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Interactive comment on "Autogenic versus allogenic controls on the evolution of a coupled fluvial megafan/mountainous catchment system: numerical modelling and comparison with the Lannemezan megafan system (Northern Pyrenees, France)" *by* Margaux Mouchené et al.

H. Sinclair (Referee)

hugh.sinclair@ed.ac.uk

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General comments: The Lannemezan Fan is a very interesting system to analyse, as it comprises a large radiating fan of incised channels, and forms the dominant morphological feature of the Aquitaine basin. This well presented study focuses on a numerical model using the code CIDRE in order to improve understanding of the controls on formation and subsequent incision of the fan. The model generates some interesting output which appears to approximately simulate the topography of the catchment and

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Discussion paper

a fan system that is broadly comparable to the Lannemezan system. I think there is an interesting story here in relation to controls on local base levels in continental foreland basins and the impact on growth, stability and incision of large alluvial fans; in this case, the analysis suggests autogenic control through capture of drainage networks has played a role in determining the form of the fan. As outlined in the specific comments below, there is a lot of scope for expanding the documentation of the Lannemezan fan. For example, it would be good to understand more on the timing of growth of the fan in relation to deformation of the north Pyrenean thrust wedge, and in terms of the sedimentological evolution of the system, and the evidence for tilting of its stratigraphy rather than its relatively modern terrace system. In these aspects, it is hard to judge whether the parameter combinations and boundary conditions used in the model are wholly suitable for the Lannemezan system. My recommendation is that the manuscript should be refocused primarily on the model as a series of generic experiments without aiming them at simulating one system. But that the aspects of the modelled fans be presented as examples of the autogenic controls likely to control a number of natural systems including the Lannemezan Fan. The developments of local base-levels generated by neighbouring river systems, and the implications for capture and incision of fan systems is very interesting and represents an important insight into the generic processes of alluvial fan growth in foreland basins.

P2 – L20-25 – The final paragraph of the Introduction is aimed at informing the reader of the aims and motivations for the study. The section starts by suggesting that the study will test hypotheses, but then doesn't define a hypothesis, and goes on to describe how the study will explore autogenic versus allogenic controls. This felt a bit vague, and so needs tightening up. I also think the title could reflect a more focused approach.

P3 – L3 – What is a well sorted 'sequence' in this context – are you referring to grainsize distributions in the sand, or a clear distinction of sand and mudstone beds?

P3 – If the Lannemezan Fan is the system to which the subsequent modelling is to be compared, then we need to know a bit more about the geological context of the fan, particularly its upstream catchment, as the title suggests this is an important component of the story. It needs to be stated that the growth of the fan is all post-orogenic (I assume?), and that there is no reason to expect that the feeder catchment has changed in size over the period of growth and erosion of the fan. It would also be important to describe the glacial impact on the catchment as this will have affected the sediment and water flux. Some of the brevity in this section points to the manuscript by Mouchené et al that has been submitted. Even if that paper is published by the time this comes out, I think there is a need to summarise in more detail some of the conclusions of that study, and give more background.

Bottom P3 – On initial reading, I was unclear how L is defined – it is stated that this is the transport length, but its not clear what transport this is referring to; L is often used as transport length in diffusion models referring to catchment length (e.. Allen et al., 2013). Now having read on, I realise we are talking about a sediment transport length per unit time – this needs clarification.The parameters for the model need summarising on a figure.

P6 – L5 – The model set-up involves a fault displacement of 0.3mm/yr at the mountain front allowing for the erosion of the range while depositing in the basin. It is suggested that this is reasonable for the Lannemezan Fan – in what way? When did the uplift of the northern Pyrenean thrust wedge relative to the Aquitaine Basin cease? The model reflects syn-orogenic rather than post-orogenic boundary conditions. Given many would argue that the Pyrenees ceased active crustal thickening at around 20 Ma, doesn't the fan represent a dominantly post-orogenic setting with some normal faulting in its recent past?

