A 3D polarized Monte Carlo spaceborne LIDAR system simulator for investigating cirrus inhomogeneity effects on retrieved optical properties

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Scientific context:
LIDAR is a powerful tool for deriving the cirrus properties, but the main difficulty to overcome is the significant extinction of the LIDAR beam in its path through the cloud, and one must take into account multiple scattering (Hogan, 2008, Hu et al., 2001).

The cirrus properties are also assumed to be horizontally homogenous at each level into and around the LIDAR system “footprint” or field of view (FOV).

Our objective is to quantify the effects of cirrus inhomogeneities, corresponding to 3D spatial fluctuations of extinction, on the apparent backscatterer and the apparent depolarization ratio as measured by CALIOP/CALIPSO on the A-Train.

**Methodology:**
We developed a 3D polarized LIDAR simulator (3DMCPoLid) based on 3DCMCPoL (Cornet et al., 2010), a forward Monte Carlo radiative transfer model using the local estimate method and variance reduction methods (Buras et al., 2010) which allows the computation of the Stokes vectors $S = (I,Q,U,V)$.

3DMCPoLid computes the apparent backscatterer and the apparent depolarization ratio as a function of $z$, $z$ is the height above ground, as “seen” by CALIOP/CALIPSO.

3D cirrus scenes are provided by the thermodynamic/stochastic cloud generator (3DCLUD) which is able to constrain the cloud invariant scale properties, the mean optical depth, the distribution of the extinction and the amplitude of the cloud inhomogeneity.

**Results:**
- Good agreement between 3DMCPoLid and Hogan’s codes for small and large optical depth, but not for optical depth close to 3.
- 3D cirrus inhomogeneities effects are not negligible for space LIDAR systems and can provide large relative error on backscatterer (10%) and on depolarization ratio (25% to 100%), especially on cirrus top, even for an averaging scale of 500 m, close to CALIOP resolution (333 m).

**Perspectives:**
In order to generalize these early results, sensitivity tests must be carried out with others realistic fluctuations of cirrus extinction and with other ice crystals shapes.

- To take into account laser beam divergence.
- To investigate 3D cirrus inhomogeneities on retrieved optical depth by LIDAR system.
- To develop a 3D polarized RADAR simulator

**Acknowledgements:** This work is supported by the Programme National de Télédétection Spatiale (PNTS) of the Institut National des Sciences de l’Univers (INSU) and EELCAT (Expecting Earth-Care, Learning from A-Train)