Comments from Reviewer 2 and reply:

General comments from reviewer 2

This manuscript presents an interesting study focused of detecting the sources responsible for elevated grass pollen load within city area. Authors used several different techniques (from GIS analysis to aerobiological methods) to obtain theirs goals. Very importantly authors used also management information to select places where Poaceae species can reach the maturity and liberate pollen. This is very valuable and novel approach in such kind of studies stressing that the identification of possible sources where plants can grow is not always equivalent to the areas of pollen emission. The testing hypothesis are correctly formulated and the experiments is very well designed. The manuscript is well written, the methods (ex. 2.3 GIS analysis) and discussion sections are clearly presented and are truly interesting. Generally the whole paper has logic structure. I have only few comments that should be briefly addressed.

Answer to the general comment from reviewer 2:

We are pleased that reviewer 2 considers the manuscript to be interesting and that the reviewer agree on the chosen methods. Below we have answered each of the questions by reviewer 2 and provided a list of additional changes to the manuscript that will complement the list in reply to reviewer 1.

Specific comments from reviewer 2

1)Page 14229, line 14. Sentence: “However, at the same(: : :) counts (Table 1).” My question is how the situation looks like during the days with low pollen concentrations, i.e.<50P/m3. Does the correlation coefficient was still high (as for entire pollen season) or does it also decrease? Maybe it would be good to add some additional information to the Table 1, ex. below the sentence: Correlation with the operational trap in Viborg (above 50 grains m3) add Correlation with the operational trap in Viborg (below 50 grains m3).

Answer to the specific comment from reviewer2:

The reviewer has a very good point here. We have therefore expanded the table with one more row, so that the bottom of Table 1 looks as follows:

	Rundhøjskolen	TV2-Østjylland	Aarhus centre
Correlation with the operational trap in Viborg (all data in season)	0.76	0.61	0.70
Correlation with the operational trap in Viborg (above 50 grains/m^3)	-0.35	0.15	0.06
Correlation with the operational trap in Viborg (up to 50 grains/m^3)	0.68	0.74	0.88

To take this extra result into account, we have changed the text on page 14226, line 14-16 from:

“ The correlation coefficient for the daily pollen counts between each of the stations and the operational trap in Viborg is for the entire season between 0.61 and 0.76, whereas the correlation for the peak days is between −0.35 and 0.15.”

Into

“ The correlation coefficient (Pearson) for the daily pollen counts between each of the stations and the operational trap in Viborg is for the entire season between 0.61 and 0.76. Similarly, the correlation for the peak days is between −0.35 and 0.15 and for days with pollen concentration up to 50 grains/m^3 between 0.68 and 0.88”

<u>Specific comments from reviewer 2</u>

2)Page 14226, line 6. I think it would be more correctly to write 95% method then 2.5% - it is not very common to find that kind of definition in aerobiological papers. Furthermore the value 2.5% is used only for calculating the start of pollen season but not the end of pollen season.

Answer to the specific comment from reviewer2:

The reviewer is right. It has to be the 95% method. We have therefore changed page 14226, line 6-7 from

“..using the 2.5% accumulation method (Goldberg et al, 1988)“

Into

“..using the 95% method (Goldberg et al, 1988) “

<u>Specific comments from reviewer 2</u>

3)Page 14230, lines 6 - 18. The conclusions of this paragraph is not fully clear for me. In one hand authors stated that the highest concentrations of grass pollen in Aarhus Central (one of the three examined stations in the city) cannot be link with local sources but with long-distance transport (LDT) from eastern direction. The authors wrote that: “: : :either regional scale or long range transport of grass pollen can be relevant”. However authors stressed that LDT of pollen is only episodically - based on the transport of Ambrosia pollen to Poland (Smith et al. 2008) and therefore still the local sources are the most important sources of grass pollen. I’m not sure if Ambrosia pollen is a good example here: the LTD of Ambrosia pollen to Poland usually concerns several hundreds of kilometers and additionally through very diverse landscapes (ex. mountains). In the case of grass in Aarhus I suspect that the distance from the nearest grass sources located somewhere on the east is much closer (probably less than 100 km?) and the transport of air masses is easier (more or less "flat" land area or sea surface). In other words, based on the one year pollen data, it is just difficult to conclude that the long (maybe medium?) transport of grass pollen to Aarhus Central is a rare phenomenon and should not influence strongly on the pollen counts. Although I believe that authors are right about this issue and generally I agree with theirs last sentences in the Discussion chapter (page 14235, lines 2-7) however probably more data are needed to conclude without doubts that LTD of grass to Aarhus occurs only episodically. Therefore I would like to encourage authors to continue this interesting experiment during the next years just to be able to estimate the real importance of medium range transport of grass pollen to the city.

