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Measuring the greenhouse effect and radiative forcing through the atmosphere

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In spite of a large body of existing measurements of incoming shortwave solar radiation and outgoing longwave terrestrial radiation at the Earth's surface and at the top of the atmosphere, there are few observations documenting how radiation profiles change through the atmosphere - information that is necessary to fully quantify the greenhouse effect of the Earth's atmosphere. Using weather balloons and specific radiometer equipped radiosondes, we continuously measured shortwave and longwave radiation fluxes from the surface of the Earth up to altitudes of 35 kilometers in the upper stratosphere. Comparing radiation profiles from night measurements with different amounts of water vapor, we show evidence of large greenhouse forcing. We show, that under cloud free conditions, water vapor increases with Clausius-Clapeyron (7% / K), and longwave downward radiation at the surface increases by 8 Watts per square meter per Kelvin. The longwave net radiation however, shows a positive increase (downward) of 2.4 Watts per square meter and Kelvin at the surface, which decreases with height and shows a similar but negative increase (upward) at the tropopause. Hence, increased tropospheric water vapor increases longwave net radiation towards the ground and towards space, and produces a heating of 0.42 Kelvin per Watt per square meter at the surface.

References: Philipona et al., 2012: Solar and thermal radiation profiles and radiative forcing measured through the atmosphere. Geophys. Res. Lett., 39, L13806, doi: 10.1029/2012GL052087.