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An inverse modelling framework to reconstruct the Andean vegetation dynamics with lipid biomarkers in plants and soil

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This study is meant to contribute to the reconstruction of the historic upper forest line in the Ecuadorian Andes and link it to past changes in climate and human interference. In a previous study we found that the plant species responsible for the dominant biomass input into soil and peat records in the area indeed contain plant(group) specific biomarkers in their leaves and roots in the form of unique combinations of n-alkanes and n-alcohols of different carbon chain length. In addition, the compounds in question were found to be very well preserved in both soil and peat records in the area.Biomarker signals preserved in such records consists of the mixed contribution of many different plants collected over time. Since it is the unique combinations of otherwise ubiquitous n-alkanes and n-alcohols of various carbon chain-lengths that constitute the unique plant biomarkers, unraveling the mixed signal preserved in paleoecological records poses a major challenge. A challenge that is difficult to overcome by simple visual interpretation of the mixed signal retrieved from soils or peat deposits. This not only hinders the application of biomarkers to reconstruct the historic upper forest line but points to a more general problem in modern paleoecology; the problem that increasingly detailed and complex records are increasingly difficult to interpret unambiguously without the aid of advanced interpretative techniques. We present a simple discrete linear model which describes the accumulation of lipids in the soil. By inversion we derive the most likely vegetation composition leading to this

biomarker-record. To stabilize the result, we apply a form of Tikhonov-regularization which imposes a smoothness constraint on vegetation transitions in time, and constraint which promotes consistent vegetation communities. We show that this model, is well-posed under realistic observation sets, and various forms of Gaussian and non-Gaussian noise. Also results for real observations are shown. The model and the inverse modelling framework is implemented in Matlab, and available for download from the matlab central.