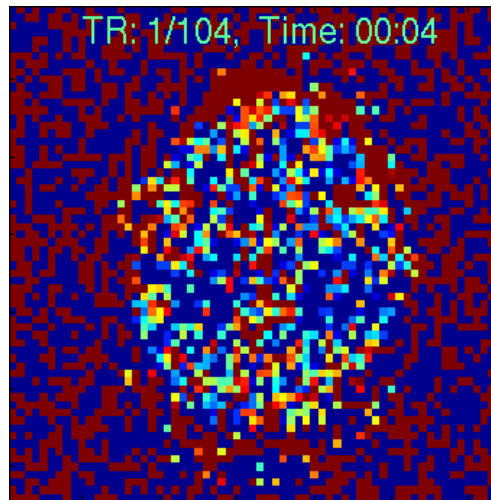


Measurement Stability in Arterial Spin Labeling Investigated Using Multiple Sites



ISMIRM 2010

J.M. Rasmussen¹, T. Liu², B. Mueller³, G. Brown², C. Wierenga² and G.H. Glover⁴

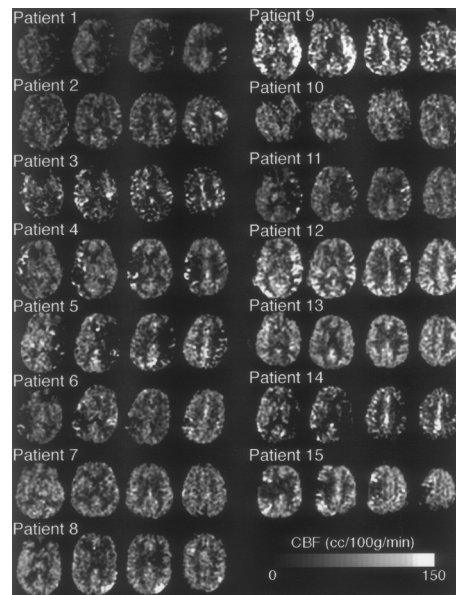
¹University of Cal., Irvine, Irvine, CA, USA, ²University of Cal., San Diego, San Diego, CA, USA,

³University of Minnesota, Minneapolis, MN, USA, ⁴Stanford University, Palo Alto, CA, USA

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Cerebral Blood Flow (CBF) and Physiology

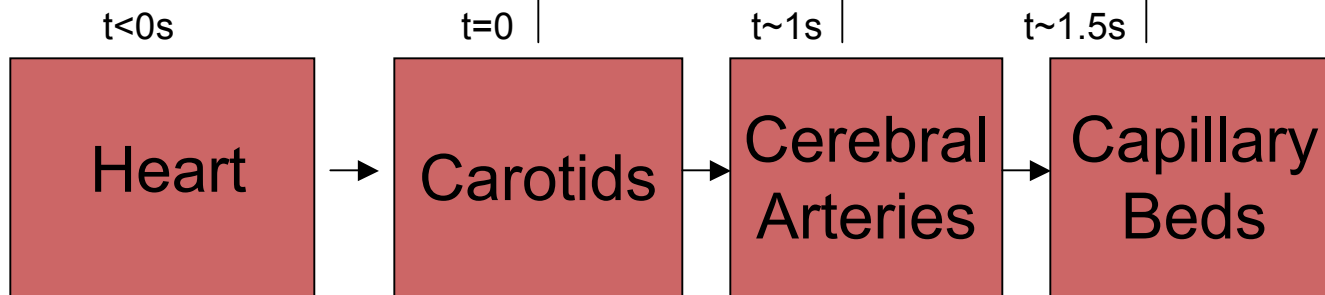
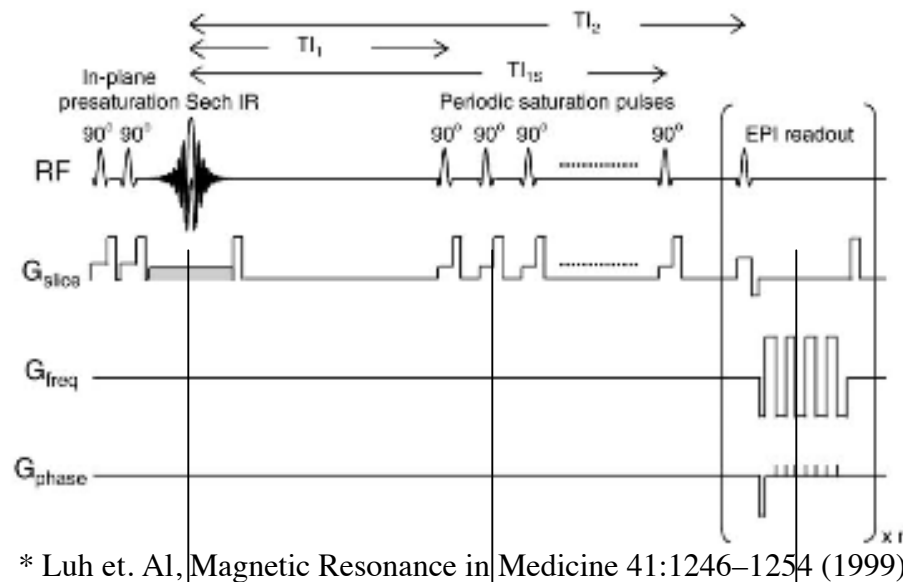
- CBF is the metabolic delivery mechanism for neuronal activity.
- Provides insight into vascular and neuronal deficiencies.



