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SHORT CONTRIBUTION

Surface albedo measurements in Mexico City metropolitan area

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RESUMEN

Las propiedades ópticas y térmicas de suelos son datos importantes para los módulos meteorológicos y fotoquímicos de los modelos de calidad del aire. Conforme aumenta la resolución espacial del modelo se vuelve más importante contar con buenos datos de albedo. En este artículo se presentan mediciones de albedo superficial de radiación Ultravioleta (295-385 nm) y visible (450-550 nm) para diferentes superficies urbanas y rurales en la vecindad de la Cd. de México. Se encuentra un valor promedio de 0.05 para la zona centro, lo cual está de acuerdo con valores reportados para superficies urbanas. Los valores medidos de albedo en la región UV para cemento gris y pasto verde son de 0.10 y 0.009, respectivamente, y son muy similares a los reportados en la literatura, 0.11 y 0.008 para este tipo de superficies.

ABSTRACT

Optical and thermal properties of soils are important input data for the meteorological and photochemical modules of air quality models. As development of these models increase on spatial resolution good albedo data become more important. In this paper measurements of surface albedo of UV (295-385 nm) and visible (450-550 nm) radiation are reported for different urban and rural surfaces in the vicinity of Mexico City. It was found for the downtown zone an average albedo value of 0.05 which is in very good agreement with reported values for urban surfaces. Our albedo values measured in UV region for grey cement and geen grass are of 0.10 and 0.009, respectively, and quite similar to those found at the literature of 0.11 and 0.008 for those type of surfaces.

1. Introduction

The Mexico City Metropolitan Area (MCMA) extends over the nation's Federal District and parts of the State of Mexico, covering a total surface of 4 945 km^2. The urban development of Mexico City (MC) covers a surface of over 1 400 km^2, into which many previously separated villages and towns have been engulfed by its expansion. (GDF, 1997). MCMA has 2 320 km of main roads and 8 400km of secondary roads with asphalt (Villegas, 2000) that represent 10% of the total urban area.

Urbanization and land use in the MCMA have a direct impact on the social-spatial organization and certainly on environmental urban problems, as is the case of the air pollution (Schteingart, 2000).

The surface albedo (term used to describe the reflected light from a surface) is one of the important parameters in air pollution studies, used mainly in Air Quality and Radiation Models. For example, the irradiance and actinic flux values at the surface can vary between 10 - 30% depending of the surface (Madronich, 1987; Cotte *et al.*, 1997; Castro *et al.*, 1997). Surface albedo has also been measured for different surfaces (snow, ocean, forest, stone, black lava, etc.) by Coulson and Reynolds (1971), Dickerson (1980), Doda and Green (1980, 1981) and Shetter *et al.* (1992).

In this paper we present surface albedo measurements, in two spectral regions, UV and blue, at different locations within the MCMA and nearby surround.

2. Methodology

The measurements were made during May 1-3, 1996 close to the RAMA stations (Government Automatic Pollution Monitoring Network) because they are distributed over the MCMA, and because different kinds of surfaces can be found near them. During these days was clean sky and calm winds. Measurements were also made at other sites, and their location was obtained using land use maps at 1:50000.

Two different radiometers were used to measure the irradiance. An Eppley radiometer (Model 8-48) was used to measure UV irradiance between 295 and 385 nm while the blue spectral region between 450 and 550 nm (TM-A) was measured with an EXOTECH radiometer (Model 100 BX). In each location we measured the up ($E\uparrow$) and down ($E\downarrow$) irradiances and the albedo was calculated as (Seinfeld and Pandis, 1998):

$$A = \frac{E\uparrow}{E\downarrow} \tag{1}$$

3. Results

Figures 1, 2 and 3 show the land use map in the MCMA and some locations where the albedo measurements were done. Figure 1 shows the downtown zone, which has similar categories of land use (buildings and asphalt roads). Surface albedo found in this zone was from 0.02 to 0.06 with an average value of 0.05 for UV region. The north zone is shown in Figure 2, with an average of 0.06. The south part is characterized by a green grass extend area, within this zone is located the National University (CU), as we can see it in Figure 3. At this region we have an average albedo value of 0.009.

