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Interactive comment on "EMPOL 1.0: a new parameterization of pollen emission in numerical weather prediction models" *by* K. Zink et al.

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First of all, we would like to thank our two referees for their highly appreciated suggestions. We are sure that their input improves the quality of our publication.

Comments of the referees are printed in italics and smaller font. Our answers are printed in normal font. Text that is changed/added in the manuscript is printed in quotes and italics.

The technical corrections were mostly adopted but are not mentioned here.

Answers to Referee Number 1: Branko Sikoparija

However, the EMPOL parameterization is evaluated only for birch and therefore application for other species needs to be tested and therefore remains speculation.

> In the meantime, we have applied the EMPOL parameterization to grasses and ragweed. The results are promising. However, this data has not been published yet. We have changed/added the following sentences:
> *"For the time being, the functions have only been tested for birch pollen emission. However, during the last months, EMPOL has also been employed for grasses and ragweed using plant-specific constants (e.g., in the functions for temperature, humidity and TKE). First results are very promising (not shown)."*

It is difficult to discern exact differences between EMPOL and other known parameterizations for pollen release (as mentioned in the text H_{orig}, H_{opt}, S13), or at least H_{opt} which is used in evaluation process. I would suggest including a table (as supplementary material) that will present the exact differences which are described in sections 3.2 and 3.3.

> A table has been added to the supplementary materials. A reference to the table has been added in chapter 3.

I would also recommend presenting the section 4.1 in the form of a flow chart (maybe provided as supplementary material).

> A flowchart has been added to the supplementary materials. A reference to the flowchart has been added at the end of chapter 4.1.

In addition, the authors should stress critical points where adjustment might be required if the EMPOL parameterization is used for other trees, grasses or ragweed.

The following text has been added at the end of chapter 4.1:
"If EMPOL is used for other pollen species, the plant-specific values in the following parameters need to be adapted: $Q_{pollen,day}$, $Q_{pollen,\Delta t}$, $f_{R,T}$, $f_{R,RH}$, $f_{E,TKE}$, $f_{E,RH}$, Ψ_{random}, and Ψ_{precip}. Additionally, the following input fields/values need to be provided: $f_{Q,cov}$, $f_{Q,seas}$, $f_{Q,alt}$, the pollen diameter, and the pollen density."

It was shown that in herbaceous annuals (e.g., ragweed) the production (including pollen production) positively correlates to the amount of available CO_2 in the atmosphere (Rogers et al., 2006; Ziska et al., 2000). As a result, the given function would have different outcomes for plants living in urban and those living in rural areas. Similarly, atmospheric CO_2 would have different effects at increased distances from roads.

Thank you very much for this interesting remark. In the present parameterization, adapted for birch pollen, this has not been considered. However, for a future version of EMPOL, this could well be one of the improvements. We have added the following text to the *Summary and conclusions* summarizing possible improvements including the ones suggested by the referee:
"For the future development of EMPOL, the following paragraph lists some of the possible improvements.

- *Conducting field or laboratory experiments to deduce better functions relating meteorological conditions to the different steps of pollen emission.*
- *Introducing a mechanism that hinders pollen release and/or entrainment for a certain time period after a precipitation event.*
- *Introducing the influence of rising CO_2 on the pollen production (e.g., Ziska et al. 2000, Rogers et al. 2006). With respect to the present parameterization this could be done in several ways: (1) $Q_{pollen,day}$*

could be transformed into a variable field (right now, its value is fixed for the entire domain), (2) a new input field could be introduced that reflects the influence of CO$_2$, e.g., f_{Q,CO_2}, (3) the influence of CO_2 could even be calculated within the model if COSMO-ART is run in a 'full mode' including reactive trace gases."

It should be stressed here that opening of the flowers does not necessarily mean that the pollen will be released. Therefore after the pollen is ripe the emission will happen after flowers and anthers are opened. This is illustrative in anemophilous plants (e.g., birch, hazel) in which inflorescences are extended and the flowers are opened (making anthers exposed to environmental conditions) before the anthesis and the release of pollen grains. This means that the opening of flowers is a step before pollen release. In some species flower opening and anthesis are simultaneous, or anthesis can even precede the opening of flowers (e.g., Vitis vinifera) (Staudt, 1999). For other species, particularly anemophilous plants, the flowers have to be opened before pollen is released from the anthers. Since the paper tends to present parameterization concept applicable to a wide spectra of species, the authors should indicate all steps at which modifications could improve the quality of the emission model. Bearing this in mind, besides two given questions (page 3139, line 16), the emission parametrization should also adress how the emission takes place (i.e. the mechanism).