Chalela, J. A. et al. *Stroke* 2000;31:680-687

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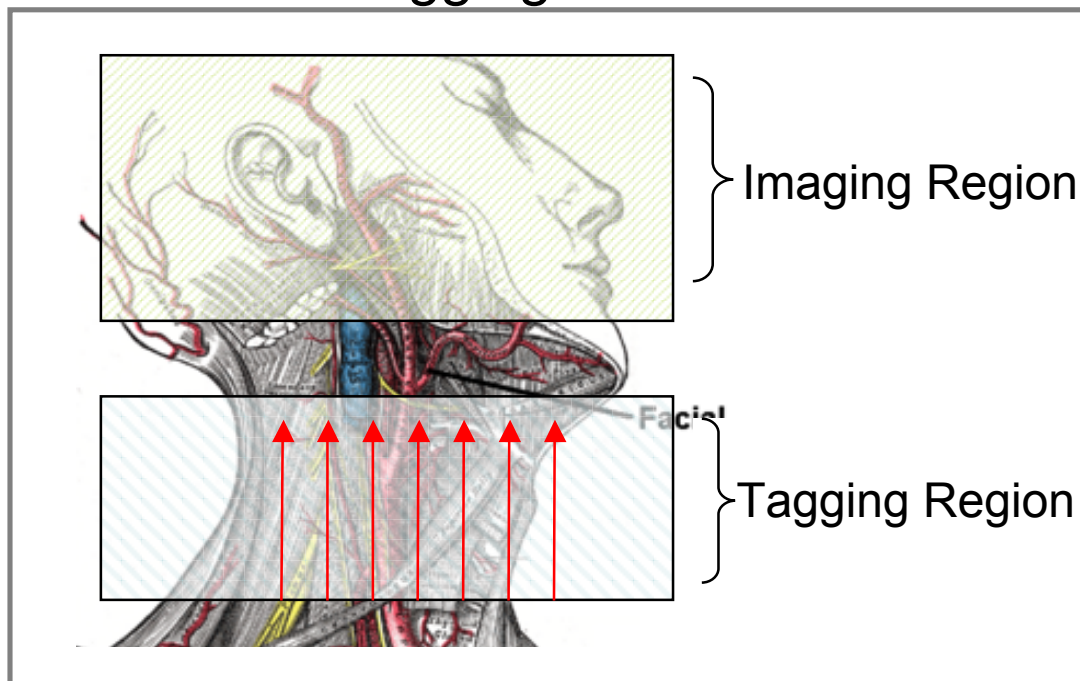
CBF and Flow Dynamics



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CBF and Arterial Spin Labeling (ASL)

Tagging in ASL



*anatomy image borrowed

Initial magnetization from the presaturation pulse in the tagging region.

Initial magnetization in imaging region.

$$M_{tag} = M_z - M_{OB}$$

$$M_{control} = M_z + M_{OB}$$

$$S_{CBF} \propto M_{tag} - M_{control} = 2 M_{OB}$$

~~$$S_{BOLD} \propto M_{tag} + M_{control} = 2 M_z$$~~

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Number of TRs and Time in Scanner

- No clear recommendations exist for the number of acquisitions necessary for a stable CBF measurement.
- Time is valuable from both a financial and patient experience perspective.
- Minimizing the number of TRs means less time.

Procedure rate: \$400-3500

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Traveling Subjects Study

- Combined data across two separate traveling subject studies.



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Acquisitions

- Two different vendors.
- Hardware and software limitations lead to varied acq parameters. PASL, QUIPSS II

Common:

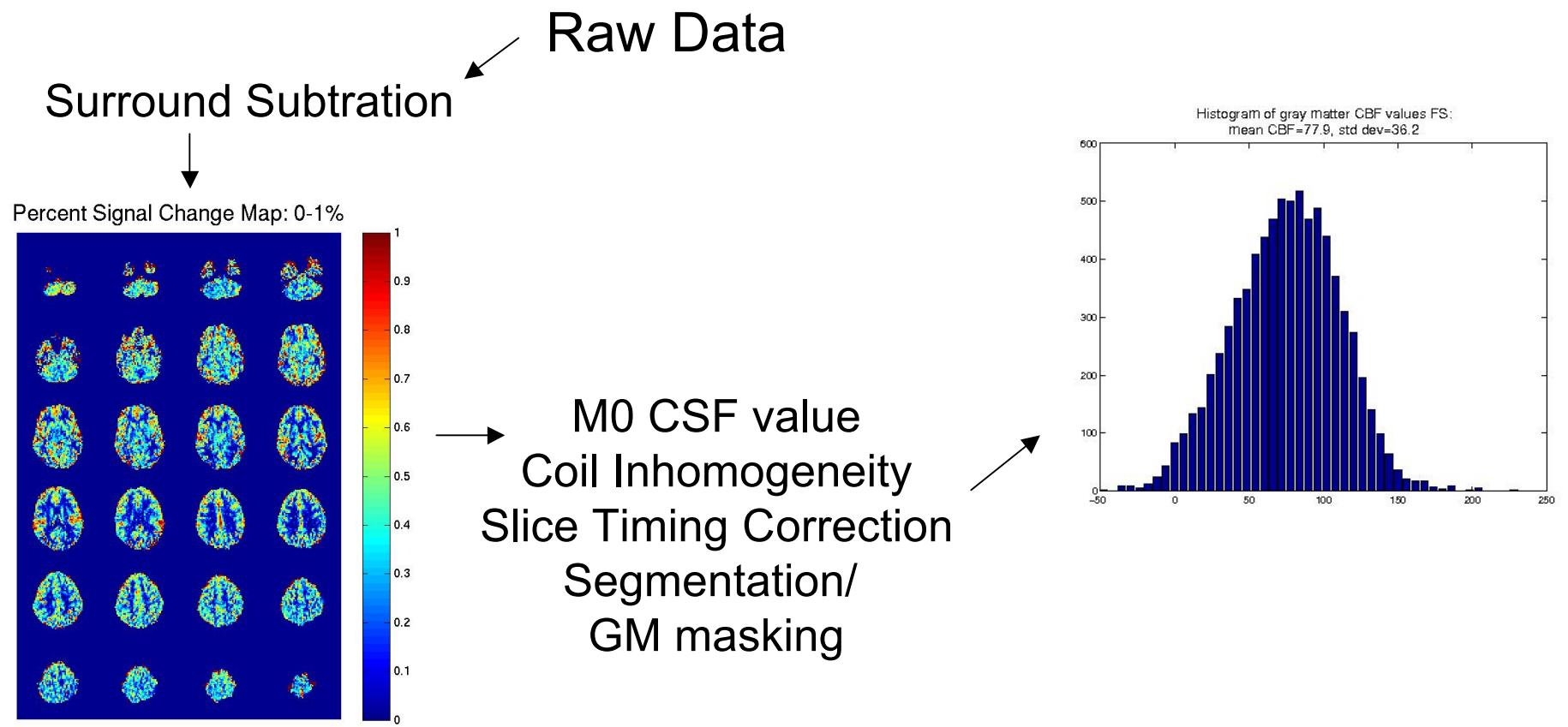
- Field Strength- 3T
- FOV: 220mmx220mm (64x64 matrix), TH=4mm
- TR=4000ms, TI1/TI2=600/1600ms, Tag Gap=10cm

