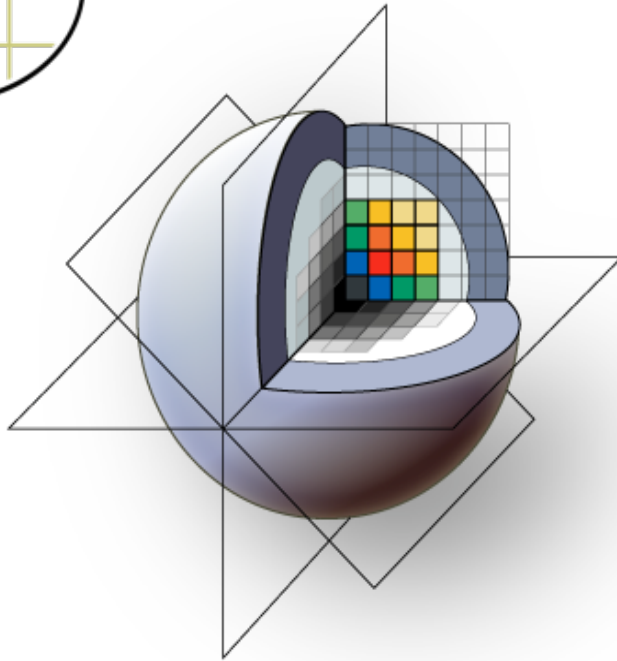




Slicer3 Training Compendium

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

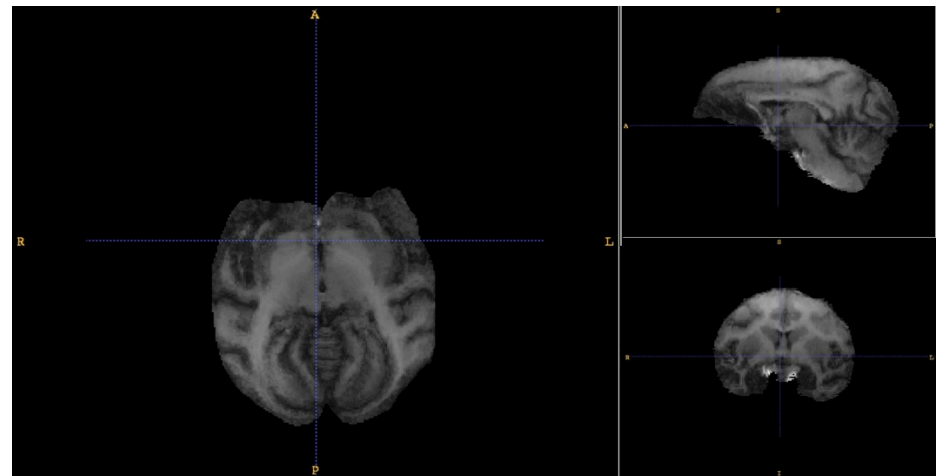
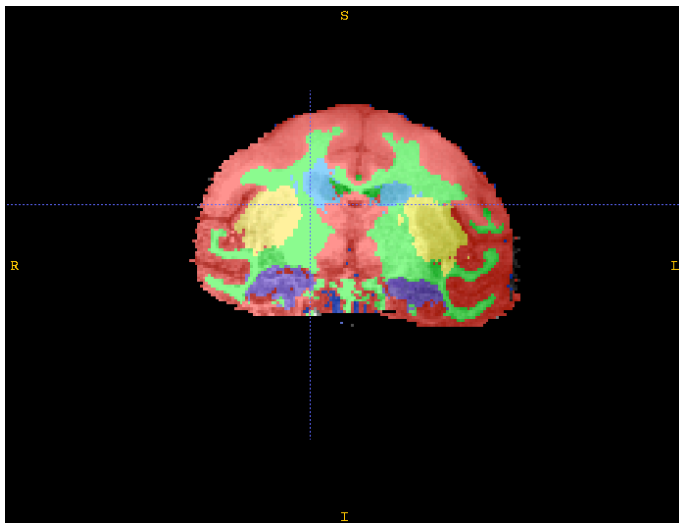


Vidya Rajagopalan
Christopher Wyatt
BioImaging Systems Lab
Dept. of Electrical Engineering
Virginia Tech

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

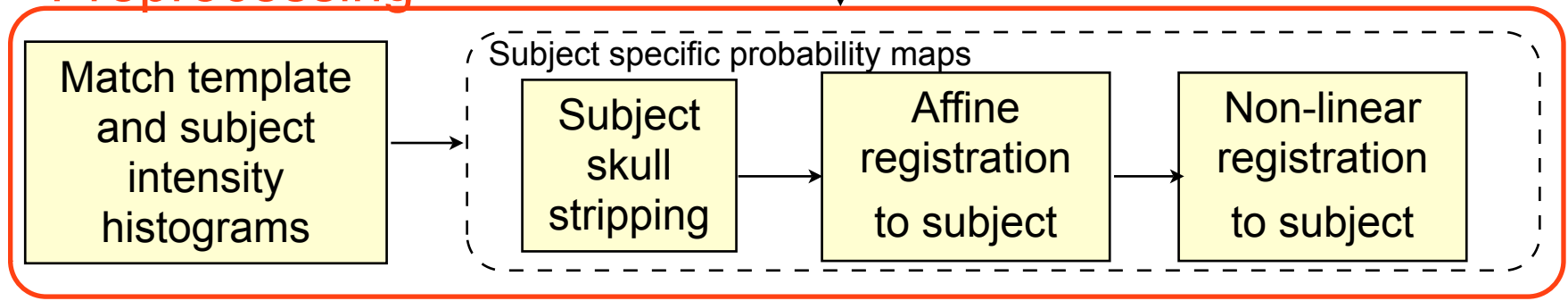
Disclaimer: *It is the responsibility of the user of Slicer to comply with both the terms of the license and with the applicable laws, regulations, and rules.*

Segmentation Procedure

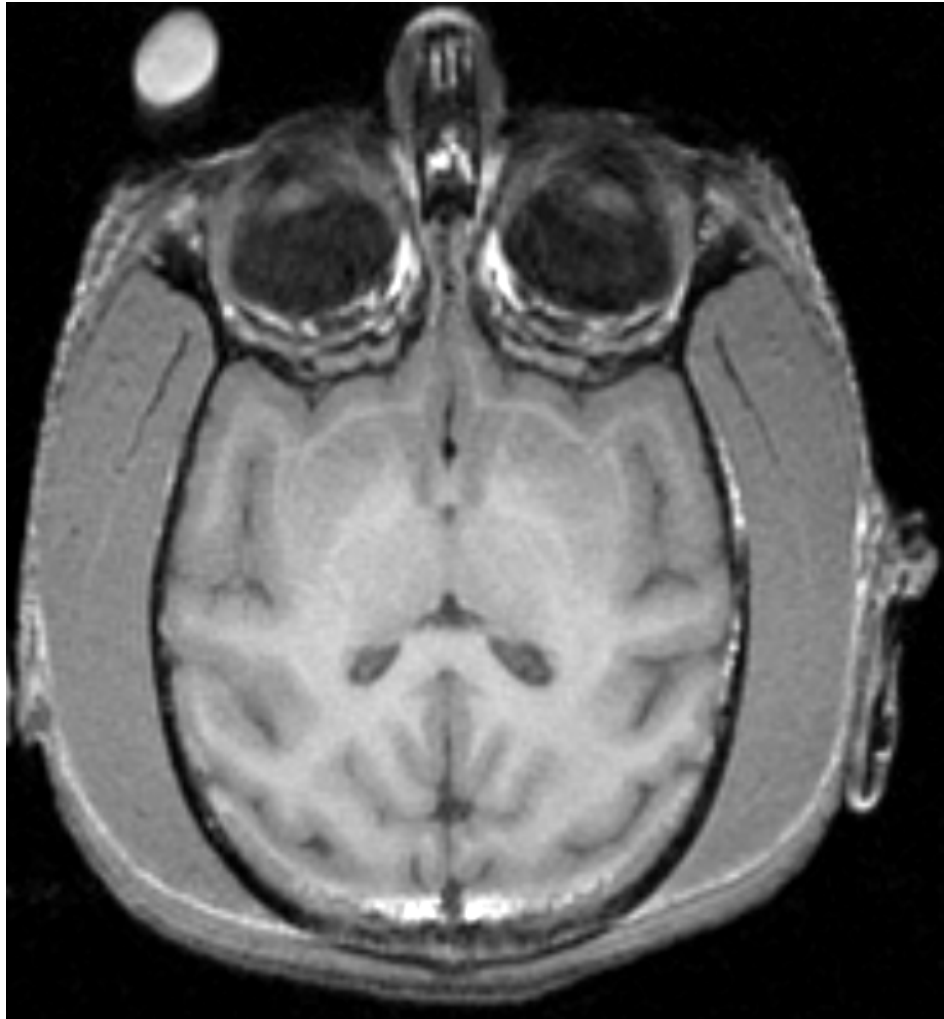
Input



Preprocessing



Input for Segmentation



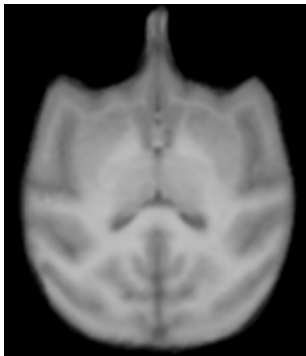
- The image to be segmented is the primary input.
- In this tutorial we deal with segmenting the T1 image of a vervet subject.
- This can be extended to multi-channel segmentation using the example in: http://wiki.na-mic.org/Wiki/images/2/2f/AutomaticSegmentation_SoniaPujol_Munich2008.ppt
- The subject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



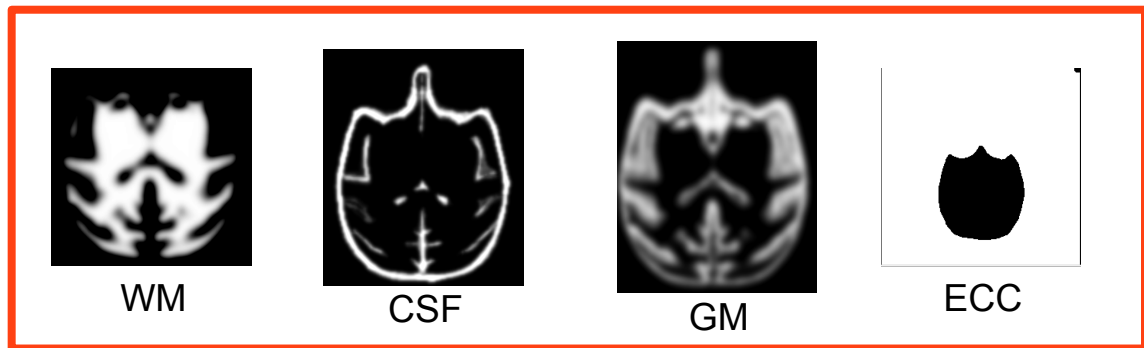
Input - Template Image and Probability Maps

- 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



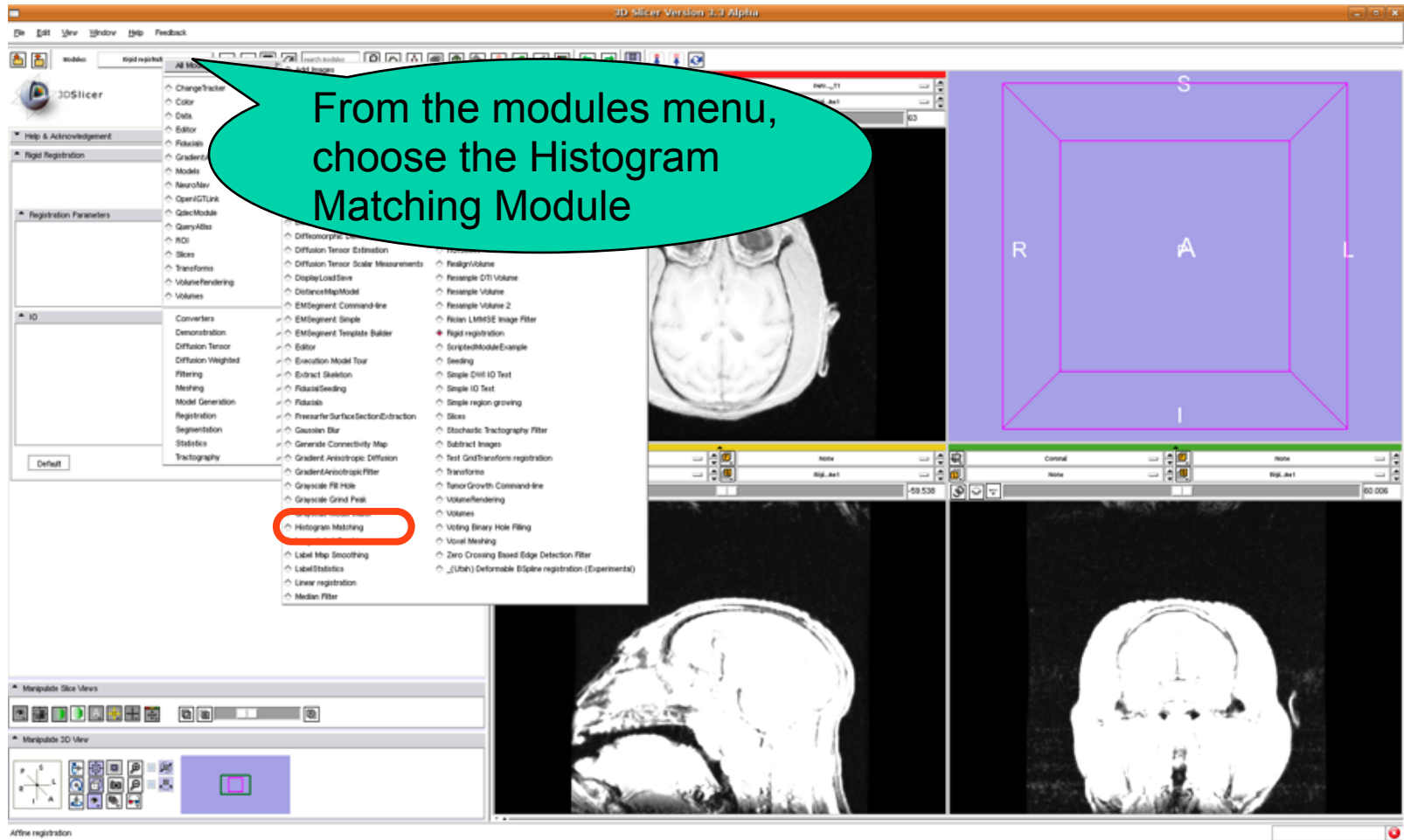
**Template
Image**



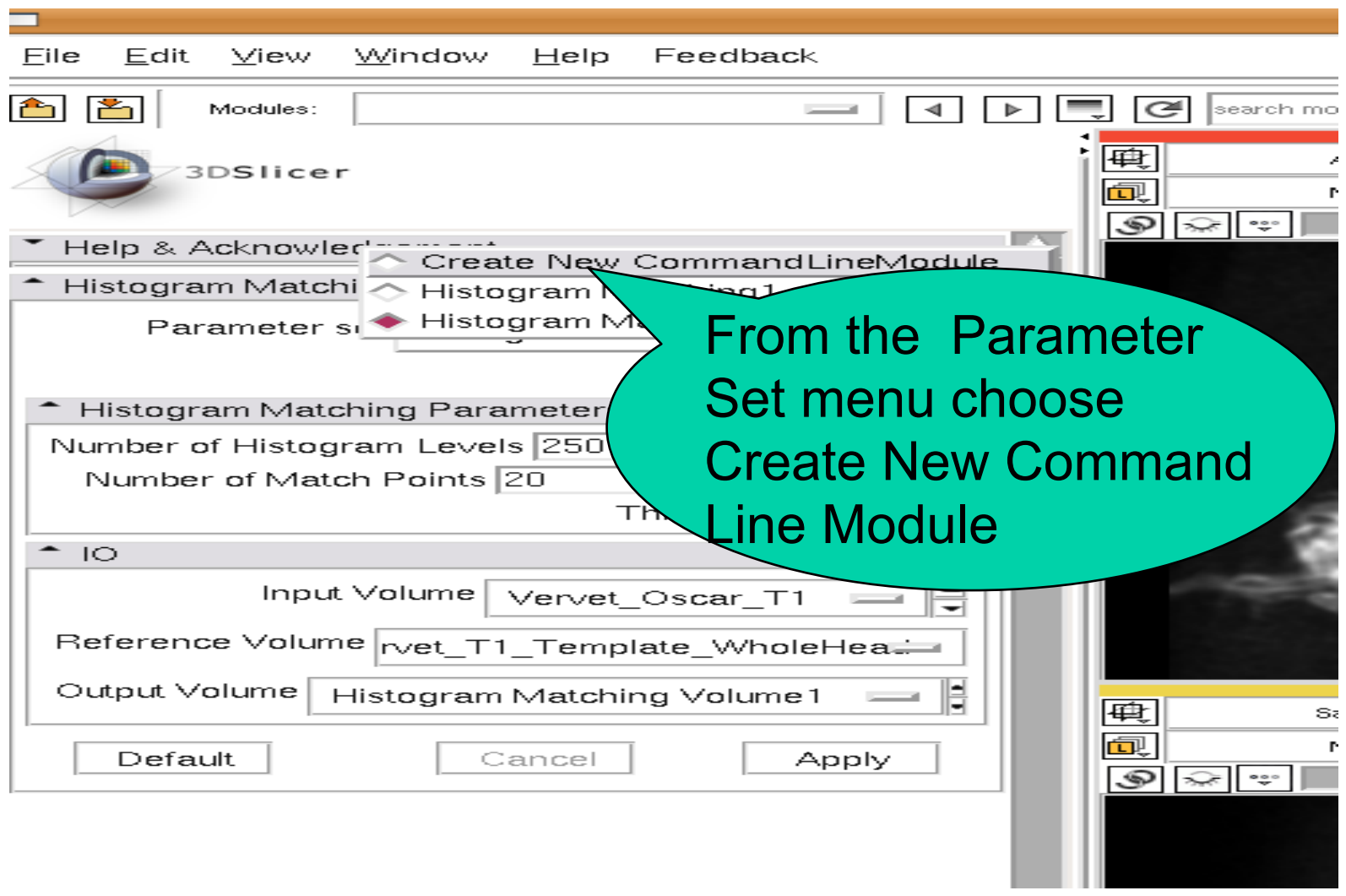
Probability Atlas

Preprocessing

Histogram Matching



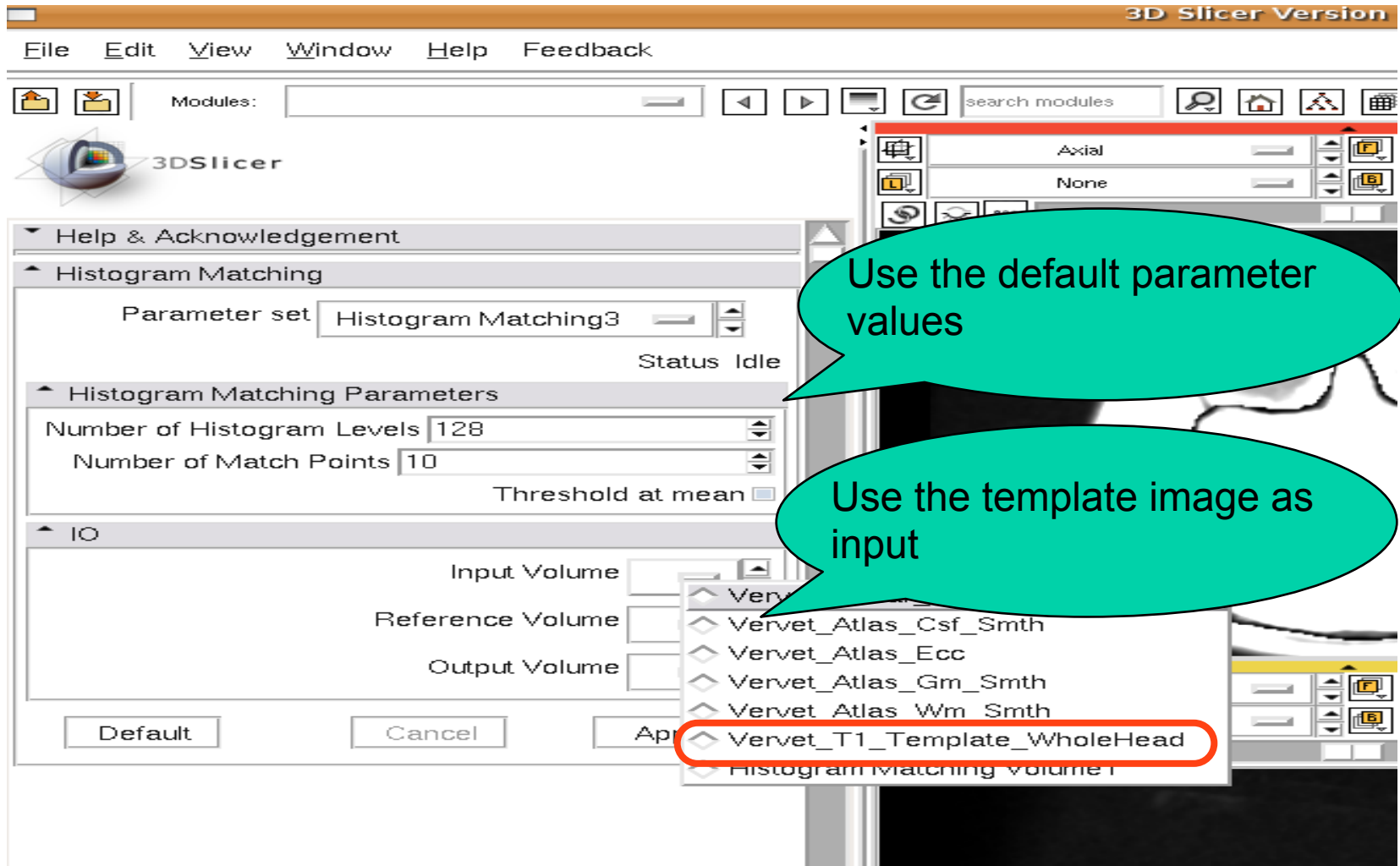
Histogram Matching



The screenshot shows the 3DSlicer interface with the Histogram Matching dialog box open. The dialog box has a menu bar with 'File', 'Edit', 'View', 'Window', 'Help', and 'Feedback'. Below the menu bar is a 'Modules:' field and a search box. The dialog box is titled 'Histogram Matching' and has a 'Parameter set' dropdown menu. The 'Parameter set' dropdown menu is open, showing a list of options: 'Create New Command Line Module', 'Histogram Matching 1', and 'Histogram Matching 2'. The 'Histogram Matching 1' option is selected. Below the dropdown menu, the dialog box has a 'Histogram Matching Parameter' section with two input fields: 'Number of Histogram Levels' (set to 250) and 'Number of Match Points' (set to 20). Below this is an 'IO' section with three input fields: 'Input Volume' (set to 'Vervet_Oscar_T1'), 'Reference Volume' (set to 'Vervet_T1_Template_WholeHead'), and 'Output Volume' (set to 'Histogram Matching Volume 1'). At the bottom of the dialog box are three buttons: 'Default', 'Cancel', and 'Apply'.

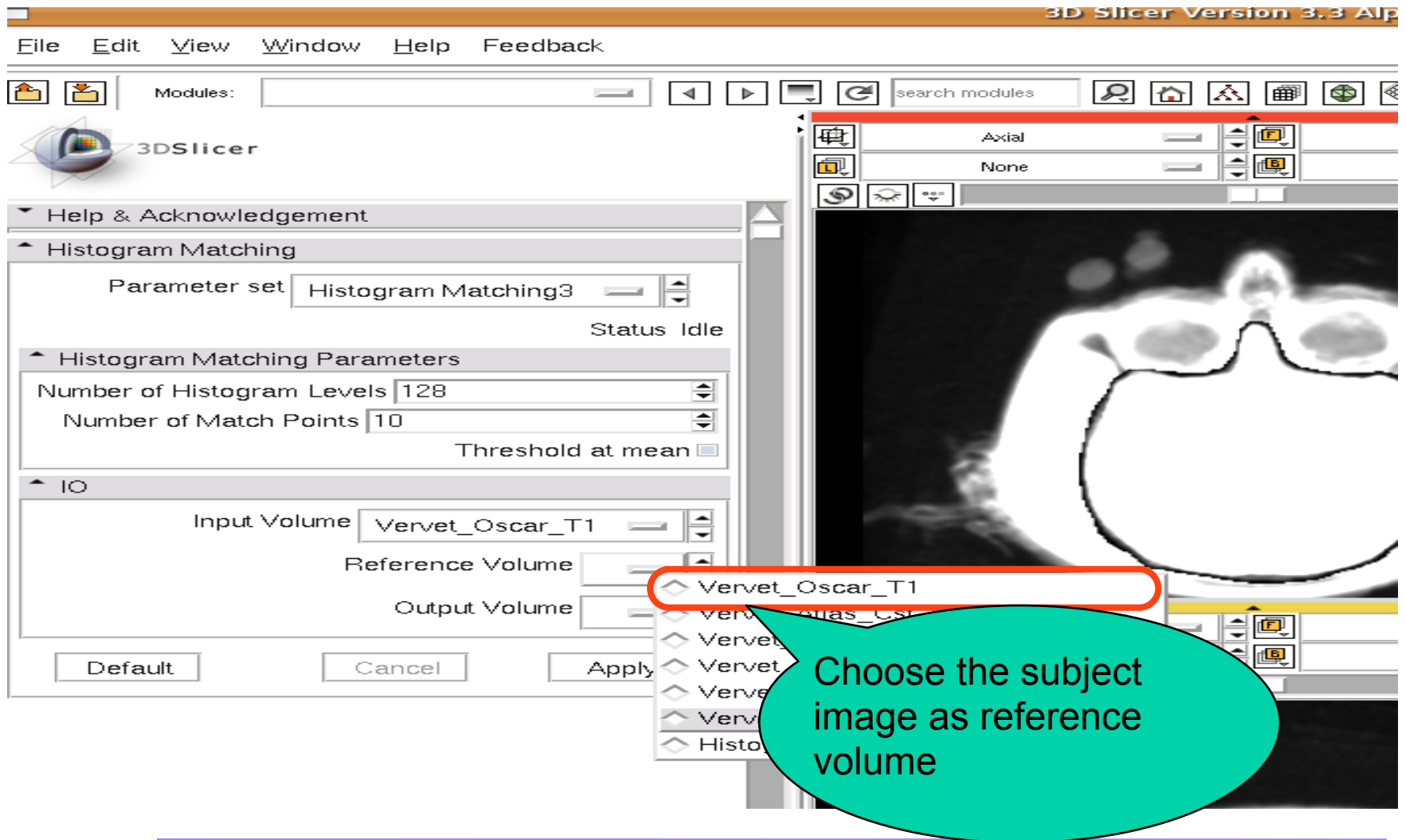
From the Parameter Set menu choose Create New Command Line Module

Histogram Matching



The screenshot shows the 3D Slicer software interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. Below the menu bar is a toolbar with various icons. The main window displays the Histogram Matching module settings. The 'Parameter set' is set to 'Histogram Matching3'. The 'Status' is 'Idle'. Under 'Histogram Matching Parameters', the 'Number of Histogram Levels' is set to 128 and the 'Number of Match Points' is set to 10. The 'Threshold at mean' checkbox is checked. Under 'IO', the 'Input Volume', 'Reference Volume', and 'Output Volume' fields are empty. A dropdown menu is open for the 'Input Volume' field, showing a list of volumes: Vervet_Atlas_Csf_Smth, Vervet_Atlas_Ecc, Vervet_Atlas_Gm_Smth, Vervet_Atlas_Wm_Smth, Vervet_T1_Template_WholeHead (highlighted with a red circle), and Histogram matching volume 1. Two teal speech bubbles are overlaid on the interface. The first bubble points to the 'Parameter set' dropdown and contains the text 'Use the default parameter values'. The second bubble points to the 'Input Volume' dropdown and contains the text 'Use the template image as input'.

