Interception of water and reactive nitrogen in Norway spruce canopies along an altitudinal gradient in the Bavarian Forest National Park – summary –

During the summer 2012 and 2013, measurements on atmospheric deposition have been performed at Großer Falkenstein summit (1315 m.a.s.l.) and at the upper slope location Ruckwiesberg (1192 m.a.s.l.) in the Bavarian Forest National park, focussing on reactive nitrogen (N). In addition to wet deposition (open site) and throughfall measurements in the nearby Norway spruce stands (*Picea abies* L.), fog and cloud water was sampled with a cylindrical harp, covered with Teflon strands. Combining these approaches was expected to give insight into the quality and quantity of deposition due to the interception of water droplets. This path of atmospheric input is called moist or occult or horizontal deposition, respectively. The intensive monitoring plots and stations of the UNECE Integrated Monitoring programme in the Forellenbach catchment were used as a reference concerning physical and chemical conditions at middle and low elevation sites: wet deposition and throughfall measurements at Taferlruck (770 m.a.s.l.) and in the mature Norway spruce stand Weitau (787 m.a.s.l.). At the measuring tower Schachtenau (807 m.a.s.l.), visibility has been measured and compared with results from the Großer Arber summit (1435 m.a.s.l.). The aim of this small programme was (I) to improve the regional data base and knowledge about deposition at high elevation sites and (II) to contribute to the modelling and mapping work on reactive nitrogen background pollution of the German Environment Agency ("PINETI-2", UBA-Forschungsprojekt 3712 63 240-1, SCHAAP et al. 2015).

Large throughfall amounts pointed to the importance of fog and cloud droplet interception for the quantity of water and element gains. Throughfall of individual samplers, which exhibited high spatial variability due to canopy structure, summed up to 604 mm, 1079 mm und 1191 mm on lower slope, upper slope and summit site. Gross water yield by interception was calculated to 383 mm and 587 mm on upper slope and summit site. Visibility measurements at the measuring tower Schachtenau and Großer Arber underpinned that moist deposition is insignificant at low elevation, but important at summits or highly exposed locations. Großer Arber and the measuring tower Schachtenau offered 546 and 234 foggy days per year and foggy conditions on 64% and 3% of all records (16 per day). In addition, mean visibility was 96 m and 284 m, indicating large differences in the number of droplets and liquid water content of the air.

Mean volume of fog and cloud water samples differed substantially between upper slope (136 ml) and summit (623 ml), verifying the differences in water yield by interception and in visibility. N concentration varied in the opposite direction. On upper slope, mean N concentration was 6.3 mg l^{-1}. On summit however, mean N concentration reached 60% of this, as did dissolved organic carbon and manganese. This points to larger evaporation effects and reinsertion of already deposited quantities from nearby spruce stands on upper slope. On both

locations, ammonium (NH_4^+) und nitrate (NO_3^-) had equal proportions and dissolved organic nitrogen DON showed small concentrations (0.3 mg l^{-1}).

Therefore, it's plausible to attribute the high concentrations of DON in expense of NH_4^+, found in throughfall, to the in situ biological transformation of deposited NH_4^+, whereas the proportion of NO_3^- didn't change. Througfall deposition was 14, 22 and 26 kg N ha^{-1} on lower and upper slope and on summit site, but offered high spatial variability on the latter. Open site deposition was only 7.5 - 7.7 kg N ha^{-1} and independent from altitude. Assuming that moist deposition is not important on lower slope and the dry deposition rate there may serve as a minimum estimate of it on the high elevation sites, moist deposition amounts to 12 kg N ha^{-1} on summit and to 8 kg N ha^{-1} on upper slope. The mean concentrations in sampled fog and cloud water (3.6 mg N l^{-1} and 6.3 mg N l^{-1}) and even the first quartiles (2.0 mg N l^{-1} and 4.1 mg N l^{-1}) are sufficient to create the calculated N input via moist deposition, on Großer Falkenstein as well as on Ruckwiesberg.

On the study sites, moist deposition of nitrogen in Norway spruce stands accounted for 36% (upper slope) and 48% (summit) of total measured input. The quantity itself depends on the exposure to clouds and wind, especially, which is mostly found on the crests of low mountain ranges. Relevant quantities of moist deposition are to be expected above 1000 – 1100 m.a.s.l., in the Inner Bavarian Forest. Elevation per se and the number of foggy days per year alone is an insufficient indicator for a notable moist deposition contribution to be considered in nitrogen deposition mapping.