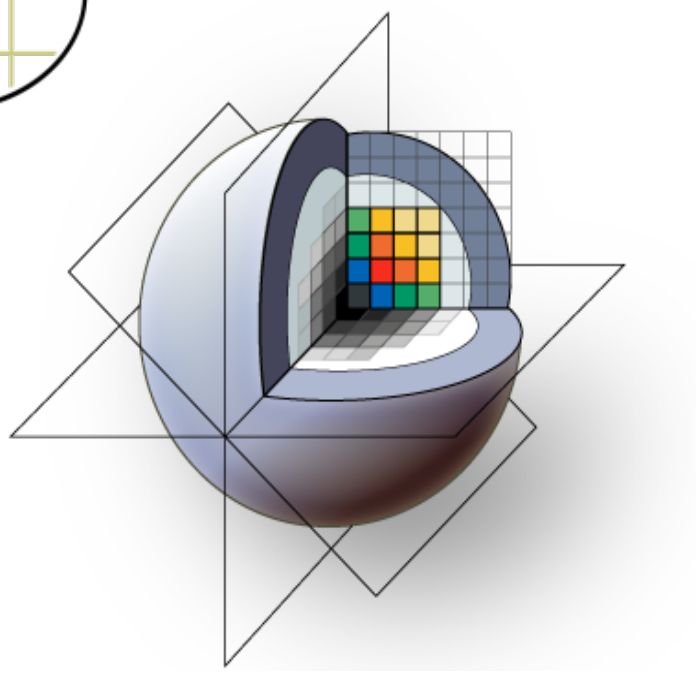
Slicer3 Training Tutorial
Using EM Segmenter with Non-Human Primate Images



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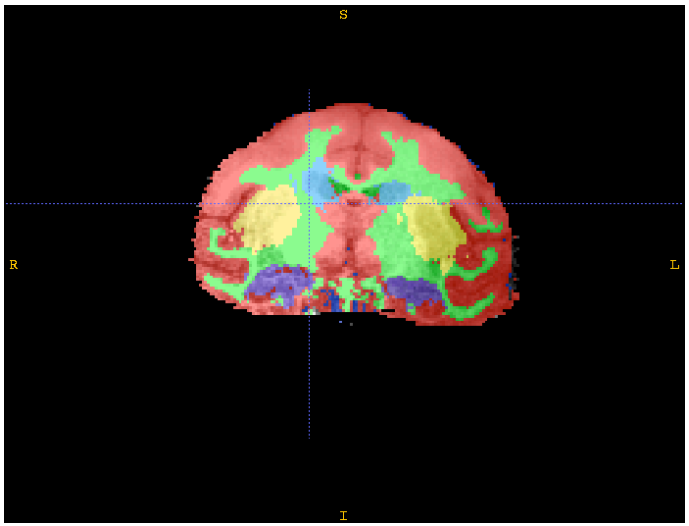
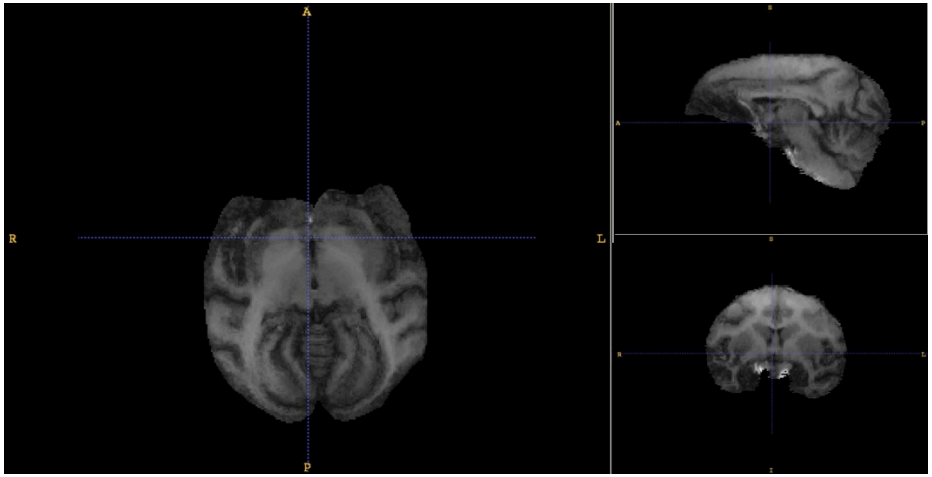
Learning Objective

The objective of this tutorial is to demonstrate how to use EM Segmenter to segment non-human primate images.

We have used examples of vervet T1 images in this tutorial but the procedure has been used successfully for other species as well.





Prerequisites

This tutorial assumes that you have already completed the tutorial **Data Loading and Visualization**. Tutorials for **Slicer3** are available at the following location:

- **Slicer3** tutorials
http://www.na-mic.org/Wiki/index.php/Slicer3.2:Training

Prerequisites

We have developed two command-line tools for this procedure:

i. MaskImage - Uses a binary image to mask required input image

ii. RescaleIntensity - Rescale the intensity range of an image between user-specified lower and upper limits

These are available for download (using subversion) from:

https://bsl-1.ece.vt.edu/svn/BSL-Slicer3-Modules/

These tools can be installed by following the tutorials at:

http://wiki.na-mic.org/Wiki/images/4/46/Slicer3CourseForDevelopers_SPujol.ppt

Prerequisites

This procedure requires the use of a non-registration method. We recommend the use of Diffeomorphic Demons method which is available in Slicer3:

It can be obtained in two ways:

i. CLI module in the latest developmental version of Slicer3 (Slicer3.3 Alpha).

ii. As a part of Slicer3 NITRC modules, downloadable from: http://www.nitrc.org/projects/brainsdemonwarp/

In this tutorial we use the CLI module available in Slicer3.3 Alpha

Diffeomorphic Demons is also available from: http://hdl.handle.net/1926/510

Materials

This tutorial requires the installation of the **Slicer3** software and the tutorial dataset. They are available at the following locations:

- **Slicer3** download page (***Slicer 3.2***)

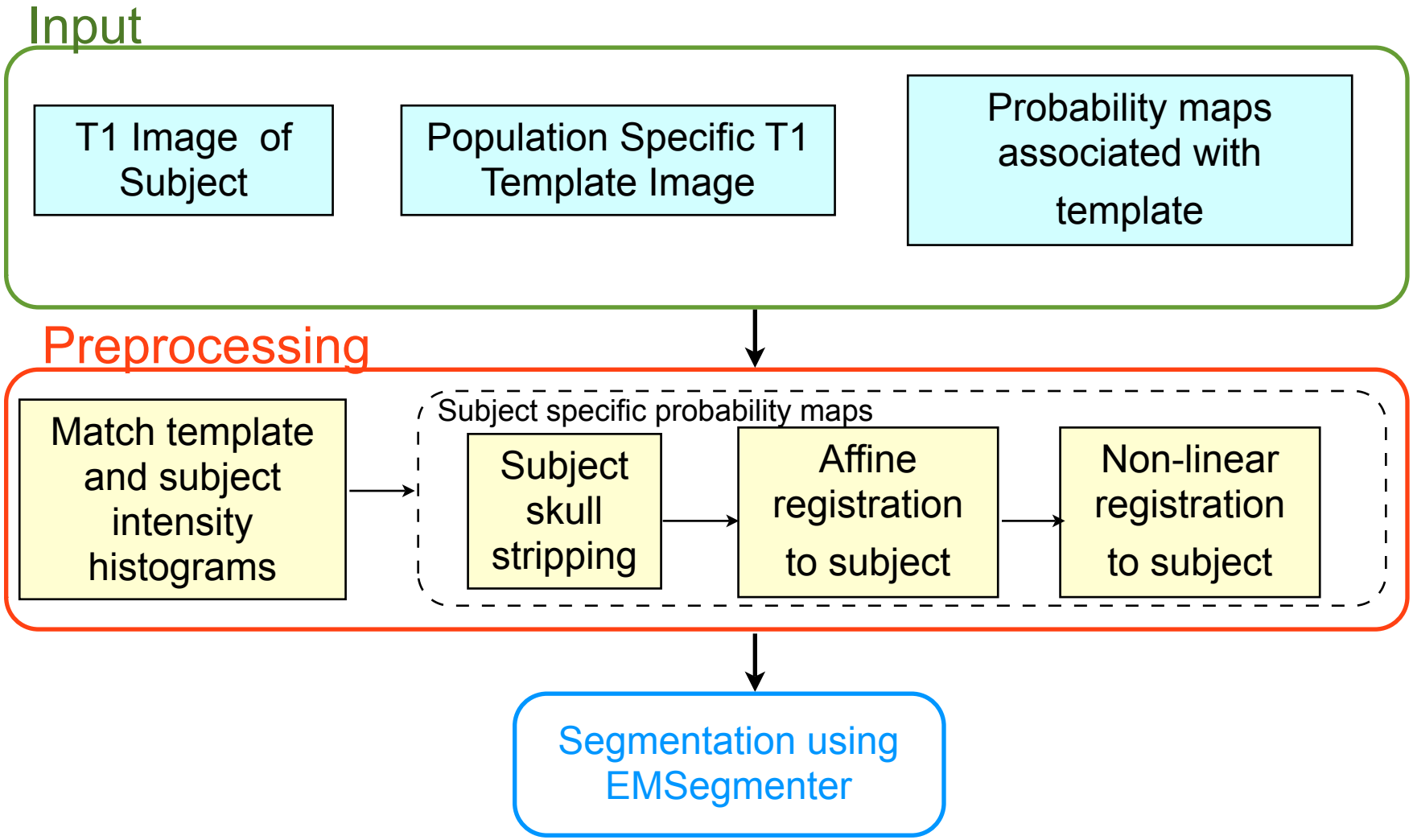
http://www.slicer.org/pages/Downloads/

- Tutorial dataset (***Vervet Slicer Tutorial***)

http://www.bsl.ece.vt.edu/data/vervet_atlas/vervet.php

Disclaimer: *It is the responsibility of the user of Slicer to comply with both the terms of the license and with the applicable laws, regulations, and rules.*

Segmentation Procedure



Input for Segmentation

Input

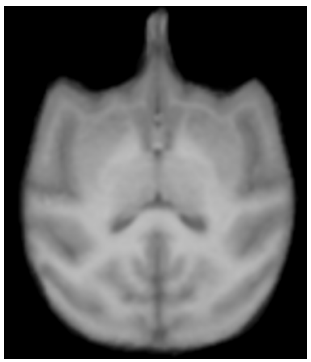
- The image to be segmented is the primary input.
- In this tutorial we deal with segmenting the T1 image of a vervet subject.
- This can be extended to multi-channel segmentation using the example in:http://wiki.na-mic.org/Wiki/images/2/2f/AutomaticSegmentation_SoniaPujol_Munich2008.ppt
- The subject T1 volume is loaded into Slicer.

Input - Template Image and Probability Maps

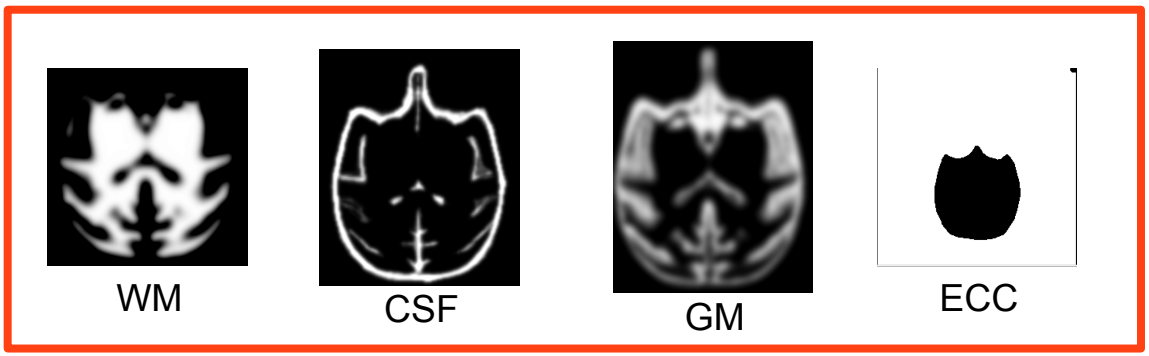
- We now load the vervet template image and tissue probability maps

- In this tutorial we have used the template and probability maps available for download from:

