Morphologist Pipeline
BrainVISA Morphologist Toolbox

Human brain T1 MRI image
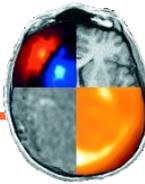
- T1 weighted image

- Anatomical image

- Contrast enables to distinguish tissues: values in white matter > gray matter > CSF
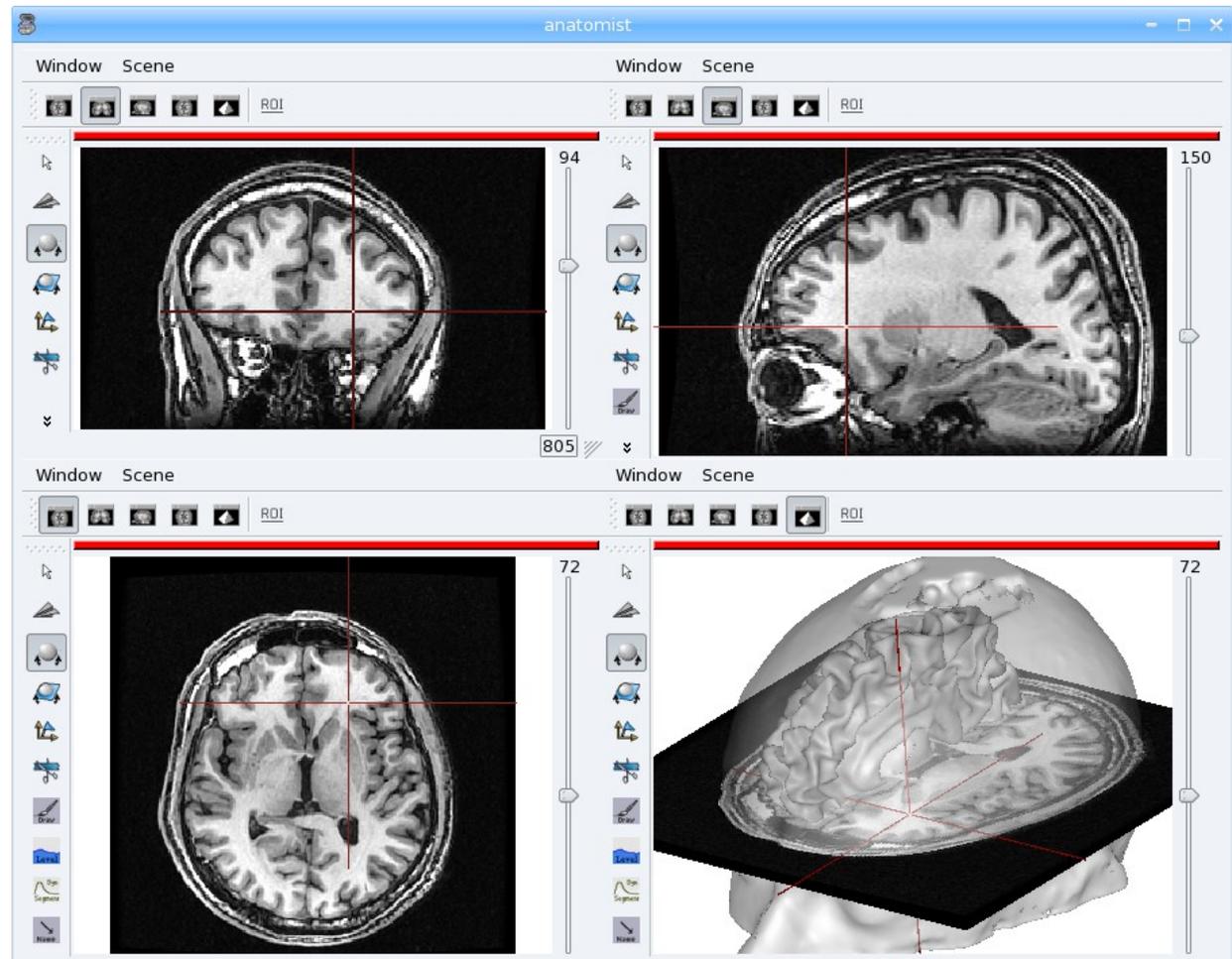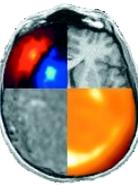
- BrainVISA Morphologist pipeline
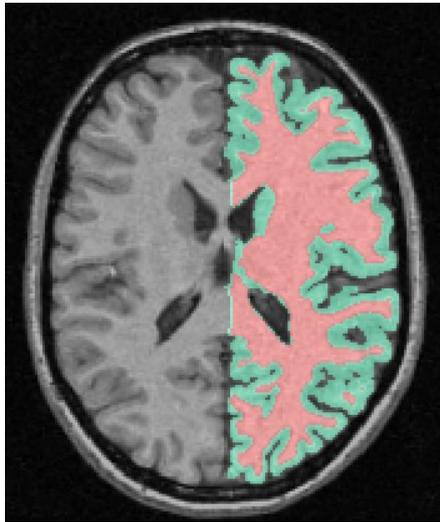
Grey white matter segmentation
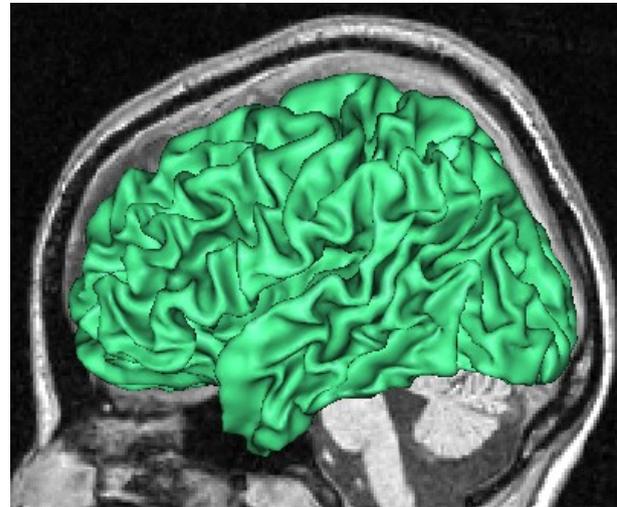
White matter mesh
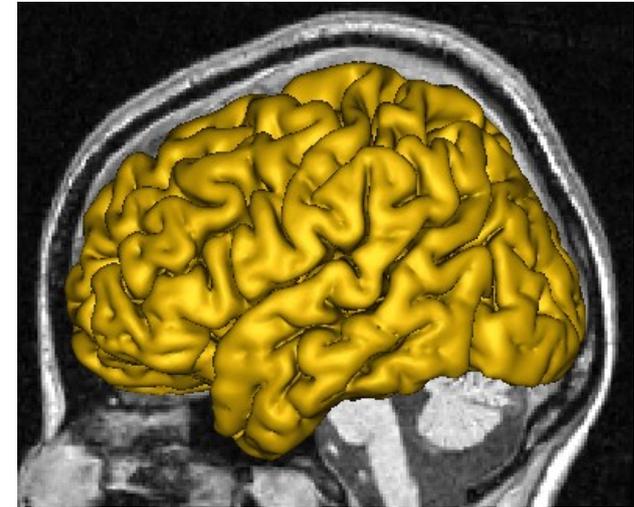
Grey matter mesh
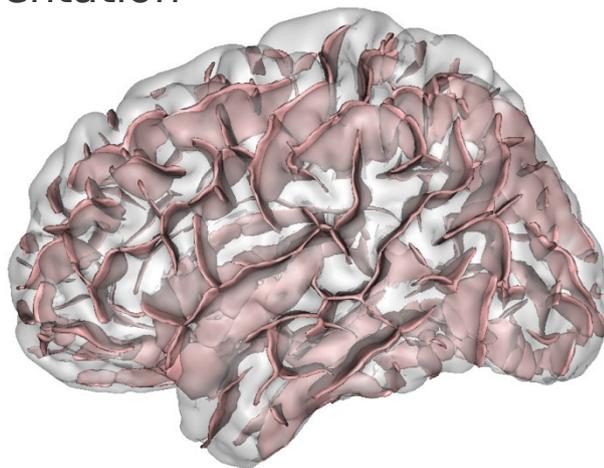
Cortical folds graph
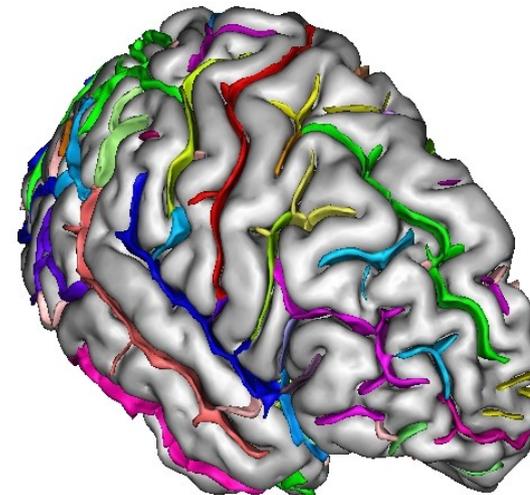
Automatically identified sulci

