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An Application of the Random-Walk Model to Proper Motions of Coronal Bright Points from SDO Data

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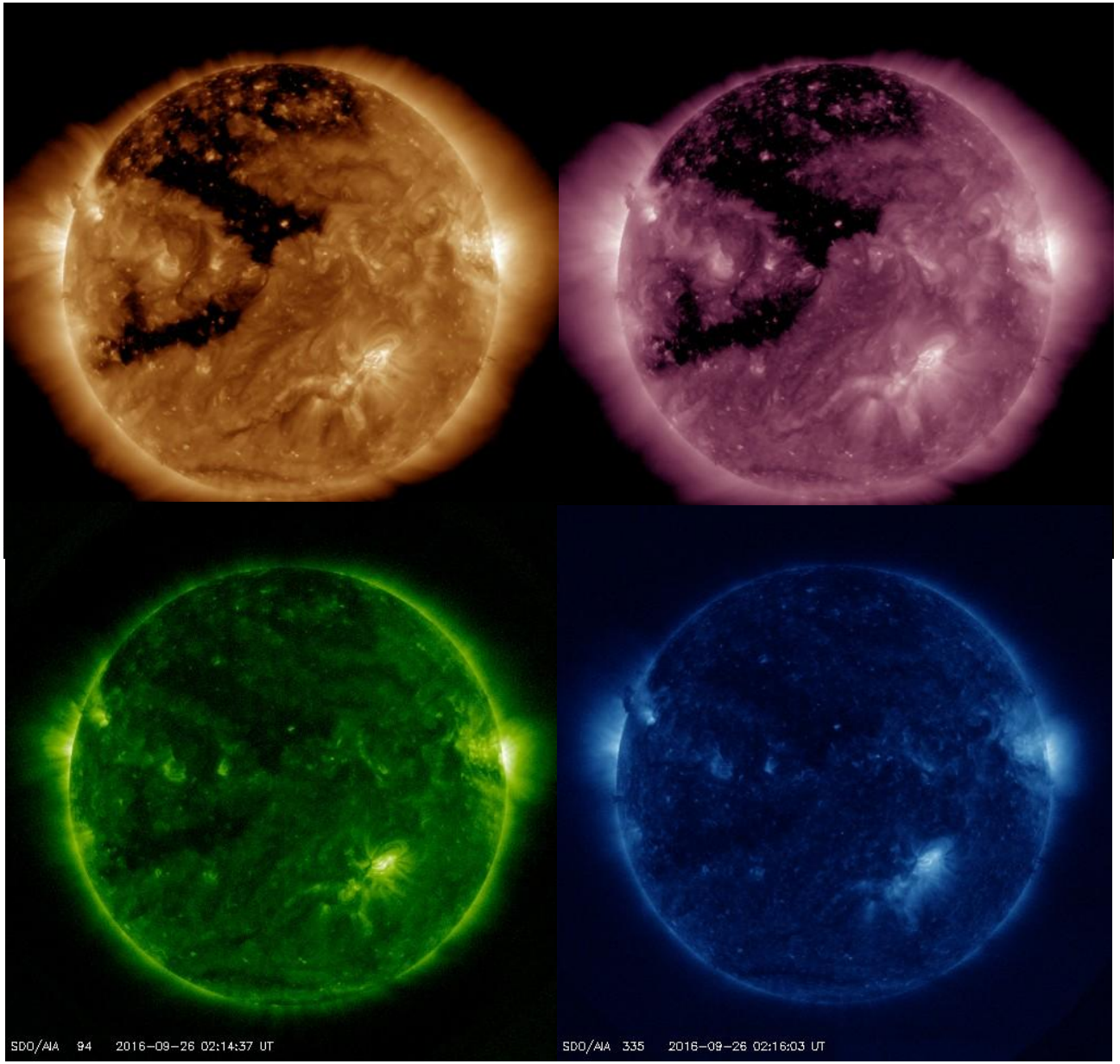
Outline

- Coronal Bright Points
- Dataset, SDO/AIA, method
- Solar velocity field
- CBP proper motions and random walk model
- Diffusion of magnetic elements
- Comparison with other measurements
- Conclusion

