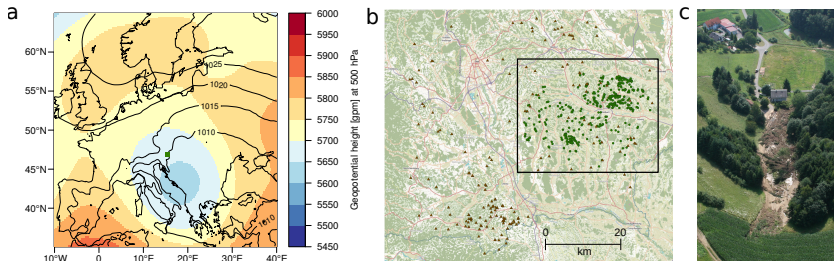




A severe landslide event in the Alpine foreland under possible future climate and land-use changes

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Feldbach region, Styria, June 2009



- ▶ Persistent cut-off low over the Adriatic;
- ▶ widespread heavy rain 22-25 June 2009 in Feldbach region;
- ▶ Some 3000 landslides triggered.

Research Questions



- ▶ What would be the hazard of a 2009 event in a warmer climate?
- ▶ What is the relative contribution of changes in rainfall and soil moisture to changes in the landslide hazard?
- ▶ What is the role of climate mitigation?
- ▶ How could land-use management reduce the hazard?

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Generalised additive model

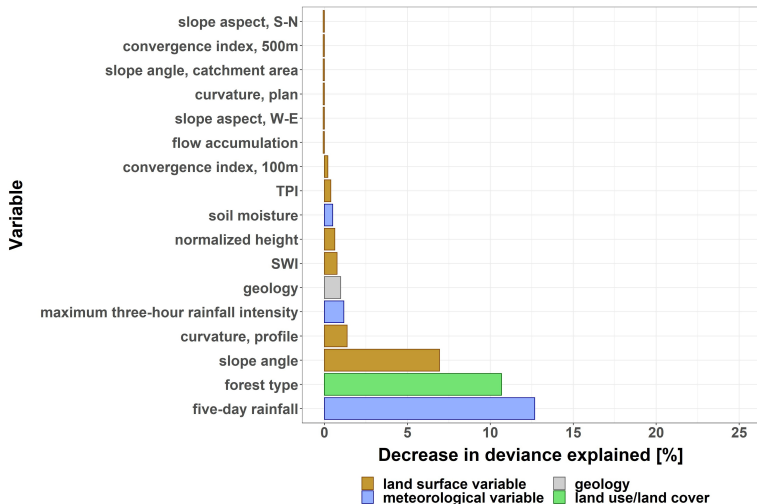
Fit a statistical model that predicts the landslide occurrence probability Y in a 10m x 10m cell based on m predictors x_m describing land surface, geological, land use/land cover and meteorology:

$$g(E(Y)) = \beta_0 + f_1(x_1) + \dots + f_m(x_m),$$

Use data from 2009 and a similar event in 2014 to calibrate the model.

Statistical Landslide Model

Relevance of different predictors



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Event Storyline Approach

Idea

- ▶ Keep large-scale circulation fixed
- ▶ Simulate event under counterfactual past and hypothetical future thermodynamic conditions taken from similar events in different GCMs
- ▶ Include 9 month spin-up to generate a balanced soil moisture field

Circulation fixed

- ▶ Double nest: IFS → CLM 25km → CLM 3km

Thermodynamic changes (historical/RCP8.5 from GCM)

- ▶ Adjust 3D temperature and relative humidity fields and sea level pressure.

Meteorological Storylines

(a) maximum 5-day rainfall, (b) maximum 3-hour intensity, (c) soil moisture prior to event

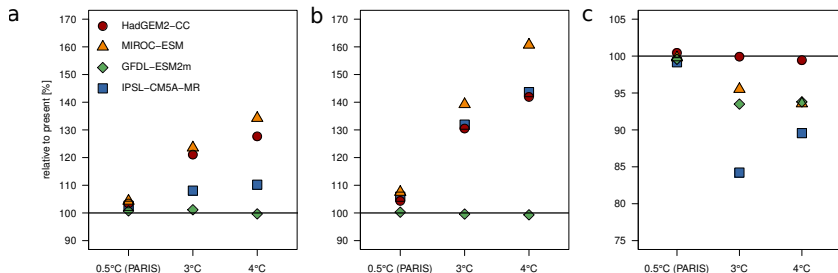
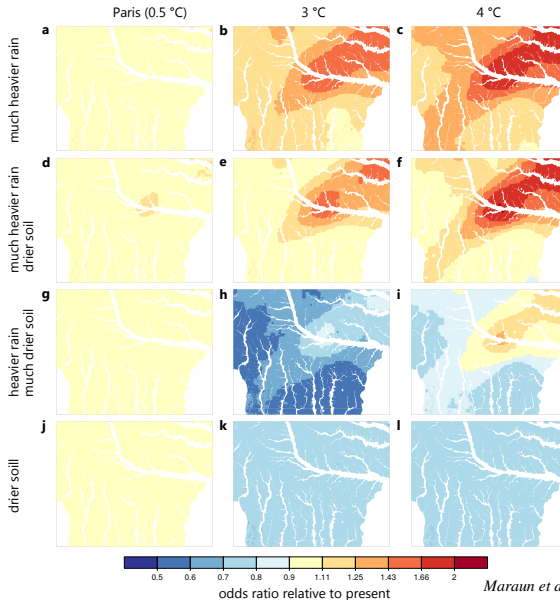


Table 1 Hydrometeorological storylines. Soil moisture values refer to the day prior to the 5-day aggregation period.

Model	5-day rain	3-h rain	Soil moisture	Description
HadGEM2-CC	++	++	o	much heavier rain
MIROC-ESM	++	++	-	much heavier rain, drier soil
IPSL-CM5A-MR	+	++	- -	heavier rain, much drier soil
GFDL-ESM2m	o	o	-	drier soil

++ strong increase, + increase, o no change, - decrease, - - strong decrease.

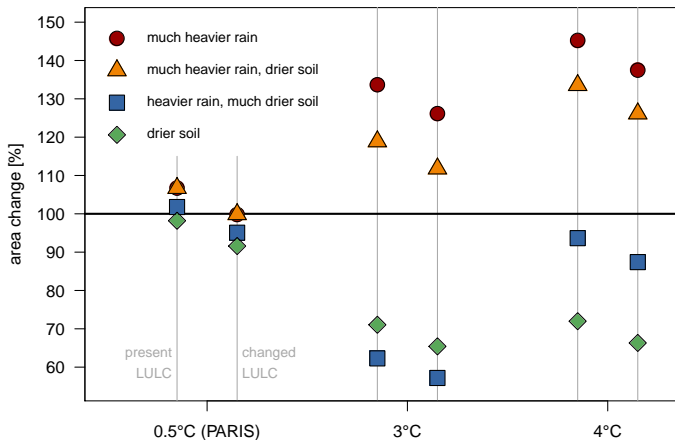
Landslide Storylines (Odds Ratios)



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Landslide Storylines

Change in area affected by high occurrence probability



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- ▶ Depending on the changes of rainfall and soil moisture, the area affected during a 2009-type event could grow by 45% at 4 K global warming.
- ▶ Such growth could be reduced to less than 10% by limiting global warming according to the Paris agreement.
- ▶ Anticipated land-use changes towards a climate resilient forest would fully compensate for such a limited increase in hazard.

Thank you for your attention!

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