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**Weather-wise: A weather-aware planning tool for improving construction
productivity and dealing with claims**

Authors:

Ballesteros-Pérez, Pablo ^a ; Rojas-Céspedes, Yonatan Alexis ^b ; Hughes, Will ^c ;
Kabiri, Shabnam ^d ; Pellicer, Eugenio ^e ; Mora-Melià, Daniel. ^f ; del Campo-Hitschfeld, Maria Luisa ^g

^a Lecturer

School of the Built Environment

Whiteknights, Reading RG6 6DF

United Kingdom

Email: p.ballesteros@reading.ac.uk; pabbalpe@hotmail.com

Phone: +44 (0) 118 378 7186 Fax: +44 (0) 118 931 3856

Corresponding author

^b Construction engineer

Facultad de Ingeniería. Universidad de Talca

Camino los Niches, km 1. Curicó (Chile)

Tel.: (+56) 984 330 846

Email: rojascespedes.y@gmail.com

^c Professor

School of the Built Environment

Whiteknights, Reading RG6 6DF

United Kingdom

Phone: +44 (0) 118 378 7175 Fax: +44 (0) 118 931 3856

E-mail: w.p.hughes@reading.ac.uk

^d Lecturer

School of the Built Environment

Whiteknights, Reading RG6 6DF

United Kingdom

Phone: +44 (0) 118 378 6038 Fax: +44 (0) 118 931 3856

E-mail: s.kabiri@reading.ac.uk

^e Associate Professor

Civil Engineer, M.Sc., Ph.D.

School of Civil Engineering. Universitat Politècnica de València

Camino de Vera s/n, 46022, Valencia, Spain

Phone: +34 963 879 562 Fax: +34 963 877 569

E-mail: pellicer@upv.es

^f Assistant Professor

Dpto. de Ingeniería y Gestión de la Construcción

Facultad de Ingeniería. Universidad de Talca

Camino los Niches, km 1. Curicó (Chile)

Phone.: (+56) 75 2201786 Fax: (+56) 75 325958

E-mail: damora@utalca.cl

^g Assistant Professor

Centro de Sistemas de Ingeniería KIPUS

Facultad de Ingeniería. Universidad de Talca

Camino los Niches, km 1. Curicó (Chile)

Phone.: (+56) 75 2201767 Fax: (+56) 75 325958

E-mail: mdelcampo@utalca.cl; mdelcampo@kipus.cl

1 **Weather-wise: A weather-aware planning tool for improving construction**
2 **productivity and dealing with claims**

3
4 **Abstract**

5 The influence of unforeseen, extreme weather in construction works usually impacts
6 productivity, causes significant project delays and constitutes a frequent source of
7 contractor's claims. However, construction practitioners cannot count on sound
8 methods for mediating when weather-related claims arise, nor harnessing the influence
9 of weather variability in construction projects. Building on the few most recent
10 quantitative studies identifying those key weather agents and levels of intensity that
11 affect some standard building construction activities, a new stochastic model that
12 processes and replicates the spatio-temporal variability of combined weather variables
13 is proposed. This model can help anticipate weather-related project duration
14 variability; improving construction productivity by selecting the best project start date;
15 and objectively evaluating weather-related claims. A two-building construction case
16 study using different Spanish locations is used to demonstrate the model. The results
17 showed that ignoring the influence of weather can lead to an extension of 5-20%
18 longer project duration compared to planned.

19
20 **Keywords:** *Building; Productivity; Weather; Climate; Claims; Delays.*

22 **1. Introduction**

23 Construction projects consist of numerous technological operations that can
24 generally be structured in multiple alternative ways. The work breakdown structure
25 (WBS) and the activity precedence relationships have a big impact on the actual
26 project duration. However, the sensitivity of technological operations to adverse
27 (local) weather conditions is also frequently recognised as one of the factors causing
28 noticeable project delays, cost overruns, and contractual claims [1].

29 According to Mentis [2], projects may take significantly longer, cost more and
30 foster a larger number of conflicts partly when threat identification is inaccurate, its
31 scope is too narrow or its assessment is not satisfactorily incorporated into the project
32 contract, planning and execution stages. Overall, the lesson from Mentis, involving
33 construction projects from several developing countries, is that “almost by definition,
34 what is poorly known is likely to cause problems”. Maybe not that surprisingly though,
35 adverse weather conditions stand out as one of the most recurrent threats in half of the
36 projects discussed in his analysis.

37 The presence of unfavourable and unpredicted weather conditions can only have
38 two possible outcomes from the execution point of view. The first is work that is
39 suspended until the adverse weather subsides (prolongation). The second is the need
40 to apply extra costly measures to counteract the influence of the weather and continue
41 carrying out the works (disruption). Either outcome irremediably leads to extra time,
42 the need for more resources (lower productivity) and, eventually, financial losses. Any
43 of these consequences may cause disputes among the contractor and the client because,
44 eventually, someone has to pay.

45 Accordingly, the influence of weather in construction projects is recognised by
46 both researchers [3–5] and practitioners [6,7] but with two very different interests and
47 motivations. Researchers are mostly focused on work that systematically addresses
48 the influence of poor weather conditions in planning project execution or modelling

49 building performance (e.g. [4,8–12]). Practitioners mostly focus on issuing
50 recommendations for preparing weather-proof construction systems [7] or drawing up
51 contracts that can deal with weather-related and delay-related claims [6,13]. In both
52 cases, despite the different aims of each group, it is clear that regular practice has
53 subdivided the weather into two categories: foreseeable and unforeseeable.

54 Foreseeable, or just “normal” weather can be relatively easily inferred from
55 historical weather data [5], which is typically processed as a monthly average of
56 severe weather days. This can be used to anticipate the average number of days in
57 which a specific construction activity cannot be carried out [14].

58 Ideally, the effects of normal weather on construction works should be routinely
59 taken into account. Ballesteros-Pérez *et al.* [15] have shown that, unfortunately, and
60 despite its inherent simplicity, few projects take account of the weather factor
61 systematically in the planning and execution stages. There are two reasons for this:
62 compressed tender periods and availability of data for a specific site. Tender periods
63 are frequently too short, as discussed by Hughes *et al.* [16]. Moreover, a lot of
64 information needed for preparing a bid is simply missing at that stage. Thus, estimating
65 and planning may be far less reliable and organized than it should be. This can be
66 exacerbated by the, sometimes, large differences between the weather on a specific
67 site and the weather at the nearest meteorological station. However, even if normal
68 weather data were regularly used, three problems arise. First, the weather involves the
69 confluence of multiple phenomena (wind, rain, heat, etc.) and those phenomena,
70 contrary to expectations, do not involve a clear correlation of occurrence with each
71 other. This will be proven later in this paper. Second, each weather agent has
72 variability, and that variability has been addressed by very few studies [4], generally
73 combining only up to two or three phenomena (see Table 1). Third, weather data are
74 generally measured at a ground level, probably quite far away from where the
75 construction works will be located [14], and, perhaps, with a different topography [17].

76 Concerning unforeseeable or abnormal weather, it is, paradoxically, brought up
77 more frequently in the daily practice of projects, as most construction contracts usually
78 include clauses stating that the contractor may be entitled to a time extension or cost
79 compensation due to the occurrence of unusual severe weather conditions [18–20].
80 Yet, the problem is that normal weather conditions, or rather their interaction in
81 relation to productivity decrease, are not properly known or registered somewhere
82 (e.g. in the contract itself). Hence, how is it possible to compare a severe weather
83 episode or its effects versus an inexistent baseline? In other words, how is it possible
84 to state that something is abnormal when normal weather is neglected by default?

85 The aim of this study is to tackle preconceptions about weather-related uncertainty.
86 This will be achieved by developing a holistic model that enables practitioners to use
87 weather data for forecasting project durations, improving construction productivity
88 and the settlement of contract claims. A case study is carried out involving the
89 construction of two different buildings in different Spanish locations. This enables
90 several applications of this model to be developed for progressively dealing with three
91 aspects: normal weather, its multivariate statistical variability, and distinguishing
92 exceptional from non-exceptional weather. Such applications allow the reduction of
93 weather-related uncertainty at the planning and construction stages. They also provide
94 an objective and independent estimate as to how exceptional the weather conditions
95 were at the construction stage. Hence, in general, the model will allow working
96 ‘weather-wise’, that is, in favour of the weather, instead of against it.

97

98 **2. Literature review**

99 2.1 Weather and claims

100 The risks of weather-related delays are generally dealt with in contracts through
101 provisions such as weather, default, and *force majeure* clauses [19]. However, from
102 the standpoint of the contractor, the effect of weather in construction works is

103 materialised in two ways: work stoppage or productivity loss [14]. Severe weather
104 conditions impact any construction work that is either totally or partially carried out
105 outdoors because either the equipment cannot work properly, the quality of the
106 materials is deteriorated, or workers' health and safety is threatened [21]. Regardless
107 of the reason, the consequence is a financial loss that must be borne by either the
108 contractor, the client or both.

109 From the client's perspective, the initial effects of weather issues are mostly
110 connected to project (time) delays [19,22]. Only if the contractor tries to mitigate
111 weather-related losses at the expense of the client, or if due to an inauguration delay
112 the client misses a business opportunity (e.g., the timely exploitation of an
113 infrastructure), will the extreme weather also entail financial losses for the client [23].
114 Unfortunately, the weather impact is almost always associated with negative effects
115 for these two key stakeholders. It is no surprise that many regulations and codes of
116 practice have tried to address the effect of weather on construction works but , so far,
117 with not much success [15].

118 The common problem with most contracts is that they are qualitative, too generic
119 and/or not conveniently updated (e.g. [24–30]). Yet contractors need to know how the
120 weather will impact their construction work, and both the contractor and the client
121 require “clear and specific” weather-related clauses in the construction contract in
122 order to mediate between their interests. The challenges to reach these objectives are
123 manifold. First, it is necessary to objectively identify which weather variables are
124 relevant. Second, which are the intensities (threshold values) beyond which some
125 construction activities will be affected and even to what extent they might be affected.
126 Third, which party/parties are to assume the consequences (financial losses) if a severe
127 weather episode happens. The first two challenges have not yet been solved by the
128 research community [19]. The third challenge, which is the one reflected in contracts

129 and connected to practitioners' interests, remains loose and unclear [31]. Overall, the
130 three have become a recurrent source of conflict [32,33].

131 An alternative approach to dealing with these issues is to exclude any clause that
132 deals with weather-related delays. In such cases, there are no excusable delays relating
133 to weather. This would mean that all weather-related delays are treated just as a
134 consequence of the contractor's mismanagement, lack of foresight or irregular work
135 processes [19]. The downside of this approach is that the consequences are always
136 absorbed by one side, the contractor, and since this party also has leverage in other
137 contract aspects [3], in the persistent absence of shared responsibilities, legal claims
138 and disputes are likely to arise and escalate [34].

139

140 2.2 Weather and productivity

141 Extremely adverse weather conditions are frequently identified as one of the top
142 causes producing project delays and waste of resources (e.g. [2,3,32,33,35]). As can
143 be easily deduced, a project delay is the result of a temporary work stoppage or a
144 performance decline at some point; both of which could be labelled as lower-than-
145 expected productivity.

146 The real problem becomes more evident when one tries to establish a quantitative
147 relationship between specific weather variables, their levels of intensity and their
148 corresponding impacts on productivity. As stated earlier, this is the real source of
149 conflict because the same level of intensity (for example 10 mm of precipitation or
150 high/low temperatures) can cause very different effects depending on several aspects
151 such as the nature of the project, contractor's equipment, soil materials, geotechnical
152 conditions, landscape topography, intensities of other concomitant weather agents,
153 even the country in which the project is being built. Indeed, construction workers
154 exhibit very different temperature tolerance depending on their country of origin. In
155 addition, it is important to consider the contractor's anticipation of the weather and

156 whether any specific approaches were implemented beforehand to mitigate the impact
157 of the weather.

158 Due to the wide range of factors when trying to establish measurable relationships
159 between intensities and consequences of weather agents, very few quantitative
160 research studies have addressed these specific shortcomings. In this regard, Table 1
161 identifies and summarises the most significant “quantitative” works by including their
162 scope (nature of works), the construction activities discussed, and the specific weather
163 agents that were analysed.

164 <Insert Table 1 here>

165 As shown in Table 1, although the weather factor is recognised as having a
166 significant influence on construction work, quantitative studies connecting the
167 intensities of weather agents with construction activities are rather scarce and, mostly,
168 less than ten years old. To sum it up, the situation is that quantitative research has
169 merely scratched the surface of the tripartite weather-productivity-delay issue [35].
170 Most national regulations and contracts are too vague or just not quantitative enough
171 to allow their application. Yet, the weather problem in construction projects is a real
172 and pressing matter due to its high-frequency and severe financial implications.

173

174 **3. Materials and methods**

175 3.1. Methodology outline

176 In the next subsections a model is developed. The purpose is to enable weather
177 data to be used for forecasting project durations, improve construction productivity,
178 and settle contract claims.

179 First, the kind of weather that impacts some standard and typical construction
180 operations is identified. Identifying the corresponding intensities of relevant weather
181 variables and analysing the historical weather information makes it possible to define
182 the likelihood of performing those standard construction operations. This probability

183 is expressed as a proportion of workable days per month and labelled climatic
184 reduction coefficients (CRCs).

185 Second, the spatial and seasonal variation of the CRCs are analysed in the
186 peninsular region of Spain for certain typical construction operations: earthworks,
187 formworks, concrete, steelworks, scaffolding, outdoor paintings, and asphalt
188 pavements.

189 Third, the kind of weather analysis that is usually performed, with an average
190 (deterministic) approach, is revisited. However, this time with a stochastic approach.
191 This stochastic treatment of the weather allows the calculation of a probability
192 distribution curve for any construction project duration. It also enables the
193 determination of, among other things, the optimum start date so that the overall project
194 duration is minimised.

195 Fourth, a case study involving the construction of two buildings in different cities
196 of Spain is developed. This case exemplifies how the decision about where and when
197 a project is carried out entails significant financial implications.

198 Fifth, it is argued that a slightly adjusted model may be used retrospectively as a
199 tool for mediating in weather-related disputes between the contractor and the project
200 owner.

201

202 3.2. Measuring the weather-related productivity impact

203 Previous quantitative studies have measured some of the impacts of weather
204 variables and intensities on the execution of specific construction activities. As there
205 are several different studies, some simplifications are necessary. This is mainly related
206 to merging and homogenising expressions and thresholds from those studies in Table
207 1 to enable modelling productivity impacts on some significant construction activities,
208 as shown in Table 2.

209

<Insert Table 2 here>

Overall, Table 2 is divided in two major vertical blocks: raw climatic coefficients (RCC)¹ and construction activities. The first column of the RCC block (named “Monthly days without...”) contains the main weather variables, along with the most commonly agreed thresholds or levels of intensity from the literature. The second column (“Mathematical expressions”) shows the way that each weather variable has been translated into a coefficient C_x^i that reflects the proportion of “workable days” in a scale from 0 to 1. The superscript $i = 1, 2, 3 \dots 12$ denotes the month of the year, whereas the subscript $x = t, p1, p10, p30, w, s, e$ denotes the specific weather variable and/or its intensity. Equations (1) to (7) specify how the seven most relevant C_x^i RCCs are calculated for each month of the year and for a particular location where there is at least one nearby meteorological station.

However, as expected, not all of the weather variables (now converted into RCCs) affect all of the construction activities. In this regard, only the cells populated with references from the last seven columns to the right make explicit the connection between specific RCCs and their impact on each of the construction activities (E, F, C, T, S, O and P). Most of these references are taken from studies previously reflected in Table 1, along with a sample of construction regulations from three countries included as representative examples in Table 2. In the absence of a single intensity agreement among cited sources, either average values were adopted (e.g., the wind speed at 55 Km/h) or several steps of intensities considered (e.g., the precipitation with intensities of 1, 10 and 30 mm).

By establishing the connection of the RCCs to some standard construction activities, the CRCs from the row at the bottom of the table is straightforward. Equations 8 to 14 demonstrate how a composite productivity coefficient, calculated as

¹ We are following Ballesteros-Pérez *et al.*'s [15] notation. According to those authors, naming coefficients as “Climatic” instead of as “Weather” is pertinent since the calculated coefficients are representative of a broader area and approximately stable during a particular period of the year.

234 the product of two to four RCCs, represents the proportion of workable days (on a 0-
235 to-1 scale) in month i for each of the seven construction activities considered:
236 earthworks, formworks, concrete, steelworks, scaffolding, outdoor paintings and
237 asphalt pavements (E^i , F^i , C^i , T^i , S^i , O^i and P^i , respectively).

238 Two major simplifications are assumed. First, only weather influence on
239 technological operations have been considered; that is, no influence on workers'
240 labour productivity (mostly due to high temperature and humidity levels [49]) is
241 included in the analysis. For example, a temperature of 24°C is considered very high
242 in northern (colder) countries, whereas it is considered optimal in southern (warmer)
243 countries. Therefore, more research is needed to adapt or calibrate this dimension. This
244 is beyond the scope of the present study. Second, although the generic mathematical
245 expression of CRCs in equations 8 to 14 seem quite intuitive (the simple product of
246 RCCs), it is worth checking whether a high covariance between the variables from a
247 RCC might affect (or exaggerate) the CRC values. In this regard, Table 3 reflects the
248 auxiliary calculations of covariances among the seven RCCs from Table 2 in four
249 locations of Spain with different climatic conditions (Valencia, Zaragoza, Madrid and
250 La Coruña). The four covariance matrices indicate how the covariances (values
251 outside the diagonals) are very small in general. This agrees with previous studies and
252 other models which neglect this same effect [50] and makes our second simplification
253 perfectly tenable.

254 **<Insert Table 3 here>**

255

256 3.3. Monthly and annual average Climatic Reduction Coefficient (CRC) values

257 So far, very simple calculations have been developed in order to identify the
258 “average” or “normal” weather conditions that might affect some typical construction
259 works. The way they can be implemented in practice simply consists of calculating

260 the RCC values (equations 1 to 7) from the most recent years and then take their
261 respective averages to calculate each of the CRC values (with equations 8 to 14).

262 As an example, Figures 1 and 2 represent the average monthly and annual data for
263 two of the seven CRC values. These Figures present data from all the peninsular
264 province capital cities in Spain with at least one weather station. The complete set of
265 six CRCs used for the two-building building case study can be accessed as
266 supplemental online material. In these calculations, the average values of the RCC
267 made use of the last 30 years of weather data from the peninsular Spanish weather
268 stations.

269 **<Insert Figure 1 here>**

270 **<Insert Figure 2 here>**

271 A first reading of Figure 1 immediately provides some interesting patterns.
272 Earthworks activities are not sensitive to the average Spanish weather since most of
273 the CRC values (which denote the proportion of workable days per month/year) are
274 close to 1 (cells mostly green). The opposite could be said about Outdoor Painting
275 activities in Figure 2; the predominant orange and even red colours highlight much
276 lower values.

277 As might be expected, summer months (June to September) generally have the
278 highest CRC values, but the location effect is much more important. Cities like
279 Córdoba and Jaén (Andalusia) allow very good working conditions, on average and
280 throughout the year; whereas other cities have the opposite, such as San Sebastián
281 (Basque Country).

282 One of the limitations of Figures 1 and 2 is that they must be developed for single
283 specific map locations. Arguably, many buildings or infrastructures will, probably, be
284 built within a close radius of one of these urban centres, but there will always be others
285 significantly far from them. Therefore, a spatial extrapolation is necessary to obtain
286 the CRC values where no weather stations are close or data is unavailable. This is

287 exactly what Figure 3 shows for the annual CRC values of the same two CRC
288 coefficients represented in Figures 1 and 2. Again, the complete set of annual maps
289 (*E, F, C, T, S, P*) can be found as supplemental online material. By observing the maps
290 represented in Figure 3, it is easy to see how cities that were mentioned above
291 (Córdoba, Jaén and San Sebastián) are located in areas where the climatic conditions
292 are very favourable or unfavourable, respectively.

293 **<Insert Figure 3 here>**

294 Again, these maps have some obvious limitations. The first is that, as can be
295 anticipated, one map is needed per construction activity and per month. Figure 3 has
296 only represented the annual average of the monthly maps but, obviously, as more
297 activities are considered, more maps would be needed. Although elaboration of these
298 maps can be made with software like Surfer[®] or ArcGIS[®], a multi-layer digital map
299 representation would be preferred over working with multiple paper-printed maps.

300 The second limitation is that no topography conditions (like the altitude) have been
301 considered, since this would have required the application of more complex algorithms
302 for adjusting the spatial variation of the CRC values. Fortunately, in countries such
303 Spain where the number of weather stations is abundant and very well dispersed all
304 over the country, the massive number of data points means that this analytical
305 simplification is not that crucial. However, it is recognised that, for special projects
306 like high-rise buildings [14] or those with isolated locations and difficult access, these
307 maps would not provide reliable values and the only option would be to resort to more
308 precise on-site weather station measurements (set up preferably at least a couple of
309 years before commencing the project). Many observers may object to the expense of
310 monitoring the weather for two years prior to construction, but the expense is dwarfed
311 by the expense of delayed completion, litigation or other losses following from
312 inadequate data.

313

314 3.4. Modelling stochastic weather variability

315 The understanding brought about by considering weather data, CRCs and RCCs is
316 useful in considering the impact of adverse weather on construction activities. It is
317 clear from the foregoing that weather affects various tasks in different ways. One
318 important factor is that not all kinds of weather occur simultaneously. When one or
319 two variables become abnormally high, progress will be affected. This will cause a
320 real productivity loss and a potential element of dispute between the contractor and
321 the project client. The question is whether weather events with a positive effect might
322 compensate those with negative effects. Current analytical approaches would not help
323 either the contractor or the client to answer such a question. But, based on the approach
324 provided in this study, an objective answer could be provided. More specifically, if all
325 the RCCs are treated as stochastic variables, instead of average values, the overall
326 effect of the weather conditions during the construction phase could be determined.

327 Many recent studies have addressed multiple ways of generating stochastic
328 weather data for use in operations research and management science [50]. However,
329 applications within the construction environment count among the most numerous
330 [14,37,51]. These provide a basis for extending the analytical model proposed so far.