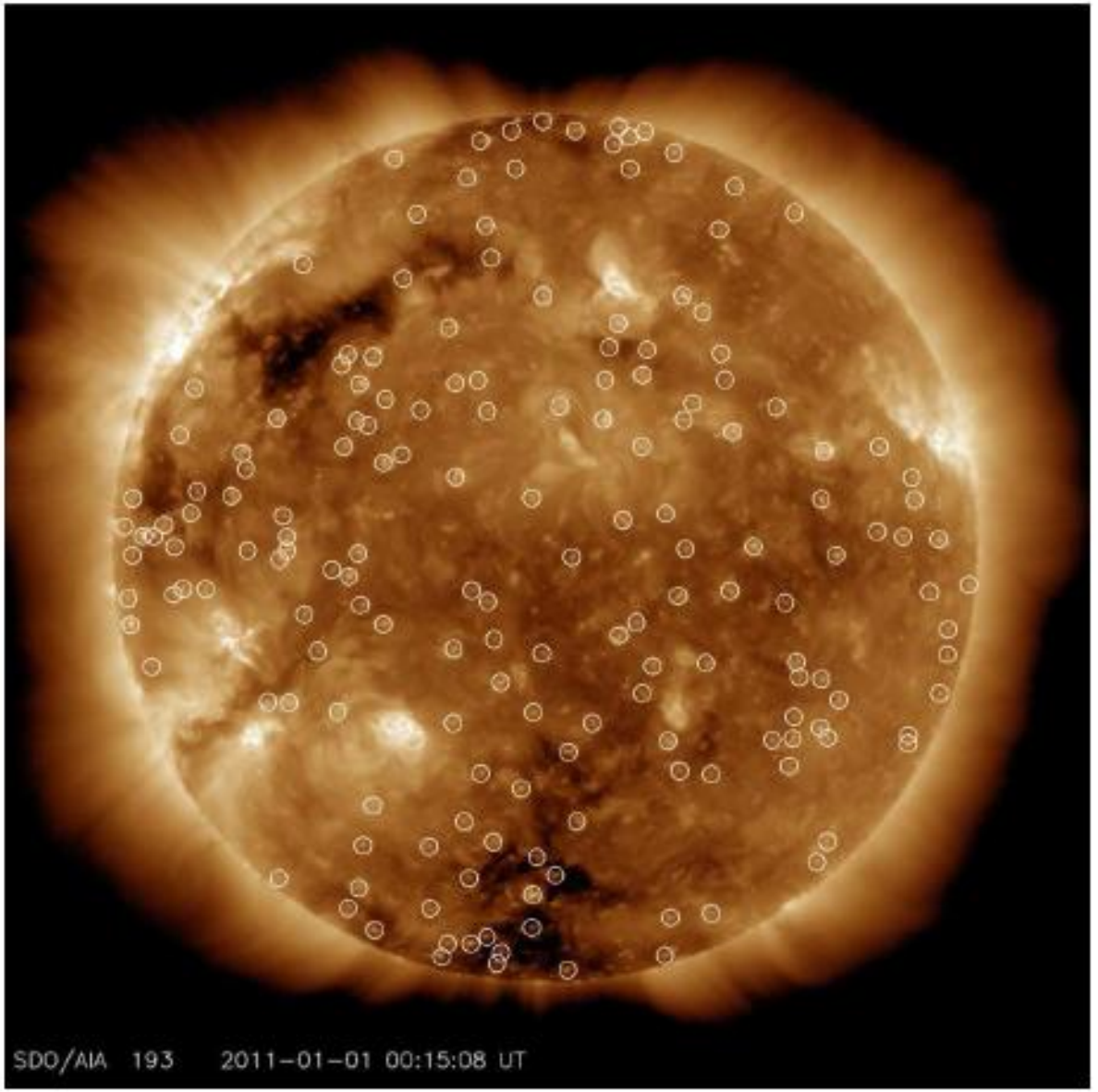
Coronal Bright Points (CBPs)?

- small bright structures in lower corona
- visible in EUV and X-ray images
- associated with small magnetic bipolar regions in the photosphere
- lifetime from few minutes to several days
- several hundred CBPs present on the Sun every instant

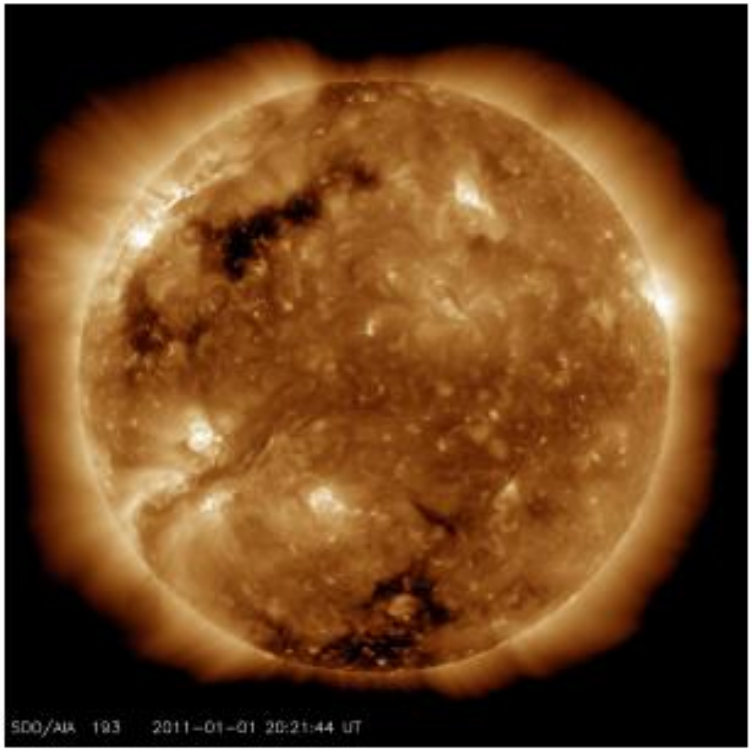


Data – Solar Dynamics Observatory

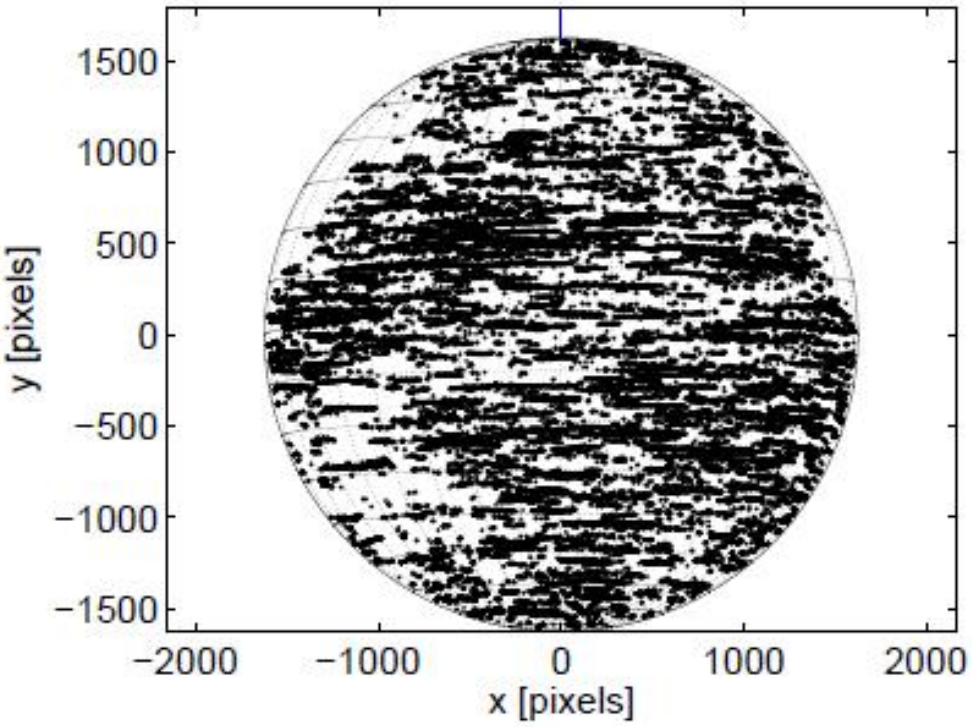
- SDO/AIA, 19.3 nm channel
- segmentation algorithm, modification of the McIntosh and Gurman (2005) (Martens et al. 2012)
- t ~ 5 months
- cadence 10 min
- processing, height correction, outlier removal, etc.



