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Construction of Unified Global 3D Cloud Fields Combining Multiple Satellite Products and AI/ML-Derived Environmental Data

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Knowledge of three-dimensional (3D) cloud structures is important for a wide range of weather and climate studies. While satellites have provided valuable cloud observations, data from conventional passive radiometers is often limited to cloud-top properties. To overcome the limitation, we have developed a statistical Cloud Base Height algorithm using NASA A-Train satellite data, which is now part of the NOAA Enterprise Cloud Algorithm Suite and enables providing vertically extended cloud layer information. We recently introduced satellite-based cloud vertical cross-sections for flight routes to maximize the use of satellite cloud products for aviation weather applications based on feedback from operational forecasters and pilots. It uses newly processed 3D cloud data that combines multiple satellite cloud products and additional environmental datasets. While leveraging research efforts and being mindful of the current/future of global cloud data development activities such as the International Satellite Cloud Climatology Product—Next Generation (ISCCP-NG) in parallel, we are now extending our work to generate global 3D cloud fields by applying cloud retrieval algorithms to multiple sensors onboard both geostationary and polar satellites. We incorporate enhanced cloud properties into the global framework by adopting AI/Machine Learning (ML) approaches such as AI-based vertical cloud water profiles, synthetic global radar and passive microwave data. Advanced AI/ML tools are also employed to optimize the blending process between sensors for seamless global cloud structure information. Validation activities are ongoing to comprehensively evaluate new 3D data fields against ground and space-borne active sensor measurements. Our work is expected to support weather applications in analyzing and predicting environmental conditions on a global scale, as well as advanced climate research, particularly in assessing cloud feedback.