Magnetic loops: A comparison of extrapolations from the photosphere with chromospheric measurements

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- Coronal magnetic field models
- Potential and linear force-free fields
- Non-linear force-free fields
- Observational tests
- Conclusions

Coronal magnetic field models

Model	Mathematics	Observations needed	Validity
Potential Fields	$\nabla \times B = 0$ $\nabla \cdot B = 0$	Line of sight magnetogram	(Global) current free regions, quiet sun

Potential and Linear Force-Free Fields

We have to solve the equations:

$$(\nabla \times \mathbf{B}) = \alpha \mathbf{B}$$
$$\nabla \cdot \mathbf{B} = 0$$

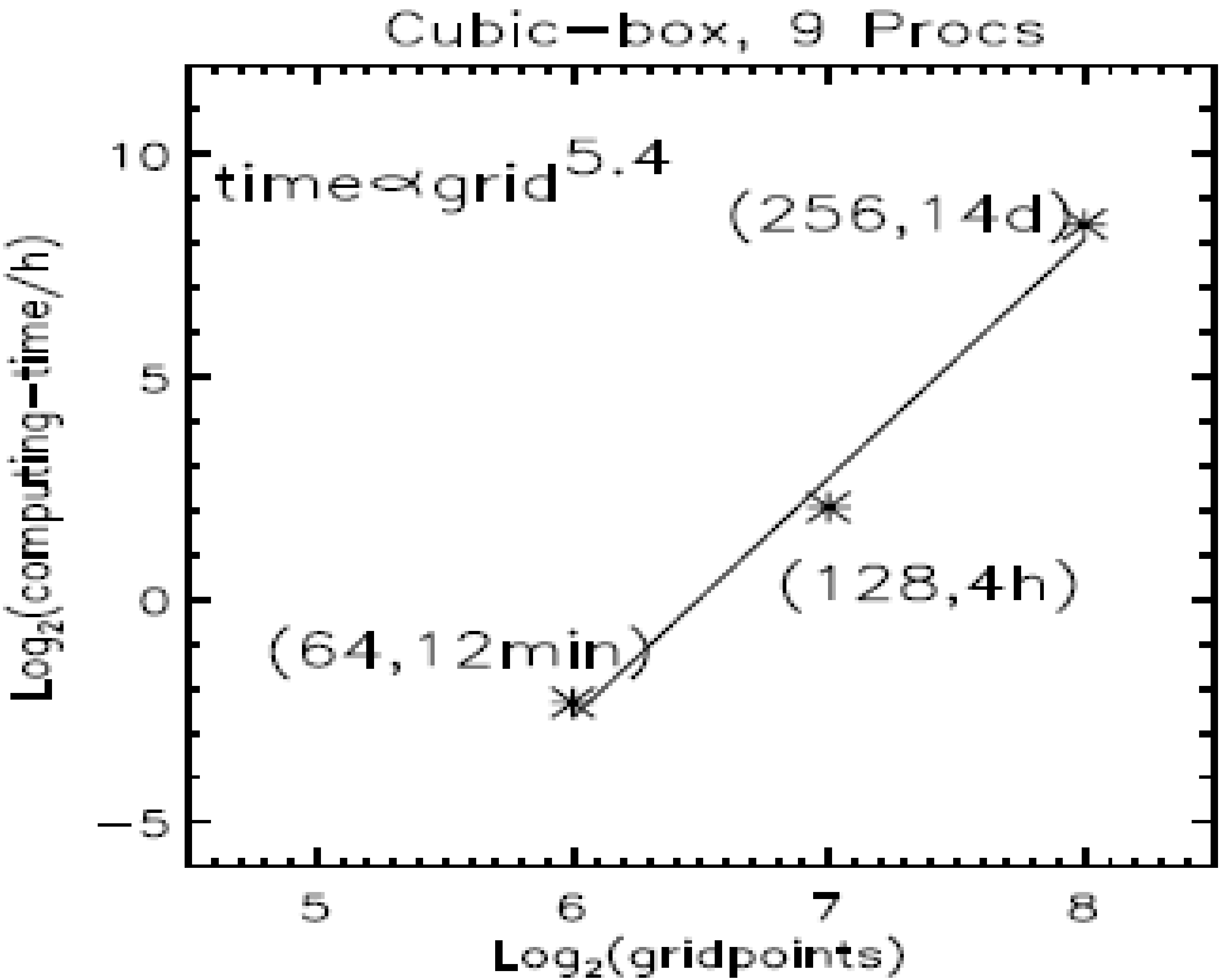
Non-linear force-free fields

- Why do we need non-linear force-free fields?
  - In general alpha changes in space.
  - Potential and linear force-free fields have no free energy to be released during an eruption.