http://www.bsl.ece.vt.edu/data/vervet_atlas/vervet.php



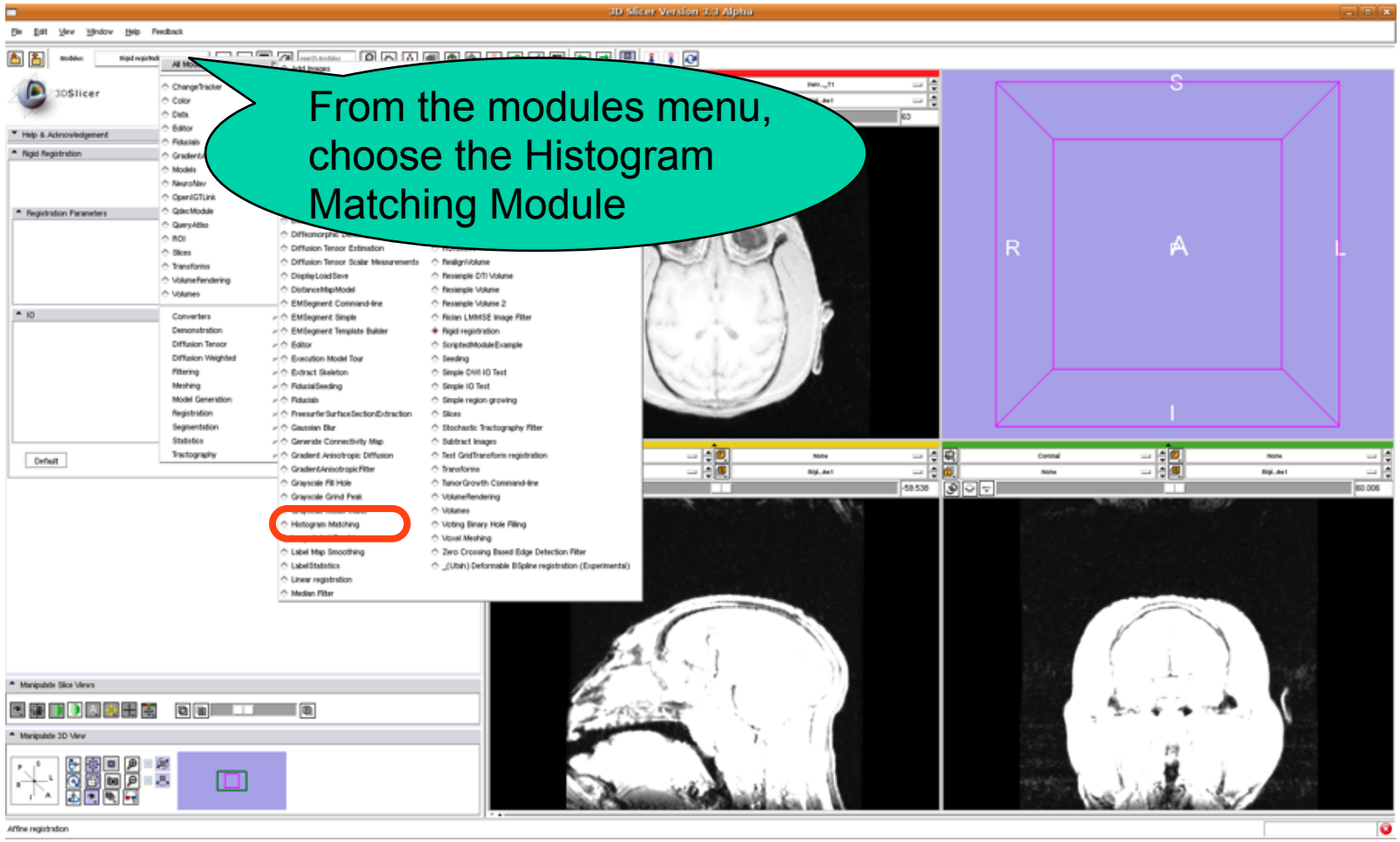
Template Image



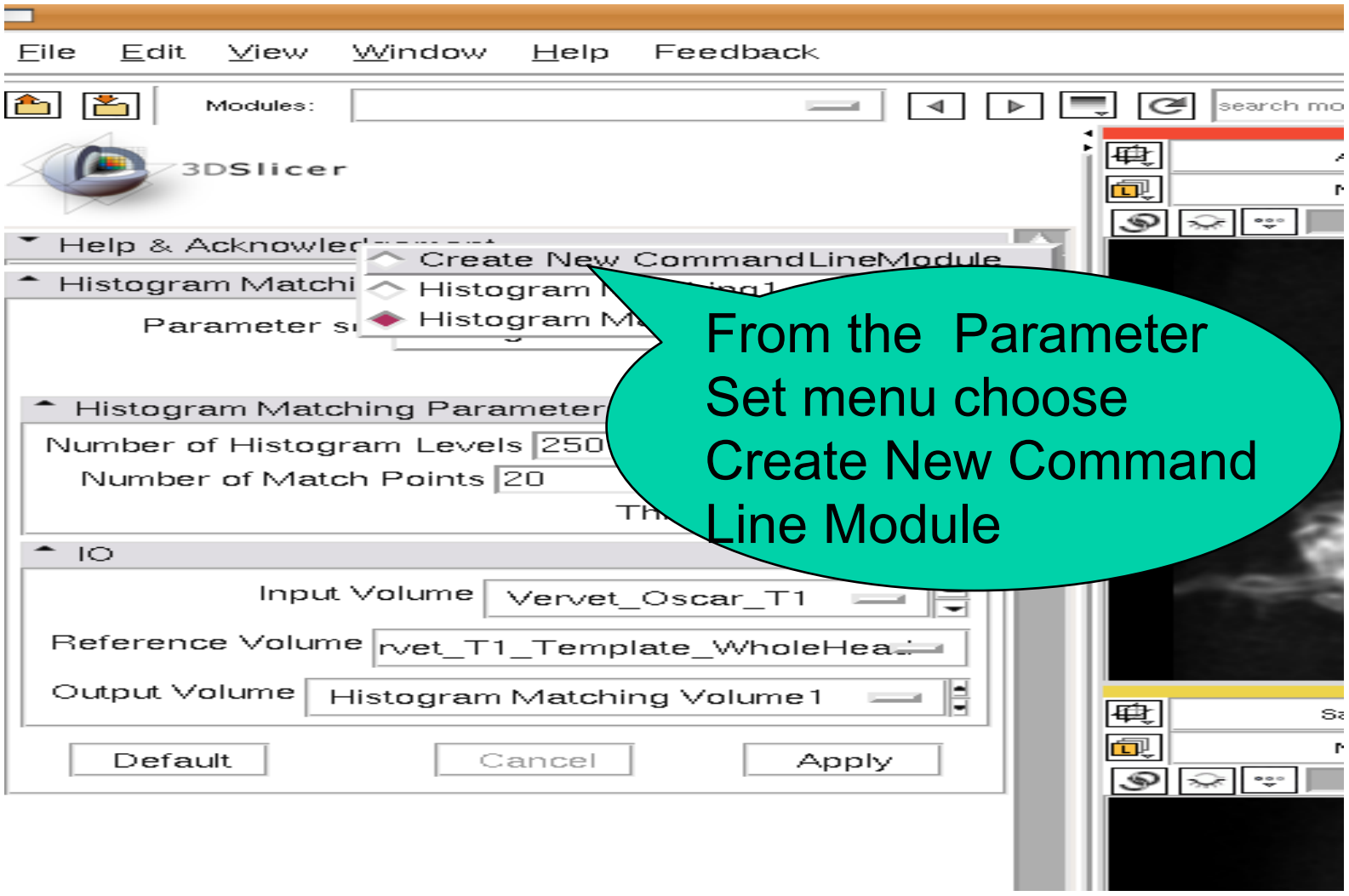
Probability Atlas

Preprocessing

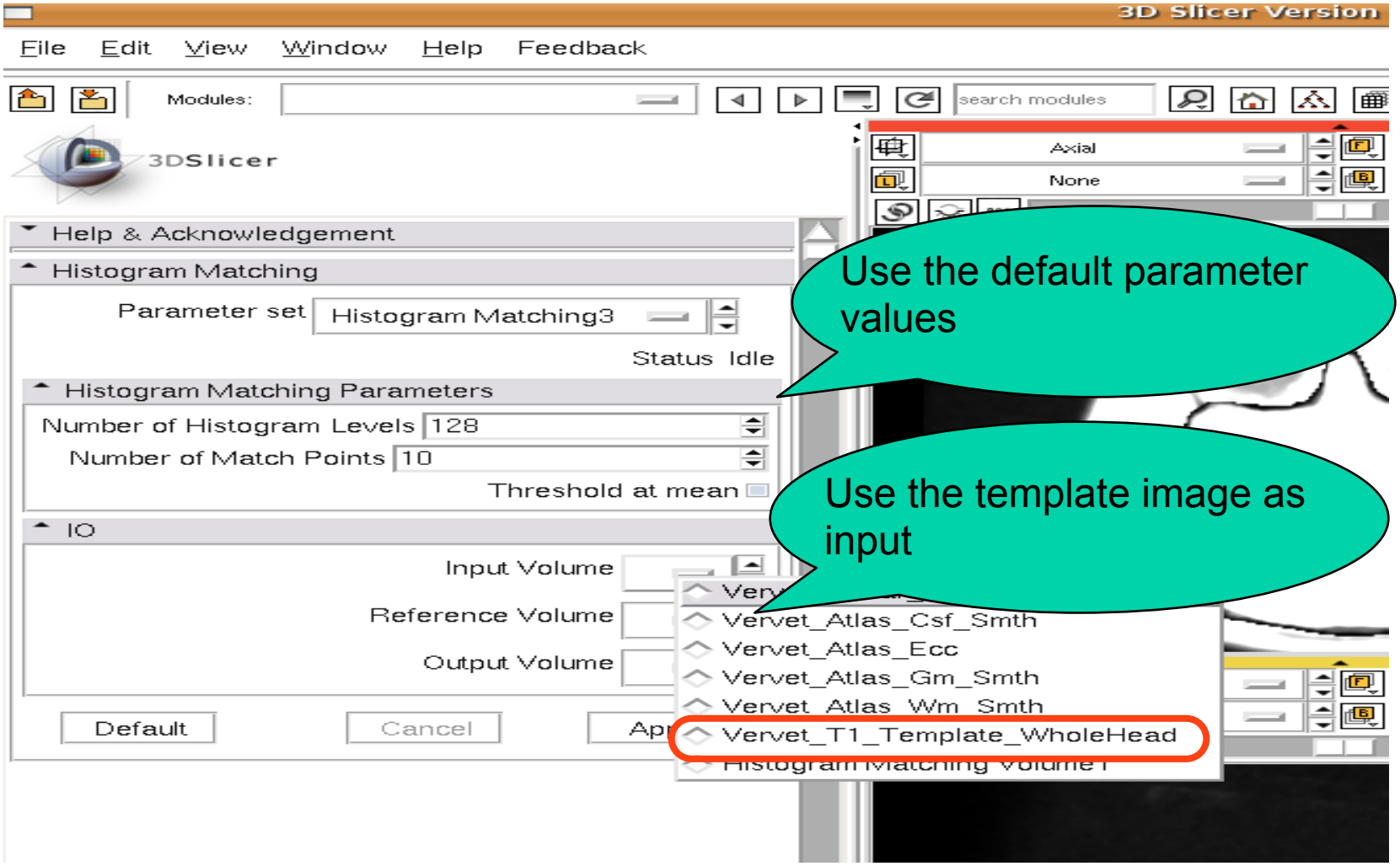
Histogram Matching



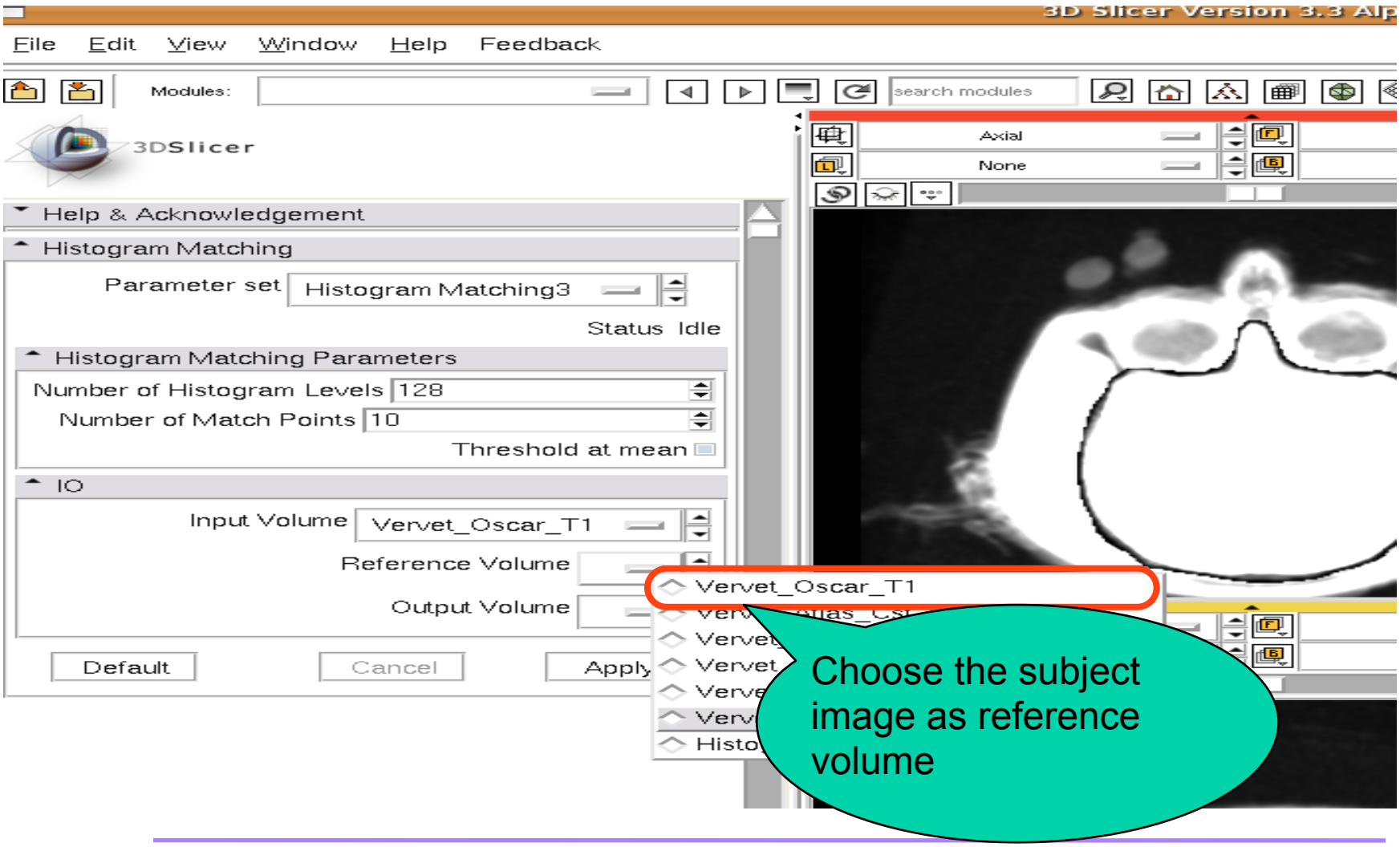
Histogram Matching



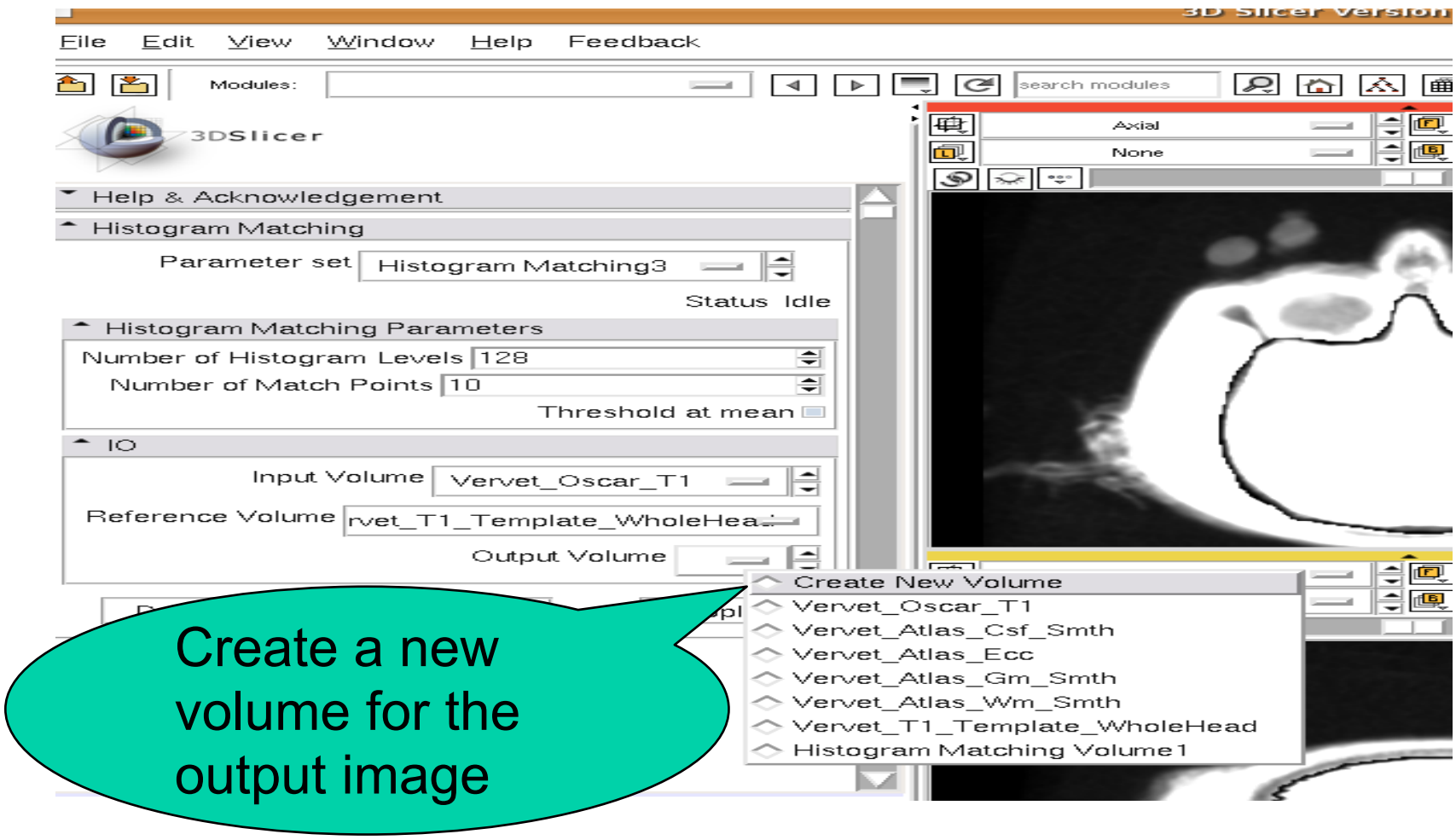
Histogram Matching



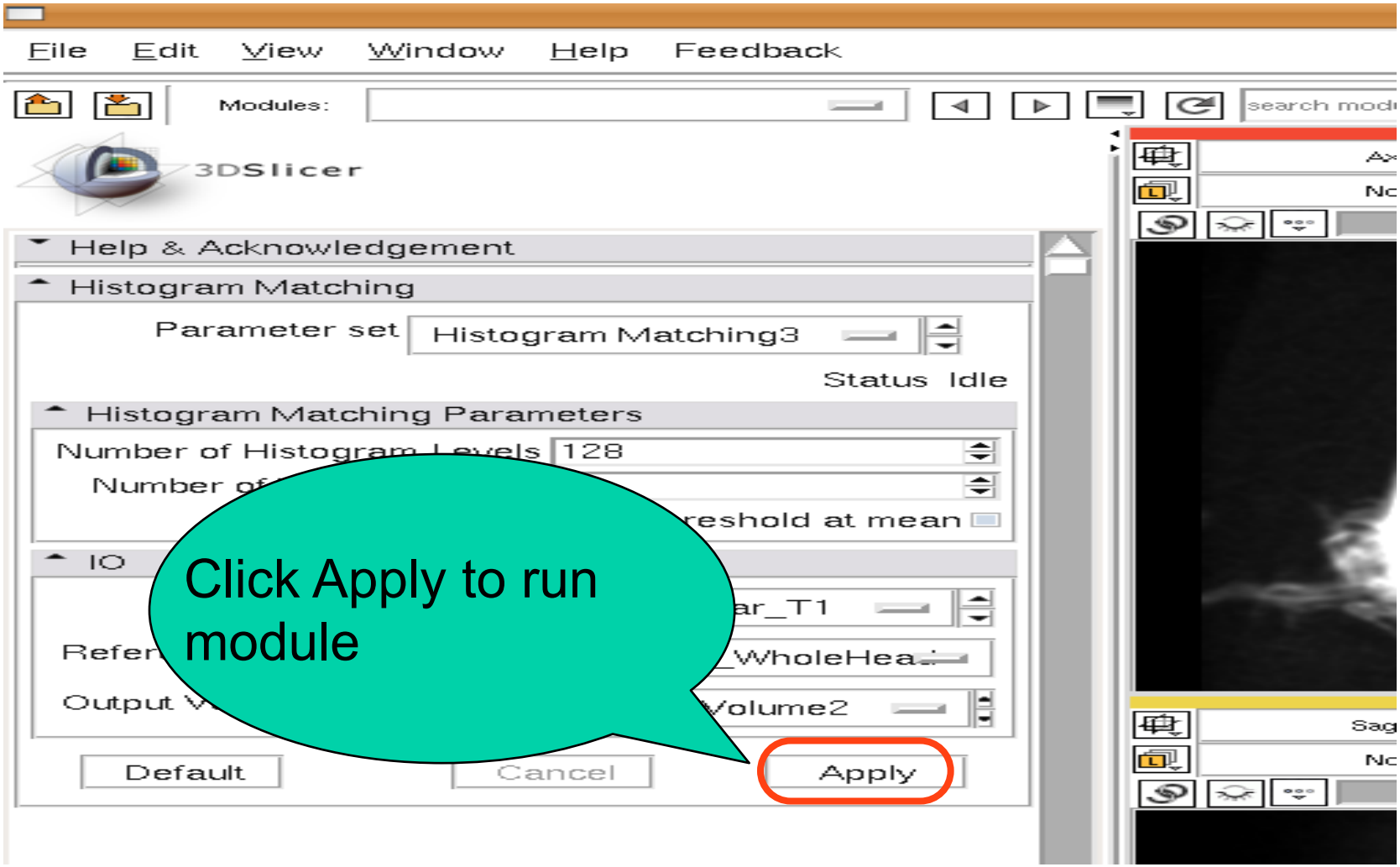
Histogram Matching



Histogram Matching

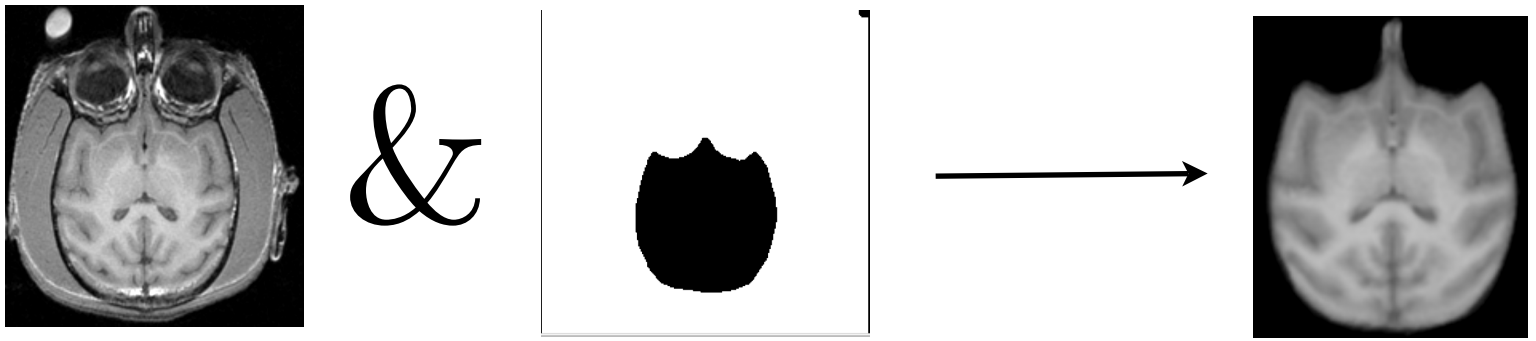


Histogram Matching



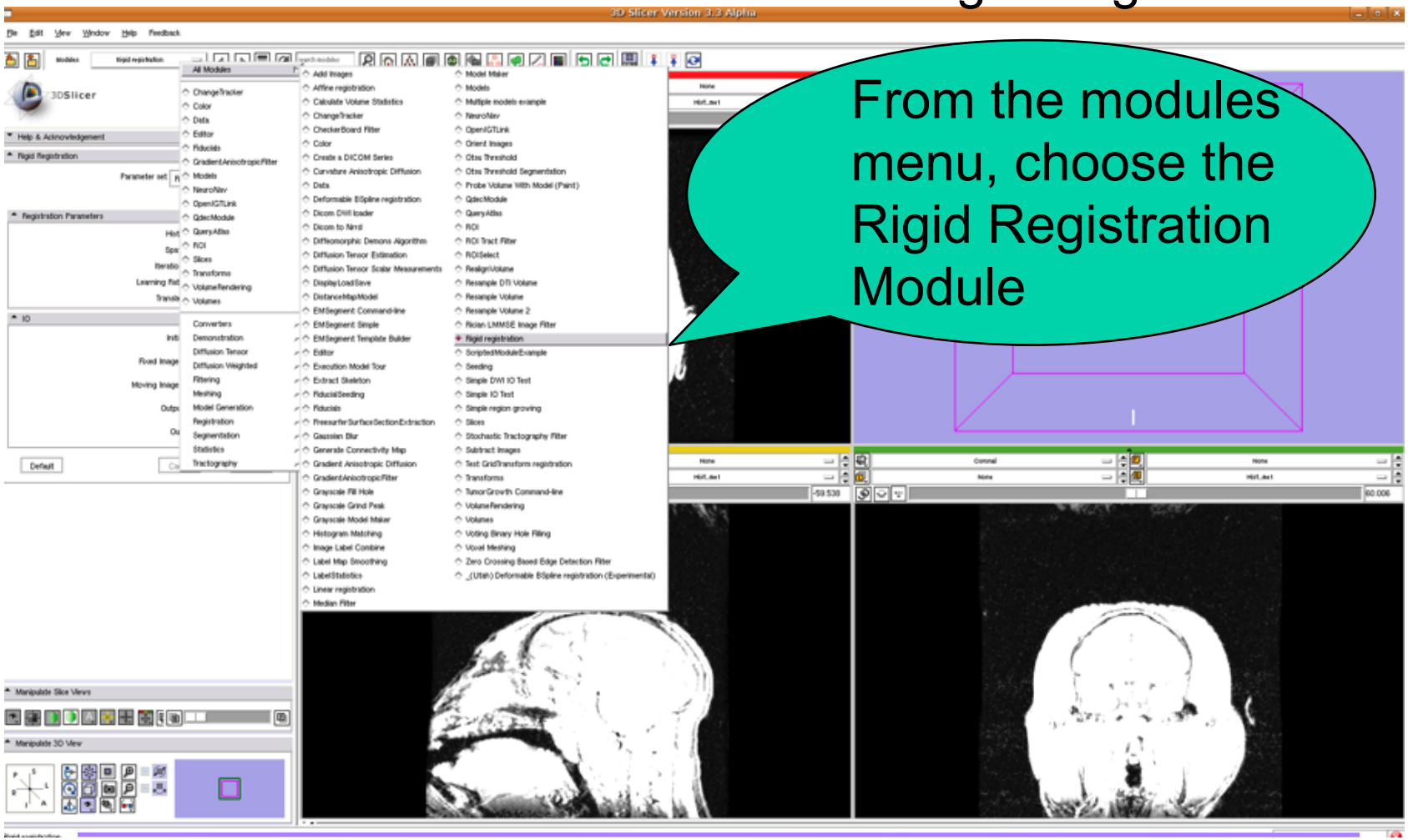
Subject Image Skull Stripping

- The Intra Cranial Content (ICC) of the subject is extracted.
- Improves probability map registration accuracy
- Creates more accurate patient specific atlas
- Two step procedure:
  - affine registration of ECC mask to subject
  - masking of subject by ECC mask



