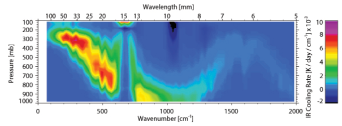
Looking at the Full Spectrum for Water Vapor



Radiative cooling across the full infrared spectrum: The far-infrared (the left half of the figure, from 15 to 1000 microns) plays a key role in heat transfer in the atmosphere, but scientists could not measure it, and model calculations were consequently very uncertain. Field observations from newly developed spectrometers, followed by modeling studies, have improved and confirmed advances in radiative transfer calculations.

Research Highlight

Absorption and emission of infrared radiation by water high in the atmosphere helps cool the Earth and fuels the updrafts and downdrafts that can lead to cloud formation. Until recently, technology limitations prevented scientists from collecting data in one of the most important subsections of the infrared scale, the far-infrared. Lacking such data, global climate models cannot accurately simulate the movement of heat through the atmosphere.

A two-phased field measurement effort, called the Radiative Heating in Underexplored Band Campaign, or RHUBC, used newly developed spectrometers to gather radiation data across the entire infrared scale. Using these data, researchers were able to improve radiative transfer calculations—the portion of global climate models that simulate how radiant energy moves through the atmosphere.

Earth's climate is driven by the total incoming solar energy versus outgoing infrared energy, as well as how this radiant energy is distributed within the atmosphere. The studies demonstrated and then confirmed that improved radiative transfer calculations can result in significant changes in how climate models predict temperature, humidity, cloud amount, and radiative cooling in the middle and upper troposphere in all regions of the globe, from the tropics to the poles. These types of studies illustrate the importance of using accurate treatments of radiation within global climate models and provide motivation for different modeling groups to improve this aspect of their models—especially since there are large discrepancies among radiation treatments in various models. The RHUBC analysis also identified smaller second-order effects, such as temperature effects on water absorption, which are still deficient in the radiative transfer model and need to be improved.

Scientists used data from the first RHUBC campaign at NSA to revise radiative transfer calculations and test them in a climate model. Compared to the observations, the revised calculations improved model results for water vapor absorption in the far-infrared part of the spectrum by a factor of two. Scientists then used data from the second field measurement campaign, conducted at 17,500 feet in northern Chile's Atacama Desert, where the water vapor amount was five times drier, to evaluate how the revised radiative transfer calculations stood up under different conditions. Data from the second test largely confirmed the improvement in the original calculations.

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Cloud-Aerosol-Precipitation Interactions