Histogram Matching

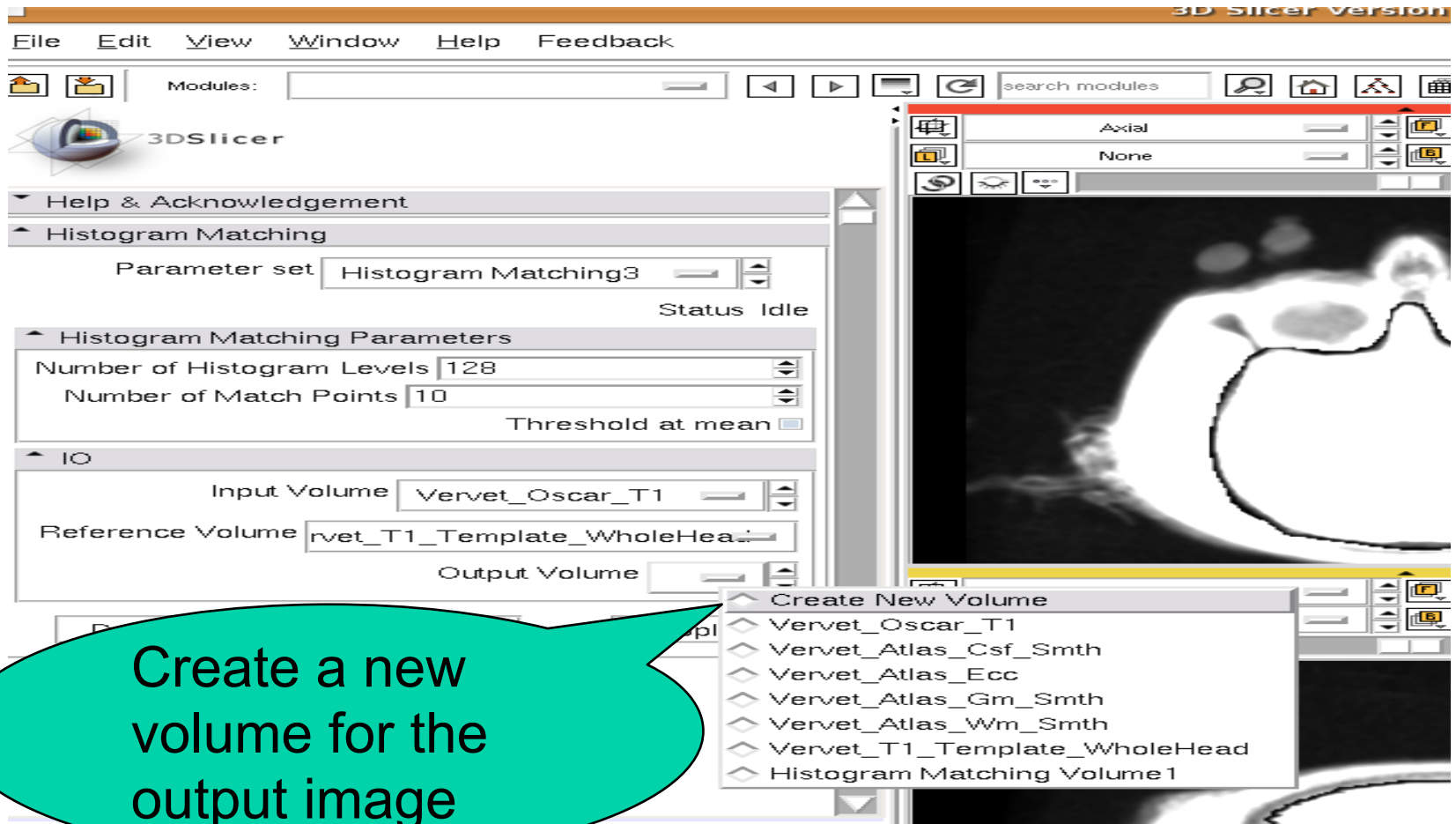


The screenshot shows the 3D Slicer Version 3.3 Alpha interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. Below the menu is a toolbar with various icons and a search field for modules. The main window displays a 3D view of a brain scan with a white mask overlaid. On the left, the Histogram Matching module is active, showing the following settings:

- Parameter set: Histogram Matching3
- Status: Idle
- Number of Histogram Levels: 128
- Number of Match Points: 10
- Threshold at mean:
- Input Volume: Vervet_Oscar_T1
- Reference Volume: (empty)
- Output Volume: (empty)

At the bottom of the module panel are buttons for Default, Cancel, and Apply. A dropdown menu is open for the Reference Volume field, listing several volumes including Vervet_Oscar_T1, which is highlighted with a red circle. A green callout bubble points to this selection with the text: "Choose the subject image as reference volume".

Histogram Matching



The screenshot shows the 3DSlicer interface with the Histogram Matching module active. The 'Parameter set' is 'Histogram Matching3'. Under 'Histogram Matching Parameters', 'Number of Histogram Levels' is 128, 'Number of Match Points' is 10, and 'Threshold at mean' is checked. Under 'IO', 'Input Volume' is 'Vervet_Oscar_T1' and 'Reference Volume' is 'rvet_T1_Template_WholeHea...'. An 'Output Volume' field is present but empty. A 'Create New Volume' dropdown menu is open, showing a list of volumes including 'Histogram Matching Volume 1'. A teal callout bubble points to this menu.

File Edit View Window Help Feedback

Modules: search modules

3DSlicer

Help & Acknowledgement

Histogram Matching

Parameter set Histogram Matching3 Status Idle

Histogram Matching Parameters

Number of Histogram Levels 128

Number of Match Points 10

Threshold at mean

IO

Input Volume Vervet_Oscar_T1

Reference Volume rvet_T1_Template_WholeHea...

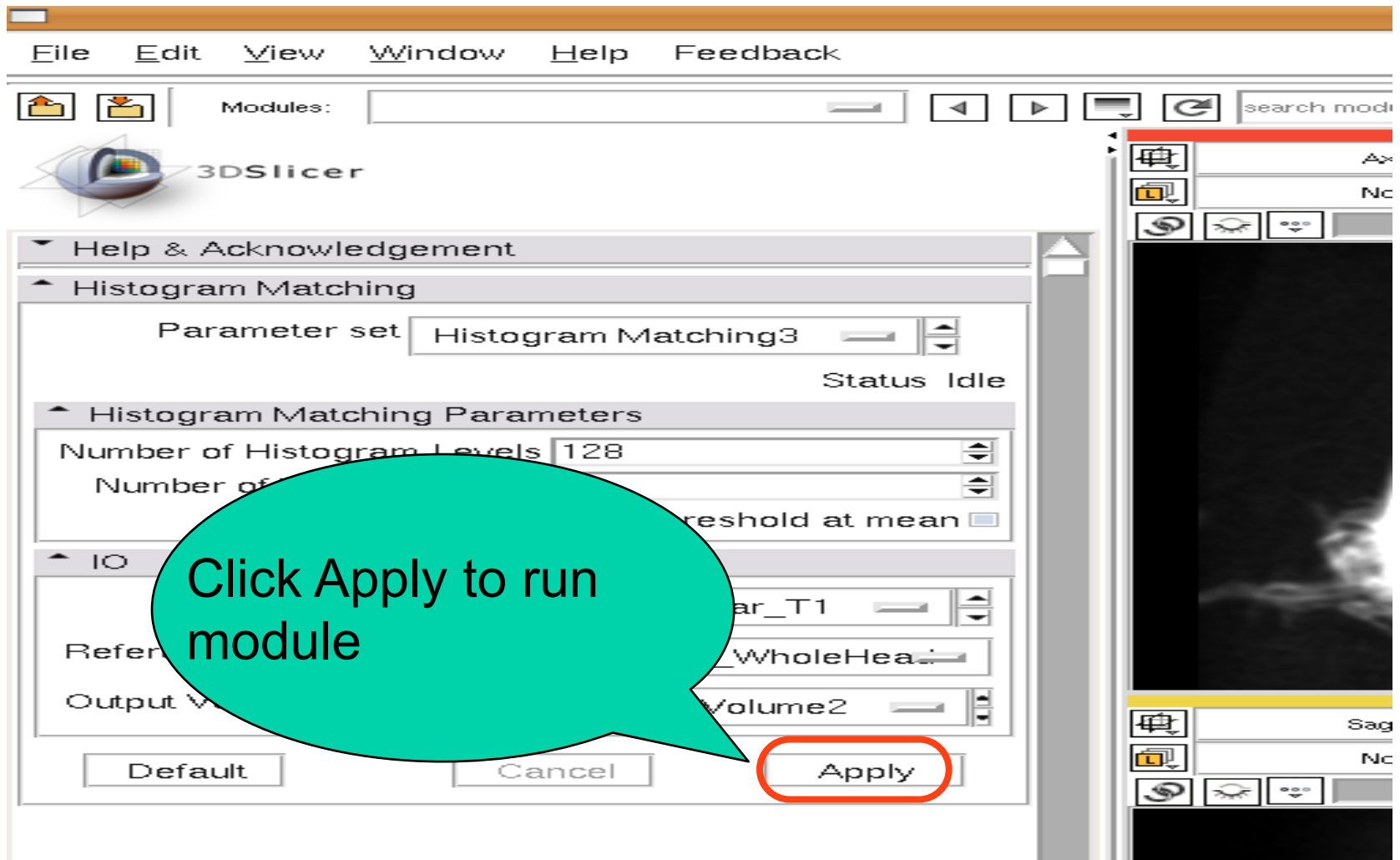
Output Volume

Create New Volume

- Vervet_Oscar_T1
- Vervet_Atlas_Csf_Smth
- Vervet_Atlas_Ecc
- Vervet_Atlas_Gm_Smth
- Vervet_Atlas_Wm_Smth
- Vervet_T1_Template_WholeHead
- Histogram Matching Volume 1

Create a new volume for the output image

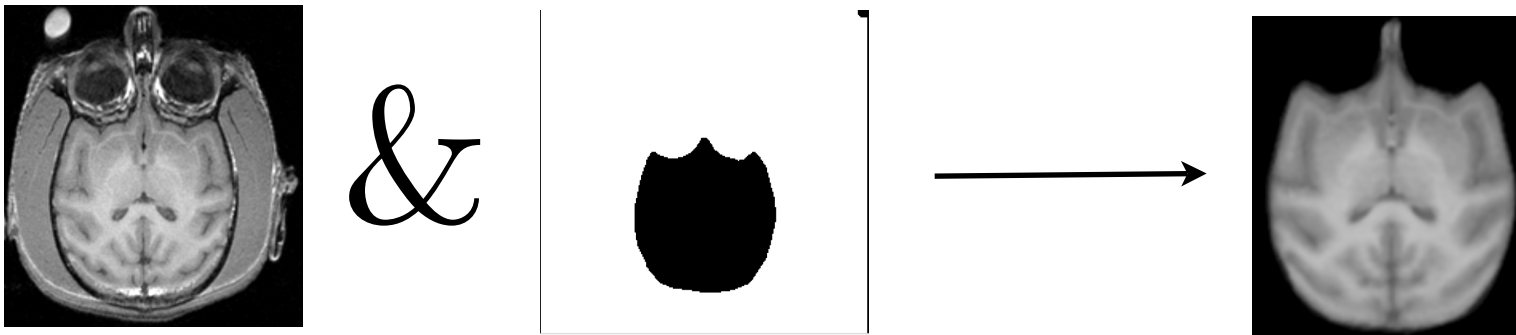
Histogram Matching



The screenshot shows the 3DSlicer software interface. At the top is a menu bar with 'File', 'Edit', 'View', 'Window', 'Help', and 'Feedback'. Below the menu bar is a toolbar with icons for home, save, and other functions. The main window displays the 'Histogram Matching' module. The 'Parameter set' is 'Histogram Matching3' and the status is 'Idle'. Under 'Histogram Matching Parameters', 'Number of Histogram Levels' is set to 128. The 'IO' section shows 'Refer' and 'Output V' fields. At the bottom of the module panel are 'Default', 'Cancel', and 'Apply' buttons. A red circle highlights the 'Apply' button. A green speech bubble points to the 'Apply' button with the text 'Click Apply to run module'. To the right, a vertical toolbar contains icons for view manipulation, and a 3D viewer shows a grayscale medical image.

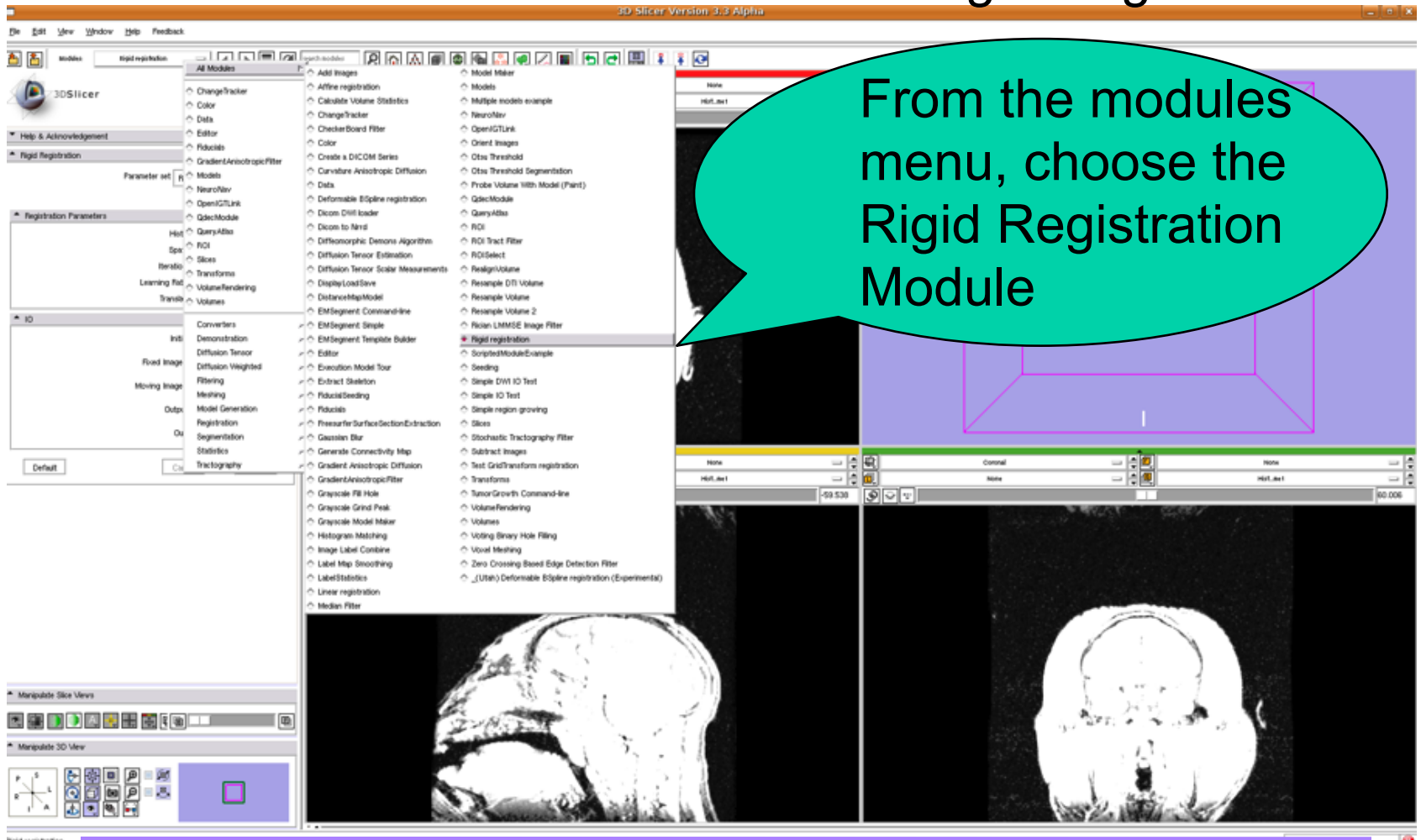
Subject Image Skull Stripping

- 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



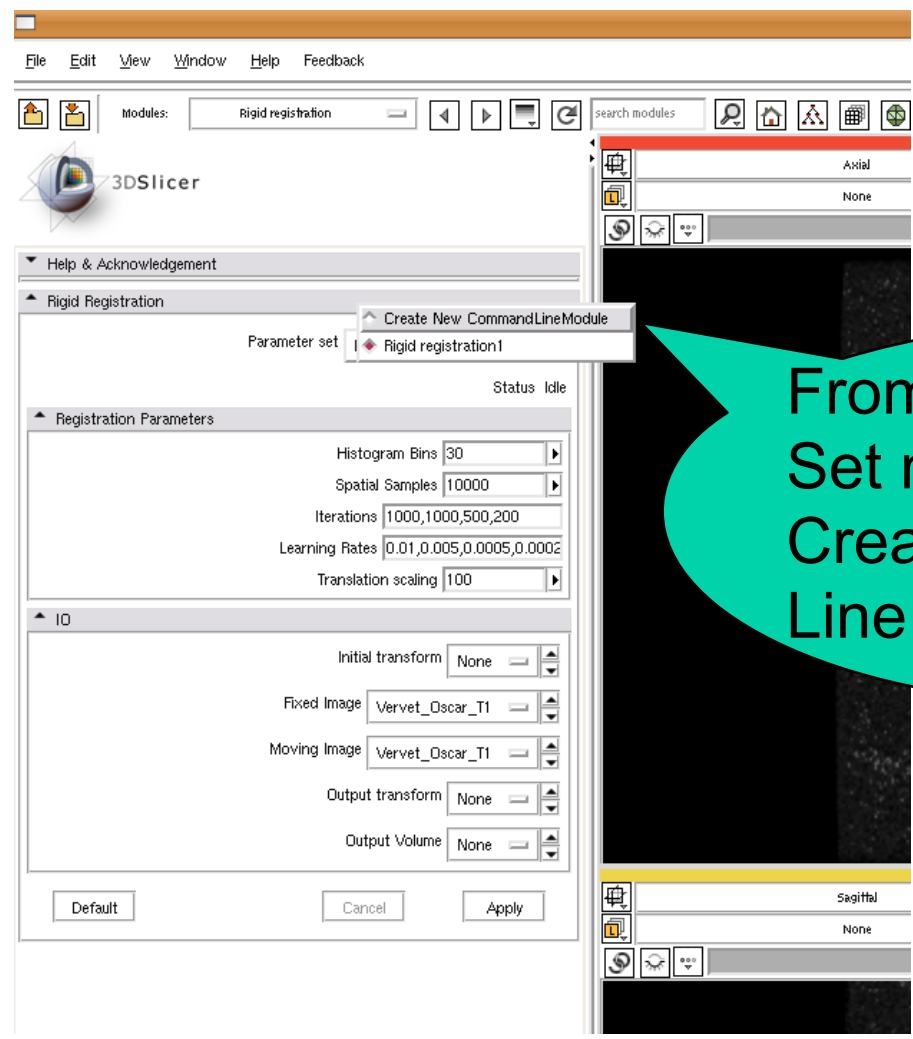
Subject Image Skull Stripping

Rigid Registration



Subject Image Skull Stripping

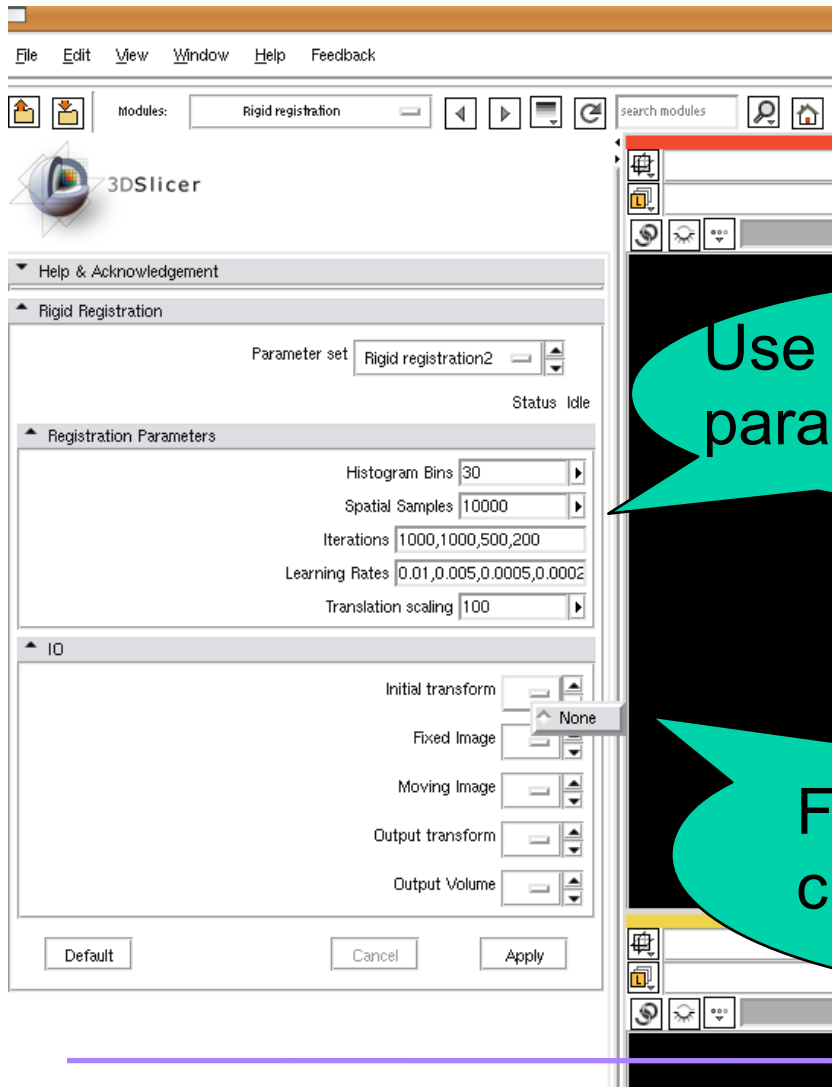
Rigid Registration



From the Parameter Set menu choose Create New Command Line Module

Subject Image Skull Stripping

Rigid Registration

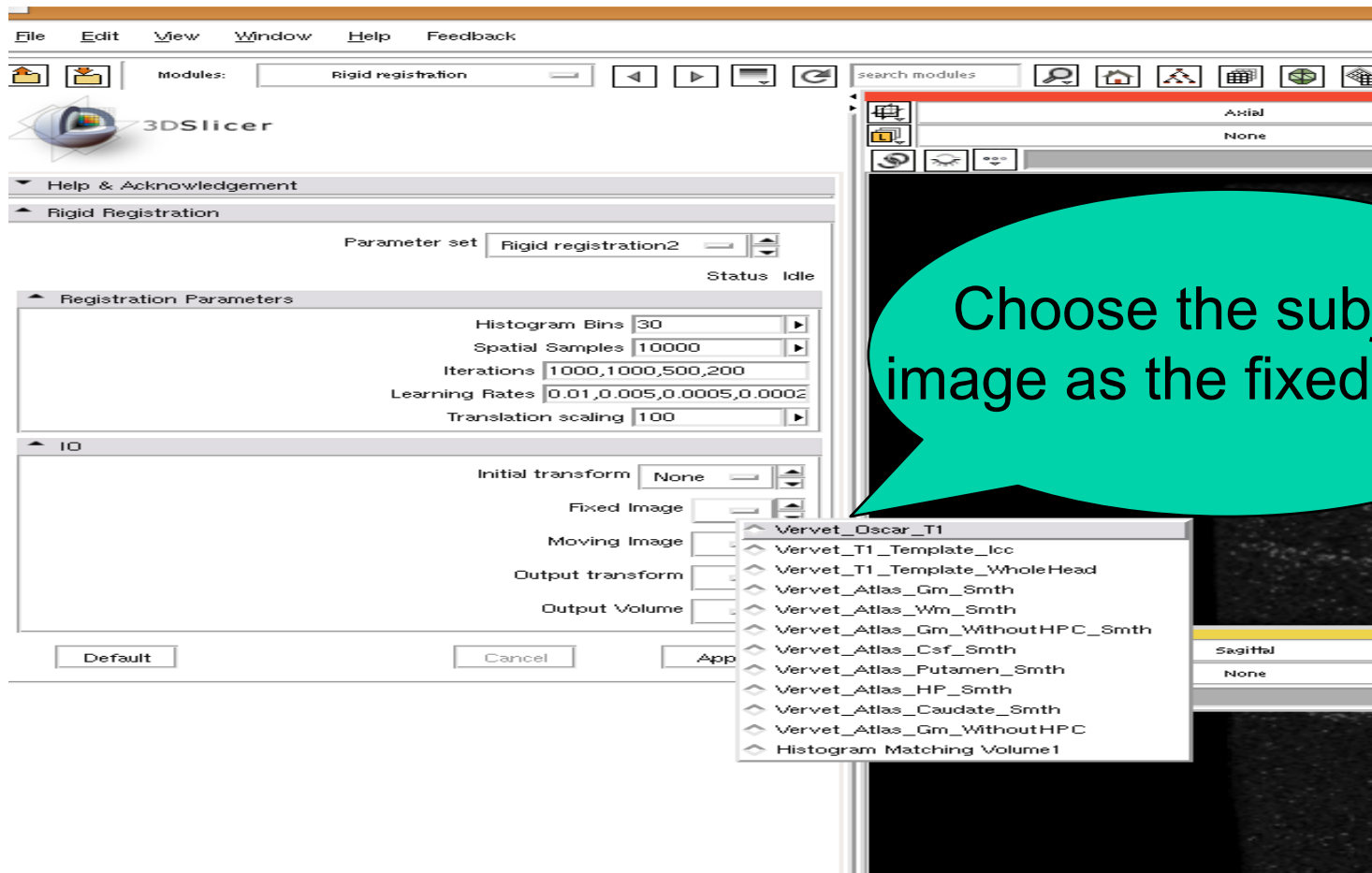


Use the default registration parameters

For initial transforms, choose None

Subject Image Skull Stripping

Rigid Registration



The screenshot shows the 3DSlicer Rigid Registration module interface. The 'Fixed Image' dropdown menu is open, displaying a list of available images. A red speech bubble points to the 'Vervet_Oscar_T1' option, indicating it should be selected as the fixed image.

