Using STEREO/EUVI to Study Active Region Magnetic Fields

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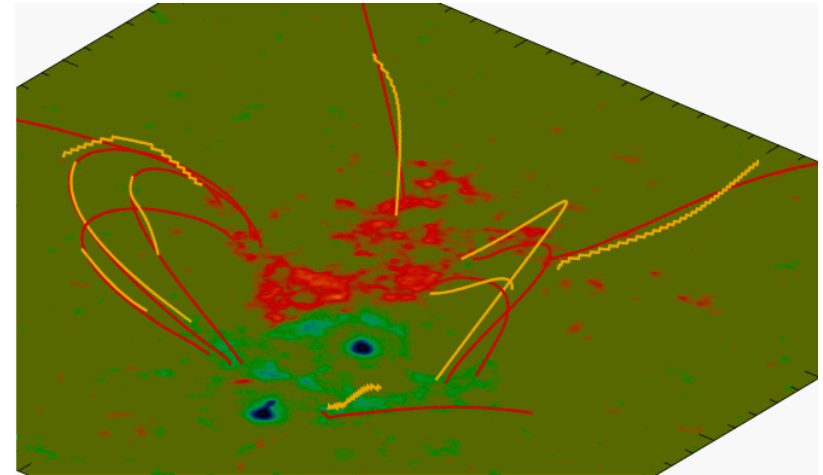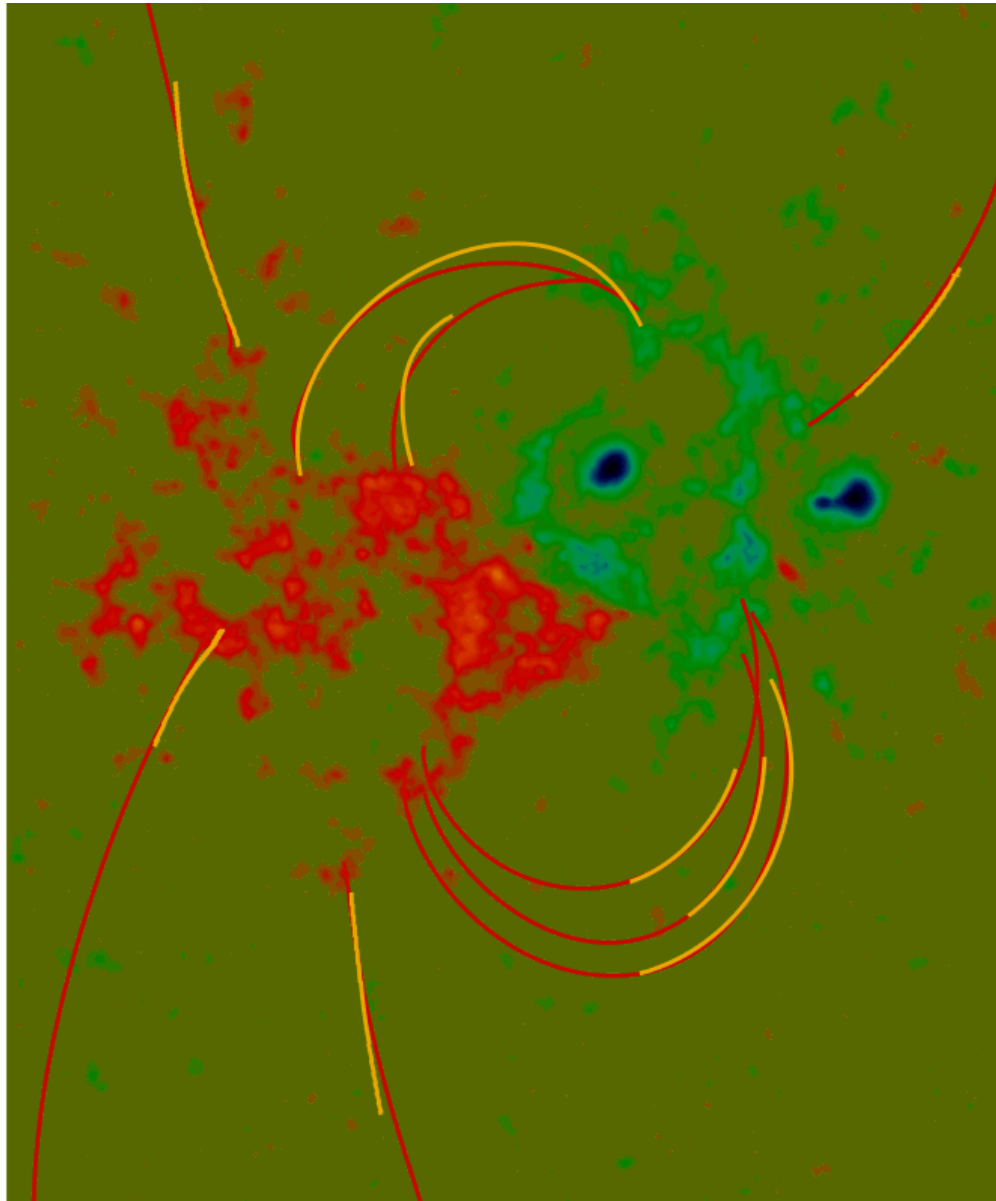
Markus Aschwanden, Jean-Pierre Wuelser,

Marc DeRosa (LMSAL), David Alexander (Rice)
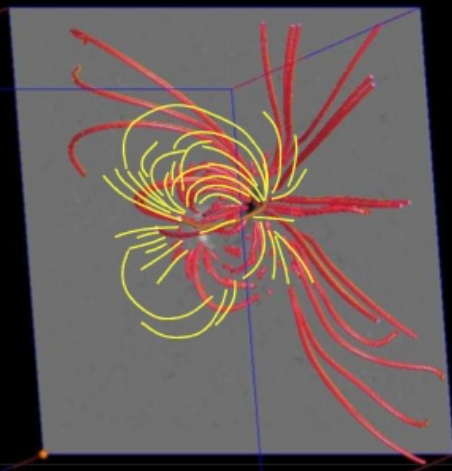
STEREO SWG #19

Pasadena, CA, 4 February 2009

Overview

- **Objective**
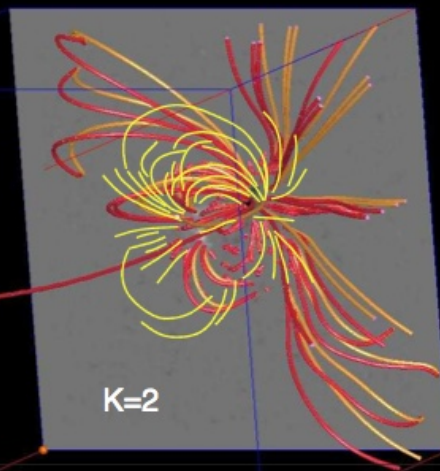- **Data set**
- **Procedure**
- **Findings and future work**

Red: linear force-free field lines (MDI).
Yellow: STEREO loops.

