size distributions derived from Shettle and Fenn [3] for urban area which could match some of experimental conditions encountered during trials on transport infrastructures opened to traffic.

In order to calculate the influence of relative humidity on refractive index, the Hänel's model [4] could be used. The change in the particulate size is first related to relative humidity through dry particle radius, particle density and water activity. Once the wet aerosol particle size is found, the effective complex refractive index is the volume weighted average of the refractive indexes of the dry aerosol substance and the water. These changes in refractive indexes lead to the evolution of extinction coefficient Kext according to relative humidity.

Using such models in very low visibility conditions leads to the following question: Up to which optical depth (i.e. tau=Kext.d) can we use a simple scattering model as Mie Theory? To show the effect of multiple scattering on previous transmission estimation, Monte-Carlo calculations have been performed. Calculations used a software dedicated to photometrical rendering of fog (PROF [5]). Up to an optical depth tau=1, simple and multiple scatterings differ of less than 2%. For tau >1 the simple scattering model is no more available to keep the error less than 10%.

Finally, study of fog effect is proposed. Results obtained by numerical simulations but also by experiments carried out in a dedicated fog tunnel are presented and discussed. Perspectives about possible implementation on on site measurement systems are evocated.

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