Data-driven cortical clustering to provide a family of plausible solutions to the M/EEG inverse problem

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1 MOTIVATION

- Sources are represented as a **connected cortical region**, rather than a dipole
- Several separated cortical regions can fit the data with similar accuracy. While convex optimization based methods give a single solution, we explore a **family of plausible solutions**
- Estimate not only the position, but also **extension range** of the regions

2 ASSUMPTIONS

- Data model: $y = Lx + N$ (L is a lead field)
- Source space: cortical mesh
- Brain activity x : single region with a constant amplitude over this region; one time sample

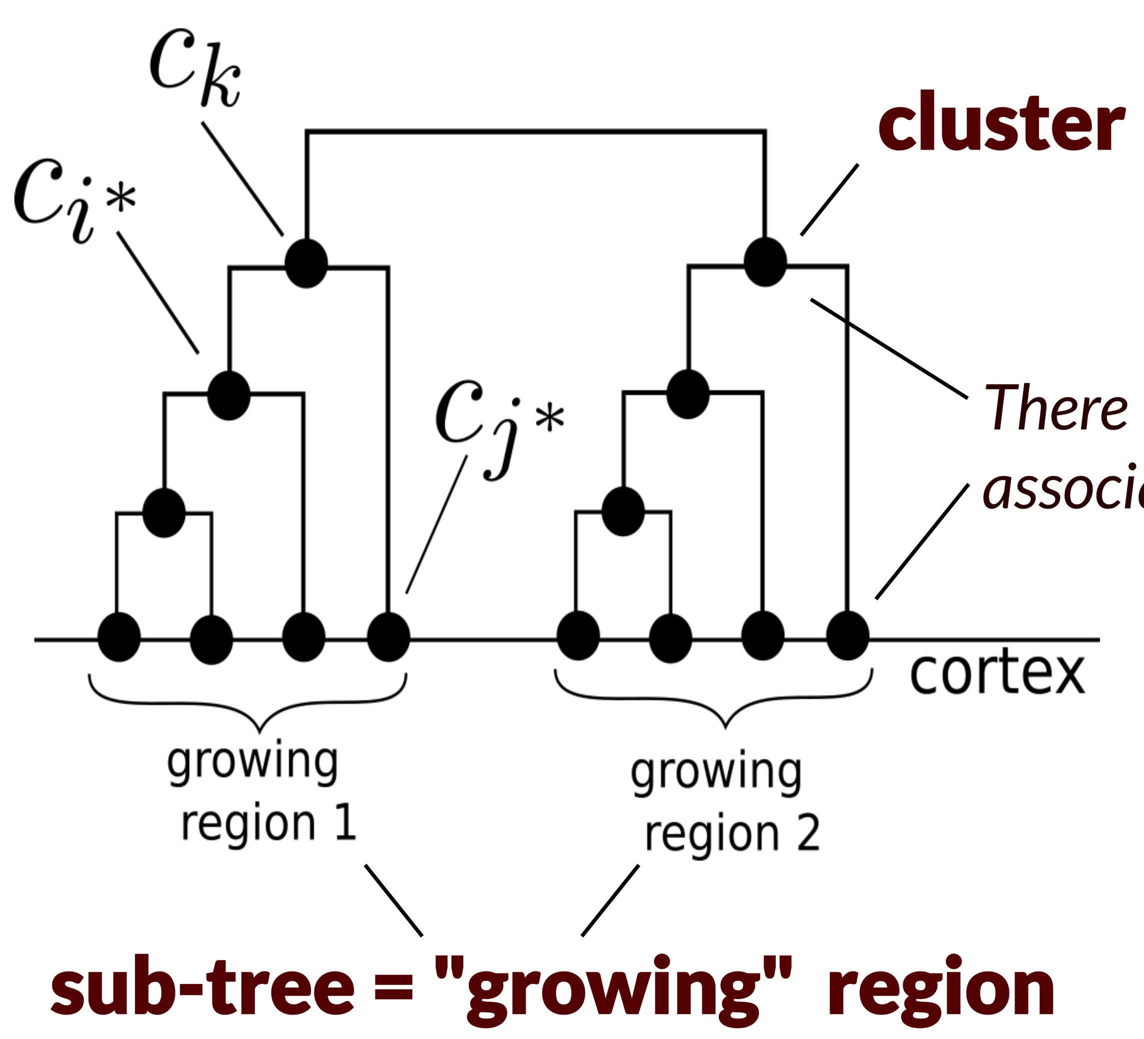
3 METHOD

Adapting **hierarchical clustering** algorithm [1] to fit M/EEG data :