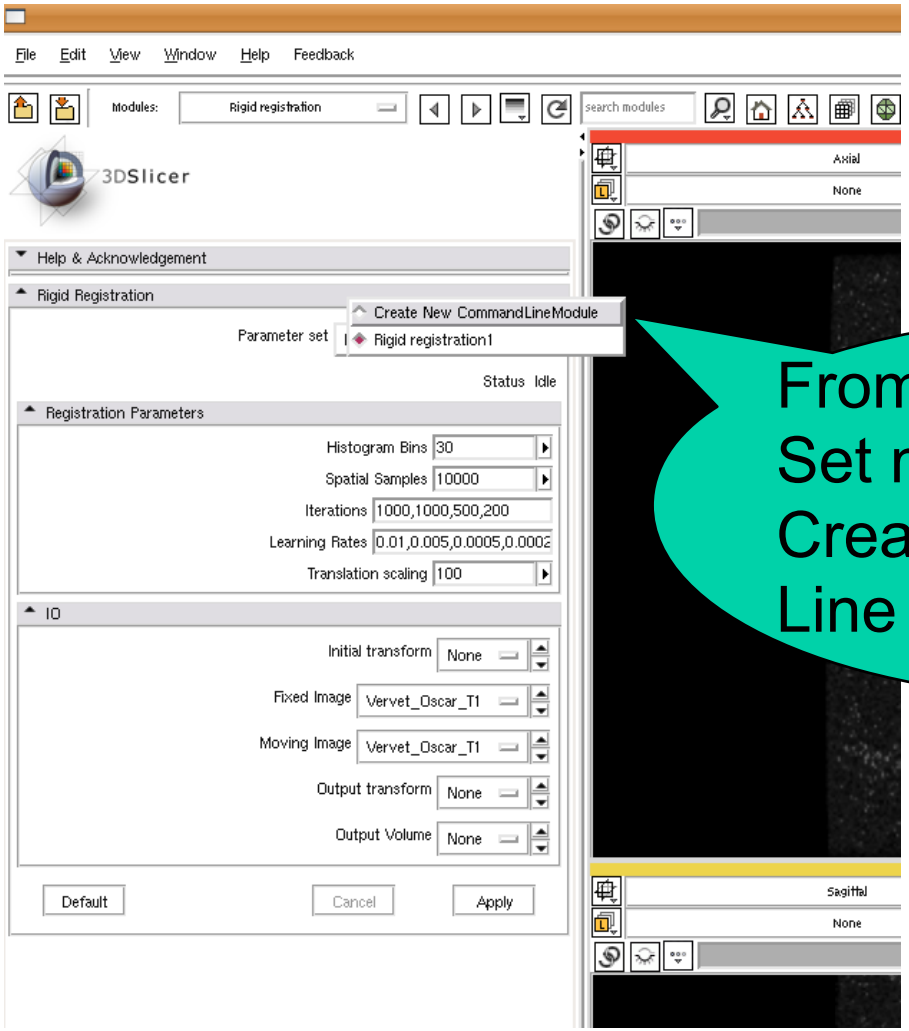
Subject Image Skull Stripping

Rigid Registration



Subject Image Skull Stripping

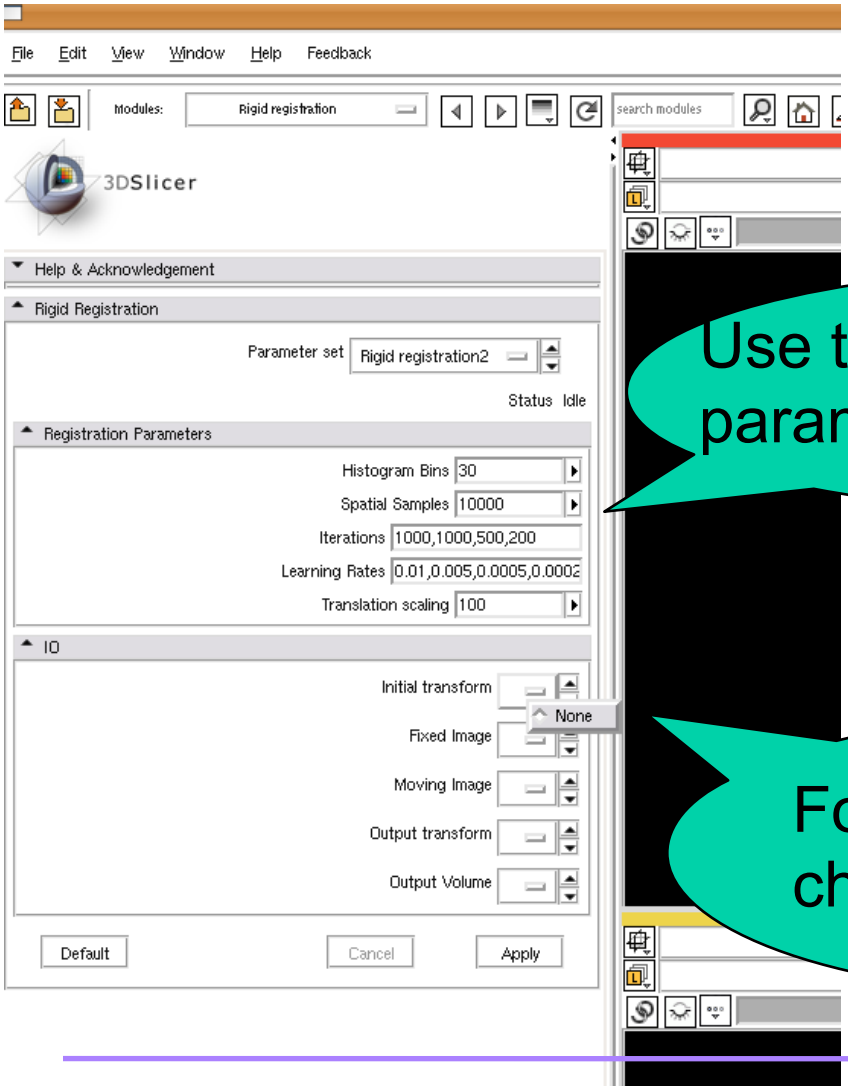
Rigid Registration



From the Parameter Set menu choose Create New Command Line Module

Subject Image Skull Stripping

Rigid Registration

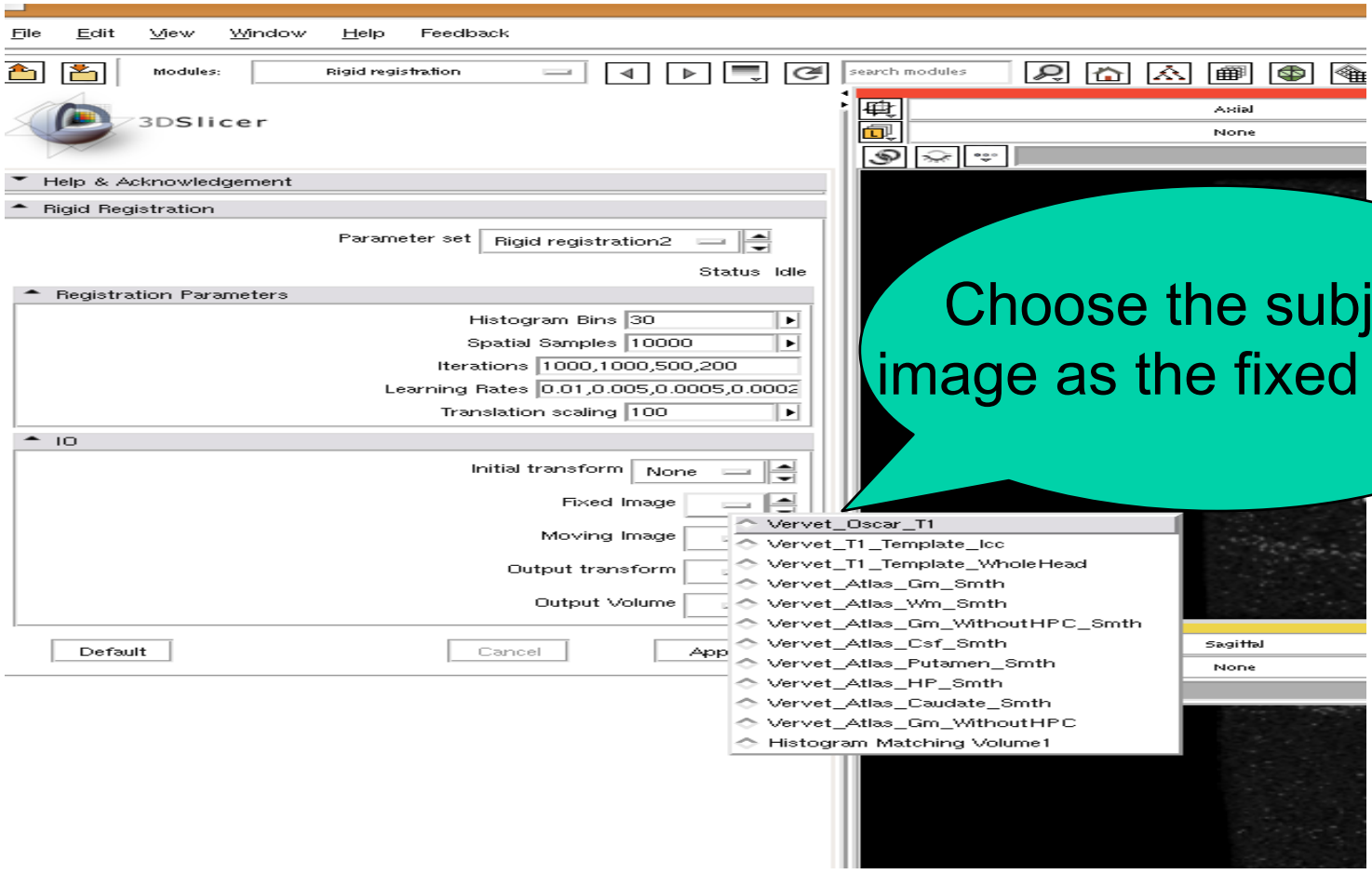


Use the default registration parameters

For initial transforms, choose None

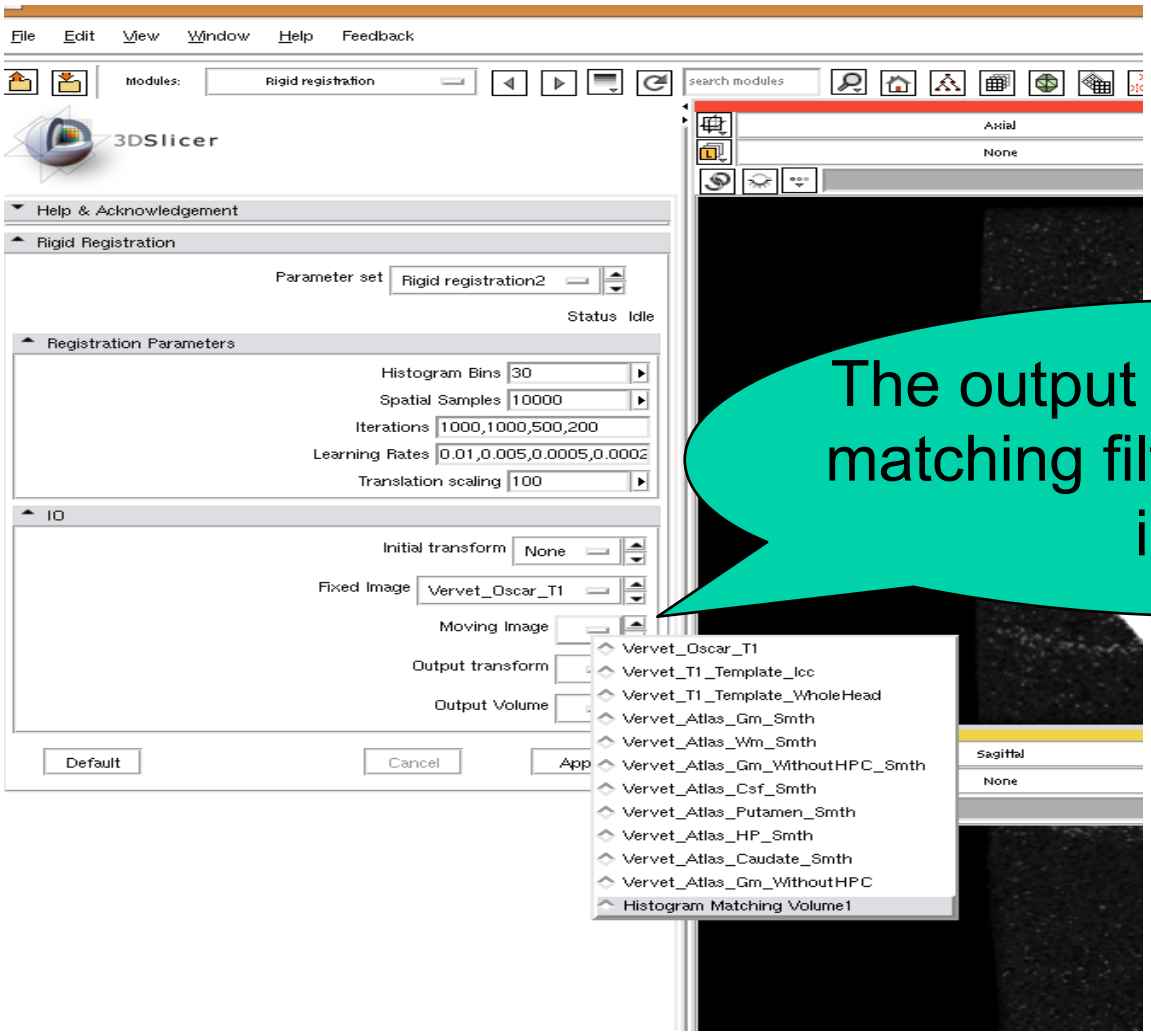
Subject Image Skull Stripping

Rigid Registration



Subject Image Skull Stripping

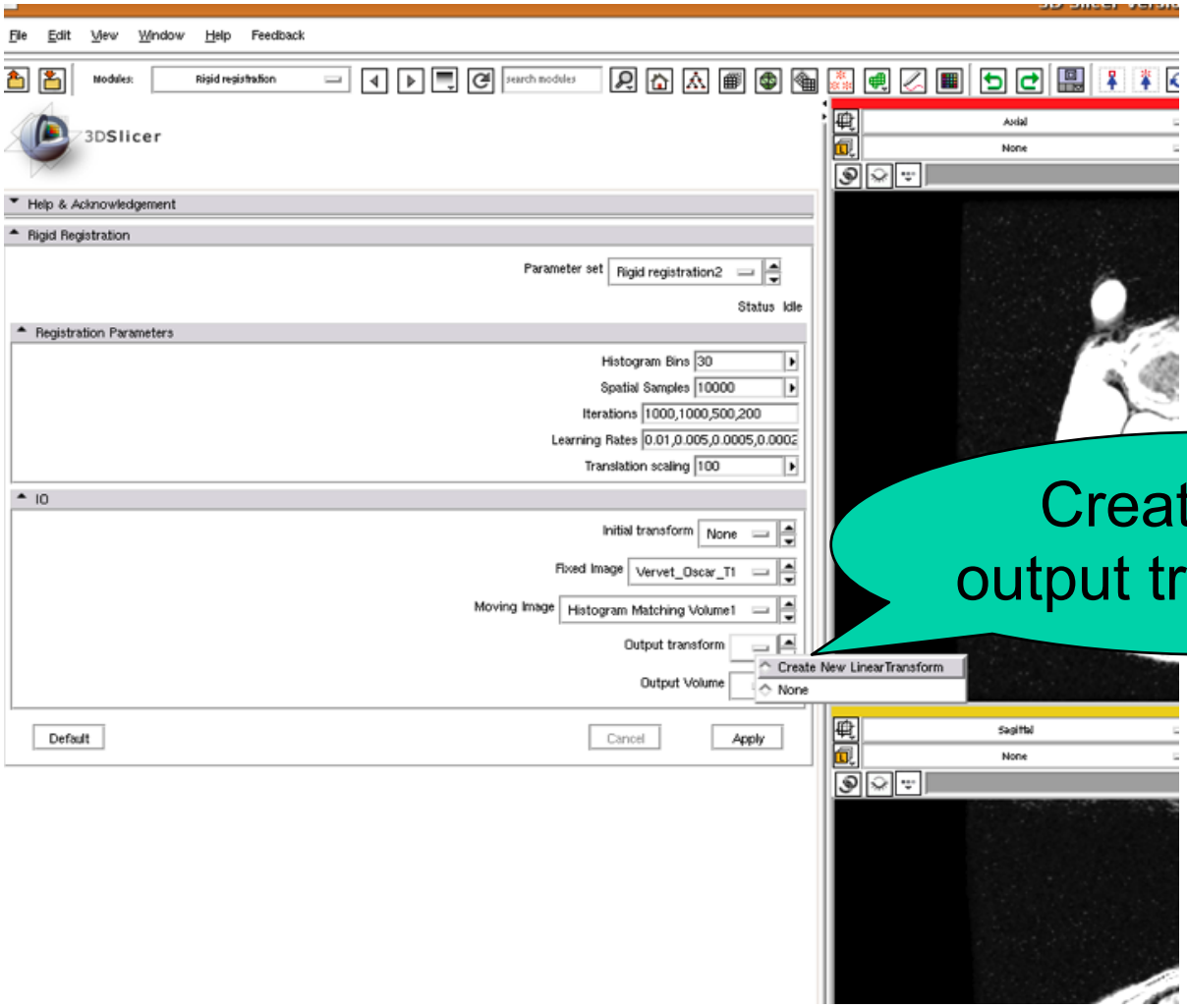
Rigid Registration



The output of the histogram matching filter is the moving image

Subject Image Skull Stripping

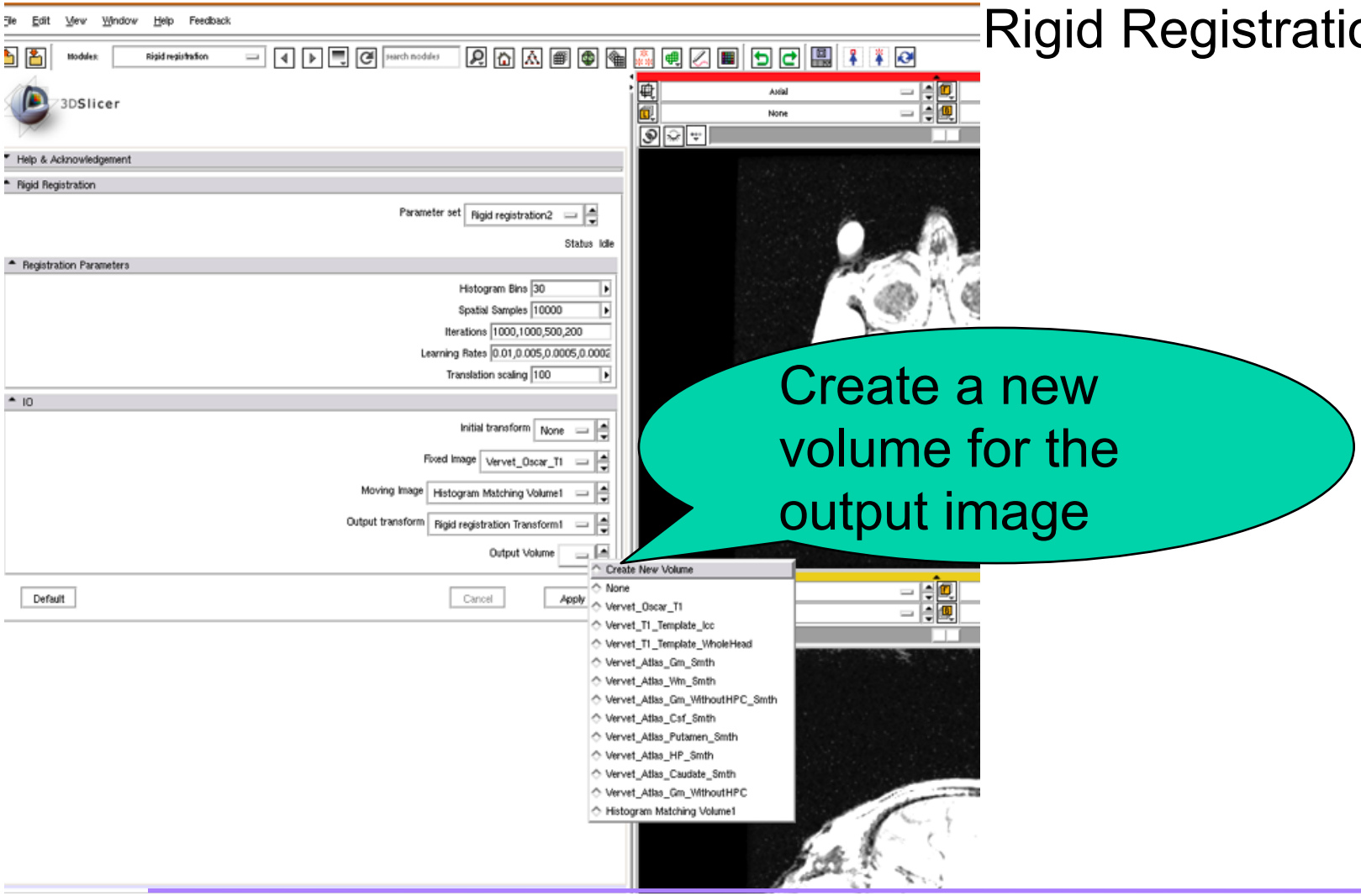
Rigid Registration



Create a new output transform

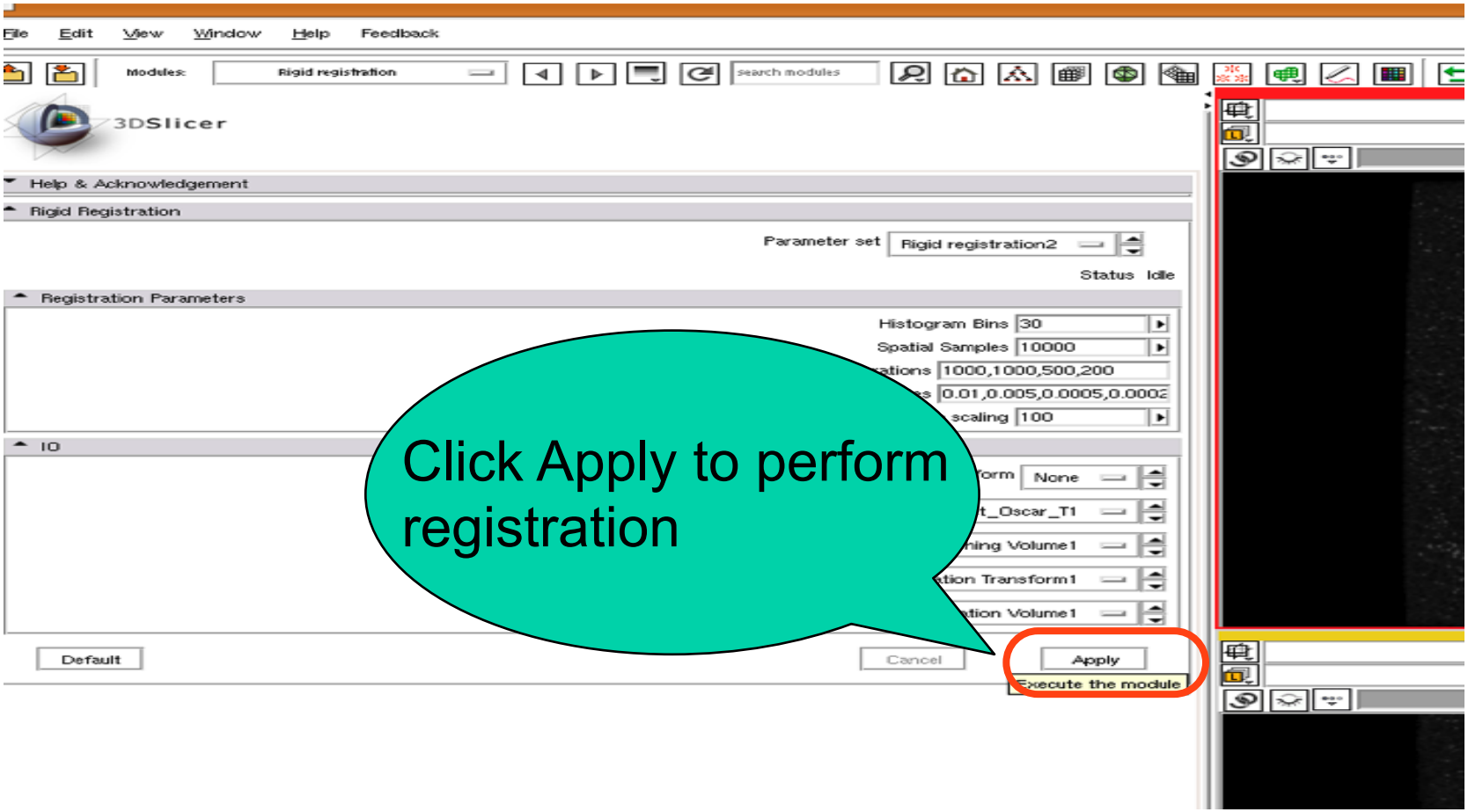
Subject Image Skull Stripping

Rigid Registration



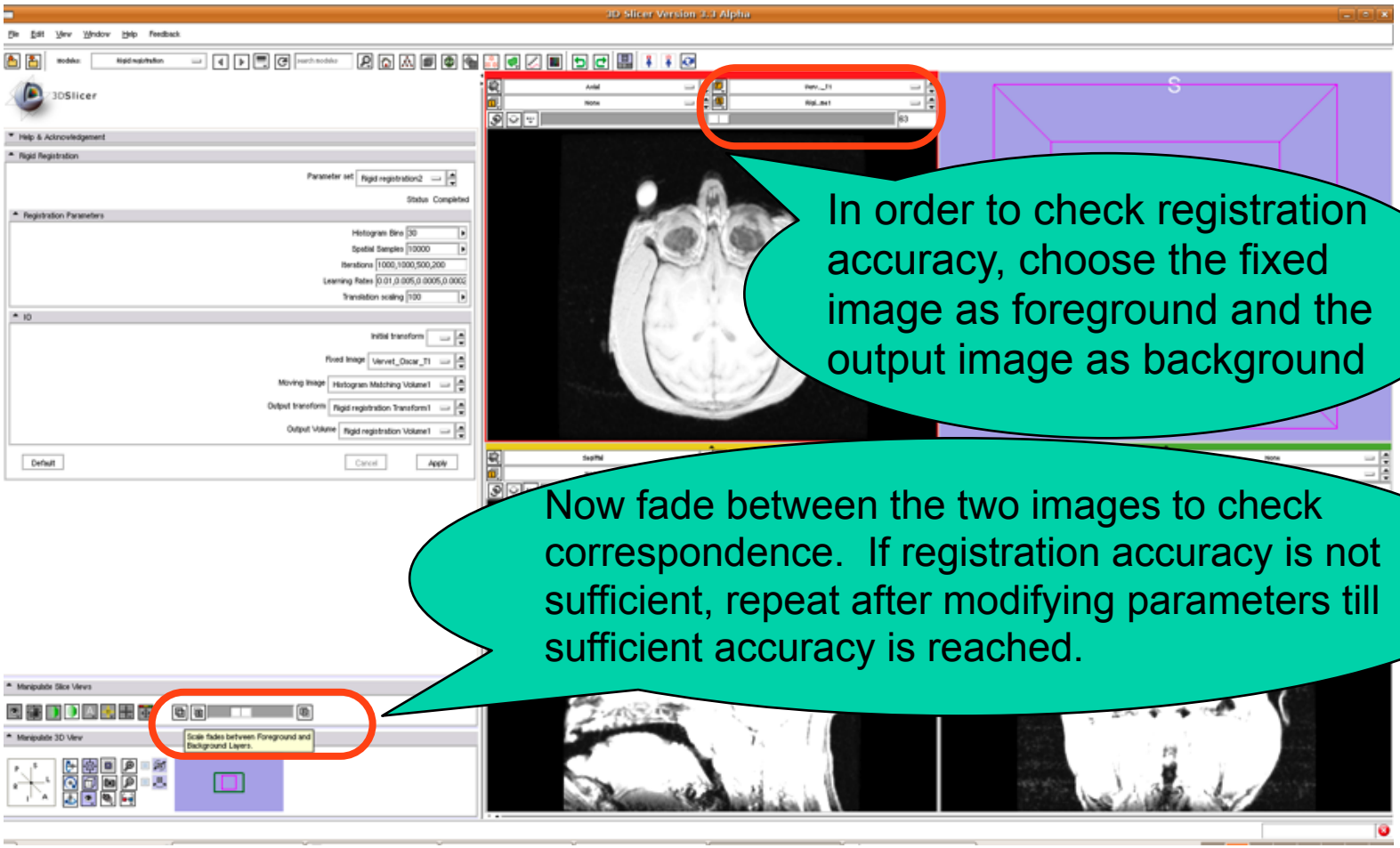
Subject Image Skull Stripping

Rigid Registration



Subject Image Skull Stripping

Rigid Registration



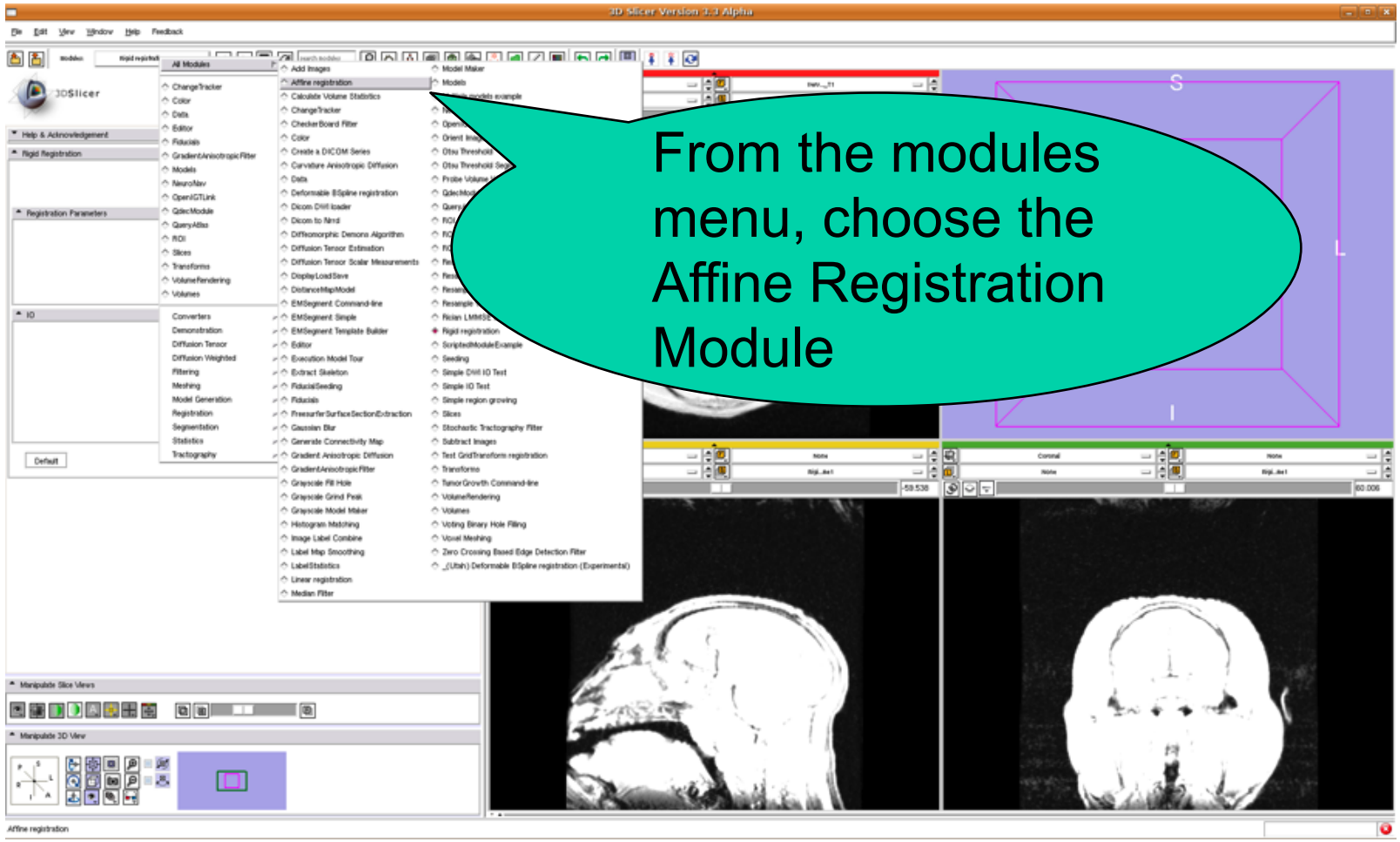
Subject Image Skull Stripping

Affine Registration

- The next step is to perform affine registration.
- The rigid transform is used as the starting point

Subject Image Skull Stripping

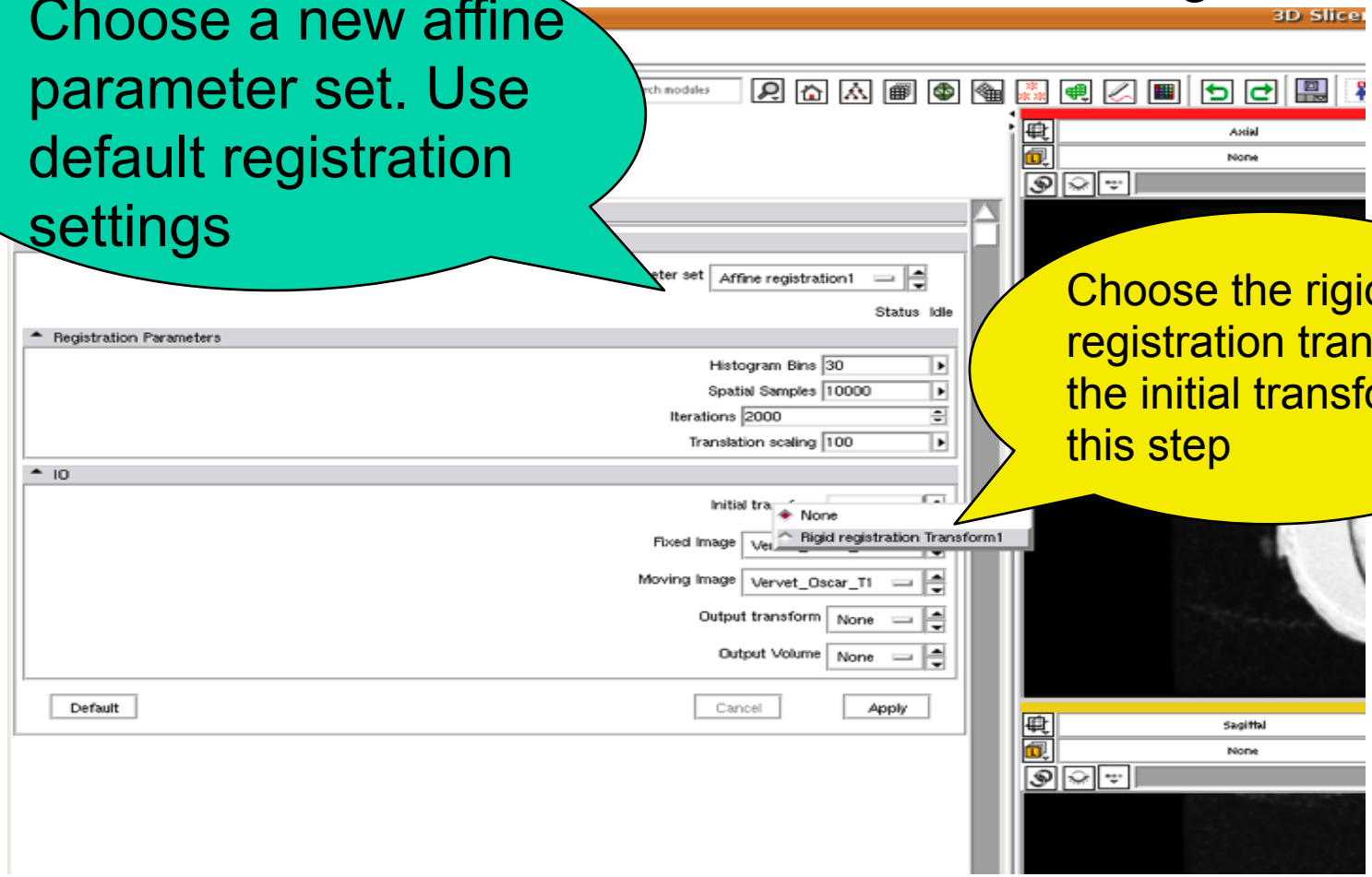
Affine Registration



Subject Image Skull Stripping

Affine Registration

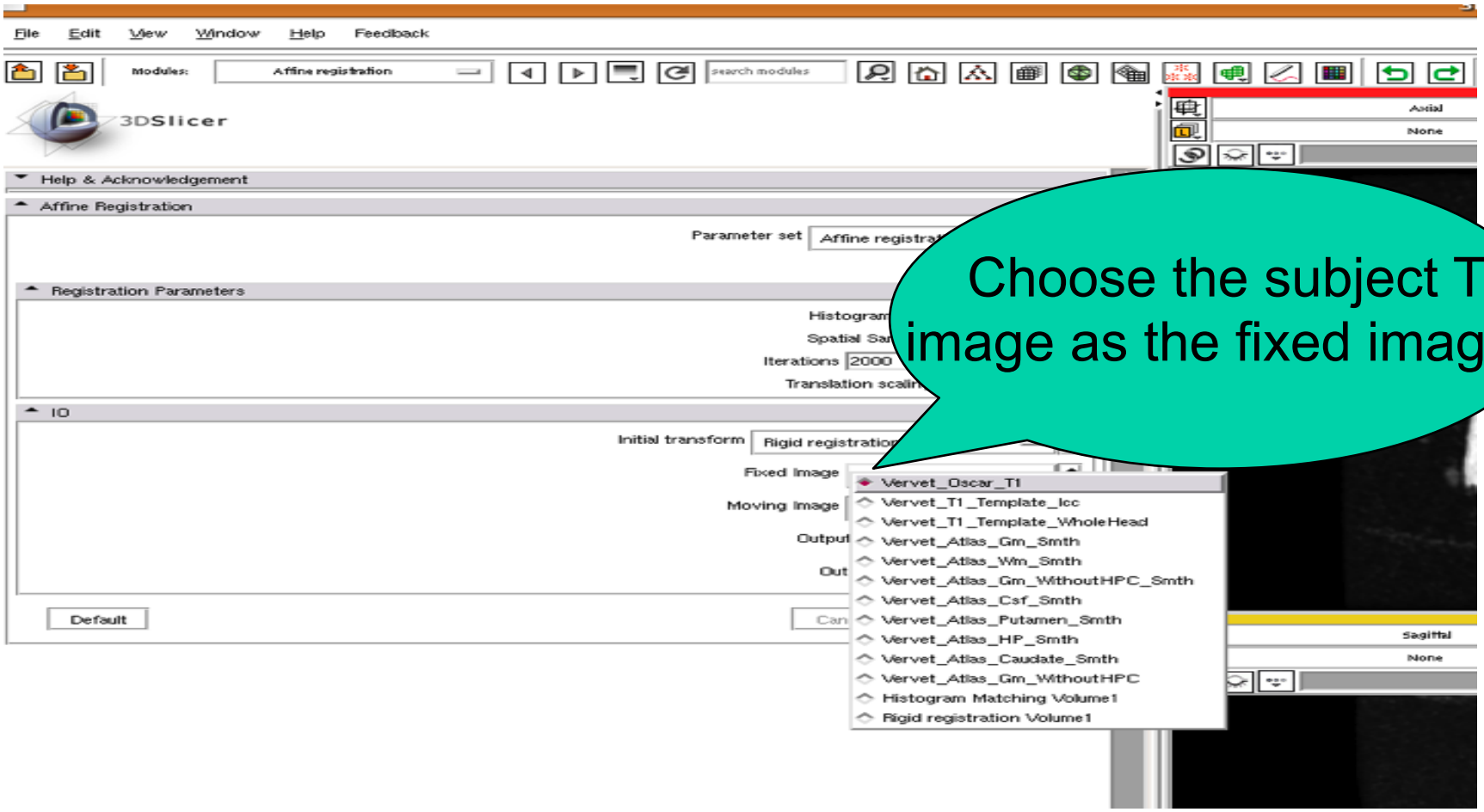
Choose a new affine parameter set. Use default registration settings



