The Faint Young Sun Paradox

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While much (necessary) attention is being paid to the possible influence of the Sun on global climate variation in the last millennium, there is an even more astounding problem in the mismatch between solar luminosity and terrestrial climate in the first several billions of years of the Earth's existence, an issue known as the "Faint Young Sun Paradox". In brief the paradox is this: The geological and biological record support that the Earth's biosphere was considerably warmer than currently during the origin of life on Earth and for several billions of years thereafter. Yet, stellar evolution calculations support the Sun reaching the Zero Age Mean Sequence at about 75% of its present luminosity, and linearly increasing in time up to its current level. Climate models predict a "Snowball Earth"; for such a low solar constant, unless the greenhouse effect was much stronger than what it is now. However, there is no geological evidence for a hugely increased presence of greenhouse gasses in the early atmosphere. For possible solutions scientists have typically pointed fingers at other disciplines: Earth scientists suspect the Sun was much more luminous in the past than astronomers calculate. Solar scientists point to stronger geological activity on the early Earth, etc. As of now there is no theory, or even a credible scenario, to resolve this issue.

However, recent observations point towards the Sun for a resolution of the paradox. Most important are the results from the Mars Rovers that show that Mars has had periods with a seeming abundance of liquid water over billions of years. If both Mars and Earth both have had liquid water over their history then it is reasonable to look for a common cause, i.e. a more luminous Sun than simulations indicate. One possibility for a brighter young Sun would be if the Sun had only about 5% more mass at its origin than it has now, and consequently, has lost the excess mass through the solar wind. Model calculations have been invoked to discard this possibility, but a comparison with observations of other Sun-like stars in earlier phases of their evolution have been observed to have much higher mass losses, potentially enough for a 5% mass loss over the Sun's almost five billion year lifespan. The question remains what observations can be made to verify or discard the existence of a massive solar wind through much of the Sun's history.