Thank you for your thorough review of our paper. We will be taking into account all of your suggestions, which will greatly improve the manuscript. As part of the interactive ACPD discussion, we would like to address your major concern early on. Please see below for our response to reviewer #3's major concern (reviewer comment in italic font), and the rest of our responses to all reviewers will follow at a later time.

Serious concern: In the authors' implementation of the bidirectional NH_3 flux, they assumed that there was an infinite soil pool of NH_4^+. This is an unreasonable assumption that is recognized and discussed by the authors. However, due to this or other assumptions in the implementation of the NH_3 bidirectional flux mechanism, the NH_3 emission/reemission flux is similar to or greater than the total (wet + dry) NHx deposition. This implies that the ecosystems are taking up little to no deposited NHx, which does not seem to be a reasonable result during the growing season. This casts doubt that any improvements in model performance is for the "right reasons" and on the value of the source apportionment results. I think that the authors should investigate and discuss the net total reduced nitrogen deposition, and if they cannot justify the high emission/reemission rates of ammonia, then I question the value of the final source attribution results.

While the simplification in our scheme means that the soil and canopy pools of NH_4^+ are "infinite", which is not realistic, we can justify it for the following reasons. First, we note that Zhu et al (2015) use this method for the canopy pool of NH_4^+ in GEOS-Chem (used empirical average values for constant stomatal NH_4^+, which essentially makes for an infinite canopy pool). And while they more realistically model the soil pool, they required a 3-month spin up to get the soil pool stable. This means that the soil pool is sufficiently large that once stable it may be considered an infinite source, especially over shorter time scales, such as those we have used in our study; our assumption that the pool won't get depleted is reasonable. Second, we have replotted the modelled deposition, combining the dry NH_3 deposition + the wet NH_4^+ deposition to get a <u>total NHx deposition</u>. For the base, bidi, and fire+bidi, the results of the total deposition are shown below:

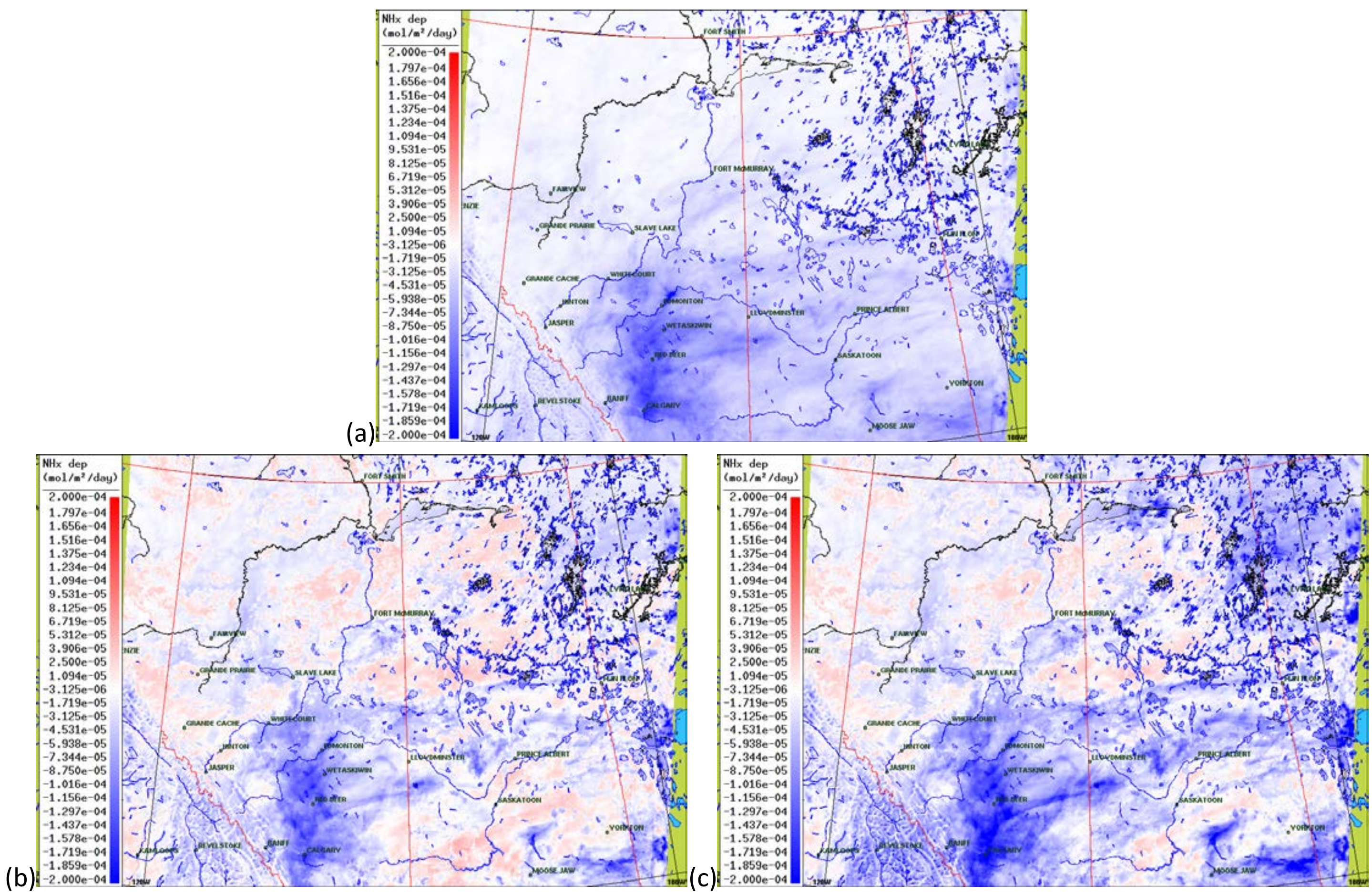

Figure R.1: Total deposited NHx (dry NH_3 + wet NH_4^+) in (a) base, (b) bidi, and (c) fire+bidi

Here we can better see that the ecosystems are in fact taking up deposited NHx over most of the domain over the time period we have simulated (anywhere that's blue is net deposition, anywhere that's red is net upward flux) – which was not easy to see when the deposition maps were presented separately (e.g., Figures 12 & 14 for dry and wet dep, respectively, in the original manuscript). In the revised manuscript, we will present and discuss Figure R.1 instead of showing the two separately since the total deposited NHx is the more important and relevant value. The average NHx flux values across the domain are:

NET FLUX (moles/m2/day)	Base	Bidi	Fire+bidi
Mean	-3.025E-5	-1.811E-5	-3.765E-5
Median	-2.061E-5	-1.299E-5	-2.843E-5

From these numbers you can see that in fact, the mean net flux of NHx across the domain from each simulation is similar and is net *downward* (negative). In fact, the fire+bidi has the largest mean net flux downward. Thus, our bidi scheme – even with a soil pool that can't be depleted – does not cause unrealistic net upward flux. In fact, Figure R.1c, shows that there is net deposition where NHx atmospheric concentrations are highest, but that parts of the domain where NHx atmospheric concentrations are low have a net upward flux.

Addressing those "red" areas in Figure R.1; While the red areas in Figure R.1 have net upward flux during our study's time period, it is important to note that our study occurred during August and September, which are very warm months, and the compensation point increases exponentially with temperature (Figure R.2 showing an example for one of the dominant land use categories in the northern part of the domain).

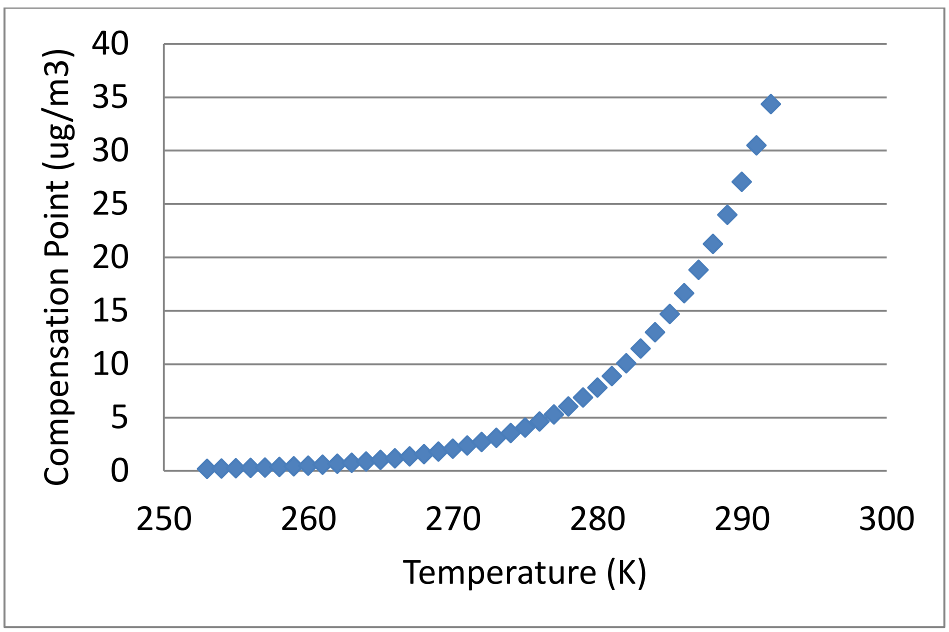

Figure R.2: Compensation point (Cg) relationship to temperature; Cg for evergreen needle leaf LUC shown as example.

The higher the compensation point value is, the greater the likelihood there will be upward flux, and the lower it is, the greater the likelihood there will be deposition. Therefore, during the rest of the year (e.g., the preceding winter and spring), the compensation point is much lower, greatly increasing the likelihood of net deposition, even in the areas shown as net upward flux in Figure R.1. This seasonal effect of winter filling the reservoir should be more pronounced with increasing latitude. While we did not run our bidirectional flux simulation for the whole year, a standard (deposition only) GEM-MACH run for the whole year of 2013 yielded a cumulative NHx (wet NH4 + dry NH3) deposition that was greater than our upward flux for Aug/Sept. This means that we can expect the soil pool to be replenished during cooler times of the year, rather than depleted. We therefore feel that our modelling assumptions in this study – especially given that we modelled a short time period in the summer – are justified. The above discussion will be added to the revised manuscript.