Choose the rigid registration transform as the initial transform for this step

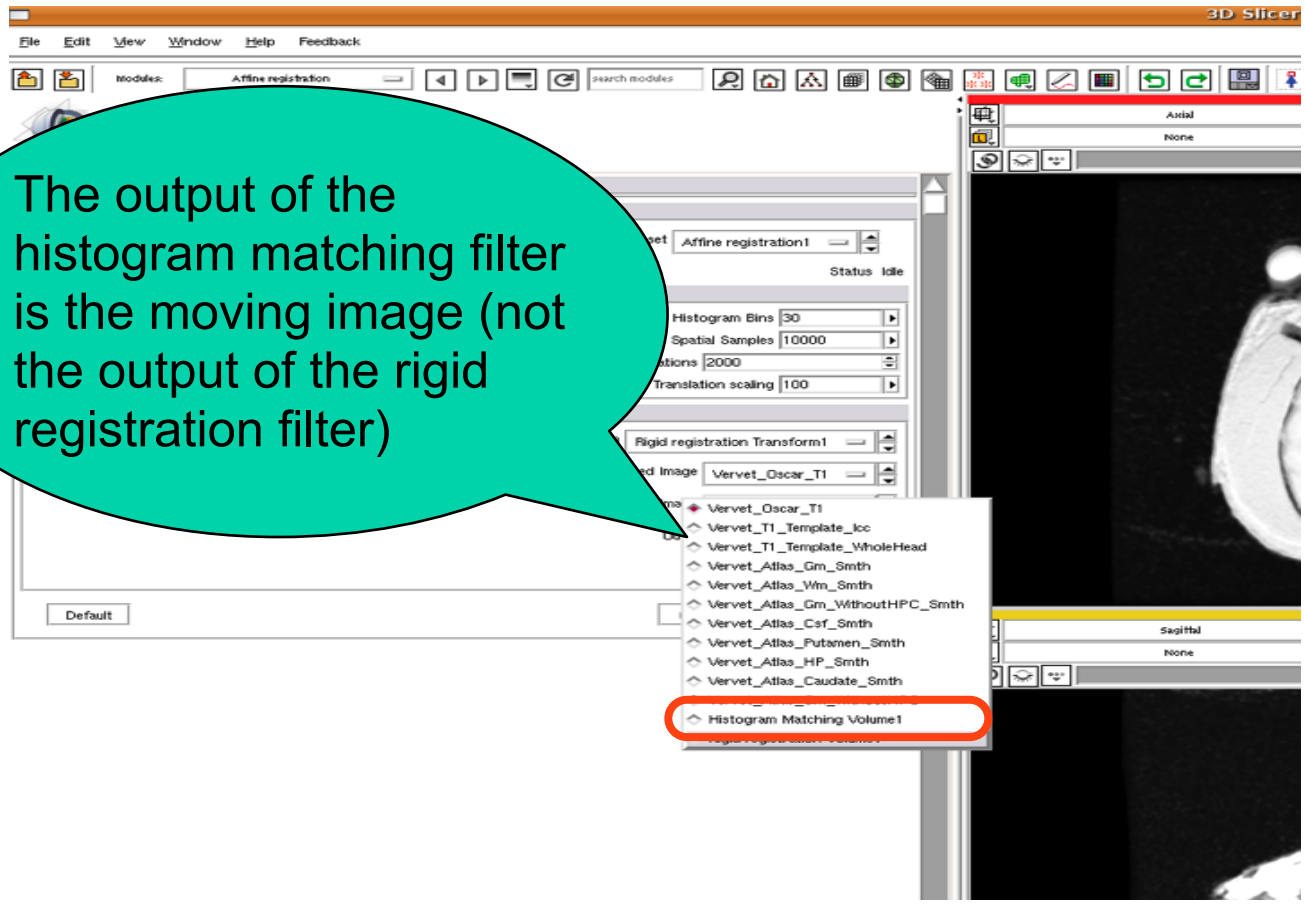
Subject Image Skull Stripping

Affine Registration



Subject Image Skull Stripping

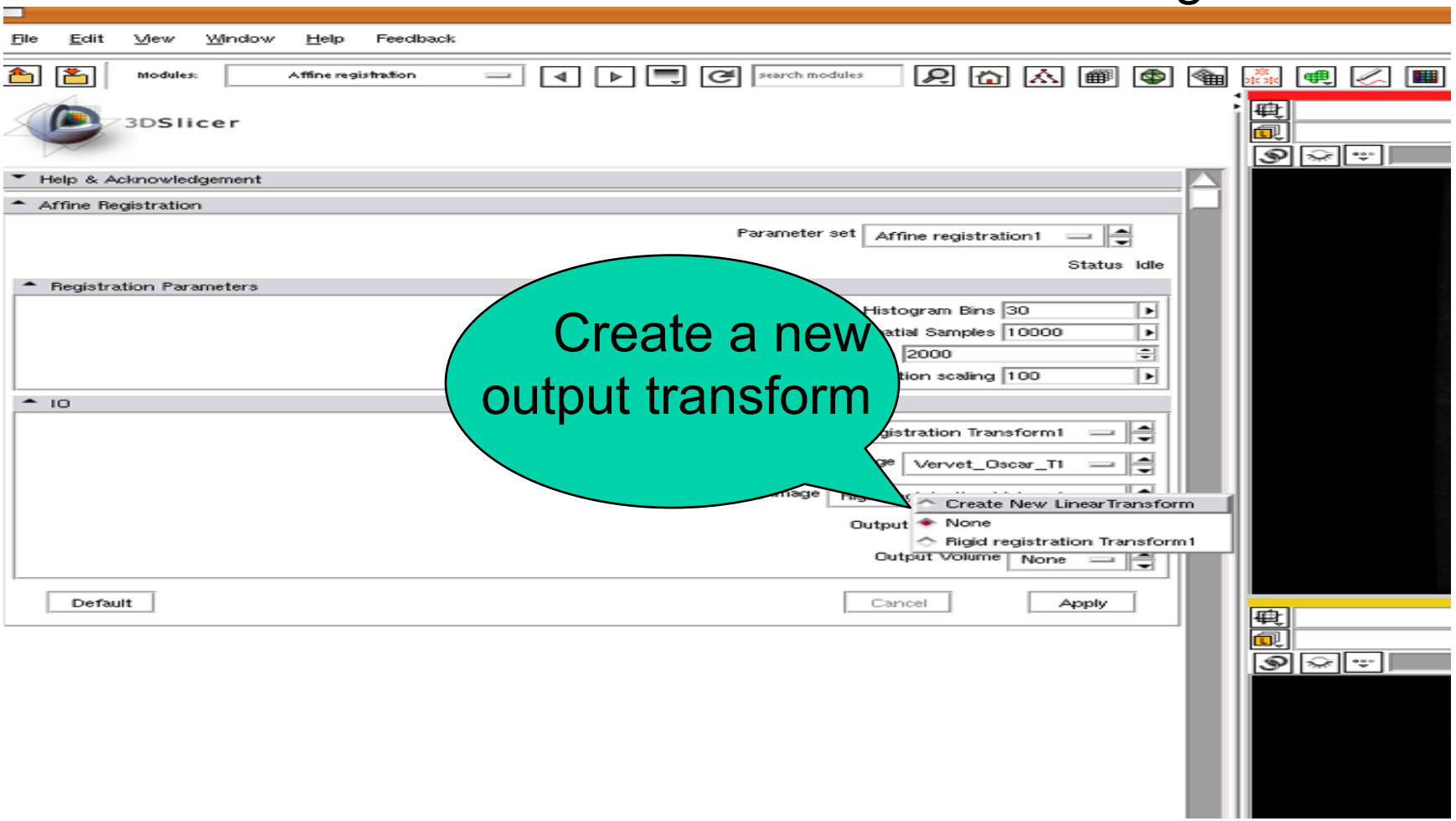
Affine Registration



The output of the histogram matching filter is the moving image (not the output of the rigid registration filter)

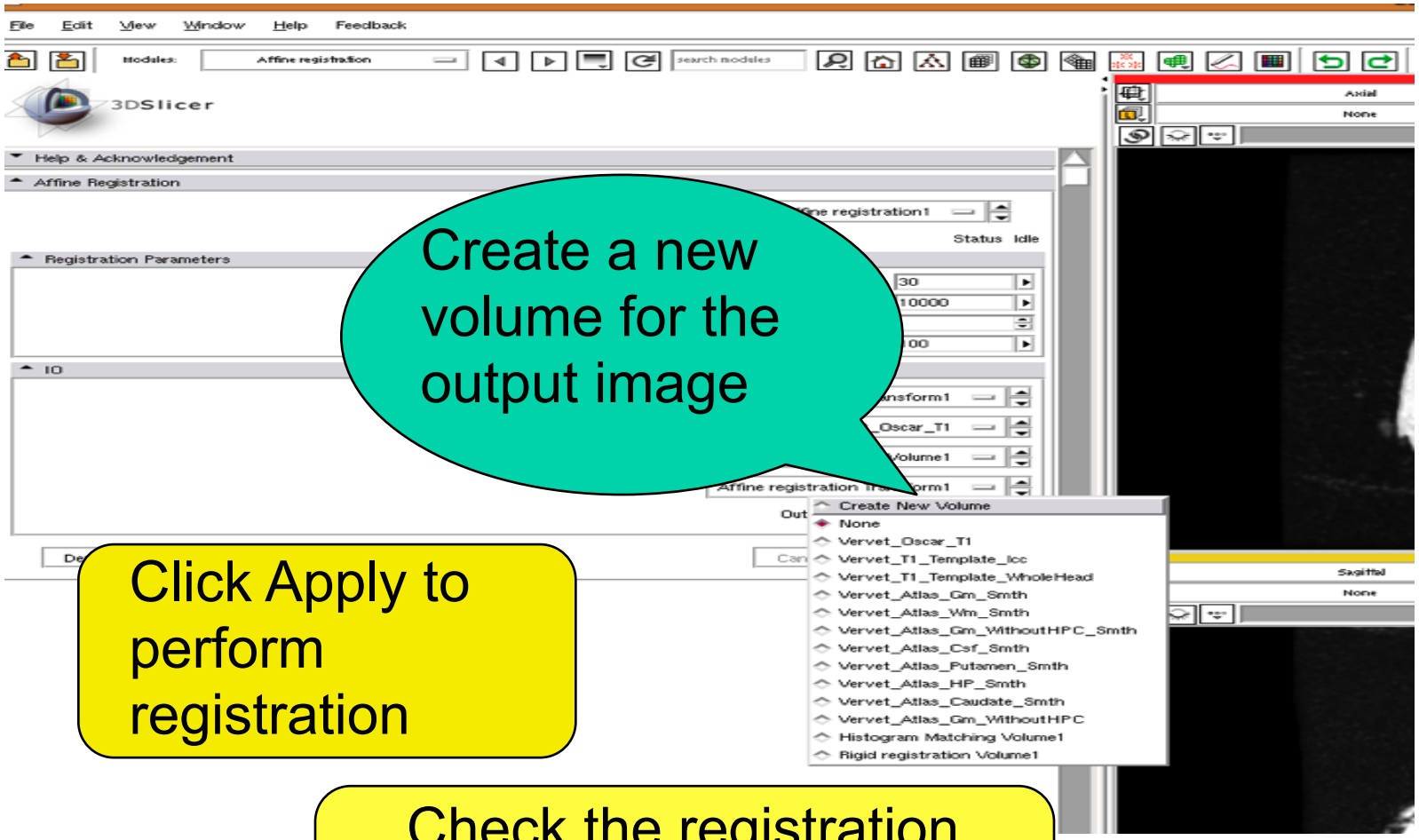
Subject Image Skull Stripping

Affine Registration



Subject Image Skull Stripping

Affine Registration



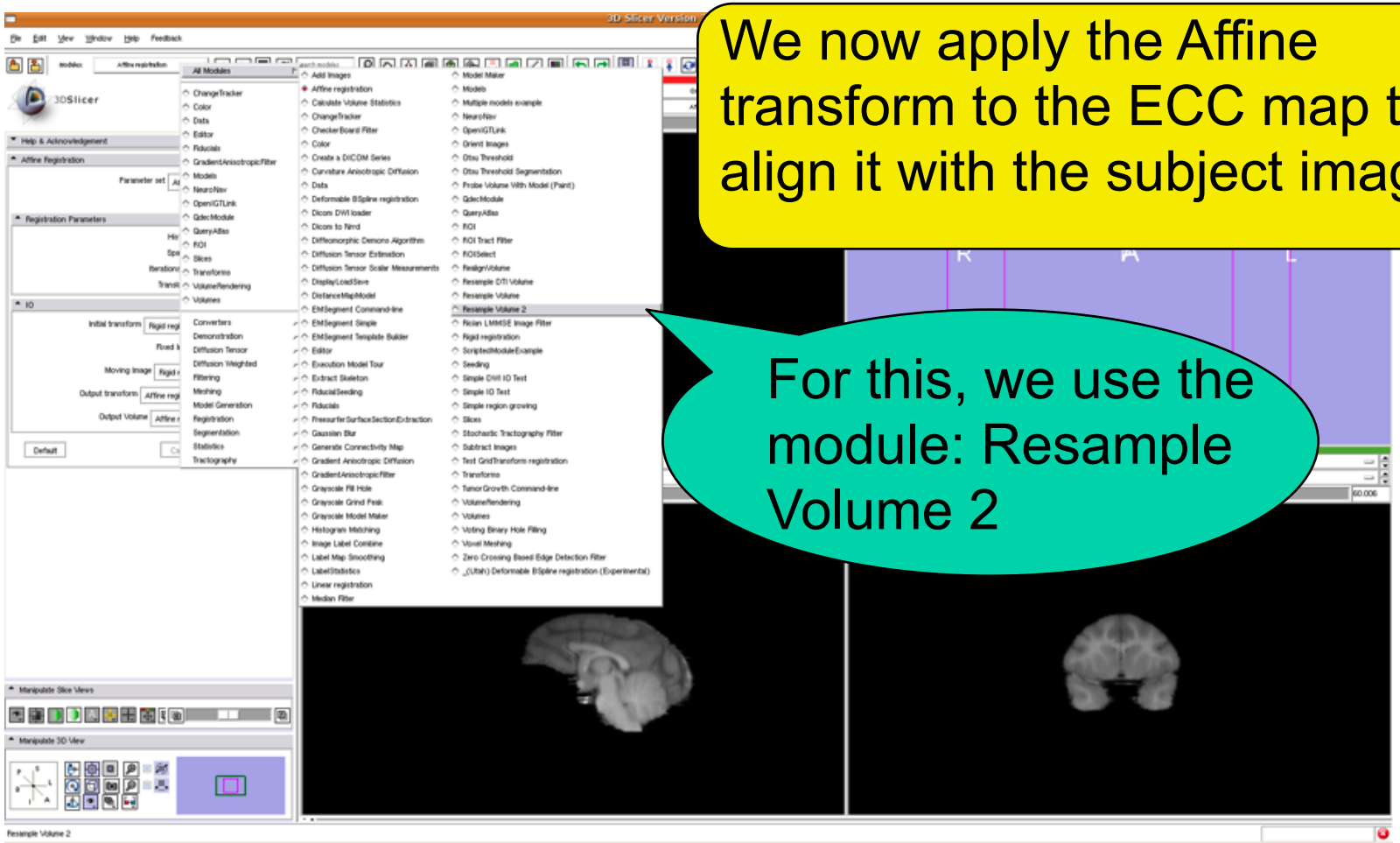
Create a new volume for the output image

Click Apply to perform registration

Check the registration accuracy as in the rigid registration step.

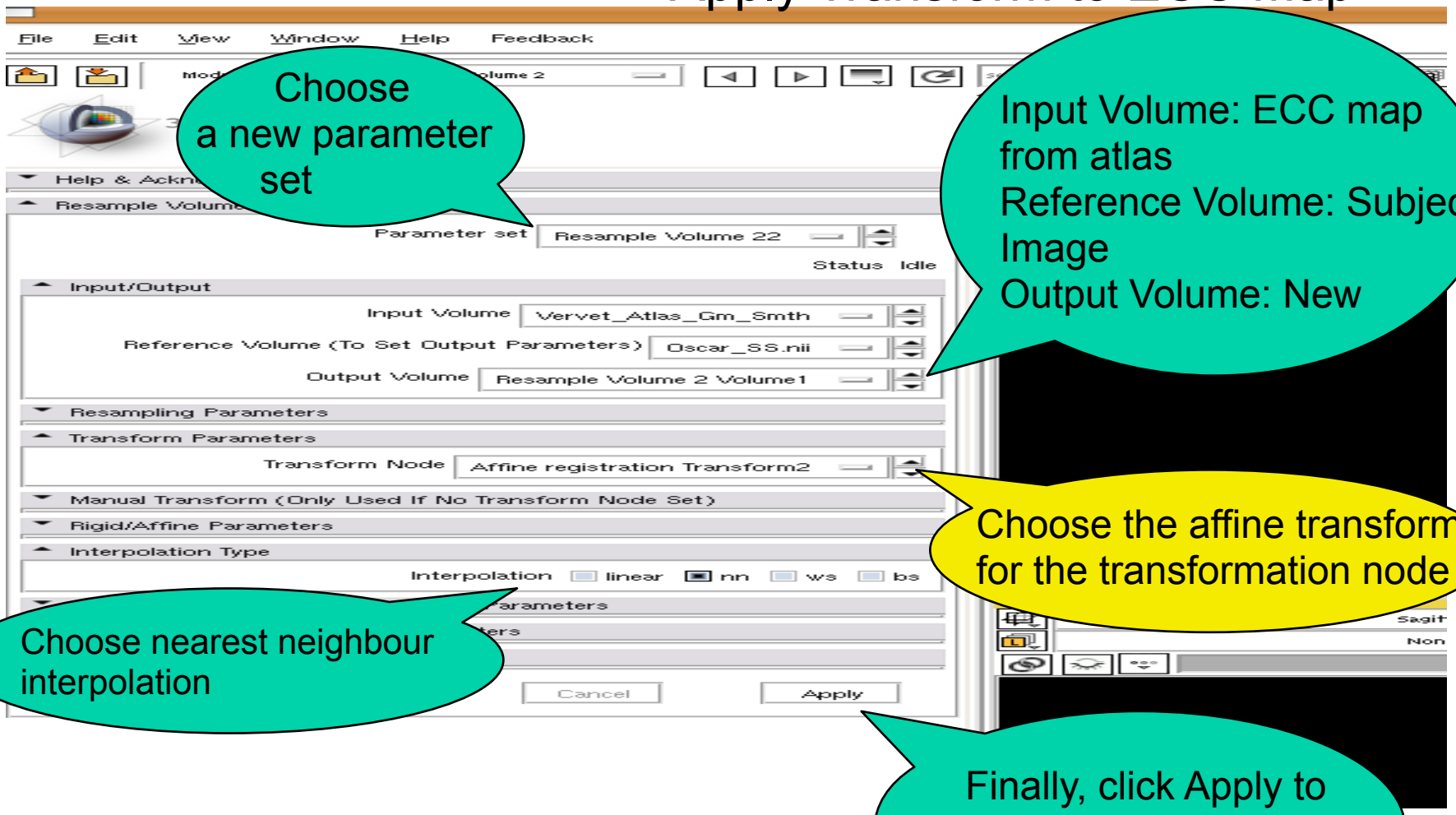
Subject Image Skull Stripping

Apply Transform to ECC Map



Subject Image Skull Stripping

Apply Transform to ECC Map



Choose a new parameter set

Input Volume: ECC map from atlas
Reference Volume: Subject Image
Output Volume: New

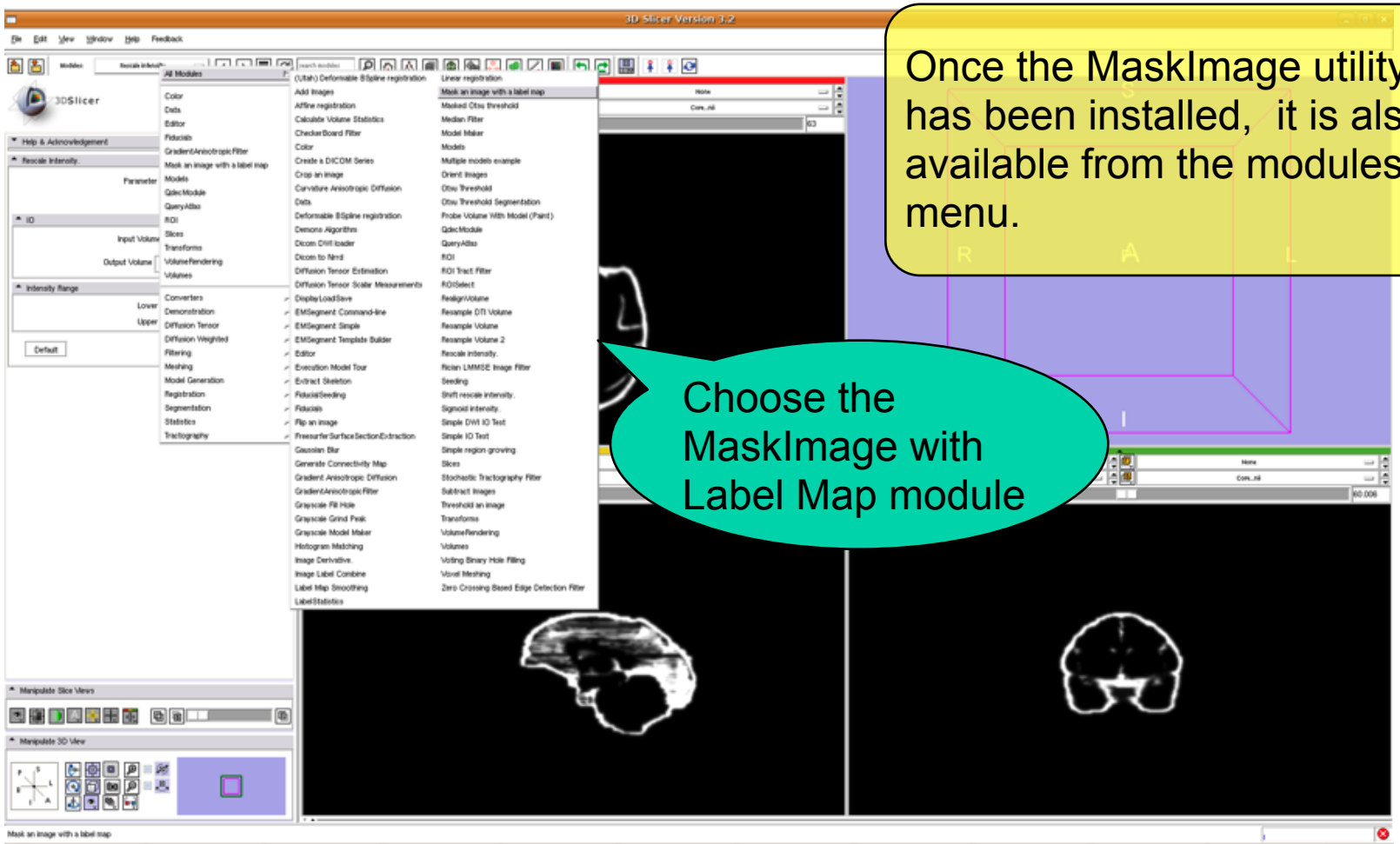
Choose the affine transform for the transformation node

Choose nearest neighbour interpolation

Finally, click Apply to get the registered ECC map

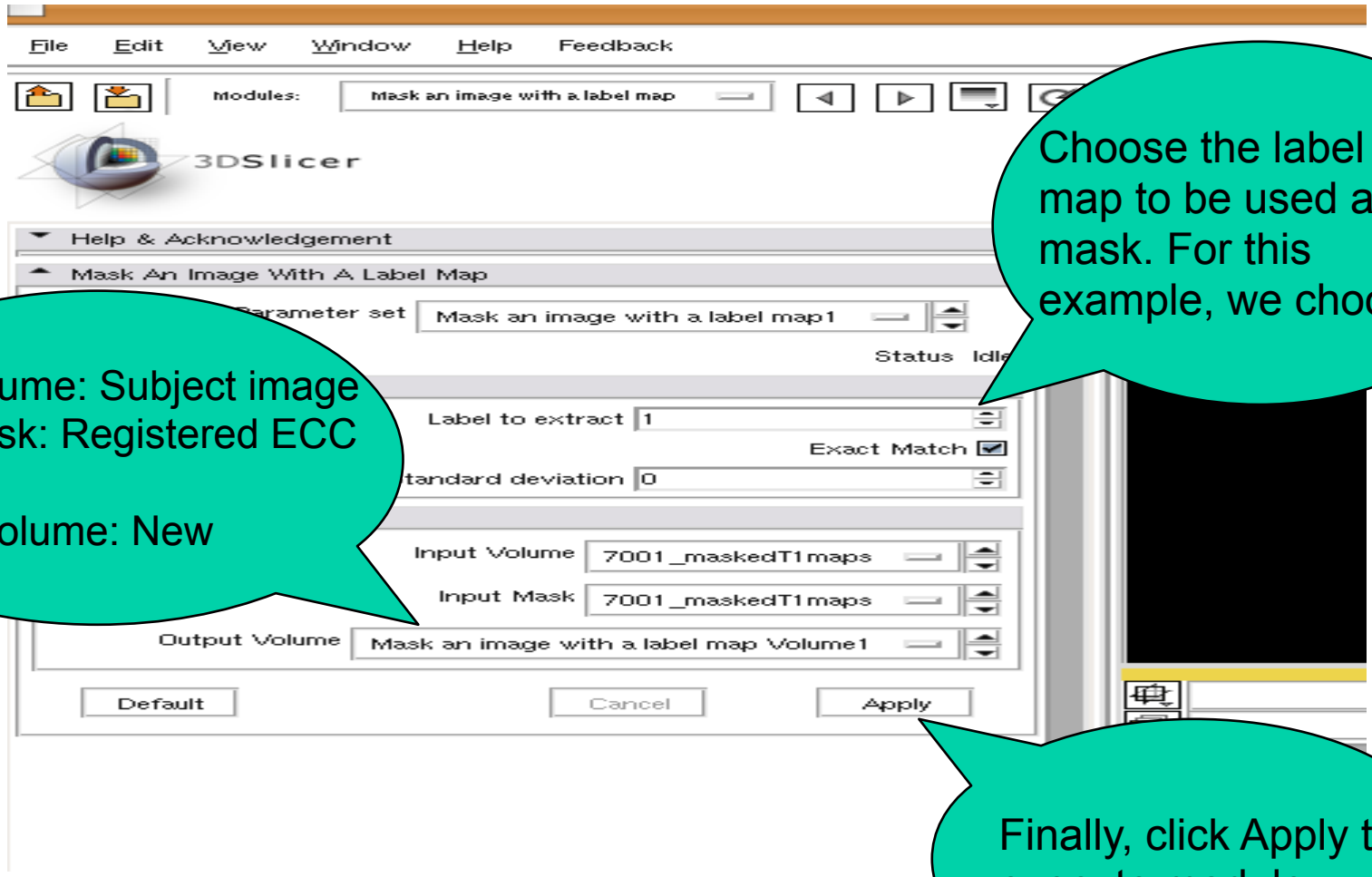
Subject Image Skull Stripping

Mask Subject Image with ECC Mask



Subject Image Skull Stripping

Mask Subject Image with ECC Mask



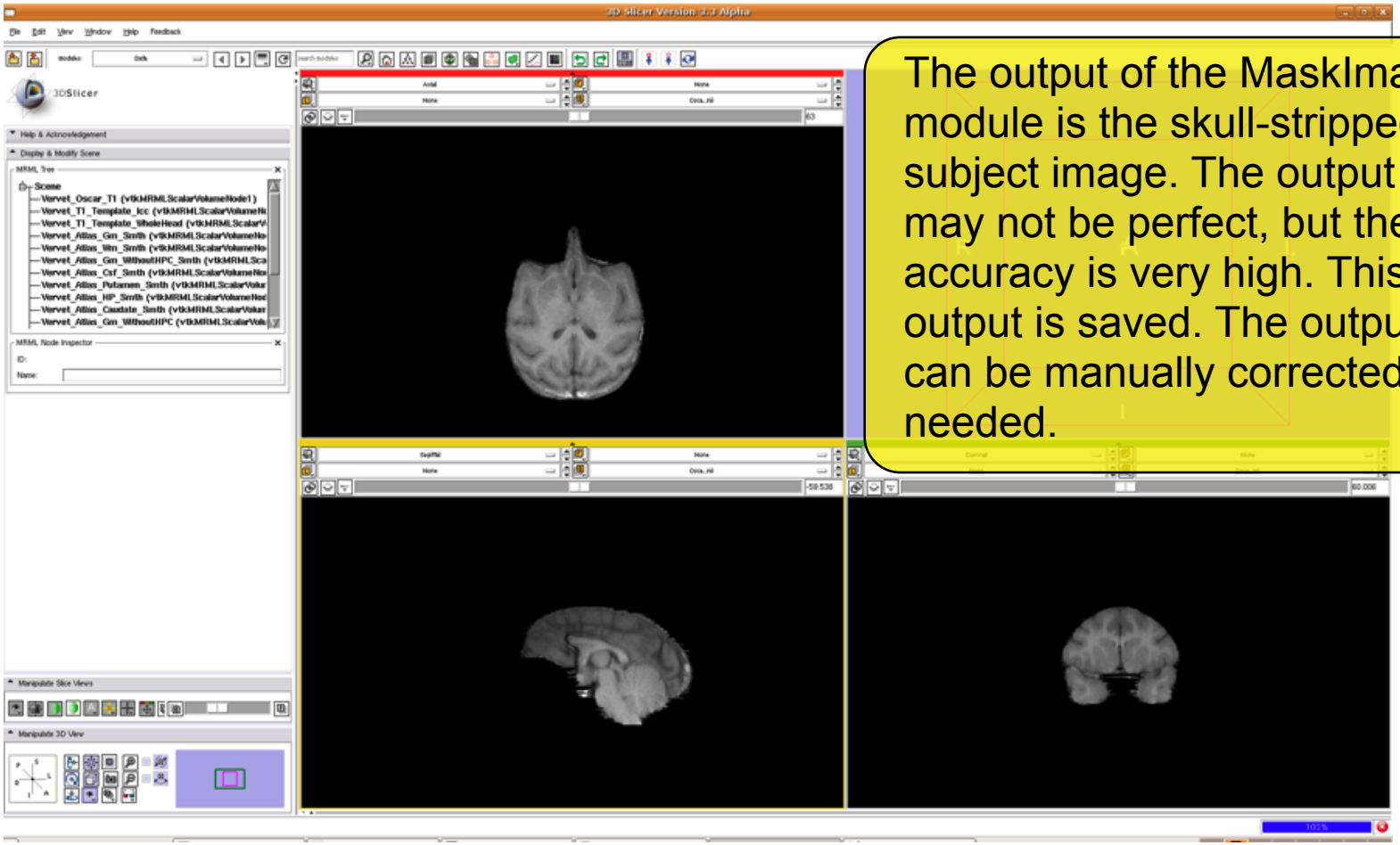
Choose the label in the map to be used as a mask. For this example, we choose 1.