Bias correction
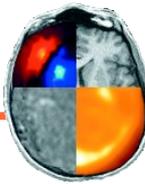
- Spatial bias correction in usual MR images

- Values in raw image not only depend on the tissue but also on the localization in the field of view => need to be corrected before segmentation

- Entropy minimization for automatic correction of intensity non uniformity, J.-F. Mangin, MMBIA (Math. Methods in Biomed. Image Analysis), Hilton Head Island, South Carolina, IEEE Press 162-169, 2000
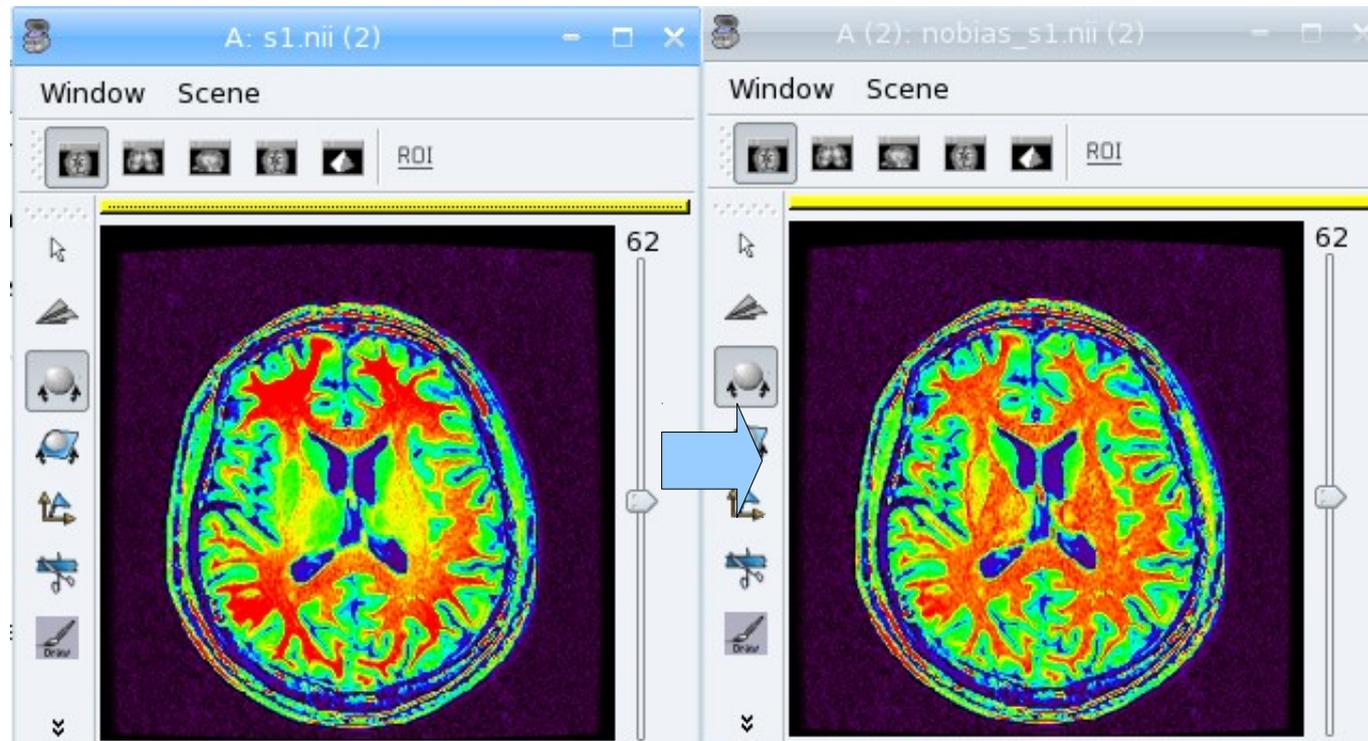
Histogram analysis
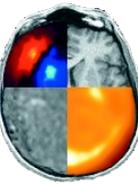
- Analyses a T1-weighted histogram to estimate grey/white statistics