331 Generating stochastic weather values is quite simple whenever the covariance
332 among different weather variables is not considered (a simplification that was shown
333 in Table 3 to be tenable in this case study). Basically, previous calculations required
334 that the RCC values are calculated for each month and year of the historical weather
335 data before taking their average. But, if RCC standard deviation values are also
336 calculated along with their averages (mean values) for the N years of analysis, fitting
337 a Beta distribution to the monthly RCC values of each weather variable would be
338 straightforward using the method of moments.

339 As supplemental online material, the third set of figures shows these calculations
340 for the same four cities (by columns) that were selected as examples in Table 3 when

341 calculating the covariance matrices. The RCC values of the 30 years have not been
342 included for the sake of brevity, but indication of the number of values years (N), the
343 mean and standard deviation of the N RCC values, as well as the α and β shape
344 parameter values for the Beta distributions, representing the monthly RCC values
345 variability, have been stated for each of the seven RCCs. The last row from each of
346 the Tables from the seven RCCs reflects the Kolmogorov-Smirnov D statistic which
347 corresponds to the maximum deviation observed between the actual data and the Beta
348 distributions fitted to each month of the year per RCC series of N values. From the
349 tables at the bottom, it is easy to check that these D values are “without exception”
350 below the critical K-S’s values for three levels of significance ($\alpha=1\%$, 5% and 10%).

351 Having verified that the Beta distribution has a good fit with historical RCC values,
352 the next step is to use this distribution for generating stochastic values by Monte Carlo
353 simulations, while modelling the climatic trends from previous years. Essentially,
354 once the Beta α and β parameters are calculated for each month and for each type of
355 RCC, one iteration (one artificial year) will produce a series of twelve CRC values.
356 With these values known, it will be possible to calculate the monthly E^i , F^i , C^i , T^i , S^i ,
357 O^i and P^i values of that artificial year by just applying equations 8 to 14. Now, it only
358 remains to apply several thousand of these stochastic values to a particular schedule
359 to measure the potential productivity losses and project delays as a consequence of the
360 changing weather.

361

362 3.5. Case study: construction of two buildings

363 To explain the issues more fully, a case study applying the method developed so
364 far is presented. Namely, the case study comprises the construction of a five-storey
365 building with two options concerning the structure: Reinforced Concrete (RC
366 building) and Steel Structure (SS building). Figure 4 represents the main activities of
367 these two alternative buildings (Gantt charts can be found as supplemental online

368 material as the fourth set of Figures). The project duration is 108 working days for the
369 RC building (left) and 95 working days for the SS building (right).

370 **<Insert Figure 4 here>**

371 From left to right, the table columns of Figure 4 represent the activities: identifier
372 (ID), units, description, quantities (Q), performance or expected productivity (P),
373 duration (as Q/P), a rounded-up duration of the latter column values for the sake of
374 simplicity, details of the technological activity precedences, the zone where each
375 activity is performed (outdoor = influenced by the weather, indoor = not influenced
376 by the weather), and the specific CRC to which each activity is assimilated (outdoor
377 activities only).

378 Despite the authors' acknowledgement that these two buildings represent just a
379 simplification of the large number of activities that any real building involves, this
380 case study allows a fair representation of the method proposed. In real-life settings,
381 therefore, the only difference would be the allocation of CRC coefficients to a longer
382 list of activities.

383

384 **4. Results**

385 Figure 5 and 6, respectively, represent the average durations that both the RC
386 building and the SS building would have had if they had been built in each of the
387 Spanish capitals of province, depending also on the date (season) the projects had
388 started, but only considering the "average" weather conditions. Namely, the duration
389 of each activity is calculated as its original duration divided by its respective CRC,
390 which changes according to the month(s) in which the activity is executed. Overall, in
391 the absence of any weather consideration, the RC building required 108 working days,
392 whereas the SS building required 95 working days. However, the real durations when
393 taking the weather into account are invariantly longer.

394 **<Insert Figure 5 here>**

clear from the outset (e.g., design- build contracts), numerous schedule variations (even scope variations) might take place. In these cases, it would be difficult to have access to reliable duration estimates at the early stages of the project. Obviously, all these aspects might limit the model accuracy while anticipating the future likely project duration and its optimum start date. However, and maybe paradoxically, this limitation does not affect the capability of the model in mediating conflicts arising from weather-related contractual claims.

5. Discussion

This section will be mostly devoted to the discussion of why (and how) it is possible to know whether a contractor has experienced a project delay as a consequence of the weather or of something else, and how to use the time deviation to state whether the contractor is entitled to compensation. The answer to this question is also applicable to the “average” weather conditions by which the project durations from Figures 5 and 6 have been derived. However, (stochastically) variable weather conditions will also be considered in this case. This paper promised, as a by-product of the main model, to offer a method for mediating in weather-related construction claims. To do so, the model should be applied following the steps described below.

First, the contractor should register the execution start and end dates of all the ongoing activities in the construction site and their precedence relationships (i.e. which ones have had to finish before the subsequent activities could start). This ‘as-built’ schedule (e.g. Gantt chart) will act as the ‘baseline’ document between the contractor and the project owner. To avoid ambiguities, it is advisable that the Work Breakdown Structure (WBS) resemble the budget items against which the progress is reported and billed. The advantage of this approach is that by establishing a coherent correspondence between progress and payments, both parties are invited to share the same progress information regarding the actual execution.

449 Second, on sharing a common as-built schedule, both parties should agree on the
450 specific CRC to be allocated to each activity (whenever it is exposed to the weather).
451 In short, this is exactly what was represented in Figure 4, but instead of doing this
452 allocation *ex-ante*, in this occasion the allocation can also be done *ex-post*, that is,
453 retrospectively (when the works have partially or totally finished).

454 Third, monthly RCC values (by equations 1 to 7) for calculating the monthly CRC
455 values (by equations 8 to 14), from as many recent years as possible prior to the project
456 start date, have to be calculated. Also, the monthly RCC and CRC values during
457 project execution have to be calculated separately, preferably via an on-site weather
458 station for more accurate results. Then, for the pre-execution period, either take the
459 CRC monthly averages or go a little further and fit the Beta distributions described
460 earlier.

461 Fourth, using the steps above, the actual duration of each activity is multiplied by
462 its actual CRC. Since the CRC values are between 0 and 1, the result of this
463 multiplication will be shorter activity durations. In other words, the fourth step will
464 result in obtaining the original ‘planned’ activity durations before the weather
465 influenced those activities. These ‘planned’ durations will be shorter than the ‘actual’
466 durations, except for non-weather-sensitive activities which will be the same (CRC
467 values equal to 1 for all months).

468 Fifth, now that the original planned project schedule has been inferred from the as-
469 built schedule by means of the actual CRC multiplications, it is possible to calculate
470 how long that original planned schedule would have taken to complete (or to reach the
471 current progress stage), if the weather conditions had been like those in the years
472 before the project started. For that, it is only necessary to ‘divide’ each activity
473 duration by its respective (average or Beta-distributed stochastic) CRC value, as
474 gathered before the project execution period. If the resulting overall project duration
475 is longer than the as-built schedule, then the contractor has suffered weather conditions

476 more adverse than the historical average. Conversely, if the as-built schedule duration
477 is shorter, then that means that the contractor has enjoyed better-than-average weather
478 conditions and would not be entitled to this kind of compensation. Of course, this
479 analysis can be focussed, not only on the whole project duration, but also on the
480 circumstances of a single activity or a subset of activities.

481 If the contractor and project client want to be more precise, for example, because
482 they agreed that only exceptionally severe weather conditions (e.g. top 10% severe
483 weather conditions) would lead to economic compensation for the contractor, they
484 would need to resort to fully stochastic weather analysis. The underlying philosophy
485 would be exactly the same as for the average weather analysis though. However,
486 instead of working with “average” historical CRC values, a Monte Carlo simulation
487 would be needed to generate multiple artificial years (each with a series of random
488 CRC values calculated from the original Beta-distributed RCC values). By performing
489 10,000 simulations (iterations), sufficient potential project durations would be
490 obtained, ordered and assigned a probability as in Figure 7. The closer as-built project
491 duration was to a probability of zero, the more severe the weather conditions suffered;
492 the closer to one (100%), the more lenient the weather was.

493 <Insert Figure 7 here>

494 Figure 7 represents the probability distributions obtained for the RC building (left)
495 and the SS building (right). Coloured curves represent the project duration probability
496 curves depending on when the project might start. Also, a fit to Fréchet distributions
497 is provided for the sake of additional future statistical modelling. In this case, the
498 Fréchet distribution, also known as inverse Weibull distribution, constitutes a logical
499 candidate as it is an Extreme Value distribution for modelling maxima of events.
500 Particularly, this distribution, along with the Gumbel distribution, are common
501 alternatives when dealing with Stochastic Network Analysis (SNA) [52], that is, when
502 calculating the total project duration of schedules whose activities have variable

503 durations, such as in this case study. More simulation results and comparisons can be
504 found as supplemental online material (fifth set of figures).

505

506 **6. Conclusions**

507 Project delays and cost overruns attributed to the weather are numerous in
508 construction projects and this is reflected in the construction literature. However, few
509 studies have addressed how to quantify (versus just stating or proving its connection)
510 the precise extent to which weather variables and/or their intensities influence
511 construction activities. Consequently, productivity forecasts are difficult to make and
512 construction contracts that normally include weather-related clauses cannot count on
513 objective approaches for their fair enforcement.

514 In this paper, multiple contributions towards improving the current situation have
515 been presented. First, the most representative and recent research addressing the
516 specific influences of weather on construction works were identified. Drawing on
517 them, a series of coefficients were developed which help to anticipate weather-related
518 productivity losses and activity duration extensions. Second, an approach was
519 proposed to extrapolate coefficients in a wider geographic location with no weather
520 data. Third, building on the above outcomes, a case study was presented, which
521 demonstrated how much longer a building project can take as a consequence of
522 location and project start date. Fourth, guidance was provided to generate stochastic
523 Beta-distributed monthly and annual weather coefficients so that the weather
524 conditions experienced over recent years can be modelled and reproduced during the
525 execution stage. Fifth, a method for estimating the approximate percentile to which
526 the real project duration corresponds in relation to the weather has also been proposed.
527 Overall, the proposed model offers great advantages for anticipating weather-related
528 productivity losses at the planning stage. Furthermore, during the construction phase,

529 this method can be used to determine whether the weather conditions really entitled
530 the contractor to compensation.

531 However, despite the simplicity and practicability of the model, there are some
532 limitations. The covariances between the climatic coefficients that affect the
533 productivity and the human dimension being affected by extreme weather events were
534 not considered. In addition, topography considerations (e.g., the altitude) have been
535 omitted for the sake of simplicity of the model. This was however, partially
536 compensated by having a dense grid of available weather data. Finally, in those types
537 of contract in which the project schedule needs to be fast tracked and/or the schedule
538 itself cannot be easily anticipated from the outset, the ability of the proposed method
539 for providing accurate activity duration extensions and overall project duration
540 forecasts, as well as optimum start dates, may be limited. In spite of these limitations,
541 the beauty of the proposed method relies on its mathematical simplicity, its wide
542 applicability and for being the first in its kind to address the long-enduring problem of
543 the weather-related claims in construction works.

544

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548

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Región	Province capital	Earthworks (E)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,88	0,90	0,93	0,92	0,93	0,95	0,97	0,97	0,93	0,86	0,83	0,85	0,91
	Lugo	0,83	0,84	0,90	0,88	0,92	0,94	0,97	0,96	0,92	0,85	0,81	0,82	0,89
	Orense	0,88	0,91	0,94	0,92	0,94	0,96	0,98	0,98	0,95	0,88	0,87	0,86	0,92
	Pontevedra	0,78	0,82	0,86	0,82	0,87	0,92	0,95	0,94	0,89	0,77	0,76	0,77	0,85
Asturias	Oviedo	0,87	0,86	0,89	0,89	0,92	0,94	0,96	0,95	0,93	0,90	0,86	0,89	0,91
Cantabria	Santander	0,87	0,89	0,90	0,88	0,92	0,94	0,95	0,93	0,91	0,88	0,82	0,86	0,90
País Vasco	Vitoria	0,87	0,88	0,91	0,90	0,93	0,95	0,96	0,95	0,95	0,91	0,87	0,88	0,91
	San Sebastián	0,81	0,80	0,86	0,84	0,88	0,92	0,91	0,89	0,87	0,83	0,78	0,81	0,85
	Bilbao	0,85	0,86	0,89	0,88	0,92	0,94	0,96	0,94	0,93	0,88	0,81	0,86	0,89
Navarra	Pamplona	0,89	0,87	0,90	0,90	0,95	0,95	0,96	0,97	0,95	0,93	0,90	0,89	0,92
La Rioja	Logroño	0,93	0,94	0,96	0,95	0,96	0,96	0,97	0,98	0,97	0,96	0,96	0,94	0,96
Castilla y León	Ávila	0,84	0,83	0,91	0,91	0,94	0,97	0,99	0,98	0,98	0,94	0,89	0,86	0,92
	Burgos	0,82	0,84	0,89	0,88	0,93	0,95	0,98	0,98	0,97	0,94	0,88	0,83	0,91
	León	0,83	0,87	0,92	0,93	0,94	0,97	0,98	0,98	0,96	0,94	0,91	0,86	0,92
	Palencia	0,85	0,89	0,93	0,92	0,94	0,97	0,98	0,98	0,97	0,93	0,90	0,88	0,93
	Salamanca	0,93	0,92	0,97	0,95	0,95	0,97	0,99	0,99	0,97	0,95	0,94	0,92	0,96
	Segovia	0,97	0,87	0,92	0,92	0,93	0,95	0,99	0,98	0,98	0,94	0,90	0,90	0,94
	Soria	0,81	0,79	0,88	0,86	0,92	0,95	0,97	0,97	0,96	0,94	0,88	0,83	0,90
	Valladolid	0,87	0,91	0,96	0,93	0,95	0,97	0,99	0,98	0,97	0,94	0,92	0,90	0,94
	Zamora	0,93	0,94	0,98	0,95	0,97	0,98	0,99	0,99	0,97	0,95	0,94	0,92	0,96
Aragón	Huesca	0,94	0,94	0,96	0,93	0,95	0,97	0,98	0,97	0,95	0,94	0,95	0,94	0,95
	Teruel	0,90	0,90	0,92	0,92	0,94	0,96	0,97	0,97	0,96	0,96	0,95	0,93	0,94
	Zaragoza	0,96	0,96	0,98	0,96	0,96	0,97	0,99	0,99	0,97	0,97	0,97	0,97	0,97
Cataluña	Barcelona	0,95	0,95	0,96	0,96	0,96	0,97	0,98	0,94	0,92	0,92	0,94	0,96	0,95
	Gerona	0,93	0,94	0,95	0,93	0,93	0,93	0,96	0,96	0,93	0,92	0,94	0,94	0,94
	Lérida	0,96	0,98	0,97	0,97	0,95	0,97	0,99	0,98	0,96	0,95	0,97	0,98	0,97
	Tarragona	0,96	0,96	0,97	0,96	0,95	0,98	0,99	0,96	0,93	0,93	0,95	0,96	0,96
Madrid	Madrid	0,94	0,92	0,97	0,94	0,95	0,98	0,99	0,99	0,98	0,93	0,93	0,92	0,95
Extremadura	Cáceres	0,93	0,95	0,96	0,95	0,95	0,98	0,99	0,99	0,97	0,91	0,90	0,91	0,95
	Badajoz	0,94	0,94	0,97	0,95	0,97	0,99	1,00	1,00	0,98	0,93	0,93	0,92	0,96
Castilla-La Mancha	Albacete	0,96	0,93	0,95	0,96	0,96	0,97	0,99	0,99	0,97	0,96	0,95	0,95	0,96
	Ciudad Real	0,94	0,94	0,97	0,95	0,97	0,98	0,99	1,00	0,98	0,94	0,96	0,93	0,96
	Cuenca	0,89	0,89	0,93	0,92	0,94	0,95	0,99	0,98	0,95	0,93	0,92	0,91	0,93
	Guadalajara	0,95	0,93	0,97	0,94	0,95	0,97	0,99	1,00	0,97	0,92	0,95	0,93	0,95
	Toledo	0,96	0,96	0,97	0,96	0,96	0,98	0,99	0,99	0,98	0,95	0,96	0,96	0,97
Valencia	Alicante	0,98	0,98	0,98	0,97	0,98	0,99	1,00	0,99	0,96	0,96	0,96	0,98	0,98
	Castellón	0,96	0,97	0,97	0,96	0,96	0,98	0,99	0,98	0,93	0,94	0,95	0,96	0,96
	Valencia	0,97	0,96	0,97	0,96	0,96	0,99	0,99	0,98	0,94	0,95	0,95	0,95	0,96
Andalucía	Almería	0,98	0,98	0,98	0,99	0,99	1,00	1,00	1,00	0,99	0,98	0,97	0,97	0,98
	Cádiz	0,92	0,93	0,96	0,95	0,98	0,99	1,00	1,00	0,97	0,93	0,90	0,90	0,95
	Córdoba	0,92	0,94	0,95	0,94	0,96	0,99	1,00	0,99	0,96	0,91	0,92	0,88	0,95
	Granada	0,93	0,95	0,97	0,97	0,97	0,99	1,00	1,00	0,98	0,95	0,93	0,94	0,97
	Huelva	0,93	0,95	0,97	0,95	0,97	1,00	1,00	1,00	0,98	0,92	0,92	0,90	0,96
	Jaén	0,92	0,92	0,94	0,95	0,96	0,98	1,00	0,99	0,97	0,95	0,93	0,92	0,95
	Málaga	0,93	0,95	0,95	0,95	0,98	0,99	1,00	0,99	0,98	0,94	0,92	0,90	0,96
	Sevilla	0,92	0,95	0,96	0,94	0,97	0,99	1,00	0,99	0,97	0,93	0,91	0,88	0,95
Murcia	Murcia	0,97	0,98	0,97	0,98	0,97	0,99	1,00	0,99	0,97	0,96	0,97	0,97	0,98

Note: values closer to 1.00 represented in green. Lower values progressively represented in yellow and lowest in red.

Figure 1. Annual and monthly Earthworks average CRC values of Spanish peninsular capital of province cities.

Region	Province capital	Outdoor painting (P)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,39	0,40	0,48	0,41	0,54	0,70	0,79	0,78	0,68	0,48	0,39	0,37	0,53
	Lugo	0,52	0,50	0,57	0,49	0,60	0,78	0,85	0,82	0,71	0,53	0,49	0,54	0,61
	Orense	0,64	0,66	0,71	0,62	0,68	0,84	0,90	0,89	0,81	0,66	0,64	0,62	0,72
	Pontevedra	0,54	0,55	0,60	0,50	0,60	0,75	0,83	0,82	0,71	0,56	0,53	0,49	0,62
Asturias	Oviedo	0,51	0,48	0,53	0,49	0,55	0,70	0,73	0,72	0,69	0,56	0,49	0,49	0,58
Cantabria	Santander	0,41	0,42	0,52	0,46	0,58	0,71	0,73	0,73	0,63	0,49	0,38	0,42	0,53
País Vasco	Vitoria	0,52	0,53	0,59	0,53	0,61	0,73	0,76	0,75	0,72	0,60	0,55	0,53	0,61
	San Sebastián	0,28	0,30	0,35	0,34	0,45	0,57	0,61	0,58	0,52	0,37	0,30	0,30	0,41
	Bilbao	0,44	0,46	0,52	0,48	0,60	0,73	0,75	0,71	0,68	0,55	0,47	0,46	0,57
Navarra	Pamplona	0,59	0,56	0,59	0,55	0,64	0,76	0,78	0,78	0,75	0,64	0,59	0,58	0,65
La Rioja	Logroño	0,68	0,67	0,72	0,63	0,67	0,77	0,82	0,84	0,82	0,72	0,70	0,68	0,73
Castilla y León	Ávila	0,64	0,63	0,73	0,65	0,67	0,84	0,94	0,92	0,85	0,72	0,65	0,63	0,74
	Burgos	0,54	0,54	0,60	0,52	0,58	0,71	0,77	0,78	0,73	0,61	0,55	0,51	0,62
	León	0,57	0,60	0,66	0,59	0,63	0,78	0,84	0,86	0,80	0,66	0,65	0,60	0,68
	Palencia	0,60	0,61	0,69	0,60	0,65	0,77	0,83	0,84	0,78	0,67	0,63	0,60	0,69
	Salamanca	0,67	0,65	0,71	0,62	0,64	0,81	0,89	0,89	0,81	0,68	0,68	0,63	0,72
	Segovia	0,67	0,60	0,65	0,60	0,59	0,84	0,91	0,82	0,78	0,71	0,68	0,57	0,70
	Soria	0,55	0,53	0,63	0,57	0,63	0,77	0,83	0,83	0,79	0,69	0,62	0,57	0,67
	Valladolid	0,65	0,66	0,74	0,64	0,69	0,80	0,87	0,88	0,81	0,71	0,68	0,65	0,73
	Zamora	0,72	0,74	0,79	0,73	0,74	0,86	0,92	0,91	0,84	0,74	0,72	0,71	0,78
Aragón	Huesca	0,61	0,61	0,66	0,59	0,62	0,69	0,90	0,89	0,85	0,79	0,62	0,65	0,71
	Teruel	0,81	0,81	0,82	0,75	0,75	0,80	0,91	0,88	0,83	0,79	0,83	0,76	0,81
	Zaragoza	0,64	0,60	0,60	0,58	0,62	0,70	0,72	0,77	0,76	0,69	0,66	0,65	0,67
Cataluña	Barcelona	0,83	0,79	0,79	0,75	0,81	0,87	0,93	0,83	0,80	0,76	0,78	0,80	0,81
	Gerona	0,80	0,79	0,79	0,73	0,76	0,82	0,89	0,82	0,77	0,78	0,80	0,82	0,80
	Lérida	0,75	0,75	0,74	0,67	0,76	0,81	0,88	0,87	0,81	0,80	0,77	0,78	0,78
	Tarragona	0,68	0,87	0,72	0,70	0,83	0,90	0,94	0,88	0,83	0,81	0,74	0,87	0,81
Madrid	Madrid	0,74	0,72	0,80	0,70	0,73	0,86	0,95	0,91	0,87	0,75	0,76	0,72	0,79
Extremadura	Cáceres	0,68	0,68	0,76	0,67	0,73	0,87	0,93	0,93	0,84	0,68	0,66	0,64	0,75
	Badajoz	0,72	0,73	0,77	0,70	0,77	0,90	0,97	0,96	0,87	0,73	0,72	0,68	0,79
Castilla-La Mancha	Albacete	0,84	0,79	0,83	0,80	0,81	0,89	0,97	0,95	0,88	0,83	0,82	0,82	0,85
	Ciudad Real	0,78	0,74	0,82	0,72	0,78	0,87	0,96	0,95	0,87	0,79	0,77	0,73	0,82
	Cuenca	0,69	0,69	0,75	0,66	0,70	0,80	0,91	0,87	0,82	0,71	0,71	0,67	0,75
	Guadalajara	0,78	0,76	0,84	0,73	0,76	0,87	0,94	1,00	0,87	0,74	0,81	0,78	0,82
	Toledo	0,74	0,71	0,75	0,66	0,71	0,82	0,90	0,89	0,86	0,73	0,73	0,71	0,77
Valencia	Alicante	0,84	0,85	0,83	0,83	0,85	0,93	0,98	0,96	0,88	0,85	0,84	0,84	0,87
	Castellón	0,80	0,81	0,82	0,78	0,83	0,90	0,94	0,91	0,81	0,81	0,83	0,79	0,84
	Valencia	0,76	0,77	0,81	0,77	0,83	0,90	0,96	0,91	0,82	0,80	0,80	0,78	0,82
Andalucía	Almería	0,75	0,71	0,70	0,65	0,70	0,77	0,83	0,87	0,83	0,79	0,75	0,75	0,76
	Cádiz	0,65	0,60	0,66	0,67	0,75	0,81	0,84	0,88	0,80	0,70	0,63	0,60	0,72
	Córdoba	0,76	0,78	0,84	0,78	0,84	0,95	0,99	0,98	0,89	0,78	0,80	0,74	0,85
	Granada	0,76	0,73	0,80	0,75	0,82	0,91	0,96	0,94	0,88	0,81	0,74	0,71	0,82
	Huelva	0,71	0,75	0,81	0,73	0,86	0,95	0,99	0,97	0,90	0,74	0,73	0,69	0,82
	Jaén	0,78	0,77	0,83	0,77	0,82	0,93	0,99	0,98	0,91	0,81	0,77	0,75	0,84
	Málaga	0,63	0,68	0,74	0,75	0,82	0,94	0,98	0,96	0,90	0,80	0,68	0,61	0,79
	Sevilla	0,72	0,72	0,78	0,70	0,82	0,92	0,96	0,96	0,89	0,74	0,73	0,68	0,80
Murcia	Murcia	0,82	0,83	0,84	0,83	0,85	0,91	0,97	0,96	0,89	0,86	0,84	0,84	0,87

Note: values closer to 1.00 represented in green. Lower values progressively represented in yellow and lowest in red.

