The Dependence of Ephemeral Region Emergence on Local Flux Imbalance

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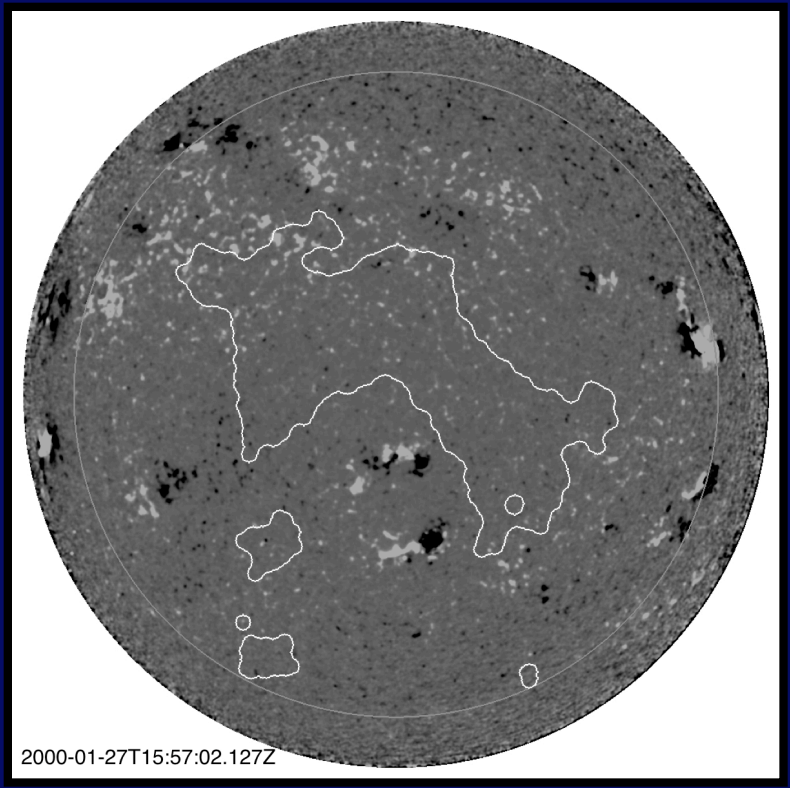
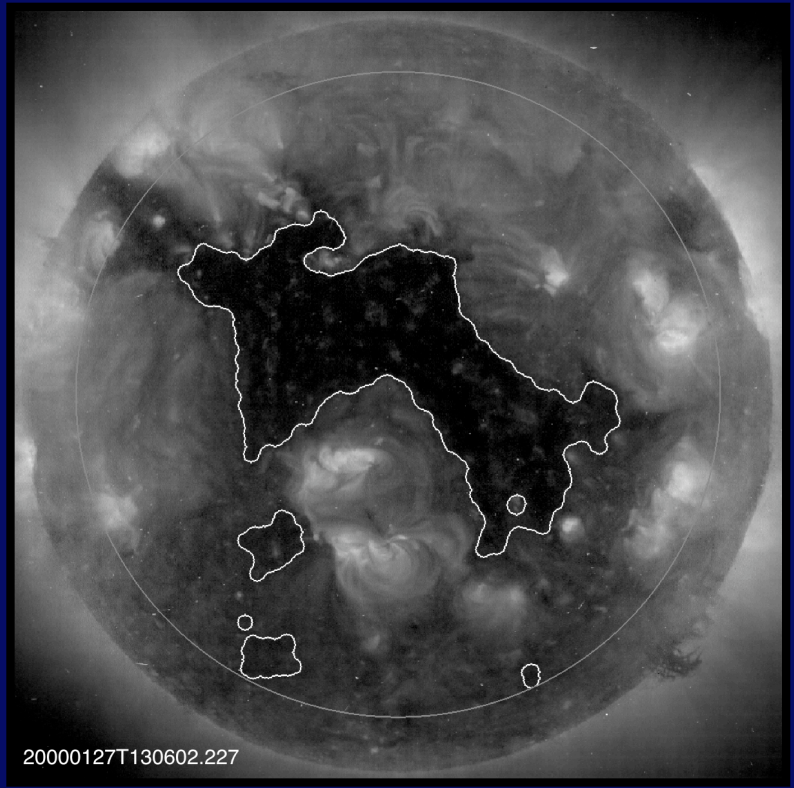


