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The Impact of Phase Errors on Mapping the Flow of the Cerebral Vasculature with Phase Contrast MRI

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Introduction

- Volume flow rate (VFR) measurements based on phase contrast (PC) magnetic resonance (MR) imaging datasets have a known spatially varying bias due to eddy currents [1-4]
- The purpose of this study was to explore the effect of phase errors and correction on quantitative analysis of PC-MR images

Methods

- Three phase error correction schemes were compared (local bias correction, local polynomial fitting, and whole brain polynomial fitting) using PC-MR datasets obtained in thirty healthy subjects previously assessed in ref [5]
- The methods were first calibrated in background tissue to confirm the performance of the methods, and then used to correct measurements of cerebral vessels
- Measurement locations are show in Figure 1 at the bottom
- Bland-Altman analysis was used to assess the effect of correction in the vessel measurements
- ANOVA tests were used to test the effect of correction

Results

- In the background tissue, the bias was significantly reduced ($p < 0.001$) by all methods, while no correction scheme led to significantly different measurements in the vessels ($p = 0.997$)
- There was no statistical difference between the different correction schemes ($p = 0.242$ in background, $p = 0.738$ in vessel measurements)
- In the background tissue with expected no flow, the bias was reduced on average by 65.6% with local bias correction, 58.4% with local polynomial fitting, and 47.8% with whole brain polynomial fitting
- In the vessel measurements, the three correction schemes led to flow measurement differences compared to the non-corrected measurements of -0.0360 ± 0.0475 ml/s, 0.0876 ± 0.155 ml/s, and -0.017 ± 0.059 ml/s, respectively (Figure 2)

Conclusions

- We conclude that phase correction methods do not differ significantly and also do not have a significant effect on flow measurements of cerebral vessels, likely due to dominating biological variance of the flow between subjects

References

- [1] Gatehouse, *et al.* Journal of Cardiovascular Magnetic Resonance. 2010;12(1):5.
- [2] Walker, *et al.* J Magn Reson Imaging 1993;3(3):521-530.
- [3] Gatehouse, *et al.* Journal of Cardiovascular Magnetic Resonance 2012;14(1):1-7.
- [4] Gatehouse, *et al.* Eur Radiol 2005;15(10):2172-2184.
- [5] MacDonald, *et al.*, Physiological Measurement. 2015;36(7):1517-1527.

Figure 2: Bland Altman Analysis of uncorrected VFR measurements and the three correction schemes. Correlations are strong, showing little variation between the corrected and uncorrected measurements. Bland-Altman plots elude to the bias change with correction.

