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Current helicity and magnetic field anisotropy in solar active regions

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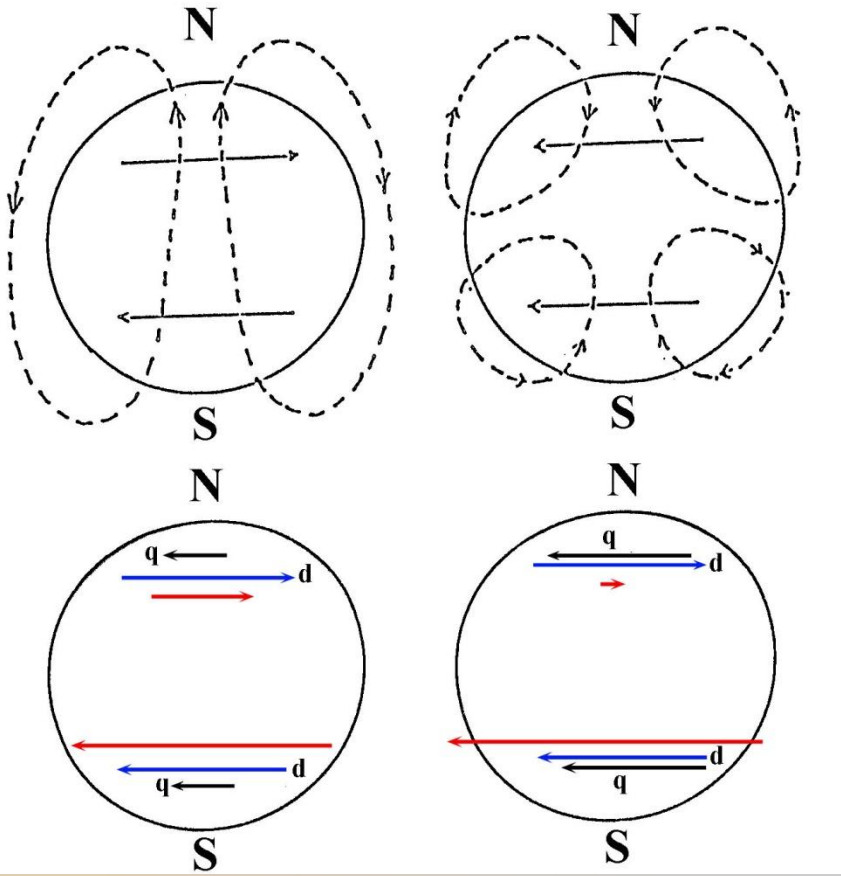
Parker Dynamo

$$B_P \xrightarrow{\Omega} B_T$$

Differential rotation

$$B_T \xrightarrow{\alpha} B_P$$

Mirror asymmetry



How to observe mirror asymmetry?

For magnetic field mirror asymetry an approach was suggested by Seehafer in 1990th.

α-effect

$$\alpha = \frac{\tau < v \; \mathrm{rot} \; v >}{3}$$

$$E = \alpha B$$

How we could observe mirror asymmetry? Seehafer suggested (1990):