Input Volume: Subject image
Input Mask: Registered ECC map
Output Volume: New

Finally, click Apply to execute module

Subject Image Skull Stripping

Mask Subject Image with ECC Mask

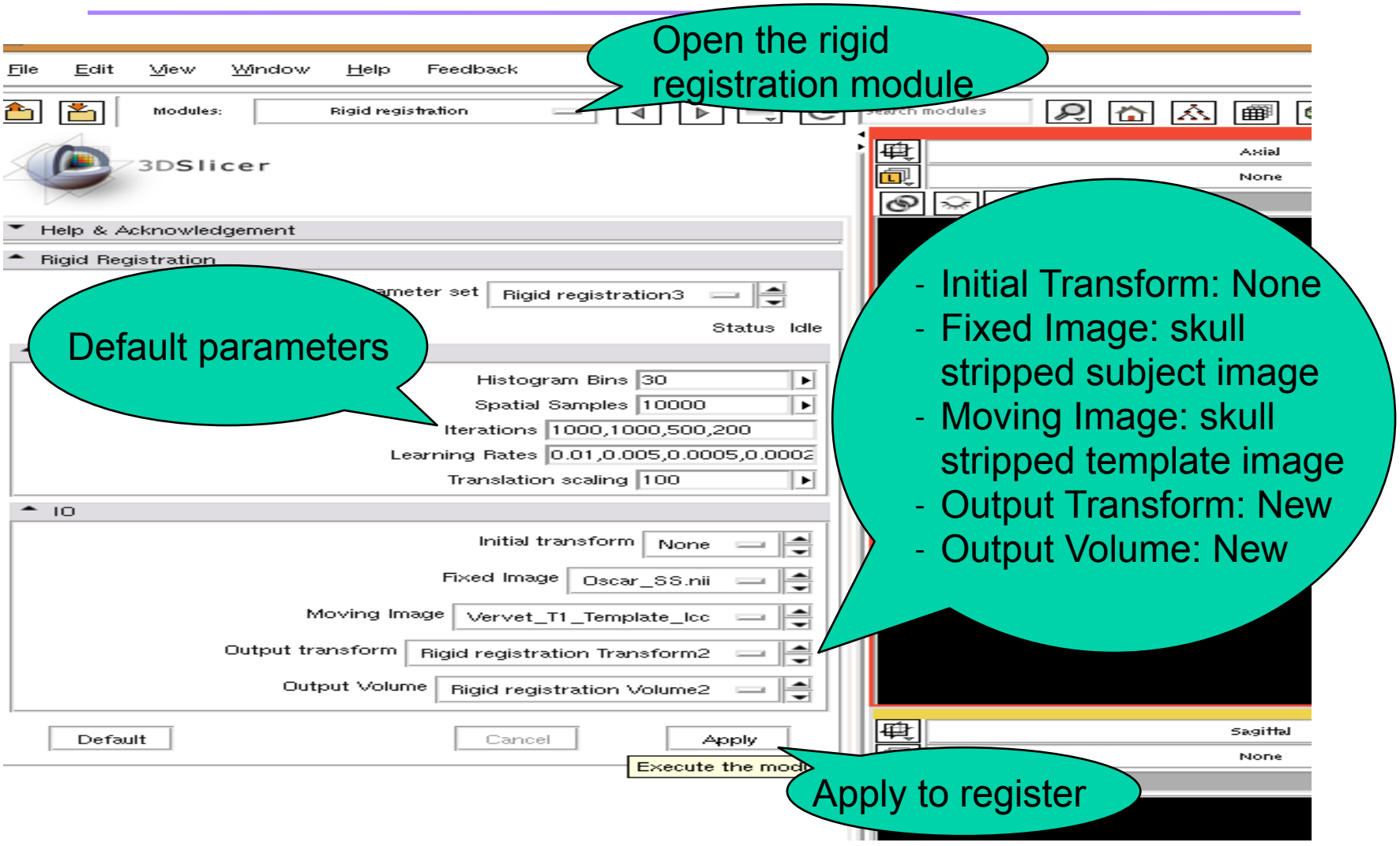


The output of the MaskImage module is the skull-stripped subject image. The output may not be perfect, but the accuracy is very high. This output is saved. The output can be manually corrected if needed.

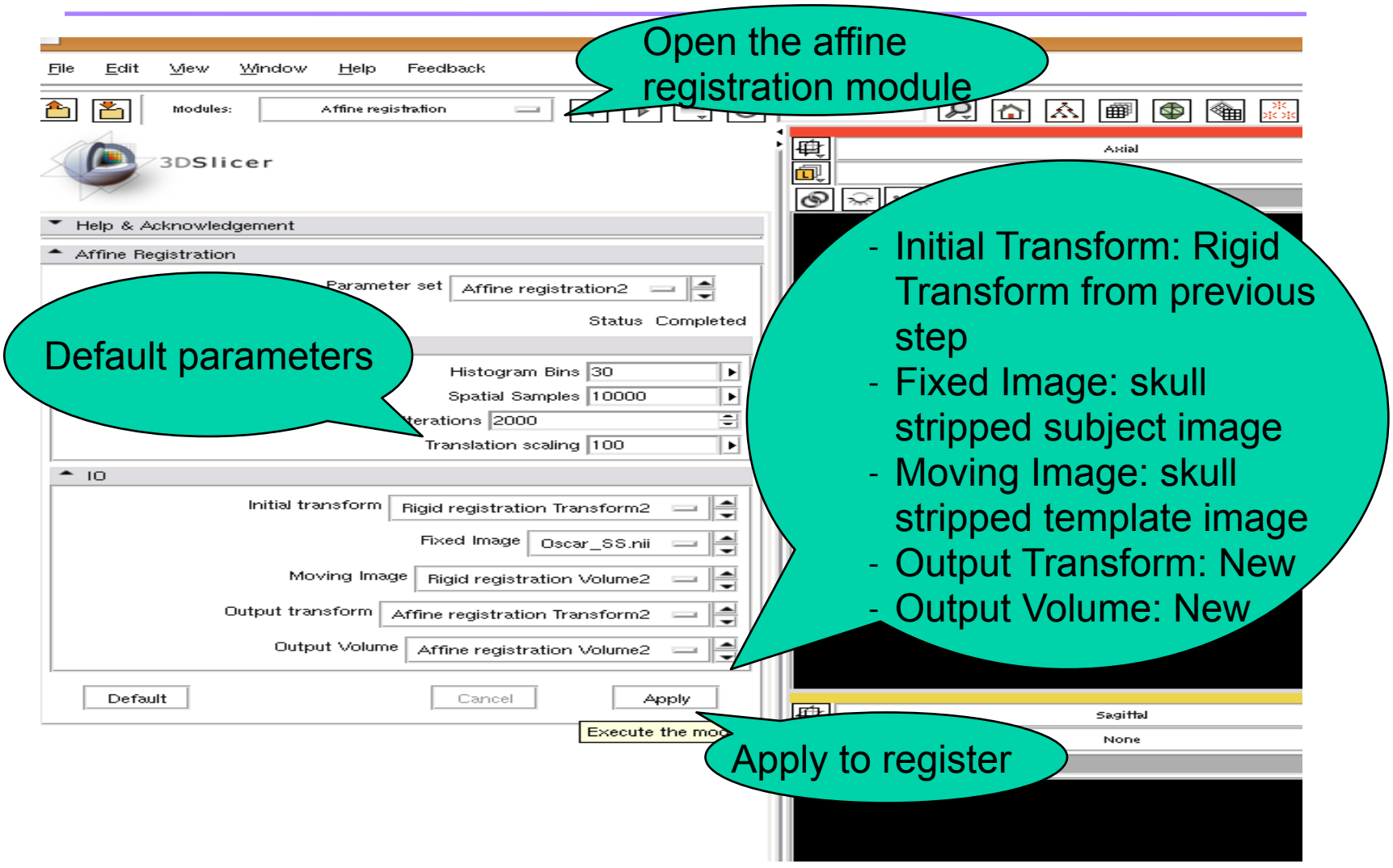
Creating patient specific atlas

- Register skull-stripped subject image to skull-striped template image
- Use affine registration followed by deformable registration
- Apply transformation to probability maps to get patient specific atlas
- Registered maps are rescaled to values between 0-255 to be used with EMSegmenter

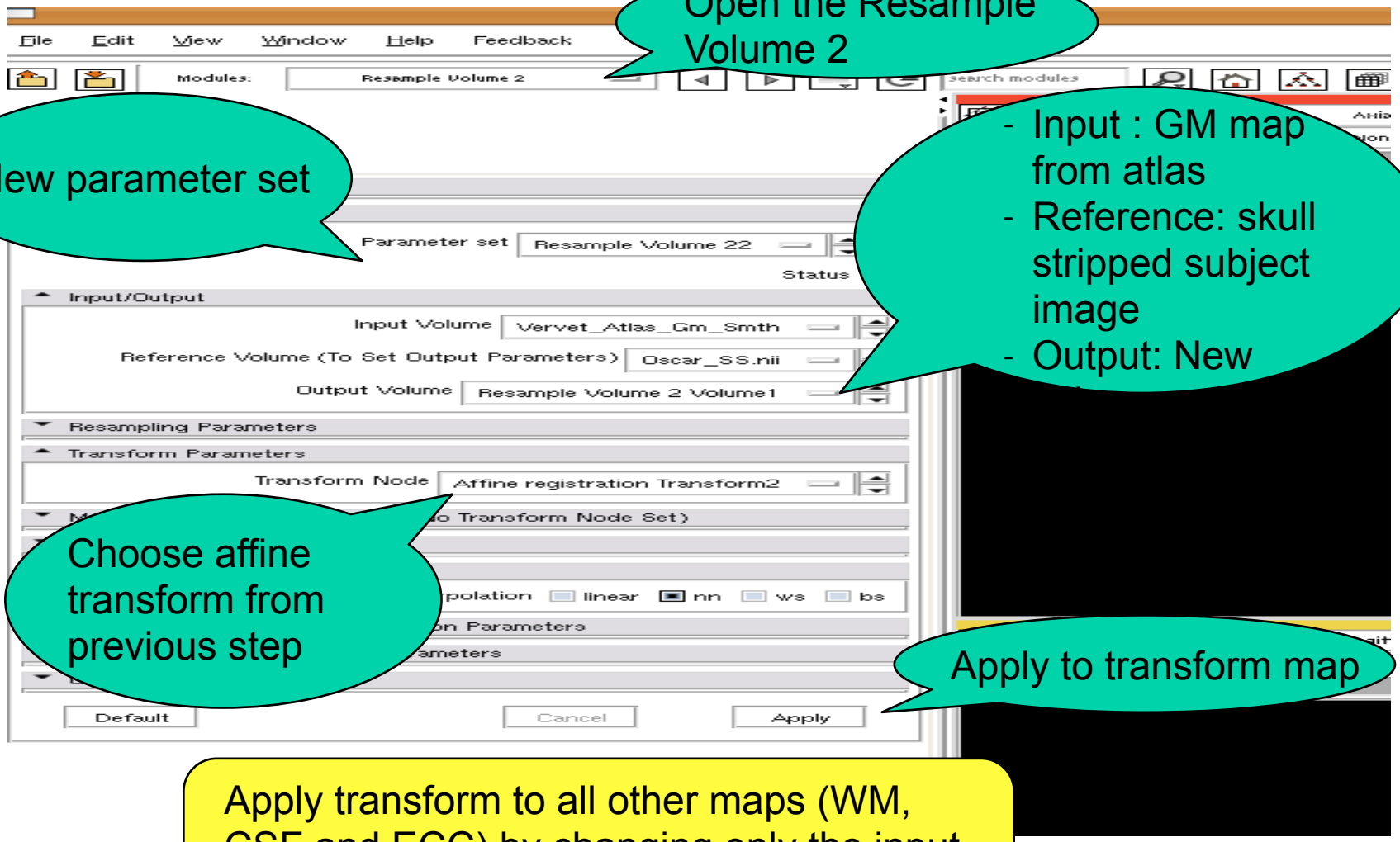
Creating patient specific atlas - Rigid Registration



Creating patient specific atlas - Affine Registration



Creating patient specific atlas - Apply Transform



Apply transform to all other maps (WM, CSF and ECC) by changing only the input each time. Save all the transformed maps as separate volumes.

Creating patient specific atlas - Non-Linear Registration

- To use the Diffeomorphic Demons CLI , open a new terminal to the directory containing: Slicer3-Build/lib/Slicer3/Plugins/

- use the command: ./DemonsRegistration
  - The skull stripped subject is the fixed image,
  - the affinely registered, skull-stripped template is the moving image and,
  - choose symmetrized gradient option.
  - For our application, we set the number of levels to 4 with the following iterations [90, 70,45,25]. The deformation field should be saved as a MHA file.

Creating patient specific atlas - Applying deformation field to probability maps

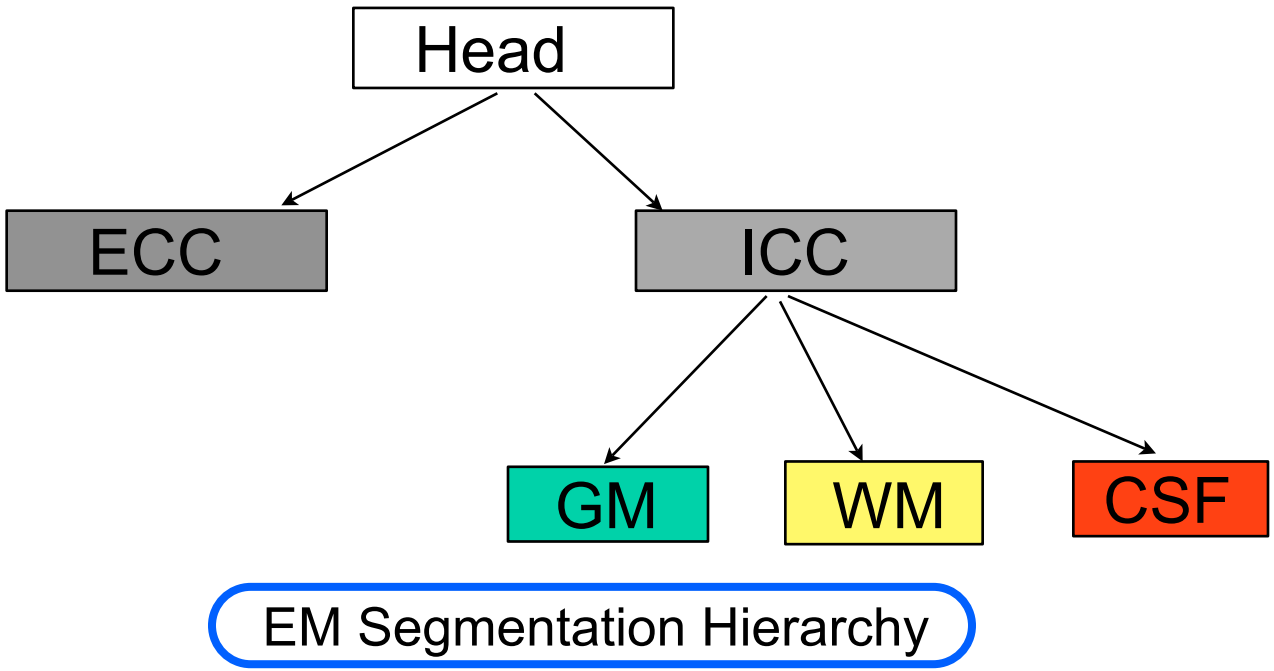
- Once registration has been completed, we use another tool in the same folder to apply the deformation field to the probability maps one at a time

- use the command: ./applydeformationITK
  - The GM probabilty map after affine registration is the moving image,
  - the diffeomorphic demons deformation field is the field to be apply and,
  - choose apply transformation option.
  - For our application, we set the interpolation to nearest neighbor
  - Repeat this for all other affinely registered probability maps by changing the moving image

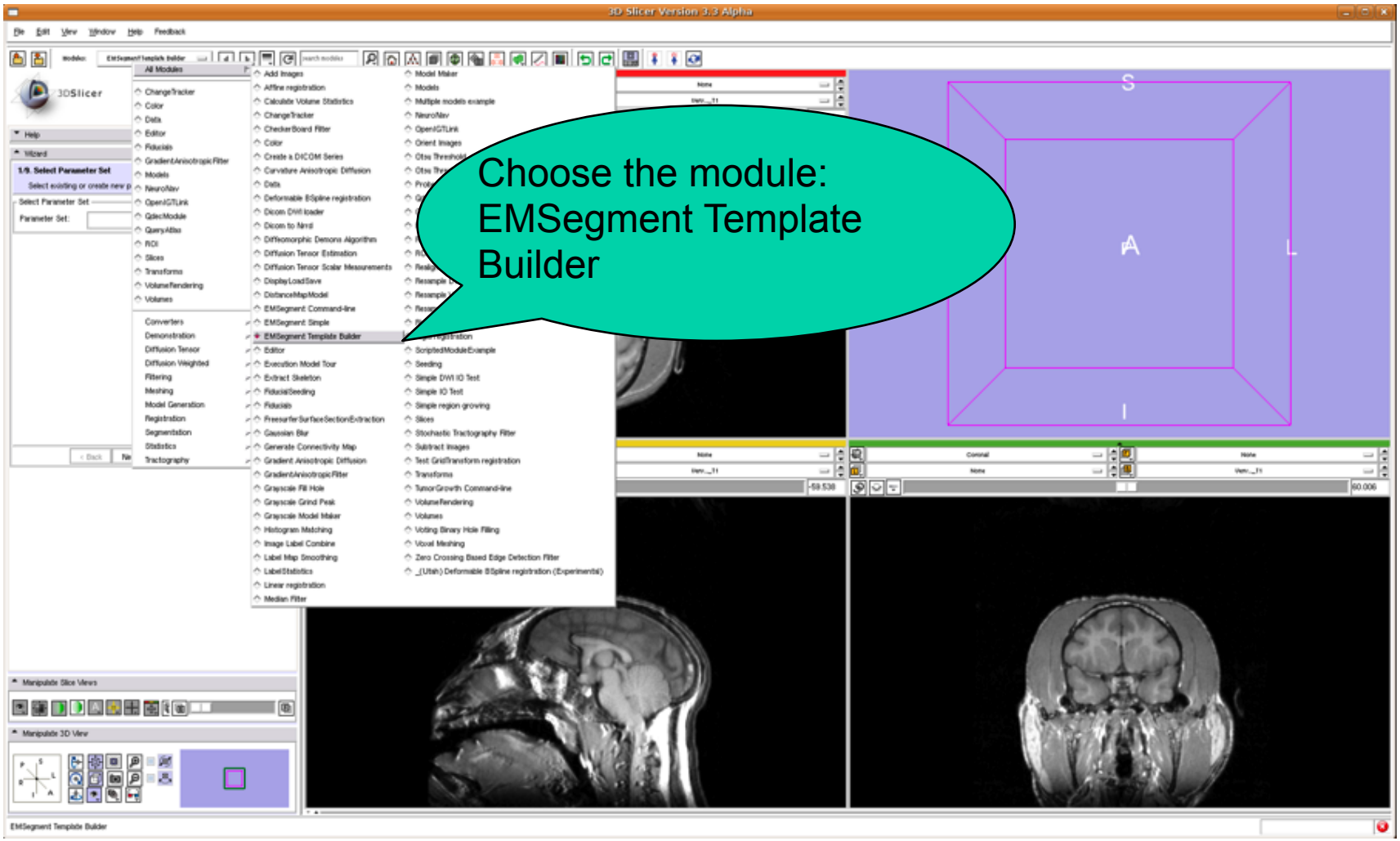
Segmentation using EMSegmenter

Segmentation

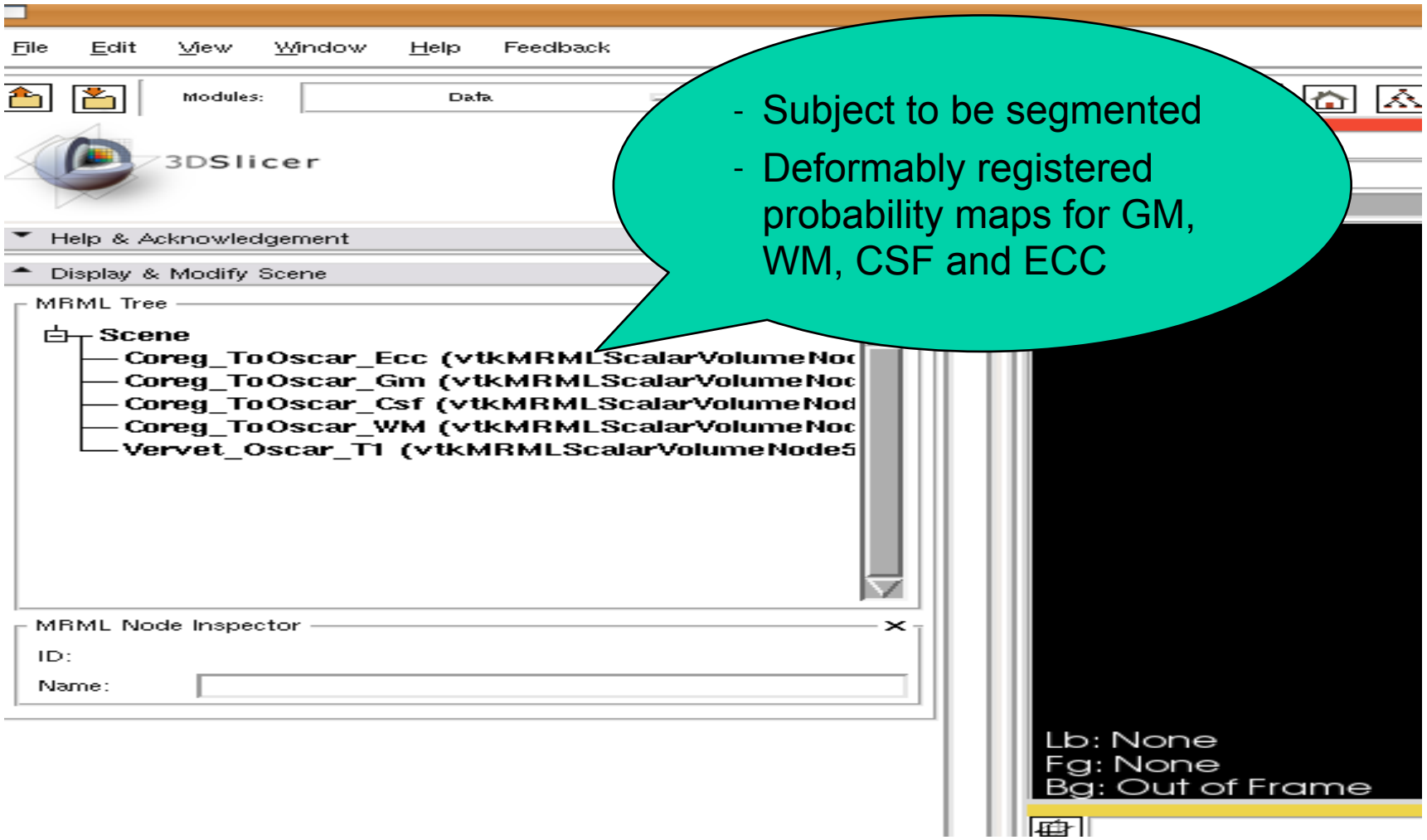
- Once the patient specific atlas has been created, we use that along with the subject image in EMSegmenter



