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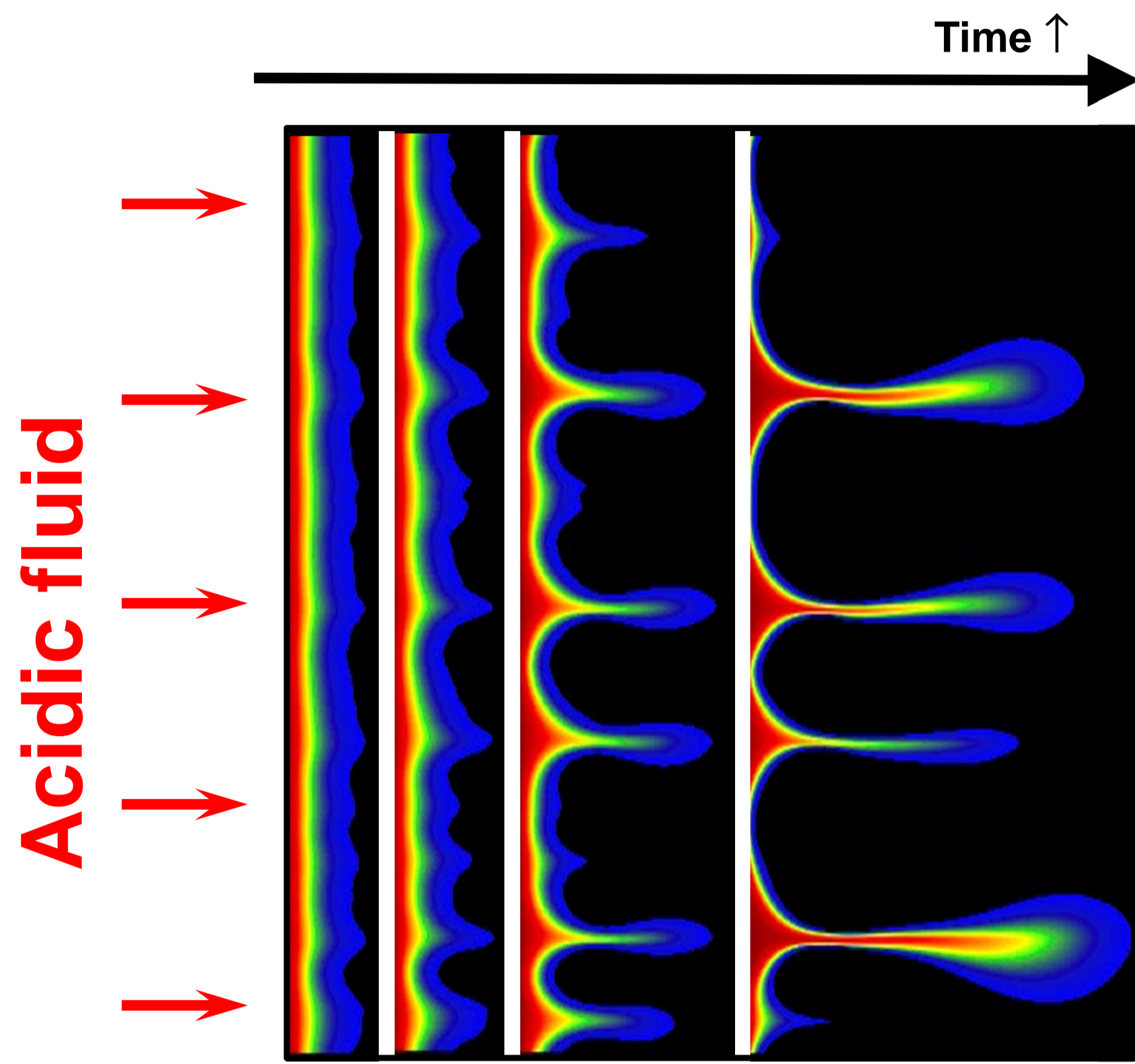