Answer to the specific comment from reviewer2:

The reviewer is right. In fact the reviewer has identified some of the major challenges in aerobiology and also an area with a less strict definition. Firstly, a recent review by Sofiev et al. (2013) states that a major challenge in the modelling of allergenic pollen is the near source distribution and fraction of pollen that reaches the regional scale of transport. Secondly, there is the issue of spatial scales in atmospheric transport of pollen. This issue was also covered by Sofiev et al (2013), where they adapted the definition by Seinfeld and Pandis (2006). However from a modelling point the adapted definition from Seinfeld and Pandis (2006) is less precise and also less practical as the choice of atmospheric models determines the scale that can be investigated (Orlanski 1975; Seinfeld and Pandis 2006; Sofiev et al. 2013). Instead the rigid scale definitions described by Orlanski (1975) can be very useful as Orlanski separates the mesoscale phenomena into meso-gamma (2-20 km), meso-beta (20-200 km) and meso-alfa (200-2000 km), where each of the scales are suited to be studies by a certain type of model .

Our study concerns the microscale and meso-gamma scale which is the spatial scale up to 20 km. Such a spatial scale is well suited to be studied by Gaussian dispersion models. Studies that cover the meso-beta scale are in general beyond the scope of the Gaussian approach (e.g. Olesen et al. (1992)). Instead source based models of either the Lagrangian type or the Eulerian type should be applied. Long distance of pollen is in general at the meso-alfa scale or larger spatial scales. It is this scale that has been studied by a number of authors that have been cited in the manuscript (e.g. Smith et al, 2008; Belmonte et al 2008, Stach et al, 2007). This suggests that more effort should be made to study atmospheric transport of pollen on the meso-beta scale (20km -200km).

To strengthen the arguments and highlight the different spatial scales and scientific challenges we have modified and extended page 14230, line 9-18 from:

“.. both suggests that there are no sources in that direction.This again suggests that either regional scale or long range transport of grass pollen can be relevant. The latter is supported by studies by Smith et al. (2005), which shows that long range transport of grass pollen is likely to be seen. However, another study by Smith et al. (2008) adds to this finding that long range transport is seen only episodically for species such as ragweed (*Ambrosia*). It is therefore likely that a strong signal from long range transport of grass pollen, which has a much larger settling velocity than ragweed (*Ambrosia*), is even less frequently. This highlights the importance of local sources, and is thus supporting our hypothesis about urban gradients in grass pollen concentrations.”

Into

“.. both suggests that there are no sources in that direction. The nearest sources are about 20 km – 60 km away. This again suggests that either regional scale or long range transport of grass pollen can be relevant. The latter is supported by a study of Smith et al. (2005), which shows that grass pollen could originate from sources more than 100 km away. Another study by Smith et al. (2008) adds to this finding that long range transport is seen only episodically for species such as ragweed (*Ambrosia*).It is therefore likely that a strong signal from long range transport of grass pollen, which has a much larger settling velocity than ragweed (*Ambrosia*), is even less frequently than for *Ambrosia*. Instead shorter distances are likely to be the relevant scales for grass pollen. According to the definition by Orlanski (1975), the typical distances for mesoscale atmospheric transport can be divided in three groups: meso-gamma (2-20km), meso-beta (20-200km) and meso-alfa (200-2000km), where the latter covers Long-Distance transport. This study in combination with the existing studies on Long Distance Transport (e.g. Smith et al, 2008) suggests that the majority of the signal for grass pollen consists of a mixture of atmospheric transport processes on microscale (below 2 km), meso-gamma and meso-beta. From a modelling point, this has been identified as one of the major challenges to understand and describe with respect to airborne pollen transport (Sofiev et al, 2013). This highlights the importance to study local sources, and also supports our hypothesis about urban gradients in grass pollen concentrations.”

and also later in the text we have modified page 14236, line 6-8 from:

"..by taking into account variations in pollen productivity (Brostrom et al., 2008). DAMOS has been shown to be highly useful in assessments of air pollutants with a considerable contribution from both local and regional sources (Hertel et al., 2012)."