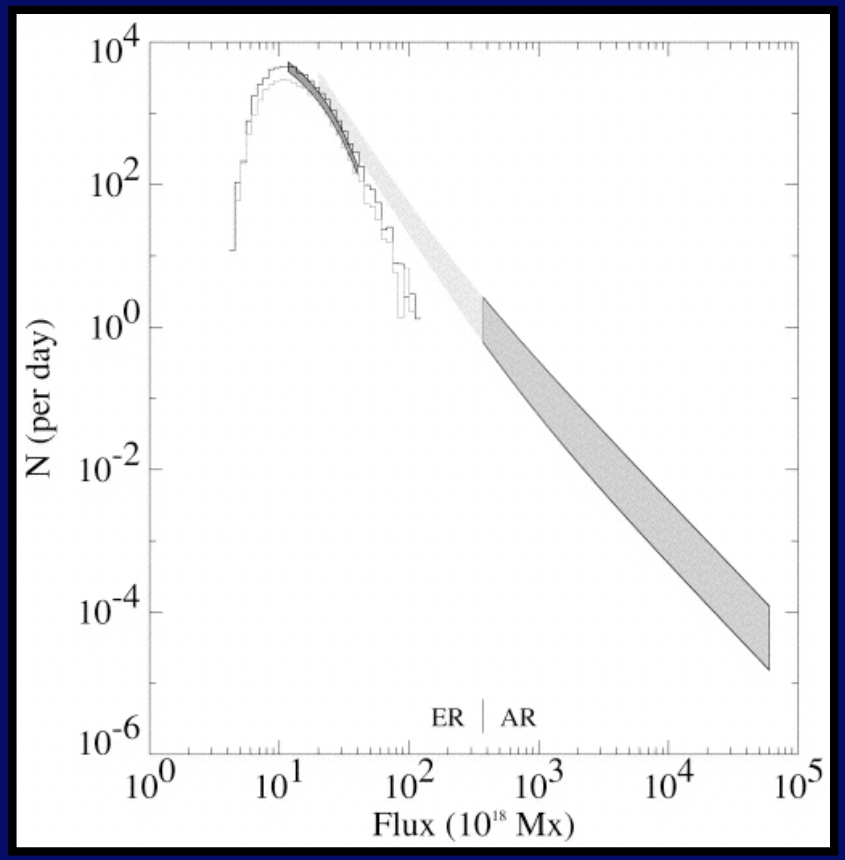


Outline Talk

1. What are Ephemeral Regions??
2. Recognizing ER's
3. Claim by Fisk & Abramenko
4. Data: Magnetograms & Corona
5. Grid Method
6. Results
7. Conclusions
8. Abstract Paper
9. Future

1. Introduction to Ephemeral Regions

- Dodson (1953) first used the term *ephemeral* for short lived active regions.
- Harvey & Martin (1973) discovered the regular presence in large numbers of these small, short lived centers of activity
- Harvey & Martin (1975): ER are the small-scale end of a broad spectrum of active regions
- Martin & Harvey (1979): The number of ER appears to vary with the solar cycle
- Hagenaar, Schrijver & Title (2003): ER are in *anti-phase* with solar cycle