# Impact of channel-like erosion patterns on the frequency-magnitude distribution of earthquakes

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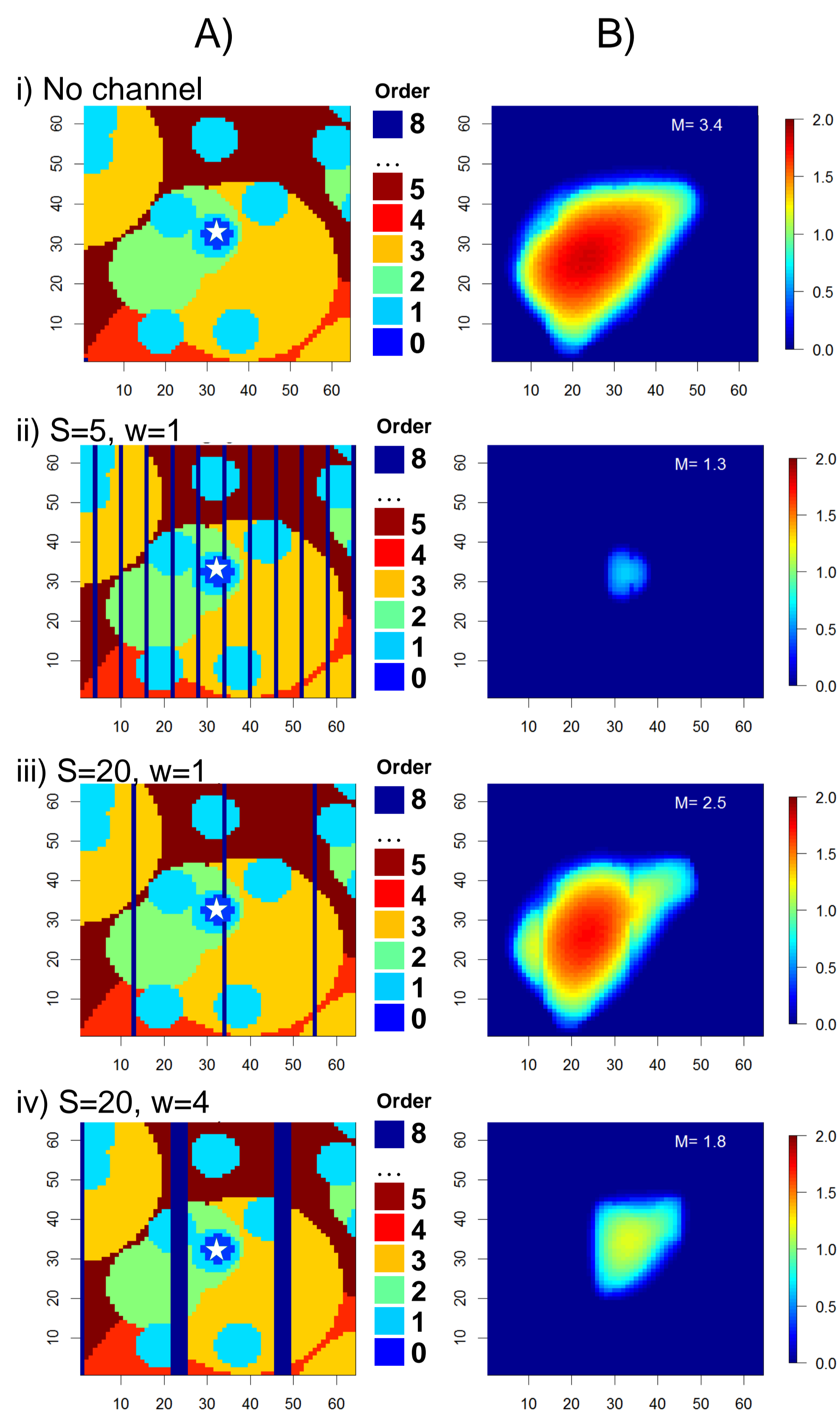
## Wormholes induced by dissolution



Extracted from <http://www.fuw.edu.pl/~piotrek/c.mpg>

Depending on the flow and reaction rates, instability of the dissolution front can lead to a wormhole-like pronounced erosion pattern [Szymczak & Ladd 09].

