

Prediction of Daily Ambient Temperature and Its Hourly Estimation Using Artificial Neural Networks in Urban Allotment Gardens and an Urban Park in Valladolid, Castilla y León, Spain

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Supplementary Materials.

Table S1. Prediction models for average hourly temperatures (°C) in urban gardens and forested urban park in Valladolid (Spain), according to the different ANNs architectures (X-Y-Z)=(6-Y-1), changing the number of neurons in the hidden layers Y=(2, 3,...,8). Where the inputs are X=[Ta(t) Puente Poniente, Ta(t) Plaza San Miguel, Ta(t) Catedral, Ta(t) Don Sancho, Ta(t) Dos de Mayo, Hour of day (t=0, 1,..., 23)], and the output is Z=[Ta(t) Jardín Botánico], Z=[Ta(t) Valle de Arán], Z=[Ta(t) Los Santos-Pilarica], Z=[Ta(t) Parque Alameda], and Z=[Ta(t) Campo Grande] in each case. Adjustment of statistical values..

Outputs for Jardin Botánico							
Statistics	ANN 6-2-1	ANN 6-3-1	ANN 6-4-1	ANN 6-5-1	ANN 6-6-1	ANN 6-7-1	ANN 6-8-1
RMSE (°C)	0.72	0.61	0.60	0.65	0.64	<u>0.60</u>	0.61
R ²	0.988	0.991	<u>0.992</u>	0.990	0.991	<u>0.992</u>	<u>0.992</u>
DW	1.098	1.236	1.298	1.148	1.121	<u>1.309</u>	1.176
MPE	-0.005	-0.005	<u>-0.004</u>	-0.005	-0.009	-0.005	-0.005
FA	0.980	<u>0.984</u>	<u>0.984</u>	<u>0.984</u>	0.982	0.983	<u>0.984</u>
Outputs for Valle de Arán							
Statistics	ANN 6-2-1	ANN 6-3-1	ANN 6-4-1	ANN 6-5-1	ANN 6-6-1	ANN 6-7-1	ANN 6-8-1
RMSE (°C)	0.53	0.46	0.46	0.50	0.44	<u>0.42</u>	0.46
R ²	0.993	0.995	0.995	0.994	0.995	<u>0.996</u>	0.995
DW	0.846	<u>1.024</u>	0.923	0.799	0.876	0.864	0.960

MPE	-0.001	-0.004	-0.002	-0.002	0.001	-0.001	<u>0.000</u>
FA	0.983	0.986	0.986	0.985	0.986	<u>0.987</u>	0.986
Outputs for Los Santos-Pilarica							
Statistics	ANN 6-2-1	ANN 6-3-1	ANN 6-4-1	ANN 6-5-1	ANN 6-6-1	ANN 6-7-1	ANN 6-8-1
RMSE (°C)	0.77	0.73	0.72	<u>0.60</u>	0.61	0.62	0.60
R ²	0.986	0.988	0.988	<u>0.992</u>	0.991	0.991	<u>0.992</u>
DW	0.773	0.768	<u>0.877</u>	0.591	0.859	0.837	0.653
MPE	0.005	0.002	0.002	0.001	0.002	0.001	<u>0.000</u>
FA	0.975	0.977	0.978	<u>0.981</u>	0.980	<u>0.981</u>	<u>0.981</u>
Outputs for Parque Alameda							
Statistics	ANN 6-2-1	ANN 6-3-1	ANN 6-4-1	ANN 6-5-1	ANN 6-6-1	ANN 6-7-1	ANN 6-8-1
RMSE (°C)	0.69	0.61	0.63	0.64	0.63	0.63	<u>0.61</u>
R ²	0.989	<u>0.991</u>	<u>0.991</u>	0.990	<u>0.991</u>	0.990	<u>0.991</u>
DW	1.008	1.034	1.159	<u>1.277</u>	1.021	1.139	1.120
MPE	0.002	-0.003	0.002	<u>-0.001</u>	-0.002	-0.004	-0.002
FA	0.981	<u>0.984</u>	0.983	<u>0.984</u>	0.982	<u>0.984</u>	<u>0.984</u>
Outputs for Campo Grande							
Statistics	ANN 6-2-1	ANN 6-3-1	ANN 6-4-1	ANN 6-5-1	ANN 6-6-1	ANN 6-7-1	ANN 6-8-1
RMSE (°C)	1.20	1.20	1.15	1.10	1.14	1.07	<u>0.96</u>
R ²	0.956	0.956	0.960	0.963	0.960	0.965	<u>0.972</u>
DW	0.369	0.317	0.242	0.306	0.268	0.319	<u>0.615</u>
MPE	0.021	0.016	0.016	0.014	0.015	0.013	<u>0.010</u>
FA	0.961	0.965	0.968	0.969	0.969	0.967	<u>0.972</u>

