Classification: Open

Norwegian Meteorological Institute

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**Our date**
15 June 2022

# Review of the Habilitation thesis of Dr. Peter Huszár entitled “Impact of urbanization on climate and atmospheric chemistry”

Dear Mrs Michálková,

This is my review of the Habilitation thesis of Dr. Peter Huszár.

The thesis is based on as many as eight peer-reviewed papers published during the 2014 to 2021 period, which is a relatively short period for 8 first-author publications at this scientific level. The thesis is well written and comprehensive. It constitutes a solid body of work and, in my opinion, does fulfill the expectations for a habilitation.

The originality check by the Turnitin system, as far as I can see, does not reveal any intentional plagiarism. Coincidence with some of Huszár’s own papers exists for obvious and acceptable reasons: Dr. Huszár´s habilitation thesis is a collection of reprints and summaries of several published papers first-authored by himself, accompanied by his commentary. Coincidence with other books and papers can be found mainly in the lists of references or it concerns textbook knowledge.

The first paper, entitled “Regional climate model assessment of the urban land-surface forcing over central Europe”, deals with the impact of cities and urban surfaces on meteorological parameters such as temperature, boundary layer height, surface wind speed, humidity and precipitation. The calculations are based on the regional climate model RegCM4.2, extended with the Single-layer Urban Canopy Model (SLUCM). The paper received positive reviews with some requests for revision, but those were properly addressed by the authors.

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The second paper, on the "long term impact of emissions from central European cities on regional air quality" addresses the impact of cities on air pollution using the RegCM4.2/CAMx *coupled* regional climate-chemistry model system. Even today, most studies on the effects of urban emissions on Air Quality on local to regional scales are based on offline models, so that calculations like this and other papers in this collection - i.e. including two-way interactions between climate/meteorology and air pollution - can still be considered cutting-edge research. Admittedly, not all coupling processes (in particular the effects on emissions and other surface-atmosphere exchange) are properly included in current models so that many uncertainties remain. Therefore one has to judge carefully the benefits of coupled models vs offline models (which allow a much larger number of experiments), but this question was well addressed by the authors in the answer to reviewers, clearly stating any shortcomings, and also that the main focus of this particular study (as far as climate impacts on chemistry are concerned) was on radiative effects on air pollution.
As stated in the paper, modeled fine particulates ($PM_{2.5}$) are usually underestimated, especially in winter, mainly due to underestimation of nitrates and carbonaceous aerosols. It can be noted that underestimation of the emissions (e.g. lack of inclusion of condensables in current emission inventories for PM) and natural sources (e.g. dust resuspension) can play an important role.
The paper also reflects on the politically difficult issue of ozone pollution, which sometimes can *increase* due to NOx reductions in cities and sometimes *decrease*, depending on the available NOx and VOC and thus on the location, as well as meteorological conditions. Effects can also depend on the emission sector which is targeted by the policy measures. For example, industrial emissions have other spatial distributions and chemical compositions than road traffic.
Also this paper has received rather positive reviews.

The third paper, with the title "The regional impact of urban emissions on climate over central Europe: present and future emission perspectives" stays close to the subject of the second paper, but adds the future perspective to it. Scenario runs are done for the 10-year period centered around 2050. Again, the focus is on the effects of chemistry on climate rather than the opposite way, although two-way coupling is effective in the model system. One of the conclusions is that the non-$CO_2$ emissions from cities play a rather minor role in modulating regional climate over central Europe. Much more important is the direct climate impact of urban surfaces via the urban canopy meteorological effects.

The forth paper, "The impact of urban canopy meteorological forcing on summer photochemistry", turns more to the question of climate impacts on chemistry, here in the flavor of urban-canopy induced changes in local scale meteorology on biogenic emissions and ozone concentrations. For this study, RegCM4.4 is coupled *offline* to the CAMx air quality model (i.e. any effects of chemistry back to climate are not possible), but the model system is now extended with the Community Land Model CLM version 4.5.

The study gives quite detailed answers about which meteorological parameters affect ozone, and in what ways. Although the quantitative results are - to some extent - model dependent, the discussion is very useful also in a qualitative way for the purpose of mere process understanding.

The fifth paper, "Impact of urban canopy meteorological forcing on aerosol concentrations", is very similar in scope and model setup to the previous paper but deals with the effect on various types of aerosols, rather than ozone. Again, the effects of different meteorological parameters, and any competition among them, is carefully scrutinized. Details are given on the various processes through which the impacts of the different meteorological parameters occur. A model evaluation is performed, showing that the inclusion of urban canopy effects improves model performance.
The paper received very positive reviews and the few requests for revision were well addressed by the authors.

The sixth paper, "Urban canopy meteorological forcing and its impact on ozone and $PM_{2.5}$: role of vertical turbulent transport", builds on the findings of the two previous studies, but goes into even more detail about the mechanisms by which the Urban Canopy Meteorological Forcing (UCMF) operates, in particular the uncertainty in *vertical eddy diffusion* arising from the different representations in numerical models.
The paper received a somewhat less favorable review, inter alia because of the lack of clarity in the first version (and not because of any shortcomings in scientific rigor or relevance). The comments by the reviewer and by the editor were well addressed by the authors in the revised and finally published paper.

The seventh paper, "The impact of urban land-surface on extreme air pollution over central Europe", focuses on extremes. These are of particular interest from an air quality perspective because exceedances of targets and thresholds often occur during extreme meteorological and chemical situations ('air pollution episodes'). Rather than looking at specific episodes, the study aims to provide statements about the impact on high percentiles in general. It is shown that the (urban-canopy induced) increase in planetary boundary layer (PBL) height is stronger for thicker PBLs, and that wind speed is reduced much more for strong winds compared to average ones. As is often the case, in polluted areas these meteorological changes lead to increases in ozone but to decreases in $NO_2$ and PM *averages*. Interestingly, $NO_2$ and PM levels are much more affected in their *high percentile* occurrences than in their *average* concentrations.
In this paper, several models are used, increasing the robustness of results. It received rather positive reviews, with requests only for minor revisions, which were addressed by the authors in the published manuscript.

Finally, the eighth paper, on "The regional impact of urban emissions on air quality in Europe: the role of the urban canopy effects", investigates contributions to air pollution from urban emission sources (Urban Emission Impact - UEI) and rural areas outside the

city. It is argued that the exclusion of UCMF (which many model studies neglect) can lead to a strong overestimation of UEI. As the previous paper, it is based on several models, including also the very widely used WRF-Chem model, and results are shown specifically for a small selection of European cities.
Also this paper received positive reviews with requests only for minor revisions, which were addressed by the authors in a timely manner.

Overall, the eight papers, and also the overview material (Chapters 1 and 10), are well written and clearly reveal not only the expertise of Dr. Huszár, but also his enthusiasm for this field of research.

As far as I can see, the conclusion section was well up-to-date at the time of writing (2021), while some more recent publications and context could perhaps have been included in the introduction (Chapter 1). The conclusion section ("Summary and Outlooks", Chapter 10) ties the different papers together, discusses improvements in methodology over the years, provides the main conclusions and gives useful hints to further work and recommendations.

While the main focus of this habilitation thesis is on climate-chemistry interactions, and in particular on the effects of urban canopy on meteorology and air pollution, it does span over a sufficiently wide range of different processes and chemical constituents to fulfill the expectations for habilitation also in terms of versatility.

I therefore recommend that the theses be accepted for habilitation by the University.

Yours sincerely

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