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Geoscientific
Model Development
Discussions



# *Interactive comment on* "The regional aerosol-climate model REMO-HAM" *by* J.-P. Pietikäinen et al.

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## General comments

**This manuscript describes the development and initial application of a regional aerosolclimate model for a 1-year simulation at two spatial scales over Europe. The model is compared to the global aerosol-climate model ECHAM5-HAM and observations made at four European measurement sites. My overall impression is generally favorable. The manuscript is nicely organized, in that it first describes the model that is its starting point (REMO), then the modifications made to the model, then the application and evaluation.**

**However, there are several points that should be clarified, as detailed below.**

**Furthermore, while I recognize that actually using the model to address scientific questions is beyond the scope of this paper, I would like to see some discussion of what scientific questions this model will be able to address. In short, why is this model needed?**

We thank the reviewer for valuable comments for improving our manuscript. Throughout the text reviewers comments are marked with boldface and after each comment follows our reply.

We have merged Figures 1 and 2 so the numbering is changed in the corrected version starting from the Figure 2 (previously Figure 3). In addition, the Figures 2, 6 and 7 (new numbering) have been updated.

The motivation to this model came from the current limitations of ECHAM-HAM model. As it is a global aerosol-climate model, it needs quite a lot of computational power. In order to study the aerosol-climate effects in smaller scales than (currently possible) with ECHAM-HAM, the implementation of aerosol model to (existing) regional climate model REMO was natural. As mentioned in the manuscript, this is not the first time with such an approach. We think that REMO, a well known and validated regional model, with aerosols included can bring much to the regional aerosol-climate community. In this work we have presented the implementation and some results what we have learned so far.

**Specific Comments**

**Abstract: It seems contradictory to say that REMO-HAM "includes all of the major aerosol processes" but then to note that total number concentrations are "underestimated due to the missing boundary layer nucleation and online secondary organic aerosol model." Also, it seems that aerosol effects on radiation are not included, so I think this statement needs to be qualified.**

That is a good point. We have rephrased the beginning of the abstract to:"REMO-HAM



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is a new regional aerosol-climate model. It is based on the REMO regional climate model and includes most of the major aerosol processes. The structure for aerosol is similar to the global aerosol-climate model ECHAM5-HAM, for example the aerosol module HAM-M7 has been coupled with a two-moment stratiform cloud scheme. On the other hand, REMO-HAM does not include online coupled aerosol-radiation module..."

We have also rephrased the second part of the comment to:"...represent the measured values reasonably well. Since we did not use boundary layer nucleation and online secondary organic aerosol model, the total number concentrations are slightly underestimated. The differences in the..."

**Introduction: Please provide some more details for the references given on 741.11-14. Instead of merely listing those papers, say something about what was learned from them, or how they differed from each other. How does the present study build on and differ from that previous work?**

We have listed the main points of all the references mentioned.

**In the model description, please clarify which processes are included and which are excluded. On first reading the paper, I thought aerosol direct and semi- direct effects were included in REMO-HAM until I got to 757.25, which implies that modeling the direct effect would be a valuable addition.**

We have corrected the manuscript to be more clear on this.

**Lateral and upper boundary: What is the vertical extent (model top) used for these simulations? How many vertical layers are used? For the comparisons at Jungfraujoch, what model layer corresponded to the pressure observed at the site, and how much does this affect the particle number concentrations?**

We have added the following to the Lateral and upper boundary section: "In this work, we have used 31 vertical levels for the models. In ECHAM5-HAM, the uppermost level



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reaches 10 hPa, and in REMO-HAM 20 hPa is reached."

In addition, when Jungfraujoch results are discussed, we added: "Later we can see (Figure 4) that at higher altitudes the concentrations increase. This explains why the concentrations are so high at Jungfraujoch. The reason for the high concentration on higher altitudes is explained in Section 3.1.2."

**For the model evaluation, it would be helpful to compare the performance to that of other models, to establish what are expected performance criteria for total particle number.**

Comparison with other models would indeed be interesting. Nevertheless, in this work we wanted to show how REMO-HAM performs compared to measurements and ECHAM5-HAM (which is similar (global) model). Hopefully in the future such a comparison effort can be done.

