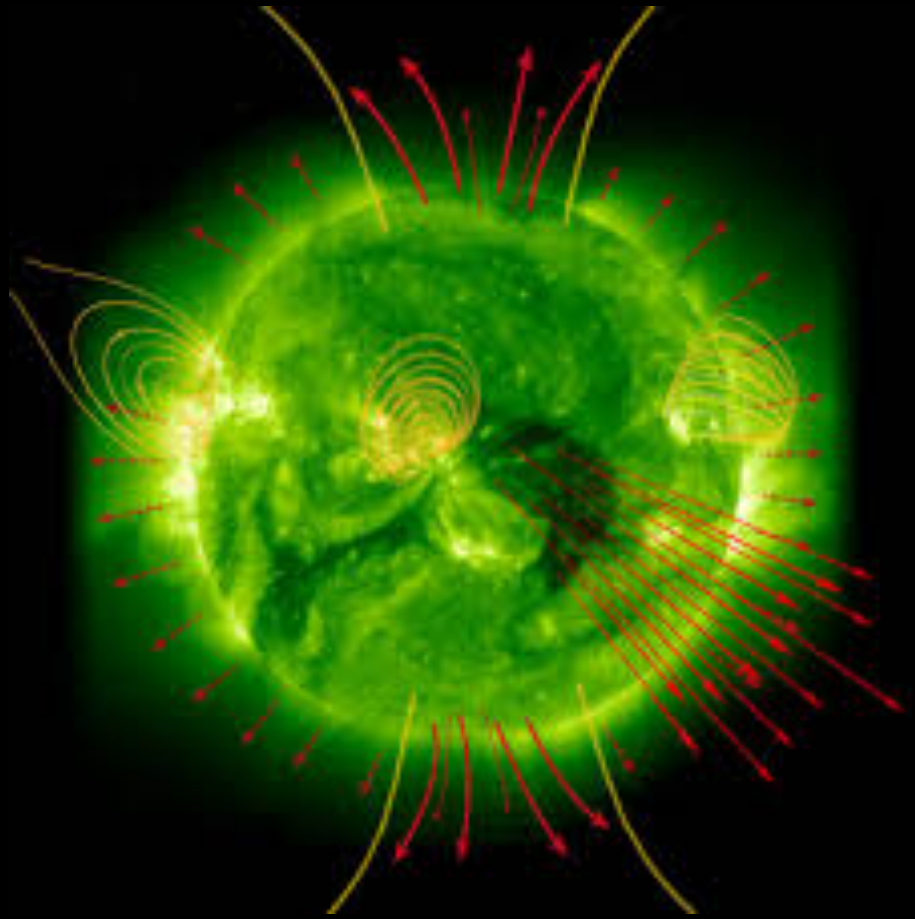
Predicting the wind speeds of solar-like stars



Moira Jardine, Victor See, Aline Vidotto

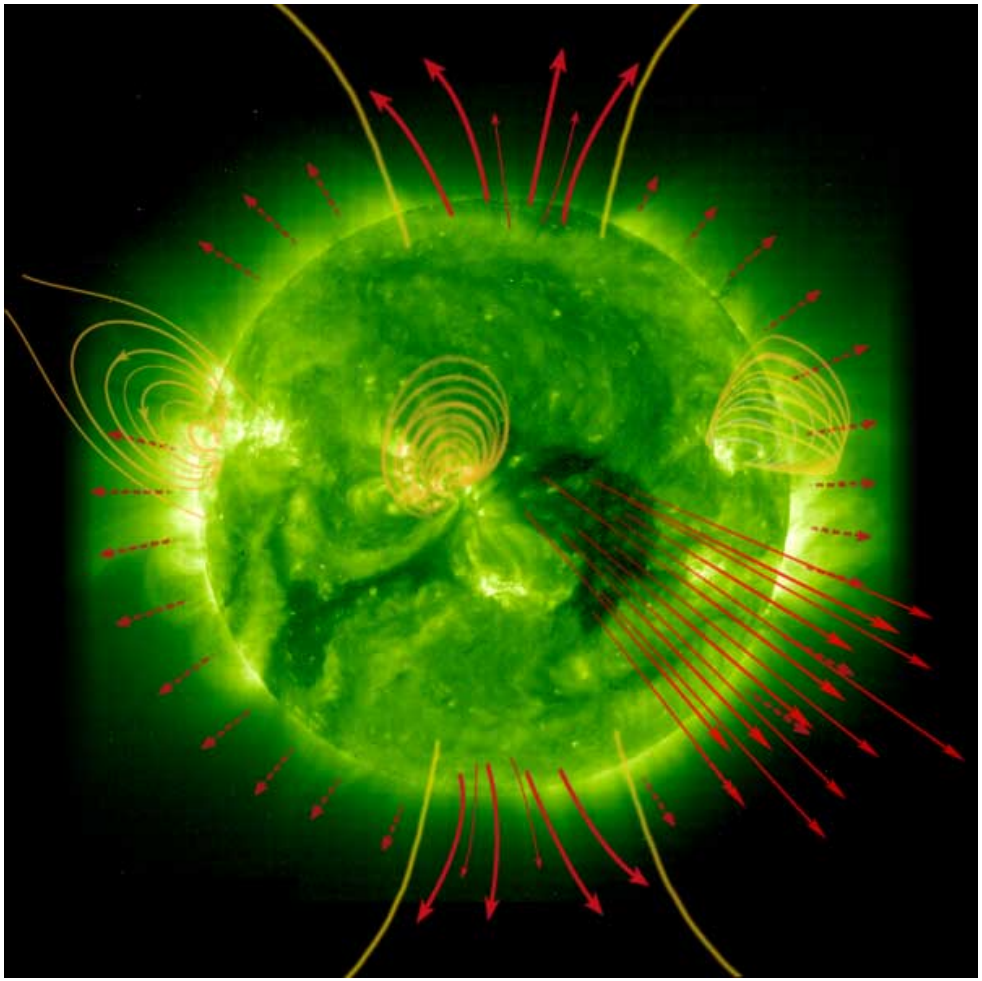
Solar wind speed can be calculated from the expansion factor (f_i) of flux tubes

