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Influence of spatial heterogeneity of surface albedo on its retrieval from airborne irradiance measurements

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The surface albedo is an important boundary condition for radiative transfer calculations and a key quantity for various algorithms applied in the field of atmospheric remote sensing. Also with respect to the surface and atmosphere energy budgets from global to small scales, the surface albedo plays an important role. When using airborne measurements of upward and downward irradiances to determine the surface albedo, scattering and absorption by the atmosphere between flight level and surface need to be removed (e.g., Wendisch et al. 2004). For increasing flight altitudes, the natural heterogeneity in the surface albedo is partially smoothed out by the airborne measurements. Consequently, over inhomogeneous terrain, airborne measurements yield the areal surface albedo which may differ from the actual heterogeneous surface albedo.
This presentation shows the effect of surface albedo heterogeneity and aerosol parameters on the extrapolation of the measurement on the surface albedo from airborne upward and downward irradiance measurements.
To quantify these effects, spatially heterogeneous surface albedo maps were input into a 3-dimensional (3D) Monte Carlo radiative transfer model to simulate 3D irradiance fields. The calculated up- and downward irradiances in altitudes between 0.1 km and 5 km are used to extrapolate the areal surface albedo using an iterative method that is based on 1-dimensional (1D) simulations. For the simple case of adjacent land and sea surfaces a parameterization is presented which quantifies the distance to the coastline required to reduce surface heterogeneity effects to a given limit as a function of flight altitude, aerosol optical depth, and the ratio of land and sea albedo. In addition, the deviation between extrapolated areal and the actual heterogeneous surface albedo is determined for more complex surface albedo maps. A strong dependence on altitude and grid size of the homogeneous albedo areas is demonstrated, whereas the effect of aerosol load can be neglected. For moderate aerosol conditions (optical thickness less than 0.4) the flight altitude and the heterogeneity of the surface albedo are the dominant factors determining the mean deviation between actual heterogeneous and areal surface albedo. Additionally, the derived parameterization is applied to an albedo map that was derived from Landsat images of an area in East Anglia (UK). Parameterization and direct comparison of heterogeneous and extrapolated surface albedo show similar mean deviations (30 %, 36 %) over land.