## Channel pattern's effect on rupture

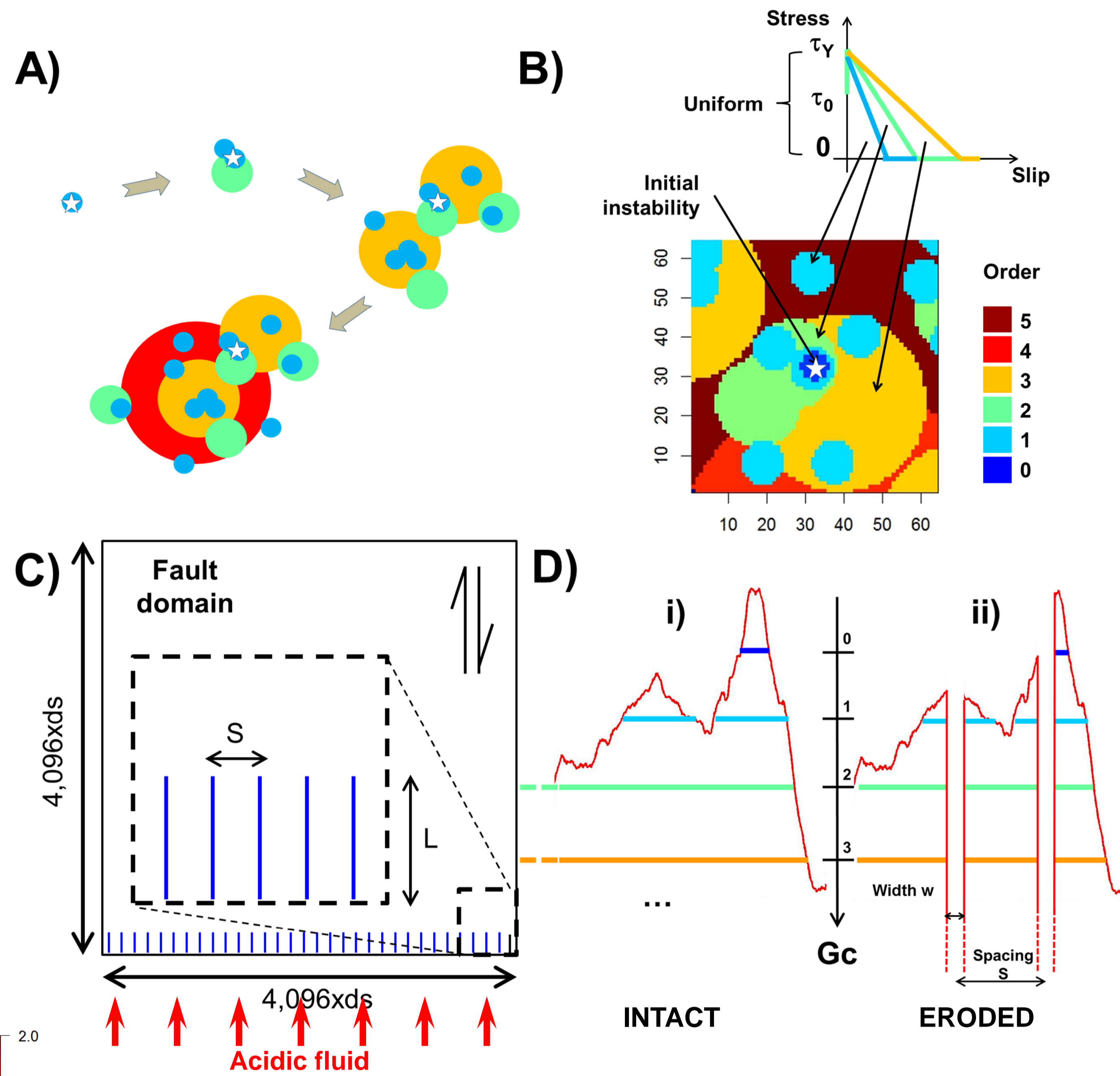


**Spatial distribution of patches (A) and corresponding slip spatial distribution (B)** given a rupture sequence initiated at the central zero-order patch (dark blue). The channels are outlined by dark blue vertical lines (order 8) considering: i) Original patch distribution; ii) Channel-like pattern with different spacings and widths. The final magnitude value of the generated earthquake is indicated in white.