Vendor Specific:

- TE=3/12ms
- Spiral/Cartesian k-space acquisition.

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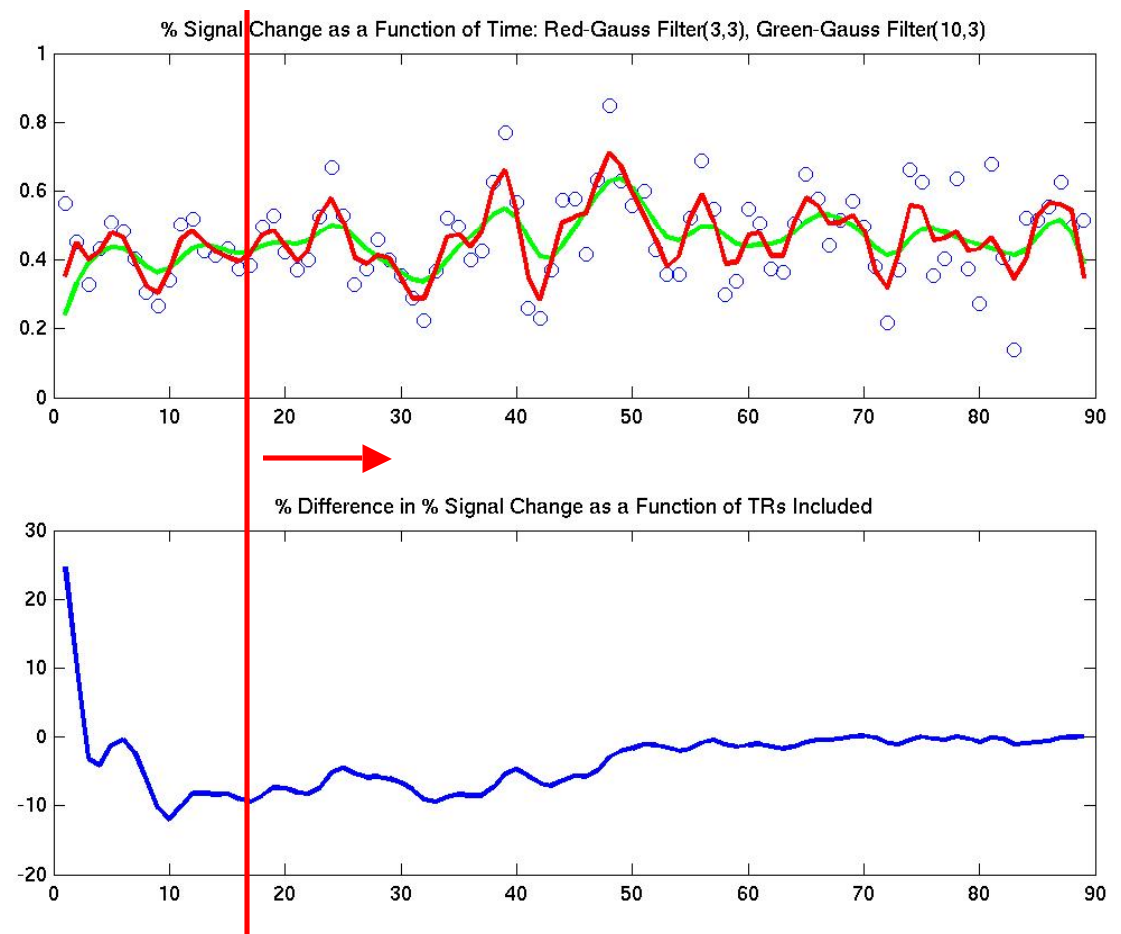
CBF Quantification