Table 1 shows albedo measurements, type of surface and location for different sites in the MCMA for two spectral regions (450-550 and 295-385 nm). These may be all considered typical urban sites. For asphalt surface, albedo measurements in the UV range were from 0.03 to 0.06 with an average value of 0.05. In the visible region this range was from 0.04 to 0.14 with an average of 0.07. Madronich and Floke (1999) base on Blumthaler and Ambach (1988) and Coulson and Reynolds (1971) report for asphalt surface a value from 0.04 to 0.11. In this work, albedo measurements for grey cement are 0.10 and 0.11 in the UV range and 0.009 for green grass, Harvey *et al.* (1977) report values of 0.11 and 0.008 respectively in the same spectral region. The differences between the values reported in this work and by other authors could be because of small differences in the materials composition.

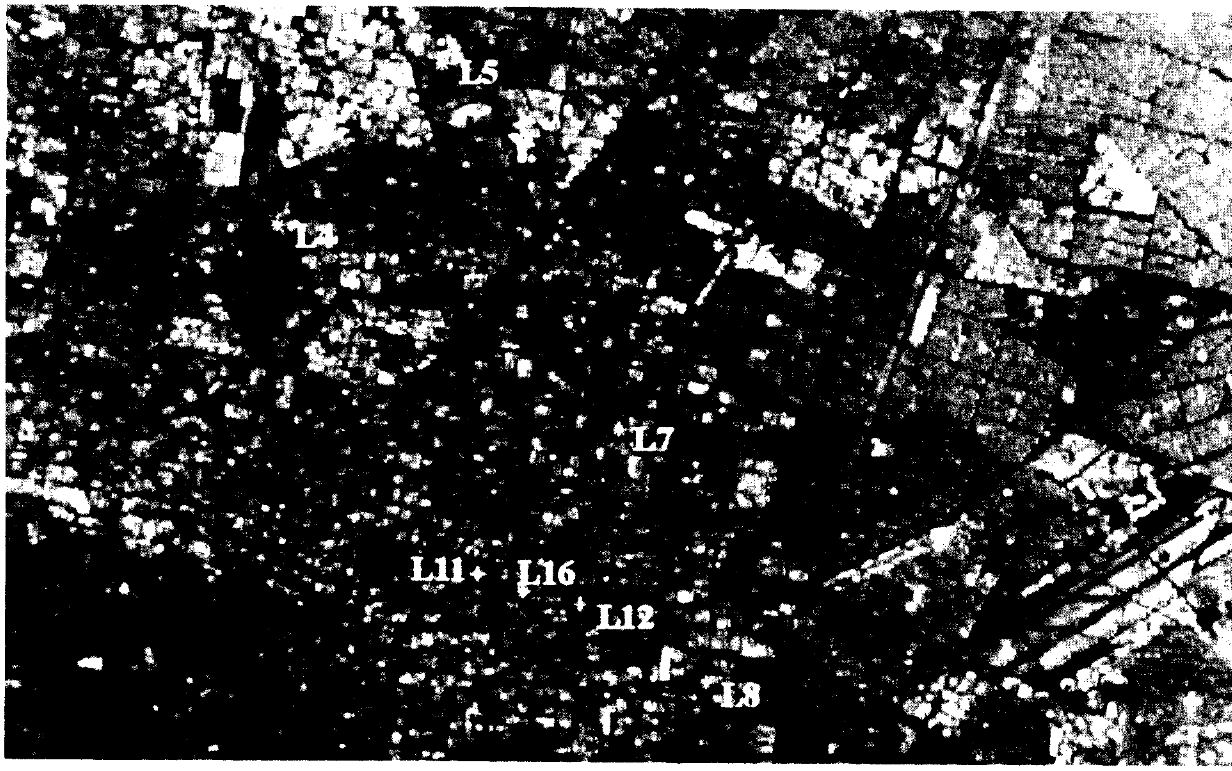

Fig. 1. Land use map of downtown zone of the MCMA and sites where albedo measurements were taken.