## References

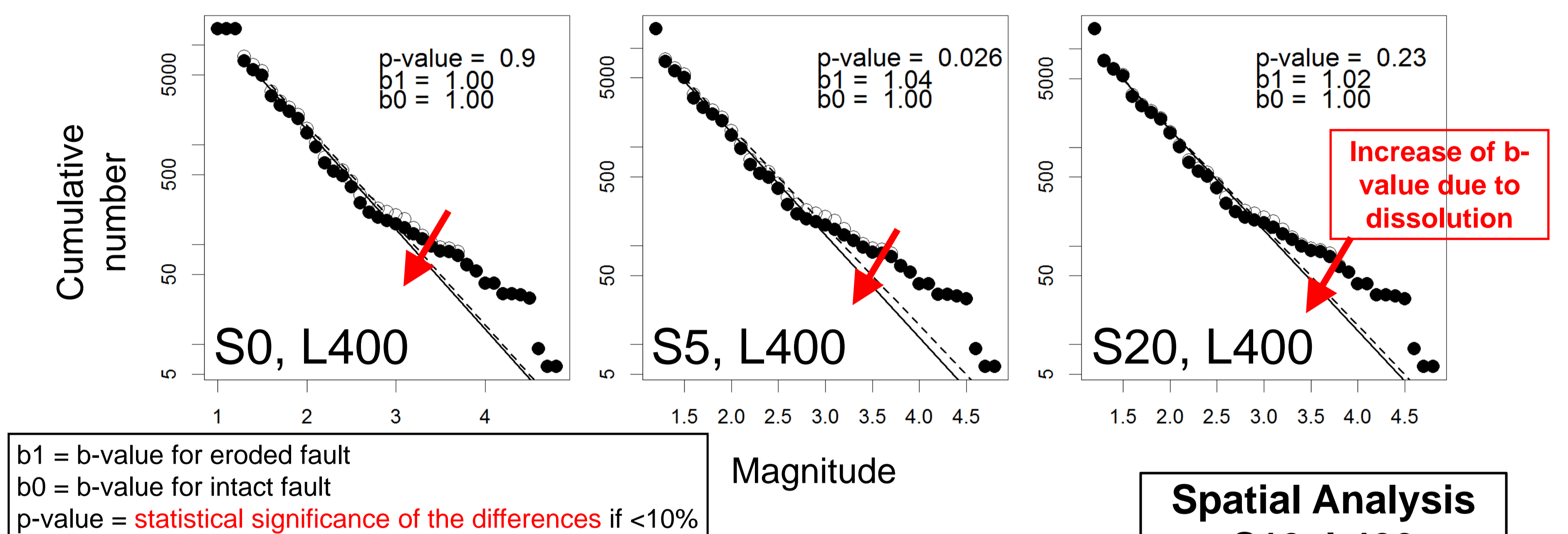
[Ide, S., Aochi, H., 2005]. Earthquakes as multiscale dynamic rupture with heterogeneous fracture surface energy, J. Geophys. Res., 110, B11303.  
[Szymczak, P., Ladd, A.J.C., 2009]. Wormhole formation in dissolving fractures. J. Geophys. Res., 114, B06203.  
[Rohmer, J., Aochi, H., 2015]. Impact of channel-like erosion patterns on the frequency-magnitude distribution of earthquakes, Geophysical Journal International, 202 (1): 670-677.

