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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mesoscale processes for super heavy rainfall of Typhoon Morakot (2009) over Southern Taiwan" *by* C.-Y. Lin et al.

Anonymous Referee #1

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Review of the manuscript entitled, " Mesoscale processes for super heavy rainfall of Typhoon Morakot (2009) over southern Taiwan", by C.-Y. Lin et al.

Reviewer used the PDF file

Recommendation: major revision

Summary: Typhoon Morakot delivered more than 2880 mm of rain at one location over 5 days in the Central Mountain Region (CMR) of Taiwan, and set numerous other rain records. The authors review the events, use the NCEP-GFS to diagnose water vapor flux and divergence and apply a coarse (10 km horizontal resolution) numerical model to examine the key factors responsible for the dramatic rains. The interaction of the SW monsoon and the typhoon circulation initially yields heavy rain followed by convergence

and lifting along the Central Mountain Range. The manuscript needs several changes to reach its full potential. These include at least a brief goals section, more editing of the English, the inclusion of a figure or figures to show the interaction of the large scale flow with the typhoon, and soundings that show the evolving vapor content. The description of the simulation also needs much more background information given that the 10 km model got closer to the actual rain amounts than a 3 km run from Ge et al. (2010). For the paper to really command attention it should offer more than a brief description of the event.

Major comments:

1) In the introduction we never learn why the study is being undertaken. This reduces the paper to a brief description of the heavy rain event followed by a briefer discussion of a simulation of the event. There is some mention of a finer scale model producing less rain, so is the authors' goal to understand why that fine-scale run delivered far less rain than was observed? If so then they need to tell us more about the prior run and defend why a 10 km horizontal scale should be viewed as a more accurate depiction of the event. Are there differences in the boundary conditions/ initialization procedure that mattered? The authors suggest that their higher vertical resolution and the use of 0.5 degree NCEP-GFS initial conditions makes a difference, but no analyses are provided that proves these suppositions.

2) At horizontal scales of 10 km the model cannot resolve convective scale motions. This is a dangerous scale to choose because it falls in a region where most cumulus parameterizations were not designed for, and the scale also fails miserably for the typical updrafts and downdrafts associated with convective clouds. I note that the authors do not present any views of the typhoon. I wonder if the model produces realistic rainbands, an eyewall and reasonable vertical structure.

3) Seems like an important part of the story is the role of the large scale and specifically the SW monsoon flow, but there is only Fig. 3c that shows the large scale evolving flow.

This is for only one level and does not show the earlier set-up for the heavy rains. The authors could delete three virtually useless panels (3b – satellite isn't used , 4d -no idea what we are supposed to see here and 4e- yes, it is a cyclonic circulation) and create a figure that shows the interaction of the typhoon flow with the SW monsoon or extend Fig. 3c. There are no figures showing the environmental water vapor conditions. Are there no soundings available to show evolving moisture conditions? The phrase "high moisture content" isn't really that useful (the SW monsoon generally has high moisture content).

4) The authors seem to stress the rain at one point too much. Comparing a point value for two numerical simulations is not a good test. This single point measurement focus is continued in Table 1. I suspect that the maximum value is controlled by the fine-scale topography (A-Li Shan sets most of the records) and I'll bet neither model really captures that very well. A good comparison would include rain rates over the period of interest and region of interest. If the fine-scale model simply produced a stronger convective cell in a different location then one could imagine that large differences would arise.

5) Model discussion is a little too brief. The authors do not mention exactly when the model was started, its domain, if the typhoon structure was bogussed in and how if it was. There is no discussion of the initial typhoon structure (rainbands and eyewall, typhoon size, wind field) that would be highly relevant to the issues at hand. The ice physics of the model, surface fluxes and tuning parameters such as horizontal diffusion are not mentioned. I wouldn't be a bit surprised to see that the model got some approximate answers simply by dumb luck, or by tuning to the desired results. Were there any sensitivity tests conducted? Can the model be used to isolate rain from the monsoon- typhoon convergence from the orographic lifting? What does the terrain in the model look like compared to the actual terrain?

6) Numerous English errors make the manuscript tough to read. Have an editor make a careful pass through the final manuscript. See the minor comments where I identify

about >50 corrections and I am sure that I missed plenty.

