Referee 1 (S. Mudd)

This paper describes experiments from the CIDRE landscape evolution model. The model uses an erosion and deposition module that allows particles not only to be ex- humed but also deposited. Particles can be traced from upland sources, along rivers, and the model allows them to be stored in terraces or colluvial deposits. The approach is novel and the model is very much a step in the right direction toward understanding how sediment pathways may influence chemical wreathing fluxes in actively eroding mountain ranges. I have annotated a pdf with most of my comments. There are a few comments of a general nature that I will make here. Firstly, combining particles with a landscape evolution model is not simple and it necessitates choices about how particle evolutions proceeds. There are some simplification that could be relaxed at a later stage or that could be significant to weathering rates in real landscapes. One that strikes me as possibly important is the physical weathering processes that may fragment grains as they move from hillslopes to rivers and on to sedimentary deposits. The authors might make a comment about this component.

Thanks for these comments. Physical weathering is a good point we have been thinking. Fragmentation could be possible to incorporate but would require another choices. We decided to not include this process for the moment. The small clasts (<2 mm) used in the presented experiments may not break significantly during hillslope and river transport. Nevertheless, if this process was significant in the real word, it would increase the weathering rate in colluvium and along the valleys because smaller grains would weather faster, thus increasing the contribution of colluvium to the mountain weathering rate. We added a sentence in the discussion: *In addition, we neglected the fragmentation of clasts during hillslope and river transport by physical weathering and crushing. This fragmentation should increase the weathering contribution of sediment trapped in the valleys as smaller grains weather faster.*

The governing equations use combined erosion and deposition rules. The equations describing these rules are somewhat different to the typical equations that focus on the divergence of sediment transport, especially for hillslopes. However a previous ESURF paper by Carretier et al have shown how the model is able to reproduce analytical solutions of hillslope sediment transport so I think that should be mentioned in this current paper.

OK, in the model description, we added: *Note that the erosion-deposition hillslope model leads to similar solutions as the critical slope-dependent hillslope model studied for example by Roering et al. (1999) (Carretier et al., 2016).*

(...) The fluvial transport law seems to use a slope exponent of n = 1. This is not the first paper to do so but there is little field evidence to suggest n = 1 and quite a lot of evidence to suggest it is frequently 2 or greater. The authors should at least mention this, although I suspect that, since the model is run to a steady condition, the exponent mainly controls the timing of weathering fluxes but not the overall pattern.

Indeed, a larger-than-one n value may indicate that detachment thresholds for sediment and bedrock play a significant role (e.g. Snyder et al., 2003; Lague, 2014). We added this sentence: *Note that the duration of the weathering peak may depend on the choice of $n = 1$ in Equation 2. The n exponent is known to control the response time of the topography to uplift (Tucker and Whipple, 2002) and the time required to develop the drainage network on the initial uplifted surface (Carretier et al., 2009). In regions where detachment threshold is significant, $n > 1$ (Lague, 2014). Using a $n > 1$ would thus increase the period during which a thick regolith covers the initial uplifted surface. It would thus probably affect the duration of the weathering peak, but not the contribution of colluvial deposit once this regolith has been eroded.*

(Another component that concerned me was that most of the simulations are conducted with a very large grid spacing. A smaller spacing is used to show results do not depend on grid spacing (500m vs 20m) but I do think some more detail beyond simply the time series of weathering fluxes should be used to reassure readers that the grid scale is not changing the results.

Yes this kind of models can be pixel size-dependent (Passalacqua et al., 2006). Note however that the mean transport rate (and thus residence time) of clasts does not depend on pixel size (Carretier et al., 2016 in Esurf). Here we reason by comparing fluxes and relative contributions of different landscape elements between experiments. We show that using a small scale landscape leads to the same conclusion for a small peace of a mountain (OROGRAPHYdx=20m). Would it be the same if we had used a smaller pixel size but keeping the same domain size ? In this case, narrower valleys would probably limit the residence time of colluvial deposits, but at the same time we would get a much denser drainage network, thus increasing the volume of colluvium. We expect that both effects would compensate themselves. In order illustrate this point, we ran a complementary experiment based on the OROGRAPHIC simulation but using dx = 200 m instead of 500 m and keeping the same domain size (700x500 cells instead of 300x200). We divided the lateral erosion parameter by 2.5 in order to decrease the local amount of colluvium. We still observe that the weathering of colluvial deposits produces a bit smaller but significant weathering outflux during the cold period where regolith is absent. We added Figure S3 as supplementary material to illustrate these experiments.

