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Challenges in the Development of a Self-Calibrating Network of Ceilometers.

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There are more than 700 Automatic Lidars and Ceilometers (ALCs) currently operating in Europe. Modern ceilometers can do more than simply measure the cloud base height. They can also measure aerosol layers like volcanic ash, Saharan dust or aerosols within the planetary boundary layer. In the frame of E-PROFILE, which is part of EUMETNET, a European network of automatic lidars and ceilometers will be set up exploiting this new capability.

To be able to monitor the evolution of aerosol layers over a **large spatial scale**, the measurements need to be **consistent** from one site to another. Currently, most of the instruments do not provide calibrated, only relative measurements. Thus, it is necessary to **calibrate** the instruments to develop a consistent product for all the instruments from various network and to combine them in an European Network like E-PROFILE.

As it is not possible to use an external reference (like a sun photometer or a Raman Lidar) to calibrate all the ALCs in the E-PROFILE network, it is necessary to use a **self-calibration** algorithm. Two calibration methods have been identified which are suited for automated use in a network: the Rayleigh and the liquid cloud calibration methods

In the **Rayleigh** method, backscatter signals from molecules (this is the Rayleigh signal) can be measured and used to calculate the lidar constant (Wiegner et al. 2012). At the wavelength used for most ceilometers, this signal is weak and can be easily measured only during cloud-free nights. However, with the new algorithm implemented in the frame of the TOPROF COST Action, the Rayleigh calibration was successfully performed on a CHM15k for more than 50% of the nights from October 2013 to September 2014. This method was validated against two reference instruments, the collocated EARLINET PollyXT lidar and the CALIPSO space-borne lidar. The lidar constant was on average within 5.5% compare to the lidar constant determined by the EARLINET lidar. It confirms the validity of the self-calibration method. For 3 CALIPSO overpasses the agreement was on average 20.0%. It is less accurate due to the large uncertainties of CALIPSO data close to the surface.

In opposition to the Rayleigh method, **Cloud** calibration method uses the complete attenuation of the transmitter beam by a liquid water cloud to calculate the lidar constant (O'Connor 2004). The main challenge is the selection of accurately measured water clouds. These clouds should not contain any ice crystals and the detector should not get into saturation. The first problem is especially important during winter time and the second problem is especially important for low clouds. Furthermore the overlap function should be known accurately, especially when the water cloud is located at a distance where the overlap between laser beam and telescope field-of-view is still incomplete.

In the E-PROFILE pilot network, the Rayleigh calibration is already performed automatically. This demonstration network maked available, in real time, calibrated ALC measurements from 8 instruments of 4 different types in 6 countries. In collaboration with TOPROF and 20 national weathers services, E-PROFILE will provide, in 2017, near real time **ALC measurements in most of Europe**.