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The Potential Importance of Non-Local, Deep Transport on the Energetics, Momentum, Chemistry, and Aerosol Distributions in the Atmospheres of Earth, Mars and Titan

Scot Rafkin

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A review of non-local, deep transport mechanisms in the atmosphere of Earth provides a good foundation for examining whether similar mechanisms are operating in the atmospheres of Mars and Titan. On Earth, deep convective clouds in the tropics constitute the upward branch of the Hadley Cell and provide a conduit through which energy, moisture, momentum, aerosols and chemical species are moved from the boundary layer to the upper troposphere and lower stratosphere. This transport produces mid-tropospheric minima in quantities such as water vapor and moist static energy and maxima where the clouds detrain. Analogs to this terrestrial transport are found in the strong and deep thermal circulations associated with topography on Mars and with Mars dust storms. Observations of elevated dust layers on Mars further support the notion that non-local deep transport is an important mechanism in the atmosphere of Mars. On Titan, the presence of deep convective clouds almost assures that non-local, deep transport is occurring and these clouds may play a role in global cycling of energy, momentum, and methane. Based on the potential importance of non-local deep transport in Earth's atmosphere and supported by evidence for such transport in the atmospheres of Mars and Titan, greater attention to this mechanism in extraterrestrial atmospheres is warranted.

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