Revised Phanerozoic atmospheric CO_2 concentrations from paleosol carbonate

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CO_2 concentrations in Earth's atmosphere ($[CO_2]_{atm}$) during Phanerozoic greenhouse climates have been estimated using a number of different proxies. $[CO_2]_{atm}$ based on $\delta^{13}C$ values of paleosol carbonate ($\delta^{13}C_{pc}$) tend to be significantly higher than those based on other proxies such as stomatal indices or the $\delta^{13}C$ value of fossil bryophytes. Understanding this discrepancy is important for quantifying the geologic carbon cycle and accurately estimating Earth's average, long-term climate sensitivity.

$[CO_2]_{atm}$ calculated from $\delta^{13}C_{pc}$ values are particularly sensitive to soil-derived CO_2 concentrations (*S(z)*). Whereas *S(z)* values between 4000 and 10,000 ppmV are typically assumed in order to calculate $[CO_2]_{atm}$, our results indicate that seasonal variability in *S(z)* greatly exceeds this range. We hypothesize that the lowest warm season *S(z)* values correspond to soil carbonate formation because calcite solubility decreases with pCO_2. In modern soils from New Mexico, USA, minimum annual *S(z)* values (<2000 ppmV during late spring) coincide with the timing of isotope equilibrium between soil CO_2 and carbonate [1], supporting our hypothesis. The possibility that appropriate values for *S(z)* are higher in wetter climates is currently being investigated. However, a calibration based on a variety of soils suggests that appropriate values for *S(z)* are lower than previously thought and are generally independent of soil type. $[CO_2]_{atm}$ calculated from Holocene $\delta^{13}C_{pc}$ values [2] more closely matches actual Holocene $[CO_2]_{atm}$ [3] if 2000 ppmV instead of 5000 ppmV [2] is used for *S(z)*. Using *S(z)* = 2000 ppmV results in relatively low Phanerozic $[CO_2]_{atm}$ that agree with estimates from other proxies. We therefore suggest that the large discrepancy between different proxy-based Phanerozoic $[CO_2]_{atm}$ records is due to overestimates from paleosol carbonate as opposed to underestimates from the other proxies.

[1] Breecker *et al*. (2009) *Geol. Soc. Am. Bul.* **121**, 630-640.
[2] Ekart *et al.* (1999) *Am. J. Sci.* **299**, 805-827.
[3] Indermühle *et al*. (1999) *Nature* **398**, 121-126.

Aerosol, clouds and climate : Using satellite observations to detect and quantify aerosol indirect effects

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The hydrological cycle is a crucial feedback process in the Earth climate system. Clouds indeed control the spatial distribution of water vapour, an efficient natural green house gas, and they significantly contribute to the Earth albedo and to the green house effectiveness of the atmosphere. Clouds however are poorly represented in climate models both in terms of spatial and seasonal distributions. Unlike surface temperature, global precipitation is not measured with sufficient accuracy to constrain and tune the models.

Long term satellite observations provide the global perspective that allow to progressively improve cloud parameterizations in climate models. Up to now they have mainly been used to map the spatial, seasonal, and vertical distributions of the cloud systems and associated precipitation. The key question however remains to identify the mechanisms that connect anthropogenic forcings, climate change, cloud amount and precipitation. More specifically, anthropogenic aerosols are well known for modifying cloud microphysics, but the way such microphysical changes may scale up and compete with large scale meteorological forcings is still unclear. Indeed, it is particularly difficult to disentangle aerosol impacts from meteorological forcings because the susceptibility of cloud properties to the former are more than two orders of magnitude smaller than the susceptibility to the meteorology.

This difficulty calls for a new approach in satellite observations, namely to move from a global monitoring of static cloud properties to the retrieval of their time evolution on short time scales to characterize the dynamics of cloud properties and how they might be modulated by anthropogenic aerosols.