- The histogram shape is variable : 3-5 peaks (background, grey, white, CSF, fat)

- Robust brain segmentation using histogram scale-space analysis and mathematical morphology, J.-F. Mangin, O. Coulon, and V. Frouin MICCAI, MIT, LNCS-1496, Springer Verlag 1230-1241, 1998
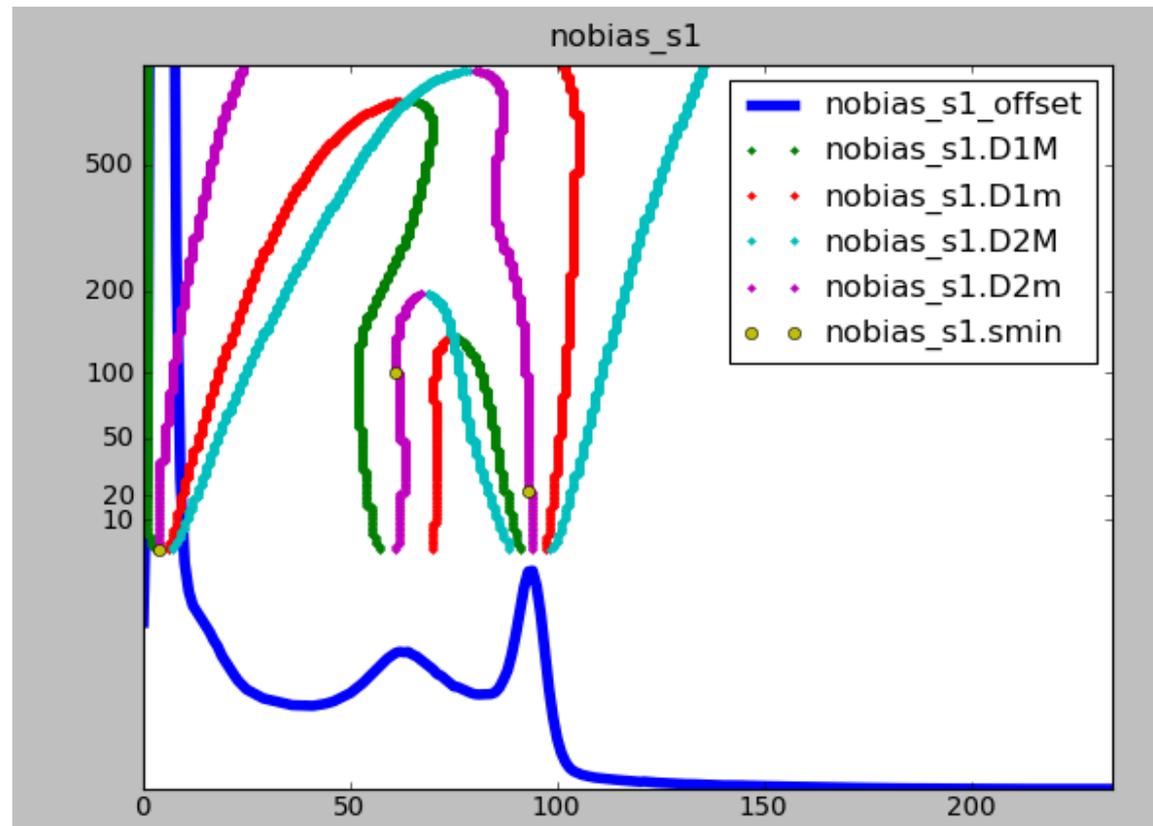
Brain mask segmentation
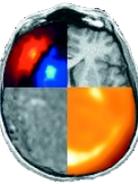
- Computes a binary mask of the brain from a bias corrected T1-weighted image