Into

".. by taking variations in pollen productivity into account (Brostrom et al., 2008), at species level as well as in the flowering pattern of the main grass species. The applied methodology behind DAMOS has proven highly useful in assessment of air pollutants for which it is crucial to account for sources that contribute as a result of atmospheric flow pattern on micro-scale, meso-gamme as well as meso-beta scale (Hertel et al., 2012) (in this context see the highly useful definitions of micro, meso-gamme, and meso-beta scale in Orlanski et al., 1975)."

Specific comments from reviewer 2

Some other technical/spelling mistakes were noticed however they have been already corrected by Authors in theirs "Reply to reviewer 1" so I will not write it once again.

Answer to the specific comment from reviewer2:

We are pleased that the reviewer is happy with the extensive list of technical corrections.

REFERENCES

Belmonte, J., Alarcon, M., Avila, A., Scialabba, E., and Pino, D.: Long-range transport of beech (Fagus sylvatica L.) pollen to Catalonia (north-eastern Spain), Int. J. Biometeorol., 52, 675–687, 2008.

Olesen, H. R., Løfstrøm, P., Berkowicz, R., and Jensen, A. B.: An Improved dispersion model for regulatory use – the OML model, Air pollution Modelling and its Application, IX, 29–38, 1992.

Orlanski I. 1975. A rational subdivision of scales for atmospheric processes. Bulletin of the American Meteorological Society 56(5): 527-530.

Seinfeld JH, Pandis SN. 2006. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change: John Wiley and Sons, New York, pp 1203

Smith, M., Emberlin, J., and Kress, A.: Examining high magnitude grass pollen episodes at Worcester, United Kingdom, using back-trajectory analysis, Aerobiologia, 21, 85–94, 2005.

Smith, M., Skjøth, C. A., Myszkowska, D., Uruska, A., Malgorzata, P., Stach, A., Balwierzg, Z.,Chlopek, K., Piotrowska, K., Kasprzyk, I., and Brandt, J.: Long-range transport of Ambrosia pollen to Poland, Agr. Forest Meteorol., 148, 1402–1411, 2008.

Sofiev M, Belmonte J, Gehrig R, Izquierdo R, Smith M, Dahl A, et al. 2013. Airborne Pollen Transport. In: Allergenic Pollen: A Review of the Production, Release, Distribution and Health Impacts, (Sofiev M, Bergmann K-C, eds):Springer Netherlands, 127-159, DOI 10.1007/978-94-007-4881-1_5

Stach, A., Smith, M., Skjøth, C. A., and Brandt, J.: Examining Ambrosia pollen episodes at Poznan (Poland) using back-trajectory analysis, Int. J. Biometeorol., 51, 275–286, 2007.

List of changes that have been made to the manuscript due to the requests by reviewer 2:

Page 14226, line 6-7: Changed from “..using the 2.5% accumulation method (Goldberg et al, 1988)“

Into “..using the 95% method (Goldberg et al, 1988) “

Page 14226, line 14-16 Changed from:

“ The correlation coefficient for the daily pollen counts between each of the stations and the operational trap in Viborg is for the entire season between 0.61 and 0.76, whereas the correlation for the peak days is between −0.35 and 0.15.”

Into:

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Into

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Additions to the reference list:

Orlanski I. 1975. A rational subdivision of scales for atmospheric processes. Bulletin of the American Meteorological Society 56(5): 527-530.

Seinfeld JH, Pandis SN. 2006. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change: John Wiley and Sons, New York, pp 1203,

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Changes to figures and tables, including the changed figures:

<u>Page 14244:</u> Expanded Table 1 with one more row, so that the bottom of Table 1 looks as:

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