Parameter set: Rigid registration2

Status: Idle

Registration Parameters

- Histogram Bins: 30
- Spatial Samples: 10000
- Iterations: 1000,1000,500,200
- Learning Rates: 0.01,0.005,0.0005,0.0002
- Translation scaling: 100

IO

Initial transform: None

Fixed Image: Vervet_Oscar_T1

Moving Image: [Empty]

Output transform: [Empty]

Output Volume: [Empty]

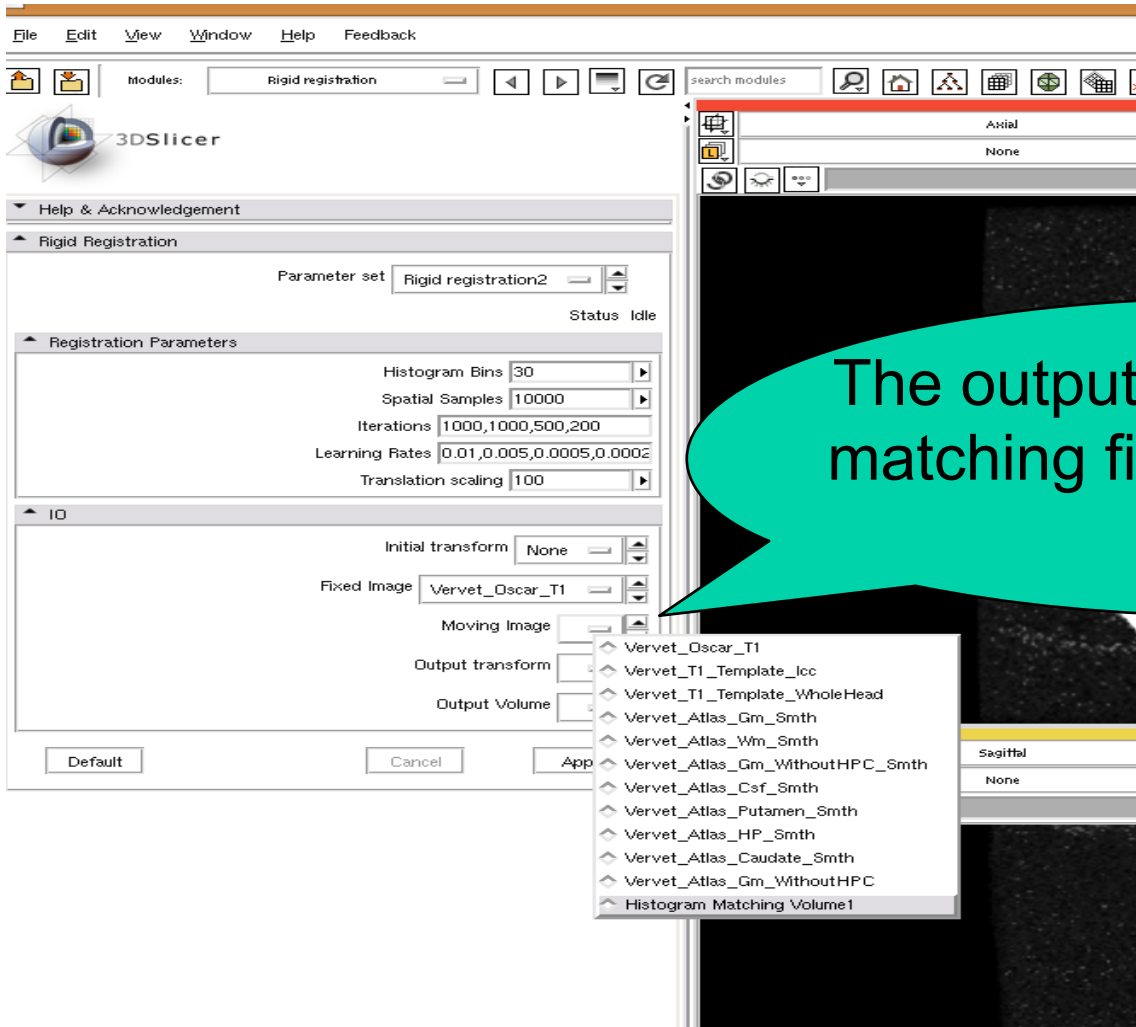
Buttons: Default, Cancel, Apply

Dropdown menu items:

- Vervet_Oscar_T1
- Vervet_T1_Template_Icc
- Vervet_T1_Template_WholeHead
- Vervet_Atlas_Gm_Smth
- Vervet_Atlas_Wm_Smth
- Vervet_Atlas_Gm_WithoutHPC_Smth
- Vervet_Atlas_Csf_Smth
- Vervet_Atlas_Putamen_Smth
- Vervet_Atlas_HP_Smth
- Vervet_Atlas_Caudate_Smth
- Vervet_Atlas_Gm_WithoutHPC
- Histogram Matching Volume1

Subject Image Skull Stripping

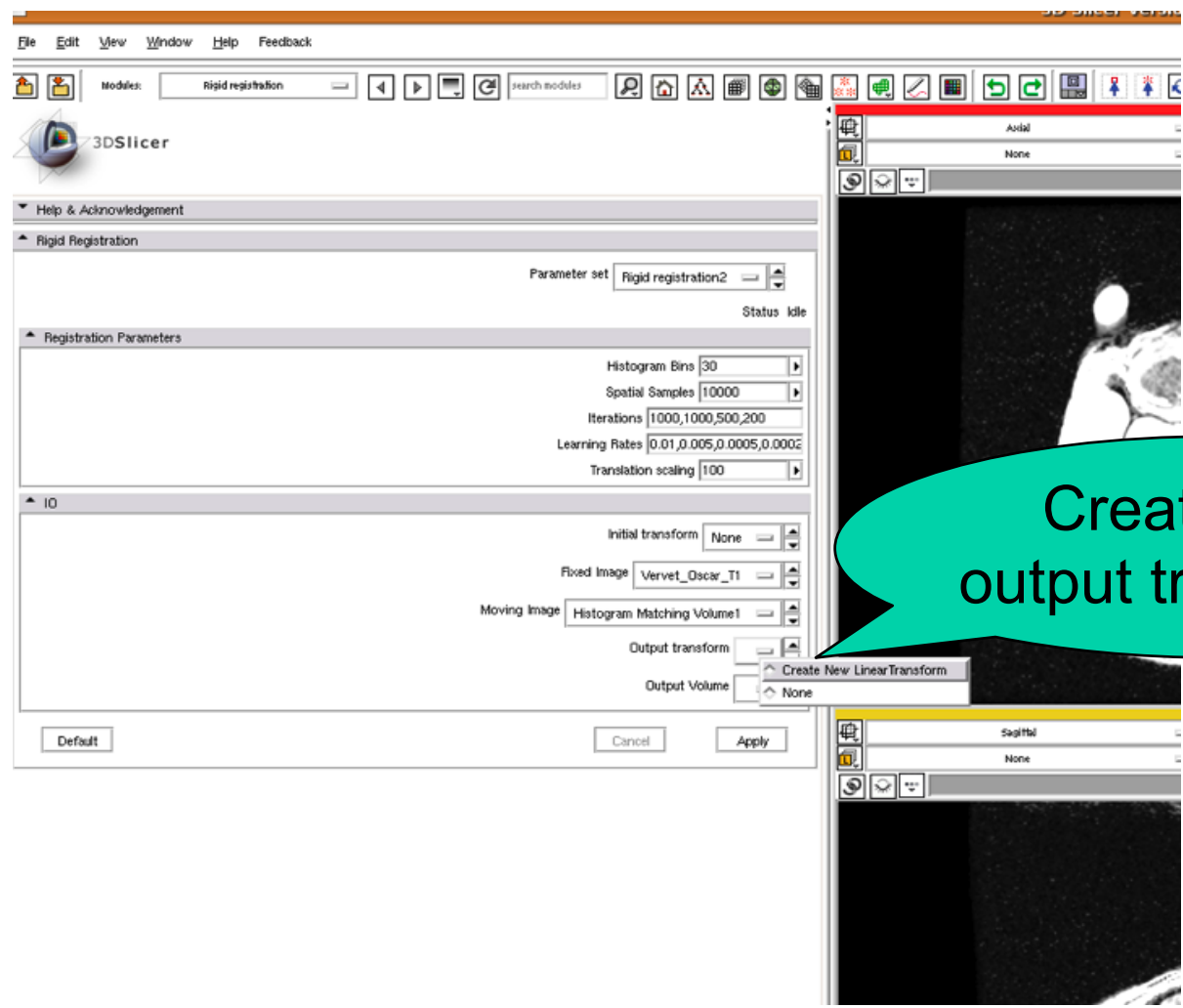
Rigid Registration



The output of the histogram matching filter is the moving image

Subject Image Skull Stripping

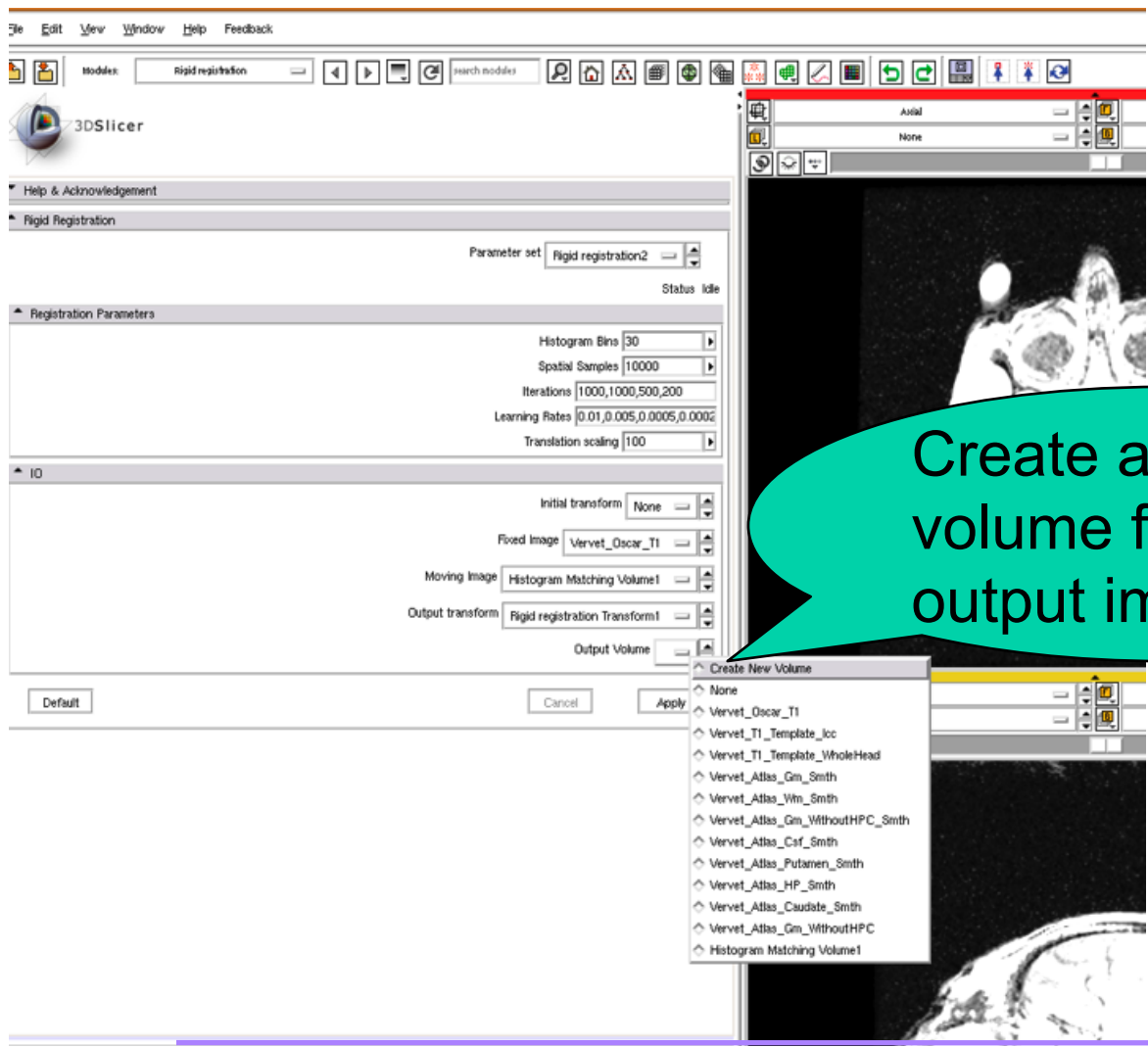
Rigid Registration



Create a new output transform

Subject Image Skull Stripping

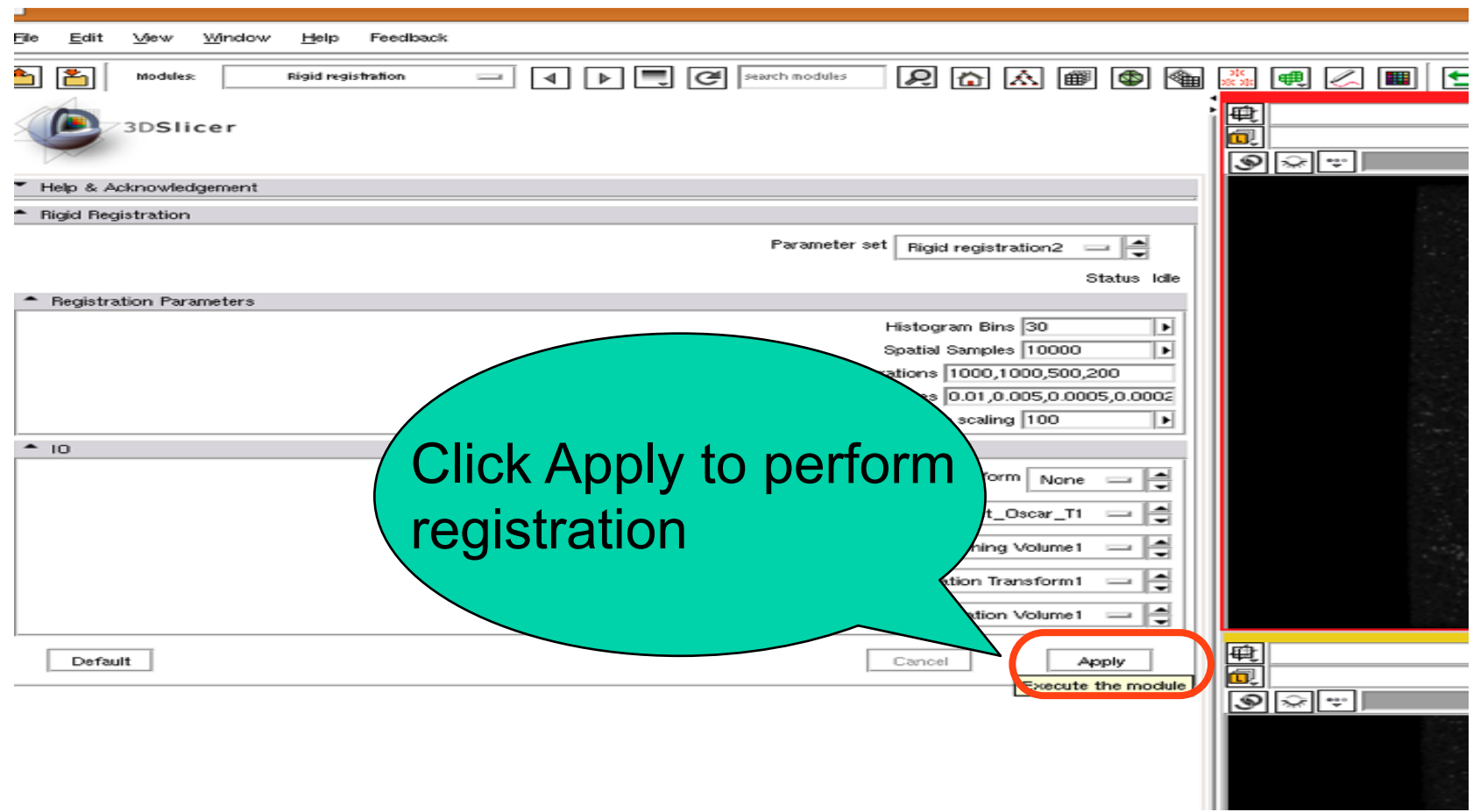
Rigid Registration



Create a new volume for the output image

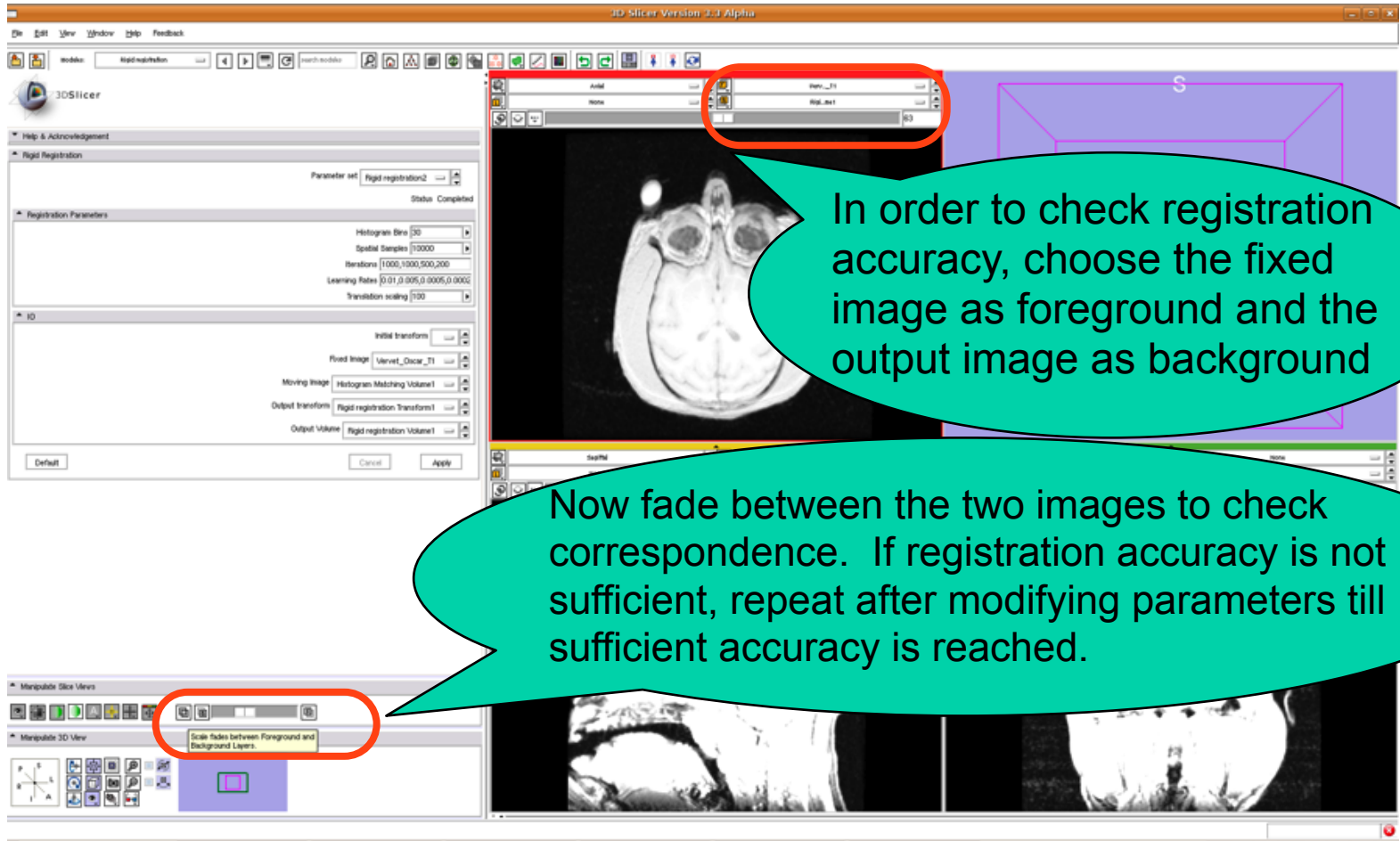
Subject Image Skull Stripping

Rigid Registration



Subject Image Skull Stripping

Rigid Registration



The screenshot shows the 3D Slicer interface with the Rigid Registration module active. The 'Rigid Registration' panel on the left shows parameters for 'Rigid registration2'. The 'Fixed Image' is 'Vessel_Docor_T1' and the 'Moving Image' is 'Histogram Matching Volume1'. The 'Output Volume' is 'Rigid registration Volume1'. The 'Manipulate Slice Views' panel at the bottom shows a 'Scale' slider between 'Foreground and Background Layers'.

In order to check registration accuracy, choose the fixed image as foreground and the output image as background

Now fade between the two images to check correspondence. If registration accuracy is not sufficient, repeat after modifying parameters till sufficient accuracy is reached.



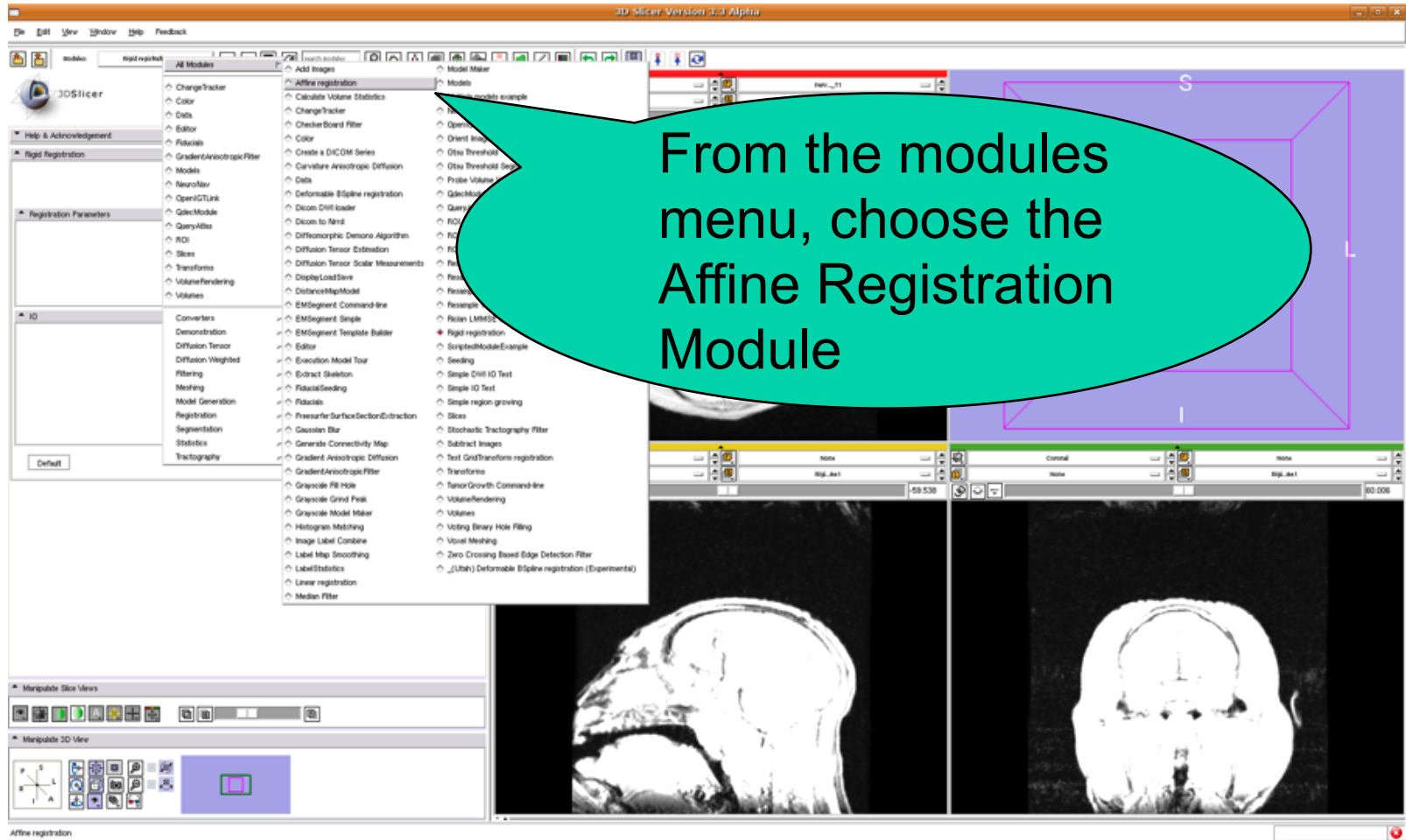
Subject Image Skull Stripping

Affine Registration

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

Subject Image Skull Stripping

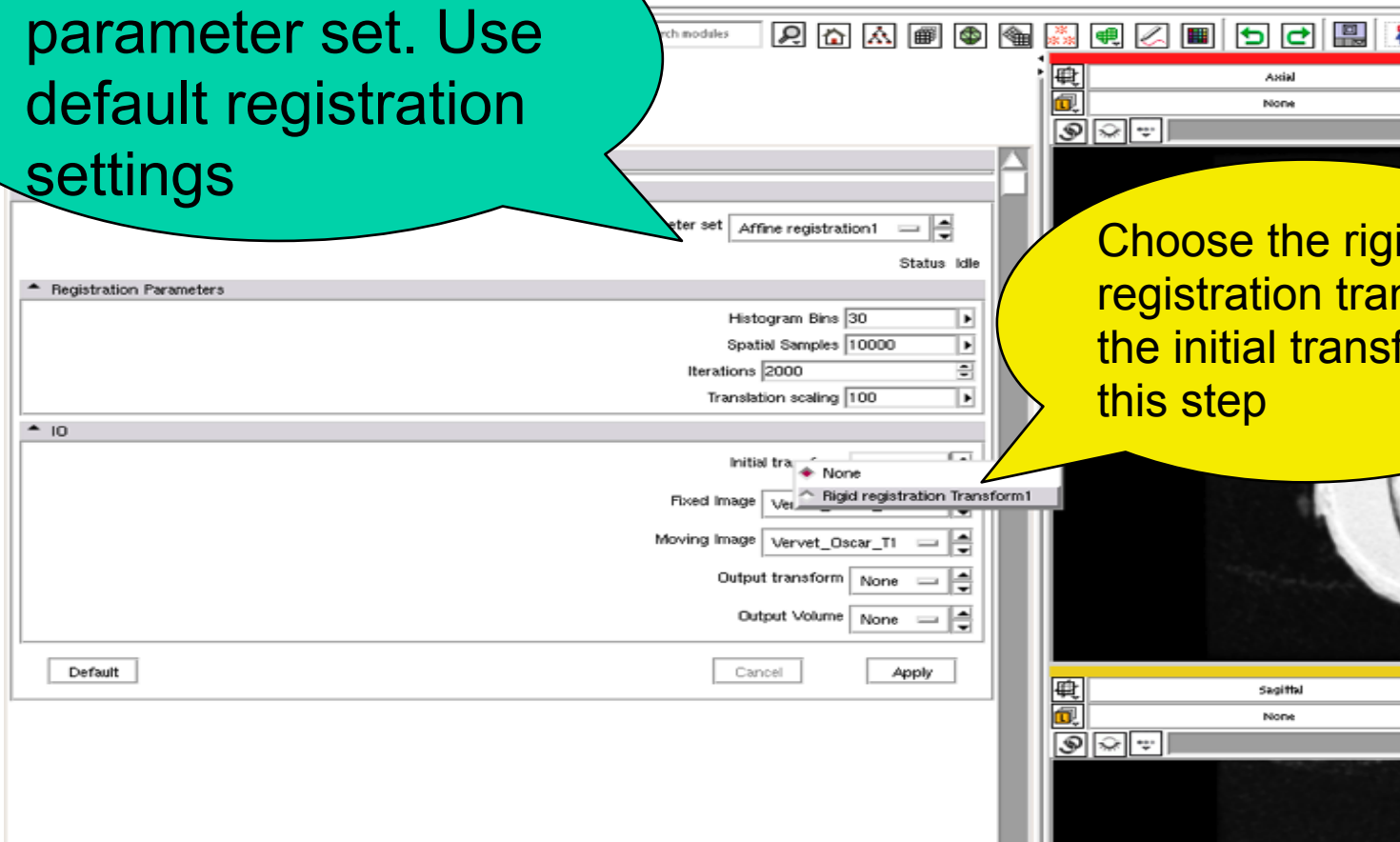
Affine Registration



Subject Image Skull Stripping

Affine Registration

Choose a new affine parameter set. Use default registration settings

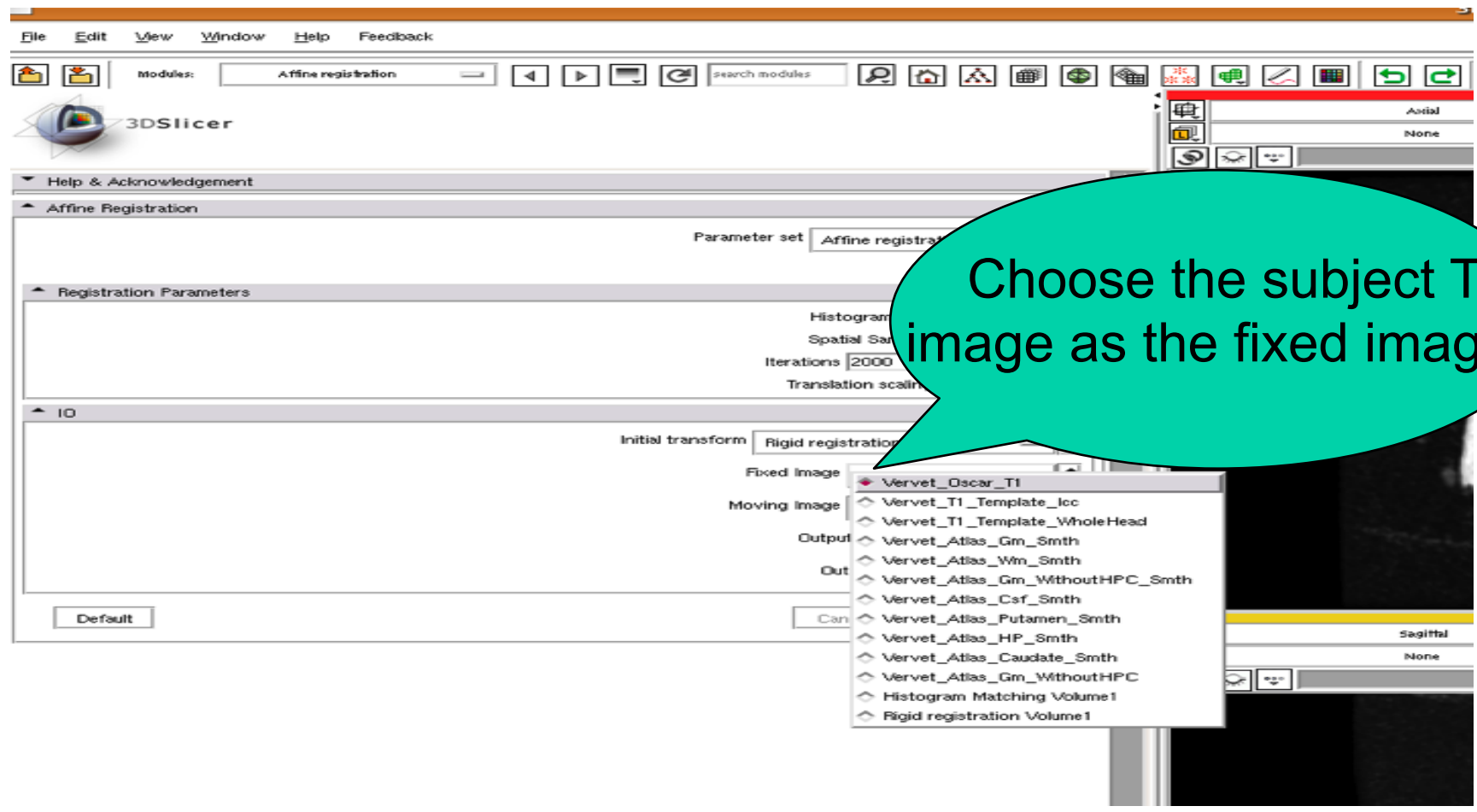


Choose the rigid registration transform as the initial transform for this step



Subject Image Skull Stripping

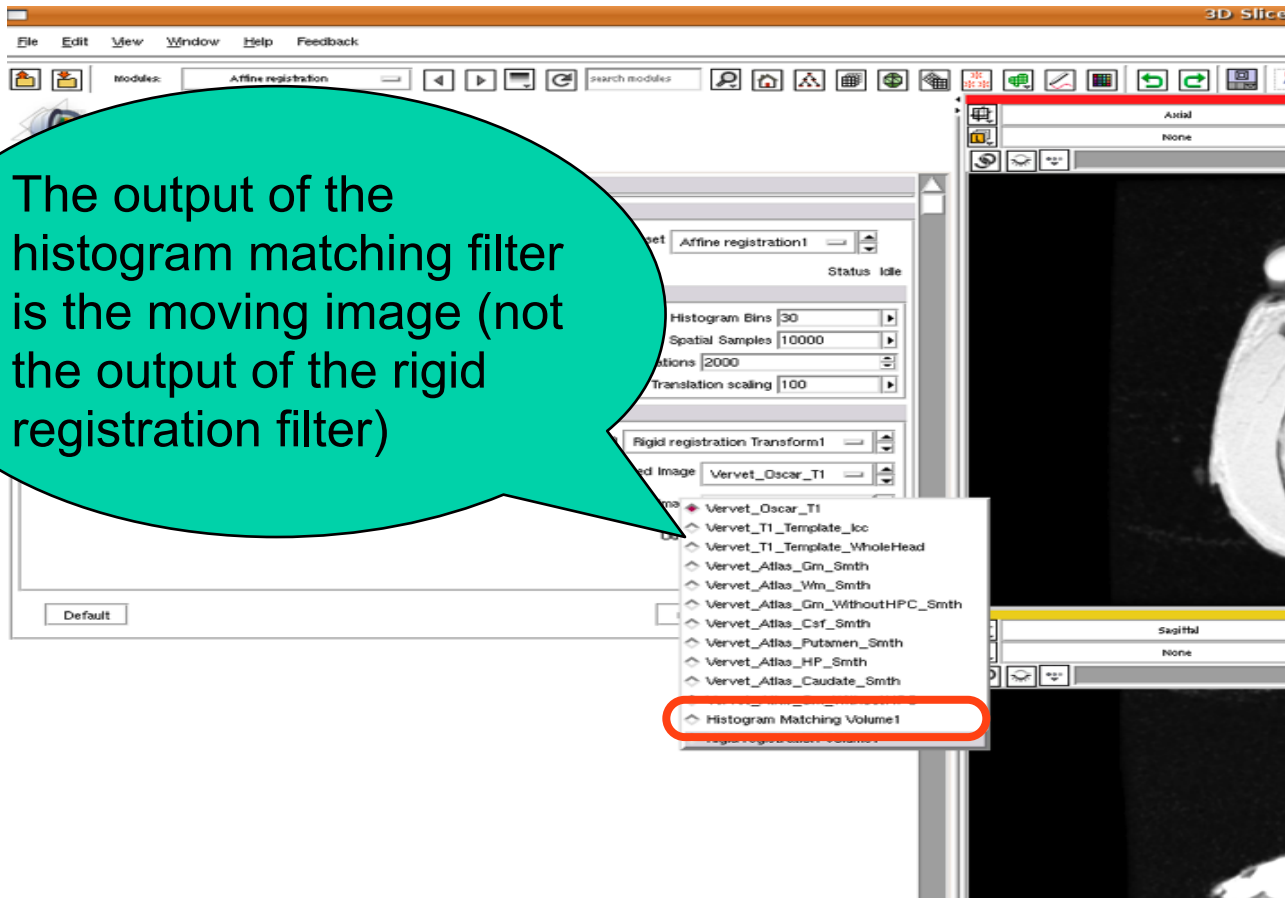
Affine Registration



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)