Data – CBP distribution

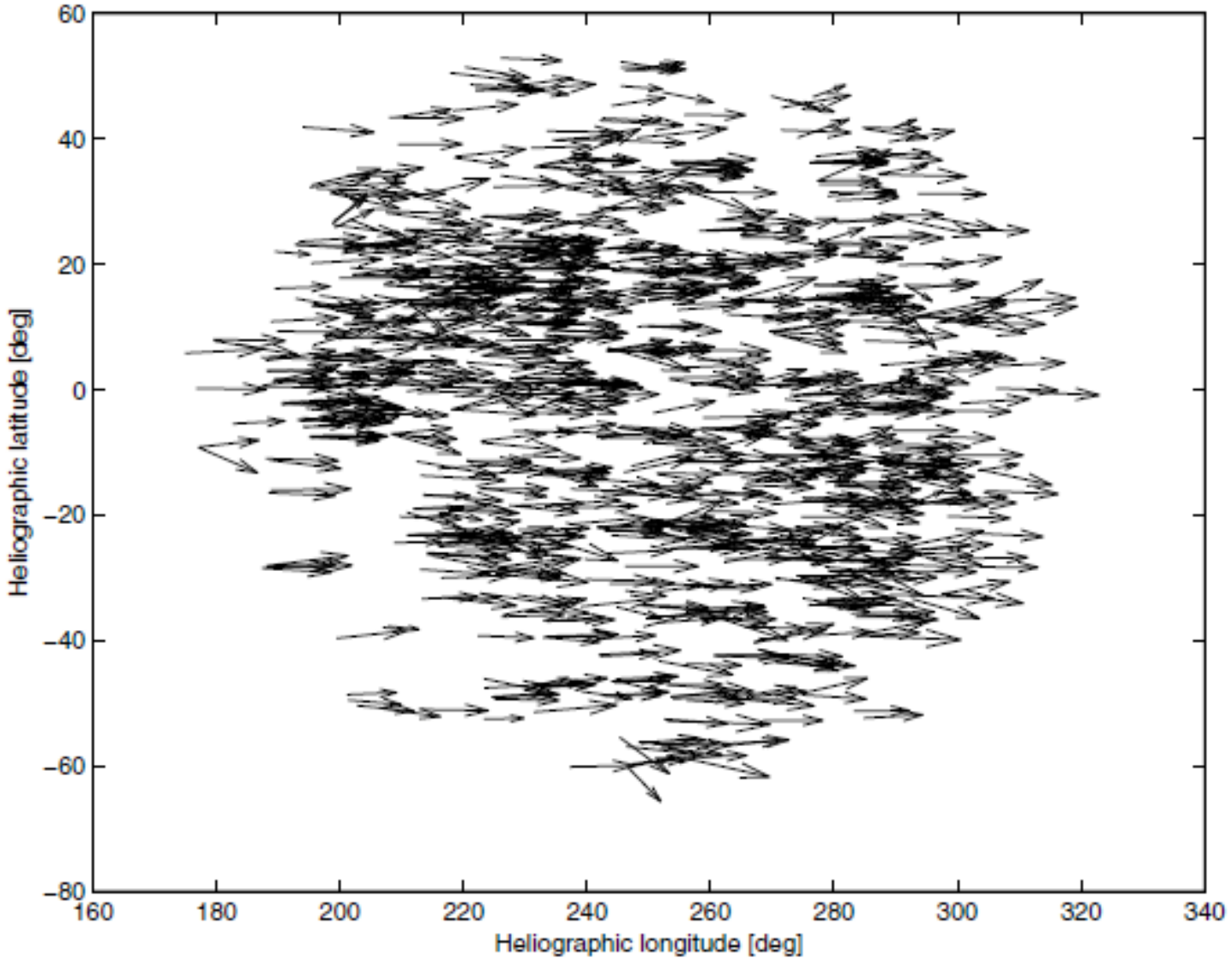


(a)



(b)