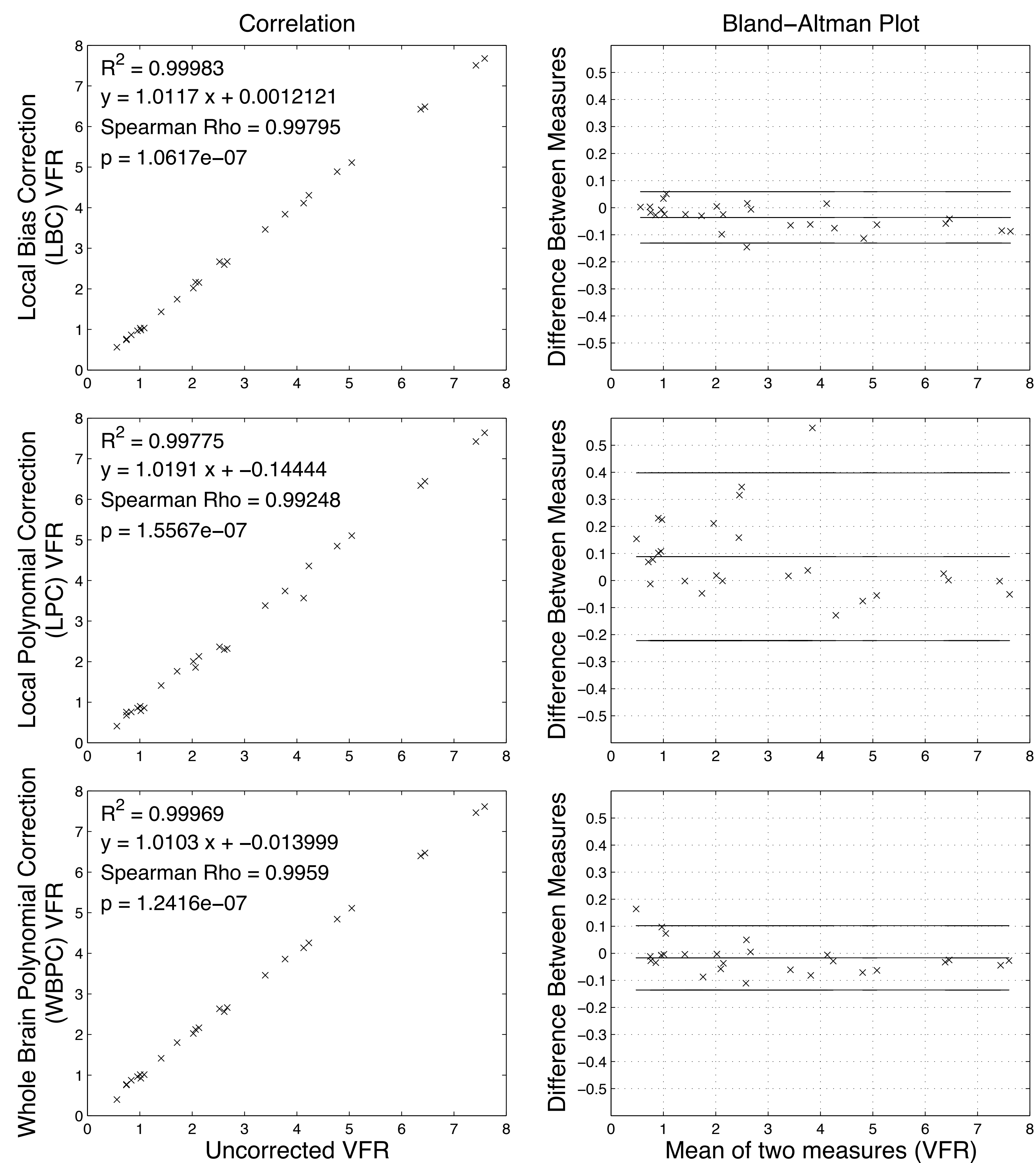
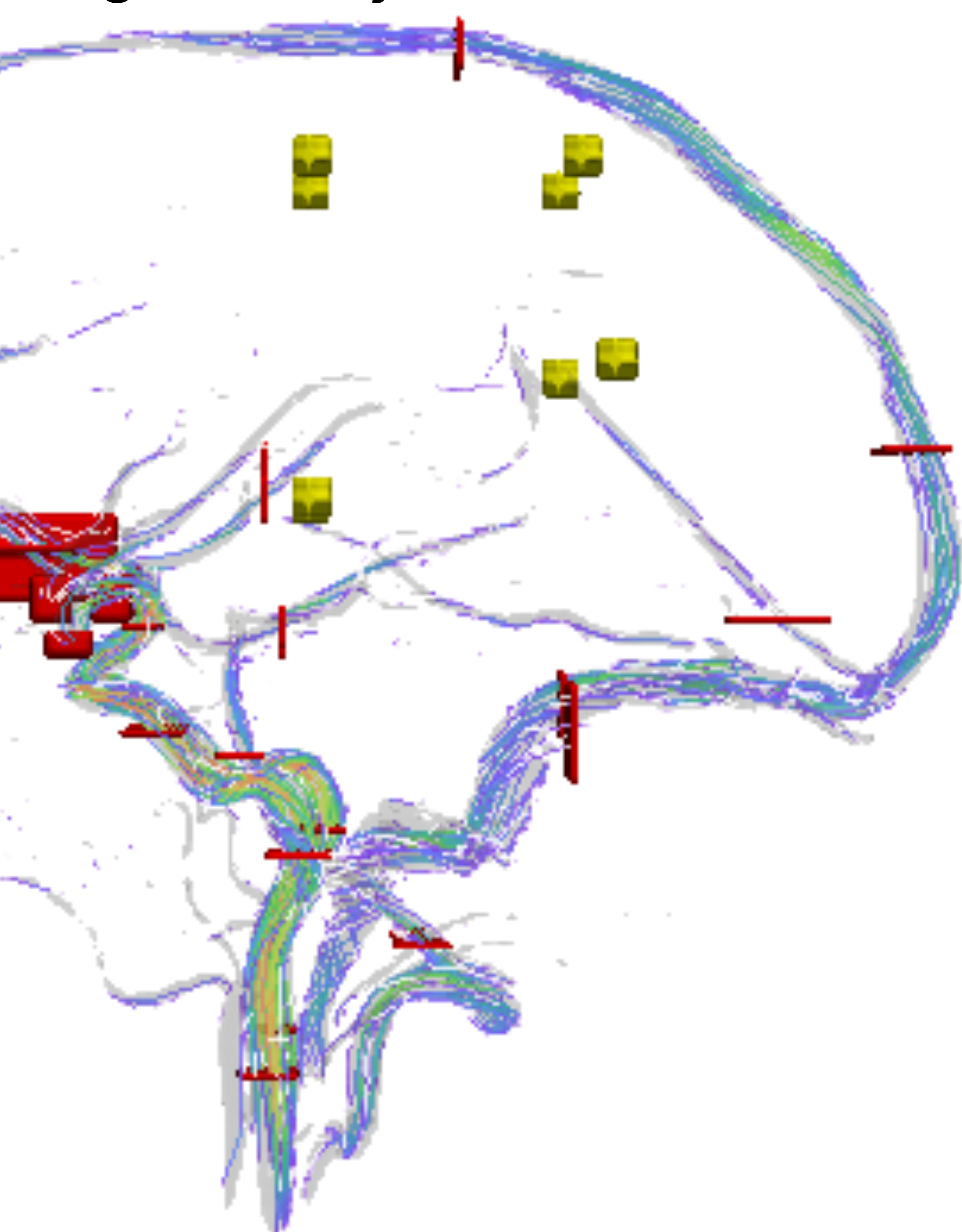