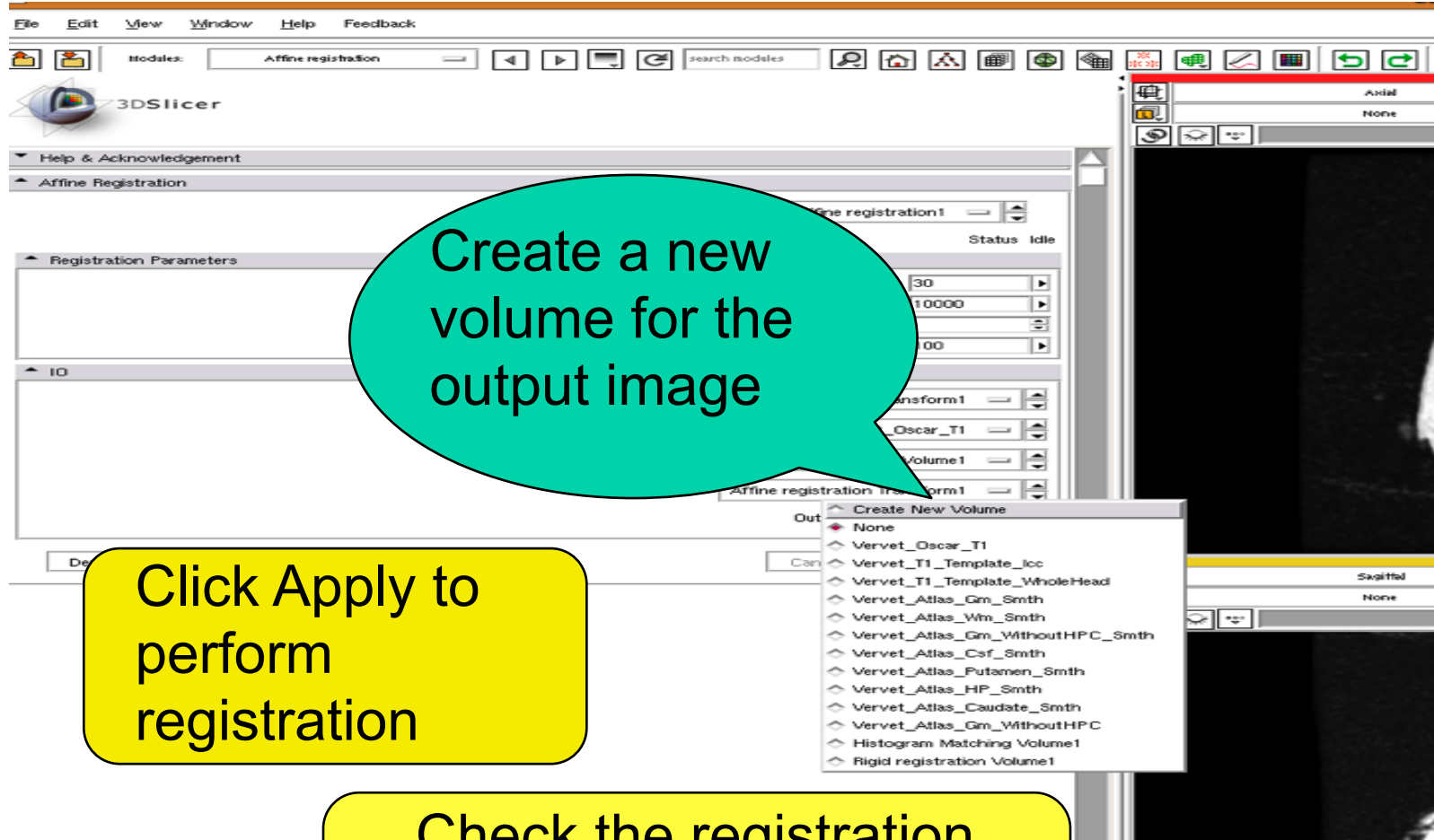
Subject Image Skull Stripping

Affine Registration

The screenshot shows the 3DSlicer software interface with the Affine Registration module selected. The dialog box is open, showing various parameters for registration. A callout bubble points to the 'Output' dropdown menu, which is currently set to 'None'. The callout bubble contains the text: 'Create a new output transform'. The 'Output' dropdown menu is open, showing options: 'None', 'Rigid registration Transform1', and 'Create New Linear Transform'. The 'Create New Linear Transform' option is highlighted. The 'Output Volume' is also set to 'None'. The 'Apply' button is visible at the bottom right of the dialog box.

Subject Image Skull Stripping

Affine Registration

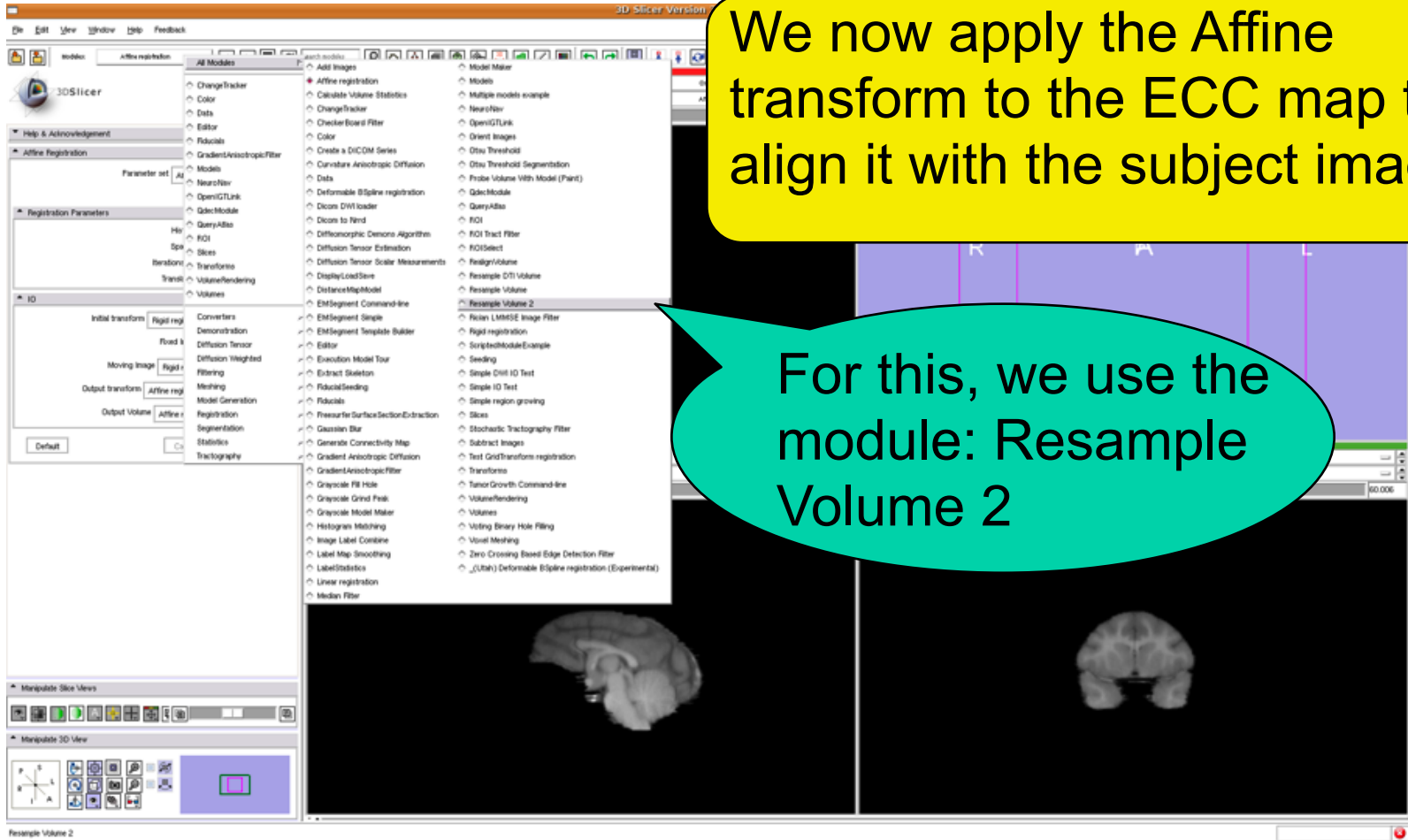


Subject Image Skull Stripping

Apply Transform to ECC Map

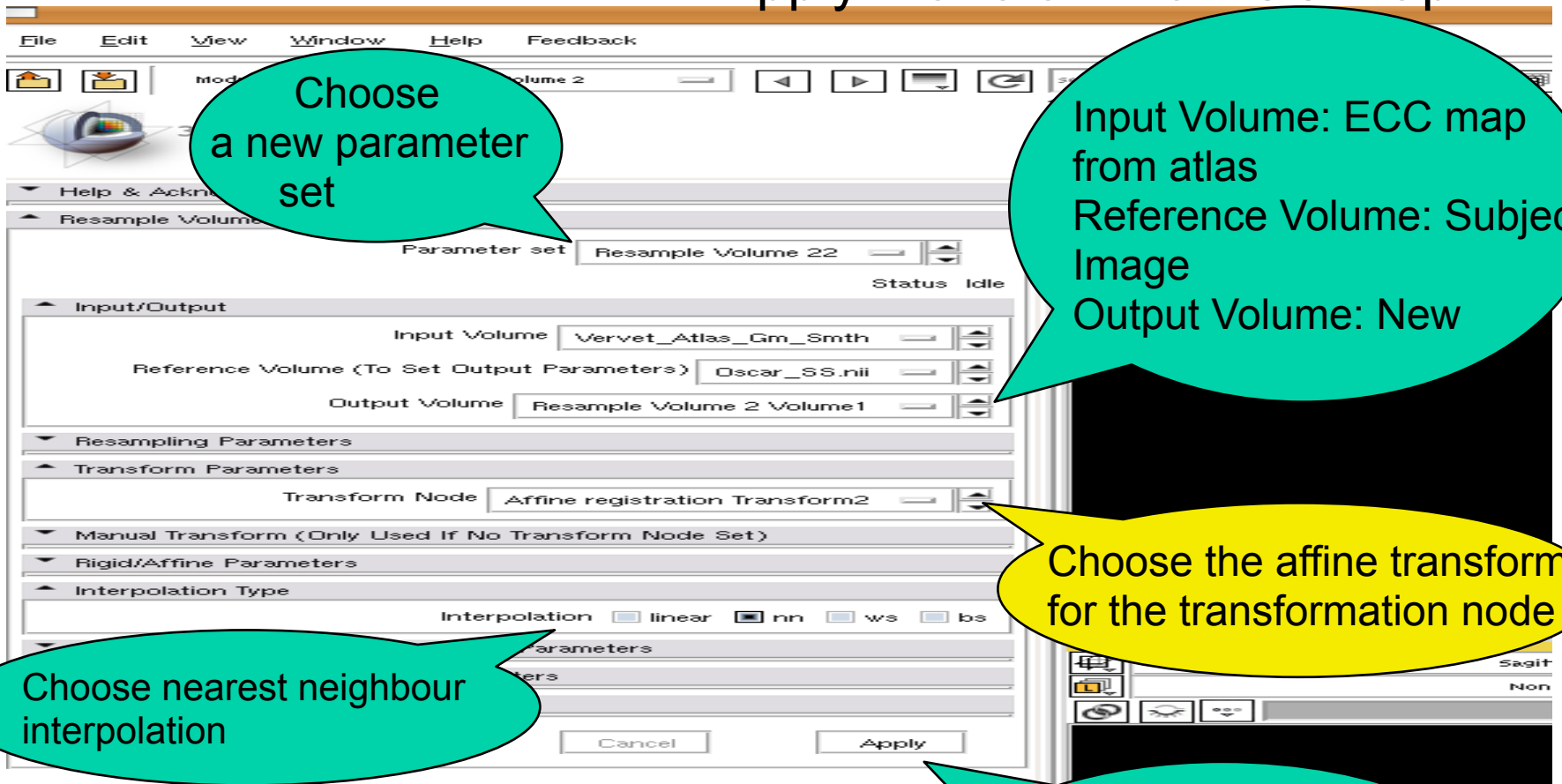
We now apply the Affine transform to the ECC map to align it with the subject image

For this, we use the module: Resample Volume 2



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

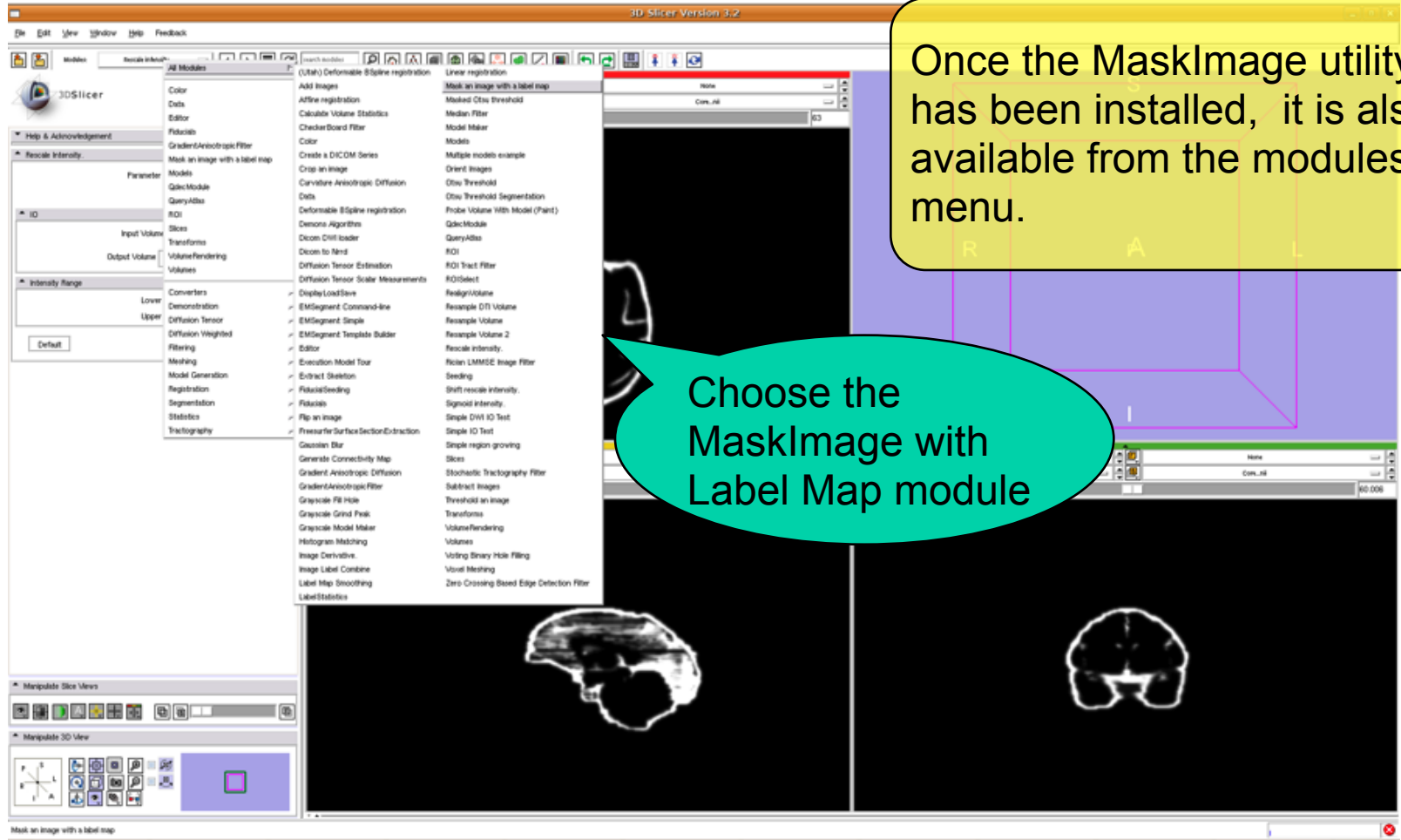
Choose the affine transform for the transformation node

Choose nearest neighbour interpolation

Finally, click Apply to get the registered ECC map

Subject Image Skull Stripping

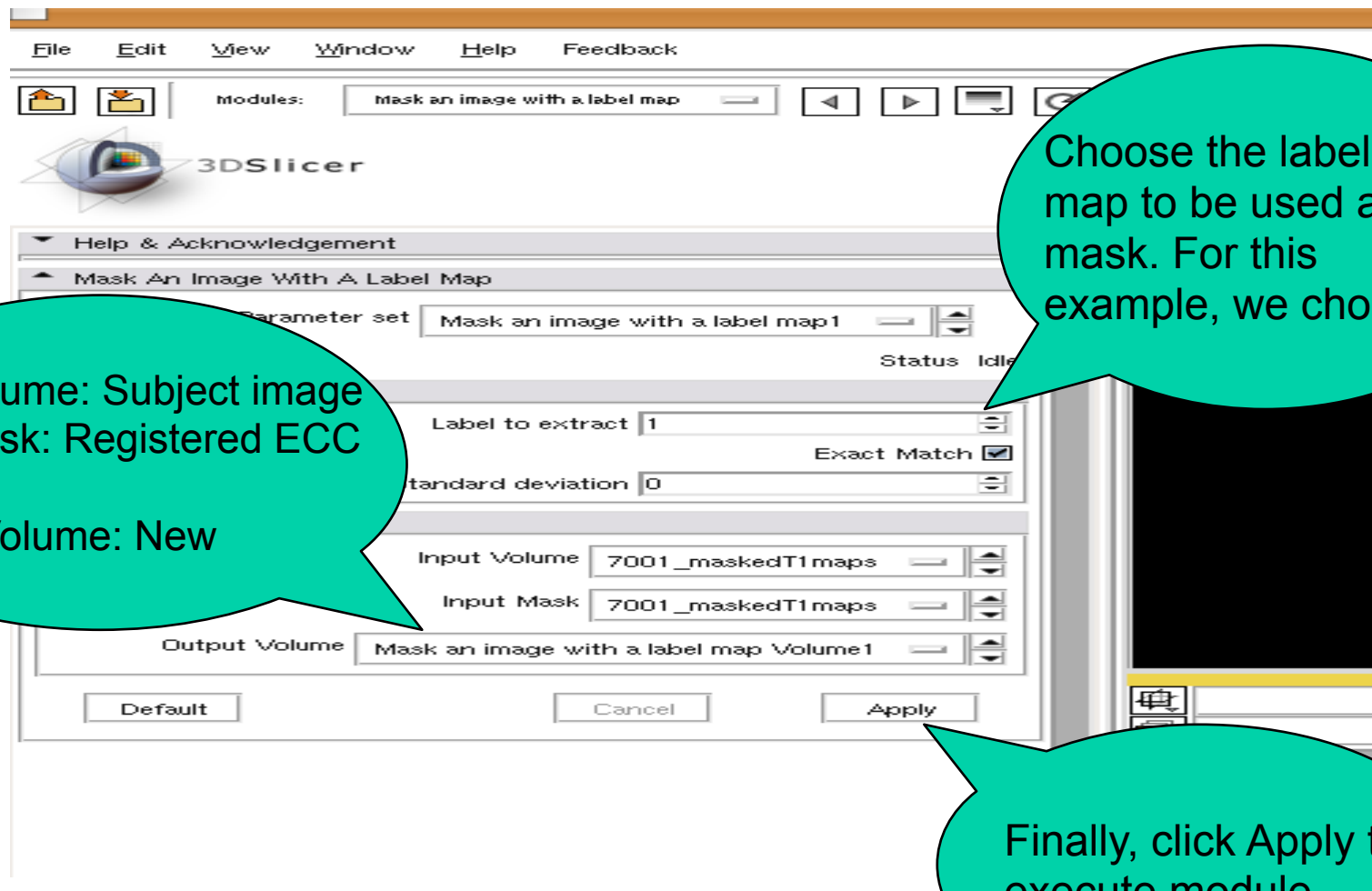
Mask Subject Image with ECC Mask





Subject Image Skull Stripping

Mask Subject Image with ECC Mask



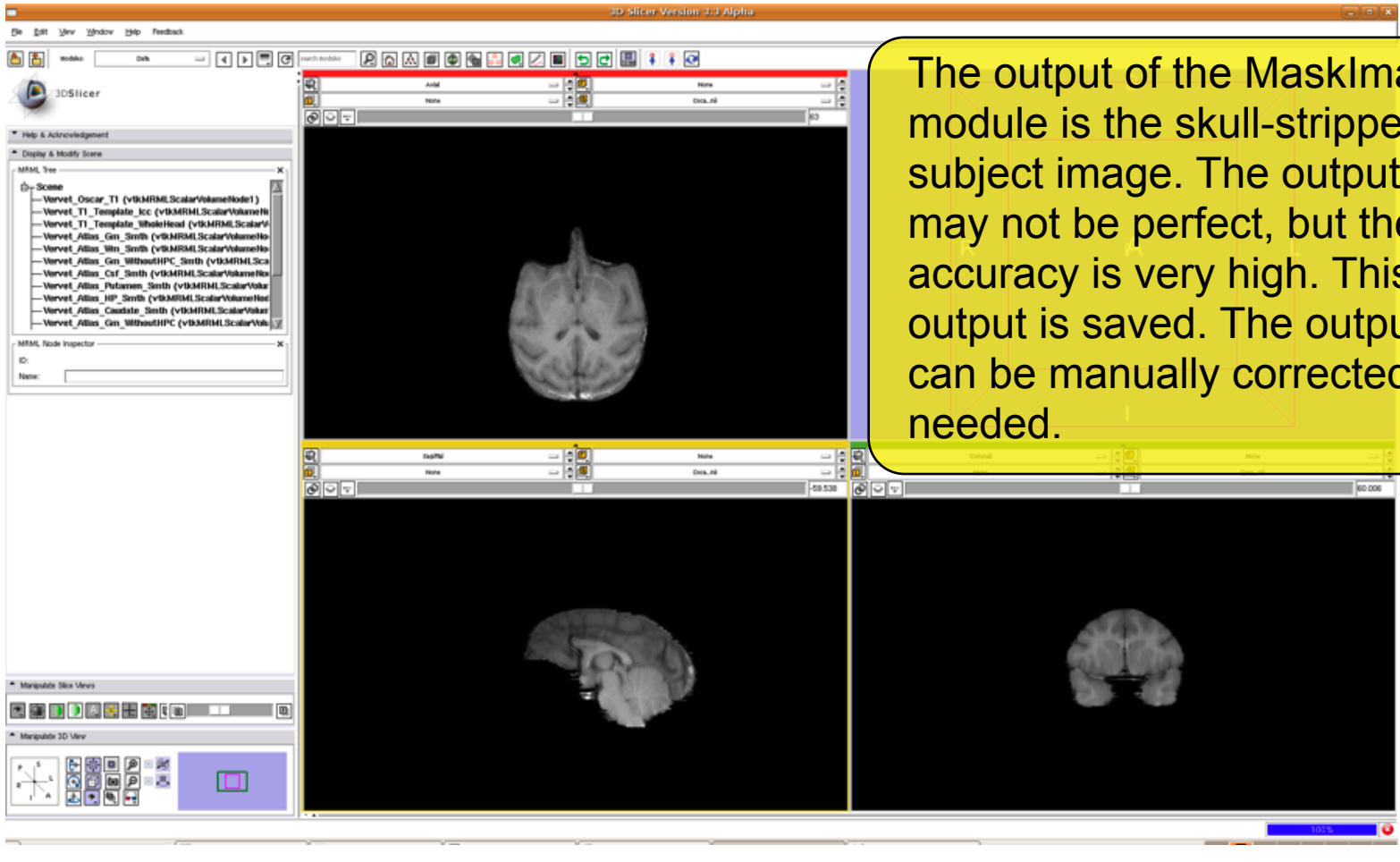
Input Volume: Subject image
Input Mask: Registered ECC map
Output Volume: New

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

Finally, click Apply to execute module

Subject Image Skull Stripping

Mask Subject Image with ECC Mask



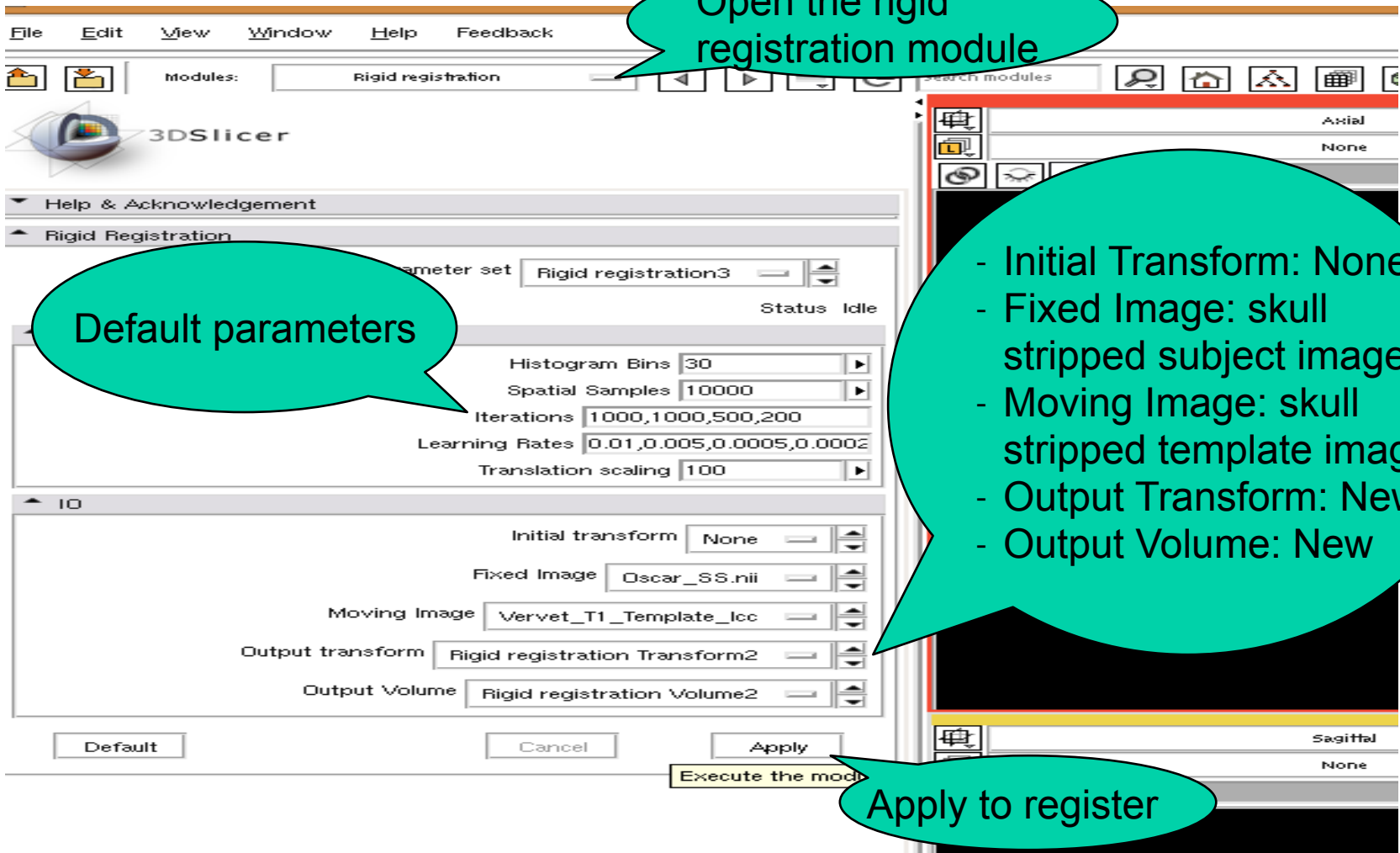
The output of the MaskImage module is the skull-stripped subject image. The output may not be perfect, but the accuracy is very high. This output is saved. The output can be manually corrected if needed.