Thank you for this clarification. In our discussion paper, we have used the term 'opening of the flowers' as a synonym for 'anthesis'. We now see that this is not correct. We have therefore replaced the term 'opening of the flowers' with 'anthesis' throughout the paper. In the present version of the model, the emission parameterization neglects the opening of the flowers and only simulates the anthesis. If a distinction of these two processes yielded better results, it would indeed be interesting to add the opening of the flowers as an additional step in a future version of the parameterization. However, this only seems promising if observational data were available connecting each separate step leading to pollen presentation to variables that are available in the model (thus mostly meteorological variables). If such data is not available in a high temporal resolution, the model cannot 'see' the difference between 'opening of the flowers' and 'anthesis'. Since this is rather hypothetical, we have refrained from adding this aspect to the possible future improvements of the parameterization.

The mean of pollen presentation is different among plant species. The authors mentioned ragweed that presents part of its pollen on surface of the leaves under the flowers. However, there are also plant taxa such as Urticaceae (Dahl et al., 2013) and Moraceae (Rohwer, 1993) that tend to release pollen in an explosive manner. In such species, pollen enters the atmosphere as small puffs. Bearing in mind that the proposed concept is designed to be the basis for the parameterization of pollen release in different plants, it is necessary for the authors to indicate to what extent the type of pollen presentation alters the influence of proposed environmental factors to the entrainment of pollen grains in the atmosphere.

The type of pollen presentation should be considered through the functions $f_{R,T}$, $f_{R,RH}$, $f_{E,TKE}$, and $f_{E,RH}$. We would like to give a hypothetical example: a plant species opens its anthers under certain conditions of temperature and relative humidity. The pollen is released from the anthers and entrained into the atmosphere during or at the end of the anthesis explosively, regardless of the wind speed or turbulence. In such a case, $f_{R,T}$ and $f_{R,RH}$ would have to be adapted to represent the influences of temperature and relative humidity on the anthesis. $f_{E,TKE}$ and $f_{E,RH}$ would then be set to 1 since they do not influence the emission process. In that case, the pollen grains would not fill up the reservoir, but would be entrained into the atmosphere directly. If the efficiency of the explosive release depends on the state of the atmosphere (e.g., the turbulent kinetic energy), this dependency should be described via $f_{E,TKE}$. We have added the following text:
"If pollen grains are released from the anthers in an explosive manner (compare Rohwer 1993) and entrained into the atmosphere regardless of the turbulent kinetic energy and relative humidity, these two functions $f_{E,TKE}$ and

$f_{E,RH}$ can be set to a fixed value of one. In that case, the pollen reservoir will not be filled, but all pollen released from the anthers will be entrained into the atmosphere directly."

Before the evaluation of the performance of the EMPOL, the authors need to give a short evaluation of the pollen dataset used in the development and validation process (2010-2012). Are there any irregularities in the birch pollen seasons from different locations? As mentioned in the paper, birch shows bi-annual cycle in pollen season intensity (Dahl et al., 2013). Although taking two years (2010-2011) for tuning the parameterization could resolve the problem, I wonder, whether a mast year (more pollen in the pollen season) in 2012 in some stations, would affect the model performance with the respect to predicting concentrations.

Concerning irregularities, we have added the following paragraph to Section 5.2:
"The observational data has been checked for outliers. Additionally, we excluded sites that had less than 7 days of observations within the chosen period (see above)."
Concerning mast years, we have added a new subsection to the results including a table:
"As mentioned before, birch shows a bi-annual variation of the pollen production (years with high pollen production are referred to as 'mast years'). The overall level of the pollen concentrations in the model is tuned based on simulations and observations of pollen concentrations of a predefined set of years. Usually, such a set of years will contain both mast years and normal years. This will result in a simulated pollen level somewhere between mast years and normal years. Therefore, the occurrence or non-occurrence of a mast year in the period chosen for the experiment will have an influence on the performance of the model for the statistical scores that are sensitive to the overall level of the pollen concentrations (e.g., the fraction of predictions within a factor of 2 of observations). Scores that are not sensitive to