Feng et al. (2007, ApJ 671, L205)

Comparison of PTA Models & Observation

Radial Stretching

K=2

K=3
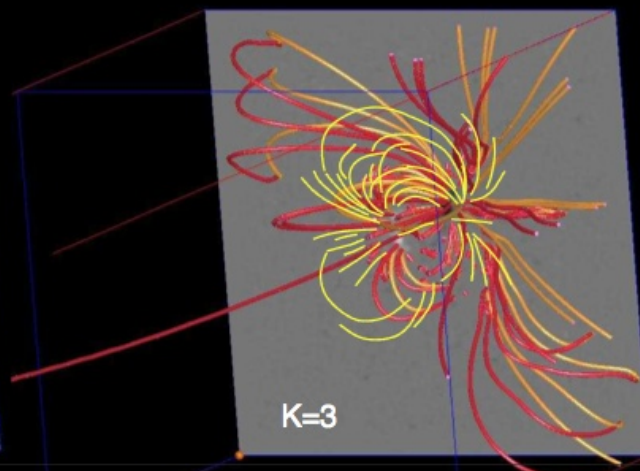
Photosphere
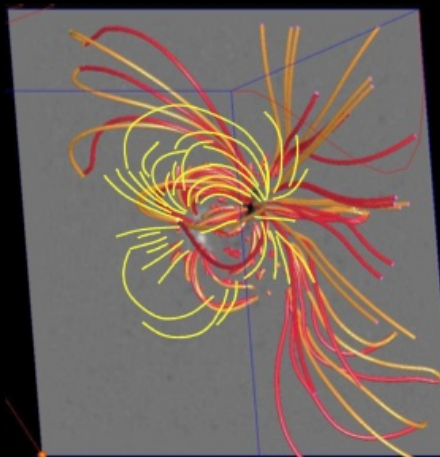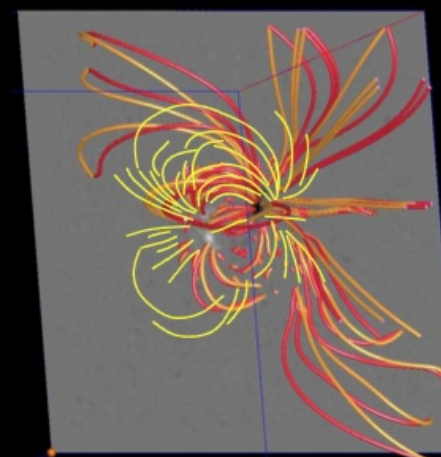
Photosphere

Photosphere

Center Twist (60°)

Longitudinal Sheared

Development items to be included
1) Identify EIS/XRT loops
2) Employ vector magnetograms and NLFFF models
3) Complete L_F minimization process
4) Use STEREO results in a 3D implementation

Gary (2007)

Data Set

- Three active regions:

  - AR 10953: 23:00 UT April 30 2007.

  - AR 10955: 20:30 UT May 9 2007.

  - AR 10956: 12:40 UT May 19, 2007.

- EUVI images in 171, 195, and 284Å.

- High-pass filter and boxcar smoothing.

Procedure

1. **Trace loops in EUVI images**.

2. Compute 3D potential magnetic field.

3. Calculate discrepancy between data and model.

4. Transform model magnetic field.

5. Recalculate misalignment angles.

Loop stereoscopy
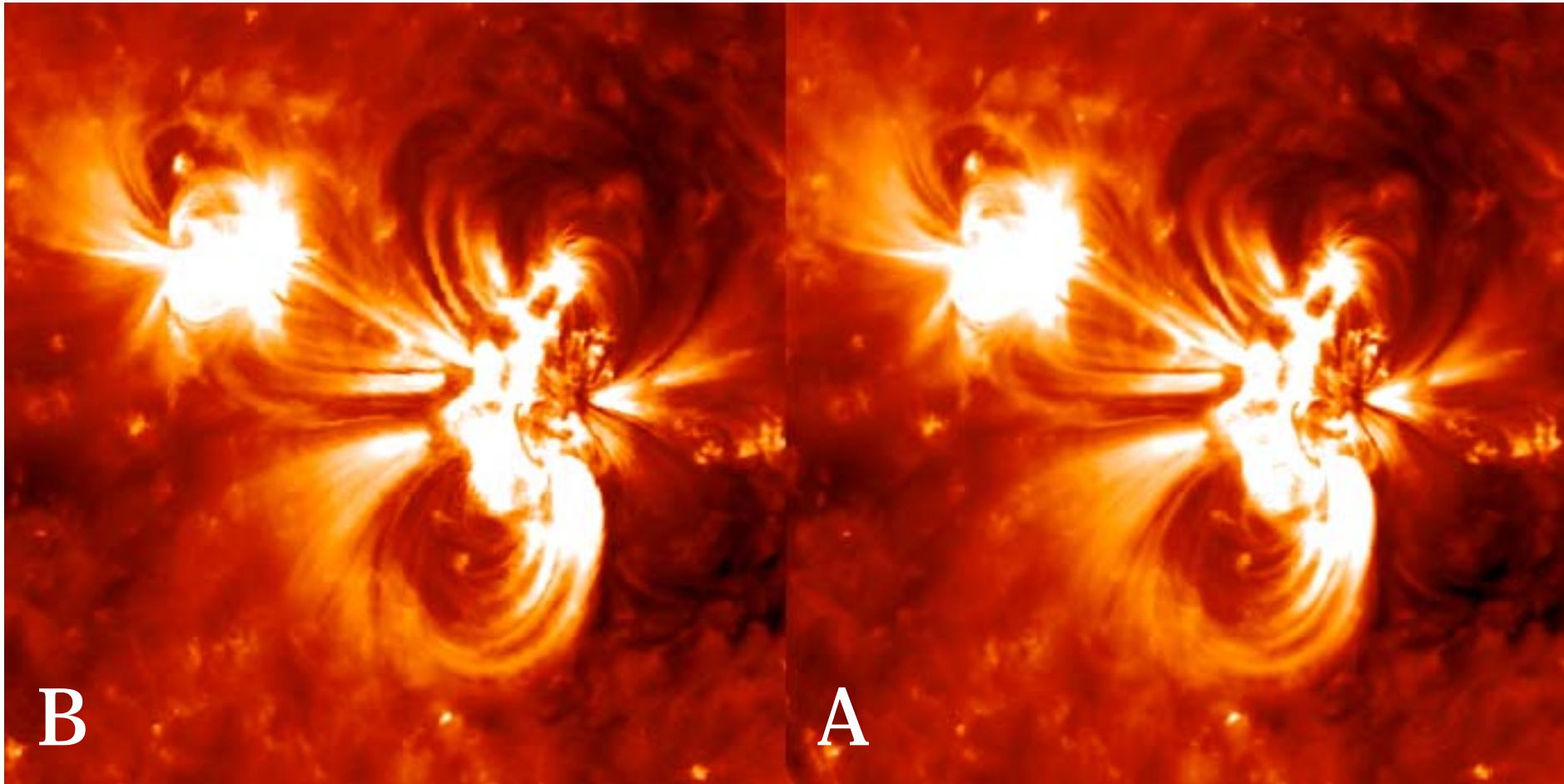
B   A

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Potential
Field
Source
Surface

$B_\theta = B_\phi = 0$

$\mathbf{B} = -\nabla \chi$

$R_\odot$

R_s

Longcope (2005)

Procedure

1. Trace loops in EUVI images.

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3. **Calculate discrepancy between data and model.**