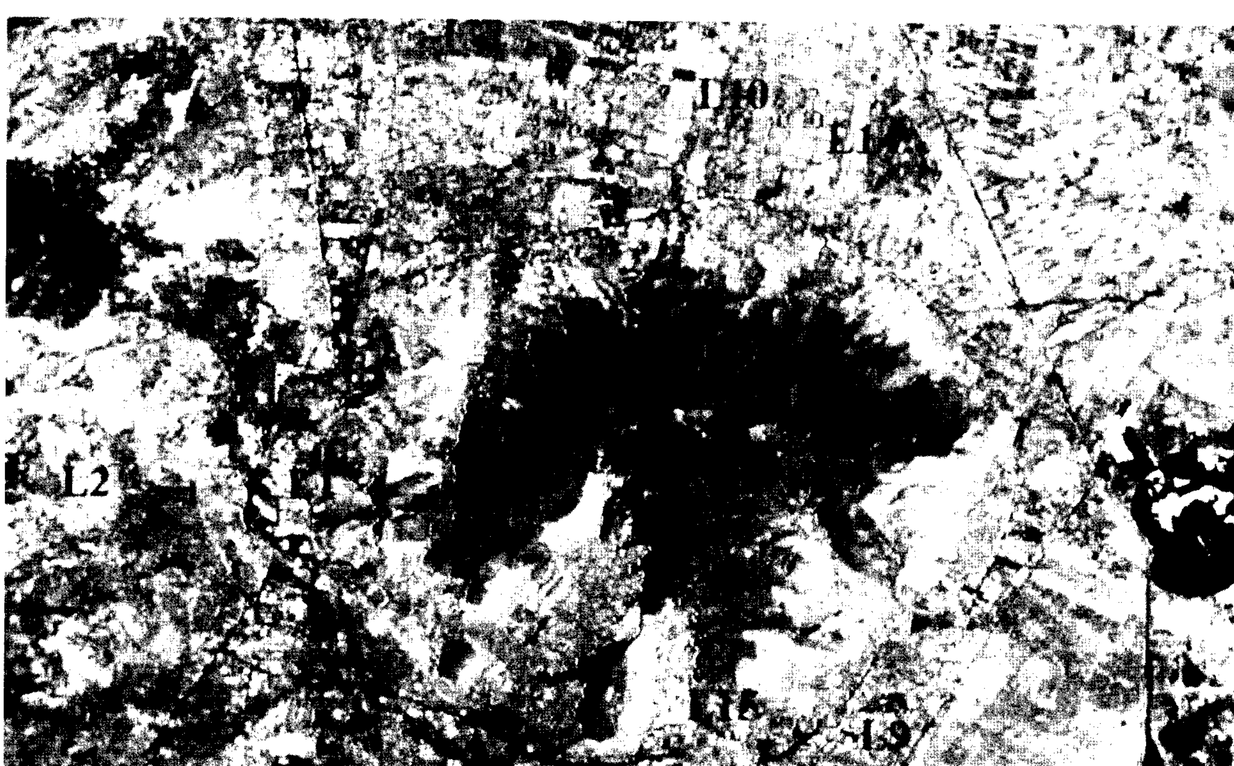

Fig. 2. Land use map of North zone of the MCMA and sites where albedo measurements were taken.

