Geophysical Research Abstracts
Vol. 20, EGU2018-8543-2, 2018
EGU General Assembly 2018

Producing an enhanced millennium-length temperature reconstruction from tree-ring density for the European Alps

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Skillful, annually resolved proxy records, spanning the entire past millennium, are urgently needed to place recent warming into a historical context and compare with the differently forced Medieval Warm Period (MWP). At elevational and latitudinal treelines, temperature variability is fingerprinted in tree-ring width (TRW) and maximum latewood density (MXD) data providing essential information to large scale climate reconstructions. Büntgen et al. (2006) produced a MXD chronology for the European Alps, resulting in a highly cited and influential millennium-length temperature reconstruction. However, this reconstruction has some limitations which we will address and eliminate within this study: (i) Living trees do not reach millennial age in the European Alps, thus timbers from historical buildings were used by Büntgen et al. (2006) to extend the chronology back into time. The exact provenance of the timber material is, however, unknown and climate signals may vary between trees from treeline and non-treeline sites. We will perform a living tree multiple-site sampling along elevational transects and apply a living tree-based provenance model to the historical material for estimating its origin and to gain robust climate signals. (ii) The underlying samples in the Büntgen et al. (2006) record originate from different subalpine valleys in Switzerland, with all pre-1200 samples exclusively originating from buildings in the Simplon region, while the recent data is from buildings and living trees in the Lötschental. The ecological differences among these valleys have not been assessed, but very likely influence the chronology and derived temperature reconstruction, which is reflected by statistical discrepancies in the record. We will produce a MXD chronology based on ecological homogenous data from the Simplon valley to match the existing data covering the entire MWP. (iii) Sample replication in the Büntgen et al. (2006) chronology is low around 1200 AD emphasizing individual tree responses and weakening the chronology signal strength. We will include additional samples covering this crucial period and will develop a well replicated and temporally robust MXD chronology back to Medieval times. (iv) As the Büntgen et al. reconstruction ends in 2004, it cannot be used to place the recent warmest decades into a long-term context. We will produce an updated millennium-length temperature reconstruction extended until 2018 and providing robust estimates back to Medieval times.