Atmos. Chem. Phys. Discuss., 11, C3403–C3406, 2011
www.atmos-chem-phys-discuss.net/11/C3403/2011/

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 #2

Received and published: 16 May 2011

Abstract:

This paper deals with the diagnostics and comparison of vertical velocities calculated with the AROME model and observed over Germany, the Lindenberg Observatory, and the USA, the ARM Southern Great Plains site. Large differences are found between the modelled cloud base vertical velocities and the observed ones, which is attributed to the model not being capable of resolving scales smaller than approximately 10 km (4 times the model grid). This vertical velocity is important as it is one of the parameters determining the activated cloud condensation nuclei, when they are incorporated in the model calculations. Also a large difference is shown in the cloud characteristics in Winter and Summer, due to the large difference in forcing from the surface which is strong in Summer and weak or absent in Winter.

General comments:

In the, well written, no comments on the English that is used, paper the authors only look at the resolved vertical velocity of the AROME model, which has a resolution of 2.5 km, and therefore does not employ a deep convection parameterization. However, a shallow convection parameterization, one that should represent non precipitating cumulus and stratocumulus, is active in this model. It is an EDMF (Eddy Diffusion Mass Flux) scheme that represents the largest thermals in the boundary layer through a Mass flux scheme (the Kain Fritsch shallow cumulus parameterization) and the small scale eddies through a TKE scheme (Cuxart et al, 2000).

The authors are looking at all clouds together and do not distinguish between cumulus clouds (very small scale) and stratocumulus/stratus clouds (all represented by the parameterization) or large scale clouds. Especially the parameterized clouds have their own dynamics embedded in the parameterizations, with their own vertical velocity calculations for determination of the cloud dimensions. Somehow this should be incorporated into the diagnostics, as the conclusion that AROME is not representing the vertical velocities in the correct way may not be true when the subgrid scale contribution present in the parameterization is added to the resolved part.

Note that this cannot be done by simply adding a TKE term due to the fact that AROME works with a EDMF-type of scheme. This causes the TKE to be very small at the top of the parameterized boundary layer, where the turbulence is dominated by the large eddies represented by the mass flux part of the scheme. This of course depends on the weather situation, with the situation above being representative for the surface forced boundary layer during the day in Spring and Summer.

One other problem lies in the interpretation of the observations and the assumption that clouds are only present with positive (upward) vertical velocities. It has been demon-

ACPD

11, C3403–C3406, 2011

Interactive Comment

strated (Heus and Jonker, 2008) that the updraft of cumulus clouds is surrounded by a subsiding shell still containing cloud water, where the interaction with the environment takes place. This means that the velocities can be quite negative for cumulus clouds and it all depends on how the cloud moves over the observation site which part of the cloud is visible for the doppler radar. Further, the very nice case of January 2008 was a situation under the influence of a high pressure area with large scale subsidence, probably causing the average vertical velocity to be negative.

Concluding I think that the data could be used much better by putting the different situations into different categories (boundary layer cumulus, stratocumulus with large scale subsidence, large scale clouds) and looking at the diagnostics of these different categories also taking into account what really happens in the AROME model with the boundary and shallow convection parameterization.

More specific comments:

Section 3.1: model setup.

Why is there a difference in the size of the model domain for the SGP and Lindenberg experiments and why do you only use the 3-hourly output instead of much higher resolution (in time) output? Now you have the possibility that the fixed timing of the output causes some waves travelling through the domain artificially influencing the model results, which can be less when e.g. hourly output is used. Also how do you distinguish between large scale vertical motion and the motion being caused by the buoyancy underneath the clouds? Also the temporal resolution of the boundaries is quite coarse.

Section 5.1: Direct comparison with observations

Normal vertical velocities in high pressure situation usually on the order of a few cm/s, so negative vertical velocities of 0.4 m/s are very strong! This may be caused by (standing) waves or wave-like phenomena, as there is a significant height difference of more than 100 metres in 100 km. A strong wind from the west would then mean strong subsiding motions, even close to the surface. This is another reason why I would like to see more differentiation into different cases.

Cuxart, J., Bougeault, P. and Redelsperger, J.-L. (2000), A turbulence scheme allowing for mesoscale and large-eddy simulations. Quarterly Journal of the Royal Meteorological Society, 126: 1-30. doi: 10.1002/qj.49712656202

Heus, T & Jonker, HJJ., 2008: Subsiding shells around shallow cumulus clouds. Journal of the atmospheric sciences, 65, 1003-1018.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 9607, 2011.