

Observations of the Sun's corona

Katharine Reeves

Harvard-Smithsonian Center for Astrophysics
(with thanks to the Hinode/XRT team)

Outline

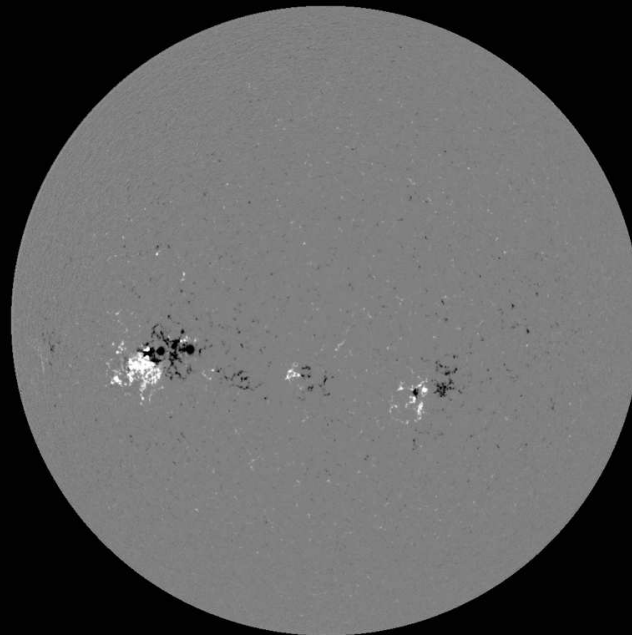
1. Introduction - The Sun's corona in X-rays
2. X-ray observations of the Sun
3. Active region morphology
4. Active region thermal structure
5. Connections between the corona and the solar wind
6. Evidence for reconnection in flares and CMEs
7. Concluding remarks

The X-ray Sun



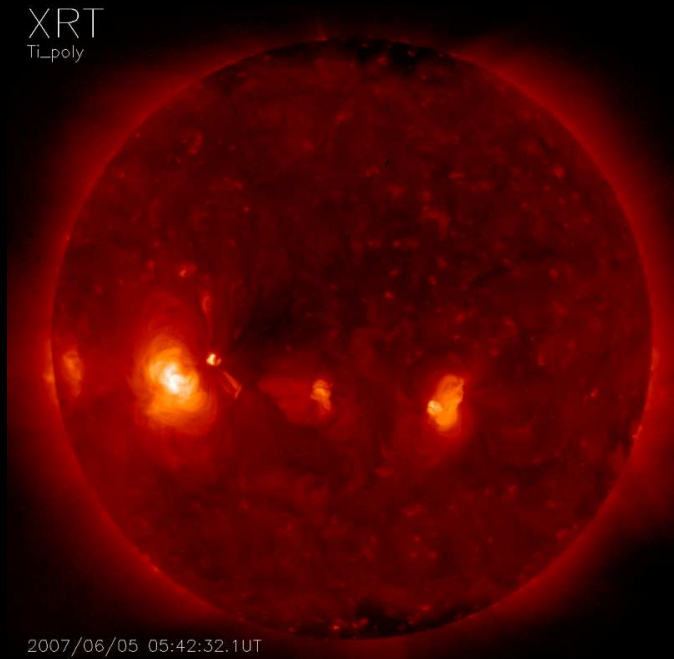
2007/06/05 03:25

visible light



2007/06/05 08:05

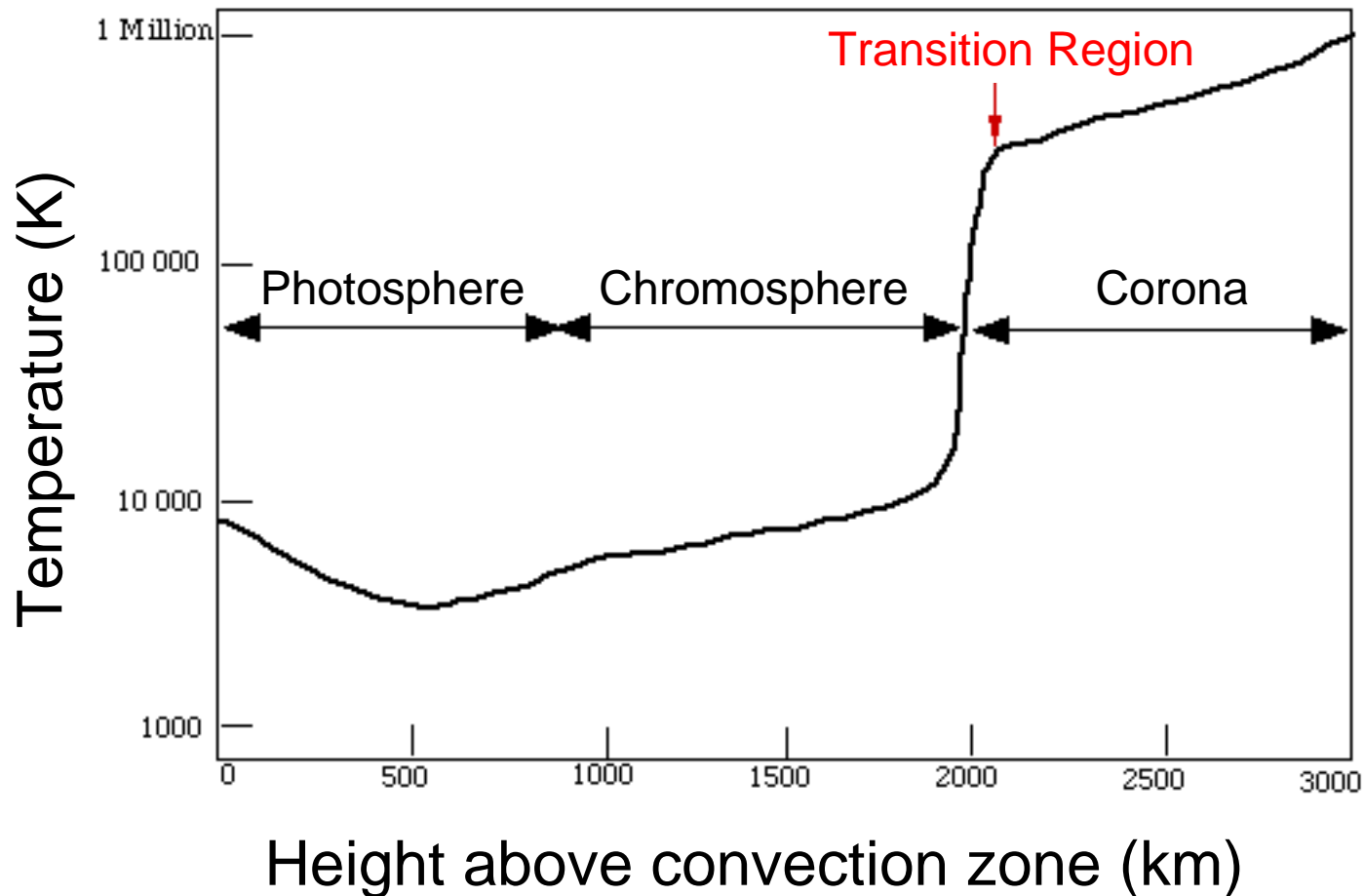
magnetic field



2007/06/05 05:42:32.1UT

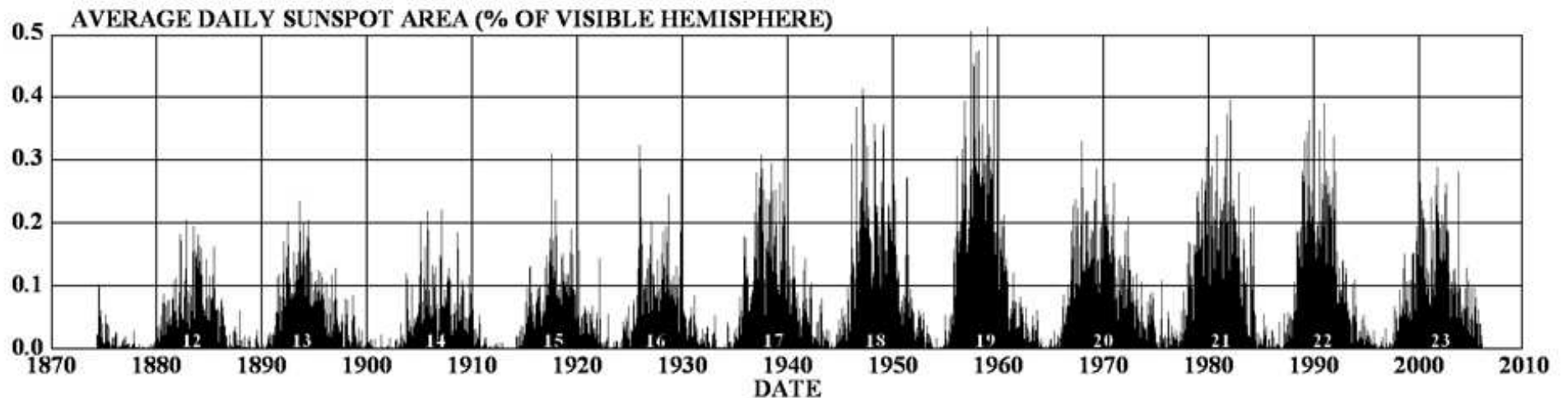
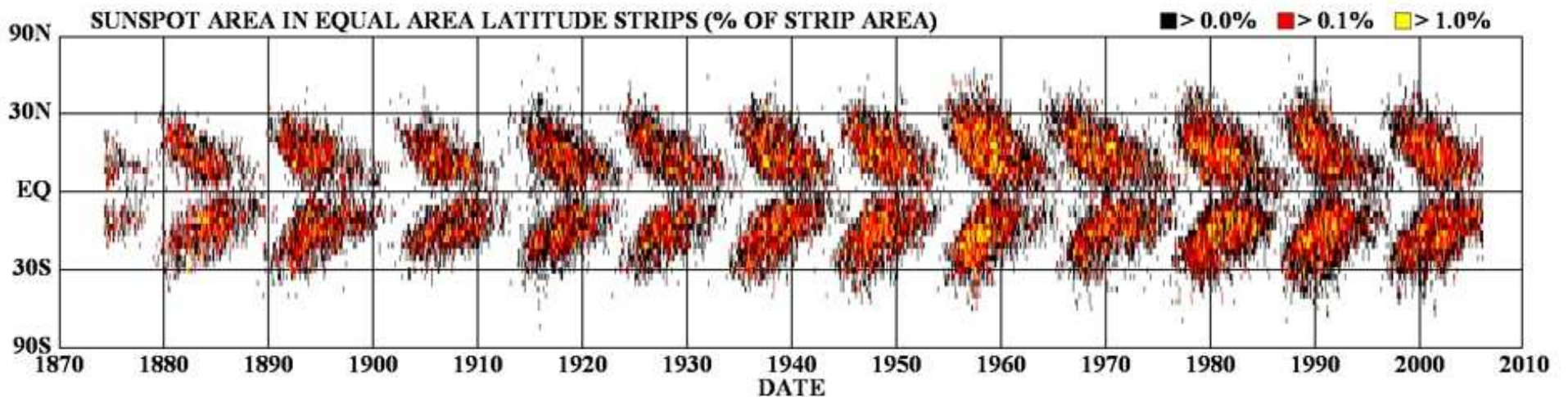
X-rays