Architecture of the model based on the number of neurons in each layer (Input-Hidden-Output). The best architectures (results) obtained for each ANN model with their respective statistical variables of interest are shown / Underlining identifies the best result found.

Table S2. Prediction models for average hourly temperatures (°C) in urban gardens and forested urban park in Valladolid (Spain), according to the different ANNs architectures (X-Y-Z)=(7-Y-1), changing the number of neurons in the hidden layers Y=(2, 3,...,8). Where the inputs are X=[Ta(t) Puente Poniente, Ta(t) Plaza San Miguel, Ta(t) Catedral, Ta(t) Don Sancho, Ta(t) Dos de Mayo, Day of year (J=1, 2,..., 365), Hour of day (t=0, 1,..., 23)], and the output is Z=[Ta(t) Jardín Botánico], Z=[Ta(t) Valle de

Arán], Z=[Ta(t) Los Santos-Pilarica], Z=[Ta(t) Parque Alameda], and Z=[Ta(t) Campo Grande] in each case. Adjustment of statistical values.

Outputs for Jardín Botánico							
Statistics	ANN 7-2-1	ANN 7-3-1	ANN 7-4-1	ANN 7-5-1	ANN 7-6-1	ANN 7-7-1	ANN 7-8-1
RMSE (°C)	0.76	0.77	0.69	0.80	<u>0.68</u>	1.09	1.26
R ²	0.987	0.986	0.989	0.985	<u>0.990</u>	0.973	0.963
DW	0.990	0.990	1.102	1.224	<u>1.347</u>	1.201	0.603
MPE	0.002	-0.010	-0.014	-0.008	-0.004	<u>-0.001</u>	-0.030
FA	0.977	0.976	<u>0.979</u>	0.974	<u>0.979</u>	0.967	0.958
Outputs for Valle de Arán							
Statistics	ANN 7-2-1	ANN 7-3-1	ANN 7-4-1	ANN 7-5-1	ANN 7-6-1	ANN 7-7-1	ANN 7-8-1
RMSE (°C)	<u>0.69</u>	0.78	0.73	0.97	0.81	0.95	0.91
R ²	<u>0.989</u>	0.985	0.987	0.978	0.984	0.979	0.980
DW	0.545	0.418	0.284	0.400	<u>0.608</u>	0.245	0.255
MPE	-0.019	-0.022	-0.022	-0.019	<u>-0.006</u>	-0.028	-0.018
FA	<u>0.977</u>	0.975	<u>0.977</u>	0.965	0.975	0.970	0.971
Outputs for Los Santos Pilarica							
Statistics	ANN 7-2-1	ANN 7-3-1	ANN 7-4-1	ANN 7-5-1	ANN 7-6-1	ANN 7-7-1	ANN 7-8-1
RMSE (°C)	<u>0.80</u>	0.93	0.85	1.05	1.02	1.03	1.21
R ²	<u>0.985</u>	0.980	0.983	0.975	0.976	0.975	0.966
DW	0.755	0.560	0.369	0.464	0.603	0.488	<u>0.875</u>
MPE	<u>0.000</u>	-0.003	-0.002	-0.015	0.022	-0.027	<u>0.000</u>
FA	<u>0.975</u>	0.969	0.972	0.966	0.968	0.963	0.957
Outputs for Parque Alameda							
Statistics	ANN 7-2-1	ANN 7-3-1	ANN 7-4-1	ANN 7-5-1	ANN 7-6-1	ANN 7-7-1	ANN 7-8-1
RMSE (°C)	<u>0.81</u>	1.13	0.83	1.05	0.85	0.97	0.89
R ²	<u>0.984</u>	0.970	0.983	0.974	0.983	0.978	0.981
DW	<u>0.685</u>	0.594	0.646	0.418	0.636	0.643	0.622