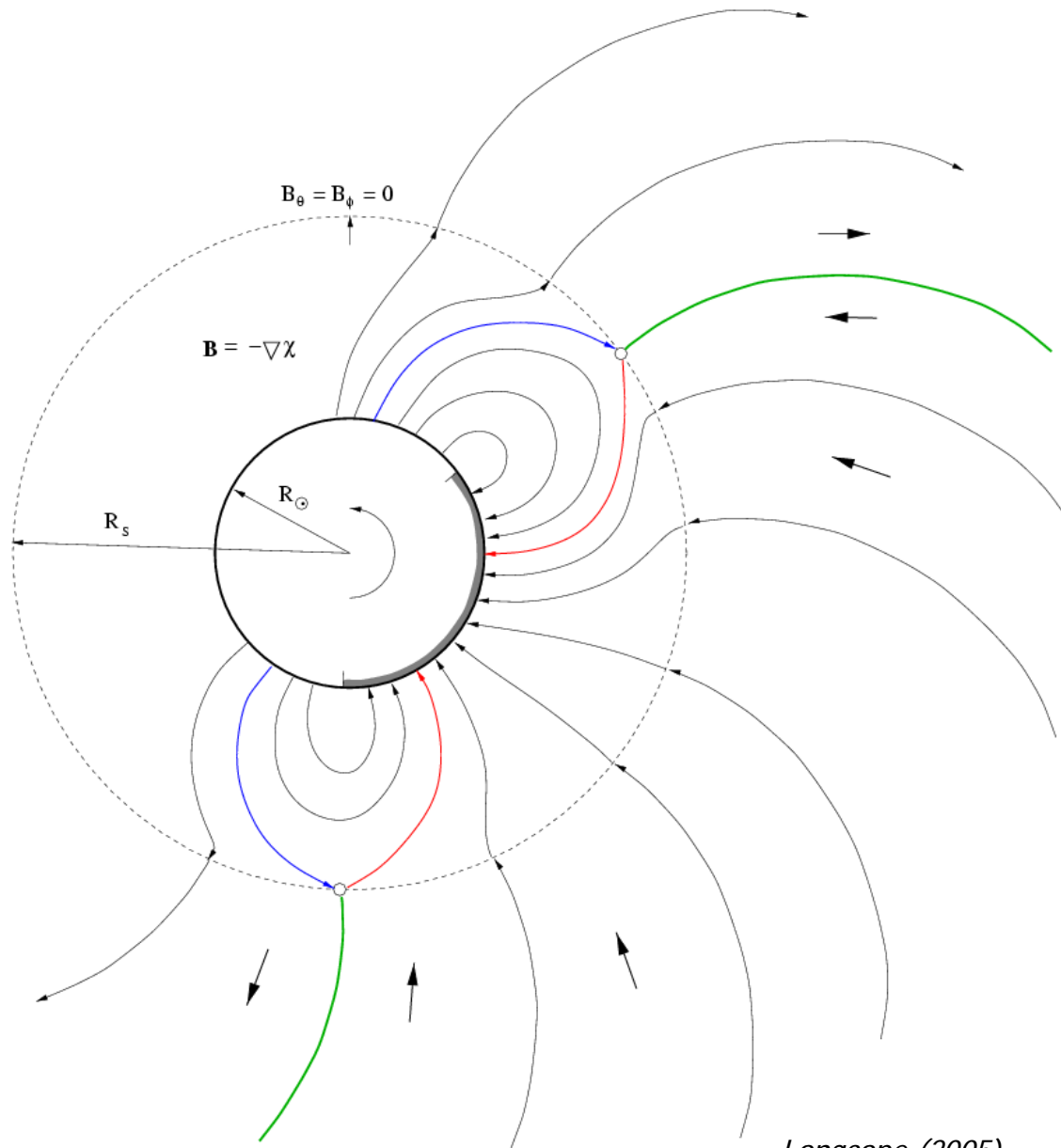4. Transform model magnetic field.
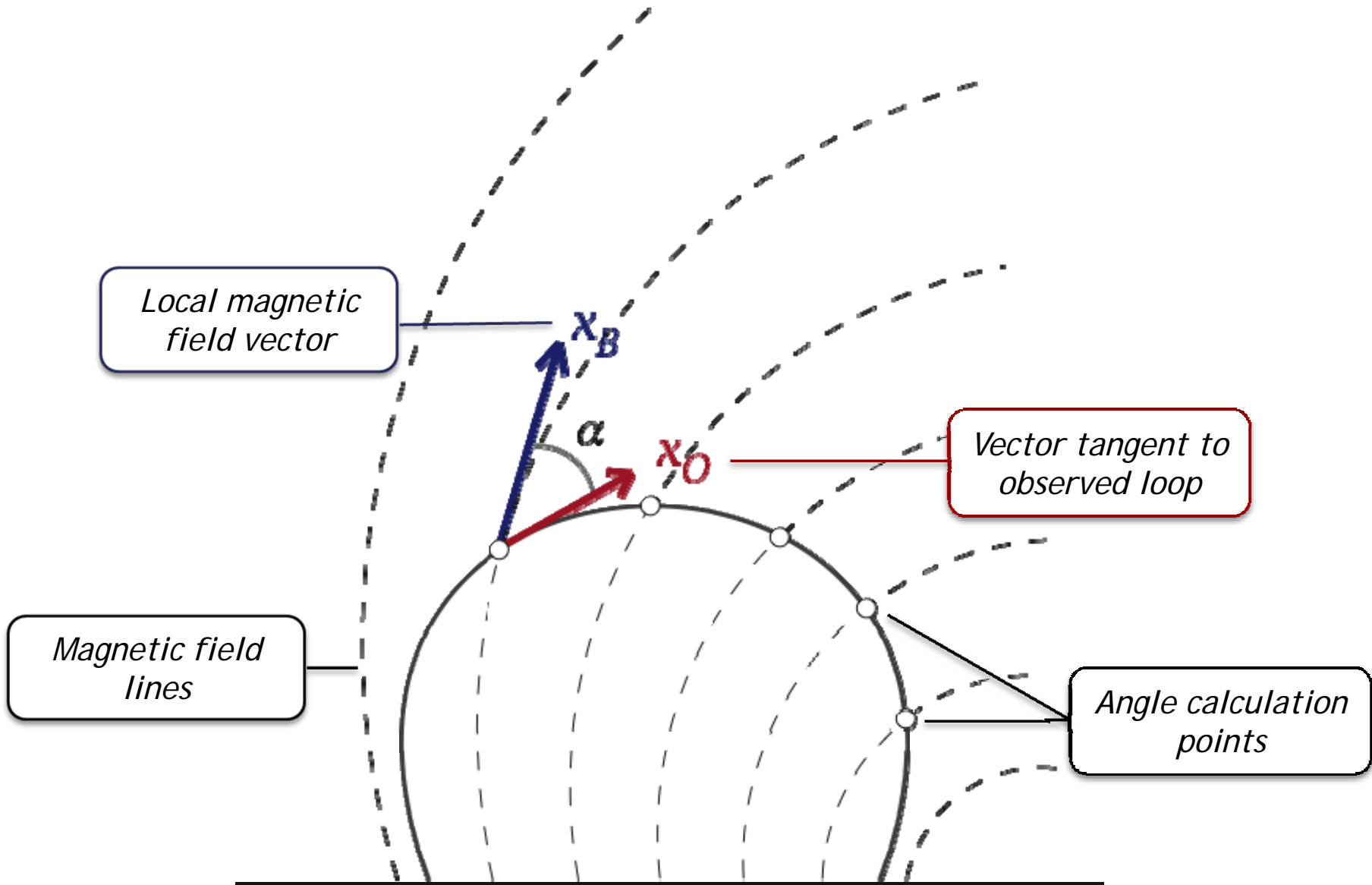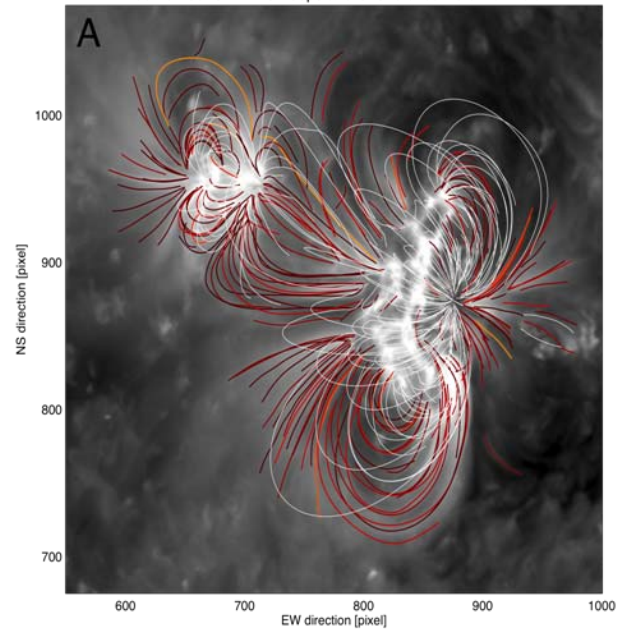
5. Recalculate misalignment angles.