Figure 2. Annual and monthly Outdoor Paintings average CRC values of Spanish peninsular capital of province cities.

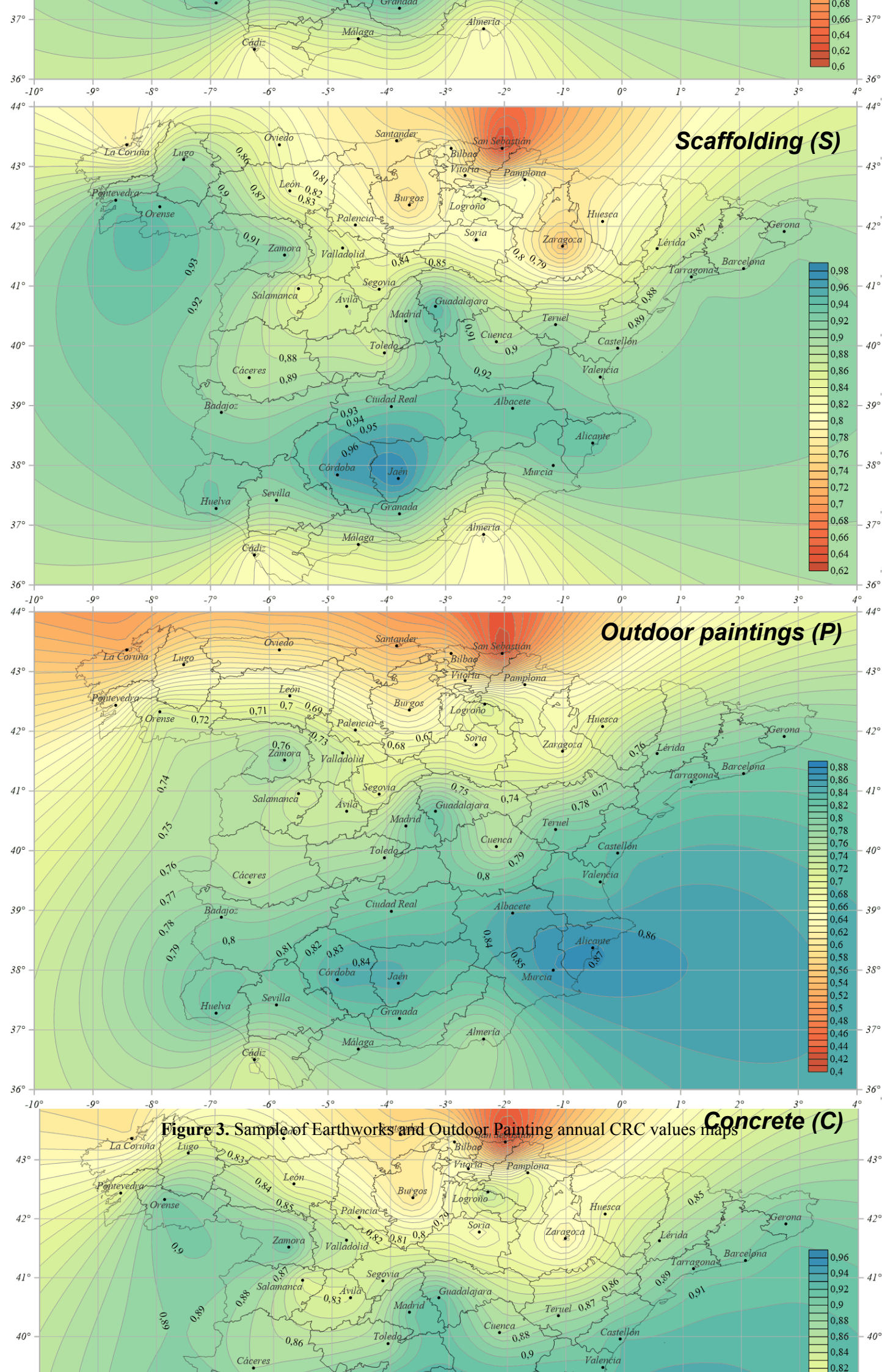
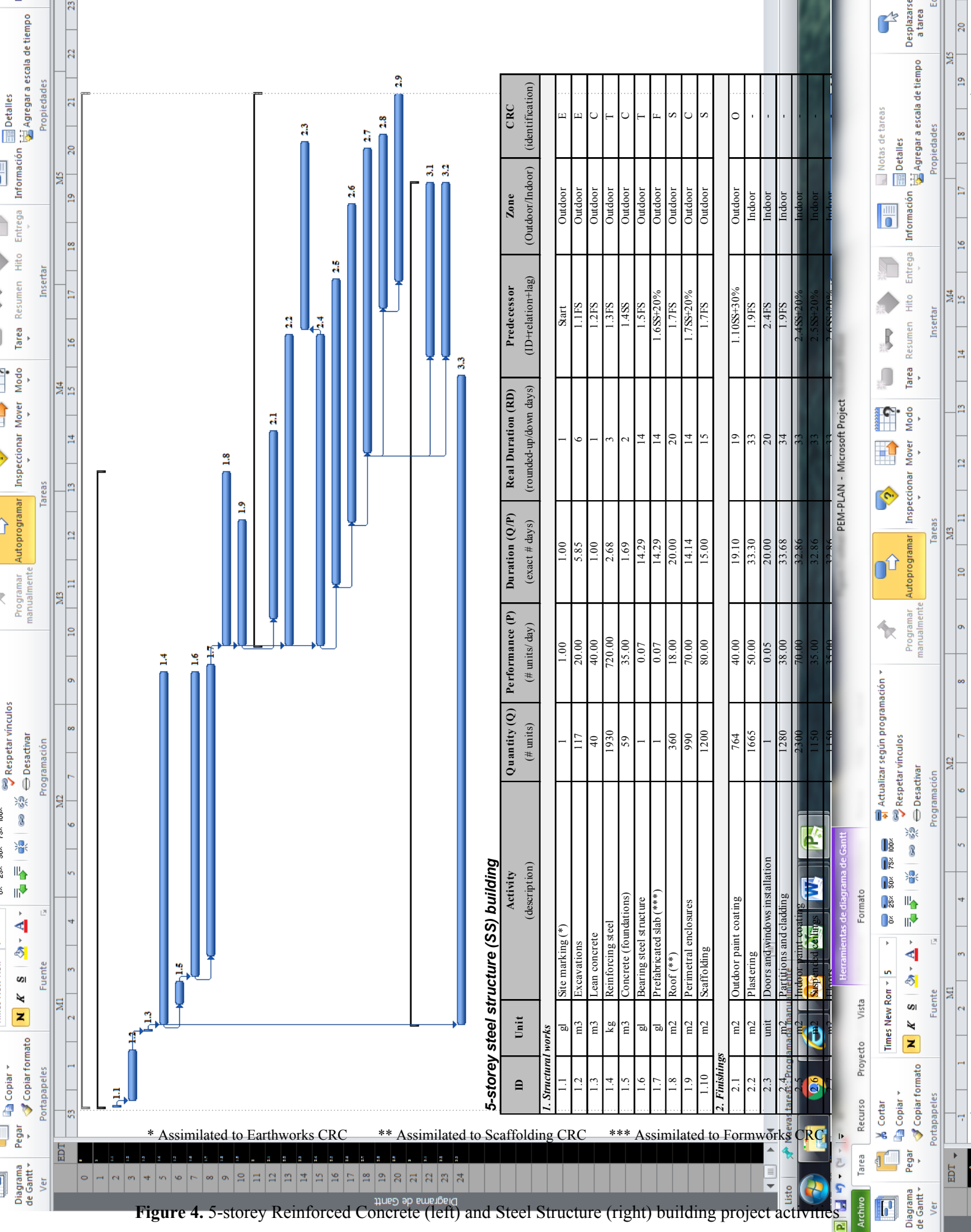


Figure 3. Sample of Earthworks and Outdoor Painting annual CRC values maps



Baseline without climate: 108 working days									
Region	Province capital (Spain)	RC building				Duration		Extension	
		Project start date				Max	Min	Max	Min
		January 1st	April 1st	July 1st	October 1st	(days)	(days)	(%)	(%)
Galicia	La Coruña	129	120	112	134	134	112	24	4
	Lugo	121	115	111	120	121	111	12	3
	Orense	114	112	110	115	115	110	6	2
	Pontevedra	121	116	110	123	123	110	14	2
Asturias	Oviedo	126	117	112	123	126	112	17	4
Cantabria	Santander	131	119	113	137	137	113	27	5
País Vasco	Vitoria	126	118	113	124	126	113	17	5
	San Sebastián	152	127	126	163	163	126	51	17
	Bilbao	129	118	113	128	129	113	19	5
Navarra	Pamplona	123	117	113	119	123	113	14	5
La Rioja	Logroño	118	115	112	114	118	112	9	4
Castilla y León	Ávila	126	113	110	119	126	110	17	2
	Burgos	130	121	114	127	130	114	20	6
	León	124	116	112	117	124	112	15	4
	Palencia	123	117	112	118	123	112	14	4
	Salamanca	121	116	111	117	121	111	12	3
	Segovia	121	116	112	113	121	112	12	4
	Soria	130	116	112	120	130	112	20	4
	Valladolid	120	114	111	116	120	111	11	3
	Zamora	114	111	110	113	114	110	6	2
Aragón	Huesca	125	123	110	118	125	110	16	2
	Teruel	120	112	110	113	120	110	11	2
	Zaragoza	128	123	119	119	128	119	19	10
Cataluña	Barcelona	113	112	112	114	114	112	6	4
	Gerona	113	112	111	113	113	111	5	3
	Lérida	118	115	112	114	118	112	9	4
	Tarragona	115	112	110	114	115	110	6	2
Madrid	Madrid	114	112	110	113	114	110	6	2
Extremadura	Cáceres	116	114	111	118	118	111	9	3
	Badajoz	114	112	110	114	114	110	6	2
Castilla-La Mancha	Albacete	112	110	109	110	112	109	4	1
	Ciudad Real	111	111	110	110	111	110	3	2
	Cuenca	120	114	111	114	120	111	11	3
	Guadalajara	114	111	108	113	114	108	6	0
	Toledo	115	115	111	114	115	111	6	3
Valencia	Alicante	111	110	108	111	111	108	3	0
	Castellón	113	111	110	112	113	110	5	2
	Valencia	114	111	110	113	114	110	6	2
Andalucía	Almería	119	123	114	116	123	114	14	6
	Cádiz	123	117	114	122	123	114	14	6
	Córdoba	111	110	108	112	112	108	4	0
	Granada	115	111	110	113	115	110	6	2
	Huelva	113	111	109	116	116	109	7	1
	Jaén	112	109	108	110	112	108	4	0
	Málaga	120	113	109	119	120	109	11	1
	Sevilla	116	114	109	117	117	109	8	1
Murcia	Murcia	112	111	110	111	112	110	4	2
Duration	Max. (days)	152	127	126	163	163			
	Min. (days)	111	109	108	110		108		
Extension	Max. (%)	41	18	17	51			51	
	Min. (%)	3	1	0	2				0

Note: Lowest durations represented in green. Highest durations represented in red. Medium durations in yellow/orange.

Figure 5. Calculations of the average 5-storey Reinforced Concrete (RC) building project duration extension in Spain.

Baseline without climate: 95 working days									
Region	Province capital (Spain)	SS building				Duration		Extension	
		Project start date				Max	Min	Max	Min
		January 1st	April 1st	July 1st	October 1st	(days)	(days)	(%)	(%)
Galicia	La Coruña	108	104	96	109	109	96	15	1
	Lugo	103	99	96	101	103	96	8	1
	Orense	98	97	95	98	98	95	3	0
	Pontevedra	103	100	96	103	103	96	8	1
Asturias	Oviedo	106	103	96	102	106	96	12	1
Cantabria	Santander	109	102	97	111	111	97	17	2
País Vasco	Vitoria	107	103	97	105	107	97	13	2
	San Sebastián	123	109	103	125	125	103	32	8
	Bilbao	107	103	97	107	107	97	13	2
Navarra	Pamplona	104	102	99	101	104	99	9	4
La Rioja	Logroño	100	100	97	97	100	97	5	2
Castilla y León	Ávila	107	98	95	99	107	95	13	0
	Burgos	109	104	99	103	109	99	15	4
	León	105	101	96	98	105	96	11	1
	Palencia	105	102	96	99	105	96	11	1
	Salamanca	103	101	96	98	103	96	8	1
	Segovia	102	102	96	97	102	96	7	1
	Soria	109	102	96	99	109	96	15	1
	Valladolid	103	98	96	98	103	96	8	1
	Zamora	98	96	95	97	98	95	3	0
Aragón	Huesca	106	103	95	99	106	95	12	0
	Teruel	103	97	95	96	103	95	8	0
	Zaragoza	106	104	101	102	106	101	12	6
Cataluña	Barcelona	97	97	96	98	98	96	3	1
	Gerona	97	96	96	98	98	96	3	1
	Lérida	100	99	96	97	100	96	5	1
	Tarragona	98	97	96	99	99	96	4	1
Madrid	Madrid	98	97	95	97	98	95	3	0
Extremadura	Cáceres	99	98	96	100	100	96	5	1
	Badajoz	97	97	95	97	97	95	2	0
Castilla-La Mancha	Albacete	97	96	95	96	97	95	2	0
	Ciudad Real	97	96	95	96	97	95	2	0
	Cuenca	102	98	96	97	102	96	7	1
	Guadalajara	99	96	95	97	99	95	4	0
	Toledo	98	100	96	97	100	96	5	1
Valencia	Alicante	96	96	95	96	96	95	1	0
	Castellón	97	96	95	96	97	95	2	0
	Valencia	97	96	95	97	97	95	2	0
Andalucía	Almería	102	104	97	98	104	97	9	2
	Cádiz	104	99	97	103	104	97	9	2
	Córdoba	97	96	95	97	97	95	2	0
	Granada	98	96	96	97	98	96	3	1
	Huelva	97	96	95	98	98	95	3	0
	Jaén	97	96	95	96	97	95	2	0
	Málaga	103	97	95	99	103	95	8	0
	Sevilla	99	98	95	99	99	95	4	0
Murcia	Murcia	96	96	95	96	96	95	1	0
Duration	Max. (days)	123	109	103	125	125			
	Min. (days)	96	96	95	96		95		
Extension	Max. (%)	29	15	8	32			32	
	Min. (%)	1	1	0	1				0

Note: Lowest durations represented in green. Highest durations represented in red. Medium durations in yellow/orange.

Figure 6. Calculations of the average 5-storey Steel Structure (SS) building project duration extension in Spain.

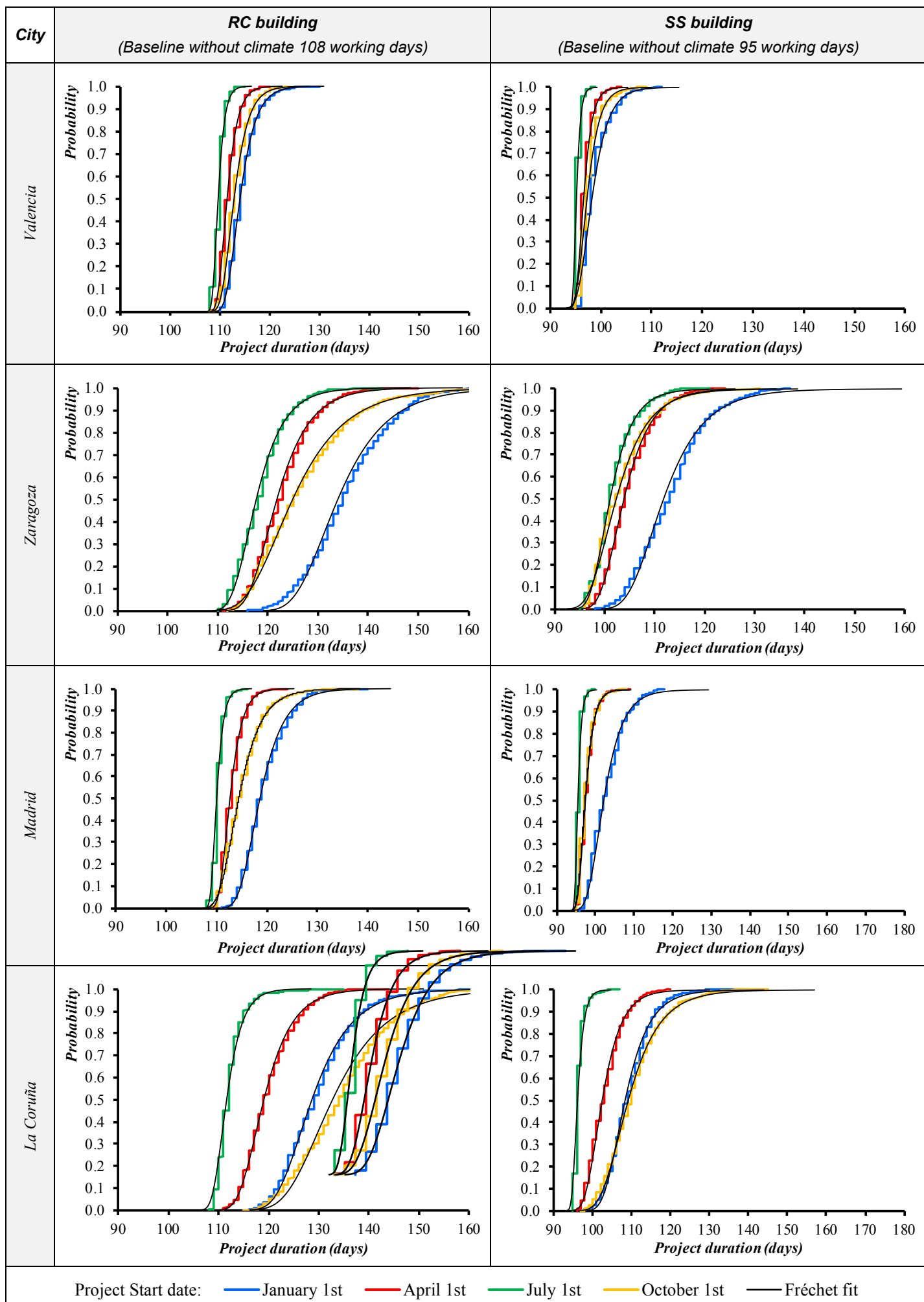


Figure 7. Concrete (RC) and Steel structure (SS) building actual values and stochastic simulations

Reference		Construction work	(Sub) activities	Weather agents
(Thomas et al., 1999)	[36]	(Steel) Buildings	Steel structure delivery and erection activities	Temperature and Snow
(El-Rayes and Moselhi, 2001)	[20]	Highways	Earthworks, Base courses, Drainage layers and Paving	Precipitation
(Jang et al., 2008)	[10]	Buildings	Generic	Temperature and Precipitation
(Thorpe and Karan, 2008)	[9]	Buildings	Clearing and grubbing, Excavation, Foundations, Structural erection, Floors, interiors, roofs and HVAC.	Temperature, Snow, Humidity and Precipitation
(Apipattanasri et al., 2010)	[31]	Highways	Concrete and Asphalt paving, Structures, Excavations and Grading	Precipitation, Air and soil Temperature, and Wind
(David et al., 2010)	[37]	Buildings	Generic	Solar radiation, Temperature, Humidity, Wind
(Shahin et al., 2011)	[11]	Pipelines	Clearing and grading, Trenching, Bedding, Pipe-fusing, Laying-in, Hydro testing, Compaction and Backfilling	(Air and soil) Temperature, Wind, Humidity and Precipitation
(Duffy et al., 2012)	[38]	Pipelines	Grading, stringing, bending, welding, trenching, coating, lower-in, backfill, cleanup	Temperature, Wind , Precipitation
(Dytchak et al., 2013)	[39]	Buildings	Generic	Temperature and wind
(Chinowsky et al., 2013)	[40]	Roads	Generic	Temperature and Precipitation
(Marzouk and Hamdy, 2013)	[41]	Buildings	Formwork	Precipitation and Temperature
(Shan and Goodrum, 2014)	[42]	Buildings	Steel structure	Temperature and Humidity
(Alshehri and Wedawatta, 2014)	[43]	Any	Concretes, equipment-related and workers' productivity in general	(Hot) temperature
(González et al., 2014)	[35]	Buildings	(RC) structures and Finishings (e.g., partition walls, windows, and doors)	Not specified
(Shahin et al., 2014)	[44]	Tunnelling	All tunnelling process, hoisting and muck car cleaning	(Air and Soil) Temperature and Wind
(Ballesteros-pérez et al., 2015)	[15]	Bridges	Earthworks, Formworks, Concrete and Asphalt pavings	Temperature, Precipitation, wind and electrical storms
(Jung et al., 2016)	[14]	(High-rise) Buildings	Generic + core wall, steel frame, deck plate, RC, curtain wall	Solar radiation, Temperature, Wind, Dew point temperature and Precipitation
(Li et al., 2016)	[45]	(RC) Buildings	Steel reinforced bars	(Hot) temperature