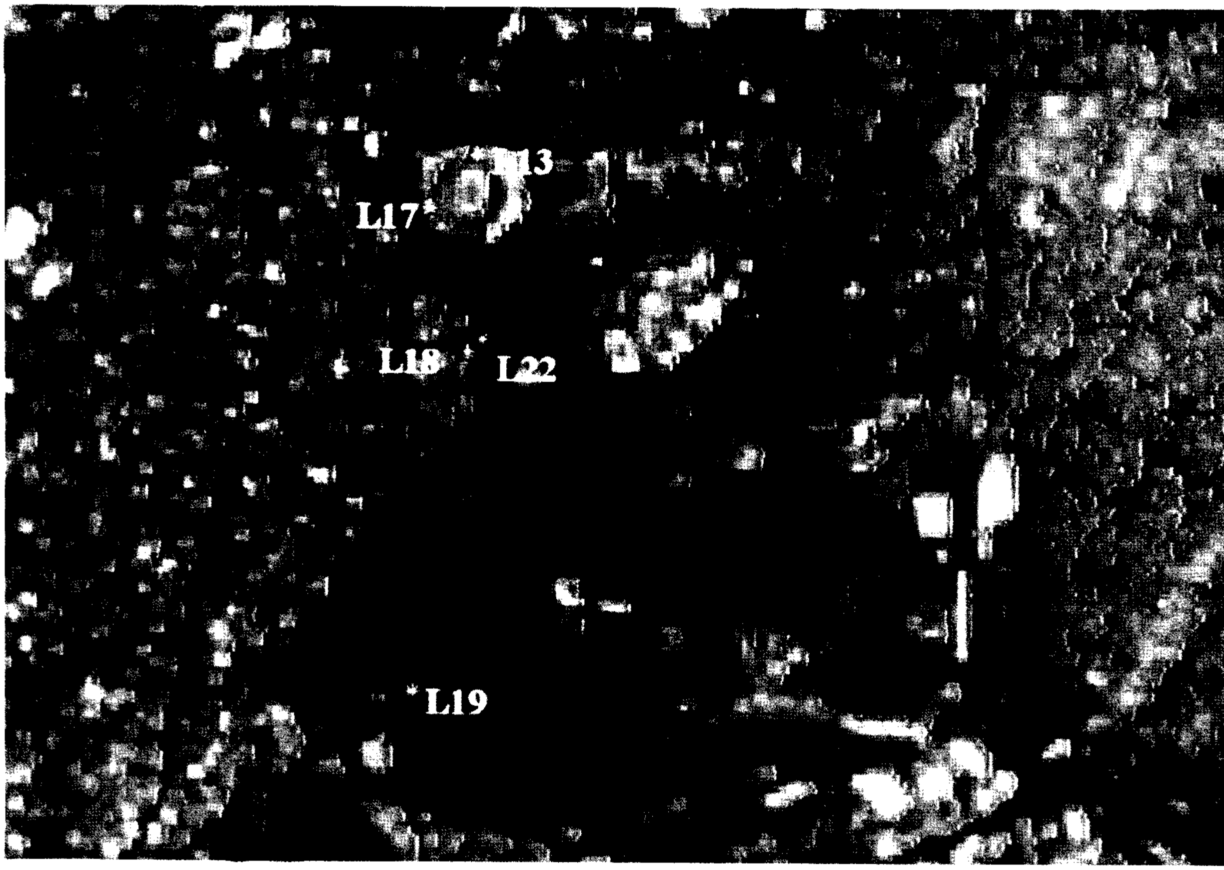

Fig. 3. Land use map of South zone of the MCMA (National University) and sites where albedo measurements were taken.