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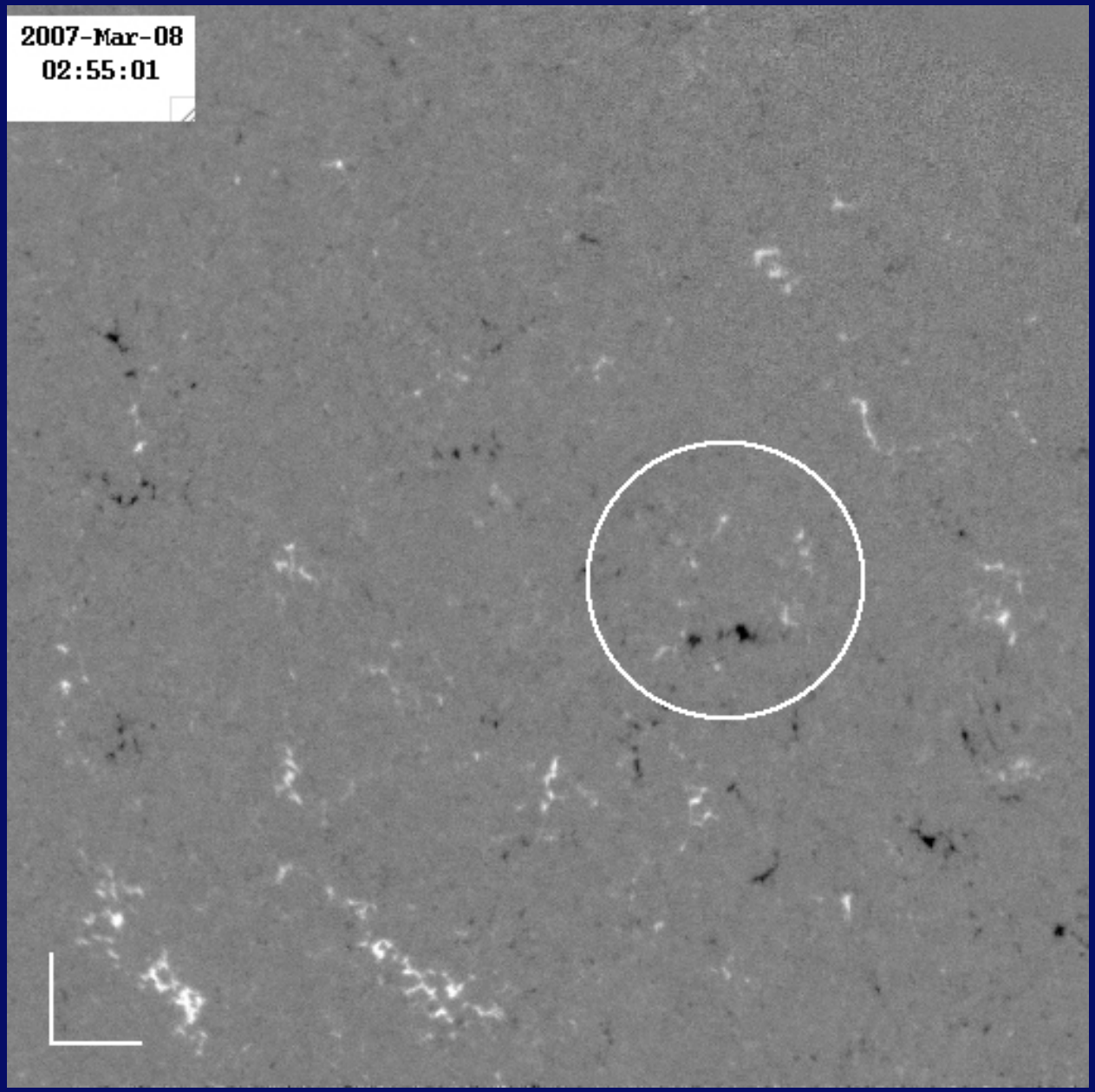


R = 15 Mm

10 Mm

119 Mm x 119 Mm

2. Ephemeral Regions

Newly emerged Bipoles = Ephemeral Regions

Method developed by Hagenaar (2001), based on Harvey (1993):

- Find all network concentrations outside active regions:

$|\Phi_{conc}| > 2 \times 10^{17}$Mx

- Find which opposite polarity concentrations of comparable flux content (within a factor 3) are close enough to be considered magnetic bipoles

$|\Phi_{eph}| > 4 \times 10^{17}$Mx

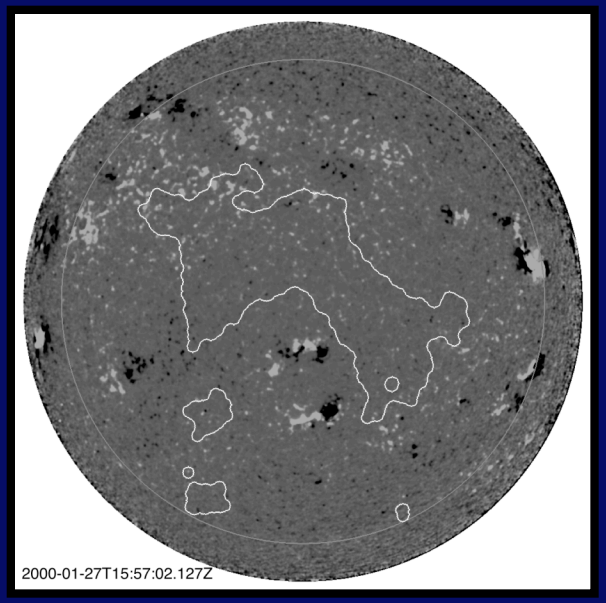
- Cannot have resulted from chance encounter
- Were not present in a previous map of the same region