**Also, the discussion on page 751 is rather unclear, and unlike the minor technical corrections listed below, really impairs the ability of the reader to understand the paper. Here is a suggested partial rephrasing: Although a boundary layer (BL) nucleation scheme has been implemented in the models, this scheme was turned off for these simulations. The absence of BL nucleation may have contributed to the underestimation of particle number at Hyytiälä during spring and autumn, which are typical nucleation event times at that site (Dal Maso et al., 2005).**

Corrected as suggested + some other corrections.

**751.17 This is unclear. Do you mean that the number concentration does not differ seasonally? Or does not differ between ECHAM5-HAM and REMO-HAM? On 751.18 the text says that the "except for the nucleation and Aitken mode" the number concentrations does not differ much (b etween ECHAM5-HAM and REMO-HAM at Hyytiala). But on 751.26 the text says "Unlike at Hyytiälä, the nucleation mode concentrations [at Melpitz] differ the most" [between ECHAM5-**



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**HAM and REMO-HAM].**

The idea is to show where the difference between the model is coming from. It is true that this part was unclear. Now it has been rephrased: "From Figure 3 we can see that the modal number concentrations between the models does not differ much at Hyytiälä. Aitken mode is smaller with REMO-HAM during the whole year, which can explain the differences in the Figure 3. The nucleation mode concentrations are a bit higher in REMO-HAM, but the difference is not very big. The differences in Aitken mode concentrations are discussed in Section 3.1.2."

**Technical Corrections - noted by page and line number**

**739.7: was -> were**

Corrected as suggested.

**739.25-26: "This effect is known as..." or "This is an effect referred to as..." Also, it is usually called the aerosol "semi-direct effect" rather than the "semi-indirect effect".**

Corrected to: "This effect is known as..." and "semi-direct effect"

**740.1 insert "The" before "indirect effect is"**

Corrected as suggested.

**740.4-5 reduced -> reduce and prolongs -> prolong**

Corrected as suggested.

**740.20 delete "the" before "nucleation"**

Corrected as suggested.

**741.16 delete "will concentrate to"**

Corrected as suggested.



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**742.9: does REMO use a sigma-pressure coordinate system? If so, consider adding "sigma-pressure" after "hybrid".**

Corrected as suggested.

**743.6 "population" should be plural, "populations", or perhaps "modes".**

Corrected to: "populations"

**743.9 intermodal 743.13 ...insoluble Aitken, accumulation, and coarse modes, and one soluble...**

Corrected as suggested.

**743.14 standardize spelling as "sulfate" or "sulphate" throughout the paper**

Corrected to: sulfate

**743.15 "component" should be "components"**

Corrected as suggested.

**743.19 (Jacobson et al., 1996)**

Corrected as suggested.

**743.19-20 Are both of these two water uptake methods used, or does the user select either one method or the other at runtime?**

Added: "In this work, the latter has been used."

**743.26 "committed to" -> "placed in"**

Corrected as suggested.

**744.16 "excluding sea salt and DMS emissions"**

Corrected as suggested.



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**744.19-20 "All the emission species...primary emissions." I do not understand what this sentence means. "Primary" species are those which are emitted.**

Primary emissions means that they are emitted directly to corresponding species. Corrected to: "...primary emissions (emitted directly)"

**744.21 insert "the" before "marine biosphere"**

Corrected as suggested.

**745.4 delete "being"**

Corrected as suggested.

**745.18 "organic" matter**

Corrected as suggested.

**745.18+ Awkward. Perhaps "With the exception of the fire and fuel sectors, soluble organic matter is emitted as organic carbon and is divided between..."**

Corrected as suggested.

**745.24 mode "parameters". What are these parameters? Perhaps cite Vignati et al. again?**

We wanted to express that the mode properties (width, height...) match. Changed to: "mode properties" + citation to Vignati et al.

**746.6 It is confusing to mention a "new" double-moment scheme and cite a paper from 1996. Also, I think one reference should be sufficient here. "In order to use the information in the stratiform clouds, we implemented the double-moment cloud microphysics scheme of Lohman et al. (2007)."**

Corrected to: "In order to use the information in the stratiform clouds, we have implemented the double-moment cloud microphysics scheme by Lohmann et al. (2007). This scheme has..."



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**746.24 crystals**

Corrected as suggested.

**747.25 delete repeated "the"**

Corrected as suggested.

**747.28 what is the spatial resolution of the driving data?**

It is 1.125*1.125 degrees. Corrected to "We have used the European Centre for Medium-Range Weather Forecasts (ECMWF) operational data set (1.125(degrees)*1.125(degrees)) for..."