## Earthquake as a cascading rupture growth process



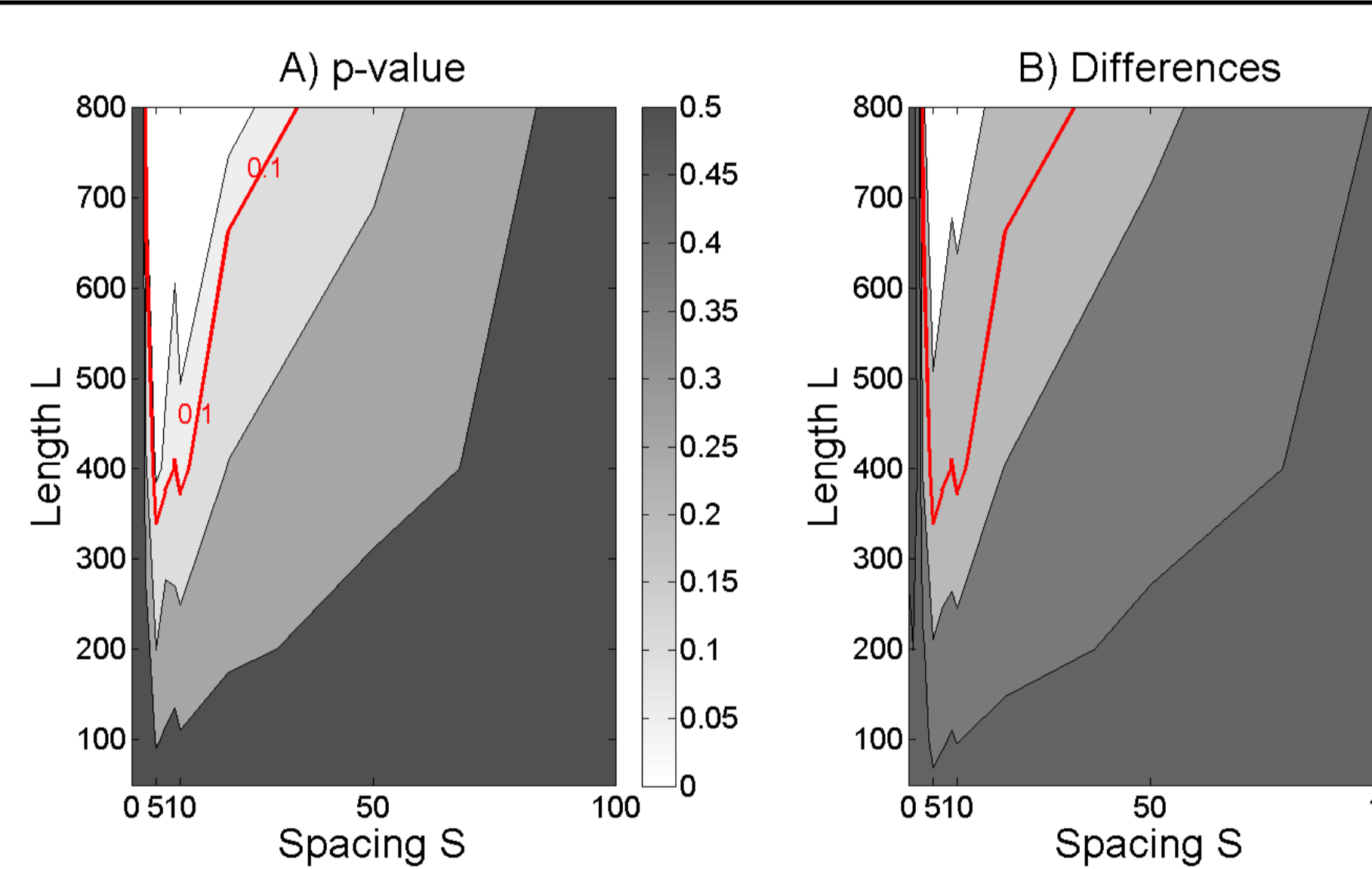
- A) Fractal circular patch model [Ide & Aochi 05].** A small rupture is initiated (star-like marker) and propagates on one of the smallest patches (lowest fracture energy area) and grows up on larger patches with a progression depending on the interaction between patches;
- B) Example of patches' distribution.** Circular patches of different sizes (order in right bar) are distributed on a planar fault. Each patch has slip weakening friction law (inset), with slip weakening distance  $D_c$  proportional to the patch radius;
- C) Fault domain (4,096x4,096)** with position of the aligned channels (characterised by a length  $L$  and a spacing  $S$ ) with same direction as the shear stress acting on the fault ( $d_s$  is the grid cell size assumed to be 4m in the present study);
- D) Schematic representation of:** i) the fracture microtopography viewed as a series of patches of increasing energy  $G_c$  depending on the order of the patch; ii) the deep erosion induced by channels through the whole series of patches until reaching the host rock (8th largest patch).