Creating patient specific atlas

- Register skull-stripped subject image to skull-stripped 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



The screenshot shows the 3DSlicer interface with the Rigid Registration module active. The 'Modules' dropdown at the top is set to 'Rigid registration'. The 'Rigid Registration' panel is expanded, showing the 'Parameter set' dropdown set to 'Rigid registration3' and the 'Status' as 'Idle'. The 'IO' section contains the following settings:

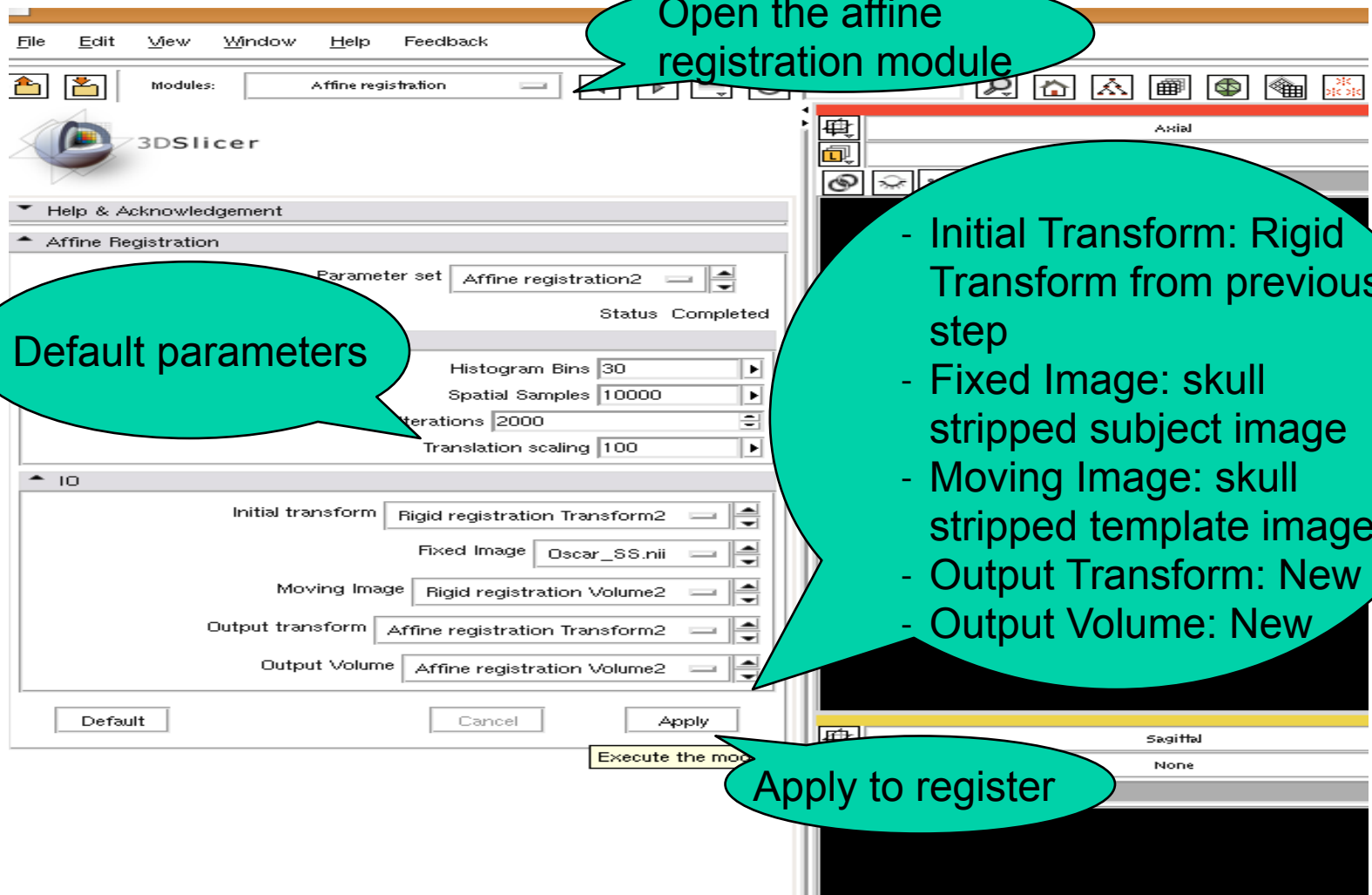
- Initial transform: None
- Fixed Image: Oscar_SS.nii
- Moving Image: Vervet_T1_Template_1cc
- Output transform: Rigid registration Transform2
- Output Volume: Rigid registration Volume2

At the bottom of the panel are buttons for 'Default', 'Cancel', and 'Apply'. A tooltip 'Execute the mod' is visible over the 'Apply' button.

Callouts in the image:

- 'Open the rigid registration module' points to the 'Rigid registration' dropdown in the top toolbar.
- 'Default parameters' points to the 'Parameter set' dropdown.
- A large callout lists the registration parameters: 'Initial Transform: None', 'Fixed Image: skull stripped subject image', 'Moving Image: skull stripped template image', 'Output Transform: New', and 'Output Volume: New'.
- 'Apply to register' points to the 'Apply' button.

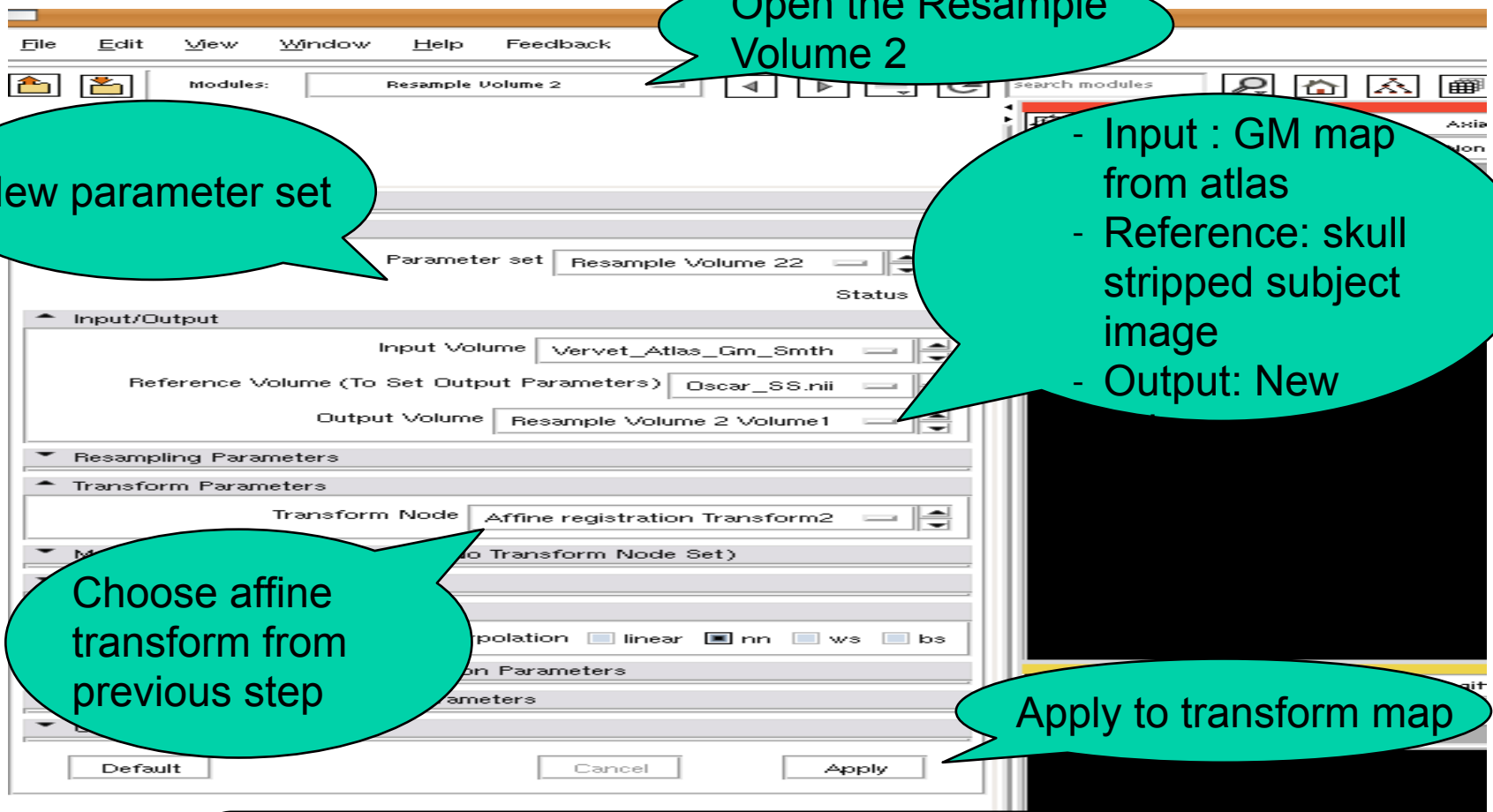
Creating patient specific atlas - Affine Registration



The screenshot shows the 3DSlicer interface with the Affine Registration module active. The 'Affine Registration' panel is open, showing various settings. A callout bubble points to the 'Affine registration' module in the top toolbar. Another callout bubble points to the 'Affine Registration' panel, highlighting the 'Default parameters' section. A third callout bubble points to the 'Apply' button, with the text 'Execute the module' and 'Apply to register'. A large callout bubble on the right lists the registration parameters:

- Initial Transform: Rigid Transform from previous step
- Fixed Image: skull stripped subject image
- Moving Image: skull stripped template image
- Output Transform: New
- Output Volume: New

Creating patient specific atlas - Apply Transform



Open the Resample Volume 2

New parameter set

- Input : GM map from atlas
- Reference: skull stripped subject image
- Output: New

Choose affine transform from previous step

Apply to transform map

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.
-



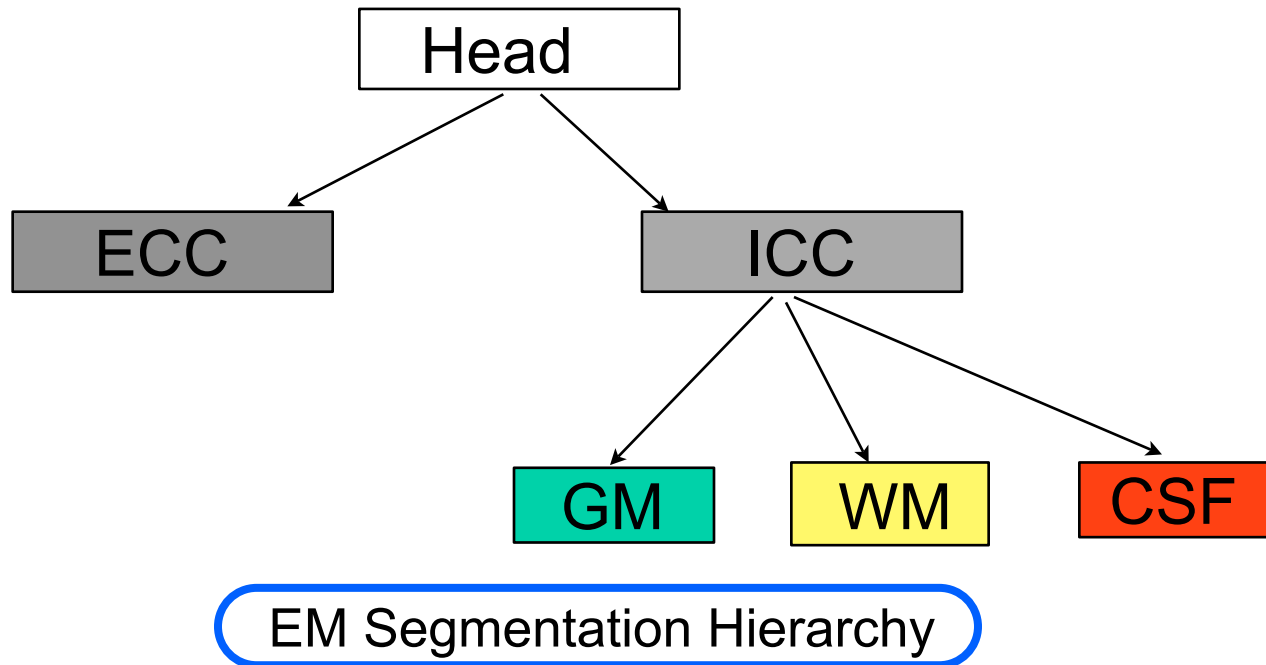
Creating patient specific atlas - Applying deformation field to probability maps

- 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 probability 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
-

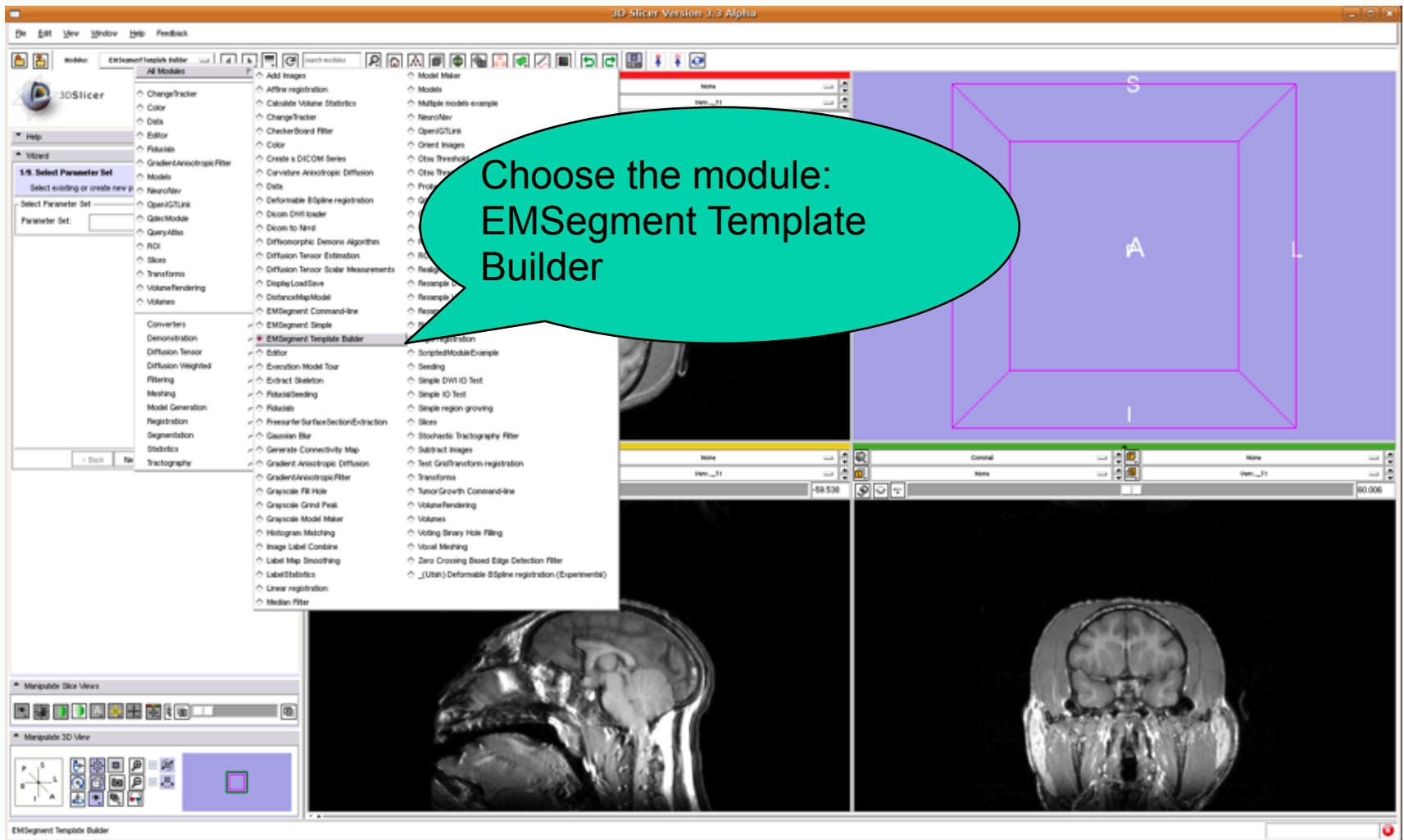
Segmentation using EMSegmenter

Segmentation

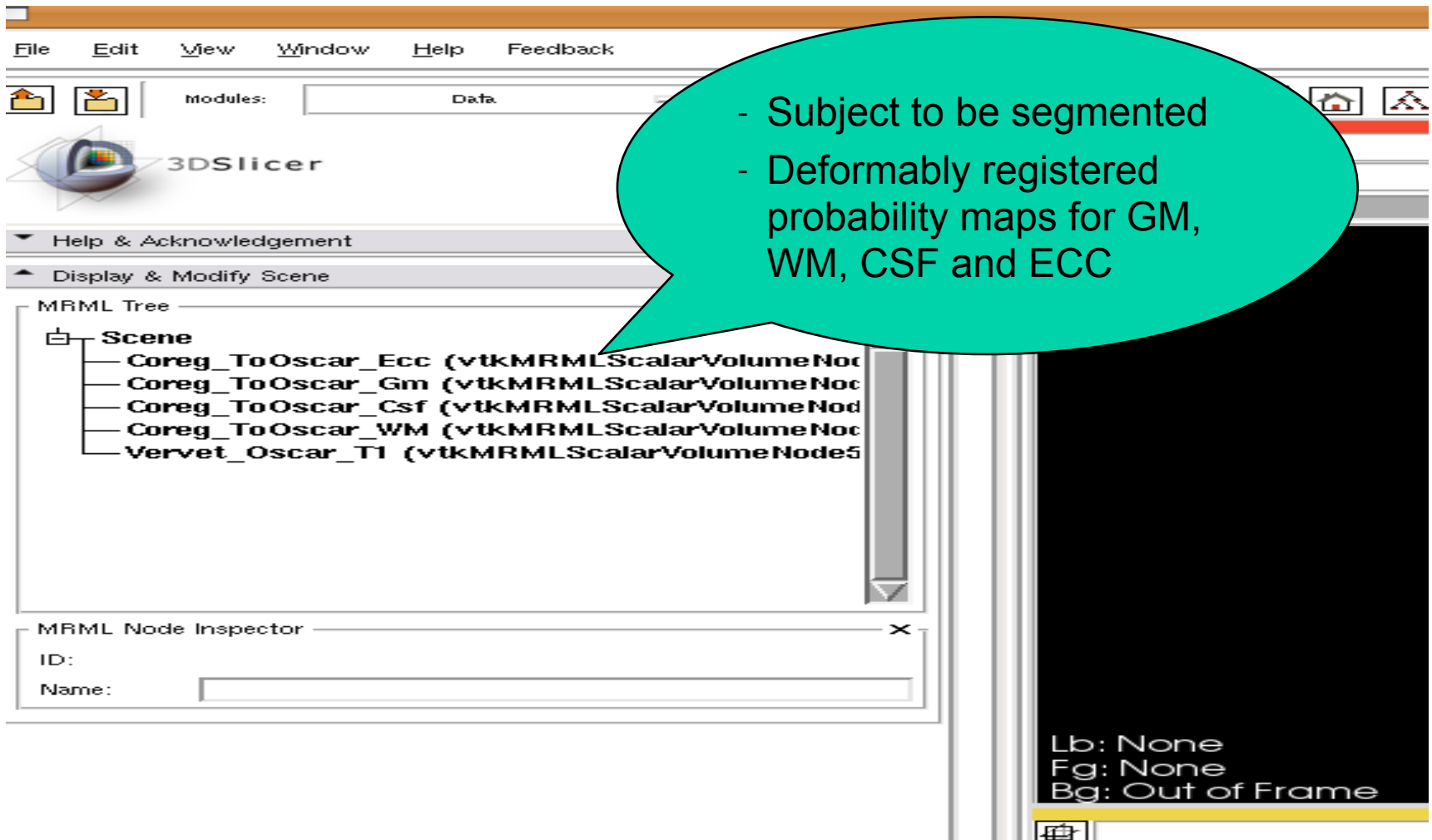
- Once the patient specific atlas has been created, we use that along with the subject image in EMSegmenter



Segmentation



Segmentation - Input Data

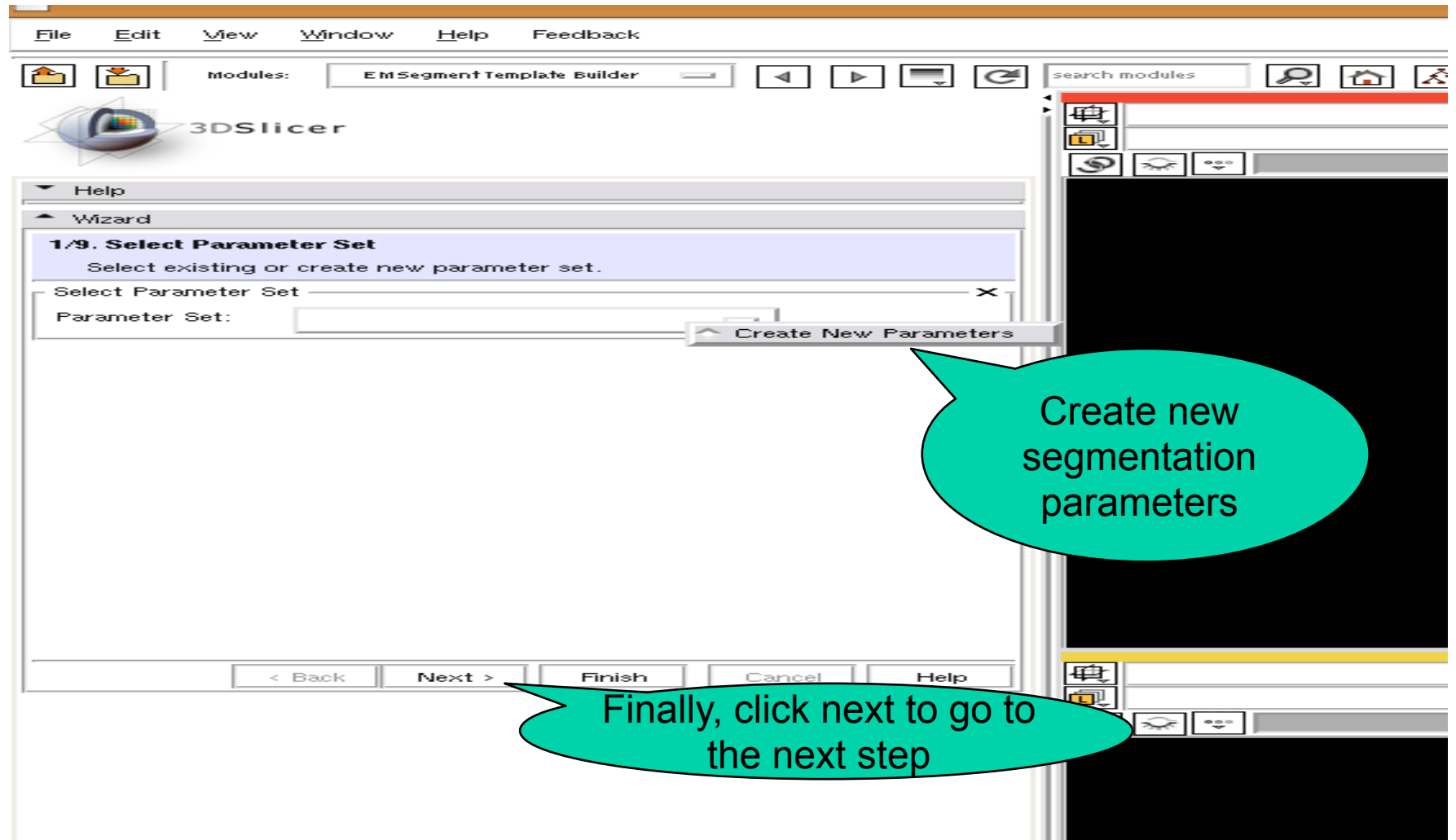


The screenshot shows the 3DSlicer software interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. Below the menu bar, there are icons for home and a folder, and a 'Modules:' dropdown menu set to 'Data'. The 3DSlicer logo is visible on the left. The main interface is divided into several panels:

- Help & Acknowledgement**: A panel with a downward arrow.
- Display & Modify Scene**: A panel with an upward arrow.
- MRML Tree**: A tree view showing the scene structure:
 - Scene
 - Coreg_ToOscar_Ecc (vtkMRMLScalarVolumeNode)
 - Coreg_ToOscar_Gm (vtkMRMLScalarVolumeNode)
 - Coreg_ToOscar_Csf (vtkMRMLScalarVolumeNode)
 - Coreg_ToOscar_WM (vtkMRMLScalarVolumeNode)
 - Vervet_Oscar_T1 (vtkMRMLScalarVolumeNode5)
- MRML Node Inspector**: A panel with fields for ID and Name.
- Property Panel**: A panel on the right showing properties: Lb: None, Fg: None, Bg: Out of Frame.

- Subject to be segmented
- Deformably registered probability maps for GM, WM, CSF and ECC

Segmentation



File Edit View Window Help Feedback

Modules: EMSegment Template Builder

3DSlicer

Help

Wizard

1/9. Select Parameter Set
Select existing or create new parameter set.

