Monitoring the 3D structure of diffuse volcanic ash clouds : a case study after the 2011 Puyehue-Cordon Caulle Eruption

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Volcanic eruptions of the past few years have highlighted particular weaknesses in the current infrastructure used to monitor volcanic ash for aviation. In addressing these weaknesses, recent reports from the International Civil Aviation Organization have notably stressed the importance of improving our understanding of the vertical structure of volcanic ash and how its persistence at cruise levels for several weeks can affect air traffic. Through its aerosol and cloud profiling capability, space-borne lidar represents a very promising technique to address some of these concerns. In June 2011, a persistent volcanic ash cloud from the eruption of the Puyehue-Cordon Caulle volcano disrupted the air traffic in most of the southern hemisphere. The resulting volcanic ash clouds which were present near the tropopause between 30000-45000 ft. , could be observed by the CALIPSO space-borne lidar for several weeks between 40S-70S latitude. We show here how the optical parameters obtained from CALIPSO can be used to detect volcanic ash. Notably, the color ratio between the 1064 and 532 nm channels exhibited significant lower values (0.3-0.4) for ash relative to unity that are typically observed for ice clouds. Based upon this and other optical properties, the volcanic ash clouds were isolated in the CALIPSO dataset and used to initialize a forward trajectory model. A domain-filling approach was then developed to reconstruct maps and cross-sections of volcanic ash backscatter with a better temporal and spatial continuity than using CALIPSO alone. Despite limitations of the CALIPSO lidar sampling and the possible confusion of volcanic ash with dust in the low troposphere, this tool could nevertheless provide a step forward for the Volcanic Ash Advisory Centers to improve volcanic ash advisories, especially for extensive zonal dispersion regimes. Future research to understand how limb observations from the upcoming SAGE III/ISS mission could also be used to detect volcanic ash clouds and be combined with trajectory models to provide additional improvements.