MPE	-0.018	-0.020	<u>0.002</u>	0.016	<u>-0.002</u>	0.014	-0.014
FA	<u>0.975</u>	0.966	<u>0.975</u>	0.965	0.974	0.968	0.972

Outputs for Campo Grande

Statistics	ANN 7-2-1	ANN 7-3-1	ANN 7-4-1	ANN 7-5-1	ANN 7-6-1	ANN 7-7-1	ANN 7-8-1
RMSE (°C)	<u>1.44</u>	1.72	1.64	1.80	1.68	1.92	2.05
R ²	<u>0.937</u>	0.910	0.918	0.901	0.914	0.888	0.872
DW	0.415	0.210	0.334	0.243	<u>0.977</u>	0.412	0.350
MPE	-0.029	-0.033	0.015	-0.039	<u>-0.006</u>	-0.034	0.047
FA	<u>0.954</u>	0.937	0.944	0.937	<u>0.954</u>	0.934	0.937

Architecture of the model based on the number of neurons in each layer (Input-Hidden-Output). The best architectures (results) obtained for each ANN model with their respective statistical variables of interest are shown / Underlining identifies the best result found.

Table S3. Prediction models for average hourly temperatures (°C) in urban gardens and forested urban park in Valladolid (Spain), according to the different ANNs architectures (X-Y-Z)=(6-Y-5), changing the number of neurons in the hidden layers Y=(6, 7,...,14). Where the inputs are X=[Ta(t) Puente Poniente, Ta(t) Plaza San Miguel, Ta(t) Catedral, Ta(t) Don Sancho, Ta(t) Dos de Mayo, Hour of day (t=0, 1,..., 23)], and the outputs are Z=[Ta(t) Jardín Botánico, Ta(t) Valle de Arán, Ta(t) Los Santos-Pilarica, Ta(t) Parque Alameda, Ta(t) Campo Grande]. Adjustment of statistical values..

Outputs for Jardín Botánico

Statistics	ANN 6-6-5	ANN 6-7-5	ANN 6-8-5	ANN 6-9-5	ANN 6-10-5	ANN 6-11-5	ANN 6-12-5	ANN 6-13-5	ANN 6-14-5
RMSE (°C)	0.65	0.64	<u>0.61</u>	0.67	0.62	0.63	0.62	0.62	0.64
R ²	0.990	0.990	<u>0.991</u>	0.990	<u>0.991</u>	<u>0.991</u>	<u>0.991</u>	<u>0.991</u>	<u>0.991</u>
DW	1.067	0.987	1.065	1.040	1.048	<u>1.131</u>	1.089	1.048	1.061
MPE	-0.008	-0.009	-0.008	-0.009	<u>-0.007</u>	-0.008	-0.010	-0.009	-0.008
FA	0.983	0.983	0.984	0.982	<u>0.985</u>	0.983	0.983	0.984	0.982

