Thermal structure of Titan's troposphere and middle atmosphere

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The thermal structure of Titan's atmosphere is reviewed, with particular emphasis on recent Cassini-Huygens results. Titan's has a similar troposphere-stratosphere-mesosphere pattern like Earth, but with a much more extended atmosphere, because of the weaker gravity, and also much lower temperatures, because of its greater distance from the sun. Titan's atmosphere exhibits an unusually large range in radiative relaxation times. In the troposphere, these are long compared to seasonal time scales, but in the stratosphere they are much shorter than a season. An exception is near the winter pole, where the stratospheric relaxation times at 100-170 km become comparable to the seasonal time scale; at the warm stratopause, they are comparable to a Titan day. Hence, seasonal behavior in the troposphere should be muted, but significant in the stratosphere. This is reflected in the small meridional contrast observed in temperatures in the troposphere and the large stratospheric contrasts noted above. A surprising feature of the vertical profiles of temperature is the abrupt transition between these regimes in at high northern latitudes in winter, where the temperatures in the lower stratosphere exhibit a sudden drop with increasing altitude. This could be a radiative effect, not associated with spatial variations in gaseous opacity, but rather from an optically thick condensate at thermal-infrared wavelengths. A curious aspect of Titan's middle atmosphere is that the axis of symmetry of the temperature field is tilted by several degrees relative to the rotational axis of the moon itself. Whether this is driven by solar heating or gravitational perturbations is not known. Titan's surface exhibits weak contrasts in temperature, ~3 K in the winter hemisphere. At low latitudes, there is evidence of a weak nocturnal boundary layer on the morning terminator, which is not radiatively controlled, but can be explained in terms of vertical mixing with a small eddy viscosity.