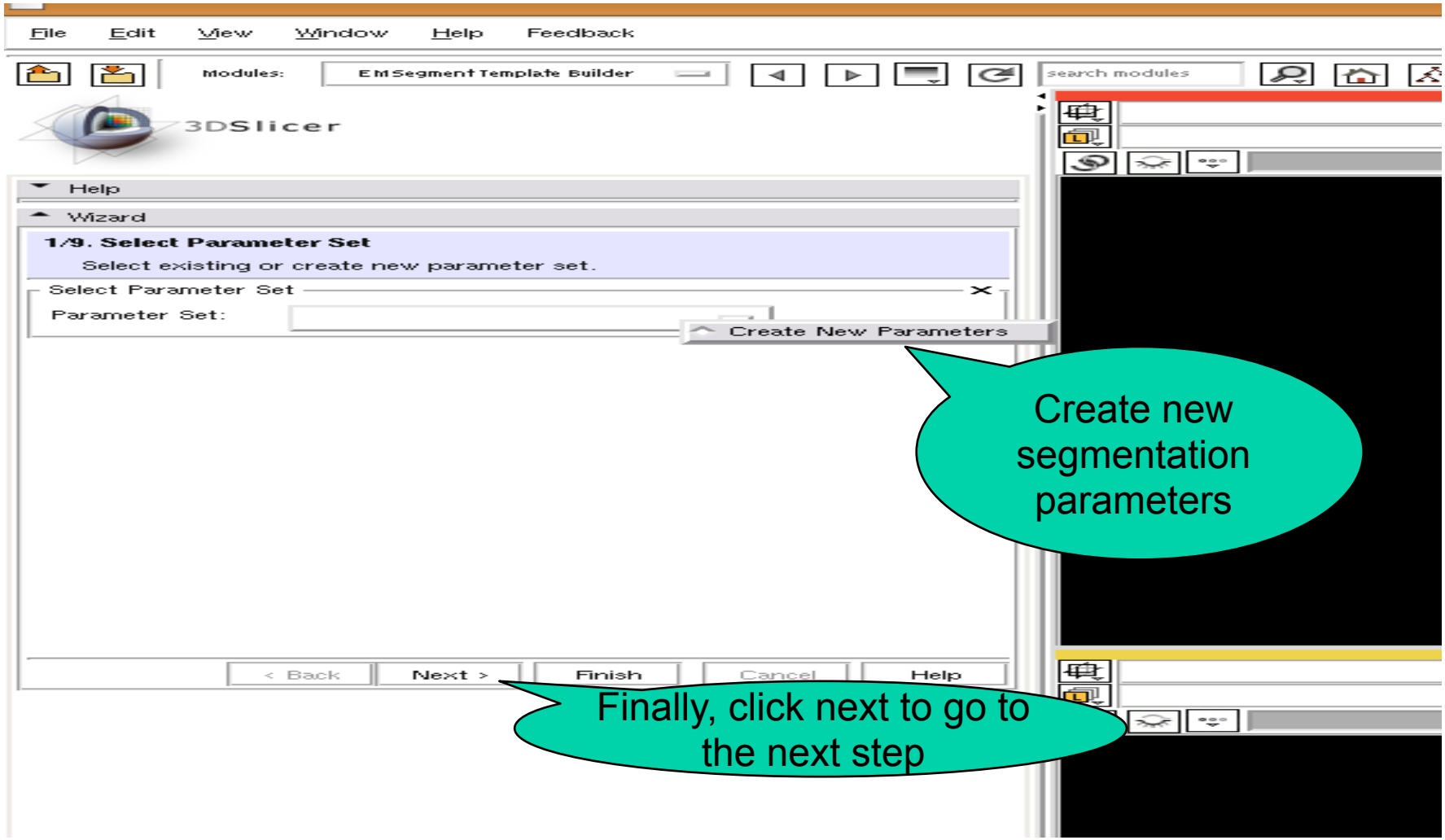
Segmentation



Segmentation - Input Data

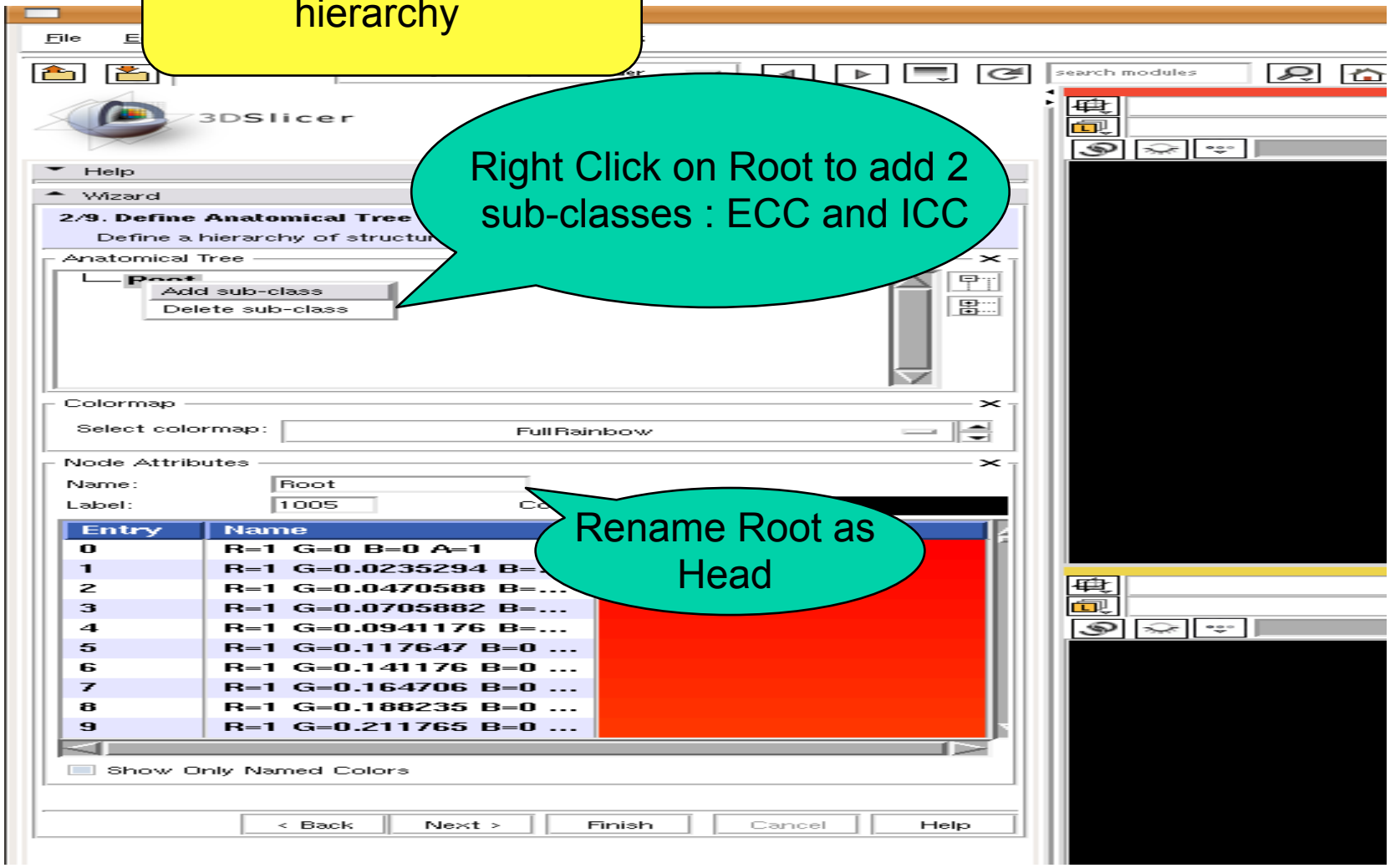


Segmentation

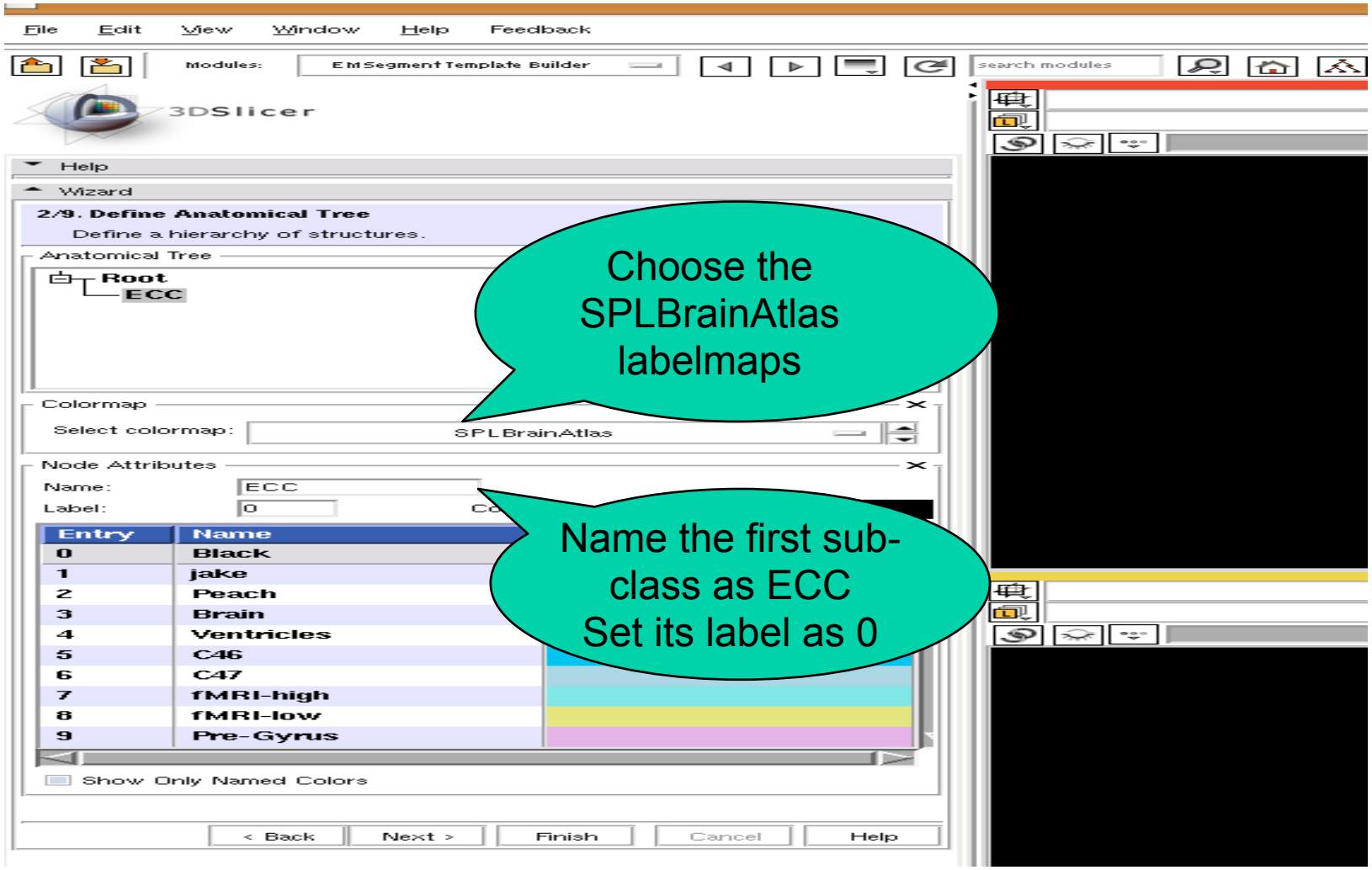


Segmentation

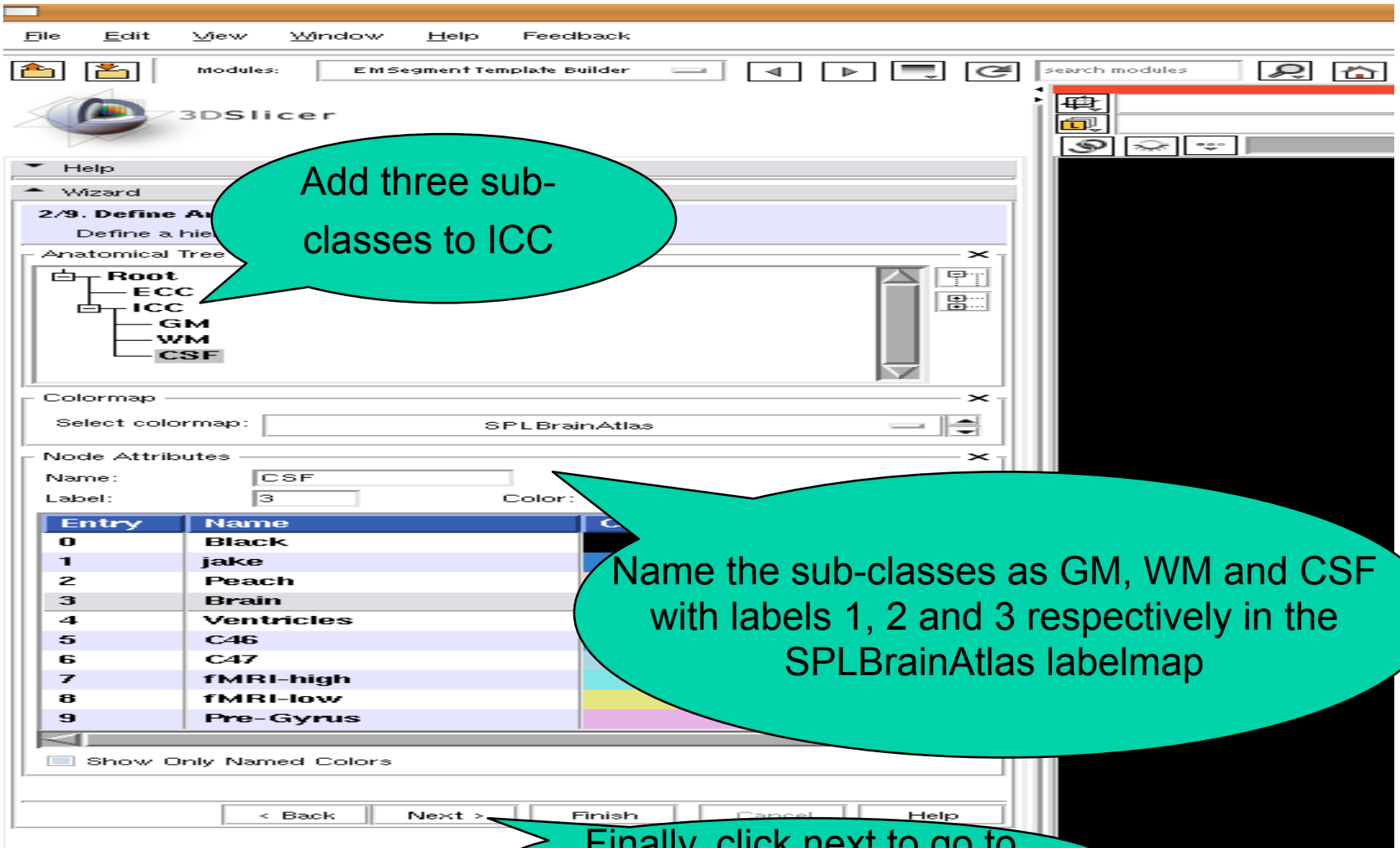
The second step is to specify the segmentation hierarchy