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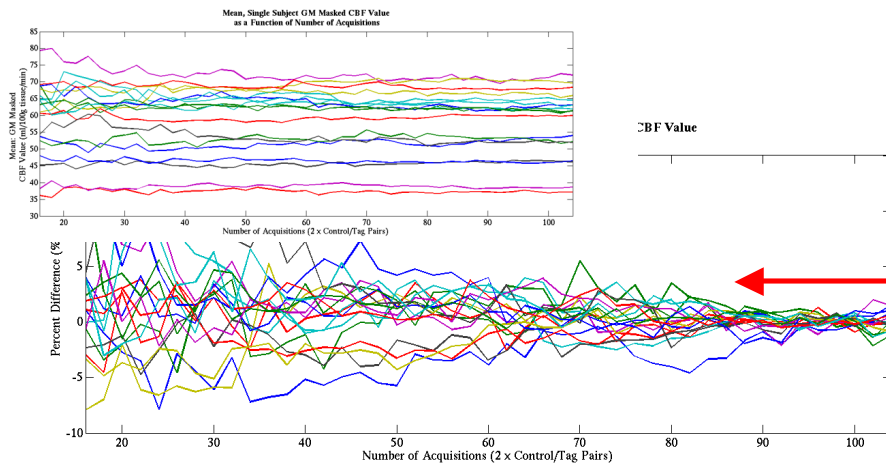
NTR Analysis - Subject Level

- Truncate 102 time point series by 2.
- Repeat identical processing for $NTR = \{18, 20, 22, \dots, 96, 98, 102\}$
- Vector of $\langle GM_{CBF} \rangle, u\{GM_{CBF}\}$ values for each iteration.



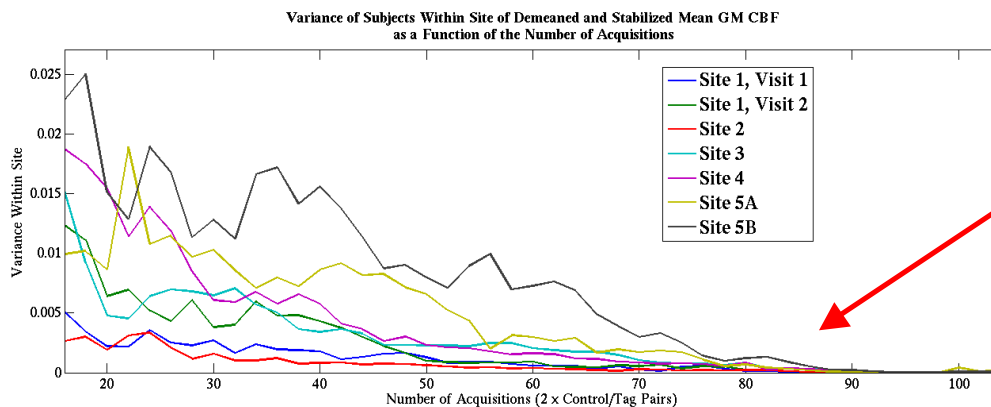
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NTR Analysis - Site Level



- Demean and express subject level analysis as a % difference from steady state value (<TR92-102>).

- Calculate mean and variance across subjects for each site.