Data – velocity field

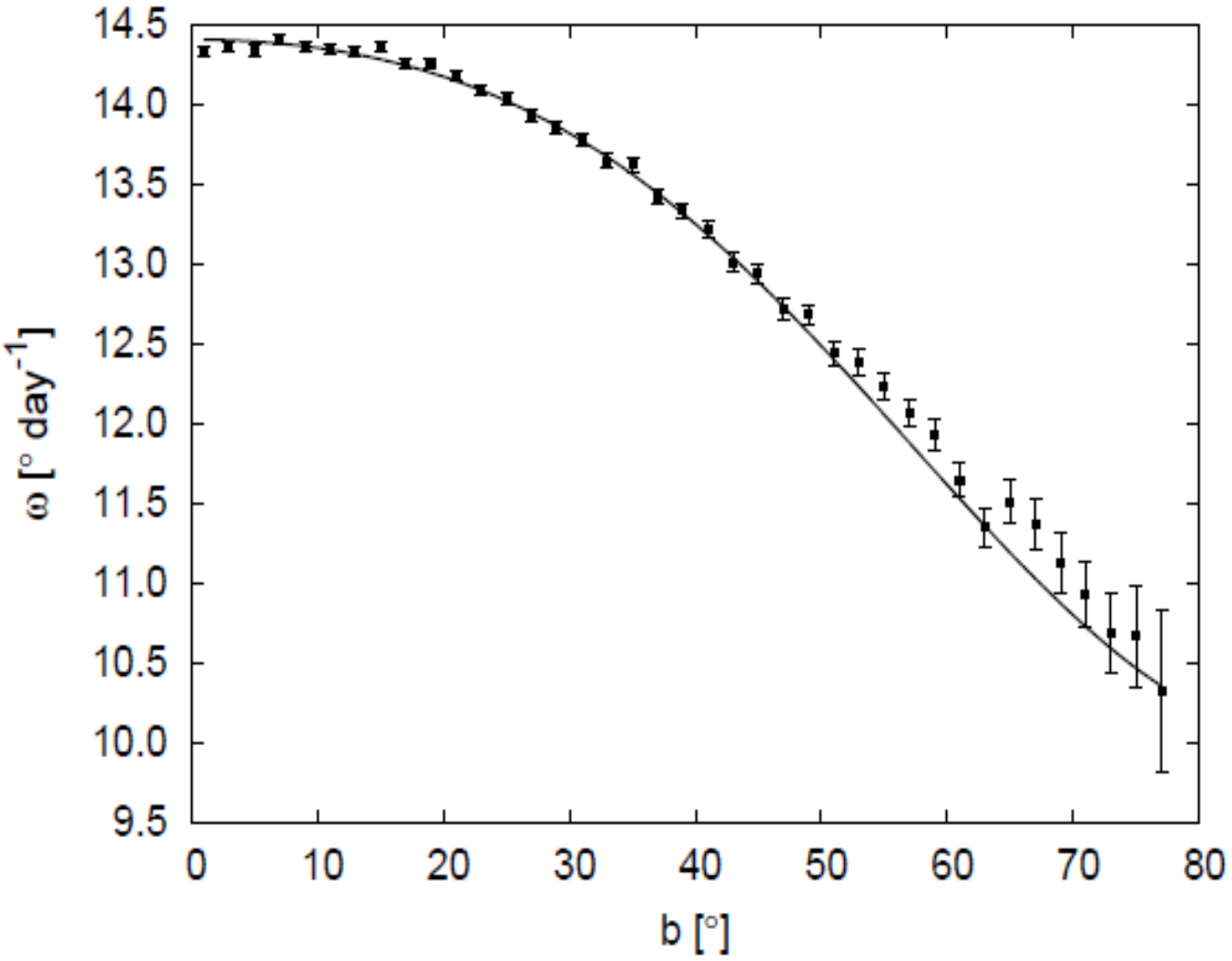


CBP derived differential rotation profile

Sudar et al. (2016)

