Name of research institute or organization:

Institut für Umweltphysik, Universität Heidelberg

Title of project:

Long-term observations of $^{14}CO_2$ at Jungfraujoch

Project leader and team:

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Project description:

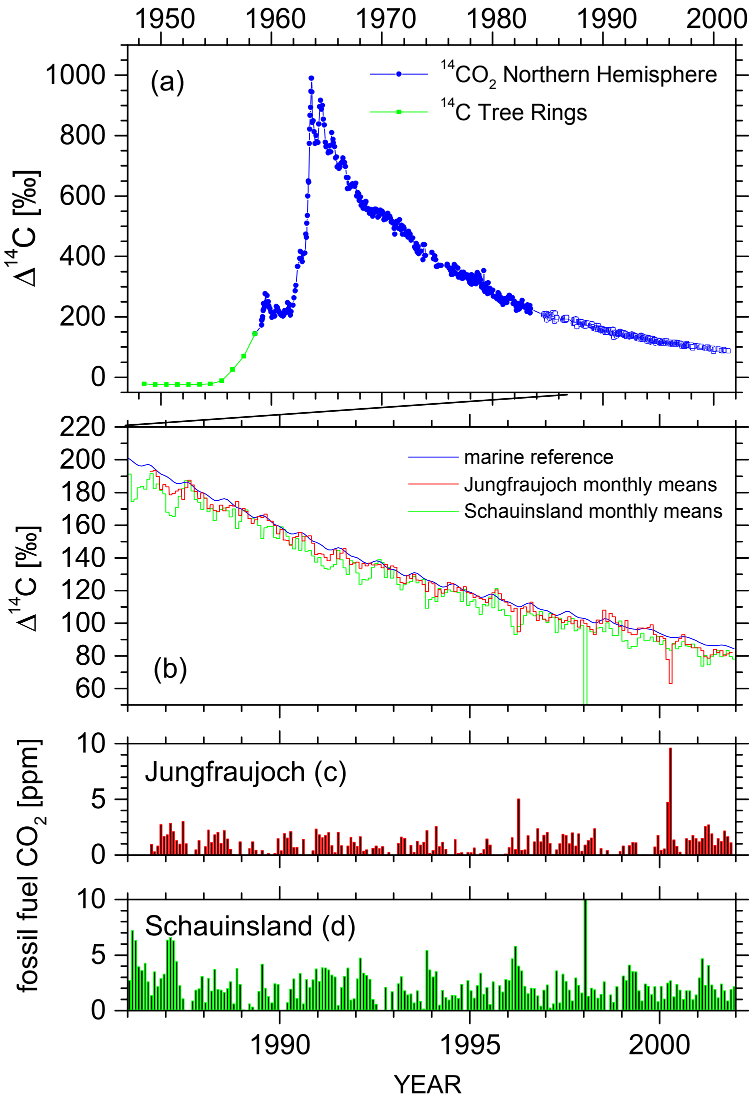
Introduction:

Budgeting Europe's anthropogenic greenhouse gases emissions in the frame of the Kyoto Protocol is generally performed by so-called bottom-up source estimates derived from statistical emissions inventories. A completely independent method to estimate trace gas emissions is the so-called top-down approach using atmospheric observations. In the case of CO_2 from burning of fossil fuels, a difficulty to derive its surface fluxes are co-emissions from biogenic sources. However, it is possible to clearly distinguish fossil fuel CO_2 from recent biogenic emissions via its lack of ^{14}C.

^{14}C is the natural radioactive carbon isotope which is produced in the atmosphere through cosmic ray induced reactions with atmospheric nitrogen. The radioactive half life of ^{14}C is 5730 years. The natural equilibrium level of atmospheric $^{14}CO_2$ has been disturbed by man's activities in the last century, via the ongoing input of fossil fuel CO_2 into the atmosphere known as Suess effect (Suess, 1955), and through nuclear detonations in the atmosphere in the 1950s and early 1960s (^{14}C bomb effect, Figure 1a). CO_2 from burning of fossil fuels, due to its age of several hundred million years, is free of ^{14}C; adding fossil fuel CO_2 to the atmosphere, therefore, not only leads to an increase of its mixing ratio but also to a decrease of the $^{14}C/^{12}C$ ratio in atmospheric CO_2. From this decrease we can directly calculate the contemporary fossil fuel CO_2 surplus at the measurement site, e.g. on the European continent, if the undisturbed marine background level is known.

Results:

Figure 1b shows monthly mean values of $^{14}CO_2$ at Jungfraujoch in comparison to those at the marine background station Izaña, Tenerife (28°18'N, 16°29'W, 2367 m a.s.l.) and at Schauinsland observatory in the Black Forest (47°55'N, 7°55'E, 1205 m a.s.l.). Particularly during the winter months, mean $\Delta^{14}CO_2$ is frequently depleted at Jungfraujoch and Schauinsland by about 10 to 20‰ if compared to the marine reference level. Using a two-component mixing approach, these $\Delta^{14}CO_2$ depletions from marine background translate into monthly mean fossil fuel contributions of 3 to 6 ppm (Figure 1c&d) during this time of the year. During summer, fossil fuel contributions to the continental CO_2 level are generally lower due to enhanced vertical mixing and respective atmospheric dilution of ground-level pollutants but also due to reduced domestic heating emissions. Annual mean fossil fuel contributions are smaller by about a factor of two at the high alpine site Jungfraujoch than at Schauinsland station, the latter being frequently influenced by pollution from the nearby Rhine valley. The measured fossil fuel CO_2 concentrations can now be



compared to respective results derived from atmospheric transport model estimates based on statistical emissions inventories.

Figure 1: (a) Development of $\Delta^{14}C$ in atmospheric CO_2 in the Northern Hemisphere in the last 50 years. Data before 1959 have been derived from tree rings (Stuiver and Quay, 1981). From 1959 to 1983 measurements were performed at the Alpine site Vermunt (Levin et al., 1985) subsequent data from 1984 onwards are from the GAW station Izaña (Tenerife). (b) $^{14}CO_2$ observations performed at Jungfraujoch and Schauinsland. The smooth line is a harmonic fit curve through the Izaña data and is used as marine reference for Jungfraujoch and Schauinsland. (c) Monthly mean continental fossil fuel surplus at Jungfraujoch and (d) at Schauinsland.

References

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Internet data bases:

http://www.iup.uni-heidelberg.de/institut/forschung/groups/kk/

Collaborating partners/networks:

CARBOEUROPE, AEROCARB (http://www.aerocarb.cnrs-gif.fr/)

Scientific publications and public outreach 2002:

Refereed journal article

Levin, I. and V. Hesshaimer, Radiocarbon – a unique tracer of global carbon cycle dynamics. Radiocarbon **42**, 69-80, 2000.

Conference paper

Levin, I and B. Kromer, Long-term measurements of 14CO2 at Jungfraujoch: Observing fossil fuel CO2 over Europe, Proc. Workshop on ‘Atmospheric Research at the Jungfraujoch and in the Alps’, Davos, Switzerland, 20 September 2002, Swiss Academy of Sciences SAS, 19-20, 2002.

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