Responses to Reviewer 2

We thank Reviewer 2 for the thoughtful comments. We have transcribed only the comments that suggest modifications to the manuscript and responded to each comment below. We believe that these modifications will significantly improve the manuscript.

Most of the analysis is well done. However, there are statements regarding the amount of water associated with the AR that is not backed up by any analysis. Are the authors confident the AR plume carried 1,500 kg/(ms) and the amount of precipitation that reached the basin was 70,000 CMS?

Yes, the reviewer is correct. We will include a more detailed description of the calculations in our "Methods" section. We repeated the analysis using another dataset, and are now confident that the plume carried on the order of 1,500 kg/(ms) at its core. Figure 1a in our manuscript uses data from ERA-Interim Reanalysis, we have double checked with MERRA Reanalysis, and found similar results (see Figure 5a).

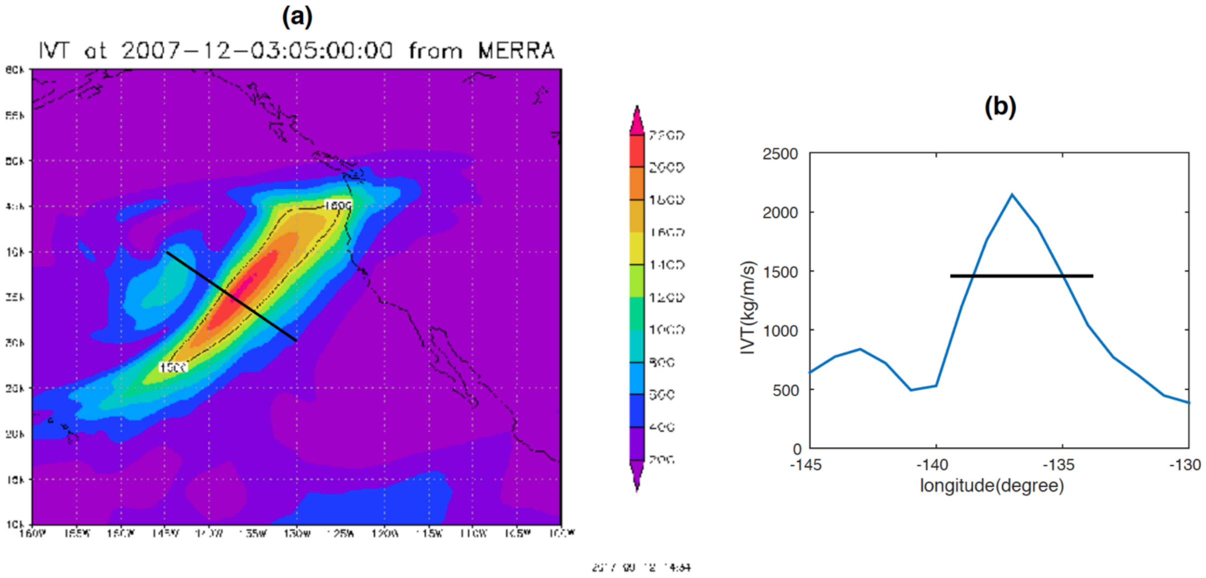

Figure 1 (left) IVT from MERRA data for the December 2007 event. (right) IVT for the cross-section shown on the left.

To calculate the water transported by this AR, we integrate IVT along the cross-section shown in Fig 5a. If we integrate along the full cross section, which has a length of ~1757 km, we get a value of 1.78e+09 kg/s (1.78e+6 CMS). If we only integrating along the core (IVT >1500 kg/m/s) with a width of ~468 km, we get a value of 8.47e+08 kg/s (8.47e+5 CMS). In the value reported in the text, we had actually only done it for the inner 400km, however, we will now report the more objective criteria for the core above 1500 kg/m/s. The value is now 84,700 m^3/s. However, it is important to keep in mind that this is the water carried by the AR – NOT the amount of precipitation. We will make this clear in the text.

The descriptions of the models are well done. Error analysis of WRF precipitation is well explained, however hydrologic models calibration and verification may not be sufficiently presented.

