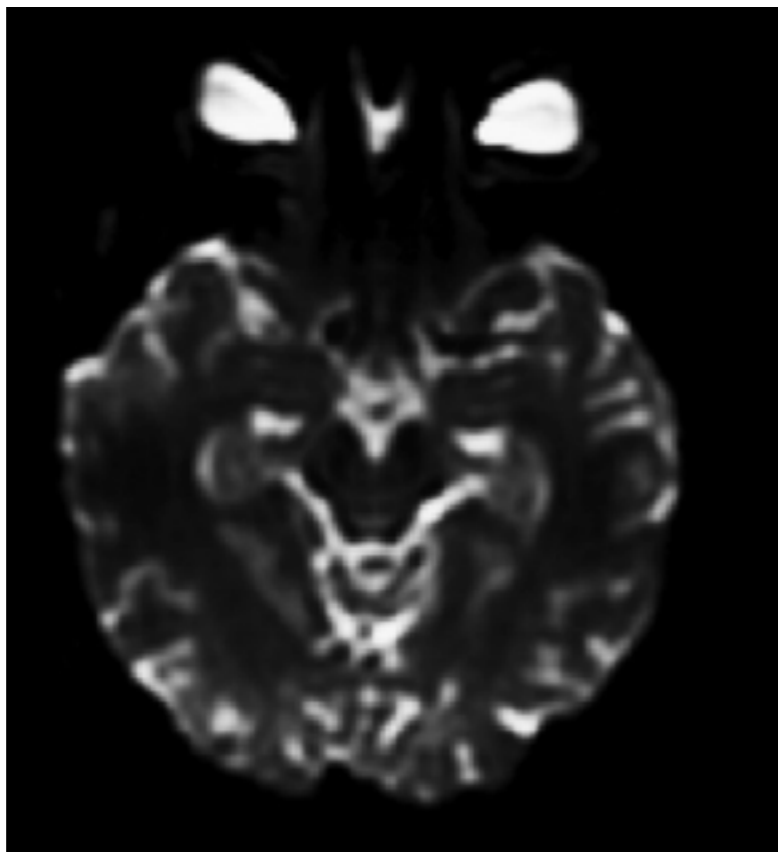# Unwarping EPIs using fieldmaps

Alex Huth
MRI analysis clinic
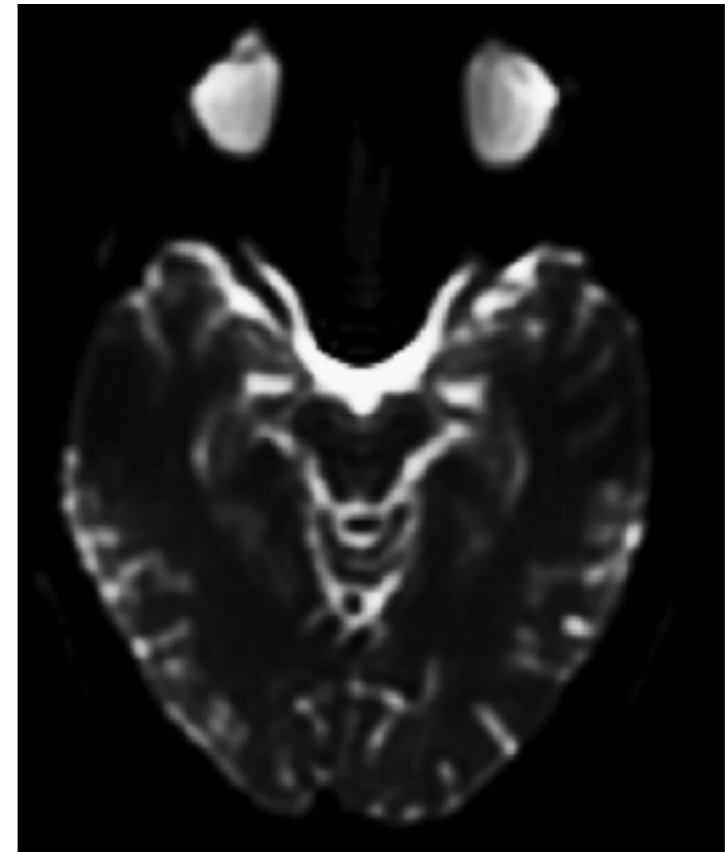March 16, 2015

What is warping?