- Mesh vertices represent initial clusters
  Mesh edges define the cluster heighborhood
- Among all inter neighbors clusters, find clusters c_{i^*} , c_{j^*} which minimize:

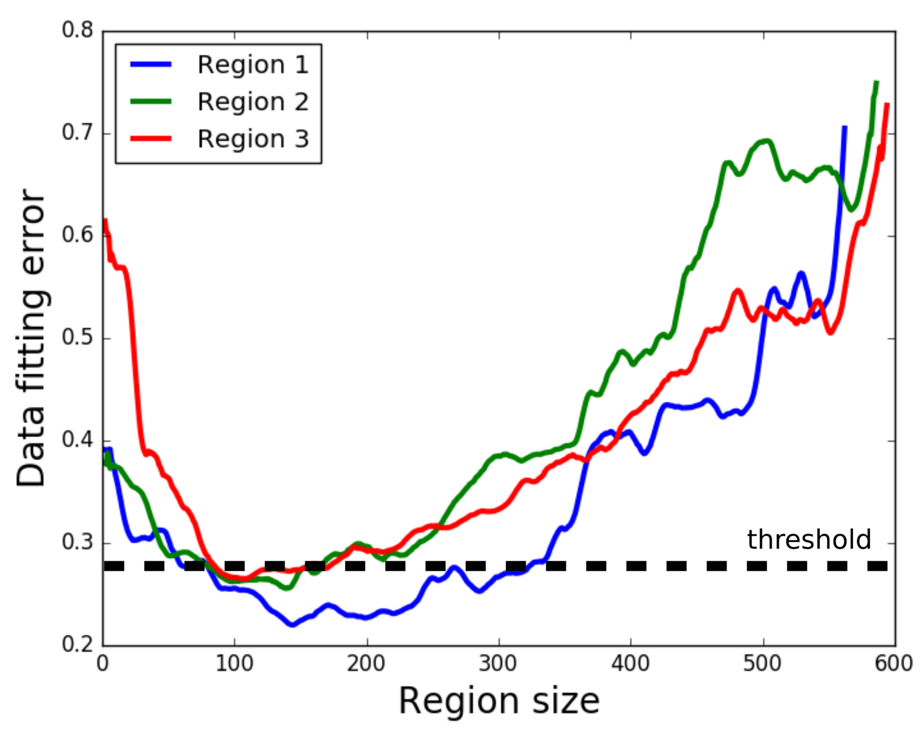
$$E(i,j) = \min_a \|y - a \cdot (L(c_i) + L(c_j))\|_2 + R(i,j)$$

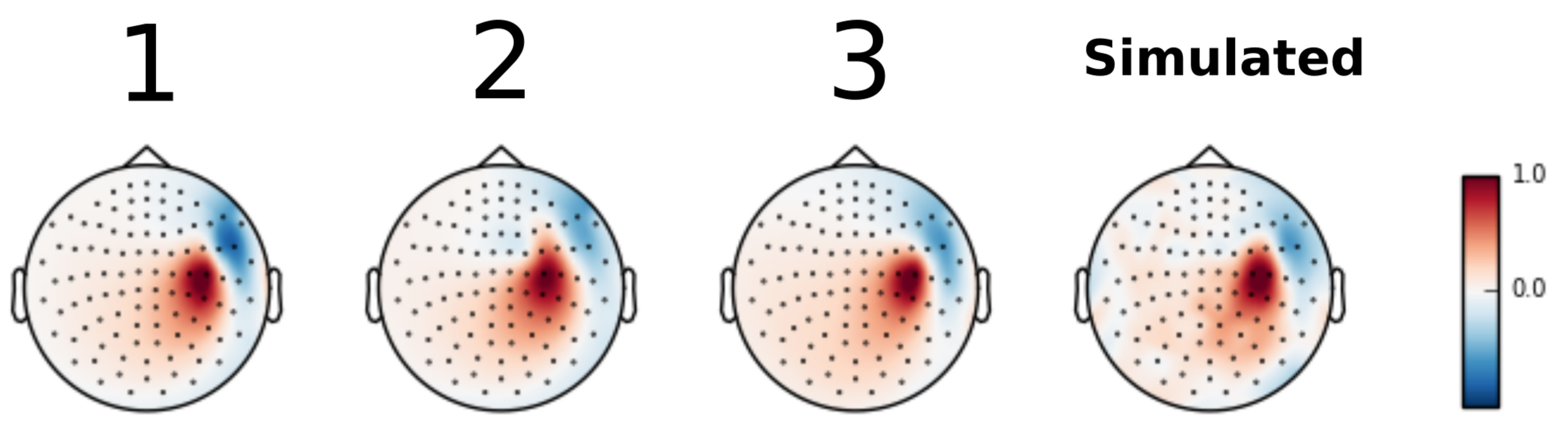
- Merge these clusters: $c_k = c_{i^*} \cup c_{j^*},\ L(c_k) = L(c_{i^*}) + L(c_{j^*})$
- Repeat until the whole cortex is one cluster
- Cut the tree to obtain separated "growing" regions
- Select best regions by thresholding data fitting error

