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Geoscientific Model Development Discussions

Interactive comment on "Advantages of using a fast urban canopy model as compared to a full mesoscale model to simulate the urban heat island of Barcelona" *by* M. García-Díez et al.

Anonymous Referee #2

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This paper is aimed at showing the advantages of an off-line urban canopy model with respect to a regional climate model coupled to an urban canopy model for urban heat island studies. It is undeniable that there is benefit in the use of application-specific models such as UrbClim, particularly in terms of computational costs. In such circumstances, even if they both show similar results, the computational costs associated with the regional climate model make the use of UrbClim very attractive. However, in order to justify the use of a standalone urban model, the authors compare completely different tools (i.e. a more like-to-like comparison would be to show benefits of UrbClim over the Single-Layer Urban Canopy Model, both running offline with the same boundary conditions) and do not fully acknowledge (only at the very end of the paper)

that a regional climate model coupled with an urban model incorporate features that an offline model cannot (e.g. two-way interaction with surrounding circulation such as sea-breeze). But what is more important, the comparison is to a large extent unfair because the authors claim a better representation of local temperatures when the UrbClim is driven by ERA-Forecast, but do not test the regional climate model running with the same large/mesoscale information. Finally, the authors do not provide any explanation of what processes are better represented in UrbClim that make it perform better than the regional climate model?. In my opinion, the starting point is not correctly posed and the authors do not adequately support their conclusions with a rigorous analysis. I agree with the authors that for this particular application, UrbClim might present advantages over a Regional Climate Model coupled with an urban model, but I don't think the authors provided enough evidence for that.

In my opinion, the authors could make additional experiments, perform a like-to-like and more in-depth comparison, with possible reasons as to why UrbClim outperforms the RCM. In that case, they should also mention that RCMs are a tool design to conduct atmospheric research and therefore have a wider range of applications, and this is the reason why they are selected over offline and faster models.

As it is, I am unsure the paper makes a scientific or model development contribution worth publishing. Perhaps including the additional analyses suggested above could lead to a paper that is adding to the current knowledge. In addition to some general comments, I have also suggested some specific and technical comments aimed at improving a future version of the manuscript.

Therefore, I would not recommend this paper for its publication at Geoscientific Model Development.

General comments

1.- The authors mention internal variability in multiple occasions, but it is unclear from their discussion what they mean by internal variability. It is also unclear why internal

variability is regarded as intrinsically negative (L161-165). I understand that the authors preference is to avoid model departures from the boundary conditions in terms of the large scale (or mesoscale) conditions and I agree that in that sense, UrbClim does not generate any "internal variability" (L178), but in a broader sense, it is required that models produce some internal variability so they produce results the are different from the boundary conditions (added information). In any case, the authors need to be more explicit about what they mean by "internal variability". The authors also mention internal variability to justify the resolution jump between the boundary conditions and the UrbClim resolution (L121-123). I don't quite understand the sentence and why it is acceptable to have such a difference between resolutions. UrbClim is effectively downscaling a single grid point of ERA-Interim and therefore forced everywhere with the same conditions. This is something that compromises the representativeness of the results.

2.- What does UrbClim do better than WRF-SLUCM? It is necessary that the authors provide a better description of the models and a reasoning of which processes UrbClim might be improving. It is necessary to describe how are the city characteristics seen by the models, what are the differences in the two models (e.g. extension, density, types of building, vegetation cover. . .) Are they different in each of the models? What are the differences how UrbClim deals with urban and rural areas? And WRF-SLUCM?

3.- The extension of UrbClim domain is roughly 25 km by 25 km. UrbClim is essentially an offline model driven by 1-grid point from ERA-Interim and 4 grid points in ERA-FC. It is obviously much faster than the RCM (considering the number of grid points, including the vertical, in each model provides an idea of the considerably lower computational requirements of UrbClim. This is a very important feature, but it should be considered that the area simulated is much smaller and the applications more limited.

4.- The comparison is unfair in many different ways. UC-FC and WRF cannot be compared in any way (They are forced by different mesoscale conditions). In the abstract, the author anticipate a better performance of UC-FC, but in my opinion this result does

not prove that UC outperforms the RCM. The authors are evaluating at the same time the performance of ERA-Interim and ERA-FC, and UrbClim and WRF. This comparison would only be acceptable if WRF is driven by ERA-FC too. I would suggest the authors consider other experiments to adequately assess the performance of the models. In addition to WRF driven by ERA-FC, UrbClim could be driven by WRF outputs and test if it improves WRF estimates.

6.- The question that arises after reading the manuscript is, why not using statistical downscaling, which is even faster, allows for large ensembles and will reproduce present climate results much better as the are purposely calibrated. Why would an user opt for UrbClim over statistical downscaling? I would guess the answer is the spatial coverage of UrbClim.

Specific comments

L44 Regional climate models have multiple applications, not just downscaling climate projections. Perhaps: "RCMs are limited area models used to downscale climate change projections from coarse resolution Global Circulation Models as well as other applications."

