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Impact of Changes in the Sun's Conveyor-belt on Recent Solar Cycles

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Puzzlingly, solar cycle 23, which ended recently, lasted longer than previous cycles, with a prolonged phase of low activity. In fact the solar minimum at the end of cycle 23 has been the longest in 100 years; one has to go back 9 cycles to find such a long minimum. In one class of solar dynamo models, called the flux-transport dynamo, the duration of a cycle is primarily governed by the path-length and speed of the Sun's conveyor-belt. Just as Earth's global ocean circulation transports water and heat around the planet, the Sun's conveyor-belt is constituted of plasma that flows along the surface toward the poles, sinks, and returns toward the equator, transporting magnetic flux along the way. Recent analysis of Mount Wilson Observatory data shows that in solar cycle 23, the poleward flow extended all the way to the poles, while in previous solar cycles 19, 20, 21 and 22, the flow turned back toward the equator at about 60-degree latitude. Furthermore, from mass conservation the return flow was slower in cycle 23 than in previous cycles. We used a flux-transport dynamo to simulate how the solar plasma conveyor belt affects the solar cycle and found that the longer conveyor belt and the slower return flow during cycle 23 compared to that in cycle 22 could have caused the longer duration of cycle 23. These results lead to an obvious question – is a long conveyor-belt traversing all the way to the pole unusual? Or, is a high-latitude reverse plasma flow-cell the Sun's more natural choice? To find an answer to this question, we are modelling the Sun's plasma flow at high latitudes. Our preliminary results indicate that the Sun's common choice is to have a second cell at high latitudes with a reversed flow compared to the primary poleward flow-cell. By assimilating SDO data we will be able to more accurately estimate the amplitude and the latitudinal extent of the Sun's plasma flow-cells.