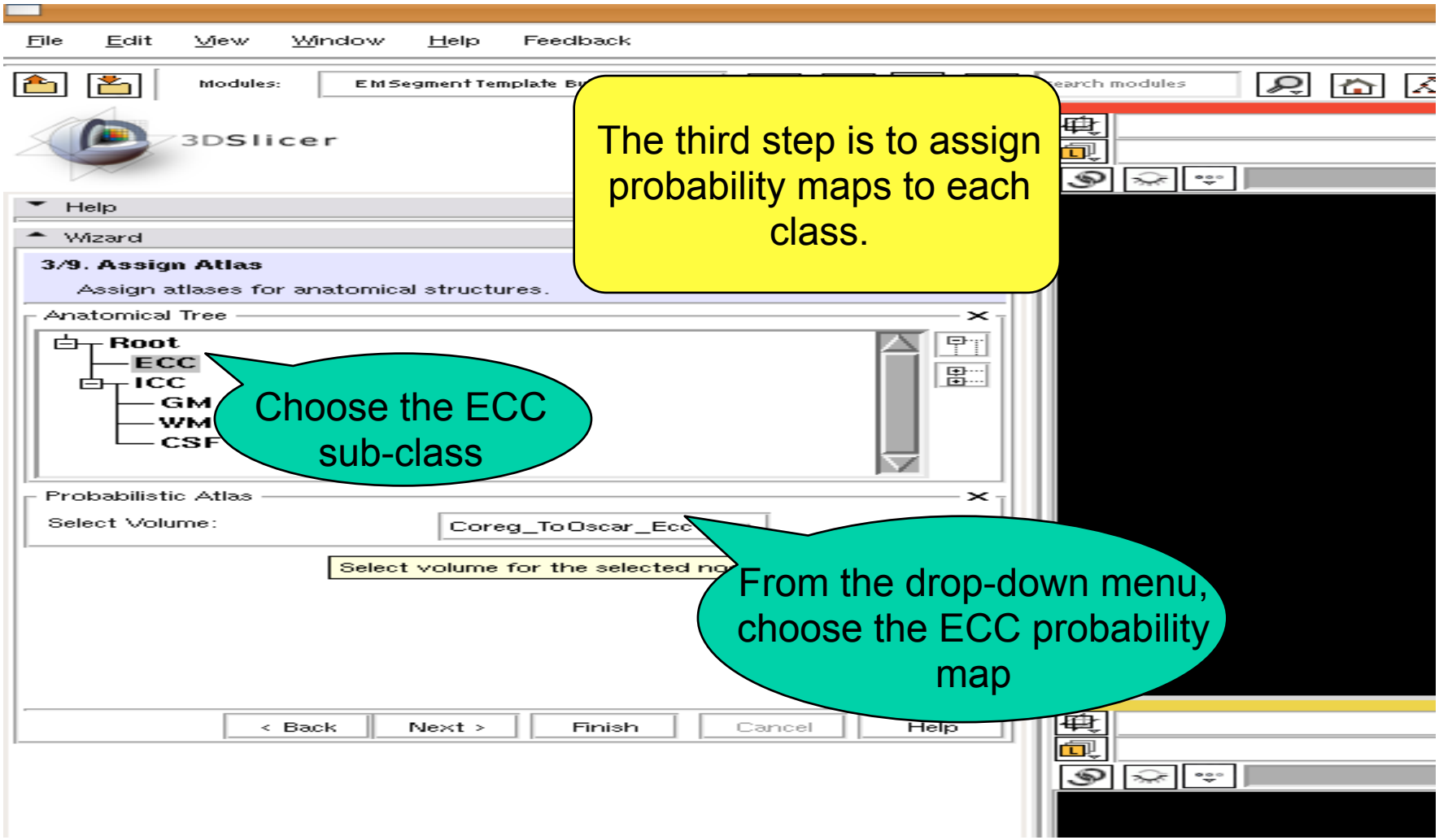
Segmentation



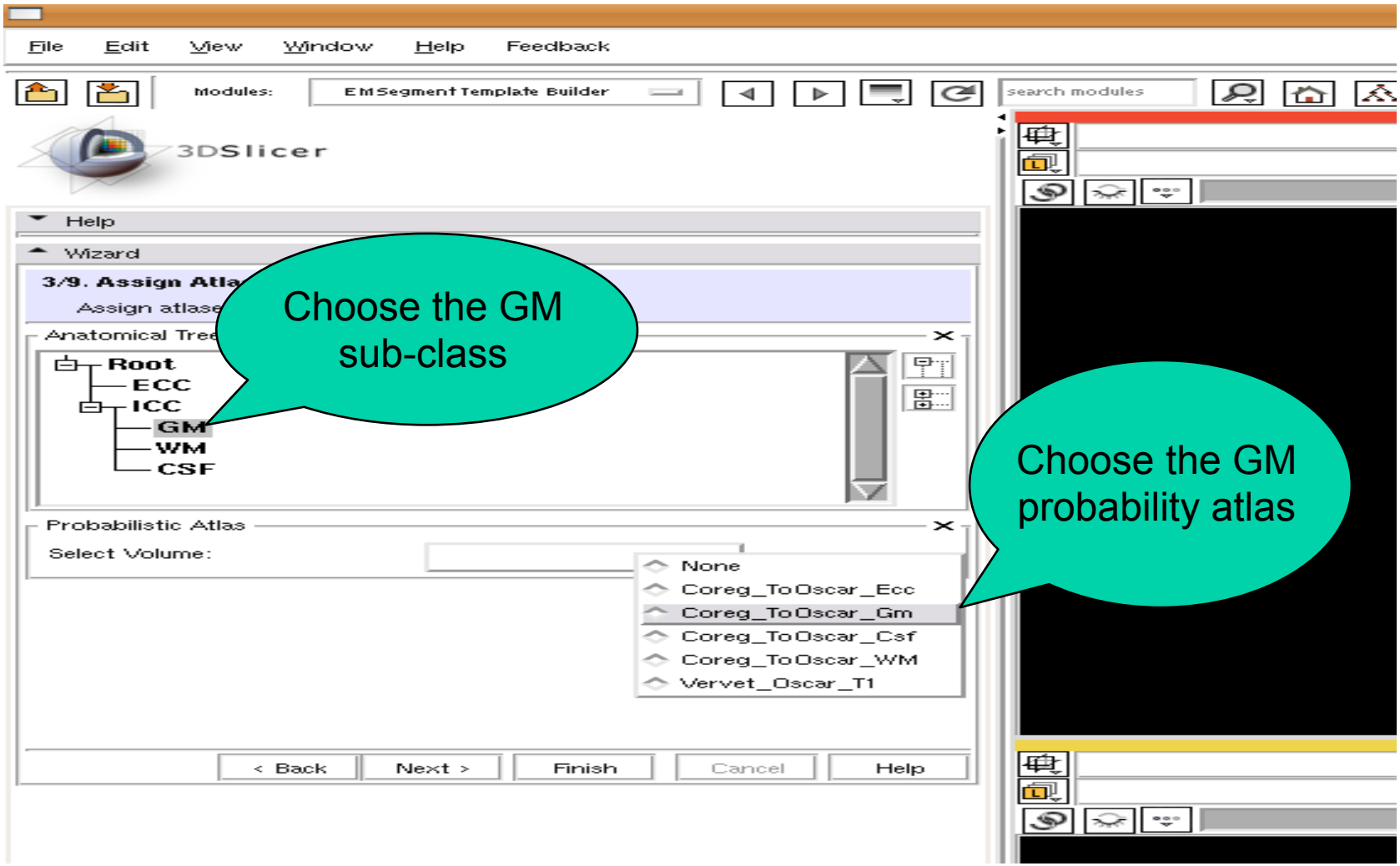
Segmentation



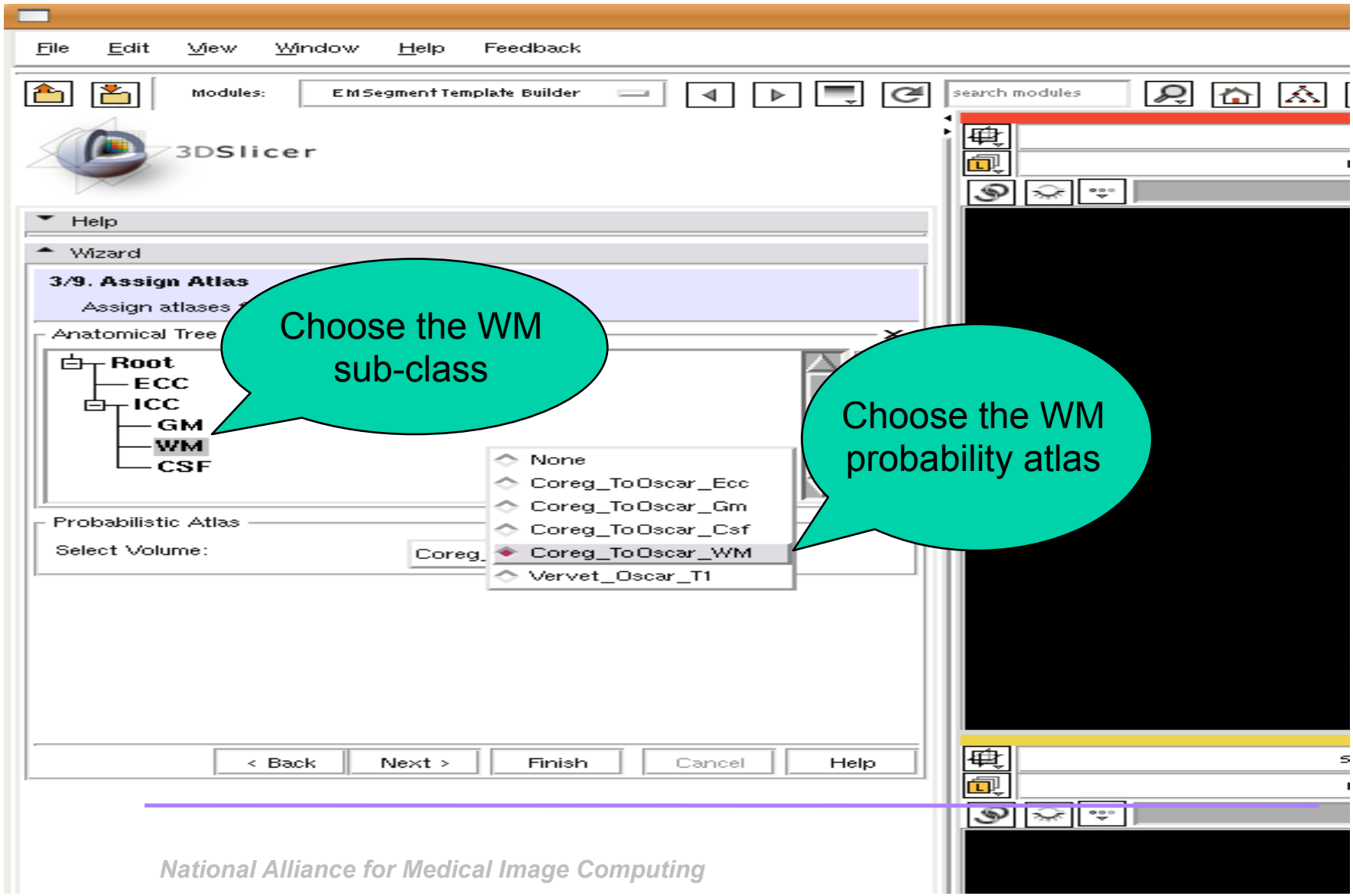
Segmentation



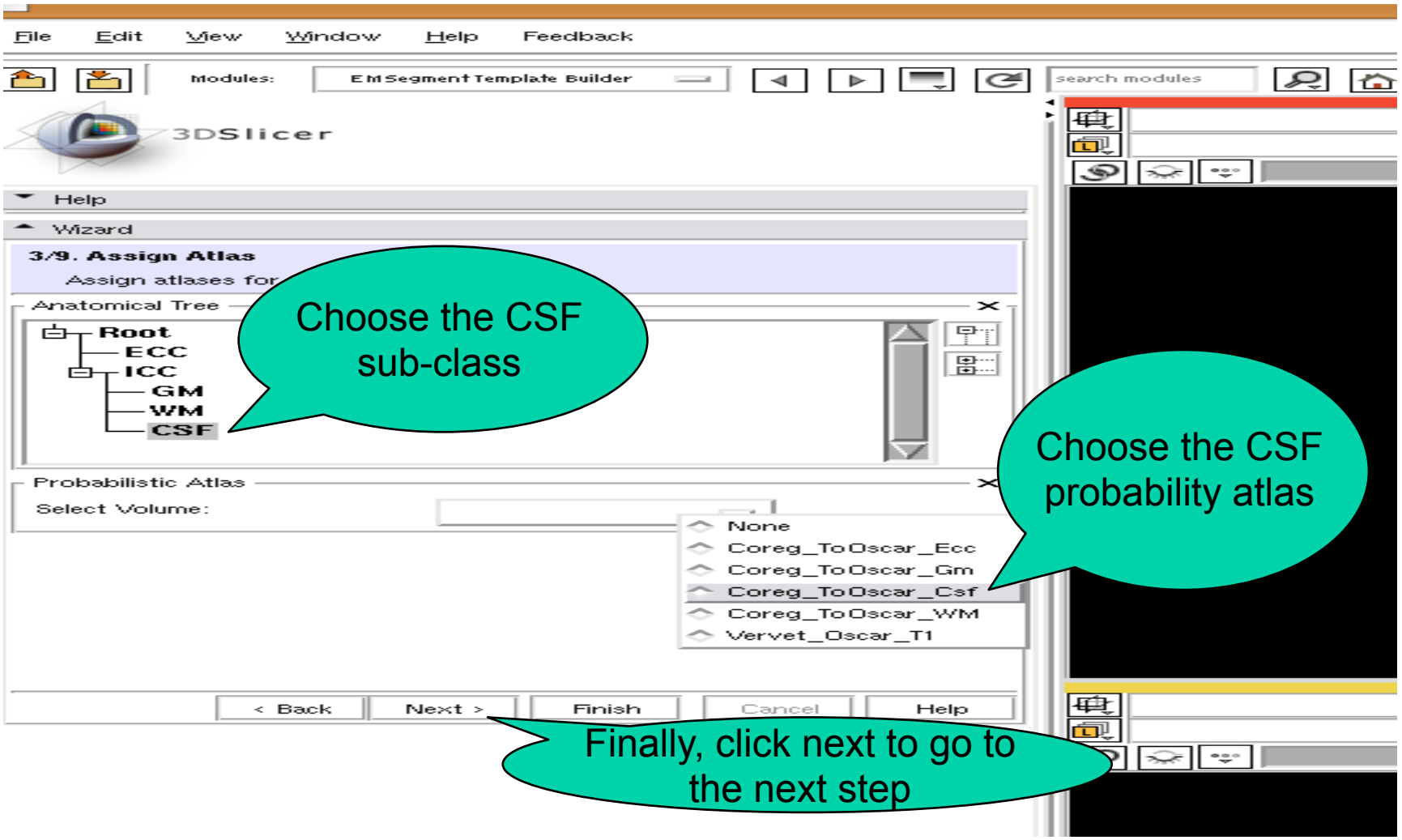
Segmentation



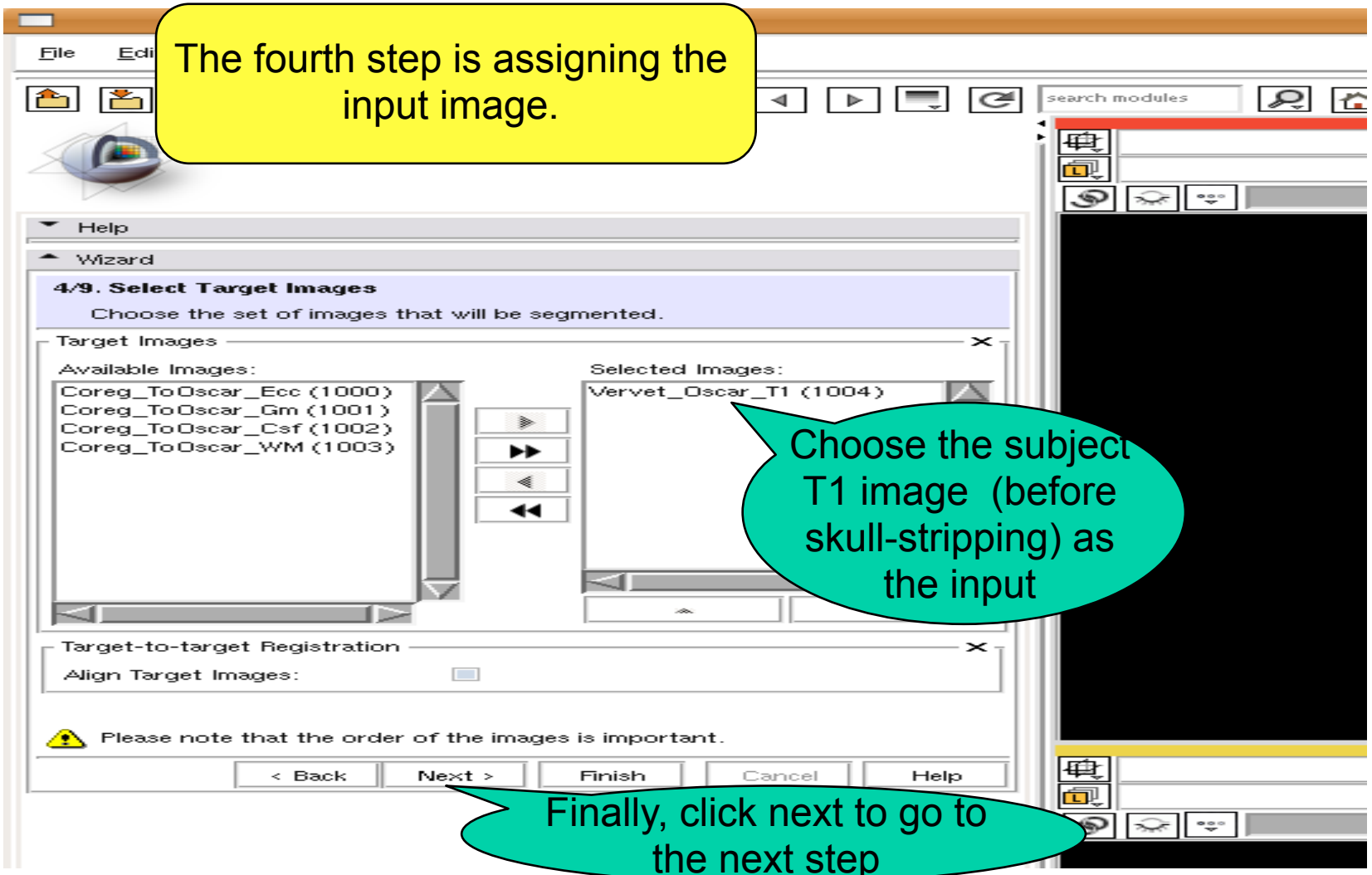
Segmentation



Segmentation



Segmentation



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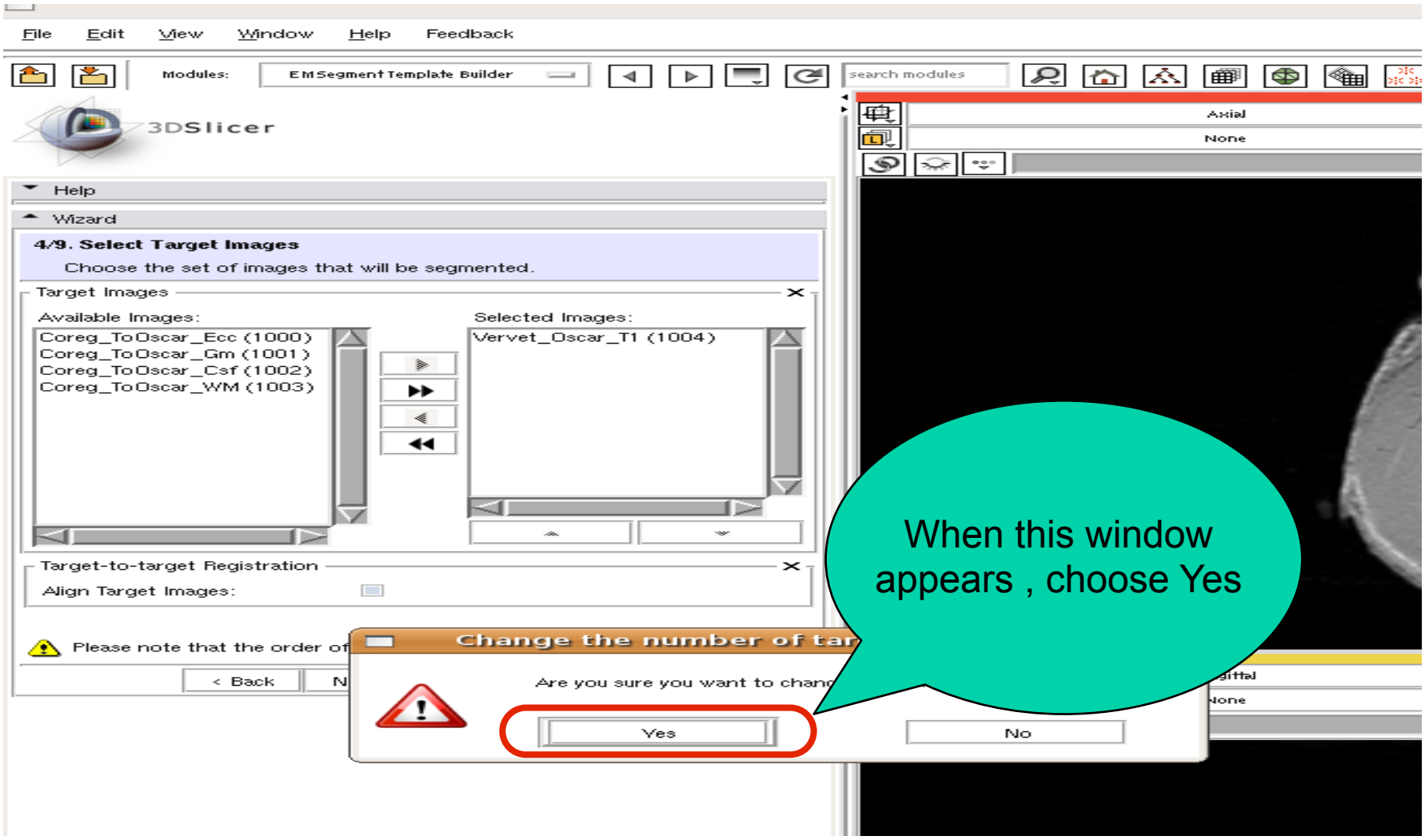

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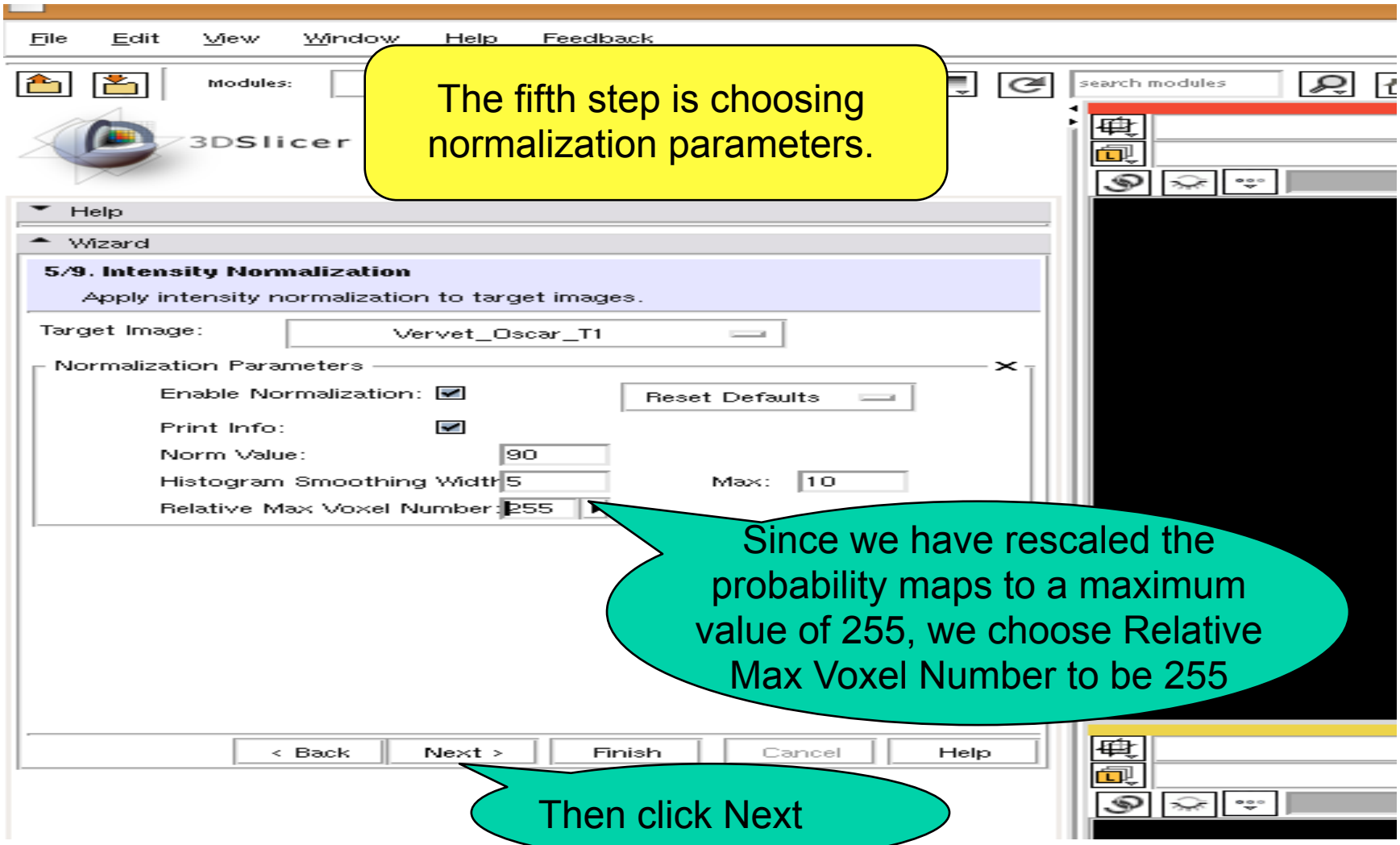

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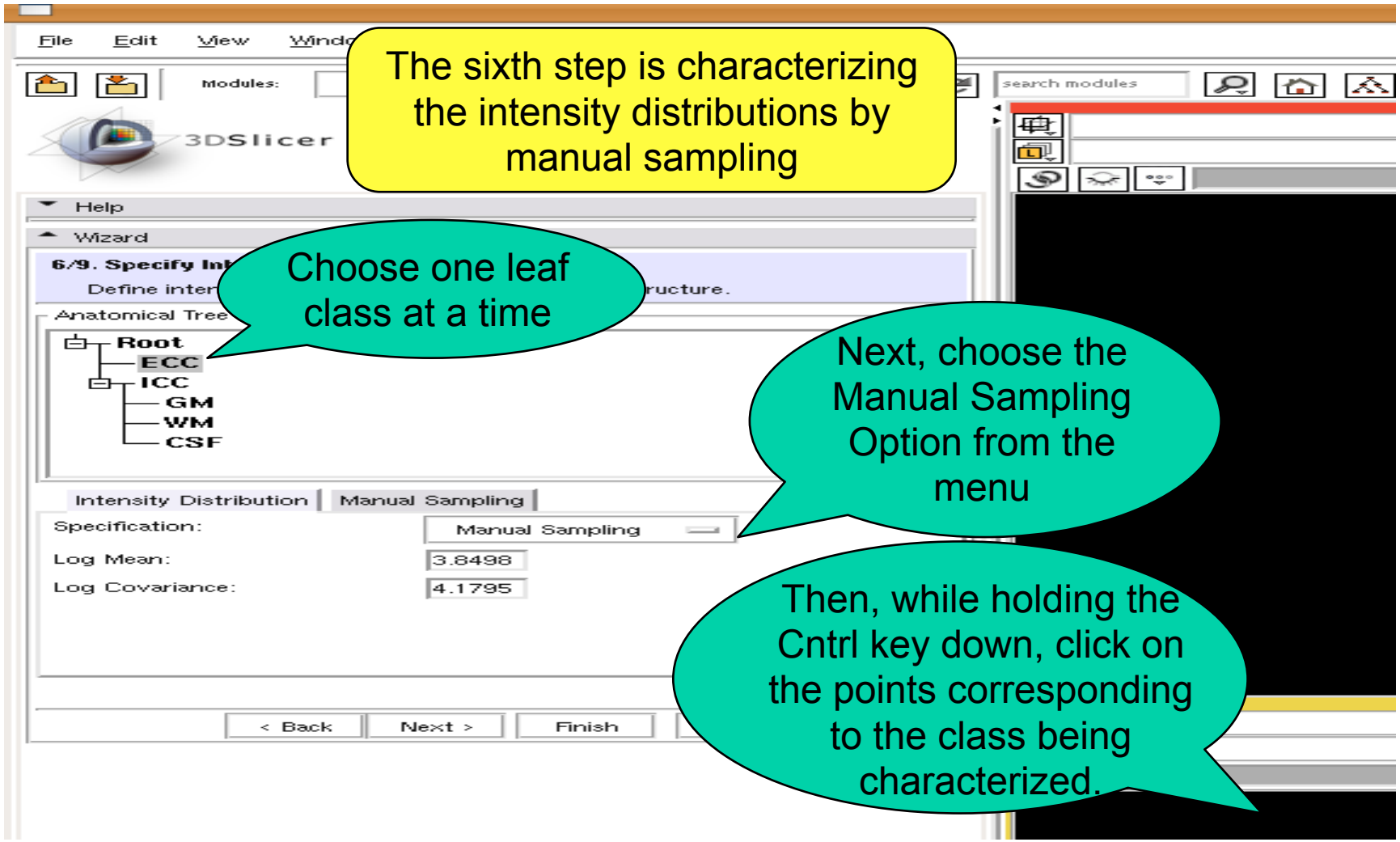

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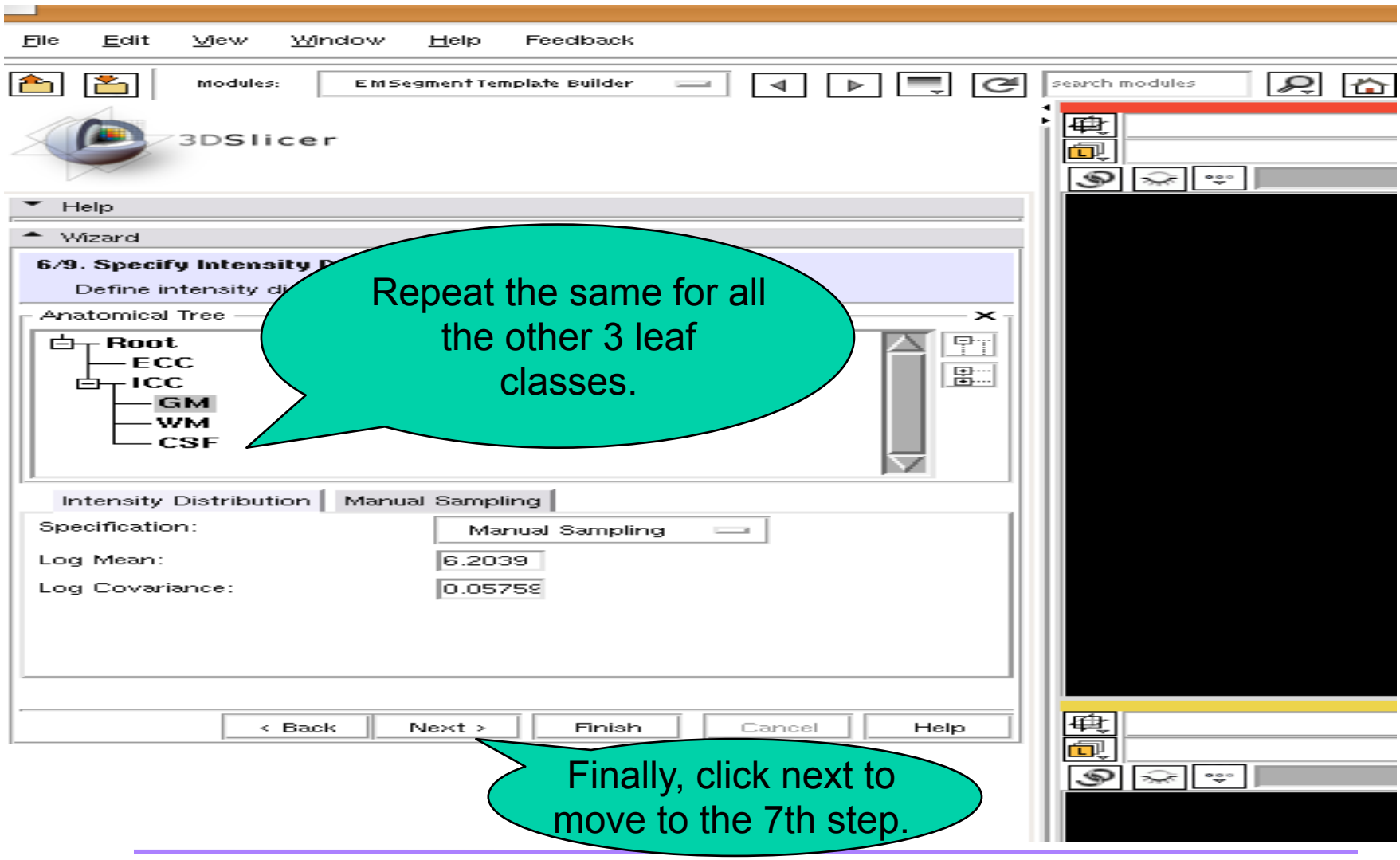

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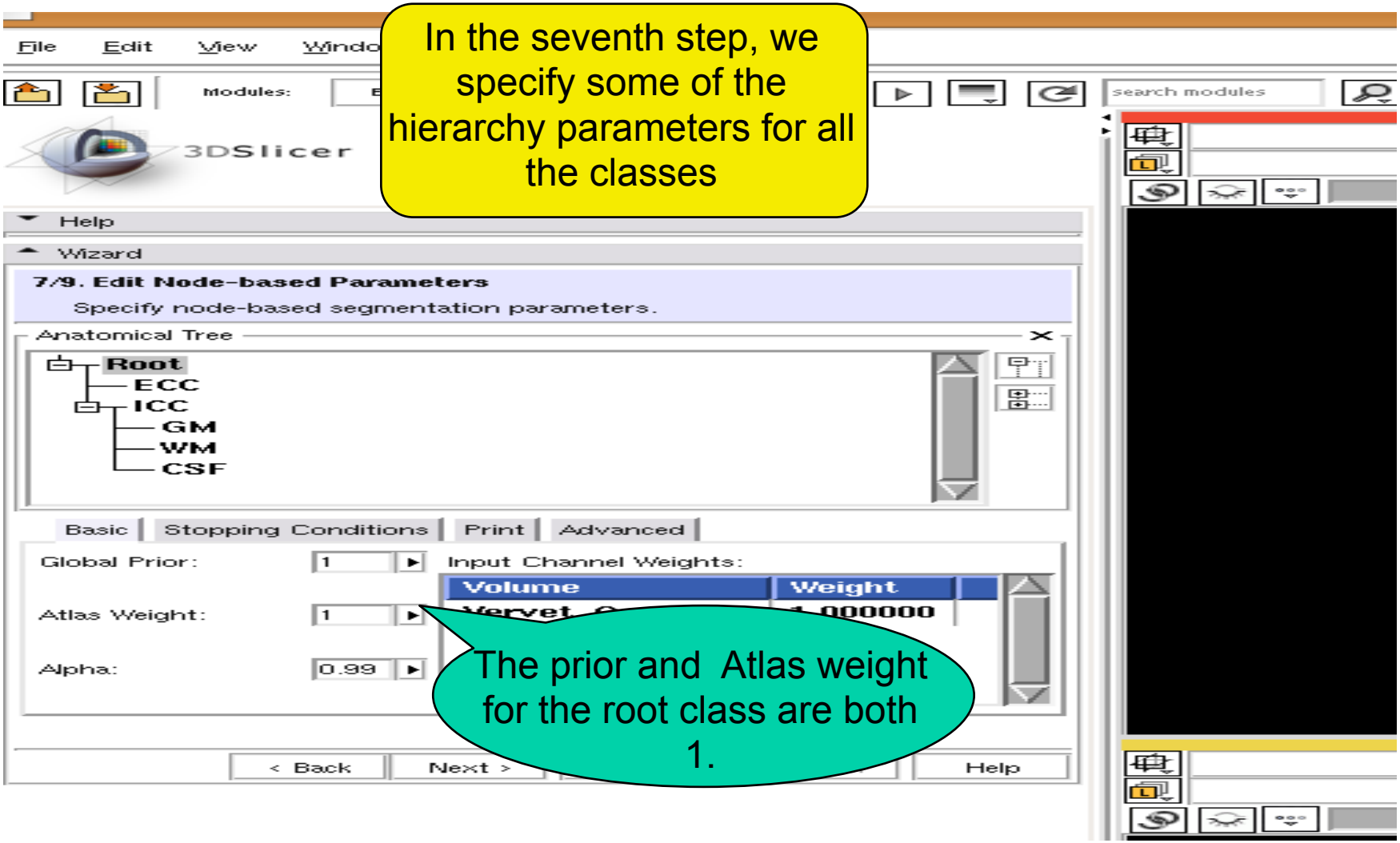

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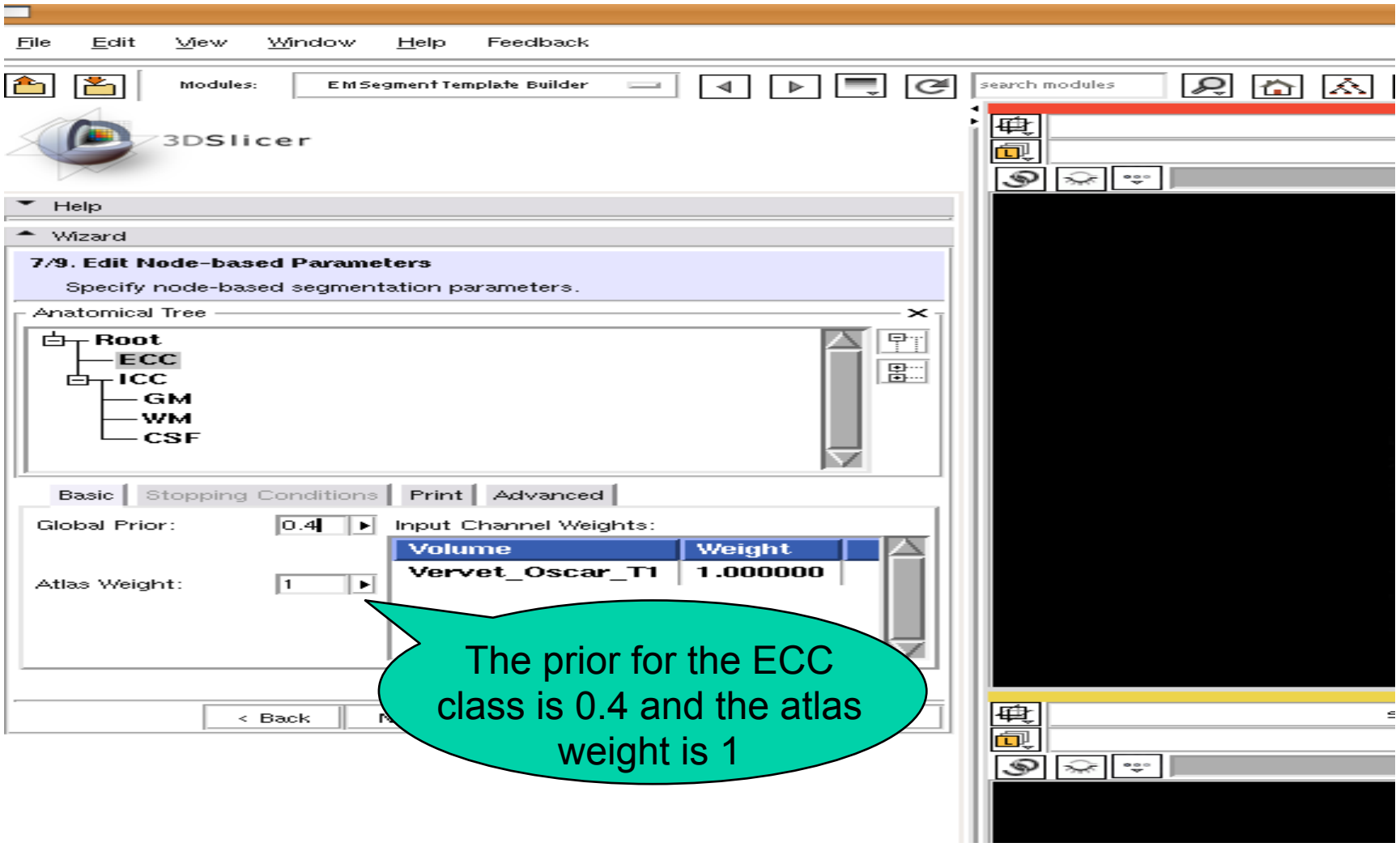