the overall level (e.g., the correlation coefficient) will not be influenced by the occurrence of a mast year. We tried to identify the mast and normal years in the period used in this study (2010 to 2012) based on the Swiss observational data. Values of the seasonal pollen index SPI (yearly sum of the observed daily pollen concentrations) for the Swiss observational sites is given in Table 8. It is not possible to make a clear statement. Four of the Swiss observational sites show the highest SPI in the year 2010, three in the year 2011 and two in the year 2012. The variation between the years can be very small (e.g., sites 5 and 9) or very strong (e.g., sites 6 and 11). Looking at this data, it is obvious that it is not even possible to make an overall statement for these stations that are relatively close to each other about a certain year being a mast year or not. It is not consistent between the different observational sites. Additionally, the difference between mast years and normal years can be strong or very weak, depending on the observational site."

Finally, there is an impression that there are not enough references to support some of the statements given in the paper. For example, on page 3142, line 15 the authors say: "Following measured pollen data, the shape of the pollen curve is chosen to be positively skewed". Does this refer only to measured data from Swiss stations or it is expected throughout Europe? Recent publication by Grewling et al. (2012) confirmed positive skewness of the birch pollen curve in an area of Central Europe.

Thank you very much for this useful reference. We have used measured pollen concentrations at different stations in Switzerland to derive the assumption that the shape of the pollen curve is positively skewed. However, we have not done an in-depth investigation of this phenomenon. Therefore, we have changed the text to:
"Following measured pollen data in Switzerland, the shape of the pollen curve is chosen to be positively skewed. A similarly skewed shape of the pollen curve has been reported for Central Europe by Grewling et al., 2012."

Also on the page 3152, line 24 the statement "These thresholds are based on allergological studies" requires references, especially as the reader is not know the proportion of hay fever sufferers this relates to (e.g., is it the majority of sensitised patients?).

We have changed the text and added some references:
"Manual operational pollen forecasts are usually done for pollen classes that reflect more or less the strength of the allergenic symptoms that are induced by the given pollen concentration. These thresholds depend on the sensitization rates and are not constant over regions (Jäger, 2011). Table 2 gives the thresholds for birch pollen concentrations used for the operational pollen forecasts at MeteoSwiss (Gehrig et al., 2013)."

Page 3146 line 9 The construction "fill up a pollen reservoir" has a botanical synonym "pollen presentation" and as such should be defined.

We have changed the text to:
"Depending on biological and meteorological conditions, a certain number of pollen grains are released from the flowers and fill up a pollen reservoir. Botanically, this process is called pollen presentation."

I do not think that the design of figure 7 is appropriate for presentation of correlation coefficients and corresponding p-values because it is really difficult to link them. In addition, it is difficult to link some of the columns in the upper panel to corresponding station code. I understand the intention to emphasize that higher coefficients tend to have lower p-values but I believe table would be better option.

We have replaced the figure with a table.

Answers to Referee Number 2: Carmen Galán

As authors have transmitted, airborne pollen has been detected by Hirst type spore trap (Hirst 1957) (you can include this reference in the text). On the other hand, you can also mention that all EAN members follow the Minimum Requirement in the Methodology for Routinely Performed Monitoring of Airborne Pollen Recommendations (News, 1995. Aerobiologia, 11:69-70).

We do not have a confirmation of all of the EAN members that they really do follow these recommendations. Therefore, we have not added the corresponding sentence. Concerning the pollen trap, we have added the following text:
"Pollen grains were sampled using Hirst type traps (Hirst, 1952)."

In some occasions, appear in the text "pollen emission" as synonymous of "pollen production". When referring to pollen production, it is important to express "pollen production per plant" or "per flower" or "per inflorescence"...Probably it should be better to use the term "airborne pollen" or "pollen content in the air", instead "pollen concentration", when referring to pollen under different aerobiological process to avoid confusions. This term is not useful when referring to pollen production.