Table 1. Sample of recent publications dealing with the effect of weather in construction works

Raw Climatic Coefficients (RCC) ▼		Construction activities considered ▼						
Monthly days without...	Mathematical expressions	Earthworks (<i>E</i>)	Formworks (<i>F</i>)	Concrete (<i>C</i>)	Steelworks (<i>T</i>)	Scaffolding (<i>S</i>)	Outdoor paintings (<i>O</i>)	Asphalt Pavements (<i>P</i>)
...temperatures below 0°C (C_t^i)	$C_t^i = 1 - \frac{\text{Days of month } i \text{ with temperatures } \leq 0^\circ\text{C}}{\text{Total days of month } i}$ (1)			[9,15,24,26,27,44]	[9,27,36]			[15,25–28]
...precipitation above 1 mm (C_{p1}^i)	$C_{p1}^i = 1 - \frac{\text{Days of month } i \text{ with precipitations } \geq 1 \text{ mm}}{\text{Total days of month } i}$ (2)						[9,12]	[15,25,28]
...precipitation above 10 mm (C_{p10}^i)	$C_{p10}^i = 1 - \frac{\text{Days of month } i \text{ with precipitations } \geq 10 \text{ mm}}{\text{Total days of month } i}$ (3)	[15,25,26,31,44]		[15,25,26,46]				
...precipitation above 30 mm (C_{p30}^i)	$C_{p30}^i = 1 - \frac{\text{Days of month } i \text{ with precipitations } \geq 30 \text{ mm}}{\text{Total days of month } i}$ (4)				[9,15]			
...wind speed above 55 km/h (C_w^i)	$C_w^i = 1 - \frac{\text{Days of month } i \text{ with wind speed } \geq 55 \text{ km/h}}{\text{Total days of month } i}$ (5)		[12,15,19,27,29,41,47]	[19,27,48]	[15,19,27]	[12,19,27,30]	[19,27]	
...snow precipitation (C_s^i)	$C_s^i = 1 - \frac{\text{Days of month } i \text{ with snow precipitation}}{\text{Total days of month } i}$ (6)	[9,11,20,44]		[9,20,24]		[9,30]	[9,30]	[20,25,28]
...electrical storm (C_e^i)	$C_e^i = 1 - \frac{\text{Days of month } i \text{ with electrical storm}}{\text{Total days of month } i}$ (7)		[15,30]		[12,15]	[12,30]		
	Climatic Reduction Coefficients (CRC) ►	$E^i = C_{p10}^i \times C_s^i$ (8)	$F^i = C_w^i \times C_e^i$ (9)	$C^i = C_t^i \times C_{p10}^i \times C_w^i \times C_s^i$ (10)	$T^i = C_t^i \times C_{p30}^i \times C_w^i \times C_e^i$ (11)	$S^i = C_w^i \times C_s^i \times C_e^i$ (12)	$O^i = C_{p1}^i \times C_w^i \times C_s^i$ (13)	$P^i = C_t^i \times C_{p1}^i \times C_s^i$ (14)

Table 2. Monthly Climatic Reduction Coefficient calculations from the monthly Raw Climatic Coefficient values with bibliographic references

Valencia							
RCC	C_t	C_{p1}	C_{p10}	C_{p30}	C_w	C_s	C_e
C_t	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_{p1}	0.000	0.007	-	-	0.000	0.000	-
C_{p10}	0.000	-	0.002	-	0.000	0.000	-
C_{p30}	0.000	-	-	0.000	0.000	-	0.000
C_w	0.000	0.000	0.000	0.000	0.003	0.000	0.000
C_s	0.000	0.000	0.000	-	0.000	0.000	0.000
C_e	0.000	-	-	0.000	0.000	0.000	0.002

Zaragoza							
RCC	C_t	C_{p1}	C_{p10}	C_{p30}	C_w	C_s	C_e
C_t	0.007	-0.001	0.000	0.000	0.000	0.000	0.000
C_{p1}	-0.001	0.008	-	-	-0.001	0.000	-
C_{p10}	0.000	-	0.001	-	0.000	0.000	-
C_{p30}	0.000	-	-	0.000	0.000	-	0.000
C_w	0.000	-0.001	0.000	0.000	0.017	0.000	-0.001
C_s	0.000	0.000	0.000	-	0.000	0.000	0.000
C_e	0.000	-	-	0.000	-0.001	0.000	0.002

Madrid							
RCC	C_t	C_{p1}	C_{p10}	C_{p30}	C_w	C_s	C_e
C_t	0.005	-0.001	0.000	0.000	0.000	0.001	0.000
C_{p1}	-0.001	0.012	-	-	0.001	0.000	-
C_{p10}	0.000	-	0.002	-	0.000	0.000	-
C_{p30}	0.000	-	-	0.000	0.000	-	0.000
C_w	0.000	0.001	0.000	0.000	0.002	0.000	0.000
C_s	0.001	0.000	0.000	-	0.000	0.001	0.000
C_e	0.000	-	-	0.000	0.000	0.000	0.002

La Coruña							
RCC	C_t	C_{p1}	C_{p10}	C_{p30}	C_w	C_s	C_e
C_t	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_{p1}	0.000	0.023	-	-	0.009	0.000	-
C_{p10}	0.000	-	0.005	-	0.004	0.000	-
C_{p30}	0.000	-	-	0.000	0.000	-	0.000
C_w	0.000	0.009	0.004	0.000	0.013	0.000	0.001
C_s	0.000	0.000	0.000	-	0.000	0.000	0.000
C_e	0.000	-	-	0.000	0.001	0.000	0.002

Note: diagonal cells represent the variances, cells with “-” represent combinations of RCC not used.

Table 3. Covariance matrices among the RCC variables for four specific Spanish locations

Region	Province capital	Earthworks (E)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,88	0,90	0,93	0,92	0,93	0,95	0,97	0,97	0,93	0,86	0,83	0,85	0,91
	Lugo	0,83	0,84	0,90	0,88	0,92	0,94	0,97	0,96	0,92	0,85	0,81	0,82	0,89
	Orense	0,88	0,91	0,94	0,92	0,94	0,96	0,98	0,98	0,95	0,88	0,87	0,86	0,92
	Pontevedra	0,78	0,82	0,86	0,82	0,87	0,92	0,95	0,94	0,89	0,77	0,76	0,77	0,85
Asturias	Oviedo	0,87	0,86	0,89	0,89	0,92	0,94	0,96	0,95	0,93	0,90	0,86	0,89	0,91
Cantabria	Santander	0,87	0,89	0,90	0,88	0,92	0,94	0,95	0,93	0,91	0,88	0,82	0,86	0,90
País Vasco	Vitoria	0,87	0,88	0,91	0,90	0,93	0,95	0,96	0,95	0,95	0,91	0,87	0,88	0,91
	San Sebastián	0,81	0,80	0,86	0,84	0,88	0,92	0,91	0,89	0,87	0,83	0,78	0,81	0,85
	Bilbao	0,85	0,86	0,89	0,88	0,92	0,94	0,96	0,94	0,93	0,88	0,81	0,86	0,89
Navarra	Pamplona	0,89	0,87	0,90	0,90	0,95	0,95	0,96	0,97	0,95	0,93	0,90	0,89	0,92
La Rioja	Logroño	0,93	0,94	0,96	0,95	0,96	0,96	0,97	0,98	0,97	0,96	0,96	0,94	0,96
Castilla y León	Ávila	0,84	0,83	0,91	0,91	0,94	0,97	0,99	0,98	0,98	0,94	0,89	0,86	0,92
	Burgos	0,82	0,84	0,89	0,88	0,93	0,95	0,98	0,98	0,97	0,94	0,88	0,83	0,91
	León	0,83	0,87	0,92	0,93	0,94	0,97	0,98	0,98	0,96	0,94	0,91	0,86	0,92
	Palencia	0,85	0,89	0,93	0,92	0,94	0,97	0,98	0,98	0,97	0,93	0,90	0,88	0,93
	Salamanca	0,93	0,92	0,97	0,95	0,95	0,97	0,99	0,99	0,97	0,95	0,94	0,92	0,96
	Segovia	0,97	0,87	0,92	0,92	0,93	0,95	0,99	0,98	0,98	0,94	0,90	0,90	0,94
	Soria	0,81	0,79	0,88	0,86	0,92	0,95	0,97	0,97	0,96	0,94	0,88	0,83	0,90
	Valladolid	0,87	0,91	0,96	0,93	0,95	0,97	0,99	0,98	0,97	0,94	0,92	0,90	0,94
	Zamora	0,93	0,94	0,98	0,95	0,97	0,98	0,99	0,99	0,97	0,95	0,94	0,92	0,96
Aragón	Huesca	0,94	0,94	0,96	0,93	0,95	0,97	0,98	0,97	0,95	0,94	0,95	0,94	0,95
	Teruel	0,90	0,90	0,92	0,92	0,94	0,96	0,97	0,97	0,96	0,96	0,95	0,93	0,94
	Zaragoza	0,96	0,96	0,98	0,96	0,96	0,97	0,99	0,99	0,97	0,97	0,97	0,97	0,97
Cataluña	Barcelona	0,95	0,95	0,96	0,96	0,96	0,97	0,98	0,94	0,92	0,92	0,94	0,96	0,95
	Gerona	0,93	0,94	0,95	0,93	0,93	0,93	0,96	0,96	0,93	0,92	0,94	0,94	0,94
	Lérida	0,96	0,98	0,97	0,97	0,95	0,97	0,99	0,98	0,96	0,95	0,97	0,98	0,97
	Tarragona	0,96	0,96	0,97	0,96	0,95	0,98	0,99	0,96	0,93	0,93	0,95	0,96	0,96
Madrid	Madrid	0,94	0,92	0,97	0,94	0,95	0,98	0,99	0,99	0,98	0,93	0,93	0,92	0,95
Extremadura	Cáceres	0,93	0,95	0,96	0,95	0,95	0,98	0,99	0,99	0,97	0,91	0,90	0,91	0,95
	Badajoz	0,94	0,94	0,97	0,95	0,97	0,99	1,00	1,00	0,98	0,93	0,93	0,92	0,96
Castilla-La Mancha	Albacete	0,96	0,93	0,95	0,96	0,96	0,97	0,99	0,99	0,97	0,96	0,95	0,95	0,96
	Ciudad Real	0,94	0,94	0,97	0,95	0,97	0,98	0,99	1,00	0,98	0,94	0,96	0,93	0,96
	Cuenca	0,89	0,89	0,93	0,92	0,94	0,95	0,99	0,98	0,95	0,93	0,92	0,91	0,93
	Guadalajara	0,95	0,93	0,97	0,94	0,95	0,97	0,99	1,00	0,97	0,92	0,95	0,93	0,95
	Toledo	0,96	0,96	0,97	0,96	0,96	0,98	0,99	0,99	0,98	0,95	0,96	0,96	0,97
Valencia	Alicante	0,98	0,98	0,98	0,97	0,98	0,99	1,00	0,99	0,96	0,96	0,96	0,98	0,98
	Castellón	0,96	0,97	0,97	0,96	0,96	0,98	0,99	0,98	0,93	0,94	0,95	0,96	0,96
	Valencia	0,97	0,96	0,97	0,96	0,96	0,99	0,99	0,98	0,94	0,95	0,95	0,95	0,96
Andalucía	Almería	0,98	0,98	0,98	0,99	0,99	1,00	1,00	1,00	0,99	0,98	0,97	0,97	0,98
	Cádiz	0,92	0,93	0,96	0,95	0,98	0,99	1,00	1,00	0,97	0,93	0,90	0,90	0,95
	Córdoba	0,92	0,94	0,95	0,94	0,96	0,99	1,00	0,99	0,96	0,91	0,92	0,88	0,95
	Granada	0,93	0,95	0,97	0,97	0,97	0,99	1,00	1,00	0,98	0,95	0,93	0,94	0,97
	Huelva	0,93	0,95	0,97	0,95	0,97	1,00	1,00	1,00	0,98	0,92	0,92	0,90	0,96
	Jaén	0,92	0,92	0,94	0,95	0,96	0,98	1,00	0,99	0,97	0,95	0,93	0,92	0,95
	Málaga	0,93	0,95	0,95	0,95	0,98	0,99	1,00	0,99	0,98	0,94	0,92	0,90	0,96
	Sevilla	0,92	0,95	0,96	0,94	0,97	0,99	1,00	0,99	0,97	0,93	0,91	0,88	0,95
Murcia	Murcia	0,97	0,98	0,97	0,98	0,97	0,99	1,00	0,99	0,97	0,96	0,97	0,97	0,98

First set. Annual and monthly CRC values of Spanish peninsular capital of province cities (1 out of 6)

Región	Province capital	Formworks (F)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,69	0,68	0,74	0,69	0,80	0,87	0,92	0,92	0,87	0,79	0,70	0,67	0,78
	Lugo	0,99	0,88	0,90	0,89	0,85	0,94	0,95	0,93	0,92	0,91	0,93	0,99	0,92
	Orense	0,95	0,94	0,96	0,92	0,88	0,93	0,94	0,94	0,95	0,95	0,96	0,95	0,94
	Pontevedra	0,96	0,90	0,90	0,92	0,91	0,96	0,97	0,97	0,96	0,95	0,96	0,87	0,94
Asturias	Oviedo	0,80	0,78	0,80	0,78	0,80	0,90	0,89	0,89	0,89	0,86	0,81	0,79	0,83
Cantabria	Santander	0,68	0,68	0,74	0,73	0,83	0,90	0,90	0,92	0,85	0,74	0,65	0,66	0,77
Pais Vasco	Vitoria	0,77	0,77	0,79	0,76	0,77	0,82	0,83	0,82	0,85	0,81	0,80	0,78	0,80
	San Sebastián	0,48	0,52	0,57	0,58	0,66	0,78	0,79	0,77	0,72	0,57	0,51	0,49	0,62
	Bilbao	0,73	0,73	0,76	0,75	0,81	0,87	0,89	0,86	0,87	0,80	0,78	0,75	0,80
Navarra	Pamplona	0,87	0,86	0,80	0,78	0,78	0,82	0,79	0,79	0,85	0,84	0,88	0,90	0,83
La Rioja	Logroño	0,87	0,86	0,86	0,81	0,78	0,80	0,80	0,81	0,89	0,89	0,91	0,88	0,85
Castilla y León	Ávila	0,92	0,91	0,90	0,92	0,89	0,91	0,94	0,94	0,95	0,94	0,91	0,89	0,92
	Burgos	0,84	0,83	0,82	0,76	0,73	0,77	0,78	0,79	0,83	0,82	0,81	0,82	0,80
	León	0,88	0,85	0,84	0,78	0,77	0,83	0,83	0,87	0,89	0,89	0,90	0,90	0,85
	Palencia	0,87	0,85	0,86	0,81	0,79	0,82	0,83	0,85	0,87	0,89	0,88	0,87	0,85
	Salamanca	0,87	0,86	0,85	0,82	0,80	0,82	0,87	0,88	0,88	0,87	0,89	0,85	0,86
	Segovia	0,86	0,86	0,84	0,84	0,78	0,86	0,92	0,80	0,86	0,98	1,00	0,84	0,87
	Soria	0,86	0,84	0,86	0,83	0,79	0,81	0,82	0,81	0,86	0,90	0,89	0,87	0,85
	Valladolid	0,90	0,88	0,90	0,85	0,82	0,83	0,84	0,87	0,89	0,92	0,91	0,91	0,88
	Zamora	0,93	0,94	0,95	0,95	0,88	0,92	0,92	0,92	0,93	0,94	0,95	0,94	0,93
Aragón	Huesca	0,75	0,74	0,76	0,71	0,73	0,70	0,88	0,87	0,89	0,96	0,77	0,82	0,80
	Teruel	1,00	1,00	0,99	0,98	0,90	0,86	0,86	0,83	0,89	0,96	1,00	0,94	0,93
	Zaragoza	0,75	0,70	0,68	0,69	0,68	0,70	0,69	0,73	0,77	0,81	0,79	0,78	0,73
Cataluña	Barcelona	0,93	0,92	0,90	0,87	0,90	0,94	0,94	0,86	0,86	0,86	0,90	0,92	0,90
	Gerona	0,95	0,95	0,91	0,91	0,90	0,90	0,89	0,82	0,86	0,90	0,94	0,96	0,91
	Lérida	0,88	0,83	0,84	0,77	0,82	0,83	0,85	0,84	0,84	0,90	0,90	0,91	0,85
	Tarragona	0,78	1,00	0,82	0,82	0,95	0,95	0,96	0,92	0,90	0,94	0,85	0,99	0,91
Madrid	Madrid	0,94	0,92	0,91	0,88	0,86	0,88	0,94	0,92	0,91	0,93	0,97	0,93	0,92
Extremadura	Cáceres	0,88	0,88	0,88	0,84	0,83	0,91	0,93	0,93	0,89	0,86	0,90	0,87	0,88
	Badajoz	0,92	0,92	0,90	0,85	0,86	0,92	0,96	0,96	0,92	0,91	0,93	0,90	0,91
Castilla-La Mancha	Albacete	1,00	1,00	0,98	0,95	0,90	0,89	0,93	0,91	0,88	0,95	0,99	0,99	0,95
	Ciudad Real	1,00	0,95	0,96	0,93	0,88	0,88	0,94	0,93	0,93	0,97	0,97	0,97	0,94
	Cuenca	0,95	0,94	0,93	0,91	0,86	0,82	0,89	0,86	0,90	0,93	0,96	0,94	0,91
	Guadalajara	1,00	1,00	0,99	0,95	0,88	0,90	0,92	1,00	0,94	0,96	1,00	1,00	0,96
	Toledo	0,90	0,86	0,86	0,82	0,80	0,82	0,89	0,87	0,89	0,90	0,90	0,90	0,87
Valencia	Alicante	0,95	0,94	0,92	0,91	0,91	0,94	0,97	0,96	0,90	0,92	0,96	0,95	0,94
	Castellón	0,91	0,92	0,91	0,87	0,90	0,90	0,92	0,86	0,85	0,89	0,93	0,91	0,90
	Valencia	0,88	0,88	0,91	0,88	0,91	0,92	0,94	0,92	0,89	0,88	0,92	0,91	0,90
Andalucía	Almería	0,82	0,78	0,76	0,70	0,73	0,77	0,83	0,86	0,84	0,84	0,82	0,82	0,80
	Cádiz	0,80	0,75	0,75	0,80	0,82	0,83	0,83	0,89	0,85	0,81	0,79	0,77	0,81
	Córdoba	0,99	0,98	0,97	0,94	0,94	0,96	0,98	0,98	0,94	0,95	0,98	0,98	0,96
	Granada	0,95	0,93	0,93	0,91	0,90	0,91	0,94	0,93	0,93	0,93	0,94	0,92	0,93
	Huelva	0,91	0,92	0,92	0,89	0,96	0,98	0,99	0,97	0,96	0,91	0,90	0,88	0,93
	Jaén	1,00	1,00	0,99	0,98	0,97	0,97	0,99	0,98	0,97	0,98	1,00	0,99	0,99
	Málaga	0,74	0,79	0,83	0,84	0,88	0,94	0,97	0,96	0,92	0,89	0,80	0,74	0,86
	Sevilla	0,89	0,89	0,89	0,84	0,89	0,94	0,96	0,96	0,94	0,88	0,90	0,87	0,91
Murcia	Murcia	0,94	0,94	0,93	0,89	0,90	0,91	0,96	0,94	0,88	0,91	0,96	0,96	0,93

First set. Annual and monthly CRC values of Spanish peninsular capital of province cities (2 out of 6)

