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Interactive comment on "The effect of secondary ice production parameterization on the simulation of a cold frontal rainband" *by* Sylvia C. Sullivan et al.

Anonymous Referee #1

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The study simulates a frontal rain band over the UK for which extensive radar and insitu observations exist. Two new secondary production parameterizations are introduced to the COSMO model. The modeling is extensive in that it covers 16 sensitivities (+1 control) with 10 perturbations per configuration. These data are then used to compare to observations and assess the impact of the new parameterizations on ice number concentration and precipitation.

I think the study will be publishable after the following comments are addressed.

1/ My main issue is the experimental design (or my interpretation of it). To me, the problem is that the study appears to mix one secondary production process into the control

model and then looks at the impact of the two new processes and modifications to the rime-splintering process as 'the effect of secondary ice production...'. From what i can see in table 2 there is no sensitivity with all secondary processes off. At the same time, the control model is stated as using Seifert and Beheng microphysics. The Seifert and Beheng described in the literature included rime splintering ice production. There are some comments later in the paper that suggest to me that the control does have rime splintering off. Therefore, either i have misinterpreted and some additional description of the control model configuration is needed, or I think we need an additional set of control runs that have no secondary ice production processes included

Until there is a clean control with no secondary ice production processes it is difficult to interpret the statements about the impact of secondary ice production.

2/ The thrust of the paper is to show the impact of the different secondary ice production processes. Given the potential of introducing many unknown parameters into the model I think that it would be really useful for the community to try and identify if certain processes can be ignored. At the moment the paper is pushing us to try to represent more complexity, but it would be advantageous if simplifications could be identified.

For instance, questions that arise as i read through the paper include:

i. what is the relative impact of rime-splintering to droplet shattering to collisional breakup? (something similar was done for primary versus secondary)

ii. Can we ignore any of them or do they interact?

iii. Given the number of unknowns is it possible to write a single parametrization that captures all of the processes with less parameters? (this one would be speculation)

To try and answer i) and ii) the following families of model runs are suggested -some of which you already have.

a) control : no secondary ice production

b) control + rime splintering

c) control + rime splintering + droplet shattering

d) control + rime splintering + droplet shattering + collisional breakup

e) control + droplet shattering

f) control + droplet shattering + collisional breakup

g) control + collisional breakup

h) control + collisional breakup + rime splintering

....

Additional points:

p5 eqn 7. qrim is not defined. Is it the rate of change of ice due to riming?

p6 table2. SY not defined (typo on p5?)

p6, 13. CTRL=Seifert and Beheng - this has rime splintering secondary production as standard? [see main comment above]

p8, 20. Maybe change secondarily-> secondary, primarily -> primary?

p8, 28-29. Is COSMO able to capture this sort of mixing process?

p8, 30-p9,3. 1Ag and 1Ac contain 2 changes. Its difficult to say which change is most important. Including 1An would provide a way to decide the relative importance of the changes.

p10,7: 'There are no heating...' - do you mean because the structures are outside of the traditional temperature range for rime splintering?

p10,8-10. 'Zhu et al....'. I don't know if this can be inferred. I would imagine the melting differences affect the strength of downdrafts and cold pools leading to changes in sub-

sequent convection which would be substantially different to the dynamical coupling due to latent heating in updrafts.

p10,13-14. '...smaller droplets form, diminishing the riming...'. I think making smaller droplets could lead to increase cloud liquid water that would lead to increased riming.

p10,16. Ni,sec - does this include all rime-splintering too? How does it compare to Ni,pri in a control model with no secondary ice production?

p10,27. This is a large domain that includes some of the warm front too?

p10,30. '...filtered out'. These are in-cloud values then. Is it same thresholding for the observations?

p11,2. Control simulation - does this include rime splintering?

p11. figure 4. How many points go into the 10ˆ-3 and lower probability for the observations? If it is less than $\sim$10 it might be good to ignore them?

p12, 26. 'The control simulation without secondary ice...'. Is this the additional secondary ice processes or all secondary ice including rime splintering? If it is the latter then that needs to be made clear that the control has no secondary ice processes in it (see main point 1 and p11,2, p6,13)

p12,32. How does figure 5 compare to observed accumulations?

p13,3. Please could you also give the domain mean precipitation change?

p13, 8. The red (positive) regions are also correlated with a combination of the location of the front and the orography, where convection may be enhanced.

p14, 4. The structures in Crosier et al are on the scale of $\sim$5km, whereas these are much bigger $\sim$50km?

p14, 9-11. 'suggesting that rime splintering is responsible for much of the change in Ptot'. Does this mean that the control did not have rime-splintering?

p14, 14: NCRF not defined?

p14, 34. The variation in the means is now within 10% of the mean of the ensemble of results.

p15, 1-6. Why not use the model to provide the diagnosed rates?

p17. It would be good to see answers to the points raised in 2/ above. It would also be good to state what the overall domain mean change in precipitation is due to secondary ice production processes.

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