



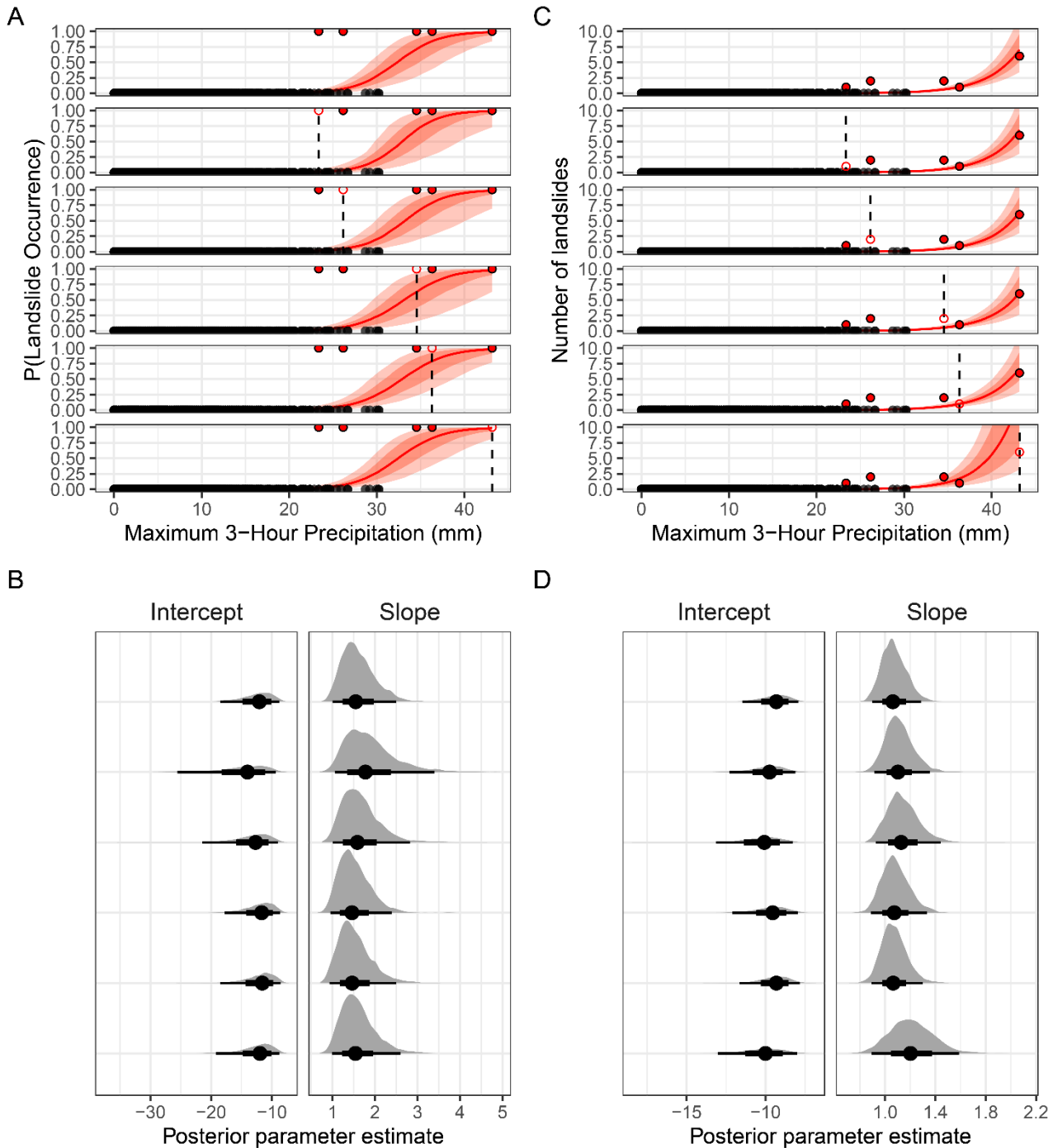
Supplement of

Landslide initiation thresholds in data-sparse regions: application to landslide early warning criteria in Sitka, Alaska, USA

