Answer to Reviewer 1 HESS-2019-152

We thank Reviewer 1 for his comments. We provide here our responses to his comments, including the plan to revise the manuscript in response to reviewer comments. The original review comments are in normal black font while our answers appear in blue font.

General comments:

This paper investigates the current modelling techniques available for flood forecasting and the associated required inputs. The evaluation was performed on a well documented significant flood in Canada in 2013, which resulted in large losses and damages in the affected area. The topography of the study area is very complex and addresses the limitation of the current flood prediction system used at ECCC. The material presented would benefit the modelling community working on refining and adjusting models to better predict floods in similar conditions and in complex terrain. In general the paper well written and relatively clear.

Specific comments:

On page 8, OPL and SND are introduced, its not clear what they mean.

"OPL" refers to the Open Loop GEM-Hydro simulation from June 2012 to June 2013 used to derive the initial land surface conditions. "SND" refers to the simulation with insertion of SNODAS SWE on 1st May 2013 near peak snow accumulation. Experiment SND provides another estimation of land surface conditions prior to the flooding event. These acronyms will be more clearly defined in the revised manuscript.

On page 9 and 10 section 3.2, could the authors give some more details for the cumulative underestimation of the stations.

The revised manuscript will include a more detailed evaluation of the different CaPA experiments, both spatially and temporally. As suggested by Reviewer 3, a table containing the performances metrics (Bias, RMSE, R2) for each CaPA experiment and each main basin (Oldman, Bow and Red Deer Rivers) will be added. The performances metrics will be also computed for the whole event and separately for the convective and stratiform periods as defined in Kochtubajda et al. (2016) and Li et al. (2017). Following the general comment of Reviewers 2 and 3, the CaPA experiment at 10 km using the default stations (*CaPA 10km Def*) that was characterised by a large underestimation of precipitation in the mountains and the foothills will be not used anymore in the paper.

Also some possible explanation why going from a 10km Capa grid to 2.5km grid provided better results.

Improvements in the precipitation analysis from 10 km to 2.5 km resulted from the improvement in the precipitation background provided by the Canadian NWP system GEM. GEM at 2.5 km resolves explicitly part of the convection with the cloud microphysical scheme P3 whereas all the convection is parameterised in GEM at 10 km. Previous studies by Li et al. (2017) and Milrad et al. (2017) showed that atmospheric models at convection-permitting resolution performed best for this event. As detailed by Milrad et al. (2017), this is mainly due to (i) an improved representation of the orographic ascent that contributed to the magnitude of the extreme rainfall (ii) an anchoring and increasing duration of the precipitation on the Eastern side of the Rockies. These explanations will be clearly given in the revised manuscript.

Why does the Red Deer basin have a decrease in cumulative precipitation.

Fig. 6 in the initial manuscript shows a decrease in cumulative precipitation for an area of the Red Deer basin for each CaPA experiment including the additional stations compared to the analysis with the default stations (*CaPA 10km Def).* This is explained by an overestimation of precipitation in this area for *CaPA 10km Def* (Fig 5. b). The additional stations in the new precipitations analysis (see their

location on Fig. 1 in the initial manuscript) corrected this overestimation leading to a decrease of precipitation in this area. We will include a better explanation in the revised manuscript.

How much does convection potentially play in these underestimates.
We thank Reviewer 1 for this comment. Indeed, the extreme rainfall event of June 2013 in Alberta consisted of 2 stages: a convective period followed by a stratiform period (Liu et al., 2016; Kochtubajda et al. 2016; Li et al., 2017). The convection was associated with an intense lightning activity and substantial rainfall accumulation, triggering high flows in the eastern slopes the Rockies. In the revised manuscript, we will evaluate separately the performance of the different CaPA experiments during the convective and the stratiform period. As mentioned earlier, table containing the performances metrics (Bias, RMSE, R2) for each CaPA experiment and each main basin (Oldman, Bow and Red Deer Rivers) will be added. The performances metrics will be computed for the whole event and as well as for the convective and stratiform periods.

On page 12, it seems that the river routing is a large unknown, in these simulations, are there ways to determine the actual routing for this event and apply it to the simulation. Is this even feasible?
As mentioned by Reviewer 1, the river routing strongly influenced the timing of the peak flow simulated by GEM-Hydro for this extreme flood. Determining the routing parameters for this specific event is challenging since major changes occurred in the geometry of the riverbeds so that parameters based on historical data may not be suitable for this extreme event. Routing parameters could be potentially determined for this event for river sections located in between two hydrometric stations. The observed discharge at the upstream station could be used as an input of the routing scheme and a calibration of the routing parameters could be carried out using the discharge of the downstream station for model evaluation. This would still require an estimation of the water input to river in between the two stations. This method would be restricted to certain portions of the river and could not be used for the headwaters of the catchments. Therefore, we will still used in the revised manuscript a correction factor applied to the default Manning coefficient to optimise overall peak magnitude and timing.

What is the frequency of reporting of the precipitation stations?
Precipitation stations used in this study were reporting at an hourly frequency. 6-h hour cumulated precipitation have then been derived from these hourly data to be used as input of the precipitation analysis. We will mention clearly the frequency of reporting of the stations in the revised manuscript.

Technical corrections:

We will include the below technical comments in the revised version of the manuscript.

Page,3 line 20. Use "Another objective" rather than "Another main objective"

Page 8, what does OPL and SND stand for.

Page 10, line 1. Remove "in", should read foothills of the Red Deer Basin.

Page 10, line 11. "in particular in", remove the second "in".

Page 10, line 20, use analyzed instead of analysed. “

Page 11, line 17. "with to that " is awkward.

Page 12, line 14. Remove space between 59 and %.

Page 12, line 30 . Remove space between number signs.

Page 12, line 33. Comma after however.

Page 25, line29. "Radar data was" “

Page 14, line 12. Theses should be These.

Page 15, line 13, similarly should be similar.

Page 15, line 26. Calibration of these parameters.

Page 15 Lines 1-10. This sentence is very long and the entire section doe snot flow well. Consider rewriting to make the flow better.

Page 17 Line15. remove "are" to read forecasting systems can be expected. Also remove SVS from the sentence.