

## ***Interactive comment on “Impact of natural and anthropogenic aerosols on stratocumulus and precipitation in the Southeast Pacific: a regional modelling study using WRF-Chem” by Q. Yang et al.***

**Anonymous Referee #2**

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Review for “Impact of natural and anthropogenic aerosols on stratocumulus and precipitation in the Southeast Pacific: a regional modelling study using WRF-Chem”

General comments

The manuscript shows WRF-Chem sensitivity simulations of anthropogenic and oceanic emissions in order to show their impact on the predictions of aerosols, clouds and radiative forcing. It uses state of the art measures to inter-compare the different simulations and successfully attempts to provide explanations to the responses of the

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system. The paper is scientifically sound, very well written and is in the scope of the journal. I recommend publication after some changes. My main concerns are related to a lack of explanation of why the anthropogenic effects are completely different depending if emissions x1 or x5 the base emissions, and the attempts of the authors to separate the aerosol indirect and direct radiative forcings in this highly coupled system.

Specific comments

Abstract. “The reduction of precipitation due to this increase in anthropogenic aerosols more than doubles the aerosol lifetime in the clean marine boundary layer.” What’s the uncertainty on this given that there is no aerosol re-suspension after raindrops evaporate in the wet deposition parameterization? First, demonstrate directly that aerosol lifetime in the modeled MBL is simulated skillfully before considering this change.

Page 14628, lines 19-22: “To our knowledge, this is the first use of a regional model with prognostic aerosols and coupled aerosol-cloud-radiation to study the relative contributions of oceanic and anthropogenic aerosols to changes in cloud properties and radiative forcings over the SEP under realistic meteorological conditions at cloud-system resolving scale.” I recommend removing this claim. There has been some work on this that the authors should probably be aware of, as they presented in the same meetings. From the VOCALS publication page (<http://www.eol.ucar.edu/projects/vocals/publications/publications.html>): Spak, S., M. Mena-Carrasco, and G.R. Carmichael (2010). Simulating contemporary and preindustrial atmospheric chemistry and aerosol radiative forcing in the Southeast Pacific (Invited), Abstract A54B-07 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec. From the VOCALS 3rd Meeting: Spak, S., Simulating aerosol radiative forcing and impacts on marine stratocumulus, [http://www.eol.ucar.edu/projects/vocals/meetings/2011/miami/presentations/tuesday/spak\\_tr](http://www.eol.ucar.edu/projects/vocals/meetings/2011/miami/presentations/tuesday/spak_tr)

Page 14630, lines 13-26. The emissions inventory appears to also contain volcanic emissions ([http://www.cgrer.uiowa.edu/VOCA\\_emis/](http://www.cgrer.uiowa.edu/VOCA_emis/)). For the 0ANT,5ANT, did you

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separate these emission sources so you wouldn't apply the 0x and 5x scaling factors?

Page 14630, lines 23-26. "The results are, therefore, an extreme condition, and the magnitude of the influence would likely be smaller for changing anthropogenic emissions under most scenarios, although we expect that the tendency of the results will likely be the same." Your results clearly show that when going from no anthro to 1xanthro and 5xanthro they generate very different responses, sometimes even with a different sign (radiation). So the tendency is not the same.

Page 14631, lines 11-12: "The aerosol direct radiative forcing at the surface is calculated as the difference in surface shortwave fluxes under cloud-free conditions with and without aerosols." What about cloudy conditions? Those are the ones that dominate here. Please quantify the percentage of gridcell-hours during the study period contain cloud-free conditions and their location to assess the representativeness of this value.

Section 3.1. I believe there is a missing explanation. For region C, you show almost no contribution to Nacc, CCN and AOD from anthropogenic, but then when anthropogenic is scaled by 5 it does show a contribution. Why? My first thought was that anthro aerosol doesn't get to region C so there is no contribution, but this is not correct as the scaled emissions wouldn't show an increase as well if this were true. As there is no anthropogenic contribution here, then there are also no sensitivities for cloud properties (Sect. 3.2).

Page 14635, Lines 23-25. You say DMS by itself generates an 8% increase in Nd, but before you said DMS generates not more than 6% increase in Naccum. I would expect increases in Naccum to always be higher than the increases in Nd. Can you elaborate on this and explain why this is happening?

Page 14638, Lines 28-29. "(~ 65% reduction in cloud-base and near-surface rain rate) due to anthropogenic aerosols leads..." I see almost no cloud sensitivity to anthro emissions in region C (figs 2-3), but you are saying that anthropogenic emissions generate a 65% rain reduction? You mean 5x anthropogenic? It would be helpful to show

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an additional plot of rain rates (cloud base will do) in Fig. 3.

Section 3.3. You say there are changes in entrainment. I don't see a discussion about the additional/less aerosol that is being entrained and their impacts. It might be helpful to show the changes in the aerosols that are being entrained with their respective base quantities, maybe an additional panel in Fig. 2 showing delta Naccum on a layer above cloud top. Also, the changes in MBL height generated should generate changes in aerosol concentration as well (higher MBL for the same aerosol means dilution) which should be discussed.

Page 14640, Lines 24-26. "Anthropogenic emissions increase daytime maximum decoupling frequencies to 33% and 61% over regions P and C." This is 5x anthro? Or no anthro vs base?

Page 14643, lines 20-21. "Note that this neglects below-cloud wet-scavenging, but it is negligible for accumulation-mode number." This sentence makes sense as impaction efficiency is the lowest for accumulation mode aerosol, but I don't know if it's negligible considering that the wet scavenging parameterization in WRF-Chem does not consider aerosol re-suspension after rain evaporation. What fraction of simulated and observed accumulation mode loss in the MBL is due to wet deposition?

Section 3.5, first paragraph. This paragraph is very hard to read as it is right now, too many numbers. I think adding an additional panel to figure 5 showing the direct aerosol forcing would help.

Section 3.5. You show results for the direct effect, but the model you use to compute it only considers clear-sky conditions, right? Is this computed for cloud free columns only and you assign 0 for the cloudy ones? What about the direct effect when there are clouds present (which is most of the time)? My concern is that you are not estimating the fraction of the total forcing due to the direct effect on a regional basis or over the stratocumulus deck when you compute this one without considering clouds. Maybe it's not possible to separate the effects with this approach. Please discuss the presence

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or absence of non-additive effects of direct, semi-direct, and indirect radiative effects on low clouds in the model code for this set of physics schemes, those used in LES simulations for the same region and study period (e.g. Feingold et al., 2010; Kazil et al., 2011), and those included in GCMs, as well as results from empirical studies. Use box models if necessary to clearly isolate effects. If you can show a consistent process understanding and empirical evidence that the radiative effects are entirely additive, then the leave-one-out approach gains support, and the article and its results transcend the bounds of the specific model and configuration employed. If not, please reconsider the approach.

Page 14648, line 21. Again, it's hard to quantify in an independent way direct and indirect effects in this coupled system. Direct effects could be overestimated by not considering clouds in the radiative transfer model used for this purpose.

Page 14648, Lines 26-27. "and regional anthropogenic emissions have a negligible impact over this region." 1x Anthro doesn't have an impact but 5x anthro has a huge impact. You should rephrase this. Also, saying that it doesn't have an impact just by comparison to No anthro emissions scenario it's not appropriate, there should be an inflection point in between. Maybe it's something to explore.

Technical corrections

Page 14627, Line 17. Change "presentation" to "representation".

Page 14634, Lines 10-11. "four-times" should be "five-times", right?

Fig 2. Caption. "sigma is the standard deviation of the mean changes." What does this mean? Why not state the overall standard deviation?

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