- PE-axis distortion due to B0 inhomogeneity

A-P

P-A

What affects warping?

- **Echo spacing**

  - Longer echo spacing is bad

  - GRAPPA reduces effective echo spacing by GRAPPA factor

Warping can be corrected (ish)

- Using a **fieldmap**

  - A fieldmap shows how the B0 (main magnetic field) changes across your sample
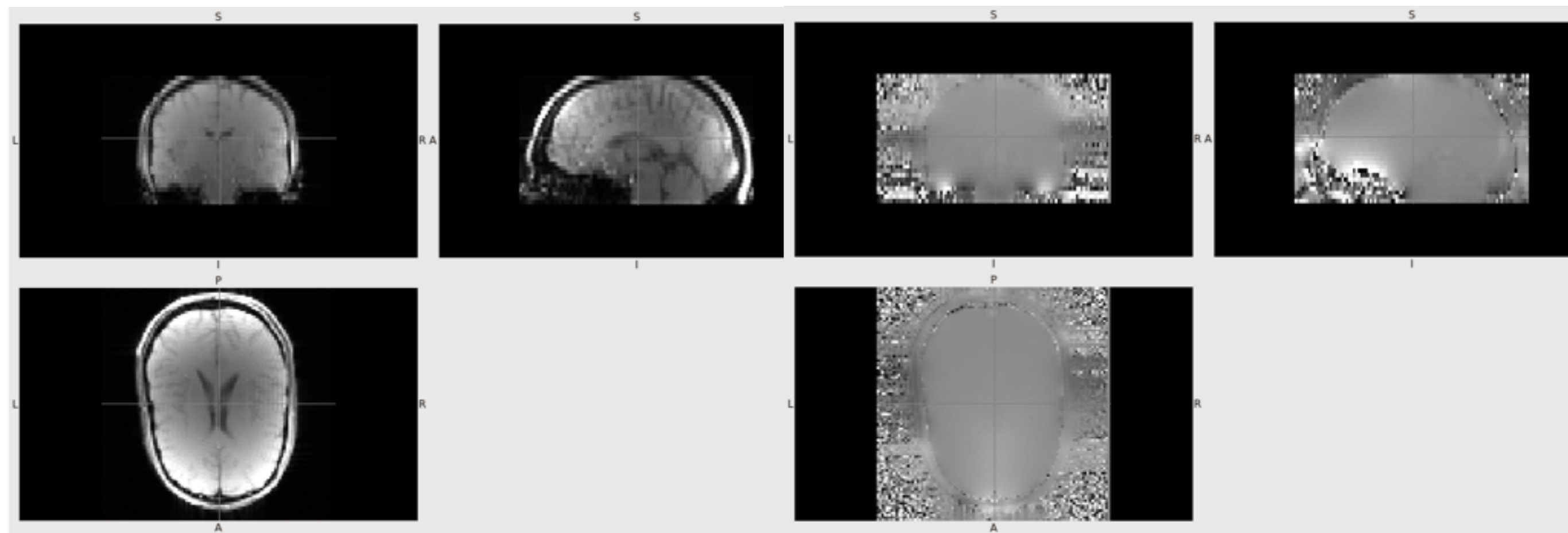
How do I get a fieldmap?

- `gre_field_mapping` sequence

  - Acquires 2 GRE images with slightly different TE's (e.g. 5.5ms and 7ms)

  - Outputs magnitude and phase difference images

How do I get a fieldmap?