Outputs for Valle de Arán

Statistics	ANN 6-6-5	ANN 6-7-5	ANN 6-8-5	ANN 6-9-5	ANN 6-10-5	ANN 6-11-5	ANN 6-12-5	ANN 6-13-5	ANN 6-14-5
RMSE (°C)	0.48	0.48	<u>0.45</u>	0.54	0.46	0.46	0.48	0.49	0.46
R ²	0.994	<u>0.995</u>	<u>0.995</u>	0.993	<u>0.995</u>	<u>0.995</u>	<u>0.995</u>	0.994	<u>0.995</u>
DW	0.846	0.703	0.714	0.766	0.815	0.849	<u>0.857</u>	0.806	0.816
MPE	<u>-0.003</u>	-0.005	-0.004	<u>-0.003</u>	<u>-0.003</u>	-0.005	-0.006	-0.006	-0.004

FA	0.985	0.986	<u>0.987</u>	0.984	0.986	0.986	0.985	0.985	0.986
Outputs for Los Santos Pilarica									
Statistics	ANN 6-6-5	ANN 6-7-5	ANN 6-8-5	ANN 6-9-5	ANN 6-10-5	ANN 6-11-5	ANN 6-12-5	ANN 6-13-5	ANN 6-14-5
RMSE (°C)	0.67	0.66	0.65	0.68	0.67	<u>0.64</u>	0.64	0.66	0.64
R ²	0.990	0.990	0.990	0.989	0.989	<u>0.991</u>	0.990	0.990	<u>0.991</u>
DW	0.681	0.812	0.681	0.760	0.809	0.844	0.859	<u>0.953</u>	0.770
MPE	0.002	-0.001	-0.001	0.003	0.003	<u>0.000</u>	<u>0.000</u>	-0.002	0.004
FA	0.979	0.980	0.980	0.979	0.979	<u>0.981</u>	0.980	0.980	0.980
Outputs for Parque Alameda									
Statistics	ANN 6-6-5	ANN 6-7-5	ANN 6-8-5	ANN 6-9-5	ANN 6-10-5	ANN 6-11-5	ANN 6-12-5	ANN 6-13-5	ANN 6-14-5
RMSE (°C)	0.63	0.63	0.60	0.66	0.68	0.63	0.62	0.62	<u>0.59</u>
R ²	0.991	0.991	0.991	0.990	0.989	0.991	0.991	0.991	<u>0.992</u>
DW	0.937	0.940	0.969	0.943	<u>1.127</u>	0.975	1.116	0.962	1.090
MPE	<u>-0.001</u>	-0.005	-0.003	<u>0.001</u>	<u>0.001</u>	-0.004	-0.002	-0.006	-0.002
FA	0.983	0.983	0.984	0.983	0.982	0.984	0.983	0.984	<u>0.985</u>
Outputs for Campo Grande									
Statistics	ANN 6-6-5	ANN 6-7-5	ANN 6-8-5	ANN 6-9-5	ANN 6-10-5	ANN 6-11-5	ANN 6-12-5	ANN 6-13-5	ANN 6-14-5
RMSE (°C)	1.17	1.13	1.16	1.26	1.11	1.02	1.10	1.04	<u>1.00</u>
R ²	0.958	0.961	0.959	0.951	0.962	0.968	0.963	0.967	<u>0.969</u>
DW	0.291	0.279	0.316	0.289	0.313	0.507	0.256	0.402	<u>0.530</u>
MPE	0.020	0.018	0.018	0.020	0.015	0.012	0.017	0.016	<u>0.011</u>
FA	0.968	0.968	0.966	0.964	0.968	<u>0.972</u>	0.970	0.970	0.971

Architecture of the model based on the number of neurons in each layer (Input-Hidden-Output). The best architectures (results) obtained for each ANN model with their respective statistical variables of interest are shown / Underlining identifies the best result found.

Table S4. Prediction models for average hourly temperatures (°C) in urban gardens and forested urban park in Valladolid (Spain), according to the different ANNs architectures (X-Y-Z)=(7-Y-5), changing the number of neurons in the hidden layers Y=(6, 7,...,14). Where the inputs are X=[Ta(t) Puente Poniente, Ta(t) Plaza San Miguel, Ta(t) Catedral, Ta(t) Don Sancho, Ta(t) Dos de Mayo, Day of year (J=1, 2,..., 365), Hour of day (t=0, 1,..., 23)], and the outputs are Z=[Ta(t) Jardín Botánico, Ta(t) Valle

de Arán, Ta(t) Los Santos-Pilarica, Ta(t) Parque Alameda, Ta(t) Campo Grande]. Adjustment of statistical values.

