Estimation of cloud water content over land using satellite-based passive microwave observations with a coupled land and atmosphere assimilation method

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We proposed a method to estimate the cloud water content (CWC) over land at multiple-kilometer resolutions and to concurrently assimilate the estimated CWC into the model by using multi-frequency satellite-based passive microwave brightness temperatures (TBs) and coupled land and atmosphere assimilation.
The need for a better understanding and more accurate representation of clouds in atmospheric models has been apparent for decades. However, a lack of sufficient observations and reanalysis products is a major obstacle. The use of TBs is an effective way to retrieve CWC of extensive and heterogeneous cloud systems all at once, but it is challenging to estimate CWC over land due to complexities of cloud processes and uncertainties in strong and heterogeneous land emissions. Our method overcomes the difficulty of retrieving clouds over land from TBs and representing them in models by simultaneously optimizing land emissions and CWC over land, and assimilating the estimations into models.
The estimated CWC was in good accordance with vertical two-dimensional products of CloudSat in terms of cloud water path and the vertical distribution of CWC. In addition, we examined the uncertainties of this method by sensitivity analysis of CWC estimates of TBs and cloud top height. The results suggested that the error in TBs is not large, and that cloud top height affects the estimated CWC more sensitively than TBs. The addition of cloud top height information from other satellite observations as a constraint of optimization allows further improvement of the vertical distributions of CWC.
This study revealed that the proposed method has great potential to provide unprecedented data for CWC with adequate accuracy, which are continuously distributed over land and ocean.

Keywords: estimation of cloud water content over land, satellite-based passive microwave brightness temperature, coupled assimilation of land and atmosphere

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