Cosmogenic Proxies (COPROX)

Simulations of the Atmospheric Transport and Deposition of Cosmogenic Isotopes as Proxies for Solar Activity and Atmospheric Dynamics

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In Short

- Extracting information from cosmogenic isotopes
- Cosmogenic Proxies for solar dynamics such as SPE
- Cosmogenic Tracers for atmospheric processes such as mass exchange between strato- and troposphere
- Modelling with modular chemistry-climate models

Cosmogenic Isotopes such as Beryllium-10 (^{10}Be), Beryllium-7 (^{7}Be) and Carbon-14 (^{14}C) are continuously generated via the interaction of galactic cosmic rays (GCR) with the atmosphere of the earth, mainly the stratosphere. After their generation they are deposited in natural archives e.g. ice cores or tree rings. The concentration of cosmogenic isotopes within these archives varies on multiple time-scales and depends on the production rate. The production rate, however, depends on the solar activity as well as the strength and structure of the magnetic field of the earth [1]. For example, the decadic variations of the concentration of ^{10}Be in ice cores correlate with the periodic cycle of sunspots, since the sunspot cycle is an articulation of periodic variations of the magnetic field of the sun which influences the amount of GCR that reaches the atmosphere of the earth [2]. In that way cosmogenic isotopes in natural archives provide information about past variations of the solar activity and earth's magnetic field, especially when the data from natural archives are combined with simulation approaches to reconstruct the specific conditions of the period under which the considered variation was observed. Furthermore, the concentration of cosmogenic isotopes depends on atmospheric dynamics as well as local (tropospheric) circulation patterns. Variations on annual time scales are determined by seasonal atmospheric transport. Thus changes in the concentration of cosmogenic isotopes can also be used as a proxy for local climate and weather changes. Cosmogenic isotopes such as ^{7}Be also serve as tracer e.g. to explore the mass exchange between the stratosphere and troposphere or allow to improve the forecast of large scale weather systems such as monsoon [3]. Since the production, transport and deposition of cosmogenic isotopes is a very complex interplay, the simulation of these processes can also be used to evaluate chemistry-climate models (CCMs) or even full earth system models (ESMs). Besides GCR solar proton events (SPE) are a sporadic source of cosmogenic isotopes. If the SPE is strong enough, the cosmogenic isotopes from this source can be distinguished from the GCR induced isotopes and utilized as a distinct time makers for geochronological purpose. Furthermore, SPE induced cosmogenic isotopes are useful tracers of atmospheric mass transport [4].

Specifically, we are going to simulate phases of documented solar proton events (SPE) as a primary source of cosmogenic isotopes such as ^{10}Be and ^{14}C (see e.g. [5, 6]). Here, we aim to find out the precise season in which the SPE occurred and further investigate the role of the seasonality of the lower stratosphere and troposphere. In addition, we plan to simulate the phase 1950 to 2019 with galactic cosmic rays (GCR) being the main source of cosmogenic isotopes and to investigate the impact of man-made climate change on the transport and deposition of the isotopes. Particularly, we focus on the mass exchange between strato- and troposphere, incorporating ^{7}Be as a passive tracer.

The model simulations will be performed with the CCM EMAC (ECHAM/MESSy Atmospheric Chemistry). EMAC was developed at the Max-Planck-Institut (MPI) for Chemistry and has, with some modifications, been locally implemented at FUB and successfully applied in a number of scientific studies. EMAC is based on the ECHAM5 general circulation model (GCM) developed at the MPI for Meteorology, originally derived from the weather forecast model of the ECMWF ("European Centre for Medium-range Weather Forecasts"), and has been extended to a modular CCM at the MPI for Chemistry allowing the implementation of multi-institutional codes via the MESSy ("Modular Earth Submodel System") interface [7].

EMAC is specifically qualified for the goals of COPROX because it allows the description of the dynamics and chemistry of the stratosphere and troposphere coupled to the ocean system as well as the impact of solar variations on the Earth system. Due to the modular structure, EMAC can be configured according to the different tasks we aim to solve.

More Information

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Project Partners

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