**Keeling Methode**

Keeling Analyse

~~It is essential to recognise that the model described by equations (1)– (3) involves two basic assumptions. First, we assume that a simple mixing of only two gas components is considered (a source S and the bulk background B). Second, we assume that the isotope ratio of these two components does not change over the course of the observation. It is rare for these two assumptions to hold true in a strict sense under natural field conditions. Rather, researchers have found appropriate points in time and space for which these assumptions are acceptable. Below we outline recommendations for minimizing error in the use of the Keeling plot for assessing the carbon isotope composition of respiration.~~

*~~The application and interpretation of Keeling plots in terrestrial carbon cycle research D. E. Pataki,1~~*

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* ~~measured isotope ratio~~ 
  + ~~δX = (R\_sample -R\_standard)/R\_standard~~
  + ~~R ratio of light vs heavy isotope (C12/C13)~~
  + ~~Δ in per mil~~
* ~~In the isotope measurements the isotopic composition is rst determined relative to a reference gas (WS) of known isotopic composition. The isotopic ratio of the sample compared to the working standard δsample/WS is converted to the interna- tional isotope scale as follow:~~

~~δsample/IS = δWS/ISδsample/WS + δWS/IS + δsample/WS (2.26)~~

~~The isotope values are reported versus the international reference materials VPDB for δ13C and VSMOW for δ2H.~~

* ~~The keeling approach is a mass balance/mass Conservation approach.~~
* ~~Methane Concentration in ambient air is ca~~ 
  + ~~Sum of Methan concentration in background c~~~~b~~ ~~and sorce methan concentration c~~~~s~~
  + ~~C\_a = c\_b + c\_s~~
* ~~mass balance equation for heavy isotopes~~ 
  + ~~δaca = δbcb + δscs~~
* ~~Combining both equations:~~
  + ~~δa =c\_b/c\_a (δb −δs)+δs~~
* ~~δ = isotopic ratio~~
* ~~c = concentration~~
* ~~multiple possible sources δs is a source emissions weighted mean isotopic signature~~
* ~~Equation is a linerare correlation of δa and 1/c\_a~~
* ~~Y intersect is the isotopic signature of the source~~
* ~~With knowledge of the isotopic content of methane of an air sample and its concentration it is possible to calculate the isotopic signature C13 and H2~~
  + ~~Compare the signiture to literature and identify its sorce~~
* ~~Plot:~~
  + ~~orthogonal distance regression approach~~
  + ~~signature for C13 and H2~~
  1. **~~The Keeling method~~**

~~Using the Keeling method, the methane origin sources have been estimated. While investigating the entire timeline. The indicated production mechanisms of methane are thermogenic and microbial CO2 reduction. In particular, wetland, agriculture, and waste. Fossil fuel and other anthropogenic sources play a minor role in the composition of the methane mixture. This is surprising as Hamburg has a significant amount of Heavy industry, including fossil fuel refinery, chemical industry, shipping, energy production etc. On the other hand, this is expected, as the surrounding Countryside has significant ecocultural use, including cattle farmers and large wetland and marshland areas nearby. This also includes the vast Wadden Sea of the German bight near the city. This Wadden Sea region lay upwind in the dominant wind direction to the west.~~

~~When applying the Peak finding algorithms to the methane measurements data. The Keeling method indicates methane production mechanisms much clearer in the Microbial CO2 reduction region and less in the Thermogenic, shifting this more clearly into the Wetland region, while less likely to originate from waste and agriculture. The Keeling method points toward the origin of the methane peaks due to biogenic mechanisms in the river Elbe, its contributors and the wetlands at its riverbanks.~~

~~By using the Wind direction, it is possible to take an even closer look at the methane emission type depending on its estimated origin location/direction. In the dual isotope plot~~ *~~12\_Keeling\_Wind.png,~~* ~~one can identify a difference in isotope signature and origin type by the wind direction. For the total measurement series, one can see that the signature shifts to the abiotic production type for general northern wind directions, hence towards fossil fuels and other anthropogenic sources. As in this region, considerably fewer wetlands are present, and many residential areas lay there, one can assume that this shifts the methane mixture towards the fossil fuels. Probably unburned methane from heating and cooking, leakage in the Gas grid and energy generation plays a significant role in the composition of the Methan mixture.~~

~~For the southern and western directions, the Methan signature is quite strong in the microbial CO2 reduction region, pointing out that the largest contributors to this Methan mixture are wetlands, Agriculture and Waste. While waste can be more or less eliminated due to the absence of large landfills in the region. As mentioned previously, this is expected due to its Geographical and biological features, together with the strongly agraguluraly use of the region. What is rather surprising is the seemingly neglegtebal effect of anthropogenic sources, like fossil fuel and industry, as this region is also heavily used in that regard.~~

~~The same analyses have been done for the methane peaks, as seen in the dual isotope plot,~~ *~~12\_Keeling\_Peaks\_Wind.png.~~* ~~hier, it has to be noted that not all wind directions had sufficient peaks to create a statistically meaningful keeling analyse. For the remaining wind directions, the dual isotope plot indicates a wetland and agricultural origin. Point again toward a biogenic origin in the river Elbe and its wetlands.~~