Satellite Retrievals of Mixed-phase Cloud Properties

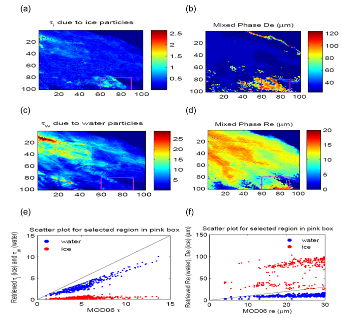
Research Highlight

Middle-level clouds such as altocumulus and altostratus and some well-developed cirrus clouds with temperatures less than -40oC contain ice particles that coexist with supercooled water droplets. These clouds cover a large fraction of the sky (20-30%). Detecting mixed-phase clouds and retrieving their optical properties by ground-based and space-borne sensors are important for providing needed data to understand their microphysics, dynamics, and radiative transfer processes, as well as for developing physically based parameterizations of these clouds for incorporation in weather and climate models. Observations of the microphysical and optical properties of mixed-phase clouds from aircraft and ground-based remote sensing instruments have been conducted only recently.

Mixed-phase clouds are generally mistyped in the satellite cloud masking program as either water or ice clouds. In the current NPOESS/VIIRS cloud algorithm, cloud phase is determined by the NPOESS/VIIRS cloud mask designed specifically to differentiate between a mixed-phase cloud and a thin ice cloud overlapped with a water cloud, using the near-IR band reflectances and the 8.5- and 11-µm channel brightness temperatures.

We have developed an approach to retrieve pixel-level, mixed-phase cloud optical depths and mean effective particle sizes using NPOESS/VIIRS 0.67, 1.6, 2.25, and 3.7 µm bands. This approach utilizes the look-up tables of reflectances constructed from radiative transfer simulations coupled with a numerical iterative search method. The capability of this new approach has been demonstrated using MODIS data as proxy. We have analyzed two proxy scenes located at North Platte, Nebraska, during the ninth Cloud Layer Experiment (CLEX-9) on October 14, 2001, and at the Great Lakes and eastern Canada during the Canadian CloudSat/CALIPSO Validation Project (C3VP) on November 9, 2006. The performance of the mixed-phase retrieval algorithm was assessed by comparing the retrieved optical depth and particle size for mixed-phase clouds to those in the MODIS retrieval products, as well as the results derived from airborne in situ observations during CLEX-9 and CloudSat data during C3VP (Ou et al. 2009).

The retrieved cloud optical thicknesses and mean effective sizes were first examined by comparison with the MODIS cloud products. These assessments show that retrieved cloud optical thicknesses and mean effective sizes correlate well with the MODIS cloud products for both cases.Retrieved ice crystal mean effective sizes are generally well correlated with mean sizes derived from 2D-C measurements, but retrieved water droplet mean effective sizes are generally smaller in magnitude. The retrieved cloud particle sizes and cloud water path for the C3VP case was evaluated by comparison with collocated CloudSat data products. Retrieved ice crystal mean effective sizes are generally smaller than CloudSat mean sizes, because CloudSat radar tends to miss smaller particles.



Images of mixed-phase retrieved (a) #i, (b) De, (c) #w, and (d) re for the Terra/MODIS scene of 14 October 2001 over North Platte, Nebraska. Also shown are (e) retrieved #i and #w versus MODIS # within the pink box and (f) retrieved De and re versus MODIS re within the pink box.

Reference(s)

Ou SS, K Liou, X Wang, D Hagan, A Dybdahl, M Mussetto, L Carey, J Niu, J Kankiewicz, S Kidder, and T Von der Haar. 2009. "Retrievals of mixed-phase cloud properties during the National Polar-Orbiting Operational Environmental Satellite System." Applied Optics, 48(8), 1452-1462.

Contributors

Szu-cheng Ou, *University of California, Los Angeles*

Working Group(s)

Cloud Properties