- Mathematical morphology : thresholding – erosion - dilation

- Robust brain segmentation using histogram scale-space analysis and mathematical morphology, J.-F. Mangin, O. Coulon, and V. Frouin MICCAI, MIT, LNCS-1496, Springer Verlag 1230-1241, 1998
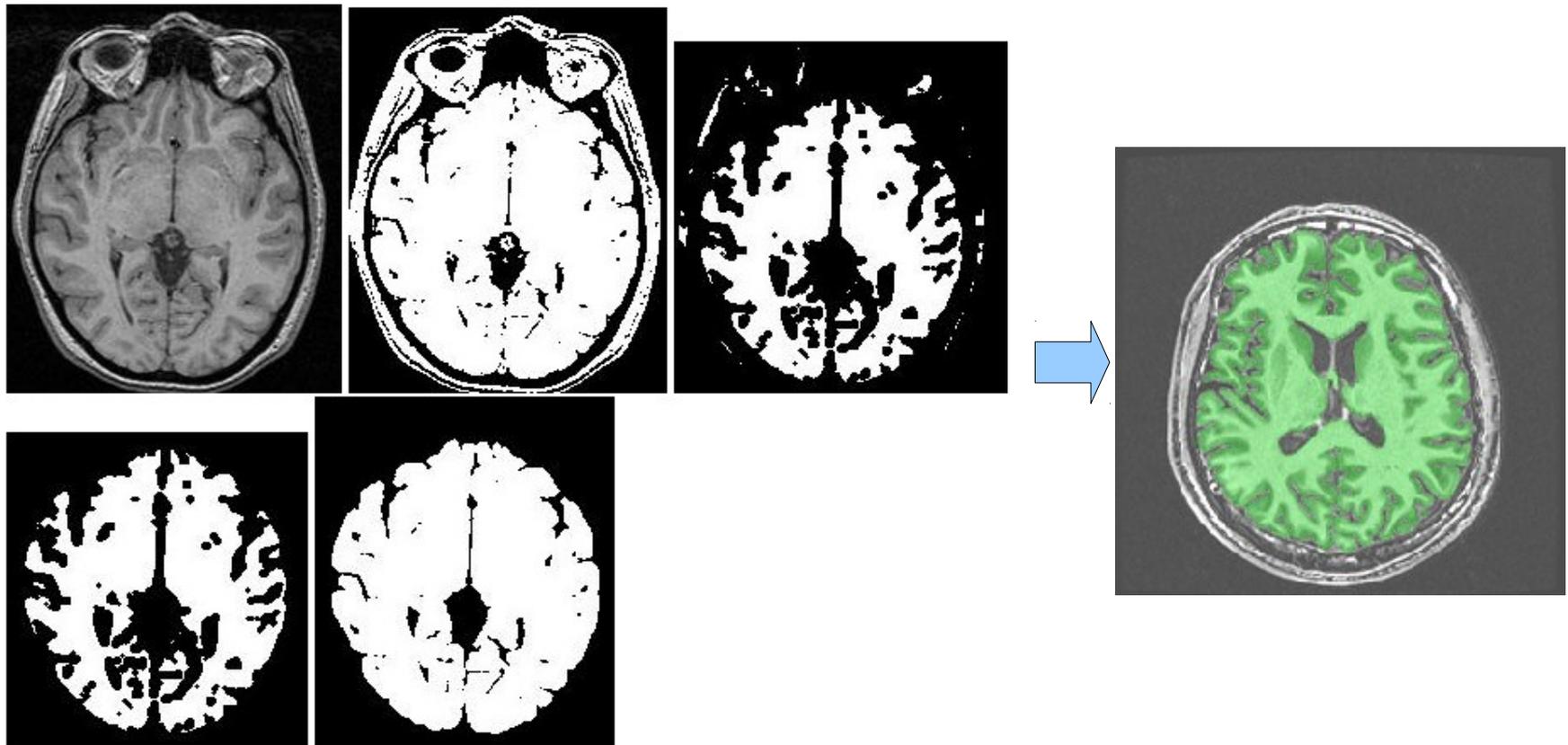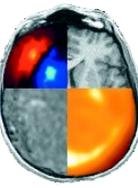
- Split Brain Mask: three parts: hemispheres + cerebellum/stem
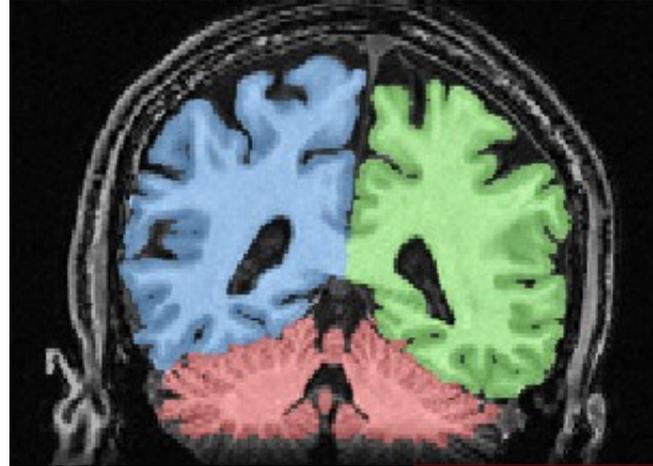
- Grey / White interface
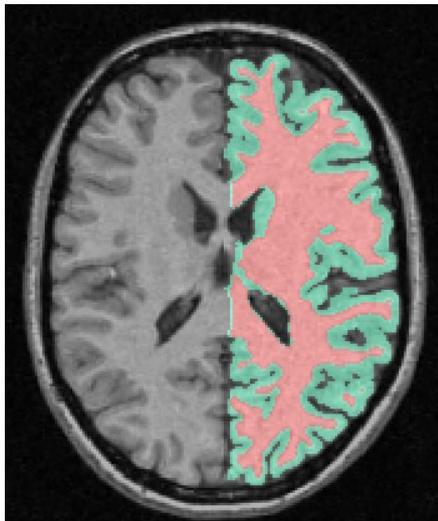
Grey white matter segmentation
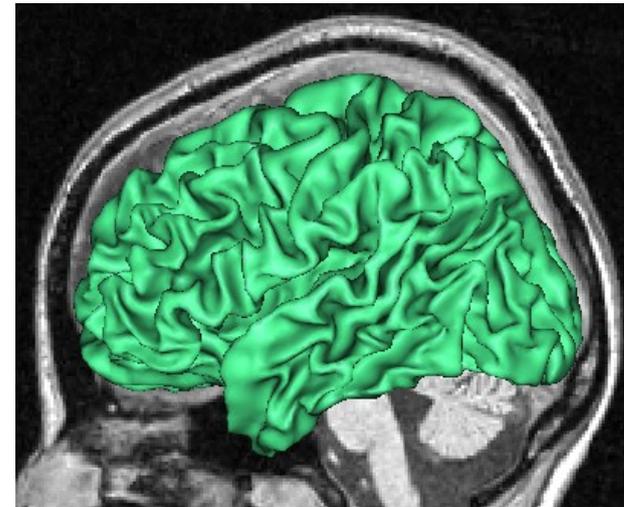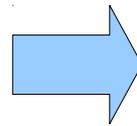
White matter mesh

Cortical folds
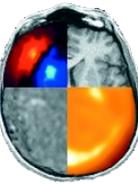
- Structural representation of the sulci folds: surfaces going inside the folds and neighbouring information.

- Automatic recognition of sulci. Several methods exist:

  - Artificial Neural Network (ANN) recognition

D. Rivière, J.-F. Mangin, D. Papadopoulos-Orfanos, J.-M. Martinez, V. Frouin, and J. Régis. Automatic recognition of cortical sulci of the Human Brain using a congregation of neural networks. Medical Image Analysis, 6(2):77-92, 2002.

