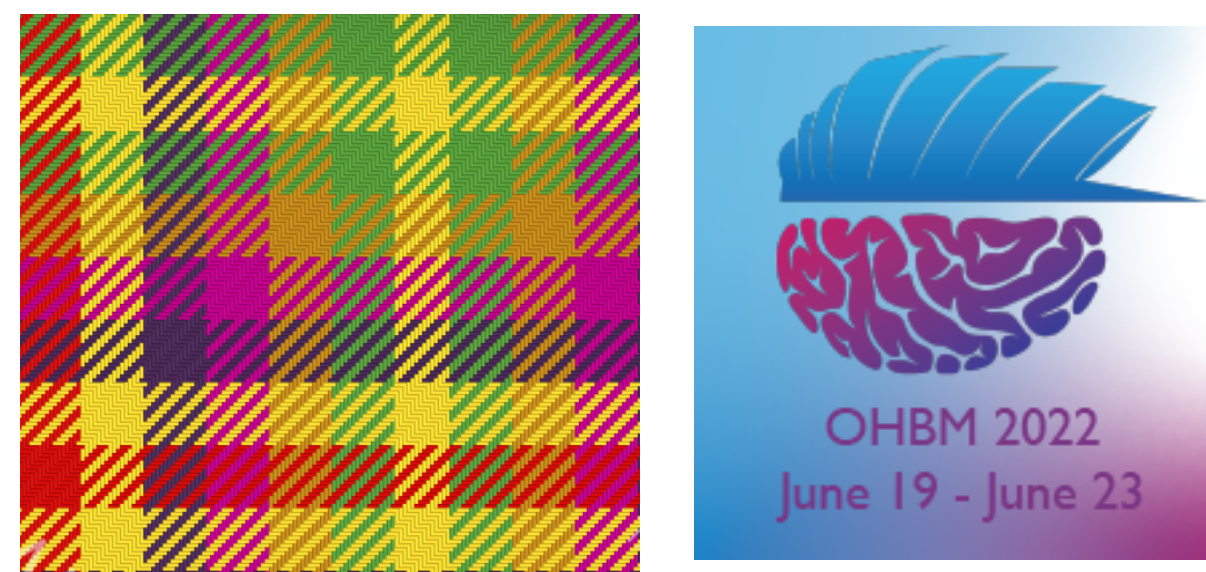


Using Clipping Planes to Analyze Brain Data in suma

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SUMA clipping planes allow relevant structures to be revealed by removing intervening data

The brain volume is 3D and gray matter (GM) has a complicated geometry, which is not constrained to simple viewing planes. Relevant data may be obscured by intervening layers in standard volumetric projections or by intervening structures in embedded surface views.

We present new clipping plane functionality in AFNI's¹ 3D visualization tool, SUMA², to facilitate the viewing of "internal" parts of the brain volume by interactively clipping away intervening parts of the brain. This may be particularly beneficial when combined with recent surface layer interpolation functionality in SUMA, for viewing high resolution data such as Layer fMRI (e.g. via VASO)³.

The 6 available planes are represented as translucent squares, each identified with a unique color that can also be toggled on/off. Each plane can be tilted and translated to define the part of the brain that is visible, unobscuring parts that are not of interest. All of this can be manipulated with keypresses or 'driven' in command line scripts.

SUMA's clipping planes enable the viewing of internal brain structures in ways that neither purely volumetric slicewise viewing nor standard surface-based viewing allow. Additional functionality is discussed in [4]. We plan to add further functionality, and are happy to hear suggestions from users to facilitate their research.

Link to online **SurfLayers** and **Clipping Planes** demos.

REFERENCES

[1] Cox RW (1996). AFNI: software for analysis and visualization of functional magnetic resonance neuroimages. *Comput Biomed Res* 29(3):162-173. doi:10.1006/cbmr.1996.0014

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[3] Huber L, Ivanov D, Handwerker DA, Marrett S, Guidi M, Uludağ K, Bandettini PA, Poser BA (2018). Techniques for blood volume fMRI with VASO: From low-resolution mapping towards sub-millimeter layer-dependent applications. *NeuroImage*. 164:131-143. doi: 10.1016/j.neuroimage.2016.11.039.

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Application to Surfaces

Figure 1 provides a brief demonstration of the behavior and utility of the clipping planes, allowing the visualization of the internal structures of the brain. In this example, the internal structures are colorized.

The clipping planes can be added, spatially translated and tilted interactively via the keyboard or automatically with the DriveSuma program.