**748.13 "are used as boundary data"**

Corrected as suggested.

**748.16, 19, and elsewhere: delete "the" before a numbered figure.**

Corrected as suggested.

**748.16 Figure 1 shows...**

Corrected as suggested.

**748.24 insert "the" before "time period"**

Corrected as suggested.

**749.23-24 All the longitudes are given in minutes, but they should be in degrees.**

Corrected to degrees.

**749.27 delete "the" before "Differential"**

Corrected as suggested.

**750.1 Condensation Particle Counter (CPC) data was used for total number con-**



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**centration at Jungraujoch (Collaud Coen et al., 2007, 2011) and at Mace Head (OâConnor et al., 2008).**

Corrected as suggested.

**750.4 insert "a" before "Scanning"**

Corrected as suggested.

**750.13 "From all" -> "Of" and delete repeated "the"**

Corrected as suggested.

**752.11 delete "(The Alps)"**

Corrected as suggested.

**752.19 change "later on" to "in Section x.y".**

Corrected as suggested.

**752.28 starts -> start**

Corrected as suggested.

**754.10 "lead" -> "led"**

Corrected as suggested.

**755.12 delete "the" before "otherwise"**

Corrected as suggested.

**755.21 "concentrations decrease" or "concentration decreases"**

Corrected to: "concentrations decrease"

**755.21 "not anymore high enough" should be "no longer high enough" or "too low" or "insufficient"**



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Corrected to: "no longer high enough"

**755.27 "unrealistic" -> "unrealistically" and "with" -> "on the"**

Corrected as suggested.

**755.28 "another" -> "other"**

Corrected as suggested.

**756.14 "lowest model layer"**

Corrected as suggested.

**756.22 "was the same for both simulations"**

Corrected as suggested.

**756.25 "It should also be mentioned"**

Corrected as suggested.

**757.1 "presentation" -> "representation"**

Corrected as suggested.

**757.16 "the nudging method" -> "nudging"**

Corrected as suggested.

**757.19 "both models reproduce"**

Corrected as suggested.

**757.21 "Both models have a warm bias"**

Corrected as suggested.

**757.22 "seems to overestimate" -> "overestimates"**

Corrected as suggested.



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**757.25 Insert "The" before "direct effect"**

Corrected as suggested.

**758.1 insert "a" before "dry bias"**

Corrected as suggested.

**758.3 delete "more"**

Corrected as suggested.

**758.8 "decreases exponentially" (both words misspelled)**

Corrected as suggested.

**758.18 "The simulations were done"**

Corrected as suggested.

**758.20 "the ECHAM5-HAM simulation"**

Corrected as suggested.

**759.8 "lead" -> "led"**

Corrected as suggested.

**759.11 see comment for 755.21**

Corrected to: "no longer high enough"

**759.15 "to" -> "in"**

Corrected as suggested.

**759.24 "was" -> "were"**

Corrected as suggested.

**759.25 "CRU observations"**



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Corrected as suggested.

**768 "orographies" is misspelled. Change "used domains" to "domains used". Shown on the left hand side is...**

Corrected as suggested.

**770 Fig. 3. Put the locations as the titles for each panel, as in Fig. 4. Change the legend and/or caption to say that the black line is "measurements" or "observations".**

Corrected as suggested. In addition, Figures 7 and 8 changed to similar style.

**775 Fig. 8. Same comment as above. Also, REMOHAM is missing a hyphen in the legend.**

Please see previous comment + hyphen corrected

**777 Fig. 10 "mean" -> "means"**

Corrected as suggested.

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Interactive comment on Geosci. Model Dev. Discuss., 5, 737, 2012.