Hot corona emits X-rays



Solar cycle

DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS



Solar cycle variations

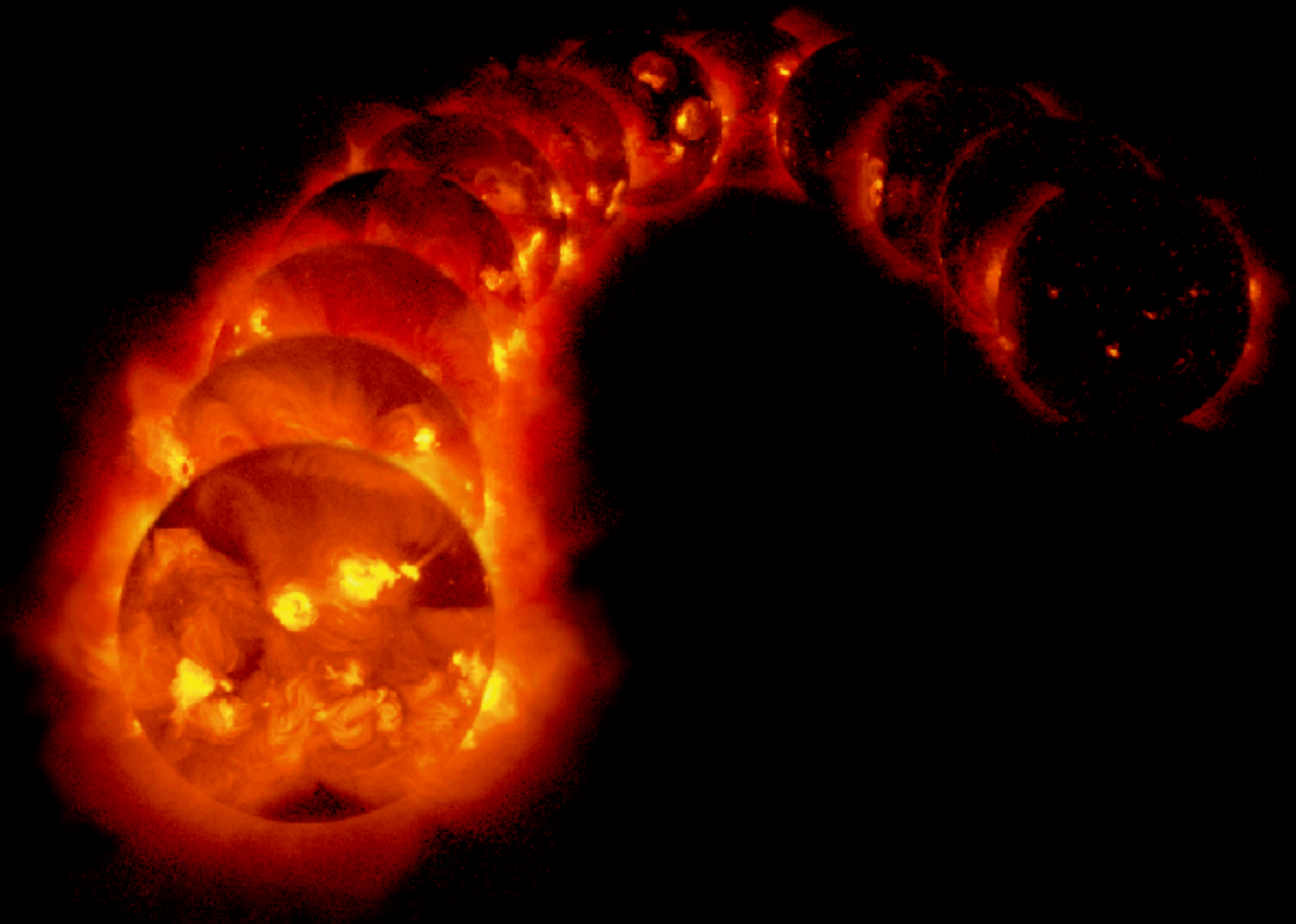
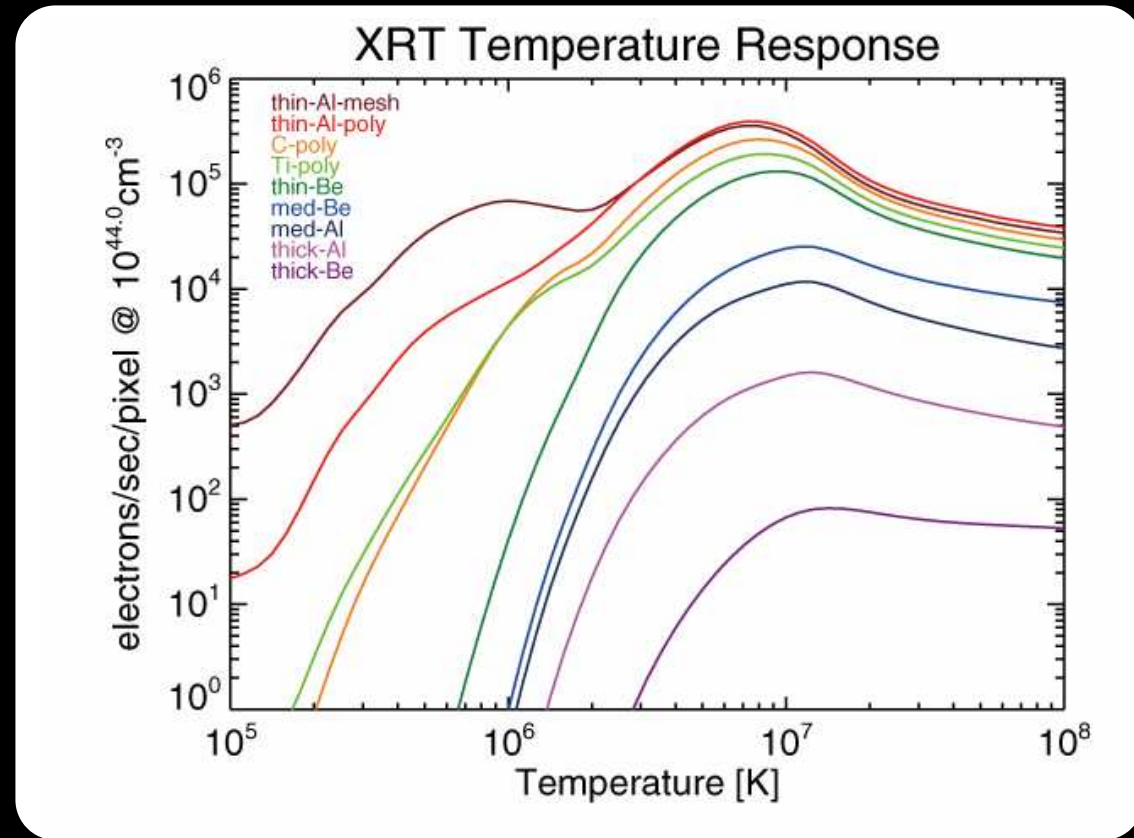
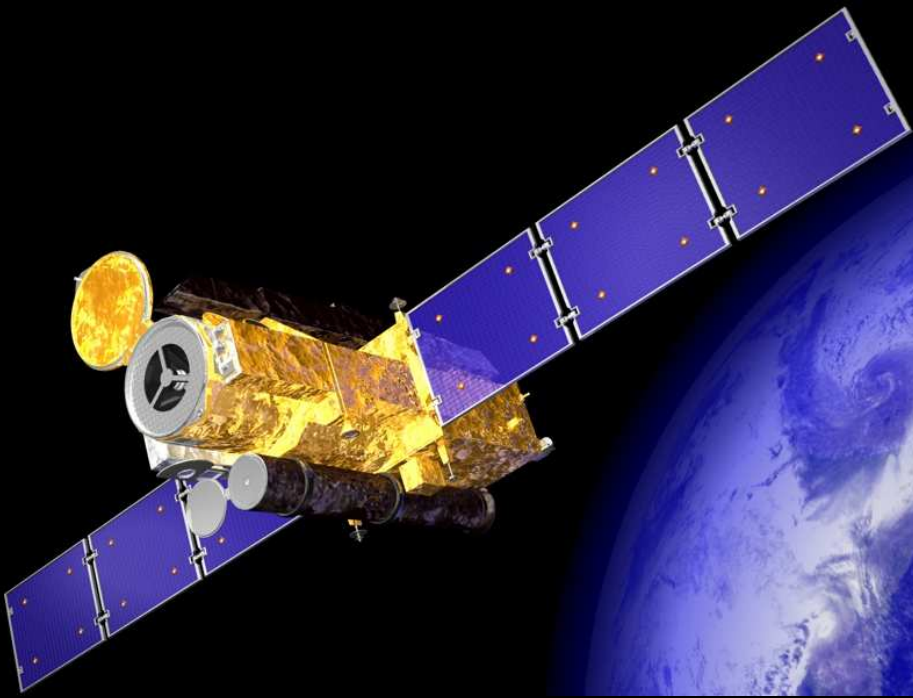
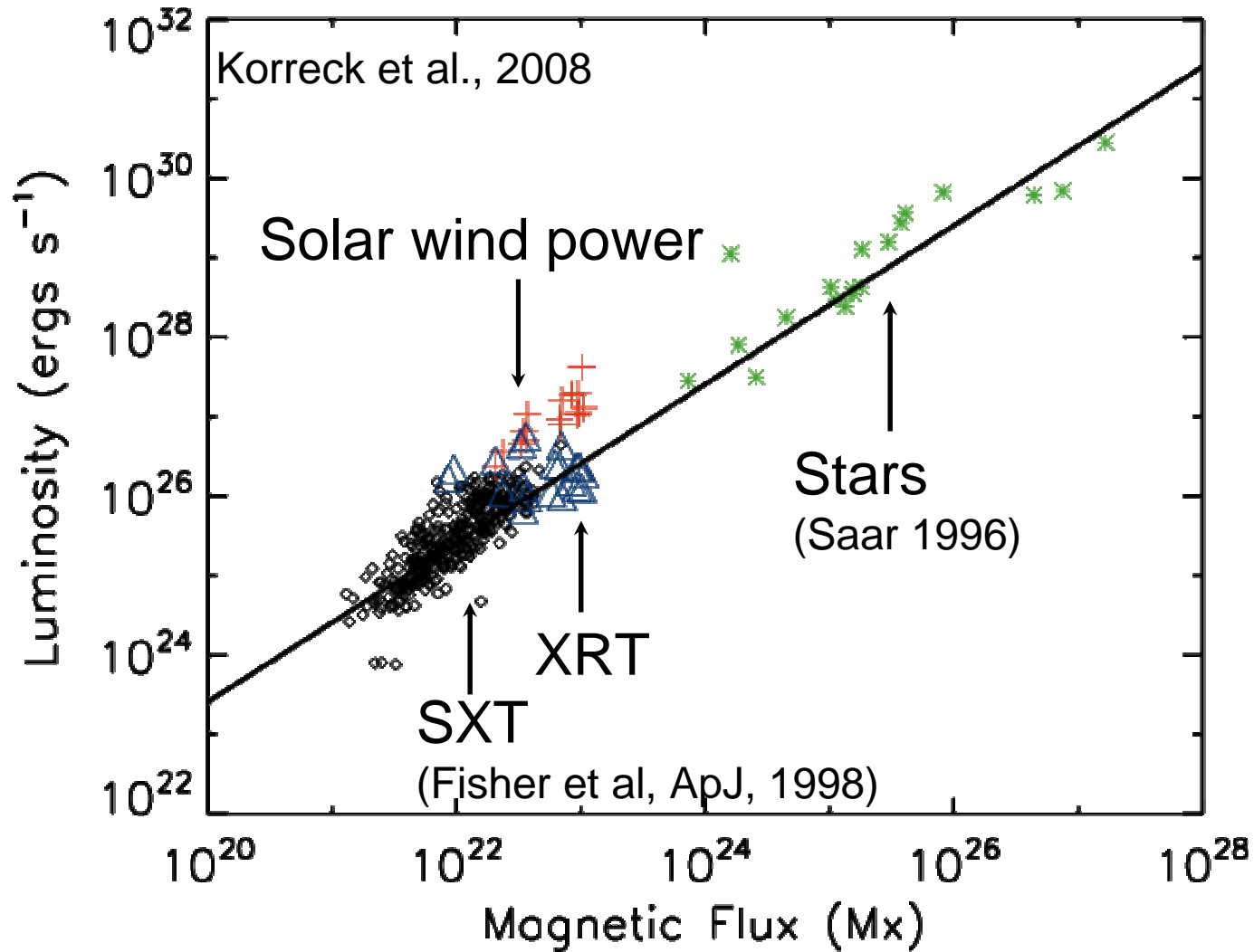


