

WEEKLY VARIATION IN THE LOW CLOUD COVER AND FREQUENCY OF CLOUD-TYPES SERIES IN SPANISH CITIES

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ABSTRACT: Cloudiness records from 5 Spanish cities and their airports covering the period 1972-2004 are compared to detect a possible urban-induced weekly cycle. Analysed variables are low-level cloud cover amount (in oktas) and relative frequency of cloud types. Results are not conclusive, but a slight increase in both low-level cloudiness and frequency of low-level stratiform clouds has been found in the urban centers during weekdays. This cycle is more evident at the two biggest cities (Madrid and Valencia).

OBJECTIVES, DATA AND METHODOLOGY

□ The main **goal** of this study is to detect urban influences on cloudiness, and, specifically, to check for a urban-induced weekly cycle.

□ **Data** are cloudiness series from 5 Spanish cities (Figure 1) and their airports: Alicante (1), Madrid (2) and Valencia (3) -Mediterranean climate-; A Coruña (4) and San Sebastian (5) -Atlantic climate-, from 1972-2004 with 3-daily observations (7, 13 and 18 UTC).

□ Analysed **variables** are low-level cloud cover (LCC, in oktas) and relative frequency of cloud types: the 10 genera are grouped into 4 families -high clouds (Ci, Cs and Cc), middle clouds (Ac and As), low stratiform clouds (St, Sc and Ns) and vertical clouds (Cu and Cb).

□ The **statistical significancy** of the checked weekly cycles is verified by the χ^2 test. The null hypothesis (H0) is that there are no significant differences between days of the week as far as cloudiness is concerned; while the alternative hypothesis (H1) accepts the existence of significant differences, to a significant level $\alpha = 0.05$ (95%).



Figure 1. Location map of the cities analysed.

RESULTS AND DISCUSSION

Weekly variation of the low cloud cover

□ Similar weekly evolution is detected in all cities (Table 1.A): maximum amounts of LCC between Monday and Thursday, and minimum values concentrated on weekends. The χ^2 test confirms a significant weekly cycle in Madrid-city (Figure 2.A) and airport, Valencia-city, Alicante-city and A Coruña-city.

Weekly variation of the cloud type frequency

□ The low stratiform clouds (Table 1.B) in Madrid-city and Valencia-city (Figure 2.B) have a more marked weekly cycle, with a maximum frequency on Wednesday and minimum on Sunday. In the other cities, an evident pattern between weekdays and weekend is not present. With the χ^2 test, only Valencia-city results are significant.

□ When analyzing high clouds, a weekly cycle is also detected at some cities (Table 1.C), with a marked increase on weekends. This pattern is also evident in their airports. The χ^2 test confirms significance in Madrid (city and airport), Valencia (city and airport) and Alicante-City (Figure 2.C).

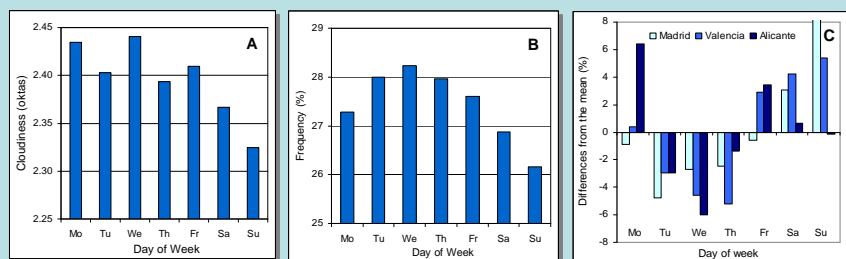


Figure 2. A - LCC amount (oktas) in Madrid-city. B - Stratiform clouds frequency (%) in Valencia-city. C - Differences (%) relative to the mean value of the high cloud frequencies in Madrid, Valencia and Alicante (cities).