Wang-Sheeley-Arge (WSA) model

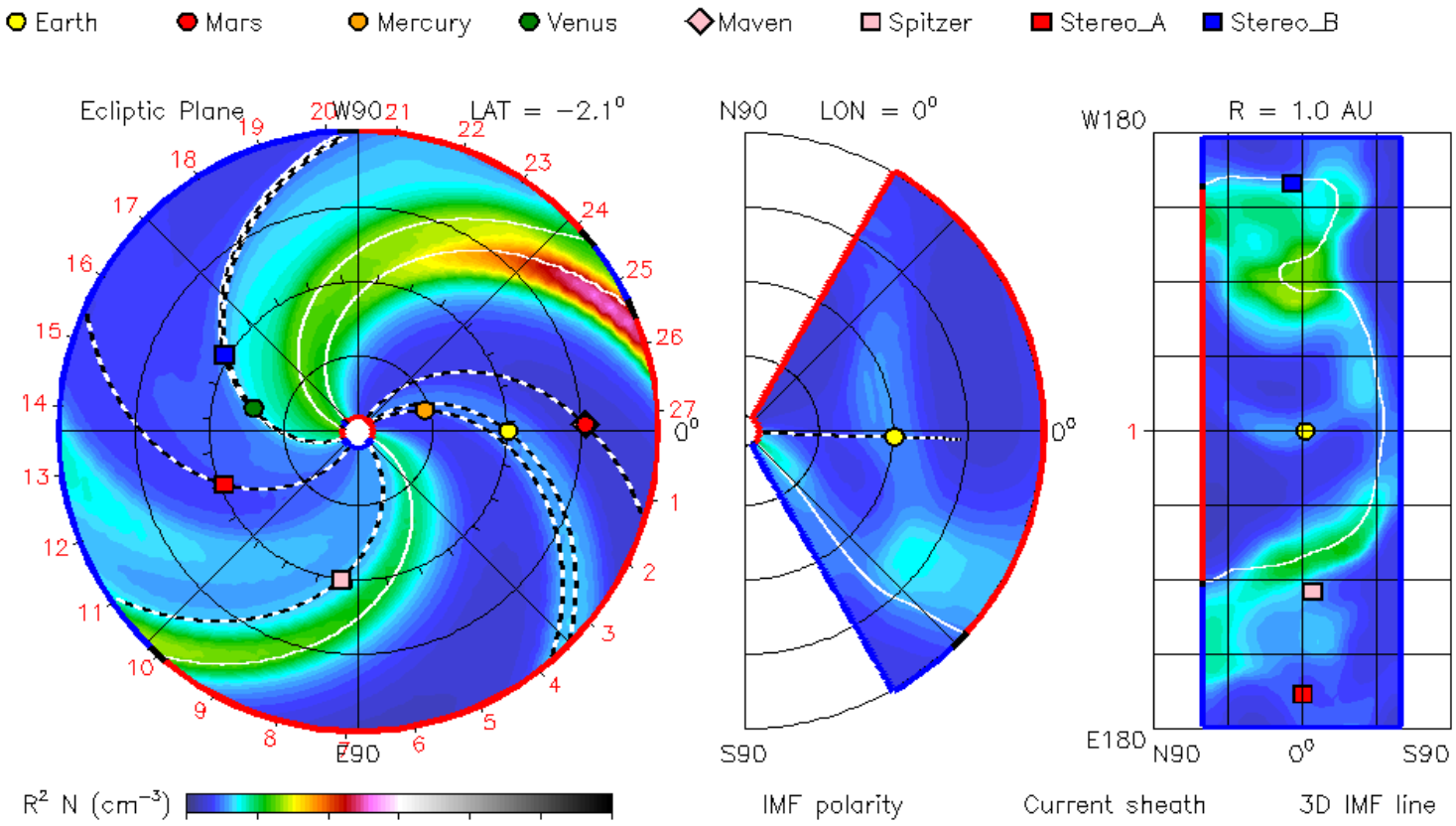
(Wang & Sheeley 1990,1992; Arge & Pizzo 2000)

$$f_i = \frac{\left(B_i r^2\right)_{r=r_{Sun}}}{\left(B_i r^2\right)_{r=2.5 r_{Sun}}}$$