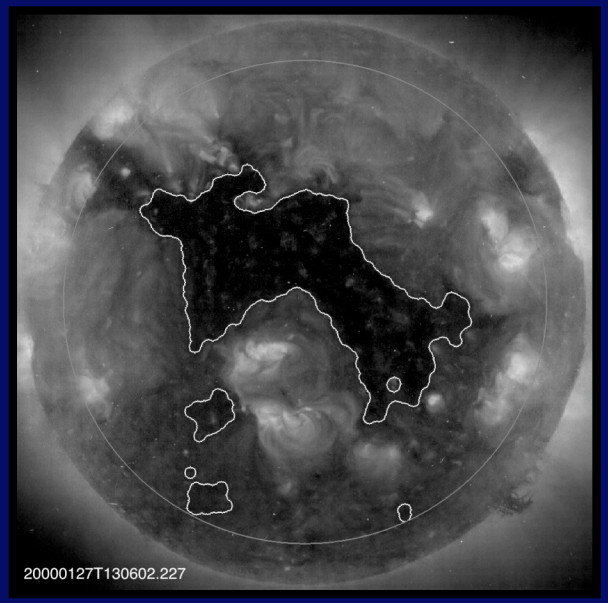
3. Emergence Rates

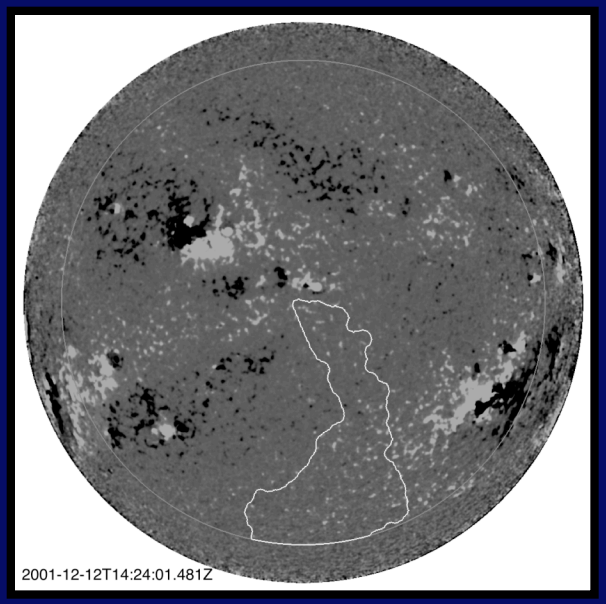
- Fisk (2005): Coronal holes form where the magnetic flux emergence rate is minimum. Open magnetic flux is transported by random convective motions in photosphere and reconnection with coronal loops.
- Zhang, Ma, and Wang (2006): Evolution of magnetic flux is much faster in quiet Sun outside coronal holes: flux emerges 4.3 times faster; and disappears by cancellation 2.9 times faster.
- Abramenko, Fisk, and Yurchyshyn (2006): The emergence of magnetic flux is systematically lower by a factor 2-2.5 in coronal holes.

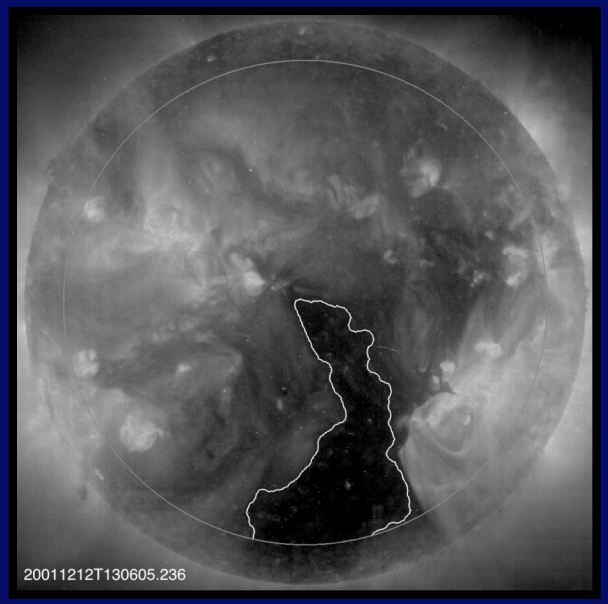
- Flux emergence from sub-photospheric layers should not depend on the topology of the overlying corona!

