Geophysical Research Abstracts,
Vol. 11, EGU2009-11114, 2009
EGU General Assembly 2009

A triple stable isotope approach in tree rings for detecting the impact of nitrogen emissions on tree physiology

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Over the last decades, human activities have contributed to increase reactive nitrogen (N) in the atmosphere (such as NOx and NHx compounds) and their deposition on terrestrial ecosystems. The relevance of the current N deposition (Ndep) on carbon (C) sequestration has lately been questioned by both experimental and modelling approaches. Widely a different estimates of C sensitivity to Ndep have been reported in recent investigations (Magnani et al., 2007; Högberg 2007; De Vries et al. 2008; Magnani et al. 2008; Sutton et al. 2008, which highlights the need for a through re-assessment of all the physiological mechanisms and processes involved.
The impact of Ndep on forest ecosystems can be investigated near the pollution sources, where the effects are expected to be easily detectable. Therefore, tree rings represent a valuable archive for disturbances due to pollution events, which can be detected by combining d13C, d18O, d15N and dendrochronological approaches.
The aim of this research was to investigate the impact of long term exposure to NOx emissions on two tree species, namely: a broadleaved species (Quercus cerris) that was located close to an oil refinery in Southern Italy, and a coniferous species (Picea abies) located close to a freeway in Switzerland.
The analysis of d15N in tree rings allowed to detect the input of N from anthropogenic emissions. Further, variations in the ratio of intercellular and ambient CO2 concentrations (ci/ca) and the distinction between stomatal (gs) and photosynthetic (A) responses to NOx emissions in trees were assessed using a conceptual model (Scheidegger et al., 2000), which combines d13C and d18O in tree rings. The strongest fingerprint of N emissions was detected for Q. cerris at the oil refinery site, as assessed by d15N. Long-term exposure to NOx emissions had a different impact on the ci/ca ratio in the two experimental sites: at the oil refinery (Quercus cerris), gs influenced ci/ca more, as assessed by d18O, while at the freeway site (Picea abies) the ci/ca ratio was mainly altered by variations in A, as assessed by d13C.
This study highlights that a single method approach does not always provide a complete picture of which physiological traits are more affected by N emissions. While, the triple isotope approach in tree rings can give a differentiated insight into the A-gs relationship, representing a promising tool to investigate the long-term effect of N emissions on trees.