Comment on nhess-2021-337

Anonymous Referee #1

Referee comment on "A performance-based approach to quantify atmospheric river flood risk" by Corinne Bowers et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2021-337-RC1, 2021

General Comments

The authors provide a process-based probabilistic framework for predicting damages associated with ARs based on AR intensity and duration and antecedent hydrologic conditions. This is a useful tool. There are a number of technical innovations throughout the study. The 2019 Russian River case study contains several creative data sourcing and manipulation steps to overcome inherent data availability issues. The overall method has broader applications than AR damage prediction. It could be applied to any damaging hydrometeorogic events, including hurricanes and tropical storms. The AAL and loss exceedance curve calculations are compelling. A number of valuable insights are presented in the discussion section.

My only comment of substance is that the current ordering of sections makes the model difficult to follow as variables are introduced before being defined and the multivariate Monte Carlo integration framework is explained after presenting the series of integrals.

I'd put section 2 paragraph 1 first, then 3.2 paragraph 1, then 2.1 description of pinch point variables, then 2 framework description with the equations, then 3.2 paragraph 2 explanation of Monte Carlo integration. Or something along those lines. The current ordering was difficult for me to follow although it did all make sense at the end.

The rest of the comments are minor technical corrections / suggestions or requests for clarification. Overall this is a great contribution to the literature. I recommend accepting the manuscript after minor revisions.

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Specific Comments / Technical Corrections

1 Introduction

26 California experiences ARs coming from a pathway called the Pineapple Express ->
California often experiences ARs coming from a pathway called the Pineapple Express [not
all ARs in CA are considered Pineapple Express storms]

31 $300 million -> $660 million

Data appendix S1 Top Counties lists damages for CA counties over 40 years at 26.53
billion of which AR damages were 24.86 billion in 2019 dollars. This translates into annual
AR damages of 24.86/40 = 621.5 million. In 2021 dollars this is approximately $660 in
2021 dollars (e.g., https://www.minneapolisfed.org/about-us/monetary-policy/inflation-
calculator)

1.1 Disciplinary Context

In addition to FEMA's Hazus, USACE's HEC-FIA and HEC-FDA are potential methods that
can be used to convert HEC-RAS outputs to economic impacts.

2 Framework Description

109 total probability theorem -> law of total probability

116 decision variable DV appears here for the first time but is described later at 165.
Either move the section on pinch point variables above the introduction of DV, etc., or
note that the variables are defined in detail below.

Eq 2 consider \cdot or \times in place of asterisks.

Eq 2 consider six integrals evenly spaced rather than two sets of three integrals.

Eq 2 it would perhaps make sense to include the supports over which the pinch point variables are being integrated. But perhaps it would be a distraction.

Eq 2 ideally, the variables should be defined as they are introduced. Perhaps it is sufficient to note that the variables are defined below in Sect. 2.1.

Eq 2 An explanation of why f(Q | PRCP, HC) has two conditional variables while all other elements in the chain have only one may be useful for the reader, at some point in the text.

Maybe something like: at each point in the causal chain one pinch point variable depends on the next. Flow, Q, depends on two variables precipitation, PRCP, and antecedent hydrologic conditions, HC. Could perhaps write out the whole chain in English in the paragraph below the equation. This would be easier to follow than waiting to read the text in the next section. Or else note that all variables are defined in the following section.

Eq 2 Each pinch point variable is a scalar here?

Eq 2 I'm unclear on how \lambda(AR) works and on how \lambda(DV > x) and P(DV > x | DM) work... An additional line providing some context could be helpful.

2.1 Pinch Point Variables

(The following comments were written as I was reading through the manuscript. They could be avoided if you are clear upfront about how the integration is Monte Carlo integration and how the pinch point variables can be vectors.)

I'm a little unclear on how the causal chain works with scalar variables given that the process is spatially heterogeneous. Should I think of the PARRA process running in parallel over all locations? But what about spatial correlations?

AR is a measure of intensity, so it could be something like peak IVT or cumulative vapor transport over some time period, the duration of the AR, say. But IVT is a vector field. So you'd need to aggregate or average over time and space to get a scalar metric of intensity.

PRCP as a scalar field has the same issue. You'd need to integrate over time and space to get a scalar value. Should I think of this as some metric of precipitation over the whole watershed? Or is there a way to apply PARRA with a time series of precipitation grids as inputs?

HC, same as AR and PRCP.

Q makes more sense as a single input if you're considering a single channel, although the hydrograph is a curve which captures the duration as well as the intensity of the flow above flood stage, so I'm unclear on how this enters into the formulation.