Minor comments (page and line number are given as reference based on the PDF form of the paper) 13496, 8: delete highly moist and tell us the specific humidity or mixing ratio for a layer or layers ", 15: don't start a sentence with a number not written out, alternatively ....Over 2885 mm.... ", 17: change ...the 5-day period...to ...over 5 days....(5-day period is a redundancy) 13497, 2: ...with a strong southwesterly.... ", 3: generates to generated ", 9: terrain (no s) ", 19 and 20: damage (no s), though the use of the plural is now more of an editorial call ", 28: circulation (no s) 13498, 3: In addition....this sentence repeats claim on prior page, collect references and state once ", 17: delete more ", 18: a coarser model does better...ok, did the runs by Ge et al. have the same initial conditions? Are you using a cumulus parameterization scheme that he didn't need? ", 19: ....the most important and direct process.... Change....to the most important factor.... ", 23: ...joined the system... reword ", 25: the use of the word process is really not the best here and in the lines above. Interaction of the monsoon and the typhoon is not in itself a process. A process usually means a series of actions, but here the authors use it to describe the collision of SW and typhoon flow. ", 25: earlier it was a single process, now there are two....reorganize this section 13499, 6: ...at a 6 h interval. ", 9: dynamically consistent ", 20: The event might not be well simulated simply because of model inadequacies, which has nothing to do with the use of the NCEP-GFS input. 13500, 3: ...it quickly was downgraded (people grade storms) ", 4: incoherent structure? The following sentence you describe structure that is coherent ", 8: comment in parentheses is unclear, then following phrase needs a rewrite, too. ",12: impinged? Does this mean the eye made landfall? Clarify please. ", 13: ...was limited to... ", 14:...the South China .... ", 18: ...the extent south? Rewrite please ", 25: northerlies....while southerlies dominated the southern half of the island. (or CMR?) ", 29:...pouring down in a narrow N-S belt (about 50 km x 25 km) over the mountains. 13501, 6: high moisture content would be better described using specific values of mixing ratio or specific humidity over a given layer or layers ", 11: temporal evolution is a redundancy, simply say evolution (no s) ", 11: horizontal water vapor flux

(moisture is ambiguous as it could include liquid. . .). In the following paragraph this ambiguity is continued. If you want to use moisture (it is ok to) then first mention that it only vapor. “, 11: why does the zonal flux include the meridional wind component? “, 23: Total vapor flux would simply be reported as Kg s-1 for vapor flux through the surface of interest. The authors could report the total vapor flux for their approximately 200,000 m x 3000 m surface, and I suspect they would have values of $\sim$2. 0 x 108 kg s-1 (for about 20 m/s flow with a mean q of 15 - 18 g/kg). The units they use appear to be in the kinematic form by dividing by the density of moist air but they expressed it in units that aren't quite mks. Suggest a sentence or two of clarification here. They might mention what is a typical vapor flux for monsoon flow which would place the Morokat values in a context. It might be on the order of .4 x 108 kg s-1. Now what is the change in the mean q through the 3000 m depth of interest for Morokat versus the typical SW monsoon flow? 13502, 2: . . .accumulation. . ..delete amount (redundancy) “, 13: so is the convergence of the flows crucial or is the lifting along the CMR? Seems like you could express this more clearly. In the early stages the convergence between the typhoon's flow from the north and the SW monsoon yielded heavy rain; later the rain was produced more from the convergence along the CMR? 13503, 6: farther instead of further “, 15: The red. . .the color codes for the fig. belong in the caption, and the sentence needs editing “, 21: deeper instead of higher? “, 25: directly averaged means what? 13504, 10: . . ..gradual increase. . ...delete toward “, 15: . . .are presented next. “, 25: resolution (no s). What is the actual observation resolution of the NCEP GFS? The GFS is really the result of coarse data that are dynamically adjusted. What were the obs that improved the resolution to a half degree? “, 25: delete took from. . .used NCEP. . .. 13505, 1: evolution (no s) “, 3: what is meant by “the model evolution is much stronger. . .” “, 13: resolution “, 14:. . .of a persistent. . .and the convergence and lifting due to the presence of the CMR. . .. “, 20: convergence (no s) “, 23: last sentence in the summary is obvious and can be deleted Fig. 1a. The best track . . .at 6-h intervals Fig. 1b. reword caption to 426 rain gage stations. . . also topographic height. . .black dashed rectangle convert area means what? Fig. 1e: delete amount . . .. rewrite

as. . .. simulation of the accumulated rainfall Fig. 3: cannot read the upper right yellow print, presumably the radars that are used for the composite. Is radar a composite of a single time? Vertical maximum radar reflectivity means what? Radar shows that location of rainbands would be important in the simulation. Fig. 3b. Authors do not use the satellite picture to make any point – consider deleting. Fig. 3c. Moisture flux derived from the GFS – how is this field produced given that there are few obs in the typhoon? GFS view of Typhoon Morakot seems unrealistic with the eyewall too far from center or not resolved at all. This is horizontal moisture flux and should be stated as such. Where it rapidly decreases is where the rain should be. . .well, is it? Based on the three pictures it doesn't look like it. Fig. 4. Repeated the wind scale and color scale three times! Fig. 4a isn't depicting just the zonal mean, looks like the total horizontal flux. Fig. 4d,e: delete – they add nothing to the story. Fig. 5. Could shorten the caption considerably by reorganizing it. Convergence itself is ok without wind. Not surprised that the model is close to the GFS given that the GFS is used as an initial condition. Units should be 10-6.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 13495, 2010.