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

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Associated to programme: ICOS (https://www.icos-ri.eu/)

Keywords: carbon dioxide; carbon cycle dynamics; radiocarbon; fossil fuel CO_2

1. Project description

Radiocarbon observations on carbon dioxide sampled at Jungfraujoch are being performed by the Heidelberg University since 1986. From 2018 onwards, these samples are taken for the University of Bern due to their involvement in the Integrated Carbon Observation System Research Infrastructure (ICOS RI). Jungfraujoch is an official ICOS class-1 station. The sampling protocol follows the specifications given by the atmospheric specification document for ICOS stations (ICOS RI, 2020). The staff of the High Altitude Research Station Jungfraujoch is collecting the samples according to this protocol, i.e. chemical trapping the CO_2 from the air flow when passing through a NaOH solution. We experienced no major problems in 2022 but one box containing samples from the second half of 2021 was forgotten to be sent to Heidelberg. This has now been initiated. The $^{14}CO_2$ measurements are done in the ICOS Central Radiocarbon Laboratory (CRL) at the Institute of Environmental Physics of Heidelberg University and the data are available via the ICOS Carbon Portal (www.icos-cp.eu). Data before 2018 have been published as a separate data set by Levin et al. [2021].

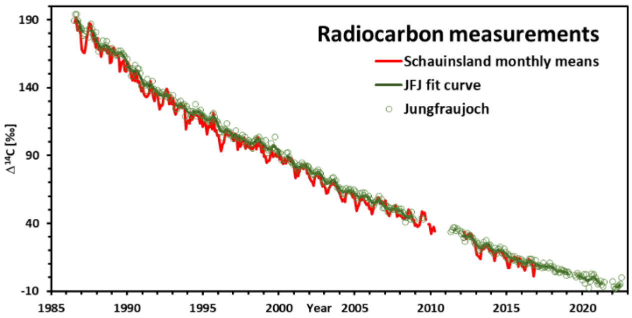

Figure 1. Atmospheric $\Delta^{14}CO_2$ observations at Jungfraujoch (green circles) in comparison to values of the Schauinsland station (red curve). The green line corresponds to a 5-months running mean of the Jungfraujoch values. Data from JFJ between January 2009 and April 2011 as well as from May 2010 to February 2012 have been preventively skipped due to pending calibration issues.

Also this year the ^{14}C record from Jungfraujoch has been used widely as reference in many publications ([*Lee et al.*, 2022; *Sensuła et al.*, 2022; *Vogel et al.*, 2022; *Wu et al.*, 2022; *Yu et al.*, 2022; *Zhao et al.*, 2023].

$\Delta^{14}C$-CO_2 is decreasing due to the CO_2 exchange with the other carbon-containing reservoirs such as the ocean and the land-biosphere, but since the 1990s almost exclusively due to the ongoing (global) input of ^{14}C-free fossil fuel CO_2 into the atmosphere i.e. the global Suess effect (Figure 1). In late 2019, the $\Delta^{14}C$ values reached zero permil.

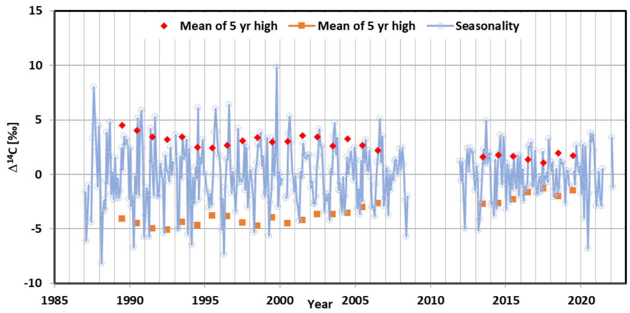

Figure 2. Seasonal amplitude of the Jungfraujoch record based on the monthly values from 1987 to 2022. The preventive gap between January 2009 and April 2011 leads to a gap in seasonality values of 3.5 years due to its calculation.

As already reported last year, the seasonal amplitude at Jungfraujoch shows inter-annual variability as documented in Figure 2. Over recent years, the amplitude seems to be smaller compared to previous periods as documented by the 5 yr minimum and maximum values. The reason for this seasonality decrease is yet unknown but these changes are in line with lower sun spot numbers and neutron counting rates (yet not in phase). The amplitude 11-year cycle modulation that we mentioned in the previous annual activity report has to be carefully reconsidered as calibration issues appeared for ^{14}C data between January 2009 and April 2011. Therefore, also the similarities of the JFJ ^{14}C data with recent ^{14}C studies on dendrochronologically dated tree ring samples [*Brehm et al.*, 2021; *Heaton et al.*, 2021] have to be questioned. Yet, some coherent signals of ^{14}C growth rate variations obtained at Jungfraujoch with STE changes [*Prather*, 2022; *Ruiz and Prather*, 2022] documenting a quasi-biannual frequency support the importance of stratospheric signals. It will be interesting to investigate the causes of this modulation. Levin et al., has shown that the STE contributes significantly to the overall seasonality [*Levin et al.*, 2010]. However, they have not investigated whether there is a quasi-biannual frequency present.

The minima and maxima of the mean seasonality at Schauinsland leads that at Jungfraujoch by 1 month. The amplitude is higher at Schauinsland compared to Jungfraujoch.

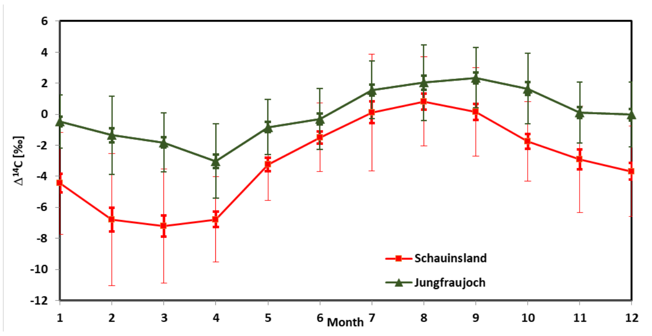

Figure 3. Mean seasonality of the Jungfraujoch and Schauinsland (shifted by the mean offset for the two stations during the overlapping period, i.e. 3.2 ‰). Corresponding uncertainty (1σ, thin line) and (1σ of the mean, thick line) based on the monthly values from 1987 to 2022 for Jungfraujoch and 1987 to 2016 for Schauinsland. January corresponds to month 1.

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Internet data bases

https://meta.icos-cp.eu/objects/L2KPGw3qDafKMReHzH2qGs5o
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Collaborating partners / networks

International Foundation Hochalpine Forschungsstationen Jungfraujoch und Gornergrat (HFSJG)
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