Select Parameter Set

Parameter Set:

Create New Parameters

< Back Next > Finish Cancel Help

Create new segmentation parameters

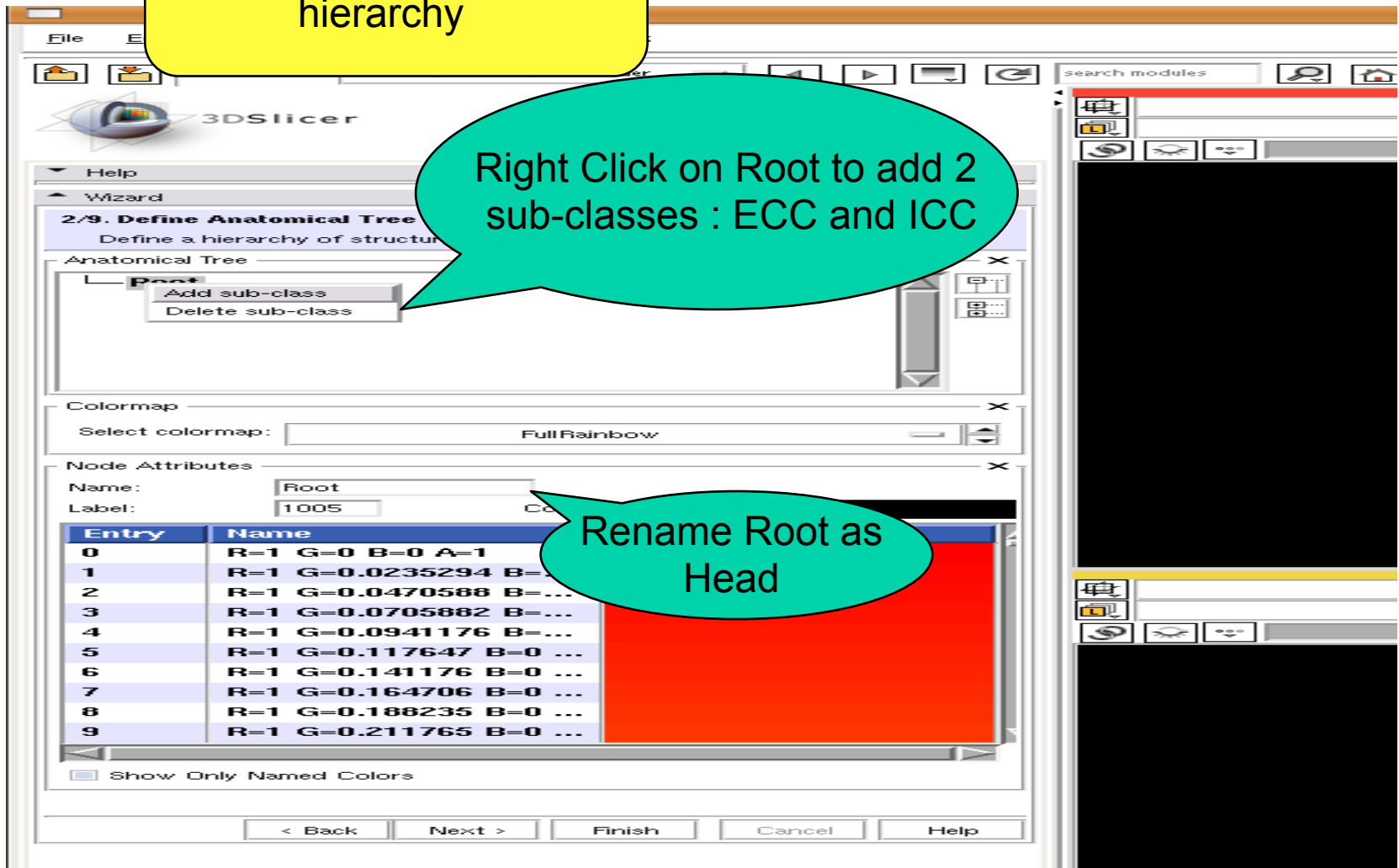
Finally, click next to go to the next step

Segmentation

The second step is to specify the segmentation hierarchy

Right Click on Root to add 2 sub-classes : ECC and ICC

Rename Root as Head



2/9. Define Anatomical Tree
Define a hierarchy of structures

Anatomical Tree

- Root
 - ECC
 - ICC

Colormap: FullRainbow

Node Attributes

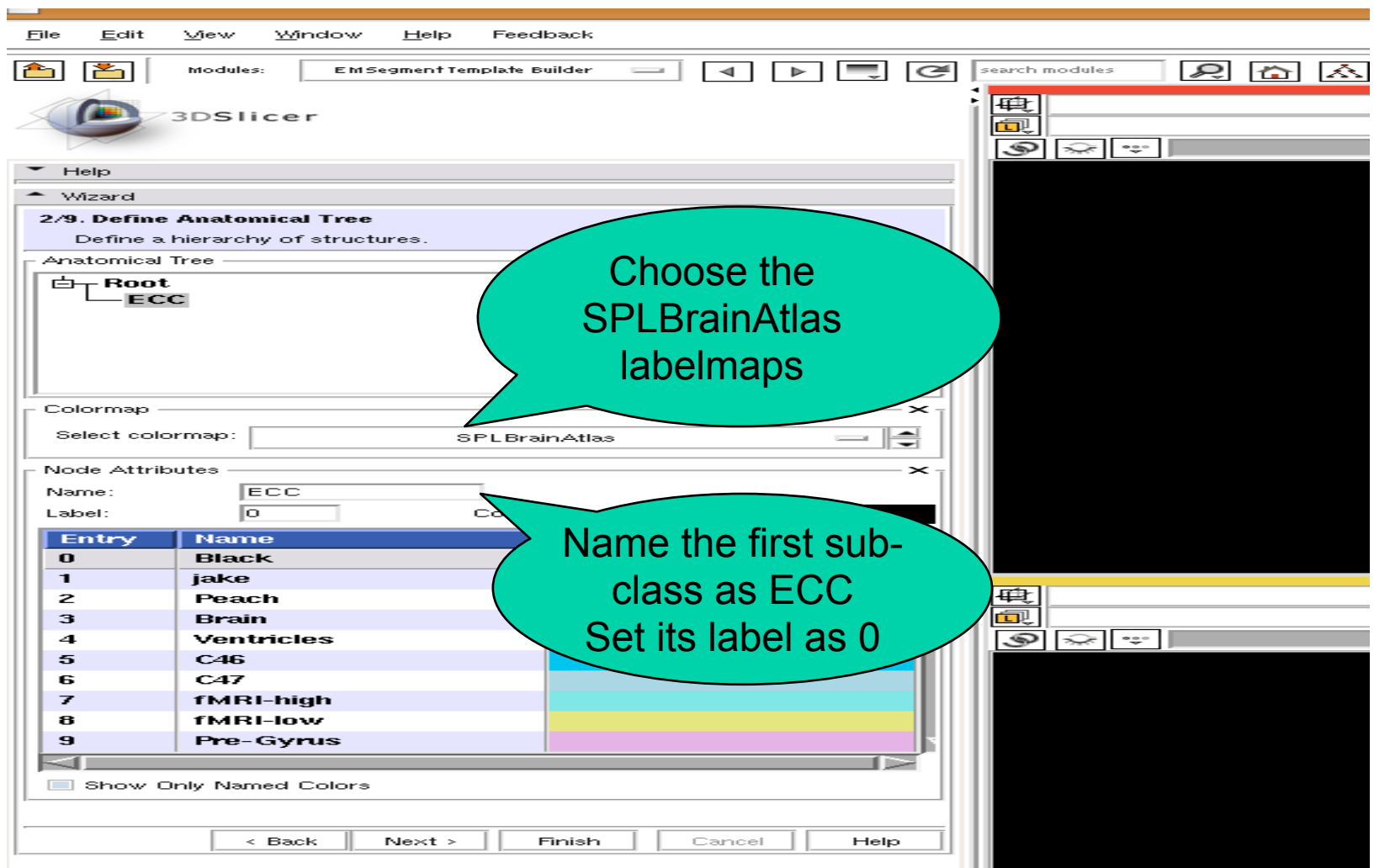
Name: Root
Label: 1005

Entry	Name
0	R=1 G=0 B=0 A=1
1	R=1 G=0.0235294 B=...
2	R=1 G=0.0470588 B=...
3	R=1 G=0.0705882 B=...
4	R=1 G=0.0941176 B=...
5	R=1 G=0.117647 B=0 ...
6	R=1 G=0.141176 B=0 ...
7	R=1 G=0.164706 B=0 ...
8	R=1 G=0.188235 B=0 ...
9	R=1 G=0.211765 B=0 ...

Show Only Named Colors

< Back Next > Finish Cancel Help

Segmentation



File Edit View Window Help Feedback

modules: EntSegment Template Builder

search modules

3DSlicer

Help

Wizard

2/9. Define Anatomical Tree
Define a hierarchy of structures.

Anatomical Tree

- Root
 - ECC

Colormap

Select colormap: SPLBrainAtlas

Node Attributes

Name: ECC
Label: 0

Entry	Name
0	Black
1	jake
2	Peach
3	Brain
4	Ventricles
5	C46
6	C47
7	fMRI-high
8	fMRI-low
9	Pre-Gyrus

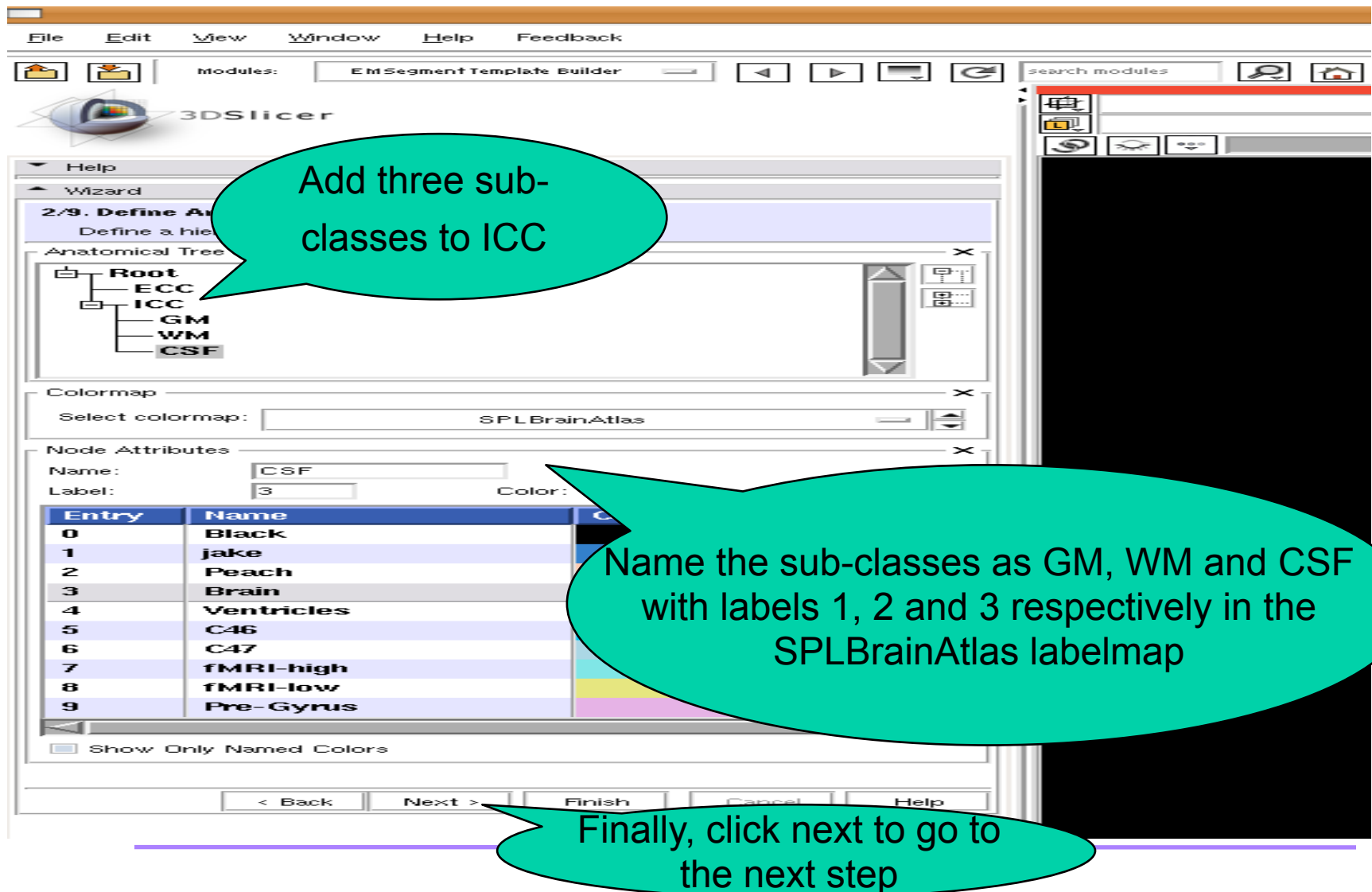
Show Only Named Colors

< Back Next > Finish Cancel Help

Choose the SPLBrainAtlas labelmaps

Name the first subclass as ECC
Set its label as 0

Segmentation



File Edit View Window Help Feedback

Modules: EMSegment Template Builder

3DSlicer

2/9. Define Anatomical Tree

Define a hierarchical anatomical tree

Anatomical Tree

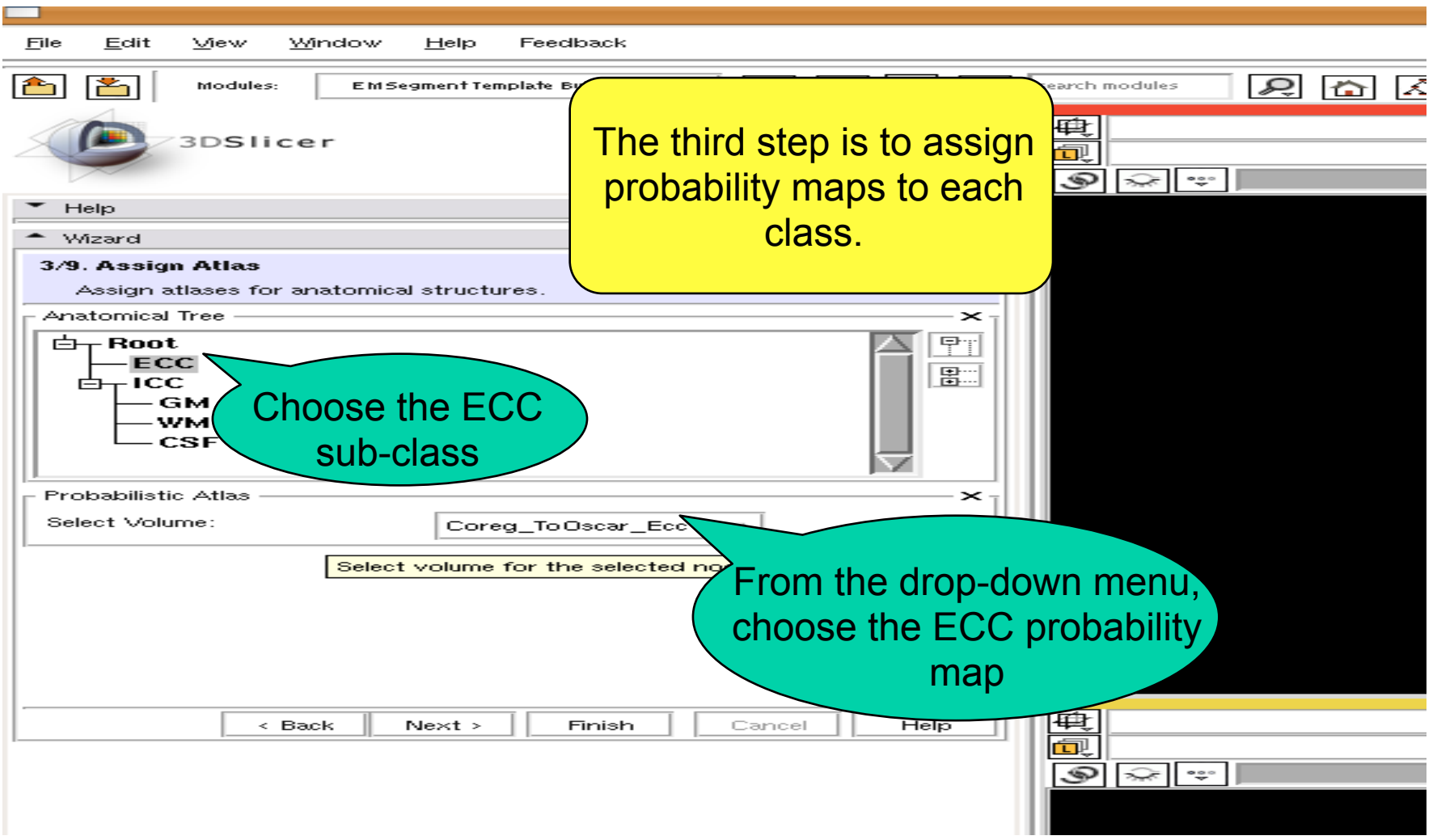
- Root
 - ECC
 - ICC
 - GM
 - WM
 - CSF

Add three sub-classes to ICC

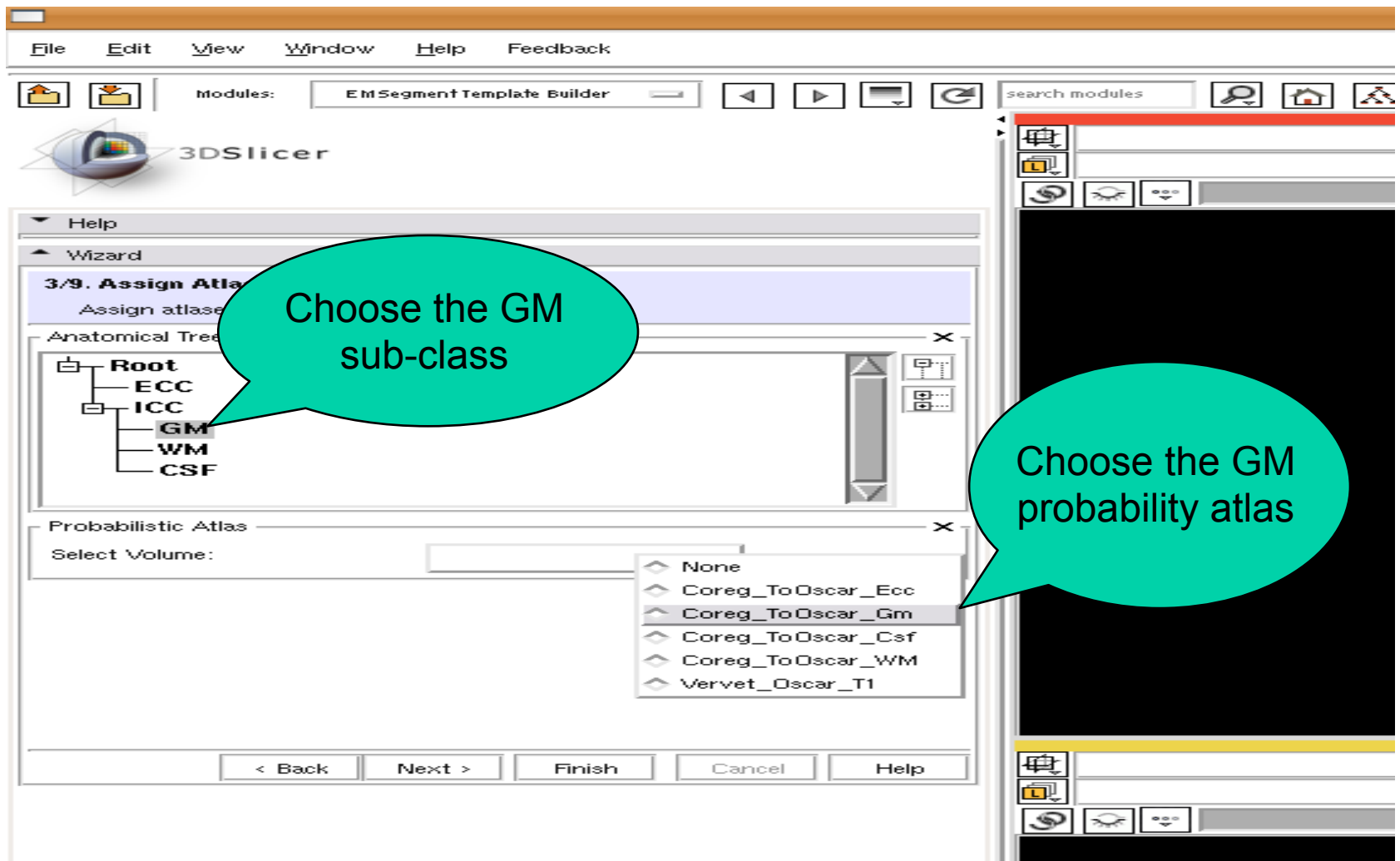
Name the sub-classes as GM, WM and CSF with labels 1, 2 and 3 respectively in the SPLBrainAtlas labelmap

Finally, click next to go to the next step

Segmentation



The screenshot shows the 3DSlicer software interface. At the top, there is a menu bar with 'File', 'Edit', 'View', 'Window', 'Help', and 'Feedback'. Below the menu bar, there are icons for home, refresh, and search, and a 'Modules:' section with 'EMSegment Template B'. The main window displays the '3/9. Assign Atlas' wizard step, which is titled 'Assign atlases for anatomical structures.'. The 'Anatomical Tree' section shows a hierarchy: Root -> ECC -> ICC -> GM, WM, CSF. The 'Probabilistic Atlas' section has a 'Select Volume:' dropdown menu with 'Coreg_ToOscar_Ecc' selected. At the bottom, there are navigation buttons: '< Back', 'Next >', 'Finish', 'Cancel', and 'Help'. Three callout boxes provide instructions: a yellow box at the top right says 'The third step is to assign probability maps to each class.', a teal box on the left says 'Choose the ECC sub-class', and a teal box at the bottom right says 'From the drop-down menu, choose the ECC probability map'.



File Edit View Window Help Feedback

Modules: EMI Segment Template Builder

search modules

3DSlicer

Help

Wizard

3/9. Assign Atlas

Assign atlas

Anatomical Tree

- Root
 - ECC
 - ICC
 - GM**
 - WM
 - CSF

Probabilistic Atlas

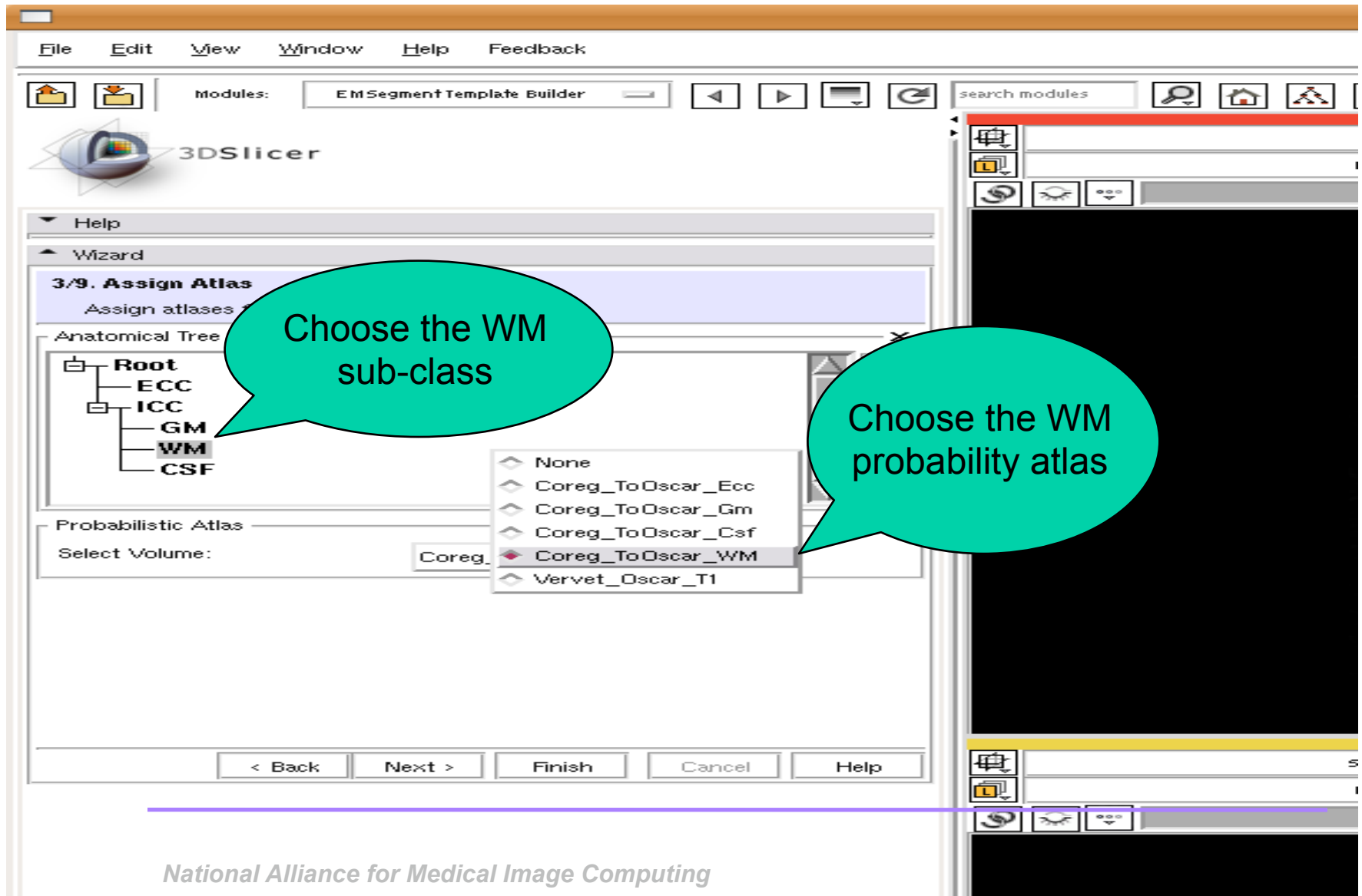
Select Volume:

- None
- Coreg_ToOscar_Ecc
- Coreg_ToOscar_Gm**
- Coreg_ToOscar_Csf
- Coreg_ToOscar_WM
- Vervet_Oscar_T1

< Back Next > Finish Cancel Help

Choose the GM sub-class

Choose the GM probability atlas



File Edit View Window Help Feedback

Modules: EMSegment Template Builder

search modules

3DSlicer

Help

Wizard

3/9. Assign Atlas
Assign atlases

Anatomical Tree

- Root
 - ECC
 - ICC
 - GM
 - WM**
 - CSF

Probabilistic Atlas

Select Volume: Coreg_

- None
- Coreg_ToOscar_Ecc
- Coreg_ToOscar_Gm
- Coreg_ToOscar_Csf
- Coreg_ToOscar_WM**
- Vervet_Oscar_T1

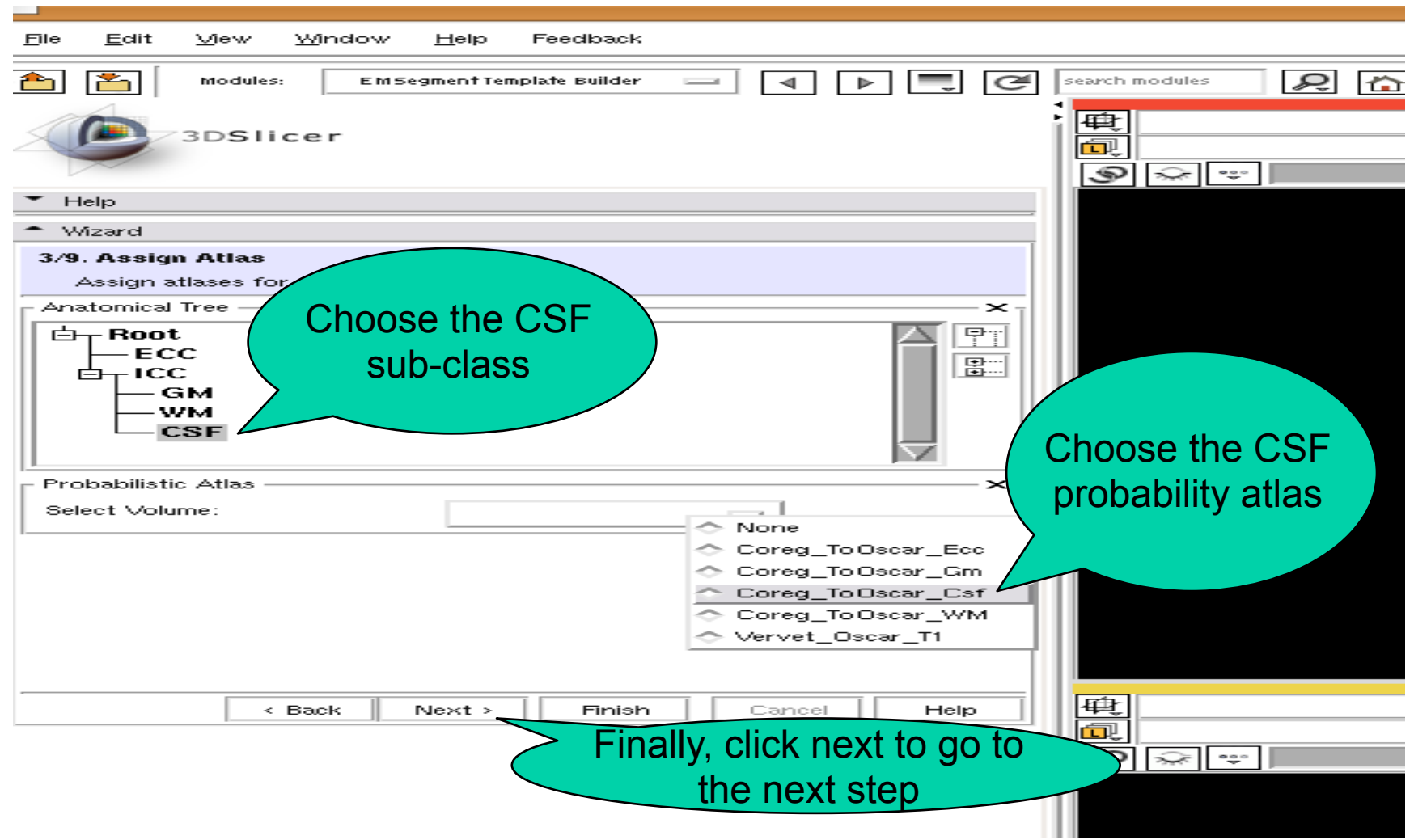
< Back Next > Finish Cancel Help

Choose the WM sub-class

Choose the WM probability atlas

National Alliance for Medical Image Computing

Segmentation



File Edit View Window Help Feedback

Modules: EntSegment Template Builder

3DSlicer

Help

Wizard

3/9. Assign Atlas
Assign atlases for

Anatomical Tree

- Root
 - ECC
 - ICC
 - GM
 - WM
 - CSF**

Probabilistic Atlas

Select Volume:

- None
- Coreg_ToOscar_Ecc
- Coreg_ToOscar_Gm
- Coreg_ToOscar_Csf**
- Coreg_ToOscar_WM
- Vervet_Oscar_T1

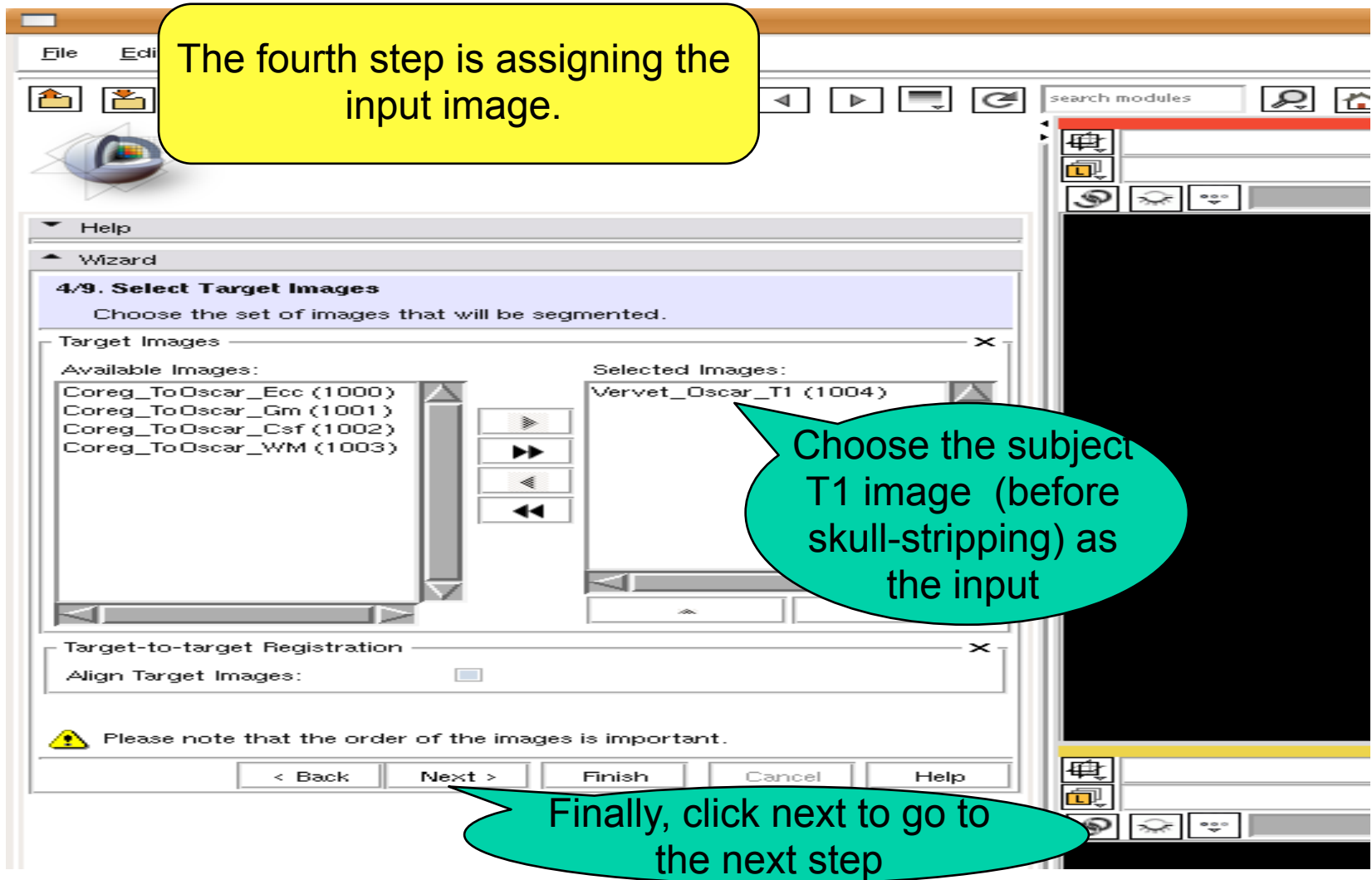
< Back Next > Finish Cancel Help

Choose the CSF sub-class

Choose the CSF probability atlas

Finally, click next to go to the next step

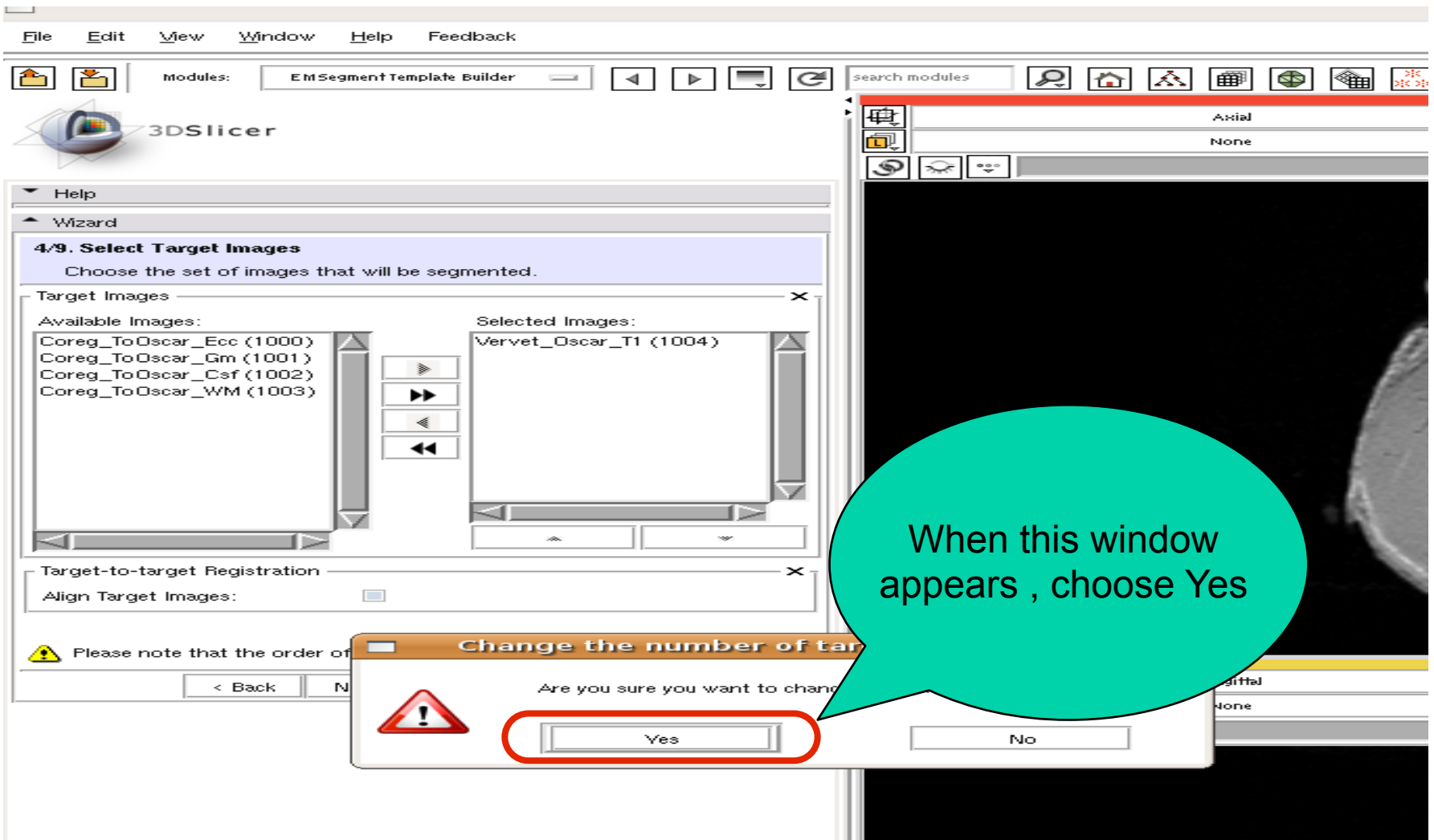
Segmentation



The fourth step is assigning the input image.

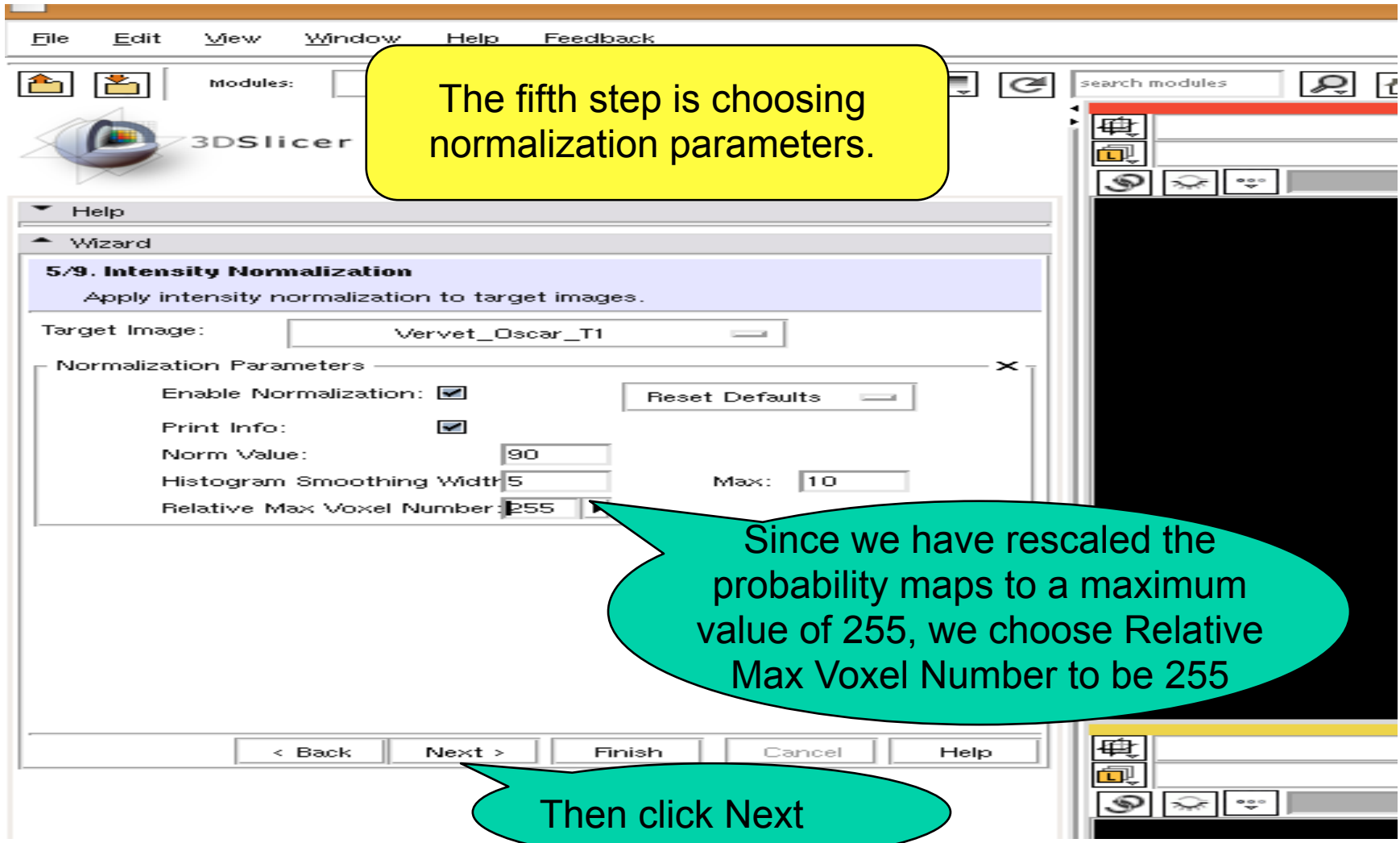
Choose the subject T1 image (before skull-stripping) as the input

Finally, click next to go to the next step



The screenshot shows the 3DSlicer software interface. The top menu bar includes File, Edit, View, Window, Help, and Feedback. Below the menu is a toolbar with various icons. The main window displays the '4/9. Select Target Images' wizard step, which prompts the user to 'Choose the set of images that will be segmented.' The wizard shows a list of 'Available Images' on the left and a 'Selected Images' list on the right. The 'Available Images' list includes: Coreg_ToOscar_Ecc (1000), Coreg_ToOscar_Gm (1001), Coreg_ToOscar_Csf (1002), and Coreg_ToOscar_WM (1003). The 'Selected Images' list includes: Vervet_Oscar_T1 (1004). Below the image lists is a 'Target-to-target Registration' section with an 'Align Target Images' checkbox. A warning icon and text are visible: 'Please note that the order of...'. A confirmation dialog box is overlaid on the wizard, titled 'Change the number of tar...', with the question 'Are you sure you want to change...'. The 'Yes' button is highlighted with a red circle. A green speech bubble points to the 'Yes' button with the text: 'When this window appears , choose Yes'. The background shows a 3D view of a brain slice in axial view.

Segmentation



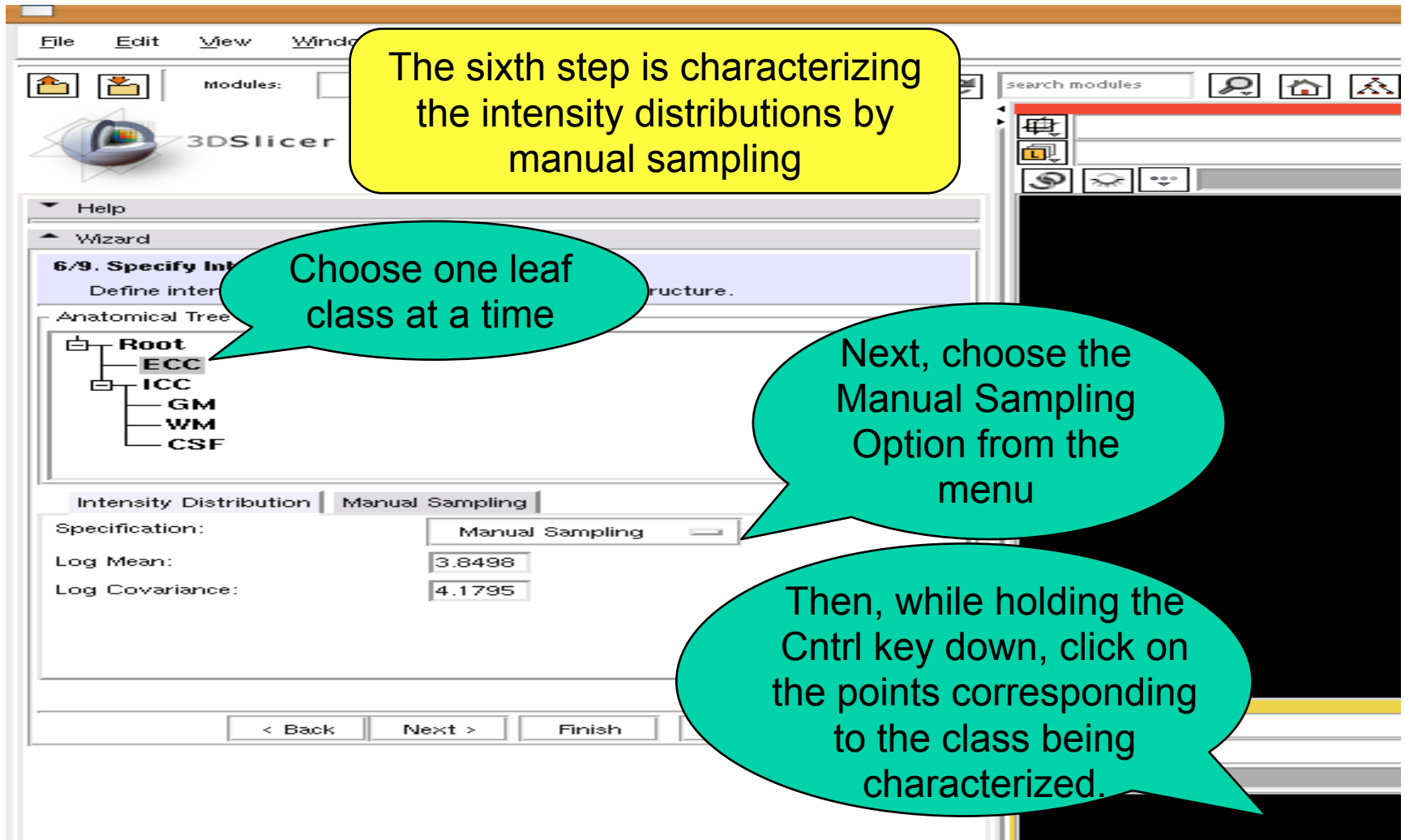
The screenshot shows the 3DSlicer software interface with the 'Wizard' panel open to the '5/9. Intensity Normalization' step. The 'Target Image' is set to 'Vervet_Oscar_T1'. Under 'Normalization Parameters', 'Enable Normalization' and 'Print Info' are checked. 'Norm Value' is 90, 'Histogram Smoothing Width' is 5, and 'Relative Max Voxel Number' is 255. A 'Reset Defaults' button is visible. At the bottom, navigation buttons include '< Back', 'Next >', 'Finish', 'Cancel', and 'Help'. Two callout boxes provide instructions: a yellow one at the top says 'The fifth step is choosing normalization parameters.' and a teal one at the bottom says 'Then click Next'. A larger teal callout on the right explains the choice of 255 for the Relative Max Voxel Number.

The fifth step is choosing normalization parameters.

Since we have rescaled the probability maps to a maximum value of 255, we choose Relative Max Voxel Number to be 255

Then click Next

Segmentation



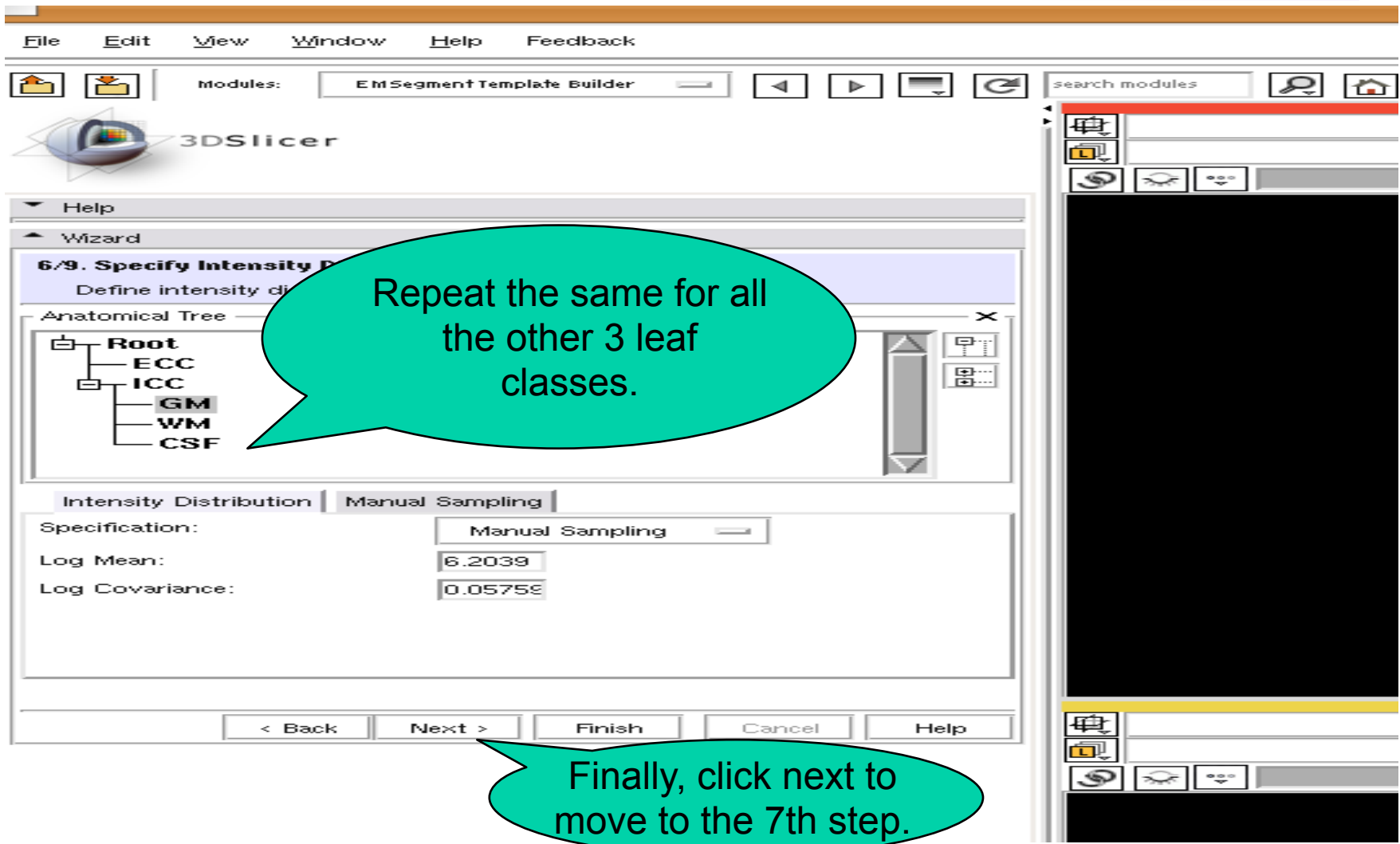
The sixth step is characterizing the intensity distributions by manual sampling

Choose one leaf class at a time

Next, choose the Manual Sampling Option from the menu

Then, while holding the Cntrl key down, click on the points corresponding to the class being characterized.

Segmentation



File Edit View Window Help Feedback

Modules: EM Segment Template Builder

3DSlicer

Help

Wizard

6/9. Specify Intensity Distribution
Define intensity distribution

Anatomical Tree

- Root
 - ECC
 - ICC
 - GM
 - WM
 - CSF

Intensity Distribution | Manual Sampling

Specification: Manual Sampling

Log Mean: 6.2039

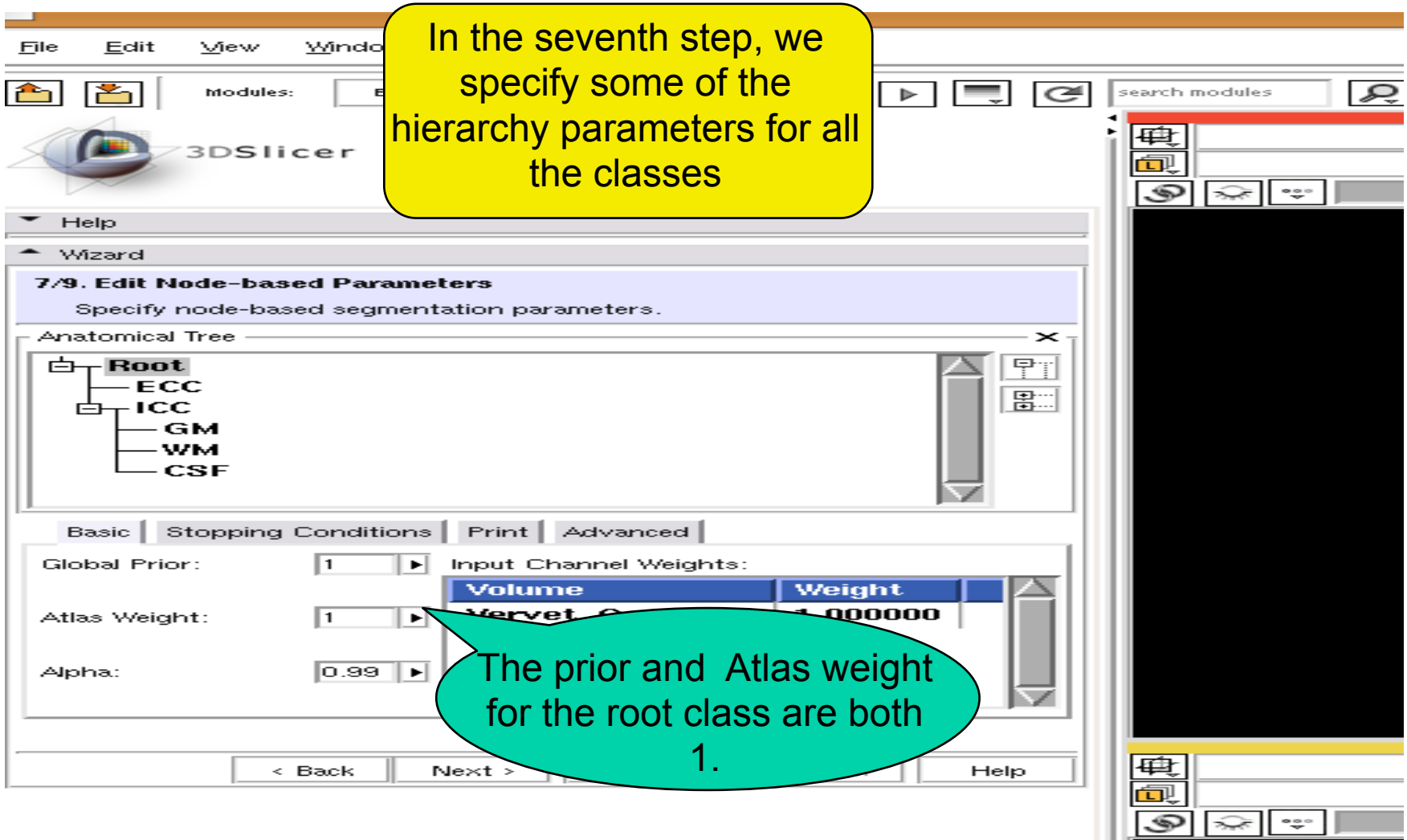
Log Covariance: 0.05759

< Back Next > Finish Cancel Help

Repeat the same for all the other 3 leaf classes.

Finally, click next to move to the 7th step.