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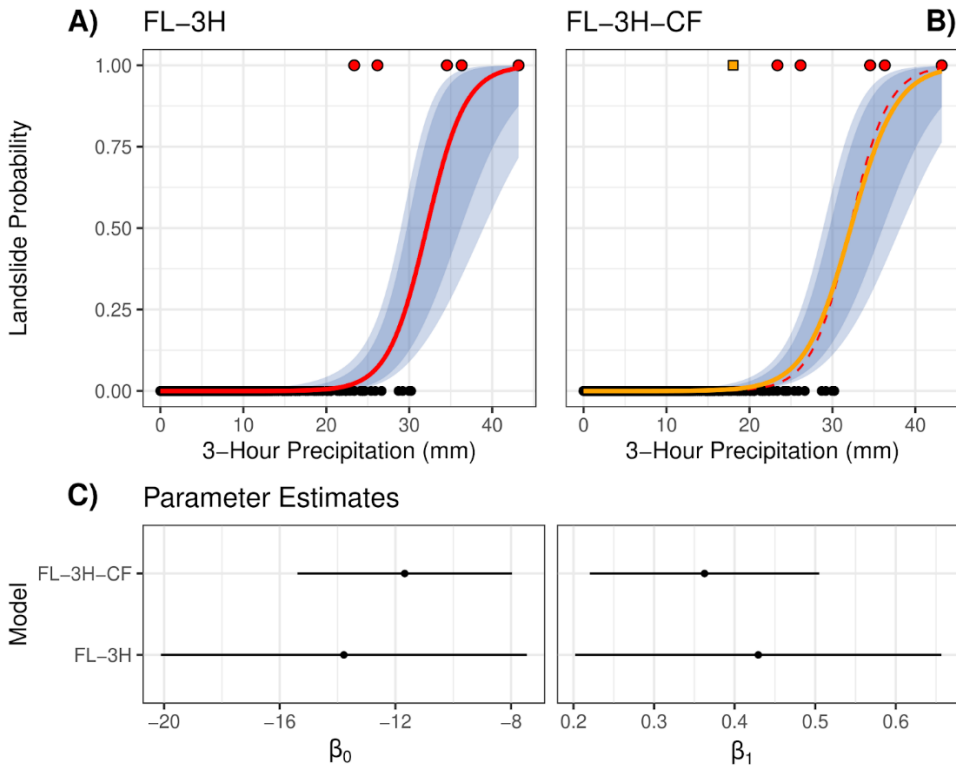
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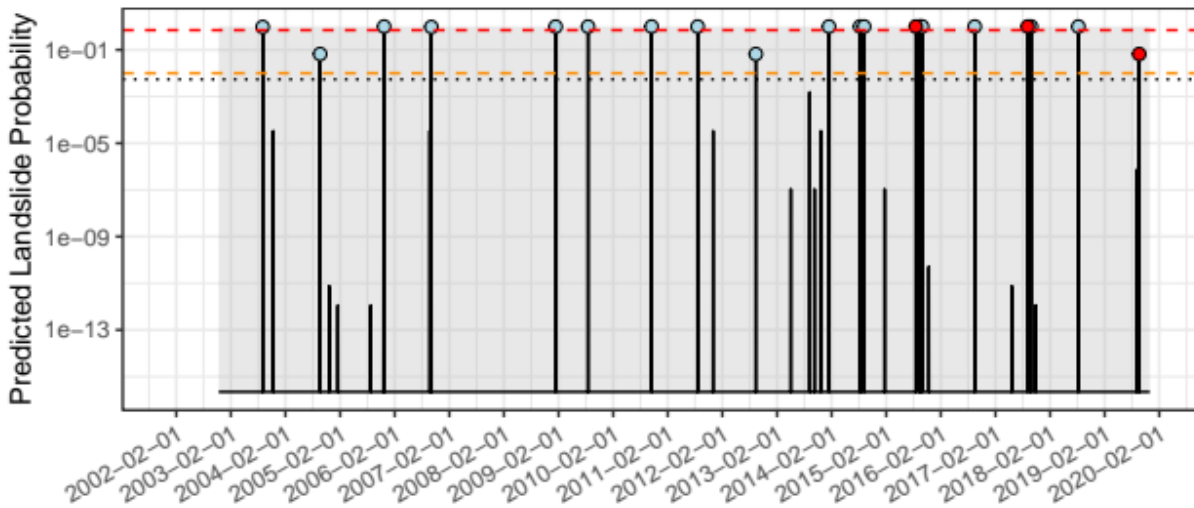
15 Fig. S1: Leave-one-out cross validation of the preferred (A) Bayesian 3-hour model (BL-3H) and (C) Poisson 3-hour model (BP-3H). Solid red points are landslide events, black points are non-landslide events, red lines show median posterior model estimates, and the dark and light blue shaded regions show the 66% and 95% credibility intervals, respectively. Hollow red circles and dashed black line show the landslide event that was omitted from each run. The 95% High Density Interval (HDI) in panel C indicates the expected average number of landslides at each precipitation value. (B) Logistic regression posterior parameter estimates with one removed landslide event (second to sixth rows) are not credibly distinguishable from the model trained on all points (top row). (D) Poisson regression posterior parameter estimates are most sensitive to the event with six landslides, but are also not credibly distinguishable from the model trained on all points. The gray shaded area in panels B and D show the posterior parameter distributions; the point is the median parameter estimate and the thicker and thinner lines show the 66% and 95% credibility intervals, respectively. Note that the posterior parameter estimates in panels B and D refer to standardized data and are thus not directly comparable to the frequentist parameter estimates in Figure 10.

