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Desert dust,Ocean spray,Volcanoes,Biomass burning: Pathways of nutrients into Andean rainforests

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Regular rain and fogwater sampling in the Podocarpus National Park, along an altitude profile between 1800 and 3185 m, has been carried out since 2002.The research area located in southern Ecuador on the wet eastern slopes of the Andes is dominated by trade winds from easterly directions. The samples, generally accumulated over 1-week intervals, have been analysed for pH,conductivity and major ions(K^+,Na^+,NH_4^+,Ca^{2+},Mg^{2+},SO_4^{2-},NO_3^-,PO_4^3). For all components a strong seasonal variation is observed,while the altitudinal gradient is less pronounced.

About 35 % of the weekly samples had very low ion contents,at or below the detection limit, with pH generally above 5 and conductivity below 10 uS/cm.10 days back trajectories (FLEXTRA) showed that respective air masses originated in pristine continental areas,with little or no obvious pollution sources.

About 65 %,however,were significantly loaded with cations and anions,with pH often as low as 3.5 to 4.0 and conductivity up to 50 uS/cm.Back trajectories showed that respective air masses had passed over areas of intense biomass burning,volcanoes,and the ocean,with even episodic Sahara and/or Namib desert dust interference.

Enhanced SO_4^{2-} and NO_3^- were identified,by combining satellite-based fire pixels with back trajectories,as predominantly resulting from biomass burning. Analyses of oxygen isotopes ^{16}O ,^{17}O ,and ^{18}O of nitrate show that nitrate in fog samples is a product of atmospheric conversion of precursors.For most cases,by using emission inventories, anthropogenic precursor sources other than forest fires could be ruled out,thus leaving biomass burning as the main source of nitrate and sulphate in rain and fogwater.

Some SO_4^{2-} ,about 10 % of the total input,could be identified to originate from active volcanoes, whose plumes were sometimes encountered by the respective back trajectories.

Enhanced Na^+, K^+ ,and Cl^- was found to originate from ocean spray sources.They were associated with strong winds providing Atlantic air masses to reach the receptor site within less than 5 days.Episodes of enhanced Ca^{2+} and Mg^{2+} were found to be associated with air masses from African deserts.Satellite aerosol data clearly confirmed desert sources both on the Northern (Sahara) as on the Southern Hemisphere (Namib),depending on season.

Few episodes of distinct PO_4^{3-}deposition are due to air masses either from north African (phosphate mining) or coastal sites of Peru (guano?).

While volcanic,oceanic and desert sources are natural, large scale biomass burning is an anthropogenic source which adds about 7 kg/ha of NO_3^- and 14 kg/ha of SO4 $^{2-}$ per year .The episodic PO_4^{3-} deposition amounts to about 2.6 kg/ha PO_4^{3-} per year.Controlled fertilizing experiments are presently carried out to investigate the impact of these disturbances on the mountain forest ecosystem.