Segmentation

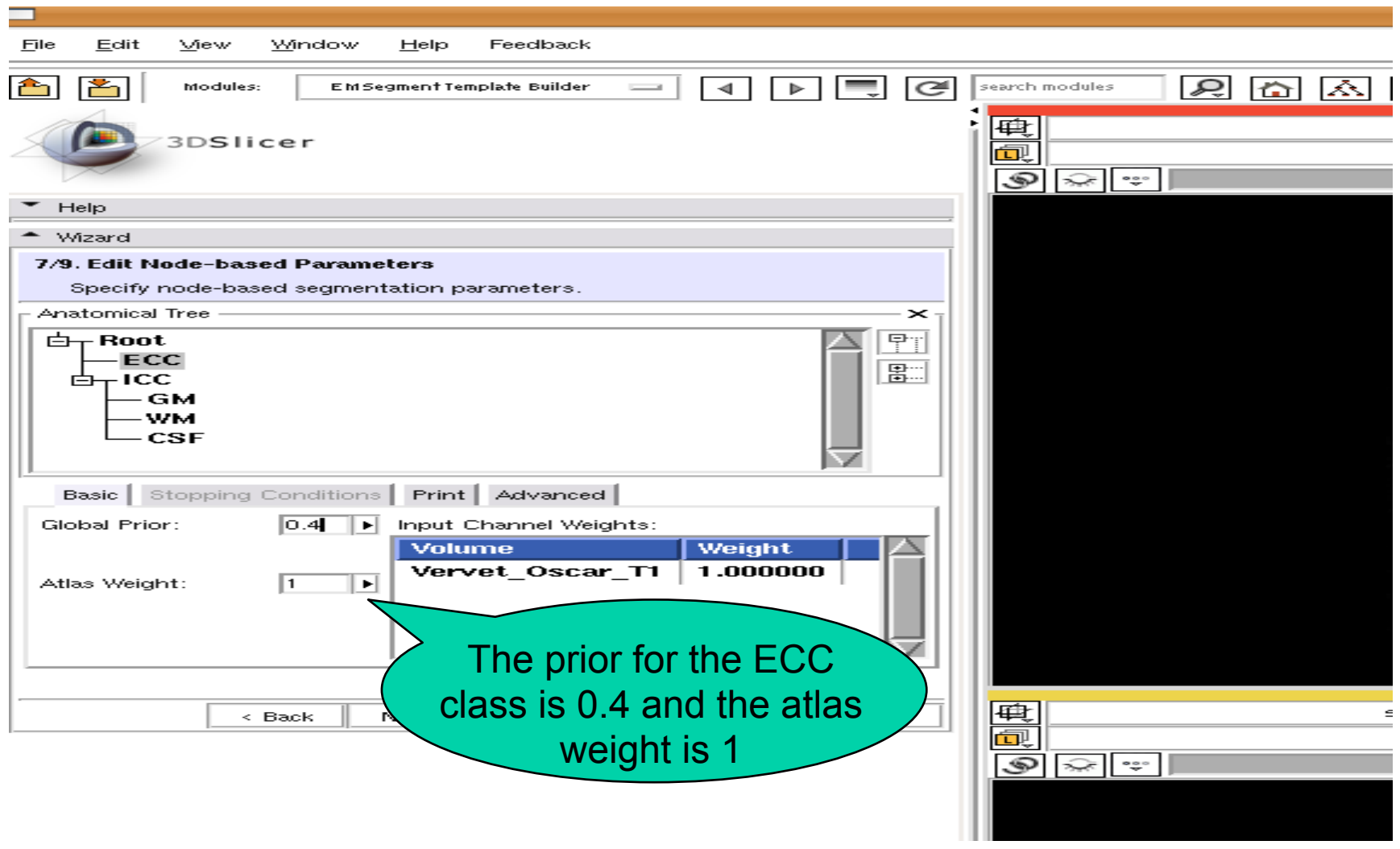


In the seventh step, we specify some of the hierarchy parameters for all the classes

7/9. Edit Node-based Parameters
Specify node-based segmentation parameters.

Anatomical Tree

- Root
 - ECC
 - ICC
 - GM
 - WM
 - CSF



File Edit View Window Help Feedback

Modules: EMSegment Template Builder

3DSlicer

Help

Wizard

7/9. Edit Node-based Parameters
Specify node-based segmentation parameters.

Anatomical Tree

- Root
 - ECC**
 - ICC
 - GM
 - WM
 - CSF

Basic | Stopping Conditions | Print | Advanced

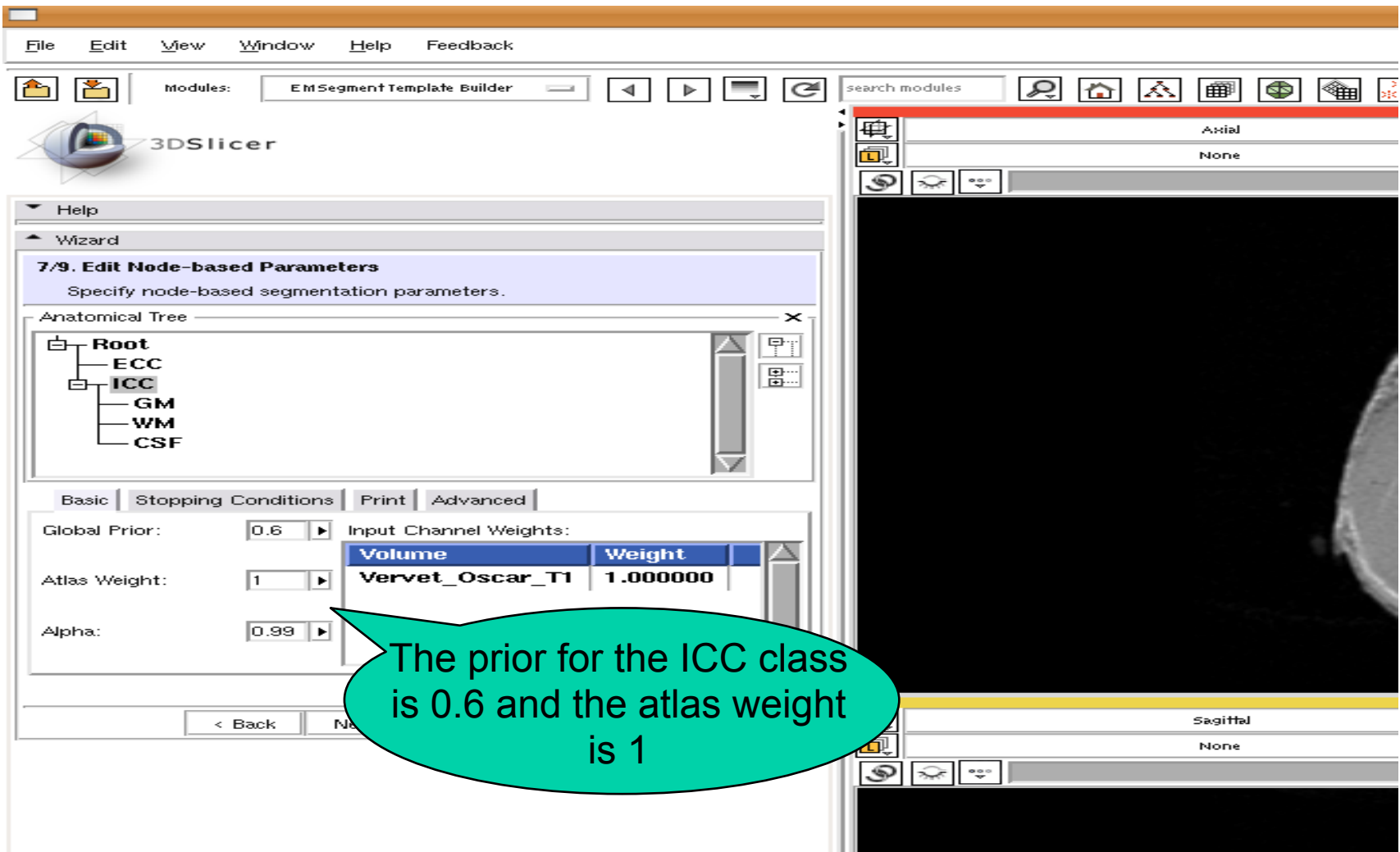
Global Prior: Input Channel Weights:

Volume	Weight
Vervet_Oscar_T1	1.000000

Atlas Weight:

< Back

The prior for the ECC class is 0.4 and the atlas weight is 1



The screenshot shows the 3DSlicer interface with the 'EM Segment Template Builder' module active. The 'Wizard' panel is open to the '7/9. Edit Node-based Parameters' step, which prompts the user to 'Specify node-based segmentation parameters.' The 'Anatomical Tree' on the left shows a hierarchy: Root -> ECC -> ICC (selected) -> GM, WM, CSF. The 'Basic' tab is selected, showing 'Global Prior' set to 0.6, 'Atlas Weight' set to 1, and 'Alpha' set to 0.99. The 'Input Channel Weights' table is as follows:

Volume	Weight
Vervet_Oscar_T1	1.000000

A green callout bubble points to the 'Global Prior' and 'Atlas Weight' fields, containing the text: 'The prior for the ICC class is 0.6 and the atlas weight is 1'.

File Edit View Window Help Feedback

Modules: EMSegment Template Builder

3DSlicer

Help

Wizard

7/9. Edit Node-based Parameters
Specify node-based segmentation parameters.

Anatomical Tree

```

  graph TD
    Root[Root] --- ECC[ECC]
    Root --- ICC[ICC]
    ICC --- GM[GM]
    ICC --- WM[WM]
    ICC --- CSF[CSF]
  
```

Basic | Stopping Conditions | Print | Advanced

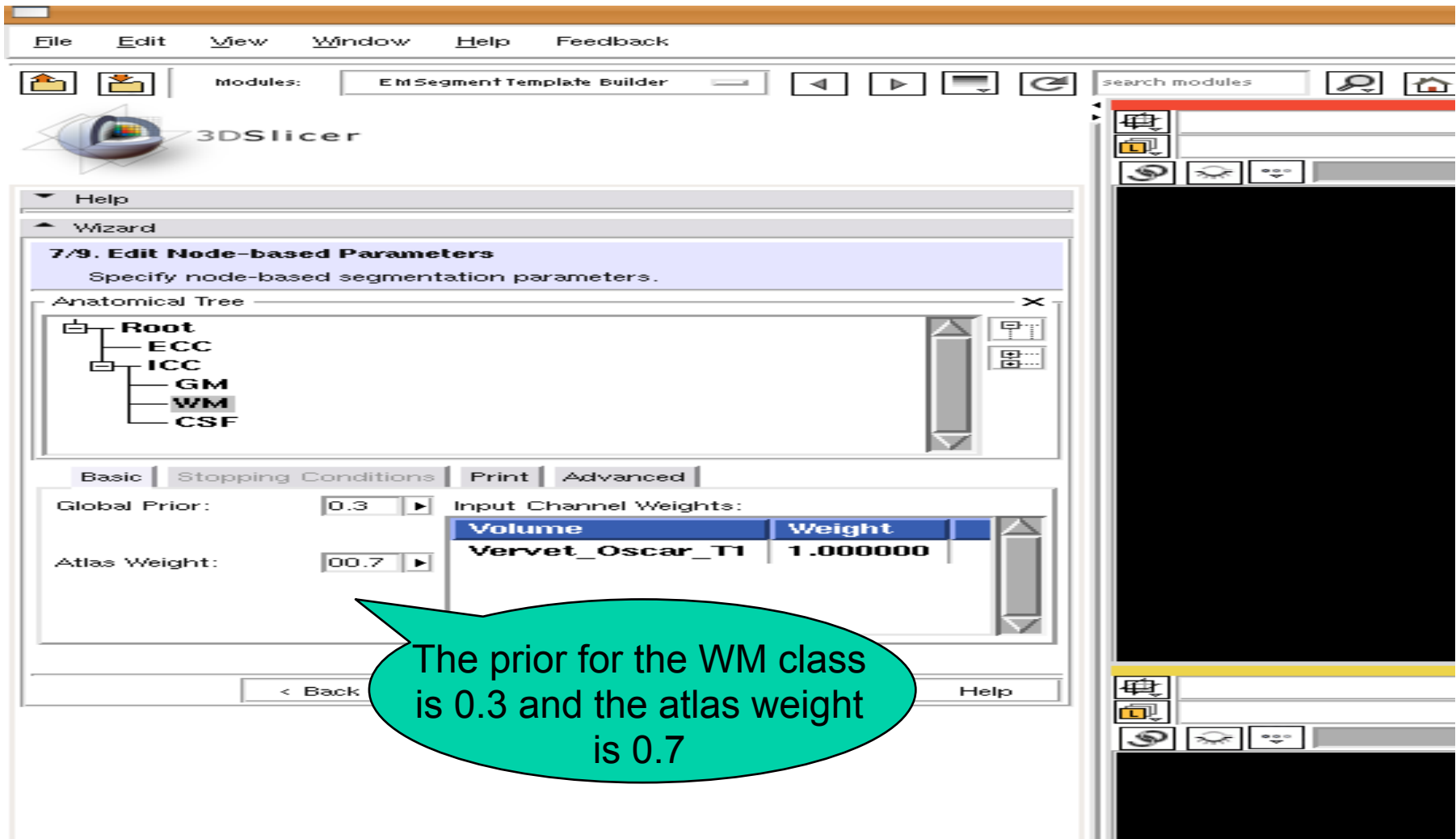
Global Prior: 0.4

Atlas Weight: 0.7

Volume	Weight
Vervet_Oscar_T1	1.000000

< Back Help

The prior for the GM class is 0.4 and the atlas weight is 0.7



File Edit View Window Help Feedback

Modules: EM Segment Template Builder

3DSlicer

Help

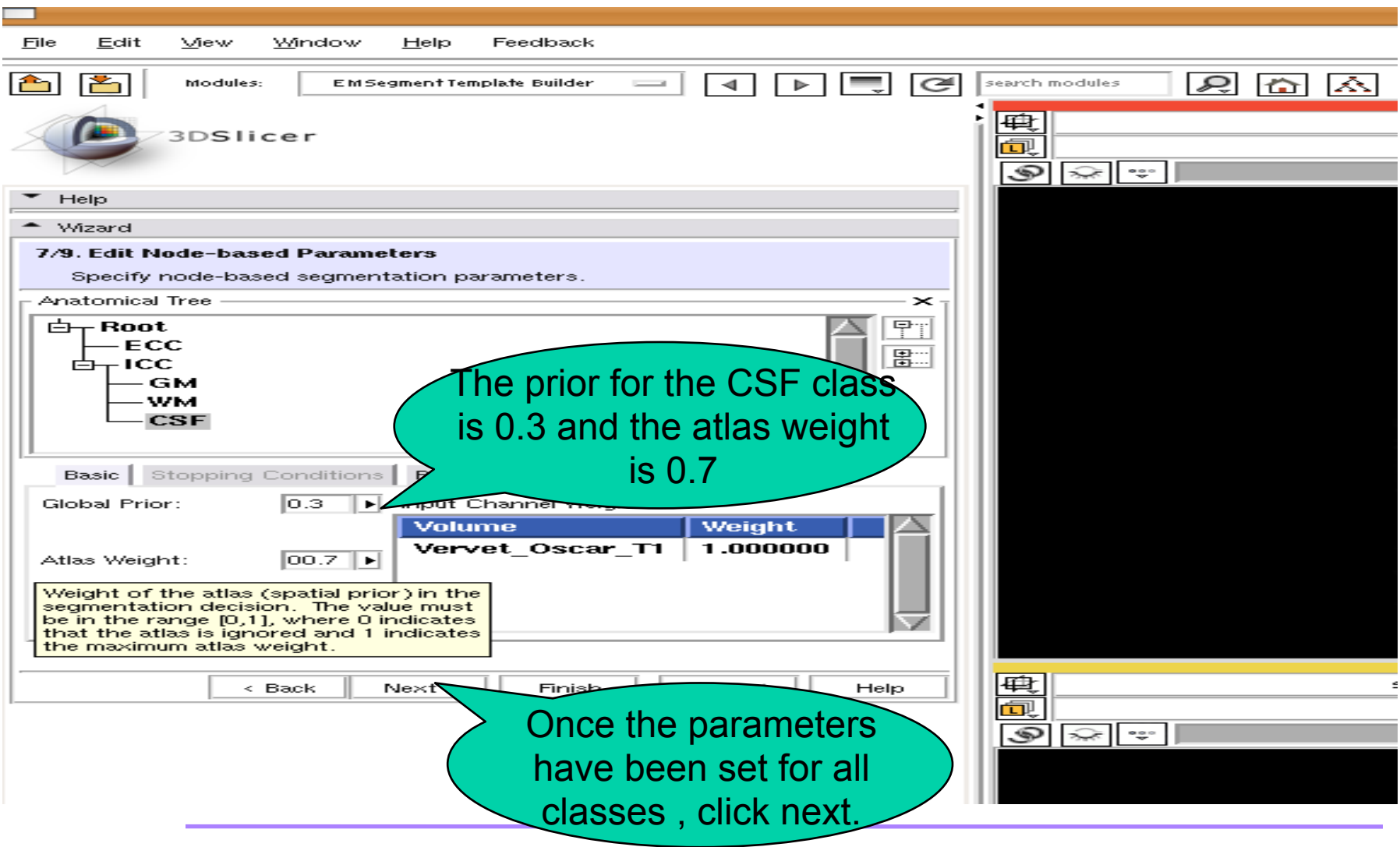
Wizard

7/9. Edit Node-based Parameters
Specify node-based segmentation parameters.

Anatomical Tree

- Root
 - ECC
 - ICC
 - GM
 - WM
 - CSF

The prior for the WM class is 0.3 and the atlas weight is 0.7



File Edit View Window Help Feedback

Modules: EM Segment Template Builder

3DSlicer

Help

Wizard

7/9. Edit Node-based Parameters
Specify node-based segmentation parameters.

Anatomical Tree

```

graph TD
    Root[Root] --- ECC[ECC]
    Root --- ICC[ICC]
    Root --- GM[GM]
    Root --- WM[WM]
    Root --- CSF[CSF]
  
```

Basic | Stopping Conditions

Global Prior: 0.3

Atlas Weight: 0.7

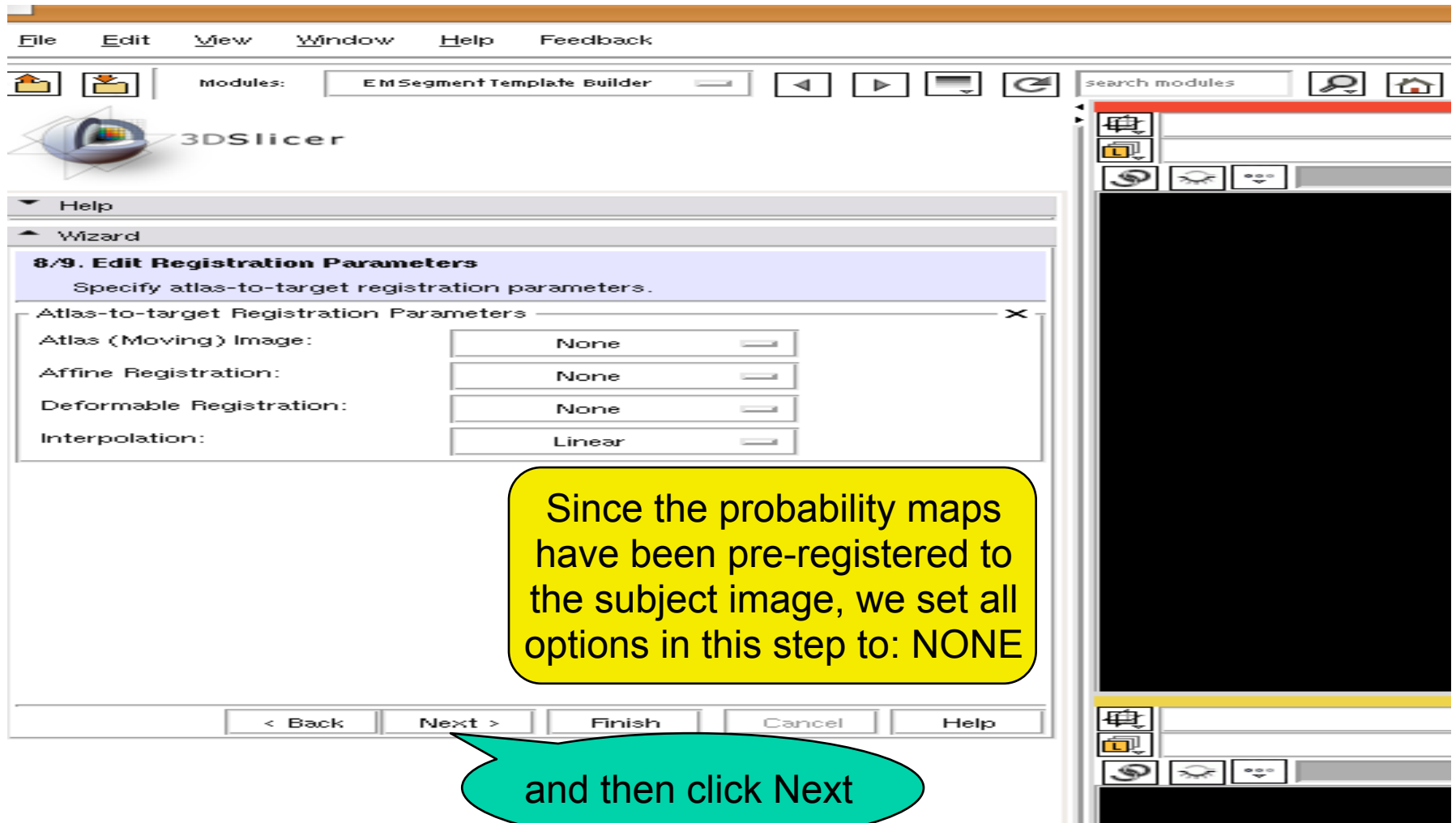
Volume	Weight
Vervet_Oscar_T1	1.000000

Weight of the atlas (spatial prior) in the segmentation decision. The value must be in the range [0,1], where 0 indicates that the atlas is ignored and 1 indicates the maximum atlas weight.

< Back Next Finish Help

The prior for the CSF class is 0.3 and the atlas weight is 0.7

Once the parameters have been set for all classes, click next.



File Edit View Window Help Feedback

Modules: EMSegment Template Builder

3DSlicer

Help

Wizard

8/9. Edit Registration Parameters
Specify atlas-to-target registration parameters.

Atlas-to-target Registration Parameters

Atlas (Moving) Image:	None
Affine Registration:	None
Deformable Registration:	None
Interpolation:	Linear

< Back Next > Finish Cancel Help

Since the probability maps have been pre-registered to the subject image, we set all options in this step to: NONE

and then click Next

Segmentation

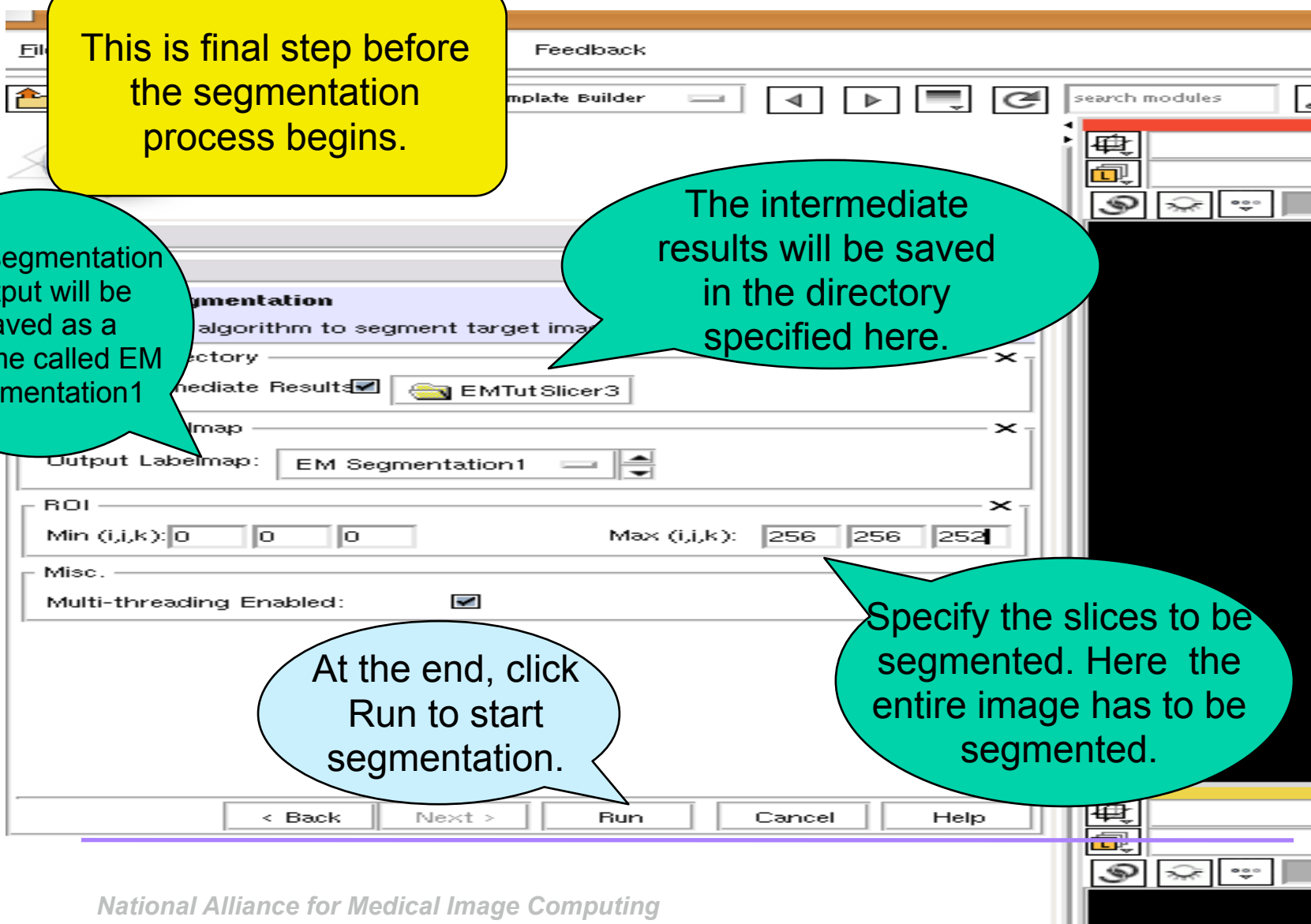
This is final step before the segmentation process begins.

The segmentation output will be saved as a volume called EM Segmentation1

The intermediate results will be saved in the directory specified here.

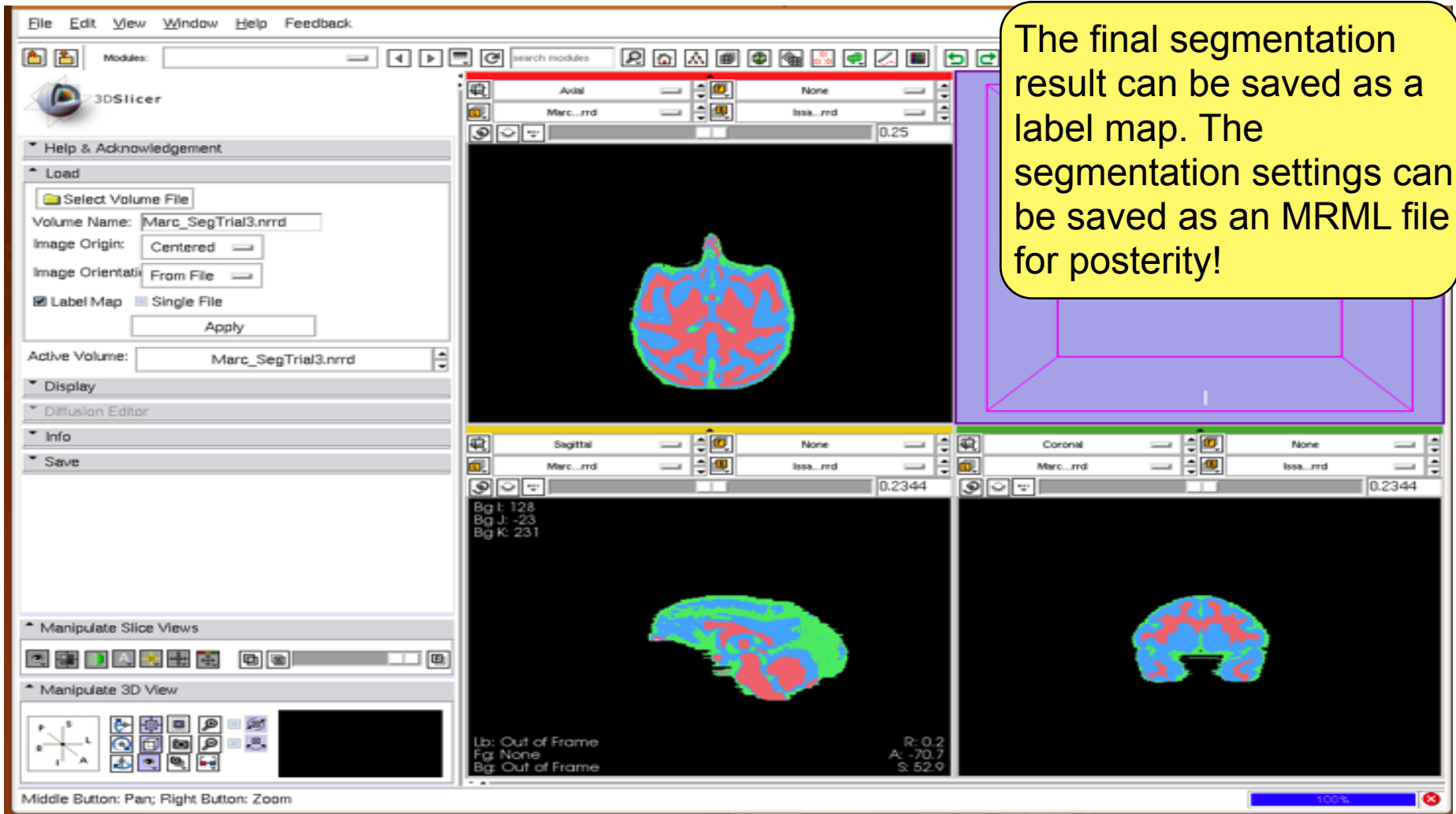
At the end, click Run to start segmentation.

Specify the slices to be segmented. Here the entire image has to be segmented.



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!



- 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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NIH U41RR019703



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