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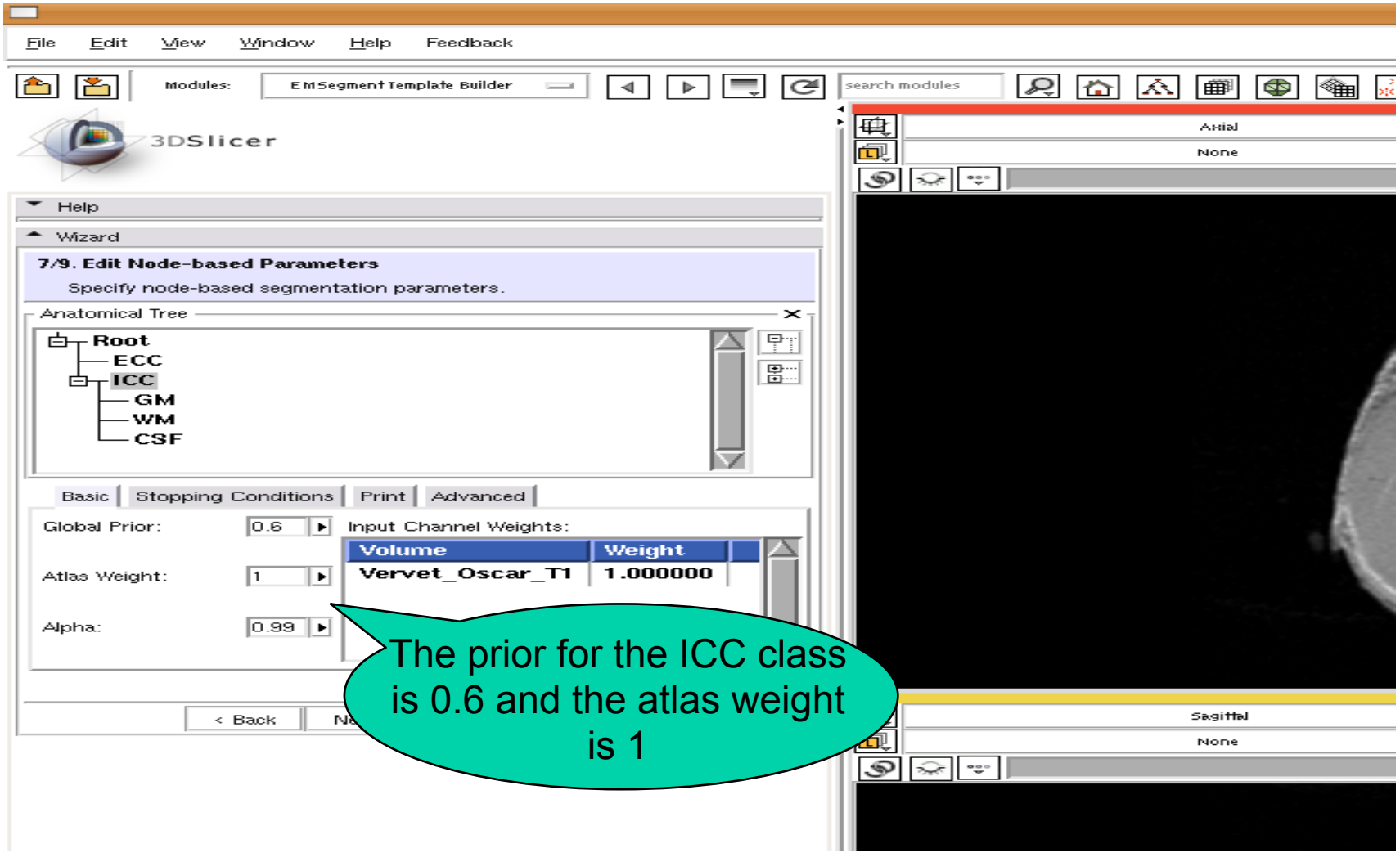

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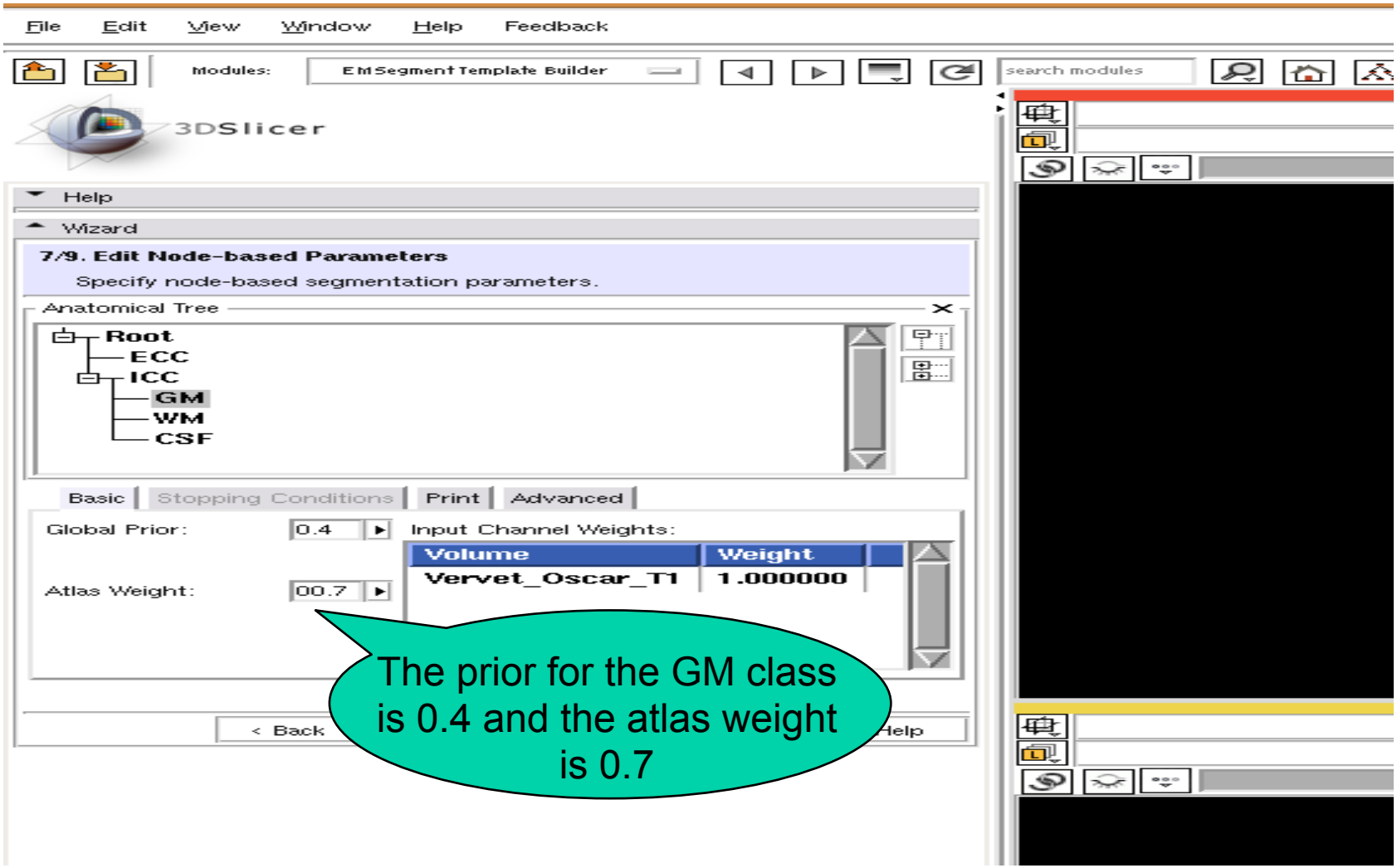

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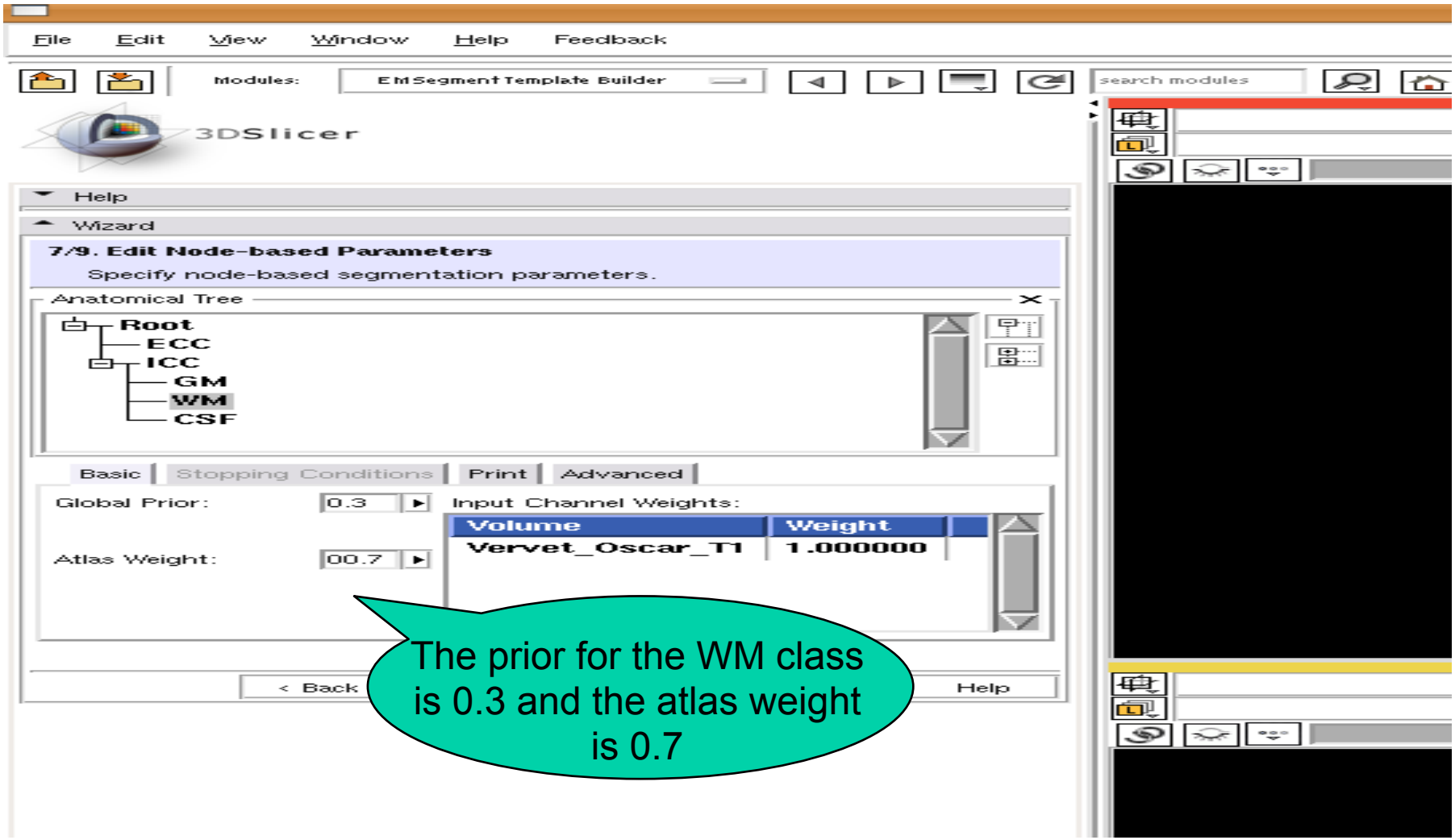

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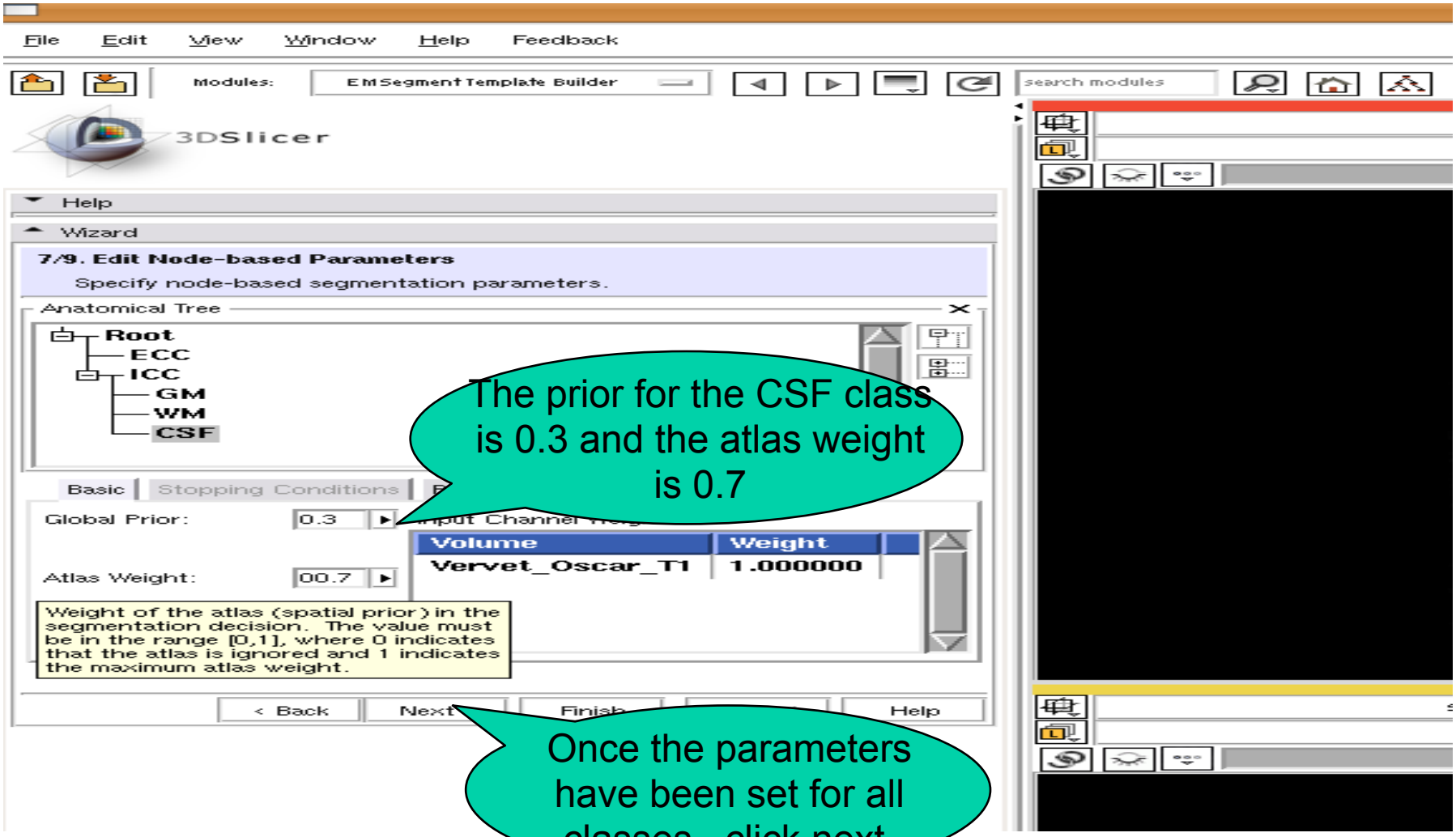

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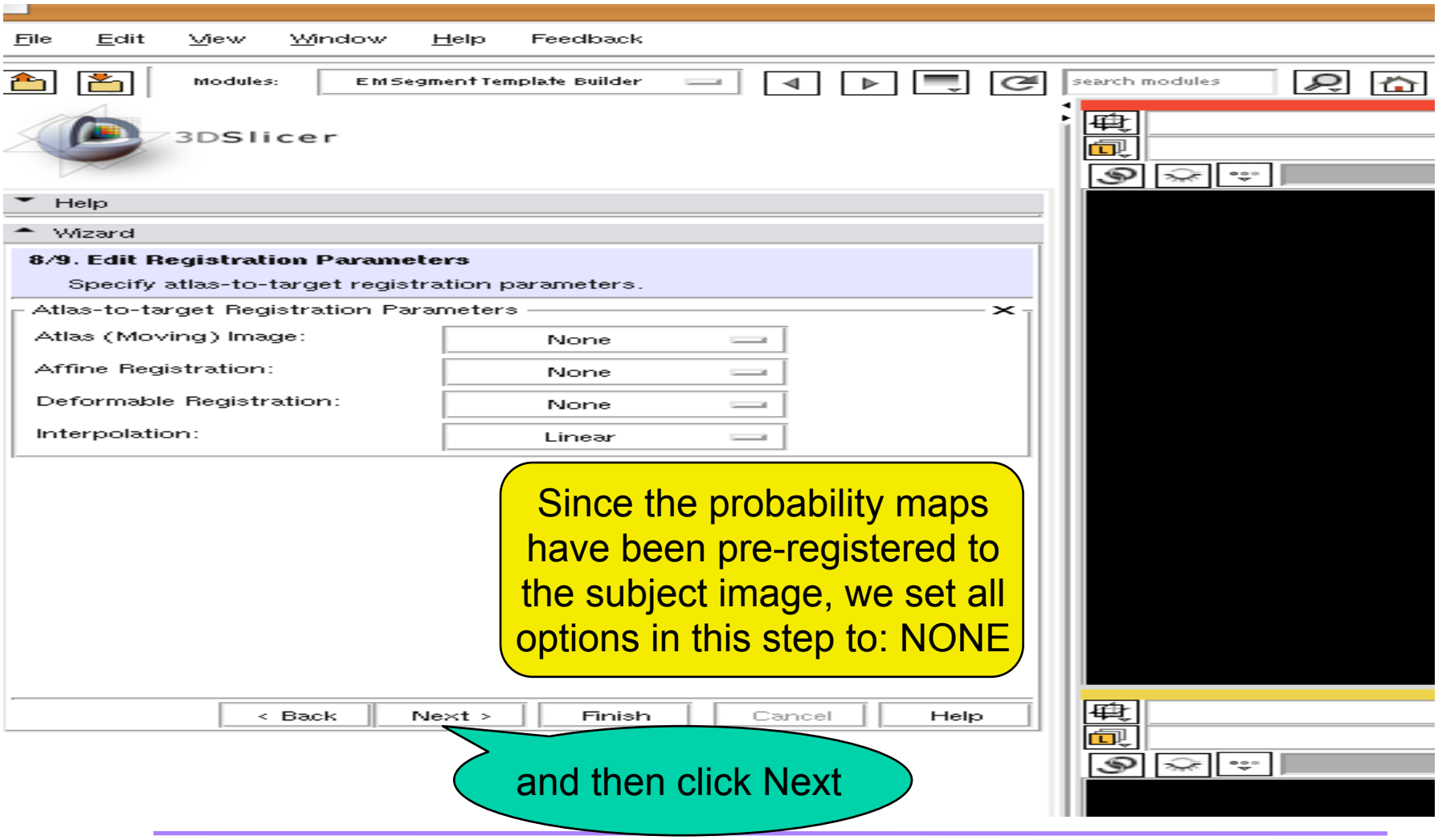

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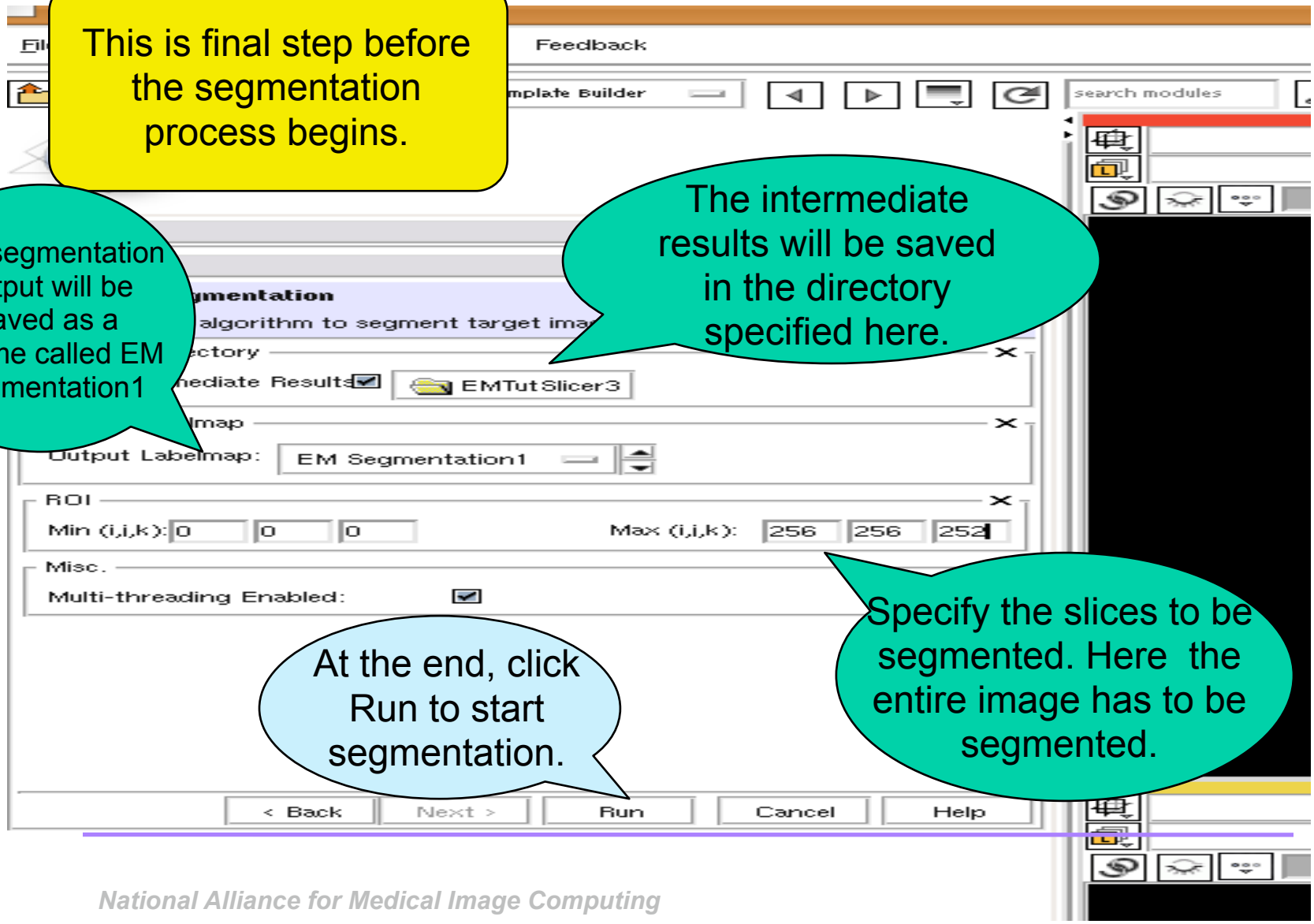
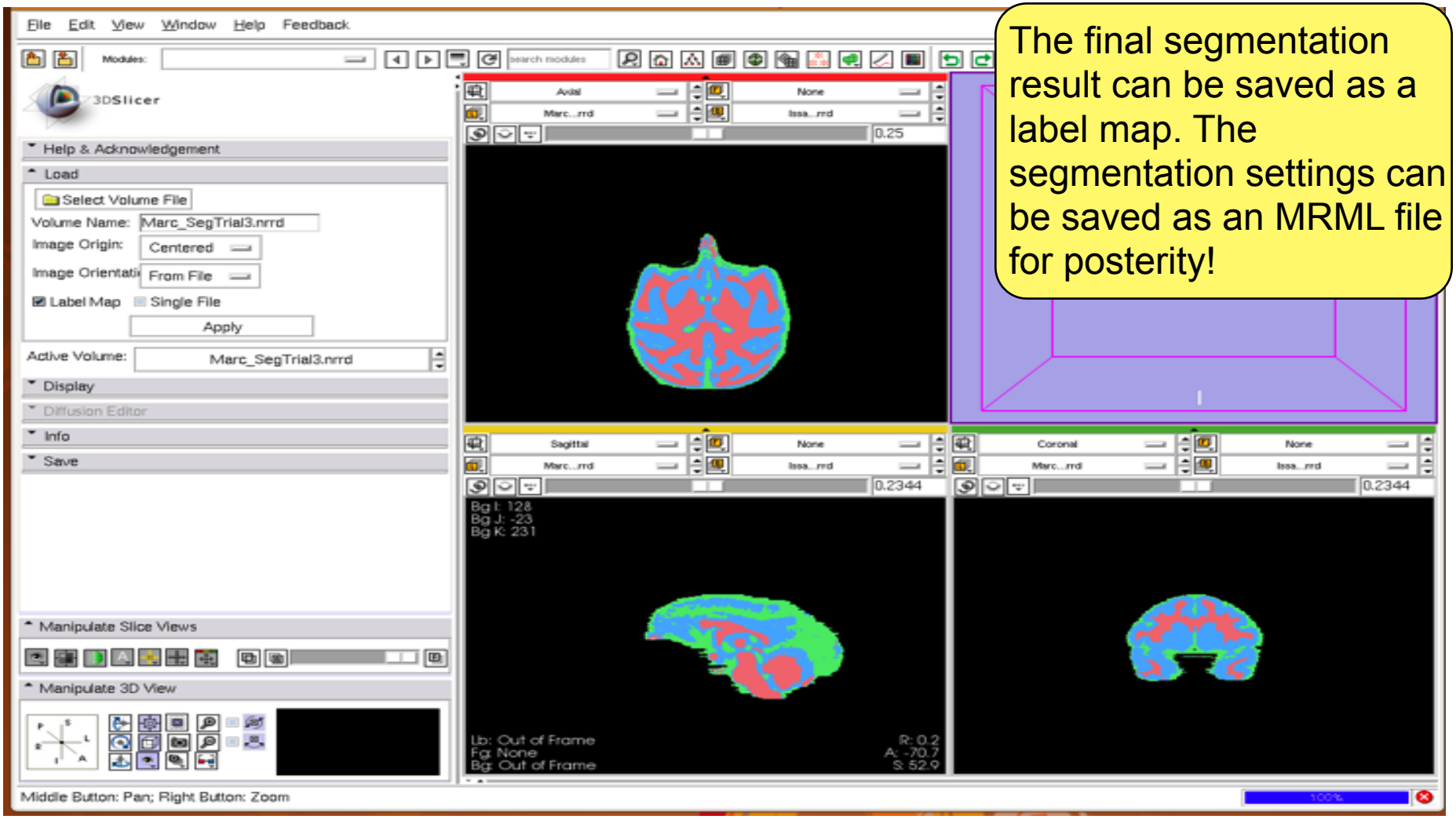


Result - Segmentation Label Map



The final segmentation result can be saved as a label map. The segmentation settings can be saved as an MRML file for posterity!

Conclusions

- The segmentation result can be saved as a labelmap
- The segmentation hierarchy can be modified to include sub-cortical structures.
- Probability maps for sub-cortical structures are also available for download along with the other maps.

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