A = 14.406 ± 0.005
B = − 1.66 ± 0.05
C = − 2.74 ± 0.08

n 80 966
t ~ 5 months

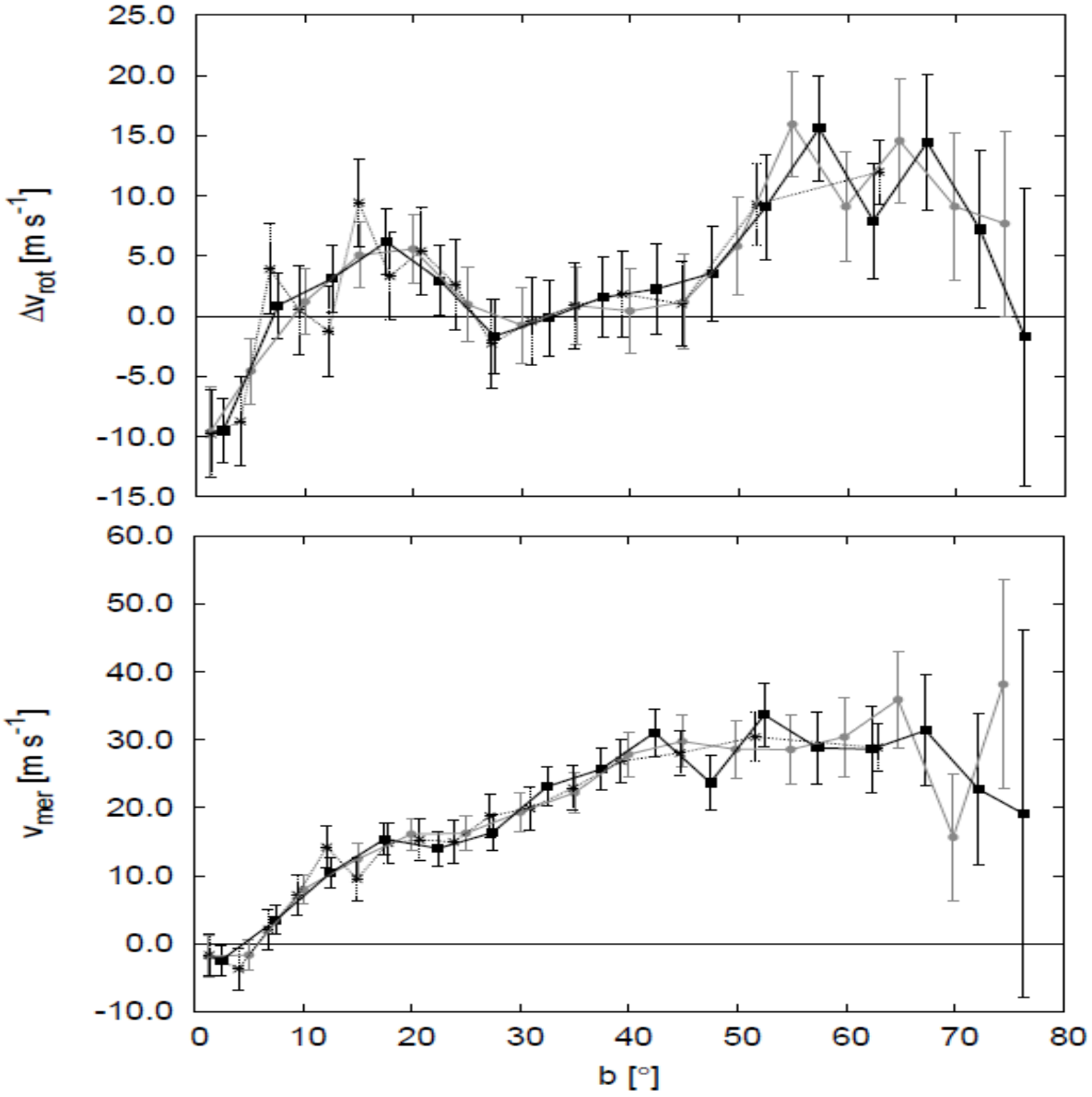


Residual rotational and meridional velocities

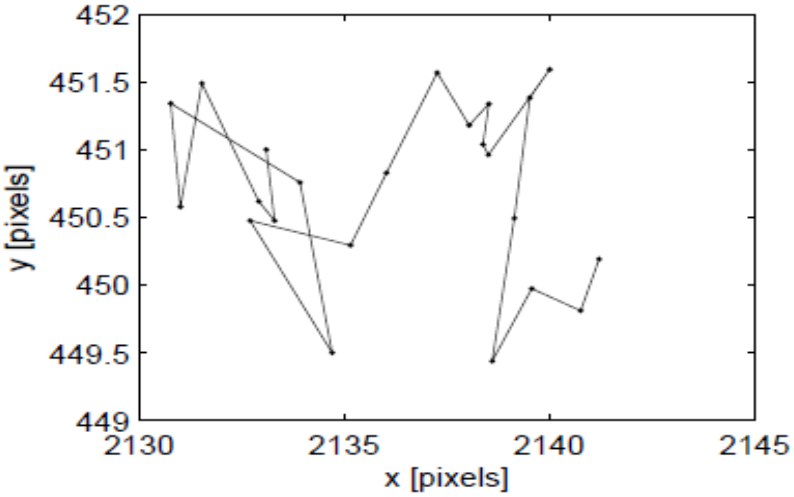
Δv_{rot} – signs of torsional oscillation pattern

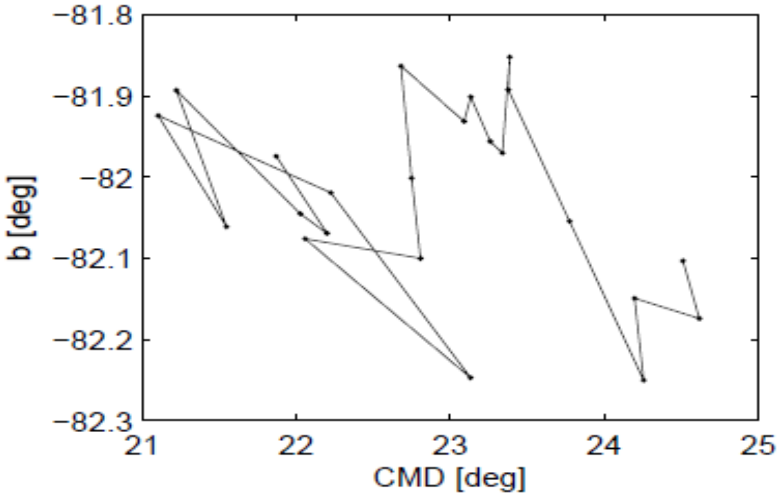
v_{mer} – predominantly polar flow in agreement with Doppler measurements

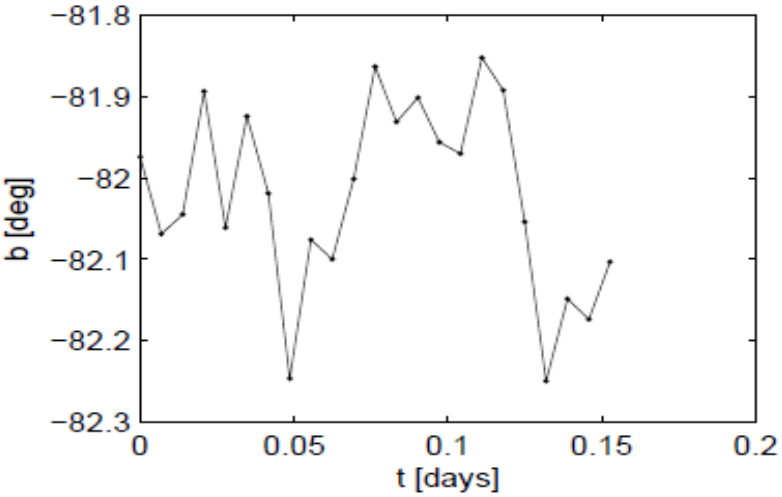
Sudar et al. (2016)