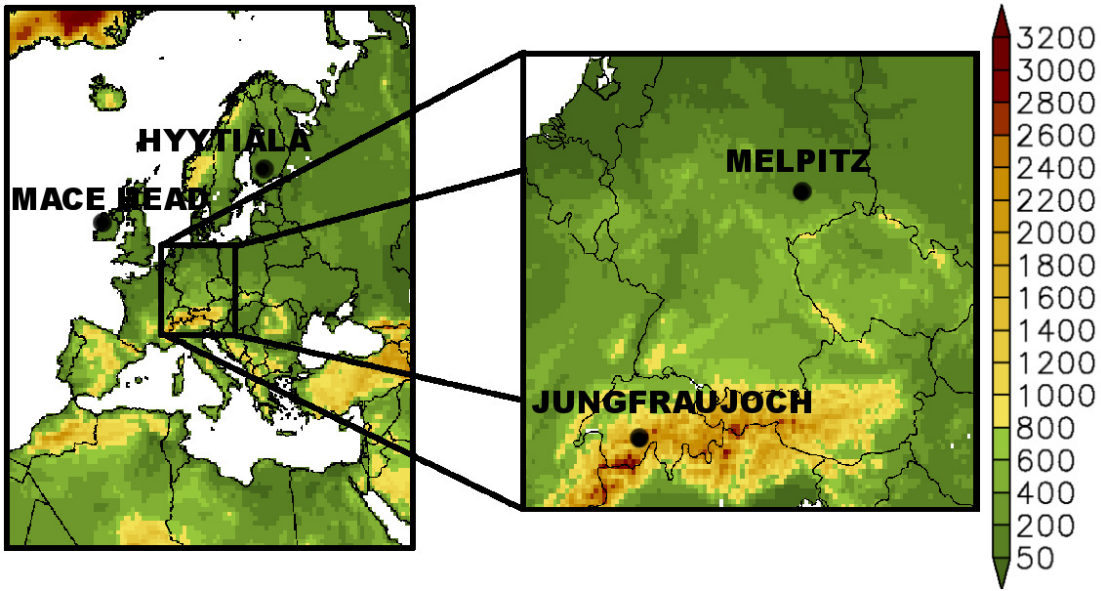


**Fig. 1.** Figure 1 of the manuscript



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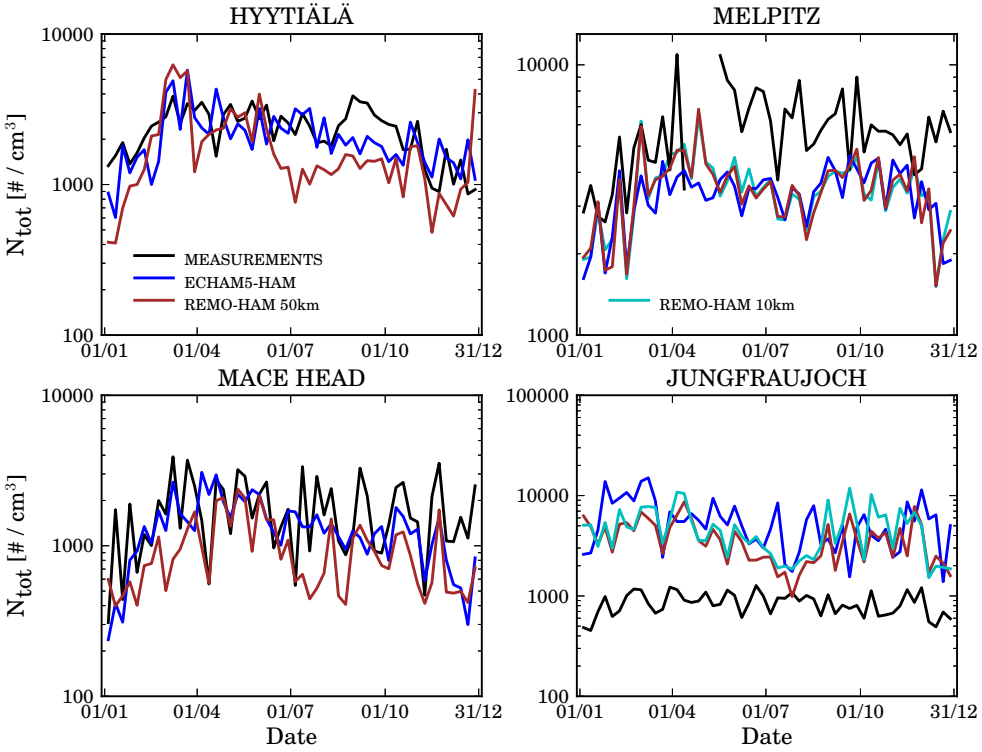