image from http://www.lmsal.com/SXT/img/The_Changing_Sun.gif

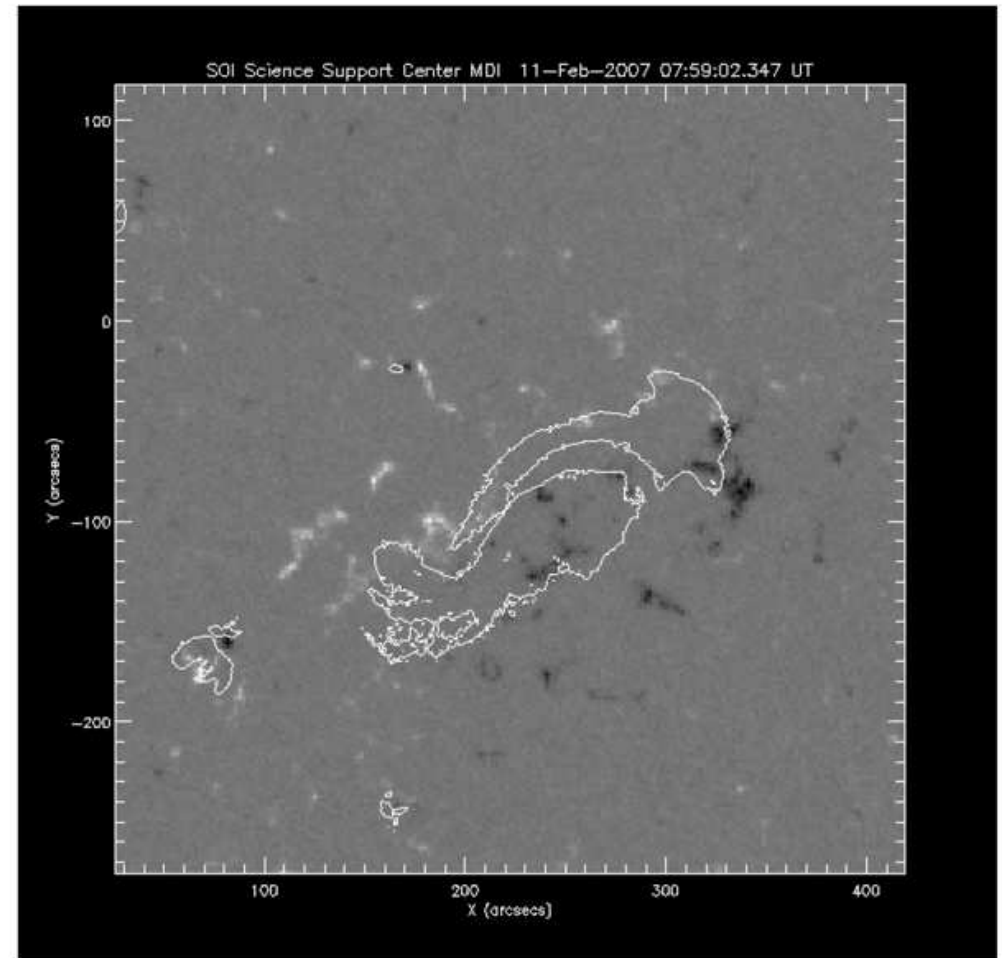
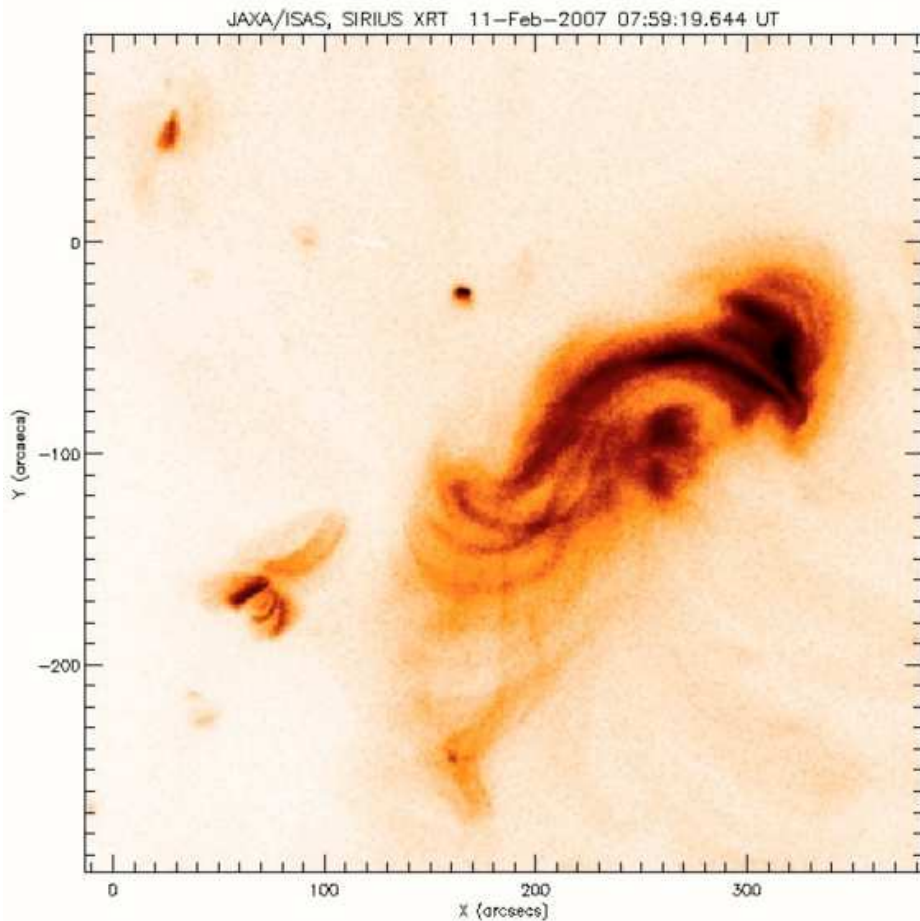
Hinode's X-Ray Telescope



