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Interactive comment on "High lightning activity in maritime clouds near Mexico" *by* B. Kucienska et al.

E. Zipser (Referee)

ed.zipser@utah.edu

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APCD, 12, 2817-2852 Kucienska, Raga, Romero-Centeno: High lightning activity in maritime clouds near Mexico

Comments by Edward J. Zipser, March 19, 2012

There is a great deal to like in this paper, presenting interesting new observations of abundant oceanic lightning in certain regimes close to the coast of Mexico. The authors use several years of lightning data from the World Wide Lightning Location Network (WWLLN), and products based upon the data from the TRMM Microwave Imager (TMI), known as the 2A12 suite of products. They report surprisingly high lightning-to-rainfall ratios for regimes that include northerly offshore flow (through the Tehuantepec

gap). They attribute the high lightning activity to high aerosol content in the air participating in the deep convection, contrasting it with the more conventional "heavy rainfall, low lightning" regime in the ITCZ well southwest of Mexico. Their arguments are reinforced with monthly variations in wind data showing higher lightning in months with more offshore flow from Mexico into the East Pacific.

This reviewer has no problem with the principal results, nor with the belief that high aerosol content, other things being equal, may well be responsible for increasing the vigor of deep convection, as indicated by many references cited in this and other papers. However, while including a few caveats toward the end of the paper that aerosols may not be the complete answer, in my opinion this paper is too willing to overlook alternative explanations for the observations. In addition, it is probably too uncritical in accepting the hydrometeor profiles from 2A12, which have many potential shortcomings because of well-known simplifications in their derivation.

The reference cited for 2A12 was published before the launch of TRMM. The most important issue to consider is that even current versions of 2A12 over both land and ocean are attempting a very difficult task in deriving rainfall, an even more difficult task in deriving hydrometeor profiles over water, and an almost impossible task over land. Some appropriate references include Kummerow et al. (2001), Nesbitt et al. (2004), Olson et al. (2006), Fiorino and Smith (2006) and Gopalan et al. (2010). This last paper summarizes the current (unsatisfactory) state of the science in rainfall estimates over land.

Over oceans, the algorithms use a Bayesian retrieval that attempts to match the brightness temperatures observed in 9 channels with forward models that in turn are based upon microphysical profiles from a limited set of cloud resolving models, often simulating specific well-observed case studies from field programs such as GATE and TOGA COARE. As far as I know, none of these cloud model runs come from the regions over or near Mexico that are the subject of this study. Over land, because the brightness temperatures in the low frequency channels include surface-based emission with unknown emissivity that varies with vegetation, soil moisture, etc., the rain and microphysical profiles are entirely empirical, and use only the brightness temperatures at 85 GHz, basically responsive to vertically-integrated ice water content. So there is no significance whatsoever to profiles over land having lots of ice, because there would be no 2A12 rain over land whatsoever without ice! Also, note that the 2A12 rain and profile algorithms treat coastal regions exactly like land regions, so only rainfall well off the coast (> about 50 km) uses the oceanic retrieval schemes. These are difficult problems that the NASA Science Teams are working hard to solve, but they are likely to be a source of frustration for the foreseeable future. Bottom line for this paper: Comparison of land vs. ocean hydrometeor profiles from 2A12 is very uncertain, and most of the significance attributed to small differences between night and day, from month to month, or subregion to subregion, is reading more into the data than can be justified.

Turning to the authors' apparent surprise that there is a regime over and near Mexico where lightning increases while rainfall decreases, they could have made more use of a paper of mine (Zipser 1994) that they cited for other reasons. One of the main points of that paper is that for many monsoon regimes around the world, it is common for frequent lightning to be observed before and after the seasonal rainfall peak, while during the lightning is often much less frequent during the rainfall peak itself. A more recent paper (Xu and Zipser, GRL 2012, in press) summarizes this behavior for a number of monsoon regimes around the world, including a marked tendency for intraseasonal variability in which heavy rain periods are "ocean-like" with less lightning, and "break periods" are more continental-like, with reduced rain but increased lightning flash rates. Such behavior has been noted often in the Australian monsoon (Rutledge et al. 1992, Williams et al. 1992, Zipser and Lutz 1994), and during the TRMM-LBA experiment in Brazil, in which the westerly regime has less lightning and easterly regime more (Petersen et al. 2002). The low lightning, heavy rainfall regime noted by the authors in the east Pacific ITCZ is an oceanic archetype, and the authors make an interesting observation that the higher aerosol content in May could be related to an increase in lightning there.

One plausible scenario presented by the authors, and by others, that under some circumstances, a cloud in a polluted environment may have more lightning than a cloud in a similar thermodynamic (but clean) environment. But it seems an oversimplification to argue that aerosols are THE most important reason. And it begs the question of whether (for example) pre-monsoon storms are strong because the pre-monsoon environment favors more intense updrafts (which aerosols may make more intense), or whether those storms have more intense updrafts BECAUSE of aerosols. It seems doubtful that all pre-monsoon regimes are also high aerosol regimes, although certainly many of them may be polluted due to end-of-dry season biomass burning. As for the supercooled cloud water deemed essential for charge separation by the accepted ice-ice-collision non-inductive process, it is quite likely that (other things being equal) stronger updrafts will carry more supercooled cloud water to colder temperatures. There are occasional lightning episodes observed in hurricane eyewalls, and it is difficult to imagine that polluted airmasses survive passage through heavy rainfall and reach the eyewall on all such occasions.

In summary, there are important and interesting observations presented in this paper, which warrant distribution and discussion. Most of the details presented on microphysical retrievals may be beyond the inherent accuracy of the algorithms to resolve. On the positive side, I might encourage the authors to make use of their knowledge of this region to find examples of specific short-term periods with intense oceanic lightning, and analyze those as case studies, employing daily (rather than monthly means) wind analyses and geosynchronous satellite observations. Perhaps some of those intense lightning periods could be attributed to advection of polluted air masses. If so, it would be worthwhile for the authors to comment whether the modestly elevated lightning-rain ratios for some of their summer months are explainable by a few short periods with frequent lightning and reduced rainfall, rather than by a persistent but weaker monthly mean signal.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 2817, 2012.