We will improve our description of the hydrologic models' calibration and verification, and update the manuscript as follows (the text in bold is new):

PG. 4 Line 28: In HEC-HMS, we partitioned the watershed into 64 sub-basins with homogenous soil and land cover properties based on data from SSURGO (USDA-NRCS) and NLCD 2011 (Homer et al., 2015). HEC-HMS provides the streamflow response of each of the sub-basins that drain to the Chehalis main channel. We calculated baseflow in three different ways: if there was a stream gauge, we used the USGS stream statistics; if the stream gauge was located downstream of a tributary, we calculated the initial base flow for the channel receiving from each sub-basin based on the fraction of the gauged area contributed by each sub-basin in the tributary; if there were no stream gauges available, we estimated the initial base flow through analogy with similar size sub-basins nearby. We used the Green and Ampt option in HEC-HMS to simulate infiltration in each sub-basin. **Given the limited observations, we estimated the Green and Ampt parameters (saturated hydraulic conductivity, effective porosity and wetting front suction head) based on the values reported in the literature for each hydraulic soil group.** For each sub-basin, we used the area-weighted properties. For purposes of calculating soil infiltration rates, we estimated percent impervious area using the land use and land cover maps obtained from SSURGO. The runoff transform uses the Soil Conservation Service (SCS) lag time. **The HEC-HMS simulated streamflow was compared to the observed streamflow at the USGS gauges listed in Table 1. The only parameter that was calibrated was the soil infiltration parameter which was adjusted within the range of each soil type. In addition, the final model setup with 64 sub-basins of homogeneous soil and land cover types was found to be the optimum representation of the basin, that resulted in streamflow closest to observations. If the basin is represented with fewer sub-basins, the HEC-HMS simulated streamflow does not capture the timing or magnitude of the peak in the observed hydrographs**.

For the DHSVM model:

Pg. 5 Line 16: **To calibrate DHSVM for the 2007 storm (12/01/2007~12/07/2017), we initially implemented a simple sensitivity analysis. DHSVM uses 18 different soil types, which the model links internally to soil hydraulic properties (e.g., saturated hydraulic conductivity, porosity, etc). We then determined sensitivity to the three dominant initial soil types (as suggested by Cuo et al. 2011), as well as other selected model parameters. We found that the soil maximum infiltration rate, and Manning's roughness coefficient (for channel flow) were the most sensitive parameters. We then developed a Monte Carlo simulation approach that randomly picked these parameters (between prescribed upper bound and lower bounds defined by Cuo et al. 2011). We compared simulated flows with USGS gauge station observed**

streamflow (using RMSE) and identified the optimal parameter combinations within each sub-basin.

The HAZUS economic model is unclear with regard to the assumptions and uncertainties. The description of its setup, calibration and verification need to be further explained.

It is important to emphasize that the HAZUS model is not "calibrated" to the event in the sense that we can use an actual value of economic losses as a counterfactual to compare to the model results. The only data we can use to evaluate the model performance is the Department of Commerce estimated losses for the states of Washington and Oregon combined for this flooding event, which were approximately $1 billion dollars. In addition, the official building and inventory damages in Lewis county were estimated at $166 million. These are very close to our economic model results. In the revised manuscript we will clearly state that the economic model is not calibrated and verified in the way that the physical models are.

We will improve our description of the HAZUS economic model assumptions and model setup. We will update the manuscript as follows (the text in bold is new):

Pg 4, Line 11: In terms of economic losses, we rely on HAZUS-MH 3.0 software with its standard infrastructure data and dasymetric dataset for buildings. **Using HAZUS-MH 3.0, we calculate the direct economic losses. However, to calculate their ripple effects throughout the economy – also called indirect losses – we rely on the Inventory-Dynamic Inoperability Input-Output Model (Inv-DIIM) proposed by Barker and Santos (2010) and on the 2008 input-output tables from IMPLAN (2015). The sector-specific inoperability levels and sector-specific recovery rates are calculated using the inventories of finished goods. Input-output data contain i**nformation about the trade flows across 16 different sectors that represent the economic structure of each of the counties within the state of Washington.