Magnetic fields

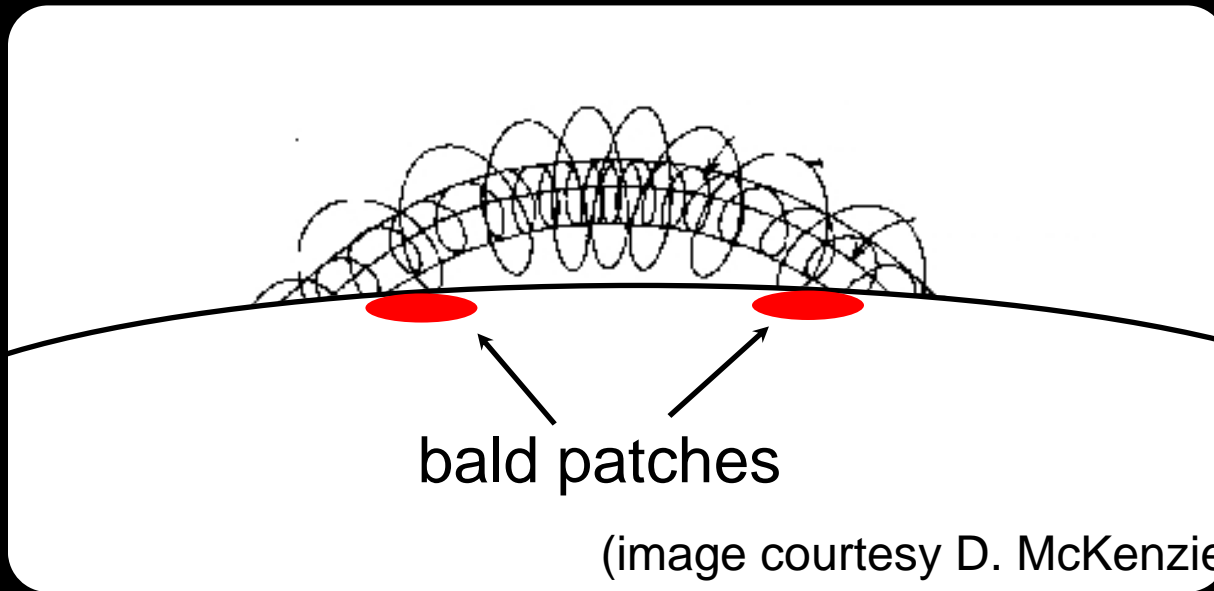


Sigmoid structure in ARs

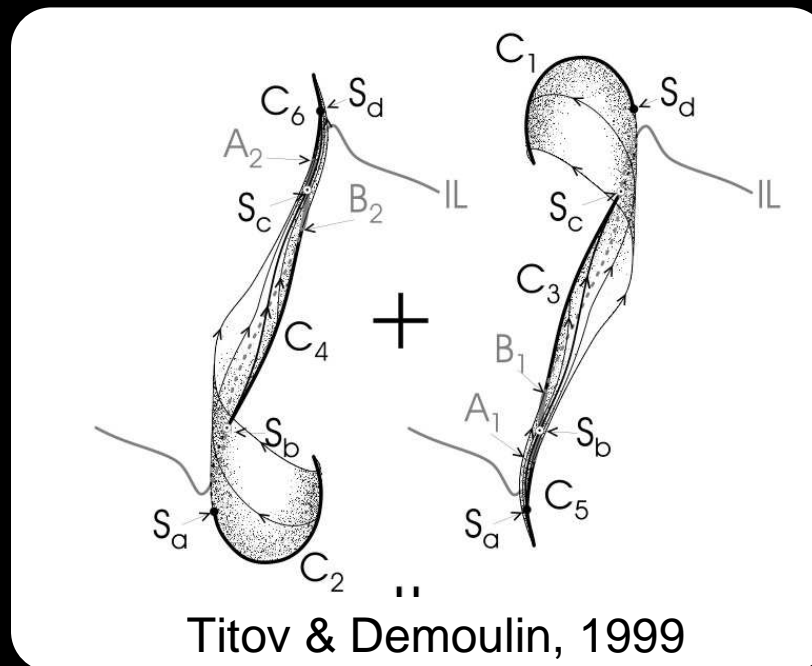


McKenzie & Canfield, A&A, 2008

Bald patch model



Side view

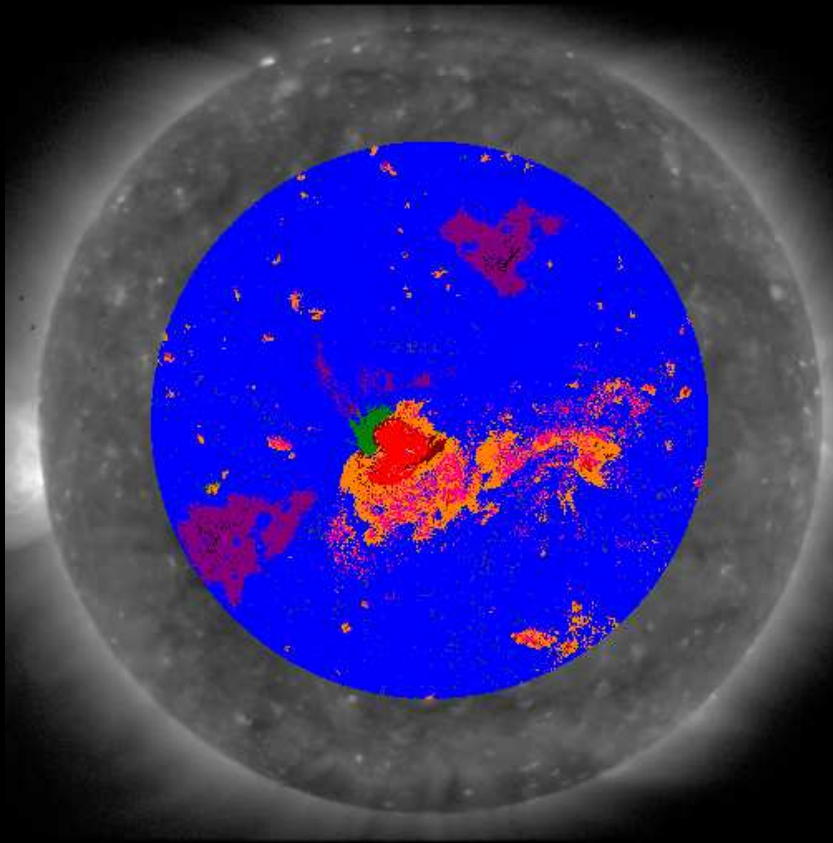


Top view

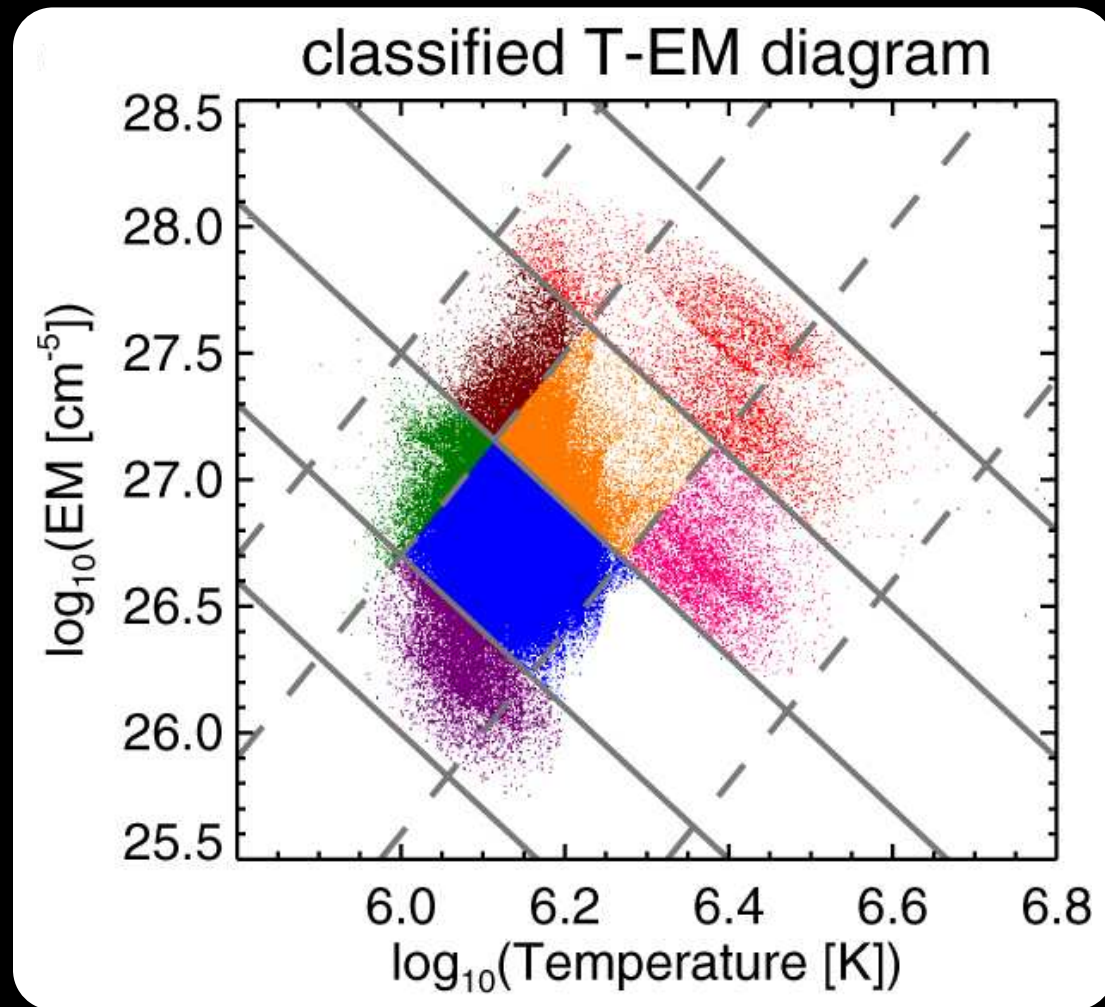
Sigmoid evolution

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

Coronal thermal structure

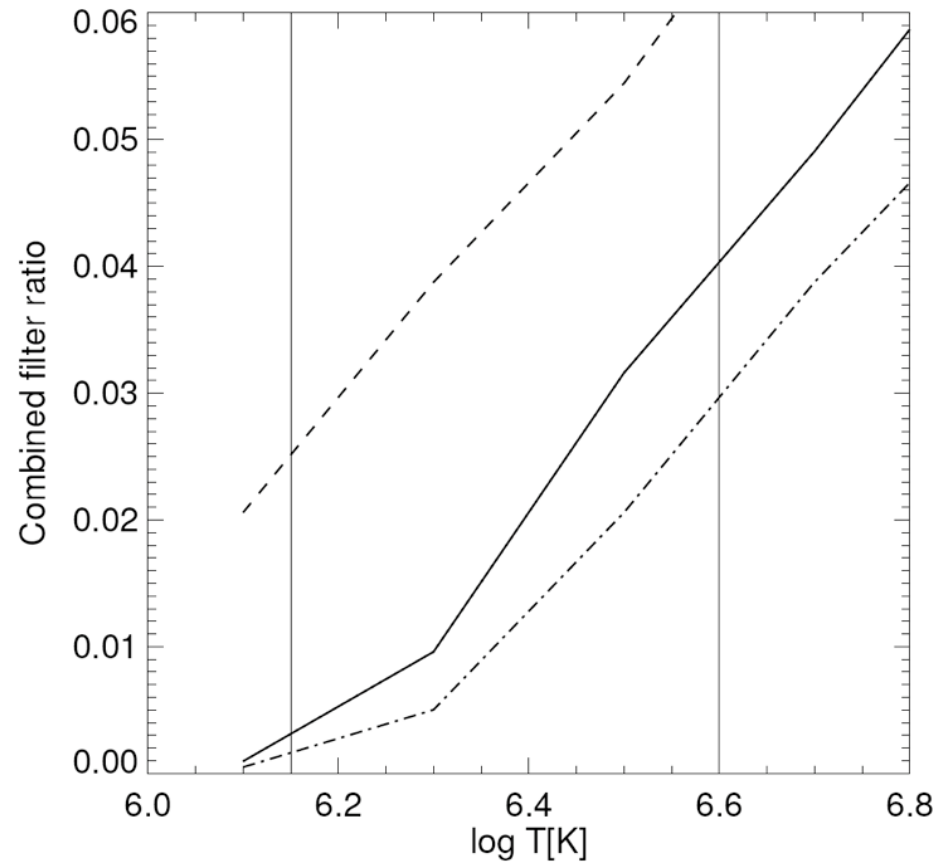
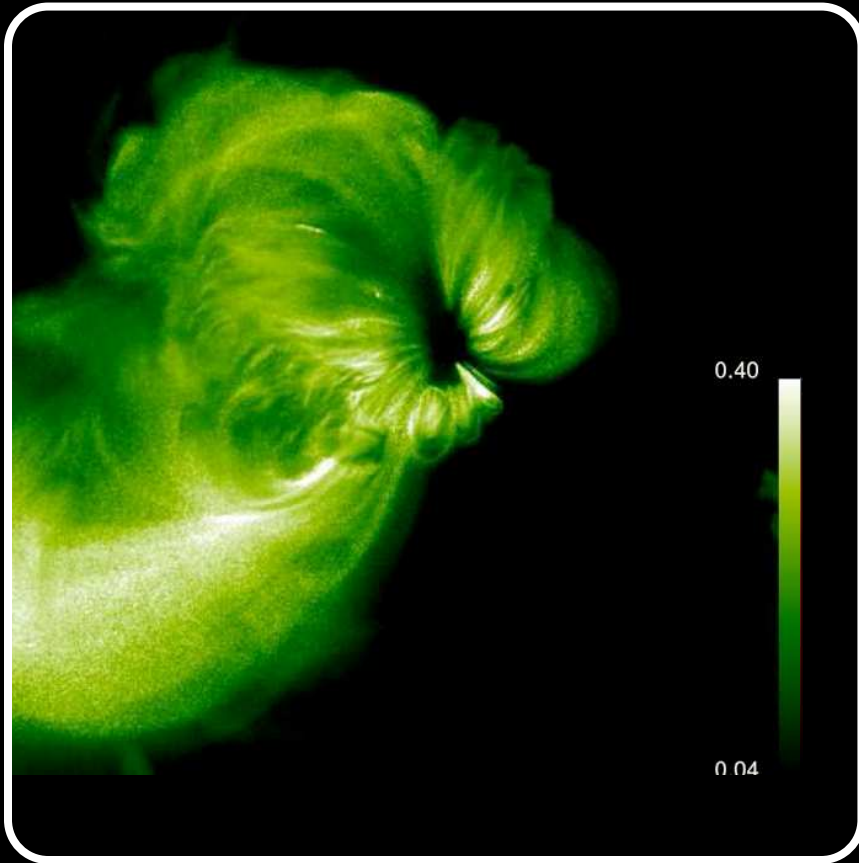


