<u>General comments of Referee #2</u>

The authors use idealized, cloud-resolving simulations of thunderstorms to determine the fate of mercury in the atmosphere. While I cannot consider it a major contribution, it is a good first cut at determining the environmental factors that influence how a thunderstorm interacts with mercury and might help explain observed climatological mercury deposition. The paper is well-written and, in general, does a good job in making their case. The results, though, hinge on the accuracy of the cloud model (which can be considered state-of-the-art) and the deposition methodology.

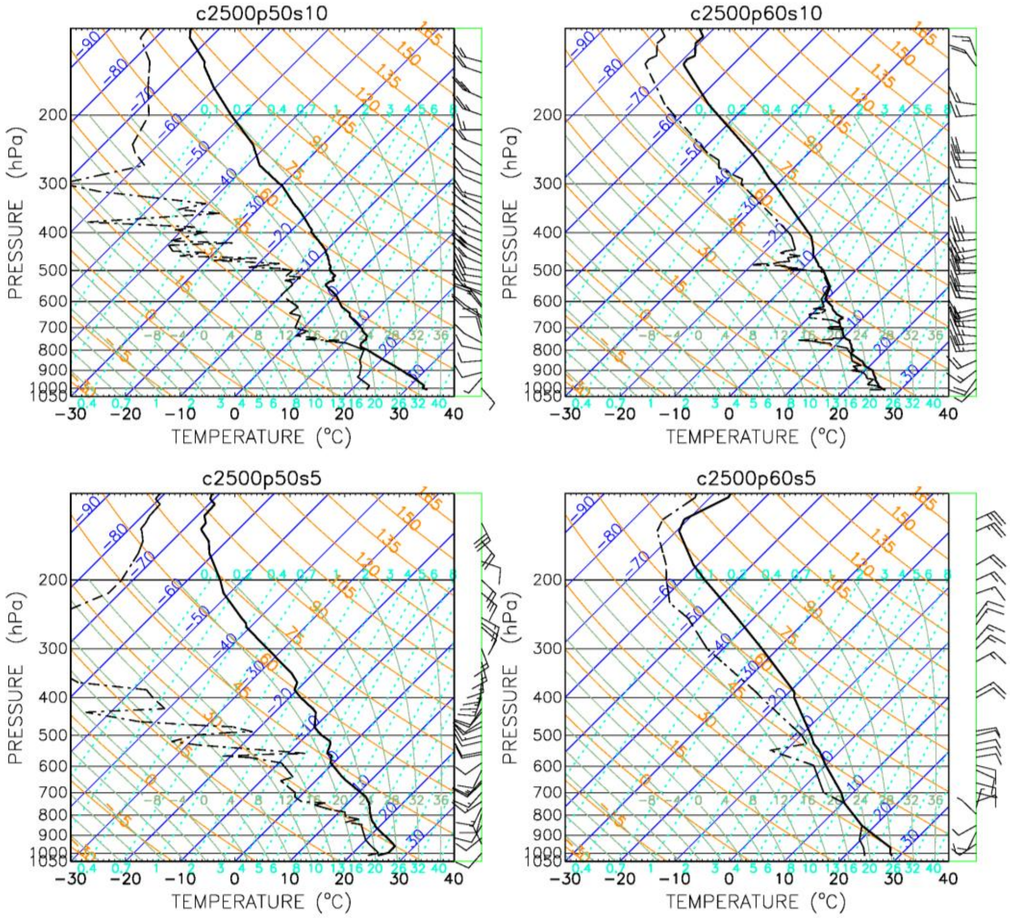
<u>Specific comments and our responses:</u>

I'm happy to see RAMS being put to good use. However, I wonder if the bubble-method to initialize the storms has an undue influence on the results. Real thunderstorms initiate in a much different manner. The authors demonstrate the importance of small changes to initial conditions on the results - I'd expect the initiation method to also have such an influence. The authors should discuss their CAPE calculations in more detail. Are they using most-unstable CAPE, surface-based CAPE, or a mixed layer CAPE? Does it matter to the results? For a given value of CAPE, the vertical distribution can vary - (tall and skinny vs. short and fat). What did the authors use and are the results sensitive to that? I would like to see a multi-panel figure showing some of the soundings used to initialize the model.