$$u = 267.5 + \frac{410.0}{f_i^{2/5}}$$



Forecasting space weather using WSA/ENLIL model

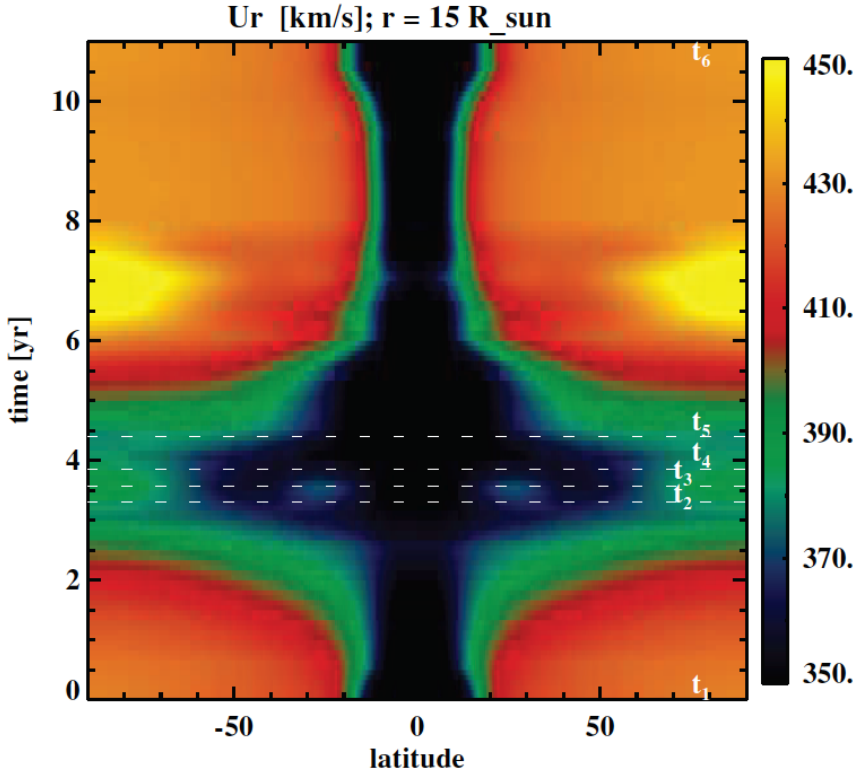


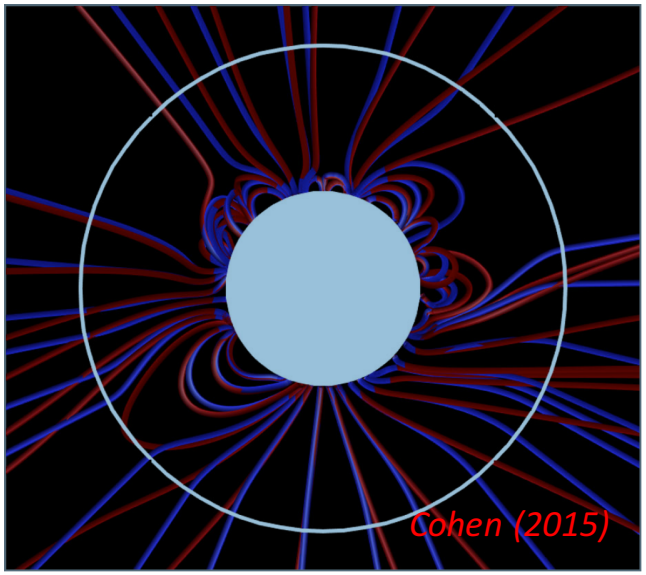
https://www.spaceweatherlive.com

Gressl + 2014 – comparison of various models with in-situ spacecraft data – general background structure similar, propagation times differed

WSA: Comparison with MHD models

- *Cohen 2015* – compared MHD with Wang-Sheeley-Arge – improving resolution from ~2°-1° has little effect on wind speeds

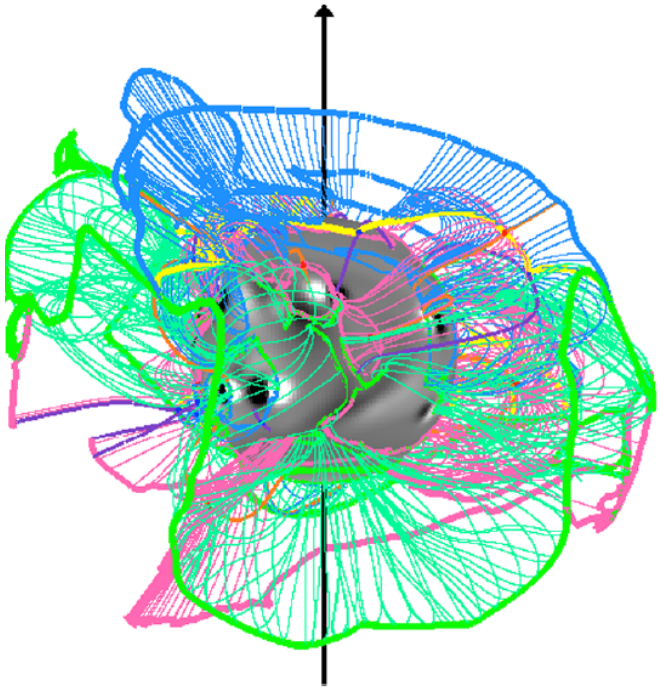


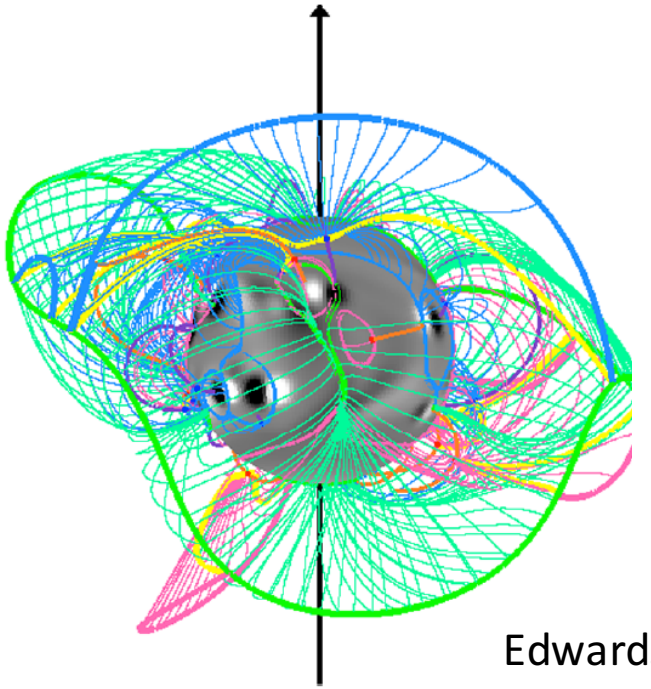


Blue (PFSS); Red (MHD) for CR 1958 (MDI)

Pinto+2011,2016 – MHD models through solar cycle to investigate role of flux tube expansion