Local magnetic field vector

Vector tangent to observed loop

Magnetic field lines

Angle calculation points
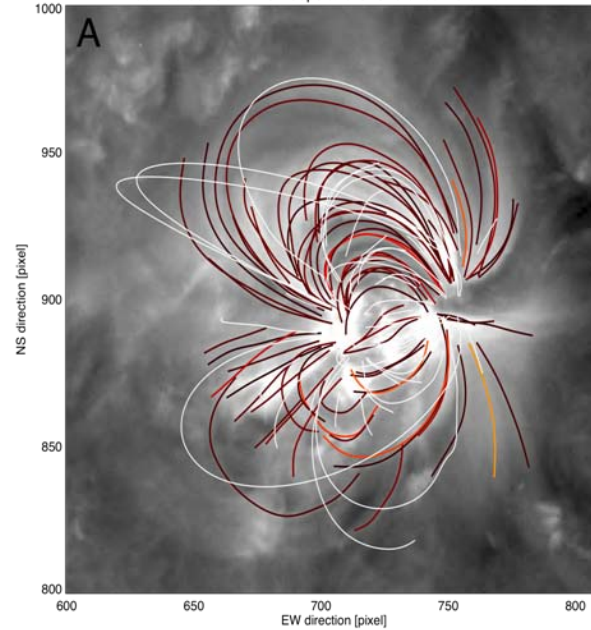
x_B

α

x_O

Visualizations

2007-04-30: STEREO Loops and Unstretched Potential Field