Narukage, et al, 2008

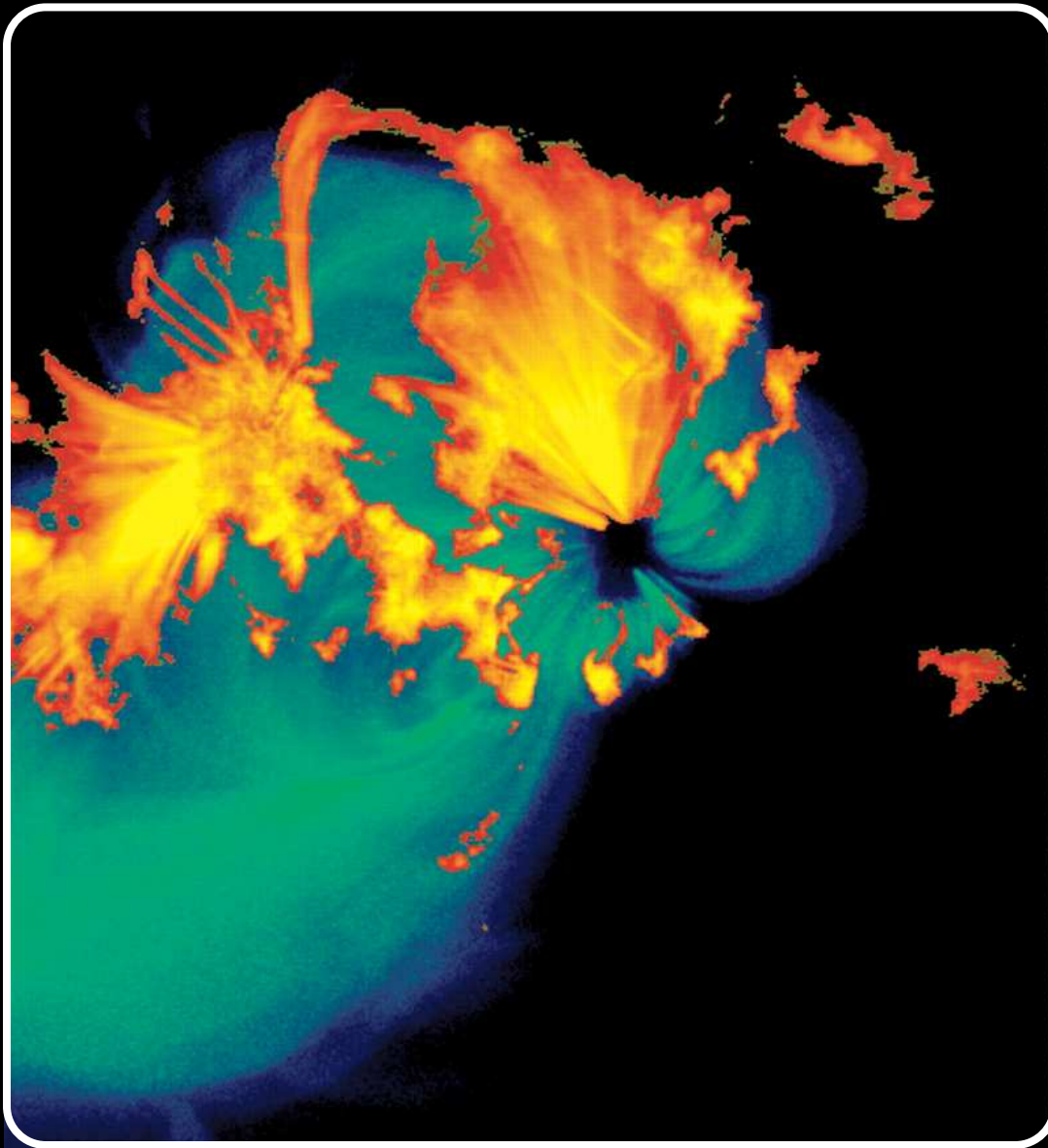


AR thermal structure

Reale et al., Science, 2007



Cool material lowers ratio

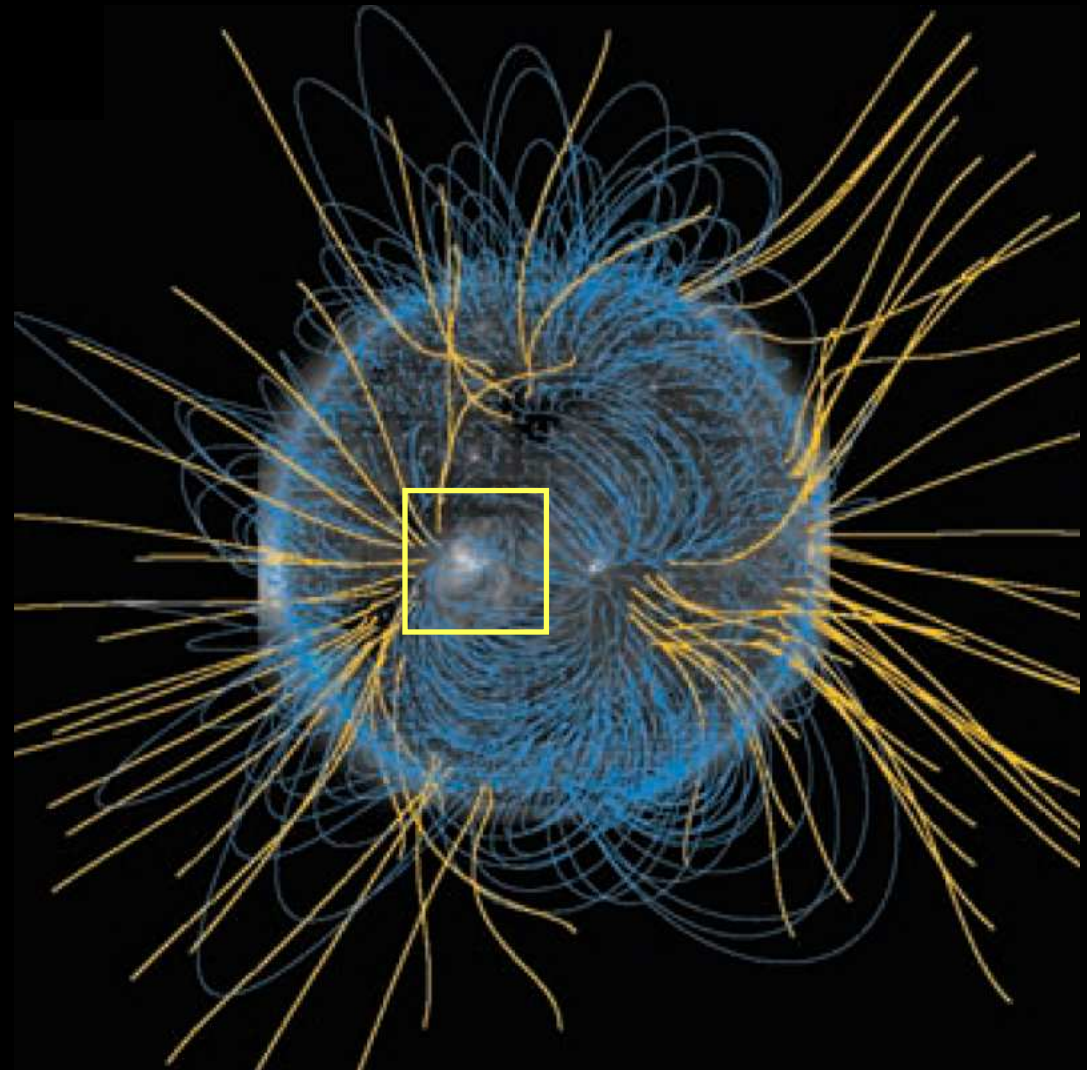
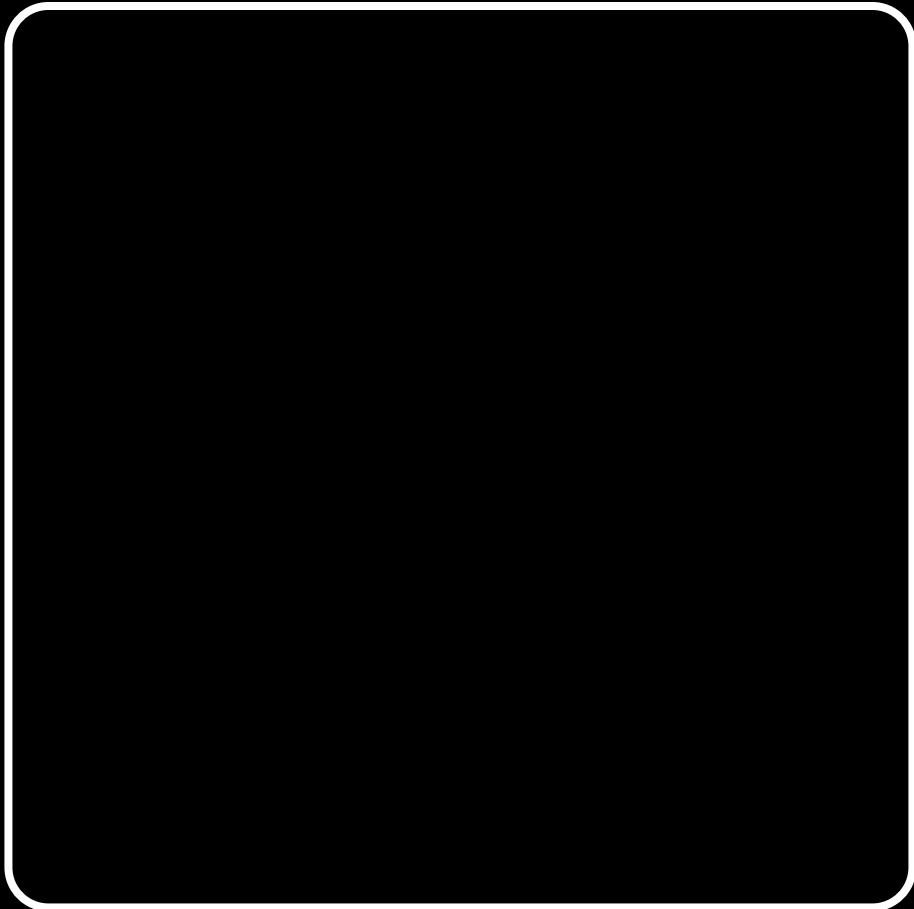


green - XRT CDFR

yellow - TRACE (1MK)