Different modelling methods

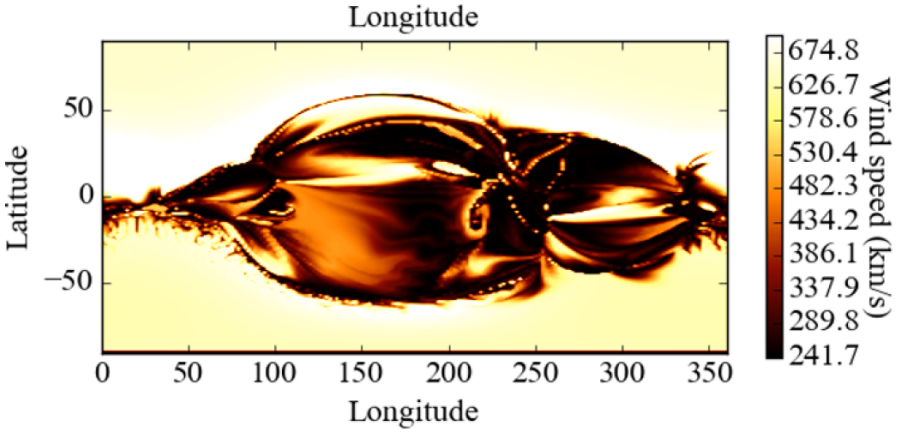


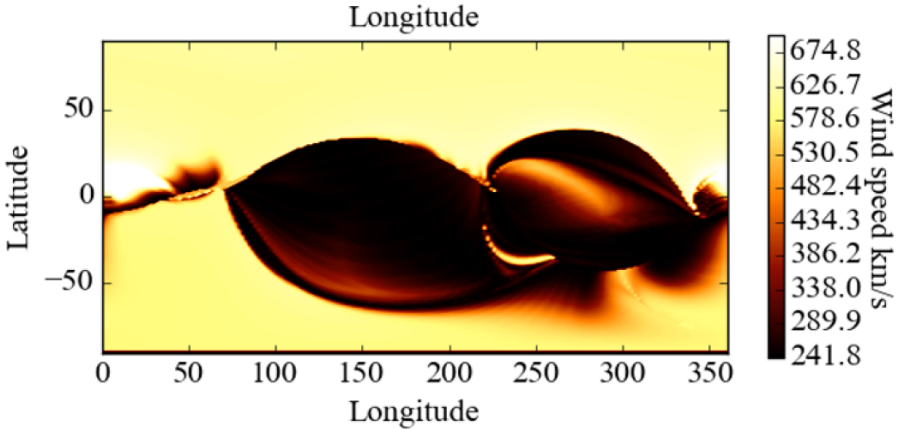


Edwards+ 2015

Magnetofrictional (non-potential)

Potential Field Source Surface

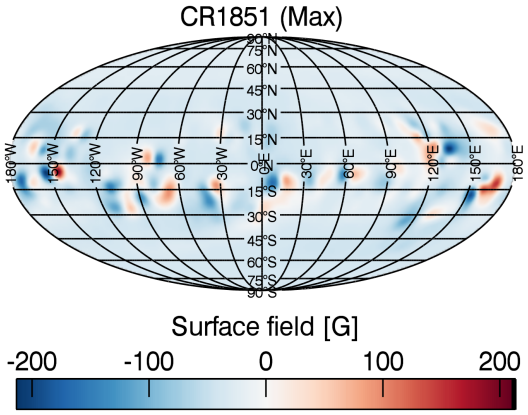


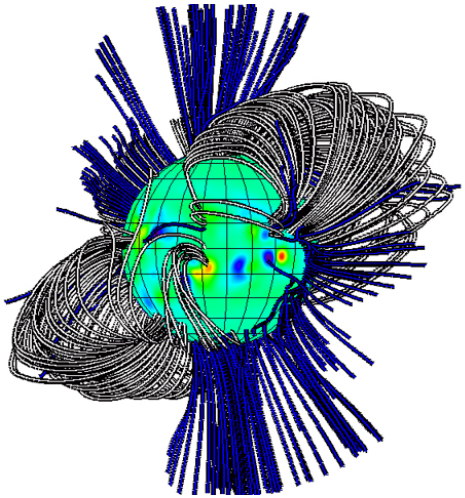


Can we use this method for stellar winds?