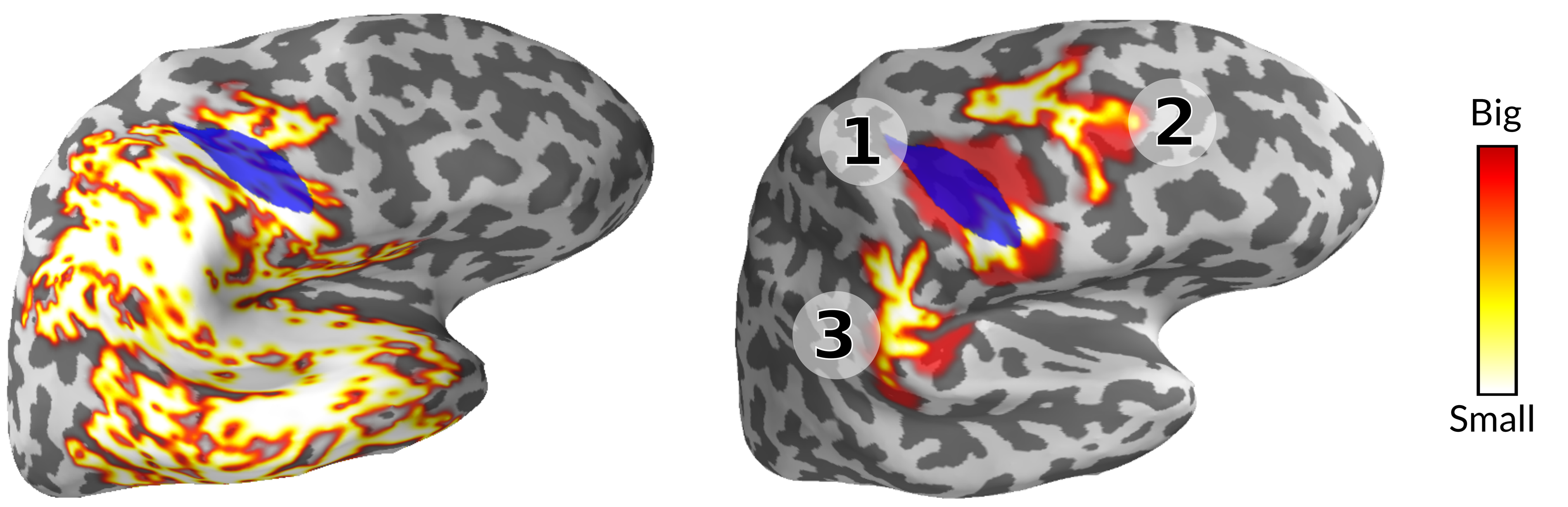


4 RESULTS

- Simulated MEG signal of one active region (in blue) with additive noise
- Reconstructed with and without regularization.
  (we regularized region shapes but other alternatives are possible)
- Obtained 3 spatially separated regions which explain the data with high accuracy (with regul.)
- Estimated the extension range of each region







No regularization
(overfitted solution)

Regularization

5 CONCLUSIONS

New approach for the M/EEG inverse problem which:

- Deals with a "growing region" object, which allows to explore space of solutions
- Gives several candidates for solution and their extension ranges

Future work:

- Regularization term to be investigated
- Error thresholding to be investigated
- Multiple source case by adapting the MUSIC method [2]

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References:
[1] F. Murtagh and P. Contreras. Methods of Hierarchical Clustering. Computing Research Repository - CORR, 2011.
[2] N. Mäkelä, M. Stenroos, J. Sarvas and RJ Ilmoniemi. Truncated RAP-MUSIC (TRAP-MUSIC) for MEG and EEG source localization. NeuroImage, Volume 167, 15 February 2018, Pages 73-83.

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