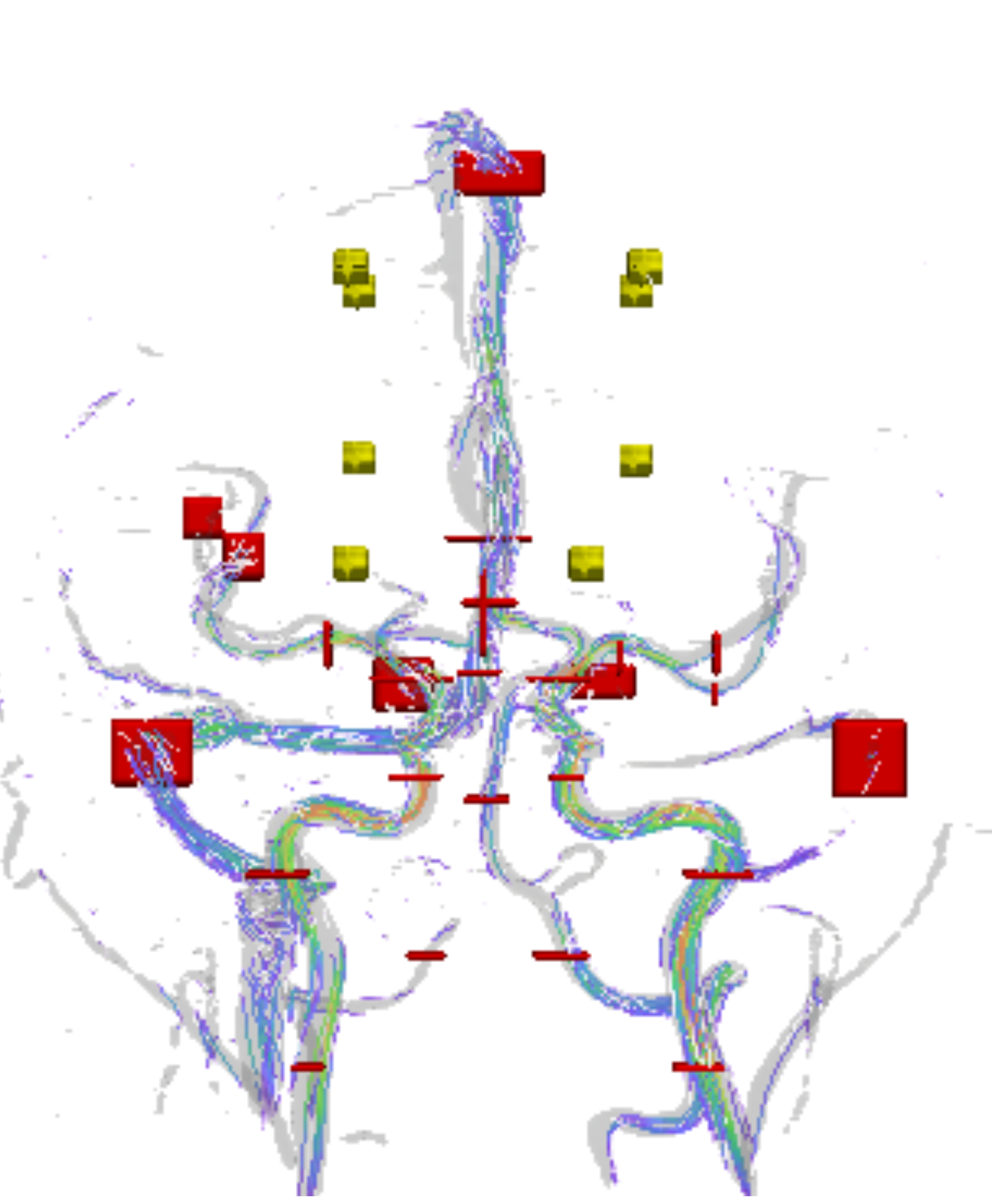


