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Is a high-latitude, second, reversed meridional flow cell the Sun's common choice?

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Abstract: Observations of surface Doppler meridional flow show that a high-latitude, reversed (equatorward) meridional flow cell, along with a poleward primary flow-cell, occurred during cycles 20, 21 and 22. The reversed cell vanished during most of cycle 23, but is reappearing in the current cycle 24. We explore theoretically what the Sun's natural choice of polar-region flow can be. We build a hydrodynamical model for computing and understanding the Sun's large-scale high latitude flows that includes Coriolis forces, turbulent diffusion of momentum and gyroscopic pumping. We solve for the meridional flow in a spherical 'polar cap' with a boundary at about 60-degree latitude. We find that there always exists at least one node in the latitudinal flow profile if the turbulent viscosity in the Sun's convection zone is 10^{10} to $10^{15}\,\mathrm{cm}^2\,\mathrm{s}^{-1}$. The Sun's turbulent viscosity is generally thought to be in the range of $10^{12} - 10^{13}\,\mathrm{cm}^2\,\mathrm{s}^{-1}$. For certain combinations of turbulent viscosity values and flow-speeds at the polar-cap boundary, our model exhibits 'node merging', producing only one flow-cell going all the way to the pole from the equator. These results suggest that it is more natural for the Sun to have one or more high-latitude reversed cells, but occasionally a single, unusually long primary cell, as was observed in cycle 23.