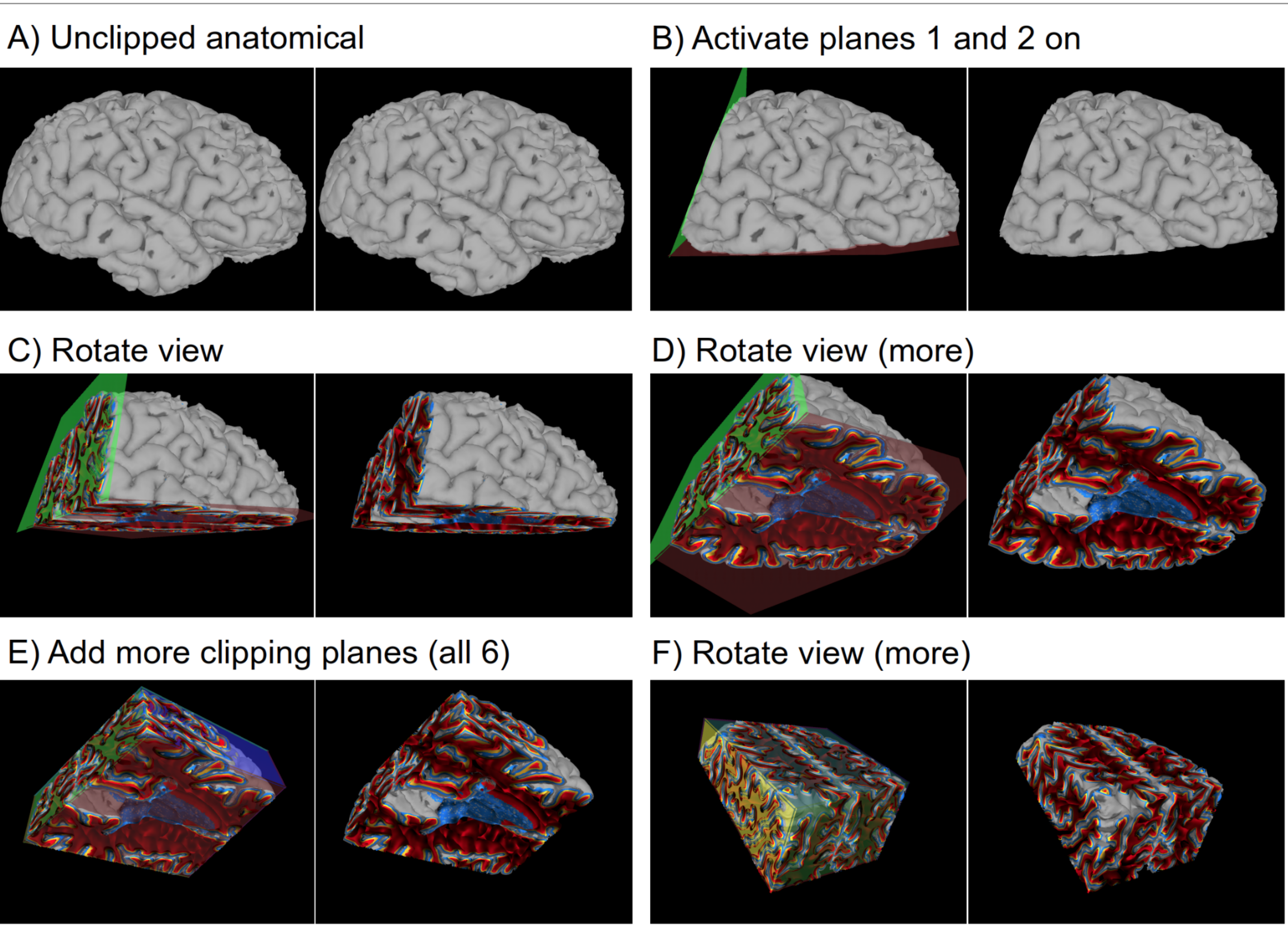


Figure 1. Basic clipping plane functionality in SUMA. In each panel a pair of images are shown for the same dataset and field of view: (left) the dataset with any active clipping planes visible; (right) the same dataset with active clipping planes *not* visible and only the dataset shown. The dataset is a pial surface (grayscale), with GM-WM boundary and two interpolated surfaces shown in red, blue and amber (respectively), when visible from clipping. Visible color planes appear in each lefthand panel pairing as translucent colored rectangles, e.g., red and green in B, and magenta, cyan and yellow in F.

Application to Volumes

Figure 2 shows the effect of applying multiple clipping planes to the brain to view statistical results. The upper row shows a standard slicewise, volumetric view of a statistical dataset overlaid on the anatomical volume.