L53 Please specify which of the Urban Canopy options if the authors want to keep the following sentence. "This parameterisation. . .". Otherwise, specify only in the methods. Also, if the authors refer to Single-Layer Urban Canopy Model, it was developed by Kusaka et al. (2001). Chen et al. (2011) describe the implementation in WRF. I also miss some references to work done with WRF/SLUCM for future projections (e.g. Georgescu et al. 2013, Argueso et al. 2015, Kusaka et al. 2012).

L64 Add ", especially" after urban pollution. Urban pollution exacerbates sensitivity to adverse conditions is for all population segments.

L70 (FIGURE 1) I would be necessary to have some sort of reference of the urban extension in Figure 1. For those of us not familiar with the region it is difficult to locate

the city, and urban areas in general, in the map. It is a major feature of this study and should be shown.

L93 How representative is the temperature in the roof of a building of the temperature at levels that matter for population? How comparable is that to the temperatures provided by both models at 2 m .

L97-99 I disagree with this statement. Flat areas are indeed characteristics of temperature inversions, particularly near the coast. Please revise.

L112-113 In the estimate of missing values, did the authors considered all land points within the UrbClim domain? Why 14%?

L116 What to the authors mean by “main features of the urban climate”? Are there hydrological variables (e.g. precipitation, evaporation).

L132. In which ways? If the extension is not described, this sentence can be removed.

L164-165 It is not clearly described how this configuration deals with soil variables. Are they obtained from ERA-Interim at every reinitialisation? If so, NOAH LSM is constantly trying to balance the information from ERA-Interim LSM and they are not necessarily compatible (the even don’t share the same layers). A similar question arises for UrbClim in terms of how it sees soil temperature and moisture.

Table 1 How is the variance ratio calculated? What does it represent?

L170-174 Do these values in UC-ERA ultimately depend on information provided by a single grid point from ERA-Interim? The resolution of ERA-Interim is equivalent to $\sim$70 km, while the extension of the UrbClim domain is $\sim$25 km by 25 km.

L179-180. It is not correct to say that the "results can be interpreted as a comparison between Urban Canopy+PBL models driven by" different boundary conditions. In WRF there is a two-way interaction, the results from Urban Canopy+PBL are fed back into the dynamical core and influences local circulation (and potentially larger scale circulation).

L181-182 is especially concerning since the authors disregard that this comparison is mixing multiple things, the mesoscale information to begin with. I agree that at these scales (15km to 1km) and for variables such as temperature, there is little benefit in increasing resolution, but this cannot be inferred from the authors results.

L197-198 Is this a merit of FC over ERA-I rather than UrbClim?

L200-205 It is obvious that if the model was assigning urban land use to the rural location, then for the purpose of this study they are not comparable by any means. I do not think this needs to be mention in the text. Instead, I would say that the closest grid point with a particular land cover (and specify the land cover) was selected to compare with the rural station, and perhaps say the distance between the grid point and the station.

L 206-207 I would say that the bias occurs throughout the day except in the evening (16H-00H)

L 210 This is not surprising. As the authors suggest, at 70 km the intensity of the sea breeze is often underestimated. But also, only information from 1 ERA-Interim grid point is provided to UrbClim.

Figure 3. A physical explanation of why sea breeze is weaker in urban points would be desirable. It cannot simply be increased drag because the urbanised areas along the coast act as a barrier for the rural station too. Furthermore, the urban station is located in a roof, so depending on the surrounding buildings and the height of the station, the drag could be negligible for that station. In this case, the comparison tell us about the boundary conditions, not necessarily the UrbClim. It could be well the case that UrbClim is doing a fantastic job in both cases, but ERA-FC information is more accurate (or more comparable to those scales).

L221-228 It is unclear what the authors want to illustrate with figure 4. What is the contribution to the paper? Isn’t this day-to-day variability highly influence by the boundary

conditions?

L 230-238 (Description of figure 5) This is basically qualitative. It does offer finer detail because it has finer resolution, whether this is correct remains unclear, even after comparison with relatively low resolution MODIS (Figure 6), where a more quantitative measure is provided.

L 239-240 (and onwards) Among the multiple descriptions of UHI, two are widely used. The skin temperature (or surface temperature) UHI and the screen level temperature UHI. Although linked, they involved completely different processes. Indeed, skin temperature UHI is generally positive at day and night, but the screen level temperature UHI is often negative during the daytime. The authors should capture this in their discussion.

L 241 I understand that results from Zhou et al. 2015 contrast with the authors finding rather than agreeing.

L249-250 If the authors provide these confidence bounds, both values are exactly the same (not just statistically insignificant). Not only the confidence bounds overlap but the both include the estimate from the other model.

L 300 But UrbClim does not provide rainfall at all, or does it?

Technical corrections

L34-36 Please revise sentence, how it links to the previous one. Please revise use of commas. L37 Replace "defer" with "differ" L38-39 Please revise use of commas. L41 The end of this sentence is unclear. Please rewrite. (The last half of this paragraph needs to be clarified) L59 Remove “now” (?) L93 Replace “Km” with “km" L152 Remove comma after sub-modules. Missing verb before available? L 242 Please remove “advection"

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