**Fig. 2.** Figure 2 of the manuscript



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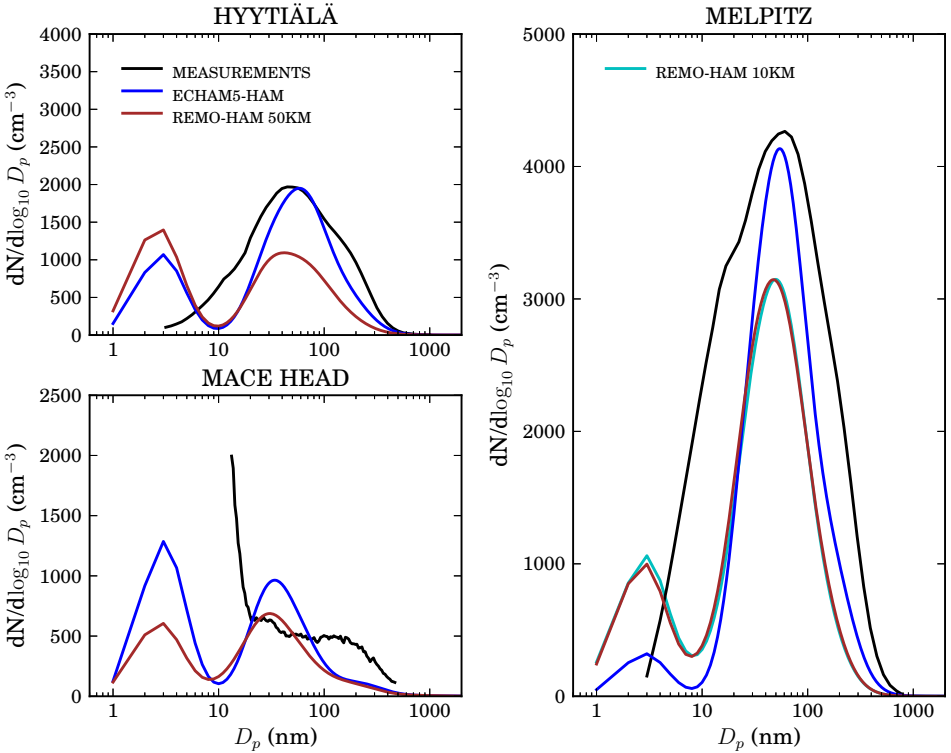


**Fig. 3.** Figure 6 of the manuscript

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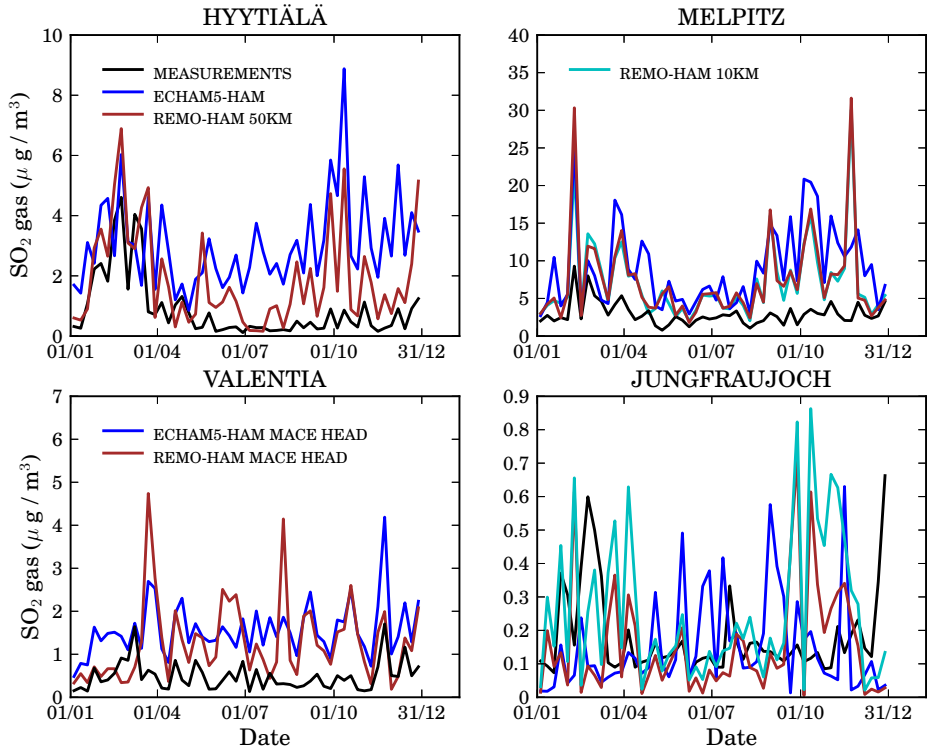


**Fig. 4.** Figure 7 of the manuscript



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