LABEL	URBAN SITES	TYPE OF SURFACE	COORDINATES UTM X	Y	ALBEDO 450-520 nm	ALBEDO 295-385 nm
L1	TLANEPANTLA	asphalt	478521	2164620	0.07	0.05
L2	ATIZAPAN	asphalt	473440	2164620	0.09	0.06
L3	VALLEJO	asphalt	482630	2158660	0.07	0.04
L4	CUITLAHUAC	asphalt	482600	2152820	0.10	0.06
L5	IMP	asphalt	484500	2154680	0.10	0.06
L6	LA VILLA	asphalt	487645	2152600	0.08	0.06
L7	LAGUNILLA	asphalt	486500	2150500	0.04	0.03
L8	MERCED	asphalt	487475	2147620	0.04	0.02
L9	XALOSTOC	asphalt	492000	2159090	0.12	0.06
L10	VILLA DE LAS FLORES	asphalt	489517	2172932	0.14	0.07
L11	ALAMEDA	asphalt	484900	2148850	0.04	0.03
L12	ZOCALO	asphalt	486050	2148500	0.08	0.06
L13	ESTADIO CU	asphalt	479650	2137350	0.08	0.04
L14	VILLA DE L AS FLORES	grey surface (cement)	489517	2172932	0.25	0.10
L15	LA PRESA	grey surface (cement)	487700	2159750	0.23	0.11
L16	PALACIO DE MINERIA	blackish-grey cobblestone	485400	2148650	0.09	-
L17	ESTADIO CU	red surface	479825	2137551	0.10	0.04
L18	VIVERO CU	sandy surface	479850	2136850	0.08	0.02
	VIVERO CU	green grass	479850	2136850	0.04	0.01
L19	SALA DE SEMINARIOS, C.U.	green grass	479600	2195500	0.02	0.008
L20	XOCHIMILCO	green grass	489750	2133950	0.26	0.01
L21	LA PRESA	dry grass	487700	2159750	0.07	-
L22	CU	dry grass	479800	2136800	0.11	0.03

Table 1. Measured UV and TM-A albedos for several surfaces in the urban MCMA sites equation.

Table 2 shows similar measurements for rural sites in two different periods. Measurements in sites 20-30 were taken from May 1-3 of 1996, those in sites 31-32 were made from March to May of 1998. The latter show the differences between bare and crop-covered agricultural soil.

LABEL	RURAL SITES	TYPE OF SURFACE	COORDINATES UTM X	Y	ALBEDO 450-520 nm	ALBEDO 295-385 nm
L23	LA CIMA, MOR.	green grass	474900	2107750	0.09	0.02
L24	TRES MARIAS, MOR.	sandy surface	475450	2109650	0.06	0.02
L25	VIAS TREN - FED	sandy surface	475100	2109000	0.06	0.03
	VIAS TREN (TRES MARIAS)	sandy surface	474850	2108800	0.08	0.02
L26	CARR. MEX.-PACHUCA KM 53	sandy-clayey surface	519250	2112550	0.09	0.034
L27	PACHUCA ITESM	clayey surface (white)	525800	2108800	0.42	0.120
L28	TRES MARIAS	grass and cement	474550	2106250	0.06	0.02
L29	MILPA ALTA	dry grass	495625	2123750	0.08	-
L30	CARR. MEX.-PACHUCA KM 53	straw (field covered)	519250	2112550	0.158	0.043
	CARR. MEX.-PACHUCA	green grass	519250	2112550	0.08	0.05
			GEOGRAPHIC LAT. (N)	COORDINATES LONG. (W)		
L31	TEÑHE, MIXQUIAHUALA, HGO.	wheat field	20° 11' 50.2	99° 10' 31.7	0.072	0.01
	TEÑHE, MIXQUIAHUALA, HGO.	dry tilled land	20° 14' 46.1	99° 09' 55.4	0.137	0.039
	TEÑHE, MIXQUIAHUALA, HGO.	alfalfa field	20° 14' 46.1	99° 09' 55.4	0.138	0.018
L32	PROGRESO, HGO.	corn field (height=35 cm)	20° 14' 45.2	99° 09' 28.3	0.078	-

Table 2. Measured UV and TM-A albedos for several surfaces in the rural sites.

4. Conclusions

For an overall urban surface has been used average values of UV albedo between 0.05 and 0.15, which are under the range that we found, Lorente and Redano de Cabo (1994) in Barcelona; Cotte *et al.* (1997) in Brittany and Portugal; Madronich (1987) near Boulder.

As air quality models increase spatial resolution, a more specific surface albedo may be required. In this communication we provide visible and UV albedos for different types of surfaces likely to being found within the domain of a regional air quality model.

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