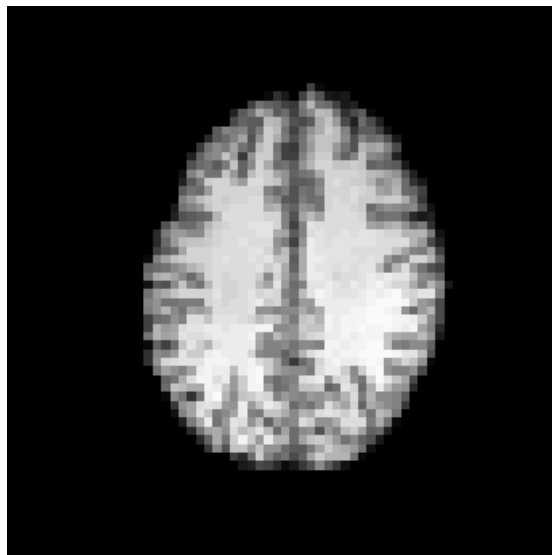


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Single Subject CBF Image

Averaging over time increases SNR

Anatomical in ASL Space

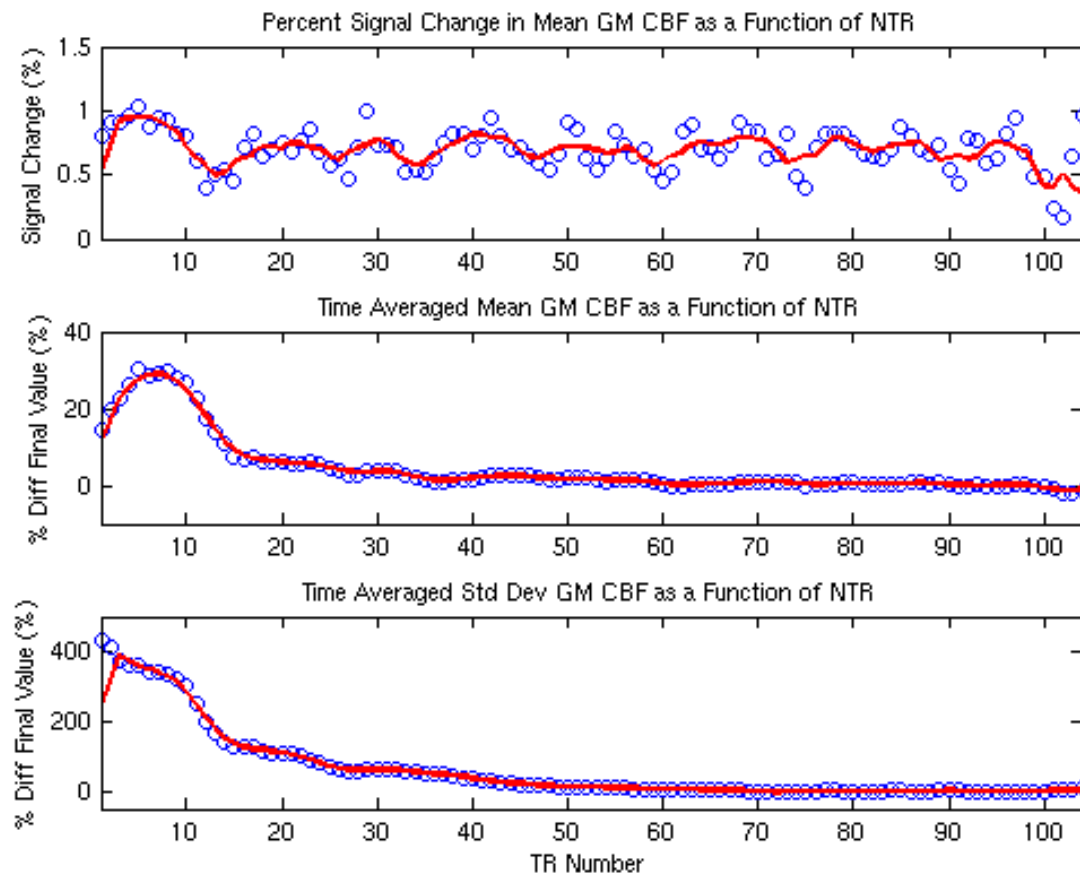


Time Averaged CBF (t)



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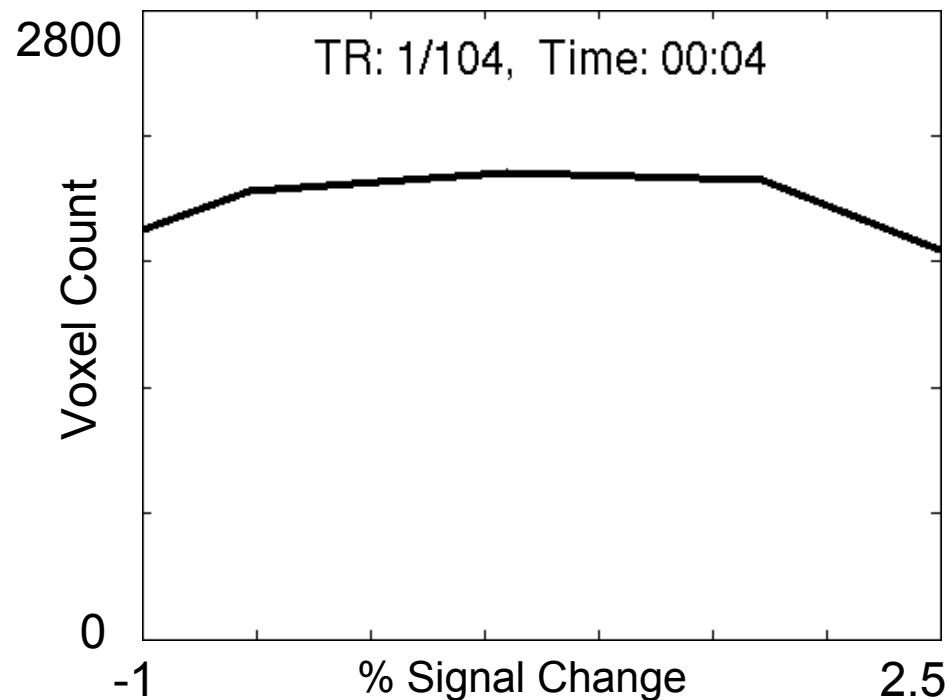
Single Subject Std. Dev. GM CBF