Solar

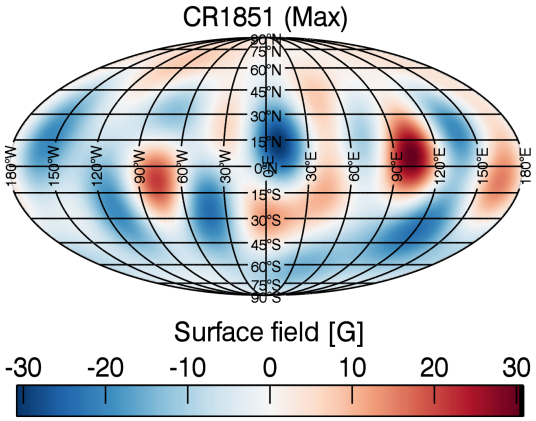
Spatial scale > 3°

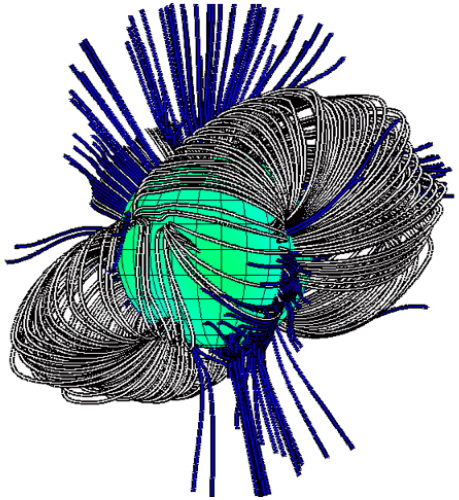




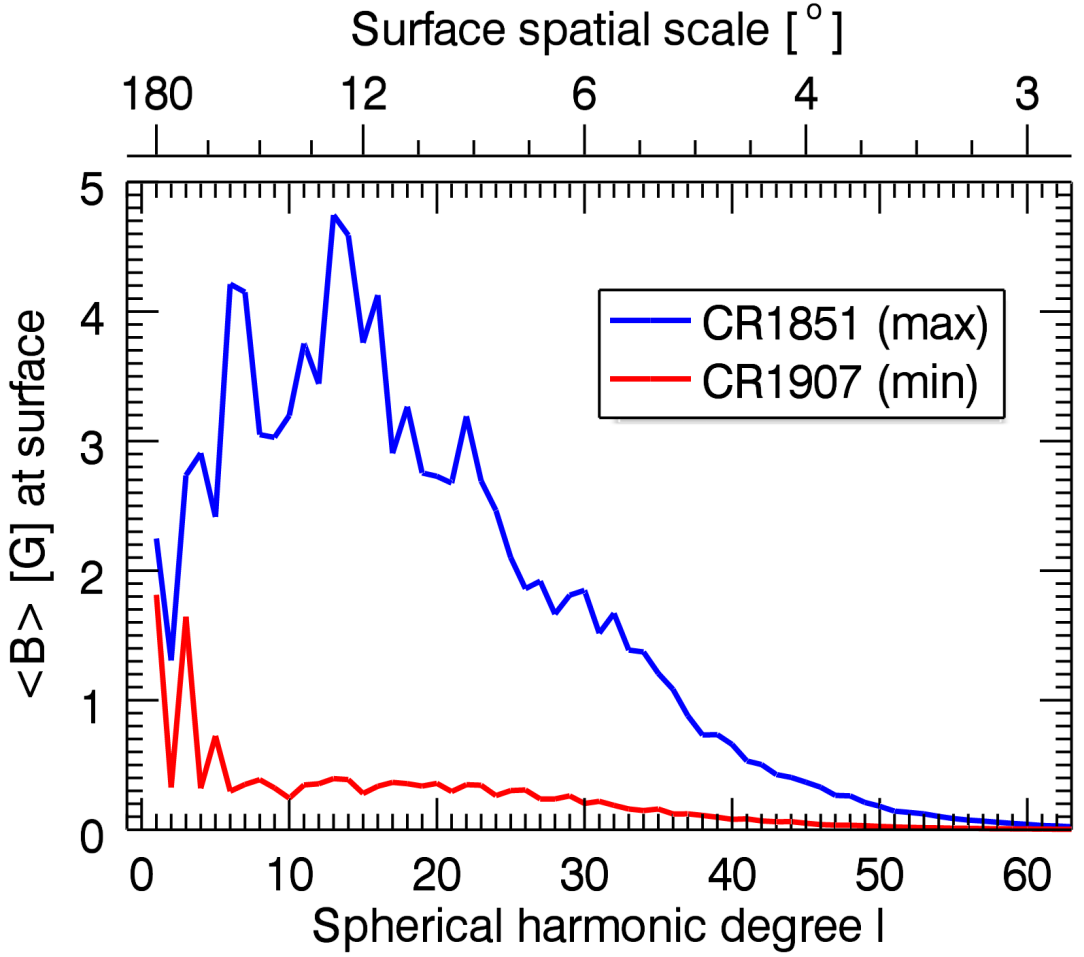
stellar

Spatial scale > 30°



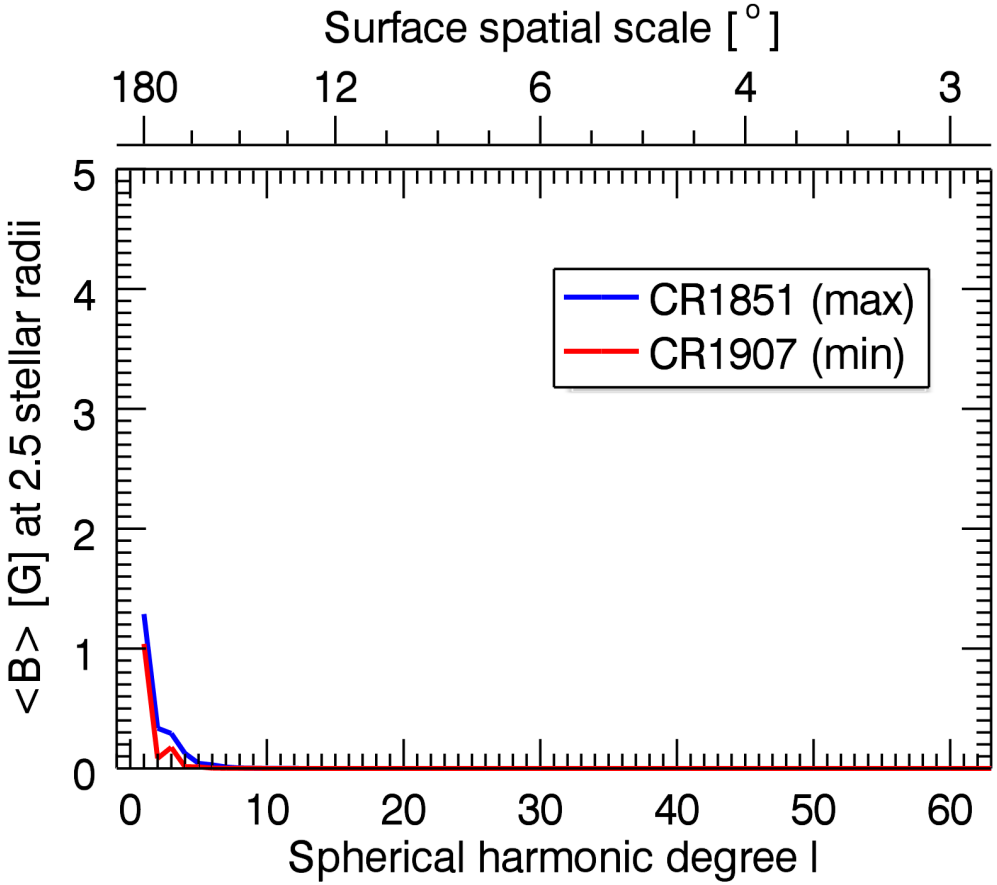


At the surface, sunspots contribute "small-scale" structure.



