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Air quality forecasts on a kilometer-scale grid over complex Spanish terrains

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Supplementary Material S1: Meteorological evaluation

Comparison with METAR reveals that WRF (both 4 km and 1 km) depicts a high agreement with observed temperature and wind, with r between 0.67-0.94 (Table S1). However, WRF shows a tendency to underestimate mean T2M (~ 0.4ºC mean), especially maximum and minimum (1.5ºC and 1.7ºC, p25 and p75, respectively); and overestimate U10 during the night and early morning (~1 ms^{-1}). Overall, the resolution increase slightly improves T2M (bias by 0.1ºC), U10 (bias by 0.1 ms^{-1} and r by 0.1) and WD10 (error in 52º and r by 0.1). However, it slightly decreases WD10 bias (by 2º).

Analysis of daily cycles by domain presents different meteorological performance at different study domains (Fig. S1, Table S1). In the AND domain, WRFv3.5 (at both resolutions) shows problems to reproduce night wind speed with overestimation ~1 ms^{-1}, and T2M is systematically underestimated by ~1ºC along the daily cycle. The resolution increase has a positive effect in T2M and U10. T2M and U10 errors and bias decrease (by 0.1ºC and 0.2 ms^{-1}). T2M bias improvements are located in the daytime, but no specific time for U10. Wind direction indicates dominant influence of southerly winds affecting AND, which transport desert dust from the North Africa as a result of the influence of the high pressure system.

Over the BCN domain, the WRF overestimation at night wind speed is present as well (~1 ms^{-1}) at both resolutions. The T2M is slightly underestimated, but the main deviations are found at daytime with a bias of ~3ºC at both resolutions. The resolution increase has a negative effect on T2M and U10. Although T2M bias decreases by 0.1º, especially at night, T2M errors increase (0.2ºC) and r decreases (from 0.90 to 0.85). For U10, errors and bias also increase (0.1 ms^{-1} and 0.2 ms^{-1}, respectively), especially at night. The speed direction reveals control of the mesoscale phenomena, sea breeze at daytime (~170 deg) and land breeze during the night (~300 deg). They show that the simulated wind directions are more northerly than those measured in the land breeze period; meanwhile during the sea breeze period the mean simulated wind was more easterly than the measurements registered.

In the MAD domain, the meteorological fields underestimate observed T2M almost systematically over de daily cycle by ~2ºC, and also underestimate U10 ~2 ms^{-1} at night at both resolutions. Simulated wind directions are more southerly than those measured at night time. Resolution increase has the lowest effect compared to other domains.

Error and bias for T2M and U10 do not change, only T2M bias is reduced by 7% when resolution increases.

Table S1. Statistics for T2M, U10 and WD for April 2013 at METAR stations as a function of horizontal resolution (4 km and 1 km). n indicates the number of pairs of data used in the discrete evaluation on an hourly basis.

	class	n (stations)	MB (μgm^{-3})		MGE (μgm^{-3})		RMSE (μgm^{-3})		r	
			4km	1km	4km	1km	4km	1km	4km	1km
T2M (ºC)	All	6072 (10)	-1.25	-1.18	1.7	1.7	2	2	0.94	0.94
	AND	3689 (6)	-1.21	-1.14	1.7	1.6	2	2	0.94	0.94
	BCN	1216 (2)	-1.09	-1.04	1.5	1.6	1.8	2	0.90	0.85
	MAD	1167 (2)	-1.55	-1.44	1.8	1.8	2.2	2.2	0.96	0.95
U10 (m/s)	All	5769 (10)	0.64	0.58	1.5	1.5	2.1	2.1	0.67	0.68
	AND	3420 (6)	0.67	0.53	1.5	1.4	2	2	0.70	0.71
	BCN	1195 (2)	0.63	0.8	1.8	1.8	2.4	2.5	0.63	0.64
	MAD	1154 (2)	0.58	0.54	1.5	1.5	1.9	1.9	0.65	0.66
WD10 (deg)	All	5029 (10)	6.1	8.4	53	51	89	89	0.58	0.59
	AND	2876 (6)	14.5	17.7	48	47	80	79	0.61	0.62
	BCN	1094 (2)	3.2	2.3	61	58	98	97	0.53	0.56
	MAD	1059 (2)	-13.7	-10.7	57	57	101	102	0.53	0.52

