Using the Suess effect on the stable carbon isotope to distinguish the future from the past in radiocarbon

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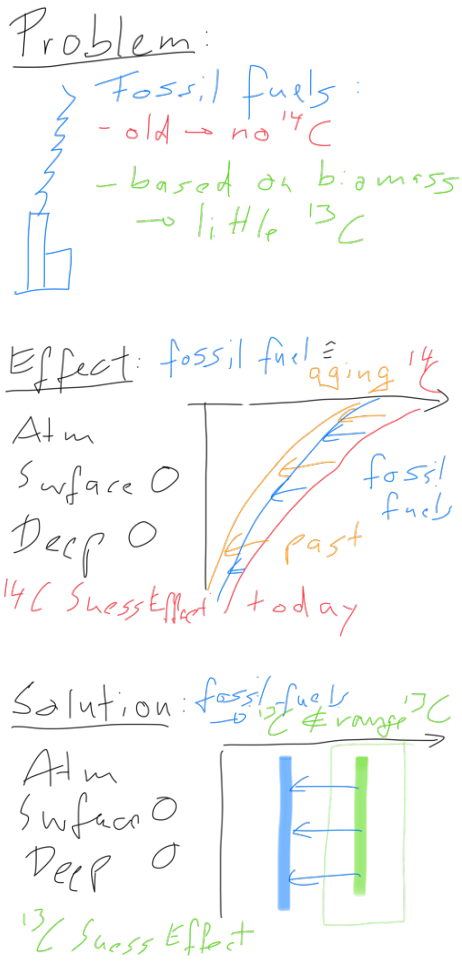
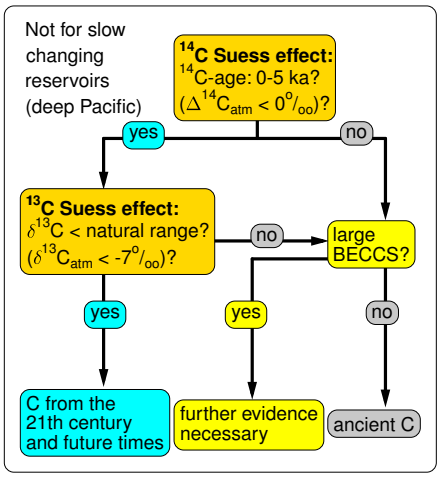
The depletion of ^{14}C due to the emission of radiocarbon-free fossil fuels (^{14}C Suess effect) might lead to similar values in future and past radiocarbon signatures potentially introducing ambiguity in dating. I here test if a similar impact on the stable carbon isotope via the ^{13}C Suess effect might help to distinguish between ancient and future carbon sources. To analyze a wide range of possibilities, I add to future emission scenarios carbon dioxide reduction (CDR) mechanisms, which partly enhance the depletion of atmospheric $\Delta^{14}C$ already caused by the ^{14}C Suess effect. The ^{13}C Suess effect leads to unprecedented depletion in $\delta^{13}C$ shifting the carbon cycle to a phase space in $\Delta^{14}C$–$\delta^{13}C$, in which the system has not been during the last 50,000 years and therefore the similarity in past and future $\Delta^{14}C$ (the ambiguity in ^{14}C dating) induced by fossil fuels can in most cases be overcome by analyzing ^{13}C. Only for slow changing reservoirs (e.g. deep Indo-Pacific Ocean) or when CDR scenarios are dominated by bioenergy with capture and storage (BECCS) the effect of anthropogenic activities on ^{13}C does not unequivocally identify between past and future carbon cycle changes.

In a nutshell

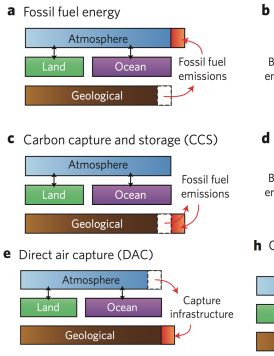


Decision Tree

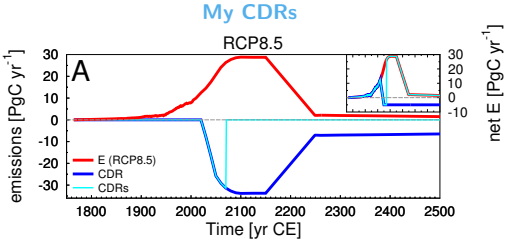


Scenarios

CDR — Carbon Dioxide Reduction (Smith et al 2016)