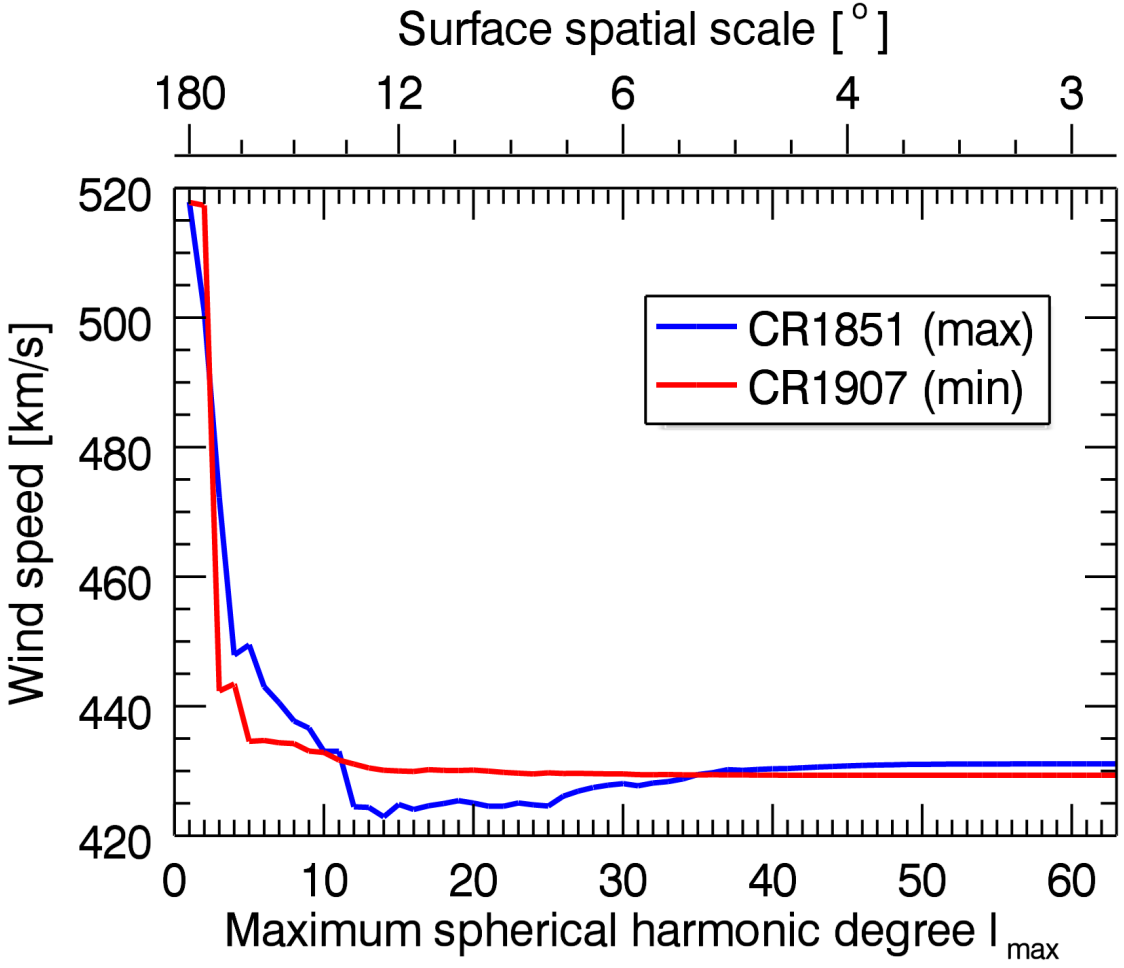
- *Around cycle maximum*
  - peak <B> seen in the sunspot pairs, which appear at a spatial scale of 14° ie l ~ 13.
- *Around cycle minimum*
  - only the dipole and low-order modes contribute significantly.

In the wind region, only low-order (large-scale) modes contribute.



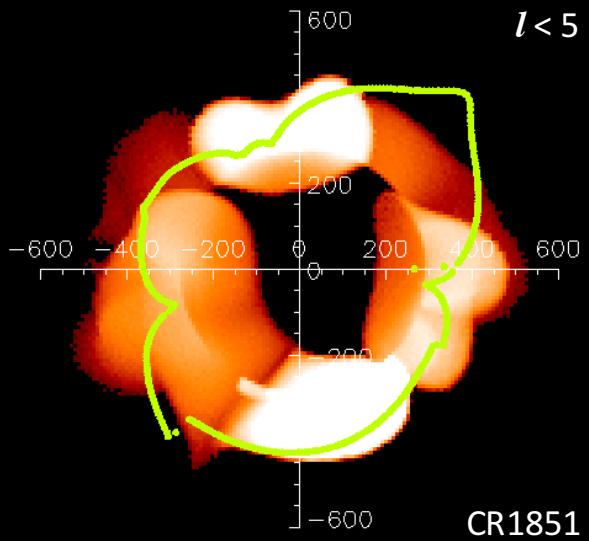
- At 2.5 stellar radii, the field is all open and supports the wind.
- Only modes with $l < 5$ (corresponding to spatial scale of around 30^o) have any significant power.
- Little variation over cycle