P4 and 6 – The final set-up is based around modifying key parameters in order to simulate a system that broadly looks like the Lannemezan Fan. I note the other reviewer asks about how this comparison is made, and this is an interesting point. With so many parameters it is impossible for the reader to assess the role of each one and the sensitivity of the system to changes in each of them. Consequently, as is often the case, we put a degree of faith in the model output based on a recognition that the values used for each component seem reasonable within the bounds of experiment and empirical evidence. Based on this, I raise the question of the exponents (n and m) on q and S in the fluvial erosion model which are given as 0.6 and 0.7 (Table 1); doesn't this end up with unrealistic looking river profiles? (cf. point raised by other reviewer about comparisons). Similarly, I am curious to understand how the grainsize distributions are captured in the parameter L, and how sensitive the system might be to reasonable changes in grainsize as might be influenced by the onset of glacial erosion for example.

P8 – L25-30. The tilt experiments are interesting, but the tilt values used in the experiments are very likely to represent a minimum relative to the real values. The surface they choose to evaluate whether the fan is tilted is the relatively recent surface that caps the system (I think the author dates it in her thesis at around 300 Ka). However, if the Pyrenees has been in a post-orogenic state for ca. 20 Myr, then it is reasonable to expect that the fan has been tilted much more than this in response to post-orogenic erosion. Which then raises the question of how much of the current morphology of the fan is a record of post-orogenic erosion with channels that are unrelated to the Miocene depositional system. I believe the authors have evidence to indicate that this is not the case, and so I suggest this should be discussed/demonstrated in this manuscript.

P11 –L5 – "This required longer L, which may be interpreted as a smaller settling rate (Davy and Lague, 2009), is consistent with the downstream fining of sediment in the Lannemezan megafan." Has downstream fining been demonstrated for the Lannemezan fan? This sedimentological evidence for both a radiating depositional system and documented fining rates needs to be summarised in a figure.

P11 – L20- The critical boundary condition effect here seems to be the open boundary at the sides of the basin. Firstly, there appears to be a rather unusual transverse (ie. E-W) set of channels that are regularly spaced, perpendicular to the main fan, and these seem to link to the open boundaries at the margins. What do these represent? Secondly, the lateral open boundary will always result in incision once a lateral channel taps into the main discharge, as it represents the shortest route, and hence steepest channel, to the zero elevation boundary. It suggests that there are no along-strike fans that maintain an elevation comparable to the modelled fan. So this modelled incision due to capture by the shortest route channel is not representative of the processes of base level change along the strike of a foreland basin, unless you're next to the coast.

P12 – The point raised above seems relevant to this discussion about the controls on incision into fans and the comparison to Pepin et al's study. The open boundary which seems to be maintained at zero elevation at the margin will result in steeper channels with higher bed shear stress than those that drain out at the northern margin of the system – therefore, the former will capture the drainage of the latter, and incise into the depositional base-level built by the longer channels. This seems an inevitable consequence of these boundary conditions. The subsequent comparison to the modern channel system, and the evolutionary model proposed in figure 12 requires that the Ariege and Upper Garonne systems are at lower elevations than the Neste, causing a steepening of the lateral channels that link the two, and incision into the previous fan. Is there evidence that these were at a lower elevation? Is the outlet of these rivers lower than the Neste? I can see this as an important mechanism for drainage capture, but I don't think the default model simulations presented here are a valuable guide to the processes of capture in the Aquitaine Basin. The model boundary conditions of a zero elevation margin to the basin are not the same as the capture by a neighbouring river along the strike of a foreland basin.

P14- L20-25. Is this 'uplift' referring to differential surface uplift between the Aquitaine Basin and the Pyrenees or is it a regional uplift relative to sea-level?

P15 – L9 – "Thus, tilting does not appear to play a major role in the evolution of the Lannemezan megafan". I don't see how we can say this. The only record of tilting is from the very young terraces, whereas the fan itself is at least 20 Myr old. Is there any clear demonstration that the stratigraphy of the Lannemezan fan is not tilted?

Hugh Sinclair, Edinburgh

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