INUN at a given location or structure is just a scalar, but over a set of n structures is an n-dimensional vector. Here, duration of inundation may also be important, in addition to depth, in terms of generating damages.

I'm unclear on how DM and DV differ. DV is a metric of impact or consequence. DM is a damage measure. So, DV could be a more broad measure of impact that is perhaps related to DM through some probabilistic relationship that is modeled using the observational record?

Ah, the variables are discussed in more detail. AR is a vector of max IVT and duration, got it.

PRCP is storm-total accumulated rainfall over the watershed. Did you experiment at all with more complex formulations for precipitation? Don't tools like HEC-RAS and LisFlood take precipitation fields as inputs?

HC watershed-average soil moisture equivalent height. There's probably some additional uncertainty introduced by averaging over the whole watershed. Upstream soil moisture may be more relevant than downstream soil moisture, for example, although these are probably highly correlated.

Q is time series of flow at inlet. This is parameterized as a 3-vector with Q_p, t_p, and m.

INUN is surface water depth at locations of interest. So this is N-dimensional.

DM is a damage ratio, expected cost to repair over the total value. Assumed to be a function of water depth.

DV actionable measure of impacts. So, it converts damage ratios into damages? So it requires observed building values then? What's the utility in splitting DM and DV? I think I can see it, but an explanation could be useful.

2.2 Component Models

This could perhaps go above the equations.

I'd put section 2 paragraph 1 first, then 3.2 paragraph 1, then 2.1 description of pinch point variables, then 2 framework description with the equations, then 3.2 paragraph 2 explanation of Monte Carlo integration. Or something along those lines. The current ordering was difficult for me to follow.

3 Case Study: Sonoma County

185 The spatially repetitive, locally severe flooding seen in Sonoma County is a signature characteristic of ARs. <- I'm not sure if I agree with this statement; I suggest removing it. The statement suggests that ARs tend to reoccur at the same locations and always generate locally severe flooding. Some ARs generate multi-basin flooding, like the 1862 event. Some locations affected by ARs flood (relatively) infrequently.

3.2.1 Precipitation Component Model

238 mixture model 90% with WLS standard errors, 10% with distribution fit to largest 10% of events. I'm familiar with WLS but not with this approach. More detail on this method, or a reference, would be helpful.

3.2.2 Precipitation 2019 Case Study

271 We note that Sonoma County is not guaranteed to see any impacts -> We note that, according to the simulated distribution, Sonoma County... (or, according to the distribution simulated from the observational record, etc.)

3.3.2 Hydrologic Conditions 2019 Case Study

289 it is interesting that soil moisture is an "input" here and not simulated, just as AR IVT and duration are "inputs." This is explicitly captured in the flow chart and in the Eq 2 multiple integral. It might be worth emphasizing this in the description of the flow chart, for example.

291 why is observed precipitation used as an input here? Shouldn't the full precipitation distribution, derived from the input AR intensity and duration, enter here? What am I missing?

3.4.1 Flow Component Model

310 - what data were you using here? The observational precipitation record? Fed into the runoff calculation? So, you have how many observations to fit the mixture OLS model?

3.4.2 Flow 2019 Case Study

Fig 5 b - any speculation on the early streamflow peak in the 2019 event? It doesn't seem to be captured within the 90% PI. A horizontal line indicating flood stage could also be informative in this figure.

3.5.1 Inundation Component Model

344 100 year peak flow -> 100-year peak flow, etc. (make this change throughout the manuscript)

367 how many buildings were there in your domain? What year were the building footprints taken from?

3.5.2 Inundation 2019 Case Study

Figure 7 in the Data Type legend it appears that Observed is dashed and Simulated in solid. Making this more clear would be helpful.

3.6.2 Damage Measure 2019 Case Study

RESA tagging is a fascinating approach.

3.7.1 Decision Variable Component Model

Interesting approach to estimating property values from tax assessments adjusted using ACS correction factors.

3.7.2 Decision Variable 2019 Case Study

451 missing comma after i.e.

Figure 9 b - it would be useful to have a high-resolution version of this figure in the appendix, or in a data appendix.

4 Results

eq 6 - consider \cdot or \times in place of asterisk, or no multiplication symbol at all. Same comment throughout equations.

4.1 AAL

487 You could note that $156m is likely to be an overestimate given that the county-wide penetration rates are lower than the penetration rates for properties at risk.

487 What is the uncertainty around the $163m estimate?

5 Discussion

There are many valuable insights in the discussion section.