Geophysical Research Abstracts
Vol. 21, EGU2019-3122-1, 2019
EGU General Assembly 2019

A process-based climatological evaluation of AIRS tropospheric thermodynamics over the high-latitude Arctic

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Measurements from space borne sensors have a unique capacity to fill spatial and temporal gaps present from the ground-based atmospheric observing systems. This is especially true for profiling over the high latitude Arctic polar region, where observing stations are limited to the pan-Arctic landmasses and infrequent field campaigns. The hyperspectral infrared sounder instrument AIRS, on the Aqua satellite, polar-orbiting within the A-Train satellite constellation, has provided retrieved thermodynamic profiles from the global atmosphere twice daily since its launch in 2002. These measurements are critically important for weather prediction models where modern data assimilation techniques allows radiances rather than retrieved temperatures to be used for determination of model initial states. Similarly, retrievals of thermodynamics from AIRS over the Arctic have been used to quantify and improve the understanding of important processes and features of the sparsely observed Arctic atmosphere. A detailed investigation into the accuracy of AIRS thermodynamic profiles over the high-latitude Arctic has however been lacking.

In this study, we have compiled a wealth of radiosounding profiles from long-term Arctic land stations, also including soundings from several intensive icebreaker-based field campaigns in the central Arctic Ocean, and use these to evaluate daily mean thermodynamic profiles from the satellite sensor. The results indicate that while the mid- to upper-troposphere temperature and specific humidity are relatively well captured by the satellite, the lower troposphere is susceptible to specific seasonal, and even monthly, biases. These differences across the lowest atmospheric levels have a critical influence on the lower tropospheric stability structure. The relatively coarse vertical resolution of AIRS retrievals, together with infrared retrievals through persistent low Arctic cloud layers, lead to artificial thermodynamic structures that fail to accurately represent the lower Arctic atmosphere. These thermodynamic errors are likely to introduce artificial and erroneous structures in the boundary layer and may have led to misinterpretations of the associated physical processes.