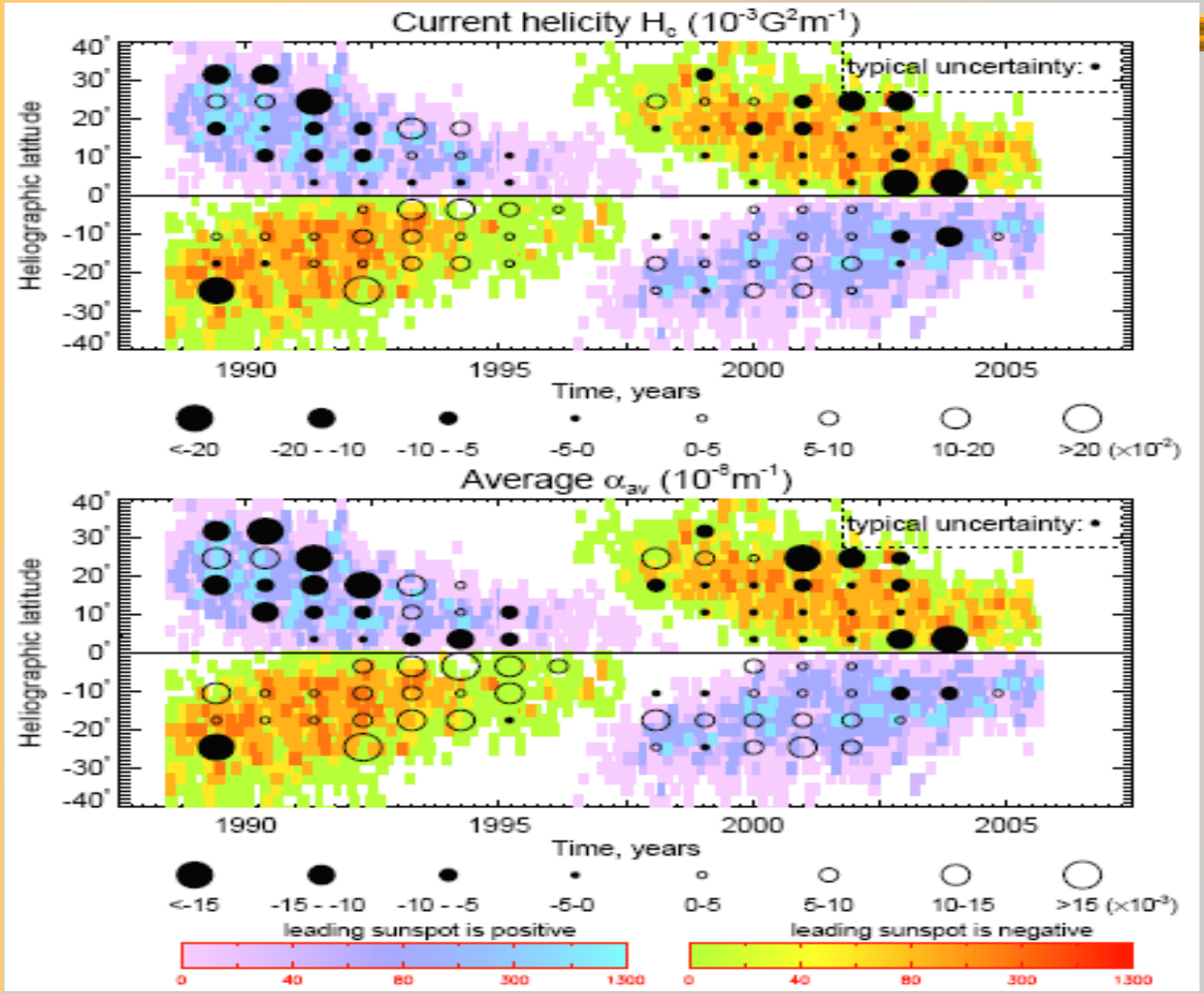
$$\chi^{c}_{xy} = < B_z J_z > = < B_z \left(\frac{\partial B_y}{\partial x} - \frac{\partial B_x}{\partial y} \right) >$$

If small-scale magnetic field is (locally) isotropic, it is 1/3 of current helicity dencity.

IF!!!!!!

Local isotropy should be in small scales. Are active regions small enough?

Bufferfly diagramm for current helicity as observed at Huairou



Rodion Stepanov suggested how to verify isotropy

If magnetic field is isotropic, all these terms have to be statistically equal

$$H_c = \int \mathbf{J}\cdot\mathbf{B}dxdy = H_1 + H_2 + H_3 + H_4 + H_5 + H_6$$

$$= \int B_z\left(\frac{\partial B_y}{\partial x}\right)dxdy + \int B_z\left(-\frac{\partial B_x}{\partial y}\right)dxdy$$

$$+ \int B_x\left(\frac{\partial B_z}{\partial y}\right)dxdy + \int B_x\left(-\frac{\partial B_y}{\partial z}\right)dxdy$$

$$+ \int B_y\left(\frac{\partial B_x}{\partial z}\right)dxdy + \int B_y\left(-\frac{\partial B_z}{\partial x}\right)dxdy\,.$$

What follows from observations:

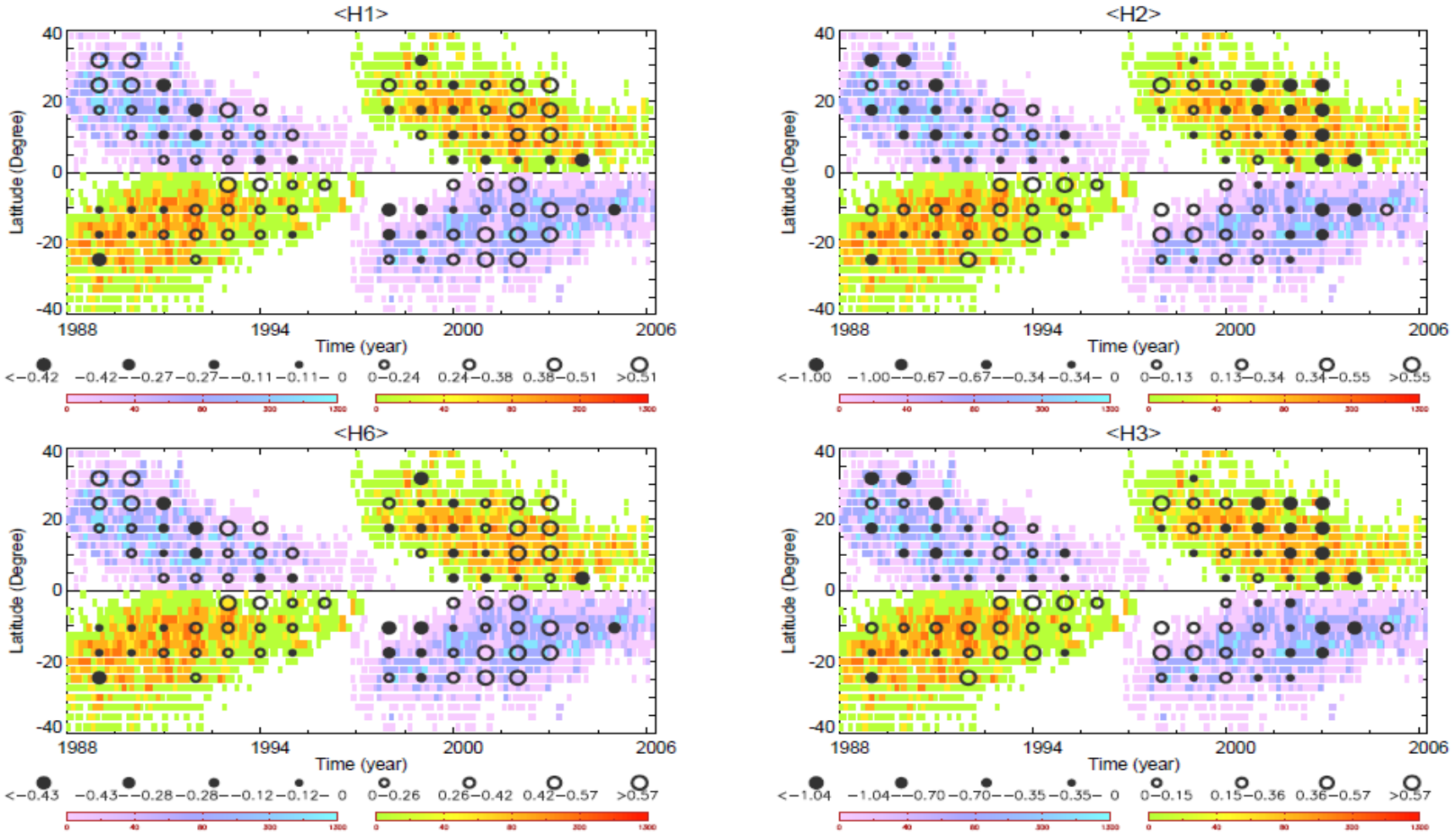


Fig. 4. Evolution of four helicity parts with the solar cycle

Several options for current helicity estimations

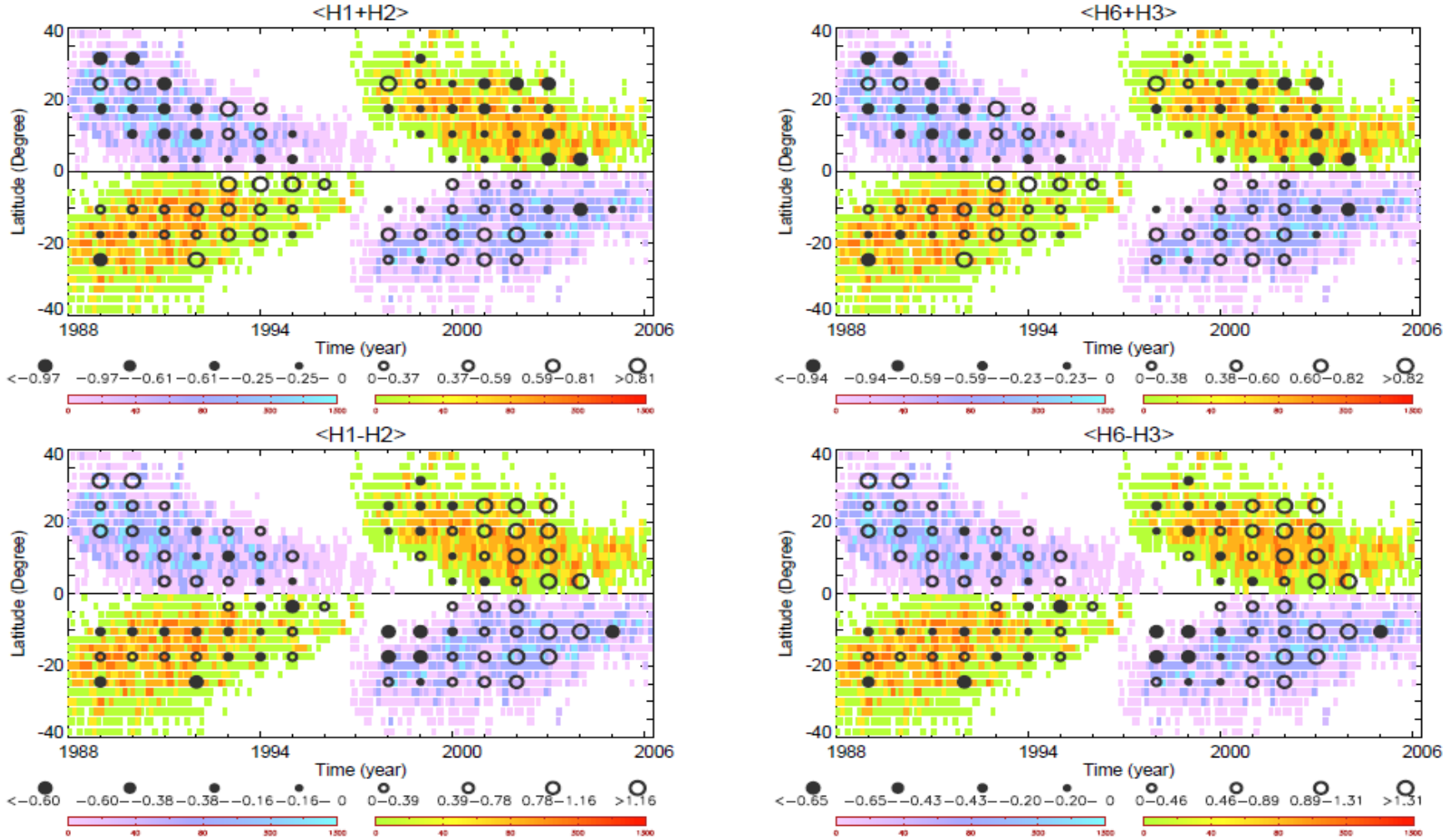


Fig. 5. Evolution of the observationally available helicity defined as a sum of two parts $\langle H_3 + H_6 \rangle$ with the solar cycle

Conclusion

- Active regions are not small enough to have isotropic magnetic field there.
- Instead of one estimate for helicity we obtain several related quantities
- Possible observational biases.