Thank you for making us aware of these inconsistencies. We have revised the entire publication and used the following definitions consistently. We have added the following paragraph at the end of the *Introduction*:
"Throughout the publication, we have used the following terms to describe the different processes and parameters in the context of pollen emission:

- ***anthesis:*** *opening of the anthers.*
- ***pollen release:*** *release of the pollen from the anthers, either into a reservoir or into the atmosphere directly.*

- ***pollen presentation:*** *making the pollen grains available for entrainment into the atmosphere. Usually, this is the result of the combined processes of anthesis and pollen release.*
- ***entrainment:*** *uplifting of the pollen from the reservoir or from the anthers into the atmosphere.*
- ***pollen emission:*** *refers to the combined processes of pollen release and entrainment into the atmosphere. This term is used when the different steps during the emission process are not distinguished. This formulation is necessary since many emission parameterizations treat pollen release and entrainment as a single process.*
- ***pollen production:*** *amount of pollen that is produced per square meter and per year.*
- ***pollen concentration:*** *concentration of airborne pollen, given in number of pollen grains per cubic meter of air."*

"The seasonal cycle of pollen emission depends on the percentage of ripe pollen grains in the anthers, hence the development of the plants". Pollen per anther is under genetic and physiological control per specie (Subba Reddi and Reddi 1986), however, the number of flowers or inflorescence per plant depend on environmental factors (Stanley and Linskens 1974), and then with annual variations. For this reason, probably it could be expressed as: "The seasonal cycle of pollen emission depends on the number of flowers or inflorescences by plant, depending on different environmental factors".

Thank you very much for this clarification. We have changed the text to:
"The seasonal cycle of pollen emission depends on the number of mature flowers or inflorescences, hence the development of the plants. It is driven by the weather conditions during the preceding weeks or months and usually is described via phenological models (e.g., Sarvas 1974, Garcia-Mozo et al. 2009)."

"The diurnal cycle of pollen emission is driven by the current meteorological conditions that lead to a rupture of the anthers...and to the entrainment of the pollen grains into the atmosphere". Yes, but not confuse that pollen emission always refers to pollen release from the anther and usually occur at the same hour of the day. However, the diurnal cycle, or diurnal airborne pollen curve, also depend on local breezes and atmospheric stability. Probably it could be expressed as: "The diurnal cycle of airborne pollen is driven by the current meteorological conditions that lead to a rupture of the anthers for pollen emission... and to the entrainment of the pollen grains into the atmosphere under different local breezes and atmospheric stability".

As described above, we have now defined the terms used in our publication. From a meteorological point of view, the term 'pollen emission' usually is used for the combined processes of making a substance available and entraining it into the atmosphere. Using this definition, we think that the sentence mentioned above is correct. If the term 'pollen emission' only referred to the release of the pollen from the anthers the above sentence should have indeed be changed accordingly. Please note that we are referring to the 'diurnal cycle of pollen emission' and not to the 'diurnal airborne pollen curve'. Usually, graphs of observed pollen concentrations show the diurnal airborne pollen curve which not only depends on the diurnal variation of pollen emission but also on transport processes. However, in the model, the emission parameterization only addresses aspects of the pollen emission while the transport process takes place in a different part of the model.

"Some plants (such as birch trees) produce less pollen when they grow at higher altitudes" (reference).

We have added two references: Sveinbjörnsson et al. (1996) and Gehrig and Peeters (2000). Additionally, we have added the sentence:
"This factor is plant-specific and must take into account the influcence of the changing climatic conditions with altitude on the plant."

MeteoSwiss, COSMO-ART use emission parameterization by including temperature, humidity and wind velocity. However, I think that wind velocity is a parameter influencing pollen dispersion and transport, not really for pollen emission. Probably this project is for airborne pollen parameterization.

See above: we use the term 'pollen emission' for the combined processes of pollen release and entrainment.

"For example, grasses need high relative humidity for the opening of their anthers since they have to swell in order to crack" (more recent references).

We have added the following references: Keijzer et al. (1996), Matsui et al. (1999) and Dahl et al. (2013).

"Small plants emit more pollen than big plants" (reference?). In my opinion it is not really clear. First of all, indicate that you are referring to anemophylous plants. Second, some studies on pollen production per plant support that in the case of grasses pollen production per inflorescence varies a lot among different annual or perennial species (Prieto-Baena et al 2003). On the other hand, most grasses (smaller plants) produce less pollen per plant than most anemophylous trees (bigger plants). Anemophylous trees are adapted to produce sufficient amount of pollen for pollination under different strategies (Tormo-Molina et al 1996).