## Impact on Frequency-Magnitude Distribution



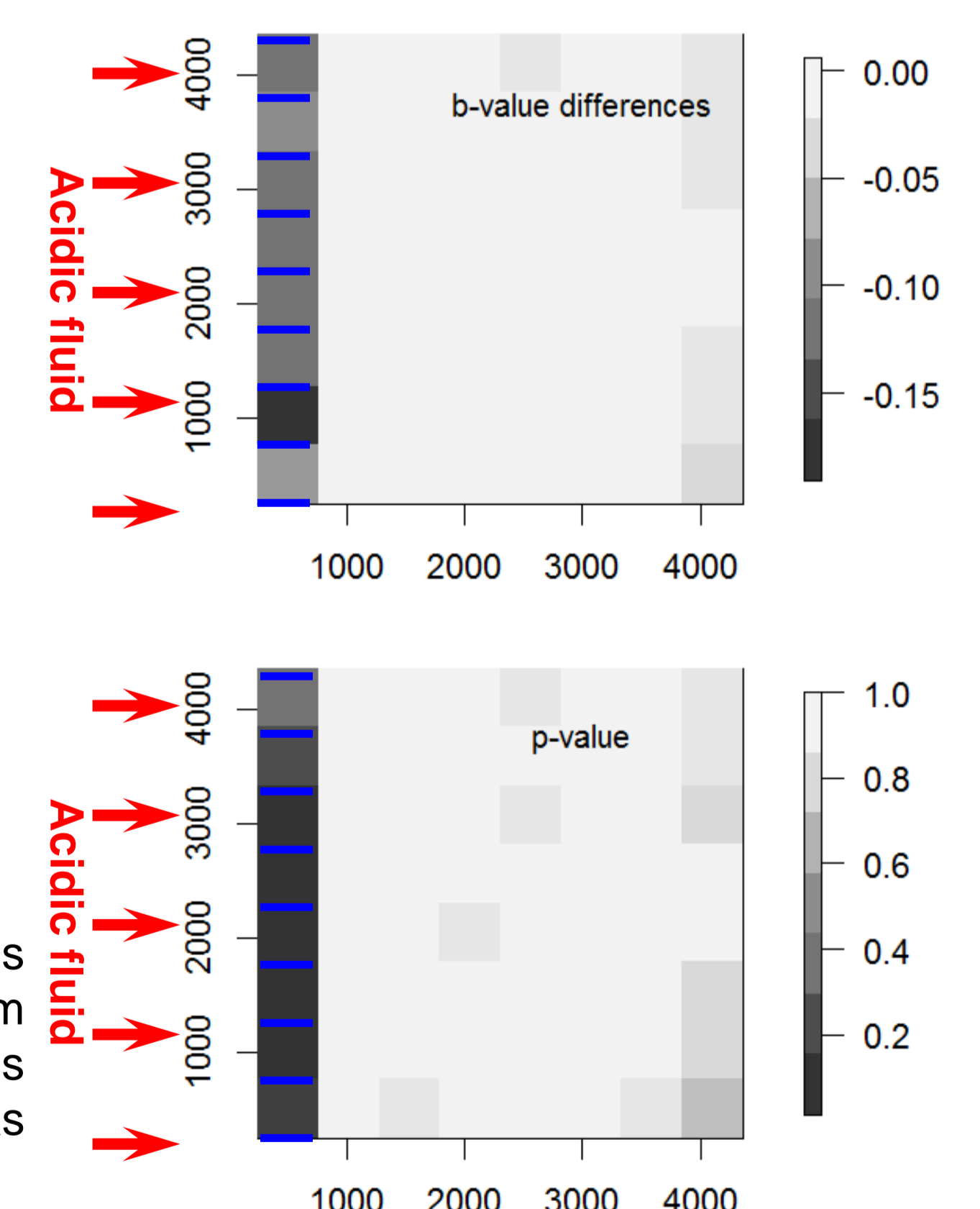
$b_1$  = b-value for eroded fault  
 $b_0$  = b-value for intact fault  
p-value = statistical significance of the differences if <10%

## Influence of channels' characteristics



**Parameter space study** considering different spacing versus length scenarios (channel width  $w=1$ ): (A) statistical significance  $p$ -value (using 1,000 random samples) of the Differences in the b-values (original minus altered cases); Cases with  $p$ -value <10% (area indicated by the red-coloured lines) are categorised as "statistically significant" (B).

## Spatial Analysis S10, L400



## CONCLUDING REMARKS [Rohmer & Aochi 15]

- A spatially uniform dissolution  $\rightarrow$  b-value remains unchanged;
- Channel-like erosion  $\rightarrow$  increase of b-value (of  $\sim 0.08$  in our case);
- Impact is significant (statistically) for optimum characteristics of the erosion pattern with spacing to length ratio of  $\sim 1/40$ ;
- The larger the spacing, the lower the channel's influence;
- **Local seismicity anomaly** concentrates in a limited zone around the channels: this opens perspective for detecting these eroded regions through high-resolution imaging surveys.