4. We study 6 MDI - FD Sequences (2000/01/02/03/04/05) that show one or more Coronal Holes in EIT 284 Å









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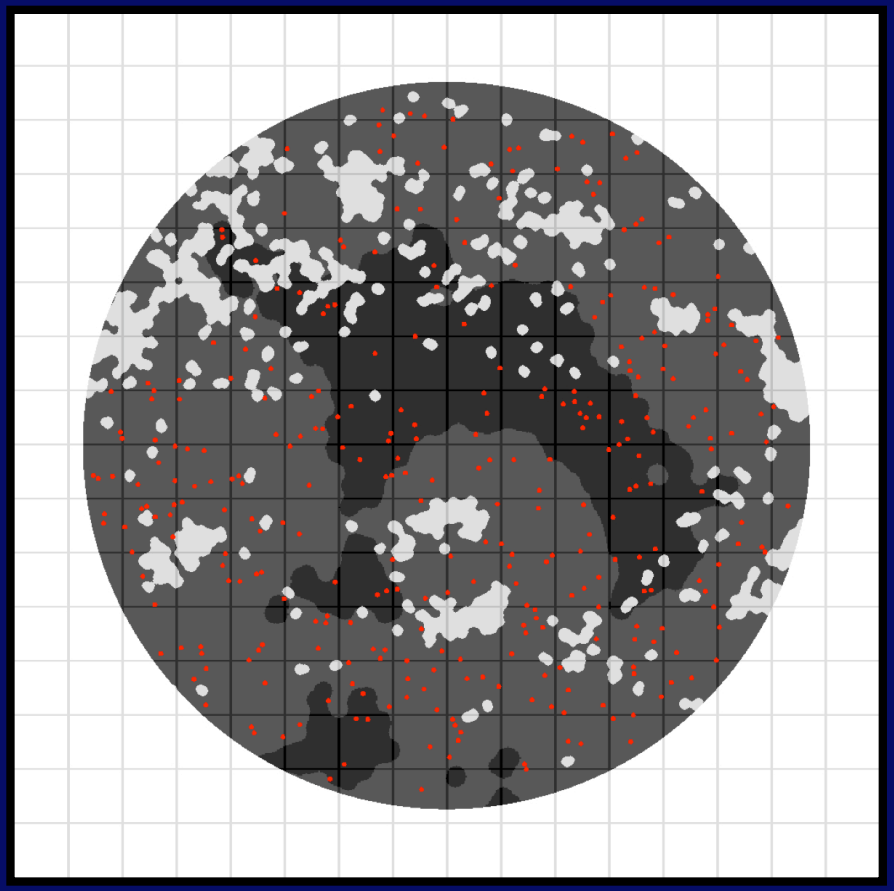
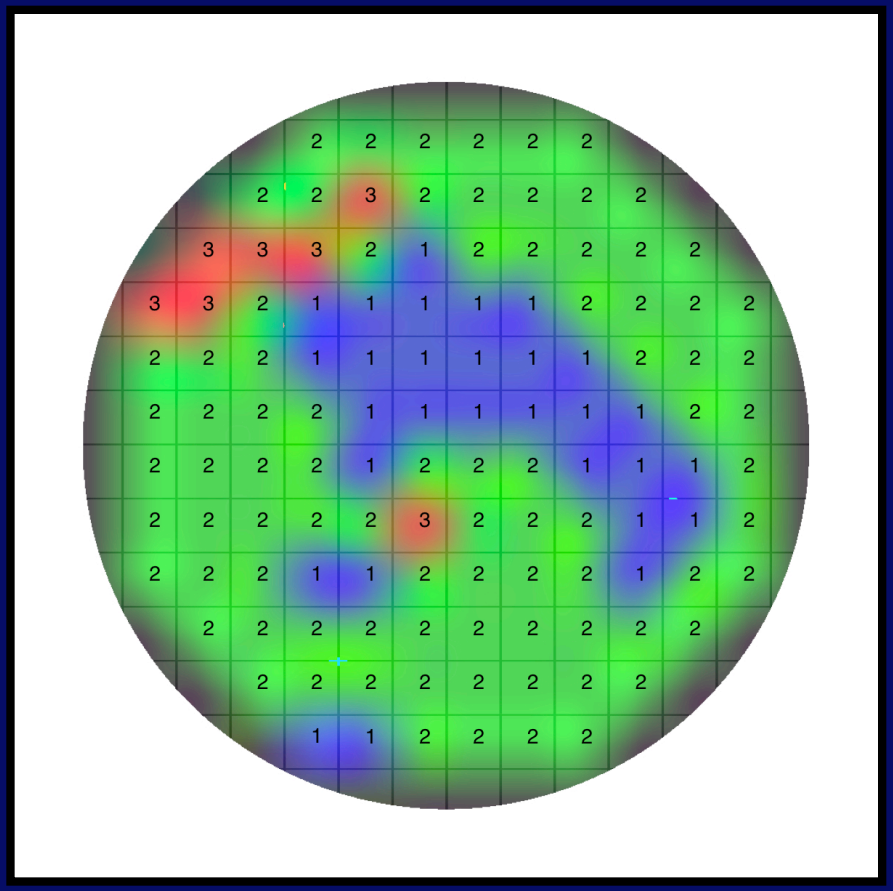
5. Grid Method