Region	Province capital	Concrete (C)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,63	0,63	0,72	0,67	0,79	0,86	0,92	0,92	0,85	0,71	0,62	0,60	0,74
	Lugo	0,78	0,72	0,81	0,82	0,88	0,94	0,97	0,95	0,88	0,80	0,77	0,77	0,84
	Orense	0,84	0,87	0,92	0,90	0,93	0,96	0,98	0,98	0,95	0,88	0,86	0,82	0,91
	Pontevedra	0,78	0,76	0,80	0,78	0,85	0,91	0,94	0,94	0,88	0,77	0,76	0,70	0,82
Asturias	Oviedo	0,71	0,69	0,74	0,75	0,84	0,91	0,92	0,92	0,87	0,79	0,73	0,72	0,80
Cantabria	Santander	0,60	0,62	0,69	0,67	0,81	0,90	0,91	0,90	0,81	0,67	0,55	0,59	0,72
País Vasco	Vitoria	0,66	0,68	0,73	0,73	0,82	0,88	0,90	0,88	0,87	0,77	0,72	0,68	0,77
	San Sebastián	0,40	0,44	0,51	0,52	0,65	0,80	0,81	0,78	0,69	0,50	0,42	0,41	0,57
	Bilbao	0,65	0,65	0,71	0,72	0,83	0,90	0,93	0,89	0,87	0,74	0,67	0,66	0,77
Navarra	Pamplona	0,74	0,73	0,74	0,75	0,85	0,90	0,86	0,89	0,88	0,82	0,79	0,77	0,81
La Rioja	Logroño	0,79	0,79	0,83	0,81	0,87	0,90	0,90	0,92	0,92	0,87	0,87	0,81	0,86
Castilla y León	Ávila	0,61	0,66	0,76	0,84	0,90	0,97	0,99	0,98	0,98	0,89	0,76	0,67	0,83
	Burgos	0,58	0,62	0,70	0,70	0,78	0,83	0,85	0,85	0,86	0,78	0,69	0,61	0,74
	León	0,65	0,69	0,76	0,76	0,83	0,90	0,90	0,92	0,90	0,84	0,81	0,73	0,81
	Palencia	0,68	0,71	0,80	0,78	0,84	0,89	0,90	0,91	0,90	0,85	0,79	0,72	0,81
	Salamanca	0,70	0,72	0,82	0,80	0,83	0,90	0,94	0,94	0,92	0,85	0,82	0,70	0,83
	Segovia	0,76	0,71	0,76	0,80	0,82	0,95	0,99	0,89	0,91	0,94	0,89	0,72	0,84
	Soria	0,58	0,59	0,73	0,75	0,85	0,90	0,92	0,91	0,92	0,87	0,76	0,63	0,78
	Valladolid	0,73	0,75	0,86	0,83	0,88	0,91	0,92	0,93	0,92	0,88	0,83	0,78	0,85
	Zamora	0,83	0,85	0,92	0,92	0,94	0,96	0,97	0,97	0,95	0,90	0,89	0,83	0,91
Aragón	Huesca	0,69	0,68	0,73	0,69	0,77	0,78	0,98	0,97	0,95	0,94	0,74	0,75	0,81
	Teruel	0,67	0,73	0,87	0,92	0,94	0,96	0,97	0,97	0,96	0,96	0,90	0,67	0,87
	Zaragoza	0,71	0,67	0,68	0,69	0,75	0,78	0,78	0,82	0,82	0,81	0,77	0,75	0,75
Cataluña	Barcelona	0,89	0,89	0,88	0,87	0,91	0,96	0,96	0,92	0,90	0,87	0,89	0,89	0,90
	Gerona	0,86	0,89	0,89	0,89	0,92	0,92	0,95	0,94	0,92	0,90	0,90	0,90	0,91
	Lérida	0,80	0,78	0,82	0,79	0,87	0,90	0,93	0,93	0,89	0,90	0,87	0,85	0,86
	Tarragona	0,75	0,96	0,80	0,80	0,95	0,98	0,99	0,96	0,93	0,93	0,83	0,96	0,90
Madrid	Madrid	0,87	0,84	0,90	0,86	0,90	0,95	0,99	0,96	0,95	0,90	0,91	0,86	0,91
Extremadura	Cáceres	0,82	0,85	0,87	0,83	0,87	0,94	0,95	0,96	0,92	0,82	0,82	0,80	0,87
	Badajoz	0,86	0,87	0,89	0,86	0,91	0,95	0,99	0,98	0,95	0,88	0,88	0,85	0,90
Castilla-La Mancha	Albacete	0,84	0,87	0,94	0,96	0,96	0,97	0,99	0,99	0,97	0,96	0,93	0,89	0,94
	Ciudad Real	0,90	0,89	0,94	0,92	0,95	0,96	0,98	0,98	0,97	0,94	0,93	0,89	0,94
	Cuenca	0,74	0,78	0,86	0,86	0,90	0,91	0,95	0,93	0,93	0,89	0,88	0,80	0,87
	Guadalajara	0,78	0,84	0,95	0,94	0,95	0,97	0,99	1,00	0,97	0,92	0,92	0,79	0,92
	Toledo	0,84	0,83	0,84	0,81	0,86	0,89	0,93	0,93	0,93	0,88	0,86	0,85	0,87
Valencia	Alicante	0,93	0,94	0,92	0,93	0,96	0,98	0,99	0,99	0,95	0,95	0,94	0,94	0,95
	Castellón	0,89	0,90	0,90	0,88	0,94	0,97	0,98	0,97	0,91	0,91	0,91	0,88	0,92
	Valencia	0,86	0,86	0,89	0,88	0,93	0,97	0,99	0,96	0,92	0,90	0,89	0,88	0,91
Andalucía	Almería	0,81	0,78	0,75	0,70	0,73	0,78	0,84	0,88	0,86	0,84	0,82	0,81	0,80
	Cádiz	0,77	0,73	0,75	0,78	0,82	0,83	0,84	0,89	0,85	0,79	0,75	0,73	0,79
	Córdoba	0,91	0,94	0,95	0,94	0,96	0,99	1,00	0,99	0,96	0,91	0,92	0,88	0,95
	Granada	0,82	0,87	0,92	0,91	0,93	0,96	0,96	0,96	0,95	0,92	0,89	0,84	0,91
	Huelva	0,86	0,89	0,91	0,87	0,96	0,98	0,99	0,98	0,96	0,86	0,85	0,83	0,91
	Jaén	0,92	0,92	0,94	0,95	0,96	0,98	1,00	0,99	0,97	0,95	0,93	0,92	0,95
	Málaga	0,72	0,78	0,81	0,84	0,90	0,96	0,98	0,97	0,94	0,88	0,76	0,70	0,85
	Sevilla	0,83	0,86	0,87	0,83	0,90	0,95	0,97	0,97	0,94	0,85	0,84	0,79	0,88
Murcia	Murcia	0,91	0,93	0,91	0,92	0,94	0,96	0,99	0,98	0,96	0,94	0,95	0,94	0,94

First set. Annual and monthly CRC values of Spanish peninsular capital of province cities (3 out of 6)

Region	Province capital	Steelworks (T)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,68	0,67	0,74	0,69	0,80	0,87	0,91	0,92	0,87	0,77	0,69	0,66	0,77
	Lugo	0,93	0,82	0,87	0,86	0,84	0,93	0,95	0,92	0,91	0,89	0,91	0,94	0,90
	Orense	0,92	0,93	0,96	0,92	0,87	0,92	0,94	0,94	0,94	0,93	0,95	0,93	0,93
	Pontevedra	0,91	0,88	0,88	0,90	0,89	0,95	0,96	0,96	0,94	0,88	0,88	0,81	0,90
Asturias	Oviedo	0,75	0,73	0,77	0,76	0,80	0,89	0,88	0,88	0,88	0,84	0,80	0,76	0,81
Cantabria	Santander	0,66	0,66	0,73	0,72	0,83	0,89	0,89	0,92	0,83	0,72	0,63	0,65	0,76
País Vasco	Vitoria	0,72	0,72	0,76	0,74	0,77	0,82	0,82	0,81	0,85	0,80	0,78	0,74	0,78
	San Sebastián	0,45	0,48	0,56	0,56	0,64	0,77	0,78	0,75	0,70	0,54	0,48	0,47	0,60
	Bilbao	0,70	0,71	0,75	0,75	0,80	0,87	0,88	0,85	0,86	0,79	0,76	0,73	0,79
Navarra	Pamplona	0,81	0,78	0,77	0,75	0,78	0,82	0,79	0,79	0,85	0,84	0,85	0,85	0,81
La Rioja	Logroño	0,83	0,81	0,85	0,80	0,78	0,79	0,80	0,81	0,88	0,89	0,90	0,86	0,84
Castilla y León	Ávila	0,78	0,77	0,83	0,85	0,88	0,91	0,94	0,94	0,95	0,93	0,85	0,80	0,87
	Burgos	0,71	0,72	0,74	0,71	0,72	0,77	0,78	0,78	0,82	0,81	0,77	0,73	0,76
	León	0,76	0,76	0,80	0,76	0,77	0,83	0,83	0,86	0,88	0,88	0,87	0,83	0,82
	Palencia	0,78	0,77	0,83	0,78	0,79	0,82	0,83	0,84	0,87	0,88	0,85	0,81	0,82
	Salamanca	0,83	0,81	0,83	0,80	0,79	0,81	0,87	0,88	0,87	0,87	0,88	0,81	0,84
	Segovia	0,86	0,77	0,80	0,80	0,77	0,85	0,92	0,80	0,86	0,97	0,95	0,78	0,85
	Soria	0,72	0,69	0,77	0,76	0,78	0,80	0,82	0,81	0,86	0,90	0,83	0,76	0,79
	Valladolid	0,81	0,81	0,87	0,82	0,82	0,82	0,84	0,87	0,89	0,92	0,89	0,86	0,85
	Zamora	0,90	0,90	0,94	0,94	0,88	0,92	0,92	0,92	0,93	0,93	0,94	0,91	0,92
Aragón	Huesca	0,73	0,72	0,75	0,71	0,72	0,70	0,88	0,87	0,88	0,96	0,77	0,80	0,79
	Teruel	0,92	0,91	0,93	0,93	0,89	0,85	0,86	0,82	0,89	0,96	0,96	0,88	0,90
	Zaragoza	0,73	0,69	0,68	0,68	0,68	0,70	0,69	0,73	0,76	0,81	0,79	0,77	0,73
Cataluña	Barcelona	0,93	0,91	0,89	0,86	0,89	0,93	0,94	0,85	0,84	0,84	0,88	0,91	0,89
	Gerona	0,92	0,93	0,91	0,90	0,89	0,90	0,88	0,81	0,84	0,88	0,93	0,94	0,89
	Lérida	0,87	0,82	0,83	0,77	0,81	0,83	0,85	0,84	0,83	0,90	0,90	0,90	0,85
	Tarragona	0,77	0,99	0,81	0,82	0,94	0,95	0,95	0,91	0,88	0,92	0,84	0,99	0,90
Madrid	Madrid	0,91	0,88	0,90	0,87	0,86	0,88	0,94	0,92	0,91	0,93	0,96	0,91	0,91
Extremadura	Cáceres	0,87	0,87	0,88	0,84	0,82	0,90	0,93	0,93	0,89	0,85	0,88	0,86	0,88
	Badajoz	0,91	0,91	0,90	0,85	0,86	0,92	0,96	0,96	0,91	0,90	0,92	0,90	0,91
Castilla-La Mancha	Albacete	0,97	0,94	0,96	0,94	0,89	0,89	0,93	0,91	0,88	0,94	0,98	0,97	0,93
	Ciudad Real	0,96	0,92	0,95	0,92	0,88	0,88	0,94	0,93	0,93	0,96	0,96	0,95	0,93
	Cuenca	0,88	0,87	0,90	0,89	0,86	0,81	0,89	0,85	0,90	0,93	0,93	0,90	0,88
	Guadalajara	0,97	0,95	0,98	0,94	0,88	0,90	0,92	1,00	0,93	0,96	0,99	0,98	0,95
	Toledo	0,88	0,85	0,85	0,82	0,80	0,82	0,89	0,87	0,89	0,90	0,90	0,89	0,86
Valencia	Alicante	0,95	0,94	0,92	0,90	0,90	0,93	0,97	0,96	0,89	0,91	0,96	0,94	0,93
	Castellón	0,90	0,91	0,91	0,87	0,89	0,90	0,92	0,85	0,83	0,87	0,92	0,90	0,89
	Valencia	0,87	0,88	0,90	0,88	0,91	0,92	0,94	0,92	0,87	0,87	0,91	0,90	0,90
Andalucía	Almería	0,81	0,78	0,76	0,69	0,73	0,77	0,83	0,86	0,84	0,83	0,82	0,82	0,80
	Cádiz	0,79	0,75	0,75	0,80	0,81	0,83	0,83	0,89	0,85	0,80	0,76	0,76	0,80
	Córdoba	0,97	0,97	0,96	0,93	0,93	0,96	0,98	0,98	0,93	0,93	0,96	0,95	0,95
	Granada	0,93	0,92	0,93	0,91	0,89	0,91	0,94	0,93	0,92	0,93	0,93	0,92	0,92
	Huelva	0,90	0,91	0,91	0,88	0,96	0,98	0,99	0,97	0,96	0,89	0,89	0,87	0,93
	Jaén	0,98	0,98	0,98	0,98	0,96	0,97	0,99	0,98	0,96	0,97	0,99	0,97	0,98
	Málaga	0,73	0,78	0,82	0,84	0,88	0,94	0,97	0,96	0,91	0,87	0,77	0,72	0,85
	Sevilla	0,88	0,88	0,88	0,84	0,89	0,94	0,96	0,96	0,94	0,87	0,87	0,85	0,90
Murcia	Murcia	0,93	0,93	0,92	0,89	0,90	0,90	0,96	0,94	0,88	0,91	0,96	0,95	0,92

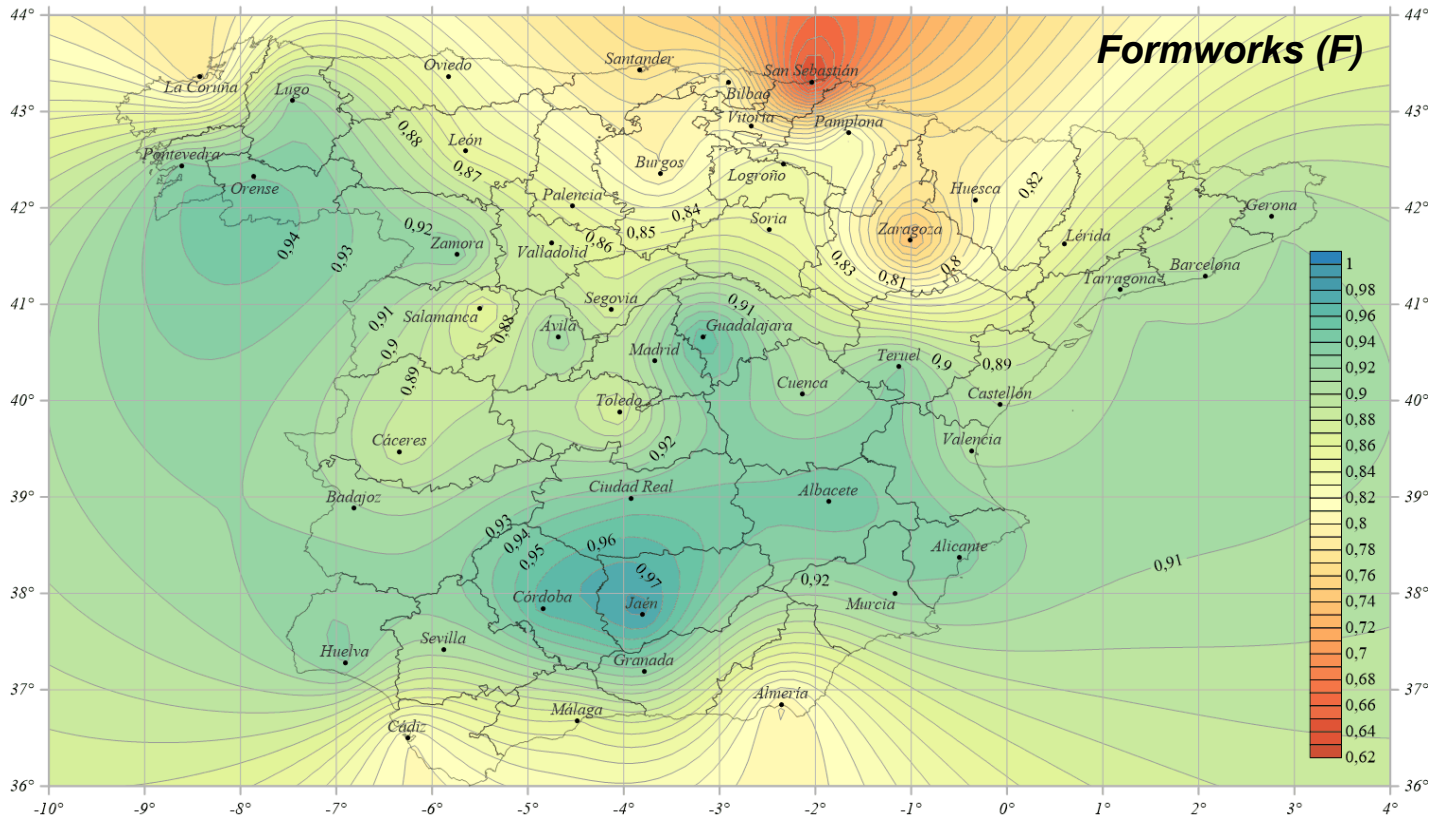
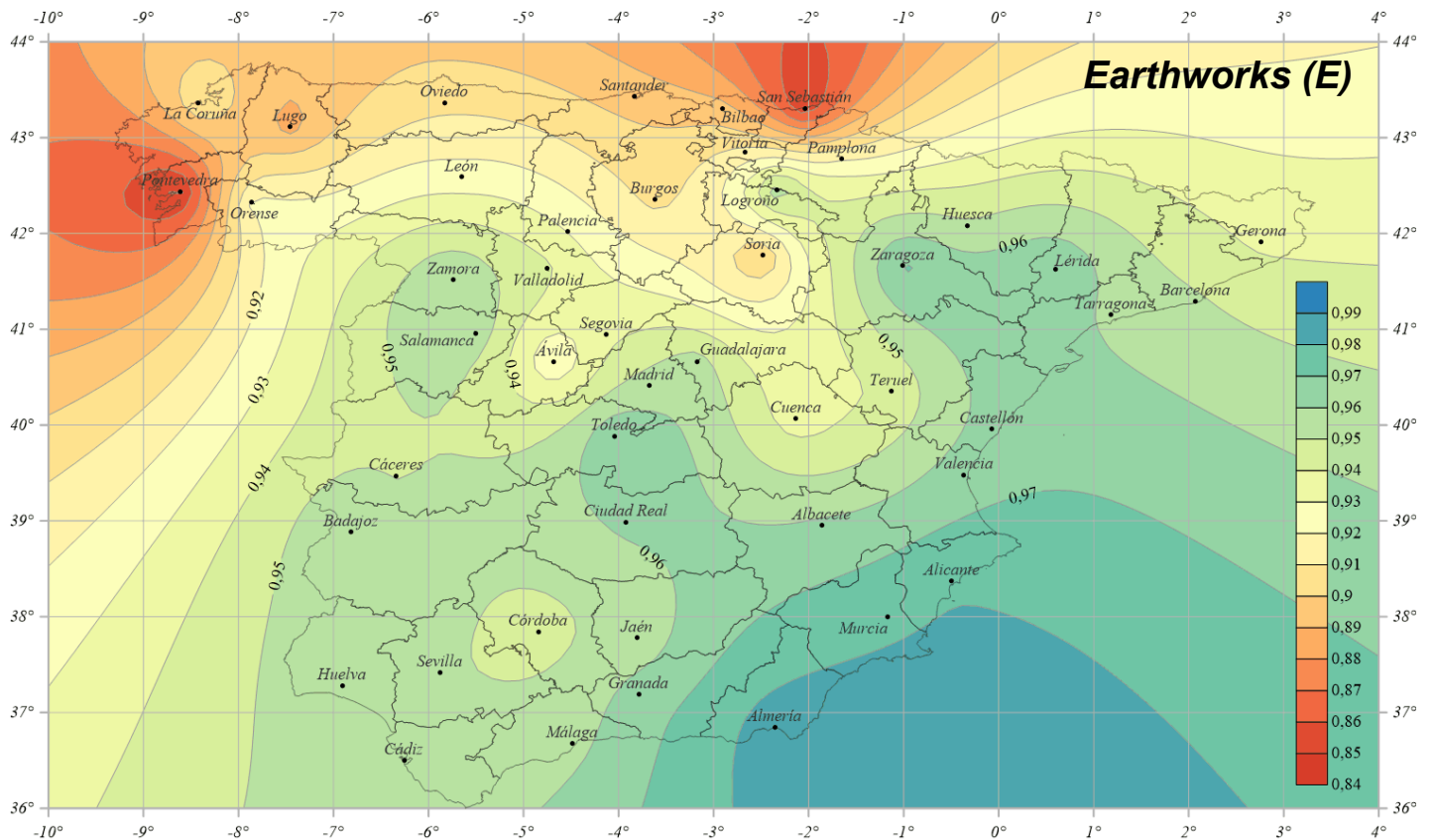
First set. Annual and monthly CRC values of Spanish peninsular capital of province cities (4 out of 6)

