Geomagnetic Measurement of the Rotation Rate of the Sun’s Radiative Interior

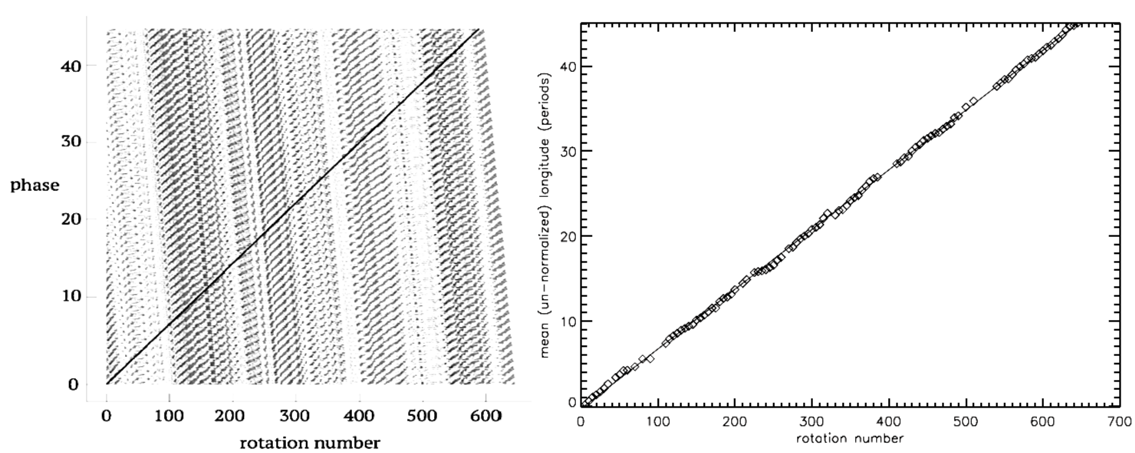
D.O. Gough, Is the Sun a Magnet? *Solar Phys* (2017) 292:70;
DOI 10.1007/s11207-017-1088-1:

“It has been argued (*Gough and McIntyre* in Nature **394**, 755, 1998) that the only way for the radiative interior of the Sun to be rotating uniformly in the face of the differentially rotating convection zone is for it to be **pervaded by a large-scale magnetic field**, a field which is responsible also for the thinness of the tachocline. It is most likely that this field is the predominantly dipolar residual component of a tangled primordial field that was present in the interstellar medium from which the Sun condensed (*Braithwaite and Spruit* in Nature **431**, 819, 2004).”

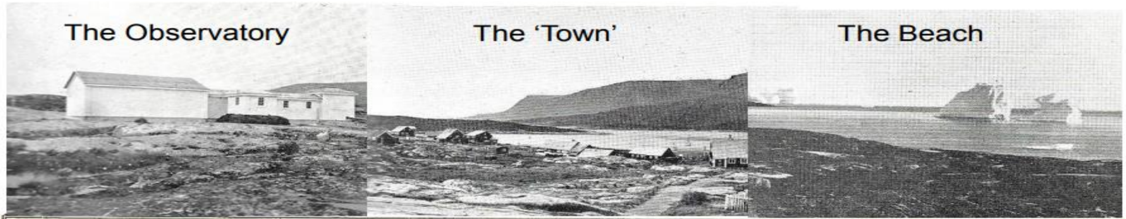
D. Gough, A Brief History of Our Perception of the Solar Tachocline;
Astro Fluid 2016: A.S. Brun, S. Mathis, C. Charbonnel and B. Dubrulle (eds)
EAS Publications Series, 82 (2019) 295–310:

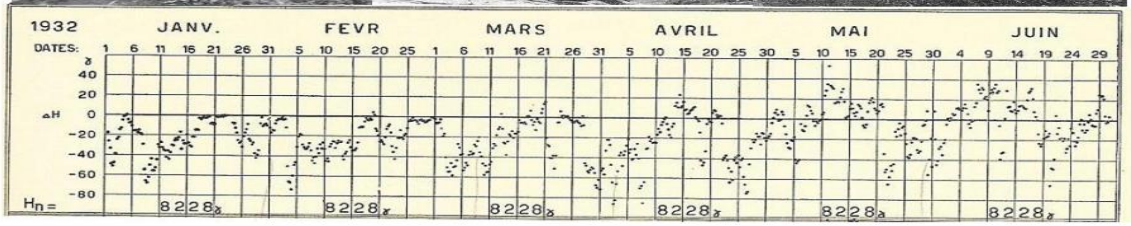
“If the interior magnetic dipole is aligned with the latitude of zero vertical shear in the tachocline one might expect an observable nonaxisymmetric consequence, rotating more-or-less at the speed of the radiative envelope, yet on average maintaining phase. […T]here is an interesting study by *Leif Svalgaard and John Wilcox* (1975) of the long-term variation of the geomagnetic field, which is believed to be intimately connected to the sector structure of the solar wind. Leif and John had plotted the polarity of the field against time, over a duration of nearly half a century, and two approximately periodic components were identified by eye. Emphasis was on one with a period of 26.84 days synodic, believed to be a signature of the solar dynamo operating in the equatorial regions of the convection zone. **The other, less obvious, secondary component had a period of about 28.7 days synodic**. Could that be the evidence sought for the global dipole field? In the Figure is plotted the “longitudes”, after imaginary rigid projection onto the Sun, of the centres of the secondary component (in units of the fiducial 26.84-day period). There are gaps in the data, near sunspot minima when the field variation was too feeble to be identified, but each time when the signal reappeared it was almost in phase. The straight line in the Figure (right, below) was obtained by linear regression: its slope is 0.07025 periods/period [26.84*(1+0.07025) = 28.726 days, synodic], corresponding to a sidereal cyclic frequency of 434.6 nHz.

That is just the rotation rate $\Omega_0/2\pi$ of the Sun’s radiative interior.