- Ephemeral Regions determined outside Active Regions
- Quiet Sun is divided into regions with (CH) or without (QS) Cor. Holes
- Grid 64 × 64 pix = 92 x 92 Mm^2 (substantial amount of supergranules)
- Light Gray: Active Regions
- Darkest Gray: Coronal Hole
- Mid Gray: Quiet without CH
- Red Dots: Ephemeral Regions





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January 2000 set

6. Results

for each “macropixel” we determine:

- Net Flux for each Cell in Grid: $$\frac{\left| |\Phi^+| - |\Phi^-| \right|}{\left| |\Phi^+| + |\Phi^-| \right|} = \xi$$
- Absolute Flux:

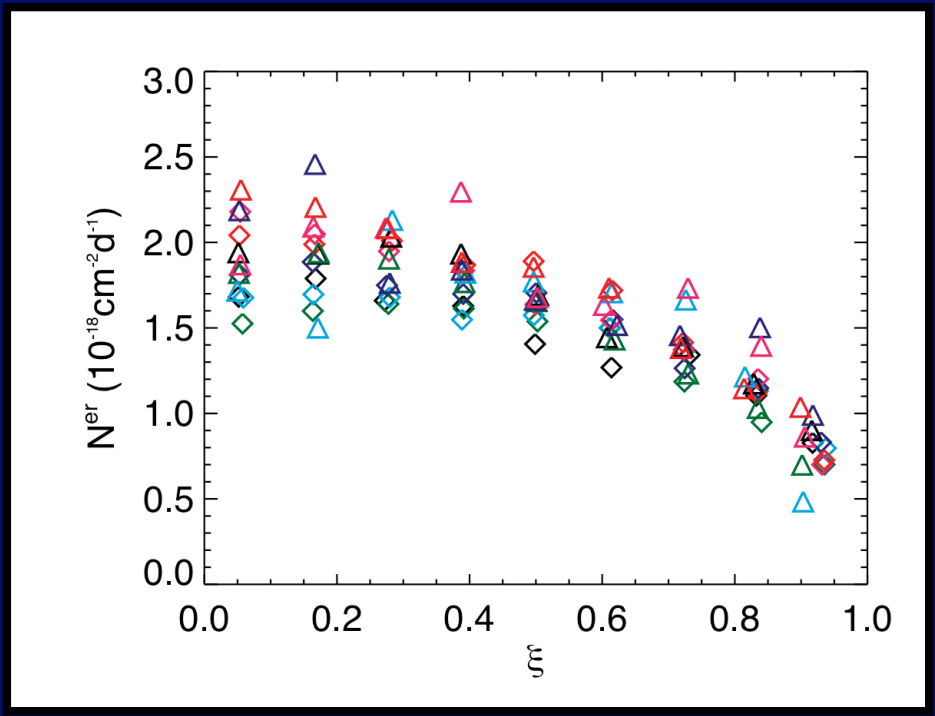
- Flux Balance ξ for each Cell in Grid:
- ξ = net Flux / total Flux
- ξ = 0 if balanced, $|\Phi^+| = |\Phi^-|$
- ξ = 1 if unbalanced (unipolar), $|\Phi^+| = 0$ or $|\Phi^-| = 0$

