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# Magnetic field and meridional flow in the solar polar regions

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Exploring the solar poles is a great frontier of the Sun. As the primary determinant, the solar polar magnetic fields are deemed to serve as seed fields for the global dynamo producing the solar cycle, and they are important for powering fast solar wind. The meridional flow in the Sun is believed to play a significant role in determining the magnetic structure and strength in polar regions. However, the long-term variation of vector magnetic fields and the pattern of meridional flow near the solar poles remain unclear.

Based on Hinode's polar observations from 2012 to 2021, we investigate the long-term variation of vector magnetic fields and the pattern of meridional flow near the poles. We find that the magnetic field polarity reversed from about 70 degree latitude to the pole successively at the epoch of solar maximum (Figure 1)[1]. In another word, the higher latitude corresponds to the later polarity reversal, reflecting a poleward migration of magnetic flux. After the polarity reversal, the magnetic inclination of the dominant polarity fields decreased, indicating that the stronger the dominant polarity field, the more vertical the field lines[2]. The Hinode observations show that in each polar cap, during most of the time of the solar cycle except for the period around the polarity reversal, the higher the latitude, the weaker the radial magnetic flux density in general. It means that the higher the latitude, the weaker the magnetic flux density. To explore the meridional flow, we employ a surface flux transport model to simulate the global radial magnetic field. For the first time, Hinode's high-resolution observations of the vector magnetic fields in polar caps are used to directly constrain the simulation. The simulation results reveal that when assuming a counter-cell meridional flow from the pole to 70 degree latitude with the maximum amplitude of 3 m/s, the simulation fits the observation well. Based on the observation and simulation, the meridional flow pattern of the Sun can be deduced (see Figure 2)[3].

These results clarify the magnetic polarity reversal process at different latitudes of the polar caps, and also provide us with a new understanding of the meridional flow in the polar regions of the Sun.

References
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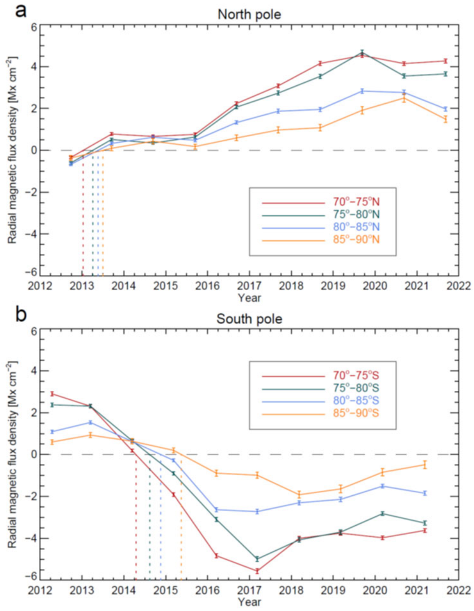


**Figure 1.** Long-term variation of the radial magnetic flux density at different latitudes in the north and south polar caps. (a) Averaged radial magnetic flux density vs. time in the north polar cap. (b) Similar to (a) but in the south polar cap. The colored curves represent the averaged radial magnetic flux density in different latitude ranges, and the vertical lines mark the times when the polarity reversals were completed. Each error bar represents 3σ, where σ is the standard error.

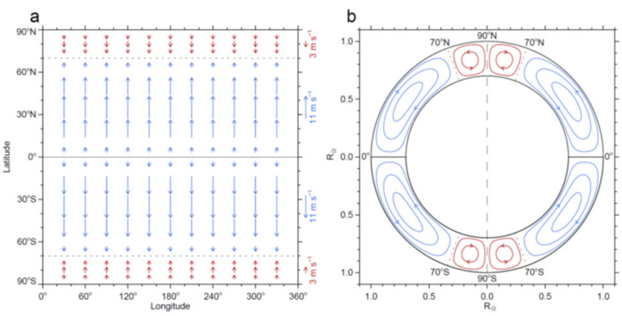


**Figure 2.** Schematic cartoon showing the meridional flow pattern of the Sun. (a) Velocity distribution of the meridional flows at the solar surface. The blue and red arrows represent the poleward meridional flow and the equatorward meridional flow, respectively. (b) Meridional flows as functions of latitude and depth assuming a single cell in radius. The blue and red closed loops represent the main-cell and the counter-cell, respectively.