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Interactive comment on “CELLS v1.0: updated and parallelized version of an electrical scheme to simulate multiple electrified clouds and flashes over large domains” *by* C. Barthe et al.

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Summary

The paper presents the latest updates to the electrification parameterizations CELLS used in Meso-NH. The highlight is on the parallelization of the lightning scheme, which allows flashes to be propagated in parallel processing with domain decomposition. A trade-off in this scheme is that channel points are no longer checked for connectivity, but the results suggest that this is more of an aesthetic issue than a practical one. The rest of the model description follows previous papers, and a sensitivity study is performed that is relevant to the updated lightning scheme. The STERAO case has been simulated before, but the EULINOX case is new.

Major Points:

1. Page 2858, lines 26-27 through Page 2859 lines 1-6: This section is somewhat confusing to me. Is the maximum electric field magnitude found separately for each height (i.e., model level)? Since the triggering threshold varies as a function of air pressure, a smaller field is needed at high altitude. Thus a maximum field at lower altitude might not be enough to trigger lightning, but a lower field aloft might do this but be missed. This would get more difficult with terrain, as the altitude becomes a function of horizontal position, although the levels probably flatten out pretty well above 6 km or so. The examples in the paper use a flat ground, so it has not yet been shown how well the system works with terrain. One could just check each point for whether the field exceeds E_trig and build a map, or perhaps use the maximum value of the ratio E/E_trig instead of the maximum E.

2. Page 2858-2859: The use of r_{tot} and q_{cell} could be elaborated on. How is "a single cloud" defined? Do you mean within the cloud boundary of a storm? A storm can have multiple cells, and lightning can propagate from one cell into a neighboring cell that have merged cloud boundaries. Considering the charge structure in Fig. 3b, it is not unreasonable for a flash to span two cells, at least through the negative charge. It seems that a flash should only be restricted by the potential, and perhaps a restriction on the potential (as in MacGorman et al., 2001) would work better than one on hydrometeor mixing ratio. How do you

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think the scheme would handle a larger convective system, like a squall line? I suppose you can wait to refine this aspect when you get to cases that need it.

Minor Points:

1. Page 2850, opening sentence of introduction: References for this? I would suggest Goodman et al. (1988) and Wiens et al. (2005) as examples of observational studies linking total lightning (IC+CG) with storm dynamics.
2. Page 2851: Some of the references to tropical cyclones used CG lightning only, at least Black and Hallett, or very infrequent total lightning (satellite overpasses). Note that these citations are not in the reference list (neither are Darden et al. 2010 nor Emersic et al. 2011). The recent paper by Fierro et al. (2011) shows results of continuous tracking high-energy IC flashes (narrow bipolar events, or NBEs) in two hurricane eyewalls, which is still not total lightning but is better than CG only or a few minutes per day of total lightning.
3. Page 2851, paragraph starting "Most of the modeling studies": The choice of references could include classic early studies by Takahashi (axisymmetric) and Helsdon (2D and 3D) and Ziegler (1D/3D), which first put the non-inductive graupel-ice mechanism at the forefront. Altaratz (2005) does not seem to be the best reference, as it did not include lightning discharges and only calculated electric fields offline. Hou et al. showed only two charge density fields and without any microphysical or kinematic context, so this reference also seems to have limited relevance.
4. Page 2856, line 1: Hail would only have a water film if it is in a wet growth mode (or melting). In dry growth mode it should be capable of charge separation. There is a UMIST (Saunders?) reference that notes the cessation of charge separation during wet growth.

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5. Page 2857, lines 23-24: Surely a Dirichlet boundary condition is used at the ground? I have found that a Dirichlet condition at the top boundary can be more stable than Neumann conditions, provided the top is high enough away from storm top (Mansell et al., 2010, switched to this top boundary condition). (Edit: Note spelling of “Neumann”).

6. Page 2859, line 13: “to avoid undesirable side effects” This could be more specific, such as “to isolate individual storm cells.”