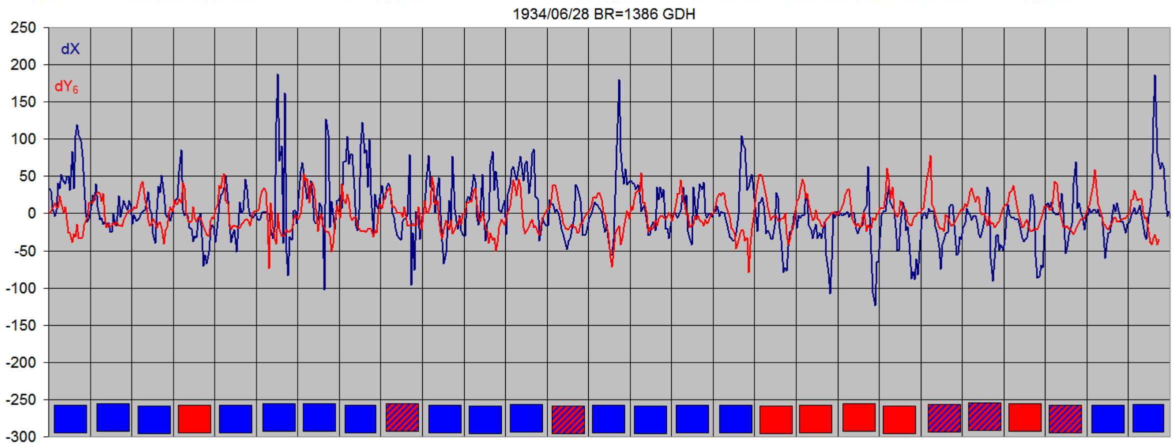


Godhavn, Greenland in 1926



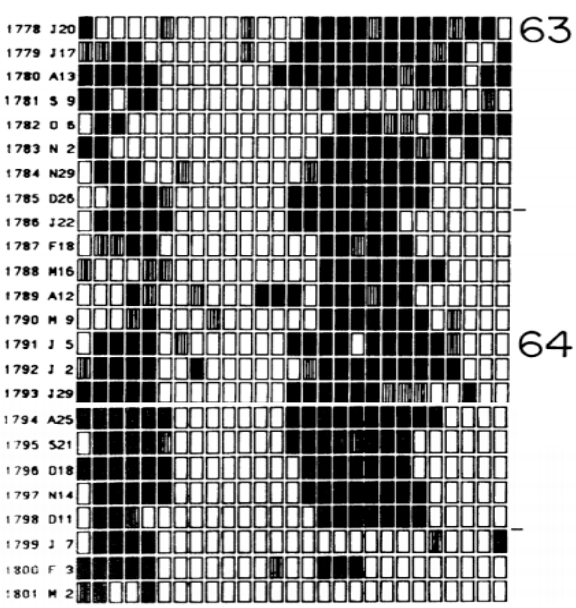


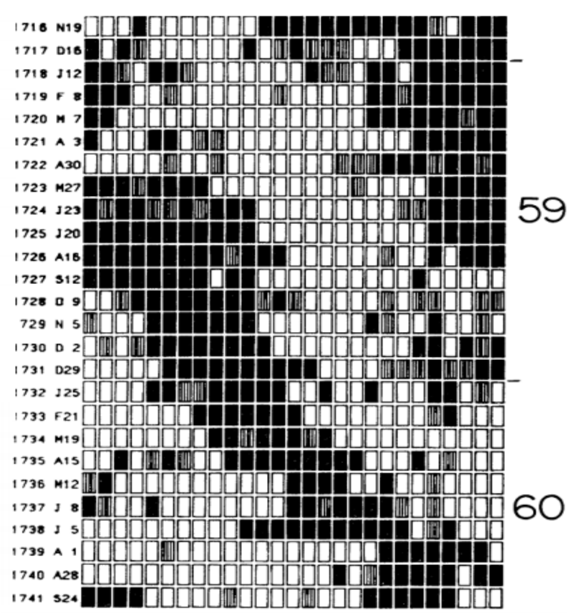
The variation of the Horizontal Component in the minimum year 1932. The recurring 'dips' are not magnetic storms. In fact, nobody knew what they were at the time