  - Statistical Probabilistic Anatomy Map (SPAM) recognition

M. Perrot, D. Rivière, and J.-F. Mangin. Cortical sulci recognition and spatial normalization. Medical Image Analysis, 15(4):529-550, 2011.
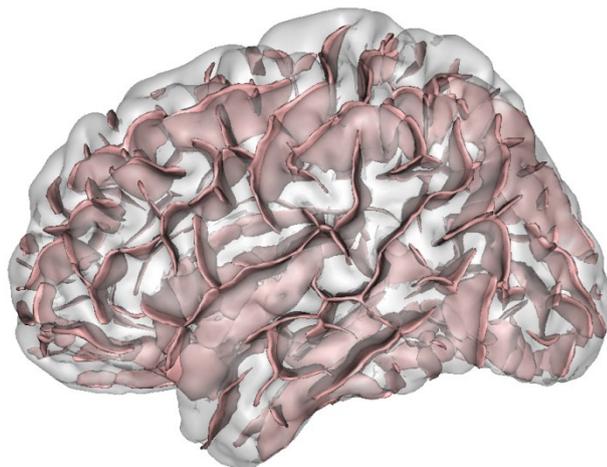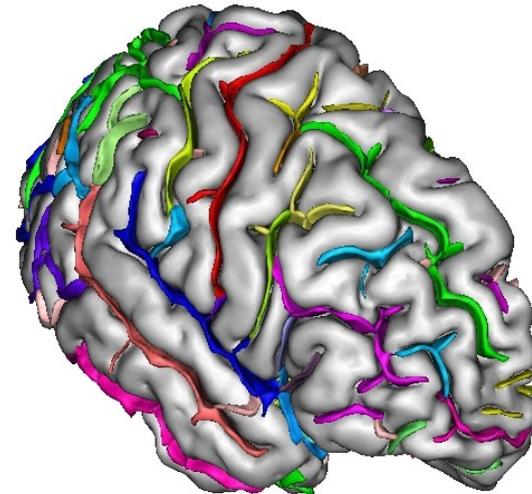
Cortical folds graph   Automatically identified sulci

Sulci recognition methods
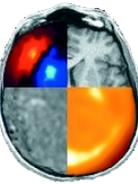
- **ANN**: Artificial neural networks trained on a base of manually labelled sulci graphs. Recognition based on sulci descriptors.

- **SPAM**: Recognition based on statistical maps of sulci presence probabilities

  - **Talairach**: no registration, spam and subject in talairach space

  - **Global** registration

  - **Global + Local** registration

  - **Global registration + Markovian model**: use the relations between sulci.

SPAM-based sulci recognition
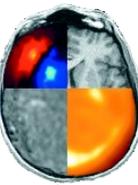
- SPAM creation on a base of manually labelled graphs
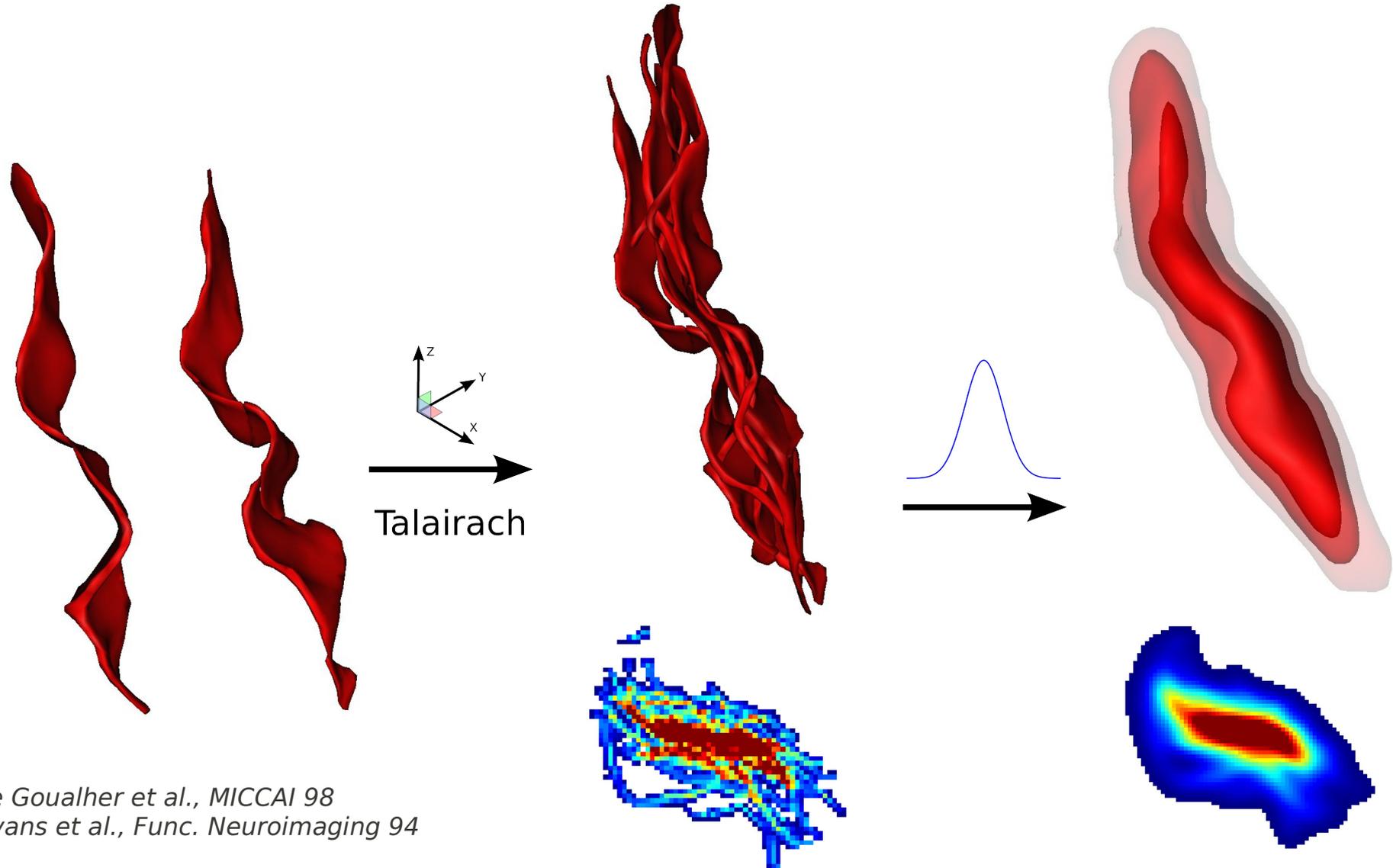
Talairach

