Ice core reconstructions of atmospheric methane (CH$_4$) and its stable carbon isotope ratio ($\delta^{13}$CH$_4$) provide important constraints for understanding the links between human activity, methane and climate. However, uncertainties in existing $\delta^{13}$CH$_4$ records since the preindustrial (~1850 CE), reconstructed from measurements of polar firn air and a small number of high-accumulation ice core sites, limit the precise determination of the timing and rate of recent changes in source/sink evolution. To re-assess methane dynamics over the last two centuries, we present continuous multi-core records of atmospheric CH$_4$ and carbon monoxide (CO) between 1824 and 1994 CE reconstructed from high snow accumulation Antarctic sites and supplement these data with new bubble ice measurements of $\delta^{13}$CH$_4$ spanning 50-years from 1938 to 1988 CE at a < 5-year resolution. Across the 50-year record, atmospheric CH$_4$ mixing ratios increase by > 580 ppb and each $\delta^{13}$CH$_4$ measurement therefore requires a considerable correction for diffusive fractionation resulting from a sustained growth in the overlying atmospheric methane burden during firn transport. An overlap with direct atmospheric observations is used to validate corrections for this phenomenon. Source/sink dynamics necessary to drive the simultaneous temporal trends observed in CH$_4$, CO and $\delta^{13}$CH$_4$ since 1850 CE are then inferred using a 6-troposphere, multi-tracer box model. Isotopic corrections, their implications and subsequent modelling results will be discussed.