Region	Province capital	Scaffolding (S)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,68	0,67	0,74	0,69	0,80	0,87	0,92	0,92	0,87	0,79	0,70	0,67	0,78
	Lugo	0,94	0,83	0,87	0,87	0,85	0,94	0,95	0,93	0,92	0,91	0,92	0,96	0,91
	Orense	0,93	0,94	0,96	0,92	0,88	0,93	0,94	0,94	0,95	0,95	0,96	0,94	0,94
	Pontevedra	0,95	0,90	0,90	0,92	0,91	0,96	0,97	0,97	0,96	0,95	0,96	0,87	0,94
Asturias	Oviedo	0,76	0,74	0,78	0,77	0,80	0,90	0,89	0,89	0,89	0,86	0,81	0,77	0,82
Cantabria	Santander	0,67	0,67	0,74	0,73	0,83	0,90	0,90	0,92	0,85	0,74	0,65	0,66	0,77
Pais Vasco	Vitoria	0,73	0,72	0,77	0,75	0,77	0,82	0,83	0,82	0,85	0,81	0,79	0,75	0,79
	San Sebastián	0,46	0,49	0,56	0,58	0,66	0,78	0,79	0,77	0,72	0,57	0,50	0,48	0,62
	Bilbao	0,72	0,71	0,76	0,75	0,81	0,87	0,89	0,86	0,87	0,80	0,78	0,74	0,80
Navarra	Pamplona	0,81	0,78	0,77	0,75	0,78	0,82	0,79	0,79	0,85	0,84	0,86	0,85	0,81
La Rioja	Logroño	0,83	0,81	0,85	0,80	0,78	0,80	0,80	0,81	0,89	0,89	0,90	0,86	0,84
Castilla y León	Ávila	0,78	0,77	0,84	0,85	0,88	0,91	0,94	0,94	0,95	0,94	0,85	0,80	0,87
	Burgos	0,71	0,72	0,74	0,71	0,72	0,77	0,78	0,79	0,83	0,82	0,77	0,73	0,76
	León	0,76	0,76	0,80	0,76	0,77	0,83	0,83	0,87	0,89	0,89	0,87	0,84	0,82
	Palencia	0,78	0,77	0,83	0,78	0,79	0,82	0,83	0,85	0,87	0,89	0,85	0,82	0,82
	Salamanca	0,83	0,81	0,83	0,80	0,79	0,82	0,87	0,88	0,88	0,87	0,88	0,81	0,84
	Segovia	0,86	0,77	0,80	0,80	0,77	0,86	0,92	0,80	0,86	0,98	0,95	0,78	0,85
	Soria	0,72	0,69	0,77	0,76	0,78	0,81	0,82	0,81	0,86	0,90	0,83	0,76	0,80
	Valladolid	0,81	0,81	0,87	0,82	0,82	0,83	0,84	0,87	0,89	0,92	0,89	0,87	0,86
	Zamora	0,90	0,90	0,94	0,94	0,88	0,92	0,92	0,92	0,93	0,94	0,94	0,91	0,92
Aragón	Huesca	0,73	0,72	0,75	0,71	0,73	0,70	0,88	0,87	0,89	0,96	0,77	0,80	0,80
	Teruel	0,92	0,91	0,93	0,93	0,89	0,86	0,86	0,83	0,89	0,96	0,97	0,88	0,90
	Zaragoza	0,73	0,69	0,68	0,69	0,68	0,70	0,69	0,73	0,77	0,81	0,79	0,77	0,73
Cataluña	Barcelona	0,93	0,91	0,90	0,87	0,90	0,94	0,94	0,86	0,86	0,86	0,90	0,92	0,90
	Gerona	0,94	0,94	0,91	0,91	0,90	0,90	0,89	0,82	0,86	0,90	0,94	0,95	0,91
	Lérida	0,87	0,82	0,83	0,77	0,82	0,83	0,85	0,84	0,84	0,90	0,90	0,90	0,85
	Tarragona	0,78	0,99	0,82	0,82	0,95	0,95	0,96	0,92	0,90	0,94	0,85	0,99	0,91
Madrid	Madrid	0,91	0,88	0,90	0,87	0,86	0,88	0,94	0,92	0,91	0,93	0,96	0,91	0,91
Extremadura	Cáceres	0,87	0,88	0,88	0,84	0,83	0,91	0,93	0,93	0,89	0,86	0,90	0,87	0,88
	Badajoz	0,91	0,91	0,90	0,85	0,86	0,92	0,96	0,96	0,92	0,91	0,93	0,90	0,91
Castilla-La Mancha	Albacete	0,97	0,95	0,96	0,94	0,90	0,89	0,93	0,91	0,88	0,95	0,98	0,97	0,94
	Ciudad Real	0,96	0,92	0,95	0,92	0,88	0,88	0,94	0,93	0,93	0,97	0,97	0,96	0,94
	Cuenca	0,88	0,87	0,90	0,89	0,86	0,82	0,89	0,86	0,90	0,93	0,93	0,90	0,89
	Guadalajara	0,97	0,96	0,98	0,94	0,88	0,90	0,92	1,00	0,94	0,96	0,99	0,98	0,95
	Toledo	0,88	0,85	0,85	0,82	0,80	0,82	0,89	0,87	0,89	0,90	0,90	0,89	0,86
Valencia	Alicante	0,95	0,94	0,92	0,91	0,91	0,94	0,97	0,96	0,90	0,92	0,96	0,95	0,94
	Castellón	0,91	0,92	0,91	0,87	0,90	0,90	0,92	0,86	0,85	0,89	0,93	0,91	0,90
	Valencia	0,88	0,88	0,91	0,88	0,91	0,92	0,94	0,92	0,89	0,88	0,92	0,91	0,90
Andalucía	Almería	0,82	0,78	0,76	0,70	0,73	0,77	0,83	0,86	0,84	0,84	0,82	0,82	0,80
	Cádiz	0,80	0,75	0,75	0,80	0,82	0,83	0,83	0,89	0,85	0,81	0,79	0,77	0,81
	Córdoba	0,98	0,98	0,97	0,94	0,94	0,96	0,98	0,98	0,94	0,95	0,98	0,98	0,96
	Granada	0,93	0,92	0,93	0,91	0,90	0,91	0,94	0,93	0,93	0,93	0,94	0,92	0,92
	Huelva	0,91	0,92	0,92	0,89	0,96	0,98	0,99	0,97	0,96	0,91	0,90	0,88	0,93
	Jaén	0,98	0,99	0,98	0,98	0,97	0,97	0,99	0,98	0,97	0,98	1,00	0,99	0,98
	Málaga	0,74	0,79	0,83	0,84	0,88	0,94	0,97	0,96	0,92	0,89	0,80	0,74	0,86
	Sevilla	0,89	0,89	0,89	0,84	0,89	0,94	0,96	0,96	0,94	0,88	0,90	0,87	0,91
Murcia	Murcia	0,93	0,94	0,93	0,89	0,90	0,91	0,96	0,94	0,88	0,91	0,96	0,96	0,93

First set. Annual and monthly CRC values of Spanish peninsular capital of province cities (5 out of 6)

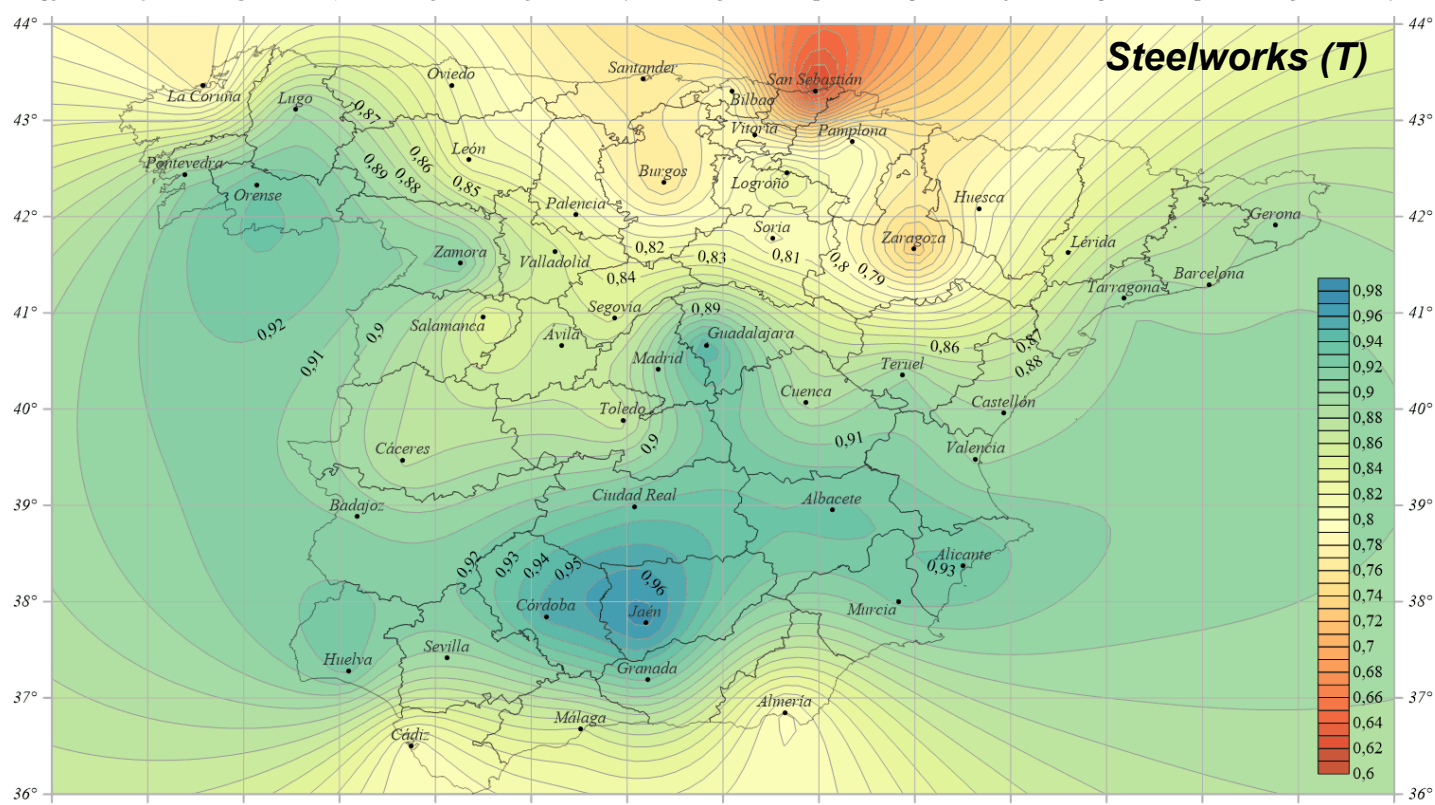
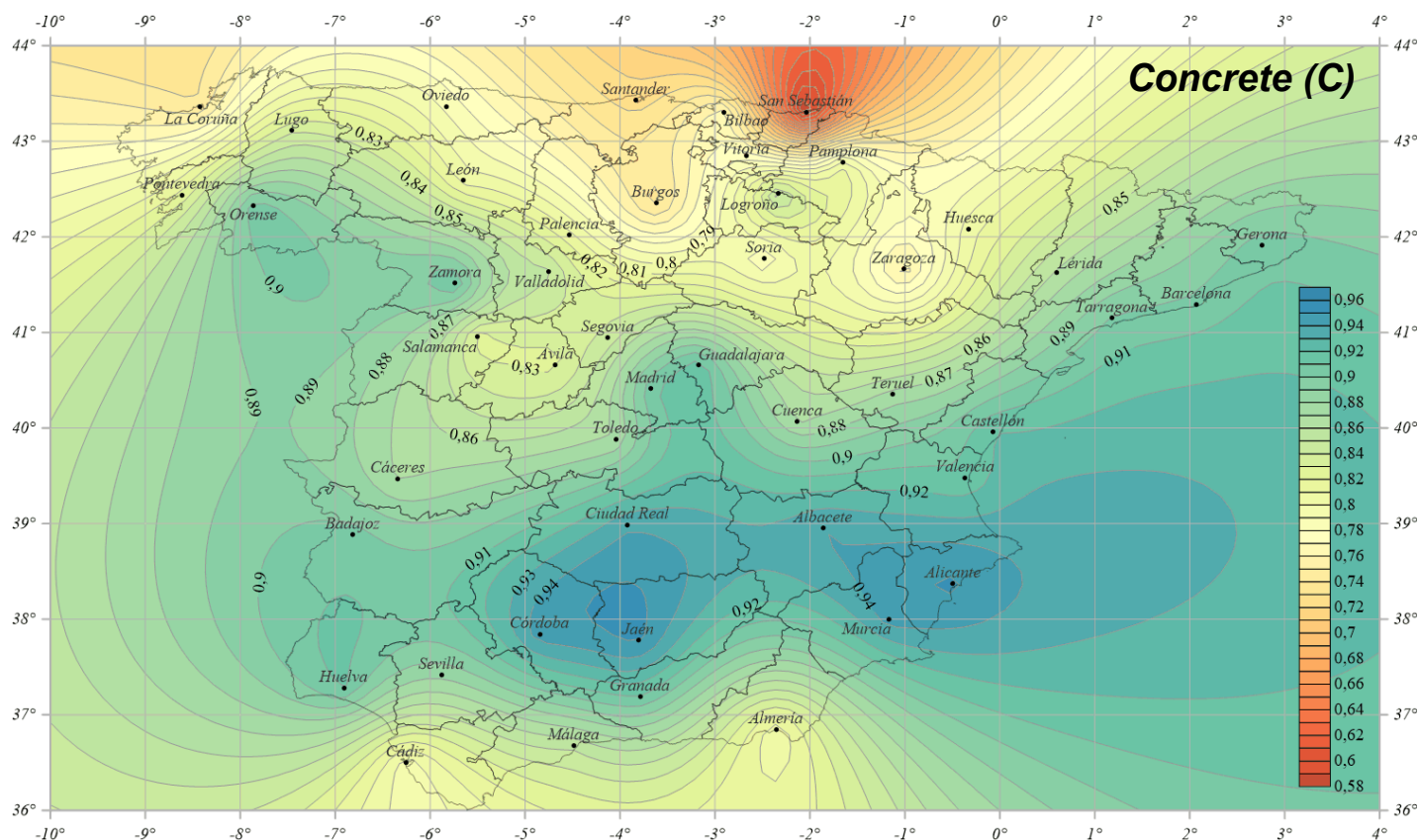
Region	Province capital	Outdoor painting (P)												
	(Spain)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Galicia	La Coruña	0,39	0,40	0,48	0,41	0,54	0,70	0,79	0,78	0,68	0,48	0,39	0,37	0,53
	Lugo	0,52	0,50	0,57	0,49	0,60	0,78	0,85	0,82	0,71	0,53	0,49	0,54	0,61
	Orense	0,64	0,66	0,71	0,62	0,68	0,84	0,90	0,89	0,81	0,66	0,64	0,62	0,72
	Pontevedra	0,54	0,55	0,60	0,50	0,60	0,75	0,83	0,82	0,71	0,56	0,53	0,49	0,62
Asturias	Oviedo	0,51	0,48	0,53	0,49	0,55	0,70	0,73	0,72	0,69	0,56	0,49	0,49	0,58
Cantabria	Santander	0,41	0,42	0,52	0,46	0,58	0,71	0,73	0,73	0,63	0,49	0,38	0,42	0,53
País Vasco	Vitoria	0,52	0,53	0,59	0,53	0,61	0,73	0,76	0,75	0,72	0,60	0,55	0,53	0,61
	San Sebastián	0,28	0,30	0,35	0,34	0,45	0,57	0,61	0,58	0,52	0,37	0,30	0,30	0,41
	Bilbao	0,44	0,46	0,52	0,48	0,60	0,73	0,75	0,71	0,68	0,55	0,47	0,46	0,57
Navarra	Pamplona	0,59	0,56	0,59	0,55	0,64	0,76	0,78	0,78	0,75	0,64	0,59	0,58	0,65
La Rioja	Logroño	0,68	0,67	0,72	0,63	0,67	0,77	0,82	0,84	0,82	0,72	0,70	0,68	0,73
Castilla y León	Ávila	0,64	0,63	0,73	0,65	0,67	0,84	0,94	0,92	0,85	0,72	0,65	0,63	0,74
	Burgos	0,54	0,54	0,60	0,52	0,58	0,71	0,77	0,78	0,73	0,61	0,55	0,51	0,62
	León	0,57	0,60	0,66	0,59	0,63	0,78	0,84	0,86	0,80	0,66	0,65	0,60	0,68
	Palencia	0,60	0,61	0,69	0,60	0,65	0,77	0,83	0,84	0,78	0,67	0,63	0,60	0,69
	Salamanca	0,67	0,65	0,71	0,62	0,64	0,81	0,89	0,89	0,81	0,68	0,68	0,63	0,72
	Segovia	0,67	0,60	0,65	0,60	0,59	0,84	0,91	0,82	0,78	0,71	0,68	0,57	0,70
	Soria	0,55	0,53	0,63	0,57	0,63	0,77	0,83	0,83	0,79	0,69	0,62	0,57	0,67
	Valladolid	0,65	0,66	0,74	0,64	0,69	0,80	0,87	0,88	0,81	0,71	0,68	0,65	0,73
	Zamora	0,72	0,74	0,79	0,73	0,74	0,86	0,92	0,91	0,84	0,74	0,72	0,71	0,78
Aragón	Huesca	0,61	0,61	0,66	0,59	0,62	0,69	0,90	0,89	0,85	0,79	0,62	0,65	0,71
	Teruel	0,81	0,81	0,82	0,75	0,75	0,80	0,91	0,88	0,83	0,79	0,83	0,76	0,81
	Zaragoza	0,64	0,60	0,60	0,58	0,62	0,70	0,72	0,77	0,76	0,69	0,66	0,65	0,67
Cataluña	Barcelona	0,83	0,79	0,79	0,75	0,81	0,87	0,93	0,83	0,80	0,76	0,78	0,80	0,81
	Gerona	0,80	0,79	0,79	0,73	0,76	0,82	0,89	0,82	0,77	0,78	0,80	0,82	0,80
	Lérida	0,75	0,75	0,74	0,67	0,76	0,81	0,88	0,87	0,81	0,80	0,77	0,78	0,78
	Tarragona	0,68	0,87	0,72	0,70	0,83	0,90	0,94	0,88	0,83	0,81	0,74	0,87	0,81
Madrid	Madrid	0,74	0,72	0,80	0,70	0,73	0,86	0,95	0,91	0,87	0,75	0,76	0,72	0,79
Extremadura	Cáceres	0,68	0,68	0,76	0,67	0,73	0,87	0,93	0,93	0,84	0,68	0,66	0,64	0,75
	Badajoz	0,72	0,73	0,77	0,70	0,77	0,90	0,97	0,96	0,87	0,73	0,72	0,68	0,79
Castilla-La Mancha	Albacete	0,84	0,79	0,83	0,80	0,81	0,89	0,97	0,95	0,88	0,83	0,82	0,82	0,85
	Ciudad Real	0,78	0,74	0,82	0,72	0,78	0,87	0,96	0,95	0,87	0,79	0,77	0,73	0,82
	Cuenca	0,69	0,69	0,75	0,66	0,70	0,80	0,91	0,87	0,82	0,71	0,71	0,67	0,75
	Guadalajara	0,78	0,76	0,84	0,73	0,76	0,87	0,94	1,00	0,87	0,74	0,81	0,78	0,82
	Toledo	0,74	0,71	0,75	0,66	0,71	0,82	0,90	0,89	0,86	0,73	0,73	0,71	0,77
Valencia	Alicante	0,84	0,85	0,83	0,83	0,85	0,93	0,98	0,96	0,88	0,85	0,84	0,84	0,87
	Castellón	0,80	0,81	0,82	0,78	0,83	0,90	0,94	0,91	0,81	0,81	0,83	0,79	0,84
	Valencia	0,76	0,77	0,81	0,77	0,83	0,90	0,96	0,91	0,82	0,80	0,80	0,78	0,82
Andalucía	Almería	0,75	0,71	0,70	0,65	0,70	0,77	0,83	0,87	0,83	0,79	0,75	0,75	0,76
	Cádiz	0,65	0,60	0,66	0,67	0,75	0,81	0,84	0,88	0,80	0,70	0,63	0,60	0,72
	Córdoba	0,76	0,78	0,84	0,78	0,84	0,95	0,99	0,98	0,89	0,78	0,80	0,74	0,85
	Granada	0,76	0,73	0,80	0,75	0,82	0,91	0,96	0,94	0,88	0,81	0,74	0,71	0,82
	Huelva	0,71	0,75	0,81	0,73	0,86	0,95	0,99	0,97	0,90	0,74	0,73	0,69	0,82
	Jaén	0,78	0,77	0,83	0,77	0,82	0,93	0,99	0,98	0,91	0,81	0,77	0,75	0,84
	Málaga	0,63	0,68	0,74	0,75	0,82	0,94	0,98	0,96	0,90	0,80	0,68	0,61	0,79
	Sevilla	0,72	0,72	0,78	0,70	0,82	0,92	0,96	0,96	0,89	0,74	0,73	0,68	0,80
Murcia	Murcia	0,82	0,83	0,84	0,83	0,85	0,91	0,97	0,96	0,89	0,86	0,84	0,84	0,87

First set. Annual and monthly CRC values of Spanish peninsular capital of province cities (6 out of 6)

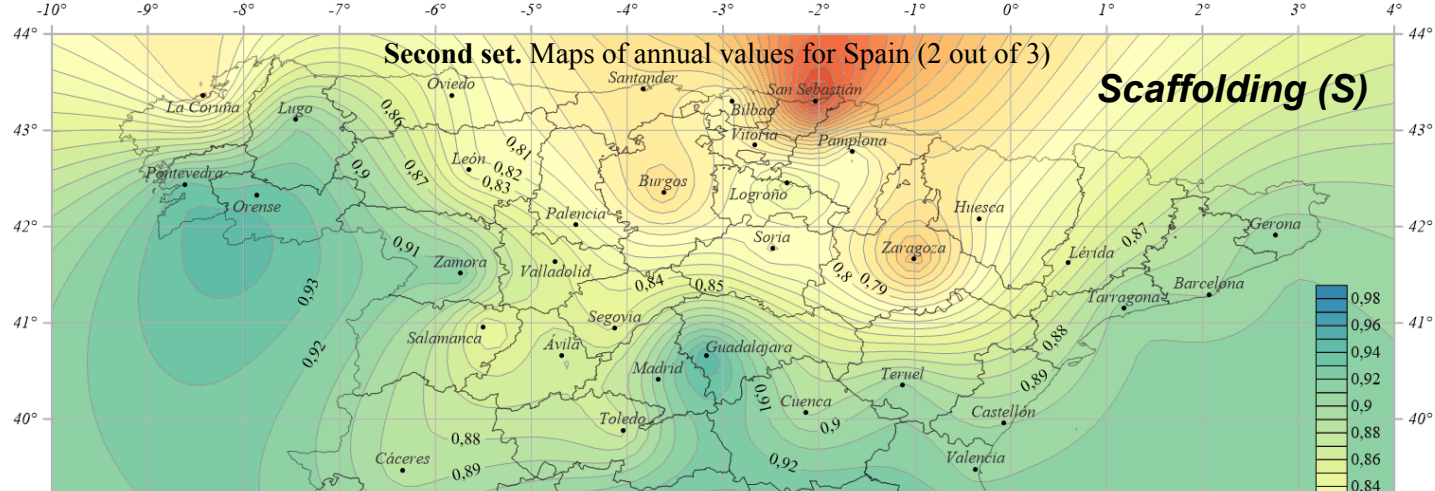


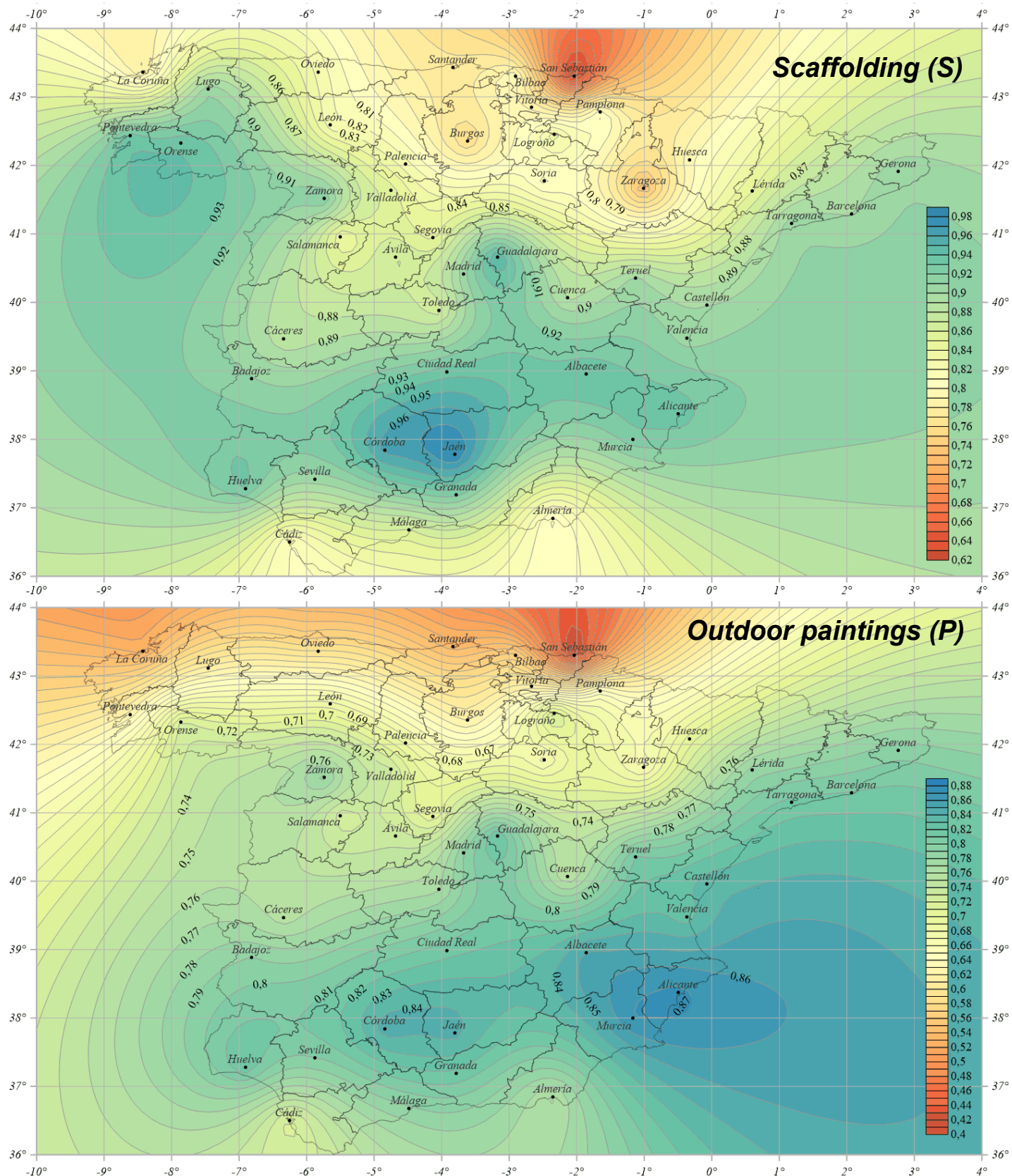
Second set. Maps of annual values for Spain (1 out of 3)