Le Goualher et al., MICCAI 98
Evans et al., Func. Neuroimaging 94

SPAM Methods

SPAM - Talairach

Recalage global

Markov

Recalage local

SPAM and normalization

Normalisation

$$\left\{\Theta_a^{(0)}\right\}_{a\in\mathcal{A}}$$

Éstimation du modèle

$$\Theta_a^{(n+1)} = \arg\max_{\Theta_a} P\left(\Theta_a \middle| D_a L_a; \mathcal{M} = m^{(n)}\right)$$

$$m^{(n)} = SPAM\left(\left\{D_a L_a \Theta_a^{(n)}\right\}_{a\in\mathcal{A}}\right)$$
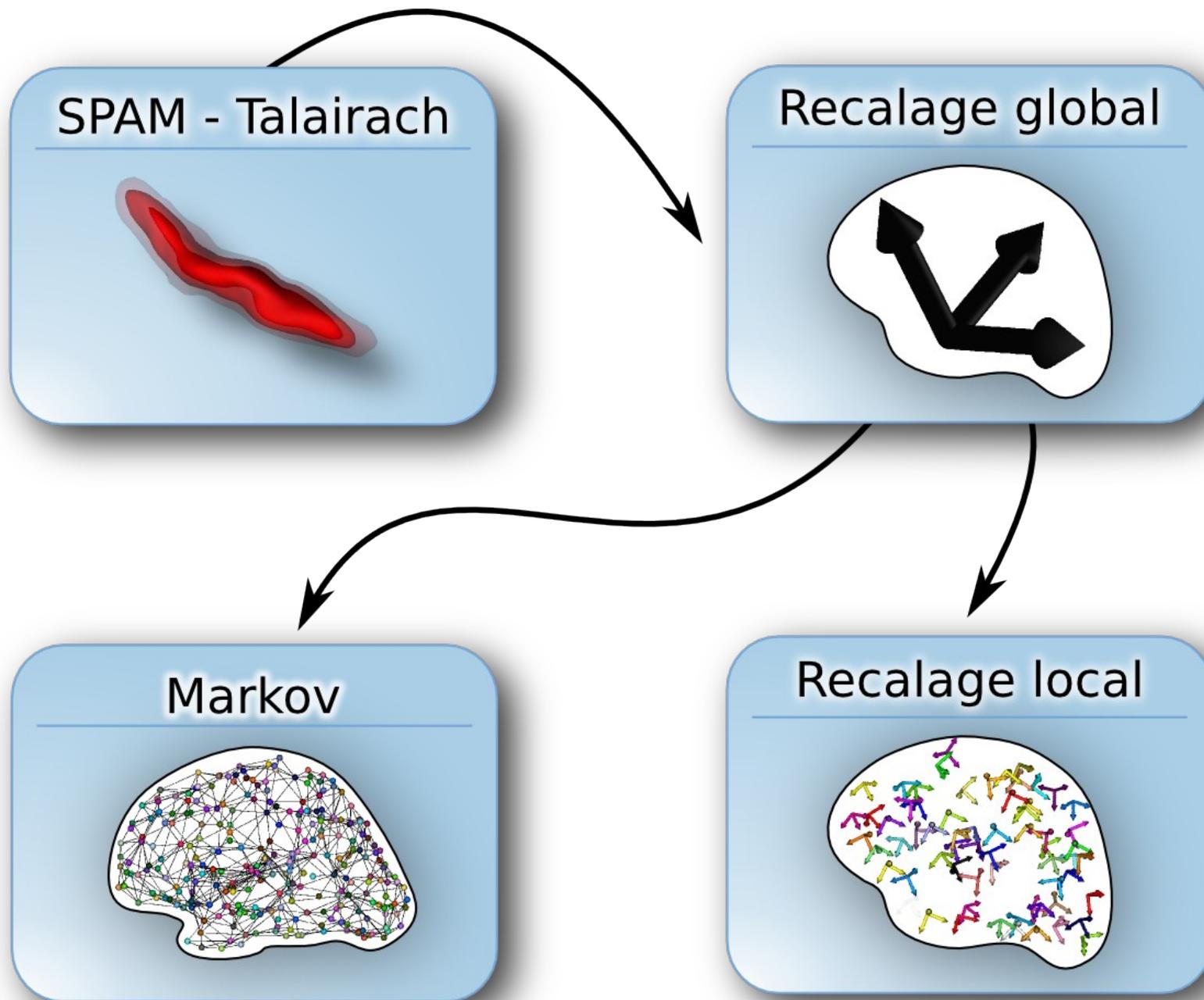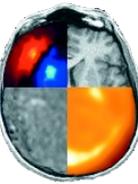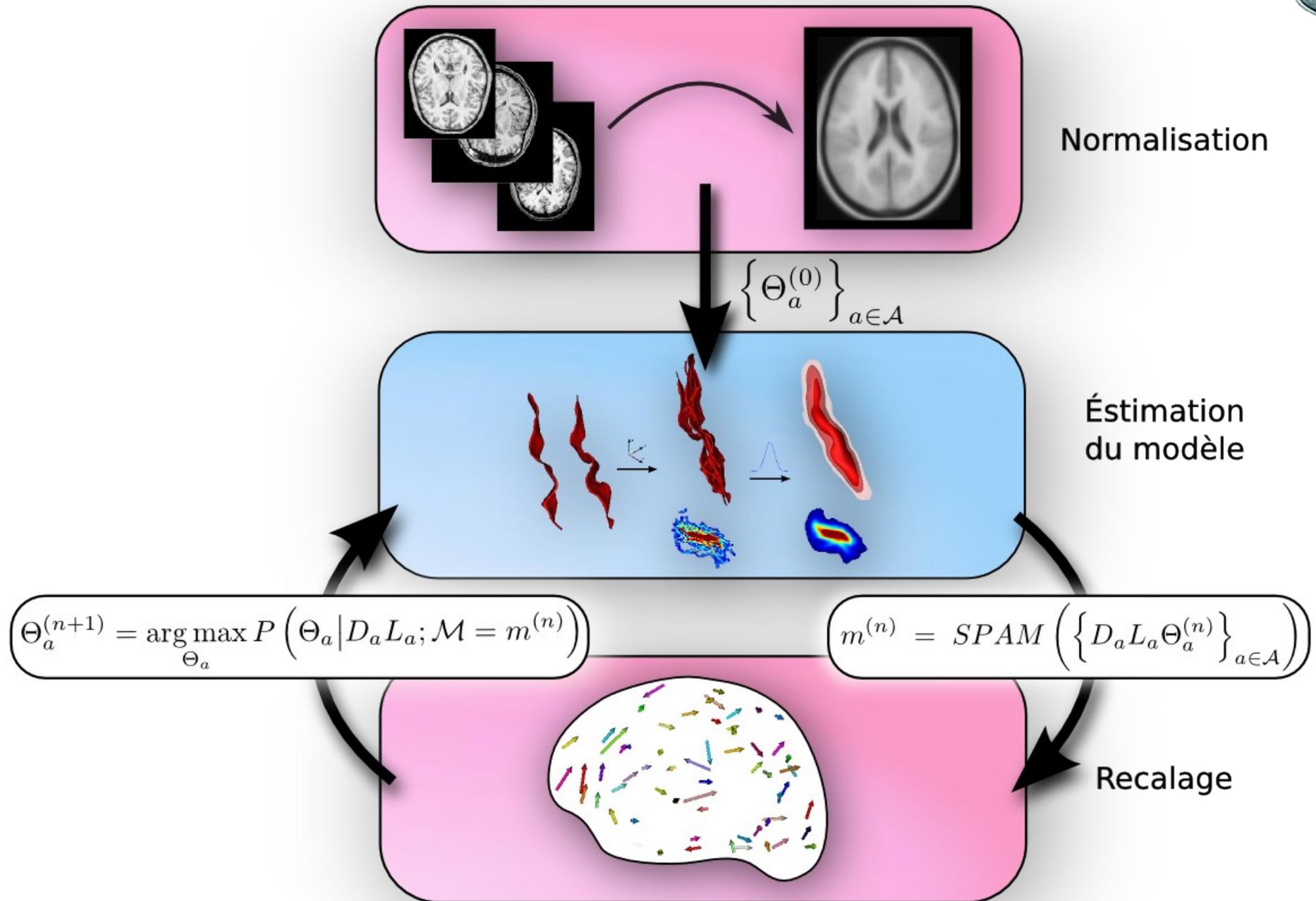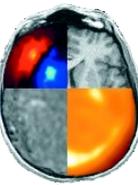
Recalage
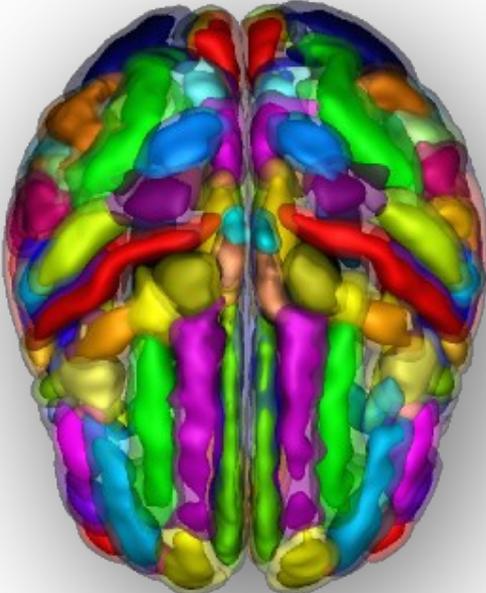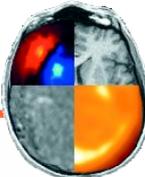
SPAM models