Magnitude image

Phase difference image

Fieldmap preprocessing

- IMPORTANT: masking the magnitude image

```
$ bet mag.nii masked.nii -R -m -f 0.5 -g 0.0
```

                                              ↑   ↑
                                          Threshold   Vertical
                                                       Gradient

- The mask should be TOO TIGHT, never TOO LOOSE

Fieldmap preprocessing

- Latest FSL has great tool for fieldmap processing
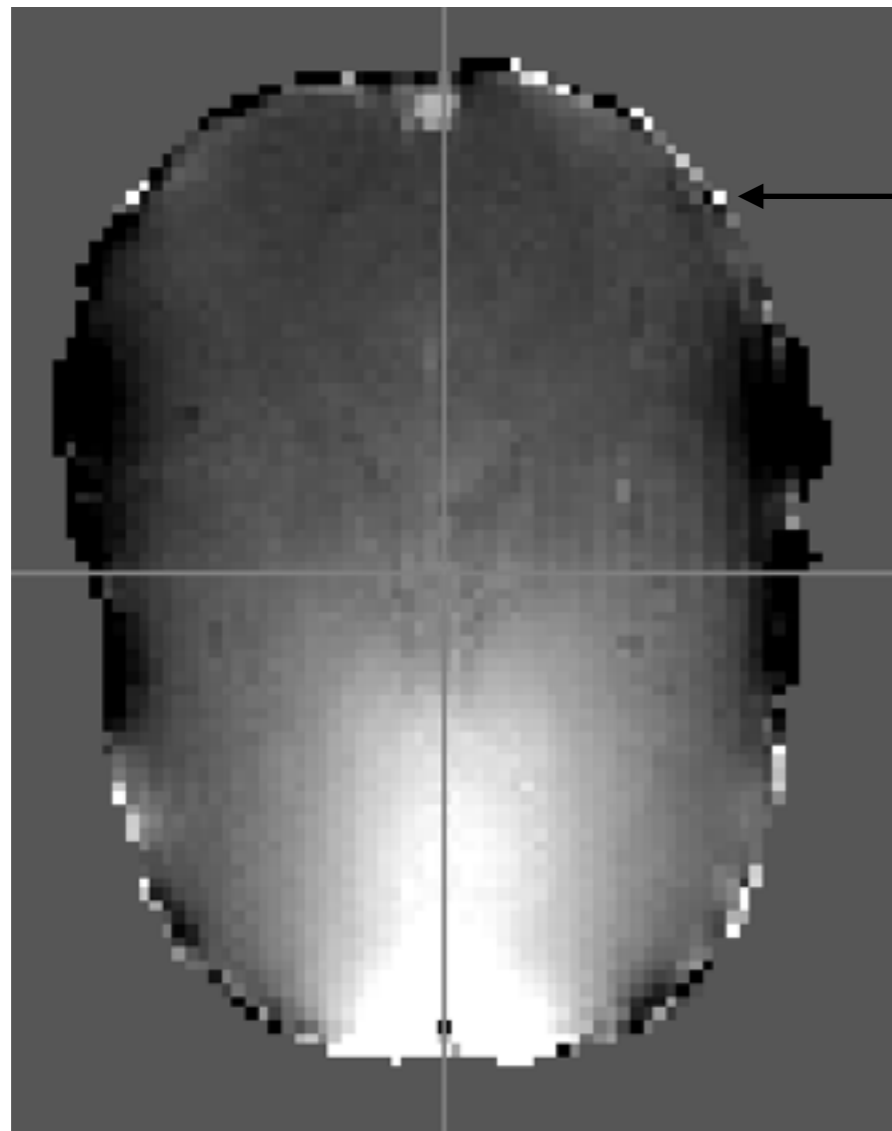
```
$ fsl_prepare_fieldmap SIEMENS phasediff.nii
        masked.nii field_map.nii 2.46
```
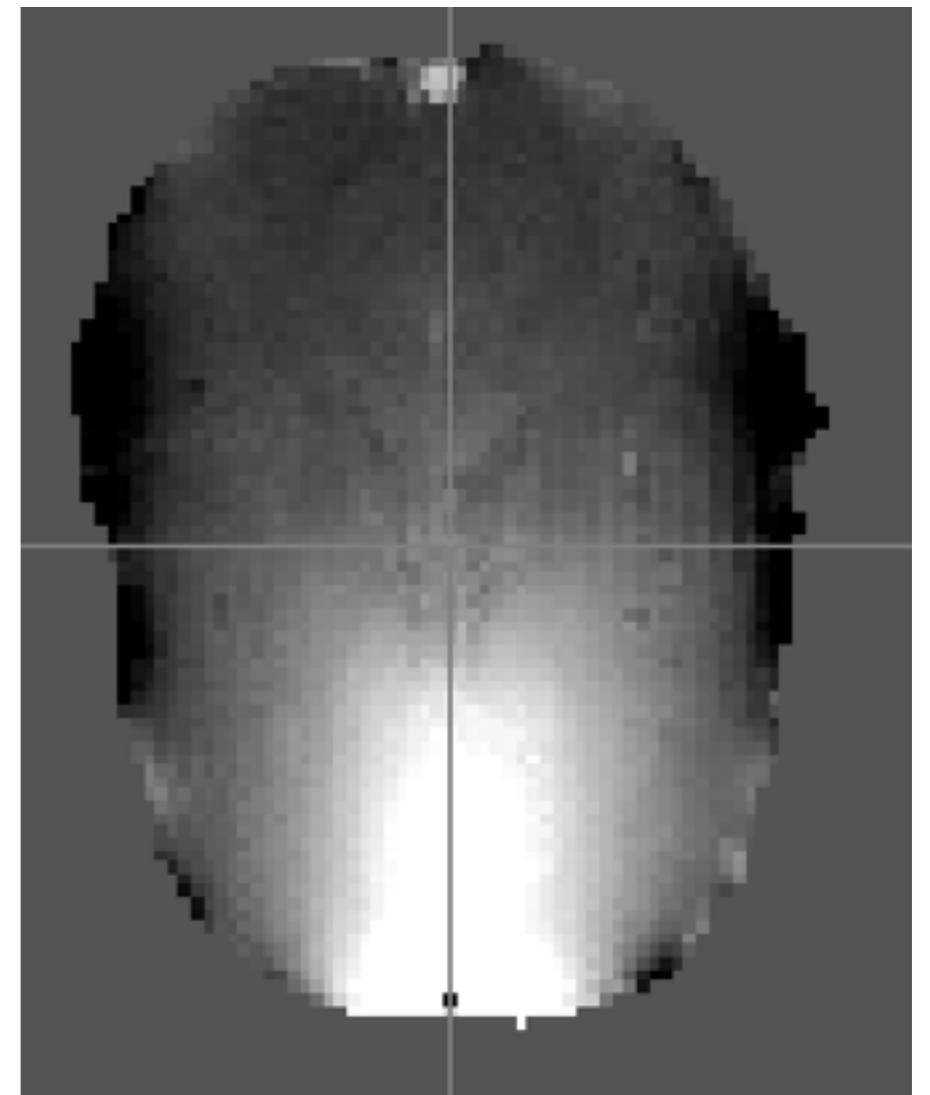
Delta TE (ms)
from fieldmap