Concrete (C)



Second set. Maps of annual values for Spain (2 out of 3)





Second set. Maps of annual values for Spain (3 out of 3)

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C _{p1}		Summary Statistics													
		Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
		N	29	30	30	30	30	30	30	30	29	30	30	30	28
		Mean	0.86	0.86	0.88	0.84	0.86	0.91	0.97	0.92	0.83	0.84	0.86	0.85	0.87
		Std. Dev.	0.12	0.09	0.08	0.07	0.08	0.07	0.03	0.06	0.08	0.09	0.10	0.10	0.03
		Beta α	6.87	11.73	13.94	19.69	14.87	13.52	31.12	16.71	17.44	13.40	9.90	10.21	119.7
		Beta β	1.13	1.86	1.81	3.78	2.39	1.26	1.11	1.38	3.46	2.60	1.67	1.87	17.38
		K-S's D	0.12	0.11	0.13	0.10	0.12	0.16	0.11	0.11	0.09	0.11	0.11	0.10	-

Summary Statistics												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
30	30	30	30	30	30	30	30	30	30	30	30	30
0.87	0.86	0.88	0.81	0.79	0.87	0.92	0.92	0.89	0.83	0.83	0.84	0.86
0.11	0.09	0.07	0.10	0.10	0.09	0.06	0.06	0.07	0.11	0.09	0.11	0.02
7.57	13.22	16.22	10.91	12.77	12.20	21.82	16.89	18.19	8.85	12.77	8.65	190.7
1.13	2.10	2.22	2.54	3.32	1.88	1.97	1.38	2.20	1.85	2.62	1.60	31.03
0.07	0.12	0.12	0.13	0.11	0.08	0.16	0.10	0.13	0.15	0.12	0.18	-

C _{p10}		Summary Statistics													
		Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
		N	29	30	30	30	30	30	30	30	29	30	30	30	28
		Mean	0.97	0.96	0.97	0.96	0.96	0.99	0.99	0.98	0.94	0.94	0.95	0.96	0.96
		Std. Dev.	0.04	0.03	0.04	0.05	0.04	0.03	0.01	0.03	0.05	0.05	0.05	0.05	0.01
		Beta α	21.53	27.98	16.57	13.95	18.20	17.92	34.58	24.37	20.25	17.36	13.89	15.32	267.6
		Beta β	0.69	1.10	0.55	0.51	0.75	0.26	0.19	0.45	1.18	1.03	0.66	0.71	9.79
		K-S's D	0.06	0.10	0.04	0.07	0.06	0.02	0.04	0.05	0.14	0.18	0.11	0.07	-

Summary Statistics												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
30	30	30	30	30	30	30	30	30	30	30	30	30
0.98	0.98	0.99	0.96	0.96	0.97	0.99	0.99	0.97	0.97	0.98	0.99	0.98
0.03	0.03	0.02	0.04	0.04	0.03	0.02	0.02	0.04	0.04	0.03	0.02	0.01
19.92	19.21	32.85	22.17	20.08	26.13	39.45	19.38	18.26	19.24	20.81	45.21	238.3
0.30	0.42	0.36	0.87	0.79	0.69	0.56	0.25	0.61	0.66	0.52	0.54	5.61
0.02	0.06	0.06	0.08	0.11	0.06	0.09	0.03	0.04	0.06	0.04	0.10	-

		Summary Statistics													
		Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
C_{p30}	N	29	30	30	30	30	30	30	30	29	30	30	30	28	
	Mean	0.99	0.99	0.99	1.00	0.99	1.00	1.00	1.00	0.98	0.98	0.99	0.99	0.99	
	Std. Dev.	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.01	
	Beta α	27.22	22.66	21.07	31.01	21.07	17.39	32.09	30.97	23.89	13.77	18.71	14.72	180.8	
	Beta β	0.21	0.16	0.16	0.10	0.16	0.06	0.10	0.07	0.48	0.23	0.25	0.16	1.57	
	K-S's D	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.06	0.02	0.03	0.07	-	

Summary Statistics												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
30	30	30	30	30	30	30	30	30	30	30	30	30
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00
0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
		30.97	32.17	32.09	32.17	30.97	32.09	33.42	33.28	31.01		349.9
		0.07	0.14	0.10	0.14	0.07	0.10	0.19	0.14	0.10		0.96
0.00	0.00	0.02	0.03	0.02	0.03	0.02	0.02	0.04	0.03	0.02	0.00	-

C _w		Summary Statistics													
		Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
		N	25	26	27	28	28	28	29	27	24	26	28	24	11
		Mean	0.88	0.90	0.92	0.91	0.97	0.98	0.99	0.98	0.98	0.95	0.93	0.92	0.94
		Std. Dev.	0.09	0.08	0.07	0.09	0.03	0.03	0.01	0.02	0.03	0.05	0.07	0.06	0.02
		Beta α	9.27	11.33	12.65	8.83	29.38	21.09	36.24	28.54	22.48	19.10	11.15	19.73	121.0
		Beta β	1.23	1.31	1.10	0.84	0.94	0.38	0.24	0.45	0.48	0.97	0.78	1.70	7.51
		K-S's D	0.14	0.14	0.08	0.09	0.14	0.03	0.05	0.04	0.04	0.06	0.07	0.12	-

Summary Statistics												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
26	27	28	27	29	27	29	24	26	26	29	28	11
0.75	0.71	0.69	0.72	0.78	0.80	0.79	0.83	0.85	0.83	0.79	0.79	0.78
0.19	0.14	0.17	0.12	0.14	0.13	0.15	0.12	0.11	0.09	0.13	0.15	0.09
3.29	6.45	4.37	9.03	6.46	6.91	4.73	8.06	9.06	14.47	6.74	5.43	16.96
1.12	2.63	1.96	3.52	1.81	1.69	1.27	1.67	1.65	2.86	1.75	1.47	4.86
0.07	0.08	0.14	0.09	0.09	0.09	0.13	0.11	0.09	0.11	0.09	0.12	-

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C _e	Summary Statistics														
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	
	Mean	0.99	0.99	0.99	0.96	0.94	0.94	0.95	0.94	0.91	0.93	0.98	0.99	0.96	
	Std. Dev.	0.02	0.03	0.03	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.03	0.02	0.02	
	Beta α	32.85	17.35	18.57	16.78	16.00	24.57	21.40	17.44	16.01	17.42	11.71	18.09	15.24	91.24
	Beta β	0.36	0.25	0.26	0.66	0.97	1.54	1.19	1.03	1.82	0.94	0.33	0.15	3.99	
	K-S's D	0.06	0.03	0.02	0.12	0.08	0.19	0.08	0.09	0.14	0.11	0.04	0.02	-	

Summary Statistics												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
30	30	30	30	30	30	30	30	30	30	30	30	30
1.00	1.00	0.99	0.95	0.87	0.87	0.88	0.88	0.91	0.97	1.00	1.00	0.94
0.00	0.01	0.02	0.05	0.09	0.08	0.07	0.07	0.06	0.03	0.01	0.01	0.02
	28.36	24.69	18.06	12.56	14.90	19.64	17.42	19.27	36.83	29.94	14.44	208.2
	0.07	0.24	0.86	1.91	2.25	2.72	2.39	2.01	1.27	0.07	0.03	12.87
0.00	0.02	0.03	0.11	0.10	0.10	0.16	0.17	0.10	0.20	0.02	0.01	-

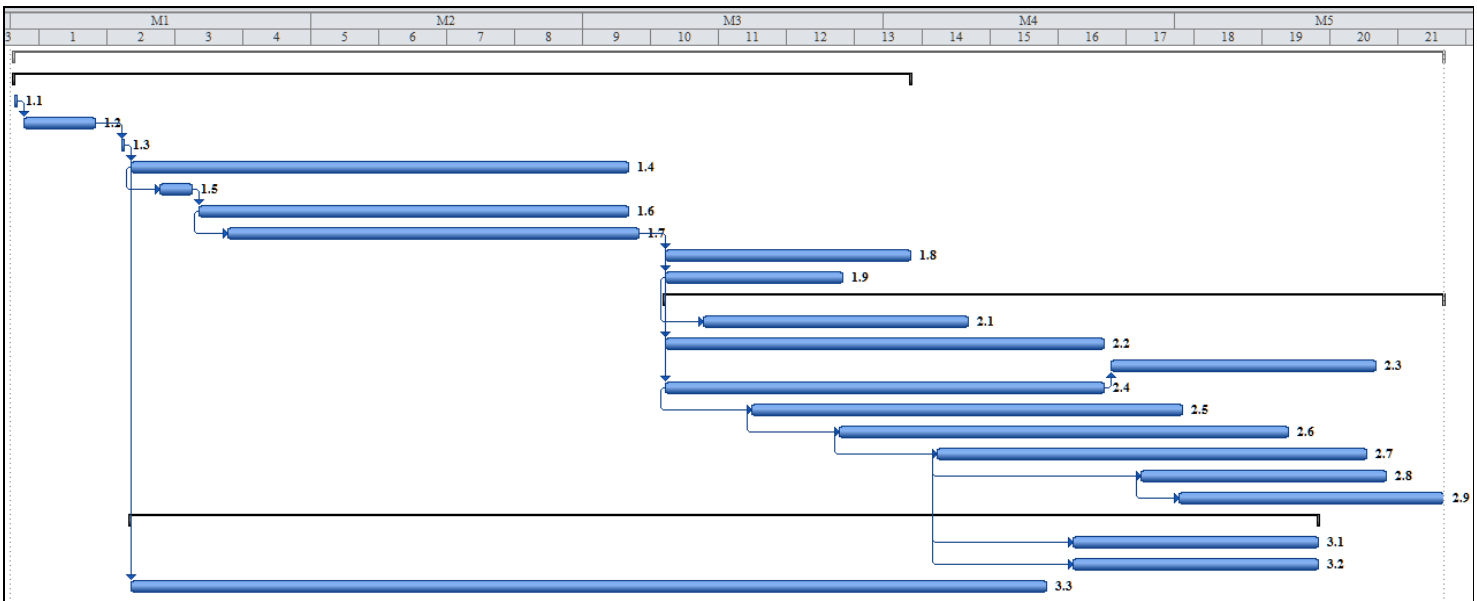
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Third set. Annual and monthly RCC values for 4 specific Spanish locations (1 out of 2)

RCC														Madrid														La Coruña													
C_t	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30														
	Mean	0.80	0.89	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.85	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00														
	Std. Dev.	0.15	0.12	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00														
	Beta α	5.06	4.89	5.77	11.15							12.84	6.98	65.83	14.92												188.1														
	Beta β	1.26	0.59	0.19	0.05							0.38	1.18	2.96	0.06												0.07														
K-S's D	0.15	0.10	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.09	-	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-														
C_{p1}	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30														
	Mean	0.82	0.81	0.87	0.78	0.76	0.89	0.94	0.95	0.89	0.78	0.78	0.78	0.84	0.55	0.57	0.63	0.56	0.64	0.78	0.82	0.82	0.74	0.58	0.52	0.53	0.65														
	Std. Dev.	0.13	0.11	0.09	0.10	0.13	0.08	0.06	0.05	0.07	0.13	0.14	0.16	0.03	0.18	0.18	0.18	0.18	0.14	0.12	0.09	0.09	0.14	0.15	0.20	0.16	0.03														
	Beta α	6.94	8.82	11.59	12.63	7.88	12.03	14.17	17.02	16.22	6.62	5.76	4.36	142.5	3.44	3.97	4.10	3.59	6.87	7.85	12.76	13.56	6.34	5.44	2.80	4.56	163.6														
	Beta β	1.55	2.01	1.77	3.63	2.44	1.55	0.84	0.97	1.98	1.90	1.60	1.23	27.67	2.83	2.96	2.43	2.86	3.85	2.24	2.73	3.03	2.28	3.89	2.54	4.08	89.94														
K-S's D	0.10	0.15	0.07	0.11	0.07	0.12	0.12	0.10	0.14	0.08	0.13	0.15	-	0.07	0.06	0.07	0.11	0.09	0.13	0.09	0.10	0.12	0.09	0.06	0.11	-															
C_{p10}	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30														
	Mean	0.97	0.96	0.98	0.95	0.95	0.98	0.99	0.99	0.98	0.93	0.94	0.94	0.96	0.88	0.90	0.93	0.92	0.92	0.95	0.97	0.97	0.93	0.86	0.83	0.85	0.91														
	Std. Dev.	0.04	0.04	0.03	0.04	0.05	0.03	0.02	0.02	0.02	0.06	0.06	0.06	0.01	0.08	0.08	0.07	0.07	0.06	0.04	0.03	0.03	0.06	0.09	0.10	0.08	0.02														
	Beta α	13.87	20.58	21.58	21.92	19.98	25.13	32.85	25.11	32.00	13.80	12.91	11.56	262.3	14.97	12.45	11.34	15.01	18.02	21.06	27.10	31.41	17.07	12.37	10.57	16.57	202.2														
	Beta β	0.45	0.86	0.52	1.15	1.11	0.51	0.36	0.16	0.65	0.99	0.87	0.71	10.04	2.05	1.32	0.84	1.34	1.47	1.06	0.90	1.05	1.33	2.03	2.20	2.86	20.13														
K-S's D	0.07	0.11	0.04	0.15	0.07	0.07	0.06	0.02	0.13	0.10	0.08	0.16	-	0.14	0.17	0.13	0.13	0.18	0.12	0.13	0.14	0.13	0.16	0.16	0.11	-															
C_{p30}	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30														
	Mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00	0.99	1.00	1.00	1.00	1.00	0.99	0.97	0.98	0.98	0.98	0.98	0.98	0.99														
	Std. Dev.	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.04	0.03	0.04	0.03	0.04	0.03	0.02	0.01														
	Beta α	29.93	27.93	29.93		20.74		29.93		31.01	19.18	36.25	29.93	272.0	37.51	18.62	33.28	29.94	32.09	32.17	34.58	32.09	33.42	15.76	16.92	31.25	229.5														
	Beta β	0.03	0.03	0.03		0.09		0.03		0.10	0.12	0.28	0.03	0.62	0.28	0.09	0.14	0.07	0.10	0.14	0.19	0.10	0.19	0.42	0.29	0.51	1.92														
K-S's D	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.02	0.02	0.06	0.01	-	0.06	0.01	0.03	0.02	0.02	0.03	0.04	0.02	0.04	0.05	0.06	0.06	-															
C_w	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	26	24	24	26	24	24	19	25	27	25	27	26	10	27	30	28	27	28	29	25	29	28	26	29	15															
	Mean	0.94	0.92	0.92	0.92	0.95	0.97	0.96	0.97	0.97	0.96	0.97	0.94	0.96	0.72	0.71	0.77	0.73	0.85	0.90	0.95	0.95	0.92	0.83	0.75	0.71	0.82														
	Std. Dev.	0.06	0.08	0.06	0.07	0.05	0.05	0.04	0.03	0.03	0.05	0.03	0.05	0.03	0.13	0.14	0.15	0.16	0.13	0.09	0.04	0.06	0.07	0.11	0.13	0.16	0.04														
	Beta α	15.87	10.62	18.69	14.88	19.75	13.93	20.43	28.06	20.45	11.01	27.83	22.45	57.50	7.54	6.98	5.53	4.93	5.72	9.31	23.87	9.84	14.14	9.09	7.26	4.78	83.39														
	Beta β	1.03	0.88	1.55	1.33	1.03	0.50	0.83	0.94	0.57	0.41	0.85	1.55	2.65	2.91	2.90	1.68	1.84	1.03	1.02	1.14	0.47	1.26	1.91	2.45	1.98	18.11														
K-S's D	0.09	0.12	0.11	0.13	0.08	0.04	0.11	0.06	0.05	0.14	0.10	0.12	-	0.09	0.10	0.07	0.13	0.13	0.08	0.21	0.12	0.11	0.10	0.07	0.07	-															
C_s	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	27	25	27	25	26	24	25	26	26	26	25	26	23														
	Mean	0.97	0.95	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00														
	Std. Dev.	0.05	0.05	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00														
	Beta α	14.27	15.25	25.11	11.52							31.01	19.28	169.4	18.06	29.63											421.5														
	Beta β	0.49	0.73	0.16	0.13							0.10	0.40	1.69	0.06	0.13										0.20															
K-S's D	0.07	0.10	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	-	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-															
C_e	Summary Statistics														Summary Statistics																										
	Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year														
	N	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30														
	Mean	1.00	1.00	0.98	0.96	0.91	0.91	0.94	0.95	0.94	0.97	1.00	1.00	0.96	0.95	0.96	0.97	0.94	0.94	0.97	0.96	0.97	0.95	0.96	0.94	0.95	0.95														
	Std. Dev.	0.01	0.01	0.03	0.04	0.08	0.08	0.07	0.05	0.04	0.04	0.01	0.01	0.02	0.04	0.05	0.05	0.06	0.05	0.03	0.04	0.04	0.05	0.04	0.08	0.05	0.01														
	Beta α	30.97	30.20	22.81	20.47	9.98	11.23	9.55	17.22	35.90	16.57	32.17	30.97	120.2	21.98	13.74	14.49	13.02	18.73	26.22	18.94	19.42	15.64	30.32	8.00	20.72	223.5														
	Beta β	0.07	0.14	0.40	0.93	1.03	1.14	0.66	0.94	2.34	0.55	0.14	0.07	4.91	1.17	0.58	0.52	0.80	1.18	0.87	0.78	0.69	0.88	1.33	0.51	1.08	10.80														
K-S's D	0.02	0.03	0.04	0.13	0.11	0.11	0.08	0.07	0.17	0.13	0.03	0.02	-	0.10	0.07	0.11	0.11	0.12	0.12	0.13	0.07	0.10	0.11	0.08	0.11	-															
K -S critical values	Crit. $\Delta\alpha$ =0.1	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22															
	Crit. $\Delta\alpha$ =0.05	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25															
	Crit. $\Delta\alpha$ =0.01	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29															

5-storey reinforced concrete (RC) building

ID	Unit	Activity (description)	Quantity (Q) (# units)	Performance (P) (# units/ day)	Duration (Q/P) (exact # days)	Real Duration (RD) (rounded-up/down days)	Predecessor (ID+relation+lag)	Zone (Outdoor/Indoor)	CRC (identification)
1. Structural works									
1.1	gl	Site marking (*)	1	1.00	1.00	1	Start	Outdoor	E
1.2	m3	Excavations	117	20.00	5.85	6	1.1FS	Outdoor	E
1.3	m3	Lean concrete	40	40.00	1.00	1	1.2FS	Outdoor	C
1.4	kg	Reinforcing steel	27000	720.00	37.50	38	1.3FS	Outdoor	T
1.5	m3	Concrete (foundations)	59	35.00	1.69	2	1.4SS+5%	Outdoor	C
1.6	m2	Formworks	2800	85.00	32.94	33	1.5FS	Outdoor	F
1.7	m3	Structural concrete	307	10.00	30.70	31	1.6SS+10%	Outdoor	C
1.8	m2	Roof (**)	360	18.00	20.00	20	1.7FS	Outdoor	S
1.9	m2	Scaffolding	1200	80.00	15.00	15	1.7FS	Outdoor	S
2. Finishings									
2.1	m2	Outdoor paint coating	764	40.00	19.10	19	1.9SS+25%	Outdoor	O
2.2	m2	Plastering	1665	50.00	33.30	33	1.7FS	Indoor	-
2.3	gl	Doors and windows installation	1	0.05	20.00	20	2.4FS	Indoor	-
2.4	m2	Partitions and cladding	1280	38.00	33.68	34	1.7FS	Indoor	-
2.5	m2	Indoor paint coating	2300	70.00	32.86	33	2.4SS+20%	Indoor	-
2.6	m2	Suspended ceilings	1150	35.00	32.86	33	2.5SS+20%	Indoor	-
2.7	m2	Floors	1150	35.00	32.86	33	2.6SS+20%	Indoor	-
2.8	gl	Moldings	1	0.05	20.00	20	2.7SS+50%	Indoor	-
2.9	gl	Other minor finishings	1	0.05	20.00	20	2.8SS+20%	Indoor	-
3. Installations									
3.1	gl	Electrical works	1	0.05	20.00	20	2.7SS+30%	Indoor	-
3.2	gl	Furnishing and fixture installation	1	0.05	20.00	20	2.7SS+30%	Indoor	-
3.3	gl	Plumbing domiciliary works	1	0.02	50.00	50	1.3FS	Indoor	-