2007-05-09: STEREO Loops and Unstretched Potential Field

2007-05-19: STEREO Loops and Unstretched Potential Field
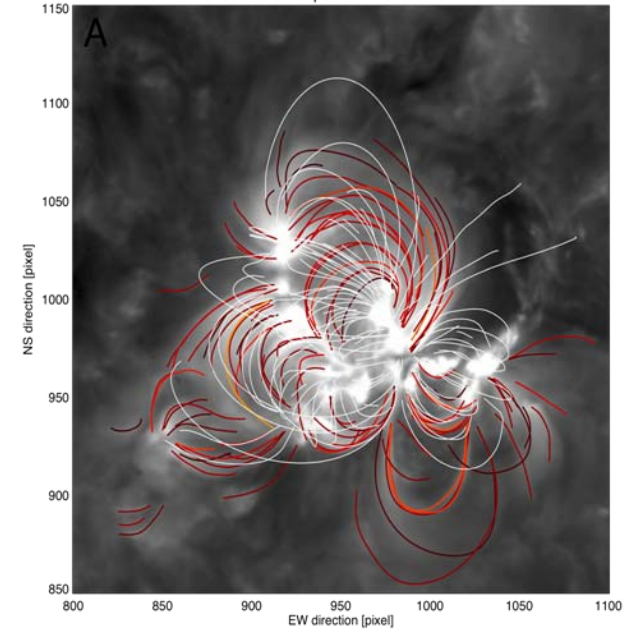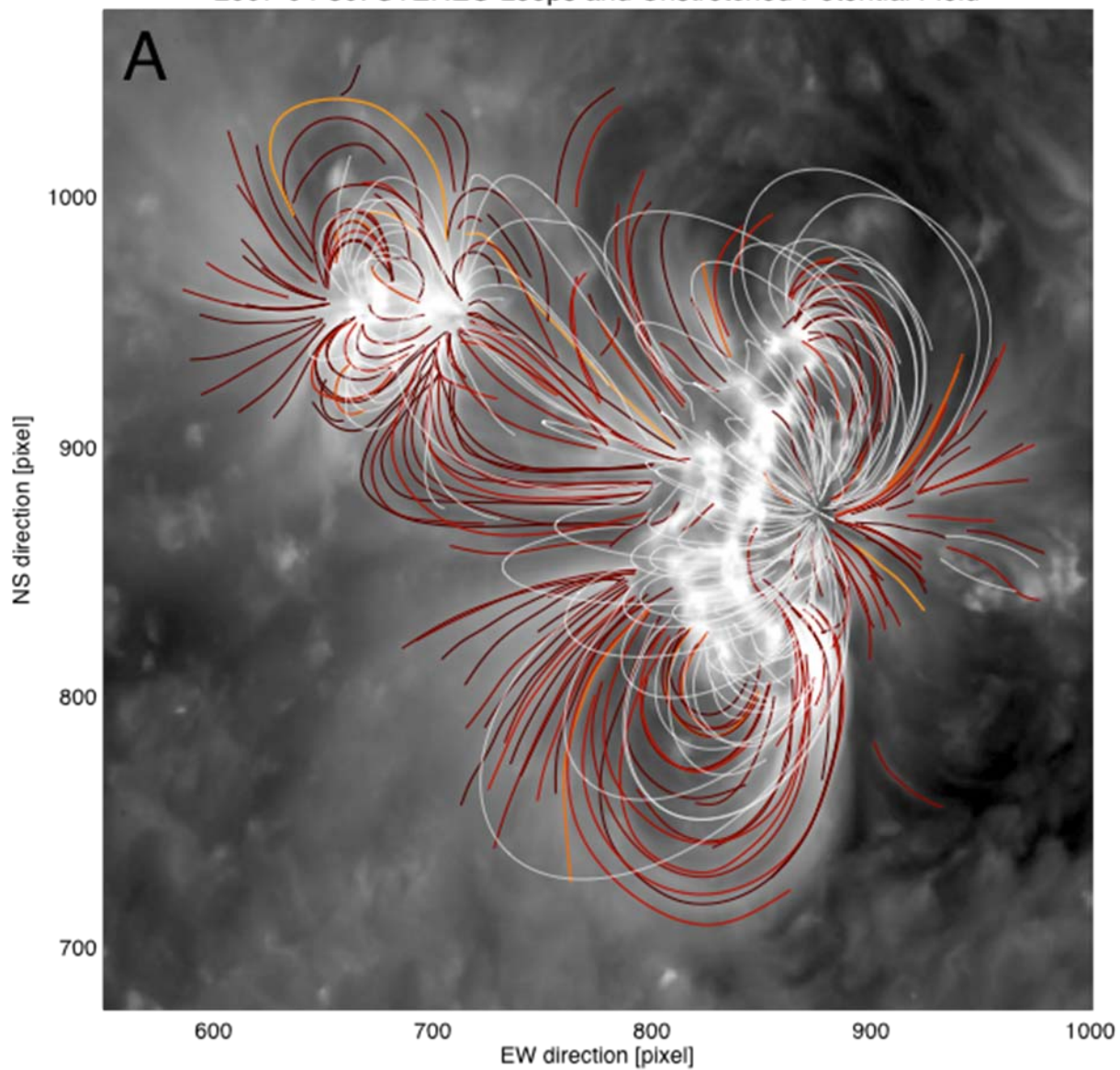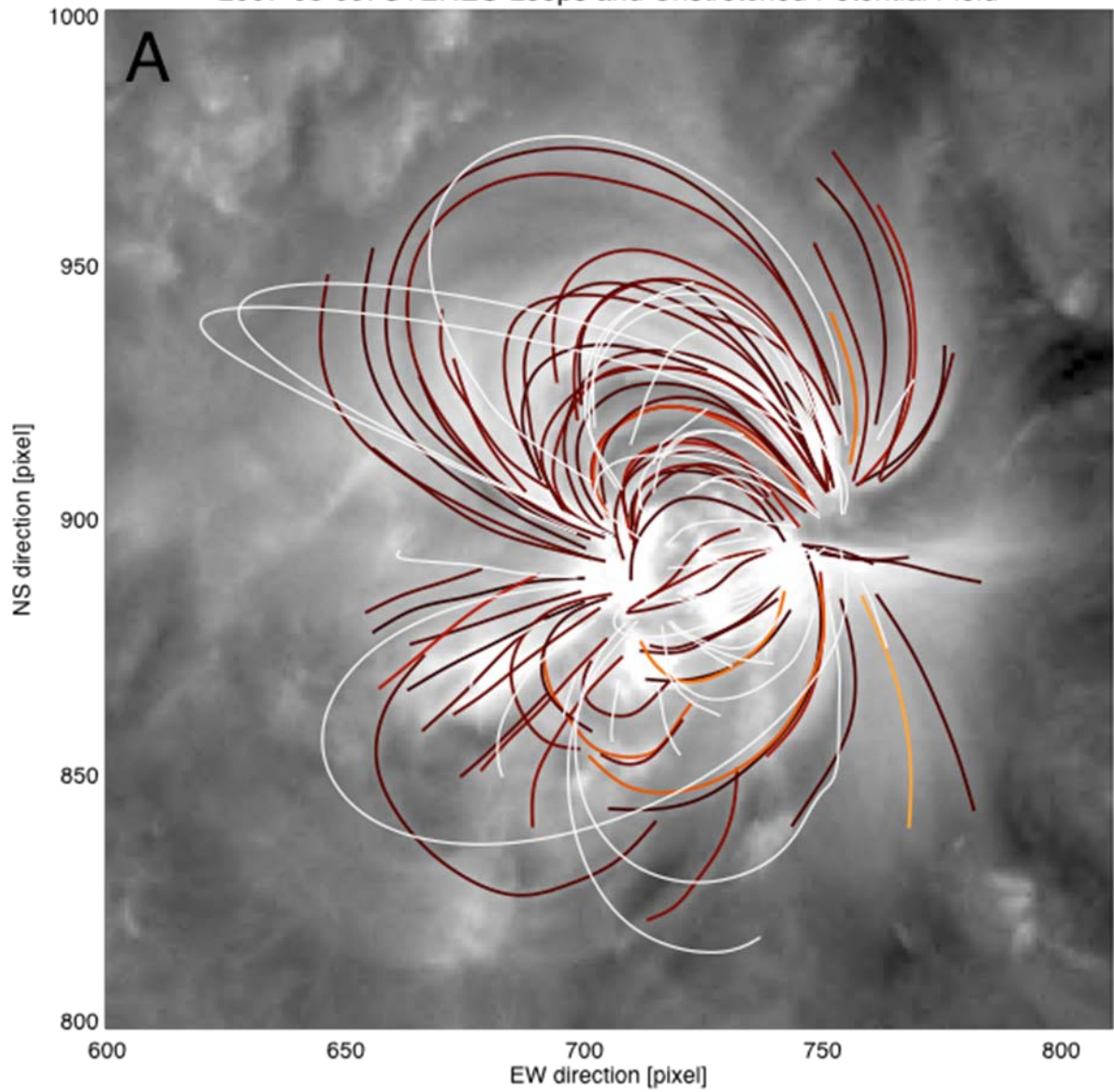
2007-04-30: STEREO Loops and Unstretched Potential Field