Mask erosion is great

Using mask from BET

Using eroded mask
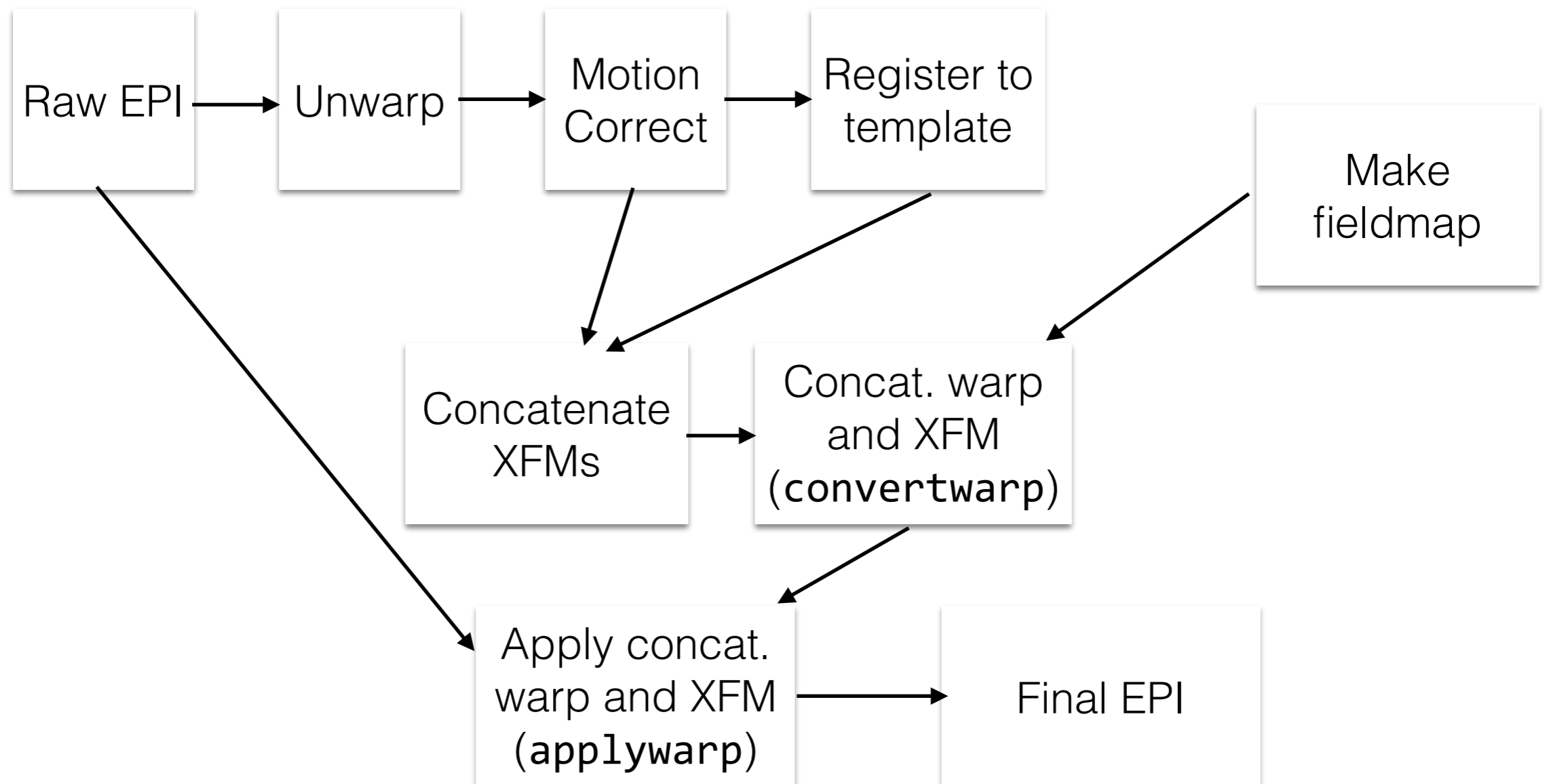

BAD

Fieldmap regularization

- FSL's FUGUE has great tools for fixing bad field maps

- Lots of available methods (see FUGUE docs)

- Despike and median filter seem to work the best (for me)

Unwarping

- Unwarp using FSL's FUGUE

```
$ fugue --loadfmap=fieldmap.nii
        -i epi.nii
        --dwell=0.00059  ←———— Echo spacing of EPI
        --unwarpdir=y  ←———— Phase encode direction
        -u unwarped_epi.nii
```

How does this fit into my preprocessing pipeline?