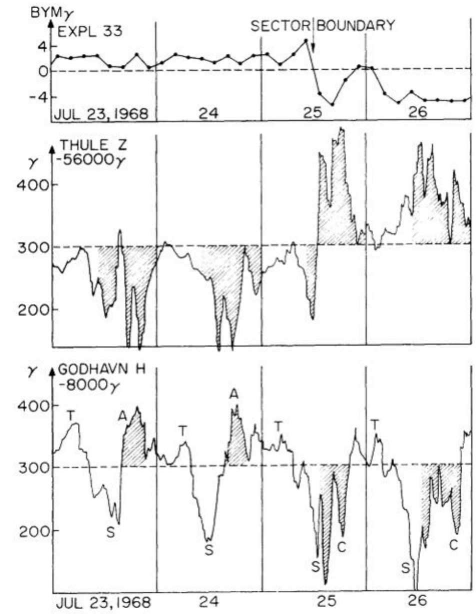


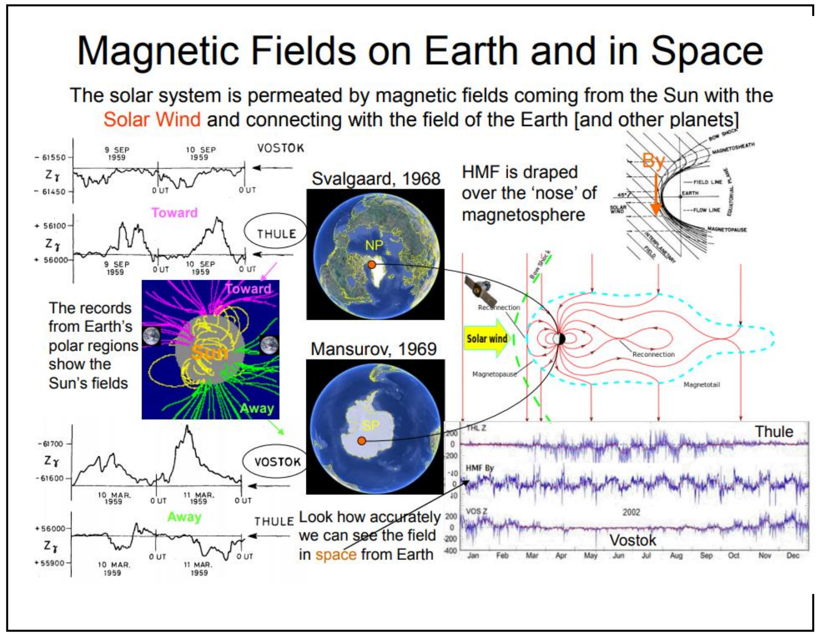
27-day

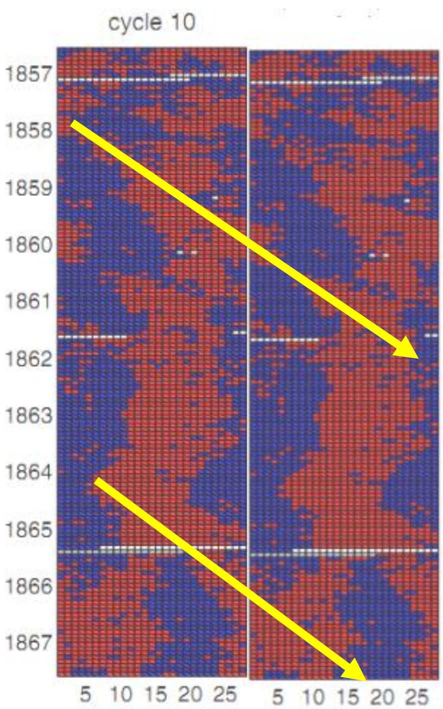
28.5-day

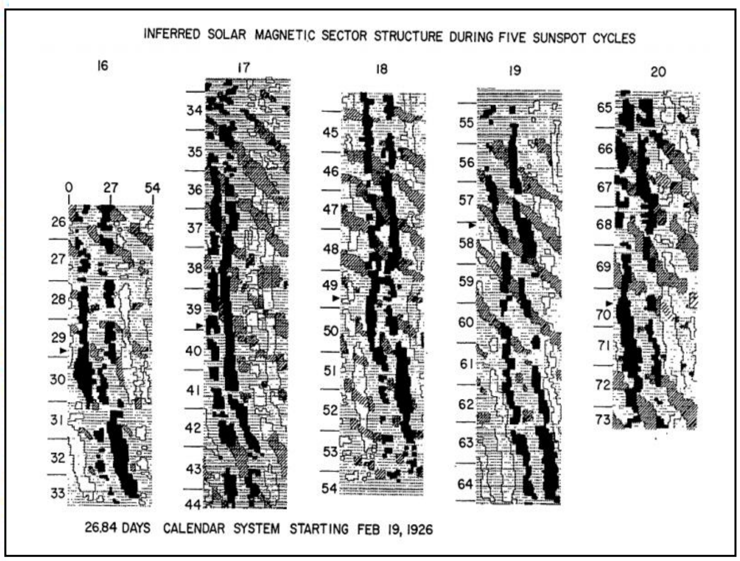












Gough's plot was based on the above.

Can We Extend the Sector Data to Before 1926? Yes: *M. V. Vokhmyanin and D. I. Ponyavin*, Sector structure of the interplanetary magnetic field in the nineteenth century, Geophysical Research Letters, 40, 3512–3516, doi:10.1002/grl.50749, 2013

Gough's plot was constructed using data from 1926-1974. We now have another half-century [1975-2020], so can extend the plot in order to verify if the speculation still holds. Perhaps we can extend it back to 1844. In any case, **it would be remarkable if we could measure the Sun's internal rotation rate using geomagnetism**. Well worth investigating, as I'm doing right now.