The CAPE used in the study is mixed layer CAPE which is more consistent with convection. A 50hPa mixed layer is utilized and computations are based on pseudoadiabatic thermodynamics without ice (CAPE-1, Cotton et al., 2011) and include virtual temperature correction. The method used for computing CAPE will change the absolute number of soundings within the parameter space bins, but the drastic differences between northern and southern sites will remain. Authors agree that the nature of initiation could modulate storm dynamics and wet deposition with sustained dynamical forcing transporting Hg from a larger area into the storm. However, unorganized and isolated convection is a natural counterpart of the storm simulations. Realistic case study simulations need to be conducted to study the impact of initiation mechanisms.

As mentioned in lines 7-9 of page 6, the parameter space considered in this study is a subset of the higher dimensional parameter space utilized in prior studies (Cohen 2000; McCaul and Weissman, 2001; McCaul et al., 2005; Cohen and McCaul, 2006; Kirkpatrick et al., 2007; Kirkpatrick et al., 2011). We chose CAPE, Shear and PW space since prior studies (McCaul et al., 2005; Cohen and McCaul, 2006; Kirkpatrick et al., 2007) show that these variables have significant impact on cloud mass flux, entrainment and vertical distribution of hydrometeors, all of relevance to wet removal of mercury. Also the northern and southern sites environments are well separated within this parameter space. Whereas we expect the variability to be governed on the first order by the differences in CAPE, Shear and PW, vertical distribution of CAPE, height of maximum buoyancy, level of free convection, lifting condensation level etc. could also introduce variability. Even though we have not specifically investigated the effects of other parameters, as described in section 3.5, the ensemble of simulations using soundings from northern and southern sites do sample such variability.

As suggested by the reviewer, we have added a multi panel figure showing the soundings:



I don’t consider 1000 J/kg to be ’weakly unstable" except in regards to supercells.

Please note that weakly unstable is defined as values less than 1000 J/Kg. We were using a subjective classification based on Wiesman and Klemp (Mesoscale Meteorology and forecasting, AMS Publication), which refers to < 1000 m^2s^{-2} as small buoyancy and > 2500 m^2s^{-2} as large buoyancy. Reworded the sentence as: ‘‘CAPE is indicative of the atmospheric instability and value ranges of less than 1000 J kg^{-1}, 1000-2500 J kg^{-1} and greater than 2500 J kg^{-1} are considered low, medium and highly unstable conditions, respectively’’

In Fig. 7 b and f why is there such a large difference in the rainwater distribution for a modest change in PW? That’s another case where it would be helpful to see the initial sounding.

We have included initial sounding for the cases shown in Figure 7. For the more tropical soundings, substantial amount of the water vapor is concentrated in the lower part of the atmosphere and thus the higher sensitivity to change in PW.

The authors demonstrate the differences between their various simulations, but don’t have much explanation for these differences. For example, they show that shear has a big impact, but why does it?

The differences are caused by differing storm structure and associated changes in vertical distribution of hydrometeors. Due to non-linear interactions it is difficult to pin down differences to couple of processes without more detailed analysis which is beyond the scope of the present work.

<u>Technical corrections</u>

p 3576, line 14: "deposited mercury deposited"

Has been modified as "mercury deposited"

p 3580, line 17: "since it the"

Has been modified as "since it is the"

p 3581, line 10: "Reginal"

Has been modified as "Regional"

p 3584, line 24: "Other possibility"

Has been modified as "Another possibility"

p 3587, line 28: an "increase in SHEAR"

Has been modified as "an increase in SHEAR"

p 3591, line 1: "deep thunderstorm

Has been modified as "deep thunderstorms"