Raw EPI → Unwarp → Motion Correct → Register to template

Make fieldmap

Concatenate XFMs → Concat. warp and XFM (`convertwarp`)

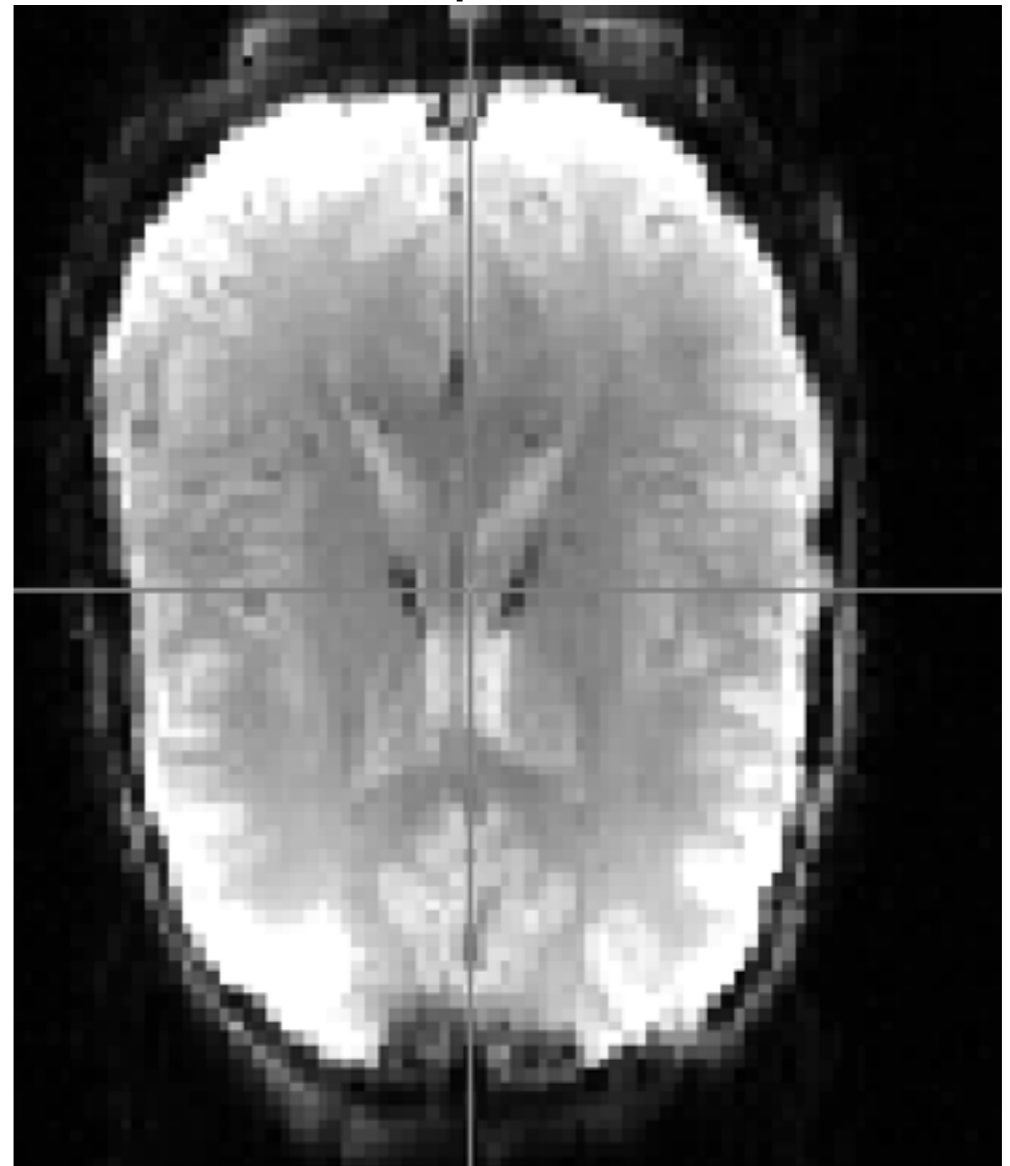Apply concat. warp