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Can the carbon isotopic composition of methane be reconstructed from multi-site firn air measurements?

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Methane is a strong greenhouse gas and large uncertainties exist concerning the future evolution of its atmospheric abundance. Analyzing methane atmospheric mixing and stable isotope ratios in air trapped in polar ice sheets helps in reconstructing the evolution of its sources and sinks in the past. This is important to improve predictions of atmospheric CH4 mixing ratios in the future under the influence of a changing climate. We present an attempt to reconcile methane carbon isotope (δ13C(CH4)) records from 11 boreholes in firn from both Greenland and Antarctica to reconstruct a consistent δ13C(CH4) history over the last 50 years. In the firn, the atmospheric signal is altered mainly by diffusion and gravitation. These processes are taken into account by firn air transport models. We show that (δ13C(CH4) reconstructions from individual sites are not always mutually consistent among the different sites. Therefore we apply for the first time a multisite isotope inversion to reconstruct an atmospheric isotope history that is constrained by all individual sites, generating a multisite δ13C(CH4) scenario. The comparison of this scenario with ice core data, atmospheric air archive results and direct atmospheric monitoring data shows that inconsistencies exist between the different types of profiles which may be explained by inter-laboratory calibration differences, by analytical errors or by the lack of constraints on the diffusive fractionation estimates.