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30 **Figure S2.** “Missed” landslide counterfactual scenario. (A) Results of FL-3H, including the five reported landslide events in Sitka (red points). (B) Counterfactual scenario with an additional landslide event (orange square) at 18 mm in three hours (FL-3H-CF). The orange line shows the results of FL-3H-CF, the red dashed line FL-3H. The confidence intervals refer to FL-3H-CF. (C) Comparison of parameter estimates for FL-3H-CF and FL-3H. Error bars show 95% confidence intervals based on standard errors.



35 **Fig. S3.** Analog to Figure 12b in the main text, with the training and testing sets reversed. This figure shows testing results for the period 2002 – November 2019, similar to model FL-TT-3H but trained on only one year of data: December 2019 – November 2020. Light blue points indicate false alarms; red points indicate true alarms. No missed alarms would have occurred, and the remaining days are true no alarms. Dashed lines show the upper threshold where estimated landslide probability = 0.70 (red); the lower threshold where landslide probability = 0.01 (orange); and the historical daily landslide probability = 0.0007 (black dotted line).

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Table S1: Additional information about landslide timing

Event Name	Date	Timing Information
S. Kramer	Aug. 18, 2015, 9:30 am (precise)	The South Kramer landslide event on 8/18/2015 was assigned “precise” timing based on eyewitness accounts that stated the fatal landslide occurred at 9:30 am. We assume that other landslides during this storm occurred near that same time.
Halibut Point Recreation Area	Sept. 4, 2017, Mid-day (approximate)	The Halibut Pt landslide on 9/4/17 was assigned “approximate” timing at 12:00 pm based on a news report of a landslide that occurred “around noon” (https://www.kcaw.org/2017/09/04/landslide-closes-halibut-point-road-sitka)
Medvejie	Sept. 20, 2019, 12:50 pm (precise)	The Medvejie slide on 9/20/19 was based on a news report of a power outage caused by the slide at “shortly before 1 pm.” We therefore assigned the time to 12:50 pm. (https://www.kcaw.org/2019/09/20/slide-cuts-off-green-lake-road-hatchery-access/). The timing of the S. Kramer Landslide was assigned based on an eyewitness account which stated the time as 9:30 am.
Harbor Mountain	Oct. 26, 2020 Early morning (approximate)	The Harbor Mountain landslide event on 10/26/2020 was labeled “approximate” because eyewitness accounts could only constrain the event to the night of occurrence. We assigned the time of “early morning” based on peak rainfall totals. Two landslides occurred this night. The timestamp plotted on Figure 2 is estimated as occurring shortly after the timing of peak rainfall.
Sand Dollar Drive	Nov. 1, 2020 6:00 pm (precise) <i>and</i> the night of Nov. 1 – Nov. 2 (approximate)	The Sand Dollar Drive landslide event included at least two periods of landsliding. Eyewitness accounts constrained timing to one “precise” event at 6:00 pm and one “approximate” event between 9:30 pm and 5:00 am (https://www.kcaw.org/2020/11/02/back-to-back-landslides-block-sitkas-sand-dollar-drive/).

45 **Table S2: Confusion matrix for 2002-November 2019 predictions, based on model FL-TT-3H trained on December 2019-November 2020 and with thresholds at probabilities of 0.01 and 0.7, showing the number of times each warning level would have been reached and the actual outcome.**

	Low	Moderate	High
Landslide	0	1	2
No landslide	6206	2	16