Atmos. Chem. Phys. Discuss., 11, C13625–C13629, 2011
www.atmos-chem-phys-discuss.net/11/C13625/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Evaluating WRF-Chem aerosol indirect effects in Southeast Pacific marine stratocumulus during VOCALS-REx" *by* P. E. Saide et al.

Anonymous Referee #1

Received and published: 27 December 2011

Summary

The manuscript presents regional WRF/Chem simulations for the VOCALS-REx domain, which are evaluated with ship and aircraft measurements of gas phase composition, aerosol concentration and composition, meteorological quantities, as well as with satellite observations. It is clearly written, and the methods, observations, and assumptions are described in detail. The manuscript closely follows the excellent work by Yang et al. (2011), generally by evaluating WRF/Chem simulations with observations, and specifically by investigating the ability of WRF/Chem to simulate the outflow of pollution from coastal sources, and the resulting response of the South-East

Pacific stratocumulus cloud deck. The present work differs from Yang et al. (2011) by investigating the response of the marine boundary layer (meteorological, chemical, aerosol, and cloud properties) to enabling/disabling wet scavenging/deposition of aerosol particles. It is debatable whether this justifies the quite general title "*Evaluating WRF-Chem aerosol indirect effects in Southeast Pacific marine stratocumulus during VOCALS-REx*". However, the main challenge of the manuscript is that it is not clear how it adds to existing knowledge beyond Yang et al. (2011) to warrant publication. The results and findings in the first place demonstrate and document deficiencies of the WRF/Chem model, but do not advance scientific insight or provide solutions to (modeling) problems. The manuscript could be significantly improved by implementing the re-generation of aerosol by evaporating cloud and rain drops in the wet scavenging scheme of WRF/Chem, and by investigating how this improves the ability of WRF/Chem to reproduce aerosol and cloud properties in the South-East Pacific during VOCALS-REx.

Specific comments

The authors pose the following questions to motivate their study:

"*Starting from the fact that the inclusion of aerosol climate interactions in the model are important to represent processes in this region (Yang et al., 2011), we perform model simulations designed to address the questions: if aerosols are improved within the model, what are the effects over cloud dynamics and microphysics? And do these effects go in the direction of bringing model results closer to the observations?*"

Here it helps to contrast the present work against Yang et al. (2011), who conclude

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"*... the inclusion of full aerosol-cloud couplings lead to significant improvements in many features of the predicted stratocumulus clouds ...*"

Hence Yang et al. (2011) do not only show, as stated by the authors of the present manuscript, that including aerosol-cloud interactions is important to represent processes in this region, but also that doing so improves many features of the predicted stratocumulus clouds. Therefore, the question posed by the authors appears to have been answered previously. The main difference between the present work and Yang et al. (2011) is that here, overestimated aerosol wet removal in WRF/Chem is remedied by turning this process off. This leads to improved (higher) aerosol concentrations. The authors then conclude that the higher aerosol loadings, obtained with disabled wet scavenging of aerosol,

"*... produce considerable changes in MBL dynamics and cloud microphysics, in accordance with the established conceptual model of aerosol indirect effects.*"

In the abstract, the authors write

"*Moreover, better statistical representation of aerosol mass and number concentration improves model fidelity in reproducing observed spatial and temporal variability in cloud properties, including top and base height, droplet concentration, water content, rain rate, optical depth (COD) and liquid water path (LWP).*"

In the light of the findings of Yang et al. (2011), and given that WRF/Chem is a relatively mature model, these findings are quite unremarkable. The fact that these findings were obtained by tweaking the model to obtain better aerosol, rather than by improving the model, makes matters worse, in particular when considering that one of the goals of VOCALS is to use the South-East Pacific as a testbed for a better

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simulation of boundary-layer cloud processes and aerosol-cloud interactions (see the VOCALS program summary).

In the conclusions, a recommendation to do cloud water composition measurements in future campaigns is given:

"*The inclusion of bulk cloud composition measurements aboard the C-130 during VOCALS provides a more direct look at interactions of clouds with aerosol particles and soluble trace gases as well as an important check on model simulations of cloud composition and aqueous phase production of secondary aerosol species, which is why their use is recommended in future campaigns.*"

This recommendation is well-intended, but its justification is trivial based on the consideration that these measurements give more information on interactions of clouds with aerosol particles and soluble trace gases, and represent an important validation for model simulations, and weak based on the fact that these measurements have been done during VOCALS-REx.

Although generally very well written, the manuscript sometimes uses expressions (e.g. "*aerosol climate interactions in the model*", "*aerosol-climate interactions*", "*semi-direct climate interactions*") which do not fit the context (in this specific case, replacing "climate" with "cloud" would work better).

The labels on some of the figures are "pixelized" so they are hard to read. This could be improved by using a vector graphics format (EPS, PDF) as opposed to a pixel graphics format (JPEG). The former also allows zooming in on the figures without a loss of resolution.

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Recommendation

For a publication in ACP, the authors should forcefully prove me wrong by showing that the manuscript provides significant, non-trivial scientific insight that transcends previously published works by more than merely incremental steps. In particular, it should be shown how it adds meaningful knowledge or understanding beyond the work of Yang et al. (2011); in this, the investigation of the response of clouds etc. to switching off/on aerosol wet scavenging seems not significant enough, since it is an ad hoc tweak of the model for the South-East Pacific during VOCALS-REx. One way the manuscript would clearly gain significance would be e.g. to improve the wet scavenging scheme of WRF/Chem by implementing the re-generation of aerosol by evaporating cloud and rain drops, and by investigating how this improves the ability of WRF/Chem to reproduce aerosol and cloud properties in the South-East Pacific during VOCALS-REx. This would meet one of the goals of VOCALS, to better simulate the South-East Pacific stratocumulus layer, and improve the WRF/Chem model in general. The existing two simulations (with and without wet scavenging) could serve as reference for the discussion of the simulation with the improved wet scavenging scheme. The title of the manuscript could then be changed to reflect the focus of the investigation.

References

Yang, Q., W. I. Gustafson Jr., Fast, J. D., Wang, H., Easter, R. C., Morrison, H., Lee, Y.-N., Chapman, E. G., Spak, S. N., and Mena-Carrasco, M. A. (2011), Assessing regional scale predictions of aerosols, marine stratocumulus, and their interactions during VOCALS-REx using WRF-Chem. *Atmos. Chem. Phys. 11*, 11951–11975, doi:10.5194/acp-11-11951-2011.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 29723, 2011.