Researchers have long been intrigued by questions about how solar variability and related solar-terrestrial influences can affect the Earth's middle and lower atmosphere. A goal of basic research programs has been to establish a comprehensive intellectual foundation for the investigation of the effect of solar variability on climate. It is clear that conclusive observations of cause-effect relationships (at the requisite level of confidence) are a very large challenge. Satisfactory work in this arena requires close collaboration between solar, magnetospheric, and atmospheric scientists. It is important to note that new generations of atmospheric models now are able to couple together all the layers of the Earth's extended atmosphere. Through such models, and with increasingly complete observations, we are in a steadily improving position to understand the complex (and often subtle) ways that solar influences at high altitudes affect the lower atmosphere. Solar irradiance and solar and magnetospheric charged energetic particles impact the temperature structure of the upper atmosphere both directly and indirectly via chemical reactions such as ozone production and loss. These temperature changes can influence atmospheric circulation, and thereby act as a coupling agent between different atmospheric regions. In this talk, we discuss long-standing questions and recent progress in understanding this crucial aspect of the Sun-Earth connection.