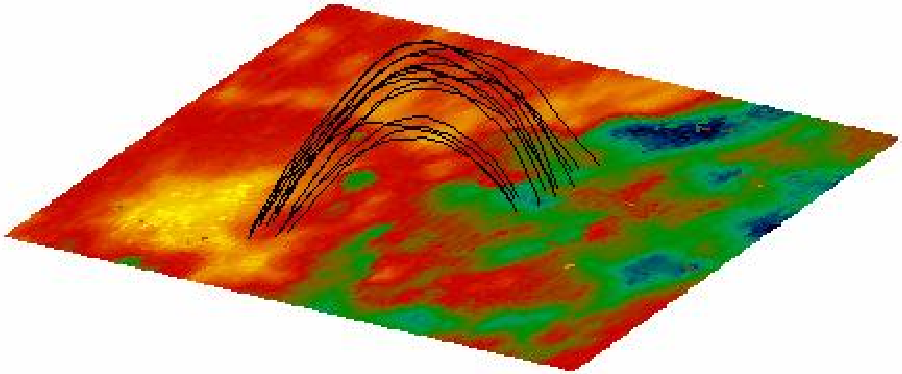
Non-linear Force-Free Fields

Force-free magnetic fields have to obey

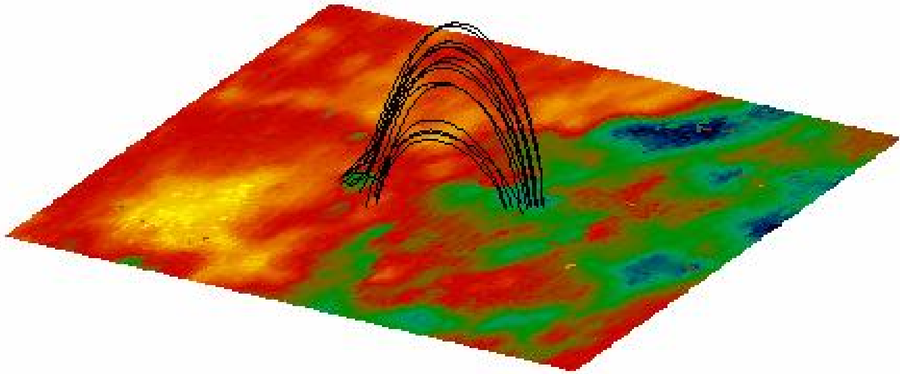
$$(\nabla \times \mathbf{B}) \times \mathbf{B} = \mathbf{0}, \; \nabla \cdot \mathbf{B} = 0$$


Cubic-box, 9 Procs
time∝grid^5.4
(256,14d)
(128,4h)
(64,12min)
10
5
0
−5
5
6
7
8
Log₂(computing-time/h)
Log₂(gridpoints)

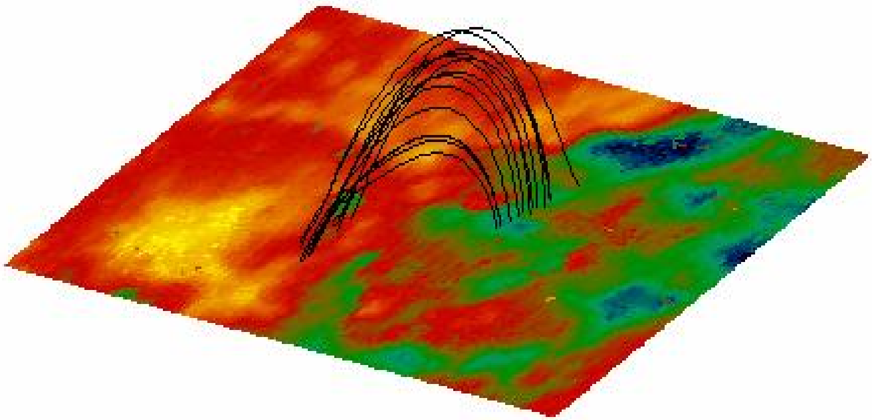
Comparison of observed magnetic loops and extrapolations from photospheric measurements