Outputs for Jardín Botánico									
Statistics	ANN 7-6-5	ANN 7-7-5	ANN 7-8-5	ANN 7-9-5	ANN 7-10-5	ANN 7-11-5	ANN 7-12-5	ANN 7-13-5	ANN 7-14-5
RMSE (°C)	0.75	0.87	0.92	0.87	<u>0.71</u>	1.13	0.81	1.02	1.07
R ²	0.987	0.983	0.981	0.983	<u>0.988</u>	0.971	0.985	0.976	0.974
DW	0.865	0.750	1.040	0.764	0.964	0.578	<u>1.165</u>	0.664	0.539
MPE	-0.012	0.002	0.007	-0.013	<u>-0.005</u>	0.022	-0.011	-0.024	-0.023
FA	0.978	0.976	0.970	0.975	<u>0.979</u>	0.963	0.975	0.968	0.962
Outputs for Valle de Arán									
Statistics	ANN 7-6-5	ANN 7-7-5	ANN 7-8-5	ANN 7-9-5	ANN 7-10-5	ANN 7-11-5	ANN 7-12-5	ANN 7-13-5	ANN 7-14-5
RMSE (°C)	0.89	0.71	0.79	0.73	<u>0.62</u>	1.55	0.79	0.94	0.68
R ²	0.981	0.988	0.985	0.987	<u>0.991</u>	0.942	0.985	0.979	0.989
DW	0.304	0.578	<u>0.869</u>	0.617	0.694	0.202	0.751	0.516	0.655
MPE	-0.027	0.007	-0.008	-0.012	<u>-0.006</u>	0.048	-0.010	-0.016	-0.011
FA	0.971	0.981	0.978	0.977	<u>0.982</u>	0.946	0.975	0.968	0.980
Outputs for Los Santos Pilarica									
Statistics	ANN 7-6-5	ANN 7-7-5	ANN 7-8-5	ANN 7-9-5	ANN 7-10-5	ANN 7-11-5	ANN 7-12-5	ANN 7-13-5	ANN 7-14-5
RMSE (°C)	1.12	1.03	1.04	<u>0.94</u>	1.02	2.01	1.23	1.30	1.26
R ²	0.971	0.975	0.975	<u>0.979</u>	0.976	0.906	0.965	0.961	0.963
DW	0.371	0.371	0.589	<u>0.635</u>	0.589	0.159	0.436	0.557	0.397
MPE	-0.026	0.020	0.006	0.002	<u>0.000</u>	0.067	0.028	0.009	0.017
FA	0.964	<u>0.971</u>	0.967	0.970	0.968	0.929	0.956	0.954	0.955
Outputs for Parque Alameda									
Statistics	ANN 7-6-5	ANN 7-7-5	ANN 7-8-5	ANN 7-9-5	ANN 7-10-5	ANN 7-11-5	ANN 7-12-5	ANN 7-13-5	ANN 7-14-5
RMSE (°C)	1.30	0.96	0.93	0.91	<u>0.80</u>	2.36	0.90	1.11	0.97
R ²	0.960	0.978	0.979	0.980	<u>0.985</u>	0.867	0.981	0.971	0.978

DW	0.302	0.592	0.750	0.529	0.794	0.164	<u>0.842</u>	0.517	0.575
MPE	-0.041	-0.002	-0.004	-0.021	<u>-0.001</u>	0.074	-0.007	-0.026	-0.016
FA	0.956	0.971	0.972	0.971	<u>0.979</u>	0.922	0.972	0.967	0.971