This sentence refers to the emission parameterization after Helbig et al., 2004, where small plants emit more pollen than big plants. This is true for any pollen species simulated with the Helbig et al., 2004, parameterization. Since this statement only describes a feature of an emission parameterization, we cannot give a reference. It has to be clearly noted that it is not our opinion that 'in reality' small plants emit more pollen than big plants. Actually, this feature was one of the arguments for developing a new emission parameterization where the height of the plants is not taken into account

anymore. In EMPOL, the difference in pollen production regarding the different species is governed by the plant-specific parameter $Q_{pollen,day}$. We have changed the text to:
"Additionally, the sensitivity of the simulated emission flux on the height of the plant shows the undesirable feature that small plants emit more pollen than big plants."

"...thresholds are based on allergological studies" (references).

We have changed the text and added some references:
"Manual operational pollen forecasts are usually done for pollen classes that reflect more or less the strength of the allergenic symptoms that are induced by the given pollen concentration. These thresholds depend on the sensitization rates and are not constant over regions (Jäger, 2011). Table 2 gives the thresholds for birch pollen concentrations used for the operational pollen forecasts at MeteoSwiss (Gehrig et al., 2013)."

"...allergenic plants shed their pollen at different times leading to several pollen peaks..." It is important to consider that "the same plant" can emit pollen at different times during the maturation process for different flowers or inflorescences. However,different peaks in the curve, usually, more correspond to "different plants" flowering at different times along the season, depending on the local clime and topography. On the other hand, this fact occurs in all plants, not only in "allergenic plants".

The term "allergenic plants" was misleading: we did not want to talk about different peaks in the pollen curve of one individual species. We meant to say that during the course of the year, different plant species shed their pollen at different times leading to different peaks in the pollen load coming from different species: e.g., the birch pollen season, the grass pollen season, the ragweed pollen season. We have changed the text to:

"Different allergenic plant species shed their pollen at different times of the year leading to several pollen seasons (e.g., birch pollen season, grass pollen season)."

"...higher wind speeds would yield higher pollen emissions..." Are you referring to higher wind speeds would yield higher pollen dispersion or transport, once pollen has been emitted? For pollen emission it is more important temperature and humidity, i.e. dry and sunny weather. Probably should be expressed: "...higher wind speeds would yield higher airborne pollen...", isn't it?

We have changed the text to:
"...higher wind speeds would yield stronger entrainment, hence more airborne pollen."

To define pollen season, it is necessary to take into account a long database and to know the phenological behavior of the plant. Authors refer to the role of temperature to defining the length of pollen season, however, the rainfall and water availability also play an important role: dryer season possible shorter pollen season.

The beginning, length and course of the pollen season are calculated within a separate model (the mathematical description of the pollen season). Up-to-now, the influence of rainfall and water availability has not been incorporated into this model. This might well be a field of future improvements, especially for plants in a Mediterranean climate where water is a growth-limiting factor. In the present study, the mathematical description of the pollen season is the same for both emission parameterizations. We have added the following paragraph to Section 5.1:
"The mathematical description of the pollen season $f_{Q,seas}$ is taken from the phenological model developed for the operational numerical pollen forecasts at MeteoSwiss (compare Sect. 3.1). It is used as an input parameter for the emission parameterization in both model configurations."

Regarding other features, it is not clear that: "leaf area index (LAI) and the height of the plants that influence the amount of emitted pollen. If leaves keep the pollen grains within the canopy"...Pollen has been really emitted by plant and deposited on the leaf area, are you referring that pollen has not been well transported? Probably it could be expressed as: "leaf area index (LAI) and the height of the plants that influence the amount of airborne pollen. If leaves keep the pollen grains within the canopy".

It has to be noted that these sentences refer to the emission parameterization after Helbig et al. (2004). In that parameterization, pollen release and entrainment are parameterized in a single function. Therefore, LAI and the height of the plants really do influence the amount of 'emitted' pollen. The descriptive view behind the parameterization is indeed what the referee supposes: the pollen grains have been released but cannot be entrained into the atmosphere since the leaves keep the already released pollen grains within the canopy. According to our definition of the term 'pollen emission' we will keep our version of the sentence because it describes a feature of the Helbig et al. (2004) model. However, we have changed the text describing the theoretical thoughts behind this feature:
"The idea behind this is that leaves keep the released pollen grains within the canopy."

This proposal is based on the "airborne pollen" refers to pollen emission (release) and entrainment (transport). "The maximal amount of pollen that can be released per day on one square meter if the conditions were perfect", in this theoretical case I suppose that it is considered the potential pollen production per plant (it is easy to calculate) and not the pollen emission (it should be predicted). Isn't it?

