Anonymous review for:

T. Berg et al. (2013), Ten years trends in atmospheric mercury concentrations, meteorological effects and climate variables at Zeppelin, Ny-Ålesund, *Atmospheric Chemistry and Physics Discussion*

General comments

Berg and colleagues present a ten-year observational record of GEM and perform statistical trend analysis, as well as correlation analysis with meteorological and climate variables. The authors find no statistically significant trend at Zeppelin, which is an interesting contrast to other high Arctic (Alert) and Northern Hemisphere (Mace Head) sites that do detect a statistically significant decrease. The decreasing trend at Alert and Mace Head and the absence of a trend at Zeppelin presents a conundrum for the Hg community since anthropogenic emissions (and hence the global background of atmospheric Hg) are thought to be increasing globally. Long-term observational records such as the one at Zeppelin are very valuable for diagnosing changes in the Hg cycle. With revision, this work may help shed light on the factors driving change in Northern Hemisphere GEM concentrations. I recommend this work for publication after substantially revising Section *3. Results and discussion*, which is overly difficult to read due to lack of clarity. Below are general comments that can be applied to the whole of Section 3 to improve its clarity and impact.

Be more quantitative.

The authors should provide quantitative information anywhere in the text where is says "correlation" or "relationship". Qualitative words like "higher", "lower", "less", and "more" are not helpful. Simple quantitative measures like correlation coefficients and percent change would vastly improve the scientific robustness of the discussion. This applies to the Abstract as well.

Break up long paragraphs.

A number of the paragraphs are very long and contain a number of disparate ideas, which makes the discussion unclear and difficult to read. Break long paragraphs into smaller paragraphs and stick to the rule of one major idea per paragraph. I also suggest paying more attention to the structure of the paragraphs. As a reader, you often don't get the main point or major result until several sentences into the paragraph. State the main point or major finding at the very beginning of each new paragraph. This will improve the clarity and impact of your discussion.

Provide more concise explanations for observed patterns/trends in your data.

The authors present a feature of their data and then attempt to explain this feature, but it frequently comes across as if the authors are just guessing and dumping every possible explanation on the reader. As a result, the discussion is confusing and unconvincing. The authors need to exercise more scrutiny in determining which explanations are plausible and which are not. The discussion would benefit from the authors placing greater emphasis on the explanations they find most compelling, and concisely summarize those explanations which are less plausible (or implausible) and providing justifications for why these explanations should be given less weight.

Revise Figures 7 and 8.

Figures 7 and 8a-g could be more effective than in their present form. Figure 7 only provides qualitative information, which doesn't add any substance to the analysis. Also, the figure caption should explain why April is selected. A more effective figure of sea ice would be to show a time series of total sea ice extent (in km^2) over the same period as the GEM data. Does the series of sea ice extent look like the AMDE curve in Figure 6?

Figures 8a-g are too busy and it's difficult to pull out the useful information. I suggest keeping the color scheme and re-plotting Figures 8a, 8d, 8f, and 8g as scatter plots. Figures 8c-d could be combined into a wind rose showing magnitude and direction. Other plots may be more effective and the authors should use their discretion here, but eight box and whisker plots is not an effective way to present this data and discuss correlations between GEM and meteorological correlations.

Specific comments

Title: "Ten years trends" seems grammatically incorrect. I suggest "Ten-year trends".

Page 2275, line 6: There is little evidence to support a 2-year atmospheric lifetime. More recent estimates (e.g. *Corbitt et al.* [2011]) are closer to 6 months. Your discussion in Section 3 (Page 2279 lines 6-11) suggest 2 years cannot be the correct atmospheric lifetime, otherwise you wouldn't see such large gradients between the Northern and Southern Hemispheres.

Page 2275, lines 10-23: Is there a reason why you omitted mentioning AMDEs occurring in non-polar environments (e.g. Dead Sea [*Obrist et al.*, 2011])?

Page 25 line 24 to page 2276 line 9: Seems worth mentioning that observed decreases are at odds with emission inventories, which suggest total global anthropogenic emissions are increasing [*Pacyna et al.*, 2010; *Streets et al.*, 2012].

Page 2276 lines 10-18: This paragraph is difficult to decipher. I'm still not quite sure what the point is. Please revise for clarity.

Page 2278 line 1: Why are you measuring CRS03 hourly dose rate?

Page 2278 line 2: Delete "(474 m a.s.l.)". You already said this on the previous page. No need to repeat.

Page 2278 lines 2-3: "…assuming the same ozone and cloud conditions." Is this a good assumption?

Page 2278 lines 8-9: "was obtained from the (Fetterer et al., 2012)." Typo?

Page 2278 lines 8-11: It's odd that these two sentences stand alone as individual paragraphs. Would be better woven into paragraphs above.

Page 2278 line 11: Surely there is a precedent for defining AMDEs to be below 1.0 ng m^{-3}. Cite previous studies that do this (e.g. *Cobbett et al.* [2007]).

Page 2279 lines 2-4: "Month values… from the National Weather Service Climate Prediction Center (Fetterer et al., 2012)." This sentence seems like it belongs in Section 2.2.

Page 2279 lines 14-15: "This is the time of the year… mid latitude source regions dominate." Please provide a citation.

Page 2279 lines 15-16: "During summer… previously deposited GEM." Please provide a citation.

Page 2281 lines 14-15: "Emission estimates do not exist for… 2006-2009." Not quite true. *Streets et al.* [2011] goes up to 2008 and is distributed by region and sector. The latest UNEP report (*Time to Act*, http://www.unep.org/PDF/PressReleases/Mercury_TimeToAct_hires.pdf) provides an estimate for 2010.

Page 2285 line 27: You define PBM in the Introduction but use "PHg" here. Either is fine, but important to be consistent to use the same terminology throughout the paper.

Page 2286 lines 18-19: What does it mean for an air mass to have "strong" contact with the ocean?

Page 2288 lines 7-10: The authors state that the diurnal pattern of GEM at Zeppelin is driven by "daytime snow surface emissions induced by solar radiation" and then immediately state that UVB and GEM aren't correlated. Isn't this a contradiction?

Page 2289 lines 18-19: Be consistent with the capitalization of "sea ice".