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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud-base vertical velocity statistics: a comparison between an atmospheric mesoscale model and remote sensing observations" *by* J. Tonttila et al.

Anonymous Referee #1

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General comments

Tonttila et al. present statistics of cloud-base vertical velocities from Cloudnet observations and from the mesoscale model AROME. The vertical velocity is an interesting variable: averaged over large spatial scales, it is close to zero, but on smaller scales, strong fluctuations occurs and these are crucial for cloud formation. In Eulerian grid models, condensation of liquid water is usually calculated independent of the vertical velocity, but it is the parameter which determines the maximum supersaturation and thus the fraction of aerosol particles which activates to cloud droplets. Therefore the growing number of models with explicit aerosol-cloud coupling require some de-

scription of the fluctuations of vertical velocity. There are not many observations of this quantity available except from aircraft observations for CCN closure studies, which were mainly conducted in marine environments (e.g., Peng et al., 2005; Fountoukis et al., 2007). There are even fewer analyses of simulated vertical velocity distributions. Therefore, this paper has the potential to make an important contribution and to incite model improvements. But in its present form, I find the manuscript presented here a bit weak and think that the results and conclusions should be of more substantial nature to be published in a high-impact journal like ACP. The authors state themselves that the underestimation of vertical velocity variability by the model is 'as expected'. I agree with this statement. Below are some suggestions on how to extend this study.

Detailed comments

- The AROME model has (to my knowledge) not been used yet for simulation of aerosol-cloud interactions, which is the probable reason why a deficiency in the simulation of vertical velocity has not been noted and addressed in previous studies. One other study with a mesoscale model at similar resolution is cited (Ivanova and Leighton, 2008), but there are many more. For example, Muhlbauer and Lohmann (2008) use a 2km horizontal resolution for the simulation of aerosol impact on orographic clouds, and Zhang et al. (2009) for a tropical cyclone. In these more extreme situations, the resolved vertical velocities were apparently sufficient. On the other hand, models at somewhat coarser resolutions are usually adding a subgrid-contribution to the resolved vertical velocity (e.g. Bangert et al., 2011; Zubler et al., 2011, with grid sizes of 14 and 50 km). It would be a logical extension of this study to analyse whether the addition of a TKE-term would also improve the AROME results.
- The observed cloud cases are all lumped together for the analysis. It would

be useful to spend some effort on the classification of the clouds for which the cloud-base vertical velocity is derived. E.g., in June at the SGP site, a higher variability of the vertical velocity is observed, and this is explained with more convective clouds in summer. Is the model underestimation of σ_w equally bad for convective and stratiform clouds? Does the model predict the correct frequency of occurrence of convective clouds? Parameters which could be used to quantify the convectivity (and other characteristics) of the observed cases include CAPE from reanalysis data, cloud top heights, LWP, IWP, and/or cloud cover.

- From your observations, can you answer the question which model resolution would actually be necessary to properly resolve the cloud-base updrafts in the observed clouds? This would basically require extending Figure 8 to smaller spatial averaging scales, ideally for different cloud regimes.
- Could you add a summary of the observed variability of the vertical velocity in the form of a table, such the data could be easily re-used for evaluation of other models?
- I am not in the position to comment in detail on the screening procedure applied to the measurements in order to avoid retrieval artifacts. However, the same screening should be applied to the model data (i.e. liquid, non-drizzling clouds only), because the clouds which are screened out in the retrieval might have different turbulence characteristics.

Technical comments

- page 9616, line 27: variabilility
- page 9617, line 1: 2 - - 5

- page 9617, line 24: ‘or so’ - colloquial language.
- I'd appreciate if you could add legends in Figures 5 and 6, which would give an overview at one glance.

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