Response to Anonymous Referee #1

This paper by S. C. Lewis and colleagues is a valuable modeling study on oxygen isotope variability in tropical precipitation during Heinrich events. The authors use the GissE model enhanced by explicit isotope modeling and vapor source identification to identify the major controls on the isotopic composition of precipitation for various low latitude sites during an idealized Heinrich event ("hosing experiment"). They rigorously compare their model results to available proxy data. The study is well outlaid and clearly provides sufficient new material and in- sights to warrant publication in Climate of the Past.

There are a few minor issues, only, where I would like to see some revisions of the authors before publication:
- The major results are all based on one VSD-enabled model experiment with a rather short simulation period of 5 years. In contrast, the available proxy data represent a mean climate state over several decades or even longer periods. How well is this mean climate state represented by this short simulation and how large is the year-to year variability in the major model results regarding the identified major vapor source regions for the different data sites?

- The hosing experiments presented here are not 5-year simulations. The coupled model is allowed to respond to 100 years of freshwater (1 Sv/year) addition to the North Atlantic. The mean sea surface temperature and sea ice conditions at the end of this freshwater addition (years 80-100) are representative of the model response to the forcing – specifically, the simulated North Atlantic "cold", NADW "off" is serving as an approximation to the climate response during Heinrich Events (described in the introduction). The reviewer is correct that it takes the ocean model many years to respond to the freshwater forcing (see Stouffer et al 2006 for individual model responses), for ModelE-R, it takes ~50 years to completely "stop" NADW. The atmospheric model response is much quicker – less than a year. For this reason, once the sea surface conditions are determined (from long runs using the coupled model), we can drive the atmospheric model for much shorter runs using the surface conditions determined from the coupled model. The reason that we did not do simply the entire experiment with the VSD tracers in the coupled model is that with 144 additional tracers, the "real" simulation time is an order of magnitude greater, and the VSD tracers are not "in" the ocean, but rather "reset" at the surface. We ran the atmosphere-only model for 6 years (only using the last 5, giving the atmosphere 1 year to respond to surface conditions) driven by the 20-year average surface conditions determined by the coupled model.

- The selection criteria for the proxy data used in this study remain somewhat unclear.
E.g., in Fig. 1 & 2 the authors use as an Antarctic record the Byrd data, only. Even if the polar records are not the focus of this study: Why did the authors include the Byrd record in their analyses, but not some newer Antarctic data, too?

- This study focuses on low-latitude $\delta^{18}O$ changes, so only one Antarctic $\delta^{18}O$ record was discussed explicitly. Changes in $\delta^{18}O$ at Byrd are specifically discussed in terms of asynchrony between the hemispheres over Dansgaard/Oeschger cycles during the last glacial (Blunier et al., 1998). Similarly, the region around Byrd is considered sensitive to climatic events of North Atlantic origin (Grootes et al., 2001). As such, the Byrd record was included in this study. We have now included proxy data from Taylor Dome to provide greater spatial coverage of reconstructed changes of Antarctica. Taylor Dome records $\delta^{18}O$ changes more abrupt and pronounced than Vostok or Byrd and millennial-scale changes are compared with those occurring over Greenland (Grootes et al., 2001). Details from Taylor Dome have been added to Fig. 1 and Tables 2 and 3.

- In Table 3 it is stated that 27% of the precipitation at the GRIP and Byrd site stem from continental recycling. These numbers seem unrealistic high for both polar regions. Once again: Even if the polar records are not the focus of this study, how trustworthy are the VSD results for low-latitudinal regions if this tracing method gives erroneous results for high-latitudinal sites in Greenland and Antarctica?