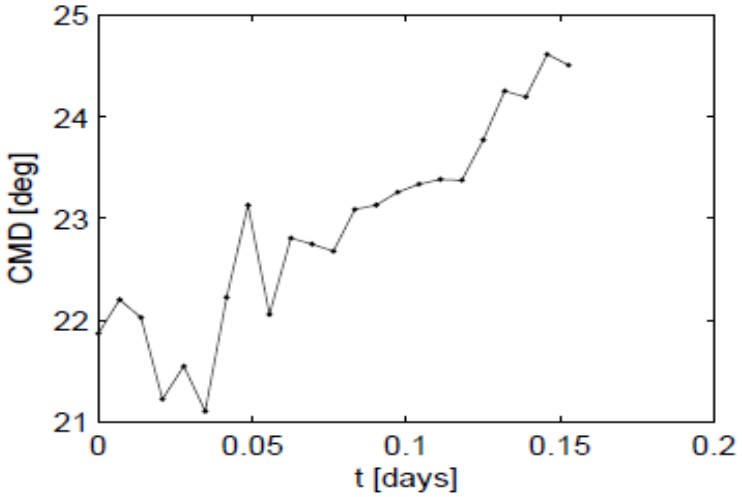


Motion of the individual CBP





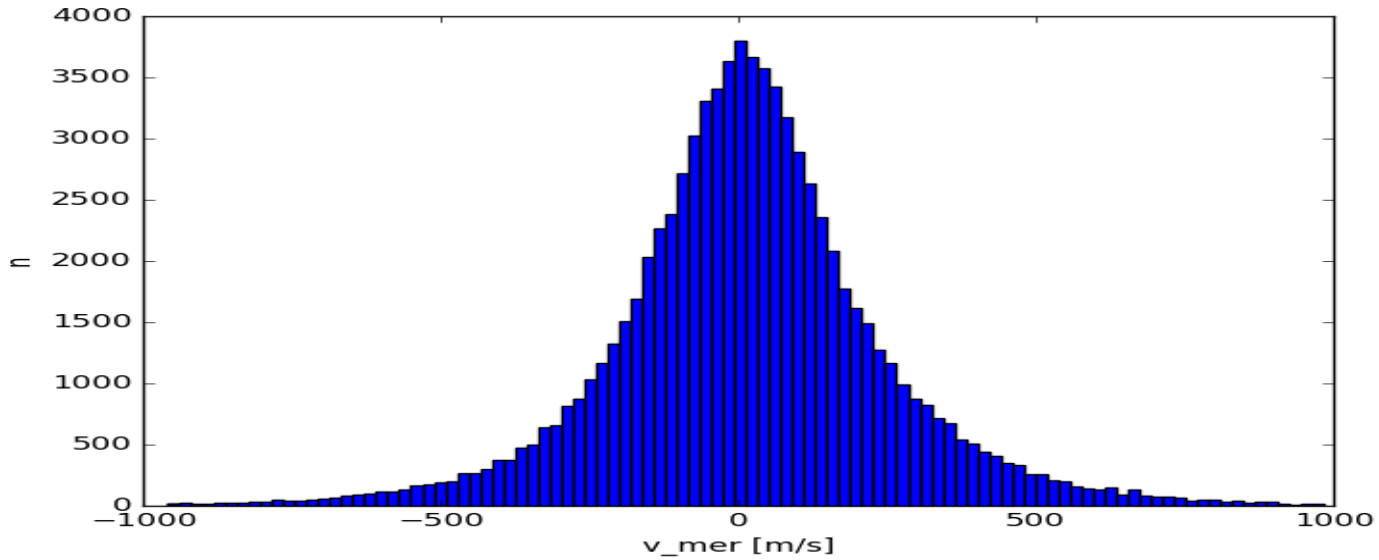


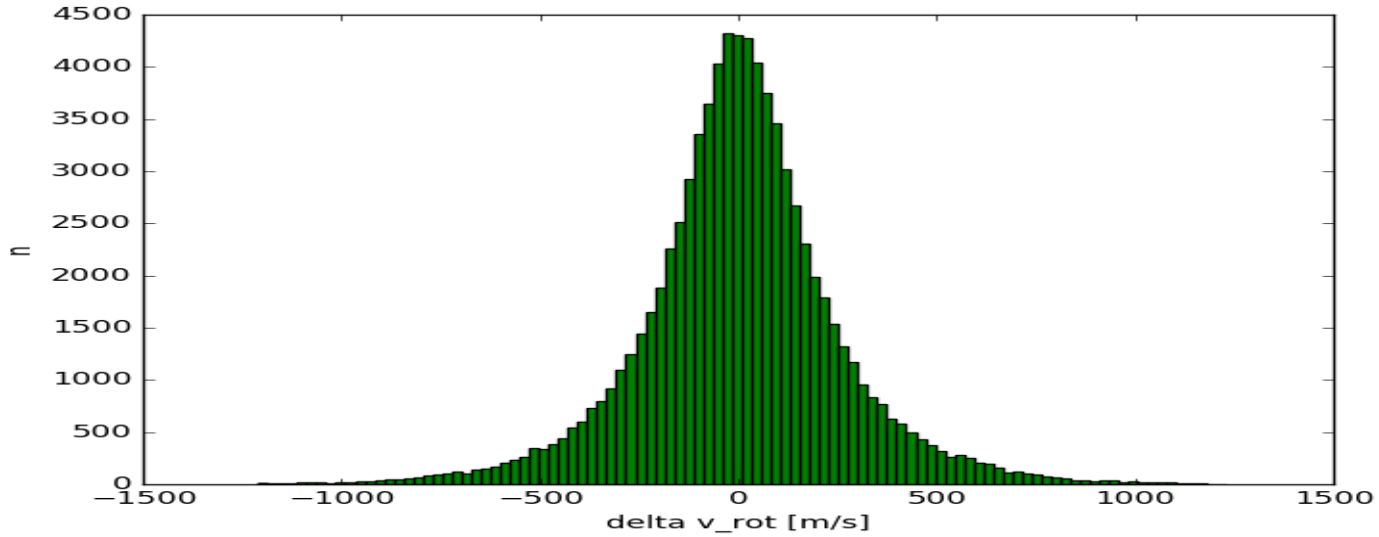


Random walk model

- CBPs as ”atoms” – tracers of small magnetic elements (Leighton, 1964)
- displacement proportional to the square of elapsed time
- lifetime τ, velocity v
- Mean free path $l = \tau \cdot v$
- Diffusion coefficient $D = \frac{\langle l^2 \rangle}{4\tau}$

