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The Ancient Martian Climate System

Today Mars is a cold, dry, desert planet. The atmosphere is thin and liquid water is not stable at the surface. But there is evidence that very early in its history, some 3.7-4.1 billion years ago, the climate system supported much warmer conditions including an active hydrological cycle with rainfall and runoff. Given the importance of liquid water to astrobiology and NASA's Mars Exploration Program, researchers have been trying to understand the ancient martian climate system since the early 1970s when the Mariner 9 spacecraft first detected fluvial features on its oldest terrains. Though the evidence for warm wet conditions is compelling, the problem is not yet solved. The main issue is coping with the faint young sun. During the period when warmer conditions prevailed the sun's luminosity was ~25% less than it is today. How can we explain the presence of liquid water on the surface of ancient Mars under such conditions? A similar problem exists for Earth, which would have frozen over under a faint sun even though the evidence suggests otherwise. Attempts to solve the "Faint Young Sun Paradox", as it is commonly known, rely on greenhouse warming from an atmosphere with a different mass and composition than we see today. This is true for both Mars and Earth. However, for Mars there is no solution in sight. Long-lived continuously warm and wet atmospheres are difficult to produce and sustain. And a new and emerging idea - that ancient Mars was fundamentally a cold planet with transient episodes of warm wet conditions brought about by external forcings such as impacts, volcanism, and/or orbital changes – also has issues. In this seminar I will review this fascinating topic and discuss some of the recent ideas on how to solve it, the issues they raise, and what I believe are some promising avenues for future research.