Geophysical Research Abstracts
Vol. 12, EGU2010-14972, 2010
EGU General Assembly 2010

Stable carbon isotopes in tree rings: the failure of uniformitarianism

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When tree rings are used to reconstruct past climate we rely on the uniformitarian principle that 'the present is the key to the past'. Relationships between measured parameters and climate that can be calibrated and verified over the instrumental period are assumed to be applicable at longer timescales. In the case of δ13C, however, the uniformitarian principle fails for two reasons. (1) The instrumental calibration period is also the period of anthropogenic increase in atmospheric CO2. δ13C is a function of the ratio of internal to ambient CO2, so maintaining constant δ13C over the industrial period requires an active plastic response, either restricting stomatal conductance or increasing assimilation rate. In some areas trees may have reached the limits of their plasticity so that over the last few decades δ13C values have been declining, independent of any changes in climate. If no correction is made, the recent response to climate will be a poor indicator of behaviour in the past. (2) Tree ring δ13C is often used to reconstruct past temperatures even though temperature rarely has a strong direct control over fractionation. The link is therefore via either sunshine or humidity, which over the calibration period may be very strongly correlated with temperature. Long isotope chronologies, when compared with independent evidence of past temperatures, however, can show periods of marked divergence. The strong covariance of temperature, sunshine and humidity over the last century may not have persisted over longer timescales with larger climatic perturbations. In the case of carbon isotopes the key to the past is not statistical inference based on recent behaviour, but a clear mechanistic understanding of the influence of climate and other factors on fractionation.