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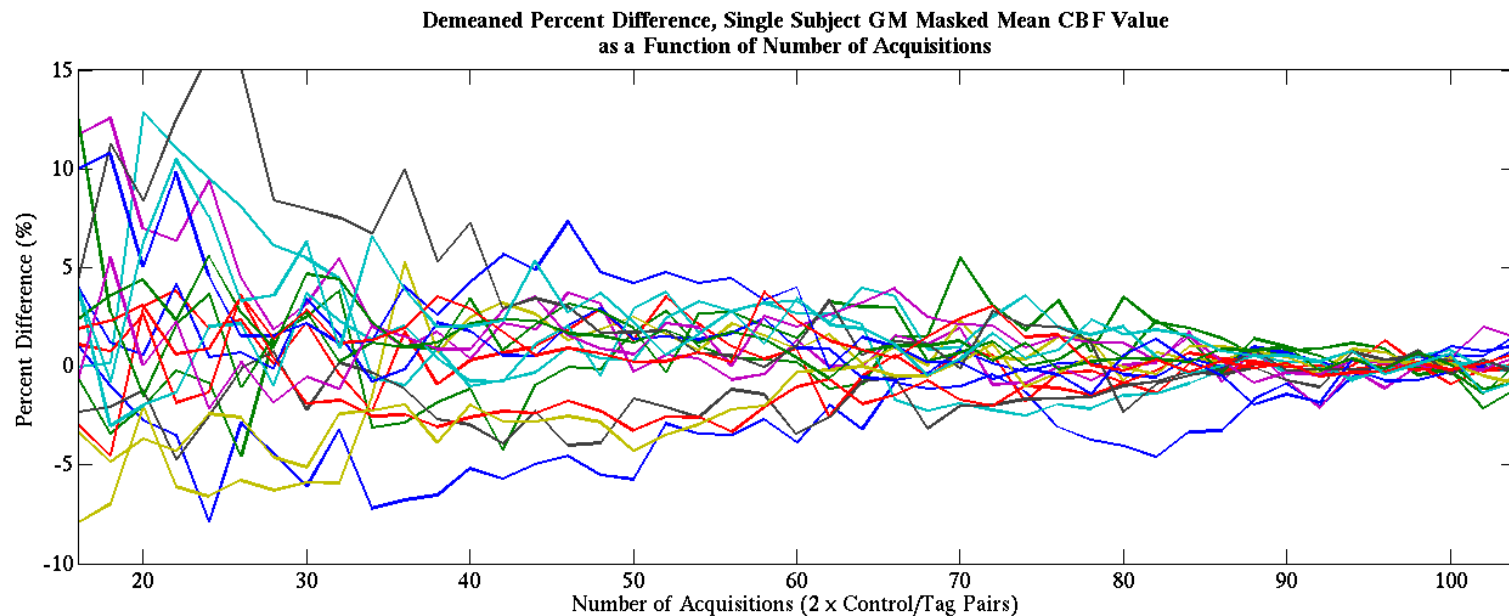
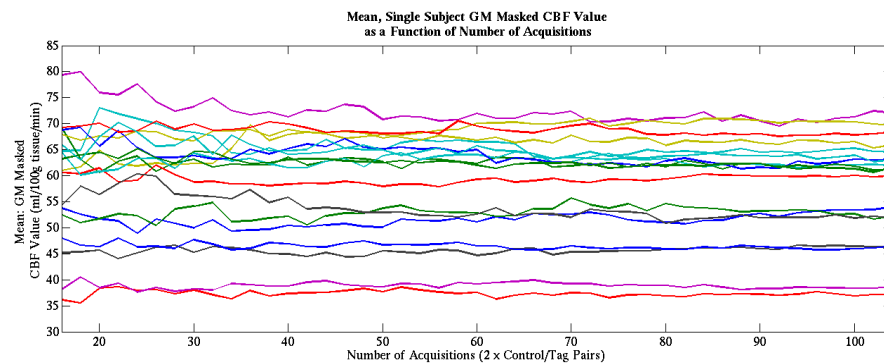
Single Subject Mean GM CBF Gauss. Distribution

Largely due to a decrease in “N”



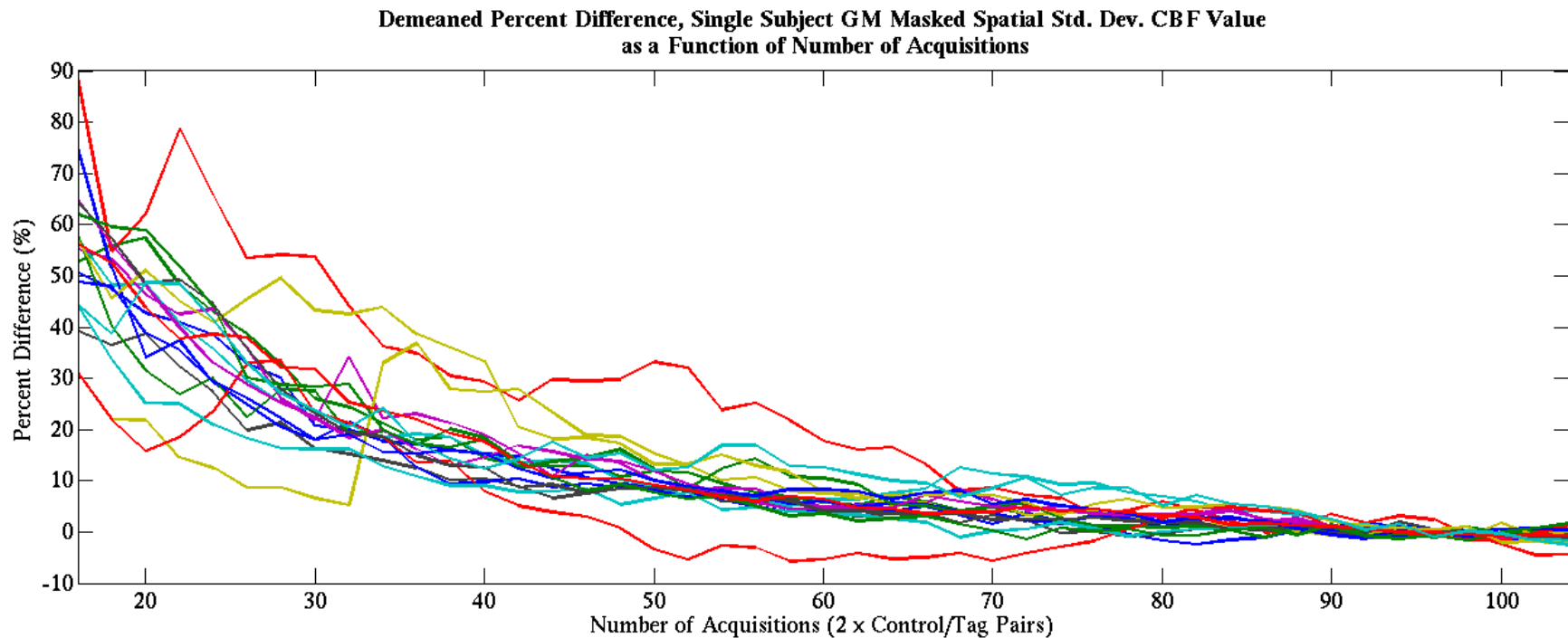
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Across Site Mean GM CBF



