

Locations for the Best Lidar View of Mid-level, High, and Polar Stratospheric Clouds

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Mid-level altocumulus clouds (Ac) and high cirrus clouds (Ci) can be considered as natural laboratories for studying cloud glaciation in the atmosphere. Polar Stratospheric Clouds (PSCs) are of critical importance for stratospheric ozone depletion during polar winter. While their altitude makes these clouds difficult to access with in-situ instruments, they can be conveniently observed from ground with lidar. However, such lidar observations require a clear line of sight between the instrument and the target cloud. Hence, the success of ground-based lidar observations of Ac, Ci, and PSCs is strongly dependent on the presence of light-attenuating clouds at height levels below the one of the target cloud. This problem is reduced for spaceborne lidar observations where attenuating clouds are generally at the end of a profile rather than the beginning. Spaceborne lidar observations therefore allow to assess the locations that provide the optimum balance between (i) the occurrence rate of suitable tropospheric cloud conditions that allow for observations of a target cloud and (ii) the occurrence rate of these target clouds.

We use spaceborne lidar observations with the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) aboard the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite and the Cloud-Aerosol Transport System (CATS) aboard the International Space Station (ISS) to study the occurrence of Ac, Ci, and PSCs in dependence of the occurrence of light-attenuating clouds below. This approach allows to assess likely observational success rates at locations for deploying ground-based lidar instruments in field experiments or for long-term observations that are focused on the target clouds listed above.

The combination of (i) the length of the CALIOP time series and (ii) the capability of CATS to provide measurements at different times of the day is important when considering Ac and Ci but has not been used on the investigation of PSCs. It is found that Ci can be best observed in the tropics, the Tibetan plateau, the western part of North America, the Atacama region, the southern tip of South America, Greenland, Antarctica, and parts of Western Europe. For the observation of Ac, a ground-based lidar is best placed on Greenland, Antarctica, the western flank of the Andes and Rocky Mountains, the Amazon, central Asia, Siberia, Western Australia, or the southern half of Africa. Of the established PSC observatories Concordia, Eureka, McMurdo, and Ny Ålesund provide the best balance between PSC occurrence and tropospheric cloudiness. It is found that Villum, Summit, Zackenberg, Thule, and Alert would be the best choices for establishing new PSC observatories with state-of-the-art lidar instruments in the Arctic. In the Antarctic, this is the case for Vostok, Troll, Mawson, Jang Bogo, Belgrano II, and Neumayer III.