



Robust Cerebral Blood Flow Map Estimation in Arterial Spin Labeling

Camille Maumet^{1,2,3}, Pierre Maurel^{1,2,3}, Jean-Christophe Ferré^{1,2,3,4}, Christian Barillot^{1,2,3}

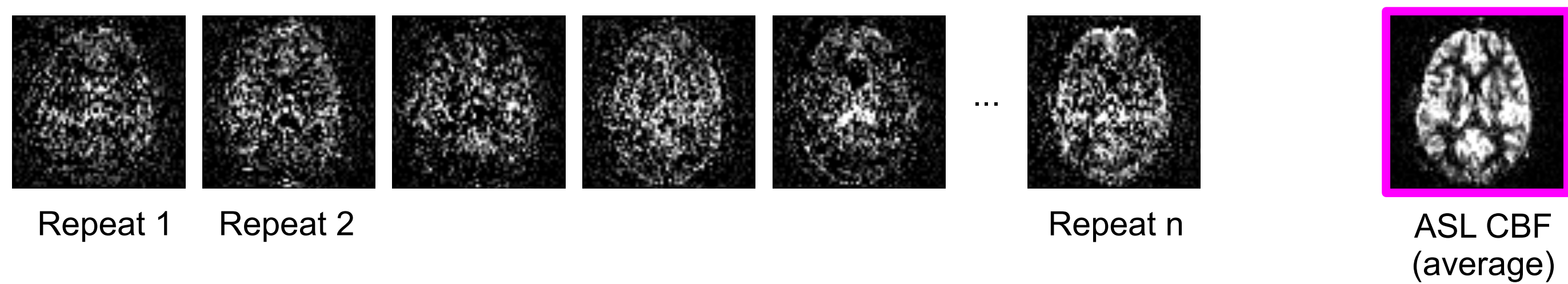


1. INRIA, VisAGeS Project-Team, F-35042 Rennes, France
2. INSERM, U746, F-35042 Rennes, France
3. University of Rennes I, CNRS, UMR 6074, IRISA, F-35042 Rennes, France
4. CHU Rennes, Department of Neuroradiology, F-35033 Rennes, France

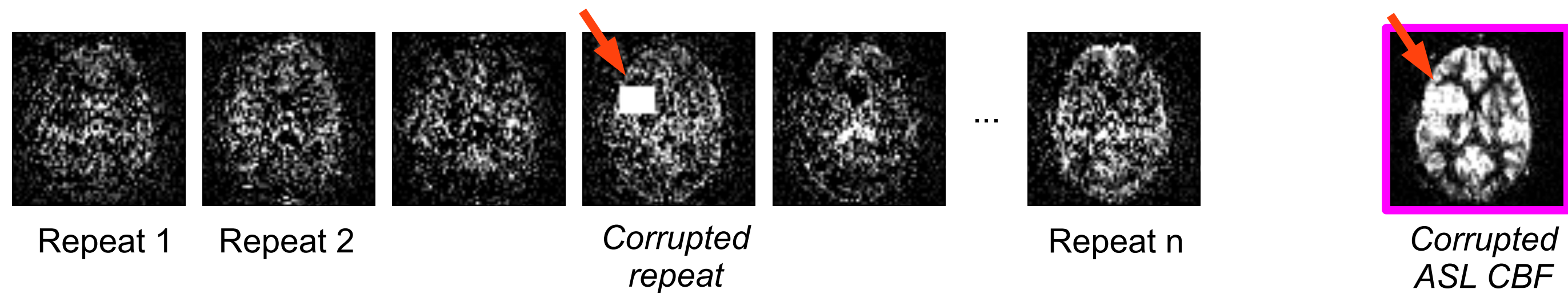


Purpose

Context: With arterial spin labeling (ASL), cerebral blood flow (CBF) is usually estimated by averaging across the repeated acquisitions:



Problem: Due to its zero breakdown point, the sample mean is very sensitive to outliers.



