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Earth System Dynamics Discussions

Interactive comment on "A Lagrangian analysis of the present-day sources of moisture for major ice-core sites" *by* A. Drumond et al.

Anonymous Referee #2

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The paper presents an analysis of moisture sources for a number of ice core sites based on a backward trajectory analysis in ERA-Interim data. The paper provides some interesting results, which eventually may become relevant for interpreting proxies. The results are nicely described and the paper seems scientifically sound. However, for a person not familiar with the methodology (like myself) the description of the method is not easy to follow and needs to be improved. Whether this is major or minor I leave up to the editor.

Main point The method was not clear to me at all. The abstract speaks about backward trajectories, but the more I read I assumed these were forward trajectories analysed backward, but I am not sure. Furthermore, it is not clear to me whether the frequency distribution of particles is accounted for or not. The 2 million particles may be evenly distributed initially, but the sampling procedure must introduce large differences in the

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density of trajectories. For instance, for the sampled particles, "summing up" (e-p) in the vertical will not give (E-P) at the surface (because there may be layers in between whose air travels in a different direction and will not reach the ice core site). Furthermore, it seems that the vertical dimension is neglected. Let's assume a (climatological) circulation such that, when your trajectories pass over a location where evaporation usually takes place, the trajectories pass mostly at high altitudes and the particles do not actually pick up a lot of moisture whereas the moist lower layers rain out upon reaching the first mountain chain and never reach the ice core site. Wouldn't this matter? The paragraph on P. 2 to 3 on dq/dt implies that you are tracking moisture changes along a trajectory, but the further I read I think you do not. Rather, it seems that you overlay the position of the particles onto a field of E-P which you could have obtained as well from a Eulerian approach (precipitable water tendency plus vertically integrated moisture flux divergence). I admit I have not read Gimeno et al. (2012), but I think the reader should be given more information here. Below are some more detailed comments P. 3. L. 2: "By summing (e-p)..." Do you mean integrating? (I anyway struggle with the units here). Is there any control (e.g., weighting) of the vertical distribution or is it sampled well enough that this is not necessary? Do you need the vertical distribution at all? P. 3. L. 9: Here's probably where my confusion starts. Since these are backward trajectories (as mentioned in the abstract) you do not need 2 million but only those that arrive at the ice core locations, right? Or are trajectories calculated forward but then the analysis treats them as backward trajectories? Furthermore, since you track the particles for 10 days, how often is the model re-initialised? If it is only initialised once and then everything else is done by sampling, I think it needs to be stated that the trajectories provide a good sample. For instance, after 30 years of simulation all particles might have ended up in the subtropical jet and stay there. Conversely, is the number of particles above a given ice core site the same for all time steps? If not, do you weigh the results somehow? Perhaps I am just ignorant and perhaps this approach is so well known that no further explanations are required, but as a reader I would be glad for some help. Otherwise I think this is a fascinating paper. P. 3. L.

11: Are retro-trajectories backward trajectories? P. 4, L. 6: What are "target areas": Are these areas where particles end after a 10-day period or an area over which they pass at any time during a 10-day period? P. 4, L. 10: "backward methodology": forward trajectories analysed backward? P. 4, L. 11: "(E-P > 0)" Now I am confused. Why not "(e-p > 0)"? If the assumption is that each particle (i.e., e-p) behaves in the same way as the integrated column (i.e., E-P), then there would be no need to track moisture at all. Simply use (Eulerian) E-P from ERA-Interim and the position of the particle from FLEXPART. Is that what you do? So why do you initially integrate (e-p) rather than taking it directly from ERA-Interim? P. 4, L. 13: "E-P averaged over the whole tracking period (10 days)" Again, I understand this such that you basically use a (Eulerian) map of E-P and then sample it at the locations and time where air parcels pass it (at any altitude) and then reach the ice-core site within at most 10 days. But you only do that if E-P is positive. It seems that there is no weighting that accounts for unequal distribution for particles. But this should be stated (and justified). I am still confused, though, why you need e-p at all. P. 4, L. 13: "95th percentile" Do I understand this correctly: For each ice core you would show the 5% grid points with the highest E-P (if you showed the annual mean)? P. 4, L. 32: The VIMF is calculated directly from ERA-Interim, right? Or is it from the Lagrangian approach? P. 5, L. 1: The difference between vertically integrated moisture flux divergence and E-P is the tendency in precipitable water (i.e., storage), which can be neglected over long time periods. So the E-P figure would look identical, right?

Minor points The first paragraph of the introduction is rather vague as to the processes causing changes in isotope abundances in ices cores: they depend on "local conditions," changes in "relative moisture of the source" (what is that?), "changes in these source conditions," etc. It would be good to be more specific P. 2. L. 29: Give a reference for MERRA. P. 2, L. 19: "unrealistic fluctuations in humidity can be taken as moisture fluxes": I do not understand that. P. 3. L. 23: "low data density": Do you mean the number of particles or the quality of the reanalysis there. P. 10, l. 16: Anchmann -> Auchmann P. 11, last reference: Chack names. P. 13, Table 1: couverture -> coverage

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Fig. 2: The arrows do not help very much; perhaps make them larger

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