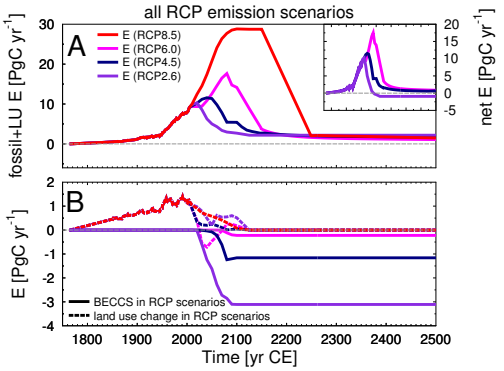


My CDRs

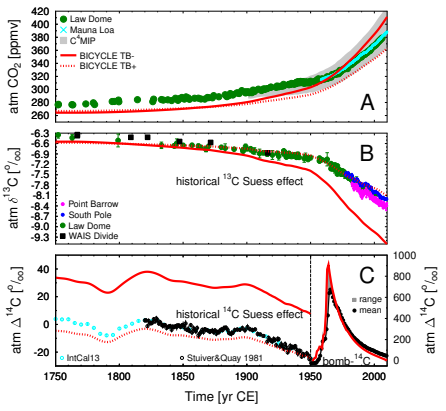


1. BECCS: Bioenergy and Carbon Capture and Storage
2. DAC: Direct Air Capture
3. EW: Enhanced Weathering: here = ocean alkalinization

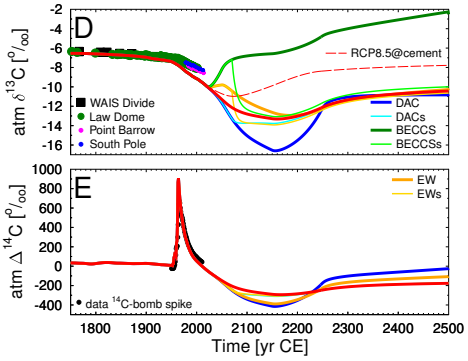
RCP — Representative Concentration Pathways

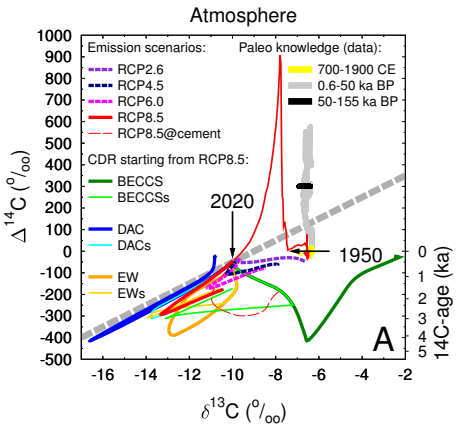


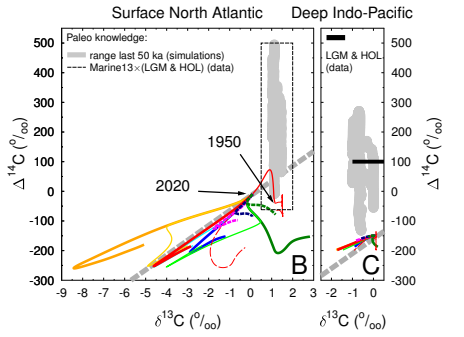
Historical Suess Effect

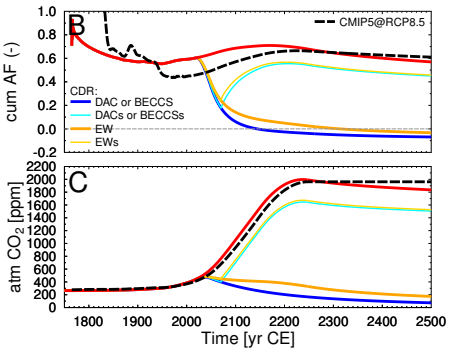


BICYCLE Results

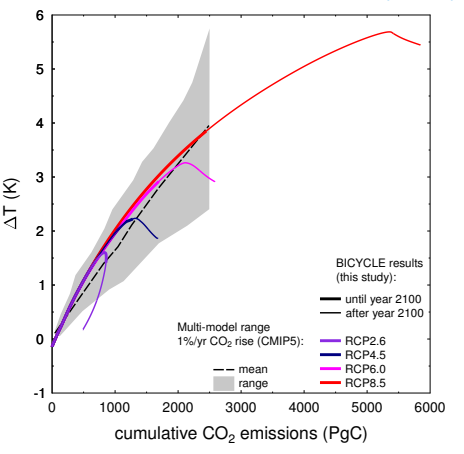








Transient climate response to emissions (TCRE)



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Review on CDR: Smith et al. (2016) Nature Climate Change, 6, 42-50, doi:10.1038/nclimate2870