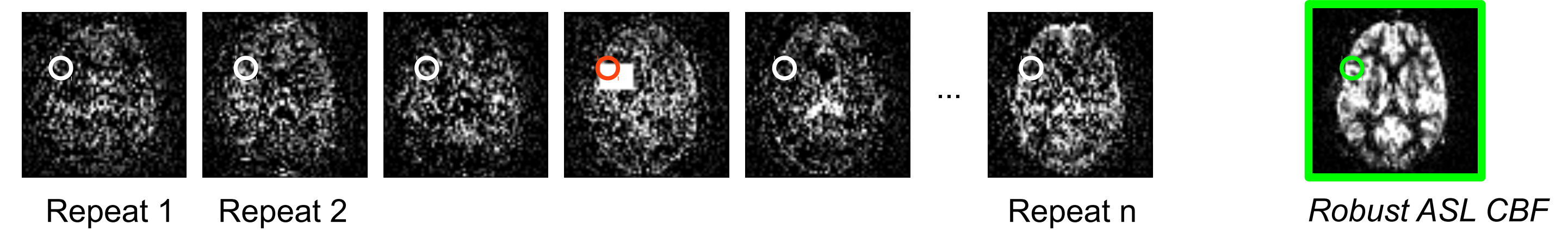
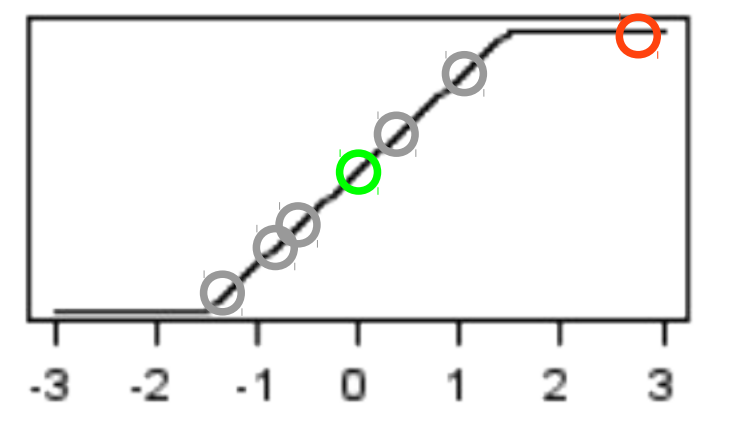
Our approach: Compute robust ASL CBF maps via **M-estimators**

Computing robust ASL CBF estimates

Our approach: Voxel-wise Huber M-estimator.

$$\hat{\theta} = \underset{\theta}{\operatorname{argmin}} \left(\sum_{i=1}^n \rho(x_i, \theta) \right)$$

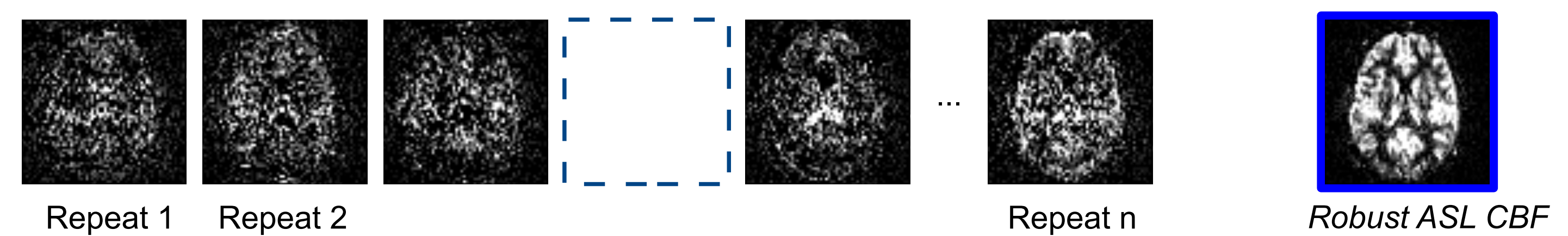
$$\psi(x_i, \theta) = \gamma \left(\frac{x_i - \theta}{\sigma} \right) \quad \text{where } \gamma(x) = \begin{cases} -k, & x < -k \\ x, & -k < x < k \\ k, & x > k \end{cases}$$



Competing approach: Z-score thresholding proposed by Tan et al, an outlier removal approach based on a z-score at the volume or slice level.