A	Madrid		Valencia		Alicante		A Coruña		San Sebastian	
	City	Airport	City	Airport	City	Airport	City	Airport	City	Airport
Monday	2.43	2.27	1.81	1.76	1.15	1.29	3.70	3.44	4.05	4.05
Tuesday	2.40	2.23	1.78	1.71	1.22	1.30	3.64	3.54	4.07	4.01
Wednesday	2.44	2.25	1.79	1.74	1.24	1.33	3.73	3.48	4.08	4.04
Thursday	2.39	2.20	1.79	1.71	1.15	1.29	3.70	3.55	4.08	4.04
Friday	2.41	2.24	1.72	1.68	1.14	1.21	3.73	3.48	4.01	4.02
Saturday	2.37	2.18	1.73	1.68	1.17	1.31	3.71	3.40	3.96	4.00
Sunday	2.32	2.21	1.76	1.69	1.20	1.28	3.62	3.43	3.98	3.88
Mean	2.40	2.23	1.77	1.71	1.18	1.29	3.69	3.47	4.03	4.01

B	Madrid		Valencia		Alicante		A Coruña		San Sebastian	
	City	Airport	City	Airport	City	Airport	City	Airport	City	Airport
Monday	20.5	28.5	27.5	27.2	22.3	20.0	32.8	41.9	37.9	39.5
Tuesday	21.3	28.6	28.0	27.5	23.3	20.9	32.7	43.4	37.8	38.9
Wednesday	21.6	28.6	28.2	28.2	23.3	21.0	32.9	41.3	38.9	40.1
Thursday	21.0	27.6	28.0	28.0	23.0	20.5	32.7	42.9	37.9	40.2
Friday	20.8	27.7	27.6	27.7	22.7	20.2	33.1	43.6	37.5	38.8
Saturday	20.8	28.0	26.9	26.9	22.9	20.0	33.0	42.6	37.6	40.3
Sunday	19.7	27.8	28.2	27.8	22.9	20.5	32.8	42.2	37.7	38.4
Mean	20.8	28.1	27.4	27.6	22.9	20.5	32.9	42.4	37.9	39.4

C	Madrid		Valencia		Alicante		A Coruña		San Sebastian	
	City	Airport	City	Airport	City	Airport	City	Airport	City	Airport
Monday	25.2	20.2	24.5	22.9	31.8	30.5	14.5	10.1	12.3	11.9
Tuesday	24.2	20.5	23.7	23.2	29.0	29.2	14.6	10.1	12.4	12.2
Wednesday	24.7	20.7	23.3	21.7	28.1	29.1	13.9	9.3	12.4	11.2
Thursday	24.8	21.9	23.1	22.5	29.4	29.4	14.7	10.2	12.1	12.2
Friday	25.3	21.6	25.1	23.6	30.9	29.9	14.2	10.1	12.8	11.6
Saturday	26.2	22.1	25.4	23.6	30.0	30.0	14.8	10.4	13.1	11.9
Sunday	27.5	21.5	25.7	23.6	29.8	29.3	15.3	10.9	12.2	11.7
Mean	25.4	21.2	24.4	23.0	29.9	29.6	14.6	10.2	12.5	11.8

Table 1. A- Weekly mean LCC (oktas). B- Weekly low stratiform frequency (%). C- Weekly high clouds frequency (%). Maximum values at each station are shown in dark grey and minimum values in light grey.

CONCLUSIONS

□ Obtained results cannot be considered conclusive, but there is a slight increase of the low cloudiness in the cities (and airports) during the weekdays (more evident in the two biggest cities, Madrid and Valencia).

□ The distribution in cloud families has revealed a slight increase of low stratiform clouds during the weekdays. Although the urban impact should be limited to the low levels of the troposphere, the most evident weekly cycle has been found for high clouds (with a clear increase on weekends). There are different explanations to this fact: less frequency of low clouds, better visibility (related to air quality), and/or possible impact of air traffic (contrails).