Talairach   recalage global   recalage local
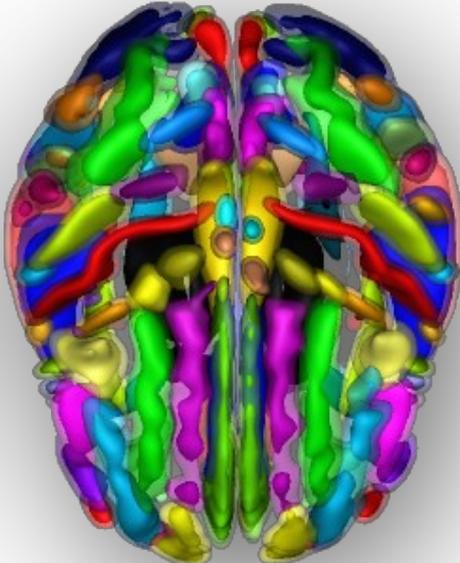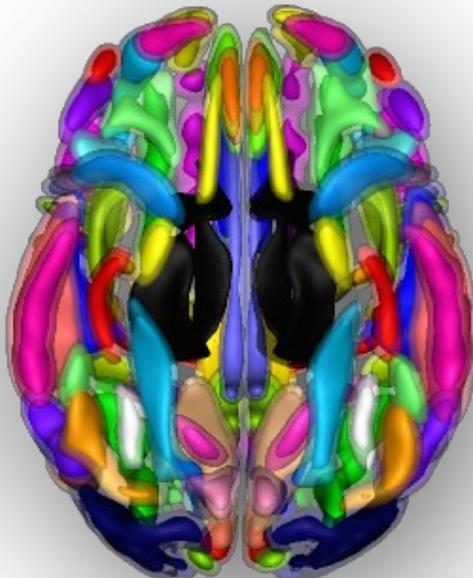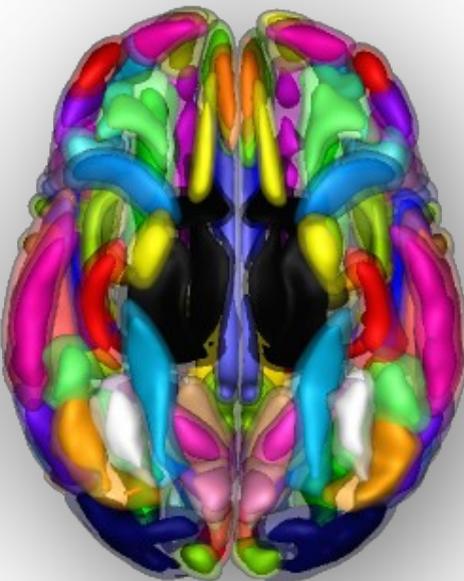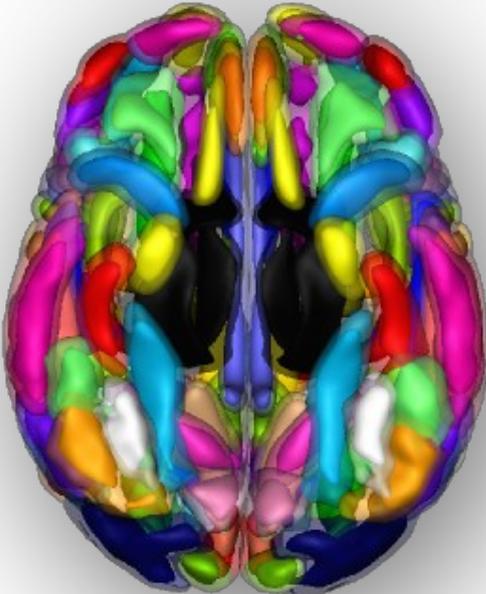
SPAM models and variability
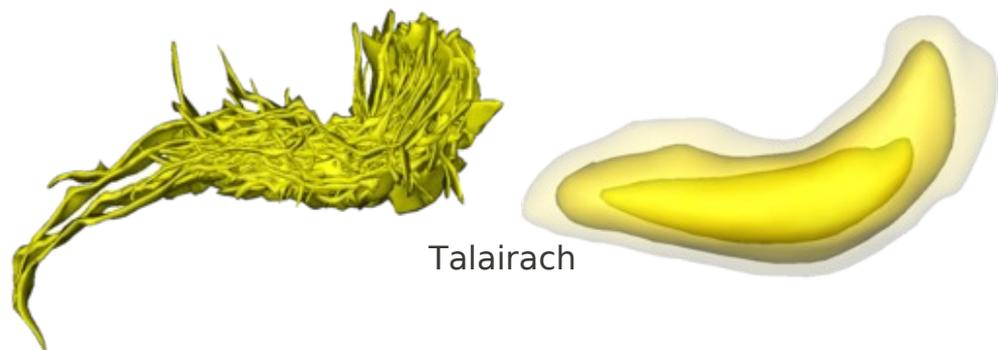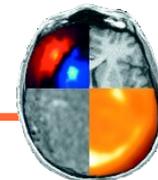
Talairach
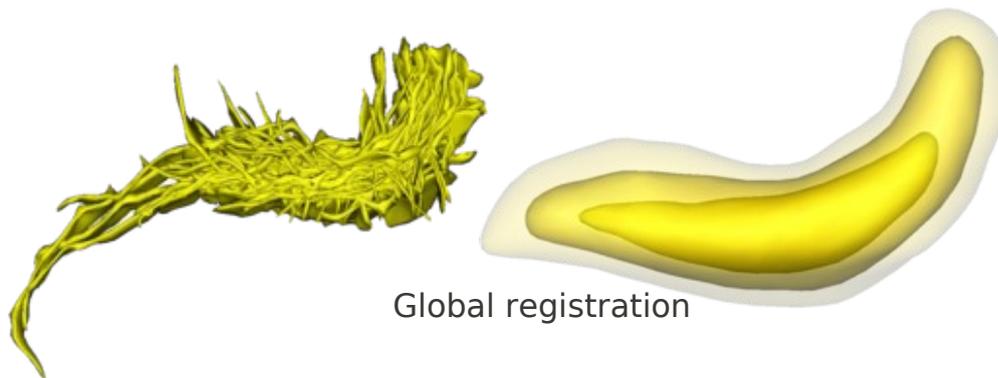
Global registration
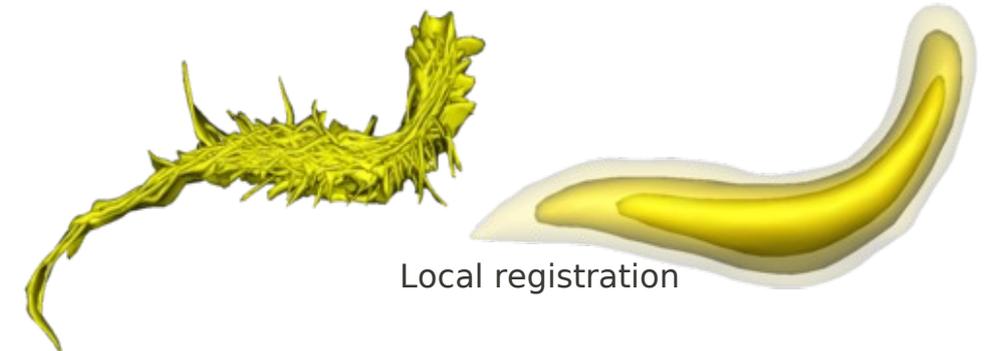
Local registration