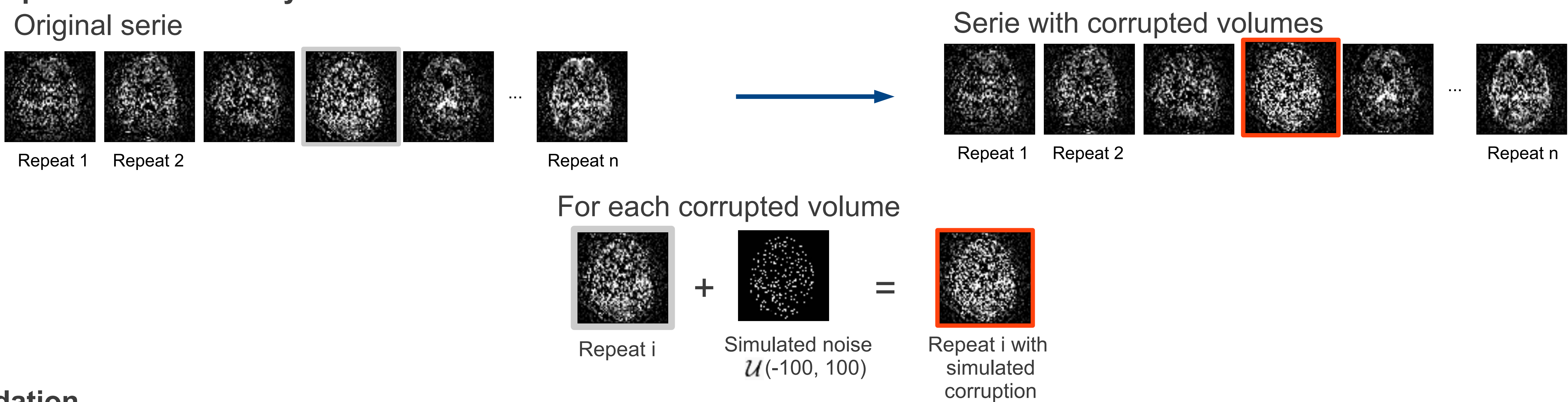
$$|\mu_v| > \operatorname{avg}_{i=1}^R(\mu_i) + 2.5 \operatorname{avg}_{i=1}^R(\sigma_i),$$

$$\text{or } \sigma_v > \operatorname{avg}_{i=1}^R(\sigma_i) + 1.5 \operatorname{std}_{i=1}^R(\sigma_i)$$