7. Page 2860, lines 18-19: Note that Helsdon et al. (1992) also used the ambient field to propagate and terminate the channel. They noted that the physical process is actually controlled by the total field, but did not model it that way.

8. Page 2861, lines 14-16: I am not sure what is meant by “physically consistent representation.” Do you mean at the microscopic scale? Or just at a different level of parameterization? Practicality and expense depend on the goal, and if the goal is real-time simulations, then certainly it has to be as simple as possible. More complex parameterizations are not necessarily “technically impractical” on parallel computers, either. (The dielectric breakdown model has been parallelized, for example.)

9. Page 2862, line 22: Keep in mind that although charge density determines the electric potential, it is really the potential that controls the extent of the branching. In simple charge arrangements they are nearly synonymous, but not for complex charge structures.

10. Page 2863, lines 19-26: Is this procedure only for the second case ($N_{poss} > N\_||$)? If so, that could be clarified, since otherwise I think the statement on line 26 would be that the flash path would contain at most (rather than exactly) $N\_||$ points.

11. Page 2867, line 17: Should the negative ice crystals be obvious in Fig. 3?

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12. Page 2868: Charge transfer in IC flashes is difficult to evaluate observationally. I don't see any such values in Shao and Krehbiel (1996). Two relevant references here would be Maggio et al. (2009) and Lu et al. (2011). Another means of evaluation could be to calculate dipole moments.

13. Page 2869: The sensitivity to the charge per collision limit is interesting. Another important factor is the graupel-ice collection efficiency. As collection efficiency increases, the charge separation decreases, not only because of fewer rebounding collisions, but also because more charged ice crystals will be collected back onto graupel. What are the settings in the microphysis for this process?

14. Did the case with multiple cells (early stage in STERAO storm) ever have simultaneous flashes (i.e., flashes in more than one cell in a time step)? Are these flashes somehow labeled with a mask? Or are the flashes actually done sequentially? Section 2.2.2 is a little ambiguous in talking about choosing a point within a cell, but not about which cell.

Technical Points:

1. Incorrect year in the Kuhlman et al. (2006) reference (should be 2006, not 2005)

2. Page 2853, line 21: "imperatively" seems redundant with "must be" and could be deleted.

3. Page 2858, line 7: Suggest "Good efficiency of the parallelization is provided by a library of high level...."

4. Page 2860, line 26: Suggest "branched of the leader [propagate] until ... at the tip[s] of the last"

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5. Page 2862, lines 8-9: The wording is a little vague. Suggest “through plastic slabs with [regions of stronger and weaker negative charge density].” Reproducing this discharge behavior was one of our tests of the dielectric breakdown model (Fig. 6 in Mansell et al., 2002), which up to then had only been used in charge-free regions between conductors held at constant potential.

6. Page 2865, line 7: What is meant by “hardly externalized”? Not able to be run off-line?

7. Page 2865, line 19: Suggest “allows [testing of] the cell ....”

8. Page 2866, line 17: Maximum radar reflectivity in a column is also known as “composite reflectivity.”

9. Page 2866, line 27: Suggest “...model is fairly successful [in reproducing] the evolution...”

10. Page 2867, lines 6-7: Suggest “the electric field increased [above] 10 kV m^{-1}” (Delete “module was”.)

11. Page 2874, line 12: Suggest “... efficiency was possibly [degraded] when the supercell...” (rather than “embarassed”).

12. Page 2874, line 18: Suggest “... proportion is clearly [underpredicted] by a factor of 10.”

13. Page 2875, line 15: Suggest “been [heavily] revised to be run in a...”

14. Page 2875, lines 17-20: Suggest “... aspect of the channel imposes difficulties for parallelization. [Previously] the growth of the ... recursive description of the [flash propagation into] positive and negative pocket[s] of charge. Here, [recursion] comes from...”

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15. Page 2876, lines 22-23: Suggest "... planned in 2012 [with the] purpose [of studying] the heavy rainfalls ...."

References

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