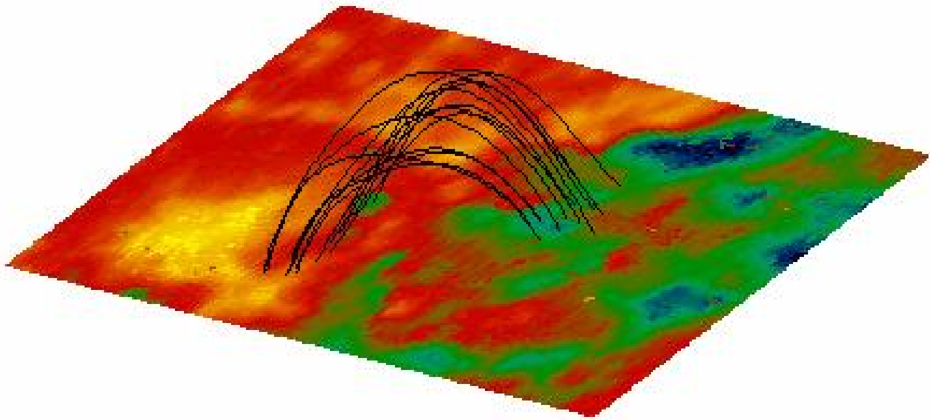
Measured loops in a newly developed AR (Solanki, Lagg, Woch, Krupp, Collados, Nature 2003)



