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Interactive comment on "Investigations of aerosol impacts on hurricanes: virtual seeding flights" *by* G. G. Carrió and W. R. Cotton

Anonymous Referee #1

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This is an interesting and informative paper.

The paper examines the feasibility of mitigating the intensity of hurricanes by enhancing the CCN concentrations in the outer rainband region. Increasing CCN concentrations at TC periphery intensifies convection at the TC periphery (mechanisms of convective intensification caused by small aerosols was discussed in many studies and summarized in the review by Khain 2009). The competition between enhanced convection at the TC periphery and that in the TC eyewall leads to weakening of convective clouds in the TC central area and to TC weakening. The mechanisms of such competition can be different. For instance, the increase in the updrafts at the TC periphery (with successive penetration of the ascending air in the outflow layer at the upper levels) may decrease the mass or air and of water vapor reaching the TC center (by the way, the

well known STORMFURY field experiment was based on the idea of such competition: it was assumed that glaciogenic seeding of clouds are the outer edge of the eyewall can increase vertical velocity there, decreasing the mass flux of air (and humidity) to the TC center). Similar mechanism was discussed in studies by Khain et al (2008, 2010) who investigated the effects of continental aerosols ingested to TC periphery by TC circulation, when the TC approaches the land. In these studies the weakening of TCs by aerosol-induced intensification of convection at the TC periphery was reported. Another mechanism of competition can be related to an increase in pressure at the upper levels in zones of enhanced convection at the TC periphery. This increase may hinder the outflow from the eyewall. It is known that two convective systems tend to suppress each other because each of them turns out to be located within the areas of compensating downdrafts caused by its counterpart. There are many studies describing the interaction between deep convective clouds developing at some distances between them.

In the paper another very important factor of such competition is investigated. Enhanced convection (and enhanced precipitation) at the TC periphery leads to an increase in evaporation and foster the formation of cold low energetic cold pools which propagates to the TC center and decreases instability of the atmosphere in the TC center. This mechanism is described in the study Rosenfeld et al. (2007) which also investigated effects of aerosols at the TC periphery on the TC intensity. In this connection, I suppose that it is necessary to mention other studies analyzed this effect. For instance Wang (2002) concluded that spiral rain bands forming at the TD periphery have a weakening effect on the tropical cyclone because they introduce low-entropy air by downdrafts into the boundary layer and hinder the boundary-layer inflow towards the eyewall.

In this connection, it would be very interesting to discuss the results of study by Frisius and Hasselbeck (2009) who used an axi-symmetric and fully 3-D mesoscale models with bulk-parameterization of microphysical processes. In their simulations switching off drop evaporation led to a decrease in the TD eye diameter and the convective inhibition outside the eyewall. As a result, their TD rapidly developed into TS when there was no evaporation of water droplets (as well as in the simulations in which the air cooling caused by melting was switched off).

A very interesting result was obtained as regards the non-monotonic response of microphysics, dynamics and precipitation of deep convective clouds (and correspondingly, of the magnitude of cold pool) to the increase in aerosol loading. I would recommend to the authors to refer some studies investigated this effect by simulation of single deep convective clouds (e.g., Khain et al 2001; Wang 2005, Khain 2009). It seems that this effect can be attributed to a decrease in the intensity of all collisions between hydrometeors and to production of a significant amount of ice crystals in cloud anvils produced by homogeneous freezing. These crystals do not participate in precipitation production and the production of such crystals decreases precipitation (and cold pool).

I suppose that these papers and discussions should be added to support the conclusions of the present study. The list of references mentioned above is presented below.

In summary, I would like to stress the importance of the study showing the existence of new factors (like aerosols) on the TC intensity. Similar results were obtained by Rosenfeld et al (2007), Khain et al (2008; 2010) using WRF model (the last paper used spectral bin microphysics). The results show that the aerosol effects should be taken into account to improve prediction of the TC intensity. Besides, this study shows principal possibility to weaken TC by seeding of clouds at its periphery with small aerosols (such possibility was formulated also by Rosenfeld et al 2007).

Frisius T. and T. Hasselbeck, 2009: The effect of latent cooling processes in tropical cyclone simulations,*Q. J. R. Meteorol. Soc.* 135: 1732–1749

Khain A. P., D. Rosenfeld and A. Pokrovsky, 2001: Simulation of deep convective clouds with sustained supercooled liquid water down to –37.5 C using a spectral microphysics model. *Geophysical Research Letters*, 28, 3887-3890.

Khain, A. N. Cohen, B. Lynn and A. Pokrovsky, 2008: Possible aerosol effects on lightning activity and structure of hurricanes. J. Atmos. Sci. 65, 3652-3667.

Khain, A. P., 2009. Effects of aerosols on precipitation: a review. Environ. Res. Lett. 4 (2009) 015004 *Environ. Res. Lett.* 4 015004 doi: 10.1088/1748-9326/4/1/015004.

Khain, A. P. B. Lynn and J. Dudhia, 2010: Aerosol effects on intensity of landfalling hurricanes as seen from simulations with WRF model with spectral bin microphysics, J. Atmos. Sci. 67, 365-384

Wang Y. 2002. An explicit simulation of tropical cyclones with a triply nested movable mesh primitive equation model: TCM3. Part II: Model refinements and sensitivity to cloud microphysics parameterization. *Mon. Weather Rev.* 130: 3022–3036.

Wang C., 2005: A modeling study of the response of tropical deep convection to the increase of cloud condensational nuclei concentration: 1. Dynamics and microphysics. J. Geophys. Res., 110; D21211, doi:10.1029/2004JD005720.

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