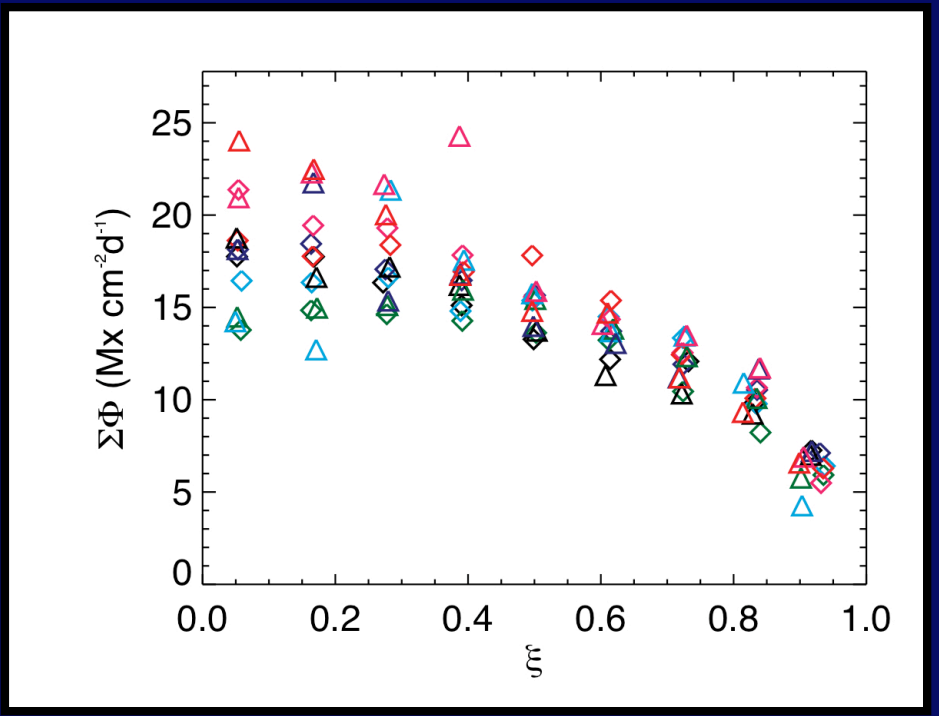
- Surface of Cell (corrected for angle)

- # of ER’s in Cell

- Type of Region, QS or CH: Type of Central Pixel in Cell

ER's per unit surface per day





Left: Emergence frequency Ner of ephemeral regions, per unit surface, per day, as a function of the flux imbalance ξ in a region.
The right panel shows the total absolute flux SF emerging in those regions.
Diamonds: for quiet Sun outside coronal holes; and triangles: inside coronal holes.
The squares and triangles do not show a difference.
Black: 2000; green: 2001; light blue: 2002; dark blue: 2003; pink: 2004; red: 2005.

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7. Conclusions

- Most important finding:

# of Ephemeral Regions depends on the Degree of Flux Imbalance in the Photosphere, independent of the Presence of Coronal Holes

Explanation?

1. The Minority Polarity is quickly “EATEN AWAY” so we never measure it to recognize the ER?
2. The Solar Dynamo works like this: Much Flux never makes it to the Surface?

8.The Dependence of Ephemeral Region Emergence on Local Flux Imbalance

Hagenaar, DeRosa, and Schrijver 2008, ApJ, 678, 541

We investigate the distribution and evolution of existing and emerging magnetic network elements in the quiet-Sun photosphere. The ephemeral region emergence rate is found to depend primarily on the imbalance of magnetic flux in the area surrounding its emergence location, such that the rate of flux emergence is lower within strongly unipolar regions by at least a factor of three relative to flux-balanced quiet Sun. As coronal holes occur over unipolar regions, this also means that ephemeral regions occur less frequently there, but we show that this is an indirect effect - independent of whether the region is located within an open-field coronal hole or a closed-field quiet region. We discuss the implications of this finding for near-photospheric dynamo action and for the coupling between closed coronal and open heliospheric fields.

