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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A new feedback mechanism linking forests, aerosols, and climate" *by* M. Kulmala et al.

M. Kulmala et al.

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By way of a reply to the comments of the Anonymous Referee and the Editor, we state the following:

Anonymous Referee (AR) General Comments

1. According to AR, our paper lacks compelling observations to support our statements.

We agree that the apparent correlations we present in our paper do not necessarily imply any causality among the variables. However, we argue that since temperature is one of the main influencing factors in BVOC emissions, we have enough grounds for the presented reasoning.

2. AR points out that we focus primarily on the BVOC response to changes in tempera-

ture, but that it is not the only response expected. AR goes on to mention several other consequences of increasing global temperatures and postulates that these (and other) effects will certainly affect the composition and amounts of BVOCs emitted.

We agree with AR, but maintain that we have already mentioned the most important factors that we have ignored in our analysis, namely Şthe possible increase in BVOC emissions due to increased temperature, lengthened growing season, nitrogen fertilization, or increased leaf area index.Ş We do not see a compelling need to include other effects that do not affect the proposed feedback, such as methane or N2O.

3. The authors present a two year dataset of particle formation and gas-phase BVOC. Nucleation rates and condensational growth is correlated to the absolute value of BVOC concentration. This correlation is then used to support that CCN and BVOC concentrations will increase as a result of global warming. Although qualitatively this makes sense, it is still unclear what the expected change in aerosol number concentration would be. This is not the only parameter influencing CCN concentration; the chemistry of the particles matter as well. It is possible that the shorter growth times will lead to the formation of less oxidized organics, which in turn, could be less hygroscopic. Such issues could be resolved if in addition to aerosol size/chemistry, a measurement of CCN concentrations (at supersaturations representative of the clouds in the forest of interest) would provide a direct link between biogenic emissions and clouds.

All of this is true, and, our measurements of accumulation mode size distribution evolution during particle formation events themselves would not be very valuable in quantifying the effect on CCN concentrations. However, we also have reported hygroscopicity measurements (with tandem DMA) for the events, giving us valuable information on the link between accumulation mode particles and actual CCN. All of this has been accounted for in our analysis presented in this paper as well as the listed references, e.g. Kurten et al. (2003), which quantifies the actual effect on earth's radiation balance.

Specific comments by AR

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1. Page 6, bottom of page ŞNote that we ignore . . . significantly strongerŤ. It is not clear whether the response will be Şmuch strongerŤ.

This is true, and we will remove the word ŚsignificantlyŠ.

2. Page 7, line 9. ŞCCN will increase by a factor of 2 to 4 . . .Ť Is this based upon the presumption that accumulation mode aerosol concentration will increase by a factor of 2 to 4? That will not necessarily translate to a CCN increase by the same amount. This should be made clear in the text.

This statement is not only based on total accumulation mode particle number concentrations but also on hygroscopicity measurements with a TDMA system. This is explained in the given references of Kulmala et al. (2000) and Kulmala et al. (2001). However, we added the reference Kurten et al. (2003) also to this context since this paper actually focuses on the radiative balance effects of the measurements made in Hyytiälä.

3. Page 7, line 20. ŞTherefore, assuming . . . increase by 10% Ť. The authors should point out that the cooling effect from a 10% increase in CCN is rather small compared to warming from a doubling of CO2.

This is a good point, and we modified the discussion section accordingly.

Editor General Comments

The Editor wonders if the proposed effect is as relevant today as it was in pre-industrial climates and goes on to consider how a large concentration of pre-existing CCN would moderate the increase in cloud drop concentrations. The Editor continues to point out that in more pristine pre-industrial climates, a large background sulfate aerosol concentration was probably not present over inland boreal regions, and the forest-aerosol-climate feedback mechanism may have played a more important role.

The editors overall comment on present day vs. pre-industrial times, regarding sulfate aerosol concentrations, is probably true. In our analysis, we rely, however, on data

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measured in present-day conditions (Kurtén et al., 2003). The measured data (both total number concentration and size distribution measurements as well as hygroscopicity measurements) on particle formation events clearly shows that CCN concentrations may be significantly affected by such events, thus having an effect on earth's radiation balance.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 6093, 2003.