Outputs for Campo Grande

Statistics	ANN 7-6-5	ANN 7-7-5	ANN 7-8-5	ANN 7-9-5	ANN 7-10-5	ANN 7-11-5	ANN 7-12-5	ANN 7-13-5	ANN 7-14-5
RMSE (°C)	1.34	1.58	<u>1.14</u>	1.73	1.75	4.58	2.59	1.64	3.72
R ²	0.945	0.923	<u>0.960</u>	0.908	0.906	0.281	0.795	0.918	0.578
DW	0.945	0.923	<u>0.960</u>	0.908	0.906	0.281	0.795	0.918	0.578
MPE	0.408	0.407	0.704	0.255	0.387	0.082	<u>1.157</u>	0.311	0.191
FA	-0.017	<u>-0.003</u>	<u>-0.003</u>	-0.048	<u>-0.003</u>	-0.170	0.009	-0.031	-0.050

Architecture of the model based on the number of neurons in each layer (Input-Hidden-Output). The best architectures (results) obtained for each ANN model with their respective statistical variables of interest are shown / Underlining identifies the best result found.

Table S5. Prediction models for average hourly temperatures (°C) in urban gardens and forested urban park in Valladolid (Spain), according to the different ANNs architectures (X-Y-Z)=(4-Y-1), changing the number of neurons in the hidden layers Y=(1, 2,...,7). Where the inputs are X=[Ta(t) Don Sancho, Ta(t) Dos de Mayo, Day of year (J=1, 2,..., 365), Hour of day (t=0, 1,..., 23)], and the output is Z=[Ta(t) Campo Grande]. Adjustment of statistical values.

“Don Sancho + Dos de Mayo vs Campo Grande”. Outputs for Campo Grande

Statistics	ANN 4-1-1	ANN 4-2-1	ANN 4-3-1	ANN 4-4-1	ANN 4-5-1	ANN 4-6-1	ANN 4-7-1
RMSE (°C)	1.89	<u>1.46</u>	1.56	1.57	1.64	1.73	1.91
R ²	0.891	<u>0.935</u>	0.926	0.925	0.918	0.908	0.889
DW	0.236	0.246	0.227	0.259	0.263	<u>0.272</u>	0.226
MPE	-0.049	<u>0.006</u>	-0.028	-0.039	-0.031	-0.045	-0.055
FA	0.939	<u>0.951</u>	0.945	0.945	0.943	0.933	0.928

Architecture of the model based on the number of neurons in each layer (Input-Hidden-Output). The best architectures (results) obtained for each ANN model with their respective statistical variables of interest are shown / Underlining identifies the best result found.

Table S6. Prediction models for average hourly temperatures (°C) in urban gardens and forested urban park in Valladolid (Spain), according to the different ANNs architectures (X-Y-Z)=(3-Y-1), changing the number of neurons in the hidden layers Y=(1, 2,...,7). Where the inputs are X=[Ta(t) Dos de Mayo, Day of year (J=1, 2,..., 365), Hour of day (t=0, 1,..., 23)], and the output is Z=[Ta(t) Campo Grande]. Adjustment of statistical values.

“Puente Poniente vs Jardín Botánico”. Outputs for Jardín Botánico

	2-1-1	2-2-1	2-3-1	2-4-1	2-5-1	2-6-1	2-7-1	2-8-1
RMSE (°C)	2.10	1.41	1.39	1.28	1.40	1.20	<u>1.11</u>	1.16
R ²	0.865	0.939	0.941	0.950	0.940	0.956	<u>0.962</u>	0.959
DW	0.351	<u>0.527</u>	0.551	0.333	0.514	0.315	0.414	0.352
MPE	0.034	0.026	0.020	0.013	0.027	0.016	<u>0.008</u>	0.013
FA	0.930	0.953	0.955	0.961	0.953	0.963	<u>0.966</u>	0.964

Architecture of the model based on the number of neurons in each layer (Input-Hidden-Output). The best architectures (results) obtained for each ANN model with their respective statistical variables of interest are shown / Underlining identifies the best result found.