The lower row shows how a broader range of brain regions can be viewed simultaneously using clipping planes in SUMA.

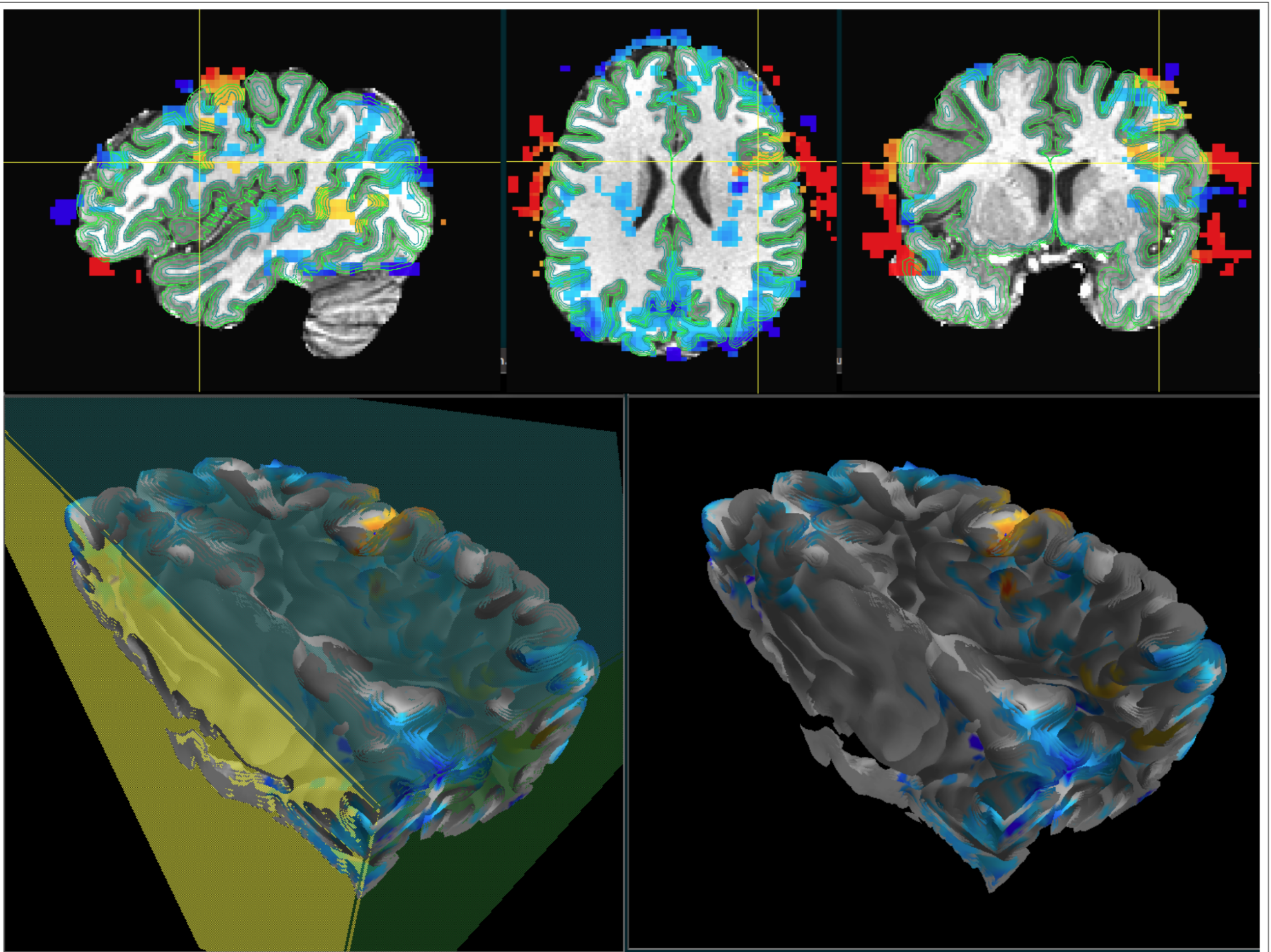


Figure 2. Clipping plane functionality. The top row shows a volumetric view of a thresholded statistical dataset overlaid on an anatomical volume in AFNI; the green lines show the GM surface projections from SUMA (GM-WM boundary, pial and interpolated surface layers). The bottom panel shows two views of the same data in SUMA: the left shows the three clipping planes (translucent yellow, cyan and green rectangles), and the right panel shows the same data with the clipping planes on but not visible. Using the clipping planes in this way provides a different and customizable view of the overlaid activity throughout the brain, including within the GM layers.