Reale et al.,
Science, 2007

Active region outflows



Sakao, et al., Science, 2007

X-ray jets

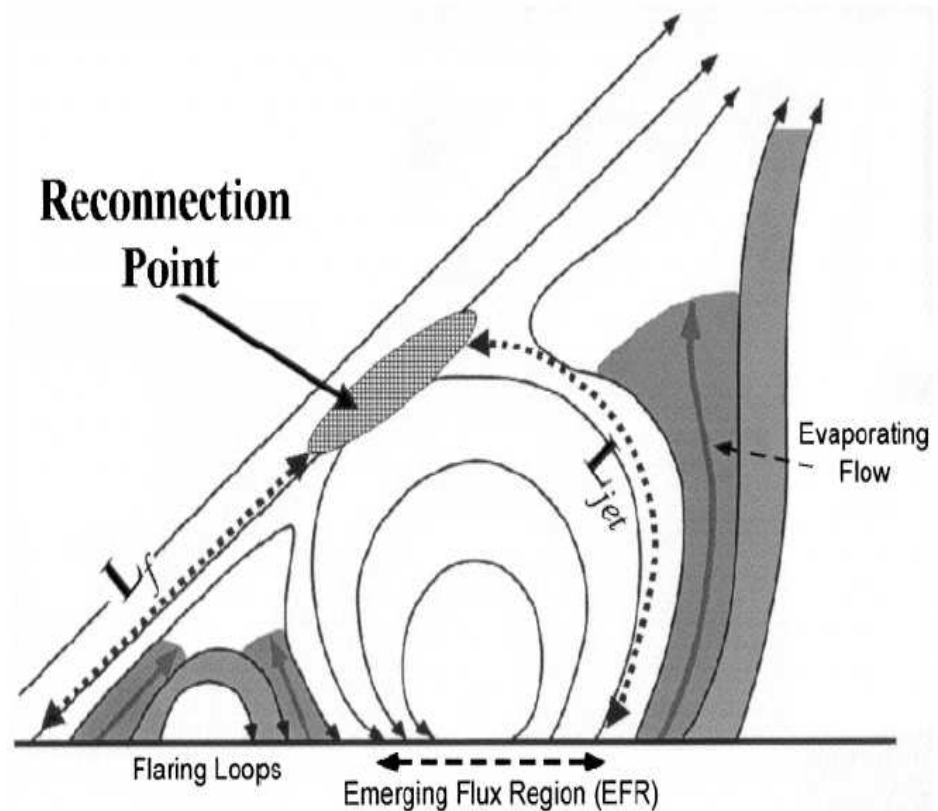
Statistics:

- 60-100 jets per day
- mean velocity 160 km/s, velocities up to 1000 km/s observed
- mean height 5×10^4 km
- mean lifetime 10 mins

from: Savcheva et al., PASJ, 2007

X-ray jets

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.



LEFT: XRT Polar Jet movie (see J. Cirtain, et al. *Science*, 318, 2008)

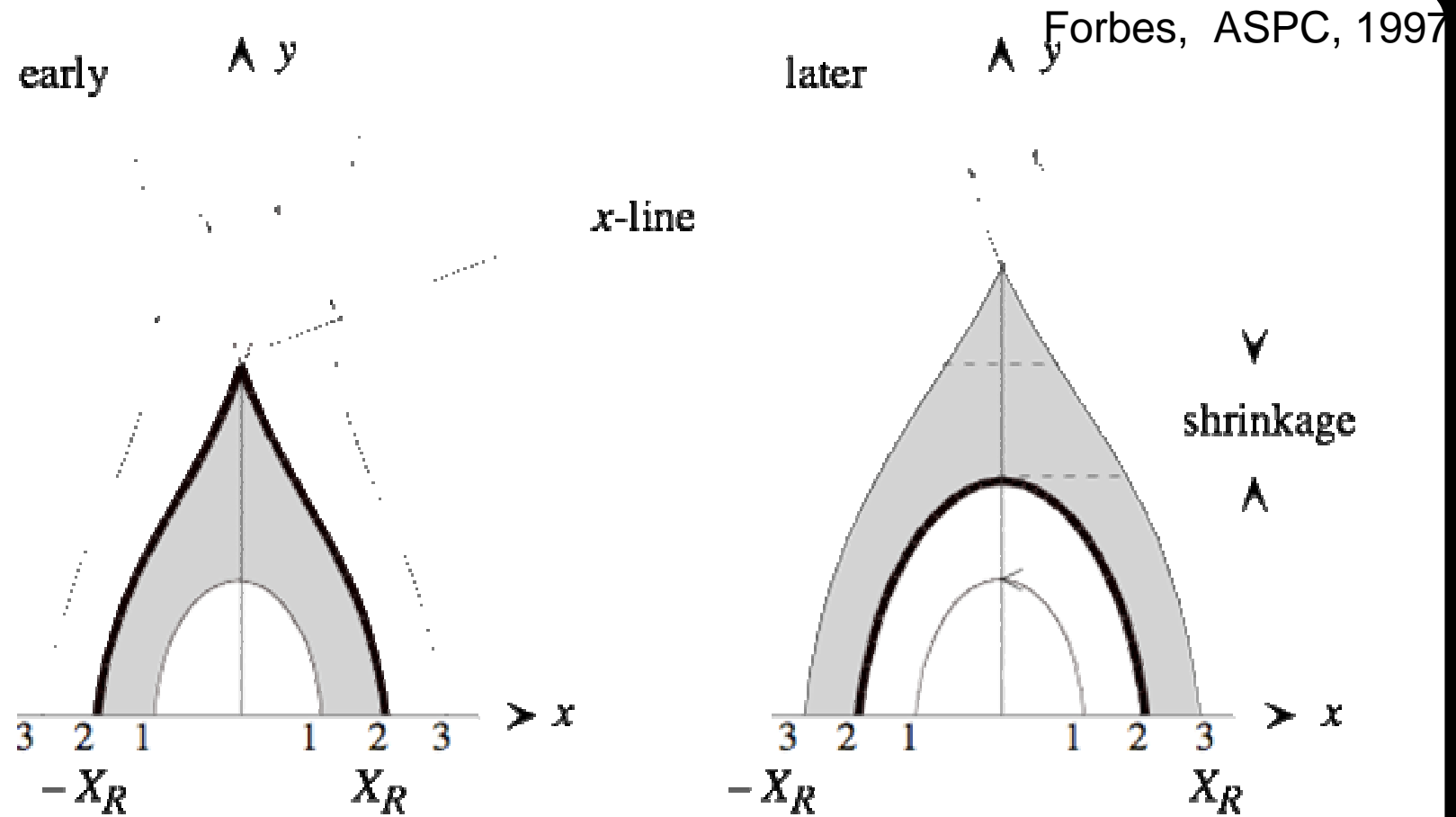
RIGHT: Shimojo, M., and Shibata, K., *ApJ* 542, 1100 (2000),
via the Hudson Solar Cartoon Archive

(<http://solarmuri.ssl.berkeley.edu/~hudson/cartoons/overview.html>)

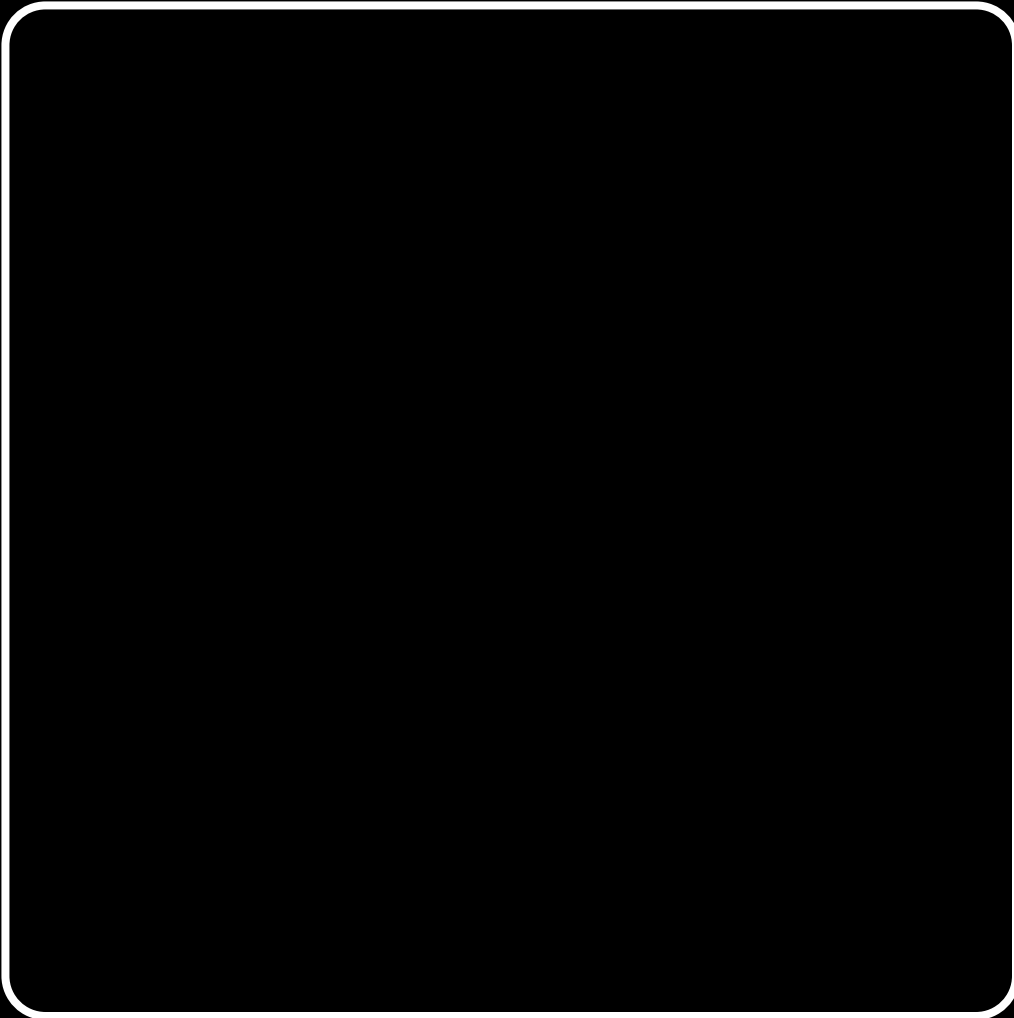
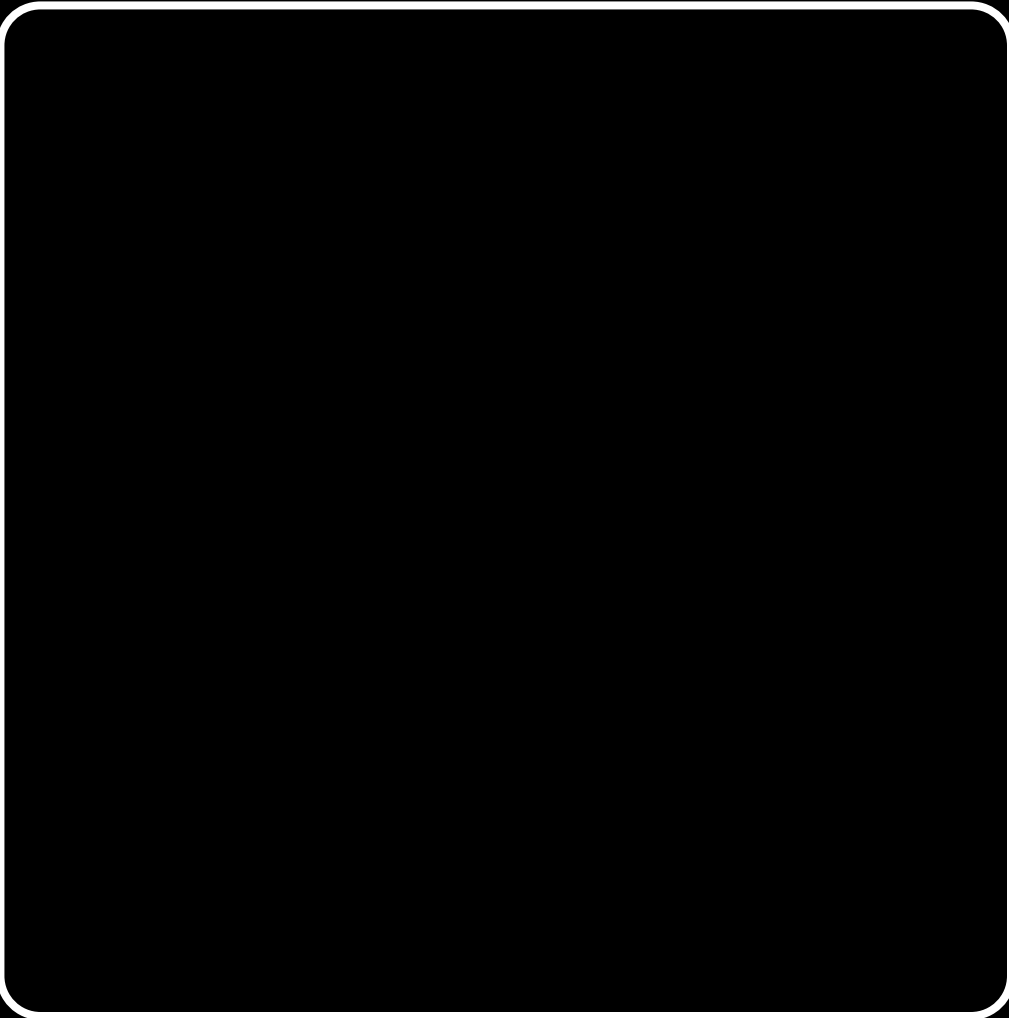
Solar flares

