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Macrophysical and optical properties of midlatitude high-altitude clouds from 4 ground-based lidars and collocated CALIOP observations

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Cirrus clouds not only play a major role in the energy budget of the Earth-Atmosphere system, but are also important in the hydrological cycle [Stephens et al., 1990; Webster, 1994]. According to satellite passive remote sensing, high-altitude clouds cover as much as 40% of the earth's surface on average (Liou 1986; Stubenrauch et al., 2006) and can reach 70% of cloud cover over the Tropics (Wang et al., 1996; Nazaryan et al., 2008). Hence, given their very large cloud cover, they have a major role in the climate system (Lynch et al. 2001).
Cirrus clouds can be classified into three distinct families according to their optical thickness, namely subvisible clouds (OD<0.03), semi-transparent clouds (0.03<OD<0.3), and thin clouds (0.3<OD<3). Long records of Lidar measurements however show that subvisible and semi-transparent clouds represent 50% or more of cirrus cloud population. The radiative effects of cirrus clouds are found to be significant by many studies both at the top of the atmosphere and surface. The contribution of the subvisible and semi-transparent classes is strongly affected by levels of other scatterers in the atmosphere (gases, aerosols). This makes them quite an important topic of study at the global scale.
In the present work, we applied the cloud structure analysis algorithm STRAT to long time series of lidar backscatter profiles from multiple locations around the world. Our goal was to establish a Mid-Latitude climatology of cirrus clouds macrophysical properties based on active remote sensing: ground-based lidars at four mid-latitude observatories and the spaceborne instrument CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization). Lidar sampling, macrophysical (cloud base height, cloud top height, cloud thickness) and optical (cloud optical thickness) properties statistics are then evaluated and compared between the four observatories ground-based lidar measurements and quasi-simultaneously CALIOP overpasses. We note an overall good consistency in the macrophysical properties statistics derived from ground- based Lidar and CALIOP. For high altitude clouds, using consistent transmission-based retrieval methods, discrepancies are found in COT retrievals between ground Lidars and CALIOP. Ground-based Lidar retrievals contain less thick cirrus clouds than CALIOP. Overall, the results show that cirrus clouds with COD<0.1 (not included in historical cloud climatologies) represent 30-50% of the non-opaque cirrus class (COD<3, Pressure<440mb from ISCCP). Finally, we analyze the statistic consistencies between each dataset and investigate the possible bias due to lidar sampling and instrument/algorithm differences between ground-based lidar and CALIOP.