New insights on the geochemistry of the Alpine drainage basin rivers from the CoDA (Compositional Data Analysis) perspective

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Abstract

The organization of the river drainage basins reflects the fundamental tendency of natural systems to deplete driving gradients as fast as possible through the maximization of free energy generation, thereby accelerating the dynamics of the system. This condition results in the maximization of sediment erosion to deplete topographic gradients as fast as possible thus involving large-scale feedbacks to continental geology (Kleidon et al., 2013) as well to water chemistry. River networks are an interesting example of organized structures in nature often described by fractal geometry. Rainfall and runoff does not randomly diffuse through the soil to the ocean, but rather collects in channels that are organized in self-similar tree-like structures along topographic gradients. The organization of river networks is not an exception but is persistent and can be found in many different regions of the Earth representing fundamental thermodynamic trends in nature to dissipate gradients as fast as possible (Kleidon et al., 2013).

The aim of this contribution is to understand how the drainage systems organization affects rivers water chemistry. To achieve this target the exploration of the behaviour of solutes by means of distributional analysis is presented. The key premise is that a distribution's shape reveals information about the governing dynamics of the solutes that gave rise to the distribution (Van Rooij al., 2013).

Weathering reactions represent the transfer of heat and entropy to the environment in geochemical cycles. Chemical weathering is a key process for understanding the global cycle of elements, both on long and short-terms and chemical weathering rates are complex functions of many factors including climate, drainage basin geometry, dissolution kinetics of minerals, mechanical erosion, lithology. As reported in Rantitsch (2001), variations in surface morphology and lithology have provided an opportunity to study lithologic and morphologic influences on the spatial pattern of stream-sediment geochemistry within two contrasting environments of the Eastern Alps (Hohe Tauern Range and Gurktaler Alpen Range).

Starting from the chemical composition of Alpine rivers water (Donnini et al., 2016) the frequency distribution of isometric log-ratio coordinates is investigated. Isometric log-ratio coordinates, or balances, can be constructed by using the sequential binary partition (SBP) method applied on the water composition. The balances can be identified to maintain, as far as possible, the similarity with weathering reactions where solutes are involved (Buccianti & Zuo, 2016). As an alternative, balances can be derived after the multivariate investigation of the variance-covariance structure of the compositional matrix. In both cases the idea is to probe the behaviour of geochemical processes through the distribution's shape of the isometric log-ratio coordinates. The emergence of self-organised non-linear processes governing water chemistry suggests the presence of dissipative systems, which require complexity, large numbers of inter-connected elements and stochasticity. Compositional Data Analysis appears to be the adequate tool to capture and evidence all these features.

References

Buccianti, A., Zuo, R. (2016). Weathering reactions and isometric log-ratio coordinates: Do they speak to each other? *Applied Geochemistry*, 75, 189-199.

Donnini, M., Frondini, F., Probst, J.L., Probst, A., Cardellini, C., Marchesini, I., Guzzetti, F. (2016). Chemical weathering and consumption of atmospheric carbon dioxide in the Alpine region. *Global and Planetary Change*, 136, 65–81.

Kleidon, A., Zehe, E., Ehret, U., Scherer, U. (2013). Thermodynamics, maximum power, and the dynamics of preferential river flow structures at the continental scale. *Hydrol. Earth Syst. Sci.*, 17, 225–251.

Van Rooij M.M.J.W., Nash, B.A., Rajaraman, S., Holden J.G. (2013). A fractal approach to dynamic inference and distribution analysis. *Frontiers in Physiology*, 4, 1-15.

Rantitsch, G., 2001. The fractal properties of geochemical landscapes as an indicator of weathering and transport processes within the Eastern Alps. *Journal of Geochemical Exploration*, 73, 27-42.