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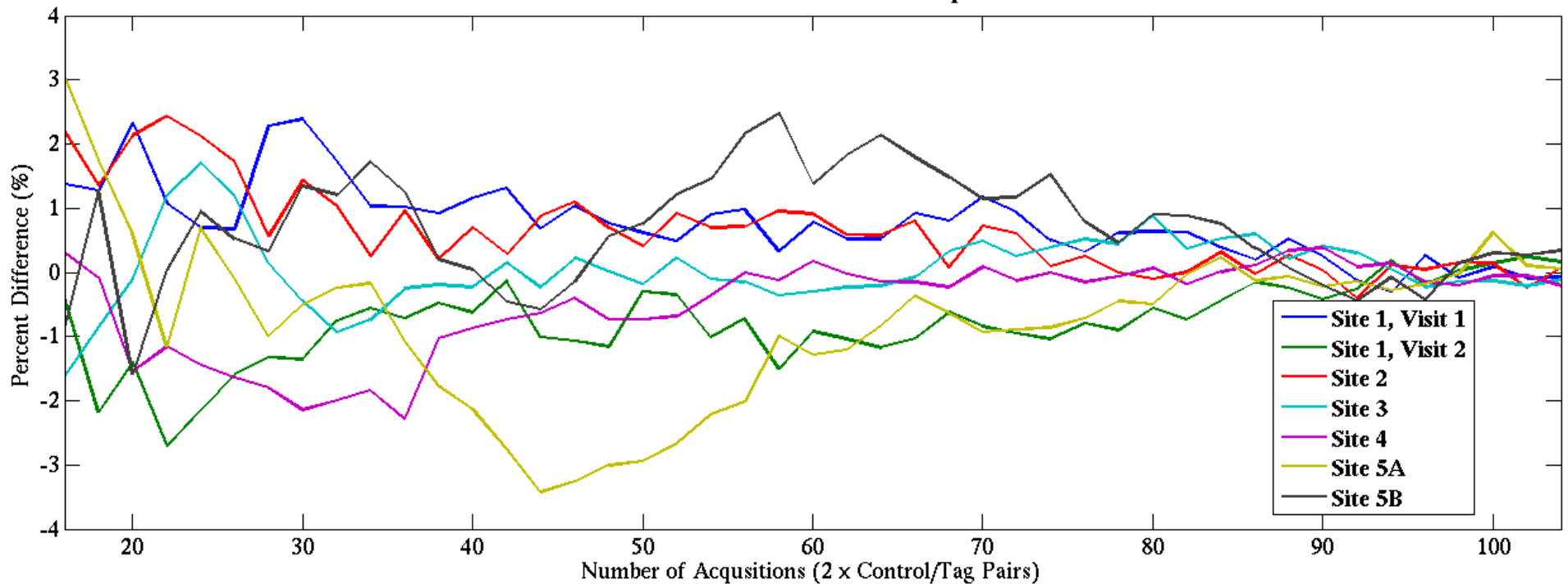
Across Site Std. Dev. GM CBF



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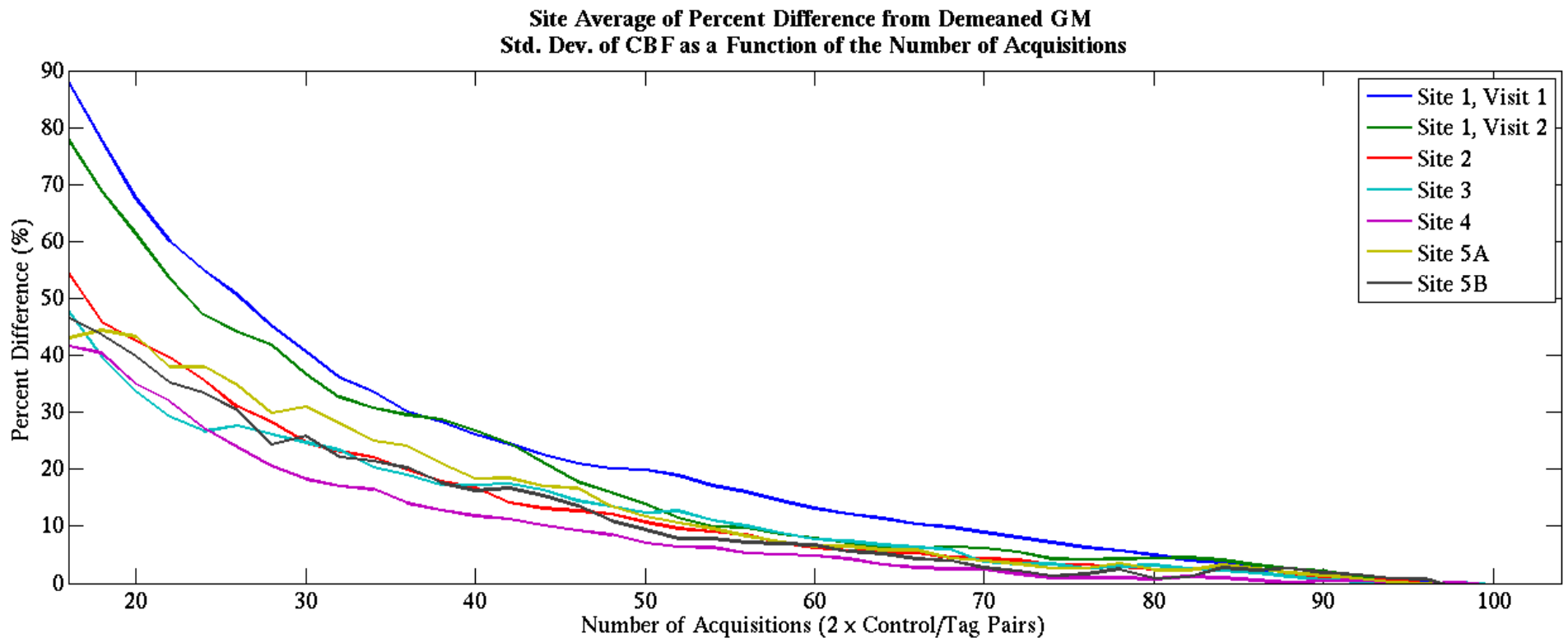
All Sites Mean GM CBF

