On the role of topography on the planetary boundary layer influence at high altitude sites

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The long-term characterization of free troposphere (FT) aerosols is often performed using measurements from high altitude stations. The analysis of high altitude station data is however complicated by the difficulty in determining the planetary boundary layer (PBL) influence at the measuring site. The methods usually applied to sort out FT from PBL influenced periods are based on the diurnal and/or seasonal pattern of aerosol parameters, wind direction selection, and/or analysis of the concentration of other pollutants (for example CO_2). Depending on observatory location, topography and meteorology, several mechanisms can cause the upward movement of lower elevation air resulting in PBL-influenced sampling conditions. Thermally–driven valley wind is the most frequently cited phenomenon bringing low elevation polluted air masses to mountain summits. However, transport mechanisms occurring on larger spatial scales are also common enough to contribute to the aerosol load at high altitude. For example, the convective boundary layer was measured by an airborne lidar up to 4000 m over the Jungfraujoch (JFJ) massif during a fair weather day in summer (Nyeki *et al.*, 2000). Depending on the various possible sources of the PBL residuals layers at high altitude, the FT aerosol should then be considered as local or regional rather than global in nature.

In this study, the effect of the topography on the influence of the PBL on 19 high elevation sites (BEO, CHC, CMN, ESP, IZA, JFJ, LLN, MBO, MSC MLO, PIC, PDD, PYR, SPL, SUM, TLL, WHI, WLG, ZUG) with aerosol measurements is evaluated. Most of these sites are GAW stations located between 1500 and 5300 m a.s.l., and have several years of scattering, absorption and/or particle number concentration measurements (Andrews *et al*, 2011). The topography information is taken from GTOPO30 ([https://lta.cr.usgs.gov/GTOPO30),](https://lta.cr.usgs.gov/GTOPO30) a global digital elevation model covering the whole earth with a horizontal grid spacing of 30 arc seconds (~ 1 kilometer). Each analysis was performed on a 3° (~330 km) square domain around the site.

To estimate if convective processes are enhanced or impeded by the topographical environment of the station, seven parameters were calculated, some of them originating from hydrology. The thermally-driven PBL influence is considered to be minimized if (a) the station elevation is at the highest point, (b) the slopes around the summit are sharp and (c) the drainage basin applied to thermal convection is large. Explicitly, we evaluate the topographic wetness index (a measure of the extent of flow accumulation), the cumulative height frequency curve, the mean altitude difference as a function of the distance, the mean gradient in elevation in eight directions and the drainage basin of the inverse topography (with elevation= - real elevation). The PBL topographic index is given by the geometrical mean of the defined parameters and it allows ranking of the 19 high altitude sites as a function of the PBL influence due to the regional topography.

The effect of the modification of the topography by adding the PBL over the low elevation regions was also investigated. For example, a PBL of 700-1000 m overlaid on low elevation terrain around the JFJ induced new flow paths (cyan) from the N-E and S-E, the S-E path explaining the frequently measured pollution from the Po Basin. This newly defined PBL topographic index was then evaluated in the context of the seasonal and diurnal cycles of the aerosol parameters measured at the high elevation stations.

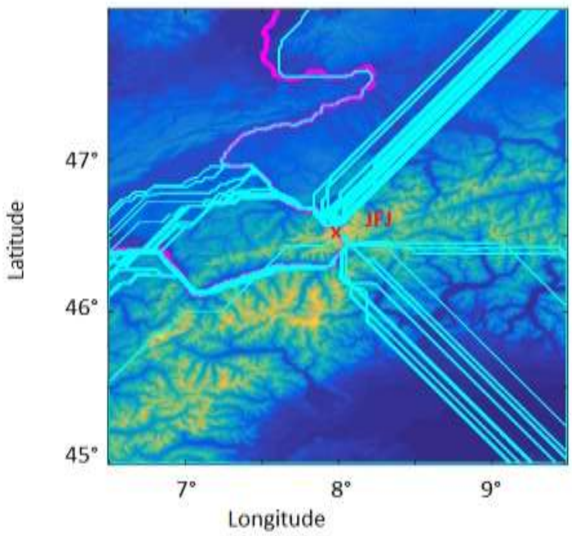

Figure 1. Topography around the JFJ with the mean flow paths (magenta) and the flow paths found if a PBL is added to the topography (cyan).

Andrews, E. et al., *Climatology of aerosol radiative properties in the free troposphere*, Atmos. Res. 102, 365–393, 2011

Nyeki, S., et al., *Convective boundary layer evolution to 4 km asl over high-alpine terrain: Airborne lidar observations in the Alps*Geophys. Res. Lett., *27, 689–692, 2000.*