AI

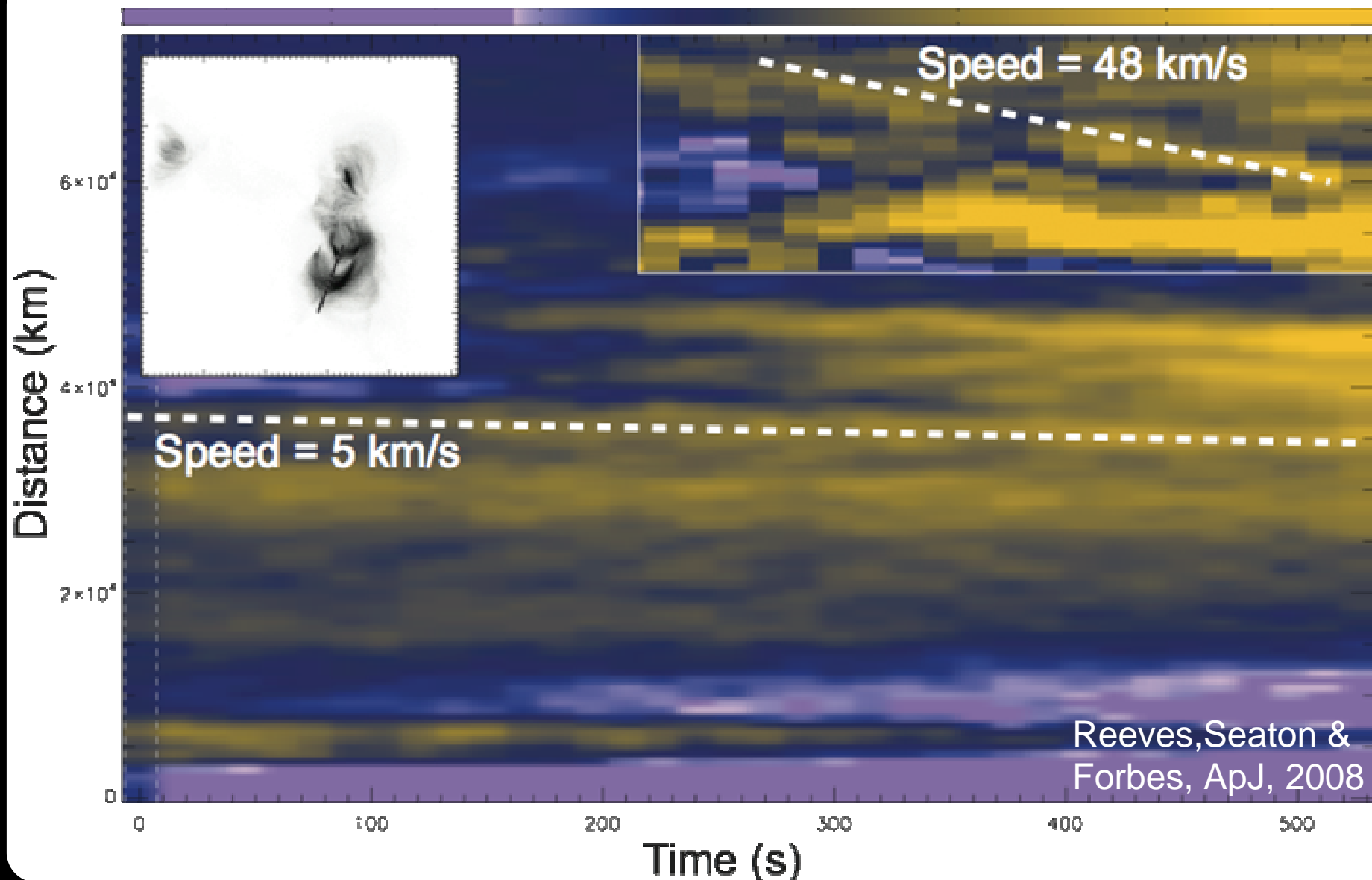
Reconnection in flares



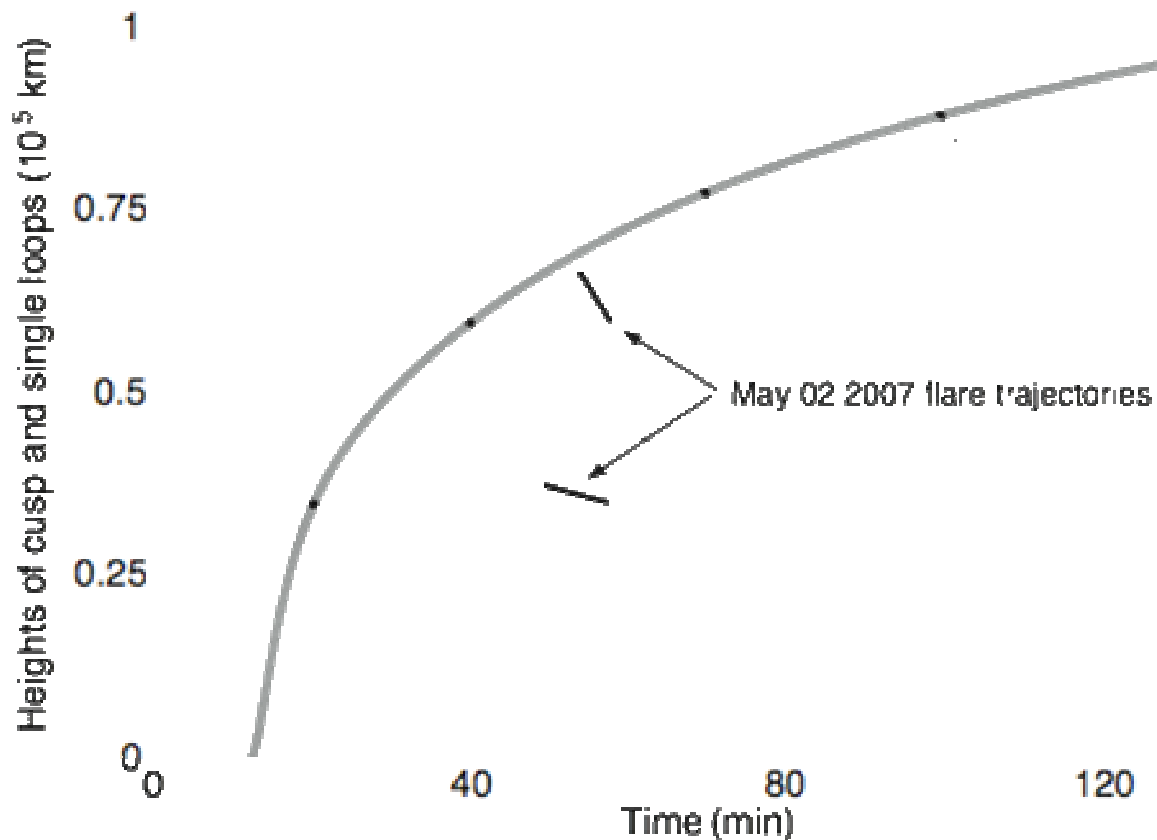
Shrinkage observations



Shrinkage trajectories

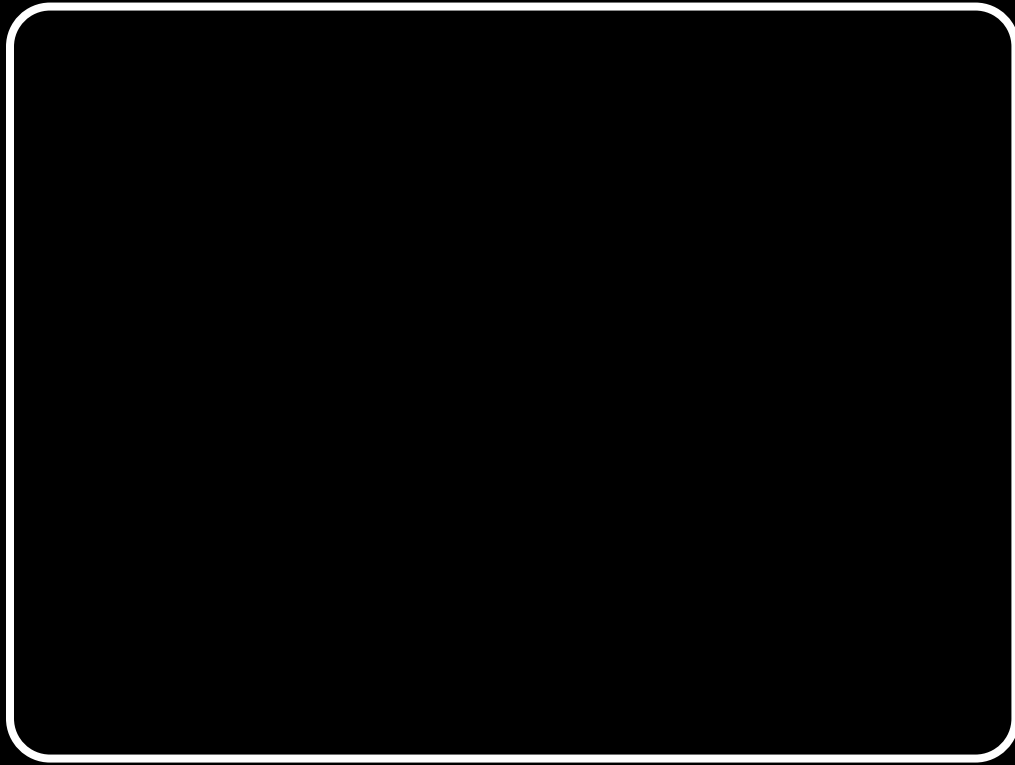


Comparison with theory

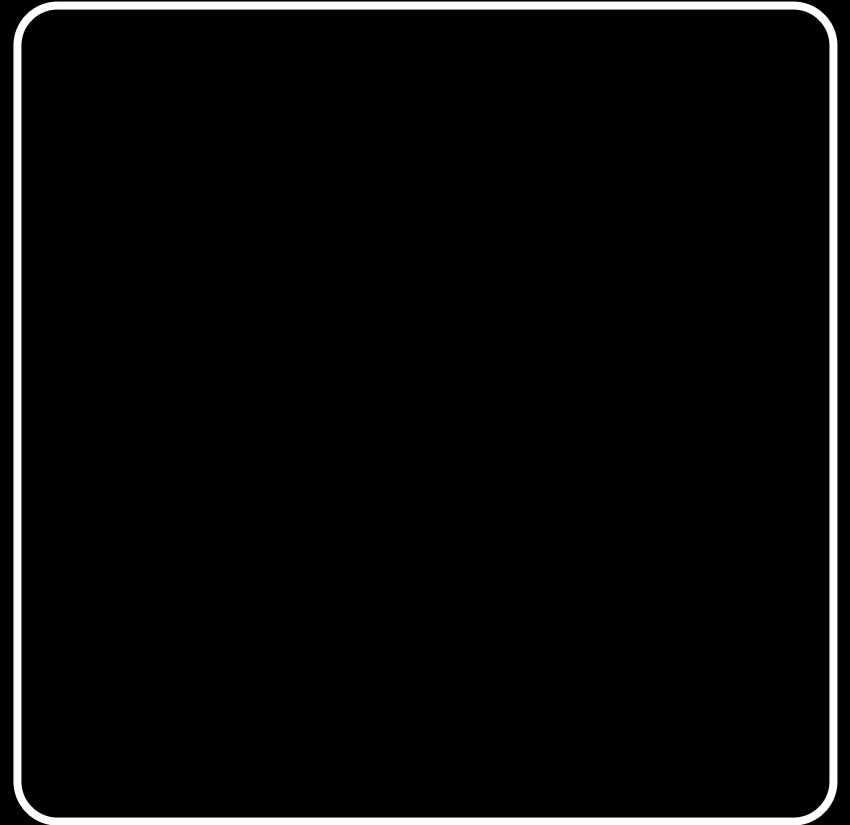


Lin, SolPhys, 2004

Supra-arcade downflows



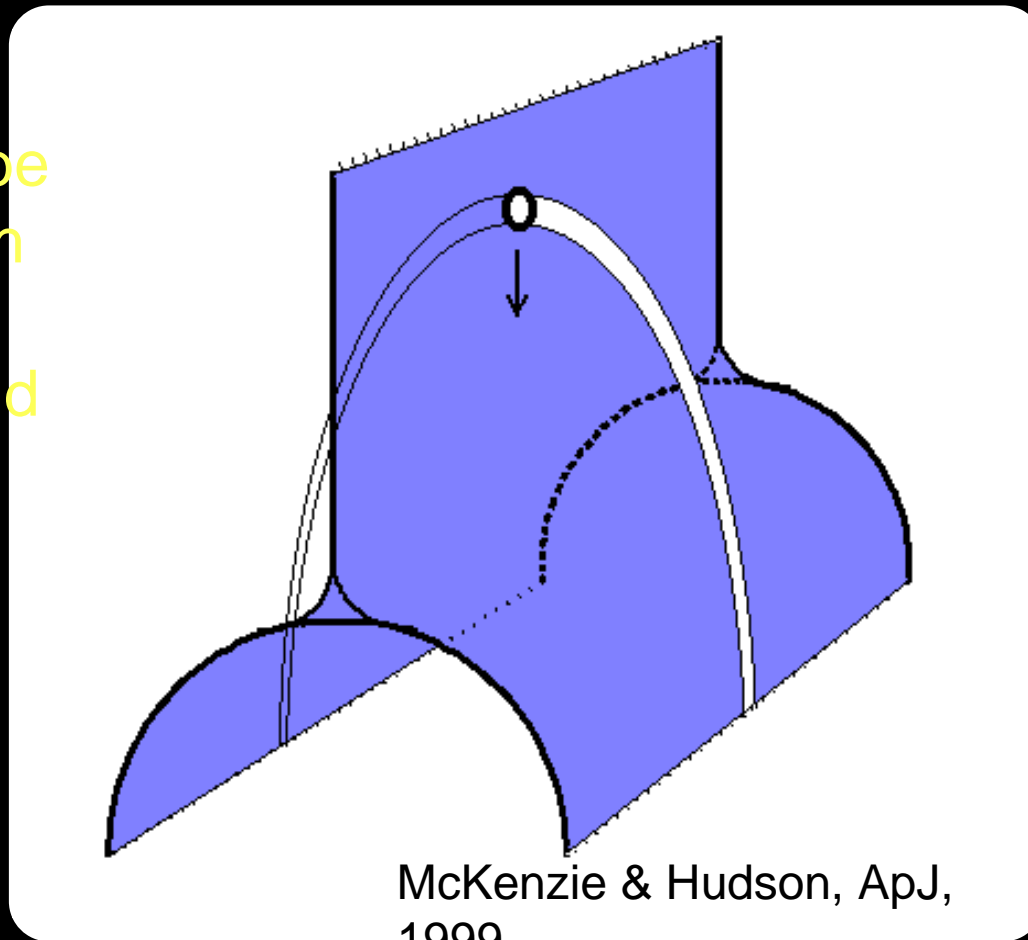
TRACE 195 Å



XRT Thin Be

Theoretical picture

2. Evacuated tube shrinking through current sheet appears as a void



1. Reconnected flux tube shrinks through current sheet.

3. Chromospheric evaporation fills the shrinking flux tube

Very similar to field line shrinkage, except that the shrinking flux tube is evacuated, and shows up as a void in observations.