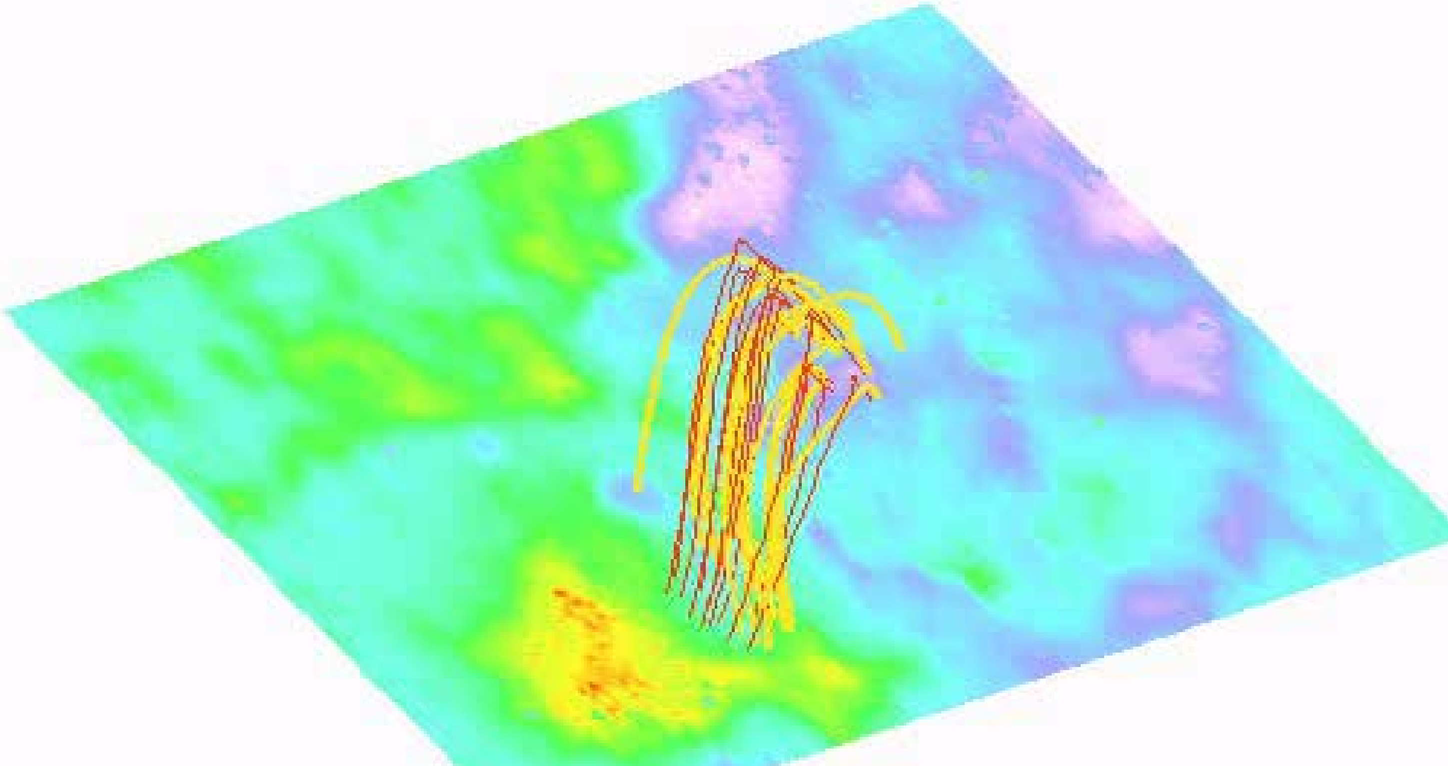
Potential field reconstruction

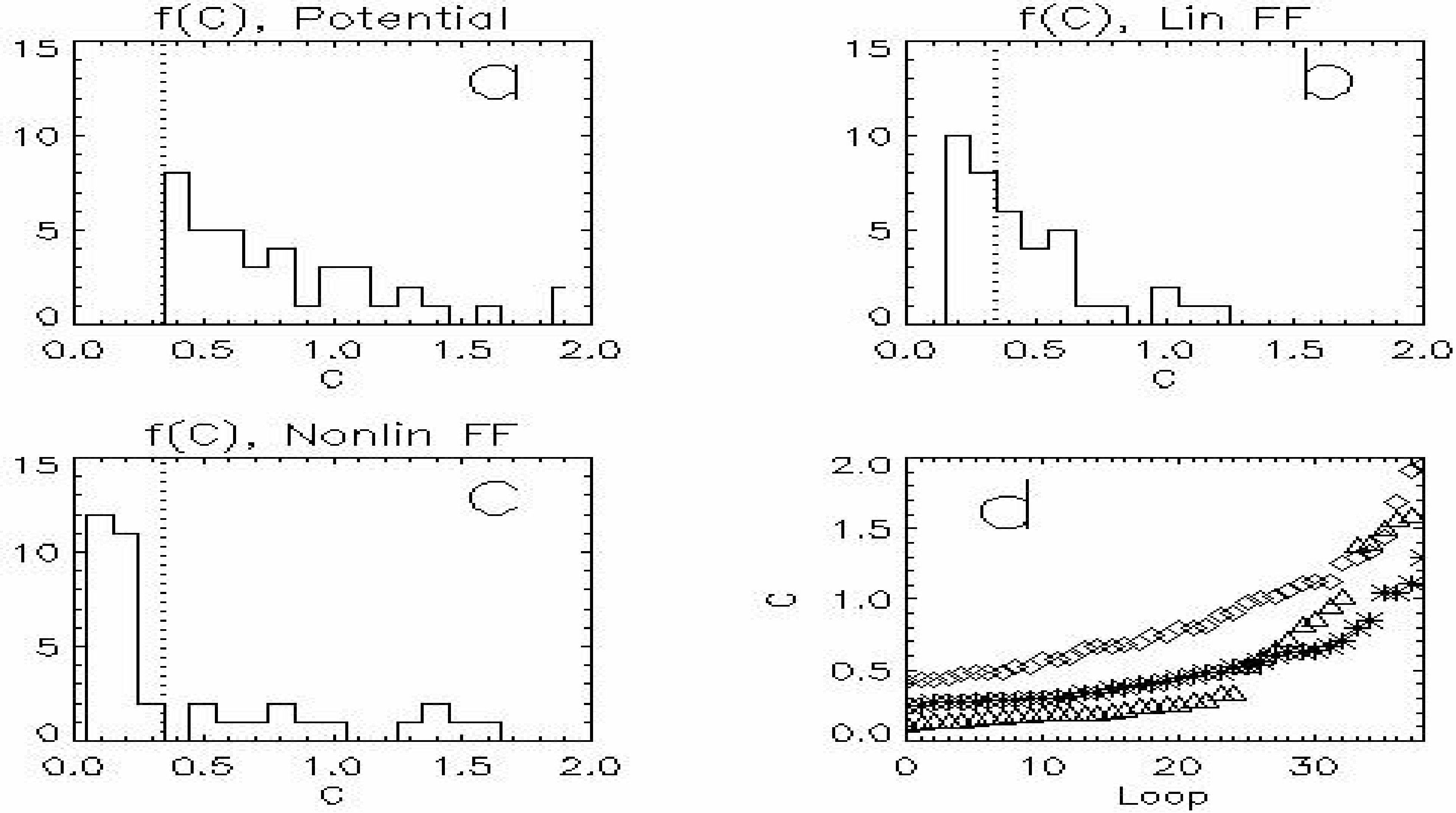


Linear force-free reconstruction



Non-linear force-free reconstruction





We compared measurements of magnetic loops in a newly developed active region with extrapolations from the photosphere. We got the best agreement of measured and extrapolated loops for a non-linear force-free magnetic field model.

Conclusions

- Potential magnetic fields and linear force-free fields are popular due to their mathematic simplicity and available data. (e.g. from MDI on SOHO, Kitt Peak)

- Non-linear force-free fields are necessary to describe active regions exactly. More challenging both observational (Vector magnetograms) and mathematical.

- Current vectormagnetograms have limited field of view and only occasional available. Future: Solis and Solar B.