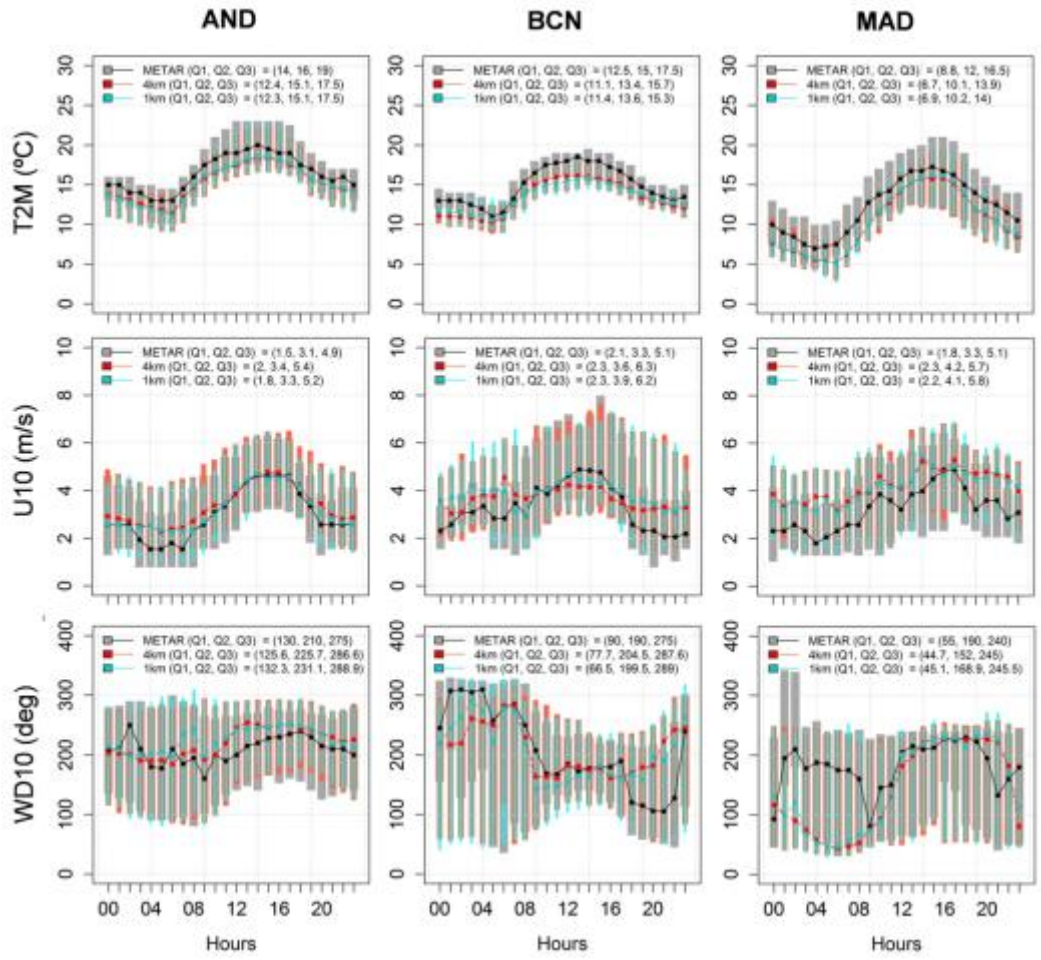

Figure S1. Daily cycles for T2M, U10 and WD10 for each study domain at METAR stations as a function of resolution. Q1, Q2 and Q3 indicate quartiles for the daily cycle. Bars show Q1 and Q3 at each hour.