Average wind speed changes little above resolutions of better than 20°

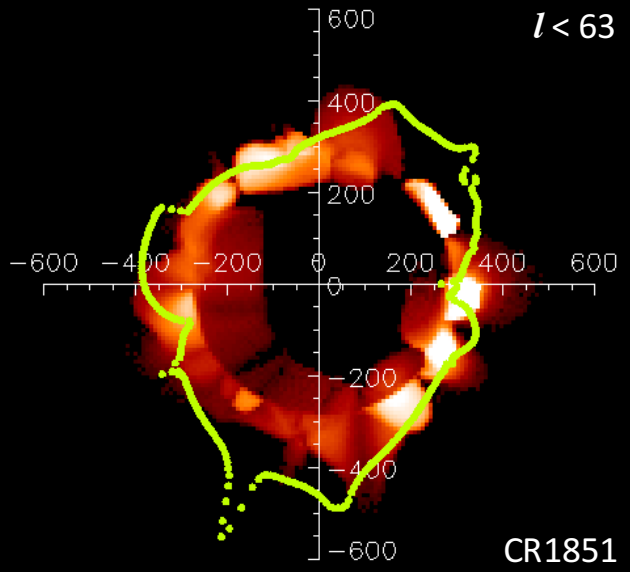


Predicted L_x higher at higher resolution

Spatial scale < 30°

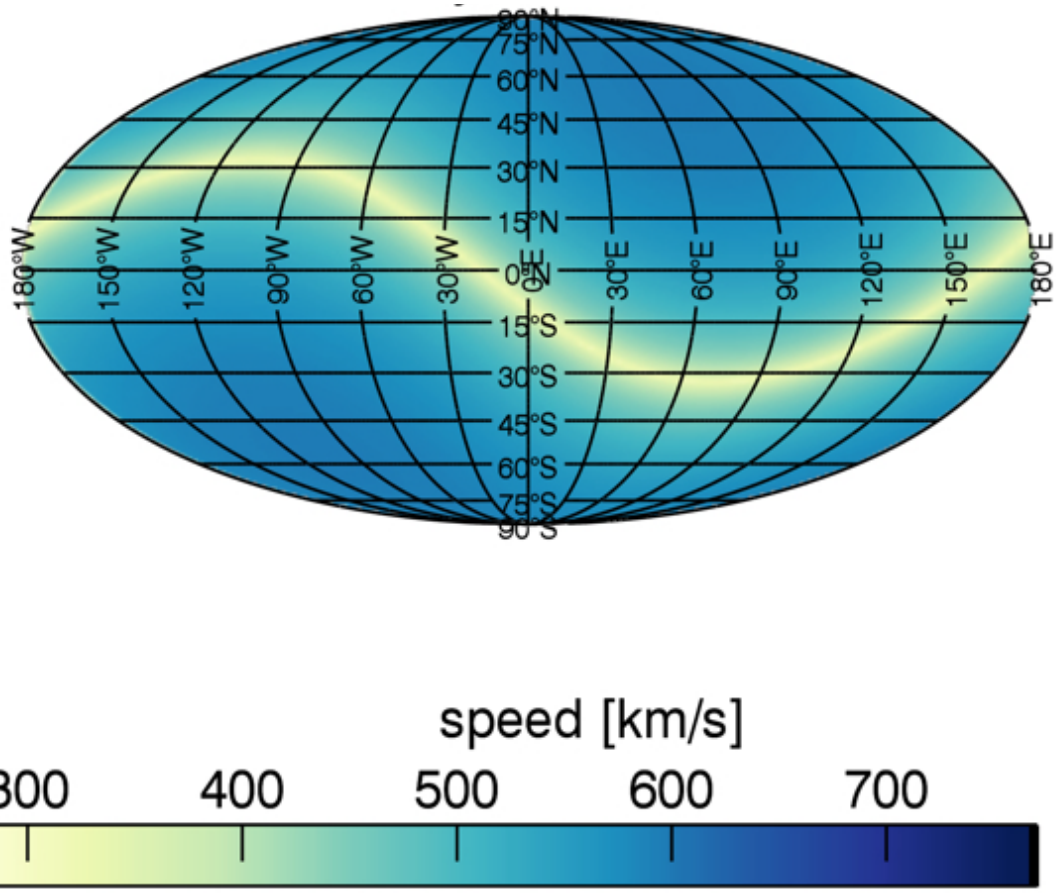


Spatial scale < 3°



Rotational modulation of L_x also increases
(see also Garrafo+ 2013)