2007-05-09: STEREO Loops and Unstretched Potential Field

2007-05-19: STEREO Loops and Unstretched Potential Field
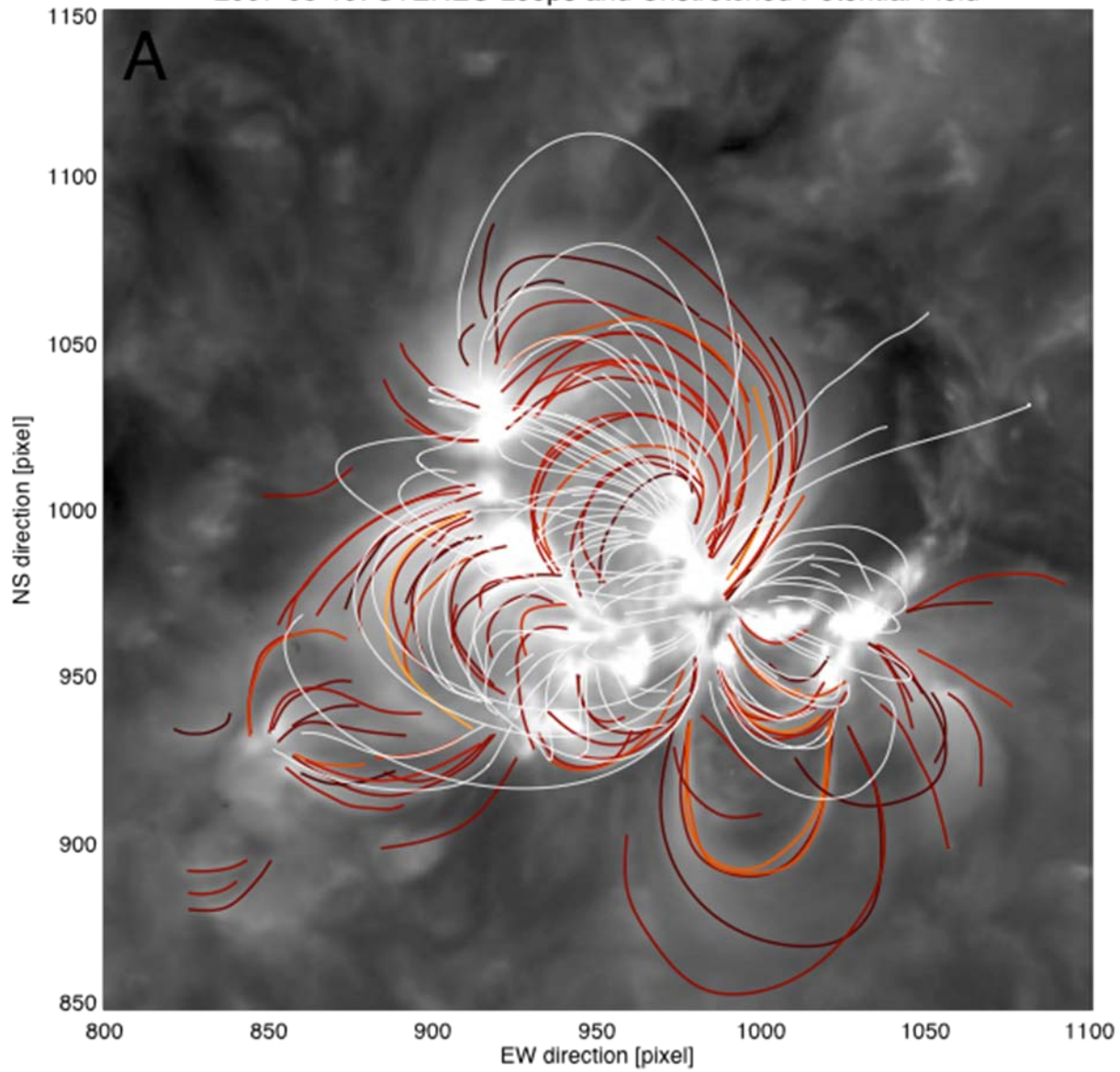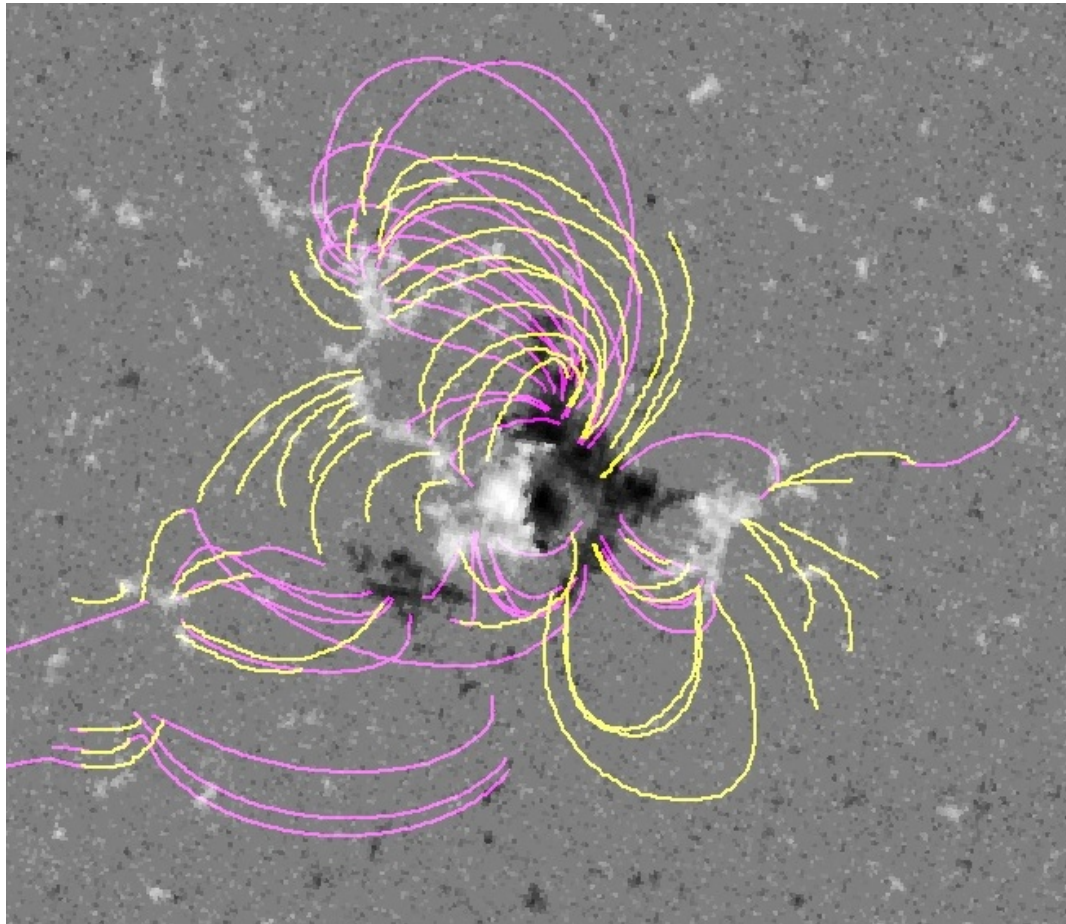
**EUVI loops (yellow) and MDI/PFSS field lines (pink)
reveal significantly different magnetic connectivities**

(courtesy of J.P.Wuelser)

AR 10953, 2007-Apr-30 23:30 UT

AR 10955, 2007-May-09 20:30 UT

AR 10956, 2007-May-19 12:40 UT
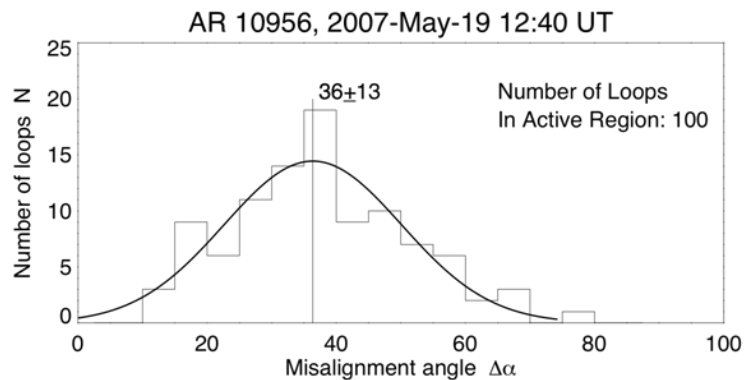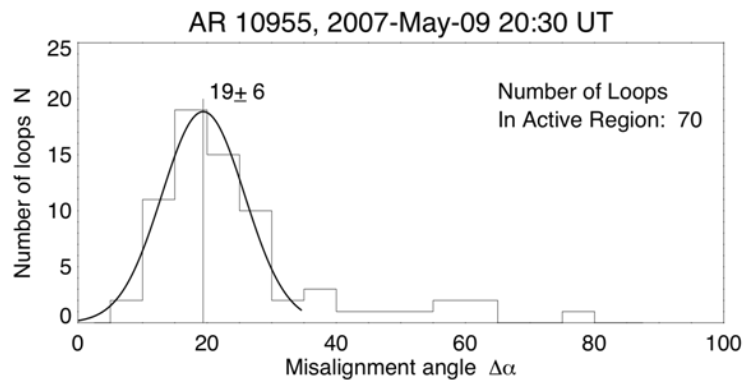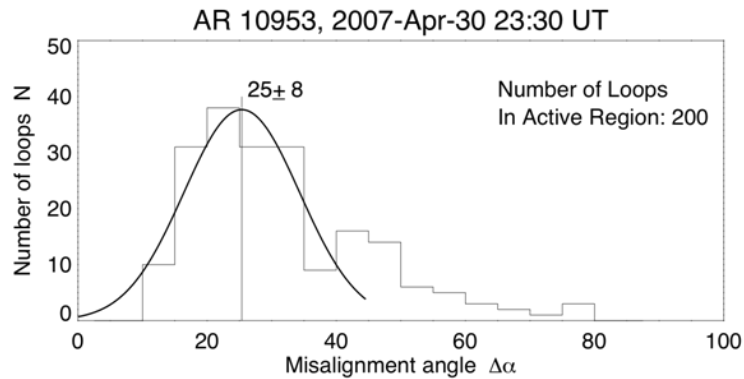
Findings:

- AR 10955 (9 May): best agreement with potential field.

- AR 10956 (19 May): worst agreement.

- NB: AR 10956 produced an eruption within 30 minutes of images.

Procedure

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4. **Transform model magnetic field.**

5. Recalculate misalignment angles.

Radial Stretching

- Gary & Alexander (1999):
- Simple radial stretching improved model's agreement with observed loop structures.
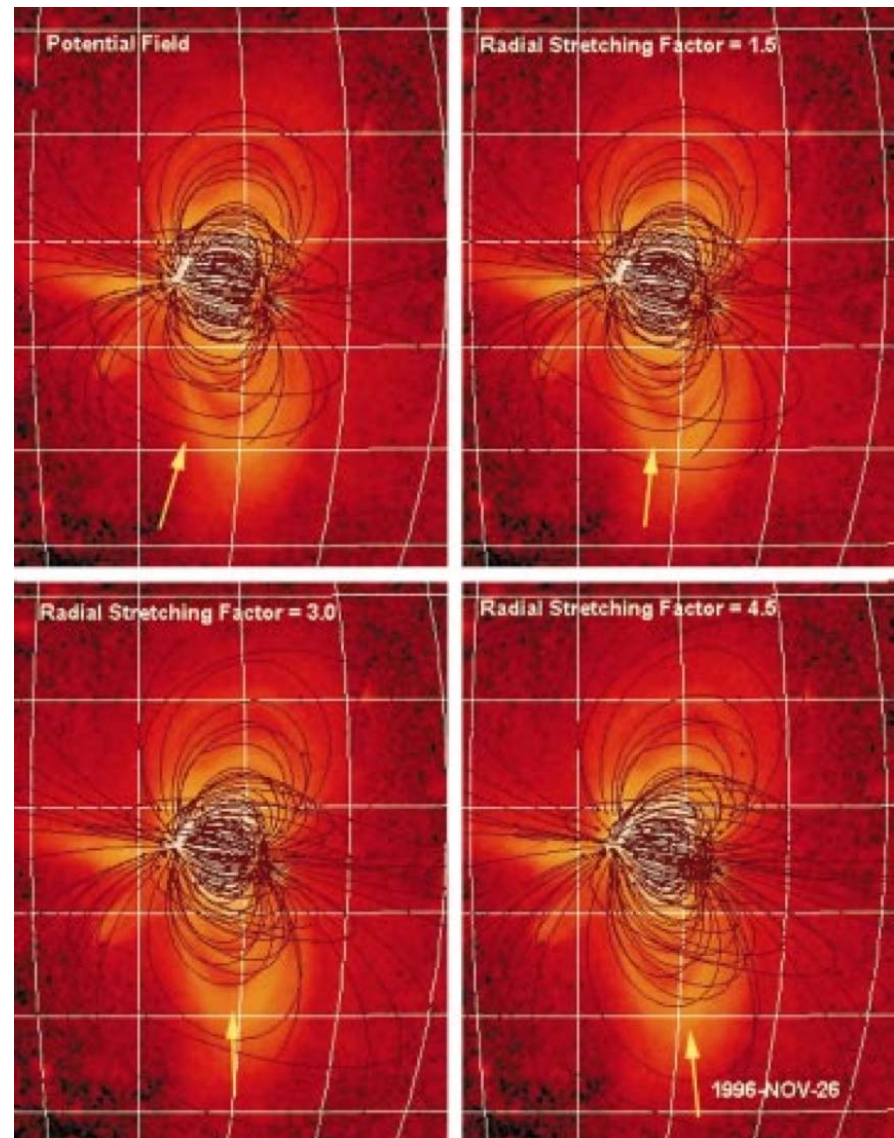
Radial Stretching

- **Preserves divergence-free condition.**
- **Injects currents.**

$$
\begin{aligned}
B_r' &= w(r, R_\odot, k) B_r \\
B_\theta' &= v(r, R_\odot, k) B_\theta \\
B_\phi' &= v(r, R_\odot, k) B_\phi
\end{aligned}
$$

$$
v(r) = \frac{h + R_\odot}{k\left[kh + R_\odot\right]} \qquad w(r) = \frac{\left[h + R_\odot\right]^2}{\left[kh + R_\odot\right]^2}
$$