Site Average, Percent Difference from Demeaned and Stabilized Mean GM CBF
as a Function of the Number of Acquisitions



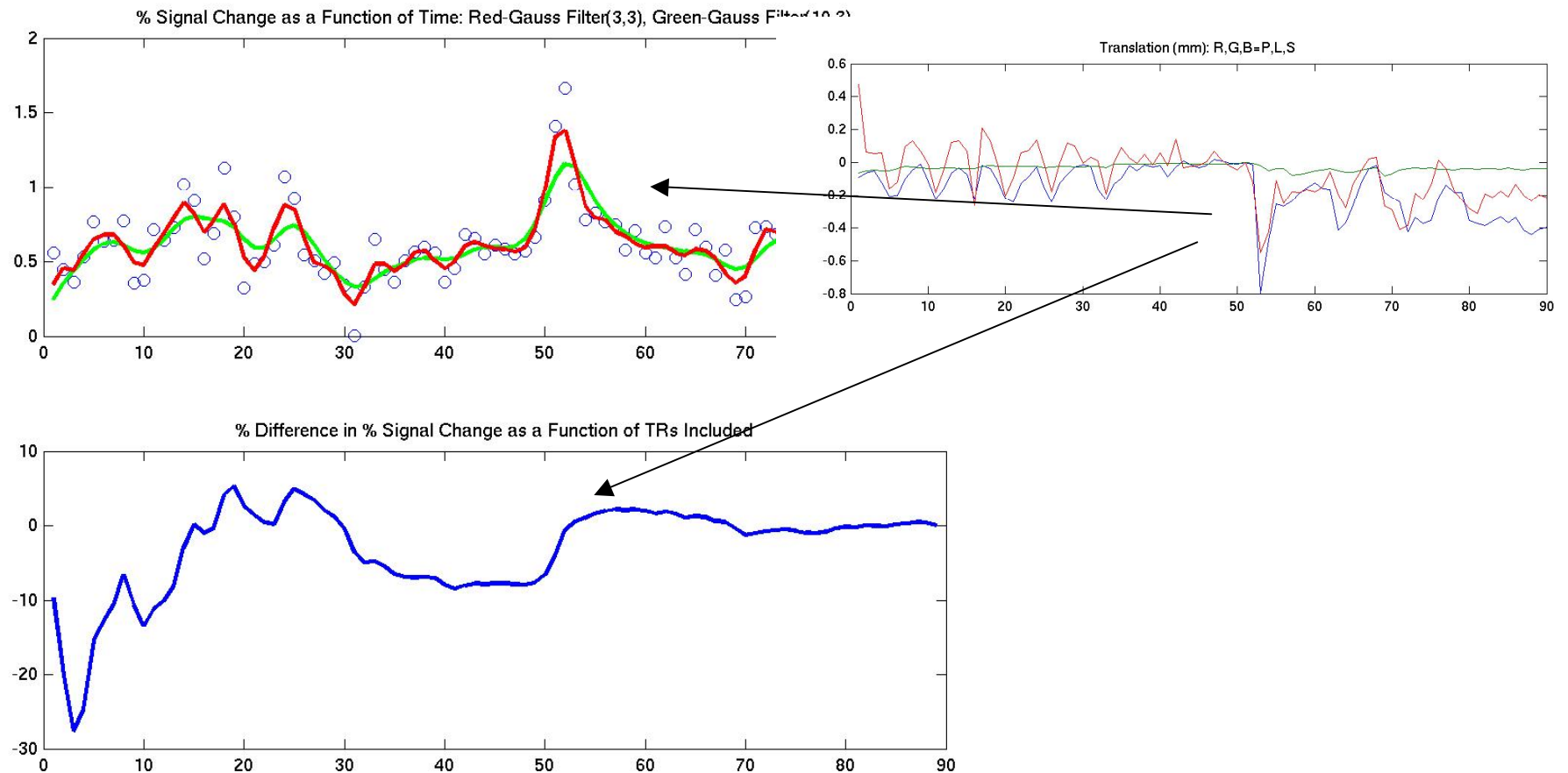
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All Sites Std. Dev. GM CBF



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Motional Effects on NTR



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Summary/Guidelines

- fBIRN is currently recommending 90 TRs necessary for steady state mean GM CBF measurements
- This may be site/subject/region dependent
- Motion likely impacts stability and should be considered in specific populations

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Implications/Future Work

- Correlate stability with QA measures. i.e. SNR, SFNR, motion, data smoothness, etc.
- Investigate regional dependence on stability.
- Consider implications of real time ASL methods that image until a steady state is reached.
- Investigate large outlying time frame removal.

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Citations

1. Wang J. 2003. Pediatric Perfusion Imaging Using PASL. JMRI 18 404-413.
2. Kim J. 2005. CASL perfusion fMRI Investigation of Higher Cognition. NeuroImage. 31 376-385.
3. Leontiev O. 2006. Reproducibility of BOLD, perfusion, CMRO2 with calibrated- BOLD fMRI. NeuroImage. 35 175-184.