and XFM (`applywarp`) → Final EPI
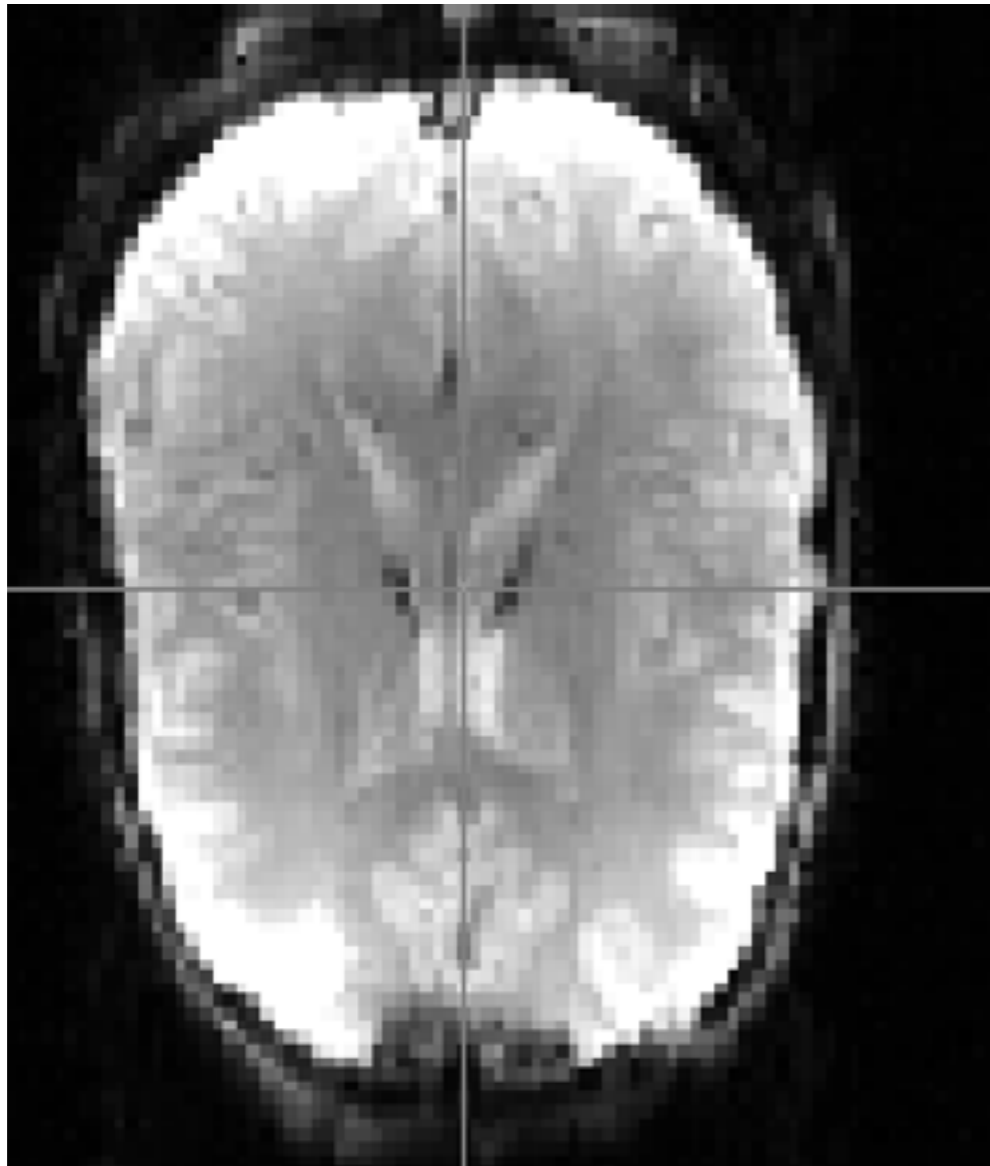
Effect? It looks a little better.

Original EPI

Unwarped EPI

Masking is important!

Nicely masked

Poorly masked