Procedure

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Conclusions and Future Work

- Wide variation in loop-model agreement.
- No significant change with radial stretching.
- More versatile transformations?
- Need more appropriate magnetic field observations.
- Use EUVI data to "bootstrap" a better boundary condition.
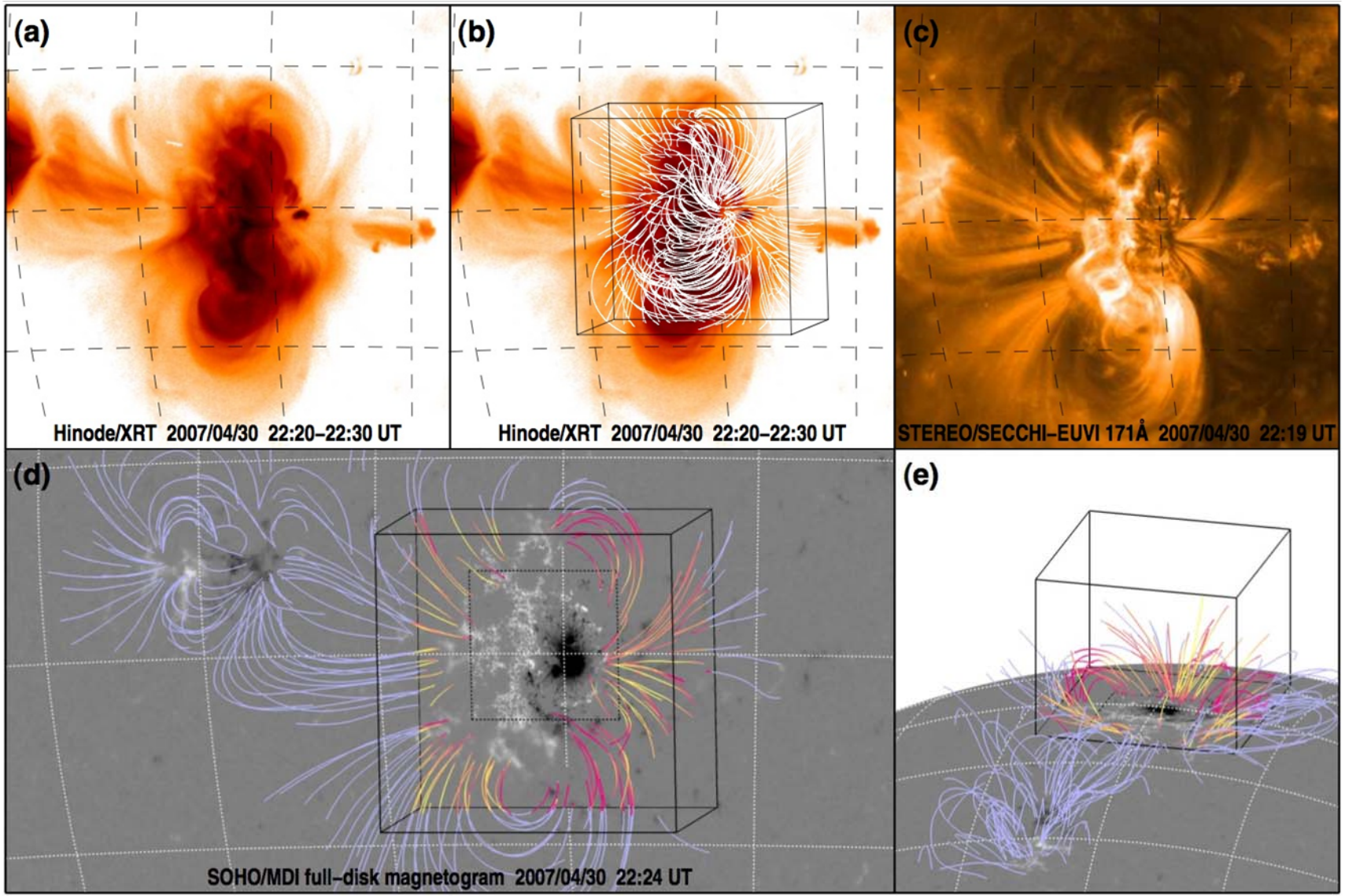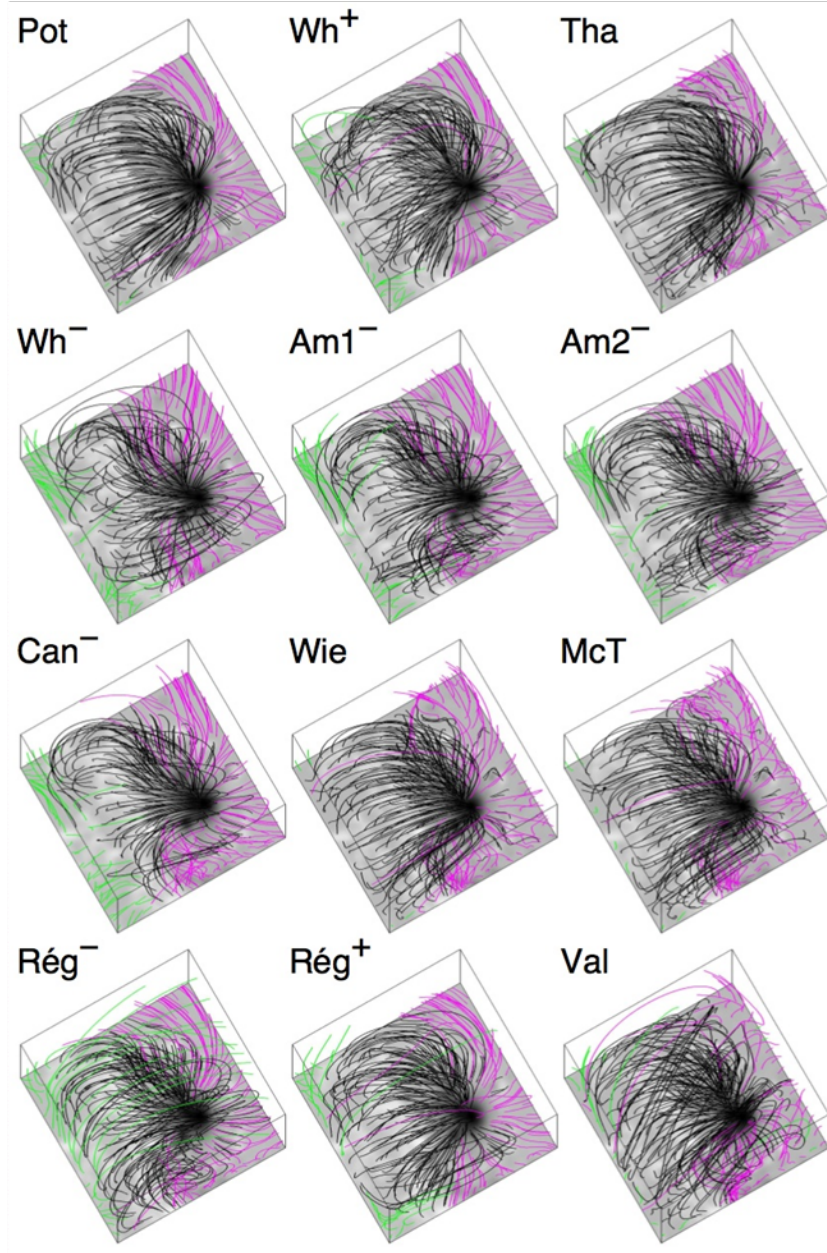
(a) Hinode/XRT 2007/04/30 22:20–22:30 UT

(b) Hinode/XRT 2007/04/30 22:20–22:30 UT

(c) STEREO/SECCHI–EUVI 171Å 2007/04/30 22:19 UT

(d) SOHO/MDI full–disk magnetogram 2007/04/30 22:24 UT

(e)

Pot Wh⁺ Tha

Wh⁻ Am1⁻ Am2⁻

Can⁻ Wie McT

Rég⁻ Rég⁺ Val

Conclusions and Future Work

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- No significant change with radial stretching.
- More versatile transformations?
- Need more appropriate magnetic field observations.
- Use EUVI data to "bootstrap" a better model.

Results of Radial Stretching

Active Region	N_{loops}	k	$\Delta\alpha$ (deg)	$B_{avg} \pm \sigma$ (G)
10953	200	0.5	26.1 ± 8.6	232.3 ± 316.5
		1.0	25.4 ± 9.0	196.0 ± 235.8
		2.0	33.5 ± 12.7	182.5 ± 217.4
10955	70	0.5	19.7 ± 5.0	211.7 ± 156.5
		1.0	19.4 ± 6.4	166.8 ± 109.6
		2.0	26.3 ± 6.6	160.6 ± 104.7
10956	100	0.5	38.8 ± 14.7	196.0 ± 171.5
		1.0	36.4 ± 13.7	158.7 ± 117.0
		2.0	38.3 ± 13.6	150.2 ± 104.4