Validation

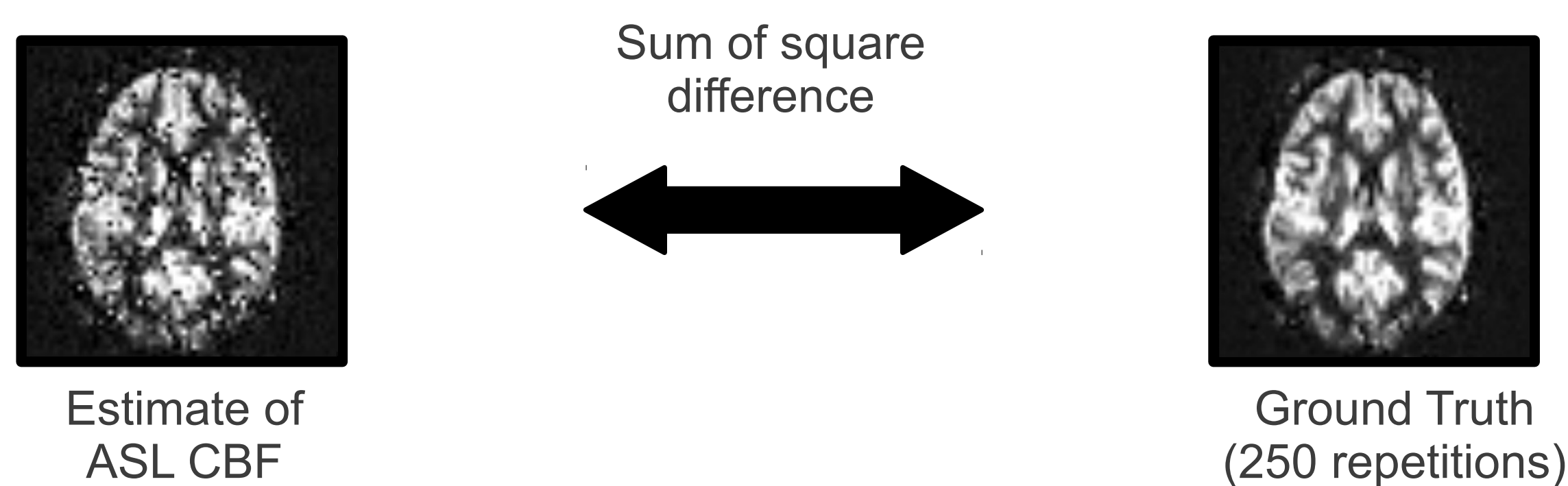
Corruption of ASL data by simulation



Validation

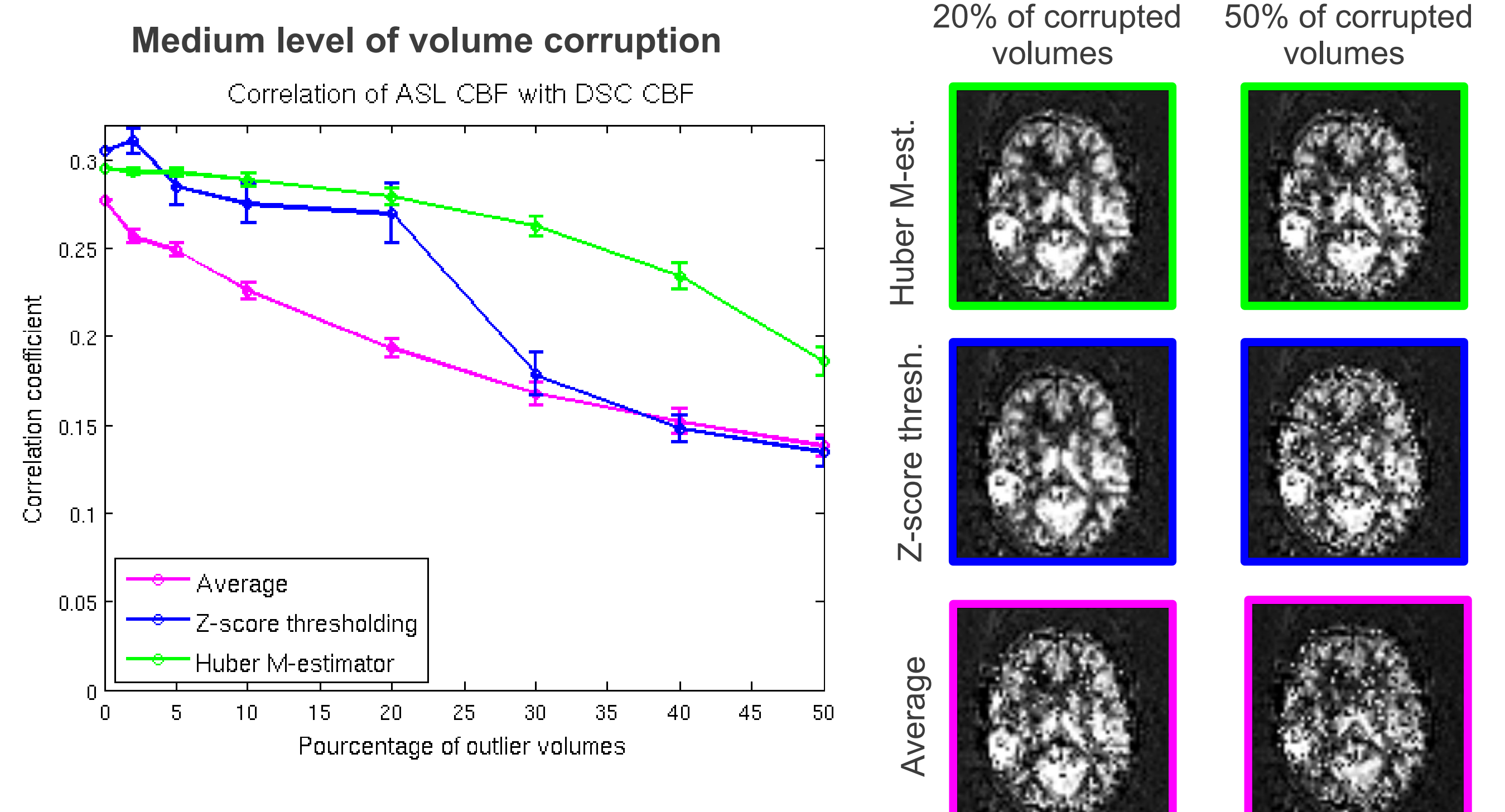
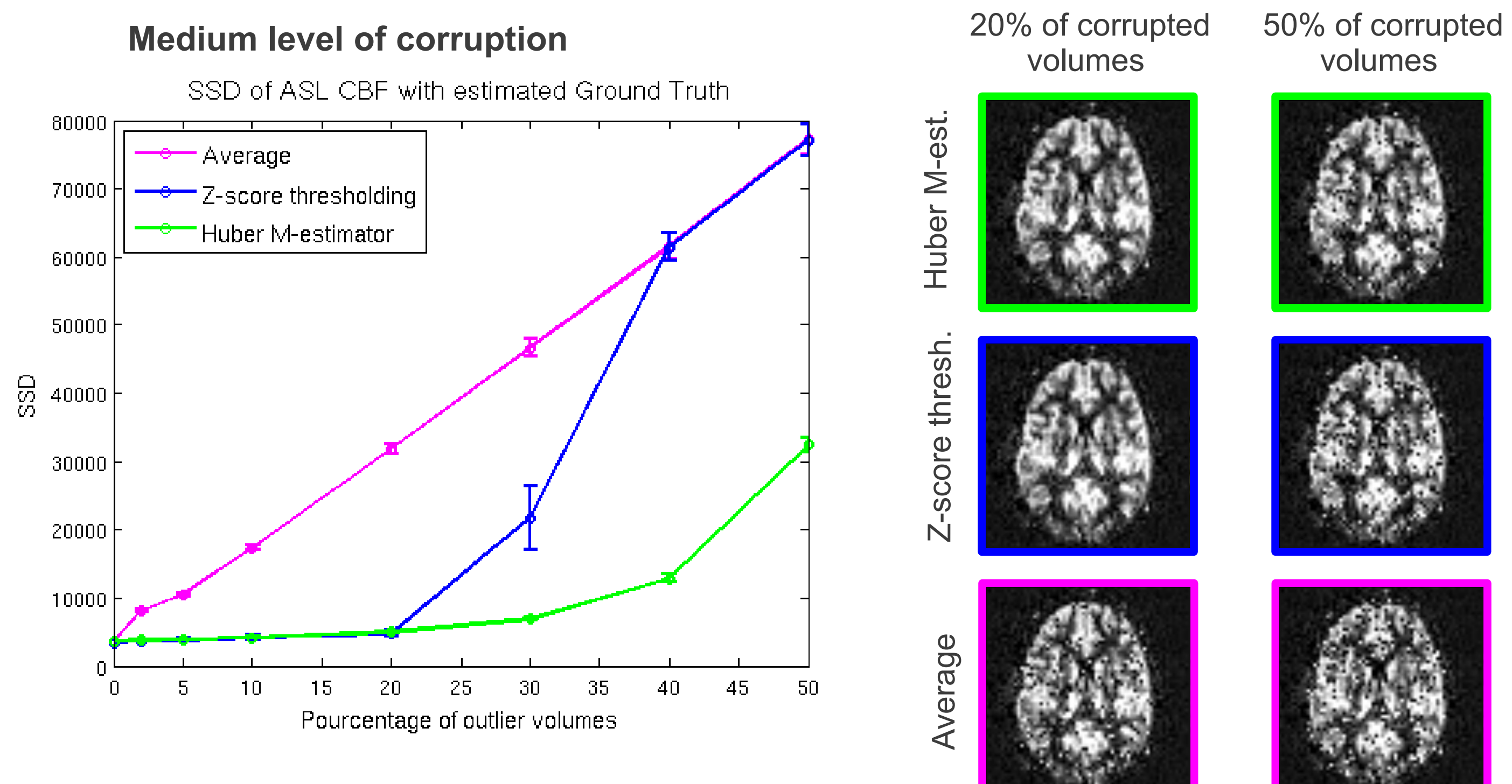
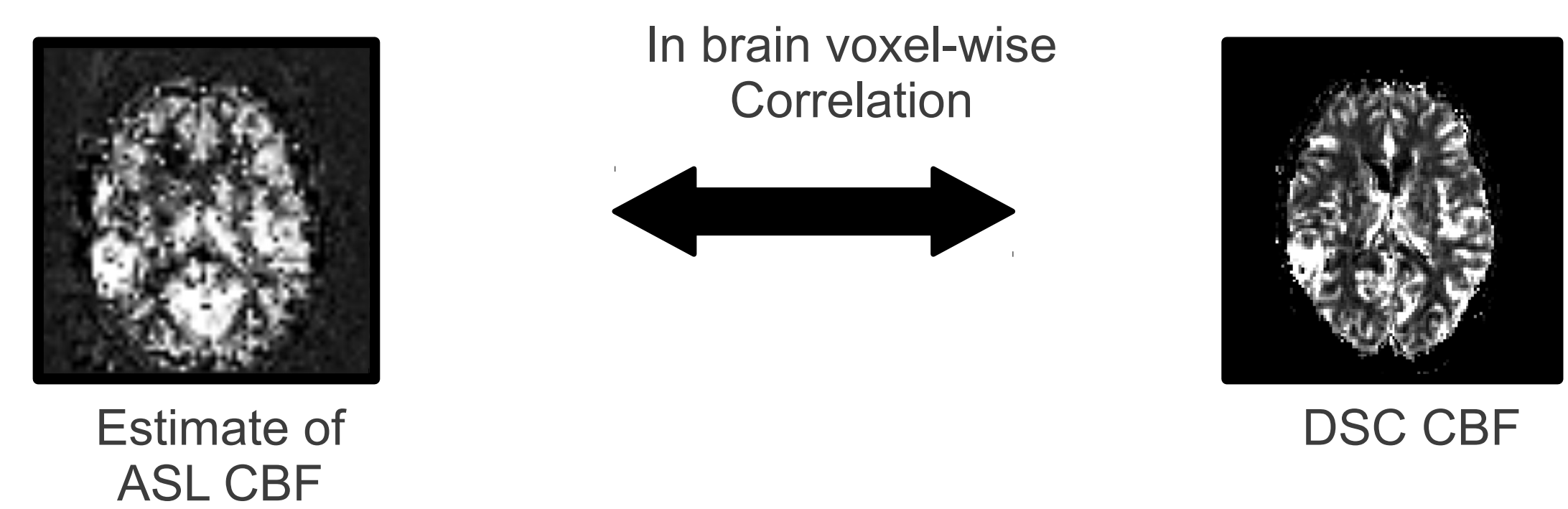
Experiment 1: Comparing the robust CBF map with a "Ground Truth" CBF map extracted from a long ASL acquisition (250 repetitions, ~25 min).

Metric: Sum of square difference



Experiment 2: Comparison with a CBF map extracted from a dynamic-susceptibility weighted contrast (DSC), the standard sequence for MR perfusion.

Metric: Correlation coefficient



Conclusion

Overall Huber's M-estimates perform equally or better than z-thresholding and are less variable. As they are able to deal with a broader range of outliers, we recommend the use of M-estimators as robust method to compute ASL CBF maps.