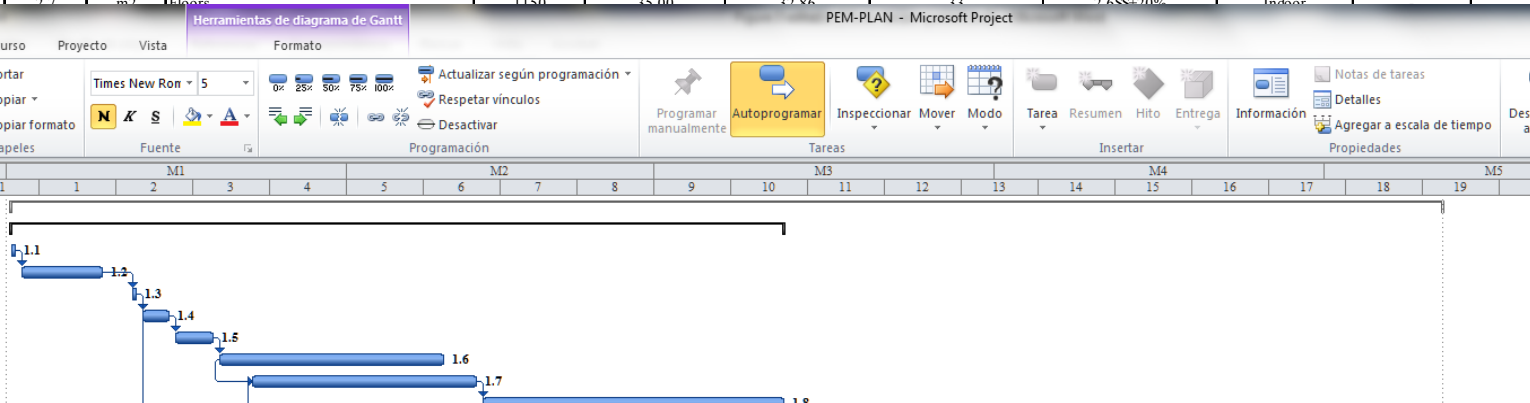
**5-storey steel structure (SS) building**

Assimilated to Earthworks CRC

** Assimilated to Scaffolding CRC

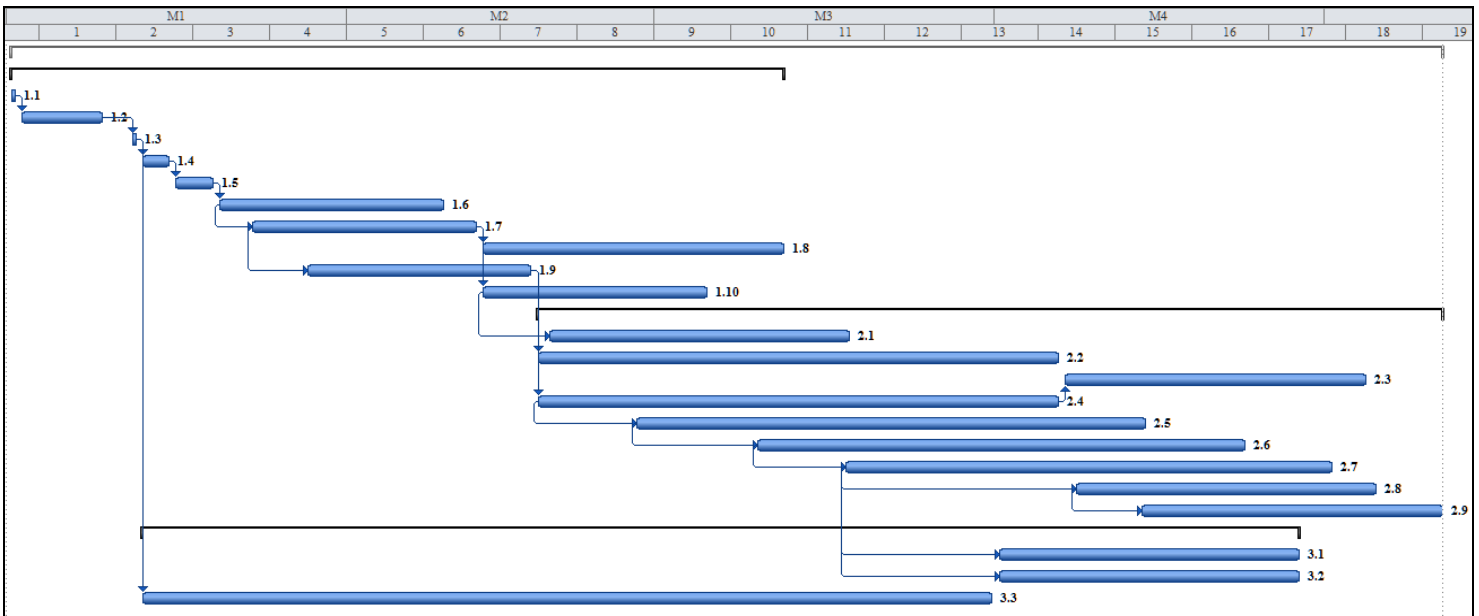
*** Assimilated to Formworks CRC

ID	Unit	Activity (description)	Quantity (Q) (# units)	Performance (P) (# units/ day)	Duration (Q/P) (exact # days)	Real Duration (RD) (rounded-up/down days)	Predecessor (ID+relation+lag)	Zone (Outdoor/Indoor)	CRC (identification)
1. Structural works									
1.1	gl	Site marking (*)	1	1.00	1.00	1	Start	Outdoor	E
1.2	m3	Excavations	117	20.00	5.85	6	1.1FS	Outdoor	E
1.3	m3	Lean concrete	40	40.00	1.00	1	1.2FS	Outdoor	C
1.4	kg	Reinforcing steel	1930	720.00	2.68	3	1.3FS	Outdoor	T
1.5	m3	Concrete (foundations)	59	35.00	1.69	2	1.4SS	Outdoor	C
1.6	gl	Bearing steel structure	1	0.07	14.29	14	1.5FS	Outdoor	T
1.7	gl	Prefabricated slab (***)	1	0.07	14.29	14	1.6SS+20%	Outdoor	F
1.8	m2	Roof (**)	360	18.00	20.00	20	1.7FS	Outdoor	S
1.9	m2	Perimetral enclosures	990	70.00	14.14	14	1.7SS+20%	Outdoor	C
1.10	m2	Scaffolding	1200	80.00	15.00	15	1.7FS	Outdoor	S
2. Finishings									
2.1	m2	Outdoor paint coating	764	40.00	19.10	19	1.10SS+30%	Outdoor	O
2.2	m2	Plastering	1665	50.00	33.30	33	1.9FS	Indoor	-
2.3	unit	Doors and windows installation	1	0.05	20.00	20	2.4FS	Indoor	-
2.4	m2	Partitions and cladding	1280	38.00	33.68	34	1.9FS	Indoor	-
2.5	m2	Indoor paint coating	2300	70.00	32.86	33	2.4SS+20%	Indoor	-
2.6	m2	Suspended ceilings	1150	35.00	32.86	33	2.5SS+20%	Indoor	-
2.7	m2	Floors	1150	35.00	32.86	33	2.6SS+20%	Indoor	-



5-storey steel structure (SS) building

ID	Unit	Activity (description)	Quantity (Q) (# units)	Performance (P) (# units/ day)	Duration (Q/P) (exact # days)	Real Duration (RD) (rounded-up/down days)	Predecessor (ID+relation+lag)	Zone (Outdoor/Indoor)	CRC (identification)
1. Structural works									
1.1	gl	Site marking (*)	1	1.00	1.00	1	Start	Outdoor	E
1.2	m3	Excavations	117	20.00	5.85	6	1.1FS	Outdoor	E
1.3	m3	Lean concrete	40	40.00	1.00	1	1.2FS	Outdoor	C
1.4	kg	Reinforcing steel	1930	720.00	2.68	3	1.3FS	Outdoor	T
1.5	m3	Concrete (foundations)	59	35.00	1.69	2	1.4SS	Outdoor	C
1.6	gl	Bearing steel structure	1	0.07	14.29	14	1.5FS	Outdoor	T
1.7	gl	Prefabricated slab (***)	1	0.07	14.29	14	1.6SS+20%	Outdoor	F
1.8	m2	Roof (**)	360	18.00	20.00	20	1.7FS	Outdoor	S
1.9	m2	Perimetral enclosures	990	70.00	14.14	14	1.7SS+20%	Outdoor	C
1.10	m2	Scaffolding	1200	80.00	15.00	15	1.7FS	Outdoor	S
2. Finishings									
2.1	m2	Outdoor paint coating	764	40.00	19.10	19	1.10SS+30%	Outdoor	O
2.2	m2	Plastering	1665	50.00	33.30	33	1.9FS	Indoor	-
2.3	unit	Doors and windows installation	1	0.05	20.00	20	2.4FS	Indoor	-
2.4	m2	Partitions and cladding	1280	38.00	33.68	34	1.9FS	Indoor	-
2.5	m2	Indoor paint coating	2300	70.00	32.86	33	2.4SS+20%	Indoor	-
2.6	m2	Suspended ceilings	1150	35.00	32.86	33	2.5SS+20%	Indoor	-
2.7	m2	Floors	1150	35.00	32.86	33	2.6SS+20%	Indoor	-
2.8	gl	Moldings	1	0.05	20.00	20	2.7SS+50%	Indoor	-
2.9	gl	Other minor finishings	1	0.05	20.00	20	2.8SS+20%	Indoor	-
3. Installations									
3.1	gl	Electrical works	1	0.05	20.00	20	2.7SS+30%	Indoor	-
3.2	gl	Furnishing and fixture installation	1	0.05	20.00	20	2.7SS+30%	Indoor	-
3.3	gl	Plumbing domiciliary works	1	0.020	50.00	50	1.3FS	Indoor	-

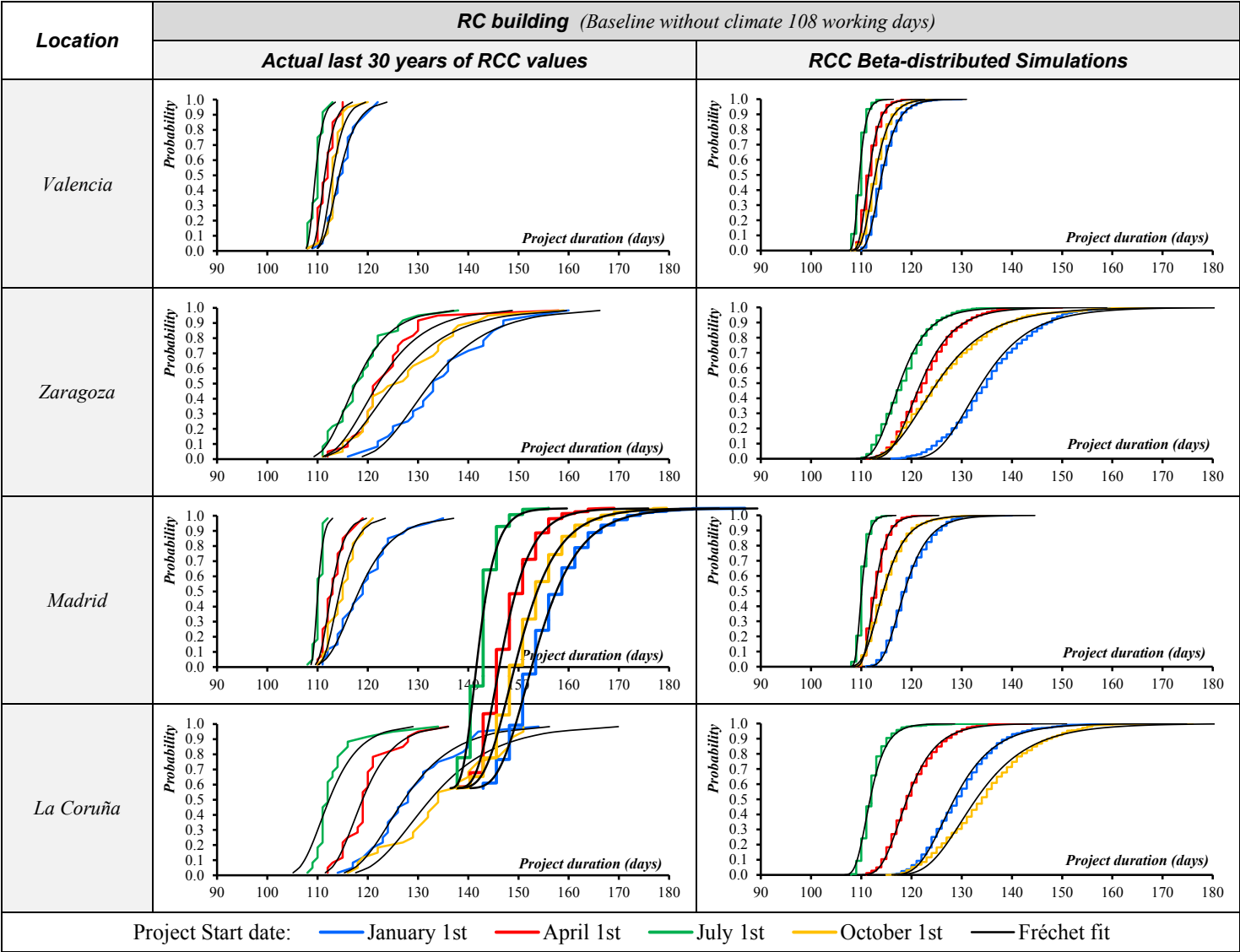


* Assimilated to Earthworks CRC

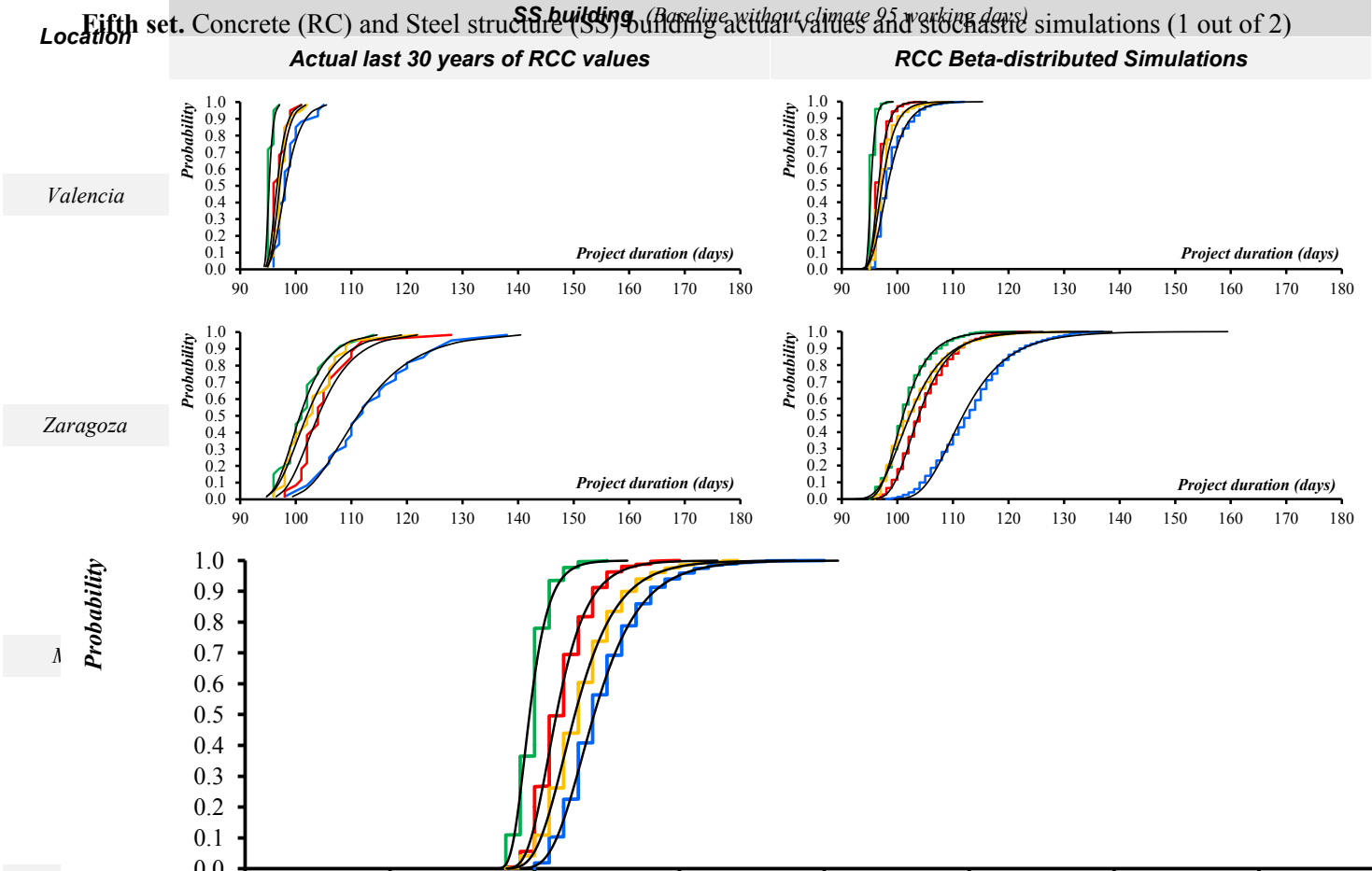
** Assimilated to Scaffolding CRC

*** Assimilated to Formworks CRC

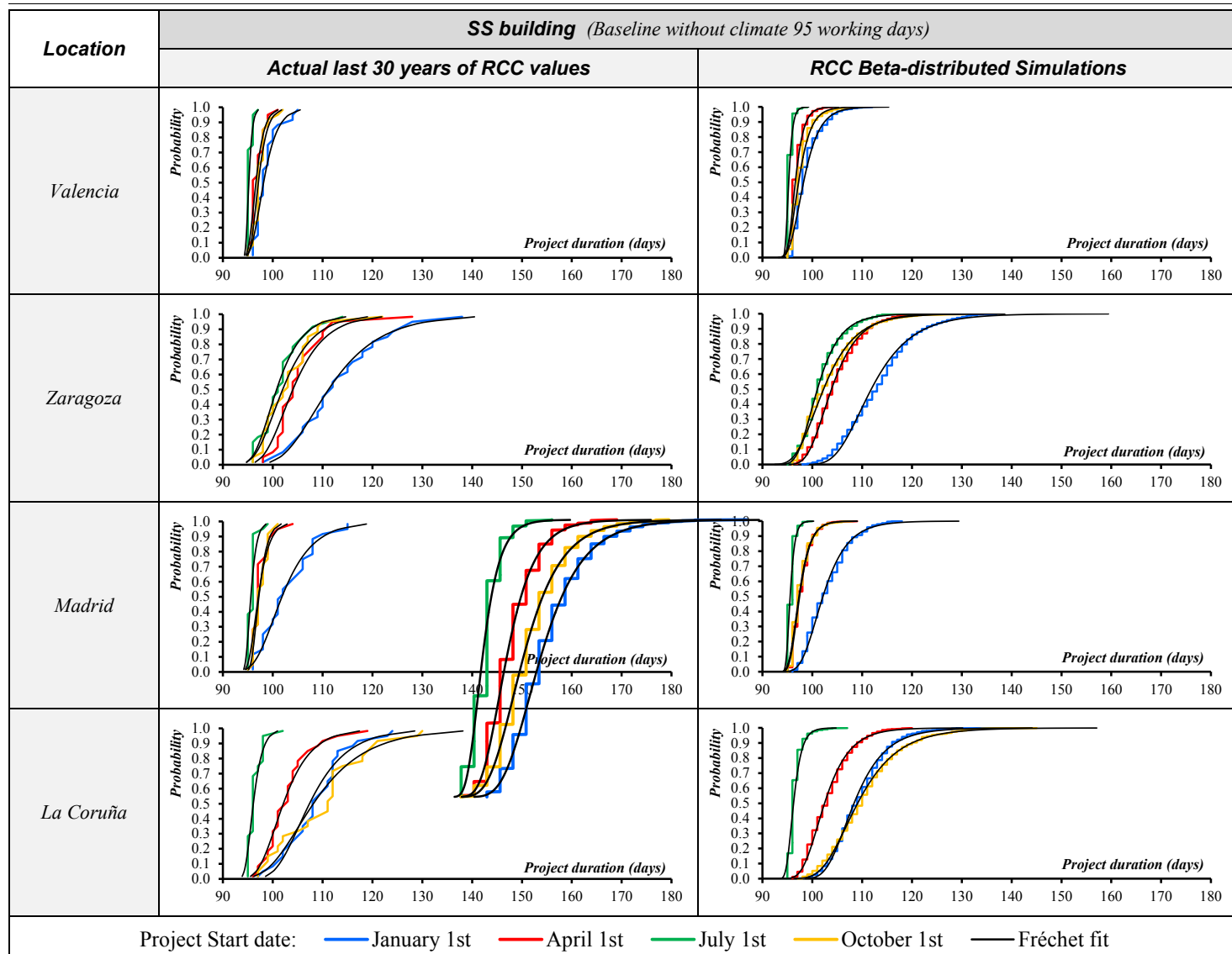
Fourth set. 5-storey Reinforced Concrete (RC) and Steel Structure (SS) project activities and Gantt charts (2 out of 2)



Fifth set. Concrete (RC) and Steel structure (SS) building actual values and stochastic simulations (1 out of 2)



Project Start date: — January 1st — April 1st — July 1st — October 1st — Fréchet fit



Fifth set. Concrete (RC) and Steel structure (SS) building actual values and stochastic simulations (2 out of 2)