9. Future

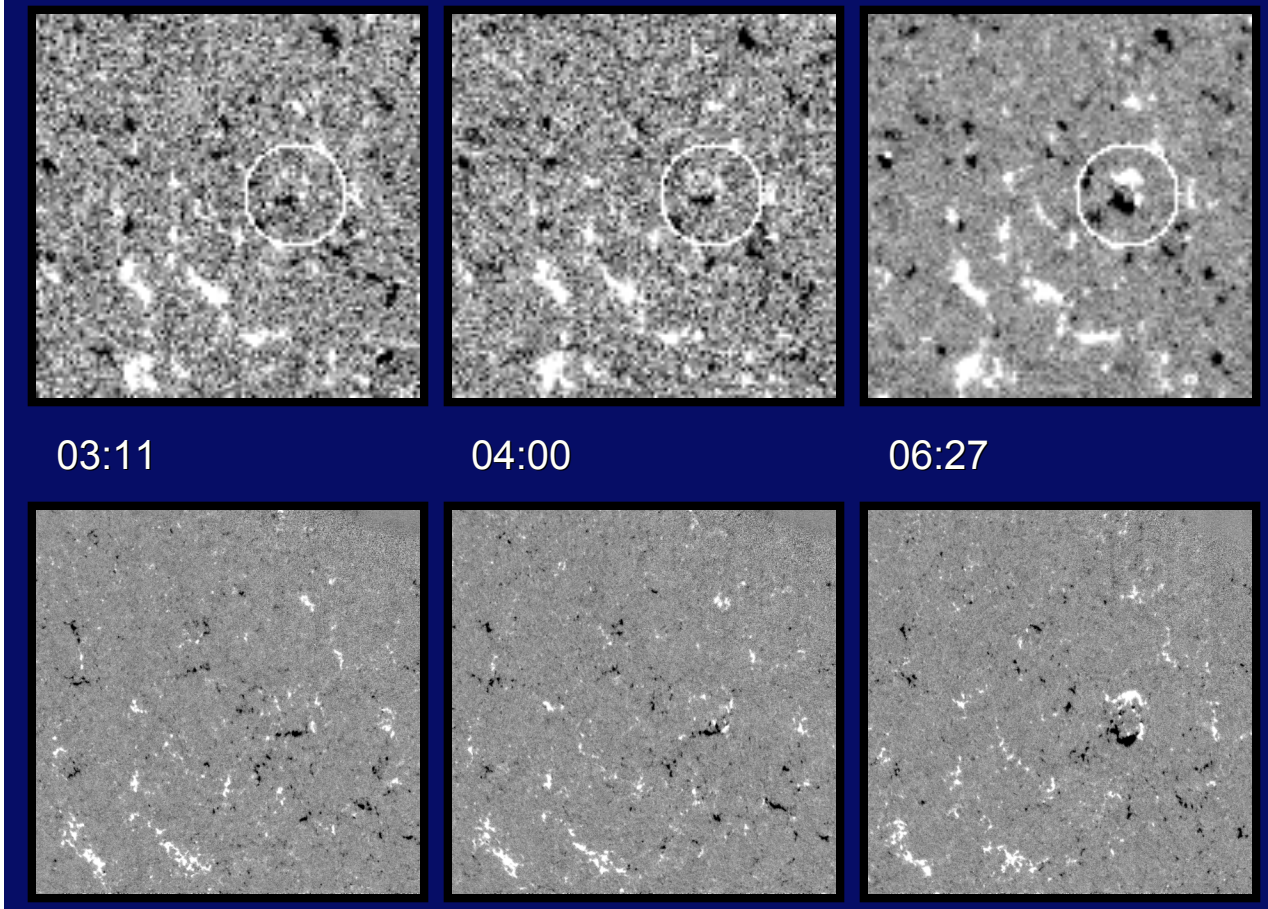
• How do the Distributions differ for the two Polarities in QS and CH?

• What can we learn from tracking magnetic Concentrations? Lifetimes of Er's vs.. Flux Contents?

• Hagenaar (2001) compared magnetograms separated by 96 minutes. In this paper we compare magnetograms separated by as short as 5 minutes.

Can we develop a method to automatically recognize magnetic flux Emergence?

Flux Emergence on Hinode



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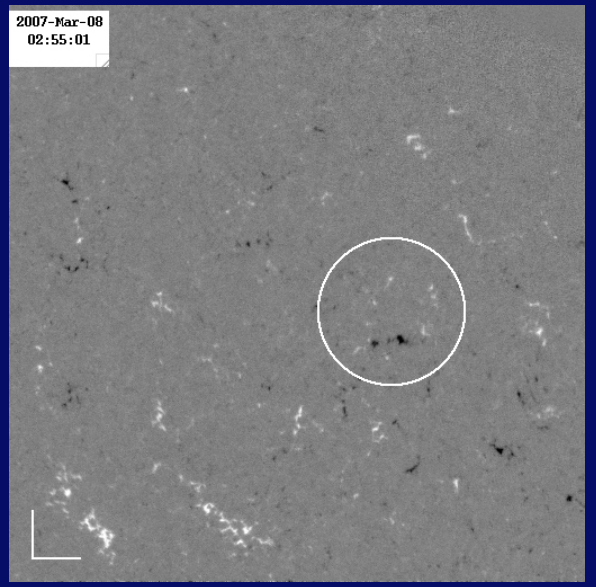

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