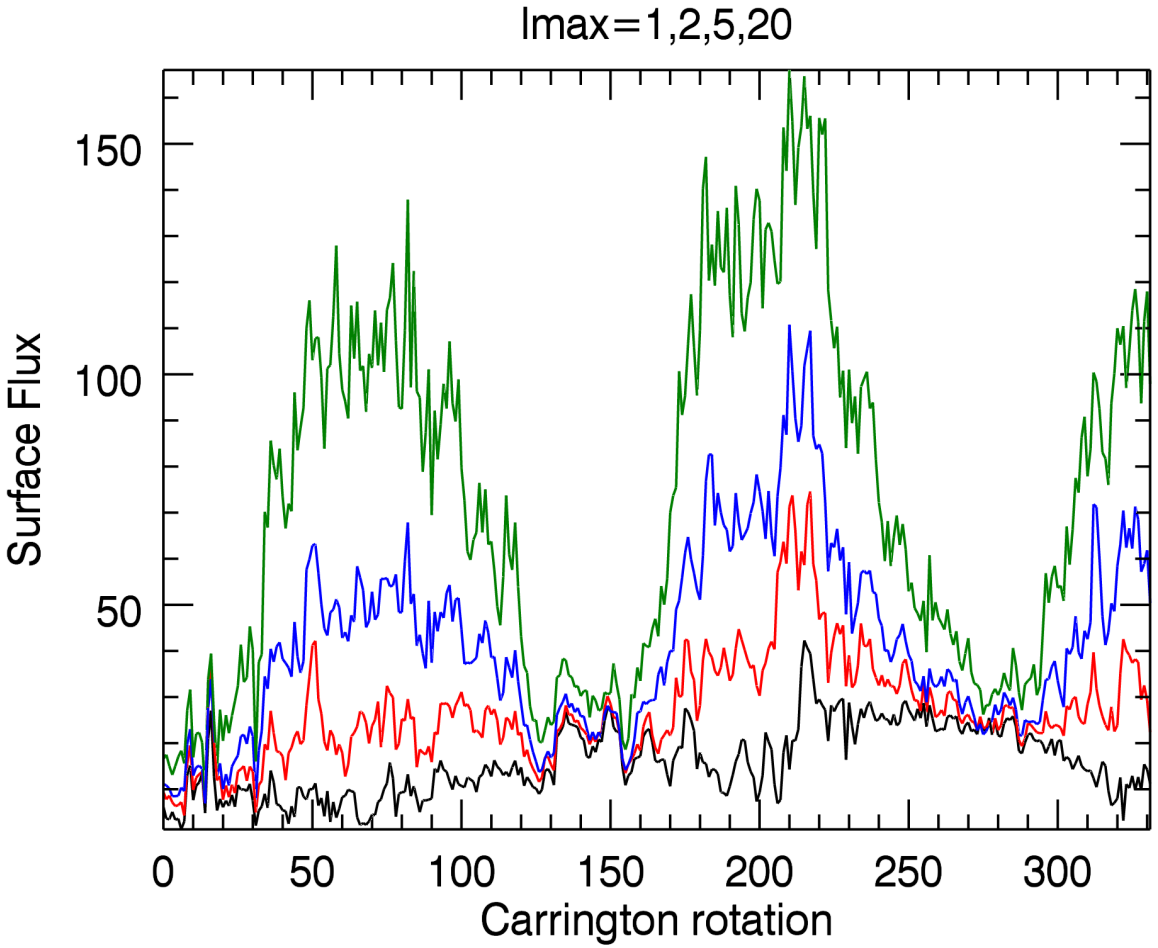
Stellar magnetograms from ZDI recover well the average wind speed



Need a job?
Like magnetic fields?

- Post-doc position available at St Andrews
- Starting earliest Sept 2016
- Come and see me or email:
- mmj@st-andrews.ac.uk

Variations through the cycle



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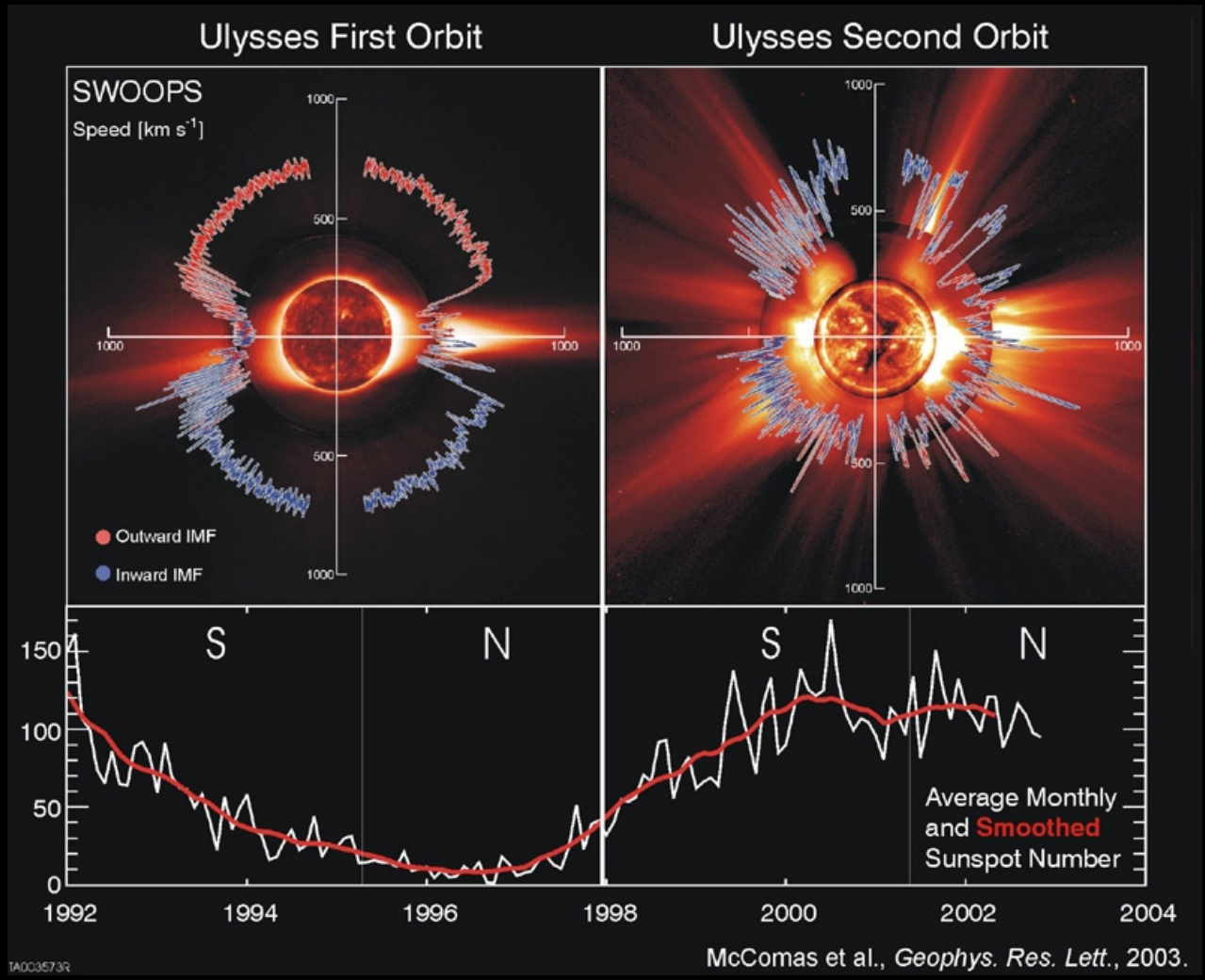

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