Figure 1: Cerebrovascular phase contrast angiographic rendering with background cut planes (yellow) and vessel cut planes (red).

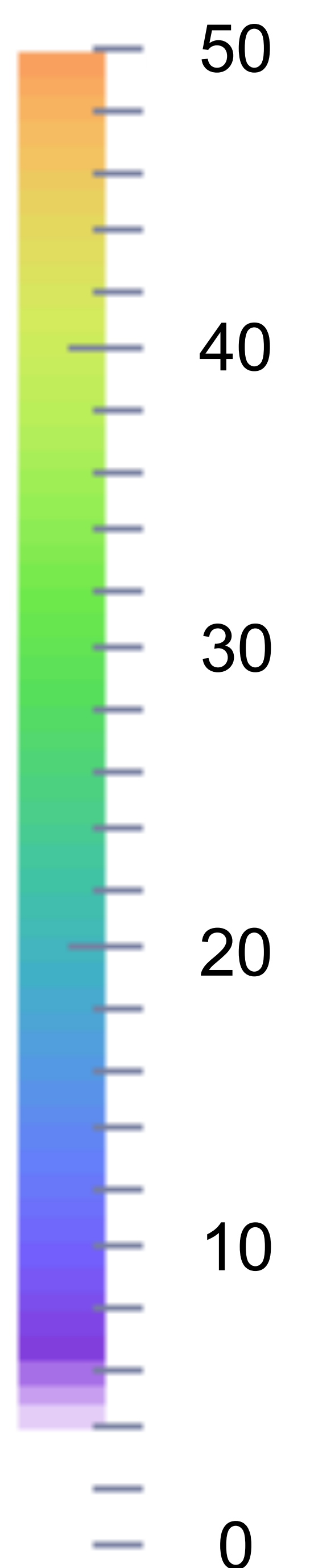
Sagittal Projection



Coronal Projection



Velocity



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Looking west from Whitefoot Mountain, into Glacier National Park in Canada