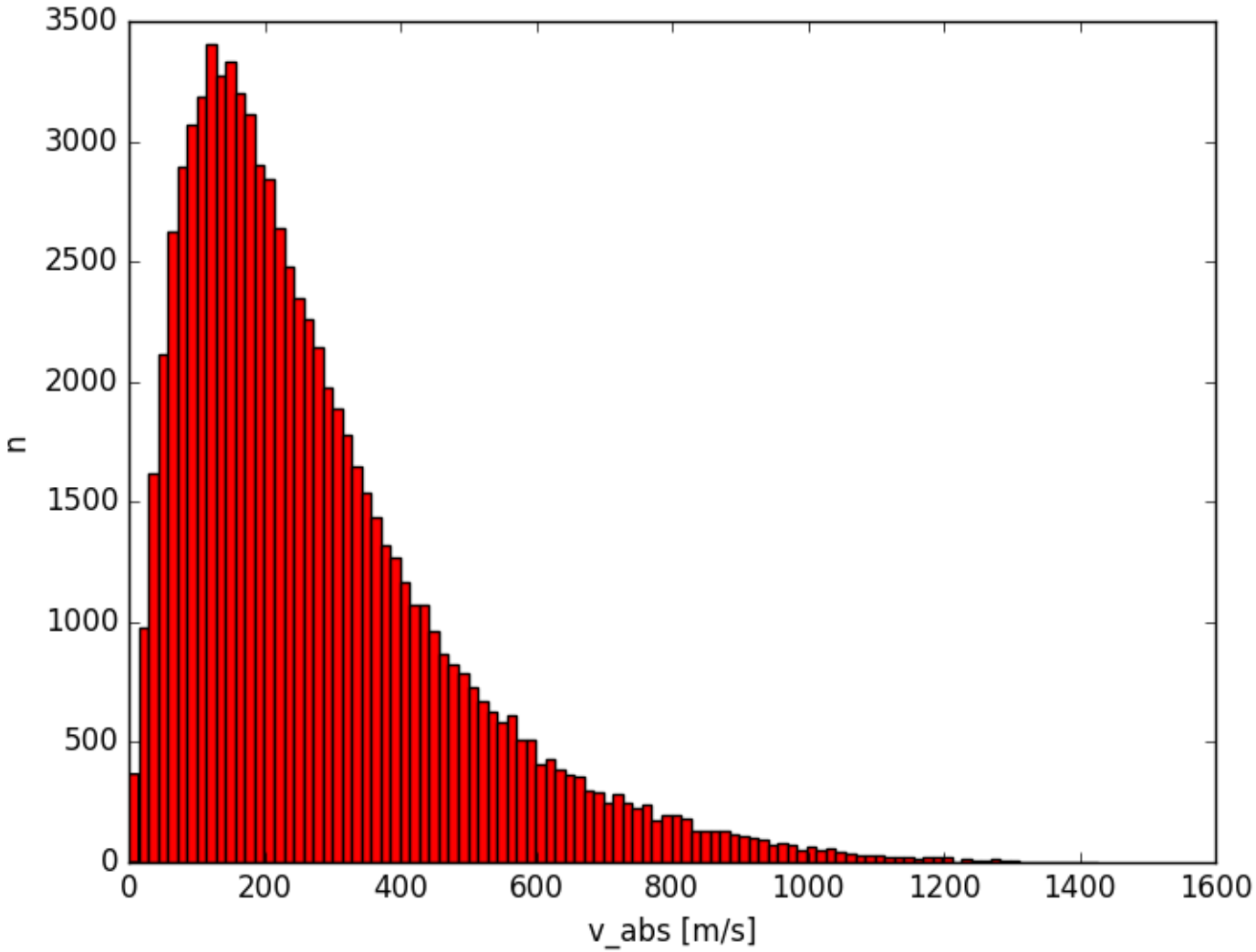
Velocity distributions



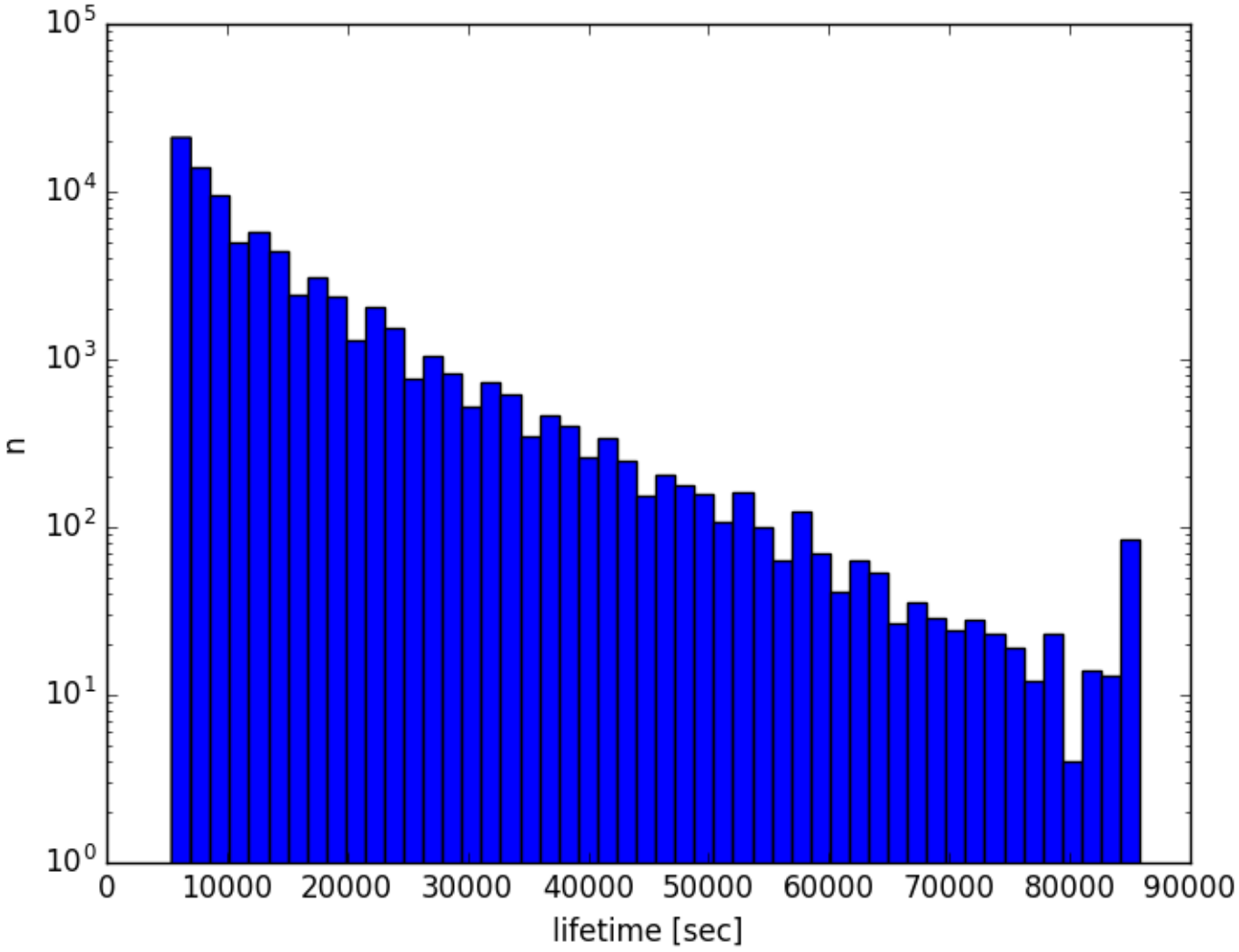


Absolute velocity

$$v_{abs} = \sqrt{v_{mer}^2 + \Delta v_{rot}^2}.$$



Data – Solar Dynamics Observatory, AIA



Resuls

- Complete dataset
  n = 80966, l ~ 3000 km, D ~ 250 km^2/s

Source	l [km]	τ [h]	D [km^2 s^{-1}]
Brajša *et al.* (2008)	5200	12	160
Brajša *et al.* (2008)	8600	30	170
Brajša *et al.* (2008)	15100	60	260
Hagenaar *et al.* (1999)		< 3	70-90
Hagenaar *et al.* (1999)		> 8	200-250
Iida (2014)		6	200
DeVore *et al.* (1985)			200-400
Wang (2004)			500-600

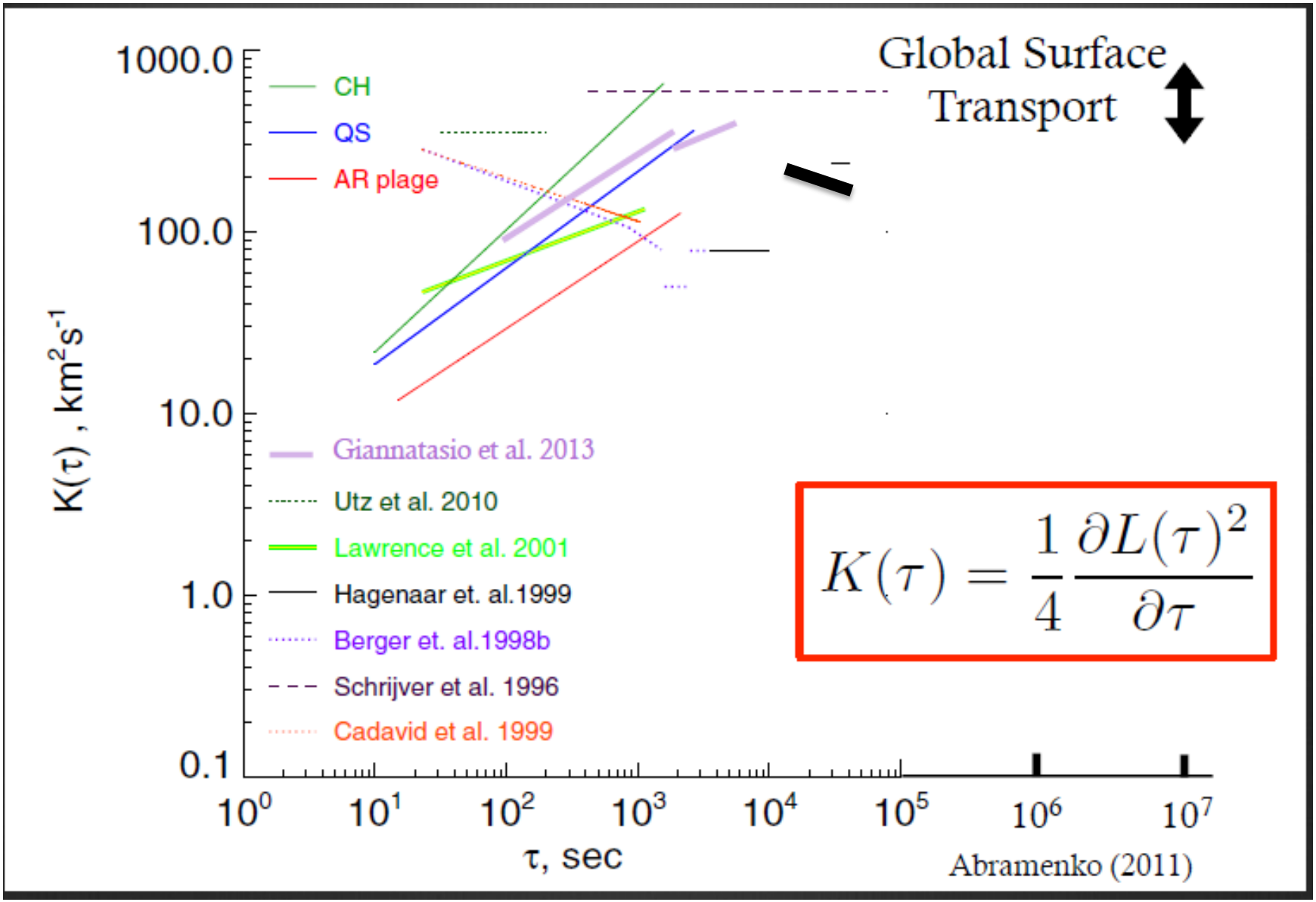
Resuls

- Over different lifetimes:

- 0..6h: n = 69603, l ~ 2800 km, D ~ 250 km^2/s
- 6..12h: n = 9475, l ~ 4000 km, D ~ 170 km^2/s
- 12..18h: n = 1551, l ~ 5100 km, D ~ 150 km^2/s
- 18..24h: n = 337, l ~ 6100 km, D ~ 140 km^2/s

- similar trend observed in two-day SDO data (Brajša et al. 2015)

Comparison with other measurements (Iida, 2014)



Conclusions

- a preliminary analysis
- CBPs good tracers of the solar velocity field (spatial and temporal coverage)
- studies of short-term variations of differential rotation and meridional motions
- better understand CBP formation, structure and evolution
- Random walk model applied to SDO CBP data results in diffusion coefficient
  $D = 150\text{-}250\ km^2/s$,
- D varies over different scales
- in general agreement with other measurements but not with simulations