Pg. 6, Line 1: We calculated the direct economic losses using HAZUS (HAZard USa), a software developed by the Federal Emergency Management Agency (FEMA, 2015) to calculate economic losses associated to different natural disasters, including floods (see, among others, Ding et al. (2008), Banks et al. (2014), Gutenson et al. (2015)). We used HAZUS-MH version 3.0 and its default dasymetric datasets to calculate how the HEC-RAS-simulated flooding led to direct economic losses to agriculture (crops), to buildings and public infrastructure such as utilities and roads. The dasymetric data embedded in HAZUS, which includes information about the location and characteristics of the buildings (e.g. construction type, number of stories), allocates the use of land and of buildings by economic sectors so that one can estimate how the direct economic losses result in direct production capacity constraints and losses by sector. **Our HAZUS implementation contains several assumptions: as usual in the literature, production capacity constraints are based on the assumption of a homogeneous productivity per square**

foot for each industry in a specific county and on the assumption that industries operated at full capacity before the disaster. As a result, we set the production capacity constraints based on the pre-disaster total output by industry. When it comes to output in the agricultural sector, our assumption is to reduce it proportionally to the share of crop and livestock output in each county. We do not consider livestock losses independently as they are not reported by HAZUS.

Because each company or institution relies on a set of suppliers and purchasers to support its activities, they too will experience production losses as a result of the flood, even though they have not been flooded themselves. These indirect economic losses are estimated from the 2008 Input-Output tables extracted from IMPLAN at a 16-sector aggregation level (Avelino and Dall'erba, 2016). In addition to production losses, the combination of HAZUS and of input-output techniques allow us to quantify how local final demand decreases as a result of the employees suffering from labor income losses due to temporary closure of their workplace. **We assume that the expenditure structure remains fixed in the post-disaster period and that demand decreases proportionally to the decrease in income.** Reconstruction costs, on the other hand, correspond to a positive stimulus corresponding to the total repair costs of buildings, infrastructure, building content and vehicles that were destroyed or damaged during the flood. **While the first two elements lead to a construction stimuli, the last two support demand in manufacturing. Since IO models are based on producer prices and HAZUS provides repair costs in purchase prices, we assume that manufacturing orders include margins split 20/80% between transportation and trade.** Due to the small size of the economy of the affected counties, the model assumes that reconstruction efforts are supplied by companies located outside of the flooded area. The duration of the recovery phase is given by HAZUS (**Tables 14.1, 14.5 and 14.12 of FEMA, 2015**) and is assumed to be linear in time. The total economic impact in the three affected counties and the rest of Washington is then estimated using the Inventory-Dynamic Inoperability Input-Output Model (Inv-DIIM) of Barker and Santos (2010). It accounts for month-to-month cascading effects on production chains due to supply restrictions and existing inventories that mitigate some of these losses. In relation to other available input-output models, the Inv-DIIM offers a dynamic view of the inoperability and recovery processes, in addition to accounting for available inventories that can alleviate disruptions in the region (Avelino and Dall'erba, 2016). **The inventory data for the DIIM are based on the December 2007 inventory-to-sales ratio for manufacturing reported by the Federal Reserve Bank of St. Louis (2016). This approach has been suggested by Barker and Santos (2010). This ratio is 1.23 for the period under study and we choose to apply it homogeneously to all counties. Since the activities of wholesale and retail are recorded as margins, these sectors do not hold finished goods inventories. While they could hold "materials and supplies" and "work-in-progress" inventories, their data are not available.**

References:

Federal Reserve Bank of St. Louis. Manufacturers: Inventories to Sales Ratio [Internet]. 2016. Available from: https://research.stlouisfed.org/fred2

Barker K, Santos JR. Measuring the efficacy of inventory with a dynamic input-output model. Int J Prod Econ. Elsevier; 2010;126(1):130–43.

The title is general with regard to the impacts of ARs and would be more clear if this was presented as a case study based on the December 2007 and RCP85 and RCP45 scenarios on Chehalis River Basin

We understand the reviewer's concern, but would prefer to keep the title more general. Our reasoning is that we are presenting a tool that could be used in other places and for other events. While we focus on this one event to demonstrate how the tool works, we want to keep the focus of the paper on the tool itself. Following the suggestion of Reviewer 1, we will change the introduction and make it more general (without so much detail about the Dec 2007 event itself). This way, it will be clear that the paper is more related to the method than the case study.