This figure indeed represents the potential pollen production per day and per square meter (not per plant!). It is not the amount of pollen that are actually released and entrained into the atmosphere, which has to be calculated (using this maximal amount of pollen as one of the variables in the parameterization).

"Φ_{plant} combines the plant-specific variables that define the potential amount of pollen that could be emitted under perfect meteorological conditions". For potential amount of pollen per m3, I also suppose that you use pollen production per plant and land cover.

The use of the term 'potential' was a bit confusing here. The pollen production per plant and land cover is only part of this factor. It also includes influences of the state of the season and the altitude. We have therefore changed the text to:
"The factor Φ_{plant} combines the plant-specific variables that define the amount of pollen that could be released per time step under perfect meteorological conditions at a given grid point."

"$Q_{pollen,day}$ was set to $2.133 \cdot 10^9$ pollen per square meter and per day. The maximal amount of pollen that can be emitted per time step. It is calculated from the amount of pollen that can be emitted per day under perfect conditions ($Q_{pollen,day}$)". My question is if this figure is for only one day and if the same amount is consider for every day of the month?

Yes, this figure is the same for each day of the year and for each grid point in the model domain. It represents the amount of pollen that can be emitted from one square meter during one day under ideal biological and meteorological conditions at the height of the pollen season. However, to respect the fact that the plants produce less pollen at the beginning and at the end of the pollen season, a correction factor called $f_{Q,seas}$ is used to reduce this figure. This correction factor is calculated for each grid point separately using temperature sums in order to respect local flowering periods. To clarify this in the text, we have changed the paragraph where $Q_{pollen,day}$ is introduced (note that it is not the paragraph the referee is quoting here!):
"Conceptually, the parameterization can be described as follows: a constant factor $Q_{pollen,day}$ gives the maximal daily amount of pollen that could

be released at the height of the pollen season on one square meter if the conditions for pollen release and entrainment were perfect."

If you express that you are using bihourly pollen count, and: "The formula takes into account that the flowers can run out of ripe pollen grains before the end of the day. In our implementation, this will happen after 16 h of optimal emission conditions". At what time you consider the maximum pollen emission?

The description of this formula obviously was confusing. We have now changed the text to:
"The amount of pollen that can be released per time step is calculated from $Q_{pollen,day}$ considering the following requirements/assumptions:

- *Under optimal conditions for pollen release, the flowers can run out of pollen grains before the end of the day.*
- *The daily cycle of pollen release is not prescribed in the model. The amount of released pollen does not depend on the time of the day but results from the functions $f_{R,T}$ and $f_{R,RH}$.*

In our implementation, we assume that the flowers will run out of pollen grains after 16 hours of constant pollen release. $Q_{pollen,\Delta t}$ can then be calculated by dividing $Q_{pollen,day}$ by the number of time steps during a 16 hour-period:"

The half-life of the reservoir is set to 12 h. Yes, but pollen content is different among the different 12 hours, isn't it?

To make the text clearer, we changed the corresponding paragraph to:
"The number of pollen that are lost from the reservoir due to random processes is derived by using the concept of a half-life. Under the premise that only the random losses are effective, we assume a continuous removal

from the reservoir such that after 12 hours, half of the pollen present in the reservoir is lost. This assumption is used to calculate the percentage of the pollen in the reservoir that are lost per time step due to random processes:"

When testing the new parameterization, the authors define the pollen season as: "the period between the first and last occurrence of 70 pollen per cubic meter in the observations (daily means). They also "exclude days outside the main pollen season from the exercise". This corresponds to a pollen class of "strong". I think that with this pollen season definition, the authors probably avoid pollen from plants booming at the beginning or the end of the season, in favor of Strong class.

Yes, this is correct and it is what we intended to do.

Table 5 with different seasons, it is not necessary due to birch flower during early spring.

Table 5 presents PSS Scores for precipitation. The aim of this table is to present values of the PSS Score for an operational parameter as a comparison to the values that we obtain for birch pollen concentrations. Since precipitation is not limited to only one season - as it is the case for birch pollen concentrations - we think that it is interesting to compare the values obtained for different seasons. We have changed the text to:
"Since precipitation, in contrast to birch pollen concentrations, is not limited to only one season, the analysis has been done for all four seasons (spring, summer, autumn, winter)."

Interactive comment on Geosci. Model Dev. Discuss., 6, 3137, 2013.