Posterior cingulate sulcus

Talairach

Global registration

Local registration
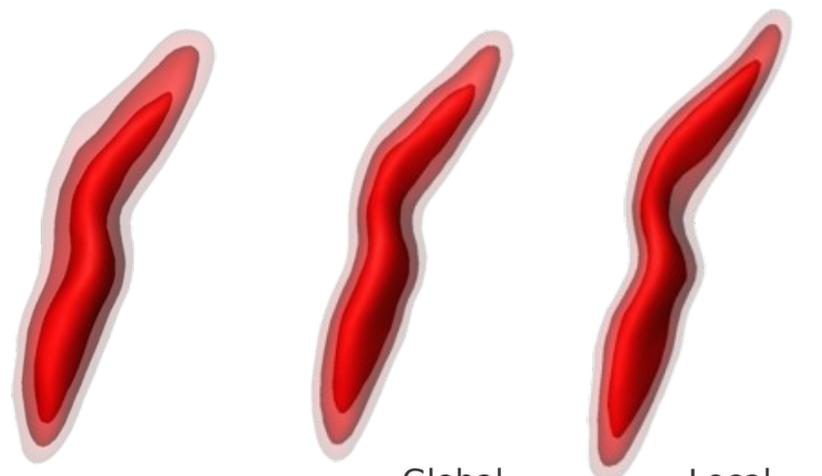
Talairach

Global registration

Local registration

Central sulcus