- The precipitation occurring at GRIP that is derived from continental recycling (~ 27%) is sourced predominantly from continental sources from North America and Eurasia, rather than from local surface sublimation within Greenland. The definition of precipitation recycling has now been clarified. Over Byrd, there is likely a bias in modelled precipitation fields that contribute to the high ratio of recycled precipitation. The estimation of continental recycling in GCMs can be high relative to moisture derived from advective moisture sources (Trenberth, 1999; Dirmeyer and Brubaker, 2007). At high-latitude sites these differences are most likely due to a combination of poor data over ice sheet regions, and biases in the GISS model (and re-analyses). At high-latitudes, differences may relate to an overestimation of summertime sublimation, to an underestimation of advective moisture source due to deficiencies in modelled wind fields or to seasonal temperature biases. In other regions, these factors are not present to the same extent, and so the apparently poor results in the polar regions are unlikely to be representative. Of course, there are clear biases in the model simulation for the tropics as well, which further indicates that our methodology should certainly be looked at in other models as well.

- The color scale of the lower left plot in Fig. 6 differs from the other three plots in this figure and should be reversed in a revised manuscript version.

- The lower left panel of Fig. 6 has now been revised. The seasonal cycle of vapour source distribution cycles over the defined China region is now plotted as DJF-JJA anomalies, rather than JJA-DJF. In this case, the colour scale is now consistent with the other VSD plots and the similarity in the spatial pattern of VSD anomalies with hosing anomalies over China is visually evident.

Response to Anonymous Referee #2

This study focuses on stable water isotopic excursions observed in speleothem records from the tropics during Heinrich events using an isotope-enabled GCM, the GISS ModelE-R. The paper provides interesting new results regarding the climatic interpretation of tropical speleothems and shows that the results can be very site-specific and that caution should be exercised when simply interpreting isotopic departures as changes in local precipitation amount (although this interpretation still seems to hold at some sites). The results presented here are likely somewhat model-dependent and they will eventually have to be confirmed using different models, but this analysis nonetheless provides an important first step in the right direction.

- The results presented in this paper are from the GISS ModelE-R alone and are model-dependent, although this model is, at the very least, similar to other isotope enabled models (Yoshimura et al., 2008).We eagerly anticipate that future studies using other stable water isotope enabled models will include similar simulations.

Caption Figure 5: change JFD to DJF

- The caption on Fig. 5 has been changed from JFD to DJF.

I have some doubts about the choice of the domains used for the monsoon indices shown in Figure 5. If I understood the authors work correctly, they apparently mix two different indices by choosing the domains as in Li and Zeng (2002) (note Zeng, not Zheng as spelled in the paper) and the type of index as in Webster and Yang (1992). In fact Webster and Yang (1992) use a very different region to define the strength of the Asian monsoon and studies based on vertical shear indices over S. America also used different domains from what is shown here. It is fine, of course, to use the Li and Zeng monsoon domains, but then one should also stick with their definition of monsoon strength.

- The monsoon domains defined by Li and Zeng (2002) are no longer included in this study. The Webster-Yang (WY) index is now calculated for the original Asian region defined by Webster and Yang (1992). Furthermore, the WY index is determined over the summer months (DJF) over a region of South America identified by Vuille and Werner (2005) as the centre of monsoonal convection, and which they consider a dynamically consistent approach to Wesbster and Yang (1992). As the Indian and Australian monsoon regions are not discussed in detail, these regions are no longer defined nor a WY index calculated. The updated regions are included in the revised Figure 5.

I can't see much of a decrease in the zonal wind shear over the Asian monsoon region in the hosing experiment as claimed on page 102 (lines 21-23). Maybe I am missing something but Figure 5 does not seem to show this.

- Using the Webster and Yang (1992) region definition of the Asian monsoon domain in the revised Figure 5, only a small hosing-drive decrease in zonal wind shear is simulated. This change is now reflected in the text on page 102.

EW Wolff (Editor)

The paper has now been in discussion for its full period, and has received two anonymous reviews. Both of them are positive and recommend the paper for publication after minor changes. The only significant caveats are about how widely we should interpret the results, given that they come from a short simulation (referee 1) and from only one model (referee 2). The authors are asked to respond with an author comment to each substantive comment from the reviewers, and are then encouraged to submit a new version for CP (using the instructions they receive) that makes minor changes as suggested: this should then be acceptable for CP.

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