Coronal mass ejections



STEREO movies courtesy A. Vourlidas

Coronal mass ejections



STEREO movies courtesy A. Vourlidas

Different wavelengths

Hinode/XRT: 5-10 MK

TRACE: 1MK

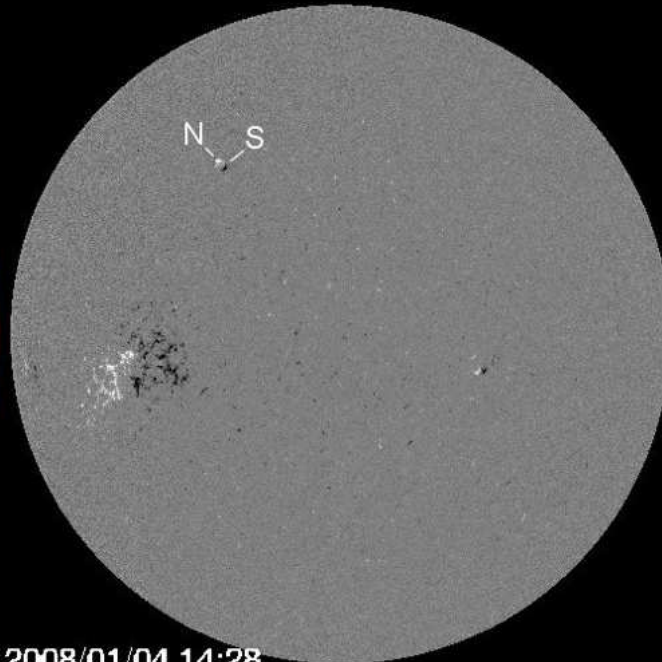
Concluding remarks

- X-rays are very important for investigating the structure, dynamics and thermal properties of the corona.
- X-rays are also important for understanding the interactions between the corona and the Earth via CMEs and the solar wind.
- Stay tuned to Solar cycle 24 for more exciting Hinode results!

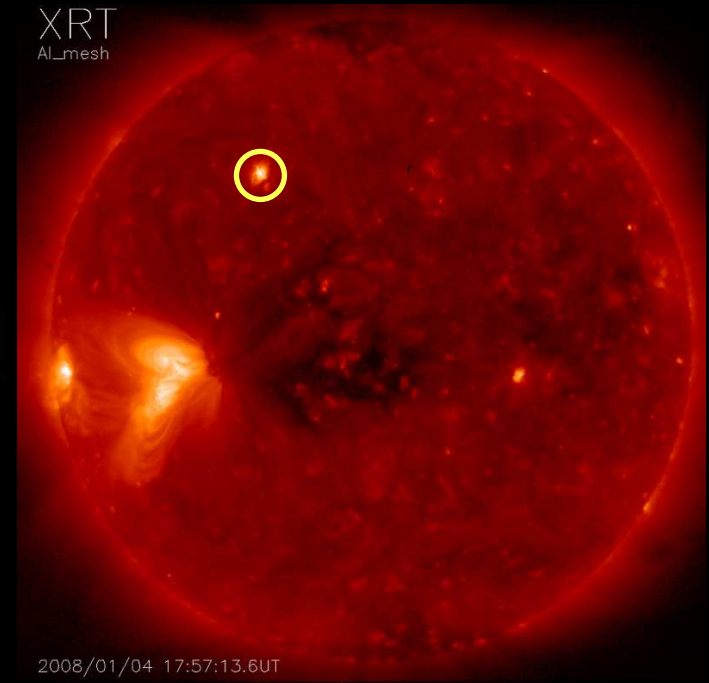
New cycle region



2008/01/04 14:24



2008/01/04 14:28



2008/01/04 17:57:13.6UT