`The choice of simulations are slightly puzzling to me: after the WARM scenario, the simulations result in either entirely or mostly bedrock hillslopes with sediment concentrated in valleys. These modelled landscapes do not feel that representative of most mountains, where regolith is present.`

We agree that most mountains have a regolith, but the experiments COOLING and OROGRAPHIC just following the WARM scenario are end-members, as stated at the beginning of section 4.2. That is why we then run the experiments COOLING REG. and OROGRAPHIC REG. which should be more realistic as they produce a regolith at least at low elevations.

`It also seems strange to set the model parameters such that 7000m mountains are formed within a model that does not contain glacial processes. I would have used lower mountains.`

We understand this concern. We designed experiments for high mountains in order to analyse the effect of wide range of temperatures on chemical weathering. Initially we wanted to evaluate the control of temperature on the distribution of regolith production rates with elevation for high mountains. We also wanted to evaluate the impact of the temperature decrease associated with increasing relief through time. Finally, although temperature decrease with increasing elevation contributes to the stripping of the regolith on the hillslopes, this effect is not crucial for our main conclusion. Indeed, in our experiments with dx =20 m, mountains reach a maximum of ∼1200 m (for which no glacier erosion is expected). Still, the effect of colluvial deposits is observed. Adding glacier erosion for high mountains would probably help to remove the regolith at high elevations and would deliver more fresh sediment to the valleys. Concerning the ratio between weathering flux produced by in situ regolith on the hillslopes versus that produced by colluvial deposits, we expect that glacier erosion would not contradict our conclusion. In our modelings producing a regolith under a cooling climate (COOLING REG and OROGRAPHIC REG), the regolith is located at low elevations, not at high elevations where glaciers dominate. Thus glaciers would not increase the contribution of hillslopes weathering. Furthermore, the weathering of sediment eroded by glaciers could increase the weathering contribution of sediment spending time in the valleys, consistently with our results. Nevertheless, we keep very cautious about the effects of paraglacial processes which remains to be evaluated.

`The paper is not really trying to recreate a real landscape, but rather explore the consequences of some simple weathering rules combined with different erosion scenarios. The model runs give insight into just how important the sedimentary reservoirs in valleys or terraces are in locations where material is escaping the hillslopes incompletely weathered. I wonder if this effect is only noticeable because there is no regolith on the hillslopes. Perhaps the authors can comment on the importance of river deposits on the weathering fluxes as a function of` $N_{depo}$ `versus` $N_{reg}$`. Presumably if` $N_{depo}/N_{reg}$ `is small, the colluvial and fluvial deposits become far less important in the overall weathering signal.`

Simon Mudd is right, the contribution of colluvium is maximum when no regolith cover the hillslopes, which must be considered as an end-member situation, or to the elevation range in a mountain without significant regolith. In order to weight the effect of colluvium weathering, we designed more realistic experiments COOLING REG. and OROGRAPHIC REG including a regolith at low elevations during the cold period. These experiments show that colluvial deposits still play a significant role, even if their contribution is smaller than that of the regolith covering the hillslopes (Figures 9 and 10).

Concerning the effect of N_{depo}/N_{reg}, we carried out another experiment based on COOLING in which N_{depo} is divided by 3 by multiplying the river transport length coefficient (ξ) by 3. We added Figure S4 as supplementary material to illustrate the following. Increasing the transport length, there is less deposition. Consequently, the sediment thickness in valley borders is smaller and the weathering outflux associated with colluvium is lower. The second effect of increasing the transport length is to increase the lateral erosion. Indeed, lateral erosion is proportional to the sediment flux. The sediment flux is greater if there is less deposition, thus the lateral erosion increases. Consequently, rivers are more straight and the residence of sediment in the river is shorter. This second effect contributes also to lower the weathering outflux associated with the weathering of colluvium. Note that the relief in the experiment with ξ x 3 appears less realistic than in the COOLING experiment (Figure S3). Yet, the colluvial deposits produce a significant weathering outlfux during the cold period. This comparison illustrates that the colluvium contribution can depend on N_{depo}, but that colluvial deposits still controls the weathering outflux in these experiments.

`Overall I think this paper contains a number of interesting innovations and will be useful to those trying to understand how weathering evolves as mountains grow. I am suggesting moderate revisions.`
We thank a lot Simon Mudd for his constructive comments that helped us clarify our paper. We took all the comments of the annotated manuscript into account.